Discovery Series II

Workshop Manual

Werkplaatshandboek

Manual d'Atelier

Werkstatthandbuch

Manuale d'Officina

Manual de Taller

Manual de Oficina

DISCOVERY SERIES II

WORKSHOP MANUAL - 1999MY ON

Publication Part No. VDR 100090 ENG (6)

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How To Use This Manual

General

To assist in the use of this Manual, it is divided into sections and sub-sections. The section title is given at the top of each page and the relevant sub-section is given at the bottom.

There is a single contents section at the front of the Manual, which is divided by section and sub-section. Each section is numbered from page 1.

The individual items comprising repair operations are to be followed in the sequence in which they appear. Items numbers in the illustration are referred to in the text.

Adjustment and Repair operations include reference to Service tool numbers and the associated illustration depicts the tool in use. Adjustment and repair operations also include reference to wear limits, relevant data, torque figures, and specialist information and useful assembly details. Each adjustment or repair operation is given its Service Repair Operation number.

WARNINGS, CAUTIONS and **NOTES** have the following meanings:

WARNING: Procedures which must be followed precisely to avoid the possibility of injury.

CAUTION: Calls attention to procedures which must be followed to avoid damage to components.

NOTE: Gives helpful information.

References

References to the LH or RH side given in this Manual are made when viewing the vehicle from the rear. With the engine and gearbox assembly removed, the crankshaft pulley end of the engine is referred to as the front.

Operations covered in this Manual do not include reference to testing the vehicle after repair. It is essential that work is inspected and tested after completion and if necessary a road test of the vehicle is carried out particularly where safety related items are concerned.

Dimensions

The dimensions quoted are to design engineering specification with Service limits where applicable.

Repairs and Replacements

When replacement parts are required it is essential that only Land Rover recommended parts are used.

Attention is particularly drawn to the following points concerning repairs and the fitting of replacement parts and accessories.

Safety features and corrosion prevention treatments embodied in the vehicle may be impaired if other than Land Rover recommended parts are fitted. In certain territories, legislation prohibits the fitting of parts not to the manufacturer's specification. Torque wrench setting figures given in this Manual must be used. Locking devices, where specified, must be fitted. If the efficiency of a locking device is impaired during removal it must be renewed.

Owners purchasing accessories while travelling abroad should ensure that the accessory and its fitted location on the car conform to legal requirements.

The Terms of the vehicle Warranty may be invalidated by the fitting of parts other than Land Rover recommended parts.

All Land Rover recommended parts have the full backing of the vehicle Warranty.

Land Rover Dealers are obliged to supply only Land Rover recommended parts.

Specifications

Land Rover are constantly seeking to improve the specification, design and production of their vehicles and alterations take place accordingly. While every effort has been made to ensure the accuracy of this Manual, it should not be regarded as an infallible guide to current specifications of any particular vehicle.

This Manual does not constitute an offer for sale of any particular vehicle. Land Rover Dealers are not agents of Land Rover and have no authority to bind the manufacturer by any expressed or implied undertaking or representation.

Abbreviations and Symbols

A	Amperes
AAP	Ambient Air Pressure
AAT	Ambient Air Temperature
ABDC	After Bottom Dead Centre
ABS	Anti-Lock Brake System
ABS / TC	Anti-lock Brake System / Traction Control
ac	Alternating current
A/C	Air Conditioning
ACE	Active Cornering Enhancement
ACEA	Association of Constructors of European Automobiles
AFR	Air Fuel Ratio
AP	Ambient Pressure
ASC	Anti-shunt Control
ATC	Air Temperature Control
ATDC	After Top Dead Centre
AUX	Auxiliary
AVC	Automatic Volume Control
BBDC	Before Bottom Dead Centre
BBUS	Battery Backed Up Sounder
BCU	Body Control Unit
BDC	Bottom Dead Centre
bhp	Brake Horse Power
BP	Boost Pressure
BPP	Brake Pedal Position
BS	British Standard
BTDC	Before Top Dead Centre
BWD	Backward
C	Celsius
CAN	Controller Area Network
CD	Compact Disc
CDC	Centre Differential Control
CDL	Central Door Locking
CD - ROM	Compact Disc - Read Only Memory
CFC	Chlorofluorocarbon
CHMSL	Centre High Mounted Stop Lamp
CKP	Crankshaft Position
CLV	Calculated Load Value
cm	Centimetre
cm^2	Square centimetre
cm^3	Cubic centimetre
CMP	Camshaft Position
CPP	Clutch Pedal Position
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COB	Clear Over Base
CR	Common Rail
CVS	Canister Vent Solenoid
dB	Decibels
DDM	Driver's Door Module
deg.	Degree, angle or temperature
DI	Direct Injection
dia.	Diameter
DIN	Deutsche Industrie Normen (German Industrial Standards)
dc	Direct current
DCV	Directional Control Valve
DOHC	Double Overhead Camshaft
DSP	Digital Signal Processing
DTI	Dial Test Indicator
DMF	Dual Mass Flywheel
DVD	Digital Versatile Disc
EACV	Electronic Air Control Valve
EAT	Electronic Automatic Transmission
EBD	Electronic Brake pressure Distribution
ECD	European Community Directive
ECM	Engine Control Module
ECT	Engine Coolant Temperature
ECU	Electronic Control Unit
EDC	Electronic Diesel Control
EEPROM	Electronic Erasable Programmable Read Only Memory
EGR	Exhaust Gas Recirculation
EKA	Emergency Key Access
ELR	Emergency Locking Retractor
EN	European Norm
EOBD	European On Board Diagnostics
EON	Enhanced Other Network
ERL	Electrical Reference Library
ETC	Electronic Traction Control
EUI	Electronic Unit Injector
EVAP	Evaporative Emission
EVR	Electronic Vacuum Regulator
F	Fahrenheit
ft.	Feet
FBH	Fuel Burning Heater
FET	Field Effect Transistor
FIP	Fuel Injection Pump
FTC	Fast Throttle Control
FWD	Forward
>	Greater than
g	Gramme or Gravity
gal.	Gallons
GMT	Greenwich Mean Time
GPS	Global Positioning System
h	Hour
hc	High compression
HC	Hydro Carbons
HDC	Hill Descent Control
HDOP	Height Dilation Of Precision
HDPE	High Density Polyethylene
HFS	Heated Front Screen
Hg	Mercury
HO_2S	Heated Oxygen Sensor
HMW	High Molecular Weight

HRW	Heated Rear Window
HSLA	High Strength Low Alloy
ht/HT	High tension
IACV	Idle Air Control Valve
IAT	Intake Air Temperature
ICE	In-Car Entertainment
i.dia.	Internal diameter
IDM	Intelligent Driver Module
IF	Intermediate Frequency
in^3	Cubic inch
ILT	Inlet Throttle
IPW	Injector Pulse Width
ISO	International Organisation for Standardisation
ITS	Inflatable Tubular Structure
k	Thousand
kg	Kilogramme
kg/h	Kilogrammes per hour
km	Kilometre
km/h	Kilometres per hour
kPa	KiloPascal
KS	Knock Sensor
<	Less than
l	Litre
lb(s)	Pounds
lbf	Pounds force
lbf.in	Pounds force inches
lbf/in^2	Pounds per square inch
lbf.ft	Pounds force feet
λ	Lambda
lc	Low compression
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEV	Low Emission Vehicle
LH	Left-Hand
LHD	Left-Hand Drive
LSM	Light Switch Module
LVS	Liquid Vapour Separator
m	Metre
µ	Micro
MAF	Mass Air Flow
MAP	Manifold Absolute Pressure
MET	Mechanical, Electrical and Trim
MFU	Multi-Function Unit
MFL	Multi-Function Logic
max.	Maximum
MEMS	Modular Engine Management System
MIG	Metal/Inert Gas
MIL	Malfunction Indicator Lamp
MPa	MegaPascal
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
min.	Minimum
-	Minus (tolerance)
'	Minute (angle)
mm	Millimetre
mph	Miles per hour
MPi	Multi-Point injection
MV	Motorised Valve
MY	Model Year
NAS	North American Specification
(-)	Negative (electrical)
Nm	Newton metre
No.	Number
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NTC	Negative Temperature Coefficient
NRV	Non Return Valve
OBD	On Board Diagnostics
OBM	On Board Monitoring
o.dia.	Outside diameter
OAT	Organic Acid Technology
ORM	Off-road Mode
Ω	Ohm
PAS	Power Assisted Steering
PCB	Printed Circuit Board
PCV	Positive Crankcase Ventilation
PDC	Parking Distance Control
PDOP	Position Dilation Of Precision
PI	Programme Information
PPS	Pulse Per Second
PS	Programme Service
psi	Pounds per square inch
pts.	Pints
%	Percentage
+	Plus (tolerance) or Positive (electrical)
±	Plus or minus (tolerance)
PTC	Positive Temperature Coefficient
PTFE	Polytetrafluorethylene
PVC	Polyvinyl chloride
PWM	Pulse Width Modulation
RDS	Radio Data Service
r	Radius
:	Ratio
ref	Reference
REG	Regionalisation
RES	Rover Engineering Standards
rev/min	Revolutions per minute
RF	Radio Frequency
RGB	Red / Green / Blue
RH	Right-Hand
RHD	Right-Hand Drive
ROM	Read Only Memory
RON	Research Octane Number
ROV	Roll Over Valve
ROW	Rest Of World
SAE	Society of Automotive Engineers
SAI	Secondary Air Injection
"	Second (angle)
SLABS	Self Levelling and Anti-Lock Brake System
SLS	Self Levelling Suspension
SOHC	Single Overhead Camshaft

SPE	Single Point Entry
sp.gr	Specific gravity
SRS	Supplementary Restraint System
std.	Standard
synchro	Synchronizer or synchromesh
TA	Traffic Announcement
TDC	Top Dead Centre
TMAP	Temperature, Manifold Absolute Pressure
TMC	Traffic Management Channel
TP	Throttle Position
TPS	Throttle Position Sensor
TV	Torsional Vibration
TWC	Three-way Catalyst
TXV	Thermostatic Expansion Valve
UK	United Kingdom
US	United States
US galls/h	US gallons per hour
V	Volt
Var.	Variable
VDOP	Velocity Dilation Of Precision
VICS	Vehicle Information Communications System
VIN	Vehicle Identification Number
VIS	Variable Intake System
VRS	Variable Reluctance Sensor
VSS	Vehicle Speed Signal
W	Watt
WOT	Wide Open Throttle

General Precautions

Dangerous substances
Modern vehicles contain many materials and liquids which if not handled with care can be hazardous to both personal health and the environment.

WARNING: Many liquids and other substances used in motor vehicles are poisonous and should under no circumstances be consumed and should, as far as possible, be kept from contact with the skin. These liquids and substances include acid, anti-freeze, asbestos, brake fluid, fuel, windscreen washer additives, lubricants, refrigerants and various adhesives.

Always read carefully the instructions printed on labels or stamped on components and obey them implicitly. Such instructions are included for reasons of your health and personal safety. Never disregard them.

Synthetic rubber
Many 'O' rings, seals, hoses, flexible pipes and other similar items which appear to be natural rubber, are in fact, made of synthetic materials called Fluoroelastomers. Under normal operating conditions this material is safe and does not present a health hazard. However, if the material is damaged by fire or excessive heating, it can break down and produce highly corrosive Hydrofluoric acid.

Contact with Hydrofluoric acid can cause serious burns on contact with skin. If skin contact does occur:

- Remove any contaminated clothing immediately.
- Irrigate effected area of skin with a copious amount of cold water or limewater for 15 to 60 minutes.
- Obtain medical assistance immediately.

Should any material be in a burnt or overheated condition, handle with extreme caution and wear protective clothing (seamless industrial gloves, protective apron etc.).

Decontaminate and dispose of gloves immediately after use.

Lubricating oils
Avoid excessive skin contact with used lubricating oils and always adhere to the health protection precautions.

WARNING: Avoid excessive skin contact with used engine oil. Used engine oil contains potentially harmful contaminants which may cause skin cancer or other serious skin disorders.

WARNING: Avoid excessive skin contact with mineral oil. Mineral oils remove the natural fats from the skin, leading to dryness, irritation and dermatitis.

Health protection precautions
The following precautions should be observed at all times.

- Wear protective clothing, including impervious gloves where practicable.
- Avoid prolonged and repeated contact with oils, particularly used engine oils.
- Do not put oily rags in pockets.
- Avoid contaminating clothes (particularly those next to the skin) with oil.
- Overalls must be cleaned regularly. Discard heavily soiled clothing and oil impregnated footwear.
- First aid treatment should be obtained immediately for open cuts and wounds.
- Apply barrier creams before each work period to help prevent lubricating oil from contaminating the skin.
- Wash with soap and water to ensure all oil is removed (proprietary skin cleansers and nail brushes will help).
- Use moisturisers after cleaning; preparations containing lanolin help replace the skin's natural oils which have been removed.
- Do not use petrol/gasoline, kerosene, diesel fuel, oil, thinners or solvents for cleaning skin.
- Where practicable, degrease components prior to handling.
- If skin disorders develop, obtain medical advice without delay.
- Wear eye protection (e.g. goggles or face shield) if there is a risk of eye contamination. Eye wash facilities should be provided in close vicinity of the work area.

Safety Instructions

Whenever possible, use a lift or pit when working beneath vehicle, in preference to jacking. Chock wheels as well as applying parking brake.

Jacking
Always use the recommended jacking points.

Always ensure that any lifting apparatus has sufficient load capacity for the weight to be lifted.

Ensure the vehicle is standing on level ground prior to lifting or jacking.

Apply the handbrake and chock the wheels.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

Do not leave tools, lifting equipment, spilt oil, etc. around or on the work bench area. Always keep a clean and tidy work area.

Brake shoes and pads
Always fit the correct grade and specification of brake linings. When renewing brake pads and brake shoes, always replace as complete axle sets.

Brake hydraulics
Observe the following recommendations when working on the brake system:

- Always use two spanners when loosening or tightening brake pipe or hose connections.
- Ensure that hoses run in a natural curve and are not kinked or twisted.
- Fit brake pipes securely in their retaining clips and ensure that the pipe cannot contact a potential chafing point.
- Containers used for brake fluid must be kept absolutely clean.
- Do not store brake fluid in an unsealed container, it will absorb water and in this condition would be dangerous to use due to a lowering of its boiling point.
- Do not allow brake fluid to be contaminated with mineral oil, or put new brake fluid in a container which has previously contained mineral oil.
- Do not re-use brake fluid removed from the system.
- Always use clean brake fluid or a recommended alternative to clean hydraulic components.
- After disconnection of brake pipes and hoses, immediately fit suitable blanking caps or plugs to prevent the ingress of dirt.
- Only use the correct brake fittings with compatible threads.
- Observe absolute cleanliness when working with hydraulic components.

Cooling system caps and plugs
Extreme care is necessary when removing expansion tank caps and coolant drain or bleed screws when the engine is hot, especially if it is overheated. To avoid the possibility of scalding, allow the engine to cool before attempting removal.

Environmental Precautions

General
This section provides general information which can help to reduce the environmental impacts from the activities carried out in workshops.

Emissions to air
Many of the activities that are carried out in workshops emit gases and fumes which contribute to global warming, depletion of the ozone layer and/or the formation of photochemical smog at ground level. By considering how the workshop activities are carried out, these gases and fumes can be minimised, thus reducing the impact on the environment.

Exhaust fumes
Running car engines is an essential part of workshop activities and exhaust fumes need to be ventilated to atmosphere. However, the amount of time engines are running and the position of the vehicle should be carefully considered at all times, to reduce the release of poisonous gases and minimise the inconvenience to people living nearby.

Solvents
Some of the cleaning agents used are solvent based and will evaporate to atmosphere if used carelessly, or if cans are left unsealed. All solvent containers should be firmly closed when not needed and solvent should be used sparingly. Suitable alternative materials may be available to replace some of the commonly used solvents. Similarly, many paints are solvent based and the spray should be minimised to reduce solvent emissions.

Refrigerant
It is illegal to release any refrigerants into the atmosphere. Discharge and replacement of these materials from air conditioning units should only be carried out using the correct equipment.

Checklist
Always adhere to the following.

Engines:
- don't leave engines running unnecessarily;
- minimise testing times and check where the exhaust fumes are being blown.

Materials:
- keep lids on containers of solvents;
- only use the minimum quantity;
- consider alternative materials;
- minimise over-spray when painting.

Gases:
- use the correct equipment for collecting refrigerants;
- don't burn rubbish on site.

Discharges to water
Most sites will have two systems for discharging water: storm drains and foul drains. Storm drains should only receive clean water, foul drains will take dirty water.

The foul drain will accept many of the normal waste waters such as washing water, detergents and domestic type wastes, but oil, petrol, solvent, acids, hydraulic oil, antifreeze and other such substances should never be poured down the drain. If in any doubt speak to the Water Company first.

Every precaution must be taken to prevent spillage of oil, fuel, solvents etc. reaching the drains. All handling of such materials must take place well away from the drains and preferably in an area with a kerb or wall around it, to prevent discharge into the drain. If a spillage occurs it should be soaked up immediately. Having a spill kit available will make this easier.

Additional precautions
Check whether the surface water drains are connected to an oil water separator, this could reduce the pollution if an incident was to occur. Oil water separators do need regular maintenance to ensure effectiveness.

Checklist
Always adhere to the following.

Disposal:
- never pour anything down a drain without first checking that it is environmentally safe to do so, and that it does not contravene any local regulations or bye-laws;
- have oil traps emptied regularly.

Spillage prevention:
- store liquids in a walled area;
- make sure that taps on liquid containers are secure and cannot be accidentally turned on;
- protect bulk storage tanks from vandalism by locking the valves;
- transfer liquids from one container to another in an area away from open drains;
- ensure lids are replaced securely on containers;
- have spill kits available near to points of storage and handling of liquids.

Spill kits
Special materials are available to absorb a number of different substances. They can be in granular form, ready to use and bought in convenient containers for storage. Disposal of used spill-absorbing material is dealt with in 'Waste Management' section.

Land contamination
Oils, fuels and solvents etc. can contaminate any soil that they are allowed to contact. Such materials should never be disposed of by pouring onto soil and every precaution must be taken to prevent spillage reaching soil. Waste materials stored on open ground could also leak, or have polluting substances washed off them that would contaminate the land. Always store these materials in suitable skips or other similarly robust containers.

Checklist
Always adhere to the following.
- Don't pour or spill anything onto the soil or bare ground;
- don't store waste materials on bare ground, see 'Spillage prevention' list.

Legal compliance
Some sites may have a discharge consent for effluent discharge to the foul drain for a car wash etc. It is important to know what materials are allowed in the drain and to check the results of any monitoring carried out by the Water Company.

Where paint-spraying operations are carried out it may be necessary to apply to the Local Authority for an air emissions licence to operate the plant. If such a licence is in operation, additional precautions will be necessary to comply with the requirements, and the results of any air quality monitoring must be checked regularly.

Checklist
Always adhere to the following.
- Know what legal consents and licences apply to the operations;
- check that the emissions and discharges comply with legal requirements.

Local issues
A number of environmental issues will be of particular concern to residents and other neighbours close to the site. The sensitivity of these issues will depend on the proximity of the site and the layout and amount of activity carried on at the site.

Noise is a major concern and therefore consideration should be given to the time spent carrying out noisy activities and the location of those activities that can cause excessive noise.

Car alarm testing, panel beating, hammering and other such noisy activities should, whenever possible, be carried out indoors with doors and windows shut or as far away from houses as possible.

Running vehicle engines may be an outside activity which could cause nuisance to neighbours because of both noise and smell.

Be sensitive to the time of day when these activities are carried out and minimise the time of the noisy operation, particularly in the early morning and late evening.

Another local concern will be the smell from the various materials used. Using less solvent, paint and petrol could help prevent this annoyance.

Local residents and other business users will also be concerned about traffic congestion, noise and exhaust fumes, be sensitive to these concerns and try to minimise inconvenience from deliveries, customers and servicing operations.

Checklist
Always adhere to the following.
- Identify where the neighbours who are likely to be affected are situated;
- minimise noise, smells and traffic nuisance;
- prevent litter by putting waste in the correct containers;
- have waste skips emptied regularly.

Use of resource
Another environmental concern is the waste of materials and energy that can occur in day to day activities.

Electricity for heating, lighting and compressed air uses resources and releases pollution during its generation.

Fuel used for heating, running cars or vans and mobile plant is another limited resource which consumes large amounts of energy during its extraction and refining processes.

Water has to be cleaned, piped to site and disposed of; all of which creates more potential pollution.

Oil, spares, paint etc., have all produced pollution in the process of manufacture and they become a waste disposal problem if discarded.

Checklist
Always adhere to the following.

Electricity and heating:
- keep doors and windows closed in the winter;
- switch off machinery or lights when not needed;
- use energy efficient heating systems;
- switch off computers and photocopiers when not needed.

Fuel:
- don't run engines unnecessarily;
- think about whether journeys are necessary and drive to conserve fuel.

Water:
- don't leave taps and hose pipes running;
- mend leaks quickly, don't be wasteful.

Compressed air:
- don't leave valves open;
- mend leaks quickly;
- don't leave the compressor running when not needed.

Use of environmentally damaging materials:
- check whether a less toxic material is available.

Handling and storage of materials:
- have the correct facilities available for handling liquids to prevent spillage and wastage as listed above;
- provide suitable locations for storage to prevent frost damage or other deterioration.

Waste Management

One of the major ways that pollution can be reduced is by the careful handling, storage and disposal of all waste materials that occur on sites. Legislation makes it illegal to dispose of waste materials other than to licensed waste carriers and disposal sites. This means that it is necessary to not only know what the waste materials are, but also to have the necessary documentation and licenses.

Handling and storage of waste

Ensure that waste materials are not poured down the drain or onto soils. They should be stored in such a way as to prevent the escape of the material to land, water or air.

They must also be segregated into different types of waste e.g. oil, metals, batteries, used vehicle components. This will prevent any reaction between different materials and assist in disposal.

Disposal of waste

Disposal of waste materials must only be to waste carriers who are licensed to carry those particular waste materials and all the necessary documentation must be completed. The waste carrier is responsible for ensuring that the waste is taken to the correct disposal sites.

Dispose of waste in accordance with the following guidelines.
- **Fuel, hydraulic fluid, anti-freeze and oil:** keep separate and dispose of to specialist contractor.
- **Refrigerant:** collect in specialist equipment and reuse.
- **Detergents:** safe to pour down the foul drain if diluted.
- **Paint, thinners:** keep separate and dispose of to specialist contractor.
- **Components:** send back to supplier for refurbishment, or disassemble and reuse any suitable parts. Dispose of the remainder in ordinary waste.
- **Small parts:** reuse any suitable parts, dispose of the remainder in ordinary waste.
- **Metals:** can be sold if kept separate from general waste.
- **Tyres:** keep separate and dispose of to specialist contractor.
- **Packaging:** compact as much as possible and dispose of in ordinary waste.
- **Asbestos-containing:** keep separate and dispose of to specialist contractor.
- **Oily and fuel wastes (e.g. rags, used spill kit material):** keep separate and dispose of to specialist contractor.
- **Air filters:** keep separate and dispose of to specialist contractor.
- **Rubber/plastics:** dispose of in ordinary waste.
- **Hoses:** dispose of in ordinary waste.
- **Batteries:** keep separate and dispose of to specialist contractor.
- **Airbags - explosives:** keep separate and dispose of to specialist contractor.
- **Electrical components:** send back to supplier for refurbishment, or disassemble and reuse any suitable parts. Dispose of the remainder in ordinary waste.
- **Electronic components:** send back to supplier for refurbishment, or disassemble and reuse any suitable parts. Dispose of the remainder in ordinary waste.
- **Catalysts:** can be sold if kept separate from general waste
- **Used spill-absorbing material:** keep separate and dispose of to specialist contractor.
- **Office waste:** recycle paper and toner and ink cartridges, dispose of the remainder in ordinary waste.

General Fitting Instructions

Component removal
Whenever possible, clean components and surrounding area before removal.

- Blank off openings exposed by component removal.
- Immediately seal fuel, oil or hydraulic lines when apertures are exposed; use plastic caps or plugs to prevent loss of fluid and ingress of dirt.
- Close the open ends of oilways exposed by component removal with tapered hardwood plugs or conspicuous plastic plugs.
- Immediately a component is removed, place it in a suitable container; use a separate container for each component and its associated parts.
- Clean bench and provide marking materials, labels and containers before dismantling a component.

Dismantling
Observe scrupulous cleanliness when dismantling components, particularly when brake, fuel or hydraulic system parts are being worked on. A particle of dirt or a cloth fragment could cause a serious malfunction if trapped in these systems.

- Blow out all tapped holes, crevices, oilways and fluid passages with an air line. Ensure that any 'O' rings used for sealing are correctly replaced or renewed, if disturbed during the process.
- Use marking ink to identify mating parts and ensure correct reassembly. Do not use a centre punch or scriber to mark parts, they could initiate cracks or distortion in marked components.
- Wire together mating parts where necessary to prevent accidental interchange (e.g. roller bearing components).
- Wire labels on to all parts which are to be renewed, and to parts requiring further inspection before being passed for reassembly; place these parts in separate containers from those containing parts for rebuild.
- Do not discard a part due for renewal until after comparing it with a new part, to ensure that its correct replacement has been obtained.

Cleaning components
Always use the recommended cleaning agent or equivalent. Ensure that adequate ventilation is provided when volatile degreasing agents are being used. Do not use degreasing equipment for components containing items which could be damaged by the use of this process.

General inspection
All components should be inspected for wear or damage before being reassembled.

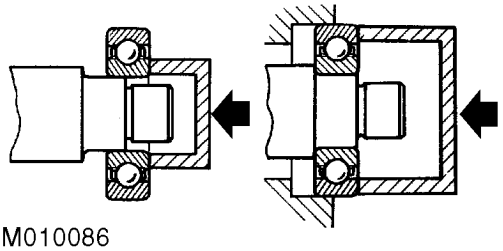
- Never inspect a component for wear or dimensional check unless it is absolutely clean; a slight smear of grease can conceal an incipient failure.
- When a component is to be checked dimensionally against recommended values, use the appropriate measuring equipment (surface plates, micrometers, dial gauges etc.). Ensure the measuring equipment is calibrated and in good serviceable condition.
- Reject a component if its dimensions are outside the specified tolerances, or if it appears to be damaged.
- A part may be refitted if its critical dimension is exactly to its tolerance limit and it appears to be in satisfactory condition. Use 'Plastigauge' 12 Type PG-1 for checking bearing surface clearances.

Ball and Roller Bearings

General

When removing and installing bearings, ensure that the following practices are observed to ensure component serviceability.

- Remove all traces of lubricant from bearing under inspection by cleaning with a suitable degreasant; maintain absolute cleanliness throughout operations.
- Conduct a visual inspection for markings on rolling elements, raceways, outer surface of outer rings or inner surface of inner rings. Reject any bearings found to be marked, since marking in these areas indicates onset of wear.
- Hold inner race of bearing between finger and thumb of one hand and spin outer race to check that it revolves absolutely smoothly. Repeat, holding outer race and spinning inner race.
- Rotate outer ring gently with a reciprocating motion, while holding inner ring; feel for any check or obstruction to rotation. Reject bearing if action is not perfectly smooth.
- Lubricate bearing with generous amounts of lubricant appropriate to installation.
- Inspect shaft and bearing housing for discoloration or other markings which indicate movement between bearing and seatings.
- Ensure that shaft and housing are clean and free from burrs before fitting bearing.
- If one bearing of a pair shows an imperfection, it is advisable to replace both with new bearings; an exception could be if the faulty bearing had covered a low mileage, and it can be established that damage is confined to only one bearing.
- Never refit a ball or roller bearing without first ensuring that it is in a fully serviceable condition.
- When hub bearings are removed or displaced, new bearings must be fitted; do not attempt to refit the old hub bearings.



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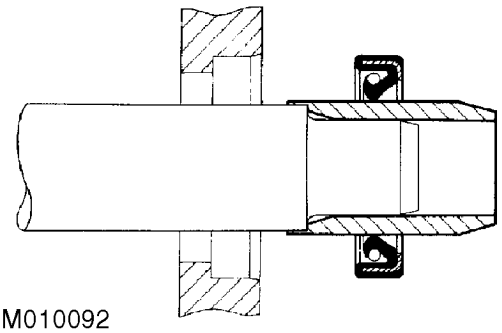
- When fitting a bearing to a shaft, only apply force to the inner ring of the bearing. When fitting a bearing into a housing, only apply force to the outer ring of the bearing.
- In the case of grease lubricated bearings (e.g. hub bearings) fill the space between bearing and outer seal with the recommended grade of grease before fitting seal.
- Always mark components of separable bearings (e.g. taper roller bearings) when dismantling, to ensure correct reassembly. Never fit new rollers in a used outer ring; always fit a complete new bearing assembly.

Oil Seals

General
Always renew oil seals which have been removed from their working location (whether as an individual component or as part of an assembly). NEVER use a seal which has been improperly stored or handled, such as hung on a hook or nail.

- Carefully examine seal before fitting to ensure that it is clean and undamaged.
- Ensure the surface on which the new seal is to run is free of burrs or scratches. Renew the component if the original sealing surface cannot be completely restored.
- Protect the seal from any surface which it has to pass when being fitted. Use a protective sleeve or tape to cover the relevant surface.
- Lubricate the sealing lips with a recommended lubricant before use to prevent damage during initial use. On dual lipped seals, smear the area between the lips with grease.
- If a seal spring is provided, ensure that it is fitted correctly. Place lip of seal towards fluid to be sealed and slide into position on shaft. Use fitting sleeve where possible to protect sealing lip from damage by sharp corners, threads or splines. If a fitting sleeve is not available, use plastic tube or tape to prevent damage to the sealing lip.



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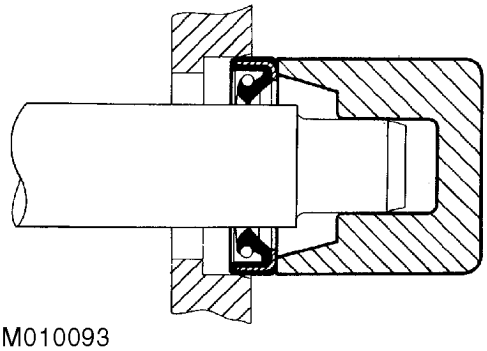
- Grease outside diameter of seal, place square to housing recess and press into position using great care, and if possible a 'bell piece' to ensure that seal is not tilted. In some cases it may be preferable to fit seal to housing before fitting to shaft. Never let weight of unsupported shaft rest in seal.



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- Use the recommended service tool to fit an oil seal. If the correct service tool is not available, use a suitable tube approximately 0.4 mm (0.015 in.) smaller than the outside diameter of the seal. Use a hammer **VERY GENTLY** on drift if a suitable press is not available.
- Press or drift the seal in to the depth of its housing with the sealing lip facing the lubricant to be retained if the housing is shouldered, or flush with the face of the housing where no shoulder is provided. Ensure that the seal does not enter the housing in a tilted position.

Joints and Joint Faces

General
Fit joints dry unless specified otherwise.

- Always use the correct gaskets as specified.
- When jointing compound is used, apply in a thin uniform film to metal surfaces; take care to prevent jointing compound from entering oilways, pipes or blind tapped holes.
- If gaskets and/or jointing compound is recommended for use; remove all traces of old jointing material prior to reassembly. Do not use a tool which will damage the joint faces and smooth out any scratches or burrs using an oil stone. Do not allow dirt or jointing material to enter any tapped holes or enclosed parts.
- Prior to reassembly, blow through any pipes, channels or crevices with compressed air.

Locking Devices

General
Always replace locking devices with one of the same design.

Tab washers
Always release locking tabs and fit new locking washers. Do not re-use locking tabs.

Locking nuts
Always use a backing spanner when loosening or tightening locking nuts, brake and fuel pipe unions.

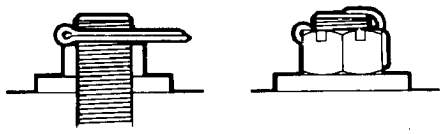
Roll pins
Always fit new roll pins of an interference fit in the hole.

Circlips
Always fit new circlips of the correct size for the groove.

Keys and keyways
Remove burrs from edges of keyways with a fine file and clean thoroughly before attempting to refit key.

Clean and inspect key closely; keys are suitable for refitting only if indistinguishable from new, as any indentation may indicate the onset of wear.

Split pins



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Always fit new split-pins of the correct size for the hole in the bolt or stud.

Screw Threads

General

Metric threads to ISO standards are used.

Damaged nuts, bolts and screws must always be discarded. Cleaning damaged threads with a die or tap impairs the strength and fit of the threads and is not recommended.

Always ensure that replacement bolts are at least equal in strength to those replaced. Castellated nuts must not be loosened to accept a split-pin, except in recommended cases when this forms part of an adjustment.

Do not allow oil or grease to enter blind threaded holes. The hydraulic action on screwing in the bolt or stud could split the housing.

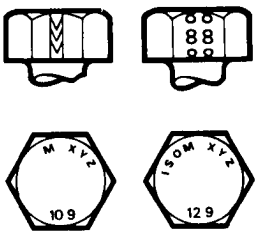
Always tighten a nut or bolt to the recommended torque figure. Damaged or corroded threads can affect the torque reading.

To check or re-tighten a bolt or screw to a specified torque figure, first loosen a quarter of a turn, then retighten to the correct torque figure.

Oil thread lightly before tightening to ensure a free running thread, except in the case of threads treated with sealant/lubricant, and self-locking nuts.

Bolt and Nut Identification

Bolt identification



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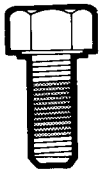
An ISO metric bolt or screw made of steel and larger than 6 mm in diameter can be identified by either of the symbols ISO M or M embossed or indented on top of the bolt head.

In addition to marks identifying the manufacturer, the top of the bolt head is also marked with symbols indicating the strength grade, e.g. 8.8; 10.9; 12.9; 14.9. As an alternative, some bolts and screws have the M and strength grade symbol stamped on the flats of the hexagon.

Encapsulated bolts and screws



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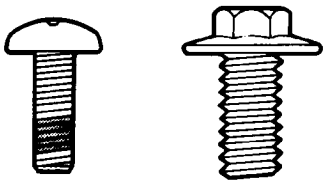
Encapsulated bolts and screws have a micro-encapsulated locking agent pre-applied to the thread. They are identified by a coloured section which extends 360° around the thread. The locking agent is released and activated by the assembly process and is then chemically cured to provide the locking action.

Unless a specific repair procedure states otherwise, encapsulated bolts may be re-used providing the threads are undamaged and the following procedure is adopted:

- Remove loose adhesive from the bolt and housing threads.
- Ensure threads are clean and free of oil and grease.
- Apply an approved locking agent.

An encapsulated bolt may be replaced with a bolt of equivalent specification provided it is treated with an approved locking agent.

Self-locking bolts and screws



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Self-locking bolts and screws, i.e. nylon patched or trilobular thread can be re-used providing resistance can be felt when the locking portion enters the female thread.

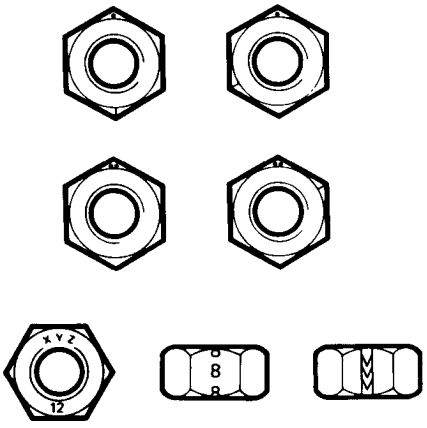
Nylon patched bolts and screws have a locking agent pre-applied to the threads. They are identified by the presence of a coloured section of thread which extends for up to 180° around the thread.

Trilobular bolts (i.e. Powerlok) have a special thread form which creates a slight interference with the thread of the hole or nut into which it is screwed.

DO NOT re-use self-locking fasteners in critical locations (e.g. engine bearings, flywheel). Always use the correct replacement self-locking nut, bolt or screw.

DO NOT fit non self-locking fasteners in applications where a self-locking nut, bolt or screw is specified.

Nut identification



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A nut with an ISO metric thread is marked on one face or on one of the flats of the hexagon with the strength grade symbol 8, 12, or 14. Some nuts with a strength grade 4, 5 or 6 are also marked and some have the metric symbol M on the flat opposite the strength grade marking.

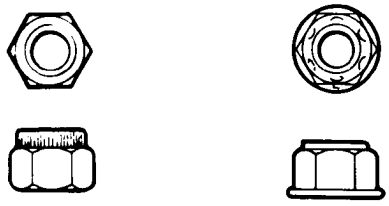
A clock face system is sometimes used as an alternative method of indicating the strength grade. The external chamfers or a face of the nut is marked in a position relative to the appropriate hour mark on a clock face to indicate the strength grade.

A dot is used to locate the 12 o'clock position and a dash to indicate the strength grade. If the grade is above 12, two dots identify the 12 o'clock position.

When tightening a slotted or castellated nut, never loosen it to insert a split pin except where recommended as part of an adjustment. If difficulty is experienced, alternative washers or nuts should be selected, or the washer thickness reduced.

Where bearing pre-load is involved, nuts should be tightened in accordance with special instructions.

Self-locking nuts



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Self-locking nuts, i.e. nylon insert or deferred thread nuts can be re-used providing resistance can be felt when the locking portion of the nut passes over the thread of the bolt or stud.

Where self-locking nuts have been removed, it is advisable to replace them with new ones of the same type.

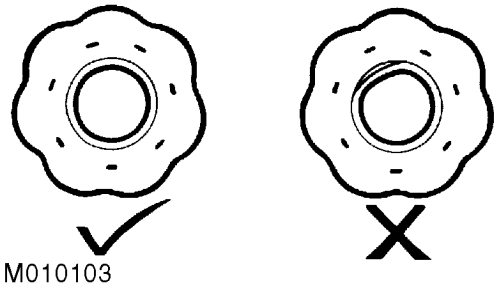
Flexible Pipes and Hoses

General

When removing and installing flexible hydraulic pipes and hoses, ensure that the following practices are observed to ensure component serviceability.

- Before removing any brake or power steering hose, clean end fittings and area surrounding them as thoroughly as possible.
- Obtain appropriate plugs or caps before detaching hose end fittings, so that the ports can be immediately covered to prevent the ingress of dirt.
- Clean hose externally and blow through with airline. Examine carefully for cracks, separation of plies, security of end fittings and external damage. Reject any faulty hoses.
- When refitting a hose, ensure that no unnecessary bends are introduced, and that hose is not twisted before or during tightening of union nuts.
- Fit a cap to seal a hydraulic union and a plug to its socket after removal to prevent ingress of dirt.
- Absolute cleanliness must be observed with hydraulic components at all times.
- After any work on hydraulic systems, carefully inspect for leaks underneath the vehicle while a second operator applies maximum brake pressure to the brakes (engine running) and operates the steering.

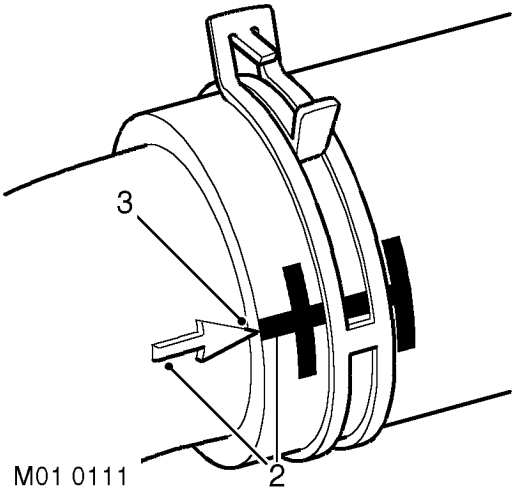
Fuel system hoses



All fuel hoses are made up of two laminations, an armoured rubber outer sleeve and an inner viton core. If any of the fuel system hoses have been disconnected, it is imperative that the internal bore is inspected to ensure that the viton lining has not become separated from the armoured outer sleeve. A new hose must be fitted if separation is evident.

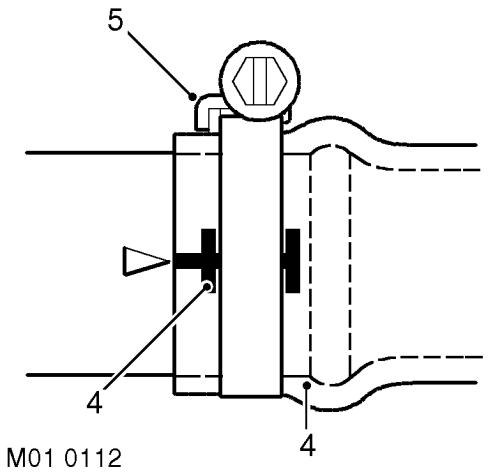
Cooling system hoses
The following precautions MUST be followed to ensure that integrity of cooling hoses and their connections to system components are maintained.

Hose orientation and connection



Correct orientation of cooling hoses is important in ensuring that the hose does not become fatigued or damaged through contact with adjacent components. Where 'timing' marks (2) are provided on the hose and corresponding connection, these must be used to ensure correct orientation. Hoses must be pushed fully onto their connection points. Usually, a moulded form (3) on the stub pipe provides a positive indicator.

Hose clips



Markings (4) are usually provided on the hose to indicate the correct clip position. If no markings are provided, position the clip directly behind the retaining lip at the end of the stub as shown. Worm drive clips should be oriented with the crimped side of the drive housing (5) facing towards the end of the hose, or the hose may become pinched between the clip and the stub pipe retaining lip. Worm drive clips should be tightened to 3 Nm (2 lbf.ft) unless otherwise stated. Ensure that hose clips do not foul adjacent components.

Heat protection

Always ensure that heatshields and protective sheathing are in good condition. Replace if damage is evident. Particular care must be taken when routing hoses close to hot engine components, such as the exhaust manifold and the Exhaust Gas Recirculation (EGR) pipe. Hoses will relax and deflect slightly when hot; ensure this movement is taken into account when routing and securing hoses.

Rolling Road Testing

General

IMPORTANT: Use a four wheel rolling road for brake testing if possible.

WARNING: Do not attempt to test ABS function on a rolling road.

Four wheel rolling road

Provided that front and rear rollers are rotating at identical speeds and that normal workshop safety standards are applied, there is no speed restriction during testing except any that may apply to the tyres.

Before testing a vehicle with anti-lock brakes on a four wheel rolling road, disconnect the ABS modulator. The ABS function will not work, the ABS warning light will illuminate. Normal braking will be available.

Two wheel rolling road
Up to 03MY

ABS will not function on a two wheel rolling road. The ABS light will illuminate during testing. Normal braking will be available.

If brake testing on a two wheel rolling road is necessary, the following precautions should be taken:

- Propeller shaft to the rear axle is removed.
- Neutral selected in gearbox.

When checking brakes, run engine at idle speed to maintain servo vacuum.

From 03MY

The differential lock must be engaged for two wheel rolling road testing. It will also be necessary to disconnect the propeller shaft from the transfer box output shaft driving the axle whose wheels are NOT on the rolling road. Additionally, the ETC system must be deactivated by either removing the 10 amp fuse (Number 28, labelled ABS in the main fuse box) or disconnecting the ABS modulator pump. This must be done with the ignition OFF ; a fault in the ABS system may still be recorded.

WARNING; VEHICLES NOT FITTED WITH A DIFFERENTIAL LOCK MUST NOT BE TESTED ON A ROLLING ROAD WHERE THE ROLLERS ARE DRIVEN BY THE VEHICLE.

Fuel Handling Precautions

Fuel vapour is highly flammable and in confined spaces is also explosive and toxic. The vapour is heavier than air and will always fall to the lowest level. The vapour can be easily distributed throughout a workshop by air currents; consequently, even a small spillage of fuel is potentially very dangerous.

The following information provides basic precautions which must be observed if fuel is to be handled safely. It also outlines other areas of risk which must not be ignored. This information is issued for basic guidance only, if in doubt consult your local Fire Officer.

General
Always have a fire extinguisher containing FOAM, CO_2, GAS or POWDER close at hand when handling or draining fuel or when dismantling fuel systems. Fire extinguishers should also be located in areas where fuel containers are stored.

Always disconnect the vehicle battery before carrying out dismantling or draining work on a fuel system.

Whenever fuel is being handled, drained or stored, or when fuel systems are being dismantled, all forms of ignition must be extinguished or removed; any leadlamps must be flameproof and kept clear of spillage.

WARNING: No one should be permitted to repair components associated with fuel without first having specialist training.

WARNING: Do not remove fuel system components while the vehicle is over a pit.

Fuel tank draining
Fuel tank draining should be carried out in accordance with the procedure outlined in the **FUEL DELIVERY** section of this manual and observing the following precautions.

WARNING: Fuel must not be extracted or drained from any vehicle while it is over a pit. Extraction or draining of fuel must be carried out in a well ventilated area.

The capacity of containers must be more than adequate for the amount of fuel to be extracted or drained. The container should be clearly marked with its contents and placed in a safe storage area which meets the requirements of local authority regulations.

Fuel tank removal
When the fuel line is secured to the fuel tank outlet by a spring steel clip, the clip must be released before the fuel line is disconnected or the fuel tank is removed. This procedure will avoid the possibility of fumes in the fuel tank being ignited when the clip is released.

As an added precaution, fuel tanks should have a 'FUEL VAPOUR' warning label attached to them as soon as they are removed from the vehicle.

Fuel tank repairs - plastic tank
No attempt should be made to repair a plastic fuel tank. If the structure of the tank is damaged, a new tank must be fitted.

Body repairs
Plastic fuel pipes are particularly susceptible to heat, even at relatively low temperature, and can be melted by heat conducted from some distance away.

When body repairs involve the use of heat, all fuel pipes which run in the vicinity of the repair area must be removed, and the tank outlet plugged.

WARNING: If welding is to be carried out in the vicinity of the fuel tank, the fuel system must be drained and the tank removed before welding commences.

Electrical Precautions

General
The following guidelines are intended to ensure the safety of the operator while preventing damage to the electrical and electronic components fitted to the vehicle. Where necessary, specific precautions are detailed in the individual procedures of this manual.

Equipment
Prior to commencing any test procedure on the vehicle ensure that the relevant test equipment is working correctly and any harness or connectors are in good condition. It is particularly important to check the condition of the lead and plugs of mains operated equipment.

Polarity
Never reverse connect the vehicle battery and always ensure the correct polarity when connecting test equipment.

High voltage circuits
Whenever disconnecting live ht circuits always use insulated pliers and never allow the open end of the ht lead to contact other components, particularly ECU's. Exercise caution when measuring the voltage on the coil terminals while the engine is running, high voltage spikes can occur on these terminals.

Connectors and harnesses
The engine compartment of a vehicle is a particularly hostile environment for electrical components and connectors:

- Always ensure electrically related items are dry and oil free before disconnecting and connecting test equipment.
- Ensure disconnected multiplugs and sensors are protected from being contaminated with oil, coolant or other solutions. Contamination could impair performance or result in catastrophic failure.
- Never force connectors apart using tools to prise apart or by pulling on the wiring harness.
- Always ensure locking tabs are disengaged before disconnection, and match orientation to enable correct reconnection.
- Ensure that any protection (covers, insulation etc.) is replaced if disturbed.

Having confirmed a component to be faulty:

- Switch off the ignition and disconnect the battery.
- Remove the component and support the disconnected harness.
- When replacing the component keep oily hands away from electrical connection areas and push connectors home until any locking tabs fully engage.

Battery disconnection
Before disconnecting the battery, disable the alarm system and switch off all electrical equipment. If the radio is to be serviced, ensure the security code has been deactivated.

CAUTION: To prevent damage to electrical components, always disconnect the battery when working on the vehicle's electrical system. The ground lead must be disconnected first and reconnected last.

CAUTION: Always ensure that battery leads are routed correctly and are not close to any potential chafing points.

Battery charging
Only recharge the battery with it removed from the vehicle. Always ensure any battery charging area is well ventilated and that every precaution is taken to avoid naked flames and sparks.

Ignition system safety precautions
The vehicle's ignition system produces high voltage and the following precautions should be observed before carrying out any work on the system.

WARNING: Before commencing work on an ignition system, ensure all high tension terminals, adapters and diagnostic equipment are adequately insulated and shielded to prevent accidental personal contacts and minimise the risk of shock. Wearers of surgically implanted pacemaker devices should not be in close proximity of ignition circuits or diagnostic equipment.

Disciplines
Switch off the ignition prior to making any connection or disconnection in the system to prevent electrical surges caused by disconnecting 'live' connections damaging electronic components.

Ensure hands and work surfaces are clean and free of grease, swarf, etc. Grease collects dirt which can cause electrical tracking (short-circuits) or high-resistance contacts.

When handling printed circuit boards, treat with care and hold by the edges only; note that some electronic components are susceptible to body static.

Connectors should never be subjected to forced removal or refit, especially inter-board connectors. Damaged contacts can cause short-circuit and open-circuit fault conditions.

Prior to commencing test, and periodically during a test, touch a good vehicle body earth to discharge static charge. Some electronic components are vulnerable to the static electricity that may be generated by the operator.

Grease for electrical connectors
Some under bonnet and under body connectors may be protected against corrosion by the application of a special grease during vehicle production. Should connectors be disturbed in service, repaired or replaced, additional grease should be applied: Part No. BAU 5811, available in 150 gm tubs.

NOTE: The use of greases other than BAU 5811 must be avoided as they can migrate into relays, switches etc. contaminating the contacts and leading to intermittent operation or failure.

Supplementary Restraint System Precautions

General
The Supplementary Restraint System (SRS) provides active protection for vehicle occupants in the event of a serious collision. The system components include airbags and pretensioner seat belts which are automatically deployed when a severe frontal crash condition is detected.

In order to assure system integrity, it is essential that the SRS system is regularly checked and maintained so that it is ready for operation in the event of an accident.

The SRS system contains components which could be potentially hazardous to the service engineer if not serviced and handled correctly. The following guidelines are intended to alert the service engineer to potential sources of danger and emphasise the importance of ensuring integrity of the SRS components fitted to the vehicle.

Where necessary, additional specific precautions are detailed in the Restraint Systems section of this Manual which should be referred to prior to commencing repair operations.

It should be noted that these precautions are not restricted to operations performed when servicing the SRS system. The same care should be exercised when working on ancillary systems and components located in the vicinity of SRS components; these include but are not limited to steering system (driver's airbag), body and trim components (passenger's airbag and seat belt pretensioners) and electrical system components (SRS harnesses etc.).

WARNING: Do not use rear facing child seats in the front passenger seat if the vehicle is fitted with a passenger airbag.

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

WARNING: Replace the airbag every 10 years.

Do not install used SRS parts from another car. When repairing an SRS system, always use approved new parts.

Carefully inspect the airbag module before installing it. Do not install an airbag module that shows signs of being dropped or improperly handled, such as dents, cracks or deformation.

Do not try to disassemble or tamper with the airbag module.

Special bolts are necessary for installing the airbag module. Do not use other bolts.

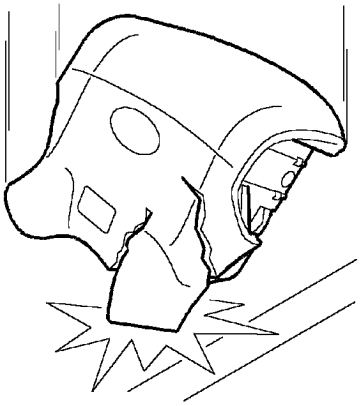
Preliminary procedures

The SRS system uses energy reserve capacitors that keep the system active in the event of electrical supply failure under crash conditions. It is necessary to allow the capacitors sufficient time to discharge in order to avoid the risk of accidental deployment.

Always remove the ignition key from the starter switch, disconnect the vehicle battery and wait 10 minutes before commencing work on the SRS system.

Carefully inspect any SRS component before installation. Do not install any SRS component that shows signs of damage such as dents, cracks or deformity.

Component handling



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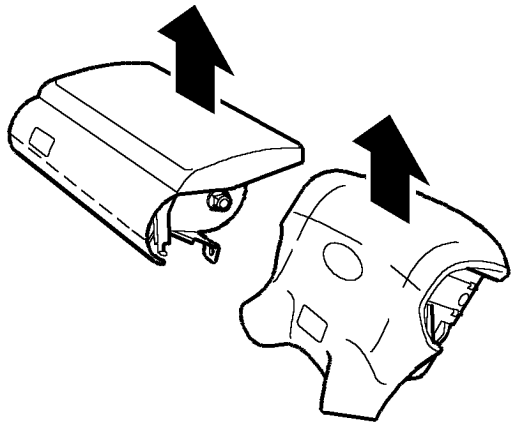
The SRS components are sensitive and potentially hazardous if not handled correctly; always comply with the following handling precautions:

- Never drop an SRS component. The airbag Diagnostic Control Unit (DCU) is a particularly shock sensitive device and must be handled with extreme care. Airbag modules and seat belt pretensioner units could deploy if subjected to a strong shock.
- Never wrap your arms around an airbag module. If an airbag module has to be carried, hold it by the cover, with the cover uppermost and the base away from your body.
- Never transport airbag modules or seat belt pretensioners in the cabin of a vehicle. Always use the luggage compartment of the vehicle for carrying airbag modules and seat belt pretensioner units.

WARNING: The airbag module contains sodium azide which is poisonous and extremely flammable. Contact with water, acid or heavy metals may produce harmful or explosive compounds. Do not dismantle, incinerate or bring into contact with electricity, before the unit has been deployed.

Storage



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Airbag modules and seat belt pretensioners are classed as explosive devices. For overnight and longer term storage, they must be stored in a secure steel cabinet which has been approved as suitable for the purpose and has been registered by the local authority.

For the temporary storage of an airbag module or seat belt pretensioner during service, place in a designated storage area. If there is no designated storage area available, store in the luggage compartment of the vehicle and inform the workshop supervisor. Always observe the following precautions when temporarily storing an airbag module:

- Ensure the cover is facing upwards and the luggage compartment is secured.
- Always keep components cool, dry and free from contamination.
- Do not allow anything to rest on the airbag module.
- Store any removed airbag assembly on a secure flat surface away from electrical equipment and heat sources exceeding 85°C (185°F).

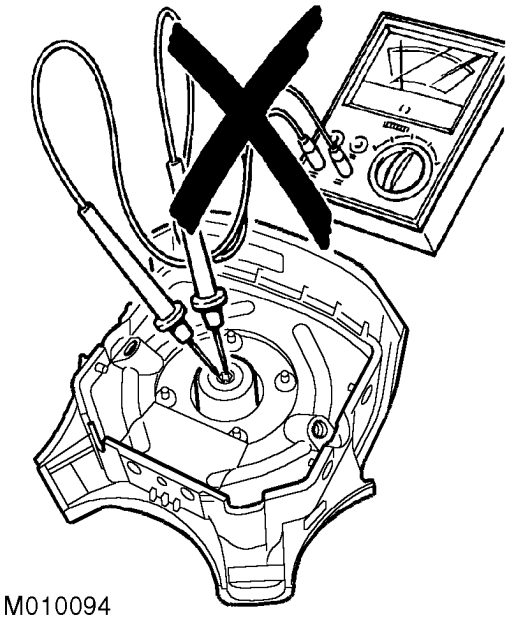
WARNING: Store the airbag module or seat belt pre-tensioner in a designated storage area. If there is no designated storage area available, store in the locked luggage compartment/ loadspace of the vehicle and inform the workshop supervisor.

Installation and testing precautions

The integrity of SRS system components are critical for safety reasons. Ensure the following precautions are always adhered to:

- Never install used SRS components from another vehicle or attempt to repair an SRS component.
- When repairing an SRS system, only use genuine new parts.
- Never apply electrical power to an SRS component unless instructed to do so as part of an approved test procedure.
- Special Torx bolts are necessary for installing the airbag assembly. Do not use other bolts. Ensure bolts are tightened to the specified torque.
- Ensure that SRS component fixings are correctly positioned and torqued during service and repair.
- Always use new fixings when replacing an SRS component.
- Ensure the airbag DCU is always installed correctly. There must not be any gap between the DCU and the bracket to which it is mounted. An incorrectly mounted unit could cause the system to malfunction.
- The airbag DCU is a non-serviceable component and no attempt should be made to repair or modify the unit.
- Do not try to disassemble the airbag assembly. It has no serviceable parts. Once an airbag has been deployed, it cannot be repaired or reused.
- If you suspect an airbag assembly could be defective, install a new unit and dispose of the old unit. Manually deploy the old unit before disposal.

WARNING: Keep clear of the deployment zone when working on or near an airbag module. Accidental deployment could cause serious injury.



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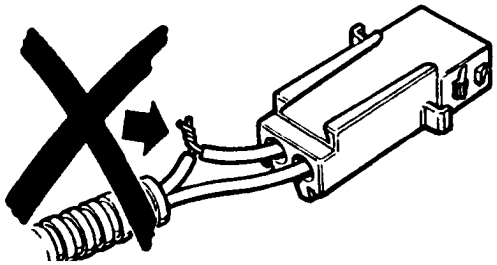
WARNING: Do not use a multimeter or other general purpose test equipment on SRS system components or accidental deployment may occur. Use only Testbook to diagnose system faults.

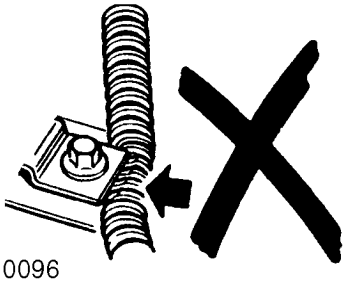
SRS harnesses and connectors



M010098

Always observe the following precautions with regard to SRS systems:

- Never attempt to modify, splice or repair SRS wiring. SRS wiring can be identified by a special yellow outer protective covering (black with yellow stripe protective coverings are sometimes used).
- Never install electronic equipment (such as a mobile telephone, two way radio or in-car entertainment system) in such a way that it could generate electrical interference in the airbag harness. Seek specialist advice when installing such equipment.

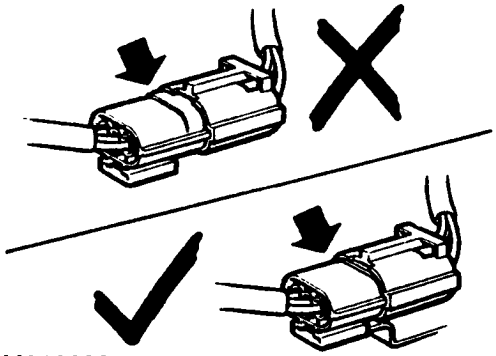


M010096

CAUTION: Always ensure the SRS harness is routed correctly. Avoid trapping or pinching the SRS harness. Look out for possible chafing points.

CAUTION: Ensure all SRS harness connectors are mated correctly and securely fastened. Do not leave the connectors hanging loose.

CAUTION: Do not allow the airbag module to hang by the airbag harness.



M010099

Rotary coupler
Always follow the Repair procedure for fitting the rotary coupler.

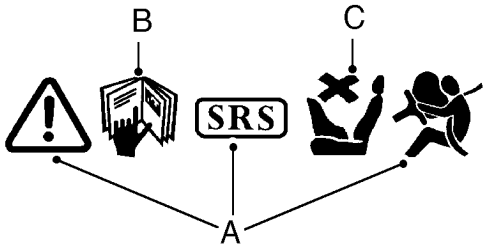
Comply with all safety and installation procedures to ensure the system functions correctly. Observe the following precautions:

- Do not install a rotary coupler if it is suspected to be defective.
- Do not attempt to service, modify or repair a rotary coupler.
- Do not cut, splice or modify the wires attached to yellow SRS connector and lead.
- Always ensure the rotary coupler connectors are mated correctly and securely fastened.
- Always ensure the battery is disconnected before working on the rotary coupler.
- Always ensure the rotary coupler is removed and installed in its centered position and with the front road wheels in the straight ahead position.
- If a new rotary coupler is being installed, ensure the locking tab holding the coupler's rotational position is not broken; units with a broken locking tab should not be used.

Warning labels
Warning symbols are displayed at various positions in the vehicle (either in a suitable prominent position such as driver and passenger side glass, or attached to the component itself) to indicate SRS items which must be treated with particular care. Exact positions of SRS warning labels may vary dependent on legislation and market trends.

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

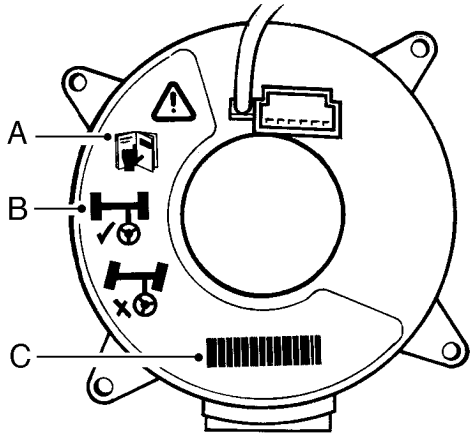
Side window label



M010097

a The need for caution when working in close proximity to SRS components.
b Refer to the publication where the procedures, instructions and advice can be found (usually the Workshop Manual) for working on the SRS system.
c Do not use rear facing child seats in the front passenger seat if the vehicle is fitted with a passenger airbag.

Rotary coupler label



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a Refer to the Workshop Manual for detailed instructions
b Ensure wheels are in the straight ahead position before removal and refitting
c Part number/Bar code. The code must be recorded and quoted for ordering purposes

Airbag and pretensioner deployment
Deployment procedures and precautions as detailed in this manual should be strictly adhered to. Only personnel who have undergone the appropriate training should undertake deployment of airbag and pretensioner modules. The following precautions must be complied with:

- Only use deployment equipment approved for the intended purpose.
- Before beginning deployment procedure, ensure deployment tool functions properly by performing the self test procedure detailed in SRS section of this manual.
- Deployment of airbag/ pretensioner modules should be performed in a well ventilated area which has been designated for the purpose.
- Ensure airbag/pretensioner modules are not damaged or ruptured before attempting to deploy.
- Notify the relevant authorities of intention to deploy airbag and pretensioner units.
- When deploying airbag pretensioner units, ensure that all personnel are at least 15 metres (45 feet) away from the deployment zone.
- Ensure deployment tool is connected correctly, in compliance with the instructions detailed in the SRS section of this manual. In particular, ensure deployment tool is NOT connected to battery supply before connecting to airbag module connector.
- When deploying seat belt pretensioners, ensure pretensioner unit is secured correctly to the seat.
- When removing deployed airbag modules and pretensioner units, wear protective clothing. Use gloves and seal deployed units in a plastic bag.
- Following deployment of any component of the SRS system within the vehicle, all SRS components must be replaced. DO NOT re-use or salvage any parts of the SRS system.
- Do not lean over airbag module when connecting deployment equipment.

If a vehicle is to be scrapped, undeployed airbag modules and pretensioner units must be manually deployed. In this case airbags can be deployed in the vehicle; before deployment, ensure the airbag module is secure within its correct mounting position. Deployment of the driver's airbag in the vehicle may damage the steering wheel; if the vehicle is not being scrapped, deploy the module outside of the vehicle.

WARNING: During deployment parts of the airbag module become hot enough to burn you. Wait 30 minutes after deployment before touching the airbag module.

SRS Component Replacement Policy

The following information details the policy for replacement of SRS components; either as a result of a vehicle accident or as a result of vehicle age.

Impacts which do not deploy the airbags or pre-tensioners
Check for structural damage in the area of the impact, paying particular attention to bumper armatures, longitudinals, crash cans and bracketry.

Impacts which deploy the airbags or pre-tensioners
The replacement and inspection policy is dependent on the type and severity of of the crash condition. The following guidelines are the minimum that should be exercised as a result of the deployment of specific SRS components.

If the front airbags or seat belt pre-tensioners are deployed, the following parts must be replaced:

- SRS DCU.
- Driver airbag module
- Passenger airbag module
- Front seat belt buckle pre-tensioners
- Rotary coupler
- Driver's seat belt retractor
- Flyleads (where applicable) connecting airbags and seat belt pre-tensioners to SRS harness

In addition, the following should be inspected for damage and replaced as necessary:

- Front passenger's seat belt retractor (webbing, tongue latching, 'D' loop, body anchorage point)
- Rear seat belt buckles (webbing, buckle covers, body anchorage and tongue latching function)
- Fascia moulding adjacent to passenger airbag module
- Steering wheel (if damage is evident)
- Front seat frames and head restraints (if there is evidence of damage to the seat frame or cushion pan)
- Steering column (if adjustment is lost or there are signs of collapse)
- Third row seats, seat belts and head restraints (where fitted). Check third row seat latching mechanism operates correctly.

Periodic replacement of SRS components
The performance of the propellants within airbags and pre-tensioners will deteriorate over a period of time. As a result, it is essential that the airbags are replaced after 10 years and seat belt pre-tensioners are replaced after 15 years in order to maintain occupant safety.

Air Conditioning System Precautions

General
The air conditioning system contains fluids and components which could be potentially hazardous to the service engineer or the environment if not serviced and handled correctly. The following guidelines are intended to alert the service engineer to potential sources of danger and emphasise the importance of ensuring the integrity of the Air Conditioning operating conditions and components fitted to the vehicle.

Where necessary, additional specific precautions are detailed in the relevant sections of this Manual which should be referred to prior to commencing repair operations.

The refrigerant used in the air conditioning system is HFC-134a (Hydrofluorocarbon) R134a.

WARNING: Servicing must only be carried out by personnel familiar with both the vehicle system and the charging and testing equipment. All operations must be carried out in a well ventilated area away from open flame and heat sources.

WARNING: R134a is a hazardous liquid and when handled incorrectly can cause serious injury. Suitable protective clothing, consisting of face protection, heat proof gloves, rubber boots and rubber apron or waterproof overalls, must be worn when carrying out operations on the air conditioning system.

Remedial actions
If an accident involving R134a should occur, conduct the following remedial actions:

- If liquid R134a enters the eye, do not rub it. Gently run large quantities of eye wash over affected eye to raise the temperature. If an eye wash is not available, cool, clean water may be used to flush the eye. After rinsing, cover the eye with a clean pad and seek immediate medical attention.
- If liquid R134a is splashed onto the skin, run large quantities of water over the affected area to raise the temperature. Implement the same action if the skin comes in contact with discharging cylinders. Wrap the contaminated body parts in blankets (or similar materials) and seek immediate medical attention.
- If the debilitating effects of inhalation of R134a vapour is suspected, seek fresh air. If the affected person is unconscious, move them away from the contaminated area to fresh air and apply artificial respiration and/or oxygen and seek immediate medical attention.

WARNING: Due to its low evaporating temperature, R134a must be handled with care. R134a splashed on any part of the body will cause immediate freezing of that area. Also, refrigerant cylinders and replenishment trolleys when discharging will freeze skin to them if contact is made.

Service precautions
Observe the following precautions when handling components used in the air conditioning system:

- Air conditioning units must not be lifted by their hoses, pipes or capillary lines.
- Hoses and lines must not be subjected to any twist or stress; the efficiency of the system will be impaired by kinks or restrictions. Ensure that hoses are correctly positioned before tightening couplings, and ensure that all clips and supports are utilised.
- Flexible hoses should not be positioned close to the exhaust manifold (less than 100mm) unless protected by heat shielding.
- Completed assemblies must be checked for refrigeration lines touching metal panels. Any direct contact of components and panels may transmit noise and so must be eliminated.
- The appropriate torque wrench must be used when tightening refrigerant connections to the stipulated value. An additional spanner must be used to hold the union to prevent twisting of the pipe when tightening connections.
- Before connecting any hose or pipe, ensure that refrigerant oil is applied to the seat of the new 'O' rings, **BUT NOT** to the threads of the connection.
- All protective plugs must remain in place to seal the component until immediately prior to connection.
- Ensure components are at room temperature before uncapping, to prevent condensation of moisture from the air that enters it.

- Components must not remain uncapped for longer than 15 minutes. In the event of a delay, the caps must be fitted.
- When disconnecting, immediately cap all air conditioning pipes to prevent ingress of dirt and moisture into the system.
- The receiver/drier contains desiccant which absorbs moisture. It must be positively sealed at all times. A receiver/drier that has been left uncapped must not be used, fit a new unit.
- The receiver/drier should be the last component connected to the system to ensure optimum dehydration and maximum moisture protection of the system.
- Whenever the refrigerant system is opened, the receiver/drier must be renewed immediately before evacuating and recharging the system.
- Use alcohol and a clean lint-free cloth to clean dirty connections.
- Ensure that all new parts fitted are marked for use with R134a.

When a major repair has been completed, a leak test should be conducted; refer to the Air Conditioning section of this manual for the correct procedure.

Refrigerant oil

Refrigerant oil easily absorbs water and must not be stored for long periods. Do not pour unused refrigerant oil back into the container. Always use an approved refrigerant oil.

☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**

When replacing components in the A/C system, drain the refrigerant oil from the component being replaced into a graduated container. On assembly, add the quantity of refrigerant oil drained to the new component.

Compressor

A new compressor is sealed and pressurised with Nitrogen gas. When fitting a new compressor, slowly release the sealing cap; gas pressure should be heard to vent as the seal is broken.

CAUTION: A new compressor should always be sealed and could be pressurised with nitrogen gas. To avoid possible oil loss, release the sealing cap(s) slowly. Do not remove the cap(s) until immediately prior to connecting the air conditioning pipes to the compressor.

Rapid refrigerant discharge

If the air conditioning system is involved in accident damage and the system is punctured, the refrigerant will discharge rapidly. The rapid discharge of refrigerant will also result in the loss of most of the oil from the system. The compressor must be removed and all the remaining oil in the compressor drained and refilled as instructed in the air conditioning section of this manual.

Precautions for refrigerant recovery, recycling and recharging

When the air conditioning system is recharged, any existing refrigerant is first recovered from the system and recycled. The system is then charged with the required weight of refrigerant and volume of refrigerant oil.

WARNING: Refrigerant must always be recycled before re-use to ensure that the purity of the refrigerant is high enough for safe use in the air conditioning system.

Recycling should always be carried out with equipment which is design certified by Underwriter Laboratory Inc. for compliance with SAE J1991. Other equipment may not recycle refrigerant to the required level of purity.

A R134a Refrigerant Recovery Recycling Recharging Station must not be used with any other type of refrigerant.

Refrigerant R134a from domestic and commercial sources must not be used in motor vehicle air conditioning systems.

CAUTION: The system must be evacuated immediately before recharging commences. Delay between evacuation and recharging is not permitted.

Air Conditioning Compressor Replacement

A new compressor is supplied filled with a full charge (X cm^3) of refrigerant oil.

☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Capacities.** A calculated quantity of oil must be drained from the new compressor before fitting. To calculate the quantity of oil to be drained:

1. Remove the drain plug from the old compressor.
2. Invert the compressor and gravity drain the oil into a calibrated measuring cylinder. Rotate the compressor clutch to ensure the compressor is completely drained.
3. Note the quantity of oil drained (Y cm^3).
4. Calculate the quantity of oil to be drained from the new compressor using the following formula:

   X cm^3 — (Y cm^3 + 20 cm^3) = Q cm^3
5. Remove the drain plug from the new compressor and drain Q cm^3 of oil. Fit and tighten the compressor drain plug.

Body Repairs

General

Body shells are of welded construction and bolted to a chassis frame. Front and rear sections of the shell are designed as 'energy absorbing' zones. This means they are designed to deform progressively when subjected to impact in order to minimise the likelihood of injury to vehicle occupants.

It is essential that design dimensions and strength are restored in accident rectification. It is important that neither structural weakness nor excessive local stiffness are introduced into the vehicle during body repair.

Repairs usually involve a combination of operations ranging from straightening procedures to renewal of individual panels or panel assemblies. The repairer will determine the repair method and this decision will take into account a balance of economics between labour and material costs and the availability of repair facilities in both equipment and skills. It may also involve considerations of the vehicles' downtime, replacement vehicle availability and repair turn-around time.

It is expected that a repairer will select the best and most economic repair method possible, making use of the facilities available. The instructions given are intended to assist a skilled body repairer by expanding approved procedures for panel replacement. The objective is to restore the vehicle to a safe running condition by carrying out a repair which is as close as is feasible to original standard. The results should not advertise to the experienced eye that the vehicle has been damaged, although the repair might not be identical in all respects to the original factory build. Commercial bodyshop repair facilities cannot always duplicate methods of construction used during production.

Operations covered in this Manual do not include reference to testing the vehicle after repair. It is essential that work is inspected and suspension geometry checked after completion. Where necessary a road test of the vehicle should be carried out, particularly where safety-related items are concerned.

Where major units have been disconnected or removed it is necessary to ensure that fluid levels are checked and topped up where necessary. It is also necessary to ensure that the repaired vehicle is in a roadworthy condition in respect of tyre pressures, lights, washer fluid etc.

Body repairs often involve the removal of mechanical and electrical units and associated wiring. Where necessary, refer to the relevant section of the Workshop Manual for removal and refitting instructions.

Taking into consideration the differences in body styles, suspension systems and engine and transmission layouts, the location of the following components as applicable to a particular vehicle is critical:

- Front suspension upper damper mountings on RH and LH chassis longitudinals.
- Front suspension or sub frame mountings.
- Engine mountings on RH and LH chassis longitudinals.
- Rear suspension upper damper mountings on RH and LH chassis longitudinals.
- Rear suspension mountings or lower pivots.

Additional points which can be used to check alignment and assembly are:

- Inner holes in cross member - side - main floor.
- Holes in front bulkhead.
- Holes in rear longitudinals.
- Holes in rear lower panels.

Apertures for windscreen, rear screen, bonnet and doors can be measured and checked using the dimensional information provided and also by offering up an undamaged component as a gauge.

Straightening

Whenever possible, structural members should be cold straightened under tension. Do not attempt to straighten with a single pull but rework the damaged area using a series of pulls, releasing tension between each stage and using the opportunity to check alignment.

Body jig

Unless damage is limited to cosmetic panels, all repair work to body members must be carried out on a body jig, to ensure that impact damage has not spread into more remote parts of the structure. Mounting on a jig will also ensure that the straightening and panel replacement procedures do not cause further distortion.

If original dimensions cannot be satisfactorily restored by these methods, damaged structural members should be replaced. Damaged areas should be cut away using a high speed saw, NOT an oxy-acetylene torch.

As a rule, body dimensions are symmetrical about the centre line. A good initial check for distortion is therefore to measure diagonally and to investigate apparent differences in dimensions.

Inspection

Every accident produces individual variations in damage. Each repair is influenced by the extent of the damage and the facilities and equipment available for its rectification.

Most accident damage can be visually inspected and the approximate extent of damage assessed. Sometimes deformation will extend beyond the directly damaged area, and the severity of this must be accurately established so that steps can be taken to restore critical body components to their original dimensions. An initial check can be carried out by means of drop checks or, preferably, trammels. Gauges are available which will accurately check for body twist.

Engine - Td5

General	
Type	2.5 litre in-line direct injection diesel, turbocharged and intercooled
Cylinder arrangement	5 in-line, No. 1 cylinder at front of engine
Bore	84.450 mm (3.3248 in)
Stroke	88.950 mm (3.5020 in)
Capacity	2498 cm^3 (152.5 in^3)
Firing order	1 - 2 - 4 - 5 - 3
Compression ratio	19.5 : 1
Direction of rotation	Clockwise viewed from the front of the engine
Dimensions:	
⇒ Length	766 mm (30.1 in)
⇒ Width	708 mm (27.8 in)
⇒ Height	788 mm (31.0 in)
Injection timing	Controlled by ECM
Injectors:	
⇒ Make/Type	Lucas EV1
⇒ Nominal operating pressure:	
⇒ Pre EU3 models	1500 bar (21750 $lbf.in^2$)
⇒ EU3 models	1750 bar (25500 $lbf.in^2$)
Maximum governed speed	4850 rev/min
Maximum overrun speed	5460 rev/min
Idle speed:	
⇒ Manual gearbox	740 ± 50 rev/min
⇒ Automatic gearbox	760 ± 50 rev/min
Glow plugs	Beru 12 V. Four plugs in cylinders 1, 2, 3 and 4
Turbocharger	Garrett GT 20
Emissions standard:	
⇒ Pre EU3 models	ECD 2
⇒ EU3 models	ECD 3
Valve timing	
Inlet valves:	
⇒ Opens	14° BTDC
⇒ Closes	33° ABDC
Exhaust valves:	
⇒ Opens	57° BBDC
⇒ Closes	14° ATDC

Lubrication	
Type	Wet sump, pressure fed
Pump type	Eccentric rotor, crankshaft driven integral with stiffener plate.
Filter type:	
⇒ Primary	Centrifuge filter
⇒ Secondary	Disposable canister with full flow by-pass
Pressure at idle (Cold)	3.0 bar (43.5 lbf.in^2)
Pressure at 3500 rev/min (Hot)	1.5-3.0 bar (21.75-43.5 lbf.in^2)
Relief valve opening pressure	4.0 bar (58 lbf.in^2)
Low oil pressure switch opening pressure	0.2-0.6 bar (3.0-8.8 lbf.in^2)
Crankshaft	
Main journal diameter	61.9875-62.0125 mm (2.4404-2.4414 in)
Crankpin journal diameter	53.99-54.01 mm (2.125-2.131 in)
End float	0.020 - 0.250 mm (0.0008 - 0.0098 in)
Main bearings	
Quantity	6 (5 main, 1 thrust)
Pistons	
Type	Graphite compound skirt with combustion chamber in crown
Clearance in cylinder bore. Measured at bottom of skirt, 90° to gudgeon pin	0.172-0.206 mm (0.007-0.008 in)
Diameter (Measured at right angles to gudgeon pin and 40.0 mm (1.5 in) from bottom of skirt)	84.270-85.254 mm (3.321-3.361 in)
Gudgeon pins	Fully floating, offset towards piston thrust side
Piston rings	
Type:	2 compression, 1 oil control
⇒ Upper compression ring	Barrel edge, chrome plated
⇒ Lower compression ring	Taper faced
⇒ Oil control ring	Bevelled ring with spring
New ring to groove clearance:	
⇒ Upper compression	Not measured
⇒ Lower compression	0.050-0.082 mm (0.002-0.003 in)
⇒ Oil control	0.050-0.082 mm (0.002-0.003 in)
Piston ring fitted gap in cylinder bore:	
⇒ Upper compression	0.30-0.45 mm (0.0118-0.0177 in)
⇒ Lower compression	0.40-0.60 mm (0.0157-0.0236 in)
⇒ Oil control	0.25-0.40 mm (0.0098-0.0157 in)

Camshaft	
Bearings	6
Drive	Duplex chain
End float	0.06-0.16 mm (0.002-0.006 in)
Tappets	
Type	Hydraulic lash adjusters with followers
Valves	
Stem diameter:	
⇒ Exhaust	6.905 ± 0.008 mm (0.271 ± 0.0003 in)
⇒ Inlet	6.915 ± 0.008 mm (0.272 ± 0.0003 in)
Head diameter:	
⇒ Exhaust	31.7 mm (1.25 in)
⇒ Inlet	34.7 mm (1.37 in)
Seat face angle:	
⇒ Exhaust	45°
⇒ Inlet	30°
Valve face angle:	
⇒ Exhaust	44° 48' ±12'
⇒ Inlet	29° 48' ±12'
Valve springs	
Type	Parallel, single coil

Engine - V8

General	
Cylinder arrangement	90° V8, numbered from the front of the engine: ⇒ Left bank cylinders 1, 3, 5 and 7 ⇒ Right bank cylinders 2, 4, 6 and 8
Bore	94.00 mm (3.70 in)
Stroke: ⇒ 4.0 litre ⇒ 4.6 litre	 71.04 mm (2.80 in) 81.92 mm (3.22 in)
Capacity: ⇒ 4.0 litre ⇒ 4.6 litre	 3950 cm^3 (241 in^3) 4554 cm^3 (278 in^3)
Firing order	1 - 8 - 4 - 3 - 6 - 5 - 7 - 2
Compression ratio: ⇒ Low - 4.0 litre ⇒ High - 4.0 and 4.6 litre	 8.23:1 9.35:1
Direction of rotation	Clockwise viewed from the front of the engine
Maximum power - 4.0 litre: ⇒ Low compression ratio ⇒ High compression ratio - UK/Japan/ROW ⇒ High compression ratio - NAS	 132 kW (177 bhp) at 4750 rev/min 136 kW (182 bhp) at 4750 rev/min 140 kW (187 bhp) at 4750 rev/min
Maximum power - 4.6 litre	162 kW (217 bhp) at 4750 rev/min
Maximum engine speed: ⇒ Continuous ⇒ Intermittent	5000 rev/min 5250 rev/min
Weight (fully dressed, wet) ⇒ Manual ⇒ Automatic	 194 Kg (435 lb) 179 Kg (402 lb)
Dimensions: ⇒ Length - Manual ⇒ Length - Automatic ⇒ Width ⇒ Height	 767 mm (30.2 in) (Including fan) 777 mm (30.5 in) (Including fan and drive plate) 652 mm (25.7 in) 746 mm (29.4 in)
Spark plugs: ⇒ Make/Type - 4.0 litre ⇒ Make/type - 4.6 litre ⇒ Gap - 4.0 and 4.6 litre	 Champion RC11 PYP B4 Champion RN11 YCC 1.00 ± 0.05 mm (0.040 ± 0.002 in) Non-adjustable
Coils: ⇒Make ⇒Type	 Bosch 0221 503 407 Twin coils
Fuel injection system: ⇒Make ⇒Type	 Bosch Motronic 5.2.1 Type 4146 Multiport fuel injection, electronically controlled with electro-mechanical injectors

Idle speed:	
⇒ All loads off	660 ± 50 rev/min
⇒ Base idle speed	Non-adjustable
⇒ Idle air control (IAC) valve position	Checked via TestBook
CO at idle:	
⇒ Catalyst vehicles	0.5 %
⇒ Non-catalyst vehicles	0.5 - 1.0 %
Valve timing	
Inlet valves: ⇒ Opens ⇒ Closes	 28° BTDC 77° ABDC
Exhaust valves: ⇒ Opens ⇒ Closes	 66° BBDC 39° ATDC
Fuel grade: ⇒ High compression catalyst vehicles ⇒ Low compression catalyst vehicles ⇒Non-catalyst vehicles	 95 RON minimum unleaded 91 RON minimum unleaded 97 RON leaded
Lubrication	
Type	Wet sump, pressure fed
Pump type	Crankshaft driven eccentric rotor
Oil filter	Disposable canister with full flow by-pass
Pressure at idle - minimum	0.7 bar (10 lbf.in^2)
Pressure at 2000 rev/min (hot)	3.4 bar (50 lbf.in^2)
Relief valve opening pressure	3.4 bar (50 lbf.in^2)
Low oil pressure switch opening pressure	0.24-0.41 bar (3.5-6.0 lbf.in^2)
Crankshaft	
Main journal diameter	63.487 - 63.500 mm (2.4995 - 2.520 in)
Crankpin journal diameter	55.500 - 55.513 mm (2.20 - 2.22 in)
End float	0.08 - 0.26 mm (0.003 - 0.010 in)
Maximum ovality	0.040 mm (0.002 in)
Main bearings	
Quantity	5
Material	Glacier Vandervell / AS 15
Diametrical clearance	0.015 - 0.016 mm (0.00059 - 0.00063 in)
Connecting Rods	
Type	Horizontally split big-end, plain small end
Distance between centres	155.120 - 155.220 mm (6.1071 - 6.1110 in)

Big-end bearings	
Quantity	8
Material	Glacier Vandervell GPL 2120/AS 124A
Diametrical clearance	0.015 - 0.016 mm (0.00059 - 0.00063 in)
End float	0.15 - 0.35 mm (0.0006 - 0.0138 in)
Gudgeon pins	
Diameter	23.995 - 24.000 mm (0.9447 - 0.9449 in)
Clearance in piston	0.006 - 0.015 mm (0.00024 - 0.00059 in)
Fit in connecting rod	Press fit
Length	60.00 - 60.50 mm (2.362 - 2.382 in)
Pistons	
Type	Solid skirt, elliptical open end with offset gudgeon pin
Material	Aluminium AE413P
Clearance in cylinder bore. Measured 10 mm (0.4 in) from bottom of skirt, 90° to gudgeon pin.	0.022 - 0.067 mm (0.0009 - 0.0026 in)
Diameter - Grade A	93.970 - 93.985 mm (3.6996 - 3.7002 in)
Diameter - Grade B	93.986 - 94.001 mm (3.7002 - 3.7008 in)
Piston rings	
Type: ⇒ Top compression ring ⇒ 2nd compression ring ⇒ Oil control ring	2 compression, 1 oil control Barrel faced nitrided steel Tapered spherical 3 piece AE Conoform
Piston ring fitted gap in cylinder bore: ⇒ Top compression ring gap ⇒ 2nd compression ring gap ⇒ Oil control ring gap	 0.3 - 0.5 mm (0.012 - 0.020 in) 0.40 - 0.65 mm (0.016 - 0.026 in) 0.38 - 1.40 mm (0.015 - 0.055 in)
Piston ring width: ⇒ Top compression ring width ⇒ 2nd compression ring width ⇒ Oil control ring width	 1.21 - 1.23 mm (0.0476 - 0.0484 in) 1.478 - 1.490 mm (0.0582 - 0.0587 in) 3.00 mm (0.1181 in)
Piston ring to groove clearance: ⇒ 1st and 2nd compression rings	 0.05 - 0.10 mm (0.002 - 0.004 in)
Camshaft	
Bearings	5
Drive	Chain, 9.52 mm (0.3748 in) pitch x 54 pitches
End float	0.075 - 0.25 mm (0.002 - 0.010 in)
Tappets	
Type	Hydraulic self adjusting
Outside diameter	21.386 - 21.407 mm (0.8420 - 0.8427 in)

Valves	
Stem diameter:	
⇒ Inlet	8.664 - 8.679 mm (0.3411 - 0.3417 in)
⇒ Exhaust – 4.0 litre up to engine nos. 55D 05677A; 56D 50787A; 97D 05504A	8.651 - 8.666 mm (0.3406 - 0.3412 in)
⇒ Exhaust – 4.0 litre from engine nos. 55D 05678A; 56D 50788A; 97D 05505A and all 4.6 litre	8.641 to 8.656 mm (0.340 to 0.341 in)
Head diameter:	
⇒ Inlet	39.75 - 40.00 mm (1.5650 - 1.5748 in)
⇒ Exhaust	34.227 - 34.481 mm (1.3475 - 1.3575 in)
Seat face angle:	
⇒ Inlet	46° 25' - 46° 00'
⇒ Exhaust	46° 25' - 46° 00'
Valve face angle:	
⇒ Inlet	45° 00' - 45° 30'
⇒ Exhaust	45° 00' - 45° 30'
Valve springs	
Free length	48.8 mm (1.92 in)
Fitted length	40.93 mm (1.61 in)

Fuel system - Td5

Type	Direct injection from pressure regulated supply with cooled return flow and in-line pressure regulator
Pressure regulator setting	4 bar (58 lbf.in^2)
Pump	Electric two stage submersible
Pump output: ⇒ Low pressure ⇒ High pressure	 30 l/h (6.6 gal/h) (7.93 US gal/h) at 0.5 bar (7.25 lbf.in^2) 180 l/h (39.6 gal/h) (47.55 US gal/h) at 4 bar (58 lbf.in^2)
Maximum consumption	30 l/h (6.6 gal/h) (7.93 US gal/h)
Injectors	Electronic unit injectors
Injector nominal operating pressure: ⇒ Pre EU3 models ⇒ EU3 models	 1500 bar (21750 lbf.in^2) 1750 bar (25500 lbf.in^2)
Filter	In-line canister filter/water separator with water detection
Air cleaner	Mann and Hummell P0037

Fuel system - V8

Type	Multiport injection from pressure regulated, returnless supply
Pump	Electric submersible
Regulated pump output pressure	3.5 bar (50.75 lbf.in^2)
Fuel pump delivery	120 litres/hr (211 pints/hr) (234 US pints/hr)
Filter	In-line canister
Air filter	Mann and Hummell P0036

Cooling system - Td5

Type	Pressurised, spill return partial flow, thermostatically controlled
Cooling fans	11 blade axial flow on viscous coupling and 11 blade axial flow electric
Electric cooling fan switching points:	
For A/C system:	
⇒ On	When vehicle speed is 50 mph (80 km/h) or less and ambient temperature is 28 °C (82 °F) or more
⇒ Off	When vehicle speed increases to 62.5 mph (100 km/h) or ambient temperature decreases to 25 °C (77 °F)
For engine cooling during normal running:	
⇒ On	110 °C (230 °F)
⇒ Off	105 °C (221 °F)
For engine cooling at ignition off (to counteract heat soak):	
⇒ On	If, within 10 seconds of ignition off, engine coolant temperature is 105 °C (221 °F) or more
⇒ Off	After 10 minutes or if engine coolant temperature decreases to 100 °C (212 °F)
Coolant pump	Centrifugal impeller, belt driven from crankshaft
Thermostat	Waxstat with pressure relief valve
Thermostat opening temperature:	
⇒ Initial opening	82 °C (179 °F)
⇒ Fully open	96 °C (204 °F)
Expansion tank cap relief valve - system operating pressure	1.4 bar (20.3 lbf.in^2)
Fuel cooler thermostat opening temperature	82°C (179°F)

Cooling system - V8

Type	Pressurised, spill return, thermostatically controlled water and antifreeze mixture. Vertical flow radiator with remote header tank and pump assisted
Cooling fans	9 blade axial flow on viscous coupling and 11 blade axial flow electric
Electric cooling fan switching points:	
For A/C system:	
⇒ On	When vehicle speed is 50 mph (80 km/h) or less and ambient temperature is 28 °C (82 °F) or more
⇒ Off	When vehicle speed increases to (62.5 mph (100 km/h) or ambient temperature decreases to 25 °C (77 °F)
For engine cooling during normal running:	
⇒ On	100 °C (212 °F)
⇒ Off	94.5 °C (202 °F)
For engine cooling at ignition off (to counteract heat soak):	
⇒ On	If, within 10 seconds of ignition off, intake air temperature is 60 °C (140 °F) or more and engine coolant temperature is 110 °C (230 °F) or more
⇒ Off	After 10 minutes or if engine coolant temperature decreases to 100 °C (212 °F)
Coolant pump	Centrifugal impeller, belt driven from crankshaft
Coolant pump drive ratio	1.293 : 1
Coolant pump output at 1000 rev/min	10 litres/min (2.64 US galls/min) at 0.7 bar (10 lbf.in^2)
Thermostat	Waxstat with pressure relief valve
Thermostat operating temperature:	
⇒ Initial opening	82 °C (179 °F)
⇒ Fully open	96 °C (204 °F)
Expansion tank cap relief valve - system operating pressure	1.4 bar (20 lbf.in^2)

Clutch - Td5

Type	Diaphragm spring, hydraulically operated with self-centering, preloaded release bearing
Drive plate diameter	267 mm (10.5118 in)
Pressure plate diameter	267 mm (10.5118 in)
Clutch plate friction material	Verto F202
Diaphragm finger height when clamped on a 8.5 mm (0.33 in) thick gauge plate	42.5 to 48.5 mm (1.673 to 1.904 in)
Diaphragm finger clearance (service limit)	1.00 mm (0.040 in)
Clutch plate thickness under 6500 N (1461 lb) axial load:	
⇒ New	8.2 to 8.8 mm (0.33 to 0.34 in)
⇒ Service limit	7.0 mm (0.27 in)

Clutch - V8

Type	Diaphragm spring, hydraulically operated with self-centering, preloaded release bearing
Clutch plate friction material	APTEC 385
Drive plate diameter	267 mm (10.5118 in)
Pressure plate diameter	268 mm (10.5512 in)
Clutch plate thickness (clamped state)	
⇒ New	8.4-8.9 mm (0.33-0.35 in)
⇒ Service limit	7.1 mm (0.28 in)
Rivet depth:	
⇒ New	1.73 mm (0.07 in)
⇒ Service limit	0.25 mm (0.01 in)
Clutch plate runout:	
⇒ New	0.5 mm (0.02 in)
⇒ Service limit	0.5 mm (0.02 in)

Manual gearbox - R380

Type	Single helical constant mesh
Gears	5 forward, 1 reverse, all synchromesh
Gear ratios: Td5 Diesel	
⇒ First	3.692 : 1
⇒ Second	2.132 : 1
⇒ Third	1.397 : 1
⇒ Fourth	1.0 : 1
⇒ Fifth	0.770 : 1
⇒ Reverse	3.536 : 1
Gear ratios: V8 Petrol	
⇒ First	3.321:1
⇒ Second	2.132:1
⇒ Third	1.397:1
⇒ Fourth	1.0:1
⇒ Fifth	0.732:1
⇒ Reverse	3.536:1
Baulk ring clearance:	
⇒ New	0.500 mm (0.0197 in)
⇒ Service limit	0.500 mm (0.0197 in)
⇒ Selector fork pad widths - minimum	6.5 mm (0.255 in)
First gear end float:	
⇒ New	0.050 - 0.200 mm (0.0020 - 0.0079 in)
⇒ Service limit	0.327 mm (0.0129 in)
Second gear end float:	
⇒ New	0.040 - 0.210 mm (0.0016 - 0.0083 in)
⇒ Service limit	0.337 mm (0.0133 in)
Third gear end float:	
⇒ New	0.110 - 0.210 mm (0.0043 - 0.0083 in)
⇒ Service limit	0.337 mm (0.0133 in)
Adjust fifth / reverse hub - shim to	
⇒ New	0.005 - 0.055 mm (0.0002 - 0.0022 in)
⇒ Service limit	0.055 mm (0.0022 in)
Reverse gear idler shaft clearance	
⇒ New	0.040 - 0.380 mm (0.0016 - 0.0150 in)
⇒ Service limit	0.380 mm (0.0150 in)
Mainshaft end float:	
⇒ New	0.000 - 0.050 mm (0.0000 - 0.0020 in)
⇒ Service limit	0.000 - 0.050 mm (0.0000 - 0.0020 in)
Layshaft end float:	
⇒ New	0.000 - 0.050 mm (0.0000 - 0.0020 in)
⇒ Service limit	0.000 - 0.050 mm (0.0000 - 0.0020 in)

Transfer box - LT230SE

Type	LT230SE, two speed reduction with front and rear drives
Reduction ratios: ⇒ High range ⇒ Low range	 1.211 : 1 3.32 : 1
Low range gear to high/low range hub clearance	0.05 to 0.15 mm (0.002 to 0.006 in)
High range gear to high/low range hub clearance	0.05 to 0.15 mm (0.002 to 0.006 in)
Mainshaft input gear bearing pre-load	0.05 mm (0.002 in)
Intermediate gear bearing pre-load	Torque intermediate shaft nut to 88 Nm (65 lbf.ft)

Automatic gearbox - ZF4HP22/24

Type	ZF4HP22, electro-hydraulic shift control with fluid torque converter
Gears	4 forward, 1 reverse
Gear ratios: ⇒ First ⇒ Second ⇒ Third ⇒ Fourth ⇒ Reverse	 2.480:1 1.480:1 1.000:1 0.728:1 2.086:1
Torque converter lock-up	Engaged in third and fourth gears above 72 km/h (45 mph)
Input shaft axial end-float	0.2 to 0.4 mm (0.008 to 0.016 in)

Rear axle

Type	Solid axle casing incorporating a spiral bevel differential and drive shafts
Reduction ratio	3.538:1

Front axle

Type	Solid axle casing incorporating spiral bevel differential and drive shafts with constant velocity joints.
Reduction ratio	3.538:1

Steering

Type	Hydraulically assisted worm and roller
Steering wheel turns lock to lock	3.5
Steering wheel diameter	400 mm (15.7 in)
Turning circle, kerb to kerb	11.9 metres (39.1 feet)
PAS pump	Hobourn Automotive Ltd. Series 500, belt driven
PAS pump pressure - engine at idle with steering at full lock	21 to 62 bar (305 to 900 lbf/in^2
Delivery pressure (nominal)	100 bar (1450 lbf.in^2) 8.5 litres/min (15.1 pints/min) (18.1 US pints/min)
Steering geometry:	
⇒ Camber angle - Front, up to VIN 2A 754807 - unladen condition	–10' ± 30'
⇒ Camber angle - Front, from VIN 2A 754808 - unladen condition	+20' ± 30'
⇒ Camber angle - Rear - unladen condition	–10' ± 30'
⇒ Cross camber - Front and rear	1° (Maximum)
⇒ Castor angle - unladen condition	3° 45' ± 45'
⇒ Cross castor	1° (Maximum)
⇒ Toe out - Front	– 0° 10' ± 0° 10' (total)
⇒ Toe in - Rear	+ 0° 5' ± 0° 15' (total)
Thrust angle	20' (Maximum)
⇒ Swivel pin inclination	13° 11'

Note: Measurements taken at EEC kerb weight.

Suspension

Type - Front	Beam axle with coil springs, longitudinal radius arms, Panhard rod, twin tube dampers and either anti-roll bar or active cornering enhancement (ACE)
Nominal height from hub centre to wheel arch (not liner)*	500 ± 15 mm (19.7 ± 0.6 in)
Front road spring colour codes:	
⇒ V8 LHS	Pink/orange
⇒ V8 RHS - LHD	Pink/orange
⇒ V8 RHS - RHD	White/purple
⇒ Td5 LHS	White/purple
⇒ Td5 RHS - LHD	White/purple
⇒ Td5 RHS - RHD	White/purple
Rear road spring colour codes:	
5 seat, LHS	Purple
5 seat, RHS - LHD	Purple
5 seat, RHS - RHD	Purple/purple
7 seat, LHS - LHD	Grey/blue
7 seat, LHS - RHD	Grey/green
7 seat, RHS - LHD	Grey/blue
7 seat, RHS - RHD	Grey/white
Bump stop height (top of bump stop to axle bracket)	44.5 mm (1.75 in)
Anti-roll bar diameter - front	
⇒ With ACE fitted	35 mm (1.38 in)
⇒ Without ACE	30 mm (1.18 in)
Type - Rear	Beam axle with coil or air springs, longitudinal radius arms, Watts linkage, twin tube dampers and either anti-roll bar or active cornering enhancement (ACE)
Nominal height from hub centre to wheel arch (not liner):*	
⇒ Coil spring	483 ± 15 mm (19.0 ± 0.6 in)
⇒ Air spring	473 ± 15 mm (18.6 ± 0.6 in)
Road spring colour code	Purple (all models)
Bump stop height (top of bump stop to axle bracket):	
⇒ Coil spring	71.5 mm (2.8 in)
⇒ Air spring	61.5 mm (2.4 in)
Anti-roll bar diameter - rear	
⇒ With ACE fitted	35 mm (1.38 in)
⇒ Without ACE - SLS fitted	29 mm (1.14 in)
⇒ Without ACE - SLS not fitted	5 seats = 19 mm (0.75 in) 7 seats = 16 mm (0.63 in)

* Measurement taken with vehicle at unladen weight.

Brakes

Type	Servo assisted, diagonally split hydraulic on outboard discs, with four channel electronic control ABS
Disc diameter: ⇒ Front ⇒ Rear	 297.0 - 297.4 mm (11.693 - 11.709 in) 303.8 - 304.2 mm (11.961 - 11.976 in)
Front disc minimum thickness: ⇒ New ⇒ Service limit	 24.9 - 25.1 mm (0.980 – 0.988 in) 22.0 mm (0.866 in)
Rear disc minimum thickness: ⇒ New ⇒ Service limit	 12.5 – 12.7 mm (0.492 – 0.500 in) 11.7 mm (0.461 in)
Maximum disc runout	0.15 mm (0.006 in)
Minimum pad material thickness	2.0 mm (0.079 in)
Handbrake	Cable operated drum on transfer box rear output shaft

Wheels and tyres

Wheel size:		
⇒ Steel		7J x 16
⇒ Alloy		7J x 16 8J x 16 8J x 18
Tyre size		
⇒ With 7J x 16 wheels		235/70 R16 Wrangler HP 105H 235/70 R16 Michelin XPC * 105H
⇒ With 8J x 16 wheels		255/65 R16 Wrangler HP 109H 255/65 R16 Michelin XPC * 109H
⇒ With 8J x 18 wheels		255/55 R18 Wrangler HP 109H
Tyre Pressures		
All tyres - normal operating conditions	Front	Up to 03MY - 1.9 Bar (28 lbf.in²) From 03MY - 2.1 Bar (30 lbf.in²)
	Rear	2.6 Bar (38 lbf.in²)
All tyres - vehicle at GVW	Front	Up to 03MY - 1.9 Bar (28 lbf.in²) From 03MY - 2.1 Bar (30 lbf.in²)
	Rear	3.2 Bar (46 lbf.in²)

CAUTION: When towing, the additional load imposed may cause the tyre maximum load rating to be exceeded. This is permissible provided the load rating is not exceeded by more than 15% and that road speeds are limited to 62 mph (100 km/h) and tyres pressures are increased by at least 3 lbf/in² (0.2 bar).
NOTE: The tyre size is displayed on the outer wall of each tyre.

Normal operating conditions: carrying up to 4 passengers and luggage.

Air conditioning

Type	CFC free, sealed closed loop
Compressor:	
⇒ Displacement	177.7 cm^3/rev (10.84 in^3/rev)
⇒ Relief valve operating pressure	34.3 to 41.4 bar (497 to 600 $lbf.in^2$)
⇒ Refrigerant oil quantity	180ml (6.3 fl.oz)
Dual pressure switch operating pressures (nominal):	
⇒ Low pressure switch Opens	2.0 bar (29.0 $lbf.in^2$), pressure decreasing
⇒ Low pressure switch Closes	2.3 bar (33.4 $lbf.in^2$), pressure increasing
⇒ High pressure switch Opens	32 bar (464 $lbf.in^2$), pressure increasing
⇒ High pressure switch Closes	26 bar (377 $lbf.in^2$), pressure decreasing

Electrical - Td5

System	12 volt, negative earth
Battery:	
⇒ Type	Delco Freedom
⇒ Capacity	110 amp hour
Alternator:	
⇒ Type	Nippon Denso
⇒ Maximum output	120 amp
Starter motor:	
⇒ Type	Nippon Denso
⇒ Power	2 kW

Electrical - V8

System	12 volt, negative earth
Battery:	
⇒ Type	Delco Freedom
⇒ Capacity	72 amp hour
Alternator:	
⇒ Type	Bosch NC65/130
⇒ Maximum output	130 amp
Starter motor	
⇒ Type	Nippon Denso
⇒ Power	1.8 kW

Dimensions

Overall length - including towing hitch	4715 mm (185.6 in)
Overall length - including spare wheel	4705 mm (185.24 in)
Overall width (excluding mirrors)	1885 mm (74.2 in)
Overall height - Open sunroof *	2015 mm (79.3 in)
Overall height (without roof bars) *	1940 mm (76.40 in)
Minimum ground clearance *	253.5 mm (10.0 in)
Wheelbase	2540 mm (100.00 in)
Turning circle (kerb to kerb)	11.9 metres (39.1 feet)
Track - front	1540 mm (60.63 in)
Track - rear	1560 mm (61.42 in)

* Measurement taken with vehicle at unladen weight.

Weights

	kgs	lbs
Unladen weight:		
⇒ V8 models	2095 - 2235	4619 - 4928
⇒ Td5 model	2150 - 2280	4740 - 5027
Max.GVW:		
⇒ All 5 seat vehicles (coil springs)	2750	6063
⇒ All 7 seat Diesel engine vehicles (coil springs)	2880	6347
⇒ All 7 seat Petrol engine vehicles (coil springs)	2825	6215
⇒ V8 models with self levelling suspension	2825	6228
⇒ Td5 models with self levelling suspension	2880	6349
Max. front axle load	1200	2646
Max. rear axle load:		
⇒ With coil springs	1720	3792
⇒ With self levelling suspension	1800	3968

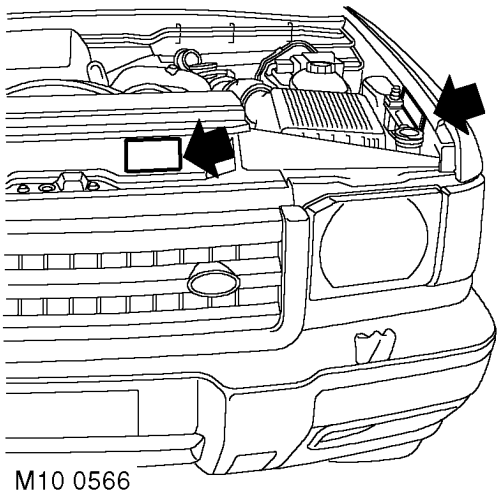
NOTE: The rear axle load for vehicles with self levelling suspension can be increased to a maximum of 1928 kg (4249 lb) when towing, provided road speed is limited to 60 mph (100 km/h).
NOTE: Axle weights are non additive. The individual maximum weights and gross vehicle weight must not be exceeded.

Vehicle Identification Number

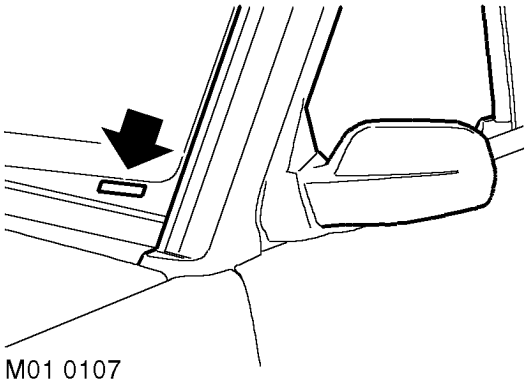
Location

The Vehicle Identification Number (VIN) plate is stamped on a plate attached to the bonnet locking platform. The VIN is also stamped in the following locations:

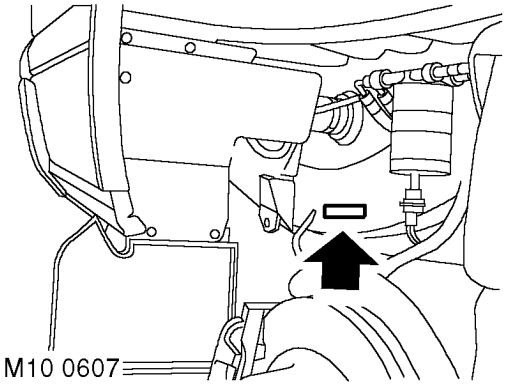
- On a plate behind the LH lower corner of the windscreen.
- On the chassis RH longitudinal behind the rear wheel.



Bonnet locking platform VIN

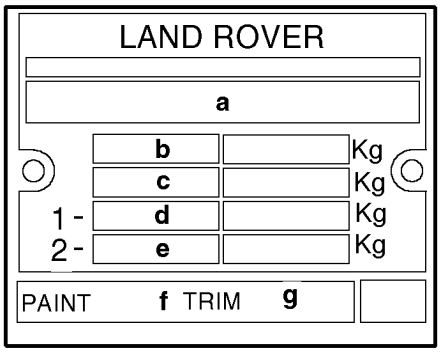


Windscreen VIN



Chassis VIN

VIN plate content



M01 0113B

The VIN plate contains the following information.

- **a** Vehicle Identification Number (VIN)
- **b** Gross vehicle weight
- **c** Gross train weight
- **d** Maximum front axle load
- **e** Maximum rear axle load
- **f** Paint code
- **g** Trim code

Vehicle identification number - except NAS and Canada
Example: **SALLTGM87WA600172**

SAL	Manufacturer's identifier (Land Rover UK)
LT	Marque/Model LT = Discovery
G	Class A = Japan G = 100 inch
M	Body Style B = 5 door models
8	Engine 1 = 4.0 V8 LC Cat 2 = 4.0 V8 HC Cat 3 = 4.0 LC Non Cat 8 = TD5 engine EGR/Cat 9 = TD5 engine EGR/ Non Cat
7	Transmission and Steering 3 = RHD automatic gearbox 4 = LHD automatic gearbox 7 = RHD manual gearbox 8 = LHD manual gearbox
W	Model Year W = 1998 Model year X = 1999 Model year Y = 2000 Model year 1 = 2001 Model year 2 = 2002 Model year 3 = 2003 Model year
A	Assembly plant A = Solihull F = KD build
6 figures= Serial number	

Vehicle identification number - NAS and Canada
Example: **SALTY124OWA600180**

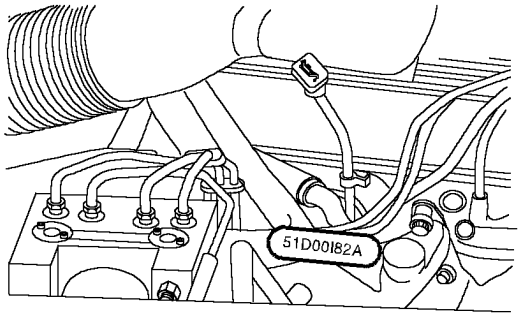
SAL	Manufacturer's identifier (Land Rover UK)
T	Marque/Model T = Discovery
Y	Class Y = 100 inch USA/Canada N = 100 inch California
1	Body Style 1 = 4 door Station Wagon
2	Engine 2 = 4.0 V8 HC Cat
4	Transmission and Steering 4 = LHD automatic gearbox
O	Check digit
W	Model Year W = 1998 Model year X = 1999 Model year Y = 2000 Model year 1 = 2001 Model year 2 = 2002 Model year 3 = 2003 Model year
A	Assembly plant A = Solihull
6 figures= Serial number	

Paint and trim colour codes
Paint code (F): a 3 digit code identifying the original paint colour is stamped on the VIN plate. Refer to Parts Catalogue for full list of colour codes.

Trim code (G): a code identifying the original trim type and colour is stamped on the VIN plate. Refer to the relevant Parts Catalogue for coding details

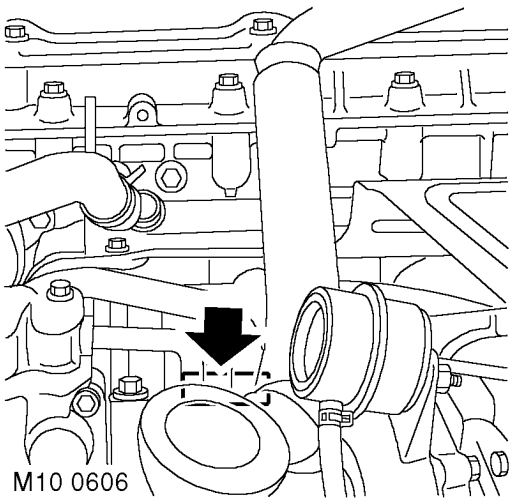
Identification Number Locations

Engine number



M01 0106

V8 Engine

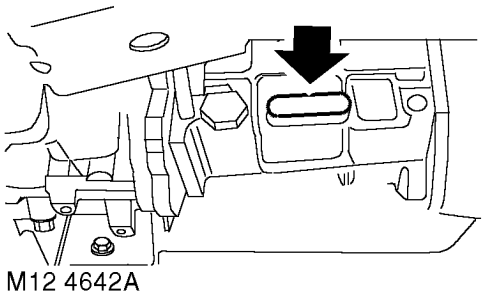


M10 0606

Td5 Engine

Stamped on the LH side of the cylinder block below the exhaust manifold

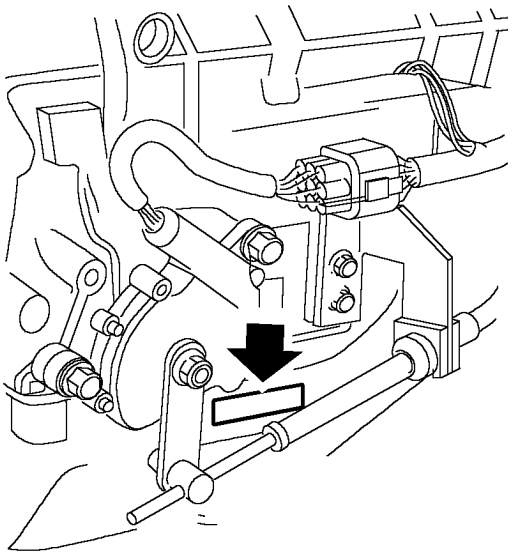
Manual gearbox number



M12 4642A

Stamped on the RH side of the gearbox casing, adjacent to the oil drain plug.

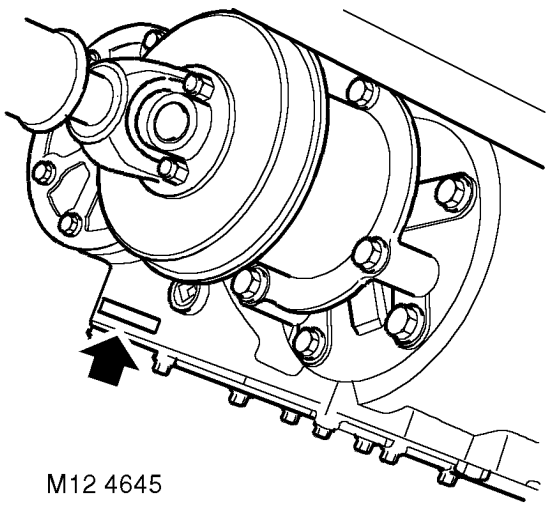
Automatic gearbox number



M10 0605

Stamped on a plate attached to the LH side of the gearbox casing adjacent to the selector mechanism.

Transfer box number



M12 4645

Stamped on the rear of the transfer box casing above the bottom cover plate.

Front axle number

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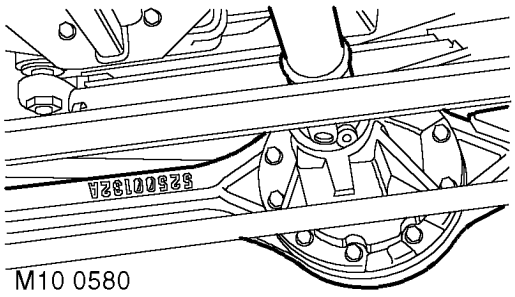
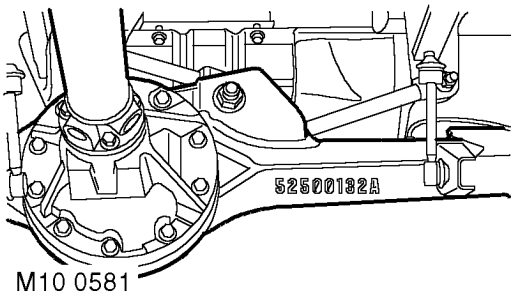


M10 0580

Stamped on the rear face of the axle tube on the LH side.

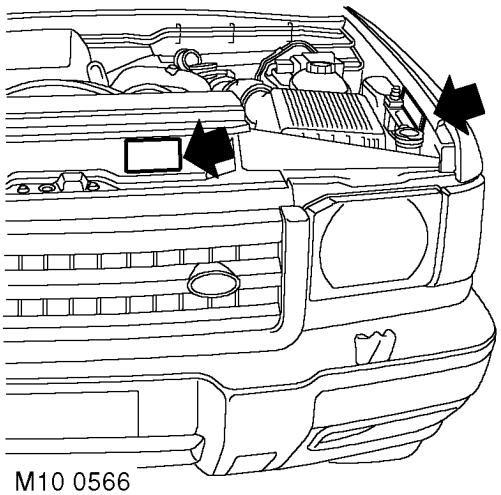
Rear axle number



M10 0581

Stamped on the front face of the axle tube on the LH side.

Body number



M10 0566

Stamped on a label attached to the LH inner wing behind the headlamp.

Maintenance

TORQUE DESCRIPTION	METRIC	IMPERIAL
Wheel nuts	140 Nm	(103 lbf.ft)
V8 oil drain plug	33 Nm	(24 lbf.ft)
Td5 oil drain plug	23 Nm	(17 lbf.ft)
Oil filter element, tighten two thirds of a turn by hand or to -	17 Nm	(13 lbf.ft)
Manual gearbox oil drain plug	50 Nm	(37 lbf.ft)
Manual gearbox oil filler/level plug	30 Nm	(22 lbf.ft)
Automatic gearbox oil drain plug	15 Nm	(11 lbf.ft)
Automatic gearbox oil drain plug	30 Nm	(22 lbf.ft)
Transfer gearbox oil drain plug	30 Nm	(22 lbf.ft)
Transfer gearbox oil filler/level plug	25 Nm	(18 lbf.ft)
Axle oil drain plug	64 Nm	(47 lbf.ft)
Axle oil filler/level plug	10 Nm	(7 lbf.ft)

Engine Td5

TORQUE DESCRIPTION	METRIC	IMPERIAL
ACE pump bolts	25 Nm	(18 lbf.ft)
A/C compressor bolts	25 Nm	(18 lbf.ft)
Alternator support bracket to cylinder head bolts	25 Nm	(18 lbf.ft)
Alternator/vacuum pump oil feed pipe union	10 Nm	(7 lbf.ft)
Camshaft cover to camshaft carrier bolts	10 Nm	(7 lbf.ft)
Camshaft sprocket to camshaft bolts	37 Nm	(27 lbf.ft)
Centrifuge cover bolts	10 Nm	(7 lbf.ft)
Centrifuge oil drain pipe to sump bolts (or nuts)	10 Nm	(7 lbf.ft)
Centrifuge to oil drain pipe bolts	10 Nm	(7 lbf.ft)
Centrifuge to oil cooler housing bolts	25 Nm	(18 lbf.ft)
CKP sensor bolt	10 Nm	(7 lbf.ft)
Coolant pipe bolt	50 Nm	(37 lbf.ft)
Connecting rod bolts, then a further 80°	20 Nm	(15 lbf.ft)
Crankshaft pulley bolt	460 Nm	(340 lbf.ft)
Crankshaft pulley TV damper bolts	80 Nm	(59 lbf.ft)
Crankshaft rear oil seal housing bolts	10 Nm	(7 lbf.ft)
Cylinder head bolts initial tighten	30 Nm	(22 lbf.ft)
Cylinder head bolts final tighten, then a further 90°, then a further 180° and finally a further 45°	65 Nm	(48 lbf.ft)
Dipstick tube to camshaft carrier bolt	10 Nm	(7 lbf.ft)
Drive plate (automatic transmission) to crankshaft bolts	115 Nm	(85 lbf.ft)
EGR pipe clamp to cylinder head bolt - if fitted	25 Nm	(18 lbf.ft)
EGR pipe Allen screws	10 Nm	(7 lbf.ft)
Engine mounting (front) to cylinder block bolts	48 Nm	(35 lbf.ft)
Engine mounting (front) to chassis nuts	85 Nm	(63 lbf.ft)
Engine mounting bracket (rear, LH & RH) to gearbox bolts	85 Nm	(63 lbf.ft)
Engine mounting bracket (rear, LH & RH) nuts	45 Nm	(33 lbf.ft)
Flywheel to crankshaft (manual transmission) bolts, then a further 90°	40 Nm	(30 lbf.ft)
Front crossmember bolts	26 Nm	(20 lbf.ft)
Fuel connector block bolts	25 Nm	(18 lbf.ft)
Fuel cooler to inlet manifold bolts	25 Nm	(18 lbf.ft)
Gearbox housing to engine bolts	50 Nm	(37 lbf.ft)
Heater pipe to cylinder head bolts	25 Nm	(18 lbf.ft)
Main bearing cap bolts then a further 90°	33 Nm	(24 lbf.ft)
Oil cooler housing to cylinder block bolts	25 Nm	(18 lbf.ft)
Oil cooler pipe clip bolts	10 Nm	(7 lbf.ft)
Oil filter adaptor housing to oil cooler housing bolts	25 Nm	(18 lbf.ft)
Oil pick-up strainer screws	10 Nm	(7 lbf.ft)
Oil pressure switch	15 Nm	(11 lbf.ft)
Oil pump drive sprocket bolt	25 Nm	(18 lbf.ft)
Oil pump pressure relief valve plug	25 Nm	(18 lbf.ft)
Oil pump and stiffener assembly to cylinder block bolts	13 Nm	(10 lbf.ft)
Oil sump to cylinder block bolts	25 Nm	(18 lbf.ft)
Oil sump to gearbox bell housing bolts	13 Nm	(10 lbf.ft)
PAS pump bracket bolts	27 Nm	(20 lbf.ft)
PAS pump pulley bolts	27 Nm	(20 lbf.ft)
Rocker arm adjusting screw locknuts	16 Nm	(12 lbf.ft)

TORQUE DESCRIPTION	METRIC	IMPERIAL
Rocker shaft bolts	32 Nm	(24 lbf. ft)
Timing chain adjustable guide bolt	25 Nm	(18 lbf.ft)
Timing chain cover bolts	27 Nm	(20 lbf.ft)
Timing chain cover to cylinder block stud	7 Nm	(5.2 lbf.ft)
Timing chain fixed guide retaining pin	25 Nm	(18 lbf.ft)
Timing chain cover to cylinder head nut and bolt	25 Nm	(18 lbf.ft)
Timing chain fixed guide (M6) bolt	10 Nm	(7 lbf.ft)
Timing chain fixed guide (M10) bolt	45 Nm	(33 lbf.ft)
Timing chain lubrication jet bolt	10 Nm	(7 lbf.ft)
Timing chain tensioner	45 Nm	(33 lbf.ft)
Torque converter to drive plate (automatic transmission) bolts	50 Nm	(37 lbf.ft)
Turbocharger heatshield bolts	10 Nm	(7 lbf.ft)
Turbocharger oil feed pipe banjo bolt	25 Nm	(18 lbf.ft)
Turbocharger to exhaust manifold nuts	30 Nm	(22 lbf.ft)
Vacuum pump oil feed pipe to cylinder head union	10 Nm	(7 lbf.ft)
Viscous fan nut	45 Nm	(33 lbf.ft)
Fuel spill return pipe unions - if fitted	20 Nm	(15 lbf.ft)

Engine V8

TORQUE DESCRIPTION	METRIC	IMPERIAL
Engine mounting bolts (rear, LH & RH) to gearbox bolts	85 Nm	(63 lbf.ft)
Engine mounting (rear, LH & RH) nuts	45 Nm	(33 lbf.ft)
Cylinder head bolts tighten, then 90°, then a further 90°	20 Nm	(15 lbf.ft)
Rocker shaft bolts	40 Nm	(30 lbf.ft)
Alternator mounting bracket	40 Nm	(30 lbf.ft)
Auxiliary drive belt tensioner	45 Nm	(33 lbf.ft)
Engine earth lead	22 Nm	(16 lbf.ft)
Rocker cover bolts	8 Nm	(6 lbf.ft)
Torque converter to drive plate	50 Nm	(37 lbf.ft)
A/C compressor	22 Nm	(16 lbf.ft)
ACE pump	22 Nm	(16 lbf.ft)
Flywheel to crankshaft	78 Nm	(58 lbf.ft)
Crankshaft sensor	6 Nm	(5 lbf.ft)
Crankshaft sensor cover	6 Nm	(5 lbf.ft)
Spacer and hub to crankshaft	85 Nm	(63 lbf.ft)
Drive plate and clamp ring	45 Nm	(33 lbf.ft)
Oil pick up strainer	10 Nm	(7 lbf.ft)
Filter head adaptor	13 Nm	(10 lbf.ft)
Filter head	8 Nm	(6 lbf.ft)
Sump bolts	22 Nm	(16 lbf.ft)
Oil pressure switch	15 Nm	(11 lbf.ft)
Timing gear cover to cylinder block	22 Nm	(16 lbf.ft)
Oil cooler pipe to timing gear cover	15 Nm	(11 lbf.ft)
Crankshaft pulley bolt	270 Nm	(200 lbf.ft)
Coolant outlet elbow	22 Nm	(16 lbf.ft)
Auxiliary housing	40 Nm	(30 lbf.ft)
Jockey pulley	50 Nm	(37 lbf.ft)
Camshaft gear	50 Nm	(37 lbf.ft)
Rocker shaft bolts	40 Nm	(30 lbf.ft)
Connecting rod bolts Final torque - turn through 80 °	20 Nm	(15 lbf.ft)
Initial torque - all main bearing cap bolts and side bolts	13.5 Nm	(10 lbf.ft)
Final torque - main bearing cap side bolts 11 to 15	45 Nm	(33 lbf.ft)
Final torque - main bearing cap bolts 1 to 8	72 Nm	(53 lbf.ft)
Final torque - main bearing cap bolts 9 and 10	92 Nm	(68 lbf.ft)
Final torque - main bearing cap side bolts 16 to 20	45 Nm	(33 lbf.ft)
Viscous fan nut	45 Nm	(33 lbf.ft)
Camshaft thrust plate bolts	22 Nm	(16 lbf.ft)
Secondary Air Injection adapters	33 Nm	(24 lbf.ft)

Emission control - Td5

TORQUE DESCRIPTION	METRIC	IMPERIAL
EGR valve pipe Allen screws	10 Nm	(7 lbf.ft)
EGR valve to inlet manifold bolts	10 Nm	(7 lbf.ft)
EGR intake pipe clip to cylinder head bolts - if fitted	25 Nm	(18 lbf.ft)
EGR cooler to cylinder head nut and bolts - if fitted	25 Nm	(18 lbf.ft)

Emission control - V8

TORQUE DESCRIPTION	METRIC	IMPERIAL
HO_2S Sensors	45 Nm	(33 lbf.ft)
SAI air manifold union nuts	25 Nm	(18 lbf.ft)
Rubber mountings to SAI pump bracket	10 Nm	(7 lbf.ft)
SAI control valve to manifold bolts	10 Nm	(7 lbf.ft)
SAI pump to bracket nuts	10 Nm	(7 lbf.ft)
SAI pump bracket to body bolt	20 Nm	(15 lbf.ft)
Vacuum reservoir to mounting bracket bolt	10 Nm	(7 lbf.ft)

Engine management system - Td5

TORQUE DESCRIPTION	METRIC	IMPERIAL
ECT sensor	15 Nm	(11 lbf.ft)
Fuel tank cradle	45 Nm	(33 lbf.ft)
CKP sensor	10 Nm	(7 lbf.ft)
MAP and IAT sensor	10 Nm	(7 lbf.ft)
Fuel cooler to inlet manifold - upper bolts	25 Nm	(18 lbf.ft)
Turbocharger to exhaust manifold	30 Nm	(22 lbf.ft)
Turbocharger drain pipe	10 Nm	(7 lbf.ft)
Banjo bolt to oil feed pipe	25 Nm	(18 lbf.ft)
Fuel temperature sensor	14 Nm	(10 lbf.ft)
Pressure regulator	25 Nm	(18 lbf.ft)
Glow plugs	16 Nm	(12 lbf.ft)
EUI clamp bolts	32 Nm	(24 lbf.ft)
EGR valve to exhaust manifold	10 Nm	(7 lbf.ft)
EGR valve to inlet manifold	10 Nm	(7 lbf.ft)
EGR clip	25 Nm	(18 lbf.ft)

Engine management system - V8

TORQUE DESCRIPTION	METRIC	IMPERIAL
Spark plugs	20 Nm	(15 lbf.ft)
Fuel tank cradle	45 Nm	(33 lbf.ft)
ECT sensor	10 Nm	(7 lbf.ft)
CKP sensor	6 Nm	(4.4 lbf.ft)
CMP sensor	8 Nm	(6 lbf.ft)
KS sensor	22 Nm	(16 lbf.ft)
Throttle body	10 Nm	(7 lbf.ft)
Plenum chamber	22 Nm	(16 lbf.ft)
Breather adaptor	6 Nm	(4.4 lbf.ft)
Throttle cable abutment bracket	10 Nm	(7 lbf.ft)
TP sensor	2.2 Nm	(1.6 lbf.ft)
IACV sensor	8 Nm	(6 lbf.ft)
HO_2S sensor	45 Nm	(33 lbf.ft)
Ignition coils	8 Nm	(6 lbf.ft)
Fuel rail	9 Nm	(7 lbf.ft)

Cooling system

TORQUE DESCRIPTION	METRIC	IMPERIAL
Cylinder block drain plug	30 Nm	(22 lbf.ft)
Coolant pump	24 Nm	(18 lbf.ft)
Coolant pump pulley	22 Nm	(16 lbf.ft)
Coolant pump cover - Td5	10 Nm	(7 lbf.ft)

Manifolds and exhaust systems - Td5

TORQUE DESCRIPTION	METRIC	IMPERIAL
Front pipe to turbocharger	27 Nm	(20 lbf.ft)
Inlet manifold	25 Nm	(18 lbf.ft)
Tail pipe	25 Nm	(18 lbf.ft)
Fuel cooler	25 Nm	(18 lbf.ft)
EGR valve	10 Nm	(7 lbf.ft)
Exhaust manifold	25 Nm	(18 lbf.ft)
Exhaust manifold heatshield (M6) bolts	10 Nm	(7 lbf.ft)
Exhaust manifold heatshield (M8) bolts	25 Nm	(18 lbf.ft)
EGR pipe Allen screws	10 Nm	(7 lbf.ft)

Manifolds and exhaust systems - V8

TORQUE DESCRIPTION	METRIC	IMPERIAL
Intermediate pipe/silencer nuts	25 Nm	(18 lbf.ft)
Inlet manifold bolts - initial tighten	10 Nm	(7 lbf.ft)
Inlet manifold gasket clamp bolts	18 Nm	(13 lbf.ft)
Inlet manifold bolts - final tighten	51 Nm	(38 lbf ft)
Tail pipe	25 Nm	(18 lbf.ft)
Coolant outlet pipe	22 Nm	(16 lbf.ft)
Front pipe flange nuts	30 Nm	(22 lbf.ft)
Exhaust manifold	55 Nm	(40 lbf.ft)

Clutch

TORQUE DESCRIPTION	METRIC	IMPERIAL
Clutch bleed screw	9 Nm	(7 lbf.ft)
Clutch cover nuts Td5	25 Nm	(18 lbf.ft)
Clutch cover bolts V8	40 Nm	(30 lbf.ft)
Clutch master cylinder to pedal box	25 Nm	(18 lbf.ft)
Hydraulic pipe union	18 Nm	(13 lbf.ft)
Clutch release bearing pivot point bolt	8 Nm	(6 lbf.ft)
Slave cylinder	25 Nm	(18 lbf.ft)

Manual gearbox - R380

TORQUE DESCRIPTION	METRIC	IMPERIAL
Bias plate bolts	25 Nm	(18 lbf.ft)
Gearbox to engine bolts	45 Nm	(33 lbf.ft)
Coolant pipe housing bolts	25 Nm	(18 lbf.ft)
Breather pipe banjo bolt	15 Nm	(11 lbf.ft)
Gear lever extension clamp bolt	25 Nm	(18 lbf.ft)
Gearbox mounting bolts	85 Nm	(63 lbf.ft)
Gearbox mounting nuts	48 Nm	(37 lbf.ft)
Seal housing bolts	18 Nm	(13 lbf.ft)
Bearing sleeve bolts	25 Nm	(18 lbf.ft)
Fork bolt	7 Nm	(5.2 lbf.ft)
Reverse light switch	24 Nm	(18 lbf.ft)
Extension housing bolts	25 Nm	(18 lbf.ft)
Gear selector housing bolts	25 Nm	(18 lbf.ft)
Oil pump to housing Torx screws	6 Nm	(4.4 lbf.ft)
Gear change lever yoke Allen screw	25 Nm	(18 lbf.ft)
5th gear stake nut	350 Nm	(258 lbf.ft)
Spool retainer bolts	8 Nm	(6 lbf.ft)
Centre plate detent spring and ball Torx screw	25 Nm	(18 lbf.ft)
Selector lever to housing bolts	25 Nm	(18 lbf.ft)
Clutch \ Bell housing bolts	73 Nm	(54 lbf.ft)

Transfer box - LT230SE

TORQUE DESCRIPTION	METRIC	IMPERIAL
High/low selector cable	30 Nm	(22 lbf.ft)
Bottom plate bolts	25 Nm	(18 lbf.ft)
Transfer box to gearbox	45 Nm	(33 lbf.ft)
Rear cover plate	25 Nm	(18 lbf.ft)
Differential lock warning lamp switch locknut - Up to 03 MY	11 Nm	(8 lbf.ft)
Differential lock warning lamp switches - 03 MY onwards	25 Nm	(18 lbf.ft)
Drive flange nut	148 Nm	(109 lbf.ft)
Output shaft housing	45 Nm	(33 lbf.ft)
Oil temperature sensor	42 Nm	(31 lbf.ft)
Inhibitor switch to transfer box	26 Nm	(19 lbf.ft)
Intermediate shaft nut †	88 Nm	(65 lbf.ft)
Side cover bolts	25 Nm	(18 lbf.ft)
Bearing retaining nut	72 Nm	(53 lbf.ft)
Output flange nut	162 Nm	(119 lbf.ft)
Selector housing bolts	25 Nm	(18 lbf.ft)
Bearing housing/cover bolts	25 Nm	(18 lbf.ft)

Note: † New Patchlok nut must be fitted.

Automatic gearbox - ZF4HP22/24

TORQUE DESCRIPTION	METRIC	IMPERIAL
Selector lever to selector shaft nut	26 Nm	(19 lbf.ft)
Starter inhibitor switch bolts	10 Nm	(7 lbf.ft)
Engine to torque converter bolts - Td5 & V8	50 Nm	(37 lbf.ft)
Closing plate to gearbox housing bolt - V8	7 Nm	(5.2 lbf.ft)
Fluid pump to intermediate plate bolts	10 Nm	(7 lbf.ft)
Intermediate plate Allen plugs (M14)	40 Nm	(30 lbf.ft)
Intermediate plate Allen plugs (M20)	50 Nm	(37 lbf.ft)
Oil cooler adaptors	42 Nm	(31 lbf.ft)
Extension housing bolts	25 Nm	(18 lbf.ft)
Oil sump to gearbox housing bolts	8 Nm	(6 lbf.ft)
Oil filter Torx screws	8 Nm	(6 lbf.ft)
Oil pick-up tube Torx screw	8 Nm	(6 lbf.ft)
Parking pawl guide Torx screw	10 Nm	(7 lbf.ft)
Pressure regulator to valve body assembly	8 Nm	(6 lbf.ft)
Lock-up solenoid valve, retaining fork Torx screw	8 Nm	(6 lbf.ft)
Lock-up solenoid valve assembly to valve body Torx screws	8 Nm	(6 lbf.ft)
Gearbox bell housing (intermediate plate and converter housing to gearbox casing) bolts	46 Nm	(34 lbf.ft)
Speed sensor bracket screws	8 Nm	(6 lbf.ft)

Propeller shafts

TORQUE DESCRIPTION	METRIC	IMPERIAL
Propeller shaft to transfer gearbox	47 Nm	(35 lbf.ft)
Propeller shaft to differential	47 Nm	(35 lbf.ft)
Propeller shaft to flexible coupling	76 Nm	(56 lbf.ft)
Flexible coupling to differential	76 Nm	(56 lbf.ft)

Axles

TORQUE DESCRIPTION	METRIC	IMPERIAL
Differential to axle bolts	55 Nm	(40 lbf.ft)
Hub to axle bolts	100 Nm	(74 lbf.ft)
Pinion flange bolt	100 Nm	(74 lbf.ft)
Drive shaft nut	490 Nm	(360 lbf.ft)

Steering

TORQUE DESCRIPTION	METRIC	IMPERIAL
Drag link to drop arm	80 Nm	(59 lbf.ft)
Track rod to steering knuckle	125 Nm	(92 lbf.ft)
Tension collet to steering knuckle	5 Nm	(3.7 lbf.ft)
Steering damper	125 Nm	(92 lbf.ft)
Steering knuckle to axle yoke upper ball joint	110 Nm	(81 lbf.ft)
High pressure pipe union	20 Nm	(15 lbf.ft)
Drag link/track rod M8 bolts	22 Nm	(16 lbf.ft)
Drag link/track rod M10 bolts	33 Nm	(24 lbf.ft)
Steering box	90 Nm	(66 lbf.ft)
Universal joint to intermediate shaft	25 Nm	(18 lbf.ft)
Panhard rod	230 Nm	(170 lbf.ft)
Steering box output shaft	88 Nm	(65 lbf.ft)
Drop arm	240 Nm	(177 lbf.ft)
Auxiliary housing bolts	40 Nm	(30 lbf.ft)
Auxiliary housing nut	10 Nm	(7 lbf.ft)
PAS pump - V8	22 Nm	(16 lbf.ft)
PAS pump pipe bracket bolt	22 Nm	(16 lbf.ft)
Jockey pulley bolt	50 Nm	(37 lbf.ft)
PAS pump adaptor pipe	10 Nm	(7 lbf.ft)
PAS pump to coolant pump bolts - Td5	25 Nm	(18 lbf.ft)
Steering column to fascia	25 Nm	(18 lbf.ft)
Universal joint to steering box	25 Nm	(18 lbf.ft)
Ball joint to swivel hub	77 Nm	(57 lbf.ft)
PAS pump pulley	22 Nm	(16 lbf.ft)
Steering wheel nut	43 Nm	(32 lbf.ft)

Front suspension

TORQUE DESCRIPTION	METRIC	IMPERIAL
Wheel nuts	140 Nm	(103 lbf.ft)
Panhard rod	230 Nm	(170 lbf.ft)
Lower ball joint nut	135 Nm	(100 lbf.ft)
Track rod and drag link	80 Nm	(59 lbf.ft)
Damper to front axle	55 Nm	(40 lbf.ft)
Anti-roll bar link - upper	100 Nm	(74 lbf.ft)
Anti-roll bar link - lower	100 Nm	(74 lbf.ft)
Turret to chassis	23 Nm	(17 lbf.ft)
Radius arm	230 Nm	(170 lbf.ft)
ACE pump pulley	25 Nm	(18 lbf.ft)
ACE pump banjo bolt	28 Nm	(21 lbf.ft)
Valve block to chassis	18 Nm	(13 lbf.ft)
Valve block clamping plate	21 Nm	(15 lbf.ft)
ACE valve block pipe clip	6 Nm	(4.4 lbf.ft)
ACE valve block filter cap	35 Nm	(26 lbf.ft)
Pressure transducer	20 Nm	(15 lbf.ft)
Fluid pipes to actuator cap	29 Nm	(21 lbf.ft)
Banjo to pump bolt	28 Nm	(21 lbf.ft)
Actuator to long arm	48 Nm	(35 lbf.ft)
Actuator to short arm	180 Nm	(133 lbf.ft)
Torsion bar clamp plate bolts	45 Nm	(33 lbf.ft)
Long arm to torsion bar bolt	185 Nm	(136 lbf.ft)

Rear suspension

TORQUE DESCRIPTION	METRIC	IMPERIAL
Wheel nuts	140 Nm	(103 lbf.ft)
Wheel hub to axle	100 Nm	(74 lbf.ft)
Damper to axle	125 Nm	(92 lbf.ft)
SLS height sensor link to radius arm	25 Nm	(18 lbf.ft)
Radius arm	230 Nm	(170 lbf.ft)
Transverse links to pivot housing	155 Nm	(114 lbf.ft)
Pivot housing to axle bolts	230 Nm	(170 lbf.ft)
Transverse link to chassis	140 Nm	(103 lbf.ft)
SLS height sensor	6 Nm	(4.4 lbf.ft)
SLS compressor	25 Nm	(18 lbf.ft)
ACE actuator to short arm	185 Nm	(136 lbf.ft)
ACE actuator to long arm	48 Nm	(35 lbf.ft)
ACE actuator pipe cap nuts	29 Nm	(21 lbf.ft)
Anti-roll bar link - upper	50 Nm	(37 lbf.ft)
Anti-roll bar link - lower	100 Nm	(74 lbf.ft)
ACE long arm to torsion bar	180 Nm	(133 lbf.ft)

Brakes

TORQUE DESCRIPTION	METRIC	IMPERIAL
Brake caliper bleed screw	10 Nm	(7 lbf.ft)
Brake disc to drive flange	13 Nm	(10 lbf.ft)
Caliper bolts - Front	175 Nm	(129 lbf.ft)
Caliper bolts - Rear	95 Nm	(70 lbf.ft)
Master cylinder to servo	25 Nm	(18 lbf.ft)
Master cylinder brake pipe, unions	25 Nm	(18 lbf.ft)
Brake caliper pivot bolt	30 Nm	(22 lbf.ft)
Vacuum pump	8 Nm	(6 lbf.ft)
Vacuum pump lubrication pipe union	10 Nm	(7 lbf.ft)
Brake caliper guide pin bolts	30 Nm	(22 lbf.ft)
Brake caliper banjo bolt	32 Nm	(24 lbf.ft)
ABS modulator to mounting bracket nuts	9 Nm	(7 lbf.ft)
ABS modulator - 13 mm unions	22 Nm	(16 lbf.ft)
ABS modulator - 11 mm union	14 Nm	(10 lbf.ft)
Handbrake lever to floor bolts	22 Nm	(16 lbf.ft)

Restraint systems

TORQUE DESCRIPTION	METRIC	IMPERIAL
Front seat belt upper anchorage	32 Nm	(24 lbf.ft)
Front seat belt reel	50 Nm	(37 lbf.ft)
Front seat belt lower anchorage to seat	32 Nm	(24 lbf.ft)
Second row upper anchorage	50 Nm	(37 lbf.ft)
Second row seat belt reel	32 Nm	(24 lbf.ft)
Second row lower anchorage	32 Nm	(24 lbf.ft)
Third row upper anchorage	50 Nm	(37 lbf.ft)
Third row seat belt reel	50 Nm	(37 lbf.ft)
Third row lower anchorage	32 Nm	(24 lbf.ft)
'B' post adjustable seat belt mounting	22 Nm	(16 lbf.ft)
Seat belt pre-tensioners	32 Nm	(24 lbf.ft)
Driver's side air bag	9 Nm	(7 lbf.ft)
Passenger side air bag	8 Nm	(6 lbf.ft)
SRS DCU	10 Nm	(7 lbf.ft)

Body

TORQUE DESCRIPTION	METRIC	IMPERIAL
Front and rear door hinges	30 Nm	(22 lbf.ft)
Tail door hinge bolts	34 Nm	(25 lbf.ft)
Door frames	10 Nm	(7 lbf.ft)
Regulator to glass	6 Nm	(4.4 lbf.ft)
Chassis cross member	25 Nm	(18 lbf.ft)
Bulkhead to chassis bolts	45 Nm	(33 lbf.ft)
Body to chassis bolts	45 Nm	(33 lbf.ft)
Quarter light glass to frame	10 Nm	(7 lbf.ft)
Glass lift motor to regulator	5 Nm	(3.7 lbf.ft)
Tail door hand rail	10 Nm	(7 lbf.ft)
Latch and motor assembly	7 Nm	(5.2 lbf.ft)
Door handle	7 Nm	(5.2 lbf.ft)
Damper to step	17 Nm	(13 lbf.ft)
Throttle pedal assembly	13 Nm	(10 lbf.ft)
Step assembly to chassis	45 Nm	(33 lbf.ft)
Wing to sill finisher bracket	17 Nm	(13 lbf.ft)
Front wing to body	17 Nm	(13 lbf.ft)
Door mirror	4 Nm	(3 lbf.ft)
Roof bars	32 Nm	(24 lbf.ft)
Bonnet release lever	10 Nm	(7 lbf.ft)
Front bumper to crash cans	13 Nm	(10 lbf.ft)
Front bumper to side mountings	13 Nm	(10 lbf.ft)
Mudshield	10 Nm	(7 lbf.ft)
Rear bumper	45 Nm	(33 lbf.ft)
Grab handle to body	3 Nm	(2.2 lbf.ft)
Fascia	26 Nm	(19 lbf.ft)
Fascia to steering column bracket	11 Nm	(8 lbf.ft)
Front seat to floor	45 Nm	(33 lbf.ft)
Second row seats to floor	45 Nm	(33 lbf.ft)
Third row seats to lower rear quarter	22 Nm	(16 lbf.ft)
Sunroof tray to frame	2 Nm	(1.5 lbf.ft)
Solenoid securing cap	11 Nm	(8 lbf.ft)
Support stay to alternator	25 Nm	(18 lbf.ft)
Sunroof glass	3 Nm	(2.2 lbf.ft)
Motor to sunroof tray	2 Nm	(1.5 lbf.ft)
Drive cable assembly to frame	2.5 Nm	(1.8 lbf.ft)
Front and rear door striker bolts	26 Nm	(19 lbf.ft)
Tail door striker bolts	26 Nm	(19 lbf.ft)

Heating and air conditioning

TORQUE DESCRIPTION	METRIC	IMPERIAL
Heater assembly	16 Nm	(12 lbf.ft)
Compressor bolts	22 Nm	(16 lbf.ft)
Blower motor	19 Nm	(14 lbf.ft)
Compressor to mounting bracket bolts	25 Nm	(18 lbf.ft)
A/C pipes to compressor bolts	10 Nm	(7 lbf.ft)
Condenser pipe bolt	5 Nm	(3.7 lbf.ft)
Receiver drier to bracket bolts	5 Nm	(3.7 lbf.ft)
Adaptor block to receiver drier bolt	5 Nm	(3.7 lbf.ft)
Evaporator pipe bolts	5 Nm	(3.7 lbf.ft)
Dual pressure switch to receiver drier	10 Nm	(7 lbf.ft)
Air conditioning pipes to receiver drier bolts	5 Nm	(3.7 lbf.ft)
TX valve pressure pipe union	22 Nm	(16 lbf.ft)
Evaporator pipe to TXV valve	32 Nm	(24 lbf.ft)
Evaporator assembly to body bolts	16 Nm	(12 lbf.ft)
High and low pressure pipe, bolts	10 Nm	(7 lbf.ft)
Fuel burning heater Torx bolts	25 Nm	(18 lbf.ft)

Wipers and washers

TORQUE DESCRIPTION	METRIC	IMPERIAL
Link to motor spindle	7 Nm	(5.2 lbf.ft)
Front motor assembly	2.5 Nm	(1.8 lbf.ft)
Spindle nut	3 Nm	(2.2 lbf.ft)
Wiper arm nut	13 Nm	(10 lbf.ft)

Electrical

TORQUE DESCRIPTION	METRIC	IMPERIAL
Alternator support stay	25 Nm	(18 lbf.ft)
Alternator lead - Td5	6 Nm	(4.4 lbf.ft)
Auxiliary drive belt tensioner bolt	50 Nm	(37 lbf.ft)
Alternator pulley	80 Nm	(59 lbf.ft)
Alternator B+ nut - V8	18 Nm	(13 lbf.ft)
Alternator B+ nut - V8	5 Nm	(3.7 lbf.ft)
Starter motor - Td5	27 Nm	(20 lbf.ft)
Starter motor solenoid	10 Nm	(7 lbf.ft)
Starter motor - V8	44 Nm	(32 lbf.ft)
Alternator	45 Nm	(33 lbf.ft)
Starter motor heat shield - V8	10 Nm	(7 lbf.ft)
Horn	13 Nm	(10 lbf.ft)
Battery carrier bolts	28 Nm	(21 lbf.ft)

LIFTING

The following instructions must be carried out before raising the vehicle off the ground.

- Use a solid level ground surface.
- Apply hand brake.
- Select 'P' (Automatic gearbox) or 1st gear (Manual gearbox) in main gearbox.
- Select Low range in transfer gearbox.

To avoid damage occurring to the under body components of the vehicle the following jacking procedures must be adhered to.

DO NOT POSITION JACKS OR AXLE STANDS UNDER THE FOLLOWING COMPONENTS:

- Body structure
- Bumpers
- Fuel lines
- Brake lines
- Front radius arms
- Panhard rod
- Steering linkage
- Rear trailing arms
- Fuel tank
- Engine sump
- Gearbox bell housing

Vehicle jack

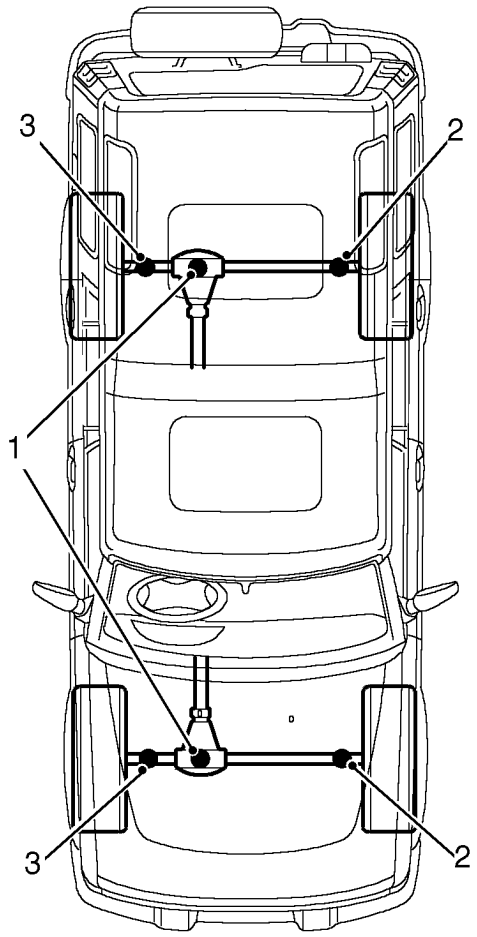
The jack provided with the vehicle is only intended for use in an emergency, for changing a tyre. DO NOT use the jack for any other purpose. Refer to Owner's Handbook for vehicle jack location points and procedure. Never work under a vehicle supported solely by the vehicle jack.

Hydraulic jack

A hydraulic jack with a minimum 1500 kg, 3,300 lbs load capacity must be used. **Do not commence work on the underside of the vehicle until suitable axle stands have been positioned under the axle**.

WARNING: Always chock the wheels when jacking. The hand brake acts on the transmission, not the rear wheels, and may be ineffective when the wheels are off the ground.

Raising and supporting the vehicle



M10 0567

Position cup of hydraulic arm under differential casing (1).**The differential casing is not central to the axle. Care should be taken when raising the front road wheels off the ground as the rear axle has less sway stiffness.**

Raise vehicle to enable an axle stand to be installed under left hand axle tube (2).

Position an axle stand under right hand axle tube (4). Carefully lower jack until vehicle sits securely on both axle stands, remove jack.

Alternatively, the axle stands can be positioned under the chassis longitudinals at the front and/or rear of the vehicle.

Before commencing work on underside of vehicle re-check security of vehicle on stands.

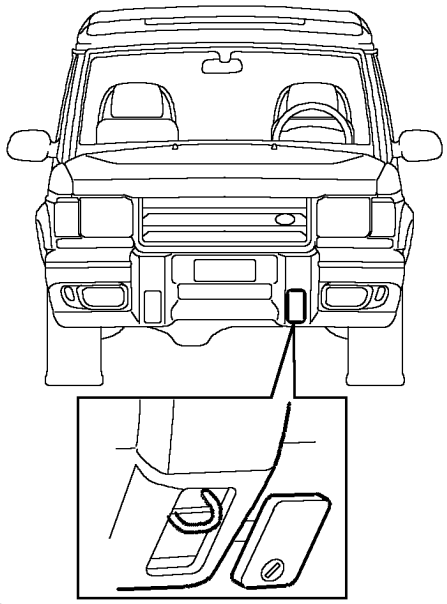
WARNING: Always chock the wheels when jacking. The hand brake acts on the the transmission, not the rear wheels, and may be ineffective when the wheels are off the ground.

Reverse procedure when removing vehicle from stands.

Hydraulic ramps
Use only a 'drive on' type ramp which supports a vehicle by it's own road wheels. If a 'wheel free' condition is required, use a 'drive on' ramp incorporating a 'wheel free' system that supports under axle casings. Alternatively, place vehicle on a firm, flat floor and support on axle stands.

TOWING

Towing
The vehicle has permanent four wheel drive. The following towing instructions must be adhered to:



M10 0585

Towing on 4 wheels with driver
Turn ignition key to position '1' to release steering lock.

Select neutral in main gearbox and transfer gearbox.

Secure tow rope, chain or cable to towing eye.

Release the handbrake.

The brake servo and power assisted steering system will not be functional without the engine running. Greater pedal pressure will be required to apply the brakes, the steering system will require greater effort to turn the front road wheels. The vehicle tow connection should be used only in normal road conditions, 'snatch' recovery should be avoided.

Suspended tow
To prevent vehicle damage, front or rear propeller shaft MUST BE removed, dependent upon which axle is being trailed.

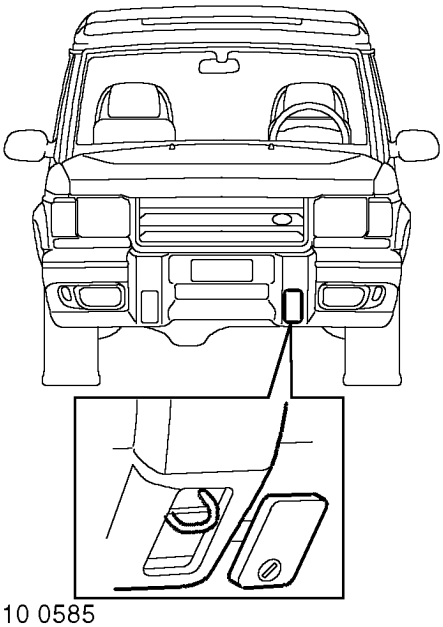
Mark propeller shaft drive flanges at transfer box and axles with identification lines to enable the propeller shaft to be refitted in its original position.

Remove the propeller shaft fixings, remove the shaft from the vehicle.

If the front axle is to be trailed turn ignition key to position '1' to release steering lock.

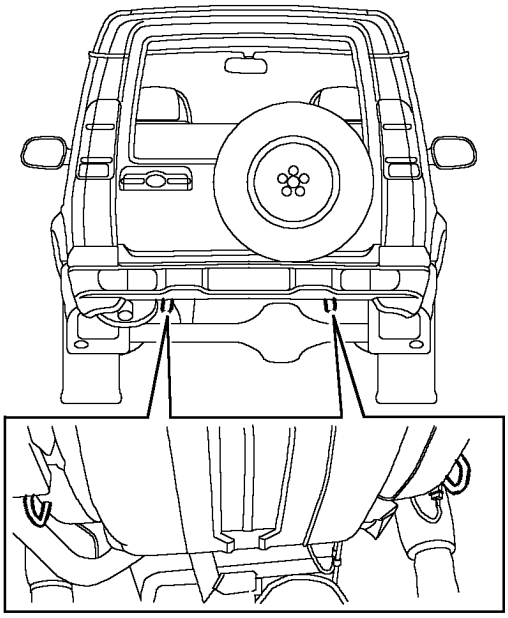
The steering wheel and/or linkage must be secured in a straight ahead position. DO NOT use the steering lock mechanism for this purpose.

Towing eyes
The towing eyes at the front and rear of the vehicle are designed for vehicle recovery purposes only and must NOT be used to tow a trailer or caravan.



M10 0585

Front:A single towing eye, set behind a removable panel in the front spoiler. DO NOT use the front lashing rings for towing.

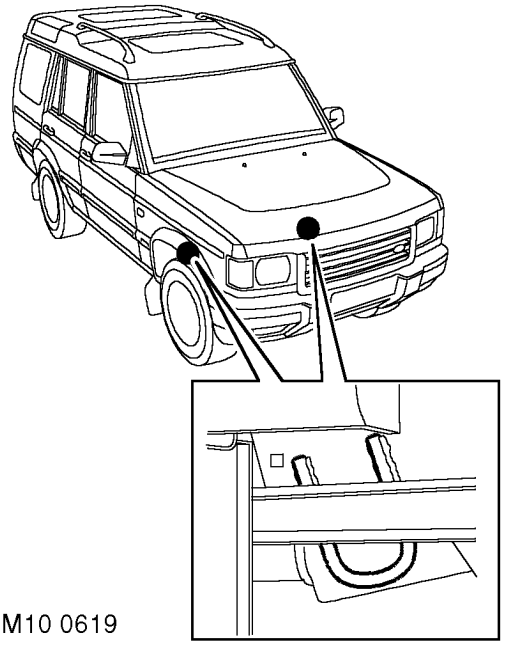


M10 0586

Rear: A pair of towing eyes at the rear of the vehicle can be used as lashing rings and for towing another light vehicle.

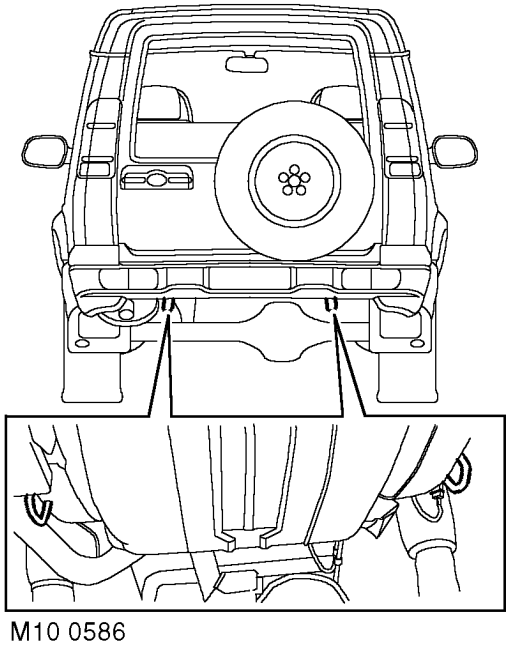
TRANSPORTING

Transporting by trailer



M10 0619

Front lashing eyes



M10 0586

Rear lashing eyes

Lashing eyes are provided on the chassis longitudinals, at the front (behind the front wheels) and at the rear (behind the rear wheels).

DO NOT secure lashing hooks or trailer fixings to any other part of the vehicle.

Position the vehicle on the trailer and apply the handbrake. Select neutral in the manual gearbox ('N' on automatic gearbox). Selecting 'N' will prevent damage to the parking pawl in the automatic gearbox.

Capacities

The following capacities are only an approximation of the amount of fluid required to fill the respective system.

Capacities - UK \ EURO \ ROW

Component	Metric Units
Fuel tank	95 litres
Engine - Td5:	
⇒ Engine oil and filter change	7.2 litres
⇒ Fill from dry	8.2 litres
Engine - V8 with oil cooler:	
⇒Engine oil and filter change	6.27 litres
⇒Engine oil refill from dry:	7 litres
Engine - V8 without oil cooler:	
⇒Engine oil and filter change	5.8 litres
⇒ Engine oil refill from dry	6.5 litres
Manual gearbox without oil cooler:	
⇒ Refill	2.3 litres
⇒ Fill from dry	2.6 litres
Manual gearbox with oil cooler:	
⇒ Refill	2.8 litres
⇒ Fill from dry	3.1 litres
Automatic gearbox fill from dry	9.7 litres
Transfer box:	
⇒ Refill	2.0 litres
⇒ Fill from dry	2.3 litres
Front and rear axle:	
⇒ Refill	1.6 litres
⇒ Fill from dry	1.7 litres
Cooling system - Td5 Engine:	
⇒ Refill	8 litres
⇒ Fill from dry	13 litres
Cooling system - V8 Engine:	
⇒ Refill	12 litres
⇒ Fill from dry	13 litres

Capacities - NAS

Component	US Units
Fuel tank	25.5 gal
Engine - V8 with oil cooler:	
⇒ Engine oil and filter change	6.6 qt
⇒ Engine oil refill from dry	7.4 qt
Engine - V8 without oil cooler:	
⇒ Engine oil and filter change	6.1 qt
⇒ Engine oil refill from dry	6.9 qt
Automatic gearbox fill from dry	19.7 pt
Transfer box:	
⇒ Refill	4.1 pt
⇒ Fill from dry	4.8 pt
Front and rear axle:	

Component	US Units
⇒ Refill	3.4 pt
⇒ Fill from dry	3.6 pt
Cooling system - V8 Engine:	
⇒ Refill	24.2 pt
⇒ Fill from dry	26.2 pt

Refrigerant - A/C system

⇒Front A/C	700 ± 25 g
⇒Front/rear A/C	900 ± 25 g

Fluids

Anti-freeze
Use Havoline Extended Life Coolant (XLC), or any ethylene glycol based anti-freeze (containing no methanol) with only Organic Acid Technology corrosion inhibitors, to protect the cooling system

CAUTION: No other anti-freeze should be used with Havoline Extended Life Coolant.

The cooling system should be drained, flushed and refilled with the correct amount of anti-freeze solution at the intervals given on the Service Maintenance Check Sheet.

After filling with anti-freeze solution, attach a warning label to a prominent position on the vehicle stating the type of anti-freeze contained in the cooling system to ensure that the correct type is used for topping-up.

Brake/Clutch fluid
Use only DOT 4 brake fluid.

PAS/ACE fluid
Use Texaco cold climate power assisted steering fluid 14315.

Air conditioning
Use only refrigerant R134a.

Refrigerant oil
Use only NipponDenso ND-oil 8 or Unipart ND-oil 8.

Refrigerant oil absorbs water and must not be stored for long periods. Do not pour unused oil back into the container.

NOTE: The total quantity of refrigerant oil in the system is 180 ml.

CAUTION: Do not use any other type of refrigerant oil.

Anti-Freeze Concentration

The overall anti-freeze concentration should not fall, by volume, below 50% to ensure that the anti-corrosion properties of the coolant are maintained. Anti-freeze concentrations greater than 60% are not recommended as cooling efficiency will be impaired.

The following recommended quantities of anti-freeze will provide frost protection to -48°C (-53°F):

Engine - TD5

Concentration	50%
Amount of Anti-freeze	4 litres

Engine - V8

Concentration	50%
Amount of Anti-freeze	6.5 litres 13.5 pts (US)

Lubrication

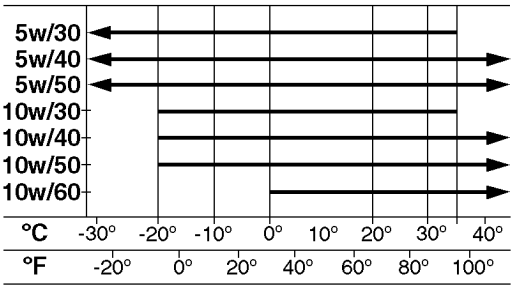
General
The engine and other lubricating systems are filled with high-performance lubricants giving prolonged life.

CAUTION: Always use a high quality oil of the correct viscosity range in the engine. The use of oil of the incorrect specification can lead to high oil and fuel consumption and ultimately to damaged components.

Oil to the correct specification contains additives which disperse the corrosive acids formed by combustion and prevent the formation of sludge which can block the oil ways. Additional oil additives should not be used.

Always adhere to the recommended servicing intervals.

Engine oil viscosity



M01 0110A

The above chart indicates the ambient temperature ranges which each engine oil viscosity is suitable for.

Engine oil - V8 - low compression engine
Use a 10W/40 oil meeting specification ACEA: A2, and having a viscosity band recommended for the temperature range of your locality.

Engine oil - V8 - high compression engine
Use a 5W/30 oil meeting specification ACEA: A1, (API SJ or ILSAC GF2 for USA).

NOTE: ACEA: A2 can be used.

Engine oil - Td5
Use oil meeting specification ACEA: A1, B1 or B2.

Gearbox oil
Use of gearbox oils other than those specified may result in serious damage to the gearbox,

Manual Gearbox
Use Texaco MTF 94 oil for refill and topping-up. If MTF 94 is not available, ATF Dexron IID or ATF Dexron III may be used.

Automatic Gearbox
Use ATF Dexron IID or Dexron III oil for refill or topping-up.

Transfer box
Use Texaco Multi-Gear 75W/90R.

Front and rear axles
Use Texaco Multi-Gear 75W/90R.

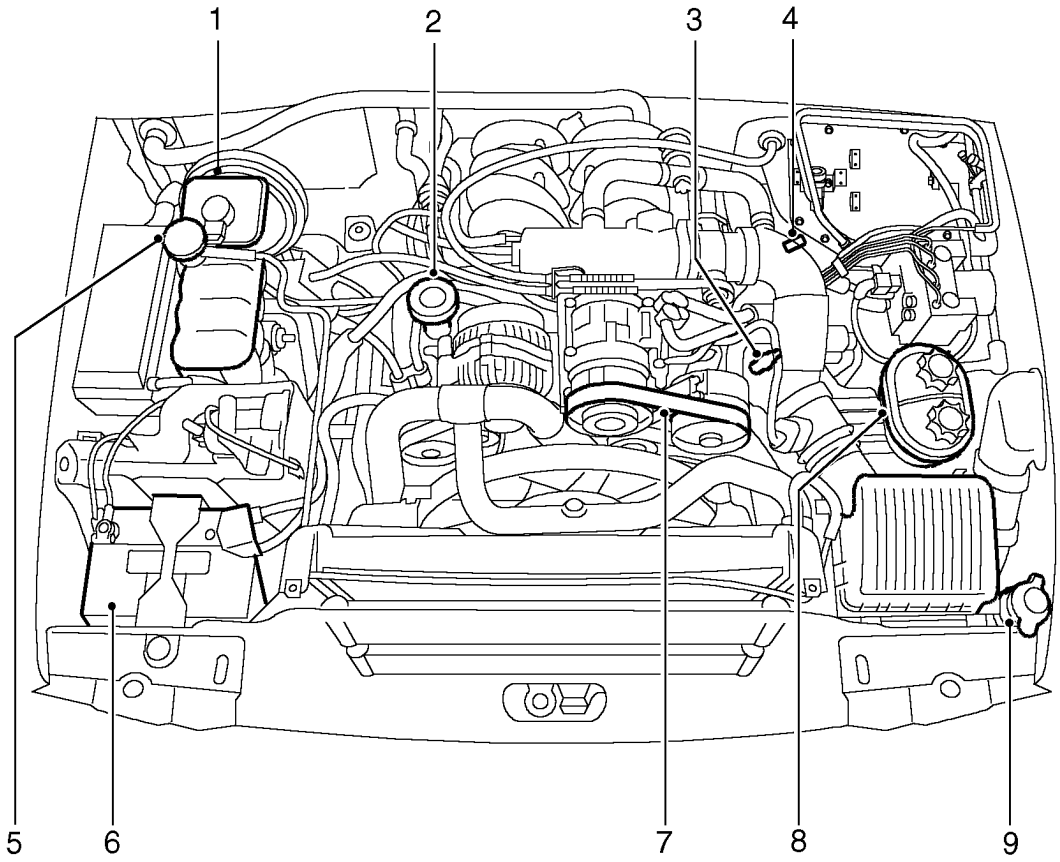
Air Conditioning
Use lubricating oil Nippon Denso ND-8.

General Greasing
Use Multipurpose Lithium Base Grease N.L.G.I. consistency No. 2.

Bonnet latch
Lubricate cable and latch with oil.

Locks, Latches and Hinges
Use Door Lock and Latch Lubricant, Part No. VWN 10075.

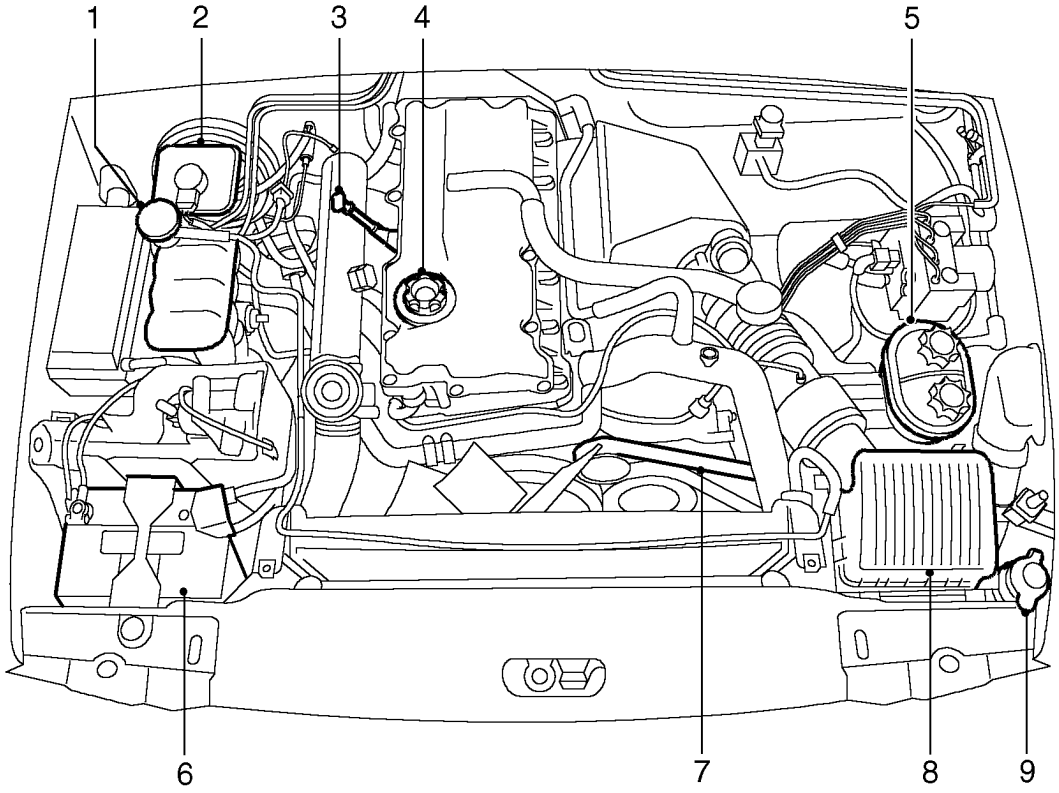
V8 engine underbonnet view



M10 0617A

1 Brake/clutch fluid reservoir filler caps
2 Engine oil filler cap
3 Spark plug
4 Engine oil dipstick
5 Coolant header tank
6 Battery
7 Auxiliary drive belt
8 ACE/PAS fluid reservoirs
9 Windscreen washer reservoir

Diesel underbonnet view

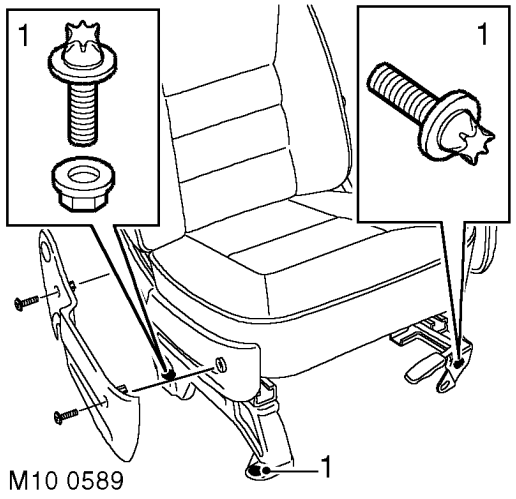


M10 0618

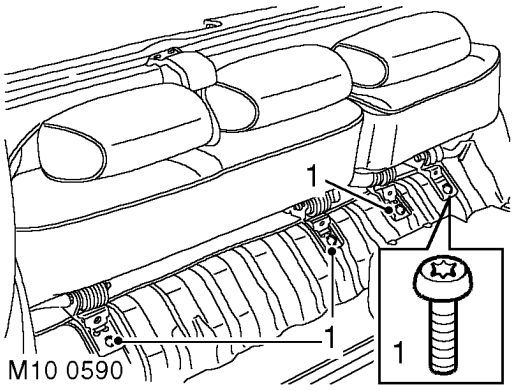
1 Coolant header tank
2 Brake/clutch fluid reservoir filler caps
3 Engine oil dipstick
4 Engine oil filler cap
5 ACE/PAS fluid reservoirs
6 Battery
7 Auxiliary drive belt
8 Air cleaner
9 Windscreen washer reservoir

Seats and seat belts

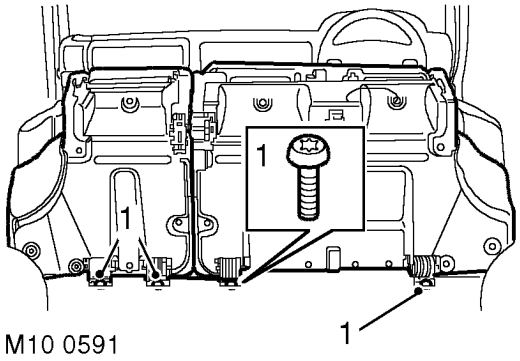
Check



Front seat

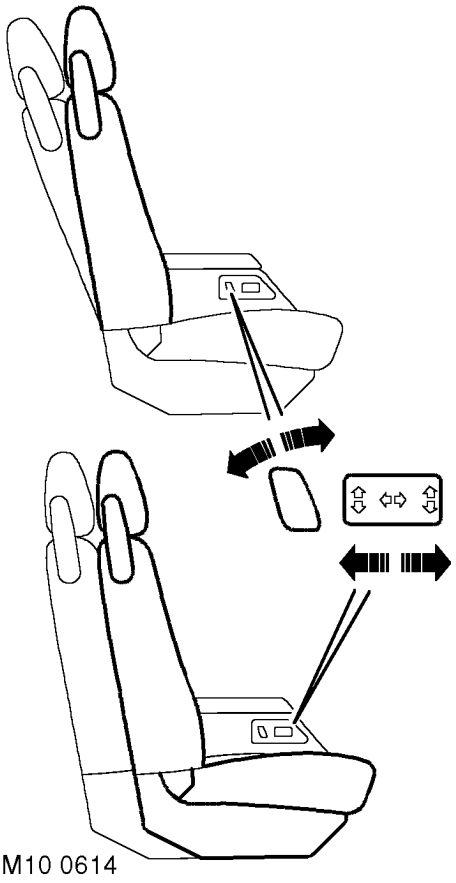


Rear seat rear fixings



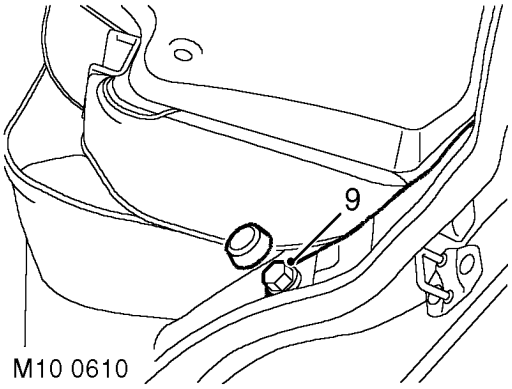
Rear seat front fixings

1. Check seat frames are secured to floor and show no signs of movement.

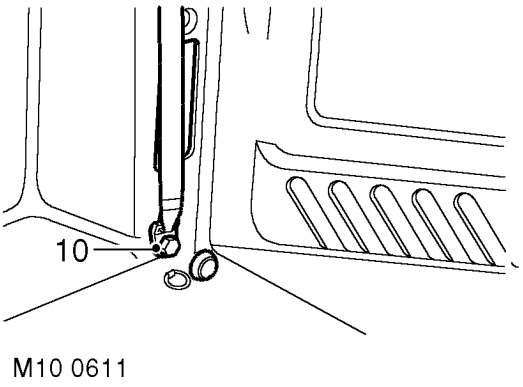


2. Check operation of seat slide and tilt mechanisms, ensuring there is no excessive play between seat cushion and seat back.
3. Fully extract seat belt and allow it to return under its own recoil mechanism. Repeat for other belts.
4. Check entire length of seat belt webbing for signs of fraying or damage. Repeat for other belts.

5. Check security of seat belt upper mountings.
6. Check for correct operation of seat belt height adjusters.
7. Check security of seat belt buckle mountings.
8. Connect each belt to the correct buckle, check seat buckle and tongue are secure. Release seat belt buckle and check for correct operation.



9. Check tightness of accessible seat belt fixings.



10. Check tightness of accessible seat belt mountings.

Lamps, horns and warning indicators

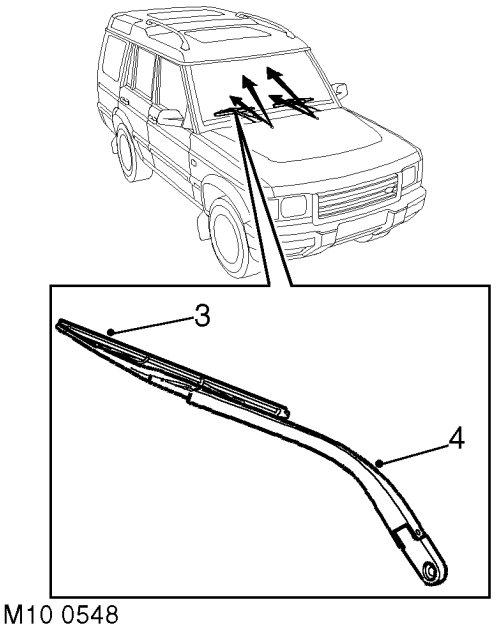
Check

1. Switch on side, head and tail lamps and check operation.
2. Check headlamp levelling operation.
3. Check turn signals and hazard warning lamps for correct operation.
4. Press brake pedal and check operation of brake lamps.
5. Check all exterior lamp lenses for clarity and condition. Pay particular attention to headlamp lenses for signs of stone chips or damage.
6. Check horn for loud, clear sound.
7. Switch on headlamps (with ignition switch at 'O' position) and check light reminder warning operates when door is opened.
8. Check operation of interior courtesy lights.
9. Check operation of all instrument pack warning and indicator lights.

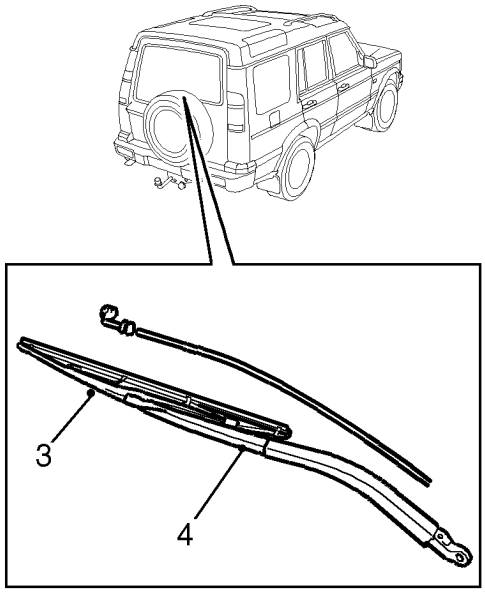
Wipers and washers

Check

1. Operate screen washer and switch on wipers. Ensure washer jets are correctly aimed and check for smooth, smear free operation of wiper blades across screen at all speeds including intermittent.
2. Repeat operation for rear screen washers/ wipers.



M10 0548



M10 0588

3. Check all wiper blades for condition and signs of splits or damage.
4. Check security of wiper arms.

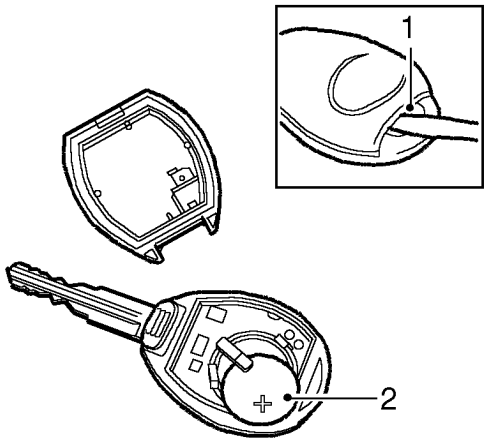
Handbrake

Check

1. With the vehicle stationary, on a level surface, apply and release handbrake and check for correct operation.
   ☞ **BRAKES, ADJUSTMENTS, Handbrake.**

Alarm handset battery

Replace



M10 0565A

1. Insert the blade of a small, flat bladed screwdriver into the slot at the rear of the handset and prise the back from the handset.
2. Slide the battery out of the clip taking care not to touch the circuit board or the battery contacts.
3. Press and hold one of the buttons for at least 5 seconds.
4. Fit the replacement battery ensuring that correct polarity is maintained (+) side facing upwards. Avoid touching the flat surfaces of the battery.
5. Press the 2 halves of the handset together.
6. Check that handset operates correctly.

Road wheels

Remove

1. Mark the wheel to stud relationship to ensure that the wheels are refitted in the same position.
2. Loosen wheel nuts. Raise the vehicle to a wheel-free condition and remove the wheel nuts.

Tyres

Check

1. Check tyres for compliance with manufacturer's specification; visually for cuts, lumps, bulges, uneven tread wear and depth.
2. Check tyre pressures, condition and tread depth. Measure the tread depth across the width of the tyre and around the circumference.

Brake pads, discs and calipers

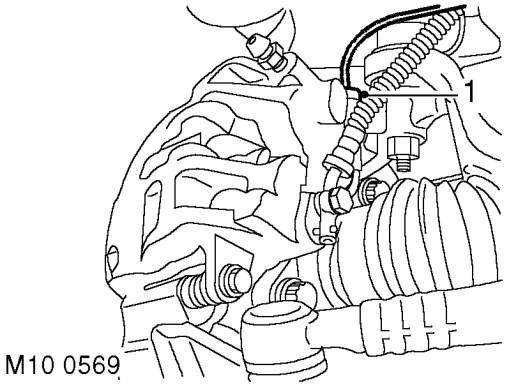
Check

1. Check front and rear brake pads for wear, ensure all pads are wearing evenly.
2. Check brake discs for signs of cracking, excessive scoring or oil contamination.
3. Check calipers for signs of fluid leaks.
4. Clean excessive deposits of brake dust from pads, calipers and disc shields using brake cleaner.

Road wheel speed sensors

Inspect

.



Front wheel

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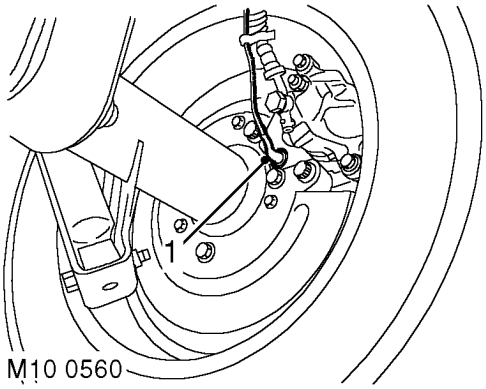


Rear wheel

1. Inspect each sensor harness for damage.

Brake fluid

Replace

1. Replace brake fluid.
   ☞ **BRAKES, ADJUSTMENTS, Brake system bleeding.**

Fuel filter - diesel engine

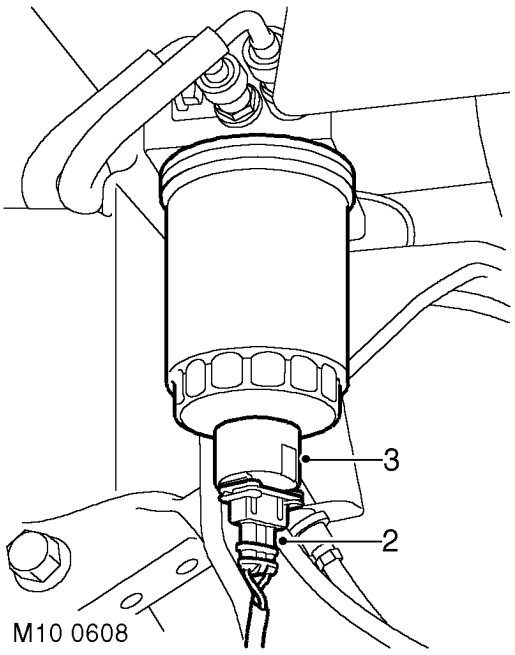
Replace

1. Replace filter element.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Element - fuel filter.**

Fuel filter sedimenter

Drain

1. Position suitable container beneath fuel filter.



2. Disconnect multiplug from sedimenter.
3. Rotate sedimenter anti-clockwise until water flows from drain tube.
4. Allow to drain until diesel fuel flows from drain tube.
5. Rotate sedimenter fully clockwise.
6. Connect multiplug.

Road wheels

Refit

1. Apply anti-seize compound to wheel hub centre.
2. Refit road wheels to original hub position. Tighten wheel nuts to 140 Nm (103 lbf.ft).

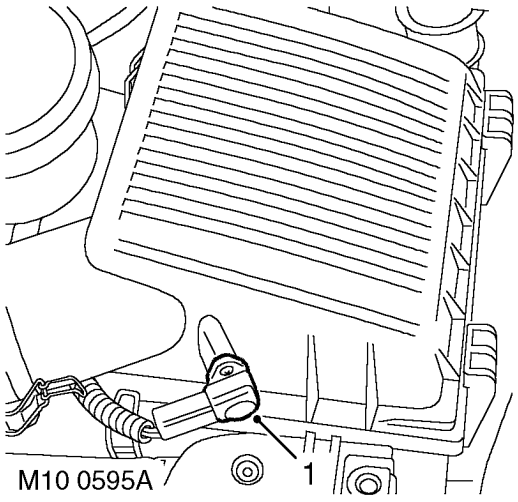
Radiator/Intercooler

Check

1. Visually check radiator/intercooler for external obstructions, remove debris.
2. Visually check fan blades for damage.

Ambient air Temperature and pressure sensor

Check



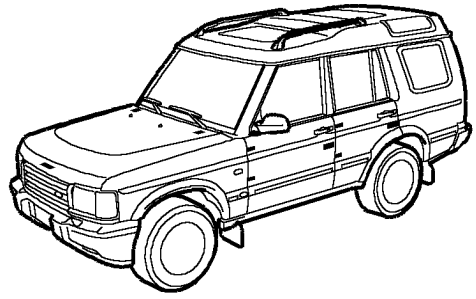
1. Check ambient air temperature and pressure sensor for damage.

Doors, bonnet and fuel filler flap

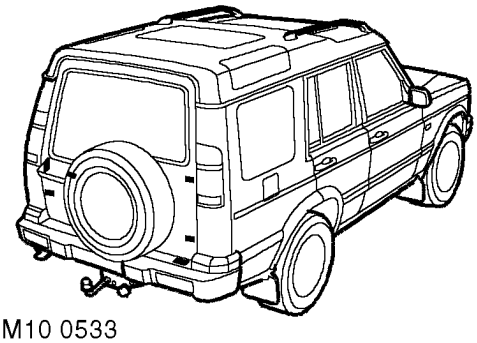
Check

1. Check operation of each door, door lock, bonnet catch and fuel filler flap. Ensure doors close securely.

Lubricate



M10 0534



M10 0533

1. Lubricate door locks, hinges, check straps, bonnet catch and fuel filler flap.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**

Air suspension intake filter

Check

1. Check condition of filter and that filter is clean, replace if necessary.
   ☞ **REAR SUSPENSION, REPAIRS, Filter - intake - SLS.**

Anti-freeze

Replace

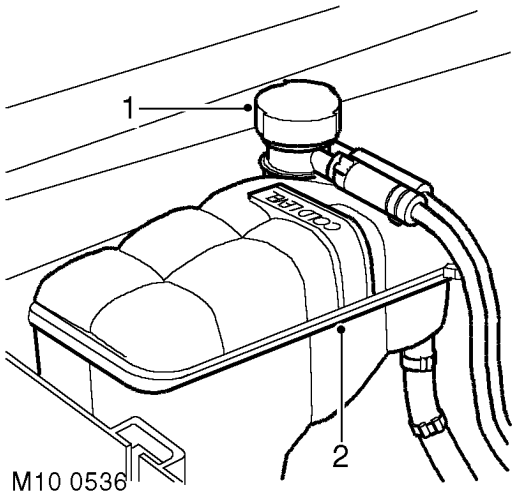
1. Replace anti-freeze.
   ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
   ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Cooling system

Check

1. Check cooling, intercooler and heating systems for leaks; hoses and oil pipes for security and condition.
2. Check accessible hose clips for tightness.
3. Check coolant level, top-up if necessary.

Top-up



M10 0536

1. With engine cold, remove expansion tank filler cap.
2. Top-up with recommended mixture of coolant until level reaches mark on expansion tank.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Anti-Freeze Concentration.**
3. Fit expansion tank filler cap.

Spark plugs - V8 engine

Replace

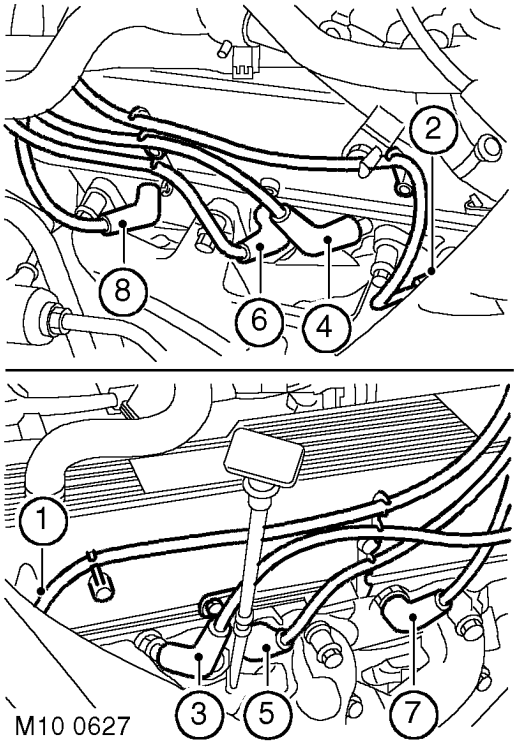
Take great care when fitting spark plugs not to cross-thread plug, otherwise costly damage to cylinder head will result. It is essential that correct grade of spark plugs are fitted. Incorrect grade of spark plugs may lead to piston overheating and engine failure. Use only approved spark plugs, use of unapproved spark plugs may cause the misfire detection system to malfunction.

1. Disconnect battery earth lead.
2. Noting their fitted position, disconnect ht leads from spark plugs.
3. Remove 8 spark plugs.
4. Ensure that gap of new spark plugs is 1.0 ± 0.05 mm (0.040 ± 0.002 in).

   Do not attempt to clean or adjust gaps. If a spark plug problem exists, try substituting defective spark plug(s) with new one(s).

   CAUTION: Do not attempt to clean or adjust spark plug gaps. If a spark plug problem exists, try substituting the defective spark plug with a new one.

5. Fit spark plugs and tighten to 20 Nm (15 lbf.ft).



6. Connect ht leads to spark plugs.
7. Connect battery earth lead.

Air cleaner - V8 engine

Replace

1. Replace air cleaner element.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Element - air filter.**

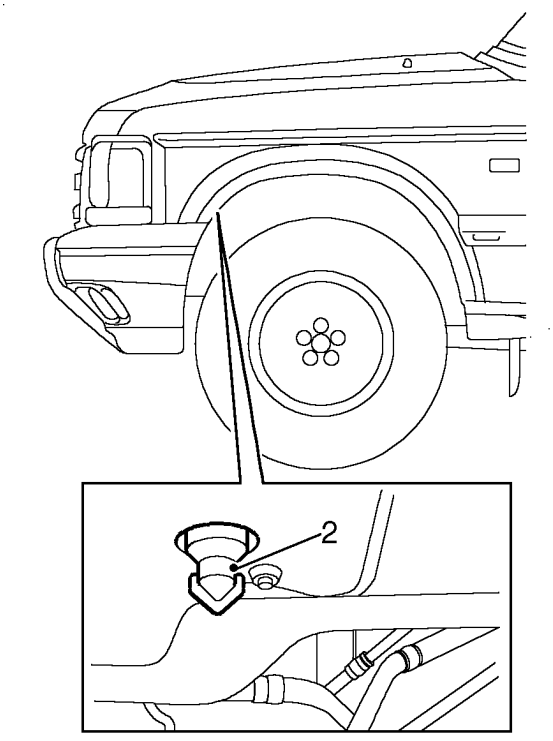
Clean

1. Clean the drain hole in filter casing.

Air cleaner and dump valve - diesel engine

Replace/clean

1. Replace air cleaner element.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Element - air filter.**

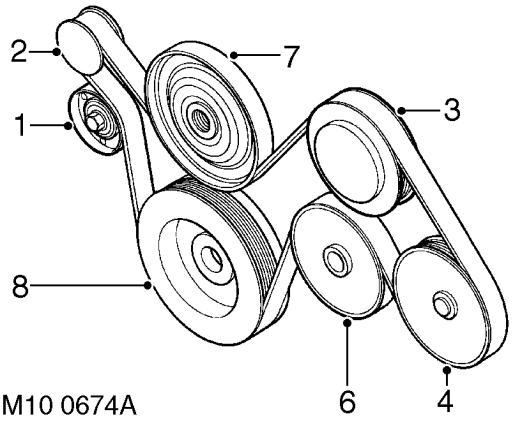


M26 0579

2. Remove all dirt from dump valve.

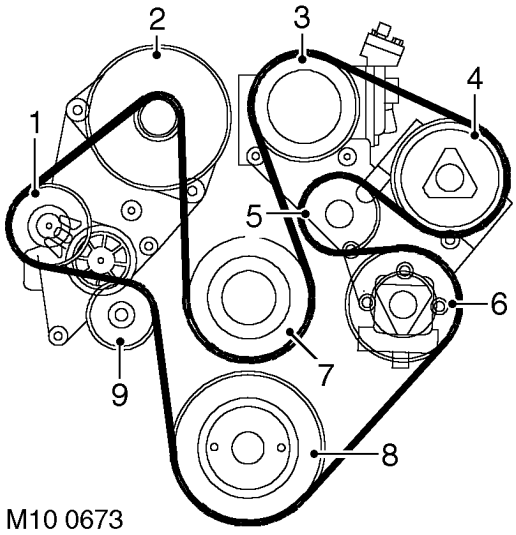
Auxiliary drive belt

Check



M10 0674A

TD5 auxiliary belt



M10 0673

V8 auxiliary belt

1 Tensioner pulley
2 Alternator
3 A/C compressor
4 ACE pump
5 Idler pulley - V8 only
6 PAS pump
7 Viscous fan pulley
8 Crankshaft pulley
9 Idler pulley - V8 only

1. Check auxiliary drive belt for signs of splits, fraying, oil contamination and wear.

Auxiliary drive belt - V8 engine

1. Replace auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

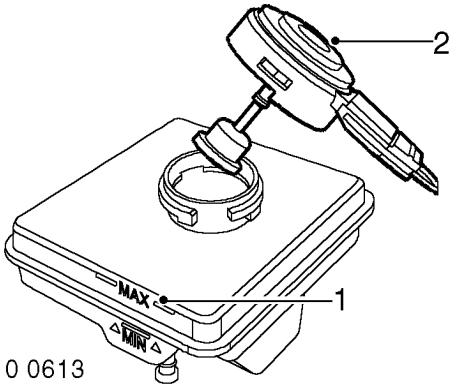
Auxiliary drive belt - diesel engine

Replace

1. Replace auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

Fluid reservoirs

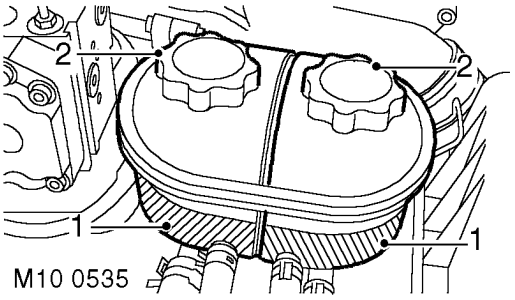
Check/top-up — Brake/Clutch reservoir



M10 0613

1. Check fluid level in brake/clutch fluid reservoirs.
2. Clean area around filler cap, remove cap.
3. Top-up if necessary to correct level on reservoir using recommended fluid.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**
4. Fit filler cap.

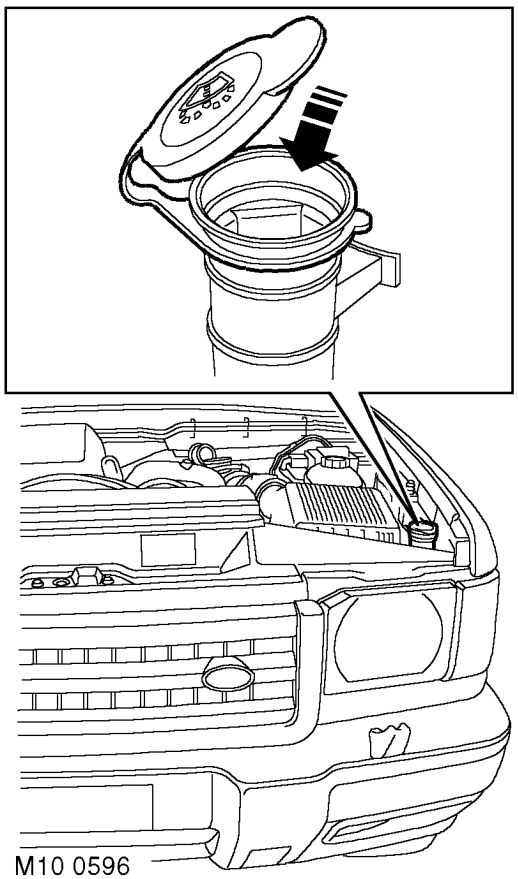
Check/top-up — PAS/ACE reservoirs



M10 0535

1. Check fluid level in PAS and ACE fluid reservoirs.
2. Clean area around filler cap, remove cap.
3. Top-up if necessary to correct level on reservoir using recommended fluid.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**
4. Fit filler cap.

Check/top-up — Washer reservoir



M10 0596

1. Check fluid level in windscreen washer reservoir.
2. Clean area around filler cap, remove cap.
3. Top-up if necessary to correct level on reservoir using recommended fluid.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**
4. Fit filler cap.

Steering box

Check

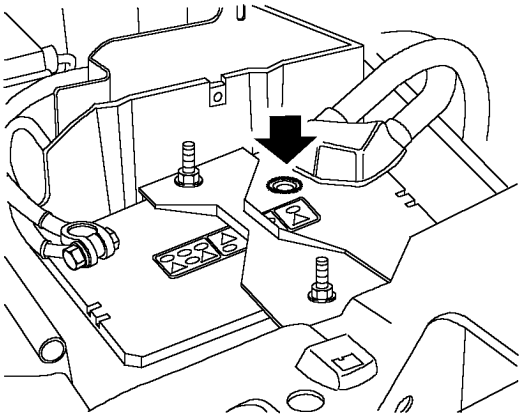
1. Check steering box for fluid leaks.

Adjust

1. Check that there is no backlash in steering box with road wheels in straight ahead position. Adjust if required.
   ☞ **STEERING, ADJUSTMENTS, Steering box - check and adjust.**

Battery

Check



M10 0547

1. Check battery condition by checking colour of condition indicator.
   - Green = O.K.
   - Black = Battery requires charging.
   - Clear/white = New battery required.

Clean

1. Clean and grease battery terminals with petroleum jelly.

Intercooler - diesel engine

Remove

1. Remove intercooler.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**

Flush

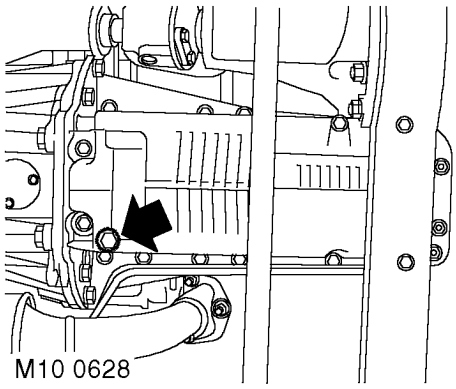
1. Flush intercooler element using Flushing Solvent Part No. STC 9713, following the manufacturer's instructions.
2. Thoroughly dry intercooler ensuring that no trace of solvent remains in the element.
3. Refit intercooler on completion.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**

Engine oil - V8 engine

WARNING: Avoid excessive skin contact with used engine oil. Used engine oil contains potentially harmful contaminants which may cause skin cancer or other serious skin disorders.

Replace

1. Position suitable container beneath sump.
2. Clean area around oil drain plug.



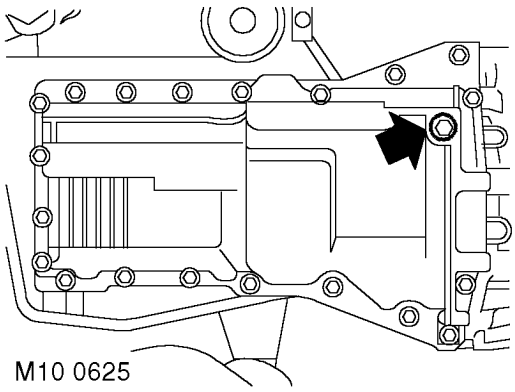
3. Remove oil drain plug, discard sealing washer.
4. Allow oil to drain.
5. Fit new sealing washer to oil drain plug.
6. Fit engine drain plug and tighten to 33 Nm (24 lbf.ft).
7. Fill engine with recommended grade of oil to correct mark on dipstick.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**

Engine oil - diesel engine

WARNING: Avoid excessive skin contact with used engine oil. Used engine oil contains potentially harmful contaminants which may cause skin cancer or other serious skin disorders.

Replace

1. Release fixings, remove underbelly panel.
2. Position suitable container beneath sump.
3. Clean area around drain plug.



4. Remove oil drain plug, discard sealing washer.
5. Allow oil to drain.
6. Fit new sealing washer to oil drain plug.
7. Fit engine drain plug and tighten to 23 Nm (17 lbf.ft).
8. Fill engine with recommended grade of oil to correct mark on dipstick.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
9. Fit front underbelly panel, secure fixings.

Centrifuge rotor – diesel engine

Replace

1. Replace centrifuge rotor.
   ☞ **ENGINE - Td5, REPAIRS, Rotor - centrifuge.**

Engine oil filter - diesel engine

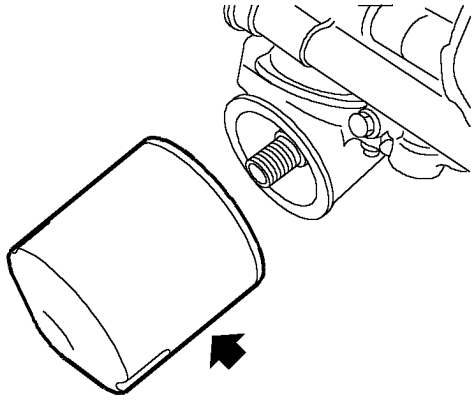
Replace

1. Replace oil filter.
   ☞ **ENGINE - Td5, REPAIRS, Filter - oil.**

Engine oil filter – V8 engine

WARNING: Avoid excessive skin contact with used engine oil. Used engine oil contains potentially harmful contaminants which may cause skin cancer or other serious skin disorders.

Replace



M10 0612A

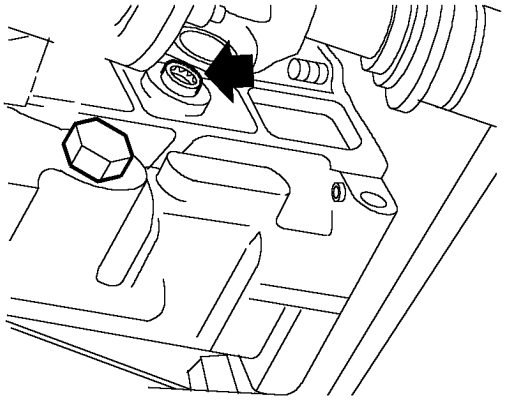
1. Disconnect battery.
2. Position suitable container beneath oil filter.
3. Using a strap type filter wrench, remove filter element, discard element.
4. Smear sealing ring of replacement filter element with engine oil.
5. Fit filter element, tighten two thirds of a turn by hand or to 17 Nm (13 lbf.ft).
6. Top-up engine with recommended grade of oil to correct mark on dipstick.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
7. Connect battery.
8. Run engine and check for oil leaks from filter.
9. Stop engine, wait for oil to return to sump.
10. Re-check oil level and top-up if necessary.

Manual gearbox

WARNING: Avoid excessive skin contact with mineral oil. Mineral oils remove the natural fats from the skin, leading to dryness, irritation and dermatitis.

Check/top-up oil level

1. Release fixings, remove rear underbelly panel.
2. Clean area around oil filler/level plug.

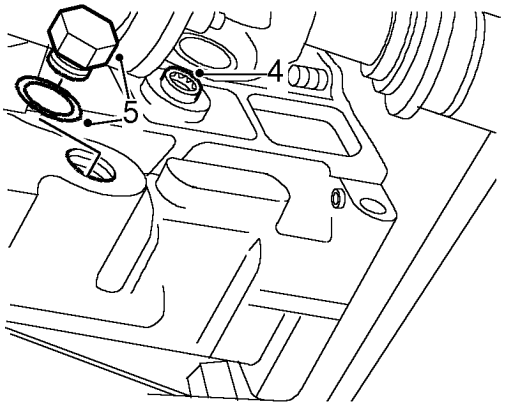


M10 0629

3. Remove oil filler/level plug.
4. Check that oil level is to bottom of oil filler/level plug hole.
5. Top-up level (if required) with recommended oil to bottom of filler/level plug hole.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
6. Remove all traces of sealant from threads of oil filler/level plug.
7. Apply Loctite 290 to threads of oil filler/level plug.
8. Fit manual gearbox filler/level plug and tighten to 30 Nm (22 lbf.ft).
9. Remove all traces of oil from gearcase.
10. Fit rear underbelly panel, secure fixings.

Replace oil

1. Release fixings, remove rear underbelly panel.
2. Place a suitable container beneath gearbox drain plug.
3. Clean area around oil filler/level and drain plugs.



M10 0584

4. Remove oil filler/level plug.
5. Remove oil drain plug, remove and discard sealing washer.
6. Allow oil to drain.
7. Clean magnet in oil drain plug.
8. Fit new sealing washer to oil drain plug.
9. Fit manual gearbox drain plug and tighten to 50 Nm (37 lbf.ft).
10. Fill gearbox with recommended oil to bottom of filler/level plug hole.
    ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
11. Remove all traces of sealant from threads of oil filler/level plug.
12. Apply Loctite 290 to threads of oil filler/level plug.
13. Fit manual gearbox filler/level plug and tighten to 30 Nm (22 lbf.ft).
14. Remove all traces of oil from gearcase.
15. Fit rear underbelly panel, secure fixings.

Automatic gearbox

WARNING: Avoid excessive skin contact with mineral oil. Mineral oils remove the natural fats from the skin, leading to dryness, irritation and dermatitis.

Replace oil filter

1. Replace oil filter.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Filter - oil.**

Replace oil

1. **Ensure that gearbox is cool.** Apply handbrake and securely chock front and rear wheels.
2. Place a suitable container beneath gearbox.
3. Clean area around oil filler/level and drain plugs.

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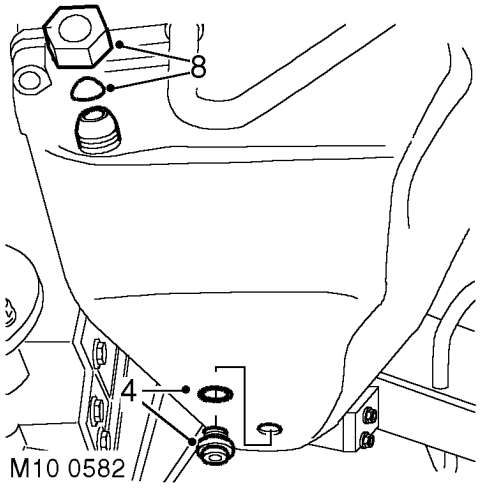
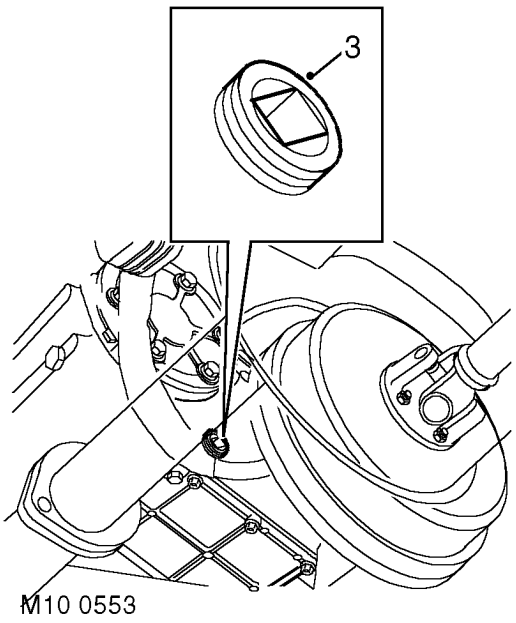


4. Remove oil drain plug, remove and discard sealing washer.
5. Allow oil to drain.
6. Fit new sealing washer to oil drain plug.
7. Fit automatic gearbox drain plug and tighten to 15 Nm (11 lbf.ft).
8. Remove oil filler/level plug, remove and discard sealing washer.
9. Fill gearbox with recommended oil to bottom of oil level/filler plug hole.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
10. Select 'P' (Park).
11. Ensure handbrake is applied.
12. Start engine and allow it to idle.
13. Apply footbrake.
14. Move selector lever through all gear positions, while continuing to fill the gearbox. Select 'P' (Park).
15. With engine idling, continue filling gearbox until a 2 mm bead of oil runs from oil filler/level plug hole.
16. Fit new sealing washer to automatic gearbox filler/level plug, fit plug and tighten to 30 Nm (22 lbf.ft).
17. Stop engine.
18. Remove all traces of oil from gearbox casing.

Transfer box

WARNING: Avoid excessive skin contact with mineral oil. Mineral oils remove the natural fats from the skin, leading to dryness, irritation and dermatitis.

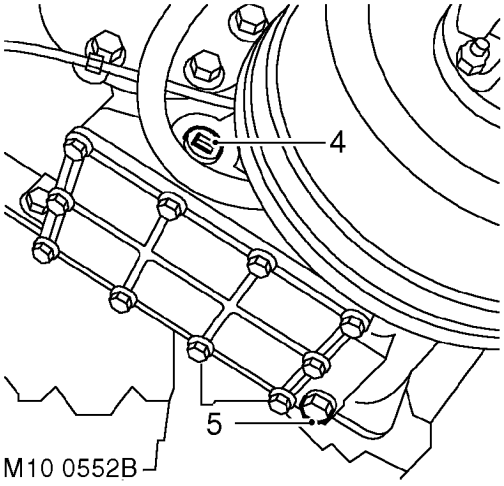
Check/top-up oil level



1. Release fixings, remove rear underbelly panel.
2. Clean area around oil filler/level plug.
3. Remove oil filler/level plug.
4. Check that oil level is to bottom of filler/level plug hole.
5. Top-up level (if required) with recommended oil to bottom of oil filler/level plug hole.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
6. Remove all traces of sealant from threads of oil filler/level plug.
7. Apply Loctite 290 to threads of oil filler/level plug.
8. Fit transfer box filler/level plug and tighten to 25 Nm (18 lbf.ft).
9. Remove all traces of oil from main casing.
10. Fit rear underbelly panel (if fitted), secure fixings.

Replace oil

1. Release fixings, remove rear underbelly panel.
2. Place a suitable container beneath transfer box drain plug.



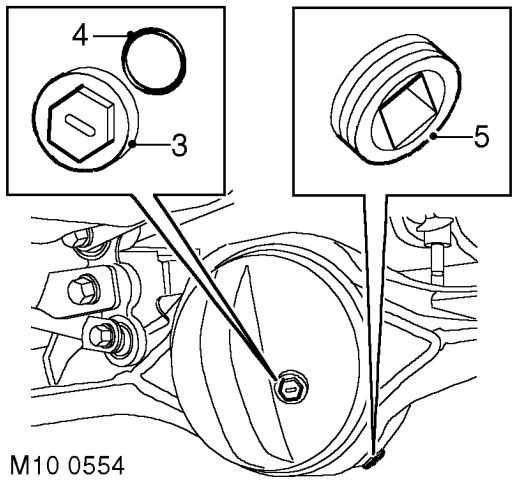
3. Clean area around oil filler/level and drain plugs.
4. Remove oil filler/level plug.
5. Remove oil drain plug.
6. Allow oil to drain.
7. Apply Loctite 290 to threads of oil drain plug.
8. Fit transfer box drain plug and tighten to 30 Nm (22 lbf.ft).
9. Fill transfer box with recommended oil to bottom of oil filler/level plug hole.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
10. Remove all traces of sealant from threads of oil filler/level plug.
11. Apply Loctite 290 to threads of oil filler/level plug.
12. Fit transfer box filler/level plug and tighten to 25 Nm (18 lbf.ft).
13. Remove all traces of oil from transfer box.
14. Fit rear underbelly panel (if fitted), secure fixings.

Front and rear axle

WARNING: Avoid excessive skin contact with mineral oil. Mineral oils remove the natural fats from the skin, leading to dryness, irritation and dermatitis.

Replace oil

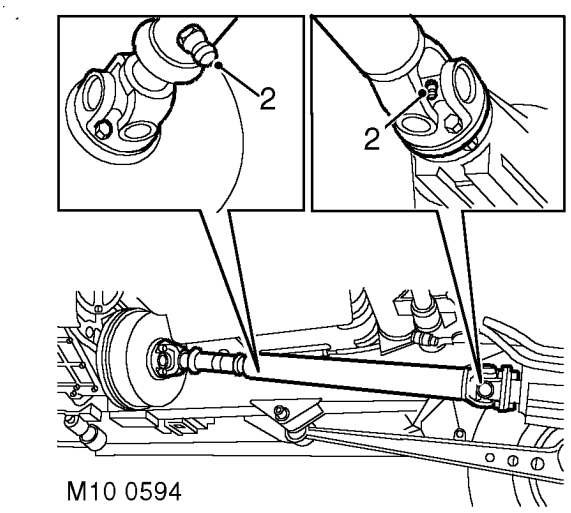
1. Place a suitable container beneath differential housing of axle to be drained.
2. Clean area around oil filler/level and drain plugs.



3. Remove oil filler/level plug.
4. Remove and discard 'O' ring from oil filler/level plug.
5. Remove oil drain plug, allow oil to drain.
6. Remove all traces of Loctite from threads of oil drain plug.
7. Apply Loctite 290 to threads of oil drain plug.
8. Fit axle drain plug and tighten to 64 Nm (47 lbf.ft).
9. Fill differential housing with recommended oil to bottom of oil filler/level plug hole.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
10. Lubricate a new 'O' ring with recommended oil and fit to oil filler/level plug.
11. Fit axle filler/level plug and tighten to 10 Nm (7 lbf.ft).
12. Remove all traces of oil from differential housing.

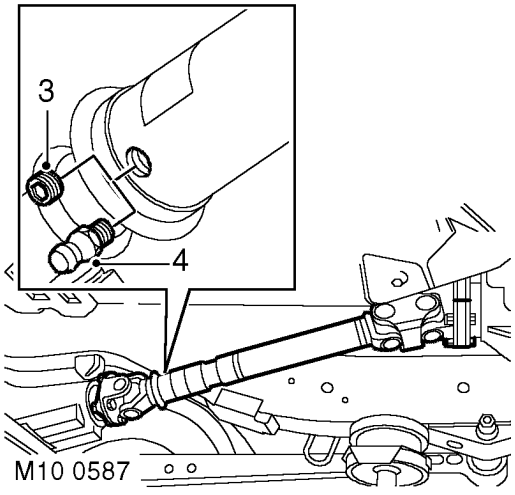
Propeller shafts

Lubricate



Rear shaft

1. Clean area around front universal joint grease nipple.
2. Apply recommended grease to the grease nipple.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**



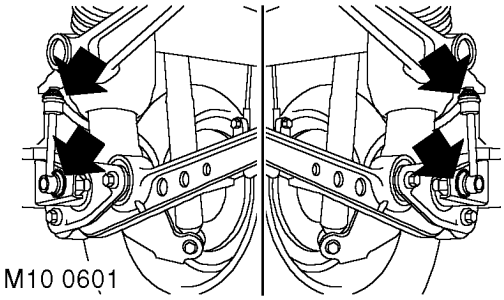
Front shaft

3. Remove blanking plug adjacent to sliding joint from propeller shaft.
4. Screw a 1/4in UNF grease nipple into blanking plug hole.

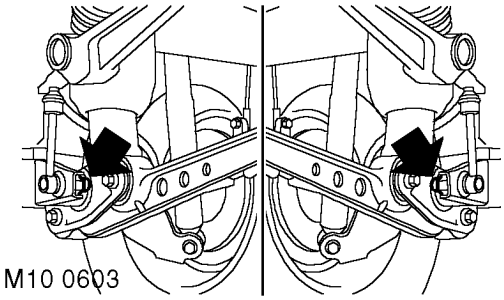
5. Apply recommended grease to the grease nipple.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
6. Remove grease nipple.
7. Fit blanking plug.

Anti-roll bar links

Check rear links



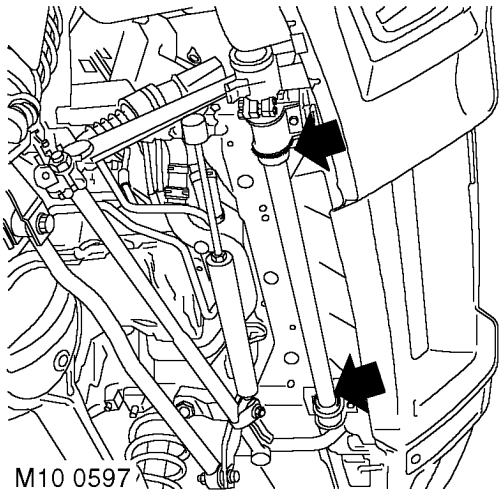
Rubber boots



Fixings

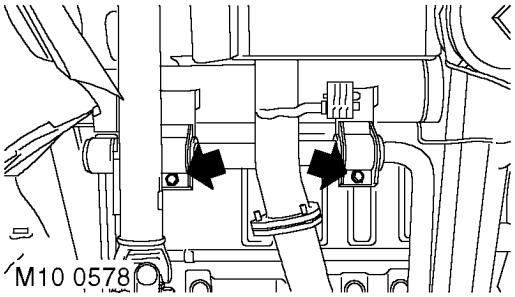
1. Check anti-roll bar links for free play.
2. Check rubber boots for splits, damage and security.

Anti-roll bar mountings - front

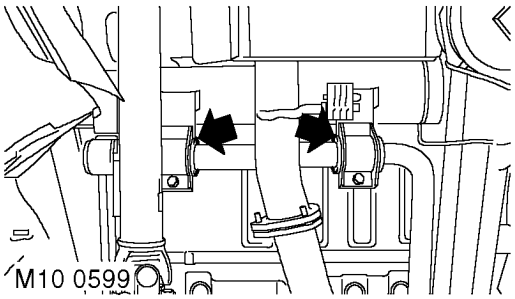


1. Check condition of mounting rubbers and security of fixings.
   ☞ **TORQUE WRENCH SETTINGS, Front suspension.**

Anti-roll bar mountings - rear



Fixings

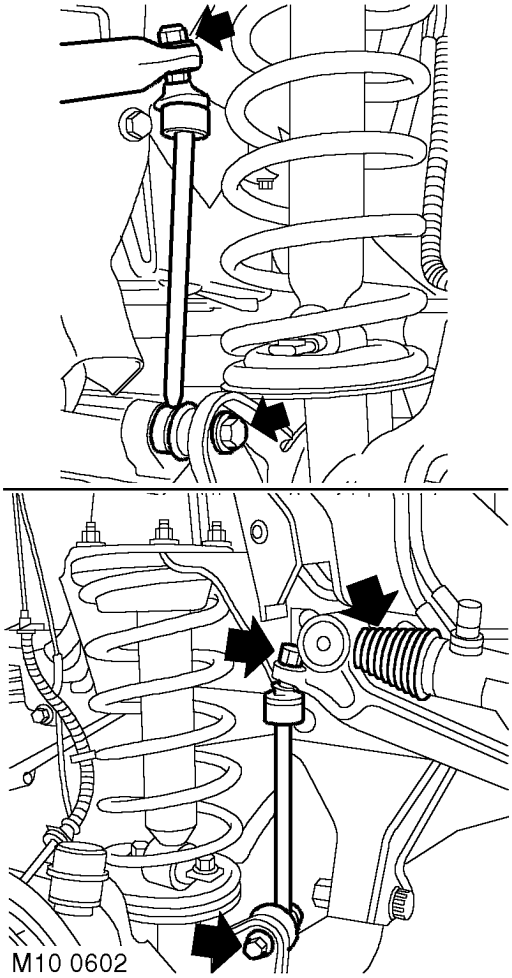


Rubber mountings

1. Check condition of mounting rubbers and security of fixings.
   ☞ **TORQUE WRENCH SETTINGS, Rear suspension.**

ACE actuators

Check



Actuator boots

1. Check ACE actuator gaiters for splits, damage and clips for security.

ACE filter

Replace

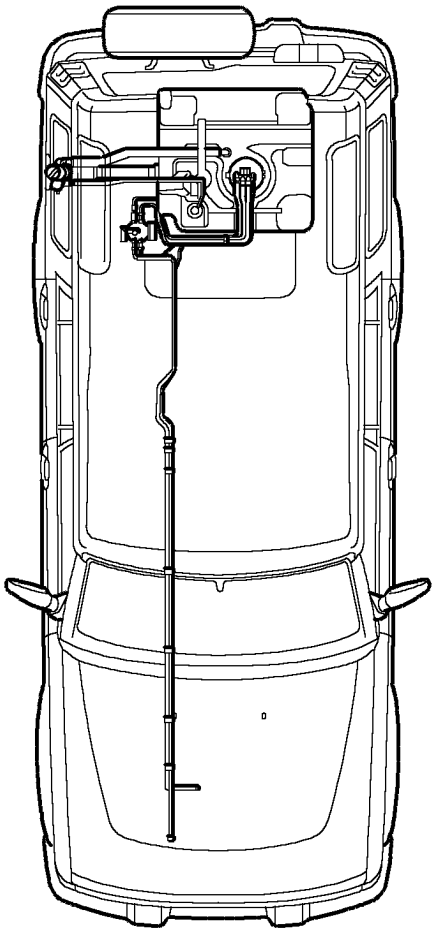
1. Replace ACE filter.
   ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**

Brake hose, brake, fuel, ACE, clutch pipes and unions/electrical harnesses

Check – General

1. Check brake servo hose for cracks, leaks and chafing.
2. Check brake, clutch pipes and unions for chafing, leaks and corrosion and that all pipes and hoses are correctly routed and secure.
3. Check electrical harnesses for chafing and damage.

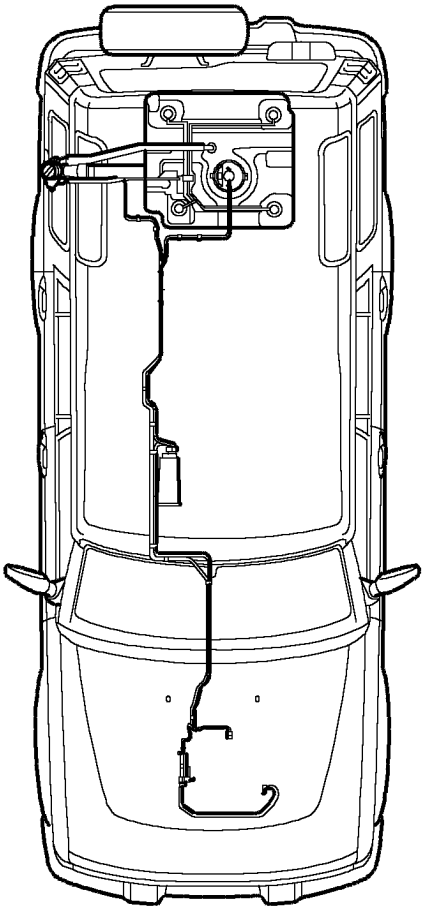
Check – V8 engine fuel pipes



M10 0537

1. Check fuel pipes and unions for chafing, leaks and corrosion and that all pipes and hoses are correctly routed and secure.

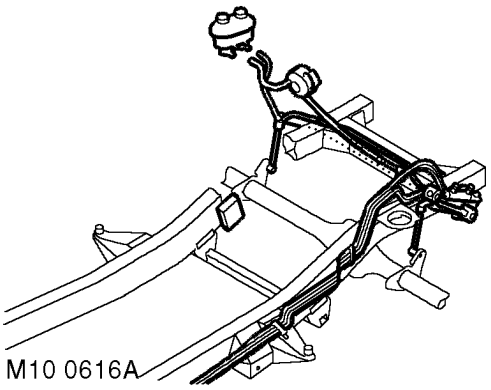
Check – Diesel engine fuel pipes



M10 0538A

1. Check fuel pipes and unions for chafing, leaks and corrosion and that all pipes and hoses are correctly routed and secure.

Power steering, suspension



ACE pipes

1. Check for fluid leaks from power steering and suspension systems.
2. Check ACE pipes and unions for chafing, leaks and corrosion and that all pipes and hoses are correctly routed and secure.

Engine, gearbox, transfer box and axles

Check

1. Check for oil leaks from engine, gearbox (manual and automatic), transfer box and front and rear axles; pay particular attention to areas around oil seals.

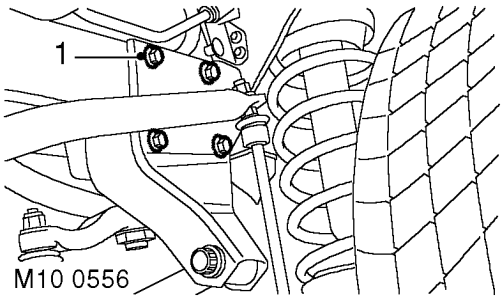
Exhaust system

Check

1. Check for signs of exhaust system leaks, damage and security.

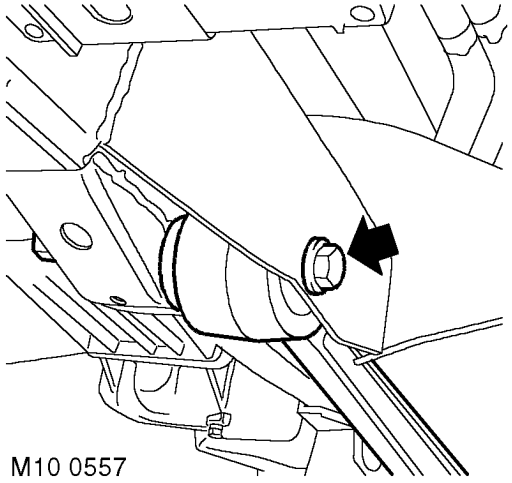
Steering box and front suspension

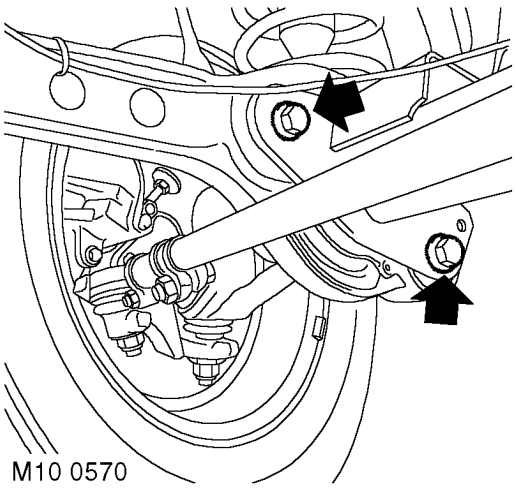
Check/tighten steering box fixings



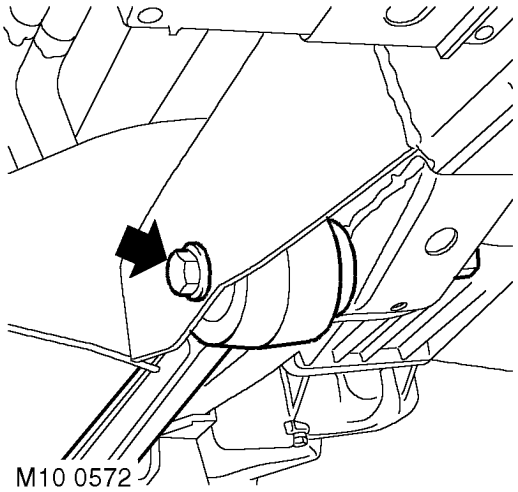
1. Check steering box fixings and tighten to 90 Nm (66 lbf.ft).

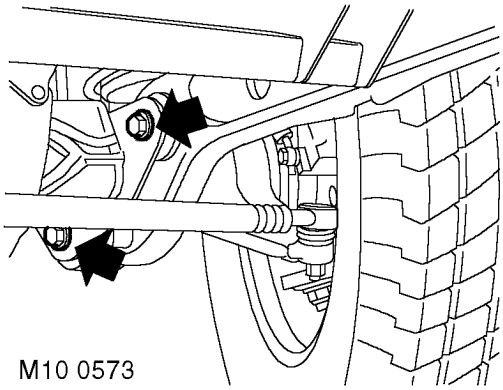
Check/tighten front axle suspension fixings



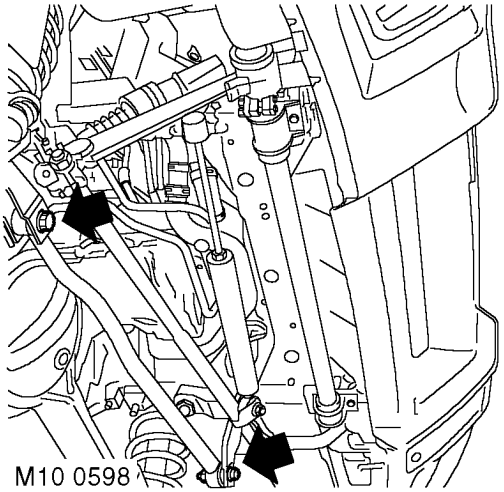


1. Check/tighten front suspension LH radius arm fixings.
   ☞ **TORQUE WRENCH SETTINGS, Front suspension.**


M10 0572

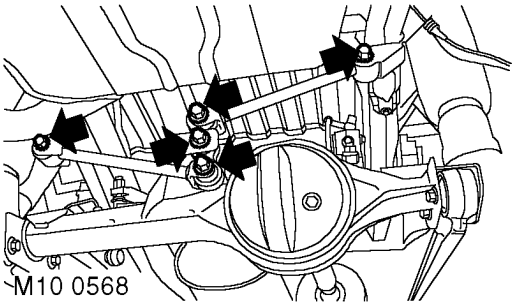

M10 0573

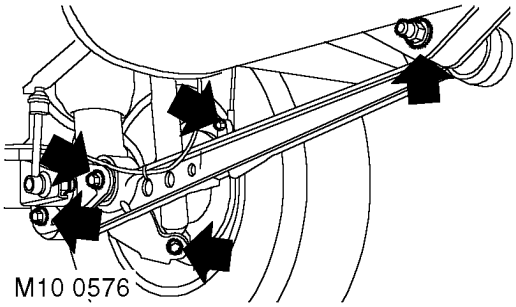
2. Check/tighten front suspension RH radius arm fixings.

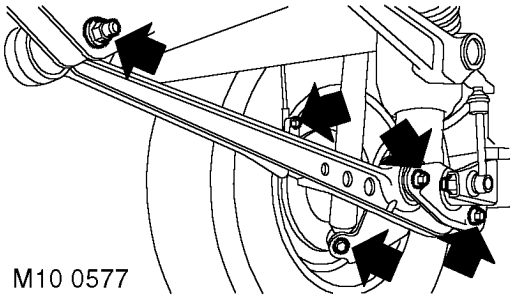

M10 0598

3. Check/tighten front suspension Panhard rod fixings

Check rear axle suspension fixings


M10 0568

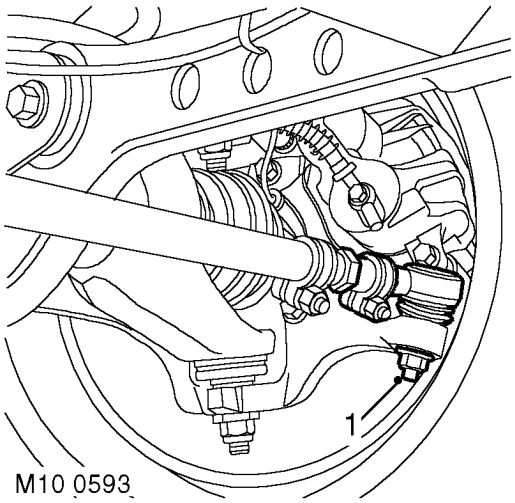

M10 0576

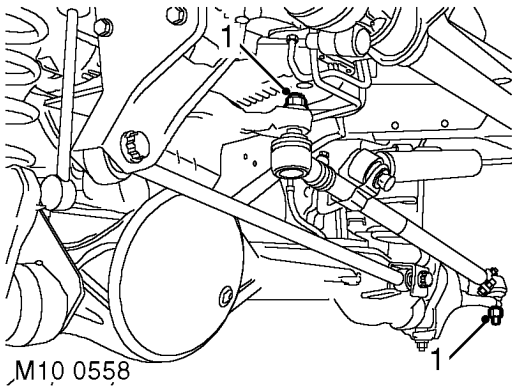

M10 0577

1. Check and tighten if necessary all rear axle suspension fixings.
   ☞ **TORQUE WRENCH SETTINGS, Rear suspension.**

Steering rod ball joints

Check

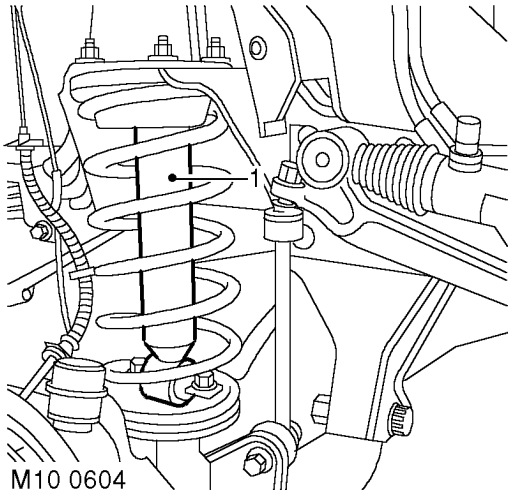




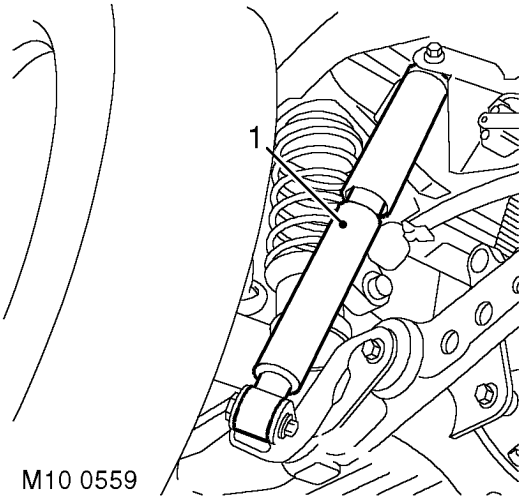
1. Check condition of ball joints and dust covers, and security of fixings.
   ☞ **TORQUE WRENCH SETTINGS, Steering.**

Dampers and SLS height sensors

Check – Dampers



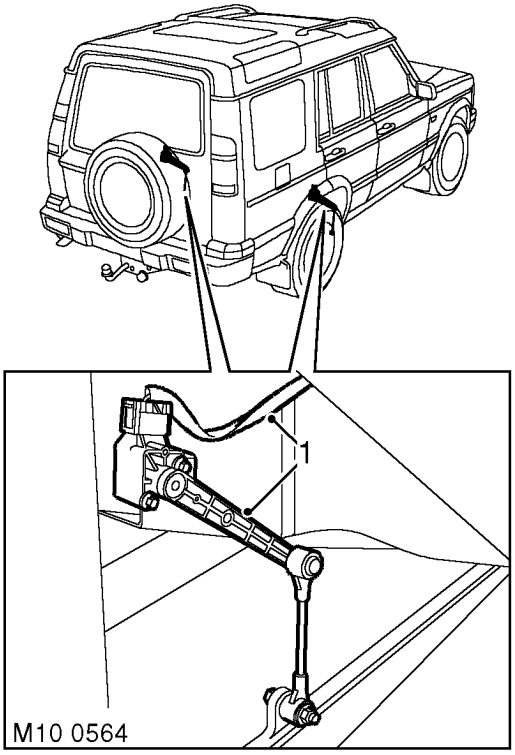
Front dampers



Rear dampers

1. Check dampers for security and signs of leakage.

Check – Height sensors

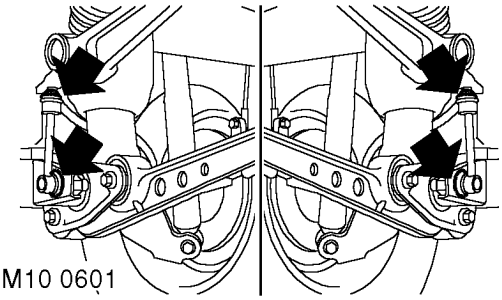


SLS height sensors

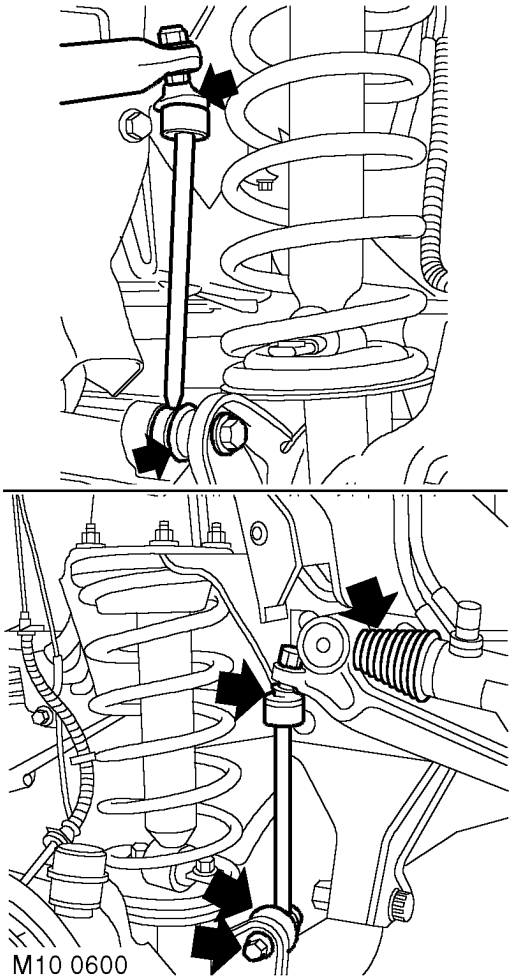
1. Check height sensors for condition and security.
2. Check electrical harness for chafing and damage.

Front and rear axle suspension links

Check



Rear suspension



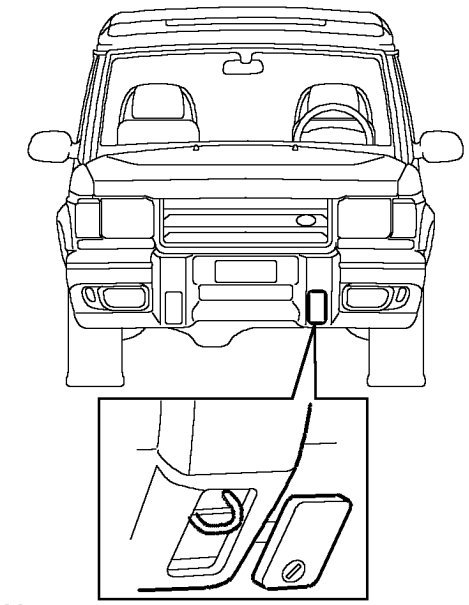
Front suspension

1. Check condition of front and rear axle suspension link mounting rubbers.

2. Check security of fixings.
   ☞ **TORQUE WRENCH SETTINGS, Front suspension.**
   ☞ **TORQUE WRENCH SETTINGS, Rear suspension.**

Towing bracket

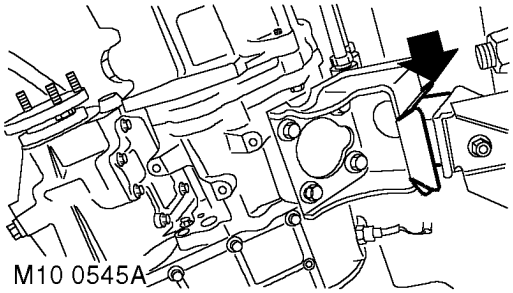
Check


M10 0585

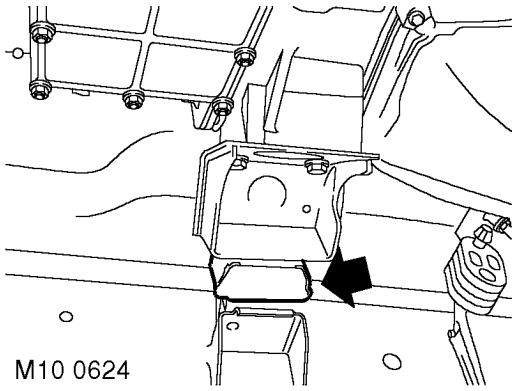
1. Check security of towing bracket.

Engine mountings - V8 engine

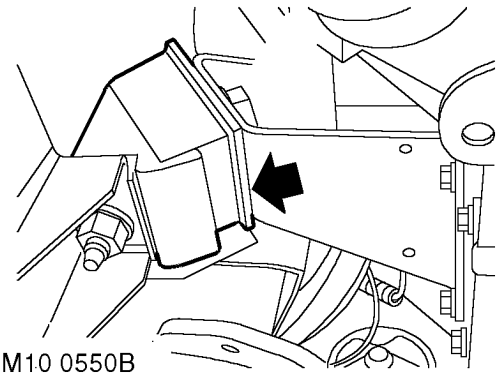
Check for security and condition


M10 0545A

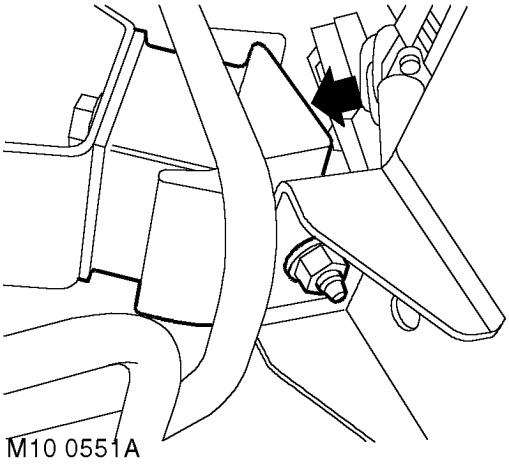
1. Check condition of Transfer box - RH mounting rubber.


M10 0624

2. Check condition of Transfer box - LH mounting rubber.


M10 0550B

3. Check condition of Engine - LH mounting rubber.

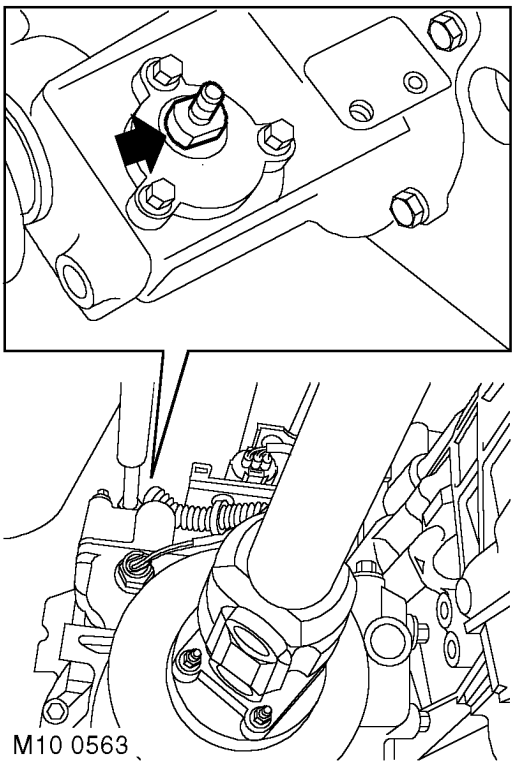


4. Check condition of Engine - RH mounting rubber
5. Check tightness of all mounting bolts.
   ☞ **TORQUE WRENCH SETTINGS, Engine V8.**

Road/roller test

WARNING: Roller test must be restricted to 3 mph (5 km/h). If 2 wheel rolling road is to be used, disconnect propeller shaft from the transfer box output shaft driving the axle which is NOT on the rolling road.

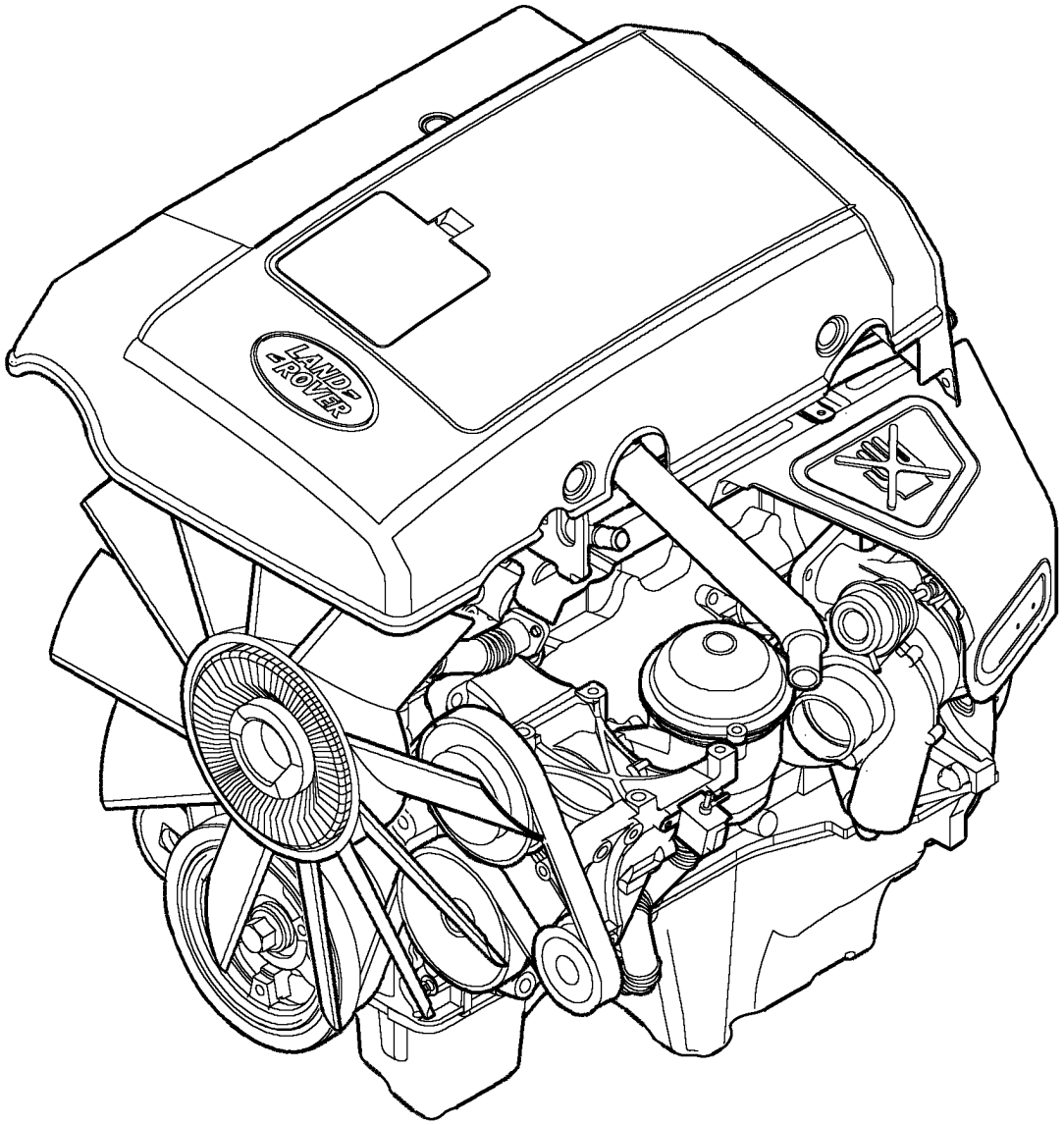
Testing



1. **2 wheel rolling road:** Engage differential lock using a 10 mm open ended spanner on flats machined on differential lock selector shaft.**Switch on ignition and check that the differential lock, electronic brake distribution and hill descent warning lamps are illuminated.**
2. Check for correct operation of starter switch, ensure engine starts correctly; leave the engine running.
3. Check for correct operation of starter switch, ensure engine starts correctly; leave the engine running.
4. With vehicle stationary, turn steering from lock to lock. Check for smooth operation and ensure there is no undue noise from power steering pump or drive belt.
5. Depress clutch and select all gears in turn, check for smooth, notch free engagement.
6. Check all vehicle systems for correct operation.
7. Check for unusual engine, gearbox and suspension noises.
8. Check braking system operation.
9. Check for smooth gear engagement.
10. Check engine performance.
11. Check operation of all instruments and warning devices where practicable.

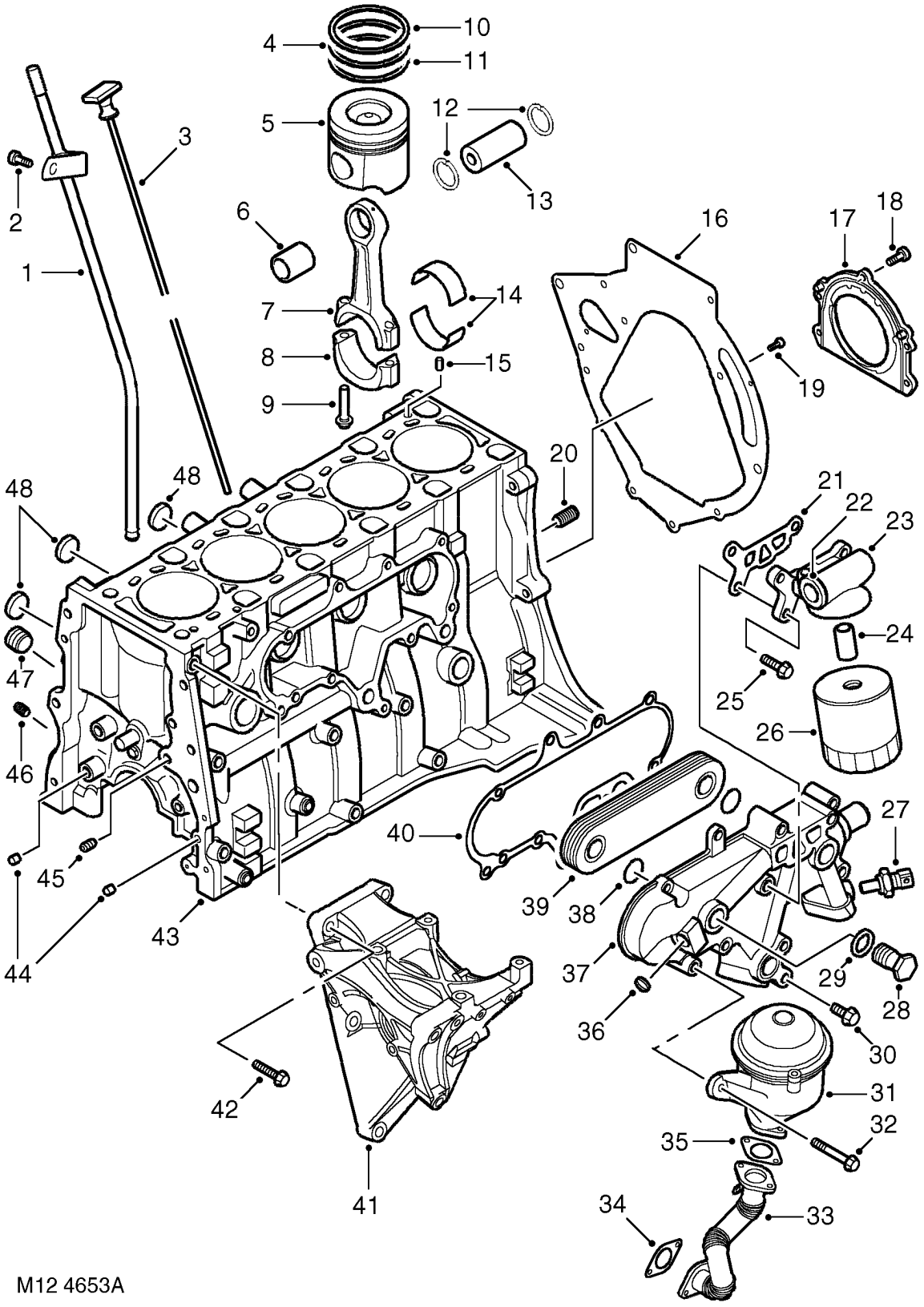
12. Where possible, check for correct operation of hill descent control (HDC) mechanism. This should not be carried out if excessive journey time is required.
13. After road/roller test, carry out a final inspection of vehicle, with vehicle on a ramp.
14. Check all fluid levels and top-up if necessary.
15. **2 wheel rolling road:** Ensure differential lock is disengaged and propeller shaft is connected on completion of test. **Switch on ignition and check that differential lock, electronic brake distribution and hill descent warning lamps are extinguished.**

Td5 Engine



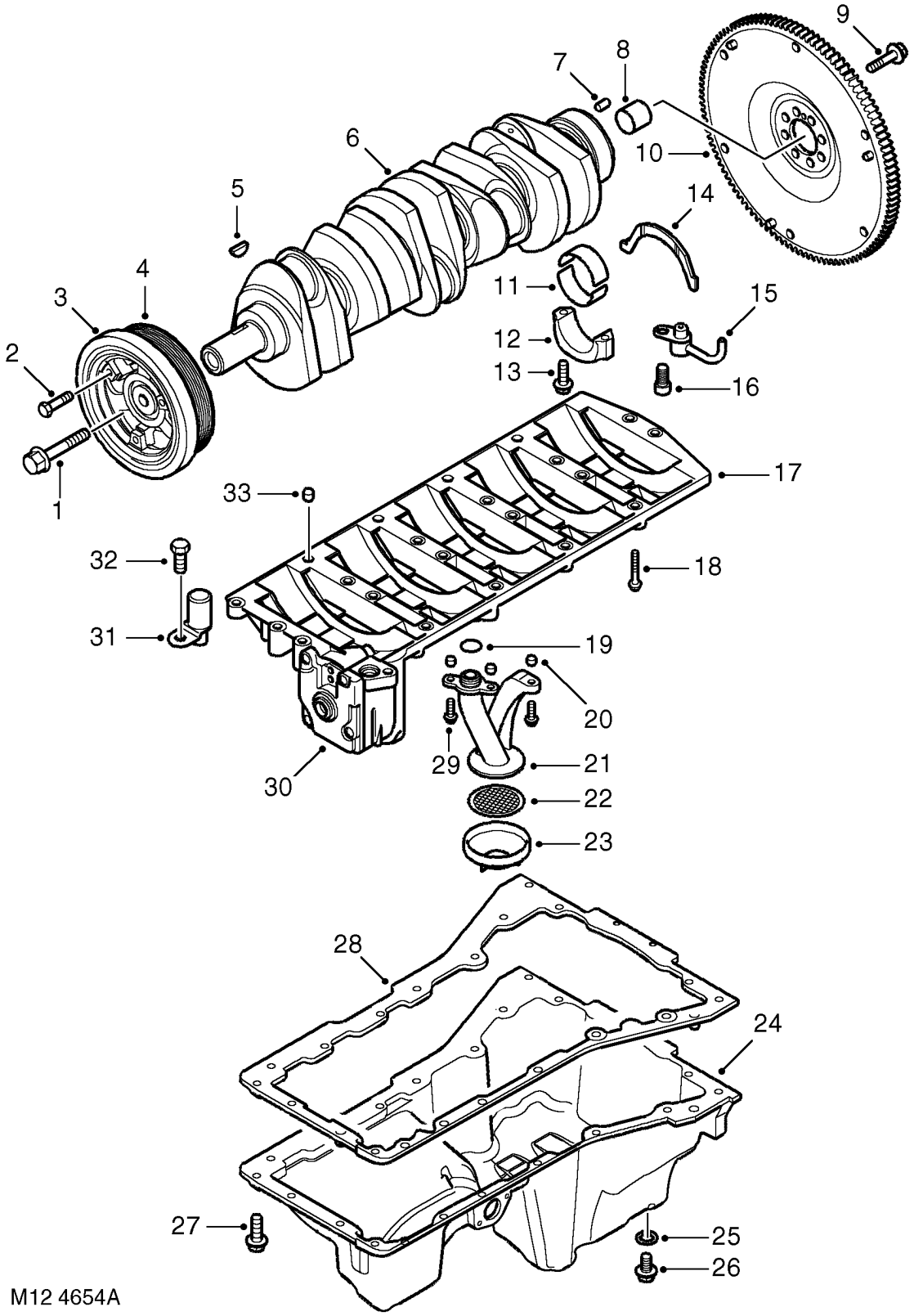
M12 4652

Cylinder block components



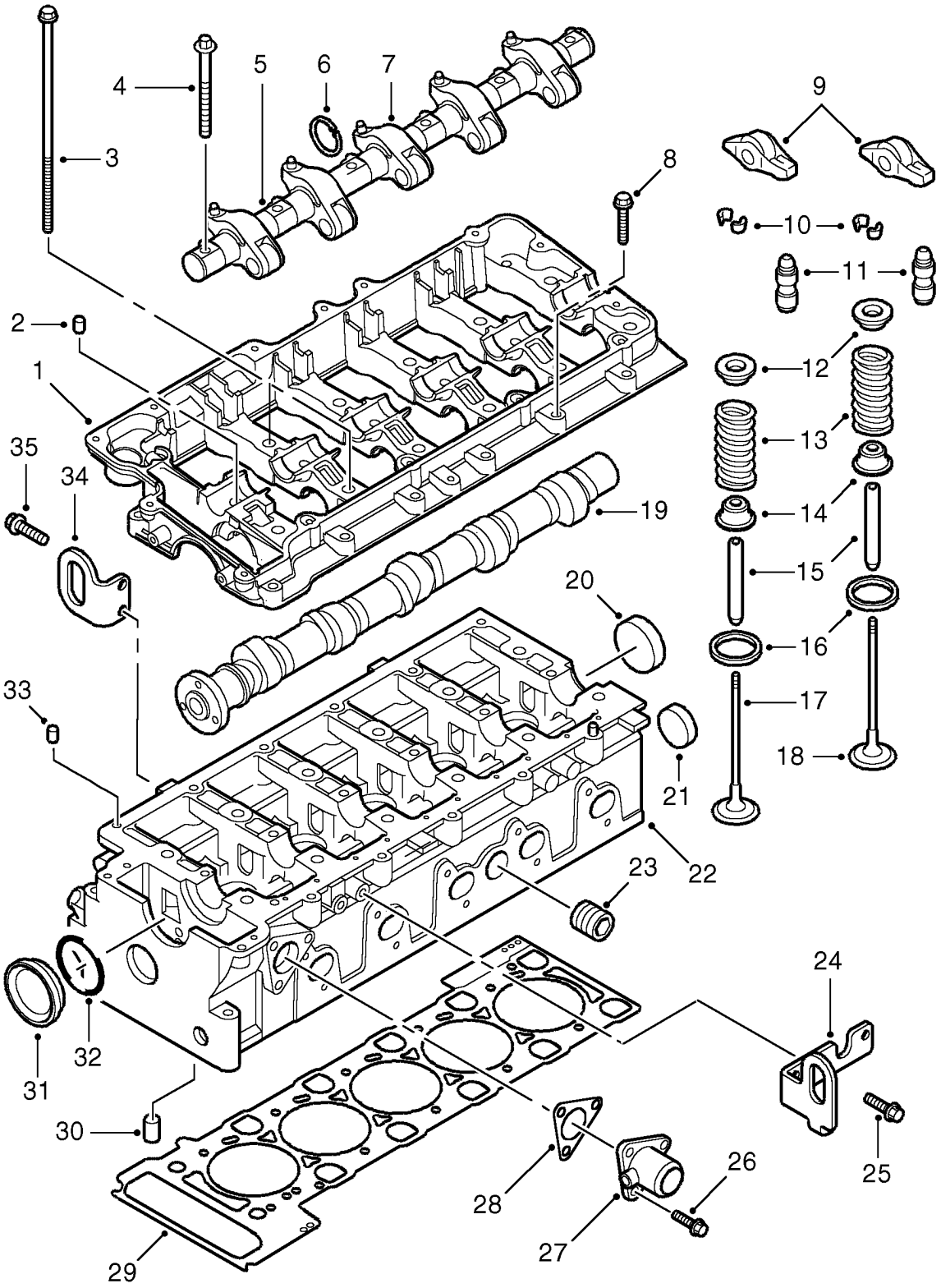
1 Oil dipstick tube
2 Screw – oil dipstick tube to camshaft carrier
3 Oil dipstick
4 2nd piston ring
5 Piston
6 Small-end bush
7 Connecting rod
8 Big-end bearing cap
9 Connecting rod bolt (2 off per connecting rod)
10 Top piston ring
11 Oil control ring
12 Circlips (2 off per gudgeon pin)
13 Gudgeon pin
14 Big-end bearing shells
15 Dowels – cylinder head (2 off)
16 Clutch housing shim plate
17 Crankshaft rear oil seal and housing
18 Screws – crankshaft seal housing to engine block (5 off)
19 Bolts – clutch housing shim plate to engine block (2 off)
20 Main oil gallery plug (rear)
21 Oil filter adaptor gasket
22 Oil filter adaptor thermostat
23 Oil filter adaptor assembly
24 Oil filter adaptor insert
25 Oil filter adaptor to cylinder block bolts (3 off)
26 Oil filter
27 Oil pressure switch
28 Oil cooler banjo bolts (2 off)
29 O-rings – oil cooler banjo bolts (2 off)
30 Oil cooler to cylinder block bolts (7 off)
31 Centrifuge assembly
32 Centrifuge to cylinder block bolts (3 off)
33 Centrifuge oil drain pipe
34 Oil drain pipe to sump gasket
35 Centrifuge to oil drain pipe gasket
36 Oil cooler plugs (3 off)
37 Oil cooler assembly
38 Oil cooler matrix 'O-rings' (2 off)
39 Oil cooler matrix
40 Oil cooler gasket
41 Coolant and PAS pump assembly bracket
42 Bracket bolts (5 off + 1 stud/nut)
43 Cylinder block
44 Dowels to timing block cover (2 off)
45 Oil gallery delivery plug
46 Cross drilling plug
47 Coolant jacket plug
48 Core plugs (3 off)

Crankshaft, sump and oil pump



1 Crankshaft pulley bolt
2 TV Damper to crankshaft pulley bolts (3 off)
3 TV Damper
4 Crankshaft pulley
5 Woodruff key
6 Crankshaft
7 Crankshaft to flywheel dowel
8 Spigot bush
9 Flywheel to crankshaft bolts (8 off)
10 Flywheel assembly (Manual shown)
11 Main bearing shells (6 pairs)
12 Main bearing caps (6 off)
13 Main bearing cap bolts (12 off)
14 Thrust washer (2 off at No. 3 Main bearing)
15 Piston lubrication jets (5 off)
16 Piston lubrication jet cap head screw (5 off)
17 Stiffener plate (oil pump integral)
18 Stiffener plate / oil pump assembly to cylinder block bolts (22 off)
19 Oil pick-up pipe O-ring
20 Oil pick-up pipe inserts (2 x 6mm; 1 x 10mm)
21 Upper oil pick-up pipe
22 Oil pick-up pipe gauze
23 Lower oil pick-up pipe
24 Sump
25 Oil drain plug seal
26 Oil drain plug
27 Sump to cylinder block bolts (20 off)
28 Sump gasket
29 Oil pick-up pipe bolts (3 off)
30 Oil pump
31 Chain lubrication jet
32 Chain lubrication jet screw
33 Stiffener to cylinder block dowel (2 off)

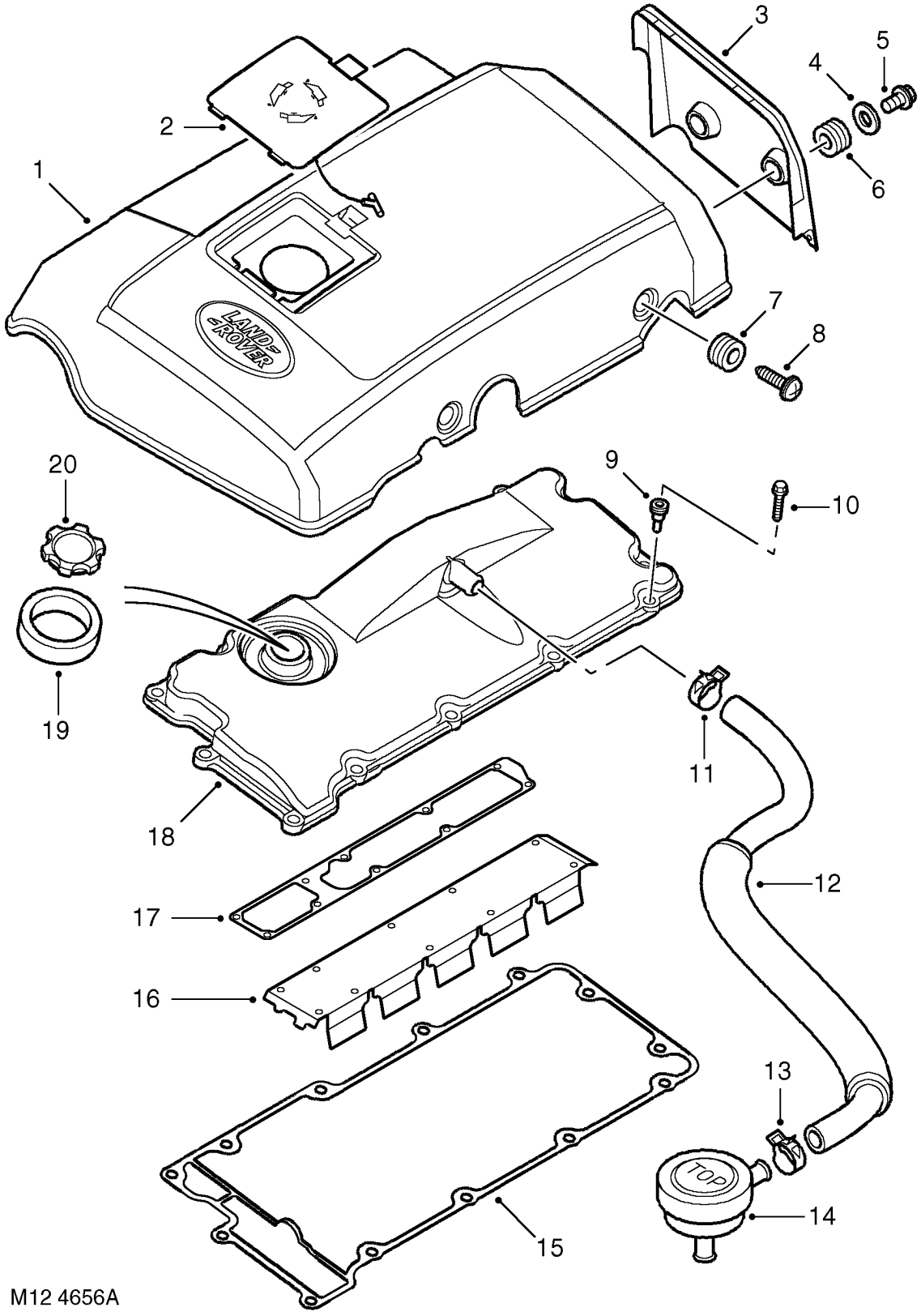
Cylinder head components



M12 4655A

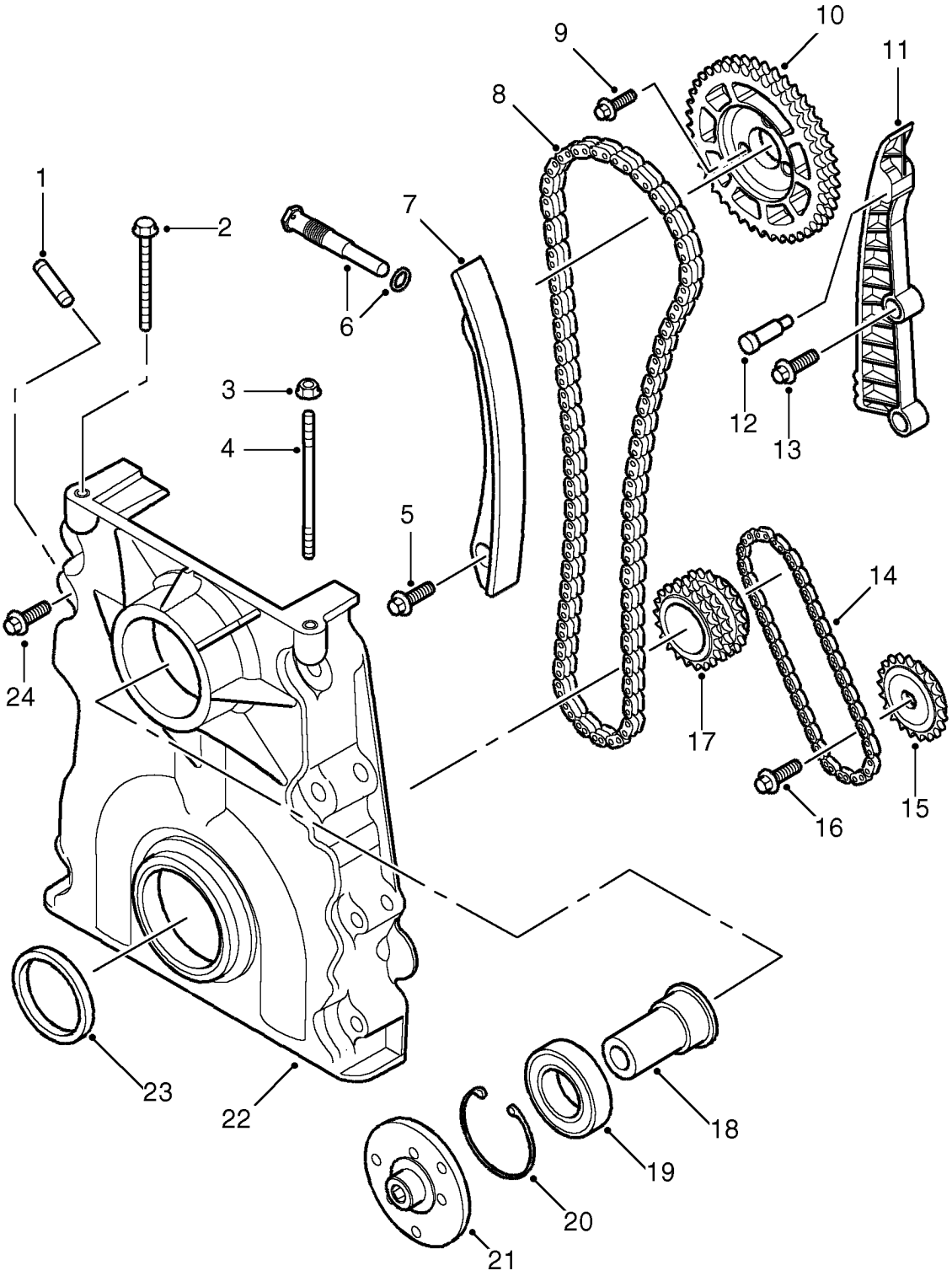
1 Camshaft carrier
2 Dowel – rocker shaft to camshaft carrier (1 off)
3 Cylinder head bolts (12 off)
4 Rocker shaft to camshaft carrier bolts (6 off)
5 Rocker shaft
6 Circlips (10 off)
7 EUI Rocker arms (5 off)
8 Camshaft carrier to cylinder head screws (13 off)
9 Finger follower (10 off)
10 Valve spring collets (20 off)
11 Lash adjuster (10 off)
12 Valve spring retainer (10 off)
13 Valve spring (10 off)
14 Valve stem seal (10 off)
15 Valve guide (10 off)
16 Valve seat insert (10 off)
17 Inlet valve (5 off)
18 Exhaust valve (5 off)
19 Camshaft
20 Camshaft bore seal (rear)
21 Coolant jacket core plug
22 Cylinder head block
23 Water jacket threaded plug
24 Engine lifting bracket (LH)
25 Engine lifting bracket bolts (2 off)
26 Coolant outlet elbow to cylinder head bolts (3 off)
27 Coolant outlet elbow
28 Coolant outlet elbow gasket
29 Cylinder head gasket
30 Non-return valve (not removable, integral in cylinder head)
31 Camshaft bore end cap (front)
32 End cap seal
33 Cylinder head to cam carrier dowel (2 off)
34 Engine lifting bracket (RH)
35 Engine lifting bracket bolts (2 off)

Camshaft cover and engine cover



1 Acoustic cover
2 Oil filler flap
3 Rear acoustic cover
4 Rear acoustic cover inserts (2 off)
5 Rear acoustic cover grommets (2 off)
6 Rear acoustic cover screws (2 off)
7 Acoustic cover grommets (3 off)
8 Acoustic cover bolts (3 off)
9 Camshaft cover isolators (13 off)
10 Camshaft cover flange screws (13 off)
11 Breather hose clip
12 Breather hose
13 Breather hose to breather valve clip
14 Breather valve
15 Camshaft cover seal
16 Oil separator plate
17 Oil separator plate gasket
18 Camshaft cover
19 Acoustic cover to camshaft cover seal
20 Oil filler cap and seal

Camshaft timing chain components



M12 4657A

1 Vacuum pump stub pipe
2 Cylinder head to timing chain cover bolt
3 Cylinder head to timing chain cover nut
4 Cylinder head to timing chain cover stud
5 Tensioner assembly pivot screw
6 Tensioner adjuster
7 Tensioner arm assembly
8 Duplex timing chain – crankshaft to camshaft sprocket
9 Camshaft sprocket bolts (3 off)
10 Camshaft sprocket
11 Fixed chain guide
12 Fixed guide pin
13 Fixed chain guide to cylinder block screws
14 Oil pump drive chain
15 Oil pump sprocket
16 Oil pump sprocket screw
17 Crankshaft sprockets
18 Bearing to viscous fan shaft
19 Viscous fan to cover bearing
20 Circlip
21 Hub – viscous fan to bearing flange
22 Timing chain cover
23 Timing chain cover to crankshaft seal
24 Timing cover to cylinder head screws (8 off)

Description

General
The Td5 diesel engine is a 2.5 litre, 5 cylinder, in-line direct injection unit having 2 valves per cylinder, operated by a single overhead camshaft. The engine emissions, on pre EU3 models, comply with ECD2 (European Commission Directive) and on EU3 models, comply with ECD3 legislative requirements. Both models employ electronic engine management control, positive crankcase ventilation and exhaust gas recirculation to limit the emission of pollutants. The unit is water cooled and turbo-charged and is controlled by an electronic engine management system.

The engine is a monobloc cast iron construction with an aluminium stiffening plate fitted to the bottom of the cylinder block to improve lower structure rigidity. The cylinder head and sump are cast aluminium. An acoustic cover is fitted over the upper engine to reduce engine generated noise.

The engine utilises the following features:
- **Electronic Unit Injectors (EUI's)** controlled by an Engine Management System for precise fuel delivery under all prevailing operating conditions.
- **Turbocharging** which delivers compressed air to the combustion chambers via an intercooler for improved power output.
- **Fuel Cooler**
- **Oil Cooler**
- **Centrifuge Oil Filter**
- **Hydraulic Lash Adjusters** with independent finger followers

Cylinder block components
The cylinder block components are described below:

Cylinder Block
The cylinders and crankcase are contained in a single cast iron construction. The cylinders are direct bored and plateau honed with lubrication oil supplied via lubrication jets for piston and gudgeon pin lubrication and cooling. It is not possible to rebore the cylinder block if the cylinders become worn or damaged. Three metal core plugs are fitted to the three centre cylinders on the right hand side of the cylinder block.

Lubrication oil is distributed throughout the block via the main oil gallery to critical moving parts through channels bored in the block which divert oil to the main and big-end bearings via oil holes machined into the crankshaft. Oil is also supplied from the cylinder block main gallery to the five lubrication jets which cool and lubricate the piston and gudgeon pins. Plugs are used to seal both ends of the main oil gallery at front and rear of the engine block. An oil cooler is fitted to the LH side of the engine block; ports in the oil cooler assembly mate with ports in the cylinder block to facilitate coolant flow. Oil is diverted through the oil cooler, centrifuge filter and full-flow filter before supplying the main oil gallery. A tapping in the oil filter housing provides a lubrication source for the turbocharger bearings and an oil pressure switch is included in a tapping in the oil cooler housing which determines whether sufficient oil pressure is available to provide engine lubrication and cooling.

Cylinder cooling is achieved by water circulating through chambers in the engine block casting. A threaded coolant jacket plug is located at the front RH side of the cylinder block.

Cast mounting brackets are bolted to both sides of the engine block for mounting the engine to the chassis on the LH and RH hydramount studs.

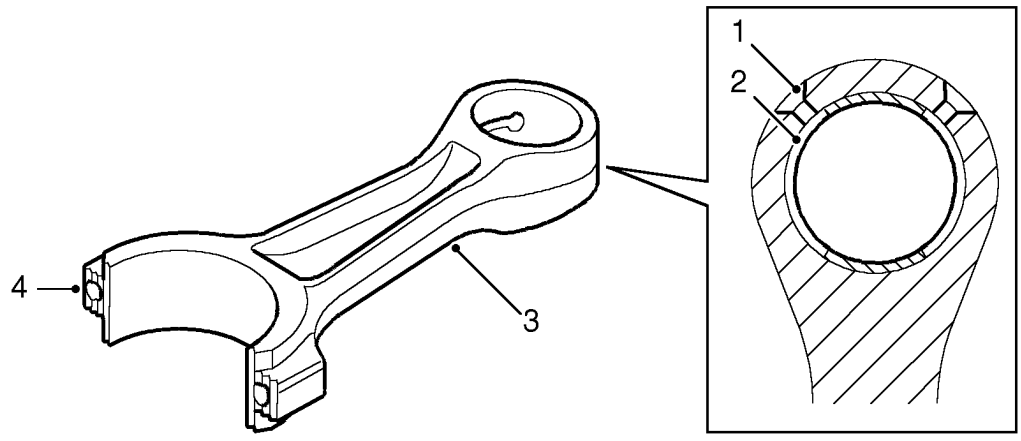
The gearbox bolts directly to the engine block; a gearbox shim plate is located between the adjoining faces of the gearbox and the flywheel side of the engine block and is fixed to the rear of the engine block by two bolts. Two hollow metal dowels locate the rear of the cylinder block to the gearbox shim plate. The gearbox casing provides the mounting for the starter motor.

A port is included at the rear left hand side of the cylinder block which connects to the turbocharger oil drain pipe to return lubrication oil to the sump.

A plug sealing the lubrication cross-drilling gallery is located at the front right hand side of the cylinder block and plugs for the main lubrication gallery is included at the front and rear of the cylinder block.

Two plastic dowels are used to locate the cylinder head to the cylinder block and must be replaced every time the cylinder head is removed from the cylinder block.

Connecting rods



M12 4712

1 Small-end oil holes
2 Small-end bushing
3 Connecting rod
4 Serrated fracture

The connecting rods are machined, H-sectioned steel forgings which feature a fracture-split at the big-end between the connecting rod and the bearing cap. The connecting rod features a serrated fracture across the big-end at right angles to the length of the connecting rod, this forms a unique mating surface between the connecting rod and the fractured end which is used as the big-end cap. The use of a fracture-split in the big-end of the connecting rod ensures a perfect match for assembly on the crankshaft bearing journals and provides the connecting rod with strong resistance to lateral movement.

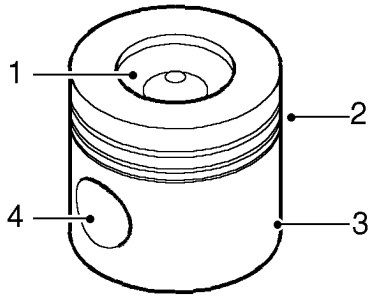
The end-cap fixing bolts are offset to ensure that the cap is fitted to the connecting rod in the correct orientation. If the end-cap is fitted incorrectly and the end-cap bolts tightened, the connecting rod must be replaced, since the matching serrations will have been damaged.

The big-end bearing shells are plain split halves without location tags. On EU2 models the two halves of the bearing shells are of different construction. The upper half bearing shell fitted to the connecting rod is treated using the sputtering process. The connecting rod bearing shell can be identified by having a slightly darker colouration than the end cap bearing shell and the back of the connecting rod bearing shell has a shinier finish than the front face.

On EU3 models both bearing shells are of the same construction as the connecting rod bearing shell.

The small-end of the connecting rod has a bushed solid eye which is free to move on the gudgeon pin, the bushing is a hand-push interference fit. The steel bushing has two slots machined in its upper surface for providing oil lubrication to the moving surface with the gudgeon pin. The oil slots must be correctly aligned to the oil slots provided in the small end of the connecting rod. The small-end lubrication is supplied by squirt feed from the piston lubrication jets.

Pistons



M12 4714

1 Bowl in piston head
2 Piston ring grooves
3 Graphite coated aluminium alloy skirt
4 Gudgeon pin bore

The five pistons have graphite-compound coated aluminium alloy skirts which are gravity die cast and machined. Each of the pistons has phosphated, shaped gudgeon pin bores and a swirl chamber (bowl-in-piston) machined in the head which partly contains the inlet air that is compressed during the combustion process and helps provide turbulence for efficient air/fuel mixture to promote complete combustion. The recesses in the piston's crown also provide clearance for the valve heads.

Pre EU3 and EU3 pistons are not interchangeable due to the EU3 piston combustion bowl being offset.

The pistons are attached to the small-end of the connecting rods by fully floating gudgeon pins which are retained in the piston gudgeon pin bushings by circlips.

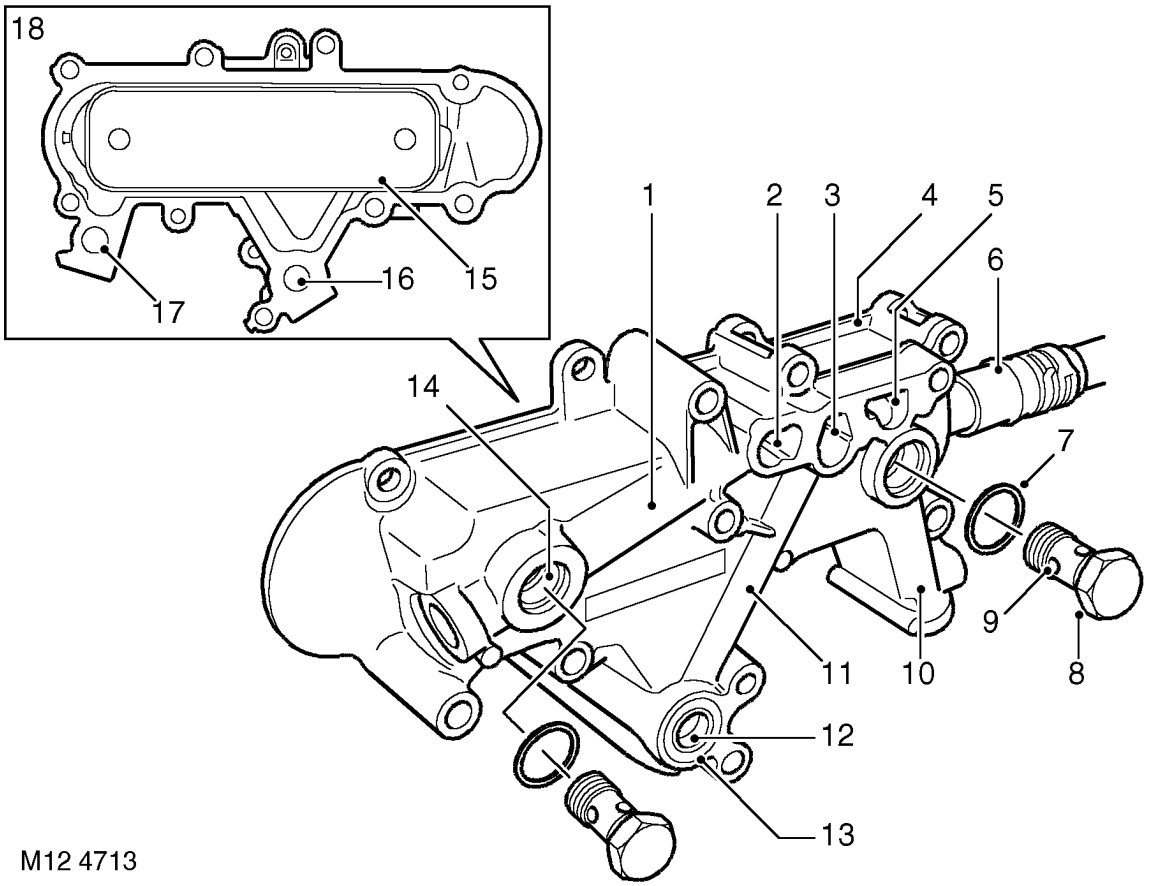
The pistons and gudgeon pins are gallery cooled, oil being supplied under pressure from the piston lubrication jets when the pistons are close to bottom dead centre.

Piston rings

Each piston is fitted with two compression rings and an oil control ring. The top compression ring is located in a steel insert ring carrier which helps to provide a minimal reaction to compression forces.

The top ring is barrel-edged and chrome-plated, the 2nd compression ring is taper-faced and the oil control ring is chrome-plated and features a bevelled ring with spring.

Oil cooler



M12 4713

1 Front oil gallery – full-flow filter to oil cooler matrix
2 Full-flow filter adaptor outlet port to oil cooler (open at >74° C)
3 Full-flow filter inlet port
4 Oil cooler housing
5 Full-flow filter outlet port to cylinder block
6 Coolant inlet port
7 Oil cooler banjo bolt seals (2 off)
8 Banjo bolts (2 off)
9 Banjo bolt oil holes – to oil cooler matrix
10 Rear oil gallery – full-flow filter/oil cooler outlet to cylinder block
11 Centre oil gallery – from pump to full-flow filter
12 Inlet port to centrifuge filter
13 Sealing ring – centrifuge filter housing to oil cooler housing
14 Port – oil cooler matrix
15 Oil cooler matrix
16 Inlet port from pump via cylinder block to oil cooler housing
17 Outlet port from oil cooler housing to cylinder block
18 Rear view of oil cooler housing

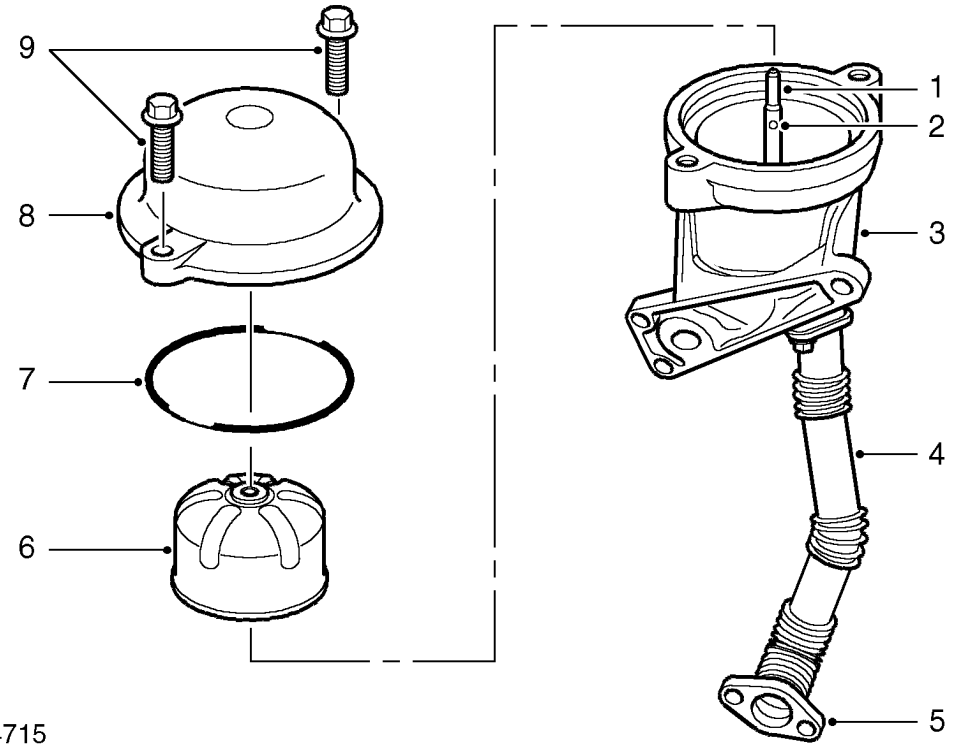
The engine oil cooler assembly is located on the left hand side of the engine block behind the oil centrifuge and oil filter. The housing is bolted to the engine block by seven bolts. A matrix is included in the oil cooler housing which acts as a heat exchanger. Coolant flow circulates through the oil cooler housing under pressure from the coolant pump and distributes the flow evenly around the matrix fins and then along the block into three core holes for cylinder cooling. Coolant enters the oil cooler through a pipe with a rubber hose extension at the rear side of the engine. The coolant hose is attached to the stub pipe of the oil cooler by a spring clip.

Oil drawn from the sump by the oil pump passes through the oil cooler via the cylinder block. The flow of coolant around the exterior surface of the oil cooler matrix cools a proportion of the engine oil flow as it passes through the oil cooler matrix.

The oil cooler is sealed to the cylinder block by a gasket which must be replaced every time the oil cooler housing is removed.

Oil filters

The Td5 engine features two types of oil filter; the main filter is a standard disposable cartridge-type full-flow oil filter which is augmented with a by-pass centrifuge filter used to filter out particulate matter having a diameter smaller than 15 micron but greater than 3 micron.



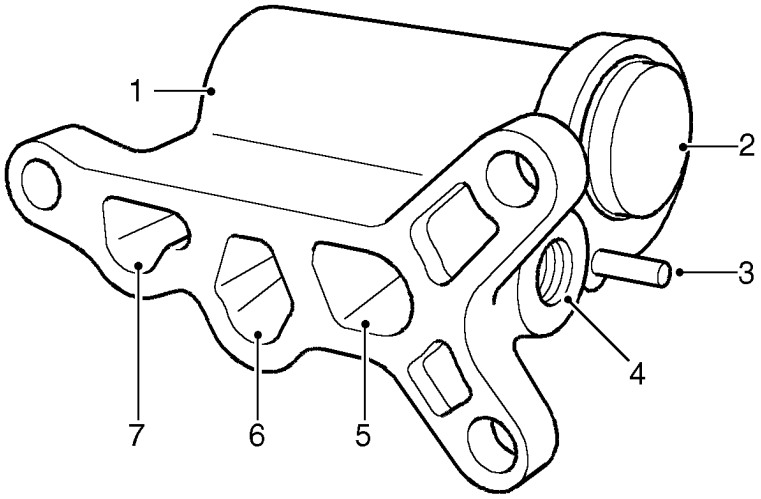
M12 4715

1 Centre spindle
2 Spindle oil holes (2 off)
3 Centrifuge filter housing
4 Centrifuge filter drain pipe
5 Port – centrifuge filter drain pipe to sump
6 Filter rotor
7 Internal seal
8 Cover
9 Cover bolts (2 off)

The centrifuge filter is located on the left hand side of the engine block by the exhaust manifold and is housed in a pot which is bolted to the oil cooler housing by means of three bolts. The pot contains a rotor located on a central spindle which spins at up to 15,000 revs/min. when oil is flowing through the unit under pressure. The rotor contains two fine holes drilled at obtuse angles which cause the rotor to spin about the centre spindle when high pressure oil is passing through it. The inner surface of the rotor captures carbon deposits and small particulate matter as it is thrown outwards under centrifugal force to form a sludge on the inner walls of the rotor. The unit is able to trap very fine impurities that build up in the oil that would be too small to filter using the normal paper-element type full-flow filters alone.

Approximately 10% of the total oil flow enters the centrifuge pot through a side port in the pot casting which is mated to an outlet port at the lower side of the oil cooler housing. A rubber O-ring sits in a recess around the oil cooler port which seals the faces between the centrifuge pot and oil cooler port, and it must be replaced every time the centrifuge assembly is removed. Oil leaves the centrifuge pot through a drain tube which is attached to the base of the pot by means of two fixing screws. The lower end of the drain tube returns oil to the sump and is fixed to the sump by means of two screws. Gaskets are included at the port interfaces between the oil drain tube and the centrifuge pot, and the oil drain tube and sump return port; these gaskets must be replaced every time the oil drain tube is removed.

The centrifuge cover is fixed to the pot by two screws and is sealed by an 'O'-ring.



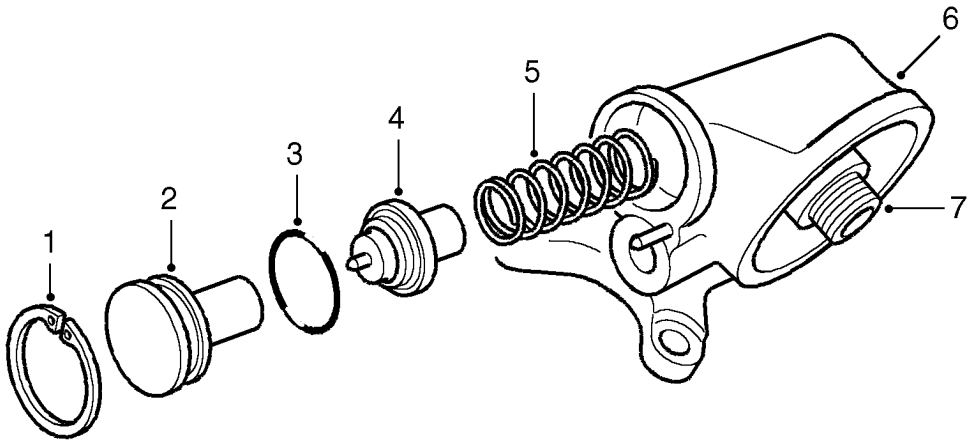
M12 4716

1 Full-flow filter housing
2 Thermostat
3 Roll-pin
4 Port – feed line to turbocharger
5 Outlet port from full-flow filter (> 74° C)
6 Inlet port to full-flow filter
7 Outlet port from full-flow filter (< 74° C)

The main filter is a conventional full-flow cartridge-type filter containing a paper element able to trap particles greater than 15 micron (0.015 mm) in diameter.

The cartridge is screwed to an adaptor casting by way of a hollow brass threaded insert which connects the filter outlet port to the adaptor casting. A sealing ring seals the union between the oil filter cartridge and the adaptor casting.

Oil filter housing thermostat



M12 4717

1 Circlip
2 Thermostat end cap
3 Oil seal
4 Thermostatic valve
5 Return spring
6 Oil filter housing
7 Threaded insert

The oil filter housing contains a thermostatically controlled valve to control the direction and proportion of oil flow through the oil cooler matrix. When the oil temperature is cool, the centre spindle of the thermostatic element is compressed. In this condition the valve completely seals the passage to the turbocharger feed tapping and flow is directed through the oil filter adaptor housing, passing from the outlet of the full-flow filter to the cylinder block via the rear oil return gallery in the oil cooler housing. A proportion of the oil flow from the right hand filter outlet port is passed through to the oil cooler matrix to supply the turbocharger oil feed line.

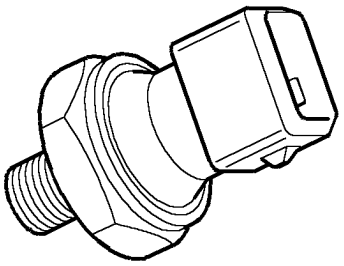
When the oil temperature rises, the heated wax in the thermostat causes the thermostat centre spindle to rise and push against the housing end cap, compressing the valve spring further and so opening the valve. In this condition oil flow from the outlet side of the full-flow filter is allowed to pass directly to the turbocharger oil feed line and reverses the flow through the oil cooler matrix, which now delivers a proportion of cooled oil flow to the cylinder block via the outlet port at the right hand side of the oil cooler housing.

The following table indicates approximate values for thermostat plunger travel against temperature:

Thermostat plunger travel mm (in.)	Oil temperature °C
0 (0)	< 74 °C
5 (0.20)	80 °C
12 (0.47)	90 °C
16 (0.63)	130 °C

The filter canister contains a by-pass valve which opens when the engine is cold or if the filter becomes blocked. The by-pass valve opens when a pressure drop of greater than 1.6 kg/cm_2 (157 kPa, 23 psi) is experienced.

Oil Pressure switch



M12 4718

The oil pressure switch is located in a port on the outlet side of the oil cooler housing. It detects when a safe operating pressure has been reached during engine starting and initiates the illumination of a warning light in the instrument pack if the pressure drops below a given value.

Crankshaft, sump and oil pump components
The crankshaft, sump and oil pump components are described below:

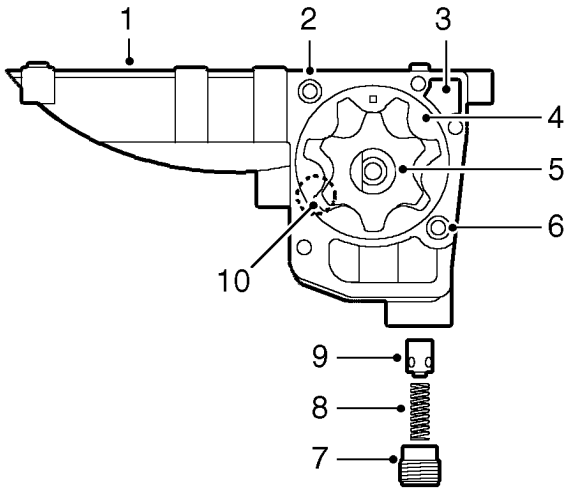
Sump
The sump is a wet-type, of aluminium construction and is sealed to the engine block by means of a rubber gasket and twenty fixing bolts. The four bolts at the gearbox end of the sump are longer than the other sixteen bolts.

The sump gasket incorporates compression limiters (integrated metal sleeves) at the bolt holes, which are included to prevent distortion of the gasket when the sump to cylinder block bolts are being tightened.

The oil drain plug is fitted at the bottom of the oil sump reservoir. An oil return drain pipe is also attached to the oil sump which returns oil from the centrifugal filter.

Stiffener Plate
The stiffener plate assembly provides lower engine block rigidity and utilises dowels to align it to the bottom of the cylinder block. A rotary oil pump is integral with the stiffener plate and an oil pick-up and strainer assembly is fitted to the underside of the stiffener plate. The stiffener and oil pump assembly is secured to the cylinder block by 22 bolts.

Oil pump



M12 4719

1 Stiffener plate
2 Ring dowel
3 Outlet port
4 Outer rotor
5 Inner rotor
6 Spring dowel
7 Oil pressure relief valve cap
8 Oil pressure relief valve spring
9 Oil pressure relief valve plunger
10 Inlet port

The eccentric rotor oil pump is integrated with the stiffener plate and contains no serviceable parts except for the pressure relief valve spring. The oil pump drive sprocket is attached to the front of the stiffener plate and is driven through a chain and sprocket system.

A pressure relief valve is included at the outlet side of the oil pump to restrict oil pressure at high engine speeds by recirculating oil through the relief valve back around the pump to the inlet. The relief valve and spring is a plunger type. When oil pressure is great enough to lift the plunger, oil is allowed to escape past the plunger to relieve pressure and prevent further rise.

Oil is delivered to the pump from the pick-up through a channel in the stiffener plate. The outlet side of the oil pump delivers pressurised oil flow to the engine block main oil delivery gallery through a port in the stiffener plate.

Piston lubrication jets

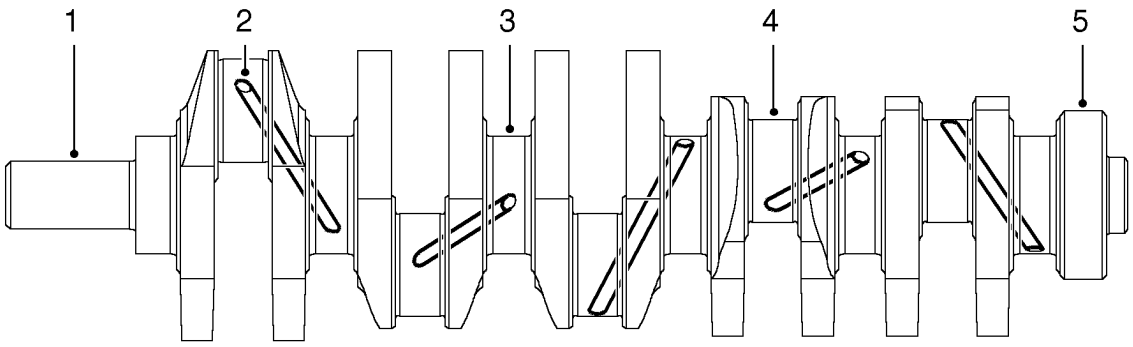
Piston lubrication jets are fitted to the cylinder block to provide lubrication to the cylinder walls, and to the piston underskirt for cooling the pistons and lubricating the gudgeon pins. The input port to each lubrication jet mates with a port provided in each mounting position tapped at the underside of the cylinder block from the main oil delivery gallery. When oil pressure is sufficient to supply flow through the jets, oil is squirted to the inside of the cylinder walls to provide piston to wall lubrication and cooling and to the underside of the piston skirt at the bottom of the piston stroke (gallery cooled piston). The squirt jets also provide splash feed lubrication supply to the small end bearings of the connecting rods.

Each lubrication jet is fixed to a mounting position on the underside of the engine block by a single Torx screw.

Chain lubrication jet

A chain lubrication jet is located on the front face of the cylinder block, behind the front engine timing chain cover. The inlet port to the lubrication jet mates with an oil supply port from the cylinder block main oil delivery gallery. The lubrication jet is fixed to the front of the engine block by a single screw. Additional chain lubrication is provided by oil supply through a small aperture tapped from the cylinder head oil delivery gallery.

Crankshaft



M12 4723

1 Front end to crankshaft sprocket
2 Oil supply cross-drillings
3 Main journals
4 Big-end journals
5 Rear end to flywheel

The crankshaft is constructed from cast iron and is surface-hardened. The areas between the crankshaft journals and the adjoining webs and balance weights are compressed using the cold roll process to form journal fillets.

Cross-drillings in the crankshaft between adjoining main and big-end bearings are used to divert lubrication oil to the big-end bearings.

A torsional vibration damper is attached to the crankshaft pulley by three bolts.

The crankshaft is carried in six main bearings, with end-float being controlled by thrust washers positioned on both sides of No. 3 main bearing.

Main bearings

There are six main bearings used to carry the crankshaft. Each of the bearing caps are of cast iron construction and are attached to the cylinder block by two bolts.

The bearing shells are of the split cylindrical type. The upper half bearing shells are grooved to facilitate the supply of lubrication oil to the bearings and fit into a recess in the underside of the cylinder block. The lower half bearing shells are smooth and fit into the bearing caps.

Steel-backed thrust washers are included at each side of No. 3 main bearing to control crankshaft end-float. One side of each of the thrust washers is grooved, the grooved side of each of the thrust washers is fitted facing outward from No. 3 main bearing.

Cylinder head components

The cylinder head components are described below:

Cylinder head

The cylinder head is of aluminium construction. It is not possible to reface the cylinder head if it becomes worn or damaged. An alloy camshaft carrier is bolted directly to the upper surface of the cylinder head. Two dowels are included in the cylinder head upper face for correct location of the camshaft carrier.

The EU3 cylinder head has a single internal fuel rail for delivering fuel to the injectors and an external fuel pipe for returning spill fuel back to the fuel connector block. Therefore, pre EU3 and EU3 model cylinder heads are not interchangeable.

CAUTION: The cylinder head incorporates drillings for the fuel injection system, any contamination which enters these drillings could cause engine running problems or injector failure. It is therefore, essential that absolute cleanliness is maintained when carrying out work on the cylinder head.

The camshaft carrier and cylinder head assembly is attached to the cylinder block by twelve cylinder head retaining bolts which pass through the camshaft carrier and the cylinder head to secure the assembly to the cylinder block.

CAUTION: The valve heads, tips of the injectors and glow plugs protrude below the face of the cylinder head and will be damaged if the cylinder head is stored face down.

The camshaft is located between the cylinder head and the camshaft carrier, and the bearing journals are line bored between the two components to form a matched pair.

CAUTION: Always fit plugs to open connections to prevent contamination.

The valve guides and valve seat inserts are sintered components which are interference fit to the cylinder head. The cylinder head machining also provide the locations for the electronic unit injectors, glow plugs, hydraulic lash adjusters, finger followers and low pressure fuel rail.

Cooling to the cylinder head is provided by coolant flow through a water jacket machined into the cylinder head. Drillings through the block provide lubrication channels for pressurised oil supply to cylinder head components such as the lash adjusters, finger followers, rocker arms and camshaft bearings.

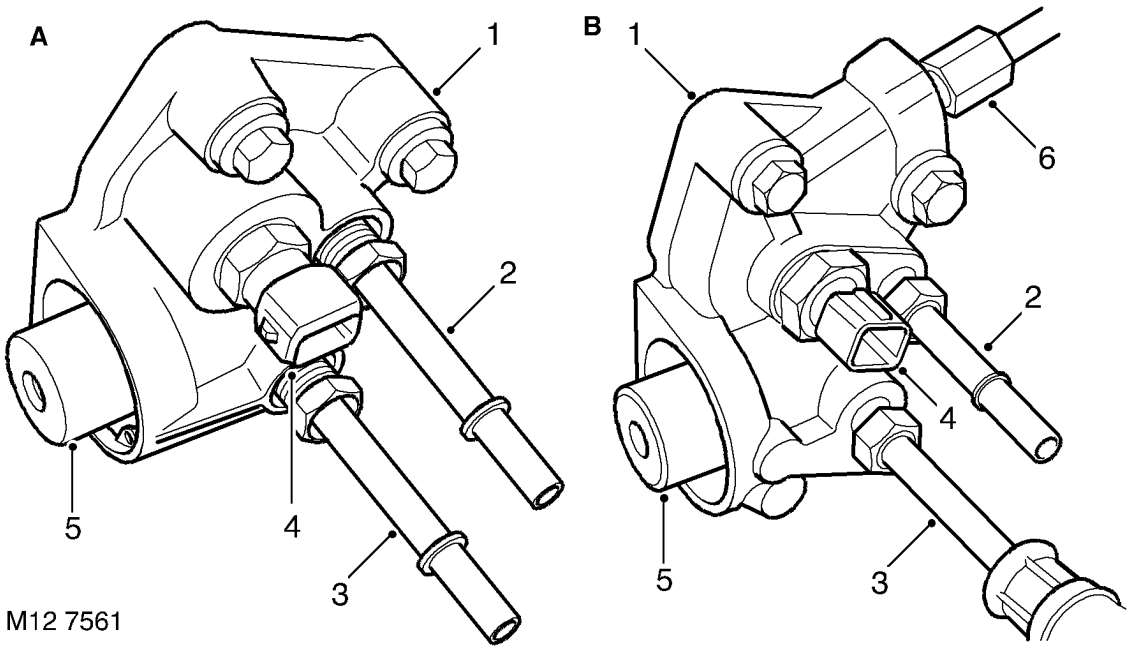
A coolant outlet elbow is fitted to the front LH side of the cylinder head to allow flow of coolant from the cylinder head back to the radiator. A metal gasket is used to seal the joint between the water outlet elbow and the cylinder head. A coolant temperature sensor is located in a port in the side of the water outlet elbow for monitoring coolant temperature.

A stub pipe is connected at the front RH side of the cylinder block above the timing cover which connects a pipe to supply oil to the vacuum pump. The timing chain tensioner adjuster is screwed in a thread in the cylinder head at a location on the front RH side of the engine below the oil feed port for the vacuum pump.

An access hole for the camshaft gear is included at the front of the cylinder head which is sealed with a plastic plug and rubber 'O'-ring. A press-fit core plug for the chain chest is located on the front face of the cylinder head.

A press-fit core plug for the cylinder head water jacket is located at the rear of the cylinder head and a threaded brass plug for the water jacket is located on the LH side of the cylinder head beneath the exhaust manifold assembly.

Fuel connector block



A = Pre EU3 models, B = EU3 models

1 Fuel connector block assembly
2 Outlet stub pipe
3 Stub pipe – to fuel cooler
4 Fuel temperature sensor
5 Fuel pressure regulator
6 Spill fuel return connection (EU3 models only)

A cast and machined alloy fuel connector block assembly is located at the rear RH side of the cylinder head, attached by three flanged bolts. A metal gasket is used to seal the faces between the fuel connector block and the cylinder head, which must be replaced every time the fuel connector block is removed.

CAUTION: The cylinder head incorporates drillings for the fuel injection system, any contamination which enters these drillings could cause engine running problems or injector failure. It is therefore, essential that absolute cleanliness is maintained when carrying out work on the cylinder head.

CAUTION: The valve heads, tips of the injectors and glow plugs protrude below the face of the cylinder head and will be damaged if the cylinder head is stored face down.

Camshaft carrier

The cast aluminium alloy camshaft carrier is bolted to the cylinder head by thirteen screws. The camshaft carrier and cylinder head assembly is attached to the cylinder block by twelve cylinder head retaining bolts which pass through the camshaft carrier and the cylinder head to secure the assembly to the cylinder block.

The carrier is machined together with the cylinder head to form a matched pair for carrying the camshaft.

Non-return valve

A non-return valve is located at the front, bottom LH side of the cylinder head. The non-return valve prevents oil from draining from the lash adjusters and is an integral component within the cylinder head and is non-serviceable.

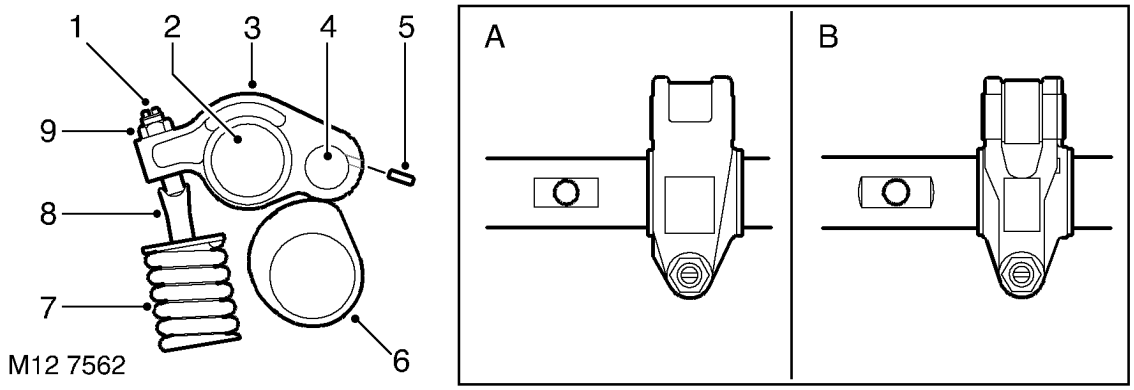
Camshaft

The camshaft is machined from cast steel and is located between the cylinder head and the camshaft carrier, and the six bearing journals are line bored between the two components to form a matched pair. The machined camshaft has 15 lobes. Ten lobes operate the inlet and exhaust valves through hydraulic lash adjusters and finger followers which are located below the camshaft. Five larger lobes activate the injector rockers which are located above the camshaft on the rocker shaft and are used to generate fuel pressure in the EUI injectors.

The camshaft is sprocket driven via a duplex chain connected to the crankshaft sprocket at a speed ratio of 2:1. The camshaft sprocket is fixed to the front end of the camshaft by three bolts.

Camshaft lubrication is splash and channel fed via pressurised oil flowing through galleries in the cylinder head.

Rocker shaft and Rocker Arms



A = Pre EU3 rocker arm, B = EU3 rocker arm

1 Rocker shaft
2 Rocker arm adjusting screw
3 Rocker arm
4 EUI pin and roller assembly
5 Roller pin retention slug
6 Camshaft lobe
7 Injector spring
8 Injector push-rod
9 Adjusting nut

The hollow rocker shaft is located in the camshaft carrier in six fixed mountings which sit above the camshaft. Six bolts are used to lock the rocker shaft to the camshaft carrier. The front rocker shaft bearing has a ring dowel located at the front rocker shaft mounting of the camshaft carrier for rocker shaft alignment. Two circlips hold each rocker arm in position at the relevant positions on the rocker shaft.

The rocker shaft from a pre EU3 model must not be fitted to an EU3 engine. This is because the stroke of the EU3 injector has increased which requires the rocker to articulate over a larger angle.

The camshaft end of each rocker arm features a roller which is free to rotate about a pin which passes through two webs in the rocker arm, the roller pins are held in place by an interference fit retention slug passing through a hole in the front web of each rocker arm.

To correctly function against the higher injection loads of the EU3 engine the geometry of the contact between the injector pushrod and rocker arm adjusting screw has been modified. Both designs of adjusting screw are separately available with the EU3 version being identified by an engraved dimple in the slotted end.

Rocker shaft and rocker arm lubrication is splash and channel fed via pressurised oil flowing through galleries in the cylinder head and through the rocker shaft.

Inlet and exhaust valves

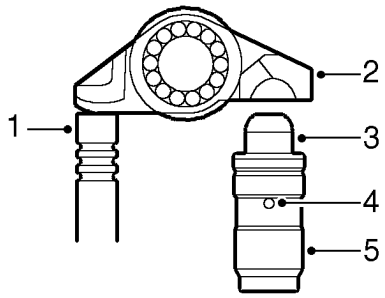
The inlet and exhaust valves are mounted directly above the engine block cylinders.

Each valve is a forged and ground solid one-piece head and stem which is hardened by heat treatment. The stems are chrome-plated then ground for improved heat transfer, wear resistance and smooth operation. It is not possible to recut the valve's face angle, but the valves can be lapped to their seats using grinding paste.

The valve springs are made from spring steel and are of the parallel single-coil type. The bottom end of the spring rests on the flange of a spring seal which has a centre bore that locates on a recess ground into the lower valve stem. The top end of the spring is held in place by a spring retainer which is held in position at the top end of the valve stem by split taper collets. The taper collets have grooves on the internal bore that locate to grooves ground into the upper stems of the valves.

The valve seats and valve guides are sintered and are interference fit into the cylinder head. The valve seats and guides are non-serviceable.

Finger followers and Lash adjusters



M12 4727

1 Valve stem
2 Finger follower
3 Lash adjuster plunger
4 Oil supply hole
5 Lash adjuster body

The valves are operated through finger followers and lash adjusters, actuated by the camshaft lobes. When the camshaft lobe presses down on the top of a finger follower roller mechanism, the respective valve is forced down opening the effected inlet or exhaust port.

The lash adjuster body contains a plunger and two chambers for oil feed and pressurised oil. Pressurised oil is supplied to the lash adjusters via the oil galleries in the cylinder head and through a hole in the side of the lash adjuster body. The oil passes into a feed chamber in the lash adjuster then through to a separate pressure chamber via a one way ball valve. Oil flow from the pressure chamber is determined by the amount of clearance between the lash adjuster outer body and the centre plunger, oil escapes up the side of the plunger every time the lash adjuster is operated, the downward pressure on the plunger forcing a corresponding amount of oil in the lash adjuster body to be displaced. When the downward pressure from the camshaft and finger follower is removed (i.e. after the trailing flank of the camshaft lobe has passed), oil pressure forces the lash adjuster's plunger up again. This pressure is not sufficient to affect the valve operation, but eliminates the clearance between the finger follower and top of the valve stem.

Camshaft cover and engine cover components
The camshaft cover and engine cover components are described below:

Camshaft cover
The camshaft cover is cast from aluminium alloy and is fixed to the camshaft carrier/cylinder head assembly by 13 bolts. The cover has spacers and sealing washers inserted into each of the thirteen bolt holes.

A breather hose is connected to a port at the top of the camshaft cover by means of a hose clip which vents crankcase gases back to the air intake via a breather valve in the air intake tract, located forward of the turbocharger in the flexible air intake duct.

A rubber seal is fitted between the camshaft cover.

An oil filler aperture is included in the top of the camshaft cover, which is sealed with a plastic cap with integral rubber seal.

Camshaft timing chain components
The timing chain cover and timing chain components are described below:

Timing chain cover
The timing chain cover is cast and machined aluminium alloy and is attached to the cylinder head by a bolt at the RH top of the cover and by a stud and nut at the LH top of the cover. Eight screws are used to attach the timing chain cover to the front of the engine block. The timing cover is located to the cylinder block front face by two dowels.

A viscous fan is attached to an idler pulley at the front of the engine block. The fan bearing is located on a shaft and held in place by a circlip and a bearing flange, the inner race of the fan bearing is an interference fit on the shaft. The fan idler pulley is attached to the bearing hub by three bolts, and the fan itself is secured to the pulley and bearing shaft by a left hand threaded nut.

☞ **COOLING SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

The front of the crankshaft passes through a hole in the lower part of the timing cover. An oil seal is pressed into a recess in the front of the timing cover to seal the interface between the front of the crankshaft and the timing cover.

A stub pipe is fitted to the front RH side of the timing cover which is used to attach the oil drain pipe from the vacuum pump by means of a hose and spring clip.

Timing chains
The timing chain between the camshaft and crankshaft sprockets is a duplex type, each chain having 56 links. The timing chain is contained between a fixed plastic guide and an hydraulically adjustable plastic tensioner arm which are attached to the front of the engine block.

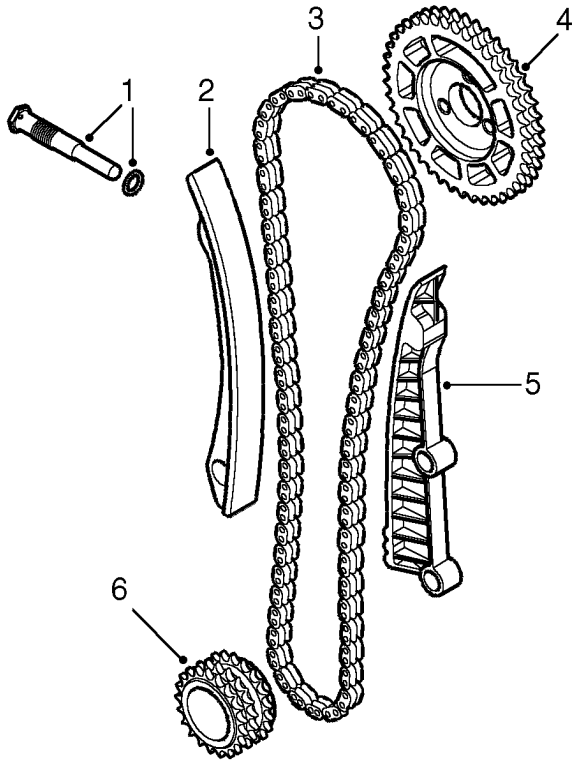
To cope with higher injection loads of the EU3 engine, the timing drive between the camshaft and crankshaft has been upgraded. This requires thicker chain links to be used, therefore, the individual pre EU3 and EU3 components are not interchangeable.

To distinguish between the two timing chains the links are different colours. A pre EU3 chain has blue links and a EU3 chain has bronze links.

The oil pump timing chain is a single type and traverses the oil pump sprocket and the rear crankshaft sprocket.

The timing chains are oil lubricated, with oil being provided by a chain lubrication jet and from oil flow returning back to the sump from the cylinder head. An oil hole is included at the front left hand side of the cylinder head which supplies oil from the cylinder head oil galleries.

Timing chain guides



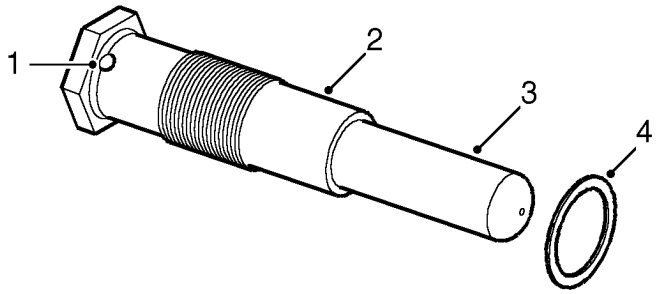
M12 4730

1 Hydraulic tensioner
2 Adjustable tensioner arm
3 Duplex timing chain
4 Camshaft sprocket
5 Fixed tensioner arm
6 Crankshaft sprocket

The crankshaft sprocket to camshaft sprocket timing chain is held taut by a tensioner arm acting on the slack side of the chain. The tensioner is automatically adjusted by means of an hydraulically operated tensioner adjuster. The drive side of the chain has a plastic guide attached to the front face of the cylinder block. The fixed guide is attached to the front of the engine block by two bolts. The tensioner arm is fixed to the front of the cylinder block by a single pivot bolt which allows the tensioner arm to pivot about its axis.

The adjustable tensioner arm is not interchangeable between pre EU3 and EU3 models due to a change in geometry on the EU3 version.

Tensioner adjuster



M12 4720A

1 Oil supply hole
2 Tensioner adjuster body
3 Tensioner adjuster plunger
4 Sealing ring

The tensioner adjuster is hydraulically operated, oil enters the adjuster from the pressurised oil supply flowing through the cylinder head to operate a plunger which pushes against a pivoting plastic tensioner arm. The lateral movement in the tensioner arm causes the timing chain to tension and consequently compensation for chain flutter and timing chain wear is automatically controlled. The adjuster is located at the front right hand side of the cylinder head, just above the timing chain cover and below the vacuum pump oil feed port. The adjuster body is threaded and screws into a tapping in the cylinder head. Holes are contained in the adjuster body to receive oil from the cylinder head galleries, the oil pressure is used to force the plunger out of the adjuster body to press the tensioner arm against the timing chain and so using the oil trapped in the adjuster body to perform as a damper.

The internal damping of the hydraulic tensioner is tuned for each application. This means that pre EU3 and EU3 components are not interchangeable.

Drive train sprockets

The camshaft sprocket has a double row of teeth which locate with the duplex timing chain. The sprocket is fitted to the camshaft by three bolts.

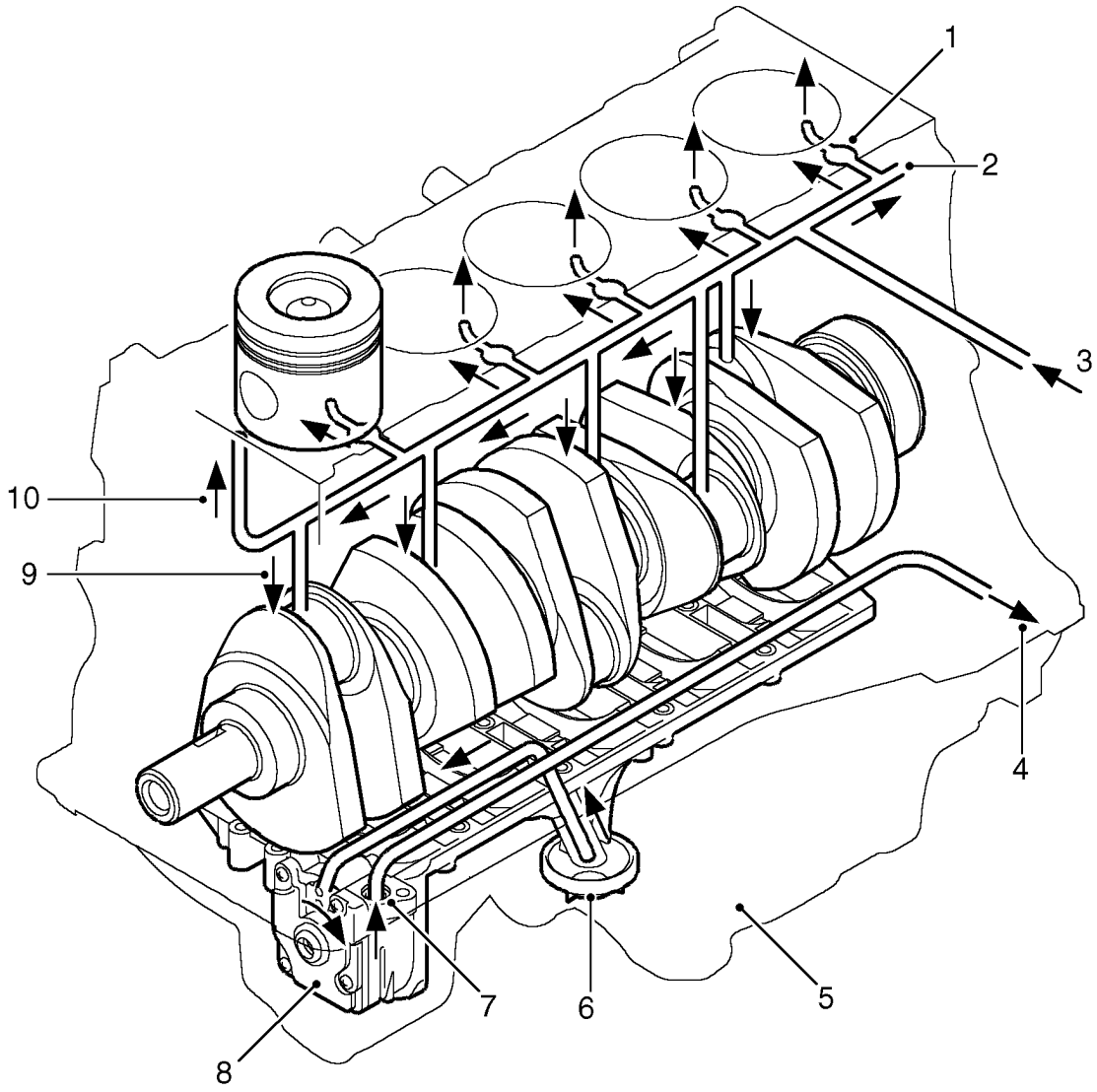
The oil pump sprocket is located on the front of the oil pump housing by a single retaining bolt. The sprocket has a single row of teeth which locates on the oil pump chain.

The crankshaft sprocket contains three rows of teeth, the rear row locates on the single oil pump chain and the front two rows locate with the duplex timing chain. The crankshaft sprocket has a slot in its internal diameter which locates with the Woodruff key on the crankshaft. The front of the crankshaft sprocket has a timing mark.

As a consequence of thicker chain links being used on EU3 models, the thickness of the camshaft and crankshaft sprocket teeth has been reduced. Individual pre EU3 and EU3 components are therefore not interchangeable.

Lubrication circuit

Cylinder block flow



M12 4728

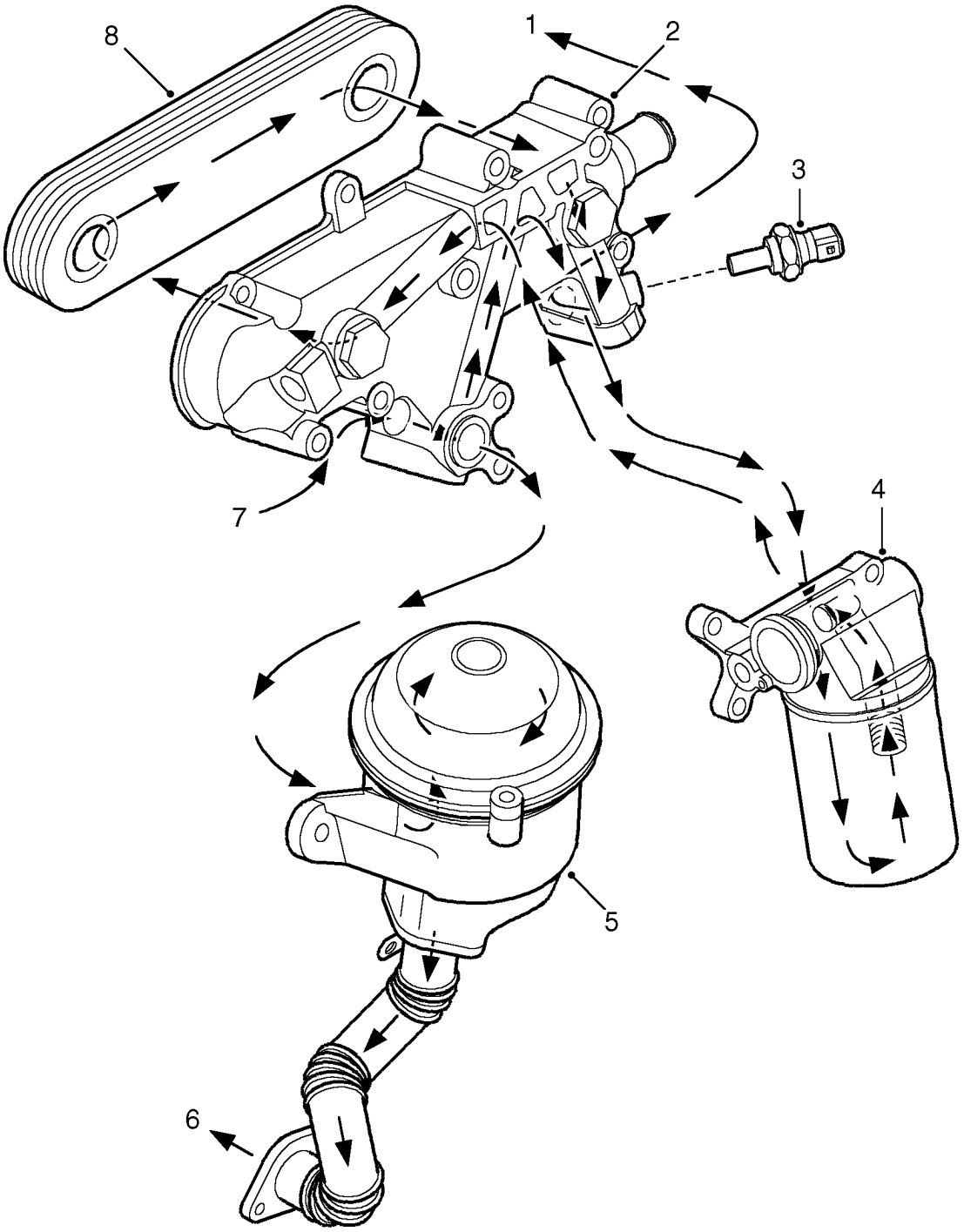
1 Oil squirt jets (5 off)
2 Main oil delivery gallery
3 Inflow from oil cooler housing
4 Flow to oil cooler / filters (from oil pump via cylinder block)
5 Sump
6 Oil pick-up pipe
7 Flow from oil pump (relief-valve in housing)
8 Oil pump
9 Cross-drilling supply to main and crankshaft bearings
10 To cylinder head

Oil from the sump is drawn up through a two-piece plastic pick-up which contains a mesh to siphon any relatively large pieces of material which could cause damage to the pump. The head of the pick-up is centrally immersed in the sump oil and oil is delivered to the inlet side of the eccentric rotor pump through a gallery in the stiffener plate.

Pressurised oil from the pump is passed through to the cylinder block where it is delivered to the centrifuge filter and full-flow filter via a port in the RH cylinder block which interfaces with a port in the centre gallery of the oil cooler housing. The oil pump contains an oil pressure relief valve which opens to allow oil to be recirculated back around the pump if the oil pressure increases to a high enough level.

10% of the oil flow from the pump is diverted through the centrifuge filter and returned to the sump via the centrifuge filter drain tube. The remaining 90% of the oil passes through the standard full-flow filter to the main oil gallery in the cylinder block.

Oil cooler / Filter flow (thermostat open)



M12 4729

1 To cylinder block main gallery (from rear of oil cooler housing)
2 Oil cooler housing
3 Oil pressure switch
4 Full-flow filter
5 Centrifuge filter
6 Return to sump
7 Flow from oil pump (via cylinder block)
8 Oil cooler matrix

When the engine temperature is below 74° C, the thermostat in the full-flow filter housing is closed and a proportion of the oil flow to the main oil gallery is diverted to the oil cooler to supply an oil feed to the turbocharger bearings. Oil passes through the oil cooler to the front gallery in the oil cooler housing where there is a tapping to connect the feed pipe to the turbocharger. Oil used by the turbocharger bearings is returned to the sump through an oil drain pipe which connects to a port in the LH side of the cylinder block.

The remainder of the oil flow leaving the full-flow filter outlet is passed into the cylinder block via a port at the rear of oil cooler rear gallery.

When the oil temperature rises above 74° C the thermostat in the full-flow filter adaptor housing begins to open to allow a proportion of the oil from the full-flow filter to pass through the oil cooler before it reaches the main oil gallery in the cylinder block. In this instance, oil supply to the turbocharger bearings is fed directly from the full-flow filter without first passing through the oil cooler. Between 74° C and 88° C the thermostat valve plunger opens by about 9mm to allow proportionally more oil to flow through the oil cooler before being passed to the cylinder block main oil delivery gallery. Above 88°C the thermostat valve continues to open by about 1mm for every 10° C increase in temperature until the valve is fully open, when all the oil flow to the cylinder block is forced to pass to the cylinder block via the oil cooler.

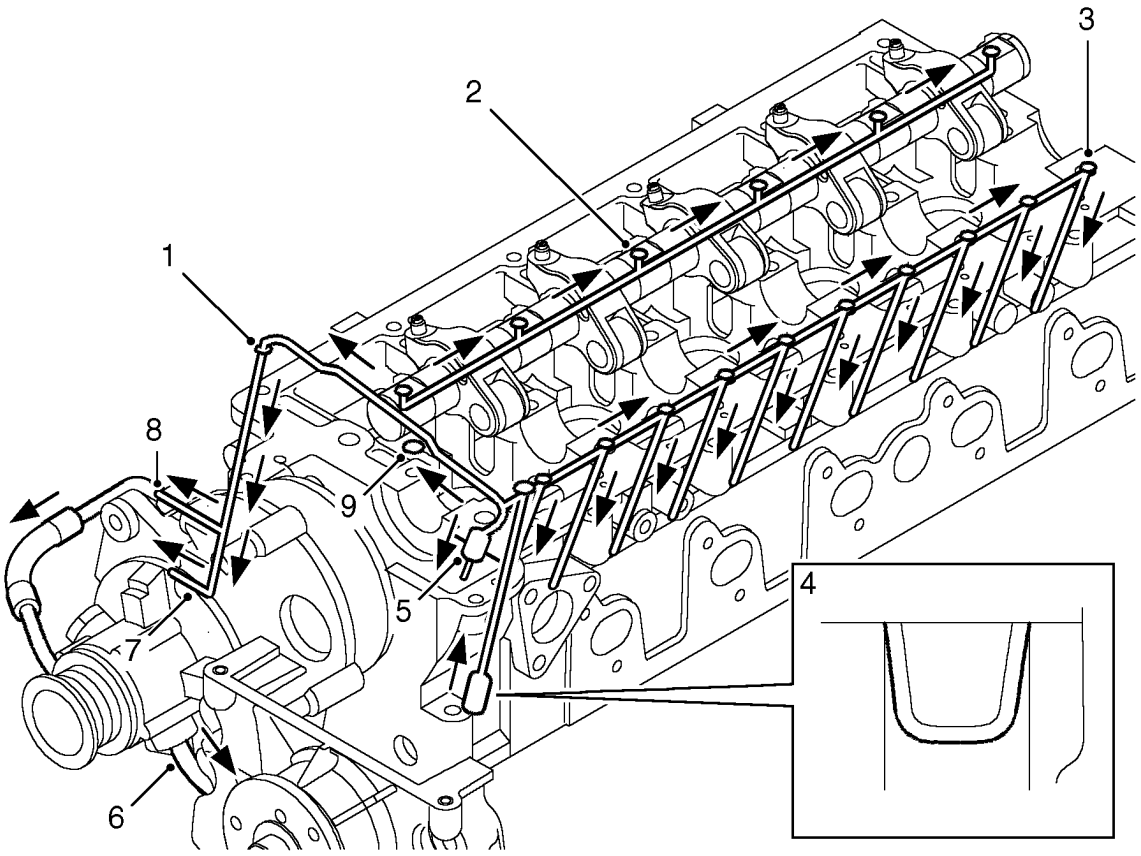
An oil pressure switch is located in a port in the rear gallery of the oil cooler housing to sense the oil pressure level before flow enters the main oil gallery in the engine block. A warning lamp in the instrument cluster is switched on if the oil pressure is detected as being too low.

☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

Drillings from the cylinder block main oil gallery direct oil to the crankshaft main bearings and cross drillings in the crankshaft direct oil to the big-end bearings. An additional five drillings in the cylinder block supply oil at reduced pressure to the oil squirt jets for piston cooling and gudgeon pin lubrication.

Oil supply from the cylinder block is then passed to the cylinder head galleries through a non-return valve which is included as an integral item in the lower face of the cylinder head.

Cylinder head flow



M12 4731

1 Cast-in groove between cylinder head and camshaft carrier
2 Rocker shaft flow
3 Lash adjuster supply channels (10 off)
4 Non-return valve
5 Chain lubrication jet supply
6 Oil return from vacuum pump
7 Oil supply to timing chain tensioner adjuster
8 Oil supply to vacuum pump
9 Oil supply hole to camshaft sprocket and timing chain

Oil passes to the cylinder head from the cylinder block via a non-return valve which is included to prevent oil draining away from the lash adjusters when the engine is switched off.

Oil is passed to a cast-in groove between the top of the cylinder head and the camshaft carrier. The part of the channel on the top left hand side of the cylinder head has ten cross-drillings which supply oil to the hydraulic lash adjusters and finger followers. Lubrication oil fed to the lash adjusters passes up through the lash adjuster body and into the socket of the finger followers. The oil exits the finger followers through a small hole to lubricate the surfaces between the camshaft lobes and rollers.

An additional tapping is included at the front left hand side of the cylinder head to supply oil to the chain lubrication jet, and a through hole near the front centre of the cylinder head allows a passage of oil through from the cast-in groove to lubricate the timing chain and camshaft sprocket.

At the centre front of the cylinder head, the cast-in groove channels oil into the rockershaft via the front rockershaft fixing. Oil flow through the rockershaft and clearance around the rockershaft fixings provides oil feed to the camshaft bearings.

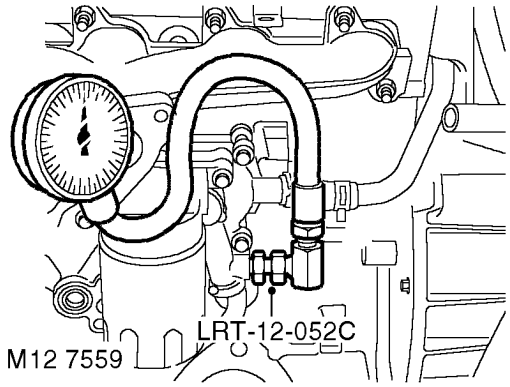
A tapping towards the right hand side of the cylinder head diverts oil supply from the cast-in groove down to a stub pipe which attaches to a feed line to the vacuum pump. An hydraulic tensioner is located below the vacuum stub pipe which receives oil through a small hole in the side of the tensioner body to force a plunger against a plastic faced adjuster shoe for timing chain tensioning. Oil from the vacuum pump is returned to a port in the timing chain cover via a short hose which connects to stub pipes at both ends using spring clips.

Engine oil pressure check

12.90.09.01

Check

1. Remove oil pressure switch.
   ENGINE - Td5, REPAIRS, Switch - oil pressure.



2. Connect pressure check kit **LRT-12-052C** adaptor and gauge to oil pressure switch position on oil cooler.
3. Check and if necessary top up engine oil.
4. Run engine at idle speed and check that oil pressure is within limits given.
   GENERAL DATA, Engine - Td5.
5. Switch off ignition.
6. Remove pressure check kit **LRT-12-052C**.
7. Clean oil spillage.
8. Fit oil pressure switch.
   ENGINE - Td5, REPAIRS, Switch - oil pressure.

Adjust

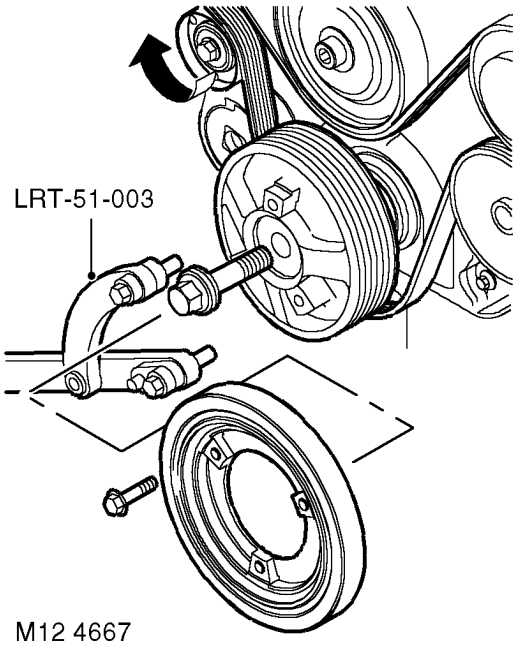
1. If engine oil pressure is outside of specified limits, check condition of oil pump and/or main and connecting rod bearings.

Pulley - crankshaft

12.21.01

Remove

1. Remove fixings and underbelly panel.
2. Remove radiator.
   COOLING SYSTEM - Td5, REPAIRS, Radiator.

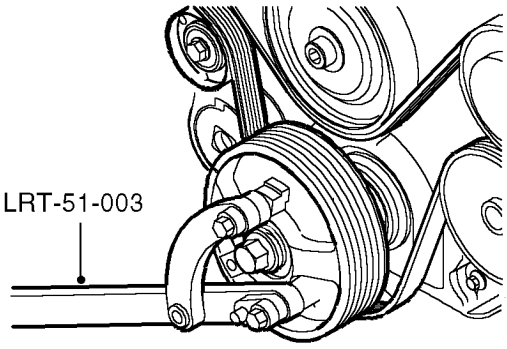


M12 4667

3. Using a 15 mm ring spanner, release the auxiliary drive belt tensioner.
4. Remove auxiliary drive belt.
5. Remove 3 bolts and remove crankshaft TV damper.
6. Position tool **LRT-51-003** to crankshaft pulley and secure with 2 bolts.
7. Remove and discard crankshaft pulley bolt. Remove crankshaft pulley.
8. Remove 2 bolts and remove tool **LRT-51-003**

Refit

1. Position new crankshaft pulley to vice.
2. Remove 3 bolts and remove TV damper from new crankshaft pulley.
3. Using a lint free cloth, thoroughly clean oil seal recess and the running surface on crankshaft pulley.
4. Fit crankshaft pulley.



M12 4668

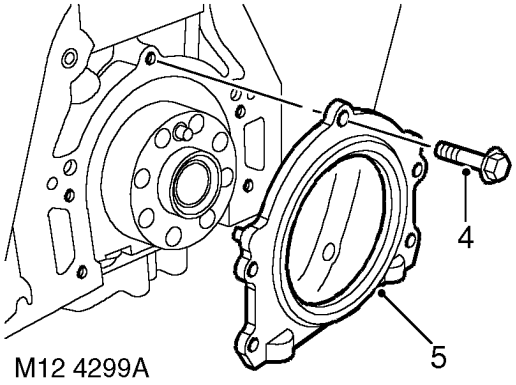
5. Fit tool **LRT-51-003** to crankshaft pulley and secure with 2 bolts.
6. Fit new crankshaft pulley bolt and tighten to 460 Nm (340 lbf.ft), using a torque multiplier.
7. Remove 2 bolts and remove tool **LRT-51-003** from crankshaft pulley.
8. Fit TV damper to crankshaft pulley and tighten – TV damper bolts to 80 Nm (59 lbf.ft) .
9. Fit auxiliary drive belt to pulleys.
10. Fit radiator.
    COOLING SYSTEM - Td5, REPAIRS, Radiator.
11. Fit underbelly panel and secure with fixings.

Seal - crankshaft - rear

12.21.20

Remove

1. **Automatic models:** Remove drive plate
   ☞ **ENGINE - Td5, REPAIRS, Plate - drive - automatic.**
2. **Manual models:** Remove flywheel.
   ☞ **ENGINE - Td5, REPAIRS, Flywheel.**
3. Remove sump gasket.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - sump.**

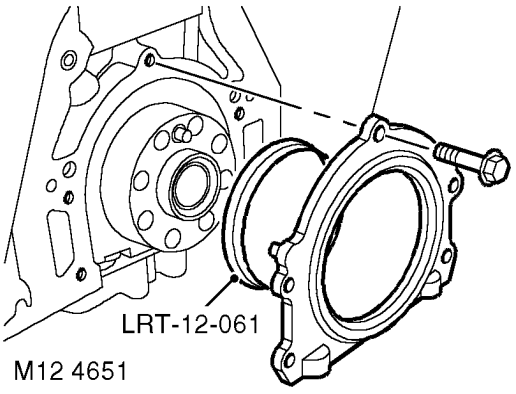


M12 4299A

4. Remove 5 bolts securing crankshaft oil seal housing to cylinder block.
5. Remove crankshaft oil seal housing.

Refit

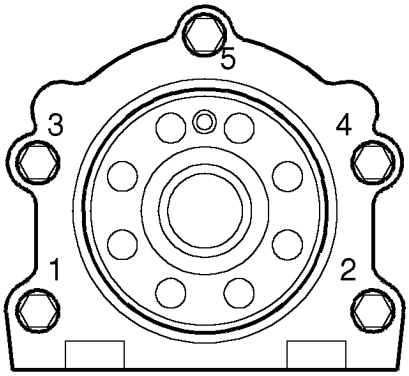
1. Clean interface between crankshaft oil seal housing and cylinder block.



M12 4651

2. Position seal protector, **LRT-12-061** over crankshaft boss. Fit new seal and remove tool **LRT-12-061** .

CAUTION: Oil seal must be fitted dry.



M12 7339

3. Fit crankshaft rear oil seal housing bolts and using sequence shown, tighten to 9 Nm (7 lbf.ft).
4. Fit new sump gasket.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - sump.**
5. **Automatic models:** Fit drive plate
   ☞ **ENGINE - Td5, REPAIRS, Plate - drive - automatic.**
6. **Manual models:** Fit flywheel.
   ☞ **ENGINE - Td5, REPAIRS, Flywheel.**

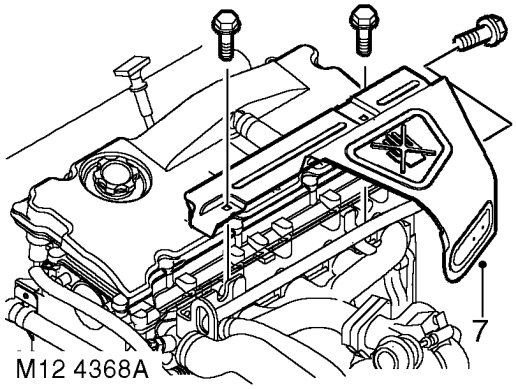
Gasket - cylinder head

12.29.02

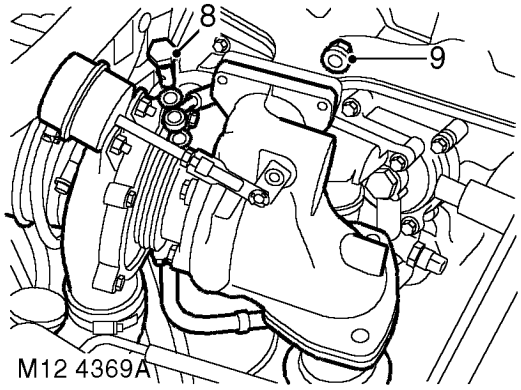
Remove

Note: The following procedures cover engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.

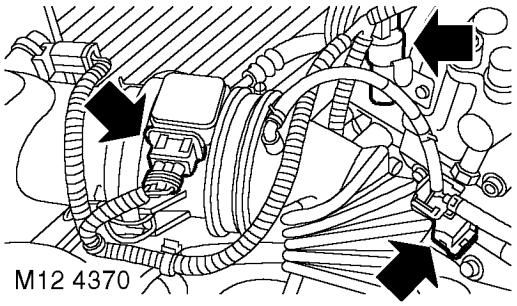
1. Remove bonnet.
   EXTERIOR FITTINGS, REPAIRS, Bonnet.
2. Release turnbuckles and remove battery cover.
3. Disconnect battery earth lead.
4. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
5. Remove camshaft cover gasket.
   ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.
6. Remove cooling fan coupling.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.



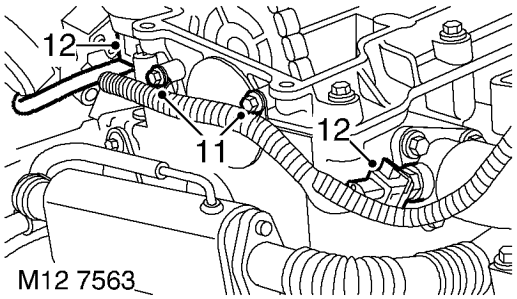
7. Remove 3 bolts and remove exhaust manifold heat shield.



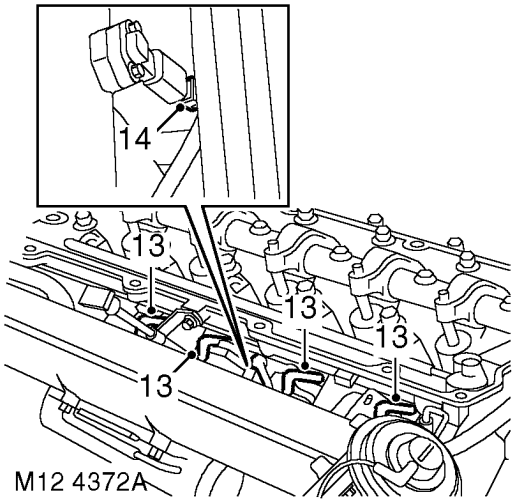
8. Remove turbocharger oil feed banjo bolt and discard sealing washers.
9. Remove 3 nuts, release turbocharger from exhaust manifold, discard gasket and tie turbocharger aside.



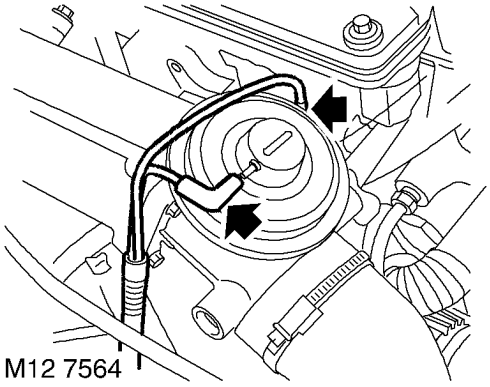
10. Disconnect multiplugs from compressor, MAF sensor, turbocharger wastegate modulator, and AAP & IAT sensor.



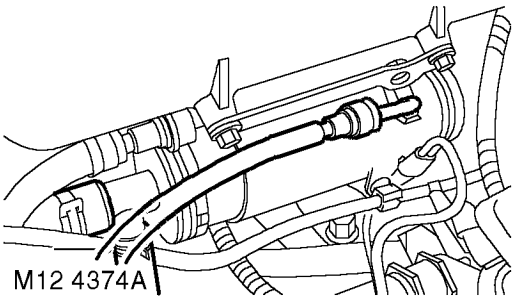
11. Remove 2 bolts securing engine harness to camshaft carrier.
12. Disconnect multiplug from EUI's and coolant temperature sensor.



13. Disconnect 4 glow plug connectors.
14. Disconnect MAP sensor multiplug from inlet manifold.



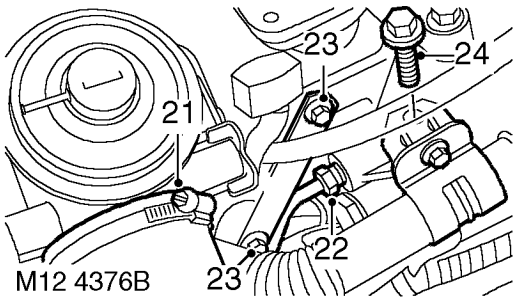
15. Position engine harness clear of inlet manifold.
16. Disconnect vacuum hose from EGR valve.



17. Release 3 clips and disconnect coolant hoses from fuel cooler.
18. Disconnect fuel hoses, tank to fuel cooler and connector block on cylinder head.

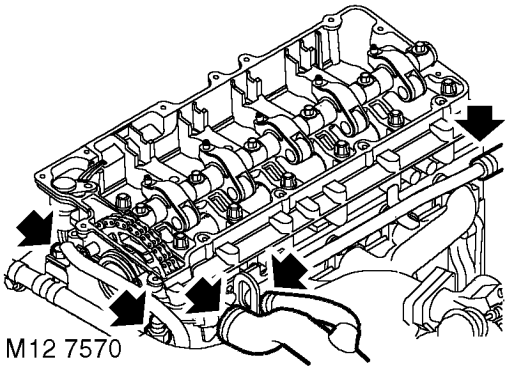
CAUTION: Always fit plugs to open connections to prevent contamination.

19. Disconnect fuel hose from connector block on cylinder head.
20. Disconnect fuel hose from fuel cooler and secure to connector block on cylinder head. **This is to prevent contamination of the fuel injection system.**



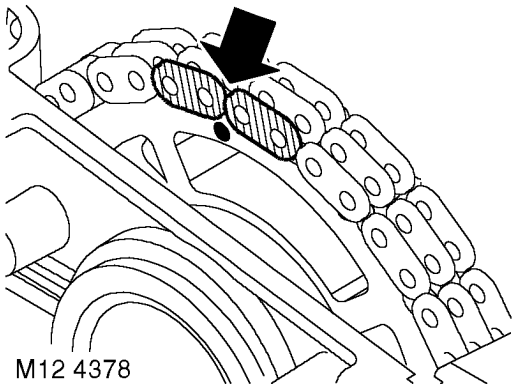
Pre EU3 model shown

21. Loosen clip screw and disconnect air intake hose from EGR valve.
22. Loosen vacuum pump oil feed pipe union from cylinder head and discard 'O' ring.
23. Loosen 2 bolts and release alternator support bracket from cylinder head.
24. **Pre EU3 model:** Remove bolt securing EGR valve pipe clamp to cylinder head.
25. **EU3 model:** Release the clips and disconnect the coolant hoses from the EGR cooler.

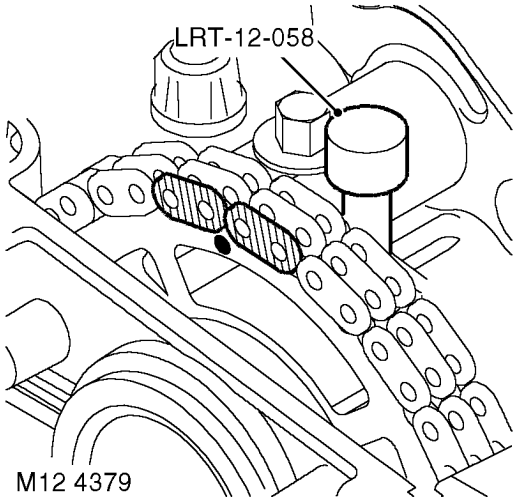


26. Remove nut and bolt securing cylinder head to timing chain cover.
27. Release clips and disconnect top hose, heater hose and heater feed hose.
28. Raise front of vehicle.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

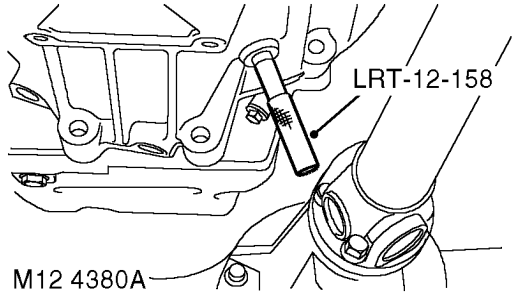

M12 4378

29. Rotate engine clockwise to align mark on camshaft sprocket between coloured links on timing chain.



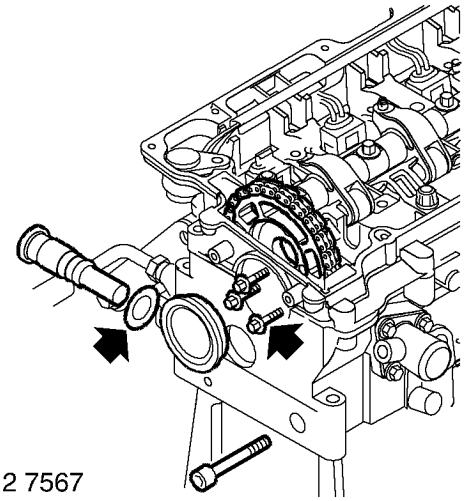
M12 4379

30. Position tool **LRT-12-058** through camshaft carrier to lock camshaft.



M12 4380A

31. Position tool **LRT-12-158** through gearbox bell housing to lock crankshaft.

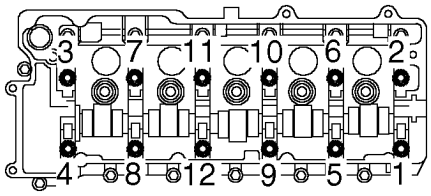

M12 7567

32. Remove timing chain tensioner and discard sealing washer.

33. Remove timing chain fixed guide Allen screw from front of cylinder head.

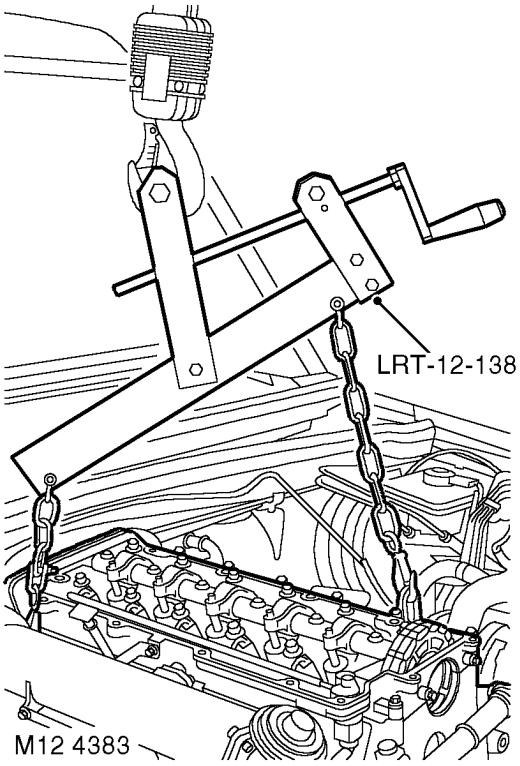
34. Lever out camshaft sprocket blanking plug and 'O'-ring seal from front of cylinder head and discard.

35. Remove 3 bolts and release timing sprocket from camshaft. Discard bolts.



M12 7343

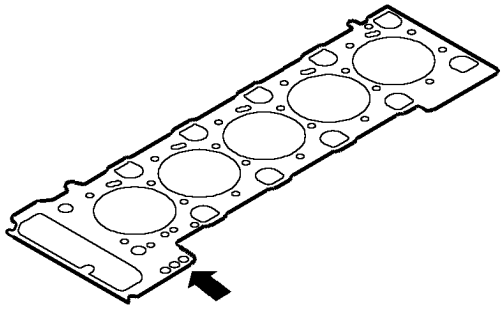
36. Using sequence shown, progressively loosen then remove and discard 12 cylinder head bolts together with their captive washers.



37. Using suitable lifting chains and tool **LRT-12-138** carefully remove cylinder head and place on wooden blocks or stands.

CAUTION: Support both ends of cylinder head on blocks of wood. With the camshaft carrier bolted down, the injector nozzles and some of the valves will protrude from the face of the cylinder head.

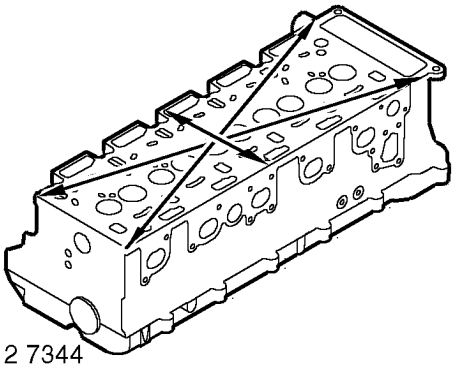
38. Remove cylinder head gasket.


M12 7548

39. Note the gasket thickness indicator and ensure the same thickness gasket is used on refitment of cylinder head.
40. Remove and discard plastic dowels from cylinder block.

Refit

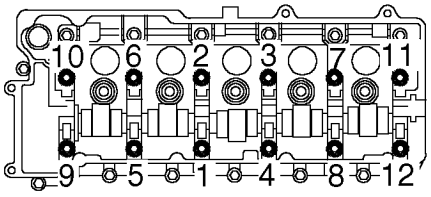
1. Clean mating faces of cylinder head and cylinder block.


M12 7344

2. Check cylinder head for warping, across centre and from corner to corner: – Maximum warp = 0.10 mm (0.0004 in)

CAUTION: Cylinder heads may not be refaced, replace cylinder head if warping exceeds figure given.

3. Ensure coolant and oil passages are clean.
4. Clean dowel holes and fit new plastic dowels.
5. Lightly lubricate threads and beneath heads of cylinder head bolts with clean engine oil.
6. Fit new cylinder head gasket of the correct thickness with the word 'TOP' uppermost.
7. Using assistance, fit cylinder head and locate onto dowels.
8. Carefully enter cylinder head bolts, **DO NOT DROP.** Lightly tighten bolts.



M12 4384

9. Using the sequence shown, progressively tighten cylinder head bolts to 30 Nm (22 lbf.ft), then to 65 Nm (48 lbf.ft), then a further 90°, then a further 180° and finally a further 45°.

CAUTION: Ensure correct sequence is followed for all 5 tightening stages. Do not tighten bolts 315 degrees in one operation.

10. Fit nut and bolt securing cylinder head to timing chain cover and tighten to 25 Nm (18 lbf.ft).

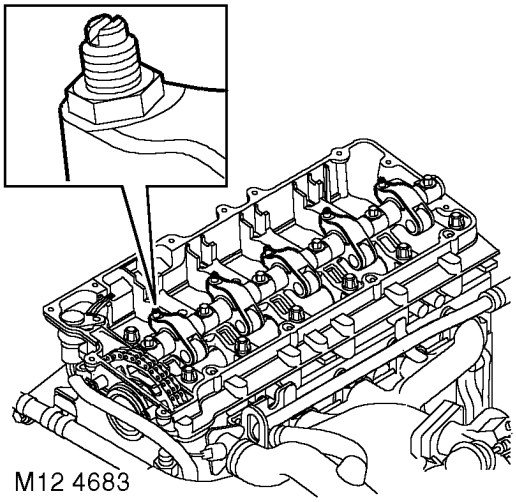
11. Clean camshaft sprocket and mating face on camshaft.
12. Ensure engine is set to TDC No. 1 cylinder and mark on camshaft sprocket is positioned between the 2 coloured links.
13. Position camshaft sprocket to camshaft; fit and lightly tighten new bolts, then loosen bolts half a turn.
14. Clean timing chain fixed guide retaining pin and apply Loctite 242 to threads.
15. Fit timing chain fixed guide retaining pin and tighten to 25 Nm (18 lbf.ft) .
16. Clean timing chain tensioner and fit new sealing washer.
17. Fit timing chain tensioner and tighten to 45 Nm (22 lbf.ft).
18. Tighten bolts securing camshaft sprocket to camshaft to 37 Nm (27 lbf.ft).
19. Remove tool **LRT-12-058** from camshaft.
20. Remove tool **LRT-12-158** from gearbox bell housing.
21. Fit new camshaft bore blanking plug and 'O'-ring seal in recess in cylinder head.
22. Clean vacuum pump union.
23. Tighten union securing vacuum pump oil feed pipe to cylinder head to 10 Nm (7 lbf.ft) .
24. Fit bolts securing alternator support bracket to cylinder head and tighten to 25 Nm (18 lbf.ft) .
25. Connect top hose and heater hoses and secure with clips.
26. **Pre EU3 model:**Fit bolt securing EGR pipe clamp to cylinder head bolt and tighten to 10 Nm (7 lbf.ft) .
27. **EU3 model:** Connect coolant hoses to EGR cooler and secure with the clips.
28. Position air intake hose to EGR valve and tighten clip screw.
29. Disconnect fuel hose from connector block and connect to fuel cooler.
30. Connect fuel hoses to fuel cooler and connector block on cylinder head.
31. Connect coolant hoses to fuel cooler and secure clips.
32. Connect vacuum hose to EGR valve.
33. Position engine harness and connect multi plugs and glow plug connectors.
34. Fit and tighten bolts, engine harness to camshaft carrier.
35. Clean exhaust manifold and turbocharger interface.
36. Fit new gasket to exhaust manifold, position turbocharger and tighten – nuts securing turbocharger to manifold to 30 Nm (22 lbf.ft).
37. Clean turbocharger oil feed hose bolt.
38. Position turbocharger oil feed hose using new sealing washers. Fit banjo bolt securing turbocharger oil feed hose and tighten to 25 Nm (18 lbf.ft) .
39. Position exhaust manifold heatshield and tighten M6 bolts to 9 Nm (7 lbf.ft) and M8 bolt to 25 Nm (18 lbf.ft).
40. Fit cooling fan coupling.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**
41. Fit camshaft cover with new seal.
    ☞ **ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.**
42. Refill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
43. Connect battery earth lead.
44. Fit battery cover and secure fixings.
45. Fit bonnet.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bonnet.**

Rocker shaft assembly

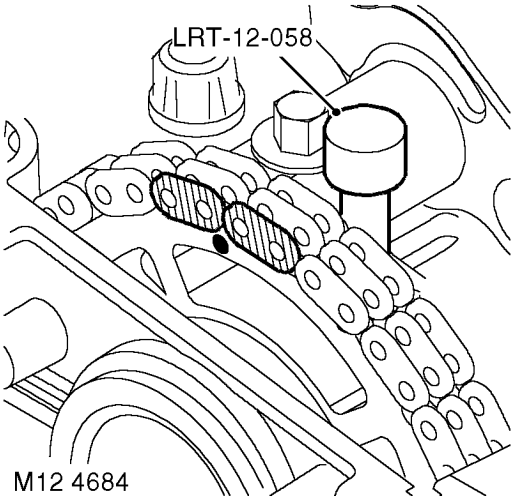
12.29.29

Remove

1. Remove cooling fan.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
2. Remove camshaft cover gasket.
   ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.

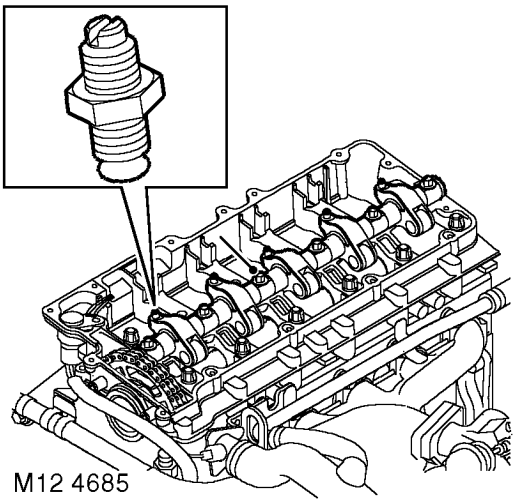

M12 4683

3. Loosen lock nuts and fully retract rocker adjusting screws to prevent damage on reassembly.



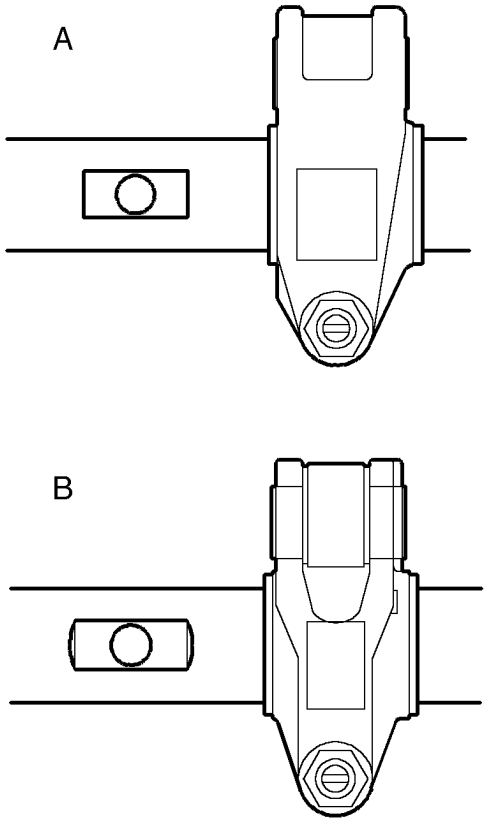
M12 4684

4. Rotate engine clockwise, until camshaft sprocket and timing chain marks are aligned and fit tool **LRT-12-058** through camshaft carrier to lock camshaft.


M12 4685

5. Progressively loosen then remove and discard 6 bolts securing rocker shaft assembly.
6. Remove and discard lock nuts and rocker adjusting screws.

Refit



M12 7558

1. Clean rocker shaft and mating faces.
   CAUTION: If rockers or rocker shaft are to be replaced, ensure replacements are correct. Engine Serial No. Prefixes 10P to 14P are fitted with type A rocker arms and shaft. Engine Serial No. Prefixes 15P to 19P are fitted with type B rocker arms and shaft. Type B rocker arms and shaft may be fitted to Engine Serial No. Prefixes 10P to 14P as an assembly.

2. Fit new rocker adjusting screws fully into rocker arm. Fit new lock nuts to screws but do not tighten.
   CAUTION: Ensure screws are correct for type of rocker arms fitted. Replacement screws for Engine Serial No. Prefixes 15P to 19P have a centre punch mark adjacent to the adjusting slot. These screws are not interchangeable with those fitted to Engine Serial No. Prefixes 10P to 14P.

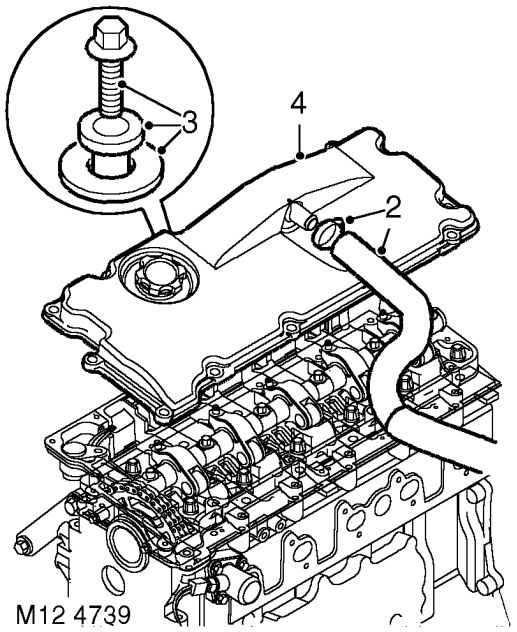
3. Fit rocker shaft ensuring it is located on dowel.
4. Fit and progressively tighten new rocker shaft bolts to 33 Nm (24 lbf.ft).
5. Before refitting the camshaft cover the electronic injection unit (EUI) rockers must be adjusted.
6. Remove tool **LRT-12-058** from camshaft.
7. Rotate engine clockwise until No 1 injector lobe is at full lift.
8. Rotate rocker adjusting screw clockwise until the injector plunger is felt to bottom out.
9. Rotate rocker adjusting screw anti-clockwise one complete turn to give plunger the required bump clearance and tighten rocker arm adjusting screw locknut to 16 Nm (12 lbf.ft) .
   CAUTION: Ensure screw does not turn as locknut is tightened.
10. Carry out above procedure for the remaining 4 rocker arms.
11. After completion of rocker arm adjustment, slowly rotate engine clockwise 2 complete turns by hand to ensure that no injectors are bottoming out on their plungers.
12. Fit camshaft cover gasket.
    ☞ **ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.**
13. Fit cooling fan coupling.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**

Gasket - cover - camshaft

12.29.40

Remove

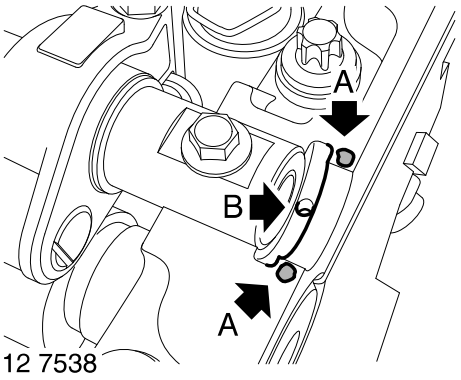
1. Remove 3 bolts and remove engine acoustic cover.



2. Release clip and disconnect breather hose from camshaft cover.
3. Remove 13 bolts securing camshaft cover.
4. Collect sealing washers and spacers.
5. Remove camshaft cover and gasket.

Refit

1. Clean camshaft cover and mating face.
2. Renew sealing washers and spacers as necessary.



3. **Not EU3 model:-** Apply two 3 mm diameter beads of sealant, STC 5433, to areas 'A' shown on illustration.

   Excessive use of sealant could result in blockage of oil drain hole, arrowed 'B' on illustration.

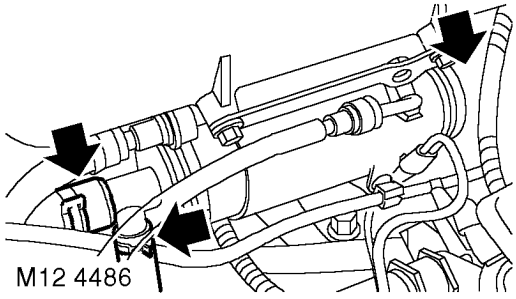
4. Fit new gasket, fit camshaft cover to camshaft carrier and tighten – camshaft cover bolts to 9 Nm (7 lbf.ft).
5. Position breather hose to camshaft cover and secure with clip.
6. Fit engine acoustic cover and secure with fixings.

Engine and ancillaries

12.41.01

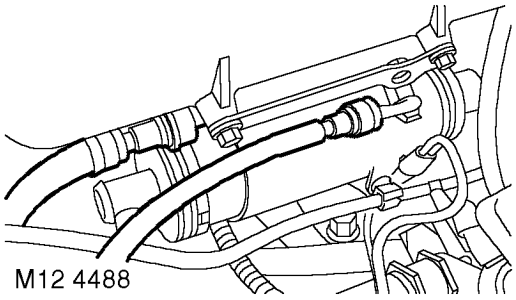
Remove

1. Remove bonnet.
   EXTERIOR FITTINGS, REPAIRS, Bonnet.
2. Remove underbelly panel.
   EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.
3. Drain engine oil.
   MAINTENANCE, PROCEDURES, Engine oil - diesel engine.
4. Remove radiator.
   COOLING SYSTEM - Td5, REPAIRS, Radiator.
5. Remove turbocharger.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.



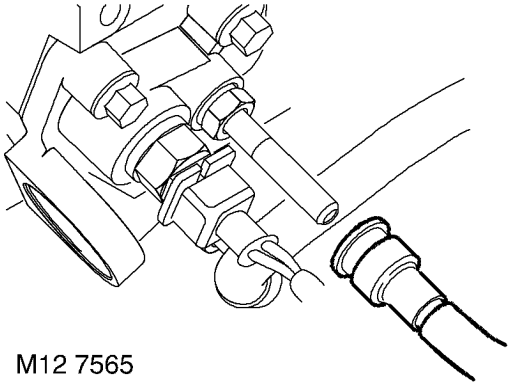
M12 4486

6. Release clips and disconnect heater hoses from fuel cooler and coolant rail.
7. Release clip and disconnect expansion tank coolant hose from fuel cooler.



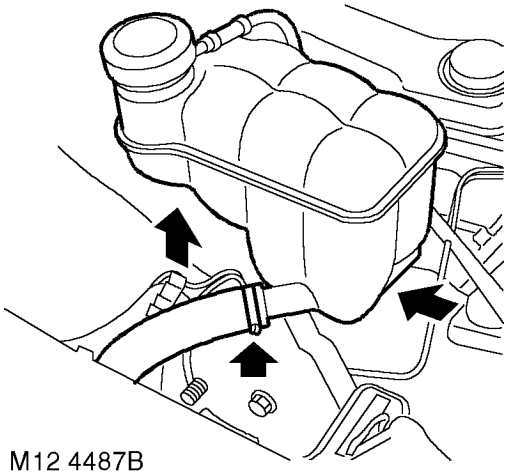
M12 4488

8. Disconnect fuel hoses, tank to fuel cooler and connector block on cylinder head.
   CAUTION: Always fit plugs to open connections to prevent contamination.



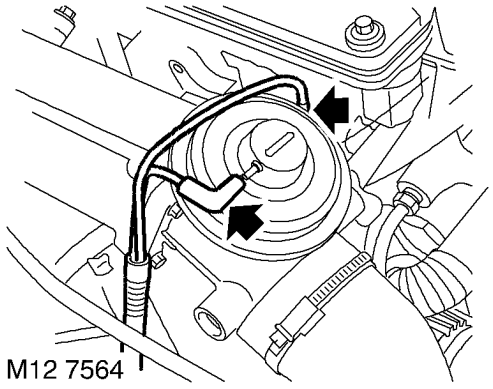
M12 7565

9. Disconnect fuel hose from fuel cooler and secure to connector block on cylinder head.
   This is to prevent contamination of the fuel injection system.
10. Release servo vacuum pipe from clip on fuel cooler and release hose from vacuum pump.

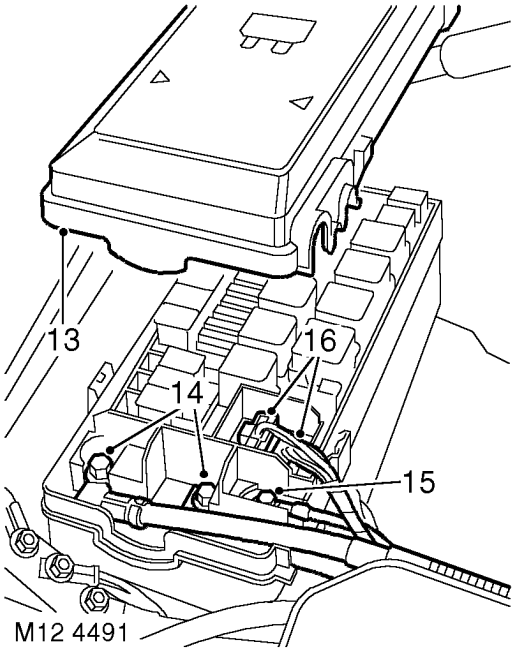


M12 4487B

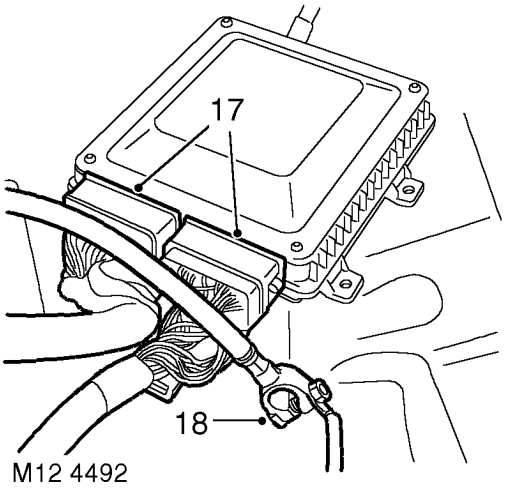
11. Release expansion tank from body mounting, release clip, disconnect hose and remove tank.



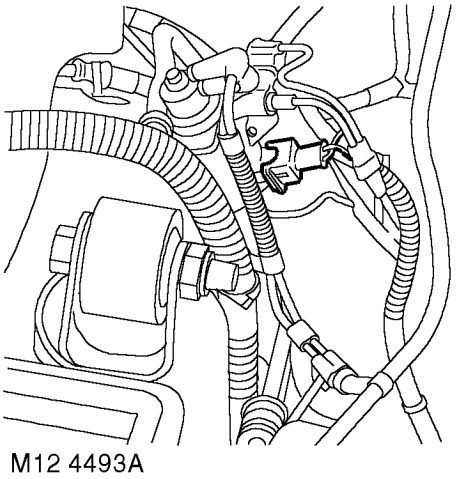
12. Disconnect vacuum hose from EGR valve.



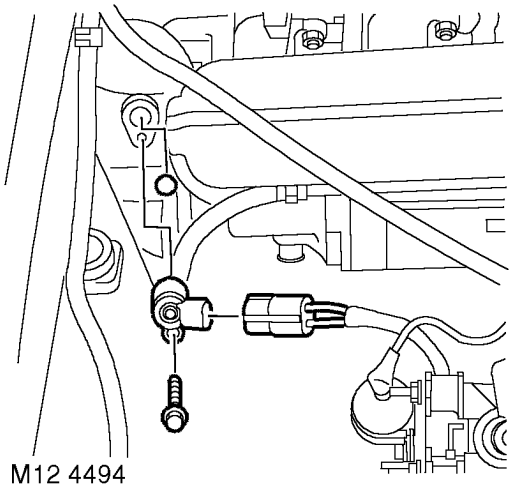
13. Remove engine compartment fuse box cover.
14. Remove bolts securing battery and alternator leads to fuse box.
15. Remove bolt securing glow plug lead to fuse box.
16. Disconnect 2 engine harness multiplugs from fuse box.



17. Disconnect 2 engine harness multiplugs from ECM and main harness.
18. Remove bolt securing engine earth lead to battery earth lead.

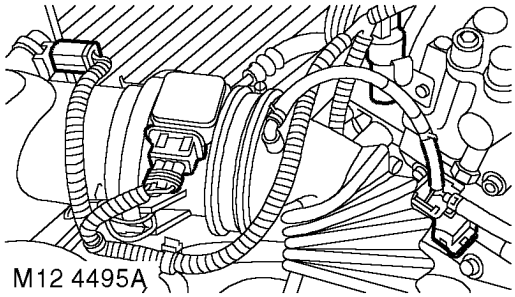


19. Disconnect multiplug from EGR modulator.

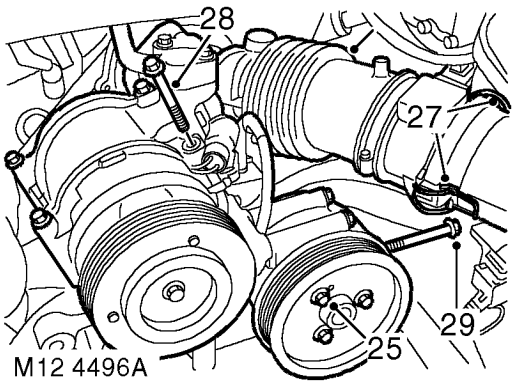

M12 4494

20. Disconnect multiplug from CKP sensor.
21. Remove bolt securing CKP sensor to gearbox housing and discard 'O' ring.
CAUTION: If fitted: Retain CKP sensor.

22. Loosen clip securing air inlet hose to turbocharger and remove hose.

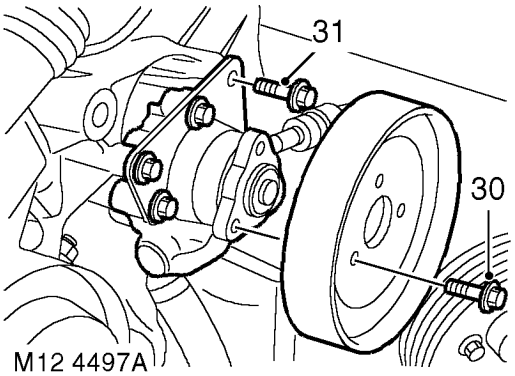

M12 4495A

23. Disconnect multiplugs from compressor, MAF sensor, turbocharger boost solenoid valve, AAP & IAT sensor.
24. Release clip and disconnect hose from turbocharger boost solenoid valve.



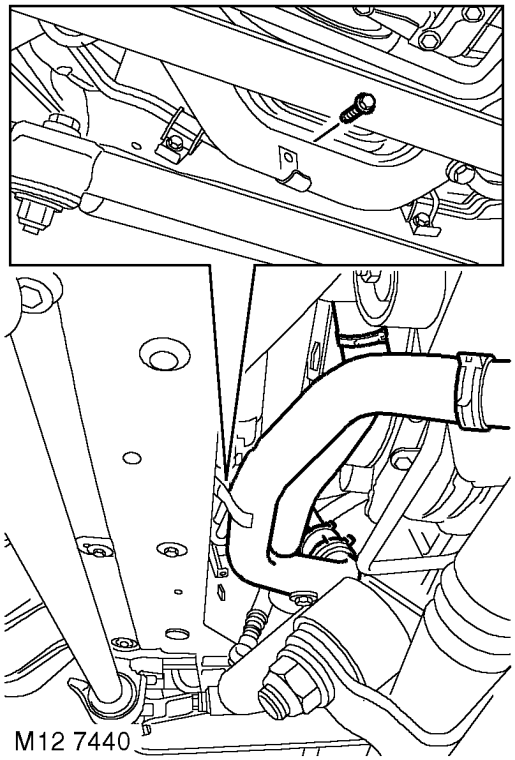
M12 4496A

25. Loosen bolts securing PAS pulley.
26. Rotate ancillary drive belt tensioner anti-clockwise, release and remove drive belt.
27. Release clips and remove air intake hose from air cleaner.
28. Remove 4 bolts and move compressor aside.
29. Remove 3 bolts and move ACE pump aside.

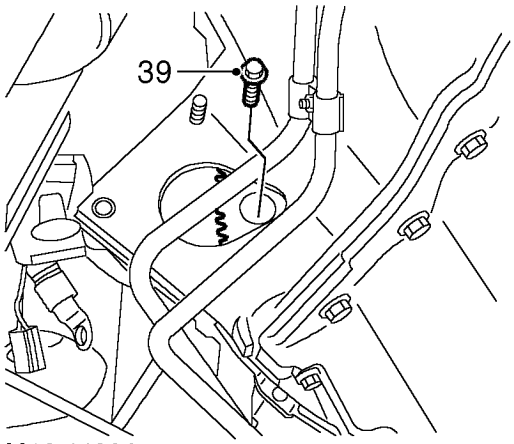


M12 4497A

30. Remove 3 bolts and remove PAS pump pulley.
31. Remove 4 bolts and move PAS pump aside.

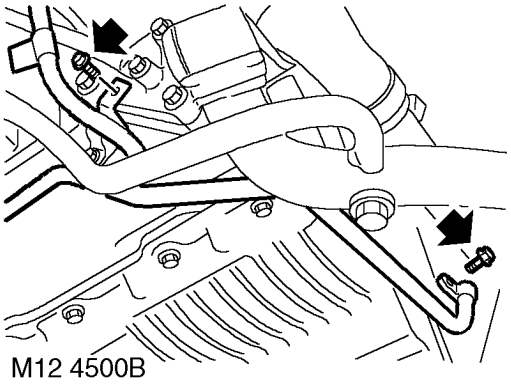

M12 7440

32. Release clip and disconnect hose from coolant pump.
33. Release clip and disconnect heater hose from coolant rail.
34. Remove bolt securing coolant rail to front chassis member.
35. Raise vehicle on ramp.
36. Release coolant rail support brackets from engine LH and RH mounting brackets.
37. Remove coolant rail.
38. Remove starter motor.
☞ **CHARGING AND STARTING, REPAIRS, Starter motor - diesel.**

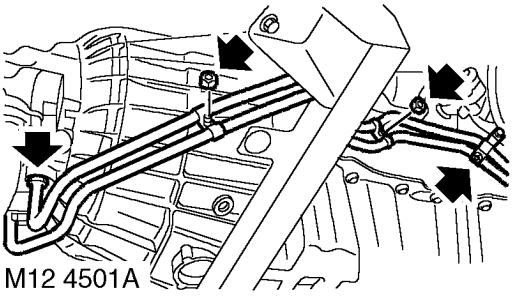


M12 4498A

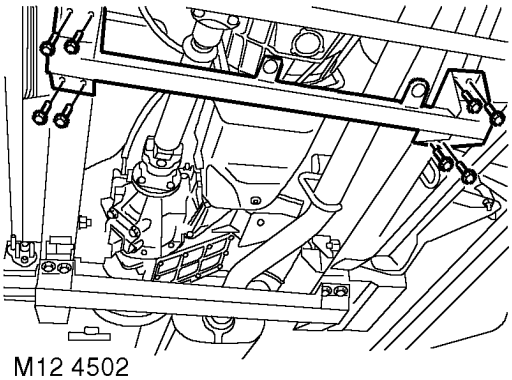
39. Remove and discard 3 bolts securing torque converter to drive plate.


M12 4500B

40. Remove 2 bolts securing gearbox oil cooler pipe clips from sump and alternator mounting bracket.
41. Mark position of gearbox oil cooler pipe clamps.

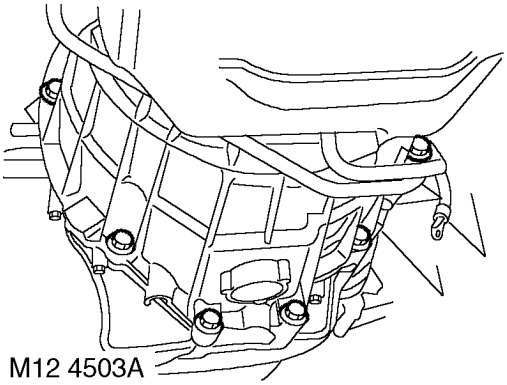

M12 4501A

42. Remove 3 nuts and remove oil cooler pipe clamps.
43. Loosen RH oil cooler pipe union.
44. Move pipes aside and tighten RH pipe union.



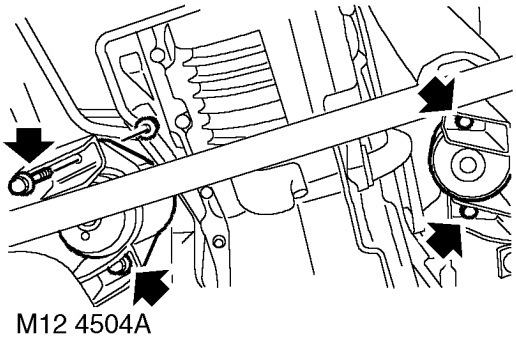
M12 4502

45. Remove 8 bolts and remove front cross member.



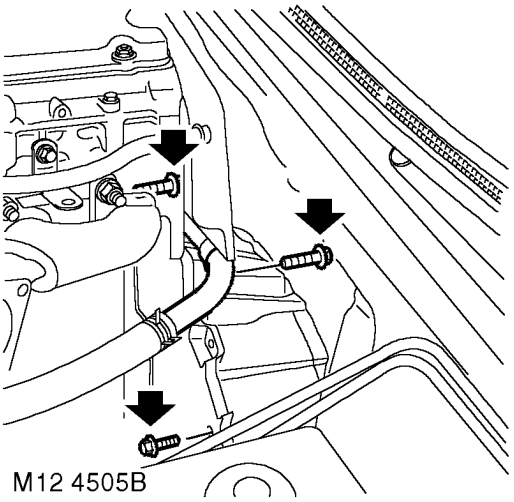
M12 4503A

46. Remove 6 bolts securing gearbox housing to engine.



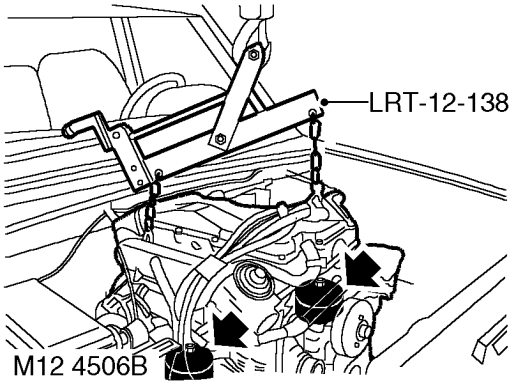
M12 4504A

47. Remove 4 bolts and nuts securing RH and LH front engine mountings to chassis.
48. Lower vehicle ramp.



M12 4505B

49. Remove 2 upper bolts securing gearbox housing and oil cooler coolant pipe to engine.
50. Release clip, disconnect hose from engine oil cooler and move aside.
51. Remove bolt securing engine closing panel to gearbox.



M12 4506B

52. Fit tool **LRT-12-138** to lifting chains and connect to lifting eyes on engine.
53. Remove 2 nuts from RH and LH front engine mountings.
54. Position trolley jack to support gearbox.
55. With assistance, raise chains, remove engine from vehicle and lower onto bench.

Refit

1. With assistance, raise engine from bench and position in vehicle.
2. With assistance, align engine to gearbox and torque converter.
3. Position engine RH and LH mountings to brackets and fit nuts.
4. Position engine oil cooler pipe, connect hose to oil cooler and secure with clip.

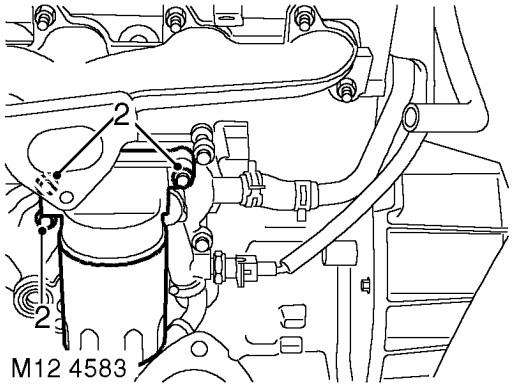
5. Fit 2 upper bolts securing engine oil cooler pipe and gearbox housing to engine and tighten to 50 Nm (37 lbf.ft) .
6. Lower engine onto mountings, and tighten nuts to 85 Nm (63 lbf.ft) .
7. Remove tool **LRT-12-138** from engine.
8. Fit and tighten bolt securing engine closing panel to gearbox.
9. Raise vehicle on ramp.
10. Fit nuts and bolts securing engine LH and RH mountings to chassis and tighten to 85 Nm (63 lbf.ft).
11. Fit remaining bolts securing gearbox housing to engine and tighten to 50 Nm (37 lbf.ft).
12. Rotate crankshaft and align drive plate to torque converter.
13. Using a magnetic socket, fit and tighten new torque converter drive plate bolts to 50 Nm (37 lbf.ft) .
14. Fit front cross member and tighten bolts to 26 Nm (19 lbf.ft).
15. Align gearbox oil cooler pipes.
16. Fit oil cooler pipe clip and tighten bolts to 9 Nm (7 lbf.ft).
17. Position gearbox oil cooler pipe clamps and tighten nuts.
18. Position coolant rail and secure support bracket in engine LH and RH mounting brackets.
19. Fit starter motor.
    ☞ **CHARGING AND STARTING, REPAIRS, Starter motor - diesel.**
20. Lower ramp.
21. Position coolant rail to front chassis member, fit and tighten bolt to 10 Nm (7 lbf.ft).
22. Connect heater hose to coolant rail and secure with clip.
23. Connect hose to coolant pump and secure with clip.
24. Position PAS pump and tighten bolts to 25 Nm (18 lbf.ft).
25. Position PAS pump pulley and lightly tighten bolts.
26. Position ACE pump, fit bolts and tighten to 25 Nm (18 lbf.ft).
27. Position A/C compressor, fit bolts and tighten to 25 Nm (18 lbf.ft).
28. Position ancillary drive belt, rotate tensioner anti-clockwise and locate belt to pulleys.
29. Tighten PAS pump pulley bolts to 10 Nm (7 lbf.ft).
30. Position air intake hose to air cleaner and secure clips.
31. Position engine harness and connect multiplugs to compressor, MAF sensor, turbocharger boost solenoid, AAP & IAT sensor.
32. Position air inlet hose to turbocharger and tighten clip.
33. Connect hoses to turbocharger boost solenoid and secure clips.
34. Clean CKP sensor and mating face.
    CAUTION: If originally fitted: Fit spacer to CKP sensor.
35. Using new 'O' ring, fit CKP sensor, tighten CKP sensor bolt to 9 Nm (7 lbf.ft) and connect multiplug.
36. Connect multiplug to EGR modulator.
37. Connect engine earth lead to battery earth lead and tighten bolt.
38. Connect engine harness multiplug to ECM and main harness.
39. Connect engine harness multiplugs to fuse box.
40. Position glow plug lead to fusebox and secure with bolt.
41. Position battery and alternator leads to fusebox and secure with bolts.
42. Fit engine compartment fuse box cover.
43. Connect vacuum hose to EGR valve.
44. Connect hose to vacuum pump and secure vacuum pipe to fuel cooler.
45. Disconnect fuel hose from connector block and connect to fuel cooler.
46. Connect fuel hoses to fuel cooler and connector block on cylinder head.
47. Position expansion tank, connect hose and secure with clip. Secure tank to body mounting.
48. Connect coolant hoses to fuel cooler and coolant rail and secure clips.
49. Fit turbocharger.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.**
50. Fit radiator.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Radiator.**
51. Fill engine with oil.
    ☞ **MAINTENANCE, PROCEDURES, Engine oil - diesel engine.**
52. Fit underbelly panel.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**
53. Fit bonnet.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bonnet.**

Mounting - front - LH

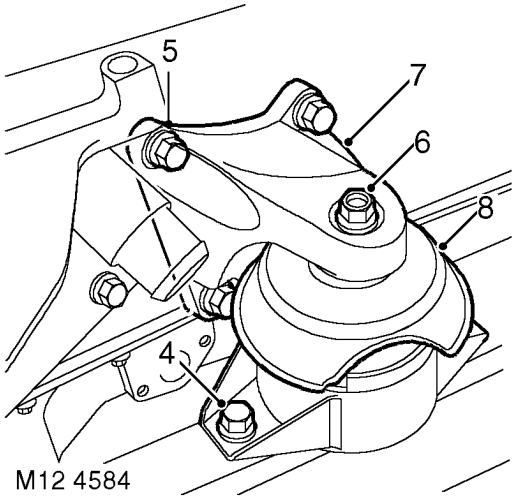
12.45.01

Remove

1. Remove centrifuge assembly.
   ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.



2. Remove 3 bolts, remove oil filter adaptor housing and discard gasket.
3. Fit suitable lifting chains to support engine.



4. With assistance remove 2 bolts securing engine mounting to chassis.
5. Remove 4 bolts securing engine mounting bracket to cylinder block.
6. Remove nut securing mounting to mounting bracket.
7. Remove mounting and mounting bracket.
8. Remove mounting shield.

Refit

1. Fit shield to mounting.
2. Fit mounting and mounting bracket.
3. Fit mounting bracket to cylinder block and tighten – bolts securing front LH engine mounting bracket to cylinder block to 48 Nm (35 lbf.ft).
4. With assistance, fit mounting to chassis and tighten – bolts securing front LH engine mounting to chassis to 85 Nm (63 lbf.ft).
5. Fit mounting to mounting bracket and tighten – nut securing front LH mounting to mounting bracket to 85 Nm (63 lbf.ft).
6. Remove engine support chains.
7. Clean oil filter adaptor housing and mating face.
8. Fit oil filter adaptor housing to oil cooler housing and tighten bolts to 25 Nm (18 lbf.ft).
9. Fit centrifuge assembly.
   ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.

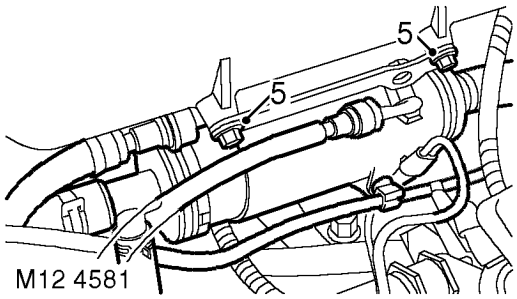
Mounting - front - RH

12.45.03

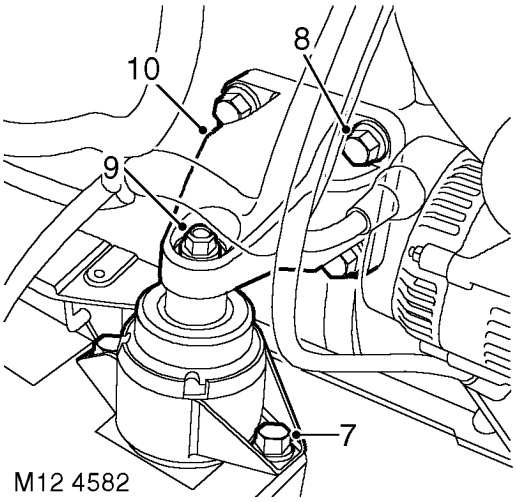
Remove

1. Remove fixings and remove engine acoustic cover.
2. Release fixings and remove battery cover.
3. Disconnect battery earth lead.
4. Raise front of vehicle.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



5. Remove 4 bolts and move fuel cooler to one side.
6. Fit suitable lifting chains to support engine.



7. With assistance remove 2 bolts securing engine mounting to chassis.
8. Remove 4 bolts securing engine mounting bracket to cylinder block.
9. Remove nut securing mounting to mounting bracket.
10. Remove mounting and mounting bracket.

Refit

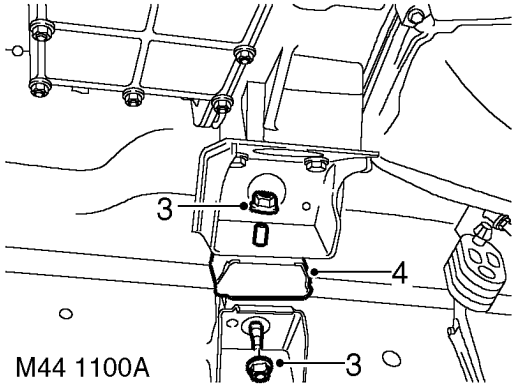
1. Fit mounting and mounting bracket.
2. Fit front RH engine mounting bracket to cylinder block and tighten bolts to 48 Nm (35 lbf.ft).
3. With assistance, fit front RH mounting to chassis and tighten bolts to 85 Nm (63 lbf.ft).
4. Fit front RH mounting to mounting bracket and tighten nut to 85 Nm (63 lbf.ft).
5. Remove engine support chains.
6. Position Fuel cooler to inlet manifold and tighten bolts to 25 Nm (18 lbf.ft).
7. Remove stand(s) and lower vehicle.
8. Connect battery earth lead.
9. Fit battery cover and secure with fixings.
10. Fit engine acoustic cover and secure with fixings.

Mounting - engine - rear - LH

12.45.07

Remove

1. Raise vehicle on ramp.
2. Position jack to support gearbox.



3. Remove 2 nuts and remove mounting.
4. Remove heat shield from mounting.

Refit

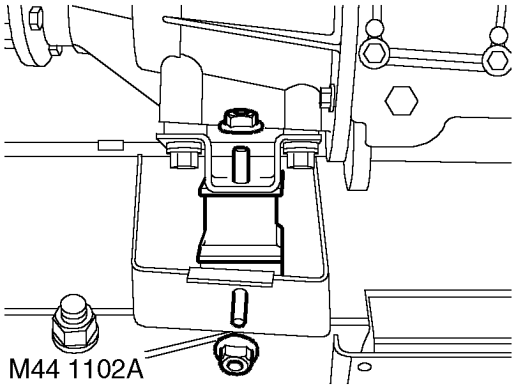
1. Clean mounting and mating faces.
2. Position heat shield to mounting.
3. Position engine rear LH mounting and tighten nuts to 48 Nm (35 lbf.ft).
4. Lower support jack.
5. Lower vehicle.

Mounting - engine - rear - RH

12.45.09

Remove

1. Raise vehicle on ramp.



2. Position jack to support gearbox.
3. Remove 2 nuts and remove mounting.

Refit

1. Clean mounting and mating faces.
2. Position engine rear RH mounting and tighten nuts to 48 Nm (35 lbf.ft).
3. Lower support jack.
4. Lower vehicle.

Flywheel

12.53.07

Remove

1. Remove clutch assembly.
   CLUTCH - Td5, REPAIRS, Clutch assembly.
2. Remove and discard 8 bolts securing flywheel to crankshaft and remove flywheel.

Refit

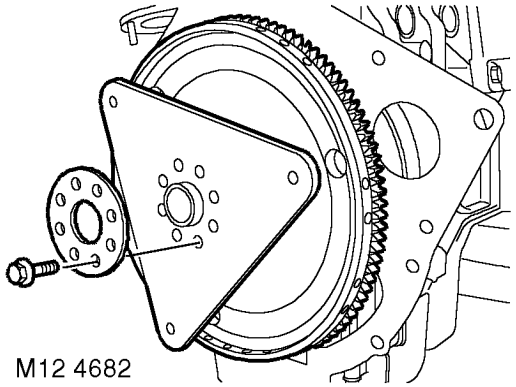
1. Clean flywheel and mating face.
2. Position flywheel to crankshaft, fit new bolts and working in a diagonal sequence tighten to 40 Nm (30 lbf.ft), then a further 90°.
   CAUTION: Do not carry out stages 1 and 2 in one operation.
3. Fit clutch assembly.
   CLUTCH - Td5, REPAIRS, Clutch assembly.

Plate - drive - automatic

12.53.13

Remove

1. Remove gearbox.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - Diesel.


M12 4682

2. Remove and discard 8 bolts and remove converter drive plate, spacer and starter ring gear.

Refit

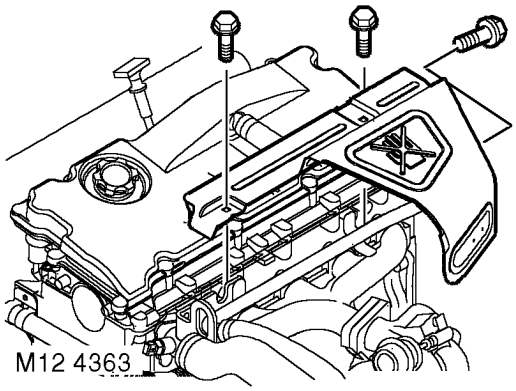
1. Clean drive plate, spacer and starter ring gear.
2. Fit starter ring gear, spacer and drive plate to crankshaft, fit new bolts and working in a diagonal sequence tighten to 40 Nm (30 lbf.ft), then a further 90°.
   CAUTION: Do not carry out stages 1 and 2 in one operation.
3. Refit gearbox.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - Diesel.

Filter - oil

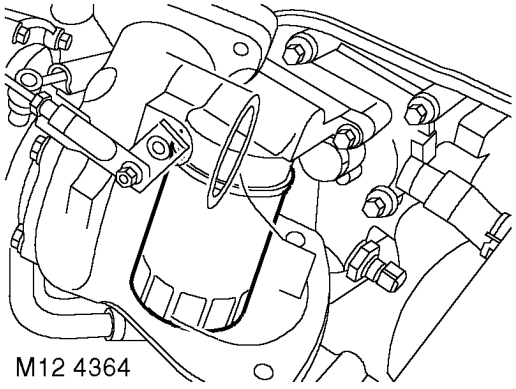
12.60.04

Remove

1. Remove 3 bolts and remove engine acoustic cover.



2. Remove 3 bolts and remove exhaust manifold heat shield.



3. Clean area around filter head and place a container beneath engine.
4. Using a strap wrench, unscrew and discard filter.

Refit

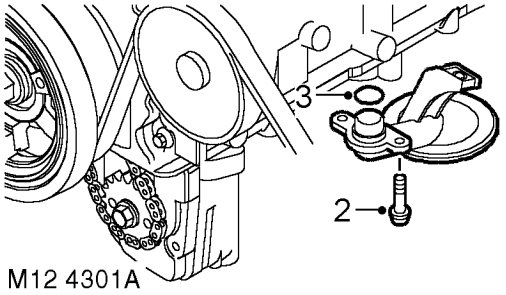
1. Clean mating face of filter head.
2. Lubricate sealing ring of new filter with clean engine oil.
3. Fit filter and tighten by hand until it seats then tighten a further three-quarters of a turn.
4. Start and run engine to check for leaks.
5. Stop engine, wait a few minutes, then check oil level.
6. Top up engine oil.
   MAINTENANCE, PROCEDURES, Engine oil - diesel engine.
7. Position exhaust manifold heatshield and tighten M6 bolts to 9 Nm (7 lbf.ft) and M8 bolts to 25 Nm (18 lbf.ft).
8. Fit engine acoustic cover and secure with fixings.

Strainer - oil pick-up

12.60.20

Remove

1. Remove sump gasket.
   ENGINE - Td5, REPAIRS, Gasket - sump.



M12 4301A

2. Remove 3 Torx screws securing oil pick- up strainer.
3. Remove and discard 'O' ring.

Refit

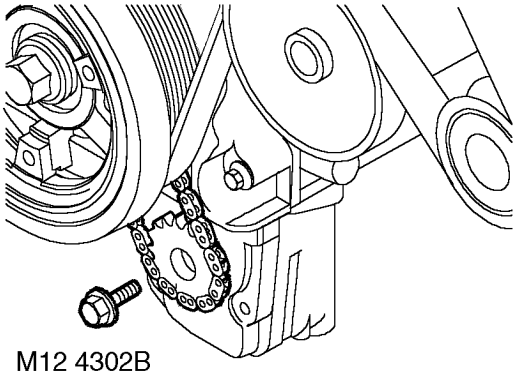
1. Clean oil pick up strainer faces.
2. Fit new 'O' ring to oil pick-up strainer.
3. Clean threads of Torx screws.
4. Fit oil pick-up strainer, apply Loctite 242 to threads of Torx screws, fit screws and tighten to 10 Nm (7 lbf.ft).
5. Fit new sump gasket.
   ENGINE - Td5, REPAIRS, Gasket - sump.

Pump - oil

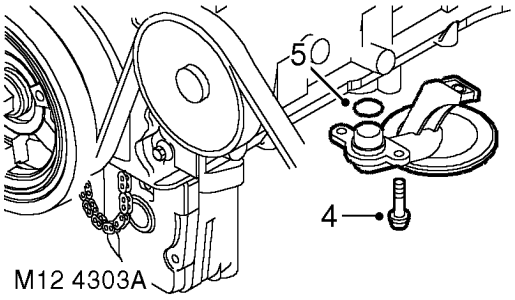
12.60.26

Remove

1. Remove sump gasket.
   ENGINE - Td5, REPAIRS, Gasket - sump.

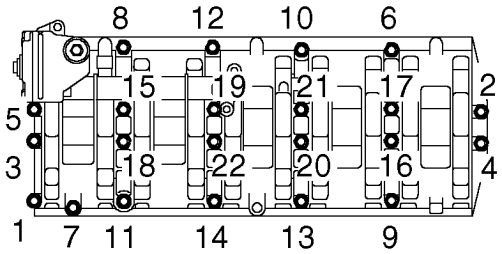

M12 4302B

2. Hold oil pump drive sprocket and remove retaining bolt.
3. Remove sprocket from oil pump.



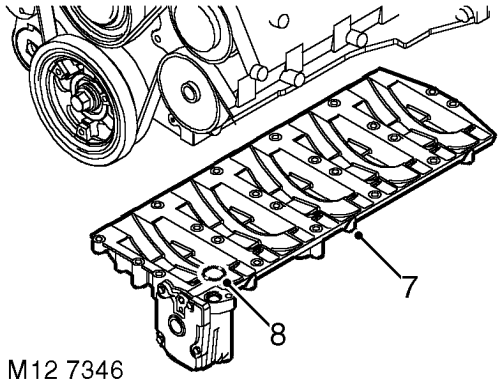
M12 4303A

4. Remove 3 Torx screws securing oil pick-up strainer.
5. Remove and discard 'O' ring.



M12 7359

6. Using sequence shown, remove and discard 22 bolts securing oil pump and stiffener assembly.

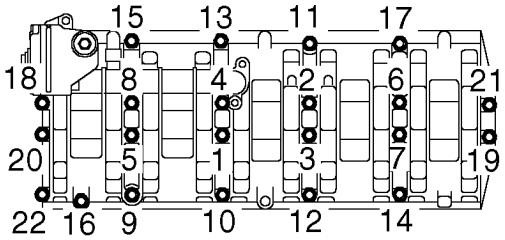


M12 7346

7. Remove oil pump and stiffener assembly from cylinder block.
8. Remove and discard 'O' ring.

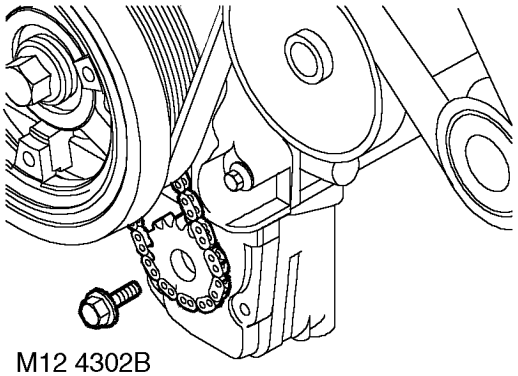
Refit

1. Clean mating faces of oil pump and stiffener assembly, main bearing caps and cylinder block.
2. Fit new 'O' ring to oil pump housing.
3. Position oil pump and stiffener assembly onto cylinder block ensuring 2 dowels are correctly located.



M12 7360

4. Fit new bolts and using sequence shown, tighten to 13 Nm (10 lbf.ft) .
5. Clean threads of oil pick-up strainer Torx screws.
6. Fit new 'O' ring to oil pick-up strainer.
7. Fit oil pick-up strainer, apply Loctite 242 to threads of Torx screws, fit screws and tighten to 10 Nm (7 lbf.ft).
8. Position oil pump drive sprocket and chain onto oil pump ensuring that the 'D' shape on the drive sprocket is located on the oil pump shaft.


M12 4302B

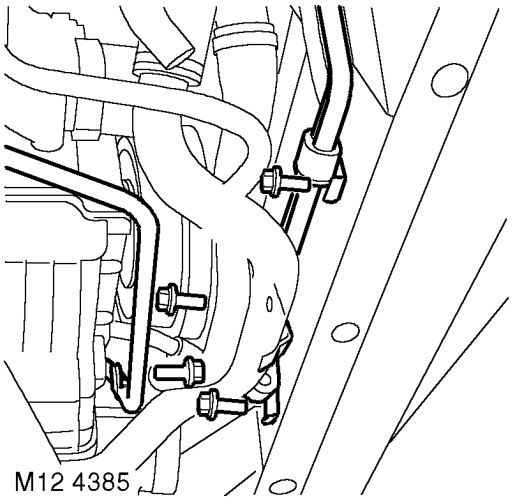
9. Clean oil pump drive sprocket retaining bolt and apply Loctite 242 to bolt threads.
10. Fit oil pump drive sprocket and tighten bolt to 25 Nm (18 lbf.ft).
11. Fit new sump gasket.
    ☞ **ENGINE - Td5, REPAIRS, Gasket - sump.**

Gasket - sump

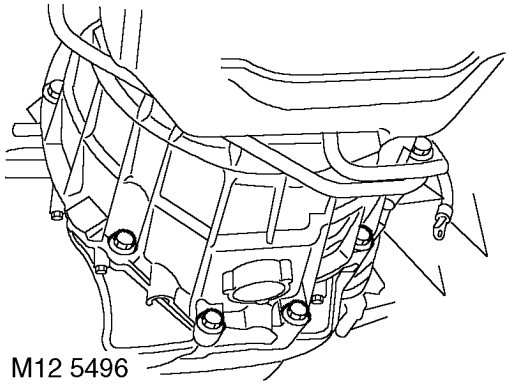
12.60.38

Remove

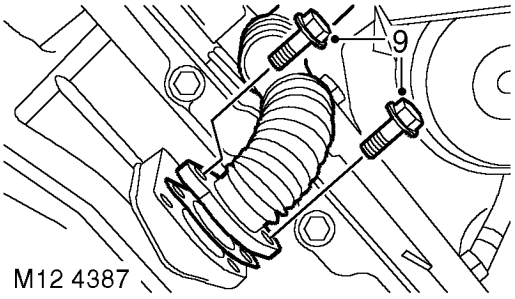
1. Remove battery cover.
2. Disconnect battery earth lead.
3. Remove exhaust front pipe.
   MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.
4. Drain engine oil.


M12 4385

5. Remove 2 bolts securing Active Cornering Enhancement (ACE) pipes to front cross member.
6. Remove bolt securing coolant pipe to front cross member.
7. Remove bolt securing automatic gearbox oil cooler pipe clip.

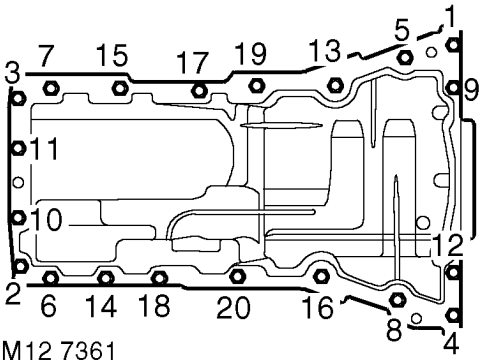

M12 5496

8. Remove 4 bolts securing sump to gearbox bell housing.



M12 4387

9. Remove 2 bolts securing centrifuge drain pipe to sump and discard gasket.

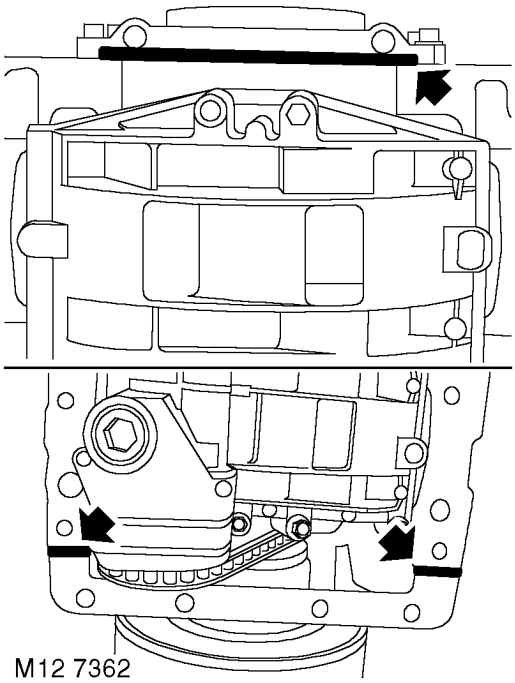


M12 7361

10. Using sequence shown and noting their different lengths, remove 20 bolts securing sump to engine.
11. Manoeuvre sump from beneath engine, remove sump and discard gasket.

Refit

1. Clean sump and mating faces.



M12 7362

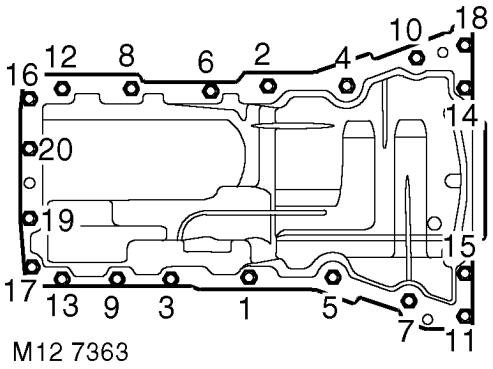
2. Apply sealant, Part No. STC 3254 to joint faces of timing chain cover and crankshaft rear oil seal housing.

   CAUTION: Assembly and bolt tightening must be completed within 20 minutes of applying sealant.

3. Position new gasket.

   CAUTION: Gasket must be fitted dry.

4. Position sump and, noting the positions of the longer bolts, fit and lightly tighten bolts.
5. Fit and lightly tighten bolts securing sump to gearbox bell housing.



M12 7363

6. Working in the sequence shown, tighten bolts securing sump to 25 Nm (18 lbf.ft).
7. Tighten – sump to gearbox bell housing bolts to 13 Nm (10 lbf.ft).
8. Fit new gasket to centrifuge drain pipe, fit to sump and tighten bolts to 10 Nm (7 lbf.ft) .

   CAUTION: Gasket must be fitted dry.

9. Fit bolts securing oil cooler pipe to sump and tighten to 9 Nm (7 lbf.ft).
10. Fit and tighten bolt securing coolant pipe to cross member.
11. Fit and tighten bolts securing ACE pipes to front cross member.
12. Fit exhaust front pipe.

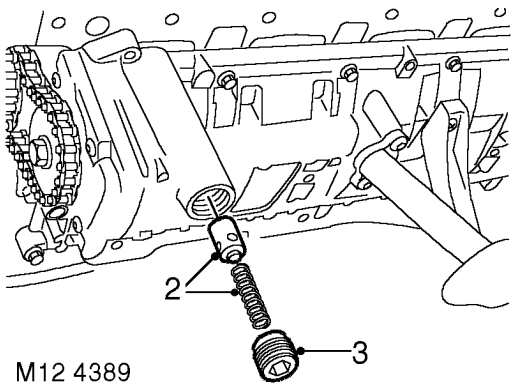
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**
13. Refill engine with oil.
14. Connect battery earth lead.
15. Refit battery cover and secure fixings.

Valve - relief - oil pressure

12.60.56

Remove

1. Remove sump gasket.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - sump.**



2. Remove and discard plug from oil pump housing.
3. Remove spring and valve.

Refit

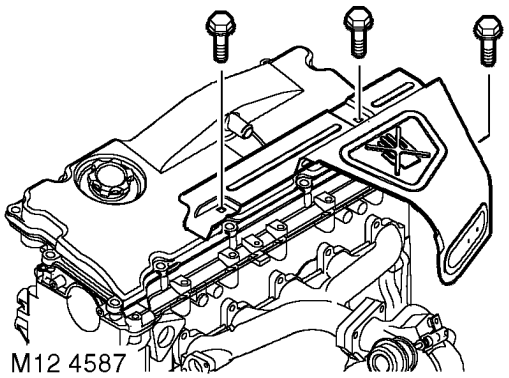
1. Clean valve, spring and plug.
2. Clean valve seating inside oil pump housing.
3. Check valve and bore for scoring and corrosion. Light scoring may be removed using grade 600 emery cloth soaked in oil.
4. Check spring for distortion, check free length of spring: Spring free length = 42.00 mm (1.65 in).
   CAUTION: Renew relief valve as an assembly.
5. Lubricate valve and seating.
6. Fit valve and spring to pump.
7. Apply Loctite 243 sealant to threads of new plug.
   CAUTION: Do not attempt to fit original plug.
8. Fit oil pump pressure relief valve plug and tighten to 23 Nm (17 lbf.ft).
9. Fit sump gasket.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - sump.**
10. Check engine oil level, top-up if necessary.

Switch - oil pressure

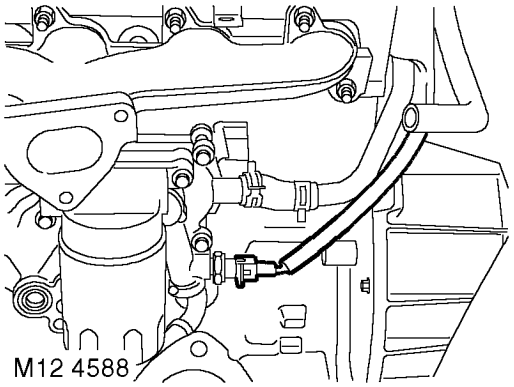
12.60.50

Remove

1. Remove fixings and remove engine acoustic cover.



2. Remove 3 bolts and remove exhaust manifold heat shield.



3. Disconnect multiplug from oil pressure switch.
4. Position container below switch to catch oil spillage.
5. Remove oil pressure switch from oil cooler housing.

Refit

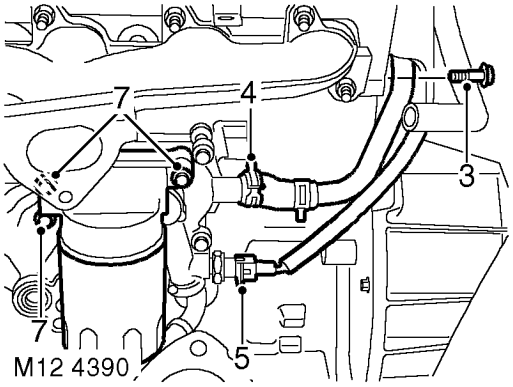
1. Clean oil pressure switch threads.
2. Fit oil pressure switch and tighten to 15 Nm (11 lbf.ft).
3. Connect multiplug to oil pressure switch.
4. Position exhaust manifold heatshield and tighten M6 bolts to 9 Nm (7 lbf.ft) and M8 bolts to 25 Nm (18 lbf.ft).
5. Fit and secure engine acoustic cover.
6. Top up engine oil.
   ☞ **MAINTENANCE, PROCEDURES, Engine oil - diesel engine.**

Cooler - engine oil

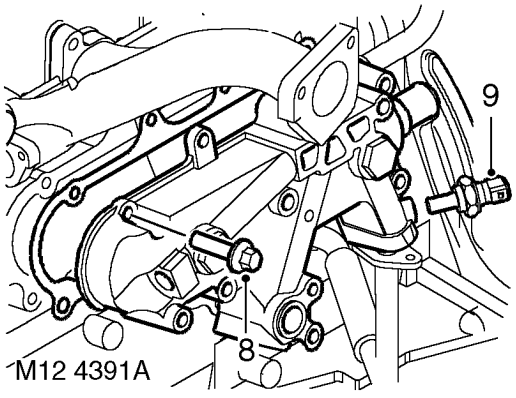
⊸ ***12.60.68***

Remove

1. Drain cooling system.
   ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
2. Remove centrifuge assembly.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.**



3. Remove clutch housing bolt and release coolant pipe from rear of engine.
4. Release clip and coolant hose from oil cooler.
5. Disconnect multiplug from oil pressure switch.
6. Remove full-flow oil filter element using a suitable strap wrench.
7. Remove 3 bolts, remove oil filter adaptor housing and discard gasket.



8. Remove 7 bolts, remove oil cooler and discard gasket.
9. Remove oil pressure switch.

Refit

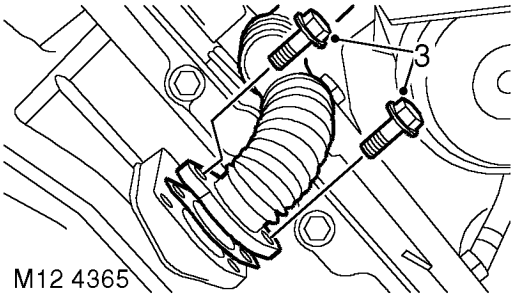
1. Clean oil cooler and mating faces.
2. Fit oil pressure switch and tighten to 9 Nm (7 lbf.ft).
3. Position new gasket and fit oil cooler housing, tighten bolts to 25 Nm (18 lbf.ft).
4. Position and fit oil filter adaptor housing, tighten bolts to 25 Nm (18 lbf. ft).
5. Fit oil filter, tighten hand tight then a further half turn.
6. Position coolant hose to oil cooler and secure clip.
7. Position coolant pipe bolt and tighten to 50 Nm (37 lbf.ft) .
8. Connect multiplug to oil pressure switch.
9. Fit centrifuge assembly.
   ☞ **ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.**
10. Refill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
11. Top up engine oil.
    ☞ **MAINTENANCE, PROCEDURES, Engine oil - diesel engine.**

Gasket - centrifuge oil drain pipe

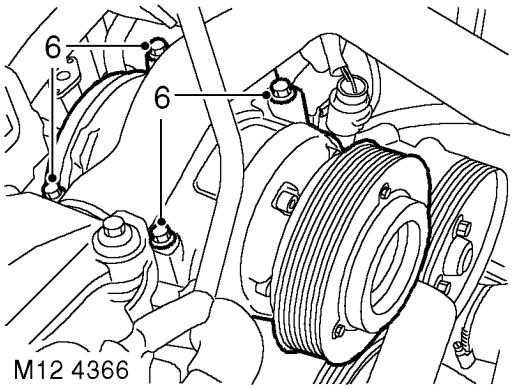
⊸ ***12.60.90***

Remove

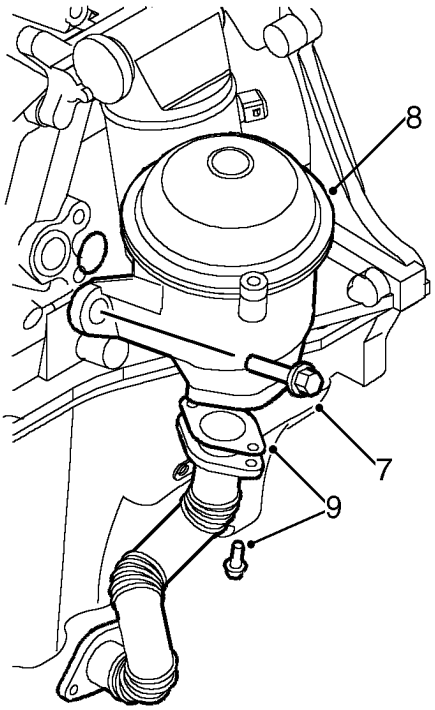
1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove fixings and remove underbelly panel.



3. Remove 2 bolts securing centrifuge drain to engine sump and discard gasket. **(Some models are fitted with studs and nuts, others with bolts).**
4. Remove turbocharger.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.**
5. **Models with air conditioning:** Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**



6. **Models with air conditioning:** Remove 4 bolts securing compressor and move to one side.



M12 4367

7. Remove 3 bolts securing centrifuge to engine oil cooler.
8. Remove centrifuge and discard 'O' ring.
9. Remove 2 bolts, remove drain pipe from centrifuge and discard gasket.

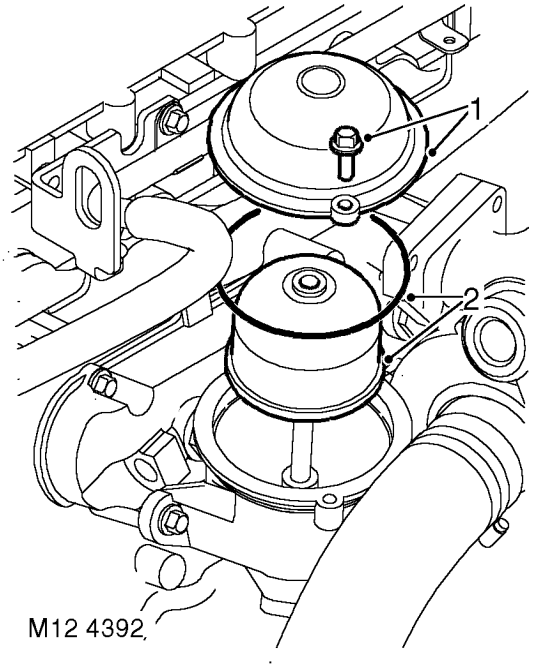
Refit

1. Clean mating faces of centrifuge, oil cooler and sump.
2. Position new gasket and fit oil drain pipe to centrifuge, tighten bolts to 10 Nm (7 lbf.ft).
   CAUTION: Gasket must be fitted dry.
3. Position new 'O' ring to oil cooler.
4. Position centrifuge to oil cooler housing and tighten bolts to 25 Nm (18 lbf.ft).
5. Using a new gasket, align the centrifuge oil drain pipe to sump and tighten bolts to 10 Nm (7 lbf.ft).
   CAUTION: Gasket must be fitted dry.
6. **Models with air conditioning:** Position A/C compressor and tighten bolts to 25 Nm (18 lbf.ft).
7. Fit turbocharger.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.**
8. **Models with air conditioning:** Fit auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
9. Fit underbelly panel and secure with fixings.
10. Remove stand(s) and lower vehicle.

Rotor - centrifuge

12.60.91

Remove



1. Remove 2 bolts and remove centrifuge cover.
2. Remove and discard 'O' ring and rotor.

Refit

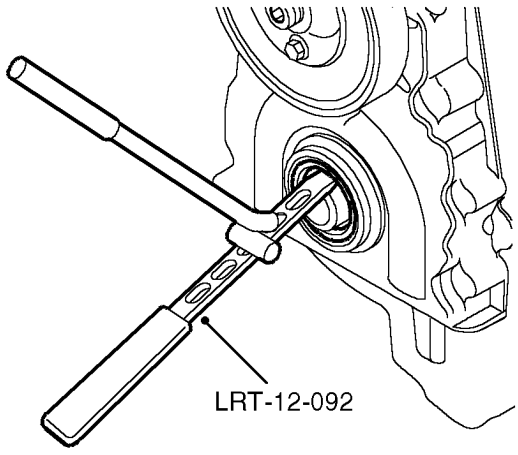
1. Clean centrifuge body and cover.
2. Fit new rotor.
3. Using a new 'O' ring, fit centrifuge cover and tighten bolts to 10 Nm (7 lbf.ft).

Seal - oil - timing cover

12.65.05

Remove

1. Remove crankshaft pulley.
   ☞ **ENGINE - Td5, REPAIRS, Pulley - crankshaft.**

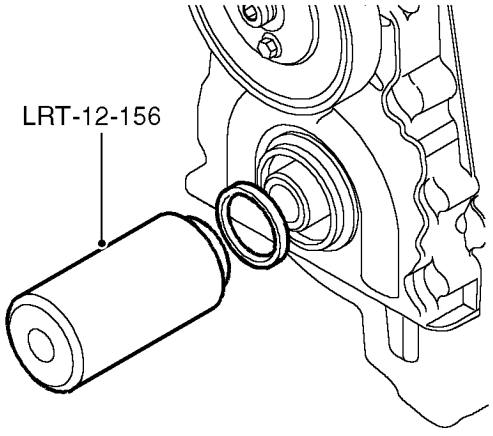


M12 4308B

2. Position tool **LRT-12-092** into crankshaft front oil seal and discard seal.

Refit

1. Using a lint free cloth, thoroughly clean oil seal recess and the running surface on crankshaft pulley.



M12 4309

2. Position new seal into timing chain housing. Drift seal into place using tool **LRT-12-156**.
   CAUTION: Oil seal must be fitted dry.

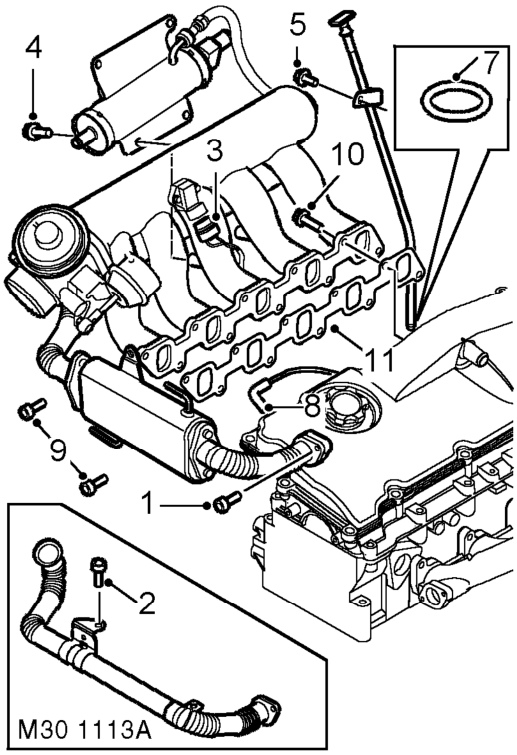
3. Remove tool **LRT-12-156**.
4. Fit crankshaft pulley.
   ☞ **ENGINE - Td5, REPAIRS, Pulley - crankshaft.**

Gasket - inlet manifold

30.15.08.01

Disassembly

Note: The following procedures cover engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.



EU3 Engine in main illustration, Pre EU3 condition shown in inset

1. Remove and discard 2 Allen screws securing EGR pipe to exhaust manifold or EGR cooler.
2. Remove bolt securing EGR pipe to cylinder head, (if fitted)
3. Disconnect multiplug from IAT and MAP sensor.
4. Remove 4 bolts securing fuel cooler to inlet manifold. and remove cooler.
5. Remove bolt securing engine dipstick tube to camshaft carrier.
6. Release and remove engine dipstick tube.
7. Remove 'O' ring from dip stick tube.
8. Disconnect 4 leads from glow plugs.
9. Remove 2 bolts securing alternator strap bracket, remove bracket, (if fitted)
10. Remove 2 nuts and 8 bolts and remove inlet manifold.
11. Remove manifold gasket.

Reassembly

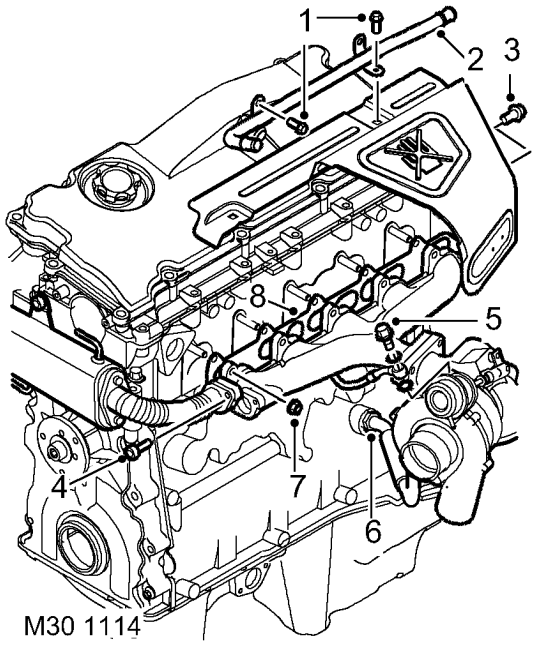
1. Clean inlet manifold and mating face, clean mating faces of EGR pipe, exhaust manifold or EGR cooler – if fitted.
2. Fit new gasket.
3. Position inlet manifold and working from the centre outwards, fit inlet manifold nuts and bolts and tighten to 25 Nm (18 lbf.ft) .
4. Fit alternator strap bracket and tighten bolts to 25 Nm (18 lbf.ft), (if fitted)
5. Connect glow plug leads.
6. Clean engine dipstick tube.
7. Fit new 'O' ring to dipstick tube.
8. Fit engine dipstick tube to camshaft carrier and tighten bolt to 10 Nm (7 lbf.ft).
9. Position fuel cooler and tighten bolts to 25 Nm (18 lbf.ft).
10. Connect multiplug to IAT and MAP sensor.
11. Position EGR pipe to exhaust manifold or EGR cooler and using new Allen screws tighten to 10 Nm (7 lbf.ft).
12. Fit EGR pipe clamp to cylinder head, (if fitted) and tighten bolt to 10 Nm (7 lbf.ft).

Gasket - exhaust manifold

30.15.12.01

Disassembly

Note: The following procedure covers engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.



EU3 engine illustrated

1. Remove 3 bolts securing heater pipe to cylinder head and turbocharger heat shield.
2. Remove heater pipe.
3. Remove bolt and remove turbocharger heat shield.
4. Remove and discard 2 Allen screws securing EGR pipe to exhaust manifold.
5. Remove banjo bolt securing oil feed pipe to turbocharger and discard sealing washers.
6. Loosen turbocharger drain hose union at cylinder block.
7. Remove 10 nuts and remove exhaust manifold and turbocharger.
8. Remove manifold gasket.

Reassembly

1. Clean exhaust manifold mating faces.
2. Position exhaust manifold to cylinder head using new gasket and fit manifold nuts. Working from the centre outwards, fit and tighten nuts to 25 Nm (18 lbf.ft).
3. Clean turbocharger drain and feed hose unions.
4. Fit turbocharger oil drain hose to cylinder block and tighten union to 48 Nm (35 lbf.ft) .
5. Fit new sealing washers to turbocharger oil feed pipe, fit banjo bolt and tighten to 25 Nm (18 lbf.ft).
6. Position EGR pipe to exhaust manifold. Fit new Allen screws and tighten to 10 Nm (7 lbf.ft).
7. Position turbocharger heat shield.
8. Position heater pipe to cylinder head and tighten bolts to 25 Nm (18 lbf.ft).
9. Position exhaust manifold heatshield and tighten M6 bolts to 9 Nm (7 lbf.ft) and M8 bolt to 25 Nm (18 lbf.ft).

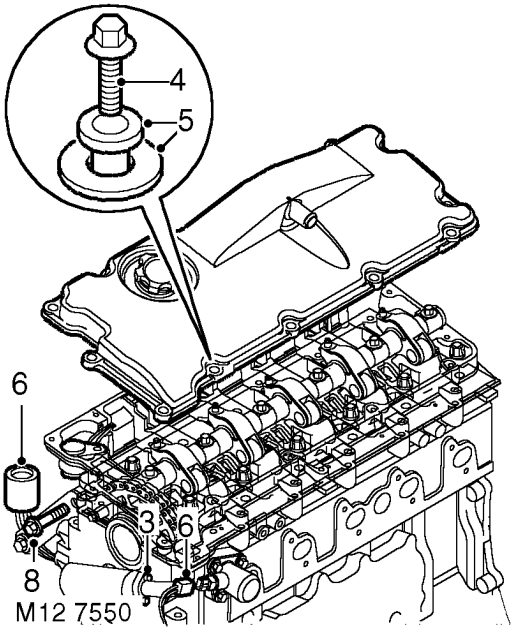
Gasket - cylinder head

12.29.02.01

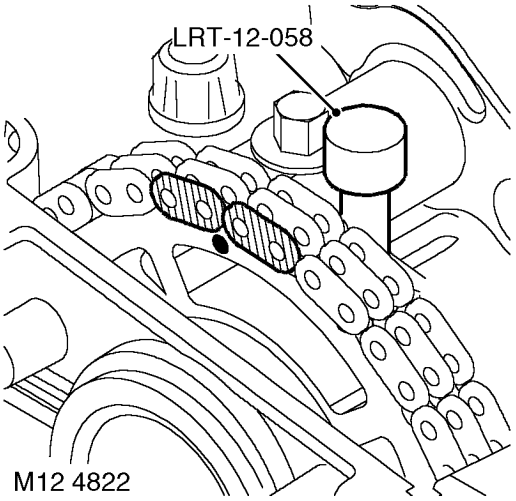
Disassembly

Note: The following procedures cover engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.

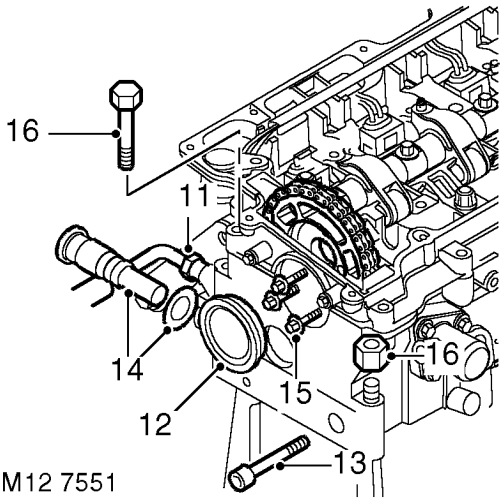
1. Remove exhaust manifold gasket.
   ☞ **ENGINE - Td5, OVERHAUL, Gasket - exhaust manifold.**
2. Remove inlet manifold gasket.
   ☞ **ENGINE - Td5, OVERHAUL, Gasket - inlet manifold.**



3. **EGR cooler fitted:** Remove and discard 2 Allen screws securing EGR pipe to cooler.
4. Progressively loosen then remove 13 bolts securing camshaft cover, remove cover; remove and discard gasket.
5. Remove isolators and sealing washers from cover.
6. Disconnect injector multiplug from camshaft carrier.
7. Disconnect multiplug from ECT sensor.
8. Remove bolt securing alternator strap bracket to cylinder head.

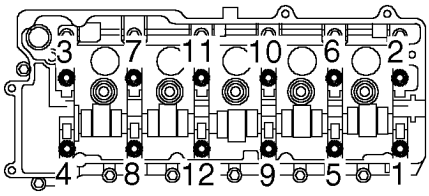


9. Using crankshaft pulley bolt, rotate crankshaft and set engine to TDC No.1 cylinder firing - coloured links on timing chain must be aligned with timing mark on camshaft sprocket.
10. Fit timing pin **LRT-12-058** into slot in camshaft.



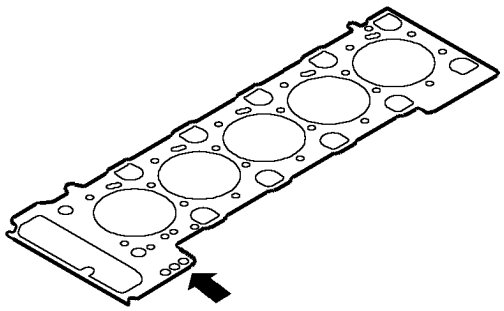
11. Disconnect alternator/vacuum pump oil feed pipe union from cylinder head, remove and discard 'O' ring.
12. Remove camshaft sprocket access plug from front of cylinder head, remove and discard 'O' ring.
13. Remove timing chain fixed guide Allen screw.
14. Remove timing chain tensioner, remove and discard sealing washer.
15. Remove and discard 3 bolts securing camshaft sprocket to camshaft; release sprocket from camshaft.

16. Remove bolt and nut securing front of cylinder head to timing chain cover.



M12 7343

17. Using sequence shown, progressively loosen then remove 12 cylinder head bolts; discard bolts together with their captive washers.
18. Using assistance, remove cylinder head and support each end of cylinder head on 2 wooden blocks.



M12 7548

19. Remove the cylinder head gasket.
20. Note the gasket thickness indicator and ensure the same thickness gasket is used on refitment of the cylinder head.

CAUTION: If new pistons, connecting rods or crankshaft are to be fitted, it will be necessary to measure piston stand proud in order to determine thickness of gasket required – See Pistons, Connecting Rods and Cylinder Bores – Cylinder head gasket selection.

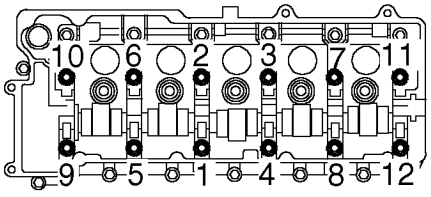
21. Remove and discard 2 plastic locating dowels from cylinder block.
22. Carry out cylinder head overhaul procedures.
☞ **ENGINE - Td5, OVERHAUL, Cylinder head - overhaul.**

Reassembly

1. Thoroughly clean cylinder block and cylinder head mating faces.
2. Ensure coolant and oil passageways are clear and bolt holes are clean and dry.
3. Ensure locating dowel holes in cylinder block are clean and dry.
4. Fit new plastic locating dowels in cylinder block.
5. Fit new cylinder head gasket of the correct thickness with the word 'TOP' uppermost.

CAUTION: Gasket must be fitted dry.

6. Ensure that timing pin **LRT-12-058** is still fitted and using assistance, fit cylinder head.
7. Carefully enter new cylinder head bolts together with their captive washers. **DO NOT DROP.** Lightly tighten bolts.

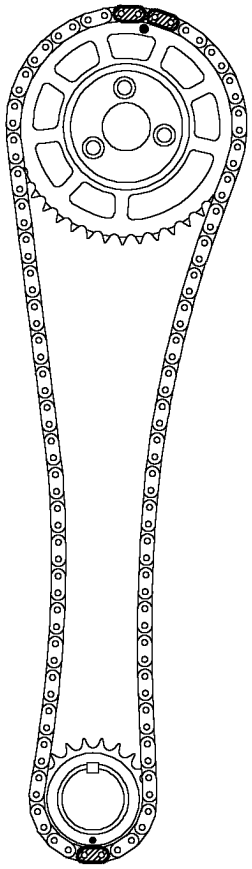


M12 4384

8. Using sequence shown tighten cylinder head bolts to:
   - Stage 1 - 30 Nm (23 lbf.ft)
   - Stage 2 - 65 Nm (48 lbf.ft)
   - Stage 3 - 90°
   - Stage 4 - Further 180°
   - Stage 5 - Further 45°

CAUTION: Ensure correct tightening sequence is followed for all 5 tightening stages, do not tighten bolts 315° in one operation.

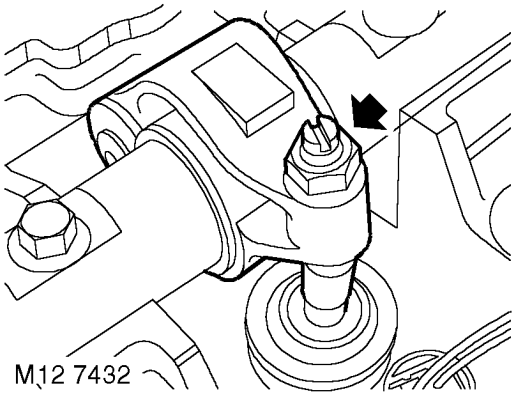
9. Fit cylinder head to timing chain cover nut and bolt and tighten to 25 Nm (18 lbf.ft).
10. Clean camshaft sprocket and mating face on camshaft.



M12 4807

11. Ensure engine is set to TDC firing - No.1 cylinder.
12. Check that mark on camshaft sprocket is positioned between the 2 coloured links on timing chain.
13. Position sprocket to camshaft, fit and lightly tighten 3 new bolts then loosen bolts half a turn.
14. Clean fixed guide Allen screw and apply Loctite 242 to screw threads.
15. Fit fixed timing chain guide Allen screw and tighten to 25 Nm (18 lbf.ft).
16. Clean timing chain tensioner and fit new sealing washer.
17. Fit timing chain tensioner and tighten to 45 Nm (33 lbf.ft).
18. Tighten camshaft sprocket bolts to 37 Nm (27 lbf.ft).
19. Remove tool **LRT-12-058** from camshaft.
20. Lubricate a new 'O' ring with engine oil and fit to camshaft sprocket access plug.
21. Fit camshaft sprocket access plug.
22. Clean alternator/vacuum pump oil hose union.
23. Lubricate a new 'O' ring with engine oil and fit to alternator/vacuum pump oil hose union.
24. Fit and tighten alternator/vacuum pump oil hose union to 10 Nm (7 lbf.ft).
25. Fit bolt securing alternator strap bracket to cylinder head and tighten to 25 Nm (18 lbf.ft).
26. Connect multiplugs to ECT sensor and EUI's.

CAUTION: Following cylinder head overhaul, it will be necessary, before fitting the camshaft cover to adjust the fuel injector rockers using the following procedures:



M12 7432

27. Rotate engine clockwise until No.1 EUI lobe is at full lift.
28. Tighten No.1 rocker adjusting screw until the EUI plunger is felt to 'bottom out'.
29. Loosen rocker adjusting screw 1 complete turn to give EUI plunger the required bump clearance and tighten rocker adjusting screw to 16 Nm (12 lbf.ft).

CAUTION: Ensure screw does not turn as locknut is tightened.

30. Carry out the above procedures for the remaining 4 rocker arms.
31. After completion of rocker adjustment, slowly rotate engine clockwise 2 complete turns by hand to ensure that no EUI's are bottoming out on their plungers.
32. Clean camshaft cover and mating face.
33. Fit new sealing washers and isolators as necessary to camshaft cover.
34. Fit new camshaft cover gasket to cover.

CAUTION: Gasket must be fitted dry.

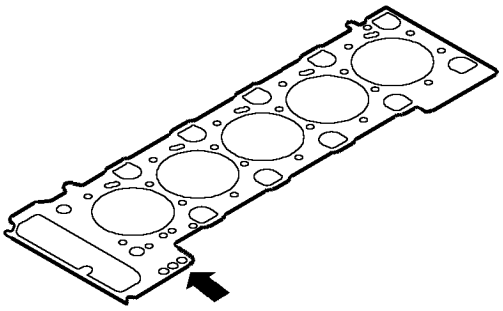
35. Fit camshaft cover to camshaft carrier, fit bolts and working from the centre outwards tighten bolts to 10 Nm (7 lbf.ft).
36. Fit inlet manifold gasket.
    ☞ **ENGINE - Td5, OVERHAUL, Gasket - inlet manifold.**
37. Fit exhaust manifold gasket.
    ☞ **ENGINE - Td5, OVERHAUL, Gasket - exhaust manifold.**
38. **EGR cooler fitted:** Position EGR pipe to cooler, fit new Allen screws and tighten to 10 Nm (7 lbf.ft)

Cylinder head - overhaul

12.29.19.01

Disassembly

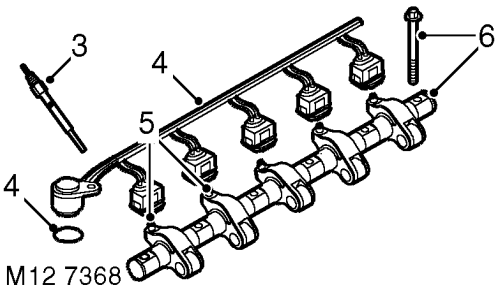
1. Remove cylinder head gasket. **Due to the design of the cylinder head, which incorporates drillings for the fuel injection system, it is important that absolute cleanliness is adhered to when carrying out any work to the cylinder head.**
   ☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**



M12 7548

2. Note the gasket thickness indicator and ensure the same thickness gasket is used on refitment of cylinder head.

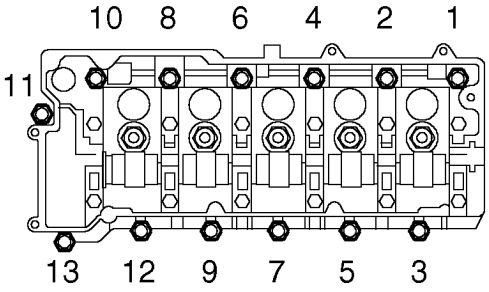
   CAUTION: If new pistons, connecting rods or crankshaft are to be fitted, it will be necessary to measure piston stand proud in order to determine thickness of gasket required – See Pistons, Connecting rods and Cylinder Bores – Cylinder head gasket selection.



M12 7368

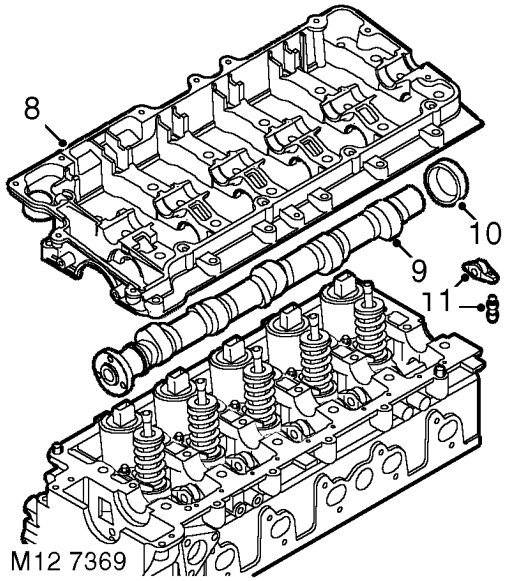
3. Remove 4 glow plugs.
4. Disconnect multiplugs from EUI's and remove harness from camshaft carrier. Remove and discard 'O' ring from harness multiplug.

5. Loosen locknuts and fully unscrew rocker adjusting screws; discard locknuts and screws.
6. Remove and discard 6 bolts securing rocker shaft, release shaft from locating dowel and remove shaft.



M12 7334

7. Using sequence shown, progressively loosen 13 bolts securing camshaft carrier to cylinder head until valve spring pressure is released; remove bolts. **Do not discard bolts at this stage.**

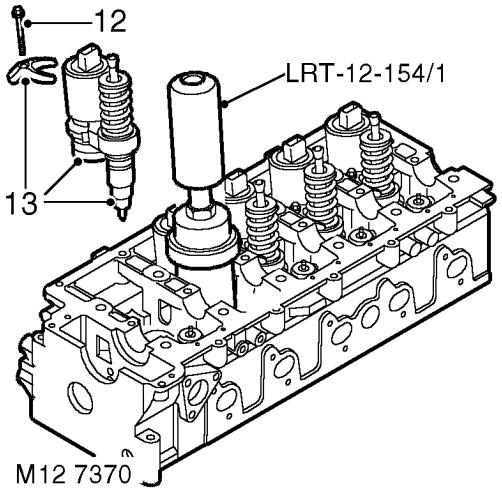


M12 7369

8. Gently tap camshaft carrier upwards to break sealant bond, release carrier from locating dowels; remove carrier.
9. Remove camshaft.
10. Remove and discard camshaft rear oil seal.

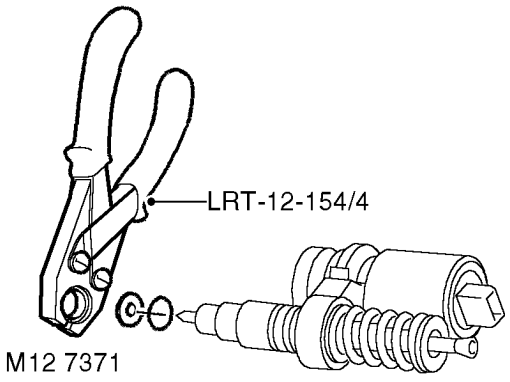
11. Remove finger followers and lash adjusters.

CAUTION: Store lash adjusters in their fitted order and store upright. Maintain absolute cleanliness when handling lash adjusters. Failure to observe these precautions can result in engine failure.



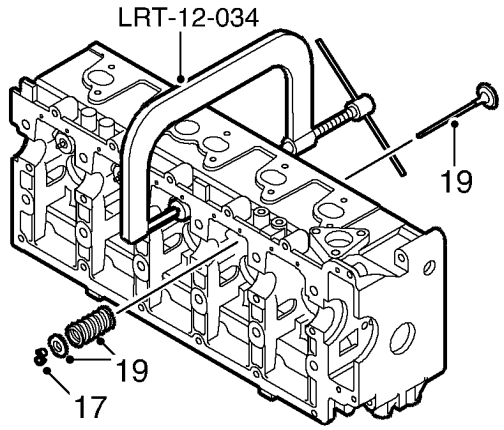
M12 7370

12. Remove and discard 5 bolts securing EUI retainers.
13. Using tool **LRT-12-154/1** remove EUI units from cylinder head and collect retainers; remove reaction posts. **Keep components in their fitted order.**



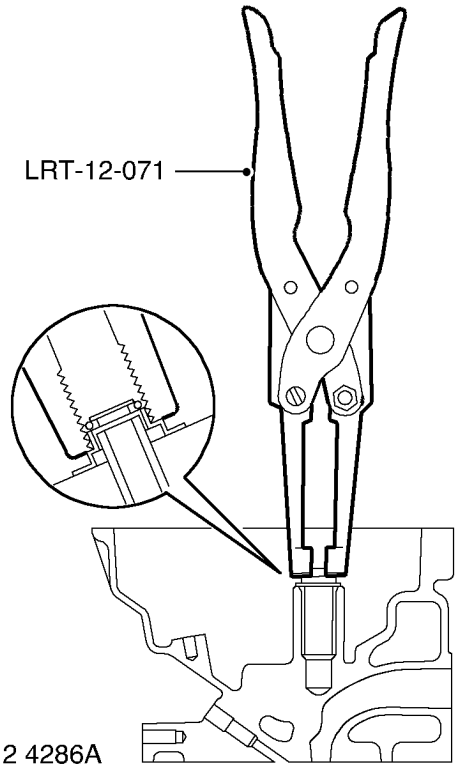
M12 7371

14. Using tool **LRT-12-154/4,** remove and discard sealing washer and 'O' ring from each injector unit.
15. Support cylinder head clear of valves, use a hollow drift and tap each spring cap to free collets.



M12 7439

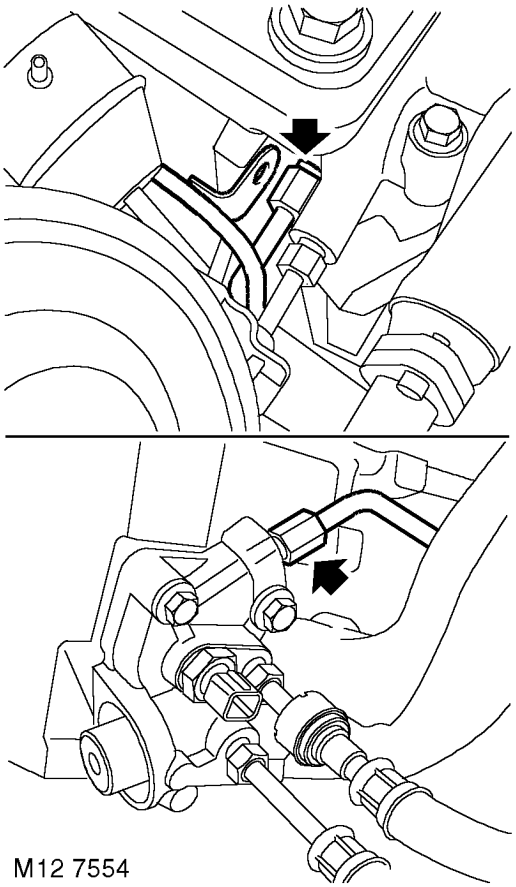
16. Using tool **LRT-12-034** compress valve spring.
17. Remove 2 collets from valve stem using a stick magnet.
18. Remove tool **LRT-12-034** .
19. Remove valve spring cap, valve spring and valve. **Keep components in their fitted order.**



M12 4286A

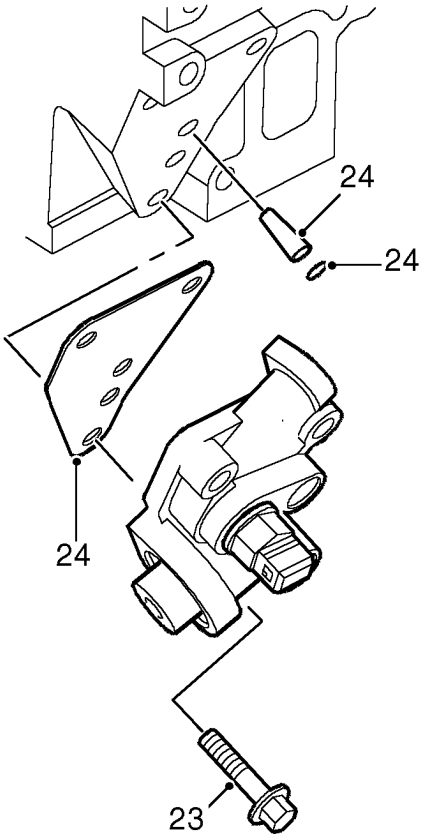
20. Using tool **LRT-12-071**, remove and discard valve stem oil seal.

21. Repeat above operations to remove remaining valves. **Keep components in their fitted order.**



M12 7554

22. **Engine Serial No. Prefixes 15P to 19P:**Disconnect spill return pipe from cylinder head and fuel connector block, remove and discard 'O' rings.



M12 7555

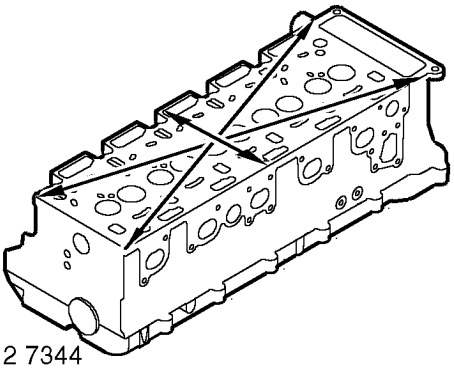
23. Remove 3 bolts and remove fuel connector block from cylinder head.
24. Remove gasket, discard 'O' ring and fuel filter.
25. **If fitted:** Remove spacer block and gasket.

Inspect

1. Thoroughly clean cylinder head mating faces, ensure that EUI drillings, oil and coolant passages are clear and bolt holes are clean and dry.
2. Using suitable solvent, remove all traces of sealant and gasket material.

   CAUTION: Do not use metal scrapers.

3. Remove all traces of oil from camshaft bearings and journals.
4. Clean glow plug threads.
5. Check core plugs for signs of leakage and corrosion, seal replacement plugs with Loctite 243.



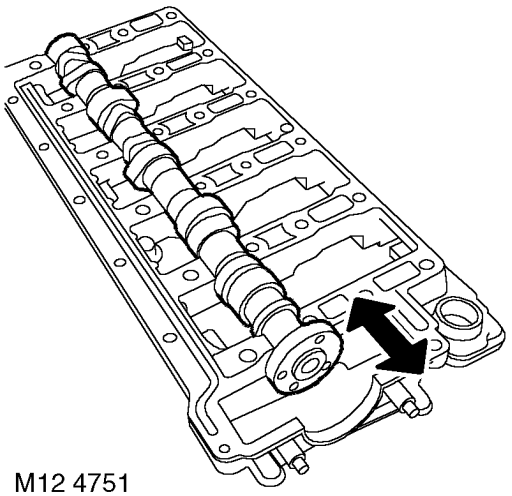
M12 7344

6. Check cylinder head for warping across centre and from corner to corner:
   - Maximum cylinder head warp = 0.1 mm (0.004 in)

   Cylinder heads must not be refaced. Replace the head assembly if warping exceeds the limit.
7. Check lash adjuster bores for scoring and signs of wear or damage.
8. Check lash adjusters for signs of wear, scoring and overheating, replace as necessary. Ensure oil hole in each lash adjuster is clear. **Store lash adjusters upright and in their fitted order.**
9. Check finger followers for wear and that rollers are free to rotate. **Store finger followers in their fitted order.**
10. Check camshaft lobes and bearing journals for signs of scoring and wear.
11. Check bearing surfaces in cylinder head and camshaft carrier for signs of scoring and wear.

    Cylinder head and camshaft carrier are machined together as an assembly. If bearing surfaces in either component are damaged, both components must be replaced as an assembly.

12. Check camshaft end-float using following procedures.
13. Position camshaft in camshaft carrier.

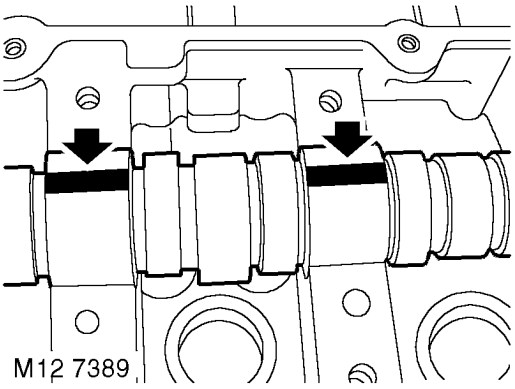


M12 4751

14. Check end-float of camshaft using a DTI:
- Camshaft end-float = 0.06 to 0.16 mm (0.002 to 0.006 in)

15. Renew components as necessary to achieve correct end-float.

16. Check camshaft bearing clearances using the following procedures.

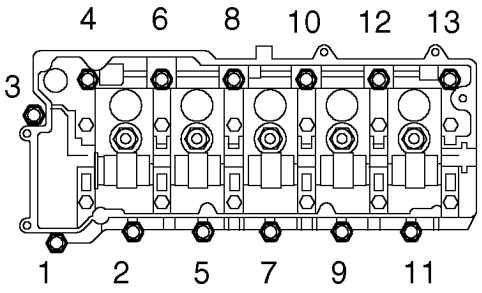


M12 7389

17. Position camshaft in cylinder head.

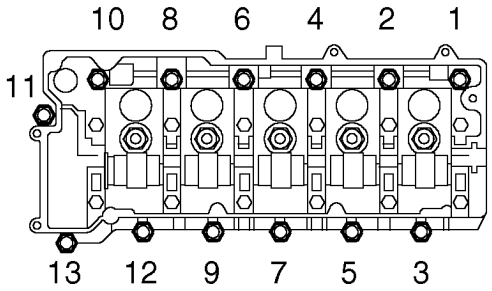
18. Place a piece of Plastigage along centre line of each camshaft bearing journal.

19. Carefully fit the camshaft carrier ensuring it is located on dowels. **Do not rotate camshaft.**



M12 7337

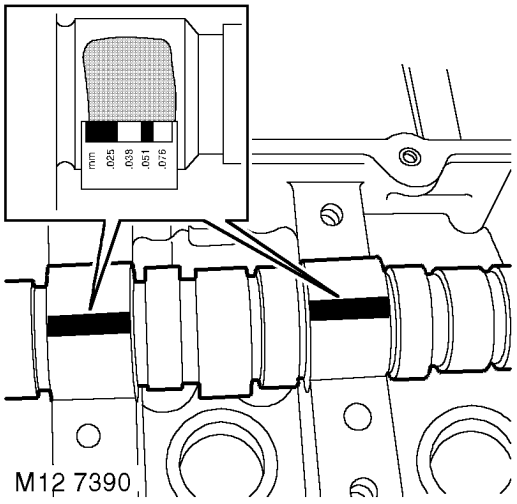
20. Fit original camshaft carrier bolts and tighten in sequence shown to 25 Nm (18 lbf.ft).



M12 7334

21. Using sequence shown, loosen then remove camshaft carrier retaining bolts. **Do not discard bolts at this stage.**

22. Carefully remove camshaft carrier.



M12 7390

23. Measure and record widest portion of Plastigage on each camshaft bearing journal.

24. Compare figures obtained with camshaft bearing clearance:
- Camshaft bearing clearance = 0.04 to 0.10 mm (0.002 to 0.004 in)

25. If any bearing clearance is found to exceed figures given, repeat the above procedures using a new camshaft. If, after repeating the clearance check using a new camshaft the clearances are still excessive, a new cylinder head and camshaft carrier assembly must be fitted.

26. Remove all traces of Plastigage using an oily cloth, do not use a scraper.

27. On completion, discard camshaft carrier bolts.

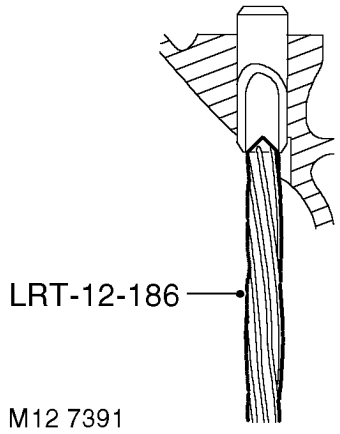
28. Check free length of valve springs:
- Free length = 46.75 to 47.25 mm (1.84 to 1.86 in)

29. **Replace valve springs as a set, if springs are to be refitted, keep them in their fitted order.**

30. Clean carbon from valves, check valves for burning, pitting or cracking; replace as necessary.

31. Clean carbon from valve seat inserts, remove all loose particles on completion.

32. Check valve seat inserts for pitting and burning. **It is not permissible to recut or replace valve seat inserts.**



33. Remove carbon deposits from valve guides using tool **LRT-12-186** inserted from the combustion chamber face side of cylinder head. Ensure all loose particles of carbon are removed on completion.

34. Check and record diameter of each valve stem:
- Valve stem diameter - Inlet = 6.907 to 6.923 mm (0.2719 to 0.2725 in)
- Valve stem diameter - Exhaust = 6.897 to 6.913 mm (0.2715 to 0.2721 in)

35. Renew any valve if stem diameter is less than specified.

36. Check and record valve stem to guide clearance using the following procedures.

37. Insert each valve into its respective guide.

38. Extend valve head 10 mm (0.375 in) out of valve seat and position a DTI gauge to rear of valve head.

39. Move valve towards front of cylinder head and zero DTI gauge ensuring that stylus of gauge remains in contact with valve head.

40. Move valve towards rear of cylinder head, record gauge reading to give valve stem to guide clearance:
- Inlet valve = 0.025 to 0.059 mm (0.0009 to 0.0023 in)
- Exhaust valve = 0.035 to 0.069 mm (0.0013 to 0.0027 in)

41. If stem to guide clearance exceeds figures given and valve stem diameters were as specified, cylinder head assembly must be replaced; it is not possible to replace valve guides.

42. Repeat above procedures for remaining valves. Keep valves in their fitted order.

43. Check face angle of each valve, renew any valve with incorrect face angles, do not attempt to recut.
- Valve face angle - inlet = 29° 48' ± 12'
- Valve face angle - exhaust = 44° 48' ± 12'

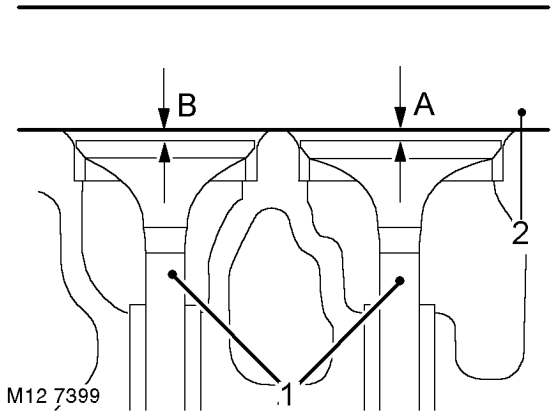
44. Lap each valve to its seat using grinding paste.

45. Apply Prussion Blue to valve seat, insert valve into guide and press it firmly, without rotating on to seat.

46. Remove valve and check that a continuous, even line of Prussian Blue has been transferred on to valve face. **Note that line does not have to be across whole width of valve face.**

47. Remove all traces of grinding paste on completion.

48. Check valve head stand down using the following procedures.



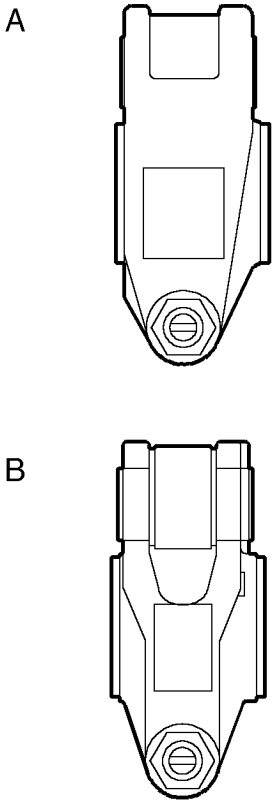
49. Insert each valve into its respective guide.

50. Using a straight edge and feeler gauges, check and record stand down of each valve head.

51. Compare figures obtained with those given below:

- Valve head stand down - Inlet valve A = 0.555 to 0.825 mm (0.022 to 0.032 in)
- Valve head stand down - Exhaust valve B = 0.545 to 1.35 mm (0.021 to 0.053 in)

52. **If any valve has a stand down greater than specified, repeat check using a new valve. If, after checking with a new valve, stand down is still excessive, cylinder head assembly must be replaced. It is not possible to replace valve seat inserts.**

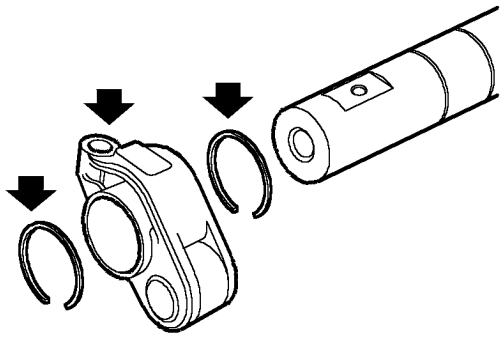


53. Suitably identify each rocker arm to its fitted position and type of rocker arm fitted.

NOTE:

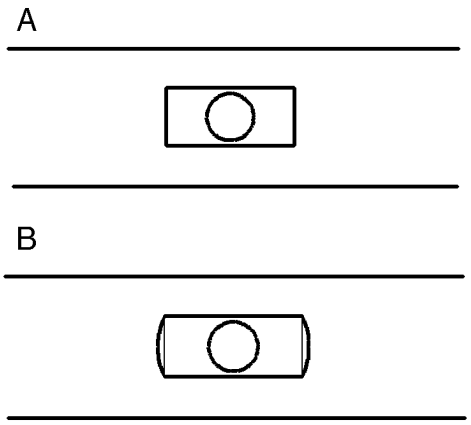
- *Engine Serial No. Prefixes 10P to 14P - Type A rocker arms*
- *Engine Serial No. Prefixes 15P to 19P - Type B rocker arms.*

Type B rocker arms and shafts may be fitted to Engine Serial No. Prefixes 10P to 14P as an assembly.



M12 7393

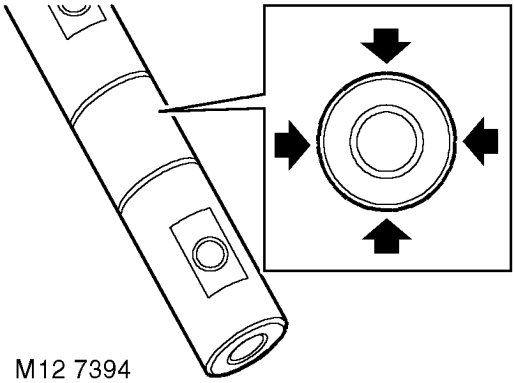
54. Remove and discard spring ring retaining rocker arm on shaft.
55. Remove rocker arm. Remove and discard 2nd spring ring.
56. Repeat above procedures for remaining rocker arms keeping them in their fitted order.



M12 7557

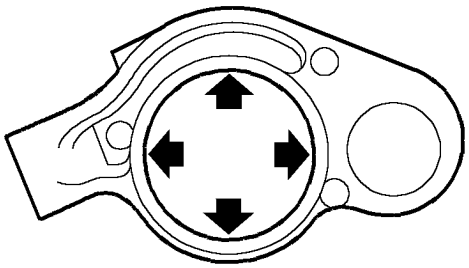
57. Clean rocker arms and shaft, ensure oilways are clear.

CAUTION: Identify type of rocker shaft fitted. Engine Serial No. Prefixes 10P to 14P – Type A rocker shaft; Engine Serial No. Prefixes 15P to 19P – Type B rocker shaft. Type B rocker shafts and arms may be fitted to Engine Serial No. Prefixes 10P to 14P as an assembly.



M12 7394

58. Check diameter of each rocker arm journal on shaft, take 2 measurements at 180°:
    - Journal diameter = 26.971 to 26.998 mm (1.061 to 1.063 in)



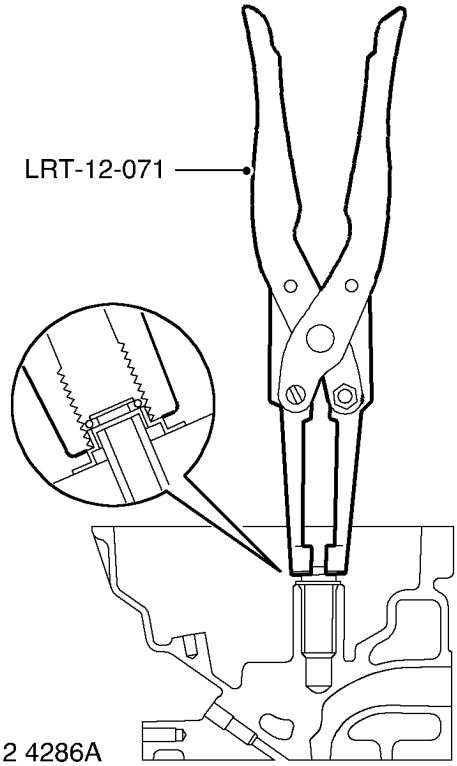
M12 7395

59. Using a vernier, check internal diameter of each rocker arm, take 2 measurements at 180°:
    - Rocker arm internal diameter = 27.0 to 27.013 mm (1.062 to 1.064 in)
60. Fit new spring ring to groove in rocker shaft.
61. Lubricate rocker shaft journals and rocker arms with engine oil.
62. Fit rocker arm to shaft ensuring it is in its original fitted order.
63. Fit new spring ring to retain rocker arm.
64. Repeat above procedures for remaining rocker arms ensuring they are in their original fitted order.
65. Fit new rocker adjusting screws and locknuts to rocker arms; do not tighten screws fully into arms at this stage.

CAUTION: Ensure screws are correct for type of rocker arms fitted. Replacement screws for Engine Serial No. Prefixes 15P to 19P have a centre punch mark adjacent to the adjusting slot. These screws are not interchangeable with those fitted to Engine Serial No. Prefixes 10P to 14P.

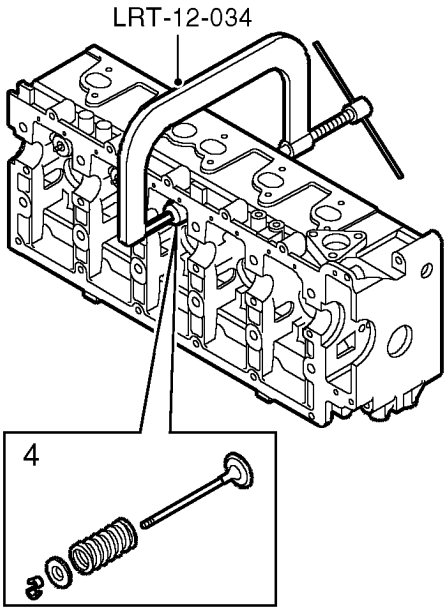
Reassembly

1. Lubricate new valve stem oil seals with engine oil.



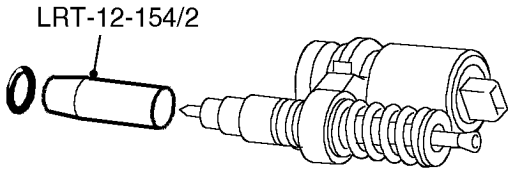
M12 4286A

2. Using tool **LRT-12-071** fit valve stem oil seals.
3. Lubricate valve guides, valve stems, valve spring caps and springs with engine oil.



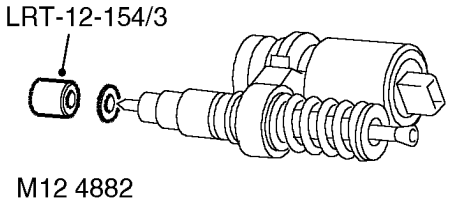
M12 7396

4. Assemble valves, springs and spring caps ensuring they are in their original fitted order.
5. Compress valve springs using tool **LRT-12-034** , fit collets.
6. Using a wooden dowel and mallet, tap each spring cap lightly to seat collets.
7. Lubricate new injector 'O' rings with engine oil.



M12 4881A

8. Using tool **LRT-12-154/2,** fit new 'O' ring to each injector.



M12 4882

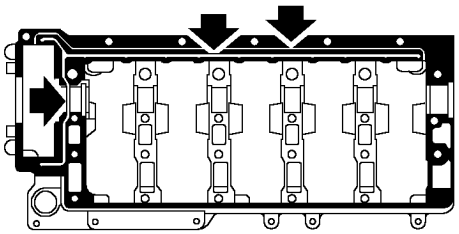
9. Using tool **LRT-12-154/3,** fit new sealing washer to each injector.
10. Support each end of cylinder head on blocks of wood ensuring blocks are clear of valves.
11. Position reaction posts in their original fitted order.
12. Carefully fit EUI's, ensuring they are in their original fitted order and that each retainer is located on its dowel.

    CAUTION: If new EUI's are fitted, ensure replacements are correct. Engine Serial No. Prefixes 10P to 14P – Push rod bushes are coloured BLACK or BLUE. Serial No. Prefixes 15P to 19P – Push rod bushes are coloured GREEN.

13. Fit new retainer bolts and tighten to 32 Nm (24 lbf.ft).

    If new injectors are fitted they must be programmed for use with the ECM using TestBook.

14. Lubricate lash adjusters and bores with engine oil.
15. Fit lash adjusters ensuring they are in their original fitted order.
16. Lubricate finger followers with engine oil.
17. Fit finger followers ensuring they are in their original fitted order.
18. Lubricate cams and bearing journals on camshaft, cylinder head and camshaft carrier with engine oil.
19. Position camshaft in cylinder head with the timing pin hole in the vertical position.

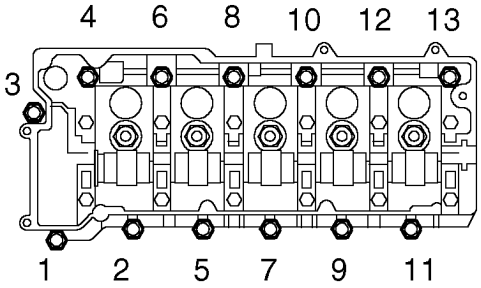


M12 7336

20. Apply an even film of sealant, Part No. STC 4600 to camshaft carrier face and spread to an even film using a roller.

    CAUTION: Ensure sealant does not block oilways (arrowed) or contaminate camshaft bearings. Assembly and bolt tightening must be completed within 20 minutes of applying sealant.

21. Fit camshaft carrier ensuring it is correctly located on dowels.
22. Fit and lightly tighten new camshaft carrier bolts.



M12 7337

23. Using sequence shown, progressively tighten bolts to 25 Nm (18 lbf.ft).
24. Lubricate a new camshaft rear oil seal with engine oil, fit seal using a suitable mandrel.
25. Position rocker shaft on camshaft carrier ensuring rocker shaft is located on dowel.
26. Fit new rocker shaft retaining bolts and working from the centre outwards, tighten rocker shaft bolts to 32 Nm (24 lbf.ft).
27. Fit injector harness and connect multiplugs.
28. Clean fuel connector block and mating face.
29. Lubricate a new fuel filter 'O' ring with engine oil.

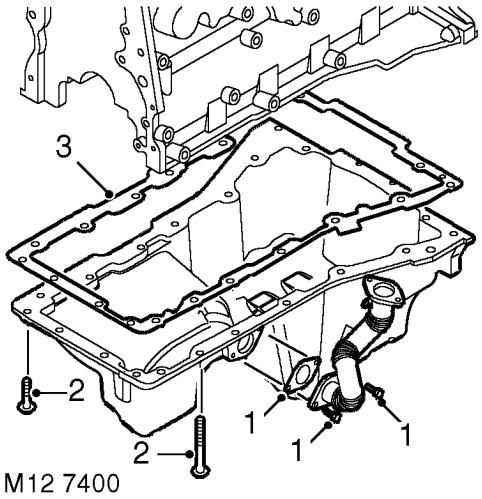
30. Fit new fuel filter, 'O' ring, and gasket.
CAUTION: Gasket must be fitted dry.

31. **If fitted:** Fit fuel connector spacer block and gasket.
32. Fit fuel connector block, fit bolts and tighten to 25 Nm (18 lbf.ft).
33. Clean glow plugs.
34. Fit glow plugs to cylinder head and tighten to 16 Nm (12 lbf.ft).
35. Fit new cylinder head gasket.
☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**
36. **Engine Serial No. Prefixes 15P to 19P:**Lubricate new 'O' rings with engine oil and fit to spill return pipe, fit pipe and tighten connectors to 20 Nm (15 lbf.ft).
37. Before fitting the camshaft cover, the fuel injector rockers must be adjusted following the procedures given in Cylinder head gasket - Refit.
☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**

Gasket - engine sump

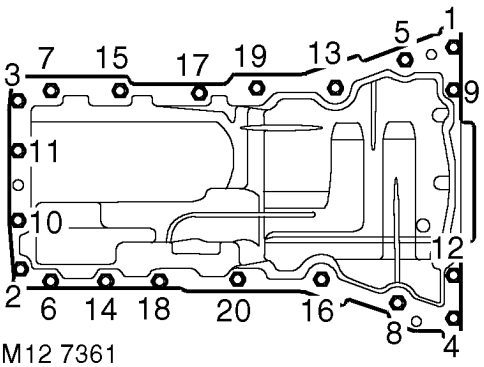
12.60.38.01

Disassembly



M12 7400

1. Remove 2 bolts securing centrifuge oil drain pipe to sump, remove and discard gasket.

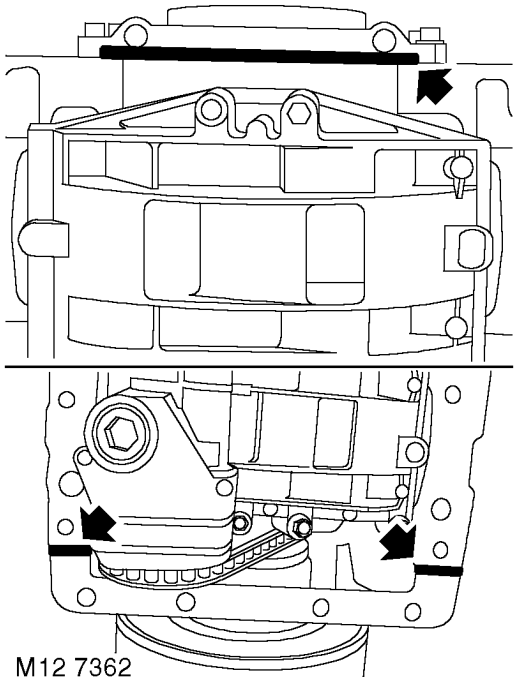


M12 7361

2. Using sequence shown and noting their fitted positions, remove 20 bolts securing sump to cylinder block.
3. Release sump from locating dowels, remove sump; remove and discard gasket.

Reassembly

1. Clean sump and mating faces, ensure bolt holes in cylinder block are clean and dry.
2. Using suitable solvent, remove all traces of sealant from joint faces of timing chain cover and crankshaft rear oil seal housing.
3. Clean centrifuge oil drain pipe and mating faces.

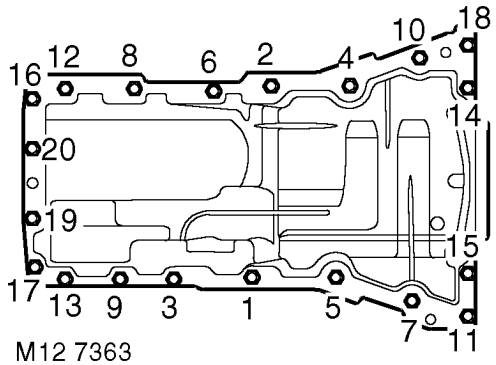


M12 7362

4. Apply a bead of sealant, Part No. STC 3254 to joint faces of timing chain cover and crankshaft rear oil seal housing.
   CAUTION: Assembly and bolt tightening must be completed within 20 minutes of applying sealant.

5. Position new sump gasket.
   CAUTION: Gasket must be fitted dry.

6. Position sump, fit and lightly tighten bolts ensuring they are in their original fitted positions.



M12 7363

7. Using sequence shown, tighten sump bolts to 25 Nm (18 lbf.ft).

8. Fit new centrifuge oil drain pipe gasket.
   CAUTION: Gasket must be fitted dry.

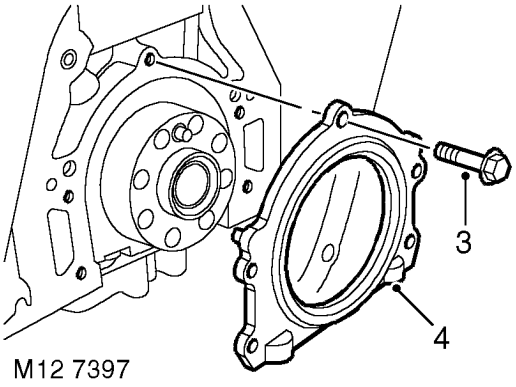
9. Fit centrifuge oil drain pipe, fit bolts and tighten to 10 Nm (7 lbf.ft).

Seal - crankshaft - rear - manual models

12.21.20.01

Disassembly

1. Remove flywheel.
   ENGINE - Td5, OVERHAUL, Flywheel.
2. Remove sump gasket.
   ENGINE - Td5, OVERHAUL, Gasket - engine sump.

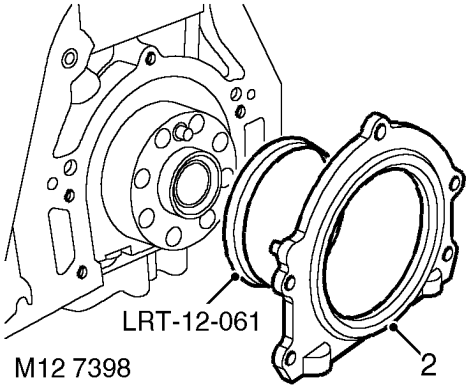


M12 7397

3. Remove 5 bolts securing crankshaft rear oil seal housing to cylinder block.
4. Release crankshaft rear oil seal housing from locating dowels, discard rear oil seal and housing.

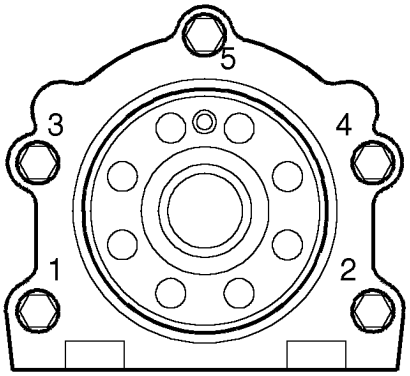
Reassembly

1. Clean crankshaft oil seal housing mating face on cylinder block, ensure bolt and dowel holes are clean and dry. Remove all traces of oil from oil seal running surface on crankshaft.



M12 7398

2. Position seal protector **LRT-12-061** over crankshaft boss. Fit new oil seal and housing and remove tool **LRT-12-061**.
   CAUTION: Oil seal must be fitted dry.



M12 7339

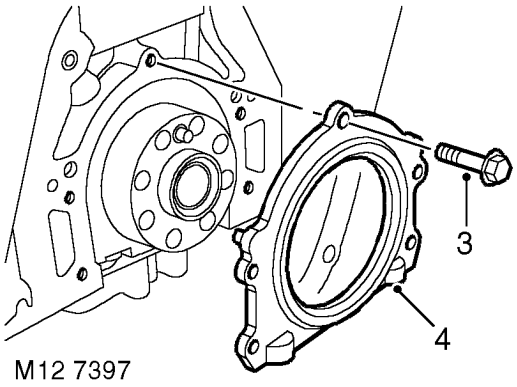
3. Fit oil seal housing bolts and using sequence shown, tighten to 9 Nm (7 lbf.ft).
4. Fit sump gasket.
   ENGINE - Td5, OVERHAUL, Gasket - engine sump.
5. Fit flywheel.
   ENGINE - Td5, OVERHAUL, Flywheel.

Seal - crankshaft - rear - automatic models

12.21.20.01

Disassembly

1. Remove sump gasket.
   ENGINE - Td5, OVERHAUL, Gasket - engine sump.
2. Remove drive plate.
   ENGINE - Td5, OVERHAUL, Drive plate.

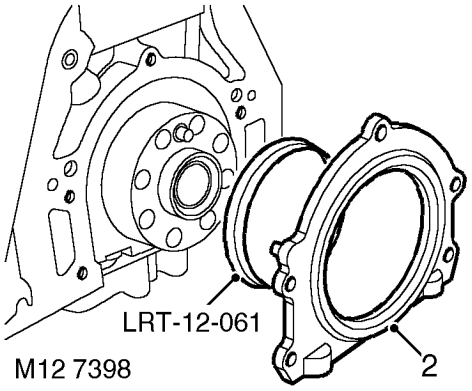


M12 7397

3. Remove 5 bolts securing crankshaft rear oil seal housing to cylinder block.
4. Release crankshaft rear oil seal housing from locating dowels, discard rear oil seal and housing.

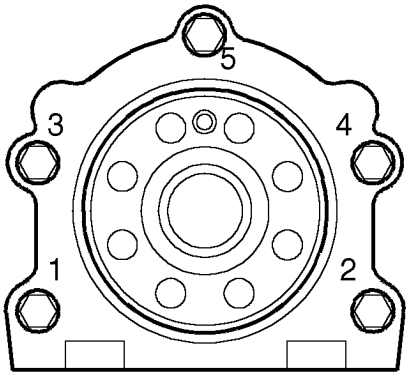
Reassembly

1. Clean crankshaft oil seal housing mating face on cylinder block, ensure bolt and dowel holes are clean and dry. Remove all traces of oil from oil seal running surface on crankshaft.



M12 7398

2. Position seal protector **LRT-12-061** over crankshaft boss. Fit new oil seal and housing and remove tool **LRT-12-061**.
   CAUTION: Oil seal must be fitted dry.



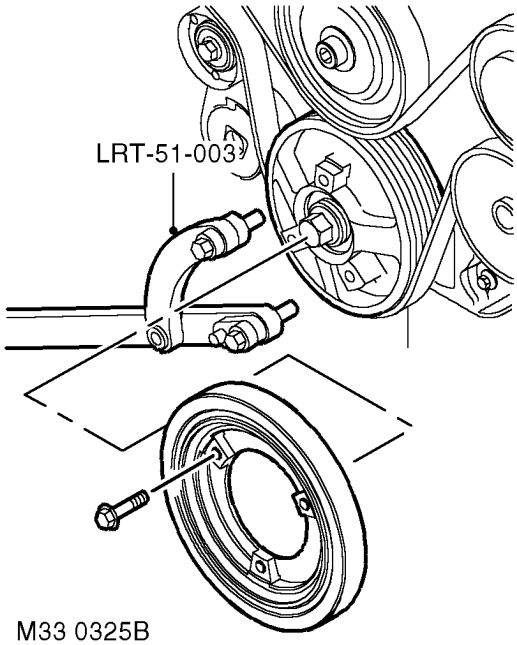
M12 7339

3. Fit oil seal housing bolts and using sequence shown, tighten to 9 Nm (7 lbf.ft).
4. Fit sump gasket.
   ENGINE - Td5, OVERHAUL, Gasket - engine sump.
5. Fit drive plate.
   ENGINE - Td5, OVERHAUL, Drive plate.

Flywheel

12.53.07.01

Disassembly



1. Remove 3 bolts securing damper to crankshaft pulley, fit **LRT-51-003** to crankshaft pulley, secure with 2 bolts.
2. Restrain crankshaft using **LRT-51-003**, remove and discard 8 bolts securing flywheel to crankshaft. Release flywheel from locating dowels; remove flywheel.

Reassembly

1. Clean flywheel and crankshaft mating faces.
2. Position flywheel on crankshaft.
3. Fit new bolts to retain flywheel and tighten by diagonal selection to:
   - Stage 1 - 40 Nm (30 lbf.ft)
   - Stage 2 - Further 90°

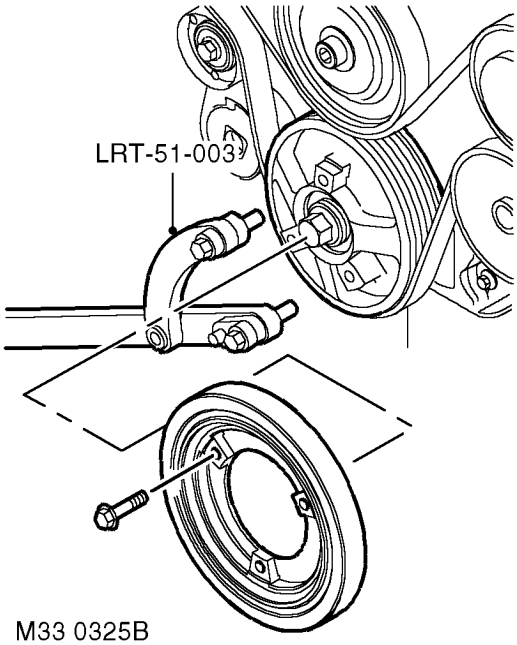
   CAUTION: Do not carry out stages 1 and 2 in one operation.

4. Remove tool **LRT-51-003**, fit damper and tighten bolts to 80 Nm (59 lbf.ft).

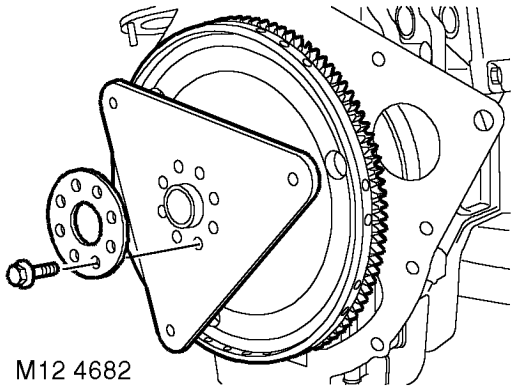
Drive plate

12.53.13.01

Disassembly



1. Remove 3 bolts securing damper to crankshaft pulley, fit **LRT-51-003** to crankshaft pulley, secure with 2 bolts.



2. Restrain crankshaft using **LRT-51-003**, remove and discard 8 bolts securing drive plate, spacer and starter ring gear to crankshaft, release starter ring gear from locating dowels and remove.

Reassembly

1. Clean drive plate, spacer, starter ring gear and crankshaft mating faces.
2. Position starter ring gear on crankshaft, fit spacer and drive plate.
3. Fit new bolts to retain assembly and tighten by diagonal selection to:
   - Stage 1 - 40 Nm (30 lbf.ft)
   - Stage 2 - Further 90°

   CAUTION: Do not carry out stages 1 and 2 in one operation.

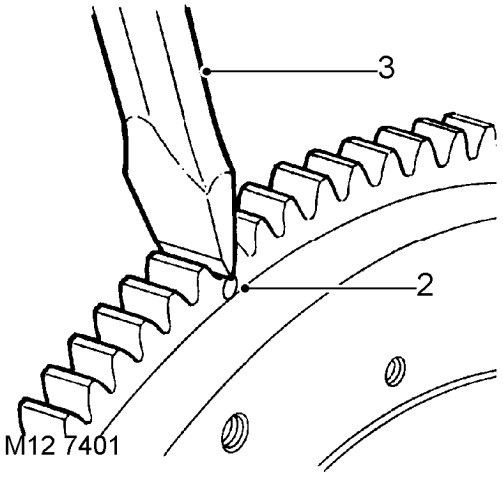
4. Remove tool **LRT-51-003**, fit damper and tighten bolts to 80 Nm (59 lbf.ft).

Starter ring gear

12.53.19

Disassembly

1. **Manual models:** Remove flywheel.
   ENGINE - Td5, OVERHAUL, Flywheel.
2. **Automatic models:** Remove drive plate.
   ENGINE - Td5, OVERHAUL, Drive plate.



3. Drill a 3 mm (0.12 in) diameter hole at root of 2 teeth.
4. Apply a cold chisel to root of teeth, break ring gear and remove from flywheel.

   WARNING: SUITABLE EYE PROTECTION MUST BE WORN.

Reassembly

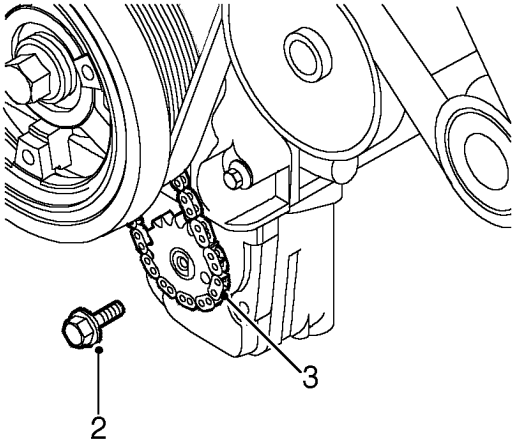
1. Heat ring gear evenly to 350° C, indicated by light blue colour.
2. Locate ring gear on to flywheel and press on to flange.
3. Allow ring gear to air cool.
4. **Manual models:** Fit flywheel.
   ENGINE - Td5, OVERHAUL, Flywheel.
5. **Automatic models:** Fit drive plate.
   ENGINE - Td5, OVERHAUL, Drive plate.

Pump - oil

12.60.26.02

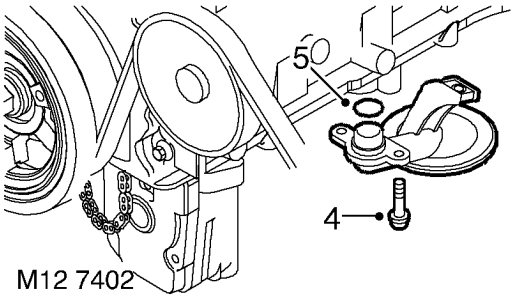
Disassembly

1. Remove sump gasket.
   ENGINE - Td5, OVERHAUL, Gasket - engine sump.



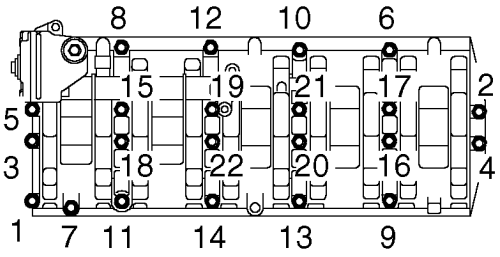
M12 7357

2. Remove bolt securing oil pump drive sprocket.
3. Release drive sprocket from chain, remove sprocket.



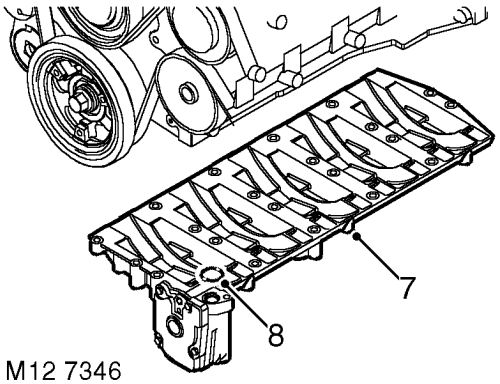
M12 7402

4. Remove 3 Torx screws securing oil pick-up strainer, remove strainer.
5. Remove and discard 'O' ring.



M12 7359

6. Using sequence shown, remove and discard 22 bolts securing oil pump and stiffener plate assembly to cylinder block.

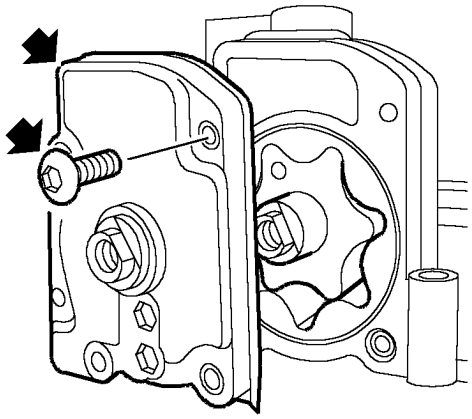


M12 7346

7. Release stiffener plate from locating dowels, remove oil pump and stiffener plate assembly.
8. Remove and discard 'O' ring from oil pump housing outlet.

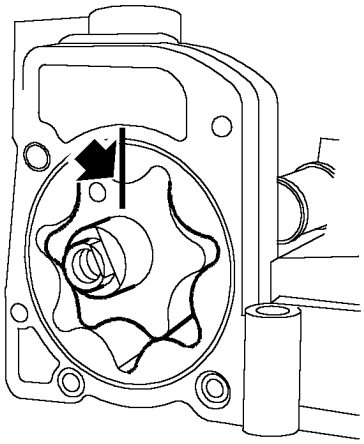
Inspection

1. **Inspection/overhaul procedures for the oil pump are limited to carrying out dimensional checks. In the event of wear or damage being found, a replacement pump and stiffener plate assembly must be fitted.**



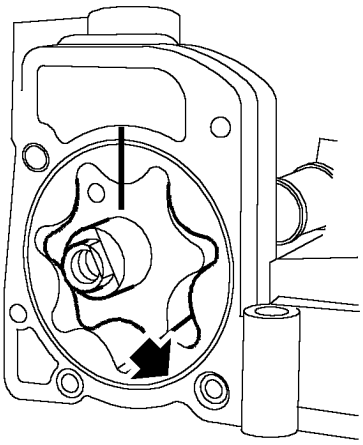
M12 7435

2. Remove and discard 5 screws securing cover to oil pump, remove cover.



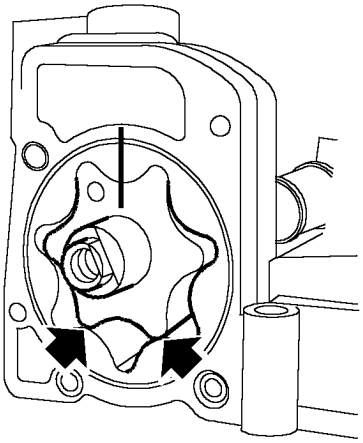
M12 7428

3. Using a felt tipped pen, make suitable alignment marks between inner and outer rotors and oil pump body.
4. Remove inner and outer rotors.
5. Check rotors and pump body for signs of scoring and wear.
6. Fit rotors ensuring that marks are aligned and identification mark on inner rotor is facing outwards.



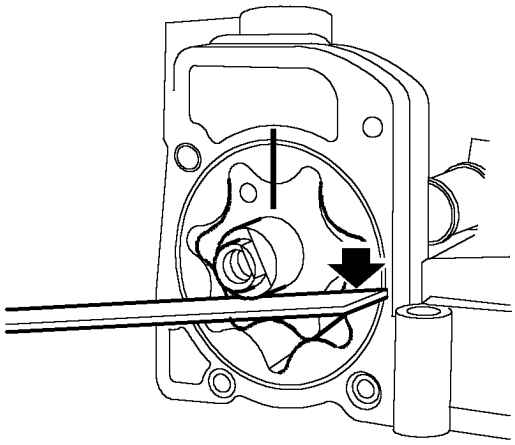
M12 7436

7. Using feeler gauges, check pump outer rotor to body clearance:
   - Outer rotor to body clearance = 0.295 to 0.375 mm (0.012 to 0.015 in)



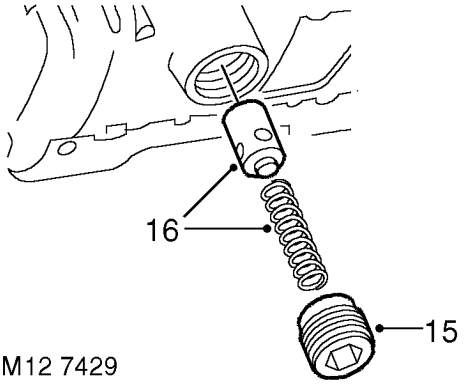
M12 7437

8. Using feeler gauges, check clearance of inner to outer rotor in 2 positions; both clearances must be within limit given:
   - Inner to outer rotor clearance = 0.13 mm (0.05 in)



M12 7438

9. Place a straight edge across pump body and using feeler gauges, measure end-float of outer rotor:
   - Outer rotor end-float = 0.038 to 0.075 mm (0.0001 to 0.003 in)
10. Check drive shaft bush in pump cover for signs of scoring and wear.
11. Renew oil pump and stiffener plate assembly if excessive scoring or wear exists.
12. Lubricate pump rotors and drive shaft bush with engine oil.
13. Fit rotors ensuring reference marks are aligned and identification mark on outer rotor is facing outwards.
14. Fit cover to pump, fit 5 new screws and tighten by diagonal selection to 6 Nm (4.5 lbf.ft).

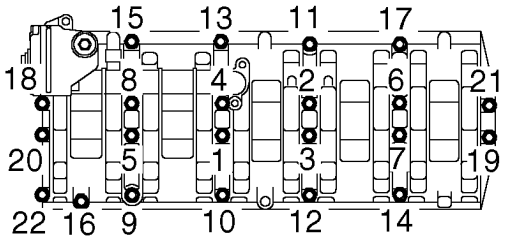


M12 7429

15. Remove and discard oil pressure relief valve plug.
16. Remove spring and relief valve plunger.
17. Clean valve plunger and spring.
18. Check valve plunger and relief valve bore for scoring and corrosion, light scoring and corrosion may be removed using grade 600 emery cloth soaked in oil.
19. Check spring for distortion, check free length of spring:
    - Spring free length = 42.0 mm (1.65 in)
20. Lubricate valve plunger and seating.
21. Fit valve plunger and spring to oil pump.
22. Apply Loctite 243 sealant to threads of a new plug. **Do not attempt to fit original plug.**
23. Fit plug and tighten to 23 Nm (17 lbf.ft).

Reassembly

1. Clean mating faces of oil pump, stiffener plate assembly and cylinder block; ensure bolt and dowel holes are clean and dry.
2. Lubricate a new 'O' ring with engine oil and fit to oil pump housing outlet.
3. Position oil pump and stiffener plate assembly on to cylinder block ensuring 2 dowels are correctly located.



M12 7360

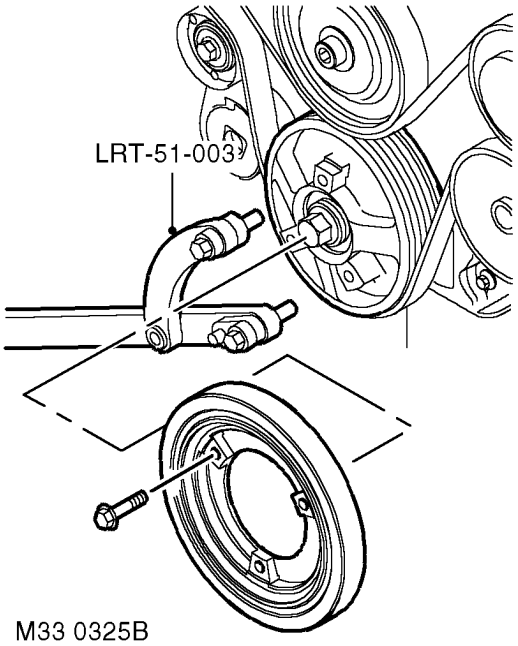
4. Fit new bolts and using sequence shown, tighten to 13 Nm (10 lbf.ft).
5. Lubricate a new 'O' ring with engine oil and fit to oil pick-up strainer.
6. Clean threads of oil pick-up strainer Torx screws and apply Loctite 242 to screw threads.
7. Fit oil pick-up strainer, fit Torx screws and tighten to 10 Nm (8 lbf.ft).
8. Position oil pump drive sprocket to chain and oil pump ensuring that the 'D' shape on the drive sprocket is located on the flat on the oil pump drive shaft.
9. Clean oil pump drive sprocket retaining bolt and apply Loctite 242 to bolt threads.
10. Fit oil pump drive sprocket and tighten bolt to 25 Nm (18 lbf.ft).
11. Fit new sump gasket.
    ☞ **ENGINE - Td5, OVERHAUL, Gasket - engine sump.**

Timing chain and sprockets

12.65.13.01

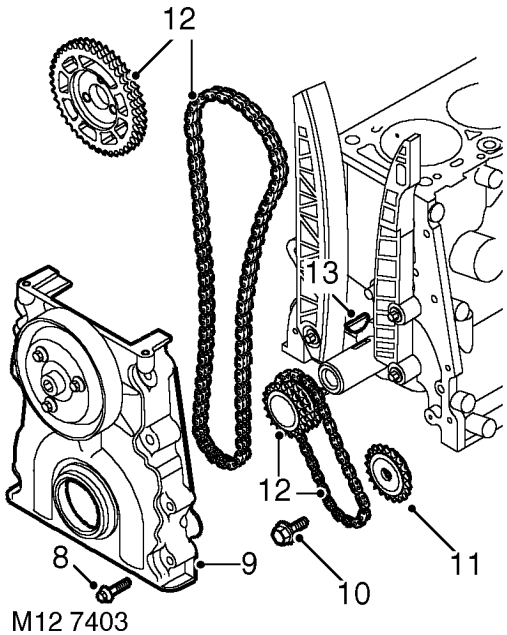
Disassembly

1. Remove cylinder head gasket.
   ☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**
   CAUTION: If timing chain tensioner is to be replaced, ensure tensioner is correct for engine. Tensioner bodies are colour coded as follows: Engine Serial No. Prefixes 10P to 14P – BLACK with, additionally on later engines, YELLOW on tensioner hex. head. Serial No. Prefixes 15P to 19P – body is colour coded YELLOW. Later tensioners may be fitted to early engines provided that the modified adjustable guide is also fitted.
2. Remove 3 bolts securing damper to crankshaft pulley, remove damper.



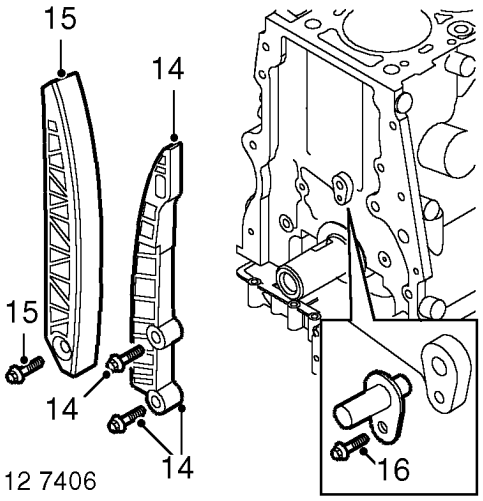
M33 0325B

3. Fit **LRT-51-003** to crankshaft pulley.
4. Secure tool using 2 bolts.
5. Using assistance, restrain engine and remove crankshaft pulley bolt; discard bolt.
   WARNING: CRANKSHAFT BOLT IS TIGHTENED TO 460 Nm (340 lbf.ft), ENSURE ENGINE IS ADEQUATELY RESTRAINED.
6. Remove crankshaft pulley.
7. Remove sump gasket.
   ☞ **ENGINE - Td5, OVERHAUL, Gasket - engine sump.**



M12 7403

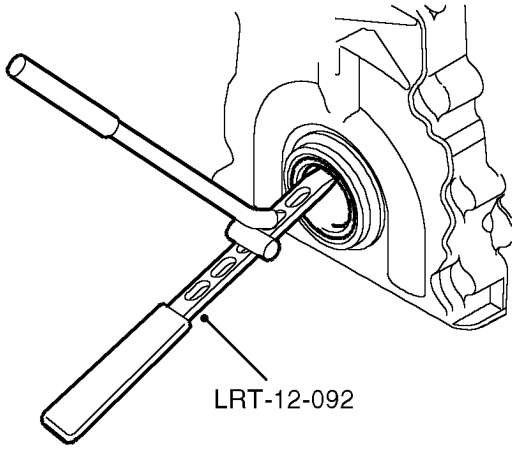
8. Noting their fitted position, remove 8 bolts securing timing chain cover.
9. Release timing chain cover from locating dowels, remove cover.
10. Remove bolt securing oil pump drive sprocket.
11. Remove oil pump drive sprocket.
12. Remove camshaft and crankshaft sprockets together with timing and oil pump drive chains.
13. Remove Woodruff key from crankshaft.



M12 7406

14. Remove 2 bolts and remove timing chain fixed guide.

15. Remove bolt and remove timing chain adjustable guide.
16. Remove bolt and remove timing chain lubrication jet.



M12 7407

17. Using tool **LRT-12-092**, remove and discard oil seal from timing cover.

Inspection

1. Clean all components.
2. Check condition of timing chain running surfaces on adjustable and fixed guides.

   CAUTION: Adjustable guide fitted to Engine Serial No. Prefixes 15P to 19P may be fitted to early engines provided that timing chain tensioner having a YELLOW coloured body is also fitted.

3. Check timing chains and sprockets for signs of wear.

   CAUTION: Timing chains and sprockets fitted to Engine Serial No. Prefixes 15P to 19P may be fitted to early engines as an assembly only, oil pump drive sprockets are interchangeable. Later timing chains have BRONZE coloured timing links.

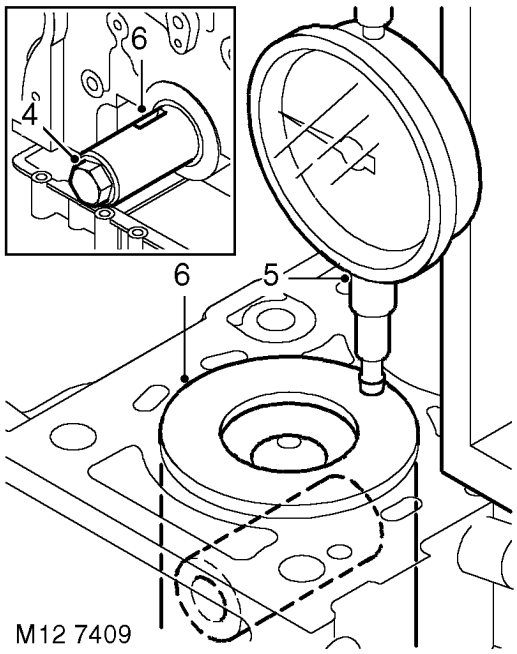
4. Check that drilling in timing chain lubrication jet is clear.
5. Clean oil seal recess in timing cover and oil seal running surface on crankshaft.
6. Remove all traces of sealant from mating faces of timing cover and cylinder block using suitable solvent.

   CAUTION: Do not use metal scrapers.

7. Ensure bolt and dowel holes are clean and dry.
8. Clean oil pump sprocket bolt threads.

Reassembly

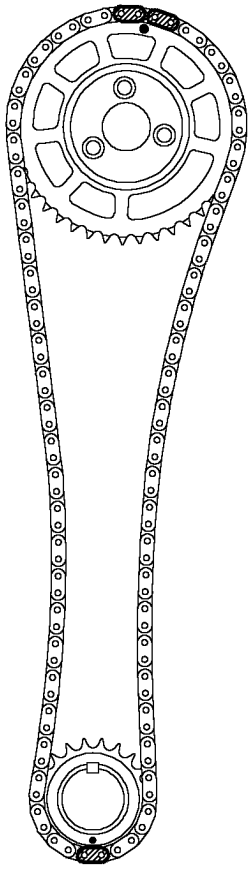
1. Fit timing chain lubrication jet.
2. Fit timing chain lubrication jet Torx screw and tighten to 10 Nm (7 lbf.ft).
3. If crankshaft has been rotated, check that No.1 piston is at TDC using the following procedures:



M12 7409

4. Temporarily fit and lightly tighten a new crankshaft pulley bolt.
5. Assemble a magnetic base DTI to cylinder block top face, position stylus to cylinder block face and zero gauge.
6. Using crankshaft pulley bolt, rotate crankshaft clockwise until No.1 piston is at top of its stroke and woodruff key slot in crankshaft is at 12 o'clock position.
7. Position stylus of DTI to No.1 piston crown and rotate crankshaft until highest reading is indicated on DTI.
8. Check that Woodruff key slot is still at 12 o'clock position indicating No.1 piston is at TDC firing.
9. Remove DTI.
10. Remove and retain crankshaft pulley bolt.
11. Fit Woodruff key to crankshaft.
12. Fit oil pump drive chain to rear row of teeth on crankshaft sprocket - i.e. teeth furthest away from timing mark on sprocket.
13. Fit sprocket to crankshaft ensuring that timing mark on sprocket is facing towards front end of crankshaft.
14. Fit oil pump drive sprocket to oil pump and drive chain ensuring that 'D' shape on sprocket is located on flat on oil pump drive shaft.

15. Apply Loctite 242 to threads of oil pump drive sprocket bolt, fit bolt and tighten to 25 Nm (18 lbf.ft).
16. Fit timing chain fixed guide, fit bolts and tighten to:
    - M6 bolt – 10 Nm (7 lbf.ft)
    - M10 bolt – 45 Nm (34 lbf.ft)
17. Fit timing chain adjustable guide, fit bolt and tighten to 25 Nm (18 lbf.ft).

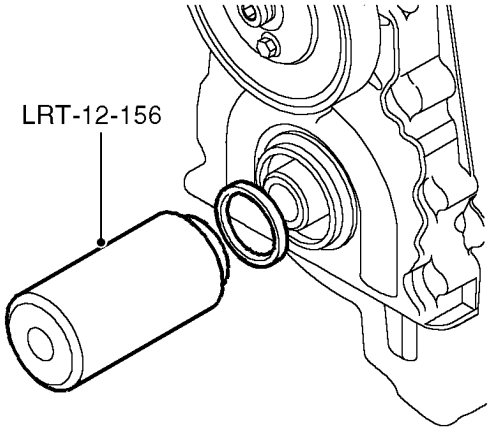


M12 4807

18. Fit camshaft sprocket to timing chain with timing mark on sprocket between the 2 coloured links, suitably retain sprocket on chain.
19. Fit timing chain to crankshaft sprocket aligning coloured link to timing mark on sprocket.
20. Ensure timing marks are positioned as shown - No.1 piston at TDC firing.
21. Apply an even film of sealant Part No. STC 4600 to mating face of timing cover and spread to an even film using a roller.

    CAUTION: Assembly and bolt tightening must be completed within 20 minutes of applying sealant.

22. Fit timing cover, fit bolts in their original fitted positions and working from the centre outwards, tighten progressively to 27 Nm (20 lbf.ft).

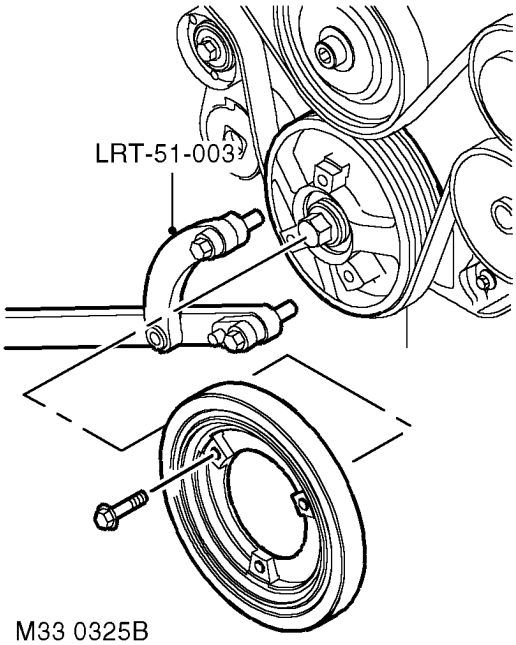


M12 7408

23. Fit oil seal guide, from seal kit over end of crankshaft.
24. Fit new oil seal into timing cover using tool **LRT-12-156**.

    CAUTION: Oil seal must be fitted dry.

25. Remove tool **LRT-12-156** and oil seal guide.
26. Fit crankshaft pulley, fit and lightly tighten crankshaft pulley bolt.



M33 0325B

27. Fit tool **LRT-51-003** to crankshaft pulley, secure with 2 bolts. Using assistance, restrain engine and using a torque multiplier tighten bolt to 450 Nm (340 lbf.ft).

WARNING: DUE TO THE HIGH TORQUE LOADING REQUIRED, IT IS ESSENTIAL THAT ENGINE IS ADEQUATELY RESTRAINED.

28. Remove tool **LRT-51-003**.

29. Position damper to crankshaft pulley, fit 3 bolts and tighten to 80 Nm (60 lbf.ft).

30. Fit sump gasket.

☞ **ENGINE - Td5, OVERHAUL, Gasket - engine sump.**

31. Fit cylinder head gasket.

☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**

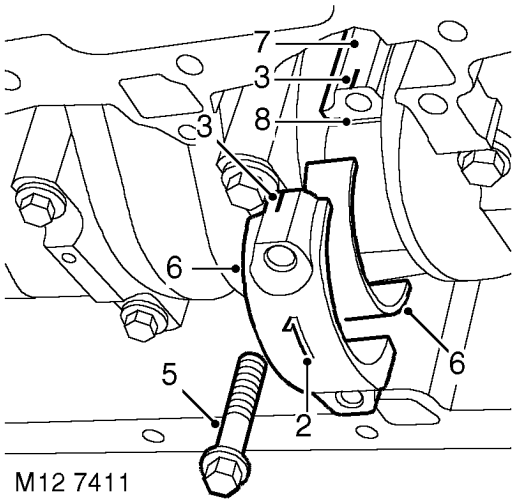
Bearings - connecting rods

12.17.16.01

Disassembly

1. Remove oil pump.

☞ **ENGINE - Td5, OVERHAUL, Pump - oil.**



M12 7411

2. Mark cylinder reference number on each connecting rod big-end bearing cap.

3. Make suitable alignment marks between each big-end bearing cap and connecting rod.

CAUTION: Due to the 'fracture split' method of manufacturing connecting rods, incorrect fitment of cap to rod will damage mating faces and necessitate replacement of connecting rod assembly.

4. Rotate crankshaft clockwise until No.1 big-end is at BDC.

5. Remove and discard 2 bolts securing each connecting rod big-end bearing cap.

6. Remove bearing cap, remove and discard big-end bearing shell.

7. Push connecting rod up cylinder bore until connecting rod is clear of crankshaft journals.

CAUTION: Ensure that connecting rod does not contact cylinder bore or oil squirt jet and piston does not contact the valves or EUI's if the cylinder head is fitted.

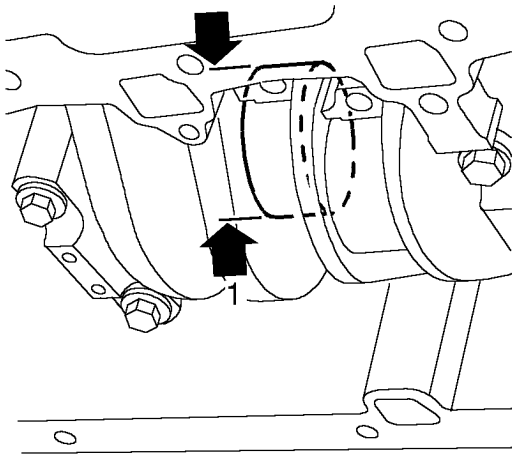
8. Remove and discard big-end bearing shell from connecting rod.

NOTE: Engine Serial No. Prefixes 10P to 14P:– The 'sputter type' connecting rod bearing shells fitted to these engines, identified by them having a slightly darker colour than the bearing cap shells should be replaced with the 'plain type' bearing shells fitted to Engine Serial No. Prefixes 15P to 19P.

9. Repeat above procedures for remaining big-end bearings. **Keep bearing caps in their fitted order.**

Inspection

1. **If crankshaft is to be removed, big-end bearing journals should be checked when crankshaft is inspected.**



M12 7412

2. Check each big-end bearing journal for scoring, wear and ovality, make 3 checks at 120° intervals in centre of journal:
   - Big-end bearing journal diameter = 54.000 ± 0.01 mm (2.125 ± 0.0004 in)

CAUTION: Big-end journals may not be ground undersize, only one size of big-end bearing shell is available and if journals are found to be scored, oval or worn, crankshaft must be replaced. Big-end bearing shells must be replaced whenever they are removed.

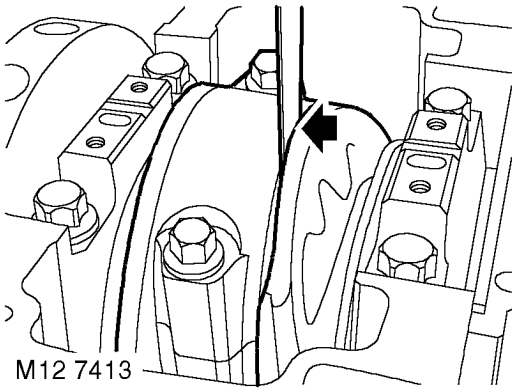
Reassembly

1. Clean connecting rod journals and bearing shell locations.
2. Lubricate new big-end bearing shells with engine oil and fit to connecting rods and bearing caps.

CAUTION: Do not fit the 'sputter type' bearings fitted to early engines.

3. Rotate crankshaft until No.1 big-end bearing journal is at BDC.
4. Taking care not to damage oil squirt jet or to displace bearing shell, pull connecting rod on to crankshaft journal.
5. Check that bearing shell is correctly located in big-end bearing cap.
6. Fit No.1 big-end bearing cap ensuring that reference marks are aligned
7. Fit new big-end bearing cap bolts and tighten to:
   - Stage 1 - 20 Nm (15 lbf.ft)
   - Stage 2 - Further 80°

CAUTION: Do not carry out stages 1 and 2 in one operation.



M12 7413

8. Carefully move connecting rod to one side of journal and using feeler gauges measure end-float of connecting rod on journal:
   - Connecting rod end-float = 0.2 to 0.5 mm (0.008 to 0.021 in)
9. Repeat end-float check for remaining connecting rods.
10. **If end-float exceeds limits given, replace connecting rod and repeat end-float check.** ☞ **ENGINE - Td5, OVERHAUL, Pistons, connecting rods and cylinder bores.**
11. Fit oil pump. ☞ **ENGINE - Td5, OVERHAUL, Pump - oil.**

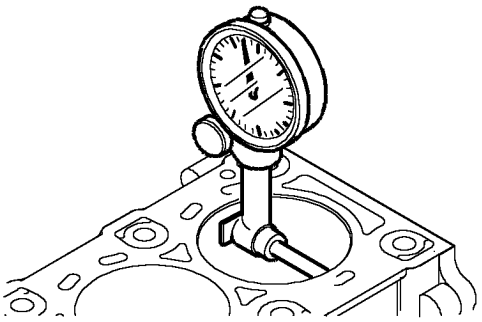
Pistons, connecting rods and cylinder bores

12.17.02.03

Disassembly

1. Remove cylinder head gasket.
   ENGINE - Td5, OVERHAUL, Gasket - cylinder head.
2. Remove connecting rod bearings.
   ENGINE - Td5, OVERHAUL, Bearings - connecting rods.
3. Remove ridge of carbon from top of cylinder bore.
4. Suitably identify each piston and connecting rod assembly to its respective cylinder bore.
5. Carefully push connecting rod to top of cylinder bore taking care that connecting rod does not contact oil squirt jet or cylinder wall; remove each piston and connecting rod in turn.
6. Using a suitable expander, remove and discard piston rings from pistons.
7. Clean carbon from piston crown and skirt. **Do not use abrasives on graphited area of piston skirt, do not use a wire brush or scraper on any part of pistons.**
8. Secure connecting rod in a soft jawed vice.
9. Suitably identify each piston to its connecting rod and fitted position of piston on rod.
10. Using suitable circlip pliers, remove and discard 2 circlips securing gudgeon pin.
11. Push gudgeon pin out of piston and connecting rod; remove piston.
12. Suitably identify each gudgeon pin to its respective piston.
13. Repeat above procedures for remaining pistons.

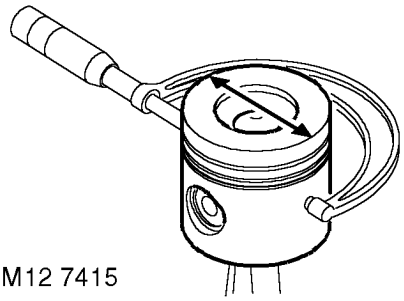
Inspect



M12 7414

1. Measure cylinder bore for wear at a point 70 mm (2.75 in) from top of cylinder bore: **Measurement must be taken from side to side and front to rear.**
   - Cylinder bore diameter = 84.460 to 84.442 mm (3.325 to 3.324 in)

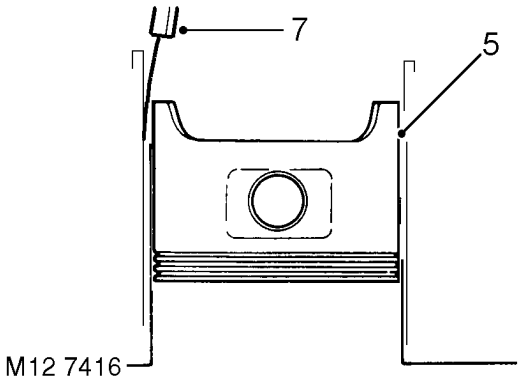
   CAUTION: Cylinder bore and ovality must be within the limits given above, no reboring, honing or de-glazing of cylinder bores is permissible; cylinder block must be replaced if bores are worn or excessively scored.
2. Check piston for cracks, burning and damage.
3. Check connecting rods for alignment. **Do not attempt to straighten misaligned connecting rods. Ensure small-end lubrication holes in connecting rods are clear.**



M12 7415

4. Measure and record diameter of each piston at right angles to gudgeon pin axis and 46 mm (1.81 in) from bottom of skirt
   - Piston diameter = 84.262 mm ± 0.009 mm (3.317 in ± 0.0003 in)

   CAUTION: Measurement point must be on the ungraphited area of the piston.

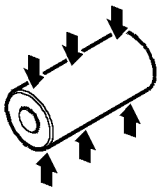


5. Starting with No.1 piston, invert piston and with arrow on piston crown pointing towards **REAR** of cylinder block, insert piston into No.1 cylinder bore.
6. Position piston with bottom of skirt 25 mm (1.0 in) from top of cylinder bore.
7. Using feeler gauges, measure and record clearance between piston skirt and **LEFT HAND** side of cylinder bore 60 mm (2.4 in) from top of bore:
   - Piston to cylinder bore clearance = 0.171 to 0.207 mm (0.007 to 0.008 in)
8. Repeat above procedures for remaining pistons.

   CAUTION: Oversize pistons are not available, if piston to cylinder bore clearance exceeds limits given, repeat check using a new piston; if clearances are still excessive, replace cylinder block.

   Pistons and lst compression rings fitted to Engine Serial No. Prefixes 15P to 19P may be fitted to Engine Serial No. Prefixes 10P to 14P in engine sets only.

9. Check fit of each gudgeon pin in its respective piston, pin must be a tight, sliding fit with no perceptible side play.

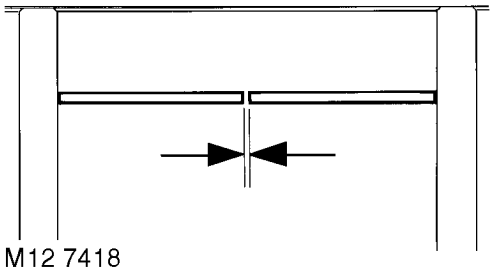

M12 7417

10. Measure gudgeon pin diameter at each end and side of pin.

    CAUTION: Renew gudgeon pin and piston as an assembly if diameters are less than specified or if excessive pin to piston side play is evident.
    - **Gudgeon pin diameter = 29.995 to 30.000 mm (1.180 to 1.181 in)**

11. Check connecting rod small end bushes for wear, check that gudgeon pin is a sliding fit in bush with no perceptible side play.

    CAUTION: Small end bushes cannot be replaced, a new connecting rod must be fitted.

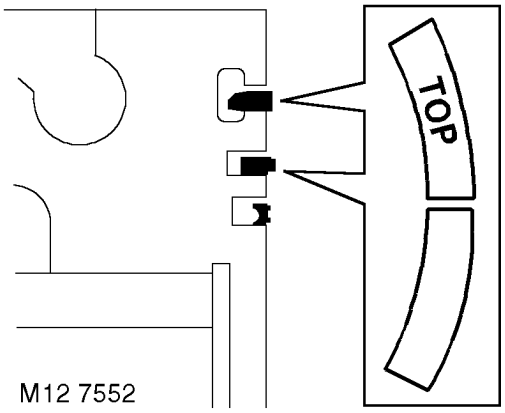

M12 7418

12. Insert new compression and oil control rings in turn into No.1 cylinder bore 30 mm (1.25 in) from top of bore and check ring fitted gaps; ensure rings are kept square to bore when checking gaps:
- 1st compression ring fitted gap = 0.30 to 0.40 mm (0.012 to 0.016 in).
- 2nd compression ring fitted gap = 0.40 to 0.60 mm (0.016 to 0.024 in).
- Oil control ring fitted gap = 0.25 to 0.50 mm 0.01 to 0.02 in).

CAUTION: 1st compression rings fitted to Engine Serial No. Prefixes 10P to 14P are not interchangeable with those fitted to Engine Serial No. Prefixes 15P to 19P. The later rings may, however, be fitted to early engines together with the later type pistons in engine sets only.

13. Repeat for each cylinder bore in turn.

CAUTION: Ensure rings are suitably identified with the cylinder bore in which they were checked and are fitted to the piston for that bore.

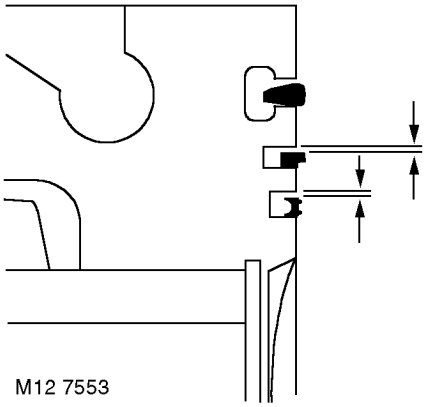


M12 7552

14. Fit oil control expander and ring to piston.

15. Fit 2nd compression ring with 'TOP' marking upwards.

16. Fit 1st compression ring with 'TOP' marking upwards.


M12 7553

17. Check piston ring to groove clearance:
- 1st compression ring = Not measured
- 2nd compression ring = 0.050 to 0.082 mm (0.02 to 0.003 in)
- Oil control ring = 0.050 to 0.082 mm (0.02 to 0.003 in)

Reassembly

1. Lubricate gudgeon pin, gudgeon pin holes in piston and small end bush with engine oil.

2. Position piston to connecting rod with arrow on piston crown on the same side as the cast boss on the connecting rod.

3. Fit gudgeon pin to its respective piston and connecting rod; secure with new circlips ensuring circlips are fully seated in their grooves.

4. Repeat above procedures for remaining pistons.

5. Lubricate piston rings and cylinder bores with engine oil.

6. Check that rings are free to rotate, position ring gaps at 120° to each other and away from the thrust, **LEFT HAND** side of piston - viewed from front of piston.

7. Using a suitable ring clamp, compress piston rings.

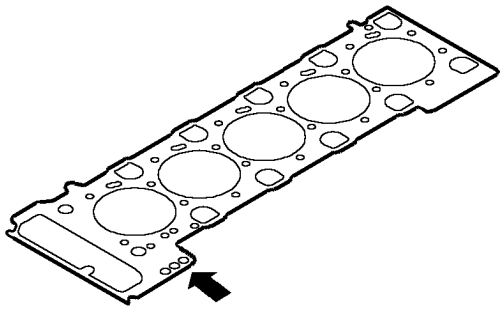
8. Insert connecting rod and piston into its respective cylinder bore ensuring that the arrow on piston crown and the cast boss on connecting rod are facing towards the front of the cylinder block.

9. Ensure that connecting rod does not contact cylinder bore or oil squirt jet. Do not pull connecting rod fully down cylinder bore at this stage.

10. Check that cut-out in piston skirt is positioned above oil squirt jet.

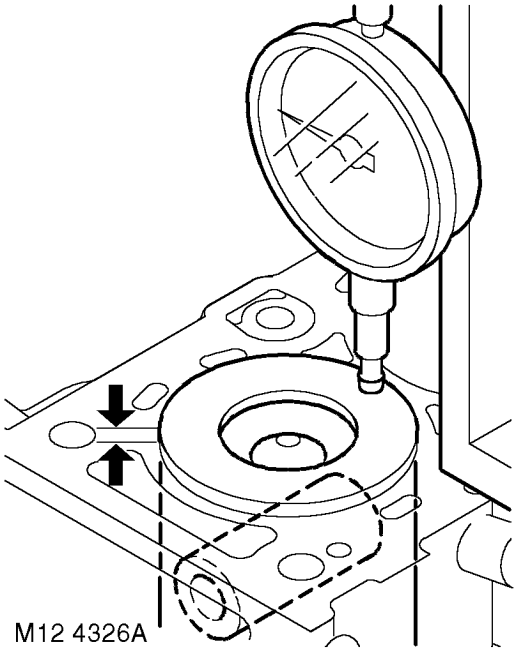
11. Repeat above procedures for other pistons in turn ensuring that pistons and connecting rods are fitted in cylinder bores from which they were removed.
12. Fit connecting rod bearings.
    ☞ **ENGINE - Td5, OVERHAUL, Bearings - connecting rods.**

    CAUTION: If new pistons, connecting rods or crankshaft have been fitted, it will be necessary to select correct thickness of cylinder head gasket using the following procedures:



M12 7548

13. **There are three thicknesses of cylinder head gasket available and in order that the correct gasket is fitted, it is necessary to determine the stand proud (protrusion) of each piston above the top face of the cylinder block. Gaskets have either 1, 2 or 3 identification holes and the following procedures must be followed in order that the correct gasket is selected.**
14. Temporarily fit and lightly tighten new crankshaft pulley bolt.



M12 4326A

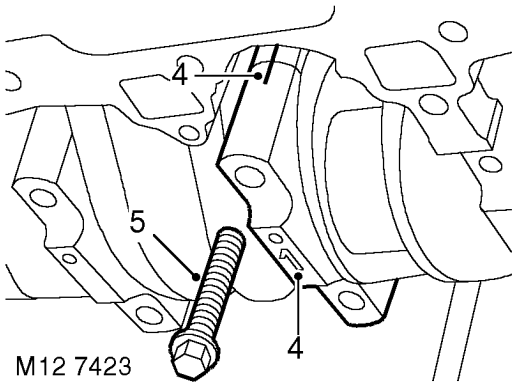
15. Assemble a magnetic base DTI to cylinder block top face adjacent to No.1 cylinder bore.
16. Position stylus to cylinder block top face and zero gauge.
17. Using crankshaft pulley bolt, rotate crankshaft in a clockwise direction until No. 1 piston is at TDC - Woodruff key slot in crankshaft is at 12 o'clock.
18. Position stylus of DTI at rear edge of piston and directly over gudgeon pin axis.
19. Measure and record No.1 piston protrusion.
20. Repeat measurement at front edge of piston.
21. Establish average of 2 readings taken.
22. Repeat above procedures for remaining pistons.
23. From readings obtained, determine **HIGHEST** piston protrusion figure and select the appropriate cylinder head gasket:
    - Piston protrusion = 0.351 to 0.50 mm (0.014 to 0.02 in) select the 2 hole gasket
    - Piston protrusion = 0.501 to 0.57 mm (0.021 to 0.022 in) select the 1 hole gasket
    - Piston protrusion = 0.571 to 0.65 mm (0.022 to 0.025 in) select the 3 hole gasket
24. Remove the DTI.
25. Remove and retain crankshaft pulley bolt.
26. Fit cylinder head gasket.
    ☞ **ENGINE - Td5, OVERHAUL, Gasket - cylinder head.**

Crankshaft

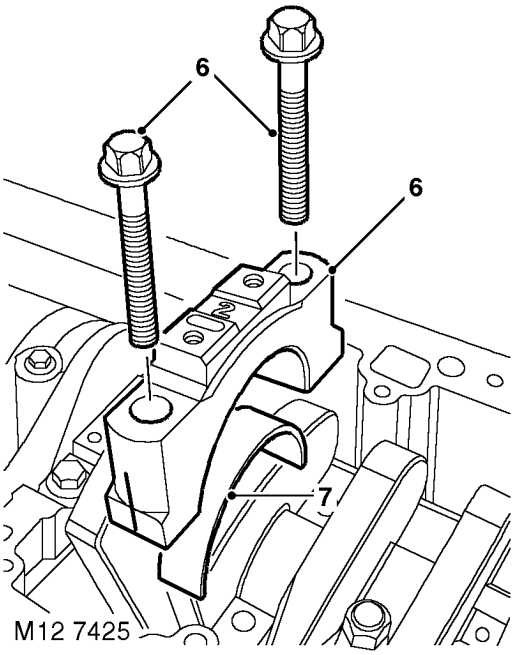
12.21.33.01

Disassembly

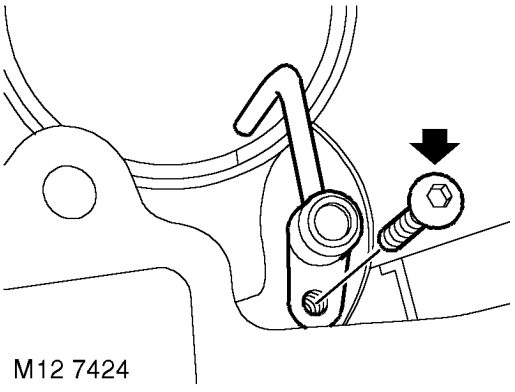
1. Remove timing chain and sprockets.
   ENGINE - Td5, OVERHAUL, Timing chain and sprockets.
2. Remove crankshaft rear oil seal.
   ENGINE - Td5, OVERHAUL, Seal - crankshaft - rear - manual models.
3. Remove connecting rod bearings.
   ENGINE - Td5, OVERHAUL, Bearings - connecting rods.



4. Check that cylinder reference number is on each main bearing cap and make alignment marks between each main bearing cap and cylinder block.
5. Starting at No.3 main bearing cap and working outwards, progressively loosen, then remove 2 bolts securing each cap. Discard main bearing cap bolts.



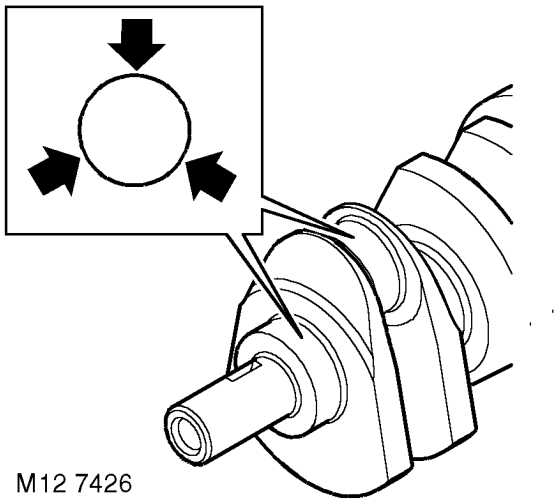
6. Fit 2 slave bolts into main bearing cap in turn and ease bearing caps from cylinder block.
7. Remove and discard plain bearing shells from each main bearing cap.
8. Using assistance, remove crankshaft.
9. Remove and discard grooved main bearing shells and 2 thrust washers from cylinder block.



10. Remove Torx screw securing each oil squirt jet to cylinder block, remove squirt jets.
11. Clean main bearing shell and thrust washer locations in cylinder block, ensure bolt holes are clean and dry.
12. Clean main bearing caps.
13. Clean crankshaft bearing journals, check oilways are clear.
14. Ensure drillings in oil squirt jets are clear.

15. Check core plugs in cylinder block for corrosion or signs of leakage, seal replacement plugs with Loctite 243.

Crankshaft - Inspection

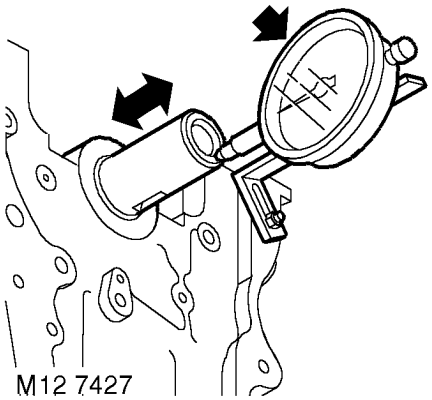

M12 7426

1. Check crankshaft main and big-end bearings for scoring, wear and ovality, make 3 checks at 120° intervals in centre of journals.
   - Main bearings = 62.0 mm ± 0.013 mm (2.441 in ± 0.001 in).
   - Big-end bearings = 54.000 mm ± 0.01 mm (2.125 in ± 0.0004 in).
2. **Crankshafts may not be reground, only one size of main and big-end bearing shell is available and if journals are found to be scored, oval or worn, crankshaft must be replaced. Main and big-end bearing shells and thrust washers must be replaced whenever they are removed.**
3. Check crankshaft spigot bush for wear, replace if necessary using the following procedures:
4. Secure crankshaft in a suitably padded vice.
5. Tap a thread in spigot bush to accommodate a suitable impulse extractor.
6. Fit impulse extractor to spigot bush.
7. Remove spigot bush.
8. Clean spigot bush recess in crankshaft.
9. Fit new spigot bush to crankshaft using a suitable mandrel.

Reassembly

1. Fit oil squirt jets, fit Torx screws and tighten to 8 Nm (6 lbf.ft).
2. Lubricate new, grooved, main bearing shells with engine oil and fit to cylinder block.
3. Lubricate new thrust washers with engine oil and fit, grooved side facing outward, to recess in each side of No.3 main bearing in cylinder block.
4. Lubricate crankshaft journals with engine oil and using assistance, position crankshaft in cylinder block.
5. Lubricate new, plain, main bearing shells with engine oil and fit to main bearing caps.
6. Fit main bearing caps in their original fitted positions ensuring reference marks are aligned.
7. Fit and lightly tighten new main bearing cap bolts. **Do not lubricate bolt threads.**
8. Starting with No.3 main bearing cap and working outwards, tighten main bearing cap bolts to:
   - Stage 1 - 33 Nm (24 lbf.ft)
   - Stage 2 - Further 90°

   CAUTION: Do not carry out stages 1 and 2 in one operation.
9. Check that crankshaft rotates smoothly.

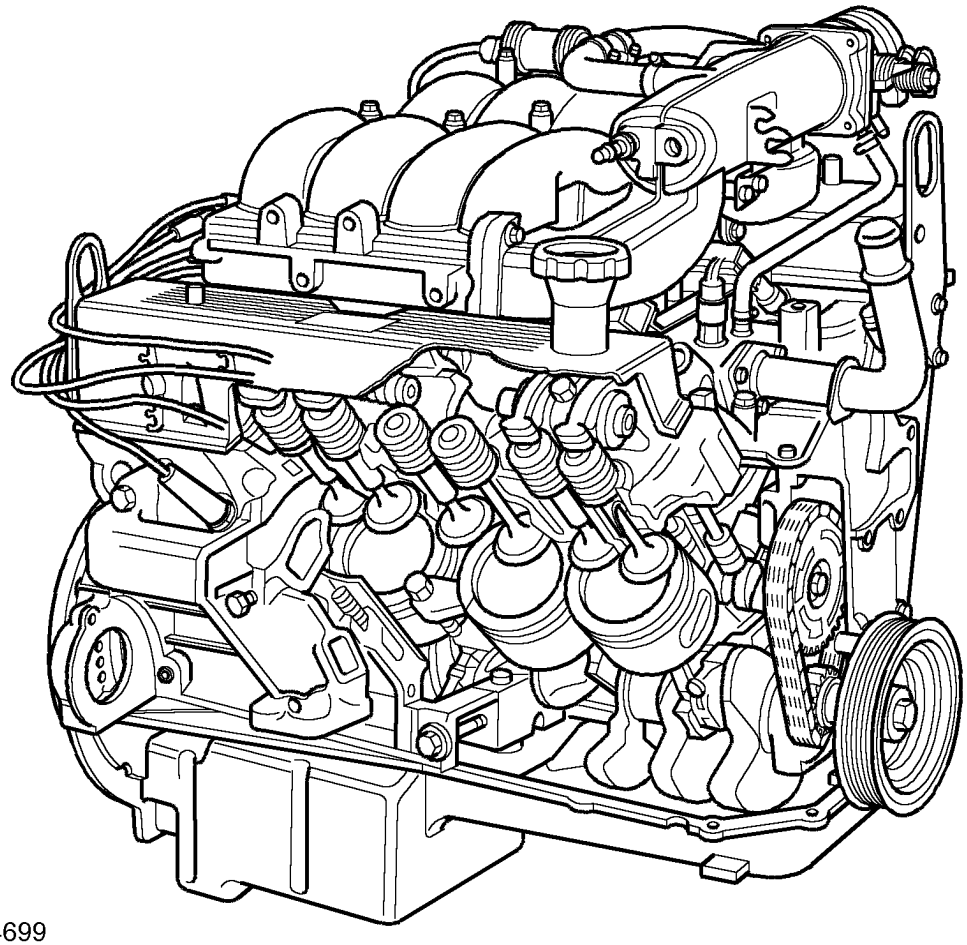

M12 7427

10. Attach a magnetic base DTI to front of cylinder block with stylus of gauge on end of crankshaft.

11. Using suitably padded levers, move crankshaft rearwards and zero DTI.
12. Move crankshaft forwards and note end-float reading on gauge:
    - Crankshaft end-float = 0.02 to 0.025 mm (0.001 to 0.11 in)

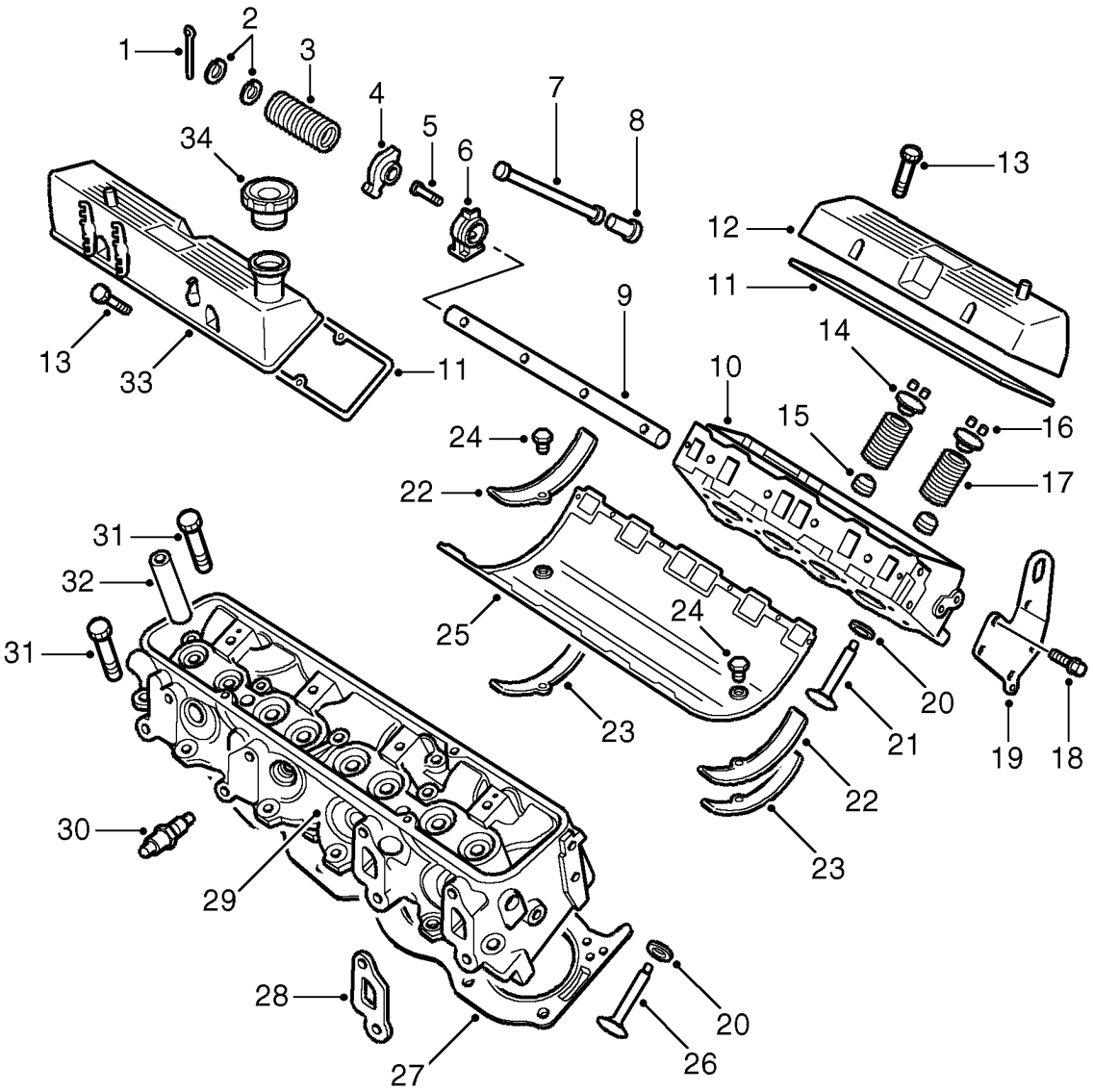
    CAUTION: Oversize thrust washers are not available, if end-float exceeds figure given, crankshaft must be replaced.
13. Remove DTI.
14. Fit connecting rod bearings.
    ☞ **ENGINE - Td5, OVERHAUL, Bearings - connecting rods.**
15. Fit timing chain and sprockets.
    ☞ **ENGINE - Td5, OVERHAUL, Timing chain and sprockets.**
16. Fit crankshaft rear oil seal.
    ☞ **ENGINE - Td5, OVERHAUL, Seal - crankshaft - rear - manual models.**

V8 Engine



M12 4699

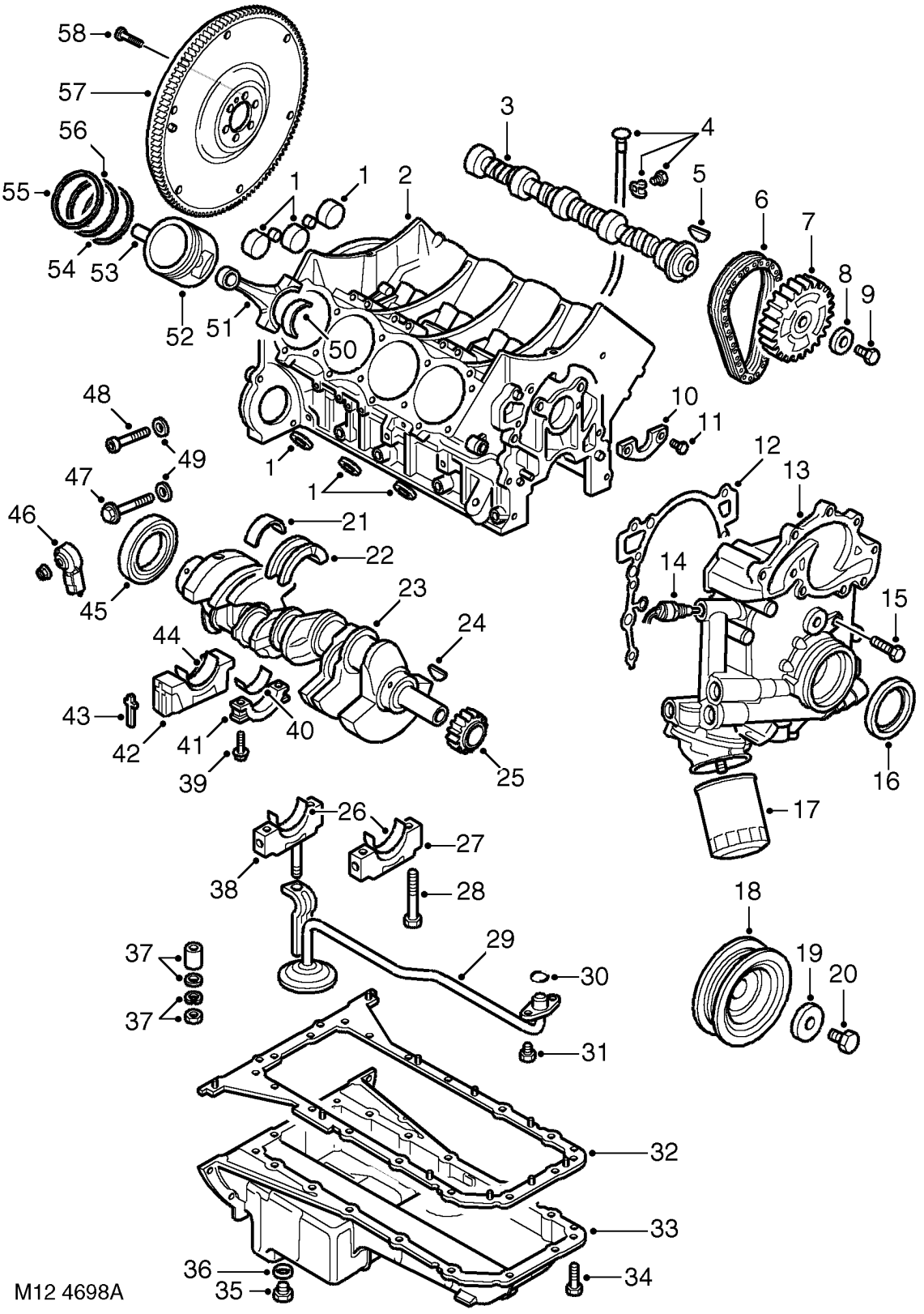
Cylinder head components



M12 4697

1 Split pin
2 Washers
3 Spring
4 Rocker arm
5 Pedestal bolt
6 Pedestal
7 Push rod
8 Hydraulic tappet
9 Rocker shaft
10 Cylinder head - left hand
11 Gasket - rocker cover
12 Rocker cover - left hand
13 Bolt - rocker cover
14 Valve spring cap
15 Valve stem oil seals
16 Collets
17 Valve spring
18 Bolt - engine lifting bracket
19 Engine lifting bracket
20 Valve seat insert
21 Exhaust valve
22 Clamp - inlet manifold gasket
23 Seal - inlet manifold gasket
24 Bolt - inlet manifold gasket clamp
25 Gasket - inlet manifold
26 Inlet valve
27 Gasket - cylinder head
28 Gasket - exhaust manifold
29 Cylinder head - right hand
30 Spark plug
31 Bolt - cylinder head
32 Valve guide
33 Rocker cover - right hand
34 Engine oil filler cap

Cylinder block components



1 Core plugs
2 Cylinder block
3 Camshaft
4 Dipstick tube, clamp and bolt
5 Woodruff key
6 Timing chain
7 Camshaft timing gear
8 Washer
9 Bolt - camshaft timing gear
10 Thrust plate - camshaft end-float
11 Bolt - camshaft thrust plate
12 Gasket - timing cover
13 Timing cover
14 Oil pressure switch
15 Bolt
16 Crankshaft front oil seal
17 Oil filter element
18 Crankshaft front pulley
19 Washer
20 Bolt - crankshaft front pulley
21 Upper main bearing shell
22 Upper centre main bearing shell and thrust washer
23 Crankshaft
24 Woodruff key
25 Crankshaft timing gear
26 Lower main bearing shells
27 Numbers 1, 2 and 3 main bearing caps
28 Bolt - main bearing caps
29 Oil pick-up pipe and strainer
30 'O' ring
31 Bolt - oil pick-up pipe
32 Gasket - sump
33 Sump
34 Bolt - sump
35 Sump oil drain plug
36 Sealing washer
37 Spacer, washers and nut - oil pick-up pipe
38 Number 4 main bearing cap
39 Bolt - connecting rod big-end bearing cap
40 Connecting rod big-end bearing shell - lower
41 Connecting rod big-end bearing cap
42 Number 5 - rear main bearing cap
43 Cruciform seal - rear main bearing cap
44 Number 5 - rear main bearing shell
45 Crankshaft rear oil seal
46 Crankshaft knock sensor
47 Side bolt - main bearing cap
48 Side Allen bolt - main bearing cap
49 Dowty washers
50 Connecting rod big-end bearing shell - upper
51 Connecting rod
52 Piston
53 Gudgeon pin
54 Oil control ring
55 Top compression ring
56 2nd compression ring
57 Flywheel/drive plate and starter ring gear
58 Bolt - flywheel/drive plate

Description

General
The V8 petrol engine is an eight cylinder, water cooled unit having two banks of four cylinders positioned at 90 degrees to each other. The engine comprises five main castings - two cylinder heads, cylinder block, timing cover and the oil sump, all of which are manufactured from aluminium alloy.

NAS market vehicles from 03 model year receive a 4.6 litre version of the V8 engine to replace the previous 4.0 litre version.

Cylinder heads
The cylinder heads are fitted with replaceable valve guides and valve seat inserts with the combustion chambers formed in the head. Each cylinder head is sealed to the cylinder block with a gasket. The exhaust manifolds are bolted to the outside of each cylinder head whilst the inlet manifolds are located in the centre of the 'Vee' and are bolted to the inside face of each head. Inlet and exhaust manifolds are sealed to the cylinder heads by means of gaskets.

Each cylinder has a single inlet and exhaust valve. The exhaust valves are of the 'carbon break' type, a recess on the valve stem prevents a build-up of carbon in the valve guide by dislodging particles of carbon as the valve stem moves up and down the guide. Inlet and exhaust valve stem oil seals are fitted at the top of each valve guide. Valve operation is by means of rocker arms, push rods and hydraulic tappets. Each of the rocker arms is located on a rocker shaft which is supported by means of pedestals bolted to the cylinder heads. A spring, positioned on either side of each rocker arm, maintains the correct relative position of the arm to its valve stem. The rocker arms are operated directly by the push rods which pass through drillings in the cylinder heads and cylinder block. The bottom end of each push rod locates in a hydraulic tappet operated by the single, chain driven camshaft.

The rocker covers are bolted to the cylinder heads and are sealed to the heads by a rubber gasket. Stub pipes for crankcase ventilation hose connections are fitted to each rocker cover, the pipe in the right hand cover incorporates an oil separator. The engine oil filler cap is situated in the right hand cover.

Cylinder block and camshaft
The cylinder block is fitted with cast iron cylinder liners which are shrink fitted and locate on stops in the block. The camshaft is positioned in the centre of the cylinder block and runs in one piece bearing shells which are line bored after fitting. Camshaft end-float is controlled by a thrust plate bolted to the front of the cylinder block. A timing gear, chain driven by the crankshaft timing gear is bolted to the front of the camshaft.

Crankshaft and main bearings
The crankshaft is carried in five main bearings. The upper main bearing shell locations are an integral part of the cylinder block casting. The lower main bearing caps are bolted to the cylinder block on either side of the upper bearing shell locations with an additional bolt being inserted into each cap from either side of the cylinder block. The rear main bearing cap carries the crankshaft rear oil seal and is sealed to the cylinder block by means of cruciform shaped seals in each side of the cap. Number four main bearing cap carries the stud fixing for the oil pick-up pipe. Lower main bearing shells are plain whilst the upper shells have an oil feed hole and are grooved. Crankshaft end-float is controlled by the thrust faces of the upper centre shell. The crankshaft timing gear is located on the front of the crankshaft by means of a Woodruff key which is also used to drive the gear type oil pump. The flywheel/drive plate carries the crankshaft position sensor reluctor ring and is dowel located and bolted to the flywheel.

Timing cover
The timing cover is bolted to the front of the cylinder block and is sealed to the block with a gasket. The disposable, full flow oil filter canister is screwed on to the timing cover which also carries the oil pressure switch, oil pressure relief valve and crankshaft front oil seal. The gear type oil pump is integral with the cover which also has an internal oilway to direct oil from the oil cooler to the filter.

NOTE: Oil coolers are only fitted to vehicles up to VIN 756821.

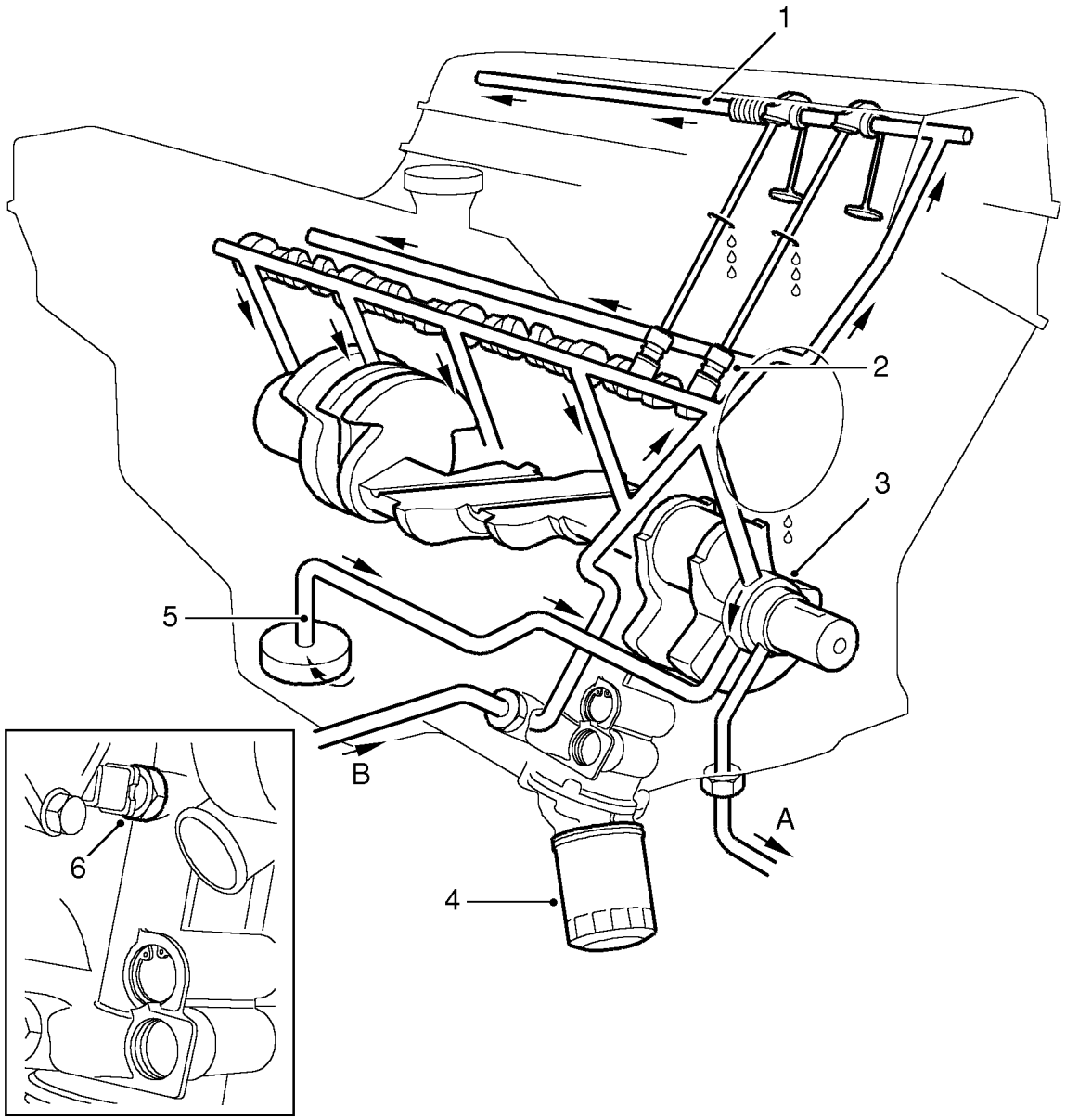
Oil sump

The oil sump is bolted to the bottom of the cylinder block and the timing cover and is sealed to both components with a one piece gasket. A removable baffle to prevent oil surge is fitted in the sump. The oil pick-up pipe and strainer assembly is positioned within the sump and is attached at the pick-up end to a stud screwed into number four main bearing cap and at the delivery end to the oil pump. The oil drain plug is located in the bottom of the sump and is sealed with a washer.

Pistons and connecting rods

Each of the aluminium alloy pistons has two compression rings and an oil control ring. The pistons are secured to the connecting rods by semi-floating gudgeon pins. Each gudgeon pin is offset by 0.5 mm (0.02 in). The top of each piston is recessed, the depth of recess determining the compression ratio of the engine. Plain, big-end bearing shells are fitted to each connecting rod and cap.

Lubrication



M12 4700A

A *- To oil cooler,* ***B*** *- From oil cooler*

NOTE: The oil cooler is only fitted to vehicles up to VIN 756821.

1 Rocker shaft assembly
2 Hydraulic tappet
3 Oil pump
4 Oil filter element
5 Oil pick-up pipe and strainer
6 Oil pressure switch

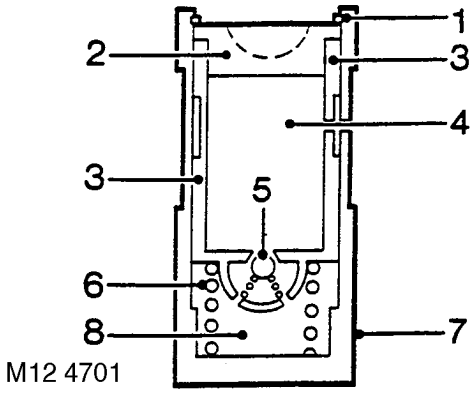
Oil is drawn from the sump through a strainer and into the oil pump via the oil pick-up pipe. Pressurised oil from the pump passes through the oil cooler (if fitted) mounted in front of the radiator and returns to the full flow oil filter

element. Oil from the filter passes into the main oil gallery and through internal drillings to the crankshaft where it is directed to each main bearing and to the big-end bearings via numbers 1, 3 and 5 main bearings. An internal drilling in the cylinder block directs oil to the camshaft where it passes through further internal drillings to the hydraulic tappets, camshaft bearing journals and rocker shafts. Lubrication to the pistons, small ends and cylinder bores is by oil grooves machined in the connecting rods and by splash.

Oil pressure switch

The oil pressure warning light switch registers low oil pressure in the main oil gallery on the outflow side of the filter. Whilst the engine is running and oil pressure is correct, the switch is open. When the ignition is switched on or if oil pressure drops below the pressure setting of the switch, the switch closes and the low oil pressure warning lamp located in the instrument pack will illuminate.

Hydraulic tappets



M12 4701

1 Clip
2 Pushrod seat
3 Inner sleeve
4 Upper chamber
5 Non-return ball valve
6 Spring
7 Outer sleeve
8 Lower chamber

The hydraulic tappet provides maintenance free, quiet operation of the valves. This is achieved by utilizing engine oil pressure to eliminate the clearance between the rocker arms and valve stems. When the valve is closed, engine oil pressure present in the upper chamber, passes through the non-return ball valve and into the lower chamber. When the cam begins to lift the outer sleeve, the resistance of the valve spring, felt through the push rod and seat, causes the tappet inner sleeve to move downwards inside the outer sleeve. This downwards movement closes the non-return ball valve and increases the pressure in the lower chamber sufficiently to ensure that the valve is fully opened by the push rod. As the tappet moves off the peak of the cam, the non-return ball valve opens thereby allowing the pressure in both chambers to equalize. This ensures that the valve will be fully closed when the tappet is on the back of the cam.

Crankcase ventilation

A positive crankcase ventilation system is used to vent crankcase gases to the air induction system. Gases are drawn from the left hand rocker cover to a tapping in the throttle body. An oil separator is incorporated in the hose connection stub pipe in the right hand rocker cover, gases from this connection are drawn to a tapping in the inlet manifold.

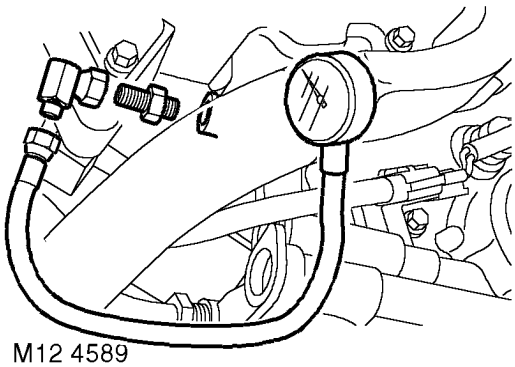
☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Crankcase emission control system.**

Engine oil pressure check

12.90.09.01

Check

1. Remove oil pressure switch.
   ENGINE - V8, REPAIRS, Switch - oil pressure.


M12 4589

2. Connect pressure check kit **LRT-12-052C** adaptor and gauge to oil pressure switch position on timing gear cover.
3. Check and if necessary top up engine oil.
4. Run engine at idle speed and check that oil pressure is within limits given.
   GENERAL DATA, Engine - V8.
5. Switch off ignition.
6. Remove pressure check kit **LRT-12-052C.**
7. Clean oil spillage.
8. Fit oil pressure switch.
   ENGINE - V8, REPAIRS, Switch - oil pressure.

Adjust

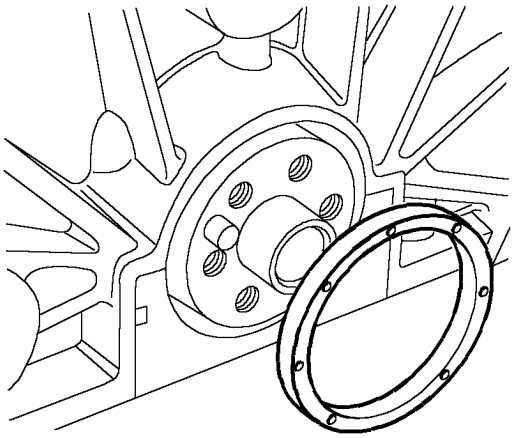
1. If engine oil pressure is below figures given, check condition of oil pump and/or main and big end bearings.

Seal - crankshaft - rear

12.21.20

Remove

1. **Automatic gearbox models:**Remove converter drive plate.
   ☞ **ENGINE - V8, REPAIRS, Plate - drive - automatic.**
2. **Manual gearbox models:**Remove flywheel.
   ☞ **ENGINE - V8, REPAIRS, Flywheel.**

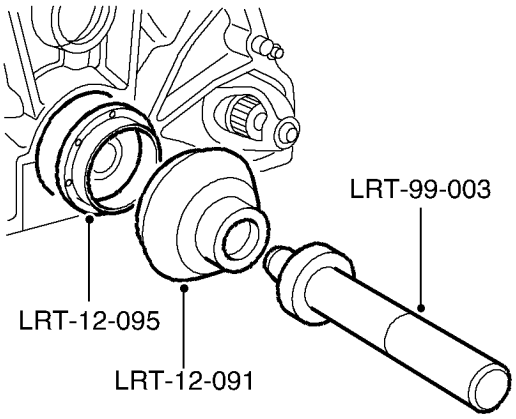


M12 4665

3. Carefully remove oil seal from cylinder block to avoid damage to seal location or running surface on crankshaft. Discard seal.

Refit

1. Ensure both seal location and running surface on crankshaft are clean.



M12 7456

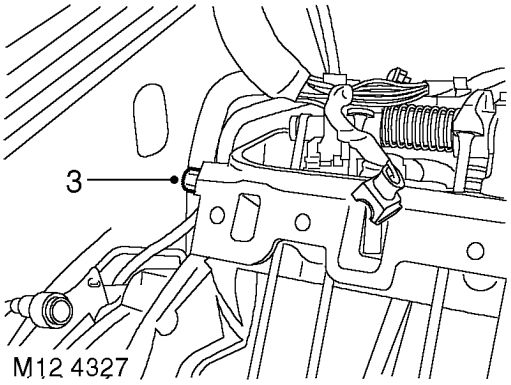
2. Fit seal guide **LRT-12-095** to crankshaft.
   CAUTION: Oil seal must be fitted dry.
3. Fit new oil seal squarely onto crankshaft and remove guide.
4. Fit seal into location using tools **LRT-12-091** and **LRT-99-003**.
5. **Automatic gearbox models:**Fit converter drive plate.
   ☞ **ENGINE - V8, REPAIRS, Plate - drive - automatic.**
6. **Manual gearbox models:**Fit flywheel.
   ☞ **ENGINE - V8, REPAIRS, Flywheel.**

Gasket - cylinder head - LH

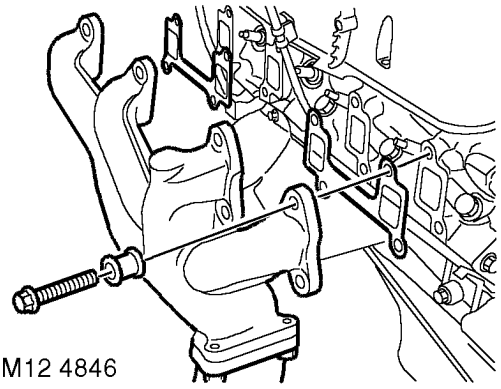
12.29.02

Remove

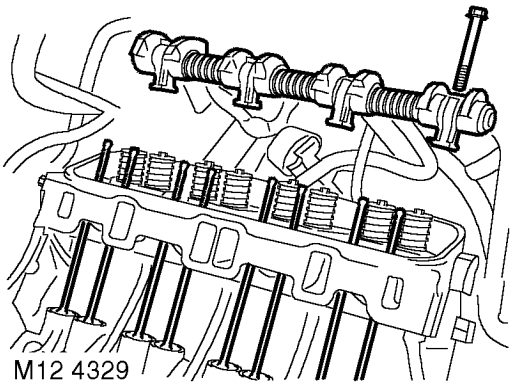
1. Remove inlet manifold gasket.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - lower.
2. Noting their fitted order, disconnect ht leads from spark plugs.



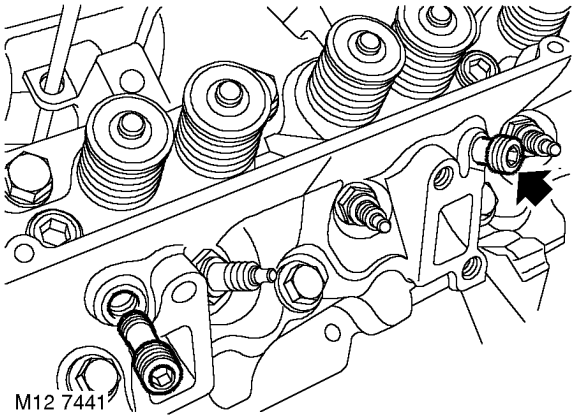
3. Remove bolt securing engine harness to rear of cylinder head.
4. **LH drive models:** Remove brake servo heat shield.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Heat shield - brake servo - Without Secondary Air Injection.



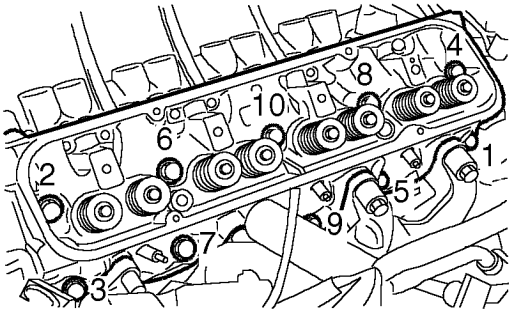
5. Remove 8 bolts securing exhaust manifold to cylinder head, release manifold and collect 2 gaskets.



6. Progressively remove 4 bolts securing the rocker shaft and remove rocker shaft.
7. Remove push rods. **Store push rods in their fitted order.**

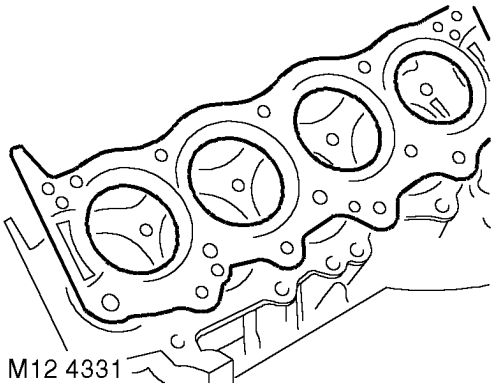


8. **Models with SAI:** Remove 2 air injection adapters from cylinder head and discard.



9. In the sequence shown, remove 10 bolts securing the cylinder head to block. Discard the bolts.

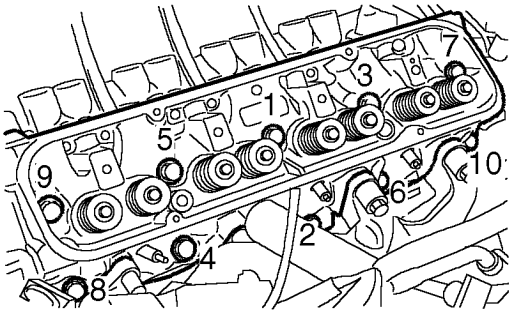
10. Remove cylinder head.
    CAUTION: Support both ends of cylinder head on blocks of wood.


M12 4331

11. Remove cylinder head gasket.

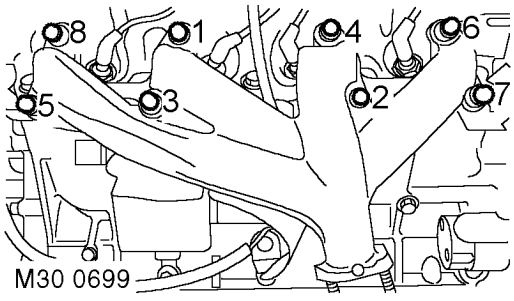
Refit

1. Clean mating faces of cylinder block and head using suitable gasket removal spray and a plastic scraper, ensure that bolt holes in block are clean and dry. Clean mating faces of cylinder head and exhaust manifold.
   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.
2. Check head and block faces for warping and pitting. If out of specification, renew head.
3. Fit cylinder head gasket with the word 'TOP' uppermost.
   CAUTION: Gaskets must be fitted dry.
4. Carefully fit cylinder head and locate on dowels.
5. Lightly lubricate new cylinder head bolt threads with clean engine oil.



M12 4332

6. Noting that bolts 1, 3 and 5 are longer than the remainder, fit cylinder head bolts and tighten in the sequence shown to 20 Nm (15 lbf.ft) then 90° , and finally a further 90° .
   CAUTION: Do not tighten bolts 180° in one operation.
7. **Models with SAI:** Fit new air injection adapters and tighten to 33 Nm (24 lbf.ft).
8. Clean push rods.
9. Lubricate ends of push rods with clean engine oil.
10. Fit push rods in their removed order.
11. Clean bases of rocker pillars and mating faces on cylinder head.
12. Clean contact surfaces on rockers, valves and push rods.
13. Lubricate contact surfaces and rocker shaft with clean engine oil.
14. Fit rocker shaft assembly and engage push rods.
15. Fit rocker shaft bolts and progressively tighten to 40 Nm (30 lbf.ft).



M30 0699

16. Using new gaskets, position exhaust manifold to cylinder head, fit bolts and using sequence shown, tighten initially to 15 Nm (11 lbf.ft), then finally to 36 Nm (28 lbf.ft).

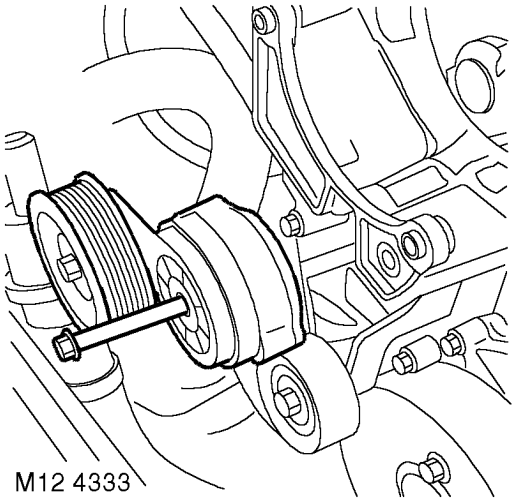
17. **LH drive models:** Fit brake servo heat shield.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Heat shield - brake servo - Without Secondary Air Injection.**
18. Fit engine harness bolt and tighten to 22 Nm (16 lbf.ft).
19. Connect ht leads to spark plugs in their correct fitted order.
20. Fit inlet manifold gasket.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - lower.**

Gasket - cylinder head - RH

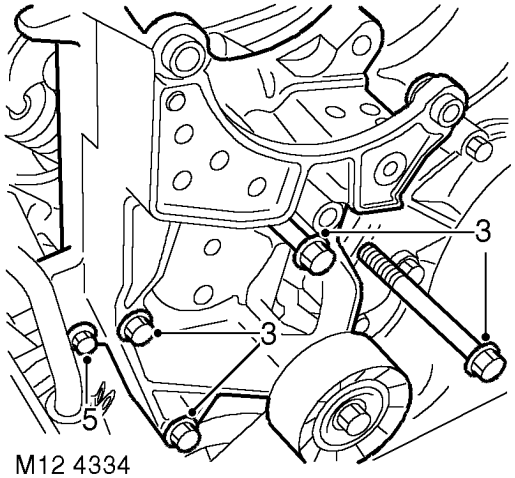
⊸ *12.29.03*

Remove

1. Remove inlet manifold gasket.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - lower.**


M12 4333

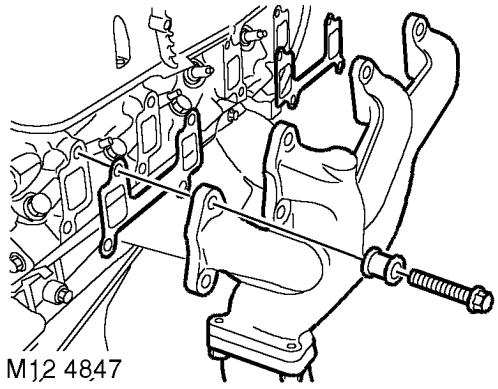
2. Remove bolt securing auxiliary drive belt tensioner and remove tensioner.



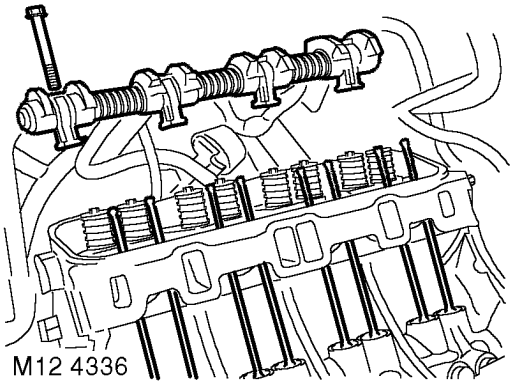
M12 4334

3. Remove 4 bolts securing alternator mounting bracket and remove bracket.
4. Noting their fitted order, disconnect ht leads from spark plugs.
5. Remove bolt securing engine earth lead.

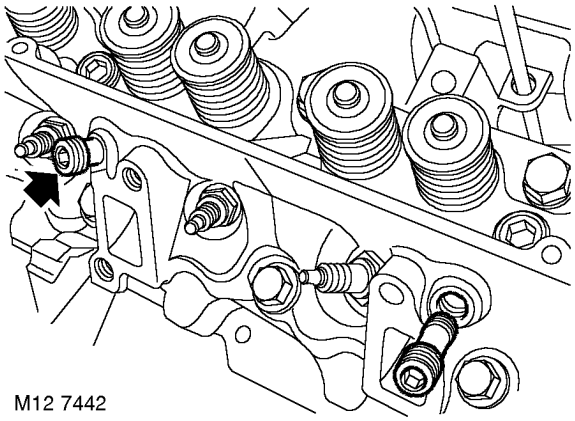
6. **RH drive models:** Remove brake servo heat shield.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Heat shield - brake servo - Without Secondary Air Injection.**


M12 4847

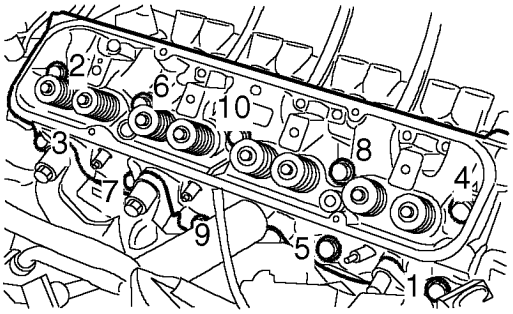
7. Remove 8 bolts securing exhaust manifold to cylinder head, release manifold and collect 2 gaskets.


M12 4336

8. Progressively remove 4 bolts securing the rocker shaft and remove rocker shaft.
9. Remove push rods. **Store push rods in their fitted order.**

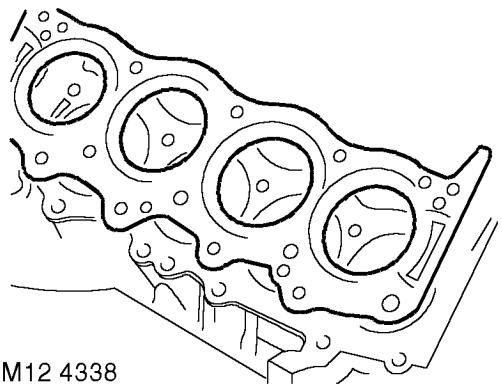

M12 7442

10. **Models with SAI:** Remove 2 air injection adapters and discard.



M12 4337

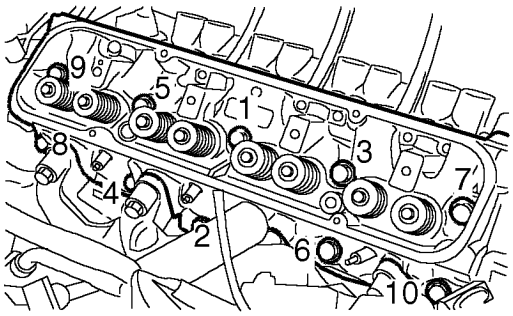
11. In the sequence shown, remove 10 bolts securing the cylinder head to block. Discard the bolts.
12. Remove cylinder head.
    CAUTION: Support both ends of cylinder head on blocks of wood.


M12 4338

13. Remove cylinder head gasket.

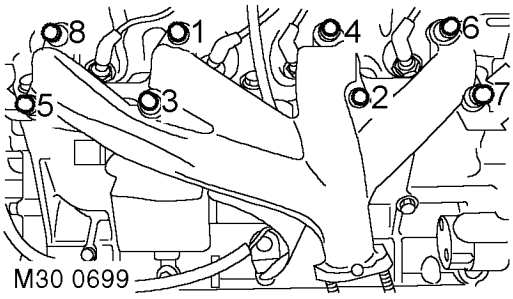
Refit

1. Clean mating faces of cylinder block and head using suitable gasket removal spray and a plastic scraper, ensure that bolt holes in block are clean and dry. Clean mating faces of cylinder head and exhaust manifold.
   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.
2. Check head and block faces for warping and pitting. If out of specification, renew head.
3. Fit cylinder head gasket with the word 'TOP' uppermost.
   CAUTION: Gaskets must be fitted dry.
4. Carefully fit cylinder head and locate on dowels.
5. Lightly lubricate new cylinder head bolt threads with clean engine oil.



M12 4361

6. Noting that bolts 1, 3 and 5 are longer than the remainder, fit bolts and tighten in the sequence shown to 20 Nm (15 lbf.ft) then 90°, and finally a further 90°.
   CAUTION: Do not tighten bolts 180° in one operation.
7. **Models with SAI:** Fit new air injection adapters and tighten to 33 Nm (24 lbf.ft).
8. Clean push rods.
9. Lubricate ends of push rods with clean engine oil.
10. Fit push rods in their removed order.
11. Clean bases of rocker pillars and mating faces on cylinder head.
12. Clean contact surfaces on rockers, valves and push rods.
13. Lubricate contact surfaces and rocker shaft with clean engine oil.
14. Fit rocker shaft assembly and engage push rods.
15. Fit rocker shaft bolts and progressively tighten to 40 Nm (30 lbf.ft).
16. Position alternator mounting bracket, fit bolts and tighten to 40 Nm (30 lbf.ft).
17. Position auxiliary drive belt tensioner, fit bolt and tighten to 45 Nm (33 lbf.ft).
18. Connect ht leads to spark plugs in their fitted order.



M30 0699

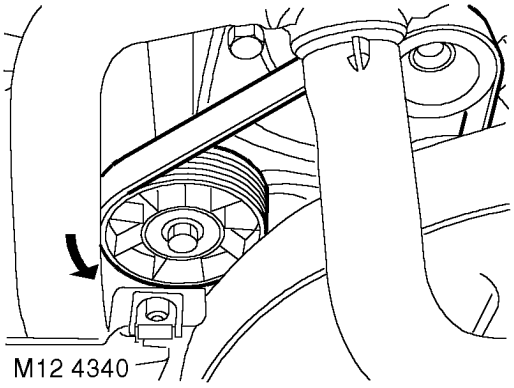
19. Using new gaskets, fit exhaust manifold to cylinder head. Fit bolts and using sequence shown, tighten initially to 15 Nm (11 lbf.ft), then finally tighten to 36 Nm (28 lbf.ft).
20. **RH drive models:** Fit brake servo heat shield.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Heat shield - brake servo - Without Secondary Air Injection.**
21. Position engine earth lead, fit bolt and tighten to 22 Nm (16 lbf.ft).
22. Fit inlet manifold gasket.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - lower.**

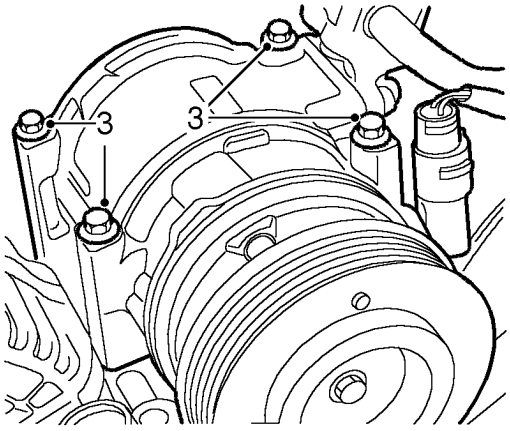
Gasket - rocker cover - LH

12.29.40

Remove

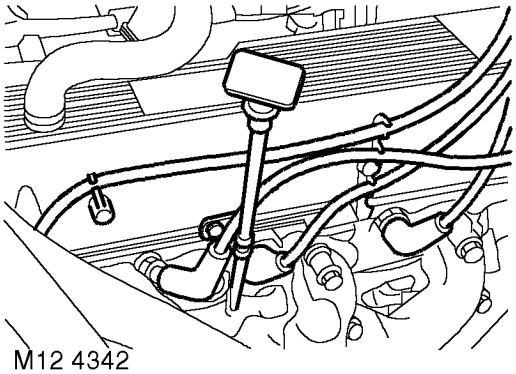
1. Remove upper inlet manifold gasket.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.
2. **Models with air conditioning:** Release 4 clips and remove fan cowl.


M12 4340

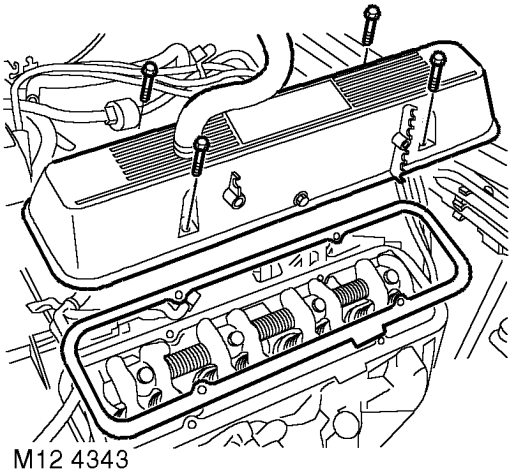


M12 4341

3. **Models with air conditioning:** Release tension on auxiliary drive belt and remove belt from air conditioning compressor. Disconnect compressor multiplug. Remove 4 bolts securing compressor and position compressor aside.


M12 4342

4. Release ht leads from rocker cover clips.
5. Remove screw securing dip stick tube.


M12 4343

6. Remove 4 bolts securing rocker cover.
7. Remove rocker cover and collect gasket.

Refit

1. Clean mating faces of rocker cover and cylinder head.
2. Using a new gasket, fitted dry, position rocker cover ensuring gasket is correctly located.
3. Fit rocker cover bolts and working in diagonal sequence, tighten to:
   - Stage 1 - 3 Nm (2.5 lbf.ft)
   - Stage 2 - 8 Nm (6 lbf.ft)
4. Ensure that outer rim of gasket is correctly positioned around periphery of rocker cover.
5. Fit and tighten screw securing dip stick tube.
6. Secure ht leads in rocker cover clips.
7. **Models with air conditioning:** Clean compressor dowels and dowel holes. Position compressor, fit bolts and tighten to 22 Nm (16 lbf.ft). Release auxiliary drive belt tensioner and fit belt to compressor.

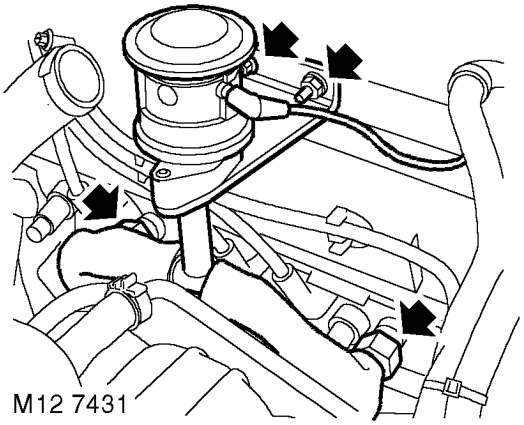
8. **Models with air conditioning:** Position fan cowl and secure clips.
9. Fit upper inlet manifold.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**

Gasket - rocker cover - RH

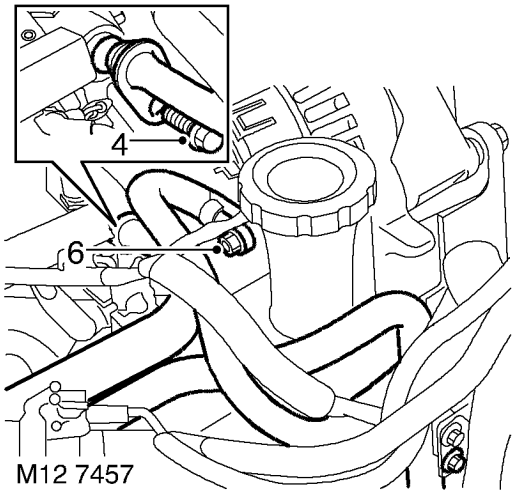
⊸ *12.29.41*

Remove

1. Drain cooling system.
   ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**
2. Remove upper inlet manifold gasket.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**

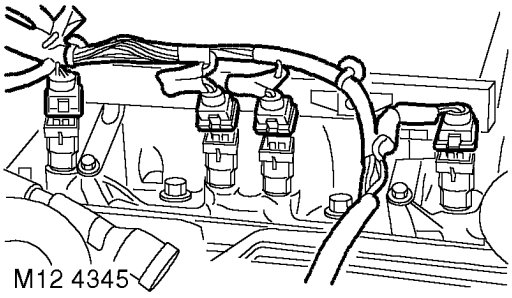


3. **Models with SAI:** Disconnect 2 air manifold unions from adapters in cylinder head and remove manifold.

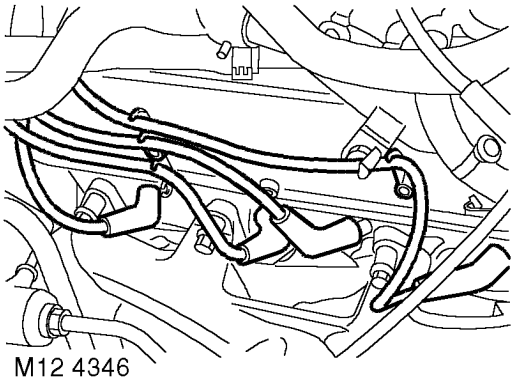


4. Remove 2 bolts securing coolant rails to inlet manifold.

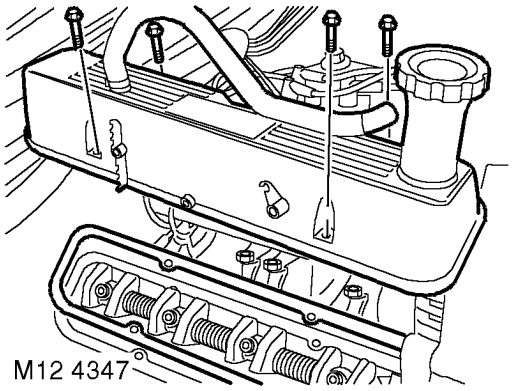
5. Release coolant rail from inlet manifold and discard 'O' ring.
6. Remove nuts securing alternator cables and release cables from alternator.


M12 4345

7. Disconnect multiplugs from RH bank of injectors and release harness from fuel rail.


M12 4346

8. Release ht leads from clips on rocker cover.


M12 4347

9. Remove 4 bolts securing rocker cover.
10. Remove rocker cover and collect gasket.

Refit

1. Clean mating faces of rocker cover and cylinder head.
2. Using a new gasket, fitted dry, position rocker cover ensuring gasket is correctly located.
3. Fit rocker cover bolts and working in diagonal sequence, tighten to:
   - Stage 1 - 3 Nm (2.5 lbf.ft)
   - Stage 2 - 8 Nm (6 lbf.ft)
4. Ensure that outer rim of gasket is correctly positioned around periphery of rocker cover.
5. Secure ht leads in rocker cover clips.
6. Secure injector harness to fuel rail and connect multiplugs to injectors.
7. Position alternator cables, and tighten terminal B+ nut to 18 Nm (13 lbf.ft) and terminal D+ nut to 5 Nm (3 lbf.ft).
8. Clean coolant rail 'O' ring recess.
9. Lubricate and fit new 'O' ring to coolant rail, position coolant rails, fit bolts and tighten to 22 Nm (16 lbf.ft).
10. **Models with SAI:** Clean air manifold unions, position manifold and tighten unions nuts to 25 Nm (18 lbf.ft).
11. Fit upper inlet manifold.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**
12. Refill cooling system.
    ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Mounting - front - LH

12.45.01

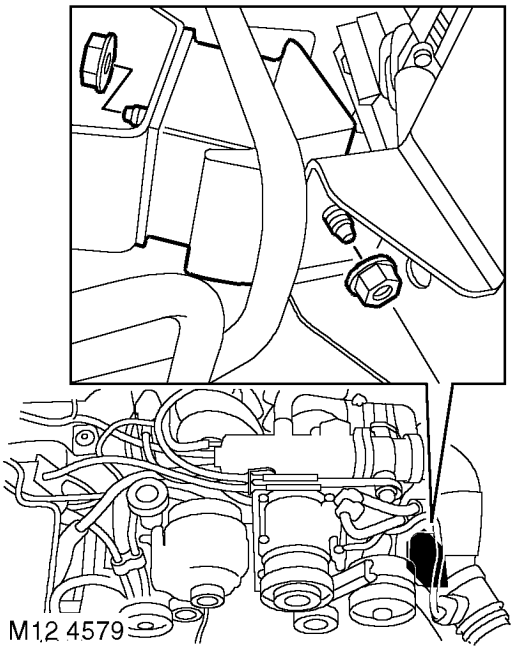
Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Remove underbelly panel.
   EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.
5. Position a jack beneath the sump, and support the engine on the jack.

   CAUTION: To prevent damage to components, cushion the jack pad with a block of wood or hard rubber.



6. Remove 2 nuts securing engine mountings to chassis.
7. Remove nut securing LH mounting to cylinder block.
8. Raise engine sufficiently to allow engine mounting to be removed, take care not to trap any cables, pipes or harness.
9. Remove engine mounting. Collect heat shield, if fitted.

Refit

1. Fit heat shield to engine mounting, if fitted.
2. Fit engine mounting ensuring dowel is located.
3. Lower the jack and engage engine mounting studs in chassis.
4. Fit nuts securing LH engine mounting and tighten to 85 Nm (63 lbf.ft).
5. Fit underbelly panel.
   EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.
6. Remove stand(s) and lower vehicle.
7. Connect battery earth lead.
8. Fit battery cover and secure turnbuckles.

Mounting - front - RH

12.45.03

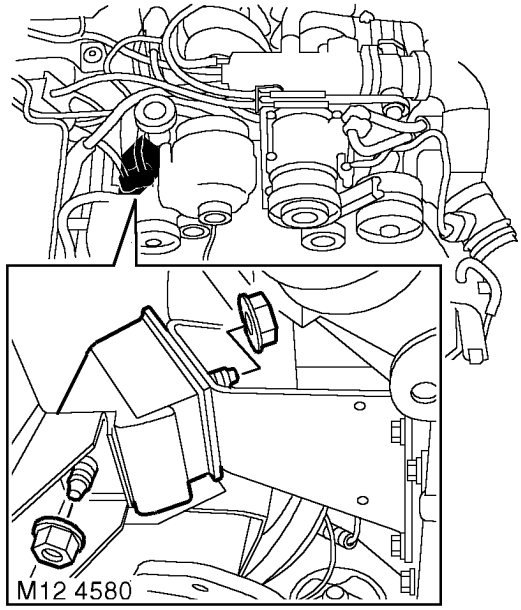
Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Remove underbelly panel.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**
5. Position a jack beneath the sump, and support the engine on the jack.

   CAUTION: To prevent damage to components, cushion the jack pad with a block of wood or hard rubber.



6. Remove 2 nuts securing engine mountings to chassis.
7. Remove nut securing RH mounting to cylinder block.
8. Raise engine sufficiently to allow engine mounting to be removed. Take care not to trap any cables, pipes or harness.
9. Remove engine mounting.
10. Collect heat shield.

Refit

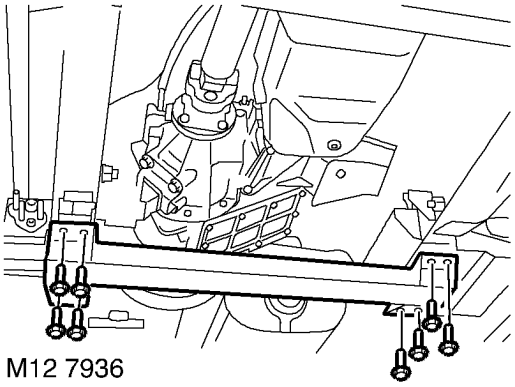
1. Position heat shield.
2. Fit engine mounting ensuring dowel is located.
3. Lower the jack and engage engine mounting studs in chassis.
4. Fit engine mounting nuts and tighten to 85 Nm (63 lbf.ft).
5. Fit underbelly panel.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**
6. Remove stand(s) and lower vehicle.
7. Connect battery earth lead.
8. Fit battery cover and secure turnbuckles.

Mounting - rear - LH

12.45.07

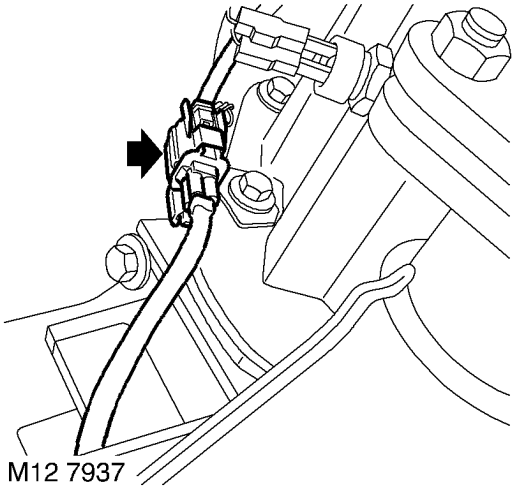
Remove

1. Raise vehicle on lift.

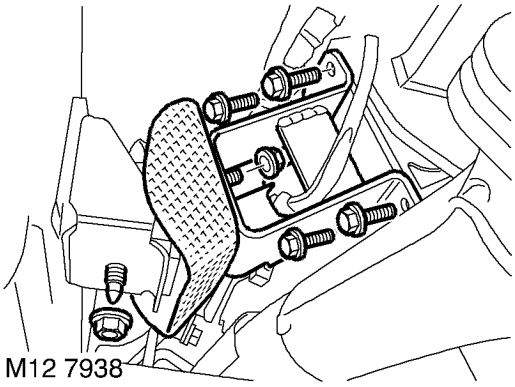

M12 7936

2. Remove 8 bolts securing rear cross member and remove cross member.
3. Support transfer gearbox on jack.

CAUTION: To prevent damage to components, cushion the jack pad with a block of wood or hard rubber.


M12 7937

4. Release and disconnect HO2S multiplug.


M12 7938

5. Remove nut securing mounting to body bracket.
6. Remove nut securing mounting to mounting bracket.
7. Remove 4 bolts securing mounting bracket to gearbox.
8. Remove mounting and mounting bracket assembly.
9. Remove mounting rubber.
10. Remove heat shield, if fitted.

Refit

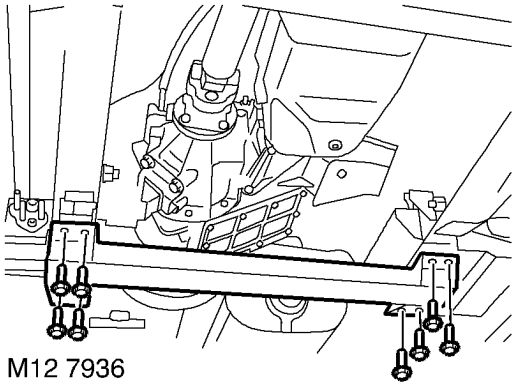
1. If fitted position heatshield, fit mounting rubber to mounting bracket, fit nut but do not tighten.
2. Position mounting bracket assembly, fit bolts securing mounting bracket to gearbox and tighten to 85 Nm (63 lbf.ft).
3. Fit nut securing mounting to body bracket and tighten to 48 Nm (35 lbf.ft).
4. Tighten nut securing mounting to gearbox bracket to 48 Nm (35 lbf.ft).
5. Connect HO2S multiplug and secure to support bracket.
6. Position rear cross member, fit bolts and tighten to 26 Nm (19 lbf.ft).
7. Lower vehicle.

Mounting - rear - RH

12.45.09

Remove

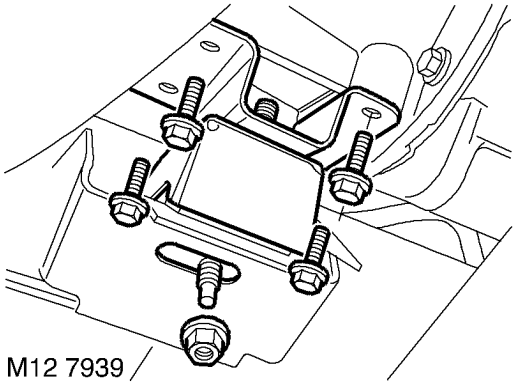
1. Raise vehicle on lift.



M12 7936

2. Remove 8 bolts securing rear cross member and remove cross member.
3. Support transfer gearbox on jack.

   CAUTION: To prevent damage to components, cushion the jack pad with a block of wood or hard rubber.



M12 7939

4. Remove nut securing mounting to body bracket.
5. Remove nut securing mounting to mounting bracket.
6. Remove 4 bolts securing mounting bracket to gearbox.
7. Remove mounting and mounting bracket assembly.
8. Remove mounting rubber.
9. Remove heat shield, if fitted.

Refit

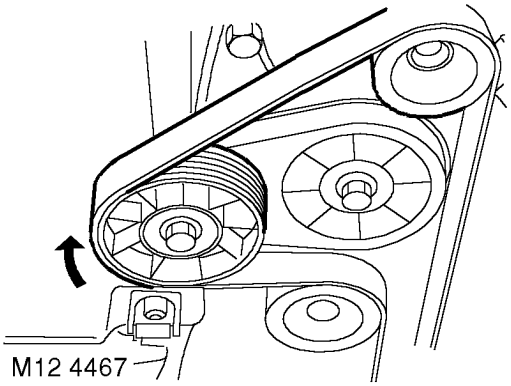
1. If fitted, position heatshield, fit mounting rubber to mounting bracket, fit nut but do not tighten.
2. Position mounting bracket assembly, fit bolts securing mounting bracket to gearbox and tighten to 85 Nm (63 lbf.ft).
3. Fit nut securing mounting to body bracket and tighten to 48 Nm (35 lbf.ft).
4. Tighten nut securing mounting to gearbox bracket to 48 Nm (35 lbf.ft).
5. Position rear cross member, fit bolts and tighten to 26 Nm (19 lbf.ft).
6. Lower vehicle.

Engine assembly

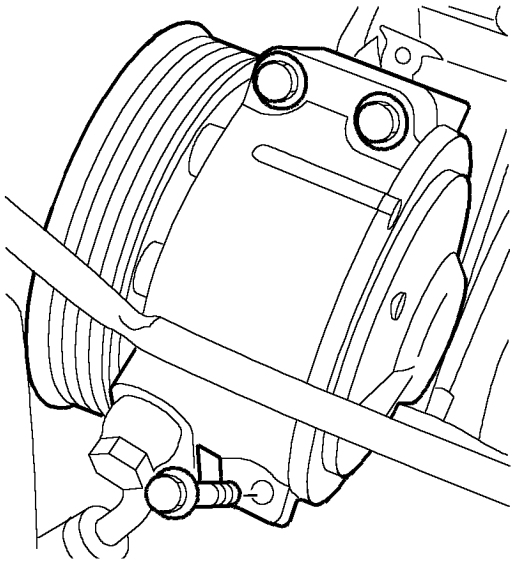
12.41.01.99

Remove

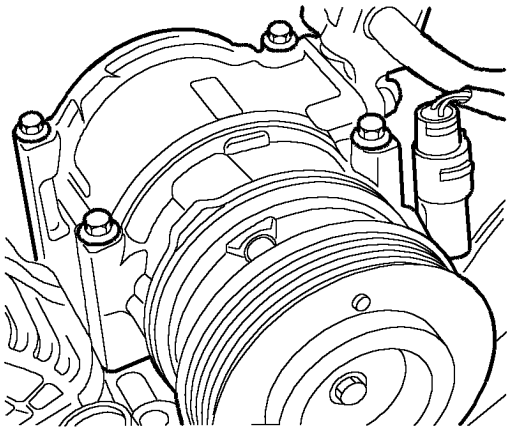
1. Drain engine oil and remove oil filter.
2. Remove radiator.
   COOLING SYSTEM - V8, REPAIRS, Radiator.
3. Remove upper inlet manifold.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.
4. Remove ignition coil assemblies.
5. Position absorbent material to catch spillage and disconnect fuel pipe from fuel rail.
   CAUTION: Always fit plugs to open connections to prevent contamination.
6. Release 2 hose clips and remove top hose.


M12 4467

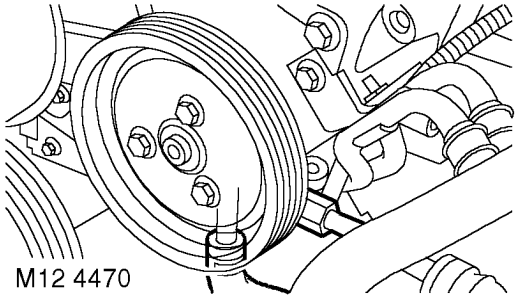
7. Using a 15 mm spanner, release auxiliary drive belt tension and remove drive belt.


M12 4468

8. Remove 3 bolts securing ACE pump, release pump and tie aside.


M12 4469

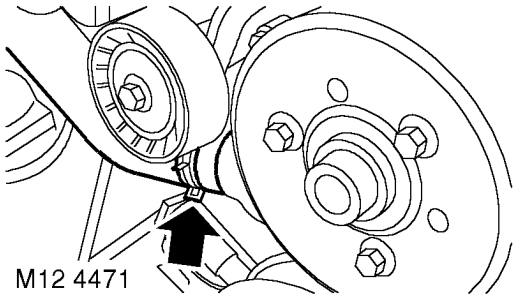
9. Disconnect multiplug from A/C compressor.
10. Remove 4 bolts securing A/C compressor, release compressor and tie aside.



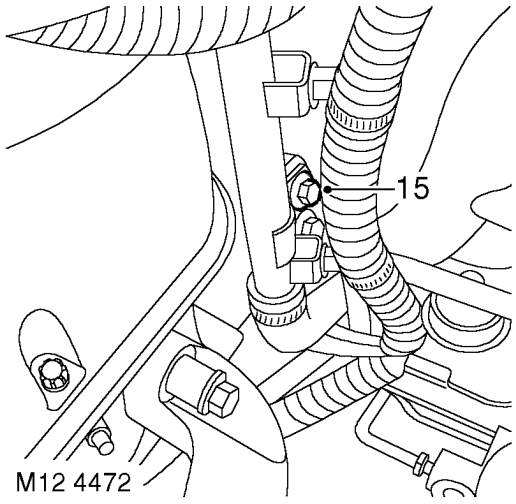
11. Remove bolt securing oil cooling pipes to PAS pump housing and remove saddle clamp.

12. Release PAS pump high and low pressure pipes and position aside.

CAUTION: Always fit plugs to open connections to prevent contamination.



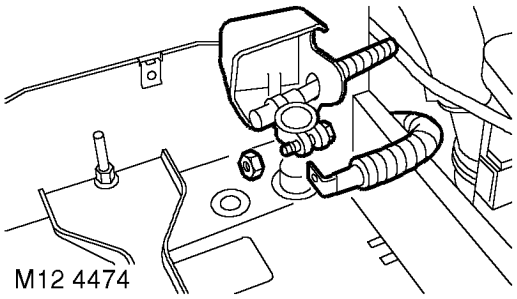
13. Release clips securing hose to coolant pump and coolant rail, release hose and position aside.



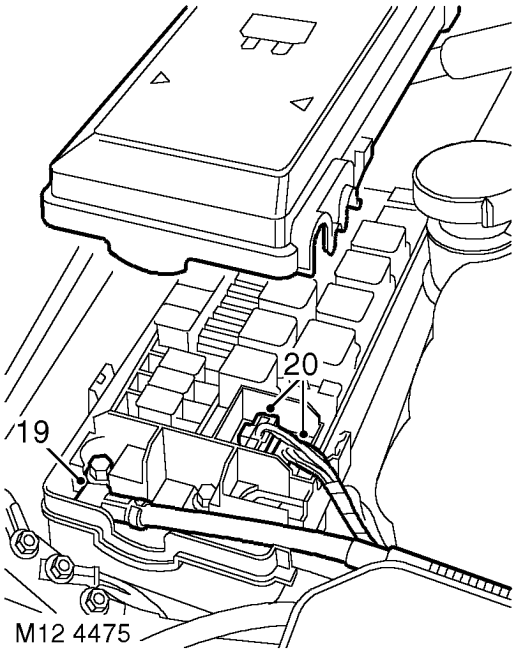
14. Release 2 harness clips from coolant rail.

15. Remove bolt securing coolant rail and position rail aside.

16. Remove bolt securing engine earth lead and position earth lead aside.



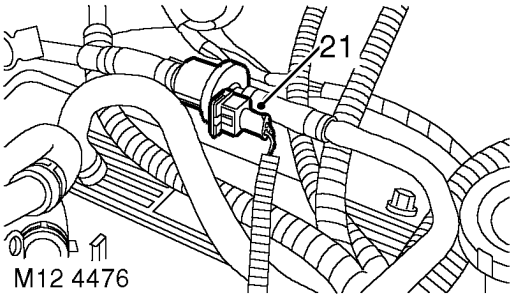
17. Remove nut securing engine harness positive lead to battery, release lead and position aside.



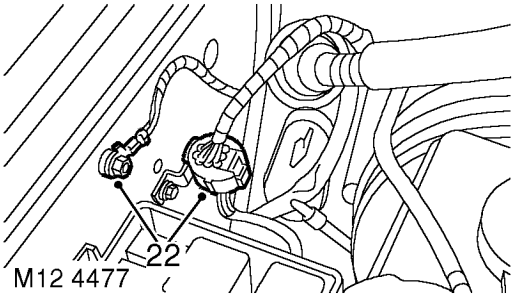
18. Release clips and remove fuse box cover.

19. Remove bolt securing starter lead to fuse box, release lead and position aside.

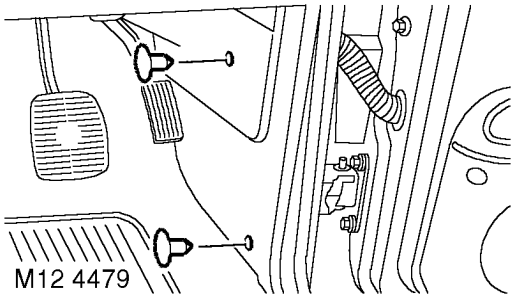
20. Disconnect 2 engine harness multiplugs from fuse box.



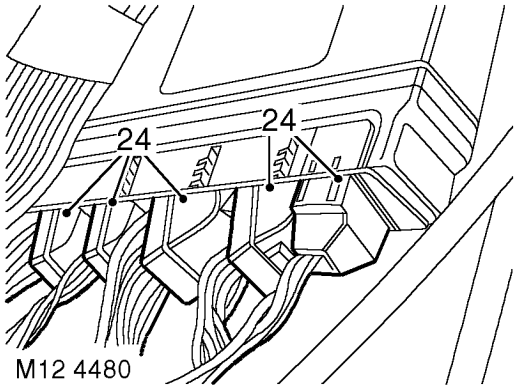
21. Disconnect multiplug from EVAP purge valve.



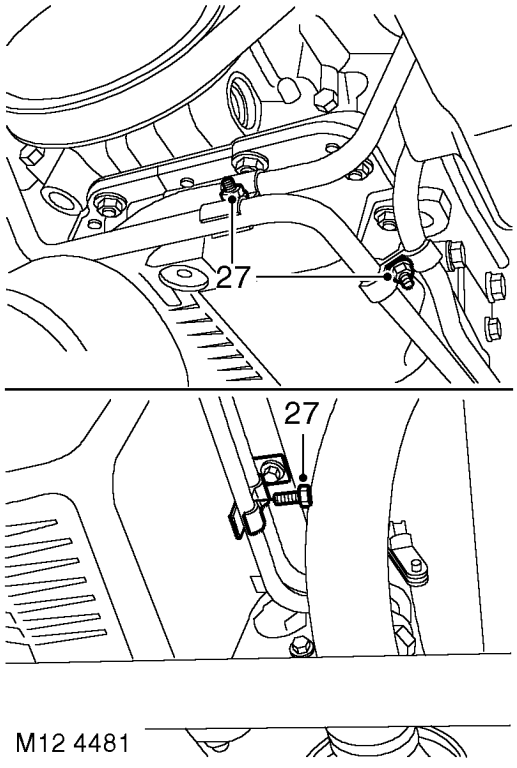
22. Remove nut securing engine harness earth to body and disconnect engine harness to main harness multiplug.



23. Remove trim fixings securing toe board and remove toe board.

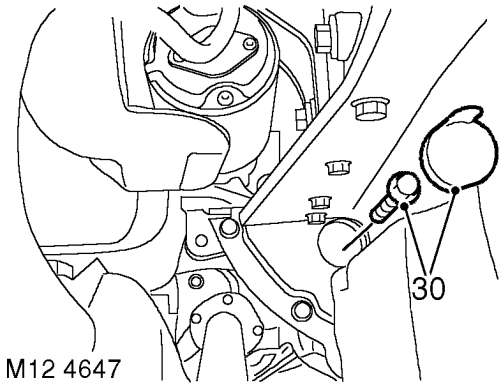


24. Disconnect 5 multiplugs connecting engine harness to ECM.
25. Release engine harness, pull into engine bay and coil on top of engine.
26. Raise vehicle on ramp.

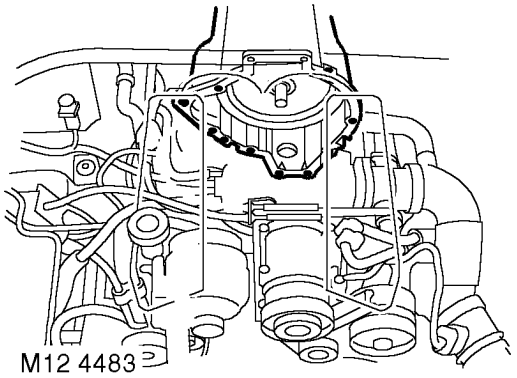


27. Remove 3 bolts securing oil cooling pipes to sump and remove saddle clamps.
28. Tie oil cooling pipes aside.
29. Remove exhaust front pipe.

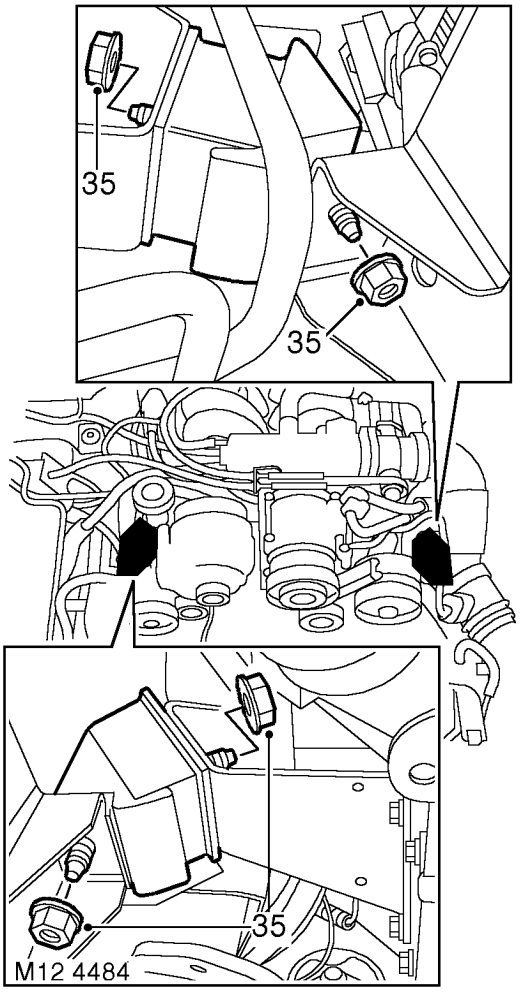
☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**



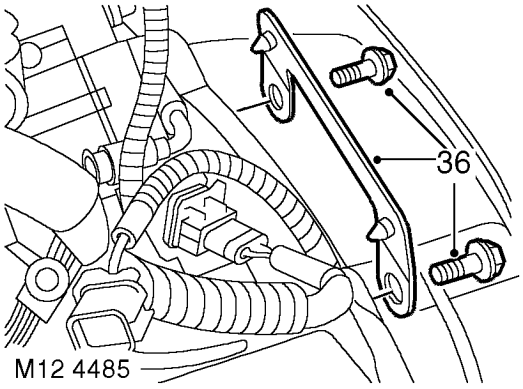
30. **Models with automatic gearbox:** Remove access plug and remove 4 bolts securing torque converter to drive plate.
31. Rotate engine to access bolts.



32. Remove 12 bolts securing engine to gearbox. **DO NOT remove the top 2 bolts at this stage**.
33. Collect support brackets from bell housing bolts.
34. Attach suitable lifting equipment to engine.



35. Remove 4 nuts securing engine mountings, raise engine and remove engine mountings.



36. Lower engine, remove top bolts securing engine to gearbox and collect bracket.
37. Support gearbox on a jack.
38. Release engine from gearbox dowels.
39. With assistance remove engine from engine bay.

Refit

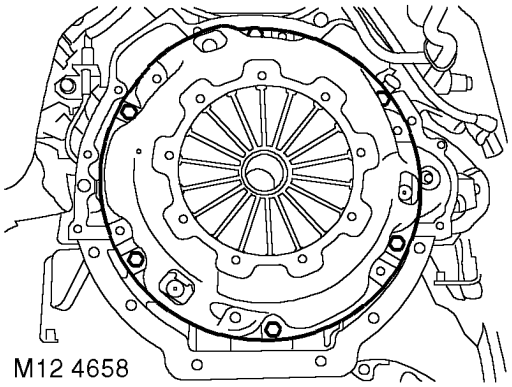
1. Clean mating faces of engine and gearbox, dowel and dowel holes.
2. Lubricate splines and bearing surface on first motion shaft with grease.
3. With assistance position engine in engine bay, align to gearbox and locate on dowels.
4. Position support brackets, fit bell housing bolts and tighten to 50 Nm (37 lbf.ft).
5. Position engine mountings, fit nuts and tighten to 85 Nm (63 lbf.ft).
6. Lower lifting equipment and remove from engine.
7. **Models with automatic gearbox:** Align torque converter to drive plate, fit bolts and tighten to 50 Nm (37 lbf.ft). Fit access plug.
8. Fit exhaust front pipe.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**
9. Position oil cooling pipe saddle clamps and tighten bolts.
10. Position engine harness into foot well.
11. Connect 5 multiplugs to ECM.
12. Fit toe board and secure with trim fixings.
13. Connect engine harness earth to body and secure with nut.
14. Connect engine harness to main harness multiplug.
15. Connect multiplug to EVAP purge valve.
16. Connect engine harness multiplugs to fuse box.
17. Connect starter lead to fuse box and secure with nut.
18. Connect engine harness positive lead to battery and tighten nut.
19. Fit fuse box cover.
20. Position engine earth lead and secure with bolt.
21. Position coolant rail and secure with bolt.
22. Connect harness clips to coolant rail.
23. Connect hose to coolant rail and coolant pump and secure with clips.
24. Connect PAS pump high and low pressure pipes and secure with clips.
25. Position oil cooling pipe saddle clamp to PAS pump housing and secure with bolt.
26. Clean A/C compressor and housing mating faces, dowels and dowel holes.
27. Position A/C compressor, fit bolts and tighten to 22 Nm (16 lbf.ft).
28. Connect multiplug to A/C compressor.
29. Clean ACE pump and housing mating faces, dowels and dowel holes.
30. Position ACE pump, fit bolts and tighten to 22 Nm (16 lbf.ft).
31. Clean all pulley 'V's, fit auxiliary drive belt, using a 15mm spanner, release belt tensioner secure belt and re-tension drive belt .
32. Ensure auxiliary drive belt is correctly located on all pulleys.
33. Fit radiator.
    ☞ **COOLING SYSTEM - V8, REPAIRS, Radiator.**
34. Fit top hose and secure with clips.
35. Connect fuel pipe to fuel rail.
36. Position ignition coils and connect ht leads.
37. Fit upper inlet manifold.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**
38. Fit new oil filter and refill engine with oil.
    ☞ **ENGINE - V8, REPAIRS, Filter - oil.**
    ☞ **MAINTENANCE, PROCEDURES, Engine oil - V8 engine.**
39. Top up gearbox oil.
    ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**

Flywheel

12.53.07

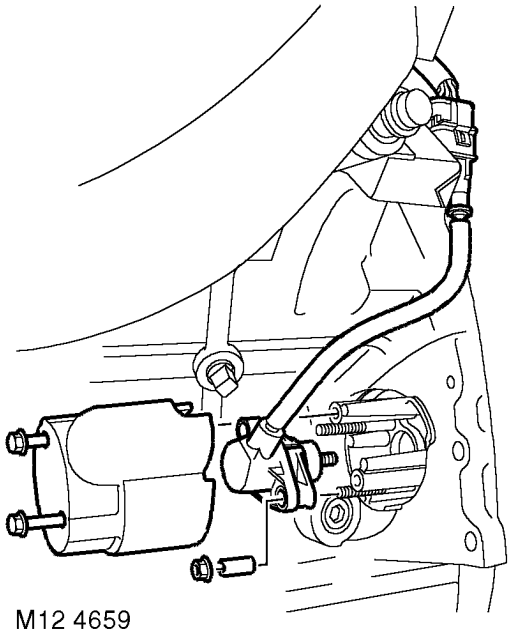
Remove

1. Remove gearbox
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.
2. Restrain flywheel.



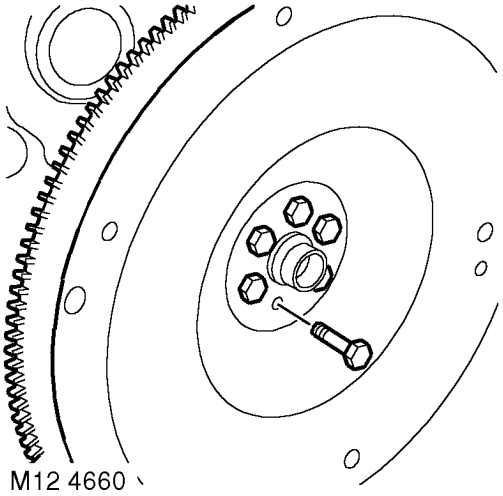
M12 4658

3. Working in sequence, progressively slacken 6 bolts securing clutch cover to flywheel. Remove bolts.
4. Remove clutch cover.
5. Remove clutch plate.



M12 4659

6. Release crankshaft sensor multiplug from bracket.
7. Remove 2 bolts securing crankshaft sensor cover.
8. Remove crankshaft sensor cover.
9. Remove 2 nuts securing crankshaft sensor.
10. Remove crankshaft sensor.



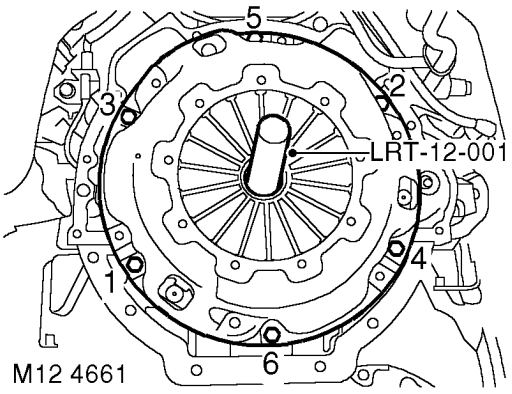
M12 4660

11. Remove 6 bolts securing flywheel.
12. Remove flywheel.

On early engines, balance weights are on engine side of flywheel; replacement flywheels will have balance weights on clutch side of flywheel.

Refit

1. Clean mating faces of flywheel and crankshaft, dowel and dowel hole.
2. Fit flywheel to crankshaft and tighten bolts to 78 Nm (58 lbf.ft).
3. Clean crankshaft sensor and mating face.
4. Fit crankshaft sensor and tighten nuts to 6 Nm (4.4 lbf.ft).
5. Fit crankshaft sensor cover and tighten bolts to 6 Nm (5 lbf.ft).
6. Fit crankshaft sensor multiplug to bracket.
7. Clean clutch cover, drive plate and spigot bush in end of crankshaft. Renew worn components as necessary.
8. If refitting existing drive plate, apply 'Molycote FB 180' to splines.



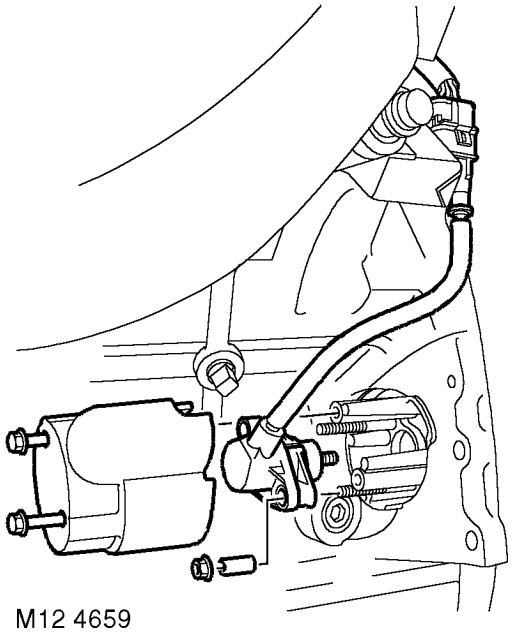
9. Fit alignment tool **LRT-12-001** to spigot bearing in crankshaft.
10. Fit drive plate onto tool **LRT-12-001** ensure side marked 'flywheel side' is towards flywheel.
11. Fit clutch cover and locate on dowels.
12. Fit clutch cover bolts and tighten in diagonal sequence to 40 Nm (30 lbf.ft).
13. Fit gearbox assembly.
    ☞ **MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.**

Plate - drive - automatic

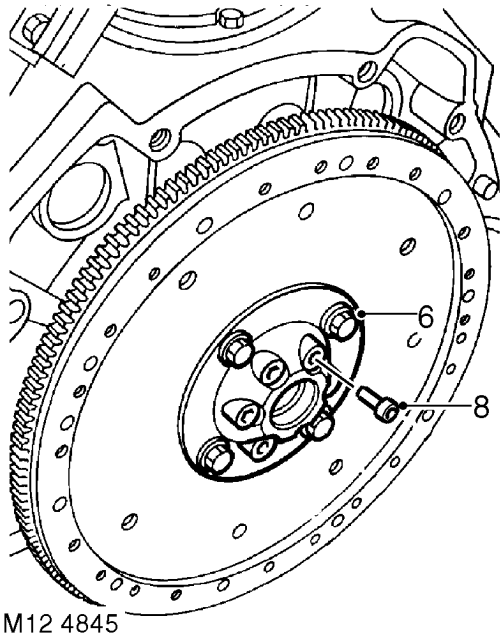
12.53.13

Remove

1. Remove automatic gearbox.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - V8.**



2. Remove 2 bolts securing CKP sensor cover.
3. Remove CKP sensor cover.
4. Remove 2 nuts securing CKP sensor.
5. Remove CKP sensor.



M12 4845

6. Remove 4 bolts securing drive plate clamp ring and remove ring.
7. Remove drive plate from hub.
8. Remove 6 Allen screws securing hub, remove hub and collect spacer.

On early engines, balance weights are on engine side of drive plate; replacement drive plates will have balance weights on torque converter side of drive plate.

Refit

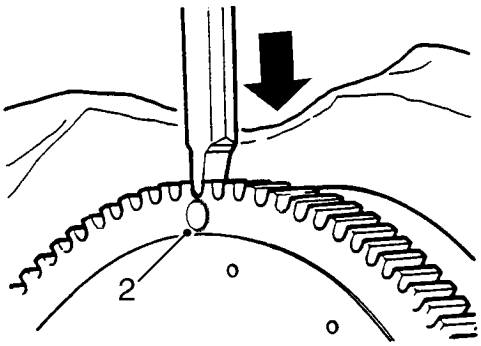
1. Clean hub and mating face, spacer and clamp ring.
2. Clean drive plate and ensure free from cracks and distortion.
3. Fit spacer and hub to crankshaft, tighten Allen screws to 78 Nm (58 lbf.ft).
4. Fit drive plate and clamp ring, tighten bolts to 45 Nm (33 lbf.ft).
5. Clean CKP sensor and mating face.
6. Fit crankshaft sensor and tighten nuts to 6 Nm (5 lbf.ft).
7. Fit CKP sensor cover and tighten bolts to 6 Nm (5 lbf.ft).
8. Fit CKP sensor multiplug to bracket.
9. Fit automatic gearbox.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - V8.**

Ring gear - starter

12.53.19

Remove

1. Remove flywheel.
   ☞ **ENGINE - V8, REPAIRS, Flywheel.**



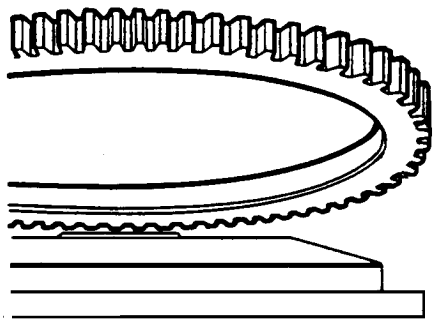
M127458

2. Drill a 3 mm (0.12 in) diameter hole at root of 2 teeth.
3. Apply a cold chisel in root of one of ring gear teeth, strike chisel with hammer to break ring gear.

WARNING: SUITABLE EYE PROTECTION MUST BE WORN.

4. Remove starter ring gear.

Refit


M124586

1. Clean flywheel and starter ring gear.
2. Heat new starter ring gear evenly to 350°C (660°F), indicated when the ring is a light blue colour.
3. Locate ring gear on flywheel and press ring gear hard against flange on flywheel.

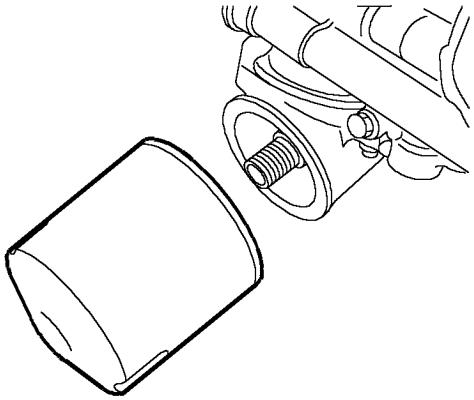
4. Ensure ring gear is correctly seated around the complete circumference of flywheel and allow to cool.
5. Fit flywheel.
   ☞ **ENGINE - V8, REPAIRS, Flywheel.**

Filter - oil

⊸ ***12.60.04***

Remove

1. Clean area around filter head and place a container beneath engine.



M12 4446

2. Using a strap wrench, unscrew and discard filter.

Refit

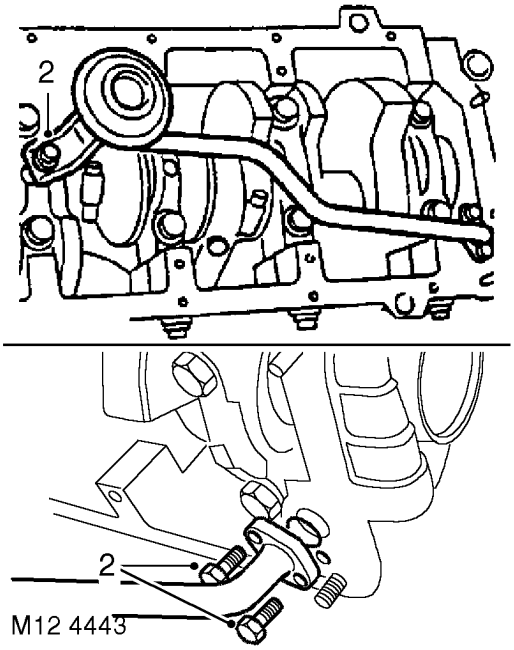
1. Clean mating face of filter head.
2. Lubricate sealing ring of new filter with clean engine oil.
3. Fit filter and tighten by hand until it seats then tighten a further half turn.
4. Start and run engine to check for leaks.
5. Stop engine, wait a few minutes, then check oil level.
6. Top up engine oil.

Strainer - oil pick-up

12.60.20

Remove

1. Remove sump gasket.
   ENGINE - V8, REPAIRS, Gasket - sump.



2. Remove 2 bolts and one nut securing oil pick-up strainer.
3. Remove oil pick-up strainer.
4. Collect spacer from stud.
5. Remove and discard 'O'ring.

Refit

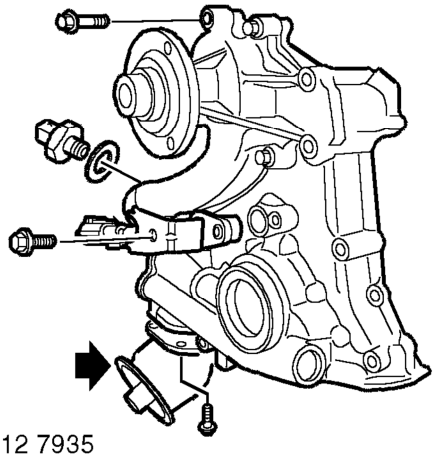
1. Clean oil pick up strainer and 'O' ring recess.
2. Lubricate and fit new 'O' ring.
3. Locate spacer on stud.
4. Position oil pick-up strainer, fit bolts and tighten to 10 Nm (8 lbf.ft). Fit nut and tighten to 22 Nm (16 lbf.ft).
5. Fit new sump gasket.
   ENGINE - V8, REPAIRS, Gasket - sump.

Pump - oil

12.60.26

Remove

1. Remove timing gear cover gasket.
   ENGINE - V8, REPAIRS, Gasket - timing gear cover.



2. Remove bolt securing CMP sensor, remove clamp and sensor.
3. Remove 6 bolts securing coolant pump, remove pump and discard gasket.
4. Remove oil pressure switch and discard sealing washer.
5. Remove 4 bolts securing oil filter head, remove filter head and discard 2 'O' rings.
6. Remove filter head adaptor.

Refit

1. Ensure filter head adaptor is clean and apply Loctite 577 sealant to thread.
2. Fit filter head adaptor and tighten bolts to 13 Nm (9 lbf.ft).
3. Clean filter head and mating face.
4. Fit new 'O' rings to filter head and filter head adaptor.
5. Fit filter head and tighten bolts to 8 Nm (6 lbf.ft).
6. Ensure oil pressure switch and mating face is clean.
7. Fit new sealing washer and tighten switch to 15 Nm (11 lbf.ft).

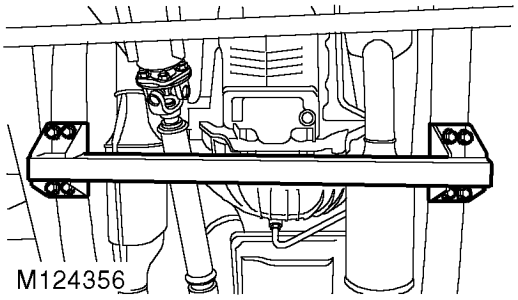
8. Clean coolant pump and mating face.
9. Use a new gasket and fit coolant pump. Tighten bolts securing coolant pump to 25 Nm (19 lbf.ft).
10. Ensure CMP sensor is clean and fit sensor to cover.
11. Fit clamp to CMP sensor and tighten bolt to 8 Nm (6 lbf.ft).
12. Fit timing gear cover gasket.
    ☞ **ENGINE - V8, REPAIRS, Gasket - timing gear cover.**

Gasket - sump

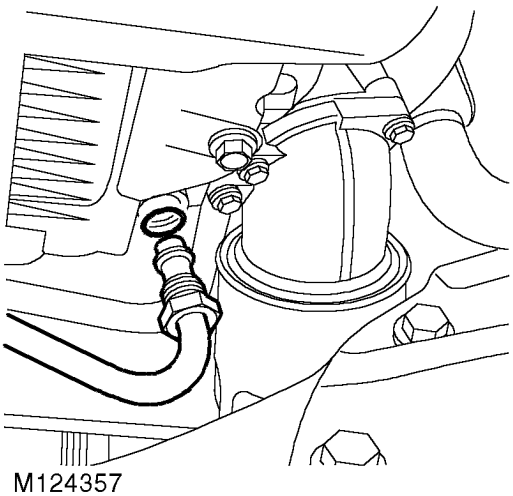
12.60.38

Remove

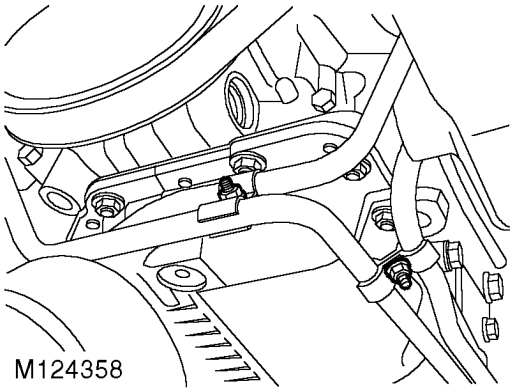
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove dipstick.
4. Raise the vehicle on a ramp.
5. Drain engine oil.
   ☞ **MAINTENANCE, PROCEDURES, Engine oil - V8 engine.**


M124356

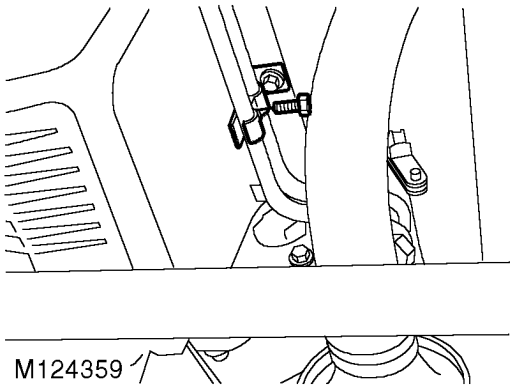
6. Remove 8 bolts securing cross member and remove cross member.
7. Raise front of vehicle under body to increase clearance between engine and front axle.


M124357

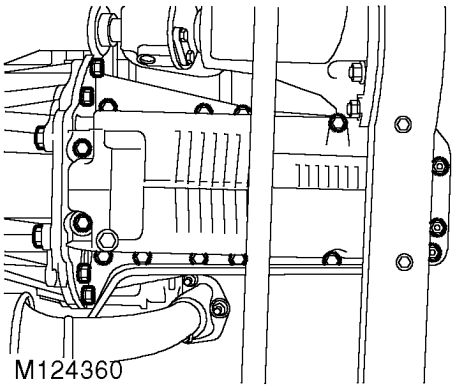
8. Disconnect and release gearbox oil cooler pipe and discard 'O' ring.


M124358

9. Remove 2 clips securing oil cooler pipes at front of sump.


M124359

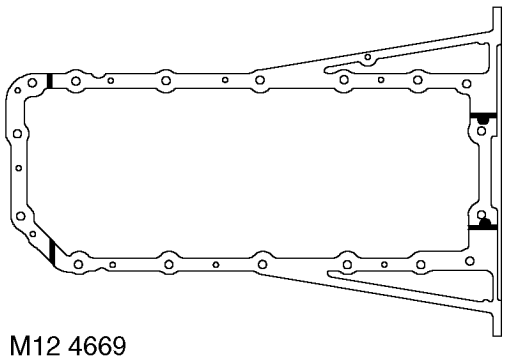
10. Remove clip securing oil cooler pipes to side of sump.
11. Remove clip bracket.


M124360

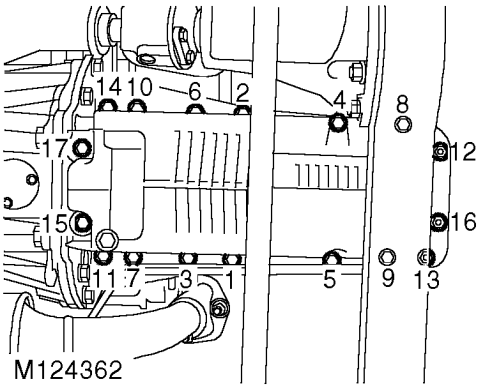
12. Remove 2 forward facing bolts securing sump to bell housing.
13. Remove 4 rear facing bolts securing sump to bell housing.
14. Remove 2 bolts in sump recess.
15. Remove 3 nuts securing front of sump.
16. Remove 12 bolts securing sump flange to engine.
17. Manoeuvre sump over front axle and remove sump.
18. Discard sump gasket.

Refit

1. Clean all traces of sealant from the sump and sump mating faces using a plastic scraper or solvent.


M12 4669

2. Apply a 5 mm wide bead of sealant, Part No. STC 50550, across the cylinder block to front cover joint and across the cylinder block to rear main bearing joint. Apply a globule of sealant to cover the end of the cruciform seal, (see illustration).
3. Fit new gasket, dry, to sump, ensuring that locating tags are correctly positioned.
4. Manoeuvre sump into position, fit and lightly tighten 2 bolts to retain sump in place, then fit and lightly tighten remainder of bolts.



M124362

5. Working in the sequence illustrated, tighten the sump bolts to 22 Nm (16 lbf.ft).
6. Position side clip bracket, fit and tighten bolt.
7. Position oil cooler pipe clips, fit and tighten nuts.

8. Clean gearbox oil cooler pipe 'O' ring recess and mating face.
9. Lubricate and fit new 'O' ring to gearbox oil cooler pipe.
10. Position pipe and tighten nut.
11. Lower front of vehicle.
12. Position cross member to chassis, fit bolts and tighten to 25 Nm (18 lbf.ft).
13. Refill engine oil and fit dipstick.
14. Connect battery earth lead.
15. Fit battery cover and retain with fixings.

Switch - oil pressure

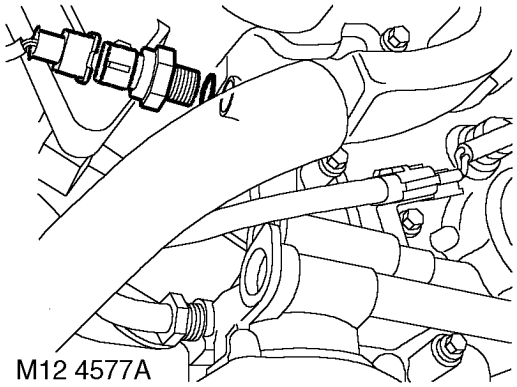
12.60.50

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Remove fixings and remove underbelly panel.


M12 4577A

5. Disconnect multiplug from oil pressure switch.
6. Position container below switch to catch oil spillage.
7. Remove oil pressure switch and discard sealing washer.

Refit

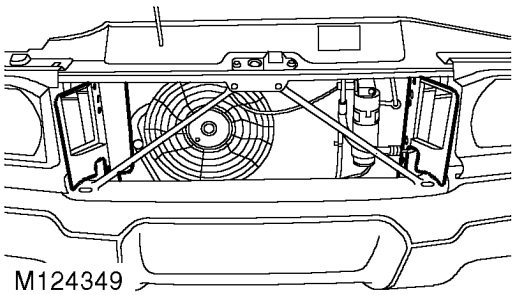
1. Clean oil pressure switch threads.
2. Fit new sealing washer to switch.
3. Fit oil pressure switch and tighten to 15 Nm (11 lbf.ft) .
4. Connect multiplug to oil pressure switch.
5. Fit underbelly panel and secure with fixings.
6. Remove stand(s) and lower vehicle.
7. Connect battery earth lead.
8. Fit battery cover and retain with fixings.
9. Top up engine oil.

Cooler - engine oil

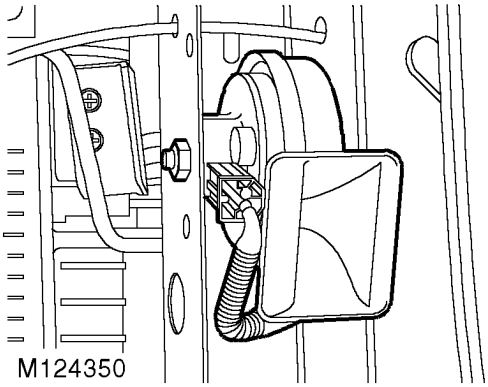
12.60.68

Remove

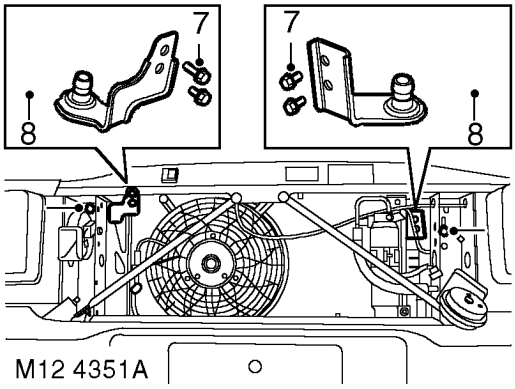
1. Release fixings and remove battery cover.
2. Release fixings and remove cooling fan cowl.
3. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



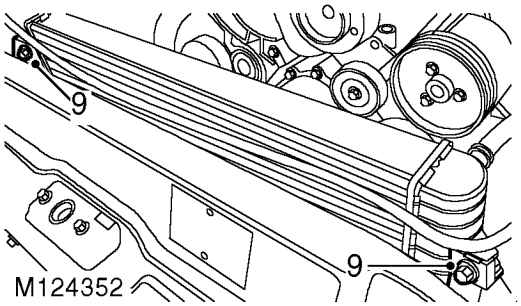
4. Remove 6 scrivets and remove LH and RH air deflectors from front panel.



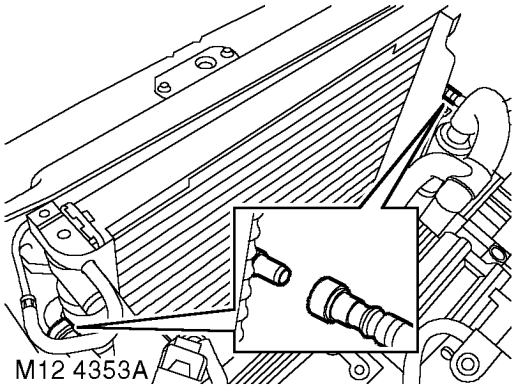
5. Remove nut and move LH horn aside.



6. Remove 2 bolts securing radiator LH and RH upper mounting brackets to body panel and remove brackets.
7. Remove 4 screws securing air conditioning condenser LH and RH upper mounting brackets to condenser.
8. Remove condenser upper mounting brackets with rubber mounts from radiator extension brackets.



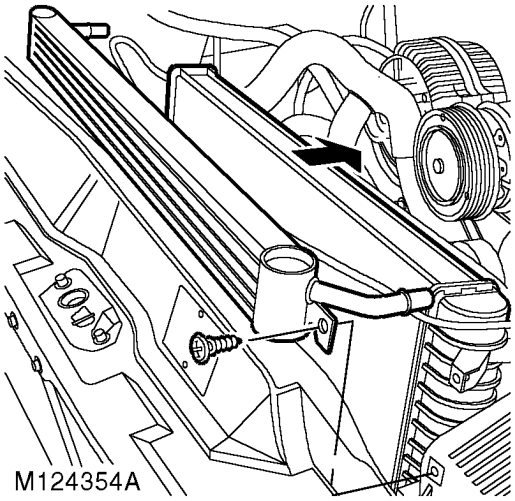
9. Remove 2 bolts securing LH and RH extension brackets to radiator and remove brackets.



10. Position absorbent cloth under each oil cooler hose connection to collect oil spillage.

11. Push against coupling release rings and disconnect both hoses from oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.



12. Remove screw securing oil cooler to radiator.
13. Release cooler from its location on radiator.
14. Release radiator lower mountings from location in chassis and carefully move radiator towards engine sufficiently only to release engine oil cooler from radiator.
15. Remove engine oil cooler.

Refit

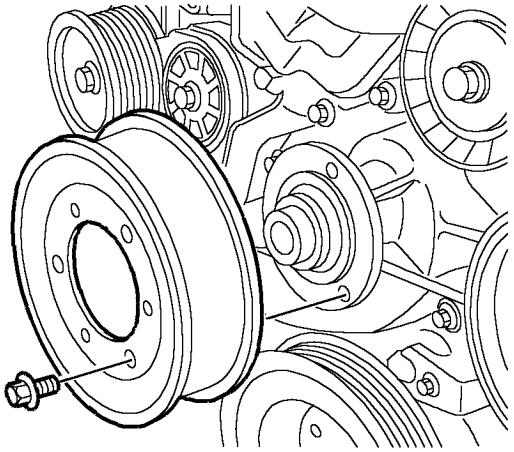
1. Fit engine oil cooler to radiator, engage in location and secure with screw.
2. Fit radiator to location in chassis.
3. Ensure connections are clean, then secure hoses to oil cooler.
4. Fit extension brackets to radiator and secure with bolts.
5. Fit brackets with rubber mounts to extension brackets and secure to air conditioning condenser with screws.
6. Fit radiator upper mounting brackets and secure to body with bolts.
7. Fit LH horn and secure with nut.
8. Fit LH and RH air deflectors to front panel and secure with scrivets.
9. Fit front grille.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**.
10. Fit cooling fan cowl and secure with fixings.
11. Fit battery cover and secure with fixings.
12. Top up engine oil.

Gasket - timing gear cover

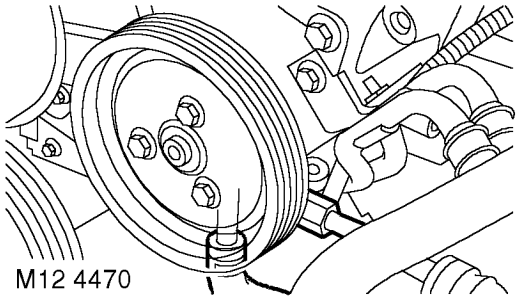
⊸ ***12.65.04***

Remove

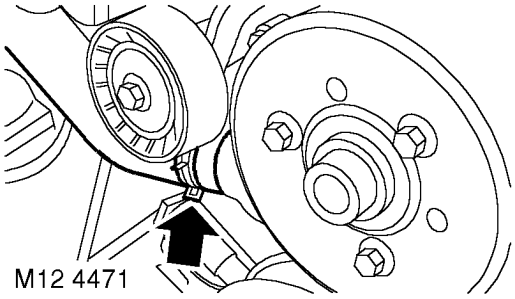
1. Remove oil pick-up strainer.
   ☞ **ENGINE - V8, REPAIRS, Strainer - oil pick-up.**
2. Remove timing gear cover oil seal.
   ☞ **ENGINE - V8, REPAIRS, Seal - cover - timing gears.**
3. Remove engine oil filter.
   ☞ **ENGINE - V8, REPAIRS, Filter - oil.**



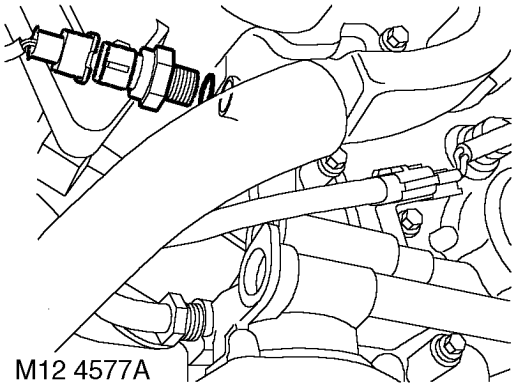
4. Remove and discard 3 bolts securing coolant pump pulley and remove pulley.



5. Remove 3 bolts securing PAS pump pulley and remove pulley.
6. Drain cooling system.
   ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

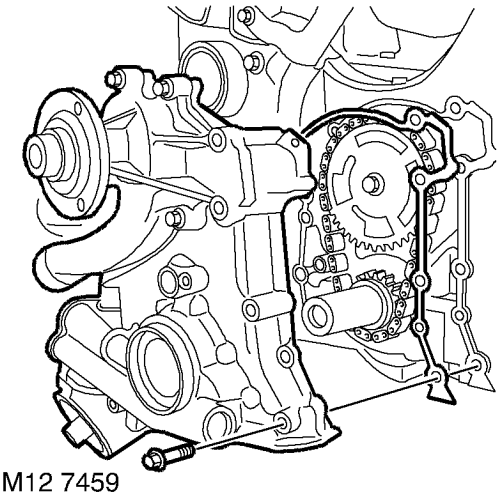

M12 4471

7. Release clip and disconnect coolant hose from coolant pump.


M12 4577A

8. Disconnect multiplug from oil pressure switch.
9. Disconnect multiplug from CMP sensor.
10. **If fitted:** Loosen union and disconnect oil cooler pipe from timing gear cover. Remove and discard 'O' ring.

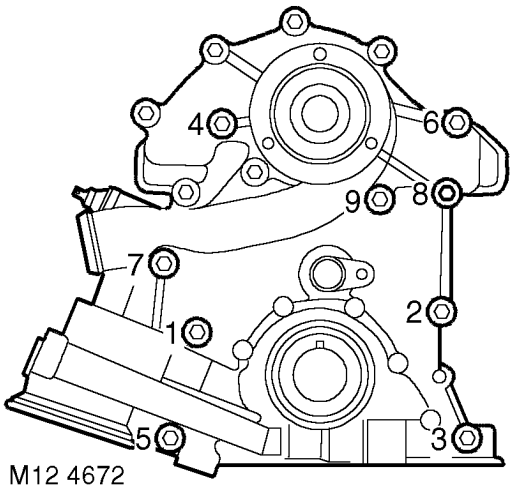
CAUTION: Always fit plugs to open connections to prevent contamination.


M12 7459

11. Remove 9 bolts securing timing gear cover and remove cover. Remove and discard gasket.

Refit

1. Clean mating faces of timing gear cover and cylinder block. Clean dowels and dowel holes.
2. Fit new gasket, dry, to dowels in cylinder block.



M12 4672

3. Fit timing gear cover to cylinder block and, working the sequence illustrated, tighten bolts to 22 Nm (17 lbf.ft) . Ensure CMP sensor multiplug bracket is secured by bolt.
4. **If fitted:** Fit new 'O' ring to oil cooler pipe, connect pipe to timing gear cover and tighten union to 15 Nm (11 lbf.ft).
5. Connect multiplug to oil pressure switch.
6. Connect multiplug to CMP sensor.
7. Connect coolant hose to coolant pump and secure with clip.

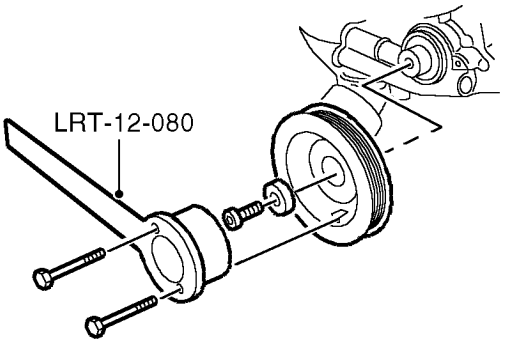
8. Ensure mating faces of PAS pump pulley and drive flange are clean, fit pulley and tighten bolts to 22 Nm (16 lbf.ft).
9. Remove all traces of thread locking material from coolant pump pulley drive flange bolt holes using an M8 tap.
10. Ensure mating faces of coolant pump pulley and drive flange are clean, fit pulley and tighten new Patchlok bolts to 22 Nm (16 lbf.ft).
11. Ensure mating faces of oil filter and adaptor are clean, smear clean engine oil onto seal and fit filter.
12. Fit timing gear cover oil seal.
    ☞ **ENGINE - V8, REPAIRS, Seal - cover - timing gears.**
13. Fit oil pick-up strainer.
    ☞ **ENGINE - V8, REPAIRS, Strainer - oil pick-up.**
14. Refill cooling system.
    ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Seal - cover - timing gears

⊸ ***12.65.05***

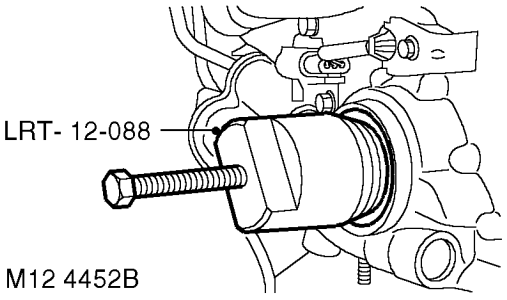
Remove

1. Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**



M12 4445A

2. Secure tool **LRT-12-080** to crankshaft pulley with 2 bolts.
3. Remove crankshaft pulley bolt.
4. Remove crankshaft pulley.

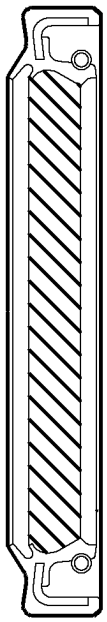


M12 4452B

5. Use tool **LRT-12-088,** to remove oil seal from timing gear cover.

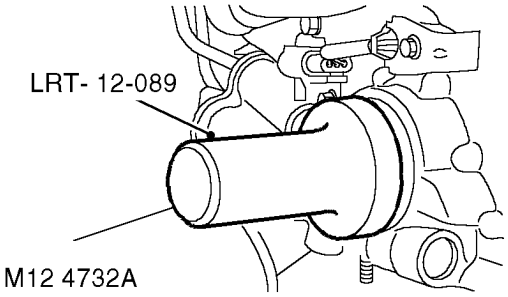
Refit

1. Clean seal register in timing gear cover and crankshaft pulley.



M12 7485

2. Apply Retinax LX grease to inner recess of new oil seal until recess is half filled with grease. **Do not allow grease to coat any other part of seal. Do not apply oil to seal.**
3. Apply smear of Retinax LX grease to seal running surface on crankshaft.



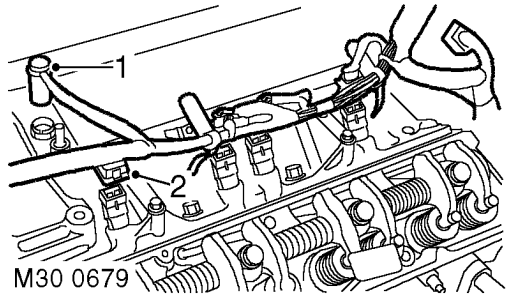
M12 4732A

4. Fit seal to timing gear cover using tool **LRT-12-089** .
5. Fit crankshaft pulley bolt and tighten to 270 Nm (200 lbf.ft).
6. Remove tool **LRT-12-080** from crankshaft pulley.
7. Fit auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

Gasket - inlet manifold

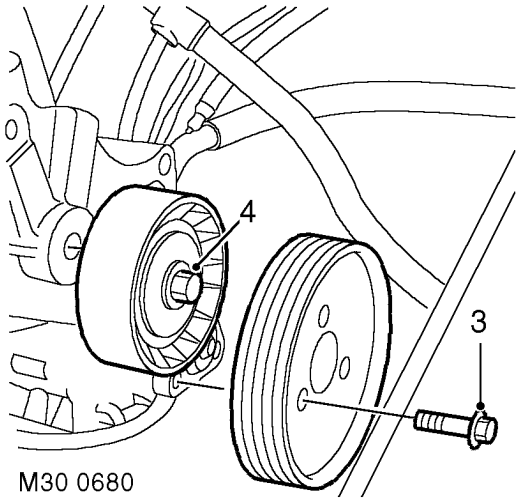
30.15.08.01

Disassembly



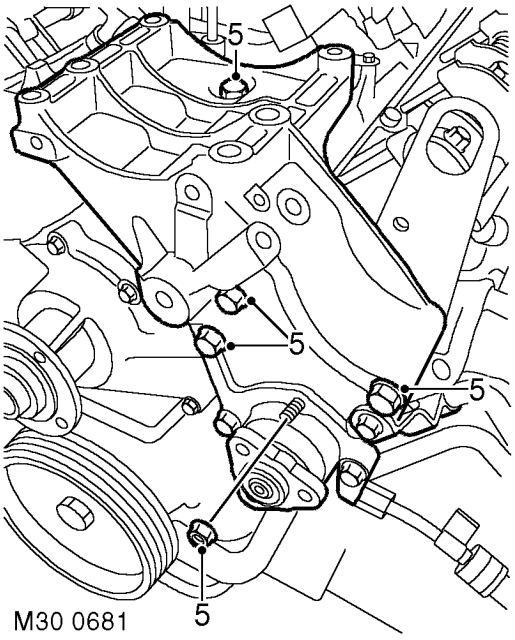
M30 0679

1. Disconnect multiplug from coolant thermistor.
2. Disconnect multiplugs from injectors; release injector harness from fuel rail and position aside.



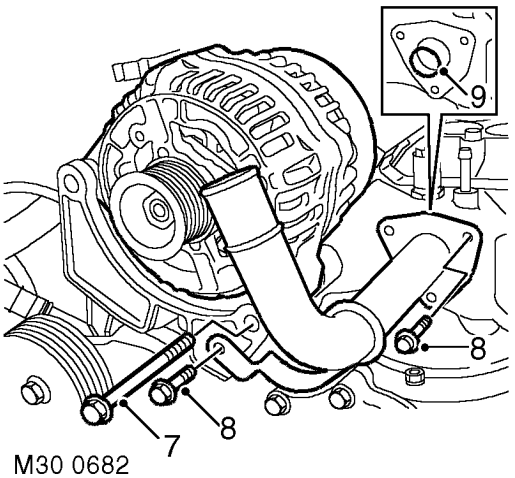
M30 0680

3. Remove 3 bolts securing PAS pump pulley and remove pulley.
4. Loosen bolt securing jockey pulley and remove pulley.



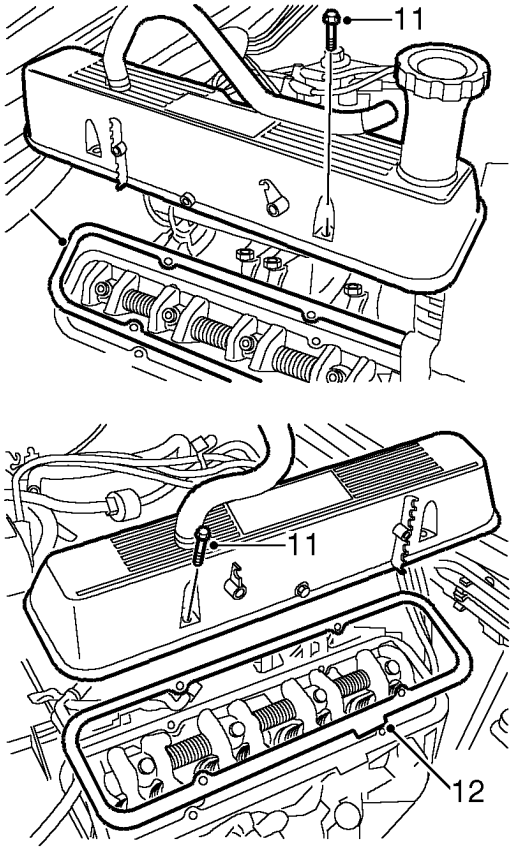
M30 0681

5. Remove 4 bolts and one nut securing auxiliary housing and remove housing.
6. Remove 2 nuts securing alternator cables and release the cables.



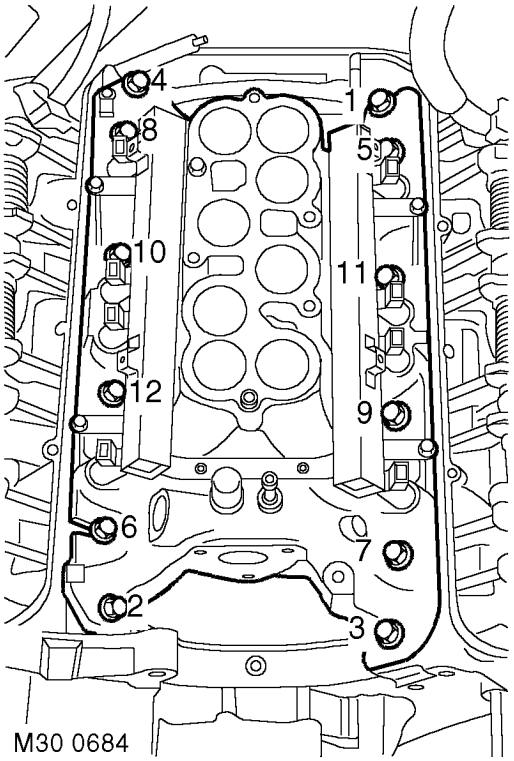
M30 0682

7. Remove two bolts securing alternator and remove alternator.
8. Remove 4 bolts securing coolant outlet elbow and remove outlet elbow.
9. Remove and discard 'O' ring.
10. Release ht leads from rocker covers.



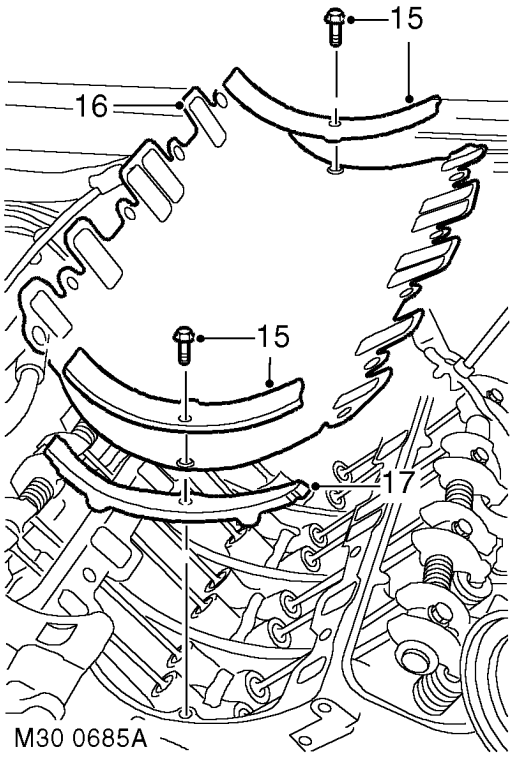
M30 0683

11. Remove 4 bolts securing rocker cover and remove cover.
12. Remove and discard rocker cover gaskets.



M30 0684

13. Using the sequence shown, remove 12 bolts securing the inlet manifold.
14. Remove inlet manifold assembly.



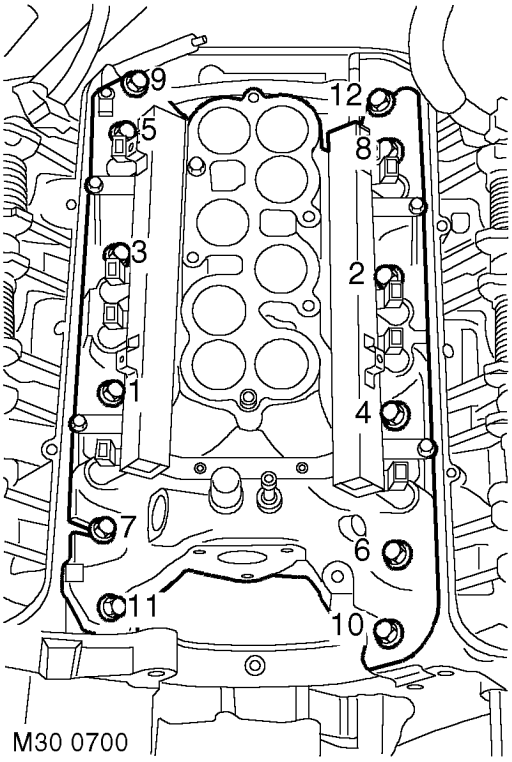
15. Remove 2 bolts securing manifold gasket and collect gasket clamps.
16. Remove inlet manifold gasket.
17. Remove gasket seals.

Reassembly

1. Clean sealant from cylinder head and from notches in the cylinder block.
2. Clean mating faces of cylinder block, cylinder head and manifold.

   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.

3. Apply sealant, Part No. STC 3254 to cylinder head and notches in cylinder block.
4. Fit new gasket seals, ensuring the ends engage correctly in notches.
5. Apply sealant, Part No. STC 3254 to gasket seals above the notches in the cylinder block.
6. Fit new manifold gasket, dry.
7. Position gasket clamps, fit and lightly tighten bolts.
8. Position inlet manifold assembly to cylinder head.



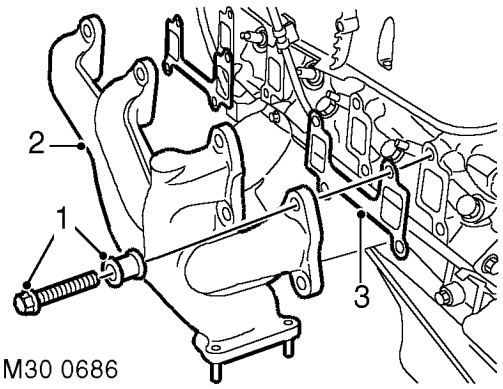
9. Fit manifold bolts and, working in the sequence illustrated, tighten as follows:
   - Initially, tighten bolts numbered 1, 4, 9 and 12 in numerical order to 5 Nm (4 lbf.ft).
   - Inlet manifold bolts - initial tighten = 10 Nm (8 lbf.ft).
   - Inlet manifold bolts - final tighten = 51 Nm (38 lbf.ft).
   - Tighten inlet manifold gasket clamp bolts to 18 Nm (14 lbf.ft).
   - Tighten inlet manifold bolts to 51 Nm (38 lbf.ft)

10. Clean mating faces of rocker covers and cylinder heads.
11. Fit new rocker cover gaskets, dry, position rocker cover, fit bolts and working in diagonal sequence, tighten to:
    - Stage 1 - 3 Nm (2.5 lbf.ft)
    - Stage 2 - 8 Nm (6 lbf.ft)
12. Ensure that outer rim of gasket is correctly positioned around periphery of rocker cover.
13. Secure ht leads to rocker cover.
14. Clean coolant outlet elbow mating faces.
15. Lubricate and fit new 'O' ring to outlet pipe.
16. Position coolant outlet elbow, fit bolts and tighten to 22 Nm (17 lbf.ft).
17. Position alternator, fit mounting bolts and tighten to 45 Nm (34 lbf.ft).
18. Position alternator cables and tighten terminal B+ to 18 Nm (13 lbf.ft) and terminal D+ to 5 Nm (3.5 lbf.ft).
19. Position auxiliary housing, fit bolts and tighten to 40 Nm (30 lbf.ft). Fit nut and tighten to 22 Nm (17 lbf.ft).
20. Clean jockey pulley mating faces.
21. Position jockey pulley and tighten bolt to 50 Nm (37 lbf.ft).
22. Clean PAS pump pulley mating faces.
23. Position PAS pump pulley, fit bolts and tighten to 22 Nm (17 lbf.ft).
24. Secure injector harness and connect injector multiplugs.
25. Connect multiplug to coolant thermistor.

Gasket - exhaust manifold

30.15.12.01

Disassembly

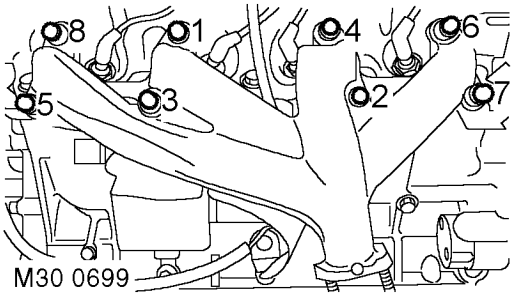


1. Remove 8 bolts securing exhaust manifold and collect spacers. Discard the bolts.
2. Remove exhaust manifold.
3. Remove 2 manifold gaskets and discard.

Reassembly

1. Clean exhaust manifold and cylinder head mating face.
   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.

2. Fit new gaskets, dry, fit exhaust manifold.
   CAUTION: Ensure that link bar on gasket is positioned below spark plugs.



LH bank illustrated

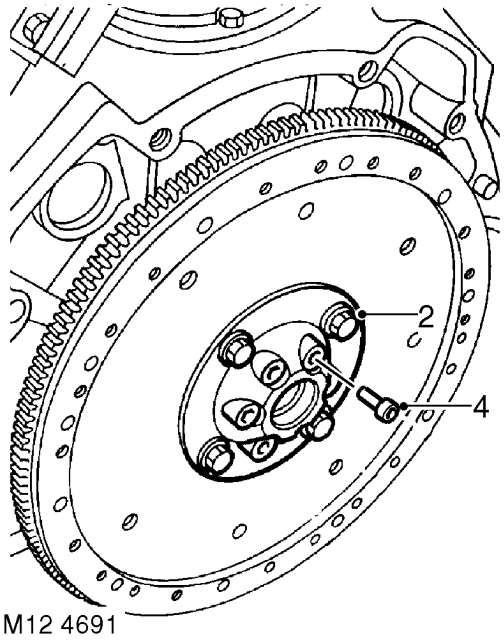
3. Fit spacers to new manifold bolts and, working in the sequence illustrated, initially tighten bolts to 15 Nm (11 lbf.ft), then finally tighten to 38 Nm (28 lbf.ft).

Seal - crankshaft - rear - automatic models

12.21.20.01

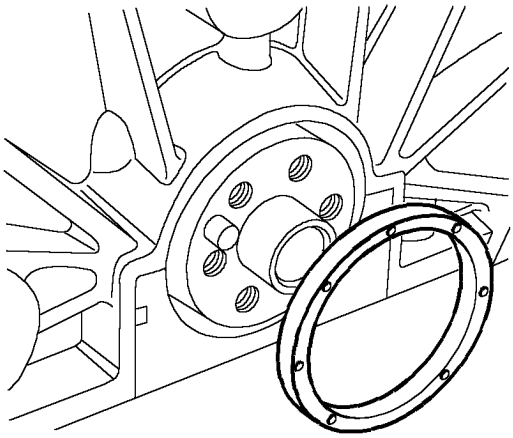
Disassembly

1. Remove CKP sensor.
   ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Sensor - crankshaft position (CKP).



M12 4691

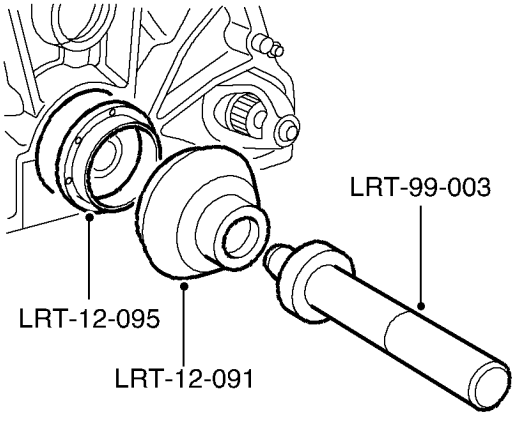
2. Remove 4 bolts securing drive plate clamp ring and remove ring.
3. Remove drive plate from hub.
4. Remove 6 Allen screws securing hub, remove hub and collect spacer.


M12 4665

5. Carefully remove oil seal from cylinder block to avoid damage to seal location or running surface on crankshaft.

Reassembly

1. Ensure both seal location and running surface on crankshaft are clean.



M12 7456

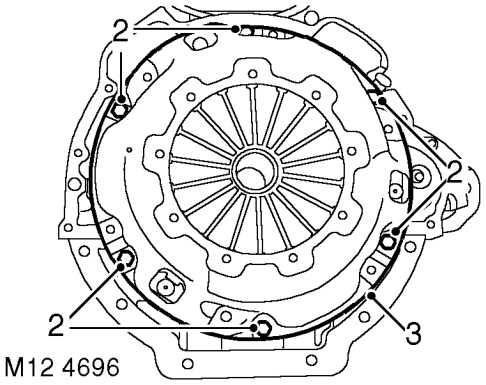
2. Fit seal guide **LRT-12-095** to crankshaft.
3. Fit new seal squarely onto crankshaft and remove guide.
   CAUTION: Oil seal must be fitted dry.
4. Fit seal into location using tools **LRT-12-091** and **LRT-99-003**.

5. Clean hub and mating face, spacer and clamp ring.
6. Clean drive plate and ensure free from cracks and distortion.
7. Fit spacer and hub to crankshaft, tighten Allen screws to 78 Nm (58 lbf.ft).
8. Fit drive plate and clamp ring, tighten bolts to 45 Nm (35 lbf.ft).
9. Fit CKP sensor.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Sensor - crankshaft position (CKP).**

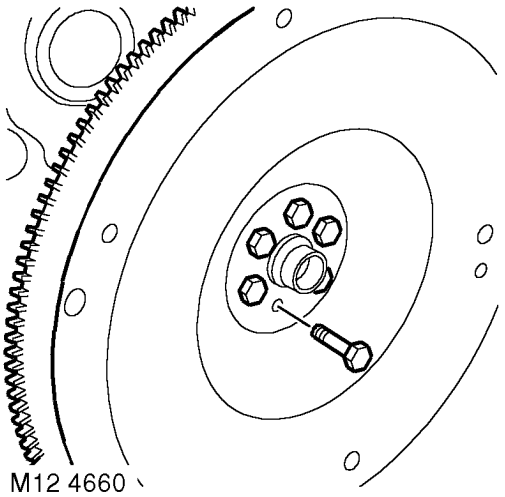
Seal - crankshaft - rear - manual models

🔧 ***12.21.20.01***

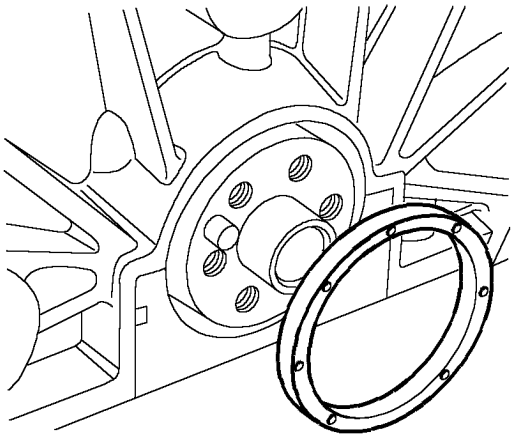
Disassembly



1. Restrain flywheel.
2. Working in sequence, loosen and remove 6 bolts securing clutch cover to flywheel.
3. Remove clutch cover.
4. Remove clutch plate.
5. Remove CKP sensor.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Sensor - crankshaft position (CKP).**



6. Remove 6 bolts securing flywheel.
7. Remove flywheel.

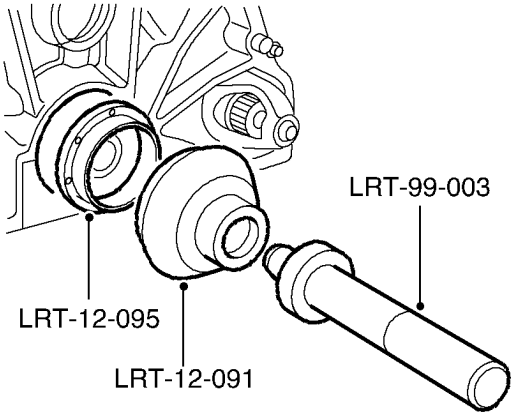


M12 4665

8. Carefully remove oil seal from cylinder block to avoid damage to seal location or running surface on crankshaft.

Reassembly

1. Ensure both seal location and running surface on crankshaft are clean.



M12 7456

2. Fit tool **LRT-12-095** to crankshaft.
3. Fit new seal squarely onto crankshaft and guide.

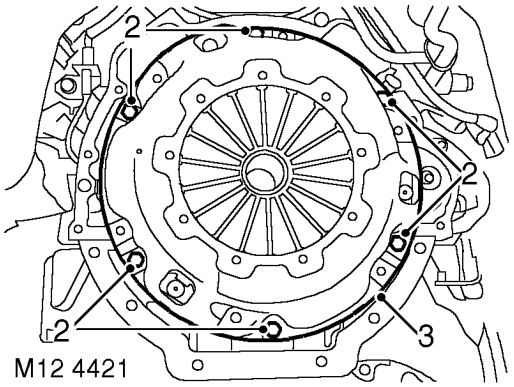
CAUTION: Oil seal must be fitted dry.

4. Fit seal into location using tools **LRT-12-091** and **LRT-99-003**.
5. Clean mating faces of flywheel and crankshaft, dowel and dowel hole.
6. Fit flywheel to crankshaft and, working in a diagonal sequence, tighten bolts to 78 Nm (58 lbf.ft).
7. Fit CKP sensor.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Sensor - crankshaft position (CKP).**
8. Clean clutch cover, drive plate and spigot bush in end of crankshaft.
9. Renew worn components as necessary.
10. If refitting existing drive plate, apply Molycote FB 108 to splines.
11. Fit **LRT-12-001** alignment tool to spigot bearing in crankshaft.
12. Fit drive plate onto alignment tool, ensure side marked 'flywheel side' is against flywheel.
13. Fit clutch cover and locate on dowels.
14. Fit clutch cover bolts and tighten in diagonal sequence to 40 Nm (30 lbf.ft).

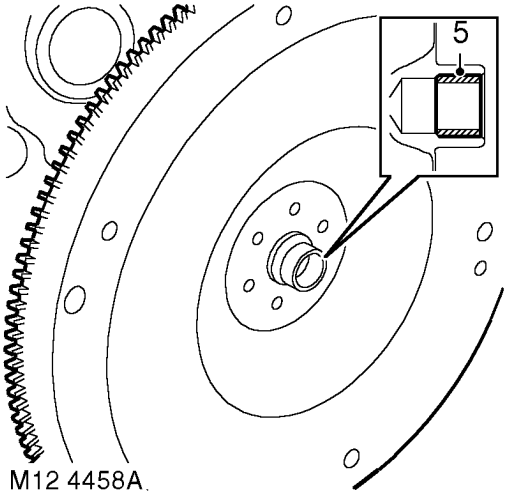
Bearing - spigot - crankshaft

12.21.45.01

Disassembly



1. Remove 6 bolts securing clutch cover.
2. Remove clutch cover.
3. Tap a thread in spigot bush to accommodate a suitable impulse extractor.
4. Fit extractor to bush.



5. Remove bush from crankshaft.

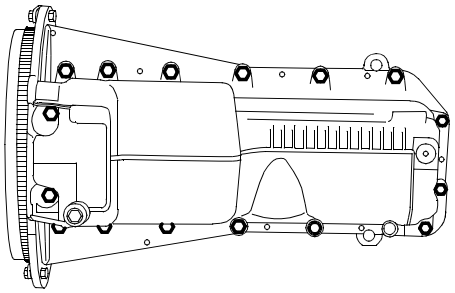
Reassembly

1. Clean bush register in rear of crankshaft.
2. Using a suitable drift, fit new bush to crankshaft so that it is flush with or up to a maximum of 1.6 mm (0.06 in) below the end of the crankshaft.
3. Ream spigot bush to 19.117 + 0.025 – 0.00 mm (0.75 + 0.001 – 0.00 in) .
4. Remove all traces of swarf on completion.
5. Clean mating faces of flywheel and crankshaft, dowel and dowel hole.
6. Fit clutch cover to flywheel and tighten bolts by diagonal slection to 40 Nm (30 lbf.ft).

Gasket - engine sump

12.60.38.01

Disassembly

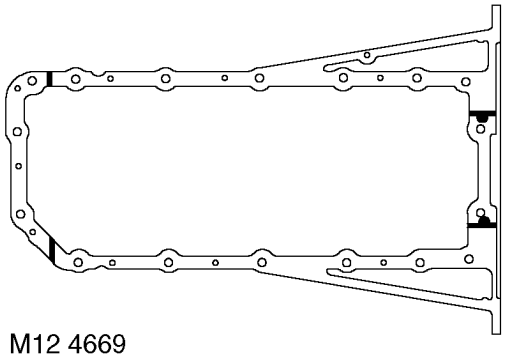


M12 5741

1. Remove 3 nuts and 14 bolts securing sump to cylinder block.
2. Remove sump.
3. Remove and discard gasket.

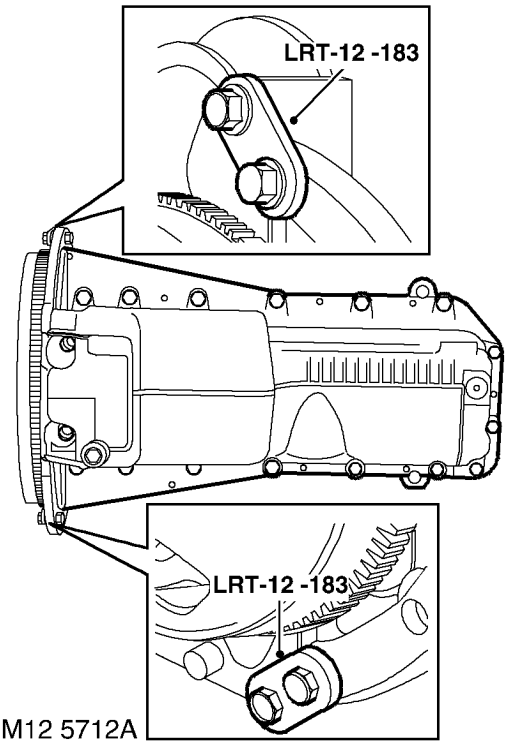
Reassembly

1. Clean all traces of sealant from the sump and sump mating faces, using a solvent cleaner or plastic scraper.



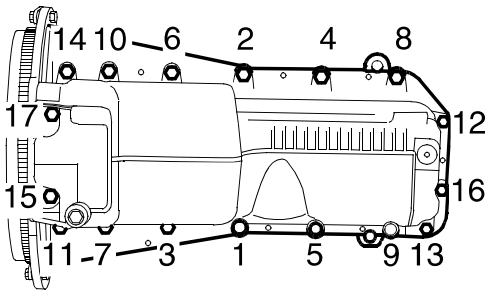
M12 4669

2. Apply a 5 mm (0.2 in) wide bead of sealant, Part No. STC 50550 across the cylinder block to front cover joint and across the cylinder block to rear main bearing joint. Apply a globule of sealant to cover the end of the cruciform seal, (see illustration above).
3. Fit new sump gasket, dry, ensure location tags are correctly positioned.
4. Fit the sump to the cylinder block.



M12 5712A

5. **Noting that the two parts of the tool are handed**, fit tool **LRT- 12-183** to the engine back plate using bell housing nuts and bolts.
6. Secure the tool to the sump using the bolts which are part of the tool. **The holes in the tool are larger than the diameter of the bolts, allowing the tool and the sump to move as the sump bolts are tightened.**



M12 5713

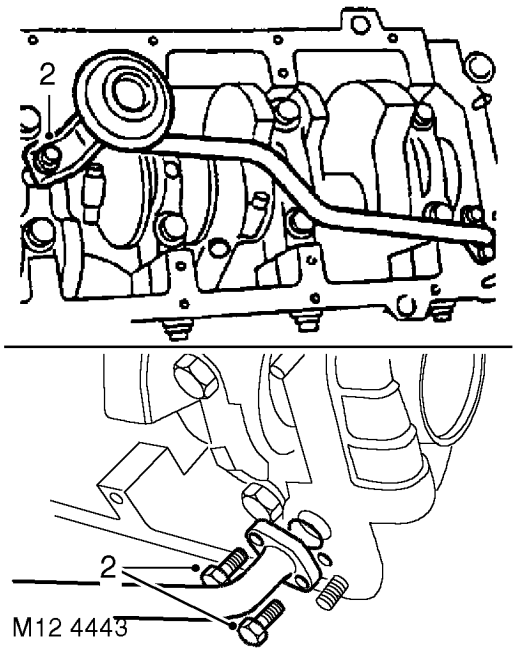
7. Fit the sump nuts and bolts, and working in the sequence shown, tighten to 22 Nm (16 lbf.ft).
8. Remove tool **LRT-12-183**.

Strainer - oil pick-up

12.60.20.01

Disassembly

1. Remove sump gasket.
   ENGINE - V8, OVERHAUL, Gasket - engine sump.



2. Remove 2 bolts and 1 nut securing oil pick up strainer.
3. Remove oil pick up strainer.
4. Collect spacer.
5. Remove and discard 'O' ring.

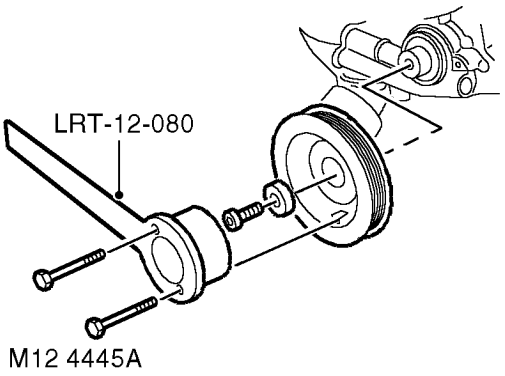
Reassembly

1. Clean oil pick up strainer and 'O' ring recess.
2. Lubricate new 'O' ring with clean engine oil and fit to recess.
3. Locate spacer on stud.
4. Position oil pick up strainer, fit bolts and tighten to 10 Nm (7 lbf.ft). Fit nut and tighten to 22 Nm (16 lbf.ft).
5. Fit new sump gasket.
   ENGINE - V8, OVERHAUL, Gasket - engine sump.

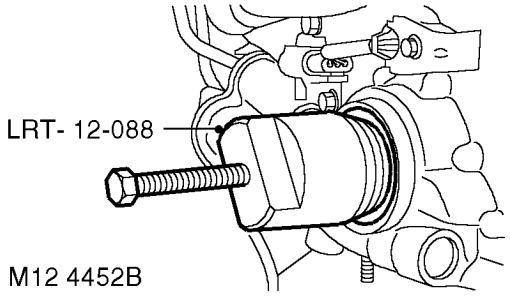
Seal - timing gear cover

12.65.05.01

Disassembly



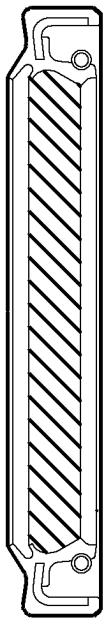
1. Secure tool **LRT-12-080** to crankshaft pulley with 2 bolts.
2. Remove crankshaft pulley bolt.
3. Remove crankshaft pulley.



4. Using tool **LRT-12-088,** remove oil seal from timing gear cover and discard.

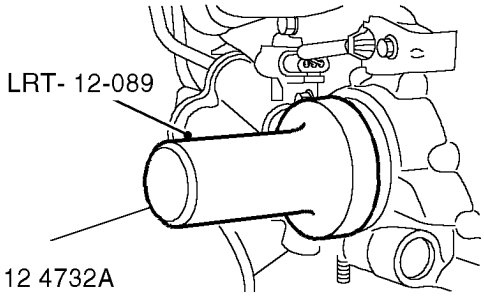
Reassembly

1. Clean seal register in timing gear cover and crankshaft pulley.



M12 7485

2. Apply Retinax LX grease to inner recess of new oil seal until recess is half filled with grease.**Do not allow grease to coat any other part of seal. Do not apply oil to seal.**
3. Apply smear of Retinax LX grease to seal running surface on crankshaft.



M12 4732A

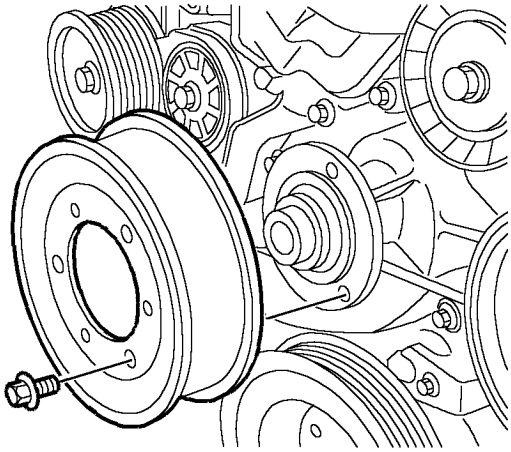
4. Fit seal to timing gear cover using tool **LRT-12-089** .
5. Secure tool **LRT-12-080** to crankshaft pulley with 2 bolts. Fit crankshaft pulley.
6. Fit crankshaft pulley bolt and tighten to 270 Nm (200 lbf.ft).
7. Remove tool **LRT-12-080** from crankshaft pulley.

Gasket - timing gear cover

12.65.04.01

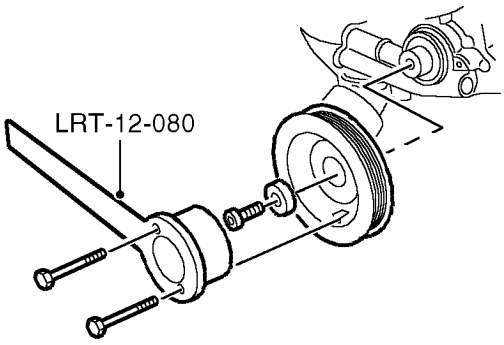
Disassembly

1. Remove oil pick up strainer.
   ENGINE - V8, OVERHAUL, Strainer - oil pick-up.



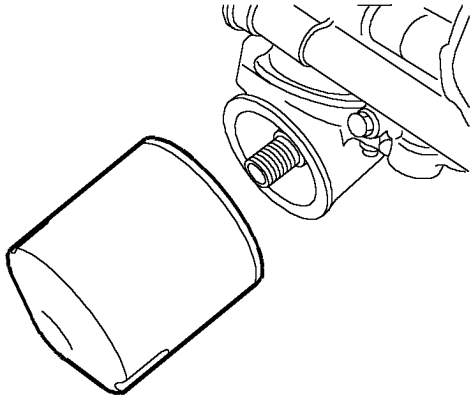
M12 4444

2. Remove and discard 3 bolts securing coolant pump pulley.
3. Remove coolant pump pulley.



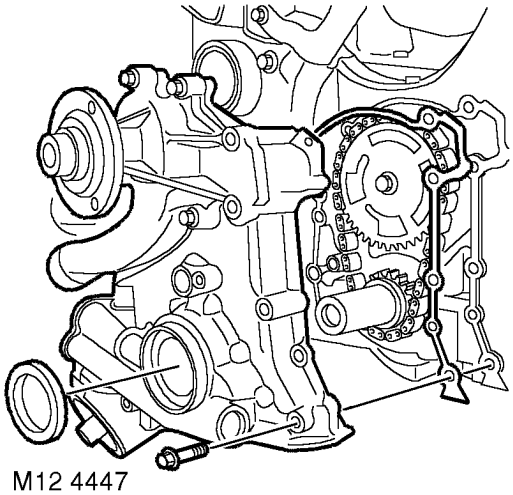
M12 4445A

4. Secure tool **LRT-12-080** to crankshaft pulley with 2 bolts.
5. Remove crankshaft pulley bolt.
6. Remove crankshaft pulley.



M12 4446

7. Remove oil filter and discard.

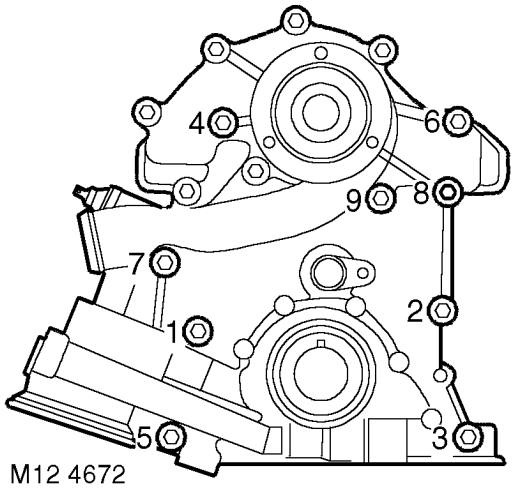


M12 4447

8. Noting the positions of the longer bolts, remove 9 bolts securing timing gear cover.
9. Remove timing gear cover.
10. Remove and discard timing gear cover gasket.
11. Remove seal from timing gear cover and discard.

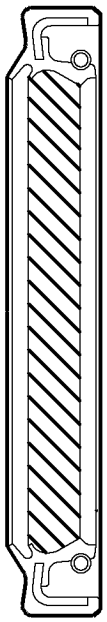
Reassembly

1. Clean timing gear cover and mating face.
2. Clean oil seal register in timing gear cover.
3. Fit a new timing gear cover gasket, dry, align oil pump drive gear to key in crankshaft and fit timing gear cover.



M12 4672

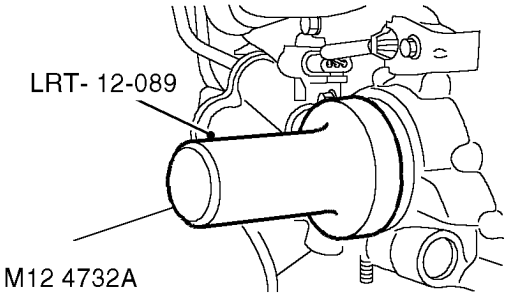
4. Align 2 camshaft sensor harness clips to timing gear cover bolt holes. Noting positions of the longer bolts and, working in the sequence shown, tighten timing gear cover bolts to 22 Nm (16 lbf.ft).



M12 7485

5. Apply Retinax LX grease to inner recess of oil seal until recess is half filled with grease. **CAUTION: Do not allow grease to coat any other part of seal. Do not apply oil to seal.**

6. Apply smear of Retinax LX grease to oil seal running surface on crankshaft.



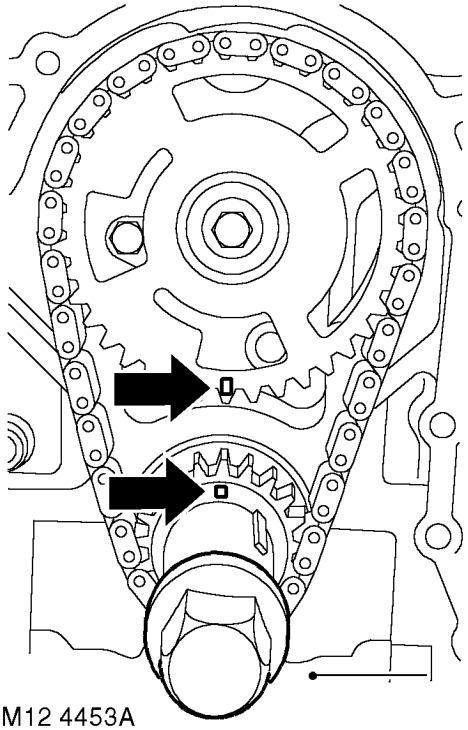
7. Fit seal to timing gear cover using tool **LRT-12-089.**
8. Clean and fit crankshaft pulley.
9. Fit crankshaft pulley bolt and tighten to 270 Nm (200 lbf.ft).
10. Remove tool **LRT-12-080** from crankshaft pulley.
11. Clean oil filter mating face.
12. Lubricate new oil filter seal with clean engine oil and fit filter.
13. Ensure coolant pump and pulley mating faces are clean.
14. Remove all traces of thread locking material from coolant pump pulley drive flange bolt holes using an M8 tap.
15. Fit coolant pump pulley and tighten new Patchlok bolts to 22 Nm (16 lbf.ft).
16. Fit oil pick up strainer.
    ☞ **ENGINE - V8, OVERHAUL, Strainer - oil pick-up.**

Timing chain and gears

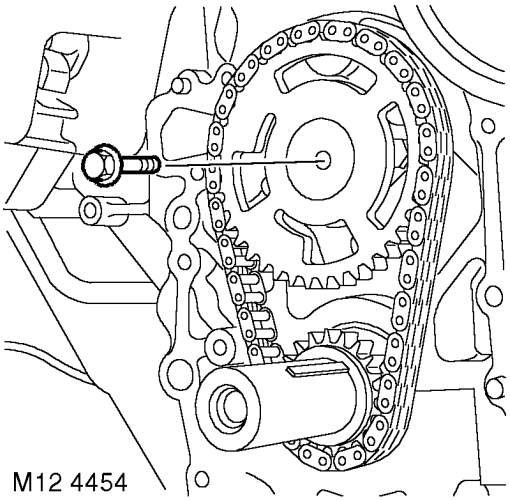
12.65.12.01

Disassembly

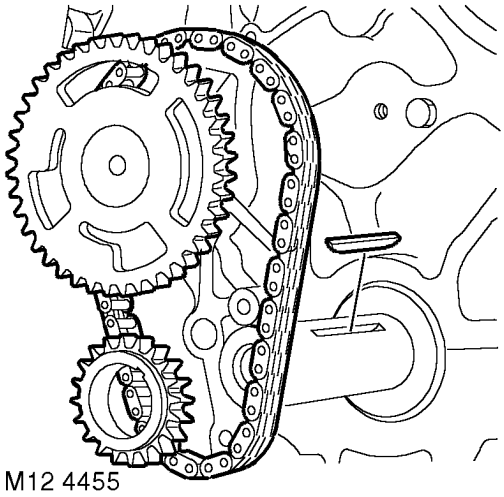
1. Remove timing gear cover gasket.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - timing gear cover.**



2. Fit crankshaft pulley bolt and rotate engine to align timing marks. Remove crankshaft pulley bolt.


M12 4454

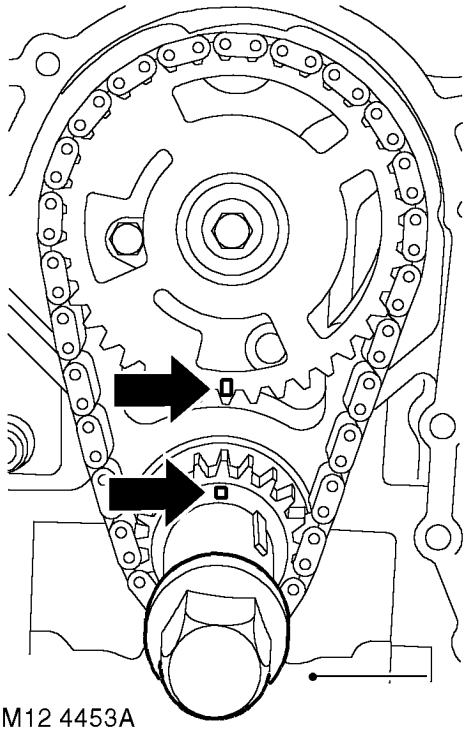
3. Restrain camshaft gear and remove gear retaining bolt.
4. Remove timing chain and gears as an assembly.


M12 4455

5. Remove gears from timing chain.
6. Remove key from crankshaft.

Reassembly

1. Clean timing chain and gears and gear locations.
2. Fit key to crankshaft.


M12 4453A

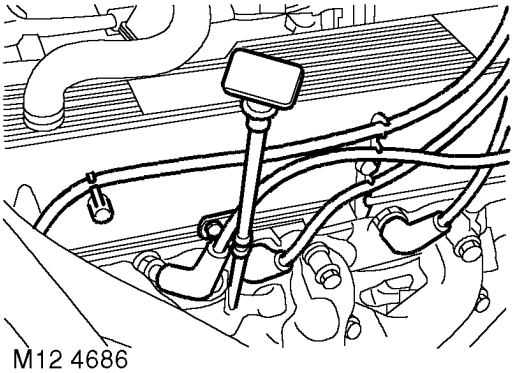
3. Temporarily fit gears to camshaft and crankshaft. If necessary, rotate shafts to align timing marks. When aligned correctly, the timing marks will face each other; crankshaft gear timing mark at twelve o'clock position and camshaft gear timing mark at six o'clock position.
4. Remove gears from shafts and fit to timing chain.
5. With timing marks aligned, fit timing chain and gears as an assembly.
6. Restrain the camshaft gear and tighten retaining bolt to 50 Nm (37 lbf.ft).
7. Fit timing gear cover gasket.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - timing gear cover.**

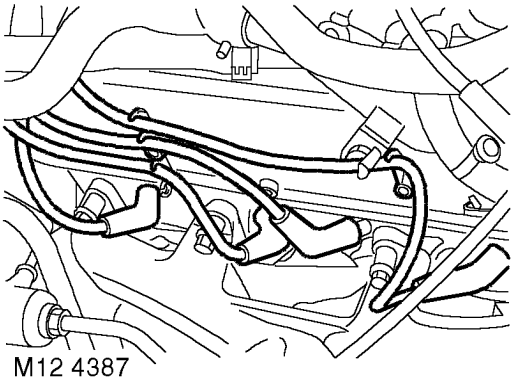
Rocker shaft - overhaul

12.29.49

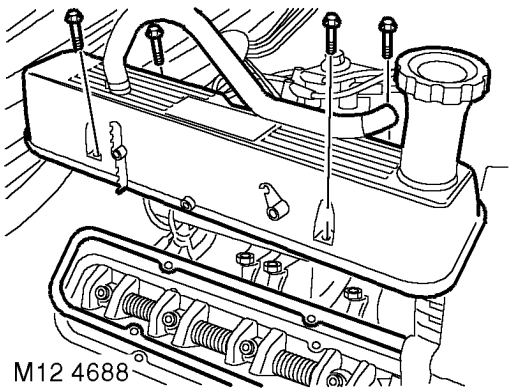
If both rocker shafts are to be removed, identify each assembly to ensure refitment to original cylinder head.

Disassembly

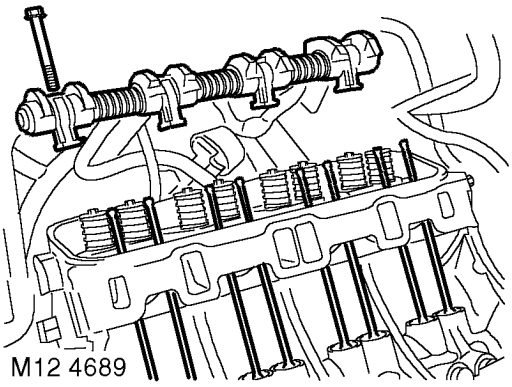

M12 4686


M12 4387

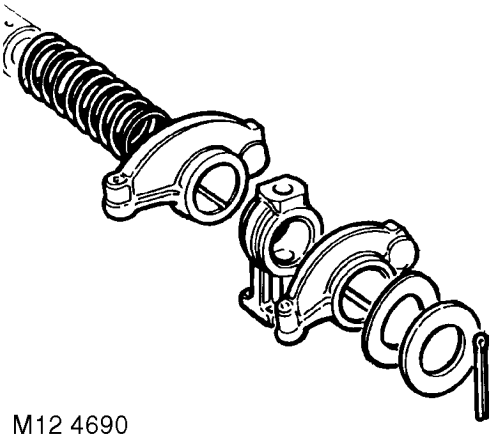
1. Release ht leads from rocker covers.


M12 4688

2. Remove 4 bolts securing rocker cover and remove cover.
3. Remove and discard rocker cover gaskets.


M12 4689

4. Progressively remove 4 bolts securing rocker shaft assembly to cylinder head, release rocker shaft from push rods and remove rocker shaft.
5. Ensure push rods remain located in tappets when rocker shaft is removed. **Retain all components in their removed sequence for re-assembly.**


M12 4690

6. Remove and discard split pin from one end of rocker shaft.
7. Collect plain and wave washers.
8. Remove the rocker arms, rocker pillars and springs.
9. Remove and discard remaining split pin and collect plain and wave washers.

Inspect

1. Clean all components.
2. Inspect rocker shaft and rocker arms for wear and scoring. Replace as required.
3. Replace weak or broken springs.
4. Lubricate moving parts with clean engine oil.

Reassembly

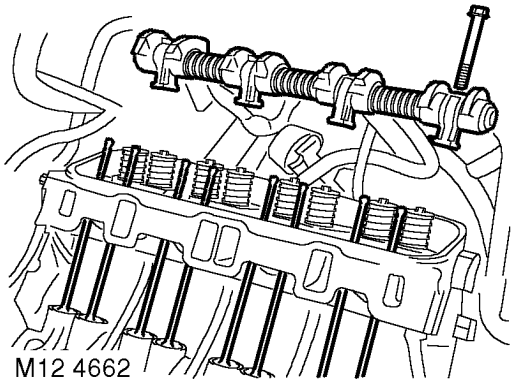
1. Reassemble rocker shafts, ensuring that components are returned to their original positions, secure plain washers with new split pins.
2. Ensure shaft identification groove is positioned at one o'clock, with push rod locations of rocker arms to the right. **Oil feed restriction will result if rocker shafts are incorrectly assembled.**
3. Position rocker shaft assembly to cylinder head ensuring push rods are engaged in rocker arms.
4. Fit rocker shaft bolts and progressively tighten to 40 Nm (30 lbf.ft).
5. Clean mating faces of rocker covers and cylinder heads.
6. Fit new rocker cover gaskets, dry, position rocker cover, fit bolts and working in diagonal sequence, tighten to:
   - Stage 1 - 3 Nm (2.5 lbf.ft)
   - Stage 2 - 8 Nm (6 lbf.ft)
7. Ensure that gasket is correctly positioned around periphery of rocker cover.
8. Secure ht leads to rocker cover.

Gasket - cylinder head

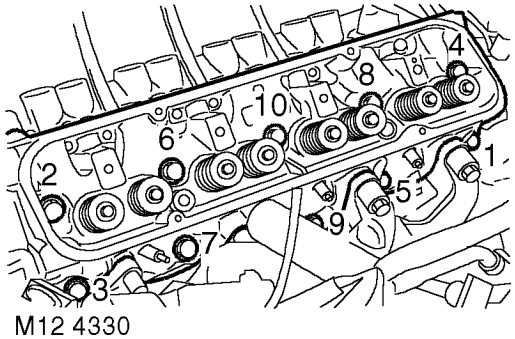
12.29.02.01

Disassembly

1. Remove inlet manifold gasket.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - inlet manifold.**
2. **RH cylinder head:** Remove auxiliary drive belt tensioner.
3. **RH cylinder head:** Remove bolts securing alternator mounting bracket and remove bracket.
4. Noting their fitted order, disconnect ht leads from spark plugs.

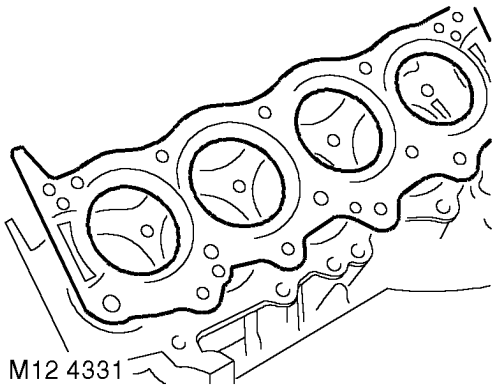

M12 4662

5. Progressively remove 4 bolts securing the rocker shaft and remove rocker shaft.
6. Remove push rods and store in their fitted order.



M12 4330

7. Working in the sequence shown remove 10 bolts securing the cylinder head to block. Discard the bolts.
8. Remove cylinder head.

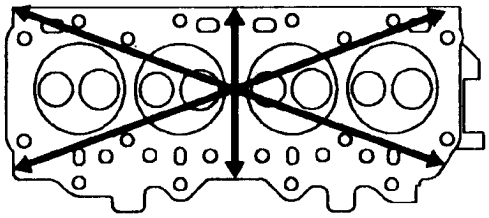


M12 4331

9. Remove cylinder head gasket.
   CAUTION: Support both ends of cylinder head on blocks of wood.

Inspect

1. Clean mating faces of cylinder block and head using suitable gasket removal spray and a plastic scraper, ensure that bolt holes in block are clean and dry.
   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.



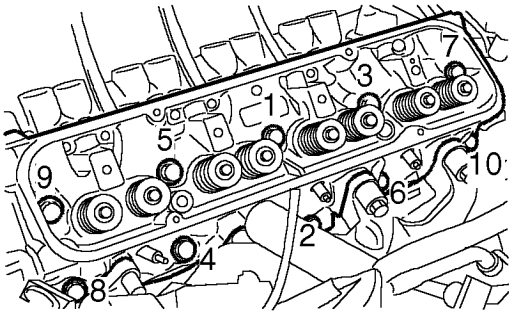
M12 4709

2. Check head and block faces for warping and pitting.
   - Maximum cylinder head warp = 0.05 mm (0.002 in).

   Note: Cylinder head can be refaced to 0.50 mm (0.02 in) maximum below head height – See cylinder head overhaul.

Reassembly

1. Fit cylinder head gasket with the word TOP uppermost.
   CAUTION: Gaskets must be fitted dry.
2. Carefully fit cylinder head and locate on dowels.
3. Lightly lubricate new cylinder head bolt threads with clean engine oil.



M12 4332

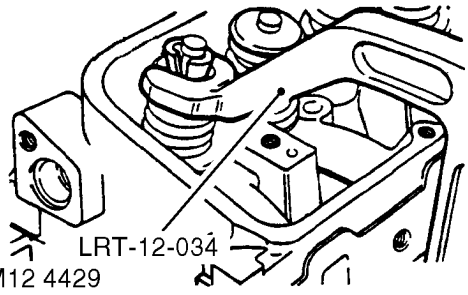
4. Noting that bolts 1, 3 and 5 are longer than the remainder, fit bolts and tighten in the sequence shown to 20 Nm (15 lbf.ft) then turn through 90 °, then a further 90 °. **CAUTION: Do not tighten bolts 180° in one operation.**
5. Clean the push rods, Lubricate ends of push rods with clean engine oil, and fit in their removed order.
6. Clean bases of rocker pillars and mating faces on cylinder head.
7. Clean contact surfaces on rockers, valves and push rods.
8. Lubricate contact surfaces and rocker shaft with clean engine oil.
9. Fit rocker shaft assembly and engage push rods.
10. Fit rocker shaft bolts and progressively tighten to 40 Nm (30 lbf.ft).
11. Connect ht leads to spark plugs in their correct fitted order.
12. **RH cylinder head:** Position alternator mounting bracket, fit bolts and tighten to 40 Nm (30 lbf.ft).
13. **RH cylinder head:** Fit auxiliary drive belt tensioner.
14. Fit inlet manifold gasket.
    ☞ **ENGINE - V8, OVERHAUL, Gasket - inlet manifold.**

Cylinder head - overhaul

12.29.19.01

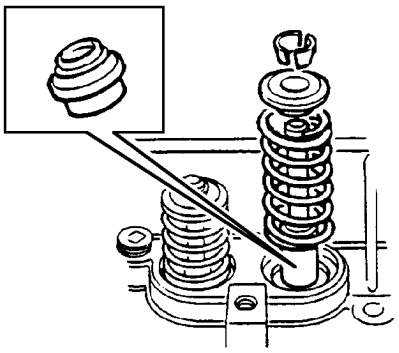
Disassembly

1. Remove cylinder head gasket.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - cylinder head.**
2. Loosen screw on tool **LRT-12-034**.



M12 4429

3. Fit tool **LRT-12-034** to valve and tighten screw to compress valve spring sufficiently to release collets from valve spring cap.

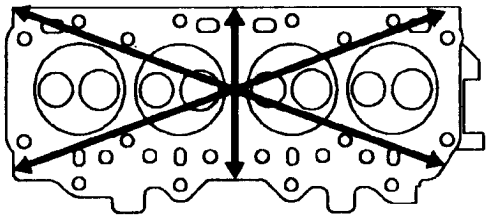

M12 4430

4. Remove 2 collets and release valve spring compressor.
5. Remove valve spring cap and valve spring.
6. Remove valve from cylinder head.
7. Remove and discard valve stem oil seal.
8. Repeat above operations for remaining valves.
9. Keep valves, springs, caps and collets in their fitted order.

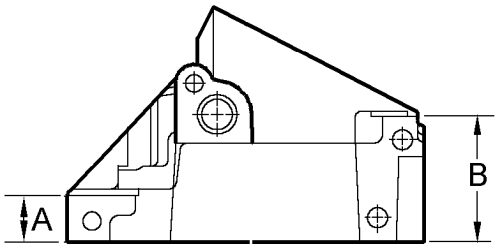
Inspect

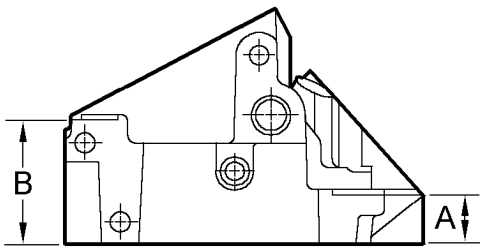
1. Clean mating faces of cylinder block and head using suitable gasket removal spray and a plastic scraper, ensure that bolt holes in block are clean and dry.
   CAUTION: Do not use a metal scraper or machined surfaces may be damaged.

2. Clean cylinder head, valve springs, valves and inlet valve guide bores. Ensure all loose particles of carbon are removed on completion.


M12 4709

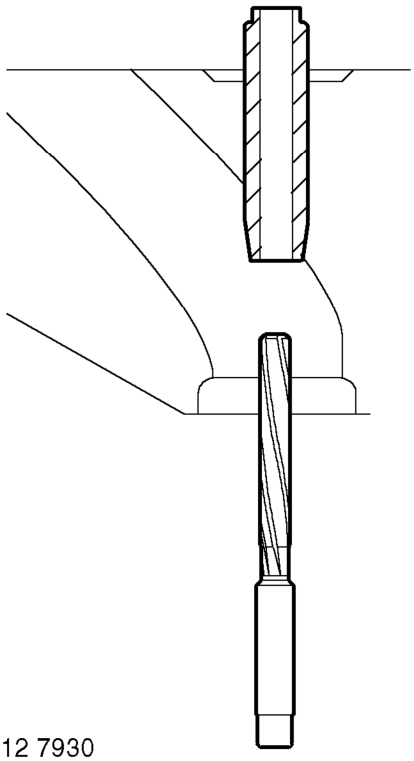
3. Check head and block faces for warping and pitting. Maximum warp = 0.05 mm (0.002 in).





M12 4671

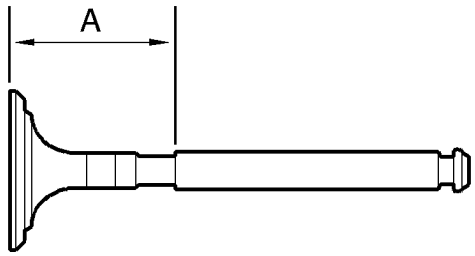
4. Check cylinder head height at each end of head. Renew a head which is outside limits.
   a 22.94 mm (0.903 in) - New
   b 62.56 mm (2.463 in) - New
5. Cylinder head can be refaced to 0.50 mm (0.02 in) max. below head height.



M12 7930

6. Remove carbon deposits from exhaust valve guide using a 8.70 mm (0.34 in) diameter reamer inserted from combustion face side of cylinder head.

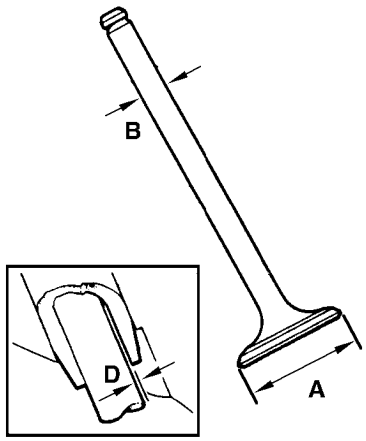
NOTE: Modified inlet valves, exhaust valves and valve guides were fitted to 4.0 litre engines from the following engine numbers: 55D 05678A; 56D 50788A and 97D 05505A and are fitted to all 4.6 litre engines.

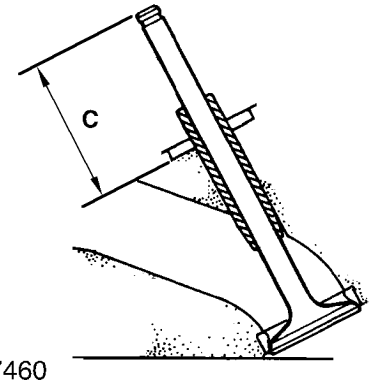


M12 7488

7. Modified inlet valves may be identified by measuring the distance 'A' from the valve head face to the top of the undercut on the valve stem:
   - Early valves = 29.5 to 30.5 mm (1.16 to 1.20 in)
   - Later valves = 32.5 to 33.5 mm (1.28 to 1.32 in)
8. Modified exhaust valves may be identified as follows:
   - Early valves 'A' – Chrome finish
   - Later valves 'B' – Black nitrided finish
9. Modified valve guides are 5 mm (0.211 in) shorter than the early type, the overall length is now 57 mm (2.24 in); the reduction in length being the distance the guide protrudes into the combustion chamber side of the cylinder head.

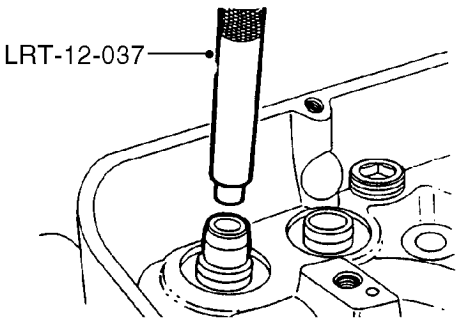
   NOTE: The modified valves and guides may be fitted to 4.0 litre engines prior to the above numbers in cylinder sets. Early type valves will continue to be supplied for early 4.0 litre engines but if valve guides are found to be worn, the later valves and guides must be fitted.





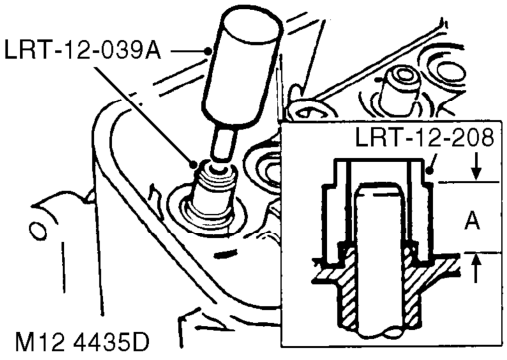
M12 7460

10. Check the following valve dimensions. Renew valves as necessary.
    - Valve head diameter 'A': Inlet = 39.75 to 40.00 mm (1.56 to 1.57 in).
    - Valve head diameter 'A': Exhaust = 34.23 to 34.48 mm (1.35 to 1.36 in).
    - Valve stem diameter 'B': Inlet = 8.664 to 8.679 mm (0.341 to 0.342 in).
    - Valve stem diameter 'B': Exhaust – 4.0 litre engines up to engine nos. 55D 05677A; 56D 50787A and 97D 05504A = 8.651 to 8.666 mm (0.340 to 0.341 in).
    - Valve stem diameter 'B': Exhaust – 4.0 litre engines from engine nos. 55D 05678A; 56D 50788A and 97D 05505A and all 4.6 litre engines = 8.641 to 8.656 mm (0.340 to 0.341 in)
11. Check installed height of valve.
    - Valve installed height, end of valve to base of spring seat, 'C' = 44.163 to 45.288 mm (1.741 to 1.802 in).
12. Check condition of valve springs. **Valve springs must be replaced as a complete set.**
    - Valve spring free length = 48.30 mm (1.90 in).
    - Valve spring fitted length = 40.40 mm (1.59 in).
    - Spring load - valve closed = 339 ± 10 N (76 ± 2.25 lbf).
    - Spring load - valve open = 736 ± 10 N (166 ± 2.25 lbf).
13. Check valve stem to guide clearance using the following procedures:
14. Insert each valve into its respective guide.
15. Extend valve head approximately 13 mm (0.6 in) out of valve seat and position a DTI gauge to rear of valve head.
16. Move valve towards front of cylinder head and zero DTI gauge ensuring that stylus of gauge remains in contact with valve head.
17. Move valve towards rear of cylinder head and record gauge reading to give valve stem to guide clearance.
    - Valve stem to guide clearance 'D': Inlet = 0.025 to 0.066 mm (0.001 to 0.002 in).
    - Valve stem to guide clearance 'D': Exhaust – 4.0 litre engines up to engine nos. 55D 05677A; 56D 50787A; 97D 05504A = 0.038 to 0.078 mm (0.0015 to 0.003 in).
    - Valve stem to guide clearance 'D': Exhaust – 4.0 litre engines from engine nos. 55D 05678A; 56D 50788A; 97D 05505A and all 4.6 litre engines = 0.048 to 0.088 mm (0.0019 to 0.0035 in).
18. Renew valve guides as necessary.



M12 4434

19. Using valve guide remover tool **LRT-12-037** press valve guide into combustion face side of cylinder head.



20. Lubricate new valve guide with engine oil and with tapered portion of guide leading, insert guide from valve spring side of head.

Note: Service valve guides are 0.025 mm (0.001 in) oversize on outside diameter to ensure an interference fit.

21. Fully fit guide using tool **LRT-12-039A** and distance piece tool **LRT-12-208**

- Valve guide installed height 'A' = 15.00 mm (0.590 in).

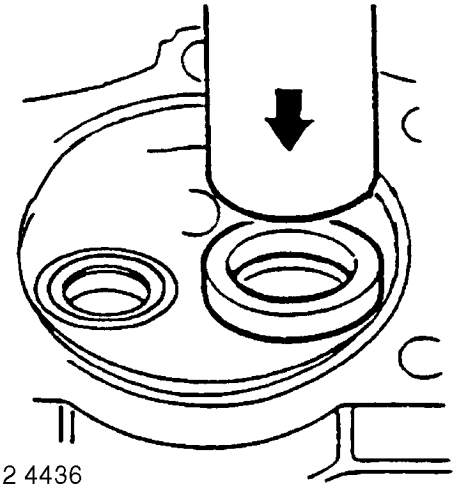
22. Ream valve guide to 8.70 mm (0.342 in).

23. Position cylinder head stands and mount cylinder head on stands.

24. Check valve seat insert for pitting, burning, cracks and wear. Replace as necessary. Service valve seat inserts are available 0.025 mm (0.001 in) oversize on outside diameter to ensure interference fit.

25. Remove worn valve seat.

CAUTION: Take care not to damage the counterbore in the cylinder head when removing valve seats.


M12 4436

26. Heat cylinder head evenly to approximately 120° C (250°F).

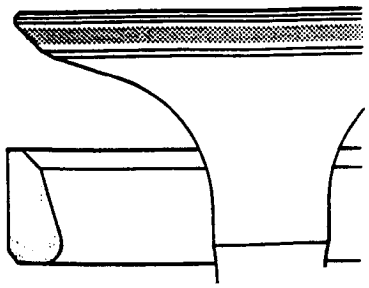
WARNING: Handle the hot cylinder head with care.

27. Using a suitable mandrel, press new insert fully into counterbore.

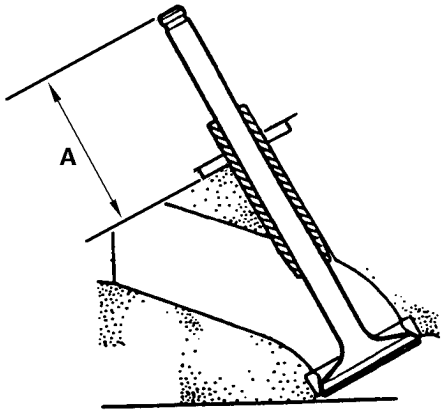
28. Allow cylinder head to air cool.

CAUTION: Renew worn valve guides and/or valve seats before lapping the valves.

29. Recut valve seat in head and lap in valves using fine paste.

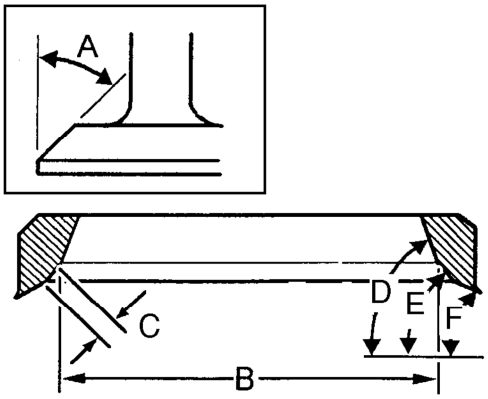

M12 4437

30. Coat valve with a small quantity of engineer's blue, insert valve and press into position several times without rotating. Seating position should be in centre of valve face.



M12 7461

31. Check valve installed height if valve seats have been refaced or renewed.
- Valve installed height, end of valve to base of spring seat, 'A' = 44.16 to 45.29 mm (1.74 to 1.80 in).



32. Reface valves as necessary. If a valve has to be ground to a knife-edge to obtain a true seat, renew valve.

33. Cut valve seats using suitable cutters:
- Valve seat angle 'A' = 45°.
- Valve seat insert diameter 'B' Inlet = 36.83 mm (1.45 in).
- Valve seat insert diameter 'B' Exhaust = 31.50 mm (1.24 in).
- Seating width 'C' - Inlet = 0.89 to 1.4 mm (0.035 to 0.055 in).
- Seating width 'C' - Exhaust = 1.32 to 1.83 mm (0.052 to 0.072 in).
- Angle 'D' = 70° .
- Angle 'E' = 46° to 46° 25'.
- Angle 'F' = 20° .

34. Check that cutter blades are adjusted so that middle of blade contacts area of material to be cut. Use light pressure and only remove the minimum of material necessary.

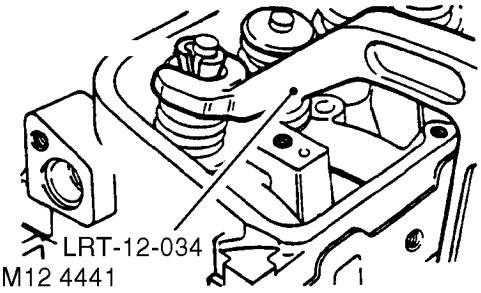
35. Clean valve seat and valve.

Reassembly

1. Clean spring caps, collets and valve springs.

2. Lubricate new valve stem oil seal with clean engine oil and fit seal.

3. Lubricate valve with clean engine oil and fit valve.



M12 4441

4. Fit spring and cap, compress spring using tool **LRT-12-034** and fit collets.

5. Release valve spring and remove tool **LRT-12-034**.

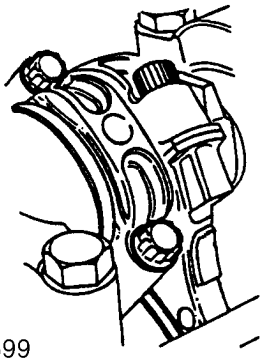
6. Fit cylinder head gasket.
☞ **ENGINE - V8, OVERHAUL, Gasket - cylinder head.**

Piston assemblies

12.17.02.01

Disassembly

1. Remove cylinder head.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - cylinder head.**
2. Remove oil pick-up strainer
   ☞ **ENGINE - V8, OVERHAUL, Strainer - oil pick-up.**

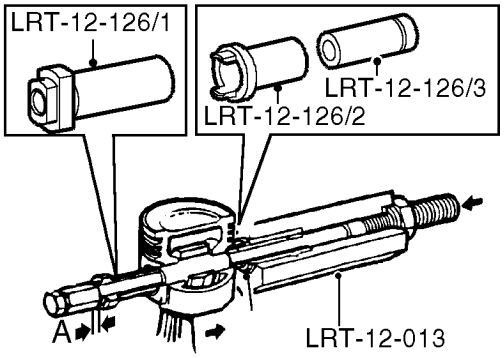


M12 4399

3. Suitably identify each connecting rod and piston assembly to its respective cylinder bore.
4. Remove 2 bolts securing each connecting rod bearing cap.
5. Remove connecting rod bearing cap and collect connecting rod bearings.
6. Remove ridge of carbon from top of cylinder bores.
7. Carefully push each piston assembly from the top of the cylinder.

   CAUTION: Ensure that connecting rods do not contact cylinder bores.

8. Refit bearing cap onto connecting rod, lightly tighten dowel bolts.
9. Suitably identify each piston to its respective connecting rod.

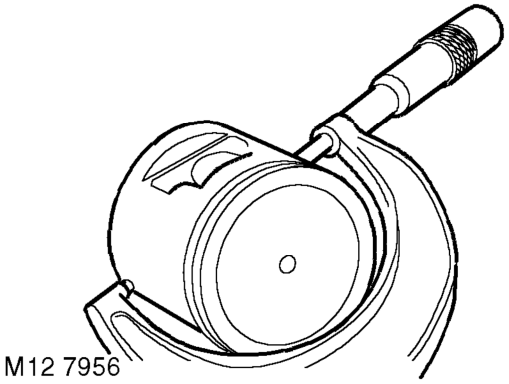


M12 4400A

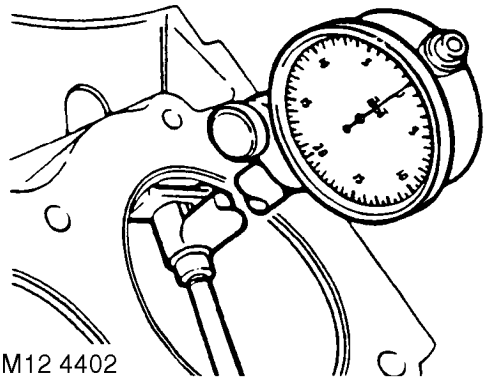
10. Position body of tool **LRT-12-013** in vice.
11. Screw large nut back until flush with end of centre screw.
12. Push centre screw forward until nut contacts thrust race.
13. Fit piston adapter tool **LRT-12-126/2** .
14. Position guide pin tool **LRT-12-126/3** in **LRT-12-126/2** with groove facing away from piston.
15. Locate piston and connecting rod assembly on centre screw and up to adapter tool **LRT-12-126/2**.
16. Fit remover/replacer bush tool **LRT-12-126/1** on centre screw with flanged end facing away from gudgeon pin.
17. Screw stop nut onto centre screw leaving clearance of 3 mm (0.125 in), dimension **'A'**, between nut and remover/replacer bush.
18. Lock the stop nut securely with lock screw.
19. Push connecting rod to locate end of gudgeon pin in adapter tool **LRT-12-126/2**.
20. Ensure remover/replacer is located in gudgeon pin bore of piston.
21. Screw large nut up to tool **LRT-12-013**.
22. Hold lock nut and turn large nut until gudgeon pin is withdrawn from piston.
23. Dismantle tool and remove piston, connecting rod and gudgeon pin.

Inspect

1. Clean carbon from piston. Inspect piston for distortion, cracks and burning.
2. Remove piston rings from piston.


M12 7956

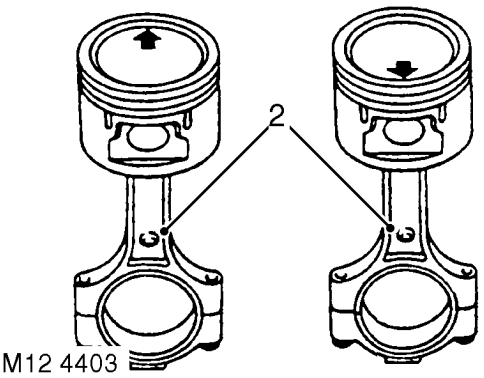
3. Measure and record piston diameter at 90° to gudgeon pin axis and 10 mm (0.4 in) from bottom of the skirt. The piston must be 0.02 to 0.045 mm (0.001 to 0.002 in) smaller than the cylinder bore.
4. Check gudgeon pin bore in piston for signs of wear and overheating.
5. Pistons fitted on production are graded 'A' or 'B', the grade letter is stamped on the piston crown.
   - Piston diameter: Grade 'A' = 93.970 to 93.985 mm (3.6996 to 3.7002 in).
   - Piston diameter: Grade 'B' = 93.986 to 94.00 mm (3.7002 to 3.7007 in).
6. Worn cylinders fitted with grade 'A' pistons may be honed to accept the grade 'B' piston provided that specified cylinder bore and ovality limits are maintained. **Grade 'B' pistons are supplied as service replacements. Do not attempt to de-glaze cylinder bores.**
7. Check gudgeon pins for signs of wear and overheating.
8. Check clearance of gudgeon pin in piston.
   - Gudgeon pin to piston clearance = 0.006 to 0.015 mm (0.0002 to 0.0006 in).
9. Check overall dimensions of gudgeon pin. Gudgeon pins are only supplied as an assembly with replacement pistons.
   - Gudgeon pin length = 60.00 to 60.50 mm (2.362 to 2.382 in).
   - Gudgeon pin diameter = 23.995 to 24.00 mm (0.9446 to 0.9448 in)


M12 4402

10. Measure cylinder bore wear and ovality in two axis 40 to 50 mm (1.6 to 2 in) from top of bore. **The temperature of piston and cylinder block must be the same to ensure accurate measurement. Do not attempt to de-glaze cylinder bores.**
    - Grade 'A' pistons: Cylinder bore = 94.00 to 94.015 mm (3.7007 to 3.7013 in).
    - Grade 'B' pistons: Cylinder bore = 94.016 to 94.030 mm (3.7014 to 3.7019 in).
    - Maximum ovality = 0.013 mm (0.0005 in).
11. Check alignment of connecting rods.

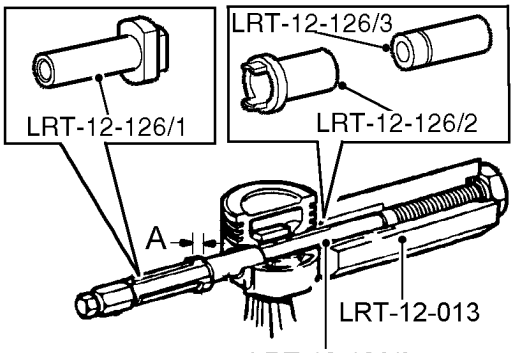
Reassembly

1. Pistons have a 5 mm (0.2 in) offset gudgeon pin which can be identified by an arrow mark on the piston crown. This arrow must always point towards the front of the engine.



M12 4403

2. Assemble pistons to connecting rods with arrow on piston pointing towards domed shaped boss on connecting rod for RH bank of cylinders and arrow pointing away from domed shaped boss for LH bank of cylinders.

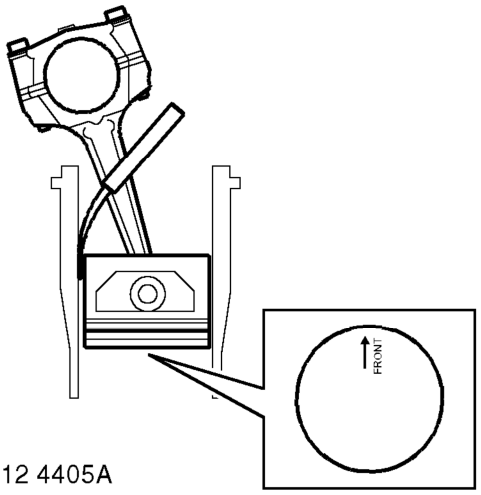


M12 4404A

3. Clamp hexagon body of tool **LRT-12-013** in vice.
4. Loosen large nut and pull the centre screw 50 mm (2 in) out of hexagon body.
5. Fit piston adapter tool **LRT-12-126/2** .
6. Position guide pin tool **LRT-12-126/3** in **LRT-12-162/2** with groove towards piston, up to shoulder on centre screw.
7. Lubricate gudgeon pin and bores of connecting rod and piston with graphite oil.
8. Locate connecting rod and piston to centre screw with connecting rod entered on sleeve up to groove.
9. Fit gudgeon pin on to centre screw and into piston bore up to connecting rod.
10. Fit remover/replacer tool **LRT-12-126/1** with flanged end towards gudgeon pin.
11. Screw the stop nut on to centre screw and position piston against groove of tool **LRT-12-126/3.**
12. Lubricate centre screw threads and thrust race with graphite oil, screw large nut up to tool **LRT-12-013.**
13. Lock the stop nut securely with lock screw.
14. Set torque wrench to 16 Nm (12 lbf.ft) and using socket on large nut, pull gudgeon pin in until flange of tool **LRT-12-126/1** is 0.40 mm (0.016 in), **dimension 'A'** from face of piston. If torque is exceeded during this procedure, fit of gudgeon pin to connecting rod is not acceptable and components must be replaced.

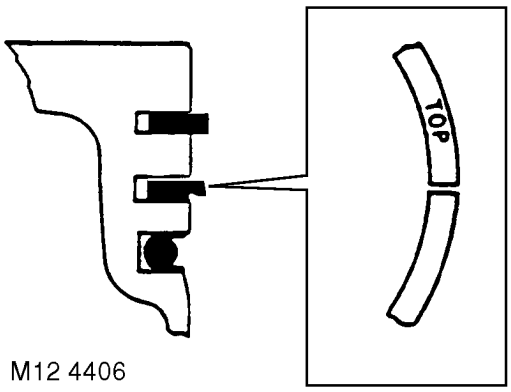
    CAUTION: The centre screw and thrust race must be kept well lubricated throughout the operation.

15. Dismantle tool, remove piston and check no damage has occurred during pressing and that piston moves freely on gudgeon pin.
16. Remove compression rings, oil control rails and expander from new piston.
17. Invert piston and with arrow pointing towards rear of cylinder block, insert piston into cylinder liner.



M12 4405A

18. Position piston with bottom of skirt 30 mm (1.12 in) from top cylinder liner.
19. Using feeler gauges, measure and record clearance between piston and left hand side of cylinder- viewed from the front of cylinder block.
    - Piston to bore clearance = 0.020 to 0.045 mm (0.001 to 0.002 in).
20. Insert piston rings into cylinder bore, use the piston to hold the rings square to bore and check the ring gap.
    - 1st compression ring = 0.30 to 0.50 mm (0.012 to 0.02 in).
    - 2nd compression ring = 0.40 to 0.65 mm (0.016 to 0.026 in).
    - Oil control ring rails = 0.38 to 1.40 mm (0.015 to 0.055 in).
21. Remove piston rings from bore.

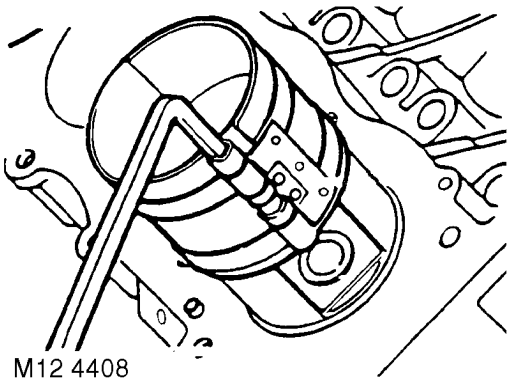


M12 4406

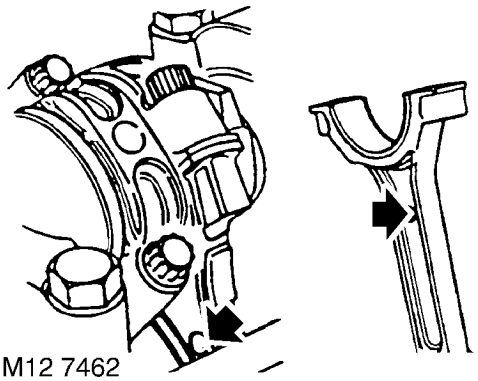
22. Fit oil control ring rails and expander, ensuring ends butt and do not overlap.

23. Fit 2nd compression ring marked 'TOP' with marking uppermost in 2nd groove.
24. Fit 1st compression ring in first groove either way round.
25. Check piston ring to groove clearance.
- 1st compression ring = 0.05 to 0.10 mm (0.002 to 0.004 in).
- 2nd compression ring = 0.05 to 0.10 mm (0.002 to 0.004 in).

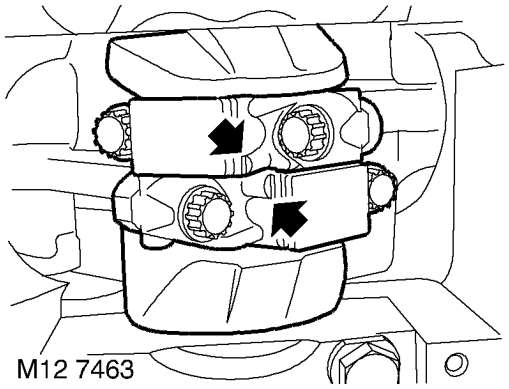
26. Position oil control expander ring joint and ring rail gaps all at one side, between gudgeon pin and away from LH side of piston - viewed from front of piston. Position the gaps in ring rails approximately 25 mm (1.0 in) each side of expander ring joint.
27. Position compression rings with gaps on opposite side of piston between gudgeon pin and RH side of piston - viewed from front of piston.
28. Thoroughly clean cylinder bores.
29. Lubricate piston rings and gudgeon pin with clean engine oil.
30. Lubricate cylinder bore with clean engine oil.


M12 4408

31. Using **LRT-12-204**, compress piston rings.


M12 7462

32. Insert connecting rod and piston into its respective cylinder bore, ensuring domed shaped boss on connecting rod faces towards front of engine on RH bank of cylinders and towards rear on LH bank of cylinders.
33. Clean connecting rod journal and bearing cap.
34. Lubricate connecting rod journal and connecting rod bearings.


M12 7463

35. Fit connecting rod bearings and connecting rod bearing caps ensuring they are in their correct fitted order.

NOTE: The rib on the edge of the bearing cap must face towards the front of the engine on the RH bank of cylinders and towards the rear on the LH bank.

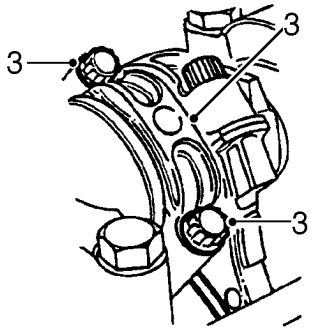
36. Fit bolts and tighten to 20 Nm (15 lbf.ft) then turn a further 80°.
37. Fit oil pick-up strainer.
☞ **ENGINE - V8, OVERHAUL, Strainer - oil pick-up.**
38. Fit cylinder head gasket.
☞ **ENGINE - V8, OVERHAUL, Gasket - cylinder head.**

Bearings - connecting rods

12.17.16.01

Disassembly

1. Remove oil pick up strainer.
   ENGINE - V8, OVERHAUL, Strainer - oil pick-up.



M12 4410

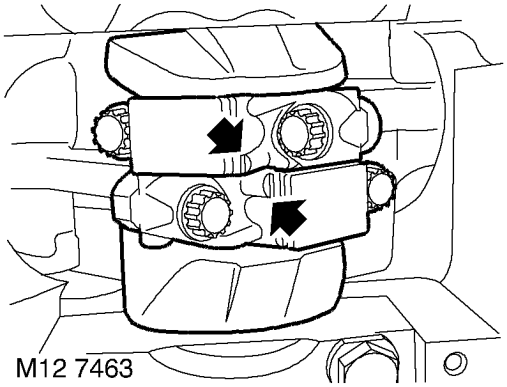
2. Suitably mark cylinder reference number on each connecting rod bearing cap.
3. Remove 2 bolts securing each connecting rod bearing cap, remove caps and recover connecting rod bearings.
   CAUTION: Keep bearing caps, bearings and bolts in their fitted order.
4. Push each connecting rod up cylinder bore until connecting rods are clear of crankshaft journals.
   CAUTION: Ensure that connecting rods do not contact cylinder bores.
5. Remove bearing shells from each connecting rod.

Inspect

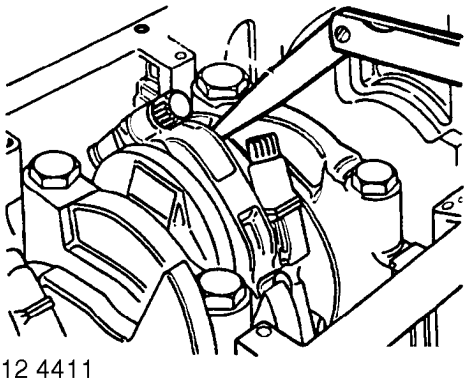
1. Clean crankshaft journals and bearing locations in connecting rods.
2. Inspect connecting rod bearings for wear and renew if necessary. Connecting rod bearings are available in two oversizes.
   - Connecting rod bearing 1st oversize = 0.254 mm (0.01 in).
   - Connecting rod bearing 2nd oversize = 0.508 mm (0.02 in).
3. Check crankshaft big-end journals for wear and scoring. Measure for ovality; taking 3 measurements at 120° intervals at each end and at centre of journals.
   - Standard journal = 55.500 to 55.513 mm (2.20 to 2.22 in).
   - 1st undersize journal - 0.254 mm (0.01 in) = 55.246 to 55.259 mm (2.17 to 2.18 in).
   - 2nd undersize journal - 0.508 mm (0.02 in) = 54.992 to 55.005 mm (2.16 to 2.165 in).
   - Journal - max. ovality = 0.040 mm (0.002 in)

Reassembly

1. Clean connecting rod caps.
2. Lubricate connecting rod journals and bearing shells with clean engine oil.
3. Fit bearing shells to connecting rods and caps.
4. Rotate crankshaft until connecting rod journals are correctly positioned.
5. Taking care not to displace bearing shells, pull connecting rods on to crankshaft journals.
6. Check that bearing shells are correctly located in connecting rod bearing caps.


M12 7463

7. Fit connecting rod bearing caps, ensuring that they are in their correct fitted order.
   NOTE: The rib on the edge of the bearing cap must face towards the front of engine on the RH bank of cylinders and towards the rear on the LH bank.
8. Lightly oil threads of connecting rod bolts. Fit connecting rod bolts and tighten to 20 Nm (15 lbf.ft) then turn a further 80°.



M12 4411

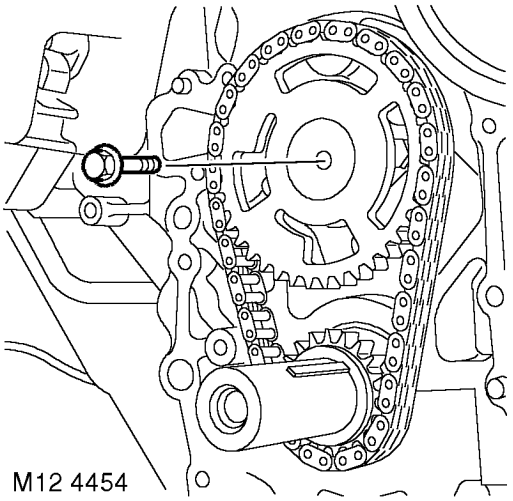
9. Check clearance between connecting rods on each crankshaft journal.
   - Connecting rod clearance = 0.15 to 0.36 mm (0.006 to 0.014 in).
10. Fit oil pick up strainer.
    ☞ **ENGINE - V8, OVERHAUL, Strainer - oil pick-up.**

Crankshaft and main bearings

🔧 ***12.21.33.01***

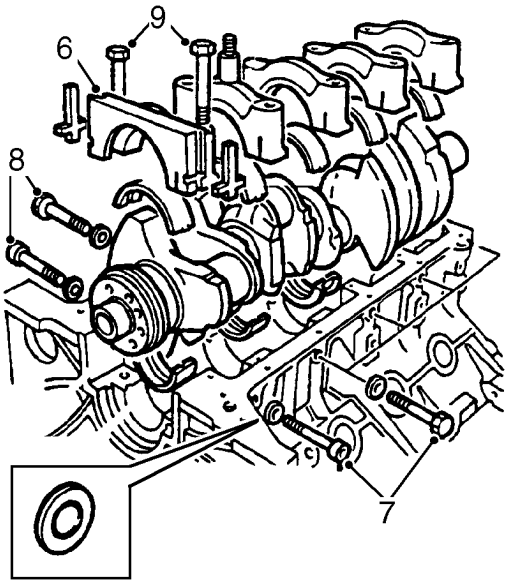
Disassembly

1. Remove crankshaft rear oil seal.
   ☞ **ENGINE - V8, OVERHAUL, Seal - crankshaft - rear - automatic models.**
2. Remove timing gear cover gasket.
   ☞ **ENGINE - V8, OVERHAUL, Gasket - timing gear cover.**

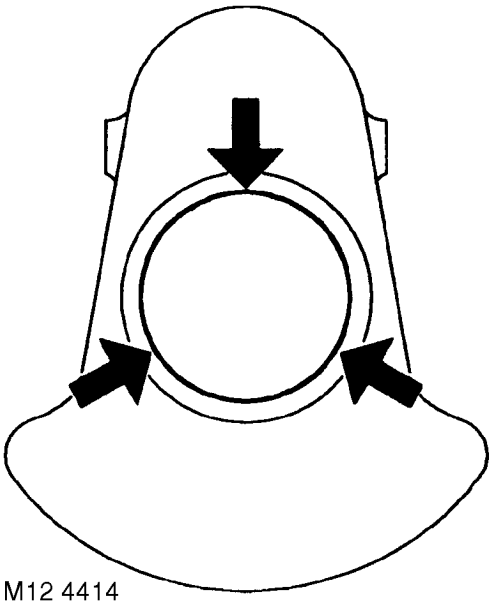


M12 4454

3. Remove bolt securing camshaft gear.
4. Remove timing chain and gears.
5. Remove connecting rod bearings.
   ☞ **ENGINE - V8, OVERHAUL, Bearings - connecting rods.**



M12 4413



M12 4414

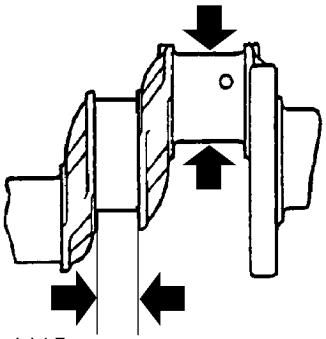
6. Reference mark main bearing caps to aid assembly.
7. Remove 10 side bolts securing main bearing caps to block.
8. Collect 'Dowty' washers from side bolts. **Rear side bolts have Allen heads.**
9. Starting at the centre main bearing cap, progressively loosen, then remove 2 bolts securing each main bearing cap.
10. Release and remove main bearing caps.

CAUTION: Keep bearing caps, bearings and bolts in their fitted order.

11. Remove crankshaft.
12. Remove main bearings from cylinder block and main bearing caps.
13. Remove key from keyway.
14. Remove rear main sealing washers.

Inspect

1. Clean crankshaft journals and bearing locations in cylinder block.
2. Inspect main bearings for wear and renew if necessary. Main bearings are available in two oversizes. **If 2nd oversize bearing is being fitted, it may be necessary to grind thrust face of centre main bearing to achieve correct end-float.**
   - Main bearing 1st oversize = 0.254 mm (0.01 in).
   - Main bearing 2nd oversize = 0.508 mm (0.02 in).

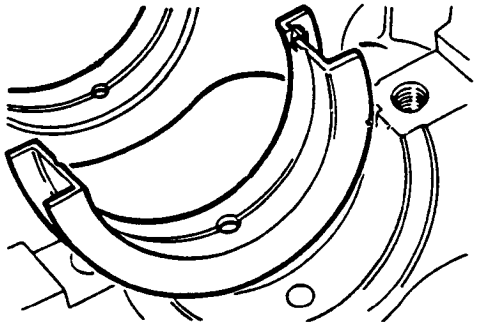


M12 4415

3. Check main bearing journals for wear and scoring. Measure for ovality; taking 3 measurements at 120° intervals at each end and at centre of journals.
   - Journal diameter - standard = 63.487 to 63.500 mm (2.499 to 2.520 in).
   - 1st undersize journal = 63.223 to 63.246 mm (2.511 to 2.512 in).
   - 2nd undersize journal = 62.979 to 62.992 mm (2.509 to 2.510 in).
   - Journal width - standard = 26.975 to 27.026 mm (1.061 to 1.064 in).
   - Maximum ovality = 0.040 mm (0.002 in)

Reassembly

1. Clean main bearing locations in cylinder block and bearing caps.
2. Clean sealant from rear main bearing cap and mating faces.
3. Fit key to keyway.
4. Check threads of main bearing cap bolts for damage, renew bolts in pairs.

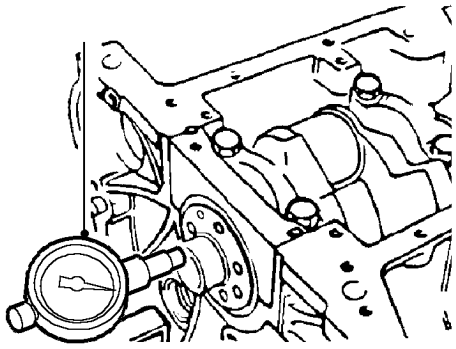


M12 4416

5. Lubricate grooved main bearing shells with clean engine oil and fit to their locations in cylinder block.

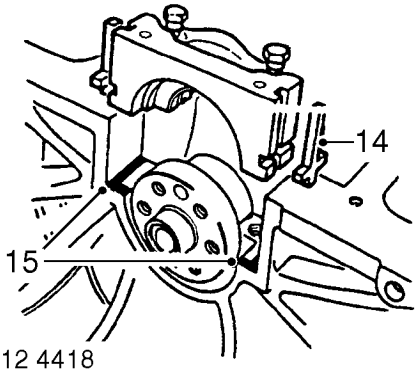
   NOTE: Ensure that the flanged bearing is fitted to the centre position.

6. Lubricate crankshaft journals with clean engine oil.
7. Position crankshaft in cylinder block.



M12 4417

8. Attach a DTI to front of cylinder block, move crankshaft rearwards, position stylus of gauge on end of crankshaft and zero gauge.
9. Move crankshaft forwards, measure and record end-float obtained.
   - Crankshaft end-float = 0.08 to 0.26 mm (0.003 to 0.01 in).
10. Lubricate plain bearing shells with clean engine oil and fit to main bearing caps.
11. Fit main bearing caps 1 to 4 only at this stage, ensuring that they are the correct way round and in their fitted order.
12. Lightly lubricate threads of main bearing cap bolts with clean engine oil.
13. Fit main bearing cap bolts but do not tighten at this stage. **Do not fit side bolts at this stage.**



M12 4418

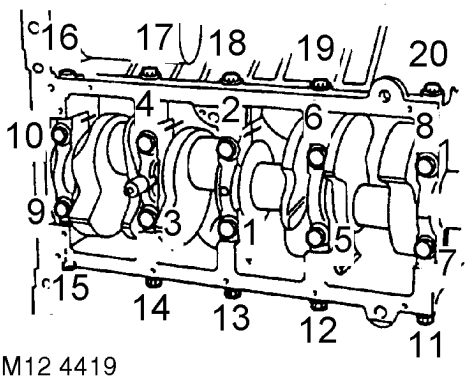
14. Fit side seals to rear main bearing cap, ensuring that seals do not protrude above bearing cap face.
15. Apply a 3 mm (0.12 in) wide bead of sealant, Part No. STC 50550 to bearing cap rear mating faces on cylinder block.

    CAUTION: Ensure sealant does not enter bolt holes.

16. Carefully fit rear main bearing cap assembly, fit but do not tighten bolts.

    CAUTION: Ensure engine oil does not enter the side bolt holes in the bearing cap.

17. Lubricate 'Dowty' washers with engine oil and fit to side bolts.
18. Fit but do not tighten side bolts. **Rear side bolts are Allen headed.**



M12 4419

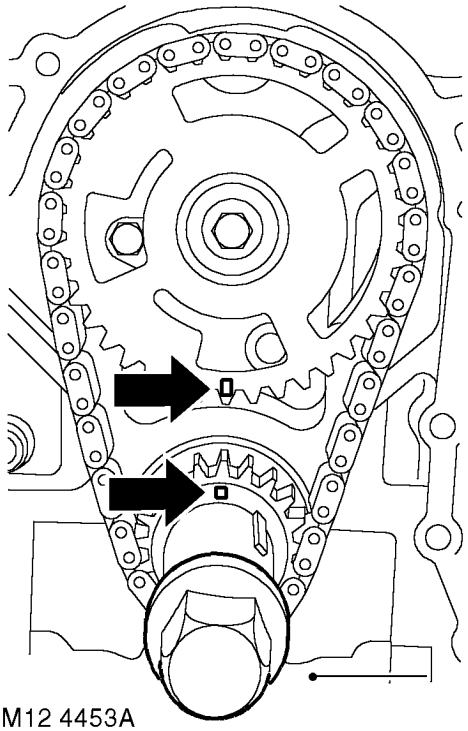
19. Using the sequence shown, tighten main bearing cap bolts as follows:
- Initial torque - all main bearing cap bolts and side bolts - 13.5 Nm (10 lbf.ft).
- Final torque - main bearing cap side bolts 11 to 15 - 45 Nm (34 lbf.ft).
- Final torque - main bearing cap bolts 1 to 8 - 72 Nm (54 lbf.ft).
- Final torque - main bearing cap bolts 9 and 10 - 92 Nm (68 lbf.ft).
- Final torque - main bearing cap side bolts 16 to 20 - 45 Nm (34 lbf.ft).

20. Fit connecting rod bearings.
☞ **ENGINE - V8, OVERHAUL, Bearings - connecting rods.**

21. Clean timing chain and gears.

22. Clean ends of crankshaft and camshaft.

23. Lubricate timing chain assembly with clean engine oil.


M12 4453A

24. Align timing marks and fit timing chain assembly.

25. Fit camshaft gear bolt and tighten to 50 Nm (37 lbf.ft).

26. Fit timing gear cover gasket.
☞ **ENGINE - V8, OVERHAUL, Gasket - timing gear cover.**

27. Clean crankshaft pulley.

28. Fit crankshaft pulley.

29. Fit crankshaft pulley bolt and tighten to 270 Nm (200 lbf.ft).

30. Remove tool **LRT-12-080** from crankshaft pulley.

31. Clean oil filter and mating face.

32. Lubricate oil filter seal and fit filter to oil pump.

33. Ensure coolant pump and pulley mating faces are clean.

34. Fit coolant pump pulley and tighten bolts to 22 Nm (16 lbf.ft).

35. Ensure drive belt pulleys are clean and damage free.

36. Fit auxiliary drive belt to pulleys.

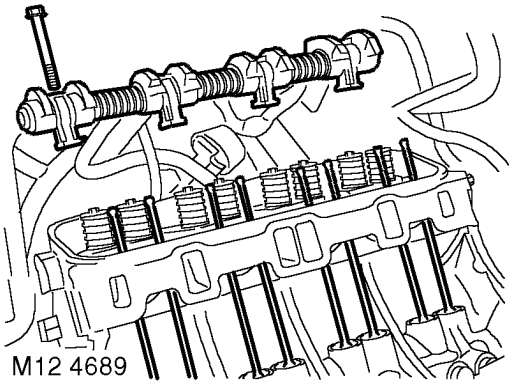
37. Fit crankshaft rear oil seal.
☞ **ENGINE - V8, OVERHAUL, Seal - crankshaft - rear - automatic models.**

Camshaft

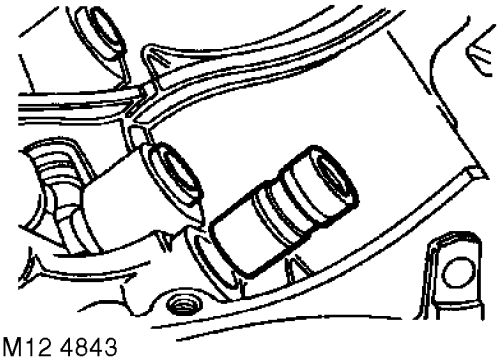
12.13.02.01

Disassembly

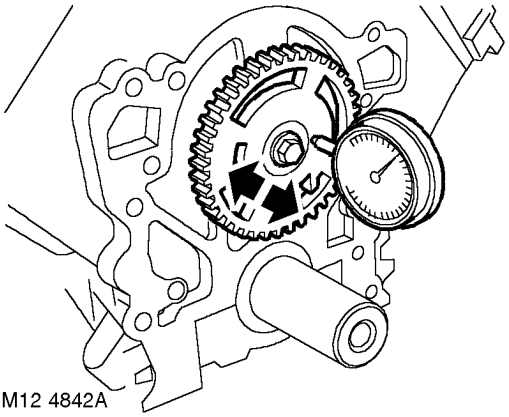
1. Remove inlet manifold gasket.
   ENGINE - V8, OVERHAUL, Gasket - inlet manifold.


M12 4689

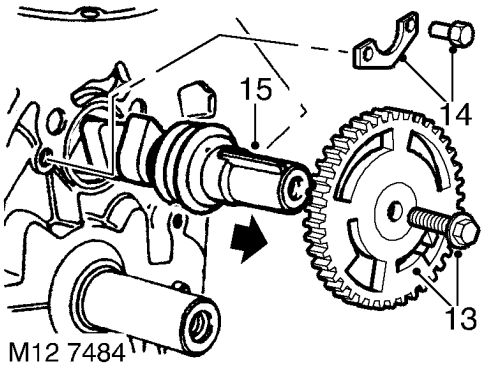
2. Progressively loosen and remove 8 bolts securing rocker shaft assemblies.
3. Mark each rocker shaft in relation to original head.
4. Remove rocker shaft assemblies.
5. Remove push rods and store in their fitted order.


M12 4843

6. Remove tappets.
7. Remove timing chain and gears.
   ENGINE - V8, OVERHAUL, Timing chain and gears.


M12 4842A

8. Temporarily fit camshaft gear and lightly tighten bolt.
9. Attach a dial test indicator (DTI) to front of cylinder block with stylus of DTI contacting camshaft gear.
10. Push camshaft rearwards and zero the DTI.
11. Using the camshaft gear, pull camshaft forwards and note reading on DTI. End-float should be from 0.075 to 0.25 mm (0.003 to 0.010 in).
12. If end-float is incorrect, fit a new thrust plate. If end-float is still incorrect, a new camshaft/gear must be fitted.



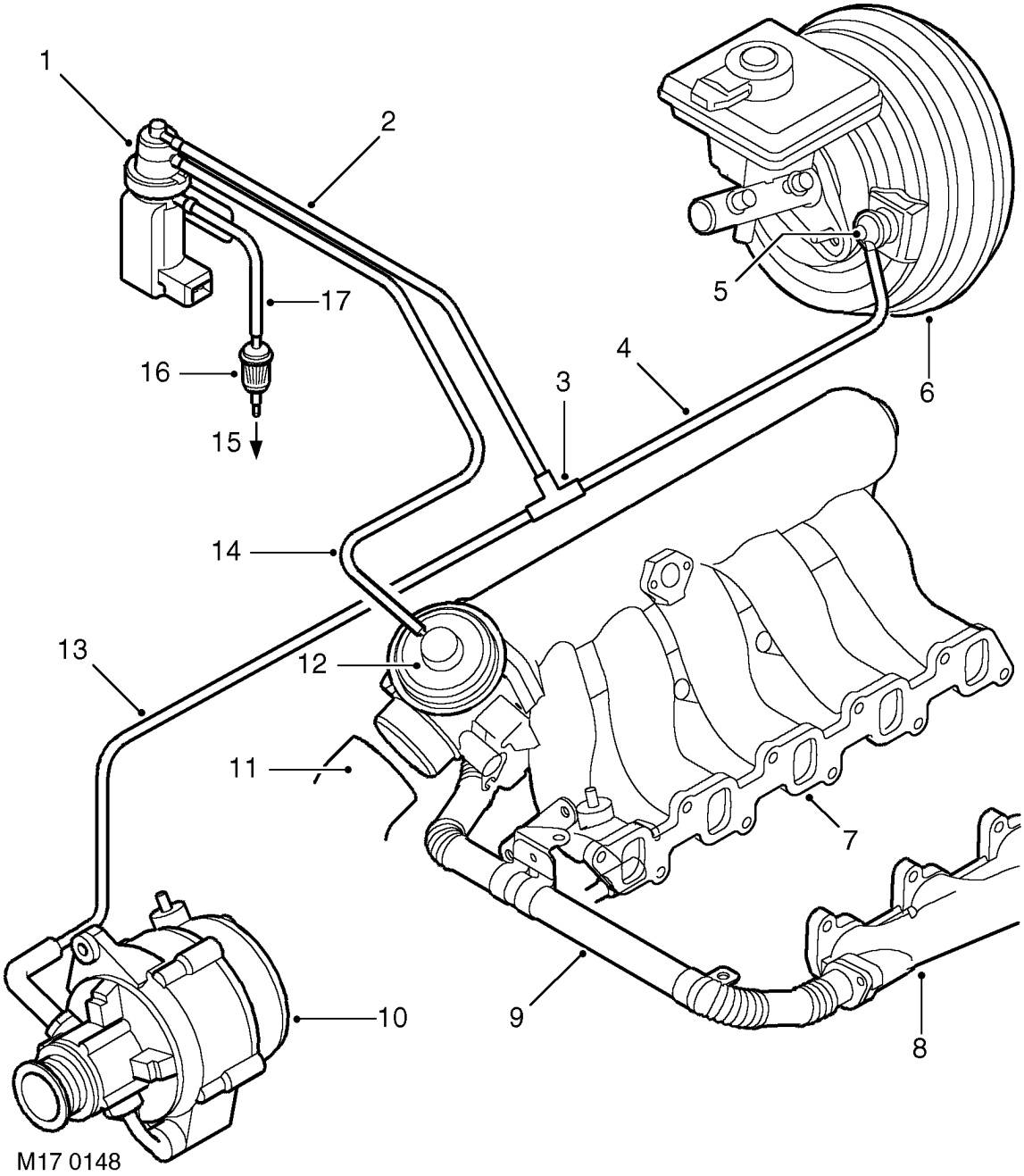
M12 7484

13. Remove camshaft bolt and gear.
14. Remove 2 bolts securing camshaft thrust plate and remove thrust plate.
15. Carefully remove the camshaft avoiding damage to the camshaft bearings.

Reassembly

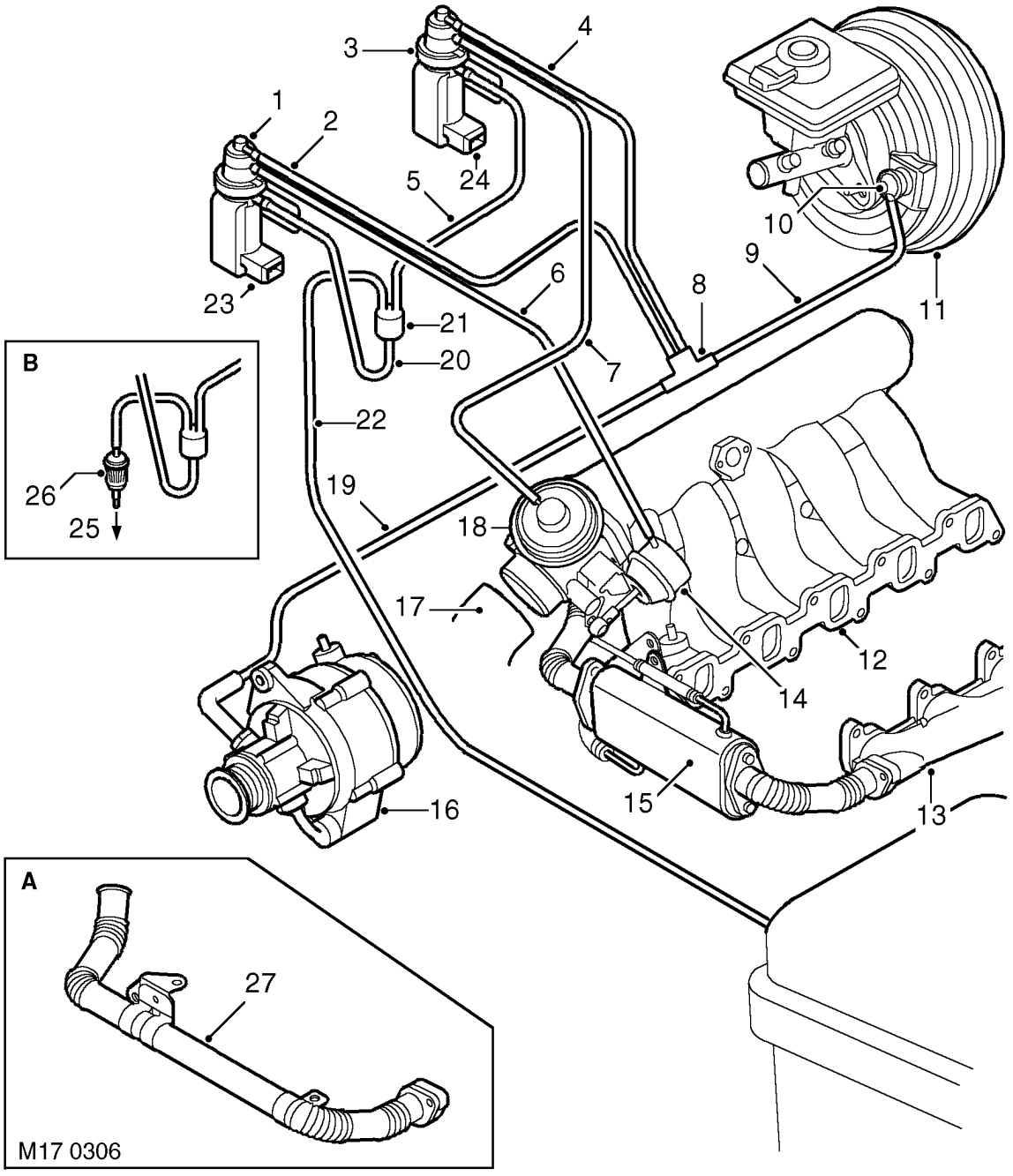
1. Clean camshaft bearings in block.
2. Clean camshaft.
3. Wipe camshaft bearing faces and lobes.
4. Clean thrust plate and mating face.
5. Lubricate camshaft bearings with clean engine oil.
6. Fit camshaft, take care not to damage camshaft bearings.
7. Lubricate thrust plate and mating face with clean engine oil.
8. Position thrust plate, fit and tighten bolts to 22 Nm (17 lbf.ft).
9. Fit timing chain and gears.
   ☞ **ENGINE - V8, OVERHAUL, Timing chain and gears.**
10. Immerse tappets in engine oil. Before fitting, pump the inner sleeve of tappet several times using a push rod to prime the tappets.
11. Clean tappet bores.
12. Lubricate tappets and tappet bores with clean engine oil.
13. Fit tappets.
14. Clean push rods.
15. Lubricate tappet end of push rods with clean engine oil.
16. Fit push rods.
17. Clean bases of rocker pillars and mating faces.
18. Clean contact surfaces on rockers and valves.
19. Lubricate contact surfaces on rockers and valves with clean engine oil.
20. Fit rocker shafts and engage push rods. Ensure rockers shafts are fitted to the correct cylinder head.
21. Fit and progressively tighten rocker shaft bolts to 40 Nm (30 lbf.ft).
22. Fit inlet manifold gasket.
    ☞ **ENGINE - V8, OVERHAUL, Gasket - inlet manifold.**

EGR system components - type 1



1 EGR valve modulator
2 Vacuum hose (brown)
3 'T'-piece
4 Vacuum hose to brake-servo
5 Non-return valve
6 Brake-servo
7 Inlet manifold
8 Exhaust manifold
9 EGR pipe
10 Vacuum pump/alternator assembly
11 Air intake hose from intercooler
12 EGR valve assembly
13 Vacuum hose to vacuum pump
14 Vacuum hose to EGR valve suction port (blue)
15 To atmosphere
16 In-line filter
17 Vent hose – modulator to in-line filter (green)

EGR system components - type 2



Inset A shows the Pre EU3 condition for the EGR pipe and inset B shows the Pre EU3 condition filter and venting.

1 ILT valve modulator
2 ILT modulator vacuum hose (brown)
3 EGR valve modulator
4 EGR modulator vacuum hose (brown)
5 Vent hose – EGR modulator to in-line filter (green)
6 Vacuum hose to ILT valve suction port (blue)
7 Vacuum hose to EGR valve suction port (blue)
8 'T'-piece (4–way)
9 Vacuum hose to brake-servo
10 Non-return valve
11 Brake-servo
12 Inlet manifold
13 Exhaust manifold
14 ILT valve
15 EGR cooler - EU3 models
16 Vacuum pump / alternator assembly
17 Air intake hose from intercooler
18 EGR valve (incorporating ILT valve) assembly
19 Vacuum hose to vacuum pump
20 Vent hose – ILT valve modulator to in-line filter (green)
21 3–way connector
22 Vent hose - to air cleaner
23 ILT modulator harness connector (green)
24 EGR modulator harness connector (black)
25 To atmosphere - Pre EU3 models
26 In-line filter - Pre EU3 models
27 EGR pipe - Pre EU3 models

Emission Control Systems

Engine design has evolved in order to minimise the emission of harmful by-products. Emission control systems fitted to Land Rover vehicles are designed to maintain the emission levels within the legal limits pertaining for the specified market.

Despite the utilisation of specialised emission control equipment, it is still necessary to ensure that the engine is correctly maintained and is in good mechanical order, so that it operates at its optimum condition.

In addition to emissions improvements through engine design and the application of electronic engine management systems, special emission control systems are used to limit the pollutant levels developed under certain conditions. Two main types of additional emission control system are utilised with the Td5 engine to reduce the levels of harmful emissions released into the atmosphere. These are as follows:

1 ***Crankcase emission control –*** also known as blow-by gas emissions from the engine crankcase.
2 ***Exhaust gas recirculation –*** to reduce NO_2 emissions.

Crankcase emission control

All internal combustion engines generate oil vapour and smoke in the crankcase as a result of high crankcase temperatures and piston ring and valve stem blow-by, a closed crankcase ventilation system is used to vent crankcase gases back to the air induction system and so reduce the emission of hydrocarbons.

Gases from the crankcase are drawn into the inlet manifold to be burnt in the combustion chambers with the fresh air/fuel mixture. The system provides effective emission control under all engine operating conditions.

Crankcase gases are drawn through the breather port in the top of the camshaft cover and routed through the breather hose and breather valve on the flexible air intake duct to be drawn into the turbocharger intake for delivery to the air inlet manifold via an intercooler.

An oil separator plate is included in the camshaft cover which removes the heavy particles of oil before the crankcase gas leaves via the camshaft cover port. The rocker cover features circular chambers which promote swirl in the oil mist emanating from the cylinder head and camshaft carrier. As the mist passes through the series of chambers between the rocker cover and oil separator plate, oil particles are thrown against the separator walls where they condense and fall back into the cylinder head via two air inlet holes located at each end of the rocker cover.

The breather valve is a depression limiting valve which progressively closes as engine speed increases, thereby limiting the depression in the crankcase. The valve is of moulded plastic construction and has a port on the underside which plugs into a port in the flexible air intake duct. A port on the side of the breather valve connects to the camshaft cover port by means of a breather hose which is constructed from a heavy-duty braided rubber hose which is held in place by hose clips. A corrugated plastic sleeve is used to give further protection to the breather hose. The breather valve is orientation sensitive, and “TOP” is marked on the upper surface to ensure it is mounted correctly.

It is important that the system is airtight so hose connections to ports should be checked and the condition of the breather hose should be periodically inspected to ensure it is in good condition.

Exhaust gas recirculation

The exhaust gas recirculation (EGR) valve permits a controlled amount of exhaust gas to combine with the fresh air entering the engine. The exhaust gas reduces the combustion temperature by delaying the fuel burning rate, which assists in reducing the quantity of oxides of nitrogen.

On EU3 models, an EGR cooler is employed to further reduce the combustion temperature. By passing the exhaust gas through a bundle of pipes flooded by coolant, the density of the exhaust gas going into the engine is increased. This process further reduces the amount of oxygen, which in turn, further reduces the amount of NO_2 in the exhaust.

Recirculating too much exhaust gas can result in higher emissions of soot, HC and CO due to insufficient air. The recirculated exhaust gas must be limited so that there is sufficient oxygen available for combustion of the injected fuel in the combustion chamber, to do this the Engine Control Module (ECM) is used to control the precise quantity of exhaust gas to be recirculated in accordance with the prevailing operating conditions. Influencing factors include:

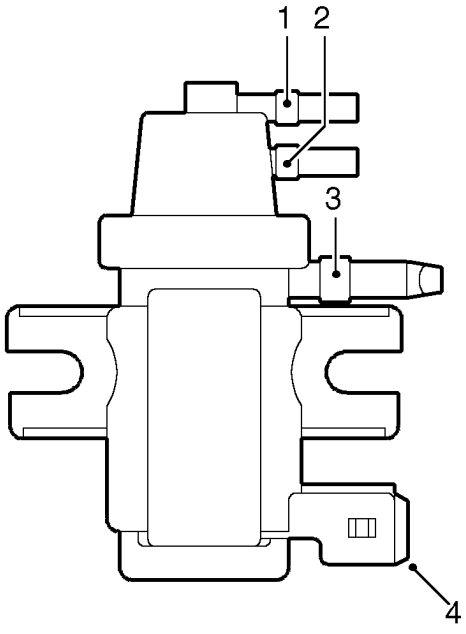
- the mass of air flow detected by the ***mass air flow sensor***.
  ☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**
- the ambient air pressure, determined by the **ambient air pressure sensor** which is used to initiate adjustments to reduce the amount of smoke produced at high altitudes.
  ☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

Other factors which are taken into consideration by the engine management system for determining the optimum operating condition include:

- Manifold inlet air temperature
- Coolant temperature
- Engine speed
- Fuel delivered

The main components of the EGR system are as follows.

EGR Modulator



M17 0150

1 Port to vacuum source (white band)
2 Port to EGR valve (blue band)
3 Port to atmosphere via in-line filter (green band)
4 Harness connector (black)

The EGR modulator is located on a plate fixed to the inner wing on the RH side of the engine. The modulator is attached to the plate by two through-studs, each with two nuts which secure the modulator assembly to a rubber mounting which helps to reduce noise. The modulator must be mounted in the vertical orientation with the two vacuum ports uppermost.

The modulator operation is controlled by a signal from the ECM which determines the required amount of EGR needed in response to inputs relating to air flow and engine operating and ambient conditions. The modulator has a black two-pin connector at its base to connect it to the ECM through the engine harness.

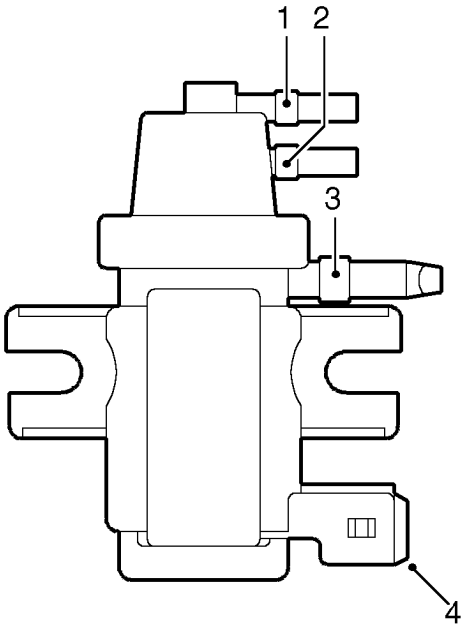
Each modulator features three ports:

- The top port of the EGR modulator is identified by a white band and connects to a 'T'-piece in the vacuum line via a small-bore brown plastic hose. On type 2 systems the brown hose is connected in parallel with the vacuum source to the ILT modulator.

  The other two ports on the 'T'-piece connects vacuum line hoses of black vinyl tubing between the vacuum pump and the brake-servo assembly attached to the bulkhead. The vacuum pump end of the vacuum line tubing terminates in a rubber elbow, which gives a vacuum tight seal on the suction port of the vacuum pump. The brake-servo end of the vacuum line tubing terminates with a non-return valve in a plastic housing which plugs into the front face of the brake-servo housing.
- The middle port of the EGR modulator is identified by a blue band and connects to the suction port on the EGR valve through a small-bore blue plastic hose.
- The lower port of the EGR modulator is identified by a green band and connects to atmosphere through an in-line filter via a small-bore green plastic hose. On type 2 models a 3 way connector is fitted to vent both modulators through a single filter. The other port of the in-line filter vents directly to atmosphere.

The blue and brown vacuum hoses are protected by corrugated plastic sheaths. The ends of the hoses are fitted with rubber boots to ensure vacuum tight seals at the component ports.

Inlet Throttle (ILT) Modulator



M17 0150

1 Port to vacuum source (white band)
2 Port to ILT valve (blue band)
3 Port to atmosphere via in-line filter (green band)
4 Harness connector (green)

The ILT modulator is located on a plate fixed to the inner wing on the RH side of the engine below the EGR modulator. The modulator is attached to the plate by two through-studs, each with two nuts which secure the modulator assembly to a rubber mounting which helps to reduce noise. The modulator must be mounted in the vertical orientation with the two vacuum ports uppermost.

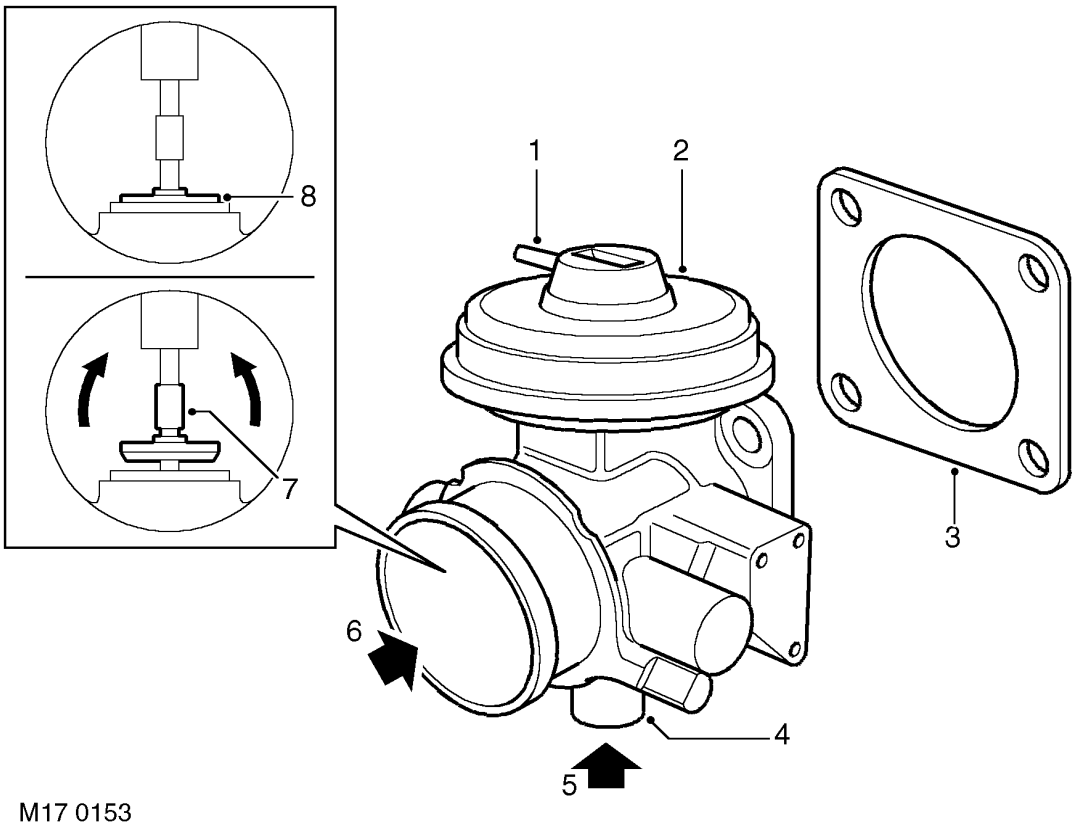
The modulator operation is controlled by a signal from the ECM which determines the required ratio of exhaust gas to fresh inlet air needed in response to inputs relating to air flow and engine operating and ambient conditions. The modulator has a green two-pin connector at its base to connect it to the ECM through the engine harness.

The ILT valve modulator features three ports:

- The top port is identified by a white band and connects to a 'T'-piece in the vacuum line via a small-bore brown plastic hose where it is connected in parallel with the vacuum source line to the EGR valve modulator. The two other ports on the 'T'-piece connect vacuum line hoses of black vinyl tubing between the vacuum pump attached to the alternator and the brake-servo assembly attached to the bulkhead.
- The middle port is identified by a blue band and connects to the suction port on the ILT valve through a small-bore blue plastic hose.
- The lower port is identified by a green band and connects to atmosphere through an in-line filter via a green plastic hose and a three-way connector positioned in-line between the modulators and the filter. The ILT modulator hose is connected opposite to the two parallel ports at the three-way connector which connect the vent lines to the EGR valve modulator and the in-line filter. The other port of the in-line filter vents directly to atmosphere.

The blue and brown vacuum hoses are protected by corrugated plastic sheaths. The ends of the hoses are fitted with rubber boots to ensure vacuum tight seals at the component ports.

EGR Valve



M17 0153

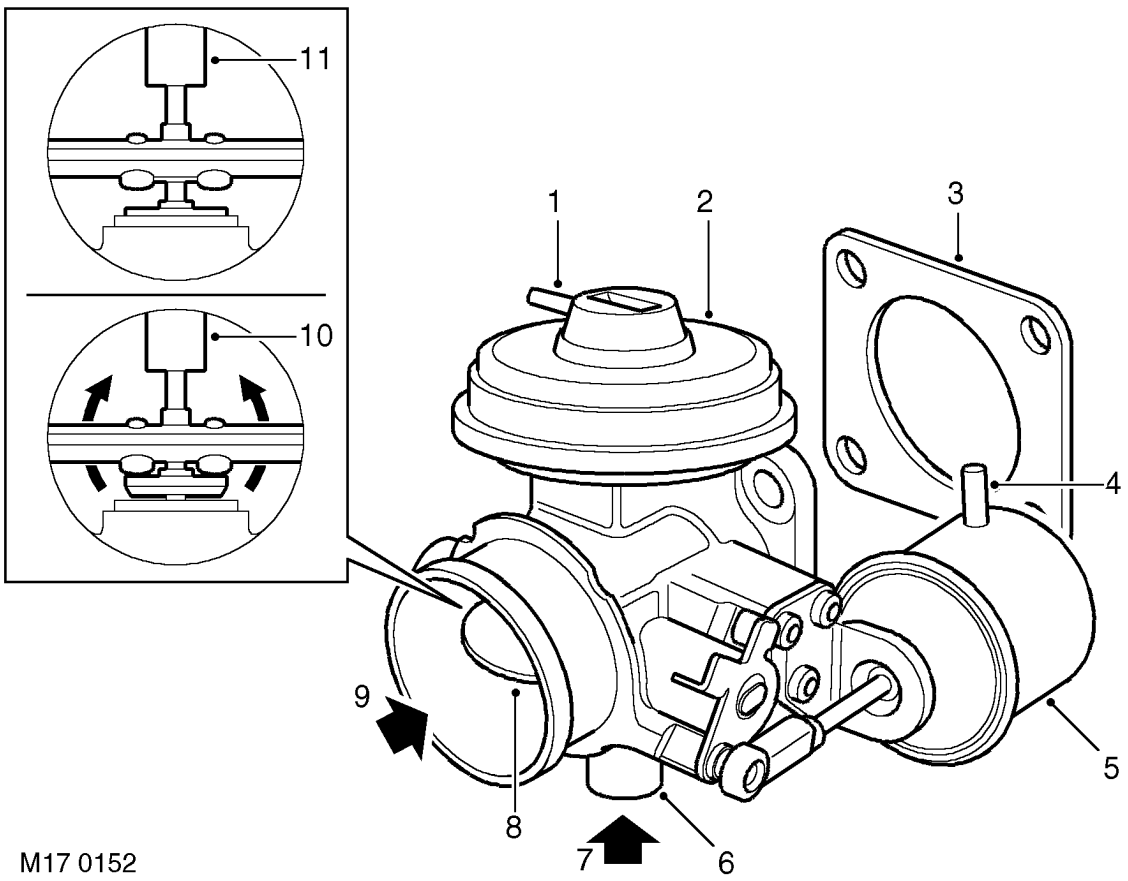
1 EGR valve vacuum port
2 EGR valve assembly
3 Gasket – EGR valve to inlet manifold
4 EGR pipe connection
5 Exhaust gas intake
6 Intake air
7 EGR valve open (vacuum applied to EGR valve)
8 EGR valve closed (no vacuum to EGR valve)

The EGR valve is a cast and machined assembly which locates on the front end of the inlet manifold assembly. The machined faces of the EGR assembly and the inlet manifold are attached together using four screws passing through the four corners of a flange in the EGR assembly to tappings in the front face of the inlet manifold. A gasket is used to seal the interface between the EGR valve and the front face of the inlet manifold. The gasket should be changed every time the EGR valve assembly is removed from the air intake manifold.

The intake side of the EGR valve allows the passage of fresh intercooled air through to the inlet manifold via a rubber hose which is attached to the front face of the EGR valve assembly by a metal band clamp. The bottom port of the EGR valve is connected to the EGR pipe using a metal band clamp.

A vacuum port on top of the EGR valve connects to the EGR modulator through a blue, small-bore suction hose. When a vacuum is applied to the EGR valve suction port it causes a spindle with sealing disc (EGR valve) to be raised, thereby opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. When the vacuum is removed from the suction port the EGR valve returns to its rest position under the influence of a spring to tightly close the exhaust gas port. Thus controlled opening of the EGR valve determines the mass of recirculated exhaust gas allowed to flow through to the inlet manifold.

Inlet Throttle (ILT) Valve



M17 0152

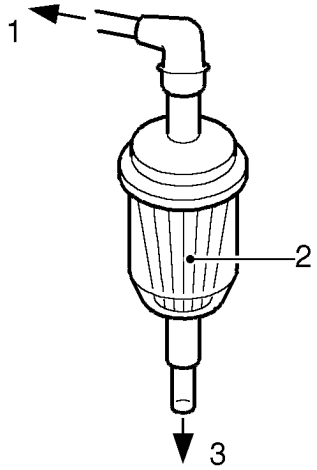
1 EGR valve vacuum port
2 EGR valve assembly
3 Gasket – EGR valve to inlet manifold
4 ILT valve vacuum port
5 ILT valve
6 EGR pipe connection
7 Exhaust gas intake
8 ILT valve – butterfly
9 Intake air
10 EGR valve open (vacuum applied to EGR valve; ILT valve butterfly shown fully open)
11 EGR valve closed (no vacuum to EGR valve; ILT butterfly valve shown fully open)

The ILT valve is used on certain exhaust gas recirculation systems in addition to the standard EGR valve described above. The ILT valve assembly is mounted at right angles to the EGR valve on the left hand side of the EGR valve assembly. It is fixed to the EGR valve assembly by three screws.

A vacuum port on top of the ILT valve connects to the ILT modulator though a blue, small-bore suction hose. When a vacuum is applied to the inlet throttle (ILT) valve suction port, a butterfly valve in the inlet manifold closes via a spindle and lever mechanism, limiting the supply of fresh intercooled air and creating a depression in the intake manifold which in turn causes a greater suction at the open port to the EGR delivery pipe. When the vacuum source is removed from the ILT valve suction port, a spring returns the butterfly to its fully open position. The ILT valve and EGR valve are operated in conjunction to control the proportional masses of fresh intake air and recirculated exhaust gas that is allowed to flow through to the inlet manifold.

The EGR valve and ILT valve should be replaced as a single assembly.

In-line air filter - Pre EU3 models



M17 0154

1 To modulator vent port
2 Filter element
3 To atmosphere

The in-line air filter is placed in the ventilation line to the EGR modulator (and the ILT modulator where fitted). The modulators need to be able to vent to atmosphere in order to release the vacuum supplied to the EGR and ILT valves. The filter prevents contamination entering the modulators via the vent port which could cause failure; the filter should be periodically changed in accordance with recommended service intervals. The filter is attached to the rear side of the mounting plate used to hold the vacuum modulators at the inner wing on the RH side of the engine. The filter is held in position by a clamping bracket which is attached to the mounting plate through a nut and bolt. The filter must be mounted in the vertical position.

Note: EU3 models are not fitted with an in-line filter, the ventilation line connects directly to the air cleaner housing, where it vents to atmosphere.

EGR systems

There are two types of exhaust gas recirculation system used with the Td5 engine dependent on legislation and market requirements, these are type 1 and type 2.

Type 1 EGR system is fitted to all Td5's built up to the introduction of 2002 MY, except for Japanese specification vehicles.

Type 2 EGR system is fitted to all Japanese specification vehicles and was introduced into European markets for 2002 MY to meet EU3 emission requirements. An additional feature introduced at 2002 MY is the EGR cooler, which is bolted to the front of the cylinder head.

EGR system - type 1
This EGR system features a single modulator which is electrically controlled to modulate a vacuum source to the EGR valve. The controlled vacuum opens and closes the valve by the amount required to ensure the optimal proportion of exhaust gas is allowed through to the inlet manifold to be combined with the fresh air intake. Control feedback is achieved by monitoring the mass of fresh air flowing through the mass air flow sensor.

The modulator operation is controlled by a signal from the ECM which determines the required amount of EGR needed in response to inputs relating to air flow and engine operating and ambient conditions. The ECM is low-side driven, sinking current returned from the vacuum modulator for switching operating condition.

The exhaust gases are routed from the exhaust manifold through a shaped metal pipe which connects to the underside of the EGR valve. The pipe is held securely in position to the front of the cylinder head using a clamp bracket. The EGR pipe is attached to a mating port at the front end of the exhaust manifold using two Allen screws and at the EGR valve assembly by a metal band clamp. The two Allen screws fixing the EGR pipe to the exhaust manifold should be replaced every time the EGR pipe is removed. **Extreme care should be exercised when removing and refitting the EGR pipe to avoid damage.**

When a vacuum is applied to the EGR suction port, it causes a spindle with sealing disc (EGR valve) to be raised, thus opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. The valve is spring loaded so that when the vacuum is removed from the suction port the valve returns to its rest position to tightly close the exhaust gas port.

By controlling the quantity of recirculated exhaust gas available in the inlet manifold, the optimum mix for the prevailing engine operating conditions can be maintained, which ensures the intake gas to the combustion chambers will have burning rate properties which will reduce the NO_x emissions to an acceptable level. Normally, full recirculation is only applicable when the NO_x emissions are most prevalent.

EGR system - type 2
This system features twin modulators mounted one above the other on a metal plate located on the inner wing at the RH side of the engine. The modulators are electrically controlled by the engine management system and are used to modulate a vacuum source to the EGR valve and a supplementary Inlet Throttle (ILT) valve; the two valves are controlled to operate in tandem. The ILT valve vacuum pot is mounted adjacent to the EGR valve housing and has a linkage which connects to a butterfly valve mounted in front of the EGR valve at the air intake manifold.

The modulator operations are electrically controlled by signals from the engine management system which determines the required volume of exhaust gas needed in response to inputs relating to air flow, engine operating conditions and ambient parameters such as temperature and altitude. The engine management ECM switches on the circuit by completing the path to ground, operating the vacuum modulators.

Pre EU3 models: The exhaust gases are routed from the exhaust manifold through a shaped metal pipe which connects to the underside of the EGR valve. The pipe is held securely in position to the front of the engine cylinder head using a metal clamp bracket. The EGR pipe is attached to a mating port at the front end of the exhaust manifold using two Allen screws and at the EGR valve assembly by a metal band clamp. The two Allen screws fixing the EGR pipe to the exhaust manifold should be replaced every time the EGR pipe is removed. **Extreme care should be exercised when removing and refitting the EGR pipe to avoid damage.**

EU3 models: The exhaust gases are routed from the exhaust manifold through the EGR cooler to the underside of the EGR valve. The EGR cooler is bolted to the front of the engine cylinder head. An EGR pipe connects the EGR cooler to the exhaust manifold and is secured by two Allen screws. The two Allen screws fixing the EGR pipe to the exhaust manifold should be replaced every time the EGR pipe is removed. A second pipe connects the EGR cooler to the EGR valve; this pipe is secured to the EGR valve by a clip, and to the cooler by two Allen screws.**Extreme care should be exercised when removing and refitting the EGR pipe to avoid damage. When refitting the EGR cooler, always tighten the pipe connections BEFORE tightening the bolts securing the cooler to the cylinder head.**

When a vacuum is applied to the EGR suction port, it causes a spindle with sealing disc (EGR valve) to be raised, opening the port at the EGR pipe to allow the recirculated exhaust gas to pass through into the inlet manifold. The valve is spring loaded so that when the vacuum is removed from the suction port, the valve returns to its rest position to tightly close the exhaust gas port.

A vacuum is simultaneously applied to the inlet throttle (ILT) valve suction port which causes the butterfly valve in the inlet manifold to close by means of a spindle and lever mechanism. Closing the butterfly valve limits the supply of fresh intercooled air entering the inlet manifold and causes a depression within the inlet manifold to create a greater suction at the open port to the EGR delivery pipe. In this condition a greater mass of recirculated exhaust gas is drawn into the inlet manifold for use in the combustion process. When the vacuum is released from the ILT valve suction port a spring returns the butterfly valve to its fully open position.

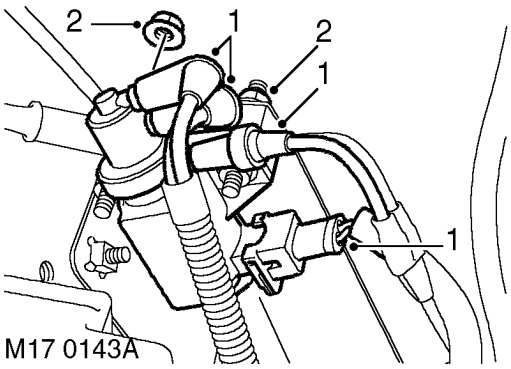
By controlling the quantities of recirculated exhaust gas and fresh intake air available in the inlet manifold, the optimum mix for the prevailing engine operating conditions can be maintained which ensures the intake gas to the combustion chambers will have burning rate properties which will reduce the NO_x emissions to an acceptable level. Normally, full recirculation is only applicable when the NO_x emissions are most prevalent.

Modulator - EGR

17.45.04

There are two types of modulator fitted. System type 1 has a single modulator, and type 2 has a second modulator (ILT modulator) bolted to the same mounting plate.

Remove



1. Disconnect vacuum pipe(s) and multiplug(s) from EGR modulator.
2. Remove 2 nuts and remove EGR modulator.

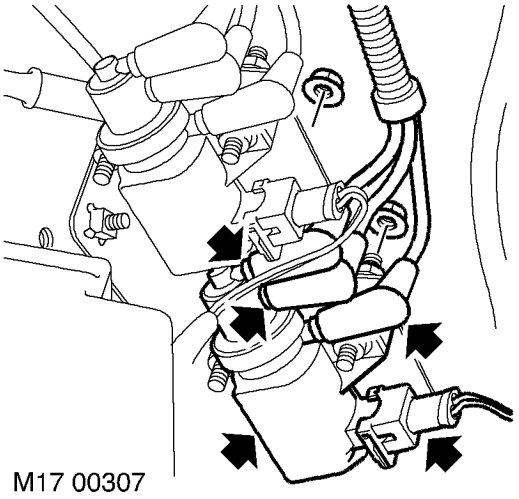
Refit

1. Position EGR modulator and tighten securing nuts.
2. Connect vacuum hose(s) and multiplug(s).

Inlet Throttle (ILT) Modulator

17.45.03

Remove



1. Identify the fitted positions of the 3 vacuum pipes, then disconnect from the ILT modulator valve.
2. Disconnect multiplug from ILT modulator.
3. Remove 2 nuts securing modulator and remove ILT modulator from its mountings.

Refit

1. Fit ILT modulator to its mountings, fit the nuts and tighten to 10 Nm (7 lbf.ft).
2. Connect vacuum pipes to the positions identified during removal.
3. Connect multiplug to ILT modulator.

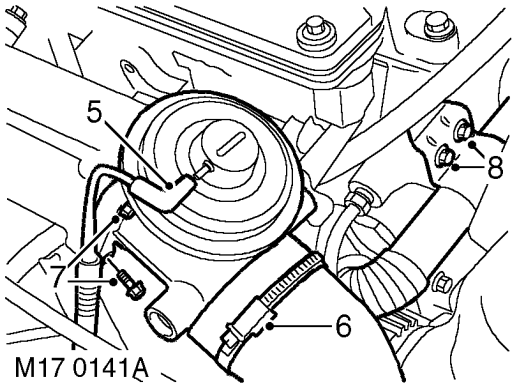
Valve - EGR - Pre EU3 models

17.45.01

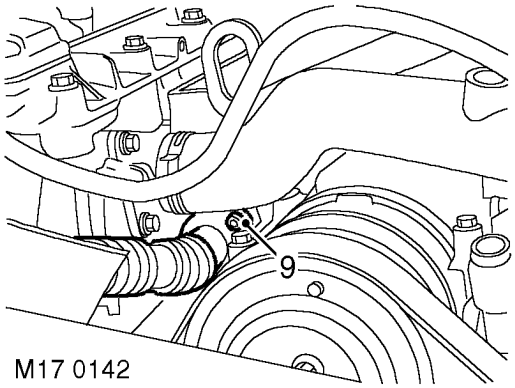
On all vehicles up to VIN number 1A736339, the EGR pipe assembly must be replaced every time the system is disturbed.

Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Remove 3 bolts and remove engine acoustic cover.
4. Remove cooling fan coupling.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.



5. Disconnect vacuum hose(s) from EGR valve.
6. Loosen clip and release air intake from EGR valve.
7. Remove 4 bolts, release EGR valve from inlet manifold and discard gasket.
8. Remove 2 bolts and release EGR valve clip from cylinder head.



9. Remove and discard 2 bolts securing EGR valve pipe to exhaust manifold.
10. Remove EGR valve assembly.
11. Remove clip and remove pipe from EGR valve.

Refit

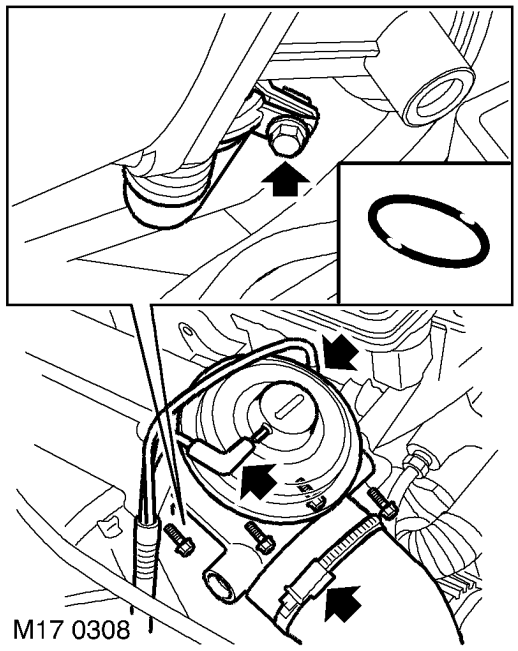
1. Clean EGR valve and mating face on pipe.
2. Position pipe to EGR valve and fit retaining clip. Fit bolt but do not tighten at this stage.
3. Position EGR valve assembly, locate pipe flange to exhaust manifold, fit new bolts but do not tighten at this stage.
4. Clean inlet manifold and EGR valve mating faces.
5. Using new gasket, position EGR valve to inlet manifold fit bolts and tighten to 10 Nm (7 lbf.ft).
6. Align EGR pipe clip to cylinder head, fit bolts but do not tighten at this stage.
7. Tighten EGR pipe bolts to correct torque in following sequence:
   - EGR pipe retaining clip bolt 6 Nm (4.5 lbf.ft)
   - EGR pipe clip to cylinder head bolts 10 Nm (7 lbf.ft)
   - EGR pipe flange to exhaust manifold bolts 10 Nm (7 lbf.ft)
8. Position air intake hose and tighten clip.
9. Connect vacuum hoses to EGR valve.
10. Fit cooling fan coupling.
    COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
11. Connect battery earth lead.
12. Fit battery cover and secure the fixings.

Valve - EGR - EU3 models

17.45.01

Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Remove 3 bolts and remove engine acoustic cover.
4. Remove cooling fan coupling.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.

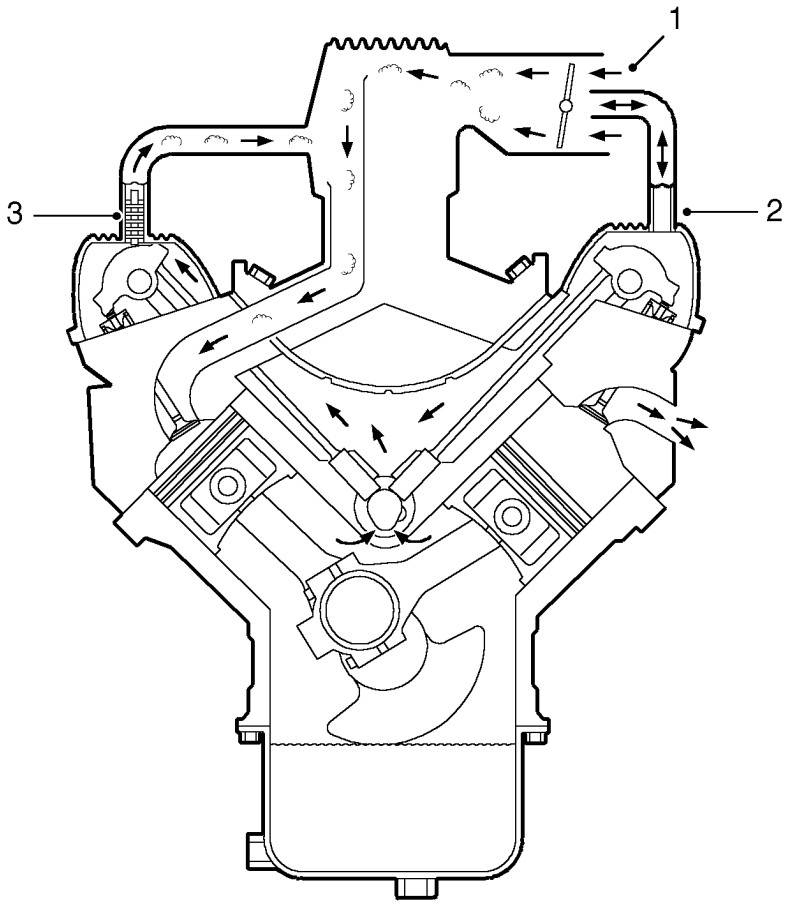


5. Disconnect vacuum hose(s) from EGR valve.
6. Loosen clip screw and disconnect air intake hose from EGR valve.
7. Remove screw and remove clamp securing EGR pipe to EGR valve.
8. Remove 4 bolts securing EGR valve, remove valve and discard gasket.
9. Discard EGR pipe gasket.

Refit

1. Clean EGR valve and mating faces.
2. Fit new gasket to EGR pipe.
3. Using new gasket, position EGR valve to inlet manifold fit bolts and tighten to 10 Nm (7 lbf.ft).
4. Fit EGR pipe clamp and tighten screw to 6 Nm (4.4 lbf.ft).
5. Connect air intake hose to EGR valve and tighten clip.
6. Connect vacuum hoses to EGR valve.
7. Fit cooling fan coupling.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
8. Fit engine acoustic cover and tighten bolts to 10 Nm (7 lbf.ft).
9. Connect battery earth lead.
10. Fit battery cover and secure the fixings.

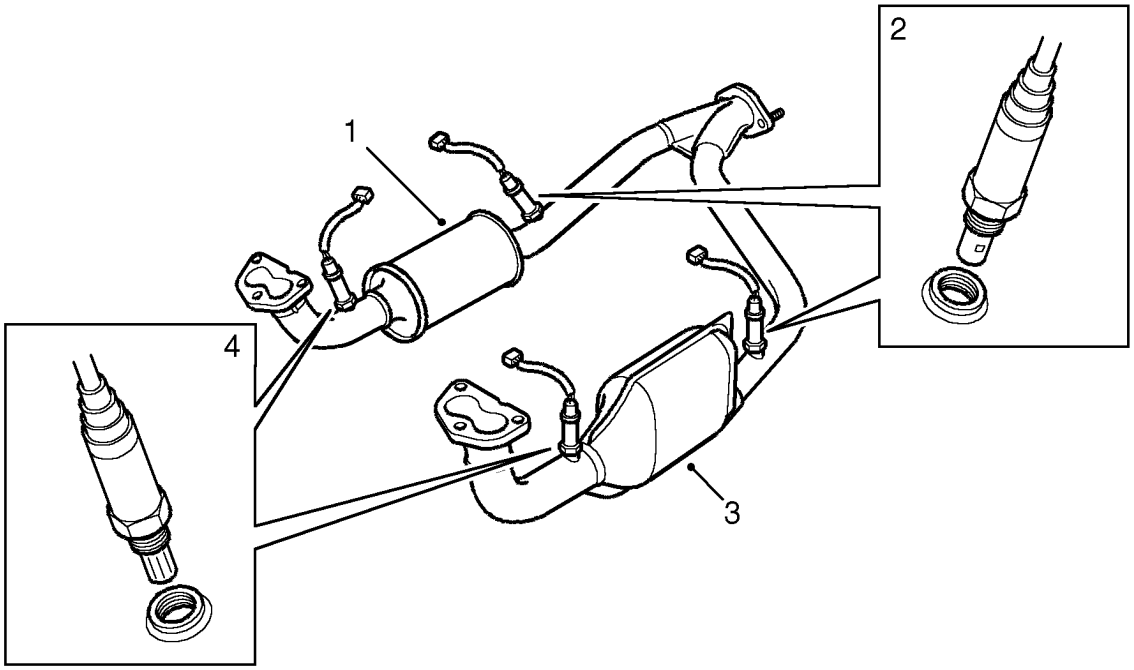
Crankcase emission control system



M17 0155

1 Intake air
2 LH rocker cover breather tube
3 Oil separator in RH rocker breather tube

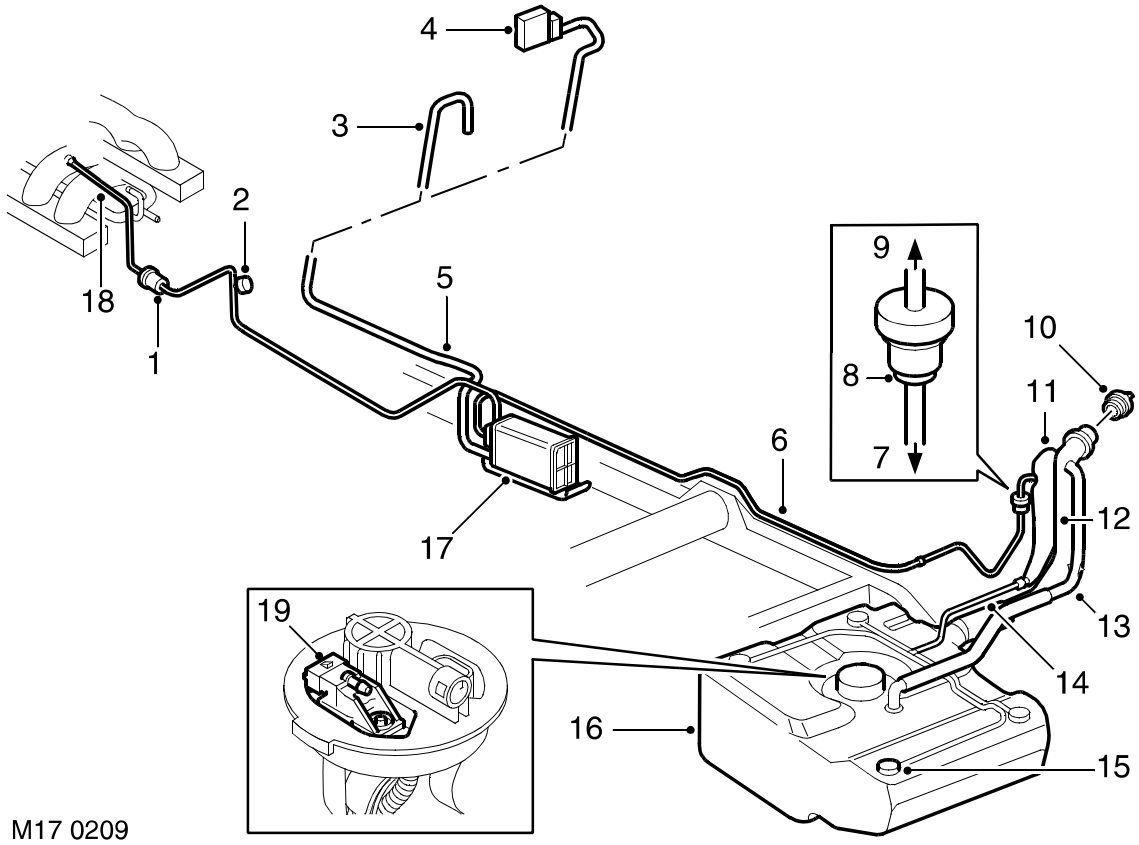
Exhaust emission control



M17 0156

1 RH catalytic converter
2 Heated oxygen sensors – post-catalytic converter (2 off – NAS only)
3 LH catalytic converter
4 Heated oxygen sensors – pre-catalytic converter (2 off)

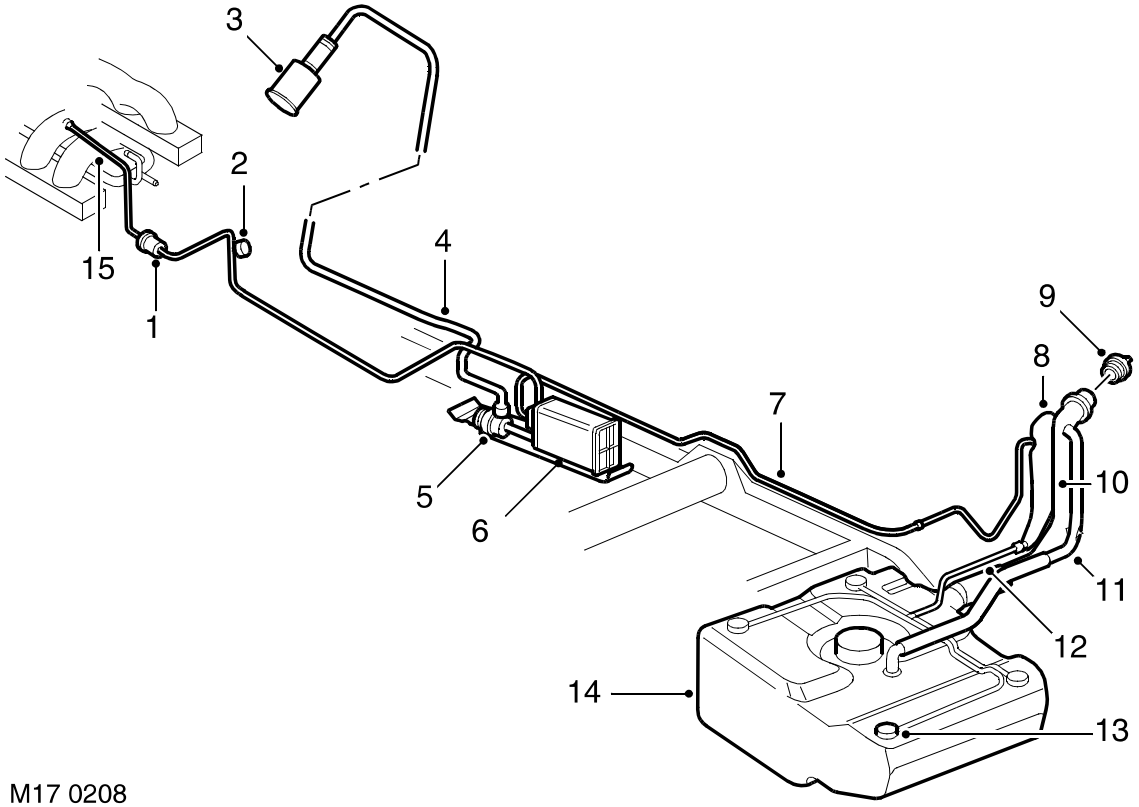
Evaporative emission system component layout



M17 0209

1 Purge valve
2 Service port
3 Snorkel tube (UK / ROW only)
4 CVS unit (NAS vehicles with vacuum type leak detection only)
5 EVAP canister breather tube
6 Vent pipe – fuel tank to EVAP canister
7 Relief valve regulated flow
8 Relief valve (UK / ROW only)
9 Relief valve free flow
10 Fuel filler cap
11 Liquid vapour separator (UK / ROW type shown)
12 Fuel filler hose (UK / ROW type shown)
13 Tank breather hose (UK / ROW only)
14 Vent hose
15 Roll over valves (ROV's) – (4 off, UK / ROW spec. shown)
16 Fuel tank and breather assembly
17 EVAP canister
18 Purge line connection to engine manifold
19 Tank EVAP system pressure sensor (NAS vehicles with vacuum type leak detection only)

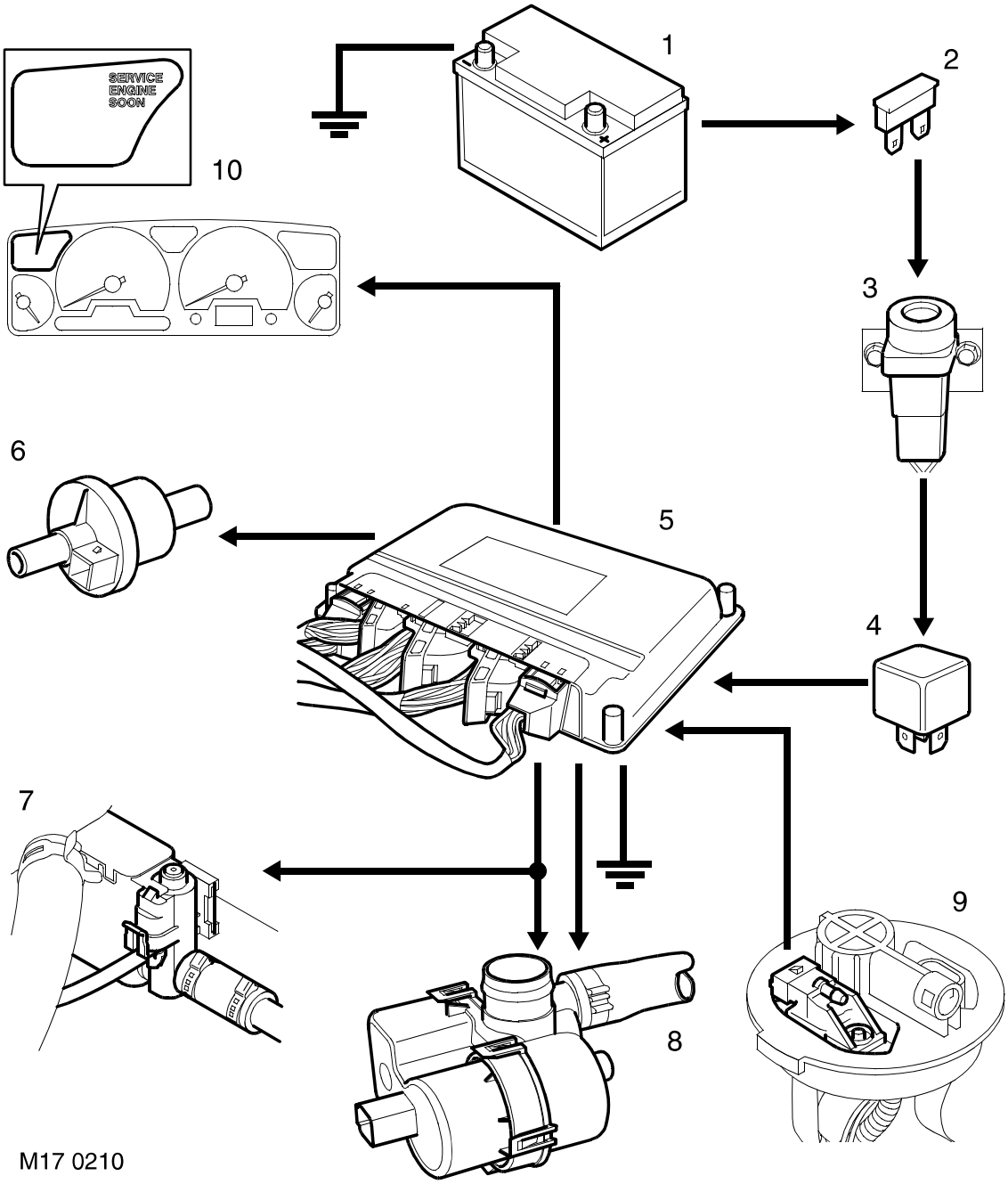
Evaporative emission system (with positive pressure leak detection) component layout (NAS only)



M17 0208

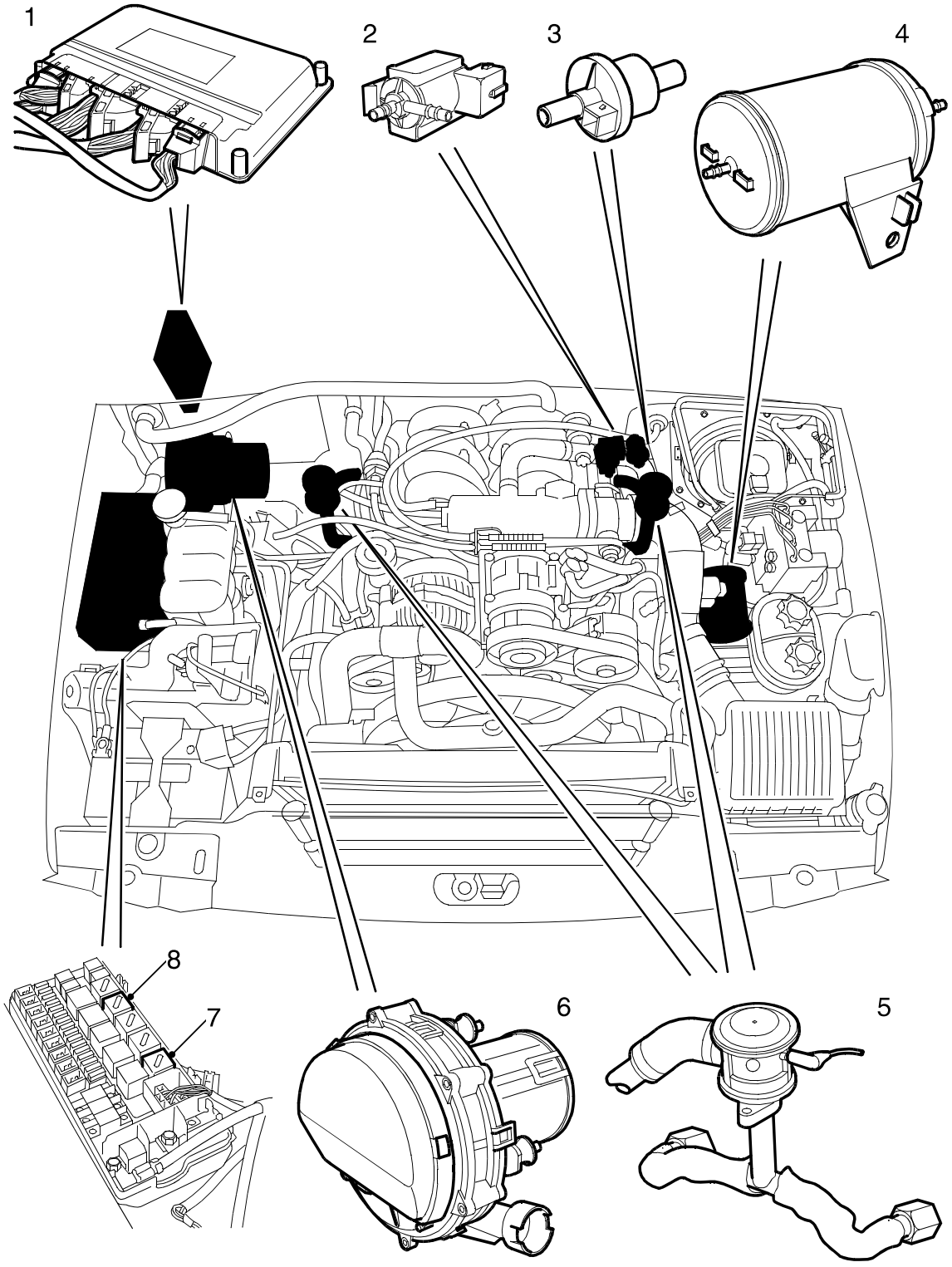
1 Purge valve
2 Service port
3 Air filter canister
4 EVAP canister breather tube
5 Leak detection pump
6 EVAP canister
7 Vent pipe – fuel tank to EVAP canister
8 Liquid vapour separator (metal)
9 Fuel filler cap
10 Fuel filler
11 Fuel tank breather assembly
12 Vent hose
13 Roll over valves (inside fuel tank)
14 Fuel tank
15 Purge line connection to engine manifold

Evaporative emission system control diagram



1 Battery
2 Fuse 13 (engine compartment fusebox)
3 Inertia switch
4 Main relay (engine compartment fusebox)
5 Engine Control Module (ECM)
6 Purge Valve (black harness connector)
7 Canister vent solenoid (CVS) valve – NAS vehicles with vacuum type EVAP system leak detection capability only
8 Leak detection pump – NAS vehicles with positive pressure type EVAP system leak detection capability only
9 Fuel tank pressure sensor – NAS vehicles with vacuum type EVAP system leak detection capability only
10 Instrument pack (MIL warning light)

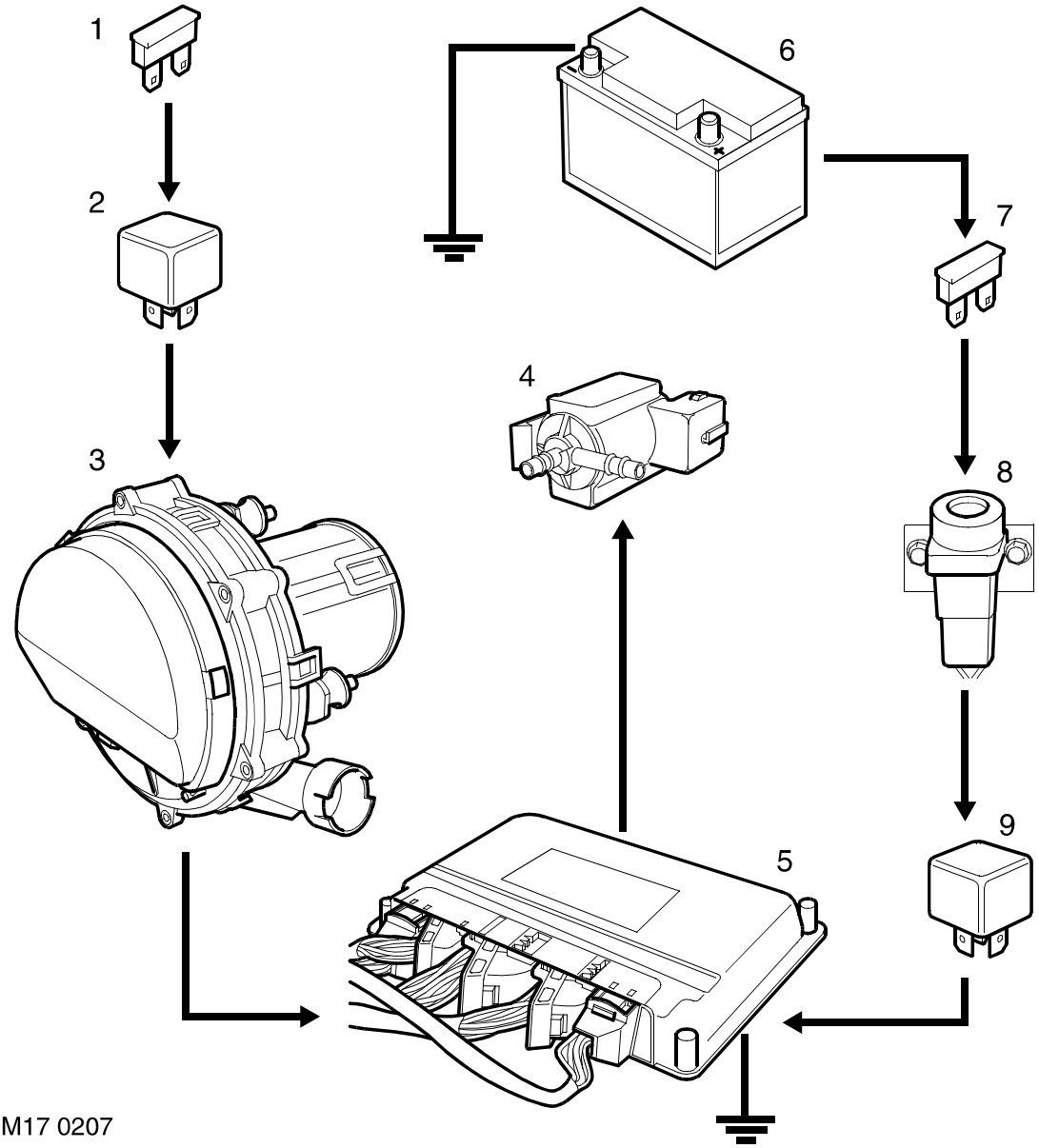
Secondary air injection system component layout



M17 0206

1 Engine Control Module (ECM)
2 SAI vacuum solenoid valve
3 Purge valve
4 Vacuum reservoir
5 SAI control valve (2 off)
6 SAI pump
7 SAI pump relay
8 Main relay

Secondary air injection system control diagram



M17 0207

1 Fuselink 2 (engine compartment fusebox)
2 SAI pump relay
3 SAI pump
4 SAI vacuum solenoid valve (grey harness connector)
5 Engine Control Module (ECM)
6 Battery
7 Fuse 13 (engine compartment fusebox)
8 Inertia switch
9 Main relay

Emission Control Systems

Engine design has evolved in order to minimise the emission of harmful by-products. Emission control systems are fitted to Land Rover vehicles which are designed to maintain the emission levels within the legal limits pertaining for the specified market.

Despite the utilisation of specialised emission control equipment, it is still necessary to ensure that the engine is correctly maintained and is in good mechanical order so that it operates at its optimal condition. In particular, ignition timing has an effect on the production of HC and NO_x emissions, with the harmful emissions rising as the ignition timing is advanced.

CAUTION: In many countries it is against the law for a vehicle owner or an unauthorised dealer to modify or tamper with emission control equipment. In some cases, the vehicle owner and/or the dealer may even be liable for prosecution.

The engine management ECM is fundamental for controlling the emission control systems. In addition to controlling normal operation, the system complies with On Board Diagnostic (OBD) system strategies. The system monitors and reports on faults detected with ignition, fuelling and exhaust systems which cause an excessive increase in tailpipe emissions. This includes component failures, engine misfire, catalyst damage, catalyst efficiency, fuel evaporative loss and exhaust leaks.

When an emission relevant fault is determined, the fault condition is stored in the ECM memory. For NAS vehicles, the MIL warning light on the instrument pack will be illuminated when the fault is confirmed. Confirmation of a fault condition occurs if the fault is still found to be present during the driving cycle subsequent to the one when the fault was first detected.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

The following types of supplementary control system are used to reduce harmful emissions released into the atmosphere from the vehicle:

1. ***Crankcase emission control*** – also known as blow-by gas emissions from the engine crankcase.
2. ***Exhaust emission control*** – to limit the undesirable by-products of combustion.
3. ***Fuel vapour evaporative loss control*** – to restrict the emission of fuel through evaporation from the fuel system.
4. ***Fuel leak detection system (NAS only)*** – there are two types of system which may be used to check the evaporative emission system for the presence of leaks from the fuel tank to purge valve.
   - **a** *Vacuum leak detection test* – checks for leaks down to 1 mm (0.04 in.) in diameter.
   - **b** *Positive pressure leak detection test* – utilises a leak detection pump to check for leaks down to 0.5 mm (0.02 in.) in diameter.
5. ***Secondary air injection system (NAS only)*** – to reduce emissions experienced during cold starting.

Crankcase emission control system

The concentration of hydrocarbons in the crankcase of an engine is much greater than that in the vehicle's exhaust system. In order to prevent the emission of these hydrocarbons into the atmosphere, crankcase emission control systems are employed and are a standard legal requirement.

The crankcase ventilation system is an integral part of the air supply to the engine combustion chambers and it is often overlooked when diagnosing problems associated with engine performance. A blocked ventilation pipe or filter or excessive air leak into the inlet system through a damaged pipe or a leaking gasket can affect the air:fuel mixture, performance and efficiency of the engine. Periodically check the ventilation hoses are not cracked and that they are securely fitted to form airtight connections at their relevant ports.

The purpose of the crankcase ventilation system is to ensure that any noxious gas generated in the engine crankcase is rendered harmless by complete burning of the fuel in the combustion chamber. Burning the crankcase vapours in a controlled manner decreases the HC pollutants that could be emitted and helps to prevent the development of sludge in the engine oil as well as increasing fuel economy.

A spiral oil separator is located in the stub pipe to the ventilation hose on the right hand cylinder head rocker cover, where oil is separated and returned to the cylinder head. The rubber ventilation hose from the right hand rocker cover is routed to a port on the right hand side of the inlet manifold plenum chamber where the returned gases mix with the fresh inlet air passing through the throttle butterfly valve. The stub pipe on the left hand rocker cover does not contain an oil separator, and the ventilation hose is routed to the throttle body housing at the air inlet side of the butterfly valve. The ventilation hoses are attached to the stub pipe by metal band clamps.

Exhaust emission control system

The fuel injection system provides accurately metered quantities of fuel to the combustion chambers to ensure the most efficient air to fuel ratio under all operating conditions. A further improvement to combustion is made by measuring the oxygen content of the exhaust gases to enable the quantity of fuel injected to be varied in accordance with the prevailing engine operation and ambient conditions; any unsatisfactory composition of the exhaust gas is then corrected by adjustments made to the fuelling by the ECM.

The main components of the exhaust emission system are two catalytic converters which are an integral part of the front exhaust pipe assembly. The catalytic converters are included in the system to reduce the emission to atmosphere of carbon monoxide (CO), oxides of nitrogen (NO_x) and hydrocarbons (HC). The active constituents of the catalytic converters are platinum (Pt), palladium (PD) and rhodium (Rh). **Catalytic converters for NAS low emission vehicles (LEVs) from 2000MY have active constituents of palladium and rhodium only.** The correct functioning of the converters is dependent upon close control of the oxygen concentration in the exhaust gas entering the catalyst.

The two catalytic converters are shaped differently to allow sufficient clearance between the body and transmission, but they remain functionally identical since they have the same volume and use the same active constituents.

The basic control loop comprises the engine (controlled system), the heated oxygen sensors (measuring elements), the engine management ECM (control) and the injectors and ignition (actuators). Other factors also influence the calculations of the ECM, such as air flow, air intake temperature and throttle position. Additionally, special driving conditions are compensated for, such as starting, acceleration, deceleration, overrun and full load.

The reliability of the ignition system is critical for efficient catalytic converter operation, since misfiring will lead to irreparable damage of the catalytic converter due to the overheating that occurs when unburned combustion gases are burnt inside it.

CAUTION: If the engine is misfiring, it should be shut down immediately and the cause rectified. Failure to do so will result in irreparable damage to the catalytic converter.

CAUTION: Ensure the exhaust system is free from leaks. Exhaust gas leaks upstream of the catalytic converter could cause internal damage to the catalytic converter.

CAUTION: Serious damage to the engine may occur if a lower octane number fuel than recommended is used. Serious damage to the catalytic converter and oxygen sensors will occur if leaded fuel is used.

Air : fuel ratio

The theoretical ideal air:fuel ratio to ensure complete combustion and minimise emissions in a spark-ignition engine is 14.7:1 and is referred to as the stoichiometric ratio.

The excess air factor is denoted by the Lambda symbol λ, and is used to indicate how far the air:fuel mixture ratio deviates from the theoretical optimum during any particular operating condition.

- When $\lambda = 1$, the air to fuel ratio corresponds to the theoretical optimum of 14.7:1 and is the desired condition for minimising emissions.
- When $\lambda > 1$, (i.e. $\lambda = 1.05$ to $\lambda = 1.3$) there is excess air available (lean mixture) and lower fuel consumption can be attained at the cost of reduced performance. For mixtures above $\lambda = 1.3$, the mixture ceases to be ignitable.
- When $\lambda < 1$, (i.e. $\lambda = 0.85$ to $\lambda = 0.95$) there is an air deficiency (rich mixture) and maximum output is available, but fuel economy is impaired.

The engine management system used with V8 engines operates in a narrower control range about the stoichiometric ideal between $\lambda = 0.97$ to 1.03 using closed-loop control techniques. When the engine is warmed up and operating under normal conditions, it is essential to maintain λ close to the ideal ($\lambda = 1$) to ensure the effective treatment of exhaust gases by the three-way catalytic converters installed in the downpipes from each exhaust manifold.

Changes in the oxygen content has subsequent effects on the levels of exhaust emissions experienced. The levels of hydrocarbons and carbon monoxide produced around the stoichiometric ideal control range are minimised, but peak emission of oxides of nitrogen are experienced around the same range.

Fuel metering

For a satisfactory combustion process, precise fuel injection quantity, timing and dispersion must be ensured. If the air:fuel mixture in the combustion chamber is not thoroughly atomized and dispersed during the combustion stroke, some of the fuel may remain unburnt which will lead to high HC emissions.

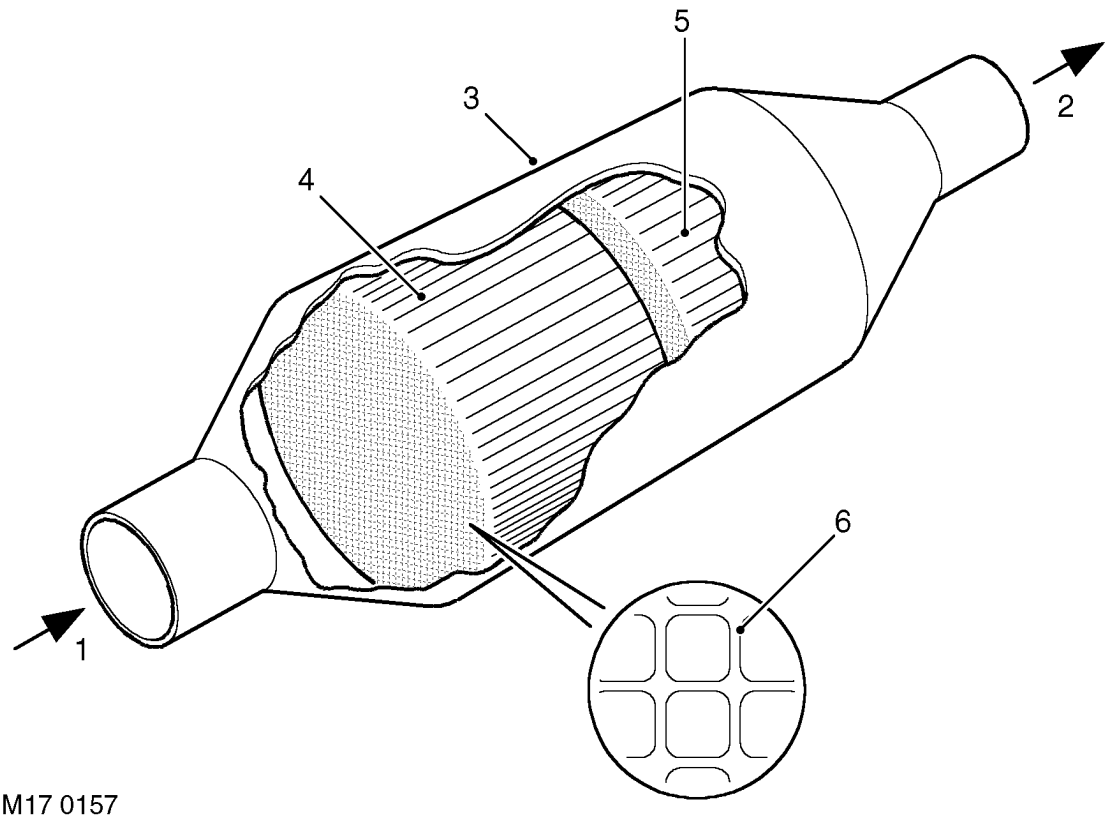
Ignition timing

The ignition timing can be changed to minimise exhaust emissions and fuel consumption in response to changes due to the excess air factor. As the excess air factor increases, the optimum ignition angle is advanced to compensate for delays in flame propagation.

Exhaust emission control components

The exhaust emission control components are described below:

Catalytic converter



M17 0157

1 Exhaust gas from manifold
2 Cleaned exhaust gas to tail pipe
3 Catalytic converter outer case
4 1st ceramic brick
5 2nd ceramic brick
6 Honeycomb structure

The catalytic converters are located in each of the front pipes from the exhaust manifolds.

The catalytic converter's housings are fabricated from stainless steel and are fully welded at all joints. Each catalytic converter contains two elements comprising of an extruded ceramic substrate which is formed into a honeycomb of small cells with a density of 62 cells / cm^2. The ceramic element is coated with a special surface treatment called 'washcoat' which increases the surface area of the catalyst element by approximately 7000 times. A coating is applied to the washcoat which contains the precious elements Platinum, Palladium and Rhodium in the following relative concentrations: **1 Pt : 21.6 PD : 1 Rh**

Catalytic converters for NAS low emission vehicles (LEVs) from 2000MY have active constituents of palladium and rhodium only. The active constituents are 14PD: 1Rh and the palladium coating is used to oxidise the carbon monoxide and hydrocarbons in the exhaust gas.

The metallic coating of platinum and palladium oxidize the carbon monoxide and hydrocarbons and convert them into water (H_2O) and carbon dioxide (CO_2). The coating of rhodium removes the oxygen from nitrogen oxide (NO_x) and converts it into nitrogen (N_2).

CAUTION: Catalytic converters contain ceramic material, which is very fragile. Avoid heavy impacts on the converter casing.

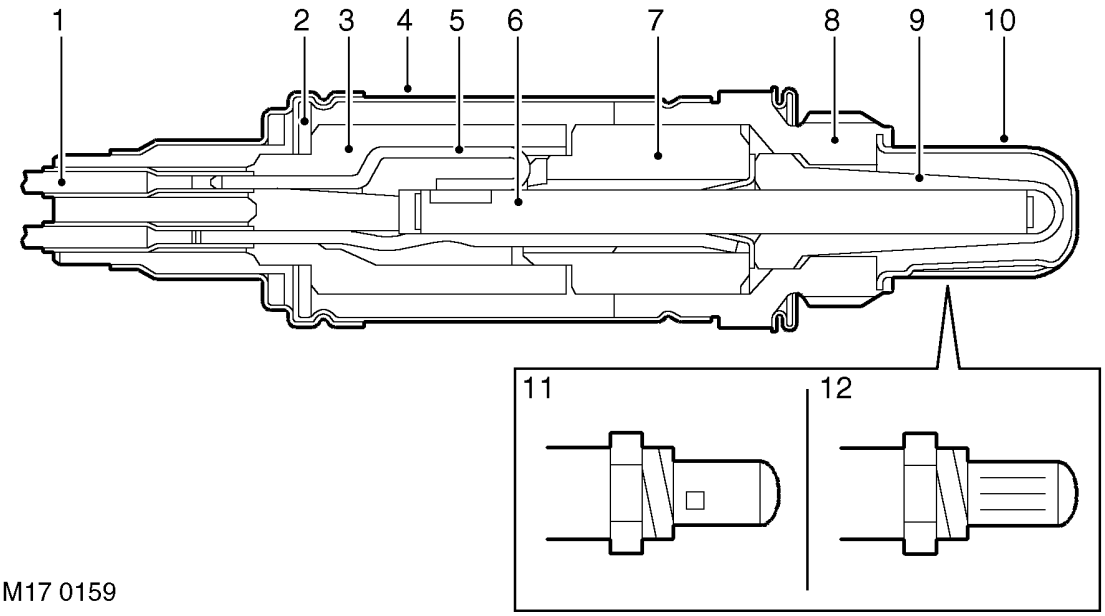
Downstream of the catalytic converters, the exhaust front pipes merge into a single pipe terminating at a flange joint which connects to the exhaust intermediate pipe.

WARNING: To prevent personal injury from a hot exhaust system, do not attempt to disconnect any components until the exhaust system has cooled down.

CAUTION: Serious damage to the catalytic converter will occur if leaded fuel is used. The fuel tank filler neck is designed to accommodate only unleaded fuel pump nozzles.

CAUTION: Serious damage to the engine may occur if a lower octane number fuel than recommended is used. Serious damage to the catalytic converter will occur if leaded fuel is used.

Heated oxygen sensor



M17 0159

1 Connection cable
2 Disc spring
3 Ceramic support tube
4 Protective sleeve
5 Clamp connection for heating element
6 Heating element
7 Contact element
8 Sensor housing
9 Active sensor ceramic
10 Protective tube
11 Post-catalytic converter sensor (NAS spec. only)
12 Pre-catalytic converter sensor

The heated oxygen sensor is an integral part of the exhaust emission control system and is used in conjunction with the catalytic converters and the engine management control unit to ensure that the air:fuel mixture ratio stays around the stoichiometric point of λ = 1, where the catalytic converters are most effective. Combinations of four (NAS only) or two heated lambda sensors are used in the exhaust system dependent on market legislation.

The heated oxygen sensor is screwed into threaded mountings welded into the top of the front exhaust pipes at suitable locations. They are used to detect the level of residual oxygen in the exhaust gas to provide an instantaneous indication of whether combustion is complete. By positioning sensors in the stream of exhaust gases from each separate bank of the exhaust manifold, the engine management system is better able to control the fuelling requirements on each bank independently of the other, so allowing much closer control of the air:fuel ratio and optimising catalytic converter efficiency.

Two pre-catalytic converter heated oxygen sensors are mounted in the front pipes for monitoring the oxygen content of the exhaust gas. NAS models also have two additional post-catalytic converter heated oxygen sensors in the exhaust front pipe.

CAUTION: HO2 sensors are easily damaged by dropping, over torquing, excessive heat or contamination. Care must be taken not to damage the sensor housing or tip.

The oxygen sensors consist of a ceramic body (Galvanic cell) which is a practically pure oxygen-ion conductor made from a mixed oxide of zirconium and yttrium. The ceramic is then coated with gas-permeable platinum, which when heated to a sufficiently high temperature (≥ 350° C) generates a voltage which is proportional to the oxygen content in the exhaust gas stream.

The heated oxygen sensor is protected by an outer tube with a restricted flow opening to prevent the sensor's ceramics from being cooled by low temperature exhaust gases at start up. The post-catalytic sensors have improved signal quality, but a slower response rate.

The pre-catalytic and post-catalytic converter sensors are not interchangeable, and although it is possible to mount them in transposed positions, their harness connections are of different gender and colour. **It is important not to confuse the sensor signal pins; the signal pins are gold plated, whilst the heater supply pins are tinned, mixing them up will cause contamination and adversely affect system performance.**

Each of the heated oxygen sensors have a four pin connector with the following wiring details:

- Sensor signal ground (grey wire – connects to engine management ECM)
- Sensor signal (black wire – connects to engine management ECM)
- Heater drive (white wire – connects to engine management ECM)
- Heater supply (white wire – connects to fuse 2, underbonnet fuse box)

The ECM connector pins for exhaust emission control are listed in the following table:

ECM Connector 2 (C635) pin-out details for exhaust emission control system

Pin Number	Function	Signal Type	Control
2-01	Post-cat sensor heater (RH) - NAS only	Output, Drive	PWM, 12 - 0V
2-07	Post-cat sensor heater (LH) - NAS only	Output, Drive	PWM, 12 - 0V
2-08	Post-cat sensor (RH) - NAS only	Ground, Signal	0V
2-09	Pre-cat sensor (LH)	Ground, Signal	0V
2-10	Pre-cat sensor (RH)	Ground, Signal	0V
2-11	Post-cat sensor (LH) - NAS only	Ground, Signal	0V
2-13	Pre-cat sensor heater (RH)	Output, Drive	PWM, 12 - 0V
2-14	Post-cat sensor (RH) - NAS only	Input, Signal	Analogue, 0 - 1V
2-15	Pre-cat sensor (LH)	Input, Signal	Analogue, 0 - 1V
2-16	Pre-cat sensor (RH)	Input, Signal	Analogue, 0 - 1V
2-17	Post-cat sensor (LH) - NAS only	Input, Signal	Analogue, 0 - 1V
2-19	Pre-cat sensor heater (LH)	Output, Drive	PWM, 12 - 0V

The heated oxygen sensors should be treated with extreme care, since the ceramic material within them can be easily cracked if dropped, banged or over-torqued; the sensors should be torqued to the recommended values indicated in the repair procedures. Apply anti-seize compound to the sensor's threads when refitting.

WARNING: Some types of anti-seize compound used in service are a health hazard. Avoid skin contact.

WARNING: To prevent personal injury from a hot exhaust system, do not attempt to disconnect any components until the exhaust system has cooled down.

CAUTION: Do not allow anti-seize compound to come into contact with tip of sensor or enter exhaust system.

NOTE: A new HO2 sensor is supplied pre-treated with anti-seize compound.

Evaporative emission control system

The evaporation emission control (EVAP) system is used to reduce the level of hydrocarbons emitted into the atmosphere from the fuel system. The system comprises an EVAP canister which stores the hydrocarbons from the fuel tank, pressure valves, vent lines and a purge control solenoid valve.

Fuel vapour is stored in the canister until it is ready to be purged to the inlet manifold under the control of the Engine Control Module (ECM).

A two-way valve is included in the vent line between the fuel tank and the EVAP canister in all markets except NAS.

A fuel vapour separator is fitted next to the fuel filler neck, the construction is different between NAS and ROW vehicles; the liquid vapour separator (LVS) on NAS vehicles is an L-shaped metal tube and for all other markets it is an integral part of the moulded plastic filler neck.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

NAS vehicles have stainless steel filler necks whilst all other markets use moulded plastic filler necks. On NAS fillers, a valve closes the roll-over valve (ROV) vent line when the fuel filler cap is removed; for all other markets a pressure relief valve is fitted into the ROV vent line.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

Four ROV's are fitted to the fuel tank, for NAS vehicles the valves are fitted inside the fuel tank and for ROW vehicles the ROV's are welded external to the fuel tank. Nylon vent lines from the ROV's connect to the liquid vapour separator allowing vapour to pass to the EVAP canister via the LVS. To prevent the canister from being overloaded (particularly in hot ambient conditions) and to prevent wastage of fuel, the vapour is allowed to condense within the LVS and flow back through the ROVs into the tank.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

Pressure / vacuum relief valves are incorporated into the fuel filler cap which operate in the event of an evaporation system failure (e.g. blockage in the evaporation system line to atmosphere). The cap relieves fuel tank pressure to atmosphere at approximately 1.8 to 2.0 psi (12 to 14 kPa) and opens in the opposite direction at approximately – 0.7 psi (- 5kPa) vacuum. All plastic bodied fuel fillers are fitted with a tank overpressure relief valve.

A vent line flow restrictor (anti-trickle valve) is fitted to the filler pipe in the line between the tank and the canister on NAS vehicles. The purpose of the anti-trickle valve is to preserve the vapour space in the tank by blocking the vent line during the fuel filling process. The valve is operated by the action of inserting the filler gun, so that when the fuel in the tank reaches the level of the filling breather, flow cut off occurs due to fuel filling the filler pipe.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

The breather ports from the EVAP canister are located high up in the engine bay (CVS unit on NAS vehicles with vacuum type, fuel evaporation leak detection capability; via an air filter on NAS vehicles with positive pressure type, fuel evaporation leak detection capability; snorkel tubes on ROW vehicles), to prevent water ingress during vehicle wading.

The ECM connectors and pins which are pertinent to evaporative emission control are listed in the following table:

Connector / Pin No.	Function	Signal type	Control
C0635-23	Main relay output	Output drive	Switch to ground
C0635-24	Leak detection pump motor (NAS vehicles with positive pressure type EVAP system leak detection only)	Output drive	Switch to ground
C0636-3	Purge valve drive	Output signal	PWM 12 - 0V
C0636-6	Fuel tank pressure sensor (NAS vehicles with vacuum type EVAP system leak detection only)	Ground	0V
C0636-30	Canister vent solenoid (CVS) valve (NAS vehicles with vacuum type EVAP system leak detection only) / Fuel leak detection pump (NAS vehicles with positive pressure type EVAP system leak detection only)	Output drive	Switch to ground

Connector / Pin No.	Function	Signal type	Control
C0637-9	Fuel tank pressure sensor (NAS vehicles with vacuum type EVAP system leak detection only)	Output reference	5V
C0637-12	Analogue fuel level (NAS vehicles with positive pressure type EVAP system leak detection only)	Input	Analogue 0 - 5V
C0637-14	Fuel tank pressure sensor (NAS vehicles with vacuum type EVAP system leak detection only)	Input signal	Analogue 0 - 5V
C0637-20	MIL "ON"	Output drive	Switch to ground

Fuel leak detection system (vacuum type) – NAS only

The advanced evaporative loss control system equipped with a vacuum type, fuel evaporation leak detection capability is similar to the standard evaporative loss system, but also includes additional components to enable the engine control module (ECM) to perform a fuel evaporation leak detection test. The system includes an EVAPs canister and purge valve, and in addition, a canister vent solenoid (CVS) valve and a fuel tank pressure sensor.

The function of the CVS valve is to block the atmospheric vent side of the EVAP canister under the control of the ECM so that an evaporation system leak check can be performed. The test is carried out when the vehicle is stationary and the engine is running at idle speed. The system test uses the natural rate of fuel evaporation and engine manifold depression. Failure of the leak check will result in illumination of the Malfunction Indicator Lamp (MIL).

The fuel evaporation leak detection is part of the On-Board Diagnostics (OBD) strategy and it is able to determine vapour leaks from holes or breaks greater than 1 mm (0.04 in.) in diameter. Any fuel evaporation system leaks which occur between the output of the purge valve and the connection to the inlet manifold cannot be determined using this test, but these will be detected through the fuelling adaption diagnostics.

Fuel leak detection system (positive pressure type) – NAS only

The evaporative loss control system equipped with a positive pressure type, fuel evaporation leak detection capability is similar to the vacuum type, but it is capable of detecting smaller leaks by placing the evaporation system under the influence of positive air pressure. The system includes an EVAPs canister and purge valve, and in addition, a leak detection pump comprising a motor and solenoid valve.

The solenoid valve contained in the leak detection pump assembly performs a similar function to the CVS valve utilised on the vacuum type pressure test. The solenoid valve is used to block the atmospheric vent side of the EVAP canister under the control of the ECM so that an EVAP system leak check can be performed. At the same time, pressurised air from the pump is allowed past the valve into the EVAP system to set up a positive pressure. The test is carried out at the end of a drive cycle when the vehicle is stationary and the ignition is switched off. The test is delayed for a brief period (approximately 10 seconds) after the engine is switched off to allow any slosh in the fuel tank to stabilise. Component validity checks and pressure signal reference checking takes a further 10 seconds before the pressurised air is introduced into the EVAP system.

During reference checking, the purge valve is closed and the leak detection pump solenoid valve is not energised, while the leak detection pump is operated. The pressurised air is bypassed through a restrictor which corresponds to a 0.5 mm (0.02 in) leak while the current consumption of the leak detection pump motor is monitored.

The system test uses the leak detection pump to force air into the EVAP system when the purge valve and solenoid valves are both closed (solenoid valve energised), to put the evaporation lines, components and fuel tank under the influence of positive air pressure. Air is drawn into the pump through an air filter which is located in the engine compartment.

The fuel leak detection pump current consumption is monitored by the ECM while the EVAP system is under pressure, and compared to the current noted during the reference check. A drop in the current drawn by the leak detection pump motor, indicates that air is being lost through holes or leaks in the system which are greater than the reference value of 0.5 mm (0.02 in). An increase in the current drawn by the leak detection pump motor, indicates that the EVAP system is well sealed and that there are no leaks present which are greater than 0.5 mm (0.02 in).

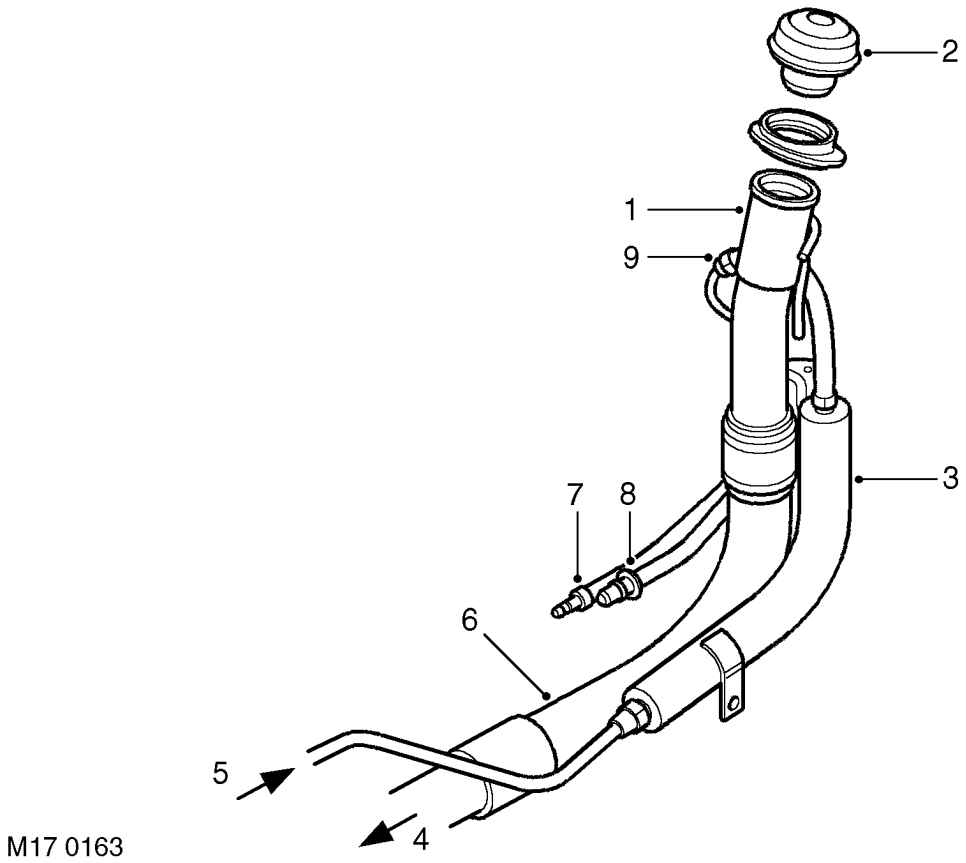
The presence of leakage points indicates the likelihood of hydrocarbon emissions to atmosphere from the evaporation system outside of test conditions and the necessity for rectification work to be conducted to seal the system. Failure of the leak check will result in illumination of the Malfunction Indicator Lamp (MIL).

The fuel evaporation leak detection is part of the On-Board Diagnostics (OBD) strategy and it is able to determine vapour leaks from holes or breaks down to 0.5 mm (0.02 in.) diameter. Any fuel evaporation leaks which occur between the output of the purge valve and the connection to the inlet manifold cannot be determined using this test, but these will be detected through the fuelling adaption diagnostics.

Evaporative emission control components

The evaporative emission control components and the fuel evaporation leak detection test components (NAS only) are described below:

Fuel vapour separator (NAS version illustrated)



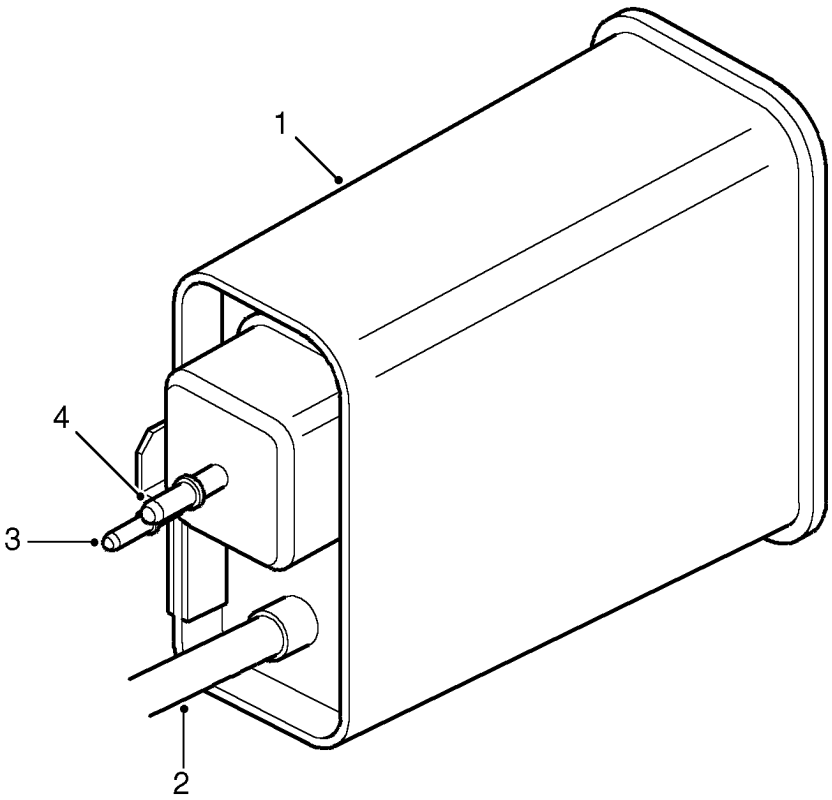
M17 0163

1 Filler neck
2 Filler cap
3 Liquid vapour separator (LVS)
4 To fuel tank
5 Vapour from fuel tank to liquid vapour separator (LVS)
6 Rubber hose
7 Pipe connection to OBD sensor in fuel pump (NAS vehicles with vacuum type leak detection system only)
8 Vent pipe to EVAP canister
9 Anti-trickle valve (NAS only)

The fuel vapour separator is located under the rear wheel arch next to the filler neck and protected by the wheel arch lining. The connections to the separator unit are quick release devices at the end of the flexible hoses which connect the fuel tank to the inlet side of the separator and the outlet of the separator to the evaporation vent line.

The fuel separator construction is different between NAS and ROW vehicles; the LVS on NAS vehicles is an L-shaped metal tube and for all other markets is an integral part of the moulded plastic filler neck.

EVAP (charcoal) canister



M17 0164

1 EVAP canister
2 Port to breather tube
3 Port – vent line from fuel tank
4 Port – purge line

The EVAP canister is mounted on a bracket fitted beneath the vehicle on the RH side of the chassis. The EVAP canister ports face towards the front of the vehicle. The EVAP canister has inscriptions next to each port for identification of the 'purge', 'tank' and 'air' connections.

The purge line from the EVAP canister is connected to the back of the inlet manifold plenum, after the throttle body via a purge valve. The pipe between the EVAP canister and the purge valve is routed over the transmission and into the LH side of the engine bay. The pipe clips to the purge port on the EVAP canister by means of a straight quick-fit connector and the connection is covered by a rubber seal which is held in position on the port stub pipe.

The vent line from the fuel tank to the EVAP canister connects to the vent port on the canister by means of an elbowed quick-fit connector. The line passes along the chassis behind the EVAP canister and terminates in a straight female quick-fit connector to the fuel vent line at the fuel filler.

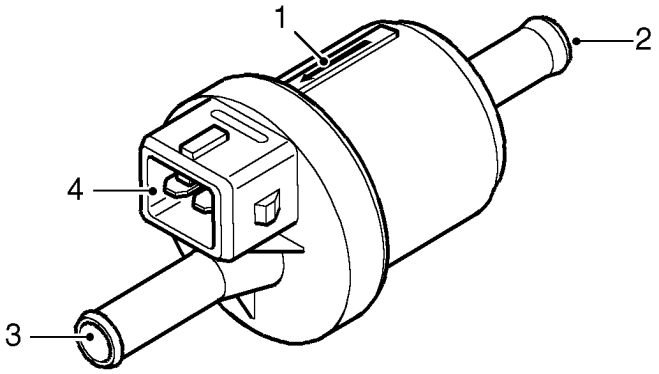
The plastic pipe to the atmosphere vent line connects to the port on the EVAP canister by means of a short rubber hose and metal band clips. The atmosphere end of the plastic pipe terminates in a quick fit connector to the pipe leading to the CVS unit on NAS vehicles with vacuum type, EVAP system leak detection and two snorkel tubes situated behind the engine at the bulkhead on ROW vehicles. The bore of the plastic breather pipe is larger on NAS vehicles than on ROW vehicles.

For NAS vehicles with positive pressure, EVAP system leak detection capability, the atmosphere vent line from the EVAP canister connects to a port on the fuel leak detection pump via a short, large bore hose which is secured to the component ports by crimped metal clips at each end. A large bore plastic hose from the top of the leak detection pump is routed to the RH side of the engine bay where it connects to an air filter canister. Under normal operating conditions (when the fuel leak detection solenoid valve is not energised), the EVAP canister is able to take in clean air via the air filter, through the pipework and past the open solenoid valve to allow normal purge operation to take place and release any build up of EVAP system pressure to atmosphere.

The EVAP system pipes are clipped at various points along the pipe runs and tied together with tie straps at suitable points along the runs.

The NAS and ROW EVAP canisters are of similar appearance, but use charcoal of different consistency. The ROW vehicles use granular charcoal of 11 bwc (butane working capacity) and NAS vehicles use pelletised charcoal with a higher absorption capacity of 15 bwc. All canisters are of rectangular shape and have capacities of 1.8 litres (3 1/8 imp. pts) with purge foam retention.

Purge valve



M17 0166

1 Direction of flow indicator
2 Inlet port – from EVAP canister
3 Outlet port – to inlet manifold
4 Integral electrical connector

The EVAP canister purge valve is located in the engine bay at the LH side of the engine intake manifold. The valve is held in position by a plastic clip which secures the inlet pipe of the purge valve to a bracket mounted at the rear of the engine compartment. On NAS vehicles with secondary air injection, the purge valve is fixed to a metal bracket together with the SAI vacuum solenoid valve; the purge valve is fixed to the bracket by two plastic clips.

A nylon pipe connects the outlet of the purge valve to the stub pipe on the plenum chamber via a short rubber hose. The connector to the plenum chamber is a quick-release type, plastic 90° female elbow; the connection is covered by a rubber seal which is held in position on the port stub pipe.

A service port is connected in line between the EVAP canister and the inlet side of the purge valve and is rated at 1 psi maximum regulated pressure. The service port must be mounted horizontally and is located close to the bulkhead at the rear of the engine bay. The service point is used by dealers for pressure testing using specialist nitrogen test equipment for localising the source of small leaks.

The purge valve has a plastic housing, and a directional arrow is moulded onto the side of the casing to indicate the direction of flow. The head of the arrow points to the outlet side of the valve which connects to the plenum chamber.

Purge valve operation is controlled by the engine control module (ECM). The purge valve has a two-pin electrical connector which links to the ECM via the engine harness. Pin-1 of the connector is the power supply source from fuse 2 in the engine compartment fusebox, and pin-2 of the connector is the switched earth from the ECM (pulse width modulated (PWM) signal) which is used to control the purge valve operation time. **Note that the harness connector for the purge valve is black, and must not be confused with the connector for the Secondary Air Injection vacuum solenoid valve which is grey.**

When the purge valve is earthed by the ECM, the valve opens to allow hydrocarbons stored in the EVAP canister to be purged to the engine inlet manifold for combustion.

If the purge valve breaks or becomes stuck in the open or closed position, the EVAP system will cease to function and there are no default measures available. The ECM will store the fault in memory and illuminate the MIL warning lamp if the correct monitoring conditions have been achieved (i.e. valve status unchanged for 45 seconds after engine has been running for 15 minutes). If the purge valve is stuck in the open position, a rich air:fuel mixture is likely to result at the intake manifold, this could cause the engine to misfire and the fuelling adaptions will change.

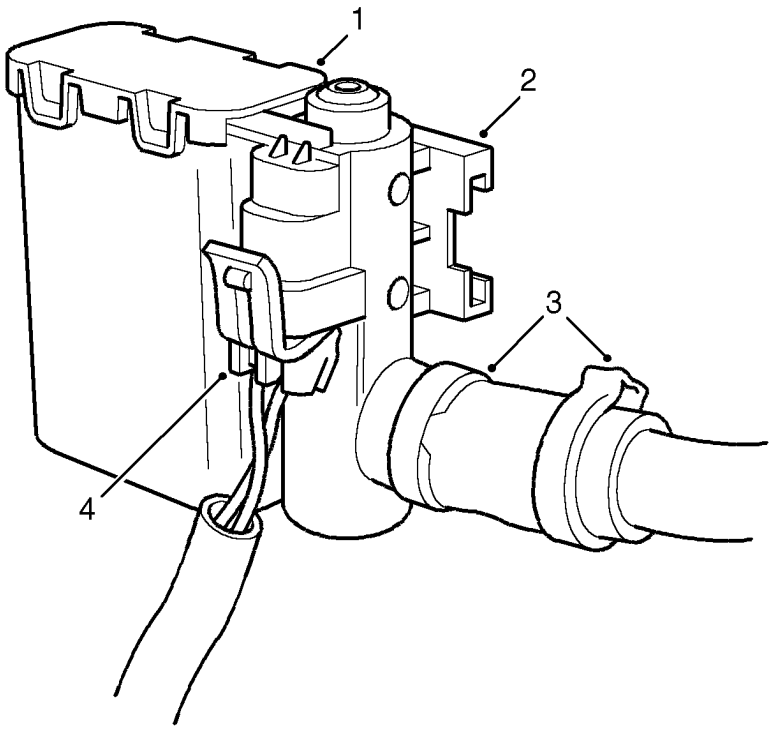
The following failure modes are possible:

- Sticking valve
- Valve blocked
- Connector or harness wiring fault (open or short circuit)
- Valve stuck open

If the purge valve malfunctions, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

P-code	Description
P0440	Purge valve not sealing
P0444	Purge valve open circuit
P0445	Purge valve short circuit to ground
P0443	Purge valve short circuit to battery voltage

Canister Vent Solenoid (CVS) unit – (NAS with vacuum type, fuel evaporation leak detection system only)



M17 0165

1 CVS unit
2 Mounting bracket
3 Spring clips to pipe from EVAP canister
4 Harness connector

The canister vent solenoid (CVS) valve is mounted on a slide-on bracket which is riveted to the cruise control bracket at the right hand side of the engine compartment. The vent pipe from the EVAP canister is connected to a stub pipe on the CVS unit via a hose and plastic pipe combination. A two-pin connector links to the engine management ECM via the engine harness for solenoid control; one of the wires is the supply feed from fuse No.2 in the engine compartment fusebox, the other wire is the valve drive line to the ECM. The solenoid is operated when the ECM grounds the circuit.

The valve is normally open, allowing any build up of air pressure within the evaporation system to escape, whilst retaining the environmentally harmful hydrocarbons in the EVAP canister. When the ECM is required to run a fuel system test, the CVS valve is closed to seal the system. The ECM is then able to measure the pressure in the fuel evaporative system using the fuel tank pressure sensor.

The ECM performs electrical integrity checks on the CVS valve to determine wiring or power supply faults. The ECM can also detect a valve blockage if the signal from the fuel tank pressure sensor indicates a depressurising fuel tank while the CVS valve should be open to atmosphere.

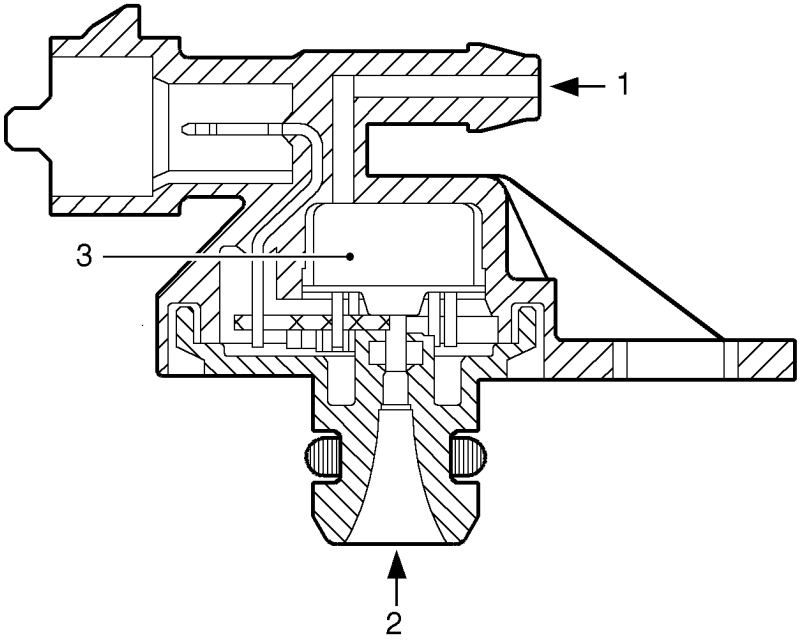
The following failure modes are possible:

- Connector or harness wiring fault (open or short circuit)
- Valve stuck open or shut
- Valve blocked

If the CVS valve malfunctions, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

P-code	Description
P0446	CVS valve / pipe blocked
P0447	CVS valve open circuit
P0448	CVS valve short circuit to ground
P0449	CVS valve short circuit to battery voltage

Fuel Tank Pressure Sensor (NAS vehicles with vacuum type leak detection system only)



M17 0167

1 Ambient pressure
2 Tank pressure
3 Sensor cell

The fuel tank pressure sensor is located in the top flange of the fuel tank sender / fuel pump module and is a non-serviceable item (i.e. if the sensor becomes defective, the complete fuel tank sender unit must be replaced). The fuel tank pressure sensor connector is accessible through the fuel pump access hatch in the boot area floor of the vehicle.

The pressure sensor is a piezo-resistive sensor element with associated circuitry for signal amplification and temperature compensation. The active surface is exposed to ambient pressure by an opening in the cap and by the reference port. It is protected from humidity by a silicon gel. The tank pressure is fed up to a pressure port at the back side of the diaphragm.

For systems utilising the vacuum method for determining evaporation leaks, the sensor is used to monitor for a drop in vacuum pressure. The evaporation system is sealed by the CVS valve and purge valve after a vacuum has been previously set up from the intake manifold while the purge valve is open and the CVS valve is closed. If any holes or leaks are present at the evaporation system joints, the vacuum pressure will gradually drop and this change in pressure will be detected by the fuel tank pressure sensor. This system is capable of determining leaks down to 1 mm (0.04 in.) in diameter.

The fuel tank pressure sensor is part of the NAS OBD system, a component failure will not be noticed by the driver, but if the ECM detects a fault, it will be stored in the diagnostic memory and the MIL light will be illuminated on the instrument pack. Possible failures are listed below:

- Damaged or blocked sensor
- Harness / connector faulty
- Sensor earthing problem
- Open circuit
- Short circuit to battery voltage
- Short circuit to ground
- ECM fault

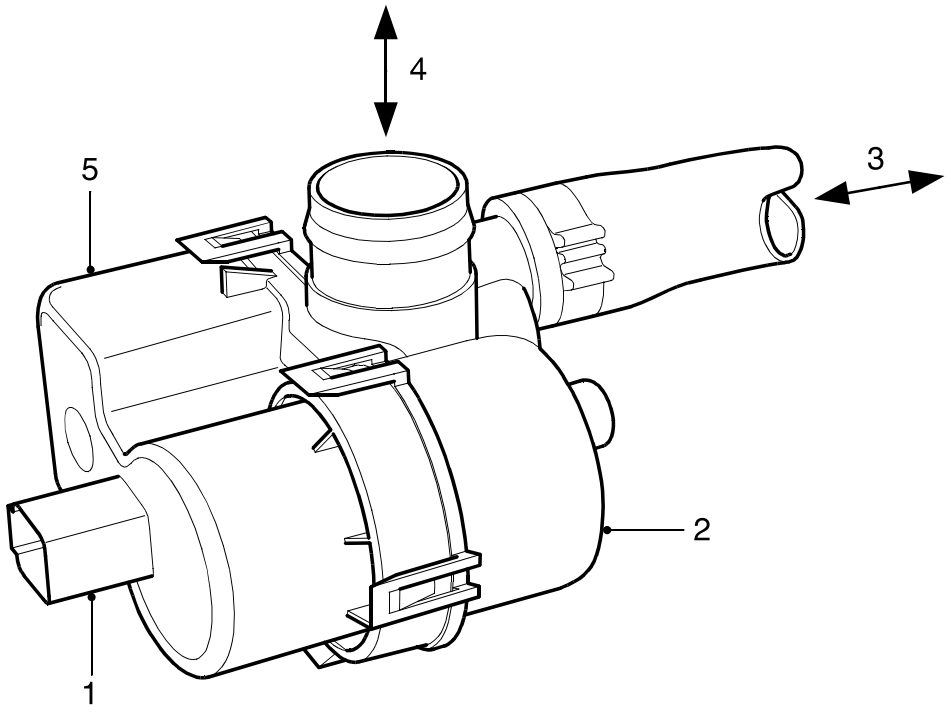
Possible failure symptoms of the fuel tank pressure sensor are listed below:

- Fuel tank pressure sensor poor performance
- Fuel tank pressure sensor low range fault
- Fuel tank pressure sensor high range fault

If the fuel tank pressure sensor should malfunction, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

P-code	Description
P0451	Fuel tank pressure signal stuck high within range
P0452	Fuel tank pressure signal short circuit to battery voltage (out of range - High)
P0453	Fuel tank pressure signal short circuit to ground or open circuit (out of range - Low)

Leak Detection Pump (NAS vehicles with positive pressure EVAP system leakage test only)



M17 0213

1 Harness connector
2 Leak detection pump motor
3 Atmosphere connection to/from EVAP canister
4 Atmosphere connection to/from air filter
5 Leak detection pump solenoid valve

The fuel evaporation leak detection pump is mounted forward of the EVAP canister on a bracket fitted beneath the vehicle on the RH side of the vehicle chassis. The leak detection pump is fixed to the bracket by three screws through the bottom of the bracket.

A short hose connects between the atmosphere vent port of the EVAP canister and a port at the rear of the fuel evaporation leak detection pump. The hose is secured to the ports at each end by crimped metal band clips.

An elbowed quick fit connector on the top of the fuel evaporation leak detection pump connects to atmosphere via a large bore pipe. The pipe is routed along the underside of the vehicle chassis and up into the RH side of the engine compartment where it connects to an air filter canister.

The leak detection pump incorporates a 3–pin electrical connector. Pin-1 is the earth switched supply to the ECM for control of the pump solenoid valve. Pin-2 is the earth switched supply to the ECM for the operation of the pump motor. Pin-3 is the power supply to the pump motor and solenoid valve and is switched on at system start up via the main relay and fuse 2 in the engine compartment fusebox.

Under normal circumstances (i.e. when the leak detection pump is not operating and the solenoid is not energised), the EVAP canister vent port is connected to atmosphere via the open solenoid valve.

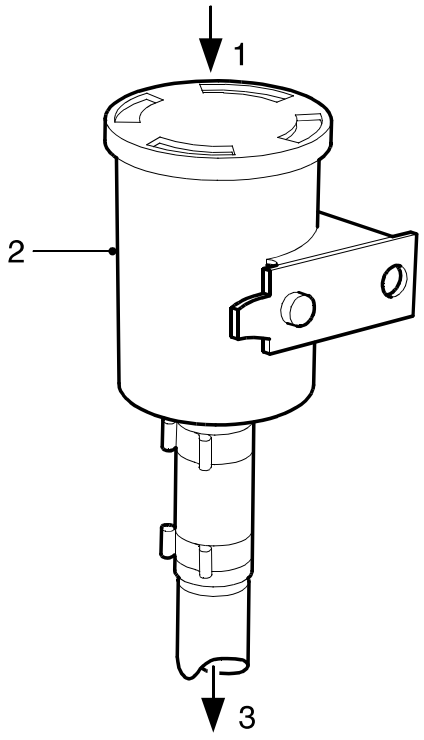
The pump is operated at the end of a drive cycle when the vehicle is stationary and the ignition is switched off.

The leak detection pump module contains an integral air by-pass circuit with restrictor (reference-leak orifice) which is used for providing a reference value for the leak detection test. The restrictor corresponds to an air leak equivalent to 0.5 mm (0.02 in) diameter. With the solenoid valve open and the purge valve closed, the pump forces pressurised air through the orifice while the current drawn by the leak detection pump motor is monitored to obtain the reference value. The orifice must be kept free from contamination, otherwise the reference restriction may appear less than for a 0.5 mm leak and consequently adversely affect the diagnostic results.

During the leakage test, the solenoid valve is energised, closing the atmosphere vent line between the EVAP canister and atmosphere and opening a path to the pressurised air supplied from the leak detection pump motor. Air is pumped into the EVAP system, while the current drawn by the pump motor is monitored. The current drawn during the leakage test is compared against the value obtained during the reference check, to determine if an EVAP system leak is present.

The fuel leak detection pump is powered from a 12V supply and operates at a working pressure of 3 kPa.

Air filter – (NAS vehicles with positive pressure leak detection system only)



M17 0203

1 Air vents through canister lid
2 Air filter canister
3 To fuel leak detection pump (EVAP canister atmosphere vent)

A paper element air filter (40 µm) is located in a plastic canister at the RH side of the engine compartment. The air filter canister is fixed to the cruise control mounting bracket by a single nut and bolt. A large bore plastic pipe is connected to a port at the base of the air filter canister and is secured to the port by a short nylon hose and two crimped metal band clips.

The air filter is used to prevent particulate contaminants down to 40 µm from entering the fuel leak detection pump. A press-fit lid on top of the canister contains slots to allow the passage of air into and out of the EVAP system.

The bottom end of the paper element is sealed to the canister and is non-serviceable (i.e fit for life). If necessary, the canister and paper filter must be replaced as a single, complete assembly.

Secondary air injection system

The secondary air injection (SAI) system comprises the following components:

- Secondary air injection pump
- SAI vacuum solenoid valve
- SAI control valves (2 off, 1 for each bank of cylinders)
- SAI pump relay
- Vacuum reservoir
- Vacuum harness and pipes

The secondary air injection system is used to limit the emission of carbon monoxide (CO) and hydrocarbons (HCs) that are prevalent in the exhaust during cold starting of a spark ignition engine. The concentration of hydrocarbons experienced during cold starting at low temperatures are particularly high until the engine and catalytic converter reach normal operating temperature. The lower the cold start temperature, the greater the prevalence of hydrocarbons emitted from the engine.

There are several reasons for the increase of HC emissions at low cold start temperatures, including the tendency for fuel to be deposited on the cylinder walls, which is then displaced during the piston cycle and expunged during the exhaust stroke. As the engine warms up through operation, the cylinder walls no longer retain a film of fuel and most of the hydrocarbons will be burnt off during the combustion process.

The SAI pump is used to provide a supply of air into the exhaust ports in the cylinder head, onto the back of the exhaust valves, during the cold start period. The hot unburnt fuel particles leaving the combustion chamber mix with the air injected into the exhaust ports and immediately combust. This subsequent combustion of the unburnt and partially burnt CO and HC particles help to reduce the emission of these pollutants from the exhaust system. The additional heat generated in the exhaust manifold also provides rapid heating of the exhaust system catalytic converters. The additional oxygen which is delivered to the catalytic converters also generate an exothermic reaction which causes the catalytic converters to 'light off' quickly.

The catalytic converters only start to provide effective treatment of emission pollutants when they reach an operating temperature of approximately 250°C (482°F) and need to be between temperatures of 400°C (752°F) and 800°C (1472°F) for optimum efficiency. Consequently, the heat produced by the secondary air injection “afterburning”, reduces the time delay before the catalysts reach an efficient operating temperature.

The engine control module (ECM) checks the engine coolant temperature when the engine is started, and if it is below 60° C (131°F), the SAI pump is started. Secondary air injection will remain operational for a period controlled by the ECM (76 seconds for NAS vehicles, 64 seconds for EU-3 vehicles). The SAI pump operation can be cut short due to excessive engine speed or load.

Air from the SAI pump is supplied to the SAI control valves via pipework and an intermediate T-piece which splits the air flow evenly to each bank.

At the same time the secondary air pump is started, the ECM operates a SAI vacuum solenoid valve, which opens to allow vacuum from the reservoir to be applied to the vacuum operated SAI control valves on each side of the engine. When the vacuum is applied to the SAI control valves, they open simultaneously to allow the air from the SAI pump through to the exhaust ports. Secondary air is injected into the inner most exhaust ports on each bank.

When the ECM breaks the ground circuit to de-energise the SAI vacuum solenoid valve, the vacuum supply to the SAI control valves is cut off and the valves close to prevent further air being injected into the exhaust manifold. At the same time as the SAI vacuum solenoid valve is closed, the ECM opens the ground circuit to the SAI pump relay, to stop the SAI pump.

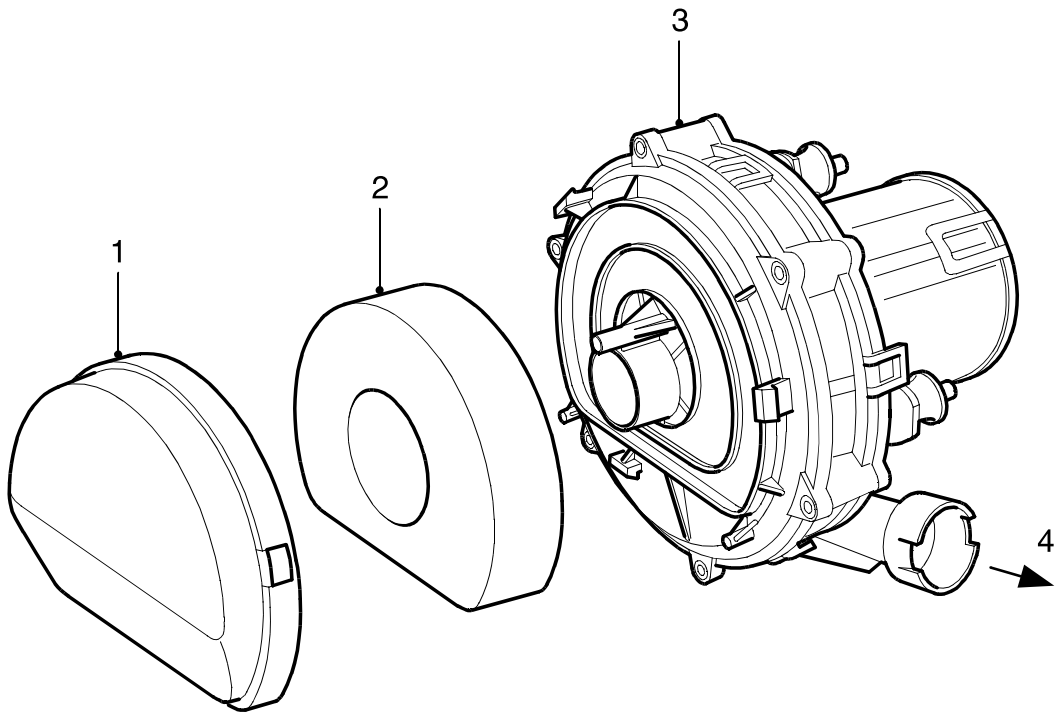
A vacuum reservoir is included in the vacuum line between the intake manifold and the SAI vacuum solenoid valve. This prevents changes in vacuum pressure from the intake manifold being passed on to cause fluctuations of the secondary air injection solenoid valve. The vacuum reservoir contains a one way valve and ensures a constant vacuum is available for the SAI vacuum solenoid valve operation. This is particularly important when the vehicle is at high altitude.

The ECM connector and pins pertinent for secondary air injection are listed in the following table:

Connector / Pin No.	Description	Signal type	Control
C0635-23	Main relay output	Output drive	Switch to ground
C0636-4	Secondary air injection vacuum solenoid valve control	Output, drive	Switch to ground
C0636-16	Secondary air injection pump relay control	Output drive	Switch to ground
C0636-21	Coolant temperature (ECT) sensor	Ground	0V
C0636-22	Coolant temperature (ECT) sensor	Input signal	Analogue 0 - 5V
C0637-20	MIL "ON"	Output drive	Switch to ground

Secondary air injection system components
The secondary air injection (SAI) system components (NAS only) are described below:

Secondary air injection (SAI) pump



M17 0204

1 SAI pump cover
2 Foam filter
3 SAI pump
4 Pressurised air to exhaust manifolds

The SAI pump is attached to a bracket at the rear RH side of the engine compartment and is fixed to the bracket by three studs and nuts. The pump is electrically powered from a 12V battery supply via a dedicated relay and supplies approximately 35kg/hr of air when the vehicle is at idle in Neutral/Park on a start from 20°C (68°F).

Air is drawn into the pump through vents in its front cover and is then passed through a foam filter to remove particulates before air injection. The air is delivered to the exhaust manifold on each side of the engine through a combination of plastic and metal pipes.

The air delivery pipe is a flexible plastic type, and is connected to the air pump outlet via a plastic quick-fit connector. The other end of the flexible plastic pipe connects to the fixed metal pipework via a short rubber hose. The part of the flexible plastic pipe which is most vulnerable to engine generated heat is protected by heat reflective sleeving. The metal delivery pipe has a fabricated T-piece included where the pressurised air is split for delivery to each exhaust manifold via the SAI control valves.

The pipes from the T-piece to each of the SAI control valves are approximately the same length, so that the pressure and mass of the air delivered to each bank will be equal. The ends of the pipes are connected to the inlet port of each SAI control valve through short rubber hose connections.

The T-piece is mounted at the rear of the engine (by the ignition coils) and features a welded mounting bracket which is fixed to the engine by two studs and nuts.

The foam filter in the air intake of the SAI pump provides noise reduction and protects the pump from damage due to particulate contamination. In addition, the pump is fitted on rubber mountings to help prevent noise which is generated by pump operation from being transmitted through the vehicle body into the passenger compartment.

If the secondary air injection pump malfunctions, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

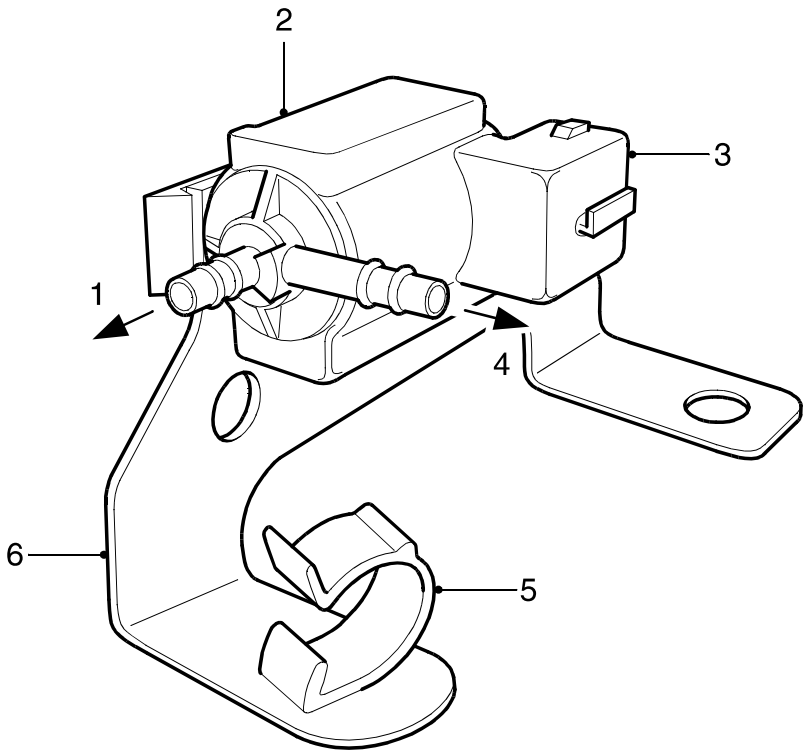
P-code	Description
P0418	Secondary air injection pump powerstage fault (e.g. - SAI pump relay fault / SAI pump or relay not connected / open circuit / harness damage).

Secondary air injection (SAI) pump relay

The secondary air injection pump relay is located in the engine compartment fusebox. The engine control module (ECM) is used to control the operation of the SAI pump via the SAI pump relay. Power to the coil of the relay is supplied from the vehicle battery via the main relay and the ground connection to the coil is via the ECM.

Power to the SAI pump relay contacts is via fusible link FL2 which is located in the engine compartment fusebox.

Secondary air injection (SAI) vacuum solenoid valve



M17 0211

1 Vacuum port to intake manifold (via vacuum reservoir)
2 SAI vacuum solenoid valve
3 Electrical connector
4 Vacuum port to vacuum operated SAI control valves
5 Purge valve clip
6 Mounting bracket

The SAI vacuum solenoid valve is located at the rear LH side of the engine and is electrically operated under the control of the ECM. The SAI vacuum solenoid valve is mounted on a bracket together with the EVAP system purge valve.

Vacuum to the SAI vacuum solenoid valve is provided from the intake manifold depression via a vacuum reservoir. A small bore vacuum hose with rubber elbow connections at each end provides the vacuum route between the vacuum reservoir and SAI vacuum solenoid valve. A further small bore vacuum hose with a larger size elbow connector is used to connect the SAI vacuum solenoid valve to the SAI control valves on each side of the engine via an intermediate connection. The SAI vacuum solenoid valve port to the SAI control valves is located at a right angle to the port to the vacuum reservoir.

The intermediate connection in the vacuum supply line is used to split the vacuum equally between the two SAI control valves. The vacuum hose intermediate connection is located midpoint in front of the inlet manifold. All vacuum hose lines are protected by flexible plastic sleeving.

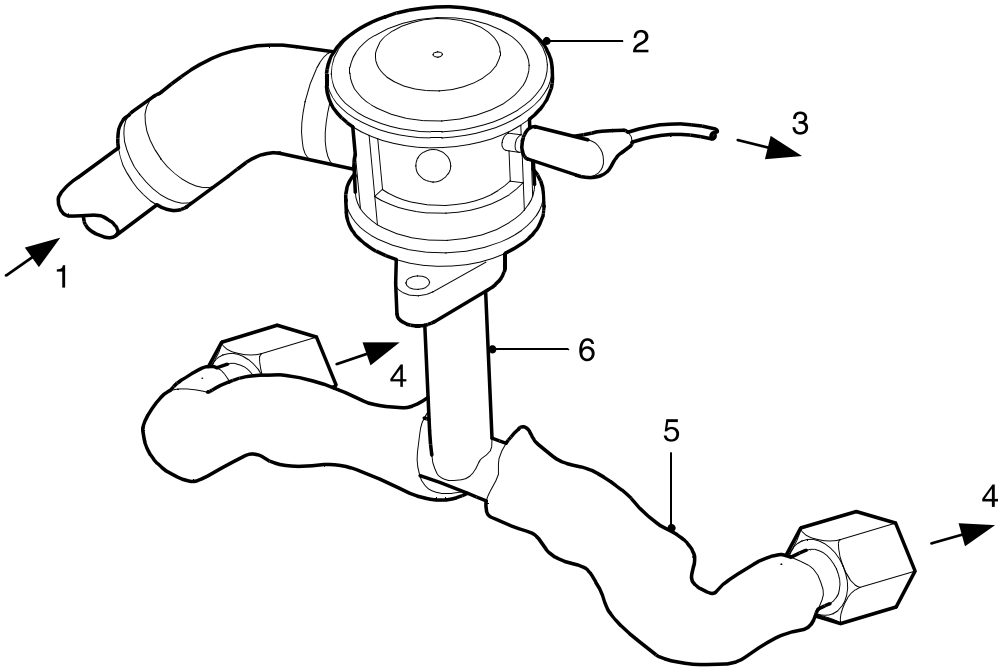
Electrical connection to the SAI vacuum solenoid valve is via a 2–pin connector. A 12V electrical power supply to the SAI vacuum solenoid valve is provided via the Main relay and Fuse 2 in the engine compartment fusebox. The ground connection is via the ECM which controls the SAI vacuum solenoid valve operation. **Note that the harness connector to the SAI solenoid valve is grey, and must not be confused with the harness connector to the EVAP system purge valve which is black.**

The ECM switches on the SAI vacuum solenoid valve at the same time as initiating SAI pump operation. When the SAI vacuum solenoid valve is open, a steady vacuum supply is allowed through to open the two vacuum operated SAI control valves. When the ECM breaks the earth path to the SAI vacuum solenoid valve, the valve closes and immediately shuts off the vacuum supply to the two SAI control valves at the same time as the SAI pump operation is terminated.

If the SAI vacuum solenoid valve malfunctions, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

P-code	Description
P0413	SAI vacuum solenoid valve not connected, open circuit
P0414	SAI vacuum solenoid valve short circuit to ground
P0412	SAI vacuum solenoid valve powerstage fault - harness damage, short circuit to battery supply voltage

SAI control valves



M17 0205

1 Pressurised air from SAI pump
2 Vacuum operated SAI control valve
3 Vacuum hose from SAI vacuum solenoid valve
4 Pressurised air to exhaust manifold
5 Protective heat sleeving
6 Air delivery pipe to exhaust manifold

The SAI control valves are located on brackets at each side of the engine.

The air injection supply pipes connect to a large bore port on the side of each SAI control valve via a short rubber connection hose. A small bore vacuum port is located on each SAI control valve at the opposite side to the air injection supply port. The vacuum supply to each vacuum operated SAI control valve is through small bore nylon hoses from the SAI vacuum solenoid valve. An intermediate connector is included in the vacuum supply line to split the vacuum applied to each vacuum operated valve, so that both valves open and close simultaneously.

When a vacuum is applied to the SAI control valves, the valve opens to allow the pressurised air from the SAI pump through to the exhaust manifolds. The injection air is output from each SAI control valve through a port in the bottom of each unit. A metal pipe connects between the output port of each SAI control valve and each exhaust manifold via an intermediate T-piece. The T-piece splits the pressurised air delivered to ports at the outer side of the two centre exhaust ports on each cylinder head. The pipes between the T-piece and the exhaust manifold are enclosed in thermal sleeving to protect the surrounding components from the very high heat of the exhaust gas, particularly at high engine speeds and loads.

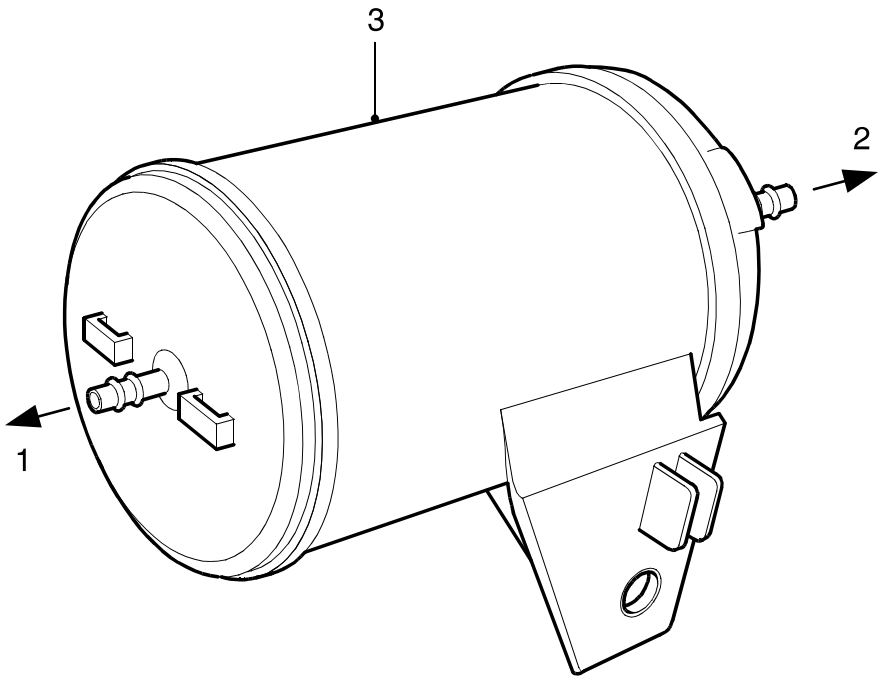
When the SAI vacuum solenoid valve is de-energised, the vacuum supply line opens to atmosphere, this causes the vacuum operated valves to close automatically and completely to prevent further air injection.

If the vacuum operated SAI control valves malfunction, the following fault codes may be stored in the ECM diagnostic memory, which can be retrieved using 'Testbook':

P-code	Description
P1412	SAI system fault (LH side) - air delivery not reaching catalysts
P1414	SAI system fault (LH side) - air delivery not reaching catalysts
P1413	SAI system fault (LH side) - air delivery not reaching catalysts
P1415	SAI system fault (RH side) - air delivery not reaching catalysts
P1417	SAI system fault (RH side) - air delivery not reaching catalysts
P1416	SAI system fault (RH side) - air delivery not reaching catalysts

The above system faults could be attributable to anything which might prevent air delivery to the exhaust manifolds (e.g. disconnected or blocked SAI delivery pipe, disconnected or blocked vacuum pipe etc.)

Vacuum reservoir



M17 0212

1 Vacuum port to SAI vacuum solenoid valve
2 Vacuum port to intake manifold (one-way valve end)
3 Vacuum reservoir

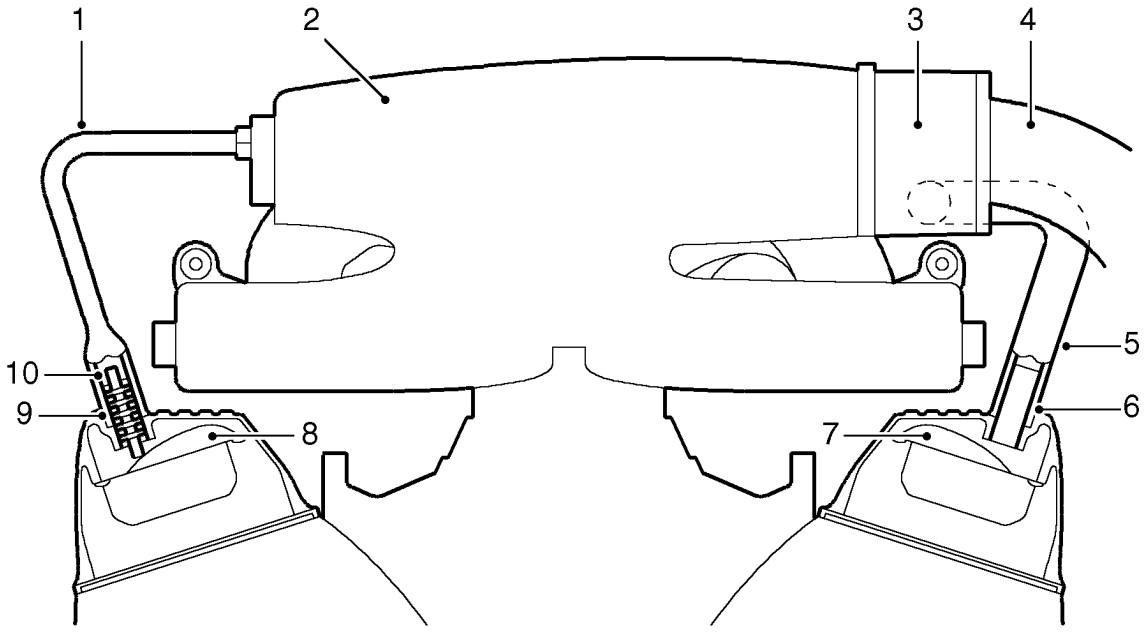
A vacuum reservoir is included in the vacuum supply line between the intake manifold and the SAI vacuum solenoid valve. The vacuum reservoir contains a one-way valve, to stop depression leaking back towards the intake manifold side. The reservoir holds a constant vacuum so that the SAI control valves open instantaneously as soon as the SAI solenoid valve is energised.

The vacuum reservoir is a plastic canister construction located on a bracket at the LH side of the engine compartment. It is important to ensure the reservoir is fitted in the correct orientation, and the correct vacuum hoses are attached to their corresponding ports. The one-way valve end of the vacuum reservoir (cap end, to inlet manifold) is fitted towards the rear of the vehicle.

A small bore nylon hose is used to connect the one-way valve end of the vacuum reservoir to a port on the RH side of the inlet manifold. A further hose connects between the other port on the vacuum reservoir and a port on the front of the SAI vacuum solenoid valve.

Crankcase emission control operation

Oil laden noxious gas in the engine crankcase is drawn through a spiral oil separator located in the stub pipe to the ventilation hose on the right hand cylinder head rocker cover, where oil is separated and returned to the cylinder head. The rubber ventilation hose from the right hand rocker cover is routed to a port on the right hand side of the inlet manifold plenum chamber, where the returned gases mix with the fresh inlet air passing through the throttle butterfly valve. The stub pipe on the left hand rocker cover does not contain an oil separator, and the ventilation hose is routed to the throttle body housing at the air inlet side of the butterfly valve. The mass of fresh air which is drawn in from the atmospheric side of the throttle butterfly to mix with the returned crankcase gas depends on the throttle position and the engine speed.



M17 0160

1 Hose – RH rocker cover to inlet manifold
2 Inlet manifold
3 Throttle body
4 Air intake
5 Hose – LH rocker cover to inlet manifold
6 LH rocker cover breather tube (without oil separator)
7 LH rocker cover baffle
8 RH rocker cover baffle
9 RH rocker cover breather tube
10 Oil separator (integral with breather tube)

When the engine is running in cruise conditions or at idle, manifold pressure is low and the majority of gases are drawn into the inlet manifold through the oil / vapour separator in the RH rocker cover stub pipe. At the same time, filtered air is drawn from the throttle body into the engine via the LH rocker cover.

During periods of driving at Wide Open Throttle (WOT), pressure at either side of the throttle disc equalizes (manifold depression collapses). The larger ventilation opening at the throttle housing positioned in the fast moving stream of intake air, now offers more 'pull' than the small opening in the RH rocker cover and the flow of ventilation reverses, drawing gases from the LH rocker cover into the throttle body for subsequent burning in the combustion chambers.

Exhaust emission control operation

The oxygen content of the exhaust gas is monitored by heated oxygen sensors using either a four sensor (NAS only) or two sensor setup, dependent on market destination and legislative requirements. Signals from the heated oxygen sensors are input to the engine management ECM which correspond to the level of oxygen detected in the exhaust gas. From ECM analysis of the data, necessary changes to the air:fuel mixture and ignition timing can be made to bring the emission levels back within acceptable limits under all operating conditions.

Changes to the air:fuel ratio are needed when the engine is operating under particular conditions such as cold starting, idle, cruise, full throttle or altitude. In order to maintain an optimum air:fuel ratio for differing conditions, the engine management control system uses sensors to determine data which enable it to select the ideal ratio by increasing or decreasing the air to fuel ratio. Improved fuel economy can be arranged by increasing the quantity of air to fuel to create a lean mixture during part-throttle conditions, however lean running conditions are not employed on closed loop systems where the maximum is $\lambda = 1$. Improved performance can be established by supplying a higher proportion of fuel to create a rich mixture during idle and full-throttle operation. Rich running at wide open throttle (WOT) for performance and at high load conditions helps to keep the exhaust temperature down to protect the catalyst and exhaust valves.

The voltage of the heated oxygen sensors at $\lambda = 1$ is between 450 and 500 mV. The voltage decreases to 100 to 500 mV if there is an increase in oxygen content ($\lambda > 1$) indicating a lean mixture. The voltage increases to 500 to 1000 mV if there is a decrease in oxygen content ($\lambda < 1$), signifying a rich mixture.

The heated oxygen sensor needs to operate at high temperatures in order to function correctly ($\geq 350^\circ$ C). To achieve this the sensors are fitted with heater elements which are controlled by a pulse width modulated (PWM) signal from the engine management ECM. The heater element warms the sensor's ceramic layer from the inside so that the sensor is hot enough for operation. The heater elements are supplied with current immediately following engine start and are ready for closed loop control within about 20 to 30 seconds (longer at cold ambient temperatures less than 0°C (32°F)). Heating is also necessary during low load conditions when the temperature of the exhaust gases is insufficient to maintain the required sensor temperatures. The maximum tip temperature is 930° C.

A non-functioning heater element will delay the sensor's readiness for closed loop control and influences emissions. A diagnostic routine is utilised to measure both sensor heater current and the heater supply voltage so its resistance can be calculated. The function is active once per drive cycle, as long as the heater has been switched on for a pre-defined period and the current has stabilised. The PWM duty cycle is carefully controlled to prevent thermal shock to cold sensors.

The heated oxygen sensors age with mileage, causing an increase in the response time to switch from rich to lean and lean to rich. This increase in response time influences the closed loop control and leads to progressively increased emissions. The response time of the pre-catalytic converter sensors are monitored by measuring the period of rich to lean and lean to rich switching. The ECM monitors the switching time, and if the threshold period is exceeded (200 milliseconds), the fault will be detected and stored in the ECM as a fault code (the MIL light will be illuminated on NAS vehicles). NAS vehicle engine calibration uses downstream sensors to compensate for aged upstream sensors, thereby maintaining low emissions.

Diagnosis of electrical faults is continuously monitored for both the pre-catalytic converter sensors and the post-catalytic converter sensors (NAS only). This is achieved by checking the signal against maximum and minimum threshold for open and short circuit conditions. For NAS vehicles, should the pre- and post-catalytic converters be inadvertently transposed, the lambda signals will go to maximum but opposite extremes and the system will automatically revert to open loop fuelling. The additional sensors for NAS vehicles provide mandatory monitoring of the catalyst conversion efficiency and long term fuelling adaptations.

Note that some markets do not legislate for closed loop fuelling control and in this instance no heated oxygen sensors will be fitted to the exhaust system.

Failure of the closed loop control of the exhaust emission system may be attributable to one of the failure modes indicated below:

- Mechanical fitting & integrity of the sensor.
- Sensor open circuit / disconnected.
- Short circuit to vehicle supply or ground.
- Lambda ratio outside operating band.
- Crossed sensors.
- Contamination from leaded fuel or other sources.
- Change in sensor characteristic.
- Harness damage.
- Air leak into exhaust system (cracked pipe / weld or loose fixings).

System failure will be indicated by the following symptoms:

- MIL light on (NAS and EU-3 only).
- Default to open-loop fuelling for the defective cylinder bank.
- If sensors are crossed, engine will run normally after initial start and then become progressively unstable with one bank going to its maximum rich clamp and the other bank going to its maximum lean clamp – the system will then revert to open-loop fuelling.
- High CO reading
- Strong smell of H_2S (rotten eggs)
- Excessive emissions

Fuel metering

When the engine is cold, additional fuel has to be provided to the air:fuel mixture to assist starting. This supplementary fuel enrichment continues until the combustion chamber has heated up sufficiently during the warm-up phase.

Under normal part-throttle operating conditions the fuel mixture is adjusted to provide minimum fuel emissions and the air:fuel mixture is held close to the optimum ratio ($\lambda = 1$). The engine management system monitors the changing engine and environmental conditions and uses the data to determine the exact fuelling requirements necessary to maintain the air:fuel ratio close to the optimum value that is needed to ensure effective exhaust emission treatment through the three-way catalytic converters.

During full-throttle operation the air:fuel mixture needs to be made rich to provide maximum torque. During acceleration, the mixture is enriched by an amount according to engine temperature, engine speed, change in throttle position and change in manifold pressure, to provide good acceleration response.

When the vehicle is braking or travelling downhill the fuel supply can be interrupted to reduce fuel consumption and eliminate exhaust emissions during this period of operation.

If the vehicle is being used at altitude, a decrease in the air density will be encountered which needs to be compensated for to prevent a rich mixture being experienced. Without compensation for altitude, there would be an increase in exhaust emissions and problems starting, poor driveability and black smoke from the exhaust pipe. For open loop systems, higher fuel consumption may also occur.

Exhaust Emission System Diagnostics
The engine management ECM contains an on-board diagnostics (OBD) system which performs a number of diagnostic routines for detecting problems associated with the closed loop emission control system. The diagnostic unit monitors ECM commands and system responses and also checks the individual sensor signals for plausibility, these include:

- Lambda ratio outside of operating band
- Lambda heater diagnostic
- Lambda period diagnostic
- Post-catalytic converter lambda adaptation diagnostic (NAS only)
- Catalyst monitoring diagnostic

Lambda ratio outside operating band
The system checks to ensure that the system is operating in a defined range around the stoichiometric point. If the system determines that the upper or lower limits for the air:fuel ratio are being exceeded, the error is stored as a fault code in the ECM diagnostic memory (the MIL light is illuminated on NAS vehicles).

Lambda heater diagnostic
The system determines the heater current and supply voltage so that the heater's resistance can be calculated. After the engine has been started, the system waits for the heated oxygen sensors to warm up, then calculates the resistance from the voltage and current measurements. If the value is found to be outside of the upper or lower threshold values, then the fault is processed (the MIL light is illuminated on NAS vehicles).

Lambda period diagnostic
The pre-catalytic converter sensors are monitored. As the sensors age, the rich to lean and the lean to rich switching delays increase, leading to increased emissions if the lambda control becomes inaccurate. If the switching period exceeds a defined limit, the sensor fault is stored in the ECM diagnostic memory (the MIL light is illuminated on NAS vehicles).

Post-catalytic converter lambda adaptation diagnostic (NAS only)
On NAS vehicles the ageing effects of the pre-catalytic converter sensors are compensated for by an adaptive value derived from the post-catalytic converter sensors. This is a long term adaption which only changes slowly. For a rich compensation the additive value is added to the rich delay time. For a lean compensation, the adaptive value is added to the lean delay time. The adaptive time is monitored against a defined limit, and if the limit is exceeded, the fault is stored in the ECM's diagnostic memory and the MIL light is illuminated on the instrument pack.

Catalyst monitoring diagnostic
On NAS specification vehicles the catalysts are monitored both individually and simultaneously for emission pollutant conversion efficiency. The conversion efficiency of a catalyst is monitored by measuring the oxygen storage, since there is a direct relationship between these two factors. The closed loop lambda control fuelling oscillations produce pulses of oxygen upstream of the catalyst, as the catalyst efficiency deteriorates its ability to store oxygen is decreased. The amplitudes of the signals from the pre-catalytic and post-catalytic converter heated oxygen sensors are compared. As the oxygen storage decreases, the post-catalytic converter sensor begins to follow the oscillations of the pre-catalytic converter heated oxygen sensors. Under steady state conditions the amplitude ratio is monitored in different speed / load sites. There are three monitoring areas, and if the amplitude ratio exceeds a threshold in all three areas the catalyst conversion limit is exceeded; the catalyst fault is stored in the diagnostic memory and the MIL light is illuminated on the instrument pack. There is a reduced threshold value for both catalysts monitored as a pair. In either case, a defective catalyst requires replacement of the downpipe assembly.

In the case of a catalytic converter failure the following failure symptoms may be apparent:

- MIL light on after 2 driving cycles (NAS market only).
- High exhaust back pressure if catalyst partly melted.
- Excessive emissions
- Strong smell of H_2S (rotten eggs).

Oxygen sensor voltages can be monitored using 'Testbook', the approximate output voltage from the heated oxygen sensors with a warm engine at idle and with closed loop fuelling active are shown in the table below:

Measurement	Normal catalyst	Defective catalyst
Pre-catalytic heated oxygen sensors	~ 100 to 900 mV switching @ ~ 0.5 Hz	~ 100 to 900 mV switching @ ~ 0.5 Hz
Post-catalytic heated oxygen sensors	~ 200 to 650 mV, static or slowly changing	~ 200 to 850 mV, changing up to same frequency as pre-catalytic heated oxygen sensors
Amplitude ratio (LH HO_2 sensors & RH HO_2 sensors)	<0.3 seconds	>0.6 seconds (needs to be approximately 0.75 seconds for single catalyst fault)
Number of speed/load monitoring areas exceeded (LH & RH)	0	>1 (needs to be 3 for fault storage)

Mass air flow sensor and air temperature sensor

The engine management ECM uses the mass air flow sensor to measure the mass of air entering the intake and interprets the data to determine the precise fuel quantity which needs to be injected to maintain the stoichiometric air:fuel ratio for the exhaust catalysts. If the mass air flow sensor fails, lambda control and idle speed control will be affected and the emission levels will not be maintained at the optimum level. If the device should fail and the ECM detects a fault, it invokes a software backup strategy.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

The air temperature sensor is used by the engine management ECM to monitor the temperature of the inlet air. If the device fails, catalyst monitoring will be affected. The air temperature sensor in integral to the mass air flow sensor.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Throttle position sensor

If the engine management ECM detects a throttle position sensor failure, it may indicate a blocked or restricted air intake filter. Failure symptoms may include:

- Poor engine running and throttle response
- Emission control failure
- No closed loop idle speed control
- Altitude adaption is incorrect

If a signal failure should occur, a default value is derived using data from the engine load and speed.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Atmospheric pressure will vary with altitude and have a resulting influence on the calculations performed by the ECM in determining the optimum engine operating conditions to minimise emissions. The following are approximate atmospheric pressures for the corresponding altitudes:

- 0.96 bar at sea level
- 0.70 bar at 2,750 m (9,000 ft.)

Evaporative emission control operation

Fuel vapour is stored in the activated charcoal (EVAP) canister for retention when the vehicle is not operating. When the vehicle is operating, fuel vapour is drawn from the canister into the engine via a purge control valve. The vapour is then delivered to the intake plenum chamber to be supplied to the engine cylinders where it is burned in the combustion process.

During fuel filling the fuel vapour displaced from the fuel tank is allowed to escape to atmosphere, valves within the fuel filler prevent any vapour escaping through to the EVAP canister as this can adversely affect the fuel cut-off height. Only fuel vapour generated whilst driving is prevented from escaping to atmosphere by absorption into the charcoal canister. The fuel filler shuts off to leave the tank approximately 10% empty to ensure the ROVs are always above the fuel level and so vapour can escape to the EVAP canister and the tank can breathe. The back pressures normally generated during fuel filling are too low to open the pressure relief valve, but vapour pressures accumulated during driving are higher and can open the pressure relief valve. Should the vehicle be overturned, the ROVs shut off to prevent any fuel spillage.

Fuel vapour generated from within the fuel tank as the fuel heats up is stored in the tank until the pressure exceeds the operating pressure of the two-way valve. When the two-way valve opens, the fuel vapour passes along the vent line from the fuel tank (via the fuel tank vapour separator) to the evaporation inlet port of the EVAP canister. The fuel tank vents between 5.17 and 6.9 kPa.

Fuel vapour evaporating from the fuel tank is routed to the EVAP canister through the fuel vapour separator and vent line. Liquid fuel must not be allowed to contaminate the charcoal in the EVAP canister. To prevent this, the fuel vapour separator fitted to the fuel neck allows fuel to drain back into the tank. As the fuel vapour cools, it condenses and is allowed to flow back into the fuel tank from the vent line by way of the two-way valve.

The EVAP canister contains charcoal which absorbs and stores fuel vapour from the fuel tank while the engine is not running. When the canister is not being purged, the fuel vapour remains in the canister and clean air exits the canister via the air inlet port.

The engine management ECM controls the electrical output signal to the purge valve. The system will not work properly if there is leakage or clogging within the system or if the purge valve cannot be controlled.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

When the engine is running, the ECM decides when conditions are correct for vapour to be purged from the EVAP canister and opens the canister purge valve. This connects a manifold vacuum line to the canister and fuel vapour containing the hydrocarbons is drawn from the canister's charcoal element to be burned in the engine. Clean air is drawn into the canister through the atmosphere vent port to fill the displaced volume of vapour.

The purge valve remains closed below preset coolant and engine speed values to protect the engine tune and catalytic converter performance. If the EVAP canister was purged during cold running or at idling speed, the additional enrichment in the fuel mixture would delay the catalytic converter light off time and cause erratic idle. When the purge valve is opened, fuel vapour from the EVAP canister is drawn into the plenum chamber downside of the throttle housing, to be delivered to the combustion chambers for burning.

The purge valve is opened and closed in accordance with a pulse width modulated (PWM) signal supplied from the engine management ECM. The system will not work properly if the purge valve cannot be controlled. Possible failure modes associated with the purge valve are listed below:

- Valve drive open circuit.
- Short circuit to vehicle supply or ground.
- Purge valve or pipework blocked or restricted.
- Purge valve stuck open.
- Pipework joints leaking or disconnected.

Possible symptoms associated with a purge valve or associated pipework failure is listed below:

- Engine may stall on return to idle if purge valve is stuck open.
- Poor idling quality if the purge valve is stuck open
- Fuelling adaptions forced excessively lean if the EVAP canister is clear and the purge valve is stuck open.
- Fuelling adaptions forced excessively rich if the EVAP canister is saturated and the purge valve is stuck open.
- Saturation of the EVAP canister if the purge valve is stuck closed.

To maintain driveability and effective emission control, EVAP canister purging must be closely controlled by the engine management ECM, as a 1% concentration of fuel vapour from the EVAP canister in the air intake may shift the air:fuel ratio by as much as 20%. The ECM must purge the fuel vapour from the EVAP canister at regular intervals as its storage capacity is limited and an excessive build up of evaporated fuel pressure in the system could increase the likelihood of vapour leaks. Canister purging is cycled with the fuelling adaptation as both cannot be active at the same time. The ECM alters the PWM signal to the purge valve to control the rate of purging of the canister to maintain the correct stoichiometric air:fuel mixture for the engine.

Fuel leak detection system (vacuum type) – NAS only

The advanced evaporative loss control system used on NAS vehicles is similar to the standard system, but also includes a CVS valve and fuel tank pressure sensor and is capable of detecting holes in the fuel evaporative system down to 1 mm (0.04 in.). The test is carried out in three parts. First the purge valve and the canister vent solenoid valve closes off the storage system and the vent pressure increases due to the fuel vapour pressure level in the tank. If the pressure level is greater than the acceptable limit, the test will abort because a false leak test response will result. In part two of the test, the purge valve is opened and the fuel tank pressure will decrease due to the depression from the intake manifold, evident at the purge port of the EVAP canister during purge operation. In part three of the test, the leak measurement test is performed. The pressure response of the tests determines the level of leak, and if this is greater than the acceptable limit on two consecutive tests, the ECM stores the fault in diagnostic memory and the MIL light on the instrument pack is illuminated. The test is only carried out at engine idle with the vehicle stationary, and a delay of 15 minutes after engine start is imposed before diagnosis is allowed to commence.

EVAP system, leak detection diagnostic (vacuum type)

The EVAP system leak detection is performed as follows:

1. The ECM checks that the signal from the fuel tank pressure sensor is within the expected range. If the signal is not within range, the leakage test will be cancelled.
2. Next the purge valve is held closed and the canister vent solenoid (CVS) valve is opened to atmosphere. If the ECM detects a rise in pressure with the valves in this condition, it indicates there is a blockage in the fuel evaporation line between the CVS valve and the EVAP canister, or that the CVS valve is stuck in the closed position and thus preventing normalisation of pressure in the fuel evaporation system. In this instance, the leakage test will be cancelled.
3. The CVS valve and the purge valve are both held in the closed position while the ECM checks the fuel tank pressure sensor. If the fuel tank pressure sensor detects a decline in pressure, it indicates that the purge valve is not closing properly and vapour is leaking past the valve seat face under the influence of the intake manifold depression. In this instance, the leakage test will be cancelled.
4. If the preliminary checks are satisfactory, a compensation measurement is determined next. Variations in fuel level occur within the fuel tank, which will influence the pressure signal detected by the fuel tank pressure sensor. The pressure detected will also be influenced by the rate of change in the fuel tank pressure, caused by the rate of fuel evaporation which itself is dependent on the ambient temperature conditions. Because of these variations, it is necessary for the ECM to evaluate the conditions prevailing at a particular instance when testing, to ensure that the corresponding compensation factor is included in its calculations.

   The CVS valve and purge valves are both closed while the ECM checks the signal from the fuel tank pressure sensor. The rise in fuel pressure detected over a defined period is used to determine the rate of fuel evaporation and the consequent compensation factor necessary.
5. With the CVS valve still closed, the purge valve is opened. The inlet manifold depression present while the purge valve is open, decreases EVAP system pressure and sets up a small vacuum in the fuel tank. The fuel tank pressure sensor is monitored by the ECM and if the vacuum gradient does not increase as expected, a large system leak is assumed by the ECM (e.g. missing or leaking fuel filler cap) and the diagnostic test is terminated.

   If the EVAP canister is heavily loaded with hydrocarbons, purging may cause the air:fuel mixture to become excessively rich, resulting in the upstream oxygen sensors requesting a leaner mix from the ECM to bring the mixture back to the stoichiometric ideal. This may cause instability in the engine idle speed and consequently the diagnostic test will have to be abandoned. The ECM checks the status of the upstream oxygen sensors during the remainder of the diagnostic, to ensure the air:fuel mixture does not adversely affect the engine idle speed.
6. When the fuel tank pressure sensor detects that the required vacuum has been reached (-800 Pa), the purge valve is closed and the EVAP system is sealed. The ECM then checks the change in the fuel tank pressure sensor signal (diminishing vacuum) over a period of time, and if it is greater than expected (after taking into consideration the compensation factor due to fuel evaporation within the tank, determined earlier in the diagnostic), a leak in the EVAP system is assumed. If the condition remains, the MIL warning light will be turned on after two drive cycles.

   The decrease in vacuum pressure over the defined period must be large enough to correspond to a hole equivalent to 1 mm (0.04 in.) diameter or greater, to be considered significant enough to warrant the activation of an emissions system failure warning.

The diagnostic test is repeated at regular intervals during the drive cycle, when the engine is at idle condition. The diagnostic test will not be able to be performed under the following conditions:

- During EVAP canister purging
- During fuelling adaption
- If excess slosh in the fuel tank is detected (excess fuel vapour will be generated, invalidating the result)

Following the test, the system returns to normal purge operation after the canister vent solenoid opens. Possible reasons for an EVAP system leak test failure are listed below:

- Fuel filler not tightened or cap missing.
- Sensor or actuator open circuit.
- Short circuit to vehicle supply or ground.
- Either purge or CVS valve stuck open.
- Either purge or CVS valve stuck shut or blocked pipe.
- Piping broken or not connected.
- Loose or leaking connection.

If the piping is broken forward of the purge valve or is not connected, the engine may run rough and fuelling adaptions will drift. The fault will not be detected by the leak detection diagnostic, but it will be determined by the engine management ECM through the fuelling adaption diagnostics.

The evaluation of leakage is dependent on the differential pressure between the fuel tank and ambient atmospheric pressure, the diagnostic is disabled above altitudes of 9500 ft. (2800 m) to avoid false detection of fuel leaks due to the change in atmospheric pressure at altitude.

Fuel leak detection system (positive pressure leak detection type) – NAS only

The EVAP system with positive pressure leak detection capability used on NAS vehicles is similar to the standard system, but also includes a fuel evaporation leak detection pump with integral solenoid valve. It is capable of detecting holes in the EVAP system down to 0.5 mm (0.02 in.). The test is carried out at the end of a drive cycle, when the vehicle is stationary and the ignition switch has been turned off. The ECM maintains an earth supply to the Main relay to hold it on, so that power can be supplied to the leak detection pump.

First a reference measurement is established by passing the pressurised air through a by-pass circuit containing a fixed sized restriction. The restriction assimilates a 0.5 mm (0.02 in) hole and the current drawn by the pump motor during this procedure is recorded for comparison against the value to be obtained in the system test. The purge valve is held closed, and the reversing valve in the leak detection pump module is not energised while the leak detection pump is switched on. The pressurised air from the leak detection pump is forced through an orifice while the current drawn by the pump motor is monitored.

Next the EVAP system diagnostic is performed; the solenoid valve is energised so that it closes off the EVAP system's vent line to atmosphere, and opens a path for the pressurised air from the leak detection pump to be applied to the closed EVAP system.

The current drawn by the leak detection pump is monitored and checked against that obtained during the reference measurement. If the current is less than the reference value, this infers there is a hole in the EVAP system greater than 0.5 mm (0.02 in) which is allowing the positive air pressure to leak out. If the current drawn by the pump motor is greater than the value obtained during the reference check, the system is sealed and free from leaks. If an EVAP system leak is detected, the ECM stores the fault in diagnostic memory and the MIL light on the instrument pack is illuminated.

On NAS vehicles, the ECM works on a 2 trip cycle before illuminating the MIL. On EU-3 vehicles, the ECM works on a 3 trip cycle before illuminating the MIL.

Following the test, the solenoid valve is opened to normalise the EVAP system pressure and the system returns to normal purge operation at the start of the next drive cycle. Possible reasons for an EVAP system leak test failure are listed below:

- Fuel filler not tightened or cap missing.
- Sensor or actuator open circuit.
- Short circuit to vehicle supply or ground.
- Either purge or solenoid valve stuck open.
- Either purge or solenoid valve stuck shut.
- Blocked pipe or air filter.
- Piping broken or not connected.
- Loose or leaking connection.

If the piping is broken forward of the purge valve or is not connected, the engine may run rough and fuelling adaptions will drift. The fault will not be detected by the leak detection test, but will be determined by the engine management ECM through the fuelling adaption diagnostics. This test can be run from TestBook.

Secondary air injection system

When the engine is started, the engine control module checks the engine coolant temperature and if it is below 55° C, the ECM grounds the electrical connection to the coil of the secondary air injection (SAI) pump relay.

A 12V battery supply is fed to the inertia switch via fuse 13 in the engine compartment fusebox. When the inertia switch contacts are closed, the feed passes through the switch and is connected to the coil of the Main relay. An earth connection from the Main relay coil is connected to the ECM. When the ECM completes the earth path, the coil energises and closes the contacts of the Main relay.

The Main and Secondary Air Injection (SAI) pump relays are located in the engine compartment fusebox. When the contacts of the Main relay are closed, a 12V battery supply is fed to the coil of the SAI pump relay. An earth connection from the coil of the SAI pump relay is connected to the ECM. When the ECM completes the earth path, the coil energises and closes the contacts of the SAI pump relay to supply 12V to the SAI pump via fusible link 2 in the engine compartment fusebox. The SAI pump starts to operate, and will continue to do so until the ECM switches off the earth connection to the coil of the SAI pump relay.

The SAI pump remains operational for a period determined by the ECM and depends on the starting temperature of the engine, or for a maximum operation period determined by the ECM if the target engine coolant temperature has not been reached in the usual time.

When the contacts of the main relay are closed, a 12V battery supply is fed to the SAI solenoid valve via Fuse 2 in the engine compartment fusebox.

The ECM grounds the electrical connection to the SAI vacuum solenoid valve at the same time as it switches on the SAI pump motor. When the SAI vacuum solenoid valve is energised, a vacuum is provided to the operation control ports on both of the vacuum operated SAI control valves at the exhaust manifolds. The control vacuum is sourced from the intake manifold depression and routed to the SAI control valves via a vacuum reservoir and the SAI vacuum solenoid valve.

The vacuum reservoir is included in the vacuum supply circuit to prevent vacuum fluctuations caused by changes in the intake manifold depression affecting the operation of the SAI control valves.

When a vacuum is applied to the control ports of the SAI control valves, the valves open to allow pressurised air from the SAI pump to pass through to the exhaust ports in the cylinder heads for combustion.

When the ECM has determined that the SAI pump has operated for the desired duration, it switches off the earth paths to the SAI pump relay and the SAI vacuum solenoid valve. With the SAI vacuum solenoid valve de-energised, the valve closes, cutting off the vacuum supply to the SAI control valves. The SAI control valves close immediately and completely to prevent any further pressurised air from the SAI pump entering the exhaust manifolds.

The engine coolant temperature sensor incurs a time lag in respect of detecting a change in temperature and the SAI pump automatically enters a 'soak period' between operations to prevent the SAI pump overheating. The ECM also compares the switch off and start up temperatures, to determine whether it is necessary to operate the SAI pump. This prevents the pump running repeatedly and overheating on repeat starts.

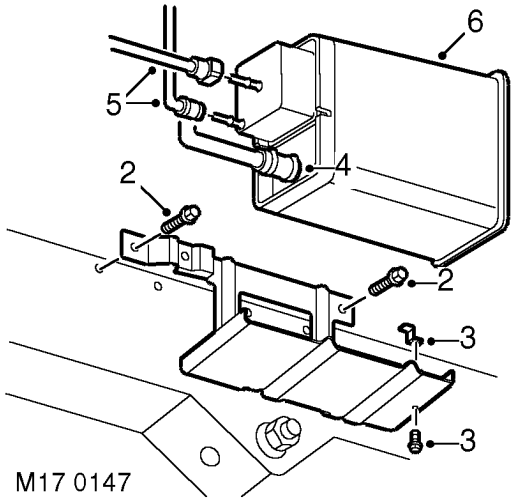
Other factors which may prevent or stop SAI pump operation include the prevailing engine speed / load conditions.

Canister - EVAP

17.15.13

Remove

1. Raise vehicle on lift.



2. Remove 2 bolts securing canister bracket to chassis.
3. Remove bolt securing canister to bracket and remove bracket.
4. Release clip and disconnect atmosphere vent pipe from canister.
5. Release and remove purge and tank vent pipes from canister.
6. Remove EVAP canister.

CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

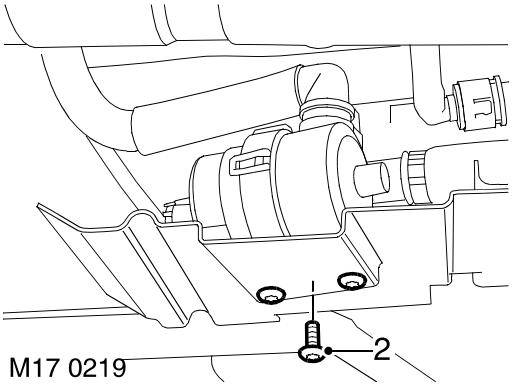
1. Ensure all connections are clean.
2. Position new canister and connect purge and tank vent pipes.
3. Connect atmospheric vent pipe to canister and secure with clip.
4. Fit bracket to canister and secure with bolt.
5. Fit canister and bracket and secure with bolts.

Canister - EVAP - Models with Fuel Leak Detection Pump - up to 03MY

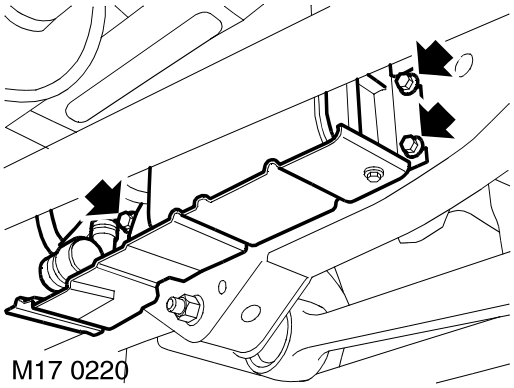
17.15.13

Remove

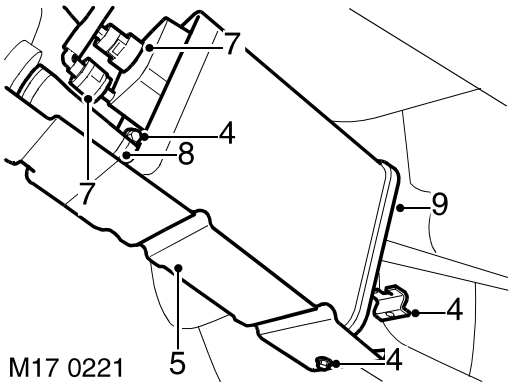
1. Raise vehicle on lift.



2. Remove 3 Torx screws securing fuel leak detection pump to mounting bracket.



3. Remove 3 bolts securing EVAP canister mounting bracket to chassis longitudinal.



4. Remove 2 bolts securing EVAP canister to mounting bracket and collect clamp.
5. Remove mounting bracket.
6. Position cloth to absorb any fuel spillage.
7. Release purge and tank vent pipes from EVAP canister.
8. Remove clip securing fuel leak detection pump pipe to EVAP canister.
9. Release pipe from EVAP canister and remove canister.

CAUTION: Plug the connections.

Refit

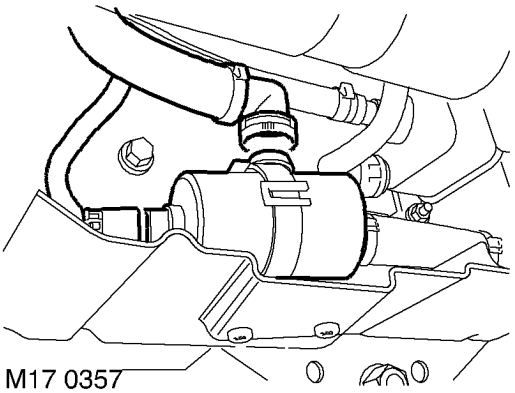
1. Remove plugs and ensure all connections are clean.
2. Connect fuel leak detection pump pipe to EVAP canister and secure with clip.
3. Connect purge and tank vent pipes to EVAP canister.
4. Position mounting bracket to EVAP canister and secure with bolts.
5. Position mounting bracket to chassis longitudinal and tighten bolts.
6. Fit Torx screws securing fuel leak detection pump to mounting bracket.
7. Lower vehicle.

Canister - EVAP - Models with Fuel Leak Detection Pump - from 03MY

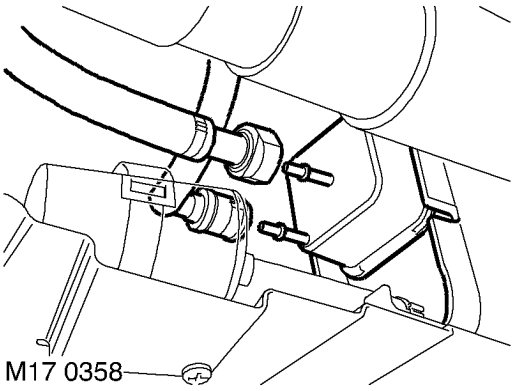
17.15.13

Remove

1. Raise the vehicle on lift.

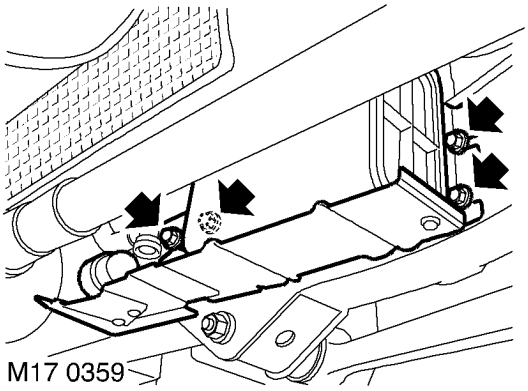


2. Disconnect multiplug from the fuel leak detection pump.
3. Disconnect the fuel leak detection filter pipe from the fuel leak detection pump.

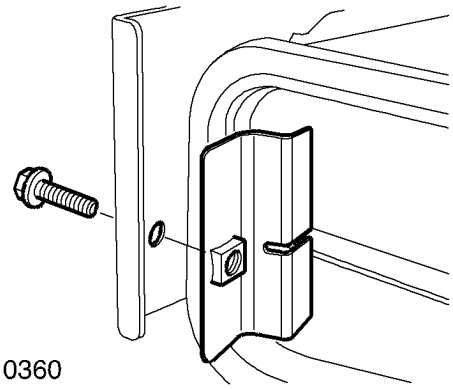


4. Release clips and disconnect 2 vent pipes from the EVAP canister.

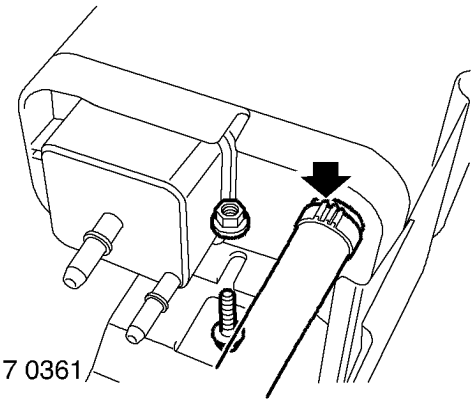
CAUTION: Always fit plugs to open connections to prevent contamination.


M17 0359

5. Remove and discard 4 bolts securing EVAP canister mounting bracket to the chassis and remove the EVAP canister assembly.
   NOTE: Do not carry out further dismantling if component is removed for access only.


M17 0360

6. Remove bolt securing EVAP canister retaining clamp to the mounting bracket and collect the clamp.


M17 0361

7. Remove nut and bolt securing EVAP canister to the mounting bracket.
8. Remove and discard clip securing fuel leak detection pump fuel pipe to the EVAP canister and disconnect the fuel pipe.
9. Remove the EVAP canister.

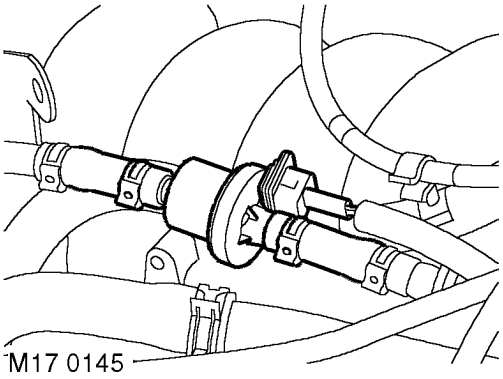
Refit

1. Position EVAP canister to the mounting bracket.
2. Connect fuel leak detection pump fuel pipe to the EVAP canister and secure with a new clip.
3. Fit nut and bolt securing EVAP canister to the mounting bracket and tighten to 10 Nm (7 lbf.ft).
4. Position EVAP canister retaining clamp to the mounting bracket, fit bolt and tighten to 10 Nm (7 lbf.ft).
5. Position EVAP canister mounting bracket to the chassis, fit new bolts and tighten to 25 Nm (18 lbf.ft).
6. Connect vent pipes to the EVAP canister.
7. Connect multiplug to the fuel leak detection pump.
8. Connect the fuel leak detection filter pipe to the fuel leak detection pump.
9. Lower the vehicle lift.

Valve - purge control

17.15.39

Remove



1. Disconnect multiplug from purge control valve.
2. Release clips securing hoses to purge control valve.
3. Disconnect hoses from purge control valve and remove valve.

   CAUTION: Always fit plugs to open connections to prevent contamination.

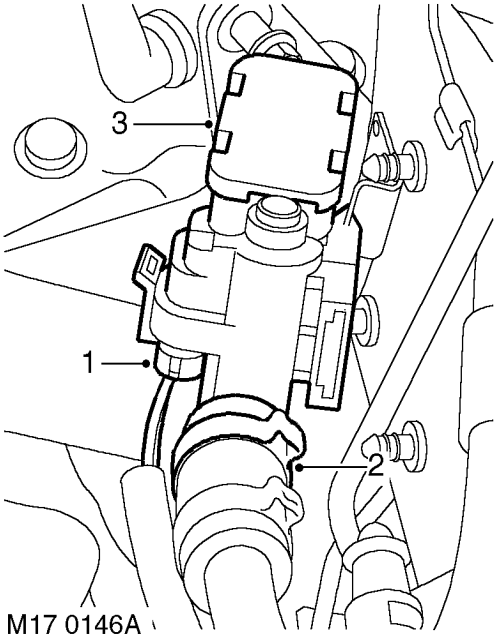
Refit

1. Position purge control valve and connect hoses.
2. Fit clips to secure hoses to purge control valve.
3. Connect multiplug to purge control valve.

Solenoid - evap canister vent solenoid (CVS) valve

17.15.47

Remove



1. Disconnect multiplug from CVS unit.
2. Remove clip and disconnect hose from vent valve.

   CAUTION: Always fit plugs to open connections to prevent contamination.

3. Remove CVS unit from bracket.

Refit

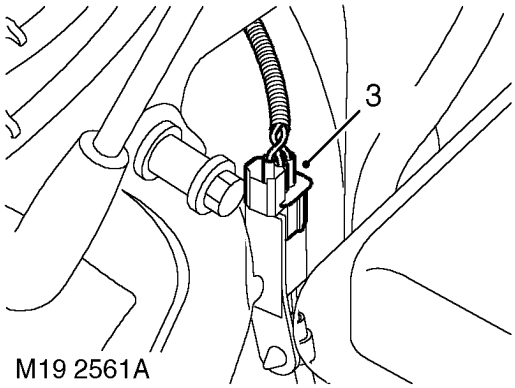
1. Fit CVS unit to bracket.
2. Connect hose to vent valve and secure with clip.
3. Connect multiplug to CVS unit.

Sensor - heated oxygen (HO_2S) - pre-catalytic converter

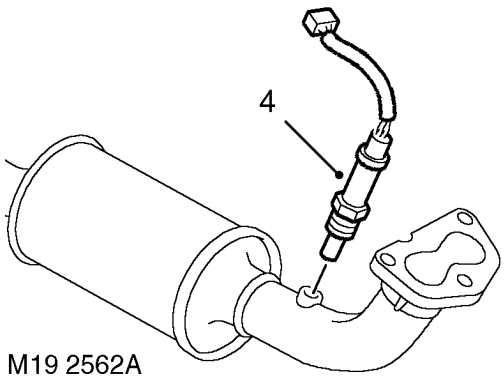
19.22.16

Remove

1. Raise vehicle on a ramp.
2. Release HO_2S multiplug from support bracket.



3. Release HO_2S harness from clip and disconnect multiplug from HO_2S .



4. Using a 22 mm crow's-foot spanner, remove HO_2S.

CAUTION: HO_2 sensors are easily damaged by dropping, excessive heat or contamination. Care must be taken not to damage the sensor housing or tip.

Refit

1. Clean sensor and exhaust pipe mating surfaces.
2. If refitting existing sensor, apply anti-seize compound to sensor threads.

WARNING: Some types of anti-seize compound used in service are a health hazard. Avoid skin contact.

NOTE: A new HO_2 sensor is supplied pre-treated with anti-seize compound.

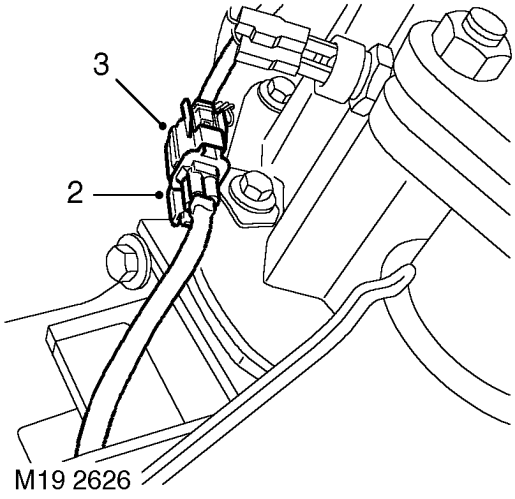
3. Fit a new sealing washer to HO_2S
4. Fit HO_2S and tighten to 45 Nm (33 lbf.ft).
5. Connect multiplug to HO_2S, and secure to support bracket and harness clip.
6. Lower vehicle.

Sensor - heated oxygen (HO_2S) - post-catalytic converter

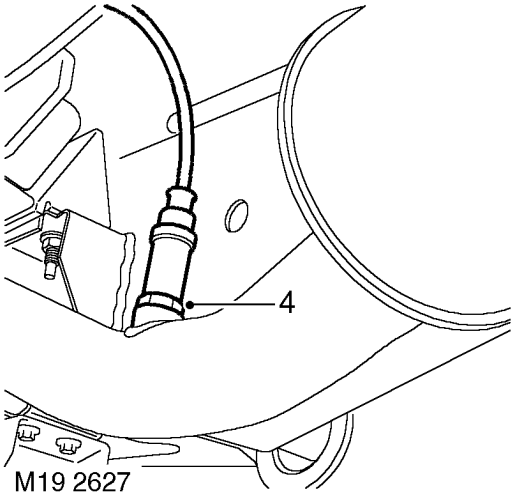
19.22.17

Remove

1. Raise vehicle on ramp.



2. Release HO_2S multiplug from support bracket.
3. Disconnect HO_2S multiplug from harness.



4. Using a 22 mm crowsfoot spanner, remove HO_2S.

CAUTION: HO2 sensors are easily damaged by dropping, excessive heat or contamination. Care must be taken not to damage the sensor housing or tip.

Refit

1. Clean sensor and exhaust pipe mating surfaces.
2. If refitting existing sensor, apply anti-seize compound to sensor threads.

WARNING: Some types of anti-seize compound used in service are a health hazard. Avoid skin contact.

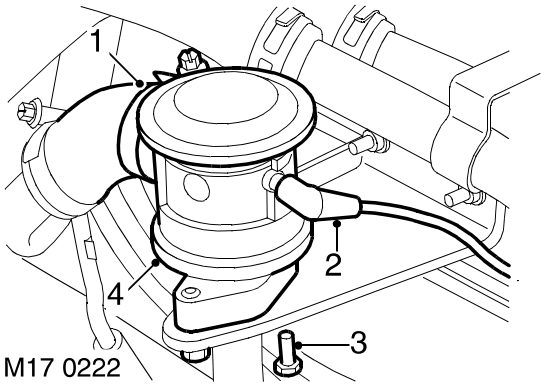
NOTE: A new HO2 sensor is supplied pre-treated with anti-seize compound.

3. Fit a new sealing washer to HO_2S
4. Fit HO_2S and tighten to 45 Nm (33 lbf.ft).
5. Connect HO_2S multiplug to harness and fit harness to bracket.
6. Secure harness to clip.
7. Lower vehicle.

Control Valve - Secondary Air Injection (SAI)

17.25.02

Remove



1. Release clip and disconnect air hose from valve.
2. Disconnect vacuum hose from valve.
3. Remove 2 bolts securing valve to air manifold.
4. Remove valve and discard gasket.

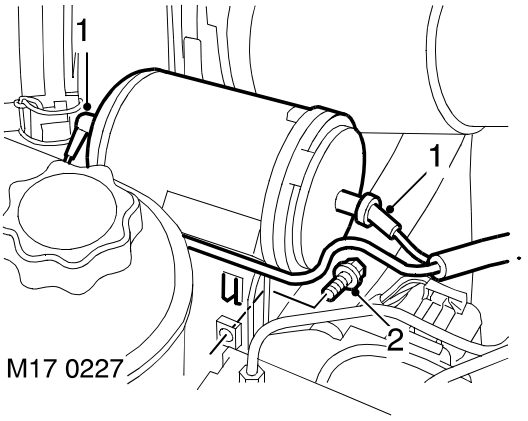
Refit

1. Clean SAI control valve and mating face on manifold.
2. Fit new gasket and fit valve. Tighten bolts to 10 Nm (7 lbf.ft).
3. Connect vacuum hose.
4. Connect air hose and secure with clip.

Reservoir - Vacuum - Secondary Air Injection (SAI) - up to 03MY

17.25.04

Remove



1. Disconnect 2 vacuum hoses from reservoir.
2. Remove bolt securing reservoir to mounting bracket and collect reservoir.

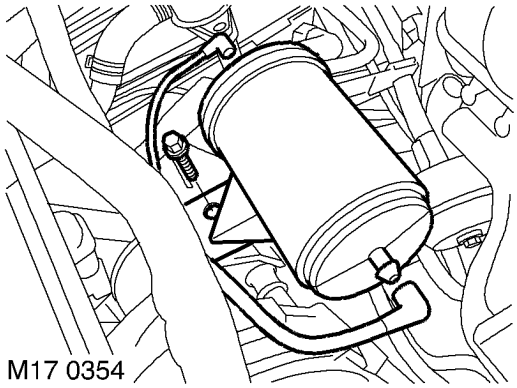
Refit

1. Position reservoir to mounting bracket and tighten bolt to 10 Nm.
2. Connect vacuum hoses to reservoir.

Reservoir - vacuum - Secondary Air Injection (SAI) - from 03MY

17.25.04

Remove



1. Disconnect 2 vacuum pipes from air reservoir.
2. Remove bolt securing air reservoir to air pump and remove the reservoir.

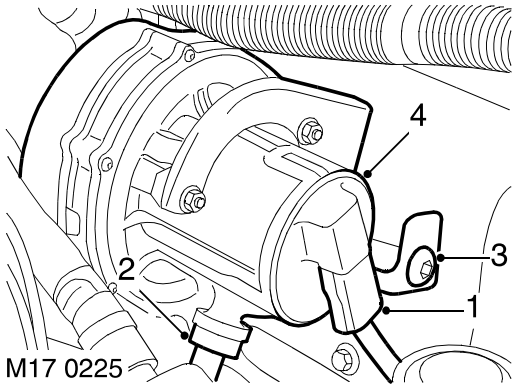
Refit

1. Position air reservoir to air pump, fit bolt and tighten to 10 Nm (7 lbf.ft).
2. Connect vacuum pipes to the air reservoir.

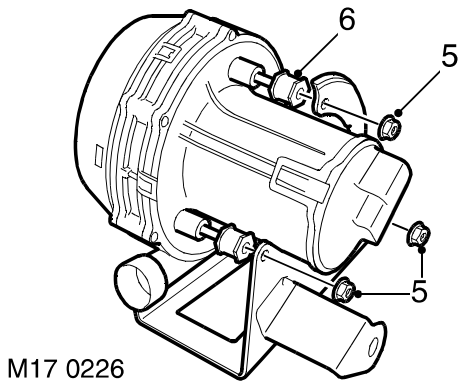
Pump - Air - Secondary Air Injection (SAI)

17.25.07

Remove



1. Disconnect multiplug from air pump.
2. Release clip and disconnect air hose from air pump.
3. Remove bolt securing air pump bracket to body.
4. Remove air pump and bracket assembly.



5. Remove 3 nuts securing bracket to air pump and collect bracket.
6. Remove 3 mountings from air pump.

Refit

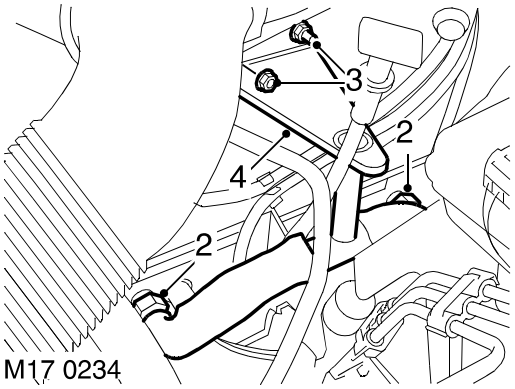
1. Fit mountings to air pump and tighten to 10 Nm.
2. Fit bracket to air pump mountings and tighten nuts to 10 Nm.
3. Position air pump assembly and tighten bolt to 20 Nm.
4. Connect air hose to SAI pump.
5. Connect multiplug to air pump.

Air Manifold - LH - Secondary Air Injection (SAI)

17.25.17

Remove

1. Remove SAI control valve.
   EMISSION CONTROL - V8, REPAIRS, Control Valve - Secondary Air Injection (SAI).



2. Loosen 2 union nuts securing air manifold to cylinder head adaptors.
3. Remove 2 nuts securing air manifold bracket to inlet manifold.
4. Remove air manifold.

Refit

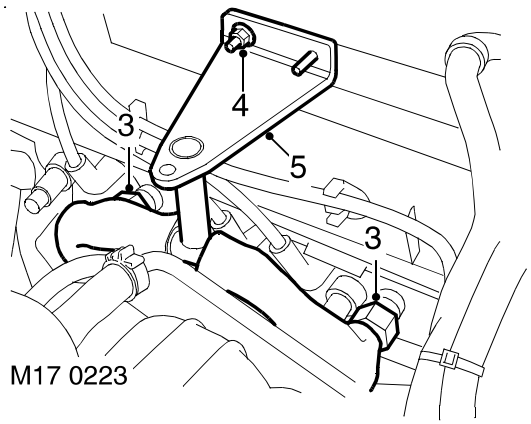
1. Clean air manifold and cylinder head adaptors.
2. Fit air manifold and start union nuts.
3. Fit nuts securing air manifold to inlet manifold.
4. Tighten air manifold unions to 25 Nm.
5. Fit SAI control valve.
   EMISSION CONTROL - V8, REPAIRS, Control Valve - Secondary Air Injection (SAI).

Air Manifold - RH - Secondary Air Injection (SAI)

17.25.18

Remove

1. Remove SAI control valve.
   EMISSION CONTROL - V8, REPAIRS, Control Valve - Secondary Air Injection (SAI).
2. Remove heater feed pipe.
   HEATING AND VENTILATION, REPAIRS, Pipe - Heater - Feed.



3. Loosen 2 union nuts securing air manifold to cylinder head adaptors.
4. Remove nut securing air manifold bracket to inlet manifold.
5. Remove air manifold.

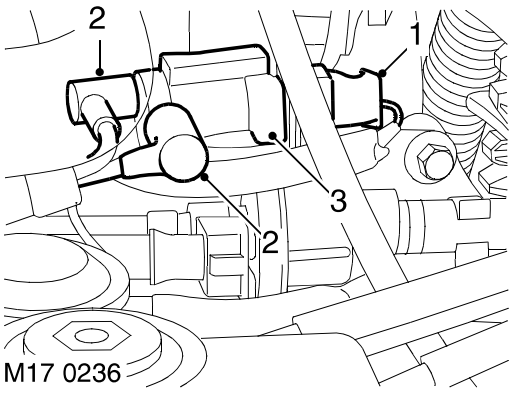
Refit

1. Clean air manifold and cylinder head adaptors.
2. Fit air manifold and start union nuts.
3. Fit nut securing air manifold to inlet manifold.
4. Tighten air manifold unions to 25 Nm.
5. Fit heater feed pipe.
   HEATING AND VENTILATION, REPAIRS, Pipe - Heater - Feed.
6. Fit SAI control valve.
   EMISSION CONTROL - V8, REPAIRS, Control Valve - Secondary Air Injection (SAI).

Solenoid - Vacuum - Secondary Air Injection (SAI)

17.25.47

Remove



1. Release multiplug from solenoid.
2. Disconnect 2 vacuum hoses from solenoid.
3. Release solenoid from mounting bracket and remove.

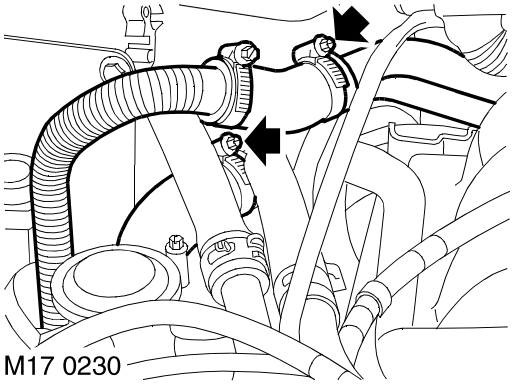
Refit

1. Secure solenoid to mounting bracket.
2. Connect vacuum hoses and multiplug to solenoid.

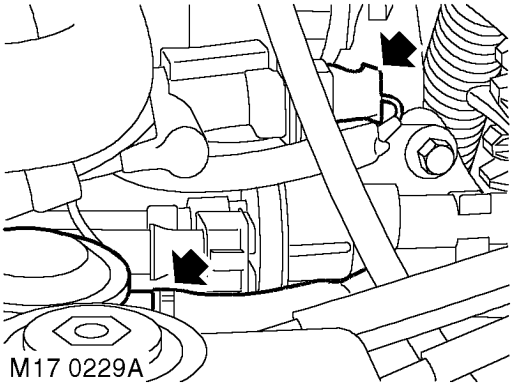
Pipe - Secondary Air Injection (SAI)

17.25.59

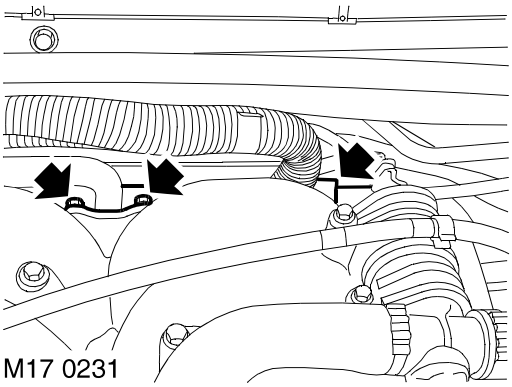
Remove



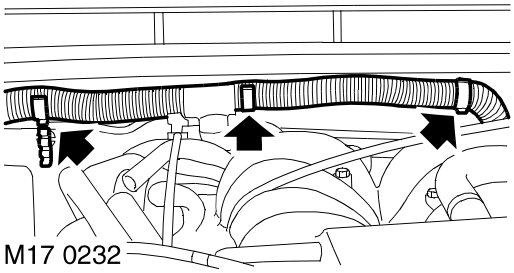
1. Loosen clip securing RH SAI control valve hose to air injection pipe.
2. Release hose from air injection pipe.
3. Loosen clip securing SAI pump hose to air injection pipe.
4. Release hose from air injection pipe.



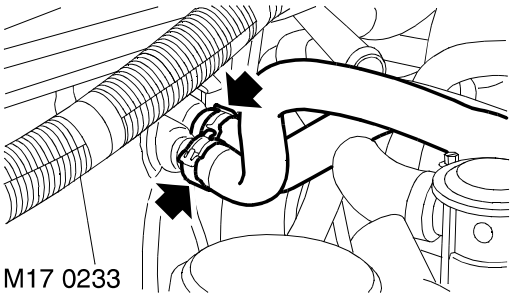
5. Loosen clip securing LH SAI control valve hose to air injection pipe.
6. Release hose from air injection pipe.
7. Disconnect multiplug from SAI vacuum solenoid.


M17 0231

8. Remove 2 nuts securing air injection pipe to air intake plenum.
9. Release pipe from clip on rear of air intake plenum.


M17 0232

10. Release 3 clips securing harness to engine bay bulkhead.
11. Position container to collect any coolant spillage.


M17 0233

12. Release clips securing heater hoses to heater.
13. Release hoses from heater.
14. With assistance, manoeuvre air injection pipe from engine bay.

Refit

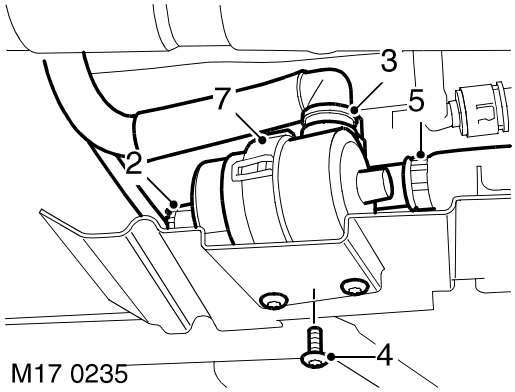
1. With assistance, manoeuvre air injection pipe into engine bay and secure onto clip at rear of air intake plenum.
2. Connect heater hoses to heater and secure with clips.
3. Reposition harness along engine bay bulkhead and secure with clips.
4. Fit and tighten nuts securing air injection pipe to air intake plenum.
5. Connect multiplug to SAI vacuum solenoid.
6. Connect air pump hose to air injection pipe and secure with clip.
7. Connect LH and RH SAI control valve hoses to air injection pipe and secure with clips.
8. Remove container.
9. Top up engine coolant.
   ☞ **MAINTENANCE, PROCEDURES, Cooling system.**

Pump - Fuel Leak Detection - up to 03MY

17.45.41

Remove

1. Raise the vehicle on lift.



2. Disconnect multiplug from fuel leak detection pump.
3. Release leak detection air filter hose from top of pump.
4. Remove 3 Torx screws securing pump to mounting bracket.
5. Remove clip securing EVAP canister hose to pump.
6. Release EVAP canister hose from pump.
7. Remove pump.

Refit

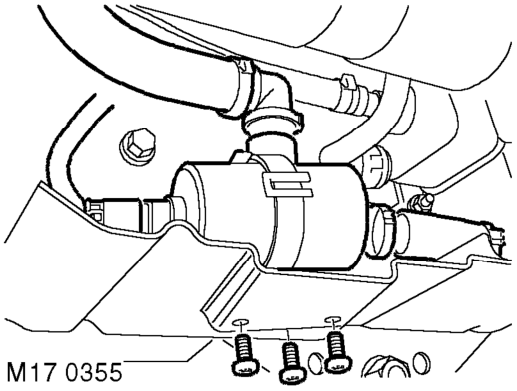
1. Connect EVAP canister hose to pump and secure with clip.
2. Position pump to mounting bracket and secure with Torx screws.
3. Connect leak detection air filter hose to top of leak detection pump.
4. Connect multiplug to pump.
5. Lower vehicle.

Pump - fuel leak detection - from 03MY

17.45.41

Remove

1. Raise the vehicle on lift.



2. Disconnect multiplug from the fuel leak detection pump.
3. Remove 3 screws securing the fuel leak detection pump to the chassis mounting bracket.
4. Position absorbent cloth around fuel hoses to collect any fuel spillage.
5. Disconnect the fuel leak detection filter pipe from the fuel leak detection pump.

   CAUTION: Always fit plugs to open connections to prevent contamination.

6. Remove and discard clip securing EVAP pipe to the fuel leak detection pump and disconnect the pipe.
7. Remove the fuel leak detection pump.

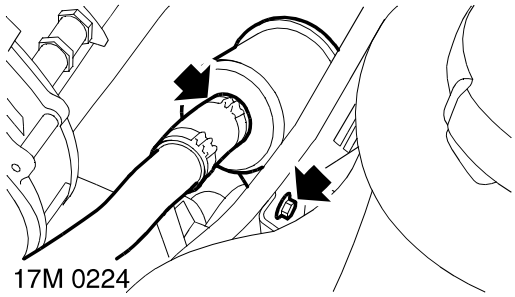
Refit

1. Connect the EVAP pipe to the fuel leak detection pump and secure with a new clip.
2. Connect the fuel leak detection filter pipe to the fuel leak detection pump.
3. Remove absorbent cloth.
4. Fit and tighten 3 screws securing the fuel leak detection pump to the chassis mounting bracket.
5. Connect multiplug to the fuel leak detection pump.
6. Lower the vehicle lift.

Filter - fuel leak detection pump - up to 03MY

17.45.42

Remove



1. Remove bolt securing air filter to mounting bracket and collect nut.
2. Remove clip securing hose to air filter.
3. Release hose from air filter.
4. Remove air filter.

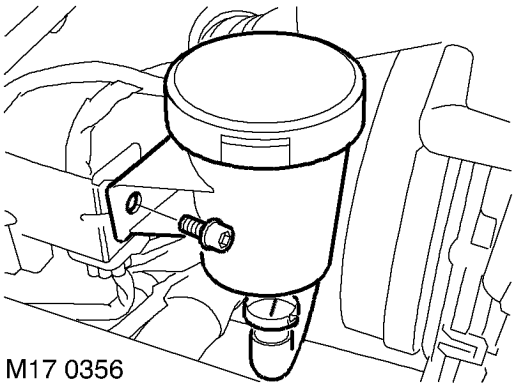
Refit

1. Connect hose to air filter and secure with clip.
2. Position air filter to mounting bracket and secure with nut and bolt.

Filter - fuel leak detection pump - from 03MY

17.45.42

Remove



1. Remove Allen bolt securing fuel leak detection pump filter to the mounting bracket.
2. Remove and discard clip securing fuel pipe to the fuel leak detection pump filter and disconnect the pipe.

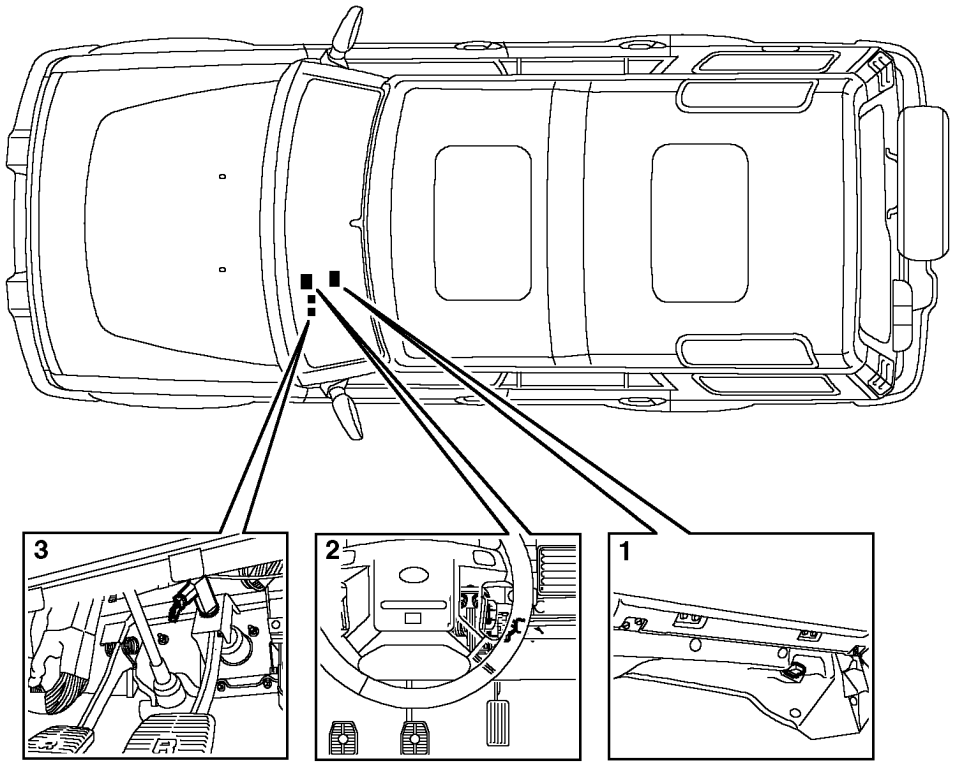
   CAUTION: Always fit plugs to open connections to prevent contamination.

3. Remove the fuel leak detection pump filter.

Refit

1. Connect fuel pipe to the fuel leak detection pump and secure with a new clip.
2. Position fuel leak detection pump filter to mounting bracket, fit Allen bolt and tighten to 3 Nm (2.2 lbf.ft).

Engine management component location - passenger compartment

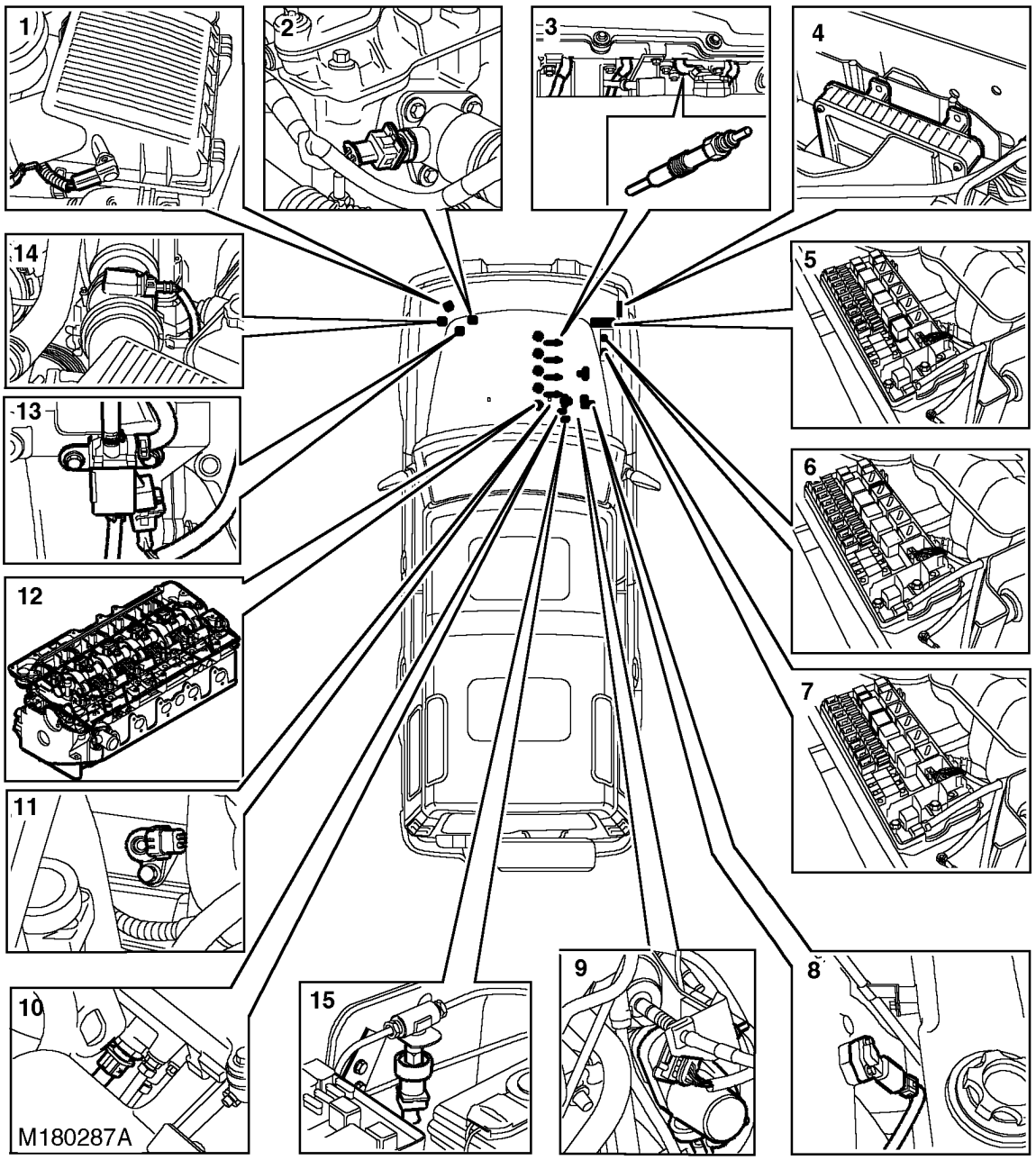


M18 0354B

LHD illustrated

1 Diagnostic connector
2 Throttle position sensor
3 Brake pedal switch

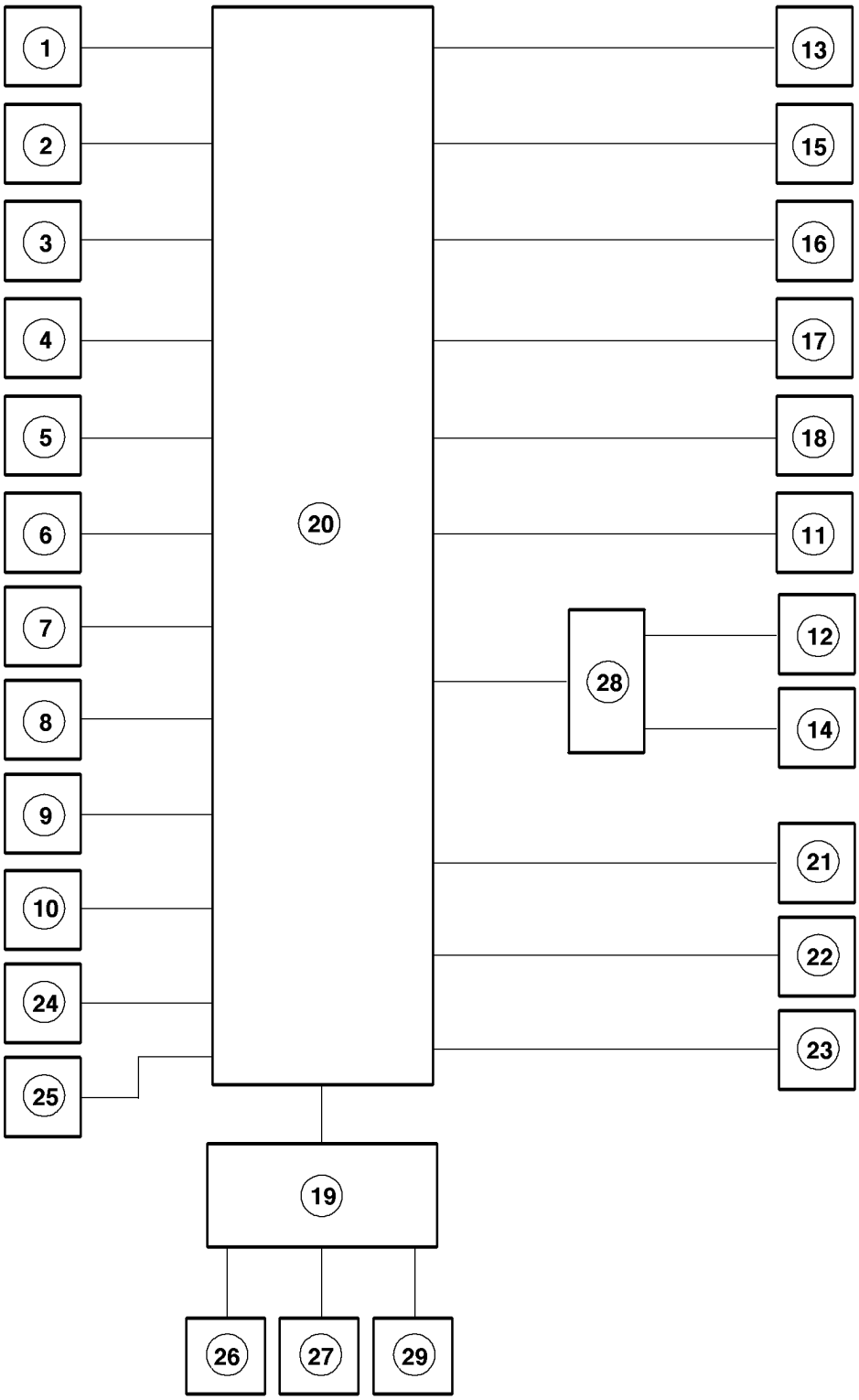
Engine management component location - engine compartment



LHD illustrated

1 Ambient air pressure sensor
2 Engine coolant temperature sensor
3 Glow plugs
4 Engine Control Module (ECM)
5 Fuel pump relay
6 Main relay
7 A/C clutch and cooling fan relays
8 Manifold absolute pressure/ inlet air temperature sensor
9 Electronic vacuum regulator solenoid
10 Fuel temperature sensor
11 Crankshaft speed and position sensor
12 Electronic unit injectors
13 Turbocharger wastegate modulator
14 Mass air flow sensor
15 Clutch switch

Engine management block diagram



M180352

1 Mass air flow sensor
2 Ambient air pressure sensor
3 Manifold absolute pressure/ inlet air temperature sensor
4 Engine coolant temperature sensor
5 Crankshaft speed and position sensor
6 Throttle position sensor
7 Fuel temperature sensor
8 Brake pedal switch
9 Clutch switch
10 High/ Low ratio switch
11 Main relay
12 Malfunction indicator lamp
13 Fuel pump relay
14 Glow plug warning lamp
15 Glow plugs
16 Electronic unit injectors
17 Turbocharger wastegate modulator
18 EGR modulator
19 Diagnostic connector
20 Engine control module
21 Cruise control master switch
22 Cruise control SET+ switch
23 Cruise control RES switch
24 Air conditioning clutch relay
25 Air conditioning cooling fan relay
26 Electronic automatic transmission ECU
27 Self levelling and anti-lock brakes ECU
28 Instrument cluster
29 Body control unit

Description

General

An engine control module (ECM) controls the five-cylinder direct injection diesel engine, and works on the drive by wire principle. This means there is no throttle cable, the ECM controls the drivers needs via a signal from the Throttle Position (TP) sensor on the throttle pedal.

The ECM is a full authoritative diesel specific microprocessor that also incorporates features for cruise control and air conditioning control. In addition, the ECM supplies output control for the exhaust gas recirculation and turbocharger boost pressure. The ECM has a self-diagnostic function, which is able to provide backup strategies for most sensor failures.

The ECM processes information from the following input sources:

- Mass air flow sensor.
- Ambient air pressure sensor.
- Manifold absolute pressure/inlet air temperature sensor.
- Engine coolant temperature sensor.
- Crankshaft speed and position sensor.
- Throttle position sensor.
- Fuel temperature sensor.
- Air conditioning request.
- Air conditioning fan request.
- Brake pedal switch.
- Clutch switch.
- Cruise control master switch.
- Cruise control SET+ switch.
- Cruise control RES switch.
- High/low ratio switch.

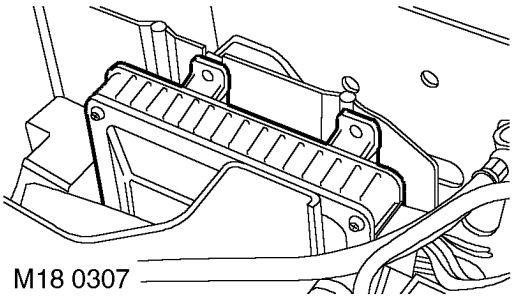
The input from the sensors constantly updates the ECM with the current operating condition of the engine. Once the ECM has compared current information with stored information within its memory, it can make any adjustment it requires to the operation of the engine via the following:

- Air conditioning clutch relay.
- Air conditioning cooling fan relay.
- Electronic vacuum regulator solenoid.
- Malfunction indicator lamp.
- Fuel pump relay.
- Glow plug warning lamp.
- Glow plugs.
- Fuel injectors.
- Main relay.
- Turbocharger wastegate modulator.
- Temperature gauge.

The ECM interfaces with the following:

- Electronic Automatic Transmission (EAT).
- Self Levelling and Anti-lock Brakes System (SLABS).
- Serial communication link.
- Instrument cluster.
- Body Control Unit (BCU).

Engine Control Module (ECM)



The ECM is made from aluminium alloy and is located in the engine compartment on the RH side inner wing. The ECM has an interface of 72 pins via two connectors providing both input information and output control. The ECM receives information from the sensors to inform it of the current state of the engine. The ECM then refers this information to stored values in its memory and makes any changes to the operation of the engine as necessary via the actuators. This is a rolling process and is called adaptive strategy. By using this adaptive strategy the ECM is able to control the engine to give optimum driveability throughout all operating conditions. There is no ECM self test, although the ECM saves driveability data from the last journey. Power down of the ECM can take between 10 seconds and 10 minutes dependent on coolant temperature.

Input/Output

ECM inputs and outputs are detailed below:

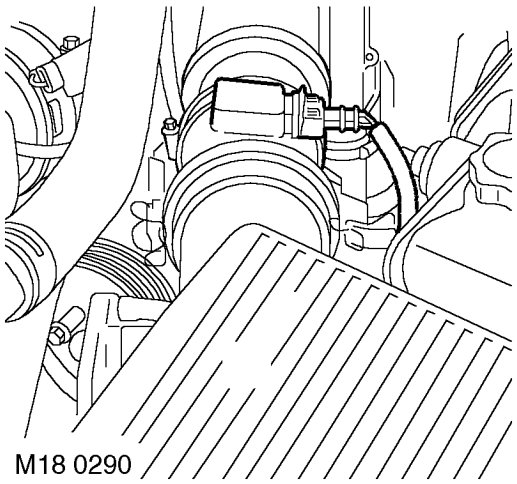
Connector C0158

Pin No.	Input/Output	Function	Signal type	Value	Interfaces
A1	Output	Injector 5	Analogue	0	
A2	Not used				
A3	Output	EGR modulator	Digital	0-12	
A4	Not used				
A5	Input	FT sensor earth	0 volts	0	
A6	Input	MAP sensor	Analogue	0-5 volts	
A7	Input	ECT sensor	Analogue	0-5 volts	
A8	Sensor supply	Sensor supply	5 volts	5 volts	
A9	HT pin				
A10	Input	AAP sensor	Analogue	0-5 volts	
A11	Input	MAF sensor	Analogue	0-5 volts	
A12	Not used				
A13	Input	CKP sensor positive	Analogue		
A14	Not used				
A15	Input	Sensor earth 5	0 volts	0 volts	
A16	Input	CKP sensor screened earth	0 volts	0 volts	
A17	Input	Sensor earth 6	0 volts	0 volts	
A18	Input	Sensor earth 3	0 volts	0 volts	
A19	Input	FT sensor	Analogue	0-5 volts	
A20	Input	Sensor earth 2	0 volts	0 volts	
A21	Output	Turbocharger wastegate modulator	Digital	0-12 volts	
A22	Output	Injector common 2	Analogue	0-85 volts	
A23	Output	Injector common 1	Analogue	0-85 volts	
A24	Output	Injector 4	Analogue	0 volts	
A25	Output	Injector 1	Analogue	0 volts	
A26	Output	Injector 2	Analogue	0 volts	
A27	Output	Injector 3	Analogue	0 volts	
A28	Not used				
A29	Output	Glow plug relay	Analogue	0-90 volts	
A30	Input	Sensor earth 4	0 volts	0 volts	
A31	Not used				
A32	Input/Output	CAN negative	Digital	2.5-5 volts	EAT
A33	Input	High/low ratio switch	Digital	0-5 volts	EAT, SLABS
A34	Input	IAT sensor	Analogue	0-5 volts	
A35	Input/Output	Can positive	Digital	2.5-5 volts	EAT
A36	Input	CKP sensor negative	0 volts	0 volts	

Connector C0658

Pin No.	Input/Output	Function	Signal type	Value	Interfaces
B1	Input	Earth 1	0 volts	0 volts	
B2	Input	Earth 4	0 volts	0 volts	
B3	Input	Supply battery voltage	12 volts	12 volts	
B4	Output	Cooling fan relay	Switch	12-0 volts	A/C ECU
B5	Output	Fuel pump relay	Switch	12-0 volts	
B6	Output	MIL	Switch	12-0 volts	Instruments
B7	Output	Temperature gauge	Digital	0-12 volts	Instruments
B8	Not used				
B9	Input	A/C clutch request	Switch	12-0 volts	A/C ECU
B10	Input	Normally closed brake switch	Switch	12-0 volts	
B11	Input	Cruise control SET+ switch	Switch	12-0 volts	
B12	Input	TP sensor 1	Analogue	0- 5 volts	
B13	Input	Vehicle speed	Digital	0-12 volts	
B14	Input	TP sensor supply	5 volts	5 volts	
B15	Input	Cruise control master switch	Switch	12-0 volts	
B16	Input	Normally open brake switch	Switch	0-12 volts	
B17	Input	Cruise control RES switch	Switch	12-0 volts	
B18	Input/Output	Serial communication link	Digital	0-12 volts	All ECU's
B19	Output	Tachometer engine speed	Digital	0-12 volts	Instrument Cluster
B20	Not used				
B21	Output	Main relay	Switch	0-12 volts	
B22	Input	Supply battery voltage	12 volts	12 volts	
B23	Input	A/C fan request	Switch	12-0 volts	
B24	Input	Earth 3	0 volts	0 volt	
B25	Input	Earth 2	0 volts	0 volts	
B26	Input	TP sensor earth	0 volts	0 volts	
B27	Input	Supply 2	12 volts	12 volts	
B28	Not used				
B29	Output	A/C relay	Switch	12-0 volts	
B30	Output	Glow plug warning light	Switch	12-0 volts	Instrument Cluster
B31	Not used				
B32	Output	ABS	digital	0-5 volts	SLABS
B33	Input	Ignition	Switch	0-12 volts	
B34	Input	Security code	digital	0-5 volts	
B35	Input	Clutch switch	Switch	12-0 volts	
B36	Input	TP sensor 2	Analogue	5-0 volts	

Mass Air Flow (MAF) sensor


M18 0290

The MAF sensor is located in the intake system between the air filter housing and the turbocharger. The ECM uses the information generated by the MAF to control exhaust gas recirculation (EGR).

The MAF sensor works on the hot film principal. The MAF sensor has 2 sensing elements contained within a film. One element is controlled at ambient temperature e.g. 25 °C (77 °F) while the other is heated to 200 °C (392 °F) above this temperature e.g. 225 °C (437 °F). As air passes through the MAF sensor the hot film will be cooled. The current required to keep the constant 200 °C (392 °F) difference provides a precise although non-linear signal of the air drawn into the engine. The MAF sensor sends a voltage between 0 and 5 volts to the ECM proportional to the mass of the incoming air. This calculation allows the ECM to set the EGR ratio for varying operating conditions.

Input/Output

The MAF sensor receives battery voltage from the main relay in the engine compartment fuse box. Signal output from the MAF sensor to the ECM is a variable voltage proportional to air drawn into the engine.

Input to the MAF sensor is via pin 5 of connector C0570 at the engine compartment fuse box. This 12 volt supply is provided by the main relay via fuse 2 in the engine compartment fuse box. The MAF sensor receives the input voltage at pin 3 of the sensor connector.

Output from the MAF sensor is measured at pin 11 of the ECM connector C0158. The earth path is via pin 20 of the ECM connector C0158.

The MAF sensor can fail the following ways or supply incorrect signal:

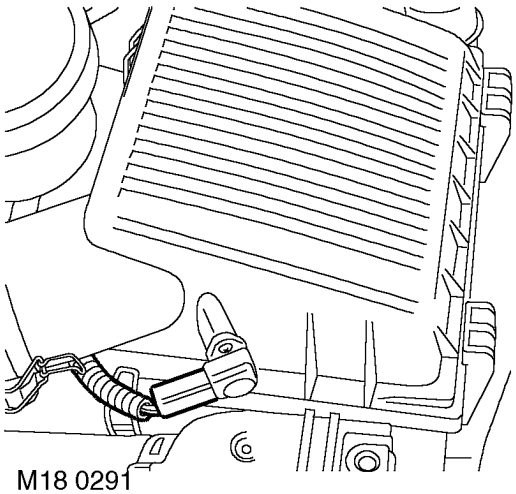
- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Contaminated sensor element.
- Damaged sensor element.
- Damaged in wiring harness.
- MAF supplies incorrect signal (due to air leak or air inlet restriction).

In the event of a MAF sensor signal failure any of the following symptoms may be observed:

- During driving engine speed may dip, before recovering.
- Difficult starting.
- Engine stalls after starting.
- Delayed throttle response.
- EGR inoperative.
- Reduced engine performance.
- MAF signal out of parameters.

The MIL will not illuminate in a MAF sensor failure, and the ECM will use a fixed default value from its memory.

Ambient Air Temperature and Pressure (AAP) sensor


M18 0291

The AAP sensor is located in the top of the air filter housing. It provides voltage signals relative to both ambient air pressure and temperature to the ECM. The AAP sensor produces a voltage between 0 and 5 volts proportional to the pressure level of the air in the air filter housing. A reading of 0 volts indicates low pressure and a reading of 5 volts indicates high pressure. The ECM uses the signal from the AAP sensor for the following functions:

- To maintain manifold boost pressure.
- To reduce exhaust smoke emissions while driving at high altitude.
- Control of the EGR system.

The sensor also supplies a voltage between 0v and 5v proportional to ambient temperature. The ECM uses this signal for the following functions:

- Exhaust gas over temperature protection.
- Turbocharger overspeed protection.

Input/Output

Connector C0158 pin 8 of the ECM supplies the AAP sensor with a 5 volt power supply. The pressure output from the AAP sensor is measured at pin 10 of the ECM connector C0158, the temperature output from the AAP sensor is measured at pin 31. The earth path is via pin 30 of ECM connector C0158.

The AAP sensor can fail the following ways or supply incorrect signal:

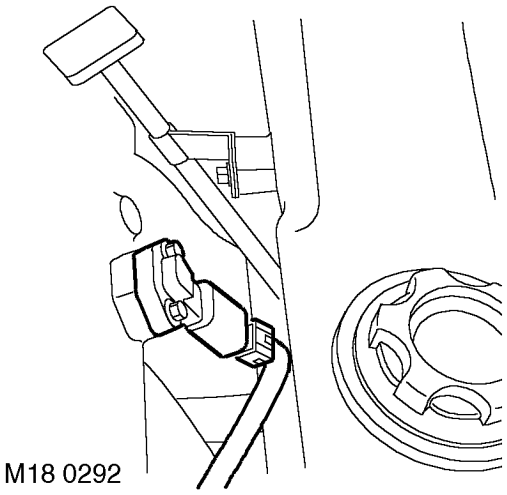
- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Contaminated sensor element.
- Damaged sensor element.
- Resistance in wiring harness.

In the event of an AAP sensor signal failure any of the following symptoms may be observed:

- Altitude compensation inoperative (engine will produce black smoke).
- Active boost control inoperative.
- Turbocharger boost pressure limited to 1 bar (14.5 lbf.in^2).
- EGR altitude compensation inoperative.

The MIL will not illuminate in an AAP sensor failure, and the ECM will use a fixed default value from its memory.

Manifold Absolute Pressure (MAP)/Inlet Air Temperature (IAT) sensor



The MAP/IAT sensors are combined in one unit located in the inlet manifold. It provides pressure and temperature information about the air in the inlet manifold to the ECM. The ECM compares the voltage signal to stored values and compensates fuel delivery as necessary. The ECM uses the signal from the MAP/IAT sensor for the following functions:

- To calculate the delivered fuel limits.
- To calculate the air mass in the cylinder.
- To calculate the air speed density.
- To calculate air temperature.

The MAP sensor works on the piezo crystal principal. Piezo crystals are pressure sensitive and will oscillate in accordance to changes in air pressure. The MAP sensor produces a voltage between 0 and 5 volts proportional to the pressure level of the air in the inlet manifold. A reading of 0 volts indicates a low pressure and a reading of 5 volts indicates a high pressure.

The IAT portion of the sensor works as a Negative Temperature Co-efficient (NTC) sensor. As air temperature rises, the resistance in the sensor decreases. As temperature decreases the resistance in the sensor increases. The ECM compares the voltage signal to stored values and compensates fuel delivery as necessary.

Input/Output

The ECM provides the MAP/IAT sensor with a 5 volt supply. There are 2 output signals from the sensor, one from the MAP and one from the IAT. Input to the MAP/IAT comes from pin 8 of the ECM connector C0158. Output from the MAP is measured at pin 6 of the ECM connector C0158. IAT output signal measured at pin 34 of the ECM connector C0158. The earth path is via pin 17 of ECM connector C0658. The MAP/IAT sensors share the same common earth.

IAT sensor temperature to resistance table.

Temperature °C	Temperature °F	Resistance, ohms (nominal)
-10	14	9397
0	32	5896
10	50	3792
20	68	2500
30	86	1707
40	104	1175
50	122	834.0
60	140	595.5
70	158	435.7

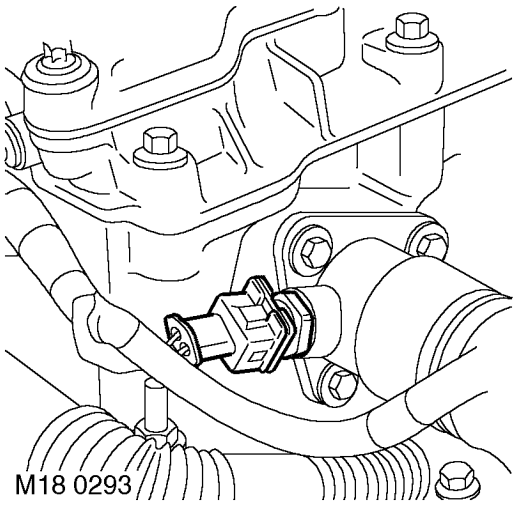
The MAP/IAT sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Contaminated sensor element.
- Damaged sensor element.
- Resistance in wiring harness.

In the event of a MAP/IAT sensor signal failure any of the following symptoms may be observed:

- If the MAP sensor fails manifold pressure is set to a predetermined default value and the engine performance will be reduced.
- If the IAT fails the ECM will set air temperature to a fixed value. The MIL will not illuminate in a MAP/IAT sensor failure and the ECM will use a fixed default value from its memory.

Engine Coolant Temperature (ECT) sensor



The ECT sensor is located in the coolant outlet elbow on the top of the engine. It provides the ECM with engine coolant temperature information. The ECM uses this ECT information for the following functions:

- Fuelling calculations.
- Temperature gauge.
- To limit engine operation if coolant temperature is too high.
- Cooling fan operation.
- Glow plug operating time.

The ECT works as an NTC sensor. As temperature rises, the resistance in the sensor decreases, as temperature decreases, the resistance in the sensor increases. The ECM compares the voltage signal to stored values and compensates fuel delivery to ensure optimum driveability at all times.

Input/Output

The inputs and outputs for the ECT are earth and signal out.

The ECT signal is measured at pin 7 of the ECM connector C0158. The earth path is via pin 18 of ECM connector C0158.

ECT sensor temperature to resistance table.

Temperature, °C	Temperature, °F	Resistance, ohms nominal)
-10	14	9397
0	32	5896
10	50	3792
30	86	1707
50	122	834.0
70	158	435.7
90	194	243.2
110	230	144.2
130	266	89.3

The ECT sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.
- Incorrect mechanical fitting.
- Signal fixed above 40 °C (104 °F) not detected.
- Signal fixed below 40 °C (104 °F) not detected.

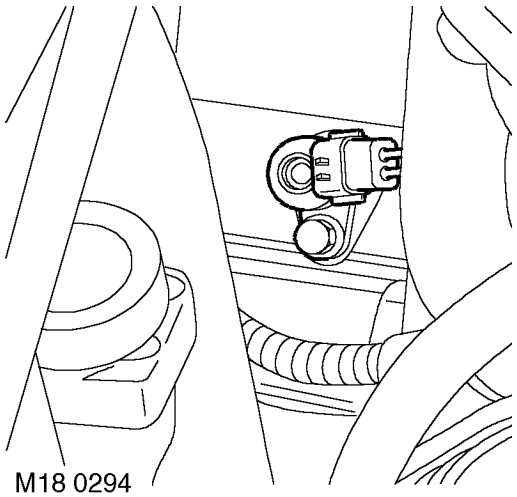
In the event of an ECT sensor signal failure any of the following symptoms may be observed:

- Difficult cold start.
- Difficult hot start.
- Driveability concerns.
- Instrument pack temperature warning illuminated.
- Temperature gauge reads excessively hot.
- Temperature gauge reads excessively cold.

In the event of component failure the ECM calculates coolant temperature from the fuel temperature sensor signal. If this occurs, the limit engine operation if coolant temperature is too high becomes inoperative.

The MIL will not illuminate in an ECT sensor failure.

Crankshaft speed and Position (CKP) sensor



The CKP is located in the transmission housing with its tip adjacent to the outer circumference of the flywheel. The CKP sensor works on the variable reluctance principle, which sends a signal back to the ECM in the form of an ac voltage.

The ECM uses the signal from the CKP for the following functions:

- To calculate engine speed.
- To determine engine crank position.
- To determine fuel injection timing.

The CKP sensor works as a Variable Reluctance Sensor (VRS). It uses an electromagnet and a target ring to generate a signal. As the target ring passes the tip of the CKP sensor the magnetic field produced by the sensor is cut and then re-instated. The ECM measures the signal as an ac voltage.

The outer circumference of the flywheel acts as the target ring for the sensor. The flywheel is divided into 36 segments each of 10°. 31 segments have drilled holes and 5 segments are spaces. This equals 360° or one engine revolution. The 5 spaces correspond to the TDC position of the 5 cylinders, this allows the ECM to control fuel injection timing for each of the cylinders.

Input/Output

The two pins on the sensor are both outputs. The ECM processes the outputs of the sensor. To protect the integrity of the CKP signal an earth shield or screen is used.

The ECM measures the outputs from the CKP. The ECM measures the positive signal from the CKP at pin 13 of ECM connector C0158. The ECM measures the negative signal from the CKP at pin 36 of ECM connector C0158. The earth path is via pin 16 of ECM connector C0158.

Voltage generation from the CKP sensor is relative to engine speed. The values expected from a good CKP sensor are as follows:

- 2 to 3 volts with engine cranking.
- Rising to 6 to 6.5 volts from 1000 rev/min upwards.

The above readings are dependent upon correct air gap between the tip of the CKP sensor and the passing teeth of the reluctor ring.

The CKP sensor can fail the following ways or supply incorrect signal:

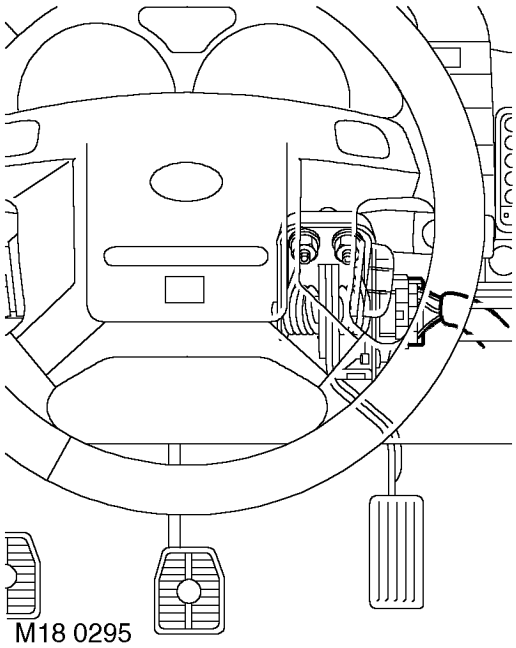
- Sensor assembly loose.
- Incorrect spacer fitted.
- Sensor open circuit.
- Sensor short circuit.
- Incorrect fitting and integrity of the sensor.
- Water ingress.

In the event of a CKP sensor signal failure any of the following symptoms may be observed:

- Engine cranks but fails to start.
- MIL remains on at all times.
- Engine misfires (CKP sensor incorrectly fitted).
- Engine runs roughly or even stalls (CKP sensor incorrectly fitted).

CKP does not have any backup strategy and if it fails the engine will stop running and fail to start.

Throttle Position (TP) sensor – Up to VIN 297136



The TP sensor is located on the throttle pedal assembly. It detects throttle pedal movement and position. It uses two position sensors to provide the ECM with the exact throttle pedal position. As the pedal operates the voltage of one position sensor increases as the other decreases.

Input/Output

The ECM provides the throttle position sensor with a 5 volt reference feed. Both position sensors send an analogue signal back to the ECM.

- Sensor one, 0 to 5 volts variable.
- Sensor two, 5 to 0 volts variable.

Input to the throttle pedal position sensor is via pin 14 of the ECM connector C0658. Output from sensor one is measured via pin 12 of the ECM connector C0658. Output from sensor two is measured via pin 36 of the ECM connector C0658. The earth path is via pin 26 of ECM connector C0658.

The TP sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Water ingress.
- Sensor incorrectly fitted.

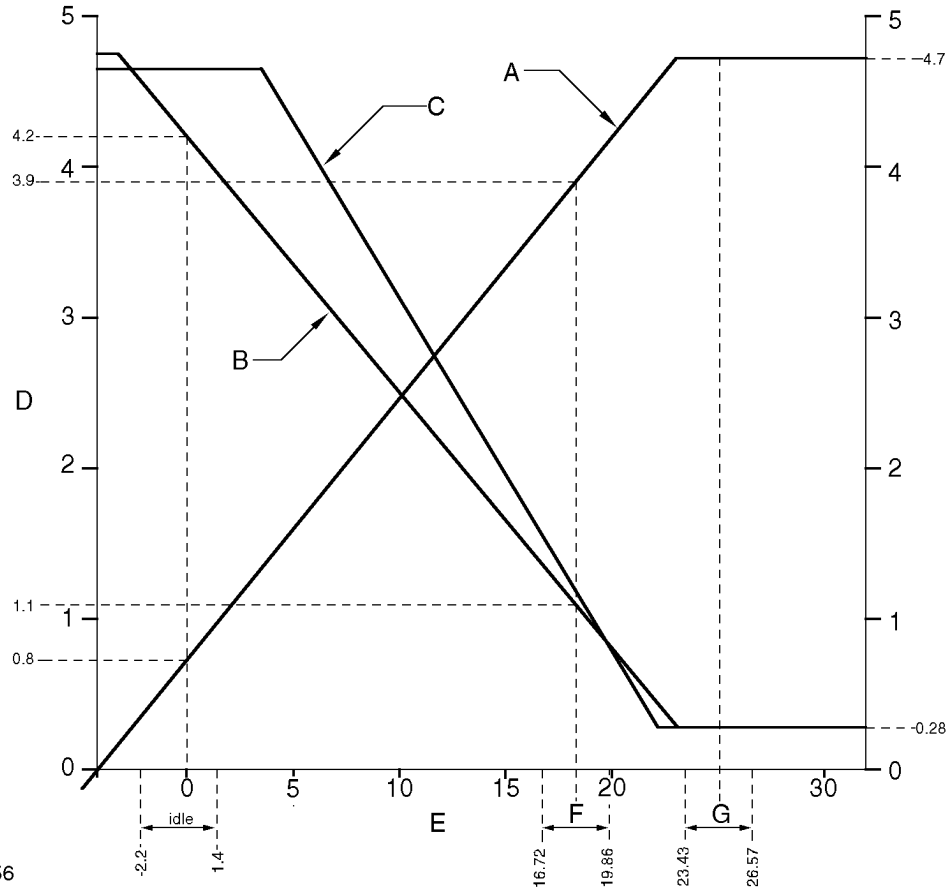
In the event of a TP sensor signal failure any of the following symptoms may be observed:

- Engine performance concern.
- Delayed throttle response.
- Failure of emission control.

If the TP sensor fails, the engine will only run at idle and the MIL will remain on until the fault is eliminated. Turning the ignition off/on can reset the MIL provided that the fault has been rectified.

Throttle Position (TP) sensor – From VIN 297137

Discovery Series II vehicles from VIN 297137 use three track thick film potentiometers. No idle speed sender switch is used on this type of sensor because the ECM can compare the two or three sets of signals to implement idle speed control and over-run fuel shut-off. The two potentiometers are known as track 1 and 2 potentiometers. The track 3 potentiometer on later models is used to improve the resolution of the pedal. The ECM provides a 5V supply and receives a signal from each of the potentiometer tracks.



a = Track 1
b = Track 2
c = Track 3
d = Voltage
e = Pedal angle (degrees)
f = Wide open throttle stop tolerance band
g = Not applicable for Discovery Series II.

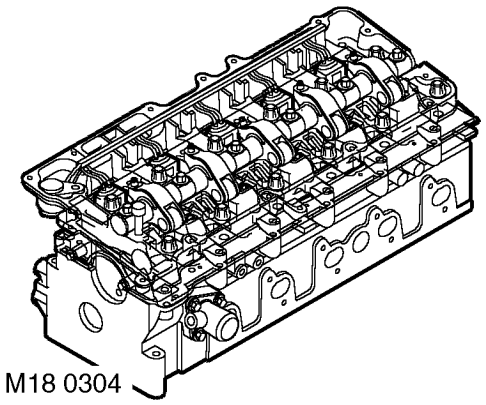
With reference to the above graph, at idle (throttle released), track 2 returns a signal of 4.2V to the ECM and track 1 returns a signal of 0.8V. The ECM calculates the sum of these two figures which totals 5.0V.

At wide open throttle, track 2 returns a signal of 1.1V and track 1 returns a signal of 3.9V to the ECM. The ECM calculates the sum of these two figures which totals 5.0V. The ECM uses this strategy to error check the TP sensor signal and ensure that the requested throttle position is applied. The third potentiometer track measures the tolerance of tracks 1 and 2 and provides an improved functionality check of the pedal angle.

NOTE: Three track TP sensors cannot be fitted as replacements on vehicles previously fitted with two track TP sensors. Replacement ECM's are configured for two track TP sensors and can be fitted to all Td5 models. When replacement ECM's are fitted to vehicles using three track TP sensors, TestBook or T4 must be used to configure the ECM for three track TP sensor use.

If the TP sensor fails, the ECM will illuminate the MIL and the engine will operate at normal idle speed only.

Electronic Unit Injector (EUI)



The EUI's are located in the top of the engine inside the camshaft cover. There is one EUI per cylinder. They inject finely atomised fuel directly into the combustion chamber. Each EUI has its own electrical connection, which is linked to a common harness also located under the camshaft cover. Each of the EUI has its own 5 letter grading code. This code is used so that greater EUI precision is achieved.

The ECM provides the earth path for the EUI. Using an injection-timing map within its memory and information from the crankshaft speed and position sensor the ECM is able to determine precise crankshaft angle. When the ECM determines the crankshaft speed and position it closes the spill valve within the EUI. Fuel pressure rises inside the EUI to a predetermined limit of, 1500 bar (22,000 lbf.in^2) on pre EU3 models, and 1750 bar (25,500 lbf.in^2) on EU3 models, at this limit the pintle lifts off its seat allowing the fuel to inject into the combustion chamber. The ECM de-energises the spill valve to control the quantity of fuel delivered. This causes a rapid pressure drop within the EUI which allows the EUI return spring to re-seat the pintle ending fuel delivery.

The electrical circuit that drives the EUI works in two stages depending on battery voltage. If battery voltage is between 9 and 16 volts the EUI's will provide normal engine performance. If however battery voltage falls to between 6 and 9 volts, on pre EU3 models, EUI operation is restricted to a limit of 2100 rev/min, on EU3 models EUI operation is restricted to idle.

If the vehicle is fitted with a new ECM, the EUI grades for that specific vehicle must be downloaded to the new ECM using TestBook. In the event of the engine failing to rev above 3000 rev/min it is probable that the EUI grading has not been completed.

Input/Output

Input to the EUI takes the form of both mechanical and electrical signals. The mechanical input to the EUI is diesel fuel via the fuel pump operating at approximately 4 to 5 bar (58 to 72 lbf.in^2). Each of the EUI's is operated mechanically by an overhead camshaft to enable injection pressures of up to 1500 bar (22,000 lbf.in^2) on pre EU3 models, and 1750 bar (25,500 lbf.in^2) on EU3 models, to be achieved. The ECM controls the EUI's to ensure that fuel delivery is precise and as intended.

The EUI's earth paths are as follows:

- EUI 1 via pin 25 of the ECM connector C0158.
- EUI 2 via pin 26 of the ECM connector C0158.
- EUI 3 via pin 27 of the ECM connector C0158.
- EUI 4 via pin 24 of the ECM connector C0158.
- EUI 5 via pin 1 of the ECM connector C0158.

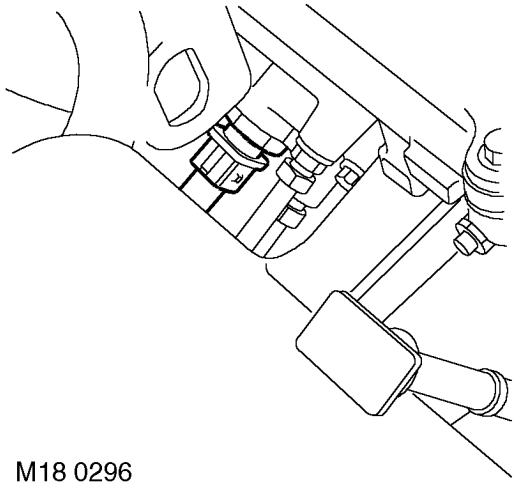
The EUI can fail as follows:

- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault.
- Connector water ingress.
- Connector failure due to excess heat.

In the event of a fuel injector failure any of the following symptoms may be observed:

- Engine misfire.
- Idle faults.
- Reduced engine performance.
- Reduced fuel economy.
- Difficult cold start.
- Difficult hot start.
- Excess smoke.

Fuel Temperature (FT) sensor



M18 0296

The FT sensor is located at the rear of the engine in the fuel rail with the tip of the sensor inserted at least 10 mm into the fuel flow. This allows the sensor to respond correctly to changes in fuel density in relation to fuel temperature.

The FT sensor works as a NTC sensor. As fuel temperature rises the resistance in the sensor decreases. As temperature decreases the resistance in the sensor increases. The ECM is able to compare the voltage signal to stored values and compensates fuel delivery as necessary for hot engine start.

The operating range of the sensor is -40 to 130 °C (-40 to 266 °F).

Input/Output

The inputs and outputs for the FT sensor are 5 volt supply and signal out. In the event of component failure the ECM reverts to a fixed value of 60 °C stored in its memory.

The output signal is measured via pin 19 of the ECM connector C0158. The earth path is via pin 5 of ECM connector C0158.

FT sensor temperature to resistance table.

Temperature, °C	Temperature, °F	Resistance, ohms (nominal)
-10	14	9397
0	32	5896
10	50	3792
20	68	2500
30	86	1707
40	104	1175
50	122	834.0
60	140	595.5
80	176	322.5
100	212	186.6
125	257	100.2

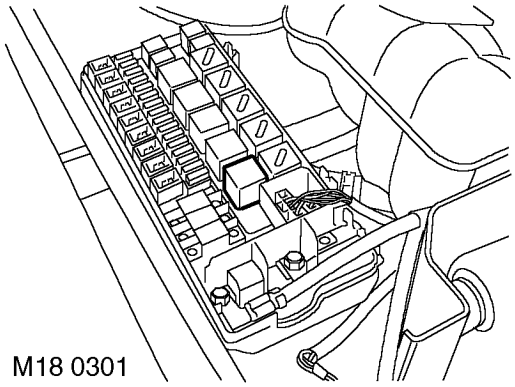
The FT sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.
- Sensor fitted incorrectly.

In the event of a FT sensor signal failure any of the following symptoms may be observed:

- Difficult cold start.
- Difficult hot start.
- Driveability concern.

Fuel pump relay



The fuel pump relay is located in the engine compartment fuse box. It switches on the fuel pump to draw fuel from the fuel tank to the electronic unit injectors (EUI).

Input/Output

The fuel pump relay is a 4 pin normally open relay. Voltage input to the fuel pump relay comes from the main relay switching contacts. When the main relay is energised the switching contacts close and the fuel pump relay windings are supplied a voltage. The ECM provides the earth for the relay windings to close the relay contacts and operate the fuel lift pump. The fuel pump relay switching contacts are supplied voltage via fuse 10 located in the engine compartment fuse box. Output from these switching contacts is supplied directly to the fuel pump. When the ECM interrupts the earth the return spring in the relay pulls the contacts apart and the fuel lift pump stops operating. The earth path is via pin 5 of ECM connector C0658.

The fuel pump relay can fail in the following ways:

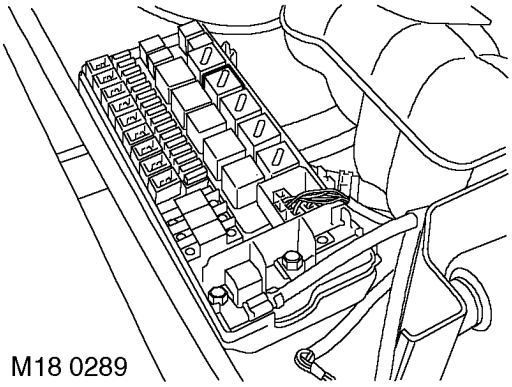
- Relay open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Broken return spring.

In the event of a fuel pump relay failure any of the following symptoms may be observed:

- Engine will crank but not start.
- If the engine is running it will stop.

The MIL will not illuminate in a fuel pump relay failure.

Main relay



The main relay is located in the engine compartment fuse box and supplies battery voltage to the following:

- ECM.
- MAF.
- Fuel pump relay.
- Cruise control master switch.
- Cruise control RES switch.
- Cruise control SET+ switch.

It is a 4 pin normally open relay and must be energised to provide voltage to the ECM.

Input/Output

The earth path for the main relay is via a transistor within the ECM. When the earth path is completed, the main relay energises to supply battery voltage to the ECM. Interrupting this earth path de-energises the main relay, preventing battery voltage reaching the ECM.

Input to the main relay is via pin 1 of connector C0632, located at the engine compartment fuse box. Output from the main relay is via fuse 1 to the ECM connector C0658 pins 3, 22 and 27. The earth path is via pin 21 of ECM connector C0658.

The main relay can fail in the following ways:

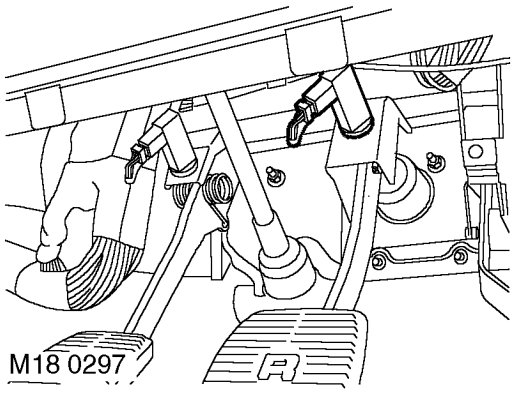
- Relay open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Broken return spring.

In the event of a main relay failure any of the following symptoms may be observed:

- Engine will crank but not start.
- If the engine is running it will stop.

For the ECM start up to take place the ignition 'on' (position II) voltage must be greater than 6.0 volts.

Brake pedal switch



The brake pedal switch is located above the pedal box assembly and activates when the brake pedal is operated. The ECM uses the signal from the brake pedal switch for the following functions:

- To activate the brake lamps.
- To limit fuelling during braking.
- To cancel cruise control if operating.

The brake pedal switch consists of two component parts, one normally open switch and one normally closed switch.

Input/Output

With the brake pedal in the off position the two switches will give opposite signals to the ECM. When the pedal is operated the signals exchange operating state.

With the brake pedal pressed the ECM receives the following:

- 12 volts via pin 10 of the ECM connector C0658.
- 0 volts via pin 16 of the ECM connector C0658.

With the brake pedal released the ECM receives the following:

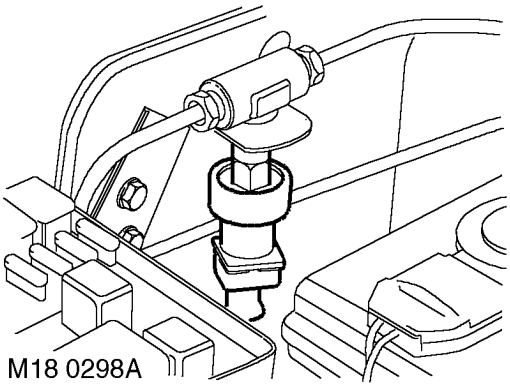
- 0 volts via pin 10 of the ECM connector C0658.
- 12 volts via pin 16 of the ECM connector C0658.

The brake pedal switch can fail in the following ways:

- Switch open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.

In the event of a brake pedal switch failure the ECM will disable cruise control.

Clutch switch



The clutch switch is located at the rear of the engine compartment on the RH side. The switch is operated by hydraulic pressure when the clutch pedal is pressed. The ECM uses the signal from the clutch switch for the following functions:

- To cancel cruise control if operating.
- To provide surge damping during gear change.

Surge damping stops engine speed rising dramatically (engine flaring) during gear change. Surge damping assists driveability as follows:

- Smoother gear change.
- Greater exhaust gas emission control.
- Improved fuel consumption.

Input/Output

The clutch switch receives battery voltage from the BCU. With the clutch pedal in the rest position the switch is closed, allowing battery voltage to pin 35 of the ECM connector C0658. When the clutch pedal is pressed the switch contacts open, interrupting the power supply to the ECM. The ECM receives 0 Volts.

The clutch switch can fail in the following ways:

- Switch open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.

In the event of a clutch switch failure the ECM will react as follows:

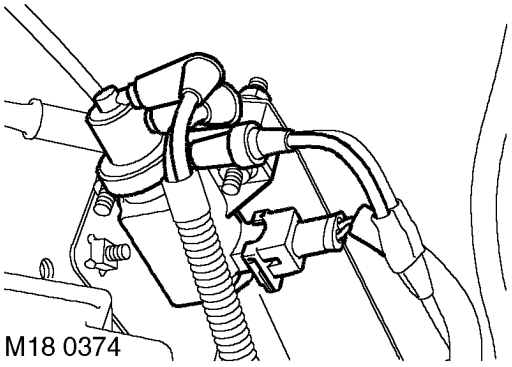
- Surge damping will be inactive.
- Cruise control will be inactive.

High/Low ratio switch

Refer to transfer box for description of the high/low ratio switch.

☞ **TRANSFER BOX - LT230SE, DESCRIPTION AND OPERATION, Description.**

Exhaust Gas Regulator (EGR) modulator



The EGR modulator is located in the engine compartment on the offside inner wing. It regulates the vacuum source to the EGR valve allowing it to open or close. The ECM utilises the EGR modulator to control the amount of exhaust gas being recirculated in order to reduce exhaust emissions and combustion noise. Optimum EGR is usually obtained when the vehicle is operating at light throttle openings, and the vehicle is cruising at approximately 2000 to 3000 rev/min.

Input/Output

The EGR modulator receives battery voltage from fuse 2 in the engine compartment fuse box. The earth path is via pin 3 of ECM connector C0158. The length of time that the ECM supplies an earth is how long the exhaust gases are allowed to recirculate. The ECM decides how long to supply the earth for by looking at engine temperature and engine load.

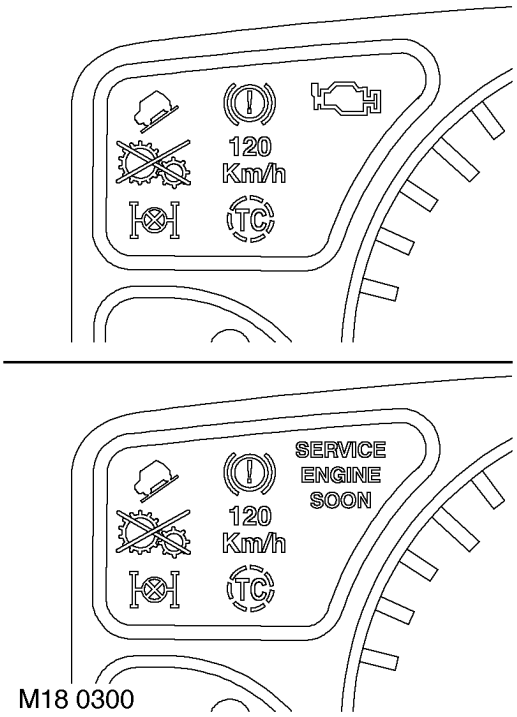
The EGR can fail in the following ways:

- Solenoid open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.

In the event of an EGR modulator failure the EGR system will become inoperative.

The MIL will not illuminate in the event of an EGR modulator failure.

Malfunction Indicator Lamp (MIL)

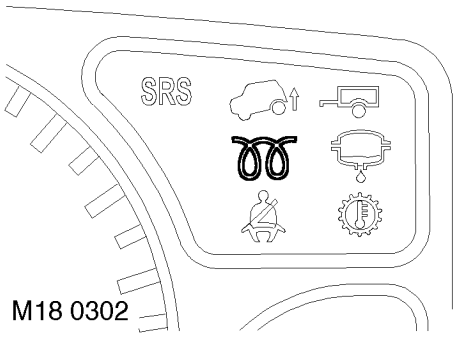


The MIL is located in the instrument cluster. It illuminates to alert the driver to system malfunctions. During ignition a self-test function of the lamp is carried out. The lamp will illuminate for 3 seconds then extinguish if no faults exist. If a fault is present the lamp will be extinguished for 1 second before illuminating.

Input/Output

The MIL is supplied with battery voltage from the instrument cluster. When the ECM detects a fault, it provides an earth path to illuminate the MIL. The earth path is via pin 6 of ECM connector C0658.

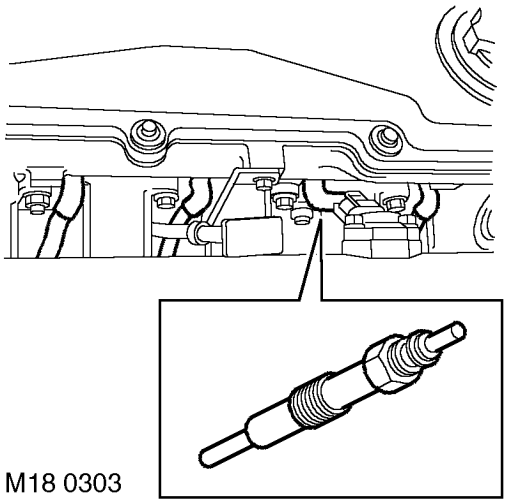
Glow plug warning lamp



The glow plug warning lamp is located in the instrument cluster. It illuminates to alert the driver that the glow plugs are being heated prior to the engine being started. The length of time that the lamp illuminates and the glow plugs are operating prior to cranking is the pre-heat period, which is subject to battery voltage and ECT sensor signal controlled by the ECM.

Input/Output
The instrument cluster supplies battery voltage to the glow plug warning lamp. The ECM provides an earth path to illuminate the lamp. The earth path is via pin 30 of ECM connector C0658.

Glow plugs



The 4 glow plugs are located in the engine block on the inlet side, in cylinder 1 to 4. Cylinder 5 has no glow plug. The glow plugs are a vital part of the engine starting strategy.

The purpose of the glow plugs is:
- Assist cold engine start.
- Reduce exhaust emissions at low engine load/speed.

The main part of the glow plug is a tubular heating element that protrudes into the combustion chamber of the engine. The heating element contains a spiral filament that is encased in magnesium oxide powder. At the tip of the tubular heating element is the heater coil. Behind the heater coil and connected in series is a control coil. The control coil regulates the heater coil to ensure that it does not overheat and cause a possible failure. The glow plug circuit has its own control relay located in the engine compartment fuse box.

Pre-heat is the length of time the glow plugs operate prior to engine cranking. The ECM controls the pre-heat time of the glow plugs based on battery voltage and coolant temperature information via the glow plug relay.

Post-heat is the length of time the glow plugs operate after the engine starts. The ECM controls the post-heat time based on ECT information. If the ECT fails the ECM will operate pre/post-heat time strategies with default values from its memory. The engine will be difficult to start.

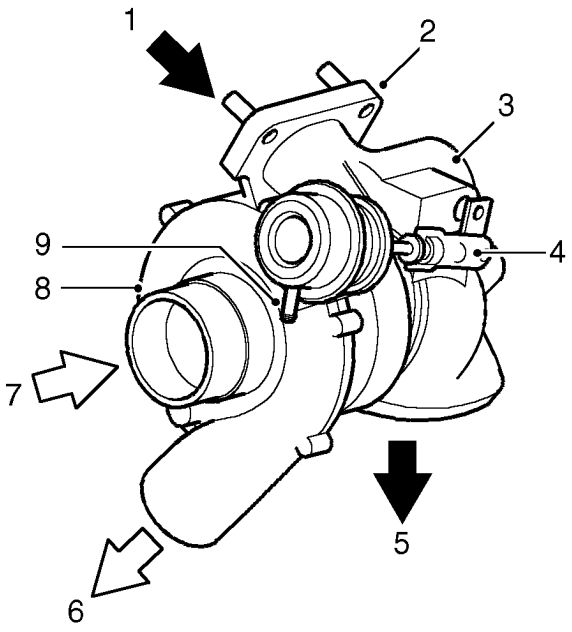
Input/Output

The glow plugs receive voltage from the glow plug relay that is controlled by the ECM. The ECM provides the earth path for the relay coil closing the relay contacts and supplying the glow plugs with battery voltage. The supply voltage heats the coils to approximately 1000 °C (1832 °F). The glow plug circuit is wired in parallel, the body of each glow plug is screwed directly into the engine block which provides each glow plug with an earth path.

The glow plugs can fail in the following ways:
- Heater coil open circuit.
- Control coil open circuit.
- Poor earth quality.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Wiring loom fault.
- Relay windings open circuit.
- Incorrect relay fitted.

In the event of a glow plug failure any of the following symptoms may be observed:
- Difficult starting.
- Excessive smoke emissions after engine start.

Turbocharger



M12 4721

1 Exhaust gas from manifold
2 Studs to exhaust manifold
3 Turbocharger cast iron housing
4 Wastegate valve linkage
5 Exhaust gas out to front exhaust pipe
6 Compressed intake air
7 Fresh intake air
8 Turbocharger aluminium alloy housing
9 Wastegate valve vacuum port

The Td5 engine utilises a Garrett GT20 turbocharger with an electronically controlled wastegate modulator to improve engine performance. The turbocharger uses the engine's exhaust gas to spin a turbine at very high speed. This causes inlet air on the other side of the turbine to be drawn in through the turbocharger intake for compression. The inlet air is carried round by the vanes of the compressor and then thrown out under centrifugal force from the turbocharger's outlet duct. This compression of air enables a greater quantity of air to be delivered to the inlet manifold via an intercooler. Combustion is improved through better volumetric efficiency. The use of a turbocharger improves fuel consumption and increases engine torque and power. Exhaust noise is also reduced due to the smoothing out of exhaust pulsations.

The rear cast iron body of the turbocharger housing connects to a port on the exhaust manifold at the LH side of the cylinder head by three studs and nuts. The interface between the exhaust manifold and the turbocharger housing is separated by a metal gasket. The exhaust outlet of the turbocharger is located at the bottom of the turbocharger cast iron housing; it is connected to the exhaust system front downpipe and is attached by three studs and nuts. The interface between the turbocharger housing and the exhaust front pipe is separated by a metal gasket.

The front casing of the turbocharger is constructed from aluminium alloy and is connected to the air inlet duct by a metal band clip. The compressed air outlet is connected to the intercooler by a metal pipe which has rubber hose extensions at each end attached by metal band clips.

The turbocharger is exposed to extremely high operating temperatures (up to 1,000 °C (1832 °F)) because of the hot exhaust gases and the high speed revolution of the turbine (up to 150,000 rev/min). In order to resist wear of the turbine bearings a flow of lubrication oil is supplied from the engine lubrication system to keep the bearings cool. Oil is supplied from a tapping at the front of the full-flow filter adaptor housing via a metal pipe with banjo connections. Oil is returned to the sump via a metal pipe which connects to the cylinder block at a port below the turbocharger assembly.

A heatshield is attached to the left hand side of the engine to protect adjacent components from the heat generated at the turbocharger. The heatshield is attached to the engine by two bolts an additional bolt attaches the heatshield to the turbocharger casting.

The engine control module controls the amount of boost pressure the engine receives by way of the turbocharger. When full boost is reached a control signal is sent to the wastegate modulator, and a vacuum is applied to the wastegate valve. The wastegate valve opens, bypassing some of the exhaust gas away from the turbine to be output to the exhaust system.

The engine should be allowed to idle for 15 seconds following engine start up and before the engine is switched off to protect the turbocharger by maintaining oil supply to the turbine bearings.

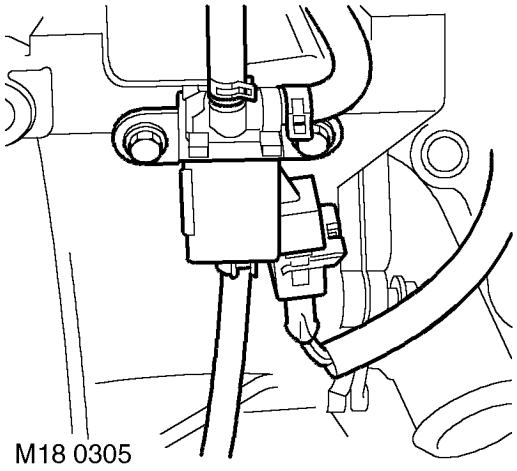
Intercooler

The intercooler is an air-to-air heat exchanger which lowers the intake air temperature to obtain a higher air density for better combustion efficiency. The intercooler receives compressed air from the turbocharger via a metal pipe; it cools the intake air via the intercooler matrix and delivers it to the intake manifold by means of a rubber hose which connects between the intercooler outlet and the intake manifold outlet. The rubber hose is connected to ports at each end by metal band clips.

☞ **COOLING SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

The intercooler is located at the front of the engine bay, forward of the radiator.

Turbocharger wastegate modulator



The turbocharger wastegate modulator is located on the ancillary bracket on the engine, and is connected by flexible pipes to the turbocharger. The modulator controls turbocharger boost pressure by varying the pressure used to open the turbocharger wastegate. This control is vital to ensure the turbocharger does not over boost the engine.

Input/Output

The turbocharger wastegate modulator receives battery voltage from the main relay. The ECM supplies the earth path in the form of a pulse width modulated (PWM) signal. The PWM signal from the ECM operates the modulator at a frequency of less than 50 Hz. This signal allows the turbocharger wastegate modulator to open and close the wastegate. This permits a proportion of the exhaust gas to bypass the turbocharger through the wastegate, thereby regulating boost pressure.

Input voltage to the turbocharger wastegate modulator is via the main relay.

The earth path is via a PWM signal generated at pin 21 of the ECM connector C0158.

The turbocharger wastegate modulator can fail as follows:

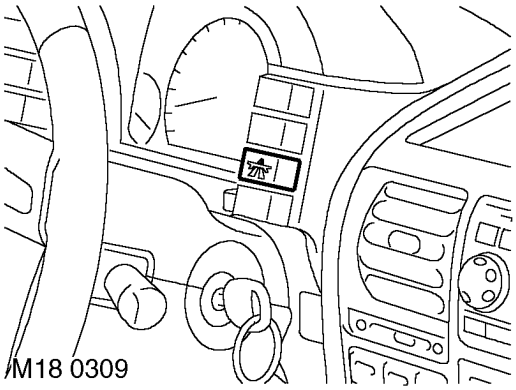
- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault.
- Connector water ingress.
- Connector failure due to excess heat.
- Component failure due to excess heat.
- Component failure due to excess vibration.

In the event of a turbocharger wastegate modulator failure any of the following symptoms may be observed:

- Reduced engine performance.
- Increased engine performance.
- Lack of power.
- Excess smoke.
- Reduced fuel economy.

The MIL will not illuminate in the event of a turbocharger wastegate modulator failure.

Cruise control master switch



The cruise control master switch is located on the dashboard. When the driver activates the switch it requests the cruise control system to be active. The switch acts as a latching switch, on the first operation of the switch the cruise control system is activated, when the switch is pressed again the cruise control system is de-activated. The cruise control warning lamp is part of the switch and illuminates when the switch is activated.

Input/Output

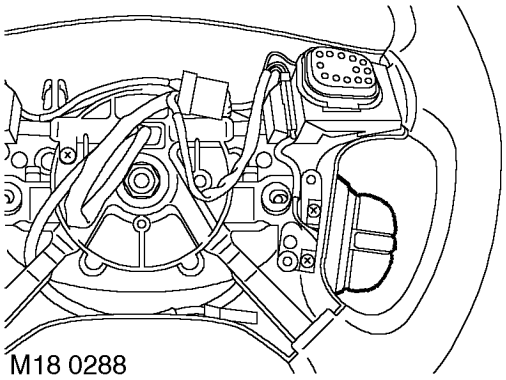
Input to the cruise control master switch is 12 volts via the main relay. When the switch is pressed the circuit is completed by the ECM providing an earth path for the relay via pin 15 of connector C0658 of the ECM.

The cruise control master switch can fail as follows:

- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault.

In the event of a cruise control master switch failure cruise control does not operate.

Cruise control set/accelerate (SET+) switch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The cruise control SET+ switch is located on the vehicle steering wheel. The switch is a momentary switch and when pressed by the driver reacts as follows:

- Requests the cruise control to become active and set at the current road speed if not already set.
- If the cruise control is already set, pressing the switch increases the road speed at 1 mph (1.6 km/h) intervals.

The cruise control SET+ switch will only become active and operate under the following conditions:

- The vehicle speed must be above 22 mph (35 km/h).
- The cruise control master switch must be 'on'.
- The brake pedal must not be pressed.
- The automatic transmission must be in 'drive'.
- The clutch pedal must not be pressed.
- The suspend switch has not been operated.

Input/Output

Input to the cruise control SET+ switch is 12 volts via the main relay. When the switch is pressed the circuit is completed by the ECM providing an earth path for the relay via pin 11 of connector C0658 of the ECM.

The cruise control SET+ switch can fail as follows:

- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault In the event of a cruise control SET+ switch failure cruise control does not operate.

Cruise control resume/suspend (RES) switch

The cruise control RES switch is located on the vehicle steering wheel. The switch is a momentary switch and when pressed by the driver reacts as follows:

- Requests the cruise control to be suspended if it has already been set.
- Requests that cruise control is resumed at the previously set road speed.

The cruise control RES switch will only become active and operate under the following conditions:

- The vehicle speed must be above 22 mph (35 km/h).
- The cruise control master switch must be 'on'.
- The brake pedal must not be pressed.
- The automatic transmission must be in 'drive'.
- The clutch pedal must not be pressed.

Input/Output

Input to the cruise control RES switch is 12 volts via the main relay. When the switch is pressed the circuit is completed by the ECM providing an earth path for the relay via pin 17 of connector C0658 of the ECM.

The cruise control RES switch can fail as follows:

- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault.

In the event of a cruise control RES switch failure cruise control resume/ suspend operation does not operate.

Operation

Engine management
The ECM controls the operation of the engine using stored information within its memory. This guarantees optimum performance from the engine in terms of torque delivery, fuel consumption and exhaust emissions in all operating conditions, while still giving optimum driveability.

The ECM will receive information from its sensors under all operating conditions, especially during:
- Cold starting.
- Hot starting.
- Idle.
- Wide open throttle.
- Acceleration.
- Adaptive strategy.
- Backup strategy for sensor failures.

The ECM receives information from various sensors to determine the current operating state of the engine. The ECM then refers this information to stored values in its memory and makes any necessary changes to optimise air/fuel mixture and fuel injection timing. The ECM controls the air/fuel mixture and fuel injection timing via the Electronic Unit Injectors (EUI), by the length of time the EUI's are to inject fuel into the cylinder. This is a rolling process and is called adaptive strategy. By using this adaptive strategy the ECM is able to control the engine to give optimum driveability under all operating conditions.

During cold start conditions the ECM uses ECT information to allow more fuel to be injected into the cylinders, this combined with the glow plug timing strategy supplied by the ECM facilitates good cold starting.

During hot start conditions the ECM uses ECT and FT information to implement the optimum fuelling strategy to facilitate good hot starting.

During idle and wide open throttle conditions the ECM uses mapped information within its memory to respond to input information from the throttle pedal position sensor to implement the optimum fuelling strategy to facilitate idle and wide open throttle.

To achieve an adaptive strategy for acceleration the ECM uses input information from the CKP sensor, TP sensor, ECT sensor, MAP/ IAT sensor, and the FT sensor. This is compared to mapped information within its memory to implement the optimum fuelling strategy to facilitate acceleration.

Immobilisation system
When the starter switch is turned on, the BCU sends a unique security code to the ECM. The ECM must accept this code before it will allow the engine to operate. If the ECM receives no security code or the ECM receives the incorrect security code, then the ECM allows the engine to run for 0.5 seconds only. During this operation all other ECM functions remain as normal.

The ECM operates immobilisation in three states:
- 'New.'
- 'Secure'.
- 'No Code'.

When an ECM is unconfigured it will operate in the 'New' state. When an unconfigured ECM is installed the engine can be started and operated once only, then the ECM has to be re-configured to either 'secure' or 'no code' configuration depending on whether a security system is fitted to the vehicle. This is achieved by using TestBook.

With the ECM in a 'Secure' state, it will not function unless an alarm system is fitted to the vehicle. A 'Secure' ECM cannot be configured into a 'No Code' ECM.

With the ECM in a 'No Code' state, it does not require an alarm system to be fitted to allow the engine to operate. If the ECM senses that an alarm system is fitted it will not start. A 'No Code' ECM can be configured to a 'Secure' ECM using TestBook. A 'Secure' ECM can not be configured to a 'No Code' state.

Setting up of the ECM immobilisation configurations can only be performed using TestBook.

If a vehicle stalls immediately after starting it is possible that it has been immobilised. This means either:
- The ECM was configured as 'No Code' but the ECM is receiving a code at its alarm input pin.
- The ECM received an incorrect code.
- The ECM was expecting a security code but did not receive one at its alarm input pin.

Fuel delivery/injection control

The fuel delivery/injection control delivers a precise amount of finely atomised fuel to mix with the air in the combustion chamber to create a controlled explosion.

To precisely control fuel delivery and control fuel injection, the following input conditions must be met:
- CKP information.
- Injection timing map information.
- FT information.
- ECT information.

The ECM monitors the conditions required for optimum combustion of fuel in the cylinder from the various sensors around the engine and then compares it against stored information. From this calculation the ECM can adjust the quantity and timing of the fuel being delivered to the cylinder.

The ECM uses CKP information as follows:
- To calculate engine speed.
- To determine engine crankshaft position.

Engine speed and crankshaft position allows the ECM to determine fuel injection timing.

The ECM also uses ECT information and FT sensor information to allow optimum fuel delivery and injection control for all engine coolant and fuel temperatures.

Turbocharger control

Turbocharger control is vital to ensure the turbocharger does not over boost the engine. Within the turbocharger is a wastegate, which when operated by the turbocharger wastegate modulator will open and close a bypass valve regulating boost pressure.

The turbocharger wastegate modulator, via the ECM, controls boost pressure under the following conditions:
- Acceleration.
- Wide open throttle.
- Idle.
- Overrun.

The turbocharger wastegate modulator receives a battery voltage supply from the main relay. The ECM supplies the earth path in the form of a pulse width modulation (PWM) signal. This signal allows the turbocharger wastegate modulator to open and close the wastegate. A proportion of the exhaust gas can bypass the turbocharger through the wastegate, regulating boost pressure.

Controller Area Network (CAN) system

The CAN system is a high speed serial interface between the ECM and the Electronic Automatic Transmission (EAT) ECU. The CAN system uses a data bus to transmit information messages between the ECM and the EAT ECU. Because there are only two components in this CAN system, one will transmit information messages and the other will receive information messages, and vice-versa.

The CAN system is used by the EAT ECU and the ECM for the following:

- Gearshift torque control information.
- EAT OBD information.
- MIL request.
- Vehicle speed signal.
- Engine temperature.
- Engine torque and speed.
- Gear selected.
- Gear change information.

The CAN system uses a twisted pair of wires to form the data bus to minimise electrical interference. This method of serial interface is very reliable and very fast. The information messages are structured so that each of the receivers (ECM or EAT ECU) is able to interpret and react to the messages sent.

The CAN data bus is connected directly between pin 32 of connector C0158 of the ECM and pin 44 of connector C0193 at the EAT ECU, and pin 35 of connector C0158 of the ECM and pin 16 of connector C0193 at the EAT ECU.

The CAN system can fail in the following ways:

- CAN data bus wiring open circuit.
- CAN data bus wiring short circuit.

In the event of a CAN data bus failure any of the following symptoms may be observed:

- EAT defaults to reverse and 4th gear if the vehicle is moving, 3rd gear if the vehicle is stationary.
- Harsh gearshifts.
- Sport and manual warning lamps flash alternately.

Vehicle Speed Signal (VSS)

The VSS is an integral part of the ECM's overall adaptive strategy. The ECM receives the signal direct from the SLABS ECU. The SLABS ECU is not connected to the controller area network (CAN) so therefore is hard wired.

Vehicles fitted with automatic transmission have two vehicle speed input signals to the ECM. One signal is from the SLABS ECU and the other is from the automatic transmission ECU. The ECU compares these speed signals.

The ECM also receives transfer gearbox information. This allows the ECM to take in to account the vehicle being driven using low range gearing and compensate as necessary. The signals generated by the SLABS ECU for manual transmission, and by the EAT ECU for automatic transmission are received by the ECM in the form of a PWM signal. The frequency of this signal changes in accordance with road speed.

The input signal for the SLABS is measured via pin 13 of connector C0658 of the ECM. The SLABS ECU generates a PWM signal switching between 0 and 12 volts at a frequency of 8000 pulses per mile.

For vehicles with automatic transmission the input signal for the EAT ECU is measured via pins 32 and 35 of connector C0158 of the ECM. These pin numbers provide a bi-directional communications link using the CAN data bus.

In the case of a VSS failure on vehicles with automatic transmissions the ECM applies default values derived from the EAT ECU. There is no default value for manual transmission vehicle.

The VSS can fail in the following ways:
- Wiring short circuit to vehicle supply.
- Wiring short circuit to vehicle earth.
- Wiring open circuit.

In the event of a VSS failure any of the following symptoms may be observed:
- Vehicle speed limiting disabled (manual transmission only).
- Hill Descent Control (HDC) warning lamp on and audible warning.

Cruise control
All markets have a common cruise control system. The cruise control system, when activated, regulates vehicle speed. The ECM controls the cruise control system.

Cruise control activation
Cruise control is a passive system, and must be activated by the driver. Cruise control is activated by switching on the cruise control master switch located on the instrument panel. A LED in the switch illuminates indicating cruise control is available. The driver must accelerate the vehicle to the desired speed using the accelerator pedal. When the desired speed is reached, cruise control can be activated by pressing the SET+ switch.

Cruise control will only activate if the following conditions are met:
- Vehicle speed is above 22 mph (35 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual transmission only).
- The transmission is not in Park, Reverse or Neutral (automatic transmission only).

The ECM receives the set signal and determines the vehicle speed provided by the SLABS ECU. The ECM then maintains current road speed.

Cruise control cancellation
Cancelling cruise control enables the driver to regain control of the vehicle speed by using the accelerator pedal.

Cruise control is cancelled if any of the following conditions occur:
- The brake pedal is pressed.
- The RES switch is pressed.
- The clutch pedal is pressed (manual transmission only).
- The cruise control master switch is switched off.
- The transmission is placed in Park, Neutral, or Reverse (automatic transmission only).

The ECM cancels cruise control operation and returns it to the control of the accelerator pedal.

The set speed will be stored in the ECM unless:
- The cruise control master switch is switched off.
- The ignition is switched off.

If cruise control is deactivated using either of the above methods, the set speed will be erased from the memory of the ECM.

Cruise control resumption
Cruise control can be resumed at the previously set speed, provided the set speed has not been erased from the ECM's memory as described above.

To resume cruise control operation to the previously set speed, depress the RES switch once when the following conditions are met:
- A set speed is stored in the ECM.
- Vehicle speed is above 22 mph (35 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual transmission only).
- The transmission is not in Park, Reverse or Neutral (automatic transmission only).

The ECM activates the cruise control system at the stored speed.

Accelerating while cruise control is active
There are three ways of increasing vehicle speed when cruise control is active:
- Temporarily increase vehicle speed (e.g. when overtaking another vehicle).
- Increase vehicle set speed in 1 mph (1.5 km/h) increments.
- Increase vehicle set speed.

To temporarily increase vehicle speed press the accelerator pedal until the desired speed is reached.

When the accelerator pedal is released, the vehicle coasts back to the set speed. When it reaches the set speed, cruise control operation continues.

To increase the vehicle set speed in 1 mph (1.5 km/h) increments, tap the SET+ switch. Each tap on the switch increases vehicle speed.

To increase the vehicle set speed, press and hold the SET+ switch until the desired set speed is reached.

Vehicle set speed will increase if the following conditions are met:
- The vehicle is under cruise control operation.
- Vehicle speed is above 22 mph (35 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual transmission only).
- The transmission is not in Park, Reverse or Neutral (automatic transmission only).

The vehicle responds as follows:
- If the driver accelerates using the throttle pedal, the ECM increases vehicle speed using the TP sensor signal. When the driver releases the accelerator pedal, the vehicle returns to the set speed.
- If the SET+ switch is tapped the stored speed and vehicle speed increases by 1 mph (1.5 km/h) per tap on the switch.
- If the driver presses and holds the SET+ switch the vehicle speed will increase and will hold the speed when the switch is released.

Switching off cruise control
Switching off cruise control allows the driver to regain control of vehicle speed, and erases the set road speed from the ECM's memory.

To switch off cruise control, press the cruise control master switch to the off position.

When the cruise control master switch is switched off, the ECM deactivates cruise control and the driver regains control of vehicle speed.

Air Conditioning (A/C)
The ECM controls operation of the A/C compressor and the engine's electric cooling fan in response to requests from the Automatic Temperature Control (ATC) ECU.

A/C request
When the ATC ECU supplies the ECM with an A/C request, the ECM energises the compressor clutch relay. The compressor clutch relay is located in the engine compartment fuse box. It is a four pin normally open relay. This means that the relay must be energised to drive the compressor clutch. During periods of high driver demand such as hard acceleration or maximum rev/min the ECM will disable the compressor clutch for a short time. This is to reduce the load on the engine.

The operation of the A/C request is via a switch being connected to earth. Voltage is supplied via pin 9 of connector C0658 of the ECM, at the point at which the switch is pressed the connection to the earth path is made and the compressor clutch is engaged.

The ECM provides the earth for the relay windings to allow the compressor clutch relay contacts to close and the compressor clutch drive to receive battery voltage. The ECM uses a transistor as a switch to generate an open circuit in the earth path of the relay windings. When the ECM closes down the earth path, the return spring in the relay will pull the contacts apart to shut down the compressor clutch drive. Fuse 6, located in the engine compartment fuse box, provides voltage to the compressor clutch relay switching contacts. The relay windings are supplied with battery voltage from the main relay, also located in the engine compartment fuse box. The earth path for the relay windings is via pin 29 of the ECM connector C0658. When the relay is energised the output from the switching contacts is directly to the compressor clutch.

Cooling fan request
The A/C fan request is an input to the ECM from the ATC ECU to request that the engine's electric cooling fan is activated to provide additional cooling for the A/C condenser.

The cooling fan relay is located in the engine compartment fuse box and is also controlled by the ECM. It is a four pin normally open relay. This means that the relay must be energised to drive the cooling fan. The cooling fan is used especially when the engine is operating at excessively high temperatures. It is also used as a part of the ECM backup strategy if the ECT sensor fails.

The operation of the cooling fan request is via a switch being connected to earth. Voltage is supplied via pin 23 of connector C0658 of the ECM, at the point at when the switch is pressed the connection to the earth path is made and the cooling fan is engaged.

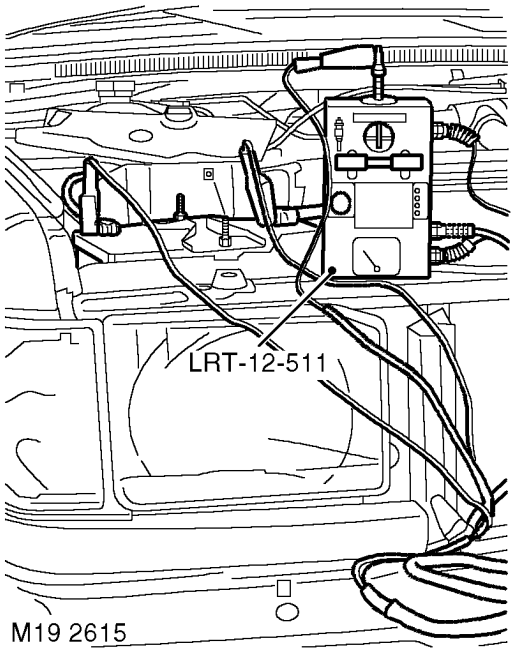
The ECM provides the earth for the cooling fan relay windings to allow the relay contacts to close and the cooling fan motor to receive battery voltage. The ECM uses a transistor as a switch to generate an open circuit in the earth path of the relay windings. When the ECM closes down the earth path, the return spring in the relay will pull the contacts apart to shut down the cooling fan motor drive. Input to the A/C cooling fan relay switching contacts is via fuse 4 located in the engine compartment fuse box. The relay windings are supplied with battery voltage from the main relay, also located in the engine compartment fuse box. The earth path for the relay windings is via pin 4 of the ECM connector C0658. When the relay is energised the output from the switching contacts is directly to the cooling fan motor.

Glow plug

19.90.20.01

Check

1. Remove glow plug.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Glow plugs.



2. Using tool **LRT-12-511**connect RED lead to battery '+' positive and the BLACK lead to battery '-' negative.
3. Position glow plug into tester and retain with spring loaded bar.
4. Connect YELLOW lead to glow plug terminal.
5. Press red button on tester and note ammeter reading. Keep button depressed, glow plug tip should start to glow after 5 seconds.**The tip of the plug must glow first, if it fails to do so, replace glow plug.**
6. The ammeter reading should show an initial current draw of 25 amps, which should fall to 12 amps after 20 seconds.
7. Refit glow plug.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Glow plugs.

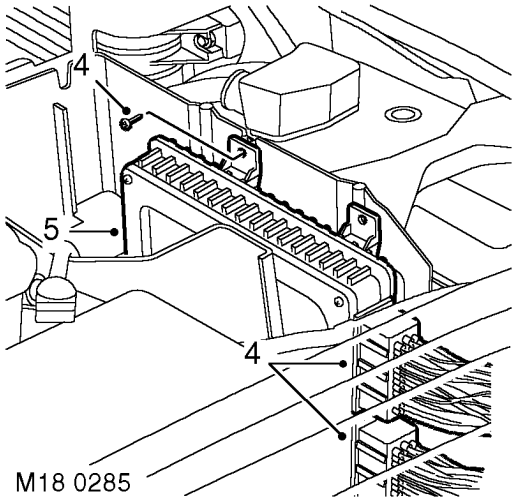
Engine control module (ECM)

18.30.03

All replacement ECM's are configured for two track TP sensors. When fitting replacement ECM to vehicle with three track TP sensor, TestBook must be used to configure ECM for three track TP sensor.

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Release retaining strap and remove vehicle jack.



4. Remove screw, release ECM and disconnect 2 multiplugs.
5. Remove ECM.

Refit

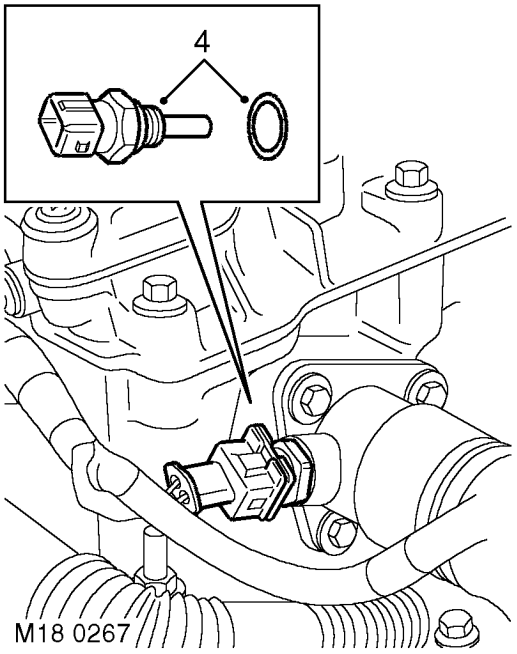
1. Position new ECM and connect multiplugs.
2. Fit ECM and tighten screw.
3. Fit vehicle jack and secure retaining strap.
4. Connect battery earth lead.
5. Fit battery cover and secure with fixings.
6. Programme ECM using TestBook.

Sensor - engine coolant temperature (ECT)

18.30.10

Remove

1. Remove fixings and remove engine acoustic cover.
2. Release fixings and remove cooling fan cowl.
3. Disconnect multiplug from ECT sensor.



4. Remove sensor from coolant outlet elbow and discard sealing washer.

Refit

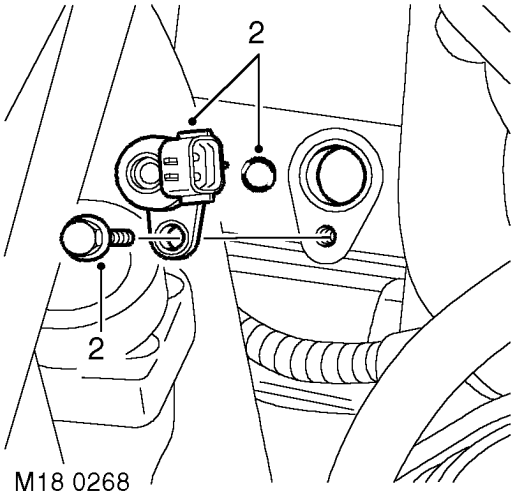
1. Clean ECT sensor and coolant outlet elbow mating faces.
2. Fit new sealing washer to ECT sensor. Fit sensor and tighten to 15 Nm (11 lbf.ft). Connect multiplug.
3. Fit cooling fan cowl and secure with fixings.
4. Fit engine acoustic cover and secure with fixings.
5. Top up cooling system.
   MAINTENANCE, PROCEDURES, Cooling system.

Sensor - crankshaft (CKP)

18.30.12

Remove

1. Disconnect multiplug from CKP sensor.



M18 0268

2. Remove bolt securing CKP sensor. Remove CKP sensor from gearbox housing and discard 'O' ring.
3. **If fitted:**Remove and discard spacer.

Refit

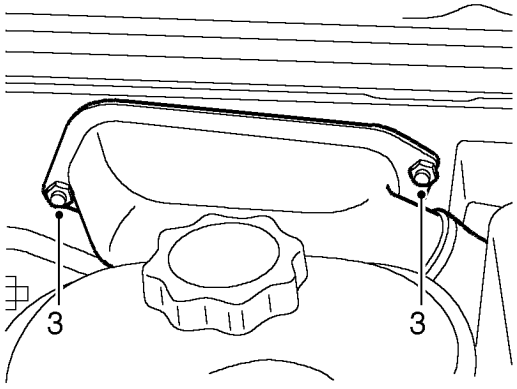
1. Clean gearbox housing and CKP sensor.
2. **If fitted:**Fit new spacer.
3. Fit new 'O' ring, position CKP sensor to gearbox housing and tighten bolt to 9 Nm (7 lbf.ft).
4. Connect multiplug to CKP sensor.

Air filter assembly

19.10.01

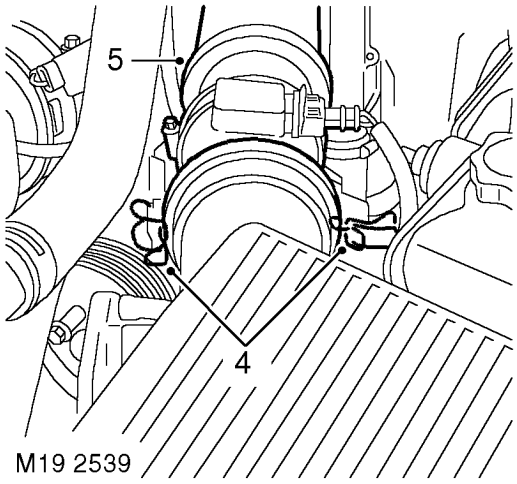
Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.



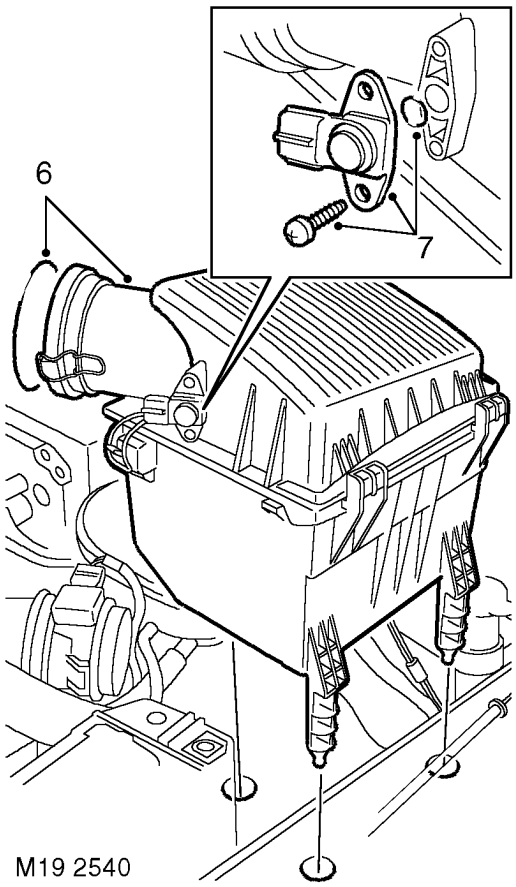
M19 2538

3. Remove 2 nuts and remove air intake duct.



M19 2539

4. Release 2 clips securing MAF sensor.
5. Release MAF sensor from air filter cover and position aside.



6. Release air filter from 3 grommets, remove assembly and discard 'O' ring.
7. Remove 2 screws, remove AAP sensor and discard 'O' ring.

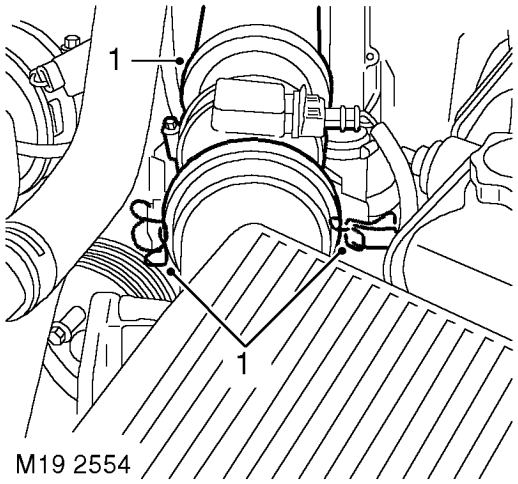
Refit

1. Clean MAF sensor and air filter mating faces.
2. Fit new 'O' ring to air filter.
3. Clean AAP sensor.
4. Using new 'O' ring, fit AAP sensor and tighten screws.
5. Position air filter assembly and secure in grommets.
6. Position MAF sensor and secure clips.
7. Position intake duct to air filter and tighten nuts.
8. Connect battery earth lead.
9. Fit battery cover and secure with fixings.

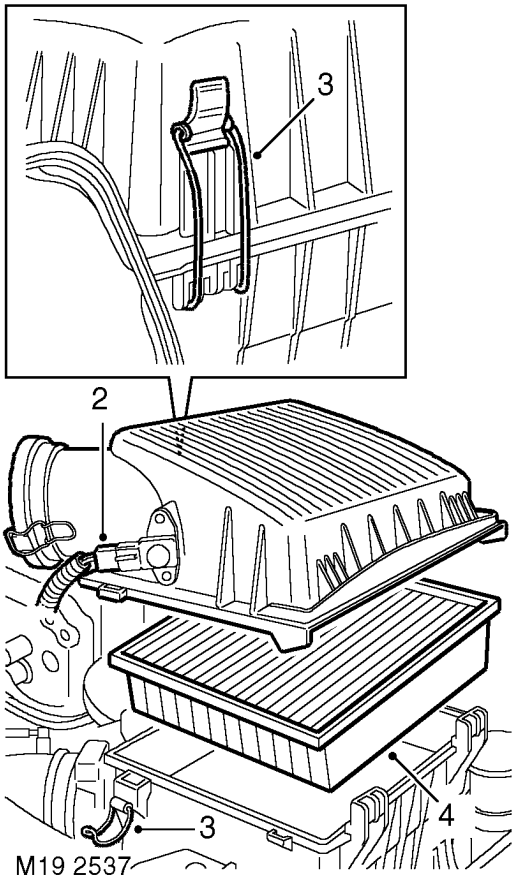
Element - air filter

19.10.10

Remove



1. Release 2 clips and disconnect MAF sensor from air filter cover.



2. Disconnect multiplug from AAP sensor.
3. Release 2 clips and remove cover from air filter.
4. Remove air filter element.

Refit

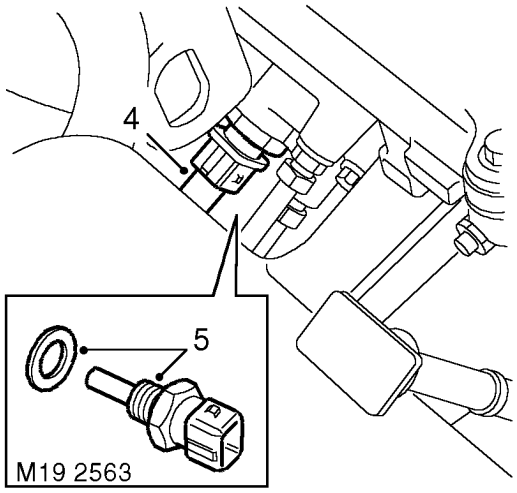
1. Clean air filter body and cover.
2. Fit new air filter element.
3. Position air cleaner cover and secure clips.
4. Position MAF sensor and secure clips.
5. Connect multiplug to AAP sensor.

Sensor - fuel temperature

19.22.08

Remove

1. Remove 3 bolts and remove engine acoustic cover.
2. Release fixings and remove battery cover.
3. Disconnect battery earth lead.



4. Disconnect multiplug from fuel temperature sensor.
5. **Thoroughly clean area around fuel temperature sensor before removal.**
6. Remove fuel temperature sensor and discard sealing washer.

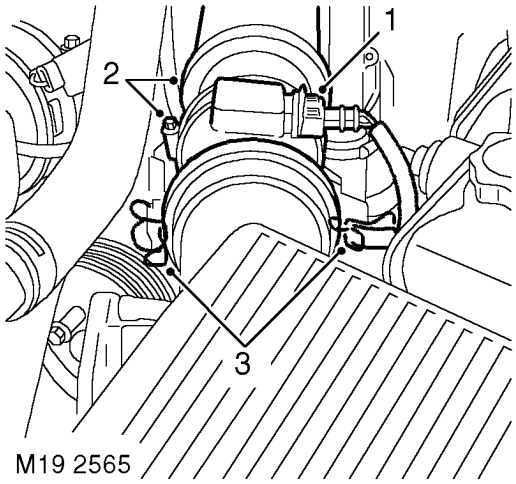
Refit

1. Clean fuel temperature sensor mating faces.
2. Fit new sealing washer and tighten fuel temperature sensor to 13 Nm (10 lbf.ft) .
3. Connect multiplug to fuel temperature sensor.
4. Connect battery earth lead.
5. Fit battery cover and secure fixings.
6. Fit engine acoustic cover, and secure with fixings.

Sensor - mass air flow (MAF)

19.22.25

Remove



1. Disconnect multiplug from MAF sensor.
2. Loosen clip and release air intake hose from MAF sensor.
3. Release 2 clips and remove sensor from air cleaner.

Refit

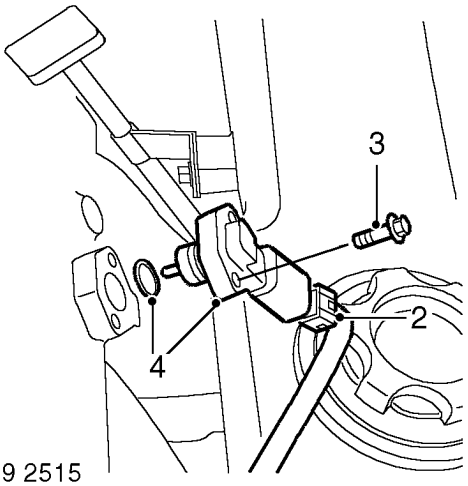
1. Position sensor to air cleaner and secure clips.
2. Position air intake hose and tighten clip.
3. Connect multiplug to MAF sensor.

Sensor - combined MAP and IAT

19.22.26

Remove

1. Remove 3 bolts and remove engine acoustic cover.



2. Disconnect multiplug from combined MAP and IAT sensor,
3. Remove 2 bolts securing sensor to inlet manifold.
4. Remove sensor and discard 'O' ring.

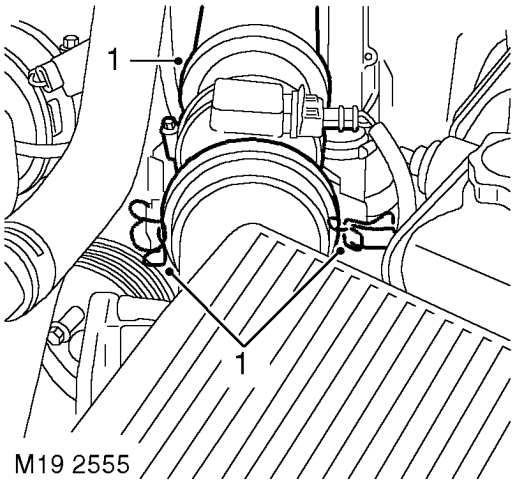
Refit

1. Clean sensor and inlet manifold mating face.
2. Fit new 'O' ring and position sensor to manifold.
3. Fit bolts securing MAP and IAT sensor and tighten to 9 Nm (7 lbf.ft).
4. Fit engine acoustic cover and secure with fixings.

Sensor - ambient air pressure (AAP)

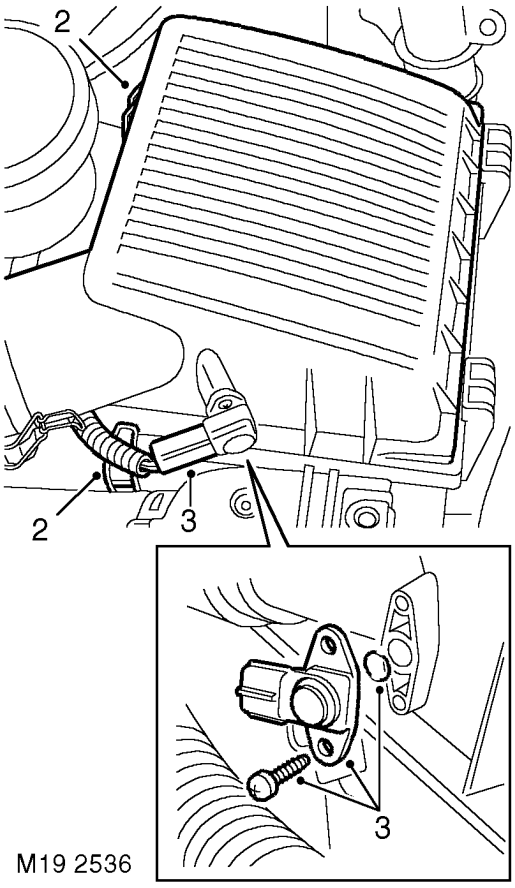
19.22.27

Remove



M19 2555

1. Release 2 clips and disconnect MAF sensor from air cleaner cover.



M19 2536

2. Release 2 clips and release cover from air cleaner.
3. Disconnect multiplug from AAP sensor, remove 2 screws, remove sensor and discard 'O' ring.

Refit

1. Clean AAP sensor and air cleaner cover.
2. Fit new 'O' ring, fit sensor and tighten screws.
3. Position air cleaner cover and secure clips.
4. Connect multiplug to AAP sensor.
5. Position MAF sensor and secure clips.

Element - fuel filter

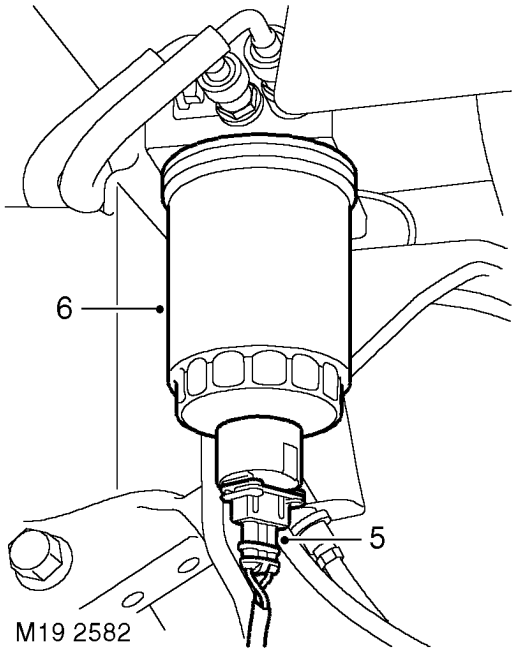
19.25.07

Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Clean area around fuel filter.



5. Disconnect multiplug from filter element.
6. Remove fuel filter element.

Refit

1. Clean fuel filter and mating face.
2. Fit new fuel filter element and connect multiplug.
3. Remove stand(s) and lower vehicle.
4. Connect battery earth lead.
5. Fit battery cover and secure the fixings.

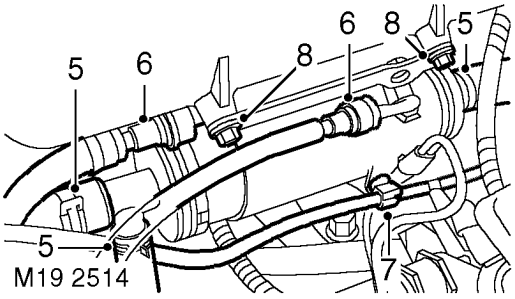
Cooler - fuel

19.25.30

Remove

1. Remove 3 bolts and remove engine acoustic cover.
2. Remove battery cover.
3. Disconnect battery earth lead.
4. Drain cooling system.

   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.



5. Release 3 clips and disconnect 3 coolant hoses from fuel cooler.
6. Release 2 fuel hoses from fuel cooler.

   CAUTION: Always fit plugs to open connections to prevent contamination.

7. Release vacuum pipe clip from fuel cooler.
8. Noting which bolts are removed from the upper fixing holes, remove 4 bolts securing fuel cooler to inlet manifold. Remove cooler.

Refit

1. Clean fuel hose connections.
2. Apply Loctite 242 to the two upper bolts.
3. Position fuel cooler to inlet manifold, fit bolts and tighten the upper bolts to 18 Nm (13 lbf.ft) and the lower bolts to 25 Nm (18 lbf.ft).
4. Connect fuel hoses to fuel cooler.
5. Connect coolant hoses to fuel cooler, secure with clips.
6. Secure vacuum hose to fuel cooler.
7. Refill cooling system.

   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.

8. Fit engine acoustic cover and secure with fixings.
9. Connect battery earth lead.
10. Fit battery cover.

Sensor - Throttle position (TP)

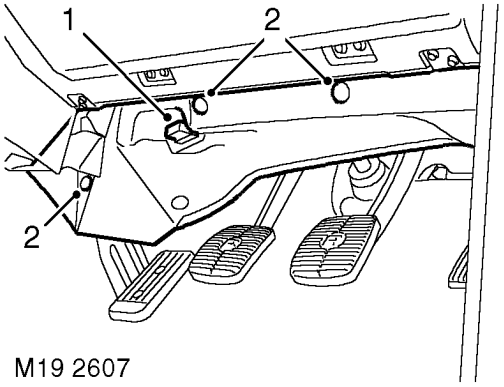
19.30.14

The TP sensor is integral with the throttle pedal assembly and must be renewed as an assembly.

Three track TP sensors were introduced from VIN 297137.

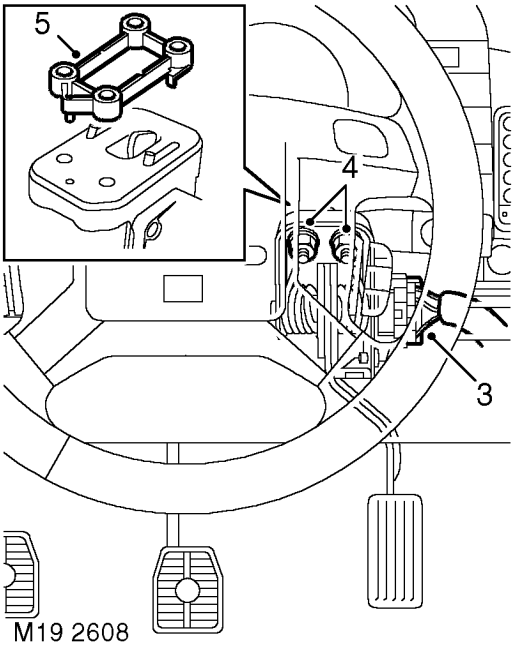
Three track TP sensors cannot be fitted to vehicles previously fitted with two track TP sensors.

Remove



M19 2607

1. Release diagnostic socket from driver's closing panel.
2. Remove 3 trim retaining studs and remove closing panel.



M19 2608

3. Disconnect multiplug from TP sensor, release harness from throttle pedal bracket and position harness aside..
4. Remove 2 nyloc nuts and remove throttle pedal assembly. Discard nuts.
5. Remove spacer block from pedal bracket.

Refit

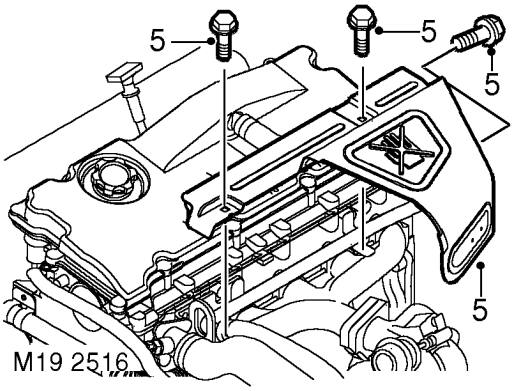
1. Position spacer block to pedal bracket.
2. Position throttle pedal assembly and tighten new nyloc nuts to 13 Nm (10 lbf.ft).
3. Fit and secure harness to pedal bracket and connect multiplug to TP sensor.
4. Position closing panel, connect diagnostic socket and fit retaining studs.

Turbocharger

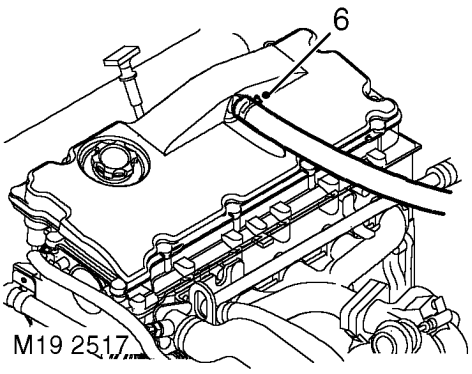
19.42.01

Remove

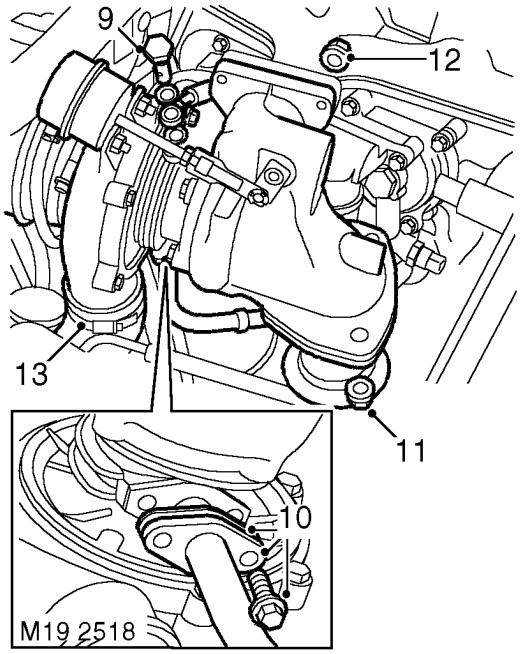
1. Remove 3 bolts and remove engine acoustic cover.
2. Release fixings and remove battery cover.
3. Disconnect battery earth lead.
4. Remove cooling fan cover.



5. Remove 3 bolts and remove exhaust manifold heat shield.



6. Release clip and disconnect breather hose from camshaft cover.
7. Release clip and disconnect vacuum hose from turbocharger wastegate.
8. Loosen clips and release air intake and outlet hoses from turbocharger.



9. Remove turbocharger oil feed banjo bolt and discard sealing washers.
10. Remove 2 bolts and release turbocharger oil drain pipe and discard gasket.
11. Remove 3 nuts and release exhaust front pipe from turbocharger and discard gasket.
12. Remove 3 nuts securing turbocharger to exhaust manifold.
13. Remove turbocharger and discard gasket.

Refit

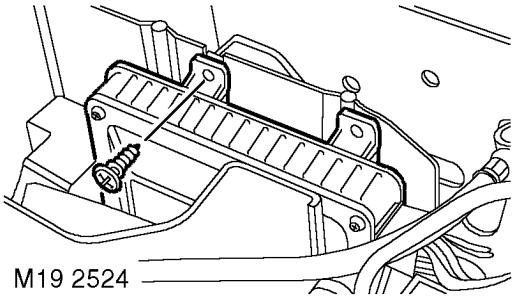
1. Clean turbocharger and exhaust manifold mating faces.
2. Using a new gasket, fit turbocharger to exhaust manifold and tighten nuts to 30 Nm (22 lbf.ft).
3. Using new gasket, align exhaust front pipe and tighten nuts to 30 Nm (22 lbf.ft).
4. Using new gasket, align turbocharger drain pipe and tighten bolts to 9 Nm (7 lbf.ft).
5. Fit banjo bolt to oil feed pipe using new sealing washers and tighten to 25 Nm (18 lbf.ft)..
6. Position air hoses to turbocharger and tighten clips.
7. Position and secure breather hose to camshaft cover.
8. Position and secure vacuum hose to turbocharger wastegate.
9. Position exhaust manifold heat shield and tighten M6 bolts to 9 Nm (7 lbf.ft) and M8 bolt to 25 Nm (18 lbf.ft).
10. Fit fan cowl and secure fixings.
11. Fit acoustic cover and secure the fixings.
12. Connect battery earth lead.
13. Fit battery cover and secure fixings.

Intercooler

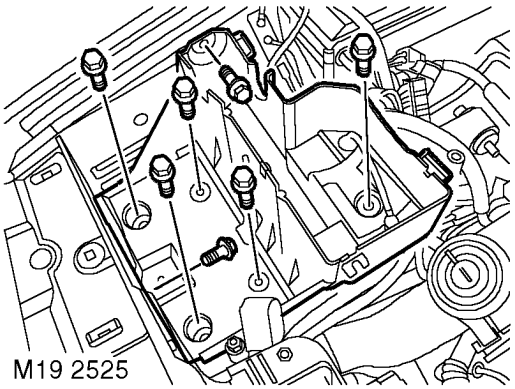
19.42.15

Remove

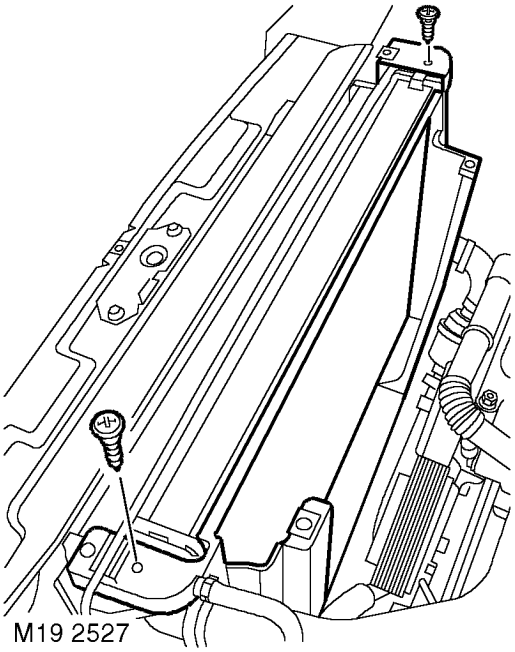
1. Remove cooling fan and coupling.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
2. Remove battery.
3. Remove vehicle jack from battery carrier.


M19 2524

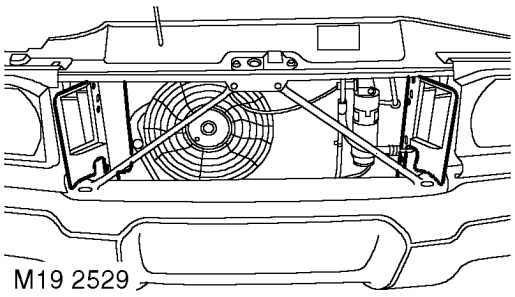
4. Remove screw and release engine control module (ECM) from battery carrier.


M19 2525

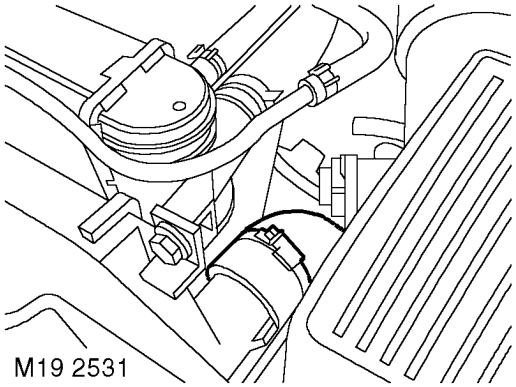
5. Remove 7 bolts and remove battery carrier.


M19 2527

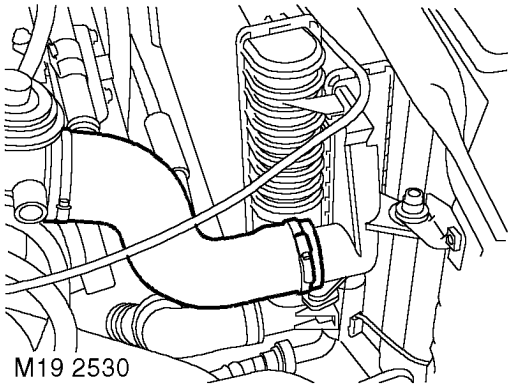
6. Remove 2 screws and remove lower half of fan cowl.
7. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.


M19 2529

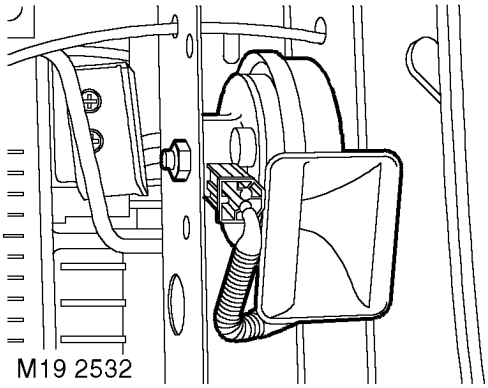
8. Remove 6 scrivets and remove LH and RH air deflectors from front panel.



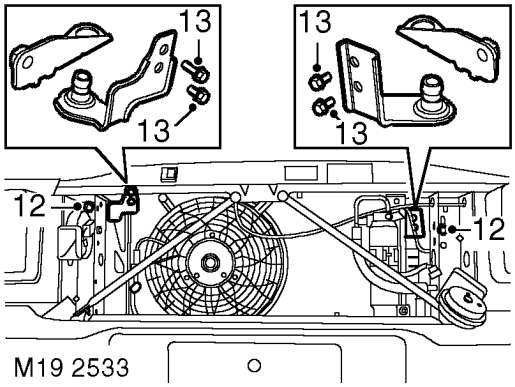
9. Loosen clip and disconnect inlet hose from intercooler.



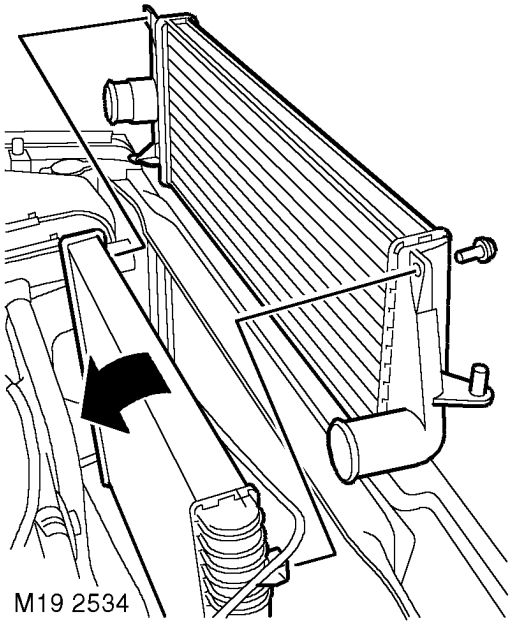
10. Loosen clip and disconnect outlet hose from intercooler.



11. Remove nut securing horn and move horn aside.



12. Remove 2 bolts securing radiator LH and RH upper mounting brackets to body panel and remove brackets.
13. Remove 4 screws securing LH and RH upper mounting brackets to condenser.
14. Remove brackets with rubber mounts from intercooler.



15. Remove 2 bolts securing intercooler to radiator.
16. Release radiator lower mountings from location in chassis and carefully move radiator towards engine sufficiently only to release intercooler from radiator.
17. Remove intercooler.

Refit

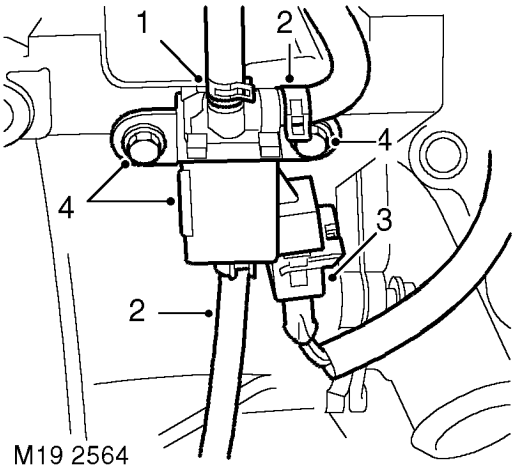
1. Fit intercooler to radiator, and fit and tighten bolts.
2. Engage radiator lower mountings in chassis.

3. Fit brackets with rubber mountings to intercooler and fit and tighten screws securing brackets to condenser.
4. Fit radiator upper mounting brackets and tighten bolts.
5. Fit LH horn and secure with nut.
6. Connect inlet and outlet hoses to intercooler and tighten clips.
7. Fit lower half of fan cowl and secure with screws.
8. Fit LH and RH air deflectors to front panel and secure with scrivets.
9. Fit front grille.
10. Fit battery carrier and secure with bolts.
11. Fit ECM and secure with screw.
12. Fit jack to battery carrier.
13. Fit battery.
14. Fit cooling fan and coupling.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**

Valve - solenoid boost control

19.42.30

Remove



1. Loosen clip and release air intake hose from MAF sensor.
2. Release clips and disconnect vacuum hoses from solenoid valve.
3. Disconnect multiplug from solenoid valve.
4. Remove 2 bolts and remove solenoid valve.

Refit

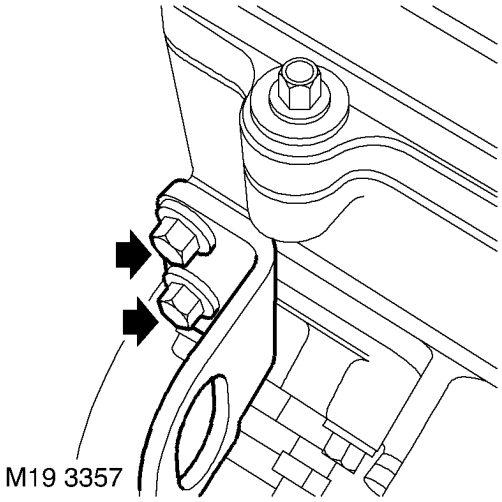
1. Position solenoid valve and tighten bolts.
2. Connect multiplug to solenoid valve.
3. Connect vacuum hoses and secure with clips.
4. Position air intake hose to MAF sensor and secure clip.

Regulator - fuel pressure

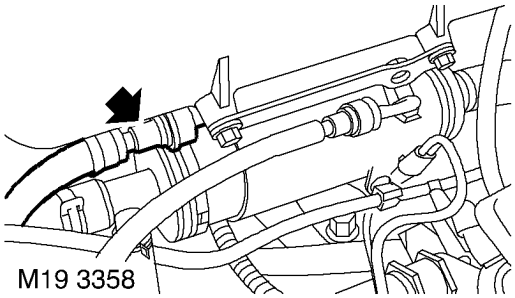
19.45.06

Remove

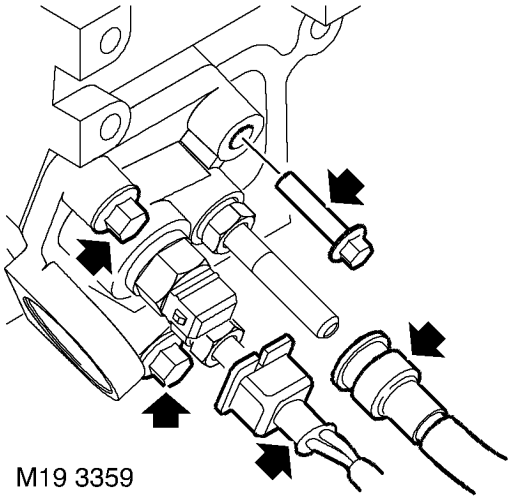
1. Release turnbuckles and remove battery cover
2. Disconnect battery earth lead.
3. Remove 3 bolts and remove engine acoustic cover.


M19 3357

4. Remove 2 bolts and remove engine lifting eye.
5. Position cloth to absorb fuel spillage.


M19 3358

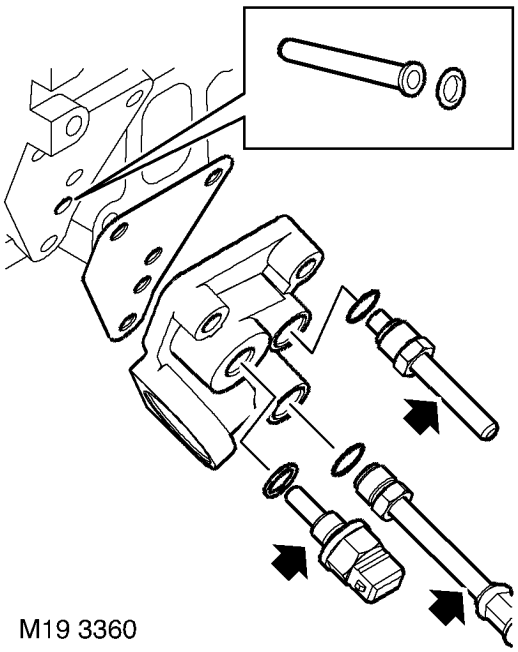
6. Release and disconnect hose from fuel cooler.


M19 3359

7. Release and disconnect fuel hose from pressure regulator.

   Always fit plugs to open connections to prevent contamination.

8. Disconnect multiplug from fuel temperature sensor.
9. Remove 3 bolts, remove pressure regulator from cylinder head and collect gasket.
10. Remove and discard 'O' ring and fuel filter.



M19 3360

11. Remove fuel temperature sensor and discard sealing washer.
12. Remove fuel hose and fuel pipe and discard 'O' rings.

Refit

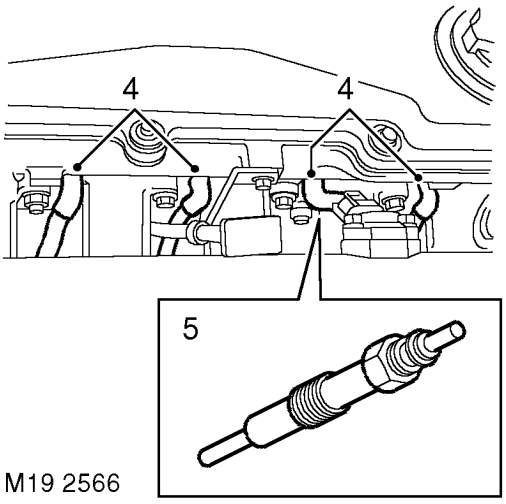
1. Clean fuel pressure regulator and mating face.
2. Clean fuel pipe unions.
3. Using new 'O' rings, fit fuel pipe and fuel hose to pressure regulator and tighten unions to 25 Nm (18 lbf.ft).
4. Using new sealing washer, fit fuel temperature sensor and tighten to 14 Nm (10 lbf.ft).
5. Fit new fuel filter and 'O' ring.
6. Using a new gasket, position pressure regulator and tighten bolts to 25 Nm (18 lbf.ft).
7. Connect multiplug to fuel temperature sensor.
8. Connect fuel hoses to pressure regulator and fuel cooler.
9. Fit engine lifting eye and tighten bolts to 25 Nm (18 lbf.ft).
10. Fit engine acoustic cover and tighten bolts to 10 Nm (6 lbf.ft).
11. Connect battery earth lead.
12. Fit battery cover and secure fixings.

Glow plugs

19.60.31

Remove

1. Remove 3 bolts and remove engine acoustic cover.
2. Release turnbuckles and remove battery cover.
3. Disconnect battery earth lead.



M19 2566

4. Disconnect 4 glow plug leads.
5. Loosen and remove 4 glow plugs.

Refit

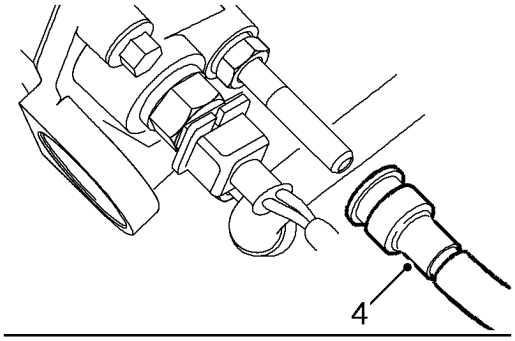
1. Thoroughly clean glow plugs and seating area in cylinder head.
2. Apply a suitable anti-sieze compound to threads of glow plugs.
3. Fit glow plugs and tighten to 16 Nm (12 lbf. ft).
4. Connect glow plug leads.
5. Fit engine acoustic cover and secure fixings.
6. Connect battery earth lead.
7. Fit battery cover and secure fixings.

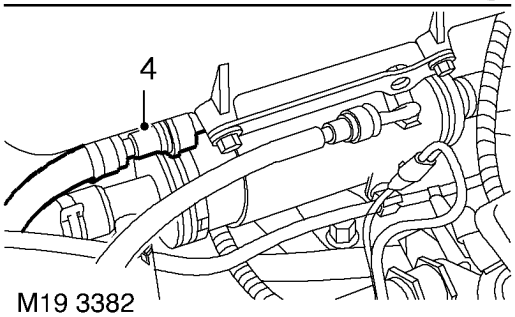
Injectors

19.60.12

Remove

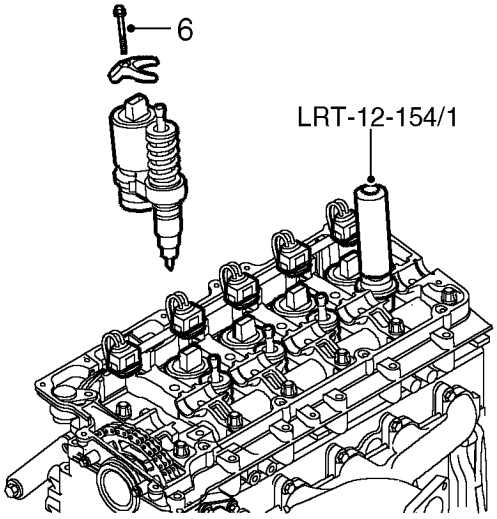
1. Remove cooling fan.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
2. Remove rocker shaft.
   ENGINE - Td5, REPAIRS, Rocker shaft assembly.
3. Position container to catch fuel spillage.





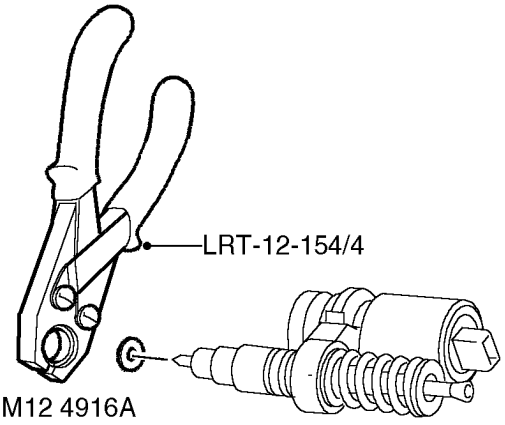
M19 3382

4. Disconnect quick release fuel hose connectors from fuel connector block on cylinder head and fuel cooler to drain fuel from cylinder head.



M19 2522C

5. Disconnect 5 multiplugs from injectors.
6. Remove 5 Torx bolts securing injectors to cylinder head.
7. Using **LRT-12-154/1**, remove injectors from cylinder head. Collect retainers.

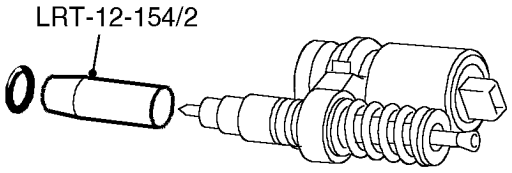


M12 4916A

8. Using **LRT-12-154/4**, remove sealing washers from injectors. Discard sealing washers.
9. Remove and discard 'O' rings from injectors.
10. Rotate engine manually until each cylinder being worked on is at TDC, and remove excess fuel from piston bowl using a syringe.

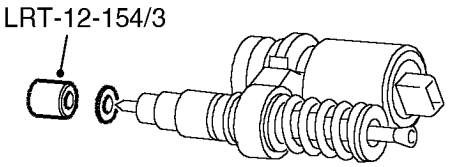
Refit

1. Clean injector units and mating faces in cylinder head.



M12 4881A

2. Using **LRT-12-154/2**, fit a new 'O' ring to each injector.



M12 4882

3. Using **LRT-12-154/3**, fit a new sealing washer to each injector.
4. Fit retainer to injector. Carefully fit injector, ensuring retainer is located on its dowel, and tighten Torx bolt to 32 Nm (24 lbf.ft)
5. Connect multiplug to injector.
6. Repeat above operations for remaining injectors.
7. Connect fuel hoses to connector block and fuel cooler.
8. Programme new injectors using TestBook.
9. Fit rocker shaft.
   ☞ **ENGINE - Td5, REPAIRS, Rocker shaft assembly.**
10. Fit cooling fan.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**

Switch - cruise control (on/off)

⊸ ***19.75.30***

Remove

1. Carefully remove switch from instrument cowl.
2. Disconnect multiplug and remove switch.

Refit

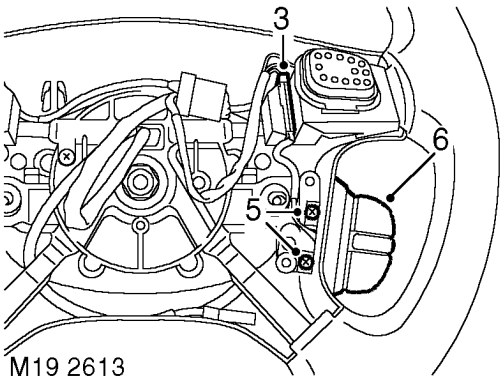
1. Position new switch and connect multiplug.
2. Carefully push switch into instrument cowl.

Switch - cruise control (set/resume)

19.75.33

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.



M19 2613

3. Release remote control switches multiplug and leads from steering wheel base.
4. Disconnect remote control switches multiplug from harness.
5. Remove 2 screws securing remote control switches to steering wheel base.
6. Release and remove remote control switches from steering wheel.

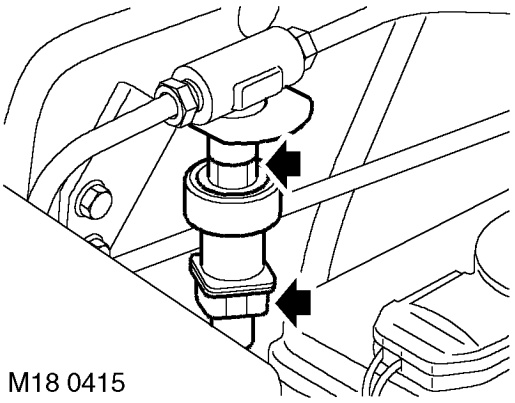
Refit

1. Fit remote control switches to steering wheel and secure with screws.
2. Connect remote control switches multiplug to harness.
3. Secure leads and multiplug to base of steering wheel.
4. Fit driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.

Switch - clutch

19.75.34

Remove


M18 0415

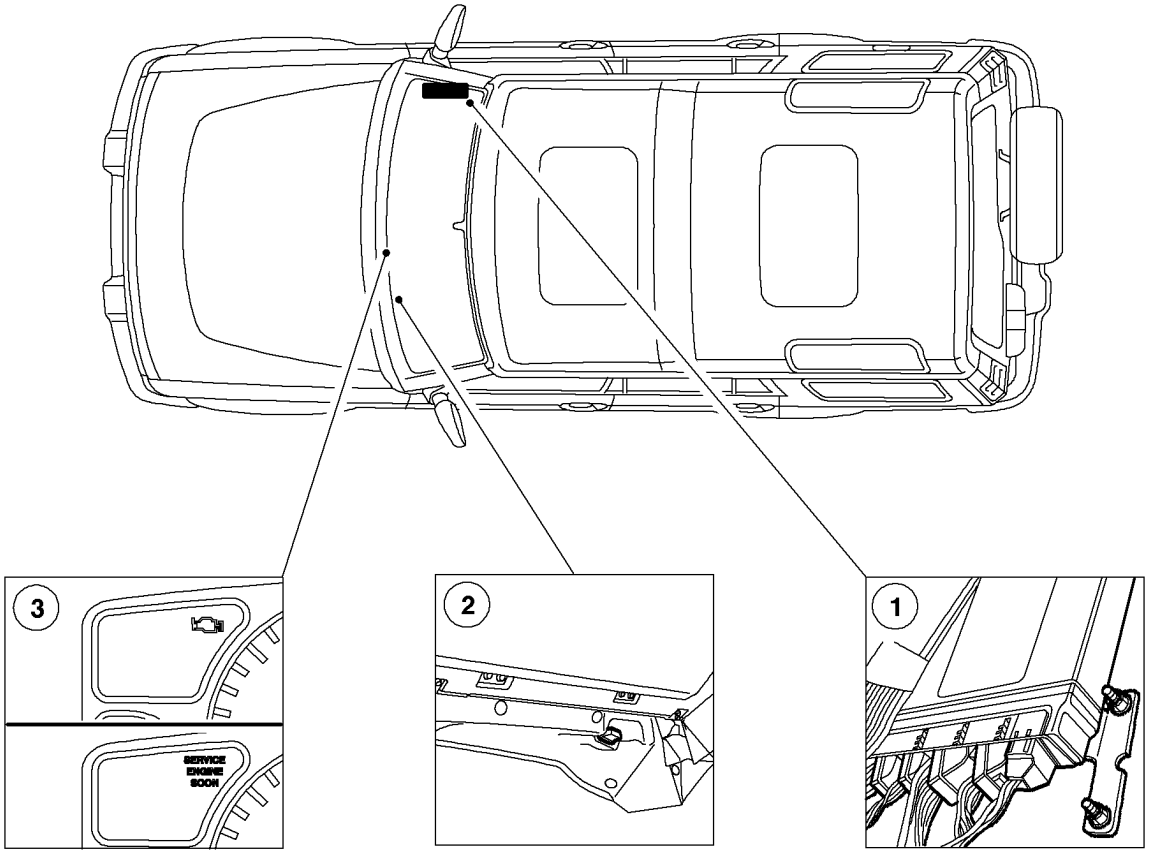
1. Disconnect the multiplug from the clutch switch.
2. Position a container below the clutch switch to collect the fluid.
3. Unscrew and remove the clutch switch.

   CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

1. Fit the clutch switch and tighten to 10 Nm (7 lbf.ft).
2. Connect the multiplug.
3. Bleed the clutch hydraulic system.
   CLUTCH - Td5, ADJUSTMENTS, Clutch hydraulic system - bleed.

Engine management component location - Passenger compartment

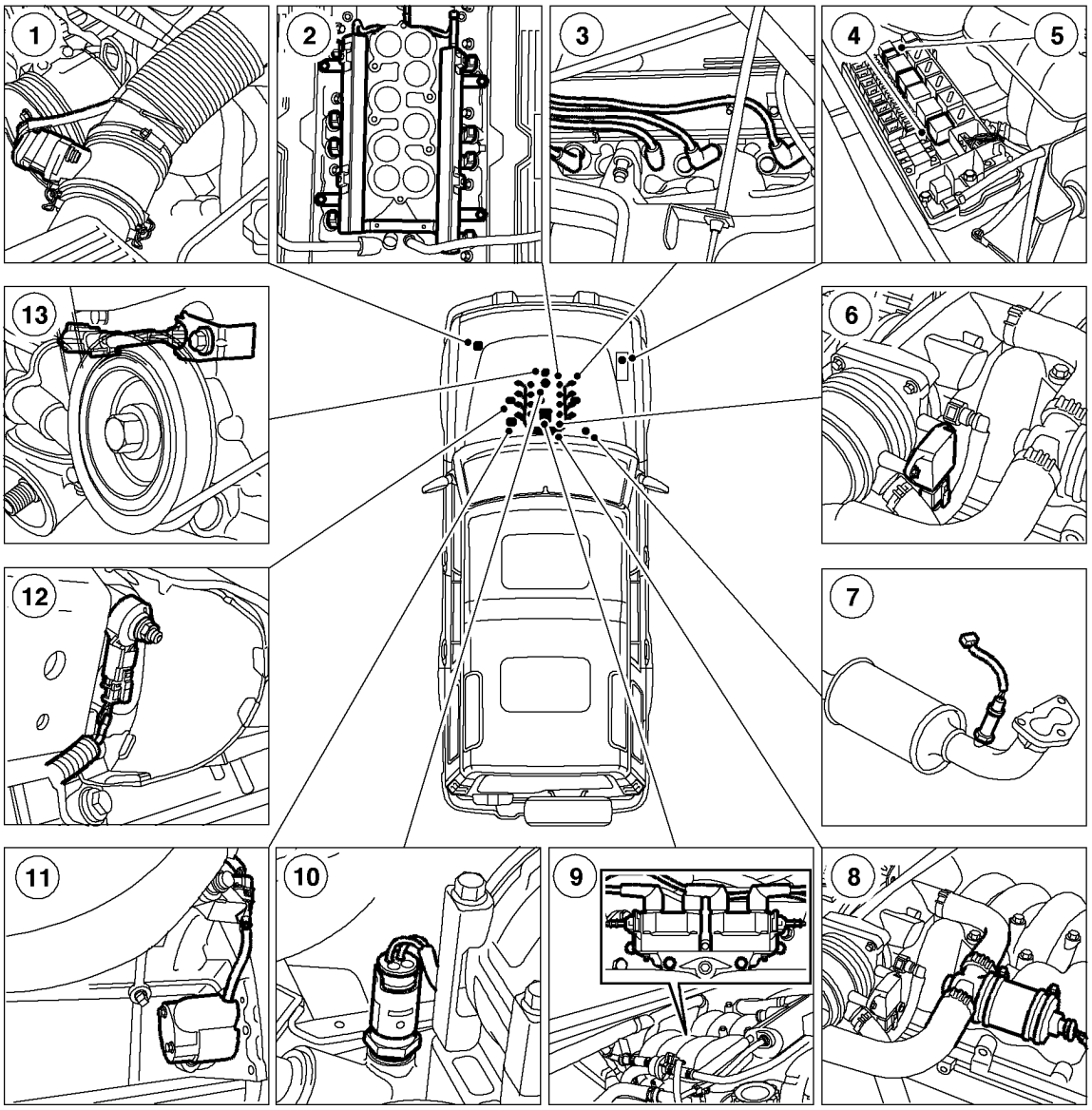


M180355

LHD illustrated

1 Engine control module
2 Diagnostic connector
3 Malfunction indication lamp

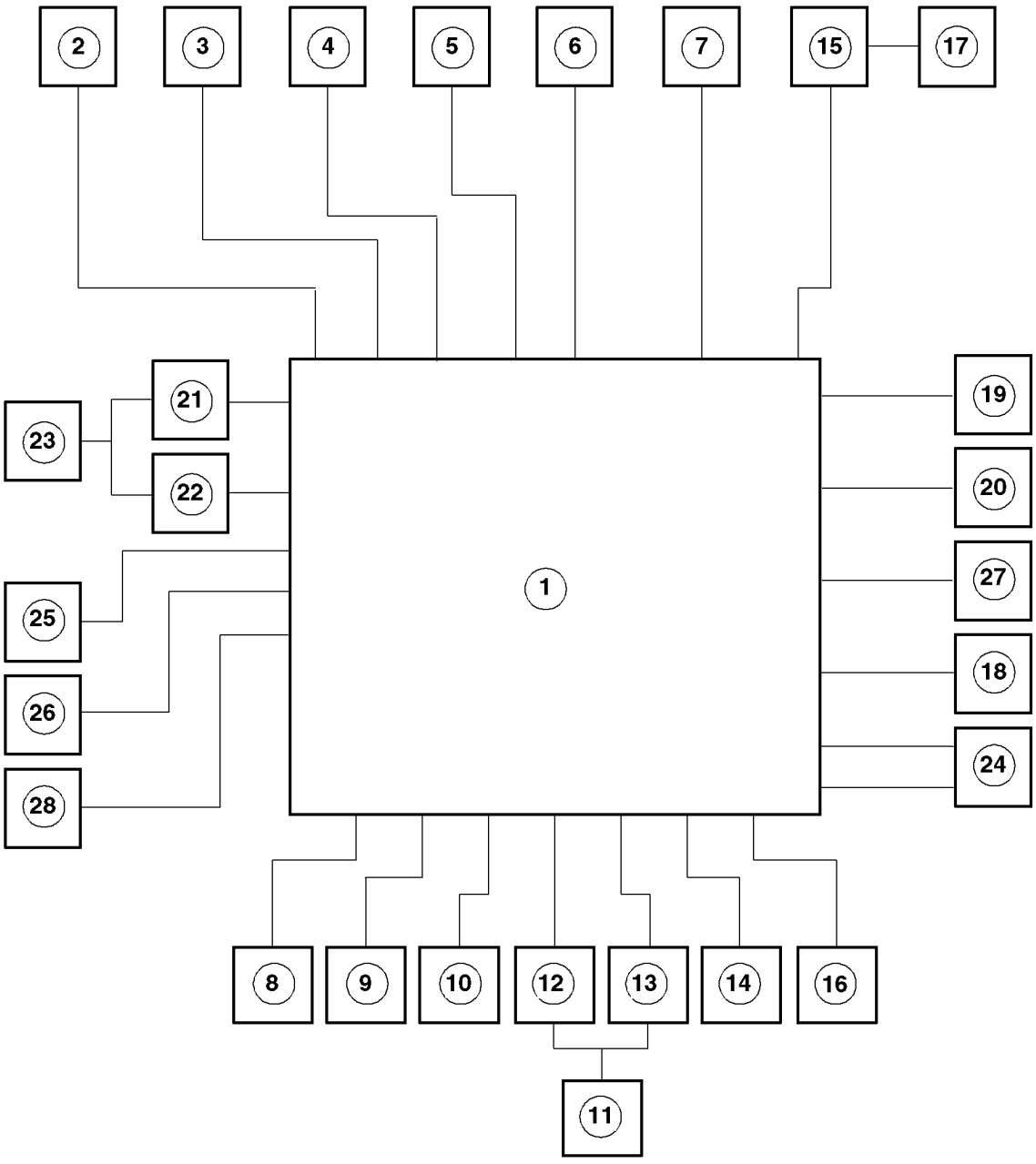
Engine management component location - Engine compartment



M18 0308

1 Mass air flow/ inlet air temperature sensor
2 Fuel injectors
3 High tension leads/spark plugs
4 Fuel pump relay
5 ATC compressor clutch relay/ cooling fan relay
6 Throttle position sensor
7 Heated oxygen sensor
8 Idle air control valve
9 Ignition coils
10 Engine coolant temperature sensor
11 Crankshaft speed and position sensor
12 Knock sensor
13 Camshaft position sensor

Engine management block diagram



M18 0353A

1 Engine control module
2 Crankshaft speed and position sensor
3 Camshaft position sensor
4 Engine coolant temperature sensor
5 Mass air flow/ inlet air temperature sensor
6 Throttle position sensor
7 Heated oxygen sensors
8 Fuel injectors
9 Idle air control valve
10 Fuel pump relay
11 EVAP canister
12 EVAP canister vent valve
13 EVAP canister purge valve
14 Fuel tank pressure sensor
15 Ignition coils
16 Knock sensor
17 Spark plugs
18 High/ Low ratio switch
19 Malfunction indication lamp
20 Diagnostic connector
21 Air temperature control clutch relay
22 Air temperature control cooling fan relay
23 ATC ECU
24 CAN link to EAT
25 SLABS ECU
26 BCU
27 Instrument cluster
28 Thermostat monitoring sensor (where fitted)

Description - engine management

General
The V8 engine is equipped with the Bosch Motronic M5.2.1 engine management system. This system is a sequential multiport fuel injection system controlled by an Engine Control Module (ECM).

A single ECM is used for the control of the existing 4.0 litre engine and the new 4.6 litre engine introduced with 03 model year vehicles for the NAS market only. The ECM contains the tunes for both engines variants. When the ECM is replaced, TestBook/T4 must be used to select the correct tune to match the engine fitment.

The ECM has On Board Diagnostic (OBD) strategies as required by various market legislative bodies. To meet these requirements the system monitors and reports on any faults that cause excessive exhaust emissions.

In markets that mandate OBD, the ECM monitors performance of the engine for misfires, catalyst efficiency, exhaust leaks and evaporative control loss. If a fault occurs, the ECM stores the relevant fault code and warns the driver of component failure by illuminating the Malfunction Indicator Light in the instrument pack.

In markets where OBD is not mandatory, the ECM will still monitor performance of the engine and store the fault code, but will **not** illuminate the Malfunction Indicator Light.

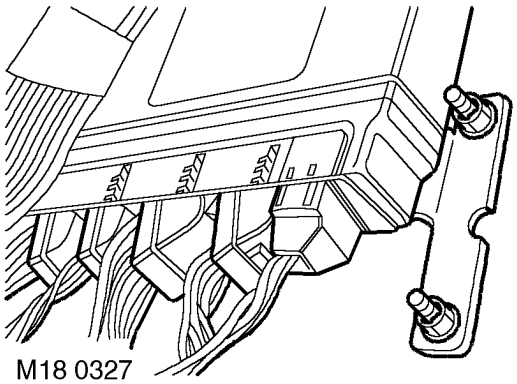
The ECM uses input and output information from its sensors and actuators to control the following engine conditions:
- Fuel quantity.
- Closed loop fuelling.
- Open loop fuelling.
- Ignition timing.
- Knock control.
- Idle speed control.
- Emission control.
- On-Board Diagnostic (OBD) where applicable.
- Vehicle immobilisation.
- Misfire detection (where applicable).
- Vehicle speed signal.
- Rough road signal (where applicable).
- Low fuel level signal (where applicable).
- Coolant temperature gauge signal.

The ECM processes sensor information from the following input sources:
- Ignition switch (position II).
- Crankshaft speed and position sensor.
- Camshaft position sensor.
- Engine coolant temperature sensor.
- Mass air flow sensor.
- Intake air temperature sensor.
- Knock sensor.
- Throttle position sensor.
- Heated oxygen sensors.
- High/ Low ratio switch.
- Fuel tank pressure sensor (where fitted)
- Thermostat monitoring sensor (where fitted)

The ECM controls the following outputs:
- Fuel injectors (1 per cylinder).
- Ignition coils/ high tension leads/ spark plugs.
- Fuel pump relay.
- Idle air control valve.
- Heated oxygen sensors.
- EVAP canister purge valve.
- EVAP canister vent solenoid (CVS) valve (where fitted).
- Malfunction Indicator Lamp (MIL)/ service engine soon lamp (where fitted).
- Hill descent control (via SLABS interface).
- EVAP system fuel leak detection pump (where fitted)
- Secondary air injection pump (where fitted)

The ECM also interfaces with the following:
- Diagnostics via diagnostic connector with TestBook.
- Controller Area Network (CAN) link to EAT ECU.
- Air conditioning system.
- Self Levelling & Anti-lock Braking System (SLABS) ECU.
- Immobilisation system via the body control unit (BCU).
- Instrument cluster.
- Cruise control ECU
- Active Cornering Enhancement (ACE) ECU

Engine Control Module (ECM)


M18 0327

The engine control module (ECM) is located on the RH side A post below the face panel inside the vehicle. It has a cast aluminium case and is mounted on a bracket. The ECM has 5 independent connectors totalling 134 pins.

The ECM is available in 4 variants:
- NAS.
- NAS low emission vehicles.
- UK/ Europe/ Japan/ Australia.
- ROW/ Gulf.

The ECM uses a 'flash' electronic erasable programmable read only memory (EEPROM). This enables the ECM to be externally configured, to ensure that the ECM can be updated with any new information, this also allows the ECM to be configured with market specific data. TestBook must be used to configure replacement ECM's. The ECM can be reconfigured up to 16 times to meet changing specifications and legislation.

The ECM memorises the positions of the crankshaft and the camshaft when the engine has stopped via the CKP and CMP sensors. This allows immediate sequential fuel injection and ignition timing during cranking. This information is lost if battery voltage is too low (i.e. flat battery). So the facility will be disabled for the first engine start.

Input/Output

The ECM has various sensors fitted to the engine to allow it to monitor engine condition. The ECM processes these signals and decides what actions to carry out to maintain optimum engine operation by comparing the information from these signals to mapped data within its memory.

Connector 1 (C0634): This connector contains 9 pins and is used primarily for ECM power input and earth. The ECM requires a permanent battery supply, if this permanent feed is lost i.e. the battery discharges or is disconnected the ECM will lose its adapted values and its Diagnostic Trouble Codes (DTC). These adapted values are a vital part of the engine management's rolling adaptive strategy. Without an adaptive strategy, driveability, performance, emission control, and fuel consumption are adversely affected. The ECM can be damaged by high voltage inputs, so care must be taken when removing and replacing the ECM.

Pin out details connector C0634

Pin No.	Function	Signal type	Reading
1	Ignition position II	Input	12 V
2	Not used	-	-
3	Not used	-	-
4	Chassis earth	Earth	0V
5	Fuel injectors earth	Earth	0V
6	Power stage earth	Earth	0V
7	Permanent battery supply	Input battery supply	12V
8	Switched relay positive	Input switched	0-12V
9	Not used	-	-

Connector 2 (C0635): This connector contains 24 pins and is primarily used for Heated Oxygen Sensors (HO_2S) control and earth. The HO_2S sensors require a heater circuit to assist in heating the tip of the sensors to enable closed loop fuelling to be implemented quickly after cold starting.

Pin out details connector C0635

Pin No.	Function	Signal type	Reading
1	HO_2S heater RH bank - downstream	Output	PWM 12-0V
2	Not used	-	-
3	Not used	-	-
4	Not used	-	-
5	Thermostat monitoring sensor	Earth	0V
6	Not used	-	-
7	HO_2S heater LH bank - downstream	Output	PWM 12-0V
8	HO_2S sensor RH bank - downstream	Earth/ Signal	0V
9	HO_2S sensor LH bank - upstream	Earth/ Signal	0V
10	HO_2S sensor RH bank - upstream	Earth/ Signal	0V
11	HO_2S sensor LH bank - downstream	Earth/ Signal	0V
12	Not used	-	-
13	HO_2S heater RH bank - upstream	Output	PWM 12-0V
14	HO_2S sensor RH bank - downstream	Input/ Signal	Analogue 0-5V
15	HO_2S sensor LH bank - upstream	Input/ Signal	Analogue 0-5V
16	HO_2S sensor RH bank - upstream	Input/ Signal	Analogue 0-5V
17	HO_2S sensor LH bank - downstream	Input/ Signal	Analogue 0-5V
18	Fuel pump relay	Output	Switch to earth
19	HO_2S heater LH bank - upstream	Output	PWM 12-0V
20	Not used	-	-
21	Thermostat monitoring sensor	Signal	Analogue 0-5V
22	Not used	-	-
23	Main relay	Output	Switch to earth
24	EVAP system leak detection pump motor (NAS vehicles with positive pressure type, EVAP system leak detection capability only)	Output	Switch to earth

Connector 3 (C0636): This connector contains 52 pins and is used for most sensor and actuator inputs and outputs. Sensor and actuator control is vital to ensure that the ECM maintains adaptive strategy

Pin out details connector C0636

Pin No.	Function	Signal type	Reading
1	Injector cylinder number 2	Output	Switch to earth
2	Injector cylinder number 5	Output	Switch to earth
3	Purge valve	Output, signal	PWM 12-0V
4	SAI vacuum solenoid valve (NAS vehicles from 2000MY only)	Output	Switch to earth
5	Not used	-	-
6	Fuel tank pressure sensor (NAS vehicles with vacuum type, EVAP system leak detection only)	Earth	0V
7	MAF sensor 5V supply	Output, reference	5V
8	Not used	-	-
9	MAF sensor earth	Earth	0V
10	TP sensor 5V supply	Output, reference	5V
11	Not used	-	-
12	Not used	-	-
13	Not used	-	-
14	Injector cylinder number 7	Output	Switch to earth
15	Injector cylinder number 6	Output	Switch to earth
16	SAI pump relay (NAS vehicles from 2000MY only)	Output	Switch to earth
17	CMP sensor	Earth	0V
18	Low range switch (manual transmission only)	Input, signal	Active low
19	Not used	-	-
20	CMP signal	Input, signal	Digital switch 0-12V
21	ECT sensor	Earth	0V
22	Coolant temperature signal	Input, signal	Analogue 0-5V
23	MAF sensor signal	Input, signal	Analogue 0-5V
24	TP sensor signal	Input, signal	Analogue 0-5V
25	TP sensor earth	Earth	0V
26	Not used	-	-
27	Injector cylinder number 3	Output	Switch to earth
28	Injector cylinder number 8	Output	Switch to earth
29	Hill decent control output	Output, signal	PWM 0-12V
30	EVAP canister vent solenoid (CVS) valve (NAS vehicles with vacuum type, EVAP system leak detection only)	Output	Switch to earth
30	Leak detection pump solenoid (NAS vehicles with positive pressure type, EVAP system leak detection only)	Output	Switch to earth
31	A/C condenser fan	Output	Switch to earth
32	CKP sensor signal	Input, signal	Analogue, 0-300V peak
33	Not used	-	-
34	IAT sensor signal	Input, signal	Analogue 0-5V
35	KS, RH bank earth	Earth	0V
36	KS, RH bank signal	Input, signal	Analogue
37	Not used	-	-
38	Not used	-	-
39	Not used	-	-
40	Injector cylinder number 4	Output	Switch to earth
41	Injector cylinder number 1	Output	Switch to earth

Pin No.	Function	Signal type	Reading
42	Idle air control valve open	Output, signal	PWM 12-0V
43	Idle air control valve close	Output, signal	PWM 12-0V
44	ECT sensor signal	Output, signal	PWM 0-12V
45	CKP sensor earth screen	Earth	0V
46	CKP sensor signal	Earth reference	0V
47	Not used	-	-
48	KS, LH bank earth	Earth	0V
49	KS, LH bank signal	Input, signal	Analogue
50	Not used	-	-
51	Not used	-	-
52	Not used	-	-

Connector 4 (C0637): This connector contains 40 pins and facilitates use of TestBook via the Diagnostic connector. Also contained in this connector is the Malfunction Indicator Lamp (MIL), this instrument panel lamp informs the driver of concerns within the engine management system.

Pin out details connector C0637

Pin No.	Function	Signal type	Reading
1	Not used	-	-
2	Not used	-	-
3	Not used	-	-
4	Not used	-	-
5	Not used	-	-
6	Not used	-	-
7	Not used	-	-
8	Low fuel level	Input, signal	Active high
9	Fuel tank pressure sensor (NAS vehicles with vacuum type, EVAP system leak detection capability only)	Output, reference	5V
10	Not used	-	-
11	Not used	-	-
12	Analogue fuel level (NAS vehicles with positive pressure type, EVAP system leak detection only)	Input, signal	0-5V
13	Not used	-	-
14	Fuel tank pressure sensor (NAS vehicles with vacuum type, EVAP system leak detection capability only)	Input, signal	Analogue 0-5V
15	Not used	-	-
16	ATC compressor request	Input, signal	Active low
17	Engine speed output	Output, signal	PWM 0-5V
18	Not used	-	-
19	Not used	-	-
20	Malfunction indicator lamp 'ON'	Output	Switched earth
21	Not used	-	-
22	Vehicle speed signal (VSS)	Input, signal	PWM 0-12V
23	Not used	-	-
24	Not used	-	-
25	Not used	-	-
26	Not used	-	-
27	Not used	-	-
28	Not used	-	-
29	ATC compressor relay	Output	Switched earth
30	Not used	-	-

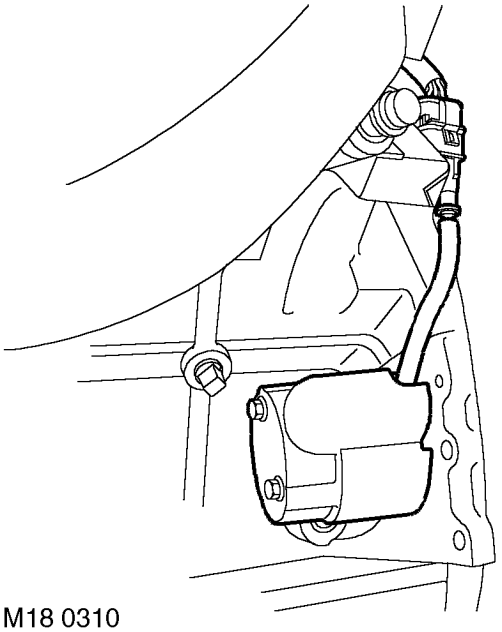
Pin No.	Function	Signal type	Reading
31	Positive pressure type EVAP system heater (02MY vehicles only)	Output, drive	Switched earth
32	Diagnostic connector K-line	Bi-directional	Serial 0-12V
33	Immobiliser serial W link	Input, signal	Serial 0-12V
34	Rough road signal	Input, signal	PWM 0-12V
35	Not used	-	-
36	CAN data bus 'high line'	Bi-directional	5-2.5V
37	CAN data bus 'low line'	Bi-directional	0-2.5V
38	ATC stand by	Input, signal	Active low
39	Not used	-	-
40	Not used	-	-

Connector 5 (C0638): This connector contains 9 pins and is used to control the ignition system. The ignition coils are supplied with power and a switching earth completes the circuit.

Pin out details connector C0638

Pin No.	Function	Signal type	Reading
1	Not used	-	-
2	Ignition , Cylinders 2 and 3	Output	Switch to earth
3	Not used	-	-
4	Not used	-	-
5	Ignition coil earth	Earth	0V
6	Ignition , Cylinders 1 and 6	Output	Switch to earth
7	Ignition , Cylinders 4 and 7	Output	Switch to earth
8	Ignition , Cylinders 5 and 8	Output	Switch to earth
9	Not used	-	-

Crankshaft speed and Position (CKP) sensor (C0168)



M18 0310

The CKP sensor is located towards the rear of the engine below cylinder number 7, with its tip adjacent to the outer circumference of the flywheel. The CKP sensor is the most important sensor on the vehicle and without its signal the engine will not run. The signal produced by the CKP sensor allows the ECM to determine crankshaft angle and speed of rotation. The ECM uses this information to calculate ignition timing and fuel injection timing.

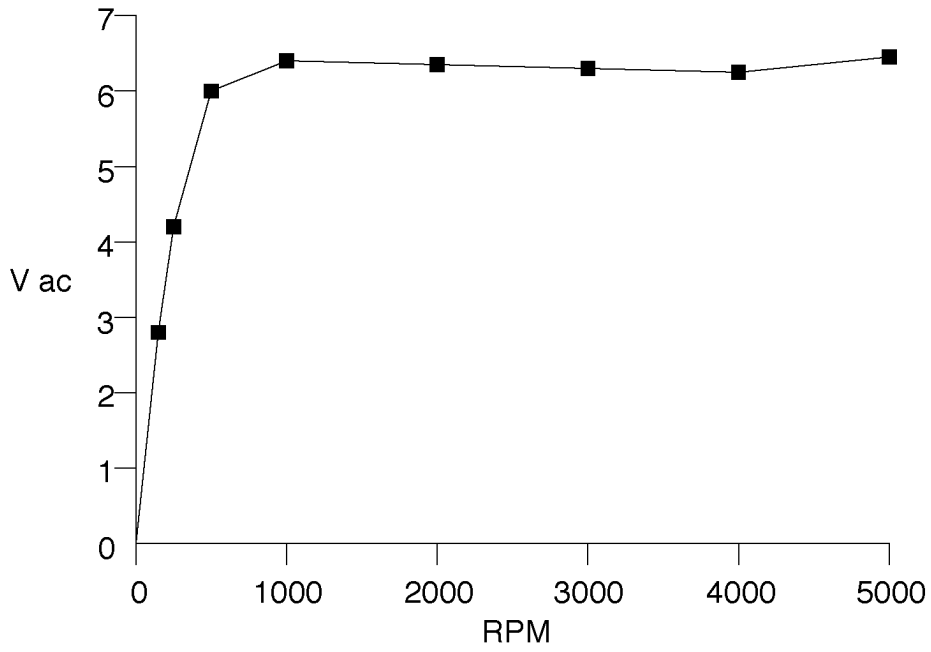
The CKP sensor works as a variable reluctance sensor. It uses an electromagnet and a reluctor ring to generate a signal. As the reluctor ring passes the tip of the CKP sensor the magnetic field produced by the sensor is cut and then re-instated. The ECM measures the signal as an ac voltage.

The output voltage varies in proportion to engine speed. The reluctor ring has a set tooth pattern, 60 teeth are spaced at 6° intervals and are 3° wide, two teeth are removed to provide a reference mark at 60° BTDC for number 1 cylinder. There is no back up strategy or limp home facility if this sensor fails, the engine does not run.

Input/Output

Because of the nature of its operation the CKP sensor does not require any electrical input source. The CKP sensor is a 3 pin variable reluctance sensor generating its own electrical output. The 2 output sources from the sensor are earthed via pin 46 of connector C0636 of the ECM and sensor output is via pin 32 of connector C0636 of the ECM. This output is in the form of an ac voltage waveform. The 3rd pin is used by the ECM as an earth screen, this screen protects the integrity of the CKP sensor signal to ensure that outside electrical interference is eliminated, it is controlled via pin 45 of connector C0636 of the ECM. The ac voltage generated from the CKP sensor is relative to engine speed.

Typical CKP sensor output



M124703

The above readings are dependent upon correct air gap between the tip of the CKP sensor and the passing teeth of the reluctor ring. The correct air gap between the tip of the CKP sensor and the passing teeth of the reluctor ring can be set by the correct fitting of a spacer as follows:

- 9.2 mm spacer for vehicles with manual gearbox fitted.
- 18 mm spacer for vehicles with automatic gearbox fitted.

It is vital that the correct air gap is maintained, if the air gap becomes too wide the CKP signal becomes too weak, causing possible engine misfires to occur.

The CKP sensor can fail the following ways or supply incorrect signal:

- Sensor assembly loose.
- Incorrect spacer fitted.
- Sensor open circuit.
- Sensor short circuit.
- Incorrect fitting and integrity of the sensor.
- Water ingress at sensor connector
- ECM unable to detect the software reference point.
- Ferrous contamination of crank sensor pin/reluctor

In the event of a CKP sensor signal failure any of the following symptoms may be observed:

- Engine cranks but fails to start.
- MIL remains on at all times.
- Engine misfires (CKP sensor incorrectly fitted).
- Engine runs roughly or even stalls (CKP sensor incorrectly fitted).
- Tachometer fails to work.
- Flywheel adaption reset – ferrous contamination

If the CKP sensor fails while the engine is running the engine will suddenly stall, this is because the CKP sensor has no backup strategy. If this happens the ECM will produce a fault code that it can store in its memory. If the engine is not running when the CKP sensor fails, the vehicle will crank but will be unlikely to start, and no fault code will be generated. In this instance the MIL lamp will remain illuminated and the tachometer will fail to read.

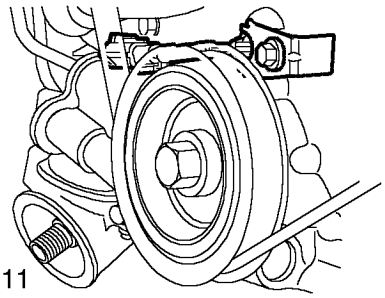
It is vital that the CKP sensor output wires are not reversed (i.e. the connector is fitted incorrectly) as this will cause a 3° advance in ignition timing. This happens because the ECM uses the falling edge of the signal waveform as its reference or timing point for each passing tooth on the reluctor.

Whenever a new crankshaft position sensor is fitted or the flywheel is removed, the adaptive values will have to be reset, using TestBook.

Should a malfunction of the component occur, the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 description	Land Rover description
P0335	Crankshaft position sensor a circuit malfunction	Reference mark outside search window for more than two revs, with engine speed above 500 rev/min
P0336	Crankshaft position sensor a circuit range/ performance	Incorrect number of teeth detected ±1 tooth between reference marks with engine speed above 500 rpm

Camshaft Position (CMP) sensor (C0176)



M18 0311

The CMP sensor is located on the front of the engine, above and behind the crankshaft pulley. The CMP sensor is a Hall effect sensor producing four pulses for every two crankshaft revolutions. The sensor is positioned close to the camshaft gear wheel, the gear wheel has four slots machined at 90° intervals. This allows the ECM to recognise 4 individual cylinders every camshaft revolution or all 8 cylinders every crankshaft revolution.

The CMP sensor Hall effect works as a magnetic switch. It switches battery voltage on or off depending on the position of the camshaft gear wheel in relationship to the sensor.

The ECM uses this signal for cylinder recognition to control sequential fuel injection, engine knock and diagnostic purposes.

Input/Output

Electrical input to the camshaft position sensor is from fuse 2 located in engine compartment fuse box. One output is sensor earth, the other is the signal output to the ECM via pin 20 of connector C0636.

The CMP sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle battery supply.
- Short circuit to vehicle earth.
- Incorrect fitting of the sensor.
- Excessive camshaft gear wheel tolerance.
- Excessive camshaft endfloat.
- Camshaft and crankshaft misalignment.
- Speed signal correlation with CKP sensor signal.
- Cam wheel magnetised / residual magnetism

In the event of a CMP sensor signal failure any of the following symptoms may be observed:

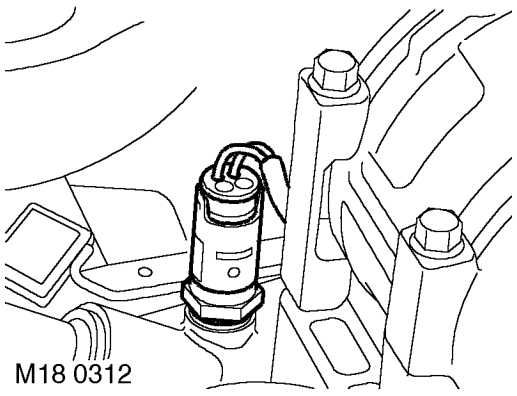
- Ignition timing reverts to default values from ECM memory.
- Loss of cylinder correction.
- Loss of active knock control.
- Loss of active knock control diagnostics.
- Loss of cylinder identification for misfire diagnostics.
- Loss of quick synchronisation of crankshaft and camshaft for cranking/ start up.
- Fuel injection could be 360° out of phase.
- Front HO_2S sensor ageing period diagnostic disabled (NAS only)

Should a malfunction of the component occur the following fault code may be evident and can be retrieved by TestBook:

P code	J2012 description	Land Rover description
P0340	Camshaft position sensor circuit malfunction	Open/short circuit to vehicle supply or earth

The fault condition has to be detected for more than 100 cam pulses (25 revolutions) when the engine speed is greater than 500 rev/min.

Engine Coolant Temperature (ECT) sensor (C0196)



The ECT sensor is located at the front of the engine adjacent to the coolant outlet pipe. The ECT sensor forms a vital part of the ECM operating strategy, and therefore the optimum control of the running of the engine. Richer air/ fuel ratio is required at lower coolant temperatures such as cold starting. Coolant temperature information from the ECT sensor is also vital to enable the ECM to weaken the air/ fuel mixture as temperature rises to maintain low emissions and optimum performance.

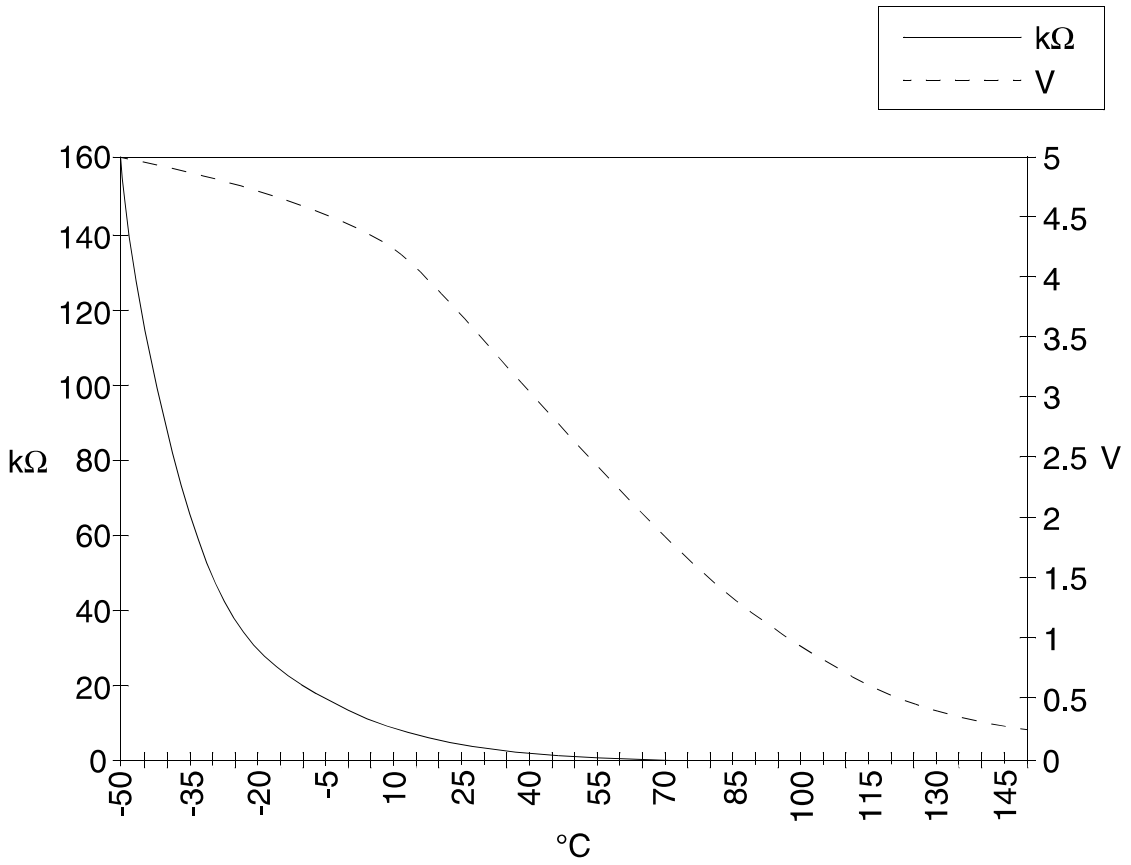
For NAS vehicles with secondary air injection, the signal from the ECT sensor is monitored at engine start, to determine whether the conditions are cold enough to warrant secondary air injection to be employed. The ECT sensor is then monitored to switch off the secondary air injection when the required engine coolant temperature has been attained.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Secondary air injection system.**

The ECT works as a Negative Temperature Coefficient (NTC) sensor. As temperature rises, the resistance in the sensor decreases, as temperature decreases, the resistance in the sensor increases. The ECT sensor forms part of a voltage divider chain with a pull up resistor within the ECM. Consequently as the ECT sensor resistance changes, the analogue voltage at the input signal from the ECT sensor to the ECM will be adjusted which corresponds to the temperature of the engine coolant. With this information, the ECM can implement the correct strategies for cold start, warm up etc. The ECM supplies the instrument cluster with a pulse width modulated (PWM) coolant temperature signal to drive the temperature gauge.

Input/Output

The electrical input and output to and from the ECT sensor are reference voltage and sensor earth. The ECM provides the ECT sensor with a 5 volt reference via pin 22 of connector C0636 of the ECM, and earth via pin 21 of connector C0636 of the ECM. The normal operating parameters of the ECT sensor are as follows



M124704A

Should the sensor fail the ECM has a back up strategy that uses a changing default value during warm up based on the signal from the inlet air temperature sensor. When the strategy default value reaches 60 °C (140 °F), the ECM implements a fixed default value of 85 °C (185 °F). It will also illuminate the MIL.

The ECT sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to earth.
- Incorrect mechanical fitting.
- Signal fixed above 40 °C (140 °F) will not be detected.
- Signal fixed below 40 °C (140 °F) will be detected.

In the event of an ECT sensor signal failure any of the following symptoms may be observed:

- Difficult cold start.
- Difficult hot start.
- Driveability concern.
- MIL illuminated.
- Instrument cluster temperature warning lamp illuminated.
- Temperature gauge reads excessively hot.
- Temperature gauge reads excessively cold.
- Cooling fan will not run.

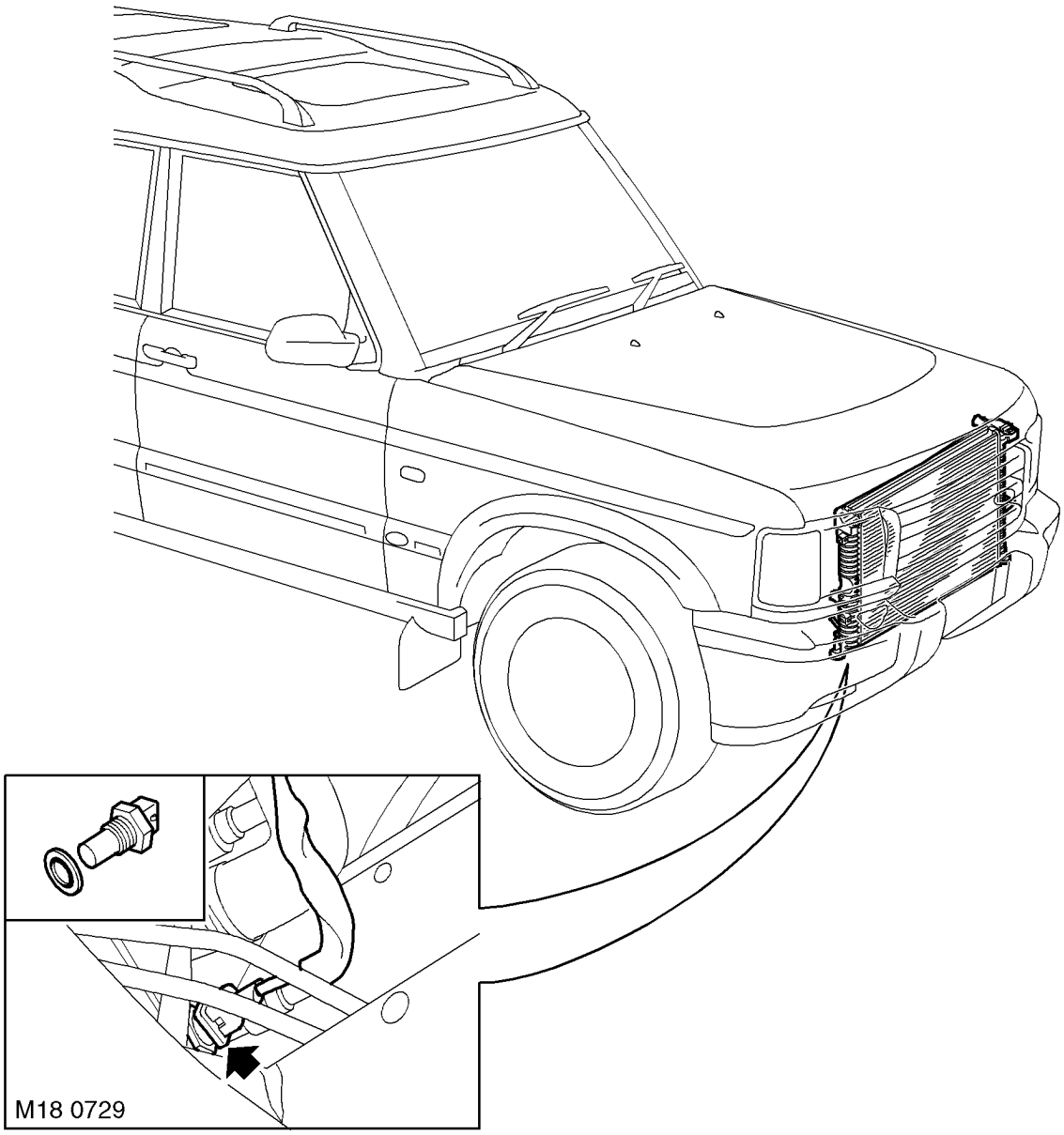
There are three types of ECT sensor diagnostic checks:

- The ECT sensor signal is within limits, but is inaccurate – the engine has to be running and the signal indicates a coolant temperature below 40°C (104°F). The signal differs too much from the coolant temperature model for longer than 2.53 seconds.
- The ECT sensor signal is greater than the maximum threshold value – the ECM has to be powered up to perform the diagnostic, but the engine does not need to be running.
- The ECT sensor signal is less than the minimum threshold value – the ECM has to be powered up to perform the diagnostic, but the engine does not need to be running.

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

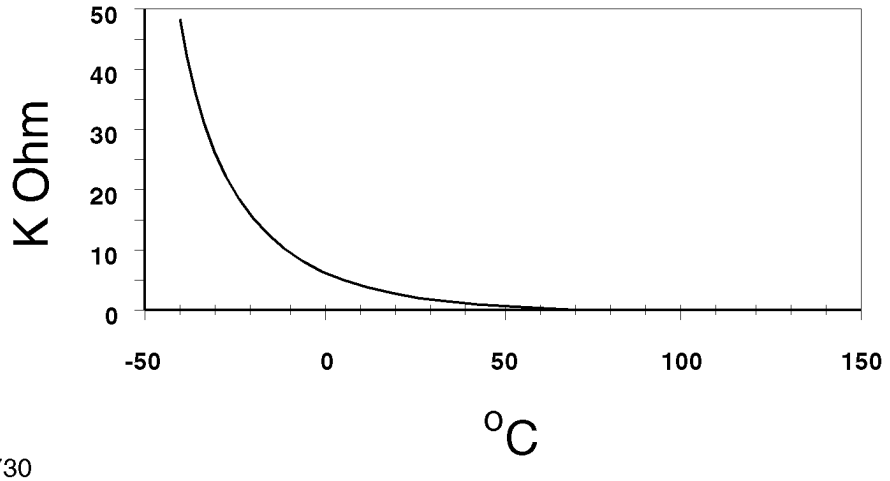
P code	J2012 description	Land Rover description
P0116	Engine coolant temperature circuit/range performance problem	Signal differs too much from temperature model for longer than 2.53s
P0117	Engine coolant temperature circuit low input	Open circuit or short circuit to battery supply
P0118	Engine coolant temperature circuit high input	Short circuit to earth

Thermostat Monitoring sensor



The thermostat monitoring sensor is located in the radiator, adjacent the bottom hose. The ECM compares the temperature measured by the thermostat monitoring sensor to the temperature measured by the ECT sensor. If the difference between the two readings is too great, the ECM determines the thermostat is stuck. In this case, the ECM registers a fault code in its memory.

The thermostat monitoring sensor works as a Negative Temperature Coefficient (NTC) sensor. As temperature rises, the resistance in the sensor decreases, as temperature decreases, the resistance in the sensor increases. With this information, the ECM is able to monitor the performance of the thermostat. The normal operating parameters of the thermostat monitoring sensor are as follows:



M18 0730

Input/Output

The ECM provides the thermostat monitoring sensor with a 5 volt reference via pin 21 of connector C0635 of the ECM, and an earth via pin 5 of connector C0635 of the ECM.

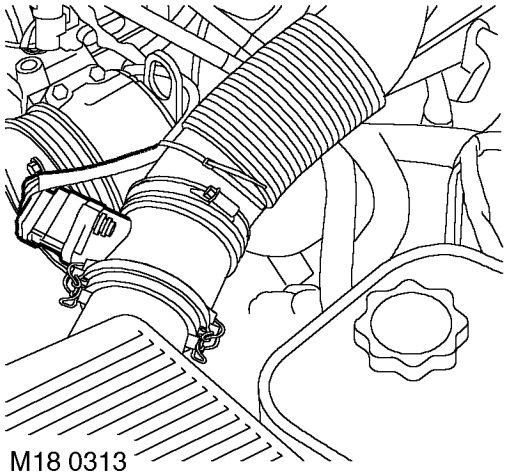
There are three types of thermostat monitoring sensor diagnostic checks:

- Sensor signal is above maximum threshold. For the ECM to register this as a fault, and illuminate the MIL, the temperature registered by the thermostat monitoring sensor must be above 140 °C (284 °F) for more than 1 second.
- Sensor signal is below minimum threshold. For the ECM to register this as a fault, and illuminate the MIL, the temperature registered by the thermostat monitoring sensor must be below -33 °C (-27 °F) for more than 1 second, while the inlet air temperature reading is greater than -32 °C (-25 °F).
- Signal difference between ECT sensor and thermostat monitoring sensor is below maximum threshold. For the ECM to register this as a fault, and illuminate the MIL, the following conditions must exist:
  - No maximum or minimum threshold signal faults exist.
  - No faults are recorded against the thermostat monitoring sensor or vehicle speed signal.
  - Engine not in idle speed control.
  - Fuel cut-off not active.
  - Engine speed is greater than 400 rpm.
  - Road speed is greater than 0 mph.
  - Integrated mass air flow from engine start to fuel cut-off is greater than set value (between 3 kg and 10 kg dependent upon engine coolant temperature at engine start).
  - Engine coolant temperature at engine start is between 9 °C and 39 °C (48 °F and 102 °F).
  - High range is selected.
  - Delay time before thermostat monitoring is enabled is between set limits (between 50 and 500 seconds dependent upon engine coolant temperature at engine start).
  - Engine coolant temperature is greater than 90 °C (194 °F).
  - The difference between the ECT sensor reading and the thermostat monitoring sensor reading is less than 39 °C (102 °F).

Should a malfunction occur, the following fault codes may be evident and can be retrieved by TestBook:

P code	J2012 description	Land Rover description
P1117	Radiator outlet temperature thermister low	Thermostat reading below -33 °C (-27 °F)
P1118	Radiator outlet temperature thermister high	Thermostat reading above 140 °C (284 °F)
P0126	Engine thermostat defective	Difference in radiator and engine coolant temperatures too small

Mass Air Flow (MAF)/ Inlet Air Temperature (IAT) sensor (C0149)


M18 0313

The MAF/ IAT sensors are combined into a single unit and located between the air filter housing and the inlet manifold. The ECM receives input signals from the MAF/ IAT sensor to calculate the mass of air flowing into the engine inlet manifold.

Input/Output

The MAF sensor has both electrical input and output. Input to the MAF sensor comes from two different sources. Battery voltage is supplied to the MAF sensor via fuse 2 of the engine compartment fuse box. The MAF sensor also utilises a 5 volt reference input via pin 7 of connector C0636 of the ECM. The MAF sensor output voltage is measured via pin 23 of connector C0636 of the ECM.

The IAT sensor has only electrical output. Output from the IAT sensor is measured at pin 34 of connector C0636 of the ECM, this is a variable voltage/ resistance measured by the sensor to provide air temperature information to the ECM.

The MAF/ IAT sensor share the same sensor earth. Sensor earth is via pin 9 of connector C0636 of the ECM.

The MAF/ IAT sensor and its connector has silver plated terminals for its low current signals to protect against corrosion. **DO NOT** apply 12V to the 5V supply, as this will destroy the internal circuitry. The MAF/IAT sensor should not be dropped or roughly handled and should be kept free from contamination.

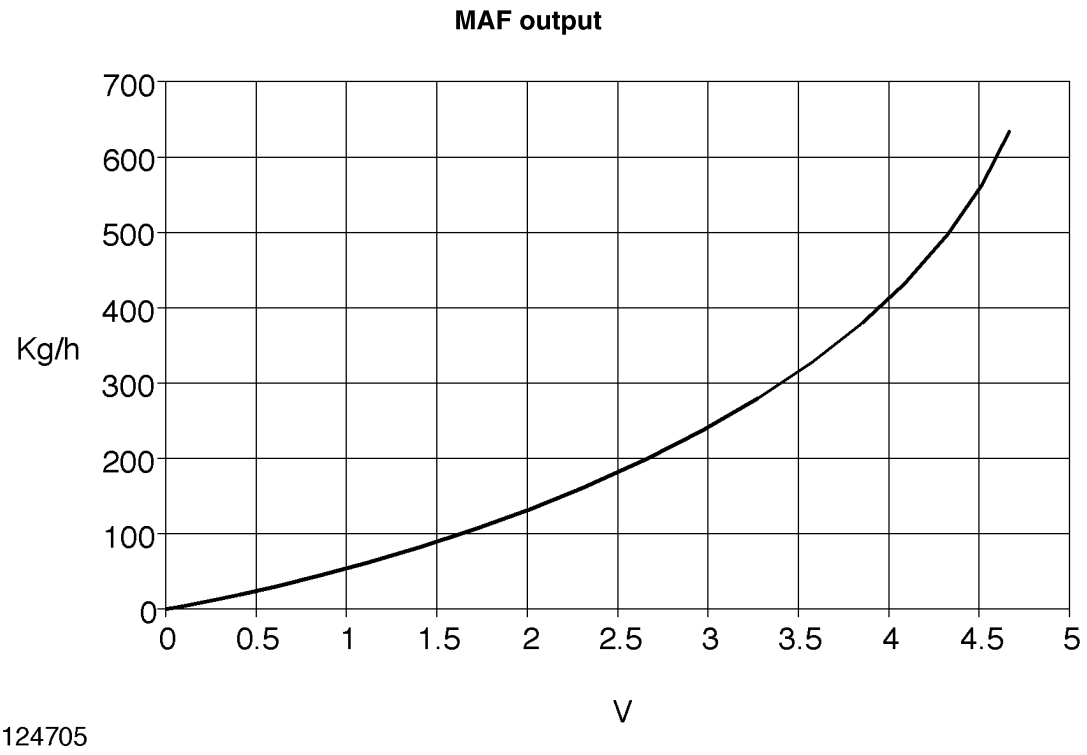
Mass Air Flow (MAF) Sensor

The MAF sensor utilises a “hot film” element contained in the air intake duct to monitor the mass of the air flow being drawn into the engine. The MAF sensor contains two sensing elements, one element is controlled at ambient temperature (e.g. 25°C (77°F)), while the other is heated to 200°C (360°F) above the ambient temperature (e.g. 225°C (437°F)).

When the intake air passes the heated element, it cools it down, so lowering the resistance of the hot film element. In order to maintain the same temperature, the circuit to the heated element has to supply more current. The change in current causes a corresponding change in potential difference to be detected in the monitoring circuit. This change is supplied to the ECM as a voltage between 0 and 5V, where it is processed by the ECM's internal mapping to interpret the data as a measure of the mass of air flow.

The measured air mass flow is used by the ECM to determine the fuel quantity to be injected in order to maintain the stoiciometric air:fuel mixture for optimum engine performance and low emissions.

Normal operating parameters of the MAF sensor are as follows:



M124705

If the MAF sensor fails, the ECM implements a back up strategy which is based on throttle angle. Poor throttle response and reduced performance will result.

The MAF sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Contaminated sensor element.
- Damaged sensor element.
- Air leak after the MAF sensor.
- Inlet air restriction.
- Resistance in wiring harness causing signal offset.

In the event of a MAF sensor signal failure any of the following symptoms may be observed:

- During driving engine rev/min may dip, before recovering.
- Difficult starting.
- Engine stalls after starting.
- Delayed throttle response.
- Emissions control inoperative.
- Idle speed control inoperative.
- Reduced engine performance.
- MAF sensor signal offset.

There are two types of MAF sensor diagnostic check:

- The MAF sensor signal is less than the minimum threshold for specific speed range – the engine must have exceeded 200 rev/min for longer than 300 ms and remain above 400 rev/min. The signal must be less than the threshold mapped against engine speed for longer than 500 ms.
- The MAF sensor signal is greater than the maximum threshold for specific speed range – the engine must have exceeded 200 rev/min for longer than 10 ms. The signal must be greater than the threshold mapped against engine speed for longer than 300 ms.

If the MAF sensor fails the following fault codes will be produced and can be retrieved by TestBook:

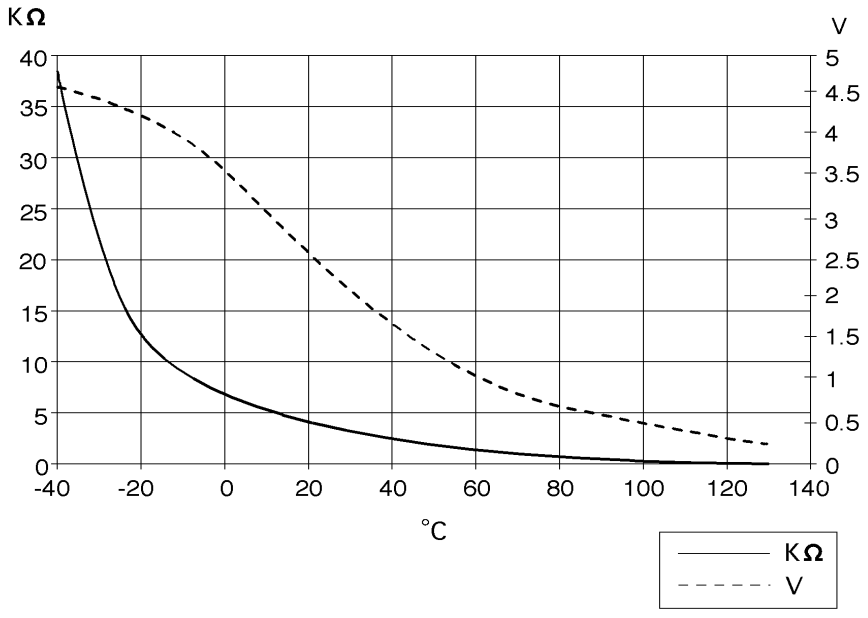
P code	J2012 description	Land Rover description
P0102	Mass or volume air flow low input	MAF signal < minimum threshold, which is speed dependent
P0103	Mass or volume air flow circuit high input	MAF signal > maximum threshold, which is speed dependent

Intake air temperature (IAT) sensor

The intake air temperature (IAT) sensor utilises a thermistor with a negative temperature coefficient (NTC); as temperature rises, the thermistor resistance decreases. The change in resistance causes a change in input voltage at the ECM. The ECM converts the voltage value it receives to provide an indication of the temperature of the inlet air.

Normal operating parameters of the IAT sensor are as follows:

IAT output



M124706

Should the IAT sensor fail, the ECM defaults to an assumed air temperature of 45 °C (113 °F).

The IAT sensor can fail the following ways or supply incorrect signal:
- Sensor open circuit.
- Short circuit to vehicle battery supply.
- Short circuit to vehicle earth.
- Increased sensor resistance.
- Damaged sensor element.

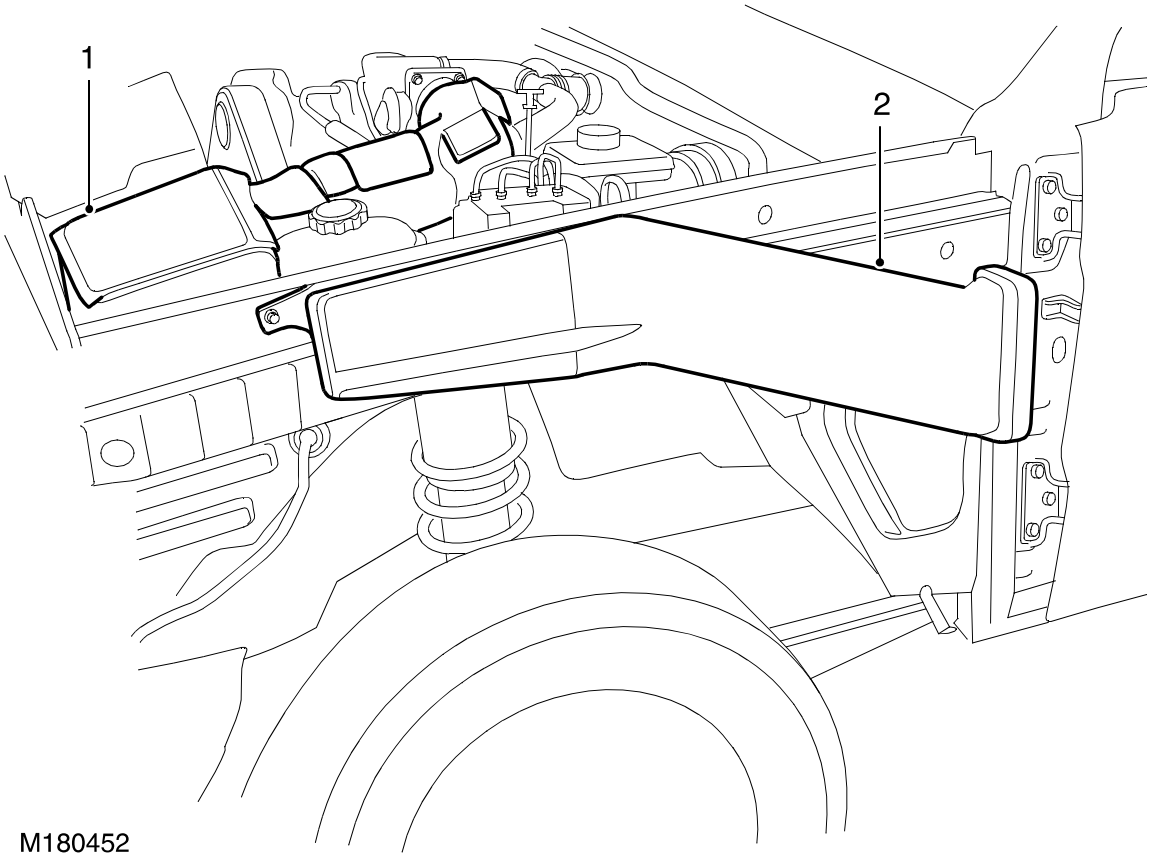
In the event of an IAT sensor signal failure any of the following symptoms may be observed:
- Adaptive fuelling disabled.
- Idle speed adaption disabled.
- Catalyst monitoring affected due to exhaust temperature model.
- Idle speed actuator test disabled.
- Warm up ignition angle affected.
- Condenser fan hot restart inhibited.

There are two types of IAT sensor diagnostic checks:
- The IAT sensor signal is less than the minimum threshold – the engine has to have been running for longer than 180 seconds, and idle speed control must have been operational for longer than 10 seconds. No fuel cut off is active. The IAT sensor signal must be less than -35°C (-31°F) for longer than 200 ms.
- The IAT sensor signal is greater than the maximum threshold – the ECM has to be powered up (engine does not need to be running), and the signal must be greater than 140°C (284°F) for longer than 200 ms.

If the IAT sensor fails the following fault codes will be produced and can be retrieved by TestBook:

P code	J2012 description	Land Rover description
P0112	Intake air temperature circuit low input	Intake air temperature signal less than minimum threshold, after time for exhaust to warm up
P0113	Intake air temperature circuit high input	Intake air temperature signal greater than maximum threshold

Air intake duct – Gulf models from 2000MY



M180452

1 Heat reflective insulation
2 Supplementary air intake duct

The density of the intake air is partly dependent on altitude and temperature. Hot air has a lower density than cold air; consequently in hot climates, the low air density can result in low power due to low volumetric efficiency.

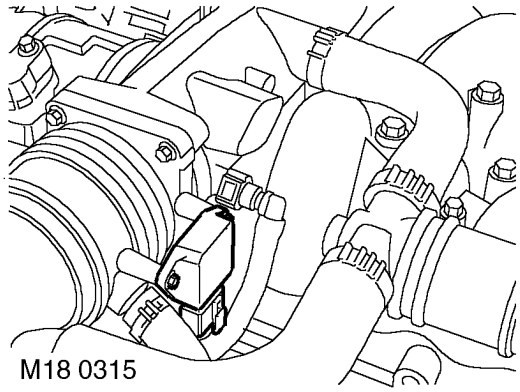
In order to improve engine performance, Gulf specification models from 2000MY have a secondary air intake duct which is located under the front left inner wing of the vehicle. Cooler air from the side of the vehicle is routed through the duct to the air cleaner, where it combines with air entering via the front grille.

In addition to the secondary air duct, the vehicles are fitted with a larger front grille and have larger cooling and condenser fans.

The MAF/IAT sensor, air cleaner and air cleaner duct are encased in insulation bags to help keep the intake air cool and so increase the mass of air entering the engine intake manifold.

The air cleaner includes a cyclone filter and also a dump valve in the bottom of the unit. Sand and dust particles which are carried into the air cleaner with the air flow are automatically expunged via the dump valve.

Throttle Position (TP) sensor (C0175)


M18 0315

The TP sensor is located on the throttle body assembly in the engine compartment. The ECM is able to determine the position of the throttle plate and the rate of change of its angle. The ECM processes the signal received from the TP sensor.

The TP sensor consists of a resistance track and a sliding contact connected to the throttle plate assembly. As the throttle is opened and closed the sliding contact moves along the resistance track to change the output voltage of the sensor. The ECM determines throttle plate position by processing this output voltage. The connection of the sensor to the throttle plate assembly is via a shaft.

The ECM is able to determine the closed throttle position, this enables the TP sensor to be fitted without the need for prior adjustment. The TP sensor signal has input into the ECM's fuelling strategy and also to determine closed throttle position for idle speed control. The TP sensor also supplies the ECM with information to enable the overrun fuel cut off strategy to be implemented. When the ECM receives closed throttle information from the TP sensor it closes the injectors for the duration of the closed throttle time.

The TP sensor signal is also used by the Electronic Automatic Transmission (EAT) ECU to determine the correct point for gear shifts and acceleration kickdown. The ECM also supplies the SLABS ECU with this TP sensor information as a PWM signal.

Input/Output

The TP sensor has electrical input and output. Input is a 5 volt supply via pin 10 of connector C0636 of the ECM. The signal output is via pin 24 of connector C0636 and is a varying voltage, less than 0.5V (closed throttle) and greater than 4.5V (wide open throttle) depending on throttle plate position. The TP sensor earth is via pin 25 of connector C0636 of the ECM, this acts as a screen to protect the integrity of the TP sensor signal.

The connector and sensor terminals are gold plated for corrosion and temperature resistance, care must be exercised while probing the connector and sensor terminals.

If the TP sensor signal fails, the ECM uses a default value derived from engine load and speed.

The TP sensor can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Signal out of parameters.
- Blocked air filter (load monitoring, ratio of the TP sensor to air flow).
- Restriction in air inlet (load monitoring, ratio of the TP sensor to air flow).
- Vacuum leak

In the event of a TP sensor signal failure any of the following symptoms may be observed:

- Engine performance concern.
- Delayed throttle response.
- Failure of emission control.
- Closed loop idle speed control inoperative.
- Automatic gearbox kickdown inoperative.
- Incorrect altitude adaptation.
- MIL illuminated (NAS only).

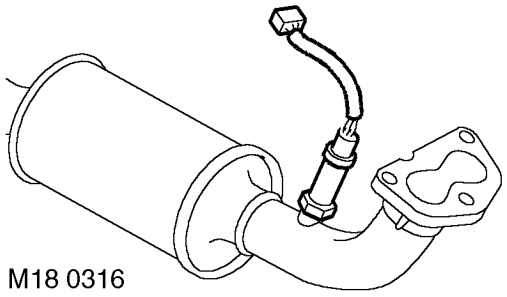
There are three throttle position sensor diagnostic checks:

- TP sensor signal is greater than the maximum threshold value – the engine speed must be greater than 400 rev/min for longer than 2 seconds and the signal must be greater than 96% for longer than 50 ms.
- TP sensor signal is less than the minimum threshold – the engine speed must be greater than 400 rev/min for longer than 2 seconds and the signal must be less than 4% for longer than 50 ms.
- Ratio of throttle position to mass of air flow – the calculated throttle angle must be outside limits when the engine speed is between 800 rev/min and 4000 rev/min, the engine load is between 2 and 6.5 and the coolant temperature is above -10°C (14°F).

Should a malfunction of the TP sensor occur the following fault codes may be evident and can be retrieved by TestBook.

P code	J2012 description	Land Rover description
P0101	Mass or volume air flow circuit range/ performance problem	Load monitoring, the ratio of throttle position to air flow
P0122	TPS a circuit low input	Signal < minimum threshold
P0123	TPS a circuit high input	Signal > maximum threshold

Heated Oxygen Sensors (HO_2S) (C0642)


M18 0316

The market requirement dictates how many HO_2S are fitted to the vehicle.

- 4 sensors are fitted to all NAS and EU-3 vehicles.
- 2 sensors fitted to all UK, European, Australia and Japanese pre EU-3 specification vehicles.
- No sensors fitted to ROW vehicles.

The HO_2S monitor the oxygen content of the exhaust gases. By positioning the sensors one for each bank upstream of the catalytic converter in the exhaust pipe, the ECM can control fuelling on each bank independently of the other. This allows greater control of the air:fuel ratio and maintains optimum catalyst efficiency. On NAS vehicles the ECM also uses two HO_2S positioned downstream of the catalytic converters in the exhaust pipe to monitor catalytic converter efficiency. The ECM is able to achieve this by comparing the values of the upstream HO_2S and the down stream sensor for the same bank. These comparative values form part of the ECM OBD strategy.

The HO_2S uses zirconium contained in a galvanic cell surrounded by a gas permeable ceramic, this produces an output voltage proportional to the ratio difference between the oxygen in the exhaust gases and to the ambient oxygen.

The HO_2S operates at approximately 350 °C (662 °F). To achieve this temperature the HO_2S incorporate a heating element which is controlled by a PWM signal from the ECM. The elements are activated immediately after engine starts and also under low engine load conditions when the exhaust gas temperature is insufficient to maintain the required HO_2S temperature. If the heater fails, the ECM will not allow closed loop fuelling to be implemented until the sensor has achieved the required temperature.

This value equates to an HO_2S output of 450 to 500 mV. A richer mixture can be shown as $\lambda = 0.97$, this pushes the HO_2S output voltage towards 1000 mV. A leaner mixture can be shown as $\lambda = 1.10$, this pushes the HO_2S output voltage towards 100 mV.

From cold start, the ECM runs an open loop fuelling strategy. The ECM keeps this strategy in place until the HO_2S is at a working temperature of 350 °C (662 °F). At this point the ECM starts to receive HO_2S information and it can then switch into closed loop fuelling as part of its adaptive strategy. The maximum working temperature of the tip of the HO_2S is 930 °C (1706 °F), temperatures above this will damage the sensor.

HO_2S age with use, this increases their response time to switch from rich to lean and from lean to rich. This can lead to increased exhaust emissions over a period of time. The switching time of the upstream sensors are monitored by the ECM. If a pre-determined threshold is exceeded, a failure is detected and the MIL illuminated.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Exhaust emission control system.**

Input/Output

The upstream and downstream HO_2S are colour coded to prevent incorrect fitting. The tips of the upstream sensors are physically different to the tips of the downstream sensors.

The HO_2S are colour coded as follows:

- Upstream sensors (both banks) - orange.
- Downstream sensors (both banks) - grey.

The four HO_2S have a direct battery supply to the heater via fuse 2 located in the engine compartment fuse box.

The heater is driven by the ECM providing an earth path for the circuit as follows:

- Upstream LH bank via pin 19 of connector C0635 of the ECM.
- Upstream RH bank via pin 13 of connector C0635 of the ECM.
- Downstream LH bank via pin 7 of connector C0635 of the ECM.
- Downstream RH bank via pin 1 of connector C0635 of the ECM.

The HO_2S output signal is measured by the ECM as follows:

- Upstream LH bank via pin 15 of connector C0635 of the ECM.
- Upstream RH bank via pin 16 of connector C0635 of the ECM.
- Downstream LH bank via pin 17 of connector C0635 of the ECM.
- Downstream RH bank via pin 14 of connector C0635 of the ECM.

The HO_2S earth path for the signal is supplied by the ECM as follows:

- Upstream LH bank via pin 9 of connector C0635 of the ECM.
- Upstream RH bank via pin 10 of connector C0635 of the ECM.
- Downstream LH bank via pin 11 of connector C0635 of the ECM.
- Downstream RH bank via pin 8 of connector C0635 of the ECM.

The HO_2S voltage is difficult to measure using a multimeter, the output can be monitored using TestBook. A rich mixture would read 500 to 1000 mV, a weak mixture would read 100 mV to 500 mV, the reading should switch from rich to weak. The open loop default voltage is 450 mV, this is used by the ECM to set the air/ fuel ratio until the tip of the HO_2S reaches operating temperature.

The HO_2S can fail the following ways or supply incorrect signal:
- Sensor open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Sensor disconnected.
- Stoichiometric ratio outside the correct operating band.
- Contamination from leaded fuel.
- Air leak into the exhaust system.
- Wiring loom damage.
- Sensors fitted incorrectly or cross wired.

In the event of a HO_2S signal failure any of the following symptoms may be observed:
- Default to open loop fuelling on defective bank.
- If the sensors are crossed over (LH bank to RH bank), the engine will run normally after initial start up, but performance will become progressively worse as the sensors go towards maximum rich for one bank of cylinders and maximum lean for the other. The ECM will eventually default into open loop fuelling.
- High CO reading.
- Excess emissions.
- Strong hydrogen sulphide (H_2S) smell until the ECM defaults to open loop fuelling. .
- MIL illuminated (NAS market only).

A number of diagnostic tests are performed by the ECM with regards to the HO_2sensors:
- HO_2 sensor and system diagnostics
- HO_2 sensor heater diagnostics
- HO_2 sensor switching period (ageing) diagnostics
- Rear HO_2 sensor adaption diagnostic (NAS only)
- Catalyst monitoring diagnostic

For further details of the heated oxygen sensors and exhaust emission control, refer to the V8 Emission Control section of this manual.

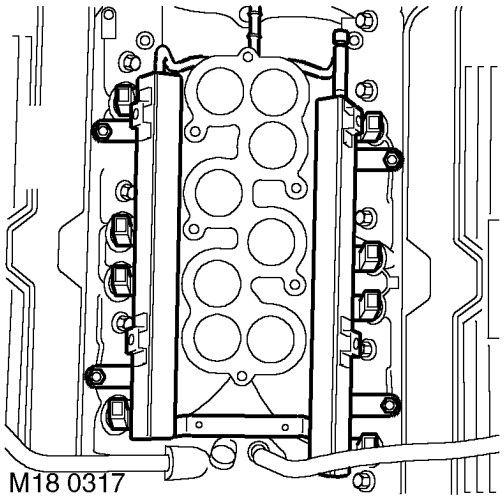
☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Exhaust emission control system.**

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P1129	O_2 sensors swapped bank to bank (sensor 1)	Front sensors transposed
P0130	O_2 sensor circuit malfunction (bank 1, sensor 1)	Front sensor LH bank stoichiometric ratio outside operating band
P0132	O_2 sensor circuit high voltage (bank 1, sensor 1)	Front sensor LH bank short circuit to battery supply
P0134	O_2 sensor circuit no activity detected (bank 1, sensor 1)	Front sensor LH bank open circuit
P0150	O_2 sensor circuit malfunction (bank 2, sensor 1)	Front sensor RH bank stoichiometric ratio outside operating band
P0152	O_2 sensor circuit high voltage (bank 2, sensor 1)	Front sensor RH bank short circuit to battery supply
P0154	O_2 sensor circuit no activity detected (bank 2, sensor 1)	Front sensor RH bank open circuit
P0136	O_2 sensor circuit malfunction (bank 1, sensor 2)	Rear sensor LH bank stoichiometric ratio outside operating band (NAS only)
P0137	O_2 sensor circuit low voltage (bank 1, sensor 2)	Rear sensor LH bank short circuit to earth (NAS only)
P0138	O_2 sensor circuit high voltage (bank 1, sensor 2)	Rear sensor LH bank short circuit to battery supply (NAS only)
P0140	O_2 sensor circuit no activity detected (bank 1, sensor 2)	Rear sensor LH bank open circuit (NAS only)
P0156	O_2 sensor circuit malfunction (bank 2, sensor 2)	Rear sensor RH bank stoichiometric ratio outside operating band (NAS only)
P0157	O_2 sensor circuit low voltage (bank 2, sensor 2)	Rear sensor RH bank short circuit to earth (NAS only)

P Code	J2012 Description	Land Rover Description
P0158	O_2 sensor circuit high voltage (bank 2, sensor 2)	Rear sensor RH bank short circuit to battery voltage (NAS only)
P0160	O_2 sensor circuit no activity detected (bank 2, sensor 2)	Rear sensor RH bank open circuit (NAS only)
P0133	O_2 sensor circuit slow response (bank 1, sensor 1)	Front sensor aged - period time too long/too short LH bank
P0153	O_2 sensor circuit slow response (bank 2, sensor 1)	Front sensor aged - period time too long/too short RH bank
P1170	Downstream fuel trim malfunction (bank 1)	Front sensor aged - rear HO_2S adaption too lean/too rich LH bank (NAS and EU-3 only)
P1173	Downstream fuel trim malfunction (bank 2)	Front sensor aged - rear HO_2S adaption too lean/too rich RH bank (NAS and EU-3 only)
P0135	O_2 sensor heater circuit malfunction (bank 1, sensor 1)	Front sensor heater LH bank - short/open circuit
P0141	O_2 sensor heater circuit malfunction (bank 1, sensor 2)	Rear sensor heater LH bank - short/open circuit (NAS and EU-3 only)
P0155	O_2 sensor heater circuit malfunction (bank 2, sensor 1)	Front sensor heater RH bank - short/open circuit
P0161	O_2 sensor heater circuit malfunction (bank 2, sensor 2)	Rear sensor heater RH bank - short/open circuit (NAS and EU-3 only)
P0420	-	Catalyst efficiency deteriorated - LH bank (NAS and EU-3 only)
P0430	-	Catalyst efficiency deteriorated - RH bank (NAS and EU-3 only)

Fuel injectors



The fuel injectors are located beneath the air inlet manifold. They utilise an electrical solenoid to lift the injector needle off its seat to allow fuel injection to take place. The fuel injectors provide excellent fuel atomisation in the lower portion of the inlet manifold, the air/fuel mixture can then be drawn into the cylinders to give good combustion characteristics and therefore excellent driveability.

There are eight fuel injectors one per cylinder that the ECM operates sequentially. All the injectors are fed from a common fuel rail as part of the returnless fuel system. Fuel pressure is maintained at a constant 3.5 bar (52 lbf.in^2) by a regulator that is integral with the fuel pump.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

Input/Output

All eight fuel injectors are supplied with battery voltage via fuse number 1 located in engine compartment fuse box. The ECM controls the individual earth path for each injector via its own pin at connector C0636 of the ECM multiplug. This facility allows the ECM to control the fuel injectors so that sequential fuel injection can take place.

Typical hot engine injector pulse width values:

- Idle = 2.5 ms.
- Peak torque (3000 rev/min) = 7 ms The ECM controls injector earth as follows:
- Cylinder No 1 - pin 41 of connector C0636 of the ECM multiplug.
- Cylinder No 2 - pin 1 of connector C0636 of the ECM multiplug.
- Cylinder No 3 - pin 27 of connector C0636 of the ECM multiplug.
- Cylinder No 4 - pin 40 of connector C0636 of the ECM multiplug.
- Cylinder No 5 - pin 2 of connector C0636 of the ECM multiplug.
- Cylinder No 6 - pin 15 of connector C0636 of the ECM multiplug.
- Cylinder No 7 - pin 14 of connector C0636 of the ECM multiplug.
- Cylinder No 8 - pin 28 of connector C0636 of the ECM multiplug.

Individual injectors can be measured for resistance using a multimeter. An acceptable injector resistance is as follows:

- 14.5 ± 0.7 ohms at 20 °C (68 °F).

The fuel injectors can fail in the following ways or supply incorrect signal:

- Injector actuator open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Blocked injector.
- Restricted injector.
- Low fuel pressure.

In the event of fuel injector signal failure any of the following symptoms may be observed:

- Rough running.
- Difficult starting.
- Engine misfire.
- Possible catalyst damage.
- High emissions.
- Adaptive fuelling disabled.
- Adaptive idle speed control disabled.

The ECM performs three types of fuel injector diagnostic check:

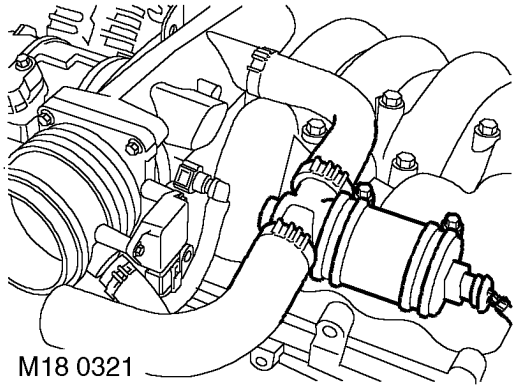
- Output short circuit to earth
- Output short circuit to battery voltage
- Output open circuit

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P0201	Injection circuit malfunction - cylinder 1	Injector 1 open circuit
P0261	Cylinder 1 injector circuit low	Injector 1 short circuit to earth
P0262	Cylinder 1 injector circuit high	Injector 1 short circuit to battery supply
P0301	Cylinder 1 misfire detected	Injector 1 excess emissions/catalyst damaging level of misfire
P0202	Injection circuit malfunction - cylinder 2	Injector 2 open circuit
P0264	Cylinder 2 injector circuit low	Injector 2 short circuit to earth
P0265	Cylinder 2 injector circuit high	Injector 2 short circuit to battery supply

P Code	J2012 Description	Land Rover Description
P0302	Cylinder 2 misfire detected	Injector 2 excess emissions/catalyst damaging level of misfire
P0203	Injection circuit malfunction - cylinder 3	Injector 3 open circuit
P0267	Cylinder 3 injector circuit low	Injector 3 short circuit to earth
P0268	Cylinder 3 injector circuit high	Injector 3 short circuit to battery supply
P0303	Cylinder 3 misfire detected	Injector 3 excess emissions/catalyst damaging level of misfire
P0204	Injection circuit malfunction - cylinder 4	Injector 4 open circuit
P0270	Cylinder 4 injector circuit low	Injector 4 short circuit to earth
P0271	Cylinder 4 injector circuit high	Injector 4 short circuit to battery supply
P0304	Cylinder 4 misfire detected	Injector 4 excess emissions/catalyst damaging level of misfire
P0205	Injection circuit malfunction - cylinder 5	Injector 5 open circuit
P0273	Cylinder 5 injector circuit low	Injector 5 short circuit to earth
P0274	Cylinder 5 injector circuit high	Injector 5 short circuit to battery supply
P0305	Cylinder 5 misfire detected	Injector 5 excess emissions/catalyst damaging level of misfire
P0206	Injection circuit malfunction - cylinder 6	Injector 6 open circuit
P0276	Cylinder 6 injector circuit low	Injector 6 short circuit to earth
P0277	Cylinder 6 injector circuit high	Injector 6 short circuit to battery supply
P0306	Cylinder 6 misfire detected	Injector 6 excess emissions/catalyst damaging level of misfire
P0207	Injection circuit malfunction - cylinder 7	Injector 7 open circuit
P0279	Cylinder 7 injector circuit low	Injector 7 short circuit to earth
P0280	Cylinder 7 injector circuit high	Injector 7 short circuit to battery supply
P0307	Cylinder 7 misfire detected	Injector 7 excess emissions/catalyst damaging level of misfire
P0208	Injection circuit malfunction - cylinder 8	Injector 8 open circuit
P0282	Cylinder 8 injector circuit low	Injector 8 short circuit to earth
P0283	Cylinder 8 injector circuit high	Injector 8 short circuit to battery supply
P0308	Cylinder 8 misfire detected	Injector 8 excess emissions/catalyst damaging level of misfire
P0171	System too rich (bank 1)	Multiplication injector adaptive fuelling - rich limit exceeded LH bank
P0172	System too lean (bank 1)	Multiplication injector adaptive fuelling - lean limit exceeded LH bank
P0174	System too rich (bank 2)	Multiplication injector adaptive fuelling - rich limit exceeded RH bank
P0175	System too lean (bank 2)	Multiplication injector adaptive fuelling - lean limit exceeded RH bank
P1171	System too rich (bank 1)	Additive injector adaptive fuelling - rich limit exceeded LH bank
P1172	System too lean (bank1)	Additive injector adaptive fuelling - lean limit exceeded LH bank
P1174	System too rich (bank 2)	Additive injector adaptive fuelling - rich limit exceeded RH bank
P1175	System too lean (bank 2)	Additive injector adaptive fuelling - lean limit exceeded RH bank
P0300	Random/multiple cylinder excess emissions detected	Excess emissions detected on more than one cylinder
P1300	Random/multiple cylinder misfire detected	Catalyst damaging level of misfire on more than one cylinder
P1319		Misfire detected with low fuel level

Idle Air Control Valve (IACV) (C0641)



The IACV is located on the side of the air inlet pipe on top of the engine. The IACV is used to maintain good quality idle speed under all operating conditions.

When an engine is running at idle it is subject to a combination of internal and external loads that can affect idle speed. These loads include engine friction, water pump, alternator operation, and air conditioning.

The IACV acts as an air bypass valve. The ECM uses the IACV to enable the closed loop idle speed calculation to be made by the ECM. This calculation regulates the amount of air flow into the engine at idle, therefore compensating for any internal or external loads that may affect idle speed.

The IACV utilises two coils that use opposing PWM signals to control the position of opening/closing of a rotary valve. If one of the circuits that supply the PWM signal fails, the ECM closes down the remaining signal preventing the IACV from working at its maximum/ minimum setting. If this should occur, the IACV automatically resumes a default idle position. In this condition, the engine idle speed is raised and maintained at 1200 rev/min with no load placed on the engine.

The idle speed in cold start condition is held at 1200 rev/min in neutral for 20 seconds and ignition timing is retarded as a catalyst heating strategy. The cold start idle speed and the default idle position give the same engine speed 1200 rev/min, and although they are the same figure they must not be confused with each other as they are set separately by the ECM.

Note that the rotary valve must not be forced to move by mechanical means. The actuator can not be serviced; if defective, the entire IACV must be replaced.

Input/Output

The input to the IACV is a 12 volt signal from fuse 2 located in the engine compartment fuse box. The output earth signal to open and close the actuator is controlled by the ECM as follows:

- IACV (open signal) - via pin 42 of connector C0636 of the ECM
- IACV (closed signal) - via pin 43 of connector C0636 of the ECM

The IACV can fail the following ways or supply incorrect signal:

- Actuator faulty.
- Rotary valve seized.
- Wiring loom fault.
- Connector fault.
- Intake system air leak.
- Blocked actuator port or hoses.
- Restricted or crimped actuator port or hoses.

In the event of an IACV signal failure any of the following symptoms may be observed:

- Either low or high idle speed.
- Engine stalls.
- Difficult starting.
- Idle speed in default condition.

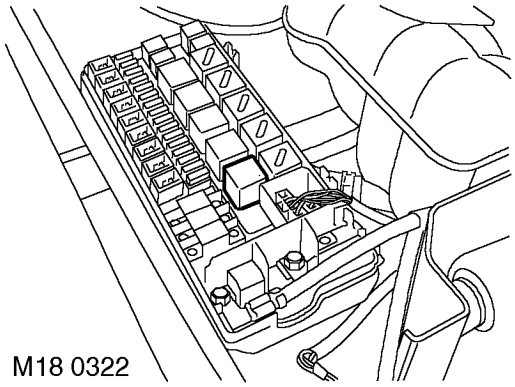
There are eight IACV diagnostic checks performed by the ECM:

- Output short circuit to earth – opening coil
- Output short circuit to battery supply – opening coil
- Output open circuit – opening coil
- Output short circuit to earth – closing coil
- Output short circuit to battery voltage – closing coil
- Output open circuit – closing coil
- Blocked IACV – rev/min error low (engine speed must be 100 rev/min less than the target speed, engine load less than 2.5 and the measured air flow more than 10 kg/h less than the expected air flow for a fault condition to be flagged).
- Blocked IACV – rev/min error high (the engine speed must be more than 180 rev/min greater than the target speed and the measured air flow more than 10 kg/h greater than the expected air flow for a fault condition to be flagged).

Should a malfunction of the component occur, the following fault codes may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P1510	IACV opening coil malfunction	Short circuit to battery supply - opening winding
P1513	IACV opening coil malfunction	Short circuit to earth - opening winding
P1514	IACV opening coil malfunction	Open circuit - opening winding
P1553	IACV closing coil malfunction	Short circuit to battery supply - closing winding
P1552	IACV closing coil malfunction	Short circuit to earth - closing winding
P1551	IACV closing coil malfunction	Open circuit - closing winding
P0505	Idle control system malfunction	Blocked IACV - high or low rev/min error

Fuel pump relay


M18 0322

The fuel pump relay is located in the engine compartment fuse box. It is a 4 pin normally open relay. Input from the ECM allows the fuel pump relay to control the electrical input to the fuel pump, regulating the fuel supply to the fuel injectors. When the ignition is switched on and the engine is cranked, the fuel pump relay is activated by the ECM, allowing the fuel system to be pressurised to 3.5 bar (52 lbf.in^2). The ECM then deactivates the relay until the engine has started.

If the fuel pump runs, but the fuel pressure is out of limits, adaptive fuel faults will be stored.

Input/Output

The input value for the relay windings is battery voltage, the input value for the switching contacts comes from fuse 10 in the engine compartment fuse box. The output control of the switching contacts is direct to the fuel pump motor, and the relay windings are controlled by pin number 18 of connector C0635 of the ECM.

At ignition 'on' (position II) the fuel pump relay contacts remain open until the ECM supplies an earth path for the relay windings via pin number 18 of connector C0635 of the ECM. At this point, the relay windings are energised, drawing the relay contacts closed. This allows voltage from fuse 10 in the passenger compartment fuse box to pass directly to the fuel pump.

The fuel pump relay can fail the following ways or supply incorrect signal:

- Relay drive open circuit.
- Short circuit to vehicle earth.
- Short circuit to vehicle supply.
- Component failure.

In the event of a fuel pump relay failure any of the following symptoms may be observed:

- Engine stalls or will not start.
- No fuel pressure at the fuel injectors.

The ECM performs three types of diagnostic test to confirm the fuel pump relay integrity:

- Output short circuit to earth
- Output short circuit to battery voltage
- Output open circuit

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P1230	Fuel pump relay malfunction	Fuel pump relay open circuit - not the fuel pump
P1231	Fuel pump relay circuit low	Fuel pump relay short circuit to battery supply - not the fuel pump
P1232	Fuel pump relay circuit high	Fuel pump relay short circuit to earth - not the fuel pump

Evaporative emissions

Refer to Emissions section for description of the evaporative emissions system components.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Evaporative emission control system.**

Secondary air injection (NAS only)

Refer to Emissions section for description of the secondary air injection system components.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Secondary air injection system.**

Fuel tank pressure sensor (NAS only)

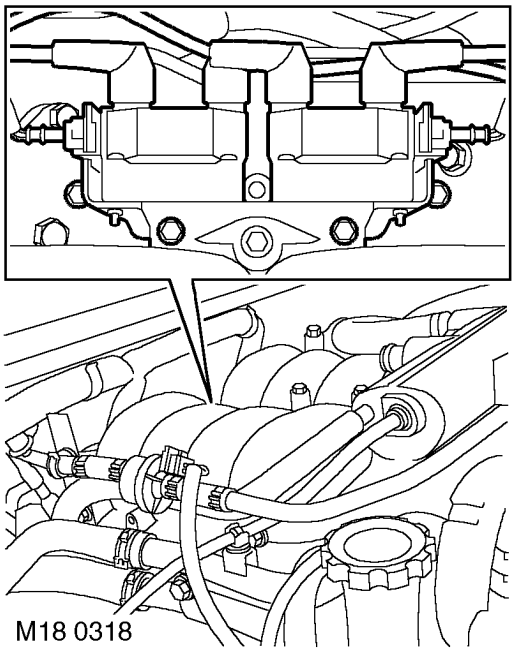
Refer to Fuel Delivery section for description of the fuel system components.

☞ **FUEL DELIVERY SYSTEM - V8, DESCRIPTION AND OPERATION, Description.**

Refer to Emissions section for description of the fuel tank pressure sensor.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Evaporative emission control system.**

Ignition coils



Two double ended ignition coils are located at the rear of the engine, below the inlet plenum camber mounted on a bracket. The ignition system operates on the wasted spark principle. When the ECM triggers an ignition coil to spark, current from the coil travels to one spark plug jumping the gap at the spark plug electrodes igniting the mixture in the cylinder. Current continues to travel along the earth path (via the cylinder head) to the spark plug negative electrode at the cylinder that is on the exhaust stroke. The current jumps across the spark plug electrodes and back to the coil completing the circuit. Since it has sparked simultaneously in a cylinder that is on the exhaust stroke it has not done any work, therefore it is wasted.

The coils are paired in the following cylinder order:

- 1 and 6.
- 8 and 5.
- 4 and 7.
- 3 and 2.

The ECM calculates the dwell timing from battery voltage, and engine speed to ensure constant secondary energy. This ensures sufficient spark energy is always available without excessive primary current flow and thus avoiding overheating or damage to the coils. Individual cylinder spark timing is calculated from the following signals:

- Engine speed.
- Engine load.
- Engine temperature.
- Knock control.
- Automatic gearbox shift control.
- Idle speed control.

During engine warm up ignition timing should be an expected value of 12° BTDC.

TestBook can not directly carry out diagnostics on the high-tension side of the ignition system. Ignition related faults are monitored indirectly by the misfire detection system.

Input/Output

Input to the low tension side of the ignition coils comes from Fuse 14 located in the passenger compartment fuse box. This fuse provides battery power for two ignition coils.

It is possible to test both primary and secondary coils of the ignition coils for resistance using a multimeter as follows:
- Expected primary coil resistance: 0.5 ± 0.05 Ω at 20 °C (68 °F).
- Expected secondary coil resistance: 13.3 ± 1.3 kΩ at 20 °C (68 °F).

The ECM provides the earth control for each coil on separate pins as follows:

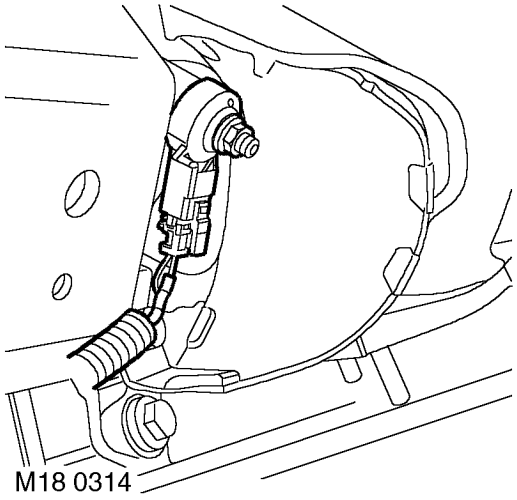
LH Bank (cylinders 1, 3, 5, 7)
- Cylinder 1 - pin 6 of connector C0638 of the ECM multiplug.
- Cylinder 3 - pin 2 of connector C0638 of the ECM multiplug.
- Cylinder 5 - pin 8 of connector C0638 of the ECM multiplug.
- Cylinder 7 - pin 7 of connector C0638 of the ECM multiplug.

RH Bank (cylinders 2, 4, 6, 8)
- Cylinder 2 - pin 2 of connector C0638 of the ECM multiplug.
- Cylinder 4 - pin 7 of connector C0638 of the ECM multiplug.
- Cylinder 6 - pin 6 of connector C0638 of the ECM multiplug.
- Cylinder 8 - pin 8 of connector C0638 of the ECM multiplug.

The ignition coil can fail the following ways or supply incorrect signal:
- Coil open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Faulty component.

In the event of ignition coil failure any of the following symptoms may be observed:
- Engine misfire on specific cylinders.
- Engine will not start.

Knock Sensor (KS)



The ECM uses two knock sensors located between the centre two cylinders of each bank to detect pre-ignition. The knock sensors consist of piezo ceramic crystals that oscillate to create a voltage signal. During pre-ignition the frequency of crystal oscillation increases, which alters the signal output to the ECM. The ECM compares the signal to known signal profiles in its memory. If pre-ignition is detected the ECM retards ignition timing for a number of cycles. If no more pre-ignition is detected, the timing is gradually advanced to the original setting.

The ignition is calibrated to run on 95 RON premium fuel, but the system will run satisfactorily on 91 RON regular fuel. If the vehicle is refuelled with a lower grade fuel, some audible detonation will initially be heard. This is non-damaging and ceases when the system adaption is completed.

Input/Output

Because of the nature of its operation, the knock sensors do not require any electrical input source. The KS output for LH bank (cylinders 1, 3, 5, 7) is measured via pin 49 of connector C0636 of the ECM. The KS output for RH bank (cylinders 2, 4, 6, 8) is measured via pin 36 of connector C0636 of the ECM. Both knock sensors have a screened earth to protect the integrity of the sensor signals. The KS earth for LH bank (cylinders 1, 3, 5, 7) is via pin 48 of connector C0636 of the ECM. The KS earth for RH bank (cylinders 2, 4, 6, 8) is via pin 35 of connector C0636 of the ECM.

The connector and sensor terminals are gold plated for corrosion and temperature resistance, care must be exercised while probing the connector and sensor terminals.

The KS can fail the following ways or supply incorrect signal:

- Sensor open circuit.
- Short circuit to vehicle battery supply.
- Short circuit to vehicle earth.
- Faulty component.
- Incorrectly tightened sensor.

In the event of a KS signal failure any of the following symptoms may be observed:

- KS disabled, the ECM refers to a 'safe ignition map'.
- Rough running.
- Engine performance concern.

The ECM performs the following diagnostic checks to confirm correct knock sensor operation:

- KS signal level is less than the minimum threshold (dependent on engine speed) – the engine must be running, coolant temperature above 60°C (140°F), number of camshaft revolutions since start greater than 50 and the KS signal profile must be less than the threshold value at a given engine speed for a fault condition to be flagged
- KS signal is greater than the maximum threshold (dependent on engine speed) – the engine must be running, coolant temperature above 60°C (140°F), number of camshaft revolutions since start greater than 50 and the KS signal profile must be greater than the threshold value at a given engine speed for a fault condition to be flagged
- Error counter for verification of knock internal circuitry exceeded – the engine must be running, coolant temperature above 60°C (140°F), number of camshaft revolutions since start greater than 50 and the error counter greater than the threshold value at a given engine speed for a fault condition to be flagged

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P0327	Knock sensor 1 circuit low input (bank 1 or single sensor)	LH bank signal less than threshold determined from ECM model above 2200 rev/min
P0328	Knock sensor 1 circuit high input (bank 1 or single sensor)	LH bank signal greater than threshold determined from ECM model above 2200 rev/min
P0332	Knock sensor 2 circuit low input (bank 2)	RH bank signal less than threshold determined from ECM model above 2200 rev/min
P0333	Knock sensor 2 circuit high input (bank 2)	RH bank signal greater than threshold determined from ECM model above 2200 rev/min

Spark plugs
The spark plugs are platinum tipped on both centre and earth electrodes. The platinum tips give a long maintenance free life.

Cleaning or resetting the spark plug gap is not recommended as this could result in damaging the platinum tips and thereby reducing reliability.

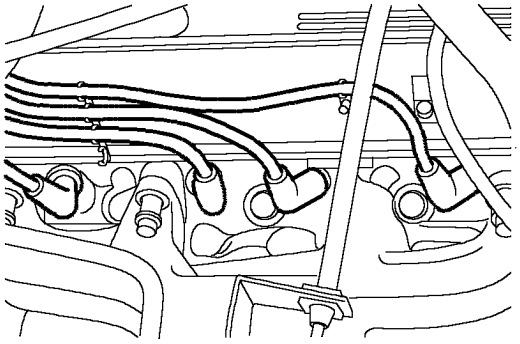
The misfire detection system will malfunction and store erroneous codes if the incorrect spark plugs are used.

Input/Output
The ignition coils provide a voltage to the spark plugs via the ht leads. The cylinder head via the individual thread of each spark plug provides the earth path.

The spark plugs can fail in the following ways:
- Faulty component.
- Connector or wiring fault.
- Breakdown of high tension lead causing tracking to chassis earth.
- Incorrect spark plugs fitted.

In the event of a spark plug failure, misfire on specific cylinder may be observed:

High tension (ht) leads



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The ht leads are located on top of the engine, below the plenum chamber. Their function is to transfer the ht voltage generated by the ignition coils to the spark plugs in the engine.

Input/Output
The input to the ht lead is ht voltage from the ignition coil pack. The ht lead then supplies this voltage to the spark plug. Output ht voltage is used by the spark plugs to ignite the air/fuel mixture in the combustion chamber.

The ht leads can fail in the following ways:
- Connector/ Wiring fault.
- Faulty component causing spark tracking to chassis earth.
- Damage to ht leads during component removal.

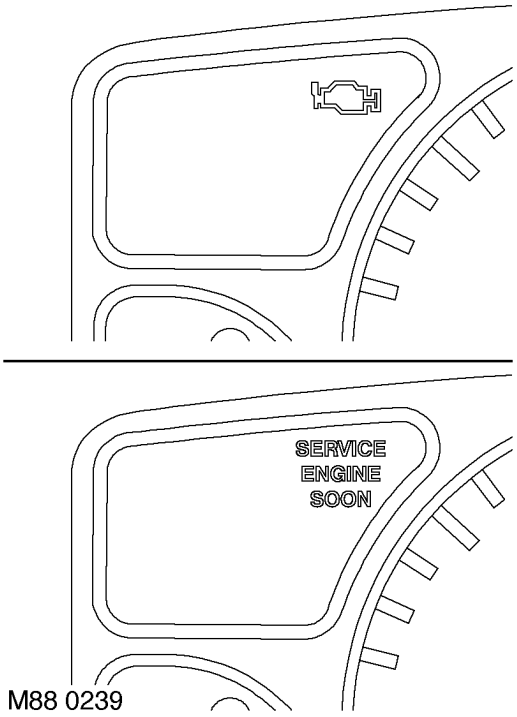
In the event of a ht lead failure the following symptom may be observed:
- Misfire on specific cylinder.

All ignition system related faults are diagnosed by the misfire detection system and its fault codes.

Hill Decent Control (HDC)
Refer to Brakes for description of the hill descent control.
☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**

High/Low ratio switch
Refer to Transfer Box for description of the high/ low ratio switch transfer box components.
☞ **TRANSFER BOX - LT230SE, DESCRIPTION AND OPERATION, Description.**

Malfunction Indicator Lamp (MIL)/ service engine soon warning lamp



The MIL/ service engine soon warning lamp is located in the instrument cluster. It illuminates to alert the driver to system malfunctions. Service engine soon warning lamp is the name for this warning lamp in NAS only, it is called MIL in all other markets.

During ignition a self-test function of the lamp is carried out. The lamp will illuminate for 3 seconds then it will extinguish if no faults exist.
☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

Input/Output
The MIL is supplied with battery voltage from the instrument cluster. When the ECM detects a fault, it provides an earth path to illuminate the MIL. Output to the MIL is via pin 20 of connector C0637 of the ECM.

Air Temperature Control (ATC) request
The ATC request comes via the ATC switch located in the facia panel. When the driver operates the switch it acts as a request from the ATC ECU to engage the ATC clutch to drive the system.

During periods of high driver demand such as hard acceleration or maximum rev/min the ATC clutch will be disabled for a short time. This is to reduce the load on the engine.

☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**

Input/Output
The operation of the ATC request is via a switch being connected to earth. Voltage is supplied via pin 38 of connector C0637 of the ECM, at the point at when the switch is pressed the connection is made and the ATC clutch is engaged.

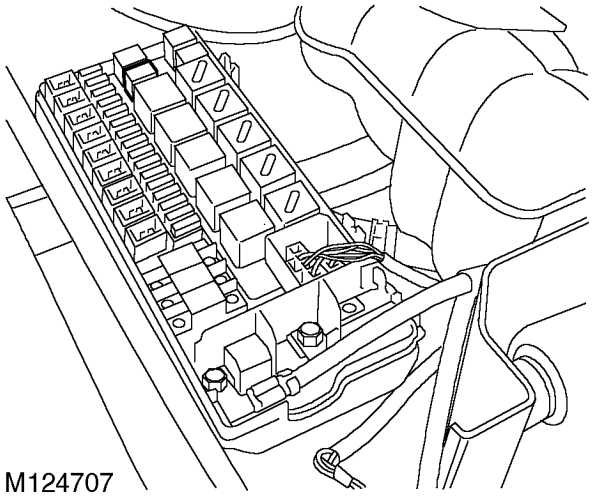
The ATC request can fail as follows:
- Open circuit.
- Short circuit to voltage supply.
- Short circuit to vehicle earth.
- Wiring loom fault.

In the event of an ATC request failure, the ATC system does not work.

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P1535	Air conditioning compressor request malfunction	ATC requested when not in standby mode

ATC compressor clutch relay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The ATC compressor clutch relay is located in the engine compartment fuse box. It is a four pin normally open relay. The relay must be energised to drive the ATC compressor clutch.

Input/Output

The ECM provides the earth for the relay coil to allow the relay contacts to close and the ATC clutch drive to receive battery voltage. The ECM uses a transistor as a switch to generate an open circuit in the earth path of the relay coil. When the ECM opens the earth path, the return spring in the relay will pull the contacts apart to shut down the ATC clutch drive.

Input to the ATC clutch relay switching contacts is via fuse 6 located in the engine compartment fuse box. The relay coils are supplied with battery voltage from the main relay, also located in the engine compartment fuse box. The earth path for the relay coil is via pin 29 of the ECM C0657 connector. When the relay is energised the output from the switching contacts goes directly to the ATC compressor clutch.

The ATC clutch relay can fail in the following ways:

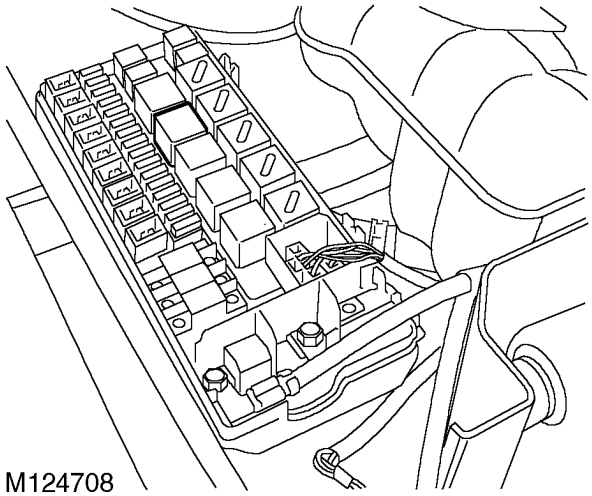
- Relay open circuit.
- Short circuit to vehicle supply.
- Short circuit to vehicle earth.
- Broken return spring.

In the event of an ATC clutch relay failure, the ATC does not work.

Should a malfunction of the component occur, the following fault codes may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P1536	Air conditioning compressor request range/ performance	ATC compressor clutch relay open circuit
P1537	Air conditioning compressor request low input	ATC compressor clutch relay short to earth
P1538	Air conditioning compressor request high input	ATC compressor clutch relay short to battery supply

Cooling fan relay



The cooling fan relay is located in the engine compartment fuse box. It is a four pin normally open relay. The relay must be energised to drive the cooling fan.

The cooling fan is used to cool both the condenser in which the ATC refrigerant is held and the radiator. This fan is used especially when the engine is operating at excessively high temperatures. It is also used as a part of the ECM backup strategy if the ECT fails.

Input/Output

The ECM provides the earth for the relay coils to allow the relay contacts to close and the cooling fan motor to receive battery voltage. The ECM uses a transistor as a switch to generate an open circuit in the earth path of the relay windings. When the ECM opens the earth path, the return spring in the relay will pull the contacts apart to shut down the cooling fan motor drive.

Input to the cooling fan relay switching contacts is via fuse 5 located in the engine compartment fuse box. The relay coils are supplied with battery voltage from the main relay, also located in the engine compartment fuse box. The earth path for the relay coils is via pin 31 of the ECM connector C0636. When the relay is energised the output from the switching contacts is directly to the cooling fan motor.

The cooling fan relay can fail in the following ways:

- Relay open circuit.
- Short circuit to vehicle battery supply.
- Short circuit to vehicle earth.
- Broken return spring.

In the event of a cooling fan relay failure, the cooling fan does not work.

Operation - engine management

Fuel quantity
The ECM controls engine fuel quantity by providing sequential injection to the cylinders. Sequential injection allows each injector to deliver fuel to the cylinders in the required firing order.

To achieve optimum fuel quantity under all driving conditions, the ECM provides an adaptive fuel strategy.

Conditions
Adaptive fuel strategy must be maintained under all throttle positions except:
- Cold starting.
- Hot starting.
- Wide open throttle.
- Acceleration.

All of the throttle positions mentioned above are deemed to be 'open loop'. Open loop fuelling does not rely on information from the HO_2 sensors, but the air/ fuel ratio is set directly by the ECM. During cold start conditions the ECM uses ECT information to allow more fuel to be injected into the cylinders to facilitate cold starting. This strategy is maintained until the HO_2 sensors are at working temperature and can pass exhaust gas information to the ECM. Because of the specific nature of the other functions e.g. hot starting, idle, wide open throttle, and acceleration they also require an 'open loop' strategy. For NAS vehicles with secondary air injection for cold start conditions, refer to the Emissions section.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Secondary air injection system.**

Adaptive fuel strategy also allows for wear in the engine and components, as well as slight differences in component signals, as no two components will give exactly the same readings.

Function
To be able to calculate the amount of fuel to be injected into each cylinder, the ECM needs to determine the amount of air mass drawn into each cylinder. To perform this calculation, the ECM processes information from the following sensors:
- Mass air flow (MAF) sensor.
- Crank speed and position (CKP) sensor.
- Engine coolant temperature (ECT) sensor.
- Throttle position (TP) sensor.

During one engine revolution, 4 of the 8 cylinders draw in air. The ECM uses CKP sensor information to determine that one engine revolution has taken place, and the MAF sensor information to determine how much air has been drawn into engine. The amount of air drawn into each cylinder is therefore 1/4 of the total amount measured by the ECM via the MAF sensor.

The ECM refers the measured air mass against a fuel quantity map in its memory and then supplies an earth path to the relevant fuel injector for a period corresponding to the exact amount of fuel to be injected into the lower inlet manifold. This fuel quantity is in direct relation to the air mass drawn into each cylinder to provide the optimum ratio.

During adaptive fuelling conditions, information from the heated oxygen sensors (HO_2S) is used by the ECM to correct the fuel quantity to keep the air/ fuel ratio as close to the stoichiometric ideal as possible.

Closed loop fuelling
The ECM uses a closed loop fuelling system as part of its fuelling strategy. The operation of the three-way catalytic converter relies on the ECM being able to optimise the air/ fuel mixture, switching between rich and lean either side of lambda one. Closed loop fuelling is not standard for all markets, vehicles that are not fitted with HO_2S do not have closed loop fuelling.

The ideal stoichiometric ratio is represented by λ =1. The ratio can be explained as 14.7 parts of air to every 1 part of fuel.

Conditions
To achieve closed loop fuelling, the ECM interacts with the following components:
- HO_2S.
- Fuel injectors.

Closed loop fuelling is a rolling process controlled by the ECM. The ECM uses information gained from the CKP, ECT, MAF/ IAT and the TP sensors, to operate under the following conditions:
- Part throttle.
- Light engine load.
- Cruising.
- Idle.

Function
When the engine is operating in the above conditions, the ECM implements the closed loop fuelling strategy. The air/ fuel mixture is ignited by the high tension (ht) spark in the combustion chambers and the resulting gas is expelled into the exhaust pipe. Upon entering the exhaust pipe the exhaust gas passes over the protruding tip of the HO_2S. The HO_2S measures the oxygen content of the gas compared to that of ambient air and converts it into a voltage, which is measured by the ECM.

The voltage signal read by the ECM is proportional to the oxygen content of the exhaust gas. This signal can then be compared to stored values in the ECM's memory and an adaptive strategy can be implemented.

If the HO_2S informs the ECM of an excess of oxygen (lean mixture), the ECM extends the opening time of the fuel injectors via the Injector Pulse Width (IPW) signal. Once this new air/ fuel ratio has been 'burnt' in the combustion chambers the HO_2S can again inform the ECM of the exhaust gas oxygen content, this time there will be a lack of oxygen or a rich mixture. The ECM reduces the opening time of the injectors via the IPW signal using the ECM's adaptive fuel strategy. During closed loop fuelling the HO_2S will constantly switch from rich to lean and back again, this indicates that the ECM and the HO_2S are operating correctly.

Open loop fuelling
Open loop fuelling does not rely on information from the HO_2S, but the air/ fuel ratio is set directly by the ECM, which uses information gained from the ECT, MAF/ IAT, the TP sensors and also the vehicle speed sensor (VSS). The ECM uses open loop fuelling under the following conditions:
- Cold start.
- Hot start.
- Wide open throttle.
- Acceleration.

The ECM uses open loop fuelling to control fuel quantity in all non adaptive strategy conditions. The ECM implements fuelling information carried in the form of specific mapped data contained within its memory.

Because there is no sensor information (e.g. HO_2S), provided back to the ECM, the process is called an 'open loop'.

The ECM will also go into open loop fuelling if a HO_2S fails.

Ignition timing

The ignition timing is an important part of the ECM adaptive strategy. Ignition is controlled by a direct ignition system using two four-ended coils operating on the wasted spark principle.

When the ECM triggers an ignition coil to spark, current from the coil travels to one spark plug, then jumps the gap at the spark plug electrodes, igniting the mixture in the cylinder in the process. Current continues to travel along the earth path (via the cylinder head) to the spark plug negative electrode at the cylinder that is on the exhaust stroke. The current jumps across the spark plug electrodes and back to the coil completing the circuit. Since it has simultaneously sparked in a cylinder that is on the exhaust stroke, it has not provided an ignition source there and is consequently termed 'wasted'.

Conditions

The ECM calculates ignition timing using input from the following:

- CKP sensor.
- Knock sensors (KS).
- MAF sensor.
- TP sensor (idle only).
- ECT sensor.

Function

At engine start up, the ECM sets ignition timing dependent on ECT information and starting rev/min from the CKP. As the running characteristics of the engine change, the ignition timing changes. The ECM compares the CKP signal to stored values in its memory, and if necessary advances or retards the spark via the ignition coils.

Ignition timing is used by the ECM for knock control.

Knock control

The ECM uses active knock control to prevent possible engine damage due to pre-ignition. This is achieved by converting engine block noise into a suitable electrical signal that can be processed by the ECM. A major contributing factor to engine 'knock' is fuel quality, the ECM can function satisfactorily on 91 RON fuel as well as the 95 RON fuel that it is calibrated for.

Conditions

The ECM knock control system operates as follows:

- Hot running engine.
- 91 or 95 RON fuel.

Function

The ECM knock control uses two sensors located one between the centre two cylinders of each bank. The knock sensors consist of piezo ceramic crystals that oscillate to create a voltage signal. During pre-ignition, the frequency of crystal oscillation increases which alters the signal output to the ECM.

If the knock sensors detect pre-ignition in any of the cylinders, the ECM retards the ignition timing by 3° for that particular cylinder. If this action stops the engine knock, the ignition timing is restored to its previous figure in increments of 0.75°. If this action does not stop engine knock then the ECM retards the ignition timing a further 3° up to a maximum of -15° and then restores it by 0.75° and so on until the engine knock is eliminated.

The ECM also counteracts engine knock at high intake air temperatures by retarding the ignition as above. The ECM uses the IAT signal to determine air temperature.

Idle speed control
The ECM regulates the engine speed at idling. The ECM uses the idle air control valve (IACV) to compensate for the idle speed drop that occurs when the engine is placed under greater load than usual. When the throttle is in the rest position i.e. it has not been pressed, the majority of intake air that the engine consumes comes from the idle air control valve.

IACV control idle speed
Conditions in which the ECM operates the IACV control idle speed is as follows:
- If any automatic transmission gears other than P or N are selected.
- If air conditioning is switched on.
- If cooling fans are switched on.
- Any electrical loads activated by the driver.

Function
The idle air control valve utilises two coils that use opposing pulse width modulated (PWM) signals to control the position of a rotary valve. If one of the circuits that supplies the PWM signal fails, the ECM closes down the remaining signal preventing the idle air control valve from working at its maximum/ minimum setting. If this should occur, the idle air control valve assumes a default idle position at which the engine idle speed is raised to 1200 rev/min with no load placed on the engine.

Evaporative emission control
Due to increasing legislation, all new vehicles must be able to limit evaporative emissions (fuel vapour) from the fuel tank.

The ECM controls the emission control system using the following components:
- EVAP canister.
- Purge valve.
- Canister vent solenoid (CVS) valve – (NAS vehicles with vacuum type EVAP system leak detection capability only)
- Fuel tank pressure sensor – (NAS vehicles with vacuum type EVAP system leak detection capability only)
- Fuel leak detection pump – (NAS vehicles with positive pressure type EVAP system leak detection capability only)
- Interconnecting pipe work.

Refer to Emissions section for operating conditions of evaporative emission systems.
☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Evaporative emission control operation.**

On-Board Diagnostics (OBD) - North American Specification vehicles only
The ECM monitors performance of the engine for misfires, catalyst efficiency, exhaust leaks and evaporative control loss. If a fault occurs, the ECM stores the relevant fault code and warns the driver of component failure by illuminating the Malfunction Indicator Light in the instrument pack.

On vehicles fitted with automatic gearbox, the ECM combines with the Electronic Automatic Transmission (EAT) ECU to provide the OBD strategy.

Conditions
If the OBD function of the ECM flags a fault during its operation, it falls into one of the following categories:
- min = minimum value of the signal exceeded.
- max = maximum value of the signal exceeded.
- signal = signal not present.
- plaus = an implausible condition has been diagnosed.

Function

All of the ECM's internal diagnostic fault paths are monitored by the OBD system. Specific faults have their own numeric code relating to certain sensors or actuators etc. These specific faults fall into two types, error codes (E xxx) or cycle codes (Z xxx). E codes represent instantaneous faults and Z codes relate to codes generated after completion of a drive cycle.

If an emission relevant fault occurs on a drive cycle, the ECM stores a temporary fault code, if the fault does not occur on subsequent drive cycles the fault code stays as a temporary fault code. If the fault recurs on subsequent drive cycles the ECM stores the fault code as a permanent code, and depending on which component has failed the ECM will illuminate the MIL.

Immobilisation system

The ECM and the body control unit (BCU) security system comprise the immobilisation system.

The ECM and the BCU combine to prevent the engine from running unless the appropriate security criteria are met. The ECM and the BCU are a matched pair, if either one is replaced for any reason, the system will not operate unless the replaced unit is correctly matched to its original specification. TestBook must be used to reconfigure the immobilisation system.

Conditions

The ECM operates immobilisation in three states:

- 'New'.
- 'Secure'.
- 'No Code'.

Function

With the ECM operating in the 'New' state, TestBook is required to instruct the ECM to learn the new BCU code. If the ECM is in delivery state (i.e. direct from the supplier), it will not run the vehicle and will store a new ECM fault code when it is fitted. This code must be cleared after instructing the ECM to learn the BCU code using TestBook.

When the ECM is in the 'Secure' state, no further action is required as the ECM has successfully learned the BCU code. A 'Secure' ECM can not be configured to a 'No Code' state.

If the vehicle is fitted with an ECM with a valid code, the engine will start and the MIL will go out.

However, if the ECM has an invalid BCU security code the engine will crank, start, and then immediately stall. The status of the security system can only be interrogated using TestBook.

TestBook is able to retrieve the following immobilisation fault codes:

P Code	J2012 Description	Land Rover Description
P1666	Engine anti-theft signal circuit malfunction	BCU serial link frame/ bit timing error
P1667	Engine anti-theft signal circuit low	Serial link short circuit to earth
P1668	Engine anti-theft signal circuit high	Serial link open circuit
P1672	Engine anti-theft signal circuit wrong code received	Secure ECM, received incorrect code
P1673	Engine anti-theft signal new engine control module not configured	New ECM fitted
P1674	Engine anti-theft signal	No code ECM, valid code received

Misfire detection
Due to increasing legislation, all new vehicles must be able to detect two specific levels of misfire.

Conditions
The ECM is able to carry out misfire detection as part of the OBD system using the following component parts:
- Flywheel reluctor adaptation.
- Calculation of engine roughness.
- Detection of excess emissions misfire.
- Detection of catalyst damaging misfire.

Function
The flywheel/ reluctor ring is divided into four segments 90° wide. The ECM misfire detection system uses information generated by the CKP to determine crankshaft speed and position. If a misfire occurs, there will be an instantaneous slight decrease in engine speed. The ECM misfire detection system is able to compare the length of time each 90° segment takes and is therefore able to pinpoint the source of the misfire.

For the ECM misfire detection system to be calibrated for the tolerances of the reluctor tooth positions, the flywheel/ reluctor ring must be 'adapted' as follows:
- 1800 - 3000 rev/min = speed range 1.
- 3000 - 3800 rev/min = speed range 2.
- 3800 - 4600 rev/min = speed range 3.
- 4600 - 5400 rev/min = speed range 4.

The ECM carries out flywheel/ reluctor ring adaptions across all the above speed ranges and can be monitored by TestBook. The test should be carried out as follows:
- Engine at normal operating temperature.
- Select second gear (for both automatic and manual transmission vehicles).
- Accelerate until engine rev limiter is operational.
- Release throttle smoothly to allow engine to decelerate throughout the speed ranges.
- Repeat process as necessary until all adaptations are complete.

TestBook is able to retrieve the following misfire detection fault codes:

P Code	J2012 Description	Land Rover Description
P0300	Random/multiple cylinder misfire detected	Excess emissions level of misfire on more than one cylinder
P0301	Cylinder 1 misfire detected	Excess emissions level of misfire detected on cylinder No.1
P0302	Cylinder 2 misfire detected	Excess emissions level of misfire detected on cylinder No.2
P0303	Cylinder 3 misfire detected	Excess emissions level of misfire detected on cylinder No.3
P0304	Cylinder 4 misfire detected	Excess emissions level of misfire detected on cylinder No.4
P0305	Cylinder 5 misfire detected	Excess emissions level of misfire detected on cylinder No.5
P0306	Cylinder 6 misfire detected	Excess emissions level of misfire detected on cylinder No.6
P0307	Cylinder 7 misfire detected	Excess emissions level of misfire detected on cylinder No.7
P0308	Cylinder 8 misfire detected	Excess emissions level of misfire detected on cylinder No.8

TestBook is able to retrieve the following Catalyst damage fault codes:

P Code	J2012 Description	Land Rover Description
P1300	Misfire detected sufficient to cause catalyst damage	Catalyst damaging level of misfire on more than one cylinder
P1301	No description	Catalyst damaging level of misfire detected on cylinder No.1
P1302	No description	Catalyst damaging level of misfire detected on cylinder No.2
P1303	No description	Catalyst damaging level of misfire detected on cylinder No.3
P1304	No description	Catalyst damaging level of misfire detected on cylinder No.4
P1305	No description	Catalyst damaging level of misfire detected on cylinder No.5
P1306	No description	Catalyst damaging level of misfire detected on cylinder No.6
P1307	No description	Catalyst damaging level of misfire detected on cylinder No.7
P1308	No description	Catalyst damaging level of misfire detected on cylinder No.8

The flywheel/ reluctor ring adaptions must be reset if the CKP sensor or the flywheel are changed.

Vehicle Speed Signal (VSS)
The VSS is used, by the ECM, to control idle speed and overrun cut off. The ECM receives the signal through a hard wired connection direct from the SLABS ECU.

For vehicles fitted with an automatic gearbox, two vehicle speed signals are received by the ECM. The second signal is derived from the main gearbox output shaft speed, and is sent to the ECM by the Electronic Automatic Transmission (EAT) ECU though the Controller Area Network (CAN). The ECM compares the vehicle speed signal generated by the SLABS ECU with that supplied via the CAN.

The ECM also receives transfer box information. This allows the ECM to take in to account the vehicle being driven using low range gearing and compensate as necessary.

On vehicles with manual transmission, the SLABS signal is checked against a threshold value stored in ECM memory. If other engine parameters indicate the engine is at high load and the VSS is below the threshold, a fault condition is registered in the diagnostic memory.

The vehicle speed signal generated by the SLABS ECU is in the form of a pulse width modulated signal (PWM). Pulses are generated at 8000 per mile, and the frequency of the signal changes in accordance with road speed. At zero road speed the ECU outputs a reference signal at a frequency of 2Hz for diagnostic purposes.

Function
The input signal for the SLABS ECU is measured via pin 22 of connector C0637 of the ECM. The SLABS ECU generates a PWM signal switching between 0 and 12 volts at a frequency of 8000 pulses per mile. For vehicles with automatic gearbox the input signal for the EAT ECU is measured via pins 36 and 37 of connector C0637 of the ECM. These pin numbers provide a bi-directional communications link using the CAN data bus.

In the case of a VSS failure on vehicles with automatic gearboxes, the ECM applies default values derived from the EAT ECU. There are no default values for manual gearbox vehicles.

The VSS can fail in the following ways:
- Wiring short circuit to vehicle supply.
- Wiring short circuit to vehicle earth.
- Wiring open circuit.

In the event of a VSS failure, any of the following symptoms may be observed:
- MIL illuminated after 2 driving cycles (NAS only).
- Vehicle speed limiting disabled (manual transmission vehicles only).
- SLABS/HDC warning lamp on and audible warning.

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P0500	Vehicle speed sensor malfunction	VSS short or open circuit
P0501	Vehicle speed sensor range/performance	VSS implausible

Rough road signal

When the vehicle travels across rough terrain, or on rough roads instability becomes evident in the drive train. The ECM could interpret these vibrations as a 'false misfire'. To counteract this 'false misfire' the SLABS ECU generates a rough road signal, sends it to the ECM so that the ECM can suspend misfire detection for as long as the vehicle is travelling on the 'rough road'.

Function

Input for the rough road signal is measured via pin 34 of connector C0637 of the ECM. The SLABS ECU generates a PWM signal that varies in accordance with changing road conditions. The rough road PWM signal operates at a frequency of 2.33 Hz ± 10%. The significance of changes in the PWM signal are shown in the following table:

PWM signal	Indication
<10%	Electrical short circuit to ground
25% ± 5 %	Smooth road
50% ± 5 %	SLABS error
75% ± 5%	Rough road
>90%	Electrical short circuit to battery voltage

The rough road signal can fail in the following ways:
- Harness or connector damage
- SLABS failure — wheel speed sensor

A rough road signal failure may be evident from the following:
- HDC / ABS warning light on

Should a malfunction of the rough road signal occur, the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P1590	ABS rough road signal circuit malfunction	Hardware is OK, but SLABS ECU is sending an error signal
P1591	ABS rough road signal circuit low	Signal from SLABS ECU short circuit to earth
P1592	ABS rough road signal circuit high	Signal from SLABS ECU short circuit to vehicle battery supply

Hill Descent Control (HDC) signal

The ECM transmits throttle angle, engine torque, engine identification (Td5 or V8), and transmission type (automatic or manual) data to the SLABS ECU to support the Hill Descent Control system. The information is transmitted via a 0 – 12V pulse width modulated (PWM) signal at a frequency of 179.27 Hz.

Function

The HDC signal output from the ECM is via pin 29 of connector C0636. The ECM generates a PWM signal that varies in pulse width in accordance with changing throttle angle or engine torque. The throttle angle data is transmitted on pulses 1, 3, 5 and 37. The engine torque data is transmitted on pulses 2,4,6 and 38. The engine and transmission information is transmitted on pulse 39. A synchronising pulse is transmitted after every 39th pulse.

The HDC signal can fail in the following ways:

- Harness or connector damage

A HDC signal failure may be evident from the following:

- HDC / ABS warning light on
- HDC inoperative
- Audible warning

Should a malfunction of the HDC signal occur, the following fault codes may be evident and can be retrieved by TestBook:

P Code	J2012 Description	Land Rover Description
P1663	Throttle angle/Torque signal circuit malfunction	SLABS HDC link open circuit
P1664	Throttle angle/Torque signal circuit low	SLABS HDC link short circuit to ground
P1665	Throttle angle/Torque signal circuit high	SLABS HDC link short circuit to battery voltage

Low fuel level signal

When the fuel level in the fuel tank becomes low enough to illuminate the low fuel level warning lamp in the instrument cluster, the instrument cluster generates a low fuel level signal. If the low fuel level signal is present during the ECM misfire detection function the ECM can use it to check for a 'false misfire'.

Conditions

The fuel sender generates the low fuel level signal when the fuel sender resistance is greater than 158 ± 8 ohms.

Function
The illumination of the low fuel level warning lamp in the instrument cluster triggers the low fuel level signal to be sent to the ECM. This signal is processed via pin 8 of connector C0637 of the ECM.

Should a misfire occur while the fuel level is low, the following fault code may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P1319	Misfire detected at low fuel level	Misfire detected with low fuel level

Coolant temperature gauge signal
The ECM controls the temperature gauge in the instrument cluster. The ECM sends a coolant temperature signal to the temperature gauge in the instrument cluster in the form of a PWM square wave signal.

The frequency of the signal determines the level of the temperature gauge.

Conditions
The ECM operates the PWM signal under the following parameters:
- -40 °C (-40 °F) = a pulse width of 768 µs.
- 140 °C (284 °F) = a pulse width of 4848 µs.

Function
The coolant temperature signal is an output from the ECM to the instrument cluster. The coolant temperature signal is generated via pin 44 of connector C0636 of the ECM.

The coolant temperature signal can fail in the following ways:
- Wiring short circuit to vehicle supply.
- Wiring short circuit to vehicle earth.
- Wiring open circuit.

In the event of a coolant temperature signal failure any of the following symptoms may be observed:
- Coolant temperature gauge will read cold at all times.
- Coolant temperature warning lamp remains on at all times.

Controller Area Network (CAN) system
The controller area network (CAN) system is a high speed serial interface between the ECM and the Electronic Automatic Transmission (EAT) ECU. The CAN system uses a 'data bus' to transmit information messages between the ECM and the EAT ECU. Because there are only two components in this CAN system, one will transmit information messages and the other will receive information messages, and vice-versa.

Conditions
The CAN system is used by the EAT ECU and the ECM for transmission of the following information:
- Gearshift torque control information.
- EAT OBD information.
- MIL request.
- Vehicle speed signal.
- Engine temperature.
- Engine torque and speed.
- Gear selected.
- Gear change information.
- Altitude adaptation factor
- Air intake temperature
- Throttle angle / pedal position

Function

The CAN system uses a twisted pair of wires to form the 'data bus' to minimise electrical interference. This method of serial interface is very reliable and very fast. The information messages are structured so that each of the receivers (ECM or EAT ECU) is able to interpret and react to the messages sent.

The CAN 'data bus' is directly connected between pin 36 of connector C0637 of the ECM and pin 16 of connector C0193 at the EAT ECU, and pin 37 of connector C0637 of the ECM and pin 44 of connector C0193 at the EAT ECU.

The CAN system can fail in the following ways:

- CAN data bus wiring open circuit.
- CAN data bus wiring short circuit.

In the event of a CAN data bus failure any of the following symptoms may be observed:

- MIL illuminated after 2 drive cycles (NAS only).
- EAT defaults to 3rd gear only.
- Harsh gearshifts.
- 'Sport' and 'manual' lights flash alternately.

Should a malfunction of the component occur the following fault codes may be evident and can be retrieved by TestBook.

P Code	J2012 Description	Land Rover Description
P0600	Serial communication link malfunction	CAN time out
P1776	Transmission control system torque interface malfunction	EAT torque interface error

Drive cycles

The following are the TestBook drive cycles:

⇒ Drive cycle A:

1. Switch on the ignition for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Connect TestBook and check for fault codes.

⇒ Drive cycle B:

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform 2 light accelerations (0 to 35 mph (0 to 60 km/h) with light pedal pressure).
5. Perform 2 medium accelerations (0 to 45 mph (0 to 70 km/h) with moderate pedal pressure).
6. Perform 2 hard accelerations (0 to 55 mph (0 to 90 km/h) with heavy pedal pressure).
7. Allow engine to idle for 2 minutes.
8. Connect TestBook and with the engine still running, check for fault codes.

⇒ Drive cycle C:

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform 2 light accelerations (0 to 35 mph (0 to 60 km/h) with light pedal pressure).
5. Perform 2 medium accelerations (0 to 45 mph (0 to 70 km/h) with moderate pedal pressure).
6. Perform 2 hard accelerations (0 to 55 mph (0 to 90 km/h) with heavy pedal pressure).
7. Cruise at 60 mph (100 km/h) for 8 minutes.
8. Cruise at 50 mph (80 km/h) for 3 minutes.
9. Allow engine to idle for 3 minutes.
10. Connect TestBook and with the engine still running, check for fault codes.

NOTE: The following areas have an associated readiness test which must be flagged as complete, before a problem resolution can be verified:

- *catalytic converter fault;*
- *Evaporative loss system fault;*
- *HO_2 sensor fault;*
- *HO_2 sensor heater fault.*

When carrying out a drive cycle C to determine a fault in any of the above areas, select the readiness test icon to verify that the test has been flagged as complete.

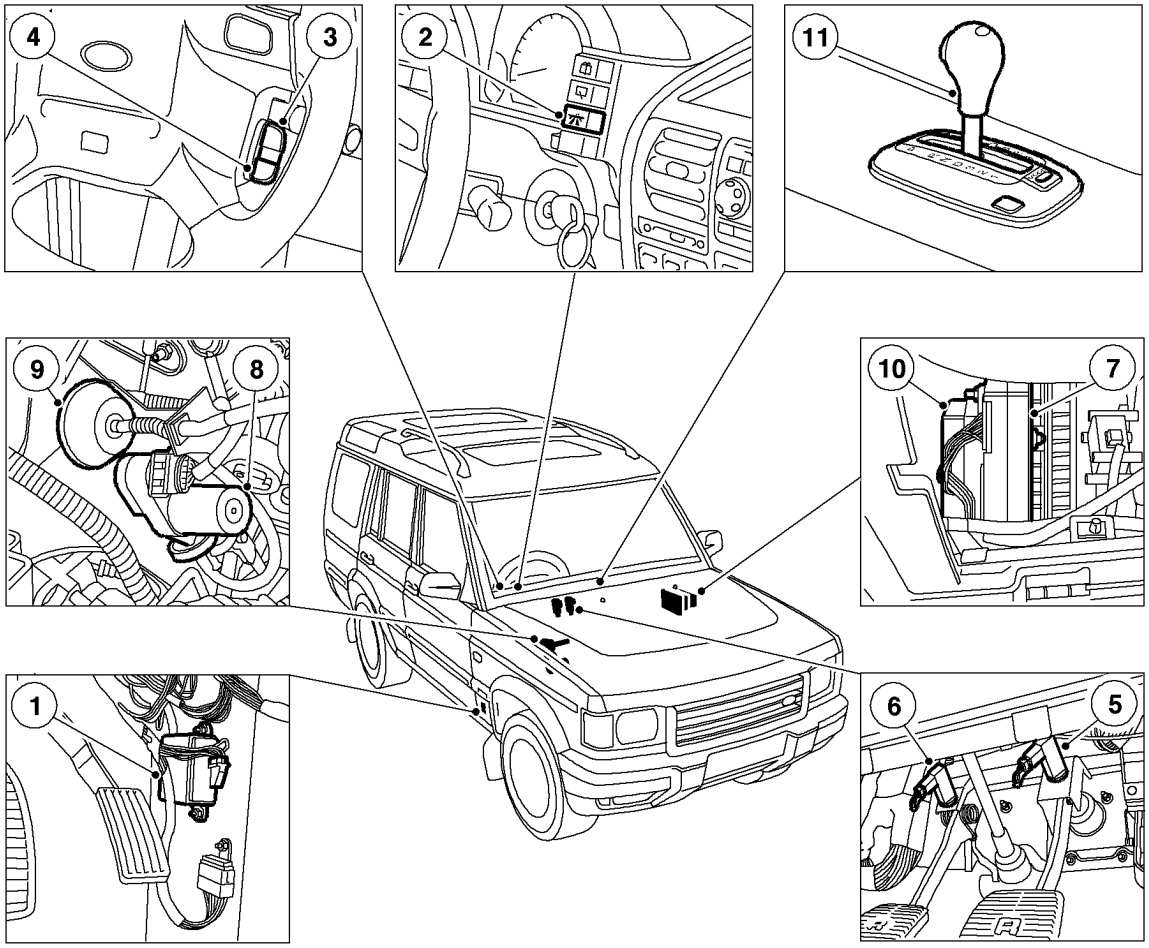
⇒ Drive cycle D:

1. Switch ignition on for 30 seconds.
2. Ensure engine coolant temperature is less than 35°C (95°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform 2 light accelerations (0 to 35 mph (0 to 60 km/h) with light pedal pressure).
5. Perform 2 medium accelerations (0 to 45 mph (0 to 70 km/h) with moderate pedal pressure).
6. Perform 2 hard accelerations (0 to 55 mph (0 to 90 km/h) with heavy pedal pressure).
7. Cruise at 60 mph (100 km/h) for 5 minutes.
8. Cruise at 50 mph (80 km/h) for 5 minutes.
9. Cruise at 35 mph (60 km/h) for 5 minutes.
10. Allow engine to idle for 2 minutes.
11. Connect TestBook and check for fault codes.

⇒ Drive cycle E:

1. Ensure fuel tank is at least a quarter full.
2. Carry out Drive Cycle A.
3. Switch off ignition.
4. Leave vehicle undisturbed for 20 minutes.
5. Switch on ignition.
6. Connect TestBook and check for fault codes.

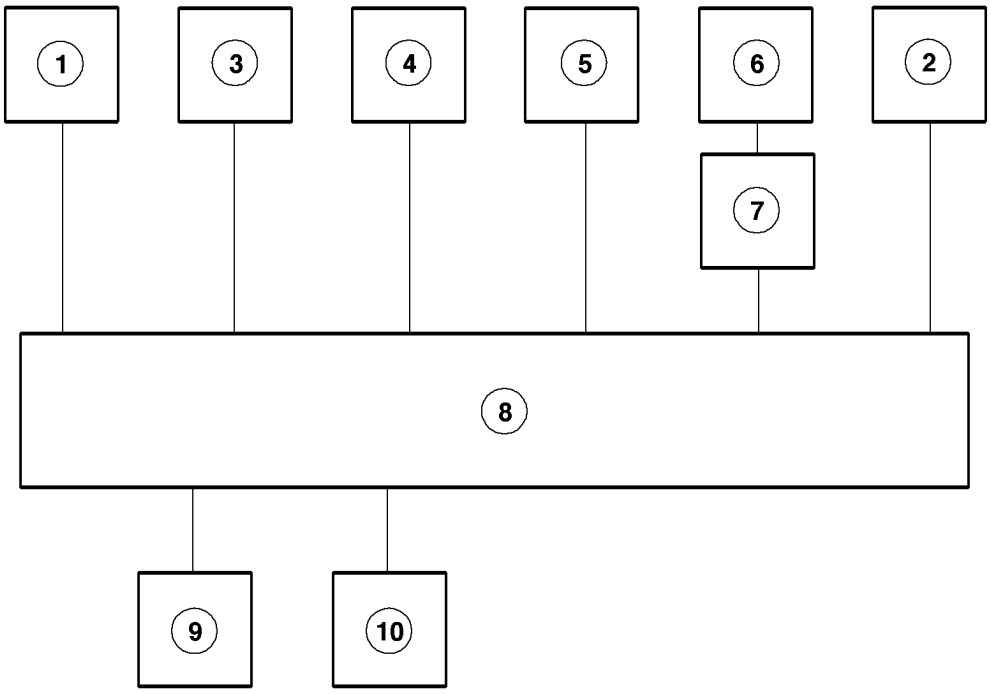
Cruise control component layout



M192556

1 Cruise control ECU
2 Cruise control master switch
3 SET+ switch
4 RES switch
5 Brake pedal switch
6 Clutch pedal switch
7 BCU
8 Vacuum pump assembly
9 Pneumatic actuator
10 SLABS ECU
11 Automatic gear selector lever

Cruise control block diagram



M192623

1 SLABS ECU
2 BCU
3 Cruise control master switch
4 SET+ switch
5 RES switch
6 Brake pedal switch
7 Clutch pedal switch
8 Cruise control ECU
9 Vacuum pump assembly incorporating pneumatic actuator
10 Automatic gear selector lever

Description - cruise control

General

All markets have a common cruise control system. The cruise control system, when activated, regulates vehicle speed. The system consists of an electrical sub-system and a mechanical sub-system.

The electrical sub-system consists of the following components:

- Cruise control master switch (on/off switch).
- SET+ switch.
- RES switch.
- Cruise control ECU.
- Vacuum pump assembly.
- Brake pedal switch.
- Clutch pedal switch (manual gearbox only).
- SLABS ECU (speed signal).
- BCU (brake pedal switch and automatic gearbox gear selector lever position signal).

The mechanical sub-system consists of the following components:

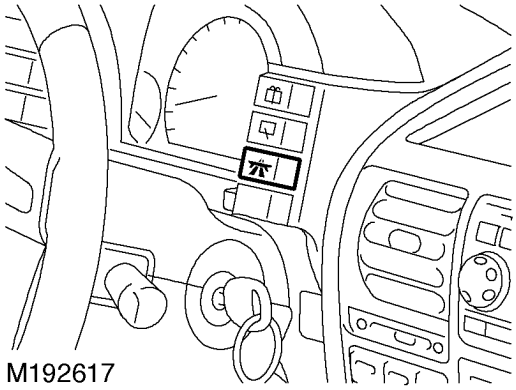
- Pneumatic actuator.
- Vacuum pump.

The cruise control ECU controls the cruise control system. It is located on the right hand A post.

The system has diagnostic capabilities through TestBook.

WARNING: To avoid the risk of losing control of the vehicle, do not use cruise control on winding, snow covered or slippery roads, or in traffic conditions where a constant speed cannot be safely maintained. In these conditions and at any time the system is not being used, ensure the cruise control switch is OFF.

Cruise control master switch



M192617

The cruise control master switch switches the system on and off. When the cruise control master switch is on, an LED within the switch illuminates. If the cruise control master switch is off, cruise control will not operate. The switch provides a 12 Volt feed to the cruise control ECU.

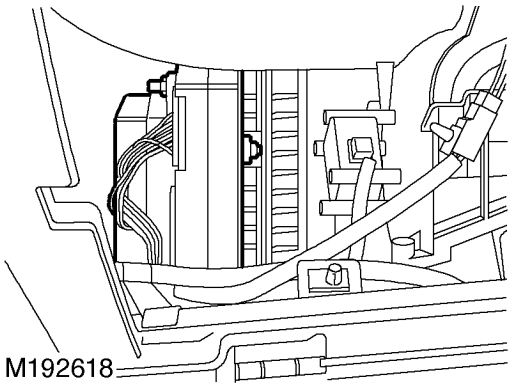
The cruise control master switch is located on the instrument panel near the steering column.

Input/Output

The input from the cruise control master switch to the cruise control ECU is either a 12 Volts ignition feed or an open circuit. 12 Volts indicates that the cruise control master switch is on and the system can be activated. An open circuit indicates that the cruise control master switch is off and cruise control cannot be activated.

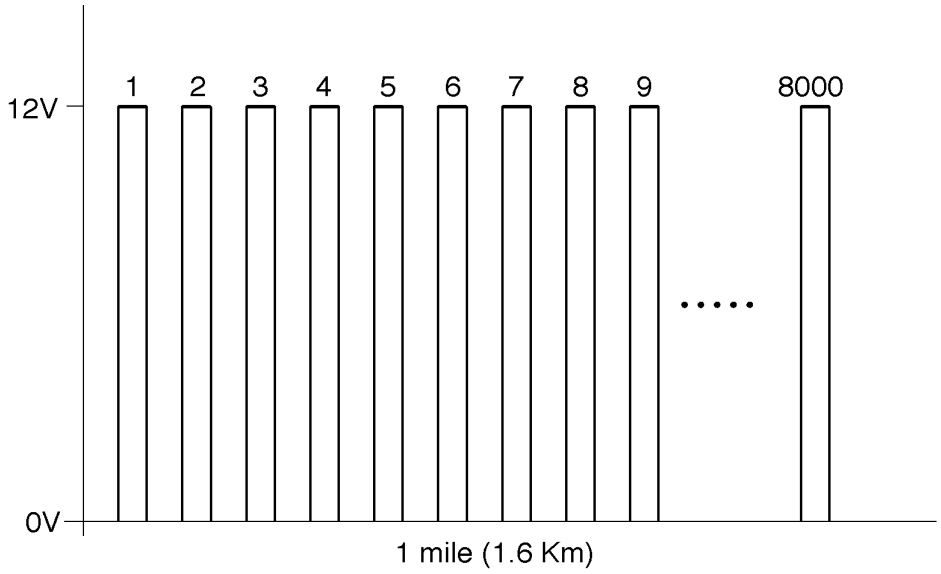
TestBook will not communicate with the cruise control ECU if the cruise control master switch is off.

SLABS ECU



The SLABS ECU provides the road speed signal to the cruise control ECU. This is the same speed signal provided to the ECM. Cruise control will only operate between 28 - 125 mph (45 - 200 km/h). Cruise control will not operate if a road speed signal is not present.

Input/Output



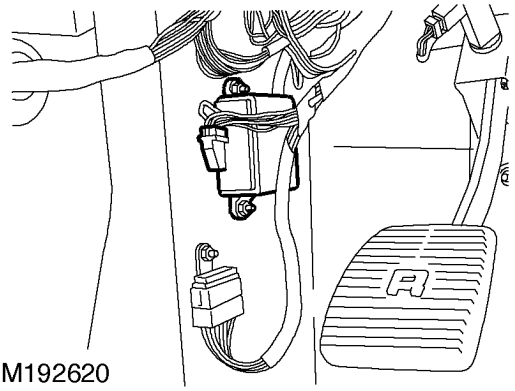
M192557

The input from the SLABS ECU to the cruise control ECU is a square wave oscillating between 0 - 12 Volts at a frequency of 8,000 pulses per mile (1.6 km).

ECU operating parameters (connector connected and cruise control master switch on)

Pin No.	Condition	Volts	Ohms
15	Road wheels stopped	0	
15	Road wheels turning	0 - 12 Volts with a frequency of 8,000 pulses per mile 1.6 km)	

Cruise control ECU



The cruise control ECU controls the cruise control system.

Most functions of the cruise control ECU are described under other components.

Input/Output

The diagnostic line for the cruise control system is between cruise control ECU and diagnostic socket.

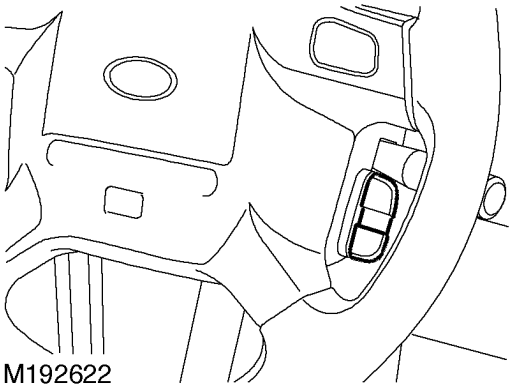
The cruise control ECU does not generate fault codes however the following system information is available via TestBook:

- Last switch off reason, which was due to unacceptable speed input.
- Speed signal detected.
- Below minimum speed threshold.
- Current vehicle speed.
- Recorded SET road speed.

ECU operating parameters (connector connected)

Pin No.	Condition	Volts	Ohms
18	All conditions		Less than 0.5 to earth

SET+/RES switches



The cruise control system uses two steering wheel switches labelled SET+ and RES.

The SET+ switch performs the set speed, tap up and accelerator functions. The RES switch performs the resume and suspend functions.

With the cruise control master switch on and the vehicle in the cruise control operating speed range, one press of the SET+ switch stores a speed value in the cruise control ECU. If the switch is pressed and held while the vehicle is under cruise control operation, speed increases until the switch is released. At this point the cruise control ECU stores the new speed value. If the switch is tapped (held down for less than 0.5 second) the cruise control ECU increases vehicle speed by 1 mph (1.5 km/h).

If the RES switch is pressed while the systems is inactive (no stored values) the system will not respond. If there is a stored value in the cruise control ECU memory and the switch is pressed, the cruise control system operates and holds the vehicle at the stored road speed. If the cruise control system is active and the RES switch is depressed, the cruise control ECU deactivates cruise operation but maintains the current set speed value.

Input/Output

The input from the SET+ switch to the cruise control ECU is either 12 Volts or an open circuit.

The input from the RES switch to the cruise control ECU is either 12 Volts or an open circuit.

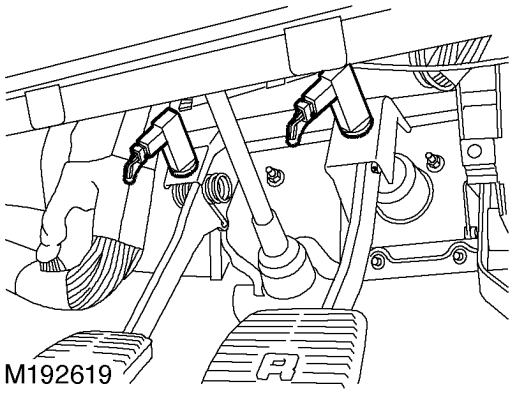
The following diagnostic information is available through TestBook:

- The state of operator switch SET+.
- The state of operator switch RES.

ECU operating parameters (connector connected)

Pin No.	Condition	Volts	Ohms
4	Ignition in position II, SET+ switch released		More than 10,000
4	Ignition in position II, SET+ switch pressed	12	
2	Ignition in position II, RES switch released		More than 10,000
2	Ignition in position II, RES switch pressed	12	

Brake pedal switch



The cruise control ECU has two inputs from the brake pedal switch that determine the position of the brake pedal. One input comes through the BCU and is low when the brake pedal is not pressed. The second input comes directly from the brake pedal switch. This input is high when the brake pedal is not pressed. On vehicles with a manual gearbox, the input from the clutch pedal switch to the cruise control ECU is connected in series with the direct signal from the brake pedal switch.

If the cruise control ECU receives a changed signal from either source, it deactivates cruise control, removing power to the vacuum pump and activating the vacuum control valve releasing all vacuum in the system.

The brake pedal switch also provides the signal to illuminate the brake lamps and the brake input to the SLABS ECU.

Input/Output

With the brake pedal and the clutch pedal in the rest position, the cruise control ECU receives 12 Volts.

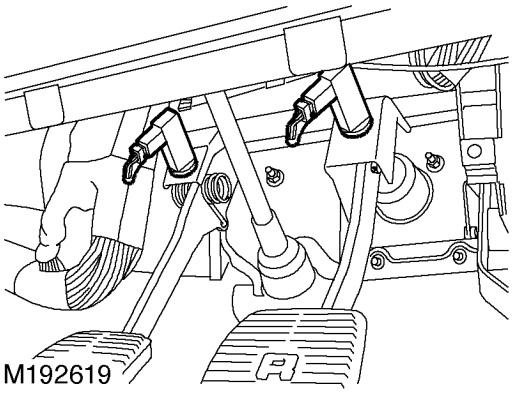
With the brake pedal pressed, the cruise control ECU receives 0 Volts and a low voltage logic signal from the BCU.

NOTE: If the clutch pedal is pressed, 0 Volts are present at the cruise control ECU irrespective of brake pedal position.

ECU operating parameters (connector connected)

Pin No.	Condition	Volts	Ohms
1	Ignition in position II, brake pedal released, clutch pedal released	12	
1	Ignition in position II, brake pedal pressed, clutch pedal released		More than 10,000
1	Ignition in position II, brake pedal released, clutch pedal pressed		More than 10,000

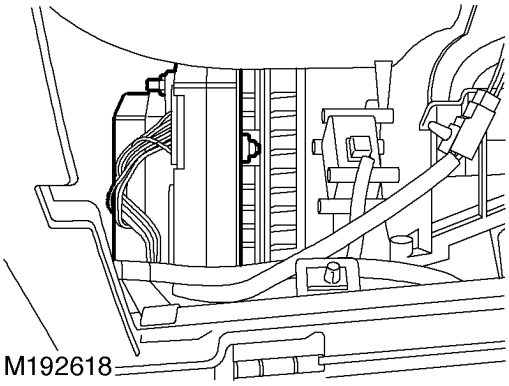
Clutch pedal switch



The clutch pedal switch is a single pole normally closed switch. It is part of the 12 Volt brake pedal switch circuit to the cruise control ECU. When the clutch pedal is pressed, the cruise control ECU deactivates the cruise control system and releases system vacuum. The last set speed is retained in the cruise control ECU.

Input/Output
The cruise control ECU receives a 12 Volt signal through the normally closed contacts of the brake pedal switch and the normally closed clutch pedal switch.

Body control unit

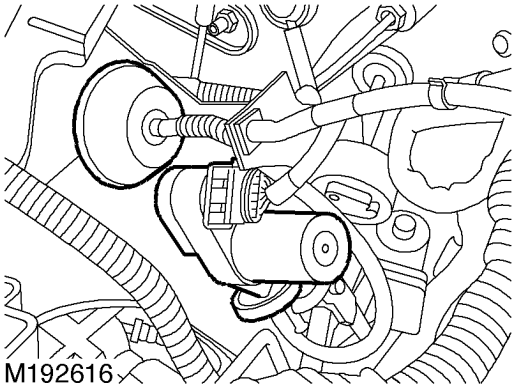


On manual gearbox vehicles, the BCU provides cruise control lockout or suspend function as described under brake pedal switch.

On vehicles with automatic gearbox, the BCU monitors the status of the brake pedal switch as well as the status of the automatic gearbox gear selector lever. The BCU monitors the gear selector lever to determine which gearbox position the driver has selected. If the BCU detects that the driver has selected park, reverse or neutral, it sends a signal to the cruise control ECU which inhibits cruise operation or deactivates cruise control if it is activated.

Input/Output
If the BCU receives a brake pedal switch signal or an automatic gearbox gear selector lever position signal, the BCU sends a HIGH signal to the cruise control ECU. The cruise control ECU cancels or inhibits cruise control functions.

Vacuum pump assembly



The vacuum pump assembly contains three components:

- The vacuum pump.
- The vacuum control valve.
- The vacuum dump valve.

The vacuum pump provides the vacuum for the system while the two valves work in conjunction to allow the pump to increase the vacuum to the pneumatic actuator (increase vehicle speed) or release vacuum from the pneumatic actuator (decrease vehicle speed). On vehicles from 03 model year, the cruise control vacuum pump and pneumatic actuator assembly is fitted with a heat shield to protect the components from heat from the exhaust manifold.

The vacuum control valve opens to allow the vacuum pump to increase the vacuum in the pneumatic actuator to increase vehicle speed. When the vehicle reaches the set speed, the vacuum pump control valve closes to hold vacuum in the pneumatic actuator and the vacuum pump is turned off by the cruise control ECU.

The vacuum dump valve is normally open. When cruise control is active, the cruise control ECU provides voltage to close the vacuum dump valve. If power is lost, (e.g. when the brakes or clutch are applied or cruise control is turned off at the cruise control master switch) the vacuum dump valve will immediately open and cruise control will be deactivated.

The cruise control ECU provides power for all three components within the vacuum pump assembly. The cruise control ECU provides earth control circuits for the vacuum pump and the vacuum control valve. The vacuum dump valve is permanently grounded.

Input/Output

The cruise control ECU provides both power and earth to the components within the vacuum pump assembly. Current draw at the vacuum pump assembly varies depending on components operating.

Vacuum pump current draw

Component	State of components			
Vacuum dump valve	Off	On	On	On
Vacuum control valve	Off	Off	On	On
Vacuum pump	Off	Off	Off	On
Current draw, amperes	0	0.23	0.37	2.14

When cruise is requested, the cruise control ECU provides voltage to the vacuum pump assembly and provides a pulsed earth signal. The pulse period is dependent on the difference between the vehicle set speed and the actual road speed. Removing the earth path switches off the pump.

Several fault codes can be generated:

Fault codes

1. "Output power LOW when HIGH is expected" is flagged when Pin C0239-11 is shorted to earth.

   This could be due to an external fault or an internal ECU fault and will be set if pin C0239-11 is LOW for longer than 240 milliseconds, while in cruise mode.
2. "Output power HIGH when LOW is expected" is flagged when Pin C0239-11 is shorted to battery voltage.

   This could be due to an external fault or internal ECU fault and will be set if pin C0239-11 is HIGH for longer than 250 milliseconds while not in cruise mode.
3. "Output pump LOW, when High is expected" is flagged when Pin C0239-7 is shorted to earth.

   This could be due to an external fault or an internal ECU fault. This fault will be set if pin C0239-11 is HIGH for longer than 7.5 milliseconds while pin C0239-7 is LOW for longer than 2.5 milliseconds while decelerating under control of cruise.
4. "Output pump HIGH, when LOW is expected" is flagged when Pin C0239-7 is shorted to battery voltage.

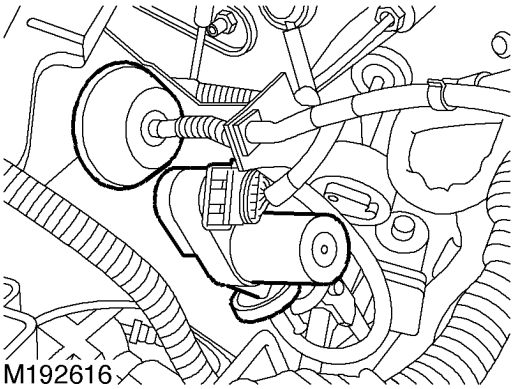
   This could be due to an external fault or an internal ECU fault. This fault will be set if pin C0239-7 is LOW for longer than 7.5 milliseconds of the last 8 pulses when the pump is switched on while accelerating under the control of cruise.
5. Output valve LOW, when HIGH is expected is flagged when Pin C0239-7 is shorted to battery voltage.

   This could be due to an external fault or an internal ECU fault and will be set if pin C0239-17 is LOW for longer than 2.5 milliseconds while pin C0239-7 is HIGH for longer than 2.5 milliseconds and pin C0239-11 is also HIGH for longer than 7.5 milliseconds, while decelerating under control of the cruise control ECU.
6. Output valve HIGH, when LOW is expected is flagged when Pin C0239-17 is shorted to battery voltage.

   This could be an external fault or an internal ECU fault. The fault will be set if pin C0239-17 remains HIGH for longer than 35 milliseconds after the vacuum control valve is switched on, while accelerating under control of the cruise control ECU.

TestBook can be used to determine the fault codes present as well as the general status of the system.

Pneumatic actuator



The cruise control ECU controls the position of the throttle disc by regulating the amount of vacuum applied by the vacuum pump to the pneumatic actuator. The pneumatic actuator is an air tight bellow coupled to the pneumatic pump via a vacuum pipe. The pump evacuates the air inside the bellow and pipe, which collapses the bellow. This pulls on a cable, which moves the throttle disc to the desired position. On vehicles from 03 model year, the cruise control vacuum pump and pneumatic actuator assembly is fitted with a heat shield to protect the components from heat from the exhaust manifold.

Operation - cruise control

Cruise control activation
Cruise control is a passive system. The driver must activate it. Switching on the cruise control master switch located on the instrument panel activates cruise control. An LED in the switch illuminates, indicating cruise control is available. The driver must accelerate the vehicle to the desired speed using the accelerator pedal. When the desired speed is reached, pressing the SET+ switch activates cruise control. Cruise control will only activate if the following conditions are met:

- Vehicle speed is between 28 - 125 mph (45 - 200 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual gearbox only).
- The gearbox is not in park, reverse or neutral (automatic gearbox only).

Function
The cruise control ECU receives the set signal and determines the vehicle speed provided by the SLABS ECU. The cruise control ECU activates the vacuum pump assembly to move the pneumatic actuator and the linkage to the throttle disc to maintain set road speed. It does this by controlling the vacuum to the pneumatic actuator.

Cruise control cancellation
Cancelling cruise control enables the driver to regain control of the vehicle speed by using the accelerator pedal. Cruise control is cancelled if any of the following conditions occur:

- The brake pedal is pressed.
- The RES switch button is pressed.
- The clutch pedal is pressed (manual gearbox only).
- The cruise control master switch is turned off.
- The gearbox is placed in park, neutral, or reverse (automatic gearbox only).

Function
The cruise control ECU cancels cruise control operation by opening a vacuum control valve in the vacuum pump assembly. This releases the throttle linkage from the control of the pneumatic actuator and returns it to the control of the accelerator pedal.

The set speed will be stored in the cruise control ECU unless:

- The cruise control master switch is turned off.
- The ignition switch is turned off.

If cruise control is deactivated using either of the above methods, the set speed will be erased from the memory of the cruise control ECU.

Cruise control resume
Cruise control can be resumed at the previously set speed, provided the set speed has not been erased from the cruise control ECU memory as described above. To resume cruise control operation to the previously set speed, depress the RES switch once when the following conditions are met:

- A set speed is stored in the cruise control ECU.
- Vehicle speed is between 28 - 125 mph (45 - 200 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual gearbox only).
- The gearbox is not in park, reverse or neutral (automatic gearbox only).

Function

The cruise control ECU activates the vacuum pump assembly to move the pneumatic actuator. This moves the throttle to the set speed by adjusting the position of the throttle disc.

Accelerating while cruise control is active

There are three ways of increasing vehicle speed when cruise control is active:

- Temporarily increase vehicle speed (e.g. when overtaking another vehicle).
- Increase vehicle set speed in 1 mph (1.5 km/h) increments.
- Increase vehicle set speed.

To temporarily increase vehicle speed press the accelerator pedal until the desired speed is reached. When the accelerator pedal is released, the vehicle coasts back to the set speed. When it reaches the set speed, cruise control operation continues.

To increase the vehicle set speed in 1 mph (1.5 km/h) increments, tap the SET+ switch. Each tap on the switch increases vehicle speed.

To increase the vehicle set speed, press and hold the SET+ switch until the desired set speed is reached.

The vehicle set speed will increase if the following conditions are met:

- The vehicle is under cruise control operation.
- Vehicle speed is between 28 - 125 mph (45 - 200 km/h).
- The brake pedal is not pressed.
- The clutch pedal is not pressed (manual gearbox only).
- The gearbox is not in park, reverse or neutral (automatic gearbox only).

Function

The vehicle responds as follows:

- If the driver accelerates using the accelerator pedal, vehicle speed increases overriding pneumatic actuator position. When the driver releases the accelerator pedal, the vehicle returns to the set speed.
- If the SET+ switch is tapped, the driver increases the stored speed and vehicle speed by 1 mph (1.5 km/h) per tap on the switch.
- If the driver presses and holds the SET+ switch, the vehicle speed increases until the SET+ switch is released. This becomes the new set speed for the cruise control ECU.

Switching off cruise control

Switching off cruise control allows the driver to regain control of vehicle speed. It erases the set road speed from the cruise control ECU memory.

To switch off cruise control, press the cruise control master switch to the off position.

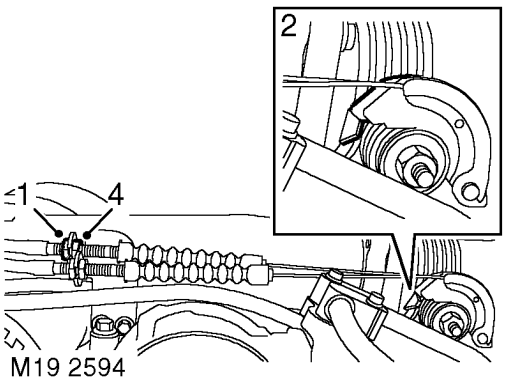
Function

When the cruise control master switch is turned off, the cruise control ECU switches off power to the vacuum pump assembly. The vacuum dump valve opens releasing the vacuum in the pneumatic actuator, returning the throttle disc to driver control via the accelerator pedal.

Cable - throttle

19.20.05

Adjust



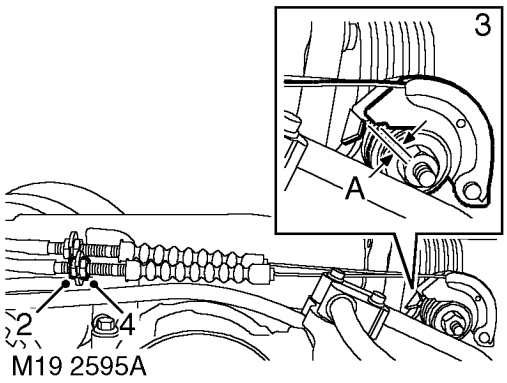
1. Loosen outer cable locknuts.
2. Adjust the rear locknut until it is in contact with the back of the abutment bracket and the throttle lever is in contact with the inner driven lever.
3. Ensure that the driven lever remains in contact with the throttle stop screw, (throttle closed).
4. Tighten cable front nut to lock cable to abutment bracket.

Cable - cruise control

19.75.11

Adjust

1. Ensure that the throttle cable is correctly adjusted.
   ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - throttle.

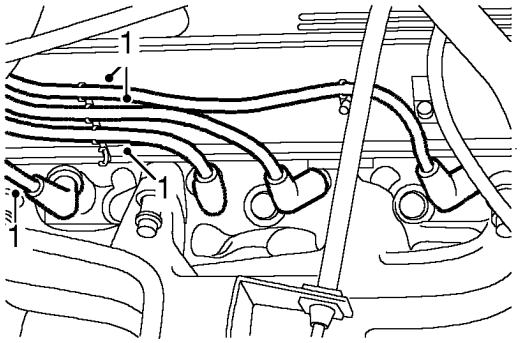


2. Loosen outer cable locknuts.
3. Adjust the rear locknut to obtain a 0.5 to 1.5 mm (0.019 to 0.060 in) gap, **dimension 'A',** between the cruise control cable lever and the throttle cable driven lever.
4. Tighten cable front locknut.

Spark plugs

18.20.02

Remove



M18 0280

1. Noting their fitted position, disconnect ht leads from spark plugs.
2. Using a spark plug socket, remove 8 spark plugs.

Refit

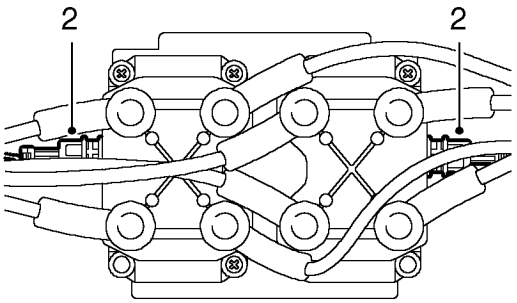
1. Fit terminals to new spark plugs.
   CAUTION: Do not attempt to adjust spark plug gaps.
2. Fit spark plugs and tighten to 25 Nm (18 lbf.ft).
3. Connect ht leads to spark plugs ensuring they are in the correct position.

Coil - ignition

18.20.45

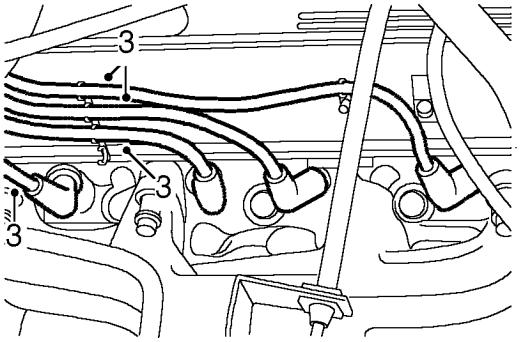
Remove

1. Remove upper inlet manifold assembly.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.



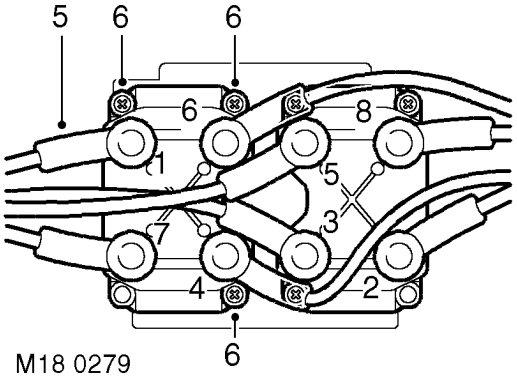
M18 0277

2. Disconnect multiplugs from ignition coils.



M18 0278

3. Release ht leads from rocker covers and disconnect ht leads from spark plugs.
4. Carefully manoeuvre ignition coil assembly from between engine and bulkhead.



M18 0279

5. Noting their fitted position disconnect ht leads from ignition coil.
6. Remove 3 screws securing ignition coil to support bracket and remove coils.

Refit

1. Position ignition coil to support bracket, fit and tighten screws.
2. Connect ht leads to ignition coil ensuring they are in the correct position.
3. Carefully position ignition coil assembly between engine and bulkhead.
4. Connect ht leads to spark plugs and secure ht leads to rocker covers.
5. Connect multiplugs to ignition coils.
6. Fit upper inlet manifold assembly.

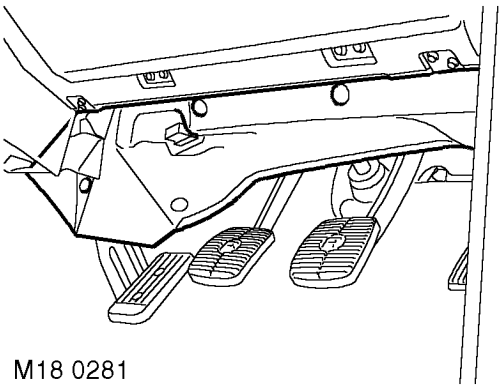
☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**

Engine control module (ECM)

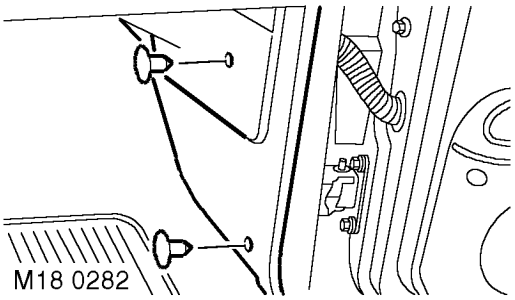
18.30.01

Remove

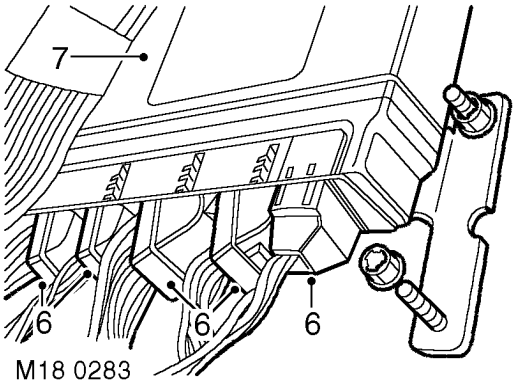
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.


M18 0281

3. Remove fixings securing fascia RH closing panel, release diagnostic socket RH drive models, and remove panel.


M18 0282

4. Remove 2 fixings and remove 'A' post lower trim.



M18 0283

5. Remove 2 nuts and release ECM from studs and location on 'A' post lower panel.
6. Lower ECM into footwell and disconnect 5 multiplugs.
7. Remove ECM.

Refit

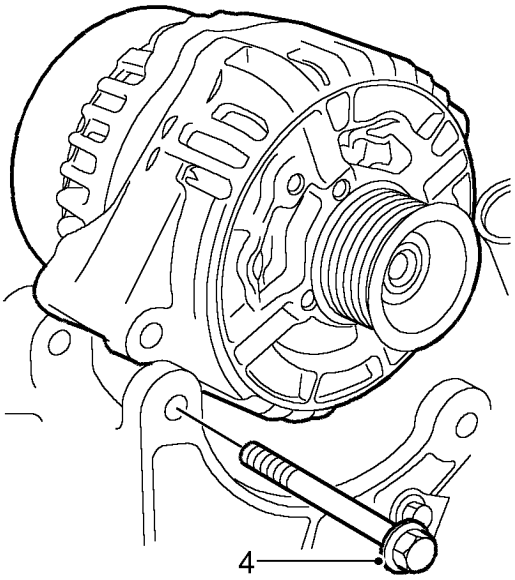
1. Position new ECM and connect multiplugs.
2. Fit ECM and secure with nuts.
3. Fit lower trim panel to 'A' post and secure with fixings.
4. Fit diagnostic socket to closing panel, fit closing panel and secure with fixings.
5. Connect battery earth lead.
6. Fit battery cover and secure with fixings.
7. Programme ECM and reset adaptions using TestBook.

Sensor - engine coolant temperature (ECT)

18.30.10

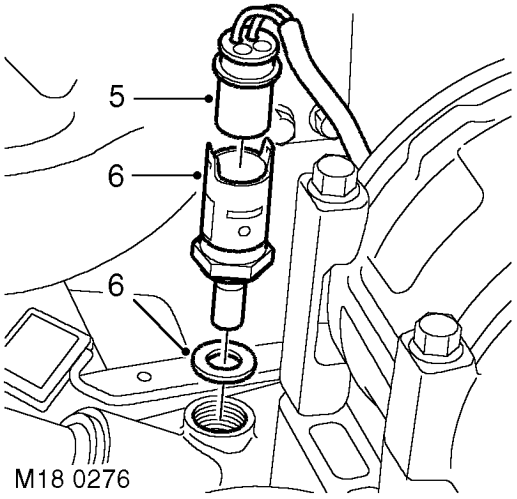
Remove

1. Release turnbuckles and remove battery cover.
2. Disconnect battery earth lead.
3. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



M18 0275

4. Remove 2 bolts securing alternator, release alternator from support bracket and position aside.



M18 0276

5. Disconnect multiplug from ECT sensor.
6. Remove sensor from inlet manifold and discard sealing washer.

Refit

1. Clean sealant from threads in manifold.
2. Apply Loctite 577 to sensor threads.
3. Fit new sealing washer to ECT sensor and tighten sensor to 10 Nm (7 lbf.ft).
4. Connect multiplug to ECT sensor.
5. Position alternator, fit bolts and tighten to 45 Nm (33 lbf.ft).
6. Fit auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
7. Top up cooling system.
8. Connect battery earth lead.
9. Fit battery cover and secure with fixings.

Sensor - crankshaft position (CKP)

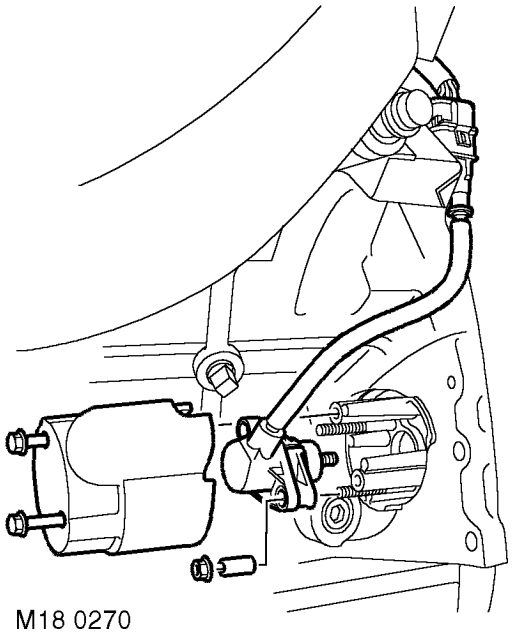
18.30.12

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Release fixings and remove underbelly panel.



M18 0270

5. Release CKP sensor multiplug from bracket.
6. Remove 2 bolts securing CKP sensor heat shield and position aside.
7. Remove 2 nuts securing CKP sensor, remove 2 spacers, CKP sensor and sensor mounting.
8. Disconnect CKP sensor multiplug from engine harness.

Refit

1. Ensure all components are clean.
2. Connect CKP sensor multiplug to engine harness.
3. Fit sensor mounting, CKP sensor, 2 spacers and tighten CKP sensor retaining nuts to 6 Nm (5 lbf.ft).

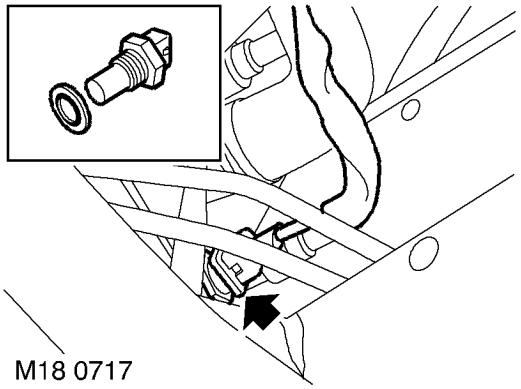
4. Fit CKP sensor heat shield and secure with bolts.
5. Fit underbelly panel and secure with fixings.
6. Remove stand(s) and lower vehicle.
7. Connect battery earth lead.
8. Fit battery cover and secure the fixings.
9. Reset adaptions using TestBook.

Sensor - radiator temperature

18.30.20

Remove

1. Disconnect battery earth lead.
2. Position container to collect coolant spillage.



3. Disconnect multiplug from sensor.
4. Remove sensor and discard sealing washer.

Refit

1. Fit new sealing washer to sensor.
2. Fit and tighten sensor.
3. Connect multiplug to sensor.
4. Refill cooling system.
5. Connect battery earth lead.

Sensor - camshaft position (CMP)

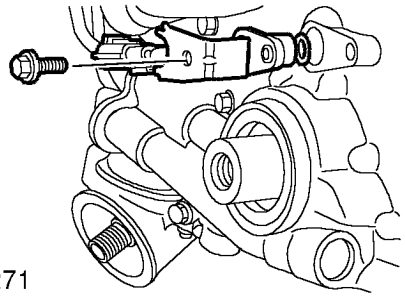
18.30.24

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Release fixings and remove underbelly panel.
5. Remove engine oil filter.
   ENGINE - V8, REPAIRS, Filter - oil.
6. Disconnect engine harness from CMP sensor and release CMP sensor multiplug from bracket.



M18 0271

7. Remove bolt from clamp securing CMP sensor to timing gear cover.
8. Remove clamp and CMP sensor. Discard 'O' ring from CMP sensor.

Refit

1. Ensure CMP sensor is clean, fit new 'O' ring and sensor to cover.
2. Fit clamp to CMP sensor and tighten bolt to 8 Nm (6 lbf.ft).
3. Fit sensor multiplug to bracket and connect engine harness to multiplug.
4. Fit engine oil filter.
   ENGINE - V8, REPAIRS, Filter - oil.
5. Fit underbelly panel and secure with fixings.
6. Lower vehicle and connect battery earth lead.
7. Fit battery cover and secure with fixings.

Knock sensor (KS)

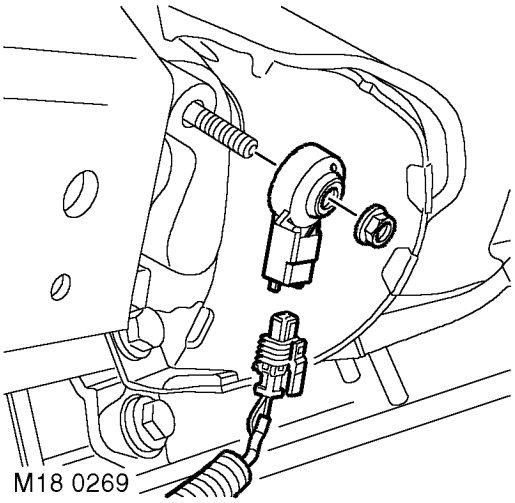
18.30.28

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Remove fixings securing underbelly panel and remove panel.



M18 0269

5. Disconnect multiplug from KS.
6. Remove nut securing KS to cylinder block and remove KS.

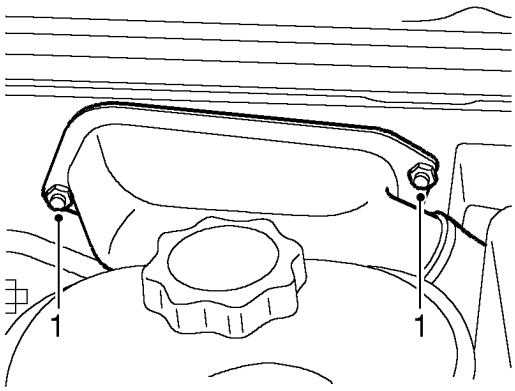
Refit

1. Clean mating faces of KS and cylinder block.
2. Fit KS to cylinder block and tighten nut to 22 Nm (16 lbf.ft).
3. Connect multiplug to KS.
4. Fit underbelly panel and secure with fixings.
5. Remove stand(s) and lower vehicle.
6. Connect battery earth lead.
7. Fit battery cover and secure the fixings.

Air cleaner assembly

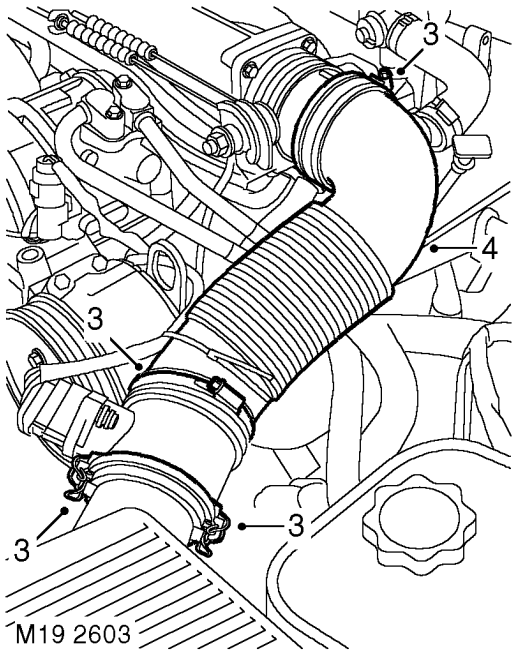
19.10.01

Remove



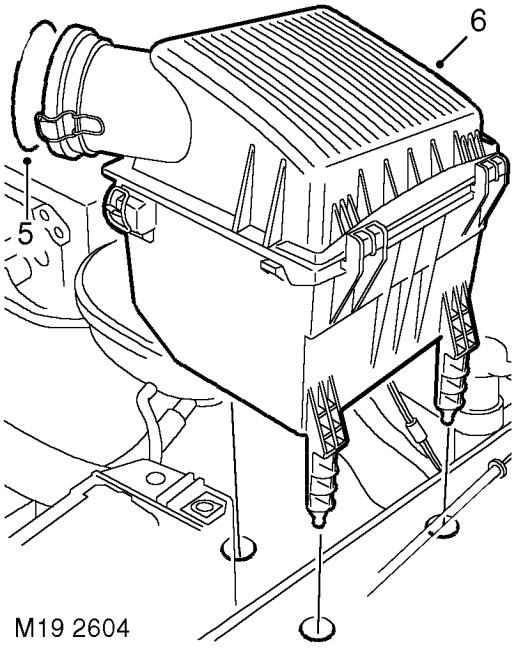
M19 2602

1. Remove 2 nuts securing air intake ducting.
2. Remove both parts of air intake ducting.



M19 2603

3. Release 2 clips securing MAF sensor, release 2 clips securing air intake hose.
   Note: Pre 03 MY air intake hose illustrated.
4. Release air intake hose and position aside.



M19 2604

5. Remove and discard MAF sensor 'O' ring.
6. Release air cleaner assembly from 3 grommets and remove assembly.

Refit

1. Position air cleaner assembly and secure in grommets.
2. Fit new 'O' ring to MAF sensor.
3. Position air intake hose, secure MAF sensor clips and tighten intake hose clips.

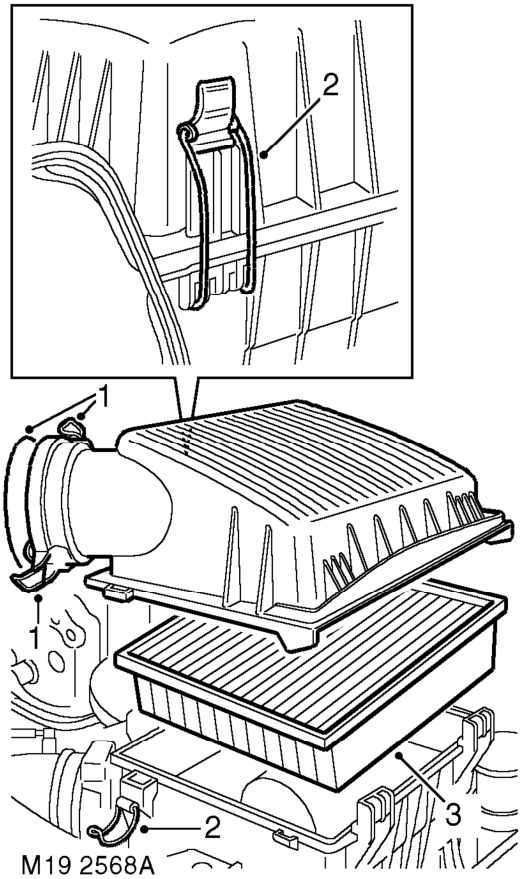
   CAUTION: Ensure MAF sensor 'O' ring is not displaced during fitting.

4. Fit air intake ducting and secure with nuts.

Element - air filter

19.10.10

Remove



1. Release 2 clips and disconnect MAF sensor from air filter cover, remove and discard 'O' ring.
2. Release 2 clips and remove cover from air filter.
3. Remove air filter element.

Refit

1. Clean air filter body and cover.
2. Fit new air filter element.
3. Position air cleaner cover and secure clips.

   CAUTION: Ensure clips are correctly located on cover.

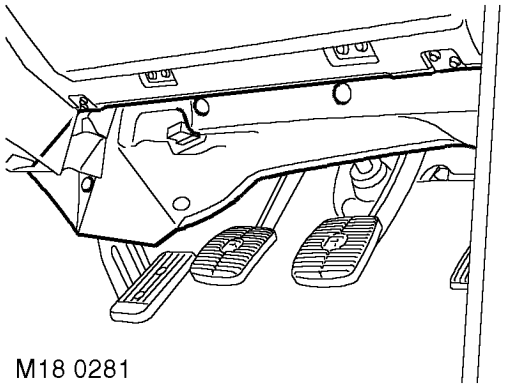
4. Fit a new MAF sensor 'O' ring, position MAF sensor and secure clips.

   CAUTION: Ensure 'O' ring is not displaced during fitting.

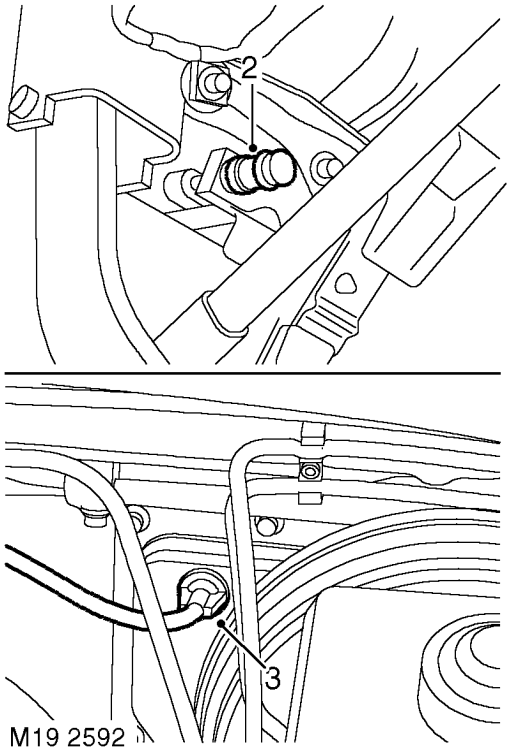
Cable - throttle

19.20.06

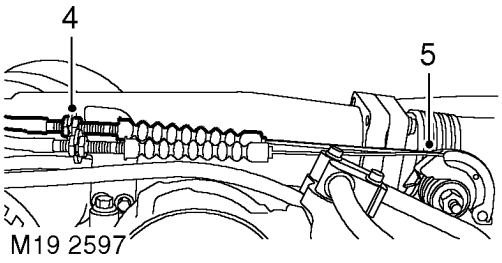
Remove



1. Release 3 fasteners and remove drivers side closing panel and move aside.



2. Release inner cable from throttle pedal.
3. Release outer cable from bulkhead.



4. Release outer cable from clip, loosen lock nuts and remove outer cable from abutment bracket.
5. Release inner cable from operating lever and remove cable.

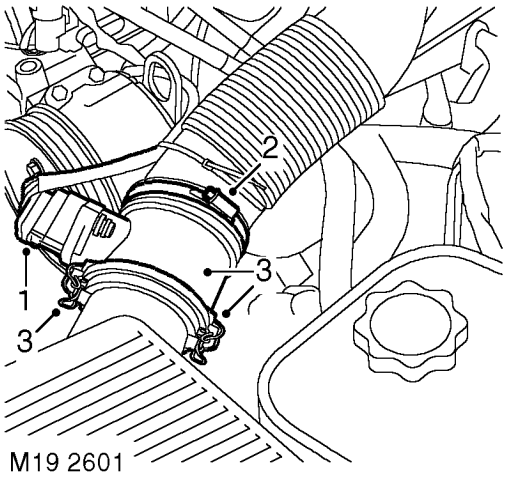
Refit

1. Position cable, secure to bulkhead and connect inner cable to throttle pedal.
2. Position inner cable to operating lever and connect outer cable to abutment bracket and retaining clip.
3. Position closing panel and secure fasteners.
4. Adjust throttle cable.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - throttle.**

Sensor - Mass Air Flow (MAF)

19.22.25

Remove



1. Disconnect multiplug from MAF sensor.
2. Loosen clip and release air intake hose from MAF sensor.
   Note: Pre 03 MY air intake hose illustrated.
3. Release 2 clips and remove MAF sensor from air cleaner, remove and discard 'O' ring.

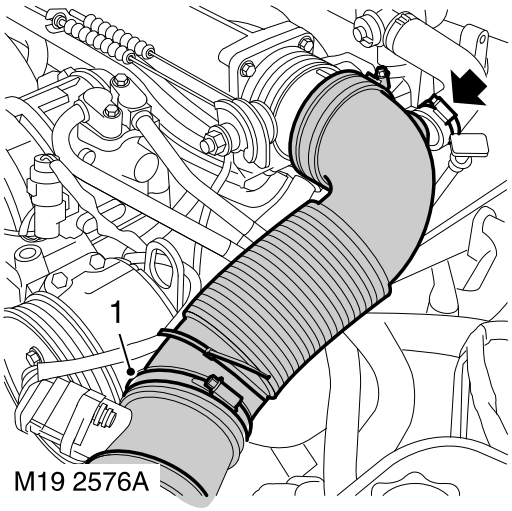
Refit

1. Fit new MAF sensor 'O' ring, position MAF sensor to air cleaner and secure with clips.
   CAUTION: Ensure 'O' ring is not displaced during fitting.
2. Position air intake hose to MAF sensor and secure with clip.
3. Connect multiplug to MAF sensor.

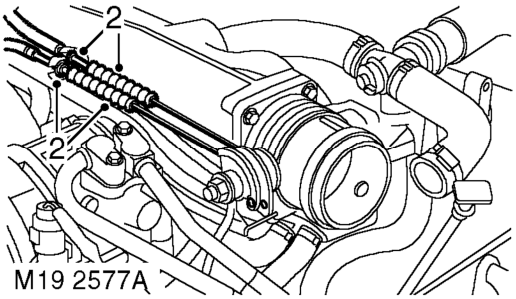
Throttle Body

19.22.45

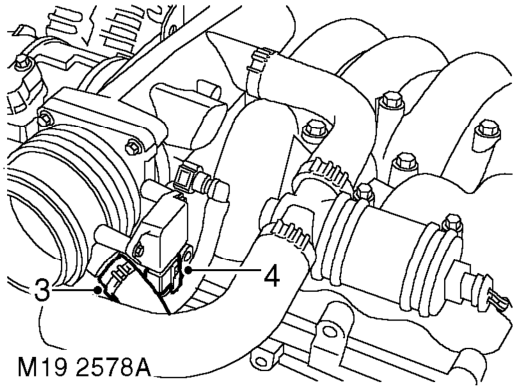
Remove



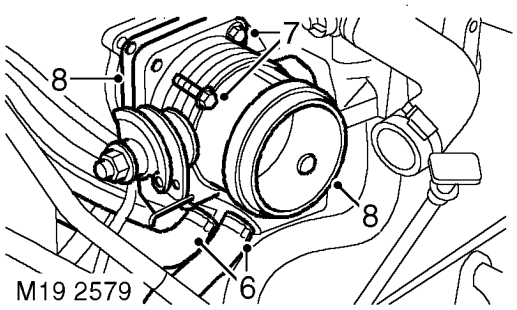
1. Loosen 3 clips securing air intake hose, release air intake hose and position aside.
   Note: Pre 03 MY air intake hose illustrated.



2. Disconnect throttle and cruise control cables from throttle body.



3. Loosen clip securing breather hose and release hose.
4. Disconnect multiplug from throttle body.
5. Position a container below the throttle body to collect coolant spillage.



6. Loosen 2 clips securing coolant hoses to throttle body and release hoses.
7. Remove 4 bolts securing throttle body to plenum chamber.
8. Remove throttle body and discard gasket.

Refit

1. Clean plenum chamber and throttle body mating faces.
2. Using a new gasket, position throttle body, fit bolts and tighten to 9 Nm (7 lbf.ft).
3. Connect coolant hoses to throttle body and secure clips.
4. Connect breather hose to throttle body and secure clip.

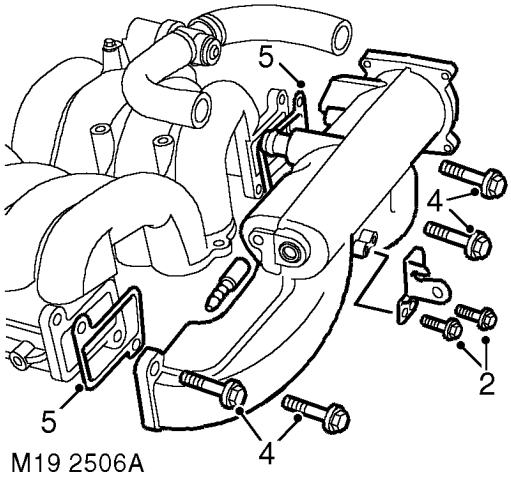
5. Connect multiplug to throttle body.
6. Connect throttle and cruise control cables.
   - ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - cruise control.**
   - ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - throttle.**
7. Position air intake hose and secure clips.
8. Top-up cooling system.

Plenum chamber

19.22.46

Remove

1. Remove upper manifold gasket.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**



M19 2506A

2. Remove 2 bolts securing throttle cable abutment bracket and remove bracket.
3. Remove breather hose adaptor.
4. Remove 4 bolts securing plenum chamber to upper manifold and remove plenum chamber.
5. Collect plenum chamber gaskets.

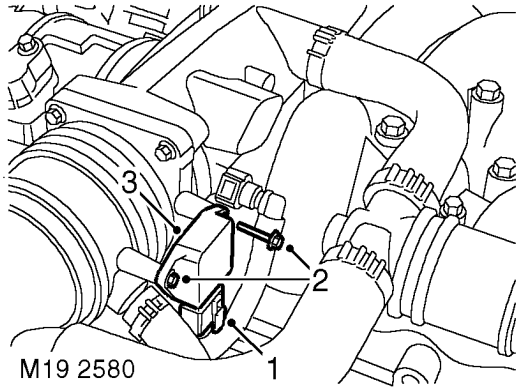
Refit

1. Clean plenum chamber and upper manifold mating faces.
2. Using new gaskets, position plenum chamber fit bolts and tighten to 22 Nm (16 lbf.ft).
3. Fit breather adaptor and tighten to 6 Nm (4.4 lbf.ft).
4. Position throttle cable abutment bracket, fit bolts and tighten to 9 Nm (7 lbf.ft).
5. Fit upper manifold gasket.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**

Sensor - throttle position (TP)

19.22.49

Remove



1. Disconnect multiplug from TP sensor.
2. Remove 2 screws securing TP sensor to throttle body.
3. Remove TP sensor and discard 'O' ring.

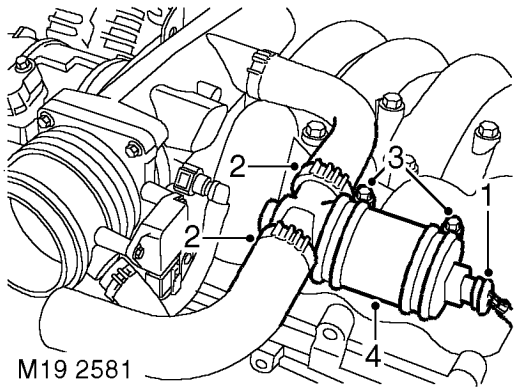
Refit

1. Clean TP sensor and throttle body mating faces.
2. Using a new 'O' ring, position TP sensor. Fit screws and tighten to 2.2 Nm (1.6 lbf.ft).
3. Connect multiplug to TP sensor.

Valve - idle air control (IACV)

19.22.54

Remove



1. Disconnect multiplug from IACV.
2. Loosen 2 clips securing air hoses and release hoses.
3. Remove 2 screws securing IACV to inlet manifold.
4. Collect clamps and remove IACV.

Refit

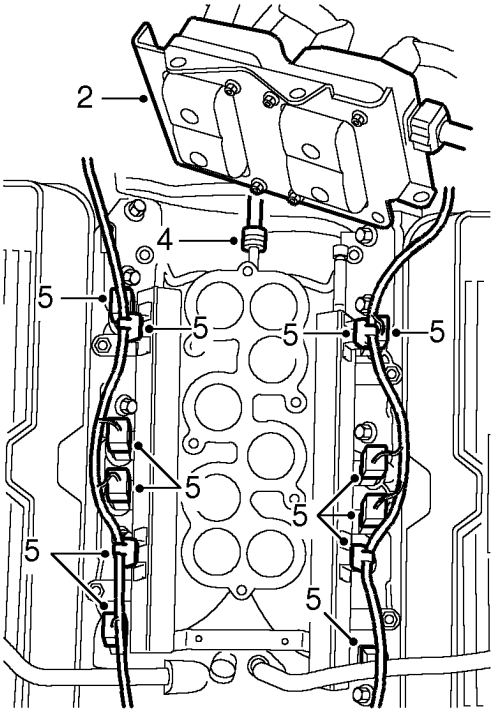
1. Position IACV to inlet manifold, locate clamps, fit screws and tighten to 8 Nm (6 lbf.ft).
2. Position air hoses to IACV and secure clips.
3. Connect multiplug to IACV.

Injectors

19.60.12

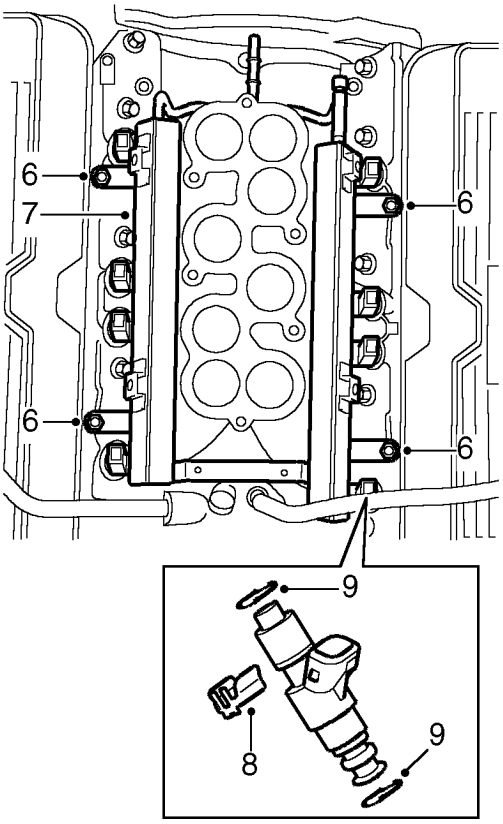
Remove

1. Remove upper manifold.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.



M19 2559

2. Carefully manoeuvre ignition coil assembly from between inlet manifold and bulkhead.
3. Position absorbent cloth beneath fuel pipe to catch spillage.
4. Disconnect fuel feed hose from fuel rail
   CAUTION: Always fit plugs to open connections to prevent contamination.
5. Release injector harness from fuel rail and disconnect injector multiplugs.



M19 2560

6. Remove 4 bolts securing fuel rail to inlet manifold.
7. Release injectors from inlet manifold and remove fuel rail and injectors.
8. Release spring clips securing injectors to fuel rail and remove fuel injectors.
9. Remove and discard 2 'O' rings from each injector.
10. Fit protective caps to each end of injectors.

Refit

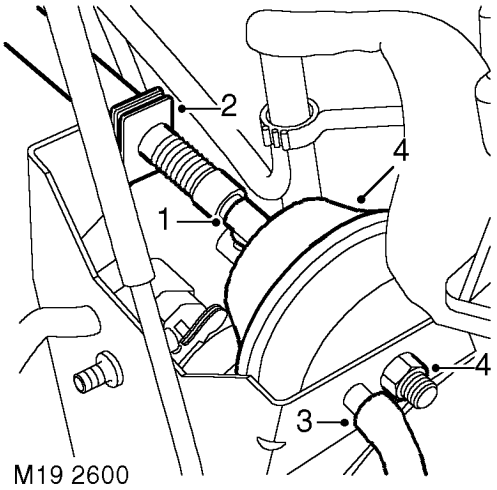
1. Clean injectors and recesses in fuel rail and inlet manifold.
2. Lubricate new 'O' rings with silicone grease and fit to each end of injectors.
3. Fit injectors to fuel rail and secure with spring clips.
4. Position fuel rail assembly and push-fit each injector into inlet manifold.

5. Fit bolts securing fuel rail to inlet manifold and tighten to 9 Nm (7 lbf.ft).
6. Connect fuel feed hose to fuel rail.
7. Connect injector harness multiplugs and secure to fuel rail.
8. Carefully position ignition coil assembly between inlet manifold and bulkhead.
9. Fit upper manifold.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**

Actuator - cruise control

⊸ ***19.75.05***

Remove



M19 2600

1. Release clip and disconnect inner cable from actuator.
2. Release outer cable from actuator mounting bracket.
3. Release vacuum hose from actuator.
4. Remove nut, and remove actuator from mounting bracket.

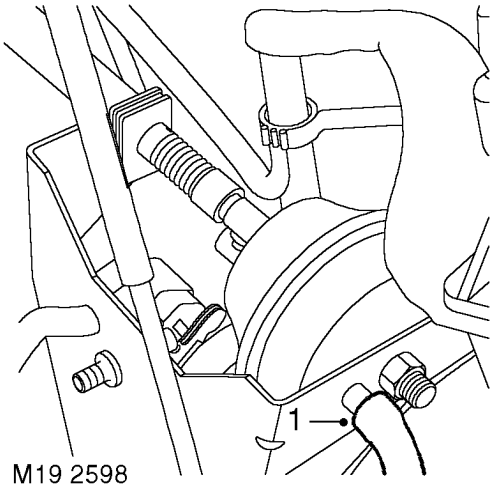
Refit

1. Position actuator and tighten retaining nut.
2. Connect vacuum hose to actuator.
3. Connect outer cable to mounting bracket.
4. Connect inner cable to actuator.

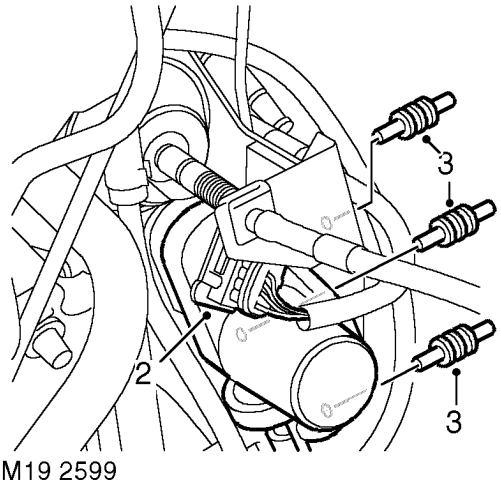
Vacuum control unit - up to 03MY

19.75.06

Remove



1. Disconnect vacuum hose from actuator.



2. Disconnect multiplug from vacuum control unit.
3. Release 3 rubber mountings securing control unit, and remove from mounting bracket.
4. Remove vacuum hose from control unit.

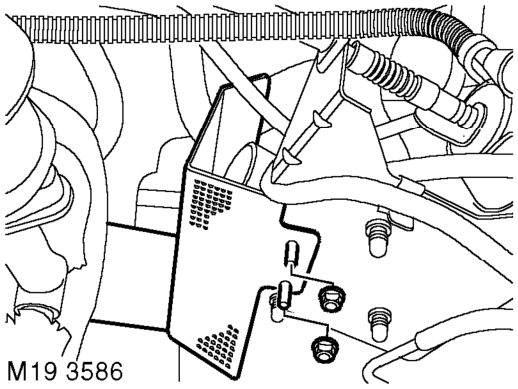
Refit

1. Position vacuum hose to control unit.
2. Position control unit and secure mountings.
3. Connect multiplug and vacuum hose.

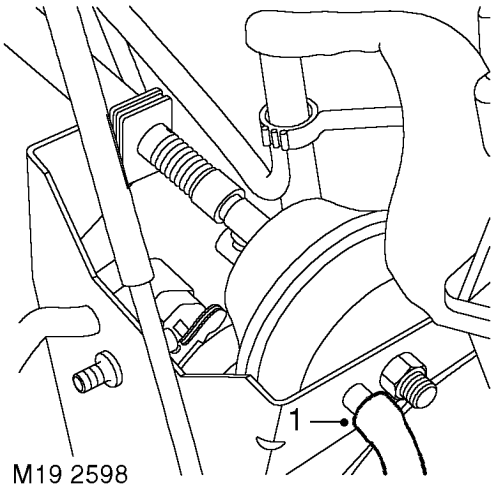
Vacuum control unit - from 03MY

19.75.06

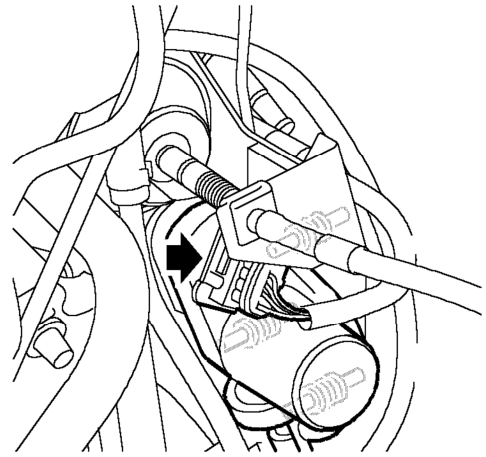
Remove



1. **If fitted:** Remove 2 nuts securing heat shield and remove heat shield.



2. Disconnect vacuum hose from actuator.


M19 2599A

3. Disconnect multiplug from control unit.
4. Release 3 rubber mounting securing control unit to mounting bracket and remove control unit.

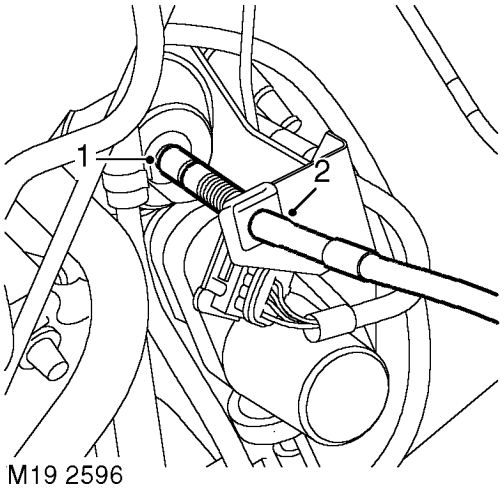
Refit

1. Position control unit and secure mountings.
2. Connect multiplug and vacuum hose.
3. **If fitted:** Fit heat shield, fit nuts and tighten to 10 Nm (7 lbf.ft).

Cable - cruise control

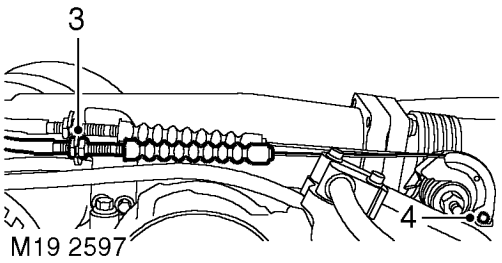
19.75.10

Remove



M19 2596

1. Release clip and disconnect inner cable from actuator.
2. Release outer cable from actuator mounting bracket.



M19 2597

3. Loosen cable locknuts, release outer cable from abutment bracket and retaining clip.
4. Release inner cable from operating lever and remove cable.

Refit

1. Position cable and connect to operating lever.
2. Position cable to abutment bracket.
3. Position outer cable to actuator mounting bracket and connect inner cable to actuator.
4. Adjust cruise control cable.
   ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - cruise control.

Switch - cruise control (on/off)

19.75.30

Remove

1. Carefully remove switch from instrument cowl.
2. Disconnect multiplug and remove switch.

Refit

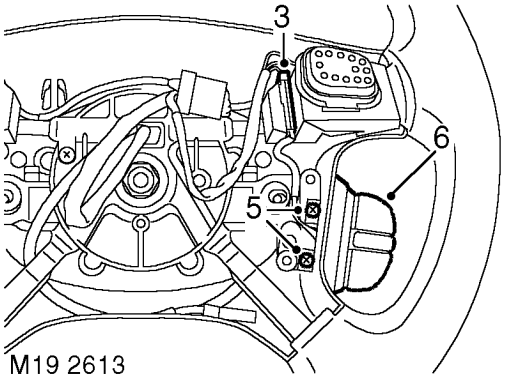
1. Position new switch and connect multiplug.
2. Carefully push switch into instrument cowl.

Switch - cruise control (set/resume)

19.75.33

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.



M19 2613

3. Release remote control switches multiplug and leads from steering wheel base.
4. Disconnect remote control switches multiplug from harness.
5. Remove 2 screws securing remote control switches to steering wheel base.
6. Release and remove remote control switches from steering wheel.

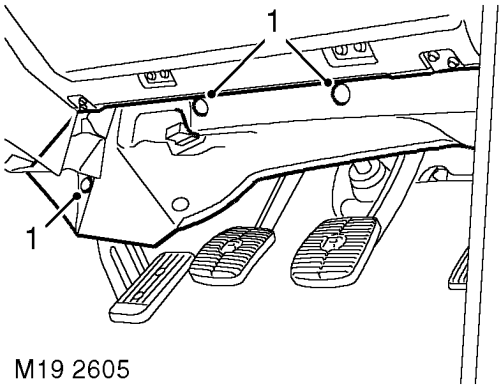
Refit

1. Fit remote control switches to steering wheel and secure with screws.
2. Connect remote control switches multiplug to harness.
3. Secure leads and multiplug to base of steering wheel.
4. Fit driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.

Switch - clutch pedal - cruise control

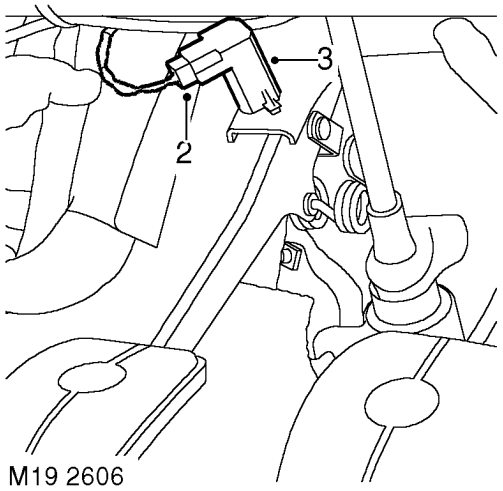
19.75.34

Remove



M19 2605

1. Remove 3 fasteners and move driver's side lower closing panel aside.



M19 2606

2. Disconnect multiplug from clutch pedal switch.
3. Remove switch from pedal bracket.

Refit

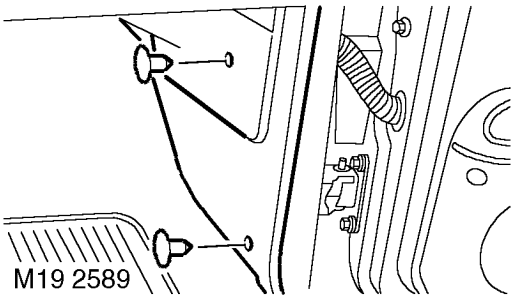
1. Engage switch fully into pedal bracket location and connect multiplug.
2. Position lower closing panel and secure with fasteners.

ECU - Cruise control

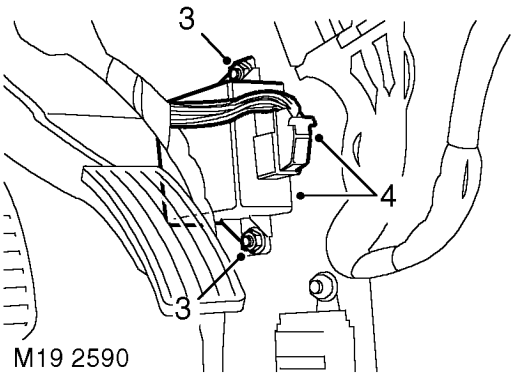
19.75.49

Remove

1. Remove fixings securing fascia RH closing panel and remove panel.


M19 2589

2. Remove 2 fixings and remove 'A' post lower trim.



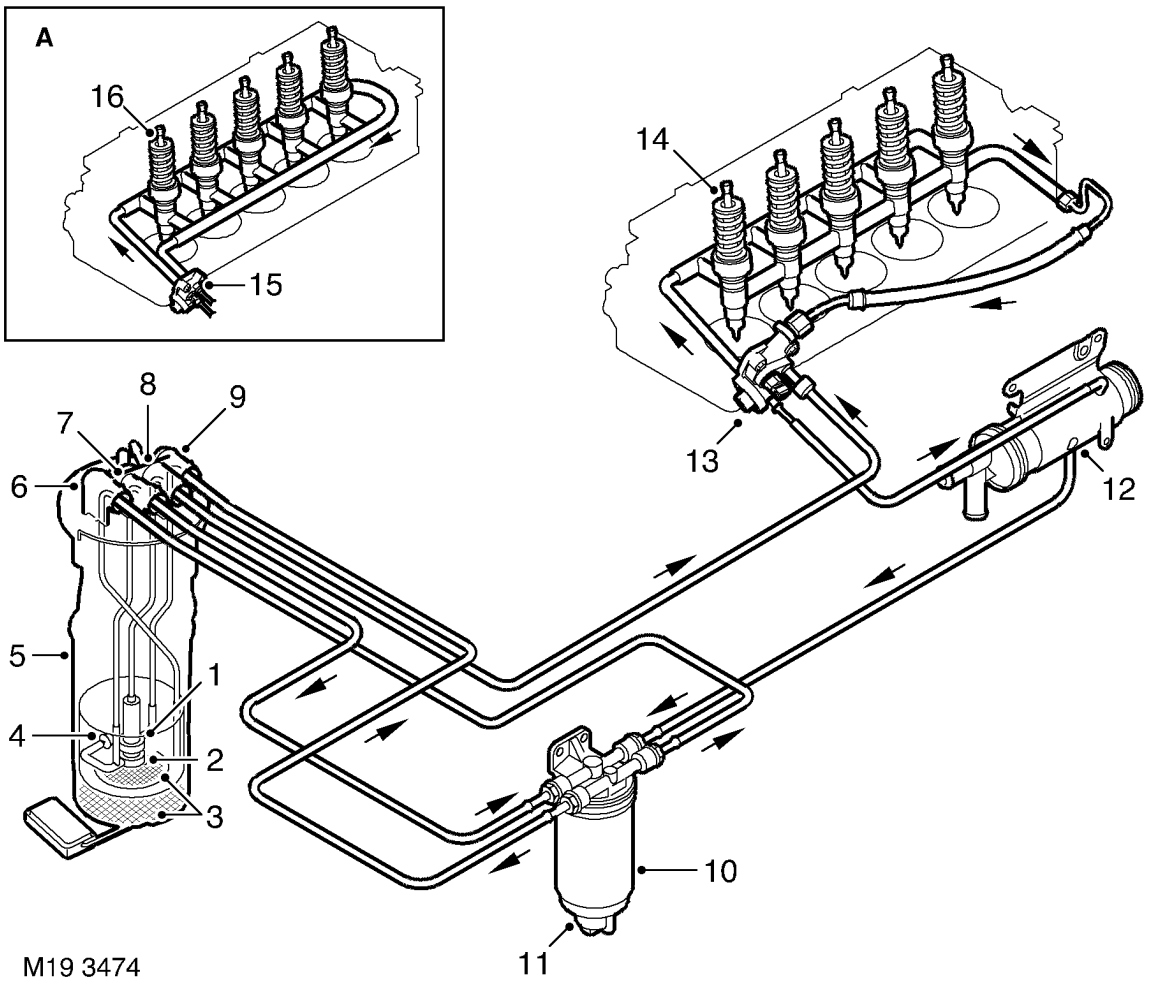
M19 2590

3. Remove 2 nuts and remove ECU from studs.
4. Disconnect multiplug from ECU and remove ECU.

Refit

1. Position new ECU and connect multiplug.
2. Fit ECU to studs and secure with nuts.
3. Fit lower trim panel to 'A' post and secure with fixings.
4. Fit closing panel and secure with fixings.
5. Programme the ECU using TestBook.

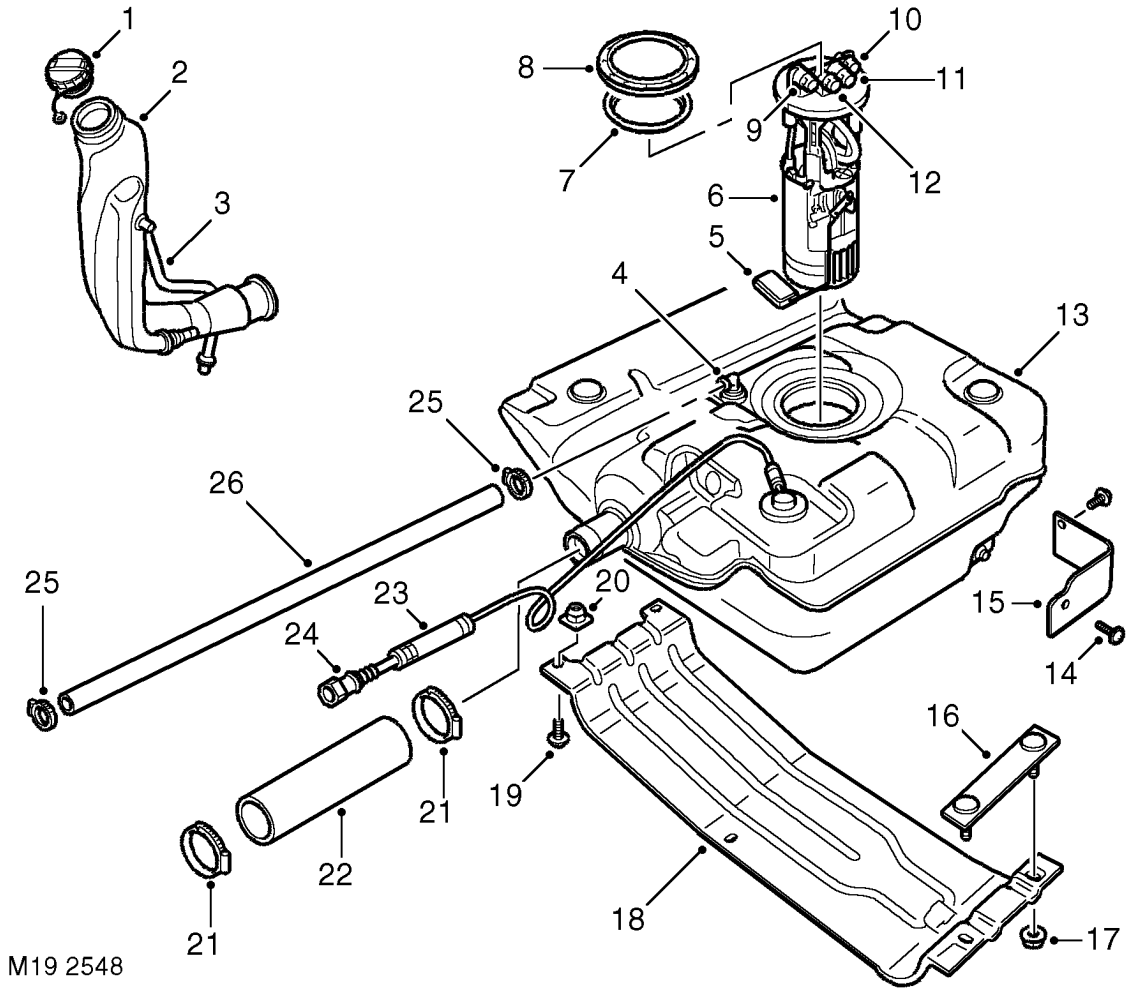
Fuel delivery system component location



A = Pre EU3 models

1 HP stage
2 LP stage
3 Filters
4 Jet pump
5 Fuel pump and fuel gauge sender assembly
6 LP return connection
7 LP feed connection
8 HP feed connection
9 Air bleed connection
10 Fuel filter
11 Water sensor
12 Fuel cooler
13 Fuel pressure regulator (EU3 models)
14 Electronic unit injectors
15 Fuel pressure regulator (pre EU3 models)
16 Electronic unit injectors

Fuel tank and breather components



1 Fuel filler cap
2 Filler tube
3 Atmospheric vent pipe
4 Tank breather connection
5 Fuel gauge sender float
6 Fuel pump and fuel gauge sender assembly
7 Seal
8 Locking ring
9 Low pressure return connection
10 Air bleed connection
11 High pressure feed connection
12 Low pressure feed connection
13 Fuel tank and breather assembly
14 Scrivet 2 off
15 Heat shield
16 Stud plate
17 Nut 2 off
18 Cradle
19 Bolt 2 off
20 Nut plate 2 off
21 Hose clip 2 off
22 Hose
23 Vent pipe
24 Vent pipe coupling
25 Hose clip 2 off
26 Breather hose

Description

General

The fuel delivery system comprises a fuel tank, fuel pump, fuel pressure regulator, five injectors and a fuel filter. The system is controlled by the Engine Control Module (ECM) which energises the fuel pump relay and controls the operation and timing of each injector solenoid.

Unlike other Diesel engines, the Td5 engine has no injection pump. The diesel direct injection system receives fuel at pressure from a two stage fuel pump located in the fuel tank. The system incorporates a fuel return to the fuel pump, via a fuel cooler attached to the inlet manifold and a fuel filter. A fuel pressure regulator is located in a housing on the rear of the cylinder head. The regulator maintains the fuel delivered to the injectors at a constant pressure and returns excess fuel back to the fuel filter and pump via the fuel cooler.

A fuel filter is positioned on the chassis to the right of the fuel tank. The fuel feed and return to and from the engine passes through the filter. The filter also incorporates a water sensor which illuminates a warning lamp in the instrument pack.

A moulded fuel tank is located at the rear underside of the vehicle between the chassis longitudinals. The tank provides the attachment for the fuel pump and fuel gauge sender unit which is located inside the tank.

Fuel tank and breather

The fuel tank and breather system is a major part of the fuel delivery system. The fuel tank and breathers are located at the rear of the vehicle between the chassis longitudinals.

Fuel tank

The moulded fuel tank is made from High Molecular Weight (HMW) High Density Polyethylene (HDPE). The diesel tank is manufactured using a proportion of recycled plastic.

The tank is retained in position by a metal cradle which is secured to the chassis with two nut plates and bolts at the rear and a stud plate and two nuts at the front. A strap above the tank is bolted to the chassis and restrains the tank from moving upwards. The fuel tank has useable capacity of approximately 95 litres (25 US Gallons).

An aperture in the top surface of the tank allows for the fitment of the fuel pump and fuel gauge sender unit which is retained with a locking ring.

A reflective metallic covering is attached to the tank with two scrivets to shield the tank from heat generated by the exhaust system.

The fuel filler is located in the right hand rear quarter panel, behind an access flap. The flap is opened electrically using a switch on the fascia which operates a release solenoid.

The filler is closed by a threaded plastic cap which screws into the filler neck. The cap has a ratchet mechanism to prevent overtightening and seals against the filler neck to prevent the escape of fuel vapour. The filler cap has a valve which relieves fuel pressure to atmosphere at approximately 0.12 to 0.13 bar (1.8 to 2.0 lbf.in^2) and opens in the opposite direction at approximately 0.04 bar (0.7 lbf.in^2) vacuum.

A moulded filler tube, made from HMW HDPE, connects the filler to the tank via a flexible hose. The filler tube is connected at its top end behind the filler flap.

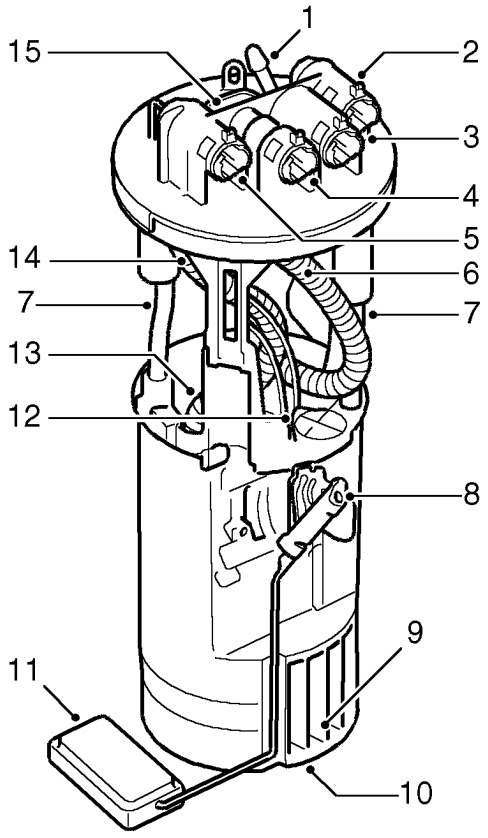
Fuel tank breather system

The filler tube incorporates a tank vent which allows air and fuel vapour displaced from the tank when filling to vent to atmosphere via the filler neck.

A breather spout within the tank controls the tank 'full' height. When fuel covers the spout it prevents fuel vapour and air from escaping from the tank. This causes the fuel to 'back-up' in the filler tube and shuts off the filler gun. The position of the spout ensures that when the filler gun shuts off, a vapour space of approximately 10% of the tanks total capacity remains. The vapour space ensures that the Roll Over Valve (ROV) is always above the fuel level and vapour can escape and allow the tank to breathe.

The ROV is welded on the top surface of the tank. The ROV is connected by a tube to the filler tube, which in turn is connected to the atmospheric vent pipe. The ROV allows fuel vapour to pass through it during normal vehicle operation. In the event of the vehicle being overturned the valve shuts off, sealing the tank and preventing fuel from spilling from the atmospheric vent pipe.

Fuel pump and fuel gauge sender



M19 2549

1 Fuel burning heater feed pipe connection
2 Air bleed connection (natural)
3 HP feed connection (green)
4 LP feed connection (blue)
5 LP return connection (black)
6 Pump feed pipe
7 Spring 2 off
8 Fuel gauge sender unit
9 Swirl pot
10 Gauze filter
11 Fuel gauge sender float
12 Electrical connections
13 HP/LP two stage pump
14 Pump LP return pipe
15 Electrical connector

The fuel pump is a 'self priming', wet type, two stage pump which is immersed in fuel in the tank and operates at all times when the ignition switch is in position II. If the engine is not started, the ECU will 'time-out' after three minutes and de-energise the fuel pump relay. The pump receives a feed from the battery via fuse 10 in the engine compartment fusebox and the fuel pump relay. The relay is energised by the ECM when the ignition switch is moved to position II.

The fuel pump assembly is retained with a locking ring and sealed with a rubber seal. The locking ring requires a special tool for removal and refitment. An access panel for the fuel pump is located in the loadspace floor below the carpet. The access panel is sealed to the floor with a rubber seal and retained by six self-tapping screws. A four pin electrical connector is located on the top cover and provides power feed and earth for the fuel pump and also inputs and outputs for the fuel gauge sender operation.

The fuel gauge sender is integral with the fuel pump. The sender is submerged in the fuel and is operated by a float which moves with the fuel level in the tank.

Fuel pump

The fuel pump assembly comprises a top cover which locates the electrical connector, fuel burning heater connection and four fuel pipe couplings. The top cover is attached to a plastic cup shaped housing and retained on three sliding clips. Two coil springs are located between the cover and the housing and ensure that the fuel pump remains seated positively at the bottom of the tank when installed.

The housing locates the two stage fuel pump and also the fuel gauge sender unit. The lower part of the housing is the swirl pot which maintains a constant level of fuel at the fuel pick-up. A coarse filter is located in the base of the housing and prevents the ingress of contaminants into the pump and the fuel system from the fuel being drawn into the pump. A fine filter is located in the intake to the low pressure stage to protect the pump from contaminants. Flexible pipes connect the couplings on the top cover to the pump.

A non-return valve is located in the base of the housing. When the fuel tank is full, fuel pressure keeps the valve lifted from its seat allowing fuel to flow into the swirl pot. As the tank level reduces, the fuel pressure in the tank reduces causing the valve to close. When the valve is closed fuel is retained in the swirl pot, ensuring that the swirl pot remains full and maintains a constant supply to the fuel pump.

The two stage pump comprises a high and a low pressure stage. The low pressure stage draws fuel from the swirl pot through the filter. The low pressure stage pumps fluid at a pressure of 0.75 bar (10.9 lbf.in^2) and a flow of 30 litres/hour (8 US Gallons/hour) to the fuel filter. A proportion of the fuel from the low pressure stage also passes, via a restrictor, through a jet pump which keeps fuel circulating in the swirl pot. The high pressure stage draws the low pressure fuel from the fuel filter and pressurises it to a pressure of 4.0 bar (58 lbf.in^2). The pressurised fuel is then passed from the pump to the injectors at a flow of 180 litres/hour (47.6 US Gallons/hour). A fuel pressure regulator is located at the rear of the engine and ensures that the delivery pressure remains at 4.0 bar (58 lbf.in^2) by controlling the amount of fuel returning to the fuel tank.

The fuel pump has a maximum current draw of 15 Amps at 12.5 V and is protected by a 20 Amp fuse in the engine compartment fusebox.

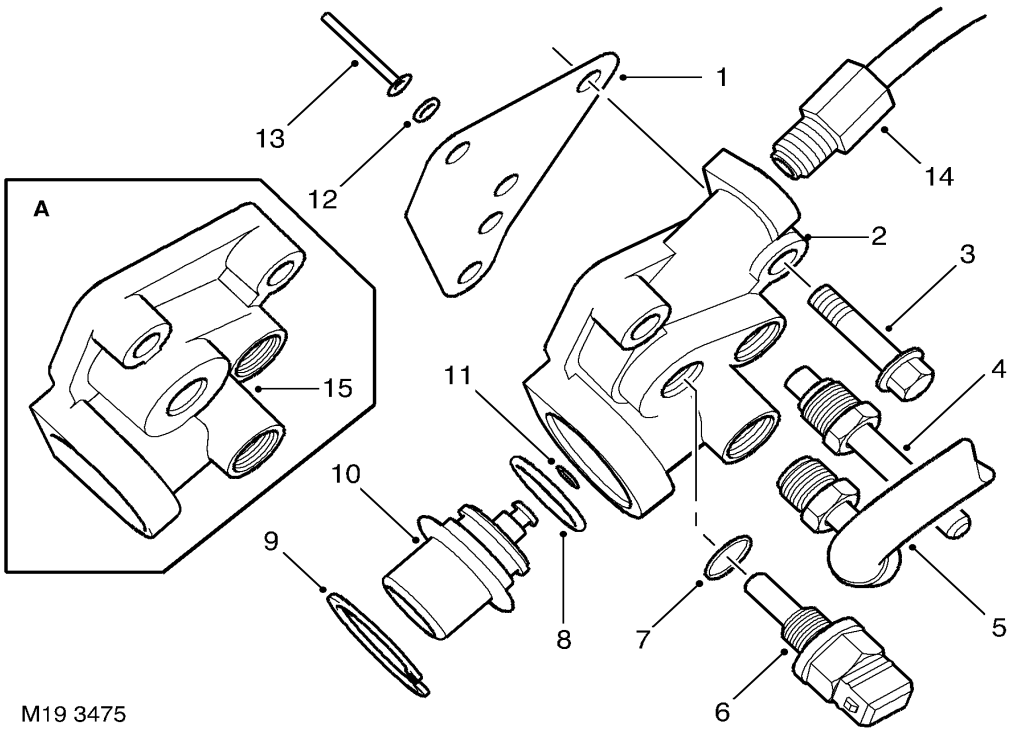
Fuel gauge sender

The fuel gauge sender unit comprises a rotary potentiometer operated by a float. The float rises and falls with the fuel level in the tank and moves the potentiometer accordingly.

A voltage of 5 V is supplied to the potentiometer from the instrument pack. The output voltage from the potentiometer varies according to the resistance through the potentiometer in relation to the fuel level. The output voltage is connected to the fuel gauge in the instrument pack. The fuel gauge receives a battery voltage input and this is compared with the output voltage from the rotary potentiometer. The difference between the two voltages determines the deflection of the fuel gauge pointer.

Fuel gauge reading	Tank volume litres *	Sender unit resistance ohms Ω
FULL	95	15
3/4	71	36
1/2	48	64
1/4	24	110
RESERVE (fuel light ON)	11	158
EMPTY	0	245
* Tank volumes are approximate		

Fuel pressure regulator and housing



A = Pre EU3 models

1 Gasket
2 Housing
3 Bolt 3 off
4 Fuel feed union and pipe
5 Fuel return union and hose
6 Fuel temperature sensor
7 Bonded seal
8 'O' ring
9 Circlip
10 Fuel pressure regulator (EU3 models)
11 'O' ring
12 'O' ring
13 Gauze filter
14 Injector spill return pipe
15 Fuel pressure regulator (pre EU3 models)

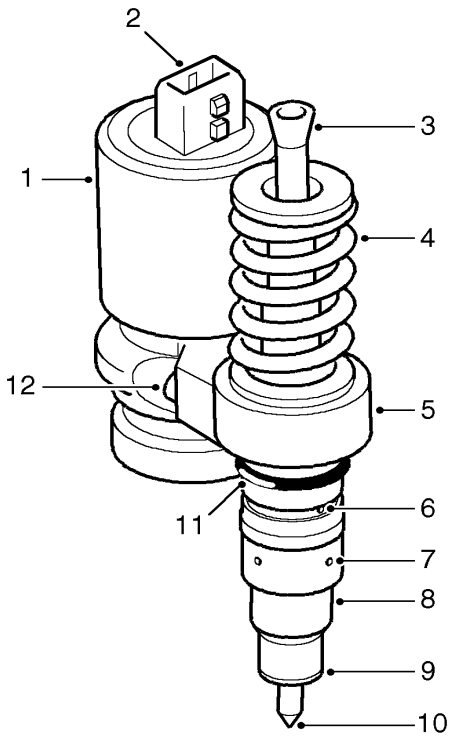
The fuel pressure regulator is located in a cast alloy housing which is attached to the rear right hand corner of the cylinder head with three flanged bolts and sealed with a metal gasket. On pre EU3 models there are two ports in the housing that connect with ports in the cylinder head for fuel pressure feed and return. On EU3 models there is a port in the housing that connects with a port in the cylinder head for fuel pressure feed and a single external port for fuel return. A gauze filter is located in the pressure feed port in the cylinder head and filters the fuel before it reaches the injectors. The filter is a fit for life item but can be changed if required. An 'O' ring is located in a recess in the cylinder head and provides additional sealing for the pressure feed port between the gauze filter, the cylinder head and the housing.

A union and pipe is attached to the feed port in the housing and connects with a quick release coupling to the fuel pressure feed pipe from the fuel pump. A second union and hose is located in the return port and provides the fuel return connection to the fuel cooler. A third port provides location for the fuel temperature sensor which is sealed to the housing with a bonded seal. The fuel temperature sensor is used by the Engine Control Module (ECM) for engine management.

The fuel pressure regulator is located in a machined port in the lower part of the housing. The regulator is sealed in the housing with two 'O' rings and secured with an internal circlip.

The regulator maintains the fuel pump delivery pressure at 4 bar (58 lbf.in^2). When the fuel pressure exceeds 4 bar (58 lbf.in^2), the regulator opens and allows fuel to return to the fuel tank via the fuel cooler. The fuel returned from the regulator is directed back into the fuel filter before being drawn by the high pressure stage of the fuel pump and directed back to the injectors. A special tool can be attached to the regulator housing fuel feed port and allows for the fitment of a suitable gauge to measure fuel pump delivery pressure.

Injectors



M19 2551

1 Solenoid housing
2 Electrical connector
3 Push rod socket
4 Push rod return spring
5 Housing
6 Fuel delivery port
7 Fuel return port
8 Nozzle cap nut
9 Copper washer
10 Nozzle
11 'O' ring
12 Cap screw 2 off

The five injectors are located in the cylinder head, adjacent to the camshaft, with the nozzle of each injector protruding directly into the cylinder. Each injector is sealed into the cylinder head with an 'O' ring and a copper washer and secured with a clamp and bolt.

Each injector is operated mechanically by an overhead camshaft and rocker and electrically by a solenoid controlled by the ECM. Each injector is supplied with pressurised fuel from the pump via the regulator housing and internal drillings in the cylinder head.

☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

The solenoid housing is secured to the injector body with two cap screws and is a sealed unit with a two pin electrical connector on its top face.

The injector body is machined from a forging. The body has a machined central bore which locates the push rod. A thread on the outer diameter provides the attachment for the nozzle cap nut. The body also provides attachment for the solenoid housing.

The injector push rod is operated from the rocker and cam assembly by a socket. The push rod is located in the housing bore and retained in its extended position by a push rod return spring. The powerful spring ensures that the push rod socket is always in contact with the rocking lever and the cam.

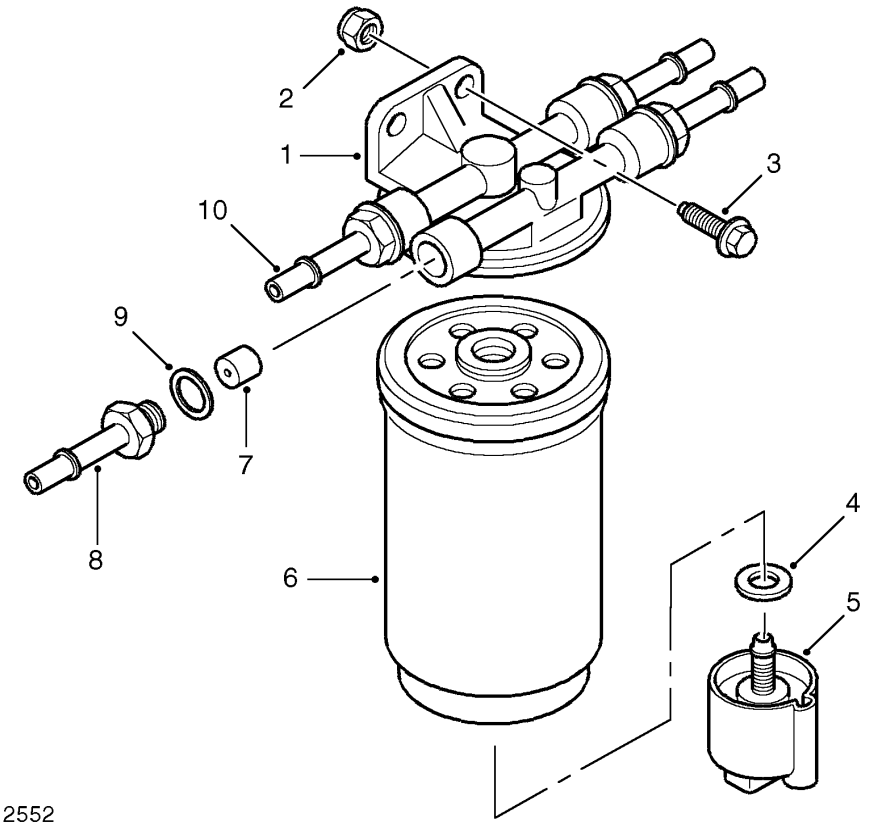
The lower part of the injector housing locates the spring loaded nozzle. The nozzle is retained in the housing by a nozzle cap nut which is screwed onto the housing. The nozzle cap nut has four holes around its circumference which connect to the fuel return drilling in the cylinder head. The injector housing has ports located above the nozzle cap nut which connect with the fuel delivery drilling in the cylinder head. An 'O' ring seals the injector in the machined location in the cylinder head and a copper washer seals the injector from the combustion chamber.

The injectors are supplied with pressurised fuel from the fuel pump, via the pressure regulator housing and internal drillings in the cylinder head. Each injector sprays fuel directly into the cylinder at approximately, 1500 bar (22000 lbf.in^2) on pre EU3 models and 1750 bar (25500 lbf.in^2) on EU3 models, atomising the fuel and mixing it with intake air prior to combustion.

The camshaft and rocker arrangement depresses the push rod which pressurises the fuel within the injector. When the injector is required to inject fuel into the cylinder, the ECM energises the solenoid which closes a valve within the solenoid housing. The closure of the valve stops the fuel entering the return line to the pump, trapping it in the injector. The compression of the fuel by the push rod causes rapid pressurisation of the fuel which lifts the injector nozzle, forcing the fuel into the cylinder at high pressure. The ECM controls the injection timing by altering the time at which the solenoid is energised and the injection period by controlling the period for which the solenoid is energised.

☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

Fuel filter



M19 2552

1 Filter body
2 Nut 2 off
3 Bolt 2 off
4 Rubber washer
5 Water sensor
6 Filter element
7 Air bleed valve
8 Air bleed connection
9 Copper washer 4 off
10 Connector 3 off

The fuel filter is located at the rear of the vehicle, to the right of the fuel tank and is attached by a bracket with two bolts and nuts to the right hand chassis longitudinal.

The filter has four quick release coupling connections; low pressure feed from the fuel pump, low pressure return to the fuel pump, return line from the fuel pressure regulator and a bleed line to the fuel pump. The fuel filter removes particulate matter from the fuel and also separates water which accumulates at the bottom of the filter.

An air bleed valve is located in the bleed line connection. The valve comprises a restrictor and a membrane. The restrictor has a small hole in its centre. This allows air and fuel to pass through the membrane. Air can pass through the membrane, but once the membrane is wet with fuel it will not allow further fuel to pass through.

The fuel filter has a replaceable screw-on canister type filter element which is sealed to the filter body with rubber seals. The lower part of the canister has a screw connection for a water sensor. The filter has a flow rate of 180 litres/hour (47.6 US Gallons/hour).

Water sensor

The water sensor has a three pin electrical connector. When the sensor detects water in the filter it illuminates a warning lamp in the instrument pack .

☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

The water sensor attachment thread has a slot machined down one side. The filter can be purged of water by partially unscrewing the sensor which aligns the slot in the threads with a corresponding hole in the sensor. When aligned, water and fuel can flow down the slot and flows from a small cast tube on the side of the sensor. Re-tightening the sensor misaligns the slot and stops the flow of fuel.

The water sensor receives a battery supply from the fuel pump relay in the engine compartment fusebox on one of the electrical connector pins. The two remaining pins are connected to the instrument pack and an earth header joint. The sensor operation uses the measurement of resistance between two electrodes submerged in the fuel and activated by the presence of water.

When the ignition is moved to position II the warning lamp will illuminate for approximately two seconds to check warning lamp functionality. TestBook can also illuminate the warning lamp to check its functionality.

When the filter is full with fuel and no water is present the resistance of the Diesel fuel will show a reading of 15 mA maximum on the feed wire to the instrument pack. This current will not illuminate the water sensor warning lamp in the instrument pack. When sufficient water surrounds both electrodes the resistance of the water will show a reading of 130 mA maximum. This will supply sufficient voltage to the instrument pack to illuminate the warning lamp to alert the driver to the presence of water in the fuel system.

Operation

When the ignition switch is moved to position II, the fuel pump relay in the engine compartment fusebox is energised by the ECM. Battery voltage is supplied from the fuel pump relay to the fuel pump which operates. If engine cranking is not detected by the ECM within a three minute period, the ECM will 'time-out', de-energising the fuel pump relay. When the ignition is turned off the ECM timer will reset.

The low pressure stage of the fuel pump draws fuel from the swirl pot and pumps it into the fuel filter. The high pressure stage of the fuel pump draws the fuel from the fuel filter and pumps it along the fuel feed pipe to the cylinder head.

The fuel enters the cylinder head through a connection on the fuel pressure regulator housing and supplies each injector with pressurised fuel. The fuel pressure regulator maintains the fuel pressure at the injectors at 4 bar (58 lbf.in^2) by returning excess fuel back to the fuel filter. The returned fuel passes through the fuel cooler in the engine compartment before it passes to the fuel filter.

When the engine is running, each injector is operated by an overhead camshaft which depresses a push rod in each injector at a timed interval. When the cam has depressed the push rod and the push rod is returning to its extended position, fuel is drawn from the fuel supply drilling into the injector.

When the ECM determines that injection is required, the ECM transmits an electrical pulse which energises the fast acting solenoid, closing the spill valve on the injector and locking fuel in the injector body. As the cam begins to depress the push rod, the fuel in the injector is rapidly pressurised. When the pressure exceeds the nozzle spring pressure, the nozzle opens and injects fuel at very high pressure into the cylinder.

When the ECM determines that the injection period should end, the solenoid is rapidly de-energised, opening the spill valve on the injector and allowing fuel to pass into the return circuit.

The ECM controls the injection timing by altering the time at which the solenoid is energised and the injection period by controlling the period for which the solenoid is energised.

Fuel system purging

19.50.07

If the vehicle runs out of fuel, or the fuel level is so low that the fuel system draws air into the fuel rail, the fuel rail will need to be purged before the engine will start. This can be achieved by following the procedure below.

If this procedure is carried out on a vehicle that has not run out of fuel or otherwise drawn air into the fuel rail, it can lead to the engine flooding and failing to start.

Purge

1. Turn the ignition switch off and wait 15 seconds.
2. Turn the ignition switch to position II and wait 3 minutes (this ensures that the fuel system purges all the air from the fuel rail within the cylinder head).
3. Fully depress the throttle pedal.
4. Keeping the throttle pedal fully depressed, crank the engine.
5. As soon as engine speed exceeds 600 rev/min, release the throttle pedal and the ignition switch.**The engine must not be cranked continuously for more than 30 seconds at any one time.**
6. If the engine fails to start, repeat the above procedure.

Fuel tank - drain

19.55.02

Drain

1. Disconnect both leads from battery.

   WARNING: Always disconnect the negative lead first. Disconnection of the positive lead while the negative lead is connected could result in a short circuit through accidental grounding and cause personal injury.

2. Remove fuel pump.

   FUEL DELIVERY SYSTEM - Td5, REPAIRS, Pump - fuel.
3. Using a fuel recovery appliance, drain the fuel from the tank into a sealed container. Follow the manufacturers instructions for the connection and safe use of the appliance.

Refill

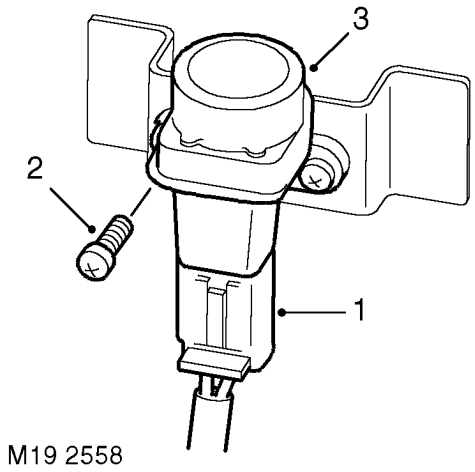
1. Fit fuel pump.

   FUEL DELIVERY SYSTEM - Td5, REPAIRS, Pump - fuel.
2. Connect battery leads, positive terminal first.

Switch - inertia - fuel cut-off

19.22.09

Remove



M19 2558

1. Disconnect multiplug from fuel cut-off switch.
2. Remove 2 screws securing fuel cut-off switch to bulkhead.
3. Remove fuel cut-off switch from bulkhead.

Refit

1. Position fuel cut-off switch to bulkhead and secure with screws.
2. Connect multiplug to fuel cut-off switch.
3. To set the fuel cut-off switch, depress the top of the fuel cut-off switch.

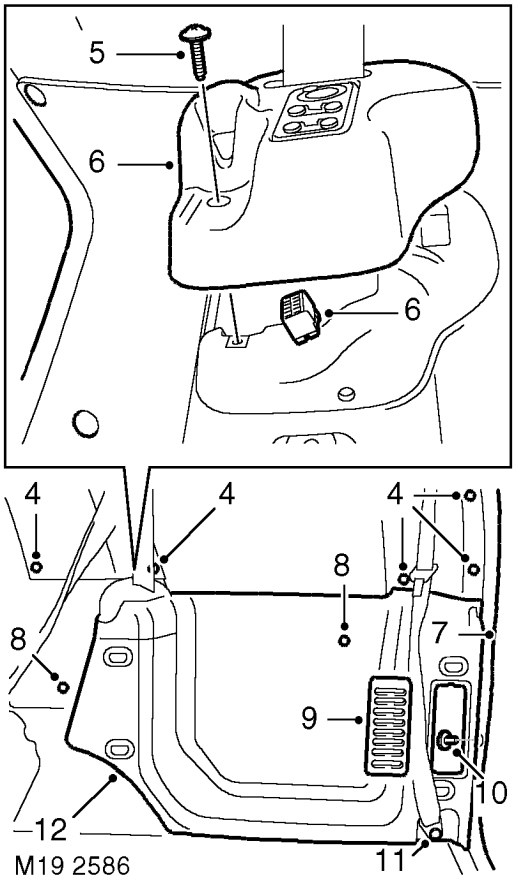
Pump - fuel

19.45.08

NOTE: The fuel pump and fuel gauge tank unit are integral parts of the fuel pump housing and cannot be renewed separately

Remove

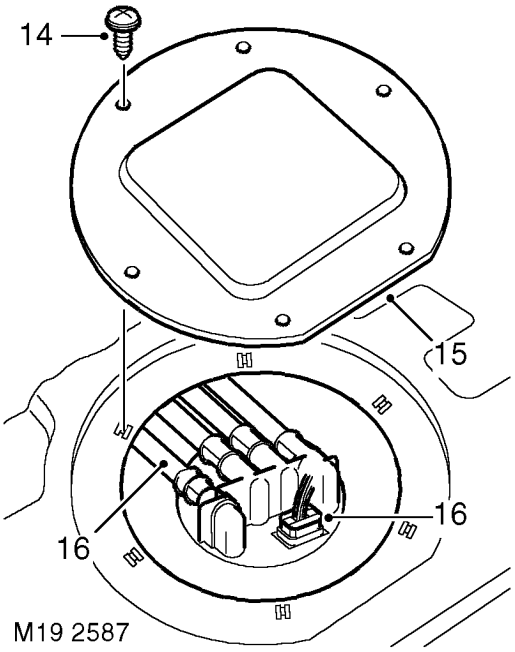
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. **Models with third row seats:** Remove RH third row seat.
   SEATS, REPAIRS, Seat - third row.



M19 2586

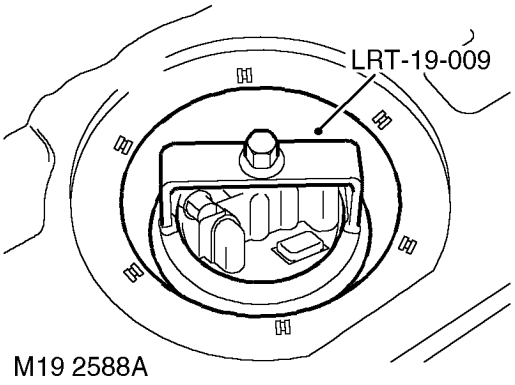
4. Remove 5 trim clips securing lower edge of RH 'D' post trim casing.
5. **Models with rear ICE controls:** Remove screw securing remote ICE controls to RH side trim casing.
6. **Models with rear ICE controls:** Release ICE controls from RH side trim casing. Disconnect multiplug and remove ICE controls.
7. Partially remove tail door aperture seal in the area of the RH side trim casing.

8. Remove 2 trim clips securing RH side trim casing to body.
9. Remove rear lamp access panel from RH side trim casing.
10. Remove trim clip securing RH side trim casing to lower 'E' post.
11. **Models with third row seats:**Remove bolt securing lower mounting of RH third row seat belt to body.
12. Remove RH side trim casing.
13. Pull back loadspace carpet from fuel pump access panel.



14. Remove 6 screws securing access panel.
15. Remove access panel.
16. Disconnect multiplug and 4 fuel hoses from fuel pump housing.

CAUTION: Always fit plugs to open connections to prevent contamination.



17. Use **LRT-19-009** to remove locking ring from fuel pump housing.
18. Remove fuel pump housing.
19. Remove and discard sealing ring from fuel pump housing.

Refit

1. Clean fuel pump housing and mating face on fuel tank.
2. Fit new seal to mating face on fuel tank.
3. Fit fuel pump housing to fuel tank and use **LRT-19-009** to fit locking ring.
4. Connect multiplug and fuel hoses to fuel pump housing. **Ensure each hose is installed in the connector with the corresponding colour code.**
5. Fit access panel and secure with screws.
6. Reposition loadspace carpet.
7. Fit RH side trim casing.
8. **Models with third row seats:**Fit bolt securing lower mounting of RH third row seat belt to body and tighten to 50 Nm (37 lbf.ft).
9. Fit trim clip securing RH side trim casing to lower 'E' post.
10. Fit rear lamp access panel to RH side trim casing.
11. Fit trim clips securing RH side trim casing to body.
12. Fit tail door aperture seal.
13. **Models with rear ICE controls:** Connect multiplug to remote ICE controls.
14. **Models with rear ICE controls:** Fit ICE controls to trim casing and secure with screw.
15. Fit trim clips securing lower edge of 'D' post trim casing to body.
16. **Models with third row seats:** Fit RH third row seat.

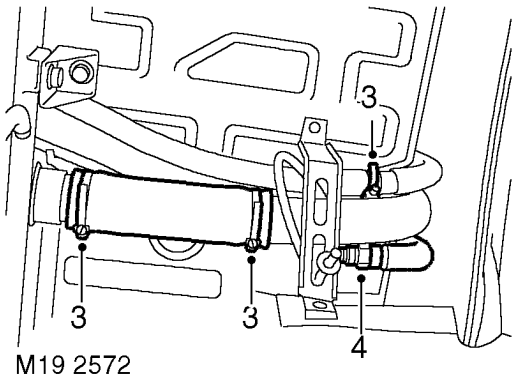
    ☞ **SEATS, REPAIRS, Seat - third row.**
17. Connect battery earth lead.

Tank - fuel

19.55.01

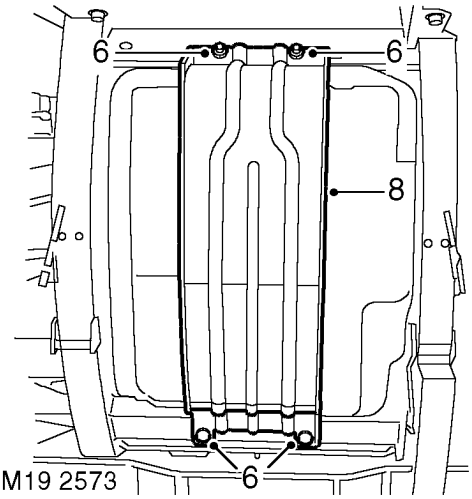
Remove

1. Drain fuel tank.
   FUEL DELIVERY SYSTEM - Td5, ADJUSTMENTS, Fuel tank - drain.
2. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



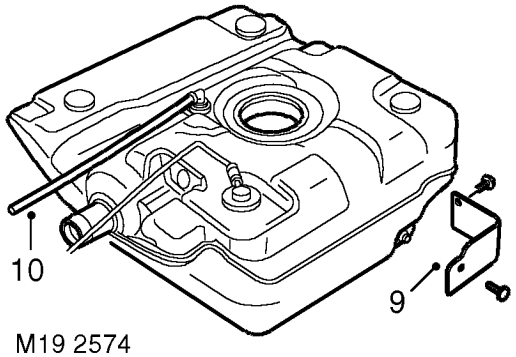
M19 2572

3. Release clips securing filler and breather hoses and release hoses from filler neck.
4. Disconnect fuel tank vent pipe from filler tube.
5. Support weight of fuel tank underneath cradle.



M19 2573

6. Remove 2 nuts and 2 bolts securing cradle to chassis.
7. With assistance, lower LH side of fuel tank then remove fuel tank from chassis.
8. Remove fuel tank from cradle.



M19 2574

9. Remove 2 scrivets securing heat shield and remove heat shield.
10. Release securing clip and remove breather hose from fuel tank.

Refit

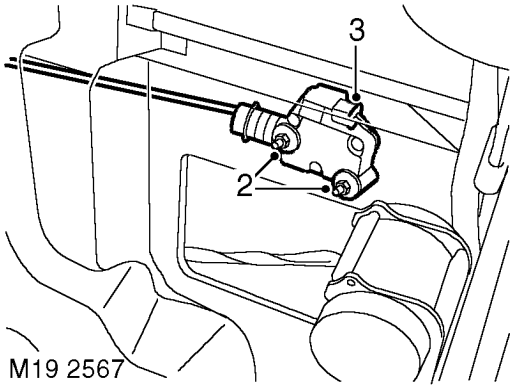
1. Fit breather hose to fuel tank and secure with clip.
2. Position heat shield and secure with scrivets.
3. With assistance, position fuel tank and cradle.
4. Fit nuts and bolts securing cradle to chassis. Tighten bolts to 50 Nm (37 lbf.ft) and nuts to 28 Nm (21 lbf.ft).
5. Connect fuel tank vent pipe to filler tube.
6. Connect breather and filler hoses and secure with clips.

Solenoid - fuel filler flap release

19.55.17

Remove

1. Remove loadspace RH side trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.



2. Remove 2 nuts and release solenoid from body panel.
3. Disconnect multiplug and remove solenoid.

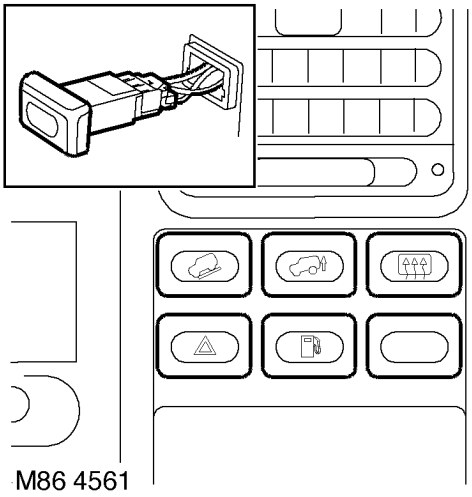
Refit

1. Position solenoid and connect multiplug.
2. Position solenoid to panel and tighten nuts.
3. Fit loadspace RH side trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.

Switch - fuel filler flap release - up to 03MY

19.55.23

Remove



1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

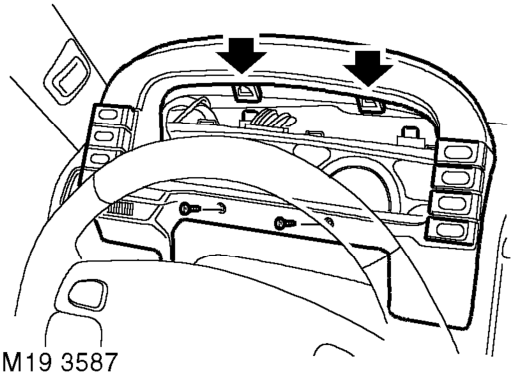
Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

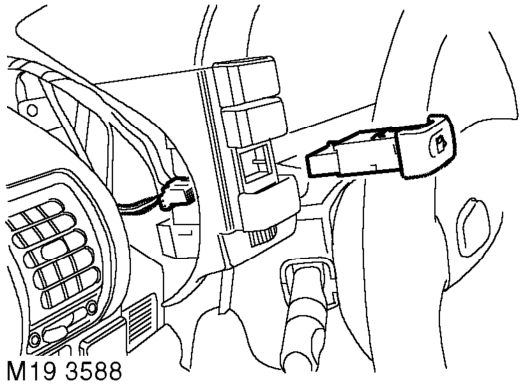
Switch - fuel filler flap release - from 03MY

19.55.23

Remove


M19 3587

1. Remove 2 screws securing instrument cowl to fascia and release the cowl from the retaining clips.

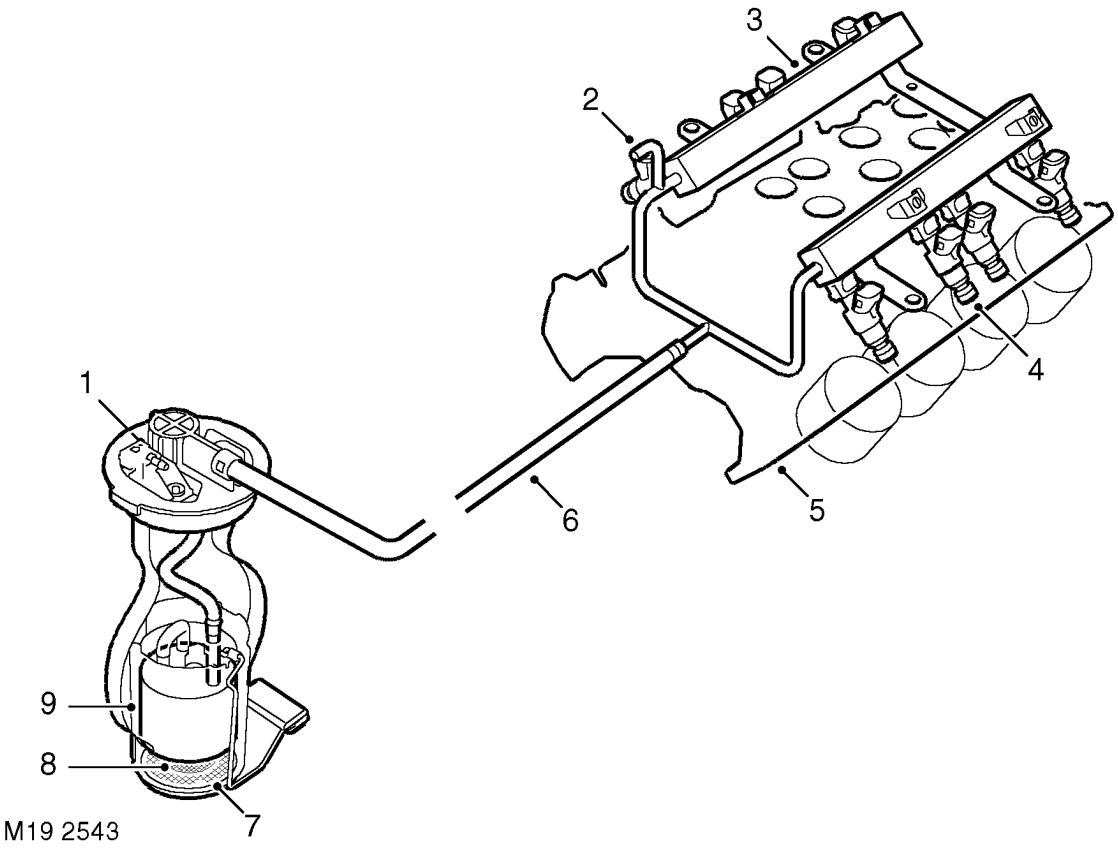

M19 3588

2. Disconnect multiplug from the fuel filler flap release switch.
3. Remove the fuel filler flap release switch from the instrument cowl.

Refit

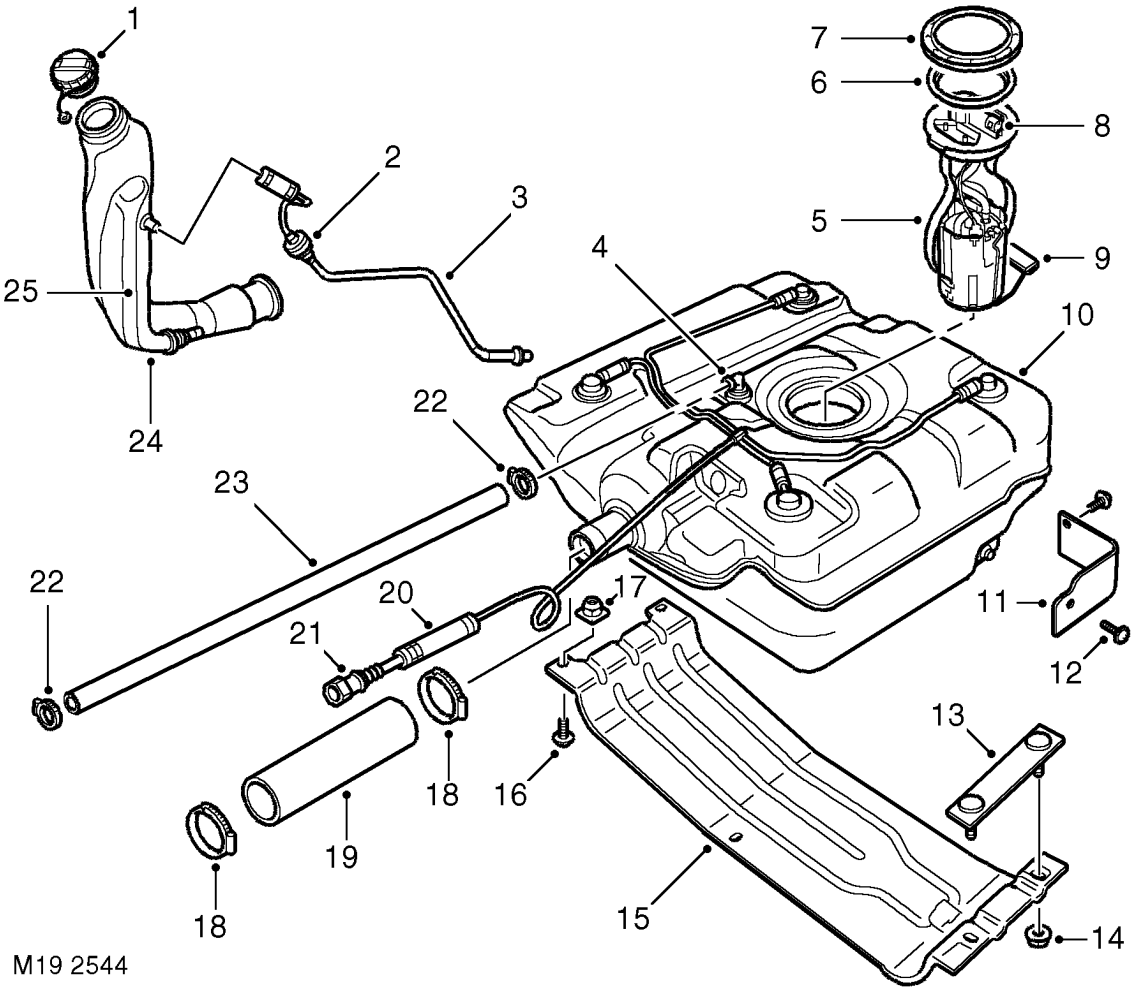
1. Fit and secure the fuel filler flap release switch to the instrument cowl and connect the multiplug.
2. Fit the instrument cowl to the fascia and secure with screws.

Fuel delivery system



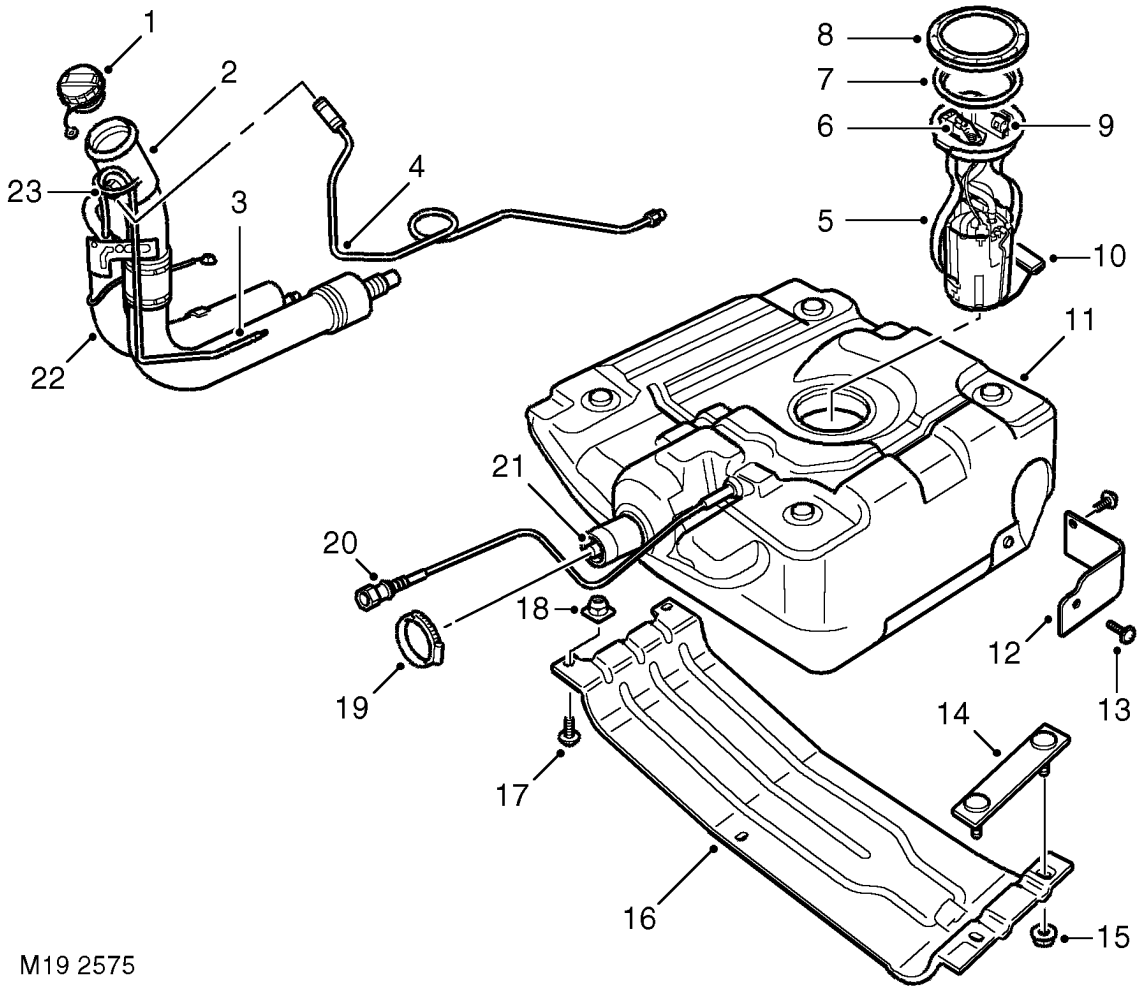
1 Fuel pressure regulator (hidden)
2 Schraeder valve
3 Fuel rail
4 Injectors
5 Engine block
6 Fuel feed pipe
7 Coarse filter
8 Fine filter
9 Fuel pump and fuel gauge sender assembly

Fuel tank and breather components (all except NAS)



1 Fuel filler cap
2 Relief valve
3 Vent to EVAP canister
4 Tank breather connection
5 Fuel pump, regulator and fuel gauge sender assembly
6 Seal
7 Locking ring
8 Fuel feed connection
9 Fuel gauge sender float
10 Fuel tank and breather assembly
11 Heat shield
12 Scrivet 2 off
13 Stud plate
14 Nut 2 off
15 Cradle
16 Bolt 2 off
17 Nut plate 2 off
18 Hose clip 2 off
19 Hose
20 Vent hose
21 Vent hose coupling
22 Hose clip 2 off
23 Hose
24 Filler tube
25 Liquid Vapour Separator (LVS)

Fuel tank and breather components (NAS)



M19 2575

1 Fuel filler cap
2 Filler tube
3 OBD pressure sensor atmospheric pipe
4 Vent pipe to EVAP canister
5 Fuel pump, regulator and fuel gauge sender assembly
6 OBD pressure sensor (vacuum type, EVAP system leak detection capability only)
7 Seal
8 Locking ring
9 Fuel feed connection
10 Fuel gauge sender float
11 Fuel tank and breather assembly
12 Heat shield
13 Scrivet 2 off
14 Stud plate
15 Nut 2 off
16 Cradle
17 Bolt 2 off
18 Nut plate 2 off
19 Hose clip
20 LVS vent pipe
21 Tank breather connection
22 Liquid vapour separator (LVS)
23 Anti-trickle fill valve

Description

General
The fuel delivery system comprises a fuel tank, fuel pump and regulator and eight injectors. The system is controlled by the Engine Control Module (ECM) which energises the fuel pump relay and controls the operation and timing of each injector solenoid.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

The multiport fuel injection system is a returnless system with the fuel pressure maintained at a constant level by a fuel pressure regulator. The regulator is located in the fuel pump housing and returns excess fuel directly from the pump to the tank.

An electrically operated fuel pump is located in the top of the fuel tank and supplies fuel at pressure to two fuel rails via a flexible hose. The hose is attached to the feed pipe on the fuel rail at the rear of the engine and the fuel pump with sealed quick release couplings.

A moulded fuel tank is located at the rear underside of the vehicle between the chassis longitudinals. The tank provides the attachment for the fuel pump and fuel gauge sender unit which is located inside the tank. The fuel system is pressurised permanently with pressurised fuel vapour venting to an EVAP canister.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Emission Control Systems.**

Fuel tank and breather
The fuel tank and breather system is a major part of the fuel delivery system. The fuel tank and breathers are located at the rear of the vehicle between the chassis longitudinals.

Fuel tank
The moulded fuel tank is made from High Molecular Weight (HMW) High Density Polyethylene (HDPE). Continuous layers of nylon additive are used during the moulding process. The nylon layers give an improved limit of fuel permeation through the tank wall and are also resistant to alcohol based fuels used in the NAS market.

The tank is retained in position by a metal cradle which is secured to the chassis with two nut plates and bolts at the rear and a stud plate and two nuts at the front. A strap above the tank is bolted to the chassis and restrains the tank from moving upwards. The fuel tank has a useable capacity of approximately 95 litres (25 US Gallons).

An aperture in the top surface of the tank allows for the fitment of the fuel pump, regulator and fuel gauge sender unit which is retained with a locking ring.

A reflective metallic covering is attached to the tank with two scrivets to shield the tank from heat generated by the exhaust system.

The fuel filler is located in the right hand rear quarter panel, behind an access flap. The flap is opened electrically using a switch on the fascia.

The filler is closed by a threaded plastic cap which screws into the filler neck. The cap has a ratchet mechanism to prevent over tightening and seals against the filler neck to prevent the escape of fuel vapour. The filler cap has a valve which relieves fuel pressure to atmosphere at approximately 0.12 to 0.13 bar (1.8 to 2.0 lbf.in^2) and opens in the opposite direction at approximately 0.04 bar (0.7 lbf.in^2) vacuum.

All markets except NAS: A moulded filler tube, made from HMW HDPE with no additional additives, connects the filler to the tank via a flexible rubber hose. The filler tube is connected at its top end behind the filler flap.

NAS markets: A fabricated filler tube, made from stainless steel, connects the filler to the tank via a flexible rubber hose. The filler tube is connected at it's top end behind the filler flap.

On all vehicles that use unleaded fuel, the filler neck is fitted with an inhibitor. The inhibitor is a tapered nozzle in the mouth of the filler neck which will only allow the use of a standard unleaded fuel filler gun. A spring loaded flap valve prevents the incorrect fuel from being trickle filled from an incorrect filler gun.

Fuel tank breather system (all markets except NAS)

The filler tube incorporates a tank vent which allows air and fuel vapour displaced from the tank when filling to vent to atmosphere via the filler neck. A relief valve in the vent line to the EVAP canister prevents vapour escaping through the canister during filling. This prevents the customer overfilling the tank and maintains the correct fuel cut-off level.

The filler tube also incorporates an integral Liquid Vapour Separator (LVS). During normal driving excess fuel vapour is passed via the vent line into the EVAP canister. To prevent the canister from being overloaded with fuel vapour, especially in hot climates, the vapour is given the opportunity to condense in the LVS. Fuel which condenses in the LVS flows back into the tank through the ROV's.

A breather spout within the tank controls the tank 'full' height. When fuel covers the spout it prevents fuel vapour and air from escaping from the tank. This causes the fuel to 'back-up' in the filler tube and shuts off the filler gun. The position of the spout ensures that when the filler gun shuts off, a vapour space of approximately 10% of the tanks total capacity remains. This vapour space ensures that Roll Over Valves (ROV's) are always above the fuel level and the vapour can escape and allow the tank to breathe.

The pressure relief valve fitted in the vent line to the EVAP canister prevents the customer trickle filling the tank. Trickle filling greatly reduces the vapour space in the tank which in turn affects the tank's ability to breathe properly, reducing engine performance and safety. When filling the tank, the pressures created are too low to open the pressure relief valve, preventing the customer from trickle filling the tank. Vapour pressures created during driving are higher and will open the valve allowing vapour to vent to the EVAP canister.

Four ROV's are welded onto the top surface of the tank. Each ROV is connected by a tube to the main vent line to the EVAP canister. The ROV's allow fuel vapour to pass through them during normal vehicle operation. In the event of the vehicle being overturned the valves shut-off, sealing the tank and preventing fuel from spilling from the vent line.

Fuel tank breather system (NAS)

The filler tube incorporates a tank vent which allows air and fuel vapour displaced from the tank when filling to vent to atmosphere via the filler neck. A filler cap operated valve within the fuel filler neck prevents vapour escaping through the EVAP canister during filling. This prevents the customer overfilling the tank and maintains the correct fuel cut-off level.

The filler tube also has an 'L' shaped, stainless steel Liquid Vapour Separator (LVS). During normal driving excess fuel vapour is passed via the vent line into the EVAP canister. To prevent the canister from being overloaded with fuel vapour, especially in hot climates, the vapour is given the opportunity to condense in the LVS. Fuel which condenses in the LVS flows back into the tank via the LVS vent line and through the Roll Over Valves (ROV's).

For NAS vehicles with vacuum type EVAP system leak detection capability, a small tube is located alongside the filler tube and terminates near to the filler neck. The tube is connected to the On Board Diagnostics (OBD) pressure sensor in the fuel pump and provides the sensor with a reading of atmospheric pressure to compare against the tank pressure.

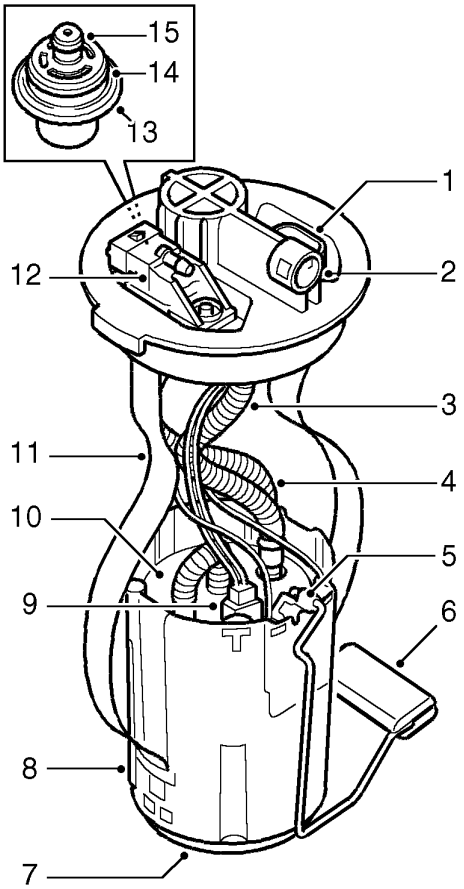
☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Emission Control Systems.**

A breather spout within the tank controls the tank 'full' height. When fuel covers the spout it prevents fuel vapour and air from escaping from the tank. This causes the fuel to 'back-up' in the filler tube and shuts off the filler gun. The position of the spout ensures that when the filler gun shuts off, a vapour space of approximately 10% of the tanks total capacity remains. This vapour space ensures that the ROV's are always above the fuel level and the vapour can escape to the LVS and allow the tank to breathe.

The filler cap operated valve closes the vent line to the EVAP canister to prevent the customer trickle filling the tank. Trickle filling greatly reduces the vapour space in the tank which in turn affects the tank's ability to breathe properly, reducing engine performance and safety. When filling the tank, the removal of the filler cap closes the valve and the vent line preventing the customer from trickle filling the tank. When the cap is installed the valve is opened by the cap allowing vapour to vent to the EVAP canister.

The four ROV's are welded inside the top surface of the tank. Each ROV is connected internally in the tank by a tube to the LVS. The ROV's allow fuel vapour to pass through them during normal vehicle operation. In the event of the vehicle being overturned the valves shut-off, sealing the tank and preventing fuel from spilling from the vent line into the LVS.

Fuel pump, regulator and fuel gauge sender



M19 2545

1 Electrical connector
2 Fuel feed pipe coupling
3 Pump feed pipe
4 Fuel regulator return pipe
5 Fuel gauge sender unit
6 Float
7 Gauze filter
8 Swirl pot
9 Pump electrical connections
10 Pump
11 Spring 2 off
12 OBD pressure sensor (NAS vehicles with vacuum type EVAP system leak detection capability only)
13 Fuel pressure regulator
14 'O' ring
15 'O' ring

The fuel pump is a 'self priming' wet type pump which is immersed in fuel in the tank. The fuel pump operates at all times when the ignition switch is in position II. If the engine is not started, the ECU will 'time-out' after 2 seconds and de-energise the fuel pump relay to protect the pump. The pump receives a feed from the battery via fuse 10 in the engine compartment fusebox and the fuel pump relay. The relay is energised by the ECM when the ignition switch is moved to position II.

The fuel pump is retained with a locking ring and sealed with a rubber seal. The locking ring requires a special tool for removal and fitment. An access panel for the fuel pump is located in the loadspace floor below the loadspace carpet. The access panel is sealed to the floor with a rubber seal and retained by six self-tapping screws.

The fuel gauge sender is integral with the fuel pump. The sender is submerged in the fuel and is operated by a float which moves with the fuel level in the tank.

Fuel pump

The fuel pump assembly comprises a top cover which locates the fuel pressure regulator, electrical connector and fuel pipe coupling. The top cover is attached to a plastic cup shaped housing by two metal springs. The housing locates the pump and the fuel gauge sender unit.

The lower part of the housing is the swirl pot, which maintains a constant fuel level at the fuel pick-up. A feed pipe from the pump to the coupling connection and a return pipe from the regulator connect between the top cover and the housing.

A coarse filter is attached to the base of the housing and prevents the ingress of large contaminants into the swirl pot. A gauze filter prevents particles entering the fuel pump.

Surrounding the pump is a large fine paper filter element which further protects the fuel pressure regulator, engine and injectors from particulate contamination. The paper filter is not a serviceable item and removes the requirement for an external in-line filter.

A non-return valve is located in the base of the housing. When the fuel tank is full, fuel pressure keeps the valve lifted from its seat allowing fuel to flow into the swirl pot. As the tank level reduces, the fuel pressure in the tank reduces causing the valve to close. When the valve is closed fuel is retained in the swirl pot, ensuring that the swirl pot remains full and maintains a constant supply to the fuel pump.

A four pin electrical connector is located on the top cover of the pump and provides power feed and return for fuel pump and fuel gauge rotary potentiometer operation. A single quick release coupling connects the fuel feed pipe to the outer top surface of the pump.

Two metal springs are attached to the top cover and the housing of the pump. When the pump is installed it seats on the lower surface inside the tank. The springs exert a downward pressure on the pump and ensure that the pump is located positively at the bottom of the fuel tank.

The fuel pump has a maximum current draw of 6.5 A at 12.5 V.

On NAS vehicles with vacuum type EVAP system leak detection capability only, the fuel pump top cover is fitted with an On Board Diagnostics (OBD) pressure sensor. This sensor has a three pin electrical connector which provides a connection between the sensor and the ECM. The sensor is sealed in the top cover with an 'O' ring and secured with a clip. The sensor monitors tank pressure during OBD tests of the fuel evaporation system integrity. A hose is connected to the sensor and is routed across the top of the fuel tank and terminates at the top of the fuel filler tube. The pipe is open to atmosphere and provides atmospheric pressure for the sensor operation.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Fuel pressure regulator

The fuel pressure regulator is located in the underside of the top cover. The regulator is sealed with two 'O' rings and retained with a clip.

The regulator is connected to the fuel feed pipe at the top of the pump housing and maintains the fuel pump delivery pressure to 3.5 bar (50 lbf.in^2). When the fuel delivery pressure exceeds 3.5 bar (50 lbf.in^2), the regulator opens and relieves excess pressure back to the swirl pot via a return pipe. The regulator ensures that the fuel rails and injectors are supplied with a constant pressure.

The fuel pump delivery pressure and pressure regulator operating pressure can be checked using a Schraeder type valve located at the rear of the engine on the fuel rail. The valve allows the pump delivery pressure to be measured using a suitable gauge and an adaptor and hose which are special tools.

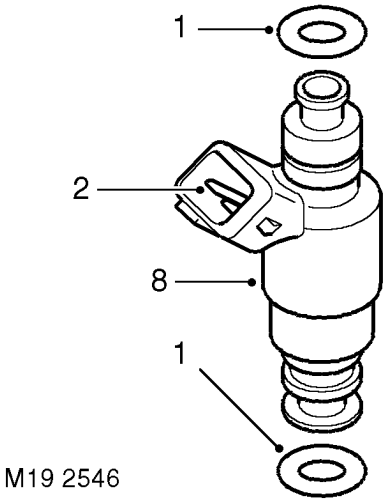
Fuel gauge sender

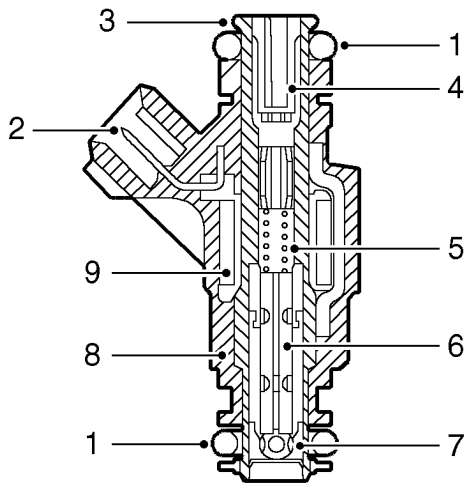
The fuel gauge sender unit comprises a rotary potentiometer operated by a float. The float rises and falls with the fuel level in the tank and moves the potentiometer accordingly.

Battery voltage is supplied to the potentiometer. The output voltage from the potentiometer varies according to the resistance through the potentiometer in relation to the fuel level. The output voltage is connected to the fuel gauge in the instrument pack. The fuel gauge receives a battery voltage input and this is compared with the output voltage from the potentiometer. The difference between the two voltages determines the deflection of the fuel gauge pointer.

Fuel gauge reading	**Tank volume litres (US Gallons) ***	**Sender unit resistance ohms Ω**
FULL	95 (25)	15
3/4	71 (18.8)	36
1/2	48 (12.7)	64
1/4	24 (6.4)	110
RESERVE (fuel light ON)	11 (2.9)	158
EMPTY	0 (0)	245
*Tank volumes are approximate.		

Injectors





1 'O' ring 2 off
2 Electrical connector
3 Steel housing
4 Filter strainer
5 Spring
6 Valve needle and armature
7 Valve seat/spray orifice
8 Plastic housing
9 Solenoid winding

An injector for each cylinder is mounted externally in the lower inlet manifold on the engine. The injector protrudes into the inlet manifold tract, where it releases a controlled delivery of fuel into the manifold air inlet.

Each injector is sealed to the fuel rail and the inlet manifold with 'O' rings. Spring clips retain each injector to the fuel rail and the attachment of the fuel rail clamps the injectors in the lower manifold.

The injector housing is manufactured from plastic which encapsulates a high-alloy steel housing. The steel housing contains all components which come into contact with fuel. The plastic housing also provides the attachment for the engine harness connector for the injector. A solenoid is located between the two housings and moves a valve needle via an armature. The valve needle seats on a valve seat which incorporates a spray orifice plate. A filter strainer is fitted at the connection with the fuel rail to remove any particulate matter from the fuel before it enters the injector.

When the ECM energises the solenoid, the armature moves lifting the valve needle off its seat. This allows pressurised fuel from the fuel rail to pass through the injector housing and needle to the spray orifice. The spray orifice controls the spray shape and fuel metering. When the solenoid is de-energised, the valve needle returns to the valve seat, aided by a spring, closing off the injection of fuel into the inlet.

Each injector receives a battery supply voltage via a fuse in the engine compartment fusebox. The fuel delivery timing is controlled by the ECM, which, at a precisely timed interval, provides a ground path for the injector. The completion of the ground path operates the injector to allow fuel at pump pressure to be delivered from the fuel rail to the injector nozzle. Each injector sprays a finely atomized spray of fuel into the inlet, where it is mixed with the intake air prior to combustion.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Faults for each injector are stored in the ECM and can be retrieved using TestBook. Each injector can be checked across the two connector pins. For a correctly functioning injector a resistance of between 13.8 and 15.2 ohms at a temperature of 20°C (65°F) should be read across the pins.

Operation

When the ignition switch is moved to position II, the fuel pump relay in the engine compartment fusebox is energised by the ECM. Battery voltage is supplied from the fuel pump relay to the fuel pump which operates. If engine cranking is not detected by the ECU within a thirty second period, the ECU will 'time-out', de-energising the fuel pump relay.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

The fuel pump draws fuel from the swirl pot and pumps it along the fuel feed pipe to the injector fuel rail on the engine. When the pressure in the fuel feed line reaches 3.5 bar (50 lbf.in^2) the fuel pressure regulator opens and relieves pressure by directing fuel back into the swirl pot. The pressure regulator is constantly opening and closing to maintain the pressure in the fuel feed pipe and the fuel rail at 3.5 bar (50 lbf.in^2).

The pressure is felt at each of the eight injectors connected to the fuel rail. The ECM controls the injection timing and energises each injector to allow a metered amount of fuel at pump pressure to be injected into the inlet tract of the inlet manifold. The atomised fuel from the injector is mixed with air from the inlet manifold before passing into the cylinder.

Fuel tank - drain

19.55.02

Drain

1. Disconnect both leads from battery.

   WARNING: Always disconnect the negative lead first. Disconnection of the positive lead while the negative lead is connected could result in a short circuit through accidental grounding and cause personal injury.

2. Connect TestBook to vehicle and depressurise fuel system.
3. Remove fuel pump.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Pump - fuel.**
4. Using a fuel recovery appliance, drain the fuel from the tank into a sealed container. Follow the manufacturers instructions for the connection and safe use of the appliance.

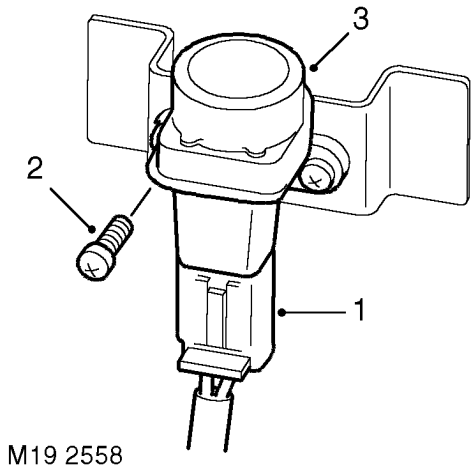
Refill

1. Fit fuel pump unit.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Pump - fuel.**
2. Refill fuel tank with extracted fuel.
3. Connect battery leads, positive lead first.

Switch - inertia - fuel cut-off

19.22.09

Remove



M19 2558

1. Disconnect multiplug from fuel cut-off switch.
2. Remove 2 screws securing fuel cut-off switch to bulkhead.
3. Remove fuel cut-off switch from bulkhead.

Refit

1. Position fuel cut-off switch to bulkhead and secure with screws.
2. Connect multiplug to fuel cut-off switch.
3. To set the fuel cut-off switch, depress the top of the fuel cut-off switch.

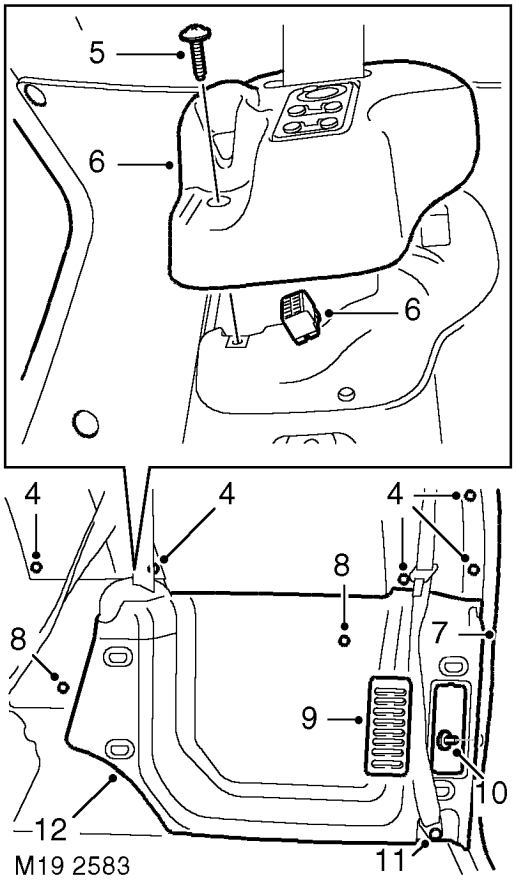
Pump - fuel

19.45.08

NOTE: The fuel pump and fuel gauge tank unit are integral parts of the fuel pump housing and cannot be renewed separately

Remove

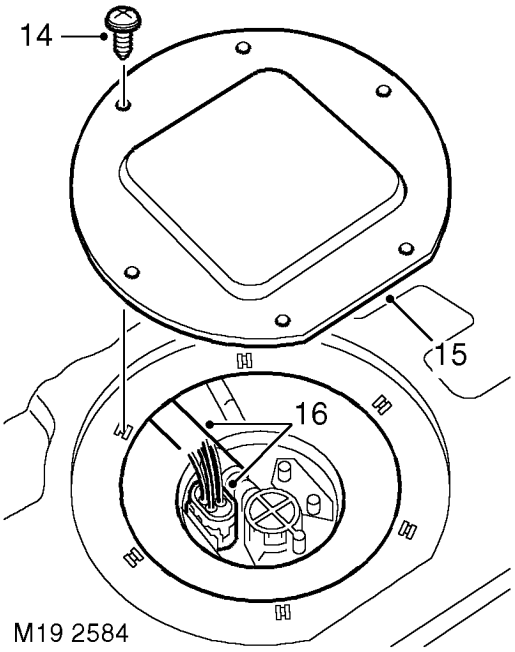
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. **Models with third row seats:** Remove RH third row seat.
   SEATS, REPAIRS, Seat - third row.



M19 2583

4. Remove 5 trim clips securing lower edge of RH 'D' post trim casing.
5. **Models with rear ICE controls:** Remove screw securing remote ICE controls to RH side trim casing.
6. **Models with rear ICE controls:** Release ICE controls from RH side trim casing. Disconnect multiplug and remove ICE controls.
7. Partially remove tail door aperture seal in the area of the RH side trim casing.

8. Remove 2 trim clips securing RH side trim casing to body.
9. Remove rear lamp access panel from RH side trim casing.
10. Remove trim clip securing RH side trim casing to lower 'E' post.
11. **Models with third row seats:** Remove bolt securing lower mounting of third row seat belt to body.
12. Remove RH side trim casing.
13. Pull back loadspace carpet from fuel pump access panel.



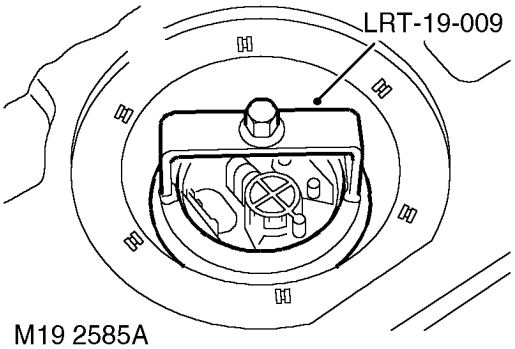
M19 2584

14. Remove 6 screws securing access panel.
15. Remove access panel.
16. Disconnect multiplug and fuel hose from fuel pump housing.

CAUTION: Always fit plugs to open connections to prevent contamination.

17. **NAS models:** Disconnect pressure sensor pipe from fuel pump housing.

CAUTION: Always fit plugs to open connections to prevent contamination.



M19 2585A

18. Use **LRT-19-009** to remove locking ring from fuel pump housing.
19. Remove fuel pump housing.
20. Remove and discard sealing ring from fuel pump housing.

Refit

1. Clean fuel pump housing and mating face on fuel tank.
2. Fit new seal to mating face on fuel tank.
3. Fit fuel pump housing to fuel tank and use **LRT-19-009** to fit locking ring.
4. Connect multiplug and fuel hose to fuel pump housing.
5. **NAS models:** Connect pressure sensor pipe to fuel pump housing.
6. Fit access panel and secure with screws.
7. Reposition loadspace carpet.
8. Fit RH side trim casing.
9. **Models with third row seats:** Fit bolt securing lower mounting of third row seat belt to body and tighten to 50 Nm (37 lbf.ft).
10. Fit trim clip securing RH side trim casing to lower 'E' post.
11. Fit rear lamp access panel to RH side trim casing.
12. Fit trim clips securing RH side trim casing to body.
13. Fit tail door aperture seal.
14. **Models with rear ICE controls:** Connect multiplug to remote ICE controls.
15. **Models with rear ICE controls:** Fit ICE controls to RH side trim casing and secure with screw.
16. Fit trim clips securing lower edge of RH 'D' post trim casing to body.
17. **Models with third row seats:** Fit RH third row seat.

☞ **SEATS, REPAIRS, Seat - third row.**

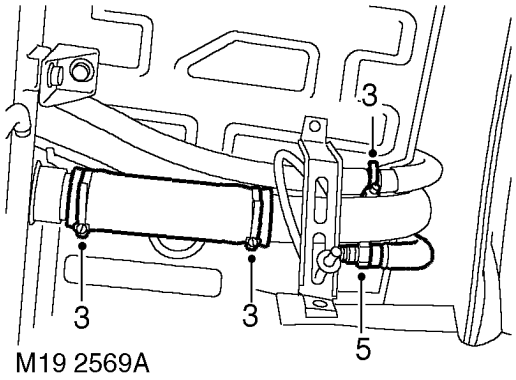
18. Connect battery earth lead.
19. Fit battery cover and secure with fixings.

Tank - fuel

19.55.01

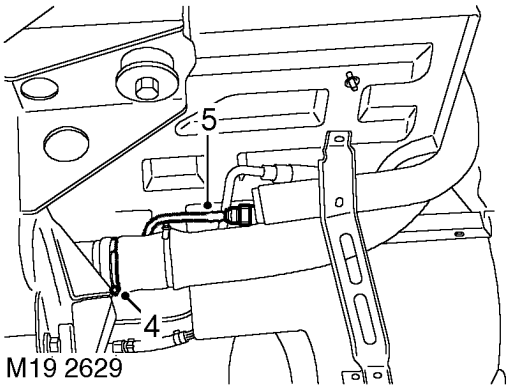
Remove

1. Drain fuel tank.
   FUEL DELIVERY SYSTEM - V8, ADJUSTMENTS, Fuel tank - drain.
2. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



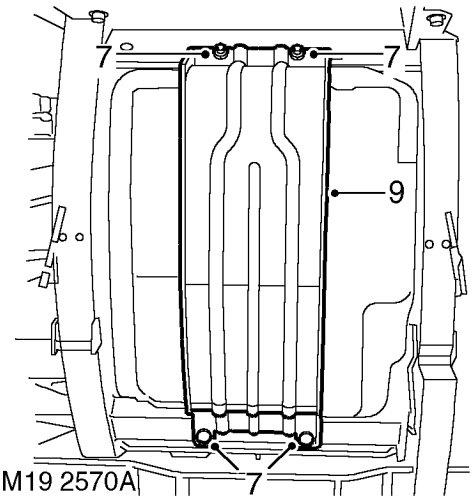
M19 2569A

3. **All except NAS models:** Release clips securing filler and breather hoses. Release hoses from filler tube.



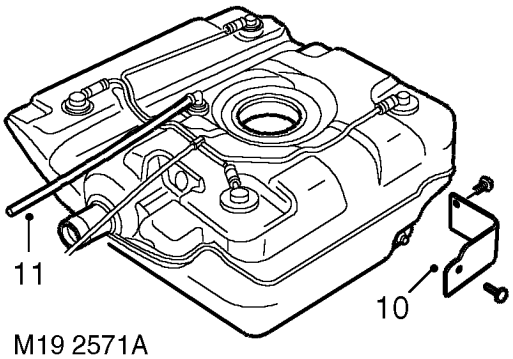
M19 2629

4. **NAS models:** Loosen securing clip and release filler tube from fuel tank.
5. Disconnect fuel tank vent pipe from filler tube.
6. Support weight of fuel tank underneath cradle.



M19 2570A

7. Remove 2 nuts and 2 bolts securing cradle to chassis.
8. With assistance, lower LH side of fuel tank then remove fuel tank from chassis.
9. Remove cradle from fuel tank.



M19 2571A

Non NAS fuel tank

10. Remove 2 scrivets securing heat shield and remove heat shield.
11. **All except NAS models:** Release securing clip and remove breather hose from fuel tank.

Refit

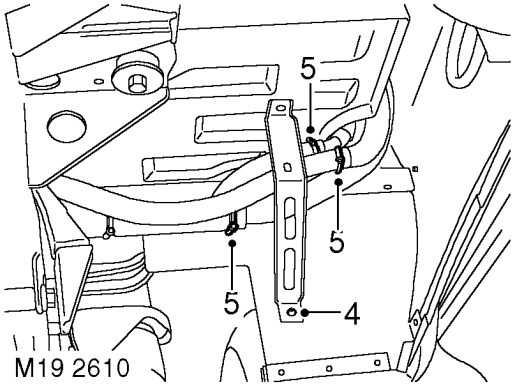
1. Fit breather hose to fuel tank and secure with clip.
2. Position heat shield and secure with scrivets.
3. With assistance, position fuel tank and cradle.
4. Fit nuts and bolts securing cradle to chassis. Tighten bolts to 45 Nm (33 lbf.ft) and nuts to 26 Nm (19 lbf.ft).
5. Connect vent hose.
6. Connect breather and filler hoses and secure with clips.

Filler tube - fuel

19.55.07

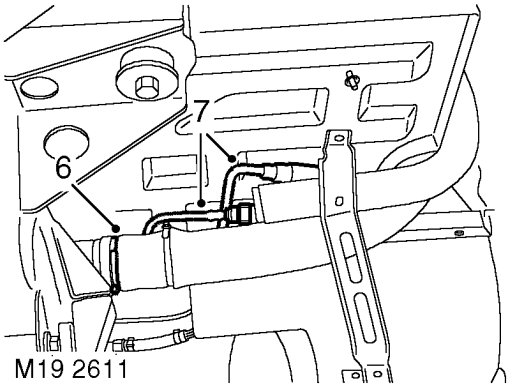
Remove

1. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Ensure fuel tank is less than half full. If not, drain fuel tank to less than half full.
   FUEL DELIVERY SYSTEM - V8, ADJUSTMENTS, Fuel tank - drain.
3. Remove filler cap.



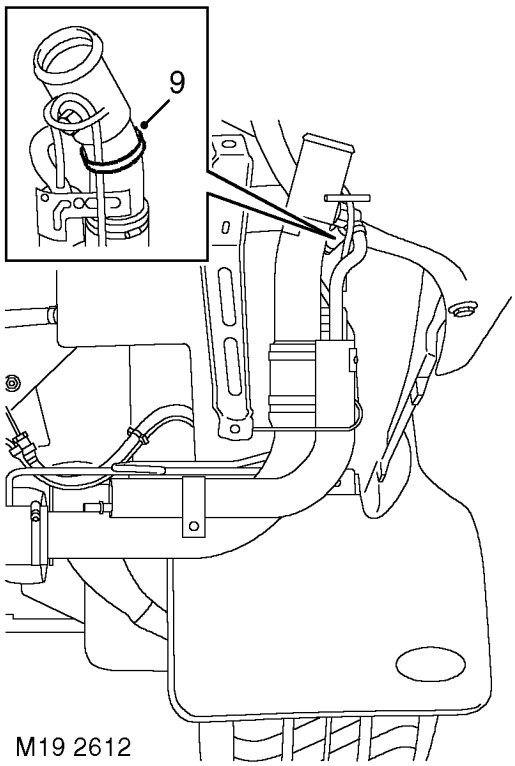
Non NAS installation

4. Drill out rivet securing lower part of mud flap support bracket and release bracket .
5. **All except NAS models:** Disconnect filler hose, breather hose and vent pipe from filler tube.



NAS installation

6. **NAS models:** Loosen securing clip and release filler tube from fuel tank.
7. **NAS models:** Disconnect vent pipes from filler tube.
8. Release filler tube from grommet in body and remove from under rear wing. Collect grommet.



9. **NAS models:** Remove cable tie securing pressure sensor pipe to filler tube and remove filler tube.

Refit

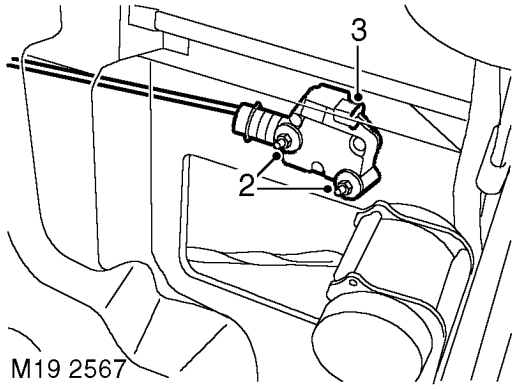
1. **NAS models:** Position filler tube to pressure sensor pipe and secure with new cable tie.
2. Fit grommet to body, position filler tube under rear wing and secure in grommet.
3. **NAS models:** Connect filler tube to fuel tank and secure with clip. Connect vent pipes to filler tube.
4. **All except NAS models:** Connect filler hose and breather hose to filler tube and secure with clips. Connect vent pipe to filler tube.
5. Position support bracket to mud flap and secure with new rivet.
6. If applicable, refill fuel tank with extracted fuel.
7. Fit filler cap.
8. Remove stand(s) and lower vehicle.

Solenoid - fuel filler flap release

19.55.17

Remove

1. Remove loadspace RH side trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.



2. Remove 2 nuts and release solenoid from body panel.
3. Disconnect multiplug and remove solenoid.

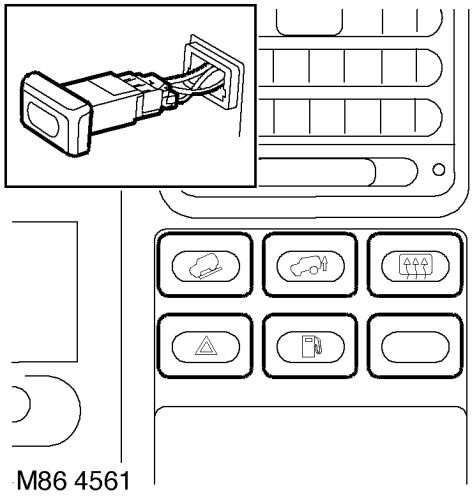
Refit

1. Position solenoid and connect multiplug.
2. Position solenoid to panel and tighten nuts.
3. Fit loadspace RH side trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.

Switch - fuel filler flap release - up to 03MY

19.55.23

Remove



1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

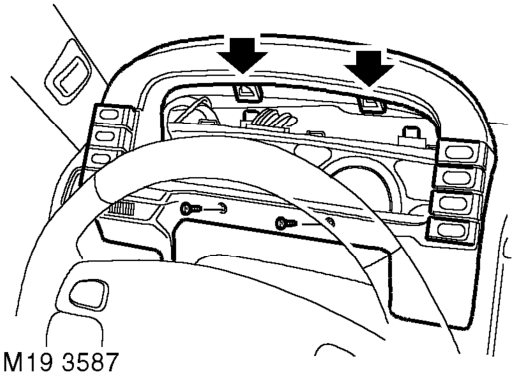
Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

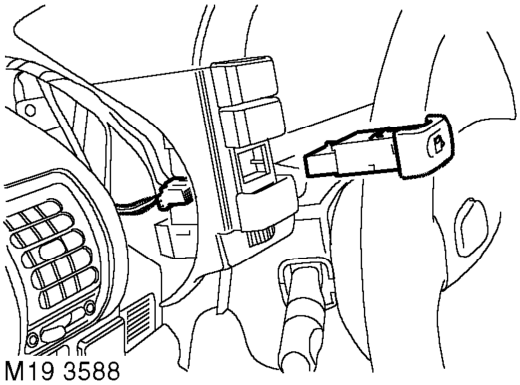
Switch - fuel filler flap release - from 03MY

19.55.23

Remove


M19 3587

1. Remove 2 screws securing instrument cowl to fascia and release the cowl from the retaining clips.

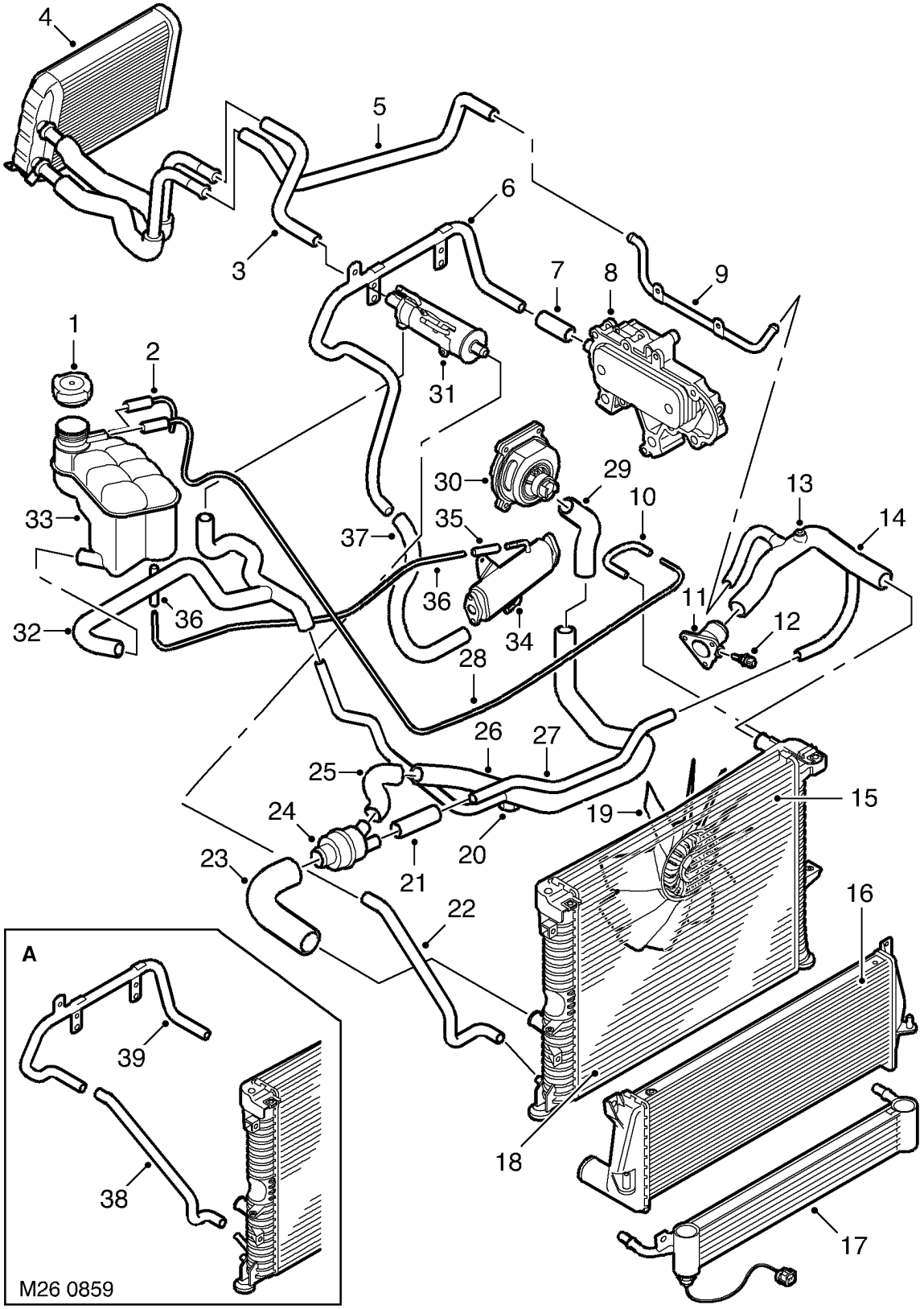

M19 3588

2. Disconnect multiplug from the fuel filler flap release switch.
3. Remove the fuel filler flap release switch from the instrument cowl.

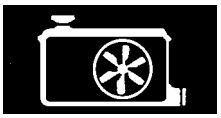
Refit

1. Fit and secure the fuel filler flap release switch to the instrument cowl and connect the multiplug.
2. Fit the instrument cowl to the fascia and secure with screws.

Cooling system component layout

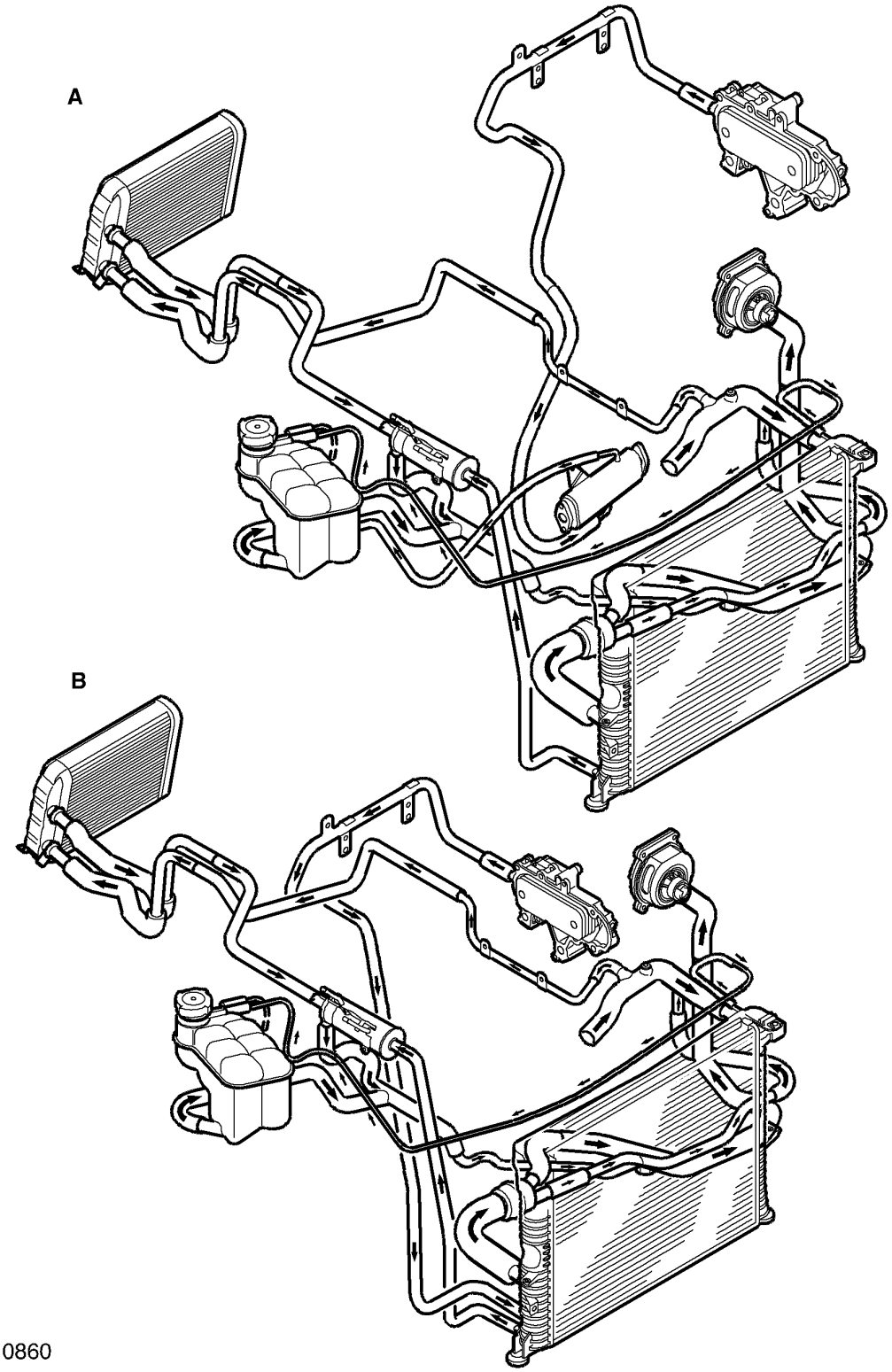


Inset A shows differences for Pre EU3 models



1 Pressure cap
2 Overflow pipe
3 Heater return hose
4 Heater matrix
5 Heater inlet hose
6 Oil cooler return pipe — EU3 models
7 Connecting hose
8 Oil cooler housing assembly
9 Heater inlet pipe
10 Connecting hose
11 Outlet housing
12 Engine Coolant Temperature (ECT) sensor
13 Bleed screw
14 Radiator top hose
15 Radiator - upper
16 Intercooler
17 Gearbox oil cooler
18 Radiator - lower
19 Viscous fan
20 Drain plug
21 Connecting hose
22 Fuel cooler feed hose
23 Radiator bottom hose
24 Thermostat housing
25 Connecting hose
26 Coolant pump feed pipe
27 Coolant by-pass pipe
28 Radiator bleed pipe
29 Connecting hose
30 Coolant pump
31 Fuel cooler
32 Heater/expansion tank return hose
33 Expansion tank
34 EGR Cooler - EU3 models
35 Connecting hose - EU3 models
36 Connecting hose - EU3 models
37 Hose - EGR Cooler to oil cooler return pipe - EU3 models
38 Radiator lower feed hose - Pre EU3 models
39 Oil cooler return pipe - Pre EU3 models

Cooling system coolant flow



Coolant flow diagram

a EU 3 Models
b Pre EU3 Models

Description

General
The cooling system used on the Diesel engine is a pressure relief by-pass type system which allows coolant to circulate around the engine block and heater circuit when the thermostat is closed. With coolant not passing through the by-pass or the radiator promotes faster heater warm-up which in turn improves passenger comfort.

A coolant pump is mounted on a casting behind the PAS pump and is driven from the PAS pump at crankshaft speed by the auxiliary drive belt. The pump mounting casting connects with passages in the cylinder block and pumps coolant from the radiator through the cylinder block.

A viscous fan is attached to an idler pulley at the front of the engine. The fan is attached to a threaded spigot on the pulley with a left hand threaded nut. The fan draws air through the radiator to assist in cooling when the vehicle is stationary. The fan rotational speed is controlled relative to the running temperature of the engine by a thermostatic valve regulated by a bi-metallic coil.

The cooling system uses a 50/50 mix of anti-freeze and water.

A Fuel Burning Heater (FBH) is available as an optional item for Diesel engine variants. The FBH is located on the bulkhead and is connected in series in the coolant supply to the heater. The FBH is used to compensate for the relatively low coolant temperatures inherent in the Diesel engine.
☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**

Thermostat housing
A plastic thermostat housing is located behind the radiator. The housing has three connections which locate the radiator bottom hose, top hose and coolant pump feed pipe. The housing contains a wax element thermostat and a spring loaded by-pass flow valve.

Thermostat - Main valve
The thermostat is used to maintain the coolant at the optimum temperature for efficient combustion and to aid engine warm-up. The thermostat is closed at temperatures below approximately 82°C (179°F). When the coolant temperature reaches approximately 82°C the thermostat starts to open and is fully open at approximately 96°C (204°F). In this condition the full flow of coolant is directed through the radiator.

The thermostat is exposed to 90% hot coolant from the engine on one side and 10% cold coolant returning from the radiator bottom hose on the other side.

Hot coolant from the engine passes from the by-pass pipe through four sensing holes in the flow valve into a tube surrounding 90% of the thermostat sensitive area. Cold coolant returning from the radiator, cooled by the ambient air, conducts through 10% of the thermostat sensitive area.

In cold ambient temperatures, the engine temperature is raised approximately 10°C (50°F) to compensate for the heat loss of 10% exposure to the cold coolant returning from the radiator bottom hose.

By-pass flow valve
The by-pass flow valve is held closed by a light spring. It operates to further aid heater warm-up. When the main valve is closed and the engine speed is below 1500 rev/min, the coolant pump does not produce sufficient flow and pressure to open the valve. In this condition the valve prevents coolant circulating through the by-pass circuit and forces the coolant through the heater matrix only. This provides a higher flow of warm coolant through the heater matrix to improve passenger comfort in cold conditions.

When the engine speed increases above 1500 rev/min the coolant pump produces a greater flow and pressure than the heater circuit can take. The pressure acts on the flow valve and overcomes the valve spring pressure, opening the valve and limiting the pressure in the heater circuit. The valve modulates to provide maximum coolant flow through the heater matrix and yet allowing excess coolant to flow into the by-pass circuit to provide the engines cooling needs at higher engine rev/min.

Outlet housing
A cast aluminium outlet housing is attached to the cylinder head with three bolts and sealed with a gasket. Coolant leaves the engine through the outlet housing and is directed through a hose to the heater matrix, the radiator or the by-pass circuit.

An Engine Coolant Temperature (ECT) sensor is installed in a threaded port on the side of the outlet housing. The sensor monitors coolant temperature emerging from the engine and sends signals to the Engine Control Module (ECM) for engine management and temperature gauge operation.

☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

Expansion tank
The expansion tank is located in the engine compartment. The tank is made from moulded plastic and attached to brackets on the right hand inner wing. A maximum coolant when cold level is moulded onto the tank.

Excess coolant created by heat expansion is returned to the expansion tank from the radiator bleed pipe at the top of the radiator. An outlet pipe is connected into the coolant pump feed hose and replaces the coolant displaced by heat expansion into the system when the engine is cool.

The expansion tank is fitted with a sealed pressure cap. The cap contains a pressure relief valve which opens to allow excessive pressure and coolant to vent through the overflow pipe. The relief valve is open at a pressure of 1.4 bar (20 lbf.in^2) and above.

Heater matrix
The heater matrix is fitted in the heater assembly inside the passenger compartment. Two pipes pass through the bulkhead into the engine compartment and provide coolant flow to and from the matrix. The pipes from the bulkhead are connected to the matrix, sealed with 'O' rings and clamped with circular rings.

The matrix is constructed from aluminium with two end tanks interconnected with tubes. Aluminium fins are located between the tubes and conduct heat from the hot coolant flowing through the tubes. Air from the heater assembly is warmed as it passes through the matrix fins. The warm air is then distributed in to the passenger compartment as required.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**

When the engine is running, coolant from the engine is constantly circulated through the heater matrix.

Radiator
The 44 row radiator is located at the front of the vehicle in the engine compartment. The cross flow type radiator is manufactured from aluminium with moulded plastic end tanks interconnected with tubes. The bottom four rows are separate from the upper radiator and form the lower radiator for the fuel cooler. Aluminium fins are located between the tubes and conduct heat from the hot coolant flowing through the tubes, reducing the coolant temperature as it flows through the radiator. Air intake from the front of the vehicle when moving carries the heat away from the fins. When the vehicle is stationary, the viscous fan draws air through the radiator fins to prevent the engine from overheating.

Two connections at the top of the radiator provide for the attachment of the top hose from the outlet housing and bleed pipe to the expansion tank. Three connections at the bottom of the radiator allow for the attachment of the bottom hose to the thermostat housing and the return hose from the oil cooler and the feed hose to the fuel cooler.

The bottom four rows of the lower radiator are dedicated to the fuel cooler. The upper of the two connections at the bottom of the radiator receives coolant from the oil cooler. This is fed through the four rows of the lower radiator in a dual pass and emerges at the lower connection. The dual pass lowers the coolant temperature by up to 24°C before being passed to the fuel cooler.

Two smaller radiators are located in front of the cooling radiator. The upper radiator is the intercooler for the air intake system and the lower radiator provides cooling of the gearbox oil.

☞ **EMISSION CONTROL - Td5, DESCRIPTION AND OPERATION, Emission Control Systems.**
☞ **MANUAL GEARBOX - R380, DESCRIPTION AND OPERATION, Description.**
☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Description.**

Pipes and hoses
The coolant circuit comprises flexible hoses and metal formed pipes which direct the coolant into and out of the engine, radiator and heater matrix. Plastic pipes are used for the bleed and overflow pipes to the expansion tank.

A bleed screw is installed in the radiator top hose and is used to bleed air during system filling. A drain plug to drain the heater and cylinder block circuit of coolant is located on the underside of the coolant pump feed pipe.

Oil cooler
The oil cooler is located on the left hand side of the engine block behind the oil centrifuge and oil filter. Oil from the oil pump is passed through a heat exchanger which is surrounded by coolant in a housing on the side of the engine.

Full water pump flow is directed along the cooler housing which also distributes the flow evenly along the block into three core holes for cylinder cooling. This cools the engine oil before it is passed into the engine. A small percentage of the coolant from the oil cooler passes into a metal pipe behind the engine. It then flows into the lower radiator via a hose.

Fuel cooler
The fuel cooler is located on the right hand side of the engine and is attached to the inlet manifold. The cooler is cylindrical in design and has a coolant feed connection at its forward end. A 'T' connection at the rear of the cooler provides a connection for the coolant return from the heater matrix and coolant return from the fuel cooler.

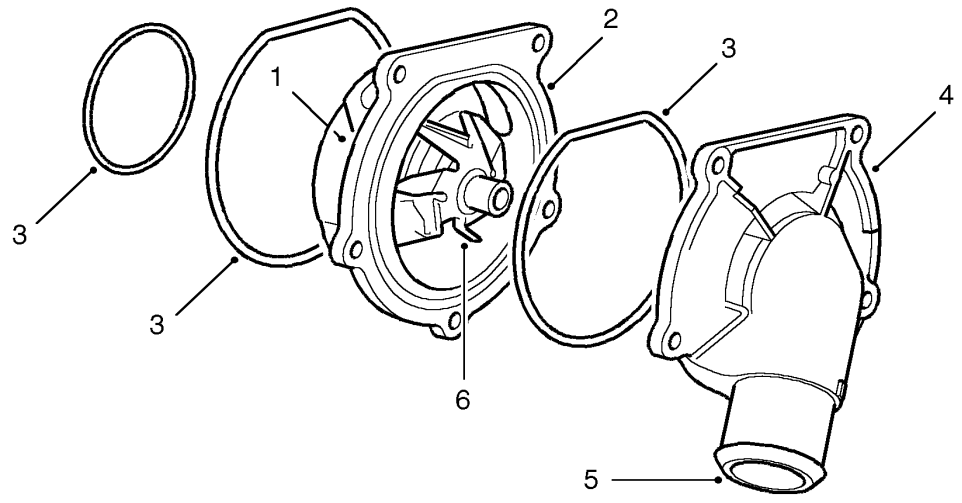
The 'T' connection houses a thermostat which opens at approximately 82°C. This prevents the cooler operating in cold climates.

Two quick release couplings on the cooler allow for the connection of the fuel feed from the pressure regulator and return to the fuel tank. A counter flow system is used within the cooler.

Fuel flows around a coolant jacket within the cooler and flows from the back to the front of the cooler. As the hot fuel cools travelling slowly forwards it meets progressively colder coolant travelling in the opposite direction maintaining a differential cooling effect.

EGR Cooler
The EGR Cooler is mounted on the front of the cylinder head. Coolant from the oil cooler flows around the EGR cooler, cooling the exhaust gas, to improve exhaust emissions, before being returned to the expansion tank.

Coolant pump



M26 0557

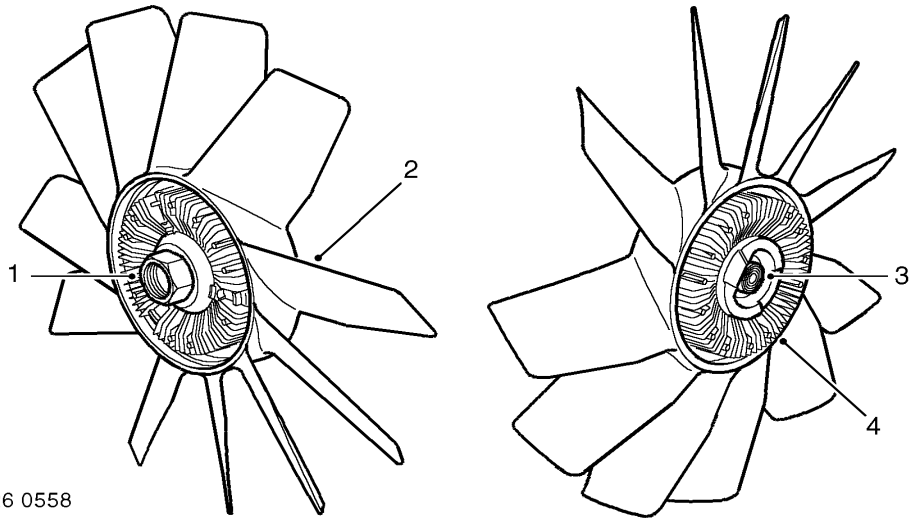
1 Drive lugs (hidden)
2 Housing
3 'O' rings
4 Cover
5 Feed hose connection
6 Impeller

The coolant pump is attached on the left hand side of the engine, behind the PAS pump. A cast housing, bolted to the cylinder block provides a common attachment point for both pumps. The housing has galleries which connect the coolant pump to the cylinder block and the oil cooler housing. The coolant pump comprises a shaft, a housing and a cover.

The shaft, which passes through the alloy housing, is supported at each end by bearings. Seals at each end of the shaft protect the bearings from the coolant. The forward end of the shaft has two lugs which engage with the PAS pump shaft. The opposite end of the shaft is fitted with an impeller which draws coolant from the feed pipe and circulates it through galleries in the cylinder block. The shaft is driven by the auxiliary drive belt at the same rotational speed as the crankshaft by a pulley attached to the PAS pump.

The pump is sealed in the cast housing with two 'O' rings. An outer cover is positioned over the pump and secured with six bolts and sealed to the pump with an 'O' ring. The cover provides the attachment for the feed pipe connecting hose.

Viscous fan



1 Idler pulley drive attachment
2 Fan blades
3 Bi-metallic coil
4 Body

The viscous fan provides a means of controlling the speed of the fan relative to the operating temperature of the engine. The fan rotation draws air through the radiator, reducing engine coolant temperatures when the vehicle is stationary or moving slowly.

The viscous fan is attached to an idler pulley at the front of the engine which is driven at crankshaft speed by the auxiliary drive belt. The fan is secured to the pulley by a nut. The nut is positively attached to the fan spindle which is supported on bearings in the fan body. The viscous drive comprises a circular drive plate attached to the spindle and driven from the idler pulley. The drive plate and body have interlocking annular grooves with a small clearance which provides the drive when silicone fluid enters the fluid chamber. A bi-metallic coil is fitted externally on the forward face of the body. The coil is connected to and operates a valve in the body. The valve operates on a valve plate with ports that connect the reservoir to the fluid chamber. The valve plate also has return ports which, when the valve is closed, scoop fluid from the fluid chamber and push it into the reservoir under centrifugal force.

Silicone fluid is retained in a reservoir at the front of the body. When the engine is off and the fan is stationary, the silicone fluid level stabilises between the reservoir and the fluid chamber. This will result in the fan operating when the engine is started, but the drive will be removed quickly after the fan starts rotating and the fan will 'freewheel'.

At low radiator temperatures, the fan operation is not required and the bi-metallic coil keeps the valve closed, separating the silicone fluid from the drive plate. This allows the fan to 'freewheel' reducing the load on the engine, improving fuel consumption and reducing noise generated by the rotation of the fan.

When the radiator temperature increases, the bi-metallic coil reacts and moves the valve, allowing silicone fluid to flow into the fluid chamber. The resistance to shear of the silicone fluid creates drag on the drive plate and provides drive to the body and the fan blades.

Operation

Coolant flow - Engine warm up
Refer to illustration.
☞ **COOLING SYSTEM - Td5, DESCRIPTION AND OPERATION, Cooling system coolant flow.**

During warm up the coolant pump moves fluid through the cylinder block and it emerges from the outlet housing. From the outlet housing, the warm coolant flow is prevented from flowing through the upper and lower radiators because both thermostats are closed. The coolant is directed into the heater circuit.

Some coolant from the by-pass pipe can pass through small sensing holes in the flow valve. The warm coolant enters a tube in the thermostat housing and surrounds 90% of the thermostat sensitive area. Cold coolant returning from the radiator bottom hose conducts through 10% of the thermostat sensitive area. In cold ambient temperatures the engine temperature can be raised by up to 10°C (50°F) to compensate for the heat loss of the 10% exposure to the cold coolant return from the radiator bottom hose.

At engine speeds below 1500 rev/min, the by-pass valve is closed only allowing the small flow through the sensing holes. As the engine speed increases above 1500 rev/min, the greater flow and pressure from pump overcomes the light spring and opens the by-pass flow valve. The flow valve opens to meet the engine's cooling needs at higher engine speeds and prevents excess pressure in the cooling system. With both thermostats closed, maximum flow is directed through the heater circuit.

The heater matrix acts as a heat exchanger reducing the coolant temperature as it passes through the matrix. Coolant emerges from the heater matrix and flows to the fuel cooler 'T' connection via the heater return hose. From the fuel cooler the coolant is directed into the coolant pump feed pipe and recirculated around the heater circuit. In this condition the cooling system is operating at maximum heater performance.

Coolant flow - Engine hot
As the coolant temperature increases the main thermostat opens. This allows some coolant from the outlet housing to flow through the top hose and into the radiator to be cooled. The hot coolant flows from the left tank in the radiator, along the tubes to the right tank. The air flowing through the fins between the tubes cools the coolant as it passes through the radiator.

A controlled flow of the lower temperature coolant is drawn by the pump and blended with hot coolant from the by-pass and the heater return pipes in the pump feed pipe. The pump then passes this coolant, via the cylinder block, to the oil cooler housing, cooling the engine oil before entering the block to cool the cylinders.

When the fuel temperature increases, the heat from the fuel conducts through the fuel cooler 'T' connection and causes the fuel thermostat to open.

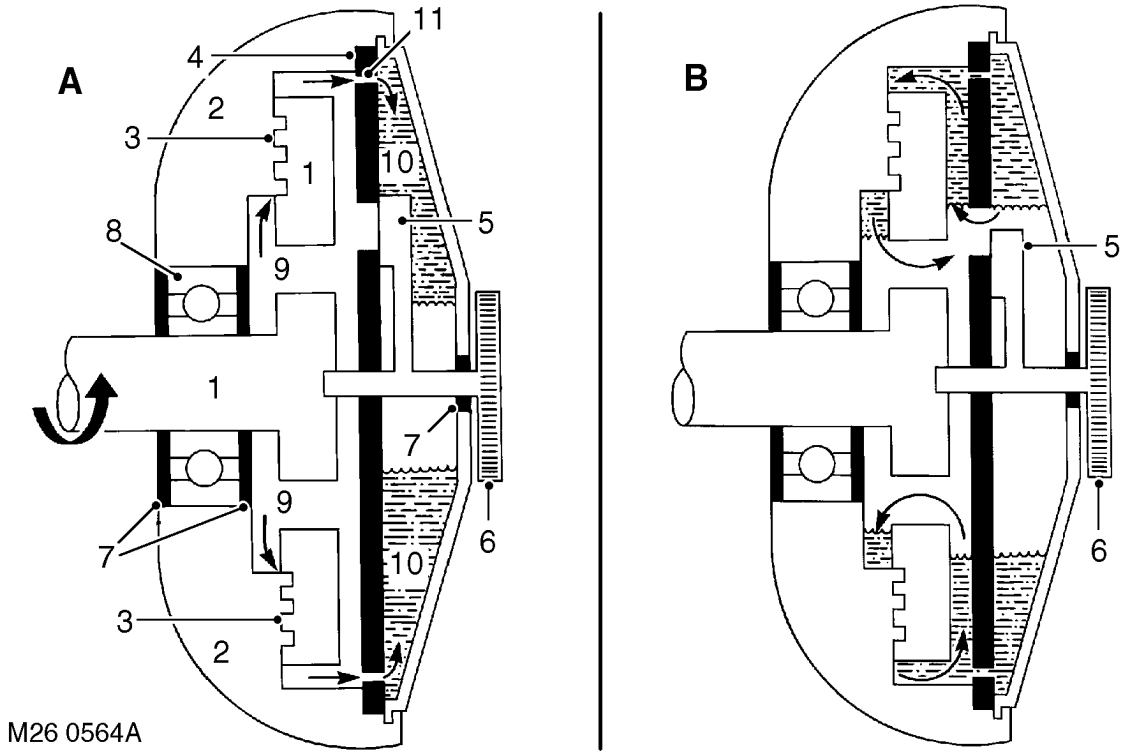
Pre EU3 models: Coolant from the cylinder block flows through the oil cooler and via a pipe and hose enters the lower radiator. The coolant in the lower radiator is subjected to an additional two passes through the lower radiator to further reduce the coolant temperature. From the lower radiator the coolant flows , via a hose, to the fuel cooler.

As the hot fuel cools, travelling slowly forwards through the cooler, it meets the progressively colder coolant travelling in the opposite direction from the lower radiator.

EU3 models: Coolant from the cylinder block flows through the oil cooler to the EGR cooler and then back to the expansion tank. and via a pipe and hose enters the lower radiator. The lower temperature coolant from the oil cooler housing is subjected to an additional two passes through the lower radiator to further reduce the coolant temperature. From the lower radiator the coolant flows , via a hose, to the fuel cooler.

As the hot fuel cools, travelling slowly forwards through the cooler, it meets the progressively colder coolant travelling in the opposite direction from the lower radiator.

Viscous fan operation



***A**= Cold, **B**= Hot*

1 Drive plate
2 Fan body
3 Clearance
4 Valve plate
5 Valve
6 Bi-metallic coil
7 Fluid seals
8 Ball race
9 Fluid chamber
10 Reservoir
11 Return port

When the engine is off and the fan is not rotating, the silicone fluid stabilises within the fluid chamber and the reservoir. The fluid levels equalise due to the return port in the valve plate being open between the fluid chamber and the reservoir. In this condition, when the engine is started, silicone fluid is present in the fluid chamber and causes drag to occur between the drive plate and the body. This causes the fan to operate initially when the engine is started.

As the fan speed increases, centrifugal force and a scoop formed on the fluid chamber side of the valve plate, pushes the silicone fluid through the return port in the valve plate into the reservoir. As the fluid chamber empties, the drag between the drive plate and the body is reduced, causing the drive plate to slip. This reduces the rotational speed of the fan and allows it to 'freewheel'.

When the coolant temperature is low, the heat emitted from the radiator does not affect the bi-metallic coil. The valve remains closed, preventing fluid escaping from the reservoir into the fluid chamber. In this condition the fan will 'freewheel' at a slow speed.

As the coolant temperature increases, the heat emitted from the radiator causes the bi-metallic coil to tighten. This movement of the coil moves the valve to which it is attached. The rotation of the valve exposes ports in the valve plate which allow the silicone fluid to spill into the fluid chamber. As the fluid flows into the clearance between the annular grooves in the drive plate and body, drag is created between the two components. The drag is due to the viscosity and shear qualities of the silicone fluid and causes the drive plate to rotate the body and fan blades.

As the coolant temperature decreases, the bi-metallic coil expands, rotating the valve and closing off the ports in the valve plate. When the valve is closed, centrifugal force pushes the silicone fluid through the return port, emptying the fluid chamber. As the fluid chamber empties, the drag between the drive plate and the body is reduced and the body slips on the drive plate, slowing the rotational speed of the fan.

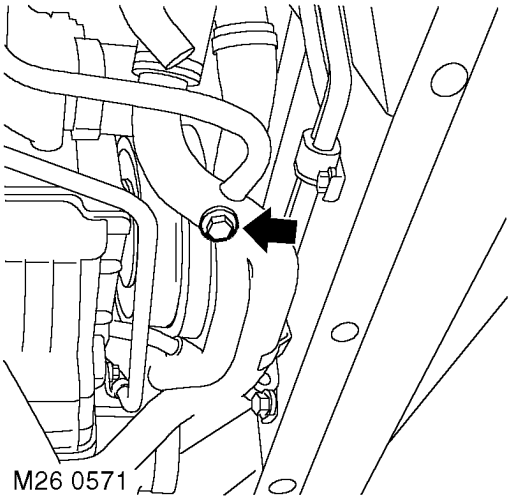
Drain and refill

26.10.01

WARNING: Since injury such as scalding could be caused by escaping steam or coolant, do not remove the filler cap from the coolant expansion tank while the system is hot.

Drain

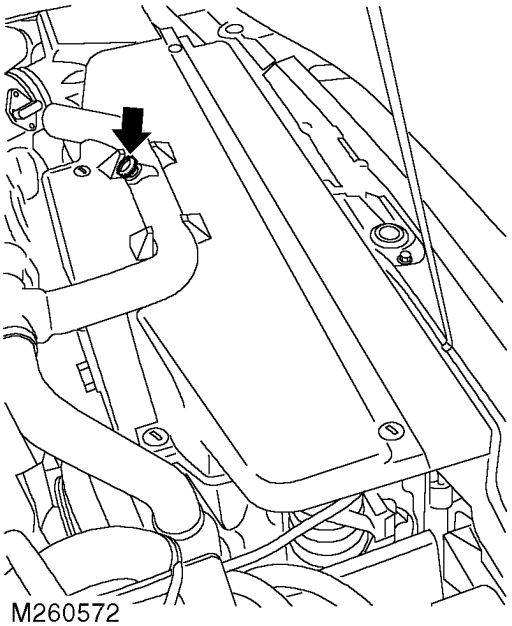
1. Visually check engine and cooling system for signs of coolant leaks.
2. Examine hoses for signs of cracking, distortion and security of connections.
3. Position drain tray to collect coolant.
4. Remove expansion tank filler cap.
5. Remove drain plug access cover from underbelly panel.


M26 0571

6. Remove drain plug from coolant pump feed pipe and allow cooling system to drain. Discard drain plug sealing washer.

Refill

1. Flush system with water under low pressure. **Do not use water under high pressure as it could damage the radiator.**
2. Fit new sealing washer to drain plug. Fit and tighten drain plug in coolant pump feed pipe.
3. Fit access cover to underbelly panel.
4. Prepare coolant to required concentration.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Anti-Freeze Concentration.**


M260572

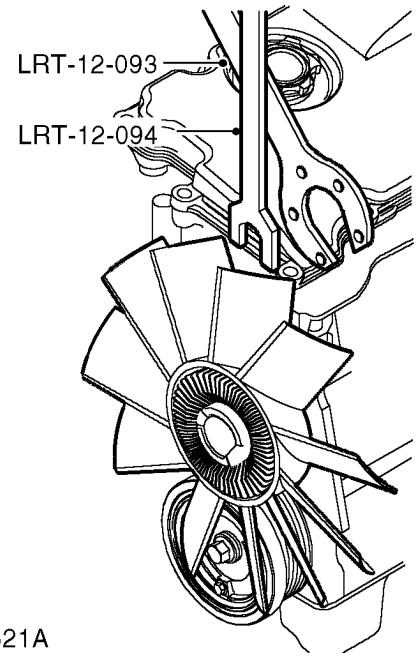
5. Remove bleed screw from top hose.
6. Unclip the bleed hose from the battery box.
7. Unclip the expansion tank from its mounting bracket, remove the expansion tank cap and raise the expansion tank vertically 10 cm (4 in). Retain the tank in this position.
8. Slowly fill the system through the coolant expansion tank until a steady flow of coolant is emitted from the bleed hole.
9. Fit the bleed screw, then, with the expansion tank still raised, continue filling the system until coolant level reaches the cold level mark on expansion tank.
10. Fit expansion tank filler cap, fit the expansion tank to its mounting bracket and clip the bleed hose to the battery box.
11. Start and run engine until normal operating temperature is reached, and check for leaks.
12. Switch off engine and allow to cool.
13. Check for leaks and top-up coolant to the cold level mark on expansion tank

Fan - viscous

26.25.19

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove 3 bolts and remove engine acoustic cover.
4. Remove upper fan cowl.



5. Remove viscous fan using tool **LRT-12-093** and tool **LRT-12-094.**
   RH thread.

Refit

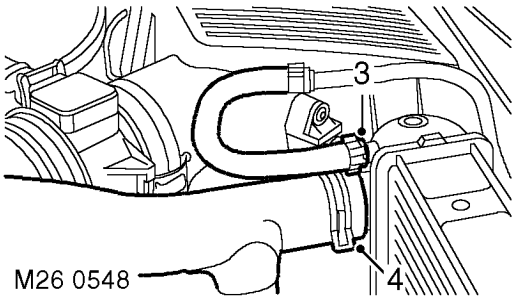
1. Position viscous fan and tighten using tool **LRT-12-093** and tool **LRT-12-094**.
2. Fit upper fan cowl.
3. Fit engine acoustic cover and tighten bolts.
4. Connect battery earth lead.
5. Fit battery cover and secure with fixings.

Radiator

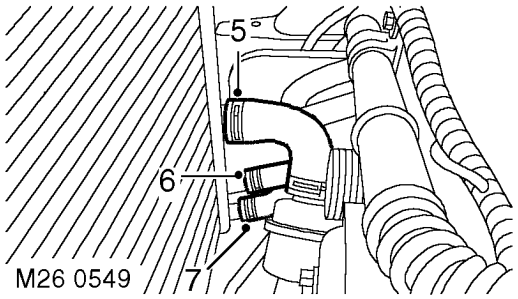
26.40.01

Remove

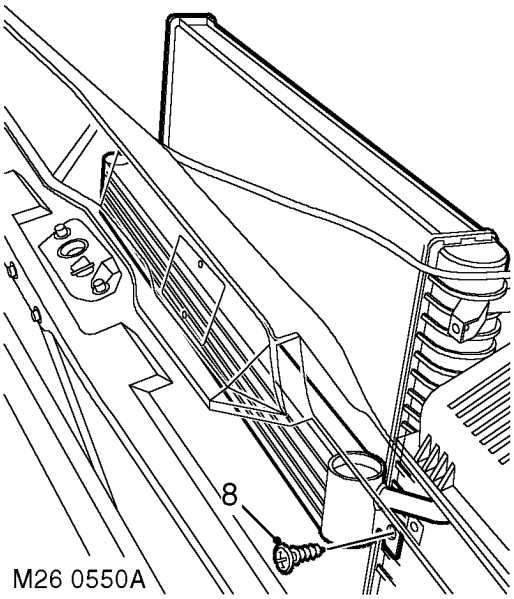
1. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
2. Remove intercooler.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.



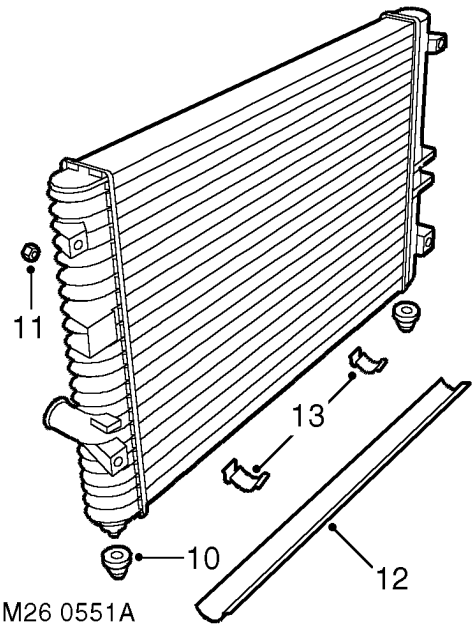
3. Remove clip and disconnect bleed hose from radiator.
4. Release clip and disconnect top hose from radiator.



5. Release clip and disconnect bottom hose from radiator.
6. Release clip and disconnect engine oil cooler hose from radiator.
7. Release clip and disconnect fuel cooler hose from radiator.



8. Remove securing screw and release gearbox oil cooler from radiator.
9. Remove radiator.



10. Remove rubber mountings from base of radiator.
11. Remove 2 captive nuts from radiator.
12. Remove sealing strip from radiator.
13. Remove cowl retaining clips from radiator.

Refit

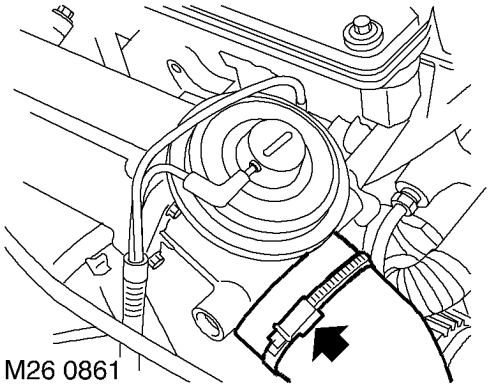
1. Fit cowl retaining clips to radiator.
2. Fit sealing strip to radiator.
3. Fit nuts and rubber mountings to new radiator.
4. Fit radiator.
5. Fit gearbox oil cooler to radiator and secure with screw.
6. Connect fuel and engine oil cooler hoses to radiator and secure with clips.
7. Connect bottom and top hoses to radiator secure with clips.
8. Connect bleed hose to radiator and fit clip.
9. Fit intercooler.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**
10. Refill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**

Thermostat

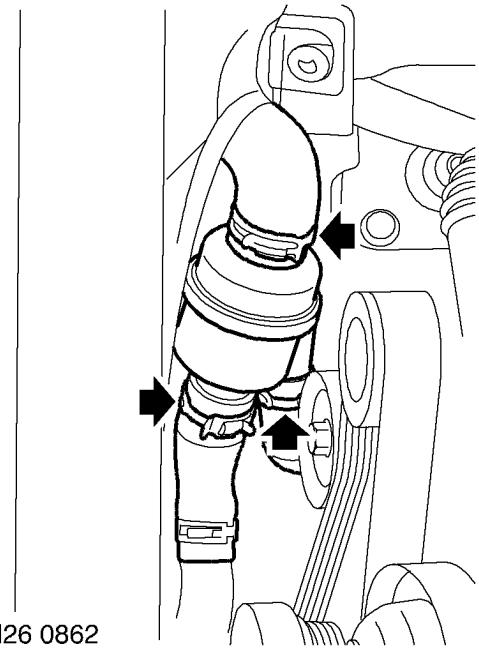
26.45.09

Remove

1. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
2. Remove viscous fan.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.


M26 0861

3. Loosen clips and release air intake hose from EGR valve.
4. Remove air intake hose.


M26 0862

5. Release 3 clips and disconnect coolant hoses from thermostat.
6. Remove thermostat.

Refit

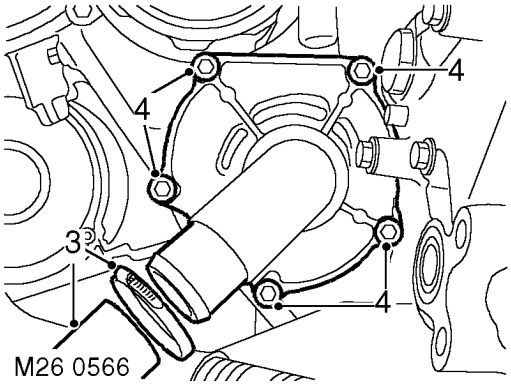
1. Position thermostat, connect hoses and secure with clips.
2. Position air intake hose to EGR valve, connect hose to intercooler and tighten clips.
3. Fit viscous fan.
   COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.
4. Refill cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.

Pump - coolant

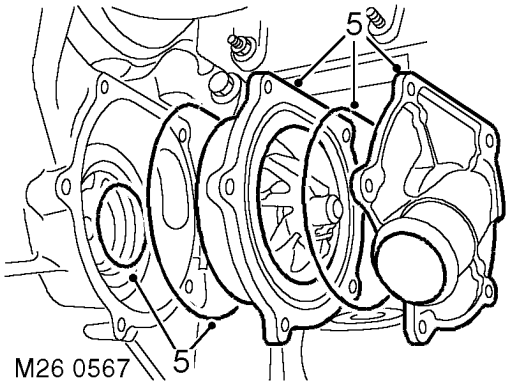
26.50.01

Remove

1. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
2. Remove centrifuge.
   ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.



3. Release clip and disconnect hose from coolant pump cover.
4. Remove 5 bolts securing coolant pump cover.

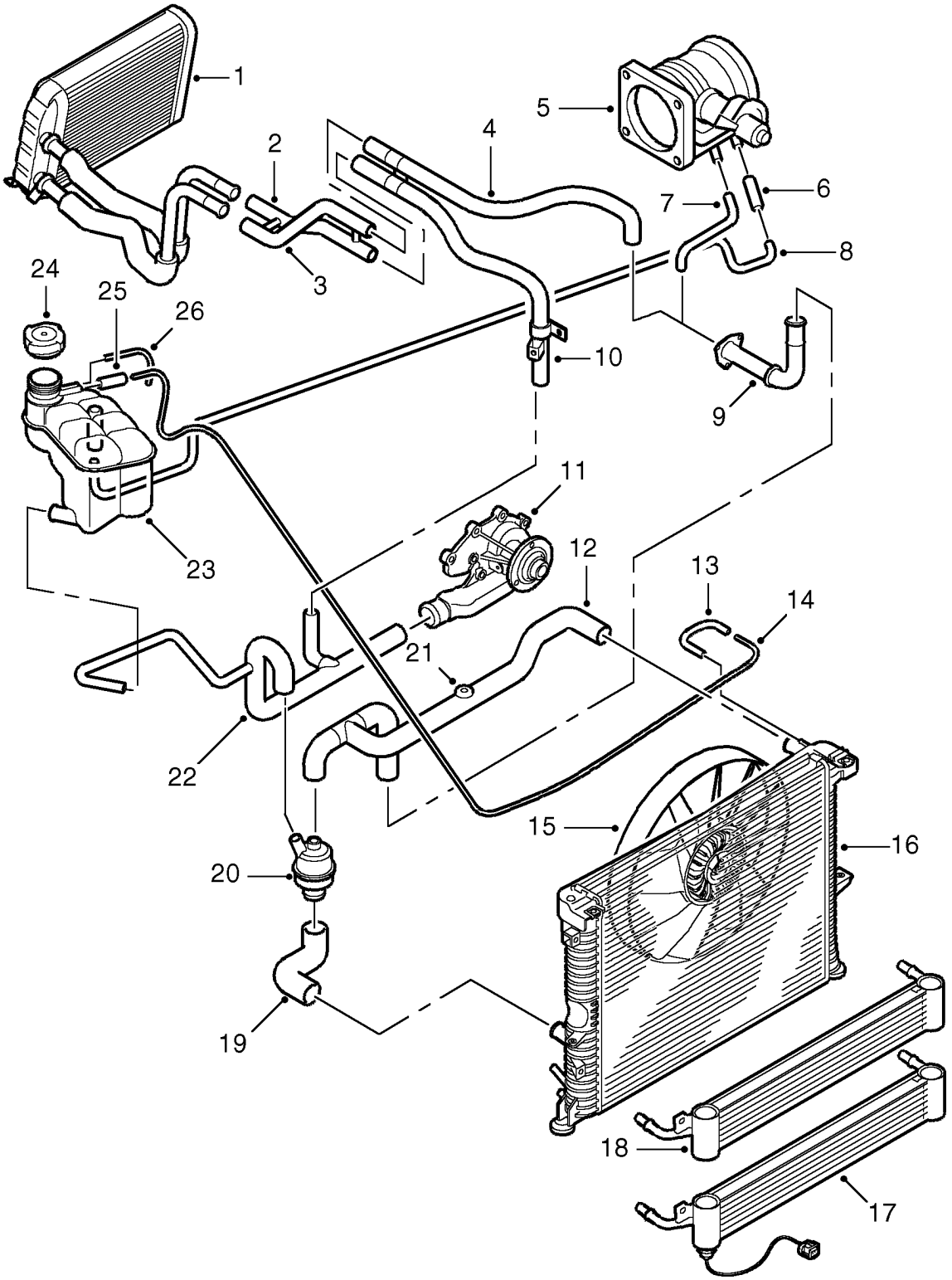


5. Remove cover and coolant pump from housing and discard 'O' rings.

Refit

1. Clean coolant pump housing and mating faces.
2. Fit new 'O' rings to coolant pump and cover.
3. Fit coolant pump and cover and tighten bolts to 9 Nm (7 lbf.ft).
4. Connect hose to pump cover and secure with clip.
5. Refit centrifuge.
   ENGINE - Td5, REPAIRS, Gasket - centrifuge oil drain pipe.
6. Refill cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.

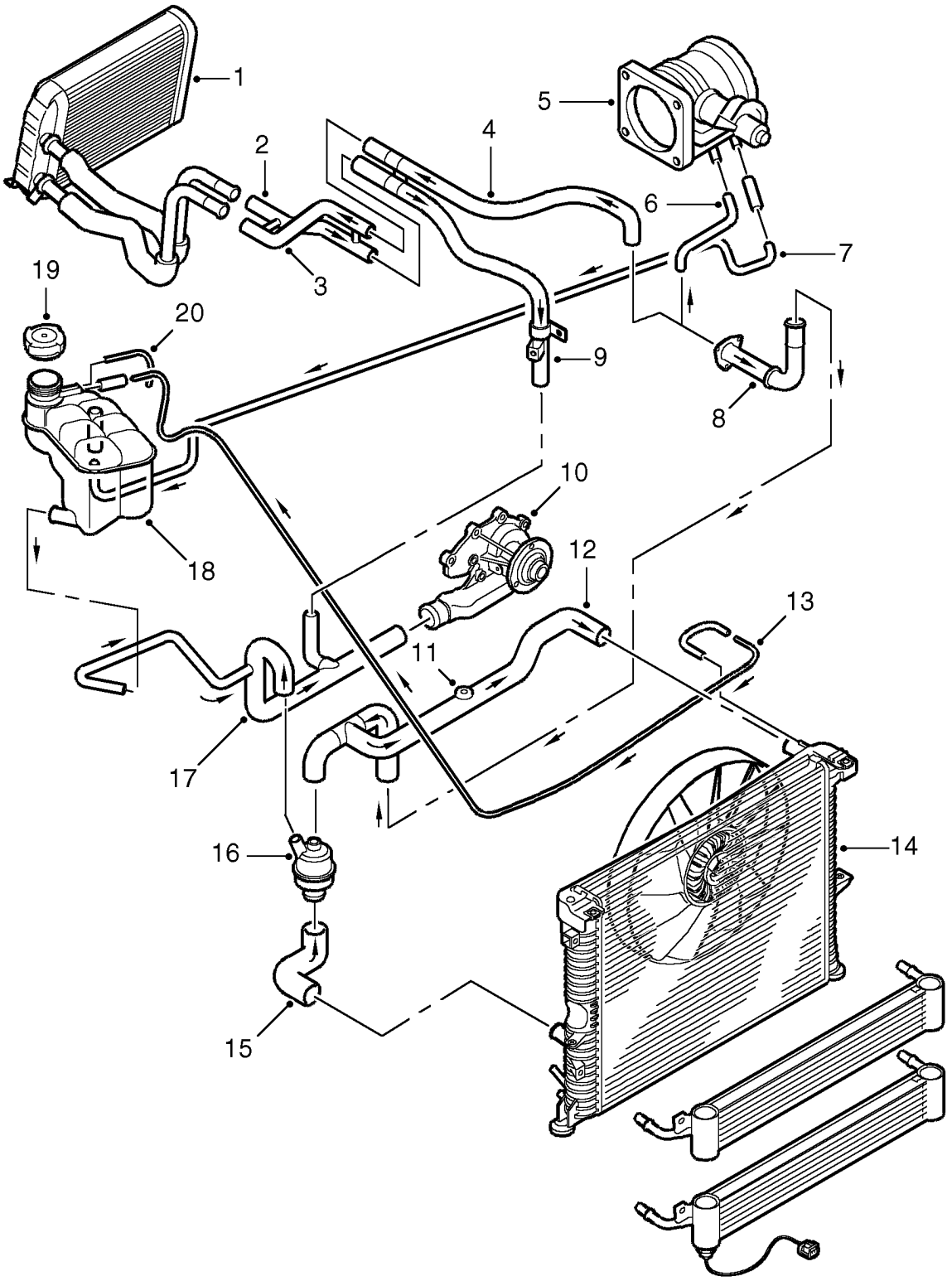
Cooling system component layout



M26 0841

1 Heater matrix
2 Heater return hose
3 Heater inlet hose
4 Heater inlet pipe
5 Throttle housing
6 Connecting hose
7 Throttle housing inlet hose
8 Throttle housing return pipe
9 Manifold outlet pipe
10 Heater return pipe
11 Coolant pump
12 Radiator top hose
13 Connecting hose
14 Radiator bleed pipe
15 Viscous fan
16 Radiator
17 Gearbox oil cooler
18 Engine oil cooler (Only applicable to vehicles up to VIN 756821)
19 Radiator bottom hose
20 Thermostat housing
21 Bleed screw
22 Coolant pump feed hose
23 Expansion tank
24 Pressure cap
25 Connecting hose
26 Overflow pipe

Cooling system coolant flow



M26 0842

1 Heater matrix
2 Heater return hose
3 Heater inlet hose
4 Heater inlet pipe
5 Throttle housing
6 Throttle housing inlet hose
7 Throttle housing return pipe
8 Manifold outlet pipe
9 Heater return pipe
10 Coolant pump
11 Bleed screw
12 Radiator top hose
13 Radiator bleed pipe
14 Radiator
15 Radiator bottom hose
16 Thermostat housing
17 Coolant pump feed hose
18 Expansion tank
19 Pressure cap
20 Overflow/breather pipe

Description

General
The cooling system used on the V8 engine is a pressure relief by-pass type system which allows coolant to circulate around the cylinder block and the heater circuit when the thermostat is closed. With coolant not passing through the radiator, this promotes faster heater warm-up which in turn improves passenger comfort.

A coolant pump is located in a housing at the front of the engine and is driven by a drive belt. The pump is connected into the coolant passages cast in the cylinder block and pumps coolant from the radiator through the cylinder block.

A viscous fan is attached by means of a nut to the coolant pump pulley drive spindle. The fan draws air through the radiator to assist in cooling when the vehicle is stationary. The fan rotational speed is controlled relative to the running temperature of the engine by a thermostatic valve regulated by a bi-metallic coil.

The cooling system uses a 50/50 mix of anti-freeze and water.

Thermostat housing
A plastic thermostat housing is located behind the radiator. The housing has three connections which locate the radiator bottom hose, top hose and coolant pump feed hose. The housing contains a wax element and a spring loaded by-pass flow valve.

Thermostat - Main valve
The thermostat is used to maintain the coolant at the optimum temperature for efficient combustion and to aid engine warm-up. The thermostat is closed at temperatures below approximately 82°C (179°F). When the coolant temperature reaches approximately 82°C the thermostat starts to open and is fully open at approximately 96°C (204°F). In this condition the full flow of coolant is directed through the radiator.

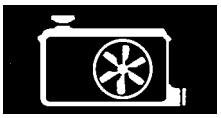
The thermostat is exposed to 90% hot coolant from the engine on one side and 10% cold coolant returning from the radiator bottom hose on the other side.

Hot coolant from the engine passes from the by-pass pipe through four sensing holes in the flow valve into a tube surrounding 90% of the thermostat sensitive area. Cold coolant returning from the engine, cooled by the radiator, conducts through 10% of the sensitive area.

In cold ambient temperatures, the engine temperature is raised by approximately 10°C (50°F) to compensate for the heat loss of 10% exposure to the cold coolant returning from the bottom hose.

By-pass flow valve
The by-pass flow valve is held closed by a light spring. It operates to further aid heater warm-up. When the main valve is closed and the engine speed is at idle, the coolant pump does not produce sufficient flow and pressure to open the valve. In this condition the valve prevents coolant circulating through the by-pass circuit and forces the coolant through the heater matrix only. This provides a higher flow of coolant through the heater matrix to improve passenger comfort in cold conditions.

When the engine speed increases above idle the coolant pump produces a greater flow and pressure than the heater circuit can take. The pressure acts on the flow valve and overcomes the valve spring pressure, opening the valve and limiting the pressure in the heater circuit. The valve modulates to provide maximum coolant flow through the heater matrix and yet allowing excess coolant to flow into the by-pass circuit to provide the engine's cooling needs at higher engine rev/min.



Inlet manifold - Cooling connections

Coolant leaves the cylinder block via an outlet pipe attached to the front of the air intake manifold. The pipe is connected to the thermostat housing and the radiator by a branch hose off the radiator top hose.

Hot coolant from the engine is also directed from the inlet manifold via pipes and hoses into the heater matrix. Coolant is circulated through the heater matrix at all times when the engine is running.

A further tapping from the inlet manifold supplies coolant to the throttle housing via a hose. The coolant circulates through a plate attached to the bottom of the housing and is returned through a plastic bleed pipe to an expansion tank. The hot coolant heats the air intake of the throttle housing preventing ice from forming.

An Engine Coolant Temperature (ECT) sensor is fitted in the inlet manifold adjacent to the manifold outlet pipe. The sensor monitors coolant temperature emerging from the engine and sends signals to the ECM for engine management and temperature gauge operation.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Expansion tank

The expansion tank is located in the engine compartment. The tank is made from moulded plastic and attached to brackets on the right hand inner wing. A maximum coolant when cold level is moulded onto the tank.

Excess coolant created by heat expansion is returned to the expansion tank from the radiator bleed pipe at the top of the radiator. An outlet pipe is connected into the pump feed hose and replaces the coolant displaced by heat expansion into the system when the engine is cool.

The expansion tank is fitted with a sealed pressure cap. The cap contains a pressure relief valve which opens to allow excessive pressure and coolant to vent through the overflow pipe. The relief valve opens at a pressure of 1.4 bar (20 lbf.in^2) and above.

Heater matrix

The heater matrix is fitted in the heater assembly inside the passenger compartment. Two pipes pass through the bulkhead into the engine compartment and provide coolant flow to and from the matrix. The pipes from the bulkhead are connected to the matrix, sealed with 'O' rings and clamped with circular rings.

The matrix is constructed from aluminium with two end tanks interconnected with tubes. Aluminium fins are located between the tubes and conduct heat away from the hot coolant flowing through the tubes. Air from the heater assembly is warmed as it passes through the matrix fins. The warm air is then distributed into the passenger compartment as required.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**When the engine is running, coolant from the engine is constantly circulated through the heater matrix.

Radiator

The 45 row radiator is located at the front of the vehicle. The cross-flow type radiator is manufactured from aluminium with moulded plastic end tanks interconnected with tubes. Aluminium fins are located between the tubes and conduct heat from the hot coolant flowing through the tubes, reducing the cooling temperature as it flows through the radiator. Air intake from the front of the vehicle when moving carries heat away from the fins. When the vehicle is stationary, the viscous fan draws air through the radiator fins to prevent the engine from overheating.

Two connections at the top of the radiator provide for the attachment of the top hose and bleed pipe. A connection at the bottom of the radiator allows for the attachment of the bottom hose to the thermostat housing.

Two smaller radiators are located in front of the cooling radiator. The lower radiator provides cooling of the gearbox oil and the upper radiator provides cooling for the engine oil.

☞ **MANUAL GEARBOX - R380, DESCRIPTION AND OPERATION, Description.**

☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Description.**

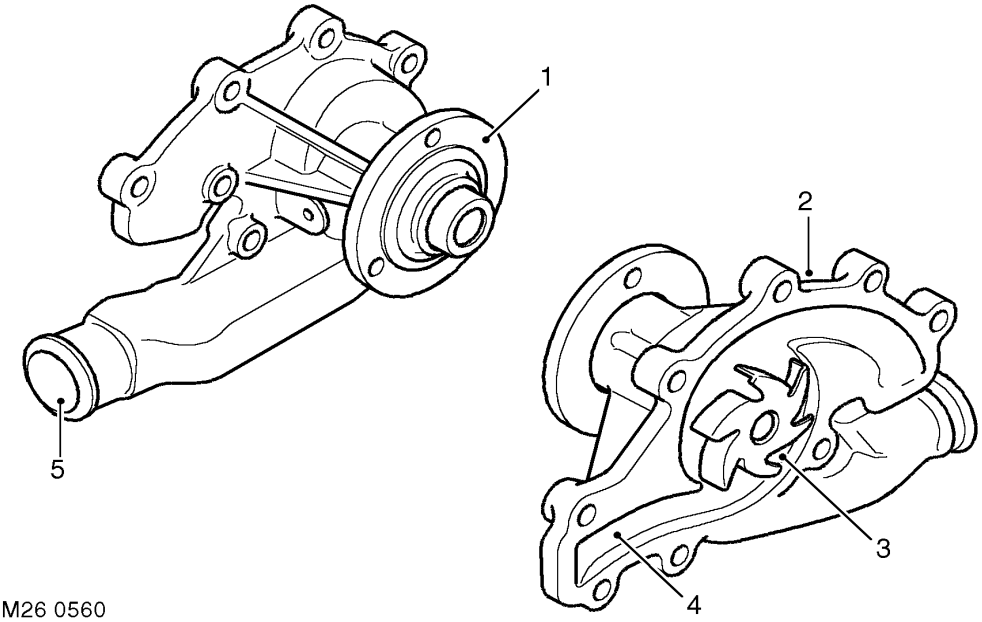
☞ **ENGINE - V8, DESCRIPTION AND OPERATION, Description.**

Pipes and hoses

The coolant circuit comprises flexible hoses and metal formed pipes which direct coolant into and out of the engine, radiator and heater matrix. Plastic pipes are used for the bleed and overflow pipes to the expansion tank.

A bleed screw is installed in the radiator top hose and is used to bleed air during system filling. A drain plug is fitted to each cylinder bank in the cylinder block. These are used to drain the block of coolant.

Coolant pump



M26 0560

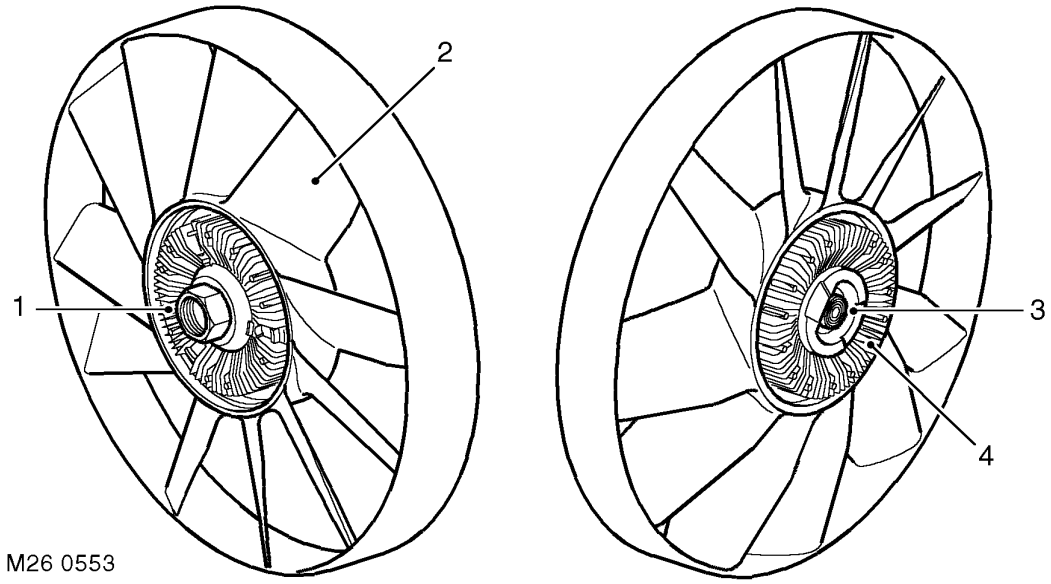
1 Pulley flange
2 Body
3 Impeller
4 Gallery
5 Inlet connection

The coolant pump is attached to the front of the cylinder block with nine bolts and sealed between the pump housing and the cylinder block with a gasket. The pump comprises a shaft which passes through an alloy housing. The outer end of the shaft has a flange which allows for the attachment of the pump drive pulley which is secured with three bolts. The drive pulley is driven by the grooved auxiliary drive belt and rotates at the same speed as the crankshaft. The inner end of the shaft is fitted with an impeller which draws coolant from the thermostat housing and circulates it through the galleries in the cylinder block and through the heater matrix.

The shaft is supported on bearings in the housing which are packed with grease and sealed for life. A seal is positioned in the housing to further protect the bearings from the ingress of coolant. The seal is manufactured from a synthetic material which will allow for expansion of the casing when hot coolant is present.

The cast alloy housing has a hose connection which provides the attachment for the coolant pump feed hose. The cast housing connects with galleries in the cylinder block and distributes coolant from the pump impeller into the galleries and water jackets.

Viscous fan



1 Coolant pump pulley drive attachment
2 Fan blades
3 Bi-metallic coil
4 Body

The viscous fan provides a means of controlling the speed of the fan relative to the operating temperature of the engine. The fan rotation draws air through the radiator, reducing engine coolant temperatures when the vehicle is stationary or moving slowly.

The viscous fan is attached to the coolant pump drive pulley and secured to the pulley by a nut. The nut is positively attached to a spindle which is supported on bearings in the fan body. The viscous drive comprises a circular drive plate attached to the spindle and driven from the coolant pump pulley and the coupling body. The drive plate and the body have interlocking annular grooves with a small clearance which provides the drive when silicone fluid enters the fluid chamber. A bi-metallic coil is fitted externally on the forward face of the body. The coil is connected to and operates a valve in the body. The valve operates on a valve plate with ports that connect the reservoir to the fluid chamber. The valve plate also has return ports which, when the valve is closed, scoop fluid from the fluid chamber and push it into the reservoir under centrifugal force.

Silicone fluid is retained in a reservoir at the front of the body. When the engine is off and the fan is stationary, the silicone fluid level stabilises between the reservoir and the fluid chamber. This will result in the fan operating when the engine is started, but the drive will be removed quickly after the fan starts rotating and the fan will 'freewheel'.

At low radiator temperatures, the fan operation is not required and the bi-metallic coil keeps the valve closed, separating the silicone fluid from the drive plate. This allows the fan to 'freewheel' reducing the load on the engine, improving fuel consumption and reducing noise generated by the rotation of the fan.

When the radiator temperature increases, the bi-metallic coil reacts and moves the valve, allowing the silicone fluid to flow into the fluid chamber. The resistance to shear of the silicone fluid creates drag on the drive plate and provides drive to the body and the fan blades.

Operation

Coolant flow - Engine warm up
Refer to illustration.
☞ **COOLING SYSTEM - V8, DESCRIPTION AND OPERATION, Cooling system coolant flow.**

During warm-up the coolant pump moves fluid through the cylinder block and it emerges from the inlet manifold outlet pipe. From the outlet pipe, the warm coolant flow is prevented from flowing through the radiator because the thermostat is closed. The coolant is directed into the heater circuit.

Some coolant from the by-pass pipe can pass through small sensing holes in the flow valve. The warm coolant enters a tube in the thermostat housing and surrounds 90% of the thermostat sensitive area. Cold coolant returning from the radiator bottom hose conducts through 10% of the thermostat sensitive area. In cold ambient temperatures the engine temperature can be raised by up to 10°C (50°F) to compensate for the heat loss of the 10% exposure to the cold coolant returning from the radiator bottom hose.

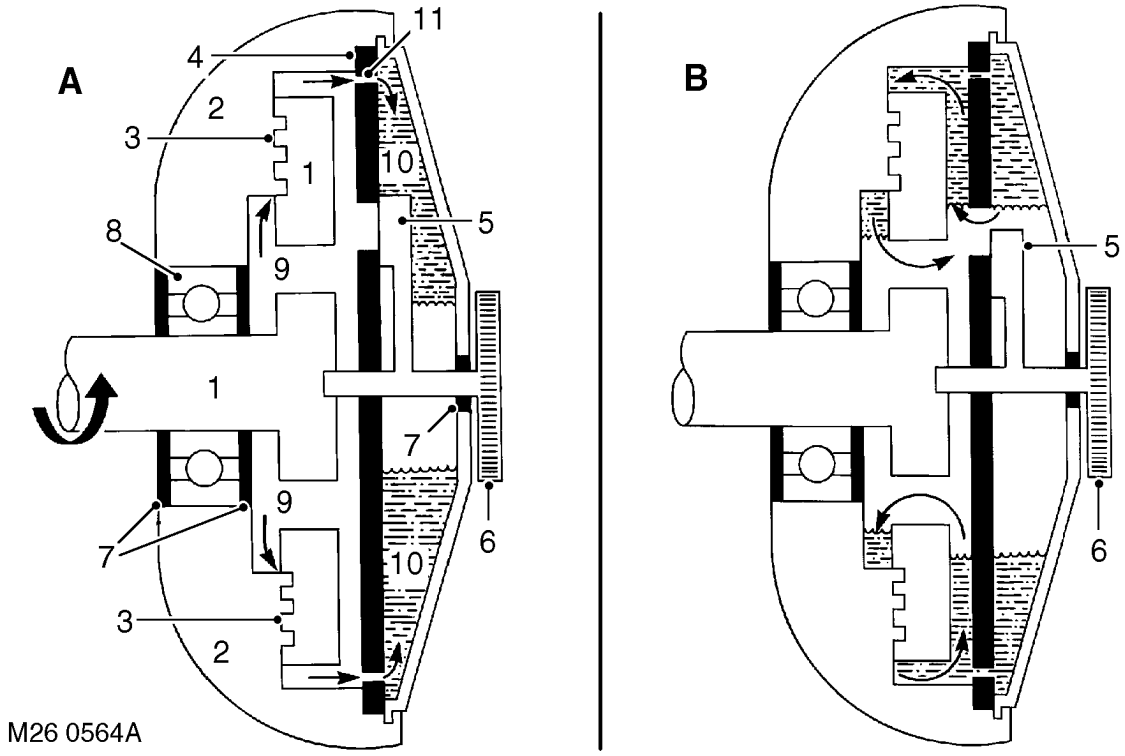
At engine idle speed, the by-pass valve is closed only allowing the small flow through the sensing holes. As the engine speed increases above idle, the greater flow and pressure from the pump overcomes the light spring and opens the by-pass flow valve. The flow valve opens to meet the engines cooling needs at higher engine speeds and prevents excess pressure in the system. With the thermostat closed, maximum flow is directed through the heater circuit.

The heater matrix acts as a heat exchanger reducing coolant temperature as it passes through the matrix. Coolant emerges from the matrix and flows into the coolant pump feed pipe and recirculated around the heater circuit. In this condition the cooling system is operating at maximum heater performance.

Coolant flow - Engine hot
As the coolant temperature increases the thermostat opens. This allows some coolant from the outlet housing to flow through the top hose and into the radiator to be cooled. The hot coolant flows from the left tank in the radiator, along the tubes to the right tank. The air flowing through the fins between the tubes cools the coolant as it passes through the radiator.

A controlled flow of the lower temperature coolant is drawn by the pump and blended with hot coolant from the by-pass and the heater return pipes in the pump feed pipe. The pump then passes this coolant into the cylinder block to cool the cylinders.

Viscous fan operation



***A** = Cold, **B** = Hot*

1 Drive plate
2 Fan body
3 Clearance
4 Valve plate
5 Valve
6 Bi-metallic coil
7 Fluid seals
8 Ball race
9 Fluid chamber
10 Reservoir
11 Return port

When the engine is off and the fan is not rotating, the silicone fluid stabilises within the fluid chamber and the reservoir. The fluid levels equalise due to the return port in the valve plate being open between the fluid chamber and the reservoir. In this condition, when the engine is started, silicone fluid is present in the fluid chamber and causes drag to occur between the drive plate and the body. This causes the fan to operate initially when the engine is started.

As the fan speed increases, centrifugal force and a scoop formed on the fluid chamber side of the valve plate, pushes the silicone fluid through the return port in the valve plate into the reservoir. As the fluid chamber empties, the drag between the drive plate and body is reduced, causing the drive plate to slip. This reduces the rotational speed of the fan and allows it to 'freewheel'.

When the coolant temperature is low, the heat emitted from the radiator does not affect the bi-metallic coil. The valve remains closed, preventing fluid escaping from the reservoir into the fluid chamber. In this condition the fan will 'freewheel' at a slow speed.

As the coolant temperature increases, the heat emitted from the radiator causes the bi-metallic coil to tighten. This movement of the coil moves the valve to which it is attached. The rotation of the valve exposes ports in the valve plate which allow silicone fluid to spill into the fluid chamber. As the fluid flows into the clearance between the annular grooves in the drive plate and body, drag is created between the two components. The drag is due to the viscosity and shear qualities of the silicone fluid and cause the drive plate to rotate the body and fan blades.

As the coolant temperature decreases, the bi-metallic coil expands, rotating the valve and closing off the ports in the valve plate. When the valve is closed, centrifugal force pushes silicone fluid through the return port, emptying the fluid chamber. As the fluid chamber empties, the drag between the drive plate and the body is reduced and the body slips on the drive plate, slowing the rotational speed of the fan.

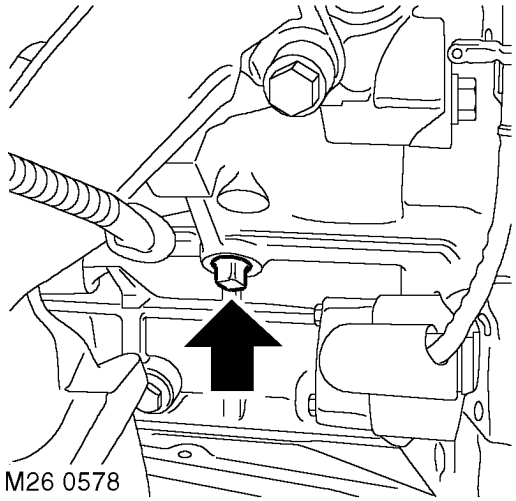
Drain and refill

26.10.01

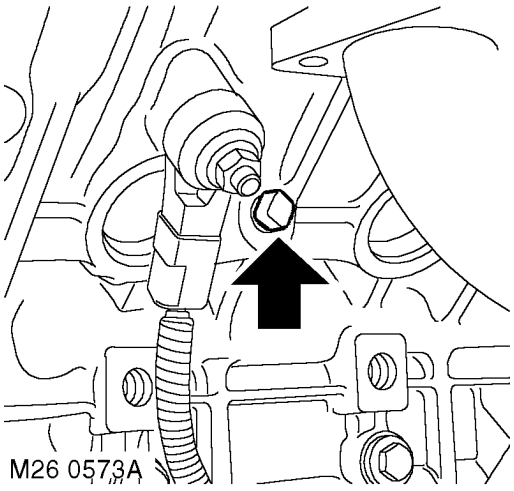
WARNING: Since injury such as scalding could be caused by escaping steam or coolant, do not remove the filler cap from the coolant expansion tank while the system is hot.

Drain

1. Visually check engine and cooling system for signs of coolant leaks.
2. Examine hoses for signs of cracking, distortion and security of connections.
3. Position drain tray to collect coolant.
4. Remove expansion tank filler cap.

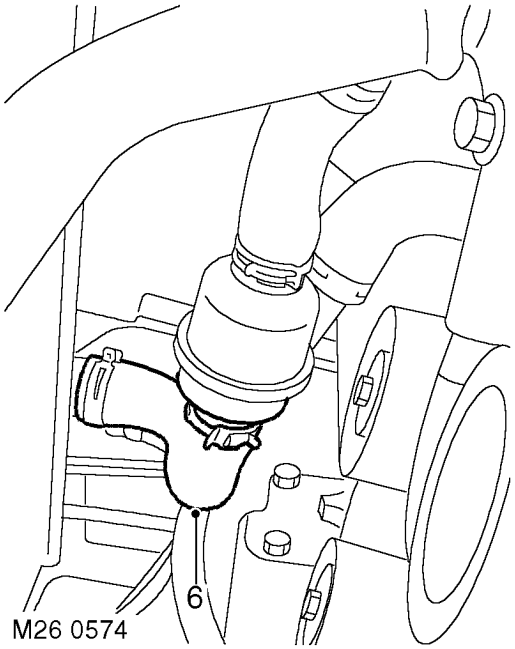


LH side



RH side

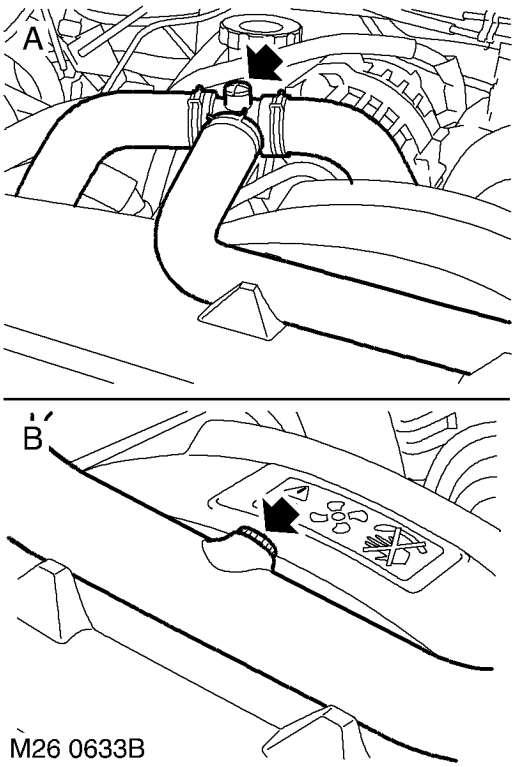
5. Remove drain plugs from LH and RH sides of cylinder block and allow cooling system to drain.



6. Disconnect bottom hose from radiator and allow cooling system to drain.
7. Disconnect top hose from thermostat and position open end of hose below level of coolant pump inlet, to allow coolant to drain from the system.

Refill

1. Flush system with water under low pressure. **Do not use water under high pressure as it could damage the radiator.**
2. Apply Loctite 577 to cylinder block drain plugs.Fit drain plugs to cylinder block and tighten to 30 Nm (22 lbf.ft).
3. Connect bottom hose to radiator and top hose to thermostat housing. Secure with hose clips.
4. Prepare coolant to required concentration.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Anti-Freeze Concentration.**



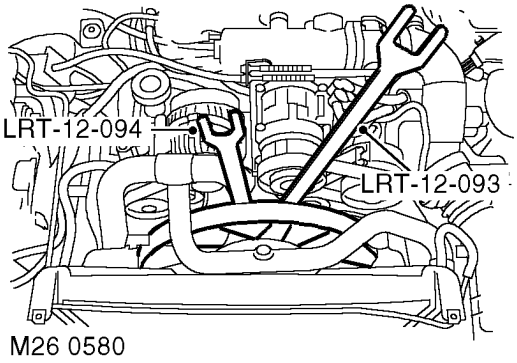
5. Release top hose from retaining lugs on the fan cowl, leaving the hose to rest on the lugs.
6. Remove bleed screw from top hose.
   - **'A'** From 03 MY
   - **'B'** Up to 03 MY
7. Unclip the bleed hose from the battery box.
8. Remove expansion tank from its mounting bracket. Slowly fill the expansion tank with coolant, approx. 4 litres (7 pt).
9. Raise the expansion tank approx. 20 cm (8 in) vertically, coolant will drain into the system.
10. Refill the coolant expansion tank until a steady flow of coolant is emitted from the bleed hole.
11. Fit the bleed screw then, with the expansion tank still raised, continue filling the system until the coolant level reaches the base of the expansion tank filler neck.
12. Fit expansion tank filler cap, fit the expansion tank to its mountings and clip the bleed hose to the battery box.
13. Refit the top hose into its lugs on the fan cowl.
14. Start and run engine until normal operating temperature is reached, and check for leaks.
15. Switch off engine and allow to cool.
16. Check for leaks and top-up coolant to cold level mark on expansion tank

Fan - viscous

26.25.19

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove upper fan cowl.



M26 0580

4. Remove viscous fan using tool **LRT-12-093** and tool **LRT-12-094.**
   RH thread.

Refit

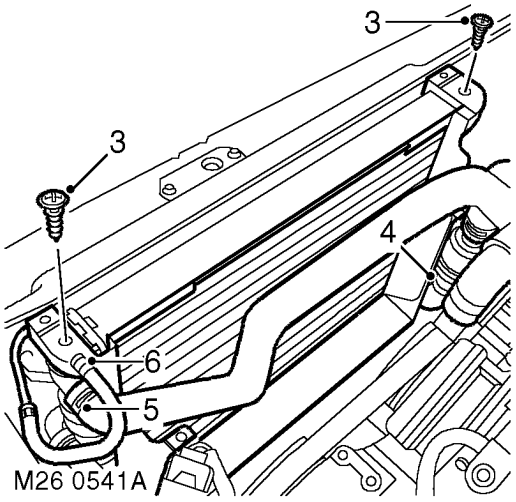
1. Position viscous fan and tighten using tool **LRT-12-093** and tool **LRT-12-094**.
2. Fit upper fan cowl.
3. Connect battery earth lead.
4. Fit battery cover and secure fixings.

Radiator

26.40.01

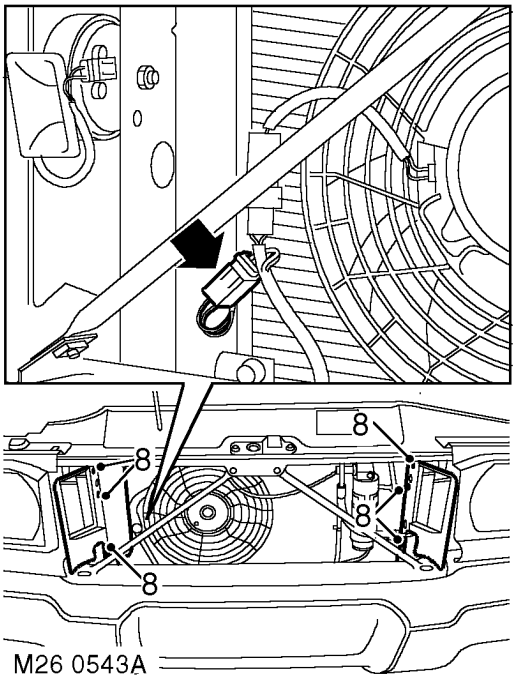
Remove

1. Remove viscous fan.
   COOLING SYSTEM - V8, REPAIRS, Fan - viscous.
2. Drain cooling system.
   COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.

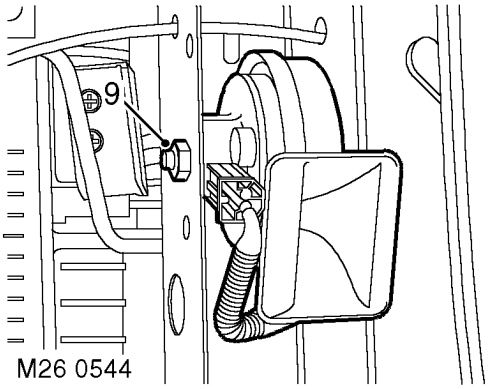


M26 0541A

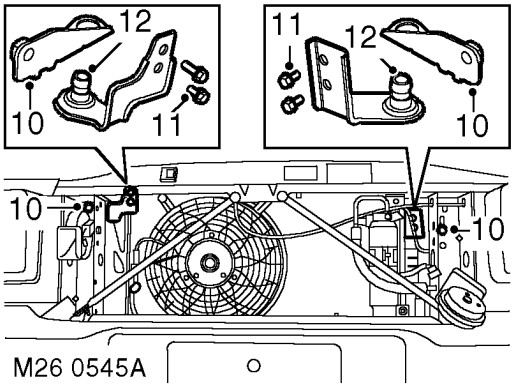
3. Remove 2 screws and remove lower of fan cowl.
4. Release clip and disconnect bottom hose from thermostat housing.
5. Release clip and disconnect top hose from radiator.
6. Remove clip and disconnect bleed hose from radiator.
7. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



8. Remove 6 scrivets and remove LH and RH air deflectors from front panel. Disconnect multiplug of gearbox oil temperature sensor (arrowed).



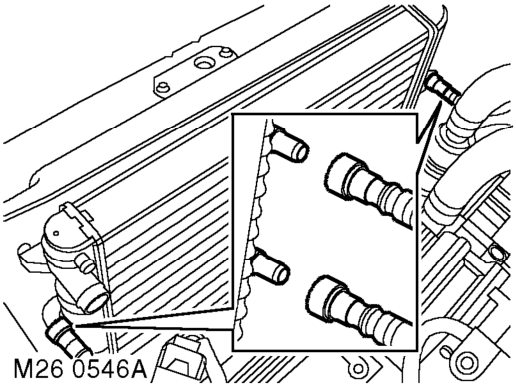
9. Remove nut and move horn aside.



10. Remove 2 bolts securing radiator LH and RH upper mounting brackets to body panel and remove brackets.

11. Remove 4 screws securing air conditioning condenser LH and RH upper mounting brackets to condenser.

12. Remove brackets with rubber mounts from radiator extension brackets.

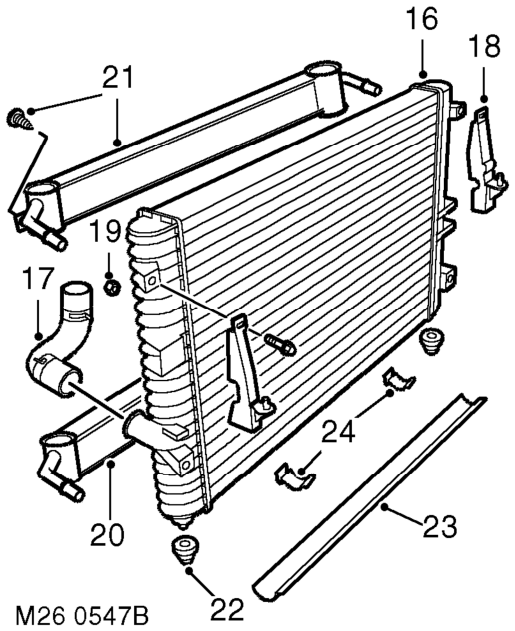


13. Position absorbent cloth under each cooler hose to collect oil spillage.

14. Push against coupling release rings and disconnect hoses from gearbox oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.

15. **If fitted:** Push against coupling release rings and disconnect hoses from engine oil cooler.



16. Remove radiator assembly.
17. Release clip and remove bottom hose from radiator.
18. Remove 2 bolts and remove extension brackets from radiator.
19. Remove 2 captive nuts from radiator.
20. Remove 2 screws and remove gearbox oil cooler from radiator.
21. **If fitted:** Remove 2 screws and remove engine oil cooler from radiator.
22. Remove 2 rubber mountings from radiator.
23. Remove sealing strip from bottom of radiator.
24. Remove 2 cowl retaining clips from radiator.

Refit

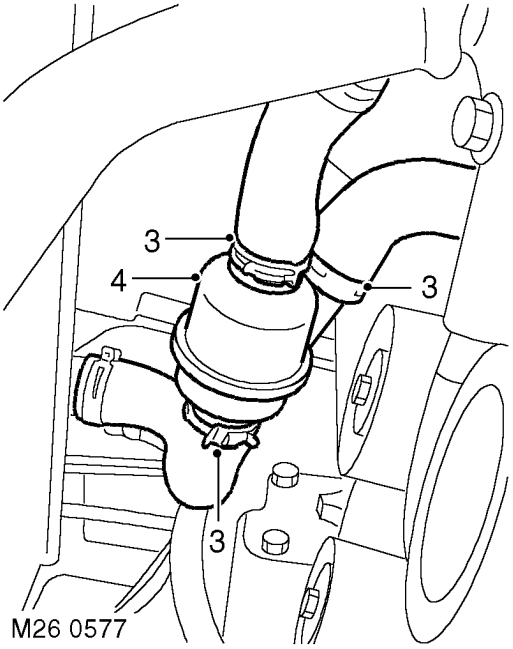
1. Fit cowl retaining clips to radiator.
2. Fit sealing strip to radiator.
3. Fit rubber mountings to radiator.
4. Fit gearbox oil cooler to radiator and secure with screws.
5. **If fitted:** Fit engine oil cooler to radiator and secure with screws.
6. Fit captive nuts to radiator.
7. Fit extension brackets to radiator and secure with bolts.
8. Fit bottom hose to radiator and secure with clip.
9. Fit radiator and engage lower mountings in chassis.
10. Ensure connections are clean, then secure hoses to oil coolers.
11. Fit air conditioning condenser brackets and secure with screws.
12. Fit radiator upper mounting brackets and secure with bolts.
13. Fit LH horn and secure with nut.
14. Fit air deflectors and secure with scrivets.
15. Connect multiplug of gearbox oil temperature sensor.
16. Fit front grille.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**
17. Connect bottom hose to thermostat housing and secure with clip.
18. Connect top hose to radiator and secure with clip.
19. Connect bleed hose to radiator and fit clip.
20. Fit lower fan cowl and secure with screws.
21. Fit viscous fan.
    ☞ **COOLING SYSTEM - V8, REPAIRS, Fan - viscous.**
22. Top up gearbox oil.
23. Top up engine oil.
24. Refill cooling system.
    ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Thermostat

26.45.09

Remove

1. Drain cooling system.
   COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.
2. Remove viscous fan.
   COOLING SYSTEM - V8, REPAIRS, Fan - viscous.



M26 0577

3. Release 3 clips and disconnect coolant hoses from thermostat.
4. Remove thermostat.

Refit

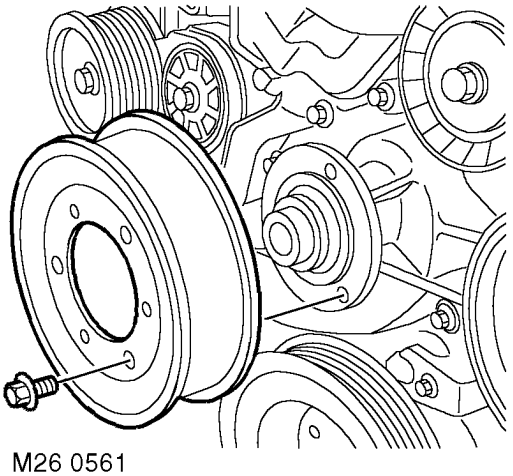
1. Position thermostat, connect hoses and secure with clips.
2. Fit viscous fan.
   COOLING SYSTEM - V8, REPAIRS, Fan - viscous.
3. Refill cooling system.
   COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.

Gasket - coolant pump

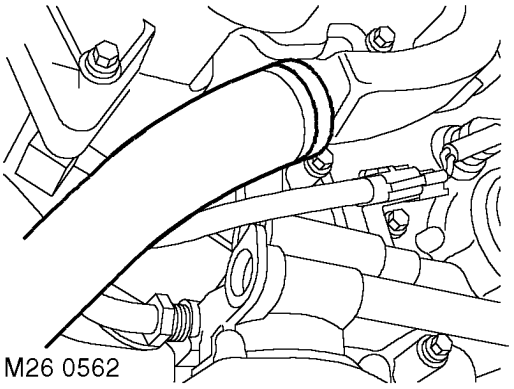
26.50.02

Remove

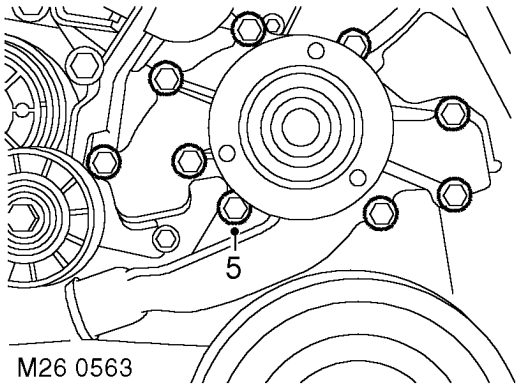
1. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.
2. Drain cooling system.
   COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.


M26 0561

3. Remove 3 bolts securing pulley to coolant pump and remove pulley.


M26 0562

4. Release clip and disconnect feed hose from coolant pump.

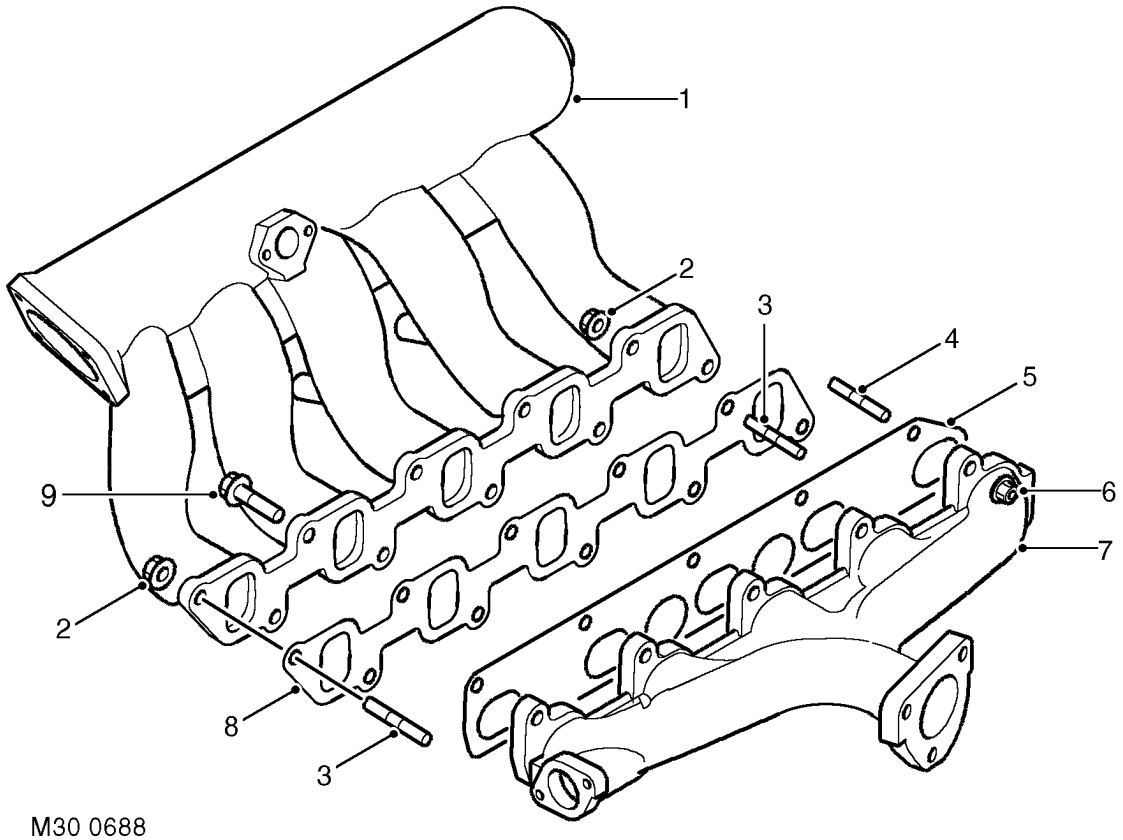


5. Remove 9 bolts securing coolant pump, remove pump and discard gasket.

Refit

1. Clean coolant pump and mating face.
2. Fit new gasket and coolant pump to cylinder block. Fit bolts and tighten to 24 Nm (18 lbf.ft).
3. Connect feed hose to coolant pump and secure with clip.
4. Ensure mating faces of coolant pump pulley and flange are clean. Fit pulley and tighten bolts to 22 Nm (16 lbf.ft).
5. Fit auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
6. Refill cooling system.
   ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

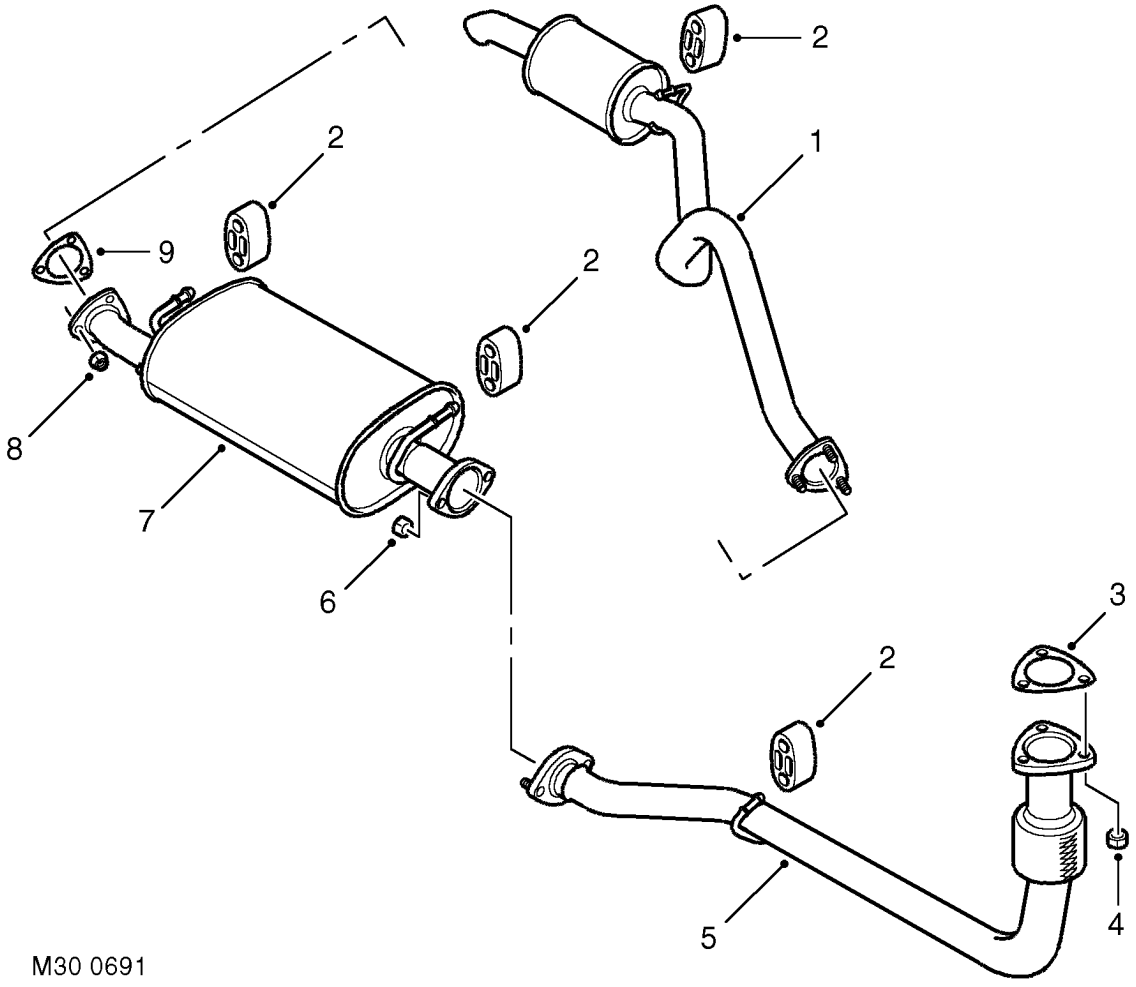
Manifold component layout



M30 0688

1 Inlet manifold
2 Flanged nut 2 off
3 Stud 2 off
4 Stud 10 off
5 Exhaust gasket
6 Flanged nut 10 off
7 Exhaust manifold
8 Inlet gasket
9 Flanged bolt 8 off

Exhaust system component layout



M30 0691

1 Tail pipe/silencer assembly
2 Mounting rubber 4 off
3 Turbo/Exhaust manifold gasket
4 Flanged nut 3 off
5 Front pipe assembly
6 Flanged nut 2 off
7 Intermediate pipe/silencer assembly
8 Flanged nut 3 off
9 Gasket

Description

General

The diesel engine has the inlet manifold attached to the right hand side of the engine and the exhaust manifold attached to the left hand side of the engine. The inlet manifold directs cooled compressed air from the turbocharger and intercooler into the cylinders, where it is mixed with fuel from the injectors. Exhaust gases from the exhaust manifold can also be directed into the inlet manifold via a pipe from the exhaust manifold and an Exhaust Gas Recirculation (EGR) valve on the inlet manifold. The exhaust manifold allows combustion gases from the cylinders to leave the engine where they are directed into the exhaust system and turbocharger.

The exhaust system is attached to the turbocharger and is directed along the underside of the vehicle to emit exhaust gases from a tail pipe at the rear of the vehicle. A silencer is installed midway along the system and a second tail silencer is located at the rear of the vehicle.

Inlet manifold

The inlet manifold is a one piece aluminium casting. The manifold is secured to the cylinder head with two studs and flanged nuts and eight flanged bolts. A one piece laminated gasket seals the manifold to the cylinder head.

Four threaded bosses on the manifold provide for the attachment of the fuel cooler. The fuel cooler is secured to the manifold with four bolts. A boss with two threaded holes allows for the attachment of the combined intake air temperature/pressure sensor. The sensor is secured to the manifold with two screws and sealed with a gasket.

At the forward end of the manifold, a machined face and four threaded holes provide for the attachment of the EGR valve. The valve is sealed to the manifold with a gasket.

☞ **EMISSION CONTROL - Td5, DESCRIPTION AND OPERATION, Emission Control Systems.**

Exhaust manifold

The exhaust manifold is made from cast iron. The manifold has five ports, one from each cylinder, which merge into one flanged outlet connection positioned centrally on the manifold.

The manifold is attached to the cylinder head with ten studs and flanged nuts. A laminated metal gasket seals the manifold to the cylinder head. The flanged outlet on the manifold provides the attachment for the turbocharger, which is attached with three studs and flanged nuts and sealed with a metal laminated gasket.

A second flanged outlet, located at the forward end of the manifold, provides attachment for the EGR pipe. The EGR pipe is secured to the manifold with two cap screws and connected to the EGR valve mounted on the inlet manifold. There is no gasket used between the pipe and the exhaust manifold.

☞ **EMISSION CONTROL - Td5, DESCRIPTION AND OPERATION, Emission Control Systems.**

Exhaust system

The exhaust system comprises a front pipe, an intermediate pipe which incorporates a silencer and a tail pipe assembly which also has a silencer. The exhaust system is constructed mainly of 63 mm (2.48 in) diameter extruded pipe with a 1.5 mm (0.06 in) wall thickness. All pipes are aluminized to resist corrosion and the silencers are fabricated from stainless steel sheet.

Front pipe assembly

The front pipe is of welded and fabricated tubular construction. The front pipe is connected to a flange on the turbocharger and secured with three flanged nuts and sealed with a metal laminated gasket. The front pipe incorporates a flexible pipe near the connection with the turbocharger and terminates in a flanged connection with the intermediate pipe.

The flexible pipe is formed into a concertina shape with woven metal strands around its outer diameter. The flexible pipe allows for ease of exhaust system alignment and also absorbs engine vibration. The woven metal strands also increase the longevity of the flexible pipe.

The front pipe is attached via a bracket and a mounting rubber to the chassis. The mounting rubber allows ease of alignment and vibration absorption.

Intermediate pipe and silencer

The intermediate pipe is of welded and fabricated tubular construction. It connects at its forward end to the front pipe flange. Two captive studs on the intermediate pipe flange allow for attachment to the front pipe with locknuts. The rear section of intermediate pipe connects to the tail pipe assembly via a flanged joint, sealed with a metal gasket and secured with locknuts and studs.

The forward and rear sections are joined by a silencer. The silencer is fabricated from stainless steel sheet to form the body of the silencer. An end plate closes each end of the silencer and is attached to the body with seam joints. Perforated baffle tubes, inside the silencer, are connected to the inlet and outlet pipes on each end plate. Internal baffle plates support the baffle tubes and, together with a stainless steel fibre packing, absorb combustion noise as the exhaust gases pass through the silencer.

The intermediate pipe is attached by two brackets, positioned at each end of the silencer, and two mounting rubbers to the chassis. The mounting rubber allows for ease of alignment and vibration absorption.

Tail pipe assembly

The tail pipe is of welded and fabricated construction. The tail pipe connects to the intermediate pipe with a flanged joint secured with locknuts and sealed with a metal gasket. The pipe is shaped to locate above the rear axle allowing clearance for axle articulation. The pipe is also curved to clear the left hand side of the fuel tank which has a reflective shield to protect the tank from heat generated from the pipe.

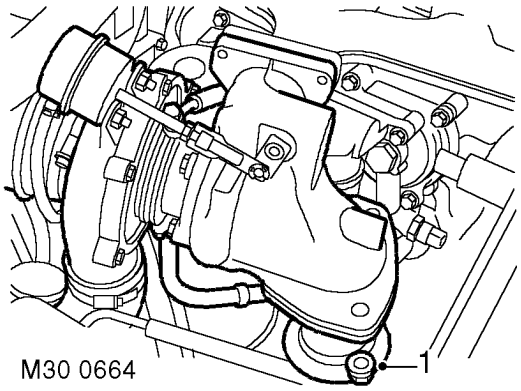
A fabricated silencer is located at the rear of the tail pipe. The silencer is circular in section and is constructed from stainless steel sheet. A baffle tube is located inside the silencer and the space around the baffle tube is packed with a stainless steel fibre. The holes in the baffle tube allow the packing to further reduce combustion noise from the engine. The tail pipe from the silencer is curved downwards at the rear of the vehicle and directs exhaust gases towards the ground. The curved pipe allows the exhaust gases to be dissipated by the airflow under the vehicle and prevents the gases from being drawn behind the vehicle.

The tail pipe is attached by a bracket, positioned forward of the silencer, and a mounting rubber to the chassis. The mounting rubber allows ease of alignment and vibration absorption.

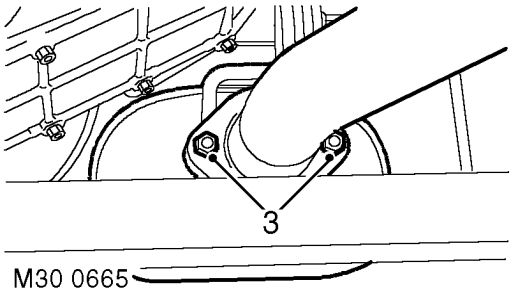
Pipe - front

30.10.09

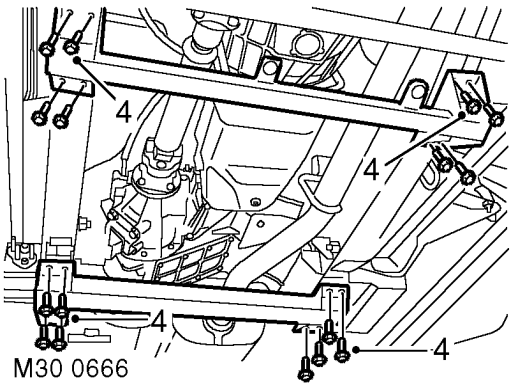
Remove



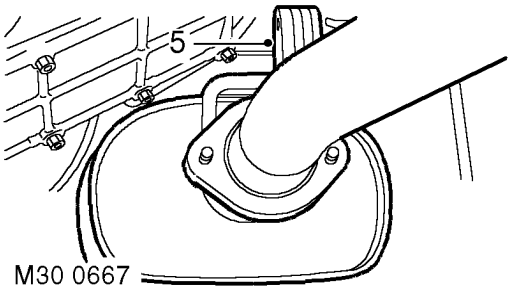
1. Remove 3 nuts, release front pipe from turbocharger and discard gasket.
2. Raise vehicle on ramp.



3. Remove 2 nuts and release front pipe from intermediate pipe/silencer.



4. Remove 16 bolts and remove chassis cross members.



5. Release and remove front pipe from mounting.

Refit

1. Clean front pipe and mating faces.
2. Position front pipe and new front pipe to turbocharger gasket. Align front pipe to intermediate pipe/silencer and turbocharger.
3. Connect mounting to front pipe.
4. Fit nuts securing front pipe to turbocharger and intermediate pipe/silencer and tighten to 27 Nm (20 lbf.ft) .
5. Fit chassis cross members and tighten bolts to 25 Nm (18 lbf. ft).

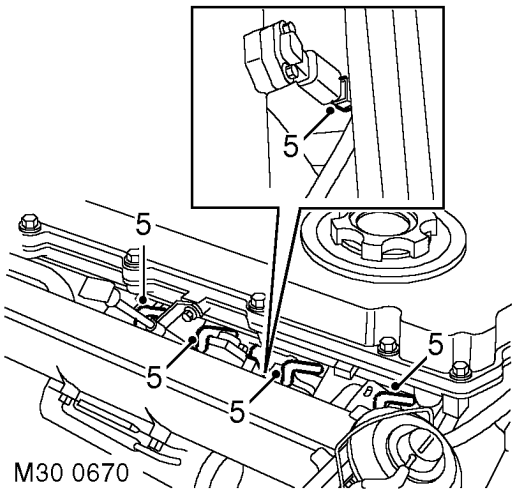
Gasket - inlet manifold

30.15.08

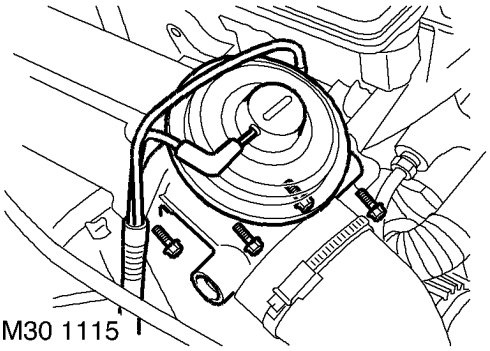
Remove

Note: The following procedure covers engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.

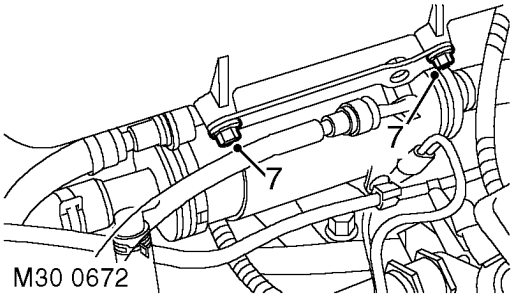
1. Remove battery cover.
2. Disconnect battery earth lead.
3. Remove 3 bolts and remove engine acoustic cover.
4. Release retainers and remove upper fan cowl.



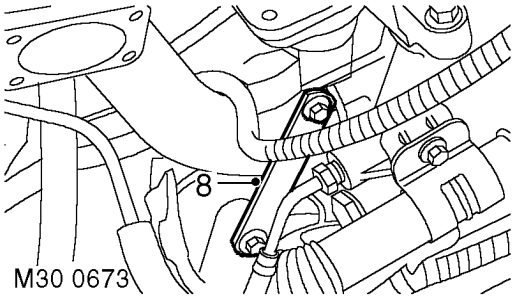
5. Disconnect leads from 4 glow plugs and multiplug from MAP sensor.



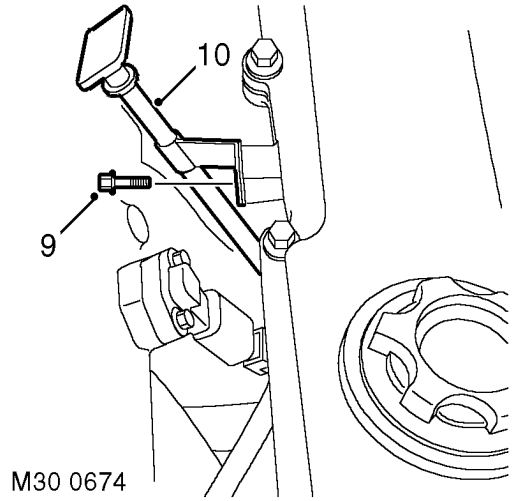
6. Remove 4 bolts, release EGR valve from inlet manifold and discard gasket.



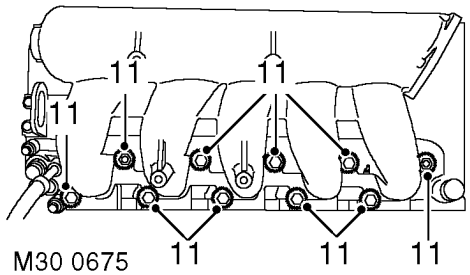
7. Remove 4 bolts securing fuel cooler to inlet manifold.



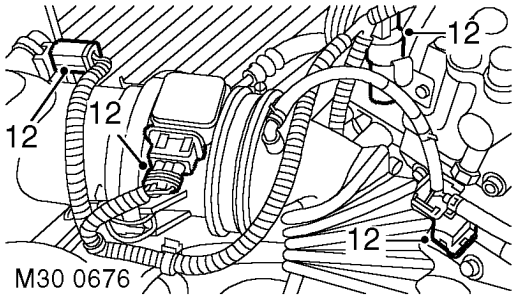
8. Remove 2 bolts and remove alternator support bracket.



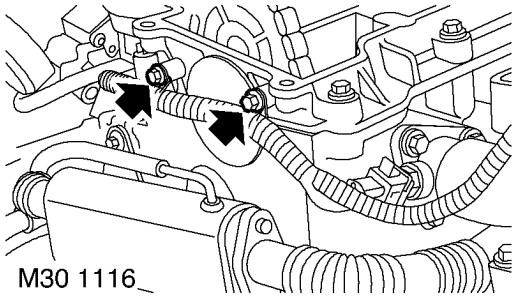
9. Remove bolt securing engine dip stick tube to camshaft carrier.
10. Remove dip stick tube and discard 'O' ring.



11. Remove 2 nuts and 8 bolts securing inlet manifold to cylinder head.



12. Disconnect multiplugs from turbocharger pressure sensor, ECT sensor, AAP sensor, MAF sensor, A/C compressor and fuel injector harness.



13. Remove 2 bolts securing harness to camshaft carrier.

Note: Engine with EGR cooler illustrated.

14. Release harness from engine and inlet manifold.

15. Remove inlet manifold and gasket.

Refit

1. Clean inlet manifold and mating faces.

2. Fit new gasket.

3. Fitinlet manifold and, working from the centre outwards, tighten nuts and bolts to 25 Nm (18 lbf.ft).

4. Position harness to sensors and connect multiplugs.

5. Tighten bolts securing harness clip to camshaft carrier to 9 Nm (7 lbf.ft).

6. Clean dip stick tube and fit new 'O' ring.

7. Fit dip stick tube and tighten bolt to 9 Nm (7 lbf.ft).

8. Connect leads to glow plugs.

9. Fit alternator support bracket and tighten bolts to 45 Nm (33 lbf.ft).

10. Position fuel cooler and tighten bolts to 25 Nm (18 lbf.ft).

11. Fit new gasket, position EGR valve and tighten bolts to 9 Nm (7 lbf.ft).

12. Connect multiplug to MAP sensor.

13. Fit upper fan cowl.

14. Fit engine acoustic cover.

15. Connect battery earth lead.

16. Fit battery cover.

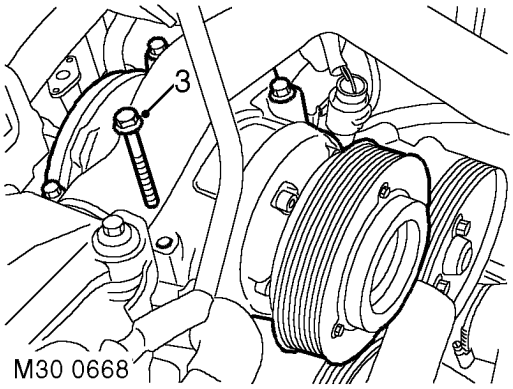
Gasket - exhaust manifold

30.15.12

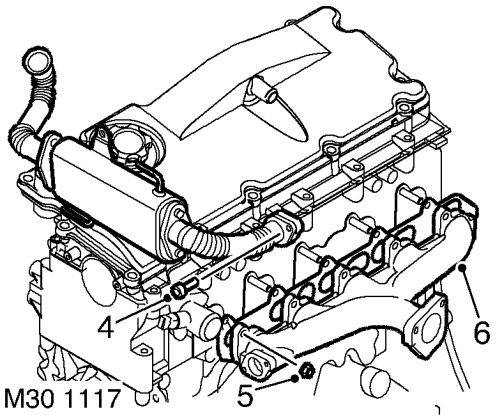
Remove

Note: The following procedure covers engines fitted with or without an EGR cooler. The EGR cooler is bolted to the front of the cylinder head.

1. Remove turbocharger.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.
2. **Models with air conditioning:** Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



3. **Models with air conditioning:** Remove 4 bolts securing compressor and move to one side.

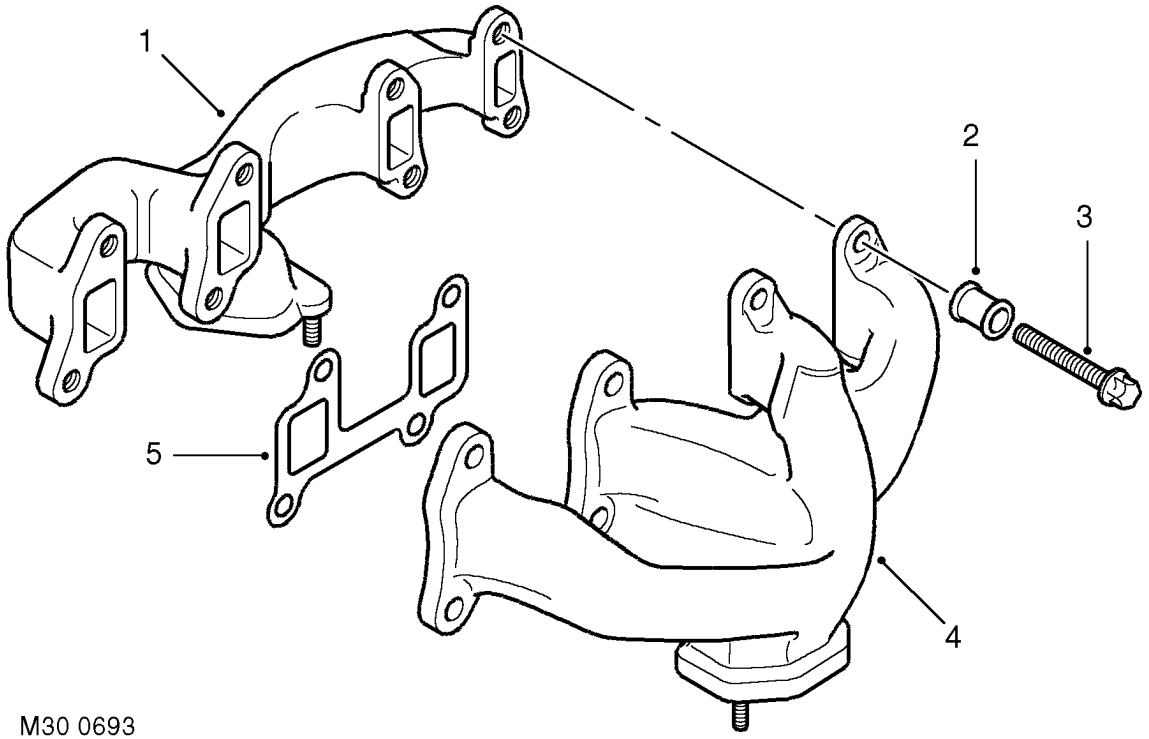


4. Remove and discard 2 Allen screws securing EGR pipe to exhaust manifold.
   Note: Engine with EGR cooler illustrated.
5. Remove 10 nuts securing exhaust manifold to cylinder head.
6. Remove exhaust manifold and gasket.

Refit

1. Clean exhaust manifold and mating faces.
2. Fit new gasket.Fit exhaust manifold and, working from the centre outwards, tighten nuts to 25 Nm (18 lbf.ft) .
3. **Models with air conditioning:** Positioncompressor and tighten bolts to 25 Nm (18 lbf.ft).
4. Position EGR valve pipe, fit new Allen screws and tighten to 9 Nm (7 lbf.ft).
5. Fit turbocharger.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Turbocharger.
6. **Models with air conditioning:** Fit auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.

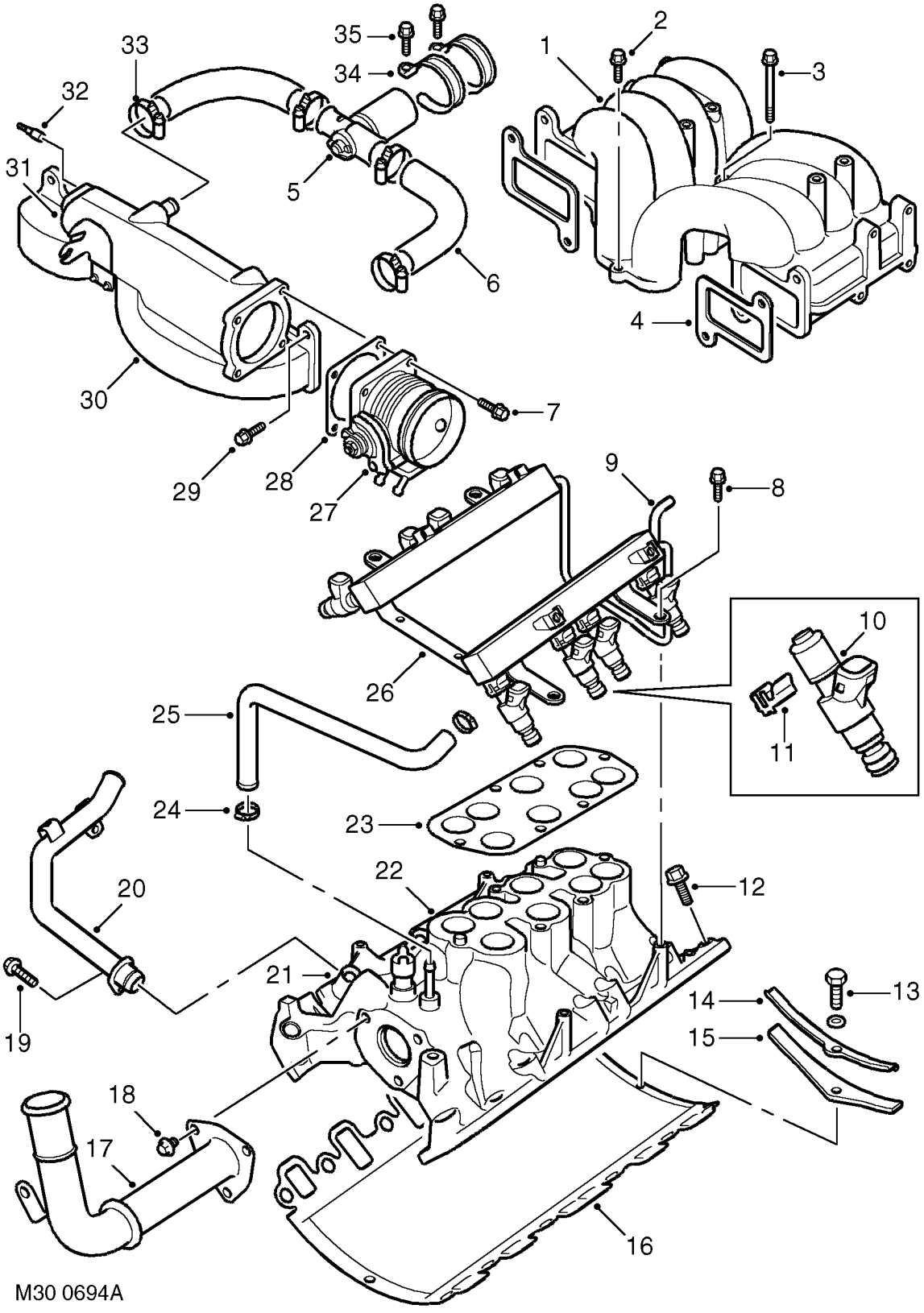
Exhaust manifold component layout



M30 0693

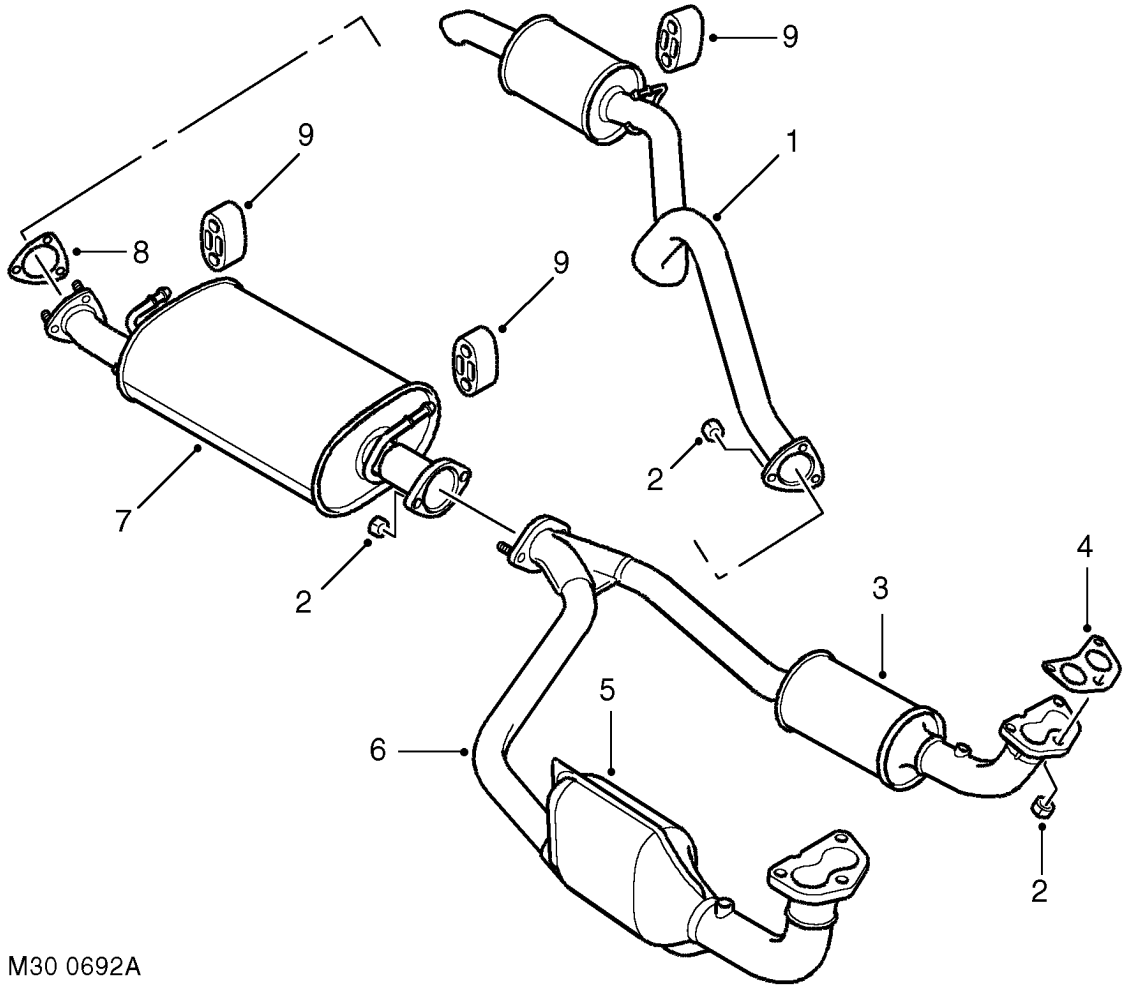
1 Exhaust manifold RH
2 Spacer 16 off
3 Torx bolt 16 off
4 Exhaust manifold LH
5 Gasket 4 off

Inlet manifold component layout



1 Upper manifold
2 Bolt 5 off
3 Bolt 1 off
4 Gasket
5 IAC Valve
6 IAC valve hose 2 off
7 Bolt 4 off
8 Bolt 4 off
9 Schraeder valve
10 Injector 8 off
11 Retaining clip 8 off
12 Bolt 12 off
13 Bolt 2 off
14 Clamp 2 off
15 Seal 2 off
16 Lower manifold/engine gasket
17 Coolant pipe
18 Bolt 3 off
19 Bolt
20 Heater return pipe
21 Pipe connection
22 Lower manifold
23 Gasket
24 Hose clip 2 off
25 Throttle housing coolant hose
26 Fuel rail
27 Throttle housing
28 Gasket
29 Bolt 4 off
30 Plenum
31 Rocker cover breather hose connection
32 Brake servo vacuum pipe connection
33 Hose clip 4 off

Exhaust system component layout



M30 0692A

1 Tail pipe assembly
2 Nut 11 off
3 Catalytic converter
4 Front pipe to manifold gasket 2 off
5 Catalytic converter
6 Front pipe assembly
7 Intermediate pipe/silencer assembly
8 Gasket
9 Mounting rubber 3 off

Description

General

The inlet manifold on the V8 engine is located on the top of the engine, between the cylinders. The manifold directs intake air into the cylinders. The intake air is mixed with fuel delivered by the injectors prior to ignition in the cylinders. The inlet manifold comprises three separate aluminium castings.

Two exhaust manifolds are used, one for each bank of four cylinders. Each exhaust manifold allows combustion gases from the cylinders to leave the engine and directs them into the exhaust system.

The exhaust system is connected to each exhaust manifold and merges into one pipe midway along the underside of the vehicle. A catalytic converter (where fitted) is located in the front pipe from each manifold. A silencer is installed midway along the system and a second tail silencer is located at the rear of the vehicle.

Inlet manifold

The inlet manifold comprises three aluminium castings; a lower manifold, an upper manifold and a plenum. The inlet manifold is located on the top of the engine and feeds air into the cylinders.

Lower manifold

The lower manifold is a one piece machined aluminium casting which locates in the vee on the top of the engine and is secured to each cylinder head with six bolts per head. A one piece coated metal gasket seals the lower manifold to each cylinder head and also serves as a cover for the cylinder block.

Eight injectors are fitted into the lower manifold, four on each side. Each injector is sealed in the manifold with O-ring seals and retained in position by the fuel rails. A fuel rail is attached to each side of the manifold and secured with two bolts.

Eight air intake ports are cast and machined on the top of the manifold, each port directing intake air into one cylinder. These ports mate with matching ports in the upper manifold and are sealed with a coated metal gasket between the two manifolds.

A cavity at the front of the manifold collects coolant flow from the engine. A coolant outlet pipe is sealed and attached to the front of the manifold and provides for coolant to flow through the cavity in the casting to the radiator top hose. A smaller port in the manifold also allows coolant to flow from the cavity to the heater matrix. The lower manifold also locates the Engine Coolant Temperature (ECT) sensor in a port in the front of the manifold.

Upper manifold

The upper manifold is a one piece machined aluminium casting. The manifold has eight ports on its lower face which mate with the eight ports on the lower manifold. The joint between the upper and lower manifolds is sealed with a coated metal gasket and secured with six bolts.

The manifold divides from the eight ports into eight branches, four on each side. Each set of four branches merge into one gallery on each side of the manifold. Each gallery has an opening at its forward end which mates with the intake plenum.

The upper manifold provides attachment for the Idle Air Control (IAC) valve and for brackets which retain pipes, plug leads and throttle cables.

Inlet plenum

The plenum is mounted transversely on the front of the upper manifold. The plenum divides into two galleries which connect with the galleries on the upper manifold. The plenum is secured to the upper manifold with four bolts and sealed with a coated metal gasket.

The plenum provides attachment for the throttle housing, which is secured with four bolts and sealed with a coated metal gasket. The plenum also has vacuum connections for brake servo, rocker cover breather and fuel vapour from the charcoal canister. A port on the top of the plenum connects via a hose to the IAC valve.

Exhaust manifolds

Two handed, cast iron exhaust manifolds are used on the V8 engine. Each manifold has four ports which merge into one flanged outlet positioned centrally on the manifold.

Each manifold is attached to its cylinder head with eight Torx bolts. Each bolt is fitted with a 'cotton reel' shaped spacer which allows for a longer bolt resulting in increased torque loading on each bolt. Two laminated metal gaskets seal each manifold to its cylinder head. The flanged outlet on each manifold provides the attachment for the front pipe of the exhaust system.

Exhaust system

The exhaust system comprises a front pipe assembly with two front pipes each incorporating a catalytic converter, an intermediate pipe incorporating a silencer and a tail pipe assembly which also has a silencer. The exhaust system is constructed mainly of 63 mm (2.48 in) diameter extruded pipe with a 1.5 mm (0.06 in) wall thickness. All pipes are aluminized to resist corrosion and the silencers are fabricated from stainless steel sheet.

Front pipe assembly

The front pipe assembly is of welded and fabricated construction. A front pipe from each exhaust manifold merges into one flanged connection. Two captive studs on the flange provide attachment to the intermediate pipe with locknuts. Each front pipe has a welded flange which is attached to each manifold and secured with three studs and flanged nuts and sealed with a metal laminated gasket. The gasket comprises a heat resistant fibre between two thin metallic layers to enhance the sealing properties of the gasket.

A catalytic converter is located in each front pipe. The catalytic converters are different shapes to allow clearance between the body and transmission. Both catalytic converters are of similar internal construction.

☞ **EMISSION CONTROL - V8, DESCRIPTION AND OPERATION, Emission Control Systems.**

CAUTION: Ensure the exhaust system is free from leaks. Exhaust gas leaks upstream of the catalytic converter could cause internal damage to the catalytic converter.

From the catalytic converters, the front pipes merge into one pipe which terminates at a flanged joint. The flange connects with the intermediate pipe, sealed with an olive and secured with studs and locknuts.

Intermediate pipe and silencer

The intermediate pipe is of welded and fabricated tubular construction. It connects at its forward end with a flange on the front pipe assembly and is secured with locknuts to captive studs in the front pipe assembly flange. The rear section of the intermediate pipe connects to the tail pipe assembly via a flanged joint, sealed with a metal gasket and secured with locknuts and studs.

The forward and rear sections are joined by a silencer. The silencer is fabricated from stainless steel sheet to form the body of the silencer. An end plate closes each end of the silencer and is attached to the body with seam joints. Perforated baffle tubes inside the silencer are connected to the inlet and outlet pipes on each end plate. Internal baffle plates support the baffle tubes and together with a stainless steel fibre absorb combustion noise as the exhaust gases pass through the silencer.

The intermediate pipe is attached by two brackets, positioned at each end of the silencer, and mounting rubbers to the chassis. The mounting rubbers allow ease of alignment and vibration absorption. The two mounting rubbers are fitted with removable heat deflectors to prevent heat from the silencer damaging the material.

Tail pipe assembly

The tail pipe is of welded and fabricated construction. It connects to the intermediate pipe with a flanged joint secured with studs and locknuts and sealed with a metal gasket. The pipe is shaped to locate above the rear axle allowing clearance for axle articulation. The pipe is also curved to clear the left hand side of the fuel tank which has a reflective shield to protect the tank from heat generated from the pipe.

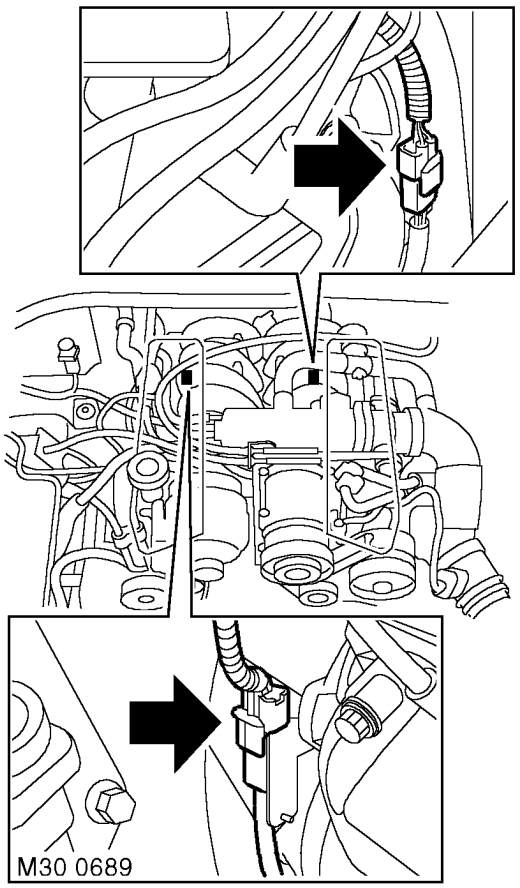
A fabricated silencer is located at the rear of the tail pipe. The silencer is circular in section and is constructed from stainless steel sheet. A baffle tube is located inside the silencer and the space around the baffle tube is packed with a stainless steel fibre. The holes in the baffle tube allow the packing to further reduce combustion noise from the engine. The tail pipe from the silencer is curved downwards at the rear of the vehicle and directs exhaust gases towards the ground. The curved pipe allows the exhaust gases to be dissipated by the airflow under the vehicle and prevents gases being drawn behind the vehicle.

The tail pipe is attached by a bracket, positioned forward of the silencer, and a mounting rubber to the chassis. The mounting rubber allows ease of alignment and vibration absorption.

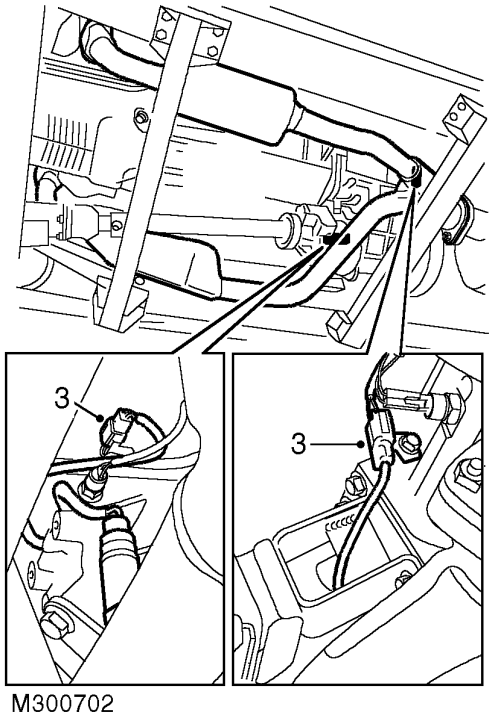
Front pipe

30.10.09

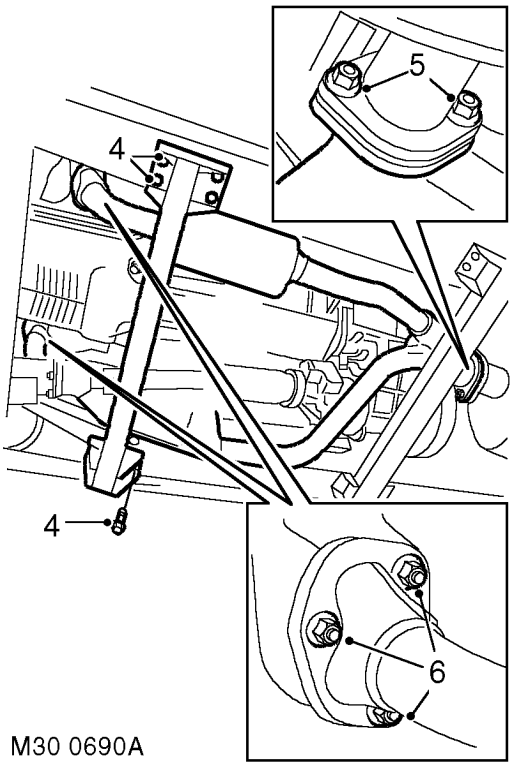
Remove



1. Release front HO2S multiplugs from support brackets and disconnect multiplugs.
2. Raise vehicle on ramp.



3. Where fitted, release rear HO2S multiplugs from support brackets on transfer box and disconnect multiplugs.



4. Remove 8 bolts securing cross member and remove cross member.

5. Remove 2 nuts securing front pipe to intermediate pipe/silencer.
6. Remove 6 nuts securing front pipe to exhaust manifolds.
7. Release front pipe and collect front pipe to manifold gaskets.
8. With assistance remove front pipe.
9. Remove HO2S from front pipe.

Refit

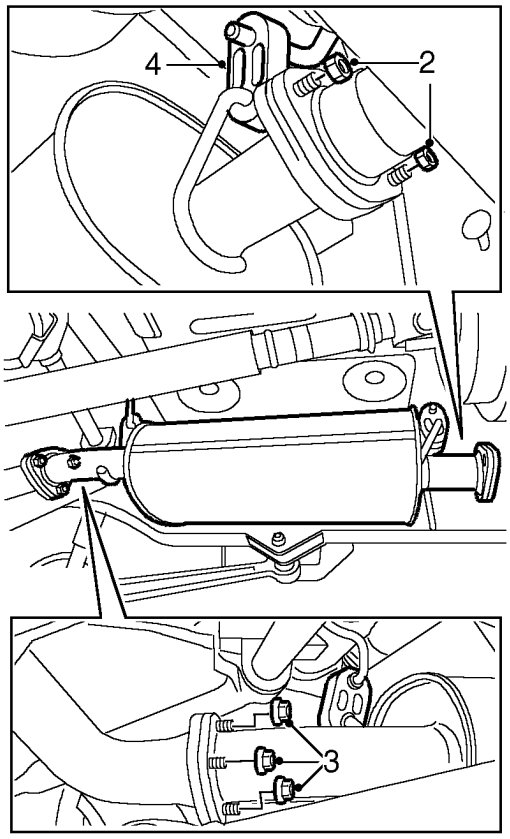
1. If refitting existing HO2S, apply anti-seize compound to HO2S threads.
   NOTE: A new HO2 sensor is supplied pre-treated with anti-seize compound.
2. Fit HO2S to front pipe and tighten to 45 Nm (33 lbf.ft).
3. Clean front pipe and mating faces.
4. Position front pipe, with new front pipe to manifold gaskets, and align front pipe with intermediate pipe/silencer and exhaust manifolds.
5. Fit and tighten exhaust manifold nuts to 30 Nm (22 lbf.ft).
6. Fit and tighten intermediate pipe/silencer nuts to 25 Nm (18 lbf.ft).
7. Fit chassis cross member and tighten bolts to 25 Nm (18 lbf. ft).
8. Connect HO2S multiplugs and secure to support brackets.

Intermediate pipe/silencer

30.10.11

Remove

1. Raise vehicle on ramp.



M30 0695A

2. Remove 2 nuts securing intermediate pipe/silencer to front pipe.
3. Remove 3 nuts securing intermediate pipe/silencer to tail pipe.
4. Release intermediate pipe/silencer from mountings and remove intermediate pipe/silencer.
5. Collect intermediate pipe/silencer to tail pipe gasket.

Refit

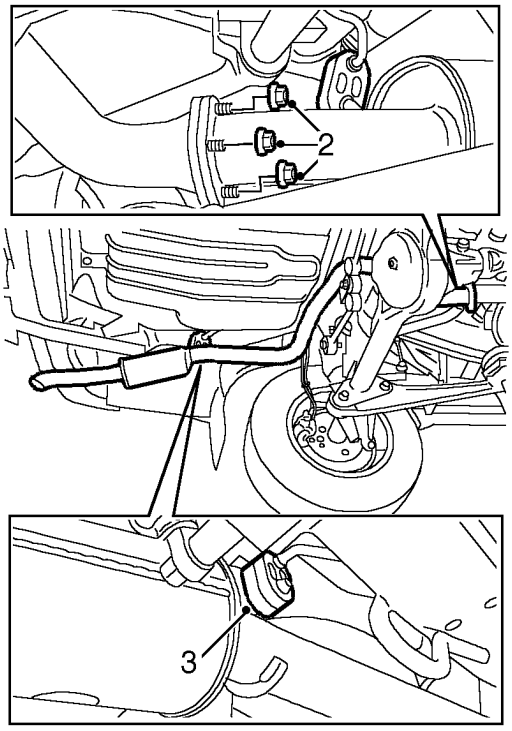
1. Clean intermediate pipe/silencer, front pipe and tail pipe mating faces.
2. Position intermediate pipe/silencer and locate on mountings.
3. Using a new intermediate pipe/silencer to tail pipe gasket, align intermediate pipe/silencer with tail pipe and front pipe.
4. Fit nuts to intermediate pipe/silencer and tighten to 25 Nm (18 lbf.ft).

Tail pipe

30.10.22

Remove

1. Raise vehicle on ramp.



M30 0696

2. Remove 3 nuts securing intermediate pipe/ silencer to tail pipe.
3. Release and remove tail pipe from mounting.
4. Collect intermediate pipe/silencer to tail pipe gasket.

Refit

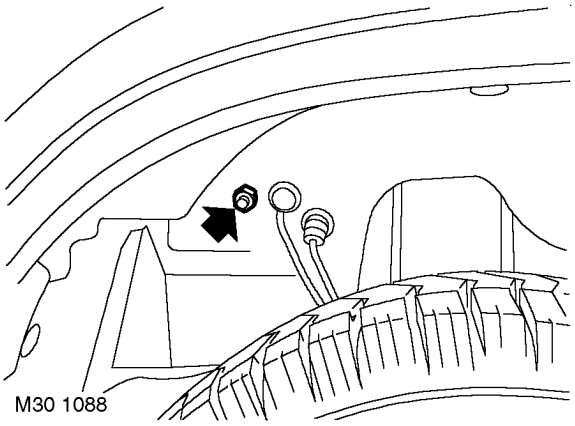
1. Clean silencer and tail pipe mating faces.
2. Position tail pipe and secure on mounting.
3. Using a new gasket, align tail pipe to intermediate pipe/silencer.
4. Fit nuts to intermediate pipe/silencer and tighten to 25 Nm (18 lbf.ft).

Heat shield - brake servo - Without Secondary Air Injection

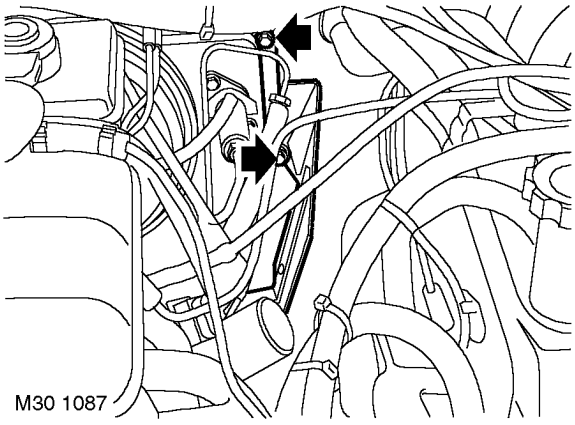
30.10.48

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.


M30 1088

3. Remove nut securing heat shield bracket to valance.


M30 1087

4. Remove 2 bolts securing heat shield and remove heat shield.

Refit

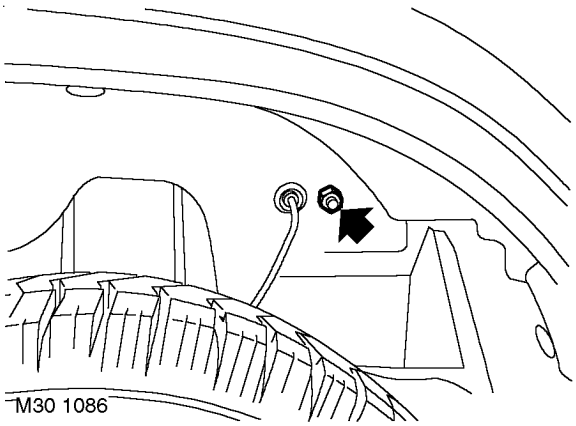
1. Fit heat shield, tightening bolts to 25 Nm (18 lbf.ft) and nut to 10 Nm (7 lbf.ft).
2. Connect battery earth lead.
3. Fit battery cover and secure with fixings.

Heat shield - brake servo - With Secondary Air Injection

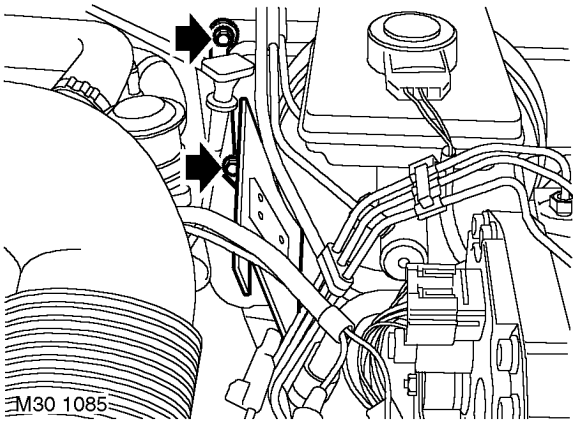
30.10.48

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



3. Remove nut securing heat shield bracket to valance.



4. Remove 2 bolts securing heat shield and remove heat shield.

Refit

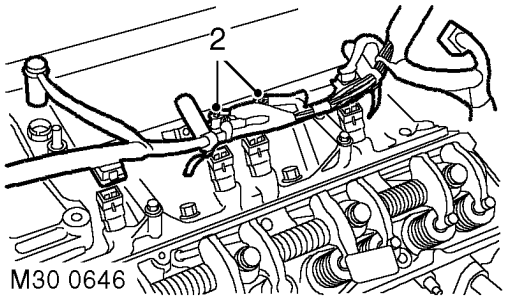
1. Fit heat shield, tightening bolts to 25 Nm (18 lbf.ft) and nut to 10 Nm (7 lbf.ft).
2. Connect battery earth lead.
3. Fit battery cover and secure with fixings.

Gasket - inlet manifold - lower

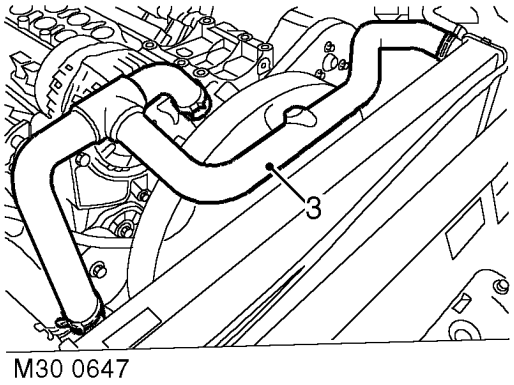
30.15.08

Remove

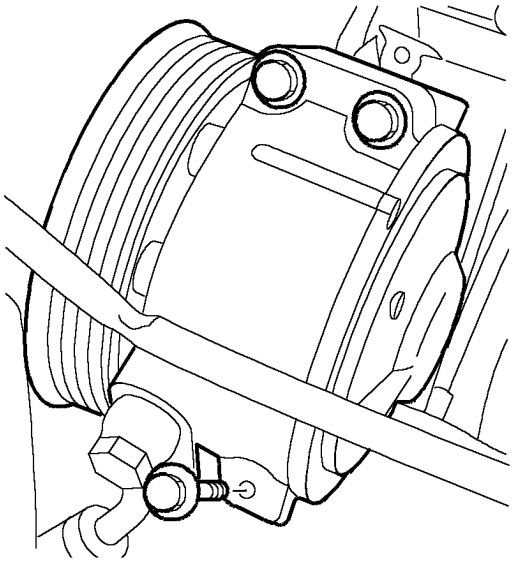
1. Remove both rocker covers.
   - **ENGINE - V8, REPAIRS, Gasket - rocker cover - LH.**
   - **ENGINE - V8, REPAIRS, Gasket - rocker cover - RH.**



2. Release and disconnect LH injector harness and multiplugs.

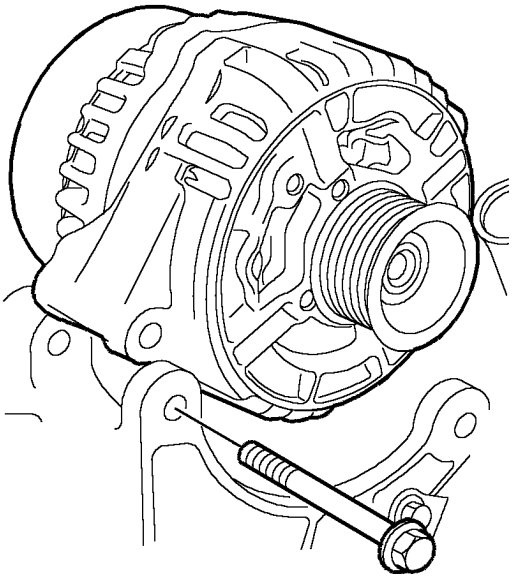


3. Release 3 clips securing top hose and remove top hose.
4. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



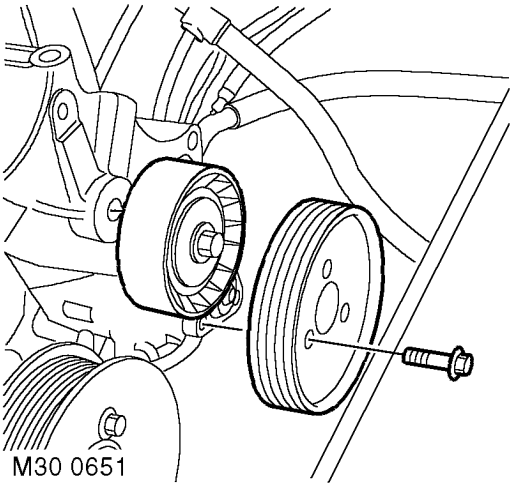
M30 0649

5. Remove 3 bolts securing ACE pump, release pump and position aside.



M30 0650

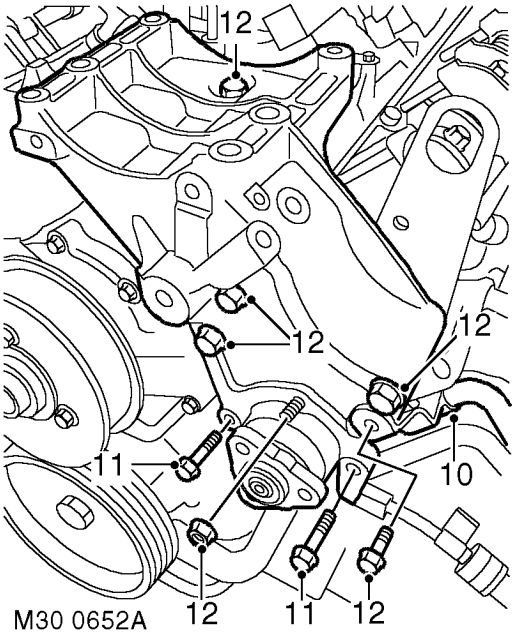
6. Remove 2 bolts securing alternator and remove alternator.



M30 0651

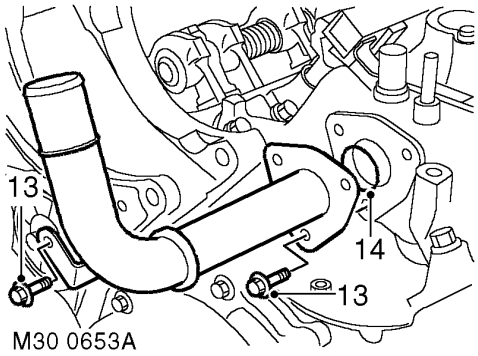
7. Remove 3 bolts securing PAS pump pulley and remove pulley.
8. Remove jockey pulley.
9. Position tray to catch spillage, release PAS pump high pressure pipe.

CAUTION: Always fit plugs to open connections to prevent contamination.

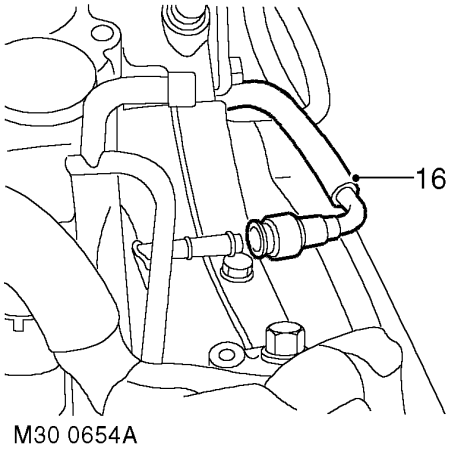


M30 0652A

10. Remove bolt securing oil cooling pipe and release bracket from auxiliary housing.
11. Remove two bolts securing PAS pump.
12. Remove 5 bolts and one nut securing auxiliary housing. Pull housing forward, release PAS pump and remove housing.

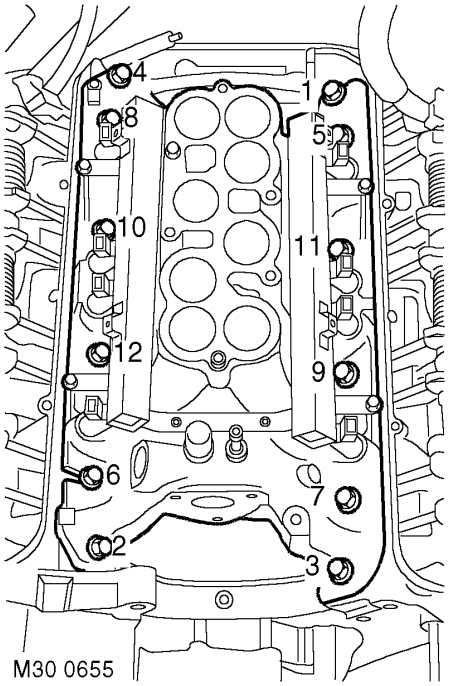


13. Remove 4 bolts securing top hose outlet and remove outlet pipe.
14. Remove and discard 'O' ring.
15. Position absorbent cloth to catch spillage.

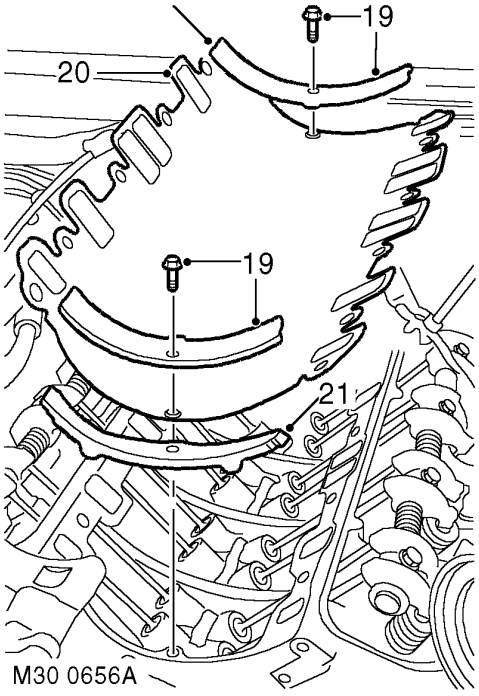


16. Disconnect fuel pipe.

CAUTION: Always fit plugs to open connections to prevent contamination.



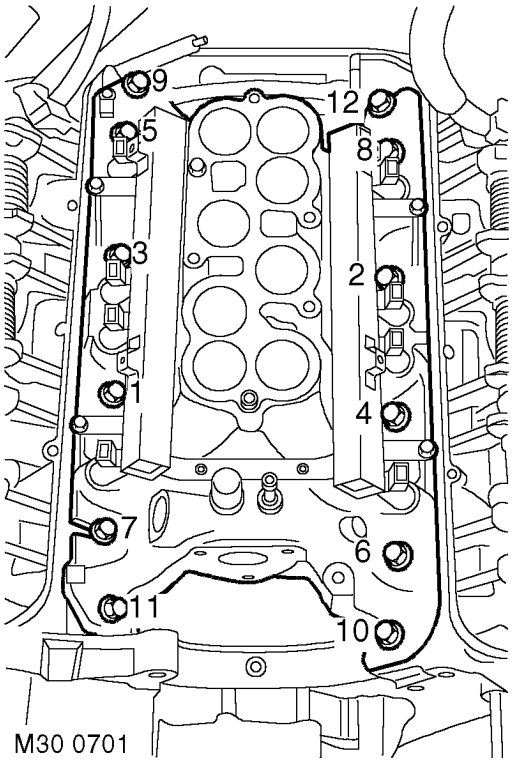
17. Using the sequence shown, remove 12 bolts securing the inlet manifold.
18. Remove inlet manifold.



19. Remove 2 bolts securing inlet manifold gasket and collect gasket clamps.
20. Remove inlet manifold gasket.
21. Remove gasket seals.

Refit

1. Clean old RTV sealant from cylinder head and cylinder block notches.
2. Clean mating faces of cylinder block, cylinder head and inlet manifold.
3. Apply RTV sealant to cylinder head and cylinder block notches.
4. Fit new gasket seals, ensuring ends engage correctly in notches.
5. Fit new inlet manifold gasket.
6. Position gasket clamps and fit bolts, but do not tighten at this stage.



7. Position inlet manifold to engine. Fit manifold bolts and, working in the sequence shown, tighten bolts initially to 10 Nm (7 lbf.ft) then to 51 Nm (38 lbf.ft).
8. Tighten gasket clamp bolts to 18 Nm (13 lbf.ft).
9. Connect fuel pipe.
10. Clean top hose outlet pipe mating faces.
11. Fit new 'O' ring to outlet pipe.
12. Position outlet pipe, fit bolts and tighten to 22 Nm (16 lbf.ft).
13. Position alternator, fit bolts and tighten to 45 Nm (33 lbf.ft).
14. Position PAS pump to auxiliary housing and locate housing on engine. Fit bolts and tighten to 40 Nm (30 lbf.ft).
15. Fit and tighten auxiliary housing nut to 10 Nm (7 lbf.ft).
16. Fit bolts securing PAS pump and tighten to 22 Nm (16 lbf.ft).
17. Position oil cooling pipe bracket fit bolt and tighten to 22 Nm (16 lbf.ft).
18. Fit and tighten PAS pump high pressure pipe.
19. Position jockey pulley and tighten bolt to 50 Nm (37 lbf.ft).
20. Clean PAS pump pulley mating faces.
21. Position PAS pump pulley, fit bolts and tighten to 22 Nm (16 lbf.ft).
22. Clean ACE pump dowels and dowel holes.
23. Position ACE pump, fit bolts and tighten to 22 Nm (16 lbf.ft).
24. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
25. Secure injector harness and connect injector multiplugs.
26. Position top hose and secure clips.
27. Fit rocker covers.
    - ☞ **ENGINE - V8, REPAIRS, Gasket - rocker cover - LH.**
    - ☞ **ENGINE - V8, REPAIRS, Gasket - rocker cover - RH.**
28. Check and top up PAS fluid

Gasket - exhaust manifold

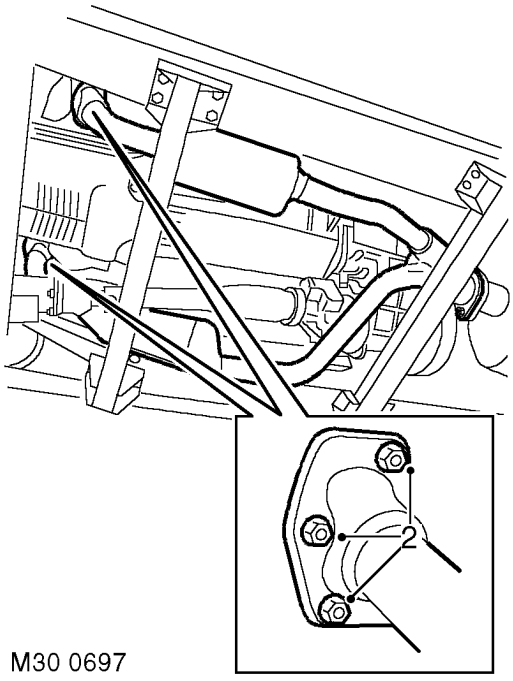
30.15.12

This procedure is the same for both exhaust manifold gaskets.

Remove

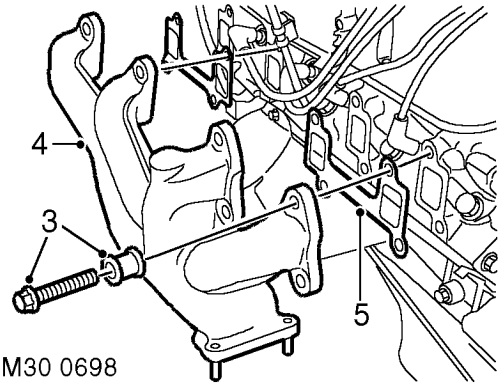
1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M30 0697

2. Remove 3 nuts securing front pipe to exhaust manifold, release front pipe and collect gasket.



M30 0698

3. Remove 8 bolts and spacers securing exhaust manifold.
4. Remove exhaust manifold.
5. Remove 2 manifold gaskets.

Refit

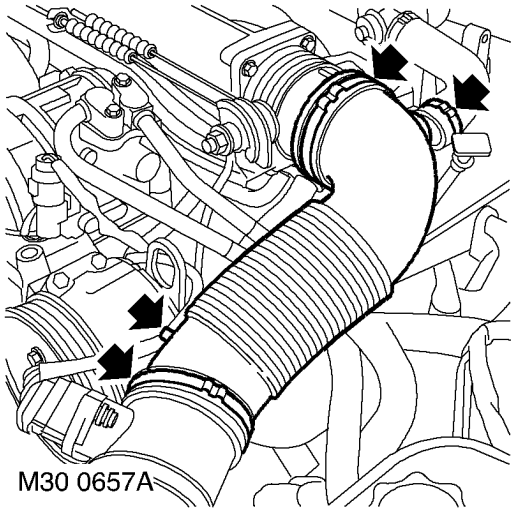
1. Clean exhaust manifold and cylinder head mating face.
2. Position exhaust manifold and new gaskets on cylinder head.
3. Fit spacers and exhaust manifold securing bolts and, working from the centre outwards, tighten bolts to 38 Nm. (28 lbf.ft).
4. Clean front pipe and manifold mating faces.
5. Using a new gasket, position front pipe, fit nuts and tighten to 30 Nm. (22 lbf.ft).
6. Remove stand(s) and lower vehicle.

Gasket - inlet manifold - upper - Without Secondary Air Injection

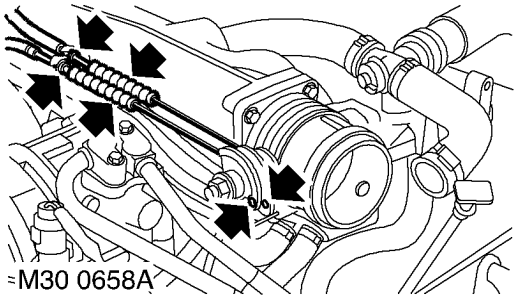
30.15.24

Remove

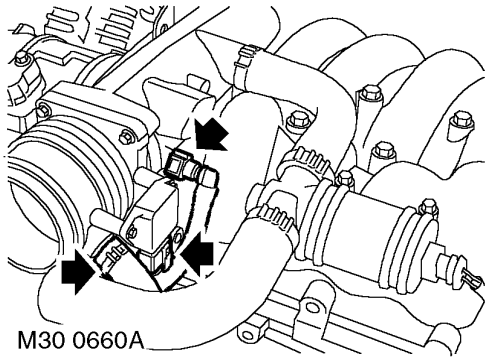
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove bonnet.
   EXTERIOR FITTINGS, REPAIRS, Bonnet.


M30 0657A

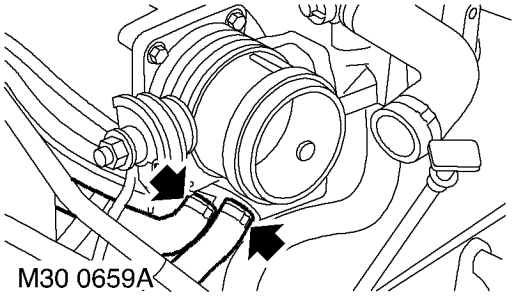
4. Release MAF sensor harness from clip.
5. Loosen clips securing air intake hose. Release and remove air intake hose.
   Note: Pre 03 MY air intake hose illustrated.


M30 0658A

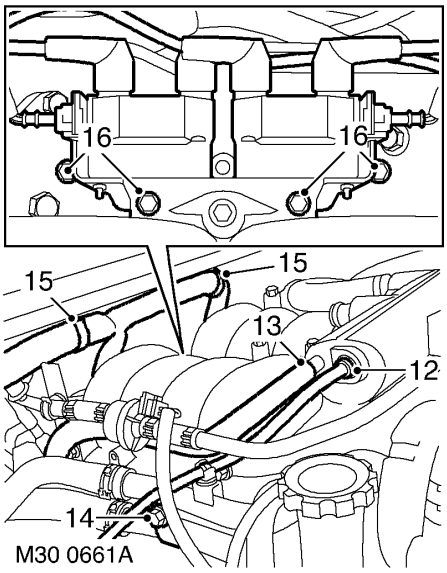
6. Disconnect throttle and cruise control cables. Release cables from abutment bracket and position aside.


M30 0660A

7. Disconnect EVAP pipe from inlet plenum.
8. Disconnect multiplug from throttle body.
9. Remove clip securing breather hose to throttle body and release breather hose.
10. Position a drain tray beneath the engine to collect coolant.


M30 0659A

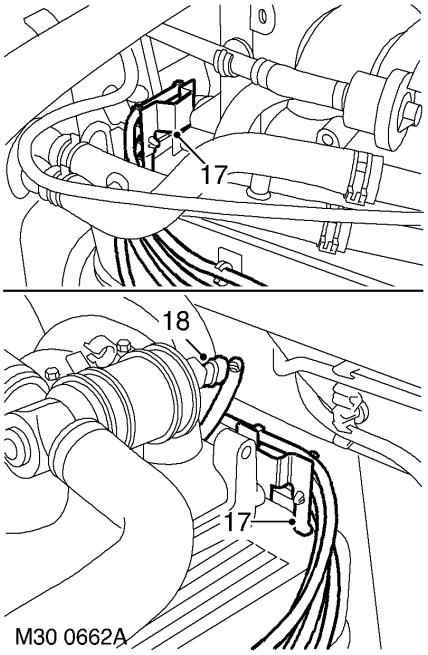
11. Release clips securing coolant hoses to throttle body and disconnect hoses.



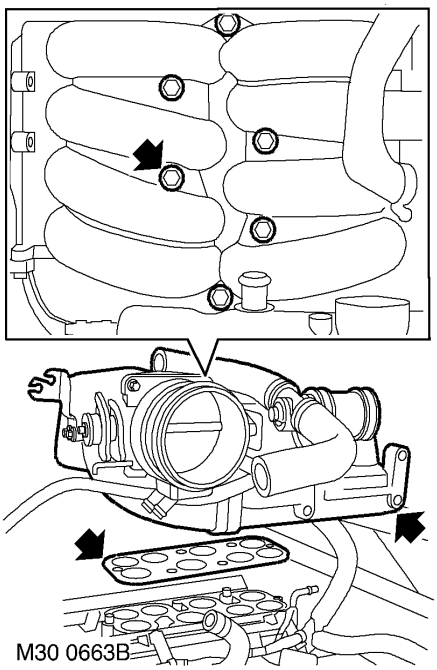
M30 0661A

12. Disconnect brake servo vacuum pipe from inlet plenum.

13. Disconnect breather hose from inlet plenum.
14. Remove bolt securing coolant rails.
15. Release engine harness from bulkhead clips and position aside.
16. Remove 4 bolts securing ignition coils and position ignition coils aside.



17. Release plug leads from upper manifold clips.
18. Disconnect multiplug from IACV.
19. Release and disconnect IACV hose.



20. Remove 6 bolts securing upper inlet manifold and remove upper inlet manifold.
21. Collect upper inlet manifold gasket.

Refit

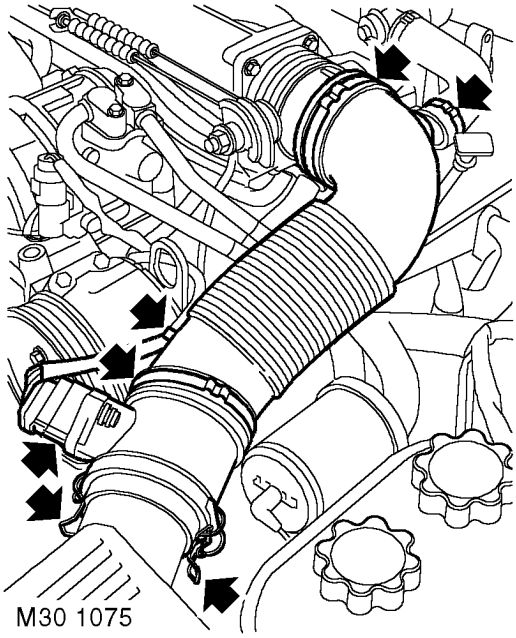
1. Clean upper and lower inlet manifold mating faces, dowels and dowel holes.
2. Using a new gasket, position upper inlet manifold. Fit bolts and, working in a diagonal sequence, tighten to 22 Nm (16 lbf.ft).
3. Connect hose and multiplug to TP sensor.
4. Connect hose and multiplug to IACV. Secure hose with clip.
5. Secure ht leads to upper inlet manifold.
6. Position ignition coils, fit bolts and tighten to 8 Nm (6 lbf.ft).
7. Ensure clip under ignition coils is located on fuel pipe.
8. Secure engine harness in bulkhead clips.
9. Fit coolant rail bolt and tighten to 22 Nm (16 lbf.ft).
10. Connect breather hose to inlet plenum.
11. Connect brake servo vacuum pipe to inlet plenum.
12. Connect EVAP pipe to inlet plenum.
13. Position coolant hoses to throttle body and secure hose clips.
14. Fit breather hose to throttle body and secure clip.
15. Connect multiplug to throttle body.
16. Connect throttle and cruise control cables and secure in throttle body cams.
17. Adjust throttle and cruise control cables.
    - ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - cruise control.**
    - ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - throttle.**
18. Connect air intake hose and tighten clips. Secure harness to air intake hose.
19. Top-up cooling system
    ☞ **MAINTENANCE, PROCEDURES, Cooling system.**.
20. Fit bonnet.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bonnet.**
21. Connect battery earth lead.
22. Fit battery cover and secure with fixings.

Gasket - inlet manifold - upper - With Secondary Air Injection

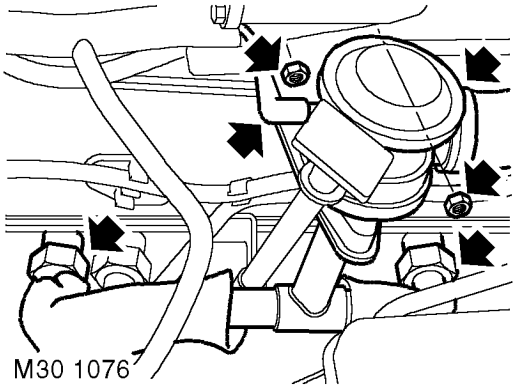
30.15.24

Remove

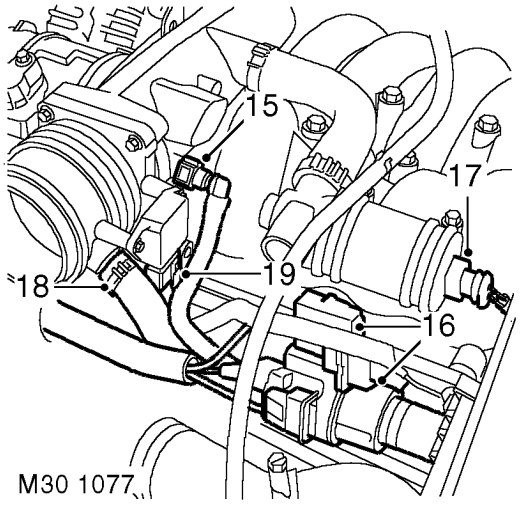
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Remove bonnet.
   EXTERIOR FITTINGS, REPAIRS, Bonnet.



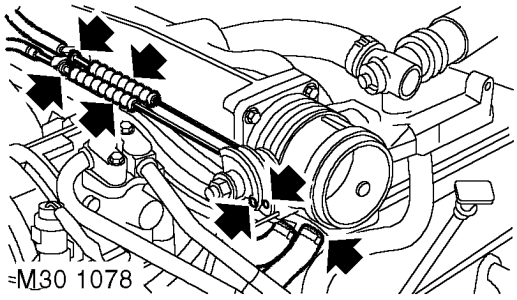
4. Disconnect multiplug from MAF sensor.
5. Release clip on intake hose and release harness.
   Note: Pre 03 MY air intake hose illustrated.
6. Release and disconnect IACV hose.
7. Loosen clip securing air intake hose to throttle body.
8. Release 2 clips securing MAF sensor.
9. Release and remove air intake hose.



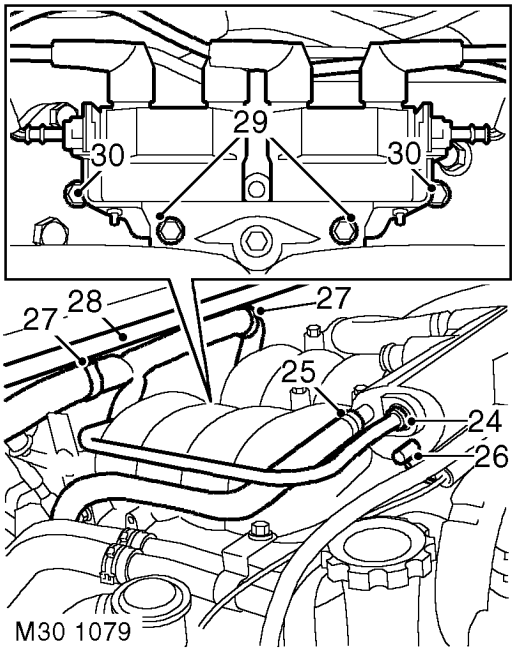
10. Disconnect vacuum hose from air valve.
11. Loosen clip securing air valve hose to air valve.
12. Remove 2 nuts securing air manifold support bracket to upper inlet manifold.
13. Disconnect 2 air manifold unions from adapters in cylinder head.
14. Remove LH air manifold.



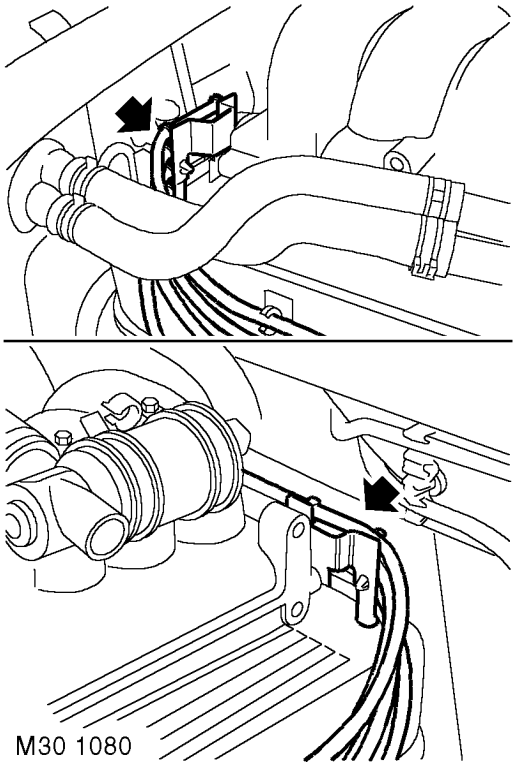
15. Disconnect purge valve hose from inlet manifold.
16. Release purge valve from clips and air control valve from bracket and lay aside.
17. Disconnect multiplug from IACV.
18. Release clip and disconnect breather hose from throttle housing.
19. Disconnect multiplug from TP sensor.



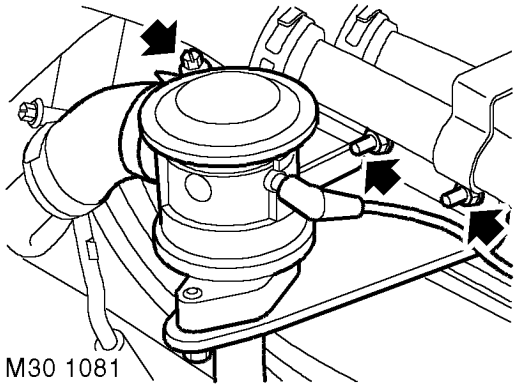
20. Position container to collect spillage.
21. Release clips and disconnect 2 coolant hoses from throttle housing.
22. Loosen outer cable locknuts and release throttle and cruise control cables from abutment.
23. Release throttle and cruise control cables from clips and throttle cams and position aside.



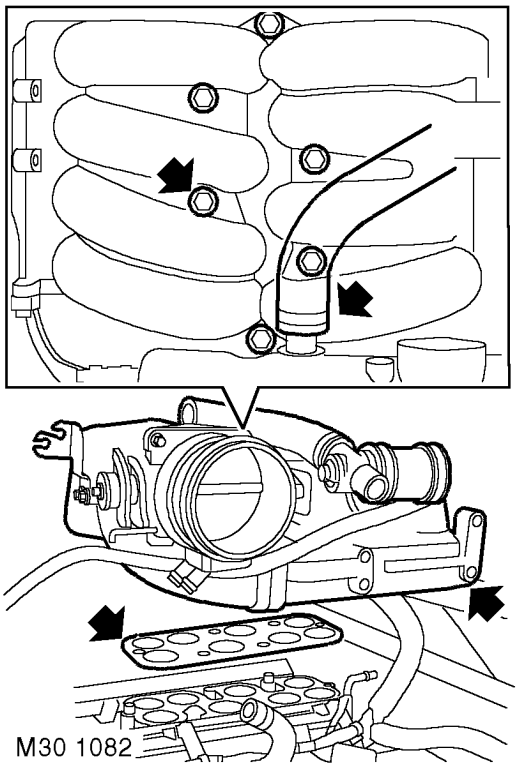
24. Depress plastic collar and disconnect brake servo hose from inlet manifold.
25. Release clip and disconnect breather hose from manifold.
26. Disconnect vacuum hose from manifold.
27. Release engine harness from bulkhead clips and position aside.
28. Release and remove bonnet seal from rear of engine bay.
29. Remove 2 bolts securing air pipe and coil bracket to manifold.
30. Loosen 2 lower bolts securing coil bracket sufficiently to allow bracket to clear manifold.



31. Release plug leads from upper manifold clips.



32. Loosen clip and disconnect air hose from air valve.
33. Remove 2 nuts securing RH air manifold support bracket to upper inlet manifold.

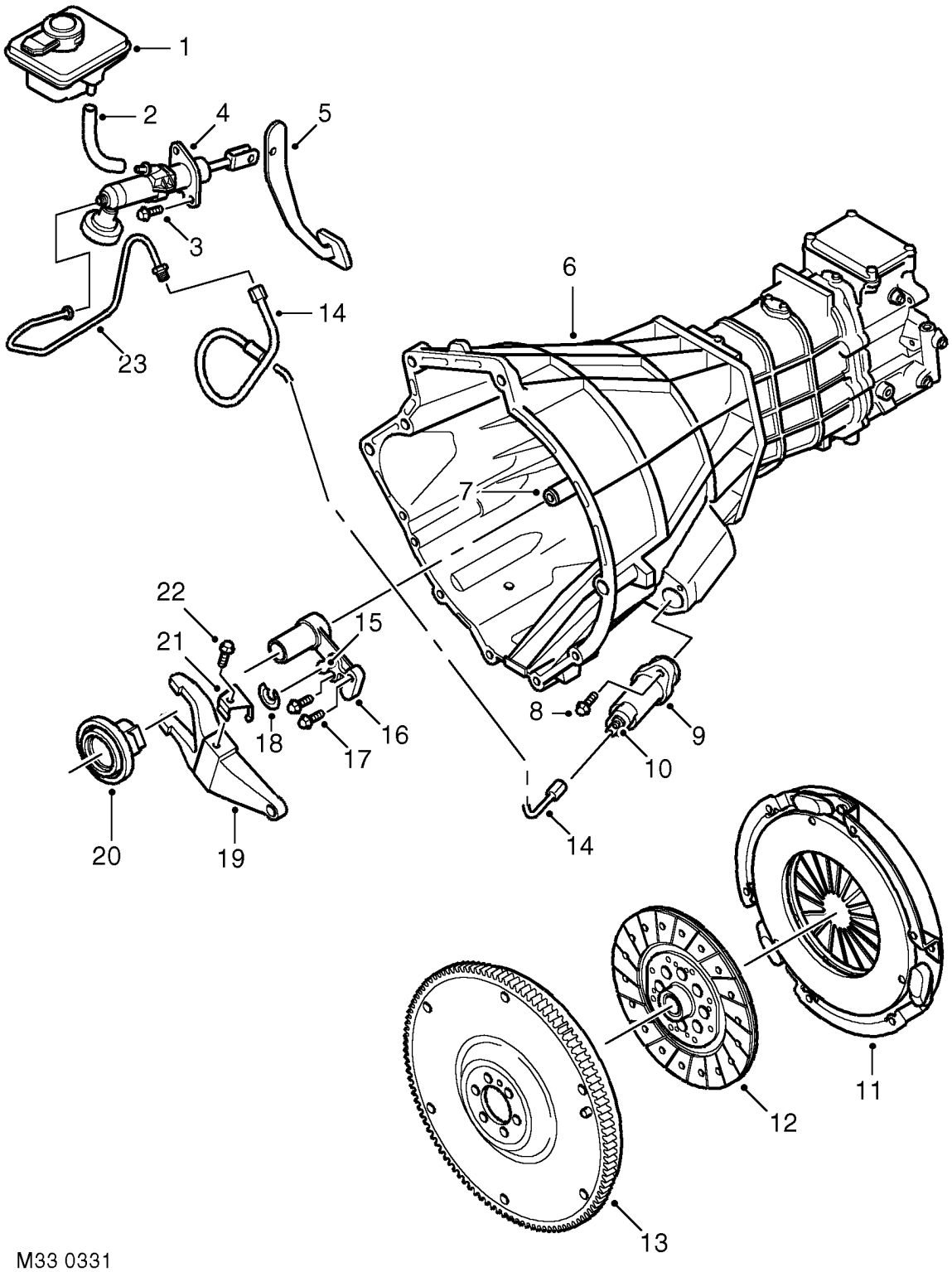


34. Release clip and disconnect IACV hose.
35. Remove 6 bolts securing upper manifold and remove manifold.
36. Collect upper manifold gasket.

Refit

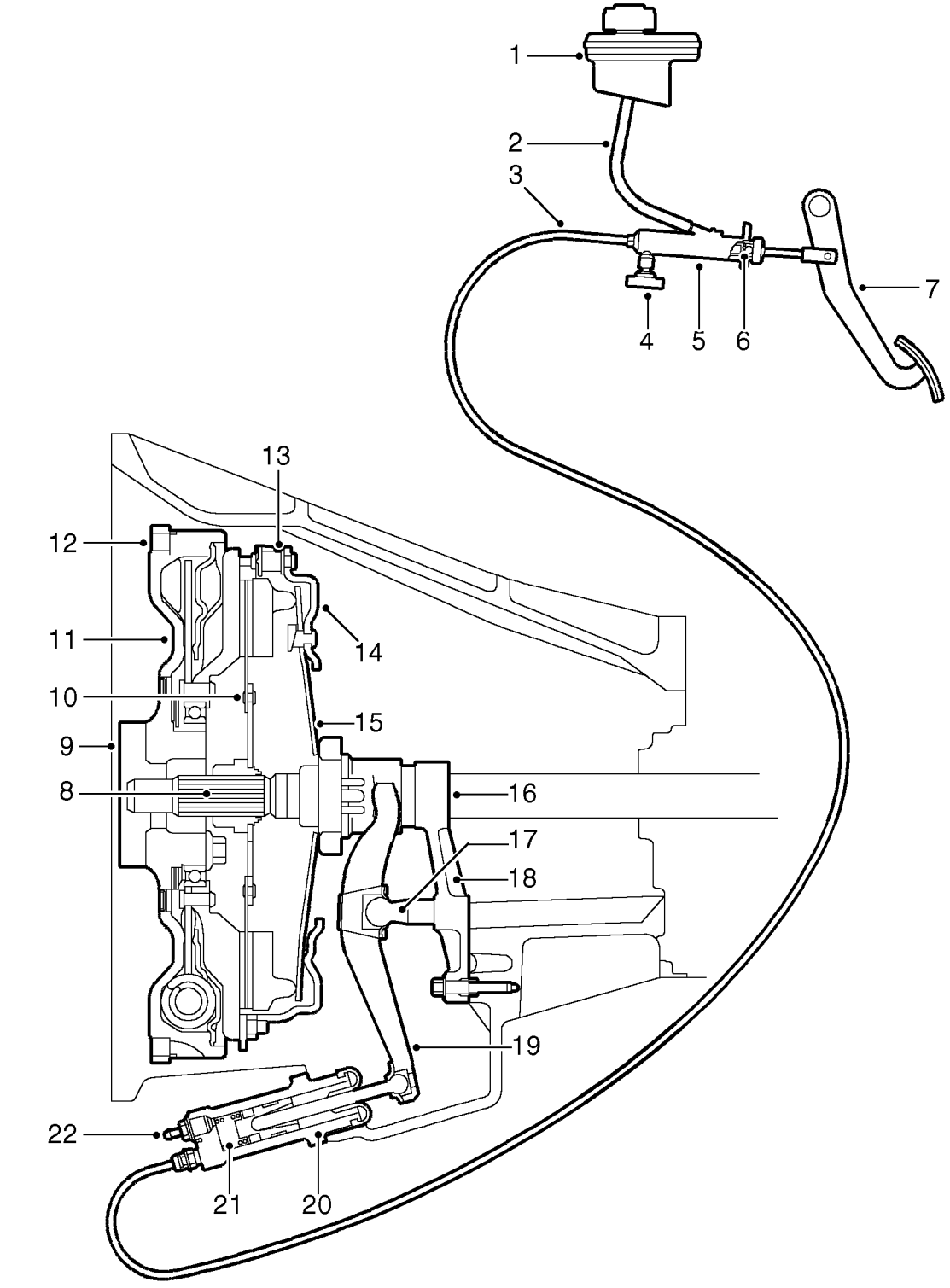
1. Clean upper and lower inlet manifold mating faces, dowels and dowel holes.
2. Using a new gasket, position upper inlet manifold. Fit bolts and, working in a diagonal sequence, tighten to 22 Nm (16 lbf.ft).
3. Connect IACV hose and secure clip.
4. Connect hose to air valve and tighten clip.
5. Secure plug leads to clips.
6. Fit and tighten nuts securing RH air manifold support bracket.
7. Align air pipe and coil bracket, fit bolts and tighten to 8 Nm (6 lbf.ft).
8. Tighten 2 lower bolts securing coil bracket to 8 Nm (6 lbf.ft).
9. Fit bonnet seal.
10. Secure engine harness in bulkhead clips.
11. Connect breather hose to manifold and secure clip.
12. Connect vacuum hose to inlet manifold.
13. Connect brake servo hose to inlet manifold.
14. Connect throttle and cruise control cables.
15. Adjust throttle cable.
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - throttle.**
16. Adjust cruise control cable.
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, ADJUSTMENTS, Cable - cruise control.**
17. Connect coolant hoses to throttle housing and secure clips.
18. Connect multiplug to TP sensor.
19. Connect breather hose to throttle housing and secure with clip.
20. Connect multiplug to IACV.
21. Secure purge valve and air control valve to clips and bracket.
22. Connect purge hose to manifold.
23. Clean air manifold unions, position manifold and start union nuts.
24. Fit and tighten nuts securing air manifold support bracket.
25. Tighten air manifold union nuts to 25 Nm (18 lbf.ft)
26. Connect hose to air valve and tighten clip.
27. Connect vacuum hose to air valve.
28. Fit air intake hose.
29. Connect multiplug to MAF sensor.
30. Secure harness to clip.
31. Connect battery earth lead.
32. Fit battery cover and secure with fixings.
33. Top up cooling system.
    ☞ **MAINTENANCE, PROCEDURES, Cooling system.**
34. Fit bonnet.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bonnet.**

Clutch components



1 Brake/clutch reservoir
2 Connecting hose
3 Bolt 2 off
4 Master cylinder
5 Clutch pedal
6 Gearbox housing
7 Primary driveshaft
8 Bolt 2 off
9 Slave cylinder
10 Bleed nipple
11 Pressure plate
12 Drive plate
13 Dual mass flywheel
14 Metal hydraulic pipe
15 Ball spigot
16 Clutch release bearing sleeve
17 Bolt 2 off
18 Pivot washer
19 Release lever
20 Release bearing
21 Retaining clip
22 Bolt
23 Plastic hydraulic pipe

Hydraulic operation



M33 0335

1 Brake/clutch reservoir
2 Fluid supply pipe
3 Hydraulic feed pipe
4 Damper
5 Master cylinder
6 Piston
7 Clutch pedal
8 Primary driveshaft
9 Engine crankshaft
10 Drive plate
11 Dual mass flywheel
12 Ring gear
13 Leaf spring
14 Cover - pressure plate
15 Diaphragm
16 Release bearing
17 Ball spigot
18 Release bearing sleeve
19 Release lever
20 Slave cylinder
21 Piston
22 Bleed nipple

Description

General
The clutch system is a diaphragm type clutch operated by a hydraulic cylinder. The drive plate is of the rigid centre type with no integral damping springs. The flywheel is of the dual mass type with damping springs integral with the flywheel. The clutch requires no adjustment to compensate for wear.

Hydraulic clutch
The hydraulic clutch comprises a master cylinder, slave cylinder and a hydraulic reservoir. The master and slave cylinders are connected to each other hydraulically by plastic and metal pipes. The plastic section of the pipe allows ease of pipe routing and also absorbs engine movements and vibrations.

The master cylinder comprises a body with a central bore. Two ports in the body connect the bore to the hydraulic feed pipe to the slave cylinder and the fluid reservoir. The bore is also connected to a damper which prevents engine pulses being transferred hydraulically to the clutch pedal. A piston is fitted in the bore and has an external rod which is attached to the clutch pedal with a pin. Two coil springs on the clutch pedal reduce the effort required to depress the pedal.

The master cylinder is mounted on the bulkhead and secured with two bolts. The cylinder is connected to the shared brake/clutch reservoir on the brake servo by a braided connecting hose.

The slave cylinder is located on the left hand side of the gearbox housing and secured with two bolts. A heat shield is fitted to protect the underside of the slave cylinder from heat generated from the exhaust system. The slave cylinder comprises a cylinder with a piston and a rod. A port in the cylinder body provides the attachment for the hydraulic feed pipe from the master cylinder. A second port is fitted witha bleed nipple used for removing air from the hydraulic system after servicing. The piston rod locates on a clutch release lever located in the gearbox housing. The rod is positively retained on the release lever with a clip.

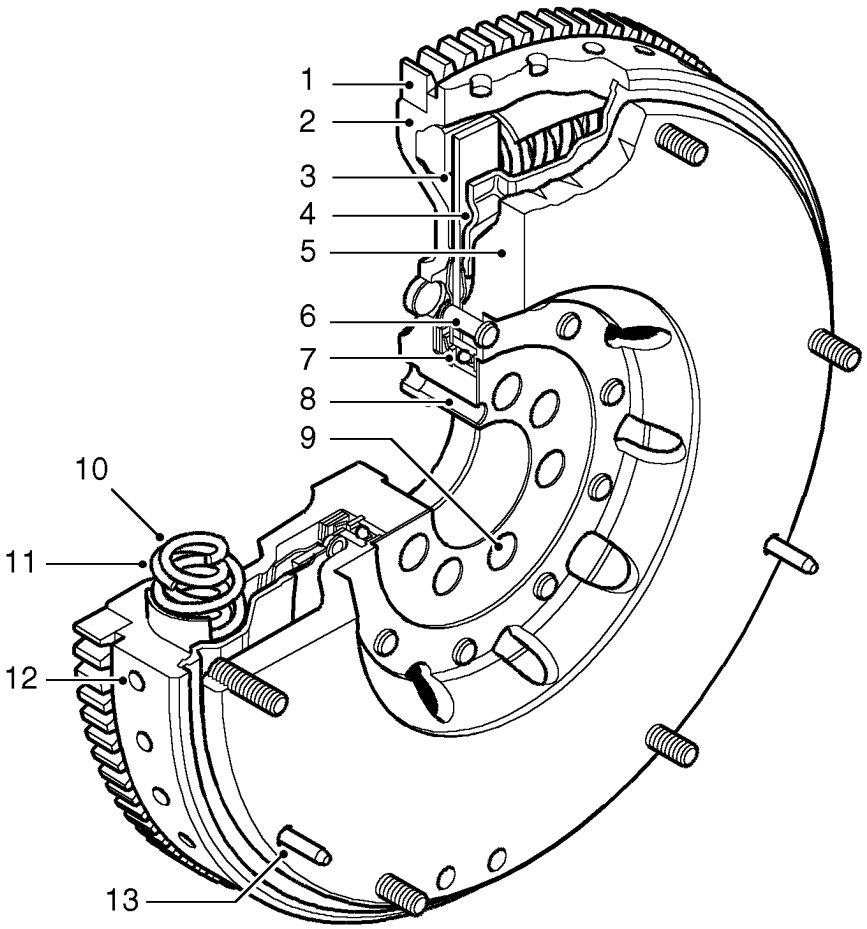
Clutch mechanism
The clutch mechanism comprises a flywheel, drive plate, pressure plate, release lever and a release bearing. The clutch mechanism is fully enclosed at the rear of the engine by the gearbox housing.

A clutch release bearing sleeve is attached in the gearbox housing with two bolts and located on two dowels. A spigot with a ball end is formed on the release bearing sleeve and provides amounting and pivot point for the clutch release lever. A dished pivot washer is located on the ball of the spigot. When the release lever is located on the ball, the pivot washer seats against the rear face of the release lever. A spring clip is located on the lever and the pivot washer and secures the lever on the spigot. A small bolt retains the spring clip in position.

The release lever is forked at its inner end and locates on the clutch release bearing carrier. The outer end of the release lever has a nylon seat which locates the slave cylinder piston rod. A second nylon seat, positioned centrally on the release lever, locates on the ball spigot of the release bearing sleeve and allows the release lever to pivot freely around the ball.

The clutch release bearing locates on the clutch release lever and release bearing sleeve. The bearing is retained on a carrier which has two flats to prevent the carrier rotating on the release lever. A clip retains the release lever on the carrier. The bearing and carrier are not serviceable individually.

Dual mass flywheel



M33 0334

1 Ring gear
2 Primary flywheel
3 Inner drive plate
4 Spring housing
5 Secondary flywheel
6 Rivet
7 Ball bearing
8 Dowel location hole
9 Mounting hole
10 Inner spring
11 Outer spring
12 Crankshaft position sensing holes
13 Pressure plate locating dowel

The dual mass flywheel is bolted on the rear of the crankshaft with eight bolts. A dowel on the crankshaft flange ensures that the flywheel is correctly located. A ring gear is fitted on the outer diameter of the flywheel. The ring gear is not serviceable. Thirty blind holes are drilled in the outer diameter of the flywheel adjacent to the ring gear. The holes are positioned at 10° intervals with four 20° spaces. The holes are used by the crankshaft position sensor for engine management.

☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**

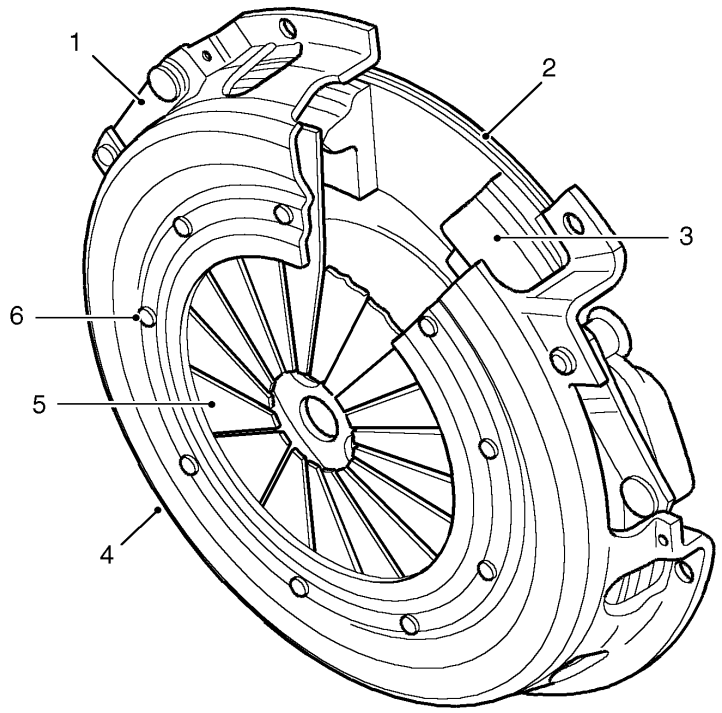
The dual mass flywheel is used to insulate the gearbox from torsional and transient vibrations produced by the engine. The flywheel comprises primary and secondary flywheels with the drive between the two transferred by a torsional damper which comprises four coil springs. The springs are located in the inside diameter of the primary flywheel. Two of the springs are of smaller diameter and fit inside the larger diameter springs.

The primary flywheel locates the ring gear and is attached to the crankshaft flange with eight bolts. The two pairs of coil springs are located in a recess in the flywheel between two riveted retainers. A roller bearing is pressed onto the central boss of the primary flywheel and retained with a riveted plate. The bearing provides the mounting for the secondary flywheel.

The secondary flywheel comprises two parts; an outer flywheel which provides the friction surface for the clutch drive plate and an inner drive plate which transfers the drive from the primary flywheel, via the coil springs, to the outer flywheel. The two components of the secondary flywheel are secured to each other with rivets. The inner drive plate is located between the two pairs of coil springs and can rotate on the ball bearing in either direction against the combined compression force of the four coil springs. Under high torque loading conditions the secondary flywheel can rotate in either direction up to 70° in relation to the primary flywheel.

The operating face of the secondary flywheel is machined to provide a smooth surface for the drive plate to engage on. Three dowels and six studs and nuts provide for the location and attachment of the pressure plate.

Pressure plate



M33 0332

1 Leaf spring
2 Drive plate
3 Pressure plate
4 Cover
5 Diaphragm
6 Rivet

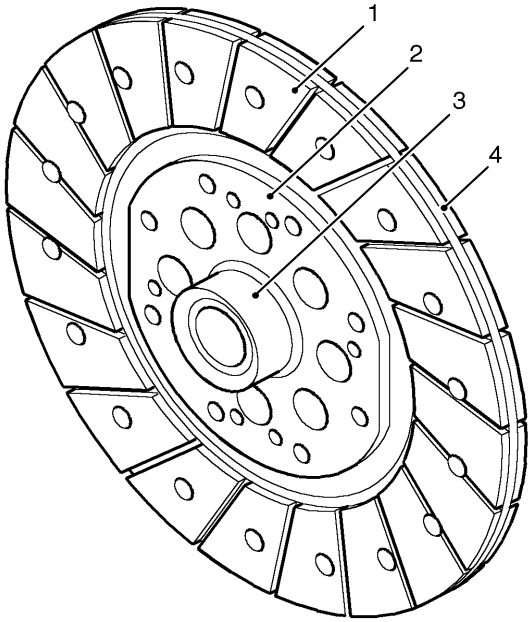
The pressure plate assembly comprises a pressure plate, cover and diaphragm and is mounted on and rotates with the dual mass flywheel.

The pressure plate is forged from cast iron and machined to provide a smooth surface for the drive plate to engage on. Three lugs on the outer diameter of the pressure plate connect it via three leaf spring to the cover. The leaf springs have three tempered steel leaves which assist in pulling the pressure plate away from the drive plate when the clutch pedal is depressed.

The cover is made from pressed steel and houses all pressure plate components. Shouldered rivets support the diaphragm inside the cover. The rivets heads are chamfered to allow the diaphragm to pivot when pressure is applied to it by the release bearing. Three holes in the cover locate on the dowels on the flywheel and six further holes provide for the attachment of the cover to the flywheel with six nuts. Larger holes in the cover provide ventilation for the drive plate and pressure plate and flywheel contact surfaces.

The diaphragm comprises a cast ring with eighteen fingers. The diaphragm is attached to the cover with nine shouldered rivets. The inner head of each rivet is chamfered to allow the diaphragm to pivot when the clutch is depressed or released. When pressure is applied to the fingers of the diaphragm by the release bearing, the diaphragm pivots on the rivets and moves away from the pressure plate, releasing the force applied to the pressure plate and allowing the drive plate to slip between the pressure plate and the flywheel.

Drive plate



M33 0333

1 Friction material
2 Inner plate
3 Hub
4 Spring steel plate

The drive plate is of the rigid centre type and is sandwiched between the flywheel and the pressure plate. The drive plate has a splined hub which engages with the splines on the primary drive shaft from the gearbox. The hub is attached to an inner plate which is pressed onto the hub. A spring steel plate is riveted to the inner plate with eight rivets and provides the attachment surface for the drive plate friction material. The spring steel plate allows some axial compliance and contributes to smooth clutch operation. The friction material comprises two 267 mm (10.5 in.) discs which are secured with rivets to each side of the spring steel plate. The rivets are installed through recessed holes in the disc and emerge in recessed holes in the opposite disc.

Operation

Hydraulic operation
Refer to illustration.
☞ **CLUTCH - Td5, DESCRIPTION AND OPERATION, Hydraulic operation.**

When the clutch pedal is depressed, the master cylinder piston is pushed into the master cylinder. The movement of the piston pressurises the fluid in the master cylinder, forcing the pressurised fluid into the hydraulic feed pipe to the slave cylinder. The hydraulic pressure is felt at the slave cylinder piston which moves under the hydraulic force applied, pushing the clutch release lever via the piston rod.

When the clutch pedal is released, the force applied to the release lever by the fingers of the diaphragm, moves the release lever, which pushes the slave cylinder piston into the cylinder. The displaced hydraulic fluid is pushed up the hydraulic feed pipe and returns to the master cylinder.

Mechanism operation
When the clutch pedal is depressed, hydraulic pressure extends the piston and rod in the slave cylinder. The extension of the piston pushes the rod against the outer end of the release lever which pivots around the ball spigot.

The inner end of the release lever pivots towards the engine applying pressure to the release bearing. The release bearing slides along the release bearing sleeve and pushes on the fingers of the diaphragm. The diaphragm pivots around the chamfered rivets in the cover. As the diaphragm is deflected, it removes pressure from the pressure plate. The pressure plate moves away from the drive plate assisted by the three leaf springs.

The removal of force from the pressure plate on the drive plate reduces the friction between the dual mass flywheel, drive plate and pressure plate. The drive plate slips between the flywheel and the pressure plate preventing rotary movement being transferred from the flywheel and pressure plate to the primary driveshaft.

When the clutch pedal is released, hydraulic force is removed from the piston in the slave cylinder. This allows the fingers of the diaphragm to push the release bearing along the release bearing sleeve. The movement of the release bearing moves the release lever which pivots on the ball spigot, pushing the piston and rod back into the slave cylinder.

The removal of pressure from the release bearing on the diaphragm, causes the diaphragm to pivot around the chamfered rivets in the cover. The force applied to the pressure plate from the diaphragm overcomes the force of the leaf springs and the pressure plate moves towards the drive plate and flywheel.

The pressure plate applies pressure to the drive plate which is pushed against the flywheel. As the clutch pedal is progressively released, the friction between the drive plate, flywheel and pressure plate increases. The increase in friction transfers the rotary movement of the flywheel and pressure plate to the drive plate, which in turn starts to rotate the primary drive shaft. When the clutch pedal is released fully, the force applied by the diaphragm to the pressure plate forces the drive plate onto the flywheel with no slippage.

Clutch hydraulic system - bleed

33.15.01

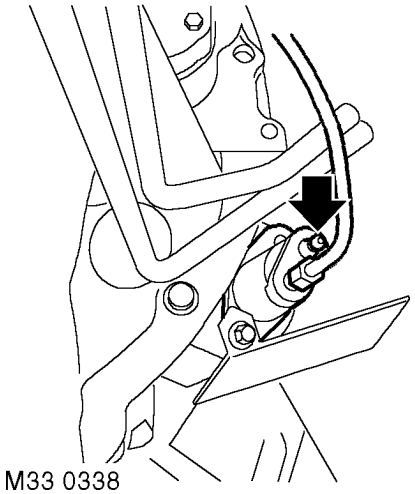
CAUTION: Ensure the fluid in the reservoir is maintained between the minimum and maximum levels throughout the bleed procedure using new brake fluid.

CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.

Bleeding

1. Top up reservoir.
2. Raise the front of the vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M33 0338

3. Connect tube to bleed screw on clutch slave cylinder and submerge free end in a clear container containing brake fluid.
4. Loosen bleed screw, then apply steady pressure to the clutch pedal, depressing it through its full stroke. Allow the pedal to return unassisted.
5. Repeat the procedure until a flow of clean, air-free fluid is purged into the container.
6. Hold the pedal to the floor and tighten the clutch bleed screw to 9 Nm (7 lbf.ft).
7. Check and top up reservoir.

   CAUTION: Never re-use fluid that has been bled from the system.

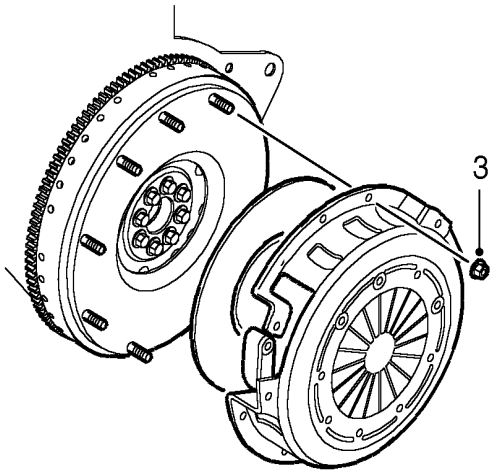
8. Remove stands and lower the vehicle.

Clutch assembly

33.10.01

Remove

1. Remove gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - Diesel.
2. Restrain flywheel.

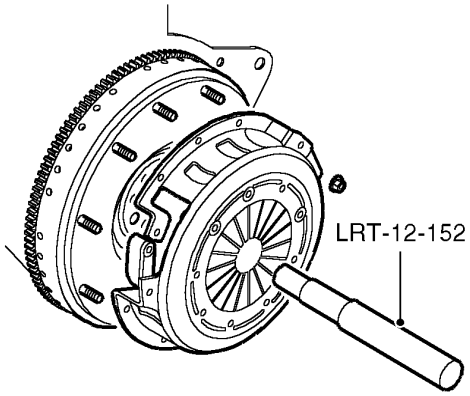


M33 0341

3. Working in diagonal sequence, progressively loosen 6 nuts securing clutch cover to flywheel.
4. Remove clutch cover and clutch plate.
5. Renew all worn or damaged components.

Refit

1. Clean clutch cover and flywheel mating faces and spigot bush in end of crankshaft.
2. Position clutch plate to flywheel with 'gearbox side' facing towards gearbox.



M33 0323

3. Position tool **LRT-12-152** through drive plate into spigot bearing in crankshaft.
4. Fit clutch cover and locate on dowels.
5. Fit clutch cover nuts and progressively tighten in diagonal sequence to 25 Nm (18 lbf.ft).
6. Fit gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - Diesel.

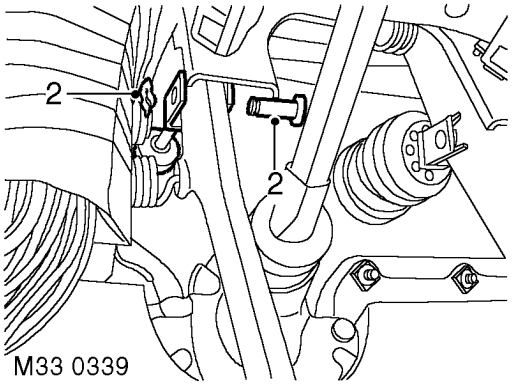
Master cylinder

33.20.01

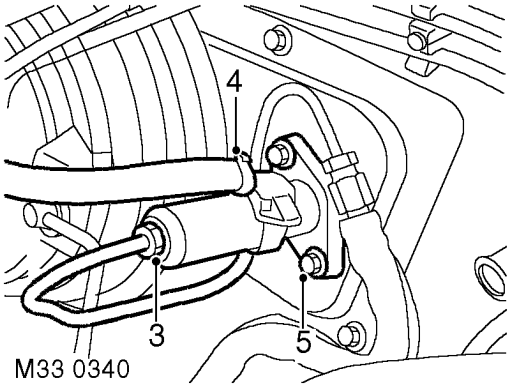
CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.

Remove

1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Release spring clip securing clutch pedal clevis pin and remove pin from push rod and clutch pedal.



3. Position container to catch spillage. Disconnect hydraulic pipe from clutch master cylinder.
   CAUTION: Always fit plugs to open connections to prevent contamination.
4. Release clip and remove connecting hose from clutch master cylinder.
5. Remove 2 bolts securing clutch master cylinder to pedal box and remove clutch master cylinder.

Refit

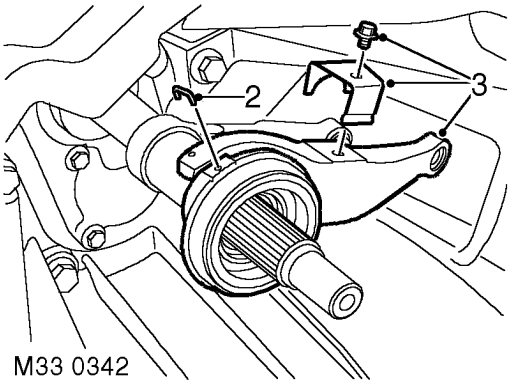
1. Clean master cylinder and pedal box mating faces.
2. Position clutch master cylinder to pedal box, fit bolts and tighten to 25 Nm (18 lbf.ft).
3. Position clevis pin to push-rod and clutch pedal and secure with spring clip.
4. Fit connecting hose to brake master cylinder and tighten clip.
5. Position hydraulic pipe and tighten union to 18 Nm (13 lbf.ft).
6. Bleed clutch.
   ☞ **CLUTCH - Td5, ADJUSTMENTS, Clutch hydraulic system - bleed.**
7. Remove stand(s) and lower vehicle.

Bearing and lever - clutch release

33.25.12

Remove

1. Remove gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - Diesel.



M33 0342

2. Remove retaining peg and remove release bearing.
3. Remove bolt securing clutch release lever. Remove retaining clip and clutch release lever.

Refit

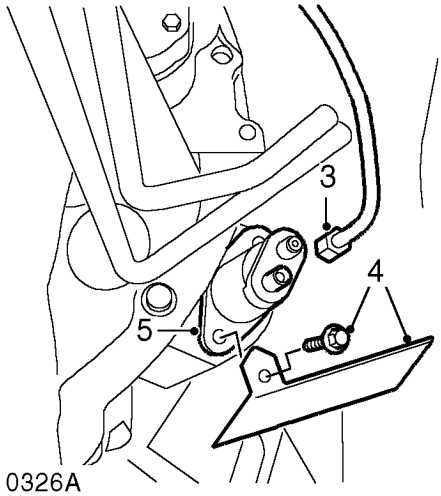
1. Clean clutch release lever.
2. Examine clutch release lever pivot points for wear.
3. Apply a smear of Molybdenum disulphide grease to clutch release lever pivot points.
4. Fit retaining clip ensuring it locates over release bearing pivot point washer, fit bolt and tighten to 8 Nm (6 lbf.ft).
5. Clean release bearing and bearing sleeve mating faces.
6. Apply a smear of Molybdenum disulphide grease to release bearing sleeve.
7. Fit release bearing and secure with retaining peg.
8. Fit gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - Diesel.

Slave cylinder

33.35.01

Remove

1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Position container to catch spillage.



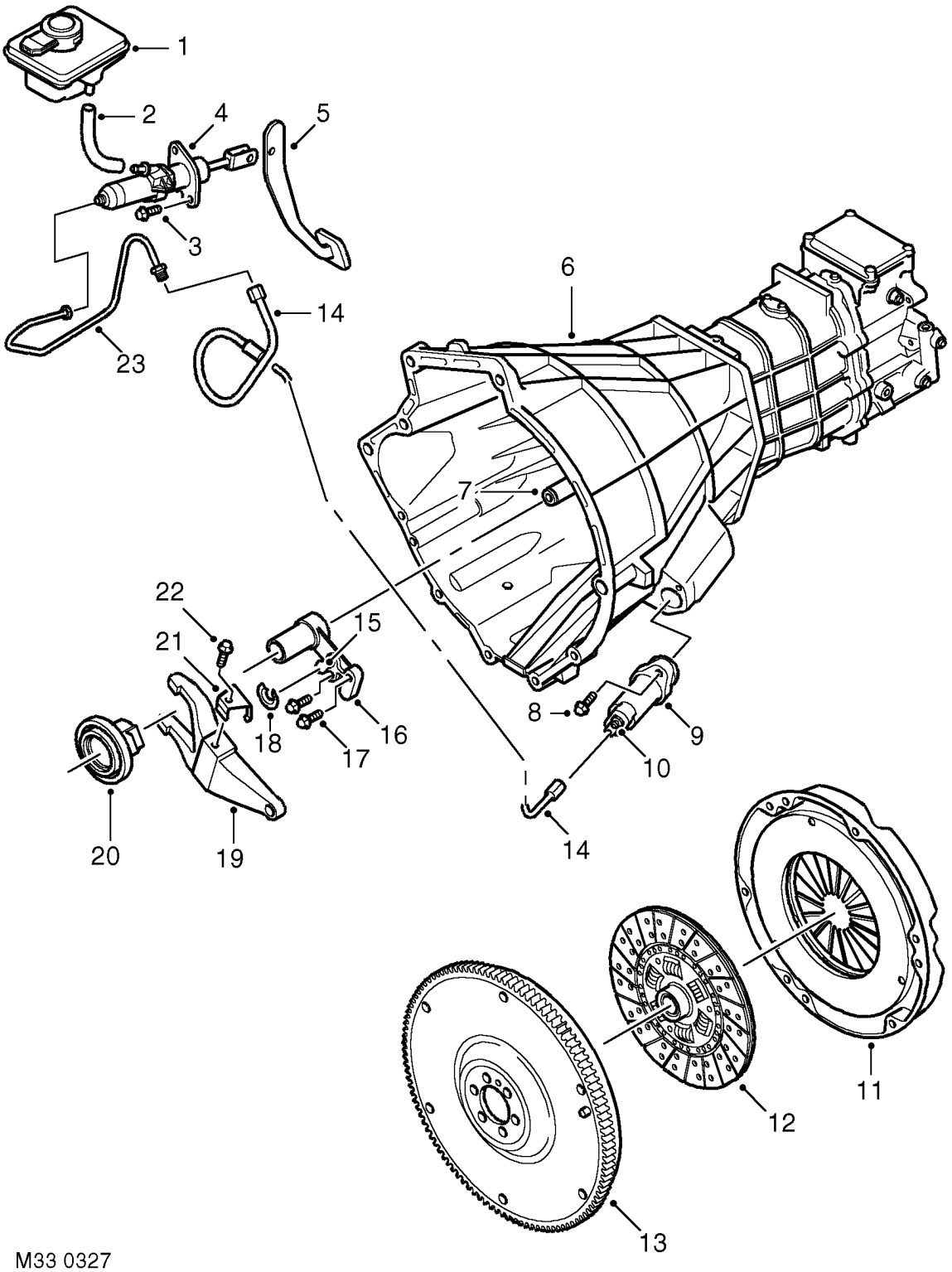
M33 0326A

3. Disconnect hydraulic pipe from slave cylinder.
   CAUTION: Always fit plugs to open connections to prevent contamination.
4. Remove 2 bolts securing slave cylinder to gearbox housing and collect heat shield.
5. Withdraw slave cylinder from gearbox housing and push rod.

Refit

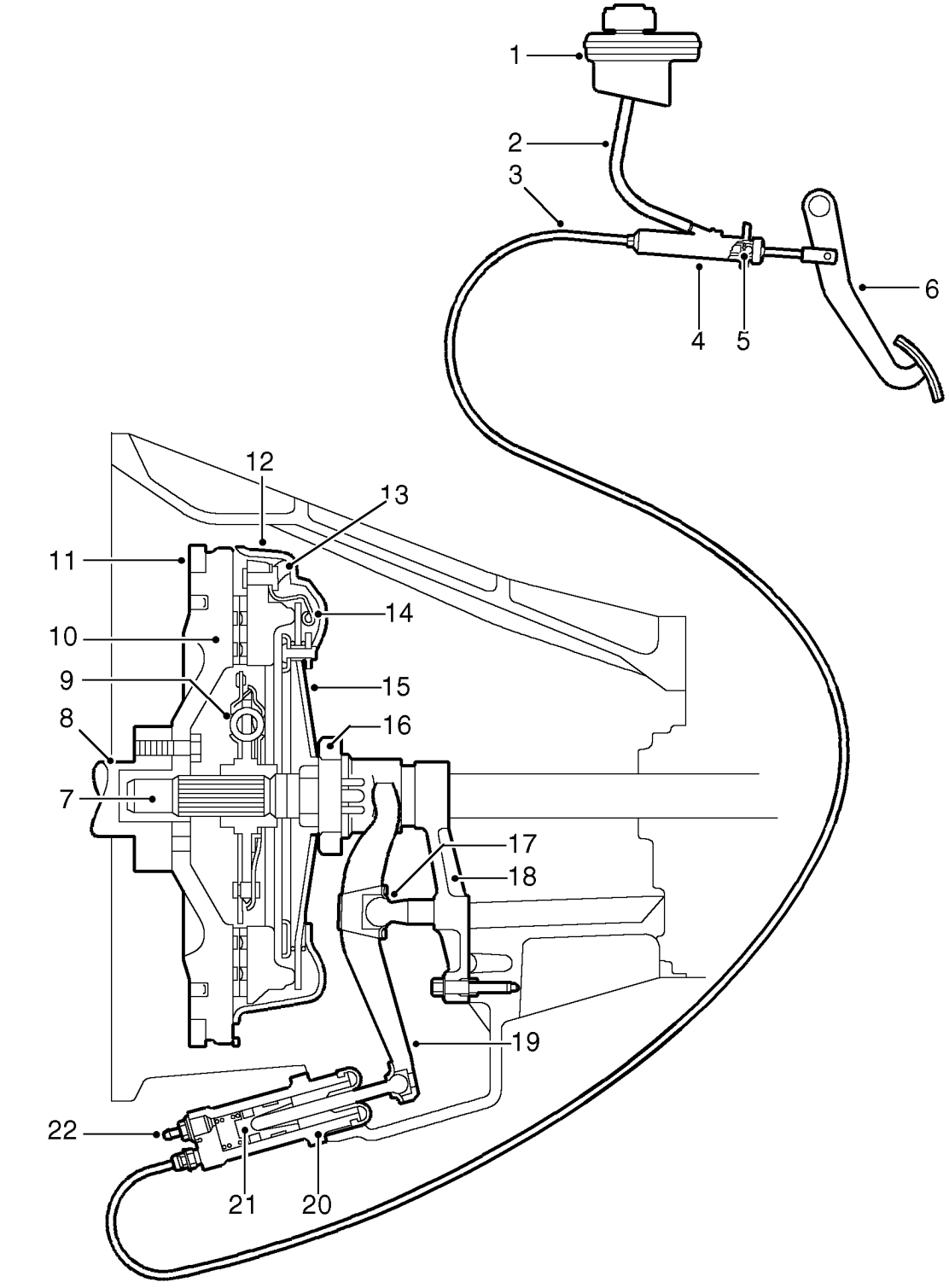
1. Clean ends of pipes, gearbox housing and slave cylinder mating faces.
2. Lubricate end of push rod with Molybdenum disulphide grease.
3. Locate slave cylinder to push rod and gearbox housing.
4. Position heatshield. Fit bolts securing slave cylinder and tighten to 25 Nm (18 lbf.ft).
5. Connect hydraulic pipe to slave cylinder.
6. Bleed clutch system.
   CLUTCH - Td5, ADJUSTMENTS, Clutch hydraulic system - bleed.
7. Remove stand(s) and lower vehicle.

Clutch components



1 Brake/clutch reservoir
2 Connecting hose
3 Bolt 2 off
4 Master cylinder
5 Clutch pedal
6 Gearbox housing
7 Primary driveshaft
8 Bolt 2 off
9 Slave cylinder
10 Bleed nipple
11 Pressure plate
12 Drive plate
13 Flywheel
14 Metal hydraulic pipes
15 Ball spigot
16 Clutch release bearing sleeve
17 Bolt 2 off
18 Pivot washer
19 Release lever
20 Release bearing
21 Retaining clip
22 Bolt
23 Bolt

Hydraulic operation



M33 0330

1 Brake/clutch reservoir
2 Fluid supply pipe
3 Hydraulic feed pipe
4 Master cylinder
5 Piston
6 Clutch pedal
7 Primary driveshaft
8 Engine crankshaft
9 Drive plate
10 Flywheel
11 Ring gear
12 Cover - Pressure plate
13 Leaf spring
14 Retractor clip
15 Diaphragm
16 Release bearing
17 Ball spigot
18 Release bearing sleeve
19 Release lever
20 Slave cylinder
21 Piston
22 Bleed nipple

Description

General
The clutch system is a conventional diaphragm type clutch operated by a hydraulic cylinder. The clutch requires no adjustment to compensate for wear.

Hydraulic clutch
The hydraulic clutch comprises a master cylinder, slave cylinder and a hydraulic reservoir, which is also shared with the braking system. The master and slave cylinders are connected to each other hydraulically by plastic and metal pipes. The plastic section of the pipe allows ease of pipe routing and also absorbs engine movements and vibrations.

The master cylinder comprises a body with a central bore. Two ports in the body connect the bore to the hydraulic feed pipe to the slave cylinder and the brake/clutch fluid reservoir. A piston is fitted in the bore and has an external rod which is attached to the clutch pedal with a pin. Two coiled springs on the clutch pedal reduce the effort required to depress the pedal.

The master cylinder is mounted on the bulkhead in the engine compartment and secured with two bolts. The cylinder is connected to the shared brake/clutch reservoir on the brake servo by a braided connecting hose.

The slave cylinder is located on the left hand side of the gearbox housing and secured with two bolts. A heat shield protects the underside of the cylinder from heat generated from the exhaust system. The slave cylinder comprises a cylinder with a piston and a rod. A port in the cylinder body provides the attachment for the hydraulic feed pipe from the master cylinder. A second port is fitted with a bleed nipple for removing air from the hydraulic system after servicing. The piston rod locates on a clutch release lever located in the gearbox housing. The rod is positively retained on the release lever with a clip.

Clutch mechanism
The clutch mechanism comprises a flywheel, drive plate, pressure plate, release lever and a release bearing. The clutch mechanism is fully enclosed at the rear of the engine by the gearbox housing.

A clutch release bearing sleeve is attached in the gearbox housing with two bolts and located on two dowels. A spigot with a ball end is formed on the release bearing sleeve and provides a mounting and pivot point for the clutch release lever. A dished pivot washer is located on the ball of the spigot. When the release lever is located on the ball, the pivot washer seats against the rear face of the release lever. A spring clip is located on the lever and the pivot washer and secures the lever on the spigot. A small bolt retains the spring clip in position.

The release lever is forked at its inner end and locates on the clutch release bearing carrier. The outer end of the release lever has a nylon seat which locates the slave cylinder piston rod. A second nylon seat, positioned centrally on the release lever, locates on the ball spigot of the release bearing sleeve and allows the release lever to pivot freely around the ball.

The clutch release bearing locates on the clutch release lever and the release bearing sleeve. The bearing is retained on a carrier which has two flats to prevent the carrier rotating on the release lever. A clip retains the release lever on the carrier. The bearing and carrier are not serviceable individually.

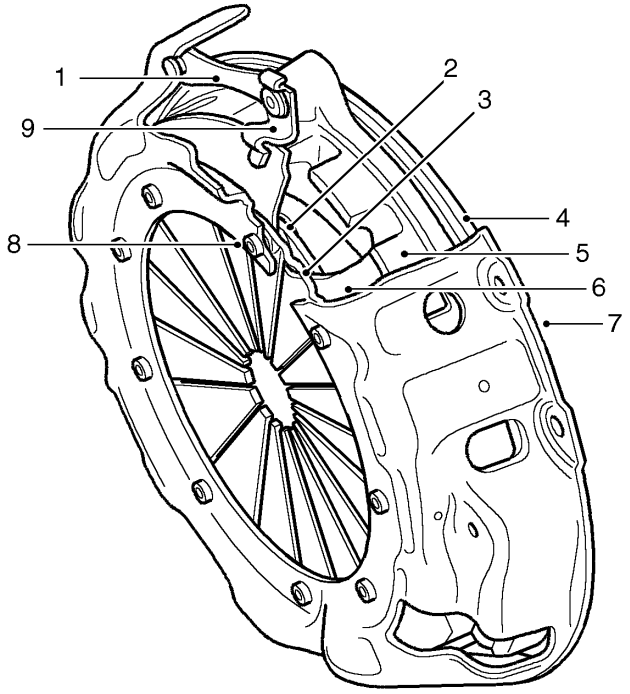
Flywheel

The flywheel is bolted to a flange on the rear of the crankshaft with six bolts. A dowel on the crankshaft flange ensures that the flywheel is correctly located. A ring gear is fitted on the outside diameter of the flywheel and seats against a flange. The ring gear is an interference fit on the flywheel and is installed by heating the ring and cooling the flywheel. The ring gear is a serviceable item and can be replaced if damaged or worn.

The operating face of the flywheel is machined to provide a smooth surface for the drive plate to engage on. Three dowels and six threaded holes provide for the location and attachment of the pressure plate. The flywheel is balanced to ensure that it does not produce vibration when rotating. A machined slot, with a series of holes within the slot, is located on the engine side of the flywheel. The slot accommodates the tip of the crankshaft position sensor which is used by the Engine Control Module (ECM) for engine management.

☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**

Pressure plate



M330328

1 Leaf spring
2 Fulcrum ring
3 Fulcrum ring
4 Drive plate
5 Pressure plate
6 Diaphragm
7 Cover
8 Rivet
9 Retractor clip

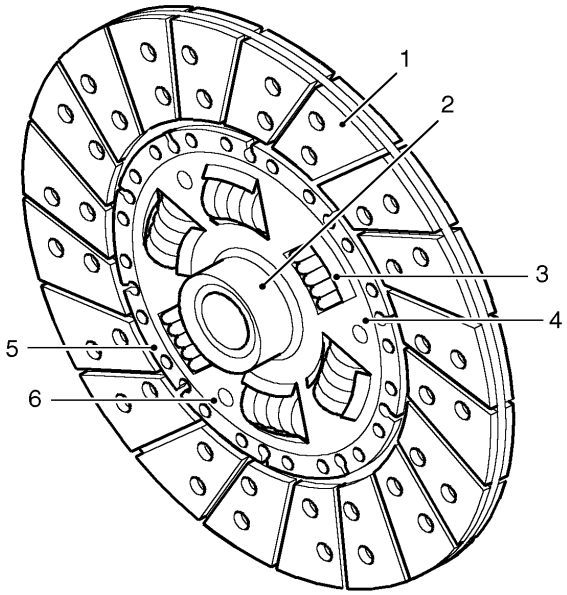
The pressure plate assembly comprises a pressure plate, cover and diaphragm and is mounted on and rotates with the flywheel.

The pressure plate is forged from cast iron and machined to provide a smooth surface for the drive plate to engage on. Three lugs on the outer diameter of the pressure plate connect it via three leaf springs to the cover. The leaf springs have two tempered steel leaves which assist in pulling the pressure plate away from the drive plate when the clutch pedal is depressed.

The cover is made from pressed steel and houses and locates all pressure plate components. Shouldered rivets support the diaphragm and fulcrum rings inside the cover. The cover also provides attachment for balance weights when the pressure plate assembly is balanced. Three holes in the cover locate on the dowels on the flywheel and six further holes provide for the attachment of the cover to the flywheel with six bolts and spring washers. Larger holes in the cover provide ventilation for the drive plate and pressure plate and flywheel contact surfaces.

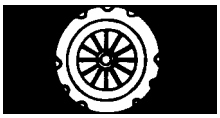
The diaphragm comprises a cast ring with eighteen fingers. The diaphragm is attached to the cover with nine shouldered rivets. Two circular steel fulcrum rings are also secured by the shouldered rivets on each side of the diaphragm. The fulcrum rings allow the diaphragm to pivot between them when the clutch is depressed or released. When pressure is applied to the diaphragm fingers by the release bearing, the diaphragm pivots between the fulcrum rings and moves away from the pressure plate. Retractor clips are secured to the pressure plate and are located on the outer diameter of the diaphragm. The retractor clips ensure that the diaphragm remains in contact with the pressure plate.

Drive plate



M33 0329

1 Friction material
2 Hub
3 Damper spring
4 Retainer plate
5 Disc adaptor
6 Stop pin



The drive plate is of the spring centred type and is sandwiched between the pressure plate and the flywheel. The drive plate has a splined hub which engages with the splines on the primary drive shaft from the gearbox. The hub is located in an inner plate which contains six compression damper springs. A spring retainer plate and a disc adaptor are secured together with stop pins which limit the angular deflection of the disc adaptor. Engine power is transmitted from the disc adaptor to the damper springs. The damper springs then transfer the power to the retainer plate and the hub. Friction washers are located between the hub, retainer plate and disc adaptor and provide further damping.

A spring steel plate is riveted to the disc adaptor and provides the attachment surface for the drive plate friction material. The friction material comprises discs which are secured with rivets to each side of the plate. The rivets are installed through recessed holes in the disc and emerge in recessed holes in the opposite disc. The drive plate is 267 mm (10.5 in) diameter and has a friction material manufactured from APTEC T385.

Operation

Hydraulic operation
Refer to illustration.
☞ **CLUTCH - V8, DESCRIPTION AND OPERATION, Hydraulic operation.**

When the clutch pedal is depressed, the master cylinder piston is pushed into the master cylinder. The movement of the piston pressurises the fluid in the master cylinder, forcing the pressurised fluid into the hydraulic feed pipe to the slave cylinder. The hydraulic pressure is felt at the slave cylinder piston which moves under the hydraulic force applied, pushing the clutch release lever via the piston rod.

When the clutch pedal is released, the force applied to the release lever by the fingers of the diaphragm, moves the release lever, which pushes the slave cylinder piston into the cylinder. The displaced hydraulic fluid is pushed up the hydraulic feed pipe and returned to the master cylinder.

Mechanism operation
When the clutch pedal is depressed, hydraulic pressure extends the piston and rod in the slave cylinder. The extension of the piston pushes the rod against the outer end of the release lever which pivots around the ball spigot.

The inner end of the release lever pivots towards the engine applying pressure to the release bearing. The release bearing slides along the release bearing sleeve and pushes on the fingers of the diaphragm. The diaphragm pivots about the fulcrum rings in the cover. As the diaphragm is deflected, it removes pressure from the pressure plate. The pressure plate moves away from the drive plate assisted by the three leaf springs and retractor clips.

The removal of force from the pressure plate on the drive plate reduces the friction between the flywheel, drive plate and pressure plate. The drive plate slips between the flywheel and the pressure plate preventing rotary movement being transferred from the flywheel and pressure plate to the primary driveshaft.

When the clutch pedal is released, hydraulic force is removed from the piston in the slave cylinder. This allows the fingers of the diaphragm to push the release bearing along the release bearing sleeve. The movement of the release bearing moves the release lever which pivots on the ball spigot, pushing the piston and rod back into the slave cylinder.

The removal of pressure from the release bearing on the diaphragm, causes the diaphragm to pivot around the fulcrum rings in the cover. The force applied to the pressure plate from the diaphragm overcomes the force of the leaf springs and the pressure plate moves towards the drive plate and flywheel.

The pressure plate applies pressure to the drive plate which is pushed against the flywheel. As the clutch pedal is progressively released, the friction between the drive plate, flywheel and pressure plate increases. The increase in friction transfers the rotary movement of the flywheel and pressure plate to the drive plate which in turn starts to rotate the primary driveshaft. When the clutch pedal is released fully, the force applied by the diaphragm to the pressure plate forces the drive plate onto the flywheel with no slippage.

Clutch hydraulic system - bleed

33.15.01

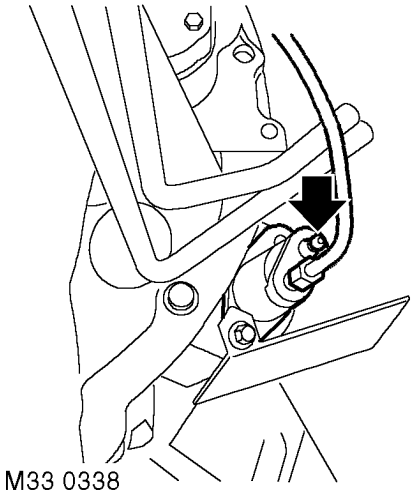
CAUTION: Ensure the fluid in the reservoir is maintained between the minimum and maximum levels throughout the bleed procedure using new brake fluid.

CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.

Bleeding

1. Top up reservoir.
2. Raise the front of the vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M33 0338

3. Connect tube to bleed screw on clutch slave cylinder and submerge free end in a clear container containing brake fluid.
4. Loosen bleed screw, then apply steady pressure to the clutch pedal, depressing it through its full stroke. Allow the pedal to return unassisted.
5. Repeat the procedure until a flow of clean, air-free fluid is purged into the container.
6. Hold the pedal to the floor and tighten the clutch bleed screw to 9 Nm (7 lbf.ft).
7. Check and top up reservoir.

   CAUTION: Never re-use fluid that has been bled from the system.

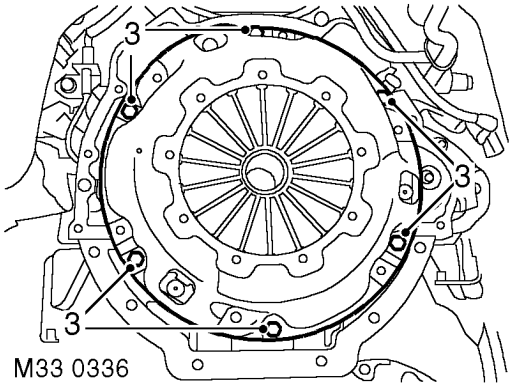
8. Remove stands and lower the vehicle.

Clutch assembly

33.10.01

Remove

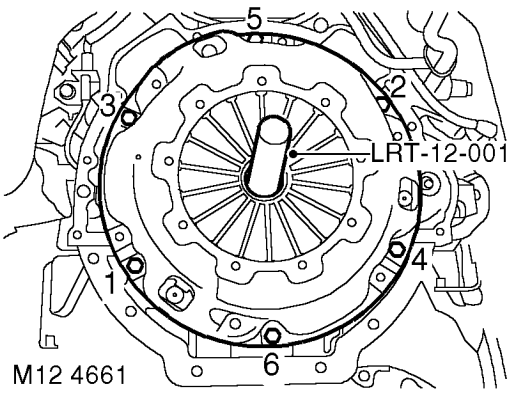
1. Remove gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.
2. Restrain flywheel.



3. Working in diagonal sequence, progressively loosen 6 bolts securing clutch cover to flywheel. Remove bolts.
4. Remove clutch cover.
5. Remove clutch plate.
6. Renew all worn or damaged components.

Refit

1. Clean clutch cover and flywheel mating faces and spigot bush in end of crankshaft.
2. Fit **LRT-12-001** to spigot bearing in crankshaft.
3. Fit clutch plate onto **LRT-12-001**, ensure side marked 'flywheel side' is against flywheel.
4. Fit clutch cover and locate on dowels.



5. Fit clutch cover bolts and progressively tighten, in diagonal sequence shown, to 40 Nm. (30 lbf.ft).
6. Fit gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.

Master cylinder

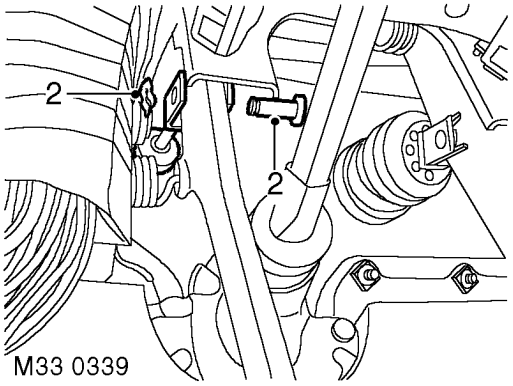
33.20.01

CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.

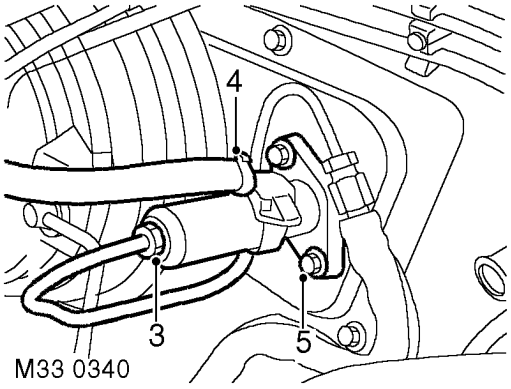
Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Release spring clip securing clutch pedal clevis pin and remove pin from push rod and clutch pedal.



3. Position container to catch spillage. Disconnect hydraulic pipe from clutch master cylinder.

   CAUTION: Always fit plugs to open connections to prevent contamination.

4. Release clip and remove connecting hose from clutch master cylinder.
5. Remove 2 bolts securing clutch master cylinder to pedal box and remove clutch master cylinder.

Refit

1. Clean master cylinder and pedal box mating faces.
2. Position clutch master cylinder to pedal box, fit bolts and tighten to 25 Nm (18 lbf.ft).
3. Position clevis pin to push-rod and clutch pedal and secure with spring clip.
4. Fit connecting hose to brake master cylinder and tighten clip.
5. Position hydraulic pipe and tighten union to 18 Nm (13 lbf.ft).
6. Bleed clutch.

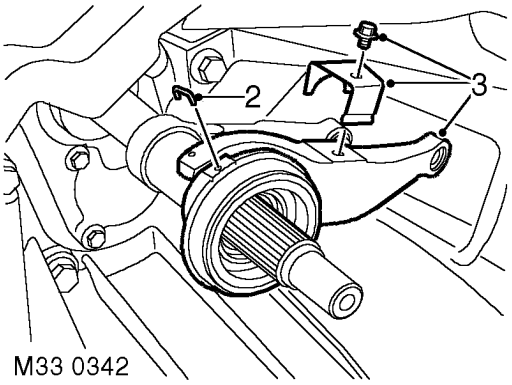
   ☞ **CLUTCH - V8, ADJUSTMENTS, Clutch hydraulic system - bleed.**
7. Remove stand(s) and lower vehicle.

Bearing and lever - clutch release

33.25.12

Remove

1. Remove gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.



2. Remove retaining peg and remove release bearing.
3. Remove bolt securing clutch release lever. Remove retaining clip and remove clutch release lever.

Refit

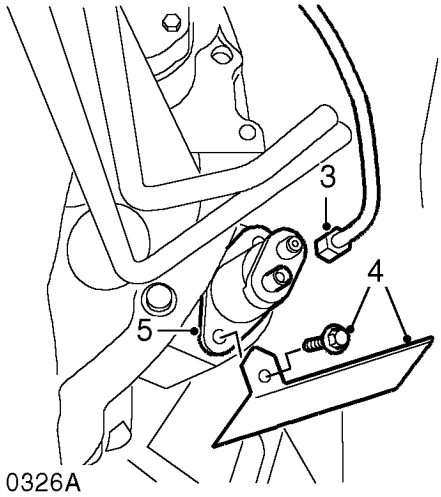
1. Clean clutch release lever.
2. Examine clutch release lever pivot points for wear.
3. Apply a smear of Molybdenum disulphide grease to clutch release lever pivot points.
4. Fit retaining clip, ensuring it locates over clutch release lever pivot point washer. Fit bolt and tighten to 8 Nm (6 lbf.ft).
5. Clean release bearing and bearing sleeve mating faces.
6. Apply a smear of Molybdenum disulphide grease to release bearing sleeve.
7. Fit release bearing and secure with retaining peg.
8. Fit gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.

Slave cylinder

33.35.01

Remove

1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Position container to catch spillage.

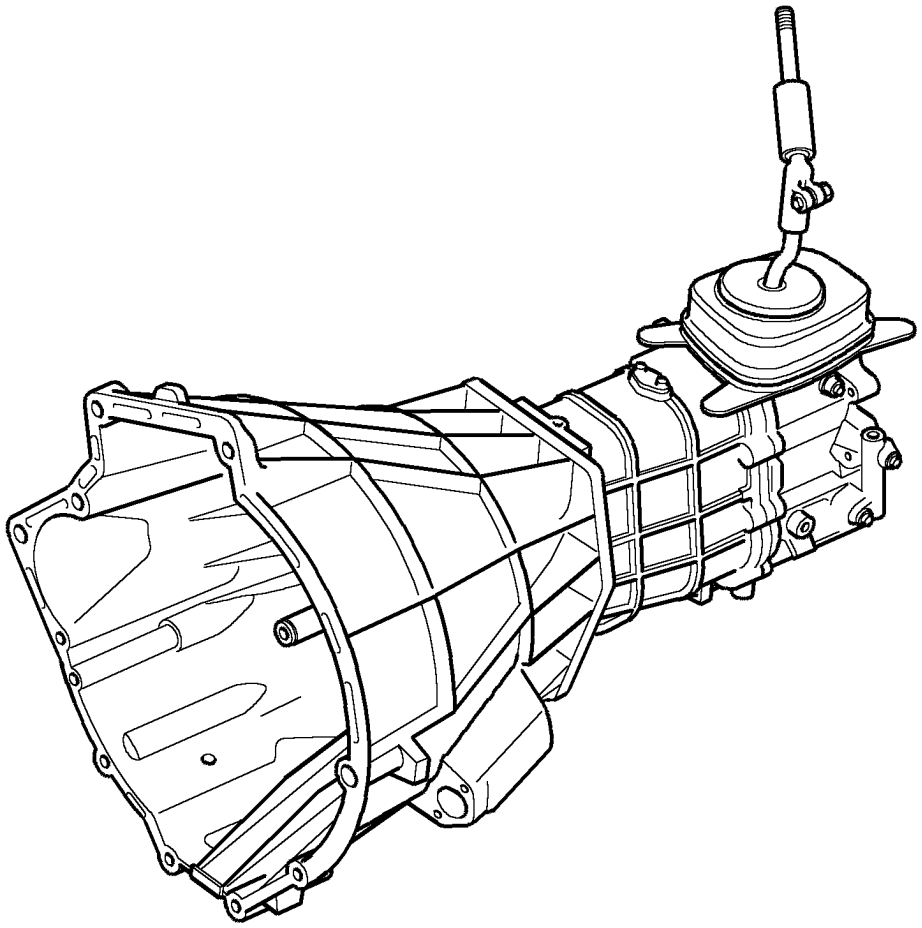


3. Disconnect hydraulic pipe from slave cylinder.
   CAUTION: Always fit plugs to open connections to prevent contamination.
4. Remove 2 bolts securing slave cylinder to gearbox housing and collect heat shield.
5. Withdraw slave cylinder from gearbox housing and push rod.

Refit

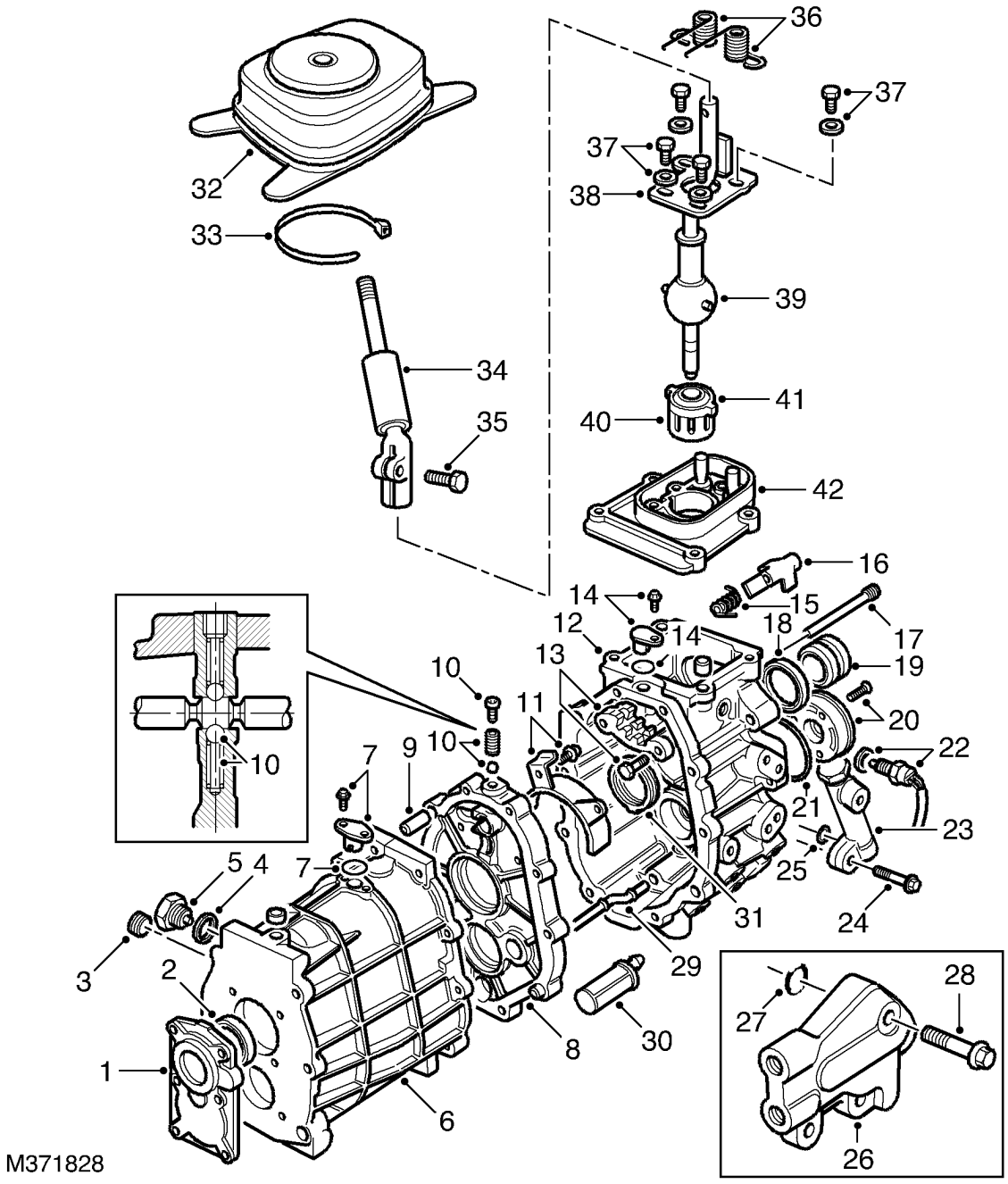
1. Clean ends of pipes, gearbox housing and slave cylinder mating faces.
2. Lubricate end of push rod with Molybdenum disulphide grease.
3. Locate slave cylinder to push rod and gearbox housing.
4. Position heatshield. Fit bolts securing slave cylinder and tighten to 25 Nm (18 lbf.ft).
5. Connect hydraulic pipe to slave cylinder.
6. Bleed clutch system.
   CLUTCH - V8, ADJUSTMENTS, Clutch hydraulic system - bleed.
7. Remove stand(s) and lower vehicle.

R380 gearbox



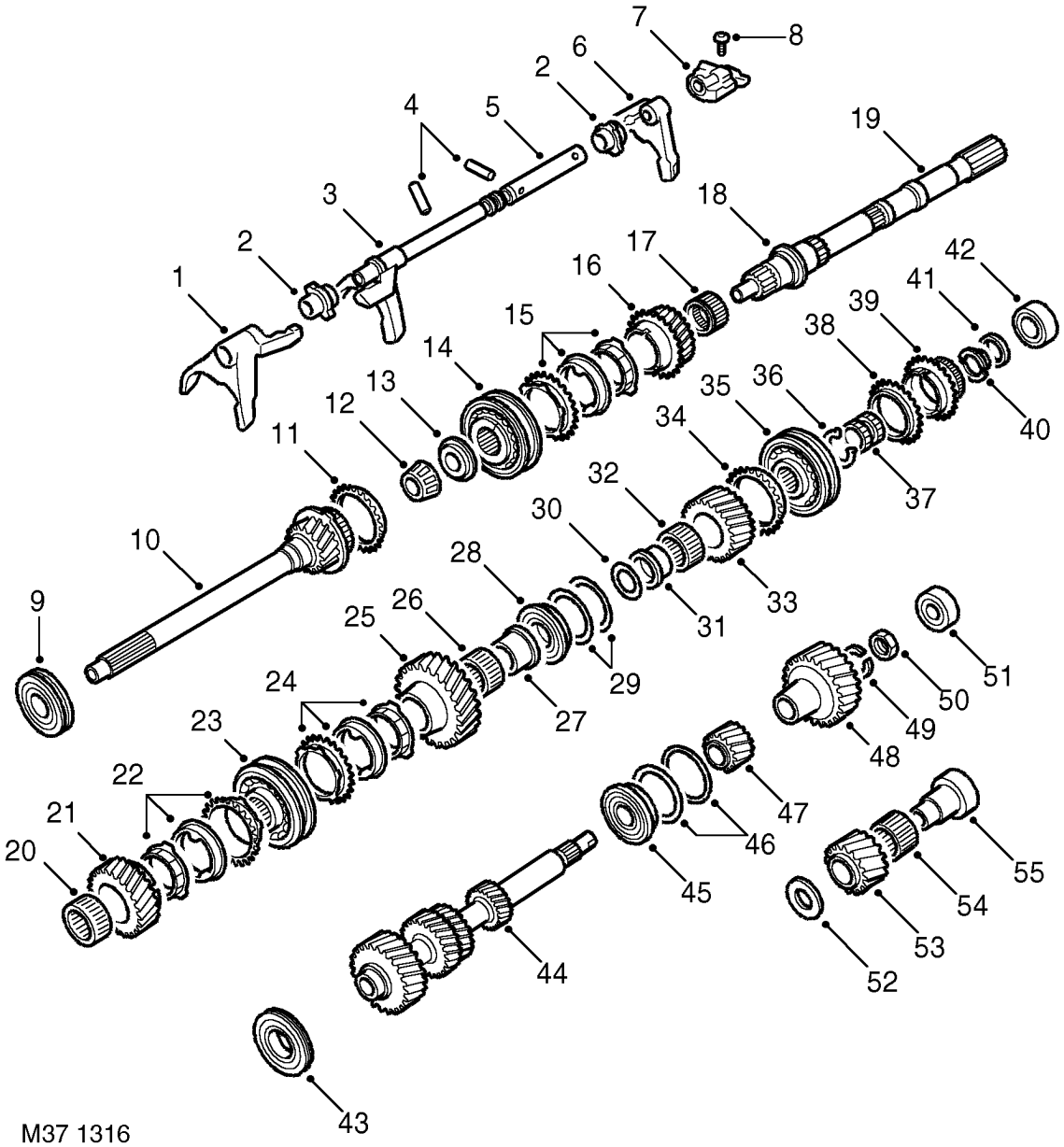
M37 1422

Gearbox casings, gear change and oil pump



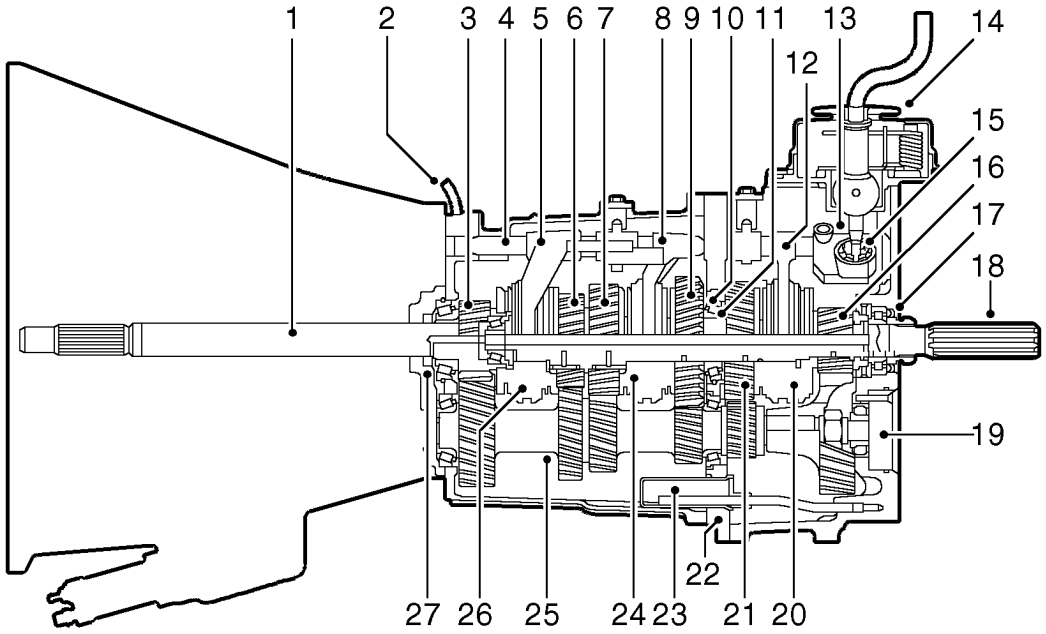
1 Front cover
2 Input shaft oil seal
3 Oil filler/level plug
4 Sealing washer
5 Oil drain plug
6 Gear case
7 Interlock spool retainer, bolt and 'O' ring
8 Centre plate
9 Locating dowels
10 Selector plug, detent balls and spring
11 Splash shield and retaining bolt
12 Extension housing
13 Gate plate and retaining bolt
14 Interlock spool retainer, retaining bolt and 'O' ring – if fitted – extension housing
15 Inhibitor cam spring
16 Inhibitor cam
17 Reverse inhibitor shaft
18 Output shaft oil seal
19 Oil seal collar
20 Oil pump and retaining bolt
21 'O' ring
22 Reverse lamp switch
23 Oil by-pass block - UK and European models
24 Bolt - oil by-pass block
25 'O' ring - oil by-pass block
26 Thermostat and housing - non UK and non European models
27 'O' ring - thermostat housing
28 Bolt - thermostat housing
29 Oil pick-up pipe
30 Oil filter
31 Oil pick-up ring
32 Rubber gaiter
33 Cable tie
34 Upper gear lever
35 Clamp bolt
36 Bias springs
37 Bolts and washers - bias adjusting plate and housing
38 Bias adjusting plate
39 Lower gear lever and ball
40 Railko bush
41 Oil seal
42 Gear change housing

Selector shaft and forks, synchromesh assemblies and gear train



1 3rd/4th gear selector fork
2 Interlock spool
3 1st/2nd gear selector fork
4 Selector shaft yoke pins
5 Selector shaft
6 Reverse/5th gear selector fork
7 Selector yoke
8 Setscrew
9 Input shaft front taper bearing
10 Input shaft
11 4th gear synchromesh ring
12 Pilot taper bearing
13 Spacer
14 3rd/4th gear synchromesh hub and sleeve
15 3rd gear synchromesh rings
16 3rd gear
17 Needle roller bearings
18 Output shaft
19 Roll pin
20 Needle bearing
21 2nd gear
22 2nd gear synchromesh rings
23 2nd/1st gear synchromesh hub and sleeve
24 1st gear synchromesh rings
25 1st gear
26 Needle roller bearing
27 Bush
28 Output shaft taper bearing
29 Selective shim
30 Selective washer
31 Bush
32 Needle roller bearing
33 Reverse gear
34 Reverse gear synchromesh ring
35 Reverse/5th gear synchromesh hub and sleeve
36 Circlip
37 Needle roller bearings
38 5th gear synchromesh ring
39 5th gear
40 5th gear segments
41 5th gear segment retaining ring
42 Output shaft rear support bearing
43 Layshaft support bearing
44 Layshaft
45 Layshaft support bearing
46 Selective shim
47 Layshaft reverse gear
48 Layshaft 5th gear
49 Split collar
50 5th gear nut
51 Layshaft rear support bearing
52 Spacer
53 Reverse idler gear
54 Needle roller bearing
55 Reverse idler shaft

R380 gearbox cross section



M37 1315

1 Input shaft
2 Breather
3 Input shaft 4th gear
4 Selector shaft
5 3rd/4th selector fork
6 Output shaft 3rd gear
7 Output shaft 2nd gear
8 1st/2nd selector fork
9 Output shaft 1st gear
10 Selective shims - output shaft and layshaft end-float
11 Selective shim - reverse gear idler shaft end-float
12 5th/reverse selector fork
13 Selector yoke
14 Gear change assembly
15 Railko bush
16 Output shaft 5th gear
17 Output shaft oil seal
18 Output shaft
19 Oil pump
20 5th/reverse gear synchromesh assembly
21 Output shaft reverse gear
22 Centre plate
23 Oil filter
24 1st/2nd synchromesh assembly
25 Layshaft
26 3rd/4th gear synchromesh assembly
27 Input shaft oil seal

Description

General
The R380 all synchromesh gearbox has five forward speeds and reverse and is mounted in line with the engine. The clutch bell housing is bolted to the front of the gearbox and the transfer box is mounted at the rear.

Gearbox casings
Gearbox casings consist of a front cover, gearcase, centre plate and extension housing. All casings with the exception of the front cover are located to each other by dowels and sealed. Gearbox filler/level and drain plugs are located in the gearcase.

Reverse lamp switch
A reverse lamp switch is inserted into the extension housing. Selection of reverse gear will close the switch allowing current from fuse 25 to flow through the switch to illuminate the reverse lamps. The switch also provides a feed to the BCU and the automatic interior mirror - if fitted; the mirror moving to the dimming position.

Gearchange assembly
The gearchange assembly is bolted to the top of the gearcase, the upper gear lever being attached to the lower gear lever by means of a clamp bolt. The lower gear lever ball is housed in a Railko bush inserted in the gear change housing, the end of the lever locating in the selector yoke which is attached to the end of the selector shaft. Bias springs provide a positive return of the gear lever to the neutral position with selection of 1st/2nd and 5th/reverse gears being against bias spring pressure. Spring loaded detent balls fitted in the centre plate locate in grooves in the selector shaft to provide positive gear and neutral selection.

Lubrication
Lubrication is by an oil pump located in the extension housing and driven by the layshaft with additional lubrication being provided by splash. The pump directs oil via a filter and internal drillings in the output shaft to lubricate the components. On non UK and non European models, provision for oil cooling is by means of a thermostat housed in a cover bolted to the side of the extension housing. The cover incorporates tappings for connections to an oil cooler. On UK and European models, the thermostat and cover are replaced by an oil by-pass block.

Internal pressures produced within the gearbox are vented to atmosphere via a plastic breather pipe. The pipe is attached to the extension housing and is routed across the top of the gearcase and secured at the open end by a clip attached to the engine cylinder block.

Selector shaft and forks
Selector forks for 1st/2nd, 3rd/4th and 5th/reverse gears are located on a single selector shaft; the 1st/2nd and 3rd/4th selector forks are inside the main gearcase whilst the 5th/reverse selector fork is inside the extension housing. Each of the selector forks locates inside its corresponding synchromesh hub.

Synchromesh assemblies
Each synchromesh assembly is located on the output shaft adjacent to its corresponding gears and comprises a synchromesh ring, hub, slippers and sleeve. The hubs and slippers are retained in the sleeves by means of spring clips. 1st/2nd and 3rd synchromesh assemblies are fitted with double synchromesh rings whilst 4th, 5th and reverse assemblies are fitted with single rings.

The gear train

The gear train comprises an input shaft, output shaft, layshaft and reverse idler shaft together with their appropriate gears and synchromesh assemblies.

The gear train input shaft, output shaft and layshaft are supported by taper roller bearings with all gears on the input and output shafts running on caged needle roller bearings. Layshaft gears are integral with the shaft with the exception of reverse/5th gears which are splined to the shaft and retained with a nut. 1st, 2nd, 3rd and 4th gears are shot peened to improve durability. The reverse idler shaft and gear are supported in the centre plate by a caged needle roller bearing. End-float of the output shaft and layshaft is controlled by selective shims located in the centre plate whilst reverse idler shaft end-float is controlled by a selective shim located behind reverse gear.

Operation

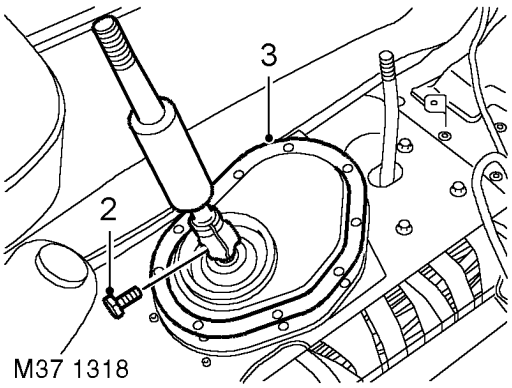
Drive is transmitted from the crankshaft, through the clutch to the gearbox input shaft which transmits drive via the layshaft to the output shaft in all gears with the exception of 4th gear which provides a direct drive from the input shaft to the output shaft. Drive from the gearbox output shaft is transmitted to the transfer box input shaft via a flange splined to the output shaft.

Spring - gear lever bias

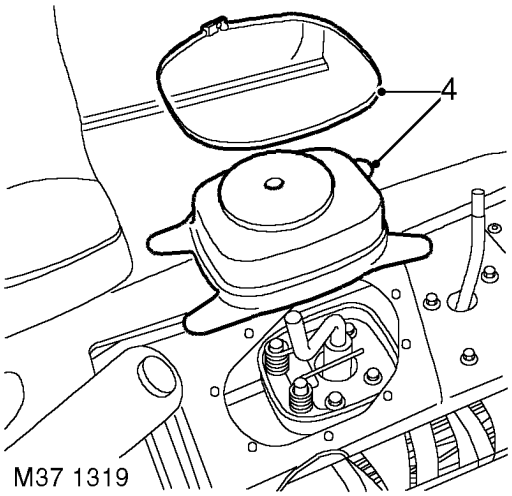
37.16.26

Adjust

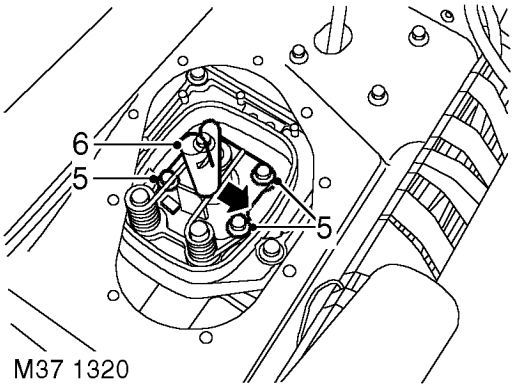
1. Remove centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.



2. Loosen pinch bolt and remove gear lever extension.
3. Drill out 9 pop rivets and remove gear lever cover plate and seal.



4. Remove retaining strap and remove gear lever housing rubber boot.



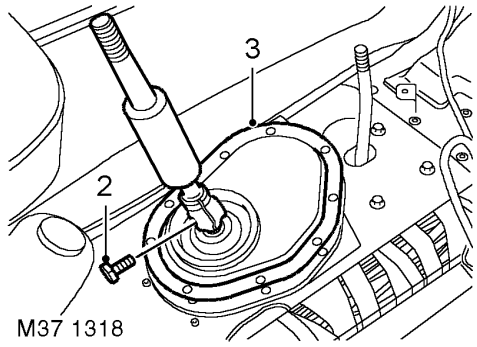
5. Loosen bias adjustment plate bolts.
6. Select 4th gear and move lever fully to the right and tighten bias plate adjustment bolts to 25 Nm (18 lbf.ft).
7. Check adjustment is correct by selecting 3rd and 4th gears.
8. Fit gear lever housing rubber and secure with retaining strap.
9. Fit seal and cover plate and secure with pop rivets.
10. Fit gear lever extension and tighten pinch bolt to 25 Nm (18 lbf.ft).
11. Fit centre console.
    INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.

Housing - gear selector

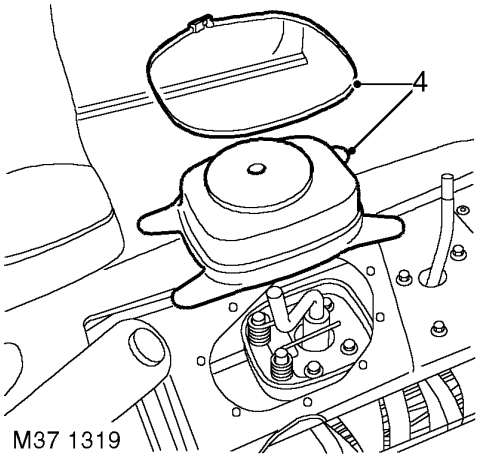
37.16.37

Remove

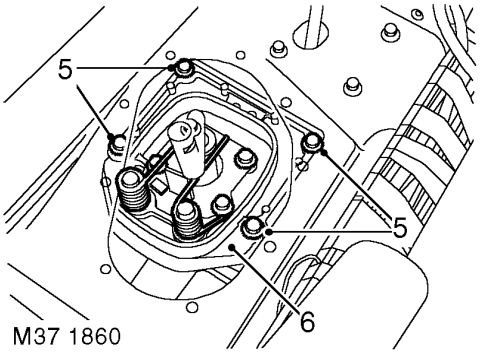
1. Remove centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.



2. Loosen pinch bolt and remove gear lever extension.
3. Drill out 9 pop rivets and remove gear lever cover plate and seal.



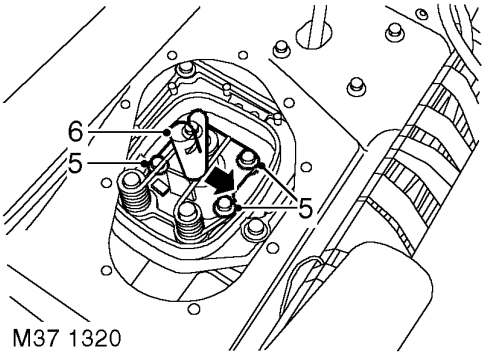
4. Remove retaining strap and remove gear lever housing rubber boot.



5. Remove 4 bolts securing gear selector housing.
6. Remove gear selector housing.

Refit

1. Clean mating faces on selector housing and gearbox.
2. Apply sealant, Part No. STC 3254 to selector housing.
3. Clean selector housing bolt threads and apply Loctite 290 to threads.
4. Position selector housing and tighten bolts to 25 Nm (18 lbf.ft).



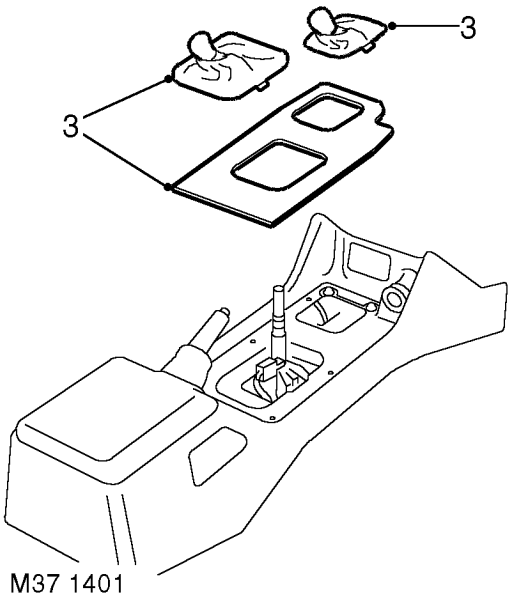
5. Loosen bias adjustment plate bolts.
6. Select 4th gear, move lever fully to the right and tighten bias adjustment plate bolts to 25 Nm (18 lbf.ft)
7. Check adjustment is correct by selecting 3rd and 4th gears.
8. Fit gear lever housing rubber and secure with retaining strap.
9. Fit seal and cover plate and secure with pop rivets.
10. Fit gear lever extension and tighten pinch bolt to 25 Nm (18 lbf.ft).
11. Fit centre console.
    INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.

Gearbox - V8

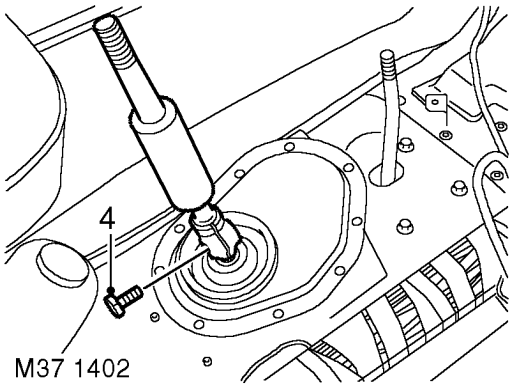
37.20.02.99

Remove

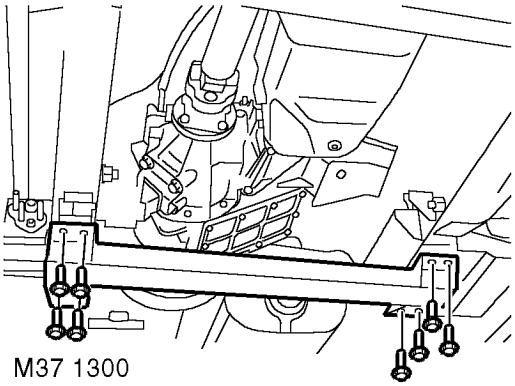
1. Release turnbuckles and remove battery cover and cooling fan cowl.
2. Disconnect battery earth lead.



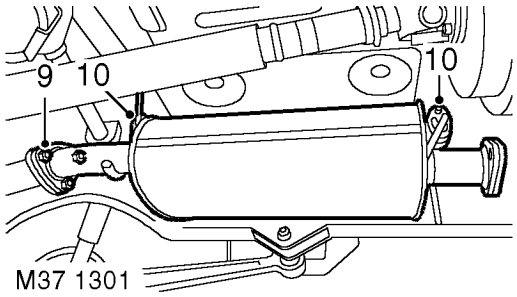
3. Remove gear lever knob and gear lever trim.



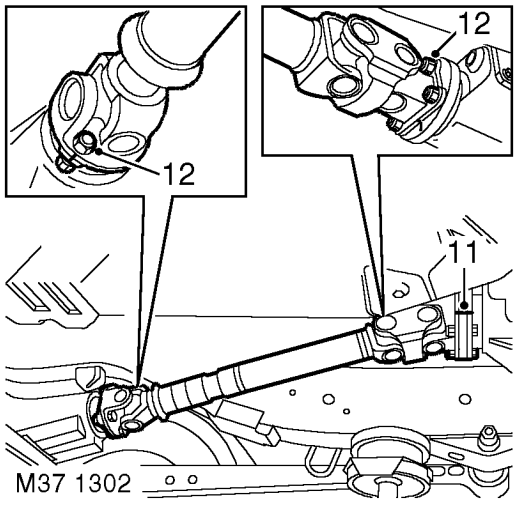
4. Remove clamp bolt and remove gear lever extension. Apply lubricant to gear lever to aid removal through grommet.
5. Remove front exhaust pipe.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.
6. Drain gearbox oil.
   MAINTENANCE, PROCEDURES, Manual gearbox.
7. Drain transfer gearbox oil.
   MAINTENANCE, PROCEDURES, Transfer box.



8. Remove 8 bolts securing rear cross member and remove cross member.

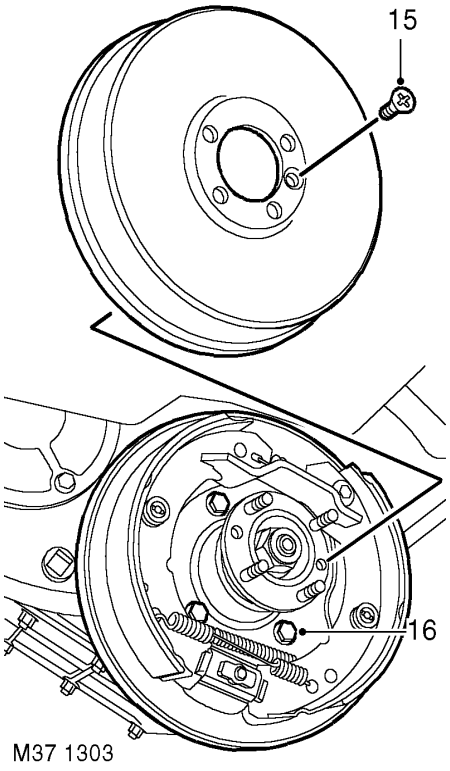


9. Remove 3 nuts securing intermediate silencer to tail pipe.
10. Release silencer from mounting rubbers, remove silencer and discard gasket.

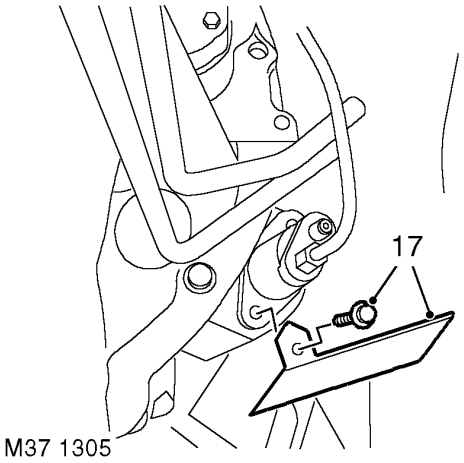


11. Mark front propeller shaft to transfer gearbox and differential flanges.

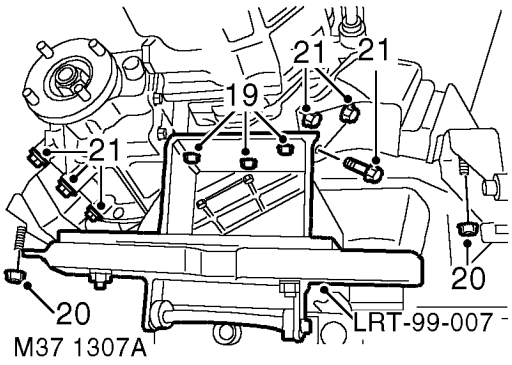
12. Remove 8 nuts securing front propeller shaft to transfer gearbox and differential.
13. Remove propeller shaft.
14. Repeat above operation for rear propeller shaft.



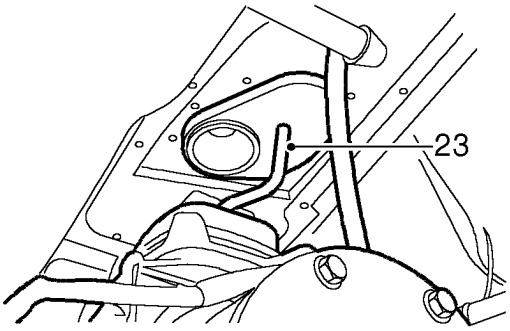
15. Remove handbrake drum retaining screw and remove handbrake drum.
16. Remove 4 bolts from handbrake back plate, release back plate and tie aside.



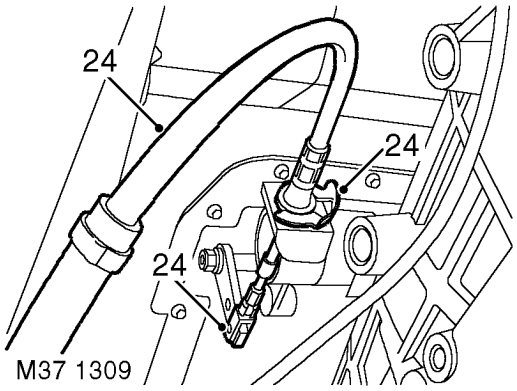
17. Remove 2 bolts securing clutch slave cylinder, collect heat shield, release slave cylinder and position aside.



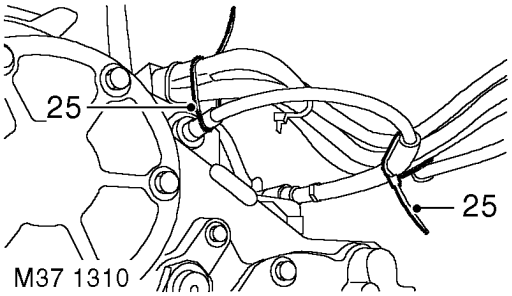
18. Fit support plate **LRT-99-007** to gearbox jack.
19. Position gearbox jack and support plate to gearbox and secure with 3 bolts.
20. Support the weight of gearbox, remove nuts securing gearbox mountings to body.
21. Remove 8 bolts securing mountings to gearbox, raise gearbox and remove both mountings.



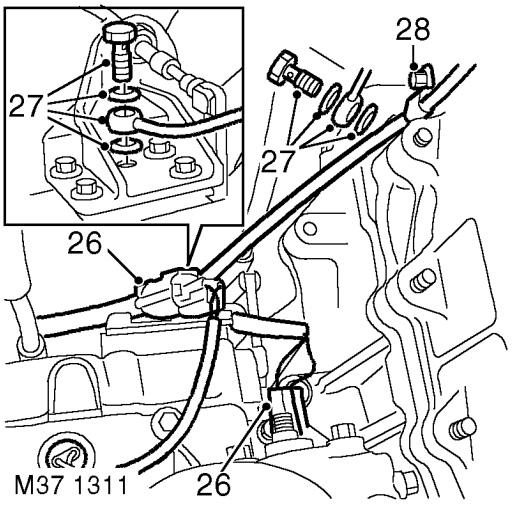
22. Lower gearbox sufficiently to access top of gearbox.
23. Ensure gear lever is released from grommet and no wires or pipes are trapped when gearbox is lowered.



24. Remove clevis pin and 'C' washer securing low ratio selector cable to lever and release cable from lever housing.



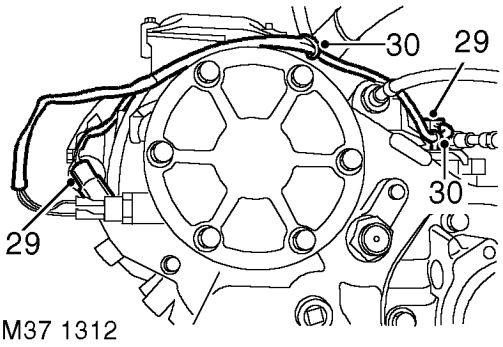
25. Remove 2 cable ties securing cable to fuel pipes.



26. Disconnect 2 Lucars from oil temperature sensor and disconnect reverse lamp switch multiplug.

27. Remove banjo bolts securing breather pipes and discard sealing washers.

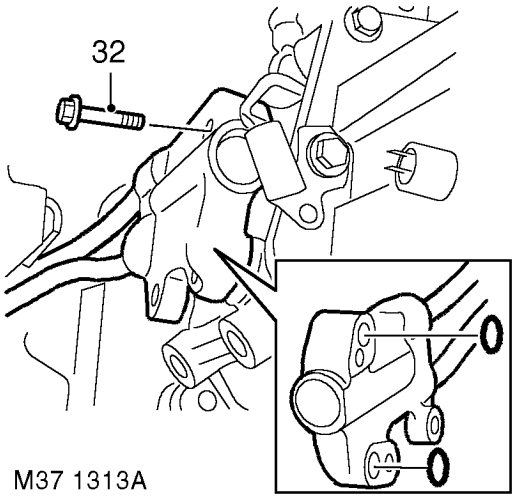
28. Remove bolt securing breather pipe 'P' clip and release breather pipes.



29. **If fitted:** Disconnect 2 Lucars from differential lock switch, release and disconnect transfer box neutral sensor multiplug.

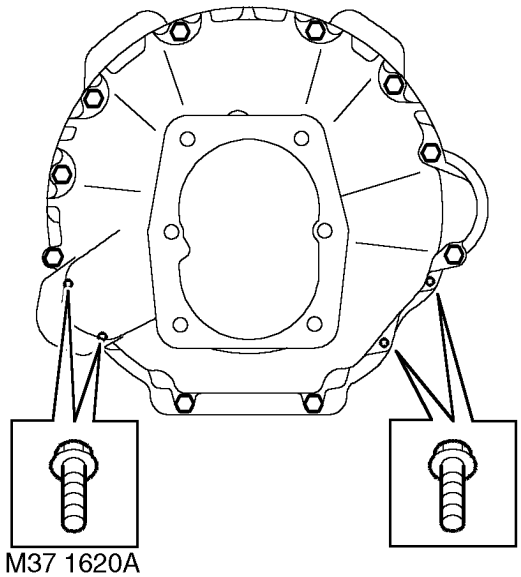
30. **If fitted:** Release harness from 2 retaining clips.

31. Position container to catch oil spillage



32. Remove 3 bolts securing oil cooling pipe housing to gearbox, release housing and discard 'O' rings.

33. Using a second jack support the weight of the engine.


M37 1620A

34. Remove 14 bolts securing gearbox to engine.
35. With assistance, remove gearbox from engine.

Refit

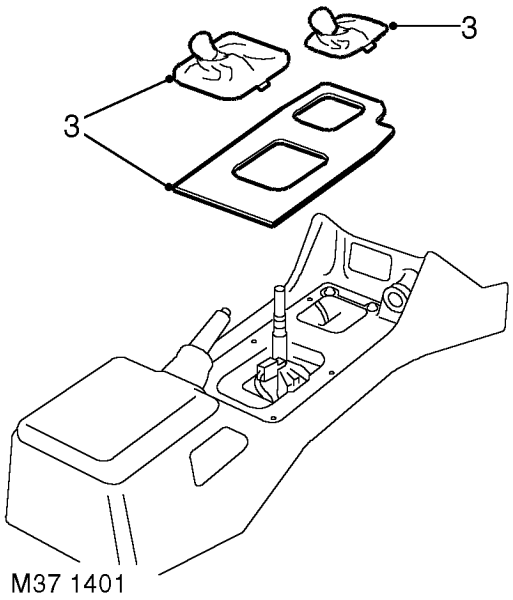
1. Clean gearbox to engine mating faces, dowels and dowel holes.
2. Raise gear gearbox on jack and align to clutch and engine.
3. Fit bolts securing gearbox to engine and tighten to 45 Nm (33 lbf.ft).
4. Lubricate and fit new 'O' rings to oil cooling pipe housing.
5. Position coolant pipe housing, fit bolts and tighten to 25 Nm (18 lbf.ft).
6. **If fitted:** Secure harness in retaining clips, connect Lucars to differential lock warning switch and multiplug to neutral sensor.
7. Position breather pipes and secure 'P' clip with bolt.
8. Using new sealing washers fit breather pipe banjo bolts and tighten to 15 Nm (11 lbf.ft).
9. Connect oil temperature sensor Lucars and reverse lamp switch multiplug.
10. Position low ratio selector cable to housing and secure with 'C' washer and clevis pin.
11. Secure cable to fuel pipes with new cable ties.
12. Raise gearbox, ensuring gear change lever is located in grommet.
13. Fit gearbox mountings and tighten bolts to 85 Nm (63 lbf.ft).
14. Fit nuts to mountings and tighten to 48 Nm (37 lbf.ft).
15. Remove 3 bolts securing support plate to gearbox.
16. Position clutch slave cylinder and heat shield, fit bolts and tighten to 25 Nm (18 lbf.ft).
17. Clean handbrake back plate and mating face.
18. Position handbrake back plate, fit bolts and tighten to 75 Nm (46 lbf.ft).
19. Clean handbrake drum.
20. Fit handbrake drum and tighten retaining screw.
21. Clean propeller shafts and mating faces.
22. Position propeller shafts, align to marks and tighten bolts to 47 Nm (35 lbf.ft).
23. Clean exhaust silencer and tail pipe mating faces.
24. Position silencer and secure on mountings, using a new gasket align to tail pipe, fit nuts and tighten to 25 Nm (18 lbf.ft).
25. Position rear cross member, fit bolts and tighten to 25 Nm (18 lbf.ft).
26. Refill gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Manual gearbox.**
27. Refill transfer gearbox oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
28. Fit front exhaust pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**
29. Fit gear lever extension, fit clamp bolt and tighten to 25 Nm (18 lbf.ft).
30. Fit gear lever trim and gear change knob.
31. Connect battery earth lead.
32. Fit battery cover and cooling fan cover and secure fixings.

Gearbox - Diesel

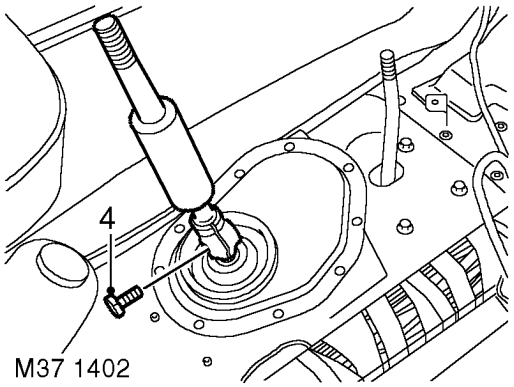
37.20.02.99

Remove

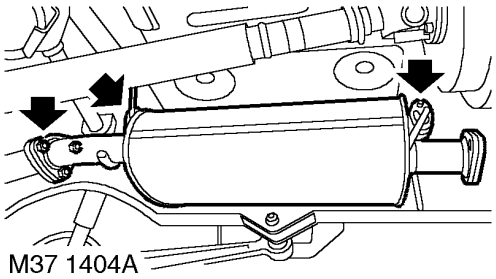
1. Release turn buckles and remove battery cover and cooling fan cowl.
2. Disconnect battery earth lead.



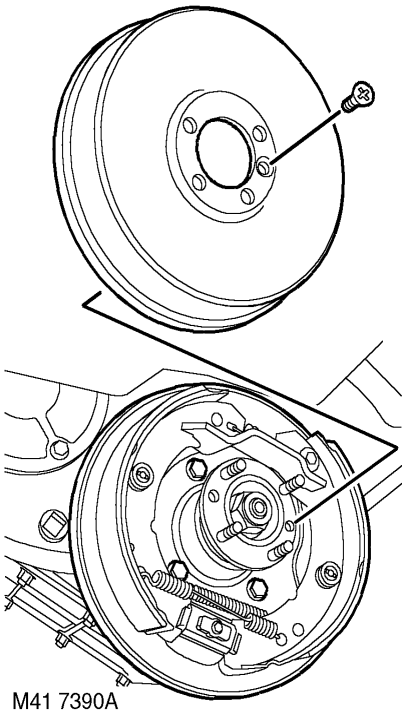
3. Remove gear lever knob and gear lever trim.



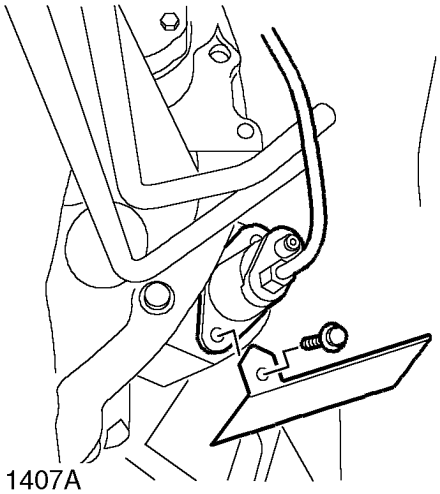
4. Remove clamp bolt and remove gear lever extension.
5. Apply a little lubricant to gear lever to aid removal through grommet.
6. Remove exhaust front pipe.
   MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.
7. Remove starter motor.
   CHARGING AND STARTING, REPAIRS, Starter motor - diesel.
8. Drain gearbox oil.
   MAINTENANCE, PROCEDURES, Manual gearbox.
9. Drain transfer gearbox oil.
   MAINTENANCE, PROCEDURES, Transfer box.



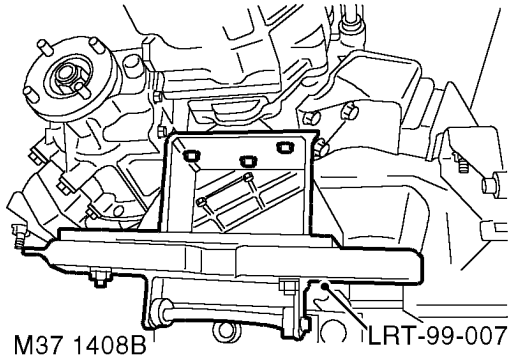
10. Remove 3 nuts securing intermediate silencer to tail pipe.
11. Release silencer from mounting rubbers, remove silencer and discard gasket.
12. Remove front propeller shaft.
    PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
13. Remove rear propeller shaft.
    PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.



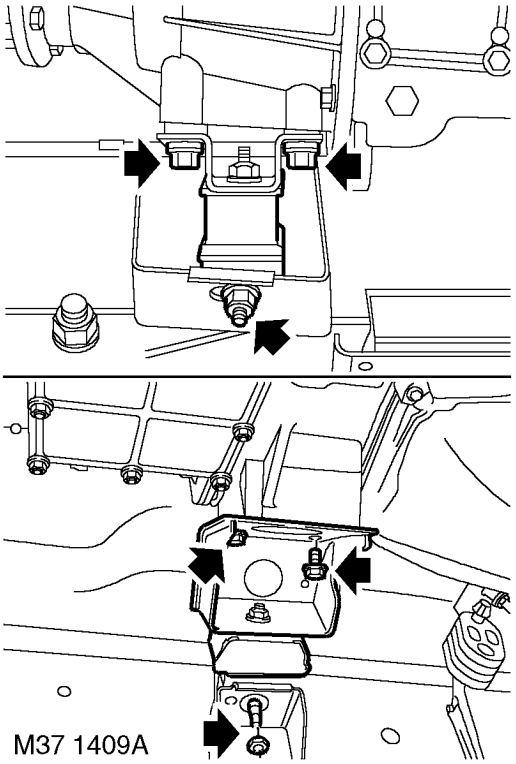
14. Remove handbrake drum retaining screw and remove handbrake drum.
15. Remove 4 bolts from handbrake back plate, release back plate and tie aside.


M37 1407A

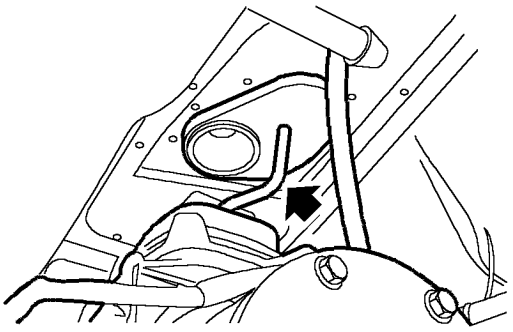
16. Remove 2 bolts securing clutch slave cylinder, collect heat shield, release slave cylinder and position aside.


M37 1408B LRT-99-007

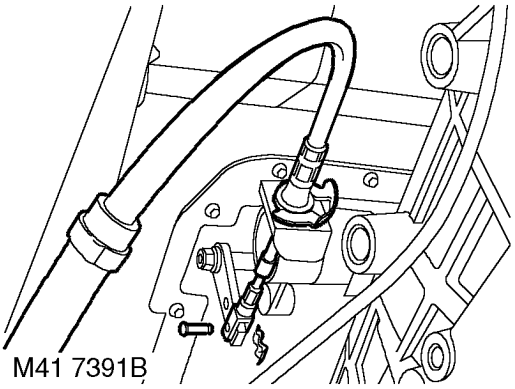
17. Fit support plate **LRT-99-007** to gearbox jack.
18. Position gearbox jack and support plate to gearbox and secure with 3 bolts.


M37 1409A

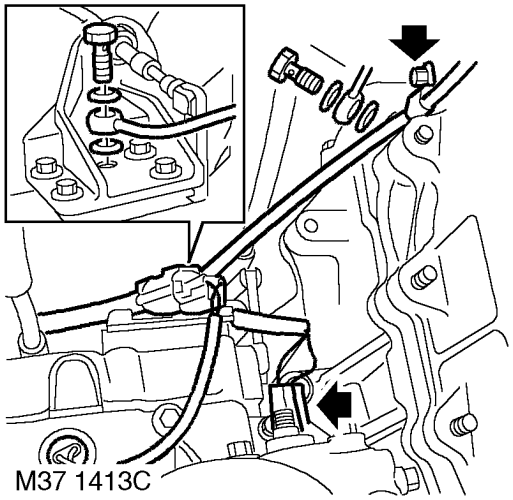
19. Support the weight of gearbox, remove nuts securing gearbox mountings to body.
20. Remove 4 bolts securing both mountings to gearbox, raise gearbox and remove both mountings.
21. Lower gearbox sufficiently to access top of gearbox.


M37 1410A

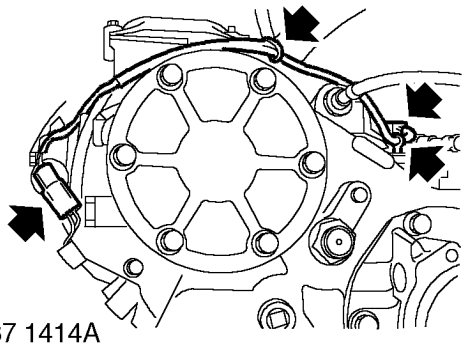
22. Ensure gear lever is released from grommet and no wires or pipes are trapped when gearbox is lowered.


M41 7391B

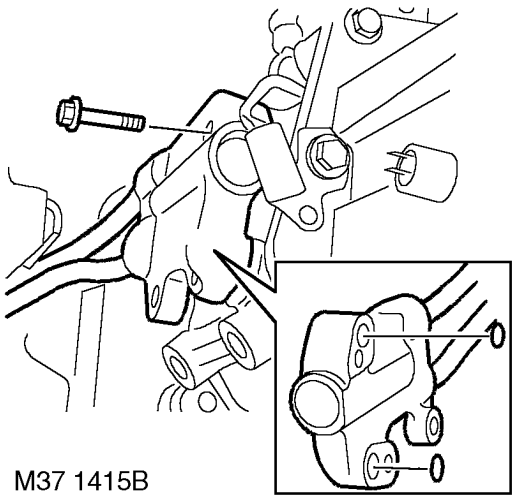
23. Remove clevis pin and 'C' washer securing low ratio selector cable to lever and release cable from lever housing.
24. Remove 2 cable ties securing cable to fuel pipes.


M37 1413C

25. Disconnect 2 Lucars from oil temperature sensor and disconnect reverse lamp switch multiplug.
26. Remove banjo bolts securing breather pipes and discard sealing washers.
27. Remove bolt securing breather pipe 'P' clip and release breather pipes.


M37 1414A

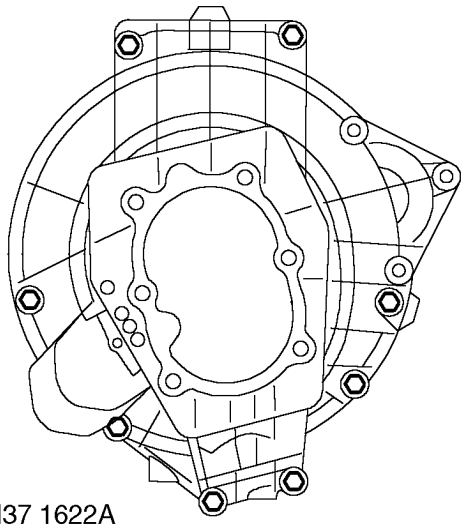
28. **If fitted:** Disconnect 2 Lucars from differential lock switch, release and disconnect transfer box neutral sensor multiplug. Release harness from 2 retaining clips.
29. Position container to catch oil spillage


M37 1415B

30. Remove 2 bolts securing oil cooling pipe housing to gearbox, release housing and discard 'O' rings.

    CAUTION: Always fit plugs to open connections to prevent contamination.

31. Using a second jack support the weight of the engine.



M37 1622A

32. Remove 8 bolts securing gearbox to engine.
33. With assistance, remove gearbox from engine.

Refit

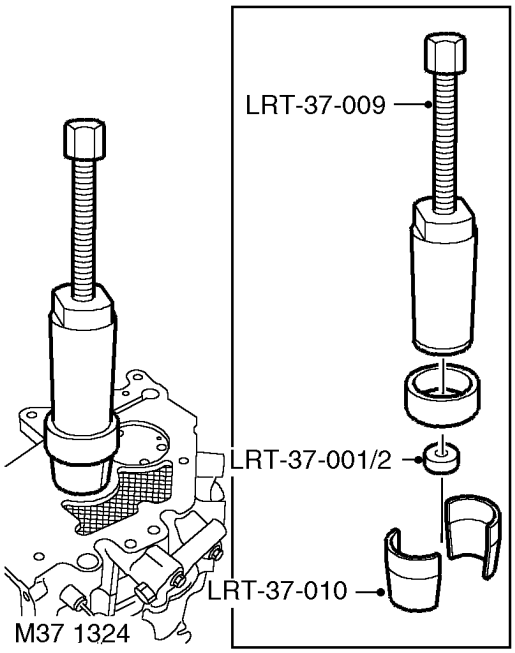
1. Clean gearbox to engine mating faces, dowels and dowel holes.
2. With assistance raise gearbox on jack and align to clutch and engine.
3. Fit bolts securing gearbox to engine and tighten to 50 Nm (37 lbf.ft).
4. Clean oil cooling pipe housing mating faces.
5. Lubricate and fit new 'O' rings to oil cooling pipe housing.
6. Position cooling pipe housing, fit bolts and tighten to 25 Nm (18 lbf.ft).
7. **If fitted:** Secure harness in retaining clips, connect Lucars to differential lock warning switch and multiplug to transfer box neutral switch.
8. Position breather pipes and secure 'P' clip with bolt.
9. Using new sealing washers fit breather pipe banjo bolts and tighten to 15 Nm (11 lbf.ft).
10. Connect oil temperature sensor Lucars and reverse lamp switch multiplug.
11. Position low ratio selector cable to housing and secure with 'C' washer and clevis pin.
12. Secure cable to fuel pipes with new cable ties.
13. Raise gearbox, ensuring gear change lever is located in grommet.
14. Fit gearbox mountings and tighten bolts to 85 Nm (63 lbf.ft).
15. Fit nuts to gearbox mountings and tighten to 48 Nm (37 lbf.ft).
16. Remove 3 bolts securing support plate to gearbox.
17. Position clutch slave cylinder and heat shield, fit bolts and tighten to 25 Nm (18 lbf.ft).
18. Clean handbrake back plate and mating face.
19. Position handbrake back plate, fit bolts and tighten to 75 Nm (55 lbf.ft).
20. Clean handbrake drum.
21. Fit handbrake drum and tighten retaining screw.
22. Fit front propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**.
23. Fit rear propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**
24. Clean exhaust silencer and tail pipe mating faces.
25. Position silencer and secure on mountings, using a new gasket align to tail pipe, fit nuts and tighten to 25 Nm (18 lbf.ft).
26. Fit exhaust front pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**
27. Refit starter motor.
    ☞ **CHARGING AND STARTING, REPAIRS, Starter motor - diesel.**
28. Refill gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Manual gearbox.**
29. Refill transfer gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
30. Fit gear lever extension, fit clamp bolt and tighten to 25 Nm (18 lbf.ft).
31. Fit gear lever trim and gear change knob.
32. Connect battery earth lead.
33. Fit cooling fan cowl and battery cover and secure fixings.

Seal - gearbox mainshaft

37.23.01

Remove

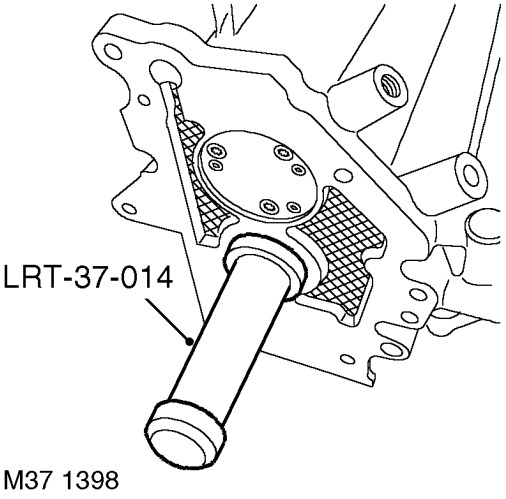
1. Remove transfer gearbox.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.



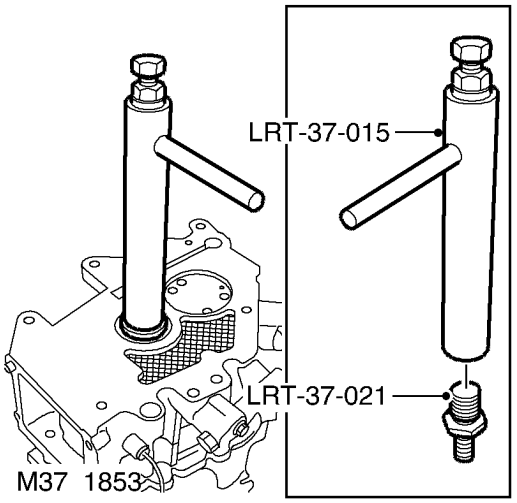
2. Using tool **LRT-37-009, LRT-37–010** and **LRT-37-001/2**, remove oil seal collar.
3. Remove main shaft oil seal.

Refit

1. Clean oil seal recess.
2. Lubricate new seal.



3. Using tool **LRT-37-014**, fit new seal.
4. Clean oil seal collar and mating face.



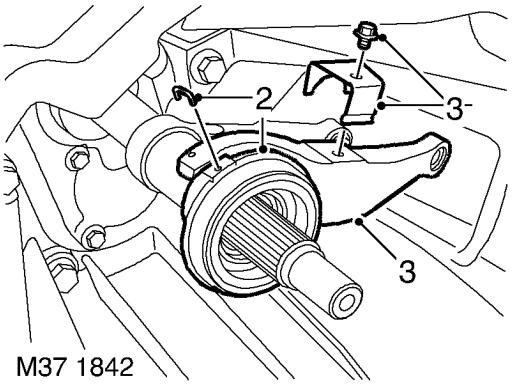
5. Using tool **LRT-37-015** and **LRT-37-021**, fit oil seal collar.
6. Fit transfer gearbox.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.

Seal - input shaft

37.23.06

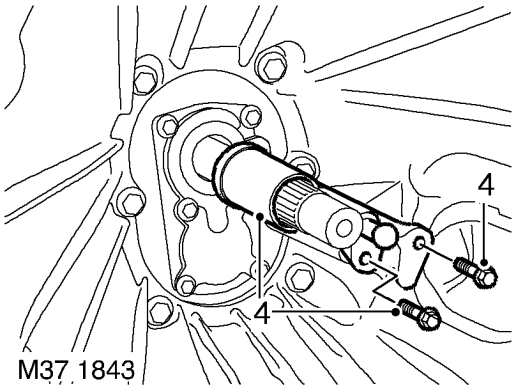
Remove

1. Remove gearbox assembly.
   MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.



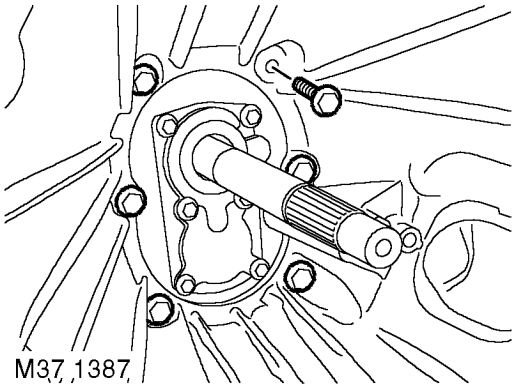
M37 1842

2. Remove retaining peg and remove release bearing.
3. Remove bolt securing clutch release fork, remove retaining clip and remove clutch release fork.

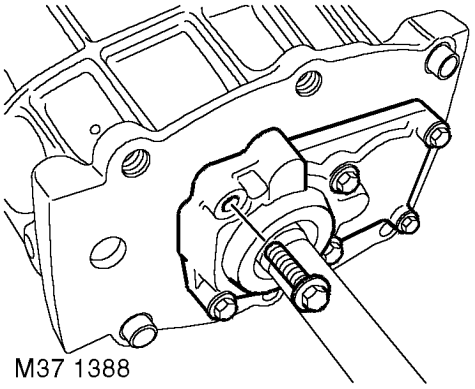


M37 1843

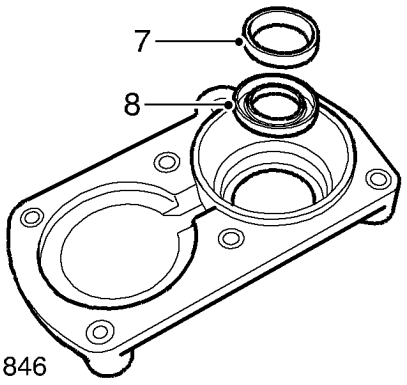
4. Remove 2 bolts securing release bearing sleeve and remove bearing sleeve.


M37 1387

5. Remove 6 bolts securing bell housing and remove bell housing.


M37 1388

6. Remove and discard 6 bolts securing oil seal housing and remove housing.

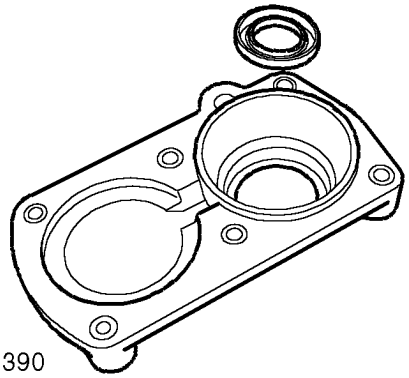


M37 1846

7. Using a soft metal drift, carefully remove input shaft front bearing track from housing.
8. Remove oil seal from housing.

Refit

1. Using a suitable solvent clean seal housing mating faces.
2. Clean seal recess, bearings and bearing races.



M37 1390

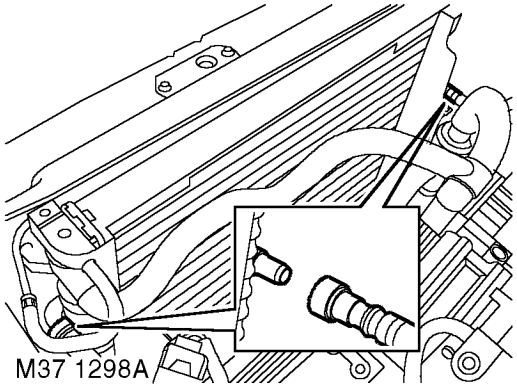
3. Lubricate new oil seal and fit using a suitable mandrel into housing.
4. Fit input shaft front bearing track using a press and suitable mandrel.
5. Apply sealant, Part No. STC 4404 to seal housing.
6. Position seal housing, fit new bolts and tighten by diagonal selection to 25 Nm (18 lbf.ft).
7. Clean bell housing mating faces, dowels and dowel holes.
8. Position bell housing, fit bolts and tighten to 75 Nm (55 lbf.ft).
9. Clean release bearing sleeve mating faces, dowel and dowel holes.
10. Position release bearing sleeve, fit bolts and tighten to 25 Nm (18 lbf.ft).
11. Examine clutch release fork pivot points for wear and replace as required.
12. Apply a smear of Molybdenum disulphide grease to pivot points and position release fork.
13. Fit retaining clip ensuring it locates over pivot point washer, fit release fork bolt and tighten to 10 Nm (7 lbf.ft).
14. Clean release bearing and bearing sleeve mating faces.
15. Apply smear of Molybdenum disulphide grease to release bearing sleeve.
16. Fit release bearing and secure with retaining peg.
17. Fit gearbox assembly.
    ☞ **MANUAL GEARBOX - R380, REPAIRS, Gearbox - V8.**

Cooler - oil - gearbox - Diesel

🔧 ***37.24.02***

Remove

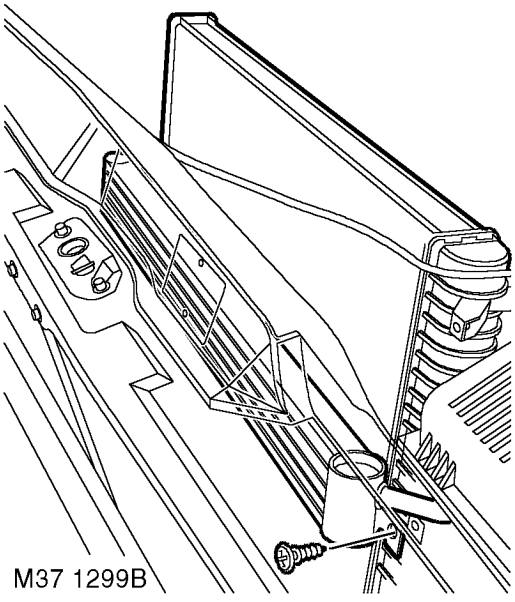
1. Remove intercooler.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**
2. Position absorbent cloth under each gearbox oil cooler hose connection to collect spillage.



M37 1298A

3. Push against coupling release ring and disconnect both fluid hoses from oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.



M37 1299B

4. Remove screw securing oil cooler to radiator.

5. Release oil cooler from location on radiator, and remove the oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

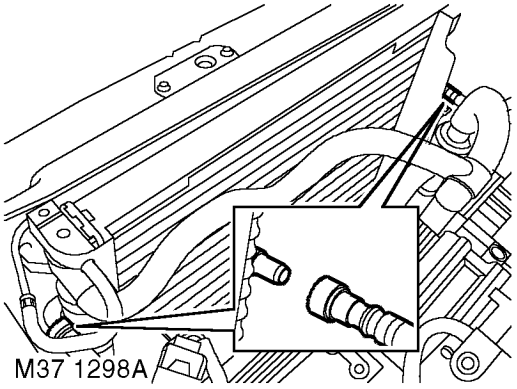
1. Fit oil cooler to radiator and secure with screw.
2. Ensure connections are clean and secure hoses to cooler.
3. Fit intercooler.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**
4. Top up gearbox oil level.
   ☞ **MAINTENANCE, PROCEDURES, Manual gearbox.**

Cooler - oil - gearbox - V8

⊸ *37.24.02*

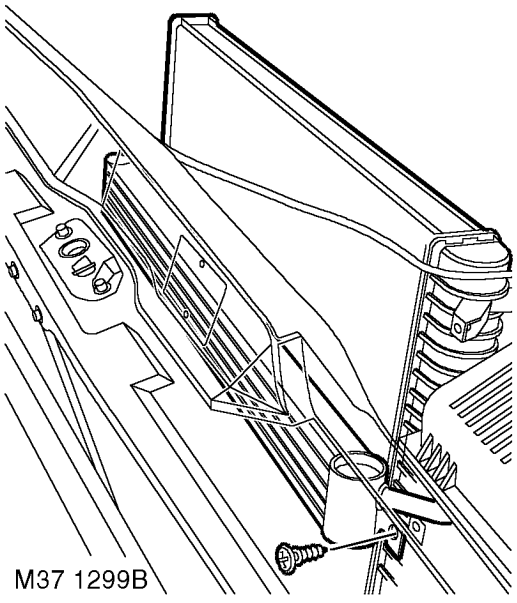
Remove

1. **If fitted:** Remove engine oil cooler.
   ☞ **ENGINE - V8, REPAIRS, Cooler - engine oil.**
2. Position absorbent cloth under each gearbox oil cooler hose connection to collect spillage.


M37 1298A

3. Push against coupling release rings and disconnect both hoses from oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.


M37 1299B

4. Remove screw securing oil cooler to radiator.
5. Release oil cooler from its location on radiator.

6. Move radiator towards engine sufficiently only to release gearbox oil cooler from radiator.
7. Remove gearbox oil cooler.

CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

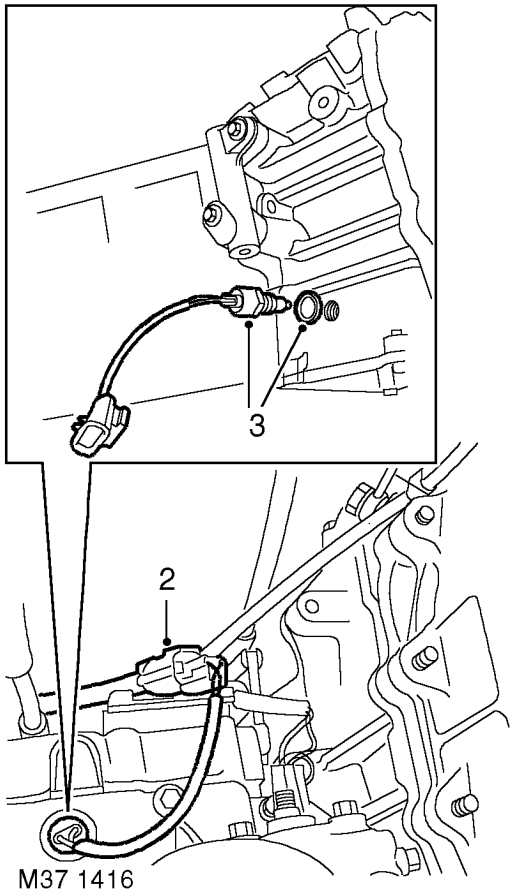
1. Fit gearbox oil cooler to radiator, engage in location and secure with screw.
2. Ensure connections are clean and secure hoses to cooler.
3. **If fitted:** Fit engine oil cooler.
   ☞ **ENGINE - V8, REPAIRS, Cooler - engine oil.**
4. Top up gearbox oil.
   ☞ **MAINTENANCE, PROCEDURES, Manual gearbox.**

Switch - Reverse light

🔧 ***37.27.01***

Remove

1. Raise vehicle on ramp.



2. Disconnect reverse lamp switch multiplug.
3. Remove switch and collect sealing washer.

Refit

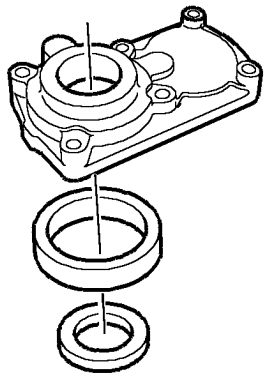
1. Clean switch and mating face on gearbox.
2. Using a new sealing washer, fit the reverse light switch and tighten to 24 Nm (17 lbf.ft).
3. Connect switch multiplug.
4. Lower vehicle.

Shaft - output

37.20.25

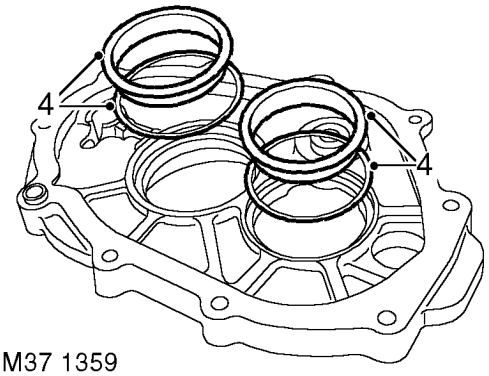
Disassembly

1. Remove gearbox selector fork - set
   MANUAL GEARBOX - R380, OVERHAUL, Fork - set - selector shaft.
2. Remove gearbox front cover.
   MANUAL GEARBOX - R380, OVERHAUL, Cover - front.



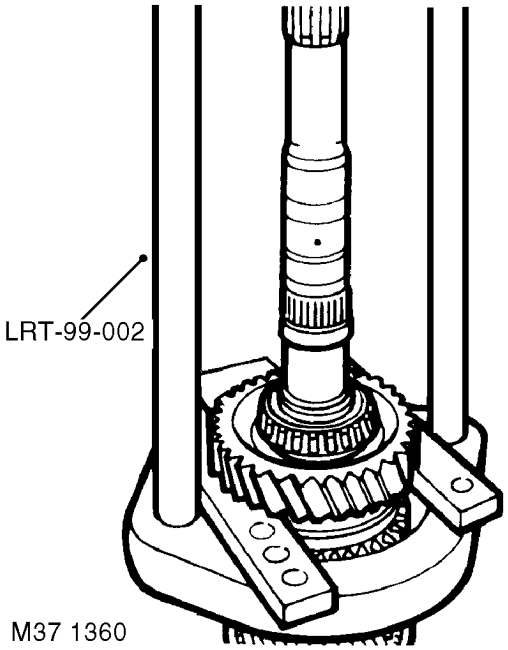
M37 1358

3. Remove and discard oil seal and bearing tracks from front cover.



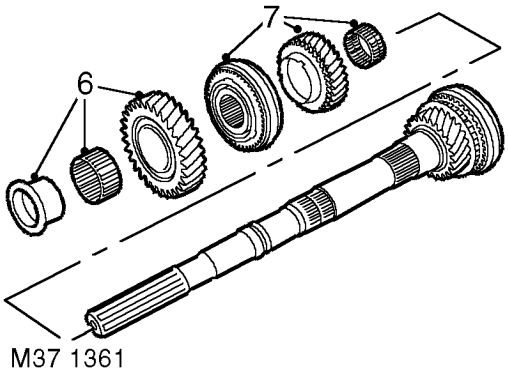
M37 1359

4. Remove and discard bearing tracks from centre plate, collect selective shims.



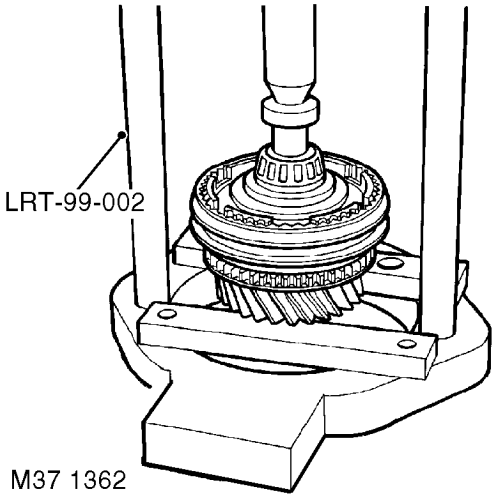
M37 1360

5. Using tool **LRT-99-002** and support bars under 1st gear, press output shaft bearing from output shaft.



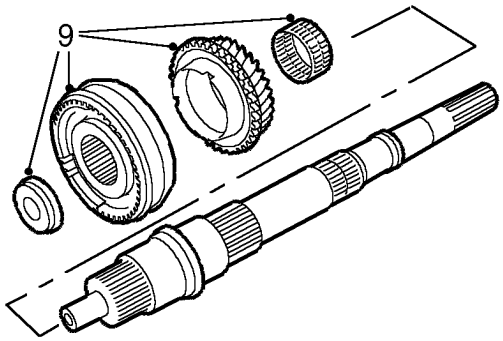
M37 1361

6. Remove 1st gear, bearing collar, needle roller bearing and synchromesh rings.
7. Noting its fitted position, remove 1st / 2nd gear synchroniser hub, 2nd gear synchromesh rings, 2nd gear and needle roller bearing.



M37 1362

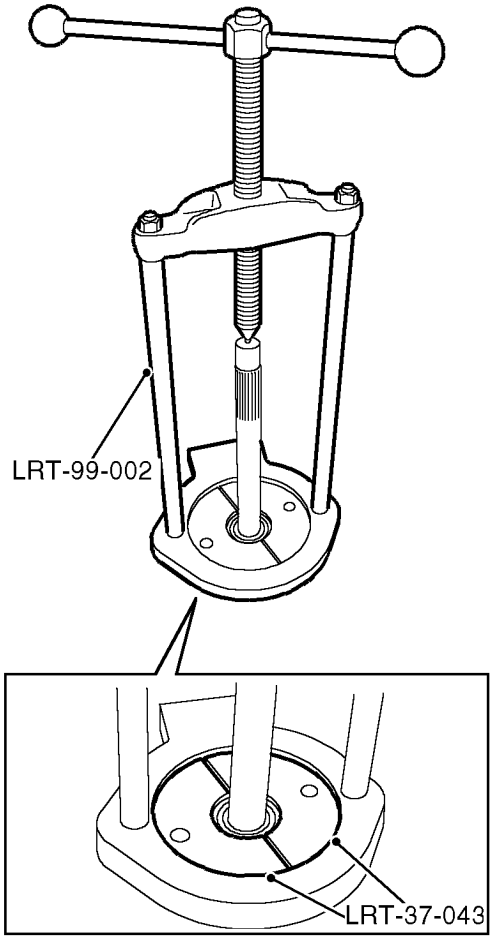
8. Using tool **LRT-99-002** and support bars under 3rd gear and press off output shaft pilot bearing.



M37 1363

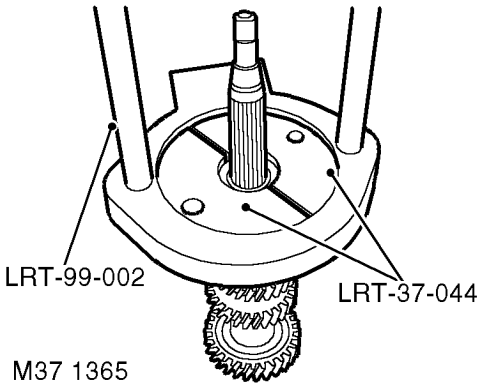
9. Remove spacer, 3rd / 4th gear synchroniser hub, synchromesh baulk rings, 3rd gear and needle roller bearing.

10. Remove output shaft.



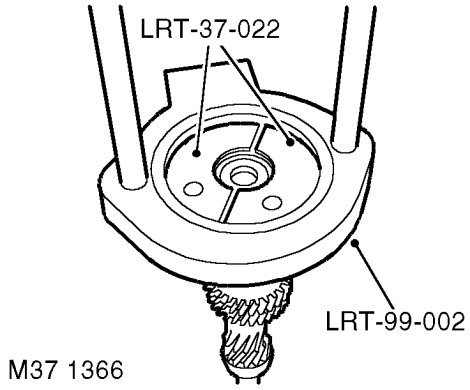
M37 1364

11. Using tool **LRT-37-043** and **LRT-99-002**, remove taper roller bearing from input shaft.



M37 1365

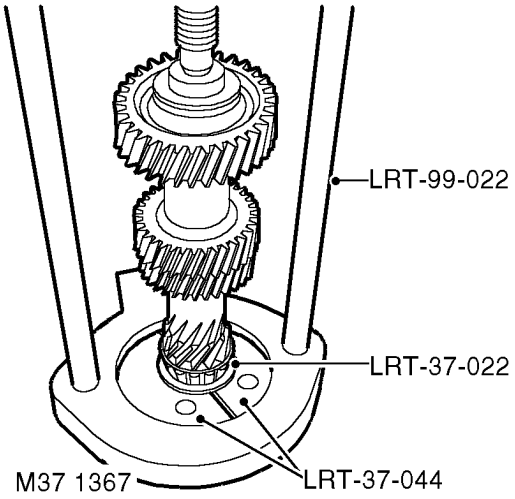
12. Using tool **LRT-37-044** and **LRT-99-002**, remove bearing from splined end of layshaft.



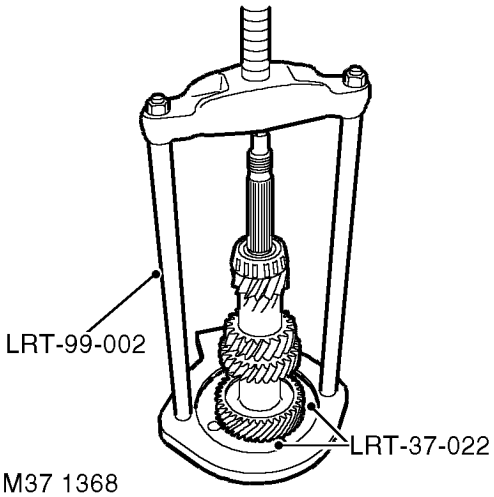
13. Using tool **LRT-37-022** and **LRT-99-002**, remove bearing from 4th gear end of layshaft.

Reassembly

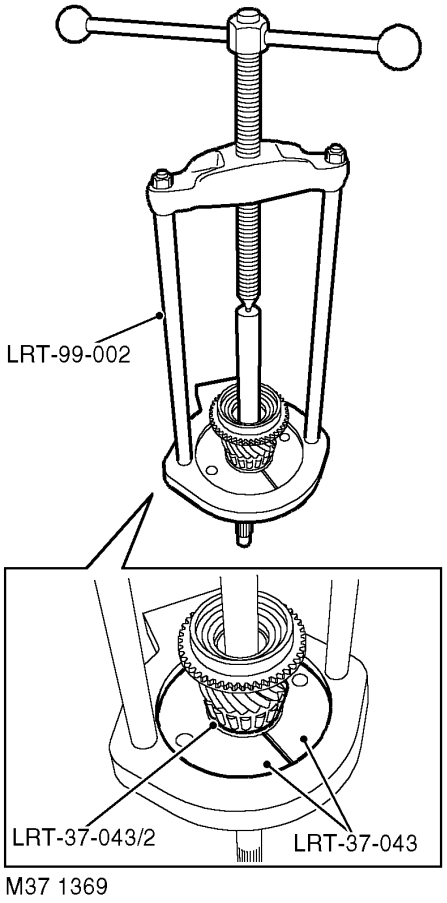
1. Clean layshaft, input shaft and output shaft bearing surfaces.



2. Using tool **LRT-37-022**, **LRT-37-044** and **LRT-99-002**, press new bearing onto splined end of layshaft.

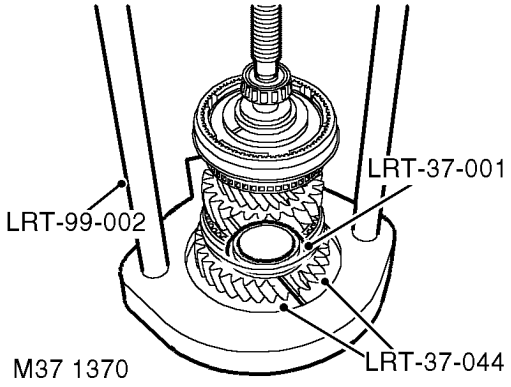


3. Using tool **LRT-37-022** and **LRT-99-002**, press new bearing onto 4th gear end of layshaft.



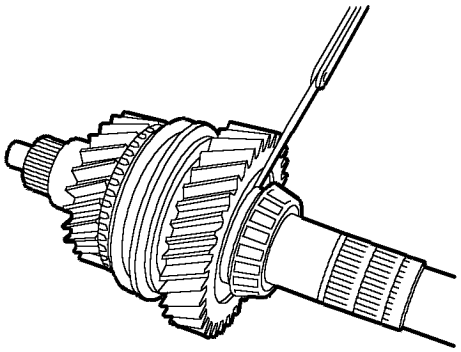
4. Using tools **LRT-37-043**, **LRT-37-043/2** and **LRT-99-002**, press new bearing onto input shaft.
5. Using tool **LRT-99-002** and a suitable mandrel, fit input shaft outer bearing track to front cover.

6. Fit layshaft bearing track to front cover.
7. Using tool **LRT-99-002** and a suitable mandrel, fit pilot bearing outer track to input shaft.
8. Clean synchroniser hubs, gears and bearings.
9. Position output shaft in protected vice jaws, output end upwards.
10. Fit 2nd gear bearing, 2nd gear and synchromesh baulk rings onto output shaft.
11. Position 1st / 2nd synchroniser hub onto output shaft. Ensure that baulk rings are correctly located in hub.
12. Position 1st gear synchromesh baulk rings, needle roller bearing, 1st gear and bearing collar onto output shaft. Ensure baulk rings are correctly located in hub.
13. Remove output shaft from vice.

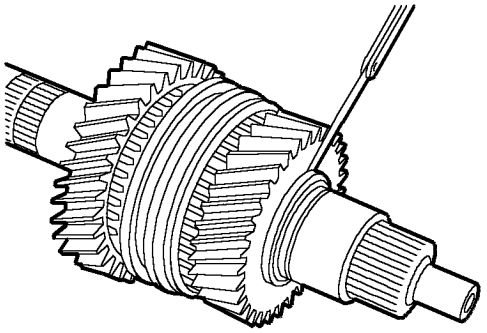


M37 1370

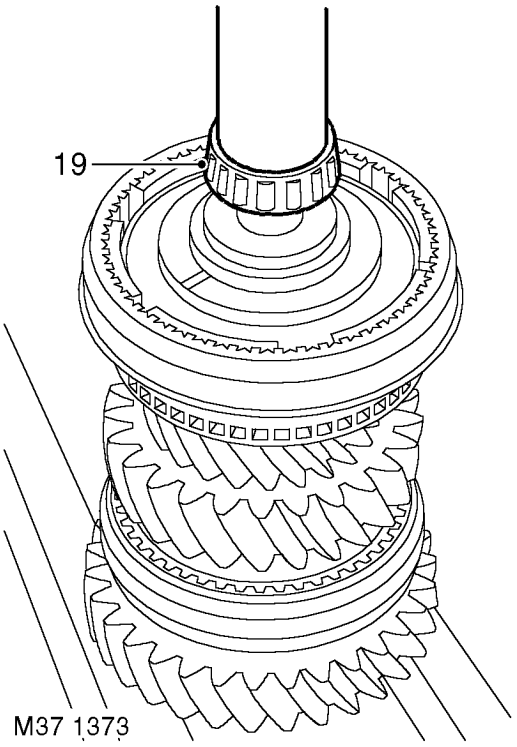
14. Using tool **LRT-37-001**, **LRT-37-044** and **LRT-99-002**, press taper bearing onto output shaft.


M37 1371

15. Using a feeler gauge, check end float of 1st gear between gear and collar flange:
    - **New =** 0.05 - 0.20 mm (0.002 - 0.008 in)
    - **Service limit =** 0.327 mm (0.012 in)

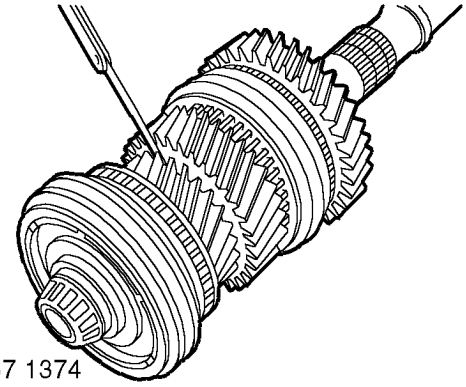

M37 1372

16. Using a feeler gauge, check end float of 2nd gear between gear and output shaft flange:
    - **New =** = 0.04 - 0.21 mm (0.0016 - 0.0083 in)
    - **Service limit =** 0.337 mm (0.013 in)
17. Invert output shaft in vise and fit 3rd gear, bearing, baulk rings, 3rd / 4th synchroniser and spacer.
18. Remove output shaft from vice.



M37 1373

19. Using tool **LRT-99-002** and a suitable mandrel, press pilot bearing onto output shaft.



M37 1374

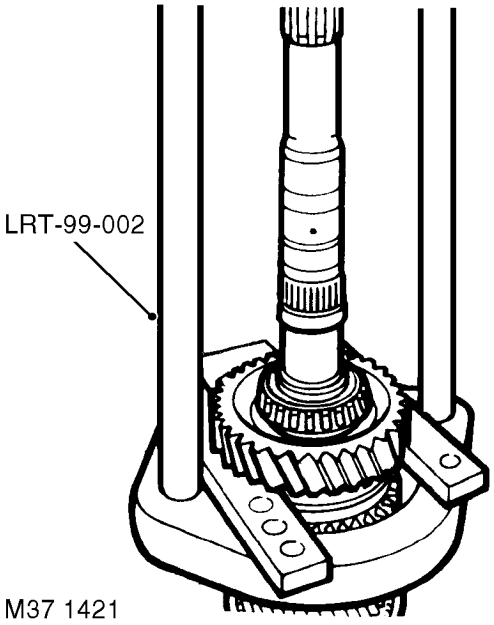
20. Check end float of 3rd gear between gear and flange on output shaft:
    - **New =** 0.11 - 0.21 mm (0.004 - 0.0083 in)
    - **Service limit =** 0.337 mm (0.013 in)
21. Check output shaft and layshaft end float as follows.
22. The end float setting for both shafts is:
    - **New =** 0.00 to 0.05 mm (0.0 to - 0.002 in)
    - **Service limit =** 0.05 mm (0.002 in)
23. Fit front cover to gearbox case without the oil seal and tighten bolts by diagonal selection to 25 Nm (18 lbf.ft).
24. Position in vice with front cover facing downwards.
25. Fit input shaft to gearbox case less 4th gear baulk ring.
26. Fit output shaft assembly to input shaft.
27. Fit output shaft bearing track and shim to centre plate.
28. Fit centre plate to gearbox case and secure using 8 slave bolts.
29. Rotate output shaft to settle bearings.
30. Fit a suitably large ball bearing into end of output shaft.
31. Position a suitable DTI and zero probe on ball bearing.
32. Lift output shaft and note DTI reading.
33. If reading is incorrect, dismantle and fit shim to give correct end float.
34. Repeat above procedure.
35. Repeat procedure for layshaft end float.
36. Remove and discard 6 bolts and remove gearbox front cover.
37. Fit gearbox selector fork - set.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Fork - set - selector shaft.**
38. Fit gearbox front cover.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Cover - front.**

Synchroniser - gearbox - set

⊸ ***37.20.07***

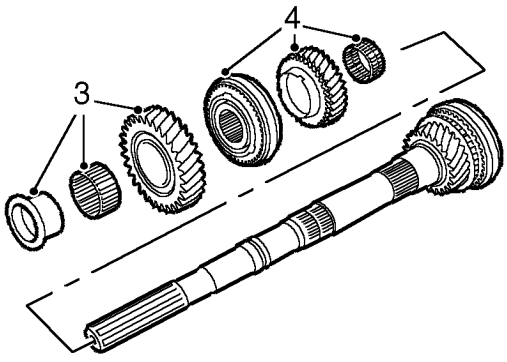
Disassembly

1. Remove gearbox selector fork set.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Fork - set - selector shaft.**



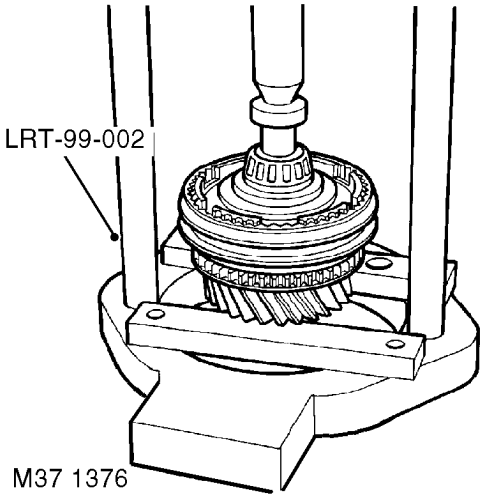
M37 1421

2. Using tool **LRT-99-002** and support bars under 1st gear, press output shaft bearing from output shaft.

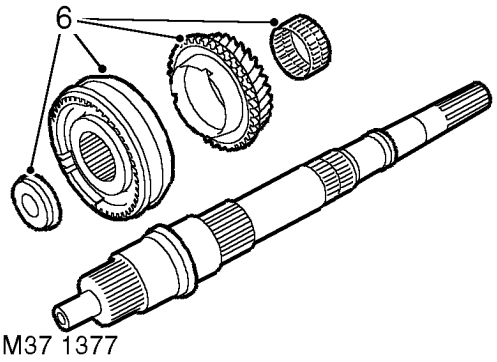


M37 1375

3. Remove 1st gear, bearing collar, needle roller bearing and synchromesh rings.
4. Noting its fitted position, remove 1st / 2nd gear synchroniser hub, 2nd gear synchromesh rings, 2nd gear and needle roller bearing.



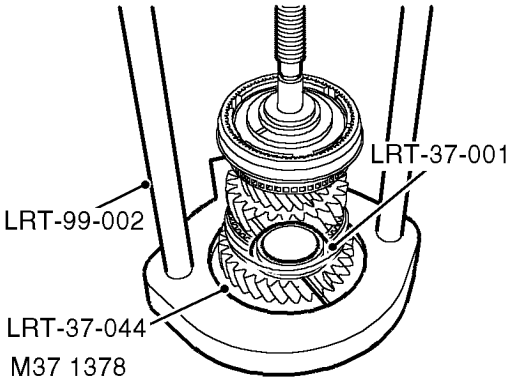
5. Using tool **LRT-99-002** and support bars under 3rd gear, press off output shaft pilot bearing.



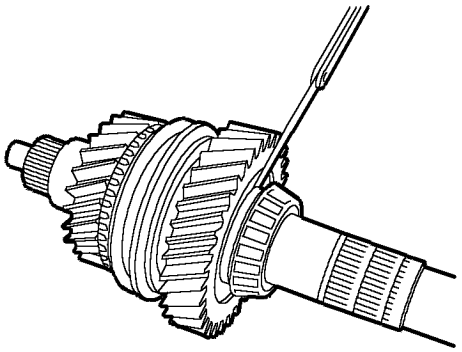
6. Remove spacer, 3rd / 4th gear synchroniser hub, synchromesh baulk rings, 3rd gear and needle roller bearing.
7. Remove output shaft.

Reassembly

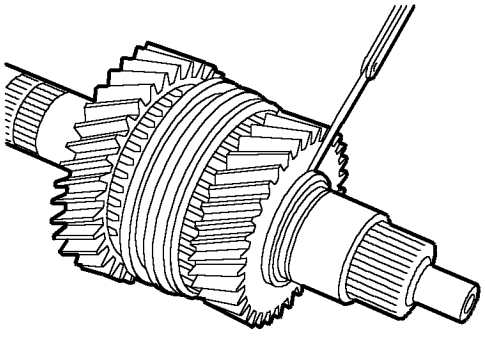
1. Clean output shaft, synchroniser hubs, gears and bearings.
2. Position output shaft in protected vice jaws, output end upwards.
3. Fit 2nd gear bearing, 2nd gear and synchromesh baulk rings onto output shaft.
4. Position 1st / 2nd synchroniser hub onto output shaft. Ensure that baulk rings are correctly located in hub.
5. Position 1st gear synchromesh baulk rings, needle roller bearing, 1st gear and bearing collar onto output shaft. Ensure baulk rings are correctly located in hub.
6. Remove output shaft from vice.



7. Using tool **LRT-37-001**, **LRT-37-044** and **LRT-99-002**, press taper bearing onto output shaft.

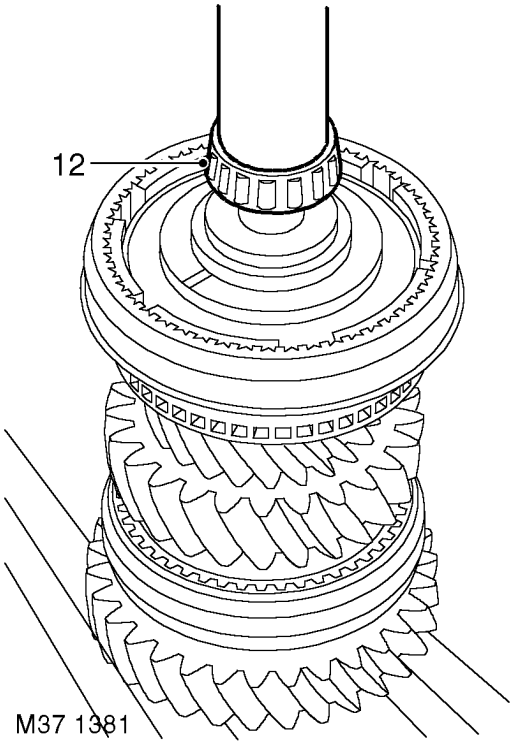


8. Check end float of 1st gear using a feeler gauge between gear and collar flange:
   - **New =** 0.05 - 0.20 mm (0.002 - 0.008 in)
   - **Service limit =** 0.327 mm (0.012 in)

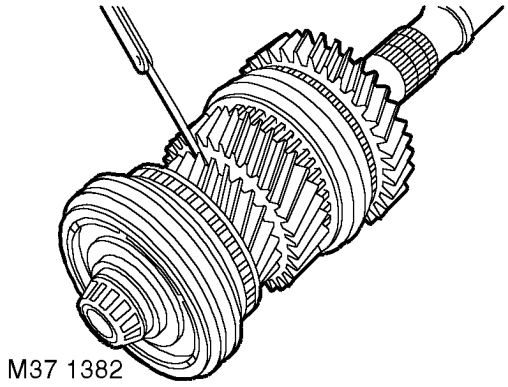


9. Check end float of 2nd gear using a feeler gauge between gear and output shaft flange:
   - **New =** 0.04 - 0.21 mm (0.0016 - 0.0083 in)
   - **Service limit =** 0.337 mm (0.013 in)

10. Invert output shaft in vice and fit 3rd gear, bearing, baulk rings, 3rd / 4th synchroniser and spacer.
11. Remove output shaft from vice.



12. Using tool **LRT-99-002** and a suitable mandrel press pilot bearing onto output shaft.



13. Check end float of 3rd gear between gear and flange on output shaft.
- **New** = 0.11 - 0.21 mm (0.004 - 0.0083 in)
- **Service limit** = 0.337 mm (0.013 in)

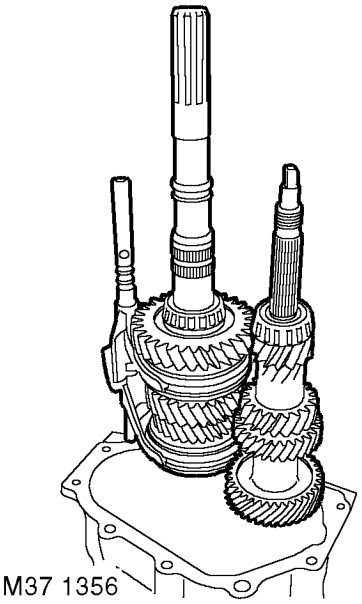
14. Fit gearbox selector fork set.
☞ **MANUAL GEARBOX - R380, OVERHAUL, Fork - set - selector shaft.**

Fork - set - selector shaft

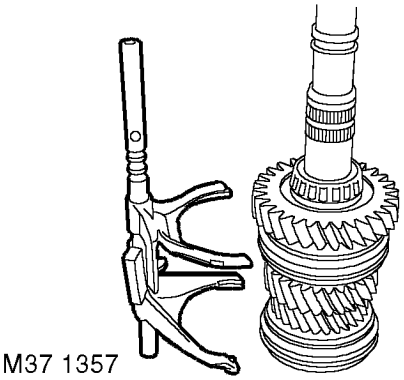
⊸ ***37.16.45***

Disassembly

1. Remove reverse idler gear shaft.
☞ **MANUAL GEARBOX - R380, OVERHAUL, Shaft - reverse idler.**



2. With assistance, remove output shaft, selector shaft and layshaft assemblies.



3. Remove selector shaft and fork assembly from output shaft synchronisers.
4. Inspect the selector fork pads for wear, the wear limit is 6.5 mm (2.559 in).

Reassembly

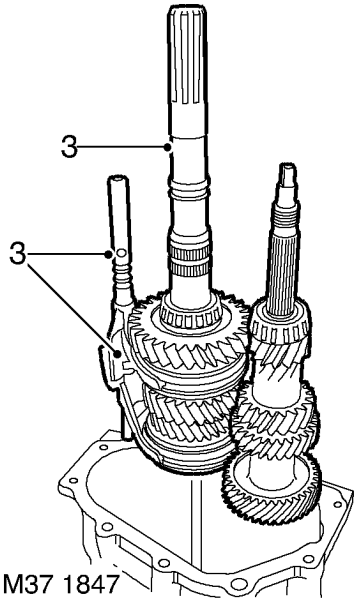
1. Clean selector shaft, forks and locations on synchronisers.
2. Lubricate forks and shaft with clean gear oil.
3. Position selector shaft assembly to output shaft synchronisers.
4. With assistance, fit output shaft and layshaft assembly into gearbox case.
5. Fit reverse idler gear shaft.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Shaft - reverse idler.**

Shaft - gearbox - input

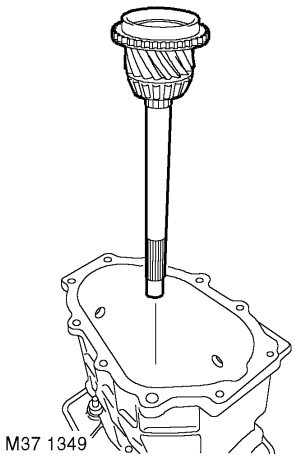
🔧 ***37.20.16***

Disassembly

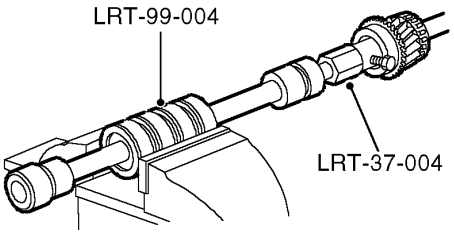
1. Remove gearbox front cover.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Cover - front.**
2. Remove reverse idler gear shaft.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Shaft - reverse idler.**



3. With assistance, remove output shaft, selector shaft and layshaft as an assembly. Remove selector shaft and fork.

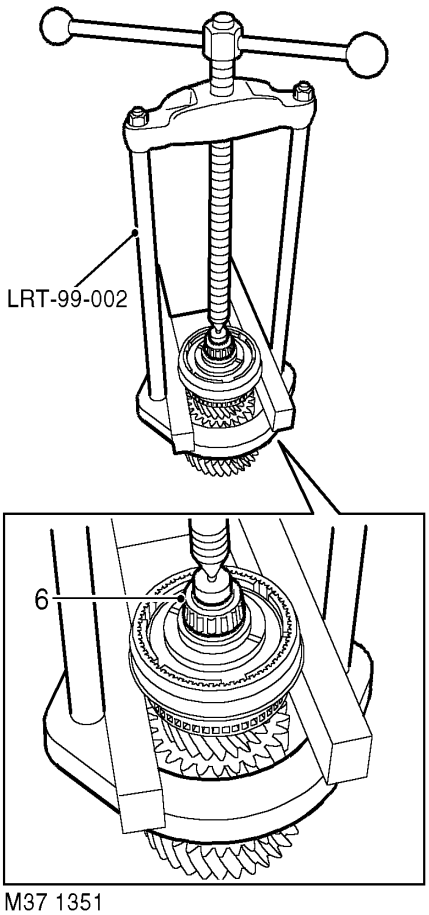


4. Remove input shaft from gearbox case.



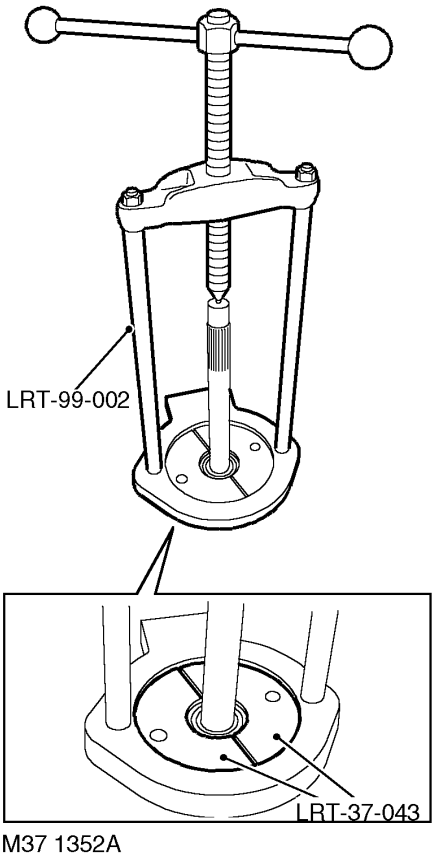
M37 1350

5. Using tool **LRT-37-004,** and **LRT-99-004**, remove pilot bearing track from input shaft.



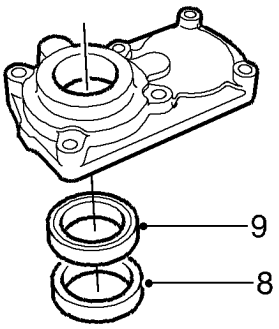
M37 1351

6. Invert output shaft and using tool **LRT- 99-002** and support bars under 3rd gear, press off pilot bearing.



M37 1352A

7. Using tool **LRT-37-043** and **LRT-99-002**, remove taper roller bearing from input shaft.



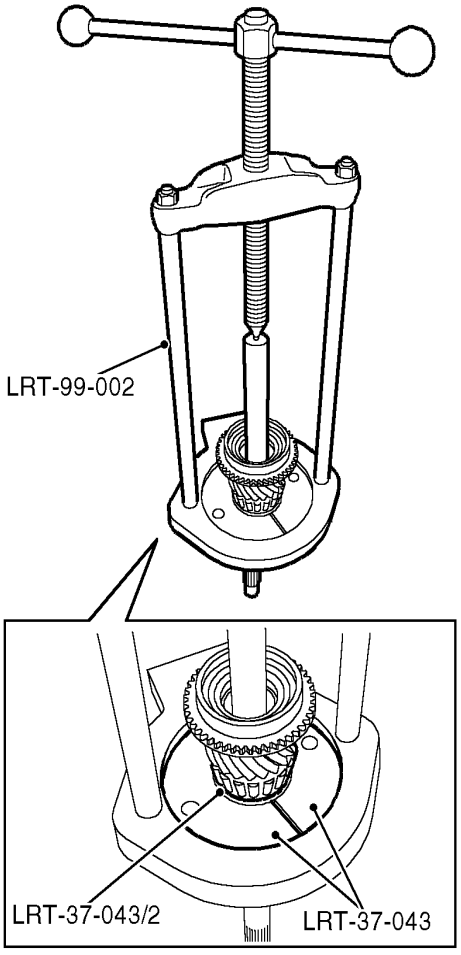
M37 1848

8. Using a suitable soft metal drift, remove bearing outer track from front cover.

9. Remove and discard input shaft oil seal from front cover.

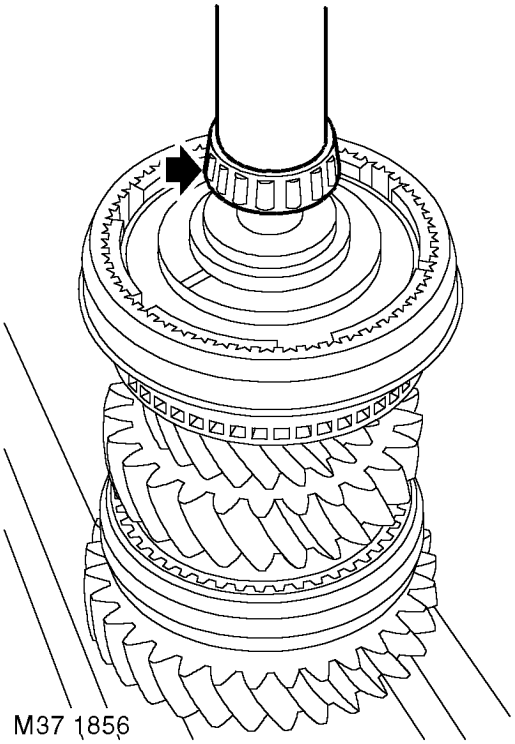
Reassembly

1. Clean input shaft and bearing/oil seal recess in front cover.
2. Lubricate a new input shaft oil seal with gearbox oil.
3. Fit oil seal using a suitable mandrel.
4. Using a press and a suitable mandrel, fit bearing outer track in front cover.
5. Using a press and a suitable mandrel, fit pilot bearing outer track to input shaft.



M37 1369

6. Using tool **LRT-37-043**, **LRT-37–043/2** and **LRT-99-002**, fit new taper bearing to input shaft.

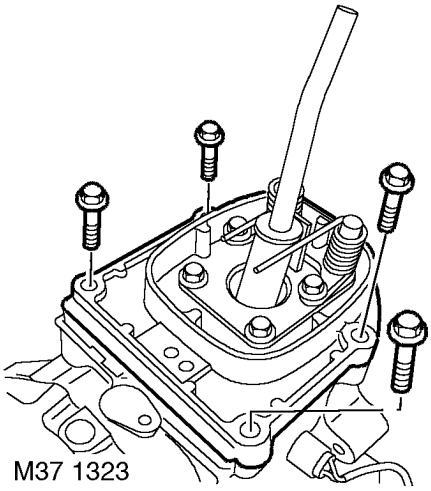

M37 1856

7. Using tool **LRT-99-002** and a suitable mandrel, press new pilot bearing onto output shaft.
8. Position input shaft to gearbox case.
9. With assistance, fit output shaft and layshaft assembly into gearbox case.
10. Fit reverse idler gear shaft.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Shaft - reverse idler.**
11. Fit gearbox front cover.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Cover - front.**

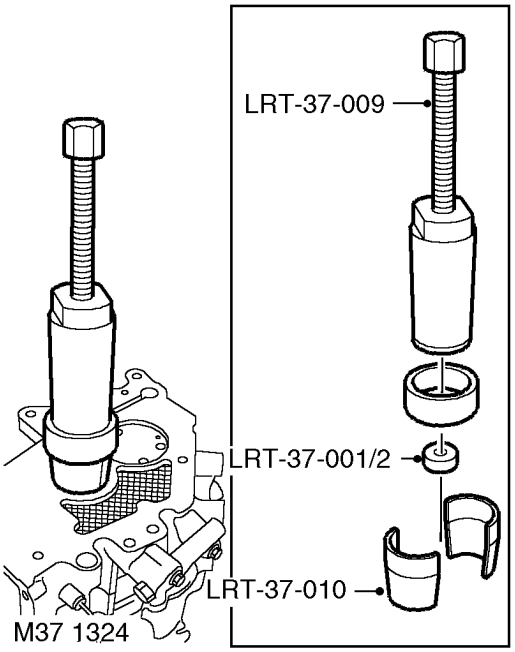
Extension - gearbox rear

37.12.01

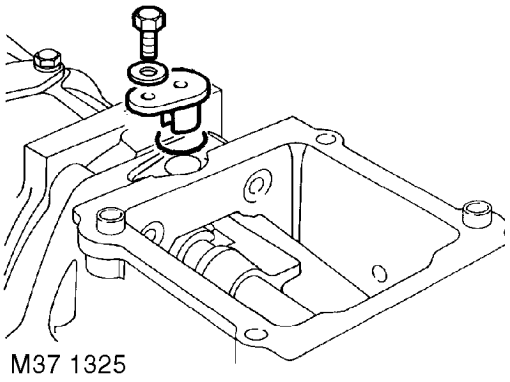
Disassembly



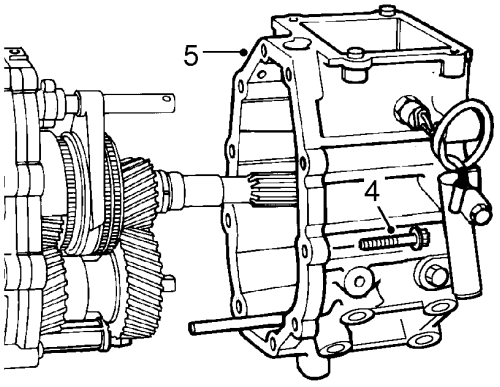
1. Remove 4 bolts and remove gear selector housing.



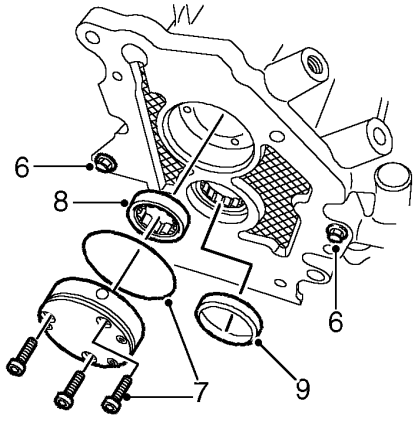
2. Using tools **LRT-37-009**, **LRT-37-001/2** and **LRT-37-010** , remove output shaft oil seal collar.



3. Remove bolt securing interlock spool retainer and discard 'O' ring.

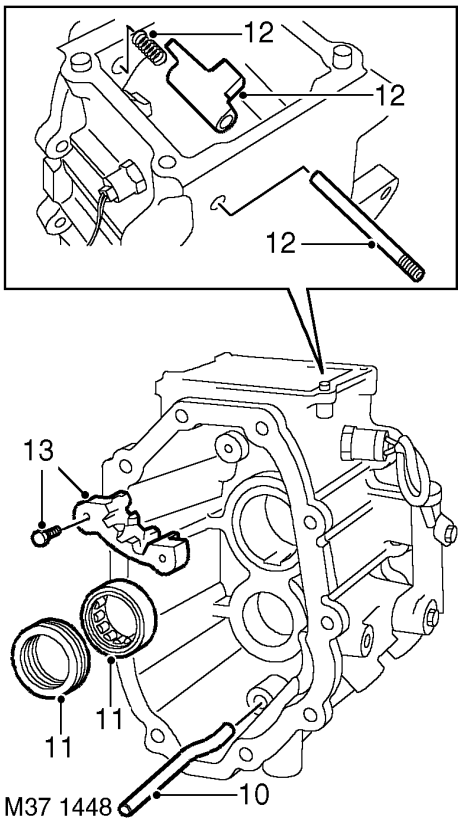


4. Noting fitted position of 2 longest bolts, remove 10 bolts securing extension housing to gearbox.
5. Remove extension housing from gearbox centre plate.



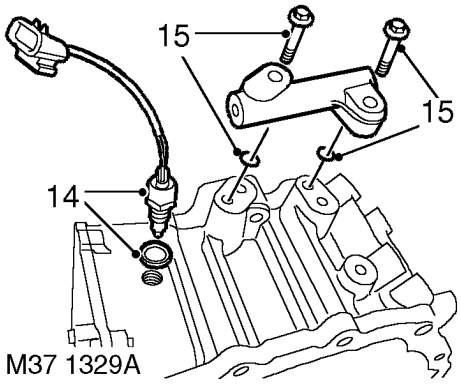
M37 1857

6. Fit 2 off 8x35 mm slave bolts to secure centre plate to gearbox casing.
7. Remove 3 Torx screws, remove oil pump and discard 'O' ring.
8. Drift out layshaft support bearing.
9. Remove and discard output shaft rear oil seal.



M37 1448

10. Remove oil pick-up pipe.
11. Drift out output shaft support bearing and oil pick-up ring.
12. Remove reverse inhibitor shaft, cam and spring.
13. Remove 2 bolts and remove gate plate.

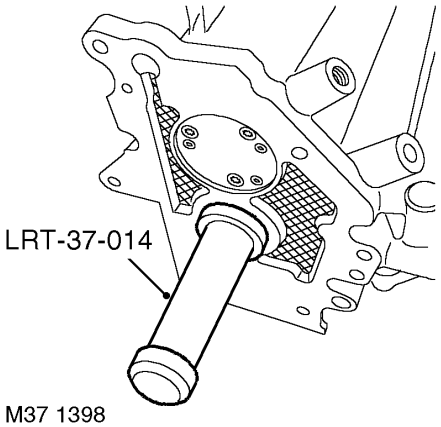


M37 1329A

14. Remove reverse light switch and discard sealing washer.
15. Remove 2 bolts, remove oil cooler by-pass and discard 'O' rings.

Reassembly

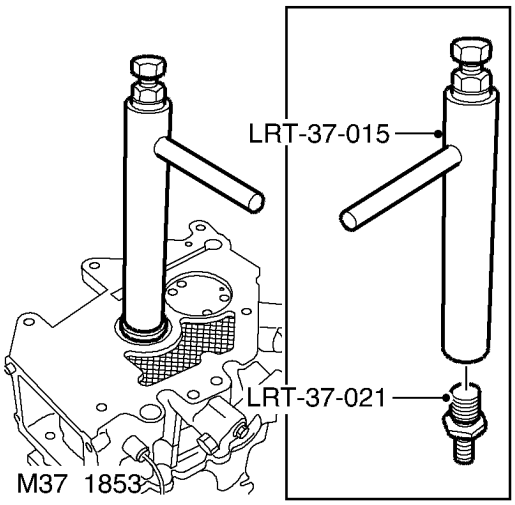
1. Clean extension housing and mating faces.
2. Clean oil cooler by-pass.
3. Using new 'O' rings, fit oil cooler by-pass and tighten bolts to 15 Nm (11 lbf.ft).
4. Using new sealing washer, fit reverse light switch and tighten to 24 Nm (17 lbf.ft).
5. Fit reverse inhibitor spring and cam.
6. Clean threads of reverse inhibitor shaft and gate plate bolts.
7. Apply Loctite 290 to threads of reverse inhibitor shaft, fit and tighten shaft.
8. Apply Loctite 290 to threads of gate plate bolts.
9. Position gate plate and tighten bolts to 15 Nm (11 lbf.ft).
10. Fit output shaft support bearing and oil pick-up ring. Align tag with centre of drain slot.
11. Fit layshaft support bearing.



M37 1398

12. Fit new output shaft oil seal using tool **LRT-37-014**.

13. Fit oil pick-up pipe with the off-set uppermost.
14. Lubricate oil pump recess with gearbox oil.
15. Lubricate a new 'O' ring with gearbox oil and fit to oil pump.
16. Locate oil pump in extension housing with word 'TOP' towards top of housing.
17. Align oil pump fixing screw holes and tap pump lightly around edges until it is fully in recess. **Do not attempt to pull pump into recess using fixing screws.**
18. Fit Torx screws and tighten to 6 Nm (4.5 lbf.ft).
19. Remove 2 slave bolts securing centre plate to gearbox casing.
20. Apply sealant, Part No. STC 3254 to gearbox casing face.
21. Position extension housing, align oil pump drive with layshaft.
22. Clean extension housing bolt threads.
23. Apply Loctite 290 to threads of extension housing bolts, fit bolts ensuring 2 longest bolts are in their original positions and tighten by diagonal selection to 25 Nm (18 lbf.ft).
24. Using new 'O' ring, fit interlock spool retainer and tighten bolt to 8 Nm (6 lbf.ft).



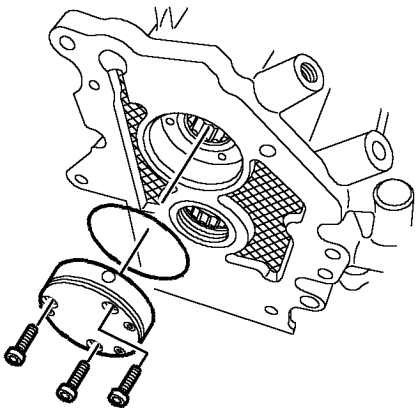
25. Using tool **LRT-37-015** and **LRT-37-021**, fit oil seal collar.
26. Clean gear selector selector housing and mating face.
27. Apply sealant, Part No. STC 3254 to gear selector housing face.
28. Position gear selector housing and tighten bolts to 25 Nm (18 lbf.ft).

Pump - gearbox oil

37.12.47

Disassembly

1. Remove gearbox extension.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.



M37 1330

2. Remove 3 Torx screws, remove oil pump and discard 'O' ring.

Reassembly

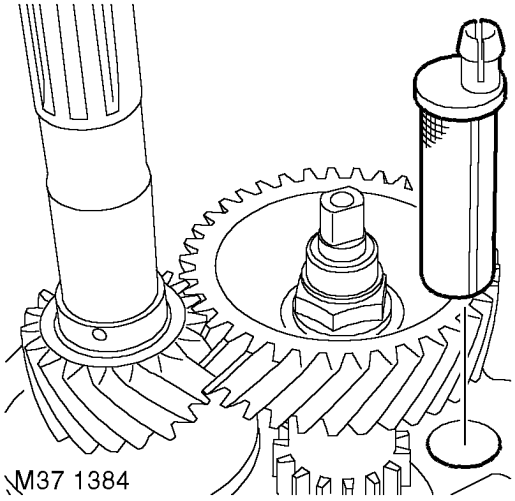
1. Clean oil pump recess in extension housing, ensure screw holes are clean and dry.
2. Lubricate oil pump recess in housing with gearbox oil.
3. Lubricate a new 'O' ring with gearbox oil and fit to oil pump.
4. Locate oil pump in extension housing with word 'TOP' towards top of housing.
5. Align fixing screw holes and tap pump lightly around edges until pump is fully in housing. **Do not pull pump into housing by tightening screws.**
6. Fit Torx screws and tighten to 6 Nm (4.5 lbf.ft).
7. Fit gearbox extension.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.

Filter - gearbox oil

37.12.38

Disassembly

1. Remove gearbox extension.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.



2. Remove oil filter from gearbox.

Reassembly

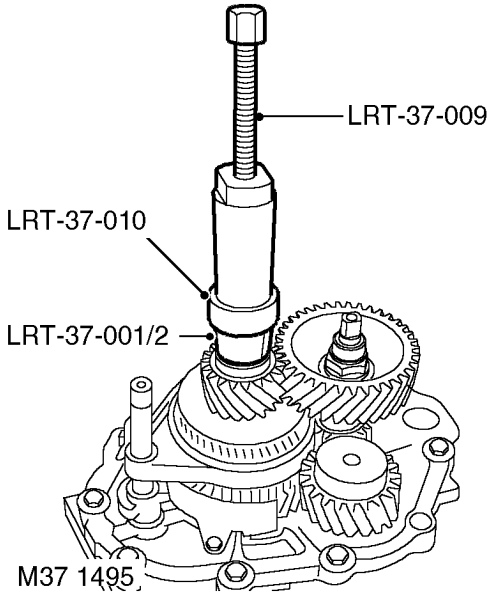
1. Clean filter recess in gearbox.
2. Fit filter.
3. Fit gearbox extension.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.

Gear - 5th gear set

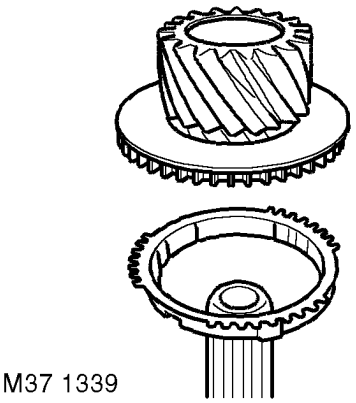
37.20.36

Disassembly

1. Remove 5th gear - layshaft.
   MANUAL GEARBOX - R380, OVERHAUL, 5th gear - layshaft.



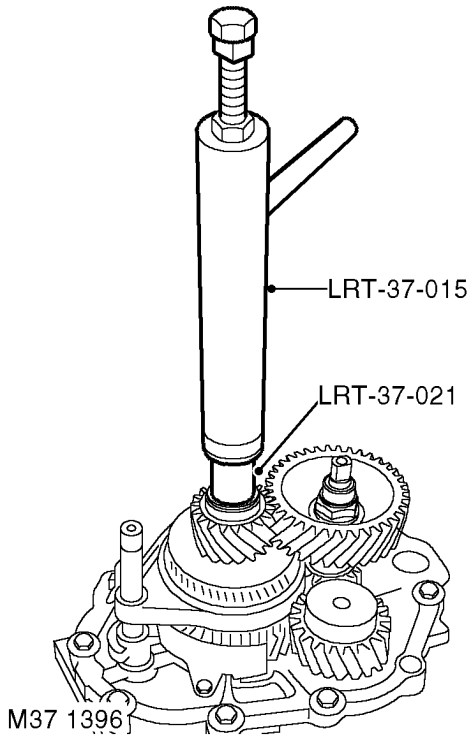
2. Using tool **LRT-37-001/2**, **LRT-37-009** and **LRT-37-010**, remove output shaft support bearing track.



3. Remove 5th gear and baulk ring from output shaft.

Reassembly

1. Clean gears and shafts.
2. Position 5th gear and baulk ring to output shaft.



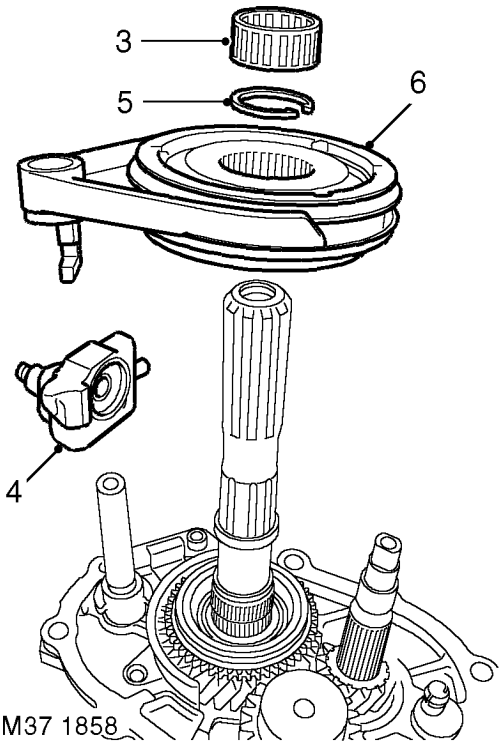
3. Using tool **LRT-37-015** and **LRT-37-021**, fit support bearing track to output shaft.
4. Fit 5th gear - layshaft.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, 5th gear - layshaft.**

Synchronizer assembly - 5th/reverse

🔧 ***37.20.38***

Disassembly

1. Remove gearbox rear extension.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.**
2. Remove 5th gear set.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Gear - 5th gear set.**



3. Remove split needle roller bearing from output shaft.
4. Remove and discard Allen screw and remove gear change yoke.
5. Remove and discard circlip securing 5th/reverse synchronizer hub to output shaft.
6. Remove synchronizer hub and selector fork assembly.

Reassembly

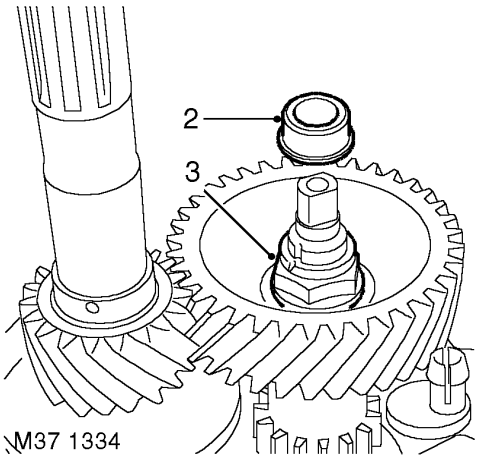
1. Clean gears, shafts, bearings and selector fork.
2. Position selector fork to synchronizer, fit assembly to output shaft and selector shaft. Fit new hub retaining circlip.**The fit of the circlip is controlled by the selective washer behind the reverse gear bearing collar on the output shaft.**
3. **Adjust to give a reverse gear end-float of 0.005 - 0.055mm (0.0002 - 0.0021in).**
4. Apply Loctite 290 to threads of new gear change lever yoke Allen screw.
5. Position gear change lever yoke and tighten Allen screw to 25 Nm (18 lbf.ft).
6. Position split needle roller bearing to output shaft.
7. Fit 5th gear set.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Gear - 5th gear set.**
8. Fit gearbox rear extension.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.**

5th gear - layshaft

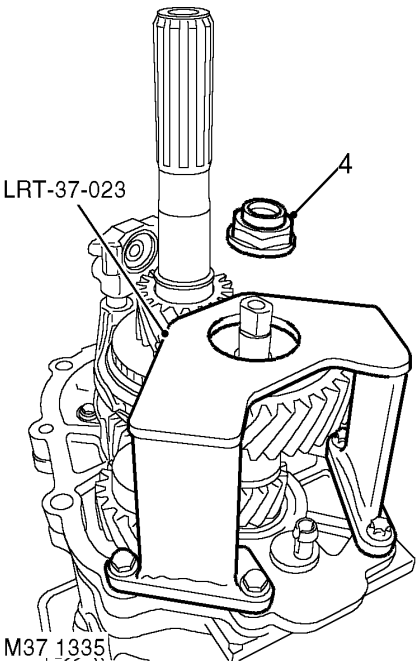
37.20.43

Disassembly

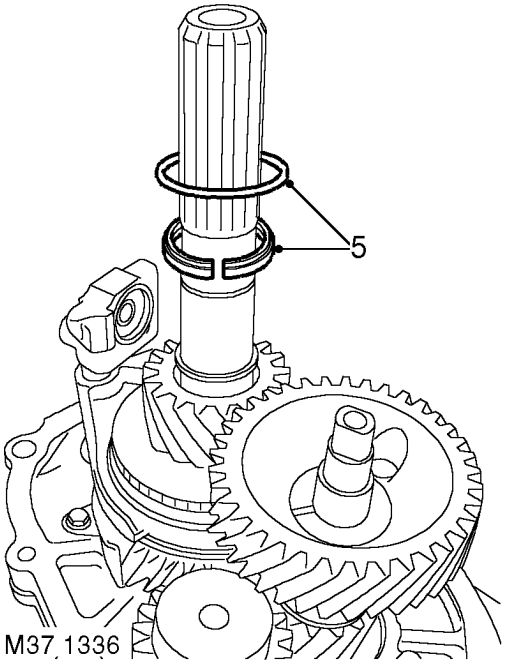
1. Remove gearbox extension.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.**



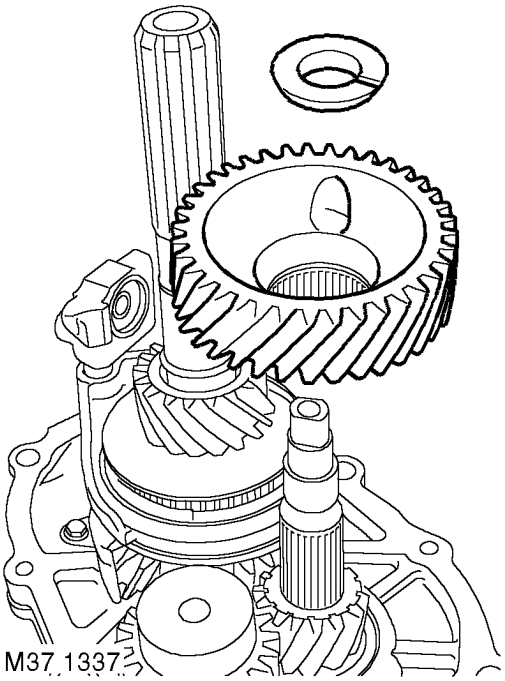
2. Using a suitable two legged puller and remove 5th gear layshaft support bearing track from end of layshaft.
3. Release staking from 5th gear retaining nut.



4. Using tool **LRT-37-023** to hold 5th gear, remove and discard stake nut.



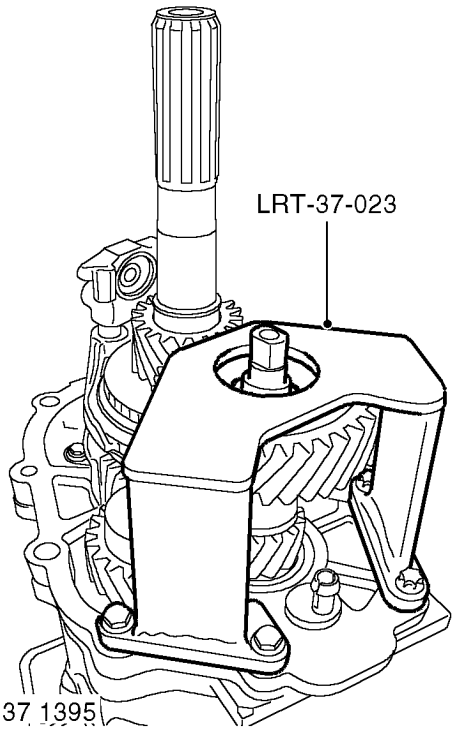
5. Remove retaining ring and split collars securing 5th gear to output shaft.



6. Remove split collar and 5th gear from layshaft.

Reassembly

1. Clean gear and layshaft.
2. Position 5th gear and split collar to layshaft ensuring that bevelled side of collar is towards 5th gear.
3. Position split collars and retaining ring securing 5th gear to output shaft.



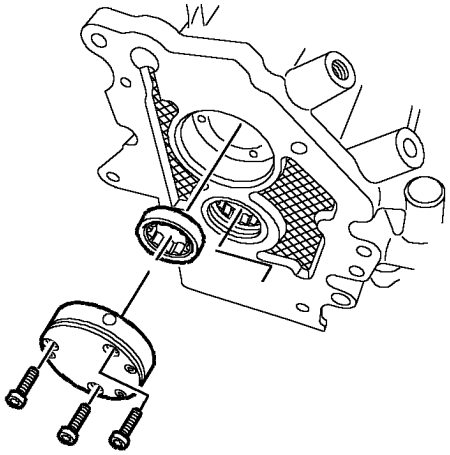
4. Position tool **LRT-37-023** to hold 5th gear and tighten new stake nut to 220 Nm (162 lbf.ft) and stake nut.
5. Apply a small amount of heat and fit support bearing track to layshaft.
6. Fit gearbox extension.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.**

Bearing - layshaft rear support

37.20.58

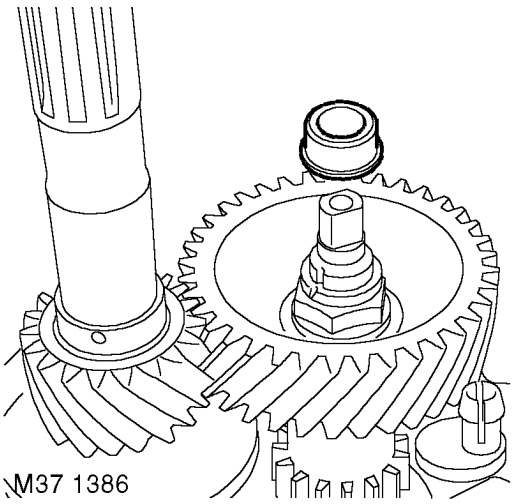
Disassembly

1. Remove extension housing.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.



M37 1385

2. Remove 3 Torx screws, remove oil pump and discard 'O' ring.
3. Drift out layshaft support bearing.



M37 1386

4. Using a suitable two legged puller remove 5th gear layshaft support bearing track from end of layshaft.

Reassembly

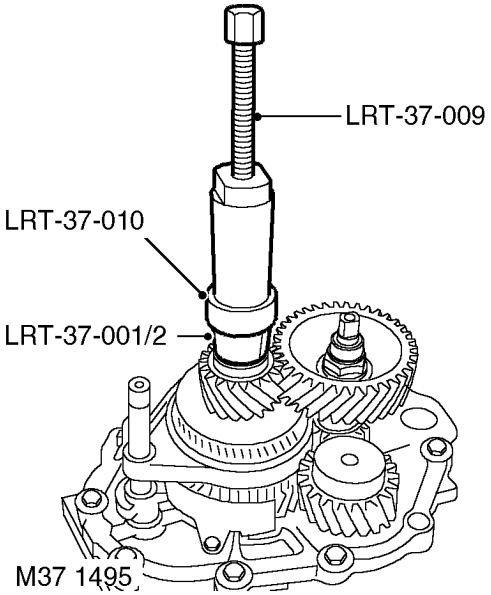
1. Clean layshaft and bearing recess in extension housing.
2. Fit layshaft support bearing.
3. Clean oil pump recess in extension housing, ensure screw holes are clean and dry.
4. Lubricate oil pump recess in housing with gearbox oil.
5. Lubricate a new 'O' ring with gearbox oil and fit to oil pump.
6. Locate oil pump in extension housing with word 'TOP' towards top of housing.
7. Align fixing screw holes and tap pump lightly around edges until pump is fully in housing. **Do not pull pump into housing by tightening screws.**
8. Fit Torx screws and tighten to 6 Nm (4.5 lbf.ft).
9. Apply a small amount of heat and fit support bearing track to layshaft.
10. Fit extension housing.
    MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.

Bearing - output shaft rear support

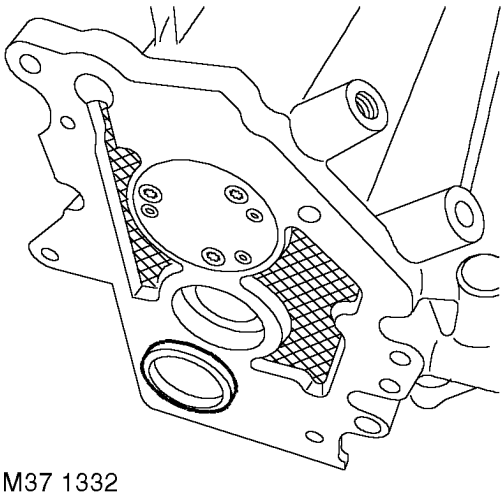
37.20.55

Disassembly

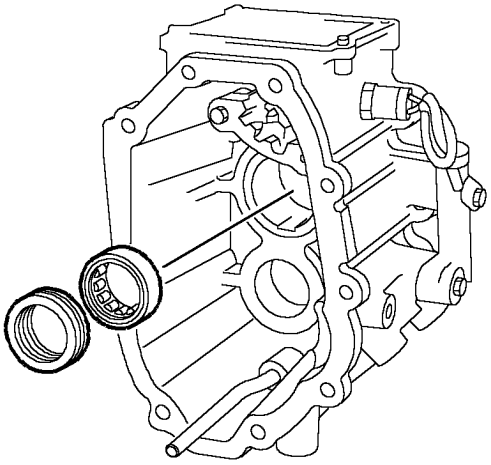
1. Remove extension housing.
   MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.



2. Using tool **LRT-37-001/2**, **LRT-37-009** and **LRT-37-010**, remove output shaft support bearing track.


M37 1332

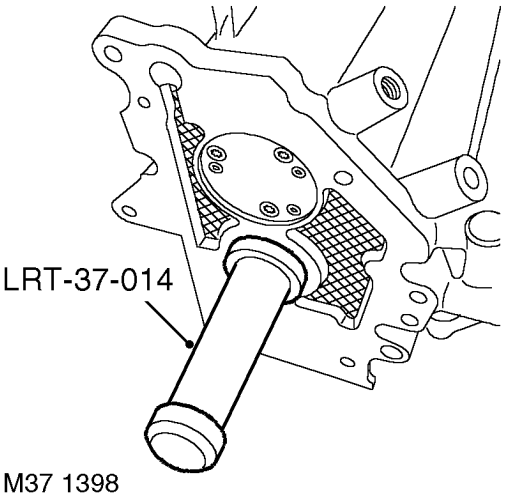
3. Remove output shaft rear oil seal.


M37 1333

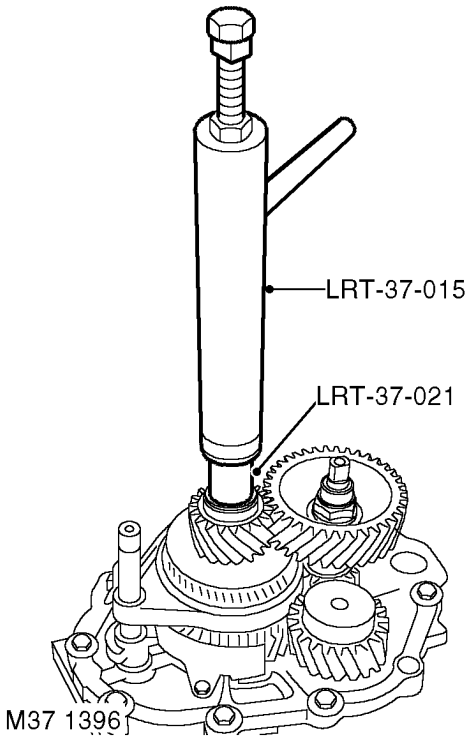
4. Remove output shaft support bearing and oil pick-up ring.

Reassembly

1. Clean output shaft and bearing recess in extension housing.
2. Fit output shaft support bearing and oil pick-up ring. (Align tag with centre of drain slot).



3. Fit new output shaft oil seal using **LRT-37-014**.



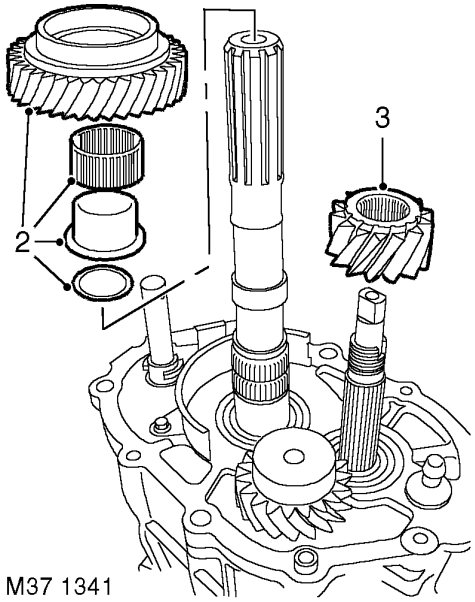
4. Using tool **LRT-37-015** and **LRT-37-021**, fit support bearing track to output shaft.
5. Fit extension housing.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Extension - gearbox rear.**

Shaft - reverse idler

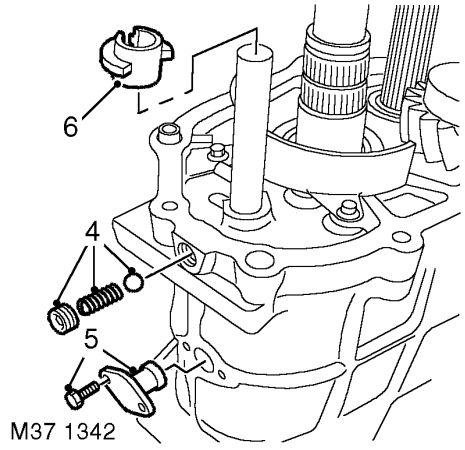
37.20.13

Disassembly

1. Remove 5th / reverse gear synchroniser.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Synchronizer assembly - 5th/ reverse.**

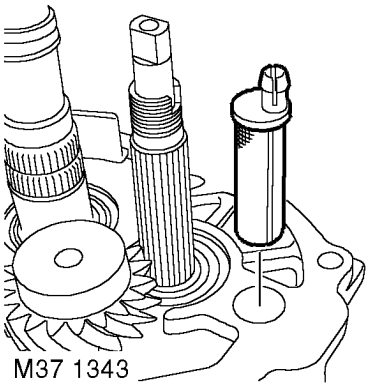


2. Remove reverse gear complete with needle roller bearing and collar noting selective spacer between collar and centre plate bearing.
3. Remove layshaft reverse gear noting oil groove faces centre plate bearing.

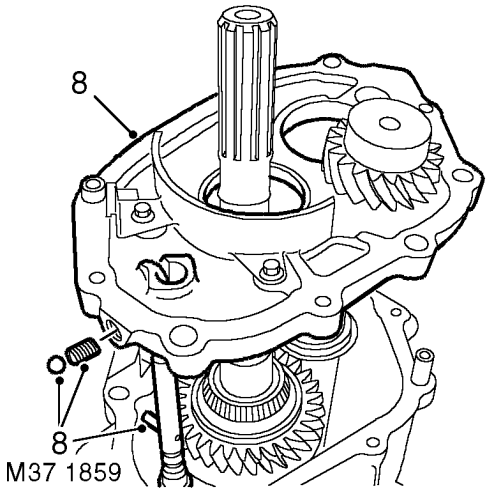


4. Remove detent screw from centre plate and collect upper detent ball and spring.

5. Remove 2 bolts securing spool retainer to gearbox case. Remove retainer, remove and discard 'O' ring - if fitted.
6. Remove interlock spool from selector shaft.

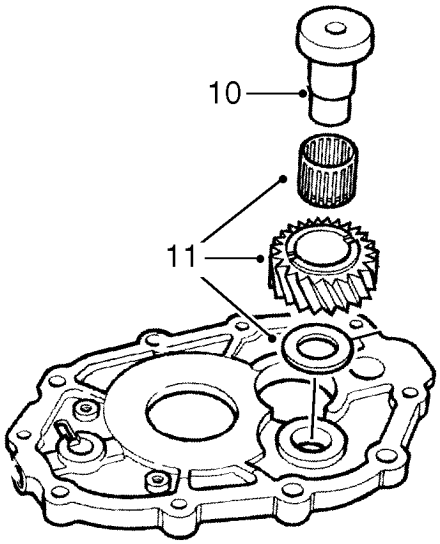

M37 1343

7. Remove filter from gearbox case.



M37 1859

8. Align selector shaft pin with slot in centre plate and using wooden blocks and hide mallet, release centre plate and collect lower detent ball and spring.



M37 1346

9. Press out reverse idler shaft using a suitable press.
10. Remove idler gear, needle roller bearing and spacer.

Reassembly

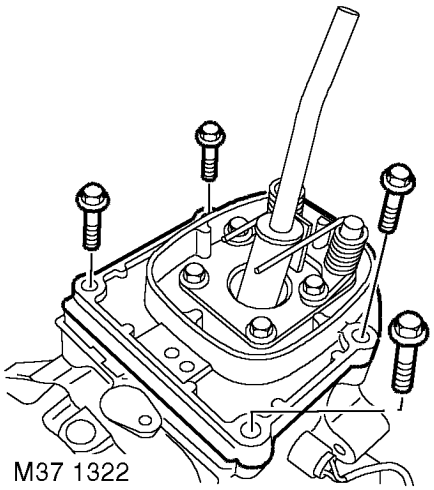
1. Clean centre plate and reverse gear components.
2. Lubricate gearbox components with clean gear oil.
3. Position idler gear, bearing and spacer to idler shaft.
4. Using a suitable press fit idler shaft to centre plate.
5. Using feeler gauges, check clearance between reverse idler and shaft flange; fit a thicker or thinner spacer if necessary in order to achieve correct clearance:
   - **New clearance =** 0.04 - 0.38 mm (0.002 - 0.015 in)
   - **Service limit =** 0.38 mm (0.015 in)
6. Apply sealant, Part No. STC 3254 to gearbox casing.
7. Fit lower spring and detent ball into centre plate, retain using a dummy shaft.
8. Align selector shaft pin with slot in centre plate.
9. Fit centre plate and fit 2 off 8x35 mm slave bolts to retain centre plate in position on gearbox case; recover dummy shaft.

10. Fit filter to gearbox case.
11. Fit interlock spool to selector shaft.
12. Using new 'O' ring, fit spool retainer and tighten bolts to 8 Nm (6 lbf.ft).
13. Clean threads of detent plug.
14. Apply Loctite 290 to threads of detent plug, fit upper detent ball and spring.
15. Fit detent plug and tighten to 25 Nm (18 lbf.ft).
16. Position reverse gear to layshaft.
17. Position reverse gear complete with bearing, collar and selective spacer to output shaft.
18. Fit 5th / reverse gear synchroniser.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Synchronizer assembly - 5th/ reverse.**

Housing - gear selector mechanism

37.16.37.01

Disassembly


M37 1322

1. Remove 4 bolts and remove gear selector housing.

Reassembly

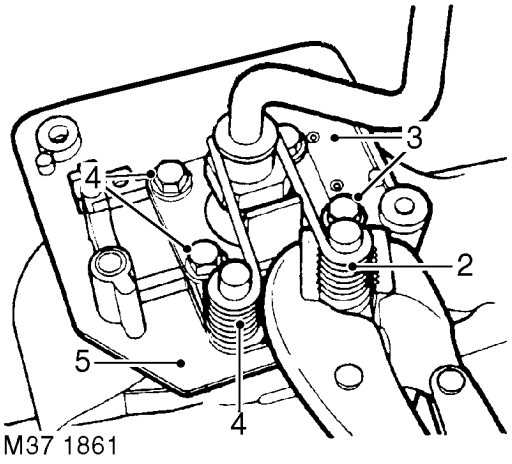
1. Clean mating faces on selector housing and gearbox.
2. Apply sealant, STC 3254, to selector housing.
3. Clean selector housing bolt threads.
4. Apply Loctite 290 to threads of selector housing bolts, position selector housing and tighten bolts to 25 Nm (18 lbf.ft)
5. Adjust gear lever bias springs.
   ☞ **MANUAL GEARBOX - R380, ADJUSTMENTS, Spring - gear lever bias.**

Lever - gear change

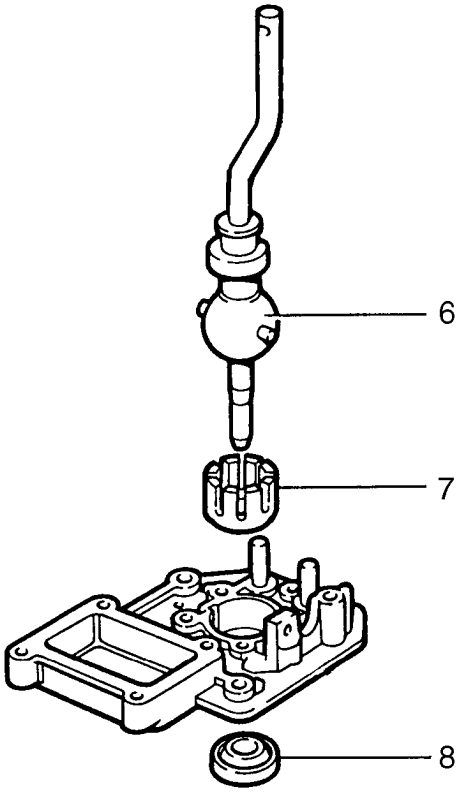
37.16.04

Disassembly

1. Remove gear selector housing.
   ☞ **MANUAL GEARBOX - R380, OVERHAUL, Housing - gear selector mechanism.**



2. Restrain right hand bias spring using a suitable pair of grips.
3. Remove 2 bolts securing right hand side of bias spring adjustment plate.
4. Repeat operations for left hand bias spring.
5. Remove bias springs and adjustment plate.



6. Remove lower gear lever.
7. Remove and discard Railko bush.
8. Remove and discard oil seal from housing.

Reassembly

1. Clean components.
2. Apply multi-purpose grease to ball and cross pins.
3. Apply multi-purpose to new Railko bush and fit to housing ensuring that slots are correctly aligned.
4. Lubricate a new seal with gearbox oil and fit, lip side towards housing using a suitable mandrel.
5. Position lower gear lever to selector housing ensuring cross pins are located in Railko bush.
6. Position bias spring adjustment plate to selector housing.
7. Clean threads of bias spring adjustment plate bolts and apply Loctite 290 to threads.
8. Fit 2 short bolts to secure front of adjustment plate and tighten to 25 Nm (18 lbf.ft).
9. Position right hand bias spring to pillar ensuring longest end of spring is against gear lever.
10. Restrain bias spring using a suitable pair of grips, ensure shortest end of spring is on outside edge of bolt hole.

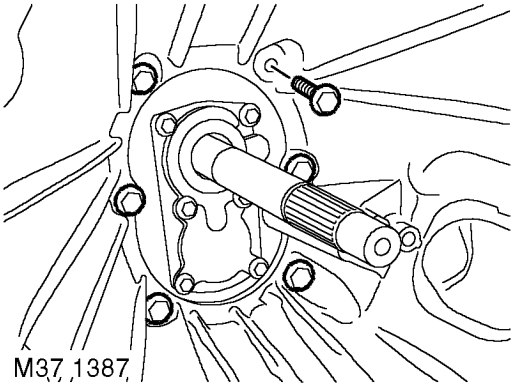
11. Fit longest bolt and washer ensuring end of bias spring is under washer, tighten bolt to 25 Nm (18 lbf.ft).
12. Repeat above procedures for remaining bias spring.
13. Fit gear selector housing.
    ☞ **MANUAL GEARBOX - R380, OVERHAUL, Housing - gear selector mechanism.**
14. Adjust gear lever bias springs.
    ☞ **MANUAL GEARBOX - R380, ADJUSTMENTS, Spring - gear lever bias.**

Housing - clutch

⊸ ***37.12.07***

Disassembly

1. Remove clutch release bearing and operating lever.



2. Remove 6 bolts and remove clutch housing.

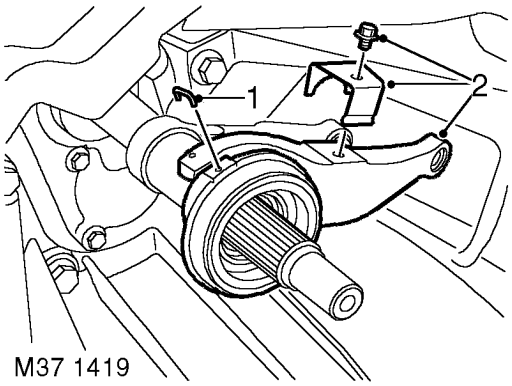
Reassembly

1. Clean clutch housing and gearbox mating face.
2. Position clutch housing and tighten bolts to 75 Nm (55 lbf.ft).
3. Fit clutch operating lever and release bearing.

Cover - front

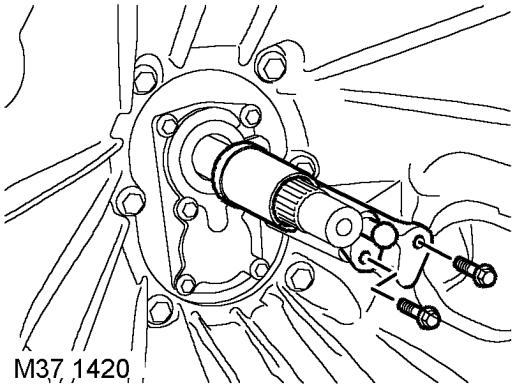
37.12.33.01

Disassembly

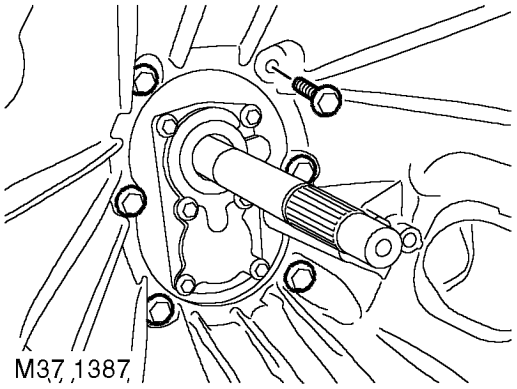


M37 1419

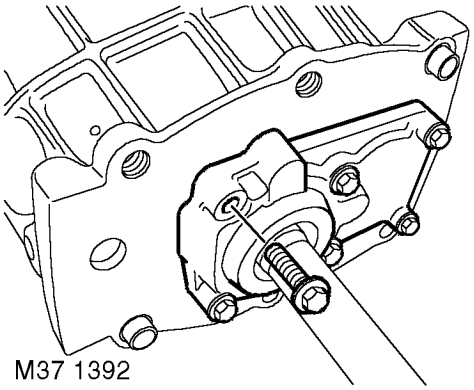
1. Remove retaining peg and remove release bearing.
2. Remove bolt securing clutch release fork, remove retaining clip and remove clutch release fork.


M37 1420

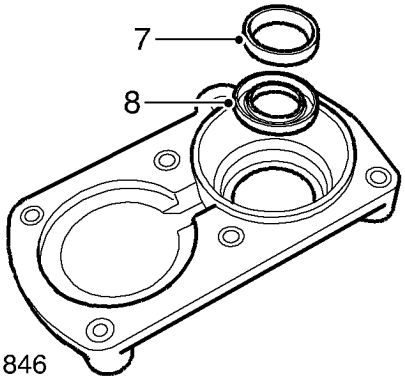
3. Remove 2 bolts securing release bearing sleeve and remove bearing sleeve.


M37 1387

4. Remove 6 bolts securing clutch housing and remove clutch housing.


M37 1392

5. Remove and discard 6 bolts securing oil seal housing.
6. Remove oil seal housing.

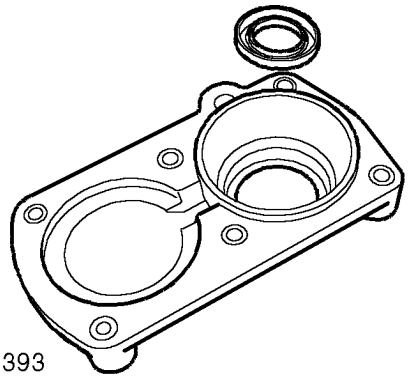


M37 1846

7. Using a soft metal drift, carefully remove input shaft front bearing track from housing.
8. Remove oil seal from housing, discard seal.

Reassembly

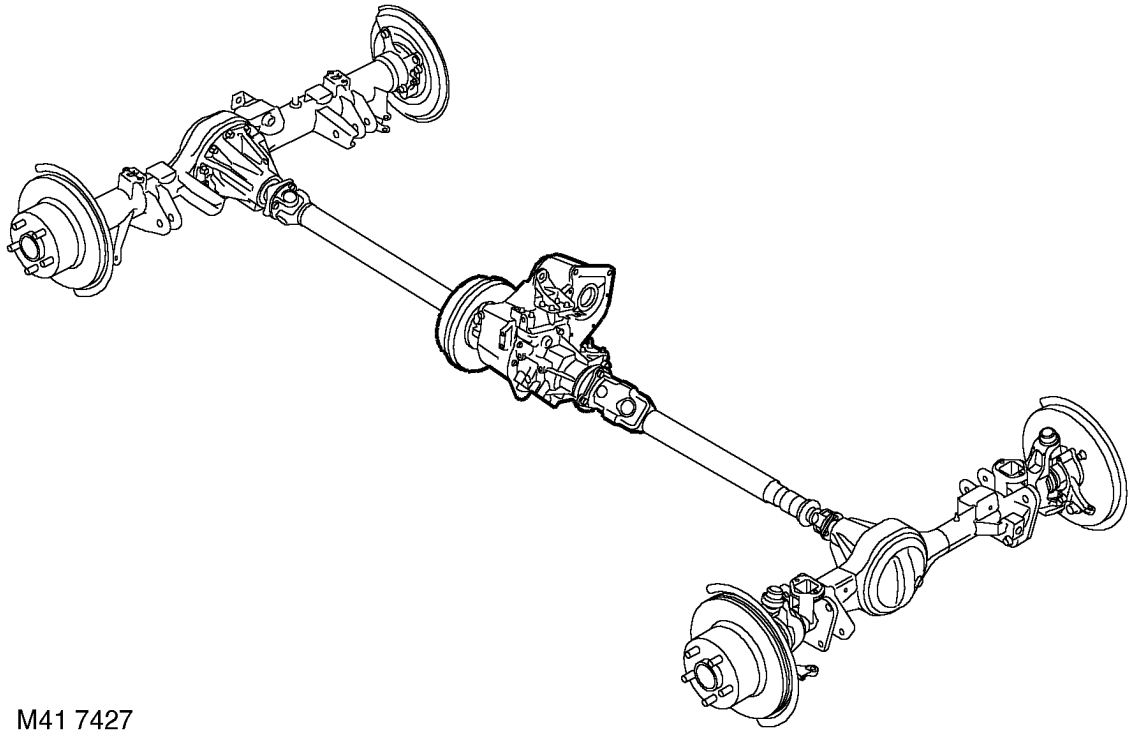
1. Using a suitable solvent cleaner, clean seal housing mating faces.
2. Clean seal recess, bearings and bearing races.



M37 1393

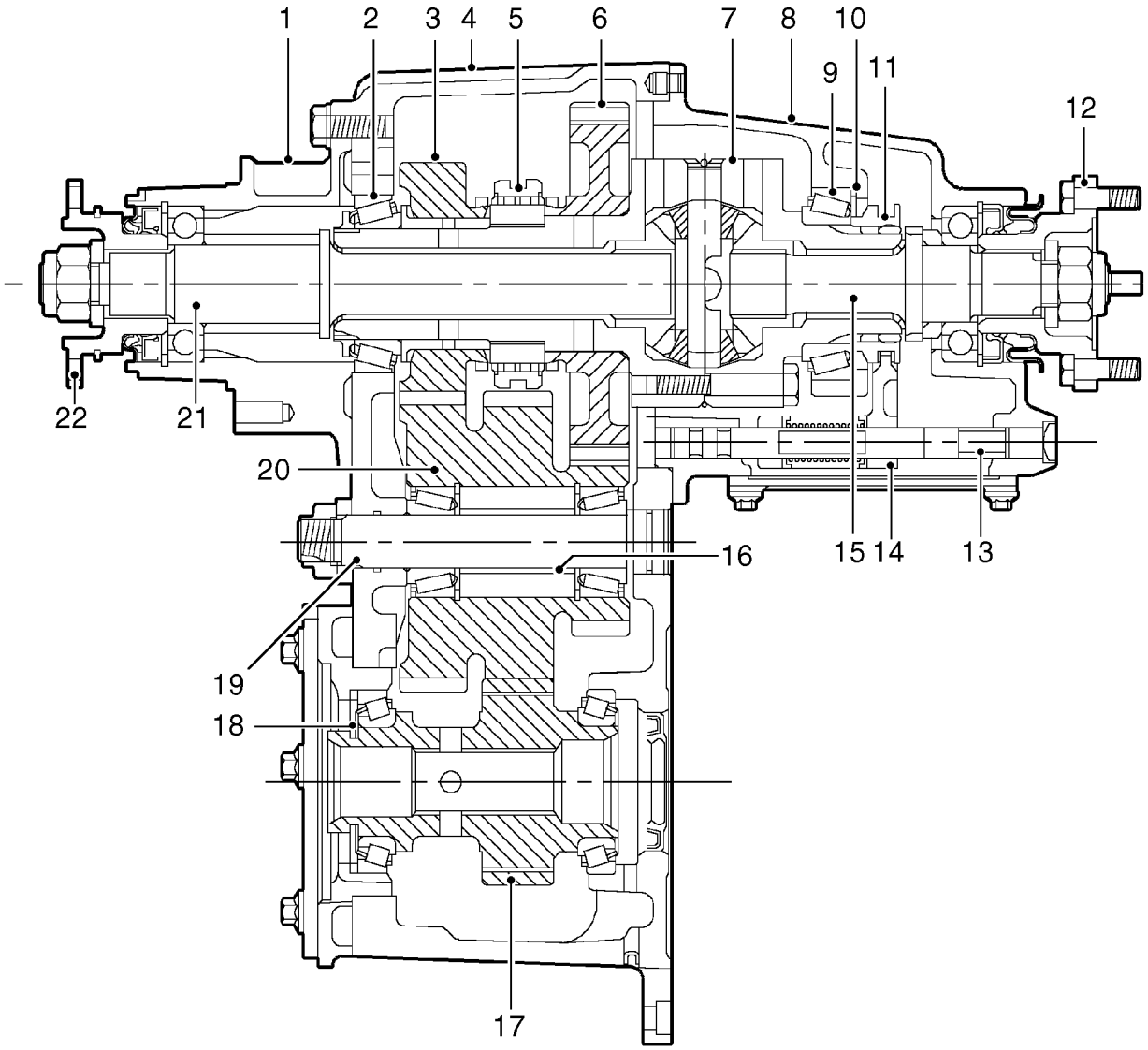
3. Lubricate new oil seal and fit using a suitable mandrel into housing.
4. Fit input shaft front bearing track using a press and suitable mandrel.
5. Apply sealant, Part No. STC 4404 to seal housing, fit new bolts and tighten by diagonal selection to 25 Nm (18 lbf.ft).
6. Clean clutch housing mating faces, dowels and dowel holes.
7. Position clutch housing, fit bolts and tighten to 75 Nm (55 lbf.ft).
8. Clean release bearing sleeve mating faces, dowel and dowel holes.
9. Position release bearing sleeve, fit bolts and tighten to 25 Nm (18 lbf.ft).
10. Examine clutch release fork pivot points for wear and replace as required.
11. Apply a smear of Molybdenum disulphide grease to pivot points and position release fork.
12. Fit retaining clip ensuring it locates over pivot point washer, fit bolt to release fork and tighten to 10 Nm (7 lbf.ft).
13. Clean release bearing and bearing sleeve mating faces.
14. Apply smear of Molybdenum disulphide grease to release bearing sleeve.
15. Fit release bearing and secure with retaining peg.

LT230SE transfer box



M41 7427

Transfer box cross section

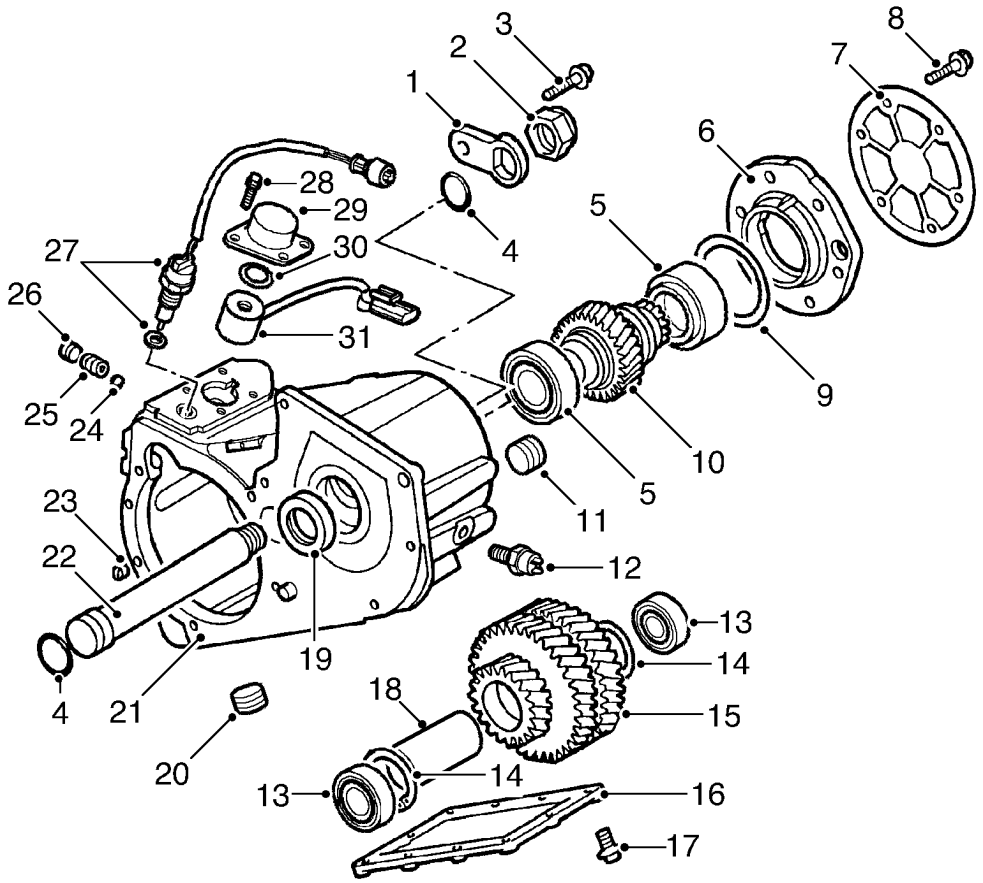


M41 7426

Up to 03 Model Year section shown

1 Rear output housing
2 Differential rear bearing
3 High range gear and bush
4 Main casing
5 High/low selector sleeve and hub
6 Low range gear
7 Differential assembly
8 Front output housing
9 Differential front bearing
10 Selective shim - differential bearing pre-load
11 Dog clutch - Differential lock - If fitted
12 Front output flange
13 Differential lock selector shaft - Differential lock - If fitted
14 Selector fork - Differential lock - If fitted
15 Front output shaft
16 Selective spacer - intermediate gear bearing pre-load
17 Mainshaft input gear
18 Selective shim - input gear bearing pre-load
19 Intermediate shaft
20 Intermediate gear cluster
21 Rear output shaft
22 Rear output flange

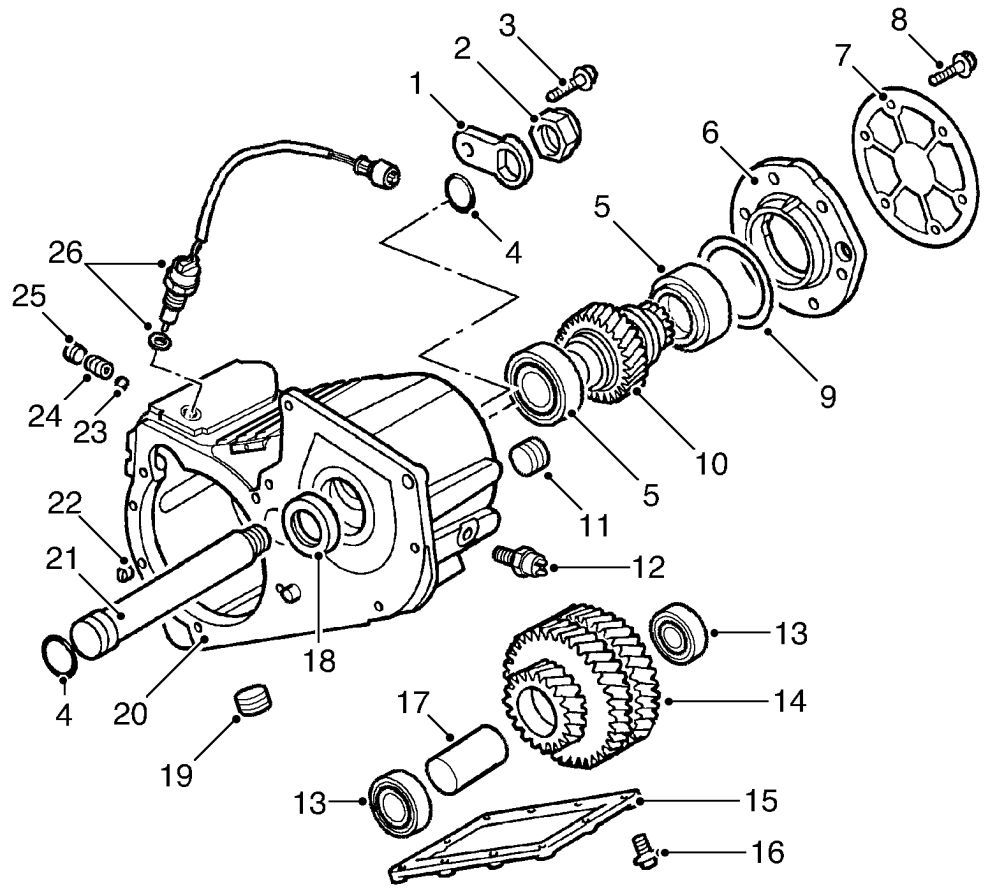
Main casing components – Vehicles up to 03 model year



M41 7424A

1 Retaining plate
2 Stake nut - intermediate shaft
3 Bolt - retaining plate
4 'O' rings - intermediate shaft
5 Bearings and outer tracks - mainshaft input gear
6 Mainshaft input gear bearing housing
7 Cover plate
8 Bolt - cover plate
9 Selective shim
10 Mainshaft input gear
11 Oil filler/level plug
12 Oil temperature switch - if fitted
13 Bearings and outer tracks - intermediate gears
14 Circlips
15 Intermediate gears
16 Bottom cover plate
17 Bolt - bottom cover plate
18 Selective spacer
19 Mainshaft oil seal
20 Oil drain plug
21 Main casing
22 Intermediate shaft
23 Locating dowel
24 Detent ball - high/low selector
25 Detent spring - high/low selector
26 Detent plug - high/low selector
27 Neutral warning switch - Automatic gearbox only - North America and Japan
28 Bolt - interlock solenoid cover - Automatic gearbox only - North America and Japan
29 Cover - interlock solenoid - Automatic gearbox only - North America and Japan
30 Belleville washer - Automatic gearbox only - North America and Japan
31 Interlock solenoid - Automatic gearbox only - North America and Japan

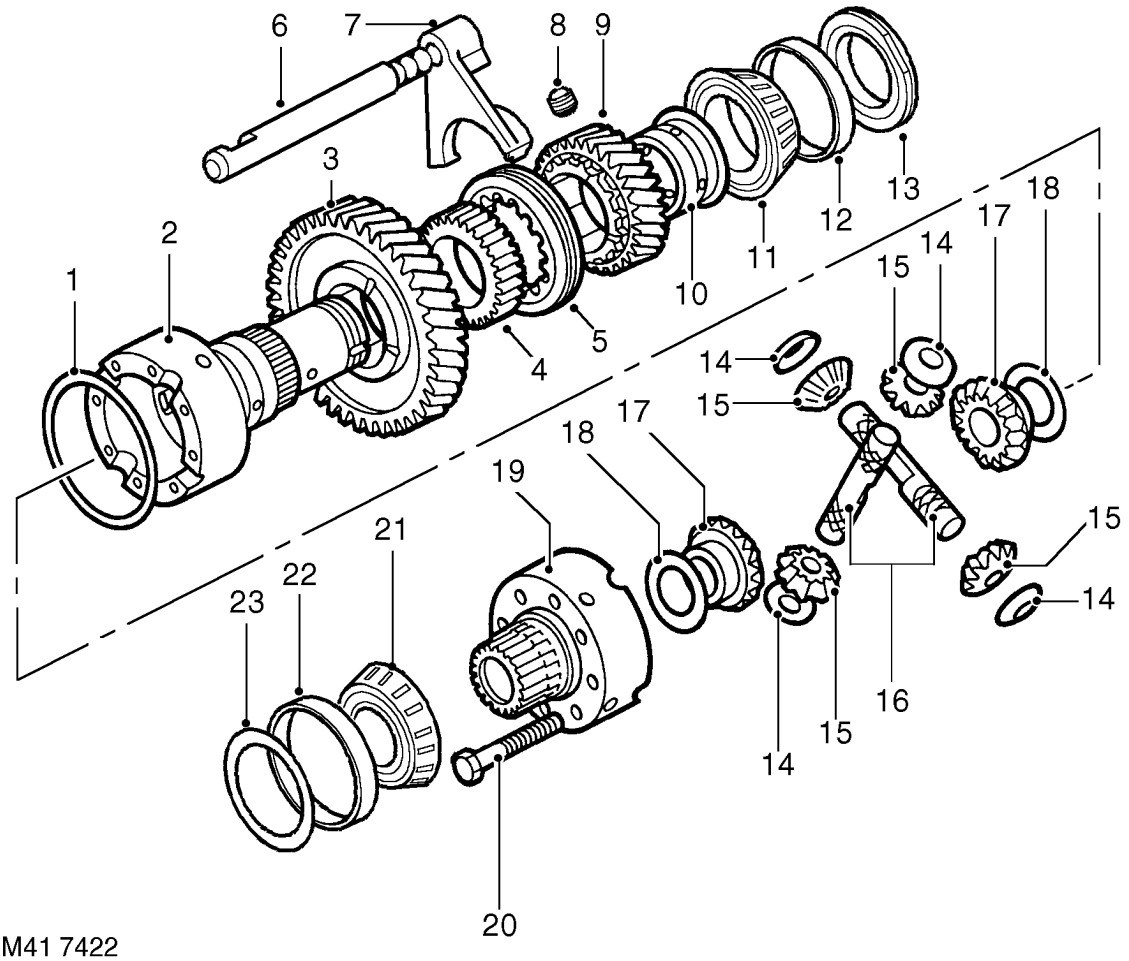
Main casing components – Vehicles from 03 model year



M41 7854

1 Retaining plate
2 Stake nut - intermediate shaft
3 Bolt - retaining plate
4 'O' rings - intermediate shaft
5 Bearings and outer tracks - mainshaft input gear
6 Mainshaft input gear bearing housing
7 Cover plate
8 Bolt - cover plate
9 Selective shim
10 Mainshaft input gear
11 Oil filler/level plug
12 Oil temperature switch - if fitted
13 Bearings and outer tracks - intermediate gears
14 Intermediate gears
15 Bottom cover plate
16 Bolt - bottom cover plate
17 Selective spacer
18 Mainshaft oil seal
19 Oil drain plug
20 Main casing
21 Intermediate shaft
22 Locating dowel
23 Detent ball - high/low selector
24 Detent spring - high/low selector
25 Detent plug - high/low selector
26 Neutral warning switch - Automatic gearbox only - North America and Japan

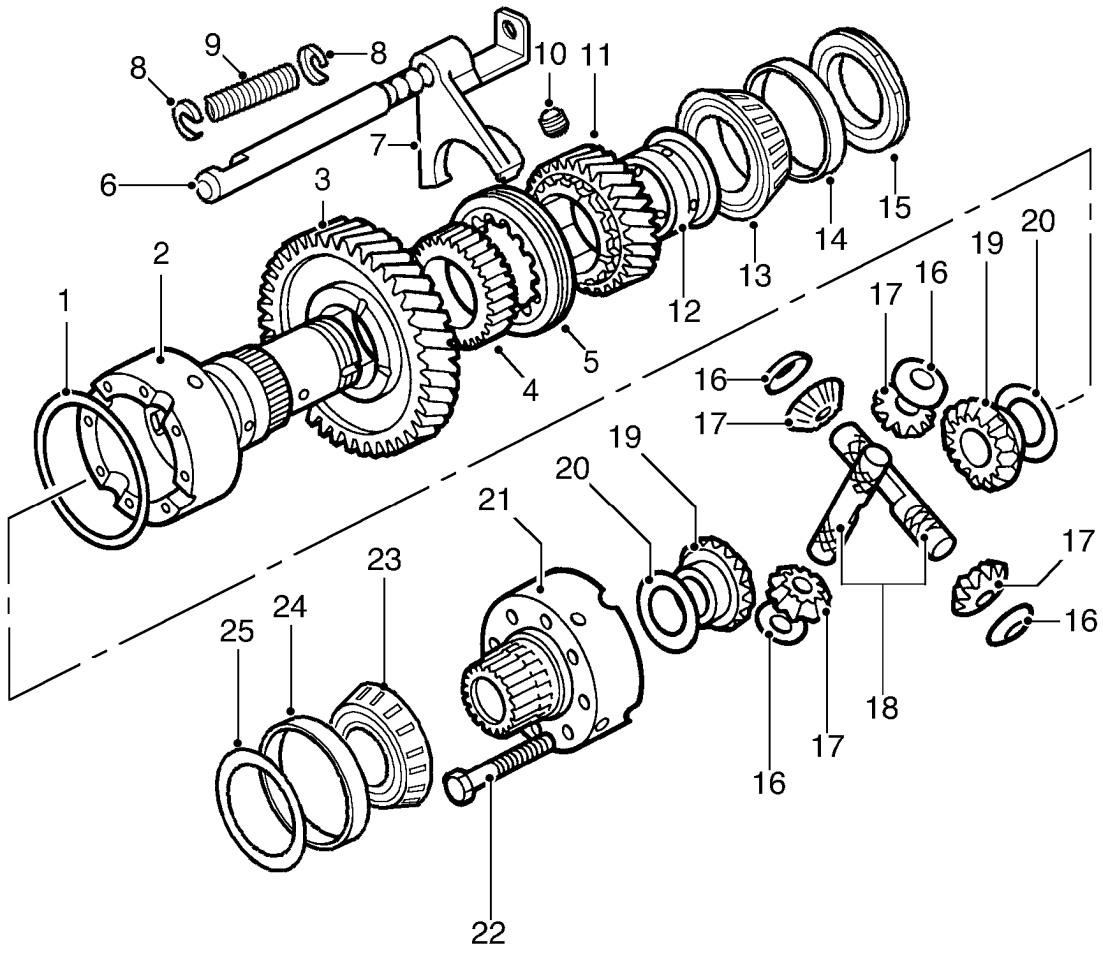
Differential components – Vehicles up to 03 model year



M41 7422

1 Retaining ring
2 Differential carrier - rear half
3 Low range gear
4 High/low hub
5 High/low selector sleeve
6 High/low selector shaft
7 High/low selector fork
8 Setscrew - high/low selector fork
9 High range gear
10 High range gear bush
11 Differential rear bearing
12 Bearing outer track
13 Bearing retaining nut
14 Dished thrust washers
15 Planet gears
16 Cross shafts
17 Sun gears
18 Selective thrust washers
19 Differential carrier - front half
20 Bolt - differential carriers
21 Differential front bearings
22 Bearing outer track
23 Selective shim

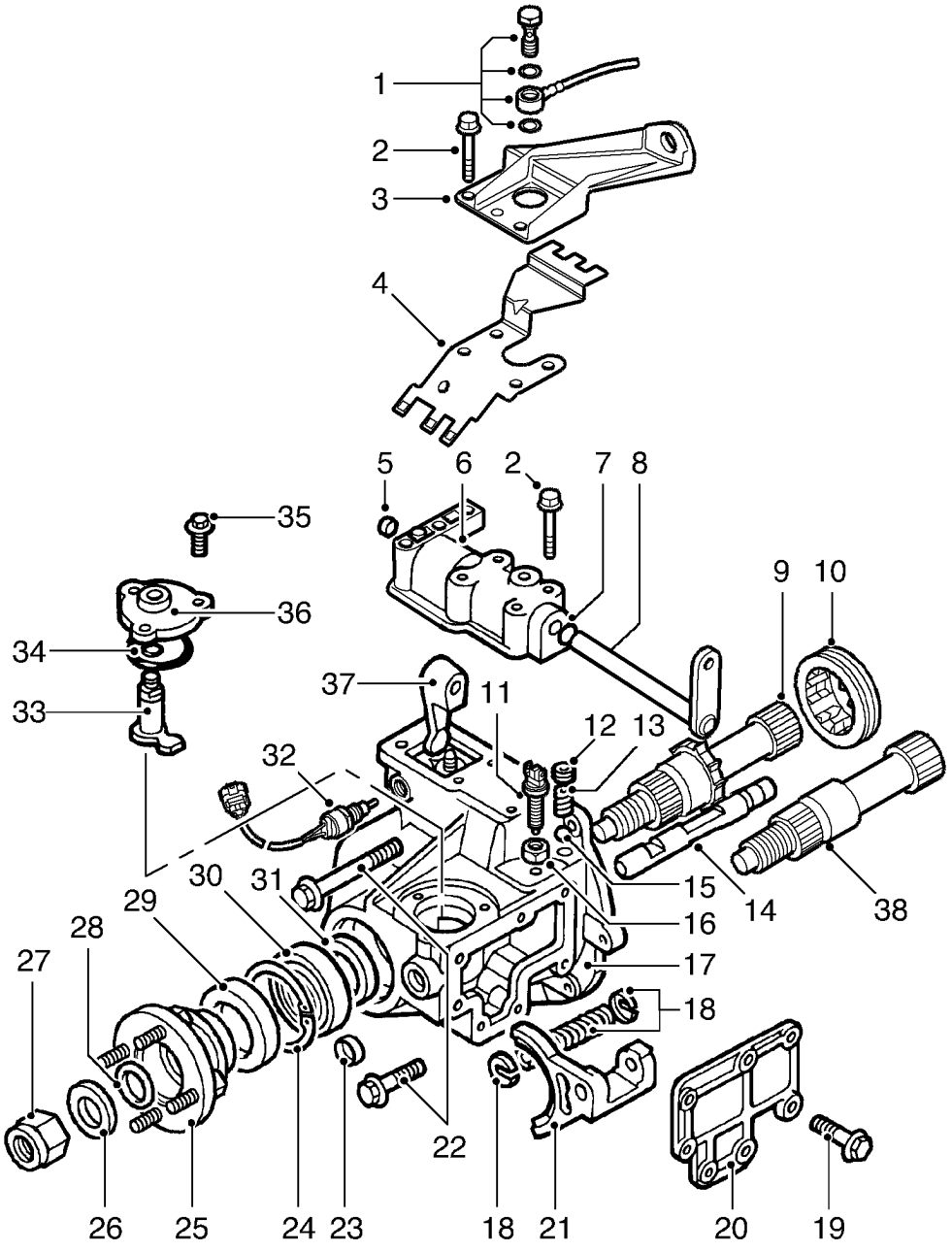
Differential components – Vehicles from 03 model year



M41 7855

1 Retaining ring
2 Differential carrier - rear half
3 Low range gear
4 High/low hub
5 High/low selector sleeve
6 High/low selector shaft
7 High/low selector fork
8 Clip (2 off)
9 Spring
10 Setscrew - high/low selector fork
11 High range gear
12 High range gear bush
13 Differential rear bearing
14 Bearing outer track
15 Bearing retaining nut
16 Dished thrust washers
17 Planet gears
18 Cross shafts
19 Sun gears
20 Selective thrust washers
21 Differential carrier - front half
22 Bolt - differential carriers
23 Differential front bearings
24 Bearing outer track
25 Selective shim

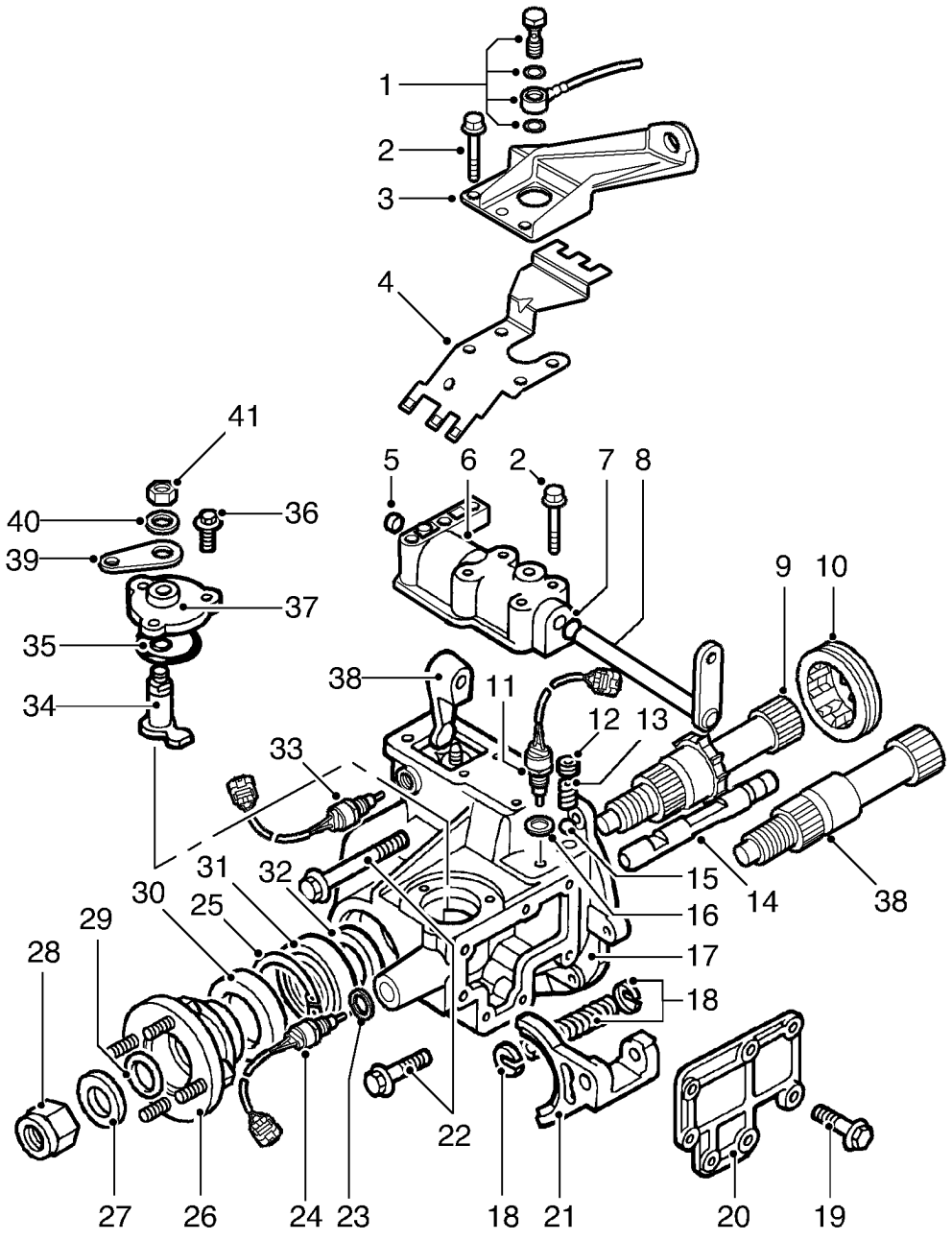
Front output housing components – Vehicles up to 03 model year



M41 7807

1 Breather pipe, banjo bolt and sealing washers
2 Bolt - high/low cross shaft housing and abutment bracket
3 Selector cable abutment bracket
4 Multiplug bracket
5 Hollow plug
6 High/low cross shaft housing
7 'O' ring
8 High/low cross shaft and lever
9 Front output shaft - Differential lock - If fitted
10 Dog clutch - Differential lock - If fitted
11 Warning lamp switch - Differential lock - If fitted
12 Detent plug - Differential lock - If fitted
13 Detent spring - Differential lock - If fitted
14 Selector shaft - Differential lock - If fitted
15 Detent ball - Differential lock - If fitted
16 Threaded spacer - Differential lock - If fitted
17 Front output housing
18 Spring and clips - Differential lock - If fitted
19 Bolt - cover plate
20 Cover plate
21 Selector fork - Differential lock - If fitted
22 Bolt - front output housing
23 Hollow plug
24 Circlip
25 Front output flange
26 Steel washer
27 Self-locking nut
28 Felt washer
29 Oil seal
30 Output shaft bearing
31 Bearing spacer
32 High/low detect switch
33 Selector finger and shaft - Differential lock - If fitted
34 'O' rings - Differential lock - If fitted
35 Bolt - selector housing - Differential lock - If fitted
36 Selector housing - Differential lock - If fitted
37 High/low selector finger
38 Front output shaft - Vehicles not fitted with differential lock

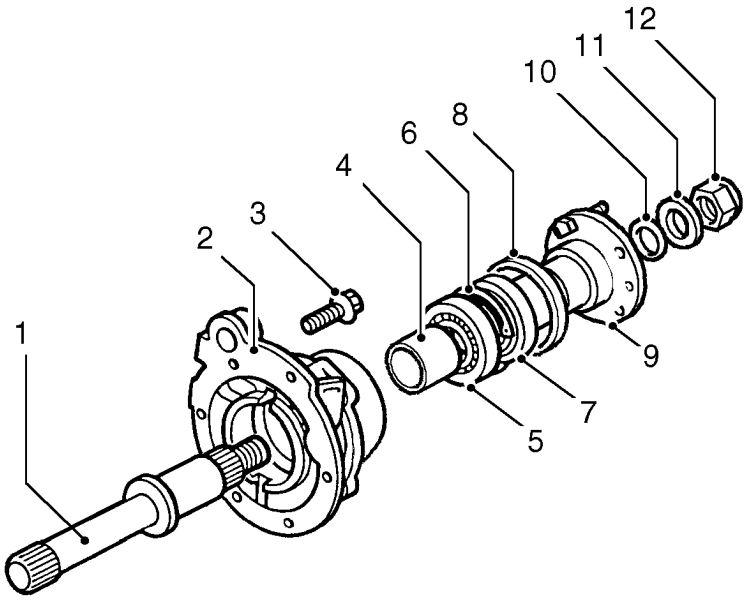
Front output housing components – Vehicles from 03 model year



M41 7856

1 Breather pipe, banjo bolt and sealing washers
2 Bolt - high/low cross shaft housing and abutment bracket
3 Selector cable abutment bracket
4 Multiplug bracket
5 Hollow plug
6 High/low cross shaft housing
7 'O' ring
8 High/low cross shaft and lever
9 Front output shaft - Differential lock - If fitted
10 Dog clutch - Differential lock - If fitted
11 Warning lamp switch - Differential lock - If fitted
12 Detent plug - Differential lock - If fitted
13 Detent spring - Differential lock - If fitted
14 Selector shaft - Differential lock - If fitted
15 Detent ball - Differential lock - If fitted
16 Threaded spacer - Differential lock - If fitted
17 Front output housing
18 Spring and clips - Differential lock - If fitted
19 Bolt - cover plate
20 Cover plate
21 Selector fork - Differential lock - If fitted
22 Bolt - front output housing
23 Aluminium washer
24 Warning lamp switch - Differential lock - If fitted
25 Circlip
26 Front output flange
27 Steel washer
28 Self-locking nut
29 Felt washer
30 Oil seal
31 Output shaft bearing
32 Bearing spacer
33 High/low detect switch
34 Selector finger and shaft - Differential lock - If fitted
35 'O' rings - Differential lock - If fitted
36 Bolt - selector housing - Differential lock - If fitted
37 Selector housing - Differential lock - If fitted
38 High/low selector finger
39 Front output shaft - Vehicles not fitted with differential lock
40 Washer
41 Nut

Rear output housing components



M41 7806

1 Rear output shaft
2 Rear output housing
3 Bolt - rear output housing
4 Spacer
5 Output shaft bearing
6 Circlip
7 Oil seal
8 Mud shield
9 Rear output flange
10 Felt washer
11 Steel washer
12 Self-locking nut

Description

General
The LT 230SE transfer box is mounted at the rear of the gearbox and transmits drive via high or low reduction ratios to the front and rear axles via the propeller shafts. The high/low ratios are 1.211:1 and 3.32:1 respectively.

Transfer boxes fitted to this model have the prefixes 41D and 42D to the unit serial number. Prefix 41D denotes that the unit is not fitted with interlock whilst 42D denotes that interlock is fitted.

Vehicles up to 03 model year – Whilst similar to LT230Q transfer boxes fitted to other models, the LT230SE transfer box has certain engineering modifications incorporated which are as follows:
- Uprated torque capacity
- Modified front and rear output and cross shaft housings
- Intermediate gear bearing pre-load now controlled by a selective, non-collapsible spacer
- Speedometer drive and driven gears not fitted for this application
- Modified high/low sleeve
- Modified front output flange and mud shield
- Differential lock fitted to certain vehicles, but no longer driver operated
- Fixed setting of differential lock warning lamp switch on vehicles fitted with differential lock

Vehicles from 03 model year – The LT230SE transfer box is as described above for vehicles up to 03 model year with the following modifications:

The following items are introduced on vehicles from 03 model year
- Ribs added to main casing to reduce operating noise
- Bearing retaining nut on the differential carrier has patchlock added to the threads
- Interlock solenoid moved from main casing to selector lever assembly
- Intermediate gears modified with machined internal shoulder and bearing circlips deleted

The following items are introduced later in the 03 model year build programme and therefore may not appear on all 03 model year vehicles
- Driver operated differential lock (if fitted)
- High/Low selector shaft fitted with spring assist
- Existing differential lock switch replaced by new design switch.
- New secondary differential lock switch installed in the front output housing

Construction
The transfer box comprises three main assemblies; the main casing, the front output housing and the rear output housing. Both output housings and all cover plates are sealed to the main casing by sealant; mud and water ingress being prevented by mud shields located on the output flanges.

Main casing
The main casing carries the mainshaft input gear, the intermediate gears and the differential, together with the high/low range gears, selector shaft and fork. The front and rear output housings are bolted to either side of the main casing.

Transmission neutral sensor
A transmission neutral sensor is fitted on automatic gearbox vehicles for North America and Japan. The sensor is connected to the BCU and is normally in the open position. The sensor provides an earth path for the BCU which then interprets the signal and activates an audible warning generated by the IDM if neutral is selected on the transfer box when the ignition is on.

Transfer box interlock solenoid - Automatic gearbox vehicles
An interlock solenoid is fitted for North America and Japan. The solenoid is located on the top of the transfer box main casing on vehicles up to 03 model year or on the selector lever assembly on vehicles from 03 model year. The solenoid is connected to the transfer box relay which, in turn, is controlled by the IDM. The purpose of the solenoid is to prevent neutral being selected on the transfer box when the ignition key is removed, thereby locking the box in either high or low ratio.

Mainshaft input gear
The gearbox output shaft is splined into the mainshaft input gear which is supported by taper roller bearings.

Input gear bearing pre-load is achieved by the use of a selective shim located in the bearing housing.

Intermediate gears
The intermediate gear cluster is supported by the taper roller bearings located at each end of the cluster and runs on the intermediate shaft which, in turn, is supported at the front and rear by the main casing.

A selective spacer, positioned between the gears, pre-loads the intermediate gear bearings when the intermediate shaft nut is tightened sufficiently to achieve the correct 'torque to turn' of the intermediate gears.

On vehicles from 03 model year, the circlips used to retain the bearings in the intermediate gear are deleted. The bore of the intermediate gear is machined with a shoulder at each end to locate the bearings.

Differential assembly
The differential assembly is supported at the front and rear by taper roller bearings, the front bearing outer track is located in the front output housing and the rear bearing outer track is located in the main casing by the rear output housing. Bearing pre-load is achieved by means of a selective shim located in the front output housing.

The differential rear shaft carries the low range gear, high/low selector sleeve and hub, high range gear and bush and the differential rear bearing; these components being secured to the shaft by a special staked nut.

The differential assembly comprises front and rear half carriers with integral shafts and with sun and planet gears mounted on cross shafts within the half carriers. Dished, non-selective thrust washers control the engagement of the planet gears with the sun gears, whilst selective thrust washers are used to control engagement of the sun gears and 'torque to turn' of the differential. The differential carrier halves are bolted together, a retaining ring providing positive location of the cross shafts.

The high/low selector shaft and fork are located at the side of the differential, movement of the shaft, fork and selector sleeve being controlled by the high/low selector finger. A spring loaded detent ball fitted in the main casing, locates in grooves in the shaft.

On vehicles from 03 model year, the selector fork is modified and fitted with a spring assistor and clips to reduce the effort required to move the selector lever.

Front output housing
The front output housing carries the front output shaft and flange, high/low cross shaft, housing and selector and on certain vehicles, the differential lock selector shaft and fork.

The front output shaft is supported in the housing by a single bearing and is splined into the differential front sun gear.

High/low selector
The high/low cross shaft is located in a housing bolted to the top of the output housing and is connected to the high/low selector finger which locates in a slot in the selector shaft.

High/low detect switch

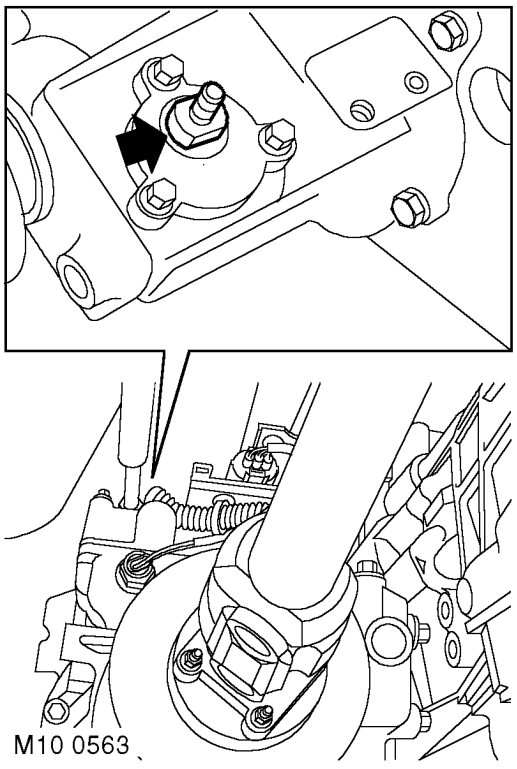
A high/low detect switch is fitted in the front output housing and connects to earth when low is selected. The switch is connected to the engine ECM, the SLABS ECU and the EAT ECU. The purpose of the switch is to enable selection of the hill descent feature and to modify the engine fuelling and automatic gearbox gearshift maps stored within the respective ECM's and ECU's.

Differential lock - Fitted to certain vehicles only

The differential lock selector housing is bolted to the top of the front output housing, the selector finger passes through the housing, locating in a slot in the differential lock selector shaft. The differential lock selector shaft passes through the selector fork which is located beneath a plate bolted to the side of the output housing. The selector fork engages the dog clutch sleeve with the differential rear shaft when the splines of the sleeve and differential rear shaft are aligned. A spring loaded detent ball fitted in the output housing locates in grooves in the shaft.

Functionality – Vehicles up to 03 model year only

The function of the differential lock used in previous applications is performed on this vehicle by the Electronic Traction Control System. However, for the purposes of 2 wheel rolling road testing , the differential lock components are retained. For all driving conditions however, the differential lock must be set in the unlocked position.



Up to 03 model year specification shown

The differential lock must only be engaged for 2 wheel rolling road testing as engagement of the lock disables the traction control feature and inhibits correct operation of the electronic brake distribution and hill descent features. It will also be necessary to disconnect the propeller shaft from the transfer box output shaft driving the axle whose wheels are NOT on the rolling road. The lock may be engaged/disengaged by using a 10 mm open ended spanner on the flats (arrowed) machined on the differential lock selector shaft.

Vehicles not fitted with a differential lock may be identified by there being no cover or selector shaft (arrowed) on the front output housing.

WARNING: VEHICLES NOT FITTED WITH A DIFFERENTIAL LOCK MUST NOT BE TESTED ON A ROLLING ROAD WHERE THE ROLLERS ARE DRIVEN BY THE VEHICLE.

Functionality – Vehicles from 03 model year only
The differential lock must be engaged for 2 wheel rolling road testing. It will also be necessary to disconnect the propeller shaft from the transfer box output shaft driving the axle whose wheels are NOT on the rolling road. In addition, the ETC system must be deactivated by either, removing a fuse (10A fuse 28 in the passenger compartment fusebox, labelled ABS) or disconnecting the ABS modulator pump. This must be done with the ignition switched off. Note that the SLABS ECU may record a system fault.

The lock can be engaged or disengaged using the selector lever. Vehicles not fitted with a differential lock can be identified by a high/low range selector lever with no differential lock functionality and the cover and selector shaft (arrowed), not visible on the front output housing.

WARNING: VEHICLES NOT FITTED WITH A DIFFERENTIAL LOCK MUST NOT BE TESTED ON A ROLLING ROAD WHERE THE ROLLERS ARE DRIVEN BY THE VEHICLE.

Differential lock warning lamp switch - if fitted - Vehicles up to 03 model year
A differential lock warning lamp switch connected to the SLABS ECU and operated by movement of the selector fork and shaft is screwed into the top of the output housing. The switch connects to earth when the differential lock is engaged.

Differential lock warning lamp switches - if fitted - Vehicles from 03 model year
Vehicles from 03 model year are fitted with two differential lock warning lamp switches.

One switch is of a new design and is fitted into the top of the front output housing in the same position as on previous models. The switch is connected to the SLABS ECU and is operated by movement of the selector fork and shaft.

The second switch is located in a threaded hole on the forward face of the front output housing. The switch is also connected to the SLABS ECU and is operated by movement of the selector shaft.

Both switches have an aluminium washer which seals the switch to the casing and also sets the switch position, removing the requirement for a setting procedure.

Both switches are connected in parallel to earth when the differential lock is engaged. This earth is sensed by the SLABS ECU which illuminates the differential lock warning lamp in the instrument pack.

Differential lock warning lamp - Vehicles up to 03 model year – if fitted
The differential lock warning lamp is located in the instrument pack and provides a warning to the driver when the ignition is switched on that the differential lock is engaged. The warning lamp illuminates in a Red colour.

With the lock engaged, the traction control and electronic brake distribution warning lamps will also be illuminated. Disengagement of the differential lock should be carried out with the ignition switched off. The warning lamps must be extinguished when the ignition is switched on again.

Differential lock warning lamp – vehicles from 03 model year – if fitted
The differential lock warning lamp is located in the instrument pack and provides a visual warning to the driver, when the ignition is on, the differential lock is engaged. The warning lamp illuminates in an amber colour.

When the lock is engaged, the warning lamp is illuminated and the instrument pack sounder emits three audible chimes. When the lock is disengaged, the warning lamp is extinguished and the instrument pack sounder emits three audible chimes.

Rear output housing
The rear output housing carries the output shaft and flange. A cable operated transmission brake is attached to the housing, the brake drum being attached to the output flange.

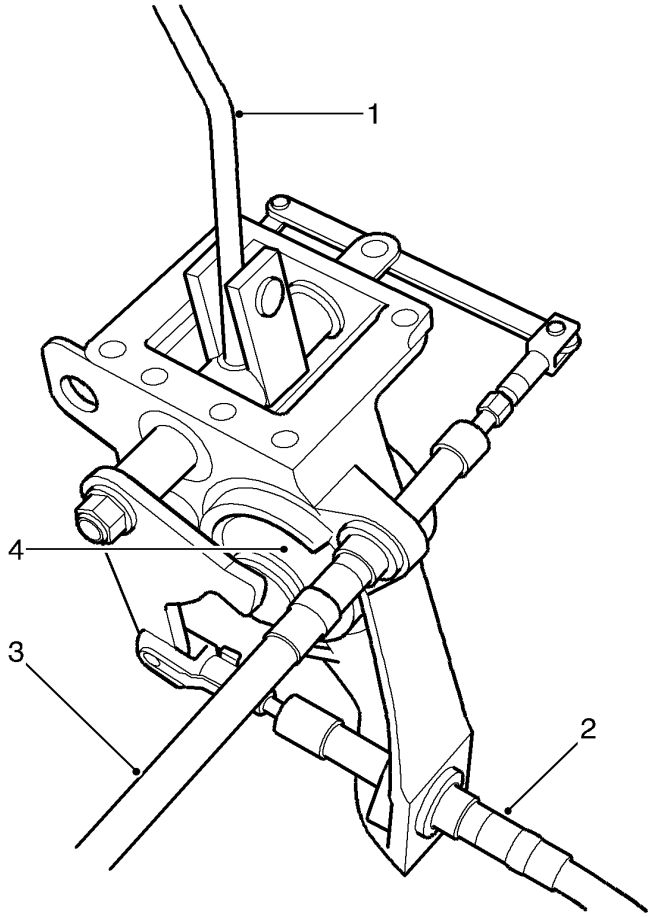
The rear output shaft is supported in the housing by a single bearing and is splined into the differential rear sun gear.

Lubrication
Lubrication is by splash, oil filler/level and drain plugs being located in the main casing.

Internal pressures caused by thermal expansion and contraction are avoided by the use of a plastic breather pipe venting the interior of the box to atmosphere. The pipe is attached to the top of the high/low selector housing by a banjo bolt and is then routed in a continuously rising path into the engine compartment where the open end is secured by a clip attached to the engine cylinder block.

Oil temperature warning lamp switch
An oil temperature switch is fitted to V8 engine models. In the event of the transfer box oil approaching maximum recommended working temperature of 145°C (293°F), the switch will close and a warning lamp in the instrument pack will be illuminated.

High/Low range and differential lock selector lever assembly – Vehicles from 03 model year



M41 7857

1 Selector lever
2 High/Low range cable
3 Differential lock cable
4 Interlock solenoid

On vehicle fitted with a differential lock, the high/low range selector lever as fitted on previous models also incorporates the differential lock selector on vehicles from 03 model year.

The lever can be moved forwards or backwards to select high, neutral or low range or sideways to select differential lock engaged or disengaged, on vehicles with differential lock fitted.

The selector lever assembly comprises an aluminium casting with bosses for location of the two cables, the selector lever mechanism and a housing for the interlock solenoid (if fitted). The upper face of the casting has threaded holes which allow for the attachment of the casting to the mounting plate which is attached to the transmission tunnel.

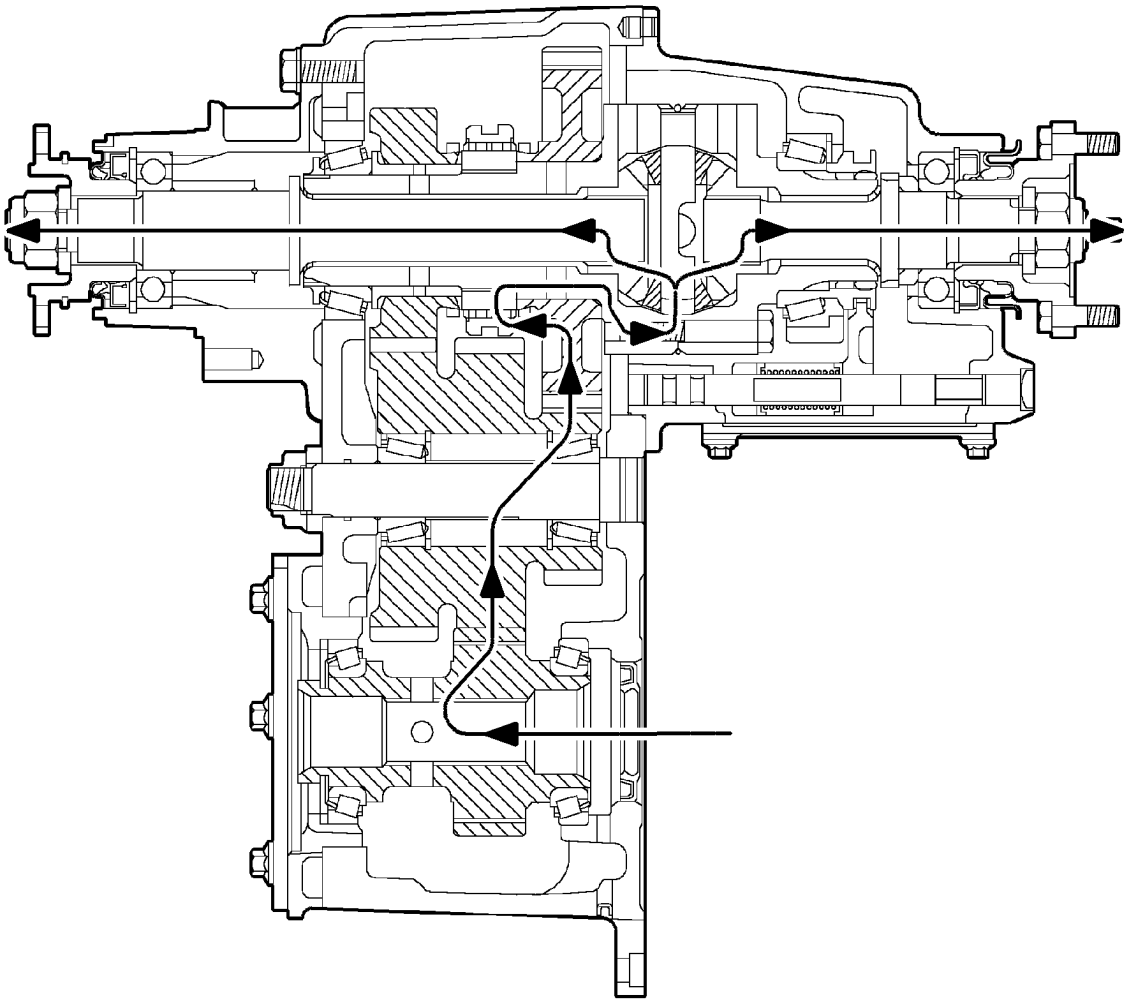
A boss at the front provides location for the differential lock cable. The cable is attached to a lever which in turn is attached to the selector lever. Movement of the selector lever is passed via the lever to the cable which moves the differential lock selector shaft.

A second boss provides for the location of the high/low range cable. The cable is attached to a plate which moves in a forward or rearward direction with the selector lever. On North American and Japanese specification models, plate movement is prevented by an interlock solenoid when the ignition key is not in the ignition.

When fitted, the interlock solenoid is located on the right hand side of the selector lever casting. The solenoid is fitted into a cast housing in the casting and retained with a circlip. Sealant is applied over the circlip to seal the solenoid in the housing to prevent the ingress of dirt and moisture. The solenoid performs the same function as on previous models, preventing the selection of neutral on the transfer box when the ignition key is not in the ignition.

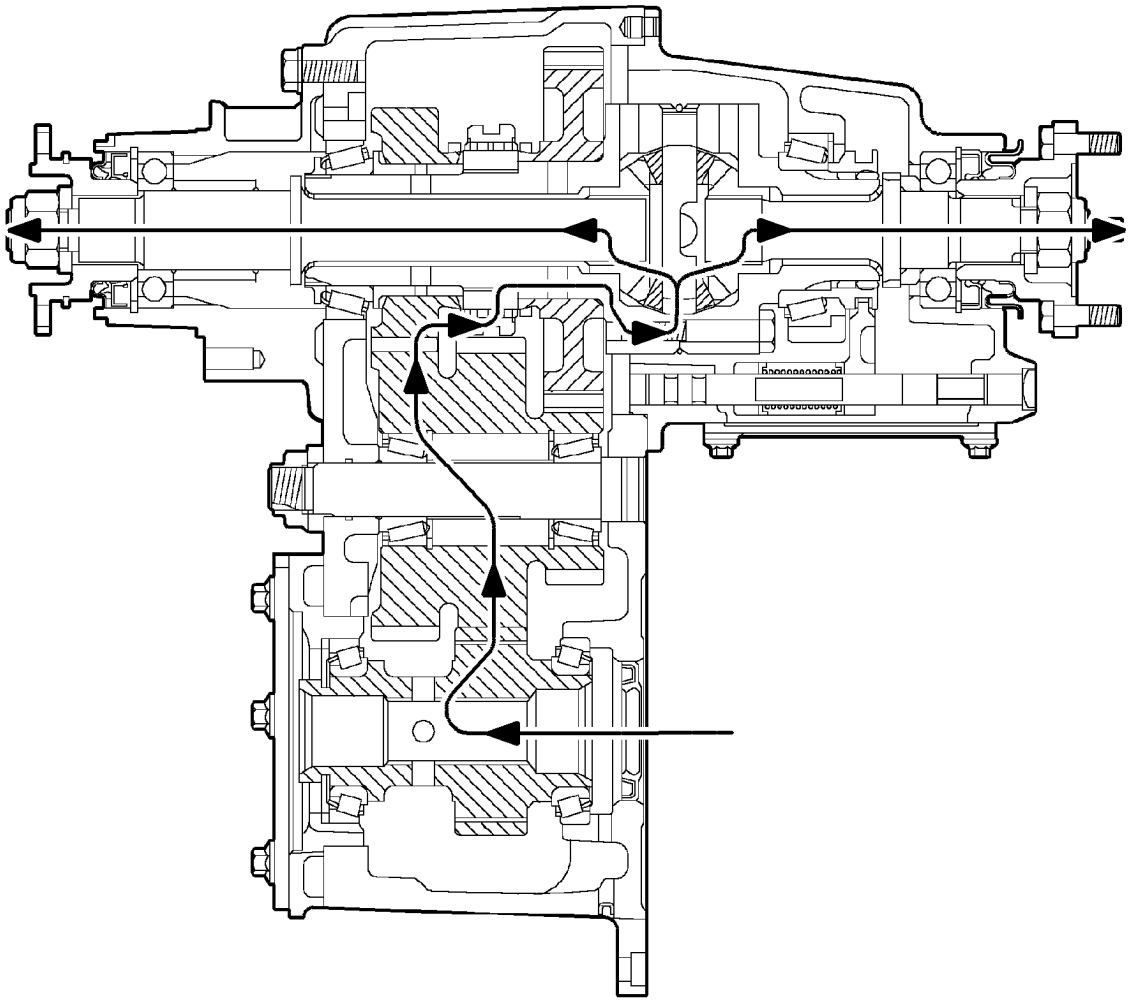
A setting procedure is required for both the differential lock cable and the high/low range cable.

Operation



M41 7505

Power flow - transfer box in LOW ratio
Up to 03 Model Year section shown. from 03 Model Year similar



M41 7504

Power flow - transfer box in HIGH ratio
Up to 03 Model Year section shown, from 03MY similar

The gearbox output shaft transmits power to the mainshaft input gear which is in constant mesh with one of the intermediate gears. The intermediate gears are in constant mesh with the high and low range output gears running on the differential rear shaft.

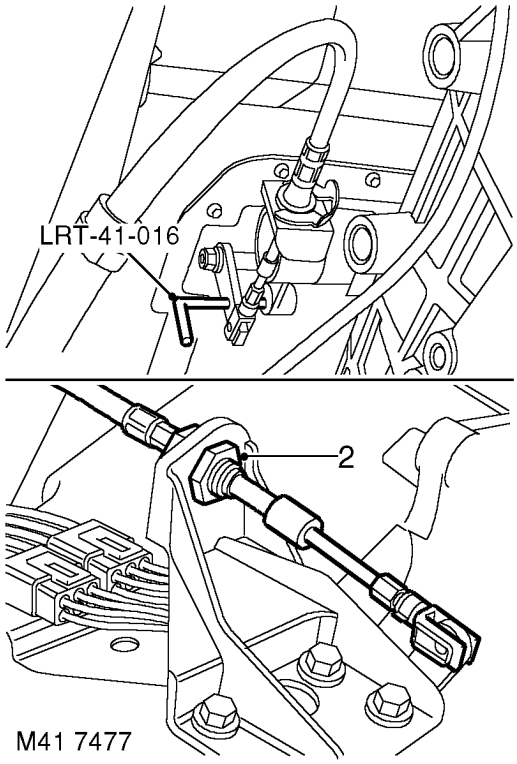
Power is transmitted to the output shafts via the differential assembly by locking either the high or low range gears to the differential rear shaft. This is achieved by means of the high/low selector fork, sleeve and splined hub.

Cable - high/low selector

41.20.46

Adjust

1. Raise vehicle on ramp.



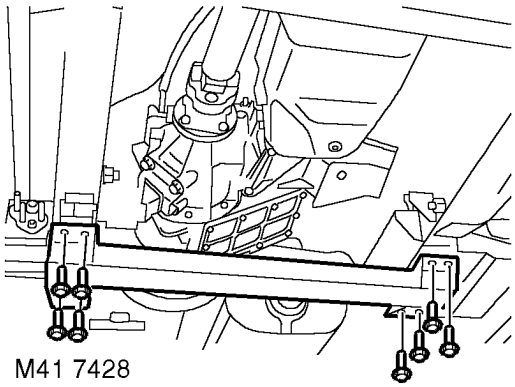
2. Using a suitable crows foot spanner, loosen lock nuts securing outer cable to abutment bracket.
3. Select high range by moving lever on transfer gearbox fully forward.
4. Insert tool **LRT-41-016** through hole in selector lever and housing. **This ensures selector lever is in the high range position.**
5. Lightly tighten outer cable lock nuts.
6. Remove tool **LRT-41-016** from gear selector lever and housing.
7. Simultaneously tighten high/low selector cable lock nuts either side of abutment bracket to 30 Nm (22 lbf.ft) .
8. Lower vehicle on ramp.

Bottom cover - transfer box

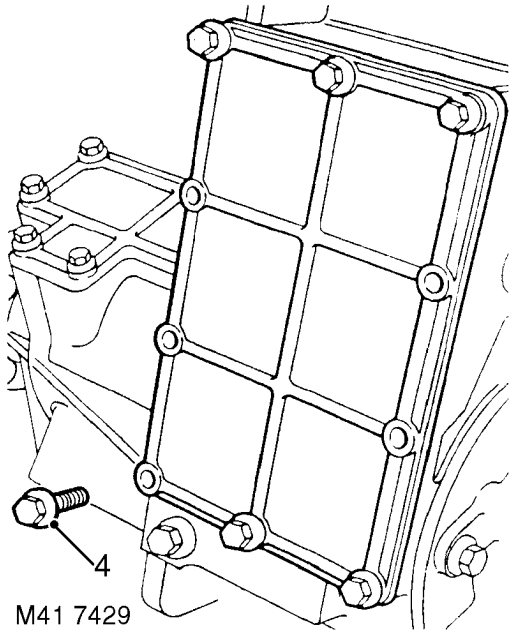
41.20.06

Remove

1. Raise vehicle on ramp.
2. Drain transfer box oil.
   MAINTENANCE, PROCEDURES, Transfer box.


M41 7428

3. Remove 8 bolts securing cross member to chassis and remove cross member.



M41 7429

4. Remove 10 bolts securing bottom cover to transfer box and remove cover.

Refit

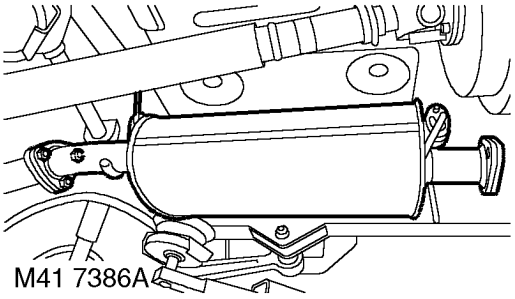
1. Clean bottom plate and mating face on transfer box.
2. Clean bolt threads.
3. Apply sealant, Part No. STC 3254 to bottom plate sealing face.
4. Apply Loctite 290 to bolt threads.
5. Position bottom plate and tighten bolts to 25 Nm (18 lbf.ft).
6. Position cross member to chassis and tighten bolts to 26 Nm (19 lbf.ft).
7. Fill transfer box with oil.
   MAINTENANCE, PROCEDURES, Transfer box.
8. Lower vehicle on ramp.

Transfer box - Diesel

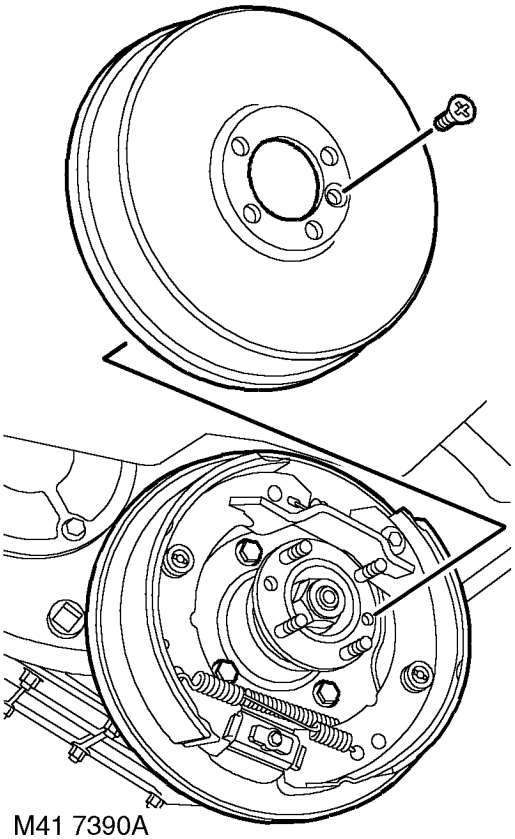
41.20.25.99

Remove

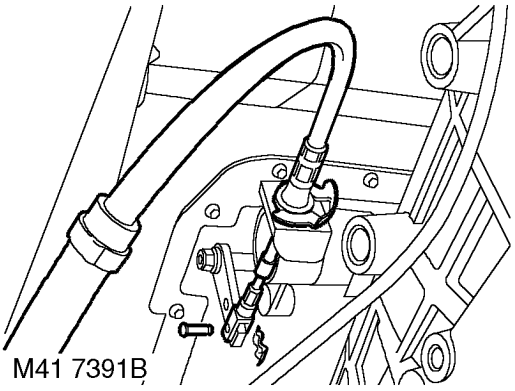
1. Remove front exhaust pipe.
   MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.
2. Raise vehicle on ramp.
3. Drain transfer box oil.
   MAINTENANCE, PROCEDURES, Transfer box.


M41 7386A

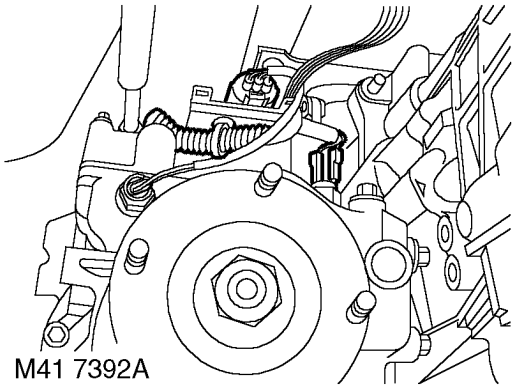
4. Remove 3 nuts securing intermediate silencer to tail pipe.
5. Release silencer from mounting rubbers.
6. Remove silencer and discard gasket.
7. Remove front propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
8. Remove rear propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.


M41 7390A

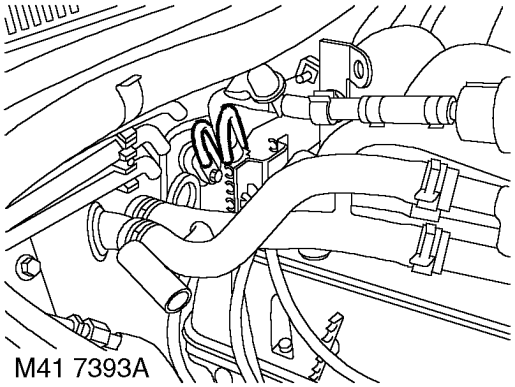
9. Remove handbrake drum retaining screw and remove drum.
10. Remove 4 bolts from handbrake back plate, release back plate and tie aside.


M41 7391B

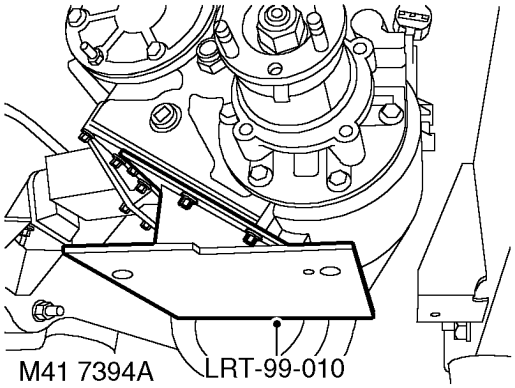
11. Remove clevis pin securing high/low ratio selector cable to selector lever, remove 'C' clip and release outer cable from abutment bracket.


M41 7392A

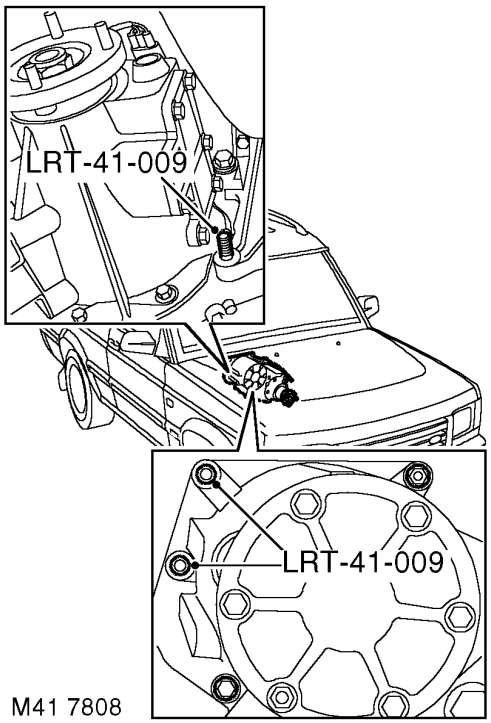
12. **If fitted:** Disconnect 2 Lucars from differential lock switch and disconnect multiplug from reverse light switch.
13. Remove cable tie and multi plug from bracket on transfer box.


M41 7393A

14. Release transfer box breather pipe from bulkhead clip.

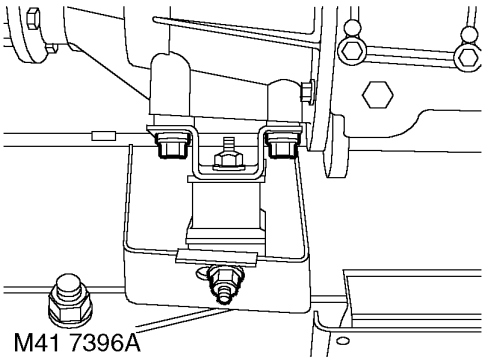

M41 7394A LRT-99-010

15. Remove 4 bolts from transfer box bottom plate, position support plate **LRT-99-010** to transfer box and tighten bolts.
16. Position gearbox support jack and secure support plate to jack using 4 bolts.



M41 7808

17. Remove 3 bolts securing transfer box to gearbox.
18. Fit 3 guide studs **LRT-41-009** through transfer box bolt holes to support it during removal.
19. Remove 2 bolts and nut securing transfer box to gearbox. **CAUTION: If securing stud is removed during this operation, it must be discarded and a new stud fitted.**
20. Position a jack to support gearbox and engine.


M41 7396A

21. Remove 4 bolts and nut, remove gearbox RH mounting.
22. With assistance, remove transfer box from gearbox.
23. Remove input shaft oil seal.
    ☞ **TRANSFER BOX - LT230SE, REPAIRS, Oil seal - input shaft.**

Refit

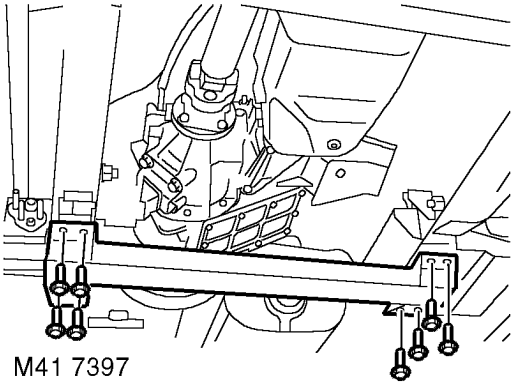
1. Fit new input shaft oil seal.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Oil seal - input shaft.**
2. Clean transfer box to gearbox mating faces.
3. Raise transfer box on jack and align to guide studs **LRT-41-009**.
4. Clean transfer box to gearbox bolt threads.
5. Apply Loctite 290 to bolt and stud threads.
6. Fit and lightly tighten 2 bolts and nut securing transfer box to gearbox. **If new stud is to be fitted, apply Loctite 290 to stud threads and tighten to 45 Nm (33 lbf.ft)**.
7. Remove guide studs, fit and lightly tighten remaining 3 bolts.
8. Tighten bolts and nut by diagonal selection to 45 Nm (33 lbf.ft).
9. Position gearbox RH mounting and tighten bolts to 85 Nm (63 lbf.ft).
10. Tighten gearbox RH mounting nut to 48 Nm (35 lbf.ft).
11. Remove 4 bolts securing support plate to gearbox jack.
12. Remove 4 bolts securing support plate **LRT-99-010** to transfer box and remove plate.
13. Clean bottom plate bolt threads.
14. Apply Loctite 290 to threads of 4 bottom plate bolts.
15. Fit 4 bolts securing bottom plate to transfer box and tighten to 25 Nm (18 lbf.ft).
16. Position breather pipe and secure to bulkhead clip.
17. Connect multiplug to reverse light switch.
18. **If fitted -** Connect Lucars to differential lock switch.
19. Fit multiplug and cable tie to transfer gearbox bracket.
20. Position high/low ratio selector cable and secure with clevis pin.
21. Clean handbrake and mating face.
22. Position handbrake back plate and tighten bolts to 75 Nm (55 lbf.ft).
23. Clean handbrake drum.
24. Fit handbrake drum and tighten retaining screw.
25. Fit front propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**
26. Fit rear propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**
27. Clean exhaust silencer and mating face.
28. Position silencer, fit new gasket , connect mounting rubbers and tighten nuts to 40 Nm (30 lbf.ft).
29. Refill transfer box with oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
30. Fit front exhaust pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**

Transfer box - V8

41.20.25.99

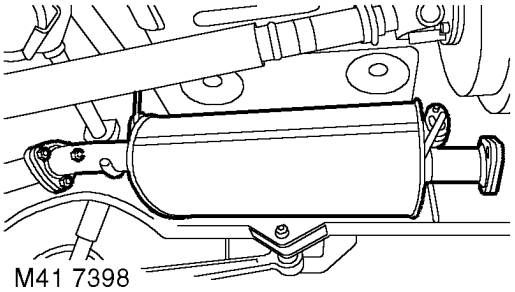
Remove

1. Remove front exhaust pipe.
   MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.
2. Drain transfer box oil.
   MAINTENANCE, PROCEDURES, Transfer box.



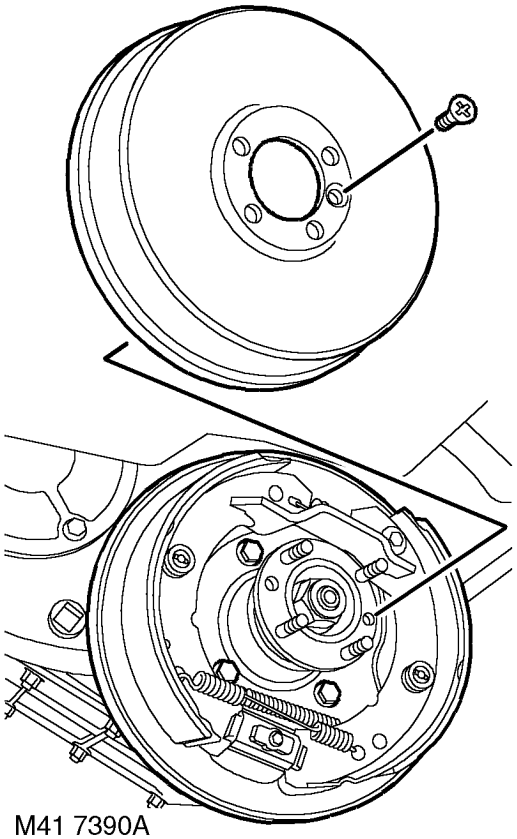
M41 7397

3. Remove 8 bolts securing rear cross member and remove cross member.



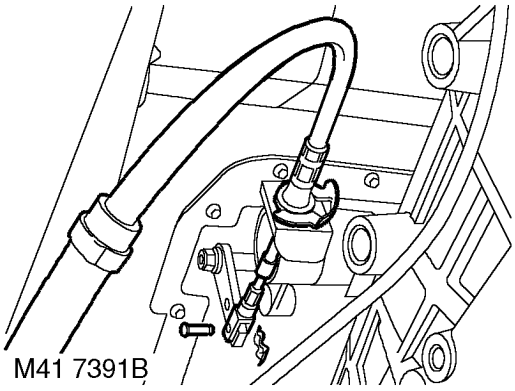
M41 7398

4. Remove 3 nuts securing intermediate silencer to tail pipe.
5. Release silencer from mounting rubbers, remove silencer and discard gasket.
6. Remove front propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
7. Remove rear propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.



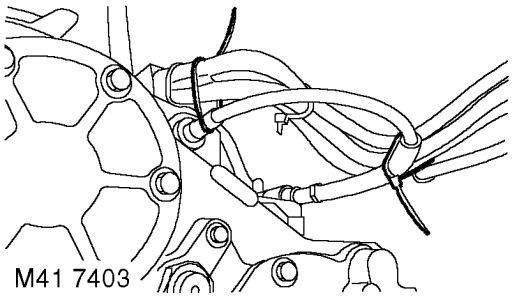
M41 7390A

8. Remove handbrake drum retaining screw and remove handbrake drum.
9. Remove 4 bolts from handbrake back plate, release back plate and tie aside.

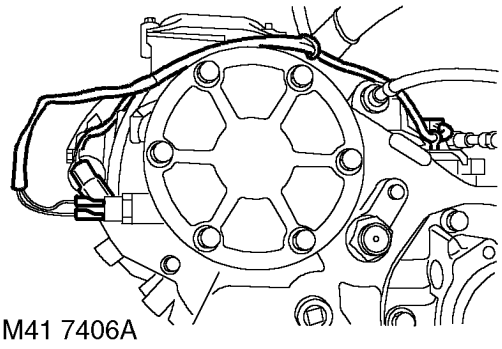


M41 7391B

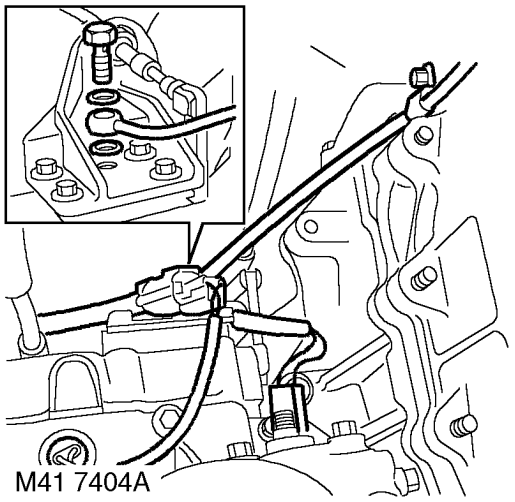
10. Remove clevis pin and 'C' washer securing high/low ratio selector cable to selector lever and release cable from abutment bracket.


M41 7403

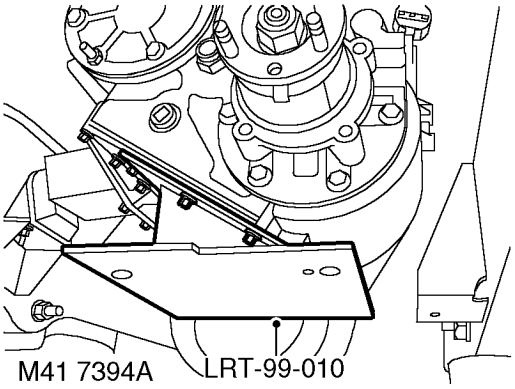
11. Remove 2 cable ties securing cable to fuel pipes.


M41 7406A

12. Disconnect 2 Lucars from oil temperature sensor and disconnect reverse lamp switch multiplug.

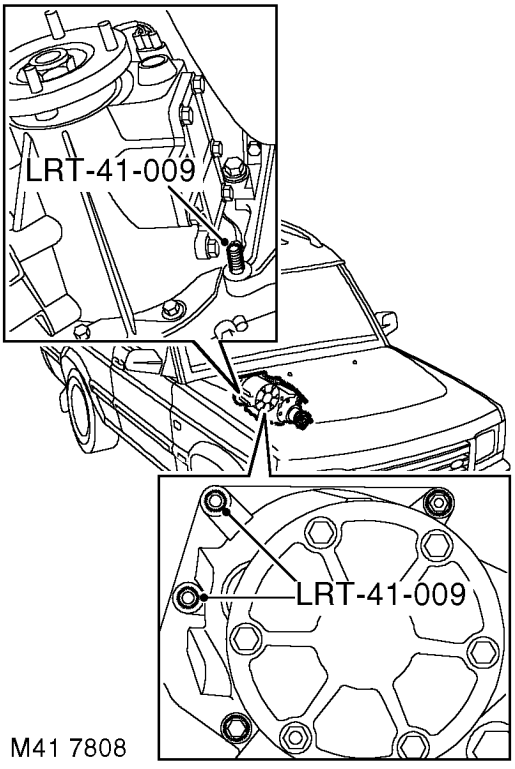

M41 7404A

13. Remove banjo bolt securing breather pipe and discard washers.
14. **If fitted -** Disconnect 2 Lucars from differential lock switch.
15. Release and disconnect transfer box neutral switch multiplug.



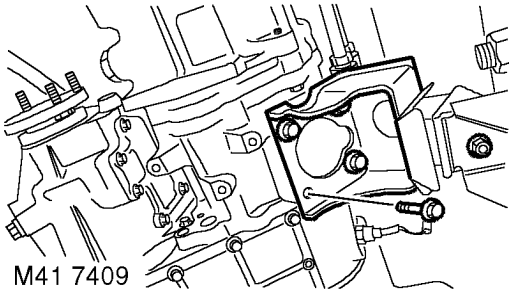
M41 7394A

16. Remove 4 bolts from transfer box bottom plate, position support plate **LRT-99-010** to transfer box and tighten bolts.
17. Position gearbox support jack and secure support plate to jack using 4 bolts.



M41 7808

18. Remove 3 bolts securing transfer box to gearbox.
19. Fit 3 guide studs **LRT-41-009** through transfer box bolt holes to support it during removal.
20. Remove 2 bolts and nut securing transfer box to gearbox case. **If securing stud is removed during this operation, it must be discarded and a new stud fitted.**
21. Position a jack to support gearbox and engine.



22. Remove 4 bolts and nut securing RH mounting to body and transfer box.
23. Remove nut securing LH mounting to body.
24. Raise gearbox and remove RH mounting.
25. With assistance, remove transfer box from gearbox.
26. Remove input shaft oil seal.
    ☞ **TRANSFER BOX - LT230SE, REPAIRS, Oil seal - input shaft.**

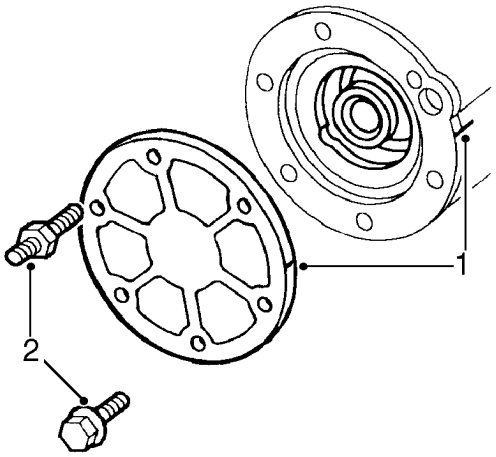
Refit

1. Fit new input shaft oil seal.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Oil seal - input shaft.**
2. Clean transfer box to gearbox mating faces.
3. Raise transfer box on jack and align to guide studs **LRT-41-009**.
4. Clean transfer box to gearbox bolt threads.
5. Apply Loctite 290 to bolt and stud threads.
6. Fit and lightly tighten 2 bolts and nut securing transfer box to gearbox. **If new stud is to be fitted apply Loctite 290 to threads of stud and tighten to 45 Nm (33 lbf.ft)**
7. Remove guide studs, fit and lightly tighten 3 bolts.
8. Tighten bolts and nut by diagonal selection to 45 Nm (33 lbf.ft.
9. Position gearbox RH mounting and tighten bolts to 85 Nm (63 lbf.ft).
10. Tighten gearbox RH mounting nut to 48 Nm (35 lbf.ft).
11. Fit nut to LH mounting and tighten to 48 Nm (35 lbf.ft).
12. Remove 4 bolts securing support plate to gearbox jack.
13. Remove 4 bolts securing support plate **LRT-99-010** to transfer box and remove plate.
14. Clean threads of bottom plate bolts.
15. Apply Loctite 290 to threads of bolts.
16. Fit 4 bolts securing bottom plate and tighten to 25 Nm (18 lbf.ft).
17. Using new washers position breather pipe and tighten banjo bolt.
18. Connect multiplug to transfer box neutral switch and secure harness.
19. **If fitted -** Connect Lucars to differential lock switch.
20. Connect multiplug and Lucars to reverse lamp switch and oil temperature sensor.
21. Position high/low ratio selector cable and secure with 'C' washer and clevis pin.
22. Secure cable to fuel pipes with new cable ties.
23. Clean handbrake back plate and mating face.
24. Position handbrake back plate, fit bolts and tighten to 75 Nm (55 lbf.ft).
25. Clean handbrake drum.
26. Fit handbrake drum and tighten retaining screw.
27. Fit front propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**
28. Fit rear propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**
29. Clean exhaust silencer and tail pipe mating faces.
30. Position silencer and secure on mountings, using a new gasket align to tail pipe, fit nuts and tighten to 25 Nm (18 lbf.ft).
31. Position rear cross member, fit bolts and tighten to 26 Nm (19 lbf.ft).
32. Refill transfer box with oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
33. Fit front exhaust pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**

Gasket - rear cover plate

41.20.30

Remove



M41 7476

1. Mark rear cover to bearing housing for assembly purposes.
2. Note fitted position of stud nut, remove stud nut and 5 bolts securing rear cover.
3. Carefully release rear cover from bearing housing.

Refit

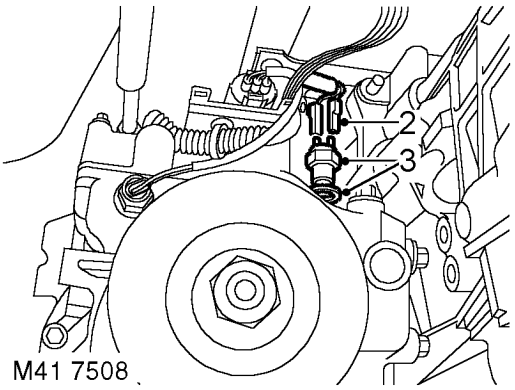
1. Clean rear cover, mating face on bearing housing and sealant from stud/bolt threads.
2. Apply sealant Part No. STC 3254 to rear cover mating face.
3. Align reference marks and position rear cover.
4. Apply Loctite 290 to stud/bolt threads, fit rear cover plate stud nut and bolts and tighten to 25 Nm (18 lbf.ft).
5. Top-up transfer box oil.
   MAINTENANCE, PROCEDURES, Transfer box.

Switch - differential lock - Up to 03 MY

41.20.34

Remove

1. Remove front propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.

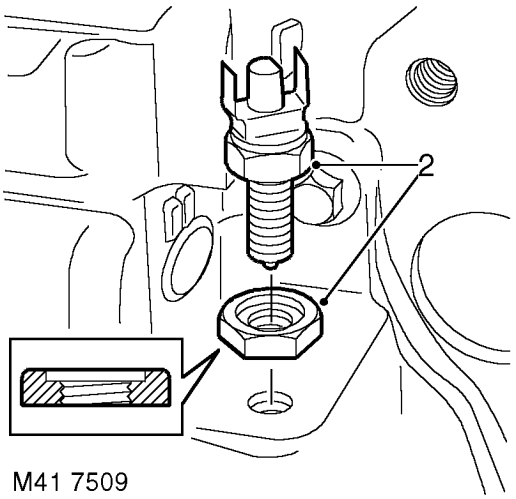


M41 7508

2. Disconnect 2 Lucars from switch.
3. Remove switch and remove nut from switch.

Refit

1. Clean switch and gearbox face.



M41 7509

2. Fit nut to switch with counterbore positioned towards switch head. **The nut acts as a spacer to ensure that switch setting is correct. Always ensure that nut is fully tightened to switch head, (no gap)**.
3. Apply Hylomar PL 32 sealant to switch thread.
4. Position switch into front output housing until nut bottoms out on housing.

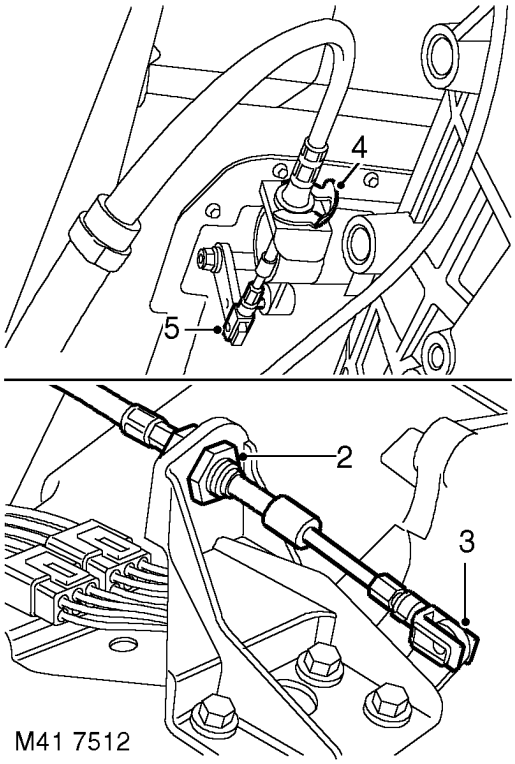
5. Tighten nut securing differential lock switch to 11 Nm (8 lbf.ft)
6. Connect Lucars to switch.
7. Fit front propeller shaft.
   ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**

Cable - high/low selector

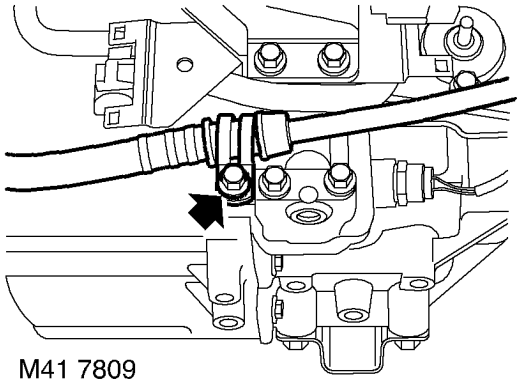
⊸ ***41.20.43***

Remove

1. Raise vehicle on a ramp.



2. Using a suitable crowsfoot spanner, remove lock nut and washer securing outer cable to abutment bracket.
3. Remove clevis pin securing inner cable to transfer box lever and release cable from abutment bracket.
4. Release 'C' clip securing outer cable to high/low lever abutment bracket.
5. Remove clevis pin securing inner cable to high/low lever.


M41 7809

6. Remove bolt securing outer cable clip to cross shaft housing, remove cable.

Refit

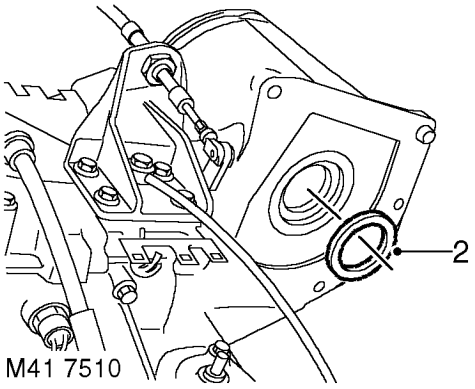
1. Clean change levers, abutment bracket and clevis pins.
2. Apply Mobilith SHC 100 grease to inner cable ends and clevis pins.
3. Position cable and secure to high/low lever abutment bracket with 'C' clip.
4. Secure inner cable to high/low lever with clevis pin.
5. Position outer cable clip to cross shaft housing, tighten bolt to 15 Nm (11 lbf.ft).
6. Adjust high/low selector cable.
   ☞ **TRANSFER BOX - LT230SE, ADJUSTMENTS, Cable - high/low selector.**

Oil seal - input shaft

41.20.50

Remove

1. Remove transfer box.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.**
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.**

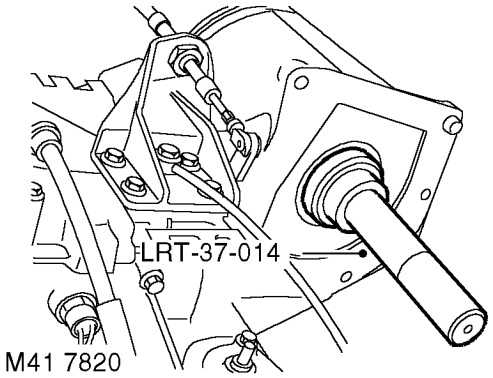


M41 7510

2. Lever input shaft oil seal from transfer box.

Refit

1. Clean oil seal recess in transfer gearbox.



M41 7820

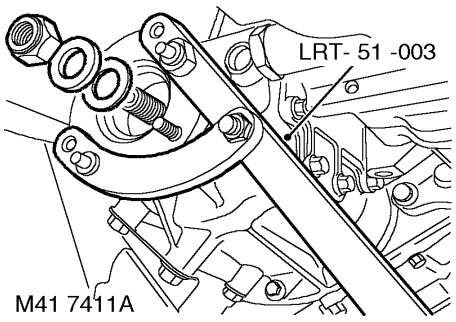
2. Lubricate new input shaft oil seal with gearbox oil.
3. Using tool **LRT-37-014** fit input shaft seal to transfer box.
4. Fit transfer box.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.**
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.**

Seal - front output shaft

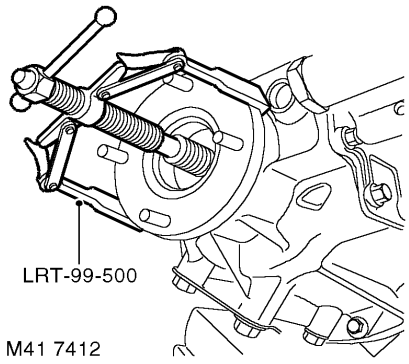
41.20.51

Remove

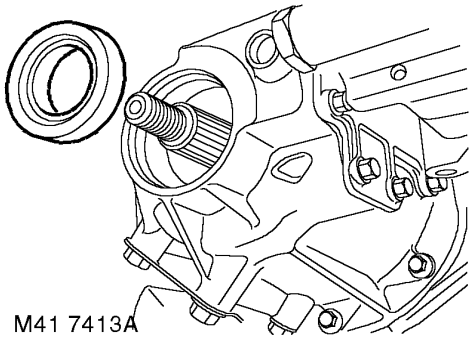
1. Position vehicle on 4 post ramp.
2. Remove front propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.



3. Restrain transfer box drive flange using tool **LRT-51-003**. Remove and discard drive flange nut, remove and discard steel and felt washers.



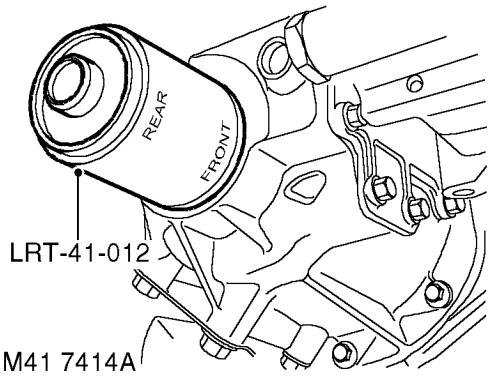
4. Using tool **LRT-99-500** if necessary, remove drive flange from transfer box.



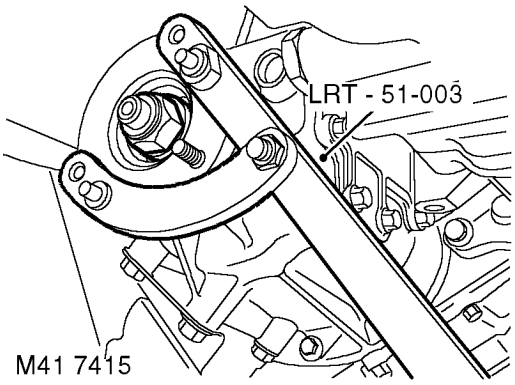
5. Remove seal from transfer box.

Refit

1. Clean seal mating faces.
2. Lubricate seal with gearbox oil.



3. Fit new seal using tool **LRT-41-012**.



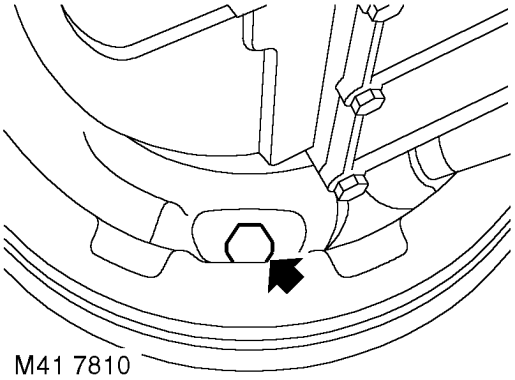
4. Position drive flange, fit new felt and steel washers.
5. Position tool **LRT-51-003** and tighten new drive flange nut to 148 Nm (109 lbf.ft).
6. Fit propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
7. Top-up transfer box oil.
   MAINTENANCE, PROCEDURES, Transfer box.

Seal - rear output shaft

41.20.54

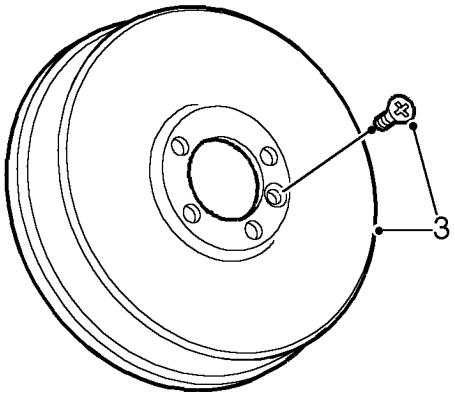
Remove

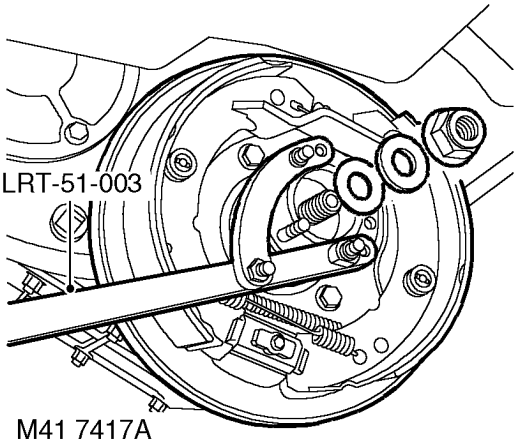
1. Remove rear propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.



M41 7810

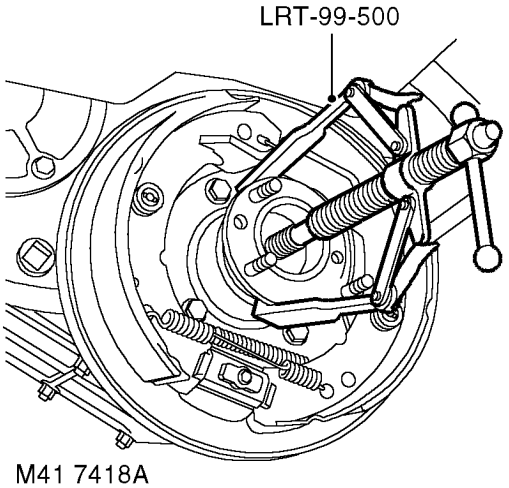
2. Loosen brake shoe adjuster bolt.





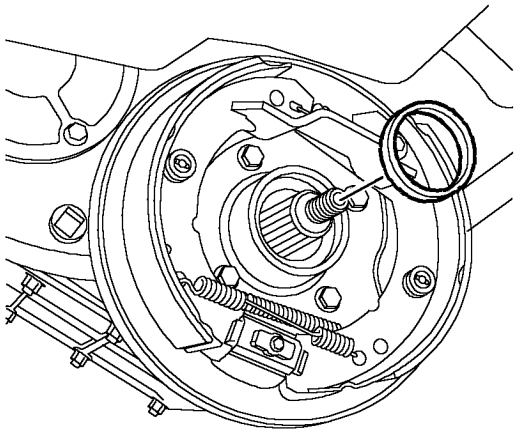
M41 7417A

3. Remove screw securing handbrake drum.
4. Remove handbrake drum.
5. Restrain transfer box drive flange using tool **LRT-51-003**. Remove and discard drive flange nut, remove and discard steel and felt washers.



M41 7418A

6. Using tool **LRT-99-500** if necessary, remove drive flange from transfer box.

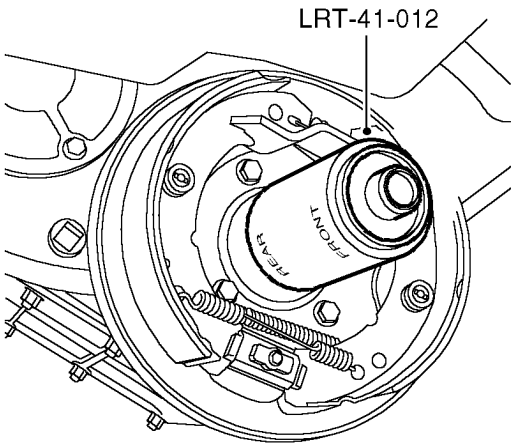


M41 7419

7. Remove seal from transfer box.

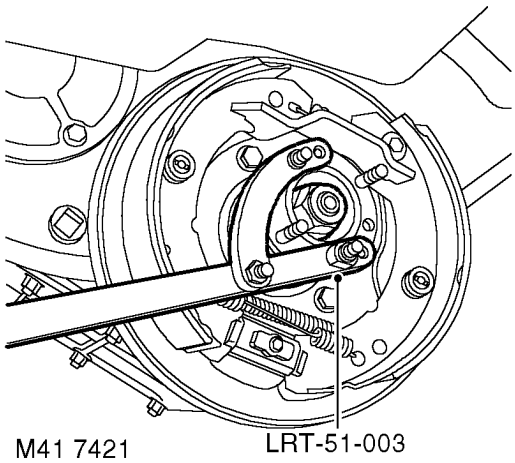
Refit

1. Clean seal mating faces.
2. Lubricate seal with gearbox oil.



M41 7420A

3. Fit new seal using tool **LRT-41-012**.
4. Position drive flange, fit new felt and steel washers.



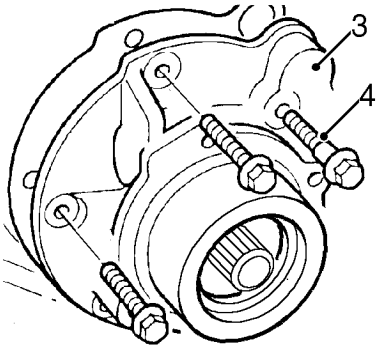
M41 7421

5. Position tool **LRT-51-003** and tighten new drive flange nut to 148 Nm (109 lbf.ft).
6. Position handbrake drum and tighten screw.
7. Tighten brake shoe adjuster bolt to 25 Nm (18 lbf.ft) then loosen one and a half turns.
8. Check that brake drum is free to rotate.
9. Fit propeller shaft.
   ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**
10. Top-up transfer box oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**

Gasket - rear output shaft housing

⊸ ***41.20.55***

Remove



M41 7485

1. Drain transfer gearbox oil.
   ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
2. Remove rear output shaft seal.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Seal - rear output shaft.**
3. Mark output shaft housing to main casing for assembly purposes.
4. Note position of shoulder bolt, remove 6 bolts securing housing to main casing.

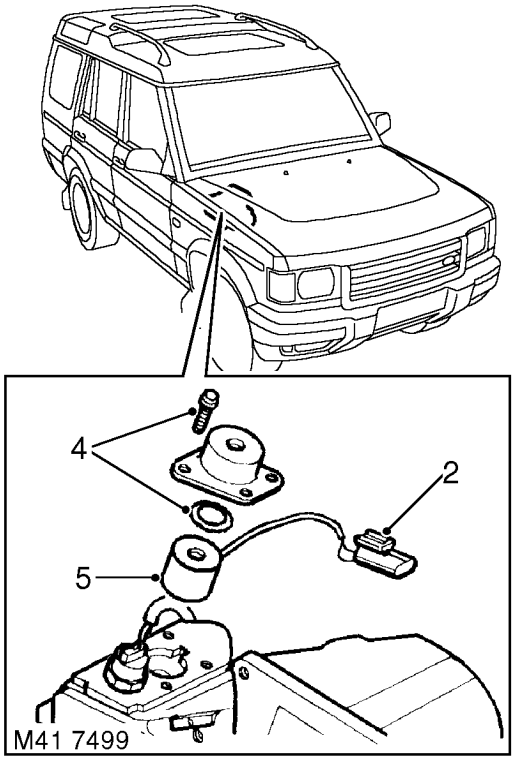
Refit

1. Clean output shaft housing, mating face on main casing and sealant from bolt threads.
2. Apply sealant, Part No. STC 3254 to mating flange on output shaft housing.
3. Fit output shaft housing to main casing.
4. Apply Loctite 290 to bolt threads.
5. Fit output shaft housing bolts and tighten by diagonal selection to 45 Nm (33 lbf.ft).
6. Fit rear output shaft seal.
   ☞ **TRANSFER BOX - LT230SE, REPAIRS, Seal - rear output shaft.**
7. Fill transfer gearbox with oil.
   ☞ **MAINTENANCE, PROCEDURES, Transfer box.**

Solenoid - interlock - Up to 03 MY

41.20.63

Remove



1. Raise vehicle on ramp.
2. Disconnect multiplug from interlock solenoid.
3. Release multiplug retainer from mounting plate on transfer box.
4. Remove 4 bolts securing solenoid cover, remove cover and Belleville washer.
5. Remove solenoid.

Refit

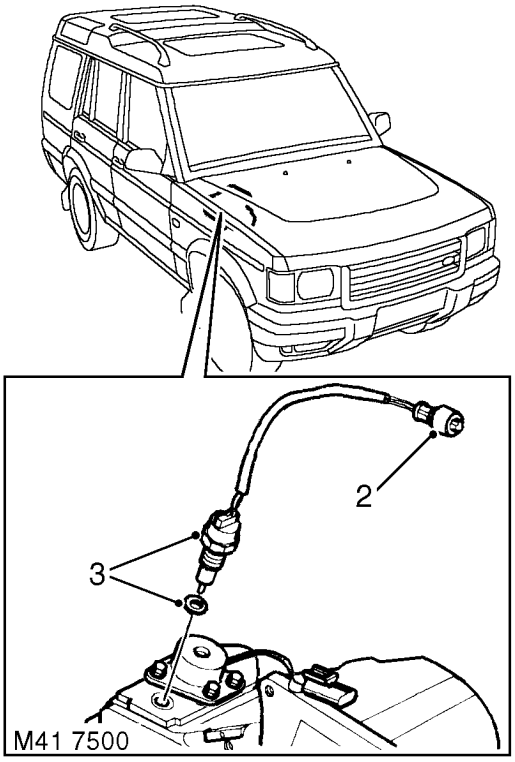
1. Clean solenoid cover and mating face.
2. Position solenoid in main casing.
3. Apply sealant, Part No. STC 3254 to solenoid cover.
4. Fit cover and Belleville washer.
5. Fit bolts securing interlock solenoid and tighten to 10 Nm (7 lbf.ft).
6. Connect and secure multiplug.
7. Lower vehicle on ramp.

Sensor - neutral

41.20.64

Remove

1. Raise vehicle on ramp.



2. Disconnect multiplug from neutral sensor.
3. Remove sensor and discard sealing washer.

Refit

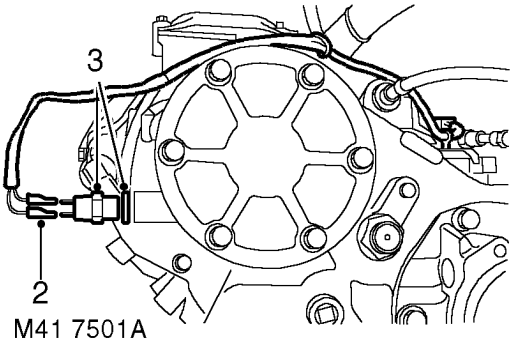
1. Clean sensor threads.
2. Fit new washer and apply Hylosil PL 32 to sensor threads.
3. Fit and tighten sensor to 25 Nm (18 lbf.ft).
4. Lower vehicle on ramp.

Sensor - oil temperature

41.20.80

Remove

1. Lower vehicle.



2. Disconnect 2 Lucar connectors from oil temperature sensor.
3. Remove oil temperature sensor and discard sealing washer.

Refit

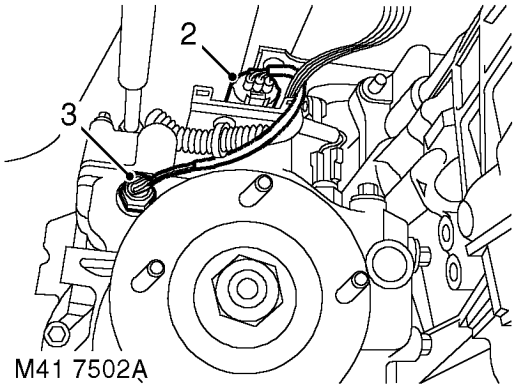
1. Clean sensor and mating face on transfer box.
2. Fit new sealing washer, position oil temperature sensor and tighten to 42 Nm (31 lbf.ft).
3. Connect Lucar connectors to oil temperature sensor.
4. Lower vehicle.

Switch - high low - warning

41.30.05

Remove

1. Raise vehicle on a ramp.



2. Release switch multiplug from bracket on transfer box and disconnect from harness.
3. Remove switch from transfer box and discard sealing washer.

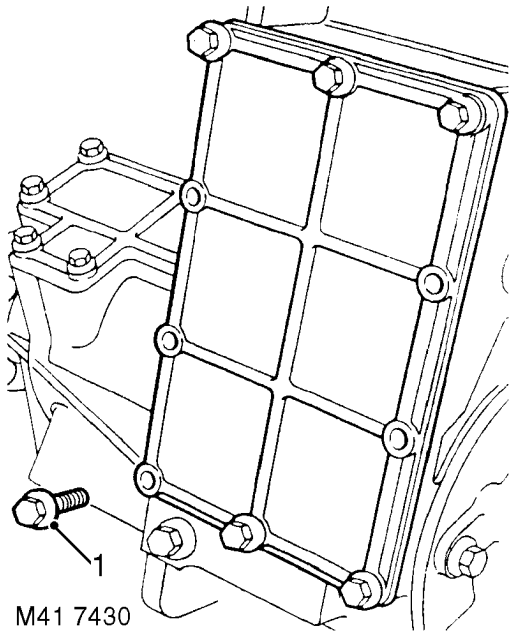
Refit

1. Ensure sealing washer, switch thread and mating face on transfer box is clean.
2. Fit sealing washer to switch, fit and tighten switch to transfer box to 26 Nm (19 lbf.ft) .
3. Connect multiplug to harness and fit multiplug to bracket on transfer box.
4. Lower vehicle.

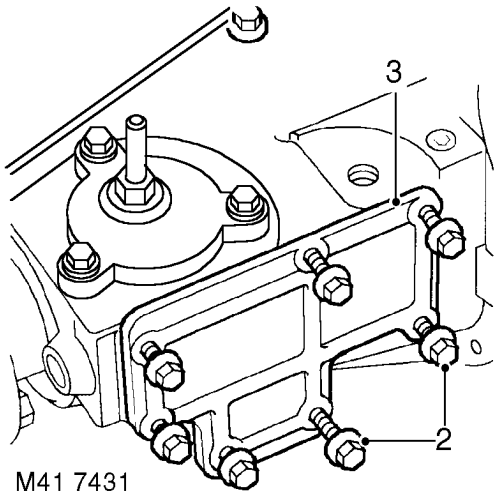
Intermediate gear assembly

41.20.10

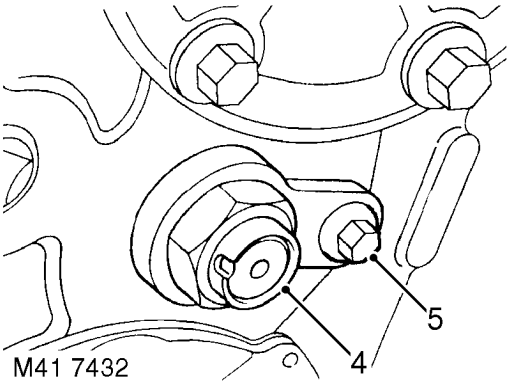
Disassembly



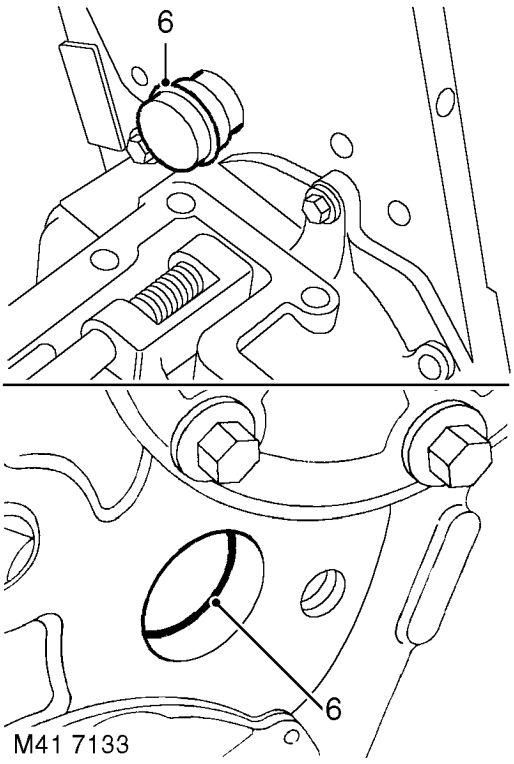
1. Remove and discard 10 bolts securing bottom cover, remove cover.



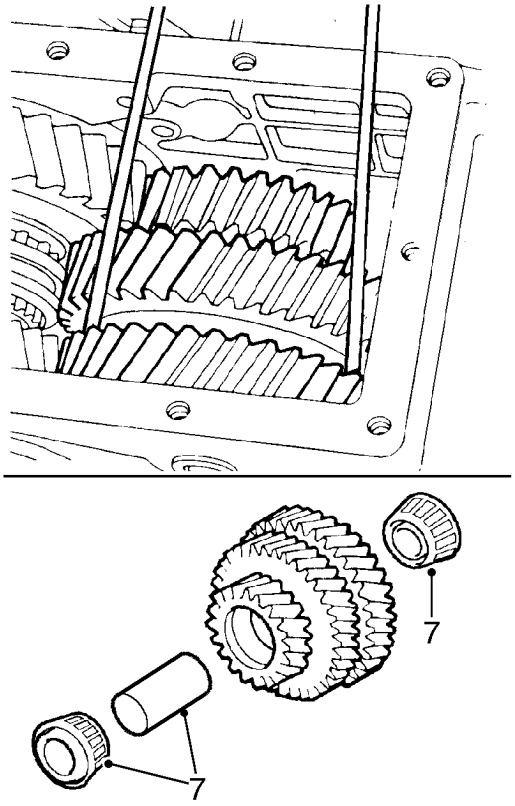
2. Remove and discard 7 bolts securing differential lock selector side cover.
3. Remove side cover.



4. Release staking from intermediate shaft nut, remove and discard nut.
5. Remove bolt securing intermediate shaft retaining plate, remove plate.

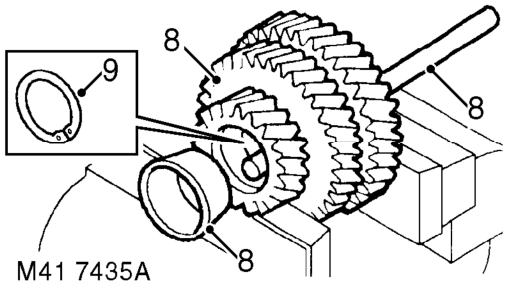


6. Remove intermediate shaft and discard 2 'O' rings.



M41 7434B

7. Remove intermediate gear assembly and collect bearings and selective spacer.



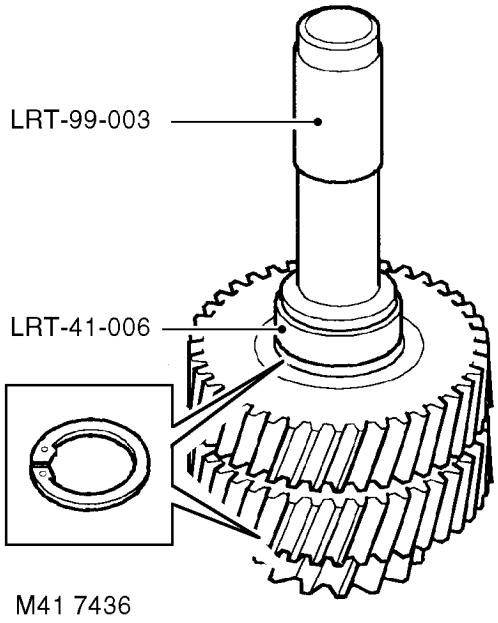
M41 7435A

8. Secure gear assembly in a soft jawed vice and using a suitable drift, remove and discard bearing tracks.
9. ***Up to 03 MY:*** Remove and discard circlips.

Reassembly

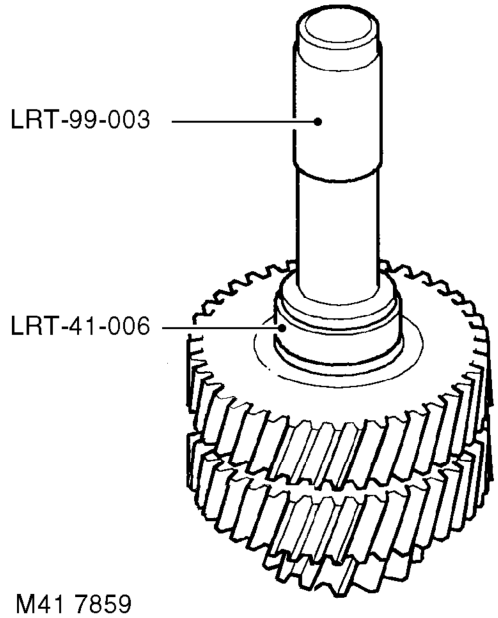
1. Clean gears, bearings, circlips and shaft.

   Note: Intermediate gear cluster and bearing assemblies fitted to 03 MY transfer boxes may be fitted as replacements to pre 03 MY transfer boxes.



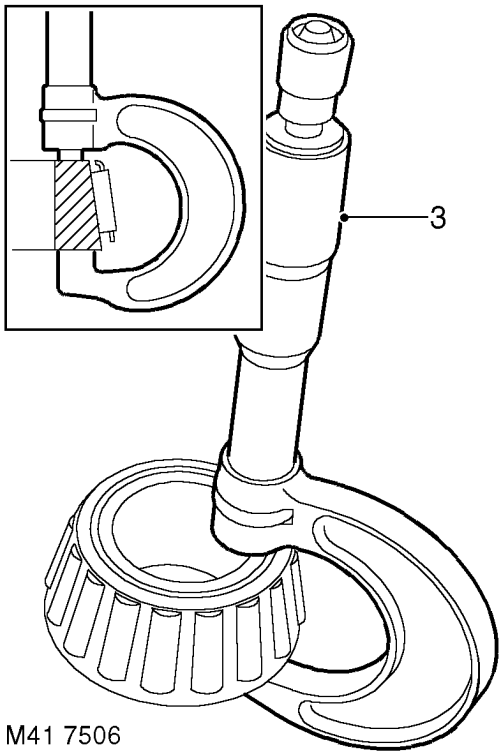
M41 7436

2. ***Up to 03 MY:*** Fit new circlips and using tools **LRT-99-003 and LRT-41-006** fit bearing tracks to intermediate gear, ensuring that the bearing tracks are fully seated against the circlips.



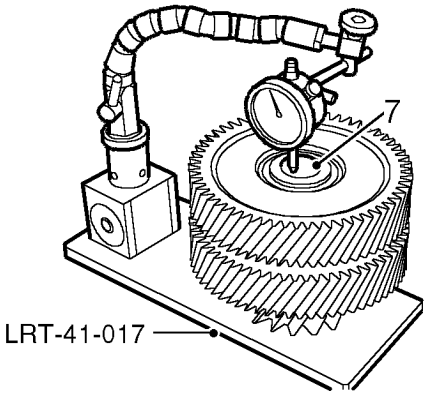
M41 7859

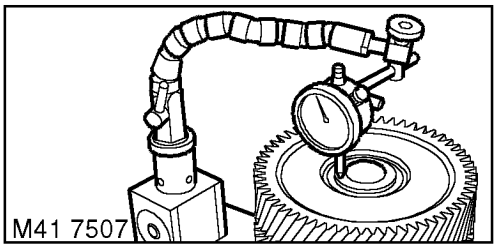
3. ***03 MY onwards:*** Using tools **LRT-99-003** and **LRT-41-006**, fit bearing tracks to intermediate gears ensuring that tracks are fully seated against shoulders in gears.



M41 7506

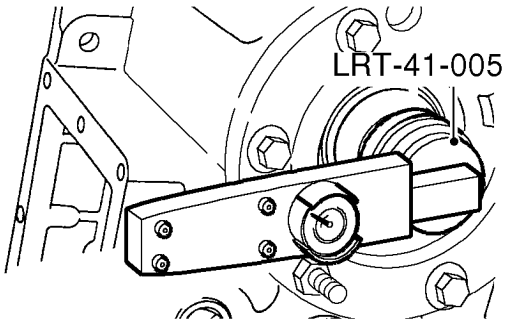
4. Using a micrometer, measure the width of each bearing inner track.
5. Record each reading as measurement 'A' and 'B', both measurements should fall within the range of 21.95 to 22.00 mm (0.864 to 0.866 in).
6. Fit inner bearing track 'A' onto tool **LRT-41-017** and position intermediate gear cluster onto bearing 'A'.
7. Fit inner bearing track 'B' to intermediate gear, apply finger pressure to bearing inner track and rotate intermediate gear 5 to 10 turns to settle in bearing rollers.





8. Attach a DTI to base of tool **LRT-41-017** , zero gauge on top of tool post and take 2 measurements at 180° of the step height between the top of the tool post and the bearing inner track. Take an average of the two readings and record this as measurement 'C'. Measurement 'C' should be in the range of 0.15 to 0.64 mm (0.006 to 0.025 in).
9. Using the formula 103.554 mm (4.0769 in) -'A'-'B'-'C', calculate the length of bearing spacer required. From the result of the calculation round DOWN to the nearest length of spacer available to give a correct bearing pre-load of 0.005 mm (0.002 in). **40 spacers are available ranging in length from 58.325 mm (2.296 in) to 59.300 mm (2.335 in) rising in increments of 0.025 mm (0.001 in).**
10. Remove intermediate gear assembly from tool **LRT-41-017.**
11. Lubricate and fit bearings and selected spacer to intermediate gear.
12. Position tool **LRT-41-004** through bearings and spacer.
13. Lubricate and fit 'O' rings to main casing and intermediate shaft.
14. With assistance, position intermediate gear assembly and fit intermediate shaft.
15. Rotate shaft until retaining plate can be located on flat on shaft.
16. Apply Loctite 290 to threads of retaining plate bolt, tighten bolt to 25 Nm (18 lbf.ft).
17. Fit new intermediate shaft Patchlok nut and tighten to 88 Nm (65 lbf.ft).**Do not stake nut at this stage.**

18. Select neutral.
19. Screw a suitable bolt into tapped hole of tool **LRT-41-005**.



M41 7811

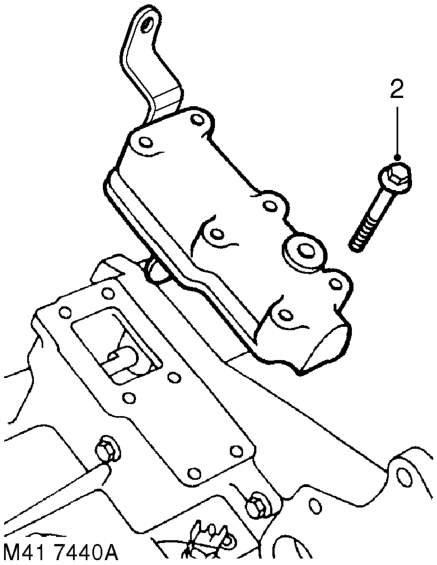
20. Insert tool **LRT-41-005** in end of mainshaft.
21. Using a suitable torque meter on tool **LRT-41-005**, check torque to turn of gear train. Torque to turn = 2.2 Nm (19 lbf.ft). **If torque to turn figure is incorrect, repeat intermediate gear bearing pre-load setting and re-check.**
22. On completion, remove tool **LRT-41-005** and stake flange of nut into recess on intermediate shaft.
23. Clean transfer box bottom and side covers.
24. Apply sealant, Part No. STC 3254 to both covers.
25. Clean bottom and side cover bolt threads.
26. Apply Loctite 290 to bolt threads.
27. Position side cover and tighten bolts to 25 Nm (18 lbf.ft).
28. Position bottom cover and tighten bolts to 25 Nm (18 lbf.ft).

Differential assembly

41.20.13

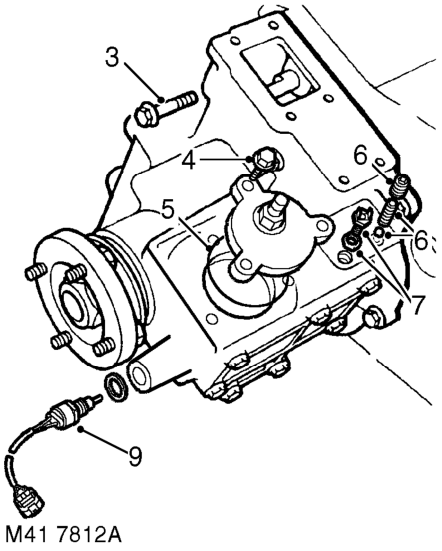
Remove

1. Remove intermediate gear cluster.
   TRANSFER BOX - LT230SE, OVERHAUL, Intermediate gear assembly.



M41 7440A

2. Remove 6 bolts securing high/low cross shaft housing to front output shaft housing and remove housing.



M41 7812A

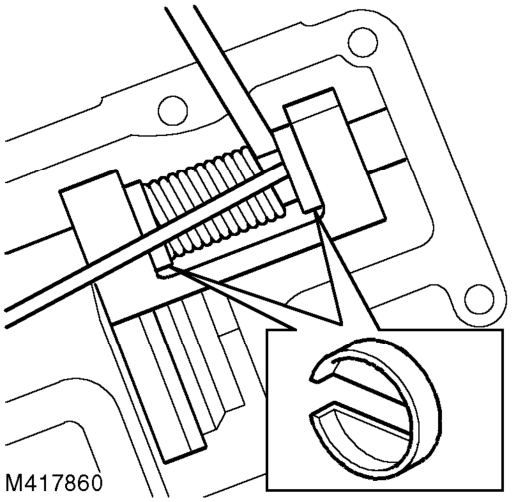
3. Note position of longest bolt and remove 8 bolts securing front output shaft housing to main casing and remove housing.

Note: Carry out the following operations if differential lock is fitted.

4. Remove 3 bolts securing differential lock selector housing and remove housing.
5. Remove and discard 'O' ring from selector housing.
6. Remove Allen plug and remove detent spring and ball.
7. Remove differential lock warning lamp switch and locknut.

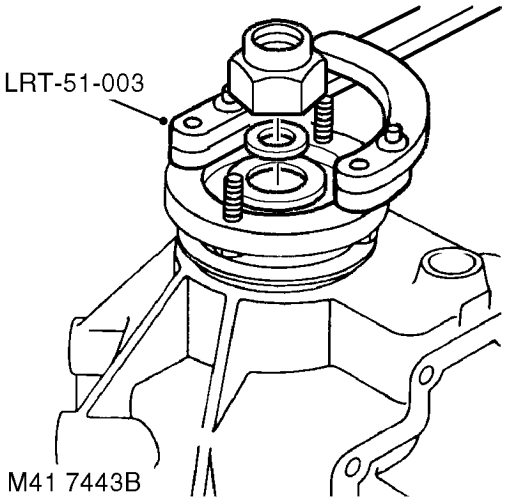
   Note: Locknut is only fitted to switches up to 03 MY, a modified switch and sealing washer is fitted from 03 MY onwards.

8. ***03 MY onwards:*** Remove differential lock warning lamp switch from end of front output shaft housing, discard sealing washer.

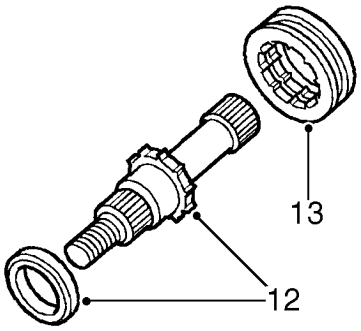


9. Compress differential lock selector fork spring and remove retaining clips from each end of spring.
10. Withdraw differential lock selector shaft from front output housing, recover spring and remove selector fork.

    Note: Carry out the following operations for all transfer boxes.

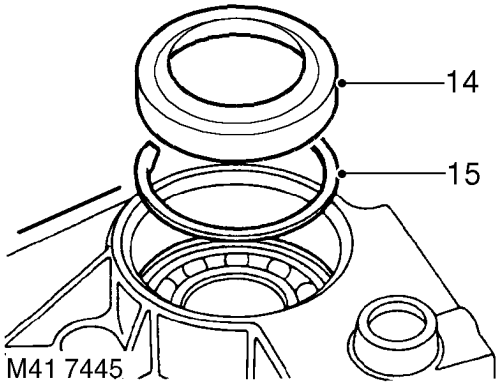


11. Position tool **LRT-51-003** to output shaft drive flange, remove and discard nut, steel and felt washers; remove output shaft drive flange.

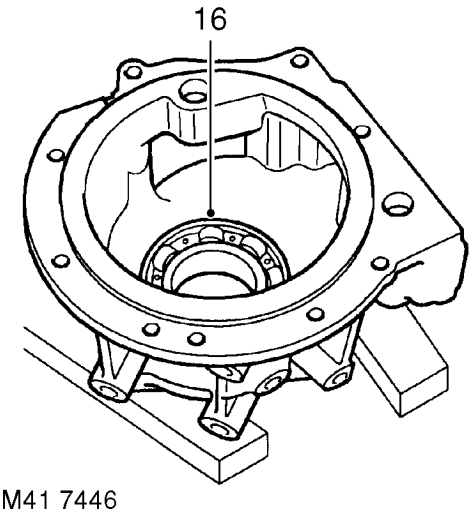


M41 7814

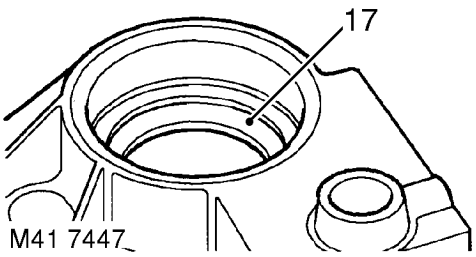
12. Using a copper mallet, drive output shaft from housing, recover bearing spacer.
13. **If fitted:** Noting its fitted position, remove dog clutch from output shaft.



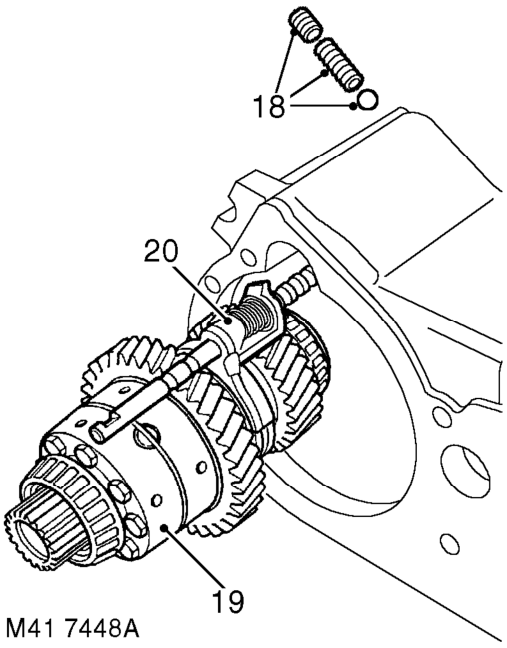
14. Remove and discard oil seal from housing.
15. Remove and discard circlip retaining output shaft bearing.



16. Support housing and drift out output shaft bearing.

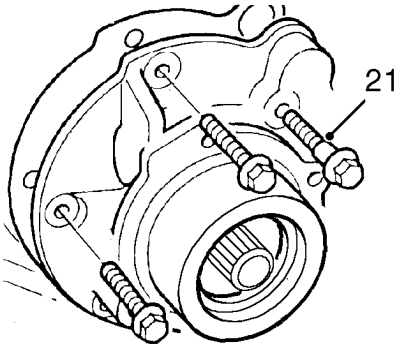


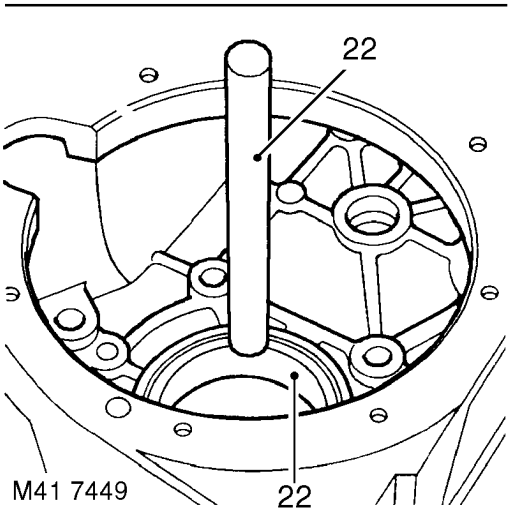
17. Remove and discard differential bearing track and collect selective shim.



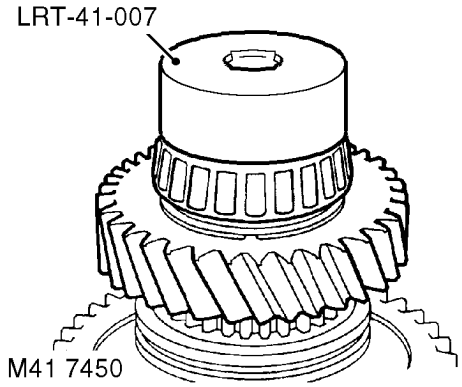
18. Remove Allen plug securing high/low selector shaft detent spring and ball, remove spring and ball.
19. Withdraw differential assembly together with high/low selector shaft and fork.
20. Remove selector fork and shaft from differential.

Note: Selector fork fitted to 03 MY onwards illustrated.

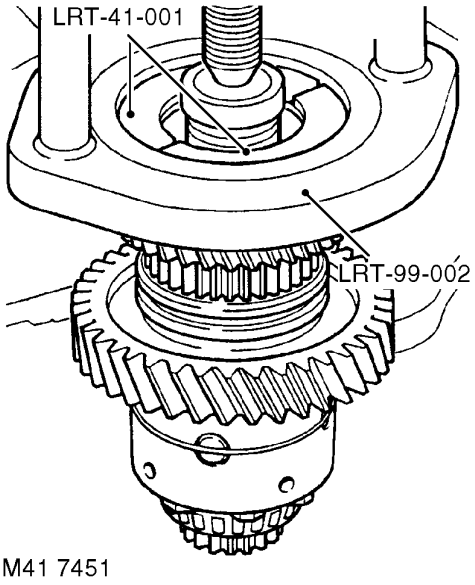




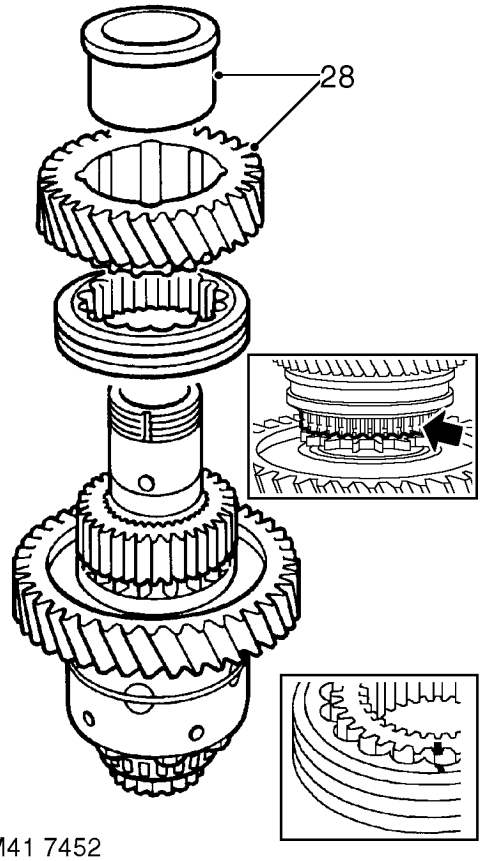
21. Note position of shoulder bolt, remove 6 bolts and remove rear output shaft housing.
22. Remove rear bearing track from main casing.



23. Secure differential in a soft jawed vice.
24. Release staking from bearing retaining nut.
25. Using tool **LRT-41-007** remove and discard bearing retaining nut.

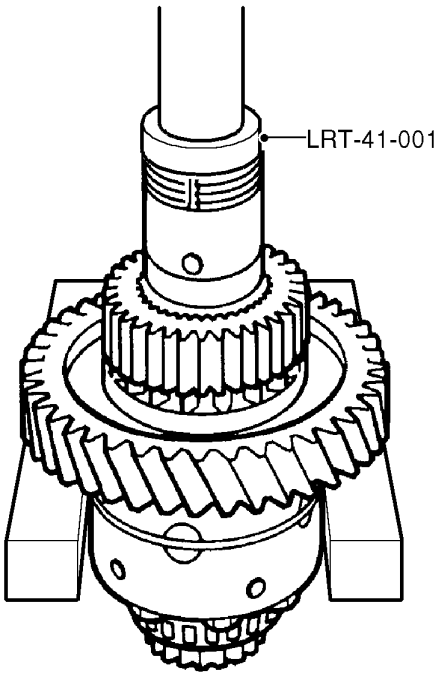


26. Position tool **LRT-99-002** to vice.
27. Position tool **LRT-41-001** around rear differential bearing, position differential to tool **LRT-99-002** and press off bearing.



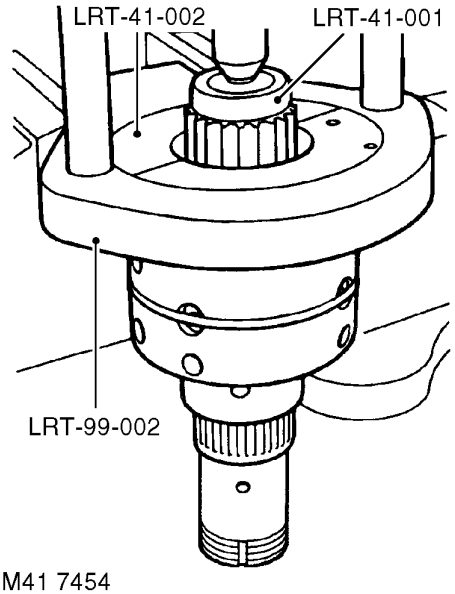
28. Remove high range gear and bush.

29. Make suitable alignment marks between high/low selector sleeve and hub, remove selector sleeve.



M41 7453

30. Using a suitable press and thrust button **LRT-41-001** remove high/low hub and low range gear.

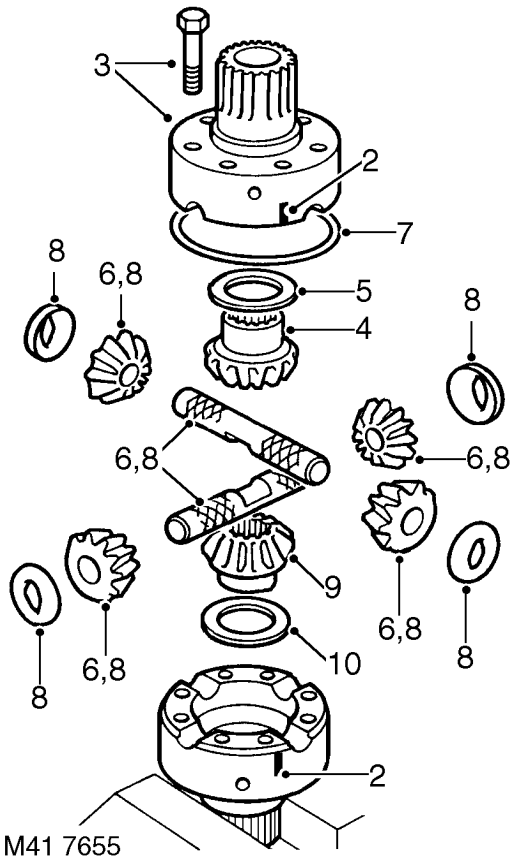


M41 7454

31. Position tool **LRT-41-002** around front differential bearing and tool **LRT-41-001** thrust button to differential shaft and press off bearing.

Disassembly

1. Secure rear half of differential carrier in a soft jawed vice.

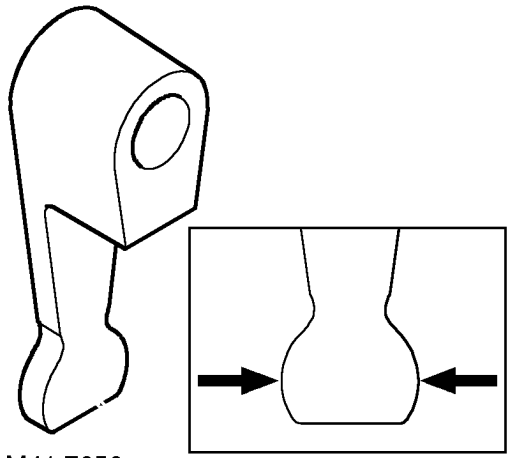


M41 7655

2. Make suitable alignment marks between front and rear halves of differential carrier.
3. Remove 8 bolts securing front half of carrier to rear and separate both halves of carrier.
4. Suitably identify front sun gear to front half of carrier, then remove sun gear.
5. Remove and discard thrust washer.
6. Suitably identify each planet gear to its shaft and fitted position of each cross shaft to rear half of carrier
7. Remove retaining ring.
8. Remove planet gears and cross shafts, remove and discard dished thrust washers.
9. Suitably identify rear sun gear to rear half of carrier, then remove sun gear.
10. Remove and discard thrust washer.

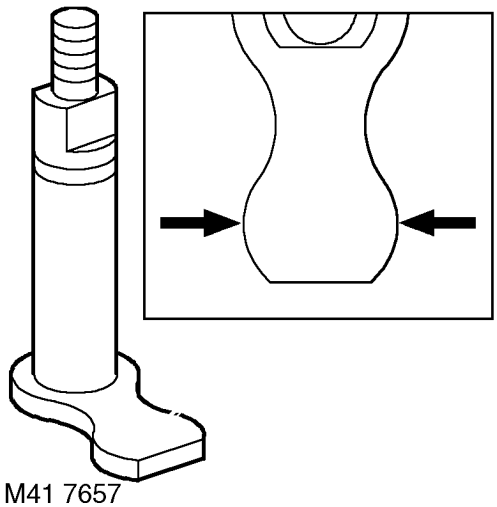
Inspect

1. Check mating surfaces of cross shaft and housing bore for wear.
2. Check core plug in housing for signs of leakage or corrosion ; apply Loctite 326 to replacement plug.



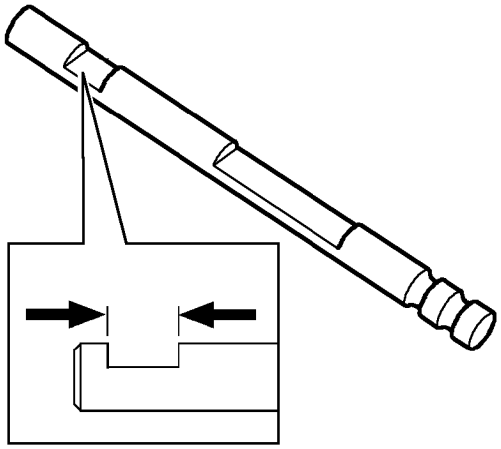
M41 7656

3. Measuring across widest portion of finger, check high/low selector finger for wear.
   - Finger width = 15.90 to 15.95 mm (0.625 to 0.627 in).
4. Check bearing track recesses in housing for damage, rectify or replace housing as necessary.
5. **If fitted:** Carry out inspection of differential lock components using following procedures.
6. Check differential lock selector shaft and housing bore for wear.



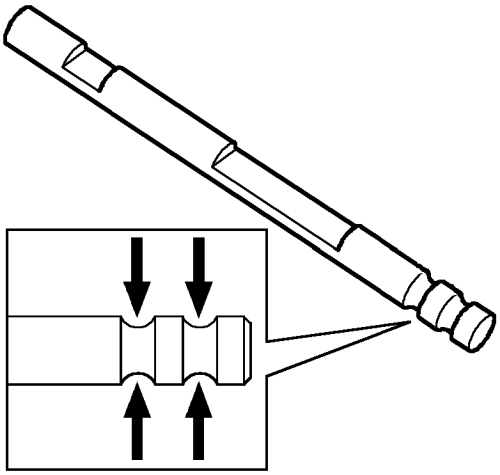
M41 7657

7. Measuring across the widest portion, check differential lock finger for wear.
   - Finger width = 15.90 to 15.95 mm (0.625 to 0.627 in).



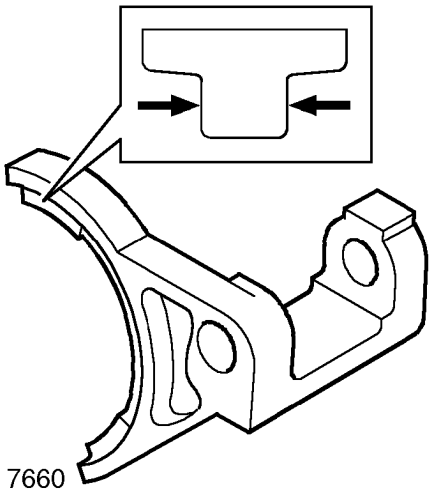
M41 7658

8. Check differential lock selector finger groove in selector shaft.
   - Groove width = 16.0 to 16.1 mm (0.63 to 0.64 in).



M41 7659

9. Check detent grooves in differential lock selector shaft for wear.
10. Check differential lock detent ball for flat spots and check detent spring for distortion.



M41 7660

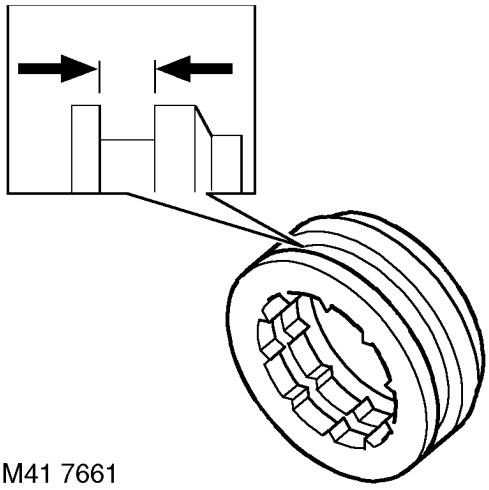
11. Check differential lock selector fork for cracks and wear.

12. Check selector fork finger width.

- Finger width = 7.92 to 7.97 mm (0.311 to 0.313 in).

13. Check differential lock selector fork clips for wear and damage. Check spring for distortion and free length.

- Spring free length = 84.58 mm (3.33 in).



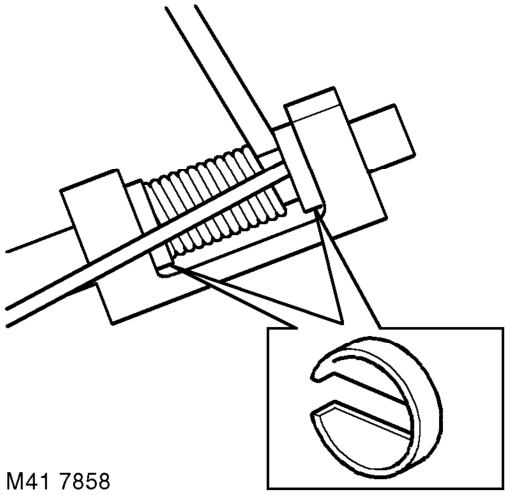
M41 7661

14. Check dog clutch internal teeth and grooves and teeth on output shaft for wear and damage. Check selector fork groove width.

- Groove width = 8.05 to 8.20 mm (0.32 to 0.33 in).

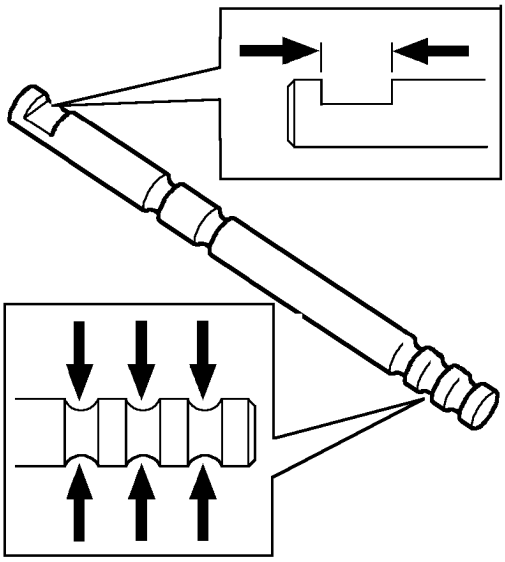
15. Carry out the following inspection procedures for all transfer boxes.

16. Check threads and splines of output shaft for damage and wear. Check dog clutch teeth on shaft for wear and damage.



M41 7858

17. ***03 MY onwards:*** Compress high/low selector fork spring and remove retaining clips from each end of spring, remove high/low selector shaft.

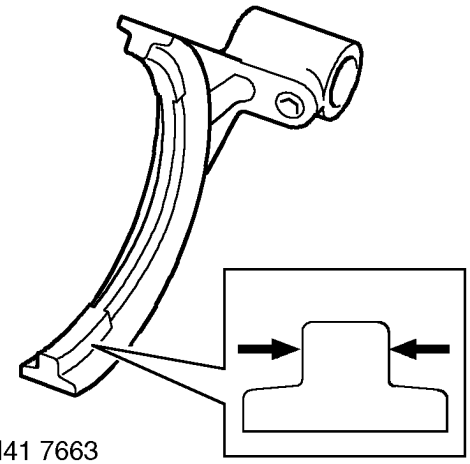


M41 7662

18. Check detent grooves in high/low selector shaft for wear. **Do not remove fork from shaft unless either component is being renewed. If fork is removed from shaft, coat the threads of the set screw with Loctite 290 prior to assembling.**

Note: High/low selector shaft fitted to pre 03 MY illustrated.

19. Check width of high/low selector groove.
- Groove width = 16.0 to 16.1 mm (0.63 to 0.64 in).



M41 7663

20. Check high/low selector fork for cracks and wear. Check selector fork finger width.
- Finger width = 7.37 to 7.47 mm (0.290 to 0.294 in).

21. ***03 MY onwards:*** Check high/low selector fork clips for wear and damage. Check spring for distortion, check free length of spring:
- Spring free length = 75 mm (2.95 in)

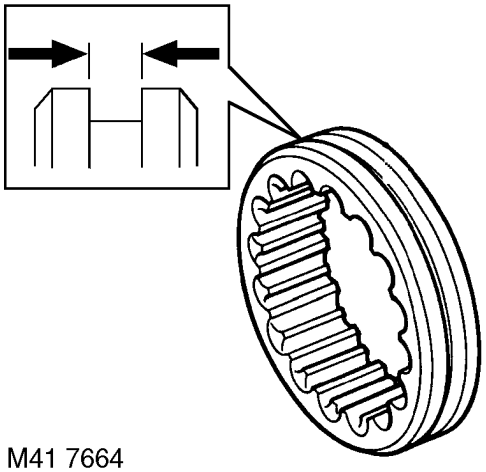
Note: High/low selector shaft, fork and spring fitted to 03 MY transfer boxes may be fitted to pre 03 MY boxes as an assembly.

22. Check differential sun and planet gears for wear, cracks and chipping of teeth.

23. Check cross shafts and recesses in both halves of differential carrier for damage and wear.**Ensure planet gears are retained with their respective shafts.**

24. Check retaining ring for distortion.

25. Check differential splines for wear and damage.



M41 7664

26. Check high/low hub for cracks, chipping and uneven wear. Check width of selector fork groove.
- Groove width = 7.5 to 7.6 mm (0.295 to 0.30 in).

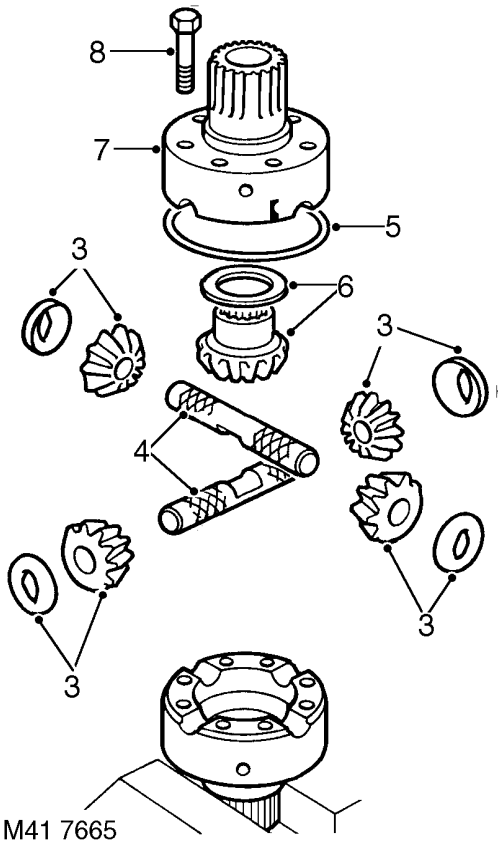
27. Check splines and teeth on high/low selector sleeve for uneven wear, cracks, damage and chipping.

28. Check teeth of high and low range gears for cracks, chipping and uneven wear.

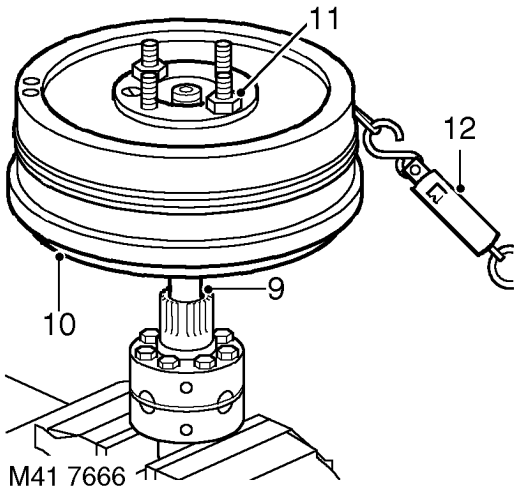
29. Check high range gear bush for wear and damage.

Reassembly

1. Lubricate all components with recommended oil and lightly oil the differential bolt threads.

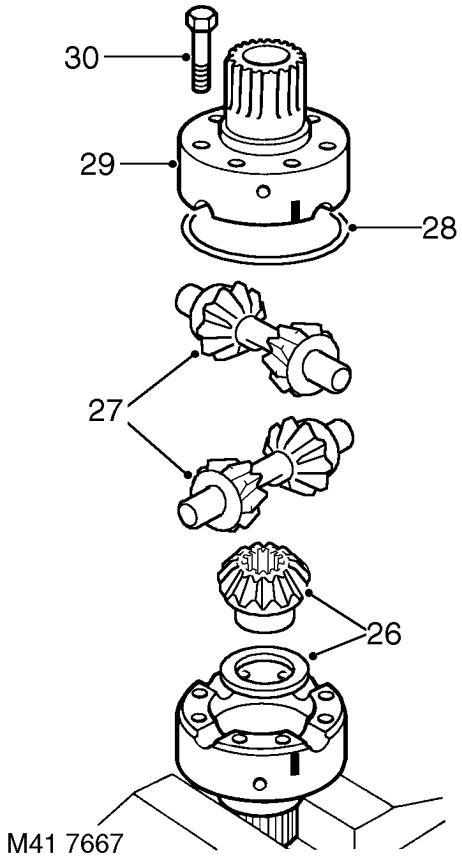


2. Secure rear half of differential carrier in a soft jawed vice.
3. Fit each planet gear to its respective cross shaft, fit new dished thrust washer to each gear.
4. Fit cross shafts, planet gears and dished thrust washers in rear half of carrier.**Ensure that cross shafts are fitted correctly. Do not fit the sun gear into the rear half carrier at this stage.**
5. Fit retaining ring.
6. Fit a 1.05 mm (0.04 in) thrust washer to sun gear from front half of carrier. Position gear in front half of carrier.
7. Ensuring that assembly marks are aligned, fit both halves of carrier together.
8. Fit the differential carrier bolts and, working in a diagonal sequence, tighten the bolts to 60 Nm, (44 lbf.ft).



9. Insert the front output shaft into the front half of the carrier and check that the gears rotate freely.
10. Fit output flange on to the splines of the output shaft, but do not fit flange nut at this stage.
11. Fit transmission brake drum to output flange and secure the drum using 2 nuts.
12. Secure a length of cord around the drum and attach one end of the cord to a spring balance.
13. Pull on the spring balance and note the load at which the brake drum starts to turn. **Used gears should rotate smoothly, while new gears will have a 'notchy' feel as they rotate.**
14. Compare the figure obtained with the following.
    - Used gears = 0.45 kg (1.0 lb)
    - New gears = 1.72 kg (3.8 lb)
15. If the load to turn figure is below the specified limits, proceed as follows.
16. Remove the front output shaft and brake drum.
17. Remove the 8 bolts securing the two halves of the differential carrier
18. Separate the differential carrier and remove the sun gear and thrust washer from the front half.
19. Select a thicker thrust washer from the range available. 5 different thrust washers are available, rising in increments of 0.10 mm (0.004 in) from 1.05 mm to 1.45 mm (0.04 to 0.06 in).
20. Repeat steps 7 to 19 as necessary until the load to turn figure is as specified
21. When specified load to turn is obtained, proceed as follows.
22. Remove the front output shaft and brake drum.
23. Remove the 8 bolts securing the two halves of the differential carrier
24. Separate the differential carrier and remove the sun gear and thrust washer from the front half.**Retain the selected thrust washer with its sun gear.**

25. Remove retaining ring, then remove the planet gears and cross shafts.



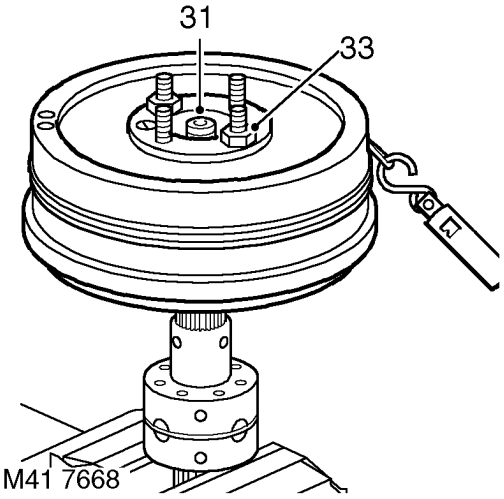
26. Fit a 1.05 mm (0.04 in) thrust washer to sun gear from rear half of carrier. Position gear in rear half of carrier.

27. Fit planet gears, cross shafts and dished thrust washers to rear half of carrier. **Ensure that cross shafts are fitted correctly. Do not fit the sun gear into the rear half carrier at this stage.**

28. Fit retaining ring.

29. Ensuring that assembly marks are aligned, fit both halves of carrier together.

30. Fit the differential carrier bolts and, working in a diagonal sequence, tighten the bolts to 60 Nm, (44 lbf.ft).



31. Invert the assembly in the vice, insert the rear output shaft into the rear half of the carrier and check that the gears rotate freely.

32. Fit output flange on to the splines of the output shaft, but do not fit flange nut at this stage.

33. Fit transmission brake drum to output flange and secure the drum using 2 nuts.

34. Carry out the load to turn check, using the same method as for the front half carrier. Record the shim thickness when the load to turn is correct.

35. Fit the sun gear and selected thickness shim to the front half carrier.

36. Ensuring that assembly marks are aligned, fit both halves of carrier together.

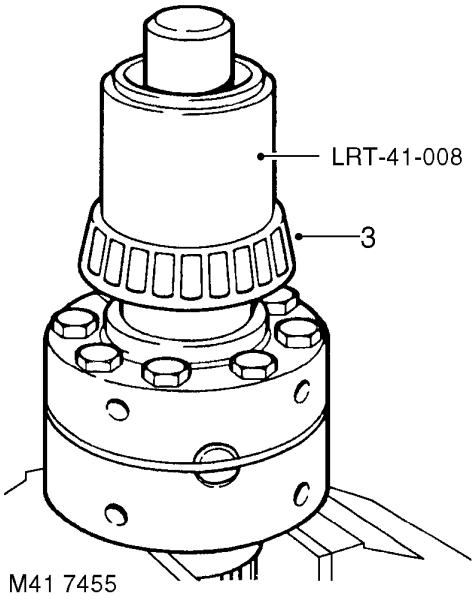
37. Fit the differential carrier bolts and, working in a diagonal sequence, tighten the bolts to 60 Nm, (44 lbf.ft).

38. With differential assembled, fit rear output shaft and brake drum, then check overall load to turn. This should be approximately the same as the combined load to turn figure of both front and rear half carriers.

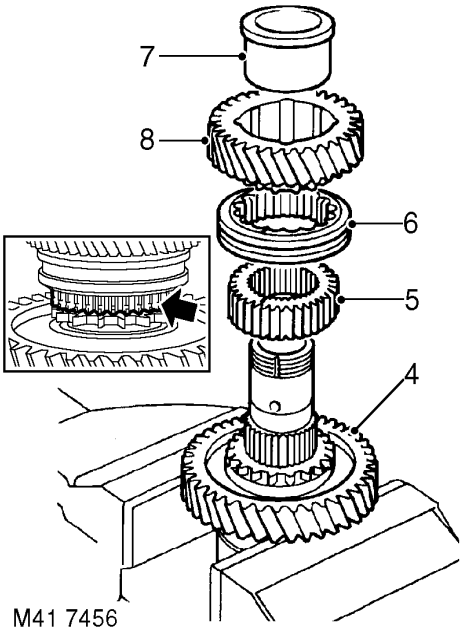
- Used gears = 0.90 kg (2.0 lb)
- New gears = 3.44 kg (7.6 lb)

Refit

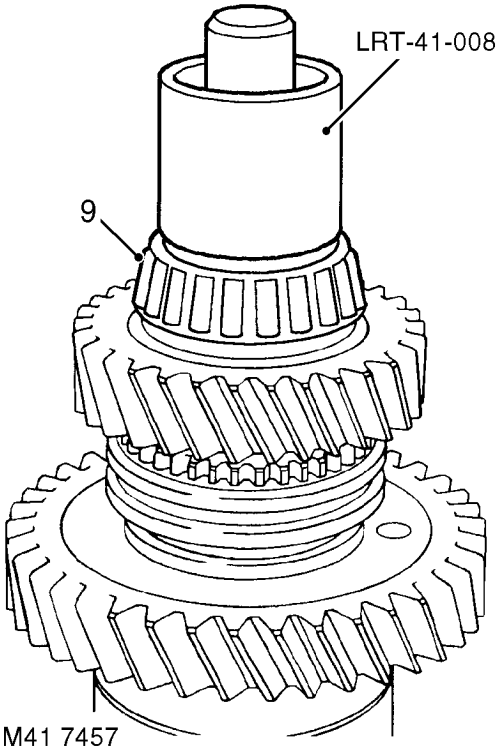
1. Clean differential components.
2. Lubricate components with gearbox oil.



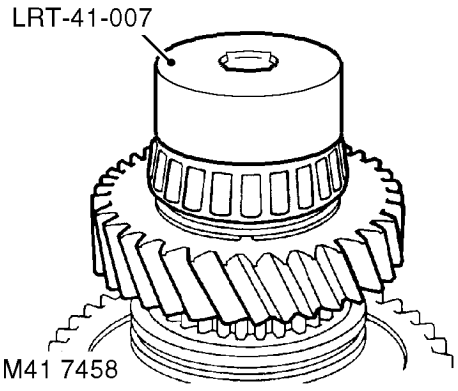
3. Position differential in soft jawed vice and fit front bearing using tool **LRT-41-008.**



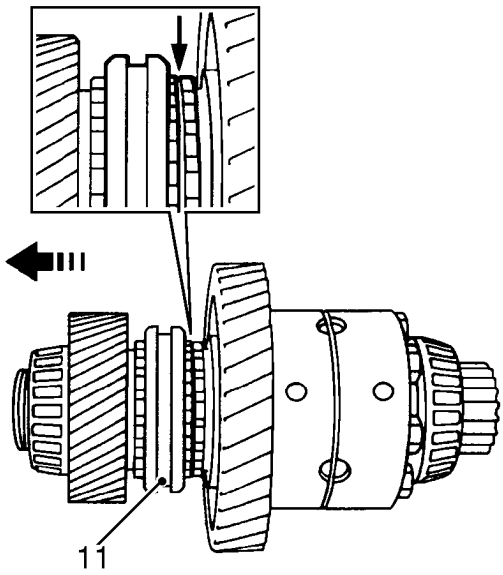
4. Invert differential in soft jawed vice, and fit low range gear with dog teeth facing uppermost.
5. Fit high/low hub ensuring that machined groove on hub teeth faces towards low range gear.
6. Fit high/low selector sleeve ensuring that alignment marks on hub and sleeve are together.
7. Fit bush to high range gear ensuring collar is uppermost.
8. Fit high range gear and bush onto shaft.



9. Fit new rear bearing using tool **LRT-41-008.**



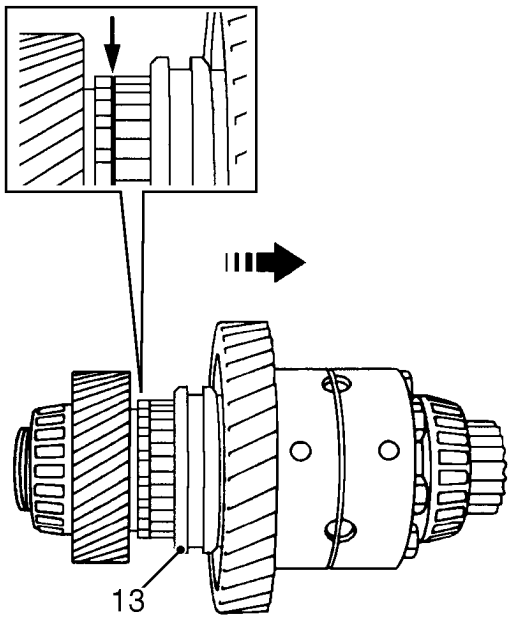
10. Using tool **LRT-41-007,** fit new bearing retaining nut and tighten to 72 Nm (53 lbf.ft). **Do not stake nut at this stage.**



M41 7459

11. Using feeler gauges, determine clearance between low range gear and high/low hub:
- Clearance = 0.05 to 0.15 mm (0.002 to 0.006 in).

12. If clearance is not as specified, fit a new low range gear and high/low hub and re-check.

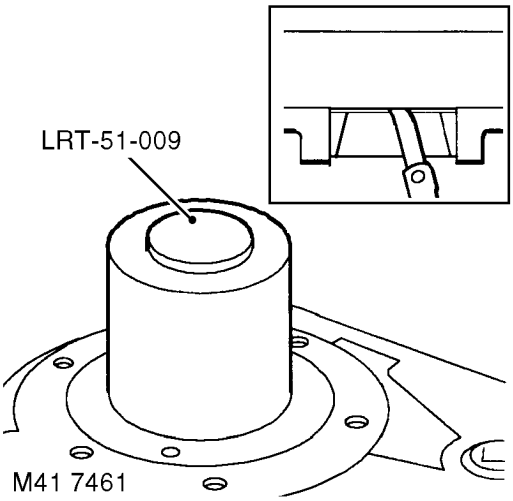


M41 7813

13. Using feeler gauges, determine clearance between high range gear and high/low hub:
- Clearance = 0.05 to 0.15 mm (0.002 to 0.006 in).

14. If clearance is not as specified, fit new high range gear and high/low hub and re-check.

15. Using a suitable drift, stake collar of nut into differential shaft recess.



16. Using **LRT-51-009**, fit new rear bearing track into main casing.

17. Using a straight edge and feeler gauges, check that bearing track is recessed 1 mm (0.04 in) below outer face of main casing.

18. Apply sealant, Part No. STC 3254 to rear output shaft housing face.

19. Position housing to main casing.

20. Apply Loctite 290 to bolt threads fit housing to main case bolts and tighten by diagonal selection to 45 Nm (33 lbf.ft).

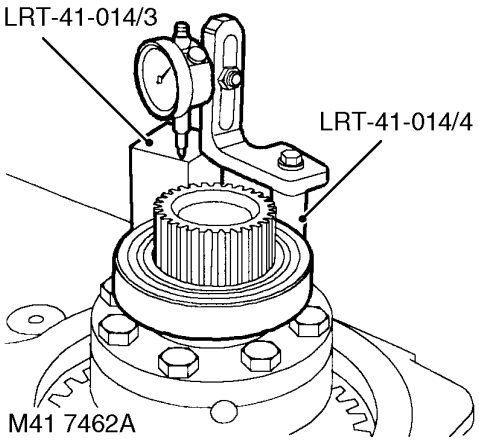
21. ***03 MY only:*** Fit high/low selector fork and spring to high/low selector shaft, fit retaining clips.

CAUTION: Ensure ends of spring are fully seated in recess in clips.

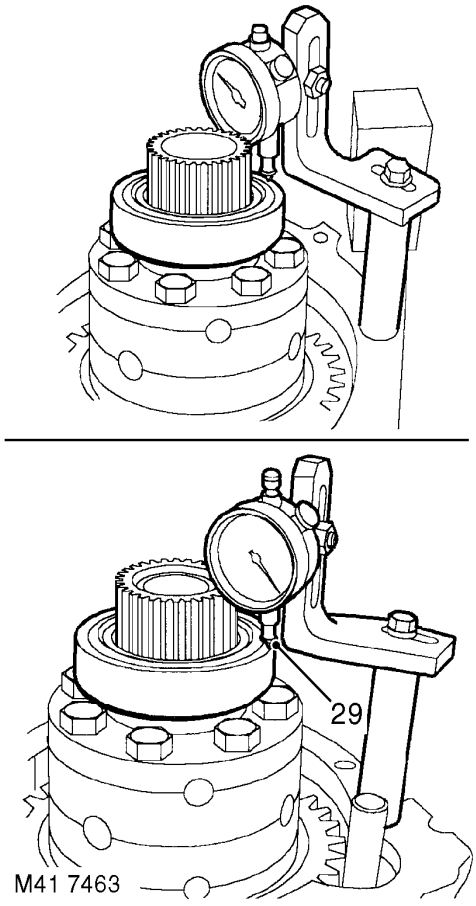
22. Position high/low selector shaft and fork to differential ensuring that fingers of selector fork are located in selector sleeve.

23. Position differential assembly into main casing ensuring that splines of rear output shaft are engaged in differential.

24. Position new differential front bearing track ensuring that track is seated squarely.

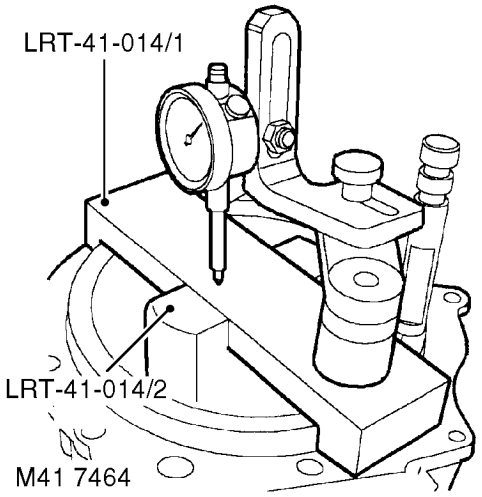


25. Position tool **LRT-41-014/3** onto main casing.
26. Screw tool **LRT-41-014/4** into tapped hole in main casing and attach suitable DTI to pillar.
27. Position stylus of gauge to setting block **LRT-41-014/3** and zero gauge.

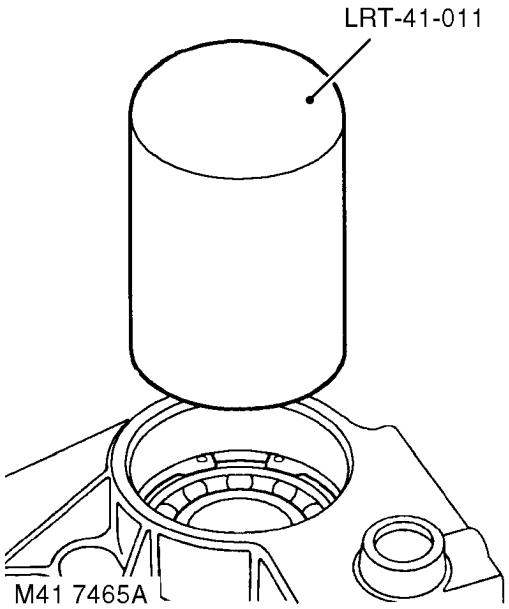


28. Position stylus onto front bearing outer track and record reading.

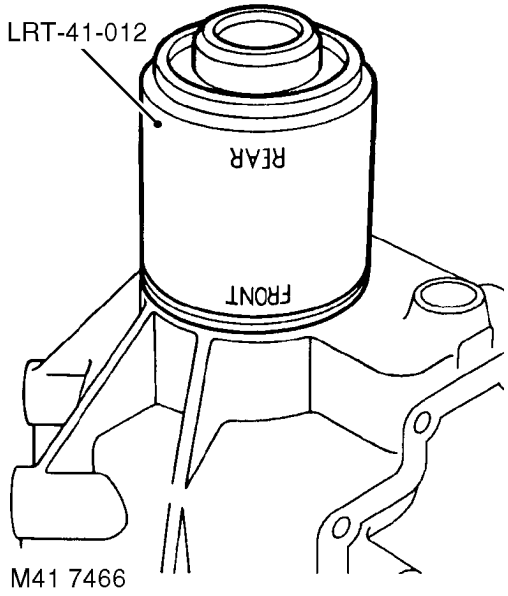
29. Taking care not to disturb bearing, position stylus on opposite side of bearing track and record reading.
30. Obtain average of the 2 readings and record figure.



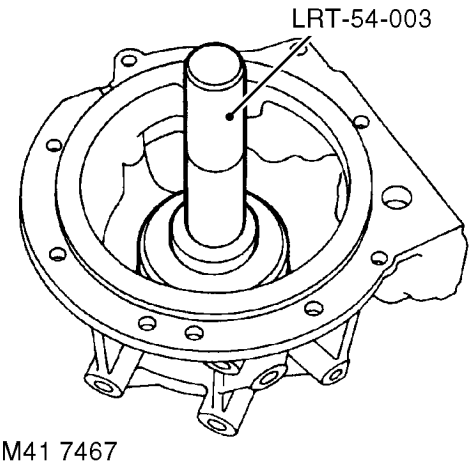
31. Position depth block tool **LRT-41-014/2** and cross bar tool **LRT-41-014/1** to front output housing.
32. Position DTI to tool **LRT-41-014/1** cross bar and zero DTI on depth block.
33. Position DTI to cross bar and record reading obtained.
34. **Using the formula:** 3.05 mm (0.120 in)+B-A=D where: B=Height difference recorded between depth block and cross bar. A=Average of readings to differential front bearing outer track. D=Thickness of shim required to give differential bearing pre-load of 0.05 mm (0.002 in).
35. From the resultant figure obtained, select appropriate thickness shim from the range available.
36. Shims are available from 2.00 to 3.25 mm (0.08 to 0.13 in) thickness, rising in increments of 0.05 mm (0.002 in).



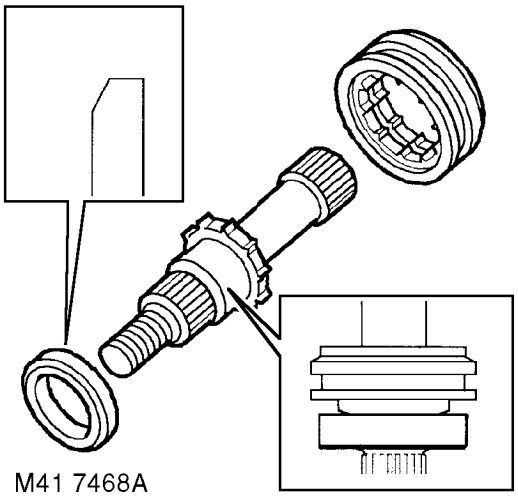
37. Heat the front output housing to 100°C (210°F) and fit new output shaft bearing using tool **LRT-41-011.**
38. Allow housing to air cool.
39. Fit new bearing retaining circlip ensuring that circlip is fully seated.



40. Using tool **LRT-41-012,** fit new output shaft oil seal. Check that oil seal is just contacting circlip.



41. Position selected shim in front output housing and using tool **LRT-54-003**, fit new differential front bearing track.



42. Fit bearing spacer to output shaft with chamfer on spacer towards threaded end.
43. **If fitted:** Fit dog clutch with flange on clutch facing towards splined end.
44. Using a copper mallet, drive output shaft into bearing.

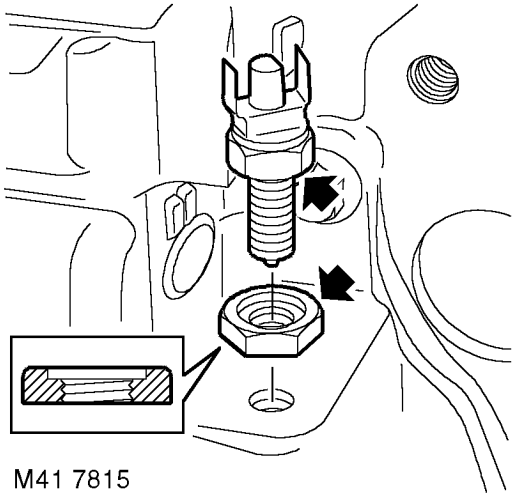
Note: Carry out the following operations for transfer boxes fitted with differential lock.

45. Compress differential lock selector spring and fit selector fork.
46. Position selector fork to groove in dog clutch.
47. Fit selector shaft and locate in housing recess, rotate shaft until the two flats for retaining clips are at right angles to the cover plate mating face.

48. Compress selector spring and fit retaining clips at each end of spring.

CAUTION: Ensure ends of spring are fully seated in recess of clips.

49. Fit detent ball and spring.
50. Apply Loctite 290 to threads of detent plug.
51. Fit and tighten detent plug, then loosen 2 complete turns.
52. Fit new 'O' ring to differential lock selector housing.
53. Fit selector housing, ensure selector finger is located in shaft recess.
54. Apply Loctite 290 to threads of bolts, and tighten selector housing bolts to 25 Nm (18 lbf.ft).

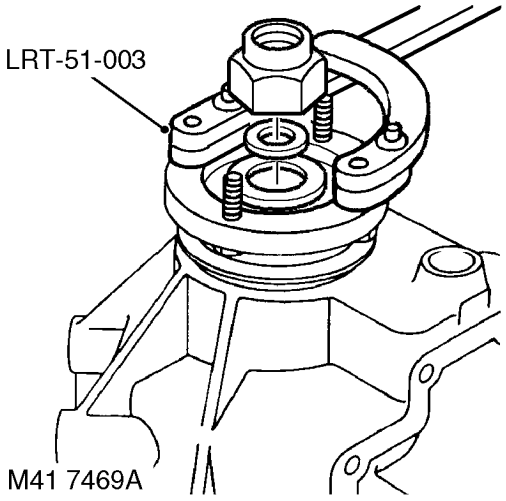


M41 7815

55. Clean threads of differential lock warning lamp switch(es).
56. ***Up to 03 MY:*** Fit nut to switch head with counterbore positioned towards switch head. **The nut acts as a spacer to ensure that switch setting is correct. Always ensure that nut is fully tightened to switch head (no gap).**
57. Apply Hylomar PL 32 sealant to threads of differential warning lamp switch(es).
58. ***Up to 03 MY:*** Position switch into front output housing until nut bottoms out on housing; tighten nut to 11 Nm (8 lbf.ft)
59. ***03 MY onwards:*** Fit new sealing washers to switches, fit switches in front output housing and tighten to 25Nm (18 lbf.ft).

Note: Carry out the following operations for all transfer boxes.

60. Apply sealant, Part No. STC 3254 to front output shaft housing.
61. Position housing ensuring that output shaft and dog clutch splines - if fitted are correctly engaged.
62. Clean output housing bolt threads.
63. Apply Loctite 290 to threads of bolts.
64. Fit output shaft housing bolts and tighten in a diagonal sequence to 45 Nm (33 lbf.ft).
65. Fit output flange, new felt washer, steel washer and new retaining nut.



M41 7469A

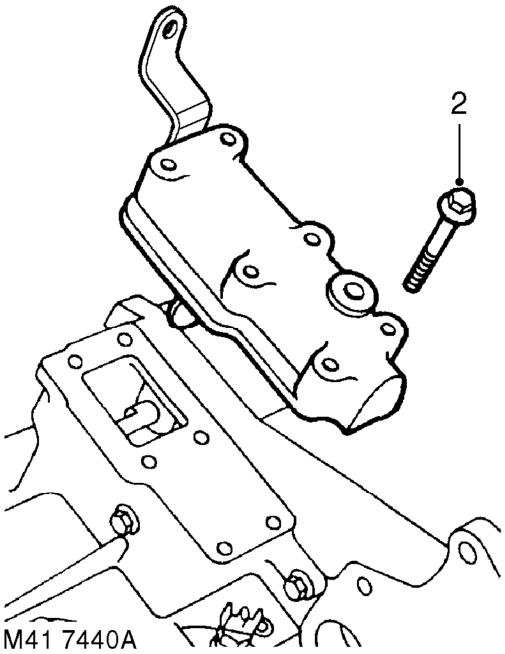
66. Using tool **LRT-51-003** to restrain flange, tighten output flange nut to 162 Nm (119 lbf.ft).
67. **If fitted -** Operate differential lock selector lever and check that detent ball can be felt to positively engage/disengage with grooves in shaft. Screw plug in or out until setting is correct.
68. Fit high/low selector shaft detent ball and spring.
69. Apply Loctite 290 sealant to threads of high/low selector shaft detent plug.
70. Fit and tighten plug, then loosen 2 complete turns.
71. Operate high/low selector lever and check that detent ball can be felt to positively engage/ disengage with grooves in shaft. Screw plug in or out until setting is correct.
72. Fit intermediate gear cluster.

☞ **TRANSFER BOX - LT230SE, OVERHAUL, Intermediate gear assembly.**

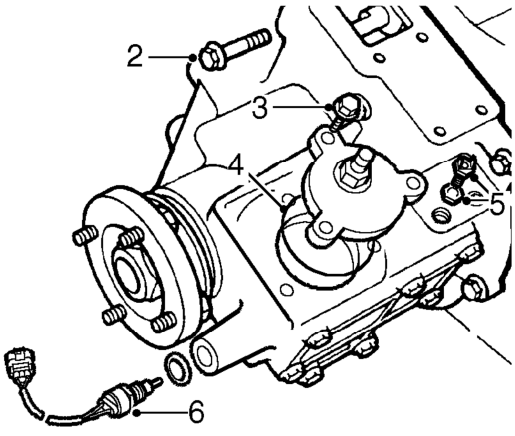
Dog clutch - differential lock

41.20.23

Disassembly



1. Remove 6 bolts securing high/low cross shaft housing to front output shaft housing and remove housing.

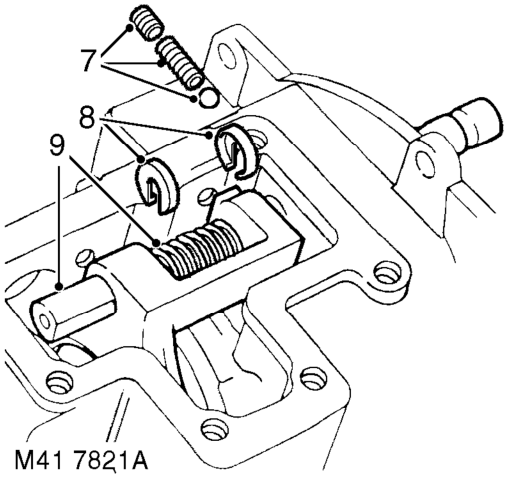


M41 7816A

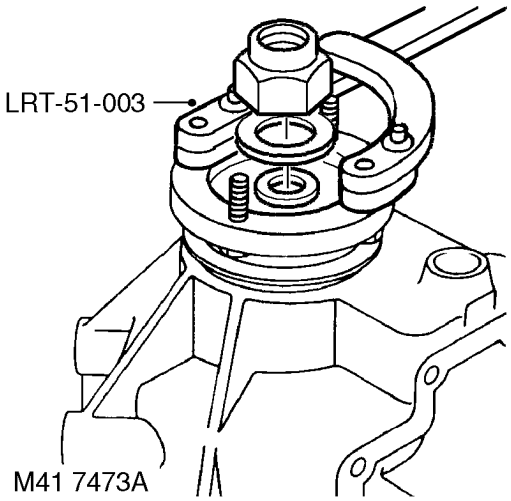
2. Note position of longest bolt and remove 8 bolts securing front output shaft housing to main casing and remove housing.
3. Remove 3 bolts securing differential lock selector housing and remove housing.
4. Remove and discard 'O' ring from selector housing.
5. Remove differential warning lamp switch and locknut.

   Note: Locknut is only fitted to switches up to 03 MY, a modified switch and sealing washer is fitted from 03 MY onwards..

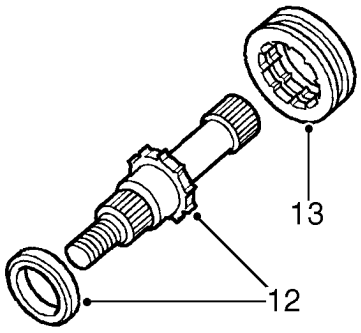
6. ***03 MY onwards:*** Remove differential lock warning lamp switch from end of front output shaft housing, discard sealing washer.



7. Remove Allen plug and remove detent spring and ball.
8. Compress differential lock selector fork spring and remove retaining clips from each end of spring.
9. Withdraw differential lock selector shaft from front output housing, recover spring and remove selector fork.



10. Position tool **LRT-51-003** to output shaft drive flange, remove and discard nut.
11. Remove and discard steel and felt washers. Remove output shaft drive flange.
12. Using a copper mallet, drive output shaft from housing.

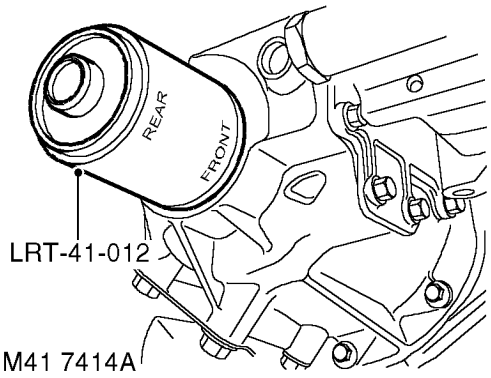


M41 7814

13. Noting its fitted position, remove bearing spacer from output shaft.
14. Noting its fitted position, remove dog clutch from output shaft.
15. Remove and discard oil seal from housing.

Reassembly

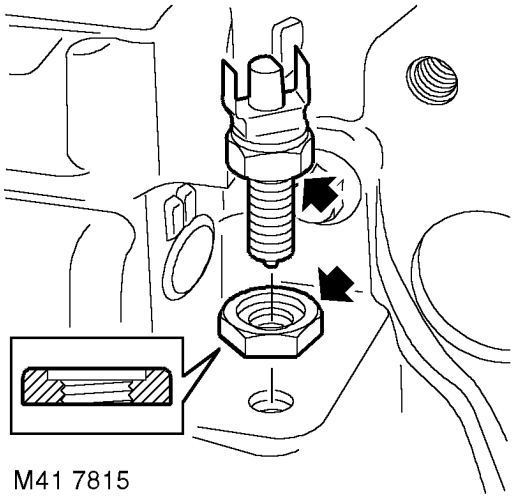
1. Clean differential lock components.
2. Lubricate components with gearbox oil.

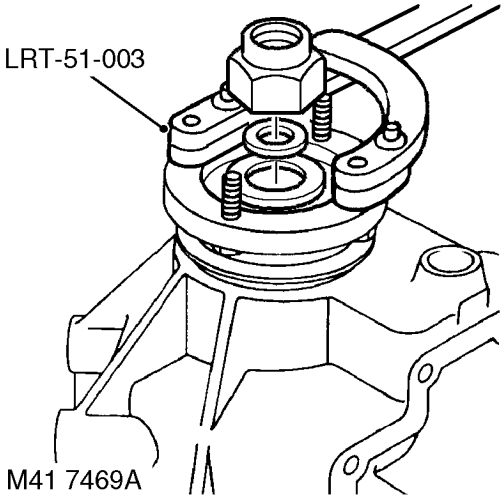


3. Using tool **LRT-41-012,** fit new output shaft oil seal.
4. Fit bearing spacer to output shaft with chamfer on spacer towards threaded end.
5. Fit dog clutch with flange on clutch facing towards splined end.
6. Using a copper mallet, drive output shaft into bearing.
7. Compress differential lock selector spring and fit selector fork.
8. Position selector fork to groove in dog clutch.
9. Fit selector shaft and locate in housing recess, rotate shaft until the two flats for retaining clips are at right angles to the cover plate mating face.
10. Compress selector spring and fit retaining clips at each end of spring.

    CAUTION: Ensure ends of spring are fully seated in recess in clips.

11. Fit detent ball and spring.
12. Apply Loctite 290 to threads of detent plug.
13. Fit and tighten detent plug, then unscrew 2 complete turns.
14. Fit new 'O' ring to differential lock selector housing.
15. Fit selector housing, ensure selector finger is located in shaft recess.
16. Apply Loctite 290 to threads of bolts and tighten selector housing bolts to 25 Nm (18 lbf.ft).
17. Apply sealant, Part No. STC 3254 to front output shaft housing.
18. Position housing ensuring that output shaft and dog clutch splines are correctly engaged.
19. Apply Loctite 290 to threads of bolts.
20. Fit front output shaft housing bolts and tighten in a diagonal sequence to 45 Nm (33 lbf.ft).


M41 7815



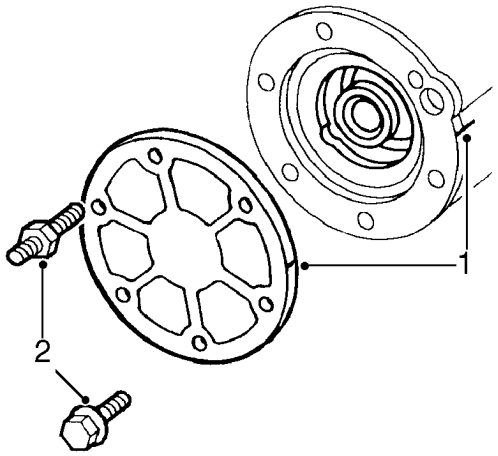
M41 7469A

21. Clean threads of differential lock warning lamp switch(es).
22. ***Up to 03 MY:*** Fit nut to switch head with counterbore positioned towards switch head. **The nut acts as a spacer to ensure that switch setting is correct. Always ensure that nut is fully tightened to switch head (no gap).**
23. Apply Hylomar PL 32 sealant to threads of differential warning lamp switch(es).
24. ***Up to 03 MY:*** Position switch into front output housing until nut bottoms out on housing, tighten nut to 11 Nm (8 lbf.ft).
25. ***03 MY onwards:*** Fit new sealing washers to switches, fir switches to front output housing and tighten to 25 Nm (18 lbf.ft).
26. Operate differential lock selector lever and check that detent ball can be felt to positively engage/disengage with grooves in shaft. Screw plug in or out until setting is correct.
27. Fit output flange, new felt and steel washers and new retaining nut.
28. Using tool **LRT-51-003** to restrain flange, tighten output flange nut to 162 Nm (119 lbf.ft).

Input gear/bearing

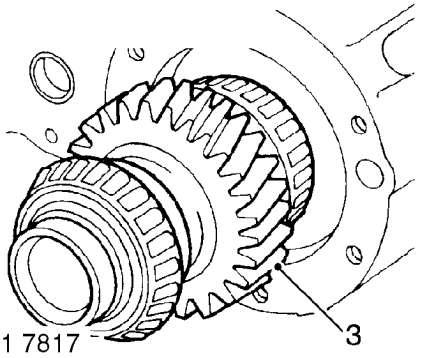
41.20.60

Disassembly



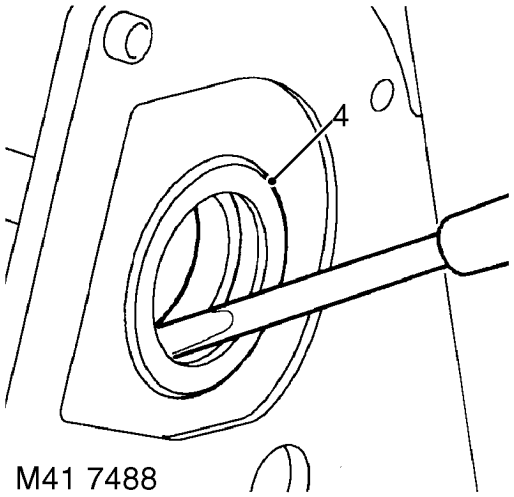
M41 7486

1. Make alignment marks between cover plate/ bearing housing and main casing.
2. Remove 5 bolts and stud nut securing cover/ bearing housing to main casing. Remove cover and bearing housing.



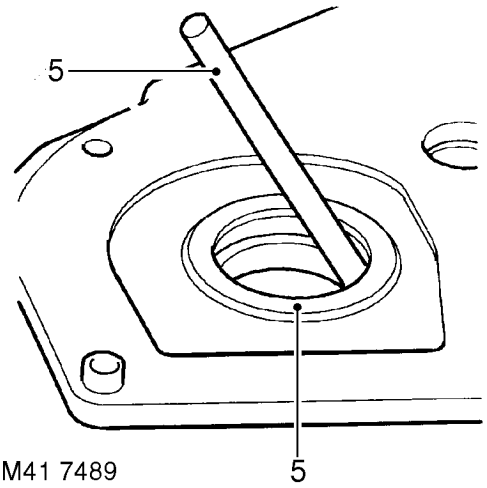
M41 7817

3. Remove input gear assembly.



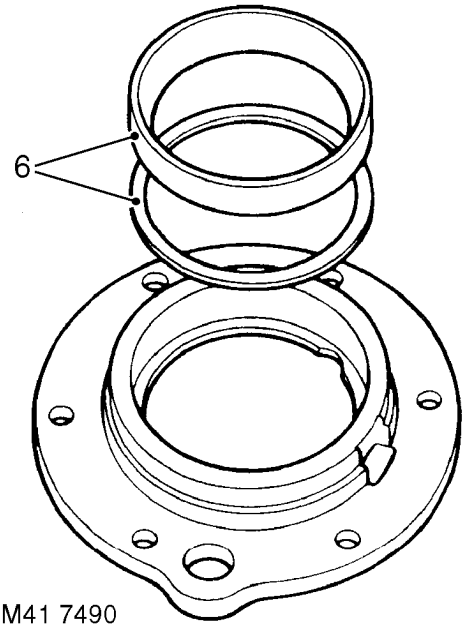
M41 7488

4. Remove and discard oil seal from main casing.



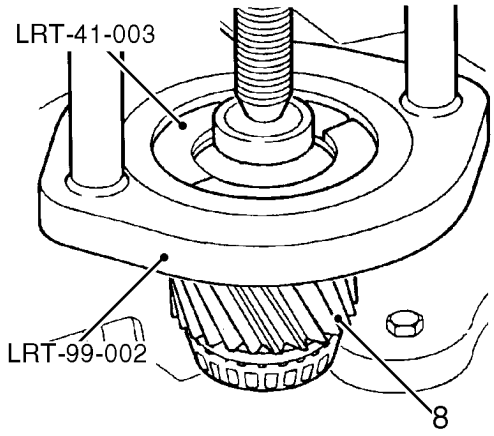
M41 7489

5. Drift out bearing track from main casing.



M41 7490

6. Drift out bearing track from housing and collect selective shim.

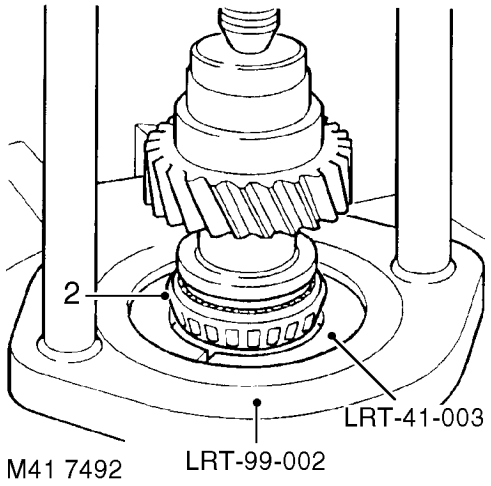


M41 7818

7. Position tool **LRT-99-002** to vice.
8. Assemble tool **LRT-41-003** to bearing, position input gear to hand press and remove bearing.
9. Repeat procedure for remaining bearing.

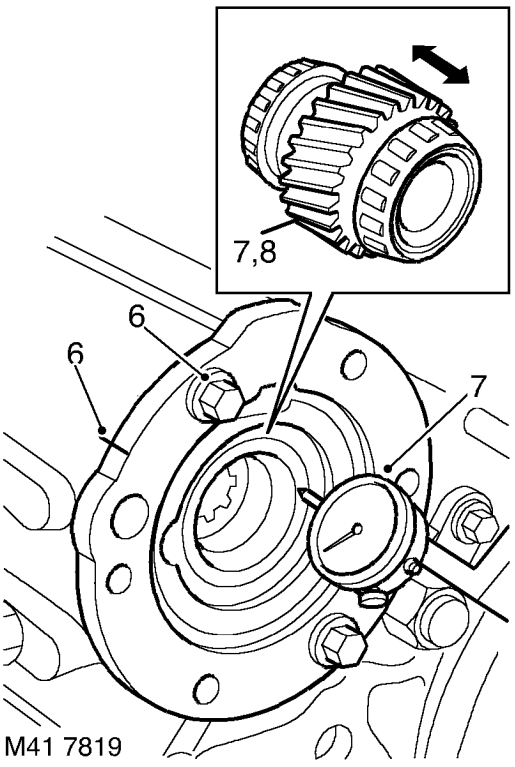
Reassembly

1. Clean input gear, cover/bearing housing and main casing.



M41 7492

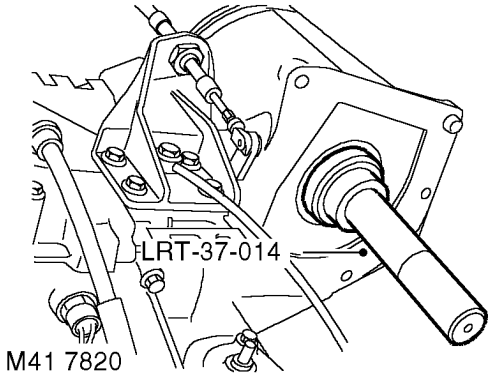
2. Using tool **LRT-99-002** and **LRT-41-003** fit new bearings to input gear.
3. Using a suitable mandrel, fit bearing track to main casing.
4. Fit a 3.15 mm (0.12 in) thick shim to bearing housing and using a suitable mandrel fit bearing track to housing.
5. Position input gear to main casing.



M41 7819

6. Fit bearing housing, ensuring reference marks are aligned, secure bearing housing with 2 bolts and tighten to 25 Nm (18 lbf.ft).

7. Position dial gauge with stylus contacting input gear, push input gear rearwards and zero gauge.
8. Push input gear forwards and note gauge reading.
9. Calculate thickness of shim required using the formula - A+B+C=D where:
   - A= Thickness of installed shim - 3.15 mm (0.12 in)
   - B= Recorded end-float.
   - C= Required pre-load - 0.05 mm (0.002 in).
   - D= Thickness of shim required.
10. If an alternative shim is required to establish correct pre-load, fit an alternative shim. **Shims are available from 3.15 to 4.00 mm (0.12 to 0.16 in) thickness, in increments of 0.05 mm (0.002 in).**
11. Remove 2 bolts, remove bearing housing and input gear.
12. Lubricate input gear and bearings with recommended oil.
13. Position input gear into main casing.
14. Apply sealant, Part No. STC 3254 to bearing housing and cover.
15. Position bearing housing/cover, align reference marks and tighten by diagonal selection to 45 Nm (33 lbf.ft).



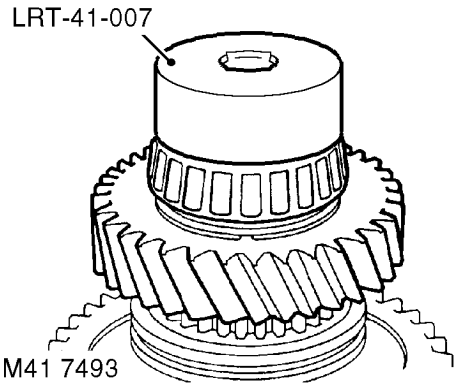
16. Using tool **LRT-37-014** fit new input shaft oil seal.

Low gear - differential

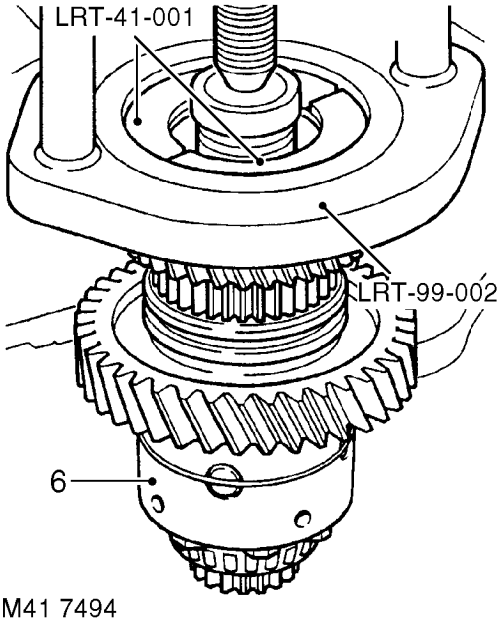
41.20.62

Disassembly

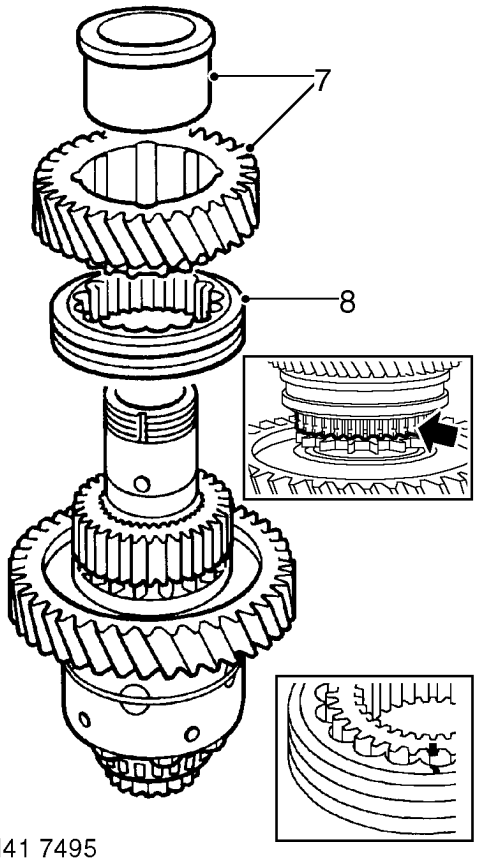
1. Remove differential.
   TRANSFER BOX - LT230SE, OVERHAUL, Dog clutch - differential lock.
2. Secure differential in a soft jawed vice.



3. Release staking from bearing retaining nut.
4. Using tool **LRT-41-007** remove and discard bearing retaining nut.

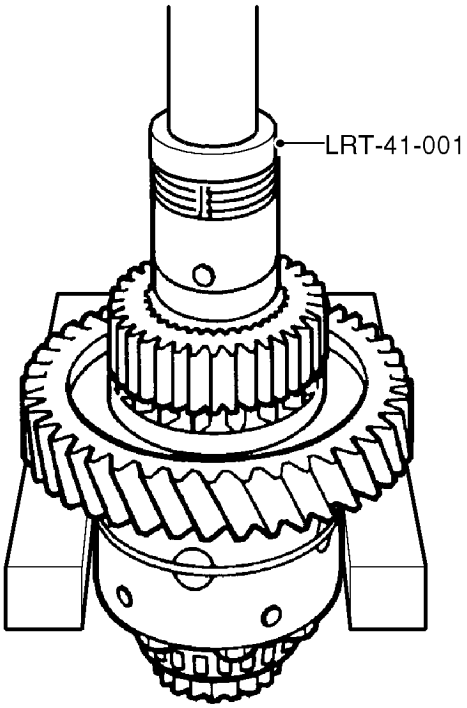


5. Position tool **LRT-99-002.** to a vice.
6. Position tool **LRT-41-001** around rear differential bearing, position differential to tool **LRT-99-002** and press off bearing.



M41 7495

7. Remove high range gear and bush.
8. Make suitable alignment marks between high/ low selector sleeve and hub, remove selector sleeve.

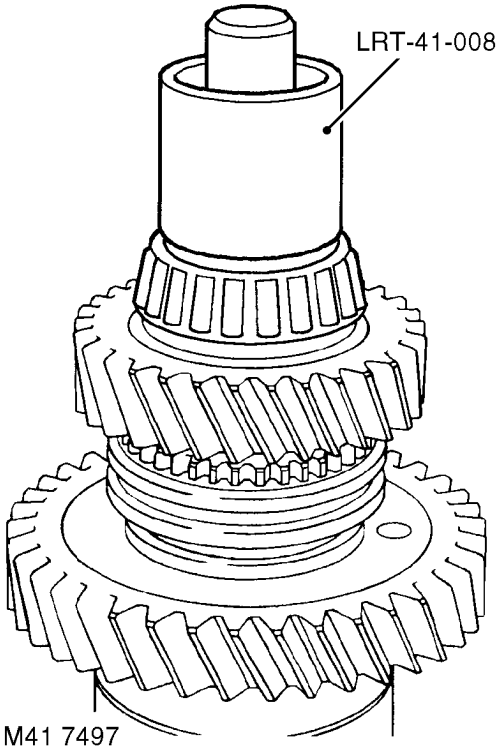


M41 7496

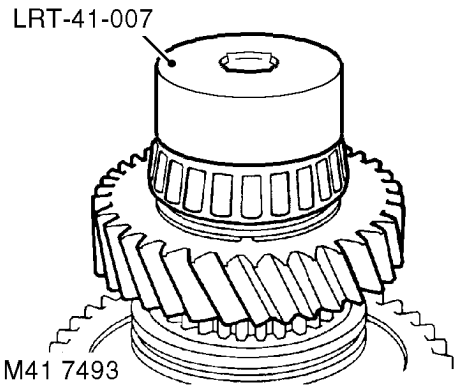
9. Using a suitable press and thrust button **LRT-41-001** remove high/low hub and low range gear.

Reassembly

1. Clean differential components.
2. Lubricate components with gearbox oil.
3. Fit differential in soft jawed vice, and fit low range gear with dog teeth facing uppermost.
4. Fit high/low hub ensuring that machined groove on hub teeth faces towards low range gear.
5. Fit high/low selector sleeve ensuring that alignment marks on hub and sleeve are together.
6. Fit bush to high range gear ensuring collar is uppermost.
7. Fit high range gear and bush onto shaft.

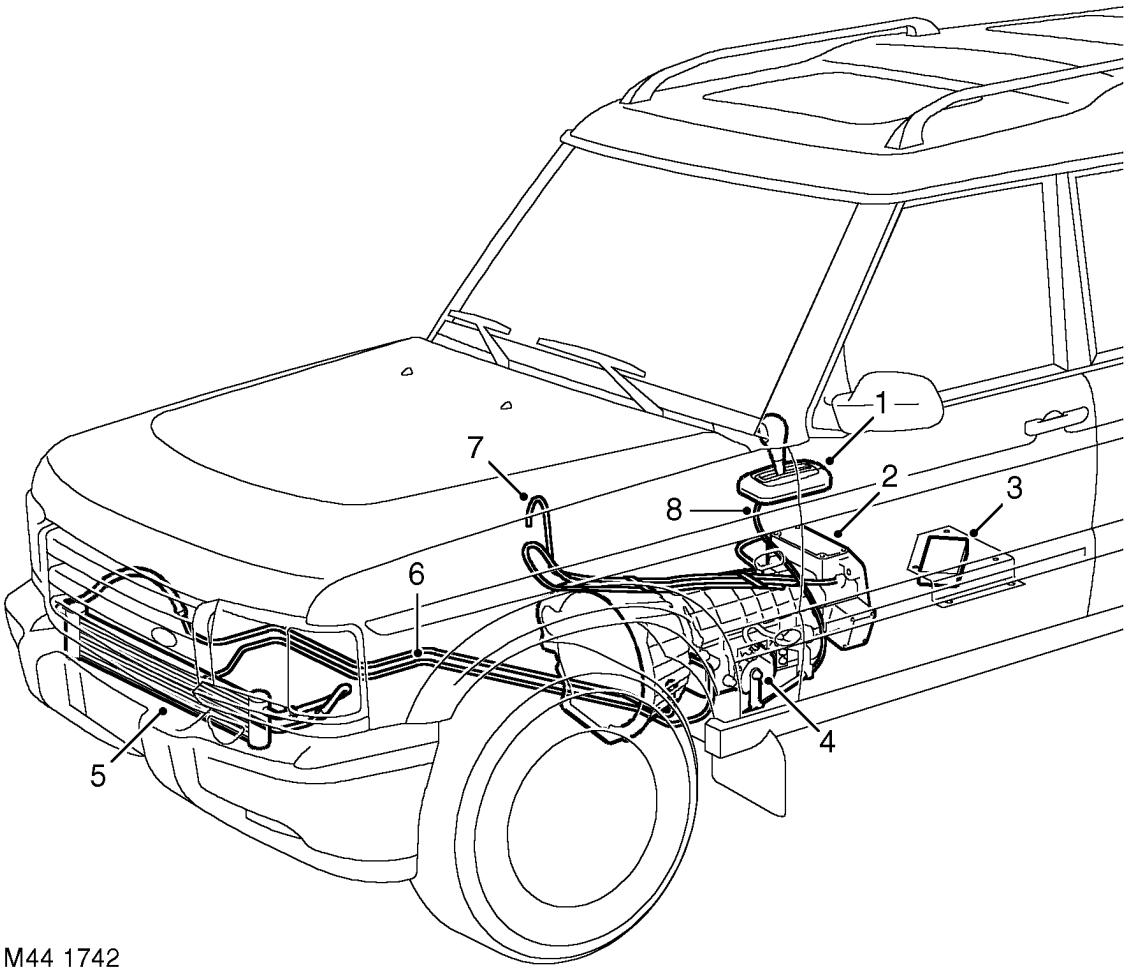


8. Fit rear bearing using tool **LRT-41-008.**



9. Fit new bearing retaining nut and using tool **LRT-41-007**, tighten to 72 Nm (53 lbf.ft).
10. Using a suitable drift, stake collar of nut into differential shaft recess.
11. Fit high/low selector shaft detent ball and spring.
12. Apply Loctite 290 sealant to threads of detent plug.
13. Fit and tighten plug, then loosen 2 complete turns.
14. Fit differential.
☞ **TRANSFER BOX - LT230SE, OVERHAUL, Differential assembly.**

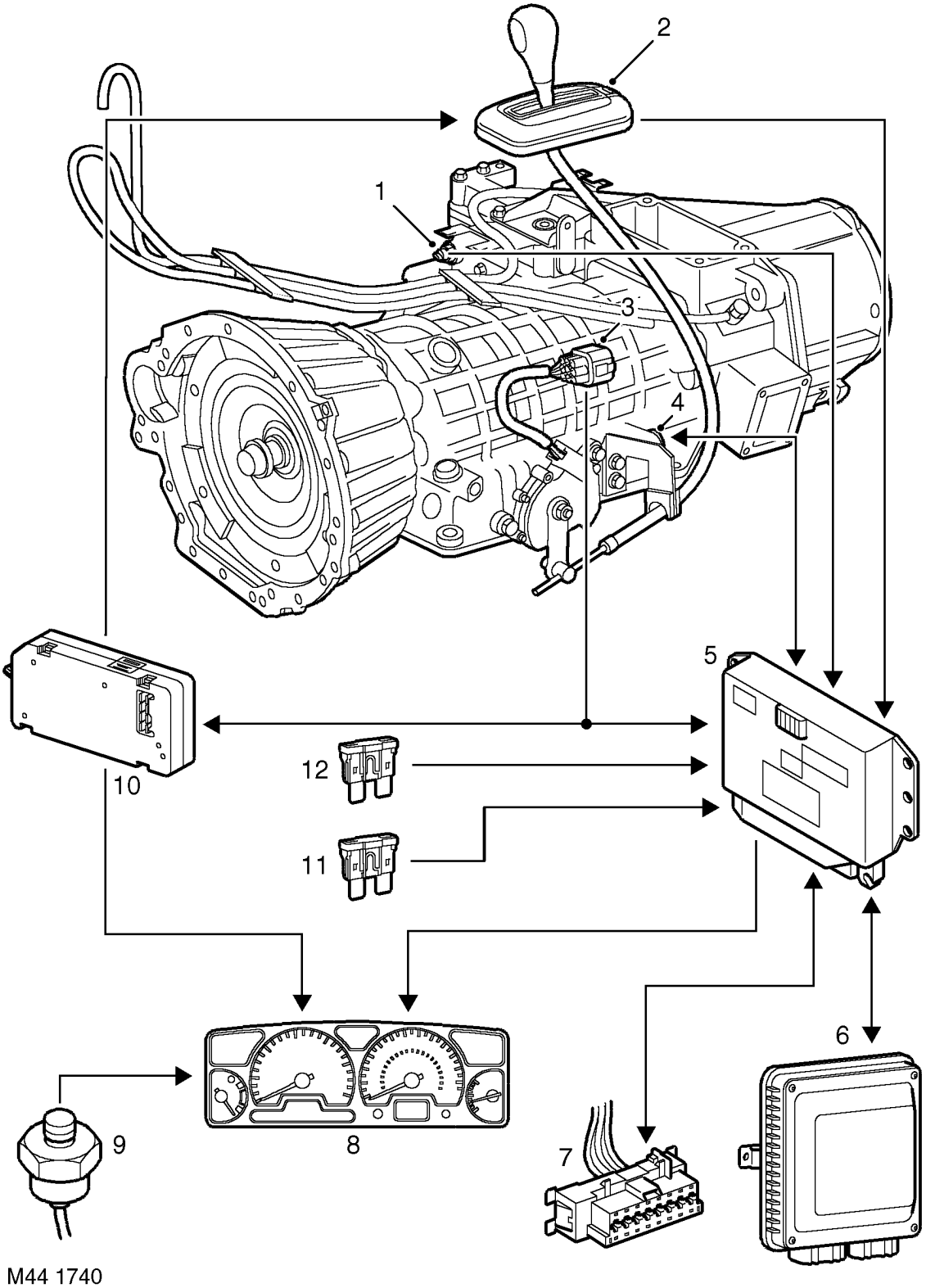
Automatic gearbox component layout



M44 1742

1 Selector lever assembly
2 Gearbox
3 Electronic automatic transmission ECU
4 Selector position switch
5 Oil cooler
6 Fluid lines
7 Breather tube
8 Selector cable

Control schematic



M44 1740

1 Transmission high/low switch
2 Mode switch
3 Gear position switch connector
4 Solenoid valve/speed sensor connector
5 Electronic automatic transmission ECU
6 Engine control module
7 Diagnostic socket
8 Instrument pack
9 Transmission fluid temperature sensor
10 Body control unit
11 Battery power supply
12 Ignition power supply

Description

General

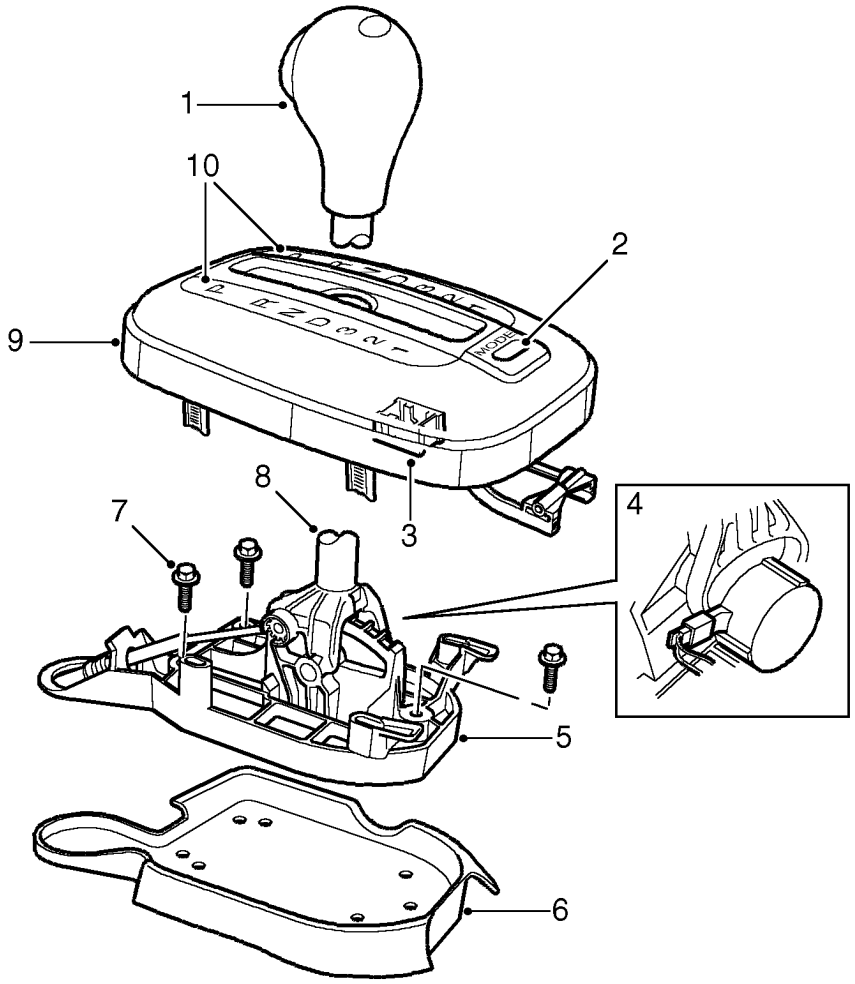
The automatic gearbox is a four speed unit with electronic control of gear selection, shift quality and torque converter lock-up. Selections on the selector lever assembly are transmitted to the gearbox by a selector cable. A gear position switch on the gearbox transmits the gear selection to an Electronic Automatic Transmission (EAT) ECU, which outputs the appropriate control signals to an electro-hydraulic valve block in the gearbox. A mode switch enables the driver to change the control mode of the EAT ECU. The EAT ECU operates warning lamps in the instrument pack to indicate the control mode and system status.

The gearbox features a pressure lubrication system and is cooled by pumping the lubricant through an oil cooler.

On NAS market vehicles from 03 model year, the ZF 4HP24 transmission unit is introduced for use with the 4.6 litre V8 engine. This transmission is required to accomodate the increased power output of the larger engine. The ZF 4HP22 transmission remains in use on vehicles with Td5 and 4.0 litre V8 engines.

Both transmission units are of similar construction, with the ZF 4HP24 unit being 15 mm longer than the 4HP22 unit to accomodate a larger fluid pump. The operation of both transmission units is the same.

Selector lever assembly



M44 1065

1 Release button
2 Mode switch
3 Electrical connector
4 Interlock solenoid (where fitted)
5 Base
6 Gasket
7 Securing bolt
8 Lever
9 Cover
10 Position indicators

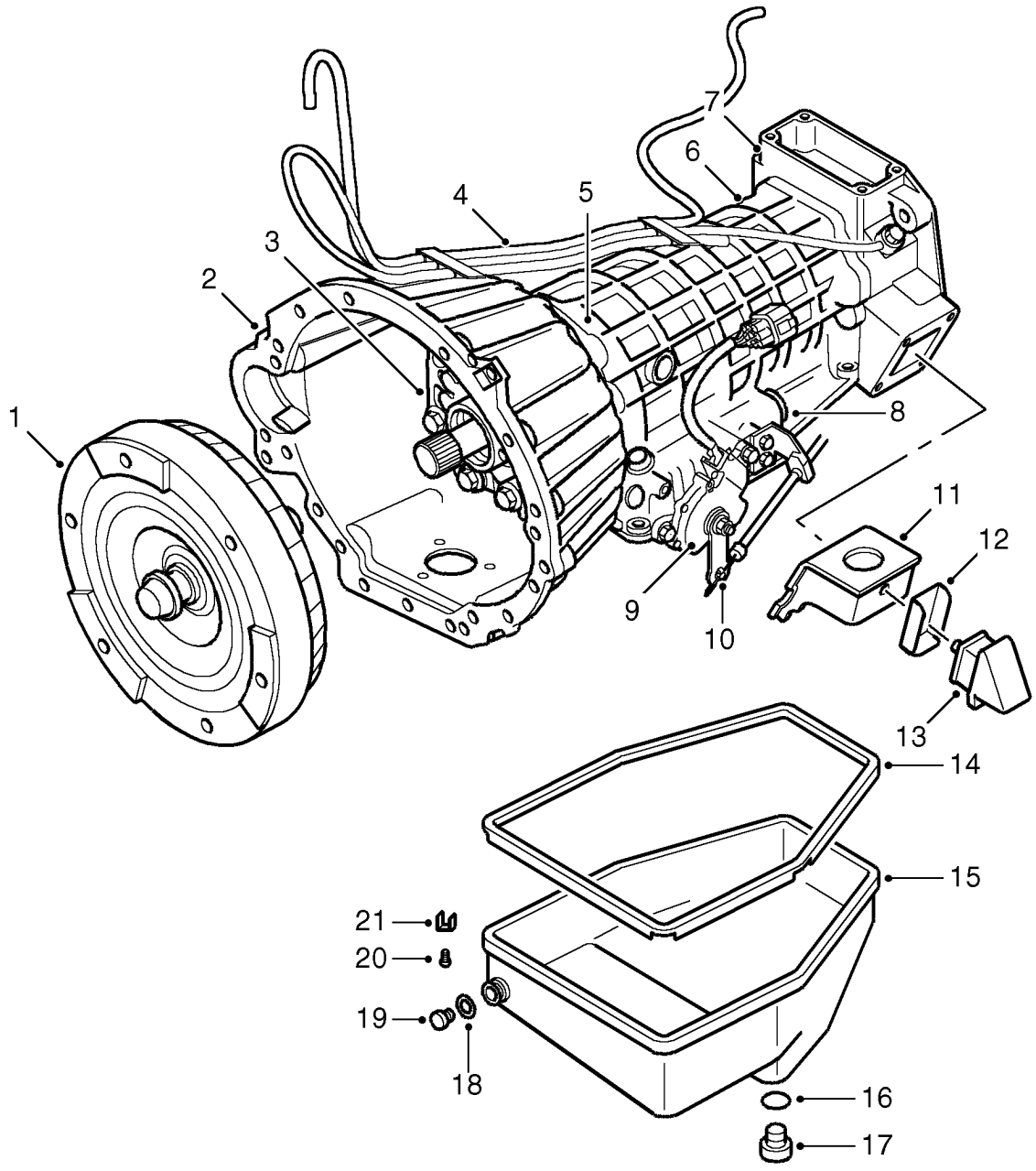
The selector lever assembly consists of a lever and a cover attached to a base. The base is located on a gasket and secured to the transmission tunnel. The lever is hinged to the base. A latch in the lever engages with detents in the base to provide the lever positions P, R, N, D, 3, 2, 1. The latch is disengaged by pressing a release button on the lever knob. Except for lever movement between positions D and 3, the button must be pressed before the lever can be moved. In some markets, vehicles incorporate an interlock solenoid at the bottom of the lever, which prevents the lever being moved from P unless the ignition switch is in position II and the foot brake is applied. **If the battery becomes flat, the interlock system will prevent selector lever movement and removal of the ignition key.**

The cover incorporates lever position indicators and the mode switch. The lever position indicators illuminate to show the position of the selector lever. Illumination is controlled by the Body Control Unit (BCU). The mode switch is a non-latching hinged switch that, when pressed, connects an earth to the EAT ECU to request a change of mode.

An electrical connector at the rear of the cover connects the selector lever assembly to the vehicle wiring.

Selector cable
The selector cable is a Bowden type cable that connects the selector lever assembly to a selector lever on the gearbox. 'C' clips secure the ends of the outer cable to brackets on the selector lever assembly and the selector lever. The inner cable is adjustable at the connection of the inner cable with the gearbox selector lever.

Gearbox

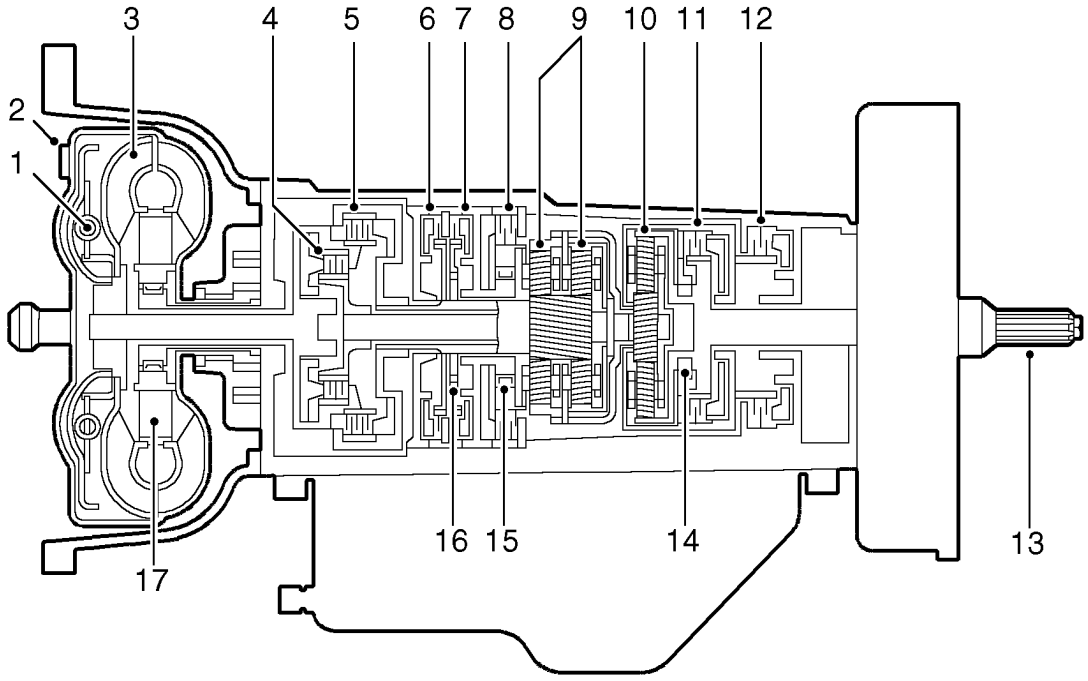


Diesel gearbox shown, V8 gearbox similar

1 Torque converter
2 Torque converter housing
3 Fluid pump
4 Breather tube
5 Intermediate plate
6 Gearbox housing
7 Rear extension housing
8 Electrical connector
9 Gear position switch
10 Selector lever
11 Mounting bracket
12 Heat shield
13 Rubber mounting
14 Gasket
15 Sump
16 'O' ring seal
17 Drain plug
18 'O' ring seal
19 Filler/level plug
20 Bolt
21 Clamp

The gearbox consists of a torque converter housing, an intermediate plate, a gearbox housing and a rear extension housing, bolted together in series. The rear of the gearbox is supported by a rubber mounting installed between a mounting bracket on the gearbox and the LH chassis rail. A heat shield is installed on the mounting to protect it from the exhaust.

Sectioned view of gearbox



M44 1067

1 Lock-up clutch
2 Impeller
3 Turbine
4 Forward drive clutch
5 Reverse drive clutch
6 Brake clutch
7 Brake clutch
8 Brake clutch
9 Epicyclic gear set
10 Epicyclic gear set
11 Clutch
12 Brake clutch
13 Output shaft
14 Freewheel (one way clutch)
15 Freewheel (one way clutch)
16 Freewheel (one way clutch)
17 Stator and one way clutch

Torque converter housing

The torque converter housing attaches the gearbox to the engine and contains the torque converter. Different torque converter housings are used to accommodate the difference between the V8 and Td5 engine interfaces. The torque converter is connected to the engine drive plate and transmits the drive from the engine to the gearbox input shaft. When engaged, a hydraulic lock-up clutch in the torque converter prevents slippage, to give a direct drive from the engine to the gearbox for improved driving response.

Intermediate plate

The intermediate plate supports the gearbox input shaft and provides the interface between the transmission fluid pump and the lubrication circuit. The pump attaches to the front of the intermediate plate and is driven by the impeller in the torque converter. The pump pressurises transmission fluid drawn from the sump on the gearbox housing. The pressurised fluid then circulates through the torque converter and gearbox housing components for cooling, lubrication and gear shift purposes. Ports around the outer periphery of the intermediate plate provide the inlet and outlet connections to the fluid cooler and a pressure take-off point for servicing.

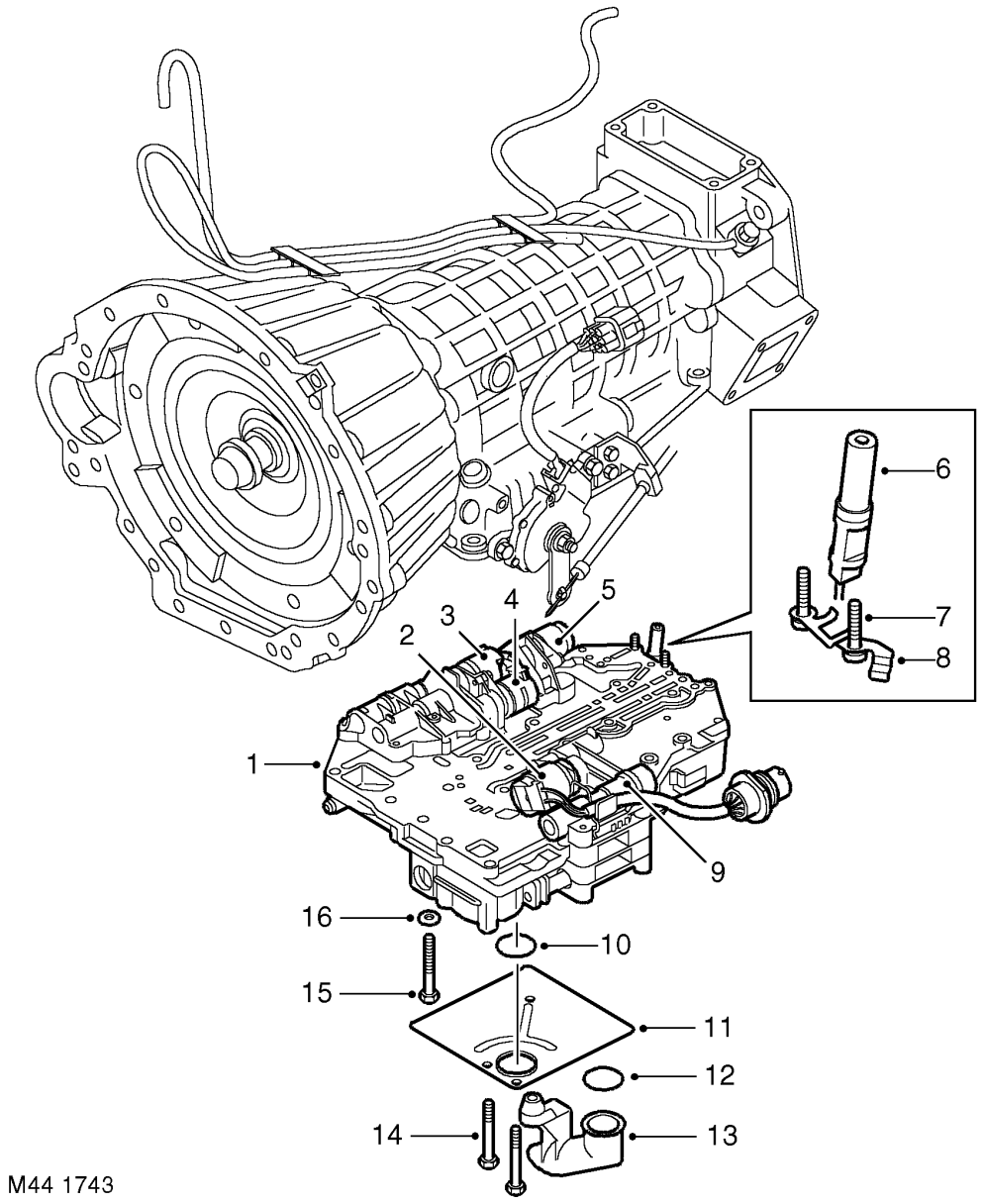
Gearbox housing

The gearbox housing contains two epicyclic gear sets on input and output shafts. Hydraulic brake clutches on the shafts, control which elements of the gear sets are engaged, and their direction of rotation, to produce the P and N selections, four forward gear ratios and one reverse gear ratio.

Gear ratios

Gear	Ratio
1st	2.480 : 1
2nd	1.480 : 1
3rd	1.000 : 1
4th	0.728 : 1
Reverse	2.086 : 1

Valve block



M44 1743

1 Valve block
2 Pressure regulating solenoid valve (MV 4)
3 Shift control solenoid valve (MV 2)
4 Shift control solenoid valve (MV 1)
5 Lock-up solenoid valve (MV 3)
6 Output shaft speed sensor
7 Bolt
8 Sensor retaining clip
9 Manual valve
10 'O' ring
11 Filter
12 'O' ring
13 Suction pipe
14 Bolt
15 Bolt
16 Washer

The lock-up and brake clutches are operated by pressurised transmission fluid from the valve block in the sump. A manual valve and four solenoid valves, also known as Motorised Valves (MV), control the supply of pressurised transmission fluid from the valve block:

- The manual valve controls the supply in P, R, N and D.
- Solenoid valves MV 1 and MV 2 control the supplies that operate the brake clutches for shift control.
- Solenoid valve MV 3 controls the supply that operates the lock-up clutch.
- Solenoid valve MV 4 modulates the pressure of the supplies to the brake clutches, to control shift quality.

Operation of the manual valve is controlled by the selector lever assembly. In the gearbox, a selector shaft engages with the manual valve. The selector shaft is connected to the selector lever assembly via the selector cable and a selector lever on the left side of the gearbox. The selector shaft also operates a mechanism that locks the output shaft when P is selected.

Operation of the solenoid valves is controlled by the EAT ECU.

An output shaft speed sensor in the gearbox housing outputs a signal to the EAT ECU. The EAT ECU compares output shaft speed with engine speed to determine the engaged gear, and output shaft speed with vehicle speed to confirm the range selected on the transfer box.

A bayonet lock electrical connector in the gearbox casing, to the rear of the selector lever, connects the solenoid valves and the output shaft speed sensor to the vehicle wiring.

A pressed steel sump encloses the valve block and collects transmission fluid draining from the gearbox housing. A suction pipe and filter on the underside of the valve block connect to the inlet side of the fluid pump. A magnet is installed in the sump to collect any magnetic particles that may be present. A level plug and a drain plug are installed in the sump for servicing.

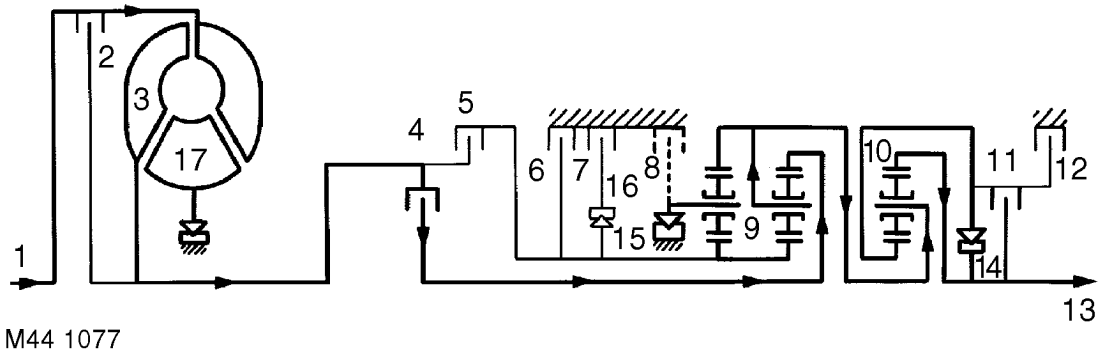
Rear extension housing

The rear extension housing provides the interface between the gearbox housing and the transfer box. A splined extension shaft, secured to the gearbox output shaft by a bolt, transmits the drive from the gearbox to the transfer box. A seal in the rear of the housing prevents leakage past the extension shaft. A breather pipe, attached to the left side of the rear extension housing, ventilates the interior of the gearbox and rear extension housings to atmosphere. The open end of the breather pipe is located in the engine compartment at the right front corner of the engine sump on gearboxes fitted to early vehicles and is clipped to the top of the gearbox on later vehicles.

Gearbox power flows

The following Figures show the power flow through the gearbox for each forward gear when D is selected, and for reverse. The key to the Item numbers on the Figures, and in parenthesis in the accompanying text, can be found on the 'Sectioned view of gearbox' Figure, above.

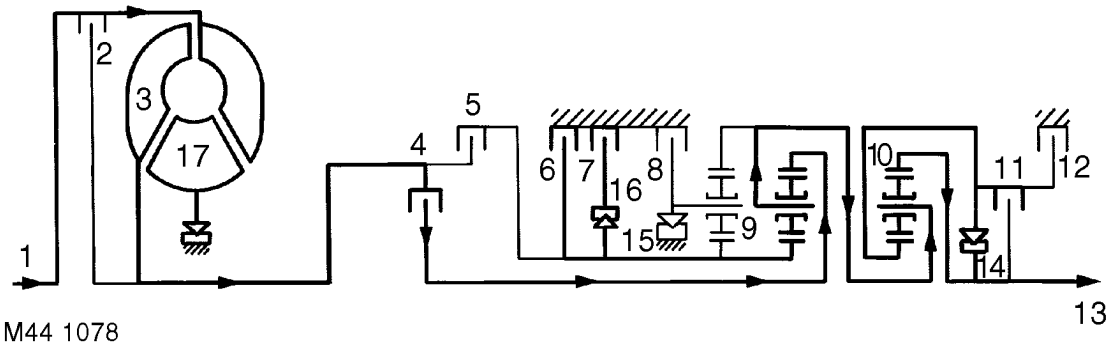
1st Gear (D selected)



M44 1077

Clutches (4) and (11) are engaged. The front planet gear carrier of gear set (9) locks against the gearbox housing through freewheel (15) when the engine powers the vehicle, and freewheels when the vehicle is coasting. Gear set (10) rotates as a solid unit with the front planet gear carrier. In 1st gear hold brake clutch (8) is applied to provide overrun braking.

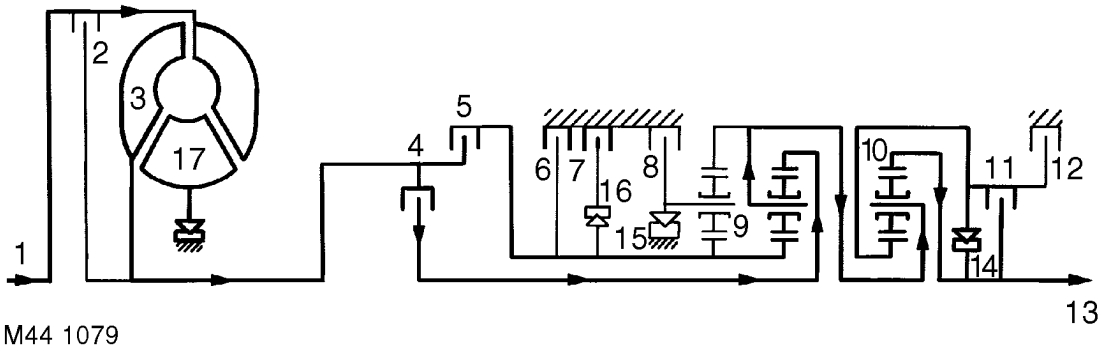
2nd Gear (D selected)



M44 1078

Clutches (4), (6), (7) and (11) are engaged. Freewheel (15) overruns. The hollow shaft with the sun wheel of gear set (9) is locked. Gear set (10) also rotates as a solid unit.

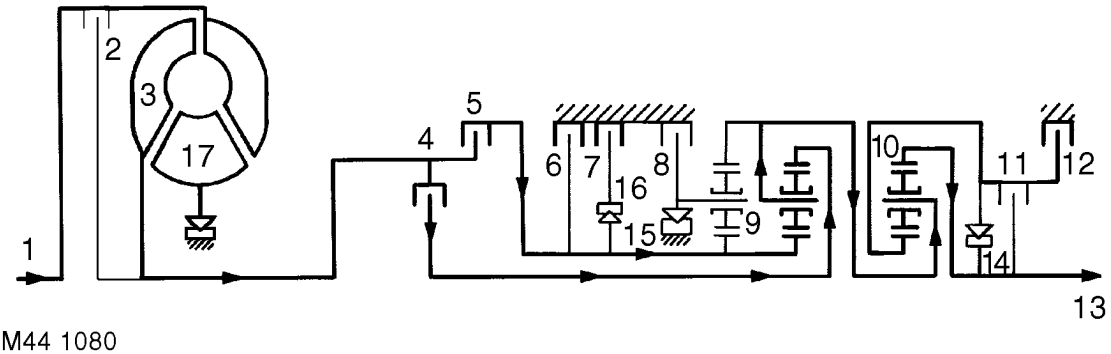
3rd Gear (D selected)



M44 1079

Clutches (4), (5), (7) and (11) are engaged. Freewheels (15) and (16) are overrun. Gear sets (9) and (10) rotate as a solid unit.

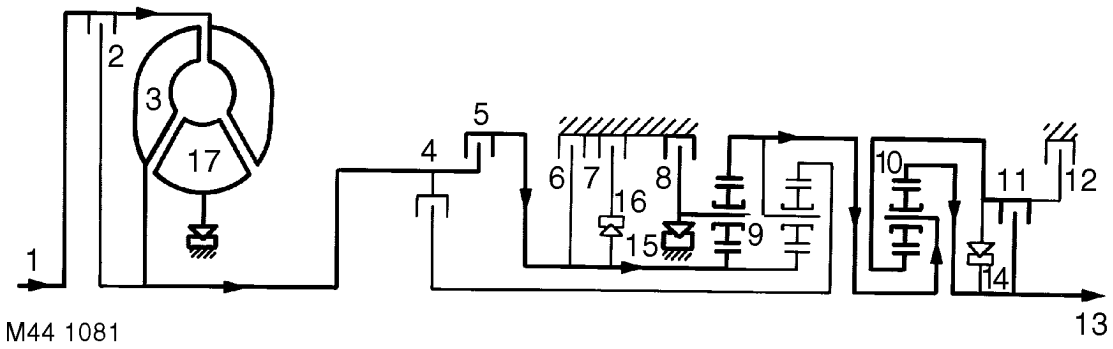
4th Gear (D selected)



M44 1080

Clutches (4), (5), (7) and (12) are engaged. Freewheels (14), (15) and (16) are overrun. Gear set (9) rotates as a solid unit. The hollow shaft with the sun wheel of gear set (10) is locked.

Reverse gear



Clutches (5), (8) and (11) are engaged. The front planet gear carrier of gear set (9) is locked. Gear set (10) also rotates as a solid block.

Gear position switch

The gear position switch outputs signals that are related to the position of the selector lever assembly. The switch is installed on the selector shaft on the left side of the gearbox. Slotted mounting holes allow the switch to be turned relative to the shaft for adjustment. A fly lead connects the switch to the vehicle wiring.

Movement of the selector lever assembly turns the selector shaft, which operates six pairs of contacts in the switch. The pairs of contacts are identified as the W, X, Y, Z, Park/Neutral and Reverse contacts. When closed:

- The W, X, Y and Z contacts output a 12V ignition supply from the BCU.
- The Park/Neutral contacts output an earth.
- The Reverse contacts output a 12V ignition supply from the passenger compartment fuse box.

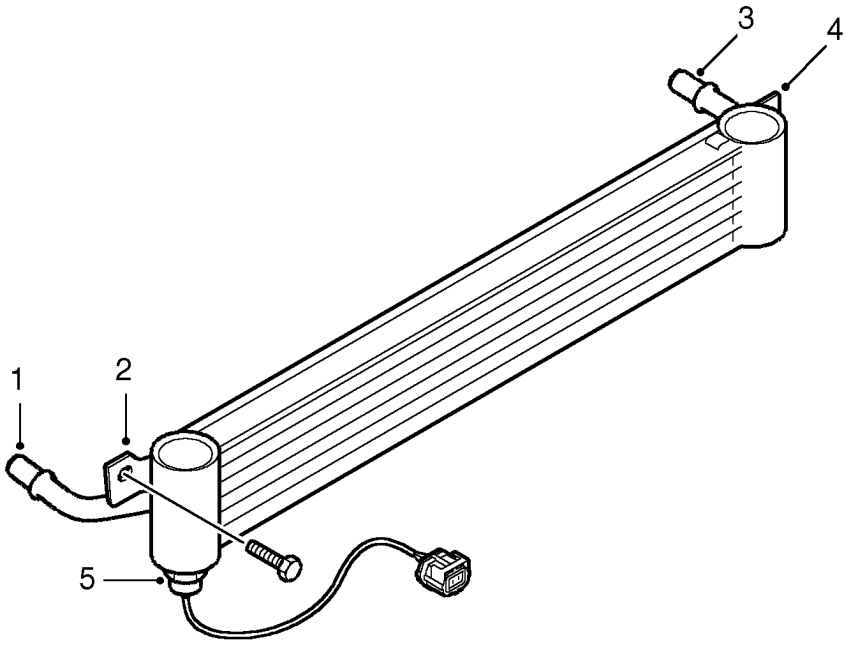
The outputs of the W, X, Y and Z contacts are monitored by the EAT ECU and the BCU to determine the position of the selector lever assembly.

Gear position switch W, X, Y, Z outputs

Switch contacts	Output						
	P	R	N	D	3	2	1
W	12V	-	12V	12V	-	-	-
X	-	12V	12V	-	12V	-	-
Y	-	-	12V	12V	12V	-	12V
Z	-	-	-	12V	12V	12V	-

The Park/Neutral contacts output to the BCU and, on diesel models, the ECM. The Reverse contacts output to the BCU, the reversing lamps, the SLABS ECU and, where fitted, the ACE ECU and the electrochromic interior mirror.

Oil cooler



M44 1073

1 Inlet connection
2 Fixing bracket
3 Outlet connection
4 Fixing bracket
5 Temperature sensor

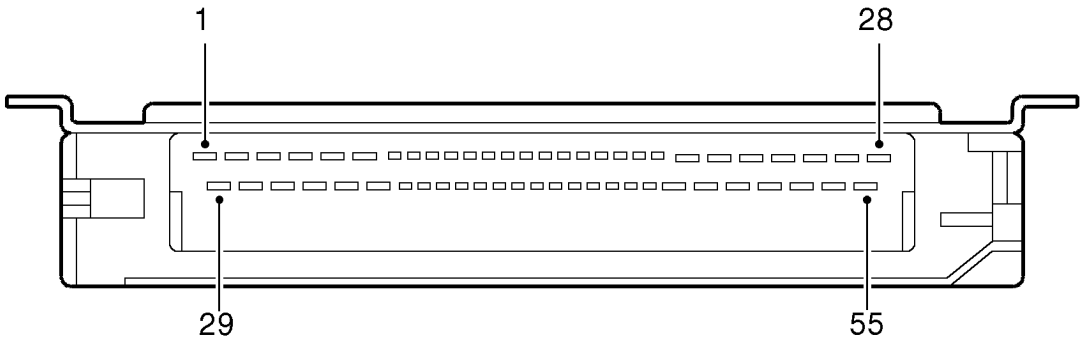
Transmission fluid from the gearbox is circulated through a cooler attached to the front of the radiator. Quick release connectors on the transmission fluid lines attach to connections on each end tank of the cooler. A temperature sensor on the RH end tank provides the instrument pack with an input of transmission fluid temperature. If the temperature exceeds a preset limit, the instrument pack illuminates the transmission temperature warning lamp. The warning lamp remains illuminated until the temperature of the fluid returns within limits.

EAT ECU

The EAT ECU operates the solenoid valves in the gearbox to provide automatic control of gear shifts and torque converter lock-up. The EAT ECU is attached to a protective bracket which is secured to the cabin floor below the LH front seat. A 55 pin connector links the EAT ECU to the vehicle wiring.

Software in the EAT ECU monitors hard wired inputs and exchanges information with the ECM on a Controller Area Network (CAN) bus to determine gear shift and torque converter lock-up requirements. Resultant control signals are then output to the gearbox solenoid valves.

EAT ECU connector



M44 1126

EAT ECU connector pin details

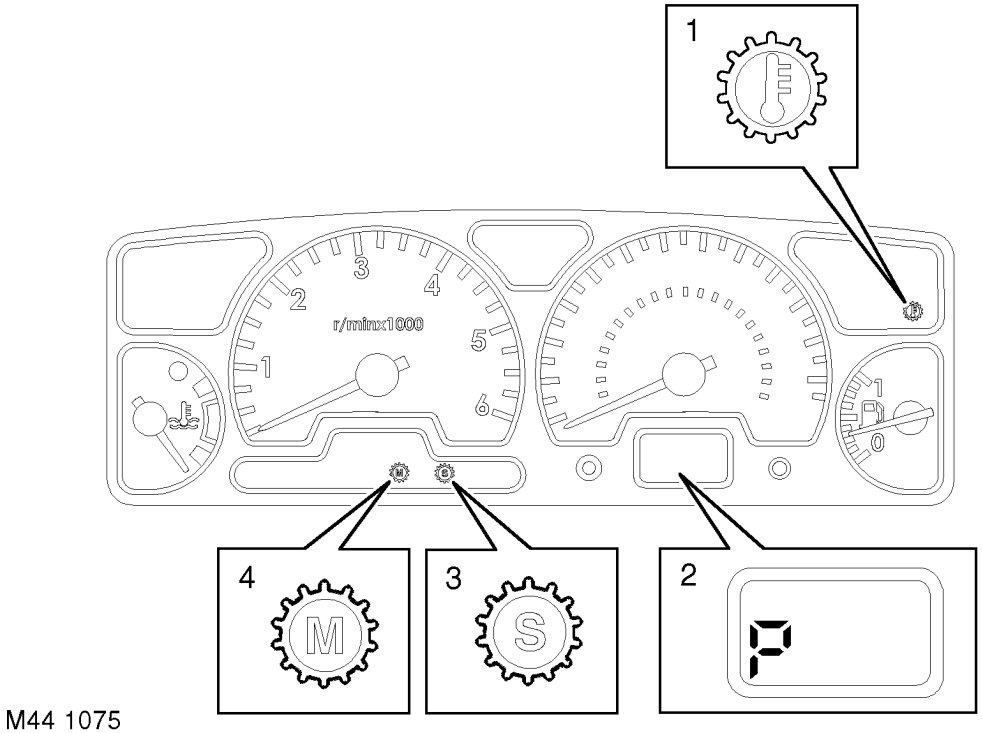
Pin No.	Description	Inputs/Outputs
1 to 4	Not used	-
5	Pressure regulator solenoid valve (MV 4)	Output
6	Power earth	-
7	Not used	-
8	Gear position switch, X contacts	Input
9	Gear position switch, Z contacts	Input
10 to 12	Not used	-
13	Transmission high/low switch	Input
14	Gearbox output shaft speed sensor, negative	Input
15	Gearbox output shaft speed sensor cable screen	-
16	CAN, high	Input/Output
17 to 24	Not used	-
25	Sport mode warning lamp	Output
26	Battery power supply	Input
27	Not used	-
28	Electronics earth	-
29	Not used	-
30	Shift control solenoid valve (MV 1)	Output
31	Diagnostics, K line	Input/Output
32	Converter lock-up solenoid valve (MV 3)	Output
33	Shift control solenoid valve (MV 2)	Output
34	Not used	-
35	Not used	-
36	Gear position switch, W contacts	Input
37	Gear position switch, Y contacts	Input
38 to 41	Not used	-
42	Gearbox output shaft speed sensor, positive	Input
43	Not used	-
44	CAN, low	Input/Output
45	Mode switch	Input
46 to 50	Not used	-
51	Manual mode warning lamp	Output
52	Not used	-
53	Solenoid valves power supply	Output
54	Ignition power supply	Input
55	Not used	-

CAN communications between EAT ECU and ECM

Inputs from ECM	Outputs to ECM
CAN version identifier	Calculated gear
Emissions (OBD II) control	Diagnostic information
Engine air intake temperature	Emission (OBD II) fault status
Engine speed	Engine torque reduction request
Engine speed fault flag	Gear position switch information
Engine temperature	Output shaft speed
Engine torque	Mode information
Engine torque fault flag	Shift information
Friction torque	Torque converter lock-up status
Maximum engine torque	
Reduced engine torque	
Road speed	
Status of engine torque reduction	
Throttle position	

Warning lamps

Warning lamps and selector lever position indication



M44 1075

1 Transmission temperature warning lamp (red)
2 Gear selector lever position indication
3 Sport mode warning lamp (green)
4 Manual mode warning lamp (green)

Illumination for each warning lamp is provided by a non serviceable LED.

Operation

Refer to illustration.

☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Control schematic.**

When the ignition is switched on, a bulb check is performed on the transmission temperature warning lamp and the mode warning lamps by the instrument pack and the EAT ECU respectively. The warning lamps are illuminated for approximately 3 seconds and then extinguished.

The gear position switch outputs are monitored by the BCU and the EAT ECU. The BCU outputs gear position signals to illuminate the position indicators each side of the gear selector lever and on the odometer LCD in the instrument pack.

In D, 3, 2, and 1, the EAT ECU outputs control signals to the gearbox to select the required gear.

In D, all forward gears are available for selection by the EAT ECU. In 3, 2 and 1, a corresponding limit is imposed on the highest gear available for selection. When R is selected, reverse gear only engages if the vehicle is stationary or moving at 5 mph (8 km/h) or less. When R is deselected, reverse gear only disengages if the vehicle is moving at 4 mph (6 km/h) or less.

Selector lever interlock (where fitted)

The interlock solenoid on the selector lever is de-energised unless the foot brake is applied while the ignition is on. While de-energised, the interlock solenoid allows the selector lever to move through the range unless P is selected. On entering the P position, the interlock solenoid engages a latch which locks the selector lever. When the ignition is on and the foot brake is applied, the BCU energises the interlock solenoid, which disengages the latch and allows the selector lever to be moved out of P.

Economy, sport and manual modes

During the power-up procedure after the ignition is switched on, the EAT ECU defaults to an economy mode. Pressing the mode switch causes the EAT ECU to change between the economy mode and the sport or the manual mode, depending on the range selected on the transfer box:

- If the transfer box is in high range, the EAT ECU changes to the sport mode and illuminates the sport mode warning lamp in the instrument pack. In the sport mode the gearbox is more responsive to accelerator pedal movement. Downshifts occur earlier and upshifts occur later.
- If the transfer box is in low range, the EAT ECU changes to the manual mode and illuminates the manual mode warning lamp in the instrument pack. Kickdown is disabled and the EAT ECU maintains the gearbox in the gear selected on the selector lever (D = 4th gear) to give improved off road performance. Downshifts occur only to prevent the engine stalling. From a standing start, the vehicle pulls away in 1st gear and, if a higher gear is selected, upshifts almost immediately to the selected gear (shifts of more than one gear can occur).

After a second press of the mode switch the EAT ECU reverts to the economy mode, for the range selected on the transfer box, and extinguishes the related mode warning lamp in the instrument pack.

Shift control

To provide the different driving characteristics for each mode of operation, the EAT ECU incorporates different shift maps of throttle position/engine speed. Base shift points are derived from the appropriate shift map. When a shift is required, the EAT ECU sends a request to the ECM for a reduction in engine torque, in order to produce a smoother shift. The percentage of torque reduction requested varies according to the operating conditions at the time of the request. When the EAT ECU receives confirmation of the torque reduction from the ECM, it then signals the shift solenoid valves in the gearbox to produce the shift. To further improve shift quality, the EAT ECU also signals the pressure regulating solenoid valve to modulate the hydraulic pressure and so control the rate of engagement and disengagement of the brake clutches.

With time, the components in a gearbox wear and the duration of the gear shifts tends to increase, which has an adverse effect on the brake clutches. To counteract this, the EAT ECU applies a pressure adaptation to each shift. To calculate the adaptations, the EAT ECU monitors the pressure modulation used, and time taken, for each shift. If a subsequent shift of the same type, in terms of throttle position and engine speed, has a longer duration, the EAT ECU stores an adaptation for that type of shift in a volatile memory. The adaptation is then included in future pressure calculations for that type of shift, to restore shift duration to the nominal.

Kickdown
The EAT ECU monitors the input of the throttle position sensor to determine when kickdown is required. When it detects a kickdown situation, the EAT ECU immediately initiates a down shift provided the target gear will not cause the engine speed limit to be exceeded.

Torque converter lock-up
The EAT ECU energises the lock-up solenoid valve to engage the lock-up clutch. Lock-up clutch operation is dependent on throttle position, engine speed, operating mode and the range selected on the transfer box.

High range
Unique lock-up maps, similar to the shift maps, are incorporated in the economy and sport modes for all forward gears. Engagement and disengagement of the lock-up clutch is dependent on throttle position and engine speed.

Low range
To enhance off road control, particularly when manoeuvring at low speeds, torque converter lock-up does not occur when there is any degree of throttle opening. When the throttle is closed above a preset engine speed, the lock-up clutch engages to provide maximum engine braking.

Increased load/reduced torque compensation
To aid performance and driveability in the high range economy mode, the EAT ECU has three adaptive shift and lock-up maps. These maps delay upshifts and torque converter lock-up similar to the sport mode if the inputs from the engine indicate:

- A sustained high load on the engine, such as occurs when the vehicle is ascending a steep gradient or towing a trailer.
- A lower than normal engine torque, such as occurs at altitude or high ambient temperatures.

The EAT ECU monitors the engine inputs and selects the most appropriate adaptive map for the prevailing conditions.

Diagnostics
While the ignition is on, the EAT ECU diagnoses the system for faults. The extent of the diagnostic capability at any particular time depends on the prevailing operating conditions, e.g. it is not possible to check torque converter lock-up while the vehicle is stationary, or to check for a short circuit to earth if the circuit concerned is already at a low potential.

If a fault is detected, the EAT ECU immediately stores a fault code and the values of three operating parameters associated with the fault. Depending on the fault, there are four possible effects:

- The fault has little effect on gearbox operation or vehicle emissions. The driver will probably not notice any change and the warning lamps remain extinguished.
- The fault has little effect on gearbox operation but may effect vehicle emissions. On NAS vehicles, if the fault is detected on a second consecutive drive cycle, the MIL illuminates.
- All gears are available but kickdown does not function. The sport and manual warning lamps flash. The MIL remains extinguished.
- Limp home mode is selected and vehicle performance is greatly reduced. The sport and manual warning lamps flash. In all markets, if the fault is detected on a second consecutive drive cycle, the MIL illuminates.

After the detection of a fault, the effects remain active for the remainder of the drive cycle. In subsequent drive cycles, as soon as the EAT ECU diagnoses the fault is no longer present, it resumes normal control of the gearbox. The conditions required to diagnose that the fault is no longer present depend on the fault. Some faults require the engine to be started, others require only that the ignition is switched on.

After a fault has not recurred for forty warm-up cycles, the fault is deleted from the EAT ECU memory. Only five different faults can be stored in the memory at any one time. If a further fault occurs, the fault with the lowest priority will be replaced by the new fault.

Mechanical limp home

In the mechanical limp home mode, gear engagement is controlled by the manual valve. The gearbox is fixed in 4th gear if the fault occurs while the vehicle is moving, or 3rd gear if the fault occurs while the vehicle is stationary. 3rd gear is also engaged if a vehicle is brought to a stop and the selector lever is moved out of, and back into, D. Neutral and reverse gear are also available.

Fault effects and warning indications

Fault code, OBD II (TestBook)	Fault description	Effect	Warning lamp illumination	
			MIL	Sport/ Manual
P0705 (14, 23)	* Gear position switch, incorrect outputs	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P0721 (21)	* Downshift safety monitor prevented downshift which would have caused engine overspeed	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P0722 (22)	* Torque converter slipping	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P0731 (29)	* Ratio monitoring, implausible 1st gear ratio	No apparent effect	On	On
P0732 (30)	* Ratio monitoring, implausible 2nd gear ratio	No apparent effect	On	Off
P0733 (31)	* Ratio monitoring, implausible 3rd gear ratio	No apparent effect	On	Off
P0734 (32)	* Ratio monitoring, implausible 4th gear ratio	No apparent effect	On	Off
P0741 (5)	* Torque converter lock-up clutch fault	May affect driveability.	On	Off
P0743 (7, 25)	* Torque converter lock-up solenoid (MV 3), open or short circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P0748 (10, 28)	* Pressure regulating solenoid (MV 4), open or short circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P0753 (8, 26)	* Shift solenoid (MV 1), open or short circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P0758 (9, 27)	* Shift solenoid (MV 2), open or short circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P1562 (24)	* Battery supply below 9V while engine running	Maintains current gear in low range, limp home mode in range. Shift pressure to maximum, harsh gear shifts/engagement.	Off	On

Fault code, OBD II (TestBook)	Fault description	Effect	Warning lamp illumination	
			MIL	Sport/ Manual
P1601 (4)	* ECU, EEPROM checksum	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P1606 (3)	* EEPROM	No apparent effect	On†	Off
P1606 (6)	* Watchdog	No apparent effect	On	On
P1612 (2)	* Solenoid valves power supply relay, sticking closed or open circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P1613 (1)	* Solenoid valves power supply relay, sticking open or short circuit	Limp home mode in low and high ranges. Shift pressure to maximum, harsh gear shifts/ engagement.	On	On
P1705 (39)	Transmission high/low range, implausible input	No apparent effect	On	Off
P1810 (12, 13)	Sport/Manual warning lamp circuit fault	Lamp fails bulb check or is permanently illuminated. No effect on gearbox operation.	On	Off
P1841 (16)	* CAN bus fault	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P1842 (15)	* CAN level monitoring	Maintains current gear in low range, limp home mode in range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P1843 (17)	* CAN time-out monitoring	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P1884 (11)	* CAN message: Engine friction invalid	No apparent effect.	On	Off
P1884 (18)	* CAN message: Throttle position invalid	Substitute throttle angle of 50% adopted. No kickdown. Operates in economy modes only.	On	On
P1884 (19)	CAN message: Engine temperature invalid	Substitute engine temperature derived from other inputs. No apparent effect.	On	Off
P1884 (20)	CAN message: Road speed invalid	No apparent effect	On	Off
P1884 (33, 34)	* CAN message: Engine torque invalid	Substitute engine torque of derived from other inputs. May affect shift quality.	On	Off
P1884 (35)	* CAN message: Engine speed invalid	Maintains current gear in low range, limp home mode in high range. Shift pressure to maximum, harsh gear shifts/engagement.	On	On
P1884 (37)	CAN message: Engine air intake temperature invalid	No apparent effect.	On	Off
P1844 (38)	Altitude shift control invalid	No reduced torque compensation, possible reduction in performance/ driveability at altitude or high ambient temperatures.	On	Off

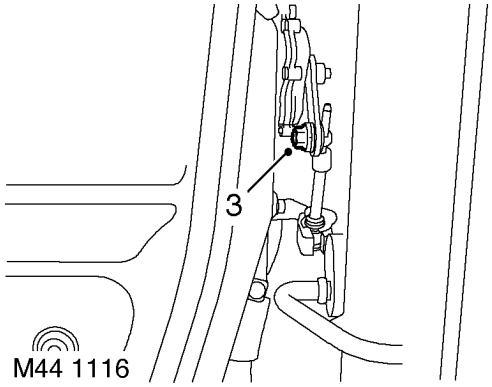
* = Emissions (OBD II) relevant
†On = MIL illuminates immediately (in all other faults, MIL On = illuminates in the 2nd consecutive drive cycle if fault still present)

Cable - selector

44.30.04

Check

1. Position vehicle on ramp.
2. Select position 'P'.



3. Loosen selector cable trunnion nut.
4. Ensure that gearbox selector lever is in 'P' position, (fully forward) and tighten trunnion nut.
5. Lower ramp.

Stall test

44.30.13

Testing

1. Chock the wheels and fully apply the handbrake.
2. Start the engine and run it until it reaches normal operating temperature.
3. Apply the footbrake and select **'D'**.
4. Fully depress the accelerator pedal and note the tachometer reading. The figures should be as given below. **Do not carry out stall test for longer than 10 seconds, and DO NOT repeat until 30 minutes have elapsed.**
   - **V8:** 2200 to 2400 rev/min
   - **Diesel:** 2600 to 2800 rev/min
5. A reading below 1300 rev/min indicates a torque converter fault, ie stator free-wheel.
6. A reading between 1300 and 2200 rev/min (V8) or between 1300 and 2600 rev/min (Diesel) indicates reduced engine power.
7. A reading above 2400 rev/min (V8) or above 2800 rev/min (Diesel) indicates clutch slip.

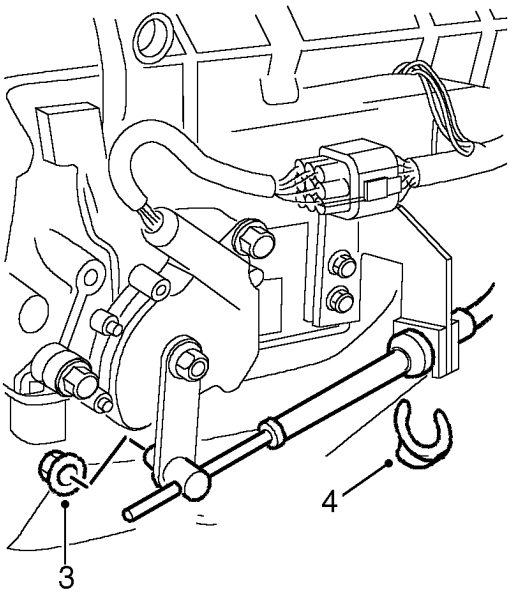
   NOTE: The figures quoted above were measured at sea level with an ambient temperature of 20°C (68°F). At higher altitudes or higher ambient temperatures, these figures will be reduced.

Cable and lever assembly - selector

44.15.08

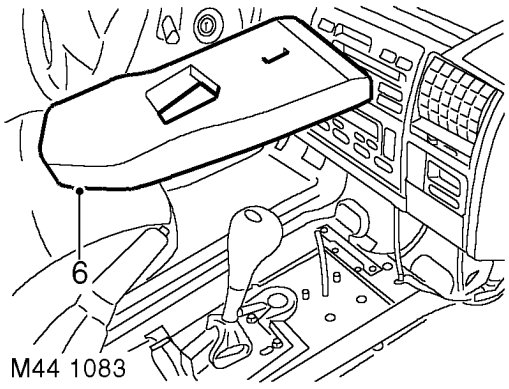
Remove

1. Remove centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
2. Raise vehicle on ramp.



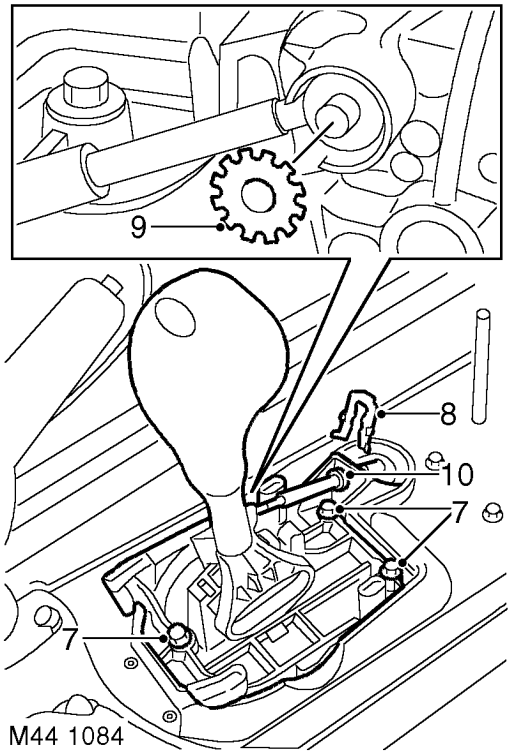
M44 1082

3. Loosen selector cable trunnion nut.
4. Remove 'C' clip and release selector cable from gearbox bracket.
5. Lower vehicle on ramp.



M44 1083

6. Remove sound deadener pad.



M44 1084

7. Remove 3 bolts securing selector lever bracket to tunnel, remove selector lever.
8. Remove 'C' clip securing outer cable to selector lever bracket.
9. Remove locking ring securing inner cable to selector lever.
10. Release inner cable from selector lever, release cable from grommet and remove cable from selector lever bracket.

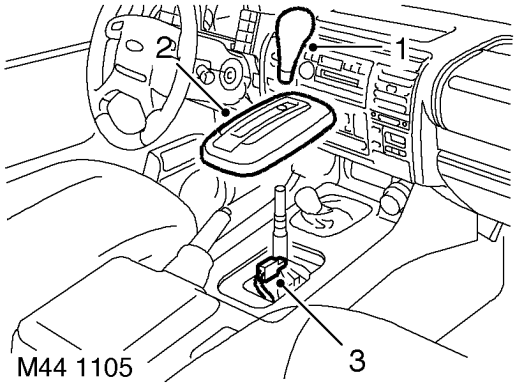
Refit

1. Position cable through grommet, align to bracket and secure with 'C' clip.
2. Fit inner cable to selector lever and secure with locking ring.
3. Feed selector cable through tunnel, align bracket, fit and tighten bolts.
4. Fit sound deadener pad.
5. Fit centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
6. Position selector cable through trunnion and gearbox bracket, secure with 'C' clip.
7. Adjust selector cable.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, ADJUSTMENTS, Cable - selector.

Selector indicator

44.15.10

Remove



1. Remove knob from gear lever.
2. Release selector panel from centre console.
3. Disconnect multiplug from selector panel and remove panel.

Refit

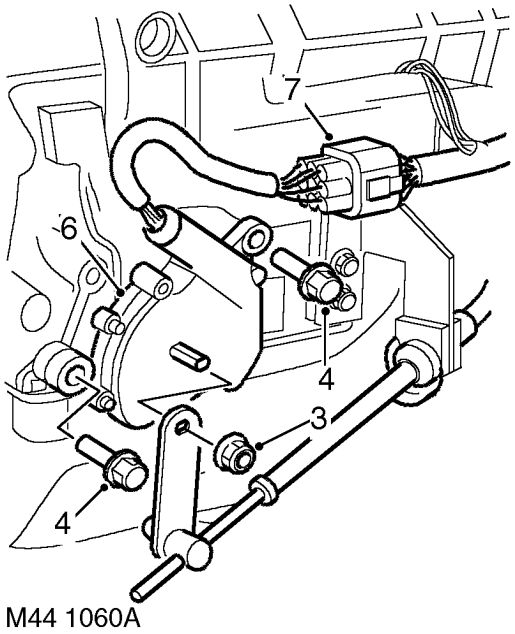
1. Position selector panel and connect multiplug.
2. Secure selector panel to console.
3. Fit gear lever knob.

Switch - starter inhibitor

44.15.19

Remove

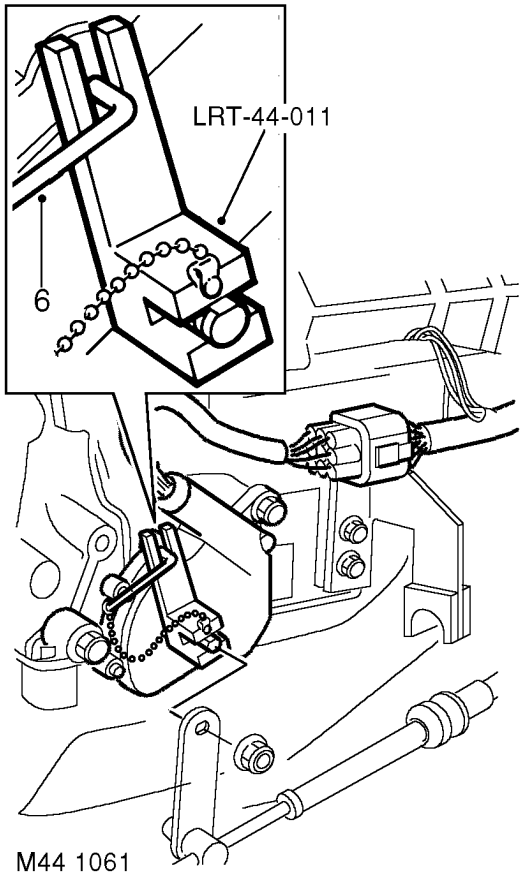
1. **Diesel models:** Remove exhaust front pipe.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**
2. Move the selector lever to position 'P'.



3. Remove nut securing selector lever to gearbox selector shaft and release lever.
4. Remove 2 bolts securing inhibitor switch to gearbox.
5. Release multiplug from gearbox bracket.
6. Release inhibitor switch from selector shaft.
7. Disconnect switch multiplug and remove switch.

Refit

1. Ensure 'P' is selected by rotating selector shaft fully clockwise.
2. Engage 'N' by rotating selector shaft 2 detents anti-clockwise.
3. Position inhibitor switch to selector shaft, connect multiplug and secure multiplug to gearbox bracket.
4. Engage switch to selector shaft, and fit but do not tighten retaining bolts.



M44 1061

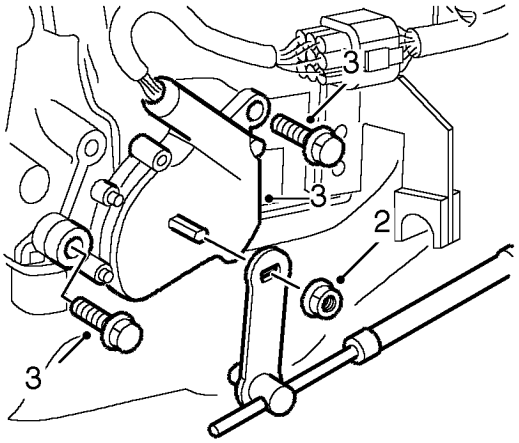
5. Fit tool **LRT-44-011** to selector shaft.
6. Insert setting pin into tool. Rotate switch until setting pin engages with hole in switch as shown and tighten bolts to 10 Nm (7 lbf.ft).
7. Remove setting tool **LRT-44-011.**
8. Position selector lever to selector shaft and tighten nut to 26 Nm (19 lbf.ft).
9. **Diesel models:** Fit exhaust front pipe.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**

Seal - selector shaft

⊸ ***44.15.34***

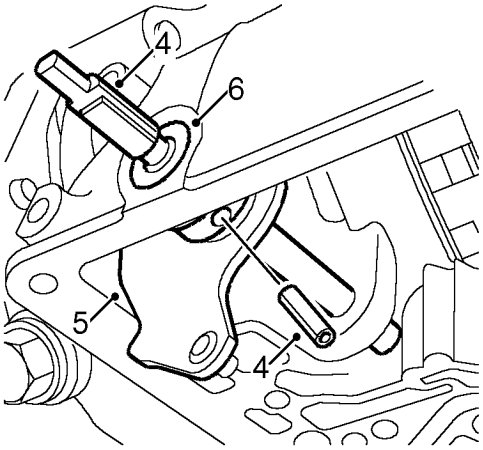
Remove

1. Remove valve body assembly.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.**



M44 1114A

2. Remove nut securing selector shaft lever and release lever from shaft.
3. Remove 2 bolts securing gear selector switch to gearbox and remove switch.



M44 1115A

4. Drift out and discard selector quadrant roll pin. Remove selector shaft.
5. Remove selector quadrant and connecting rod.
6. Remove oil seal taking care not to damage seal housing.

Refit

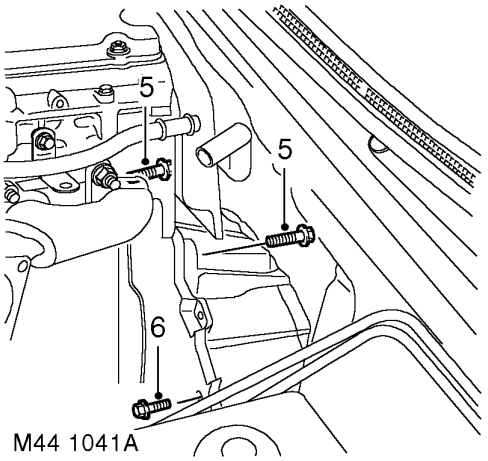
1. Clean shaft and seal housing.
2. Using a suitable adapter, fit new seal.
3. Position selector quadrant and connecting rod.
4. Position selector shaft and secure to quadrant using new roll pin.
5. Fit valve body assembly.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.**

Gearbox - convertor and transfer gearbox - Diesel

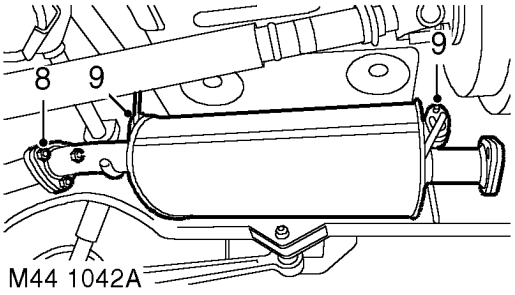
🔧 ***44.20.04.99***

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise vehicle on a ramp.
4. Remove starter motor
   ☞ **CHARGING AND STARTING, REPAIRS, Starter motor - diesel.**



5. Remove 2 upper bolts securing gearbox housing to engine.
6. Remove bolt securing closing plate to gearbox housing.
7. Remove exhaust front pipe.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**

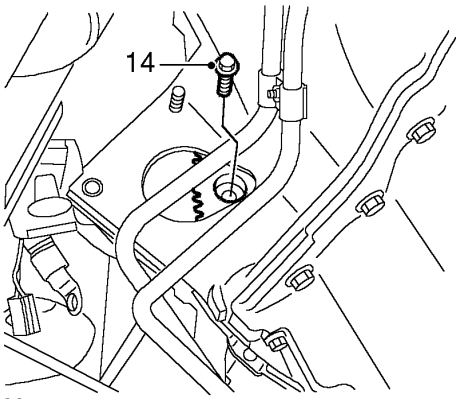


8. Remove 3 nuts securing intermediate silencer to tail pipe.
9. Release and remove silencer from rubber mountings.
10. Drain automatic gearbox oil.
    ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**

11. Drain transfer gearbox oil.
☞ **MAINTENANCE, PROCEDURES, Transfer box.**

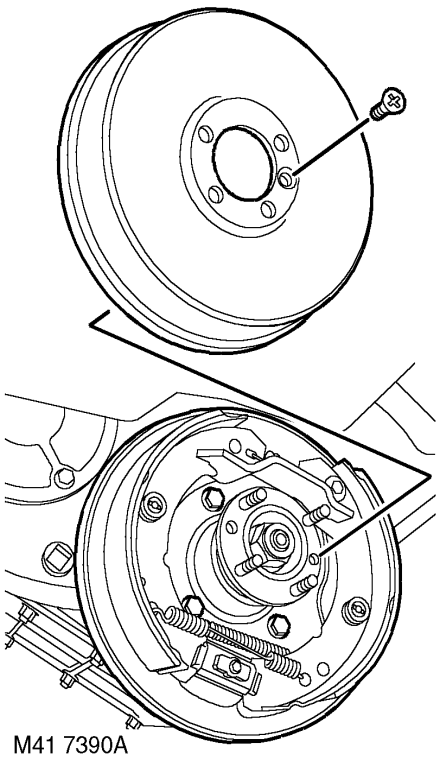
12. Remove front propeller shaft
☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**

13. Remove rear propeller shaft
☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**



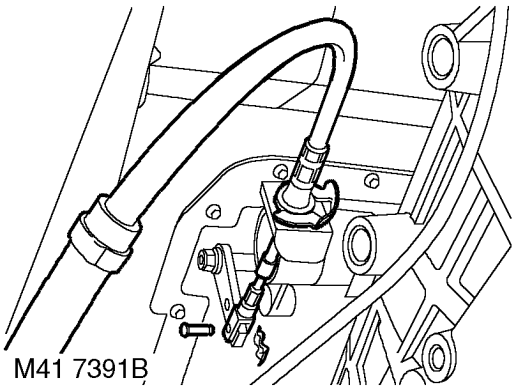
M44 1043A

14. Remove and discard 3 bolts securing torque converter to drive plate.

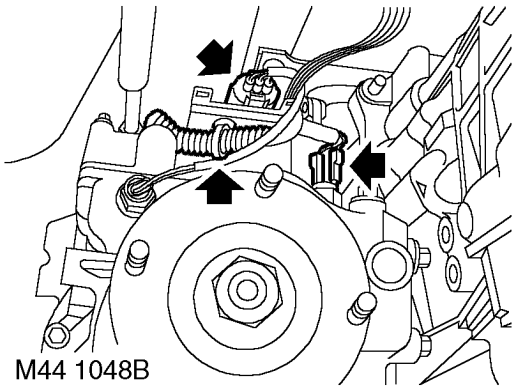

M41 7390A

15. Remove handbrake drum retaining screw and remove brake drum.

16. Remove 4 bolts from handbrake back plate, release back plate and tie aside.

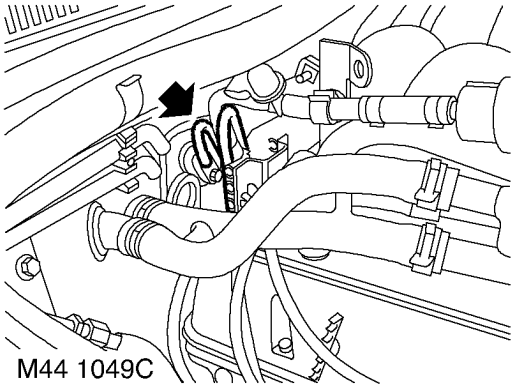

M41 7391B

17. Remove clip securing high/low ratio selector cable to transfer gearbox lever, remove 'C' clip and remove outer cable from gearbox.

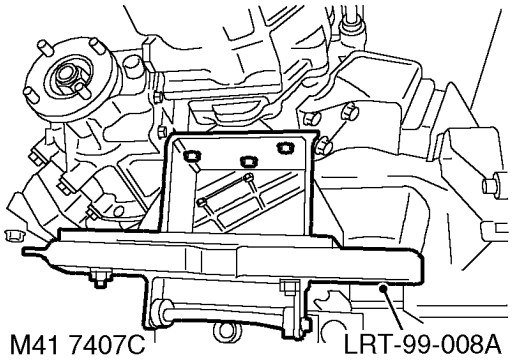

M44 1048B

18. Disconnect 2 Lucars from differential lock switch and multiplugs from high/low ratio switch and neutral sensor.

19. Remove cable tie and multi plug from bracket to transfer box.

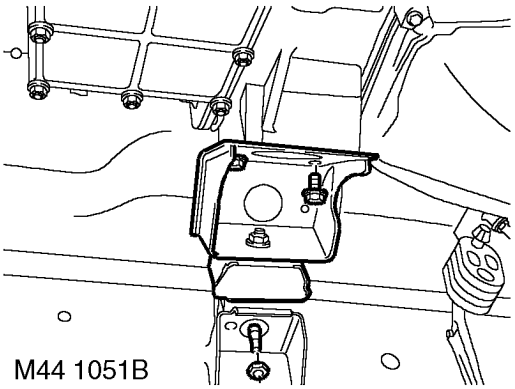

M44 1049C

20. Release transfer and automatic gearbox breather pipes from clip at rear of cylinder block.

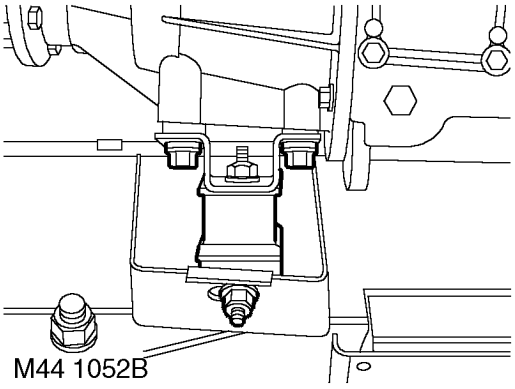

M41 7407C LRT-99-008A

21. Position gearbox support jack and secure tool **LRT-99-008A** to support plate on jack.

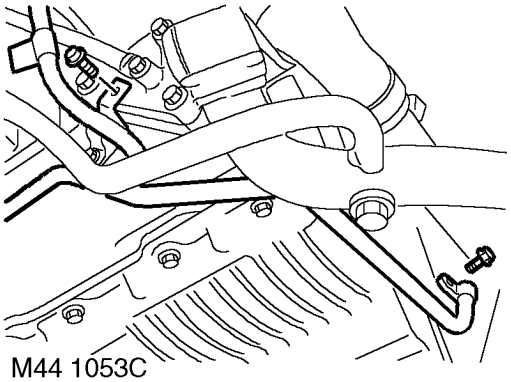
22. Position a second support jack under engine using a block between engine sump and jack to prevent damage to sump.


M44 1051B

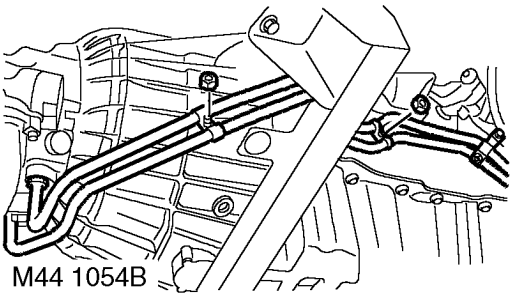
23. Remove 4 bolts and nut, remove engine LH rear mounting.


M44 1052B

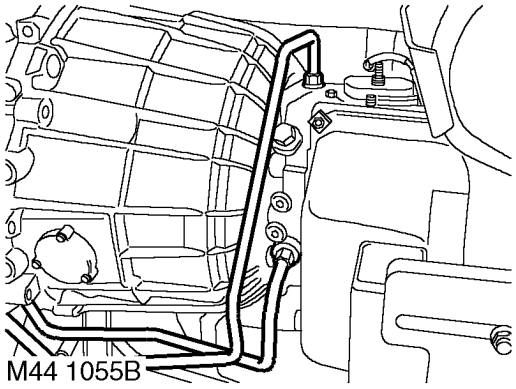
24. Remove 4 bolts and nut, remove engine RH rear mounting.


M44 1053C

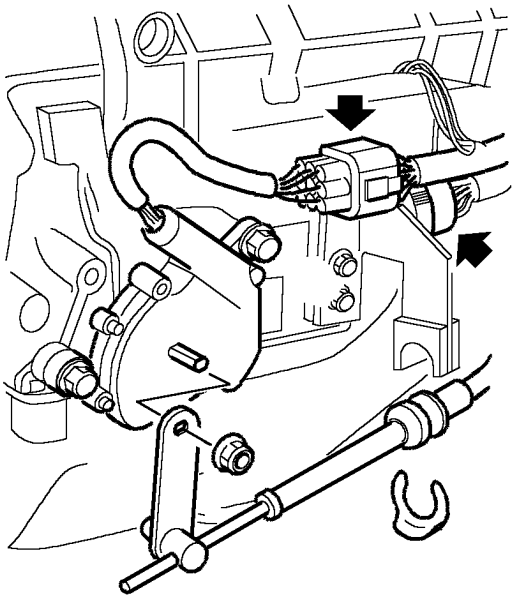
25. Remove 2 bolts securing gearbox oil cooler pipe clips to engine sump and alternator mounting bracket.


M44 1054B

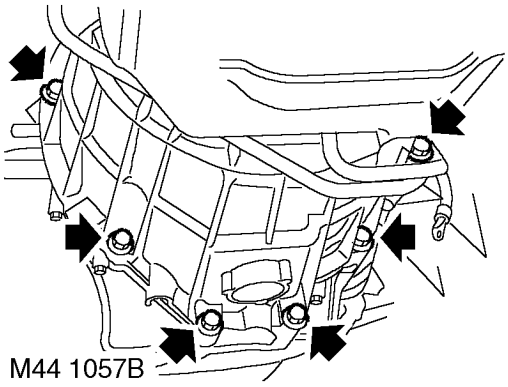
26. Remove bolt and 2 nuts securing clamps to oil cooler pipes and remove clamps.


M44 1055B

27. Loosen gearbox oil cooler pipe unions, release pipes from gearbox and discard 'O' rings.
CAUTION: Always fit plugs to open connections to prevent contamination.


M44 1056C

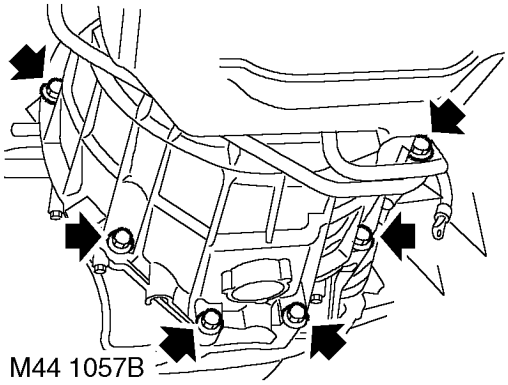
28. Remove 'C' clip securing selector cable to gearbox bracket.
29. Remove nut securing selector lever to inhibitor switch and release lever.
30. Disconnect multiplug from inhibitor switch.
31. Loosen gearbox multi plug locking ring and disconnect plug.


M44 1057B

32. Remove 6 remaining gearbox housing bolts.
33. With assistance remove automatic gearbox from engine.
34. Fit suitable strap to retain torque converter.

Refit

1. Clean gearbox to engine mating faces.
2. Remove torque converter retaining strap.
3. With assistance position gearbox to engine.


M44 1057B

4. Fit but do not tighten six bolts securing gearbox housing to engine.
5. Connect multiplug to gearbox and tighten locking ring.
6. Connect multiplug to inhibitor switch.
7. Position selector lever to inhibitor switch and tighten nut to 25 Nm (18 lbf.ft).
8. Position selector cable to gearbox and secure with 'C' clip.
9. Clean oil pipe unions and fit new 'O' rings.
10. Position and tighten pipe unions to gearbox.
11. Position and tighten oil cooler pipe clamps.
12. Position and tighten oil cooler pipe clips to engine sump and alternator bracket.
13. Position engine RH and LH rear mountings and tighten bolts to 85 Nm (63 lbf.ft) and nuts to 85 Nm (63 lbf.ft).

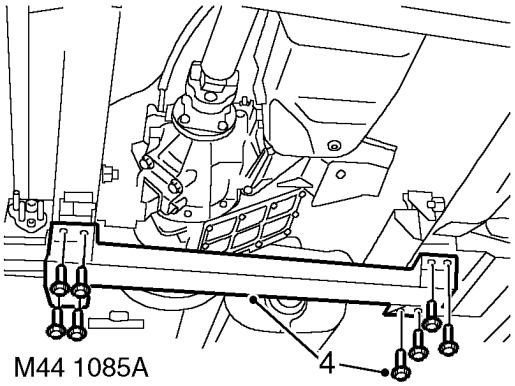
14. Secure gearbox breather pipes to bulkhead clip.
15. Connect multiplugs to high/low ratio switch and neutral sensor. Connect Lucars to differential lock switch.
16. Position cable tie and multi plug to transfer box bracket.
17. Connect high/low ratio cable to transfer box and secure with retaining clips.
18. Position hand brake back plate and tighten bolts to 75 Nm (55 lbf.ft).
19. Fit hand brake drum and tighten screw.
20. Remove bolts securing tool **LRT-99-008A** to gearbox.
21. Rotate engine to align torque converter, fit new bolts and tighten to 50 Nm (37 lbf.ft).
22. Fit rear propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**
23. Fit front propeller shaft.
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**
24. Fill transfer gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
25. Fill automatic gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**
26. Position intermediate silencer and secure to mounting rubbers.
27. Clean silencer and tail pipe mating faces.
28. Position new gasket to tail pipe and tighten nuts to 25 Nm (18 lbf.ft).
29. Fit exhaust front pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - Td5, REPAIRS, Pipe - front.**
30. Fit bolt securing closing plate to gearbox housing and tighten to 7 Nm (5.2 lbf.ft).
31. Fit upper bolts securing gearbox housing to engine and tighten to 50 Nm (37 lbf.ft).
32. Fit starter motor.
    ☞ **CHARGING AND STARTING, REPAIRS, Starter motor - diesel.**
33. Tighten remaining gearbox housing to engine bolts to 50 Nm (37 lbf.ft).
34. Connect battery earth lead.
35. Fit battery cover and secure with fixings.
36. Check and adjust selector cable.
    ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, ADJUSTMENTS, Cable - selector.**

Gearbox - convertor and transfer gearbox - V8

🔧 ***44.20.04.99***

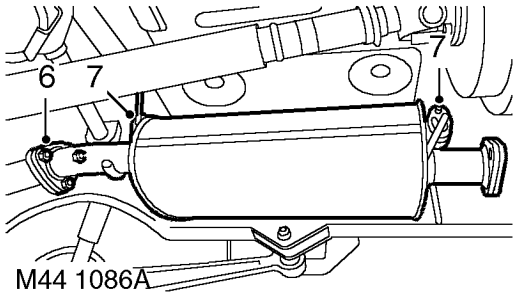
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise vehicle on a ramp.



M44 1085A

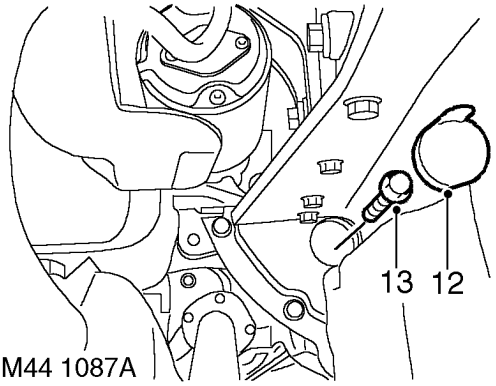
4. Remove 8 bolts securing centre cross member and remove cross member.
5. Remove exhaust front pipe.
    ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**



M44 1086A

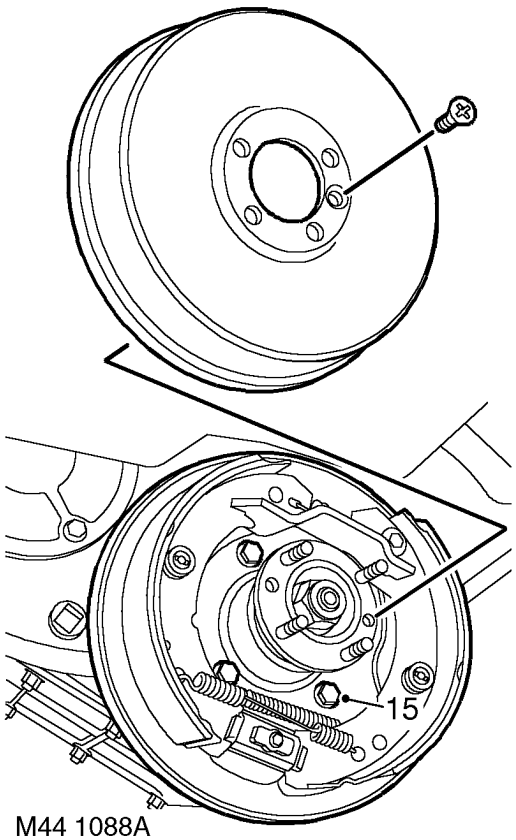
6. Remove 3 nuts securing intermediate silencer to tail pipe.
7. Release and remove silencer from rubber mountings.
8. Drain automatic gearbox oil.
    ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**
9. Drain transfer gearbox oil.
    ☞ **MAINTENANCE, PROCEDURES, Transfer box.**
10. Remove front propeller shaft
    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**

11. Remove rear propeller shaft
☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**



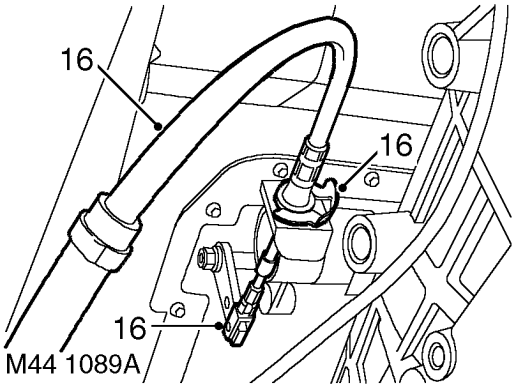
M44 1087A

12. Remove plug from torque converter housing to access torque converter bolts.
13. Remove and discard 4 bolts securing torque converter to drive plate.



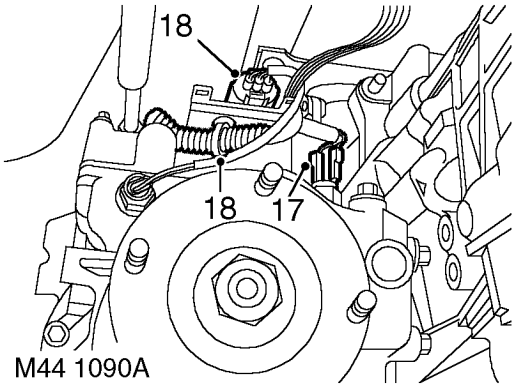
M44 1088A

14. Remove hand brake drum retaining screw and remove brake drum.
15. Remove 4 bolts from hand brake back plate, release back plate and tie aside.



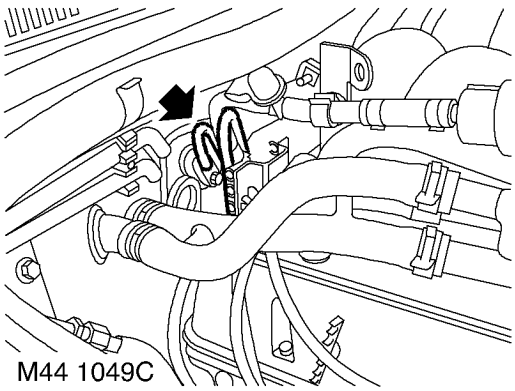
M44 1089A

16. Remove retaining clip securing high/low ratio selector cable to transfer gearbox lever, remove 'C' clip and remove outer cable from gearbox.

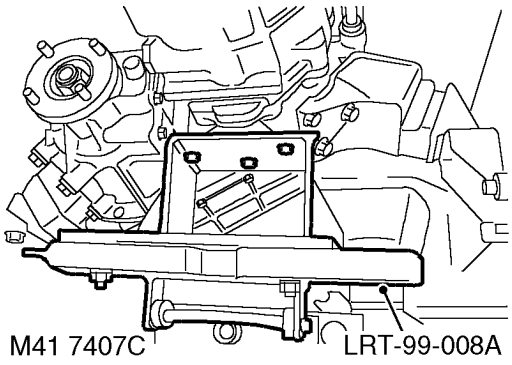


M44 1090A

17. Disconnect 2 Lucars from differential lock switch and multiplugs from high/low ratio switch and neutral sensor.
18. Remove cable tie and multiplug from bracket on transfer gearbox.

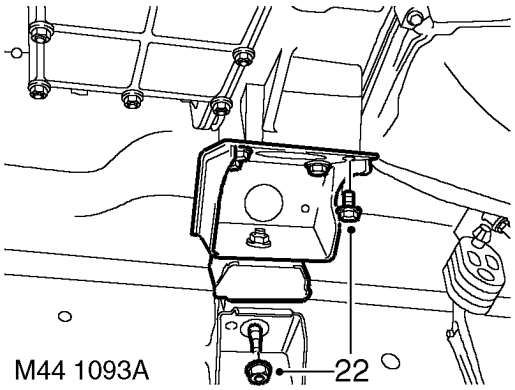

M44 1049C

19. Release transfer and automatic gearbox breather pipes from clip at rear of cylinder block.

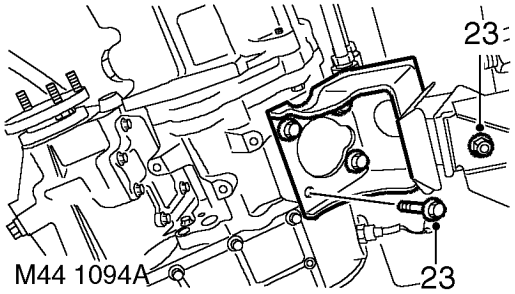


20. Position gearbox support jack and secure tool **LRT-99-008A** to support plate on jack.

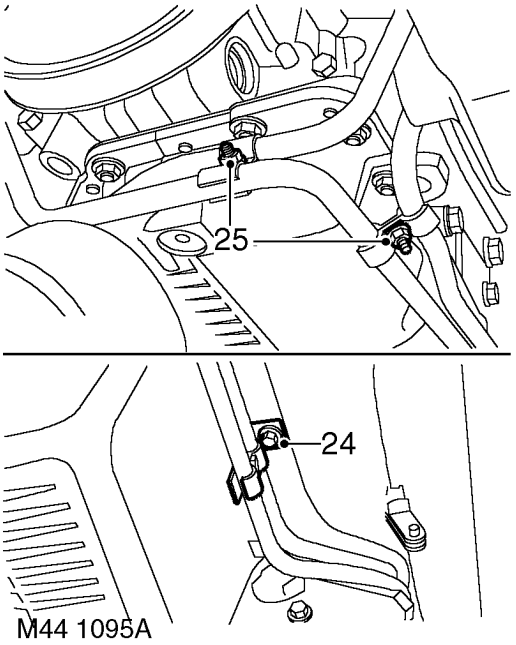
21. Position a second support jack under engine using a block between engine sump and jack to prevent damage to sump.



22. Remove 4 bolts and nut, remove engine LH rear mounting.

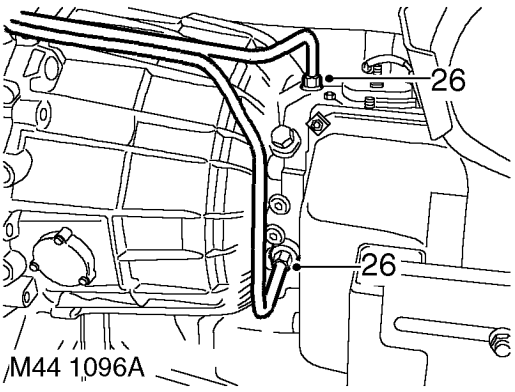


23. Remove 4 bolts and nut, remove engine RH rear mounting.



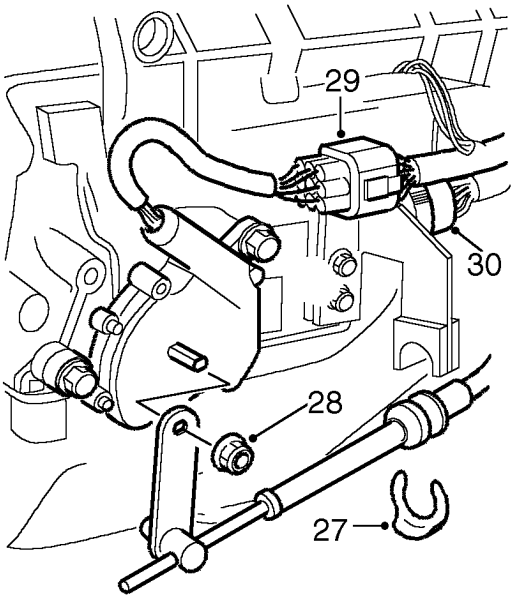
24. Remove bolt securing gearbox oil cooler pipe clips to engine.

25. Remove bolt and 2 nuts securing clamps to oil cooler pipes and remove clamps.



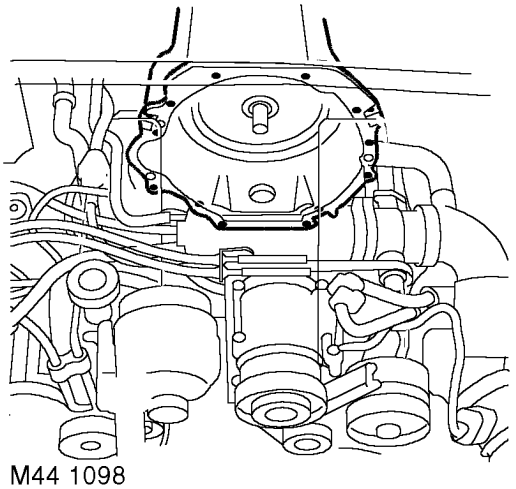
26. Loosen gearbox oil cooler pipe unions, release pipes from gearbox and discard 'O' rings.

CAUTION: Always fit plugs to open connections to prevent contamination.

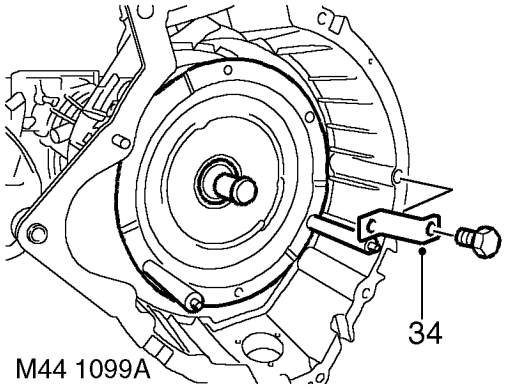


M44 1097A

27. Remove 'C' clip securing selector cable to gearbox bracket.
28. Remove nut securing selector lever to inhibitor switch and release lever.
29. Disconnect multiplug from inhibitor switch.
30. Loosen gearbox multiplug locking ring and disconnect plug.


M44 1098

31. Lower gearbox sufficiently to access bell housing bolts, take care not to trap any pipes or cables when lowering gearbox.
32. Remove 14 bolts securing gearbox to engine.
33. With assistance remove gearbox from engine.



M44 1099A

34. Fit suitable strap to retain torque converter.

Refit

1. Clean gearbox to engine mating faces.
2. Remove torque converter retaining strap.
3. With assistance position gearbox to engine.
4. Fit gearbox bell housing bolts and tighten to 46 Nm (34 lbf.ft)..
5. Connect multiplug to gearbox and tighten locking ring.
6. Connect inhibitor switch multiplug.
7. Position selector lever to inhibitor switch and tighten nut to 25 Nm (18 lbf.ft).
8. Position selector cable to gearbox and secure with 'C' clip.
9. Clean oil pipe unions and fit new 'O' rings.
10. Position and tighten pipe unions to gearbox.
11. Position and tighten oil cooler pipe clamps.
12. Position and tighten oil cooler pipe clip to engine sump.
13. Position engine RH and LH rear mountings and tighten bolts to 85 Nm (63 lbf.ft) and nuts to 85 Nm (63 lbf.ft).
14. Secure gearbox breather pipes to bulkhead clip.
15. Connect multiplugs to high/low ratio switch and neutral sensor. Connect Lucar connectors to differential lock switch.
16. Position cable tie and multiplug to transfer gearbox bracket.
17. Connect high/low ratio cable to transfer box and secure with retaining clips.
18. Position hand brake back plate and tighten bolts to 75 Nm (55 lbf.ft).
19. Fit hand brake drum and tighten screw.
20. Remove bolts securing tool **LRT-99-008A** to gearbox.
21. Rotate engine to align torque converter, fit new bolts and tighten to 50 Nm (37 lbf.ft).
22. Fit access plug to torque converter housing.
23. Fit rear propeller shaft.
☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**

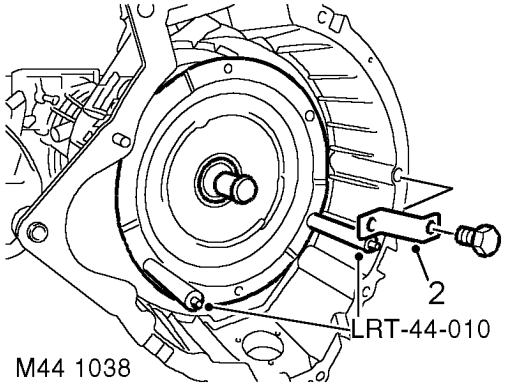
24. Fit front propeller shaft.
☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.**
25. Fill transfer gearbox with oil.
☞ **MAINTENANCE, PROCEDURES, Transfer box.**
26. Fill automatic gearbox with oil.
☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**
27. Position intermediate silencer and secure to mounting rubbers.
28. Clean silencer and tail pipe mating faces.
29. Position new gasket to tail pipe and tighten nuts to 40 Nm (30 lbf.ft).
30. Fit exhaust front pipe.
☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Front pipe.**
31. Position centre cross member, fit bolts and tighten to 26 Nm (19 lbf.ft).
32. Connect battery earth lead.
33. Fit battery cover and secure fixings.
34. Check and adjust selector cable.
☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, ADJUSTMENTS, Cable - selector.**

Torque converter and oil seal

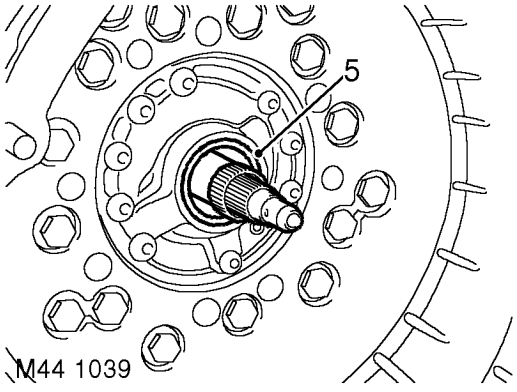
44.17.07

Remove

1. Remove automatic gearbox.
- ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - Diesel.**
- ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - V8.**



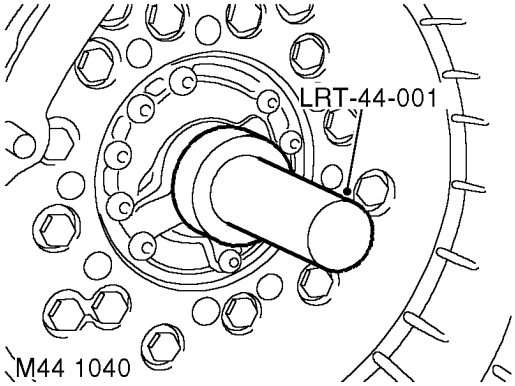
2. Remove retaining strap from torque convertor.
3. Fit tool **LRT-44-010** to torque converter and remove torque converter from gearbox.
4. Remove tool **LRT-44-010** from converter.



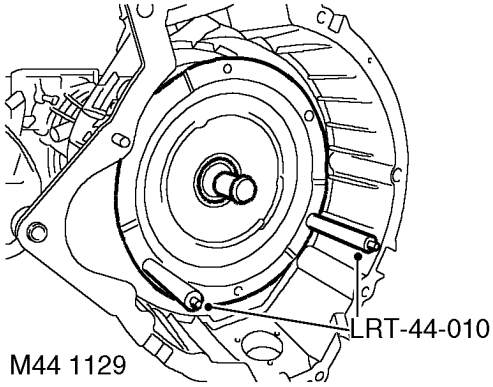
5. Remove oil seal from converter housing.

Refit

1. Clean oil seal running surfaces.
2. Lubricate oil seal with transmission fluid.



3. Fit new seal into converter housing using tool **LRT-44-001**.



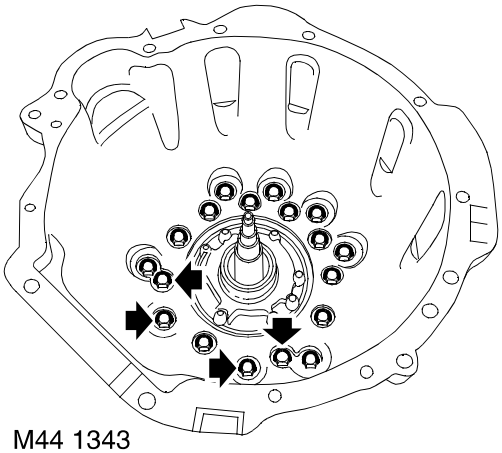
4. Fit tool **LRT-44-010** to torque converter.
5. Align oil pump drive and fit torque converter to gearbox.
6. Remove tool **LRT-44-010** from torque converter.
7. Fit torque converter retaining strap.
8. Fit automatic gearbox.
   - ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - Diesel.**
   - ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gearbox - convertor and transfer gearbox - V8.**

Housing - torque converter

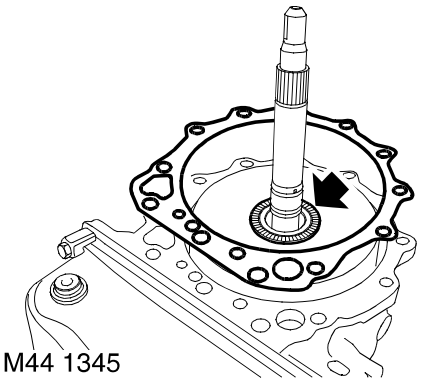
⊸ ***44.17.01***

Remove

1. Remove torque converter oil seal.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Torque converter and oil seal.**



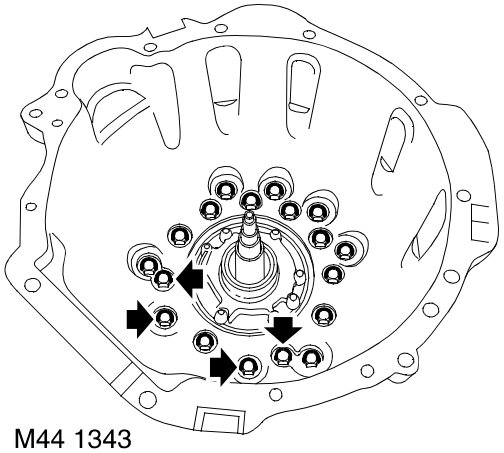
2. Remove 18 bolts and plain washers securing torque converter and intermediate plate to gearbox casing. Note the position of the 4 bolts that have sealant applied to the bolt threads and 6 bolts, (outer ring), which are shorter.
3. Hold input shaft in position and carefully remove the converter housing and intermediate plate from gearbox casing.



4. Note the position of the Torrington race on the forward clutch hub and the thrust washer which will stay attached to the intermediate plate by fluid adhesion.
5. Remove and discard intermediate plate gasket.
6. Remove thrust washer from intermediate plate.
7. Separate converter housing from intermediate plate.

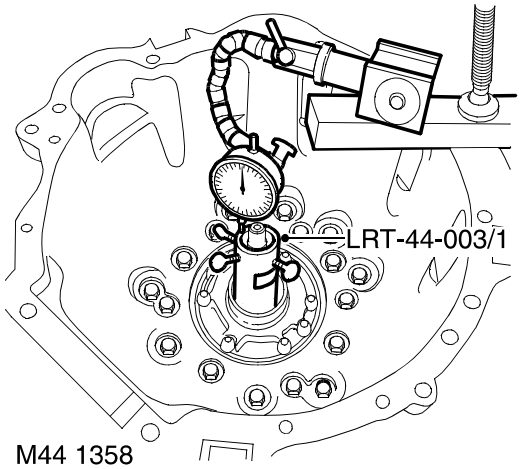
Refit

1. Clean converter housing, intermediate plate and gearbox casing mating faces.
2. Clean bolts and plain washers and sealant from 4 bolt threads.
3. Apply Petroleum Jelly to new gasket and position on gearbox casing.
4. Apply Petroleum Jelly to thrust washer and Torrington race.
5. Correctly position Torrington race and thrust washer to forward clutch hub.
6. Position intermediate plate and converter housing to gearbox casing.



M44 1343

7. Apply High Formular Hylomar sealant to 4 longer bolt threads and fit bolts in the positions shown.
8. Fit remaining bolts and tighten progressively in a diagonal sequence to 46 Nm (34lbf. ft).



M44 1358

9. Place **LRT-44-003/1** into pump housing, tighten screws to secure **LRT-44-003/1** to input shaft.
10. Clamp a suitable steel base to converter housing flange.
11. Mount DTI gauge and position gauge probe onto **LRT-44-003/1** and zero gauge.
12. Check that the axial end-float is between 0.2 to 0.4 mm. If end-float is not within limits, replace existing thrust washer, positioned at rear of intermediate plate, with a suitable thickness thrust washer to give the required end-float.
13. Remove DTI gauge and base plate.
14. Fit torque converter oil seal.

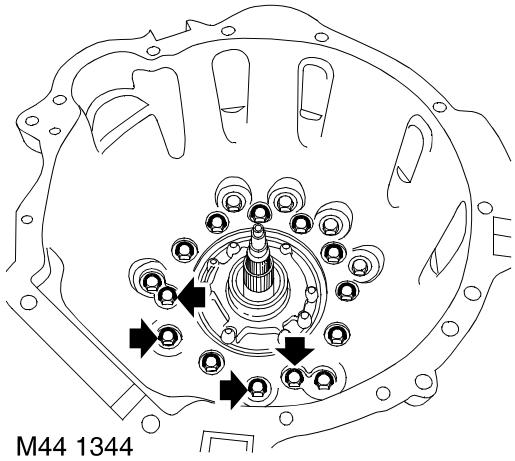
☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Torque converter and oil seal.**

Gasket - intermediate plate

44.20.11

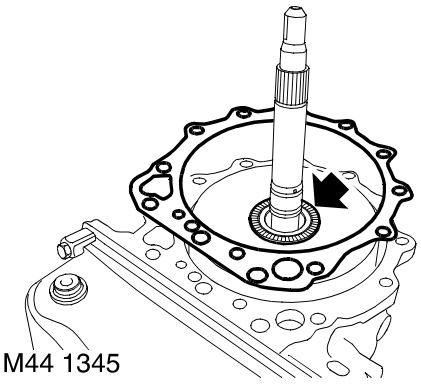
Remove

1. Remove torque converter oil seal.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Torque converter and oil seal.



M44 1344

2. Remove 12 bolts and plain washers securing converter housing and intermediate plate to gearbox casing. Note the position of the 4 bolts that have sealant applied to the bolt threads.
3. Hold input shaft in position and carefully lift off converter housing and intermediate plate as an assembly. Note the position of the Torrington race on the forward clutch hub, and the thrust washer which will stay attached to the intermediate plate by fluid adhesion.

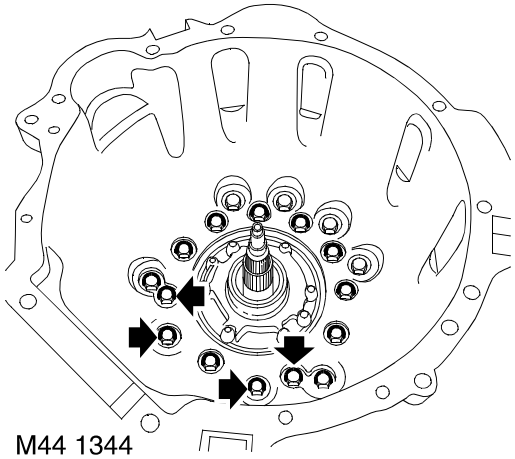


M44 1345

4. Remove and discard intermediate plate gasket.
5. Remove thrust washer from intermediate plate.

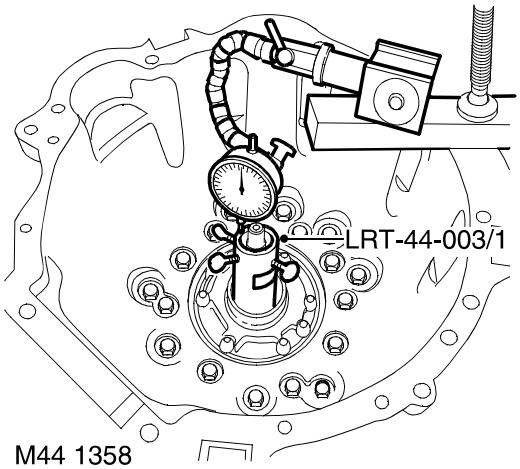
Refit

1. Clean intermediate plate and mating face on gearbox casing.
2. Apply Petroleum Jelly to new gasket and position on gearbox casing.
3. Apply Petroleum Jelly to thrust washer and Torrington race.
4. Correctly position Torrington race and thrust washer to forward clutch hub.
5. Position converter housing and intermediate plate assembly to gearbox casing.
6. Clean bolts and plain washers and old sealant from 4 bolt threads.



M44 1344

7. Apply High Formular Hylomar sealant to 4 longer bolt threads and fit bolts in position shown.
8. Fit remaining bolts and tighten progressively in a diagonal sequence to 46 Nm (34lbf. ft).



M44 1358

9. Place **LRT-44-003/1** into pump housing, tighten screws to secure **LRT-44-003/1** to input shaft.
10. Clamp a suitable steel base to converter housing flange.

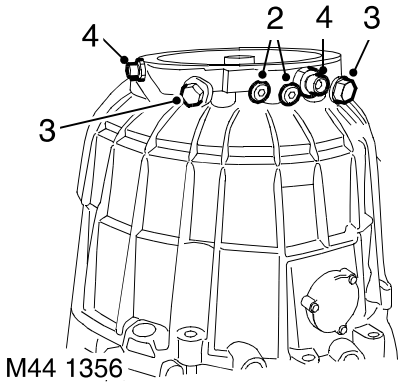
11. Mount DTI gauge and position gauge probe onto **LRT-44-003/1** and zero gauge.
12. Check that the axial end-float is between 0.2 to 0.4 mm (0.008 to 0.016 in). If end-float in not within limits, replace existing thrust washer, positioned at rear of intermediate plate, with a suitable thickness thrust washer to give the required end-float.
13. Remove DTI gauge and base plate.
14. Fit torque converter oil seal.
    ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Torque converter and oil seal.**

Intermediate plate

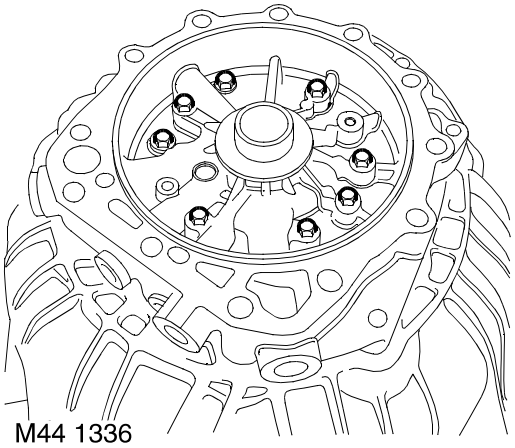
44.17.20

Remove

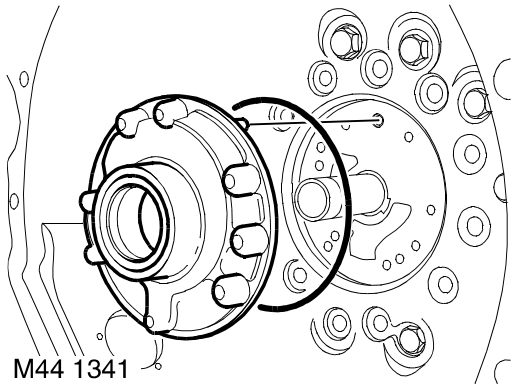
1. Remove intermediate plate gasket.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - intermediate plate.**
2. Remove selective thrust washer from intermediate plate.



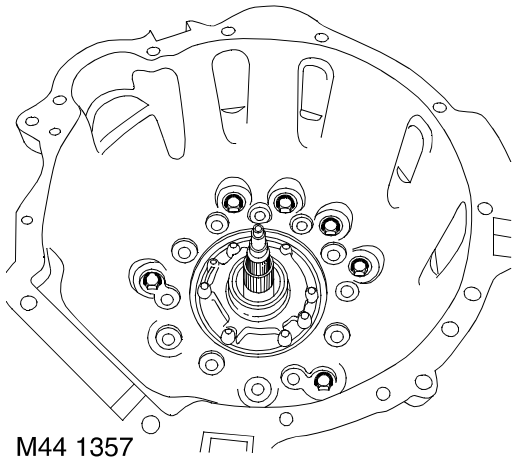
3. Remove 2 M14 Allen plugs from intermediate plate, remove and discard sealing washers.
4. Remove 2 M20 plugs from intermediate plate, remove and discard sealing washers.
5. Remove 2 oil cooler pipe adaptors from intermediate plate.



6. Remove 8 bolts securing fluid pump to intermediate plate and carefully remove pump from intermediate plate.


M44 1341

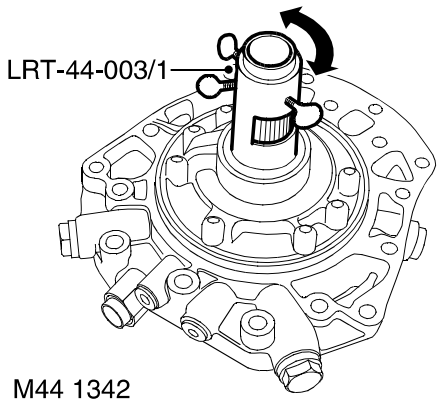
7. Note position and remove pump locating dowel.
8. Remove and discard 'O' ring from pump housing.


M44 1357

9. Remove 6 bolts securing converter housing to intermediate plate, and release intermediate plate from converter housing.

Refit

1. Clean intermediate plate and mating faces with a lint free cloth.
2. Position intermediate plate to converter housing, fit bolts and tighten evenly to 46 Nm (34 lbf.ft)
3. Fit new sealing washers to M14 Allen plugs, fit plugs and tighten to 40 Nm (30 lbf.ft).
4. Fit new sealing washers to M20 plugs, fit plugs and tighten to 50 Nm (37 lbf.ft).
5. Fit oil cooler adaptors and tighten to 42 Nm (30 lbf.ft)
6. Clean pump housing and mating face on intermediate plate with lint free cloth.
7. Lubricate new 'O' ring with transmission fluid and fit to pump housing.
8. Position pump locating dowel into intermediate plate.
9. Align pump to dowel and position in intermediate plate.
10. Fit bolts and tighten in a diagonal sequence to 10 Nm (7 lbf.ft)



M44 1342

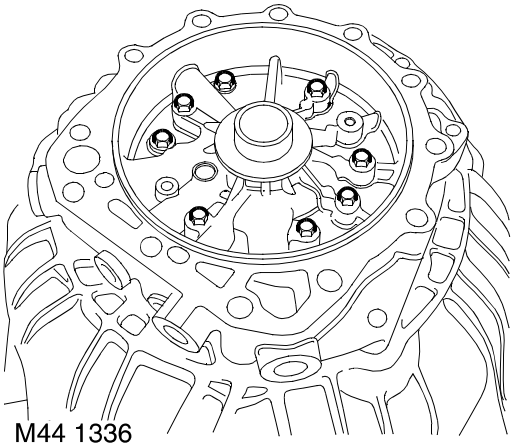
11. Position **LRT-44-003/1** into pump and check that the pump rotors turn freely.
12. Fit intermediate plate gasket.
    ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - intermediate plate.**

Pump - fluid

44.32.01

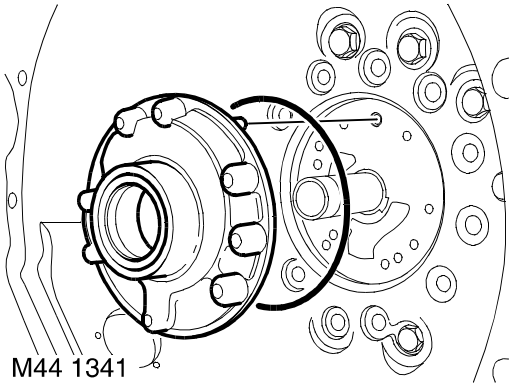
Remove

1. Remove intermediate plate gasket.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - intermediate plate.



M44 1336

2. Remove 8 bolts securing fluid pump to intermediate plate and carefully remove pump from intermediate plate.

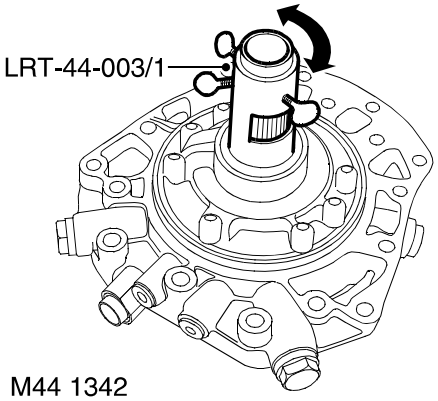


M44 1341

3. Note position and remove pump locating dowel.
4. Remove and discard 'O' ring from pump housing.

Refit

1. Clean pump housing and mating face on intermediate plate with lint free cloth.
2. Lubricate new 'O' ring with transmission fluid and fit to pump housing.
3. Position pump locating dowel into intermediate plate.
4. Align fluid pump to dowel and position in intermediate plate.
5. Fit bolts and tighten in a diagonal sequence to 10 Nm (7 lbf.ft)



M44 1342

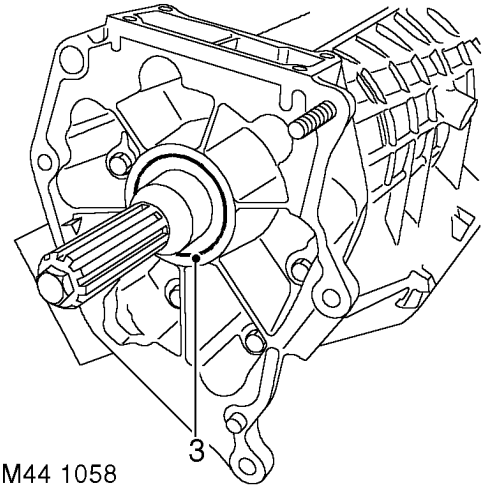
6. Position **LRT-44-003/1** into pump and check that the pump rotors turn freely.
7. Fit intermediate plate gasket.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - intermediate plate.

Seal - rear extension housing

44.20.18

Remove

1. Remove transfer box
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.
2. Drain automatic gearbox oil.
   MAINTENANCE, PROCEDURES, Automatic gearbox.

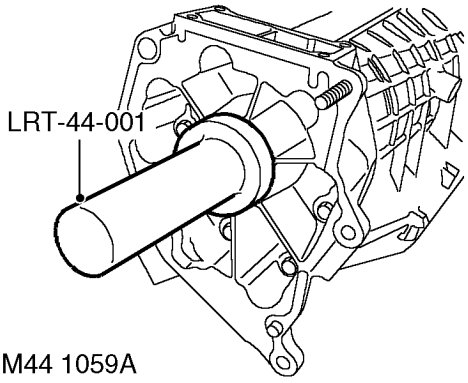


M44 1058

3. Remove rear extension housing oil seal from gearbox.

Refit

1. Clean oil seal recess in gearbox and running surface on input shaft.
2. Lubricate oil seal running surface with transmission oil.



M44 1059A

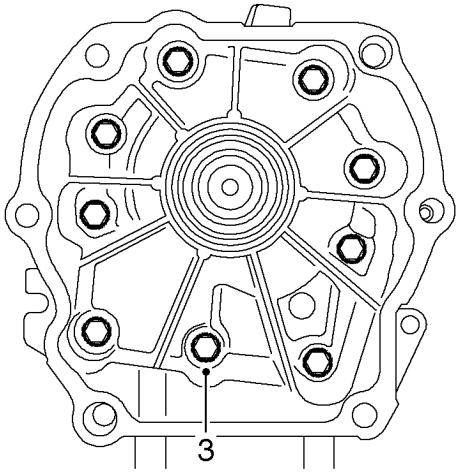
3. Using tool **LRT-44-001** fit oil seal to extension housing.
4. Fit transfer box
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.
5. Fill automatic gearbox with oil.
   MAINTENANCE, PROCEDURES, Automatic gearbox.

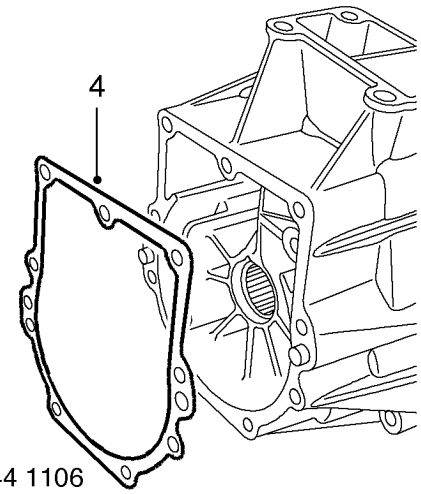
Gasket - rear extension housing.

44.20.19

Remove

1. Drain automatic gearbox oil.
   MAINTENANCE, PROCEDURES, Automatic gearbox.
2. Remove transfer gearbox.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.





M44 1106

3. Remove 9 bolts securing rear extension housing to gearbox case and remove housing.
4. Remove and discard gasket.

Reassembly

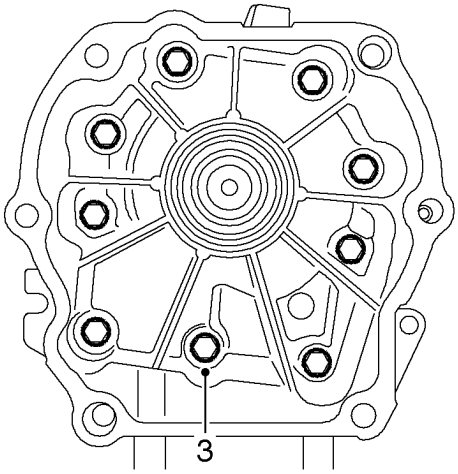
1. Clean rear extension and mating face.
2. Position new gasket to gearbox case.
3. Position rear extension housing and tighten bolts to 25 Nm (18 lbf.ft).
4. Fit transfer gearbox.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.
5. Fill automatic gearbox with oil.
   MAINTENANCE, PROCEDURES, Automatic gearbox.

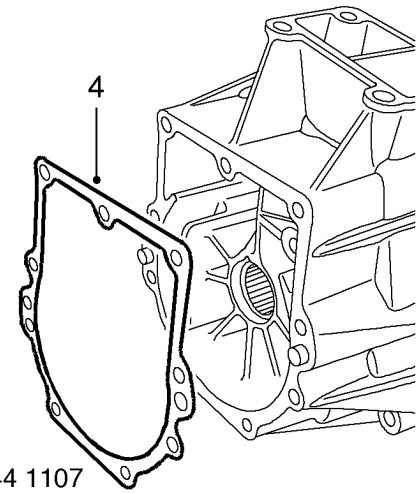
Parking pawl assembly.

44.28.07

Remove

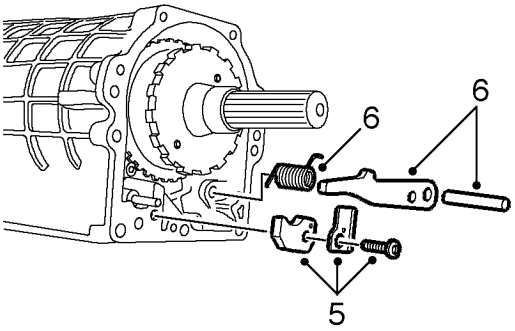
1. Drain automatic gearbox oil.
   MAINTENANCE, PROCEDURES, Automatic gearbox.
2. Remove transfer gearbox.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.
   TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.





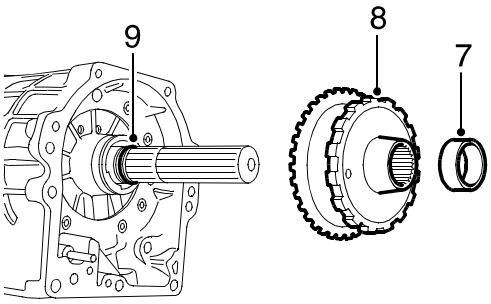
M44 1107

3. Remove and discard 9 bolts securing extension housing to gearbox case.
4. Remove extension housing and discard gasket.



M44 1108

5. Remove Torx screw and discard, lift off parking pawl guide and guide plate.
6. Remove ratchet, spring and pivot pin.



M44 1109B

7. **Td5 models:** Remove spacer from output shaft.
8. Remove park lock gear.
9. Remove and discard 'O' ring from output shaft.

Refit

1. Clean park lock components.
2. Lubricate and fit new 'O' ring to output shaft.
3. Position park lock gear on the output shaft.
4. **Td5 models:** Fit the spacer.

   CAUTION: Ensure that spacer is fitted on output shaft - Tdi Models only. If spacer is omitted, park gear and speed sensor may move out of position.

5. Position pivot pin, spring and ratchet.
6. Position parking pawl guide and guide plate, tighten Torx screw to 10 Nm (8 lbf.ft).

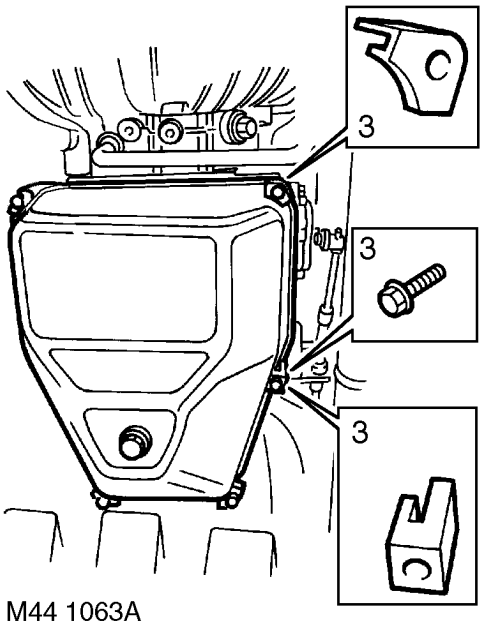
7. Clean extension housing and gearbox case.
8. Position new gasket to gearbox case.
9. Position extension housing and tighten bolts to 25 Nm (18 lbf.ft).
10. Fit transfer gearbox.
    ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - Diesel.**
    ☞ **TRANSFER BOX - LT230SE, REPAIRS, Transfer box - V8.**
11. Fill automatic gearbox with oil.
    ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**

Gasket - oil sump

44.24.05

Remove

1. Raise vehicle on ramp.
2. Drain automatic gearbox oil.
   ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**



M44 1063A

3. Remove 6 bolts and spacers securing oil sump to gearbox, remove sump and discard gasket.

Refit

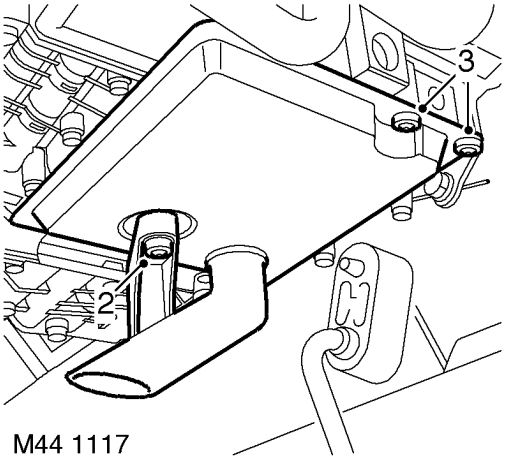
1. Clean oil sump and mating face.
2. Fit new gasket to oil sump, position sump to gearbox.
3. Position spacers and tighten bolts to 8 Nm (6 lbf. ft).
4. Fill automatic gearbox with oil.
   ☞ **MAINTENANCE, PROCEDURES, Automatic gearbox.**
5. Lower vehicle.

Filter - oil

44.24.07

Remove

1. Remove oil sump gasket.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - oil sump.



M44 1117

2. Remove Torx screw securing oil pick-up tube and remove tube.
3. Remove 2 Torx screws securing filter to valve body and discard 'O' rings.

Refit

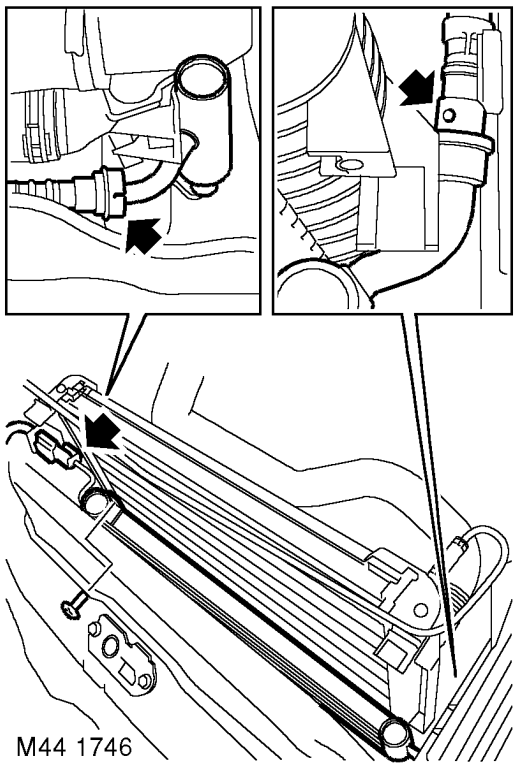
1. Clean filter and pick-up tube using a lint free cloth.
2. Fit new 'O' rings to filter.
3. Position filter and tighten Torx screws to 8 Nm (6 lbf.ft).
4. Position oil pick-up tube and tighten Torx screw to 8 Nm (6 lbf.ft).
5. Fit oil sump gasket.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Gasket - oil sump.

Cooler - fluid - Td5

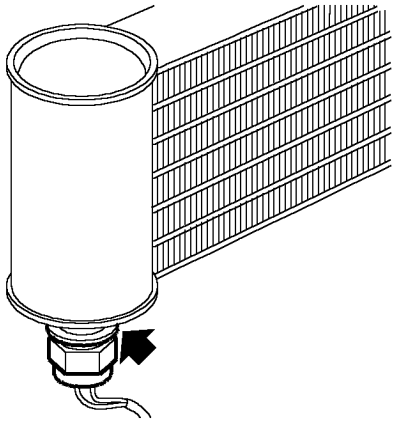
44.24.10

Remove

1. Remove intercooler.
   ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.


M44 1746

2. Disconnect fluid temperature sensor multiplug.
3. Position absorbent cloth under each gearbox cooler hose connection to collect spillage.
4. Push against coupling release ring and disconnect both fluid hoses from cooler.
5. Remove screw and release cooler from radiator.
6. Carefully remove cooler.


M44 1747

7. Remove temperature sensor and discard sealing washer.

Refit

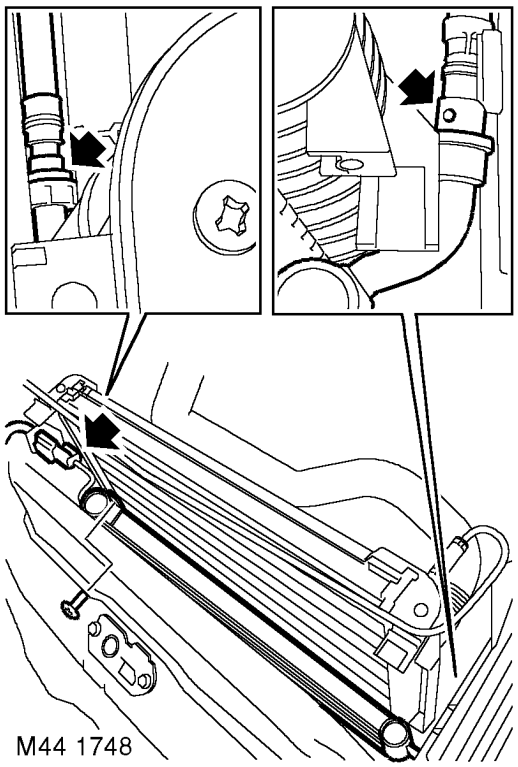
1. Use new sealing washer and tighten temperature sensor to 14 Nm (10 lbf.ft).
2. Fit cooler, engage with radiator and secure with screw.
3. Connect temperature sensor multiplug.
4. Ensure connections are clean and fit hoses to cooler.
5. Fit intercooler.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Intercooler.**
6. Check and if necessary top up gearbox fluid.

Cooler - fluid - V8

🔧 ***44.24.10***

Remove

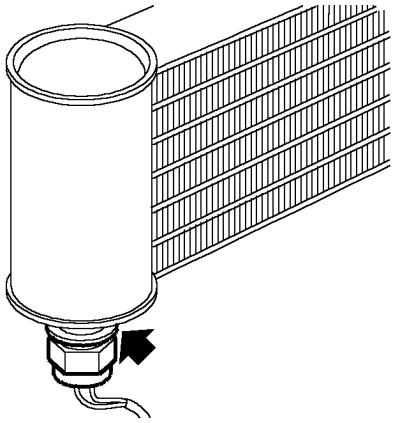
1. **If fitted:** Remove engine oil cooler.
   ☞ **ENGINE - V8, REPAIRS, Cooler - engine oil.**


M44 1748

2. Disconnect fluid temperature sensor multiplug.
3. Position absorbent cloth under each gearbox cooler hose connection to collect spillage.
4. Push against coupling release ring and disconnect both fluid hoses from cooler.

   CAUTION: Always fit plugs to open connections to prevent contamination.

5. Remove screw and release cooler from radiator.
6. Carefully move radiator towards engine and remove cooler.


M44 1747

7. Remove temperature sensor and discard sealing washer.

Refit

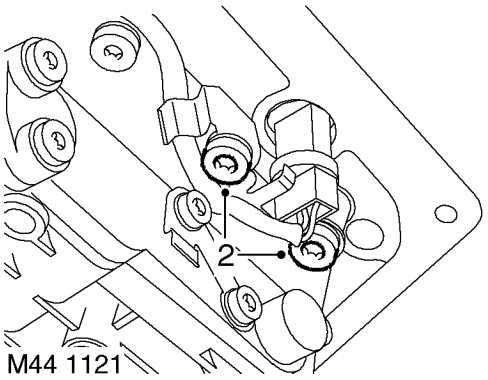
1. Use new sealing washer and tighten temperature sensor to 14 Nm (10 lbf.ft).
2. Fit cooler, engage with radiator and secure with screw.
3. Connect temperature sensor multiplug.
4. Ensure connections are clean and fit hoses to cooler.
5. **If fitted:**Fit engine oil cooler.
   ☞ **ENGINE - V8, REPAIRS, Cooler - engine oil.**
6. Check and if necessary top up gearbox fluid.

Valve body assembly

🔧 ***44.40.01***

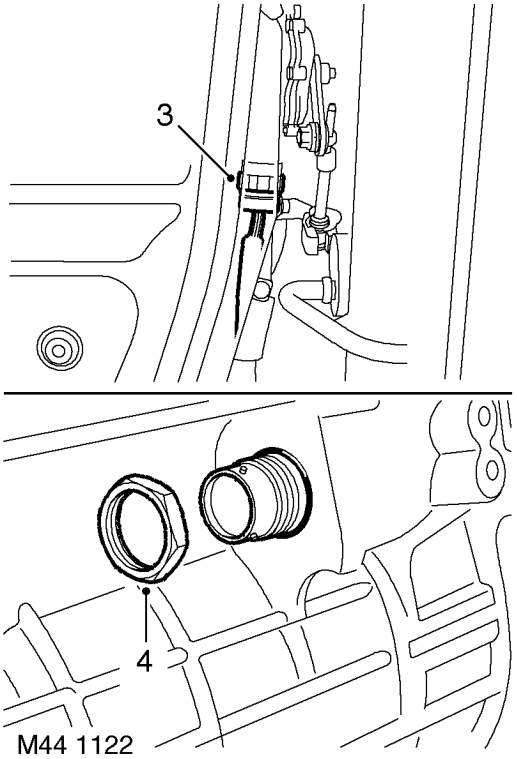
Remove

1. Remove gearbox oil filter.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Filter - oil.**



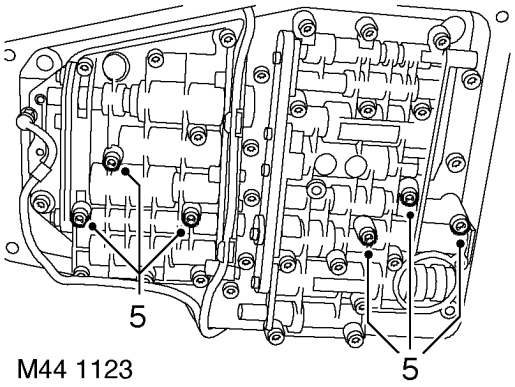
M44 1121

2. Remove 2 bolts securing speed sensor harness bracket to valve body.



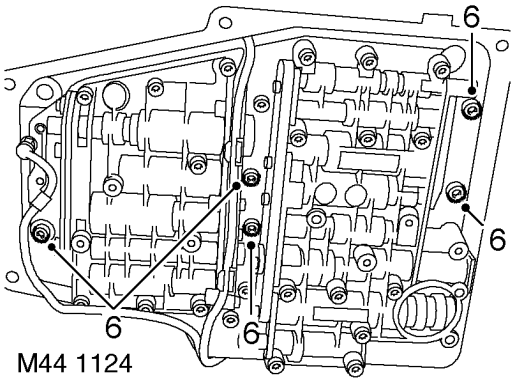
M44 1122

3. Disconnect multiplug from gearbox housing.
4. Using a 30 mm socket, remove nut securing multiplug connector block to gearbox housing.



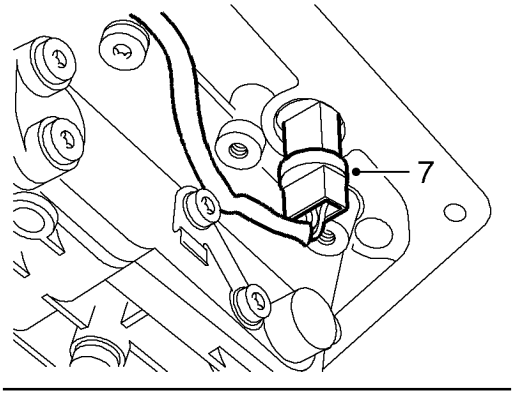
M44 1123

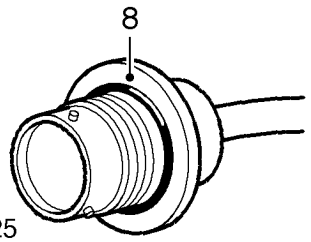
5. Remove 6 long bolts securing valve body to gearbox.



M44 1124

6. Remove 5 short bolts securing valve body to gearbox.





M44 1125

7. Release speed sensor and remove valve body.
8. Remove and discard 'O' ring from multiplug connector.

Refit

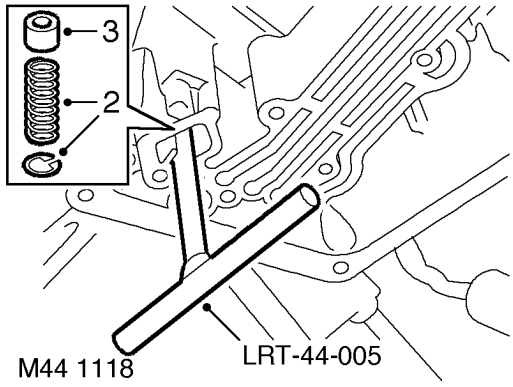
1. Clean valve body and mating faces.
2. Fit new 'O' ring to multiplug connector block.
3. With assistance, position multiplug to gearbox housing and tighten nut.
4. Align valve body to gearbox, ensure manual valve is correctly located. Position speed sensor retaining bracket, and tighten screws to 8 Nm (6 lbf.ft).
5. Connect multiplug to gearbox connector.
6. Fit gearbox oil filter.
☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Filter - oil.**

Seal - valve body

44.20.13

Remove

1. Remove valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.

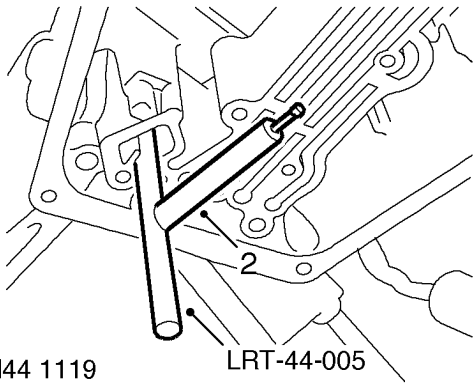


M44 1118

2. Remove circlips and springs from gearbox casing noting location of long and short springs.
3. Using tool **LRT-44-005,** remove and discard seals from gearbox casing.

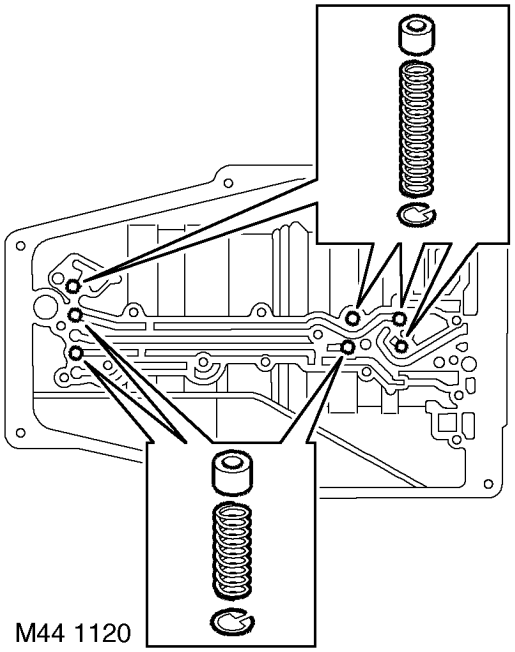
Refit

1. Clean gearbox casing, springs and circlips.



M44 1119

2. Fit new seals using tool **LRT-44-005,** ensure seals are fully seated.


M44 1120

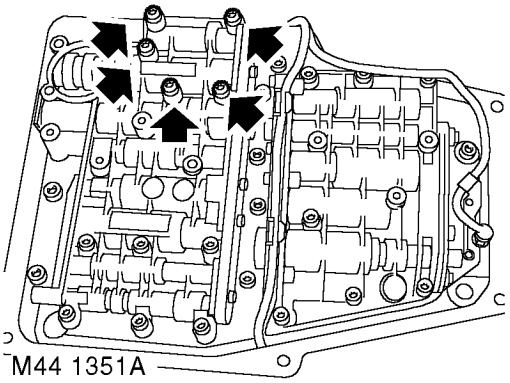
3. Position springs in their correct locations and secure with circlips.
4. Fit valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.

Pressure regulator

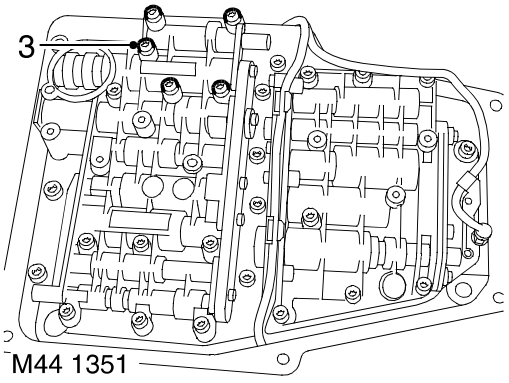
44.40.22

Remove

1. Remove valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.



2. Release and remove clip securing pressure regulator solenoid valve harness to valve body.
3. Disconnect multiplug from pressure regulator solenoid valve.



4. Remove 5 Torx screws securing pressure regulator to valve body and remove pressure regulator.

Refit

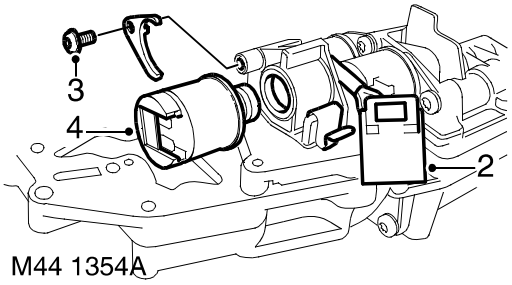
1. Clean pressure regulator and mating face with a lint free cloth.
2. Position pressure regulator to valve body, fit Torx screws and tighten to 8 Nm (6 lbf.ft).
3. Connect multiplug to pressure regulator solenoid valve, fit clip and secure harness to valve body.
4. Fit valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.

Lock-up solenoid valve (MV 3)

44.15.35

Remove

1. Remove valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.



2. Disconnect multiplug from lock-up solenoid valve and release harness from clip.
3. Remove Torx screw and retaining fork securing solenoid valve to valve body.
4. Remove solenoid valve from valve body.

Refit

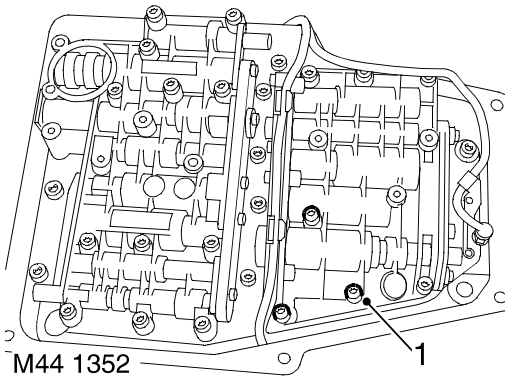
1. Clean lock-up solenoid valve with lint free cloth.
2. Position solenoid valve in valve body.
3. Position retaining fork, fit and tighten Torx screw to 8 Nm (6 lbf.ft).
4. Connect multiplug to lock-up solenoid valve and secure harness in clip.
5. Fit valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.

Solenoids - shift control valves (MV 1 & 2)

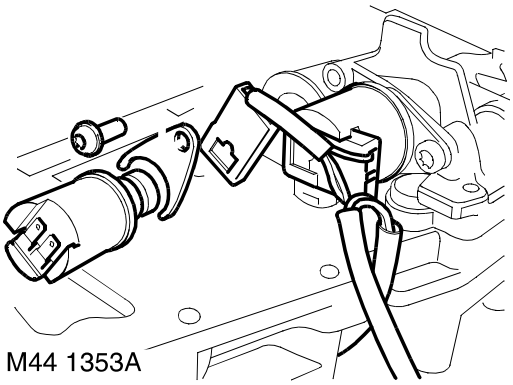
44.15.45

Remove

1. Remove valve body assembly.
   AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.



2. Remove 3 Torx screws securing lock-up solenoid valve assembly to valve body and move solenoid aside.
   NOTE: This is to gain access to remove Torx screw and MV2 shift control valve.



3. Note their fitted position and disconnect multiplugs from shift control valves MV 1 and MV 2.
4. Remove Torx screw and retaining fork securing MV2 shift control solenoid valve to valve body. Note that the tag on the retaining fork faces towards the valve body.
5. Remove shift control valve from valve body.

Refit

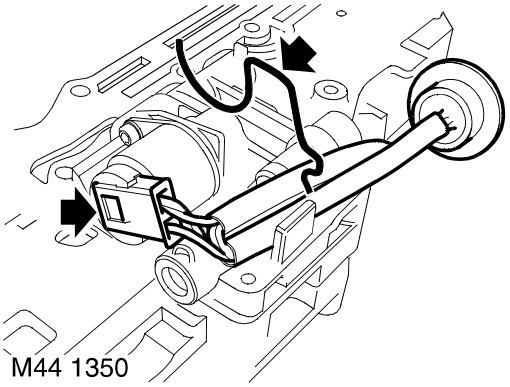
1. Clean MV2 shift control solenoid valve with lint free cloth.
2. Position MV2 shift control solenoid valve to valve body.
3. Position retaining fork, fit Torx screw and tighten to 8 Nm (6 lbf.ft).
4. Connect multiplugs to both shift control solenoid valves.
5. Clean lock-up solenoid valve assembly with a lint-free cloth.
6. Position lock-up valve assembly, fit and tighten Torx screws to 8 Nm (6 lbf.ft).
7. Fit valve body assembly.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.**

Harness - solenoid valves

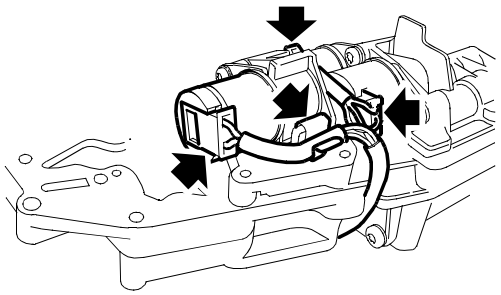
🔧 ***44.15.52***

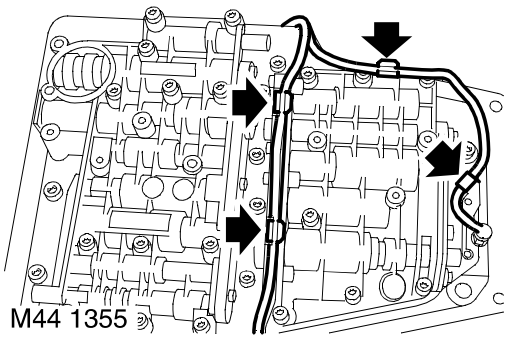
Remove

1. Remove valve body assembly.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.**

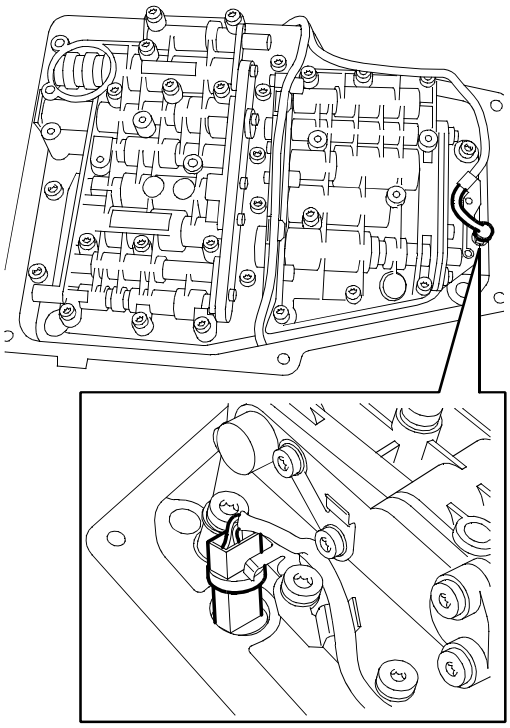

M44 1350

2. Release and remove clip securing pressure regulator solenoid harness to valve body.
3. Disconnect multiplug from pressure regulator solenoid valve.




M44 1355

4. Disconnect multiplugs from lock-up solenoid valve, shift control solenoid valves MV 1 and MV 2.
5. Release harness from 5 clips on valve body and remove harness.



M44 1359

6. Disconnect and remove speed sensor from harness.

Refit

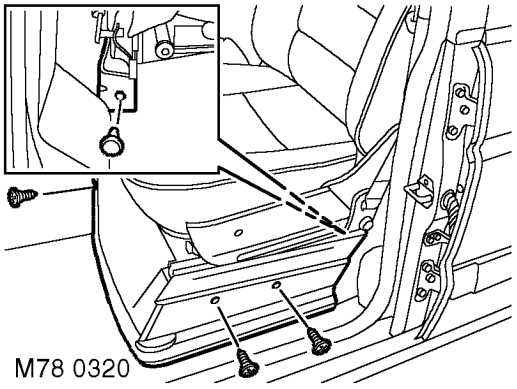
1. Connect speed sensor to harness multiplug.
2. Position harness to valve body.
3. Connect multiplugs to shift control solenoid valves MV 1 and MV 2 and lock-up solenoid valve.
4. Connect multiplug to pressure regulator solenoid valve and secure solenoid valve harness with clip to valve body.
5. Position and secure harness in clips on valve body.
6. Fit valve body assembly.
   ☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, REPAIRS, Valve body assembly.**

Electronic control unit - automatic transmission

44.15.46

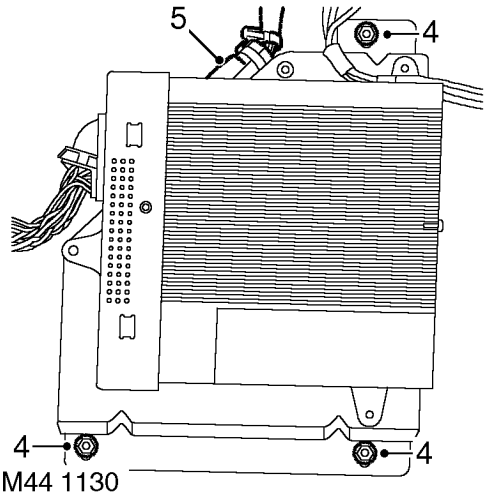
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



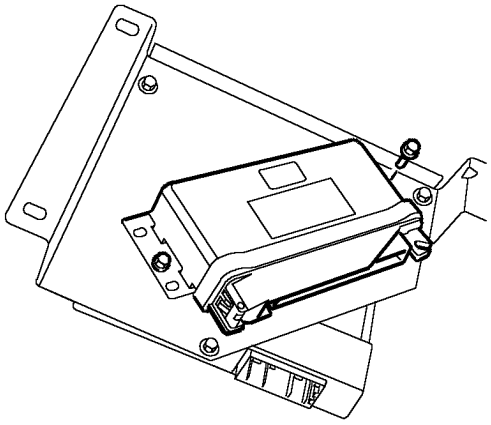
M78 0320

3. Remove 3 screws and trim clip securing lower trim casing to LH front seat.



M44 1130

4. Remove 3 nuts securing speaker power amplifier bracket to the body.
5. Disconnect multiplug from automatic transmission ECU located on underside of amplifier mounting bracket.



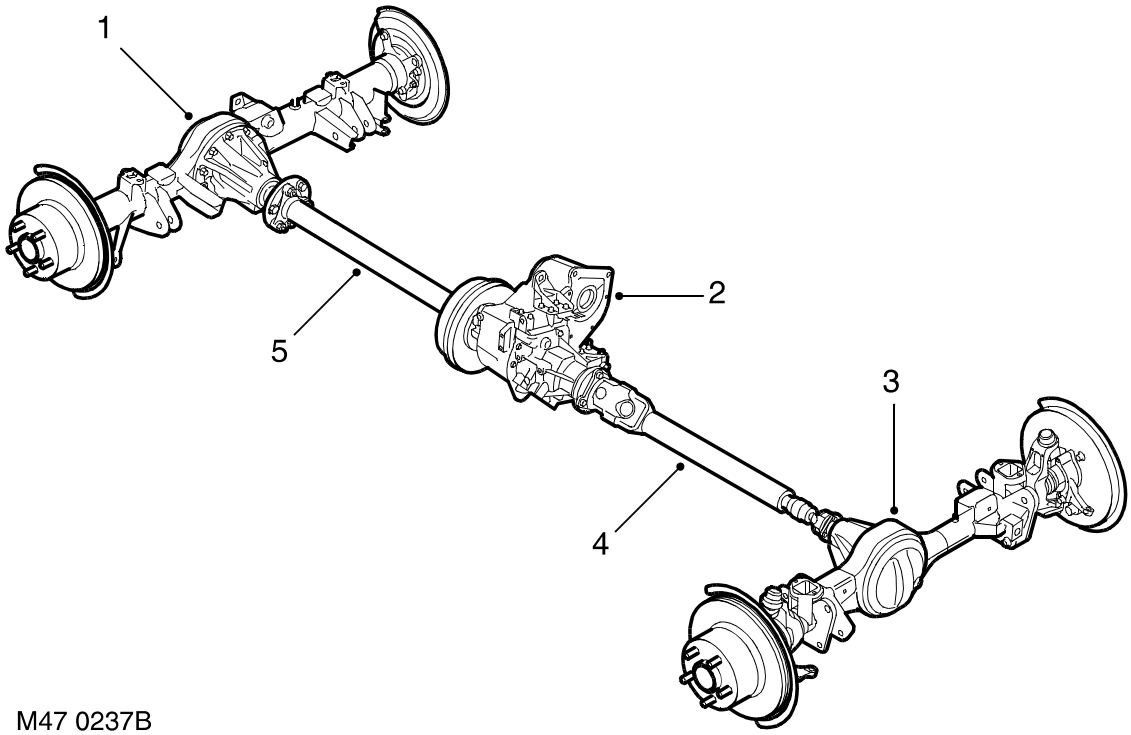
M44 1131

6. Remove 2 nuts securing ECU to mounting bracket and remove ECU.

Refit

1. Position ECU to mounting bracket and secure with nuts.
2. Connect multiplug to ECU.
3. Position speaker power amplifier mounting bracket to body and secure with nuts.
4. Position lower trim casing to seat and secure with screws and trim clip.
5. Connect battery earth lead.
6. Fit battery cover and secure fixings.

Propeller shaft component layout



M47 0237B

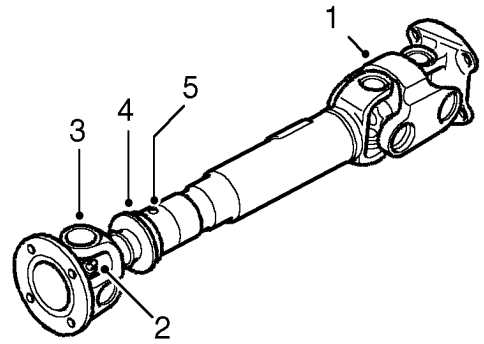
1 Rear axle and brake discs
2 Transfer box
3 Front axle and brake discs
4 Front propeller shaft
5 Rear propeller shaft

Description

General
Front and rear propeller shafts transmit the drive from the transfer box to the axles.

On vehicles from 03 model year fitted with the 4.6l V8 engine and 4HP24 transmission, the front propeller shaft is 15 mm (0.6 in) longer and the rear propeller shaft is 15mm (0.6 in) shorter than those used on vehicles with the 4.0l V8 and Td5 engines. This is to accomodate an increase in length of the 4HP24 transmission.

Front propeller shaft



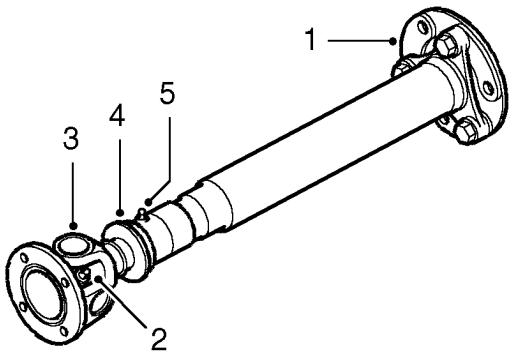
M47 0238A

1 Hookes joint
2 Grease nipple
3 Universal joint
4 Gaiter/Sliding spline joint
5 Lubrication point

The front propeller shaft consists of a tube with a universal joint and a sliding spline joint at the front end, and a Hookes joint at the rear end. The universal joint is bolted to the pinion flange of the front axle differential. The Hookes joint is bolted to the front output shaft of the transfer box.

The Hookes joint is lubricated during manufacture and sealed for life. A grease nipple is installed in the universal joint to lubricate the serviceable, sealed needle bearings of the joint. The sliding spline joint is sealed with a gaiter and lubricated through a lubrication point on the tube. Because of the proximity of a chassis crossmember to the front propeller shaft, the lubrication point is normally sealed with a grub screw. During maintenance, the grub screw is temporarily replaced by a slave grease nipple to lubricate the sliding spline joint.

Rear propeller shaft



M47 0244

1 Flexible coupling
2 Grease nipple
3 Universal joint
4 Gaiter/Sliding spline joint
5 Grease nipple

The rear propeller shaft consists of a tube with a universal joint and a sliding spline joint at the front end, and a flexible coupling bolted to the rear end. The universal joint is bolted to the rear output shaft of the transfer box. The flexible coupling is bolted to the pinion flange of the rear axle differential.

A grease nipple is installed in the universal joint for lubrication of the serviceable, sealed needle bearings in the joint. The sliding spline joint is sealed with a gaiter and lubricated through a grease nipple in the tube.

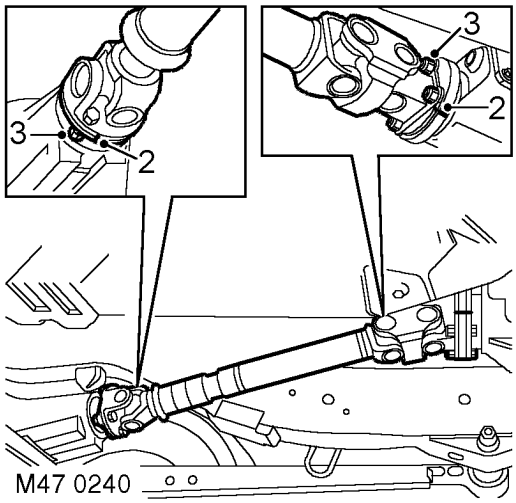
Propeller shaft - front

47.15.02

Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M47 0240

2. If same components to be refitted, reference mark propeller shaft and mating components.
3. Remove 8 nuts and bolts securing propeller shaft to differential and transfer gearbox flanges.
4. Remove propeller shaft.

Refit

1. Clean propeller shaft flanges and mating faces.
2. Position propeller shaft to transfer gearbox and differential and tighten nuts and bolts to 47 Nm (35 lbf. ft).
3. Remove stand(s) and lower vehicle.

Propeller shaft - rear

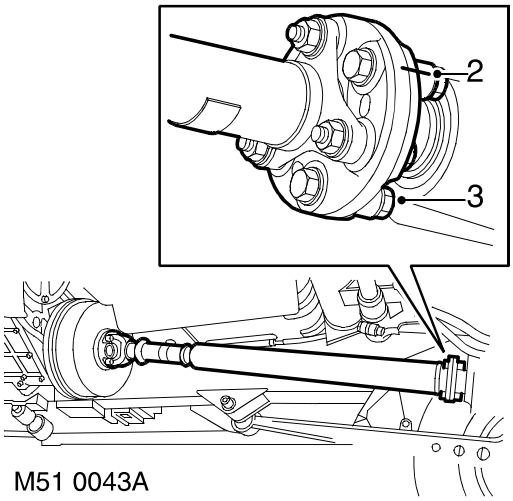
47.15.03

Remove

1. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. If same components are to be refitted, reference mark propeller shaft and mating components.



M51 0043A

3. Remove 4 nuts and bolts securing propellor shaft to transfer gearbox flange.
4. Remove 3 nuts and bolts securing propeller shaft to flexible coupling.
5. Remove propeller shaft.

Refit

1. Clean propeller shaft flanges and mating faces.
2. Position propeller shaft to transfer gearbox and flexible coupling.
3. Fit nuts and bolts securing propeller shaft to transfer gearbox and tighten to 47 Nm (35 lbf.ft).
4. Fit nuts and bolts securing propeller shaft to flexible coupling and tighten to 76 Nm (56 lbf.ft).
5. Lower vehicle.

Flexible coupling

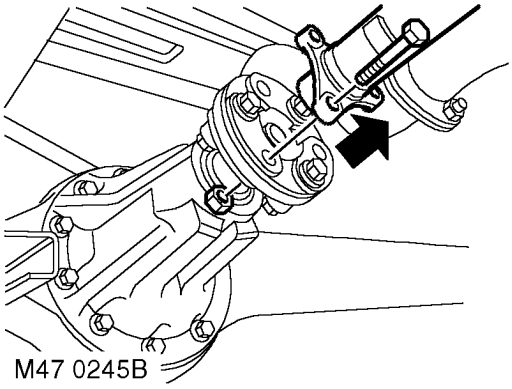
47.20.08

Remove

1. Raise rear of vehicle.

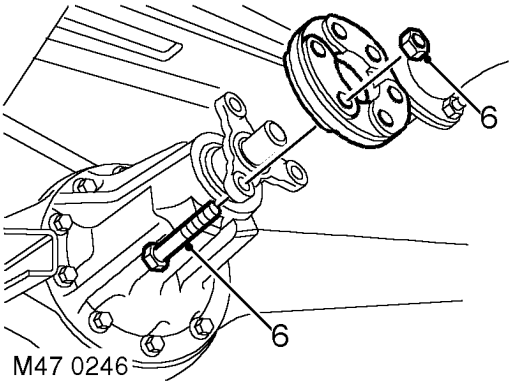
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. If same components to be refitted, reference mark flexible coupling and mating components.



M47 0245B

3. Remove 3 nuts and bolts securing propeller shaft to flexible coupling.
4. Move propeller shaft forwards to release from flexible coupling and differential drive flange spigot.
5. Tie propeller shaft aside.

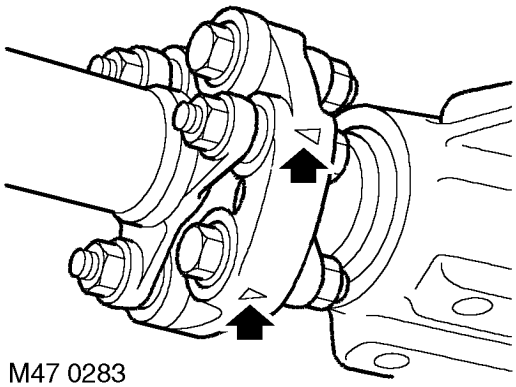


M47 0246

6. Remove 3 nuts and bolts securing flexible coupling to differential drive flange and remove flexible coupling.

Refit

1. Ensure flexible coupling, spigot and drive flanges are clean.



M47 0283

2. Align the arrows on the flexible coupling with the securing bolt positions as illustrated. Fit flexible coupling to differential drive flange and tighten nuts and bolts to 76 Nm (56 lbf.ft).
3. Fit propeller shaft to spigot and flexible coupling. Tighten nuts and bolts to 76 Nm (56 lbf.ft).
4. Remove stand(s) and lower vehicle.

Propeller shaft

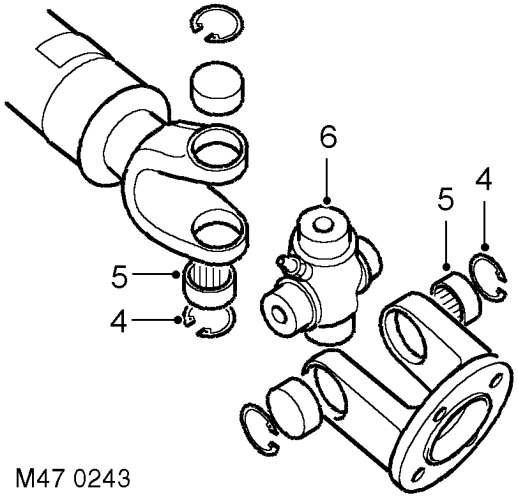
47.15.11

The following bearing replacement procedure applies to the universal joints of both the front and rear propeller shafts, including the Hookes joint (i.e. double universal joint) of the front propeller shaft.

Disassembly

1. Remove propeller shaft:
   - For front propeller shaft.
     PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
   - For rear propeller shaft.
     PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.
2. Thoroughly examine the universal joint for signs of damage or wear.
3. Clean the universal joint bearing cups and circlips.

   CAUTION: Before removal, mark the position of the spider pin relative to the journal yoke ears on the propeller shaft joint. This will ensure correct assembly and reduce the possibility of imbalance.



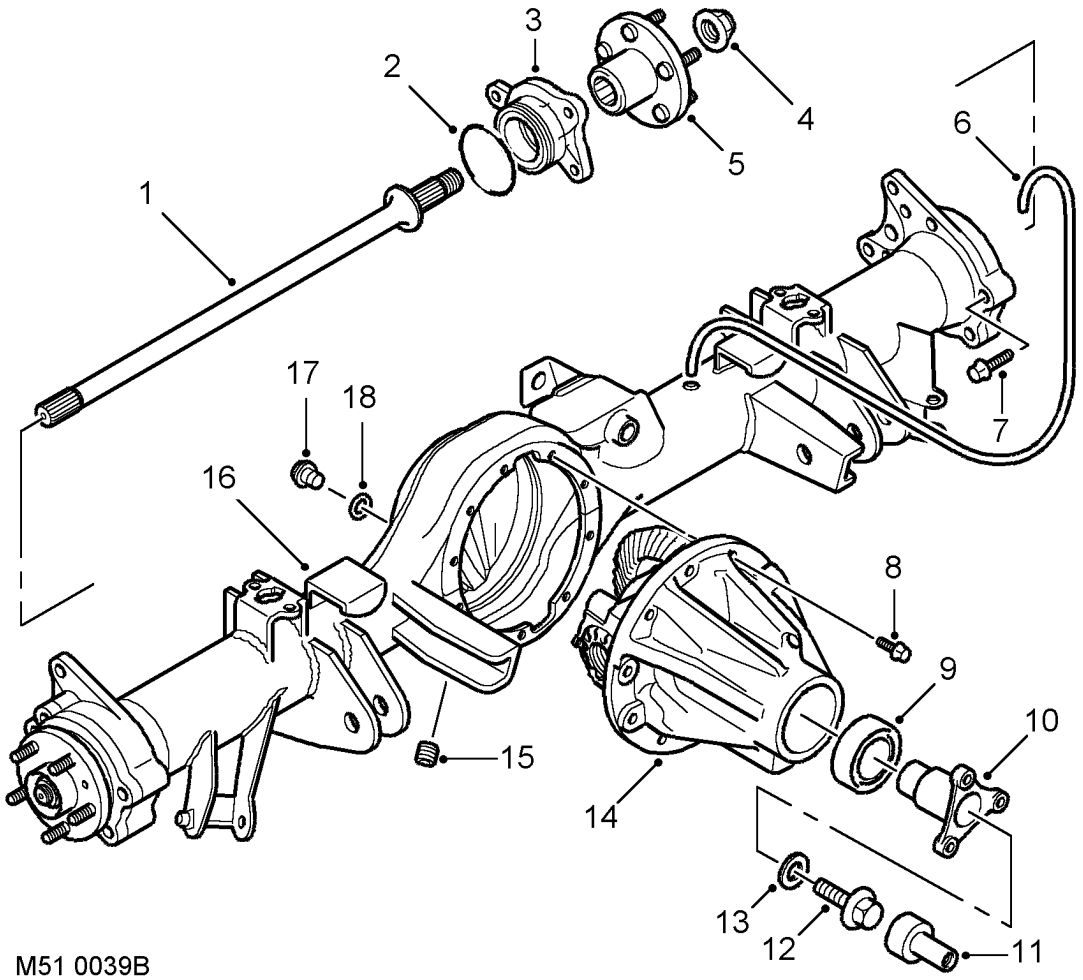
M47 0243

4. Remove the circlips.
5. Tap the yokes to eject bearing cups. Remove bearing cups.
6. Remove spider from yokes.
7. Clean yokes and bearing cup locations.

Reassembly

1. Remove bearing cups from new spider.
2. Check all needle rollers are present and correctly positioned in bearing cups.
3. Enter new spider, with seals, into one of the yokes.
4. Partially insert one bearing cup into yoke and enter spider trunnion into bearing cup.
5. Insert opposite bearing cup in yoke.
6. Press both cups into place.
7. Press each cup into its respective location in yoke up to lower land of circlip groove. **Damage may be caused to cups and seals if cups pass this point.**
8. Fit circlips and check no end float exists.
9. Engage spider in second yoke. Fit bearing cups and circlips as described in steps 4 to 8.
10. Fit propeller shaft:
    - For front propeller shaft.
      PROPELLER SHAFTS, REPAIRS, Propeller shaft - front.
    - For rear propeller shaft.
      PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.

Rear axle component layout



M51 0039B

1 Drive shaft
2 'O' ring
3 Hub bearing
4 Stake nut
5 Hub flange
6 Breather tube
7 Bolt
8 Bolt
9 Oil seal
10 Pinion flange
11 Centralising peg
12 Bolt
13 Washer
14 Differential unit
15 Drain plug
16 Axle casing
17 Oil level plug
18 'O' ring

Description

General
The rear axle consists of an axle casing with a differential unit attached to the right of the vehicle centre line. A wheel hub is installed in each end of the axle casing and connected to the differential unit by a drive shaft.

Axle casing
The axle casing is of welded construction, with brackets on the casing exterior for attachment to the rear suspension.

A differential cover on the rear of the axle casing contains an oil level plug for checking and replenishment of the differential unit lubricating oil. A magnetic drain plug is installed on the underside of the axle casing.

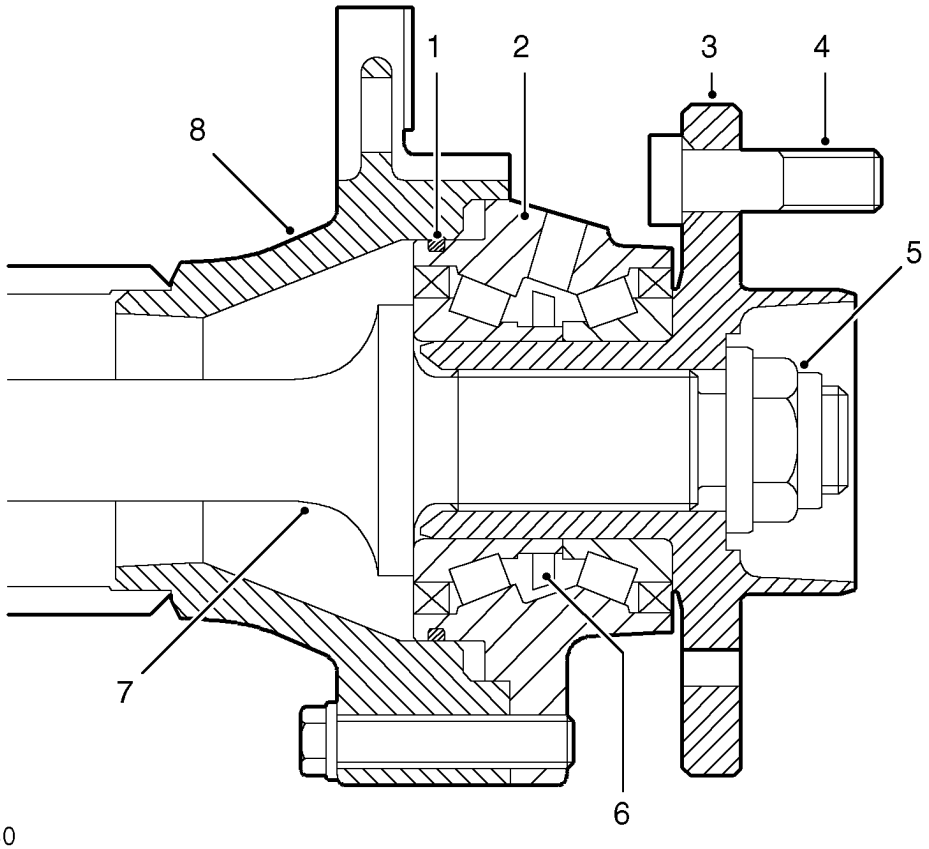
The interior of the axle casing is ventilated through a breather tube inserted in a red plastic sleeve in the top of the casing. The open end of the breather tube is located between the chassis and the left rear wheelarch.

Differential unit
The differential unit is of the spiral bevel type, lubricated by splash oil. The unit consists of a differential carrier attached to a pinion housing. In the pinion housing, the pinion is splined to a pinion flange which is secured with a bolt and washer. An oil seal prevents leakage past the pinion flange.

Centralising peg
The centralising peg is a press fit in the centre of the pinion flange and provides a positive location for the rear propellor shaft to ensure it is centralised with the flange.

Wheel hub

Section through wheel hub



M51 0040

1 'O' ring
2 Hub bearing
3 Hub flange
4 Wheel stud
5 Stake nut
6 ABS sensor ring
7 Drive shaft
8 Axle casing

Each wheel hub consists of a hub flange pressed into a hub bearing.

The hub flange is splined to accept the outboard end of the drive shaft, which is secured to the hub flange with a stake nut. Five studs are installed in the hub flange for the wheel nuts, and a threaded hole is provided for the brake disc securing screw.

The outer race of the hub bearing is bolted to the end of the axle casing. An 'O' ring seals the joint between the outer race and the axle casing to prevent leakage of differential lubricating oil. The hub bearing is a sealed unit which contains twin opposed roller bearings, pre-packed with grease during manufacture. A toothed ABS sensor ring is integrated into the inner race of the hub bearing. An opening in the outer race of the hub bearing accommodates the ABS sensor.

Drive shaft
Each drive shaft consists of a solid rod, splined at both ends.

Differential - assembly

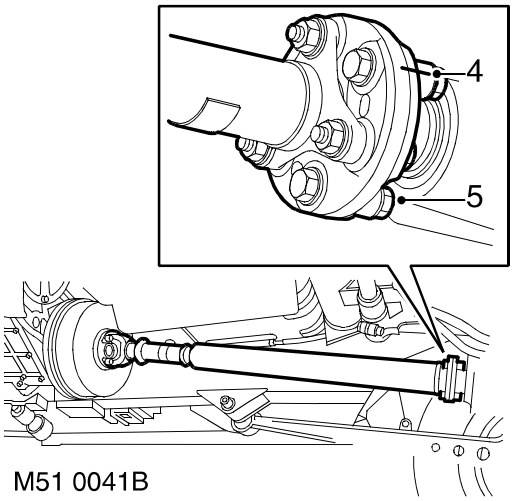
51.15.01

Remove

1. Raise rear of vehicle.

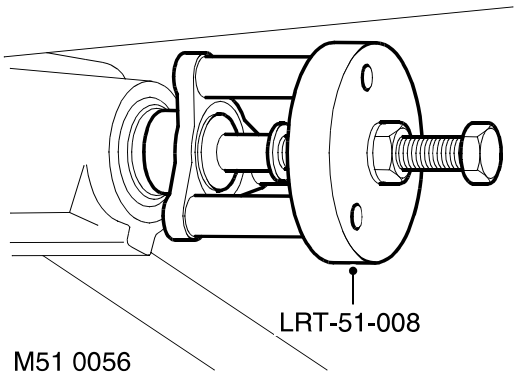
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Drain oil from differential.
   MAINTENANCE, PROCEDURES, Front and rear axle.



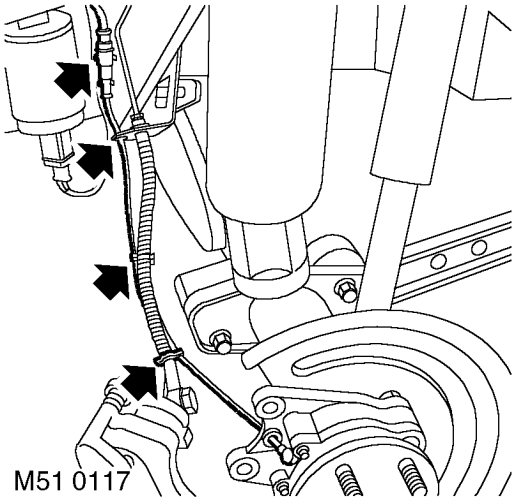
M51 0041B

3. If same components are to be refitted, reference mark propeller shaft and mating components.
4. Remove 3 nuts and bolts securing flexible coupling to pinion flange. Release propeller shaft and tie aside.

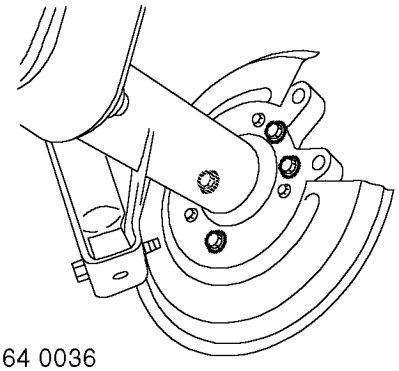


M51 0056

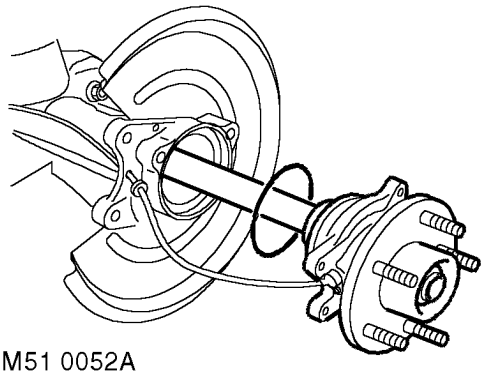
5. Using tool **LRT-51-008,** extract the centralising peg from the pinion flange. Remove the centralising peg from the tool.
6. Remove LH and RH rear brake discs.
   BRAKES, REPAIRS, Brake disc - rear.


M51 0117

7. Disconnect each ABS sensor multiplug.
8. Release each harness from brake hose and hose bracket.

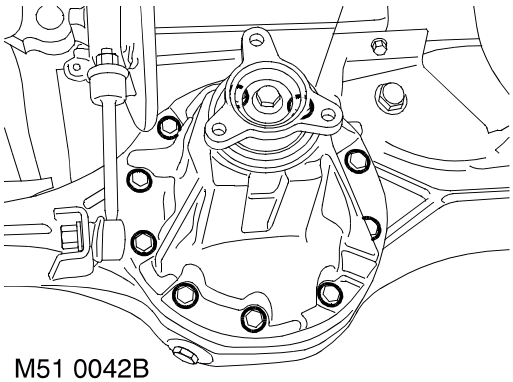

M64 0036

9. Remove 4 bolts securing each rear wheel hub to rear axle.



M51 0052A

10. Release and remove wheel hubs and drive shafts from rear axle. Remove and discard 'O' rings from wheel hubs.



M51 0042B

11. Remove 10 bolts securing differential to axle. Release and remove differential from axle.

Refit

1. Clean drive shafts, wheel hubs and wheel hub locations in rear axle.
2. Using a suitable solvent, clean old RTV sealant from differential and axle mating faces.
3. Apply RTV sealant to differential or axle mating face.
4. Apply Loctite 243 to threads of differential securing bolts.
5. Fit differential to axle, fit bolts and tighten to 55 Nm (41 lbf.ft).
6. Clean pinion flange and centralising peg.
7. Using a tubular drift, fit centralising peg to pinion flange. Ensure that the large diameter part of the centralising peg is below pinion flange mounting surface.
8. Position propeller shaft and align reference marks.
9. Fit nuts and bolts securing flexible coupling to pinion flange and tighten to 76 Nm (56 lbf.ft)
10. Lubricate 2 new wheel hub 'O' rings with clean differential oil.
    ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.** Install 'O' rings on wheel hubs.
11. Fit LH and RH drive shafts and wheel hubs to rear axle. Fit wheel hub bolts and tighten to 100 Nm (74 lbf.ft).
12. Connect each ABS sensor multiplug and secure harness to harness bracket and brake hose.
13. Fit LH and RH rear brake discs.
    ☞ **BRAKES, REPAIRS, Brake disc - rear.**
14. Remove stand(s) and lower vehicle.
15. Fill differential with oil.
    ☞ **MAINTENANCE, PROCEDURES, Front and rear axle.**

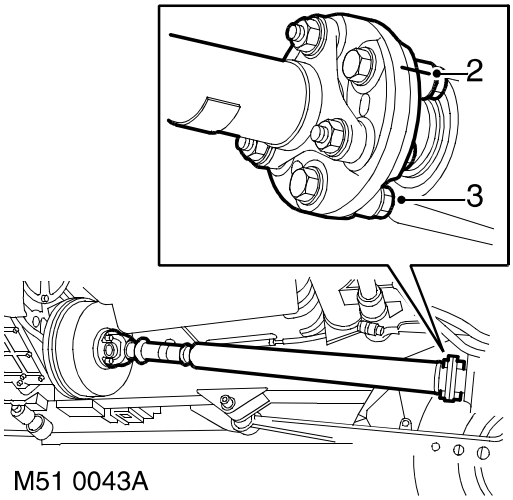
Seal - differential pinion

51.20.01

Remove

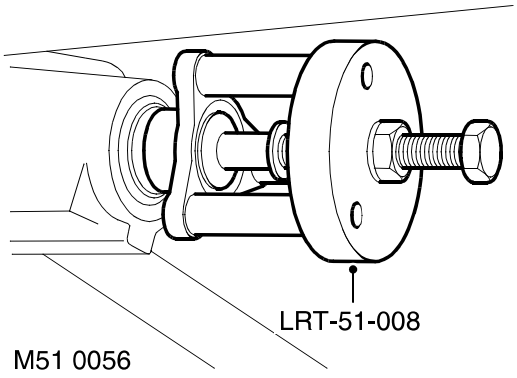
1. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



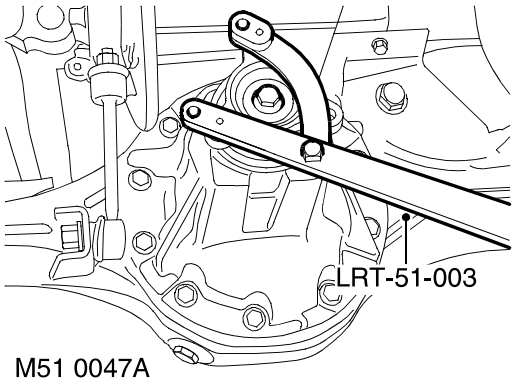
M51 0043A

2. Reference mark rear propeller shaft for reassembly.
3. Remove 3 nuts and bolts securing flexible coupling to pinion flange. Tie propeller shaft aside.



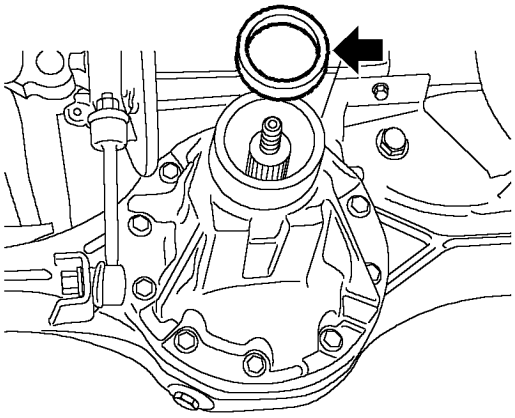
M51 0056

4. Using tool **LRT-51-008,** extract the centralising peg from the pinion flange. Remove the centralising peg from the tool.



M51 0047A

5. Using tool **LRT-51-003** to restrain pinion flange, remove bolt and washer securing pinion flange. Remove pinion flange.
6. Position container to catch oil spillage

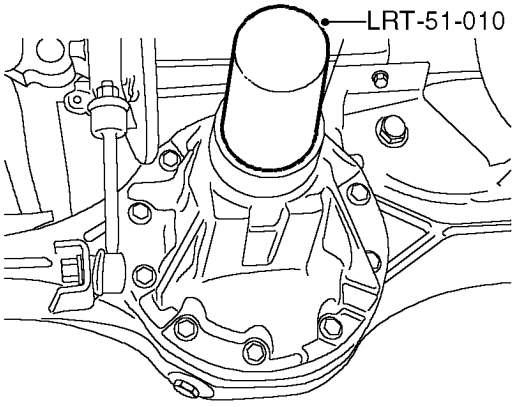


M51 0045

7. Using a suitable lever, remove pinion oil seal. **Take care to avoid damage to oil seal recess.**

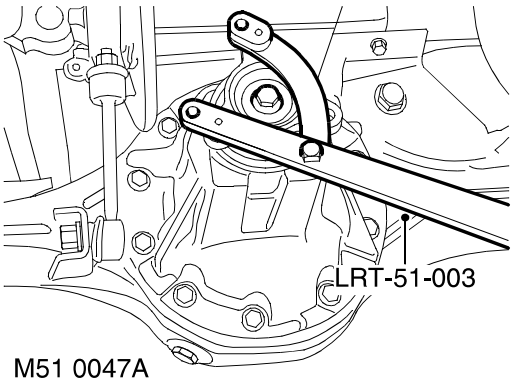
Refit

1. Clean pinion oil seal recess and pinion flange.
2. Lubricate oil seal lip with clean differential oil.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**



M51 0046

3. Using tool **LRT-51-010**, fit pinion oil seal.



M51 0047A

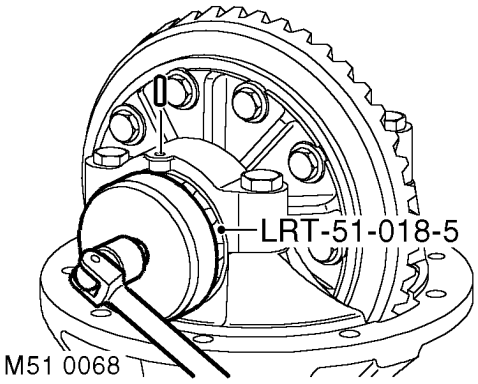
4. Fit pinion flange and securing bolt and washer. Using tool **LRT-51-003** to restrain pinion flange, tighten pinion flange securing bolt to 100 Nm (74 lbf.ft).
5. Using a tubular drift, fit centralising peg to pinion flange. Ensure that large diameter part of centralising peg is below pinion flange mounting surface.
6. Position propeller shaft and align reference marks.
7. Fit nuts and bolts securing flexible coupling to pinion flange and tighten to 76 Nm (55 lbf.ft).
8. Remove stand(s) and lower vehicle.
9. Check differential oil level.
   ☞ **MAINTENANCE, PROCEDURES, Front and rear axle.**

Differential assembly

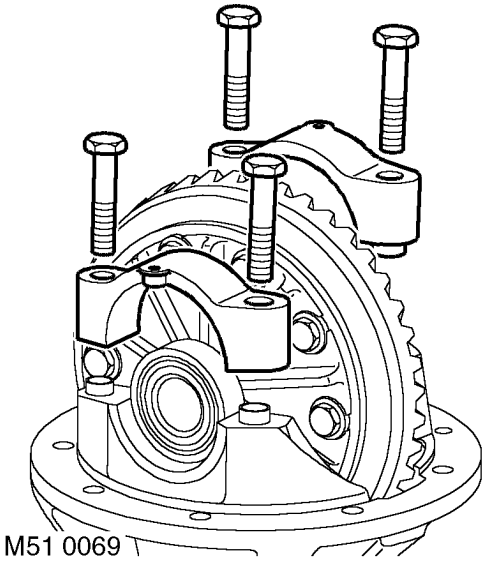
51.15.07

Disassembly

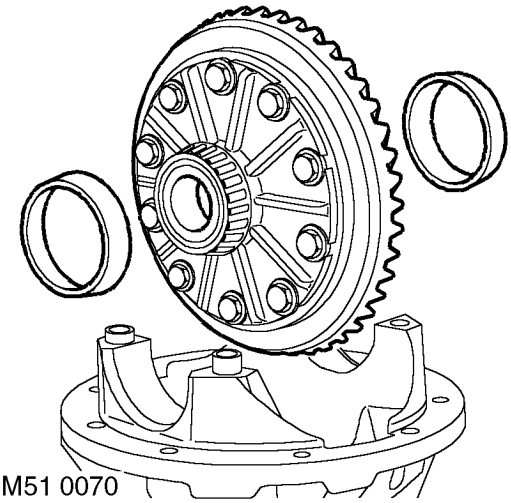
1. Remove differential assembly.
2. Secure differential assembly in a vice or stand.



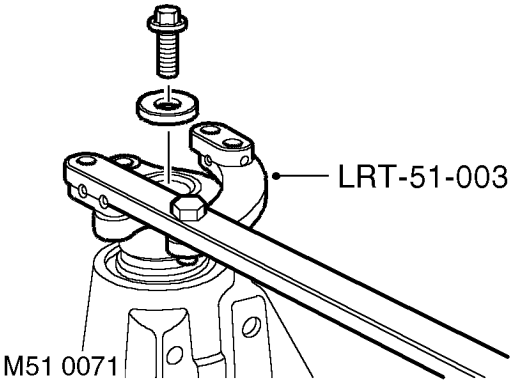
3. Remove roll pins securing adjusting nuts, using **LRT 51-018-5** loosen adjusting nuts.
4. Reference mark bearing caps to aid assembly.



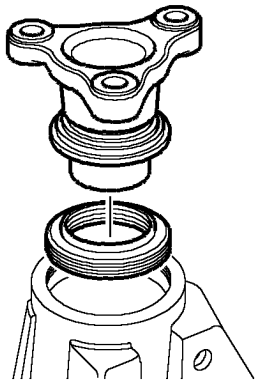
5. Remove bolts securing bearing caps and remove caps.



6. Remove crown wheel assembly and collect bearing outer races.
7. Mark outer races to bearings to aid assembly.



8. Using **LRT-51-003** to restrain pinion flange remove bolt and collect washer.



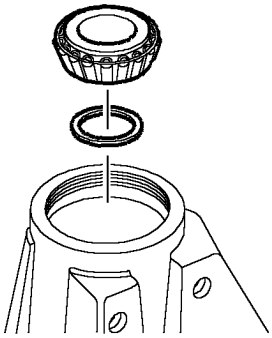
M51 0072

9. Remove pinion flange

NOTE: Older front differentials have a square flange and an extra spacer fitted, this spacer must be removed. Later front differentials have a round flange but no spacer fitted.

10. Using a lever, remove pinion oil seal.

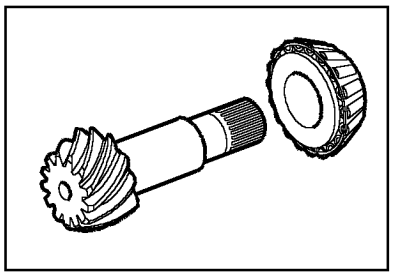
CAUTION: Take care to avoid damage to oil seal recess.

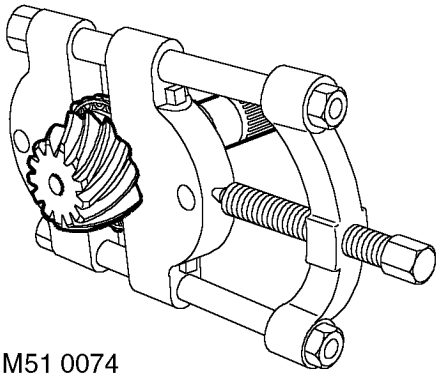


M51 0073

11. Carefully tap pinion from bearings and collect tail bearing.

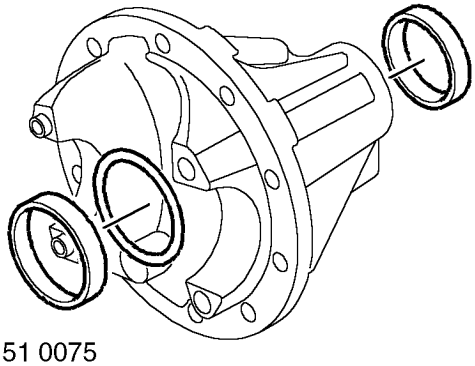
12. Remove pinion tail bearing shim and record shim size.





M51 0074

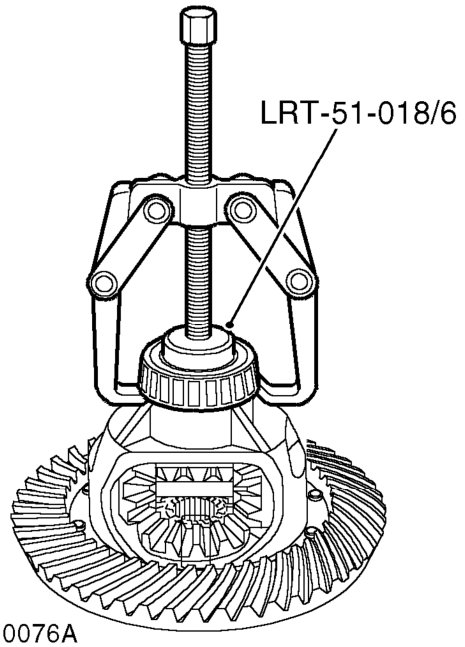
13. Using a bearing puller, remove pinion head bearing.



M51 0075

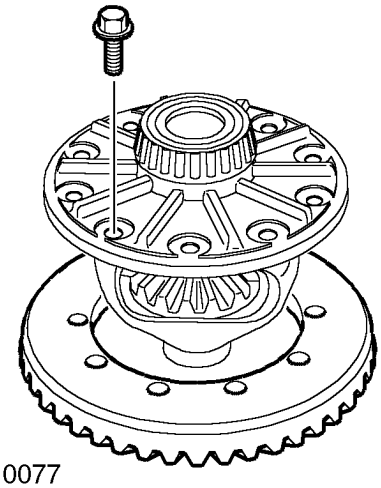
14. Remove pinion bearing races.

15. Remove pinion head bearing shim and record shim size.



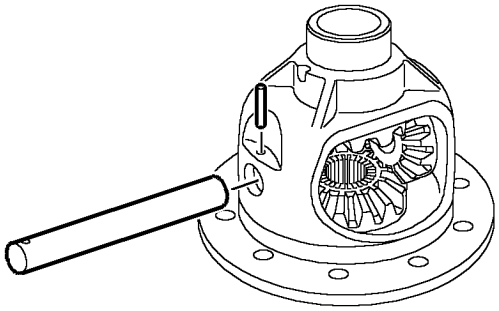
M51 0076A

16. Using a two legged puller and **LRT 51-018/6**, remove the differential bearings.
17. Secure the crown wheel assembly in a vice.



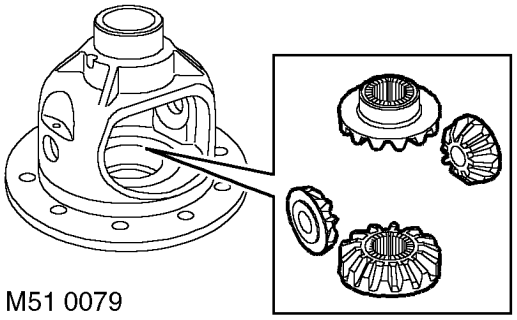
M51 0077

18. Remove and discard 10 bolts securing the crown wheel to carrier.
19. Carefully remove the crown wheel from the carrier.



M51 0078

20. Remove and discard roll pin securing carrier cross shaft and remove cross shaft.

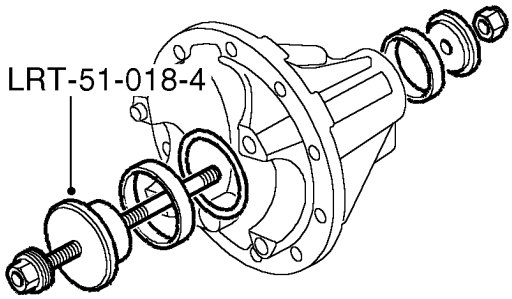


M51 0079

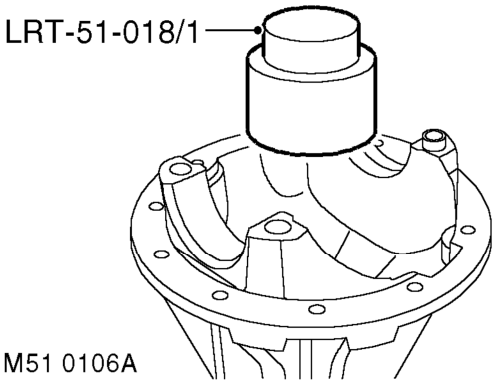
21. Rotate gears to the open part of carrier and remove planet gears.
22. Remove sun gears.

Inspect

1. Clean and inspect all components for wear and damage.
2. Fit planet gears and rotate to align cross shaft holes.
3. Fit cross shaft, ensure roll pin hole is aligned.
4. Secure cross shaft with new roll pin.
5. Fit crown wheel to carrier, fit new bolts and tighten to 60 Nm (44 lbf.ft).

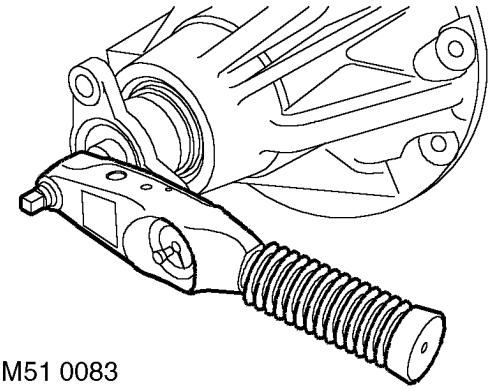


M51 0105A



M51 0106A

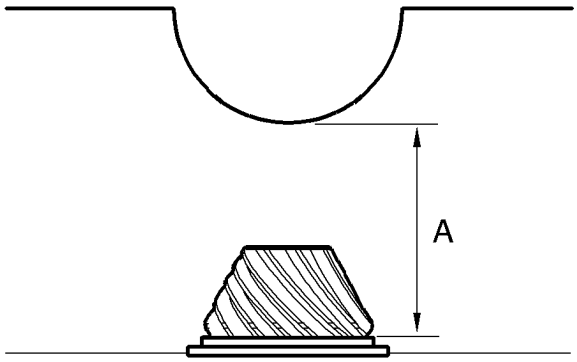
6. Ensure original head bearing shim is clean and free from burrs and fit under bearing race.
7. Ensure pinion bearing cup recesses are clean and free of burrs and using **LRT-51-018-4** fit pinion head and tail bearing races.
8. Fit pinion head bearing to pinion.
9. Lubricate bearings with thin oil.
10. Ensure original tail bearing shim is clean and free from burrs and fit under bearing race.
11. Fit pinion and pinion tail bearing.
12. Fit pinion flange, washer and bolt.
13. Use **LRT-51-003** to restrain pinion flange.
14. Tighten pinion flange bolt to 100 Nm (74 lbf.ft).
15. Check pinion for end float. Should read zero.



M51 0083

16. Rotate pinion several times to settle bearings, check pinion Torque to Turn. Torque to Turn should be recorded during pinion rotation. Pinion Torque to Turn should be 4 to 6 Nm (3 to 4.5 lbf.ft).
17. Adjust size of tail bearing shim to obtain correct pinion Torque to Turn (0.025 mm = 1 Nm (0.001' = 0.7 lbf.ft) approximately).
18. Position **LRT-51-018-7** on surface plate, establish zero and reference DTI.

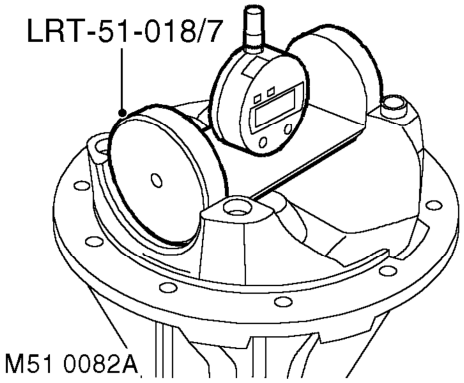
19. Ensure pinion height setting block, setting gauge and mating faces are clean and free from burrs.
20. Locate setting block **LRT-51-018/11** over pinion head, ensure it is fully seated in position.

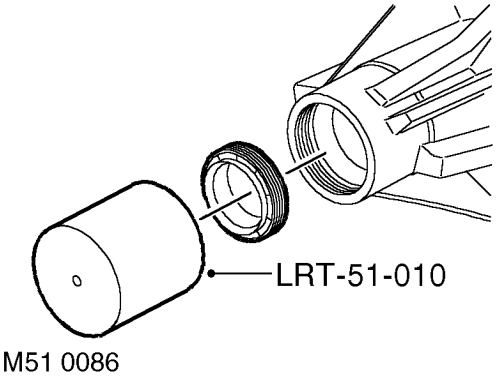


M51 0116

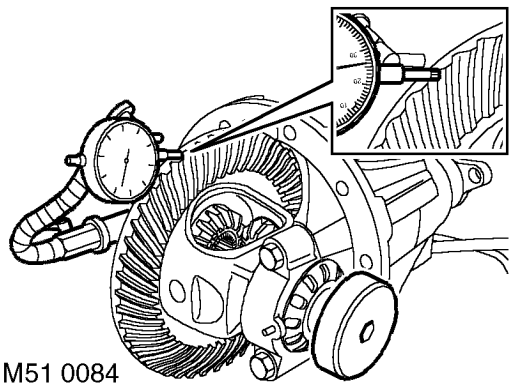
21. **Pinion height setting procedure:**
    - **'A'** = Nominal pinion height setting, 74.390.
    - **'B'** = Setting block height.
    - **'C'** = Head height setting.
    - **'C' = 'A' - 'B'.** Subtract nominal pinion height 'A' from setting block height 'B' (on side of setting block).
    - **Example:** 74.390 - 73.130 = 1.26 mm (2.929' - 2.88' = 0.049'). Therefore pinion head height reading is 1.260 mm ± 0.025 mm (0.049' ± 0.001').

CAUTION: Setting block height must be checked using figures on side of block.





22. Align setting gauge **LRT-51-018/7** to setting block, rock gauge to obtain minimum reading. If reading is lower than required reading, decrease shim size. If reading is higher than required reading, increase shim size.
23. Using **LRT-51-003** to restrain pinion flange, remove bolt and washer. Remove pinion flange.
24. Remove pinion, collect tail bearing and tail bearing shim.
25. Remove pinion head bearing outer race and shim. Discard shim. Ensure bearing race recess is clean and free from burrs.
26. Fit calculated shim, and using **LRT-51-018/4** fit head bearing outer race.
27. Fit pinion, pinion tail bearing and tail bearing shim.
28. Fit pinion flange and bolt and washer. Using **LRT-51-003** to restrain pinion flange, tighten bolt to 100 Nm (74 lbf.ft).
29. Rotate pinion in both directions to settle bearings.
30. Recheck pinion Torque to Turn, adjust if necessary.
31. Recheck pinion head height.
32. Using **LRT-51-003** to restrain pinion flange, remove bolt and washer. Remove pinion flange.
33. Discard bolt.
34. Using **LRT-51-010** fit pinion seal.
35. Ensure spacer and tail bearing are correctly located.
36. Fit pinion, pinion flange and washer.
37. Fit new pinion flange bolt and tighten to 100 Nm (74 lbf.ft).
38. Lightly oil differential bearings.
39. Ensure spring dowels are fitted in bearing caps.
40. Fit differential bearing outer races and locate differential assembly into housing.
41. Fit bearing caps and tighten bolts to 10 Nm (7.5 lbf.ft).

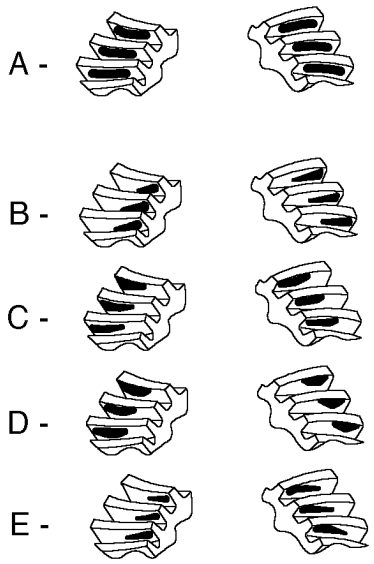


42. Fit adjusting nuts, tighten crown wheel side nut to 22 Nm (16 lbf.ft). Ensure opposing nut is loose.
43. Position DTI to check crown wheel backlash. Adjust opposing nut to obtain correct crown wheel backlash.
44. Rotate pinion in both directions to settle bearings.
45. Measure in 3 places to obtain correct crown wheel backlash.

    NOTE: Crown wheel backlash should be within 0.076 mm - 0.177 mm (0.003' - 0.007').

46. Align adjusting nuts to next roll pin slot, do not loosen nuts to align slots.

47. Tighten bearing cap bolts to 90 Nm (66.5 lbf.ft).
48. Secure adjusting nuts with new roll pins.



M51 0085

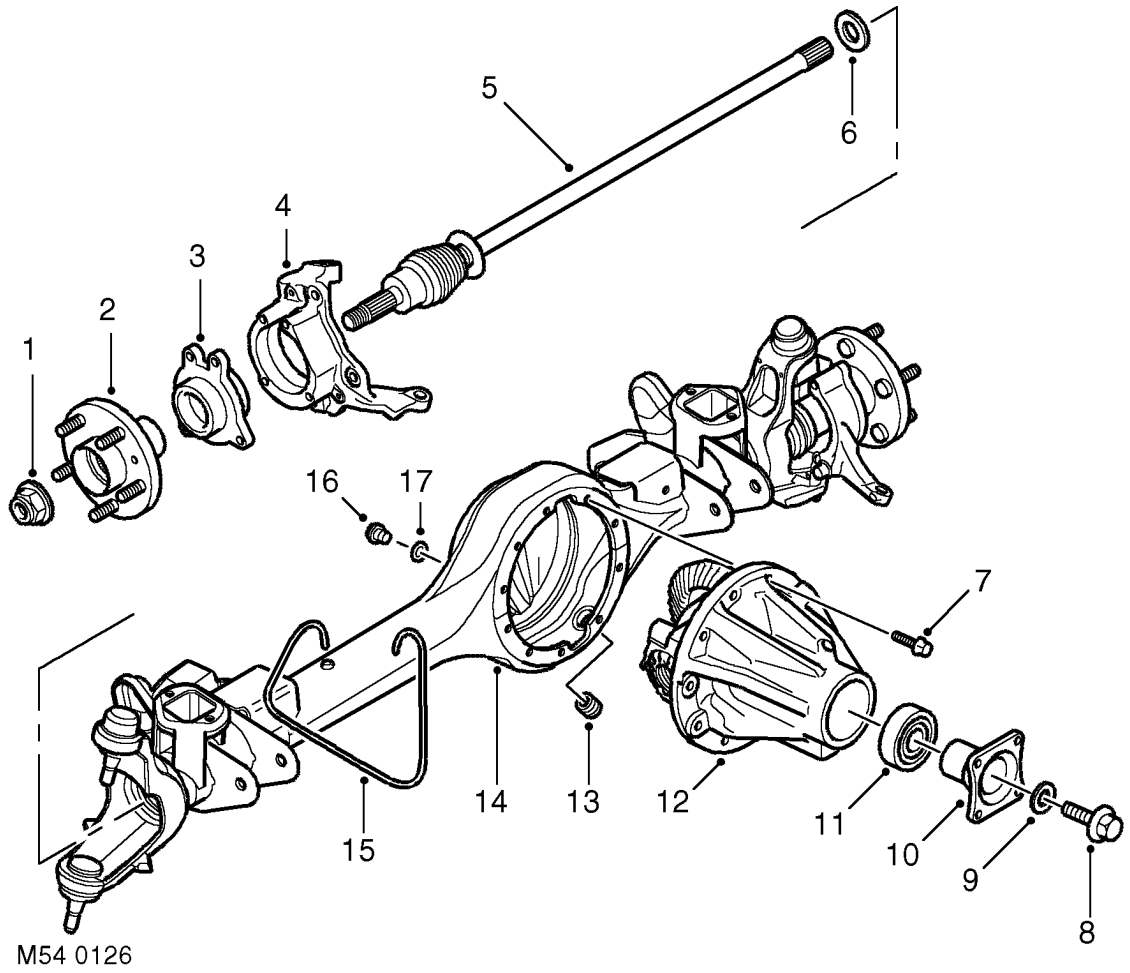
49. Apply Prussian Blue to crown wheel teeth to check tooth contact.
50. Rotate pinion several times to obtain full tooth contact.

51. A = Normal pattern, the drive pattern should be centred on the gear teeth. The coast pattern should be centred on the gear teeth but may be towards the toe. There should be some clearance between the pattern and the top of the gear teeth.
52. B = Backlash correct, thinner pinion shim required.
53. C = Backlash correct, thicker pinion shim required.
54. D = Pinion shim correct, decrease backlash.
55. E = Pinion shim correct, increase backlash.
56. Note assembly Torque to Turn when checking tooth contact. Total Torque to Turn should not exceed 10.85 Nm (8 lbf.ft).

Reassembly

1. Fit differential assembly.

Front axle component layout



1 Stake nut
2 Hub flange
3 Hub bearing
4 Steering knuckle
5 Drive shaft
6 Oil seal
7 Bolt
8 Bolt
9 Washer
10 Drive flange
11 Oil seal
12 Differential unit
13 Drain plug
14 Axle casing
15 Breather tube
16 Oil level plug
17 'O' ring

Description

General
The front axle consists of an axle casing with a differential unit attached to the right of the vehicle centre line. A wheel hub is installed in a steering knuckle at each end of the axle casing and connected to the differential unit by a drive shaft.

Axle casing
The axle casing is of welded construction, with brackets on the casing exterior for attachment to the front suspension. Yokes at each end of the casing incorporate upper and lower ball joints for attachment of the steering knuckles.

A differential cover on the front of the axle casing contains an oil level plug for checking and replenishment of the differential lubricating oil. A magnetic drain plug is installed on the underside of the casing. An oil seal is installed in each end of the axle casing to prevent leakage past the drive shafts.

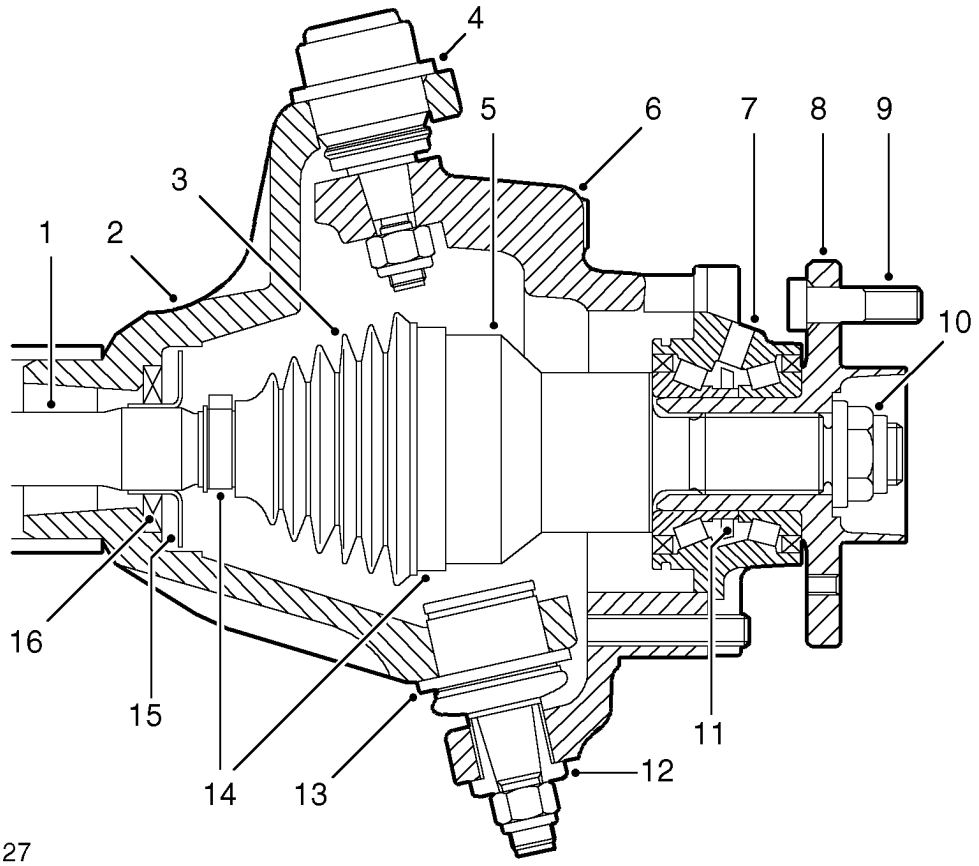
The interior of the axle casing is ventilated through a breather tube inserted in a red plastic sleeve in the top of the casing. The open end of the breather tube is located in the left rear corner of the engine compartment.

Differential unit
The differential unit is of the spiral bevel type, lubricated by splash oil. The unit consists of a differential carrier attached to a pinion housing. In the pinion housing, the pinion is splined to a drive flange which is secured with a bolt and washer. An oil seal prevents leakage past the drive flange.

Steering knuckle
The steering knuckles are mounted on upper and lower ball joints in the yokes at the end of the axle casing. A tension collet, in the lower mounting point of each steering knuckle, accommodates manufacturing tolerances to enable the correct tightening of both ball joints. Lugs are incorporated on the steering knuckles for attachment of the steering system drag link and track rod.

Wheel hub

Section through wheel hub



M54 0127

1 Drive shaft
2 Axle casing
3 Gaiter
4 Upper ball joint
5 Constant velocity joint
6 Steering knuckle
7 Hub bearing
8 Hub flange
9 Wheel stud
10 Stake nut
11 ABS sensor ring
12 Tension collet
13 Lower ball joint
14 Securing bands
15 Shield
16 Oil seal

Each wheel hub consists of a hub flange pressed into a hub bearing.

The hub flange is splined to accept the constant velocity joint of the drive shaft, which is secured to the hub flange with a stake nut. Five studs are installed in the hub flange for the wheel nuts and a threaded hole is provided for the brake disc securing screw.

The outer race of the hub bearing is bolted to the steering knuckle. The hub bearing is a sealed unit which contains twin opposed roller bearings, pre-packed with grease during manufacture. A toothed ABS sensor ring is integrated into the inner race of the hub bearing. An opening in the outer race of the hub bearing accommodates the ABS sensor.

Drive shaft

Each drive shaft consists of a solid rod, splined at both ends, with a constant velocity joint installed on the outboard end. A shield is incorporated onto each rod to protect the oil seals in the axle casing. The constant velocity joint is of the ball and socket type. A shaft on the constant velocity joint is splined to the hub flange. The constant velocity joint is pre-packed with grease and protected by a gaiter. Two securing bands retain the gaiter in position.

Differential - assembly

54.10.01

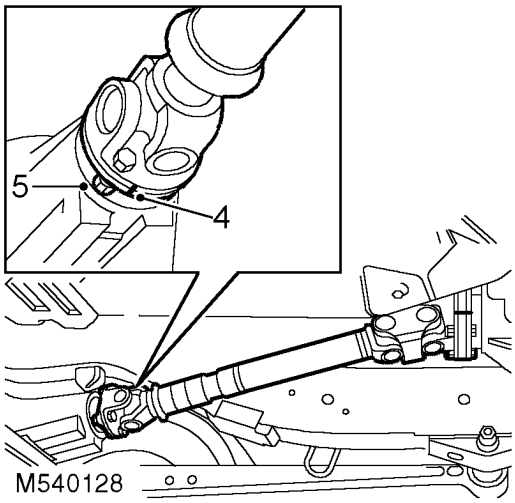
Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

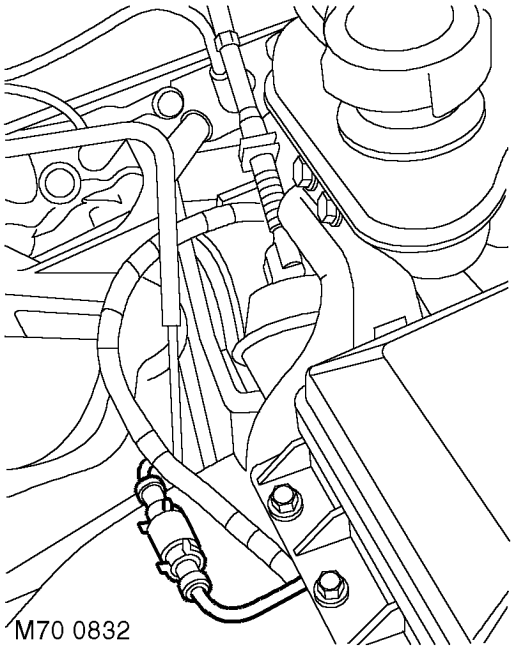
2. Remove front road wheels.
3. Drain oil from differential.

   MAINTENANCE, PROCEDURES, Front and rear axle.

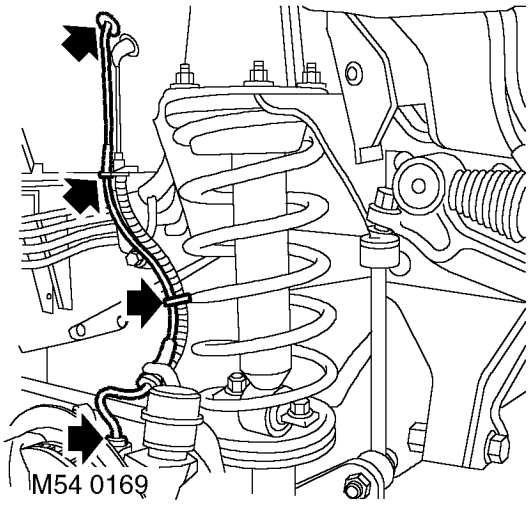


4. If same components to be refitted, reference mark propeller shaft and mating components.
5. Remove 4 nuts and bolts securing propeller shaft to differential. Release propeller shaft and tie aside.
6. Remove LH and RH front brake discs.

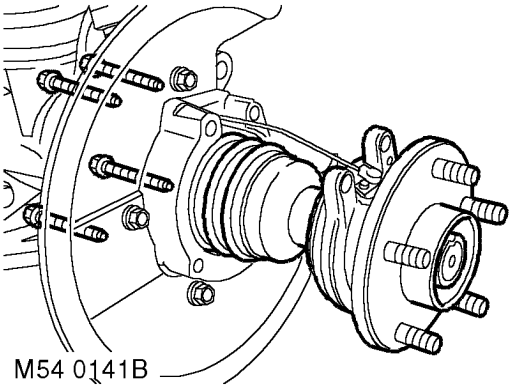
   BRAKES, REPAIRS, Brake disc - front.



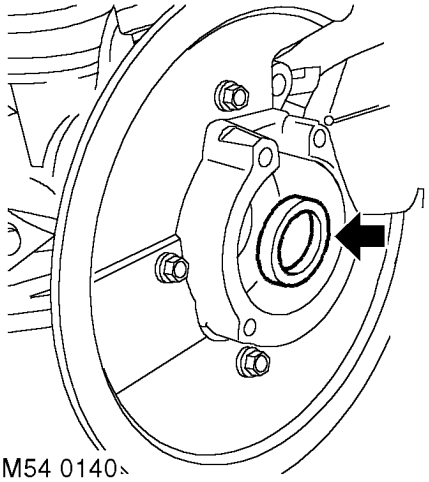
7. Disconnect each ABS sensor multiplug.



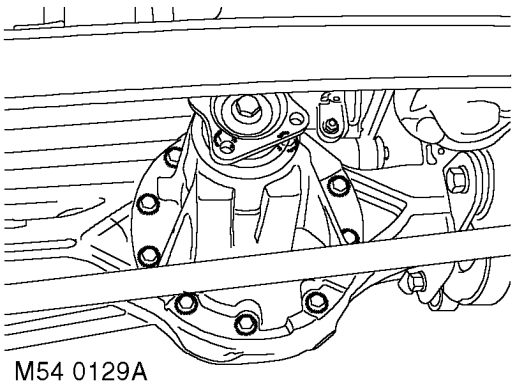
8. Release each harness from brake hose and hose bracket.


M54 0141B

9. Remove 4 bolts securing each front wheel hub to front axle.
10. Release wheel hubs from front axle. Remove wheel hubs and drive shafts from front axle.


M54 0140

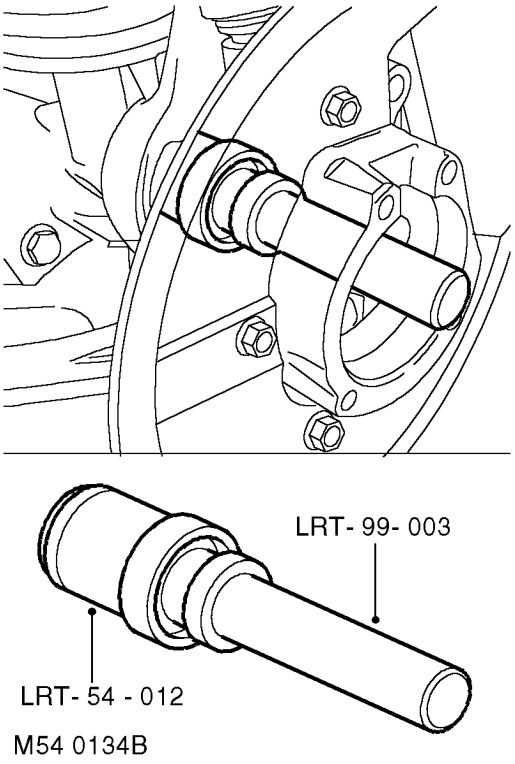
11. Remove oil seal from axle casing.


M54 0129A

12. Remove 10 bolts securing differential to axle casing. Release and remove differential from axle casing.

Refit

1. Clean drive shaft oil seal recess, oil seal running surface, wheel hub and axle mating faces.
2. Using a suitable solvent, clean old RTV sealant from differential and axle mating faces.
3. Apply RTV sealant to differential or axle mating face.
4. Apply Loctite 243 to threads of differential securing bolts.
5. Fit differential to axle, fit bolts and tighten to 55 Nm (41 lbf.ft).
6. Position propeller shaft and align reference marks. Fit bolts and tighten to 47 Nm (35 lbf.ft).
7. Lubricate oil seal lip and running surface with clean differential oil.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**



M54 0134B

8. Using **LRT-54-012** and **LRT-99-003**, fit new drive shaft oil seal to axle casing.
9. Apply anti-seize compound to wheel hub and steering knuckle mating faces.
10. Ensure ABS harnesses are located in cut out in steering knuckles.
11. Fit drive shafts in axle casing and align wheel hubs with steering knuckles. Fit wheel hub bolts and tighten to 100 Nm (74 lbf.ft).
12. Connect each ABS sensor multiplug and secure harness to harness bracket and brake hose.

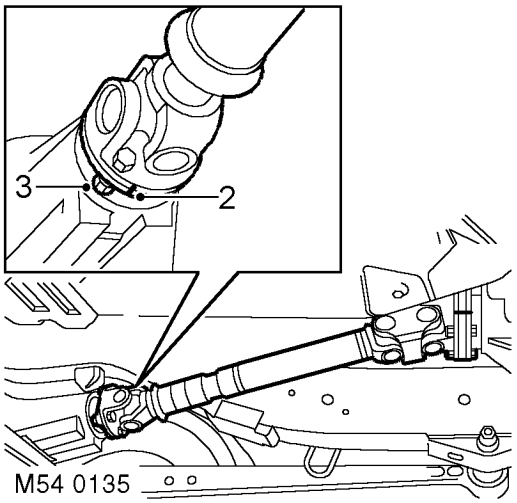
13. Fit front brake discs.
    ☞ **BRAKES, REPAIRS, Brake disc - front.**
14. Fit front road wheels and tighten nuts to 140 Nm (103 lbf.ft).
15. Remove stand(s) and lower vehicle.
16. Fill differential with oil.
    ☞ **MAINTENANCE, PROCEDURES, Front and rear axle.**

Seal - differential pinion

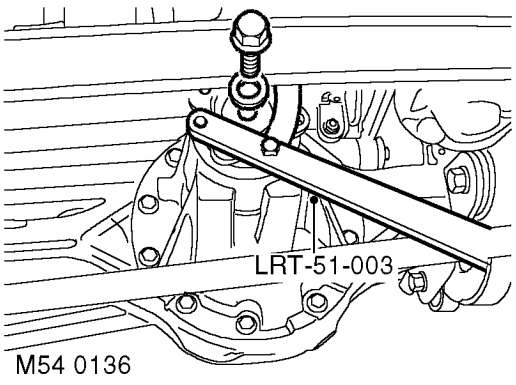
54.10.20

Remove

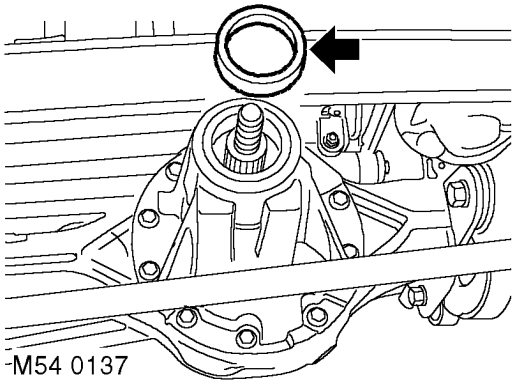
1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Reference mark front propeller shaft for reassembly.
3. Remove 4 nuts and bolts securing propeller shaft to differential. Release propeller shaft and tie aside.



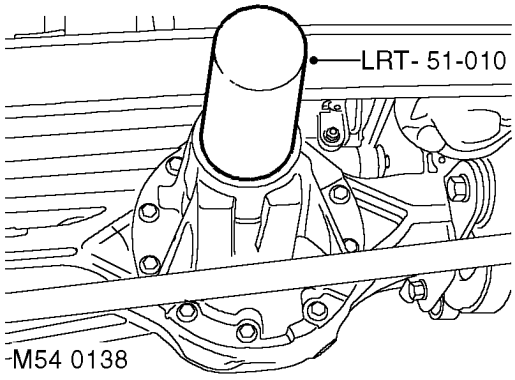
4. Using **LRT-51-003** to restrain pinion flange, remove bolt and washer securing pinion flange. Remove pinion flange.
5. Position container to catch oil spillage.



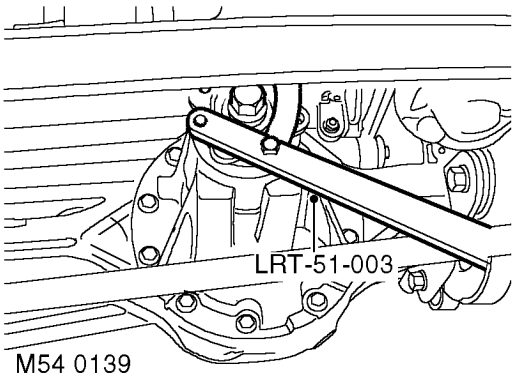
6. Using a suitable lever, remove pinion oil seal. **Take care to avoid damage to oil seal recess.**

Refit

1. Clean pinion oil seal recess and pinion flange.
2. Lubricate pinion oil seal lip with clean differential oil.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**



3. Using **LRT-51-010** , fit pinion oil seal.



4. Fit pinion flange and securing bolt and washer. Using **LRT- 51-003**, restrain pinion flange and tighten pinion flange bolt to 100 Nm (74 lbf.ft).
5. Position propeller shaft and align reference marks. Fit nuts and bolts and tighten to 47 Nm (35 lbf.ft).
6. Remove stand(s) and lower vehicle.
7. Check differential oil level.
   ☞ **MAINTENANCE, PROCEDURES, Front and rear axle.**

Seal - oil - front axle casing

54.15.04

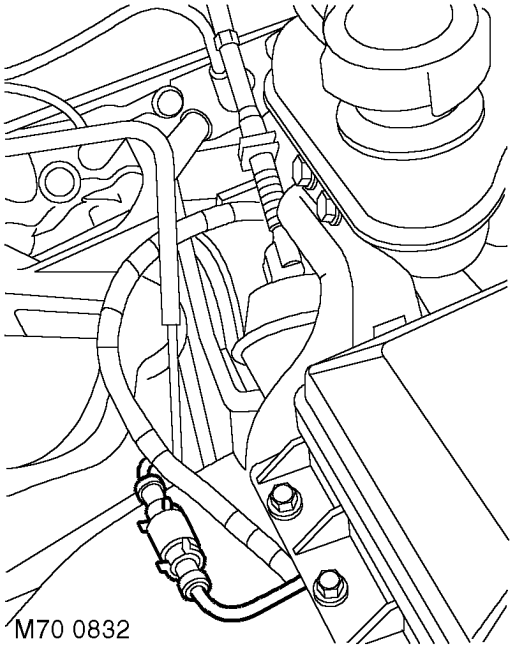
Remove

1. Raise front of vehicle.

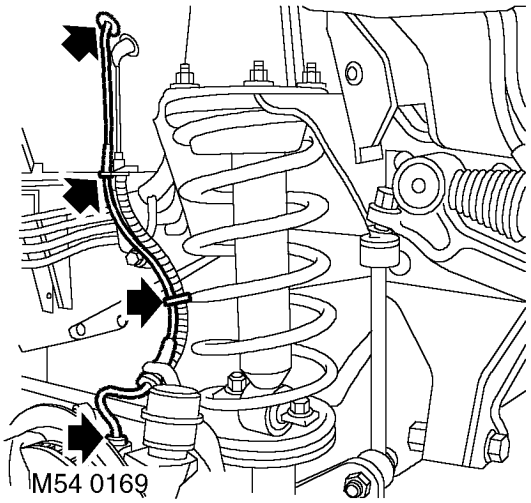
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Remove road wheel.
3. Remove front brake disc.

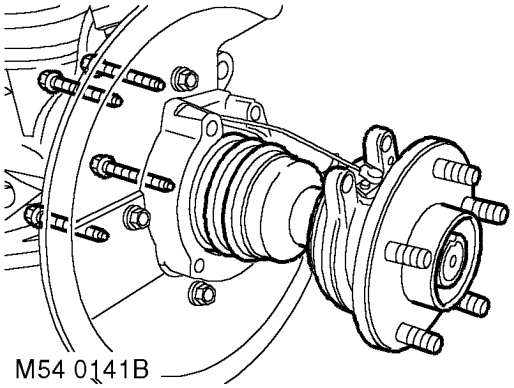
   BRAKES, REPAIRS, Brake disc - front.



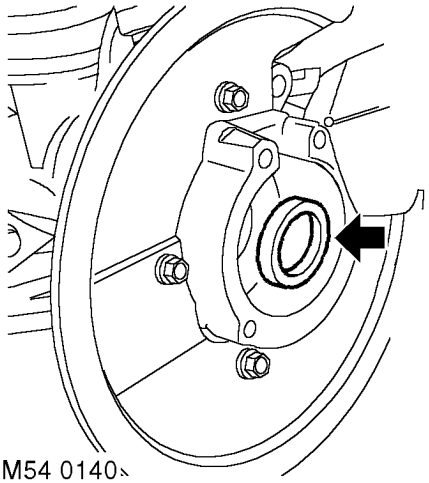
4. Disconnect ABS sensor multiplug.



5. Release harness from brake hose and hose bracket.



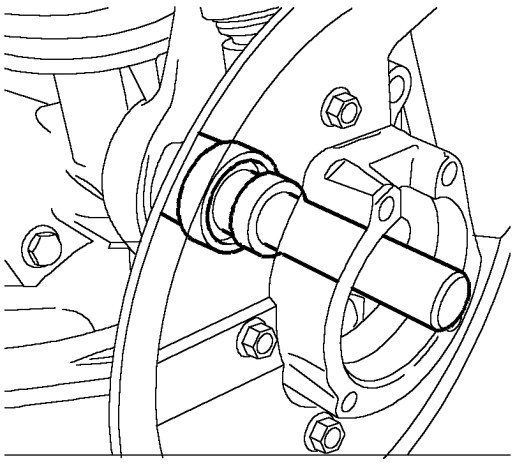
6. Remove 4 bolts securing wheel hub to steering knuckle.
7. Release wheel hub from steering knuckle.
8. Remove wheel hub and drive shaft from axle.

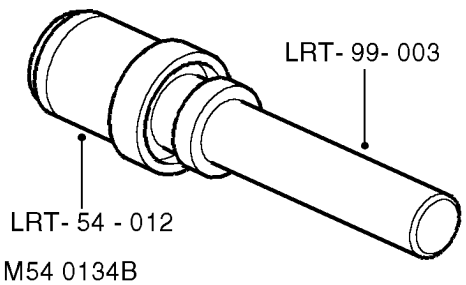

M54 0140

9. Remove oil seal from axle casing.

Refit

1. Clean drive shaft oil seal recess, oil seal running surface, wheel hub and swivel hub mating faces.
2. Lubricate oil seal lip and running surface with clean differential oil.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**





M54 0134B

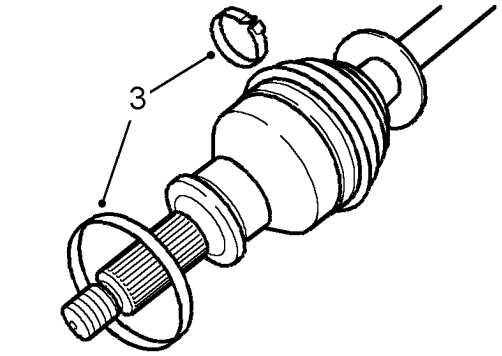
3. Using tool **LRT-54-012** and tool **LRT-99-003**, fit new drive shaft oil seal to axle casing.
4. Apply anti-seize compound to wheel hub and steering knuckle mating faces.
5. Ensure ABS harness is located in cut out in steering knuckle.
6. Fit drive shaft and wheel hub to axle casing and align wheel hub with steering knuckle. Fit wheel hub bolts and tighten to 100 Nm (74 lbf.ft).
7. Connect ABS sensor multiplug and secure harness to harness bracket and brake hose.
8. Fit front brake disc.
   ☞ **BRAKES, REPAIRS, Brake disc - front.**
9. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
10. Remove stand(s) and lower vehicle.
11. Check differential oil level.
    ☞ **MAINTENANCE, PROCEDURES, Front and rear axle.**

Constant velocity joint - drive shaft

54.20.21

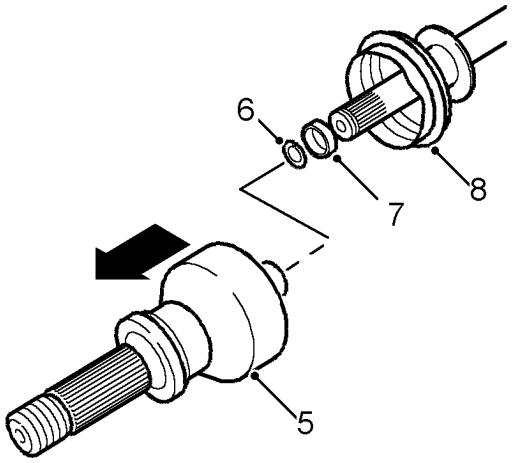
Remove

1. Remove wheel hub.
   FRONT SUSPENSION, REPAIRS, Wheel hub.
2. Place drive shaft in vice.



M54 0130

3. Release both securing bands from gaiter and discard.
4. Compress gaiter to gain access to joint.



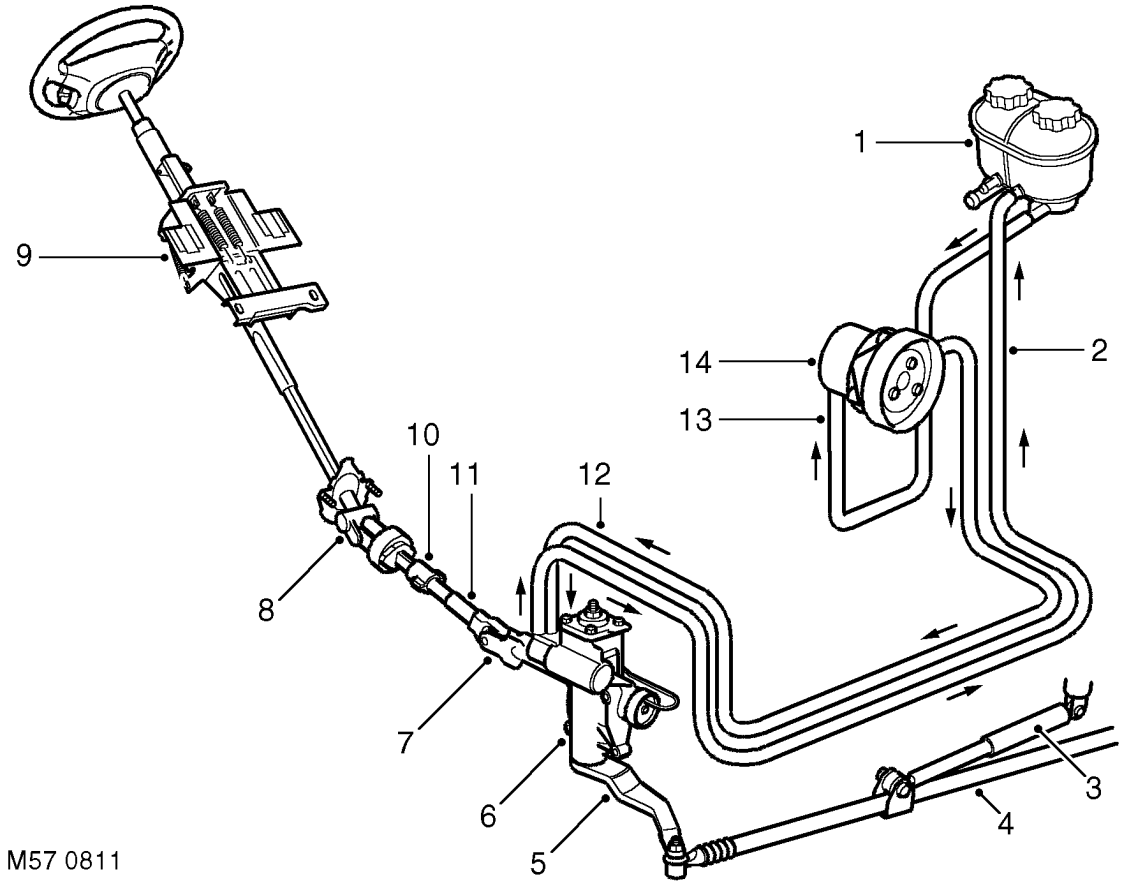
M54 0131

5. Using a suitable drift against the inner part of the joint, remove joint from shaft.
6. Remove circlip from shaft and discard.
7. Remove spacer from shaft.
8. Remove gaiter from shaft and inspect for damage. Renew if necessary.

Refit

1. Clean drive shaft and gaiter.
2. Clean spacer.
3. Fit new inner securing band to gaiter.
4. Fit gaiter to shaft.
5. Fit spacer to shaft.
6. Fit new circlip to shaft.
7. Position joint to shaft. Use a screwdriver to press circlip into its groove and push joint fully onto shaft.
8. Apply grease from the sachet to the joint.
9. Position gaiter to joint and fit new outer securing band.
10. Use a Band-it thriftool to secure inner and outer securing bands.
11. Fit wheel hub.
    FRONT SUSPENSION, REPAIRS, Wheel hub.

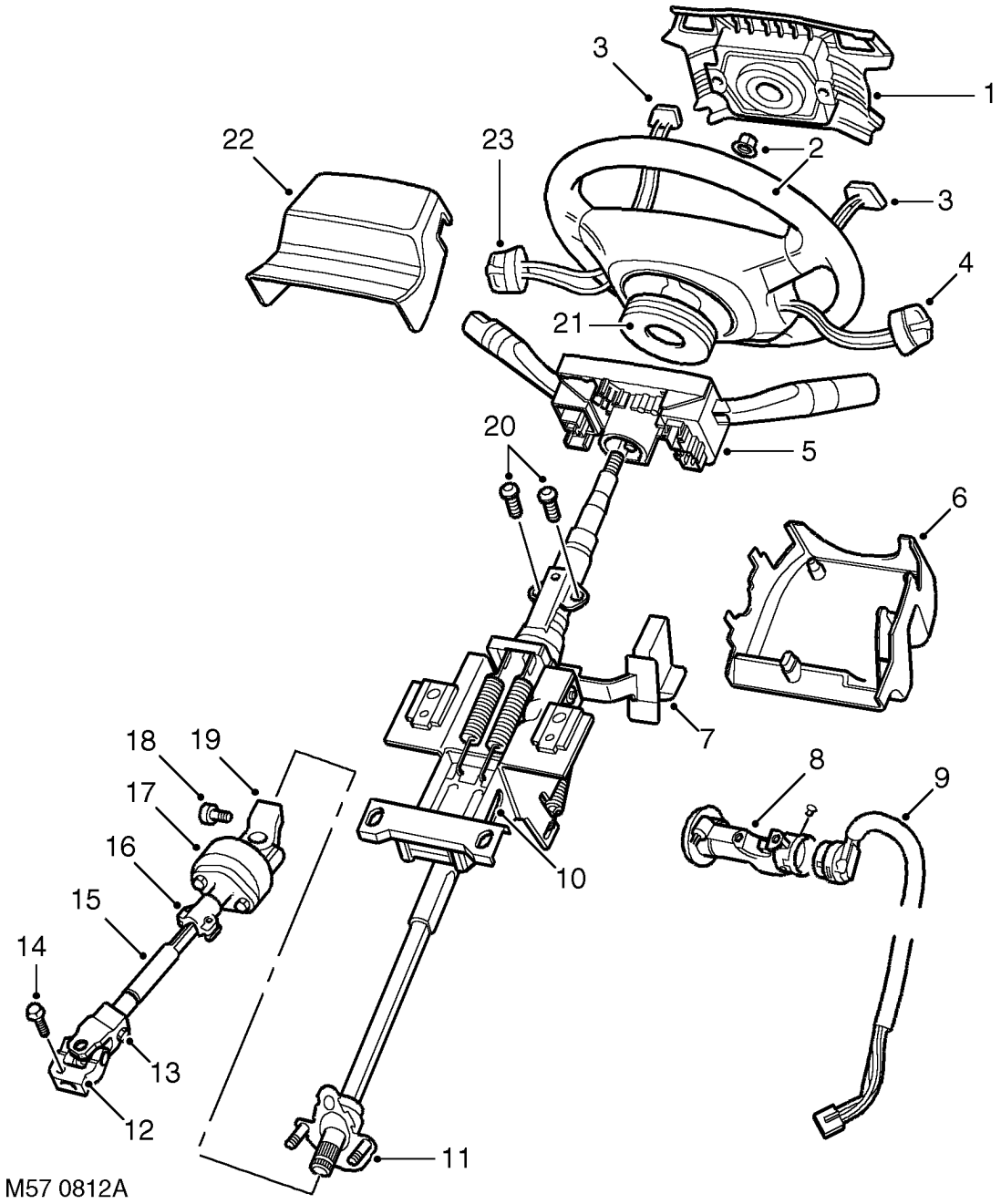
Steering system component layout



RH drive shown LH drive similar

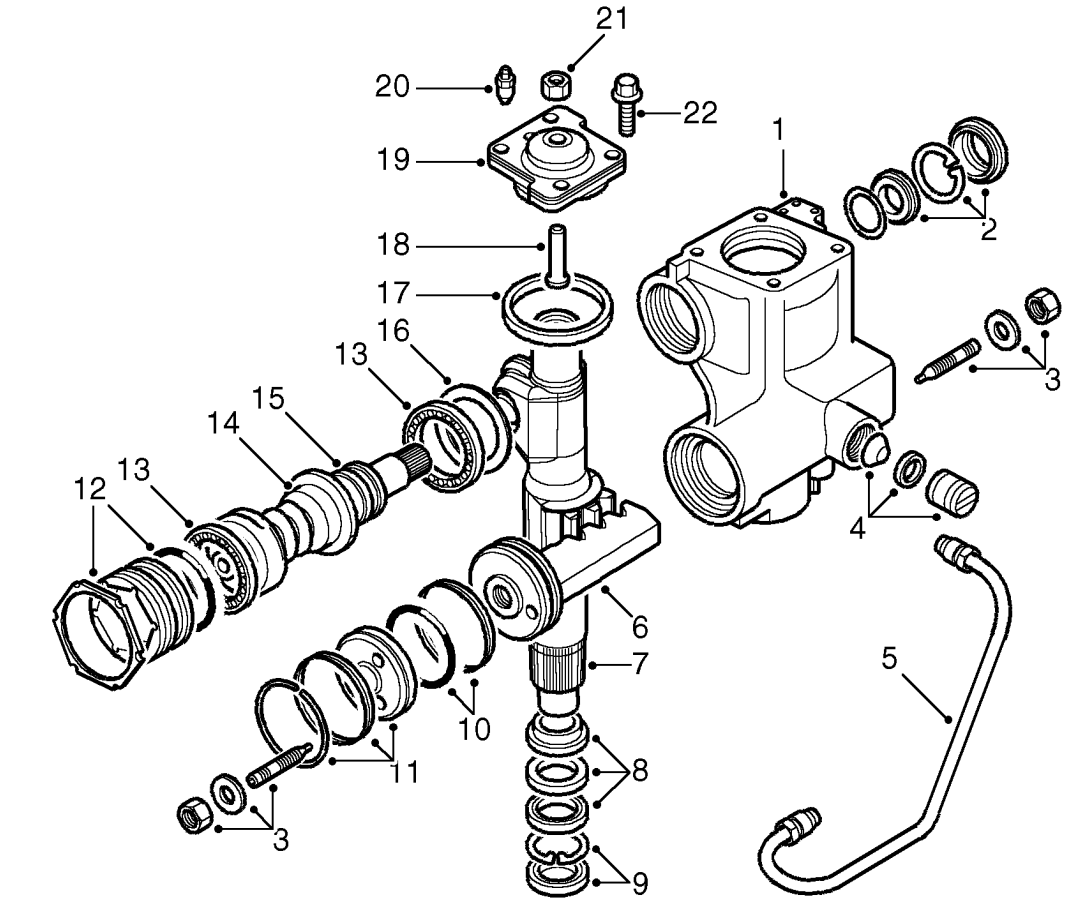
1 Fluid reservoir
2 Return line
3 Steering damper
4 Drag link
5 Drop arm
6 Steering box
7 Universal joint and split adapter
8 Universal joint and coupling
9 Steering column
10 Decouple joint
11 Intermediate shaft
12 Pressure line
13 Suction (inlet) line
14 PAS pump

Steering column assembly and intermediate shaft



1 Air bag module
2 Steering wheel and nut
3 Horn switch 2 off
4 Radio remote control switch (if fitted)
5 Column switches
6 Lower nacelle
7 Column tilt adjustment lever
8 Steering column lock
9 Ignition switch and harness
10 Upper column assembly
11 Lower column
12 Universal joint
13 Bolt
14 Bolt
15 Intermediate shaft assembly
16 Decouple joint
17 Rubber coupling and heat shield
18 Bolt
19 Universal joint
20 Shear bolt 2 off
21 Rotary coupler
22 Upper nacelle
23 Cruise control switch (if fitted)

Steering box



M57 0813

RH drive shown, LH drive similar

1 Housing with output shaft lower bearing
2 Input shaft dirt shield, circlip, backup washer and pressure seal
3 Relief valve stop, seal and locknut 2 off
4 Piston/rack adjuster
5 Hydraulic pipe
6 Piston/rack and relief valves
7 Output shaft
8 Seal, washer and backup seal
9 Circlip and dirt shield
10 Teflon and rubber seal 2 off
11 Cylinder cover, seal and snap ring
12 Bearing adjuster, locknut and seal
13 Bearing 2 off
14 Worm gear and rotary control valve assembly
15 Teflon seals 3 off
16 Worm/valve shims
17 Cover plate seal
18 Output shaft adjuster
19 Cover plate and bearing
20 Bleed screw
21 Output shaft adjuster lock nut and seal
22 Cover plate bolts 4 off

Description

General
The major steering components comprise an impact absorbing telescopic steering column, a Power Assisted Steering (PAS) box, a PAS pump, and fluid reservoir. Hydraulic fluid from the fluid reservoir is filtered and then supplied through the suction line to the inlet on the PAS pump. The PAS pump supplies fluid to the steering box through a pressure line routed above the front cross member. Fluid returns to the reservoir along the same route through a return line. On LH drive vehicles the pipe route above the front cross member is still used, the length of pipe acting as an oil cooler.

To minimise driver's injury in the event of an accident the steering system has a number of safety features including a collapsible steering column. An additional safety feature is an air bag located in the steering wheel.
☞ **RESTRAINT SYSTEMS, DESCRIPTION AND OPERATION, Description - SRS.**

Steering column assembly and intermediate shaft
The steering column central shaft comprises of two shafts, the upper shaft is splined to accept the steering wheel and located in bearings in the column tube. A universal joint is located on the bottom of the upper shaft, the joint allows for angular movement between the upper and lower shafts. The lower shaft is made in two parts, the top section of the lower shaft is located outside of the lower section. The two sections of the lower shaft are connected by two nylon injection moulded shear pins. The lower shaft goes through a lower bearing attached to the bulkhead, the lower shaft is connected by a universal joint to the intermediate shaft in the engine compartment.

Steering column
An upper column tube provides for the location of the steering lock and ignition switch and also the steering switch gear and a rotary coupler. The rotary coupler provides the electrical connection for the steering wheel mounted airbag, switches and horn. The upper mounting bracket has two slots, a slotted metal bracket is held in each slot by four resin shear pins.

The column is mounted on four captive studs which are located on a column mounting bracket. The captive studs pass through the metal brackets, locknuts secure the steering column to the bulkhead. The two lower mountings are fixed and cannot move when loads are applied to them. The upper mounting is designed to disengage or deform when a load is applied, allowing the column to collapse in the event of an accident. The steering column must be replaced as a complete assembly if necessary.

When an axial load is applied to the upper column tube, energy absorption is achieved by the following mechanism:
- the mounting bracket deforms,
- the resin shear pins holding the slotted metal brackets shear,
- the top mounting bracket slides out of the slotted metal brackets.

The slotted metal brackets remain on the captive studs on the bulkhead. If the column mounting moves, injection moulded shear pins retaining the two sections of the lower column shaft will shear. This allows the two sections of the lower shaft to 'telescope' together.

In the event of a collision where the steering box itself moves, two universal joints in the column allow the intermediate shaft to articulate, minimising movement of the column towards the driver. If movement continues energy absorption is achieved by the following mechanism:
- the decouple joint in the intermediate shaft will disengage,
- the lower section of the steering column shaft will move through the lower bearing,
- the injection moulded shear pins retaining the two sections of the lower column shaft will shear.

This allows the two sections of the lower shaft to 'telescope' together reducing further column intrusion. Protection to the drivers face and upper torso is provided by an SRS airbag module located in the centre of the steering wheel.
☞ **RESTRAINT SYSTEMS, DESCRIPTION AND OPERATION, Description - SRS.**

Tilt adjustment
The column tilt adjuster lever mechanism is located on the LH side of the steering column and allows the upper column tube, nacelle and steering wheel assemblies to be tilted up or down a maximum of 7.5° or 47 mm (NAS vehicles have a smaller range of movement than the ROW vehicles).

The pawl of the mechanism is attached to the lower column and is allowed to pivot, a toothed quadrant is fixed to the upper column tube.

When the lever on the LH side of the steering column is raised the mechanism releases the pawl from the toothed quadrant, this allows the column to be moved. When the lever is released two return springs pull the pawl into engagement with the toothed quadrant.

Steering column lock (All except NAS)
The steering column lock houses the ignition switch, ignition illumination light ring, key lock barrel and the alarm passive coil. The steering lock is attached to the upper column with two shear bolts. The bolts are tightened to a torque which shears off the heads of the bolts preventing easy removal of the steering lock.

The steering lock operates by a bolt, which emerges when the ignition key is turned to position 'O' and the ignition key removed. The bolt engages in a lock collar located on the upper shaft in the upper column tube. The lock collar is attached to the upper shaft by a 'wave form' interference ring. If a high torque is applied via the steering wheel with the lock engaged, the lock collar will slip on the upper shaft. This prevents damage to the steering lock, yet still prevents the vehicle from being driven.

Steering column lock (NAS only)
The steering column lock houses the ignition switch, ignition illumination light ring, key lock barrel and the alarm passive coil. The steering lock is attached to the upper column with two shear bolts. The bolts are tightened to a torque which shears off the heads of the bolts preventing easy removal of the steering lock.

The steering column lock operates by a bolt, which emerges when the ignition key is turned to position 'O' and the ignition key removed. The bolt engages in a groove machined into the upper shaft in the column tube.

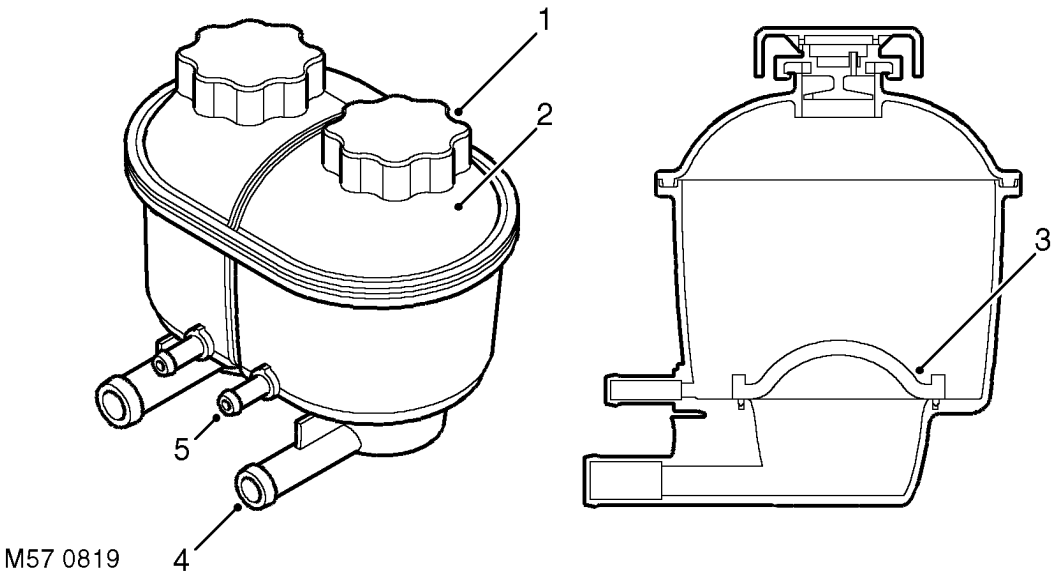
Steering wheel
The steering wheel comprises a cast centre and wire frame onto which the soft polyurethane foam is moulded. The steering wheel is located on the upper column shaft by a spline and is secured with a nut. A remote radio control switch (if fitted) is located on the LH side of the steering wheel, a cruise control switch may be located on the RH side. Horn switches are located on each side of the centre of the steering wheel and protrude through the airbag module cover. Both switches are connected by wires to the rotary coupler connector.

Intermediate shaft
One end of the intermediate shaft is attached to the steering column lower shaft by a splined universal joint and a bolt, the universal joint is part of a rubber coupling assembly. The rubber coupling assembly is covered by a heat shield and connects to the lower section of the intermediate shaft via a decouple joint. The rubber coupling reduces the shocks felt by the driver through the steering wheel. A second universal joint on the other end of the intermediate shaft is held in by a bolt. The universal joint is splined and engages with the splined rotor (input) shaft of the steering box.

The decouple joint consists of a metal plate that has open ended slots, the plate is bolted through the slots into the other half of the decouple joint. The top half of the decouple joint has a slot that accepts the lower section of the intermediate shaft. The slotted metal plate clamps the lower section of the intermediate shaft to the top section. An indicator clip is installed between the slotted metal plate and the top half of the decouple joint.

If the intermediate shaft is compressed in an accident, the slotted metal plate in the decouple joint will disengage if sufficient force is applied to the front end of the shaft. If the forces involved do not disengage the shaft, the red indicator clip located in the decouple joint will break off if the shaft moves. The intermediate shaft cannot be repaired and must be replaced as an assembly if accident damage occurs.

Reservoir



1 Filler cap
2 Reservoir body (dual PAS/ACE shown)
3 Filter
4 Supply connection
5 Return connection

The fluid reservoir is made of moulded plastic and is located on LH side of the engine compartment, on a bracket which is attached to the inner wing. Dependent on the vehicles specification the reservoir may be a dual PAS/ACE, or PAS only reservoir. Both types of reservoir are similar to each other the dual PAS/ACE reservoir has two chambers, the PAS only reservoir has one chamber of a larger capacity. On both types of reservoir the PAS chamber has its own filler cap and is identified by lettering on the reservoir body.

A filter of fine polyester mesh is moulded into the base of the chamber. The filter removes particulate matter from the fluid before it is drawn into the supply connection and is non-serviceable. Upper and lower level marks are moulded into the reservoir body, the reservoir is fitted with filler cap, a seal in the cap prevents leakage. The filler cap is pushed onto a latch and turned through 90° to lock. A breather hole is incorporated in the cap to allow venting of air due to fluid level changes during operation. The breather hole also allows air that may be in the fluid to separate out and vent to atmosphere.

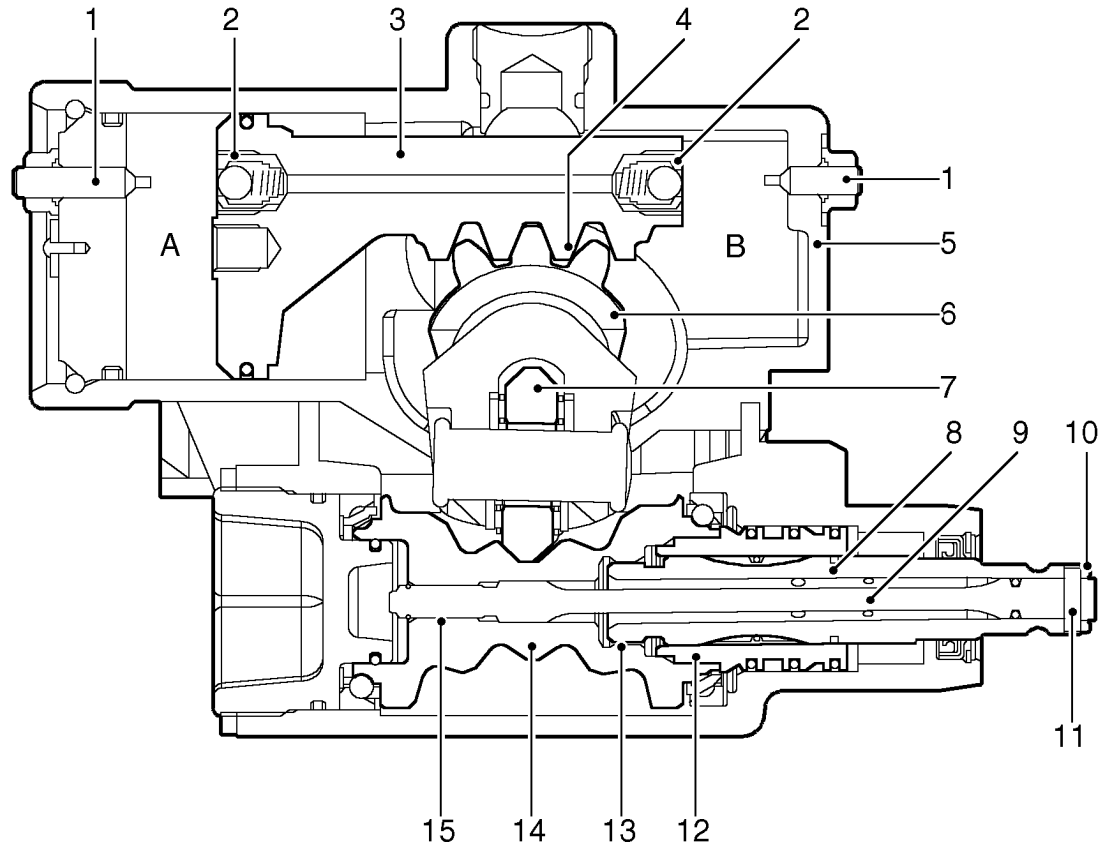
The reservoir holds hydraulic fluid and allows for expansion and contraction of the fluid due to temperature variations. With the reservoir correctly filled the inlet to the PAS pump will be kept covered at normal operational attitudes. The fluid flowing to the reservoir is cooled by convection from the pipe surfaces, the fluid held in the reservoir also allows convection from the sides of the reservoir to take place. The total capacity of the reservoir with PAS only is 1000 cc (0.264 US gallons), for vehicles fitted with PAS and ACE the total capacity of the reservoir is 500 cc (0.132 US gallons).

Steering box

The steering box is located behind the first cross member of the chassis and is secured to the chassis rail with four bolts. The steering box is of the worm and roller type and has a rotary control valve. The steering box is connected to the steering knuckles of the front road wheels by the drop arm, drag link and track rod. The steering box is lubricated by the hydraulic fluid in the housing. The input shaft is attached to the steering wheel via the intermediate shaft and steering column. The drop arm is secured to the output shaft with a nut and tab washer. A ball joint allows movement between drop arm and drag link, the ball joint is secured with a locknut. The steering box requries approximately 3.5 turns from lock to lock.

As a maintenance aid, an alignment bolt can be used to lock the drop arm at the steering box centre position. The bolt fits in a groove in the rear face of the drop arm and screws in to a threaded hole on the bottom of the steering box housing.

Cross section through steering box



M57 0814

1 Relief valve stop 2 off
2 Relief valve 2 off
3 Piston
4 Rack
5 Housing
6 Output shaft
7 Roller
8 Valve rotor
9 Torsion bar
10 Input shaft
11 Pin
12 Valve sleeve
13 Course spline
14 Worm gear
15 Spline (worm gear to torsion bar)

Principle of operation

Movement of the input shaft is transferred through the pin to the torsion bar and valve rotor on the input shaft. As the input shaft turns, the spline of the torsion bar turns the worm gear. This action causes the roller to rotate on its bearings and move. As the roller is located by a pin to a yoke on the output shaft, the output shaft rotates in the steering box housing. As the amount of torque acting on the input shaft increases the torsion bar starts to twist. As the torsion bar twists the valve rotor turns in the valve sleeve. When the ports in the valve rotor and valve sleeve are turned, hydraulic fluid is directed to chamber 'A' or 'B' in the power cylinder.

With hydraulic fluid in one chamber under high pressure, the piston moves. The return line ports in the rotary valve, aligned by the movement of the valve rotor, allow the fluid in the opposite chamber to flow to return. The teeth of the rack move and transfer the force from the piston to the output shaft, giving assistance to move the drop arm. As the output shaft rotates the torsion bar load is decreased. The rotor on the input shaft will return as the torsion bar unwinds, the rotary valve will then be in a neutral position and the pressure in chambers 'A' and 'B' will equalise. With no high pressure acting on the piston, force on the piston and rack is released.

To prevent heat accumulation at full steering lock due to excessive pressure, a relief valve inside the steering box is opened as the box approaches full lock. The relief valve pins are located in the cylinder cover and housing and are not to be adjusted.

The steering box design ensures a mechanical link through the course spline on the control valve rotor, the spline will become engaged if:

- The hydraulic pressure fails.
- The steering box rotary control valve fails.

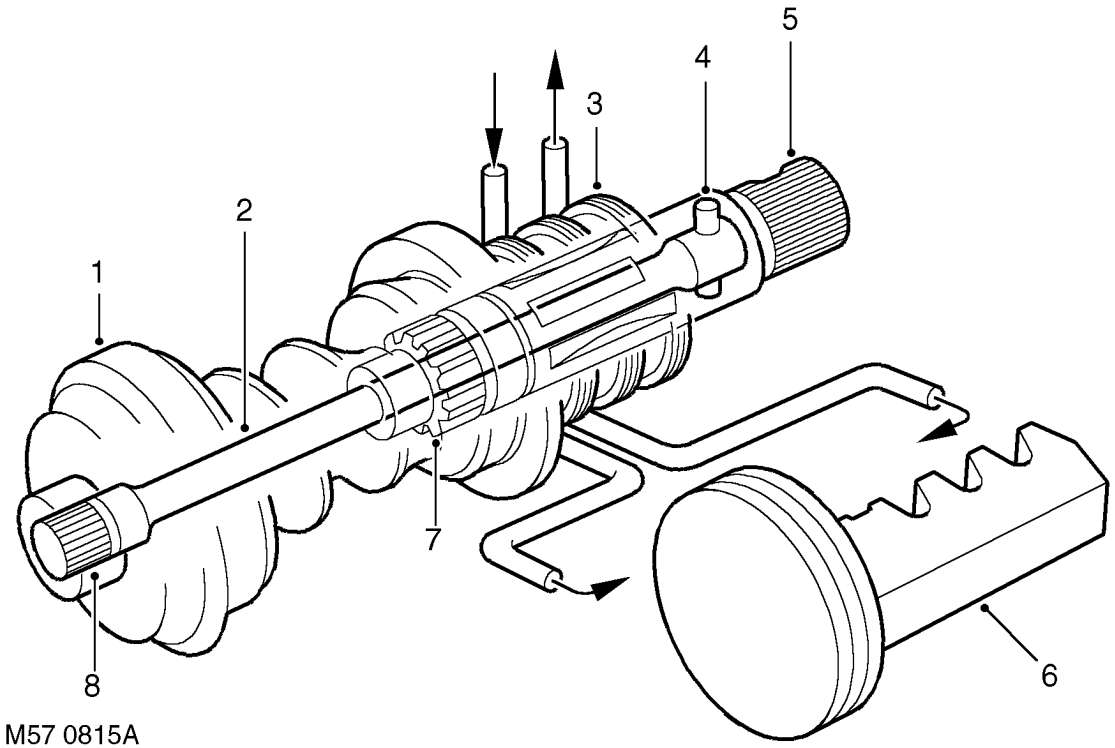
The course spline may also engage in some full lock situations if sufficient torque is applied to the input shaft.

Rotary control valve

The rotary valve assembly comprises of three parts. The valve sleeve is fixed inside one end of the worm gear, the valve sleeve has ports through it to allow the passage of hydraulic fluid. The input shaft has a valve rotor machined on one end, the valve rotor also has ports through it and can rotate in the valve sleeve. A torsion bar is attached to the input shaft by a pin, the torsion bar goes through the input shaft and valve rotor and is engaged by a spline into the worm gear.

The course spline on the end of the valve rotor is loosely engaged in the worm gear, the course spline can make contact and drive the worm gear in some full lock and in no pressure conditions. In the event of a torsion bar failure, power assistance will be lost, the course spline will drive the worm gear and enable the vehicle to be steered and driver control maintained.

Rotary control valve at neutral

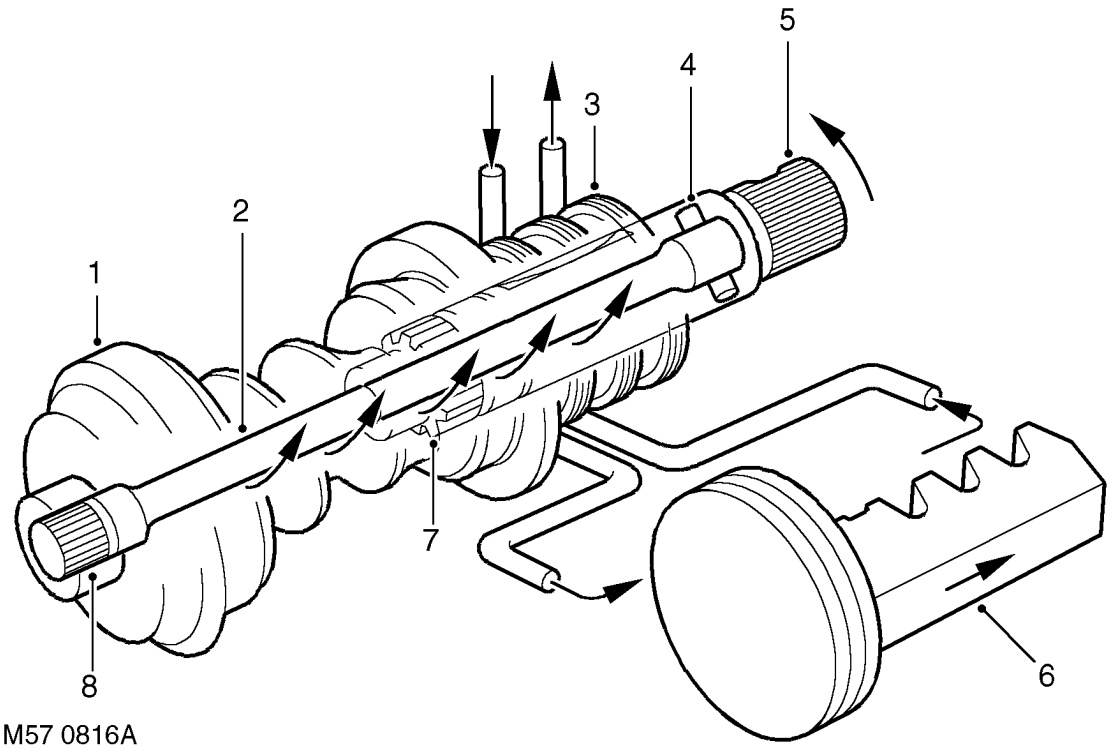


M57 0815A

1 Worm gear
2 Torsion bar
3 Valve sleeve
4 Pin
5 Input shaft and valve rotor
6 Piston/rack
7 Coarse spline
8 Spline (torque shaft to worm gear)

When there is no demand for assistance the torsion bar holds the ports in the valve sleeve and valve rotor in a neutral relationship to one another. The ports in the valve sleeve and the valve rotor are so aligned to allow equal (low) fluid pressure on each side of the piston. Excess fluid flows through ports in the valve rotor through the valve sleeve and back to the reservoir.

Rotary control valve in demand mode



M57 0816A

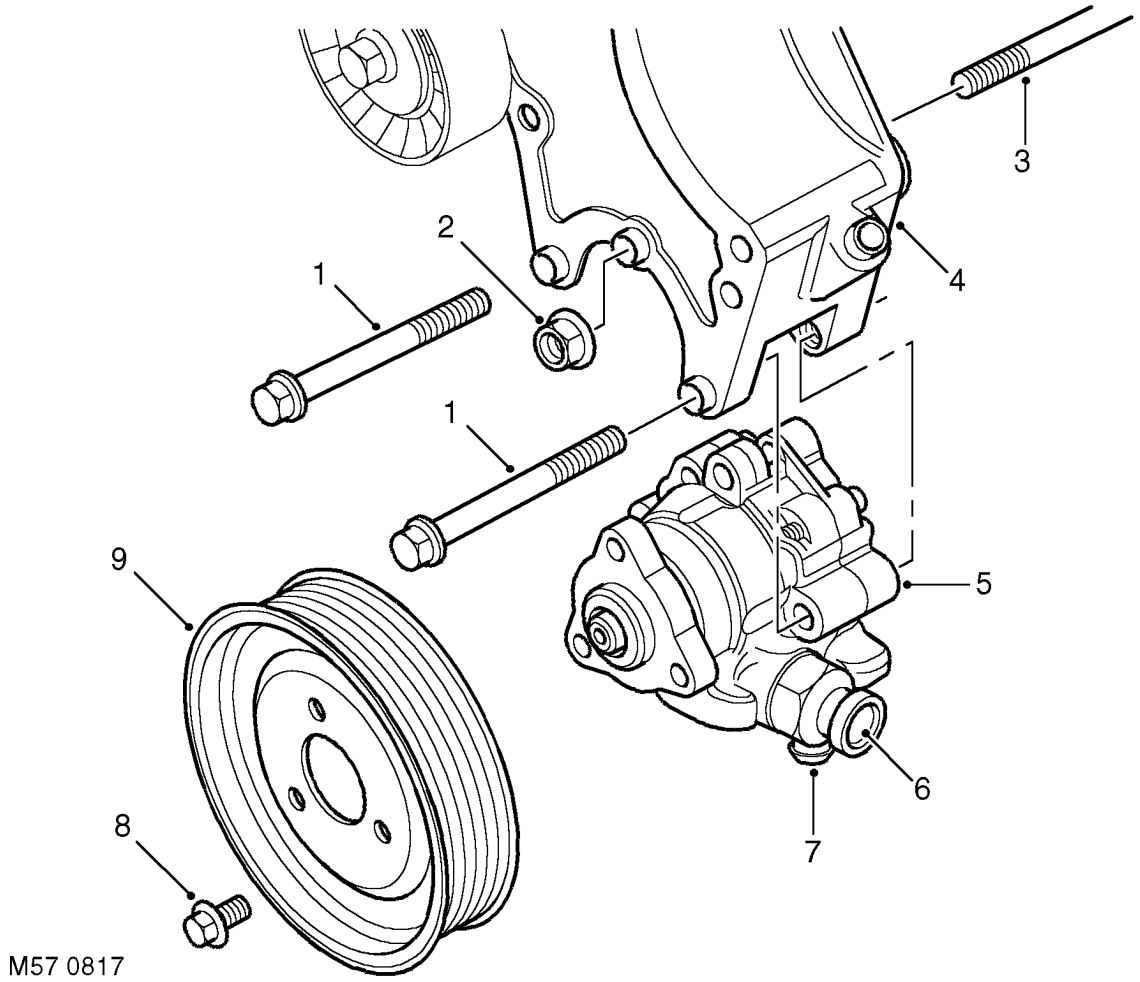
1 Worm gear
2 Torsion bar
3 Valve sleeve
4 Pin
5 Input shaft and valve rotor
6 Piston/rack
7 Coarse spline
8 Spline (torque shaft to worm gear)

When the steering wheel and input shaft is turned steering resistance transmitted to the worm causes the torsion bar to be wound up and the valve ports in the valve rotor and valve sleeve to be aligned for a right or left turn. The alignment of the valve ports directs fluid pressure 'A' from the PAS pump to one side of the piston/rack . The other side of the piston/rack is now connected to return 'B' (due the valves port alignment) and displaced fluid returns to the reservoir. The pressure difference in the cylinder on each side of the piston gives the power assistance to move the rack and so turn the steering.

The greater the resistance of the road wheels to the steering rotary movement, the greater torque acting on the torsion bar and input shaft causing greater changes of alignment of the ports in the valve. As the change of alignment becomes greater, the fluid pressure passing to the applicable side of the piston/rack increases.

Only when the steering wheel stops turning and the torsion bar has unwound, will the valve rotor return to the neutral position. In the neutral position the fluid circulates through the ports in the valve rotor and valve sleeve and back to the reservoir where it is cooled.

PAS pump - V8



1 Bolt 2 off
2 Nut
3 Stud
4 Auxiliary housing
5 PAS pump
6 Outlet
7 Inlet
8 Bolt 3 off
9 Drive pulley

The PAS pump is located on the auxiliary housing and is attached by two bolts, the bolts go through flanged bushes in the auxiliary housing. A stud passes through the PAS pump and through a flanged bush in the auxiliary housing, the auxiliary housing and PAS pump are secured by a nut. As the two bolts and nut are tightened the bushes move slightly and the flange of each bush clamps the PAS pump. A drive pulley is attached to the pump drive shaft with three bolts, and is belt driven at a ratio of 1.4 crankshaft revolutions to 1 of the drive pulley. Fluid is drawn into the PAS pump inlet from the reservoir through a flexible hose at low (suction) pressure. Fluid at high pressure from the PAS pump outlet is supplied to the rotary control valve on the steering box.

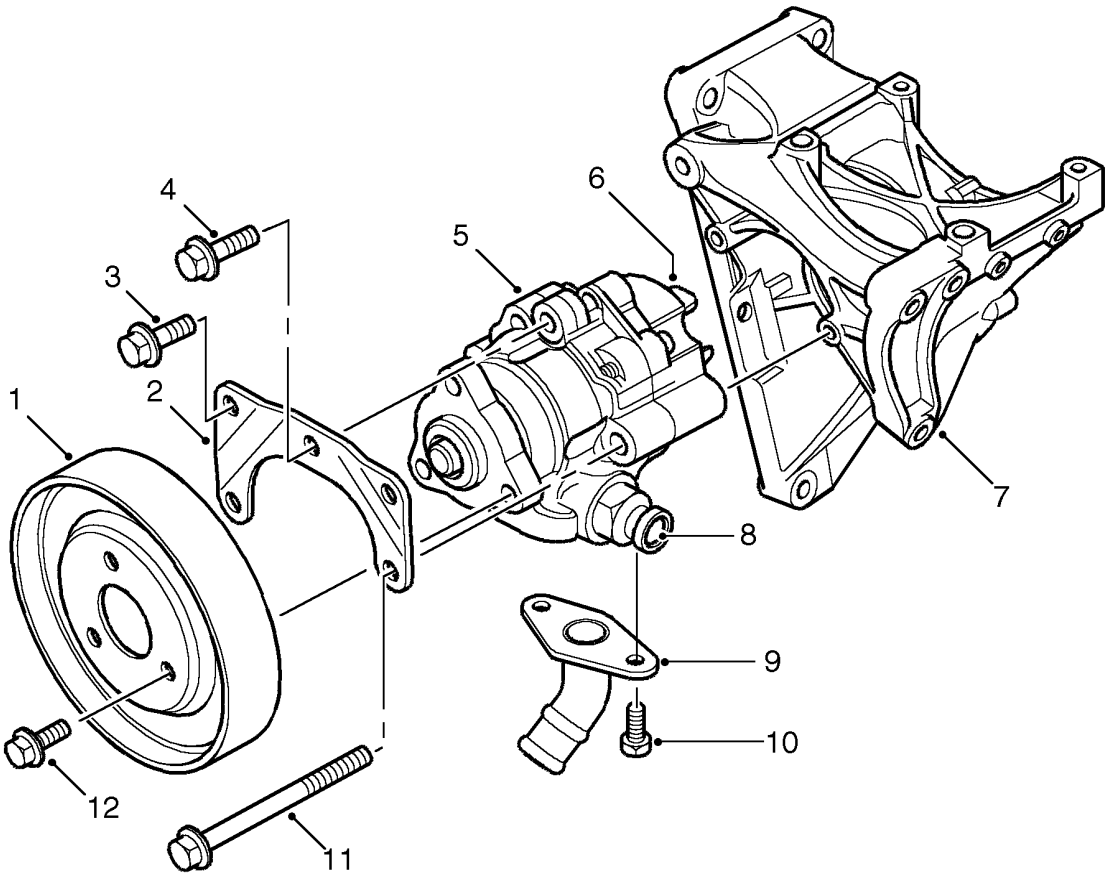
The PAS pump is a roller vane type and has an internal pressure regulator and flow control valve. The roller vanes can move in slots in the pumps rotor and are moved outwards by centrifugal force as the pump rotates. The pump rotor rotates in the pump housing, the internal shape of the housing forms a 'cam' shape. Due to the 'cam' shape the volume of the housing decreases between the inlet and outlet ports.

As the pump rotor rotates towards the pump inlet the volume between the roller vanes and the pump housing increases, this action causes a depression in the chamber between the pump roller vanes and the housing. As the rotation continues the chamber is opened to the pump inlet, and the depression in the chamber causes fluid to be drawn in. The roller vanes continue past the inlet port, closing off the inlet port and trapping the fluid in the chamber between the rollers and the pump housing.

The internal 'cam' shape of the pump housing causes the rollers to move closer together as the pump rotor rotates towards the outlet port. The reduced volume of the chamber between the roller vanes causes the fluid to become pressurised. When the chamber is opened to the outlet port of the pump the fluid escapes at high pressure. The roller vanes continue turning and go past the outlet port, closing off the chamber between the two roller vanes.

As rotation continues the inlet sequence begins again. The inlet and pressurisation/outlet sequences continue as the pump rotates, and is repeated between each two roller vanes. The pump is a positive displacement type and the potential pump output increases with engine (drive pulley) speed. The pressure relief and flow control valve regulates flow/pressure by diverting fluid back to the pump inlet through internal recirculation passages in the pump body.

PAS pump - diesel



M57 0818A

1 Drive pulley
2 Mounting bracket
3 Bolt 2 off
4 Bolt
5 PAS pump
6 Coupling
7 Auxiliary housing
8 Outlet
9 Inlet adaptor pipe and seal
10 Bolt 2 off
11 Bolt 2 off
12 Bolt 3 off

The PAS pump is located on the auxiliary housing, two bolts go through the PAS pump, mounting bracket and into the auxiliary housing. One bolt also attaches the mounting bracket to the PAS pump, two bolts secure the mounting bracket to the auxiliary housing. An inlet adaptor pipe with a seal is secured to the bottom of the pump with two bolts. A drive pulley is attached to the pump drive shaft with three bolts, and is belt driven at a ratio of 1.35 crankshaft revolutions to 1 of the drive pulley. A coupling on the rear of the PAS pump rotates the water pump impeller located in the auxiliary housing. Fluid is supplied to the PAS pump inlet from the reservoir through a flexible hose at low (suction) pressure. Fluid at high pressure from the PAS pump outlet is supplied to the rotary control valve on the steering box.

The PAS pump is a roller vane type and has an internal pressure regulator and flow control valve. The roller vanes can move in slots in the pumps rotor and are moved outwards by centrifugal force as the pump rotates. The pump rotor rotates in the pump housing, the internal shape of the housing forms a 'cam' shape. Due to the 'cam' shape the volume of the housing decreases between the inlet and outlet ports.

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As rotation continues the inlet sequence begins again. The inlet and pressurisation/outlet sequences continue as the pump rotates, and is repeated between each two roller vanes. The pump is a positive displacement type and the potential pump output increases with engine (drive pulley) speed. The pressure relief and flow control valve regulates flow/pressure by diverting fluid back to the pump inlet through internal recirculation passages in the pump body.

Steering damper

The steering damper is located behind and just below the first cross member of the chassis. The ends of the steering damper have steel 'eyes' welded on, rubber bushes are installed in each 'eye'. The steering damper is attached between brackets on the chassis rail and the drag link. Each end of the steering damper is secured by a bolt and locknut. The hydraulic damper absorbs shocks in the steering, caused by road wheel deflections when operating on rough terrain.

Operation

Hydraulic fluid is supplied to the PAS pump inlet from the PAS reservoir, the PAS pump draws in and pressurises the fluid. The PAS pump self regulates internal flow rates and operating pressure, and supplies pressurised fluid from the PAS pump outlet to a rotary control valve in the steering box. At neutral the fluid is circulated by the PAS pump and flows around the system at a lower pressure and a constant flow rate. With most of the fluid being returned to the reservoir the pressure inside the system remains very low. When a control input turns the rotary control valve in the steering box, pressure in the system will rise as the control valve directs fluid to give power assistance.

The action of turning the steering wheel turns the steering column and intermediate shaft. The intermediate shaft turns the input shaft of the steering box. The input shaft moves the rotary control valve in the steering box, the rotary valve controls the pressure used inside the steering box for power assistance. The input shaft also turns a worm gear, the worm gear acts on a roller attached to the output shaft. As the worm gear turns the roller, the roller travels along the lands of the worm gear. As the roller is attached to the output shaft the output shaft turns.

As the output shaft of the steering box turns, hydraulic pressure is supplied via the rotary control valve to the steering box. The hydraulic pressure acts on a rack that assists with the movement of the output shaft of the steering box. A drop arm is attached to the output shaft of the steering box. The drop arm is connected to a drag link by a ball joint. The drag link is connected via ball joints to one front steering knuckle and road wheel. A track rod connected to this steering knuckle links the two steering knuckles together. As one steering knuckle and road wheel is turned by the drag link, the other steering knuckle and wheel is moved by the track rod.

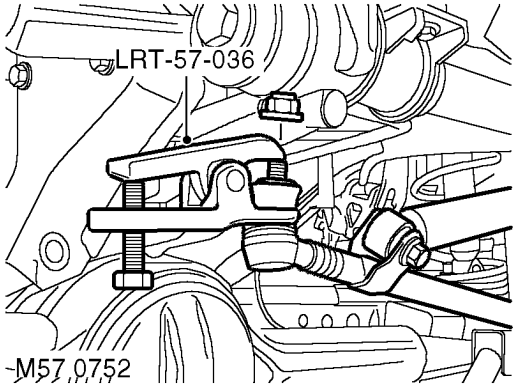
Steering box - check and adjust

57.10.13

Check

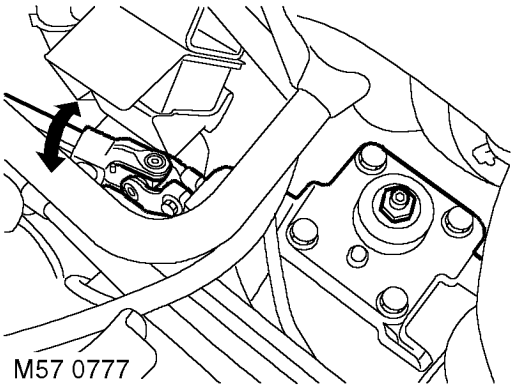
1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Remove nut securing drag link to drop arm.
3. Using **LRT-57-036**, break taper joint and release drag link.
4. Ensure steering is centralised.
5. With the drop arm held, check for rotational movement at the intermediate shaft universal joint. If any movement exists, the steering box requires adjusting.

Adjust



1. Loosen lock nut on steering box adjuster and tighten adjuster until movement is removed at universal joint.

   CAUTION: Ensure that steering box is centralised before adjustment. Never over adjust, free play should just be eliminated.

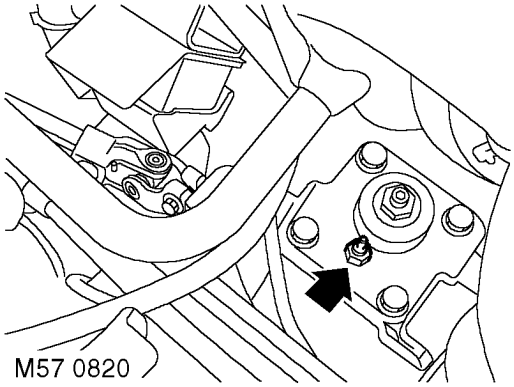
2. When adjustment is correct, hold the adjuster and tighten adjuster locknut.
3. Turn steering wheel from lock to lock and check no tightness exists.
4. Fit drag link to drop arm, and tighten nut to 80 Nm (59 lbf.ft).
5. Remove stands and lower vehicle.

Hydraulic system - bleed

57.15.02

Bleed

1. Clean PAS fluid reservoir around filler cap and fluid level indicators.
2. Remove filler cap from PAS fluid reservoir. If necessary, fill PAS fluid reservoir to upper level indicator with recommended fluid.
   CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.
   CAUTION: Ensure no dirt is allowed to enter the steering reservoir when the cap is removed.
3. Start engine and run to normal operating temperature.
4. Position container to catch fluid spillage from steering box.



5. With engine at idle speed, and an assistant turning the steering from lock to lock, loosen bleed screw on top of steering box. Keep PAS fluid reservoir topped up and allow all air to bleed from system. When fluid from bleed screw is free of air, tighten bleed screw.
   CAUTION: Do not hold steering at full lock for longer than 10 seconds.
6. Stop engine.
7. Clean spilled PAS fluid from steering box and surrounding area.
   CAUTION: Power steering fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.
8. Check fluid level in PAS fluid reservoir and fill to upper level mark. If fluid is aerated, wait until fluid is free from bubbles.
9. Fit PAS fluid reservoir filler cap.

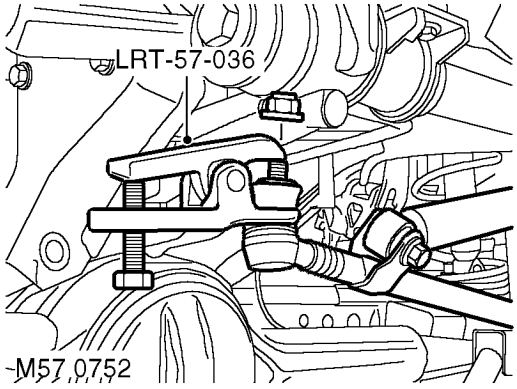
Steering linkage - centralise

57.35.05

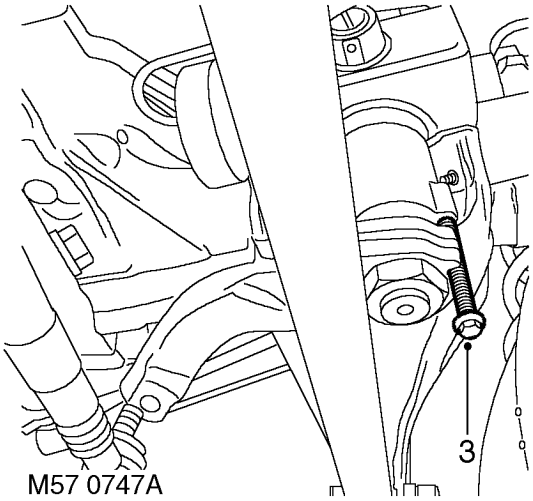
The following procedure assumes that the front wheel alignment is correctly adjusted.

Adjust

1. Raise front of vehicle, and position the road wheels at straight ahead.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

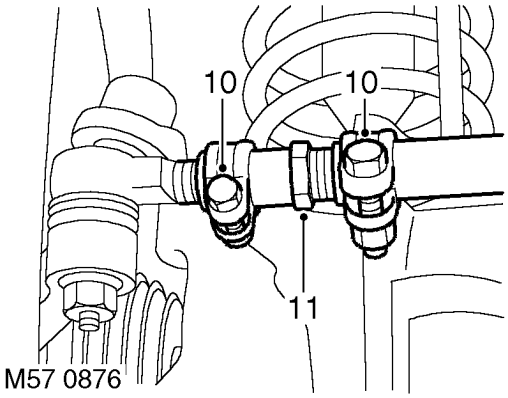


2. Remove nut securing drag link to drop arm. Using tool **LRT-57-036** break taper joint and release drag link from drop arm.



3. Fit centralising bolt to steering box and ensure that front road wheels are in the straight ahead position.
4. Loosen clamp bolts on drag link.

5. Adjust drag link so that taper joint is centralised in drop arm, then tighten drag link clamp bolts: Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft).
6. Connect drag link to drop arm and tighten nut to 80 Nm (59 lbf.ft).
7. Remove steering box centralising bolt.
8. Remove stand(s) and lower vehicle.
9. Road test the vehicle and check that the steering wheel is centralised. If steering wheel is not centralised, proceed as follows.



M57 0876

10. Slacken drag link adjuster clamp bolts.
11. Without disconnecting drag link from drop arm, adjust the length of the drag link to bring the steering wheel to the central position.

CAUTION: Repositioning the steering wheel on its splines cannot correct small (less than 5°) errors in steering wheel alignment. Always rectify small errors in alignment by adjusting the drag link as detailed above, ensuring that steering box centralisation is maintained.

12. Tighten drag link clamp bolts: Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft)

Wheel alignment - front

57.65.01

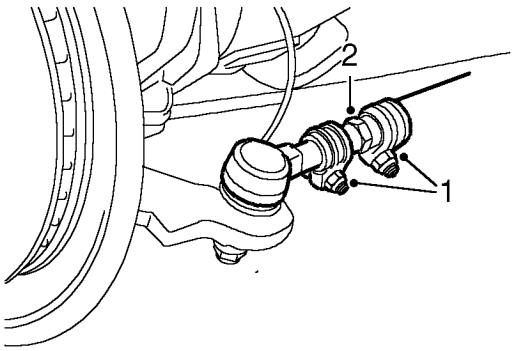
The following is the only wheel alignment equipment which has been approved.

- Beissbarth ML 4600 wheel alignment computer (6 sensor).
- Beissbarth ML 4600-8 wheel alignment computer (8 sensor).
- Beissbarth ML 4000 wheel alignment computer (8 sensor wireless).
- Hunter S411-14.

Check

1. Ensure tyre pressures are correct and vehicle is at kerbside weight.
2. Roll vehicle backwards and forwards to relieve stresses in steering and suspension.
3. Ensure road wheels are positioned straight ahead.
4. Ensure that wheel alignment equipment is properly calibrated.
5. Following the equipment manufacturer's instructions, measure the front wheel alignment. Compare with the figures given in General Data.
   ☞ **GENERAL DATA, Steering.**

Adjust



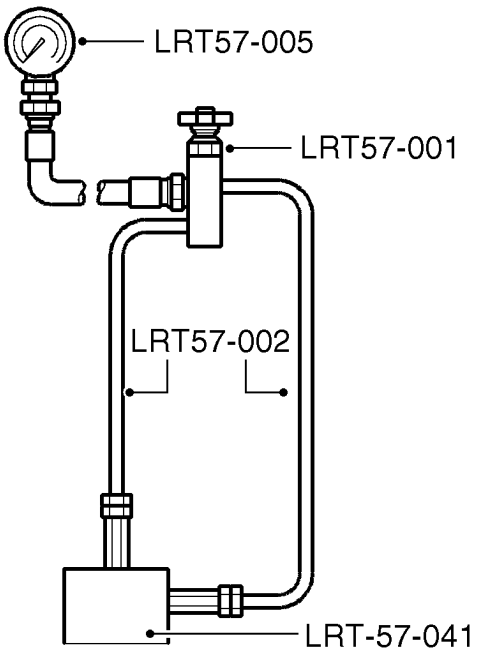
M57 0808

1. Loosen track rod and adjuster clamp bolts.
2. Rotate adjuster to obtain correct alignment.
   ☞ **GENERAL DATA, Steering.**
3. Tighten track rod and adjuster clamp bolts: Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft).
4. Recheck front wheel alignment.

Power steering pressure check - diesel models

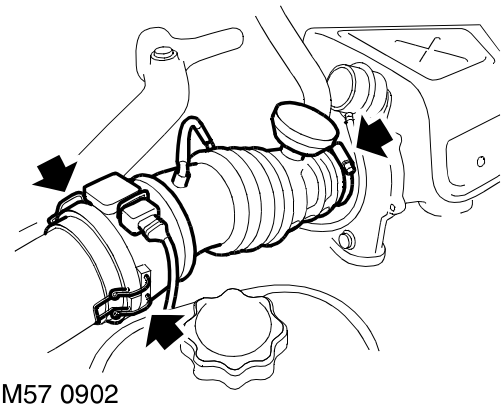
57.90.10.01

Check



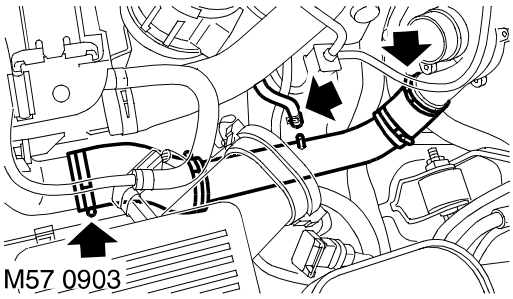
M57 0992A

1. Fit gauge and hose **LRT- 57-005** to valve assembly **LRT- 57-001** and tighten union.
2. Fit 2 hoses **LRT-57-002** to valve assembly **LRT- 57-001** and tighten unions
3. Fit adaptor and hose set **LRT-57-041** to **LRT-57-002**.
4. Disconnect battery earth lead.
5. Remove engine acoustic cover.
6. **LHD only:** Remove underbelly panel.
   EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.



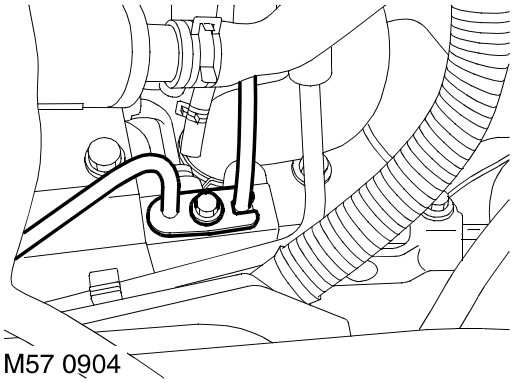
M57 0902

7. **LHD only:** Disconnect MAF sensor multiplug, release clips from air cleaner and move intake hose aside. Discard seal.
8. Position container to collect PAS fluid spillage, and syphon fluid from PAS reservoir.
9. **LHD only:** Release PAS reservoir from mounting move aside, for access to turbocharger intercooler pipe.



M57 0903

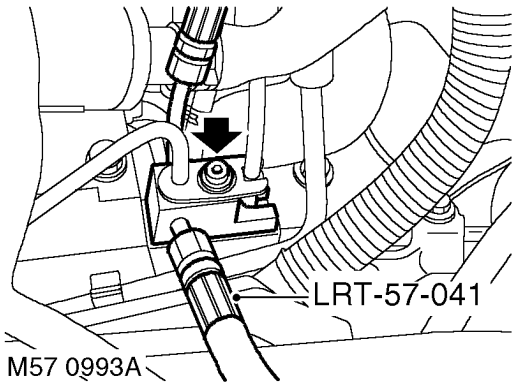
10. Remove vacuum hose from turbocharger intercooler pipe.
11. **LHD only:** Release clips and disconnect turbocharger intercooler pipe from turbocharger and intercooler.



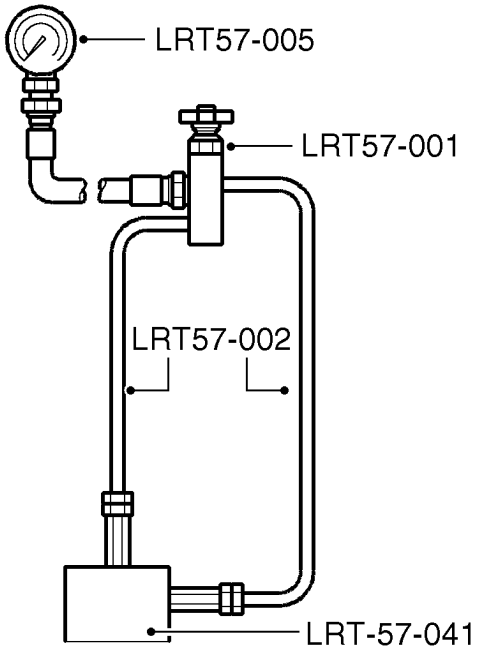
M57 0904

12. Clean steering box pipe housing.

13. Remove bolt from steering box pipe retaining clip. Leaving the PAS reservoir oil pipe in place, release pipe retaining clip and PAS cooler pipe from steering box, discard the seal.



14. Fit tool **LRT-57-041** to steering box housing.
15. Fit seal to PAS oil cooler pipe.
16. Fit PAS cooler pipe to **LRT-57-041** align the retaining clip to pipes and tighten bolt to 24 Nm (18 lbf.ft).



M57 0992A

17. Connect test hoses **LRT-57-002** to **LRT-57-041** and tighten unions. Ensure all pipes and fittings are clear of engine rotating parts.
18. Hang pressure gauge in a safe position under bonnet.
19. **LHD only:** Fit turbocharger intercooler feed pipe and vacuum connection and fit PAS reservoir to mounting bracket. Fit air intake hose to turbocharger and air cleaner and connect multiplug to MAF sensor. **The above parts must be refitted in order to run the engine.**
20. Fill PAS reservoir, connect battery earth lead. Start engine and allow air to bleed from PAS system, by turning steering from lock to lock. Stop engine and check PAS fluid level.
21. Ensure steering system is free from leaks and maintain maximum fluid level during test.
22. Open the test valve on **LRT-57-001** and start the engine.
23. With the engine at idle and normal running temperature, slowly turn the steering wheel and hold on lock.
24. Note reading on pressure gauge.
25. Repeat pressure check on opposite lock, again noting the reading on the pressure gauge.
26. The test pressure should be between 21 and 62 bar, (300 to 900 lbf/in^2. Pressure will rise to 62 bar (900 lbf/in^2) when held on full lock.
27. With the engine at idle, centralise the steering wheel. Pressure should read 7 bar (100 lbf/in^2) or below.
28. Pressure outside the above tolerance indicates a fault.
29. To determine if fault is in steering pump or steering rack, close the valve on **LRT-57-001** for a maximum of five seconds. **Pump damage may occur if test valve is closed for longer periods.**
30. If the gauge does not register between 75 and 103 bar, (1500 lbf/in^2) (maximum pump pressure), the pump is faulty.
31. If maximum pump pressure is obtained, suspect the steering box.
32. On completion, stop engine, disconnect battery earth lead and syphon fluid from PAS reservoir.
33. **LHD only:** Disconnect multiplug from MAF sensor, remove air intake hose clips and move hose aside.
34. **LHD only:** Release PAS reservoir from mounting, for access to turbocharger intercooler pipe.Remove vacuum hose from turbocharger intercooler pipe.Release clips and disconnect intercooler pipe from turbocharger.
35. Remove test equipment from tool **LRT-57-041**.
36. Remove bolt and clip from steering box.
37. Release PAS cooler pipe from tool **LRT-57-041** and discard seal. leaving PAS reservoir oil pipe in place, release tool **LRT-57-041** from steering box and discard seal.

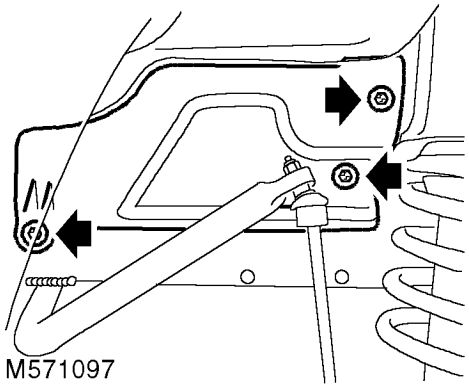
38. Fit new seal, connect PAS cooler pipe and tighten union nut to 24 Nm (18 lbf ft).
39. **LHD only:** Fit turbocharger intercooler feed pipe and vacuum connection. Fit new seal to air cleaner. Connect air intake hose and secure clips. Connect multiplug to MAF sensor.
40. Clean chassis and surrounding area.
41. Fit underbelly panel.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**
42. Remove adaptor and hose set from tool **LRT-57-041**.
43. Check PAS fluid level.
44. Connect battery earth lead.

Power steering pressure check - V8 LHD models

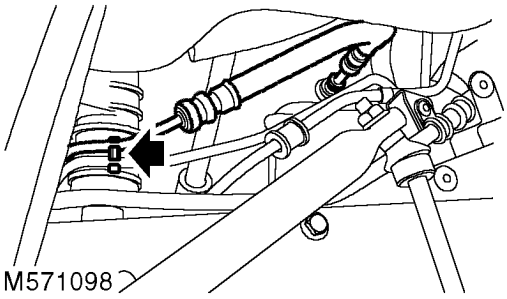
57.90.10.01

Check

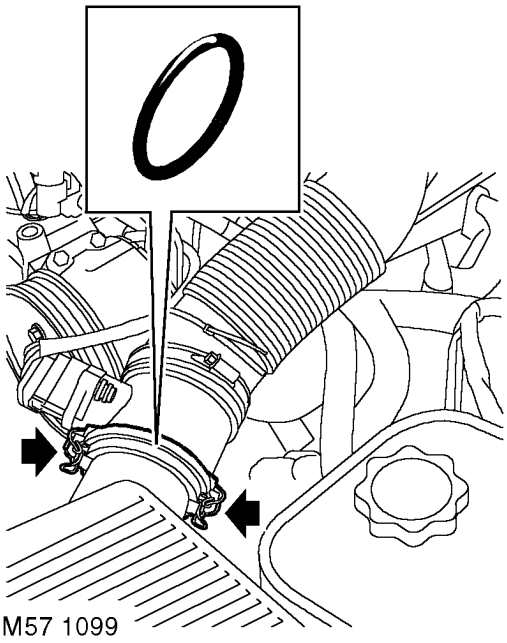
1. Disconnect battery earth lead.
2. Syphon PAS fluid from reservoir.
3. Raise front of vehicle and support on stands.
4. Turn steering on LH lock.



5. Remove 3 screws securing LH splash shield and remove shield.

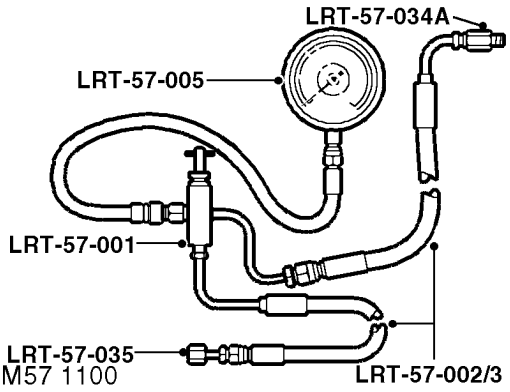


6. Release clip securing PAS pipes.
7. Position absorbent cloth to catch spillage.
8. Position container to collect PAS fluid spillage.


M57 1099

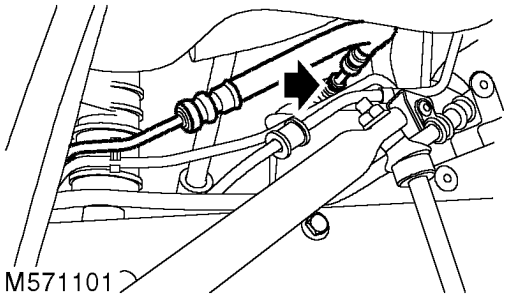
9. Release clips and remove air intake hose from air cleaner housing.
   Note: Pre 03 MY air intake hose illustrated.

10. Discard intake 'O' ring and move intake aside for access.



M57 1100

11. Loosen union securing high pressure pipe to PAS pump and release pipe.


M571101

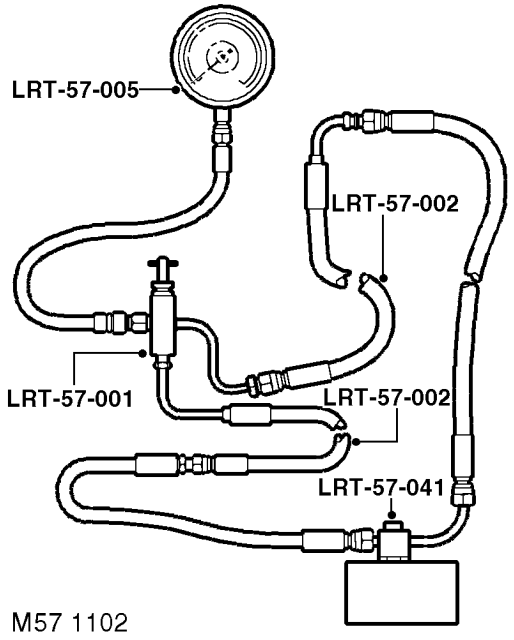
12. Fit adaptor **LRT-57-034A** to high pressure port of PAS pump.
13. Fit adaptor **LRT-57-035** to existing high pressure hose.
14. Fit hose **LRT-57-002/3** to each adaptor.
15. Fit pressure gauge **LRT-57-005** to test valve **LRT-57-001**
16. Connect hoses **LRT-57-002/3** to **LRT-57-001** and tighten unions.
17. Hang pressure gauge in a safe position under bonnet.
18. Remove PAS reservoir filler cap, fill to level indicator and refit cap.
19. Connect battery earth lead.
20. Start engine and allow air to bleed from PAS system by turning steering from lock to lock. Stop engine and check PAS fluid level.
21. Ensure steering system and test equipment are free from leaks.
22. Maintain maximum fluid level during test.
23. Open the test valve on **LRT-57-001** and start the engine.
24. With the engine at idle, slowly turn the steering wheel and hold on full lock.
25. Note the pressure reading on **LRT-57-005.**
26. Repeat the pressure check for the opposite full lock.
27. Test pressure should be between 21 and 62 bar, (300 to 900) psi. Dependant on road surface.
28. With the engine at idle, centralise the steering wheel. Pressure should read 7 bar (100 psi) or below.
29. Pressures outside the above tolerance indicates a fault.
30. To determine if fault is in steering pump or steering box, close the valve on **LRT-57-001** for a maximum of 5 seconds. Pump damage may occur if test valve is closed for longer periods.
31. If gauge does not register between 75 and 103 bar, (1500 psi), (maximum pump pressure), the pump is faulty.
32. If maximum pump pressure is correct suspect the steering box.

33. On completion stop engine, disconnect battery earth lead and syphon fluid from PAS reservoir.
34. Remove test equipment from **LRT-57-002.**
35. Clean PAS pump and pipe union.
36. Fit new 'O' ring to high pressure pipe, align to PAS pump and tighten union to 25 Nm (18 lbf.ft).
37. Secure PAS pipes in clip.
38. Using new 'O' ring fit intake hose to air cleaner and secure clips.
39. Remove PAS reservoir filler cap, fill to level indicator and refit cap.
40. Connect battery earth lead.
41. Start engine and allow air to bleed from PAS system, by turning steering from lock to lock.
42. Visually check PAS system for leaks.
43. Clean chassis member.
44. Check power steering fluid, if aerated, wait until fluid is free from bubbles then top-up reservoir to 'UPPER' level mark.
45. Lower vehicle.
46. Dismantle test equipment.

Power steering pressure check - V8 RHD models

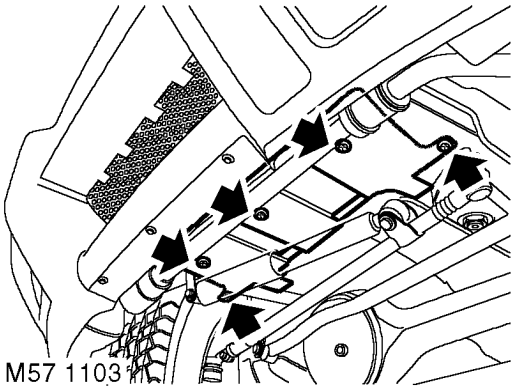
57.90.10.01

Check



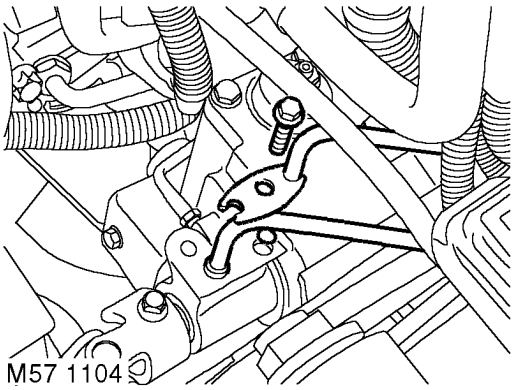
M57 1102

1. Fit gauge and hose **LRT-57-005** to valve assembly **LRT-57-001**, tighten union.
2. Fit 2 hoses **LRT-57-002** to valve assembly **LRT-57-001** and tighten unions.
3. Fit adaptor hoses **LRT-57-041** to **LRT-57-002** and tighten unions.
4. Disconnect battery earth lead.

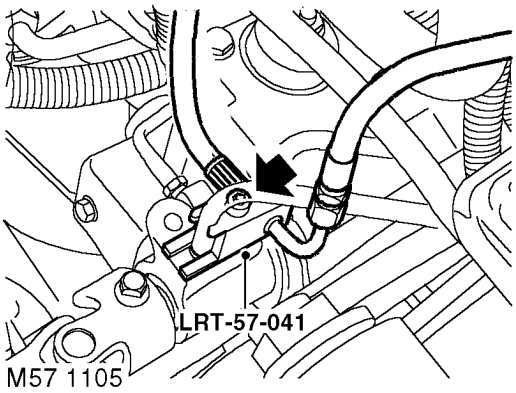

M57 1103

5. Remove 5 screws securing front splash shield to chassis. Remove shield.
6. Clean PAS fluid reservoir around filler cap and fluid level indicators.

7. Syphon PAS fluid from reservoir.
8. Position container to collect PAS fluid spillage.
9. Clean steering box pipe pipe housing.



10. Remove bolt securing pipe clip to steering box. Leaving the feed pipe from PAS reservoir in place, release clip and PAS cooler pipe from steering box. Discard lower 'O' ring.



11. Fit **LRT-57-041** adaptor to steering box.
12. Fit PAS cooler pipe to **LRT-57-041**, align retaining clip and tighten Allen bolt to 25 Nm (18 lbf.ft).
13. Hang pressure gauge in a safe position under bonnet.
14. Remove PAS reservoir filler cap, fill to level indicator and refit cap.
15. Connect battery earth lead.
16. Start engine and allow air to bleed from PAS system by turning steering from lock to lock. Stop engine and check PAS fluid level.
17. Ensure steering system and test equipment are free from leaks.
18. Open test valve on **LRT-57-001** and start engine.
19. With the engine at idle, slowly turn the steering wheel and hold on full lock.
20. Note the pressure reading on **LRT-57-005.**
21. Repeat the pressure check for the opposite full lock.
22. Test pressure should be between 21 and 62 bar, (300 to 900) psi. Dependant on road surface.
23. With the engine at idle, centralise the steering wheel. Pressure should read 7 bar (100 psi) or below.
24. Pressure outside the above tolerance indicates a fault.
25. To determine if fault is in steering pump or steering box, close the valve on **LRT-57-001** for a maximum of 5 seconds. Pump damage may occur if test valve is closed for longer periods.
26. If gauge does not register between 75 and 103 bar, (1500 psi), (maximum pump pressure), the pump is faulty.
27. If maximum pump pressure is correct suspect the steering box.
28. On completion stop engine, disconnect battery earth lead and syphon fluid from PAS reservoir.
29. Remove test equipment from **LRT-57-002.**
30. Remove bolt and clip from steering box.
31. Release PAS cooler pipe from **LRT-57-041** and discard 'O' ring. Leaving PAS reservoir oil feed pipe in place, release **LRT-57-041** from steering box and discard 'O' ring.
32. Fit new 'O' rings to PAS cooler pipe.
33. Fit PAS cooler pipe to steering box, align retaining clip, fit bolt and tighten to 25 Nm (18 lbf.ft).
34. Remove PAS reservoir filler cap, fill to level indicator and refit cap.
35. Clean chassis member.
36. Fit splash shield and secure with screws.
37. Connect battery earth lead.
38. Start engine.
39. Start engine and allow air to bleed from PAS system, by turning steering from lock to lock.
40. Visually check PAS system for leaks.
41. Check power steering fluid, if aerated, wait until fluid is free from bubbles then top-up reservoir to 'UPPER' level mark.
42. Visually check PAS system for leaks.
43. Dismantle test equipment.

Power steering box - V8

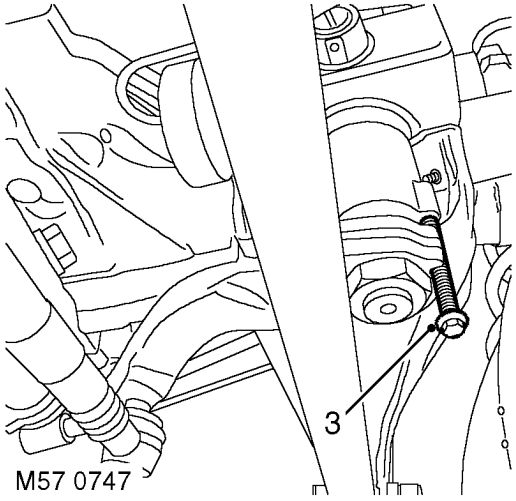
57.10.01

Remove

1. Raise front of vehicle.

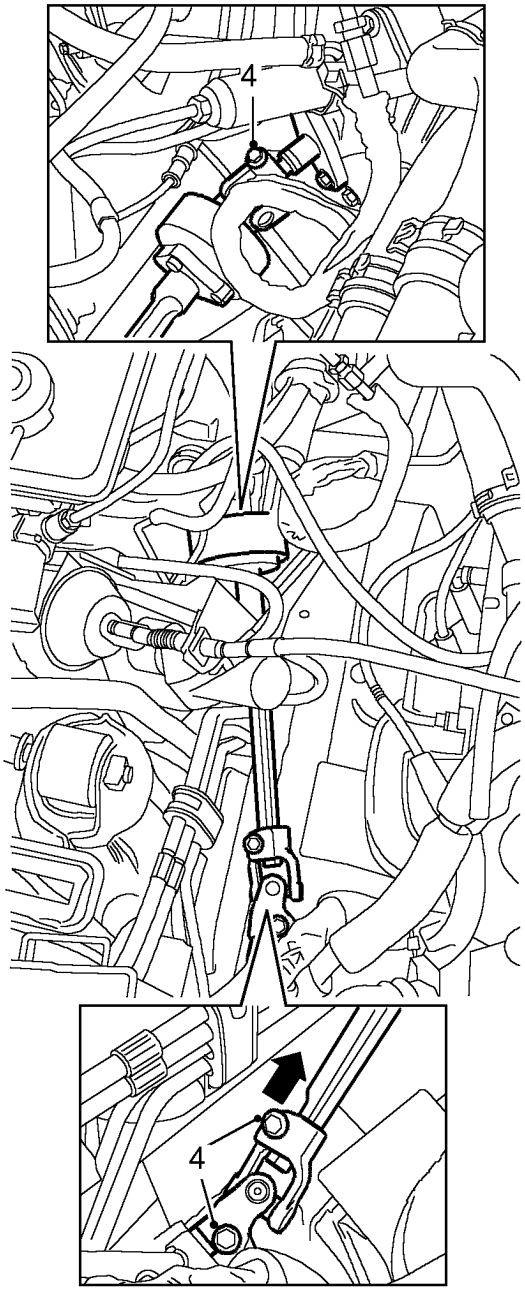
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Remove front road wheel.



M57 0747

3. Ensure steering wheel is centralised and fit centralising bolt to steering box. Remove key from steering lock and engage column lock.

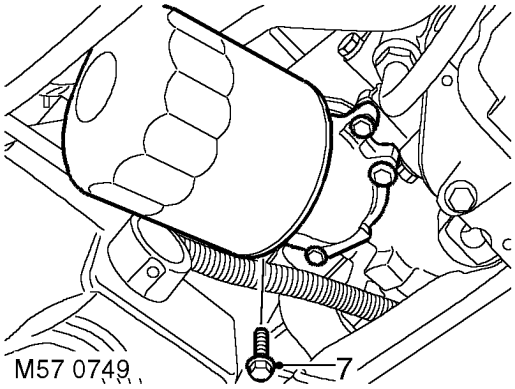


M57 0748

4. Remove 3 bolts securing intermediate shaft and universal joint.
5. Push intermediate shaft upwards, release and remove universal joint.

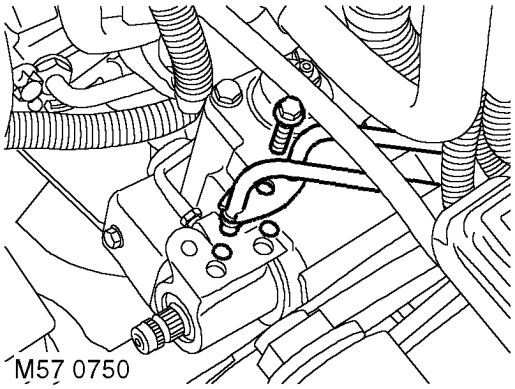
   CAUTION: Do not turn the steering wheel with the intermediate shaft or universal joint disconnected as damage to the rotary coupler and the steering wheel switches may occur.

6. Position container to catch oil spillage.



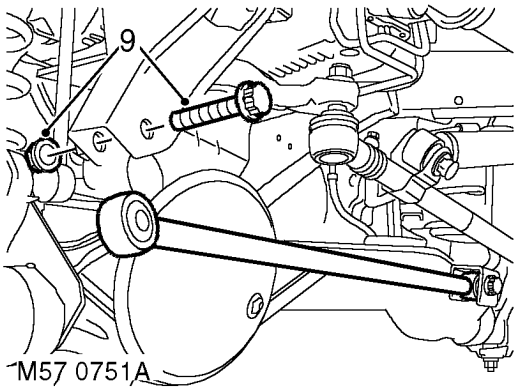
7. **RH drive models:**Remove 4 bolts securing oil filter housing, remove housing and discard 'O' ring.

CAUTION: Always fit plugs to open connections to prevent contamination.

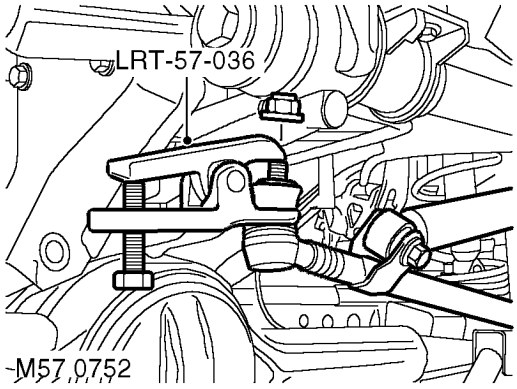


8. Remove bolt securing PAS pipe bracket to steering box, release pipes and discard 'O' rings.

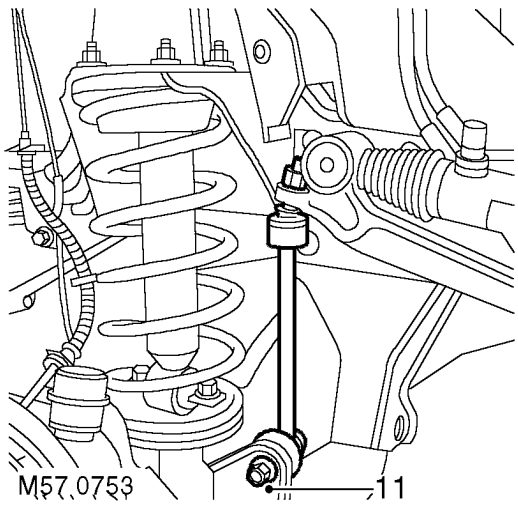
CAUTION: Always fit plugs to open connections to prevent contamination.



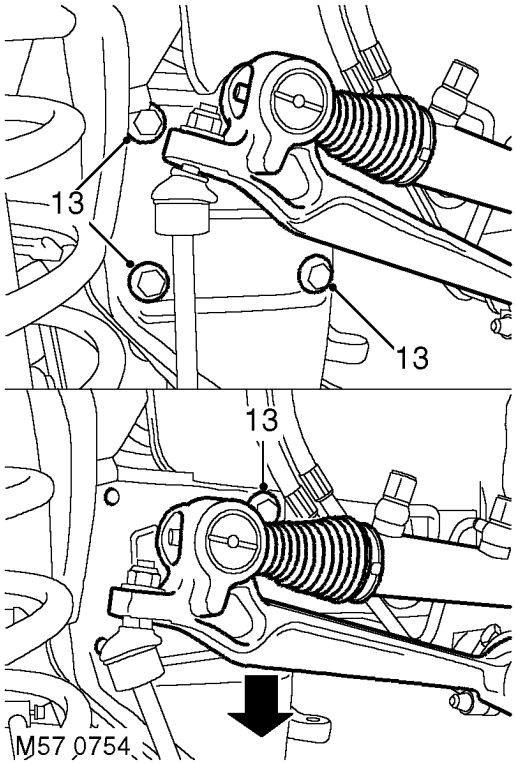
9. Remove securing nut and bolt and release Panhard rod.



10. Remove nut securing drag link to drop arm. Using **LRT-57-036,** break taper joint and release drag link.



11. **RH drive models with ACE:** Remove nut securing anti-roll bar link lower ball joint and release joint.



12. **RH drive models with ACE:** Position ACE control arms to access steering box bolts.
13. With assistance remove 4 securing bolts and remove steering box.
14. Remove centralising bolt from steering box.

Refit

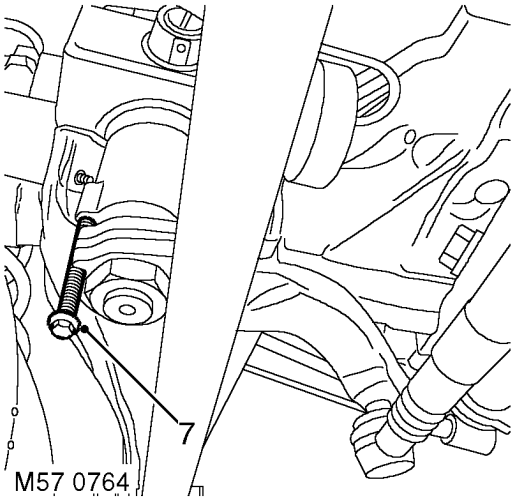
1. Fit centralising bolt to steering box.
2. With assistance, position steering box, fit bolts and tighten to 90 Nm (66 lbf.ft).
3. **RH drive models with ACE:** Ensure washer is in place on lower ball joint of anti-roll bar link, then connect lower ball joint to axle. Tighten nut to 100 Nm (74 lbf.ft).
4. Position drag link, fit nut and tighten to 80 Nm (59 lbf.ft).
5. Position Panhard rod, fit bolt and nut and tighten to 230 Nm (170 lbf.ft).
6. Clean PAS pipe ends and 'O' ring recess.
7. Lubricate new 'O' rings for PAS pipes with clean PAS fluid.
8. Fit 'O' rings to PAS pipes and position pipes in steering box. Fit PAS pipe bracket and tighten bolt to 22 Nm (16 lbf.ft).
9. **RHD models:** Fit oil filter and housing:
   - Clean oil filter housing and engine mating faces.
   - Lubricate new 'O' ring with clean engine oil and fit to housing.
   - Position oil filter housing and tighten bolts to 9 Nm (7 lbf.ft).
10. Ensure steering wheel is centralised. Fit universal joint between steering box and intermediate shaft and tighten bolts to 25 Nm (18 lbf.ft).
11. Remove centralising bolt from steering box.
12. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft)..
13. Remove stand(s) and lower vehicle.
14. Check and top up engine oil.
15. Bleed PAS system.
    ☞ **STEERING, ADJUSTMENTS, Hydraulic system - bleed.**
16. Centralise steering linkage
    ☞ **STEERING, ADJUSTMENTS, Steering linkage - centralise.**

Power steering box - LHD - diesel

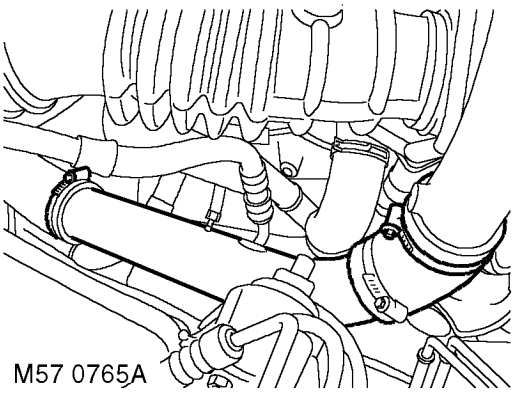
57.10.01

Remove

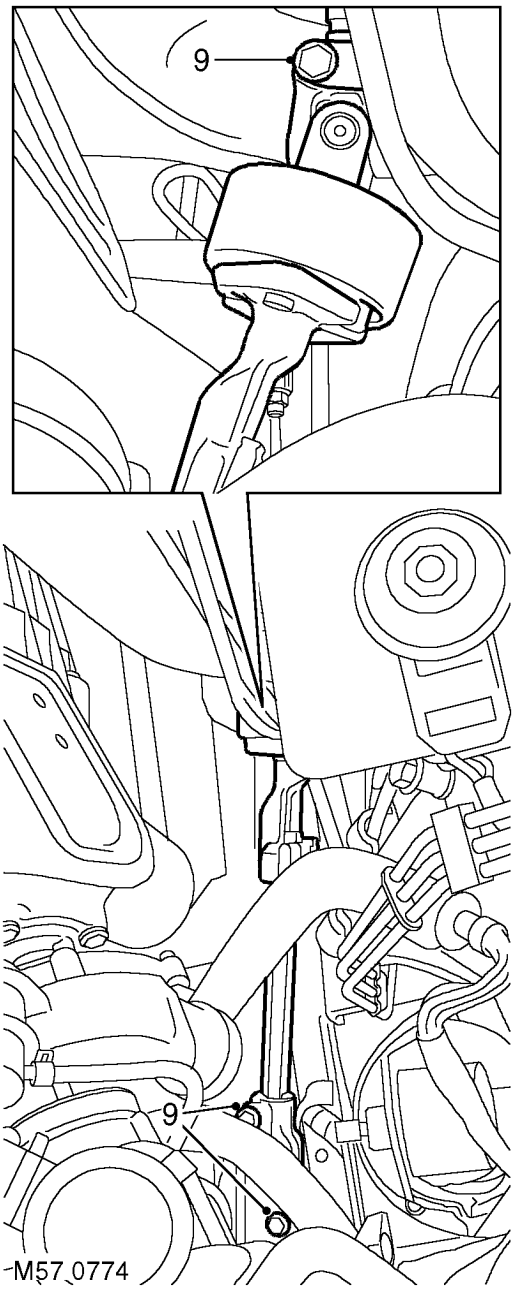
1. Remove battery cover.
2. Disconnect battery earth lead.
3. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
4. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
5. Remove LH front road wheel.
6. Ensure steering wheel is centralised, remove key from steering lock and engage column lock.



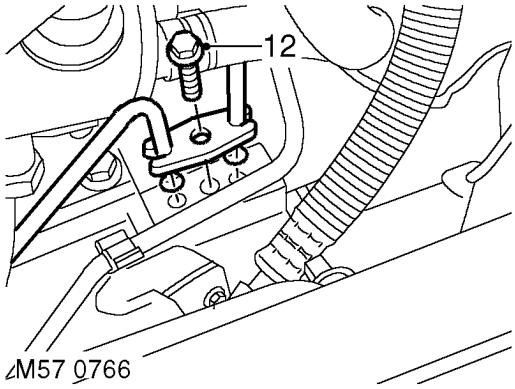
7. Fit centralising bolt to steering box.



8. Loosen 2 clips securing intercooler to turbo hose. Remove hose.

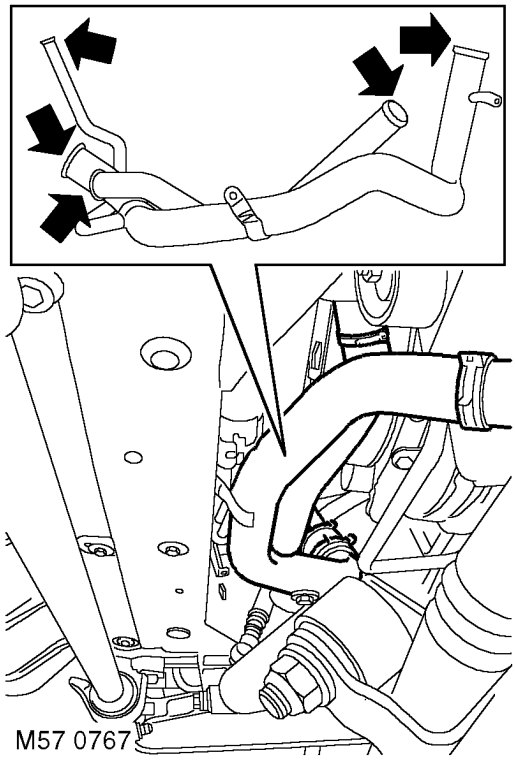


9. Remove 3 bolts securing intermediate shaft and universal joint.
10. Push intermediate shaft upwards, release and remove universal joint.
    CAUTION: Do not turn the steering wheel with the intermediate shaft or universal joint disconnected as damage to the rotary coupler and the steering wheel switches may occur.
11. Position container below PAS pipes to catch fluid spillage.

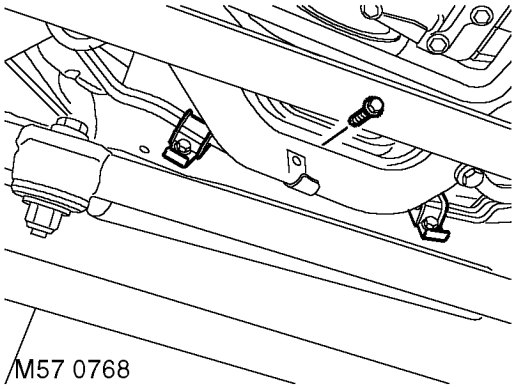


12. Remove bolt securing PAS pipe bracket to steering box, release pipes and discard 'O' rings.

CAUTION: Always fit plugs to open connections to prevent contamination.

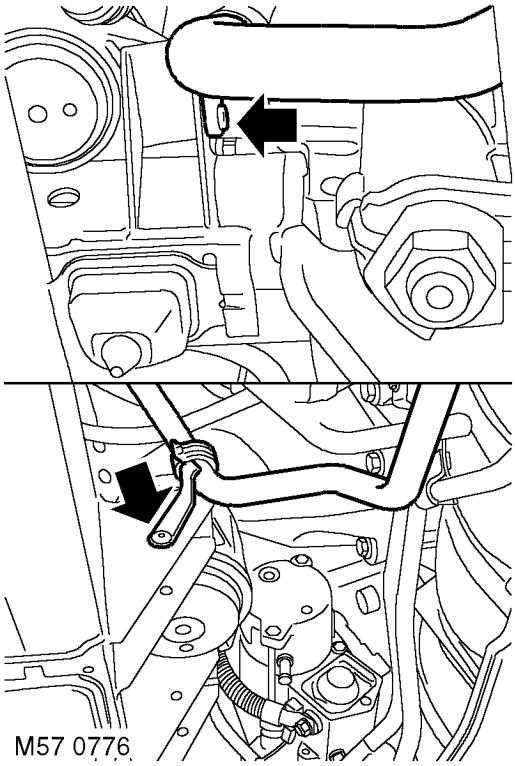


13. Release 5 clips securing hoses to coolant rail and disconnect hoses.

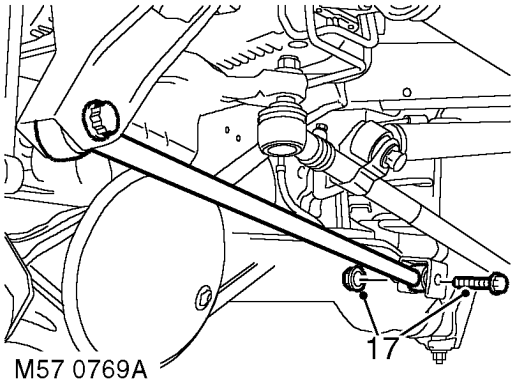


14. **Models with ACE:** Remove bolt securing ACE pipes to chassis to gain access to coolant rail bolt.

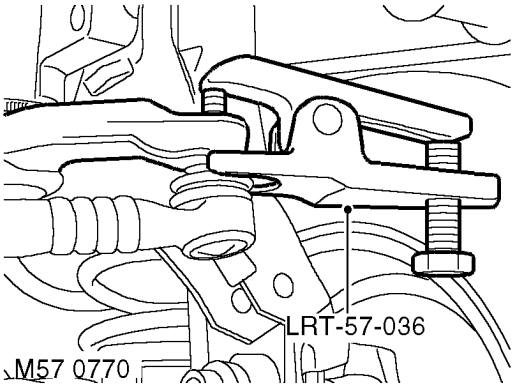
15. Remove bolt securing coolant rail.



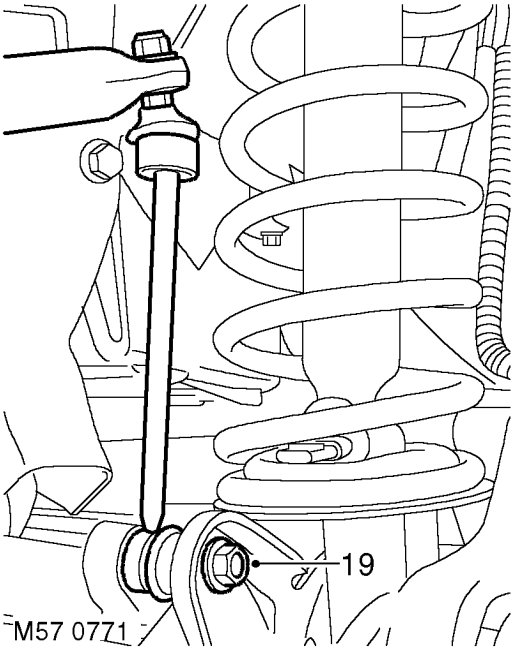
16. Release 2 clips securing coolant rails and remove coolant rail from vehicle.



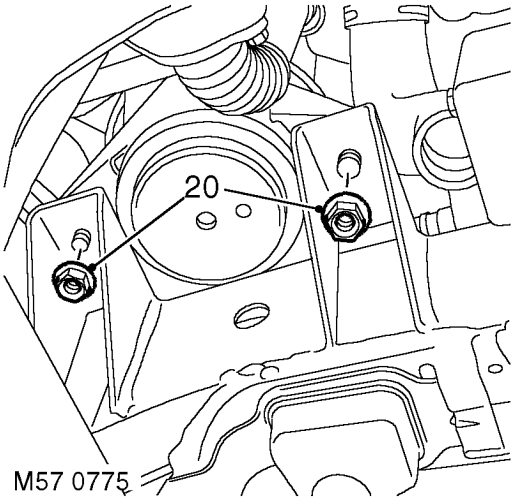
17. Remove securing nut and bolt and release Panhard rod.



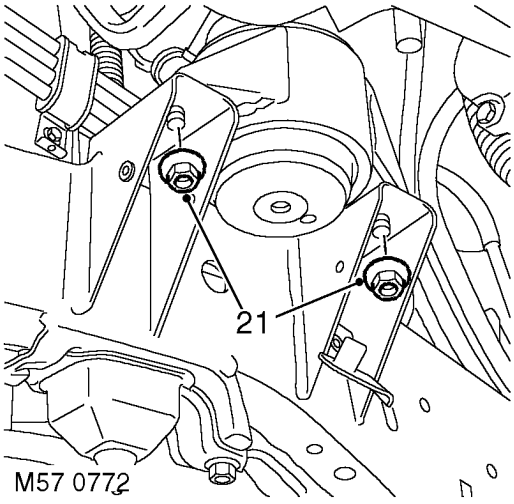
18. Remove nut securing drag link to drop arm. Using **LRT-57-036,** break taper joint and release drag link.



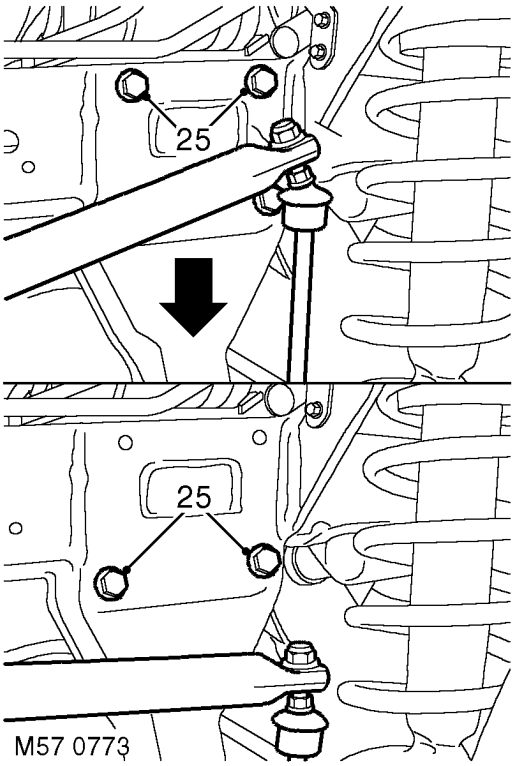
19. Models with ACE: Remove nut securing anti-roll bar link lower ball joint and release joint.



20. With assistance, remove 2 nuts and bolts securing LH engine mounting to chassis.



21. With assistance remove 2 nuts and bolts securing RH engine mounting to chassis.
22. Support the engine weight on a jack.
    CAUTION: To prevent damage to components, cushion the jack pad with a block of wood or hard rubber.
23. Raise the engine sufficiently to allow the steering box to clear the sump.



24. **Models with ACE:** Position ACE control arms to access steering box bolts.
25. With assistance remove 4 bolts securing steering box and remove steering box.
26. Remove centralising bolt from steering box.

Refit

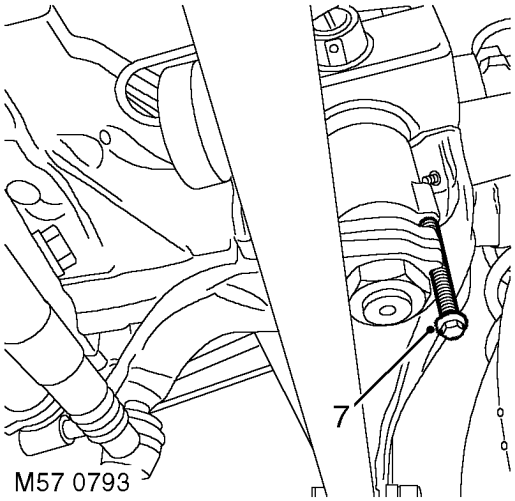
1. Fit centralising bolt to steering box.
2. With assistance, position steering box, fit bolts and tighten to 90 Nm (66 lbf.ft).
3. Lower the engine onto its mountings. Fit engine mounting bolts and tighten to 85 Nm (63 lbf.ft).
4. **Models with ACE:** Ensure washer is in place on lower ball joint of anti-roll bar link, then connect lower ball joint to axle. Tighten nut to 100 Nm (74 lbf.ft).
5. Position drag link, fit nut and tighten to 80 Nm (59 lbf.ft).
6. Position Panhard rod, fit bolt and nut and tighten to 230 Nm (170 lbf.ft).
7. Position coolant rail and secure with clips and bolt.
8. Fit coolant hoses and secure with clips.
9. **Models with ACE:** Fit and tighten bolt securing ACE pipes to chassis.
10. Clean PAS pipe ends and 'O' ring recess.
11. Lubricate new 'O' rings for PAS pipes with clean PAS fluid.
12. Fit 'O' rings to PAS pipes and position pipes in steering box. Fit PAS pipe bracket and tighten bolt to 22 Nm (16 lbf.ft).
13. Ensure steering wheel is centralised. Fit universal joint between steering box and intermediate shaft and tighten bolts to 25 Nm (18 lbf.ft).
14. Remove centralising bolt from steering box.
15. Fit intercooler to turbo hose and secure with clips.
16. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
17. Remove stand(s) and lower vehicle.
18. Connect battery earth lead.
19. Fit battery cover.
20. Refill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
21. Bleed PAS system.
    ☞ **STEERING, ADJUSTMENTS, Hydraulic system - bleed.**
22. Centralise steering linkage
    ☞ **STEERING, ADJUSTMENTS, Steering linkage - centralise.**

Steering box - RHD - diesel

57.10.01

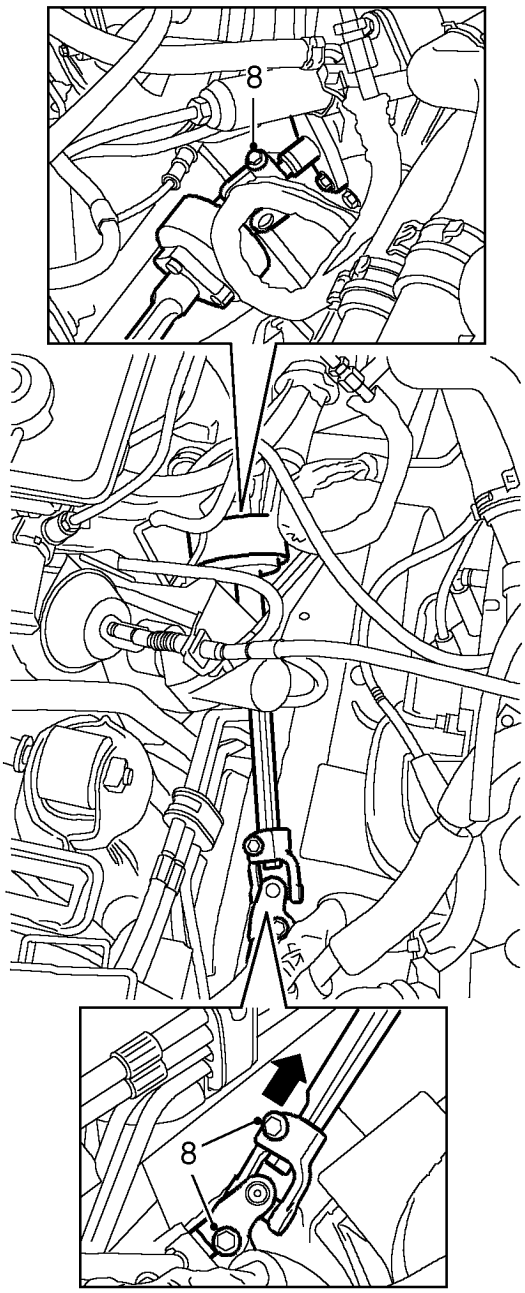
Remove

1. Remove battery cover.
2. Disconnect battery earth lead.
3. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
4. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
5. Remove RH front road wheel.
6. Ensure steering wheel is centralised, remove key from steering lock and engage column lock.



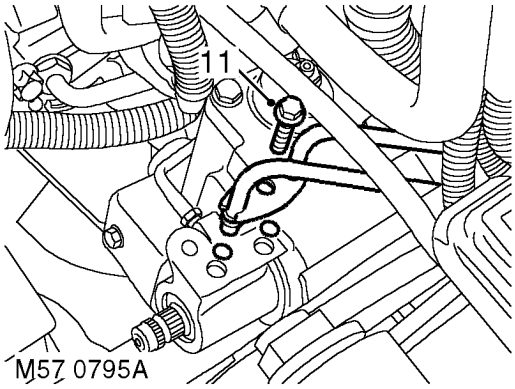
M57 0793

7. Fit centralising bolt to steering box.



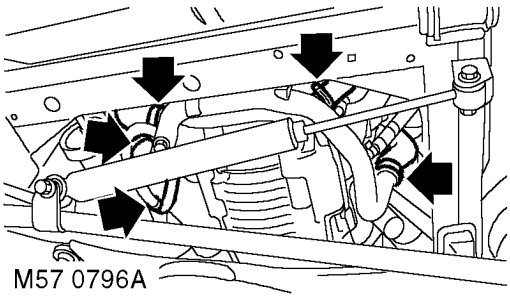
M57 0794

8. Remove 3 bolts securing intermediate shaft and universal joint.
9. Push intermediate shaft upwards, release and remove universal joint.
   CAUTION: Do not turn the steering wheel with the intermediate shaft or universal joint disconnected as damage to the rotary coupler and the steering wheel switches may occur.
10. Position container below PAS pipes to catch fluid spillage.

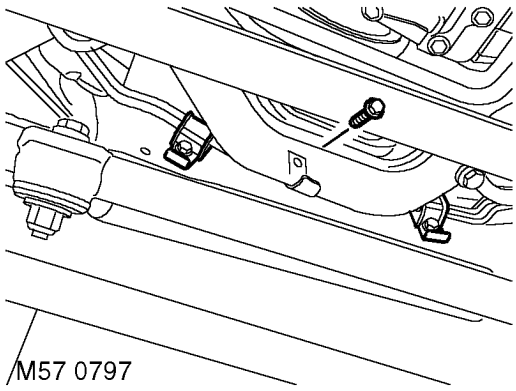


11. Remove bolt securing PAS pipe bracket to steering box, release pipes and discard 'O' rings.

CAUTION: Always fit plugs to open connections to prevent contamination.

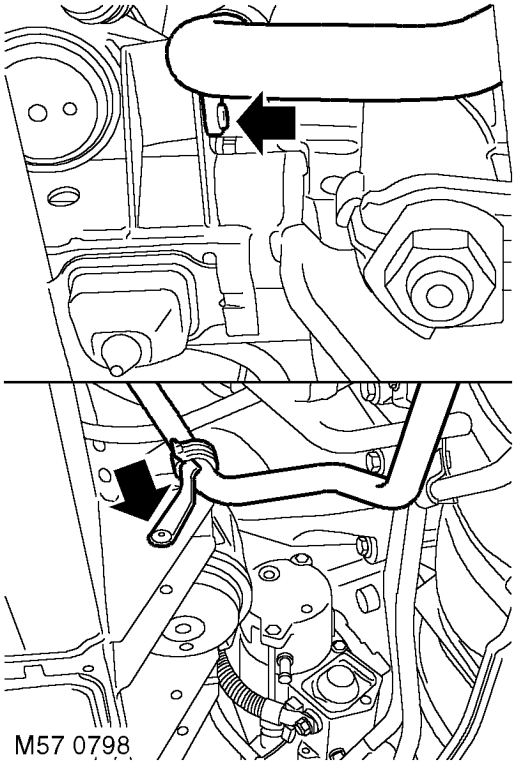


12. Release 5 clips securing hoses to coolant rail release and disconnect hoses.

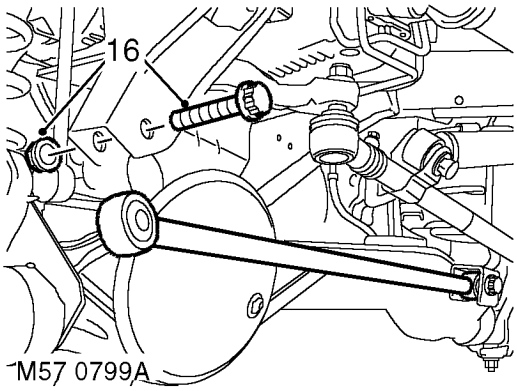


13. Models with ACE: Remove bolt securing ACE pipes to chassis to gain access to coolant rail bolt.

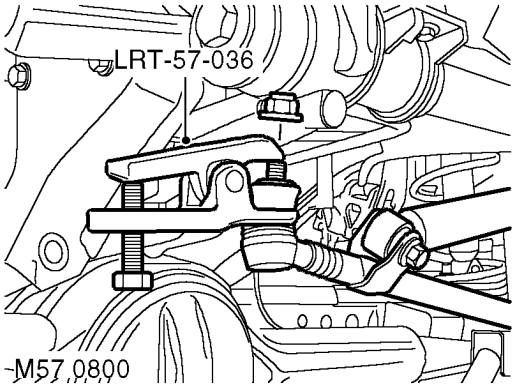
14. Remove bolt securing coolant rail.



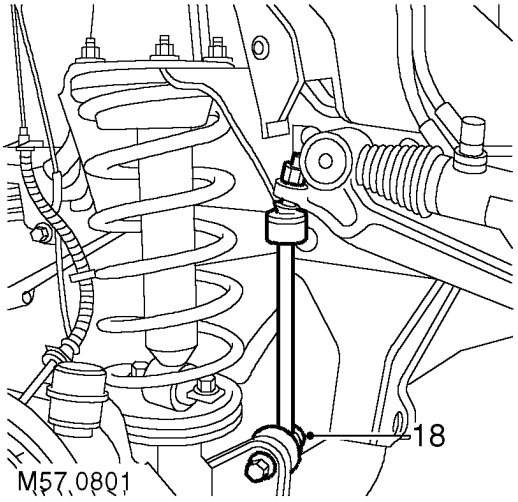
15. Release 2 clips securing coolant rails and remove coolant rail from vehicle.



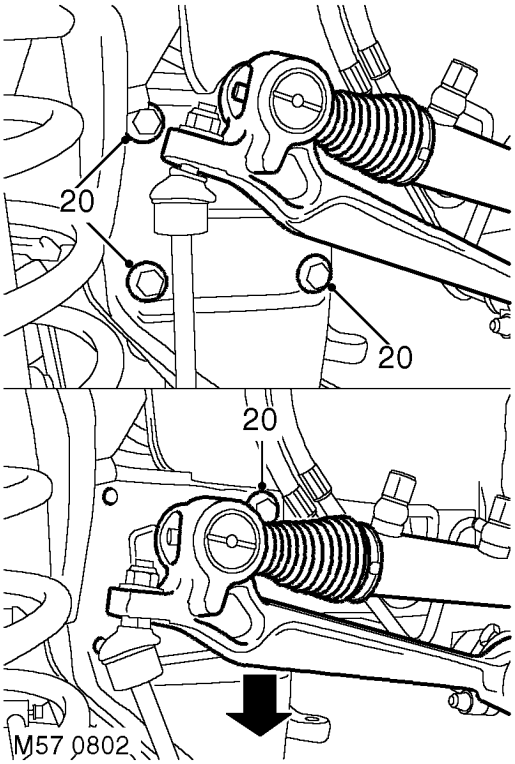
16. Remove securing nut and bolt and release Panhard rod.



17. Remove nut securing drag link to drop arm. Using **LRT-57-036,** break taper joint and release drag link.



18. **Models with ACE:** Remove nut securing anti-roll bar link lower ball joint and release joint.



19. **Models with ACE:** Position ACE control arms to access steering box bolts.
20. With assistance, remove 4 bolts securing steering box and remove steering box.
21. Remove centralising bolt from steering box.

Refit

1. Fit centralising bolt to steering box.
2. With assistance, position steering box to chassis, fit bolts and tighten to 90 Nm (66 lbf.ft).
3. **Models with ACE:** Ensure washer is in place on lower ball joint of anti-roll bar link, then connect lower ball joint to axle and tighten nut to 100 Nm (74 lbf.ft).
4. Position drag link, fit nut and tighten to 80 Nm (59 lbf.ft).
5. Position Panhard rod, fit bolt and nut and tighten to 230 Nm (170 lbf.ft).
6. Position coolant rail and secure with clips and bolt.
7. Fit coolant hoses and secure with clips.
8. **Models with ACE:** Fit and tighten bolt securing ACE pipes to chassis.
9. Clean PAS pipes ends and 'O' ring recess.

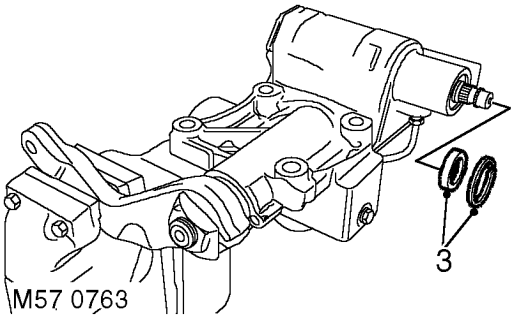
10. Lubricate new 'O' rings for PAS pipes with clean PAS fluid.
11. Fit 'O' rings to PAS pipes and position pipes in steering box. Fit PAS pipe bracket and tighten bolt to 22 Nm 16 lbf.ft).
12. Ensure steering wheel is centralised. Fit universal joint between steering box and intermediate shaft and tighten bolts to 25 Nm (18 lbf.ft).
13. Remove centralising bolt from steering box.
14. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
15. Remove stand(s) and lower vehicle.
16. Connect battery earth lead.
17. Fit battery cover.
18. Refill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
19. Bleed PAS system.
    ☞ **STEERING, ADJUSTMENTS, Hydraulic system - bleed.**
20. Centralise steering linkage
    ☞ **STEERING, ADJUSTMENTS, Steering linkage - centralise.**

Seal - input shaft - steering box

57.10.16

Remove

1. Remove steering box:
   - For V8 models:
     ☞ **STEERING, REPAIRS, Power steering box - V8.**
   - For LHD diesel models:
     ☞ **STEERING, REPAIRS, Power steering box - LHD - diesel.**
   - For RHD diesel models:
     ☞ **STEERING, REPAIRS, Steering box - RHD - diesel.**
2. Secure steering box in vice.



3. Remove circlip and extract oil seal from steering box. **Take care not to damage surface of the shaft.**

Refit

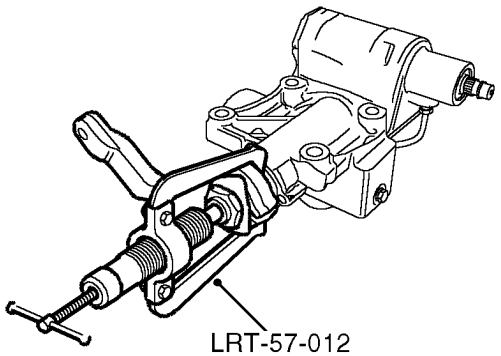
1. Clean oil seal recess and input shaft.
2. Lubricate new seal with clean PAS fluid.
3. Fit seal using **LRT-57-503**.
4. Fit circlip.
5. Fit steering box.
   - For V8 models:
     ☞ **STEERING, REPAIRS, Power steering box - V8.**
   - For LHD diesel models:
     ☞ **STEERING, REPAIRS, Power steering box - LHD - diesel.**
   - For RHD diesel models:
     ☞ **STEERING, REPAIRS, Steering box - RHD - diesel.**

Seal - output shaft - steering box

57.10.17

Remove

1. Remove steering box:
   - For V8 models:
     STEERING, REPAIRS, Power steering box - V8.
   - For LHD diesel models:
     STEERING, REPAIRS, Power steering box - LHD - diesel.
   - For RHD diesel models:
     STEERING, REPAIRS, Steering box - RHD - diesel.
2. Secure steering box in vice.
3. Release lock washer from drop arm nut.
4. Loosen but do not remove nut securing drop arm.



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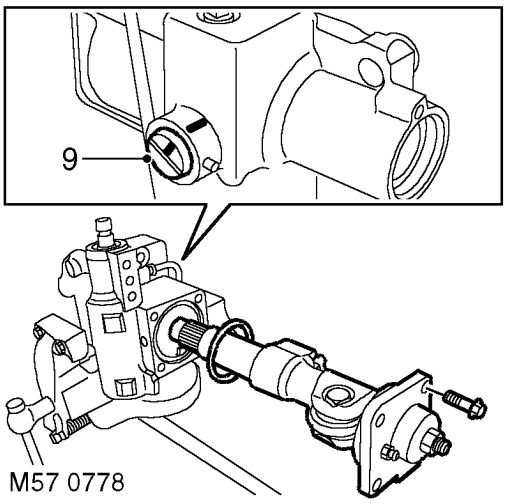
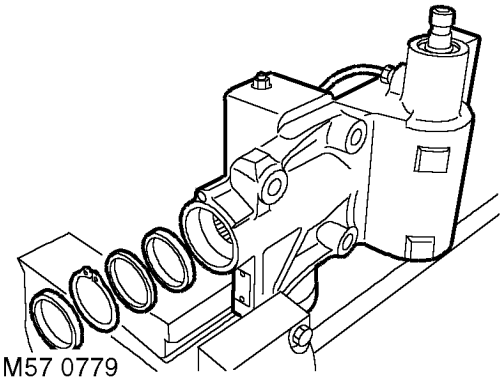
5. Using **LRT-57-012,** release drop arm.
6. Remove nut and discard lock washer.
7. Remove drop arm.



M57 0778

8. Mark position of rack adjuster.
9. Remove Allen screw securing rack adjuster and loosen adjuster one turn.
10. Remove 4 bolts securing output shaft assembly and remove output shaft assembly. Remove and discard 'O' ring from end cover.


M57 0779

11. Remove seal shield and circlip.
12. Remove seal and spacer.

Refit

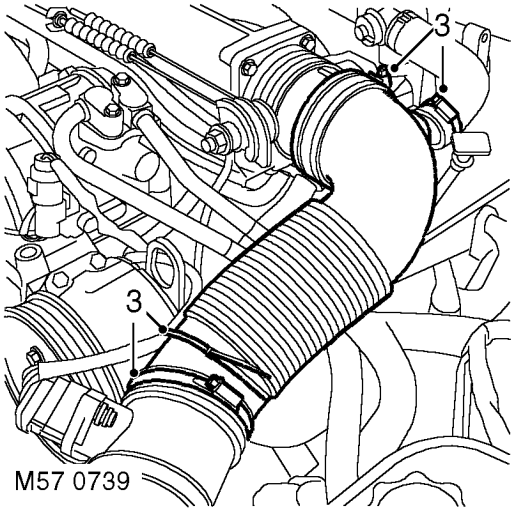
1. Clean seal recess, output shaft, end cover and mating face.
2. Lubricate new end cover 'O' ring with clean PAS fluid. Fit 'O' ring to end cover.
3. Position output shaft, fit bolts and tighten to 88 Nm (65 lbf.ft).
4. Tighten rack adjuster one turn, align marks and secure with Allen screw.
5. Lubricate new output shaft seal with clean PAS fluid.
6. Fit seal using **LRT-57-504**.
7. Fit spacer, circlip and seal shield.
8. Clean drop arm and steering box splines.
9. Ensure steering box is in the central position. Align and fit drop arm to output shaft and secure with new lock washer and nut. Tighten nut to 240 Nm (177 lbf.ft).
10. Secure lock washer to drop arm nut.
11. Fit steering box.
    - For V8 models:
      ☞ **STEERING, REPAIRS, Power steering box - V8.**
    - For LHD diesel models:
      ☞ **STEERING, REPAIRS, Power steering box - LHD - diesel.**
    - For RHD diesel models:
      ☞ **STEERING, REPAIRS, Steering box - RHD - diesel.**

Pump - power steering - V8

⊸ ***57.20.14***

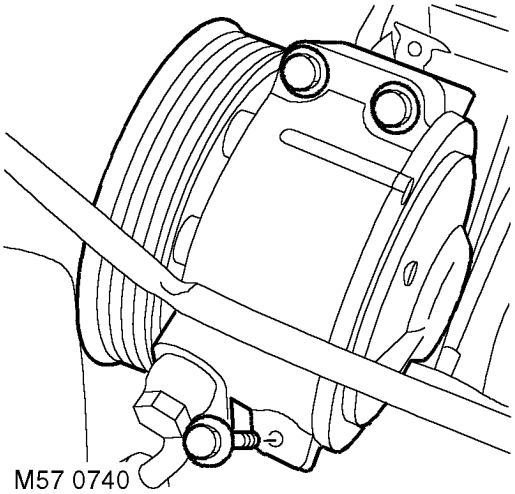
Remove

1. Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
2. Remove cable tie securing harness to air intake hose.

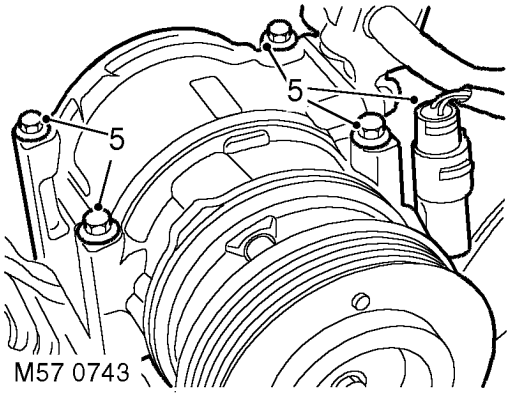


M57 0739

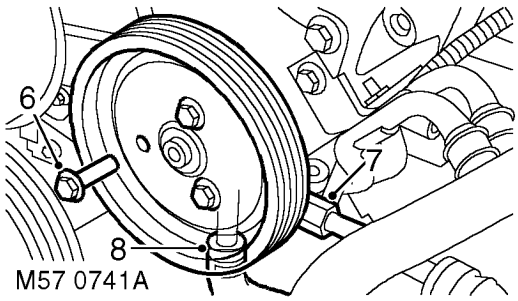
3. Loosen 3 clips securing air intake hose, release and remove hose.
   Note: Pre 03 MY air intake hose illustrated.


M57 0740

4. **Models with ACE:** Remove 3 bolts securing ACE pump, release pump and position aside.

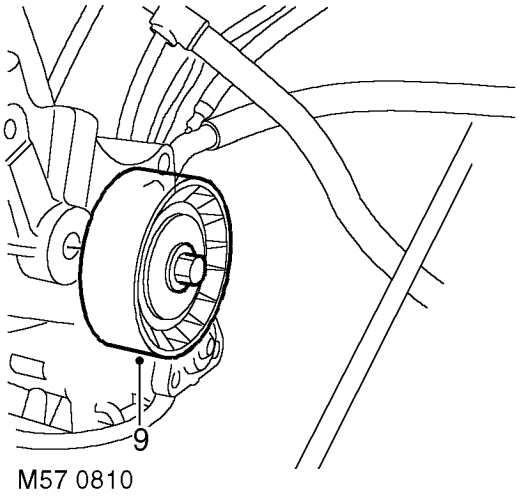


5. **Models with A/C:** Disconnect A/C compressor multiplug. Remove 4 bolts securing A/C compressor, release compressor and position aside.

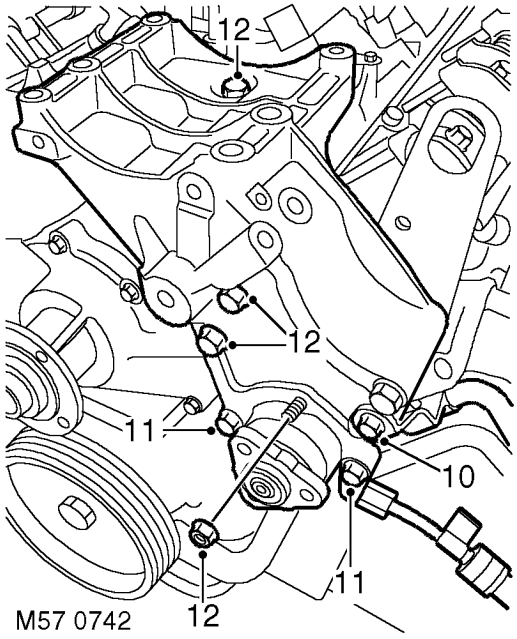


6. Remove 3 bolts securing PAS pump pulley and remove pulley.
7. Position tray to catch spillage, release PAS pump pressure pipe.
8. Remove clip and release PAS pump inlet hose.

CAUTION: Always fit plugs to open connections to prevent contamination.



9. Remove jockey pulley.



10. Remove bolt securing oil cooling pipe bracket and release bracket from housing.
11. Remove two bolts securing PAS pump.
12. Remove 4 bolts and one nut securing auxiliary housing. Pull housing forward and release PAS pump. Remove PAS pump.

Refit

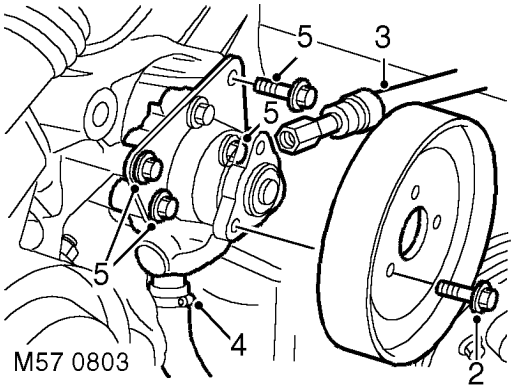
1. Position PAS pump to auxiliary housing and locate housing to engine. Fit and tighten auxiliary housing bolts to 40 Nm (30 lbf.ft).
2. Tighten auxiliary housing nut to 10 Nm (7 lbf.ft).
3. Fit bolts securing PAS pump and tighten to 22 Nm (16 lbf.ft).
4. Position PAS pump pipe bracket, fit and tighten bolt to 22 Nm (16 lbf.ft).
5. Fit and tighten PAS pump pressure pipe.
6. Fit PAS pump inlet hose and secure with clip.
7. Position jockey pulley and tighten bolt to 50 Nm (37 lbf.ft).
8. Clean PAS pump pulley mating faces.
9. Position PAS pump pulley, fit bolts and tighten to 22 Nm (16 lbf.ft).
10. **Models with ACE:** Clean ACE pump dowels and dowel holes. Position ACE pump, fit bolts and tighten to 25 Nm (18 lbf.ft).
11. **Models with A/C:** Clean A/C compressor dowels and dowel holes. Position A/C compressor, fit bolts and tighten to 22 Nm (16 lbf.ft).
12. Position air intake hose and secure with clips.
13. Secure harness to air intake hose with new cable tie.
14. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**.
15. Bleed PAS system.
    ☞ **STEERING, ADJUSTMENTS, Hydraulic system - bleed.**

Pump - power steering - diesel

57.20.14

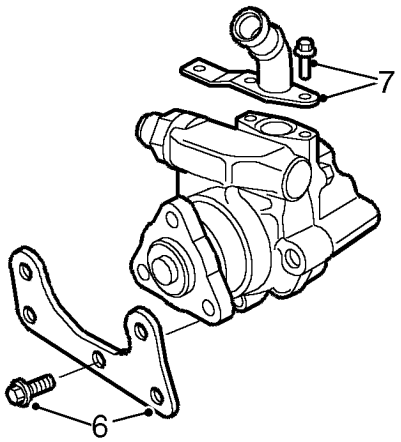
Remove

1. Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**



M57 0803

2. Remove 3 bolts securing PAS pump pulley and remove pulley.
3. Position tray to catch spillage, release PAS pump pressure pipe.
4. Remove clip and release PAS pump inlet hose.
   CAUTION: Always fit plugs to open connections to prevent contamination.
5. Remove 4 bolts and remove PAS pump.



M57 0804

6. Remove bolt, and remove mounting bracket from PAS pump.
7. Remove 2 bolts, remove low pressure adaptor pipe and discard 'O' ring.

Refit

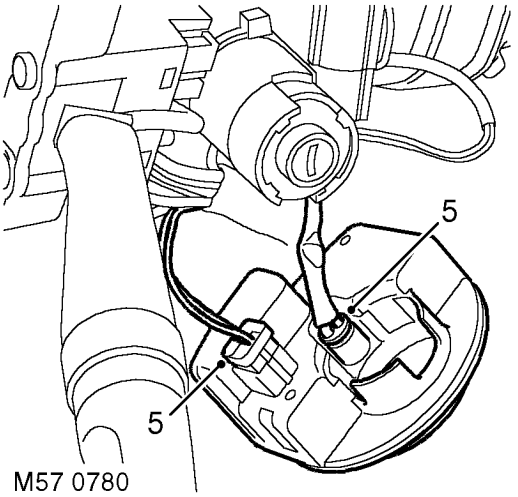
1. Clean PAS pump and adaptor pipe.
2. Fit new 'O' ring to adaptor pipe, fit pipe and tighten bolts to 10 Nm (7 lbf.ft).
3. Position mounting bracket to PAS pump, fit but do not tighten bolt.
4. Position PAS pump and align pump drive to coolant pump. Fit and tighten bolts to 25 Nm (18 lbf.ft).
5. Tighten mounting plate bolt to 25 Nm (18 lbf.ft).
6. Clean PAS pump and pipe union.
7. Fit and tighten PAS pump pressure pipe to 20 Nm (15 lbf.ft).
8. Fit PAS pump inlet hose and secure with clip.
9. Clean PAS pump and pulley mating faces.
10. Position PAS pump pulley, fit and tighten bolts to 10 Nm (7 lbf.ft).
11. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
12. Bleed power steering system.
    ☞ **STEERING, ADJUSTMENTS, Hydraulic system - bleed.**

Steering column assembly and lock

⊸ ***57.40.01***

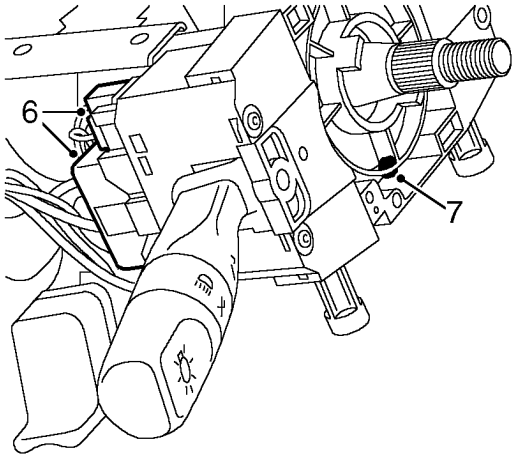
Remove

1. Remove steering column intermediate shaft.
   ☞ **STEERING, REPAIRS, Shaft - intermediate and universal joint - steering column.**
2. Remove rotary coupler.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.**
3. Open fascia lower access panel.
4. Remove steering column nacelle.
   ☞ **STEERING, REPAIRS, Nacelle - steering column.**



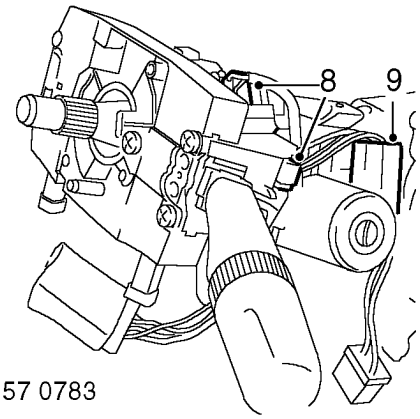
M57 0780

5. Disconnect multiplug and illumination bulb from passive coil and remove passive coil.



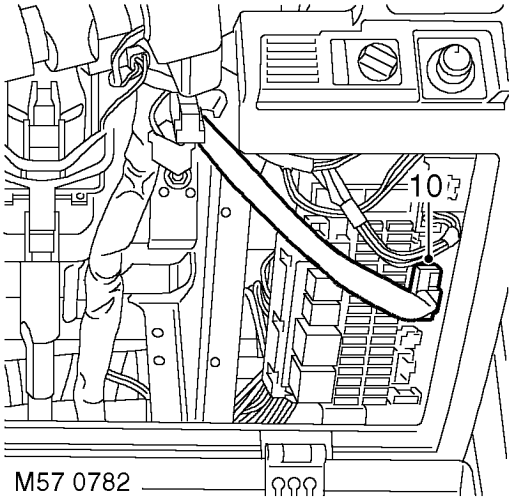
M57 0781

6. Disconnect 2 multiplugs from wiper switch assembly.
7. Disconnect 2 multiplugs from light switch assembly.



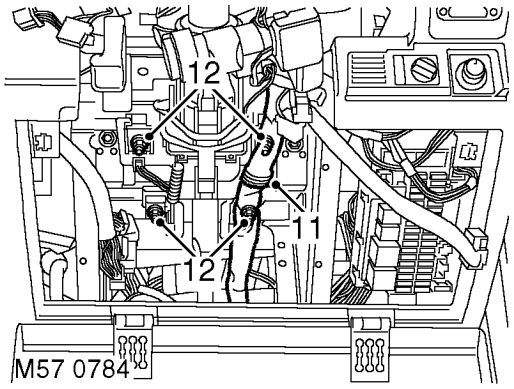
M57 0783

8. Loosen screw and remove switch assembly.
9. Disconnect ignition switch multiplug.



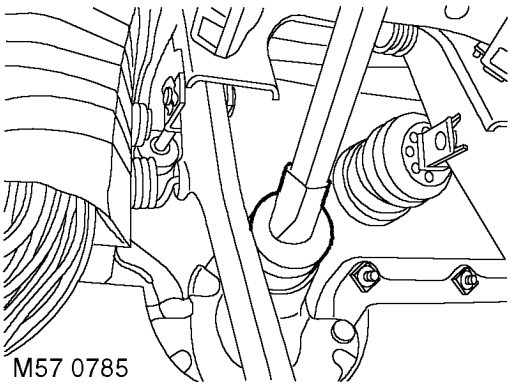
M57 0782

10. Disconnect multiplug from ignition switch housing.



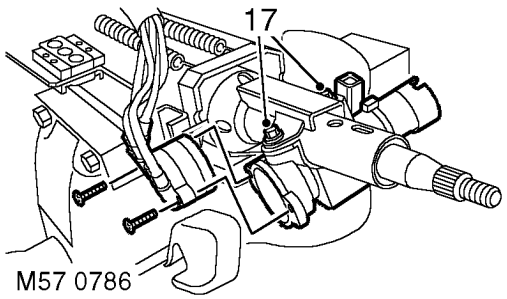
M57 0784

11. Release harness from column clip.
12. Remove 4 nuts securing steering column assembly to fascia rail and remove steering column assembly.



M57 0785

13. Remove rubber boot from steering column assembly.



14. Position steering column assembly in a vice.
15. Remove 2 screws and remove ignition switch.
16. Remove cable tie and remove multiplug from ignition switch.
17. Centre punch or drill out steering lock shear bolts.
18. Remove steering lock

Refit

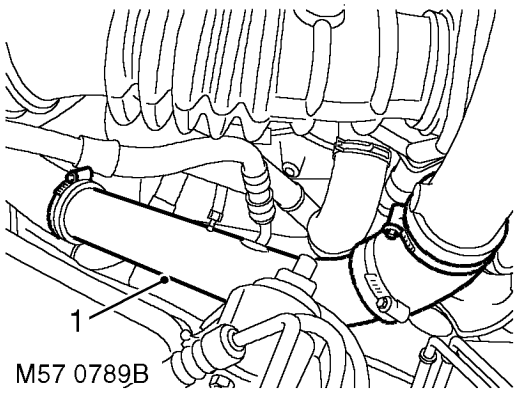
1. Position lock to steering column assembly and fit shear bolts. Do not tighten shear bolts at this stage.
2. Insert starter key, check operation of steering lock and that key turns freely.
3. Tighten shear bolts fully and shear heads off.
4. Position ignition switch to column, fit and tighten screws.
5. Position multiplug to switch and secure with new cable tie.
6. Fit rubber boot to column.
7. Remove column from vice.
8. Position steering to fascia rail fit nuts and tighten to 22 Nm (16 lbf.ft).
9. Secure harness to column clip.
10. Position rubber grommet.
11. Close access panel and secure turn buckles.
12. Connect ignition switch multiplugs.
13. Position column switch and tighten clamp screw.
14. Connect column switch multiplugs.
15. Position passive coil, connect multiplug and illumination bulb.
16. Fit steering column nacelle.
    ☞ **STEERING, REPAIRS, Nacelle - steering column.**
17. Fit rotary coupler.
    ☞ **RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.**
18. Close fascia lower access panel.
19. Fit steering column intermediate shaft.
    ☞ **STEERING, REPAIRS, Shaft - intermediate and universal joint - steering column.**

Shaft - intermediate and universal joint - steering column

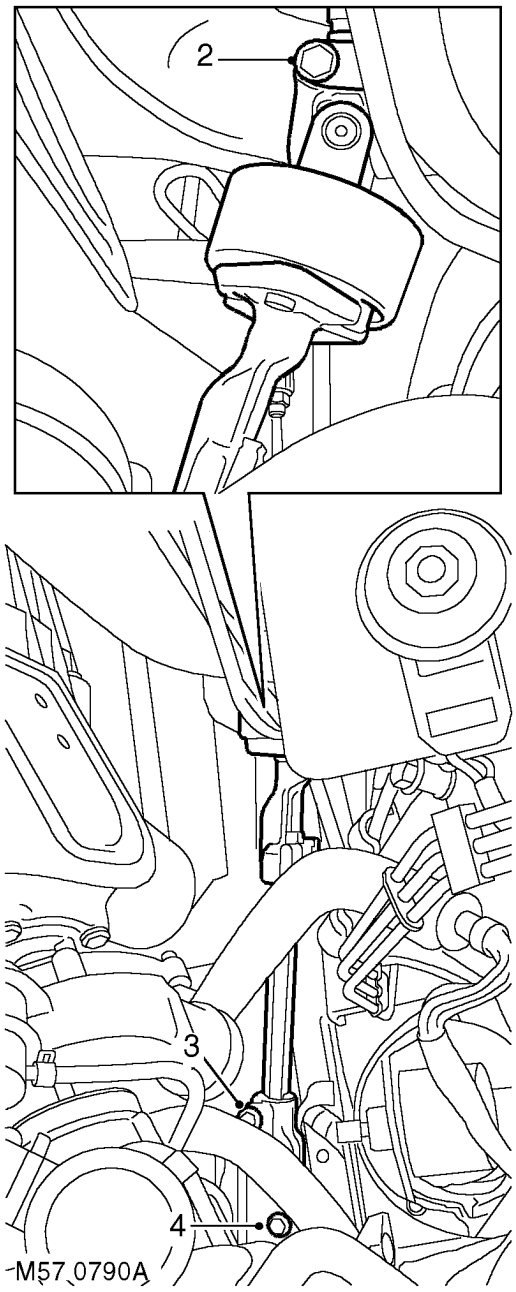
🔧 *57.40.22*

The intermediate shaft has a red indicator clip fitted which must be inspected at service, and after the vehicle has been subject to an impact. If the clip is not present or is not fully seated against the clamp plate, a new assembly must be fitted.

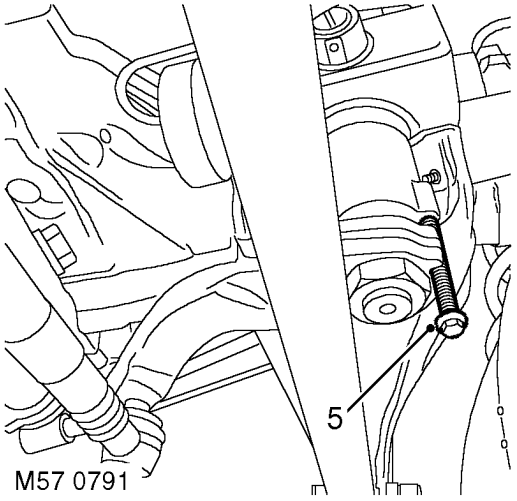
Remove



1. **LHD diesel:** Loosen 2 clips securing intercooler to turbocharger hose. Place hose aside.

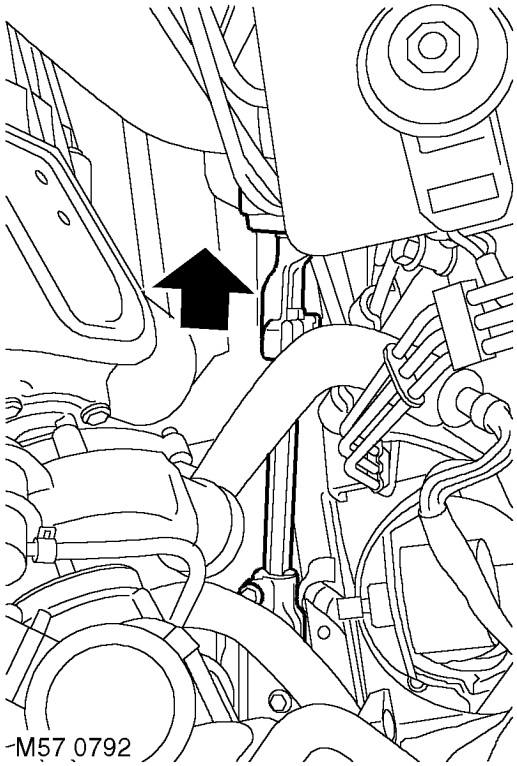


2. Remove bolt securing intermediate shaft to steering column.
3. Remove bolt securing intermediate shaft to universal joint.
4. **Universal joint:** Remove the bolt securing the universal joint to the steering box.



5. Ensure steering wheel is in the straight ahead position and fit centralising bolt to steering box. Remove the key from the ignition switch

CAUTION: Do not turn the steering wheel with the intermediate shaft or universal joint disconnected as damage to the rotary coupler and the steering wheel switches may occur.



6. **Intermediate shaft:** Slide the intermediate shaft upwards, release from the universal joint and remove intermediate shaft from the steering column.
7. **Universal joint:** Slide the intermediate shaft upwards, release from the universal joint and remove universal joint from the steering box.

Refit

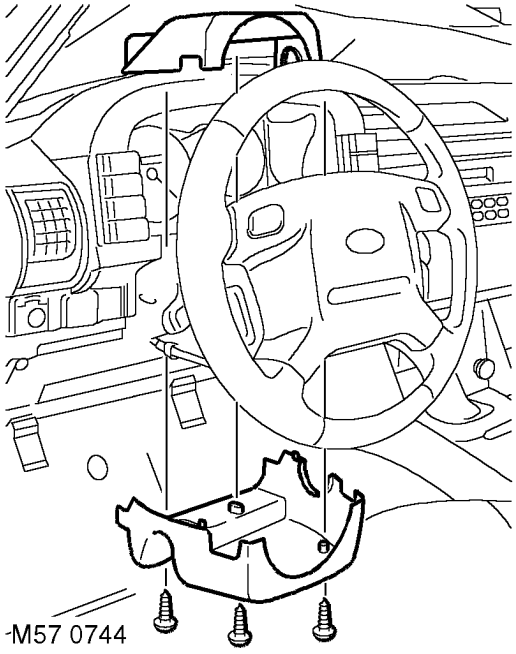
1. Clean and inspect splines for wear and damage.
2. **Intermediate shaft:** Locate intermediate shaft on steering column and engage with universal joint. Ensure splines are fully engaged and bolt holes aligned.
3. **Universal joint:** Locate universal joint on steering box and engage in intermediate shaft. Ensure splines are fully engaged and bolt holes aligned.
4. Fit bolts securing intermediate shaft to universal joint and tighten to 25 Nm (18 lbf.ft).
5. **Intermediate shaft:** Fit bolts securing intermediate shaft to steering column and tighten to 25 Nm (18 lbf.ft).
6. **Universal joint:** Fit bolts securing universal joint to steering box and tighten to 25 Nm (18 lbf.ft).
7. **LHD diesel:** Connect hose to turbocharger and intercooler and secure the clips.
8. Fit ignition key, remove steering box centralising bolt and check that steering wheel is in the straight ahead position.

Nacelle - steering column

57.40.29

Remove

1. Open fascia lower access panel.



2. Remove 3 screws securing steering column nacelle halves together.
3. Release clips securing nacelle together and remove from steering column.

Refit

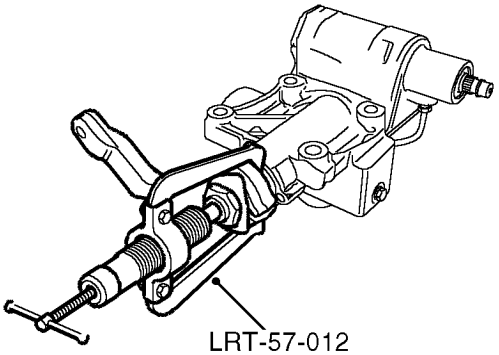
1. Position nacelle to steering column and secure with clips and screws.
2. Close fascia lower access panel.

Drop arm - steering box

57.50.14

Remove

1. Remove steering box.
   - For V8 models:
     STEERING, REPAIRS, Power steering box - V8.
   - For LHD diesel models:
     STEERING, REPAIRS, Power steering box - LHD - diesel.
   - For RHD diesel models:
     STEERING, REPAIRS, Steering box - RHD - diesel.



2. Secure steering box in vice.
3. Release drop arm nut lock washer.
4. Loosen but do not remove nut securing drop arm.
5. Using **LRT-57-012** release drop arm.
6. Remove nut and lock washer.
7. Remove drop arm.

Refit

1. Clean drop arm and steering box splines.
2. Ensure steering box is in the central position. Align and fit drop arm to output shaft and secure with lock washer and nut. Tighten nut to 240 Nm (177 lbf.ft).
3. Secure lock washer to drop arm nut.
4. Fit steering box.
   - For V8 models:
     STEERING, REPAIRS, Power steering box - V8.
   - For LHD diesel models:
     STEERING, REPAIRS, Power steering box - LHD - diesel.
   - For RHD diesel models:
     STEERING, REPAIRS, Steering box - RHD - diesel.

Ball joint - track rod

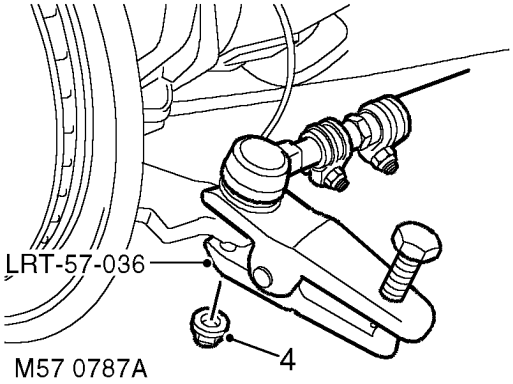
57.55.07

Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

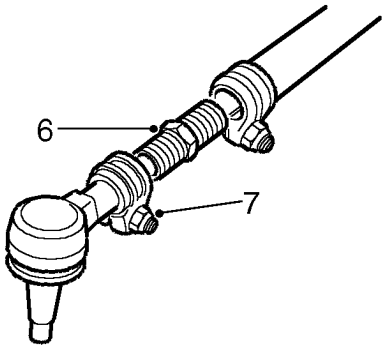
2. Remove LH front road wheel.



M57 0787A

3. Loosen adjuster clamp bolts.
4. Remove nut securing track rod ball joint to steering knuckle.
5. Using tool **LRT-57-036** break taper joint and release track rod.

   CAUTION: Before disconnecting any part of the steering linkage, ensure the road wheels are positioned straight ahead and the steering wheel is prevented from turning. Unrestricted turning of the steering wheel will damage the SRS rotary coupler.



M57 0757

6. Unscrew ball joint and adjuster.
7. Remove clamps from adjuster and track rod.

Refit

1. Clean adjuster, clamps and track rod.
2. Fit clamps to track rod and adjuster. Screw in adjuster and ball joint.
3. Clean ball joint taper and taper seat.
4. Adjust length of track rod so that ball joint taper is centralised in steering knuckle.
5. Fit track rod to steering knuckle and tighten nut to 80 Nm (59 lbf.in).
6. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
7. Remove stand(s) and lower vehicle.
8. Check and, if necessary, adjust wheel alignment.

   ☞ **STEERING, ADJUSTMENTS, Wheel alignment - front.**
9. After check/adjustment of wheel alignment, ensure track rod adjuster clamp bolts are tightened. Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft).

Ball joint - drag link

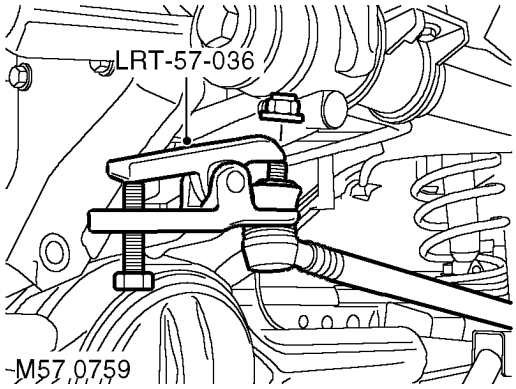
57.55.15

Remove

1. Raise front of vehicle.

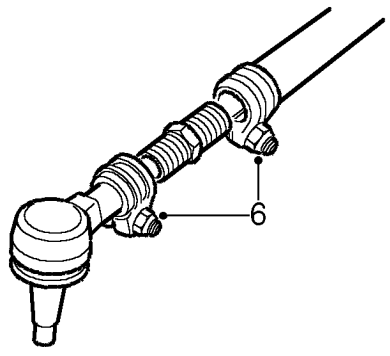
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. **RHD models:** Remove LH front road wheel.
3. **LHD models:** Remove RH front road wheel.



4. Remove nut securing drag link to steering knuckle.
5. Using **LRT-57-036**, break taper joint and release drag link.

   CAUTION: Before disconnecting any part of the steering linkage, ensure the road wheels are positioned straight ahead and the steering wheel is prevented from turning. Unrestricted turning of the steering wheel will damage the SRS rotary coupler.



M57 0788

6. Loosen adjuster clamp bolts and unscrew ball joint and adjuster.
7. Remove clamps from adjuster and drag link.

Refit

1. Clean adjuster, clamps and drag link.
2. Fit clamps to drag link and adjuster. Screw in adjuster and ball joint.
3. Clean ball joint taper and taper seat.
4. Adjust length of drag link so that ball joint taper is centralised in steering knuckle.
5. Fit drag link to steering knuckle and tighten nut to 80 Nm (59 lbf.ft).
6. Tighten drag link adjuster clamp bolts. Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft).
7. Check steering linkage is centralised.
   STEERING, ADJUSTMENTS, Steering linkage - centralise.
8. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
9. Remove stand(s) and lower vehicle.

Drag link

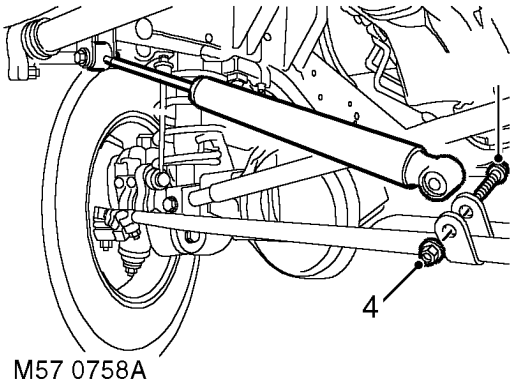
57.55.17

Remove

1. Raise front of vehicle.

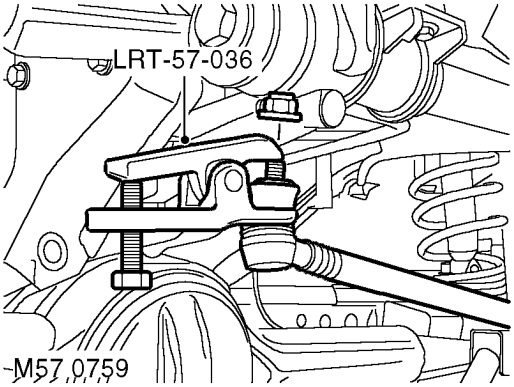
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. **RHD vehicles:** Remove the LH front road wheel.
3. **LHD vehicles:** Remove the RH front road wheel.



M57 0758A

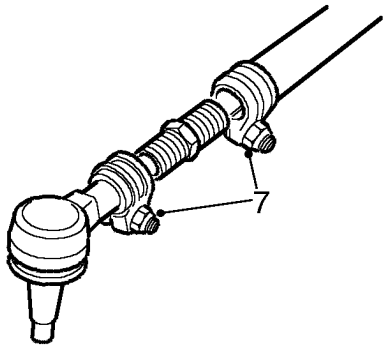
4. Remove nut and bolt securing damper to drag link and release damper.
5. Remove 2 nuts securing drag link to drop arm and steering knuckle.



M57 0759

6. Using **LRT-57-036** break taper joints and remove drag link.

   CAUTION: Before disconnecting any part of the steering linkage, ensure the road wheels are positioned straight ahead and the steering wheel is prevented from turning. Unrestricted turning of the steering wheel will damage the SRS rotary coupler.



M57 0760A

7. Loosen adjuster clamp bolts and remove ball joint and adjuster.
8. Remove clamps from adjuster and drag link.

Refit

1. Clean adjuster, clamps and ball joint.
2. Fit clamps to drag link and adjuster. Screw in adjuster and ball joint.
3. Clean ball joint tapers and taper seats.
4. Fit drag link to drop arm and tighten nut to 80 Nm (59 lbf.ft).
5. Adjust length of drag link so that ball joint taper is centralised in steering knuckle.
6. Fit drag link to steering knuckle and tighten nut to 80 Nm (59 lbf.ft).
7. Tighten drag link adjuster clamp bolts. Tighten M8 bolts to 22 Nm (16 lbf.ft) and M10 bolts to 33 Nm (24 lbf.ft)
8. Align damper to drag link, fit nut and bolt and tighten to 125 Nm (92 lbf.ft).
9. Check steering linkage is centralised.

   ☞ **STEERING, ADJUSTMENTS, Steering linkage - centralise.**
10. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
11. Remove stand(s) and lower vehicle.

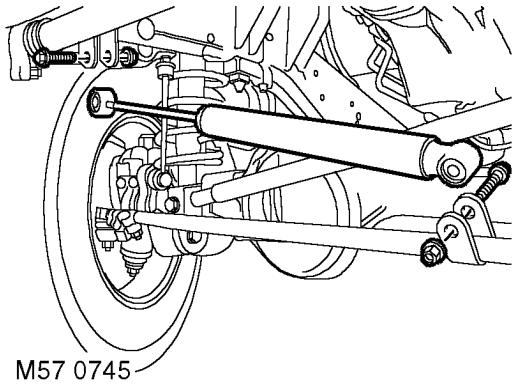
Damper - steering

57.55.21

Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.


M57 0745

2. Remove 2 nuts and bolts securing steering damper to drag link and chassis.
3. Compress damper and remove from vehicle.

Refit

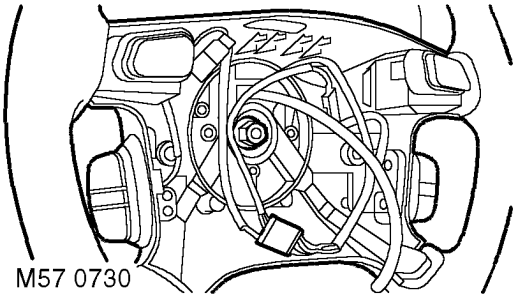
1. Position damper to chassis and drag link. Fit nuts and bolts and tighten to 125 Nm (92 lbf.ft).
2. Remove stand(s) and lower vehicle.

Steering wheel

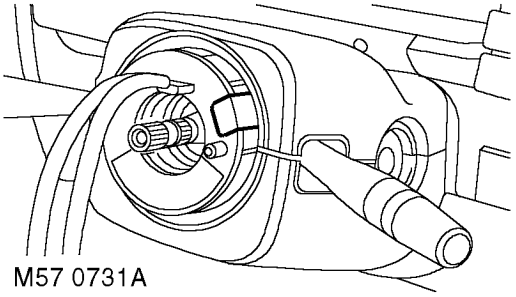
57.60.01.30

Remove

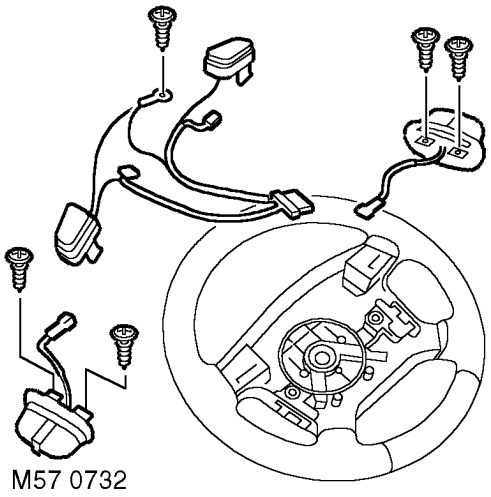
1. Remove drivers airbag.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.**


M57 0730

2. Disconnect horn multiplug.
3. Centralise steering wheel with road wheels in straight ahead position.
4. Restrain steering wheel and loosen self locking nut securing steering wheel to column.
5. Release steering wheel from column.
6. Remove and discard self locking nut.
7. Remove steering wheel.


M57 0731A

8. Attach tape across edge of rotary coupler to retain correct setting.

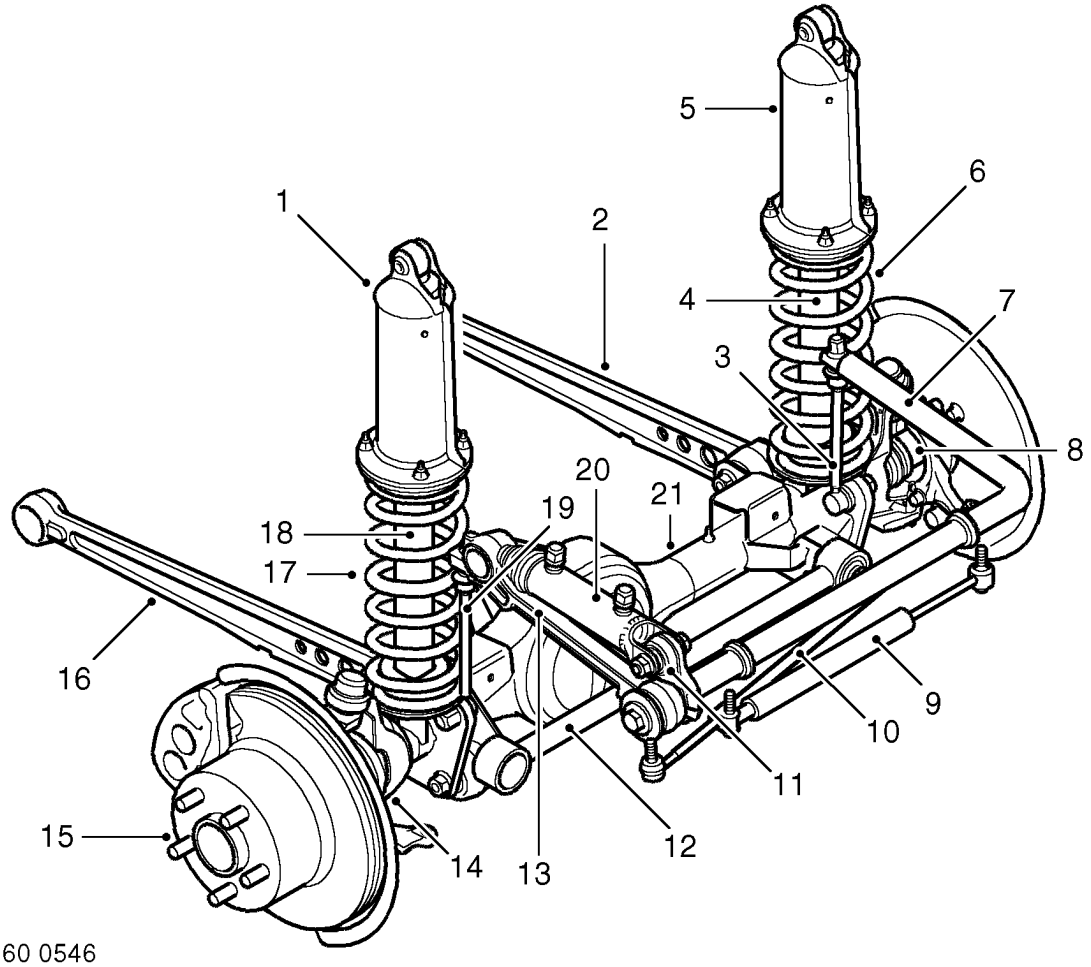

M57 0732

9. Release 2 clips securing each horn button to steering wheel.
10. Remove screw securing horn earth lead to steering wheel.
11. Disconnect radio and cruise control multiplugs.
12. Remove 2 screws securing radio switches to steering wheel.
13. Remove radio switches from steering wheel.
14. Remove 2 screws securing cruise control switches to steering wheel.
15. Remove cruise control switches from steering wheel.
16. Remove horns from steering wheel.

Refit

1. Fit horn switches to steering wheel and secure with clips.
2. Fit and tighten screw securing horn earth lead to steering wheel.
3. Fit cruise control switches to steering wheel and secure with screws.
4. Fit radio switches to steering wheel and secure with screws.
5. Connect radio and cruise control multiplugs.
6. Remove tape from rotary coupler.
7. Ensure road wheels are in straight ahead position and indicator cancelling cam are aligned horizontally.
8. Fit steering wheel to column.
9. Connect horn multiplug.
10. Fit and tighten new self locking nut securing steering wheel to column to 43 Nm (32 lbf.ft).
11. Fit drivers airbag.
    ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.**

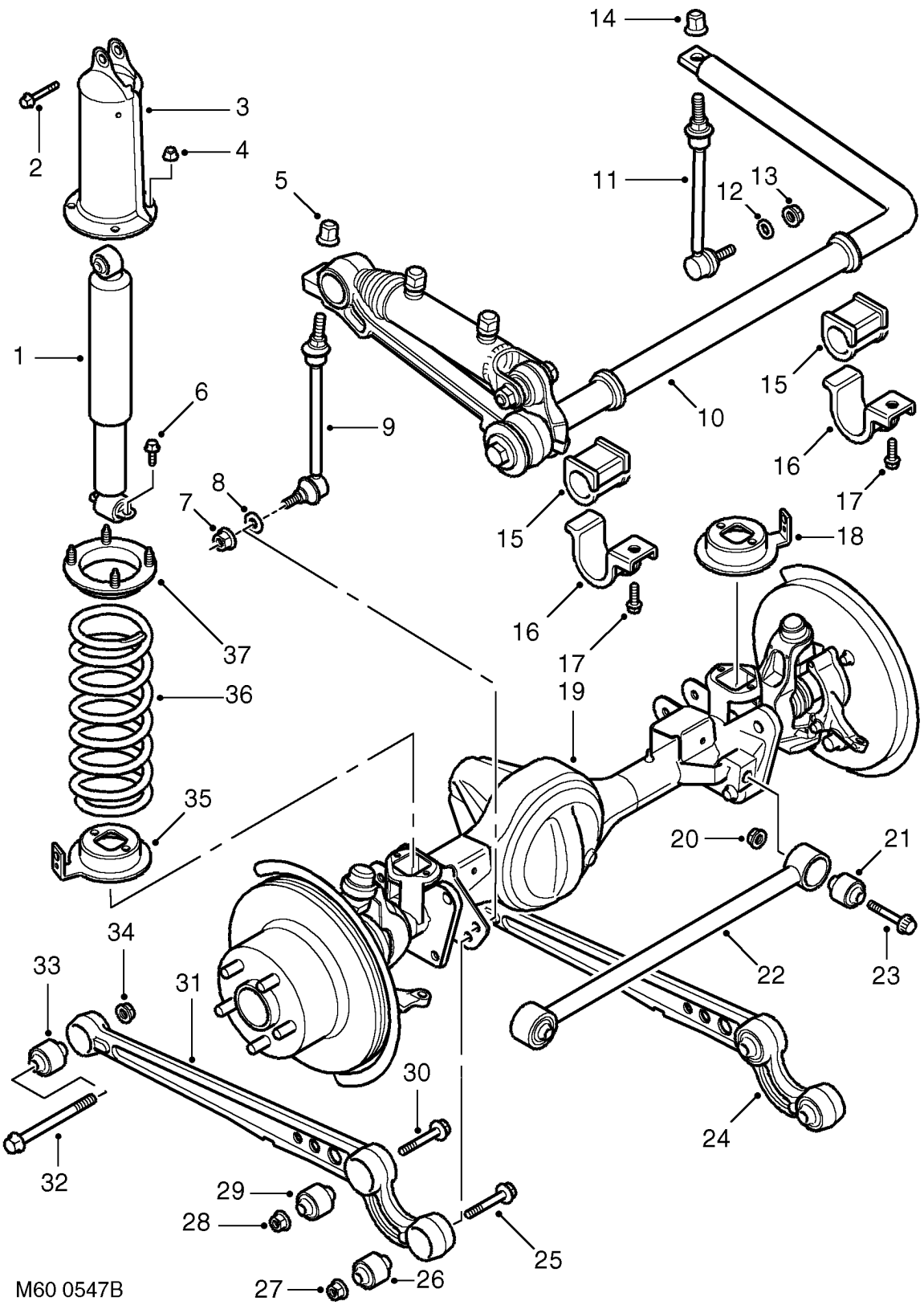
Front suspension component layout (ACE torsion bar shown)



M60 0546

1 Turret RH
2 Radius arm LH
3 Anti-roll bar link LH
4 Damper LH
5 Turret LH
6 Coil spring LH
7 Torsion/anti-roll bar
8 Steering knuckle
9 Steering damper
10 Drag link
11 ACE short arm (if fitted)
12 Panhard rod
13 ACE long arm (if fitted)
14 Steering knuckle
15 Brake caliper and hub assembly
16 Radius arm RH
17 Coil spring RH
18 ACE actuator
19 Anti-roll bar link RH
20 ACE actuator
21 Anti-roll bar link RH

Front suspension components (ACE torsion bar shown)



1 Damper 2 off
2 Bolt 2 off
3 Turret 2 off
4 Nut 8 off
5 Nut
6 Bolt 4 off
7 Nut
8 Washer
9 Anti-roll bar link RH
10 Torsion/Anti-roll bar assembly
11 Anti-roll bar link LH
12 Washer
13 Nut
14 Nut
15 Mounting rubber 2 off
16 Clamp plate 2 off
17 Bolt 2 off
18 Lower spring seat LH
19 Front axle
20 Nut
21 Bush
22 Panhard rod
23 Bolt
24 Radius arm LH
25 Bolt
26 Bush
27 Nut
28 Nut
29 Bush
30 Bolt
31 Radius arm RH
32 Bolt
33 Bush
34 Nut
35 Lower spring seat RH
36 Coil spring 2 off
37 Upper spring seat 2 off

Description

General
The front suspension comprises two dampers and coil springs, two radius arms, a Panhard rod and an anti-roll bar. The front axle provides the location points for the dampers, springs, radius arms and the Panhard rod.

The anti-roll bar assembly is an essential part of the front suspension. On vehicles without Active Cornering Enhancement (ACE) a conventional 'passive' anti-roll bar is fitted. On vehicles fitted with the ACE system, a thicker diameter anti-roll bar, known as a torsion bar, is used with an actuator at one end.

☞ **FRONT SUSPENSION, DESCRIPTION AND OPERATION, Description - ACE.**

The hydraulic dampers and coil springs provide springing for each front wheel. The long travel dampers, springs and radius arms provide maximum axle articulation and wheel travel for off-road driving. The front axle is controlled longitudinally by two forged steel radius arms and transversely by a Panhard rod.

Radius arms
Each radius arm is manufactured from forged steel. Two bushes are pressed into the forward end of the radius arm. The forward end of the radius arm is located in a fabricated bracket on the axle and secured through the bushes with two bolts and nuts. A bush is pressed into the rear of the radius arm which is also located in a fabricated bracket on each chassis longitudinal and secured through the bush with a bolt and nut.

The radius arms prevent longitudinal movement of the front axle and because of their length allow maximum axle articulation. The stiffness of the bushes in each radius arm also contributes to the vehicle roll stiffness.

Each radius arm has a notch on its lower edge which provides location for the vehicle jack.

Dampers
Two conventional telescopic dampers are used to control body/axle movement. A turret is located on a bracket welded to the chassis. The upper spring seat has four studs which pass through holes in the bracket and align with corresponding holes in the turret. Four nuts are screwed onto the studs and secure the turret and upper spring seat to the chassis.

A fabricated platform is welded to the axle. The platform has two captive nuts which provide for the attachment of the damper. A lower spring seat is located on the platform. Each spring seat is handed and has a bracket which secures the ABS sensor harness and the front brake hose.

Each damper is fitted with a bush at its upper end. The bush locates in the top of the turret and is secured with a cross bolt. The lower attachment point for the damper is also fitted with a bush. This bush has a spindle through its centre with a hole at each end. The spindle is seated on the lower spring seat and the axle platform and secured with two bolts. The coil spring is fitted in a compressed state between the upper and lower spring seats and assists the damper in controlling the body/axle movement. The upper and lower bushes are replaceable items.

Rubber bump stops are fitted to the chassis above each end of the axle. The bump stops are progressive in their compression and prevent the axle from contacting the chassis in the event of maximum suspension travel being reached. The bump stops revert to their original shape once the compression load has been removed from them.

The damper functions by restricting the flow of a hydraulic fluid through internal galleries within the damper body. A chromium plated rod moves axially within the damper. As the rod moves, its movement is limited by the flow of fluid through the galleries thus providing damping of undulations in the terrain. The damper rod is sealed at its exit point from the body to maintain fluid within the unit and prevent the ingress of dirt and moisture. The seal also acts as a wiper to keep the rod outer diameter clean. A plastic shroud protects the rod and slides over the body as the damper moves. The coil spring aids the damper to extend after being compressed and also aids the damping process.

Coil springs

Coil springs are fitted to the front axle of the vehicle. The front springs differ between petrol and Diesel variants. Each spring is retained at its base by the lower spring seat. The top of each spring is located in the upper spring seat isolator. The upper spring seat is manufactured from natural rubber , with a bonded metal plate and four bonded studs which provide for the attachment of the damper turret. The rubber isolator reduces noise transmitted to the chassis and body from the suspension.

The coil springs must be installed correctly. The bottom coil of the spring locates in a recess in the lower spring seat. The top coil of the spring is ground flat to locate the upper spring seat isolator.

Coil Spring Specifications – Models up to 03 Model Year

The front springs on petrol variants are manufactured from carbon chrome 13.9 mm (0.55 in) diameter bar. The spring has 7.6 coils and a free length of 377 mm (14.8 in). The petrol front spring is identified by a pink and orange stripe painted on a number of coils.

The front springs on Diesel variants are manufactured from carbon chrome 13.9 mm (0.55 in) diameter bar. The spring has 7.6 coils and a free length of 383 mm (15.0 in). The Diesel front spring is identified by a white and purple stripe painted on a number of coils.

Coil Spring Specifications – Models from 03 Model Year

The introduction of the 03MY vehicle introduced a range of additional spring fitments. These were introduced to cover the introduction of the 4.6l V8 engine, the fitment of a front mounted winch and to optimise the vehicle trim heights.

The coil springs are manufactured from silicon manganese 13.8 mm or 13.9 mm (0.54 in or 0.55 in) diameter bar. The following spring data table shows the colour codes, number of coils and spring free length.

Spring Data

Colour Code	Total No. of Coils	Free Length
Red/Purple	7.4	371 mm (14.6 in)
Yellow/Purple	7.4	378.4 mm (14.9 in)
Blue/Purple	7.4	365 mm (14.4 in)
Grey/Purple	7.4	387 mm (15.2 in)
Purple/Purple	7.4	373.8 mm (14.7 in)
Yellow/Orange	7.4	394.6 mm (15.5 in)
Green/Orange	7.4	382.6 mm (15 in)
Pink/Brown	7.6	405.6 mm (15.9 in)

The following table shows spring fitment applicablity.

Spring Fitment Applicability

Left Hand Drive		Right Hand Drive	
RH side	**LH side**	**RH side**	**LH side**
Red/Purple	Red/Purple	Yellow/Purple	Blue/Purple
Yellow/Purple	Yellow/Purple	Grey/Purple	Purple/Purple
Grey/Purple	Grey/Purple	Yellow/Orange	Green/Orange

The following table shows standard springs and uprated springs required when a front winch is fitted.

Winch Fitment Spring Applicability

Standard Spring		Winch Fitted Spring
RH Side	**LH Side**	**Both Sides**
Red/Purple	Red/Purple	Grey/Purple
Yellow/Purple	Blue/Purple	Yellow/Orange
Yellow/Purple	Yellow/Purple	Yellow/Orange
Grey/Purple	Purple/Purple	Green/Orange
Grey/Purple	Grey/Purple	Green/Orange
Yellow/Orange	Green/Orange	Pink/Brown

Panhard rod

A Panhard rod is used to ensure that the axle remains centrally located. The Panhard rod has bushes pressed into housings at each end which provide for the attachment to the axle and chassis. One end of the Panhard rod locates in a fabricated bracket on the axle and is secured with a bolt and locknut. The opposite end is attached to a fabricated bracket on the chassis and is also secured with a bolt and a locknut. The Panhard rod is shaped at one end to allow clearance for the axle casing.

The attachment bolts for the Panhard rod are coated with a clear, dry wax which reduces friction on the bolt and allows the correct torque to be applied to the clamping of the bushes. The bolts can be re-used, but if bolt replacement is necessary the correct bolt with the wax coating must be used.

On models from 03 Model Year, the Panhard rod is shortened by 30 mm (1.18 in). This modification was introduced to enhance the suspension bump steer characteristics in line with other suspension improvements introduced simultaneously. The change to the Panhard rod also required the relocation of the attachment brackets on the axle casing and the chassis.

Torsion/Anti-roll bar

The anti-roll bars fitted differ between ACE and non-ACE vehicles. On non-ACE vehicles a conventional 'passive' anti-roll bar is used. On ACE vehicles an 'active' torsion bar is used. Both types are attached to the front chassis cross member with mounting rubbers and clamp plates. The clamp plates locate in brackets on the cross member and are each secured with a bolt. Each end of the anti-roll bar is attached to an anti-roll bar link. Each link has a spherical bearing attached at each end. One end is attached to a bracket on the axle and secured with a locknut; a washer is installed between the spherical bearing and the bracket. The opposite end attaches through a hole in the anti-roll bar and is secured with a locknut. On 'active' torsion bars, the RH anti-roll bar link is attached to a long arm which in turn is attached to the torsion bar.

Passive anti-roll bar

The passive anti-roll bar is a conventional anti-roll bar which opposes axle movement, reducing the effects of lateral forces on the vehicle body.

With the conventional 'passive' anti-roll bar, axle movement is opposed by the anti-roll bar through links attached to the axle casing and each end of the anti-roll bar. The anti-roll bar is manufactured from 30 mm (1.18 in) diameter spring steel bar.

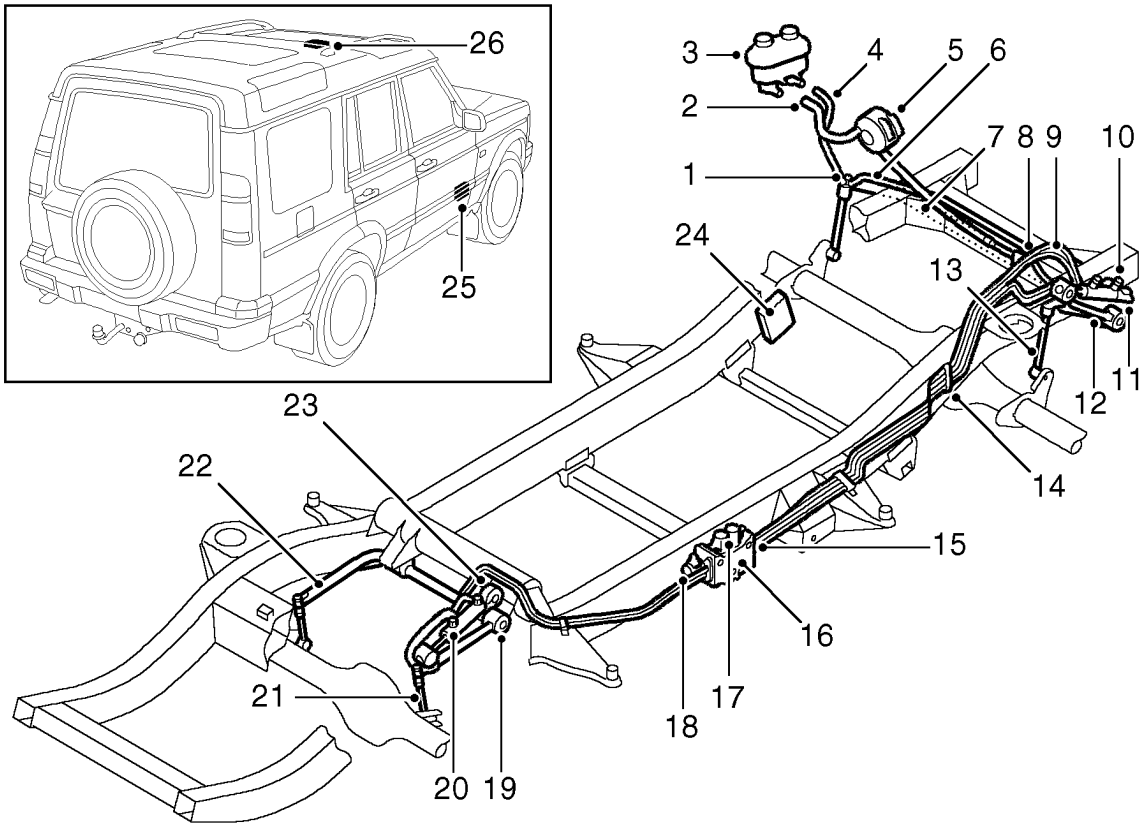
Active torsion bar

☞ **FRONT SUSPENSION, DESCRIPTION AND OPERATION, Description - ACE.**

The 'active' torsion bar is used in conjunction with the ACE system to control body roll and directional stability giving an improved reduction of the effects of lateral forces on the vehicle body over a conventional anti-roll bar.

The torsion bar opposes axle movement by the application of a hydraulic force to oppose the lateral forces through links attached to the axle casing and each end of the bar. The torsion bar is made from 35 mm (1.4 in) diameter spring steel bar. One end is fitted with an arm which is operated by a hydraulic actuator to oppose cornering forces.

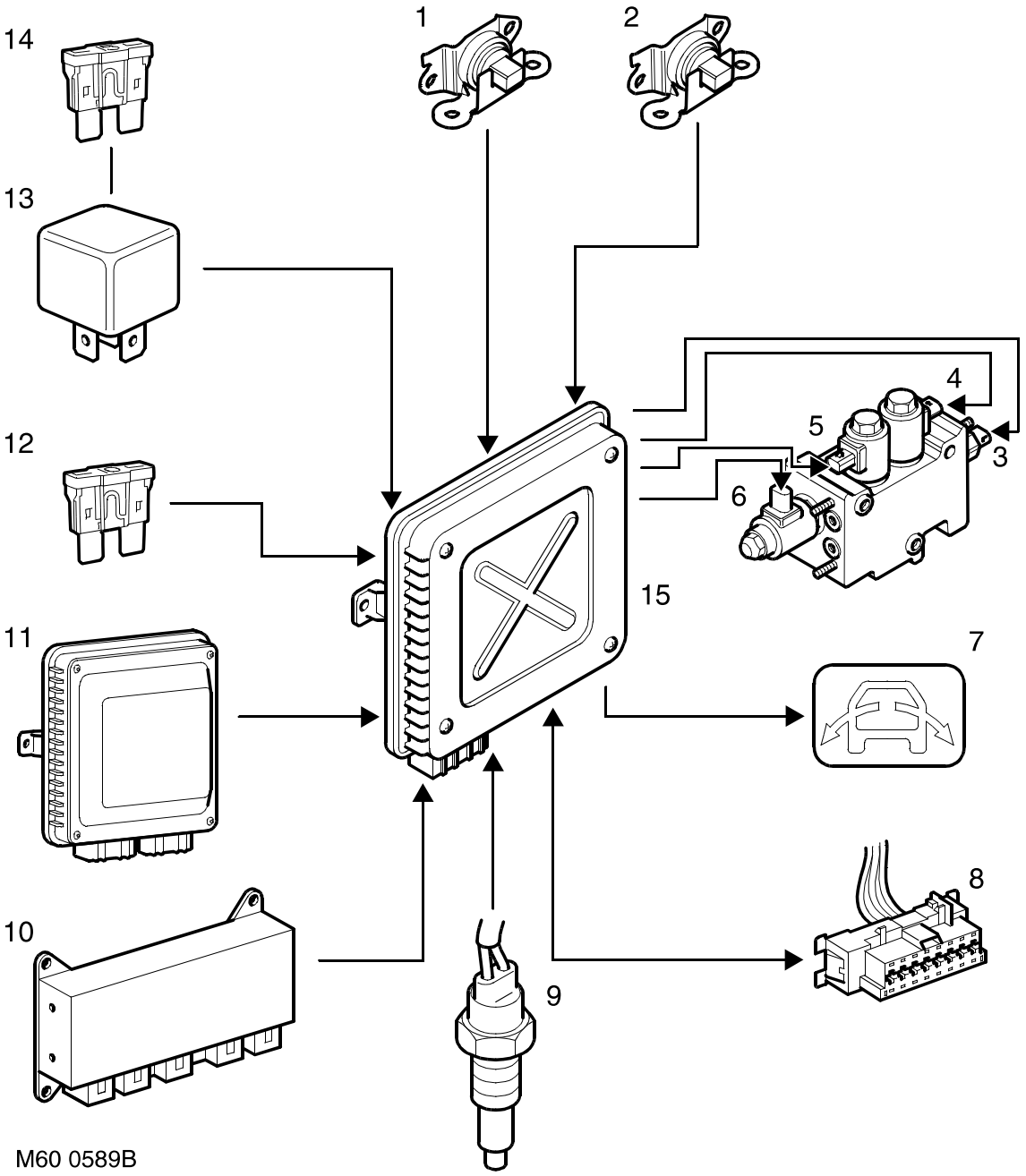
ACE system component layout



M60 0588A

1 Anti-roll bar link
2 Suction hose
3 ACE/PAS reservoir
4 Return pipe
5 ACE pump
6 Pressure pipe
7 Torsion bar - front
8 Actuator hose
9 Actuator hose
10 Actuator
11 Short arm
12 Long arm
13 Anti-roll bar link
14 Isolator and bracket (2 and 4 way) 7 off
15 Pressure transducer
16 Valve block
17 Directional control valve 2 off
18 Pressure control valve
19 Long arm
20 Actuator
21 Anti-roll bar link
22 Torsion bar - rear
23 Short arm
24 ACE ECU
25 Accelerometer - lower
26 Accelerometer - upper

ACE system control diagram



M60 0589B

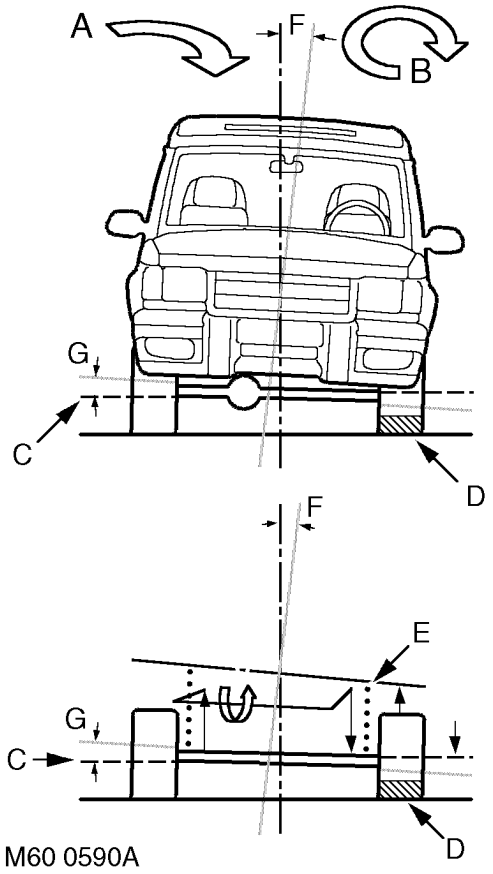
1 Upper accelerometer
2 Lower accelerometer
3 Pressure transducer
4 Directional control valve
5 Directional control valve
6 Pressure control valve
7 Instrument pack warning lamp
8 Diagnostic socket
9 Reverse lamp switch
10 SLABS ECU
11 Engine Control Module (ECM)
12 Ignition feed
13 ACE relay
14 Battery supply
15 ACE ECU

Description - ACE

General

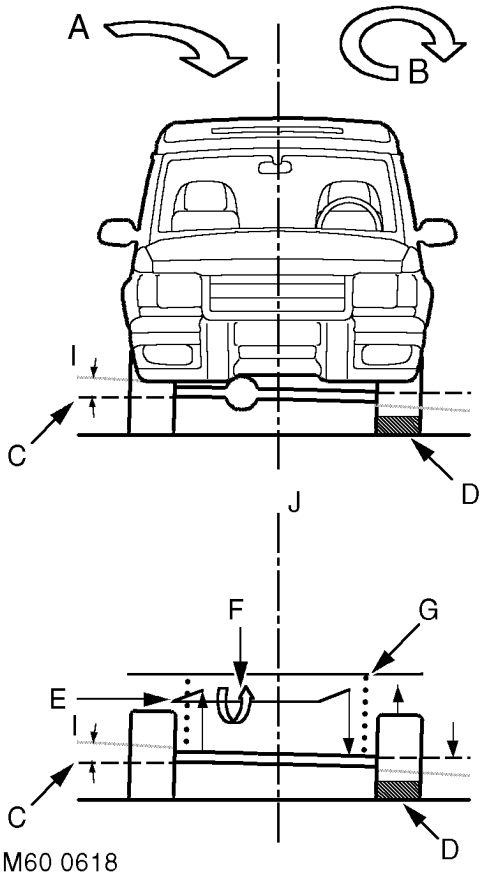
The Active Cornering Enhancement (ACE) system is used to control vehicle roll angles. The following illustrations show the difference in body roll angle between a conventional 'passive' anti-roll bar and the ACE system.

Conventional 'passive' anti-roll bar



a Direction of travel - Right hand bend
b Body roll
c Axle roll
d Tyre squash
e Coil springs
f Body roll angle
g Axle roll angle

ACE system



a Direction of travel - Right hand bend
b Body roll
c Axle roll
d Tyre squash
e Torsion/Anti-roll bar
f Direction of torsion/anti-roll bar twist
g Coil springs
h Body roll angle
i Axle roll angle
j Reduced body roll angle with ACE system

The system is electrically and hydraulically operated with all operations controlled by an ACE ECU located behind the glovebox in the passenger side footwell. The ACE system comprises front and rear torsion bars and actuators, two accelerometers, ECU, hydraulic pump, valve block and a fluid reservoir.

The ACE system gives improved vehicle handling and suspension characteristics and is active for both on and off-road driving. This is achieved by hydraulic actuators applying torque to the front and rear torsion bars in response to lateral forces sensed by accelerometers. The ACE system prevents body roll with cornering forces of up to 0.4 g. From 0.4 g there is a progressive increase in body roll but significantly lower than a passive system. A passive system will have a progressive increase in roll angle as soon as cornering forces are applied and will have a higher roll angle than the ACE system for the same cornering force.

The ACE system can also detect if the vehicle is driven off-road. If off-road conditions are detected the ACE system operation will be reduced or completely disabled at a speed of 25 mph (40 km/h) or less.

Lateral acceleration of the body is sensed by two accelerometers and signals are transmitted to the ECU. The engine driven hydraulic pump supplies a constant hydraulic flow to the valve block. Two directional control valves are solenoid operated by the ECU and these supply fluid to the applicable side of each actuator to apply an equal and opposite force to the torsion bar. In operation the ACE system maintains the attitude of the vehicle body when cornering.

The ACE system uses a semi-synthetic hydraulic fluid which is the same as the fluid used for the PAS system. The total capacity of the ACE system is 1.62 litres (0.42 US Gallons).

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

In the event of an ECU or hydraulic failure the system will fail safe to a 'locked bars' condition. The 'locked bars' condition will allow the torsion bars to operate in a similar manner as conventional 'passive' anti-roll bars. Prolonged cornering forces will allow a progressive increase in roll angle due to hydraulic leakage through the actuators and valve block. Failures will be relayed to the driver by the illumination of the ACE warning lamp in the instrument pack. Faults are recorded by the ECU and can be retrieved using TestBook.

When the ignition switch is moved to position II, the warning lamp will illuminate for two seconds to check functionality. The warning lamp functionality can also be checked using TestBook.

TestBook must also be used to perform a bleeding procedure after maintenance operations have been performed to ensure that complete system bleeding is performed. Trapped air in the system can seriously reduce the system performance.

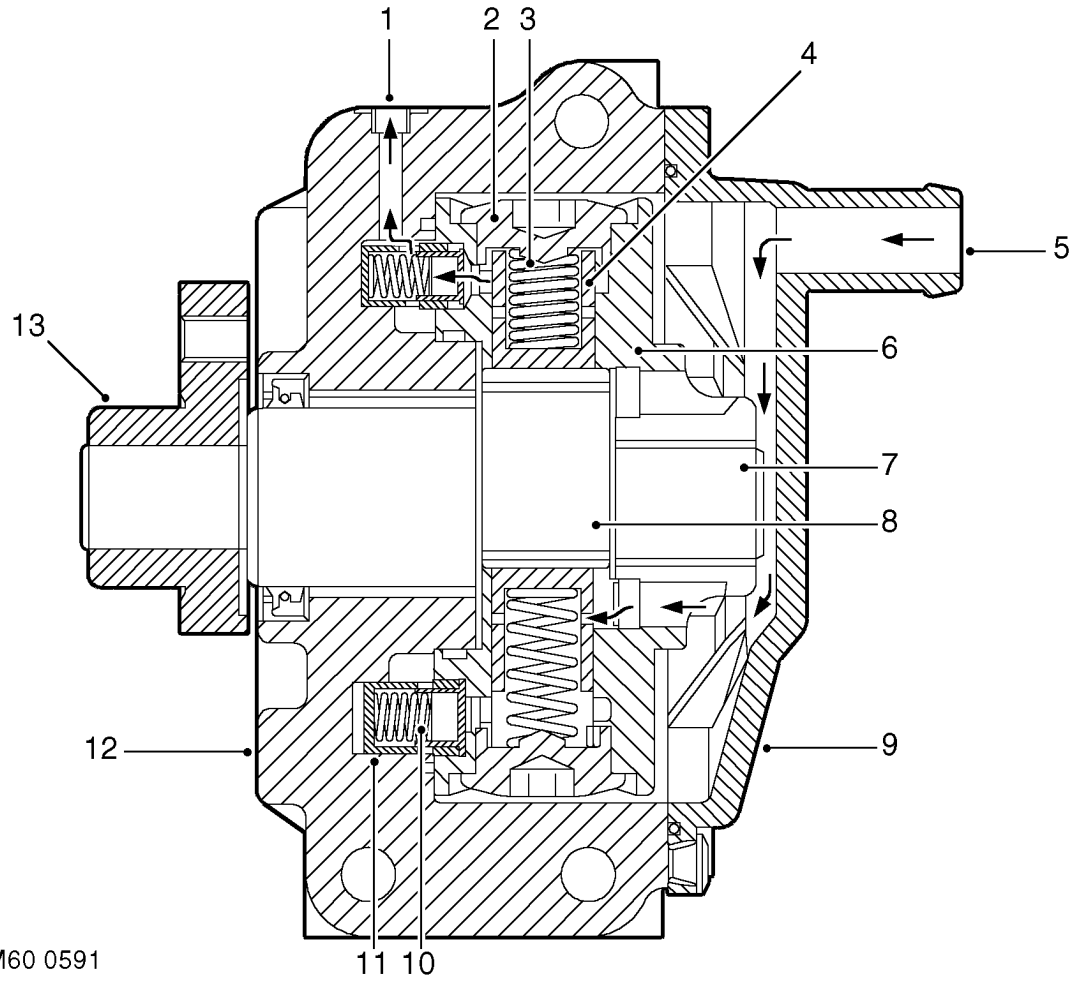
Fluid reservoir

The moulded plastic fluid reservoir is mounted on the left hand side of the engine compartment on a bracket which is attached to the inner wing. The reservoir is dual purpose, being divided into two separate chambers; one for the ACE system and one for the PAS system. Each chamber has its own filler neck and cap and is identified by moulded lettering on the reservoir adjacent to each filler.

A non-serviceable filter assembly is fitted in the base of each chamber. The filter is made from fine stainless steel mesh which is moulded into the body of the reservoir. The filter removes particulate matter from the fluid before it is drawn into the hydraulic pump.

Upper and lower fluid level marks are moulded onto the reservoir body. The capacity of the ACE reservoir chamber to the upper level mark is 0.5 litre (0.13 US Gallon).

Hydraulic pump



1 Outlet port
2 Cap
3 Piston spring
4 Piston
5 Inlet port
6 Cylinder housing
7 Shaft
8 Cam
9 Inlet housing
10 Spring
11 Discharge valve
12 Housing
13 Pulley attachment flange

The hydraulic pump is attached to a bracket on the left hand side of the engine and is driven at crankshaft speed by the auxiliary drive belt. The pump is of the radial piston type which delivers fluid at high pressure.

The radial piston pump has six pistons located in bores in a cylinder housing. A central shaft, which is driven by a pulley and the auxiliary drive belt, has a cam which operates the pistons as it rotates.

As the cam lobe reaches each piston, the piston is pushed outward, moving the fluid above the piston. The pressure created by the fluid flow from the bore opens a spring loaded discharge valve and allows the fluid to flow to the pump outlet port. When the piston reaches its full stroke, the flow reduces and the discharge valve closes under spring pressure.

As the cam lobe moves away from the piston, a spring pushes the piston down the bore creating a vacuum above the piston. As the piston moves down the bore, ports in the piston are exposed and connect with the fluid inlet. The vacuum draws fluid into the piston filling the piston and the chamber above it. As the piston is again pushed upwards, the ports are closed off by the bore and the fluid opens the discharge valve and flows to the outlet port.

The above sequence is applied to each of the six pistons for every revolution of the central shaft and cam. When the engine is running the sequence occurs rapidly creating a constant flow of fluid. The fluid flow varies with the engine speed and the rotational speed of the central shaft. The pressure felt at the actuator, created by the flow from the pump, is controlled by the pressure control valve in the valve block.

The pump has a displacement of 8.5 cm^3/rev and an operational pressure of 135 bar (1958 $lbf.in^2$). The pump output flow ranges from 7.0 l/min (1.85 US Gallons/min) at 775 rev/min to 9.25 l/min (2.44 US Gallons/min) at 7625 rev/min.

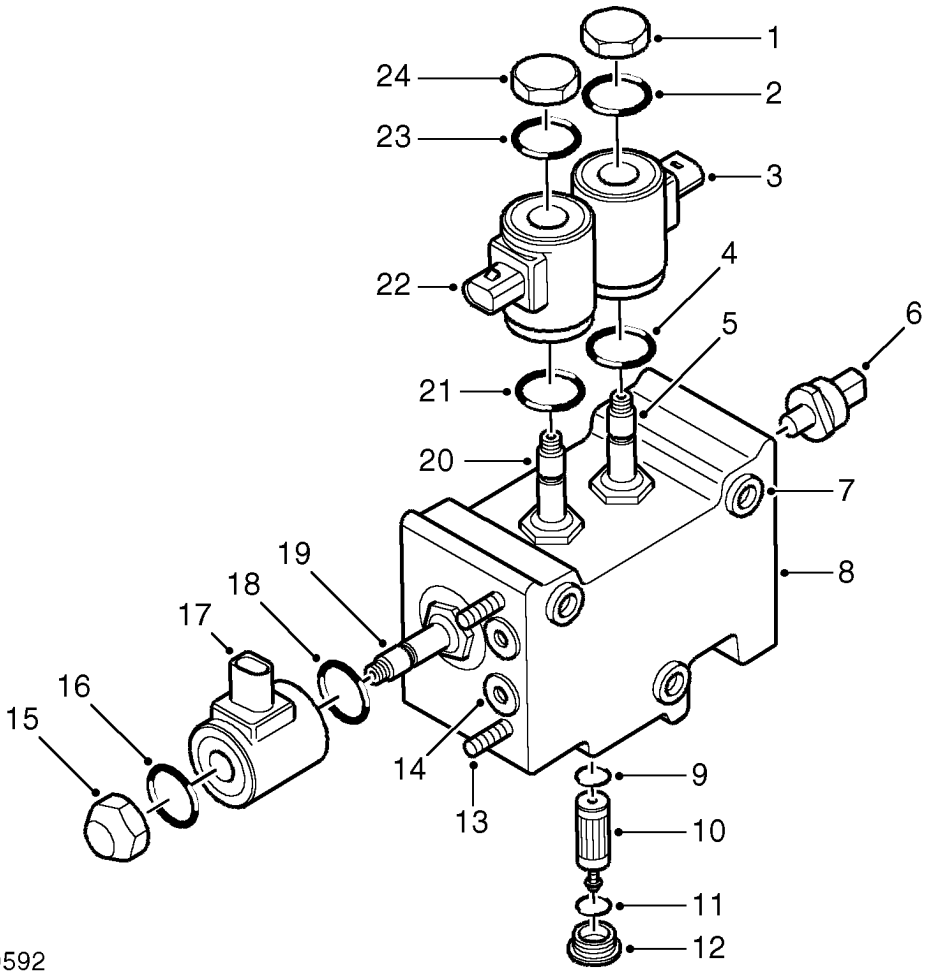
System pipes

Fluid is moved through the ACE system via a series of pipes and hoses. The pipes are mounted on brackets at strategic points to assure quiet operation of the system.

The pipes from the pump to the valve block and from the valve block to the reservoir are one piece items which are fitted at the factory before the body is attached to the chassis. If these pipes require replacement in service, the pipes must be cut to facilitate their removal. 'In service' replacement pipes are available in two parts with a connector to seal the joint.

The flexible hose which supplies pressure from the pump to the supply pipe attached to the front cross member is fitted with an attenuator. The attenuator comprises a bullet shaped valve which is located between two spiral wound springs held at each end of the flexible hose. This valve operates as a restrictor to damp pressure waves of hydraulic fluid from the pump, reducing noise and strain on components downstream. The attenuator is integral with the supply hose and pipe and cannot be serviced separately.

Valve block



M60 0592

1 Cap
2 'O' ring
3 Coil
4 'O' ring
5 Directional control valve 1 (extend)
6 Pressure transducer
7 Mounting bush 3 off
8 Valve block
9 'O' ring
10 High pressure filter
11 'O' ring
12 Cap
13 Stud 4 off
14 Pipe connections
15 Cap
16 'O' ring
17 Coil
18 'O' ring
19 Pressure control valve
20 Directional control valve 2 (retract)
21 'O' ring
22 Coil
23 'O' ring
24 Cap

The valve block directs hydraulic pressure to the actuators via solenoid operated directional control valves. A solenoid operated pressure control valve regulates the required pressure to the actuators. The three valve solenoids are controlled by signals received from the ACE ECU. A pressure transducer monitors the pressure delivered by the pump. A replacable high pressure filter is installed into the lower face of the valve block and filters fluid before it reaches the valves.

The valve block is located on the outside of the right hand chassis longitudinal. The valve block is secured to the chassis with three bolts and rubber bushes. The rubber bushes isolate the valve block from the chassis, preventing hydraulic noise from the valve block transmitting through the chassis and body.

The two solenoid operated directional control valves (DCV's) are fitted to ports in the top face of the valve block. The DCV's are screwed into the valve block and sealed with O ring seals. Each DCV has a solenoid for electrical operation of the valve. The solenoid is sealed to the DCV with two O ring and secured with a cap. The cap, coil and O rings are serviceable items. The DCV's are non-serviceable and failure of a DCV requires the replacement of the valve block assembly.

The pressure control valve is fitted to a port in the rear face of the valve block. The pressure control valve is screwed into the valve block and sealed with O rings. The pressure control valve has a coil for electrical operation. The coil is sealed to the pressure control valve with two O rings and secured with a cap. The cap, coil and O rings are serviceable items. The pressure control valve is non-serviceable and failure requires replacement of the valve block assembly.

The pressure transducer is fitted to a port in the forward face of the valve block. The pressure transducer is screwed into the valve block and sealed with an O ring seal. The pressure transducer is a serviceable item.

The high pressure filter locates in a port on the lower face of the valve block. The gauze and fibre filter is sealed in the port with O ring seals. A threaded cap secures the filter in the valve block and is also sealed with an O ring seal. A threaded hole on the lower face of the filter allows a bolt to be fitted to remove the filter from the port. If a system component is replaced, the filter must be changed.

Four ports are located on the forward face of the valve block and two ports on the rear. Each port is fitted with a seal pack which contains two O ring seals and backing rings. The ACE pipes locate and seal in the seal packs and are secured to the valve block with the studs and nuts located on the forward and rear faces.

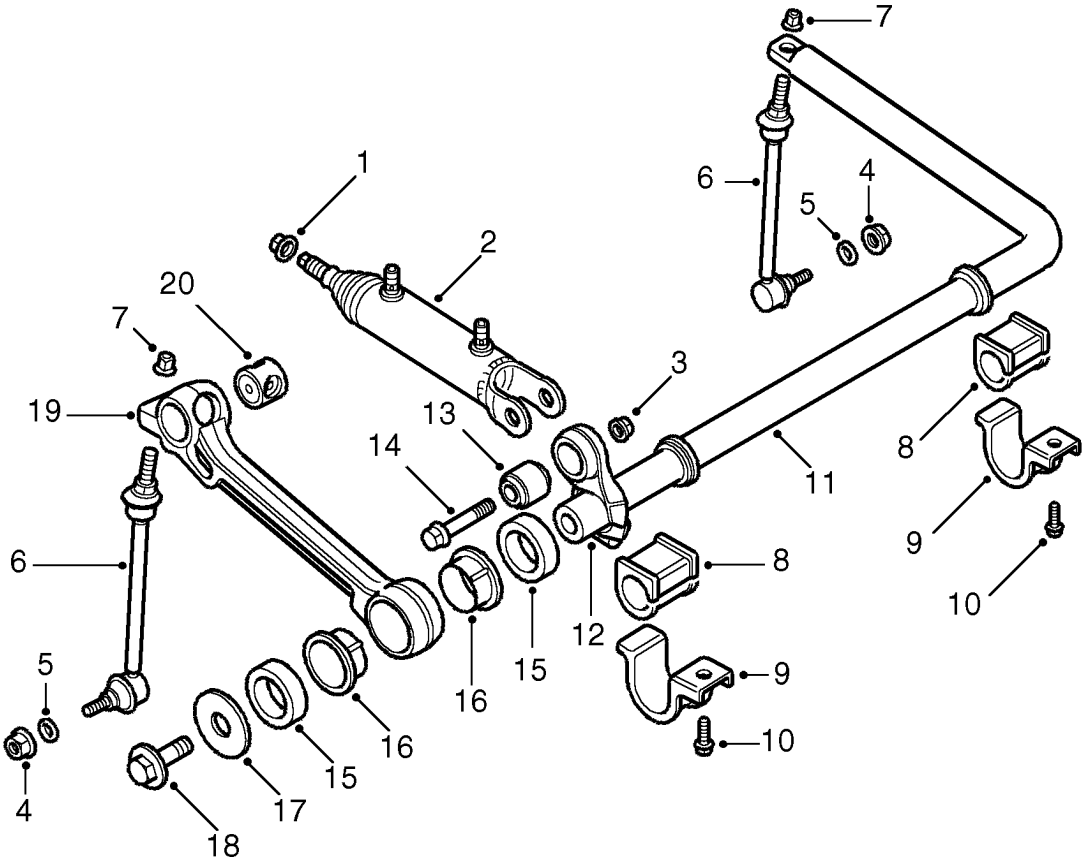
Actuators

Two actuators are used for the ACE system and are attached to the front and rear torsion bars. The actuators apply hydraulically generated force to the torsion bar to oppose lateral forces caused by the vehicle cornering.

Each actuator is a conventional double-acting cylinder. A piston is attached to a rod and moves within the cylinder when hydraulic pressure is applied. The rod is sealed at the point where it exits the cylinder. The outer end of the rod is threaded and locates in a bush in the ACE long arm and secured with a nut. A rubber gaiter covers the rod and prevents dirt and moisture from damaging the rod surface and cylinder seals. The cylinder has a forked attachment which locates on the short arm bush and secured with a bolt and nut.

Two banjo connections provide for the attachment of the hydraulic hoses from the ACE valve block. The connections provide hydraulic flow to each side of the piston to extend or retract the rod.

Torsion bar



M60 0593A

Front torsion bar shown, rear torsion bar similar

1 Locknut
2 Actuator
3 Locknut
4 Locknut 2 off
5 Washer
6 Anti-roll bar link
7 Locknut
8 Bush
9 Clamp plate
10 Bolt 2 off
11 Torsion bar
12 Short arm
13 Bush
14 Bolt
15 Outer slipper bush 2 off
16 Inner slipper bush 2 off
17 Washer
18 Bolt
19 Long arm
20 Bush

The front and rear torsion bar assemblies are similar in their construction, the rear torsion bar being narrower than the front. Each torsion bar is made from 35 mm (1.38 in.) diameter spring steel bar.

The right hand end of the torsion bar has a machined spigot which provides for the attachment of the forged steel short and long arms. The spigot for the short arm is splined and mates with splines in the short arm. The short arm is located in a specific position on the splines and clamped to the spigot with a Torx bolt and locknut. The short arm is not a serviceable item other than the actuator attachment bush. The smaller spigot diameter locates the long arm. The long arm is fitted with a slipper bush which is located on the spigot and secured with a large washer and a special bolt. The slipper bush comprises two inner and two outer bushes which are installed from each side of the long arm. The outer bushes have three lugs which locate in the long arm to prevent the bush from rotating. The long arm also provides the attachment point for the actuator piston rod and the anti-roll bar link.

The actuator has a forked end which locates on the bush in the short arm and is secured with a bolt and nut. The piston rod of the actuator locates through a hole in a cast boss on the long arm which is fitted with a special bush. A shoulder on the piston rod seats in a hole in the bush and a locknut on the end of the piston rod secures the rod to the long arm and bush.

The front torsion bar is attached to the front chassis cross member. Two rubber bushes are fitted to the torsion bar and are located in clamp plates. The clamp plates are located in slots in the cross member and secured with bolts.

The rear torsion bar is attached to the tubular cross member at the rear section of the chassis. Two rubber bushes are fitted to the torsion bar and are located in clamp plates. The clamp plates are located in fabricated brackets attached to the tubular cross-member and secured with bolts.

Two anti-roll bar links are mounted on brackets on the front and rear axles. Each anti-roll bar link is fitted with a spherical bearing at each end. One bearing is attached to the link at a 90° angle. The threaded shank of the bearing is located through a hole in a bracket on the axle and secured with a locknut; a washer is installed on the threaded shank between the bearing and the bracket. The second spherical bearing is attached in-line with the link and locates in the torsion bar on the left hand side and the long arm on the right hand side. The front anti-roll bar links are longer than the rear links and are not interchangeable.

Accelerometers

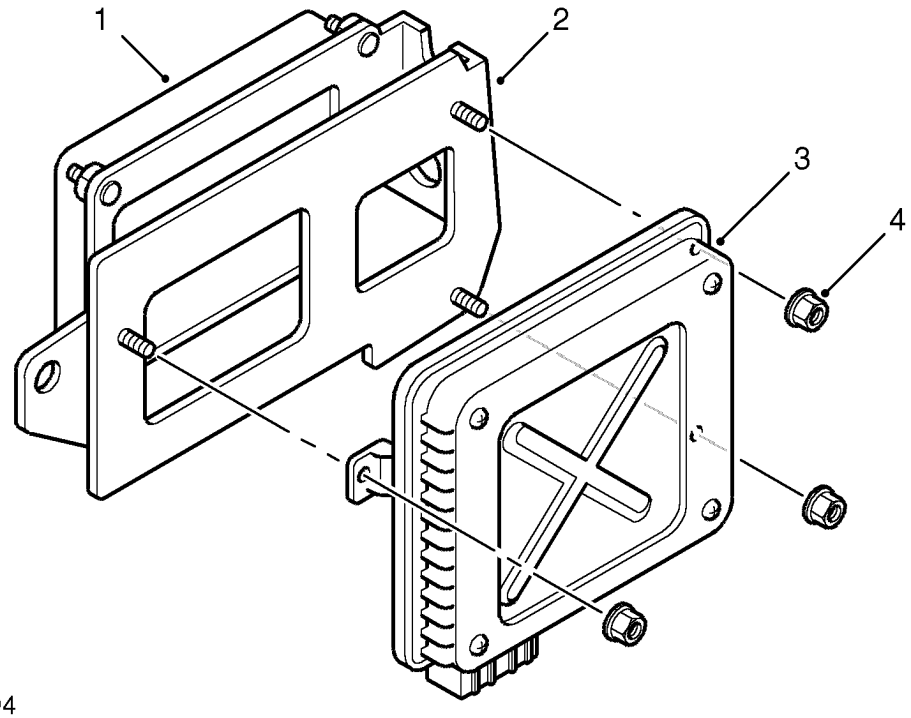
Two accelerometers are used for the ACE system. The upper accelerometer is mounted on a bracket, behind the headlining adjacent to the rear view mirror and the sunroof ECU. The lower accelerometer is located on a bracket on the inner sill panel under the RH front floor.

The lower accelerometer is the primary sensor used to measure lateral acceleration of the vehicle for roll control. The upper accelerometer is used by the ECU for roll correction and fault detection in conjunction with the lower accelerometer.

Each accelerometer is a solid state capacitive acceleration sensor and operates on a 5 V supply from the ECU. The upper and lower sensors can measure acceleration in the range of ± 1.10 g and return an output to the ECU of between 0.5 and 4.5 V.

Failures of an accelerometer are recorded by the ECU and can be retrieved using TestBook. A special tool is required to remove and replace a sensor in the bracket.

ACE Electronic control unit (ECU)



M60 0594

1 Body Control Unit (Ref. only)
2 Bracket
3 ACE Electronic control unit
4 Attachment nuts 3 off

The ACE ECU is mounted on a bracket behind the passenger glove box and is identified from the other ECU's by its single electrical harness connector. The single 36 pin connector is located on the lower face of the ECU and mates with a connector from the main harness. The connector supplies power, ground, signal and sensor information to/from the ECU for control of the ACE system.

The ACE ECU receives a battery power supply from fuse 15 in the engine compartment fusebox via the ACE relay, also located in the engine compartment fusebox. The ECU provides an earth path for the relay coil, energising the coil and supplying power to the ECU.

An ignition on signal is supplied from the ignition switch via fuse 29 in the passenger compartment fusebox. The ignition on signal provides an input to the ECU which tells the ECU that ignition has been selected on and initiates a 250 ms start time. The start time is used to prevent functions operating when software routines are being initialised.

The ignition on signal, when removed, tells the ECU that the ignition is off. The ECU will remain powered for thirty seconds after the ignition is turned off. The thirty second period allows the ECU to store values and fault flags in the memory. These values are read by the ECU when the next ignition on signal is received.

An engine speed signal is transmitted to the ECU from the Engine Control Module (ECM) as a pulsed digital signal. The engine speed signal is used by the ACE ECU to detect that the engine is running and hydraulic pressure for ACE system operation is available.

A road speed signal is transmitted to the ACE ECU as a pulsed digital signal from the Self-levelling/Anti-lock Braking System (SLABS) ECU. The road speed signal is used by the ACE ECU for on and off-road roll compensation.

When reverse gear is selected, an input is received from the reverse lamp switch. When the ACE ECU detects that reverse gear has been selected, the ACE system reverts to a 'locked bars' condition until reverse gear is disengaged.

The diagnostic connection allows diagnostic interrogation of the ACE ECU. The diagnostic socket allows diagnostic equipment to be connected to interrogate the ACE ECU for fault codes.

When system faults are detected by the ECU, the ACE warning lamp in the instrument pack is illuminated by the ECU continuously in amber for minor faults or flashing red with an audible warning for faults which require the driver to stop the vehicle immediately.

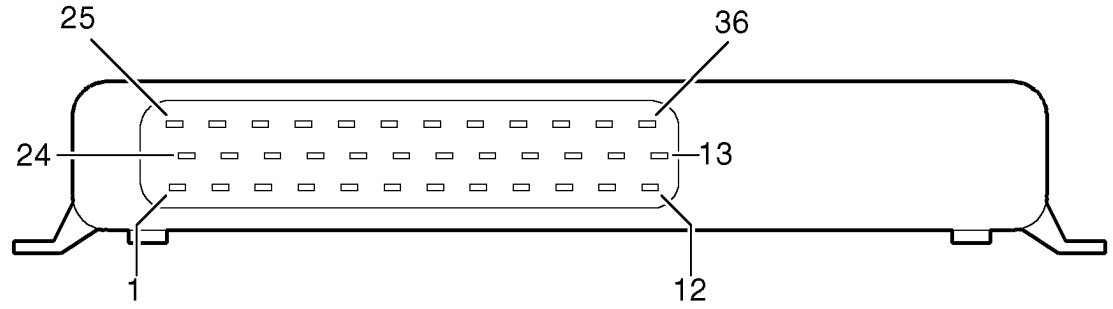
The ACE ECU supplies a control current to the pressure control valve in the valve block. The current supplied by the ECU is determined by a number of input signals from the upper and lower accelerometers, road speed etc.. The pressure control valve controls the hydraulic pressure supplied to the actuators proportional to the current supplied by the ECU.

Power is supplied to the two solenoid operated directional control valves (DCV's) in the valve block by the ECU. Together, the DCV's control the direction of flow of hydraulic fluid to the actuators. When the ECU supplies power to the solenoids the valves open allowing hydraulic fluid to flow to the actuators. When power is removed the valves close.

The pressure transducer in the valve block receives a 5 V supply from the ECU. The pressure transducer measures hydraulic pressures in the range of 0 to 180 bar (0 to 2610 lbf.in^2) and returns a linear output voltage to the ECU dependent on hydraulic pressure.

The ECU supplies a 5 V current to each of the accelerometers. Each accelerometer is capable of measuring lateral acceleration in the range of ± 1.10 g. An analogue input to the ECU of between 0.5 and 4.5 V relative to the lateral acceleration sensed is returned by each accelerometer. The ECU processes the two signals received to produce a 'pure' lateral acceleration signal which is then used as the main control signal for the ACE system.

ACE ECU connector pin details



M60 0619

Pin No.	Description	Input/Output
1	Not used	-
2	Not used	-
3	Spare	Input
4	Not used	-
5	Road speed	Input
6	ARC relay	Output
7 to 9	Not used	-
10	K line (diagnostics)	-
11	Ignition switch	Input
12	Accelerometer - lower (supply)	Output
13	Pressure transducer (supply)	Output

Pin No.	Description	Input/Output
14	Reverse switch	Input
15	Accelerometer - lower (signal)	Input
16	Pressure transducer (signal)	Input
17	Accelerometer - upper (signal)	Input
18	Accelerometer - upper (supply)	Output
19	Engine speed	Input
20	Main earth 1	-
21	Pressure transducer (earth)	Input
22	DCV 2 (earth)	Input
23	DCV 1 (earth)	Input
24	DCV 1 & 2 (supply)	Output
25	Pressure control valve (earth)	Input
26	Not used	-
27	Pressure control valve (supply)	Output
28	Main supply (+ V Batt)	Input
29 to 31	Not used	-
32	Main earth 2	-
33	Accelerometer - lower (signal)	Input
34	Accelerometer - upper (signal)	Input
35	Not used	-
36	Warning lamp	Output

Failure modes

Failures where the vehicle can still be driven safely are indicated by the ACE warning lamp illuminating continuously with an amber colour. The amber warning lamp will remain illuminated until the ignition is turned off. For all faults the warning lamp will only illuminate again if the fault is still present. Failures which require the driver to stop the vehicle immediately are indicated by the ACE warning lamp flashing with a red colour and an audible warning. All faults are recorded by the ACE ECU and can be retrieved with diagnostic equipment.

The following tables show the type of system failures and their effects on the system operation. Torsion bar 'floppy' means that fluid is allowed to circulate freely through the system. With no pressure in the actuators the torsion bar will have no effect on vehicle roll. 'Locked bars' means that all pump flow is directed through the valve block and returns to the reservoir. Both DCV's close and fluid is trapped in the actuators but can flow from one actuator to the other via the valve block. In this condition the torsion bar will perform similar to a conventional anti-roll bar, resisting roll but still allowing the axles to articulate.

Acceleration sensors

Failure	Effect
Valve stuck closed	No ACE control
Short circuit - Ground	No ACE control
Short circuit - VBatt	No ACE control
Loose sensor	Erractic ACE activity when driving in straight line

Pressure transducer

Failure	Effect
Short circuit - VBatt	Large sensor dead band - possible random movements

Road speed signal

Failure	Effect
Open circuit	No ACE control - 'Locked bars' condition
Short circuit - Ground	No ACE control - 'Locked bars' condition
Short circuit - VBatt	No ACE control - 'Locked bars' condition

Engine speed signal

Failure	Effect
Open circuit	No ACE control - 'Locked bars' condition
Short circuit - Ground	No ACE control - 'Locked bars' condition
Short circuit - VBatt	No ACE control - 'Locked bars' condition

Reverse gear signal

Failure	Effect
Open circuit	No reverse signal to ECU. ACE active in reverse, may give abnormal handling when reversing
Short circuit - Ground	No reverse signal to ECU. ACE active in reverse, may give abnormal handling when reversing
Short circuit - VBatt	Permanent reverse signal to ECU. Permanent 'Locked bars' condition

Ignition ON signal

Failure	Effect
Open circuit	ECU does not receive ignition ON signal. No ARC control, 'Locked bars' condition
Short circuit - Ground	ECU does not receive ignition ON signal. No ARC control, 'Locked bars' condition
Short circuit - VBatt	Permanent ignition ON signal to ECU. Possibility of flat battery

Pressure control valve failure

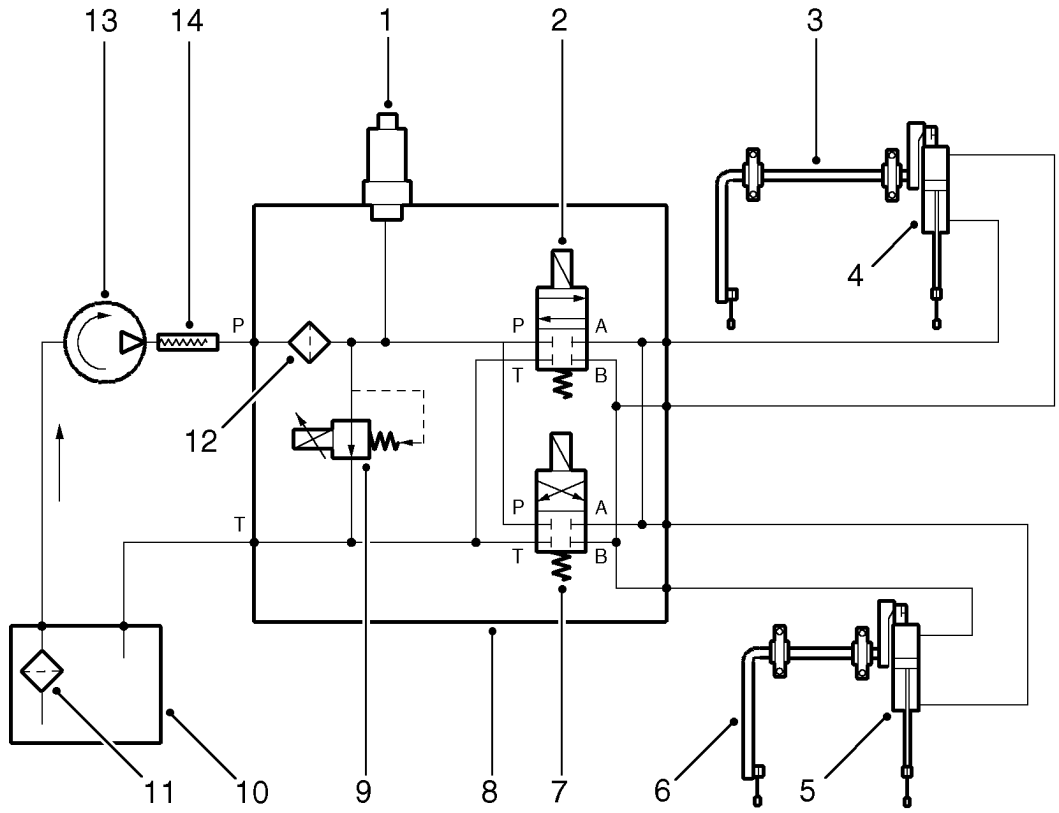
Failure	Effect
Open circuit	No ACE control
Short circuit - Ground	No ACE control
Short circuit - VBatt	No ACE control
Valve stuck open	No ACE control
Valve stuck closed	Maximum system pressure - no proportional control. Pressure relief valve operating at 185 bar (2683 lbf.in^2)

Directional control valves

Failure		Effect
DCV 1	**DCV 2**	
Valve open or stuck open	Valve open or stuck open	No ACE control - Anti-roll bars floppy
Valve closed or stuck closed	Valve closed stuck closed	No ACE control - 'Locked bars' condition (default)
Valve open or stuck open	Valve closed or stuck closed	Vehicle leans to left when pressure is applied to actuators
Valve closed or stuck closed	Valve open or stuck open	Vehicle leans to right when pressure is applied to actuators

Operation

Hydraulic circuit diagram



M60 0595A

1 Pressure transducer
2 Directional control valve 2
3 Front torsion bar assembly
4 Actuator
5 Actuator
6 Rear torsion bar assembly
7 Directional control valve 1
8 Valve block
9 Pressure control valve
10 Reservoir
11 Filter
12 High pressure filter
13 Hydraulic pump
14 Attenuator hose

Vehicle not moving
When the engine is running and the vehicle is not moving, both DCV's are closed, locking fluid in each side of the actuator pistons. The hydraulic pump draws fluid from the reservoir and passes it at very low pressure to the valve block. Because both DCV's are closed, after the fluid passes through the high pressure filter, it is directed through the pressure control valve to the reservoir. The pressure control valve is open fully to allow the full flow to pass to the reservoir. The DCV's will remain closed until the ECU detects a need to operate.

Vehicle moving and turning left
When the vehicle is turning left, the accelerometers detect the cornering forces applied and transmit signals to the ECU. The ECU determines that an opposing force must be applied to the torsion bars to counter the cornering forces. The ECU supplies a current to the solenoid of the DCV2. Simultaneously, a current is sent from the ECU to the pressure control valve which operates to restrict the flow of fluid returning to the reservoir.

The restriction causes the hydraulic pressure in the system to rise and the pressure is sensed by the pressure transducer which sends a signal to the ECU. The ECU determines from the inputs it receives what pressure is required and adjusts the pressure control valve accordingly.

The pressure in the system is applied to the annulus of each actuator, applying an opposing force to the torsion bar and minimising the cornering effect on the vehicle and maintaining the vehicle attitude. The fluid displaced from the full area of the actuator is returned to the reservoir via the valve block.

As the cornering force is removed when the vehicle straightens up, the ECU opens the pressure control valve to reduce the pressure in the system. The fluid bleeds from the actuator back into the system as the cornering force is reduced, removing the force from the torsion bar. When the vehicle is moving in a straight line DCV 2 closes.

Vehicle moving and turning right
When the vehicle is turning right, the accelerometers detect the cornering forces applied and transmit signals to the ECU. The ECU determines that an opposing force must be applied to the torsion bars to counter the cornering forces. The ECU supplies a current to the solenoid of the DCV1. Simultaneously, a current is sent from the ECU to the pressure control valve which operates to restrict the flow of fluid through the by-pass gallery.

The restriction causes the hydraulic pressure in the system to rise and the pressure is sensed by the pressure transducer which sends a signal corresponding to the pressure to the ECU. The ECU determines from the inputs it receives what pressure is required and adjusts the pressure control valve accordingly.

The pressure in the system is applied to the full area of each actuator, applying an opposing force to the torsion bar and minimising the cornering effect on the vehicle and maintaining the vehicle attitude. The fluid displaced from the annulus of the actuator is returned to the reservoir via the valve block.

As the cornering force is removed when the vehicle straightens up, the ECU opens the pressure control valve to reduce the pressure in the system. The fluid bleeds from the actuator back into the system as the cornering force is reduced, removing the force from the torsion bar. When the vehicle is moving in a straight line the DCV 1 closes.

Vehicle moving in a straight line
The ECU is constantly monitoring the signals received from the accelerometers and operates the DCV's and pressure control valve to maintain the vehicle attitude when the vehicle is moving.

Off-road driving
Off-road detection is achieved by the ECU by monitoring the signals from the upper and lower accelerometers for varying degrees of body movement. Off-road driving generates differing signals to the accelerometers which in turn produce differing outputs due to their vertical separation and the location of the roll centre of the vehicle. The two signals are passed through a filter to remove any offset caused by the vehicle leaning or the terrain. The ECU then uses this signal to calculate the percentage of road roughness.

Below 25 mph (40 km/h) the percentage of road roughness calculated is used by the ECU to limit the operation of the ACE system. The system is completely inoperative at speeds below 2 mph (3 km/h). At speeds above 25 mph (40 km/h) the system disables the percentage road roughness signal and full ACE system assistance is restored.

Side slope detection
The ECU uses side slope detection when the upper and lower accelerometers detect an average acceleration of more than ± 0.2 g and a road speed of less than 25 mph (40 km/h).

When side slope is detected both DCV's close to provide a 'locked bars' condition. This condition increases stability and gives a consistent vehicle response. As the road speed increases up to 25 mph (40 km/h), the level of average lateral acceleration must also increase and be maintained for the system to recognise that the vehicle is on a side slope. If the side slope angle is steep and the road speed is low, the ECU will detect the side slope in a short time.

ACE hydraulic system bleeding

60.60.13

Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Check

1. Check the ACE system fluid level.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, Fluid level check - ACE system.**

Bleed

1. With vehicle on ramp, connect TestBook and follow bleed procedure as described.

Fluid level check - ACE system

60.60.14

Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Check

1. Clean reservoir around fluid level marks.
2. Visually check fluid level through side of reservoir. Fluid level must be between upper and lower fluid level marks.

Top-up

1. Clean reservoir around filler cap.
2. Remove filler cap from reservoir and fill to upper fluid level mark with recommended fluid.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**
3. Fit filler cap to reservoir
4. Start and run engine for 2 minutes to circulate fluid.
5. If necessary, top-up reservoir to upper fluid level mark.

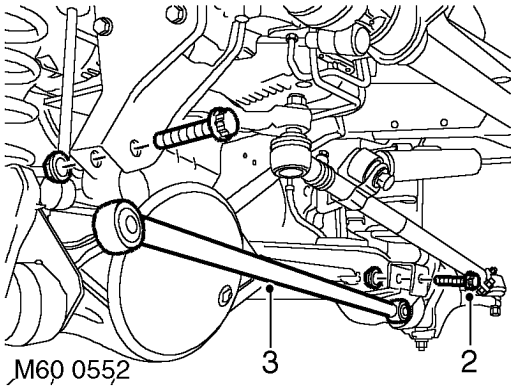
Bushes - Panhard rod

60.10.07

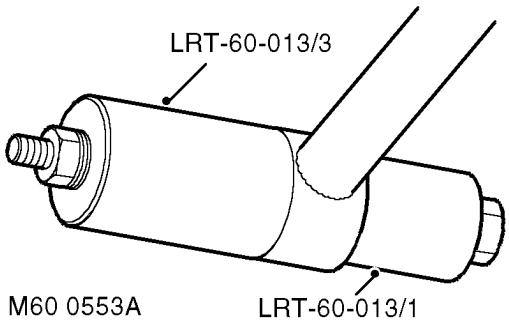
Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



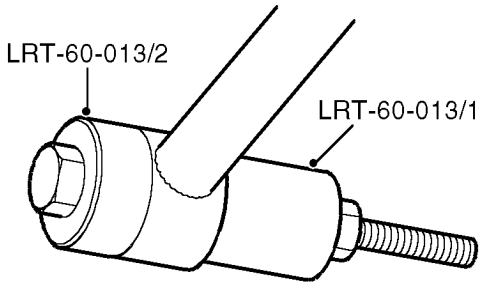
2. Remove 2 nuts and bolts securing Panhard rod to axle and chassis.
3. Remove Panhard rod from vehicle.



4. Use tool **LRT-60-013** fitted with **LRT-60-013/1** and **LRT-60-013/3** to press out bushes from Panhard rod.

Refit

1. Clean bush locations in Panhard rod.



M60 0621

2. Use tool **LRT-60-013** fitted with **LRT-60-013/1** and **LRT-60–013/2** to press new bushes into Panhard rod. **Ensure pressure is applied to the outer edge of the bush, not the rubber inner.**
3. Position Panhard rod to axle and chassis.
4. Fit bolts securing Panhard rod but do not tighten at this stage.
5. Remove stand(s) and lower vehicle.
6. Tighten bolts securing Panhard rod to 230 Nm (170 lbf.ft).

   CAUTION: Nuts and bolts must be tightened with weight of vehicle on suspension.

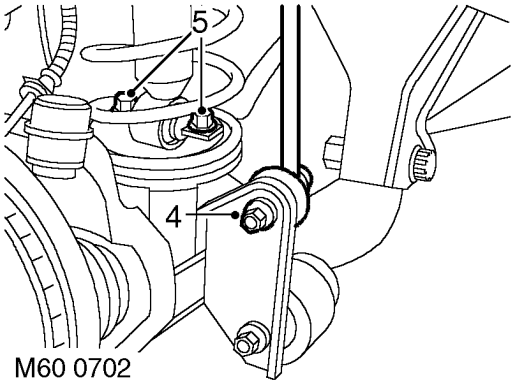
Ball joint - upper - steering knuckle

60.15.02

CAUTION: Each ball joint can be replaced up to three times before the axle yoke bore becomes oversize. Before commencing work, thoroughly clean surface of joint and check for yellow paint marks approx. 12 mm (0.5 in) wide. If 3 marks are found, the axle case must be renewed.

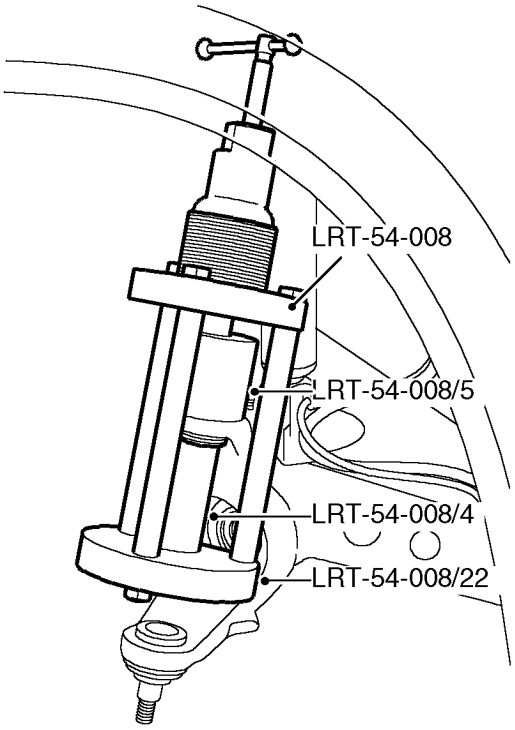
Remove

1. Remove steering knuckle.
   FRONT SUSPENSION, REPAIRS, Steering knuckle.
2. Support the chassis on stands.
3. Support the front axle on stands.



M60 0702

4. Remove 2 nuts securing anti-roll bar lower links to front axle, use a 16 mm spanner to prevent link joint from turning.
5. Remove 2 bolts securing each front damper to axle.
6. Remove 8 bolts securing chassis crossmember and remove crossmember.
7. Remove bolt securing brake hose and ABS sensor harness bracket to axle.
8. Lower the front axle, release front spring from damper and remove front spring.

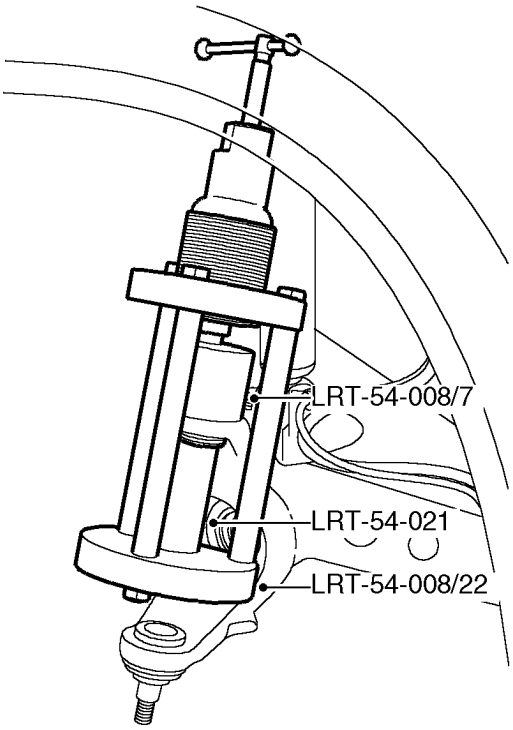


M60 0685

9. Fit tool **LRT-54-008/22** to tool **LRT-54-008**.
10. Fit tool **LRT-54-008/4** to tool **LRT-54-008**, and secure with screw.
11. Fit tool **LRT-54-008** with all attachments to upper ball joint..
12. Fit tool **LRT-54-008/5** to the top of the ball joint.
13. Press upper ball joint from axle. When ram lead screw reaches the end of its stroke, retract the lead screw and screw the ram further into the tool. Repeat the operation until the ball joint is released from the axle.
14. Dismantle the tools.

Refit

1. Clean upper ball joint location and surrounding area of axle yoke.
2. Apply a 12 mm (0.5 in) wide yellow paint stripe on axle yoke, adjacent to upper ball joint location.



M60 0686

3. Fit tool **LRT-54-021** to tool **LRT-54-008**, and secure with the screw.
4. Fit tool **LRT-54-008/7** to tool **LRT-54-008** and position tool assembly over ball joint and axle.
5. Align tool assembly and press upper ball joint into axle yoke.

   CAUTION: Damage to the joint boot will result if the tool is not correctly aligned during the fitting procedure.

6. Remove tools from axle yoke.
7. Clean the spring seats.
8. Position spring over damper and locate in cut-out in spring seat.
9. Raise the front axle, fit bolts securing dampers to front axle and tighten to 45 Nm (33 lbf.ft).
10. Fit chassis crossmember, fit bolts and tighten to 25 Nm (18 lbf.ft).
11. Locate brake hose bracket and tighten bolt to 20 Nm (15 lbf.ft).
12. Position anti-roll bar links to the axle, fit the nuts and tighten to 100 Nm (74 lbf.ft).
13. Fit steering knuckle.

    ☞ **FRONT SUSPENSION, REPAIRS, Steering knuckle.**

Ball joint - lower - steering knuckle

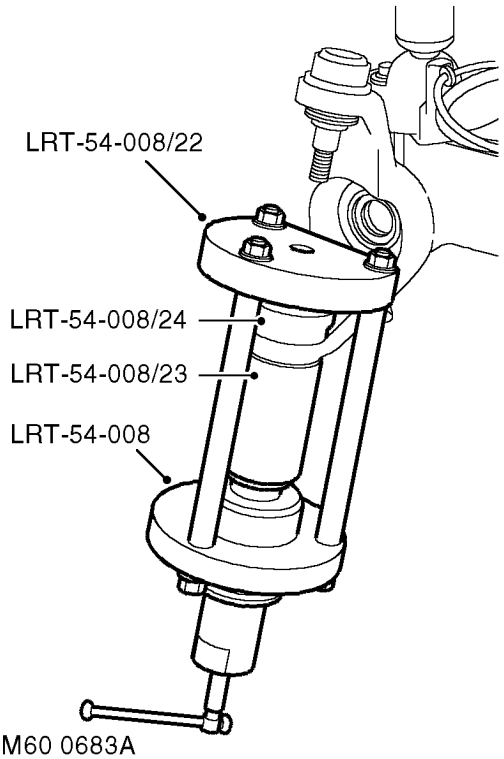
⊸ ***60.15.03***

CAUTION: Each ball joint can be replaced up to three times before the axle yoke bore becomes oversize. Before commencing work, thoroughly clean surface of joint and check for yellow paint marks approx. 12 mm (0.5 in) wide. If 3 marks are found, the axle case must be renewed.

Remove

1. Remove steering knuckle.

   ☞ **FRONT SUSPENSION, REPAIRS, Steering knuckle.**

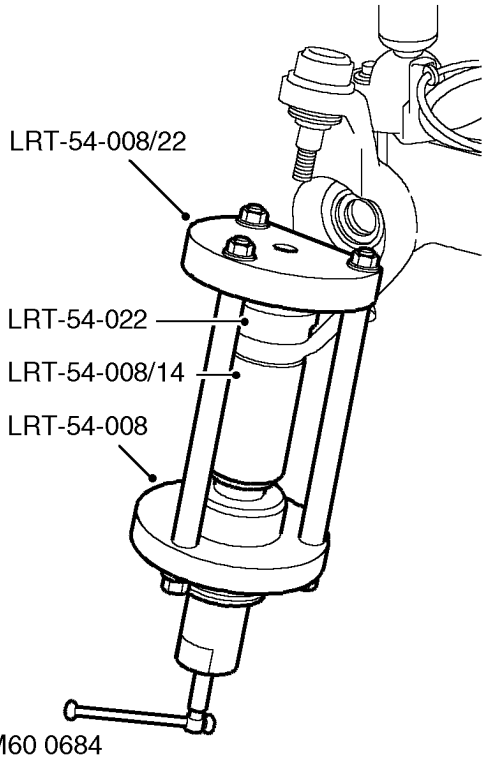


M60 0683A

2. Fit tool **LRT-54-008/22** to tool **LRT-54-008**.
3. Fit tool **LRT-54-008/24** to tool **LRT-54-008** and secure with screw.
4. Fit tool **LRT-54-008/23** to underside of lower ball joint.
5. With assistance, fit tool **LRT-54-008** assembly to lower ball joint.
6. Press ball joint from axle. When ram lead screw reaches the end of its stroke, retract the lead screw and screw the ram further into the tool. Repeat the operation until the ball joint is released from the axle.
7. Remove tools and the lower ball joint from axle yoke.

Refit

1. Clean lower ball joint location and surrounding area of axle yoke.
2. Apply a 12 mm (0.5 in) wide yellow paint stripe on axle yoke, adjacent to lower ball joint location.



3. Fit tool **LRT-54-022** to tool **LRT-54-008** and secure with screw.
4. Fit tool **LRT-54-022** and tool **LRT-54-008** to lower ball joint location on axle yoke.
5. Fit new lower ball joint to tool **LRT-54-008/14**.
6. Fit **LRT-54-008/14** and lower ball joint to **LRT-54-008**, with lower ball joint positioned on axle yoke.
7. Align tool assembly and press lower ball joint into axle yoke.

   CAUTION: Damage to the joint boot will result if the tool is not correctly aligned during the fitting procedure.

8. Remove tools from axle yoke
9. Fit steering knuckle.

   ☞ **FRONT SUSPENSION, REPAIRS, Steering knuckle.**

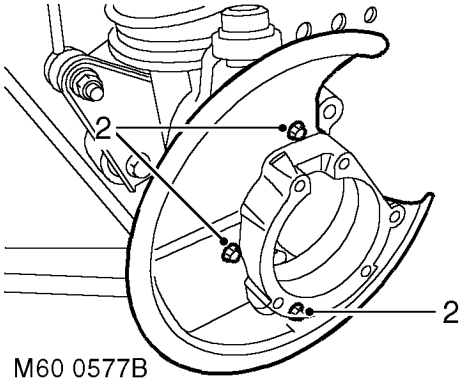
Steering knuckle

🔧 ***60.15.19***

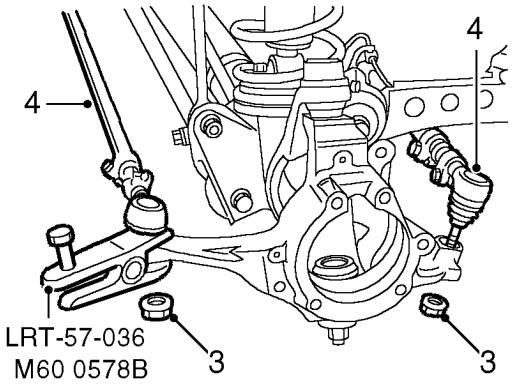
Remove

1. Remove wheel hub.

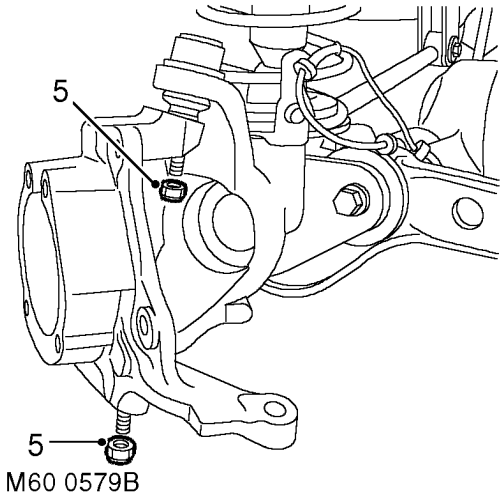
   ☞ **FRONT SUSPENSION, REPAIRS, Wheel hub.**



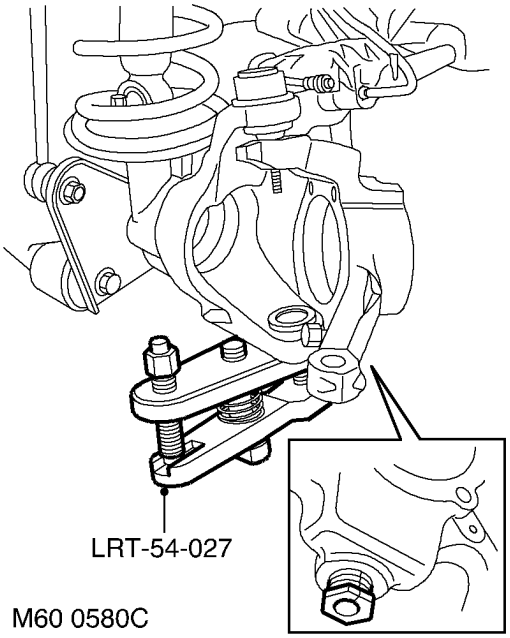
2. Remove 3 bolts securing mudshield and remove mudshield.



3. Remove 2 nuts securing track rod and (if applicable) drag link to steering knuckle.
4. Break taper joints using **LRT-57-036**, then position track rod and drag link aside.



5. Remove 2 nuts securing ball joints to steering knuckle.



6. Break taper joints using **LRT-54-027** and remove steering knuckle.
7. Remove tension collet from steering knuckle.
8. Remove drive shaft oil seal from axle casing.

Refit

1. Clean taper bores in steering knuckle and tension collet.
2. Fit tension collet into steering knuckle and tighten to 5 Nm (3.7 lbf.ft).
3. Clean ball joint tapers and taper seats.
4. Position steering knuckle to axle yoke. Fit upper ball joint nut and tighten to 110 Nm (81 lbf.ft). Fit lower ball joint nut and tighten to 135 Nm (100 lbf.ft).
5. Clean track rod and (if applicable) drag link tapers and taper seats.
6. Connect track rod and drag link to steering knuckle. Fit track rod and drag link nuts and tighten to 80 Nm (59 lbf.ft).
7. Clean mudshield and steering knuckle mating faces. Position mudshield, fit bolts and tighten to 10 Nm (7 lbf.ft).
8. Fit wheel hub.
   ☞ **FRONT SUSPENSION, REPAIRS, Wheel hub.**

Road spring - front

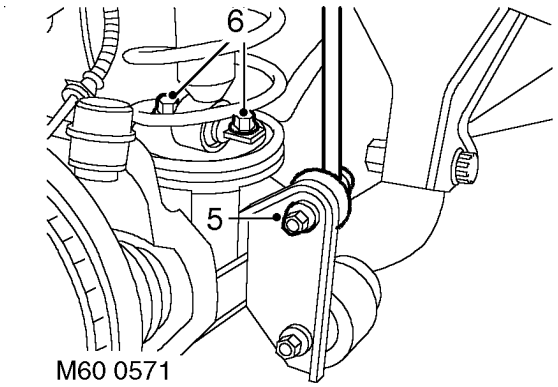
60.20.11

Remove

1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Support vehicle under chassis.
3. Remove front road wheels.
4. Support weight of front axle.



M60 0571

5. Remove 2 nuts securing anti-roll bar links to front axle and disconnect links from axle.
6. Remove 2 bolts securing each damper to front axle.

   WARNING: Make sure the axle cannot move when the damper is disconnected. The damper limits the downward movement of the axle. If the axle is not restrained, disconnecting the damper will allow unrestricted movement which may cause personal injury or damage to equipment.

7. Lower front axle.

   CAUTION: Ensure brake hoses and ABS sensor harnesses are not damaged when lowering front axle.

8. Release and remove front spring from damper.

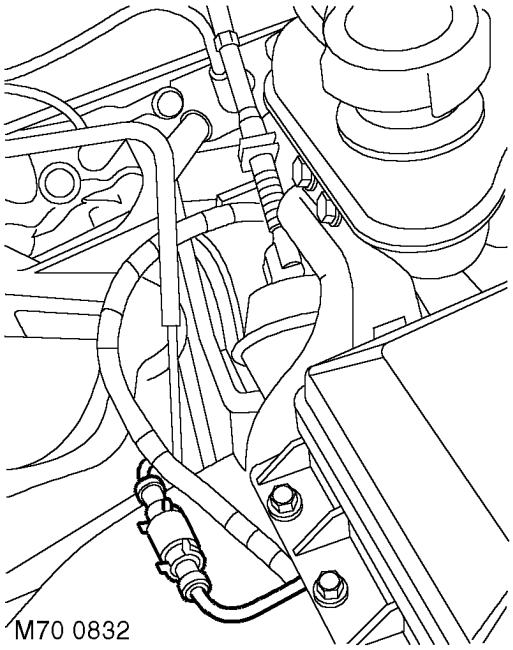
Refit

1. Clean front spring seats.
2. Position front spring, with close coil uppermost, over damper and locate in cut out in lower spring seat.
3. Ensure both front springs are correctly located in spring seats and raise front axle. Fit bolts securing both dampers to front axle and tighten to 45 Nm (33 lbf.ft).
4. Ensure washer is in place on lower ball joint of each anti-roll bar link, then connect lower ball joints to axle. Tighten nuts to 100 Nm (74 lbf.ft).
5. Fit front road wheels and tighten nuts to 140 Nm (103 lbf.ft).
6. Remove stands and lower vehicle.

Wheel hub

60.25.01

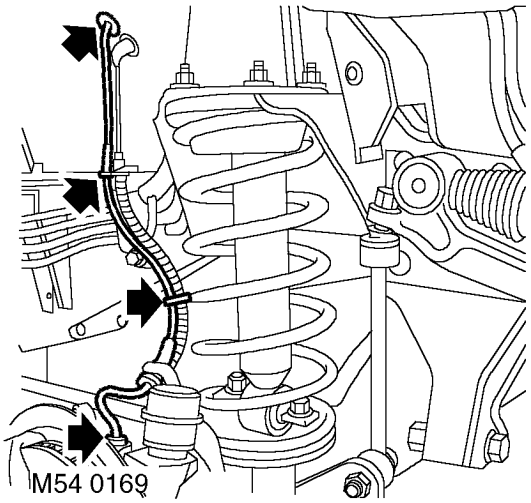
Remove



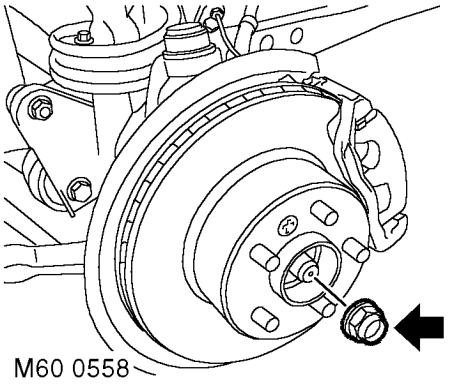
1. Release ABS sensor harness grommet from inner wing valance and disconnect multiplug.
2. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

3. Remove road wheel.

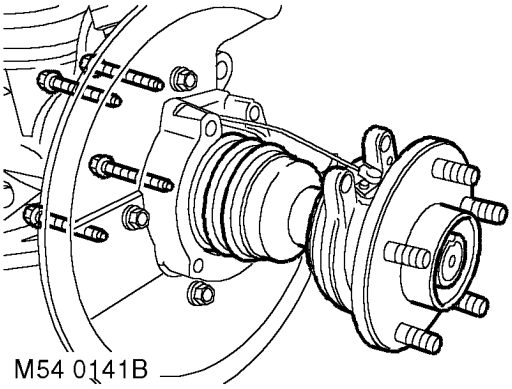


4. Pull ABS sensor harness through aperture into wheel arch.
5. Release harness from brackets on inner wing valance, suspension turret and front hub.



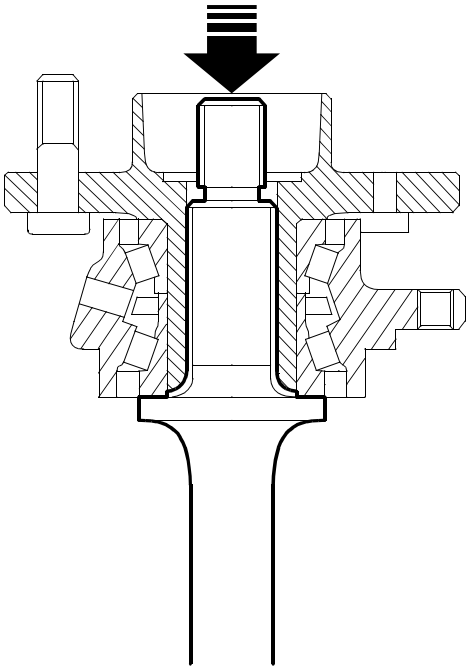
6. Release stake from drive shaft nut.
7. With assistance, remove drive shaft nut. Discard the nut.
8. Remove front brake disc.

   BRAKES, REPAIRS, Brake disc - front.


M54 0141B

9. Remove 4 bolts securing wheel hub to steering knuckle.
10. Release wheel hub from steering knuckle, then remove wheel hub and drive shaft assembly from axle.

CAUTION: Do NOT remove the ABS sensor from the hub. The hub and the sensor are supplied as an assembly.

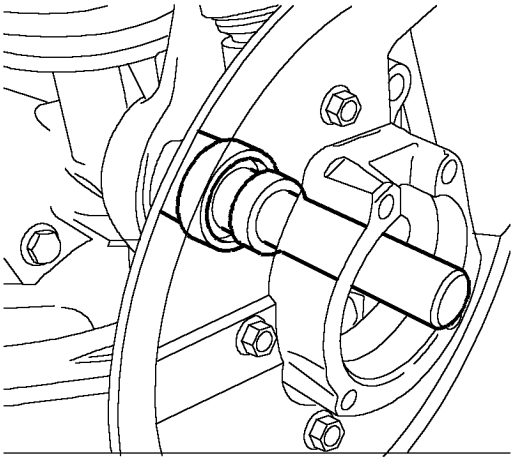

M51 0057

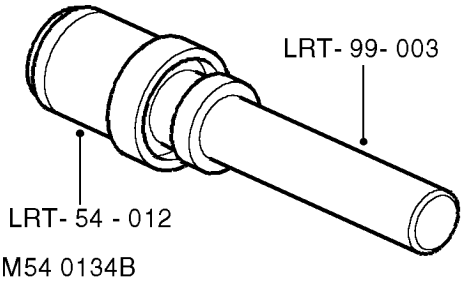
11. Position the wheel hub and drive shaft on a press, place supports beneath the wheel studs and press the drive shaft from the wheel hub.
12. Remove drive shaft oil seal from axle casing.

Refit

1. Clean drive shaft oil seal recess, drive shaft splines, oil seal running surface, wheel hub and steering knuckle mating faces, ABS sensor and sensor recess.
2. Lubricate lip of new drive shaft oil seal and running surface on drive shaft with clean differential oil.

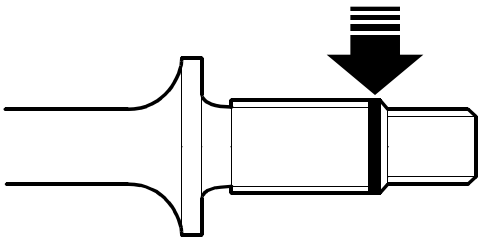
☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**





M54 0134B

3. Use tool **LRT-51-012** to fit new drive shaft oil seal to axle casing.
4. Fit drive shaft to axle casing.
5. Apply anti-seize compound to wheel hub and steering knuckle mating face.



M51 0058

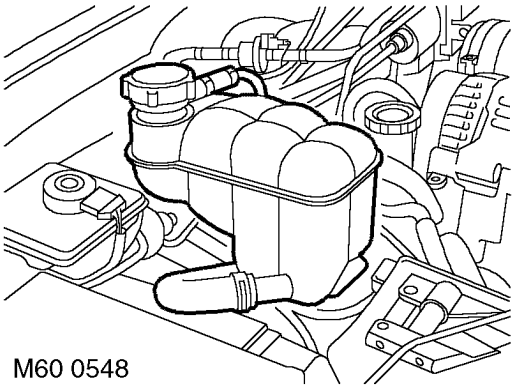
6. Apply a 3 mm (0.125 in) wide bead of Loctite 640 around drive shaft circumference, as illustrated.
7. Ensure ABS harness is located in cut out in steering knuckle.
8. Fit wheel hub to drive shaft and align steering knuckle. The Loctite will smear along the length of the splines as the wheel hub is fitted to the drive shaft.
9. Fit wheel hub bolts and tighten to 100 Nm (74 lbf.ft).
10. Fit new drive shaft nut and lightly tighten.
11. Fit front brake disc.
    ☞ **BRAKES, REPAIRS, Brake disc - front.**
12. With assistance, final tighten drive shaft nut to 490 Nm (360 lbf.ft). Stake drive shaft nut. **The drive shaft nut must be tightened before Loctite has cured.**
13. Secure ABS sensor harness to brackets and secure grommet to inner wing.
14. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
15. Remove stand(s) and lower vehicle.
16. Connect ABS sensor multiplug.

Damper - front

⊸ ***60.30.02***

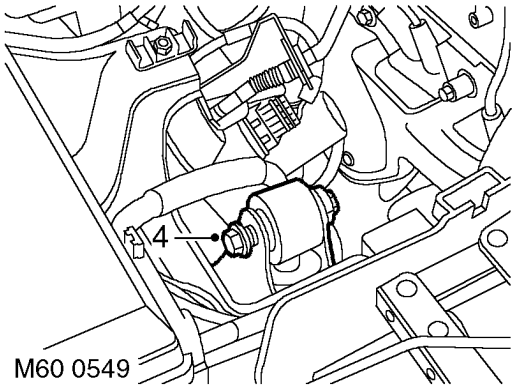
Remove

1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel.



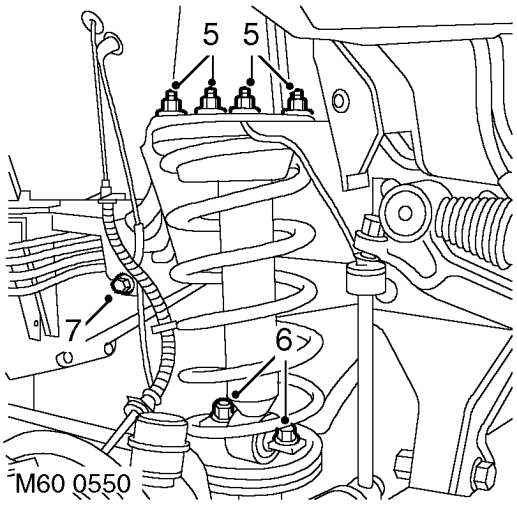
M60 0548

3. **RH damper:** Release coolant reservoir and position aside.

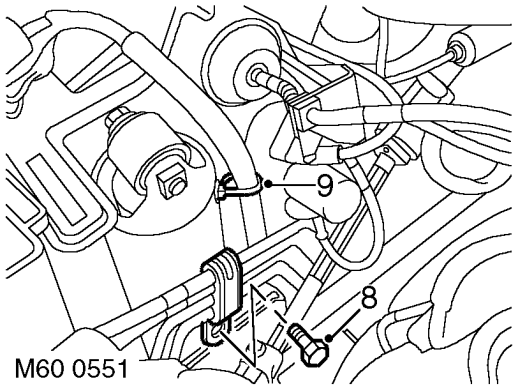


M60 0549

4. Loosen through bolt securing damper to turret.
   WARNING: Make sure the axle cannot move when the damper is disconnected. The damper limits the downward movement of the axle. If the axle is not restrained, disconnecting the damper will allow unrestricted movement which may cause personal injury or damage to equipment.



5. Remove 4 nuts securing turret base to chassis.
6. Remove 2 bolts securing damper to axle.
7. **ACE models:** Remove bolt securing ACE pipe clamp to chassis.



8. **ACE models:** Remove bolt securing ACE pipe clamp to turret.
9. Release harness clip from turret.
10. Raise turret and remove through bolt.
11. Compress damper and manoeuvre turret from engine bay.
12. Remove damper.

Refit

1. Position damper and manoeuvre turret into position. Raise damper and align to turret. Fit through bolt but do not tighten at this stage.
2. Align damper assembly to spring seat.
3. Fit bolts securing damper to axle and tighten to 45 Nm (33 lbf.ft).
4. Fit nuts securing turret to chassis and tighten to 23 Nm (17 lbf.ft).
5. Tighten through bolt to 125 Nm (92 lbf.ft).
6. **ACE models:** Position ACE pipe clamp to chassis and secure with bolt.
7. **ACE models:** Position ACE pipe clamp to turret and secure with bolt.
8. Secure harness to turret.
9. **RH damper:** Reposition coolant reservoir.
10. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
11. Remove stand(s) and lower vehicle.

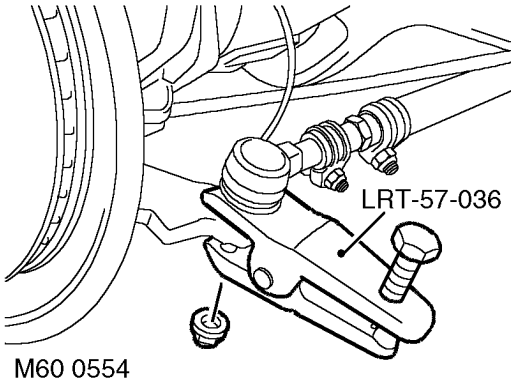
Bushes - radius arm

60.35.18

Remove

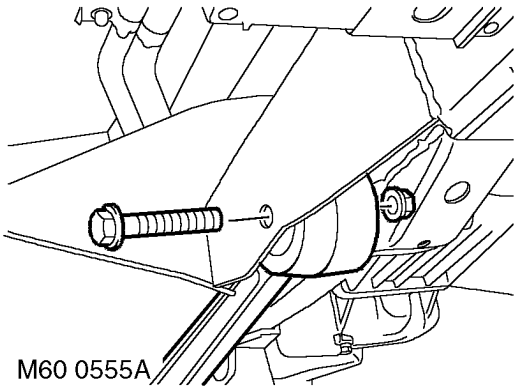
1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Remove road wheel.

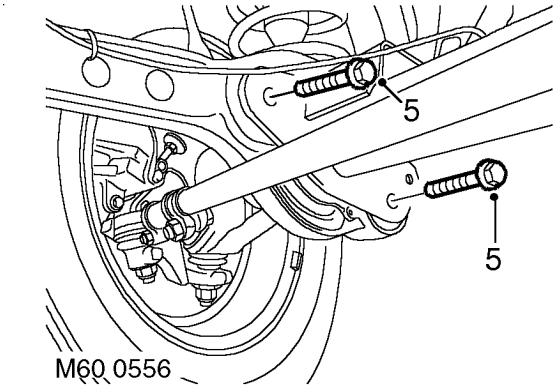


M60 0554

3. Remove nut securing track rod to steering knuckle. Use **LRT-57-036** to break taper, then release track rod and position aside.

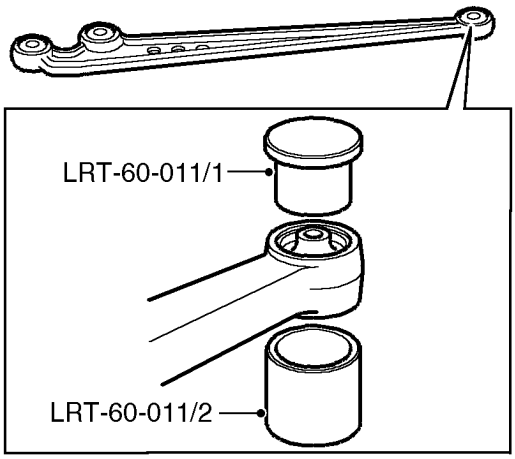

M60 0555A

4. Remove nut and bolt securing radius arm to chassis.



M60 0556

5. Remove nuts securing radius arm to axle. Remove rear bolt and lower the radius arm. Remove front bolt and remove radius arm from vehicle.
6. Press out bushes from axle end of radius arm using a length of steel tubing.

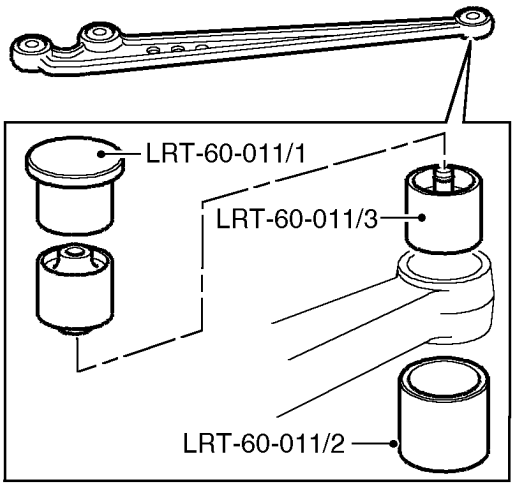


M64 0064C

7. Press out bush from rear of radius arm:
   - Use **LRT-60-011/1** and **LRT-60-011/2** to remove bush.

Refit

1. Clean bush locations in radius arm.



M64 0063C

2. Press bushes into radius arm:
   - Use **LRT-60-011/1**, **LRT-60-011/2** and **LRT-60-011/3** to fit bush at rear of radius arm.
3. Position radius arm to vehicle. Fit securing bolts and nuts but do not tighten at this stage.
4. Fit track rod to steering knuckle. Fit and tighten nut to 125 Nm (92 lbf.ft).
5. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
6. Remove stand(s) and lower vehicle.
7. Tighten radius arm nuts and bolts to 230 Nm (170 lbf.ft).

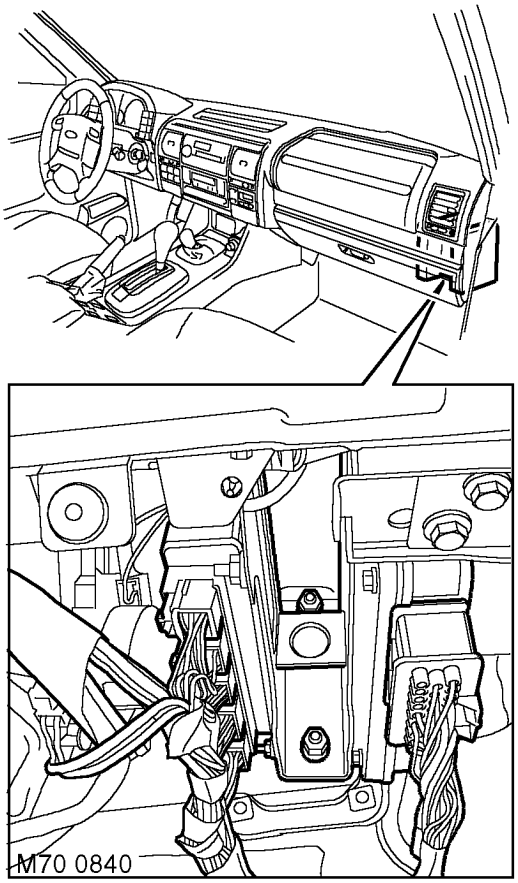
CAUTION: Nuts and bolts must be tightened with weight of vehicle on suspension.

ECU - ACE

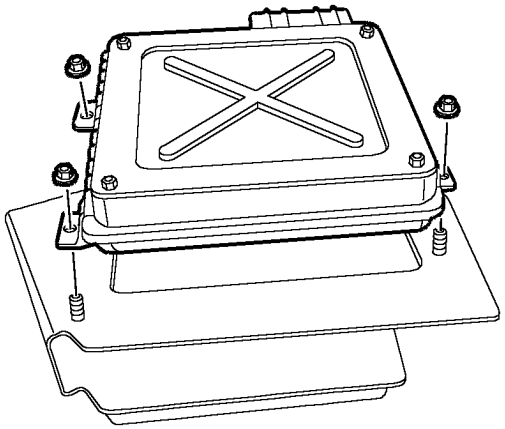
60.60.01

Remove

1. Remove BCU.
   BODY CONTROL UNIT, REPAIRS, Body control unit (BCU).


M70 0840

2. Remove 5 multiplugs from SLABS ECU.
3. Remove multiplug from ACE ECU.
4. Remove lower nut and loosen upper nut securing SLABS and ACE ECU bracket to body.
5. Remove ECU's and bracket assembly.



M60 0587

6. Remove 3 nuts securing ACE ECU and remove ACE ECU.

Refit

1. Fit ACE ECU to bracket and secure with nuts.
2. Fit ECU's and bracket assembly to body and secure with nuts.
3. Connect multiplugs to ACE ECU and SLABS ECU.
4. Fit BCU.
   ☞ **BODY CONTROL UNIT, REPAIRS, Body control unit (BCU).**
5. If a replacement ACE ECU has been fitted, use TestBook to calibrate ACE system.

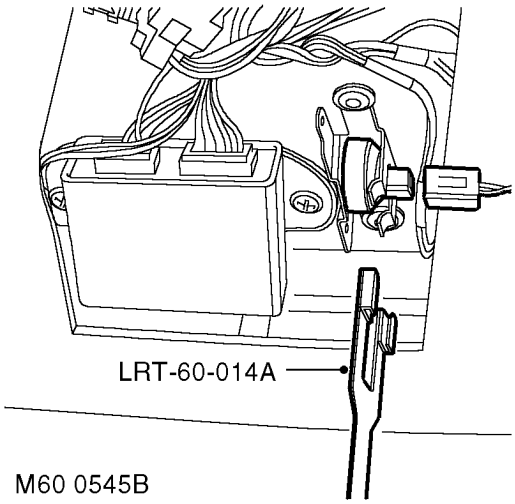
Accelerometer - ACE - upper

60.60.02

CAUTION: The accelerometer is an extremely delicate component and can easily be rendered unserviceable. Never use an accelerometer which has been dropped or subjected to mistreatment of any type.

Remove

1. Remove front stowage pocket.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.**
2. Disconnect multiplug from accelerometer.



M60 0545B

3. Use **LRT-60-014A** to release clip and remove accelerometer.

Refit

1. Using **LRT-60-014A**, fit accelerometer fully into clip.
2. Connect accelerometer multiplug.
3. Fit front stowage pocket.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.**
4. If a replacement accelerometer has been fitted, use TestBook to calibrate ACE system.

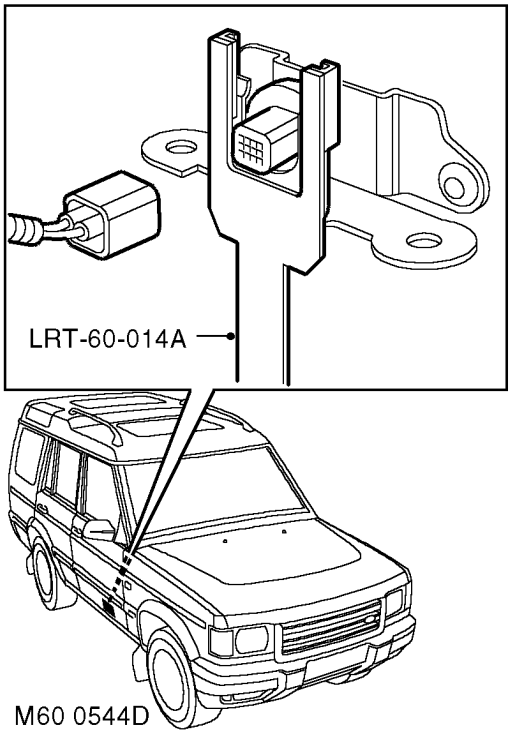
Accelerometer - ACE - lower

60.60.03

CAUTION: The accelerometer is an extremely delicate component and can easily be rendered unserviceable. Never use an accelerometer which has been dropped or subjected to mistreatment of any type.

Remove

1. Raise vehicle on a ramp.
2. Disconnect multiplug from accelerometer.



3. Use **LRT-60-014A** to release clip and remove accelerometer.

Refit

1. Use **LRT-60-014A**, fit accelerometer fully into clip.
2. Connect accelerometer multiplug.
3. Lower vehicle.
4. If a replacement accelerometer has been fitted, use TestBook to calibrate ACE system.

Pump - ACE - V8

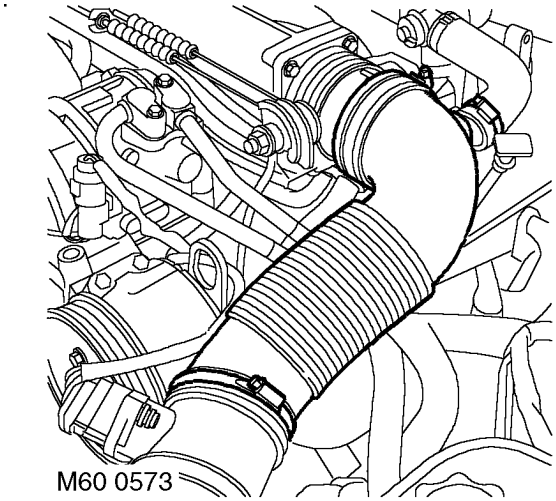
60.60.10

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

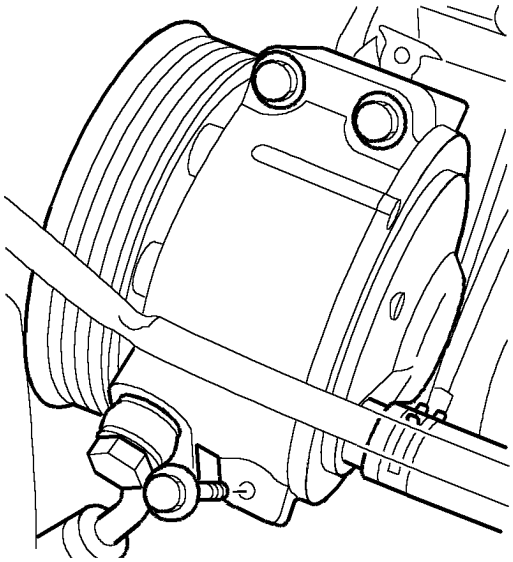
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

1. Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**



2. Loosen 3 clips securing air intake hose. Release air intake hose and position aside.
   Note: Pre 03 MY air intake hose illustrated.



M60 0574

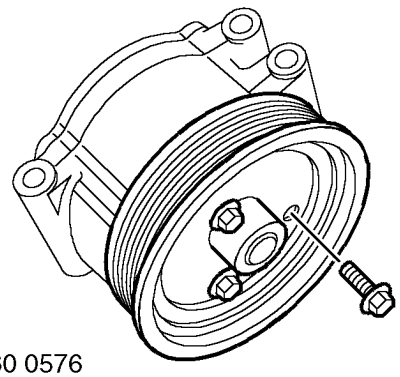
3. Position container to catch spillage.
4. Release clip on pump suction hose and disconnect hose.

   CAUTION: Always fit plugs to open connections to prevent contamination.

5. Remove banjo bolt and disconnect pressure pipe from ACE pump. Discard sealing washers.

   CAUTION: Always fit plugs to open connections to prevent contamination.

6. Remove 3 bolts securing ACE pump to mounting and remove ACE pump.



M60 0576

7. Restrain pulley, remove 3 securing bolts and remove pulley from ACE pump.

Refit

1. Clean mating faces of pulley and ACE pump.
2. Position pulley to ACE pump and fit bolts. Restrain pulley and tighten bolts to 25 Nm (18 lbf.ft).
3. Clean mating faces of ACE pump and mounting.
4. Connect suction hose to ACE pump and secure with clip.
5. Ensure there is sufficient fluid in ACE/PAS reservoir to prime ACE pump.
6. Position ACE pump below level of ACE/PAS reservoir, with suction hose uppermost, and allow fluid from ACE/PAS reservoir to completely fill ACE pump.
7. Position ACE pump to mounting, fit bolts and tighten to 25 Nm (18 lbf.ft).
8. Rotate ACE pump clockwise (viewed from pulley end) until a steady flow of fluid runs from outlet port.
9. Connect pressure pipe to ACE pump with banjo bolt and new sealing washers. Tighten banjo bolt to 28 Nm (21 lbf.ft).
10. Position air intake hose and secure clips.
11. Fit auxiliary drive belt.

    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
12. Renew ACE high pressure filter.

    ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**

Pump - ACE - diesel

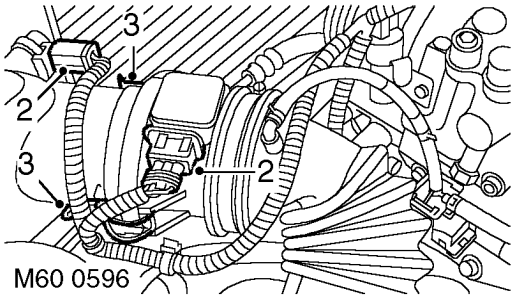
60.60.10

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

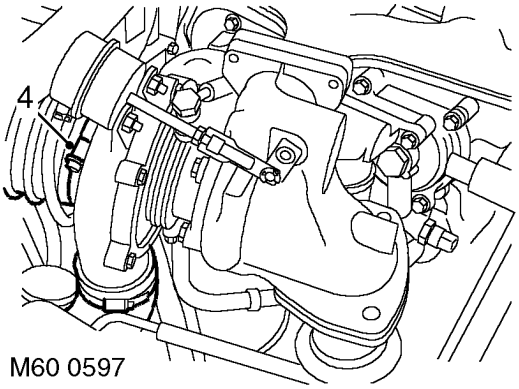
Remove

1. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



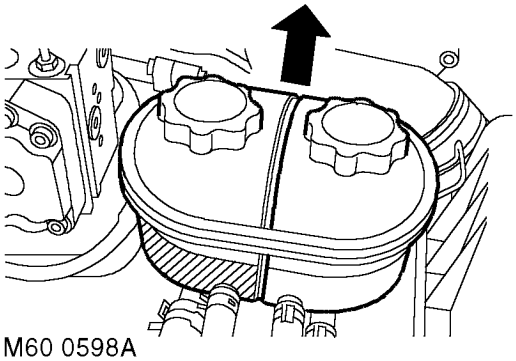
M60 0596

2. Disconnect multiplugs from mass air flow sensor and ambient air pressure sensor.
3. Release clips and disconnect mass air flow sensor from air cleaner.

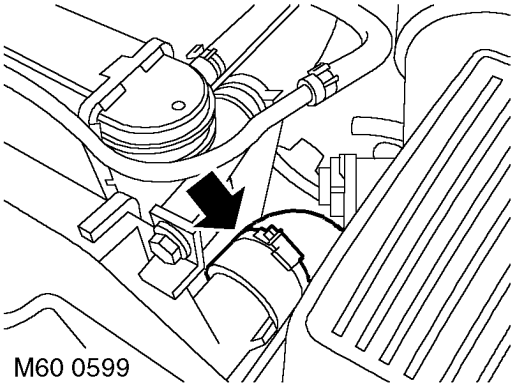


M60 0597

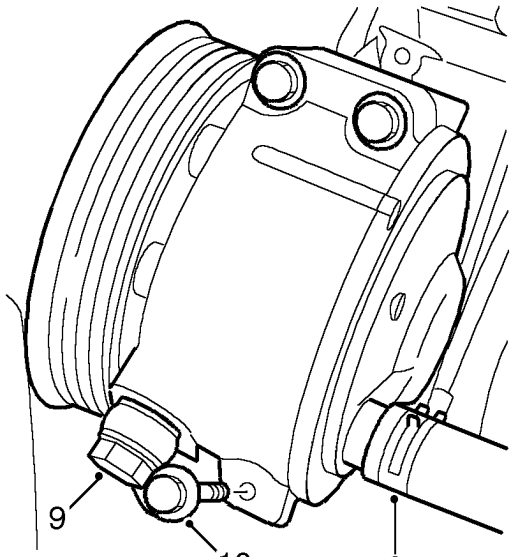
4. Loosen hose clip, disconnect inlet air hose from turbo charger and move hose aside.


M60 0598A

5. Release ACE/PAS reservoir from bracket and move aside.


M60 0599

6. Loosen clip and disconnect inlet hose from intercooler.
7. Position container to catch spillage.

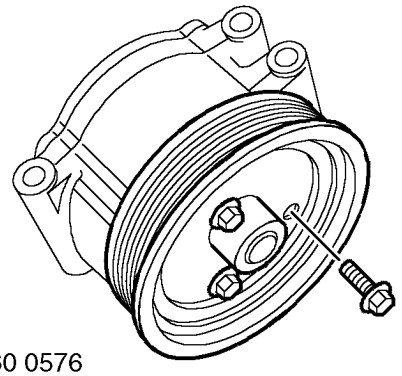


M60 0600

8. Release clip and disconnect suction hose from ACE pump.
9. Remove banjo bolt and disconnect pressure pipe from ACE pump. Discard sealing washers.

CAUTION: Always fit plugs to open connections to prevent contamination.

10. Remove 3 bolts securing ACE pump to mounting and remove ACE pump.


M60 0576

11. Restrain pulley, remove 3 securing bolts and remove pulley from ACE pump.

Refit

1. Clean mating faces of pulley and ACE pump.
2. Position pulley to ACE pump and fit bolts. Restrain pulley and tighten bolts to 25 Nm (18 lbf.ft).
3. Clean mating faces of ACE pump and mounting.
4. Connect suction hose to ACE pump and secure with clip.
5. Ensure there is sufficient fluid in ACE/PAS reservoir to prime ACE pump.
6. Position ACE pump below level of ACE/PAS reservoir, with suction hose uppermost, and allow fluid from ACE/PAS reservoir to completely fill ACE pump.
7. Position ACE pump to mounting, fit bolts and tighten to 25 Nm (18 lbf.ft).
8. Rotate ACE pump clockwise (viewed from pulley end) until a steady flow of fluid runs from outlet port.
9. Connect pressure pipe to ACE pump with banjo bolt and new sealing washers. Tighten banjo bolt to 28 Nm (21 lbf.ft).
10. Connect hose to intercooler and secure with clip.
11. Fit ACE/PAS reservoir into mounting bracket.
12. Connect air hose to turbo charger and secure with clip.
13. Fit mass air flow sensor to air filter and secure with clips.
14. Connect multiplugs to mass air flow sensor and ambient air pressure sensor.
15. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**
16. Renew ACE high pressure filter.
    ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**

Valve block - ACE

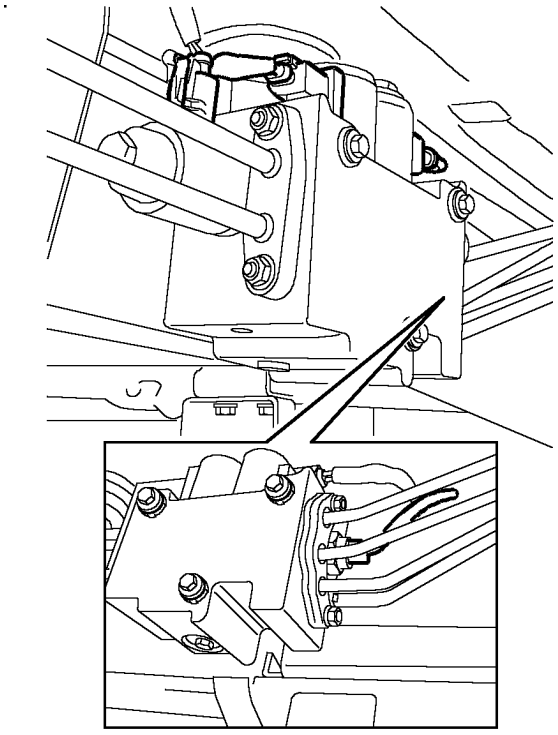
60.60.20

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

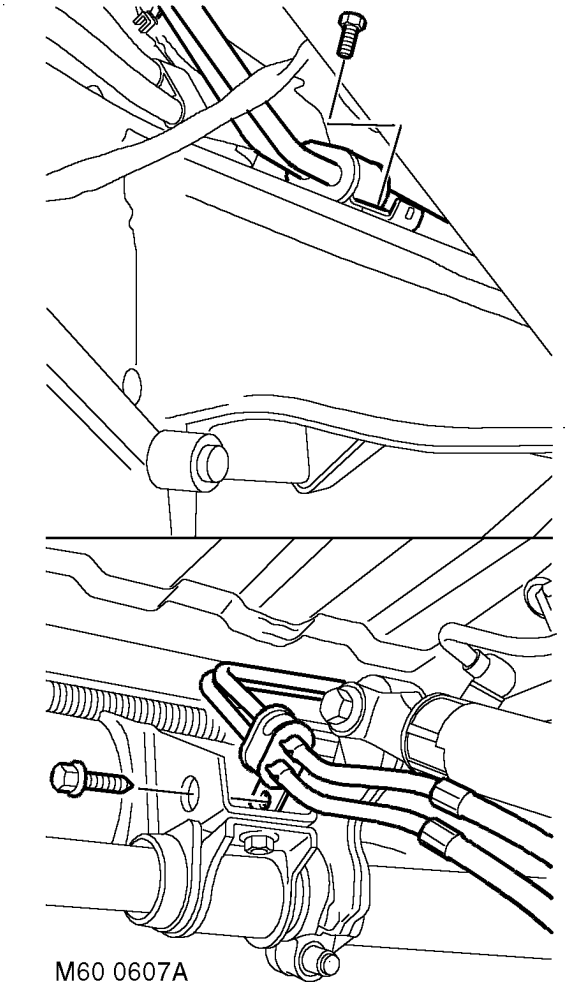
Remove

1. Raise vehicle on a ramp.



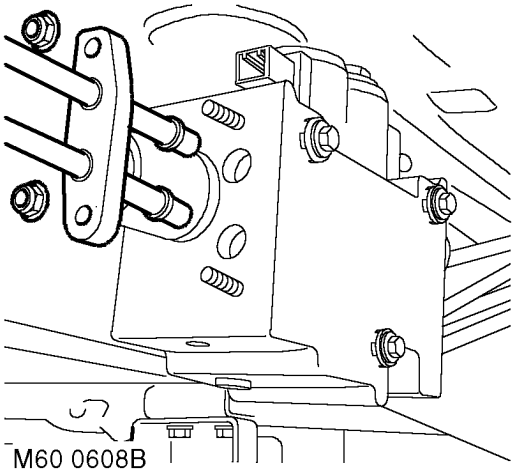
M60 0606A

2. Disconnect 4 multiplugs from valve block.
3. Position container underneath valve block to collect fluid spillage.



M60 0607A

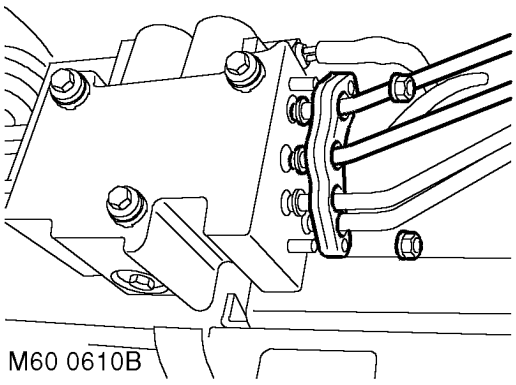
4. Remove 2 bolts securing 2 rear pipe clips to chassis.


M60 0608B

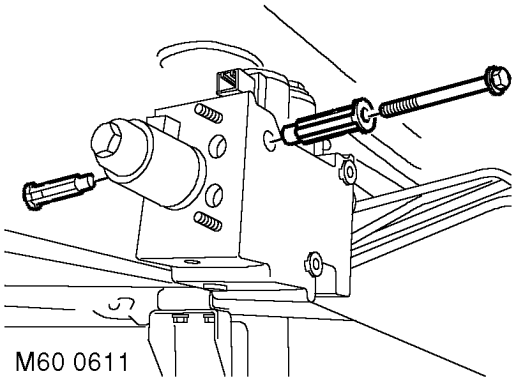
5. Remove 2 nuts securing rear pipe clamping plate. Release clamping plate and pipes from valve block.

   CAUTION: Always fit plugs to open connections to prevent contamination.

   NOTE: Keep pipes assembled to clamping plate to maintain correct pipe positions for refitting.


M60 0610B

6. Remove 2 nuts securing front pipe clamping plate.


M60 0611

7. Remove 3 bolts securing valve block to chassis.
8. Release front pipes and clamping plate from valve block and remove valve block.

   CAUTION: Always fit plugs to open connections to prevent contamination.

   NOTE: Keep pipes assembled to clamping plate to maintain correct pipe positions for refitting.

9. Remove 6 bushes from valve block.

Refit

1. Fit 6 bushes to valve block.
2. Ensure valve block and pipe connections are clean.
3. It is important that the pipe ends are in good condition to achieve a seal.
4. Position valve block and connect front pipes and clamping plate. **To avoid damage to seals, keep pipes square to valve block.** Fit and tighten bolts securing valve block to chassis to 18 Nm (13 lbf.ft).

   CAUTION: Ensure pipes are installed in their correct ports or serious system damage will occur.

5. Fit and tighten nuts securing front clamping plate to valve block to 21 Nm (15 lbf.ft).

6. Fit bolt securing front pipe clip to chassis and tighten to 6 Nm (4.4 lbf.ft).
7. Connect rear pipes and clamping plate to valve block. **To avoid damage to seals, keep pipes square to valve block.** Fit and tighten nuts securing clamping plate to valve block to 21 Nm (15 lbf.ft).

   CAUTION: Ensure pipes are installed in their correct ports or serious system damage will occur.

8. Fit bolts securing rear pipe clips to chassis and tighten to 6 Nm (4.4 lbf.ft) .
9. Connect 4 multiplugs to valve block.
10. If the same valve block has been refitted, renew ACE high pressure filter.

    FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.
11. Bleed ACE hydraulic system.

    FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.
12. Lower vehicle.

Filter - high pressure - ACE

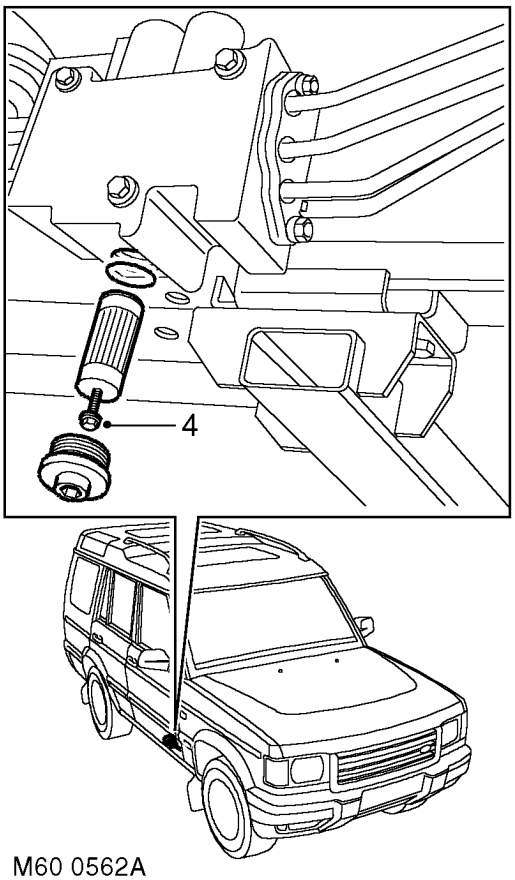
60.60.21

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

1. Raise vehicle on a ramp.
2. Position container to collect fluid spillage.



M60 0562A

3. Remove filter cap and discard 'O' ring.
4. Fit M6 bolt into base of filter and pull on bolt to remove filter from valve block. **Do not turn filter in valve block.**

   CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

1. Ensure new filter has 'O' ring fitted, then fit filter to valve block.
2. Fit new 'O' ring to filter cap. Fit cap and tighten to 35 Nm (26 lbf.ft).
3. Lower vehicle.
4. Check fluid level in ACE/PAS reservoir.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, Fluid level check - ACE system.**
5. Start and run engine for 2 minutes, then re-check fluid level in ACE/PAS reservoir.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, Fluid level check - ACE system.**

Pressure transducer - ACE

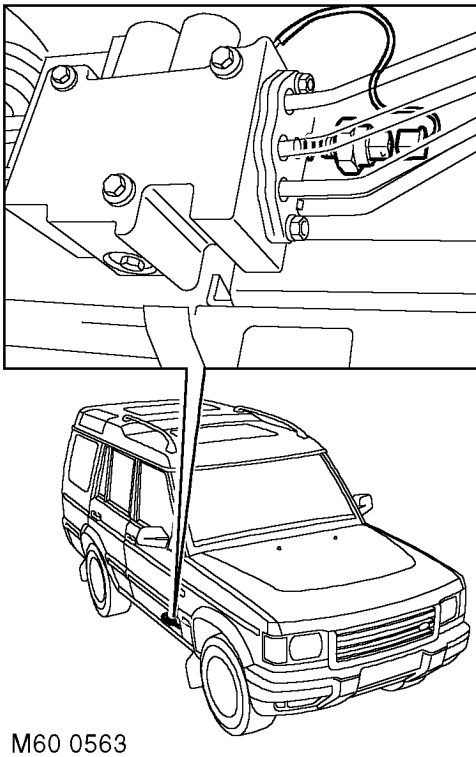
60.60.22

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

1. Raise vehicle on a ramp.



M60 0563

2. Disconnect multiplug from transducer.
3. Position container to collect fluid spillage.
4. Remove pressure transducer and discard 'O' ring.

   CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

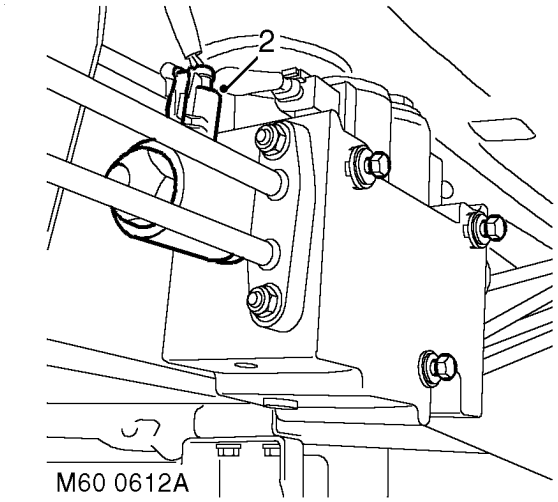
1. Ensure pressure transducer and port in valve block is clean.
2. Fit new 'O' ring to pressure transducer. Fit and tighten pressure transducer to 20 Nm (15 lbf.ft).
3. Connect multiplug to pressure transducer.
4. Renew ACE high pressure filter.
   ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
5. Lower vehicle.

Solenoid - pressure control valve - ACE

⊸ ***60.60.23***

Remove

1. Raise vehicle on a ramp.



2. Disconnect multiplug from solenoid.
3. Remove cap securing solenoid to pressure control valve and discard 'O' ring.
4. Remove solenoid from pressure control valve and discard 'O' ring from base of valve.

Refit

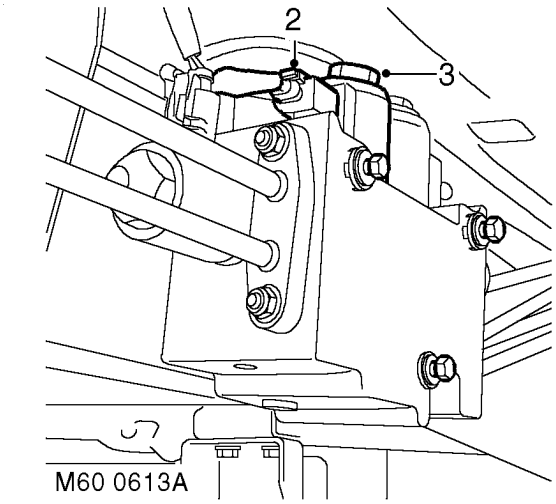
1. Ensure solenoid and pressure control valve are clean.
2. Fit new 'O' ring to base of pressure control valve.
3. Fit solenoid to pressure control valve, with arrow on solenoid pointing away from valve block and connector in correct position.
4. Fit new 'O' ring to solenoid securing cap. Fit cap and tighten to 11 Nm (8 lbf.ft).
5. Connect multiplug to solenoid.
6. Lower vehicle.

Solenoid - directional control valve - ACE

60.60.24

Remove

1. Raise vehicle on a ramp.



2. Disconnect multiplug from solenoid.
3. Loosen cap securing solenoid to directional control valve.
4. Remove 3 bolts securing valve block to chassis, lower block sufficiently only to remove solenoid.
5. Remove cap securing solenoid to directional control valve and discard 'O' ring.
6. Remove solenoid from directional control valve and discard 'O' ring from base of valve.

Refit

1. Ensure solenoid and directional control valve are clean.
2. Fit new 'O' ring to base of directional control valve.
3. Fit solenoid to directional control valve, with arrow on solenoid pointing up and connector in correct position.
4. Fit new 'O' ring to solenoid securing cap. Fit cap to solenoid but do not tighten at this stage.
5. Fit 3 bolts securing valve block to chassis and tighten to 18 Nm (13 lbf.ft) .
6. Tighten solenoid securing cap to 11 Nm (8 lbf.ft) .
7. Connect multiplug to solenoid.
8. Lower vehicle.

Pipe assembly - valve block to front actuator - ACE

60.60.31

Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

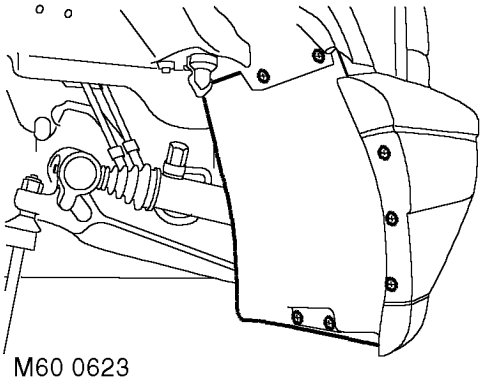
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

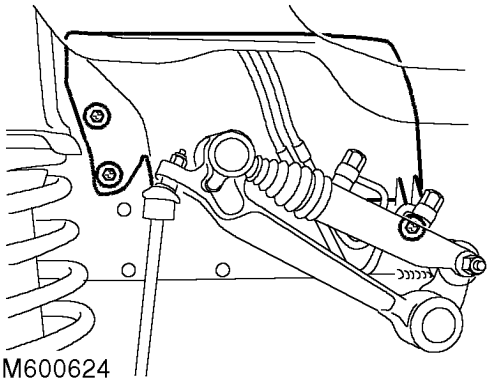
1. Raise front of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

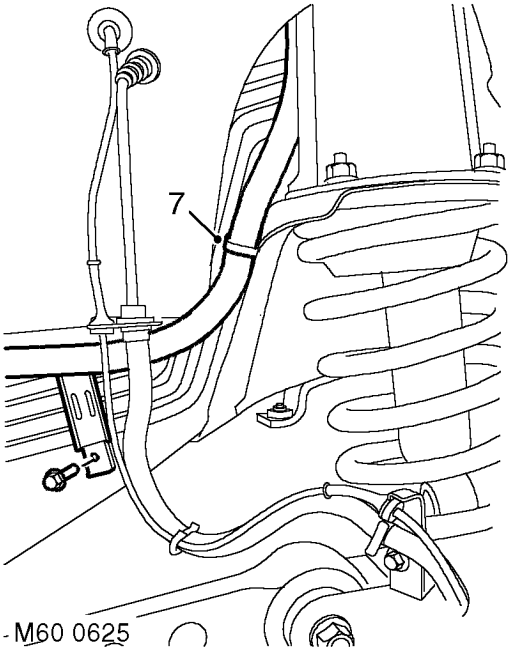
2. Remove RH front road wheel.



3. Remove 7 screws securing RH front wheel arch liner extension and remove extension.

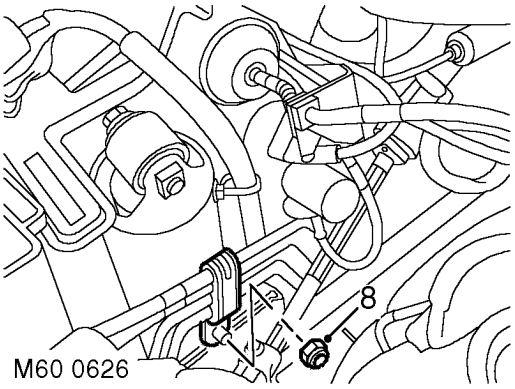

M600624

4. Remove 3 screws securing splash shield and remove shield.
5. Position containers under valve block and actuator to collect fluid spillage.
6. Remove bolt securing pipe clamp to chassis and remove clamp.



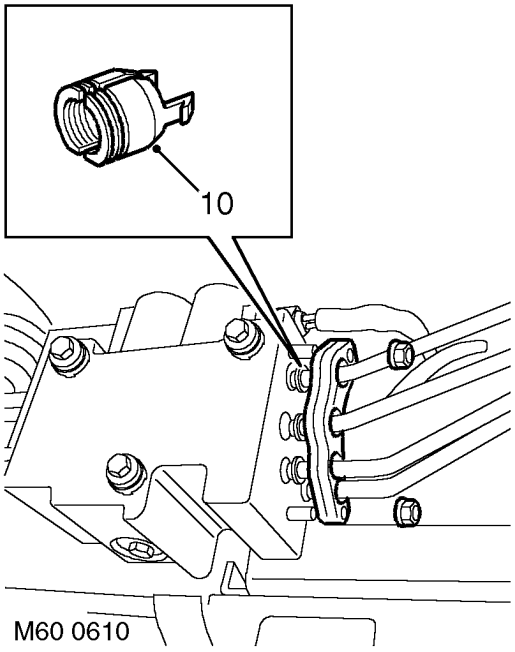
M60 0625

7. Release harness strap from suspension turret and position harness aside.



M60 0626

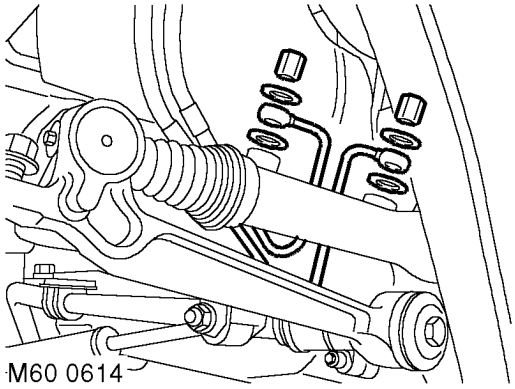
8. Remove nut securing pipe clamp to bracket on suspension turret and remove clamp.



M60 0610

9. Remove 2 nuts securing pipe clamping plate to valve block.
10. Release clamping plate and pipes from valve block. Remove collets and release pipes from clamping plate.

CAUTION: Always fit plugs to open connections to prevent contamination.


M60 0614

11. Remove 2 cap nuts securing pipes to ACE actuator. Disconnect pipes and discard sealing washers.

    CAUTION: Always fit plugs to open connections to prevent contamination.

12. Release pipes from isolator above chassis RH front outrigger.
13. Remove pipe assembly.

Refit

1. Position pipe assembly.
2. Locate pipes in isolator above chassis RH front outrigger. Fit cable tie around isolator to secure pipes.
3. Ensure valve block and pipe connections are clean.
4. Fit collets and pipes to clamping plate.
5. Connect pipes to valve block. **To avoid seal damage, keep pipes square to valve block.** Fit and tighten nuts securing clamping plate to valve block to 21 Nm (15 lbf.ft).

   CAUTION: Ensure pipes are installed in their correct ports or serious system damage will occur.

6. Fit pipe clamps. Secure to chassis with bolt and to bracket on suspension turret with nut.
7. Connect pipes to ACE actuator with cap nuts and new sealing washers Tighten cap nuts to 29 Nm (21 lbf.ft). **Ensure pipes are not under tension or kinked.**
8. Secure harness to suspension turret.
9. Fit splash shield and secure with screws.
10. Fit RH wheel arch liner extension and secure with screws.
11. Renew ACE high pressure filter.
    ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
12. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
13. Refill and bleed ARC system.
    ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**
14. Lower vehicle.

Pipe assembly - pump or reservoir to valve block - ACE - V8

60.60.32

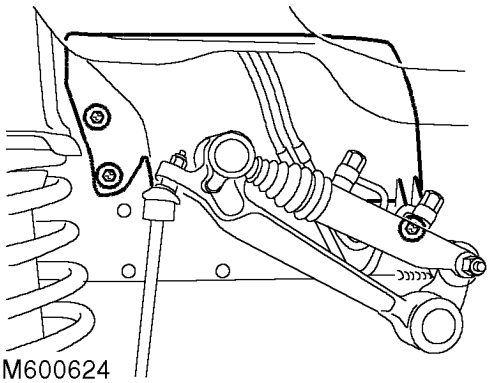
Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

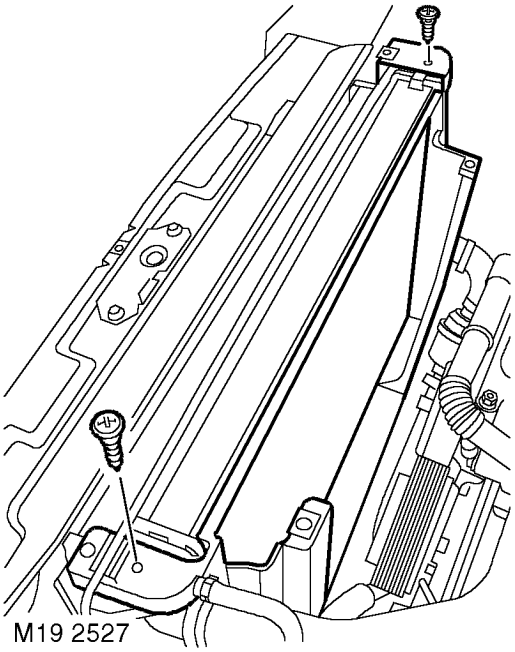
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

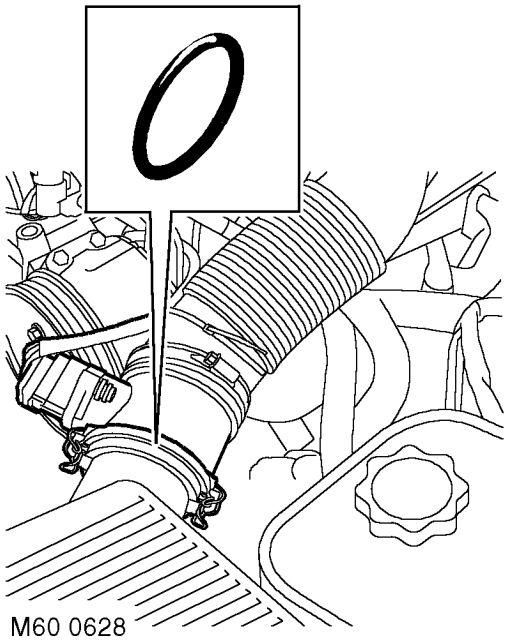
1. To avoid any possibility of swarf ingress, remove the valve block.
   FRONT SUSPENSION, REPAIRS, Valve block - ACE.
2. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
3. Remove RH front road wheel.


M600624

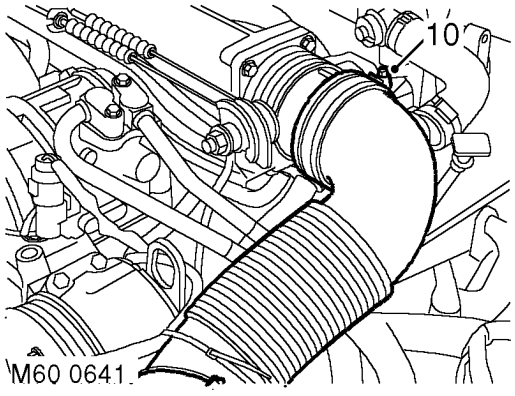
4. Remove 3 screws and remove splash shield.
5. Remove viscous fan.
   COOLING SYSTEM - V8, REPAIRS, Fan - viscous.


M19 2527

6. Remove 2 screws securing lower fan cowl and remove cowl.


M60 0628

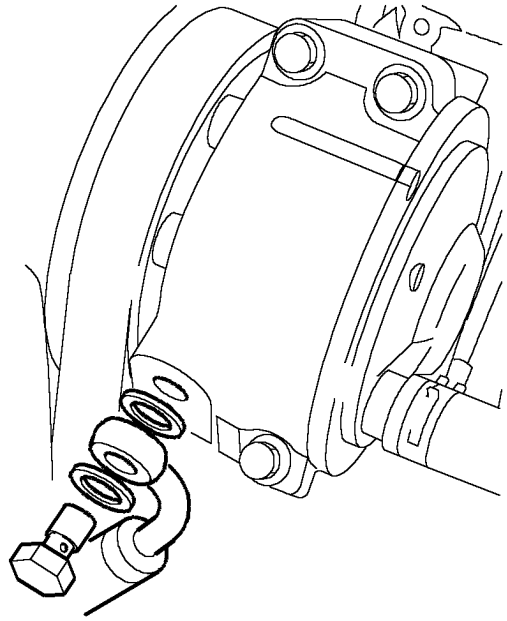
7. Disconnect multiplug from MAF sensor.
   Note: Pre 03 MY air intake hose illustrated.
8. Release clips and remove air flow meter from air cleaner.
9. Collect 'O' ring.



10. Loosen clip and disconnect air hose from throttle body.

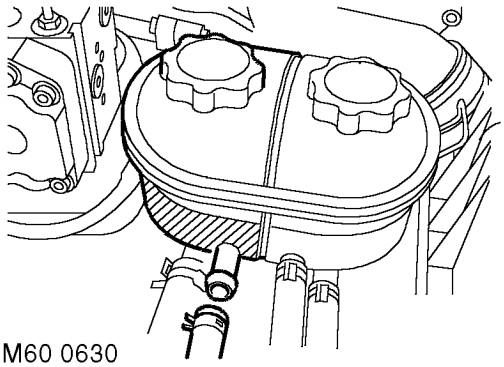
Note: Pre 03 MY air intake hose illustrated.

11. Position container to collect fluid loss.


M60 0629A

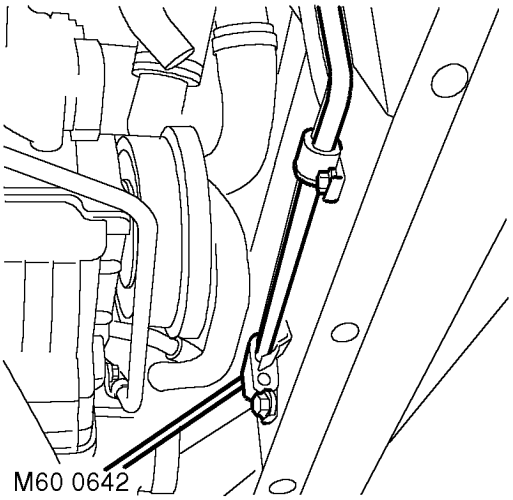
12. **Pump to valve block pipe:** Remove banjo bolt securing fluid hose to ACE pump and discard sealing washers.

CAUTION: Always fit plugs to open connections to prevent contamination.

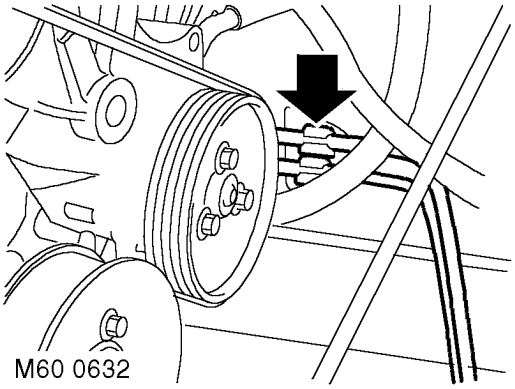

M60 0630

13. **Valve block to reservoir pipe:** Release clip, disconnect hose from ACE fluid reservoir and remove clip from hose.

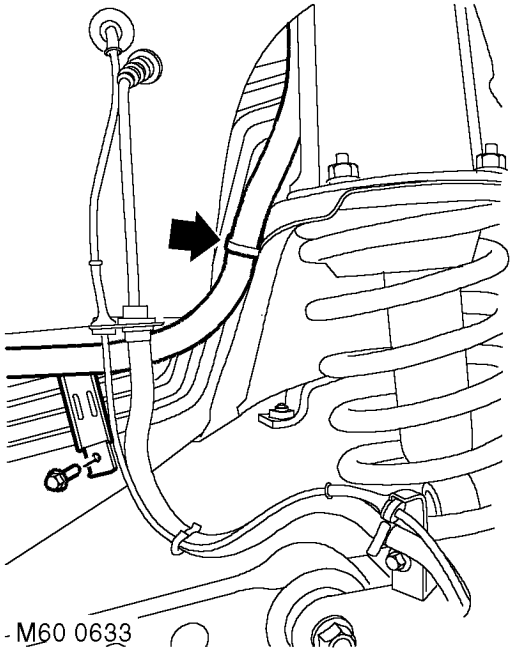
CAUTION: Always fit plugs to open connections to prevent contamination.


M60 0642

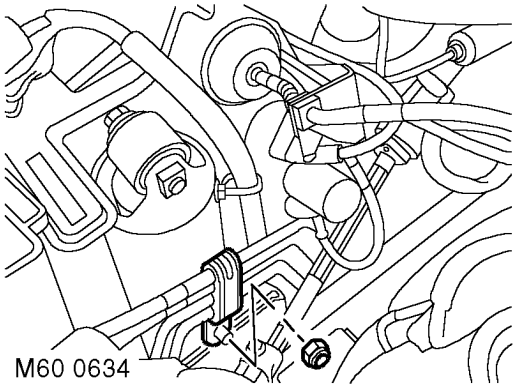
14. Remove bolts securing 2 pipe clamps to front cross member and remove clamps.



15. **Valve block to reservoir pipe:** Release pipe from clip on LH chassis member.



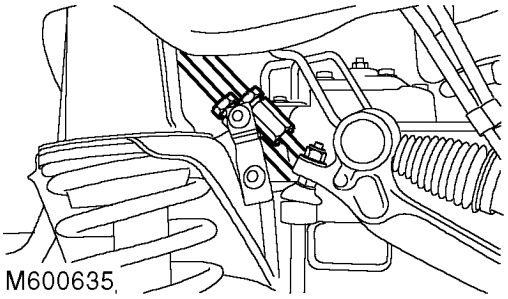
16. Remove bolt securing pipe clamp to RH chassis member and remove clamp.
17. Release harness clip from RH suspension turret.



18. Remove nut securing pipe clamp to bracket on RH suspension turret and remove clamp.
19. Release pipe from isolator above chassis RH front outrigger.
20. Cut pipe at suitable point near suspension turret.
21. Remove and discard front and rear sections of pipe.

Refit

1. Fit both sections of new pipe to vehicle.
2. Ensure 'O' ring is fitted to union on front section of pipe.



3. Push both sections ofpipe together squarely and tighten union nut to 16 Nm (12 lbf.ft).
4. Locate pipe in isolator above chassis RH front outrigger. Fit cable tie around isolator to secure pipe.
5. **Valve block to reservoir pipe:**Fit clip to reservoir hose, connect hose to reservoir and secure with clip.
6. **Pump to valve block pipe:** Ensure pipe banjo and ACE pump connections are clean, fit new sealing washers, align banjo to pump and tighten bolt to 29 Nm (21 lbf.ft).

7. Fit pipe clamps to pipe, align clamps to front cross member and fit bolts.
8. **Valve block to reservoir pipe:** Fit pipe to clip on LH chassis member.
9. Fit pipe clamp to pipes, align clamp to suspension turret and secure with nut.
10. Fit pipe clamp to pipes, align clamp to RH chassis member and secure with bolt.
11. Align and secure harness to suspension turret.
12. Fit 'O' ring to air cleaner.
13. Fit air hose to throttle body and secure with clip.
14. Fit air flow meter and secure with clips.
15. Connect multiplug to MAF sensor.
16. Fit lower fan cowl and secure with screws.
17. Fit viscous fan.
    ☞ **COOLING SYSTEM - V8, REPAIRS, Fan - viscous.**
18. Fit RH splash shield and secure with screws.
19. Fit road wheel(s).
20. Fit valve block.
    ☞ **FRONT SUSPENSION, REPAIRS, Valve block - ACE.**
21. Renew ACE high pressure filter.
22. Lower vehicle.

Pipe assembly - pump or reservoir to valve block - ACE - diesel

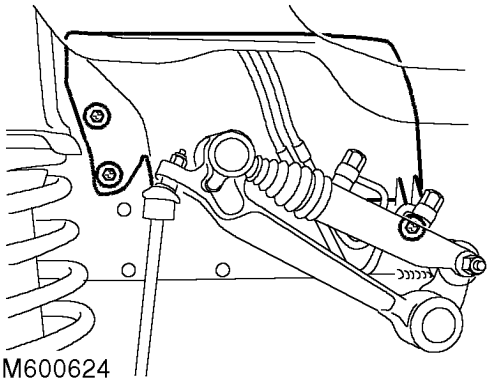
🔧 *60.60.32*

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

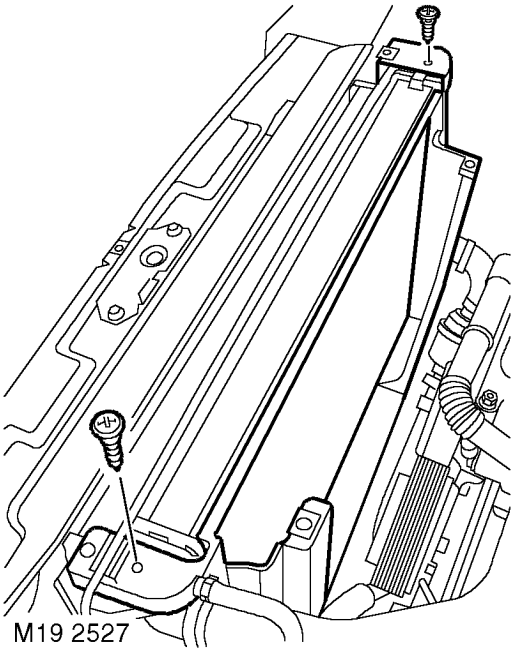
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

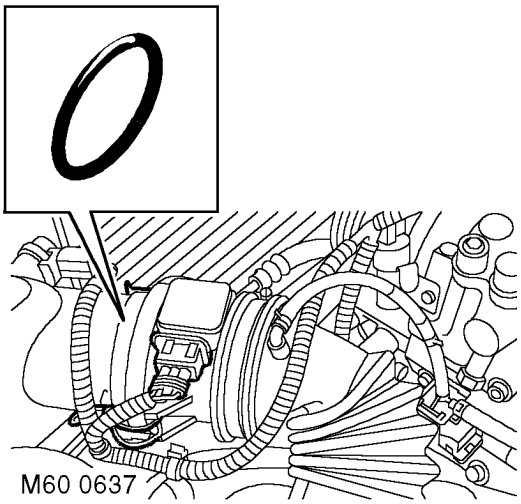
1. To avoid any possibility of swarf ingress, remove valve block.
   ☞ **FRONT SUSPENSION, REPAIRS, Valve block - ACE.**
2. Drain cooling system.
   ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
3. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
4. Remove RH front road wheel.


M600624

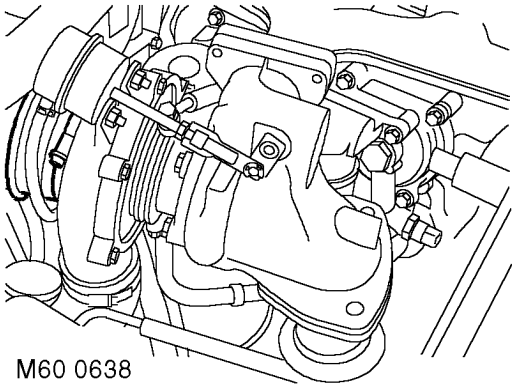
5. Remove 3 screws and remove splash shield.
6. Remove viscous fan.
   ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**



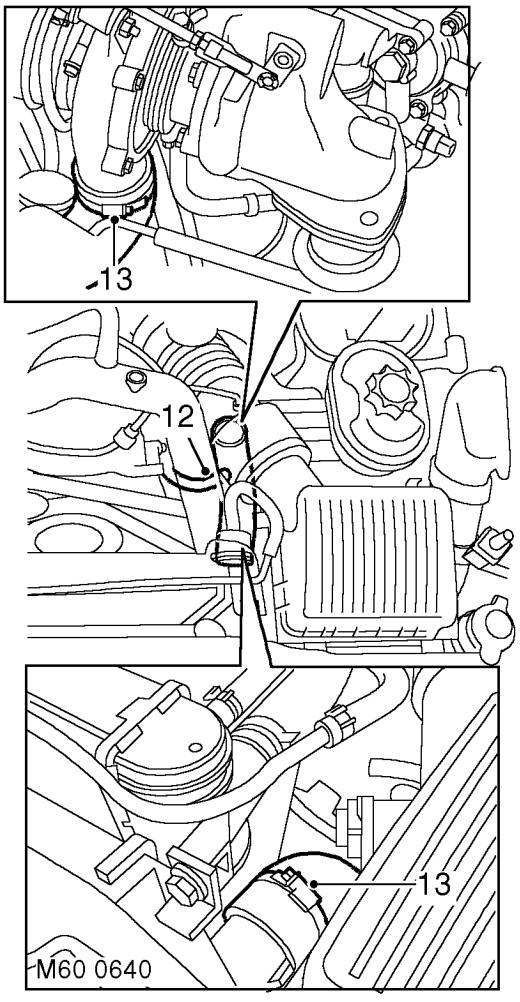
7. Remove 2 screws securing lower half of fan cowl and remove cowl.
8. Disconnect multiplug from air flow meter.



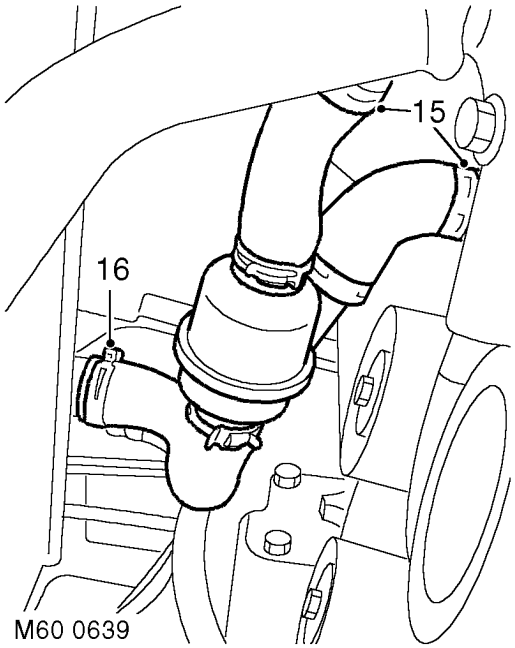
9. Release clips and remove air flow meter from air cleaner.
10. Collect 'O' ring.



11. Loosen clip, disconnect air hose from turbocharger and move hose aside.

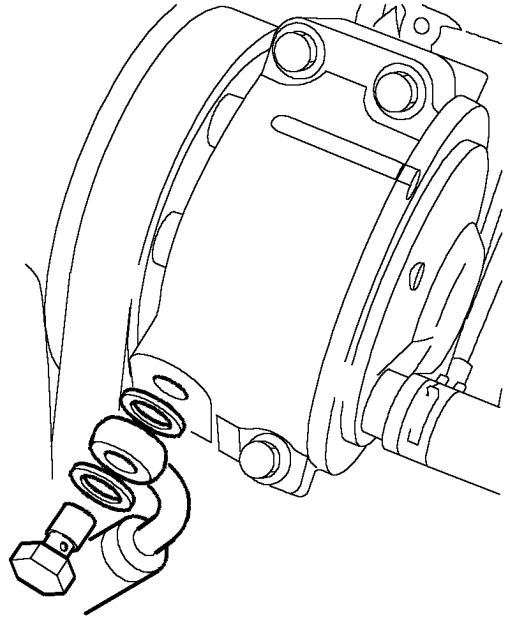


12. Release clip and disconnect pressure sensing hose from turbocharger outlet pipe.
13. Loosen clips securing turbocharger outlet pipe hoses.
14. Remove turbocharger outlet pipe and hoses as an assembly.

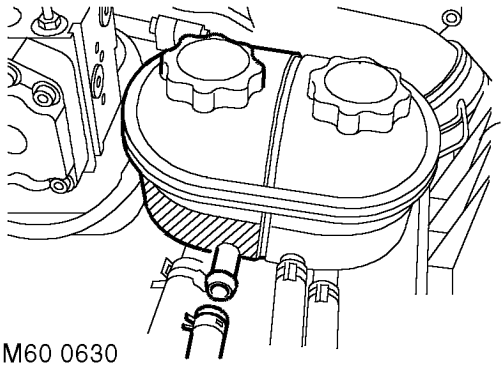


M60 0639

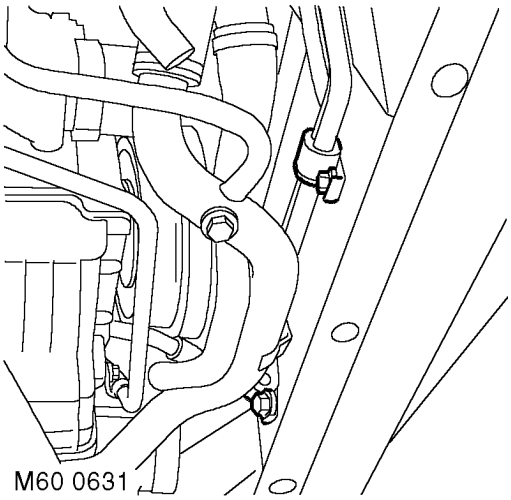
15. Release clips and disconnect 2 thermostat housing hoses from coolant pipe.
16. Release clip and disconnect bottom hose from radiator.
17. Remove thermostat housing with hoses.
18. Position container to collect ACE fluid loss.


M60 0629A

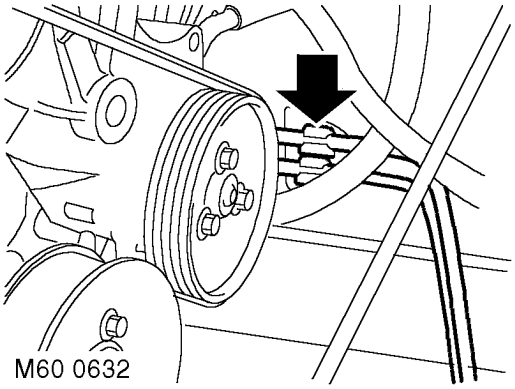
19. **Pump to valve block pipe:** Remove banjo bolt securing fluid hose to ACE pump and discard sealing washers.
CAUTION: Always fit plugs to open connections to prevent contamination.


M60 0630

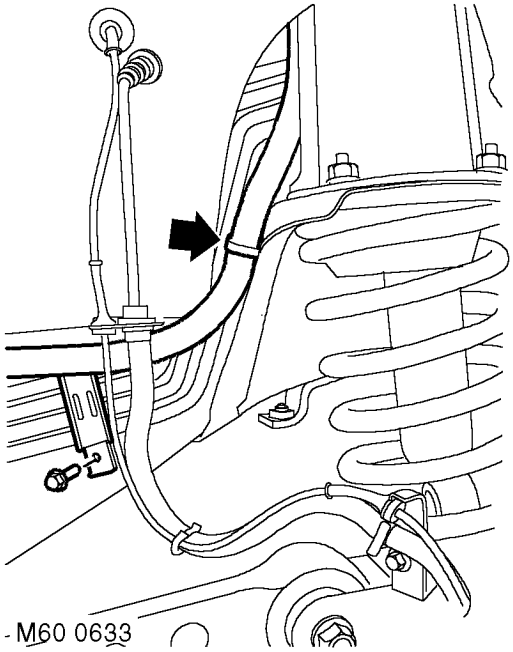
20. **Valve block to reservoir pipe:** Release clip, disconnect hose from ACE fluid reservoir and remove clip from hose.
CAUTION: Always fit plugs to open connections to prevent contamination.


M60 0631

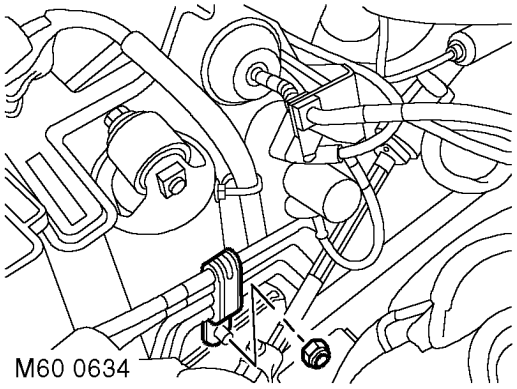
21. Remove bolts securing 2 pipe clamps to chassis front cross member and remove clamps.



22. **Valve block to reservoir pipe:** Release fluid return pipe from clip on LH chassis member.



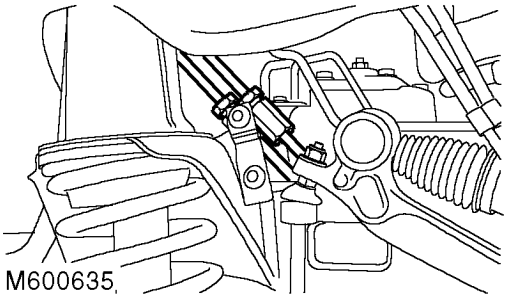
23. Remove bolt securing pipe clamp to RH chassis member and remove clamp.
24. Release harness clip from RH suspension turret.



25. Remove nut securing pipe clamp to bracket on RH suspension turret and remove clamp.
26. Release pipe from isolator above chassis RH front outrigger.
27. Cut pipe at suitable point near suspension turret.
28. Remove and discard front and rear sections of pipe.

Refit

1. Fit both sections of new pipe to vehicle.
2. Ensure 'O' ring is fitted to union on front section of pipe.



3. Push both sections of pipe together squarely and tighten union nut to 16 Nm (12 lbf.ft).
4. Locate pipe in isolator above chassis RH front outrigger. Fit cable tie around isolator to secure pipe.
5. **Valve block to reservoir pipe:** Fit clip to reservoir hose, connect hose to reservoir and secure with clip.
6. **Pump to valve block pipe:** Ensure pipe banjo and ACE pump connections are clean, fit new sealing washers, align banjo to pump and tighten bolt to 29 Nm (21 lbf.ft).

7. Fit pipe clamps to pipes, align clamps to chassis front cross member and fit bolts.
8. **Valve block to reservoir pipe:** Fit pipe to clip on LH chassis member.
9. Fit pipe clamp to pipes, align clamp to suspension turret and secure with nut.
10. Fit pipe clamp to pipes, align clamp to RH chassis member and secure with bolt.
11. Align and secure harness to suspension turret.
12. Fit thermostat housing and hoses and secure hoses with clips.
13. Fit turbocharger outlet pipe and secure hoses with clips.
14. Connect turbocharger pressure sensing hose and secure with clip.
15. Fit 'O' ring to air cleaner.
16. Fit air hose to turbocharger and tighten clip.
17. Fit air flow meter to air cleaner and secure with clips.
18. Connect multiplug to air flow meter.
19. Fit lower half of fan cowl and secure with screws.
20. Fit viscous fan.
    ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**
21. Fit RH splash shield and secure with screws.
22. Fit road wheel.
23. Fit valve block.
    ☞ **FRONT SUSPENSION, REPAIRS, Valve block - ACE.**
24. Renew ACE high pressure filter
    ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
25. Lower vehicle.
26. Fill cooling system.
    ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**

Pipe assembly - valve block to rear actuator - ACE

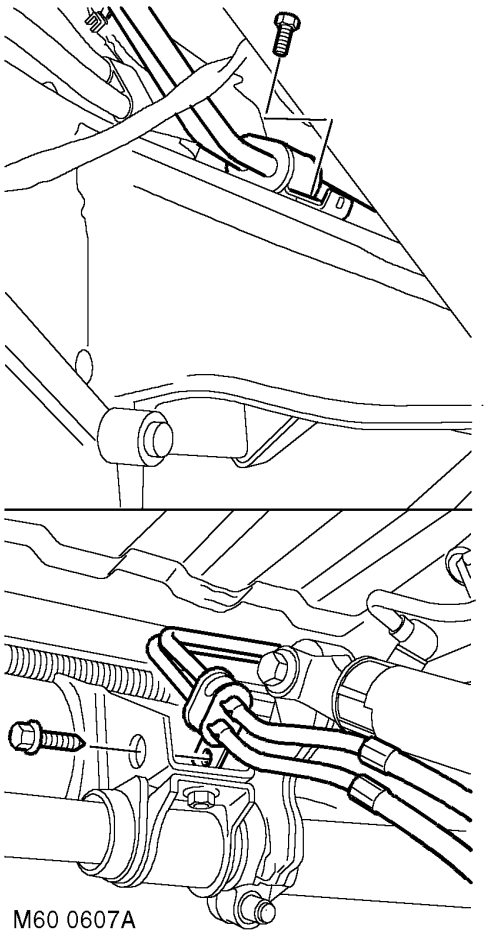
60.60.33

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

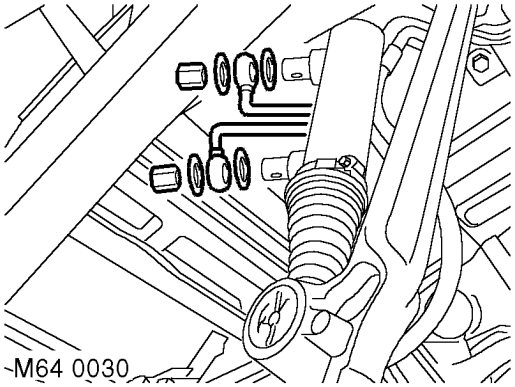
1. Raise vehicle on a ramp.
2. Position container under valve block to collect fluid spillage.



M60 0607A

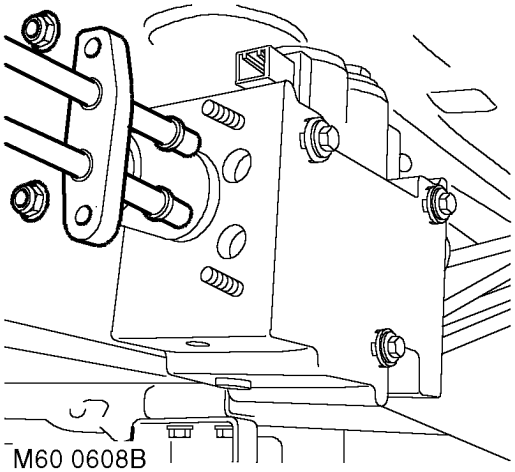
3. Remove 2 bolts securing 2 rear pipe clips to chassis.

4. Remove 2 nuts securing rear anti-roll bar links to axle.
5. Release links from axle and pull long arm down for access to actuator pipe unions.
6. Position container under actuator to collect fluid spillage.


M64 0030

7. Remove 2 cap nuts securing pipes to ACE rear actuator. Disconnect pipes, remove and discard sealing washers.

CAUTION: Always fit plugs to open connections to prevent contamination.


M60 0608B

8. Remove 2 nuts securing rear pipe clamping plate. Release clamping plate and pipes from valve block.

CAUTION: Always fit plugs to open connections to prevent contamination.

9. Remove pipe assembly.
10. Remove collets and clamping plate from rear pipes.

Refit

1. Ensure valve block and pipe connections are clean.
2. Install clamping plate and collets on rear pipes.
3. Position pipe assembly to vehicle and connect pipes and clamping plate to valve block. **To avoid damage to seals, keep pipes square to valve block.** Fit and tighten nuts securing clamping plate to valve block to 21 Nm (15 lbf.ft).

CAUTION: Ensure pipes are installed in their correct ports or serious system damage will occur.

4. Fit bolts securing rear pipe clips to chassis and tighten to 6 Nm (4.4 lbf.ft).
5. Connect pipes to actuator with cap nuts and new sealing washers. Tighten cap nuts to 29 Nm (21 lbf.ft). **Ensure pipes are not under tension or kinked.**
6. Ensure washer is in place on lower ball joint of each anti-roll bar link, then connect lower ball joints to axle and tighten nuts to 100 Nm (74 lbf.ft).
7. Renew ACE high pressure filter.
   ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
8. Bleed ACE hydraulic system.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**
9. Lower vehicle.

Actuator - front - ACE

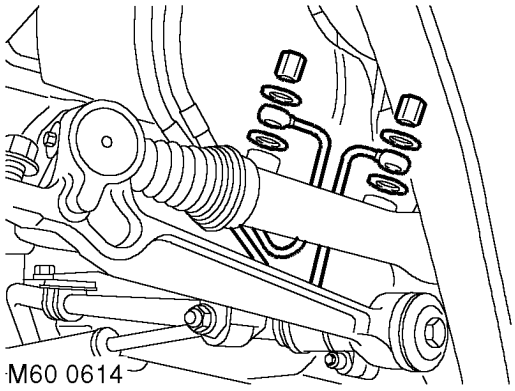
60.60.40

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Remove

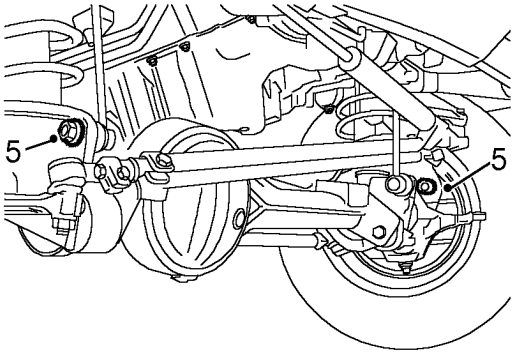
1. Raise vehicle on a ramp.
2. Remove RH front road wheel.
3. Position container to collect fluid spillage.



M60 0614

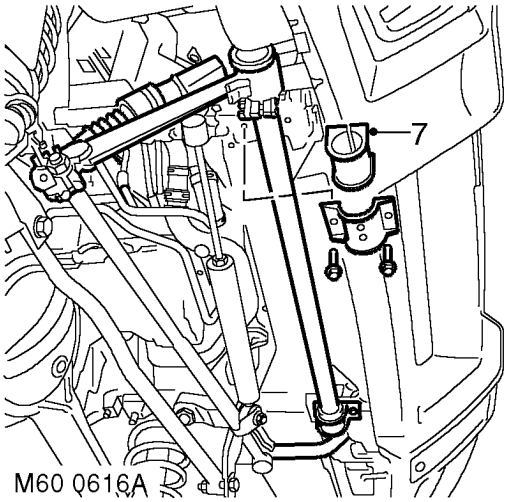
4. Remove cap nuts securing fluid pipes to actuator. Disconnect pipes and discard sealing washers.

   CAUTION: Always fit plugs to open connections to prevent contamination.



M60 0615

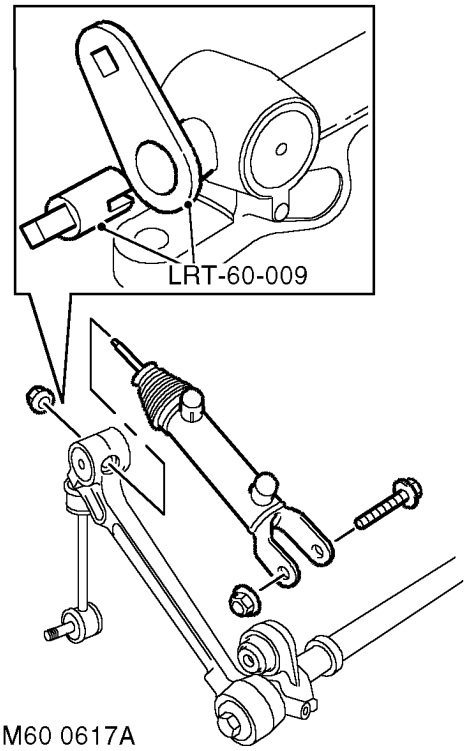
5. Remove 2 nuts securing anti-roll bar links to axle. Release links from axle.



M60 0616A

6. With assistance, remove 2 bolts and remove both clamp plates from torsion bar.
7. Remove mounting rubbers from torsion bar.
8. Remove torsion bar and actuator assembly.

   CAUTION: While removed from the vehicle, ensure torsion bar is stored without any load on the anti-roll bar links, or the ball joints and/or link rods could be damaged.



M60 0617A

9. Use **LRT-60-009** to remove nut securing actuator to long arm.
10. Remove nut and bolt securing actuator to short arm and remove actuator.

CAUTION: The short arm and torsion bar are supplied as an assembly and must not be separated.

Refit

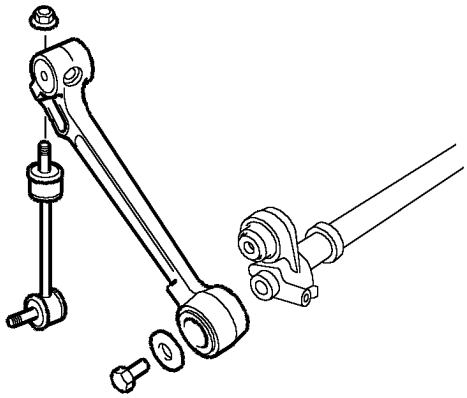
1. Fit actuator to torsion bar. Use **LRT-60-009**to tighten actuator to long arm nut to 48 Nm (35 lbf.ft). Tighten actuator to short arm nut and bolt to 180 Nm (133 lbf.ft).
2. Ensure torsion bar mounting rubber mating faces are clean and free from damage.
3. Fit mounting rubbers to torsion bar.
4. With assistance, position torsion bar and actuator assembly to vehicle. Fit clamp plates and tighten bolts to 45 Nm (33 lbf.ft).
5. Ensure washer is in place on lower ball joint of each anti-roll bar link, then connect lower ball joint to axle and tighten nuts to 100 Nm (74 lbf.ft).
6. Connect pipes to actuator with cap nuts and new sealing washers. Tighten cap nuts to 29 Nm (21 lbf.ft). **Ensure pipes are not under tension or kinked.**
7. Renew ACE high pressure filter.
   ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
8. Bleed ACE hydraulic system.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**
9. Fit RH front road wheel and tighten nuts to 140 Nm (103 lbf.ft).
10. Lower vehicle.

Bushes - front long arm - ACE

60.60.46

Remove

1. Remove ACE front actuator.
   FRONT SUSPENSION, REPAIRS, Actuator - front - ACE.



M60 0567B

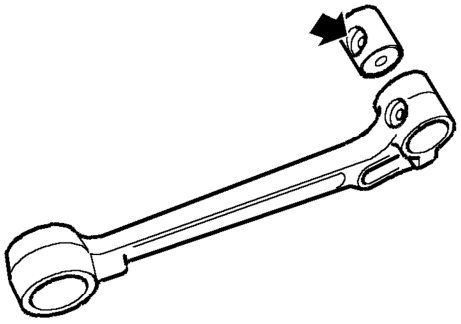
2. Remove securing nut and remove anti-roll bar link from torsion bar.
3. Restrain torsion bar and remove long arm securing bolt and washer. Remove long arm from torsion bar.

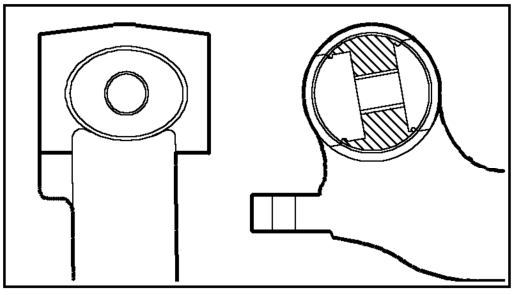
   CAUTION: The short arm and torsion bar are supplied as an assembly and must not be separated.

4. Use a suitable drift to remove both halves of slipper bush from long arm.
5. Use suitable adaptors to press actuator rod end bush from long arm.

Refit

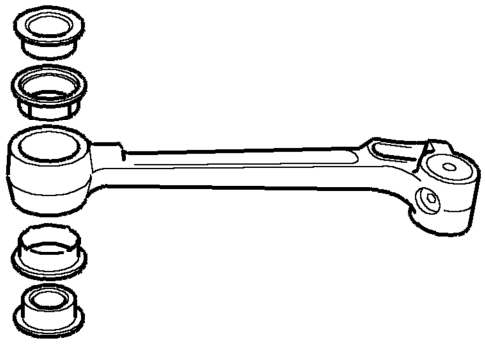
1. Clean bush locations in long arm.





M60 0568B

2. Use suitable adaptors to press new actuator rod end bush into long arm. Ensure hole in bush is correctly aligned with hole in long arm.

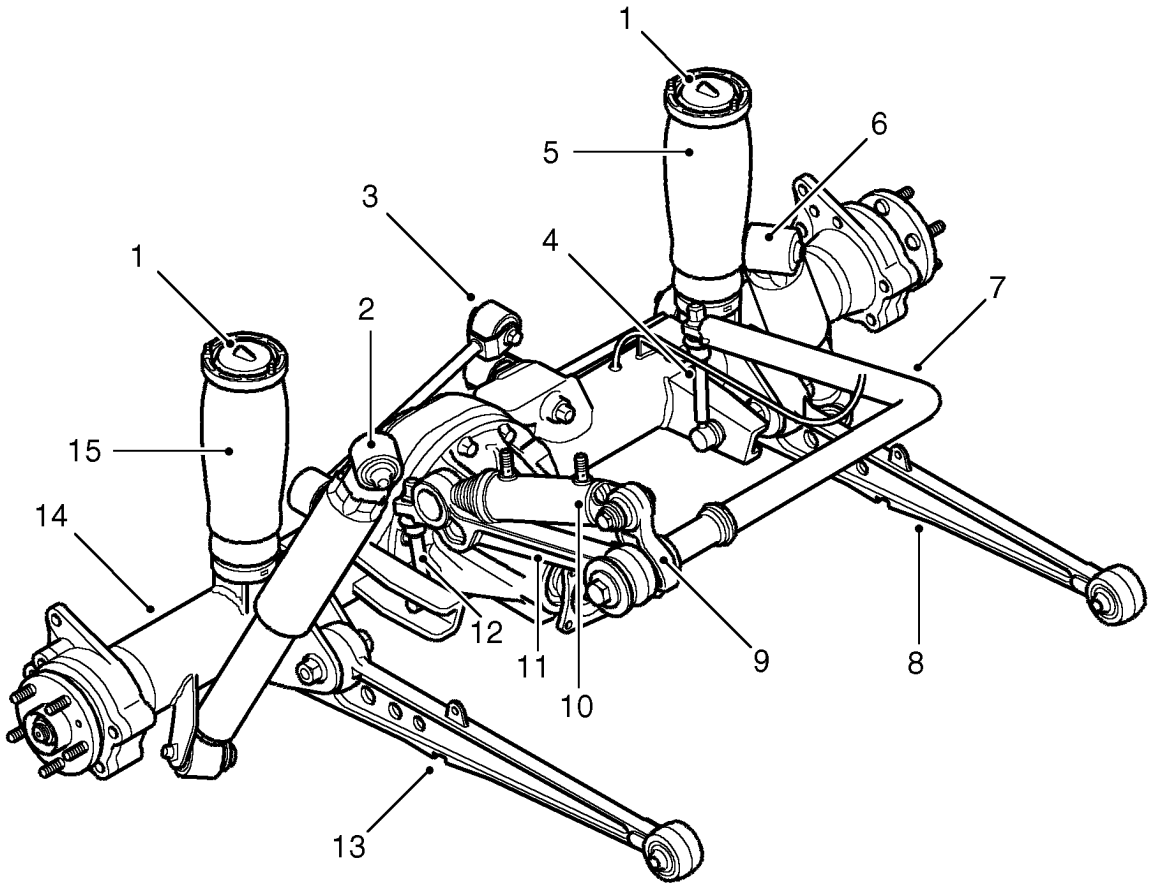


M64 0027B

3. Align slots in new slipper bush halves with those in long arm. Carefully press both halves of slipper bush into long arm. Ensure the sealing rings on the slipper bush faces are not damaged.

4. Clean long arm and mating face on torsion bar.
5. Fit long arm to torsion bar. Restrain torsion bar and tighten bolt to 180 Nm (133 lbf.ft).
6. Fit anti-roll bar link to long arm and tighten nut to 50 Nm (37 lbf.ft).
7. Fit ACE front actuator.
   ☞ **FRONT SUSPENSION, REPAIRS, Actuator - front - ACE.**

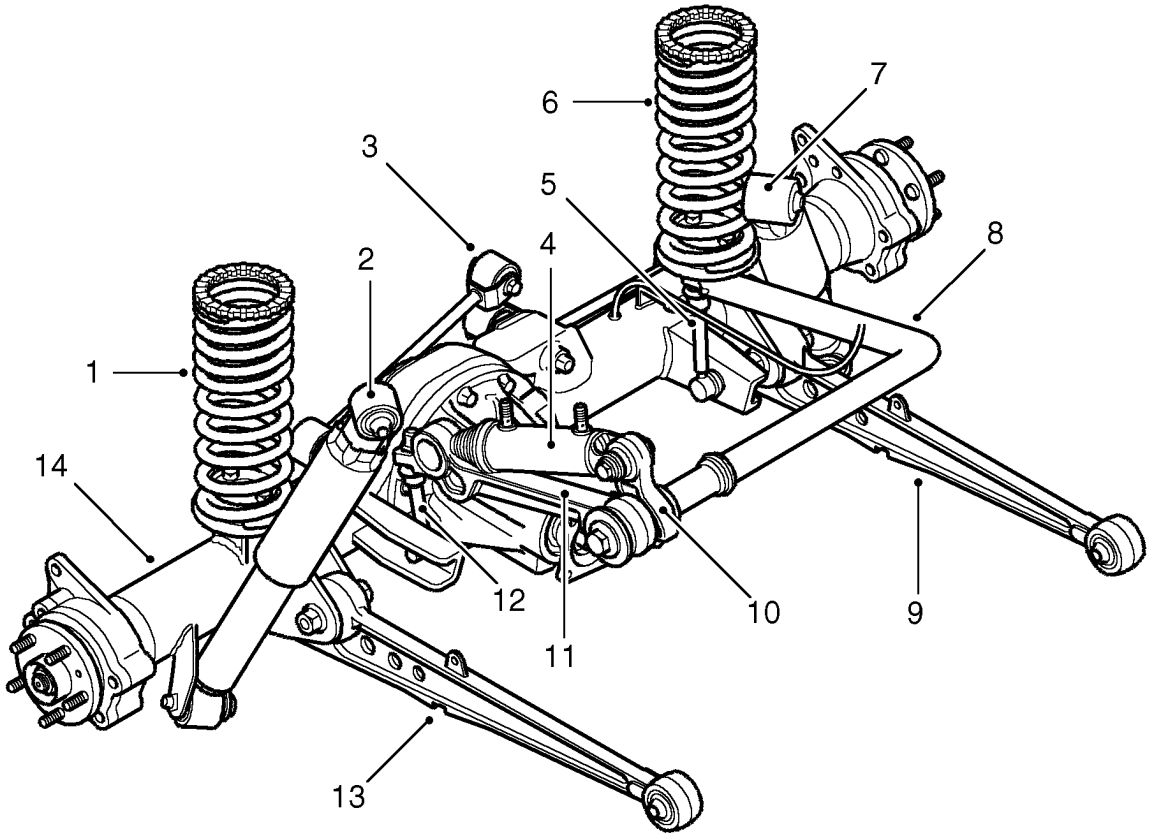
Rear suspension component layout (vehicles with SLS)



M64 0044

1 Air pressure pipe connector
2 Damper RH
3 Watts linkage
4 Anti-roll bar link LH
5 Air spring LH
6 Damper LH
7 Torsion/Anti-roll bar
8 Radius arm LH
9 ACE short arm (if fitted)
10 ACE actuator (if fitted)
11 ACE long arm (if fitted)
12 Anti-roll bar link RH
13 Radius arm RH
14 Rear axle
15 Air spring RH

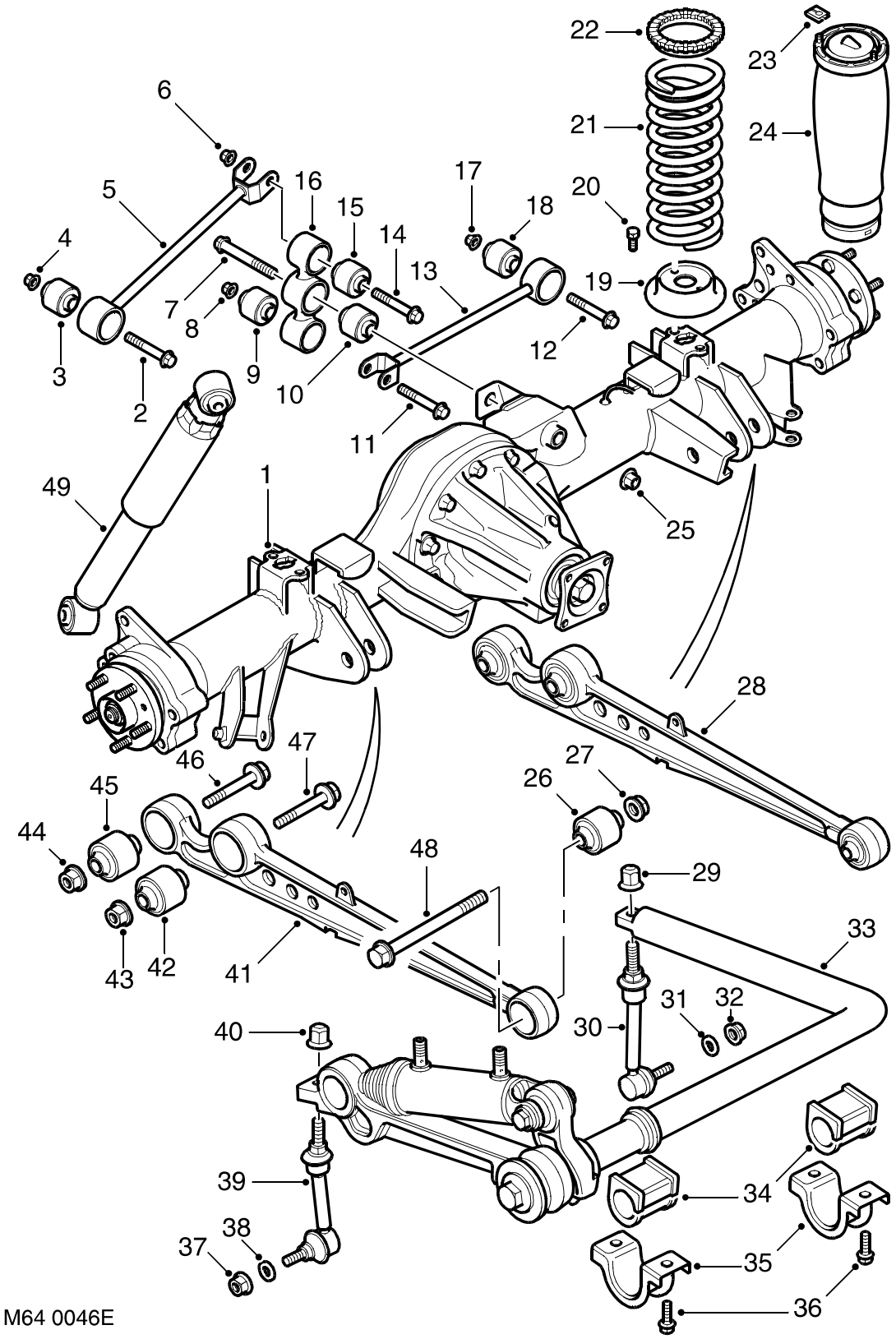
Rear suspension component layout (vehicles without SLS)



M64 0045

1 Coil spring RH
2 Damper RH
3 Watts linkage
4 ACE actuator (if fitted)
5 Anti-roll bar link LH
6 Coil spring LH
7 Damper LH
8 Torsion/Anti-roll bar
9 Radius arm LH
10 ACE short arm (if fitted)
11 ACE long arm (if fitted)
12 Anti-roll bar link RH
13 Radius arm RH
14 Rear axle

Rear suspension components



1 Rear axle
2 Bolt
3 Bush
4 Locknut
5 Transverse link
6 Locknut
7 Bolt
8 Locknut
9 Bush
10 Bush
11 Bolt
12 Bolt
13 Transverse link
14 Bolt
15 Bush
16 Pivot housing
17 Locknut
18 Bush
19 Lower spring seat 2 off (vehicles without SLS only)
20 Bolt 4 off (vehicles without SLS only)
21 Coil spring 2 off (vehicles without SLS only)
22 Spring seat isolator 2 off (vehicles without SLS only)
23 Clip 4 off (vehicles with SLS only)
24 Air spring 2 off (vehicles with SLS only)
25 Locknut
26 Bush 2 off
27 Locknut 2 off
28 Radius arm LH
29 Locknut
30 Torsion/Anti-roll bar link LH
31 Washer
32 Locknut
33 Anti-roll bar assembly
34 Mounting rubber 2 off
35 Clamp plate 2 off
36 Bolt 2 off
37 Locknut
38 Washer
39 Anti-roll bar link RH
40 Locknut
41 Radius arm RH
42 Bush 2 off
43 Locknut 2 off
44 Locknut 2 off
45 Bush 2 off
46 Bolt 2 off
47 Bolt 2 off
48 Bolt 2 off
49 Damper 2 off

Description

General
The rear suspension comprises two dampers, two radius arms, a Watts linkage and an anti-roll bar assembly. On vehicles without Self Levelling Suspension (SLS) coil springs are used. On vehicles with SLS air springs are used.

The anti-roll bar is an essential part of the rear suspension. On vehicles without ACE, a conventional 'passive' anti-roll bar is fitted. On vehicles fitted with the ACE system, a thicker diameter anti-roll bar, known as a torsion bar, is used with an actuator at one end.

☞ **FRONT SUSPENSION, DESCRIPTION AND OPERATION, Description - ACE.**

The hydraulic dampers and springs provide springing for each rear wheel. The long travel dampers, springs and radius arms provide maximum axle articulation and wheel travel for off-road driving. The rear axle is controlled longitudinally by two forged steel radius arms and transversely by a Watts linkage.

Radius arms
Each radius arm is manufactured from forged steel. Two bushes are pressed into the rear of the radius arm. The rear of the radius arm is located between a fabricated bracket on the axle and secured through the bushes with two bolts and nuts. A bush is pressed into the forward end of the radius arm which is located in a fabricated bracket on each chassis longitudinal and secured through the bush with a bolt and nut. Each radius arm is similar in its construction to the front radius arms. The rear radius arms are shorter than the front and have a lug for attachment of the SLS height sensor (when fitted).

The radius arms prevent longitudinal movement of the rear axle and because of their length allow maximum axle articulation. The stiffness of the bushes in each radius arm also contributes to the vehicle roll stiffness.

Each radius arm has a notch on its lower edge which provides location for the vehicle jack.

Dampers
Two conventional telescopic dampers are used to control body/axle movement. The upper damper mounting is fitted with a bush which locates in a bracket on the chassis longitudinal. The damper is secured with a bolt which screws into a captive nut on the bracket. The lower damper mounting is also fitted with a bush and locates in a fabricated bracket attached to the rear axle. The lower mounting is secured with a bolt which screws into a captive nut on the bracket. The upper and lower bushes are replaceable items.

Air springs (vehicles with SLS)
On vehicles with SLS fitted, air springs are fitted between the rear axle and the chassis. Each spring is located at its base on a fabricated platform on the rear axle. The top of the spring locates in a fabricated bracket attached to the outside of each chassis longitudinal.

The plastic base of the air spring has two lugs which locate in a slotted hole in the rear axle platform. The spring is secured by rotating the spring through 90°, locating the lug in the platform. The plastic top of the air spring has two grooved pins which locate in holes in the bracket on the chassis. Two spring clips locate on the grooved pins and retain the top of the spring in position.

Each air spring comprises a top plate assembly, an air bag and a base piston. The air bag is attached to the top plate and the piston with a crimped ring. The air bag is made from a flexible rubber material which allows the bag to expand with air pressure and deform under load. The top plate assembly comprises the plastic top plate with two bonded grooved pins on its top face. In the centre of the top face is a female connector which allows for the attachment of the air hose from the SLS compressor. The piston is made from plastic and is shaped to allow the air bag to roll over its outer diameter. The base of the piston is recessed with a boss moulded in the centre. The boss has two lugs which provide attachment to the axle platform.

Coil springs (vehicles without SLS)

On vehicles without SLS fitted, coil springs are fitted between the rear axle and the chassis in place of the SLS air springs. Each spring is located at its base by the lower spring seat which is secured to a fabricated platform on the rear axle with two bolts. The top of each spring is located in the upper spring seat. The upper spring seat comprises a pressed metal plate with an outer coating of natural rubber bonded to the plate. The upper spring seat is retained in position by the compression of the spring.

Coil Spring Specifications – Models up to 03 Model Year

The rear coil springs are of the variable rate type and are manufactured from silicon manganese 16.5 mm (0.65 in.) diameter bar. Each spring has 9 coils and a free length of 385 mm (15.1 in.). The variable rate of the spring is achieved by the active coils at one end being closer together. The rear coil spring is identified by a purple stripe painted on a number of coils.

Coil Spring Specifications – Models From 03 Model Year

The introduction of the 03MY vehicle introduced a range of additional rear coil spring fitments. These were introduced as a package to optimise vehicle trim heights.

The coil springs are manufactured from silicon manganese 16.35 mm (0.64 in.) diameter bar for springs on five seater models and 16.57 mm (0.65 in.) diameter bar on seven seater models. The following spring data table shows the colour codes, number of coils and spring free length.

Spring Data

Colour Code	Total No. of Coils	Free Length	Model
Brown/Orange	8.73	384.7 mm (15.14 in)	5 Seat
Grey/Orange	8.73	392 mm (15.43 in)	5 Seat
Yellow/Grey	8.73	376.6 mm (14.82 in)	5 Seat
Pink/Grey	8.73	400.3 mm (15.75 in)	5 Seat
Blue/Grey	9.10	387.8 mm (15.26 in)	7 Seat
Green/Grey	9.10	395.2 mm (15.55 in)	7 Seat
White/Grey	9.10	380.6 mm (14.98 in)	7 Seat

The following table shows spring fitment applicability.

Spring Fitment Applicability

Left Hand Drive	Right Hand Drive	
Both Sides	RH Side	LH Side
Brown/Orange	Grey/Orange	Yellow/Grey
Grey Orange	Pink/Grey	Brown/Orange
Blue/Grey	Green/Grey	White/Grey

Watts linkage

A Watts linkage is used to ensure that the rear axle remains centrally located. The Watts linkage comprises two transverse links and a pivot housing. The transverse links and pivot housing allow the rear axle to move vertically without any transverse movement.

The transverse links are made from fabricated and welded steel. Each transverse link has a bush press fitted into a housing at one end. The opposite end has a forked bracket with two cross holes.

The pivot housing is made from cast iron. Three bushes are press fitted in the housing, one in the centre and one at each end.

The pivot housing is located in a fabricated bracket centrally located on the rear of the axle. The central bush of the pivot housing is secured in the bracket with a bolt and locknut. Fabricated brackets on each chassis longitudinal provide for the attachment of each transverse link. Each link is secured through its bush with a bolt and locknut. The forked end of each link locates over the bushes at each end of the pivot housing and is secured with a bolt and locknut.

The attachment bolts for each link are coated with a clear, dry wax which reduces friction on the bolt and allows the correct torque to be applied to the clamping of the bushes. The bolts can be re-used, but if bolt replacement is necessary the correct bolt with the wax coating must be used.

Anti-roll bar

The anti-roll bars fitted differ between ACE and non-ACE vehicles. On non-ACE vehicles a conventional 'passive' anti-roll bar is used. On ACE vehicles an 'active' torsion bar is used. Both types are attached to the tubular cross-member at the rear of the chassis with mounting rubbers and clamp plates. The clamp plates locate in fabricated brackets attached to the tubular cross-member and secured with bolts.

Each end of the anti-roll bar is attached to an anti-roll bar link. Each link has a spherical bearing attached at each end. One end is attached to a bracket on the axle and secured with a locknut. The opposite end attaches through a hole in the anti-roll bar and is also secured with a locknut. On 'active' torsion bars, the RH anti-roll bar link is attached to a long arm which in turn is attached to the anti-roll bar.

Passive anti-roll bar

The passive anti-roll bar is a conventional anti-roll bar which opposes axle movement, reducing the effects of lateral forces on the vehicle body.

With the conventional passive anti-roll bar, axle movement is opposed by the anti-roll bar through links attached to the axle casing and each end of the anti-roll bar.

On vehicles with coil springs (no SLS fitted) the anti-roll bar is manufactured from 19 mm (0.74 in.) diameter spring steel bar.

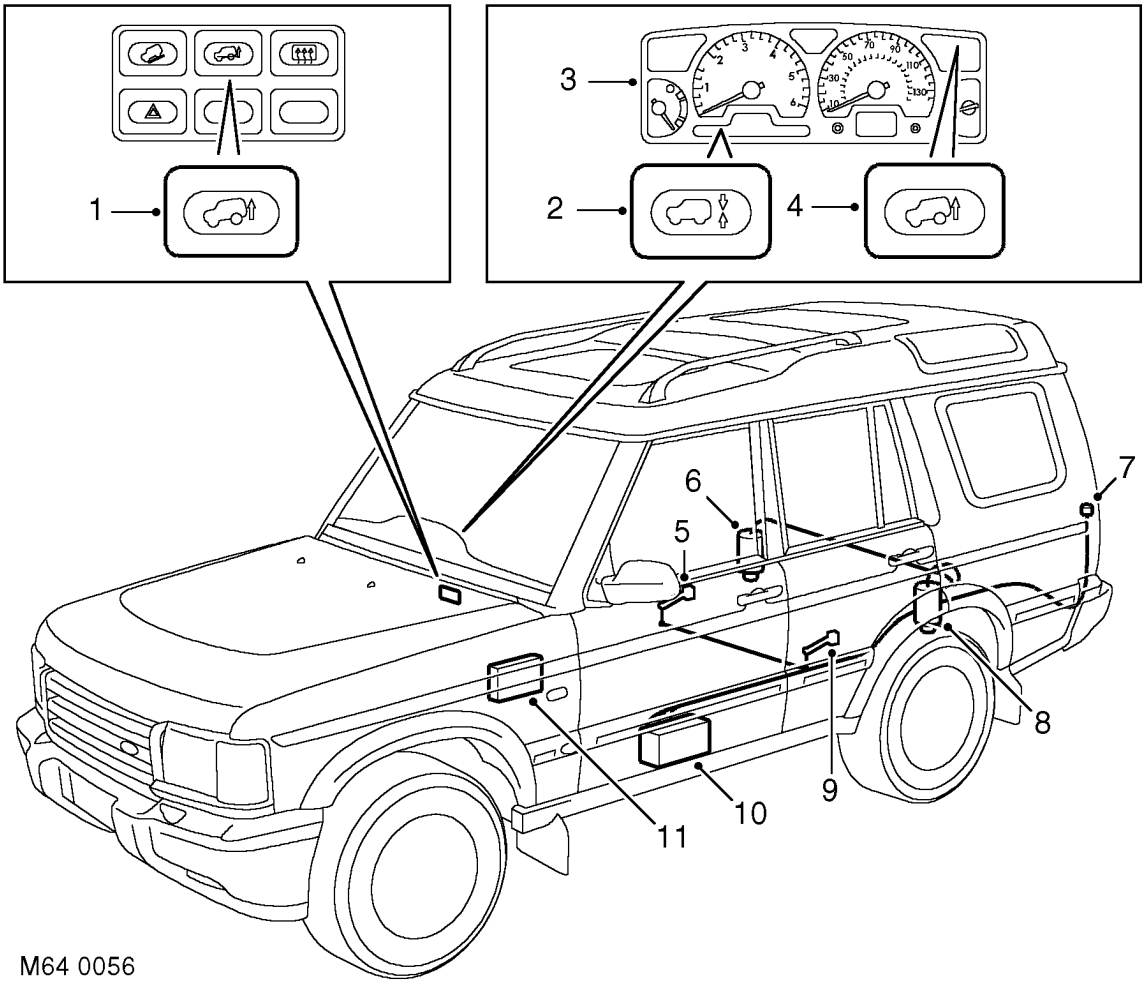
On vehicles with air springs (SLS fitted) the anti-roll bar is manufactured from 29 mm (1.14 in.) diameter spring steel bar.

Active torsion bar

☞ **FRONT SUSPENSION, DESCRIPTION AND OPERATION, Description - ACE.**The 'active' torsion bar is used in conjunction with the ACE system to control body roll and directional stability giving a reduction of the effects of lateral forces on the vehicle body over a conventional 'passive' anti-roll bar.

The torsion bar opposes axle movement by the application of a hydraulic force to oppose the lateral forces through links attached to the axle casing and each end of the bar. The torsion bar is made from 35 mm (1.4 in.) diameter spring steel. One end is fitted with an arm which is operated by a hydraulic actuator to oppose corning forces.

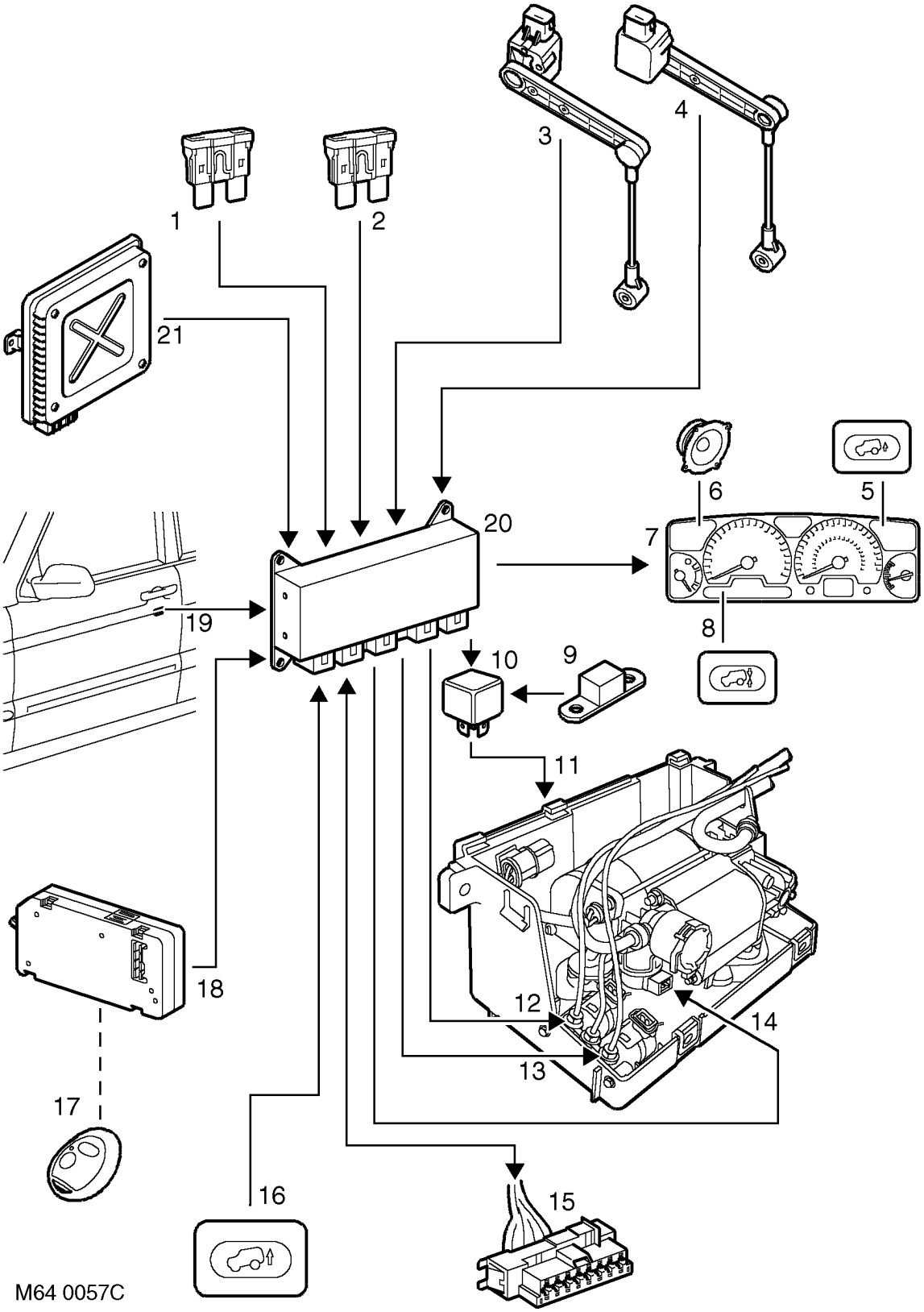
SLS component layout



RH drive shown, LH drive similar

1 Off-road mode switch
2 SLS warning lamp
3 Instrument pack
4 Off-road mode warning lamp
5 RH Height sensor
6 RH Air spring
7 Air inlet filter
8 LH Air spring
9 LH Height sensor
10 Air supply unit
11 SLABS ECU

SLS system control diagram



1 Battery supply (via SLABS relay)
2 Ignition supply
3 RH height sensor
4 LH height sensor
5 Off-road mode warning lamp
6 Audible warning speaker
7 Instrument pack
8 SLS warning lamp
9 Fusible link 9
10 SLS relay
11 Air supply unit
12 RH air valve
13 LH air valve
14 Exhaust valve
15 Diagnostic socket
16 Off-road mode switch
17 SLS remote handset
18 Body Control Unit (BCU)
19 Door switches
20 SLABS ECU
21 Engine Control Module (ECM)

Description - SLS

General

The Self Levelling Suspension (SLS) system is an optional fitment and comprises an Electronic Control Unit (ECU), air supply unit, two air springs and two height sensors. The SLS system only operates on the rear suspension and is designed to keep the vehicle level to compensate for uneven loads or when towing. The system controls the gap between the chassis and the rear axle to a tolerance of ± 0.5 mm (0.02 in). The ride height of the rear of the vehicle can be controlled in three modes of operation; normal ride height, Off-Road Mode (ORM) and extended mode. A transportation mode, initiated using TestBook, is also available for moving the vehicle on a trailer.

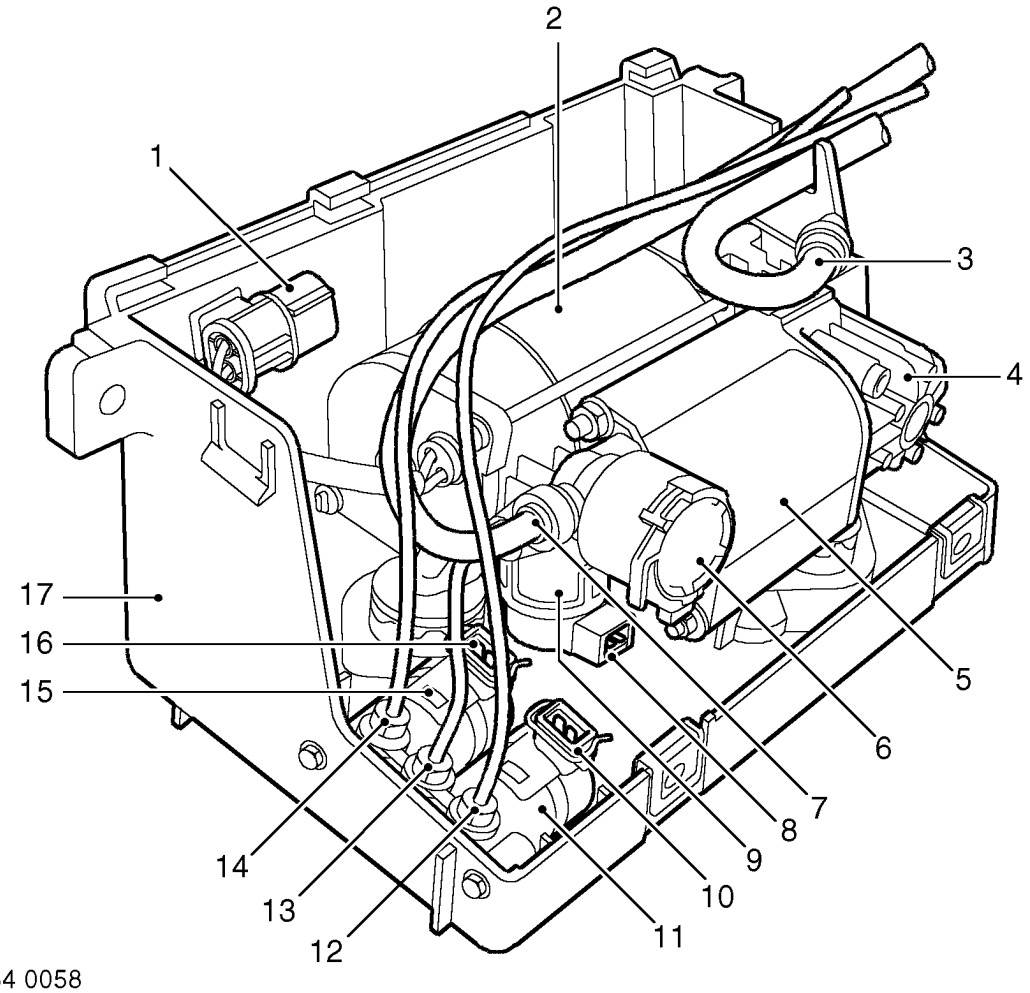
The system is controlled electronically by an ECU which is shared with the ABS system and known as the Self Levelling and Anti-Lock Braking System (SLABS) ECU. The system operates by using an air supply unit to inflate or deflate the air springs to maintain a constant ride height.

An accessory remote handset is available to remotely operate the SLS system to allow easier connection and disconnection of trailers.

Two SLS system warning lamps are located in the instrument pack. The warning lamp in the bottom left corner of the instrument pack is the SLS warning lamp. If a fault is detected in the system, the warning lamp will illuminate continuously in an amber colour. The warning lamp also flashes in an amber colour when the remote handset is being used. The second warning lamp, located in the top right of the instrument pack is the ORM warning lamp. When ORM is selected the warning lamp is continuously illuminated in an amber colour. When the SLS is between standard ride height and ORM or in extended mode, the warning lamp will flash. Standard ride height, measured between the tip of the axle bump stop rubber and the axle, is 61.5 mm (2.42 in). ORM ride height, measured between the tip of axle bump stop and the axle, is 100 mm (3.93 in).

A switch is located in the group of six switches on the fascia and is used to select the ORM. The switch is non-latching and must be depressed for a minimum of 0.5 seconds to signal the ECU that ORM has been requested.

Air supply unit



M64 0058

1 Compressor electrical connector
2 Electric motor
3 Air intake hose
4 Compressor
5 Air dryer
6 Pressure limiting valve
7 Exhaust hose
8 Exhaust valve electrical connector (black harness connector)
9 Exhaust valve
10 LH air valve electrical connector (blue harness connector)
11 LH air valve
12 LH air spring supply pipe
13 Air supply/exhaust pipe
14 RH air spring supply pipe
15 RH air valve
16 RH air valve electrical connector (natural harness connector)
17 Housing

The air supply unit is located in a central position on the outside of the left hand chassis longitudinal. The unit is contained in a plastic housing attached to the chassis. The housing has a removable lid which is secured with Dzus fasteners for access to the unit.

The air supply unit comprises a 12 V electric motor, a compressor and air dryer unit, a pressure limiting valve, an exhaust valve and two air supply control valves. The exhaust and control valves are solenoid operated responding to signals from the SLABS ECU. The electric motor, compressor, air dryer and pressure limiting and exhaust valve are mounted on flexible rubber mountings to reduce operating noise.

The electric motor drives a crank with an eccentric pin to which a connecting rod is attached. The connecting rod has a piston which fits in the bore of the compressor. Operation of the motor rotates the crank, moving the piston in the bore of the compressor.

The compressor is attached with Allen bolts to the motor housing and sealed with an O-ring. Attached to the compressor is the air dryer which contains a silicate box for removing moisture from the compressed air. Air supplied to inflate the air springs passes through the air dryer. When the air springs are deflated, the exhaust air also passes through the air dryer, removing the moisture from the unit and expelling it to atmosphere.

Attached to end of the air dryer unit is the pressure limiting valve. The valve protects the air springs from over inflation. The pressure limiting valve also operates when the exhaust valve is opened. The valve is pneumatically operated, responding to air pressure applied to it.

The exhaust valve is also located with the pressure limiting valve. The exhaust valve is solenoid operated by the ECU and directs air from the air springs and control valves to atmosphere when required.

The two air control valves for the LH and RH air springs are located at the forward end of the housing. Each valve is connected to the compressor/air dryer unit through a shared single pipe which directs air to and from the air springs. Each control valve is individually operated by the ECU.

All air connections to and from the air supply unit are made through the SLS air harness which is located along the left hand chassis longitudinal.

If faults occur with the air supply unit, fault codes are stored in the SLABS ECU. These fault codes cover the compressor power supply and the LH and RH air control valves and the exhaust valve. The current and past fault codes can be retrieved with TestBook. TestBook can also be used to operate the compressor and the valves for diagnostic purposes.

Air intake filter

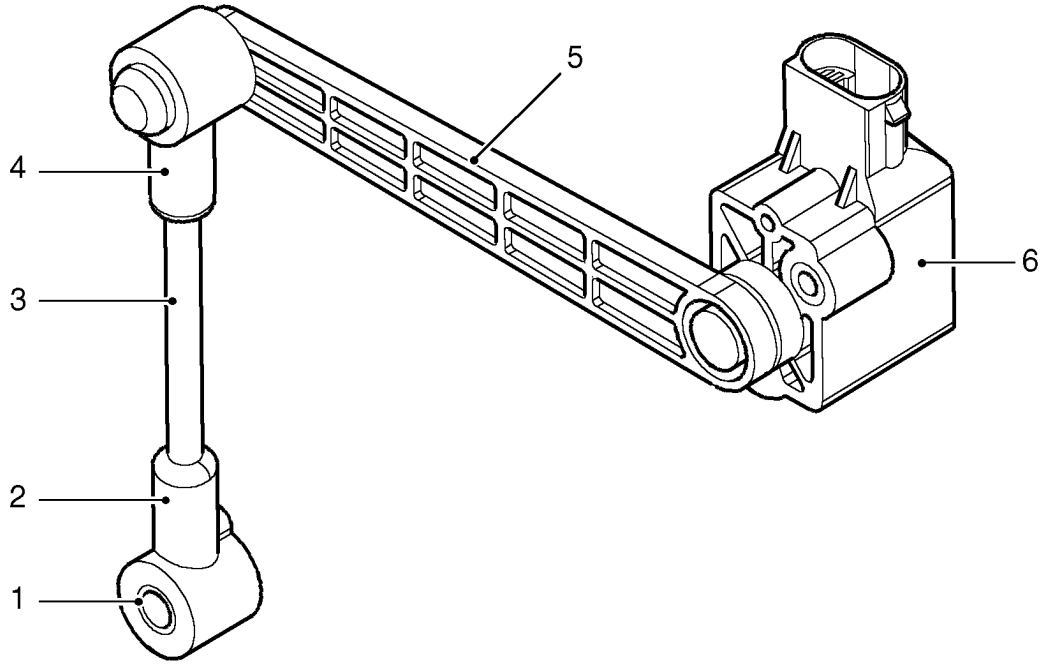
The air intake filter is located in the left hand 'E' post, behind the tail lamp assembly. The filter comprises a plastic moulded housing which contains two filters of differing density to remove particulate matter from the air drawn in by the compressor. The air intake filter has a pipe which is connected to the SLS air harness by a quick release connector. The air intake filter must be replaced as an assembly.

Air intake/Exhaust silencer

The air intake/exhaust silencer is located on the outside of the left hand chassis longitudinal, behind the air supply unit. The silencer is an integral part of the SLS air harness and cannot be serviced individually.

The intake and exhaust air to and from the compressor passes through the silencer. The plastic moulded silencer has two chambers. One chamber reduces system exhaust noise and the other dampens intake air pulses produced by the compressor.

Height sensors



M64 0059

1 Spacer
2 Link end
3 Link
4 Link end
5 Arm
6 Sensor body

Two height sensors are located on the outside of each chassis longitudinal forward of the rear axle. Each sensor body is attached to a fabricated bracket and secured with two screws. The sensor is attached to the top of each radius arm by an arm, a link and two link ends. The link ends allow articulation of the arm to allow for suspension travel. The lower link arm is attached to a lug of the top of the radius arm and is secured with a bolt and locknut.

The sensor body and arm are manufactured from moulded nylon. The two link ends are made from natural rubber and the link is made from mild steel. The rubber link ends allow flexibility of the arm and resistance to damage.

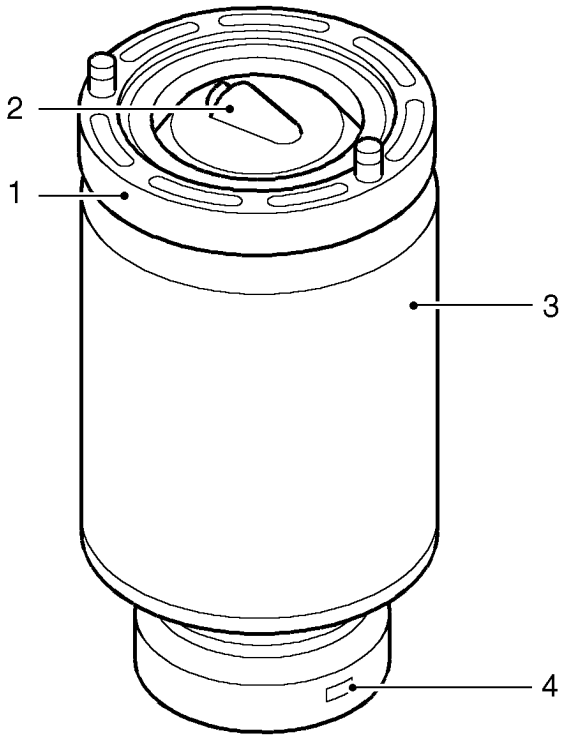
Each sensor is connected to the main chassis harness by a multiplug. The three pin multiplug provides an earth, a 5 V supply voltage and an output signal voltage to the SLABS ECU.

Each sensor operates on the Hall effect principle. A magnet is attached to the shaft and rotates with movement of the arm. The magnetic flux generated acts on a Hall effect sensor and depending on its position varies the current across the sensor. This current is measured and amplified and passed to the SLABS ECU as a linear output voltage signal, which varies depending on the angular position of the sensor. The signal information is processed and the ECU can determine the vehicle height.

When the sensors are replaced or removed for any reason, a calibration procedure is required to recalibrate the sensors and the SLABS ECU. The calibration procedure requires the use of TestBook and calibration blocks to set the axle to chassis height to a known value.

If faults occur with the height sensors, fault codes are stored in the SLABS ECU. The current and past fault codes can be retrieved with TestBook.

Air springs



M64 0060

1 Top plate
2 Voss connector
3 Air bag
4 Piston

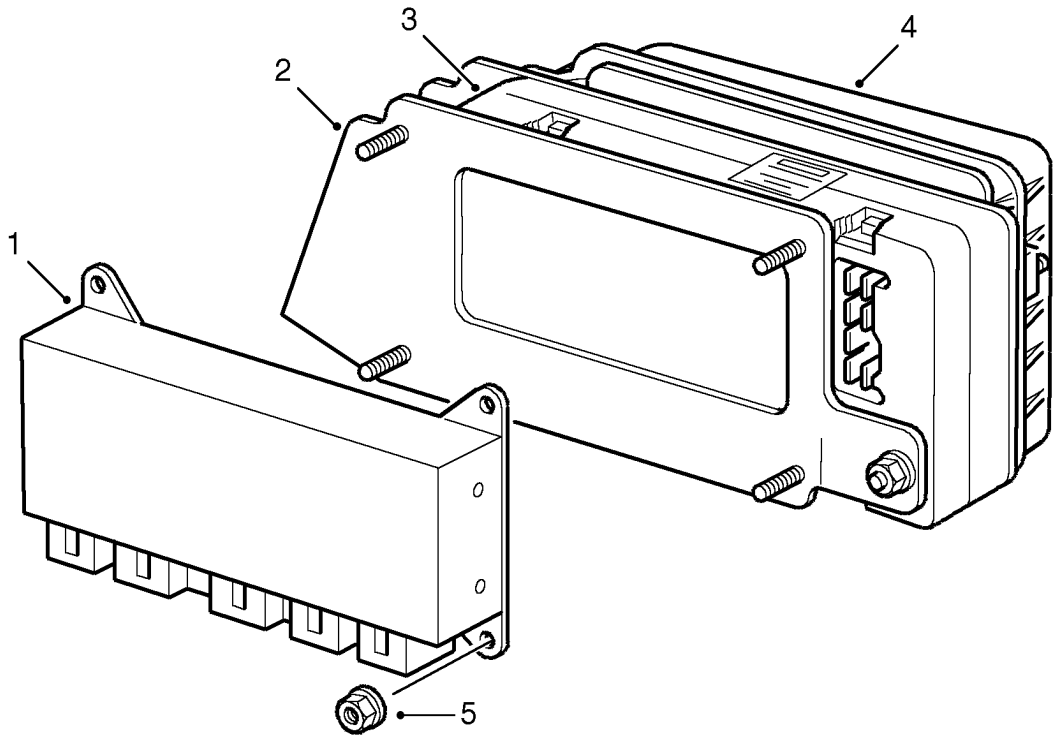
On vehicles without SLS, coil springs are used. On vehicles with SLS two air springs are fitted between the chassis and the rear axle to replace the coil springs. Each air spring is located at its base on a fabricated platform on the rear axle. The top of the spring locates in a fabricated bracket attached to the outside of each chassis longitudinal.

The plastic base piston is recessed with a boss with two lugs moulded in the centre for attachment to the axle. The piston is secured by locating the lugs in a slotted hole in the axle platform and rotating the spring through 90°, locating the lugs in the slot. The plastic top plate has two grooved pins which locate through holes in the chassis bracket. Two spring clips locate on the grooved pins and retain the top of the spring in position.

Each air spring comprises a top plate, an air bag and a base piston. The air bag is attached to the top plate and the piston with crimped rings.

The air bag is made from a fibre reinforced flexible rubber material which allows the spring to expand with air pressure and deform under load. The top plate comprises the two bonded grooved pins and a female Voss connector in the centre. The Voss connector allows for the attachment of the air supply pipe from the air supply unit. The piston is also made from plastic and is shaped to optimise the springs characteristics.

SLABS ECU



M64 0062

1 SLABS ECU
2 Bracket
3 BCU (Ref. only)
4 ACE ECU (Ref. only)
5 Attachment nuts

The SLABS ECU is mounted on a bracket behind the passenger glove box and is identified from the other ECU's by its five connectors. The five connectors are located on the lower face of the ECU and mate with five connectors from the main harness. The twelve, six and eighteen pin connectors are used to supply inputs and outputs to and from the ECU. The remaining connectors are used for the ABS operation.

☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**

The SLABS ECU receives a continuous battery supply from fuse 11 in the engine compartment fusebox. An ignition 'ON' signal is supplied from the ignition switch via fuse 28 in the passenger compartment fusebox. The ECU has the ability to control when it requires power and is not reliant on the ignition signal for it to power up.

The ECU incorporates a counter which times the operation of the SLS system and prevents the compressor exceeding its duty cycle. The ECU can remain powered for up to 1.5 hours after ignition off is sensed to allow the counter to continue running to avoid an ignition cycle resetting the counter.

Opening any of the doors will power up the ECU, irrespective of ignition switch position. The door open signal is sensed by the door switch completing an earth path which is sensed by the ECU. The ECU cannot differentiate between any of the doors. The door open signal powers the ECU for up to 30 minutes to allow the vehicle to re-level when a load is removed or passengers leave the vehicle.

The ECU supplies a 5 V current to each of the height sensors. Each height sensor uses the current to supply an analogue input to the ECU. The ECU can calculate from the input received from each height sensor the height of the vehicle and can then power the air supply unit as necessary to raise or lower one or both air springs to level the vehicle.

When SLS compressor operation is required, the ECU provides a battery supply to energise the SLS relay located in the engine compartment fusebox. When the relay contacts close, a 12 V supply passes through fusible link 9 in the engine compartment fusebox, through the relay contacts and operates the air supply unit compressor. The ECU will then supply power to operate one or both air control valve solenoids and/or the exhaust valve solenoid to inflate or deflate the air springs as required. The compressor does not need to be powered to deflate the air springs.

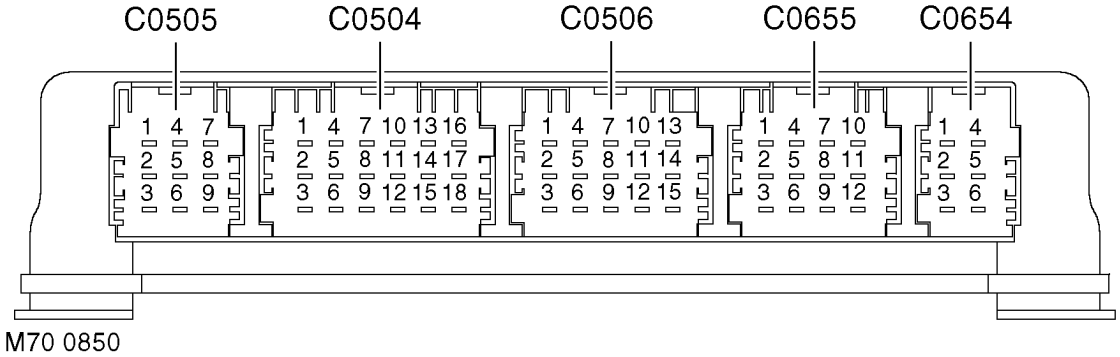
The ECU also controls the operation of the SLS audible warning, the SLS warning lamp and the ORM warning lamp. When the ignition is switched to position II, the ECU performs a three second bulb check and illuminates the SLS and ORM warning lamps in the instrument pack to check for operation. When the system is operating or a fault is sensed by the ECU, the ECU will operate the appropriate warning lamp and audible warning as required. The audible warning is operated by the Body Control Unit (BCU) when it receives a signal from the SLABS ECU. The audible warning is emitted from a speaker at the rear of the instrument pack.

Depressing the ORM switch for a minimum of 0.5 seconds, completes an earth which the ECU uses as a signal to initiate the ORM if conditions allow. When the ECU starts ORM, the same earth that was completed by the ORM switch is pulled to earth by the ECU to activate the ORM warning lamp. The ECU checks for a further operation of the ORM switch by continuously and very quickly removing the earth for the ORM warning lamp. If the ORM switch is operated for more than 0.5 seconds, the ECU will detect this and de-activate the ORM.

The SLS part of the SLABS ECU also uses the road speed data generated within the SLABS ECU by the ABS system. Operation of ORM and extended mode are road speed sensitive and use the ABS signal to monitor the vehicle speed.

When the accessory remote handset is used for the SLS lower and raise functions, the handset transmits RF signals which are received by the same RF receiver used for the alarm/remote door locking system. The RF receiver passes this data as a 25 Hz PWM signal to the BCU. The BCU then transmits this data to the SLABS ECU as raise or lower data. TestBook is required to program the BCU for remote handset operation.

SLABS ECU connector pin details



M70 0850

Connector/Pin No.	Description	Input/Output
C0504		
1	Battery supply	Input
2	Ignition supply	Input
5	K line (diagnostics)	Input/Output
12	Earth	Input
C0654		
1	Left height sensor supply	Output
2	Left height sensor earth	Input
3	Left height sensor signal	Input
4	Right height sensor supply	Output

5	Right height sensor earth	Input
6	Right height sensor signal	Input
C0655		
1	Driver's door switch	Input
2	Passenger and tail door switches	Input
3	Left air valve	Output
4	Right air valve	Output
5	Exhaust valve	Output
6	Air compressor (SLS relay)	Output
7	Audible warning	Output
8	SLS warning lamp	Output
11	ORM switch/ORM warning lamp	Input/Output
12	Remote handset raise/lower signal	Input
Connectors and pins not listed are either not used or used by the brakes system. ☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**		

Failure modes

Failures are indicated by the SLS warning lamp in the bottom left corner of the instrument pack illuminating continuously in an amber colour. The following tables show the type of system failures and their effects on the system operation.

Height sensors

Failure	Effect
Sensor output stuck at 5 V	Vehicle will not level
Sensor output stuck at 0 V	Vehicle will not level
Mechanical link between radius arm and sensor broken	Vehicle will not level

Door Switch Inputs

Failure	Effect
Harness leads for open doors are are broken or shorted to V Batt.	Air suspension levels when one or more doors are open
Harness leads to door(s) shorted to earth	Air suspension will not level

SLS off-road mode switch

Failure	Effect
Fault in wiring harness	Off-road mode cannot be selected
Failure of off-road mode switch	Off-road mode is activated when switch has not been selected

Air supply unit air control valves

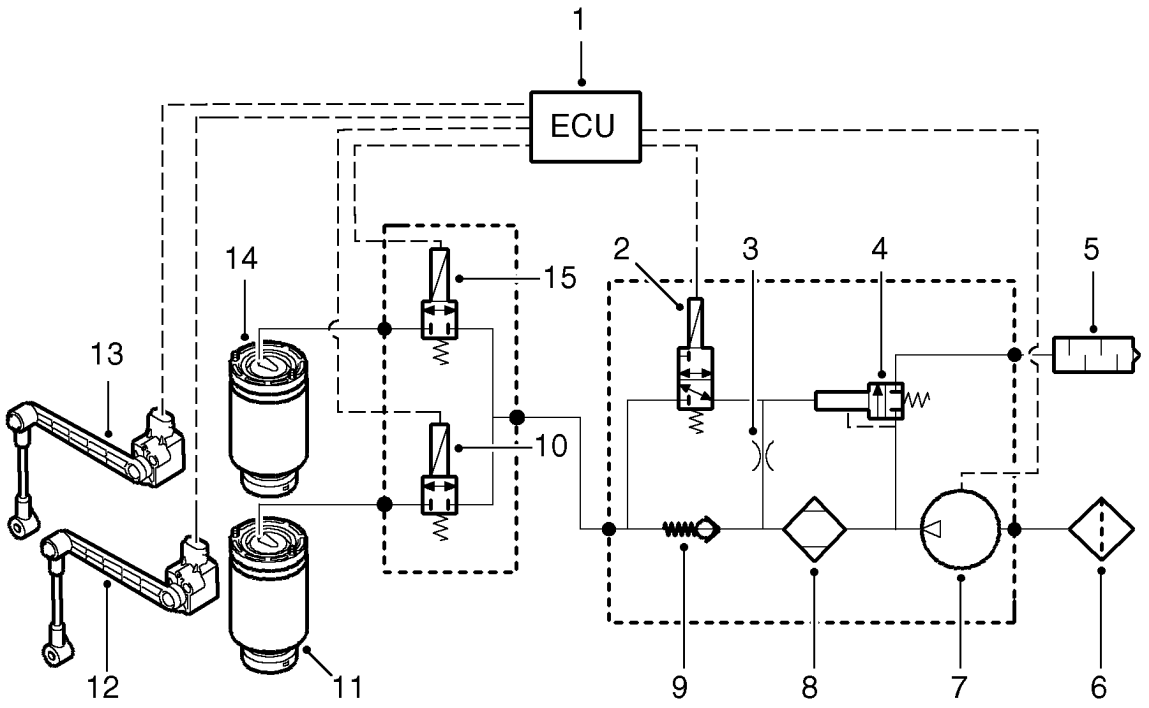
Failure	Effect
Valves open or short circuit	Vehicle does not level or levels unevenly

Air supply unit compressor

Failure	Effect
Faulty relay, harness fault or compressor fault	Vehicle does not level upwards

Operation

Circuit diagram



M64 0061A

1 SLABS ECU
2 Exhaust valve
3 Restrictor
4 Pressure limiting valve
5 Silencer
6 Inlet air filter
7 Compressor
8 Air dryer
9 Non-return valve
10 RH air control valve
11 RH air spring
12 RH height sensor
13 LH height sensor
14 LH air spring
15 LH air control valve

The SLS system is active when the ignition switch is in position II, when one or more doors are open and for up to thirty minutes after all doors have been closed. If the rear axle is articulated by more than 100 mm (3.93 in), the ECU will not activate the SLS system.

The air supply unit compressor will only operate to raise the rear of the vehicle when the engine is running, with the exception of the remote handset operation which does not require the engine running. Three modes of SLS operation are available; Normal Ride Height, Off-Road Mode (ORM) and Extended Mode. A fourth mode, transportation mode, is programmed by TestBook for transport or recovery of the vehicle on a trailer.

Normal ride height

When the vehicle is stationary, a door is open and the ignition is off, the SLS system will allow the rear of the vehicle to lower to within 20 mm of the normal ride height as load is removed from the vehicle. The SLS system will only operate the compressor to raise the rear of the vehicle when the engine is running, unless requested using the remote handset.

Off-road mode (ORM)

ORM is used to raise the rear of the vehicle from normal ride height to the ORM ride height of 100 mm between the tip of the bump stop and the axle.

ORM is activated by depressing the ORM switch located on the fascia for not less than 0.5 seconds. With the engine running, all doors closed and the vehicle speed below 18 mph (30 km/h), the audible warning will sound once and the ORM warning lamp in the instrument pack will start to flash when the switch is released. The compressor will be started and the air control valves will be energised by the ECU to inflate the air springs and raise the rear of the vehicle.

When the full ORM height is reached, the ECU will terminate compressor operation and close the air valves. The ORM warning lamp will stop flashing and remain continuously illuminated to inform the driver that the SLS system is in ORM.

When ORM is no longer required, depressing the ORM switch for not less than 0.5 seconds with all doors closed will lower the SLS to normal ride height. The audible warning will sound once and the ORM warning lamp will flash as the suspension lowers. The ECU energises the air control valves and the exhaust valve to release air pressure from the air springs. When standard ride height is reached the ORM warning lamp will extinguish and the ECU will de-energise the air control valves and the exhaust valve solenoids.

If the SLS is in ORM and the vehicle speed exceeds 18 mph (30 km/h), the ECU will lower the SLS to standard ride height. The driver will be informed of this by an audible warning and the ORM warning lamp flashing as the suspension lowers. When normal ride height is achieved, the ORM warning lamp will extinguish.

At sea level, the time to change the SLS from normal ride height to ORM or visa versa will take between 15 and 20 seconds.

If the ECU determines that conditions are not correct for SLS operation, i.e.; axle articulation or system fault, the audible warning will sound three times to inform the driver that the ORM request has not been granted.

Extended mode

The extended mode is automatically operated by the ECU and requires no input from the driver. Extended mode operates when the chassis is grounded causing the rear wheels to spin. This information is generated by the ABS function of the SLABS ECU.

When the ECU senses that the chassis is grounded and the vehicle speed is less than 6 mph (10 km/h), the ECU will operate the compressor and energise the air control valves for 25 seconds to raise the rear of the vehicle. This operates irrespective of the mode that the SLS system is in at that time. To inform the driver, the ORM warning lamp will flash continuously at all times that the system is in extended mode.

The driver can exit the extended mode by depressing the ORM switch for not less than 0.5 seconds or by exceeding 8 mph (13 km/h).

Remote handset SLS control

The remote handset is an accessory item which allows the SLS to be operated between normal ride height and bump stop height to allow easier connection and disconnection of trailers. The remote handset is similar in appearance to that of the remote door locking handset but does not have an integral key. A circular button with an arrow is used to raise the SLS and an oval button with the 'Land Rover' logo is used to lower the SLS.

The remote handset control requires all doors to be closed and the ignition to be in position II, but the engine does not need to be running.

Pressing the lower button will signal the SLABS ECU, via the RF receiver and the BCU, to energise the exhaust valve and air control valves. The SLS will lower up to 60 mm (2.36 in) below normal ride height if the button is held. If the button is released the SLS will stop at that point.

Pressing the raise button will signal the SLABS ECU, via the RF receiver and the BCU, to start the compressor and energise the exhaust valve and air control valves. The SLS will raise to normal ride height if the button is held. If the button is released the SLS will stop at that point.

When raising or lowering the SLS using the remote handset, the SLS warning lamp will flash and the audible warning will sound when the system is operating. When the SLS is fully lowered the warning lamp will stay illuminated. The SLS will reset to normal ride height if the vehicle speed exceeds 3 mph (5 km/h) for 10 seconds when the SLS is lowered.

Transportation mode

Transportation mode must be used when the vehicle is transported on a trailer and secured by the chassis. The transportation mode can only be enabled and disabled with TestBook.

The transportation mode lowers the rear suspension onto the bump stops with the engine not running. When the suspension is in transportation mode, the SLS warning lamp is continuously illuminated when the ignition is in position II.

When the engine is started in transportation mode, the SLS system will raise the rear suspension until a gap of 25 mm (1 in.) exists between the bump stop and the axle. The SLS warning lamp will flash continuously while the SLS system is raising the suspension. When the gap between the bump stop and the axle is achieved, the warning lamp will illuminate continuously.

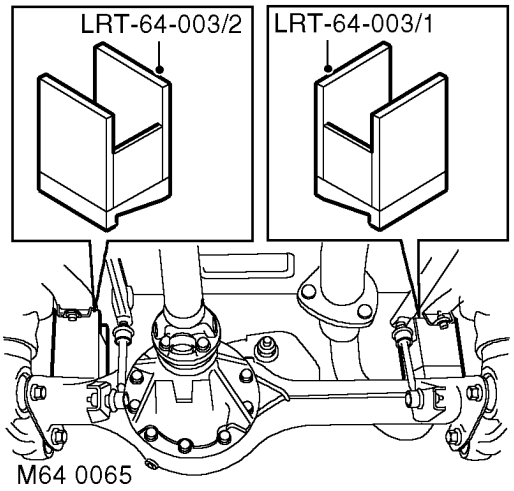
When TestBook is used to disable the transportation mode, the rear suspension will raise to normal ride height when the engine is running.

SLS calibration blocks

64.50.38

Fit

1. Connect TestBook to vehicle.
2. Ensure contact faces of calibration blocks **LRT-64-003/1** and **LRT-64-003/2** are clean.



3. Using Testbook, operate the SLS system to raise the body, position the calibration blocks **LRT-64-003/1** and **LRT-64-003/2** between the rear axle and the body, then lower the body onto the calibration blocks. **The calibration blocks are handed and only fit one way.**

Remove

1. Using Testbook, operate the SLS system to raise the body, remove the calibration blocks **LRT-64-003/1** and **LRT-64-003/2** from between the rear axle and the body.
2. Disconnect TestBook from the vehicle.

Wheel hub

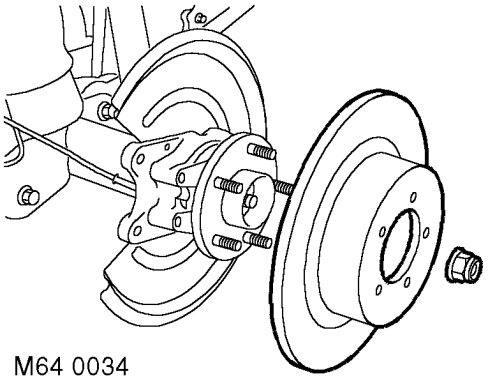
64.15.01

Models with SLS:

WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

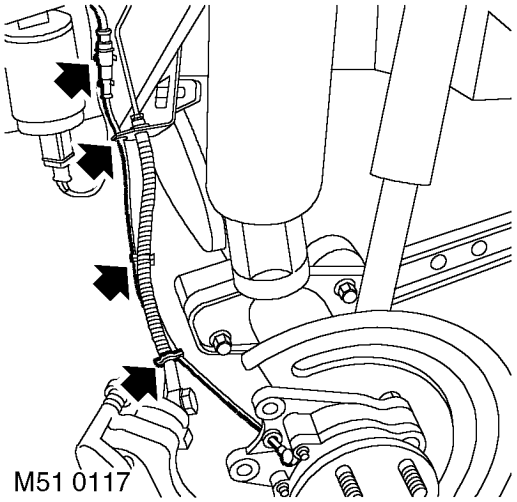
Remove

1. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel.



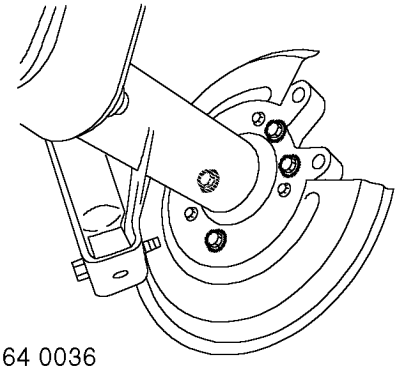
M64 0034

3. Release stake in drive shaft nut.
4. With an assistant depressing the brake pedal, remove and discard drive shaft nut.
5. Remove rear brake disc.
   ☞ **BRAKES, REPAIRS, Brake disc - rear.**



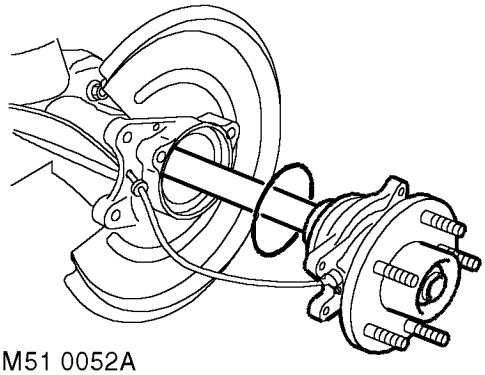
M51 0117

6. Disconnect ABS sensor multiplug.
7. Release harness from brake hose and hose bracket.



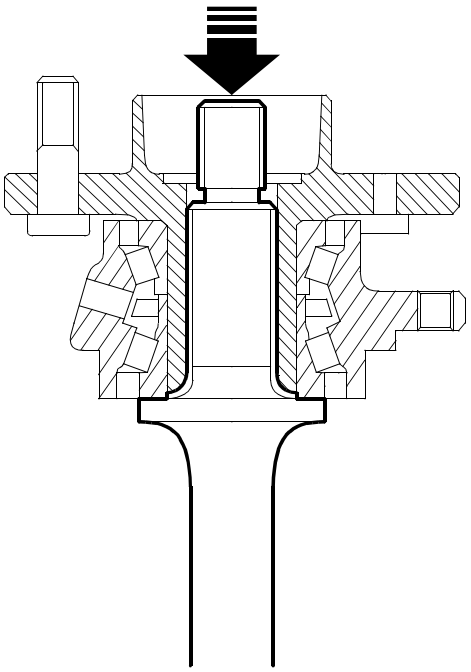
M64 0036

8. Remove 4 bolts securing wheel hub to axle.



M51 0052A

9. Release and remove wheel hub and drive shaft assembly from axle. Remove and discard 'O' ring from wheel hub.

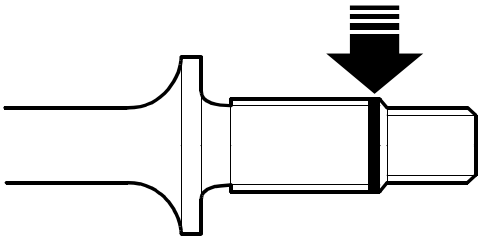


M51 0057

10. Position the wheel hub and drive shaft on a press, place supports beneath the wheel studs and press the drive shaft from the wheel hub.

Refit

1. Clean drive shaft splines, wheel hub and axle mating faces, ABS sensor and sensor recess.
2. Fit drive shaft to axle casing.
3. Lubricate new bearing hub 'O' ring with clean differential oil.
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Lubrication.**
4. Fit 'O' ring to wheel hub.



M51 0058

5. Apply a 3 mm (0.125 in) wide bead of Loctite 640 around drive shaft circumference as illustrated.
6. Fit wheel hub to drive shaft and align to axle. The Loctite will smear along the length of the splines as the wheel hub is fitted to the drive shaft.
7. Fit bolts securing wheel hub to axle and tighten to 100 Nm (74 lbf.ft).
8. Fit new drive shaft nut and lightly tighten.
9. Fit rear brake disc.
   ☞ **BRAKES, REPAIRS, Brake disc - rear.**
10. With an assistant depressing the brake pedal, tighten drive shaft nut to 490 Nm (360 lbf.ft). Stake drive shaft nut. **The drive shaft nut must be tightened before the Loctite has cured.**
11. Connect ABS sensor multiplug and secure harness to harness bracket and brake hose.
12. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
13. Remove stand(s) and lower vehicle.

Road spring - rear

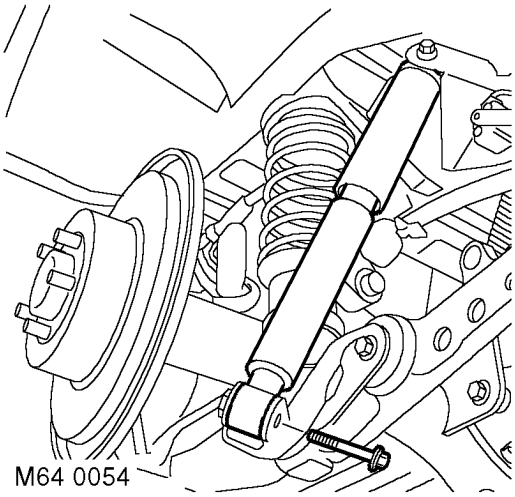
64.20.01

Remove

1. Raise rear of vehicle.

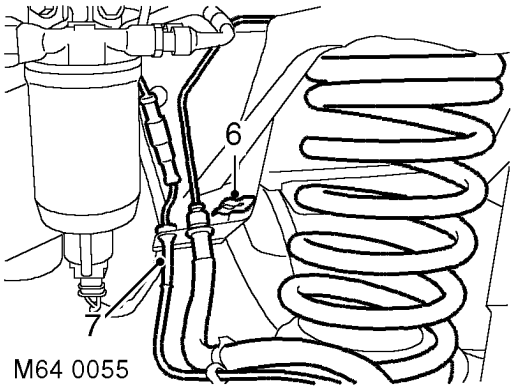
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Support vehicle under chassis.
3. Remove road wheel.
4. Support weight of axle on a jack.


M64 0054

5. Remove bolt securing damper to axle.

   WARNING: Make sure the axle cannot move when the damper is disconnected. The damper limits the downward movement of the axle. If the axle is not restrained, disconnecting the damper will allow unrestricted movement which may cause personal injury or damage to equipment.



M64 0055

6. Remove clip securing brake pipe to bracket.
7. Release ABS sensor lead from bracket.
8. Lower axle on jack and remove spring.

Refit

1. Ensure spring seats are clean.
2. Fit spring with close coil uppermost.
3. Ensure spring is correctly located on spring seats and raise axle. Fit and tighten bolt securing damper to axle to 124 Nm (91 lbf.ft).
4. Fit clip to secure brake pipe to bracket.
5. Fit ABS sensor lead to bracket.
6. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
7. Remove stand(s) and lower vehicle.

Air spring - SLS

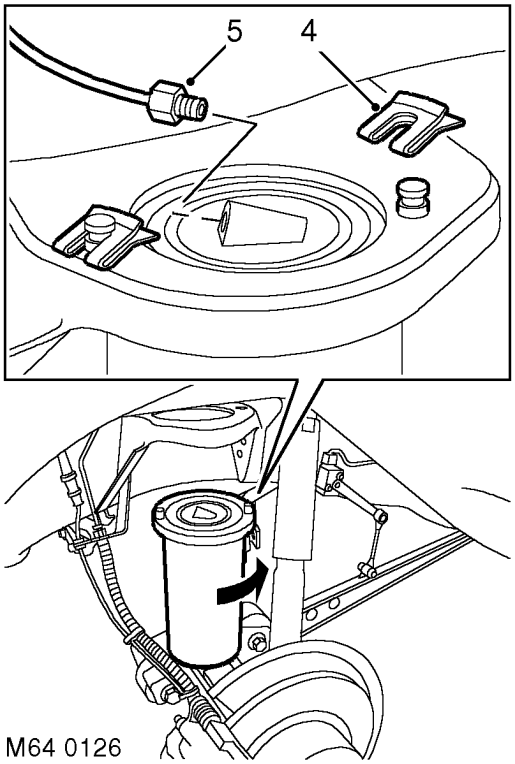
64.21.01

Remove

1. Using TestBook, depressurise SLS air system. **After depressurisation, approximately 1 bar (15 lbf.in^2) air pressure remains in the system.**
2. Raise rear of vehicle and support under chassis.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

3. Remove road wheel.



M64 0126

4. Remove 2 clips securing air spring to chassis.
5. Collapse air spring and disconnect pipe from top of air spring.

   CAUTION: Always fit plugs to open connections to prevent contamination.

6. Rotate air spring, to unlock from axle and remove from vehicle.
7. Remove connector from pipe.

Refit

1. Clean mating faces of air spring, axle and chassis.
2. Fit pipe connector to air spring.
3. Locate air spring on axle and rotate 90° to fully engage bayonet fitting.
4. Connect pipe to top of air spring.
5. Engage top locating pins of air spring in chassis and secure with clips.
6. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
7. Remove stand(s) and lower vehicle.

Damper - rear

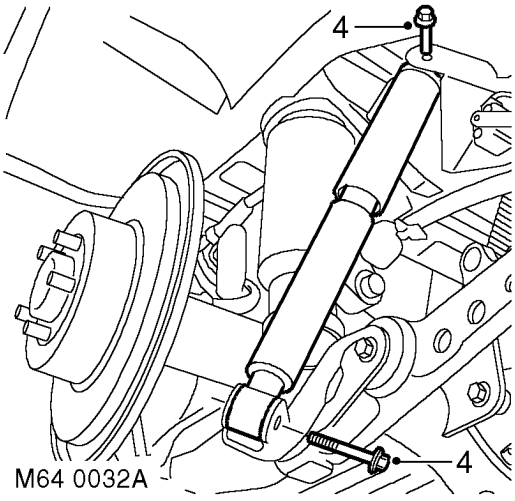
64.30.02

Remove

1. Raise rear of vehicle and support under chassis.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Remove road wheel.
3. Support weight of axle on a jack.



4. Remove 2 bolts securing damper to axle and chassis.

   WARNING: Make sure the axle cannot move when the damper is disconnected. The damper limits the downward movement of the axle. If the axle is not restrained, disconnecting the damper will allow unrestricted movement which may cause personal injury or damage to equipment.

5. Compress damper and remove from vehicle.

Refit

1. Locate damper in axle and fit lower bolt, extend damper to chassis and fit top bolt.
2. Tighten damper bolts to 125 Nm (92 lbf.ft).
3. Lower axle and remove jack.
4. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
5. Remove stand(s) and lower vehicle.

Bushes - radius arm

64.35.29

Models with SLS:

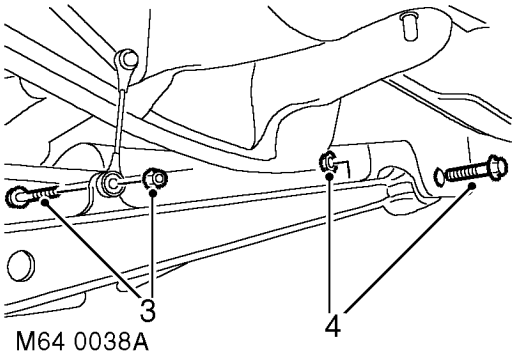
WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

Remove

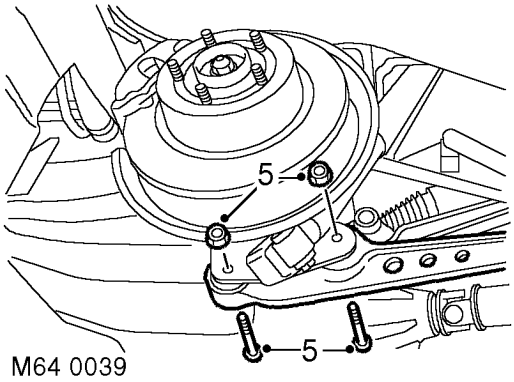
1. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

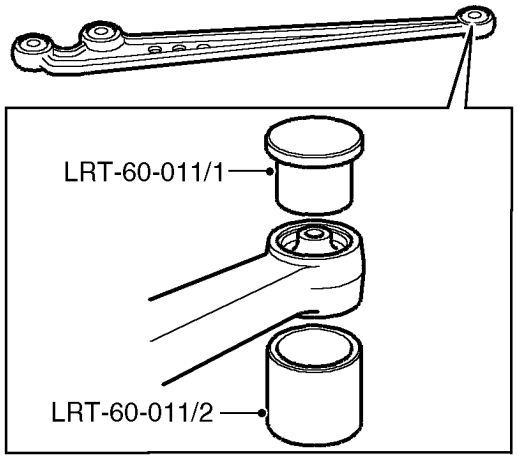
2. Remove road wheel(s).



3. **Models with SLS:** Remove nut and bolt securing height sensor link to radius arm.
4. Remove nut and bolt securing radius arm to chassis.



5. Remove nuts securing radius arm to axle. Remove rear bolt and lower radius arm. Remove front bolt and remove radius arm.

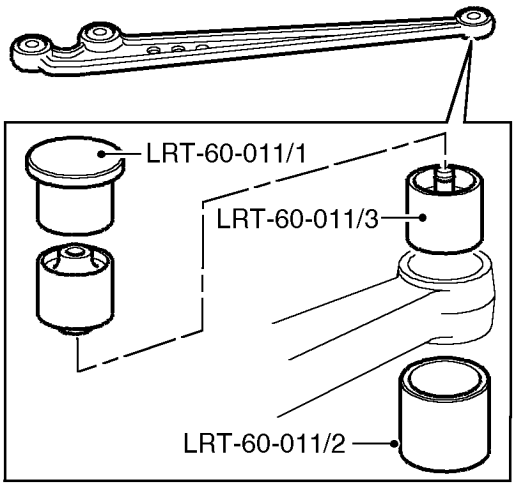


M64 0064C

6. Press out bushes from axle end of radius arm using a length of steel tubing.
7. Press out bush from rear of radius arm:
   - Use **LRT-60-011/1** and **LRT-60-011/2** to remove rear bush.

Refit

1. Clean bush locations in radius arms.



M64 0063C

2. Press in new bushes:
   - Use **LRT-60-011/1**, **LRT-60-011/2** and **LRT-60-011/3** to fit rear bush.
3. Position radius arm to vehicle. Fit bolts and nuts but do not tighten at this stage.
4. **Models with SLS:** Position height sensor link to radius arm and tighten nut and bolt to 25 Nm (18 lbf.ft).
5. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
6. Remove stand(s) and lower vehicle.
7. Tighten radius arm nuts and bolts to 230 Nm (170 lbf.ft).

   CAUTION: Nuts and bolts must be tightened with weight of vehicle on suspension.

8. Use TestBook to calibrate SLS height sensor.

Bushes - Watts linkage

64.35.35

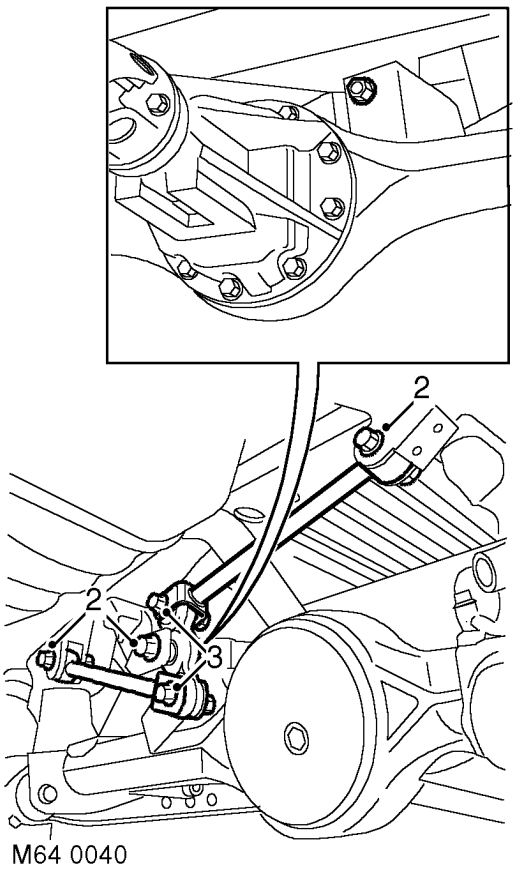
Models with SLS:

WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

Remove

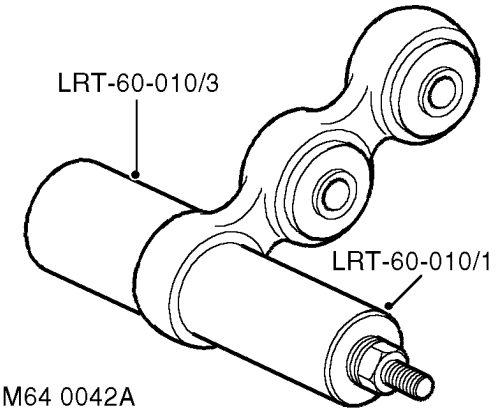
1. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M64 0040

2. Remove 3 nuts and bolts securing Watts linkage to axle and chassis and remove Watts linkage.
3. Remove 2 nuts and bolts securing transverse links to pivot housing and remove links from pivot housing.

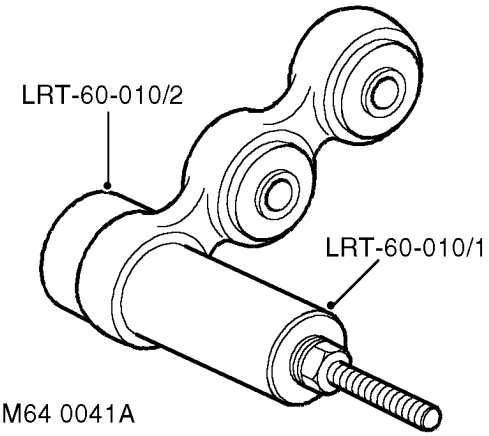


M64 0042A

4. Use **LRT-60-010/1** and **LRT-60-010/3** to press bushes from transverse links and pivot housing.

Refit

1. Clean bush locations in transverse links and pivot housing.



M64 0041A

2. Using **LRT-60-010/1** and **LRT-60-010/2**press new bushes into transverse links and pivot housing.
3. Position transverse links to pivot housing and tighten bolts to 155 Nm (114 lbf.ft).
4. Position Watts linkage to axle and chassis. Fit bolts but do not tighten at this stage.
5. Remove stand(s) and lower vehicle.
6. Tighten bolts securing pivot housing to axle to 230 Nm (170 lbf.ft). Tighten bolts securing transverse links to chassis to 140 Nm (103 lbf.ft).

   CAUTION: Nuts and bolts must be tightened with weight of vehicle on suspension.

Sensor - height - SLS

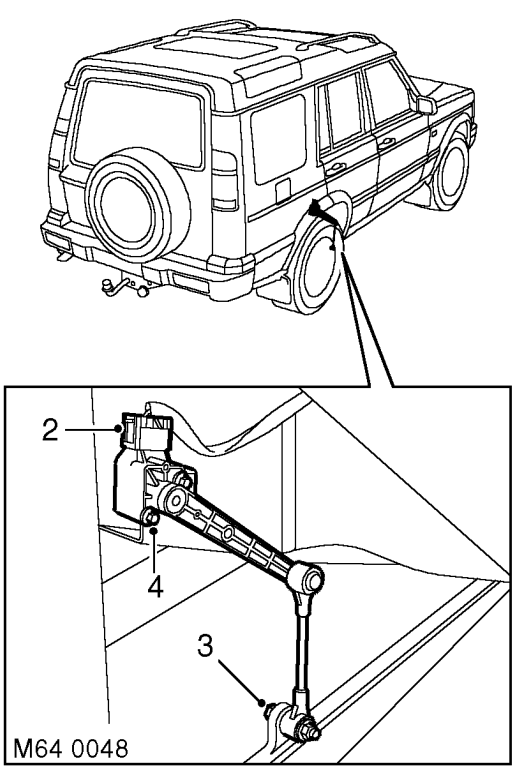
64.36.01

WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

Remove

1. Raise rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Disconnect height sensor multiplug.
3. Remove bolt securing height sensor link to radius arm.
4. Remove 2 bolts securing height sensor to chassis and remove height sensor.

Refit

1. Position height sensor to chassis and tighten bolts to 6 Nm (4.4 lbf.ft).
2. Position height sensor link to radius arm and tighten bolt to 25 Nm (18 lbf.ft).
3. Connect height sensor multiplug.
4. Remove stand(s) and lower vehicle.
5. Use TestBook to calibrate height sensor.

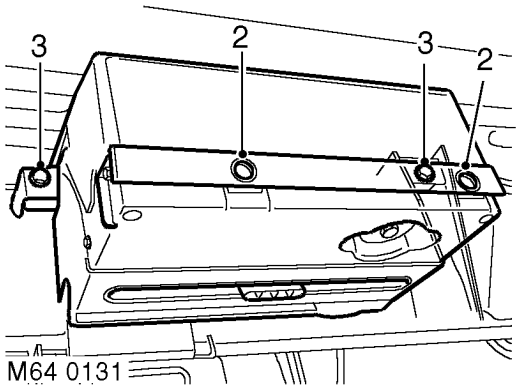
Compressor unit - air - SLS

64.50.10

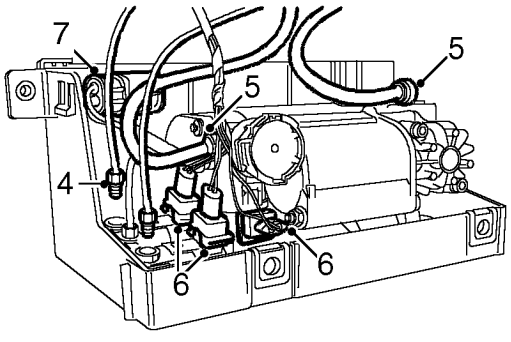
WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

Remove

1. Using TestBook, depressurise SLS air system. **After depressurisation, approximately 1 bar (15 lbf.in^2) air pressure remains in the system.**



2. Release 2 fasteners and remove air compressor unit cover.
3. Remove 2 bolts securing air compressor unit to chassis. Release unit and lower onto blocks to support the weight.

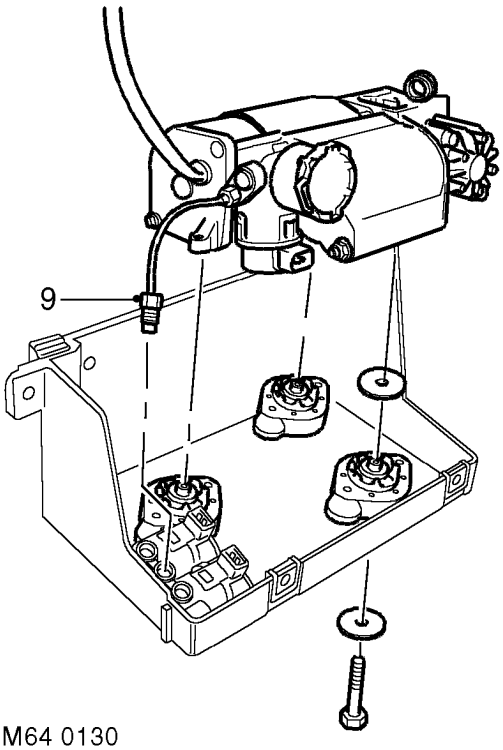


4. Noting their fitted position, disconnect pipes from air valves.

   CAUTION: Always fit plugs to open connections to prevent contamination.

5. Disconnect inlet and exhaust pipes.
   CAUTION: Always fit plugs to open connections to prevent contamination.

6. Disconnect multiplugs from air valves, exhaust valve and compressor.
7. Release and disconnect compressor multiplug from casing.
8. Remove air compressor unit from vehicle.



M64 0130

9. Release supply/exhaust pipe.
   CAUTION: Always fit plugs to open connections to prevent contamination.

10. Remove 3 bolts securing compressor to casing. Remove compressor and collect mounting washers.

Refit

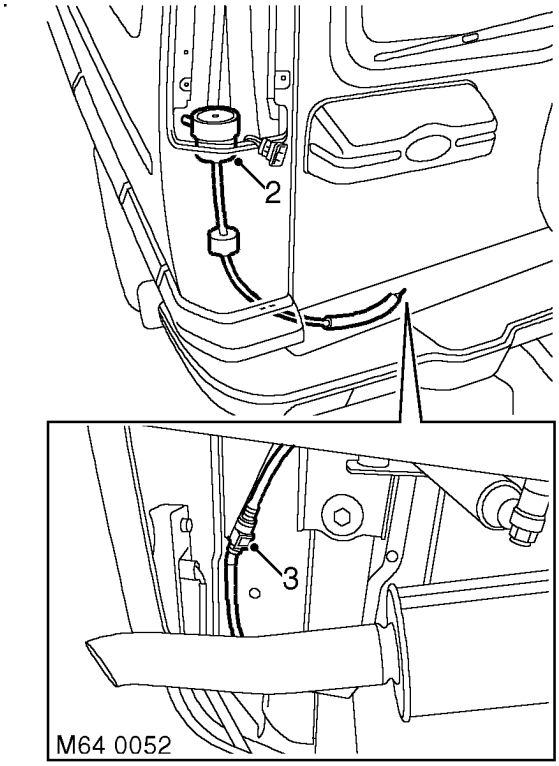
1. Locate mounting washers and position compressor in casing.
2. Apply Loctite 270 to compressor securing bolts. Fit bolts and tighten to 7 Nm (5.2 lbf.ft).
3. Connect compressor multiplug to casing.
4. Connect supply/exhaust pipe.
5. Position air compressor unit on support block, connect inlet and exhaust pipes.
6. Connect multiplugs to air valves, exhaust valve and compressor.
7. Connect pipes to air valves.
8. Position air compressor unit to chassis and engage casing in retaining lugs. Fit air compressor unit securing bolts and tighten to 25 Nm (18 lbf.ft).
9. Ensure pipes are located in cut outs in casing.
10. Position air compressor unit cover and lock fasteners.

Filter - intake - SLS

64.50.12

Remove

1. Remove LH tail lamp.
   LIGHTING, REPAIRS, Lamp - tail.



2. Disconnect filter from retaining peg.
3. Disconnect quick release connection and remove filter assembly.

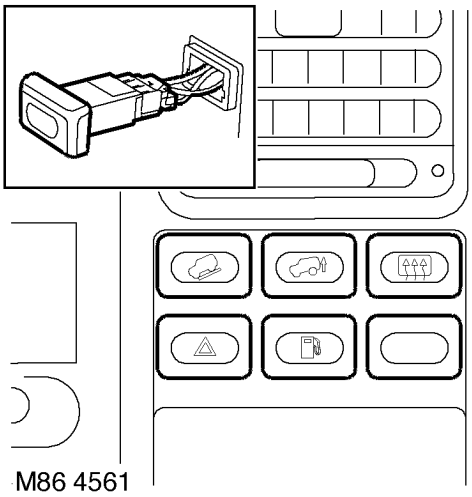
Refit

1. Position filter assembly and connect quick release connection.
2. Secure filter retaining peg.
3. Fit LH tail lamp.
   LIGHTING, REPAIRS, Lamp - tail.

Switch - ride height

64.50.45

Remove



1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

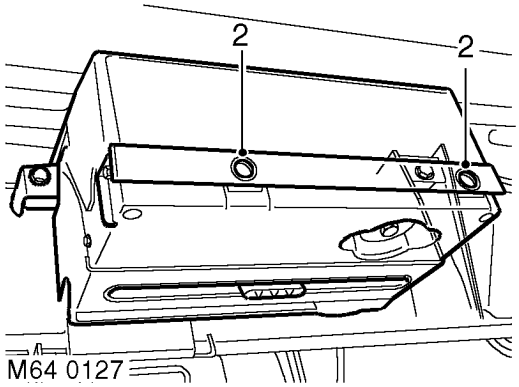
Air valve - SLS

64.50.47

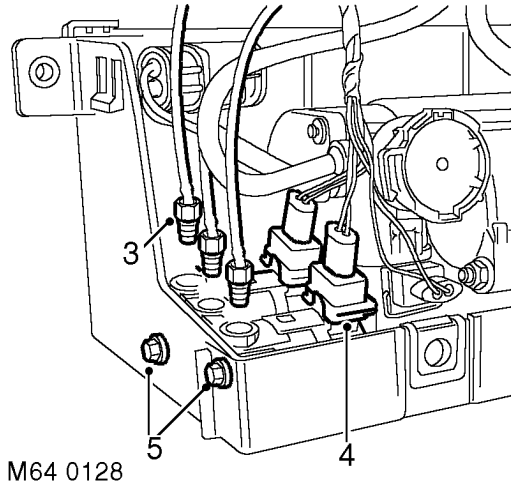
WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

Remove

1. Using TestBook, depressurise SLS air system. **After depressurisation, approximately 1 bar (15 lbf.in^2) air pressure remains in the system.**



2. Release 2 fasteners and remove air compressor unit cover.



3. Noting their fitted position, disconnect pipes from air valves and discard 'O' rings.
4. Disconnect air valve multiplugs.
5. Remove 2 bolts securing air valves and remove air valves.

Refit

1. Position air valves and fit and tighten bolts.
2. Connect air valve multiplugs.
3. Connect air valve pipes.
4. Ensure pipes are located in cut outs in casing.
5. Position air compressor unit cover and lock fasteners.

Actuator - rear - ACE

64.60.40

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

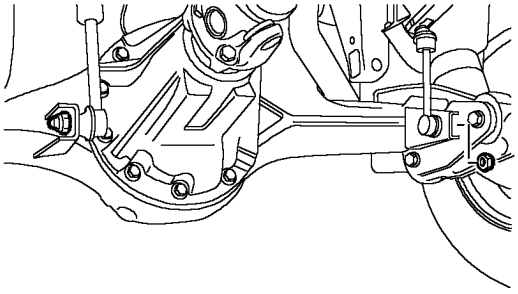
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Models with SLS:

WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

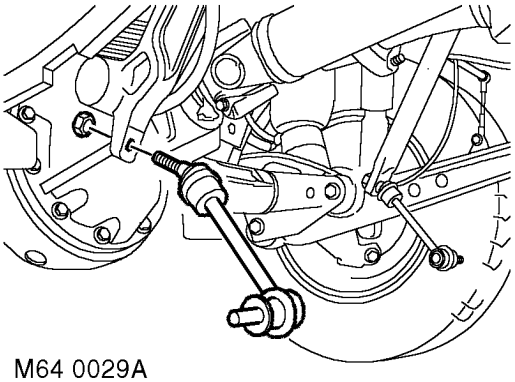
Remove

1. Raise vehicle on ramp.



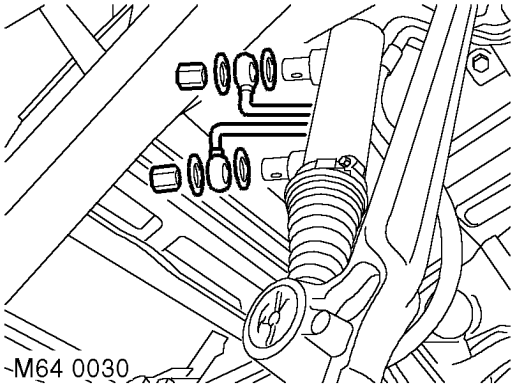
M64 0021

2. Remove nuts securing anti-roll bar links to axle. Release links from axle.
3. Pull torsion bar down for access to actuator.



M64 0029A

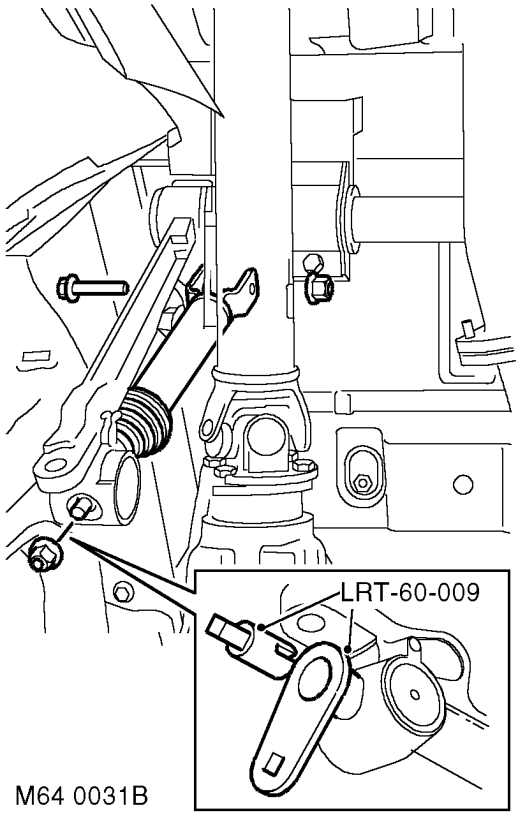
4. Remove nut securing anti-roll bar link to long arm and remove link.
5. Position container to collect fluid spillage.



M64 0030

6. Remove cap nuts securing fluid pipes to actuator. Disconnect pipes and remove and discard sealing washers.

   CAUTION: Always fit plugs to open connections to prevent contamination.



7. Use **LRT-60-009** to remove nut securing actuator push rod to long arm.
8. Remove nut and bolt securing actuator to short arm and remove actuator.

CAUTION: The short arm and torsion bar are supplied as an assembly and must not be separated.

Refit

1. Position actuator and tighten nut and bolt securing actuator to short arm to 180 Nm (133 lbf.ft).
2. Using **LRT-60-009** , fit and tighten nut securing actuator push rod to long arm to 48 Nm (35 lbf.ft).
3. Connect pipes to actuator with cap nuts and new sealing washers. Tighten cap nuts to 29 Nm (21 lbf.ft). **Ensure pipes are not under tension or kinked.**
4. Connect anti-roll bar link to long arm and tighten nut to 50 Nm (37 lbf.ft).
5. Ensure washer is in place on lower ball joint of each anti-roll bar link and connect lower ball joints to axle. Tighten nuts to 100 Nm (74 lbf.ft).
6. Renew ACE high pressure filter.
   ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
7. Lower vehicle.
8. Bleed ACE hydraulic system.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**

Bushes - rear long arm - ACE

64.60.46

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

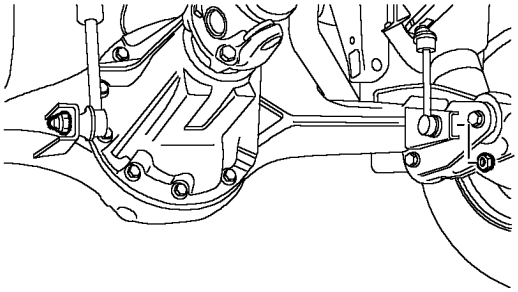
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Models with SLS:

WARNING: Ensure the air suspension system is made safe before commencing work. Otherwise the chassis may lower onto the bump stops during repair.

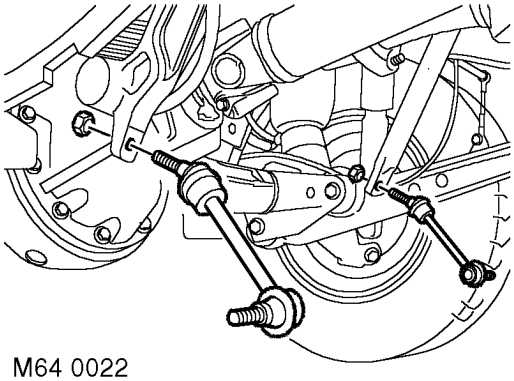
Remove

1. Raise vehicle on ramp.



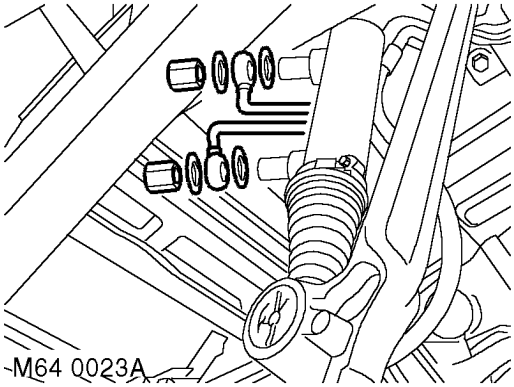
M64 0021

2. Remove nuts securing anti-roll bar links to axle. Release links from axle.
3. Pull torsion bar down for access to actuator.



M64 0022

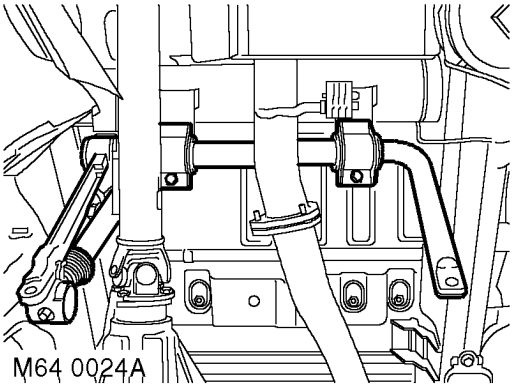
4. Remove securing nuts and remove anti-roll bar links from torsion bar.
5. Position container to collect fluid spillage.



M64 0023A

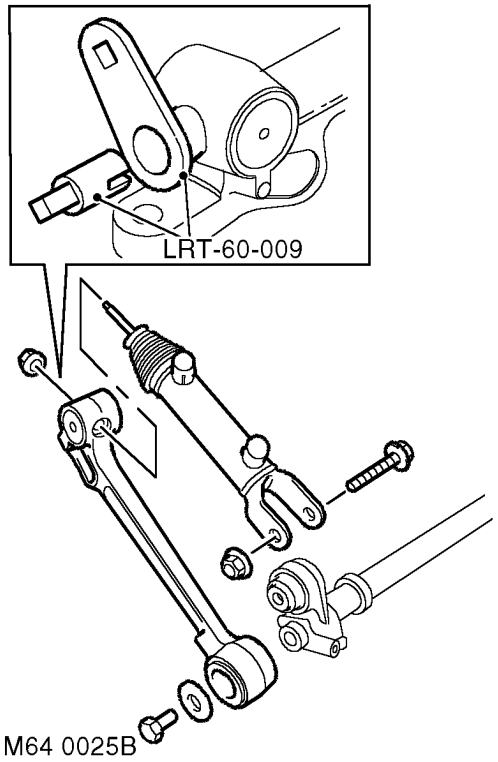
6. Remove cap nuts securing fluid pipes to actuator. Disconnect pipes and remove and discard sealing washers.

   CAUTION: Always fit plugs to open connections to prevent contamination.



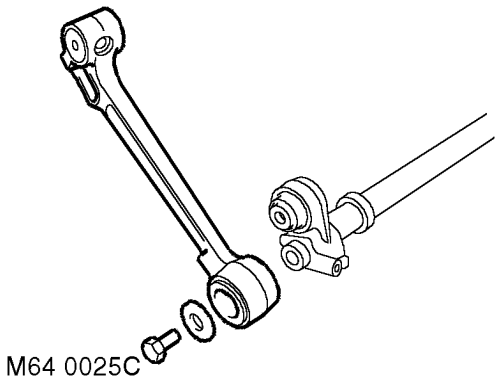
M64 0024A

7. With assistance, remove bolts securing torsion bar clamps. Remove clamps and remove torsion bar and actuator.



M64 0025B

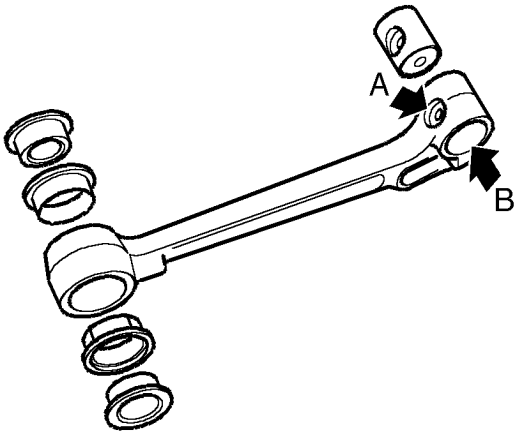
8. Use **LRT-60-009** to remove nut securing actuator push rod to long arm.
9. Remove nut and bolt securing actuator to short arm and remove actuator.

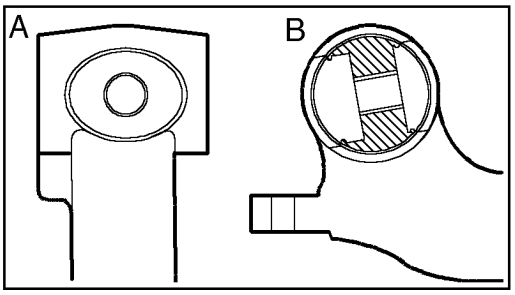


M64 0025C

10. Restrain torsion bar and remove long arm securing bolt and washer. Remove long arm from torsion bar.

CAUTION: The short arm and torsion bar are supplied as an assembly and must not be separated.



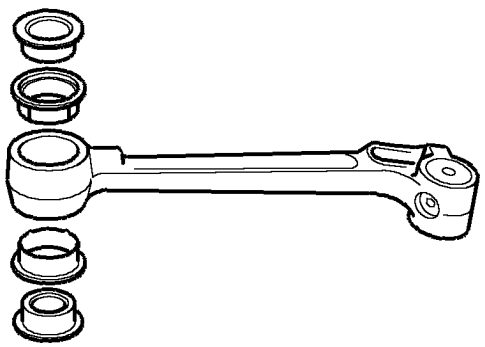


M60 0568A

11. Use a suitable drift to remove both halves of slipper bush from long arm.
12. Use suitable adaptors to press actuator rod end bush from long arm.

Refit

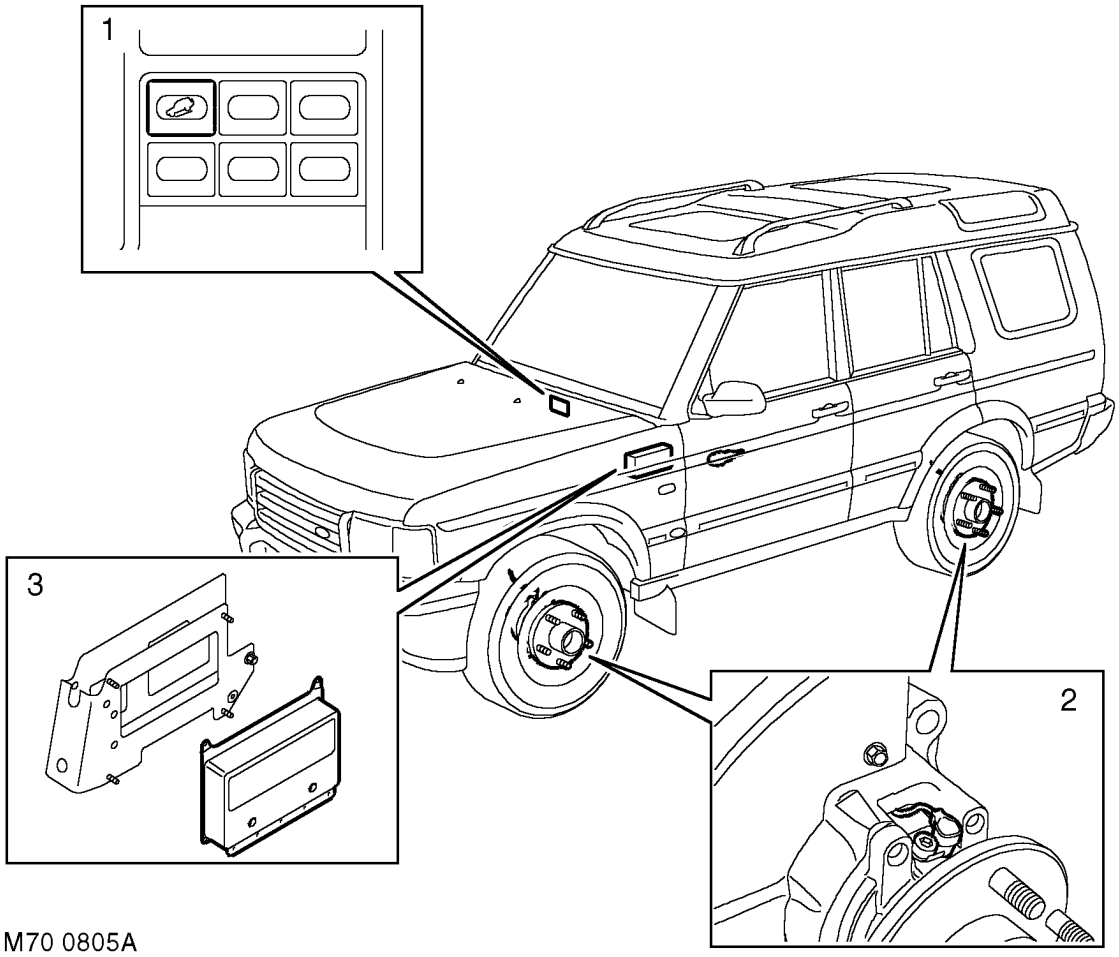
1. Clean bush locations in long arm.
2. Use suitable adaptors to press new actuator rod end bush into long arm. Ensure bush is correctly aligned.



M64 0027A

3. Align slots in new slipper bush halves with those in long arm. Carefully press both halves of slipper bush into long arm. Ensure the sealing rings on the bush faces are not damaged.
4. Clean long arm and mating face on torsion bar.
5. Fit long arm to torsion bar. Restrain torsion bar and tighten bolt to 180 Nm (133 lbf.ft).
6. Ensure actuator and bushes are clean.
7. Fit actuator and tighten nut and bolt securing actuator to short arm to 180 Nm (133 lbf.ft).
8. Using **LRT-60-009** , fit and tighten nut securing actuator push rod to long arm to 48 Nm (35 lbf.ft).
9. With assistance, position torsion bar and actuator to vehicle and fit torsion bar clamps. Tighten torsion bar clamp bolts to 45 Nm (33 lbf.ft).
10. Connect pipes to actuator with cap nuts and new sealing washers. Tighten cap nuts to 29 Nm (21 lbf.ft). **Ensure pipes are not under tension or kinked.**
11. Fit anti-roll bar links to torsion bar and tighten nuts to 50 Nm (37 lbf.ft).
12. Ensure washer is in place on lower ball joint of each anti-roll bar link and connect lower ball joints to axle. Tighten nuts to 100 Nm (74 lbf.ft).
13. Renew ACE high pressure filter.
    ☞ **FRONT SUSPENSION, REPAIRS, Filter - high pressure - ACE.**
14. Lower vehicle.
15. Bleed ACE hydraulic system.
    ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**

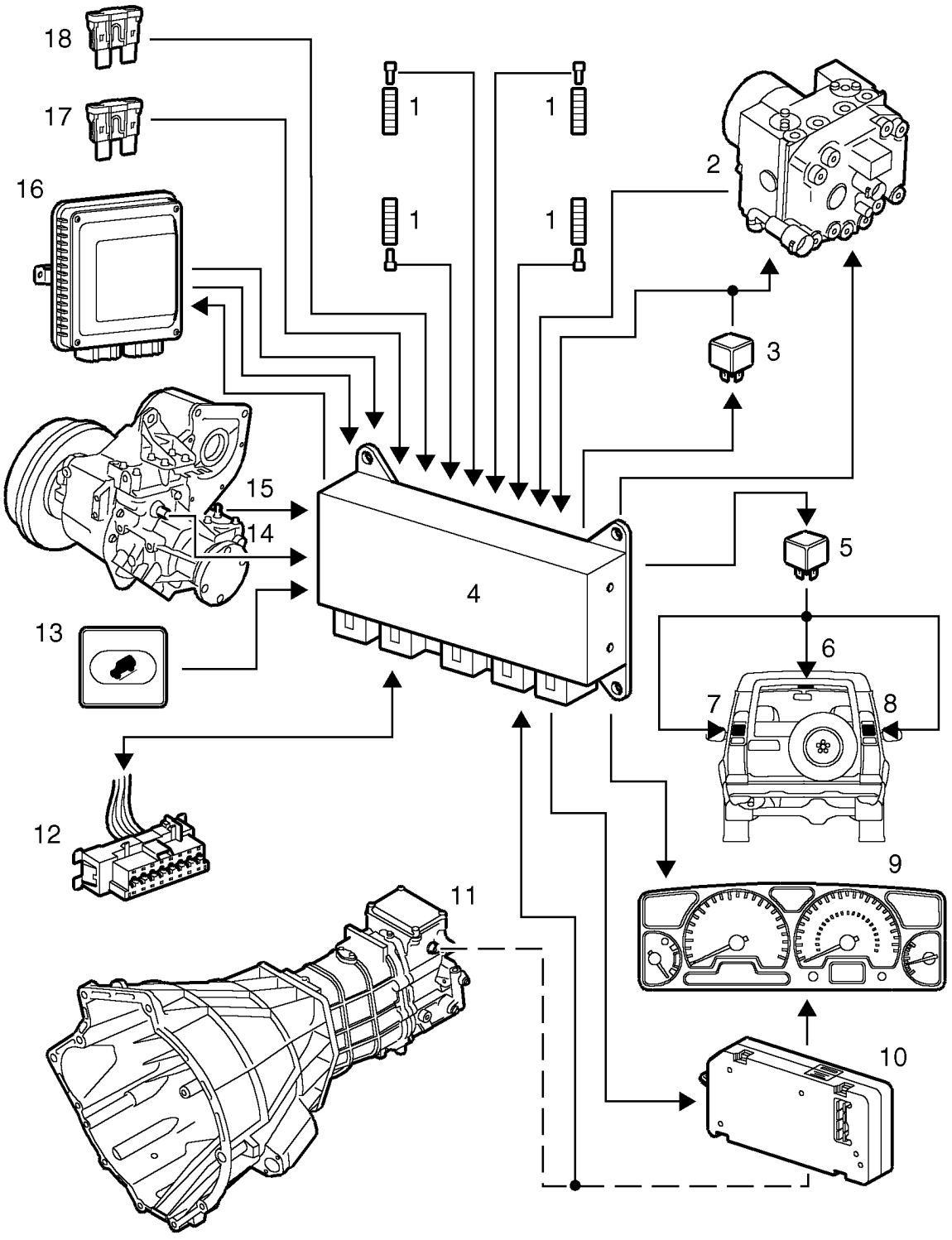
Brake system control component layout



RH drive shown, LH drive similar

1 Hill descent switch
2 ABS sensor
3 SLABS ECU

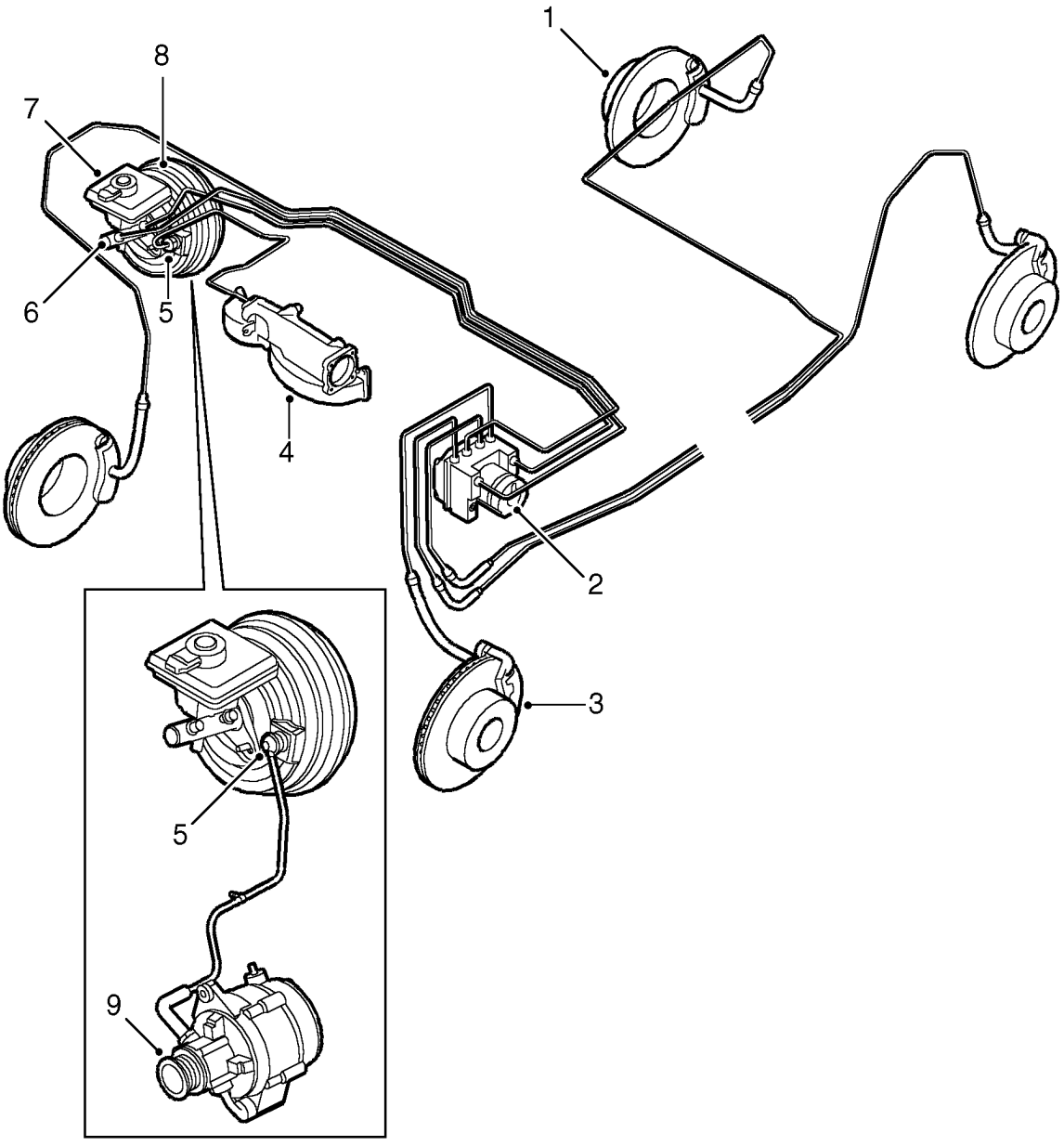
Brake system control diagram



M70 0845

1 ABS sensor
2 ABS modulator
3 Return pump relay
4 SLABS ECU
5 Brake lamp relay
6 Centre high mounted stop lamp
7 LH brake lamp
8 RH brake lamp
9 Instrument pack
10 Body control unit
11 Reverse lamp switch (manual gearbox)
12 Diagnostic socket
13 HDC switch
14 Transmission high/low switch
15 Centre differential lock switch
16 Engine control module
17 Battery power supply
18 Ignition power supply

Brake system hydraulic component layout



M70 0804

RH drive shown, LH drive similar

1 Rear brake
2 ABS modulator
3 Front brake
4 Inlet manifold plenum (V8 models)
5 Non return valve
6 Master cylinder assembly
7 Brake fluid reservoir
8 Brake servo assembly
9 Vacuum pump (diesel models)

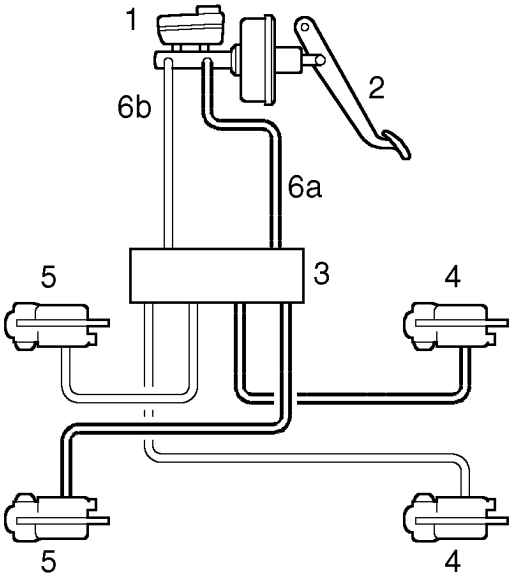
Description

General

The brakes consist of front and rear disc brakes operated by a diagonally split, dual circuit hydraulic system with vacuum servo power assistance. The system incorporates the following control functions as standard on all models:

- Anti-lock Brakes (ABS), to prevent road wheels locking during brake application.
- Electronic Brake Distribution (EBD), to control distribution of hydraulic pressure between front and rear axles. Replaces mechanical pressure limiting valve of previous systems.
- Electronic Traction Control (ETC), to maintain even torque distribution to the road wheels.
- Hill Descent Control (HDC), to provide controlled descent ability in off road conditions.

Hydraulic system schematic



M70 0806

1 Master cylinder/brake servo assembly
2 Brake pedal
3 ABS modulator
4 Rear brake
5 Front brake
6 Hydraulic circuit
  a Primary
  b Secondary

For normal brake operation, brake pedal movement is assisted by the brake servo assembly and transmitted to the master cylinder assembly. The master cylinder assembly converts brake pedal movement to hydraulic pressure. Primary and secondary brake pipe circuits supply the hydraulic pressure to the brakes via the ABS modulator: the primary circuit supplies the front left and rear right brakes; the secondary circuit supplies the front right and rear left brakes. Vacuum for the brake servo assembly is obtained from the engine inlet manifold (V8 models) or a vacuum pump (diesel models), through a vacuum line and non return valve. To reduce operating noise, sleeving is installed on some of the brake pipes in the engine compartment and the pipes are located in sprung pipe clips.

For all control functions, the ABS modulator regulates the hydraulic pressure to the brakes to control the speed of all four wheels, either individually or in axle pairs. Operation of the ABS modulator is controlled by the Self Levelling and Anti-lock Braking Systems (SLABS) ECU. The SLABS ECU also operates warning indications in the instrument pack to provide the driver with status information on each function.

Brake servo assembly

The brake servo assembly provides power assistance to reduce the pedal load when braking. If the brake servo assembly fails, the hydraulic system still functions but will require greater brake pedal effort due to the lack of vacuum assistance.

Two integral tie bolts attach the brake servo assembly to the pedal and bracket assembly on the engine bulkhead. The master cylinder assembly is attached to the forward ends of the tie bolts.

The brake servo assembly consists of a circular housing which contains two diaphragms, a central plate, a control valve assembly, input and output push rods and a filter. The input push rod is connected to the brake pedal. The output push rod locates in the primary piston of the master cylinder. A protective gaiter is installed on the control valve assembly where it extends from the rear of the housing. A non return valve, installed in a port in the front face of the housing, is connected to a vacuum line from the engine.

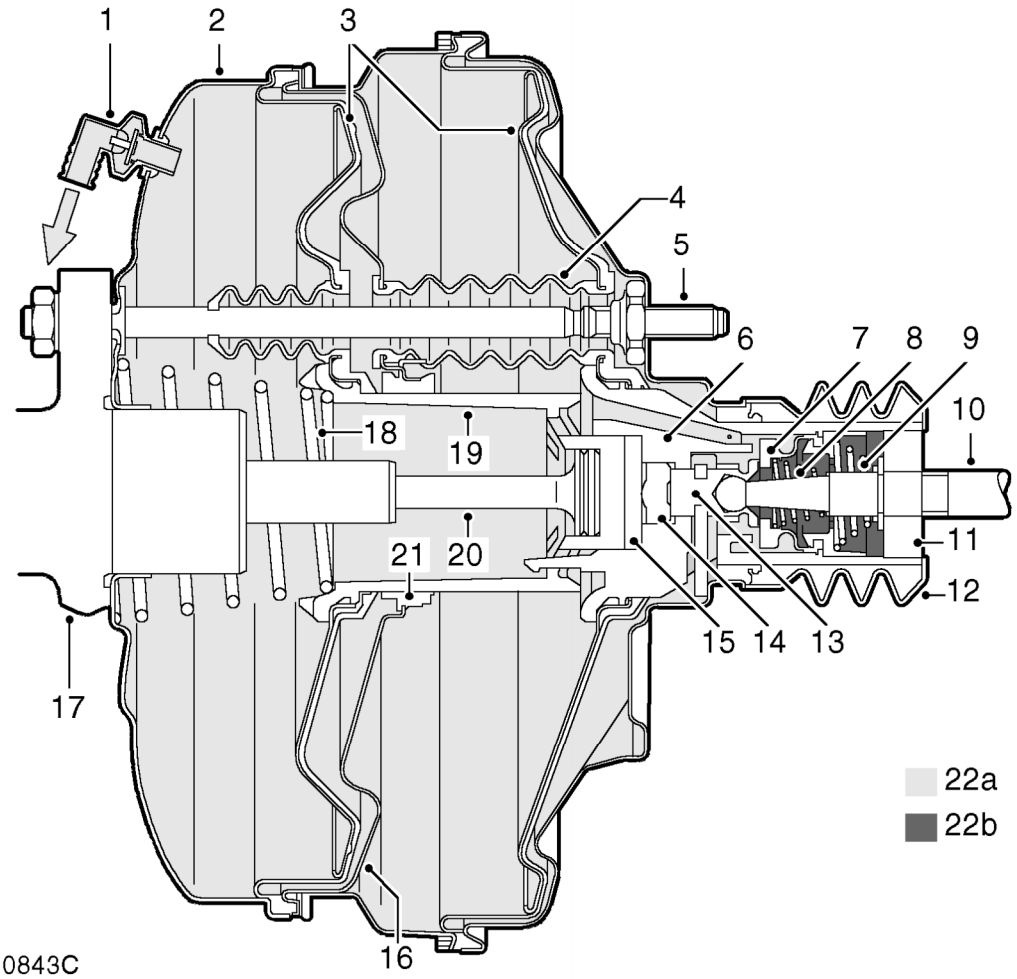
The control valve assembly consists of a valve body containing a valve, a piston, a valve spring and an input rod spring. The valve controls a vacuum port in the valve body. The piston controls an air inlet port between the valve and the piston. A reaction disc and a ratio disc separate the piston from the output push rod. A guide tube on the front of the valve body is attached to the front diaphragm and supported in a bush in the central plate. A return spring locates in the open end of the guide tube.

The two diaphragms and the central plate separate the interior of the housing into four sealed chambers. The chambers at the front of the diaphragms are connected together through fixed passages in the valve assembly. The chambers at the rear of the diaphragms are connected together through the interior of minor diaphragms on the tie bolts.

Brakes off

With the brake pedal released, the piston in the control valve assembly positions the valve so that the vacuum port is open and the two pairs of chambers are connected together. When the engine is running air is evacuated through the vacuum line and non return valve, creating a partial vacuum in all four chambers. When the engine stops, the non return valve closes to maintain the partial vacuum and, on V8 models, prevent fuel vapour entering the brake servo.

Section through brake servo assembly - brakes off



M70 0843C

1 Non return valve
2 Housing
3 Diaphragms
4 Minor diaphragm
5 Tie bolt
6 Valve body
7 Valve
8 Valve spring
9 Input rod spring
10 Input push rod
11 Filter
12 Gaiter
13 Piston
14 Ratio disc
15 Reaction disc
16 Central plate
17 Master cylinder
18 Return spring
19 Guide tube
20 Output push rod
21 Bush
22 Air pressures
- **a** Partial vacuum
- **b** Ambient

Brakes on

When the brake pedal is pressed, the input push rod and the piston initially move forward in the valve body. The valve body and output rod then move with the input rod, against resistance from the return spring, to transmit the brake pedal force to the master cylinder assembly.

During the initial movement of the piston, the valve, assisted by the valve spring, moves with the piston and closes the vacuum port to isolate the chambers at the rear of the diaphragms from the vacuum source. Further movement of the input push rod causes the piston to move away from the valve and open the air inlet port. This allows a restricted flow of filtered ambient air through the air inlet port, which creates a servo pressure in the chambers at the rear of the diaphragms. Force from the resultant pressure differential across the diaphragms is transmitted through the valve body to the output push rod, augmenting the pressure being applied by the brake pedal. The force produced by the diaphragms, in proportion to the input force, i.e. the boost ratio, is 5.6 : 1. The boost ratio remains constant, as the input force from the brake pedal increases, until the limit of assistance is reached when servo pressure is equal to ambient pressure.

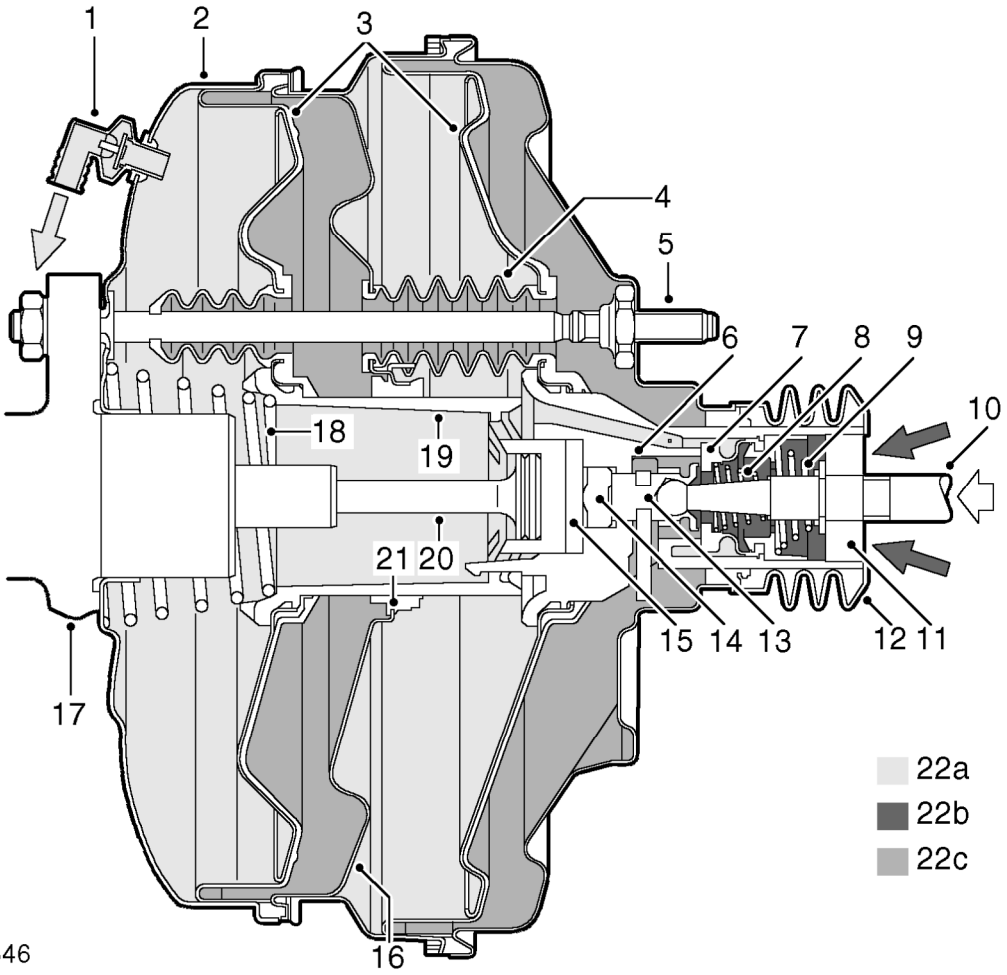
Brakes held on

When the brake pedal effort is constant, opposing pressures cause the reaction disc to extrude onto the ratio disc, which moves the piston against the valve to close the air inlet port. This prevents any further increase in servo pressure and maintains a constant output force to the master cylinder assembly.

Brakes released

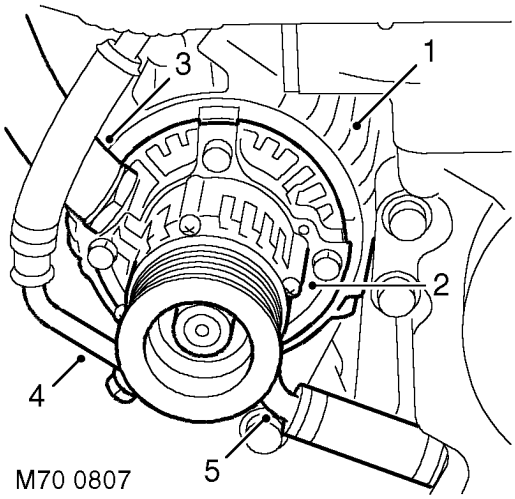
When the brake pedal is released, the input rod spring moves the input rod and piston rearwards within the valve body to close the air inlet port and open the vacuum port. The air from the chambers at the rear of the diaphragms is then evacuated, through the vacuum port and the chambers at the front of the diaphragms, to restore a partial vacuum in all four chambers. Simultaneously, the return spring moves the valve body, diaphragms, output rod and input rod rearwards to return them to their brakes off position.

Section through brake servo assembly - brakes on



1 Non return valve
2 Housing
3 Diaphragms
4 Minor diaphragm
5 Tie bolt
6 Valve body
7 Valve
8 Valve spring
9 Input rod spring
10 Input push rod
11 Filter
12 Gaiter
13 Piston
14 Ratio disc
15 Reaction disc
16 Central plate
17 Master cylinder
18 Return spring
19 Guide tube
20 Output push rod
21 Bush
22 Air pressures
- **a** Partial vacuum
- **b** Ambient
- **c** Servo

Vacuum pump (diesel models only)



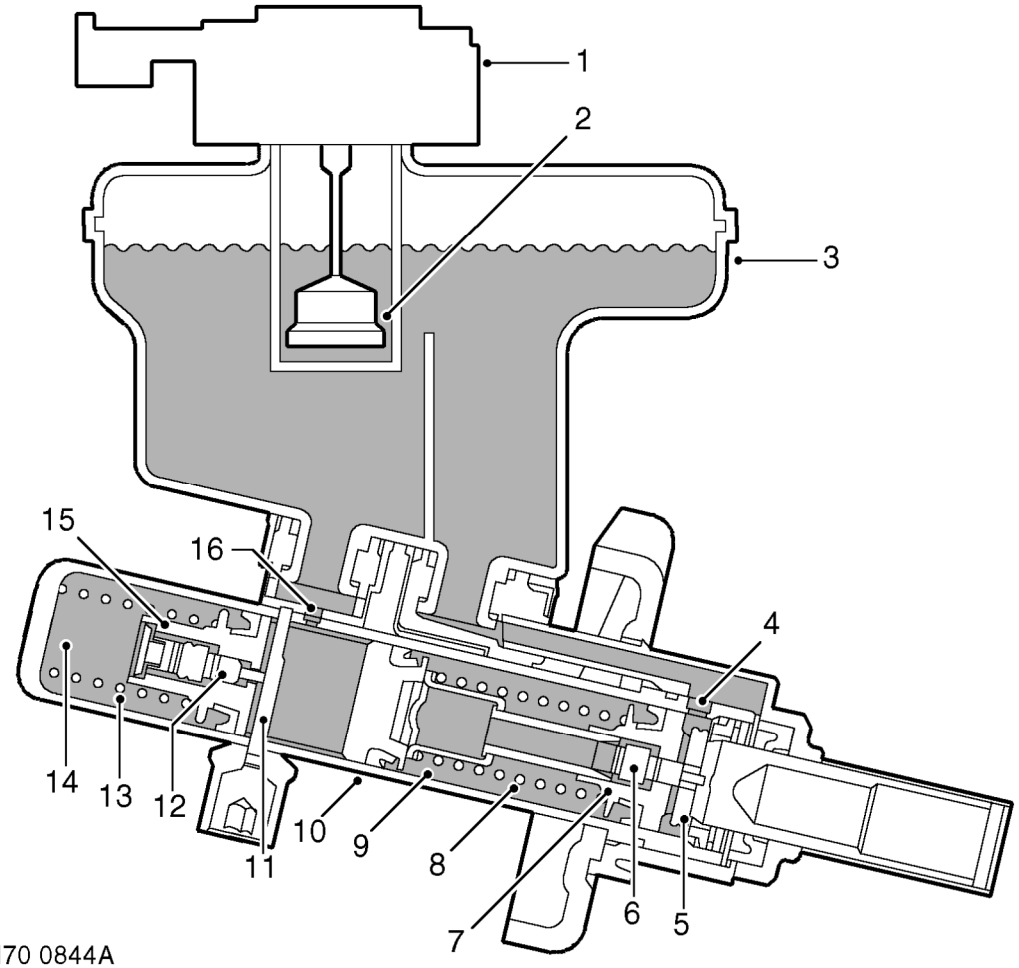
1 Alternator
2 Vacuum pump
3 Brake servo assembly vacuum connection
4 Oil feed pipe
5 Oil drain pipe

As the diesel engine air inlet system does not produce sufficient depression to operate the brake servo assembly, an engine driven vacuum pump is installed.

The vacuum pump is integrated with the engine alternator and driven by the auxiliary drive belt. The pump is a rotary vane type, lubricated and cooled by engine oil supplied through a pipe connected to the engine block and returned through a pipe connected to the engine oil sump. Air extracted from the brake servo assembly is vented into the oil sump with returning lubricating oil.

Master cylinder assembly

Section through master cylinder assembly



1 Reservoir filler cap
2 Switch float
3 Brake fluid reservoir
4 Primary feed hole
5 Valve pin
6 Primary centre valve
7 Primary piston
8 Primary spring
9 Pressure chamber
10 Cylinder
11 Valve pin
12 Secondary centre valve
13 Secondary spring
14 Pressure chamber
15 Secondary piston
16 Secondary feed hole

The master cylinder assembly produces hydraulic pressure to operate the brakes when the brake pedal is pressed.

The assembly is attached to the front of the brake servo assembly, and comprises a cylinder containing two pistons in tandem. The rear piston produces pressure for the primary circuit and the front piston produces pressure for the secondary circuit. A brake fluid reservoir is installed on top of the cylinder. The reservoir is internally divided to provide an independent supply of fluid to each brake circuit, and so prevent a single fluid leak from disabling both primary and secondary brake circuits. Should a failure occur in one circuit, the remaining circuit will still operate effectively, although brake pedal travel and vehicle braking distances will increase. If the fluid level in the reservoir is too low, a float operated switch in the reservoir filler cap connects an earth to the instrument pack, which illuminates the brake warning lamp.

Brakes applied

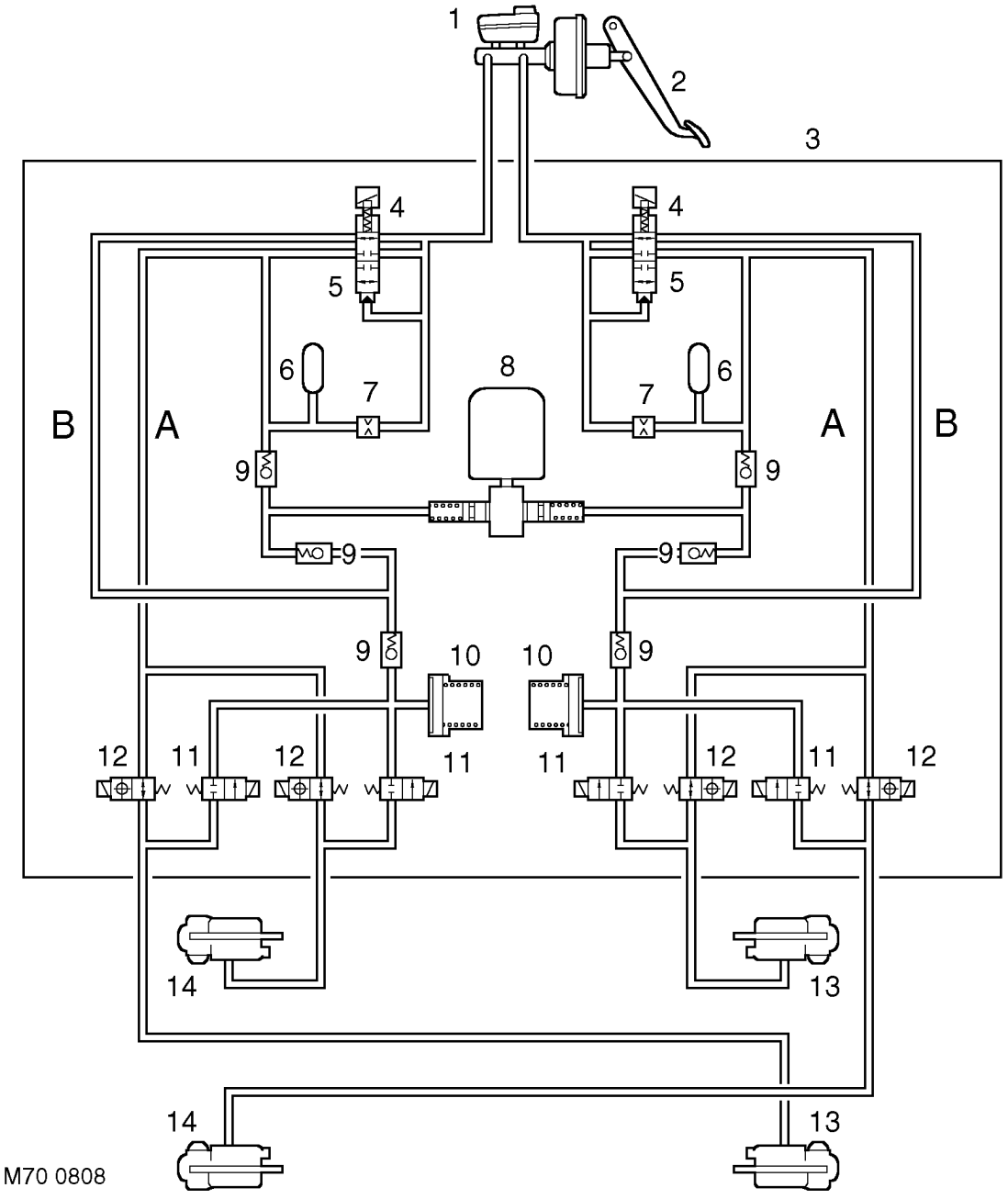
When the brake pedal is pressed, the output rod in the brake servo assembly pushes the primary piston along the cylinder bore. This produces pressure in the primary pressure chamber which, in conjunction with the primary spring, overcomes the secondary spring and simultaneously moves the secondary piston along the cylinder bore. The initial movement of the pistons, away from the piston stops, closes the primary and secondary centre valves. Further movement of the pistons then pressurizes the fluid in the primary and secondary pressure chambers, and thus the brake circuits. The fluid in the chambers behind the pistons is unaffected by movement of the pistons and can flow unrestricted through the feed holes between the chambers and the reservoir.

Brakes released

When the brake pedal is released, the primary and secondary springs push the pistons back down the bore of the cylinder. The rapid movement of the pistons cause partial vacuums to form in the pressure chambers, which opens the centre valves and allows fluid to circulate unrestricted between the two hydraulic circuits and the reservoir. When the pistons reach the brakes off position, the centre valves are held open by the piston stops.

ABS modulator

ABS modulator schematic



1 Master cylinder/brake servo assembly
2 Brake pedal
3 ABS modulator
4 Shuttle valve switch
5 Shuttle valve
6 Damper chamber
7 Restrictor
8 Return pump
9 Non return valve
10 Expansion chamber
11 Outlet solenoid valve
12 Inlet solenoid valve
13 Rear brake
14 Front brake

The ABS modulator is a 4 channel unit that controls the supply of hydraulic pressure to the brakes in response to inputs from the SLABS ECU. The modulator is attached by three mounting bushes to a bracket on the LH inner front wing, and connected to the primary and secondary hydraulic circuits downstream of the master cylinder assembly. Three electrical connectors link the ABS modulator to the vehicle wiring.

Passages within the ABS modulator, separated into primary and secondary circuits, connect to the various internal components that control the supply of hydraulic pressure to the brakes:

- Shuttle valves and non return valves control the flow through the internal circuits.
- Shuttle valve switches, connected in series to the SLABS ECU, provide a brakes on/off signal.
- A damper chamber and restrictor are included in each circuit to refine system operation.
- Inlet and outlet solenoid valves control the flow to the individual brakes.
- An expansion chamber is connected to each circuit to absorb pressure.
- A return pump is connected to both circuits to provide a pressure source.

The ABS modulator has three operating modes: Normal braking, ABS braking and active braking.

Normal braking mode

When the brake pedal is pressed, pressurised fluid from the master cylinder assembly moves the shuttle valves to open lines 'A' and close the shuttle valve switches. Pressurised fluid then flows through the open inlet solenoid valves to operate the brakes. The closed shuttle valve switches supply a brakes on signal to the SLABS ECU. If the SLABS ECU determines that EBD is necessary, it energises the inlet solenoid valves for the brakes of one axle. The inlet solenoid valves close to isolate the brakes from any further increase in hydraulic pressure.

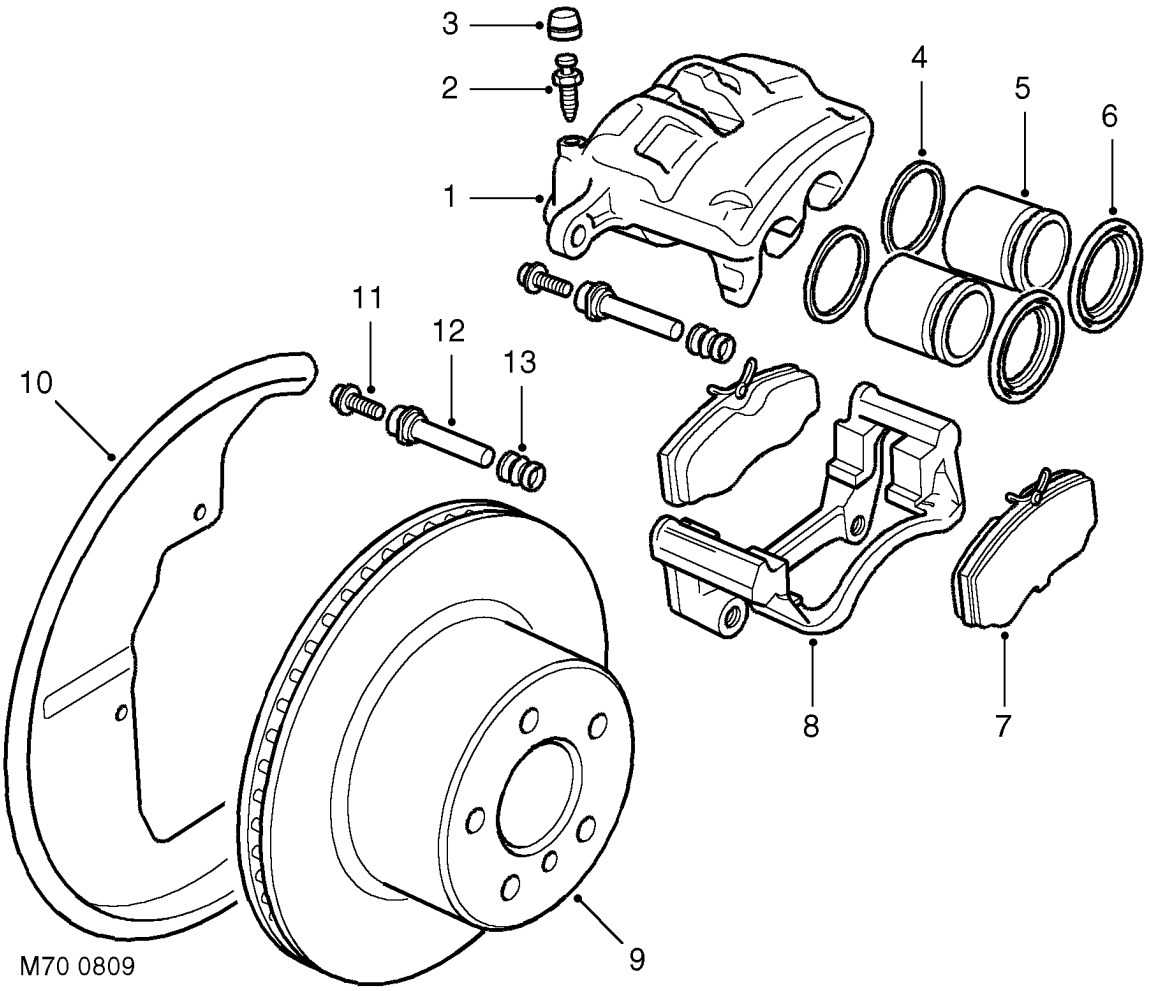
ABS braking mode

When in the normal braking mode, if the SLABS ECU determines that ABS braking is necessary, it energises the inlet and outlet solenoid valves of the related brake and starts the return pump. The inlet solenoid valve closes to isolate the brake from pressurised fluid; the outlet solenoid valve opens to release pressure from the brake into the expansion chamber and the return pump circuit. The brake releases and the wheel begins to accelerate. The SLABS ECU then operates the inlet and outlet solenoid valves to control the supply of hydraulic pressure to the brake and apply the maximum braking effort (for the available traction) without locking the wheel.

Active braking mode

When ETC or HDC are enabled, and the SLABS ECU determines that active braking is necessary, it starts the return pump. Hydraulic fluid, drawn from the reservoirs through the master cylinder, shuttle valves and lines 'B', is pressurised by the return pump and supplied to lines 'A'. The SLABS ECU then operates the inlet and outlet solenoid valves to control the supply of hydraulic pressure to the individual brakes and slow the wheel(s).

Front brakes

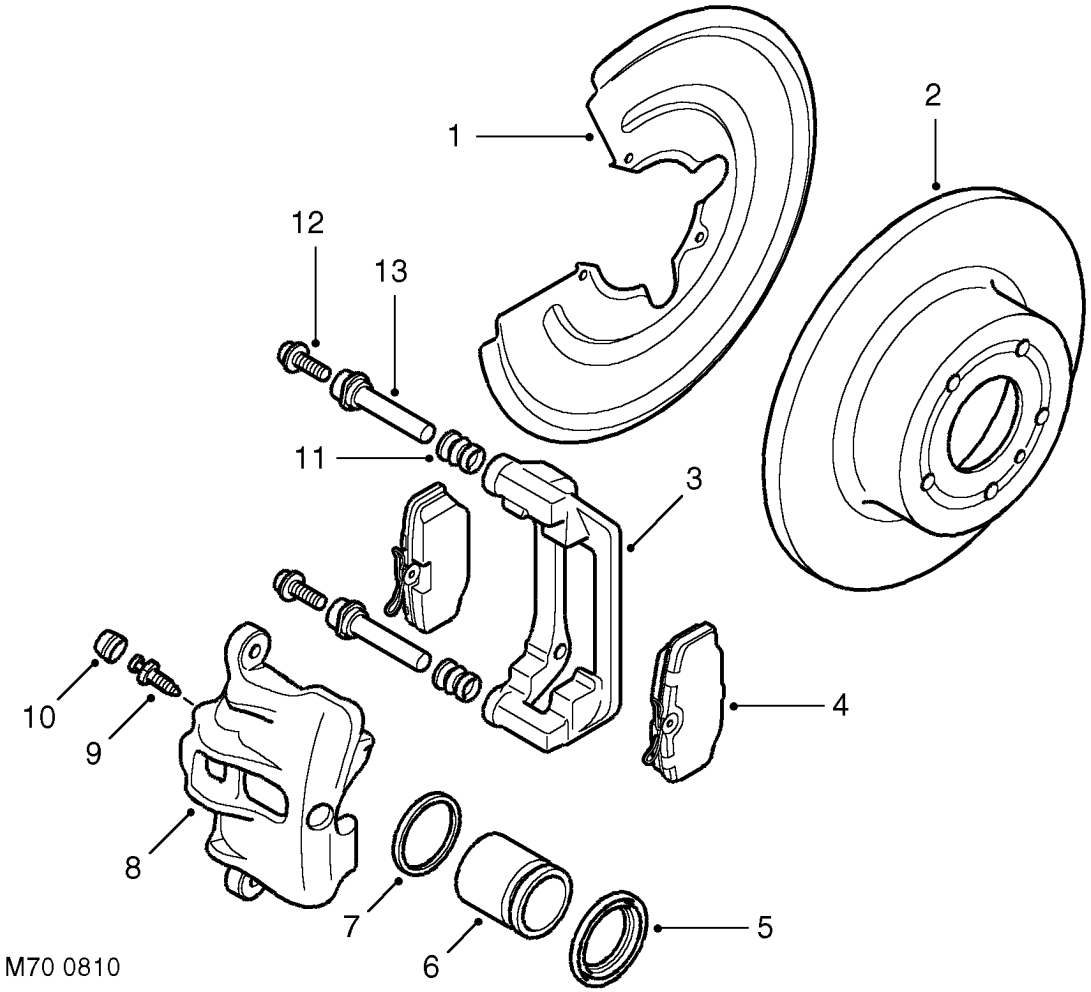


1 Caliper body
2 Bleed screw
3 Bleed screw cap
4 Piston seal
5 Piston
6 Piston dust cover
7 Brake pad
8 Caliper carrier
9 Brake disc
10 Mudshield
11 Guide pin bolt
12 Guide pin
13 Guide pin dust cover

The front brakes each comprise of a hub mounted, twin piston caliper assembly and a ventilated disc. The inboard side of the disc is protected by a mudshield.

When hydraulic pressure is supplied to the caliper, the pistons extend and force the inner pad against the disc. The caliper body reacts and slides on the guide pins to bring the outer pad into contact with the disc.

Rear brakes



1 Mudshield
2 Brake disc
3 Caliper carrier
4 Brake pad
5 Piston dust cover
6 Piston
7 Piston seal
8 Caliper body
9 Bleed screw
10 Bleed screw cap
11 Guide pin dust cover
12 Guide pin bolt
13 Guide pin

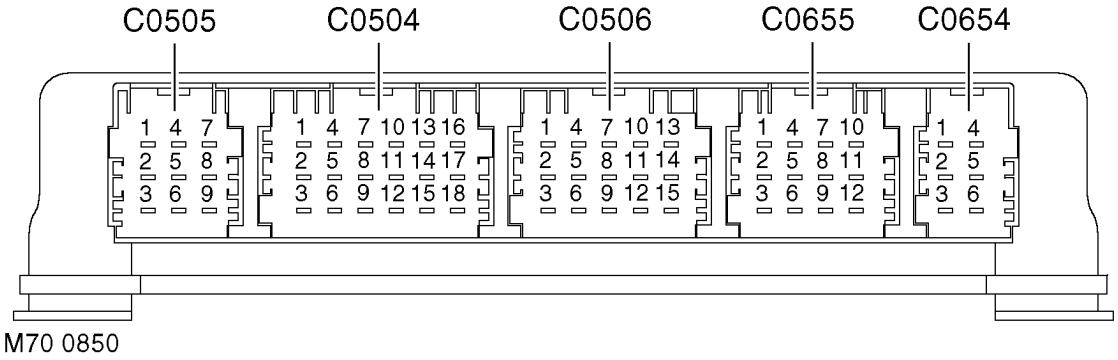
The rear brakes each comprise of a hub mounted, single piston caliper assembly and a solid disc. The inboard side of the disc is protected by a mudshield.

When hydraulic pressure is supplied to the caliper, the piston extends and forces the inner pad against the disc. The caliper body reacts and slides on the guide pins to bring the outer pad into contact with the disc.

SLABS ECU

The SLABS ECU is attached to a bracket behind the front passenger glovebox. Brake related inputs are processed by the SLABS ECU, which then outputs control signals to the ABS modulator. Five electrical connectors interface the SLABS ECU with the vehicle wiring.

SLABS ECU connector pin details



Connector/Pin No.	Description	Input/Output
C0504		
1	Battery supply	Input
2	Ignition supply	Input
3	Road speed	Output
4	Rough road (V8 models only)	Output
5	K line (diagnostics)	Input/Output
7	Reverse gear	Input
8	Return pump monitor	Input
9	Brake warning lamp	Output
10	Engine data (throttle position, torque, engine type, gearbox type)	Input
11	Transfer box range	Input
12	Earth	-
13	ETC warning lamp	Output
14	HDC switch	Input
15	Neutral selected (automatic gearbox only)	Input
16	HDC fault warning lamp	Output
17	HDC information warning lamp	Output
18	ABS warning lamp	Output
C0505		
1	Front left wheel speed	Input
2	Front left wheel speed	Input
3	Rear right wheel speed	Input
4	Front right wheel speed	Input
5	Front right wheel speed	Input
6	Rear right wheel speed	Input
7	Rear left wheel speed	Input
8	Rear left wheel speed	Input
C0506		
1	Front left outlet solenoid valve	Output
2	Front left inlet solenoid valve	Output
3	Earth	-
4	Front right outlet solenoid valve	Output
5	Front right inlet solenoid valve	Output

Connector/Pin No.	Description	Input/Output
6	Shuttle valve switches	Input
7	Rear left outlet solenoid valve	Output
8	Rear left inlet solenoid valve	Output
9	Centre differential lock switch	Input
10	Rear right outlet solenoid valve	Output
11	Rear right inlet solenoid valve	Output
12	Brake lamp relay	Output
15	Return pump relay	Output
C0655		
7	Audible warning	Output
10	Engine speed	Input
Connector and pins not listed are either not used or used by the self levelling suspension system. ☞ **REAR SUSPENSION, DESCRIPTION AND OPERATION, Description.**		

The SLABS ECU continually calculates vehicle speed using the wheel speed inputs from all four ABS sensors. The calculated vehicle speed is then used as a reference against which individual wheel speeds are monitored for unacceptable acceleration or deceleration. The ABS sensor inputs are also used by the SLABS ECU to detect vehicle deceleration rate, vehicle cornering rate and rough terrain.

The engaged forward gear and (on manual gearbox models) the clutch status are computed from the engine data input, the engine speed input and vehicle speed. Reverse gear status is provided by an input from the reverse lamp switch (manual gearbox models) or the BCU (automatic gearbox models). On automatic models, the BCU also provides the neutral selected input.

In addition to controlling the brake related functions, the SLABS ECU:

- Controls the operation of the self levelling suspension (SLS) system (where fitted).
  ☞ **REAR SUSPENSION, DESCRIPTION AND OPERATION, Description.**
- On V8 models, outputs a rough road signal to the ECM when traversing rough terrain.
- Outputs a vehicle speed signal.

The vehicle speed signal is output to the following systems (where fitted):

- Active Cornering Enhancement.
  ☞ **FRONT SUSPENSION, DESCRIPTION AND OPERATION, Description - ACE.**
- Air conditioning.
  ☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**
- Cruise control.
  ☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**
  ☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**
- Engine management.
  ☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**
  ☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - engine management.**
- In-car entertainment.
  ☞ **IN CAR ENTERTAINMENT, DESCRIPTION AND OPERATION, Description.**
- Instrument pack.
  ☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

ABS sensors

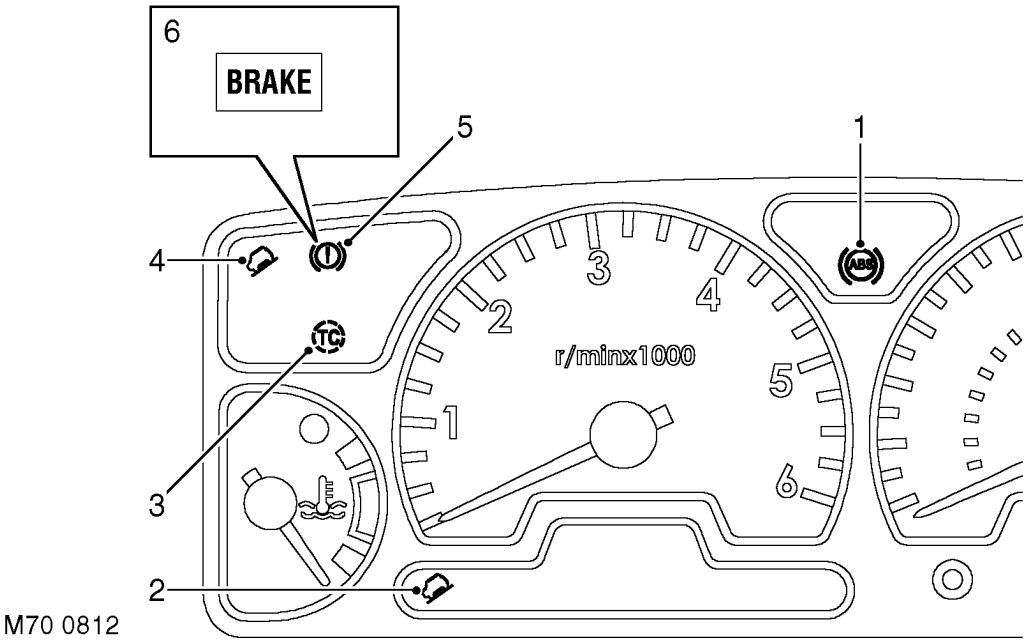
The ABS sensors supply the SLABS ECU with a sinusoidal speed signal from each wheel. An inductive sensor, installed in the hub bearing of each wheel, senses off a 60 tooth exciter ring integrated into the inner race of the hub bearing. Each ABS sensor has a fly-lead connecting it to the vehicle wiring.

HDC switch
The HDC switch is a latching push switch installed on the fascia, in the switchpack inboard of the steering wheel. When pushed in, the switch connects an ignition supply to the SLABS ECU to initiate HDC.

Warning indications
The SLABS ECU operates audible and visual warnings to convey brake system status.

Audible warning
A repetitive chime, at a frequency of 2 Hz, draws attention to warning lamp indications. The chime is produced on the speaker in the instrument pack.

Warning lamps



1 ABS warning lamp
2 HDC fault warning lamp
3 ETC warning lamp
4 HDC information warning lamp
5 Brake warning lamp (all except NAS)
6 Brake warning lamp (NAS only)

The following brake system warning lamps can be found in the instrument pack:
- A red brake graphic (all except NAS vehicles) or red BRAKE legend (NAS vehicles), to warn of low brake fluid level, handbrake on and brake control system failure affecting EBD.
- An amber ABS graphic, to warn of brake control system failure affecting the ABS function.
- An amber TC graphic, to warn of brake control system failure affecting the ETC function.
- Two inclined vehicle graphics, one amber (fault) and one green (information), to indicate operating status of HDC and to warn of brake control system failure affecting the HDC function.

Each warning lamp is illuminated by a separate LED. The ABS, brake and ETC warning lamps are continuously on while illuminated; the two HDC warning lamps are either continuously on or flash at a frequency of 2 Hz while illuminated.

Operation

Refer to illustration.

☞ **BRAKES, DESCRIPTION AND OPERATION, Brake system control diagram.**

When the ignition is switched on, the SLABS ECU performs a check of the brake related warning lamps as part of the power up procedure. The warning lamps are illuminated for approximately 3 seconds and then extinguished. If a fault warning lamp remains illuminated after the lamp check, a fault has been detected and repair action is required.

ABS

The ABS function prevents the road wheels locking during brake application, thus maintaining vehicle stability even under emergency conditions.

WARNING: ABS is an aid to retaining steering control and stability while braking:

- ***ABS cannot defy the natural laws of physics acting on the vehicle.***
- ***ABS will not prevent accidents resulting from excessive cornering speeds, following another vehicle too closely, aquaplaning, etc.***
- ***The additional control provided by ABS must never be exploited in a dangerous or reckless manner which could jeopardise the safety of driver or other road users.***
- ***The fitting of ABS does not imply that the vehicle will always stop in a shorter distance.***

NOTE: During normal braking the feel of the brake pedal on vehicles equipped with ABS will be the same as that on non ABS vehicles. During anti-lock braking operation the driver will experience feedback in the form of a pulsating brake pedal and solenoid/pump motor noise from the ABS modulator.

The anti-lock braking function is automatically enabled whenever the ABS modulator is in the normal braking mode. While the anti-lock braking function is enabled, if the SLABS ECU detects a wheel decelerating faster than the average and at the calibrated wheel slip limit for ABS operation, it operates the ABS modulator in the ABS braking mode for the affected wheel.

EBD

The EBD function optimises the distribution of hydraulic pressure between the front and rear axles, under all vehicle load configurations and road conditions, to maintain vehicle stability during braking. EBD operates in forward and reverse and is automatically enabled whenever the ABS modulator is in the normal braking mode at vehicle deceleration rates of 0.3 g and above (i.e. medium to high brake pedal loads). EBD operation is similar to that of ABS, but is calibrated to intervene at lower wheel slip limits and operates the brakes in axle pairs instead of individually.

During braking, if the SLABS ECU detects the wheels of one axle going slower than those of the other axle, i.e. a potential wheel slip situation, it signals the ABS modulator to close the inlet solenoid valve for the brakes of the slower wheels. This prevents any further increase in hydraulic pressure to those brakes, while allowing the hydraulic pressure to the brakes on the other axle to increase and so maximise the overall braking effort. If the wheel speeds of the axle being subjected to EBD control return within the calibrated wheel slip limits, the SLABS ECU signals a stepped opening of the inlet solenoid valves, which allows a progressive increase of hydraulic pressure to the related brakes.

Operation of EBD is detectable from a stiffening of brake pedal movement as the inlet solenoid valves close and a slight pulsing of the brake pedal as the inlet solenoid valves open. EBD operation ceases immediately the brake pedal is released.

The wheel slip limit for EBD operation varies with vehicle speed. During normal operation, the inlet solenoid valves always operate in axle pairs, with only one axle pair closed at any one time. Since the most lightly loaded wheel during a braking manoeuvre will usually be the first to reach the slip limit, under most vehicle load configurations and road conditions EBD control occurs on the trailing axle. However, EBD control can occur on the leading axle or switch between axles during the braking manoeuvre.

ETC

The ETC function uses brake intervention to prevent wheel spin and maintain even torque distribution to the wheels. ETC is automatically enabled while the brakes are off at speeds up to 62.5 mph (100 km/h), and operates the brakes either individually or in axle pairs:

- At speeds up to 31.3 mph (50 km/h), ETC uses individual brake intervention to maintain even torque distribution between wheels on the same axle.
- **Vehicles up to 03 model year –** At speeds between 0 and 62.5 mph (0 and 100 km/h), ETC also uses brake intervention in axle pairs to maintain even torque distribution between the front and rear axles. In effect, this mode of operation replaces the centre differential lock of the transfer box which, although still incorporated, is non operational under normal driving conditions.

  ☞ **TRANSFER BOX - LT230SE, DESCRIPTION AND OPERATION, Description.** If the centre differential lock is in the locked condition, the SLABS ECU illuminates the ABS and ETC warning lamps and inhibits the ETC function (the ABS, EBD and HDC functions are retained, but at degraded performance levels).
- **Vehicles from 03 model year (with differential lock fitted) –** At speeds between 0 and 62.5 mph (0 and 100 km/h), ETC uses brake intervention in axle pairs to maintain even torque distribution between the front and rear axles. If the centre differential lock is in the locked condition, the differential lock warning lamp in the instrument pack is illuminated. The ABS, EBD, ETC and HDC functions are retained, but with revised parameters to suit the locked differential.

While the ETC function is enabled, if the SLABS ECU detects a wheel accelerating faster than the average, indicating loss of traction, it operates the ABS modulator in the active braking mode. Depending on the vehicle speed, active braking is employed for either the brake of the affected wheel or for both brakes on the affected axle, until all four wheels are driven at approximately the same speed again. During active braking the SLABS ECU also illuminates the ETC warning lamp, for a minimum of 2 seconds or for the duration that ETC is active. ETC operation is desensitised during 'hard' cornering.

HDC

HDC uses brake intervention to provide a controlled descent ability in off road conditions when engine braking is insufficient to maintain a comfortable speed. This allows the driver to leave HDC selected and to control the vehicle's descent speed, down to the system's minimum target speed, using only the accelerator pedal. The HDC function is selected on/off by a switch on the fascia. When selected on, HDC is enabled in all forward gears and reverse provided:

- Vehicle speed is below 31.3 mph (50 km/h).
- The transfer box is in low range.
- On manual gearbox vehicles, the clutch is engaged.

When HDC is enabled, the HDC information warning lamp illuminates. If HDC is selected outside the above conditions, the HDC information warning lamp flashes and the audible warning sounds continuously.

When HDC is enabled, the SLABS ECU calculates a target speed from the throttle position element of the engine data input, and compares this with actual speed. If the actual speed is higher than the target speed, the SLABS ECU operates the ABS modulator in the active braking mode to slow the vehicle down to the target speed. While the braking force is being applied, the SLABS ECU also energizes the brake lamp relay to put the brake lamps on. Active braking is discontinued while vehicle speed is below the target speed or if the foot brakes are applied. Applying the foot brakes during active braking may result in a pulse through the brake pedal, which is normal.

During active braking, the brakes are operated predominantly on the wheels of the leading axle, but if that is not sufficient to achieve the required deceleration the brakes of the trailing axle are also applied. The deceleration rate is dependent on the speed differential between initial vehicle speed and the target speed. The deceleration rates are relatively low at higher speed differentials, then progressively increase as vehicle speed approaches the target speed. Anti-lock braking is also enabled during active braking, but at very low speeds some wheel lock can occur.

The target speed increases as the accelerator pedal is pressed, from a programmed minimum with the accelerator pedal released, up to a maximum of 31.3 mph (50 km/h). For any given accelerator pedal position, while travelling uphill or on level ground the target speed is always greater than the corresponding vehicle speed, which allows the vehicle to be driven normally without HDC intervention. However, when travelling downhill, the gravitational effect on the vehicle means that for any given accelerator pedal position the target speed is less than the corresponding vehicle speed, and HDC intervenes to limit vehicle speed to the target speed.

Minimum target speed

The minimum target speed depends on which gear is engaged. Reduced minimum target speeds are employed for some gears if rough terrain or sharp bends are encountered while already travelling at the normal minimum target speed. If loss of traction makes it impossible to maintain the minimum target speed, the SLABS ECU temporarily increases the minimum target speed to maintain stability, then restores the normal minimum target speed when traction improves.

HDC minimum target speeds

Gear	Speed, mph (km/h)			
	Manual gearbox		Automatic gearbox	
	Normal	Reduced	Normal	Reduced
1	4.4 (7.0)	4.4 (7.0)	4.4 (7.0)	4.4 (7.0)
2	5.2 (8.3)	4.4 (7.0)	4.4 (7.0)	4.4 (7.0)
3	6.0 (9.6)	4.4 (7.0)	7.5 (12.0)	6.0 (9.6)
4	7.5 (12.0)	6.0 (9.6)	7.5 (12.0)	6.0 (9.6)
5	8.8 (14.0)	7.0 (11.2)	-	-
Reverse	3.5 (5.6)	3.5 (5.6)	3.5 (5.6)	3.5 (5.6)
Neutral or clutch disengaged	8.8 (14.0)	Last off road speed	4.4 (7.0)	4.4 (7.0)

Fade out

To provide a safe transition from active braking to brakes off, the SLABS ECU invokes a fade out strategy if it detects any of the following during active braking:

- A system fault.
- The conditions for HDC are no longer being met.
- Possible brake overheat.

The fade out strategy increases the target speed at a low constant acceleration rate, independent of actual throttle position. This results in the braking effort being gradually reduced and then discontinued. The SLABS ECU operates warning indications during fade out that are dependent on the cause.

Fade out warning indications

Cause	Warning indication		
	HDC fault warning lamp	HDC information warning lamp	Audible warning
Fault detected	On	Flashes	Continuous
HDC conditions not met	Off	Flashes	Continuous
Brake overheat prevention	Flashes	Off	Continuous

Clutch disengagement/neutral selection

During active braking, if the SLABS ECU detects the clutch is disengaged or neutral is selected, it flashes the HDC information warning lamp and sounds the audible warning continuously to indicate that conditions for HDC are no longer being met. Initially, the SLABS ECU also fixes the target speed to the applicable minimum target speed, but if the condition continues for approximately 60 seconds the SLABS ECU invokes fade out.

Brake overheat prevention

To prevent the brakes overheating, the SLABS ECU monitors the amount of active braking employed and, from this, estimates brake temperature. If the SLABS ECU estimates the brake temperature has exceeded a preset limit, it flashes the HDC fault warning lamp and sounds the audible warning continuously, to indicate that HDC should be deselected to allow the brakes to cool. If active braking continues and the SLABS ECU estimates that brake temperature has increased to an unacceptable level, fade out is employed and HDC is disabled. After fade out, the audible warning is discontinued but the HDC fault warning lamp continues to flash, while HDC is selected, until the SLABS ECU estimates brake temperature to be at an acceptable level. This calculation continues even if the ignition is turned off, so turning the ignition off and back on will not reduce the disabled time. When the SLABS ECU estimates the brake temperature to be acceptable, it extinguishes the HDC fault warning lamp and illuminates the HDC information warning lamp to indicate that HDC is re-enabled. The disabled time is dependent on vehicle speed; typical times at constant vehicle speeds are as follows:

Typical disabled times

Vehicle speed, mph (km/h)	Time, minutes
1.3 (2)	40
12.5 (20)	33
15.6 (25)	17
25.0 (40)	9
31.3 (50)	6

Diagnostics

While the ignition is on, the diagnostics function of the SLABS ECU monitors the system for faults. In addition, the return pump is tested by pulsing it briefly immediately after the engine starts provided vehicle speed exceeded 4.4 mph (7 km/h) during the previous ignition cycle. If a fault exists in a warning lamp circuit, the lamp will not illuminate during the lamp check at ignition on but, provided there are no other faults, the related function will otherwise be fully operational. If a fault is detected during the power up, the SLABS ECU stores a related fault code in memory and illuminates the appropriate fault warning lamps. If a fault is detected later in the drive cycle, the SLABS ECU also sounds the audible warning three times.

Fault codes and diagnostic routines can be accessed by connecting Testbook to the vehicle's diagnostic connector in the driver's footwell.

Warning lamp fault operation

Item	Check	Warning lamp			
		ABS	Brake	ETC	HDC fault
ABS sensors	Resistance (to check status)	On	On	On	On
Brake lamps relay	Open/Short circuit	Off	Off	Off	On
Engine data	Sticking throttle, signal failure, data corruption	Off	Off	On	On
Inlet solenoid valves	Open/Short circuit	On	On	On	On
Outlet solenoid valves	Open/Short circuit	On	On	On	On
Reference earth	Connection to earth	On	On	On	On
Return pump monitor	Correct pump operation	On	On	On	On
Return pump relay	Open/Short circuit	On	On	On	On
Shuttle valve switches	Open/Short circuit	On	On	On	On
SLABS ECU	Internal failure	On	On	On	On
Supply voltages	Range (10 to 16 V)	On	On	On	On

After detecting a fault, the SLABS ECU selects an appropriate default strategy which, where possible, retains some operational capability. A shuttle valve switch fault and throttle position signal fault are classified as permanent faults. If a permanent fault is detected, the related warning lamp illumination and default strategies are automatically employed in subsequent ignition cycles, even if the fault is intermittent, until the fault has been rectified and cleared from memory. If a non permanent fault is detected, the related warning lamp illumination and default strategies will only be employed in subsequent ignition cycles if the fault is still present.

After rectification of an ABS sensor fault, the ABS and ETC functions are disabled, and the ABS warning lamp remains illuminated after the lamp check, until vehicle speed exceeds 9.4 mph (15 km/h) (to allow additional checks to be performed).

Default strategies

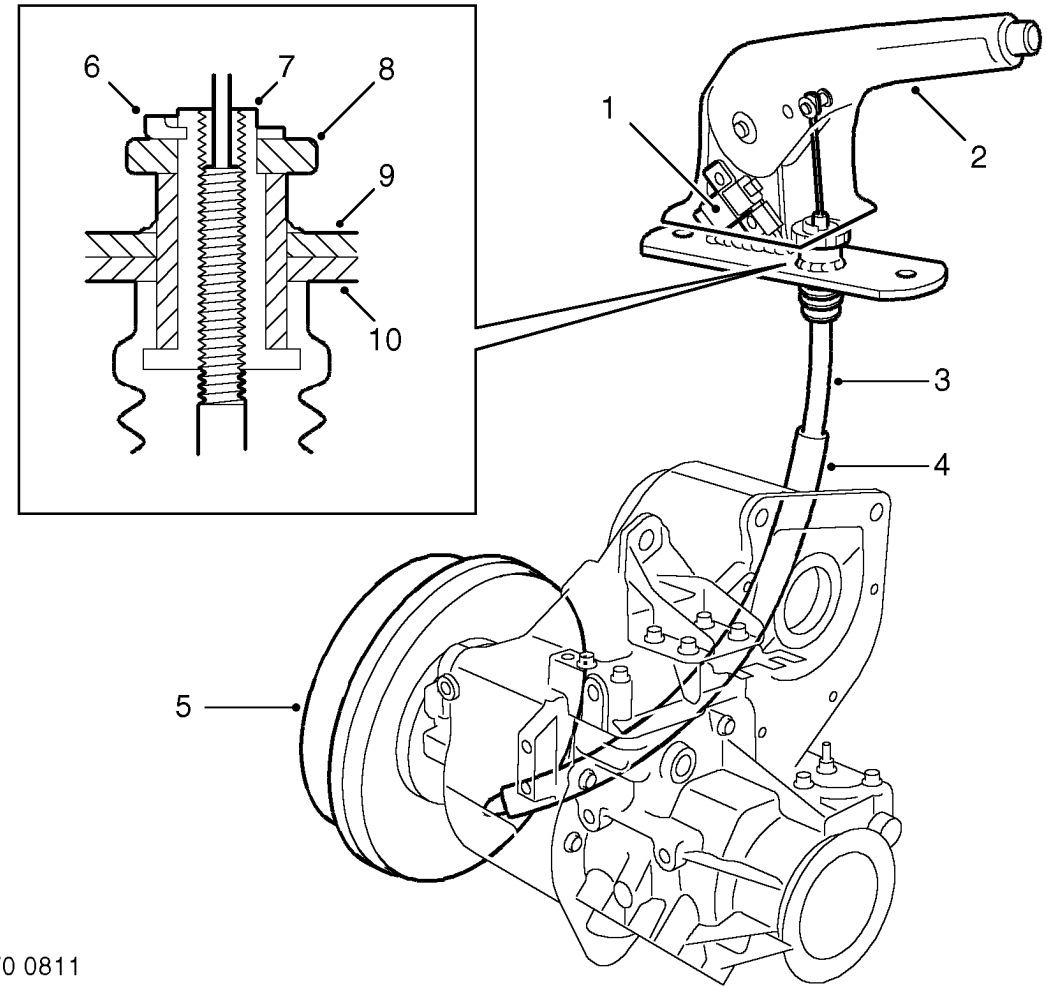
Fault	Default strategy
Brake lamps relay	ABS: Enabled. ETC: Enabled. EBD: Enabled. HDC: Enabled.
Throttle position signal failure	ABS: Enabled. ETC: Disabled. EBD: Enabled. HDC: Immediately disabled if not in active braking mode; faded out then disabled if in active braking mode.
No reference earth	ABS: Disabled. ETC: Disabled. EBD: Partly disabled. HDC: Disabled.
Return pump or relay fault	ABS: Disabled. ETC: Disabled. EBD: Partly disabled. HDC: Disabled.
Shuttle valve switch failure	ABS: Deceleration threshold increased; return pump activated if sum of output valve actuation on one axle exceeds 140 milliseconds. ETC: Disabled. EBD: Inlet valves of rear axle close at vehicle deceleration rates of 0.3 g and above. HDC: Disabled.
SLABS ECU internal failure	ABS: Disabled. ETC: Disabled. EBD: Disabled. HDC: Disabled.
Supply voltage out of limits	ABS: Disabled. ETC: Disabled. EBD: Disabled. HDC: Disabled.

Electrical data

Nominal resistance values for applicable brake control components are as detailed below:

Component	Resistance, ohms
Brake lamp relay coil	117 - 143
Return pump relay coil	82.8 - 101.2
ABS sensor	950 - 1100
Shuttle valve switches, both open (brakes off)	2977 - 3067
Shuttle valve switches, both closed (brakes on)	1007 - 1037
Shuttle valve switches, one open, one closed	1992 - 2052
Inlet solenoid valve	5.9 - 7.3
Outlet solenoid valve	3.0 - 3.6

Handbrake component layout



M70 0811

1 Warning switch
2 Handbrake lever
3 Cable
4 Protective sleeve
5 Drum brake
6 'C' clip
7 Threaded sleeve
8 Adjuster wheel
9 Base plate
10 Transmission tunnel

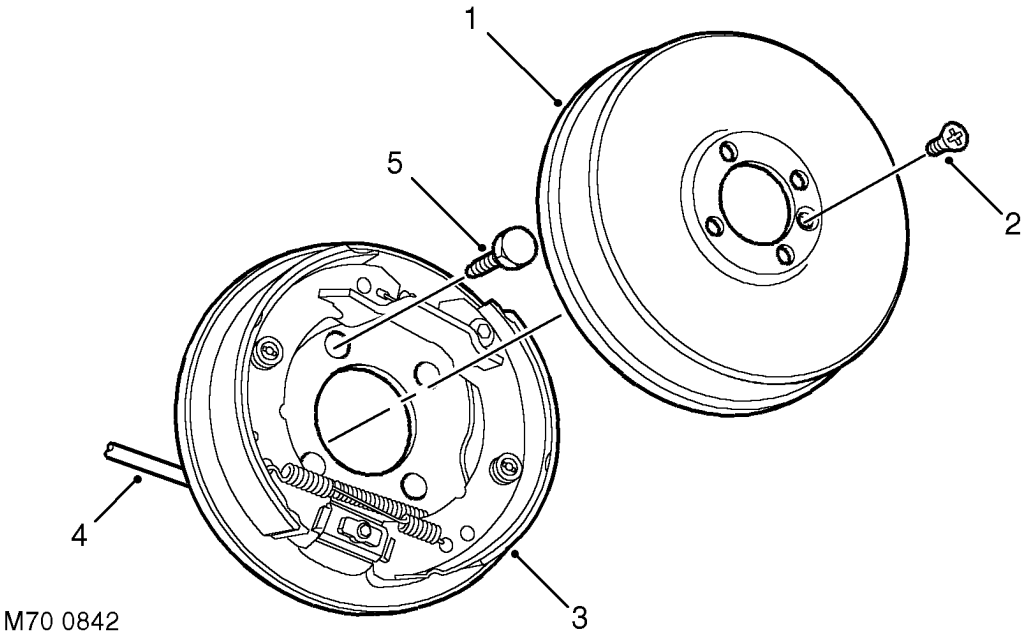
Description

General
The handbrake consists of a drum brake, installed on the rear of the transfer box, operated by a cable connected to a handbrake lever between the front seats.

Handbrake lever
The handbrake lever is mounted on a base plate which attaches to the transmission tunnel. A conventional ratchet and thumb operated release button are incorporated for locking and unlocking the lever. A warning switch on the base of the lever operates the brake warning lamp in the instrument pack. While the handbrake is applied the warning switch connects an earth to the instrument pack which, if the ignition is on, illuminates the brake warning lamp. In some markets, the instrument pack performs a bulb check of the brake warning lamp each time the ignition is switched on.

Cable
The handbrake cable consists of inner and outer cables installed between the handbrake lever and the drum brake. A protective sleeve is installed on the cable to protect the cable from heat from the exhaust system. Handbrake adjustment is provided by a threaded sleeve installed on the outer cable where it locates in the handbrake lever. Turning an adjuster wheel, which is keyed to the threaded sleeve and secured by a 'C' clip, alters the effective length of the outer sleeve and consequently changes the handbrake lever movement needed to apply the drum brake.

Drum brake



1 Drum
2 Drum securing bolt
3 Backplate
4 Cable
5 Backplate securing bolt

The drum brake consists of a backplate attached to the transfer box casing and a drum attached to the transfer box rear output shaft. When the handbrake lever is applied, the movement is transmitted by the inner cable to a lever on one of the brake shoes on the backplate. The lever pivots against the brake adjuster rod, which forces the shoes apart and into contact with the drum. Brake shoe to drum clearance is set by an adjusting bolt on the rear of the backplate.

Handbrake

70.45.09

Check

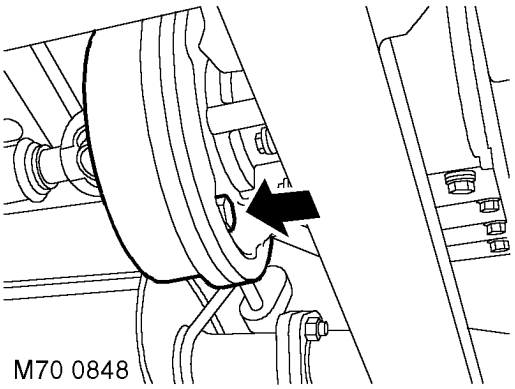
1. Apply the handbrake lever 3 notches on the ratchet. The handbrake should be fully operational.
2. If the handbrake is not fully operational, the brake shoes and/or the handbrake cable need adjusting.

Adjust

1. Raise rear of vehicle.

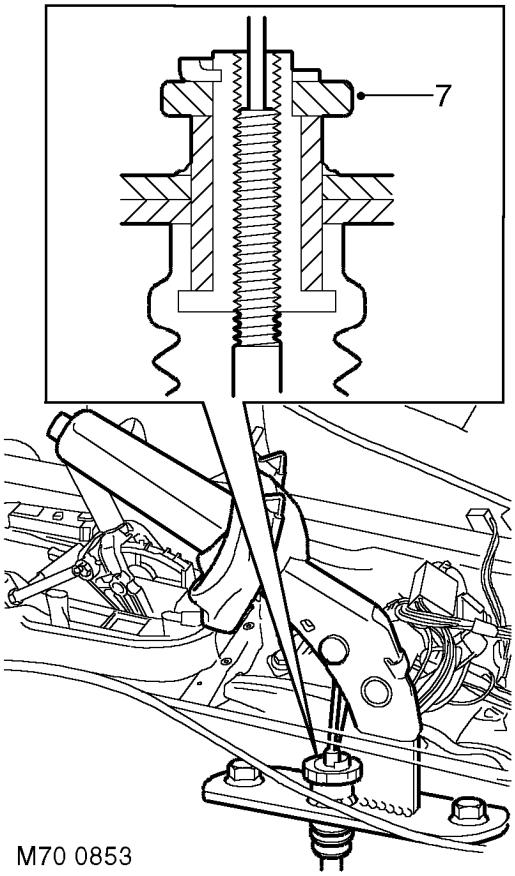
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Ensure handbrake lever is fully released.



M70 0848

3. Tighten brake shoe adjusting bolt until brake drum is locked, then back off adjusting bolt 1.5 turns. Check that the brake drum is free to rotate.
4. Recheck handbrake operation.**If handbrake is not fully applied with 3 notches on the ratchet, the handbrake cable requires adjustment.**
5. Remove switch panel from centre console.
   ☞ **WINDOWS, REPAIRS, Switch - console.**
6. Release handbrake lever gaiter from centre console.



M70 0853

7. Rotate adjuster anti-clockwise to increase cable tension (reduce notches) or clockwise to decrease cable tension (increase notches).
8. Recheck handbrake operation.
9. Secure handbrake lever gaiter to centre console.
10. Fit switch panel to centre console.
    ☞ **WINDOWS, REPAIRS, Switch - console.**
11. Remove stand(s) and lower vehicle.

Brake system bleeding

70.25.02

Bleeding of the brake system can be carried out using the procedures given on TestBook, or by following the manual procedure given below.

WARNING: If any components upstream of brake modulator, including the modulator itself are replaced, the brake system must be bled using the procedure on TestBook/T4, to ensure that all air is expelled from the new component(s).

WARNING: Do not allow brake fluid to come into contact with eyes or skin.

Bleed

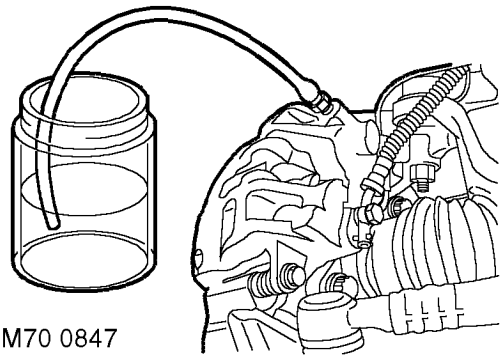
NOTE: This procedure covers bleeding the complete system, but where only the primary or secondary circuit have been disturbed in isolation, it should only be necessary to bleed that circuit. Partial bleeding of the hydraulic system is only permissible if a brake pipe or hose has been disconnected with only minor loss of fluid.

1. Do not allow fluid level in master cylinder to fall below 'MIN' mark during bleeding.
2. Do not fill reservoir above 'MAX' level.
3. Raise front and rear of vehicle.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

4. Check all pipe and hose connections are tight and there are no signs of leakage.
5. Top-up fluid level in brake reservoir to 'MAX' mark.

   WARNING: Do not allow dirt or foreign liquids to enter the reservoir. Use only new DOT 4 brake fluid from airtight containers. Do not mix brands of brake fluid as they may not be compatible.

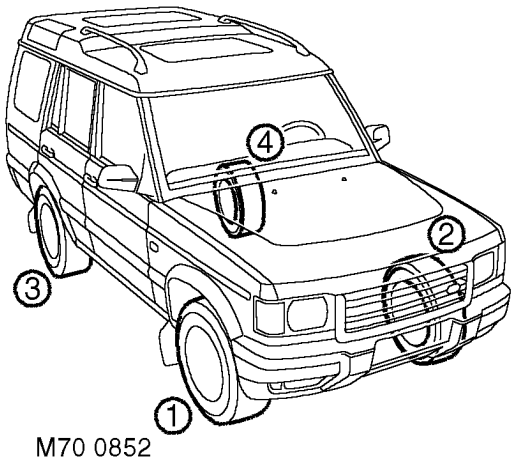


M70 0847

6. Attach bleed tube to the bleed screw on front brake caliper on the passenger side, submerge free end in a clear container containing brake fluid.
7. Apply pressure to brake pedal several times, then apply steady pressure.
8. Loosen bleed screw to release brake fluid and air. Allow pedal to return unassisted.
9. Depress brake pedal steadily through its full stroke and allow to return unassisted. Repeat procedure until a flow of clean air-free fluid is purged into container then, whilst holding pedal at end of downward stroke, tighten brake caliper bleed screw to 10 Nm (7 lbf.ft).

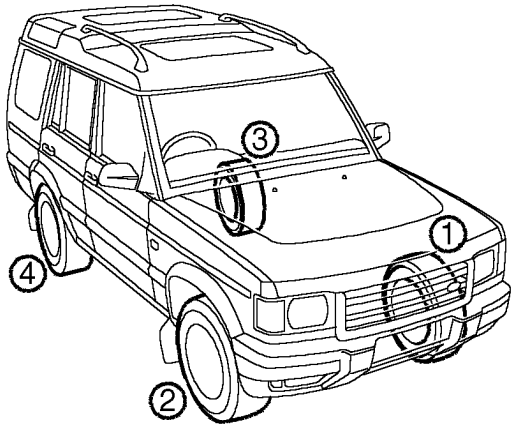
   CAUTION: Ensure the fluid in the reservoir is maintained between the minimum and maximum levels throughout the bleed procedure using new brake fluid.

10. Top-up brake fluid level to 'MAX' mark.



M70 0852

Bleed sequence LHD



M70 00851

Bleed sequence RHD

11. Working in the sequence illustrated, repeat steps 5 to 9 on remaining calipers.

WARNING: Braking efficiency may be seriously impaired if the incorrect bleed sequence is used.

12. Apply brakes and check for leakage.
13. Remove stand(s) and lower vehicle.
14. Road test vehicle. Check brake pedal for short firm travel when brakes are applied.

Brake disc - front

70.12.10

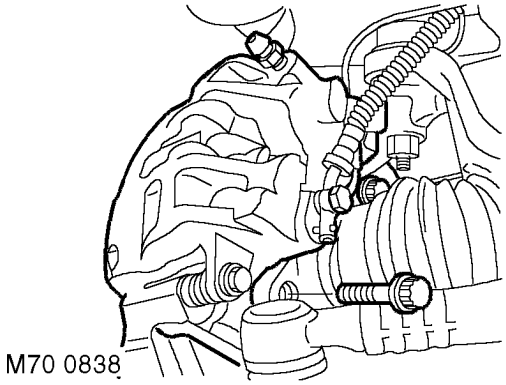
Brake discs must be renewed in pairs, unless one disc requires changing before 1000 miles (1500 km) from new.

Remove

1. Raise front of vehicle.

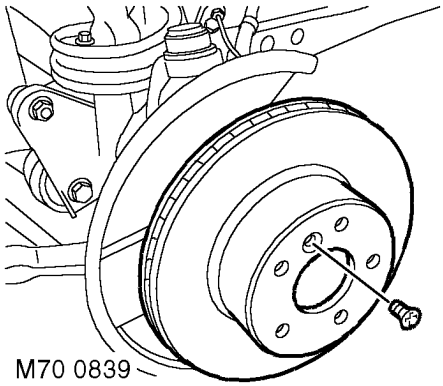
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

2. Remove road wheel(s).


M70 0838

3. Remove 2 bolts securing brake caliper to swivel hub.
4. Release caliper and tie aside clear of brake disc.

   CAUTION: Do not allow caliper to hang on brake hose.


M70 0839

5. Remove screw securing disc to drive flange.
6. Remove brake disc from drive flange

Refit

1. Clean mating faces of drive flange and new disc.
2. Fit brake disc to drive flange, fit screw and tighten to 13 Nm (10 lbf.ft).
3. Clean mating faces of caliper and hub.
4. Fit caliper, and tighten bolts to 175 Nm (129 lbf.ft).
5. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
6. Remove stand(s) and lower vehicle.

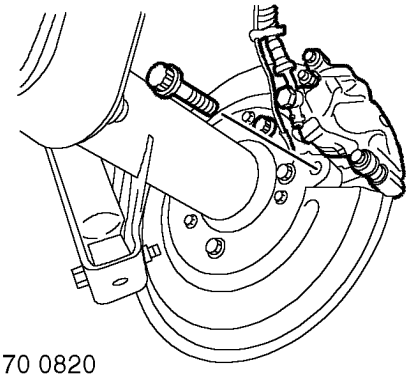
Brake disc - rear

70.12.33

Brake discs must be renewed in pairs, unless one disc requires changing before 1000 miles (1500 km) from new.

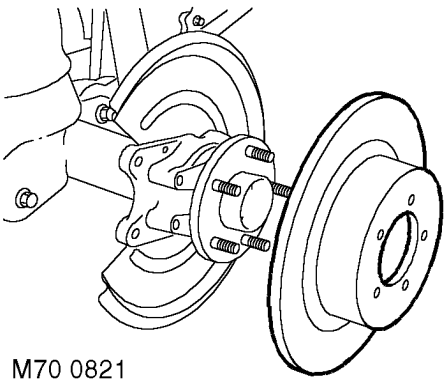
Remove

1. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel(s).



M70 0820

3. Remove 2 bolts securing brake caliper to rear hub.
4. Release caliper and tie aside clear of brake disc.
   CAUTION: Do not allow caliper to hang on brake hose.



M70 0821

5. Remove screw securing disc to drive flange.
6. Remove brake disc from drive flange.

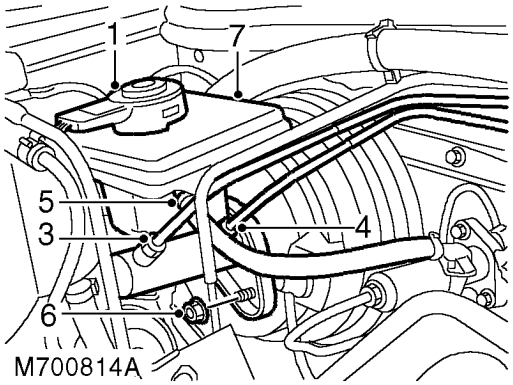
Refit

1. Clean mating faces of drive flange and new disc.
2. Fit brake disc to drive flange, fit screw and tighten to 13 Nm (10 lbf.ft).
3. Clean mating faces of caliper and hub.
4. Fit caliper and tighten bolts to 95 Nm (70 lbf.ft).
5. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
6. Remove stand(s) and lower vehicle.

Master cylinder - brake

70.30.08

Remove



1. Disconnect multiplug from fluid level switch.
2. Position cloth under master cylinder to absorb spilled fluid.

   CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.

3. Disconnect secondary system pipe union from master cylinder.
4. Disconnect primary system pipe union from master cylinder.
5. **Manual gearbox only:** Release clip and disconnect clutch fluid supply hose from reservoir.

   CAUTION: Always fit plugs to open connections to prevent contamination.

6. Remove 2 nuts and washers securing master cylinder to servo.
7. Remove master cylinder.

Refit

1. Clean master cylinder and servo mating surfaces.
2. Align push rod and position master cylinder to servo.
3. Fit nuts and washers securing master cylinder to servo and tighten to 25 Nm (18 lbf.ft).
4. Connect primary and secondary brake pipes, and tighten unions to 25 Nm (18 lbf.ft).
5. **Manual gearbox only:** Connect clutch fluid hose to reservoir, secure with clip.
6. Connect fluid level switch multiplug.
7. Bleed brake system using TestBook/T4.

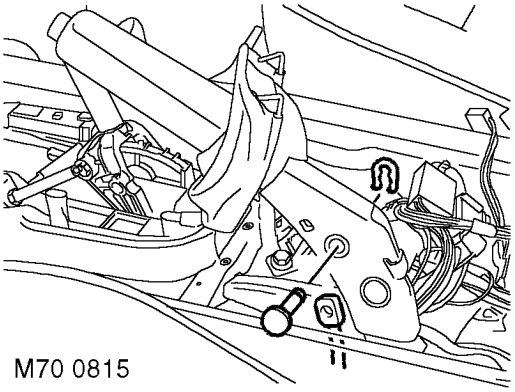
   BRAKES, ADJUSTMENTS, Brake system bleeding.

Cable - handbrake

70.35.25

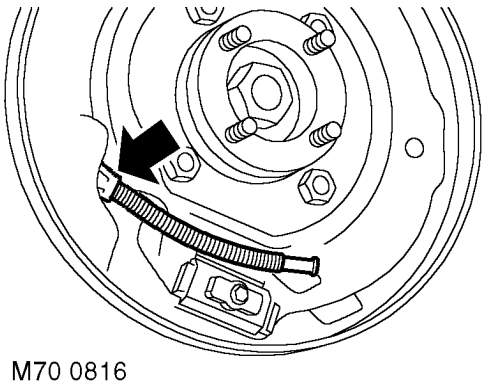
Remove

1. Remove centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.



M70 0815

2. Remove clip and clevis pin securing cable to hand brake lever.
3. Remove brake shoes from hand brake assembly.
   BRAKES, REPAIRS, Brake shoes - handbrake.



M70 0816

4. From below the vehicle, pull handbrake cable through transmission tunnel.
5. Release handbrake cable from backplate.

Refit

1. Fit and secure handbrake cable to backplate.
2. Position hand brake cable through transmission tunnel.
3. Fit brake shoes to hand brake assembly.
   BRAKES, REPAIRS, Brake shoes - handbrake.
4. Align cable to hand brake lever and secure with clip and clevis pin.
5. Fit centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.
6. Adjust handbrake.
   BRAKES, ADJUSTMENTS, Handbrake.

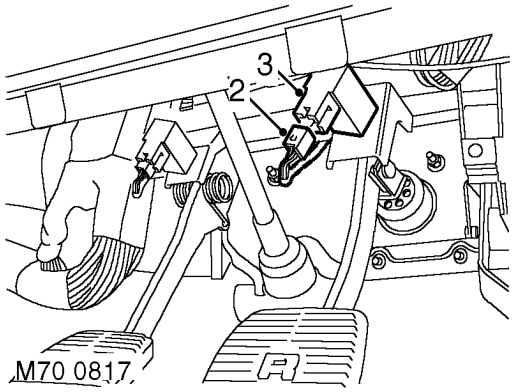
Switch - brake light

70.35.42

The brake switch is set automatically during fitment. If the setting is disturbed, the switch can be reset by depressing the brake pedal and pulling the plunger out of the switch body, until it contacts the pedal.

Remove

1. Remove 3 fasteners and move drivers side lower closing panel aside.



2. Disconnect multiplug from brake light switch.
3. Remove brake light switch from pedal bracket.

Refit

1. Engage switch fully into pedal bracket location and connect multiplug.
2. Position lower closing panel and secure with fasteners.

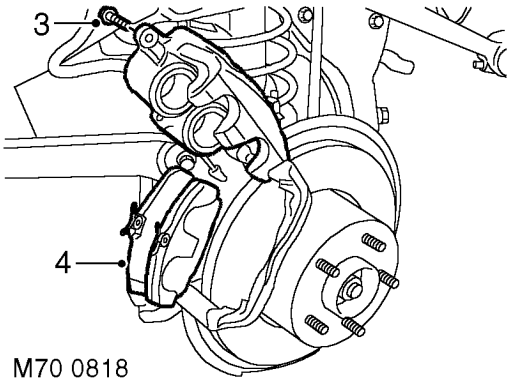
Brake pads - front

70.40.02

WARNING: Brake pads must be renewed in axle sets only, otherwise braking efficiency may be impaired.

Remove

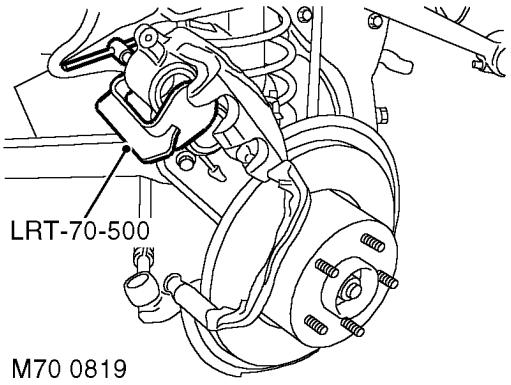
1. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel(s).



3. Remove lower guide pin bolt from caliper and pivot caliper housing upwards.
4. Remove 2 brake pads from caliper carrier. Shims are part of the brake pads.

Refit

1. Rotate disc by hand and scrape all scale and rust from around edge of disc.
2. Scrape rust from pad locating surfaces on caliper.
3. Clean dust from calipers using brake cleaning fluid.
   WARNING: Do not use compressed air to clean brake components. Dust from friction materials can be harmful if inhaled.



M70 0819

4. Using tool **LRT-70-500**, press caliper pistons fully into bores. **Ensure that displaced fluid does not overflow from reservoir.**
5. Fit brake pads with chamfer towards leading edge of disc.
6. Lower caliper housing over pads.
7. Ensure flats on guide pins locate with lugs on caliper housing. fit new pivot bolt and tighten to 30 Nm (22 lbf.ft).
8. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
9. Remove stand(s) and lower vehicle.
10. Depress brake several times to set pad to disc clearance.
11. Check and top-up brake fluid.

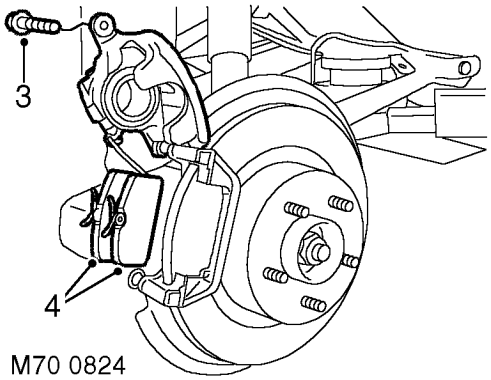
Brake pads - rear

70.40.10

WARNING: Brake pads must be renewed in axle sets only, otherwise braking efficiency may be impaired.

Remove

1. Raise rear of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel(s).

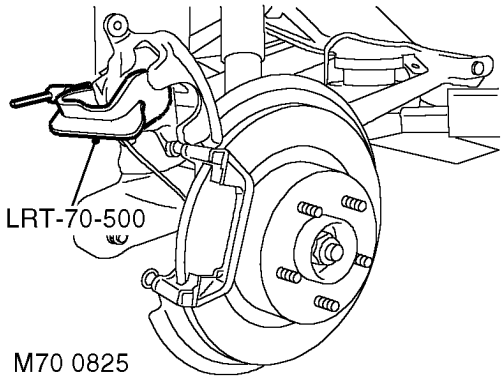


M70 0824

3. Remove lower guide pin bolt from caliper and pivot caliper housing upwards.
4. Remove 2 brake pads from caliper carrier. Shims are part of the brake pads.

Refit

1. Rotate disc by hand and scrape all scale and rust from around edge of disc.
2. Scrape rust from pad locating surfaces on caliper.
3. Clean dust from calipers using brake cleaning fluid.
   WARNING: Do not use compressed air to clean brake components. Dust from friction materials can be harmful if inhaled.



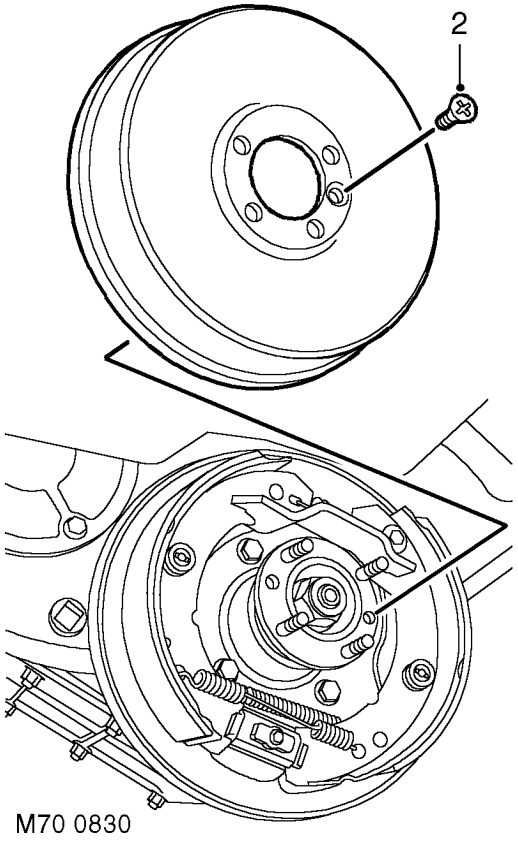
4. Using tool **LRT-70-500**, press caliper pistons fully into bores. **Ensure that displaced fluid does not overflow from reservoir.**
5. Fit pads to caliper carrier.
6. Lower caliper housing over pads.
7. Ensure flats on guide pins locate with lugs on caliper housing. fit new pivot bolt and tighten to 30 Nm (22 lbf.ft).
8. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
9. Remove stand(s) and lower vehicle.
10. Depress brake several times to set pad to disc clearance.
11. Check and top-up brake fluid.

Brake shoes - handbrake

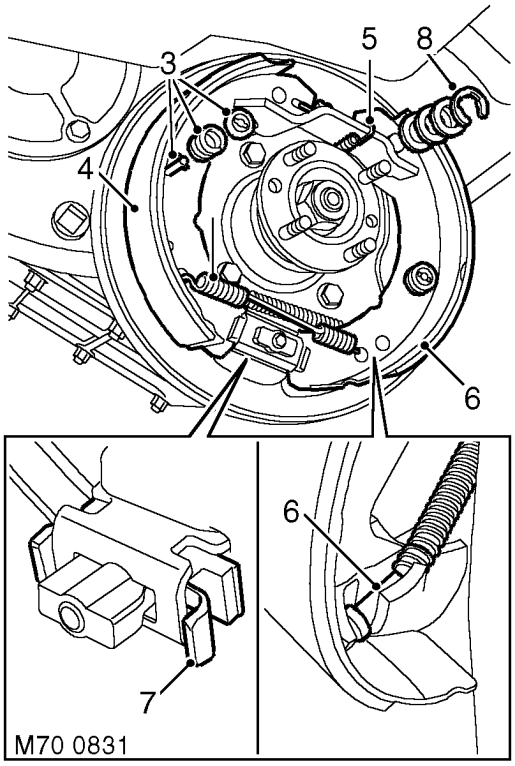
70.45.18

Remove

1. Remove rear propeller shaft.
   PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.



2. Remove screw and remove brake drum.



3. Remove 2 washers, springs and pins retaining brake shoes to back plate.
4. Release return springs and remove brake shoe.
5. Remove retaining spring securing abutment lever to back plate.
6. Release remaining brake shoe from brake cable, remove brake shoe and collect return springs.
7. Remove adjuster plungers.
8. Remove 'C' clip securing cable lever to brake shoe. Remove flat washer, lever, 2 Belleville washers and pivot pin.

Refit

1. Clean components with brake cleaning fluid.

   WARNING: Do not use compressed air to clean brake components. Dust from friction materials can be harmful if inhaled.

2. Lubricate cable lever pivot pin.
3. Fit pivot pin to shoe, fit cable lever washers and secure with 'C' clip.
4. Fit adjuster plungers.
5. Fit shoe to brake cable, align to back plate and adjuster. Secure shoe to back plate with pin, spring and washer.
6. Fit abutment plate to brake shoe.
7. Fit return springs with remaining shoe. Secure shoe to back plate with pin, spring and washer.
8. Fit abutment plate retaining spring.
9. Clean brake drum and mating face.
10. Position brake drum and tighten retaining screw.
11. Fit rear propeller shaft.

    ☞ **PROPELLER SHAFTS, REPAIRS, Propeller shaft - rear.**
12. Adjust handbrake.

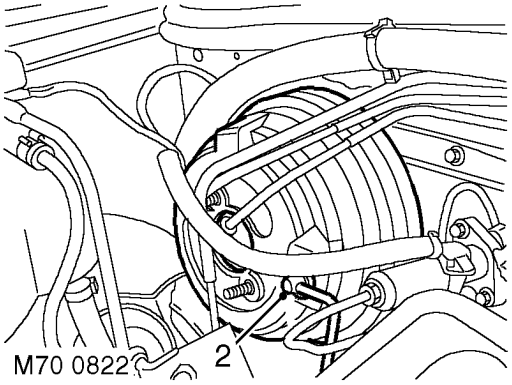
    ☞ **BRAKES, ADJUSTMENTS, Handbrake.**

Servo - brake

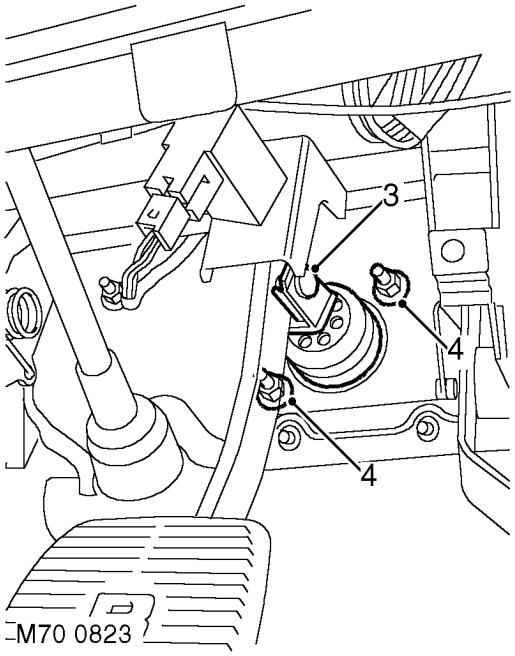
70.50.01

Remove

1. Remove brake master cylinder.
   BRAKES, REPAIRS, Master cylinder - brake.



2. Disconnect vacuum pipe from servo.



3. Release spring clip securing servo push-rod to brake pedal and release pedal.
4. Remove 2 flanged nuts securing servo to bulkhead.
5. Remove brake servo.

Refit

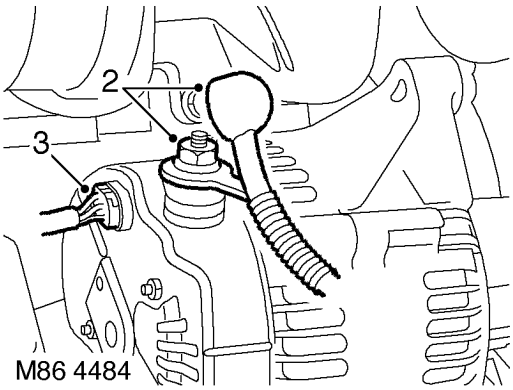
1. Clean servo and mating faces,
2. Position servo and tighten nuts to 25 Nm (18 lbf. ft).
3. Position brake pedal to servo push-rod and secure with spring clip.
4. Connect vacuum pipe to servo.
5. Fit brake master cylinder.
   BRAKES, REPAIRS, Master cylinder - brake.

Vacuum pump - servo

70.50.19

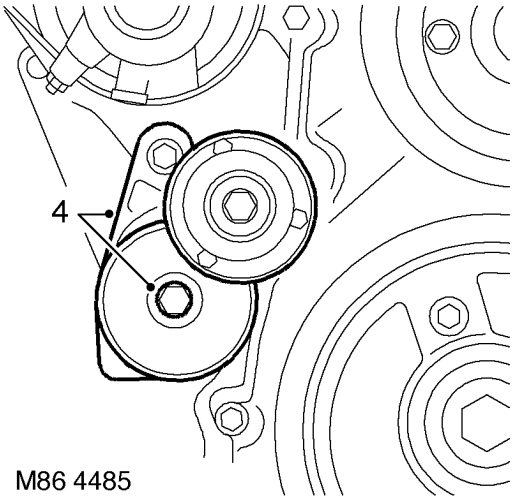
Remove

1. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



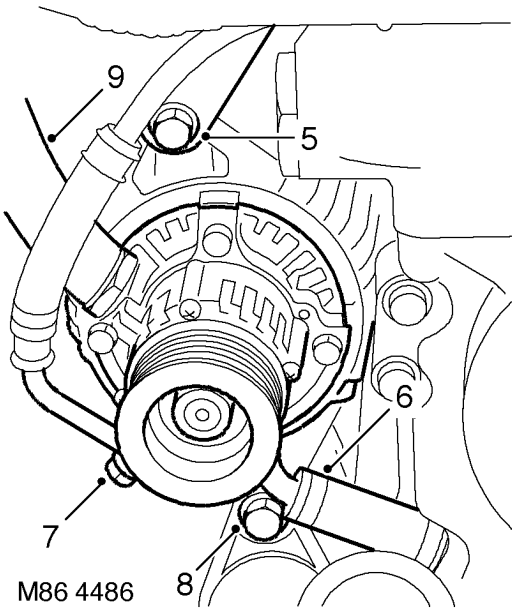
M86 4484

2. Release cover and remove nut securing lead to alternator.
3. Disconnect alternator multiplug.



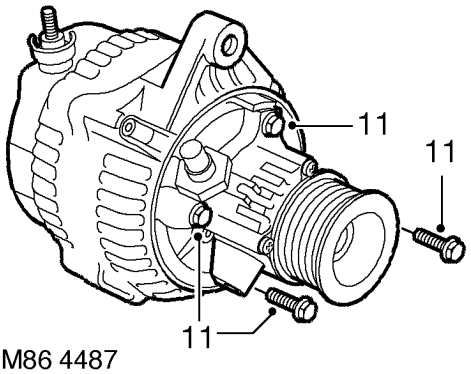
M86 4485

4. Remove bolt (LH thread) and remove auxiliary drive belt tensioner.



M86 4486

5. Remove bolt securing support stay to alternator.
6. Release clip and disconnect oil drain hose from vacuum pump.
7. Disconnect vacuum pump oil supply pipe from cylinder head and discard 'O' ring.
8. Remove bolt securing alternator and release from mounting bracket.
9. Disconnect vacuum hose from vacuum pump.
10. Remove alternator. Take care not to damage radiator cooling fins.



M86 4487

11. Remove 4 bolts, and remove vacuum pump from alternator.

CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

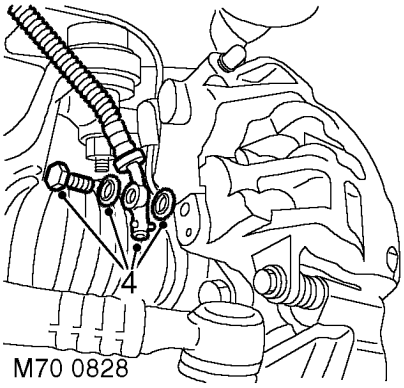
1. Clean mating faces of alternator and vacuum pump.
2. Fit vacuum pump to alternator and tighten bolts to 8 Nm (6 lbf.ft).
3. Position alternator to engine and connect multiplug.
4. Connect vacuum hose and oil drain hose to vacuum pump and secure clips.
5. With assistance align alternator to mounting bracket and fit but do not tighten bolt.
6. Fit bolt securing support stay to alternator and tighten to 25 Nm (18 lbf.ft) .
7. Tighten bolt securing alternator to mounting bracket to 45 Nm (33 lbf.ft).
8. Using new 'O' ring, connect oil supply pipe to cylinder head and tighten to 10 Nm (7 lbf.ft).
9. Connect lead to alternator and tighten nut to 6 Nm (4.4 lbf.ft).
10. Fit auxiliary drive belt tensioner and tighten bolt to 50 Nm (37 lbf.ft).
11. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

Housing - caliper - front

70.55.24

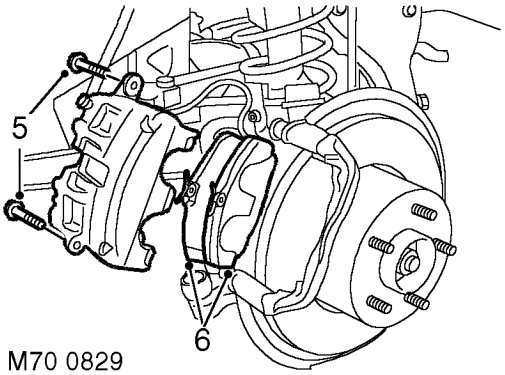
Remove

1. Raise front of vehicle, one side.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
2. Remove road wheel(s).
3. Clamp brake hose to prevent fluid loss.



M70 0828

4. Remove brake hose banjo bolt and discard sealing washers.
   CAUTION: Always fit plugs to open connections to prevent contamination.



M70 0829

5. Remove 2 guide pin bolts and remove caliper housing from carrier.
6. Remove 2 brake pads from caliper carrier.

Refit

1. Rotate disc by hand and scrape all scale and rust from around edge of disc. Clean location surfaces on caliper bracket.
2. Clean dust from brake parts using brake cleaning fluid.

   WARNING: Do not use compressed air to clean brake components. Dust from friction materials can be harmful if inhaled.

3. Fit brake pads to caliper carrier.
4. Position caliper housing to carrier, align flats on guide pins with caliper housing.
5. Fit guide pin bolts and tighten to 30 Nm (22 lbf.ft).
6. Clean banjo bolt and fit new sealing washers.
7. Position hose to caliper and tighten banjo bolt to 32 Nm (24 lbf.ft).
8. Remove clamp from brake hose.
9. Bleed brake system.

   ☞ **BRAKES, ADJUSTMENTS, Brake system bleeding.**
10. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
11. Remove stand(s) and lower vehicle.

Housing - caliper - rear

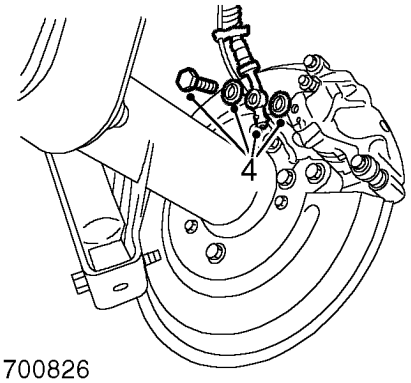
70.55.25

Remove

1. Raise rear of vehicle, one side.

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

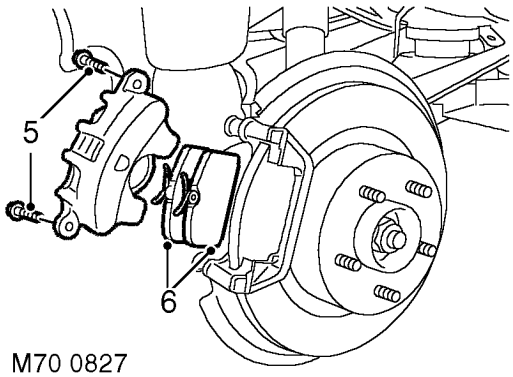
2. Remove road wheel(s).
3. Clamp brake hose to prevent fluid loss.



M700826

4. Remove brake hose banjo bolt and discard sealing washers.

   CAUTION: Always fit plugs to open connections to prevent contamination.



M70 0827

5. Remove 2 guide pin bolts and remove caliper housing from carrier.
6. Remove 2 brake pads from caliper carrier.

Refit

1. Rotate disc by hand and scrape all scale and rust from around edge of disc. Clean location surfaces on caliper bracket.
2. Clean dust from brake parts using brake cleaning fluid.

   WARNING: Do not use compressed air to clean brake components. Dust from friction materials can be harmful if inhaled.

3. Fit brake pads to caliper carrier.
4. Position caliper housing to carrier, align flats on guide pins with caliper housing.
5. Fit guide pin bolts and tighten to 30 Nm (22 lbf.ft).
6. Clean banjo bolt and fit new sealing washers.
7. Position hose to caliper and tighten banjo bolt to 32 Nm (24 lbf.ft).
8. Remove clamp from brake hose.
9. Bleed brakes.

   ☞ **BRAKES, ADJUSTMENTS, Brake system bleeding.**
10. Fit road wheel(s) and tighten nuts to 140 Nm (103 lbf.ft).
11. Remove stand(s) and lower vehicle.

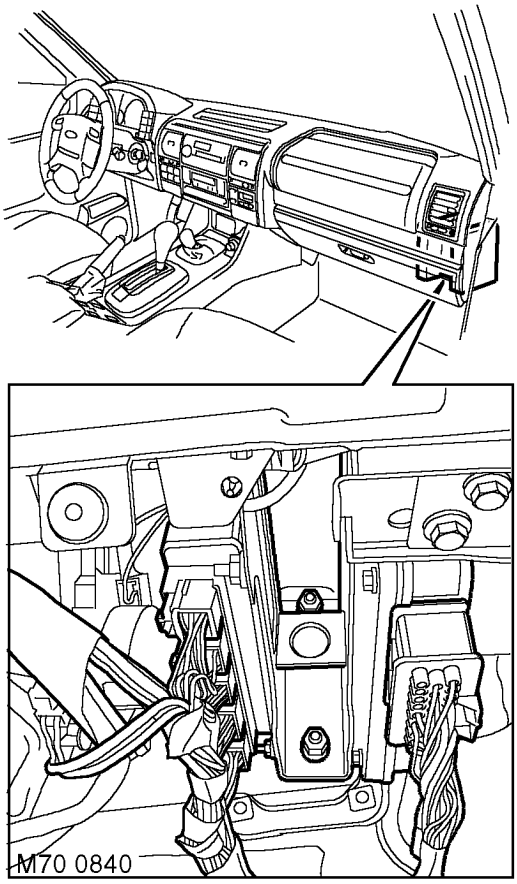
ECU - Self levelling and anti locking brakes (SLABS)

🔧 ***70.65.01***

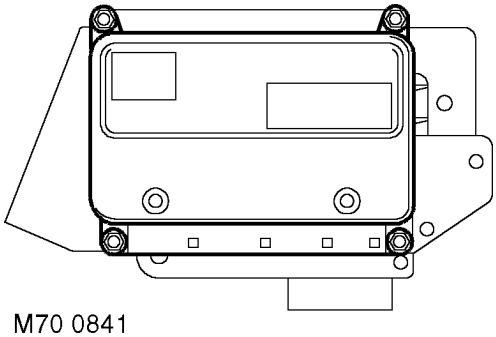
Remove

1. Remove BCU.

   ☞ **BODY CONTROL UNIT, REPAIRS, Body control unit (BCU).**



2. Remove 5 multiplugs from SLABS ECU.
3. Remove multiplug from ACE ECU.
4. Remove lower nut and loosen upper nut securing SLABS and ACE ECU bracket to body.
5. Remove ECU's and bracket assembly.



M70 0841

6. Remove 4 nuts securing SLABS ECU and remove ECU.

Refit

1. Fit new SLABS ECU to bracket and secure with nuts.
2. Fit ECU's and bracket assembly to body and secure with nuts.
3. Connect multiplugs to ACE ECU and SLABS ECU.
4. Fit BCU.
   ☞ **BODY CONTROL UNIT, REPAIRS, Body control unit (BCU).**
5. Programme the new SLABS ECU using TestBook.

Sensor – ABS – front

🔧 ***70.65.30***

ABS sensor is supplied fitted to wheel hub and must not be removed.

Remove

1. Remove wheel hub.
   ☞ **FRONT SUSPENSION, REPAIRS, Wheel hub.**

Refit

1. Fit wheel hub.
   ☞ **FRONT SUSPENSION, REPAIRS, Wheel hub.**

Sensor – ABS – rear

70.65.31

ABS sensor is supplied fitted to wheel hub and must not be removed.

Remove

1. Remove wheel hub.
   REAR SUSPENSION, REPAIRS, Wheel hub.

Refit

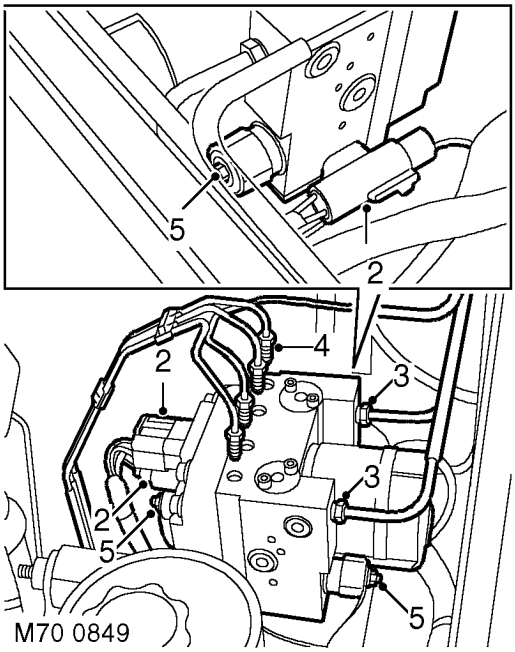
1. Fit wheel hub.
   REAR SUSPENSION, REPAIRS, Wheel hub.

Modulator unit - ABS

70.65.49

Remove

1. Position cloth under modulator to absorb fluid spillage.
   CAUTION: Brake fluid will damage paint finished surfaces. If spilled, immediately remove fluid and clean area with water.



2. Disconnect 3 multiplugs from ABS modulator.
3. Disconnect 2 inlet brake pipe unions from pump side of modulator.
   CAUTION: Always fit plugs to open connections to prevent contamination.
4. Disconnect 4 outlet brake pipe unions from top of modulator.
   CAUTION: Always fit plugs to open connections to prevent contamination.
5. Loosen 3 nuts securing modulator to mounting bracket.
6. Release and remove modulator from mounting bracket.
7. Remove 3 mounting rubbers from modulator.

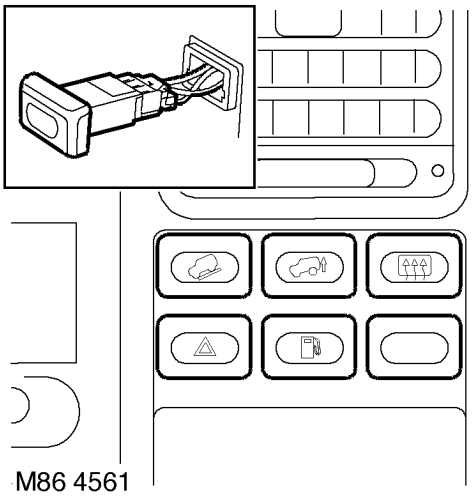
Refit

1. Position mounting rubbers to modulator.
2. Position modulator to mounting bracket, tighten nuts to 9 Nm (7 lbf.ft).
3. Clean brake pipe unions.
4. Connect brake pipe unions to modulator ensuring pipes are connected to their correct ports.
5. Tighten 13 mm unions to 22 Nm (16 lbf.ft) and 11 mm unions to 14 Nm (10 lbf.ft).
6. Connect multiplugs to modulator.
7. Bleed brakes.
   ☞ **BRAKES, ADJUSTMENTS, Brake system bleeding.**
8. To ensure correct operation, the ABS system MUST be tested using TestBook.

Switch - Hill descent control

⊸ ***70.70.11***

Remove



1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

Switch - handbrake

86.65.45

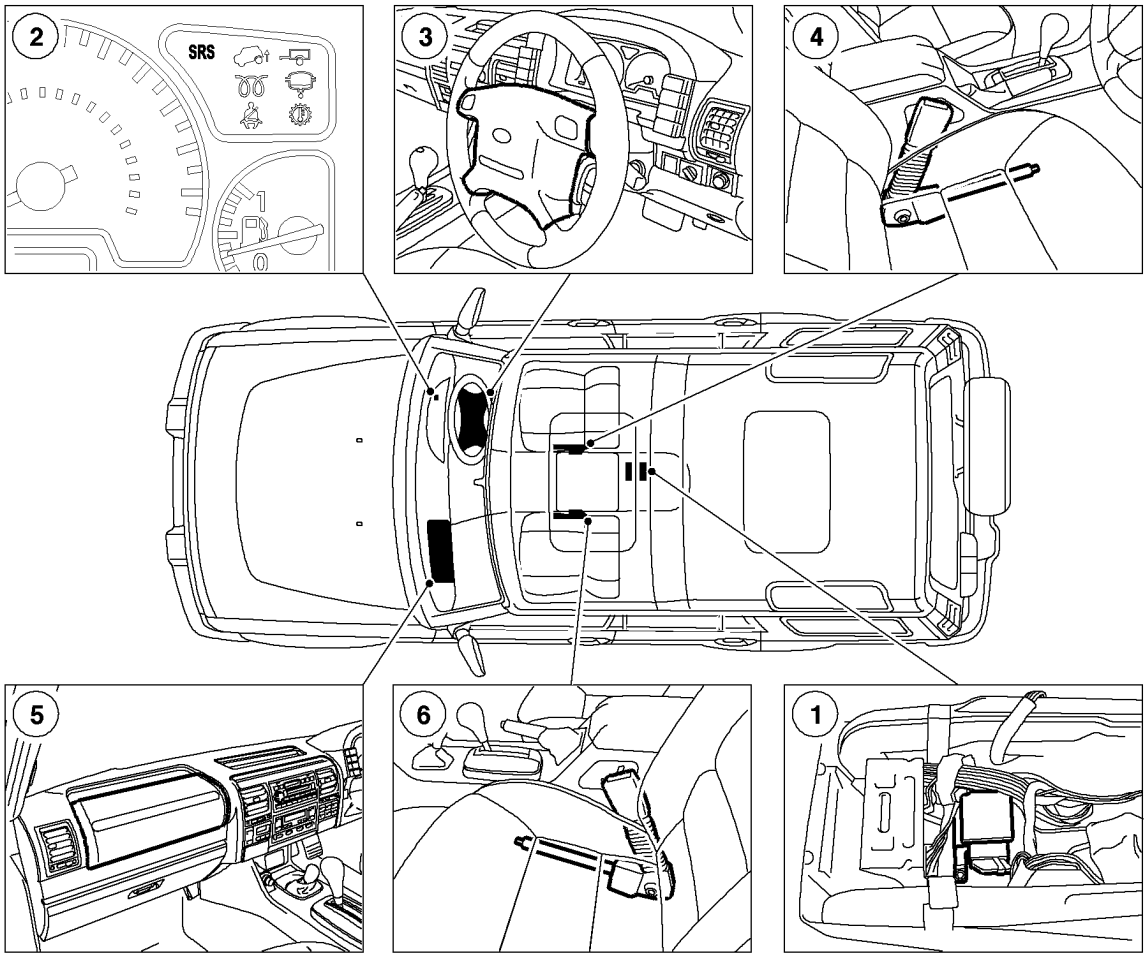
Remove

1. Remove centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.
2. Disconnect Lucar from handbrake warning switch.
3. Remove clip and clevis pin securing cable to handbrake lever.
4. Remove 2 bolts and remove handbrake lever.
5. Remove 2 screws securing switch to handbrake lever and remove switch.

Refit

1. Fit switch to handbrake lever and tighten screws.
2. Position handbrake lever to floor and tighten bolts to 22 Nm (16 lbf.ft).
3. Align cable to handbrake lever and fit clevis pin and clip.
4. Connect Lucar to handbrake switch.
5. Fit centre console.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
   INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.

SRS component layout

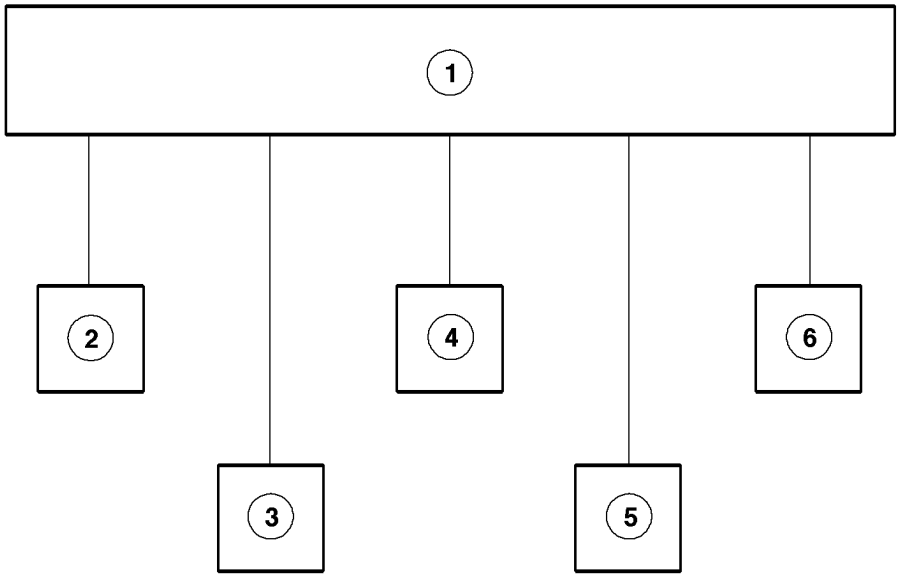


M762950

RHD shown, LHD similar

1 DCU
2 SRS warning lamp
3 Driver airbag module
4 Driver seat belt pretensioner
5 Passenger airbag module
6 Passenger seat belt pretensioner

SRS block diagram



M763036

1 DCU
2 SRS warning lamp
3 Driver airbag module
4 Driver seat belt pretensioner
5 Passenger airbag module
6 Passenger seat belt pretensioner

Description - SRS

General

The purpose of the Supplementary Restraint System (SRS) is to reduce the impact of the driver and passenger against the vehicle's interior in the event of a serious accident.

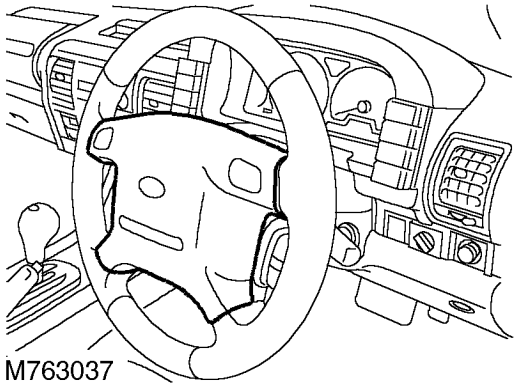
The SRS system is a stand-alone system. There are no remotely mounted crash sensors. The only external input to the DCU is power. The system only becomes live when the ignition is switched on.

The SRS consists of the following components:

- Diagnostic and control unit (DCU).
- SRS warning lamp.
- Rotary coupler.
- Driver airbag module.
- Driver seat belt pretensioner.
- Passenger airbag module.
- Passenger seat belt pretensioner.

The passenger airbag is optional in some markets. All other components are standard fit in all markets. The SRS functions the same in all markets.

Driver airbag module


M763037

The driver airbag module is located in the steering wheel and is controlled by the DCU. A bag within the module inflates to protect the driver in the event of a collision severe enough to deploy the system.

The driver airbag module connects to the steering column wiring harness via a rotary coupler.

Within the driver airbag module is a squib which, when given the correct current by the DCU, inflates the airbag by initiating a chemical reaction. In deployment, the airbag inflates within a fraction of a second and then deflates at a controlled rate as the weight of the driver presses against the bag. Vents in the bag control airbag deflation.

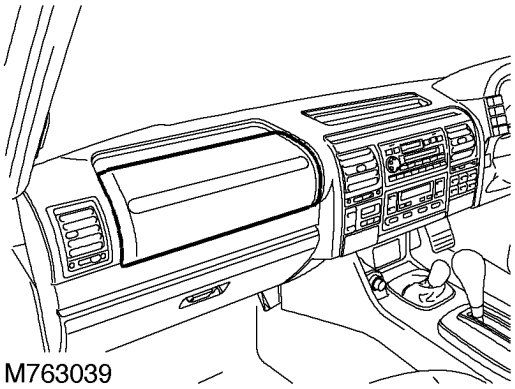
The DCU regularly applies a test current to the driver airbag squib to confirm continuity of the ignition circuitry.

The DCU is capable of detecting a short to ground, a short to battery and an open circuit for the driver airbag module squib. It will also identify if the configuration of the DCU differs from that actually fitted to the vehicle.

The DCU also stores the following additional information on each fault:

- A count indicating the number of times the fault has occurred.
- A start time and an end time for the fault to indicate duration of the fault.

Passenger airbag module


M763039

The passenger airbag module is located in the instrument panel above the glove box and is controlled by the DCU. A bag within the module inflates to protect the passenger in the event of a collision severe enough to deploy the system.

Within the passenger airbag module is a squib which, when given the correct current by the DCU, inflates the airbag by initiating a chemical reaction. In deployment, the airbag inflates within a fraction of a second and then deflates at a controlled rate as the weight of the passenger presses against the bag. Vents in the bag control airbag deflation.

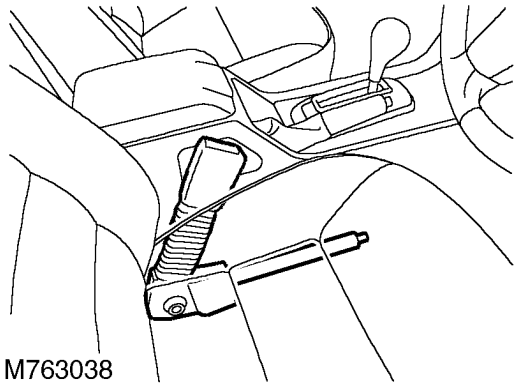
The DCU regularly applies a test current to the passenger airbag squib to confirm continuity of the ignition circuitry.

The DCU is capable of detecting a short to ground, a short to battery and an open circuit for the passenger airbag module squib. It will also identify if the configuration of the DCU differs from that actually fitted to the vehicle.

The DCU also stores the following additional information on each fault:

- A count indicating the number of times the fault has occurred.
- A start time and an end time for the fault to indicate duration of the fault.

Seat belt pretensioners


M763038

The seat belt pretensioners are located within the front seat belt anchors and are controlled by the DCU. They are pyrotechnic devices that, when deployed, tighten the front seat belts. This works in conjunction with the airbag module(s) to protect front seat occupants in the event of an accident.

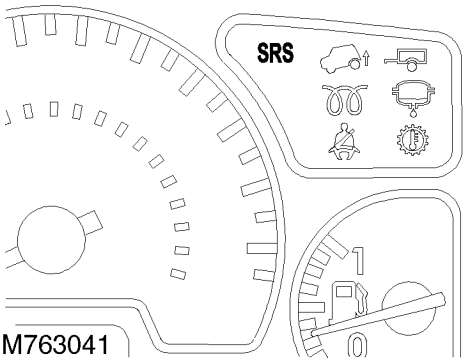
The DCU regularly applies a test current to the seat belt pretensioner squibs to confirm continuity of the ignition circuitry.

The DCU is capable of detecting a short to ground, a short to battery and an open circuit for the squibs. It will also identify if the configuration of the DCU differs from that actually fitted to the vehicle.

The DCU also stores the following additional information on each fault:

- A count indicating the number of times the fault has occurred.
- A start time and an end time for the fault to indicate duration of the fault.

SRS warning lamp



The SRS warning lamp located in the instrument cluster indicates the following:

- The status of the system readiness check on start-up.
- A fault within the SRS system.

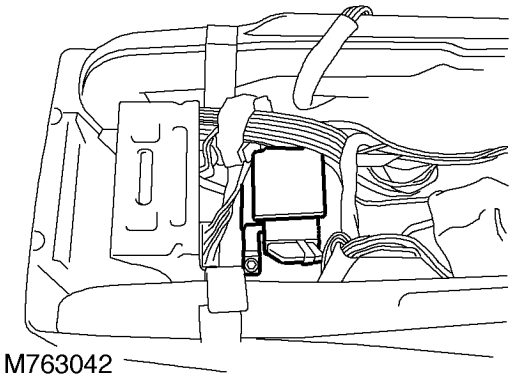
The input to the SRS warning lamp from the DCU is 12 volts during the readiness test, 0 volts if no fault present and 12 volts if a fault is detected.

The DCU is capable of detecting an open circuit or a short circuit for the SRS warning lamp.

The DCU also stores the following additional information on each fault:

- A count indicating the number of times the fault occurred.
- A start and end time for the fault to indicate the duration of the fault.

Diagnostic and Control Unit (DCU)



The SRS DCU is an electronic single point crash sensor. It is capable of sensing if a crash has taken place. If all the relevant parameters are met, then the DCU deploys the airbag(s) and seat belt pretensioners.

The DCU is bolted to the transmission tunnel beneath the centre console in the area of the handbrake.

The DCU performs the following functions:
- Internal self test, system monitoring and fault detection.
- SRS warning lamp operation.
- System deployment.

Self test, system monitoring and fault detection
The DCU performs a self-test during start-up and then continually during operation of the system. The following components are tested:
- The decelerometer.
- The electromechanical safing sensor.
- The microprocessor.
- The continuity of squib ignition circuits.
- The SRS warning lamp.

If the DCU detects a fault, it stores the fault code in memory. Diagnose the DCU with TestBook. The DCU cannot be serviced. It must be replaced if it is faulty.

SRS warning lamp operation
The DCU controls the SRS warning lamp contained in the instrument cluster.

System deployment
The DCU determines when the system deploys based on inputs from both the decelerometer and the electromechanical safing sensor. Both are located within the DCU. Neither are serviceable.

The electromechanical safing sensor uses a magnet and ball bearing system to provide a mechanical confirmation of vehicle deceleration. The ball bearing is held in place by the magnet. The strength of the magnet is calibrated such that the force required for the ball bearing to move away from the magnet will only occur if the vehicle decelerates suddenly, as in an accident.

The SRS deploys only if both the decelerometer reading and the safing sensor operation occur at the same time.

Operation - SRS

The diagnostic and control unit (DCU) controls the SRS system. The DCU is located beneath the centre console close to the handbrake area. The DCU contains both an electronic deceleration sensor as well as an electromechanical safing sensor. When the electronic deceleration sensor within the DCU detects rapid deceleration of the vehicle, it compares the deceleration rate with stored values in its' memory. If the deceleration rate exceeds the stored value and the electromechanical safing sensor triggers, the DCU deploys the airbag and the seat belt pretensioners. The DCU will not deploy the airbags and seat belt pretensioners unless both sensors trigger.

The SRS has diagnostic capabilities through TestBook. In the event that a fault is detected, the DCU alerts the driver by illuminating a warning lamp in the instrument cluster.

The DCU controls the following:

- SRS warning lamp.
- Drivers airbag module.
- Passenger airbag module (where fitted).
- Driver seat belt pretensioner.
- Passenger seat belt pretensioner.

WARNING: The integrity of the SRS system are critical for safety reasons. Ensure the following precautions are always adhered to:

- ***Never install used SRS components from another vehicle or attempt to repair an SRS component.***
- ***When repairing an SRS system only use genuine new parts.***
- ***Never apply electrical power to an SRS component unless instructed to do so as part of an approved test procedure.***
- ***Special Torx bolts are necessary for installing the airbag module - do not use other bolts. Ensure bolts are tightened to the correct torque.***
- ***Always use new fixings when replacing an SRS component.***
- ***Ensure the SRS Diagnostic Control Unit (DCU) is always installed correctly. There must not be any gap between the DCU and the bracket to which it is mounted. An incorrectly mounted DCU could cause the system to malfunction.***

System deployment

The airbag and seat belt pretensioners deploy to protect the front seat occupants when the DCU senses a rapid vehicle deceleration. The system deploys when the following conditions are met:

- The ignition switch is on.
- The vehicle decelerates beyond a threshold defined within the DCU.
- The electromechanical safing sensor within the DCU triggers.

When all of the above conditions are met, the DCU deploys the airbag(s) and seat belt pretensioners. If the above conditions are not met, the DCU will not deploy the system.

Component replacement policy

After an impact which deploys the airbags and pretensioners, the following components must be renewed:

- DCU.
- Driver and passenger airbag modules.
- Driver and passenger buckle pretensioners.
- Rotary coupler.
- Flyleads (where applicable) connecting airbags and pre-tensioners to SRS harness

SRS warning lamp

The SRS warning lamp illuminates for 5 seconds during system readiness check on starting the engine. The SRS warning lamp extinguishes for one second after the system readiness check is performed. If a fault is present the warning lamp then illuminates continuously. If no fault is present, the SRS warning lamp remains extinguished. If a system fault occurs in excess of two seconds after the readiness check has been completed, the SRS warning lamp illuminates for that ignition cycle. It remains illuminated for a minimum of 12 seconds ± 4 seconds for all fault conditions.

The SRS warning lamp will only illuminate for low voltage concerns while the low voltage condition is present. If the low voltage condition is corrected, the SRS warning lamp extinguishes and the fault is recorded in the DCU's memory.

Description - seat belts

An inertia reel, three point seat belt is installed at each seat position. The inertia reels incorporate a liftshaft locking system with webbing sensor and car sensor activating mechanisms. The webbing sensor activates the locking system if the webbing is subjected to a sharp pull. The car sensor activates the locking system if the vehicle is subjected to sudden deceleration or a severe tilt angle.

Front seat belts

The inertia reel of each front seat belt is attached to the related B/C post, behind the finishers. The webbing runs from the inertia reel, through a height adjuster, to an anchor point at the base of the B/C post. The buckle assembly for each belt is attached to the inboard side of the seat and contains the SRS pretensioner.

Rear seat belts

The inertia reels for the outboard rear seats are attached to the body behind the loadspace side trim casings. The webbing runs from each inertia reel through an upper mounting, suspended from the cantrail, to an anchor point on the rear wheel arch.

The inertia reel of the centre rear seat is mounted in the back of the seat. The webbing runs through a guide on the top of the seat and is anchored to one of the seat hinge points. The buckles for the rear seat belts are also attached to the seat hinge points.

Third row seat belts

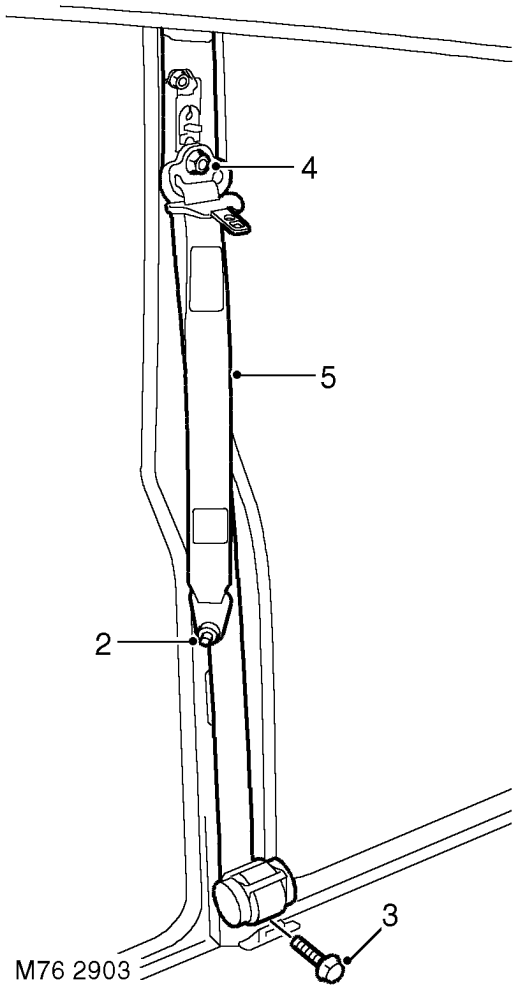
The inertia reel of each third row rear seat belt is attached to the related E post, behind the loadspace side trim casing.The webbing runs from the inertia reel, through an upper mounting on the E post to an anchor point on the loadspace floor. The buckle is mounted on the inboard side of the seat.

Seat belt - front

76.73.13

Remove

1. Remove 'B' post lower trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.



2. Remove bolt securing seat belt to front seat.
3. Remove bolt securing seat belt reel to 'B' post.
4. Remove seat belt upper anchorage nut.
5. Remove seat belt.

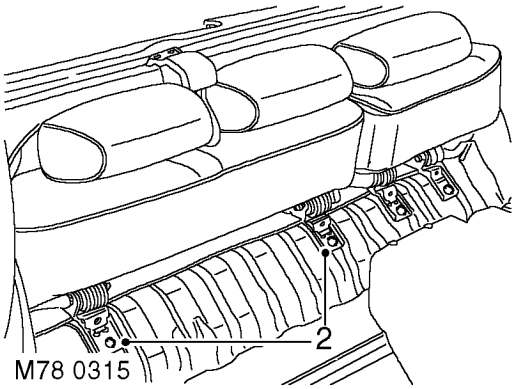
Refit

1. Fit seat belt upper anchorage and tighten nut to 32 Nm (24 lbf.ft).
2. Fit seat belt reel to 'B' post and tighten bolt to 50 Nm (37 lbf.ft).
3. Fit seat belt to front seat and tighten bolt to 32 Nm (24 lbf.ft).
4. Fit 'B' post lower trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.

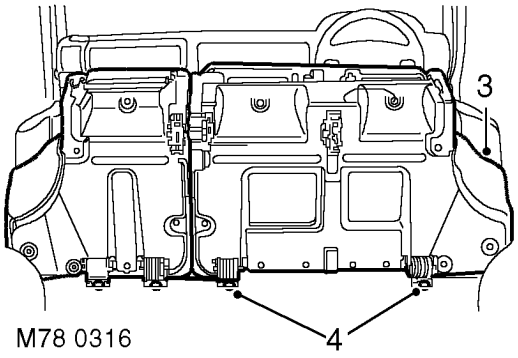
Seat belt - rear - centre

76.73.20

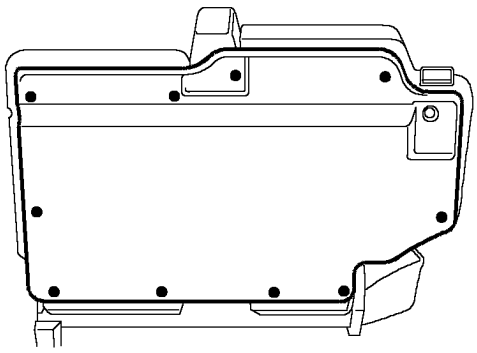
Remove



1. Carefully pull front carpet away from rear seat base to gain access to front mounting brackets of RH rear seats.
2. Remove 2 Torx bolts securing front mounting brackets of RH rear seats to floor.

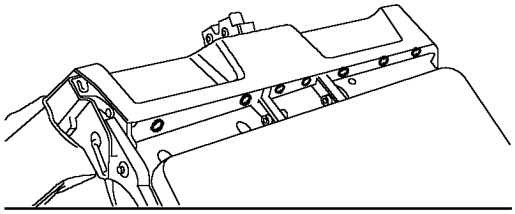


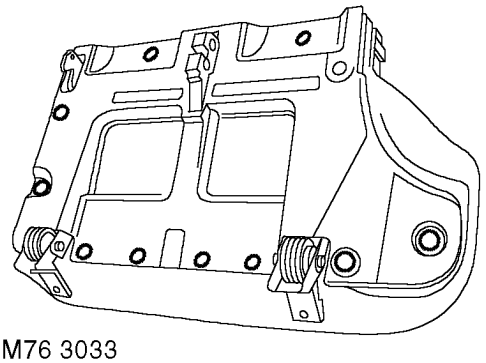
3. Recline and fold RH rear seats.
4. Remove 2 Torx bolts securing rear mounting brackets of RH rear seats to floor.
5. Remove RH rear seats.



M76 3032

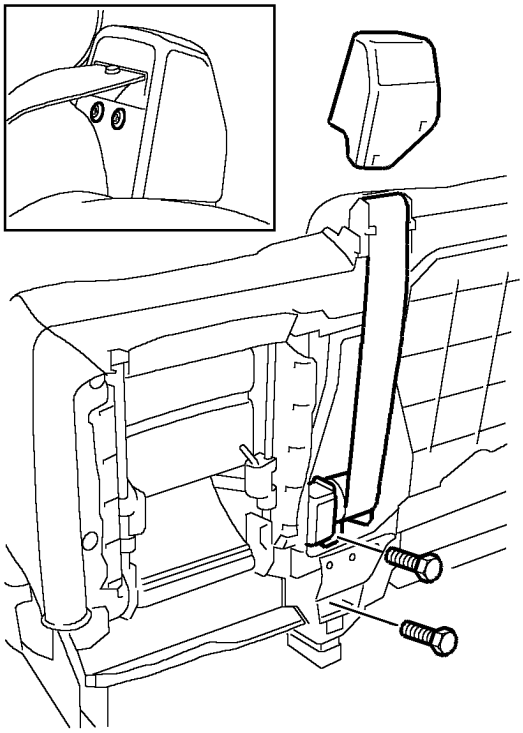
6. Remove 11 clips securing seat back finisher to RH rear seats.
7. Remove seat back finisher.





M76 3033

8. Remove 15 clips securing seat base finisher to RH rear seats.
9. Remove seat base finisher.



M76 3034

10. Remove bolt securing seat belt lower anchorage to frame of RH rear seats.
11. Remove 2 screws securing guide cover to RH rear seats
12. Remove guide cover.
13. Remove bolt securing seat belt reel to frame of RH rear seats.
14. Remove seat belt.

Refit

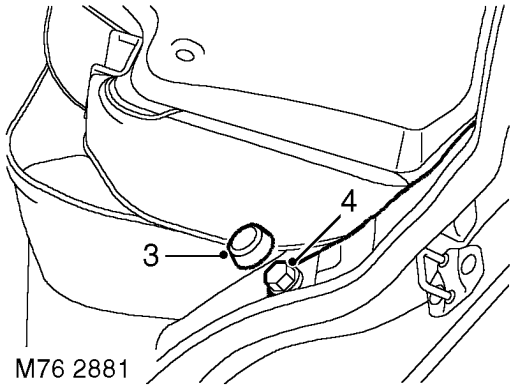
1. Fit seat belt reel and tighten bolt to 32 Nm (24 lbf.ft).
2. Position seat belt through guide on top of RH rear seats.
3. Fit seat belt lower anchorage to frame of seats and tighten bolt to 32 Nm (24 lbf.ft).
4. Position guide cover to RH rear seats and secure with screws.
5. Position seat base finisher to RH rear seats and secure with clips.
6. Position seat back finisher to RH rear seats and secure with clips.
7. Position RH rear seats and secure rear mounting brackets to floor with Torx bolts tightened to 45 Nm (33 lbf.ft).
8. Put RH rear seats in upright position and secure front mounting brackets to floor with Torx bolts tightened to 45 Nm (33 lbf.ft).
9. Position front carpet.

Seat belt - rear - side

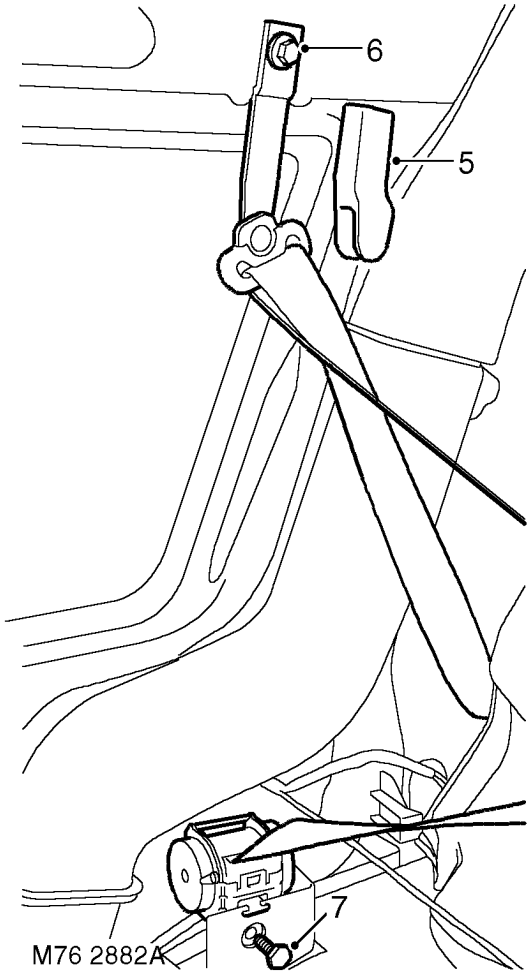
76.73.23

Remove

1. Remove 'D' post trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**
2. Remove loadspace side trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**



3. Remove cap from seat belt lower anchorage bolt.
4. Remove lower anchorage bolt.



5. Remove cover from seat belt upper anchorage bolt.
6. Remove upper anchorage bolt.
7. Remove bolt securing seat belt reel to body.
8. Remove seat belt.

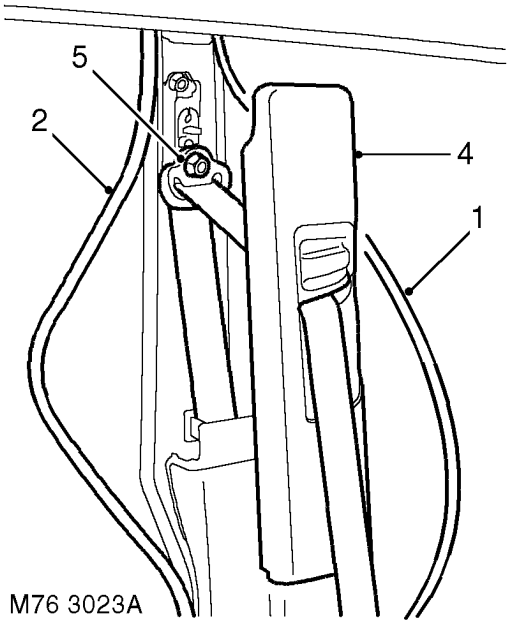
Refit

1. Fit seat belt reel to body and tighten bolt to 32 Nm (24 lbf.ft).
2. Fit seat belt upper anchorage to body and tighten bolt to 50 Nm (37 lbf.ft).
3. Fit cover to upper anchorage bolt.
4. Fit seat belt lower anchorage to body and tighten bolt to 32 Nm (24 lbf.ft).
5. Fit cap to lower anchorage bolt.
6. Fit loadspace side trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
7. Fit 'D' post trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**

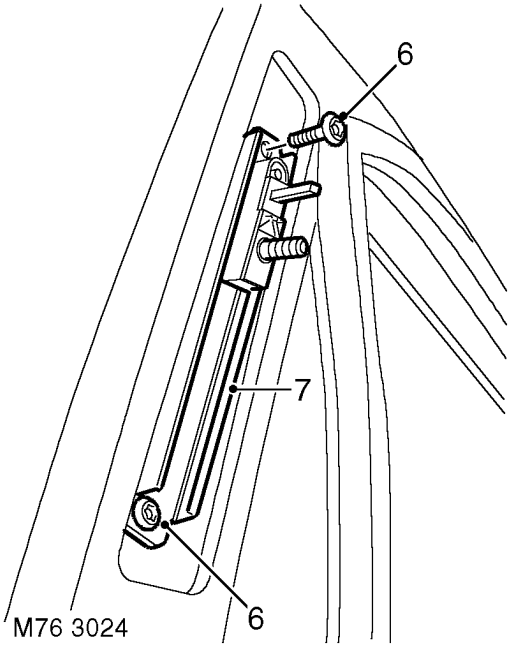
Mounting - seat belt - 'B' post

76.73.26

Remove



1. Release front door aperture seal from 'B' post.
2. Release rear door aperture seal from 'B' post.
3. Release clip securing upper 'B' post trim.
4. Remove 'B' post upper trim.
5. Remove nut securing seat belt upper anchorage to mounting.



6. Remove 2 Torx bolts securing mounting to 'B' post.
7. Remove mounting.

Refit

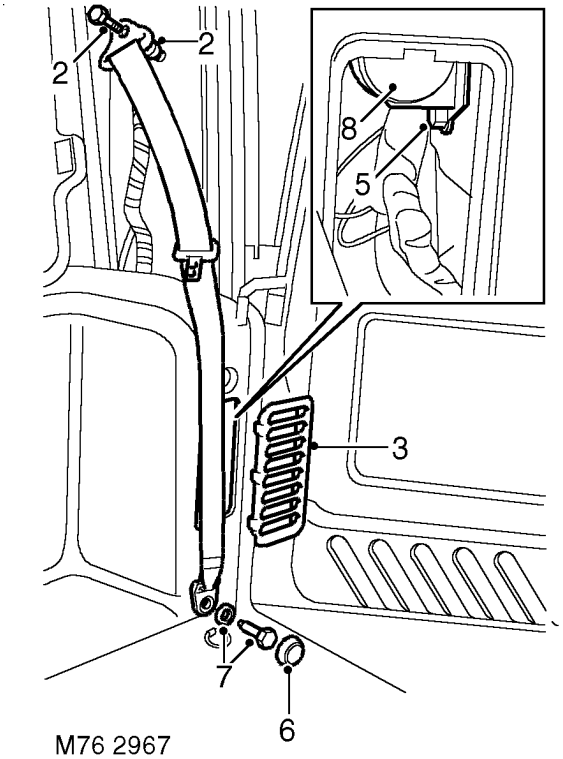
1. Fit mounting to upper 'B' post and tighten Torx bolts to 22 Nm (16 lbf.ft).
2. Fit seat belt upper anchorage to mounting and tighten nut to 32 Nm (24 lbf.ft).
3. Secure trim casing to 'B' post with clip.
4. Fit front and rear door aperture seals to 'B' post.

Seat belts - third row

76.73.28/21

Remove

1. Remove 'D' post trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.



M76 2967

2. Remove seat belt upper anchorage bolt and collect spacer.
3. Release access panel from loadspace side trim casing.
4. Remove access panel.
5. Remove bolt securing seat belt reel to body.
6. Remove cap from seat belt lower anchorage bolt.
7. Remove lower anchorage bolt and collect washers.
8. Remove seat belt.

Refit

1. Fit seat belt lower anchorage to body and tighten bolt to 32 Nm (24 lbf.ft). Fit cap to bolt.
2. Fit seat belt reel to body and tighten bolt to 50 Nm (37 lbf.ft).
3. Fit seat belt upper anchorage and tighten bolt to 50 Nm (37 lbf.ft).
4. Fit access panel to luggage compartment side trim casing.
5. Fit 'D' post trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.

Pre-tensioner - front seat belt

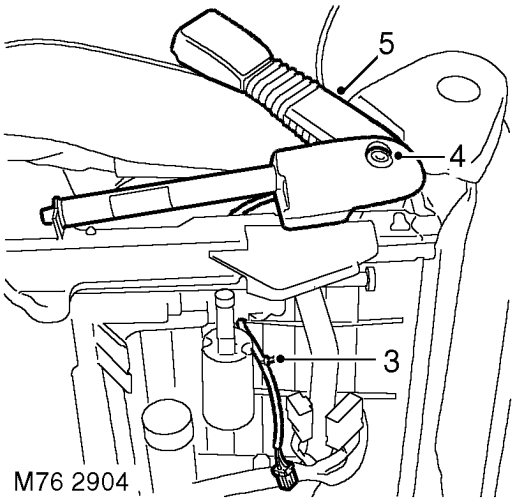
76.73.30

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

WARNING: Always disconnect both battery leads before beginning work on the SRS system. Disconnect the negative battery lead first. Never reverse connect the battery.

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove front seat.
   SEATS, REPAIRS, Seat - front.



3. Release cable tie securing pre-tensioner harness to seat.
4. Remove Torx screw securing pre-tensioner to seat.
5. Remove pre-tensioner.

   WARNING: Store the airbag module or seat belt pre-tensioner in a designated storage area. If there is no designated storage area available, store in the locked luggage compartment/loadspace of the vehicle and inform the workshop supervisor.

Refit

1. Fit pre-tensioner to seat and tighten Torx bolt to 32 Nm (24 lbf.ft).
2. Secure harness to seat with new cable tie.
3. Fit front seat.
   SEATS, REPAIRS, Seat - front.
4. Connect battery leads, earth lead last.

Airbag module - drivers

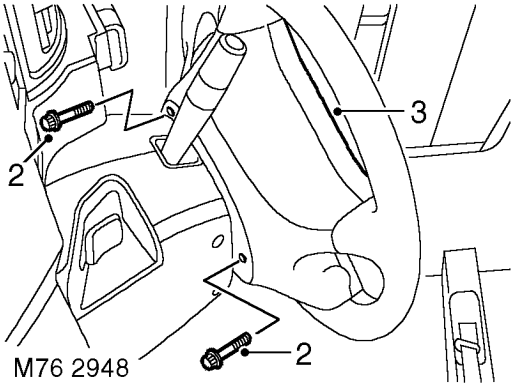
76.74.01

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

WARNING: Always disconnect both battery leads before beginning work on the SRS system. Disconnect the negative battery lead first. Never reverse connect the battery.

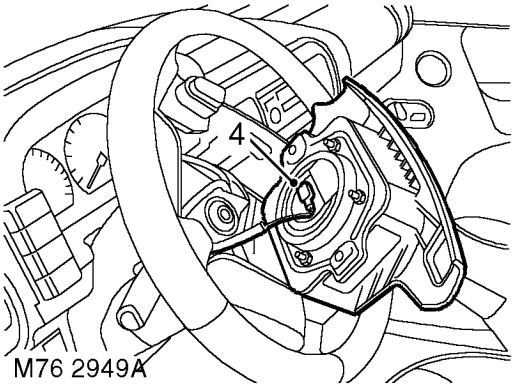
Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.



2. Remove 2 Torx bolts securing airbag module to steering wheel.
3. Release airbag module from steering wheel.

   CAUTION: Do not allow the airbag module to hang by the airbag harness.



4. Disconnect multiplug from airbag module.

5. Remove airbag module.

WARNING: Store the airbag module with the deployment side uppermost. If it is stored deployment side down, accidental deployment will propel the airbag module with enough force to cause serious injury.

WARNING: Store the airbag module or seat belt pre-tensioner in a designated storage area. If there is no designated storage area available, store in the locked luggage compartment/loadspace of the vehicle and inform the workshop supervisor.

Refit

NOTE: If the airbag module is to be replaced, the bar code of the new module must be recorded.

1. Position airbag module and connect multiplug.
2. Fit airbag module to steering wheel and tighten Torx bolts to 9 Nm (7 lbf.ft).
3. Connect battery leads, earth lead last.

Airbag module - passenger

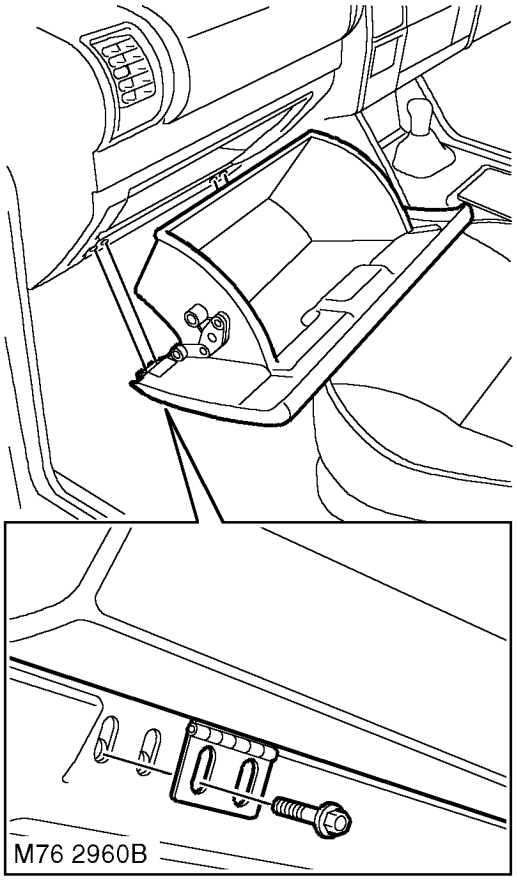
76.74.02

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

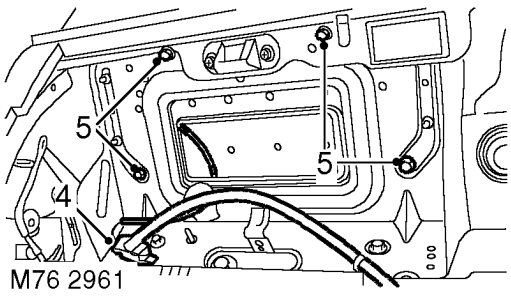
WARNING: Always disconnect both battery leads before beginning work on the SRS system. Disconnect the negative battery lead first. Never reverse connect the battery.

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.



2. Release guides supporting glove box.
3. Lower glove box to gain access to airbag module.



M76 2961

4. Disconnect multiplug from airbag module.
5. Remove 4 Torx bolts securing airbag module to fascia.
6. Remove airbag module from fascia panel.

WARNING: Store the airbag module with the deployment side uppermost. If it is stored deployment side down, accidental deployment will propel the airbag module with enough force to cause serious injury.

WARNING: Store the airbag module or seat belt pre-tensioner in a designated storage area. If there is no designated storage area available, store in the luggage compartment of the vehicle and inform the workshop supervisor.

Refit

NOTE: If the airbag module is to be replaced, the bar code of the new module must be recorded.

1. Fit airbag module to fascia and tighten Torx bolts to 8 Nm (6 lbf.ft).
2. Connect multiplug to airbag module.
3. Position glove box and engage supporting guides. Close glove box.
4. Connect battery leads, earth lead last.

DCU

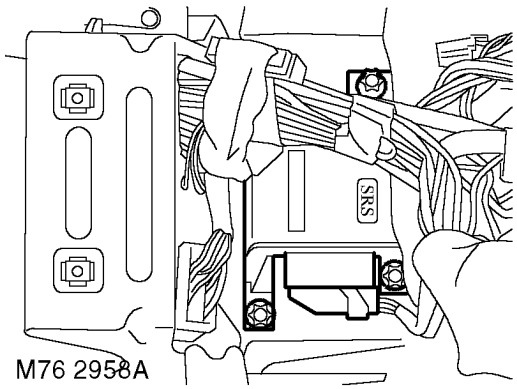
76.74.06

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

WARNING: Always disconnect both battery leads before beginning work on the SRS system. Disconnect the negative battery lead first. Never reverse connect the battery.

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove centre console.
   - On manual gearbox models:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.**
   - On automatic gearbox models:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.**



M76 2958A

3. Disconnect multiplug from DCU.
4. Remove 3 Torx bolts securing DCU to body and remove DCU.

CAUTION: The SRS diagnostic control unit is a non-serviceable component and no attempt should be made to repair or modify the unit.

Refit

CAUTION: The SRS diagnostic control unit is a shock sensitive device and must be handled with extreme care.

1. Position DCU to body and connect multiplug.
2. Fit and tighten DCU Torx bolts to 10 Nm (7 lbf.ft).
3. Fit centre console.
   - On manual gearbox models:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.**
   - On automatic gearbox models:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.**
4. Connect battery leads, earth lead last.

Rotary coupler

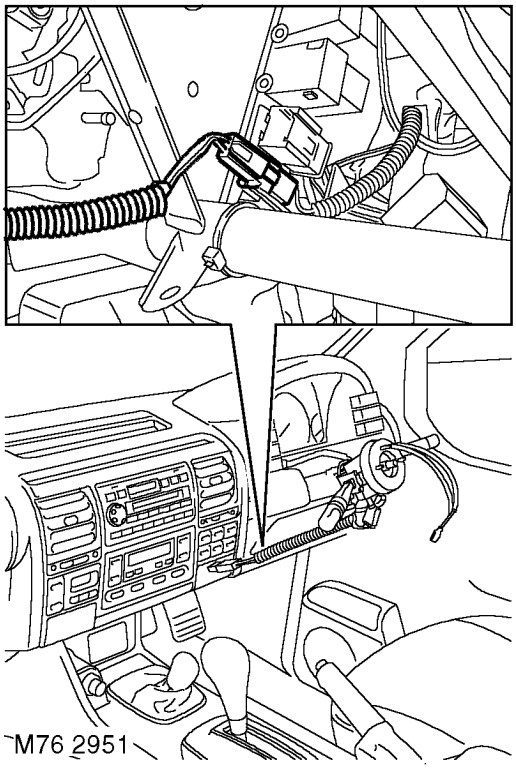
🔧 *76.74.20*

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

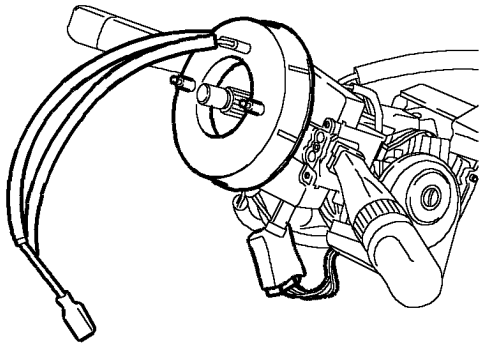
WARNING: Always disconnect both battery leads before beginning work on the SRS system. Disconnect the negative battery lead first. Never reverse connect the battery.

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove steering wheel.
   ☞ **STEERING, REPAIRS, Steering wheel.**



3. Remove steering column nacelle.
   ☞ **STEERING, REPAIRS, Nacelle - steering column.**



M76 2952

4. Release rotary coupler multiplug from bracket and disconnect from harness.
5. Disconnect rotary coupler multiplug from harness.
6. Remove rotary coupler.

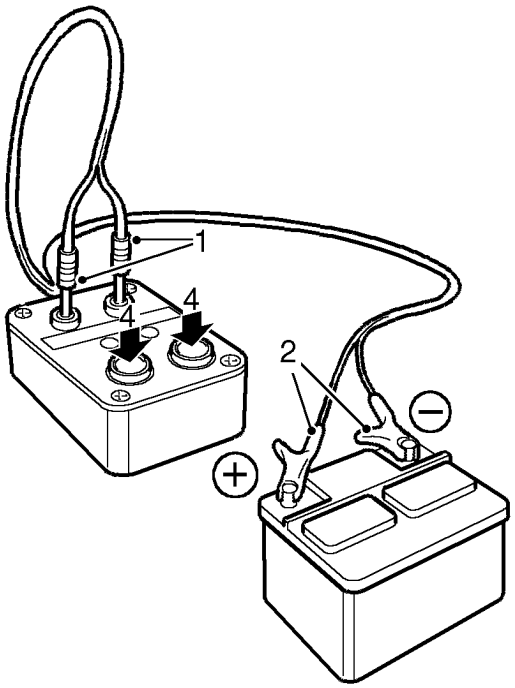
Refit

1. Fit rotary coupler to steering column and connect multiplug to harness.
2. Connect rotary coupler multiplug to harness and secure to bracket.
3. Fit steering column nacelle.
   ☞ **STEERING, REPAIRS, Nacelle - steering column.**
4. Fit steering wheel.
   ☞ **STEERING, REPAIRS, Steering wheel.**

Airbag deployment tool - self test

🔧 ***76.74.99***

Test



M76 3052

1. Insert BLUE and YELLOW connectors of tool lead into corresponding sockets on face of tool.
2. Connect crocodile clips of second tool lead to battery, RED to positive and BLACK to negative.
3. RED "READY" light should illuminate.
4. Press and hold both operating buttons.
5. GREEN "DEFECTIVE" light should illuminate.
6. Release both operating buttons.
7. RED "READY" light should illuminate.
8. Disconnect tool from battery.
9. Disconnect blue and yellow connectors from tool face sockets.
10. Self test now complete.

Airbag module - drivers - deployment

76.74.99

These guidelines are written to aid authorised personnel to carry out the safe disposal of airbag modules when removed from the vehicle.

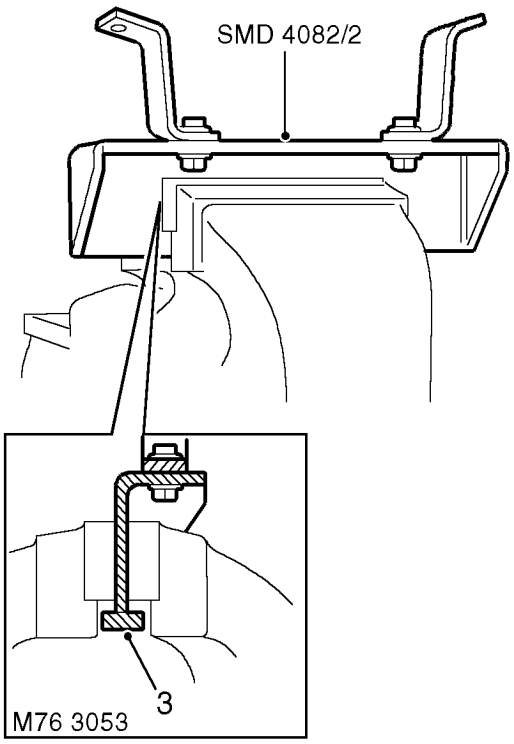
If a vehicle is to be scrapped and contains an undeployed airbag module, the module must be manually deployed. This operation should only be carried out using the following recommended manual deployment procedure. Before deployment is started the deployment tool self test procedure should be carried out.

WARNING: Only use approved deployment equipment, and only deploy SRS components in a well ventilated designated area. Ensure SRS components are not damaged or ruptured before deployment. Notify the relevant authorities.

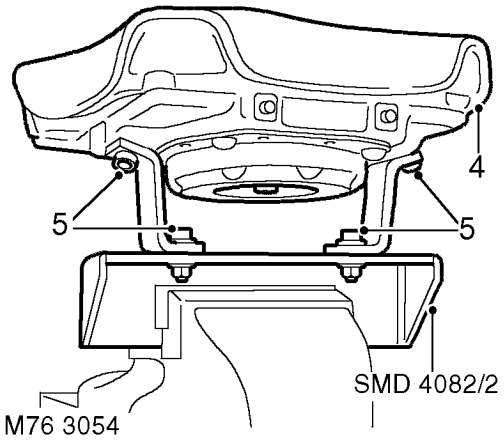
CAUTION: Deployment in the vehicle will damage the steering wheel. If the vehicle is not being scrapped, deploy the module away from the vehicle in accordance with the correct procedure.

Deploy

1. Carry out deployment tool self test.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag deployment tool - self test.**
2. Remove airbag module from steering wheel.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.**



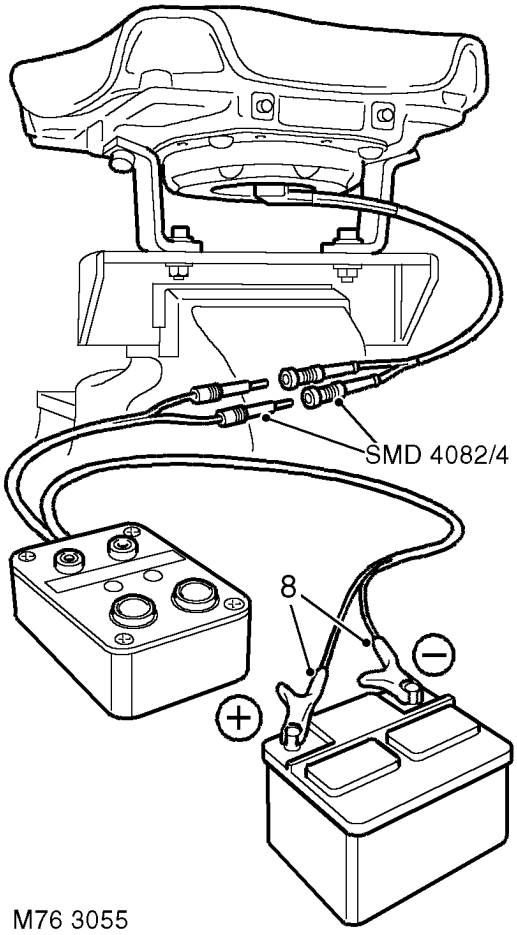
3. Position tool **SMD 4082/2** in vice, ensuring that vice jaws grip tool above bottom flange to prevent possibility of tool being forced upwards from vice. Tighten vice.



4. Secure airbag module to tool **SMD 4082/2**. Ensure module is correctly secured using both fixings.

   WARNING: When removing, testing or installing an airbag module, do not lean directly over it.

5. Ensure airbag module mounting brackets are secure.

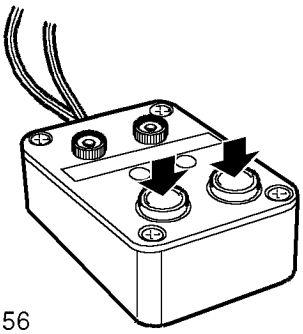


M76 3055

6. Connect flylead **SMD 4082/4** to airbag module.
   WARNING: Ensure the deployment tool is not connected to the battery.

7. Connect flylead **SMD 4082/4** to tool **SMD 4082/1**.
   WARNING: Do not lean over module whilst connecting.

8. Connect tool **SMD 4082/1** to battery.
   WARNING: Ensure all personnel are at least 15 metres (50 ft) away from the airbag module.



M76 3056

9. Press both operating buttons to deploy airbag module.
10. DO NOT return to airbag module for 30 minutes.
11. Using gloves and face mask, remove airbag module from tool, place airbag module in plastic bag and seal bag.
12. Wipe down tool with damp cloth.
13. Transport deployed airbag module to designated area for incineration.
    NOTE: DO NOT re-use or salvage any parts of the airbag system including steering wheel or steering column. Do not transport deployed SRS components in the vehicle passenger compartment.

Airbag module - passenger - deployment

76.74.99

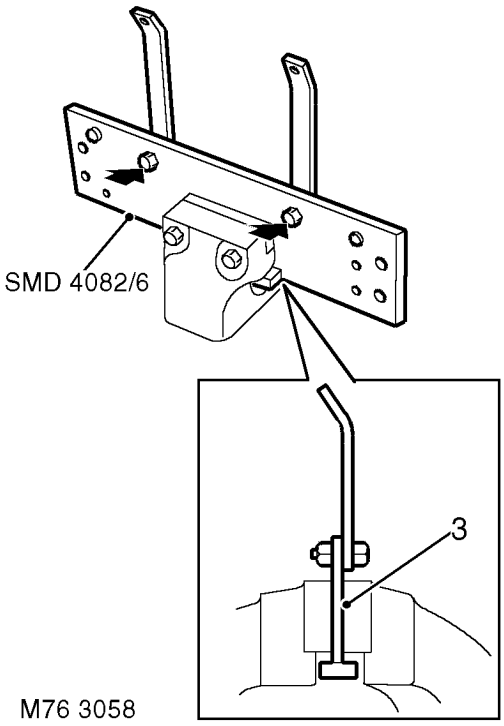
These guidelines are written to aid authorised personnel to carry out the safe disposal of airbag modules when removed from the vehicle.

If a vehicle is to be scrapped and contains an undeployed airbag module, the module must be manually deployed. This operation should only be carried out using the following recommended manual deployment procedure. Before deployment is started the deployment tool self test procedure should be carried out.

WARNING: Only use approved deployment equipment, and only deploy SRS components in a well ventilated designated area. Ensure SRS components are not damaged or ruptured before deployment. Notify the relevant authorities.

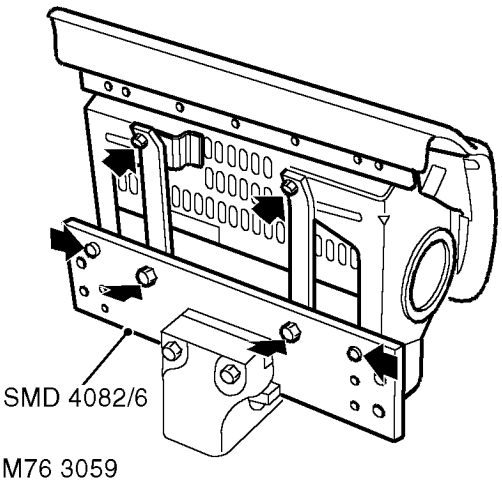
Deploy

1. Carry out deployment tool self test.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag deployment tool - self test.**
2. Remove airbag module from fascia.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - passenger.**



M76 3058

3. Position tool **SMD 4082/6** in vice, ensuring that vice jaws grip tool above bottom flange to prevent possibility of tool being forced upwards from vice. Tighten vice.
4. Position brackets **SMD 4082/7** to tool; lightly tighten bolts.

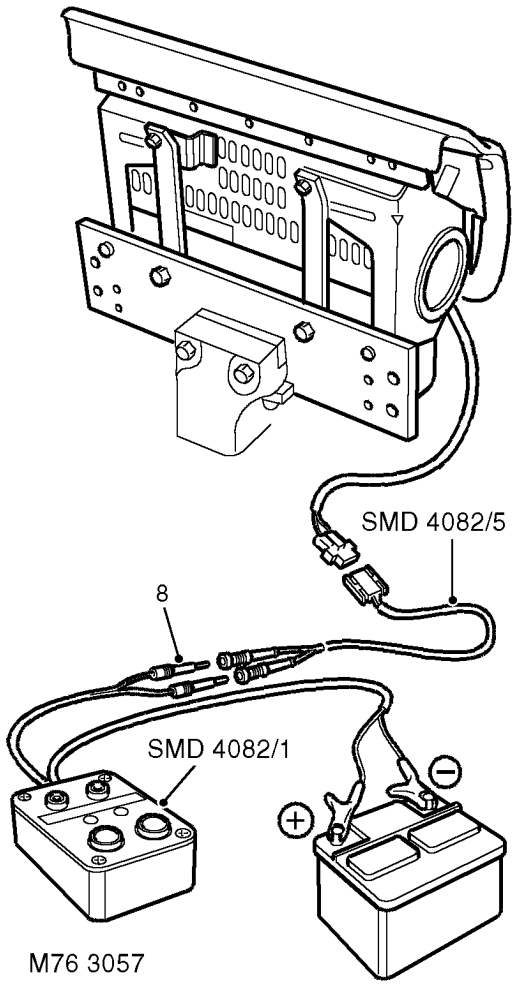


M76 3059

5. Position airbag module to tool **SMD 4082/6**. Ensure module is correctly secured using all fixings.

   WARNING: When removing, testing or installing an airbag module, do not lean directly over it.

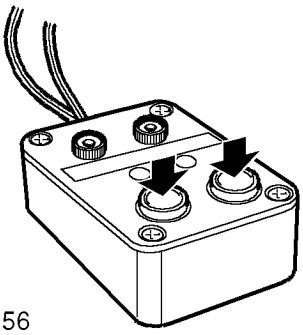
6. Ensure airbag module mounting brackets are secure.



M76 3057

7. Connect flylead **SMD 4082/5** to airbag module.
   WARNING: Ensure the deployment tool is not connected to the battery.

8. Connect flylead **SMD 4082/5** to tool **SMD 4082/1**.
9. Connect tool **SMD 4082/1** to battery.
   WARNING: Ensure all personnel are at least 15 metres (50 ft) away from the airbag module.


M76 3056

10. Press both operating buttons to deploy airbag module.
11. DO NOT return to airbag module for 30 minutes.
12. Using gloves and face mask, remove airbag module from tool, place airbag module in plastic bag and seal bag.
13. Wipe down tool with damp cloth.
14. Transport deployed airbag module to designated area for incineration.
    NOTE: DO NOT re-use or salvage any parts of the airbag system.Do not transport deployed SRS components in the vehicle passenger compartment.

Pre-tensioner - deployment

76.74.99

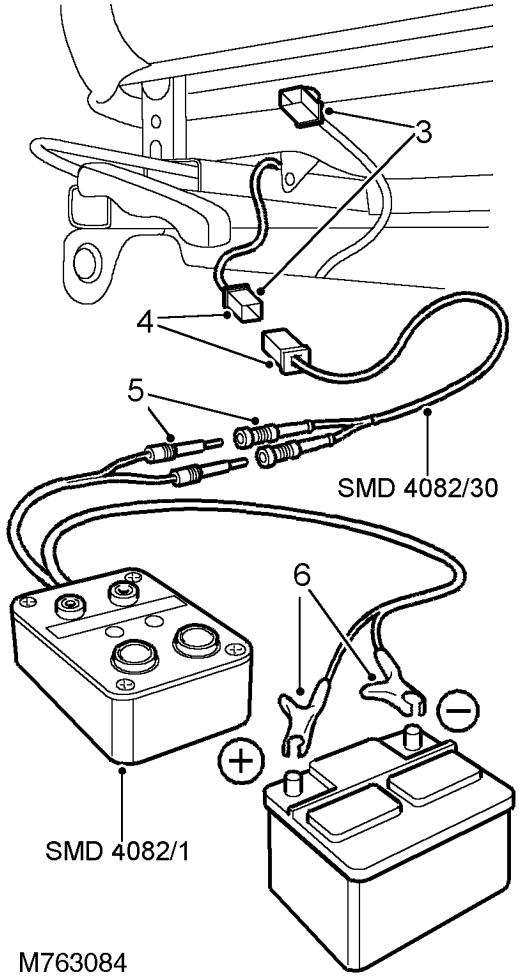
These guidelines are written to aid authorised personnel to carry out the safe disposal of pre-tensioners.

If a vehicle is to be scrapped and contains an undeployed pre-tensioner, the pre-tensioner must be manually deployed. This operation should only be carried out using the following recommended manual deployment procedure. Before deployment is started the deployment tool self test procedure should be carried out.

WARNING: Only use approved deployment equipment, and only deploy SRS components in a well ventilated designated area. Ensure SRS components are not damaged or ruptured before deployment. Notify the relevant authorities.

Deploy

1. Carry out deployment tool self test.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag deployment tool - self test.**
2. Slide seat fully rearwards to access pre-tensioner harness connector.
3. Disconnect pre-tensioner harness connector. **Ensure deployment tool SMD 4082/1 is not connected to battery.**



M763084

4. Connect flylead **SMD 4082/30** to pre-tensioner connector.
5. Connect flylead **SMD 4082/30** to tool **SMD 4082/1**

   WARNING: Ensure pre-tensioner is secured tightly to seat.

6. Connect tool **SMD 4082/1** to battery.

   WARNING: Ensure all personnel are standing at least 15 metres 50 (ft) away from vehicle.

7. Press both operating buttons to deploy pre-tensioner.
8. Wearing gloves, disconnect flylead **SMD 4082/30** from pre-tensioner connector and remove pre-tensioner from seat. Place pre-tensioner in plastic bag and seal bag.

9. Transport deployed pre-tensioner to designated area for incineration.

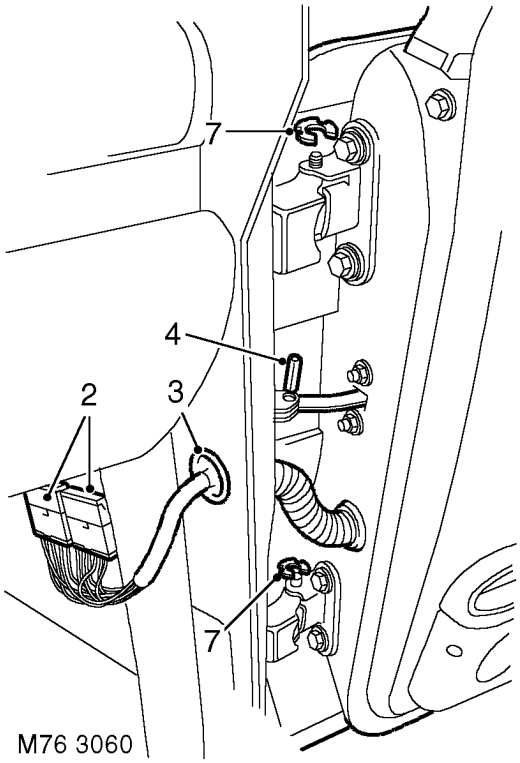
NOTE: DO NOT transport pre-tensioner in the vehicle passenger compartment. DO NOT re-use or salvage any parts of the airbag system. If the vehicle is being scrapped, scrap all remaining parts of airbag system.

Door - front

76.28.01.99

Remove

1. Release 'A' post lower trim and position aside.



2. Release and disconnect multiplugs from lower 'A' post.
3. Release harness sleeve and pull harness through 'A' post.
4. Remove roll pin from door check strap.
5. Release check strap from 'A' post.
6. Discard roll pin.
7. Remove 2 'C' clips from door hinges.
8. With assistance raise and remove door.

Refit

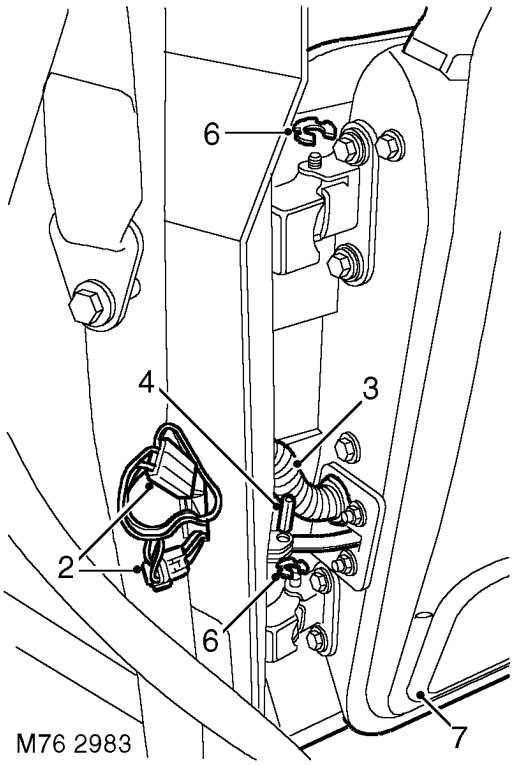
1. With assistance position door to hinges.
2. Fit 'C' clips to hinge pins.
3. Position check strap to 'A' post and secure with new roll pin.
4. Feed door harness through 'A' post.
5. Connect and secure multiplugs at lower 'A' post.
6. Connect harness sleeve to 'A' post and door.
7. Fit 'A' post finisher.
8. Check door for flush fit to adjacent panels and door edges for equal gap. If adjustment is necessary:
   - **a** Open door
   - **b** Place a wooden block on jack and position jack to support door lower edge.
   - **c** Loosen 4 bolts securing hinges to door.
   - **d** Loosen 2 Torx bolts securing door latch striker.
   - **e** Use jack to assist with door alignment.
   - **f** Tighten hinge bolts.
   - **g** Remove jack, close door and check for correct alignment.
   - **h** When alignment is correct, tighten door hinge bolts to 30 Nm (22 lbf.ft).
   - **i** Adjust door latch striker and tighten Torx bolts to 26 Nm (19 lbf.ft).

Door - rear

76.28.02.99

Remove

1. Release 'B' post lower trim casing and position aside.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.



2. Release multiplugs from within 'B' post and disconnect.
3. Release harness sleeve and pull through 'B' post.
4. Remove roll pin from check strap and discard.
5. Release check strap from 'B' post.
6. Remove 2 'C' clips securing door to each hinge.
7. With assistance raise and remove door.

Refit

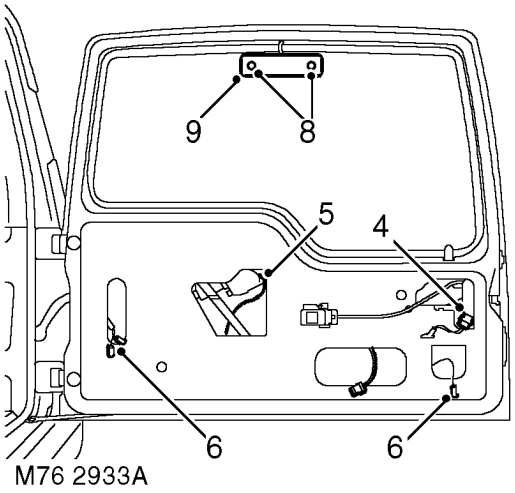
1. With assistance position door to hinges.
2. Fit 'C' clips to hinge pins.
3. Position check strap to 'B' post and secure with new roll pin.
4. Feed door harness through 'B' post and connect multiplugs.
5. Connect harness sleeve to 'B' post and door.
6. Fit 'B' post lower trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.
7. Check door for flush fit to adjacent panels and door edges for equal gap. If adjustment is necessary:
   - **a** Open door.
   - **b** Place a wooden block on jack and position jack to support door lower edge.
   - **c** Loosen 4 bolts securing hinges to door.
   - **d** Loosen 2 Torx bolts securing door latch striker.
   - **e** Use jack to assist with door alignment.
   - **f** Tighten hinge bolts.
   - **g** Remove jack, close door and check for correct alignment.
   - **h** When alignment is correct, tighten door hinge bolts to 30 Nm (22 lbf.ft).
   - **i** Adjust door latch striker and tighten Torx bolts to 26 Nm (19 lbf.ft).

Door - tail

76.28.19.99

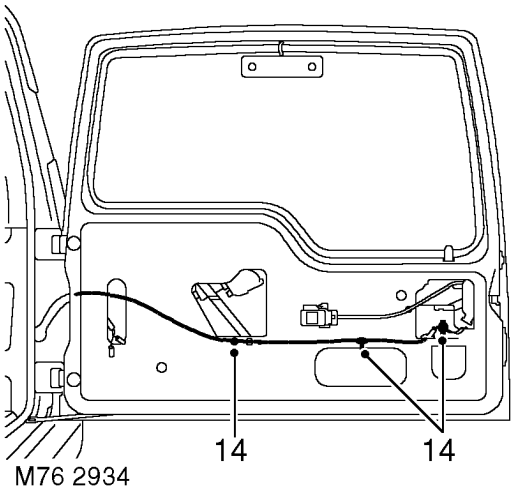
Remove

1. Remove spare wheel from tail door.
2. Remove tail door trim casing.
   DOORS, REPAIRS, Trim casing - tail door.
3. Carefully release water shedder from tail door.



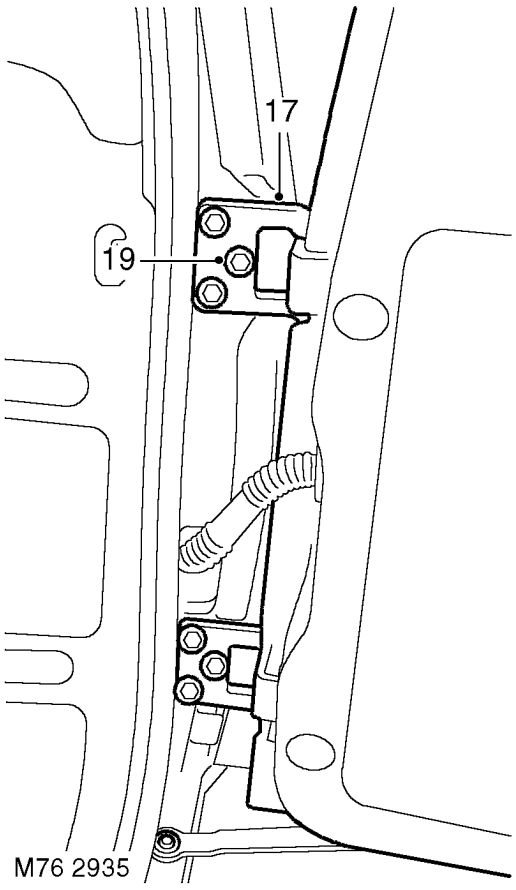
M76 2933A

4. Disconnect multiplug from door latch.
5. Disconnect multiplug from rear wiper motor.
6. Disconnect 2 Lucars from Heated Rear Window (HRW).
7. Disconnect multiplug from number plate lamp.
8. Remove 2 screws securing Centre High Mounted Stop Lamp (CHMSL) cover to tail door glass.
9. Remove CHMSL cover.
10. Disconnect 2 Lucars from CHMSL.
11. Attach draw string to CHMSL wires and draw wires through tail door. Disconnect draw string from wires.
12. Tape draw string in tail door to retain its position.
13. Release washer tube from rear of wiper arm.



M76 2934

14. Release 3 clips securing harness to tail door.
15. Release harness sleeve from door outer edge and feed harness and washer tube through door.
16. Remove spring clip securing check strap to tail door aperture and collect washer.



M76 2935

17. Mark position of hinges.
18. Support the tail door on a jack, using a block of wood to protect the door.

19. Remove 6 bolts securing tail door hinges to body and, with assistance, remove tail door.

Refit

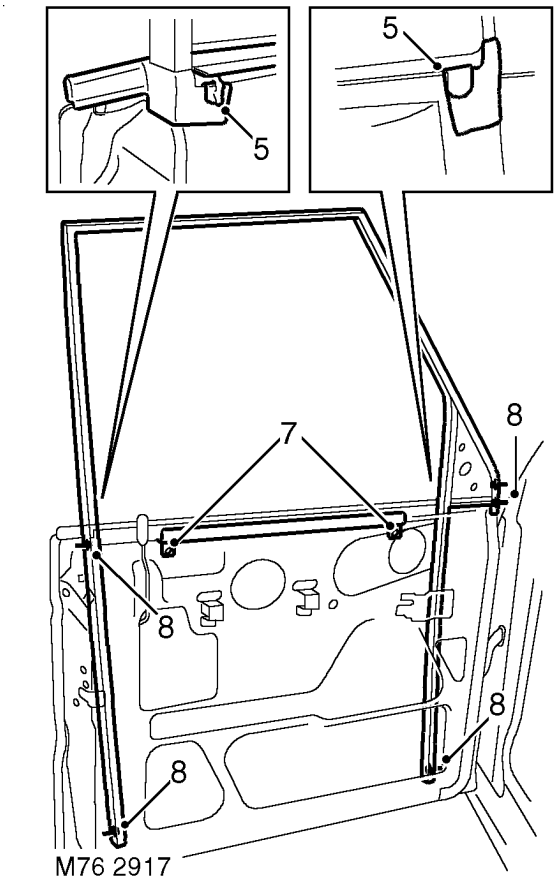
1. Support the tail door on a jack, using a block of wood to protect the door.
2. With assistance position door. Fit securing bolts but do not tighten at this stage.
3. Fit washer and spring clip securing check strap to aperture.
4. Adjust position of tail door in relation to aperture, ensuring gaps around all 4 edges are consistent, and door closes cleanly onto dove tail.
5. When tail door is correctly adjusted, tighten tail door hinge bolts to 34 Nm (25 lbf.ft).
6. Feed harness and washer tube through outer edge of door and connect harness sleeve to door.
7. Secure harness to tail door with clips.
8. Connect washer tube to rear of wiper arm.
9. Remove tape from draw string and secure to CHMSL wires.
10. Draw wires through tail door and connect Lucars to CHMSL.
11. Fit CHMSL cover and secure with screws.
12. Connect multiplug of number plate lamp.
13. Connect Lucars to HRW.
14. Connect multiplug to rear wiper motor.
15. Connect multiplug to door latch.
16. Fit water shedder to door.
17. Fit tail door trim casing.
    ☞ **DOORS, REPAIRS, Trim casing - tail door.**
18. Fit spare wheel to tail door.

Glass - front or rear door

⊸ ***76.31.01***

Remove

1. Remove door trim casing.
   ☞ **DOORS, REPAIRS, Trim casing - front door.**
   ☞ **DOORS, REPAIRS, Trim casing - rear door.**
2. Carefully release water shedder from door.
3. **Front door glass only:** Remove exterior door mirror.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Mirror - exterior - electric.**
4. Remove inner waist seal.



Front door shown, rear door similar

5. Remove 2 clips securing ends of outer waist seal.
6. Remove outer waist seal.
7. Remove 2 bolts securing glass to regulator. If necessary, lower glass to access bolts.
8. Remove bolts securing frame to door.
9. Remove door frame complete with glass.
10. Slide out and remove glass from frame.

Refit

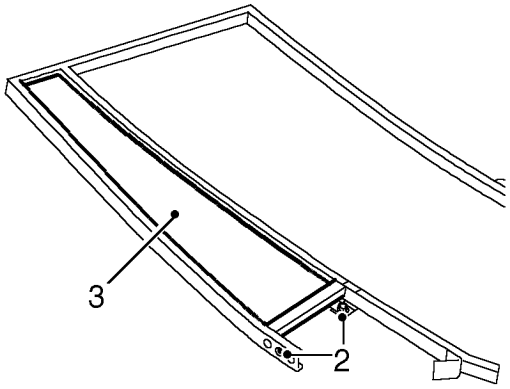
1. Fit glass to frame.
2. Position frame to door and tighten bolts securing front door frame to 10 Nm (7 lbf.ft) and bolts securing rear door frame to 22 Nm (16 lbf.ft).
3. Secure regulator to glass with bolts and tighten to 6 Nm (4.4 lbf.ft).
4. Fit inner and outer waist seal and secure with clips.
5. **Front door glass only:** Fit exterior door mirror.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Mirror - exterior - electric.**
6. Fit water shedder to door.
7. Fit door trim casing.
   ☞ **DOORS, REPAIRS, Trim casing - front door.**
   ☞ **DOORS, REPAIRS, Trim casing - rear door.**

Quarter light

⊸ ***76.31.31***

Remove

1. Remove rear door glass.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**



M76 2930

2. Remove 2 bolts securing quarter light glass to frame.
3. Remove quarter light glass from frame.

Refit

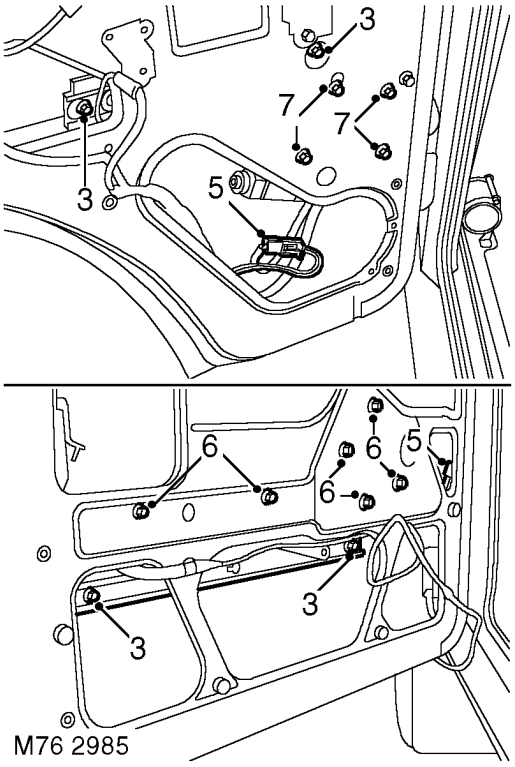
1. Fit quarter light glass to frame.
2. Fit bolts securing quarter light glass to frame and tighten to 10 Nm (7 lbf.ft).
3. Fit rear door glass.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**

Regulator and motor - front and rear door glass

76.31.45

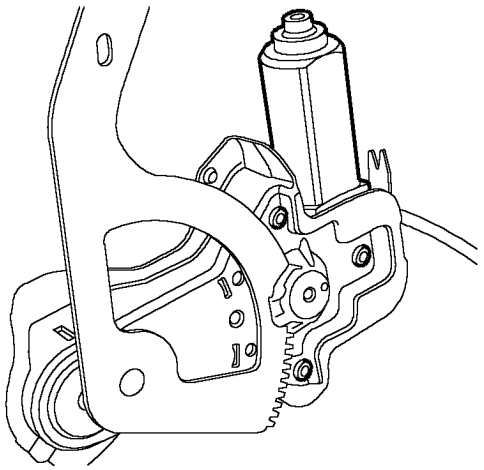
Remove

1. Remove door trim casing.
   DOORS, REPAIRS, Trim casing - front door.
   DOORS, REPAIRS, Trim casing - rear door.
2. Carefully release water shedder from door.



M76 2985

3. Lower glass and remove 2 bolts securing door glass to regulator.
4. Raise glass and secure with a suitable wedge.
5. Disconnect multiplug from glass lift motor.
6. **Front door:** Remove 6 bolts securing glass regulator assembly to door.
7. **Rear door:** Remove 4 bolts securing glass regulator assembly to door.
8. Manoeuvre regulator through access hole at bottom of the door.


M76 2986

9. Remove 3 Torx screws securing glass lift motor to regulator and remove motor.

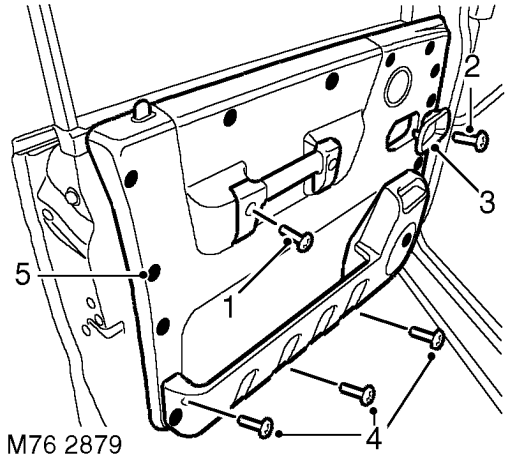
Refit

1. Clean mating faces of regulator and motor.
2. Fit glass lift motor to regulator and tighten 3 Torx screws to 5 Nm (3.7 lbf.ft).
3. Position regulator in door. Fit bolts securing regulator to door and tighten to 6 Nm (4.4 lbf.ft).
4. Connect multiplug to glass lift motor.
5. Remove wedge holding glass and position glass to regulator.
6. Secure glass to regulator with bolts and tighten to 6 Nm (4.4 lbf.ft).
7. Fit water shedder to door.
8. Fit door trim casing.
   DOORS, REPAIRS, Trim casing - front door.
   DOORS, REPAIRS, Trim casing - rear door.

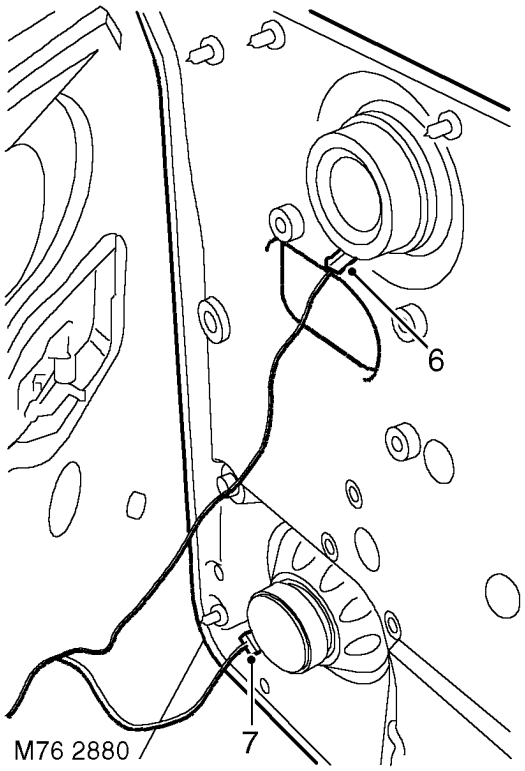
Trim casing - front door

76.34.01.99

Remove



1. Remove 2 screws securing hand rail to door.
2. Remove screw securing door handle escutcheon to door.
3. Remove escutcheon.
4. Remove 4 screws securing pocket to door.
5. Carefully release 10 clips securing trim casing to door.



6. If fitted, disconnect multiplug from upper door speaker.
7. Disconnect multiplug from lower door speaker.
8. Remove trim casing from door.

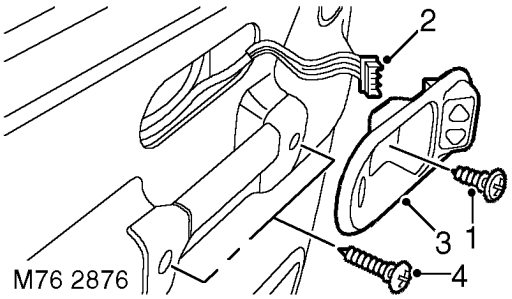
Refit

1. Position trim casing to door and connect door speaker multiplug(s).
2. Secure trim casing to door with clips.
3. Fit escutcheon to door handle and secure with screw.
4. Fit hand rail to door and secure with screws.
5. Fit pocket to door and secure with screws.

Trim casing - rear door

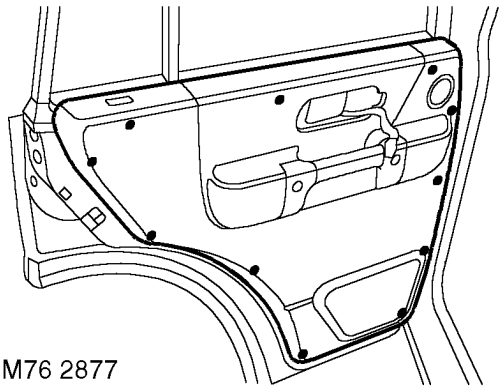
76.34.04.99

Remove

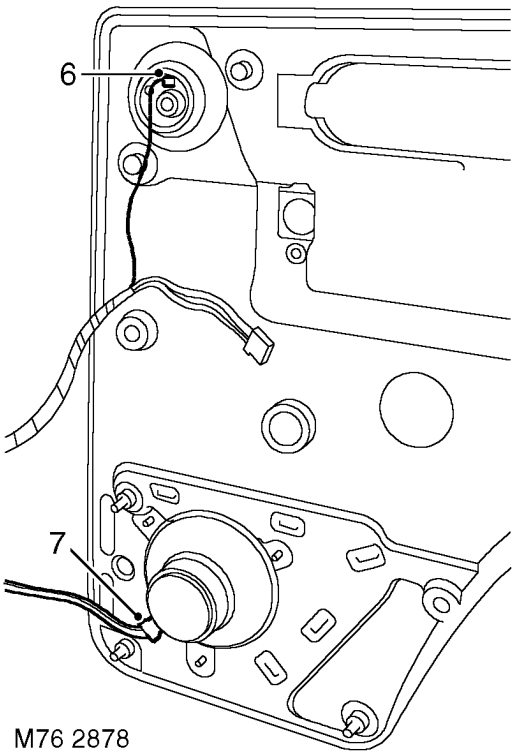


M76 2876

1. Remove screw securing door handle escutcheon to door.
2. Disconnect multiplug from window switch.
3. Remove door handle escutcheon.
4. Remove 2 screws securing hand rail to door.


M76 2877

5. Carefully release 11 clips securing trim casing to door.



M76 2878

6. If fitted, disconnect multiplug from upper door speaker.
7. Disconnect multiplug from lower door speaker.
8. Remove trim casing from door.

Refit

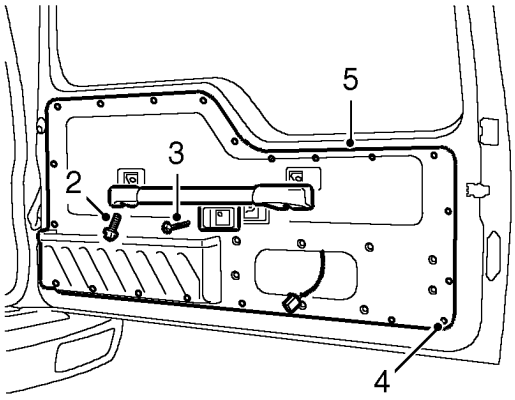
1. Position trim casing to door and connect door speaker multiplug(s).
2. Secure trim casing to door with clips.
3. Fit hand rail to door and secure with screws.
4. Connect multiplug to window switch.
5. Fit escutcheon to door handle and secure with screw.

Trim casing - tail door

76.34.09.99

Remove

1. If fitted, remove tail door speaker.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Speaker - tail door.**



M76 2932A

2. Remove 2 bolts securing hand rail to tail door and remove hand rail.
3. Remove screw securing door handle escutcheon to door and remove escutcheon.
4. Carefully release 20 clips securing trim casing to tail door.
5. Remove tail door trim casing.

Refit

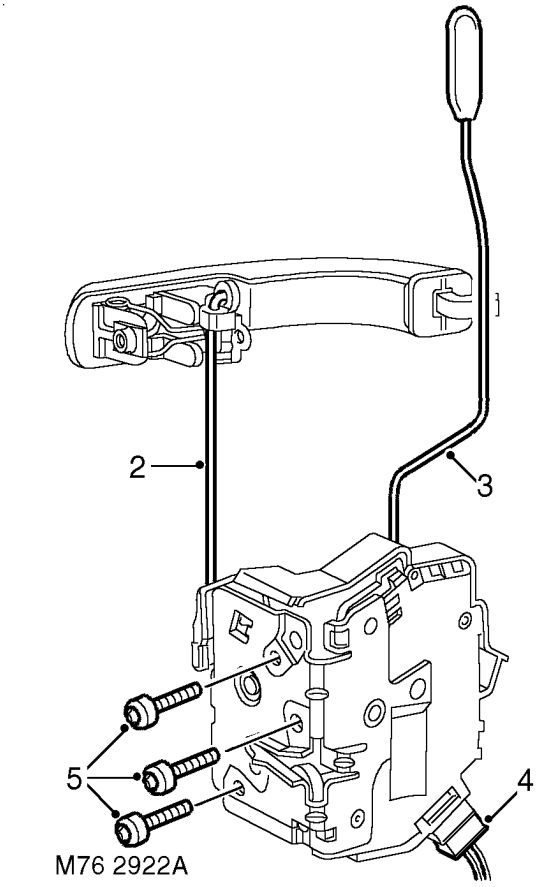
1. Fit trim casing to tail door and secure with clips.
2. Fit escutcheon to door handle and secure with screw.
3. Fit hand rail to tail door and secure with bolts tightened to 10 Nm (7 lbf.ft).
4. If applicable, fit tail door speaker.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Speaker - tail door.**

Latch and motor - front door

76.37.12

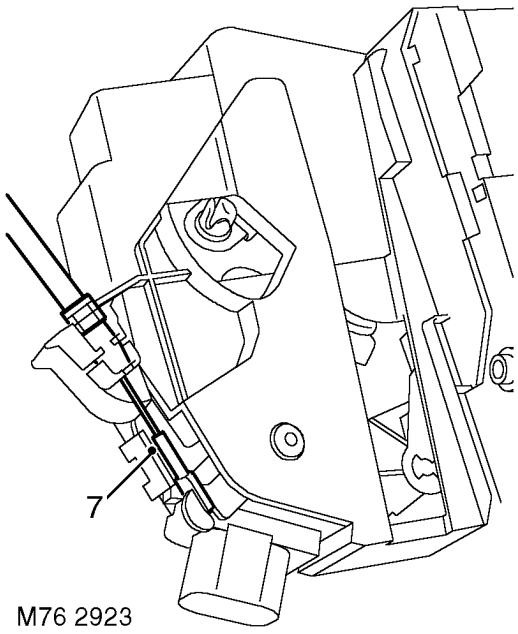
Remove

1. Remove front door frame.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**



M76 2922A

2. Release exterior handle control rod from latch.
3. Release and disconnect sill button lock rod from latch.
4. Disconnect multiplug from motor.
5. Remove 3 Torx screws securing latch and motor assembly to door.
6. Remove latch and motor assembly through aperture in the lower section of the door.



7. Disconnect release cable from latch and remove latch and motor assembly.

Refit

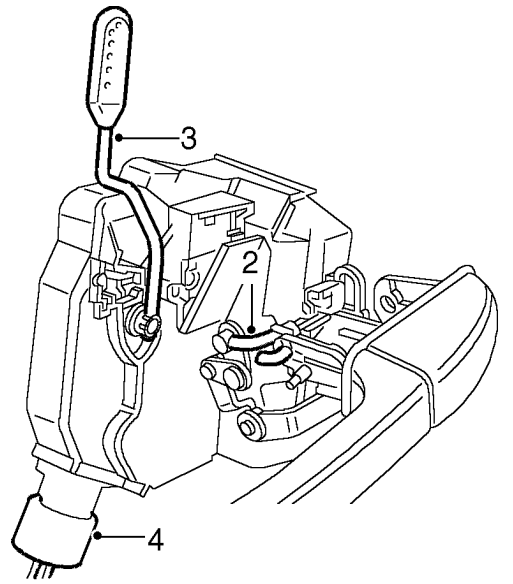
1. Connect release cable to latch.
2. Position latch and motor assembly to door. Fit Torx screws securing latch to door and tighten to 7 Nm (5.2 lbf.ft).
3. Connect multiplug to motor.
4. Connect exterior handle control rod to latch.
5. Connect sill button lock rod to latch.
6. Fit front door frame.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**

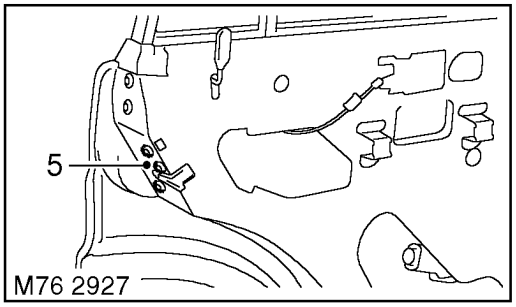
Latch and motor - rear door

76.37.13

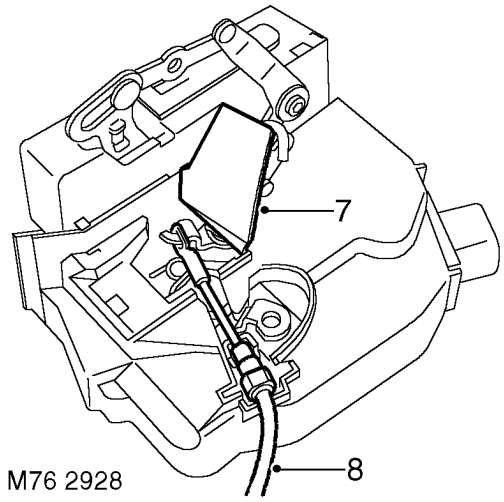
Remove

1. Remove rear door frame.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**





2. Release exterior handle control rod from latch.
3. Release sill button lock rod from door latch.
4. Disconnect multiplug from motor.
5. Remove 3 Torx screws securing latch and motor assembly to door.
6. Remove latch and motor assembly through lower aperture in door.



M76 2928

7. Open security flap on latch.
8. Disconnect release cable from latch.

Refit

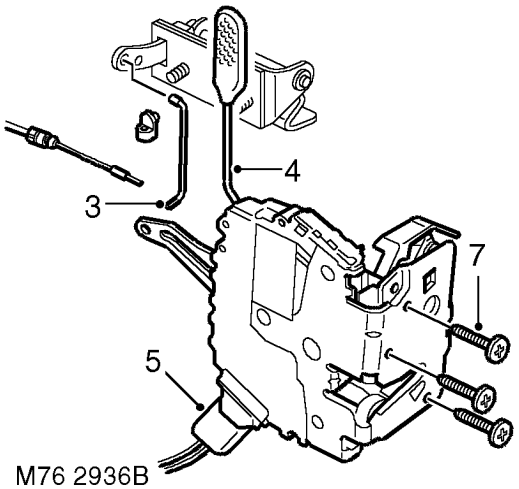
1. Connect release cable to latch and close security flap.
2. Position latch to door, fit Torx screws securing latch to door and tighten to 7 Nm (5.2 lbf.ft).
3. Connect multiplug to motor.
4. Connect exterior handle control rod to latch.
5. Connect sill button lock rod to latch.
6. Fit rear door frame.
   ☞ **DOORS, REPAIRS, Glass - front or rear door.**

Latch and motor - tail door

76.37.16

Remove

1. Remove tail door trim casing.
   ☞ **DOORS, REPAIRS, Trim casing - tail door.**
2. Carefully release water shedder from tail door.



M76 2936B

3. Release and remove control rod from exterior handle and latch.
4. Release and remove sill button lock rod.
5. Disconnect multiplug from motor.
6. Remove release cable from clip.
7. Remove 3 Torx screws securing latch and motor assembly to door.
8. Remove door latch.
9. Disconnect release cable from latch.

Refit

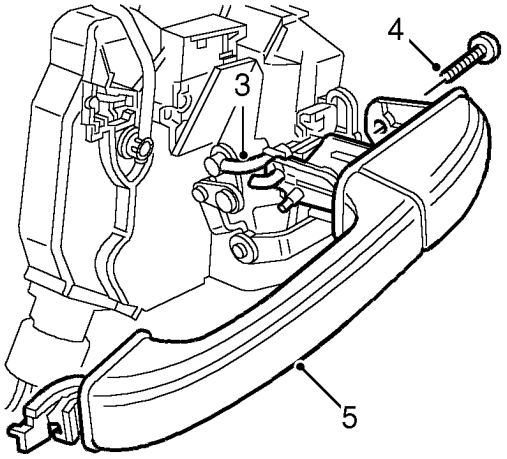
1. Connect release cable to latch.
2. Position door latch and motor assembly, secure with Torx screws and tighten to 7 Nm (5.2 lbf.ft).
3. Position control rod and connect to exterior handle and latch.
4. Position sill button lock rod and connect to latch.
5. Secure release cable in clip.
6. Connect multiplug to motor.
7. Fit water shedder to door.
8. Fit tail door trim casing.
   ☞ **DOORS, REPAIRS, Trim casing - tail door.**

Handle - exterior - rear door

76.58.02

Remove

1. Remove rear door trim casing.
   DOORS, REPAIRS, Trim casing - rear door.
2. Carefully release water shedder from door.



M76 2926B

3. Release control rod from latch.
4. Remove Torx bolt securing exterior handle to door.
5. Remove exterior handle.
6. Remove control rod from exterior handle.

Refit

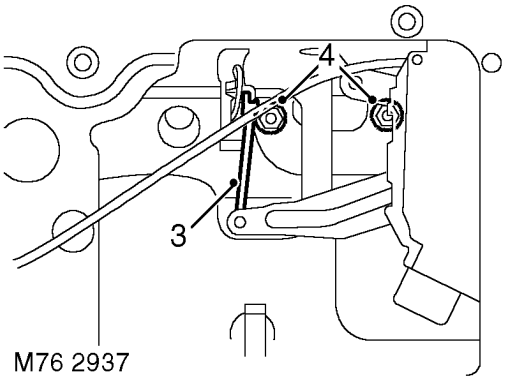
1. Fit control rod to exterior handle.
2. Position exterior handle and secure to door with Torx bolt.
3. Connect control rod to latch.
4. Fit water shedder to door.
5. Fit rear door trim casing.
   DOORS, REPAIRS, Trim casing - rear door.

Handle - exterior - tail door

76.58.05

Remove

1. Remove tail door trim casing.
   DOORS, REPAIRS, Trim casing - tail door.
2. Carefully release water shedder from door.



M76 2937

3. Remove control rod between exterior handle and door latch.
4. Remove 2 nuts securing exterior handle to door.
5. Remove exterior handle.

Refit

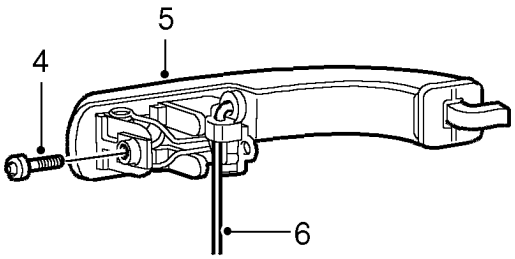
1. Position exterior handle to door. Fit nuts and tighten to 7 Nm (5.2 lbf.ft).
2. Connect control rod to exterior handle and door latch.
3. Fit water shedder to door.
4. Fit tail door trim casing.
   DOORS, REPAIRS, Trim casing - tail door.

Handle - exterior - front door

76.58.07

Remove

1. Remove front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.
2. Carefully release water shedder from door.



M76 2921A

3. Release control rod from latch.
4. Remove Torx bolt securing exterior handle to door.
5. Remove exterior handle.
6. Remove control rod from exterior handle.

Refit

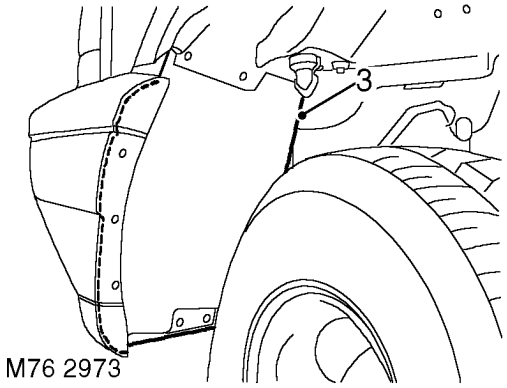
1. Fit control rod to exterior handle.
2. Position exterior handle to door, fit Torx bolt and tighten to 7 Nm. (5.2 lbf.ft).
3. Connect control rod to door latch.
4. Fit water shedder to door.
5. Fit front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.

Wing - front - up to 03MY

76.10.24

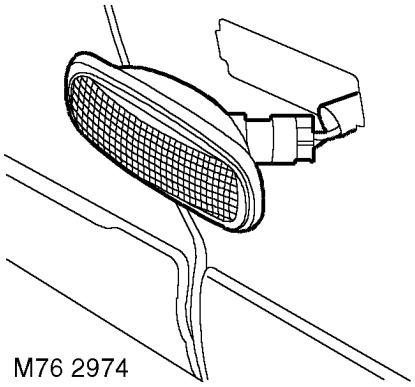
Remove

1. Remove front repeater lamp.
   LIGHTING, REPAIRS, Lamp - front repeater.
2. Remove front wheel arch liner.
   EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - front.

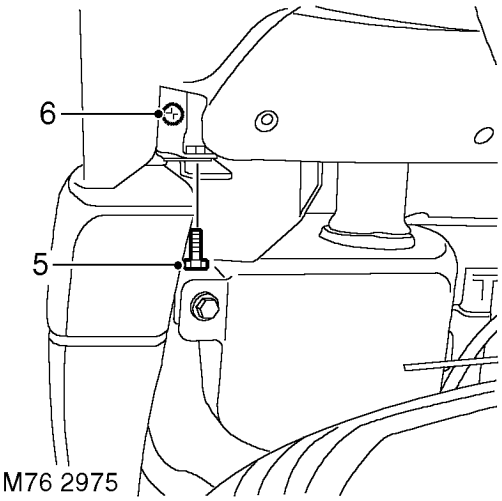


M76 2973

3. Remove 5 screws securing wheel arch liner extension to bumper valance and remove liner.

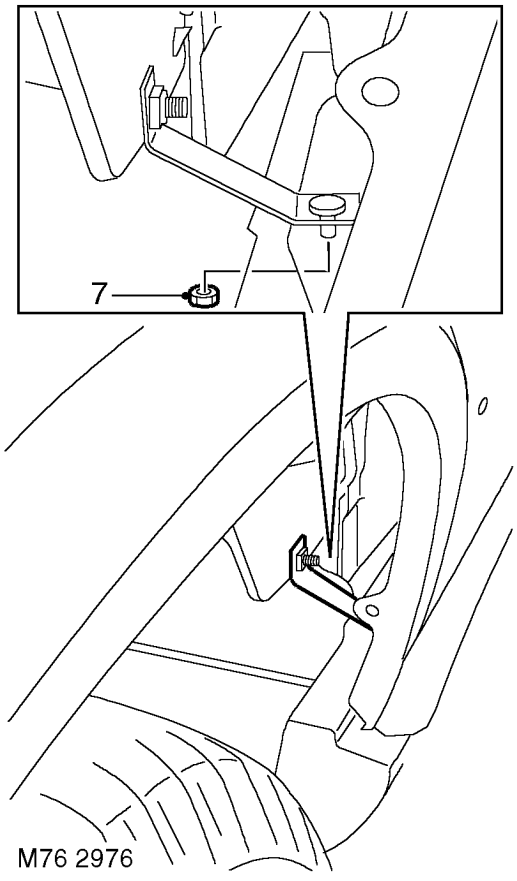

M76 2974

4. Remove side repeater lamp from wing, disconnect multiplug and remove lamp.



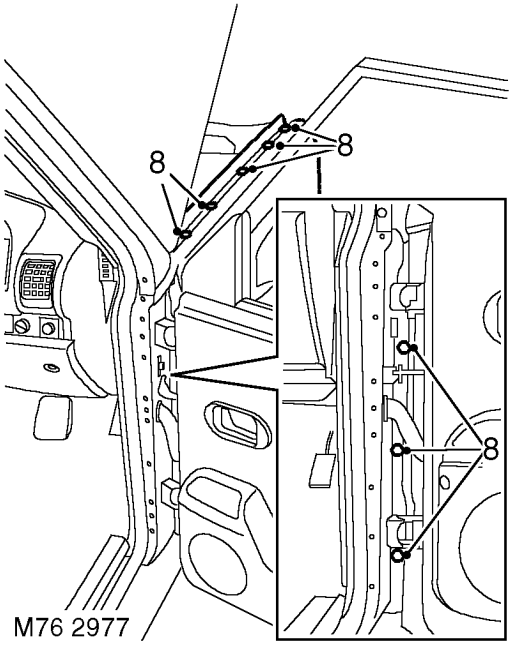
M76 2975

5. Remove bolt securing front of wing to bracket on body.
6. Remove screw securing headlamp surround panel to wing.



M76 2976

7. Remove nut securing wing to bracket on sill finisher.



8. Remove 8 bolts securing wing to body and remove wing.

Refit

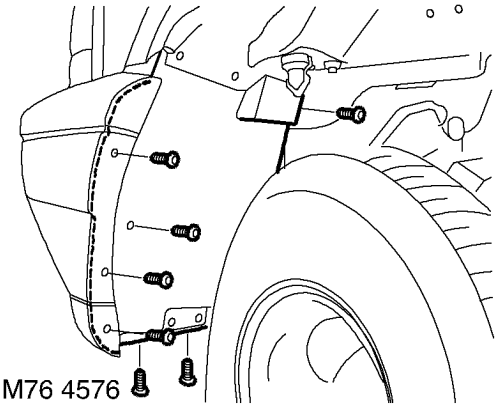
1. Position wing to body.
2. Connect side repeater lamp to multiplug and fit to wing.
3. Position wing to body, align wing to bonnet and front door so that the correct gaps are achieved and tighten bolts to 17 Nm (13 lbf.ft).
4. Check alignment of wing to bonnet and front door. If necessary, adjust wing to achieve correct gaps.
5. Fit and tighten nut securing wing to bracket on sill finisher to 17 Nm (13 lbf.ft).
6. Fit and tighten screw securing wing to headlamp surround panel.
7. Fit and tighten bolt securing front of wing to bracket on body to 17 Nm (13 lbf.ft).
8. Fit wheel arch liner extension to bumper and secure with screws.
9. Fit front wheel arch liner.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - front.**
10. Fit front repeater lamp.
    ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**

Wing - front - from 03MY

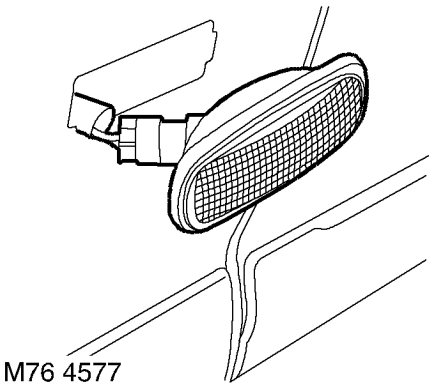
⊸ ***76.10.24***

Remove

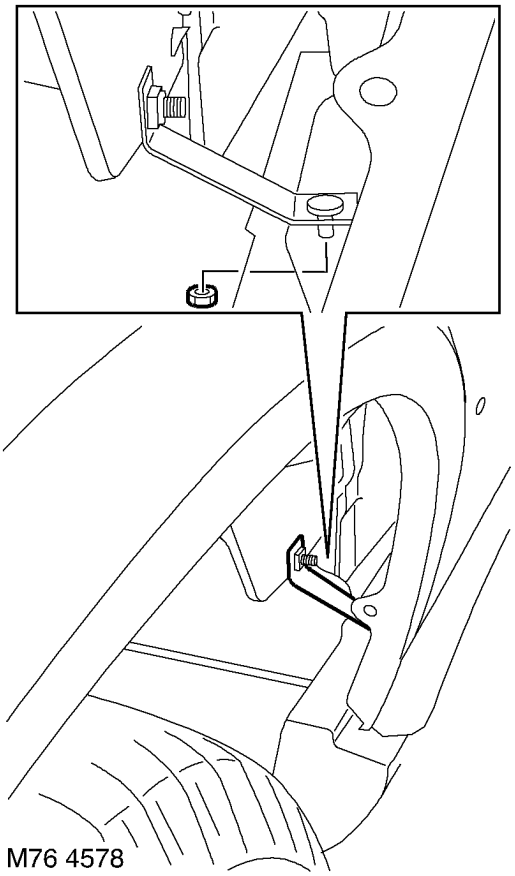
1. Remove the headlamp assembly.
   ☞ **LIGHTING, REPAIRS, Headlamp - from 03MY.**
2. Remove the front wheel arch liner.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - front.**



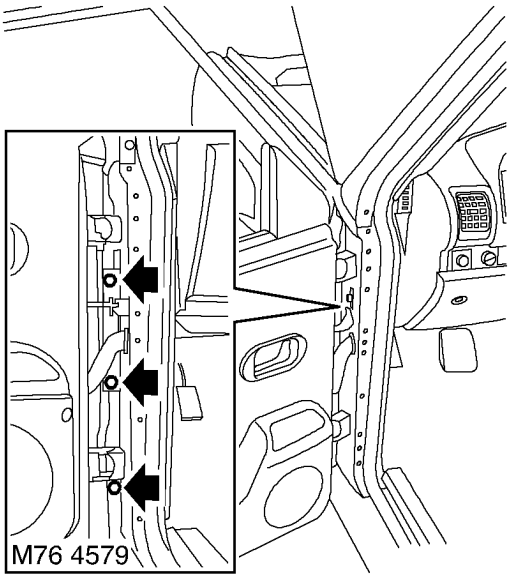
3. Remove screw securing wheel arch liner extension panel to the inner wing.
4. Remove 6 screws securing wheel arch liner extension panel to the front bumper and remove the extension panel.



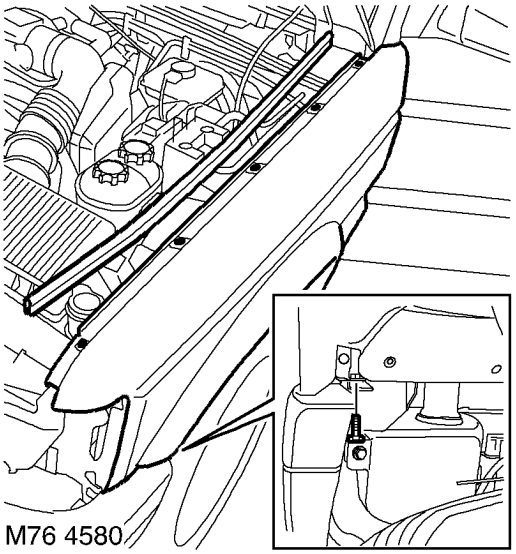
5. Release side repeater lamp from front wing, disconnect the multiplug and remove the lamp.


M76 4578

6. Remove bolt securing front wing lower support bracket to the body.
7. Remove nut securing sill finisher to the front wing lower support bracket.


M76 4579

8. Remove 3 bolts securing front wing rear edge to the body and collect the bracket.


M76 4580

9. Remove bonnet sealing rubber from the front wing flange.
10. Remove bolt securing front wing to the front support bracket.
11. Remove 5 bolts securing front wing to the body and remove the front wing.

NOTE: Do not carry out further dismantling if component is removed for access only.

12. Remove nut securing lower support bracket to the front wing and remove the bracket.
13. Remove the front wing wheel arch finisher.

Refit

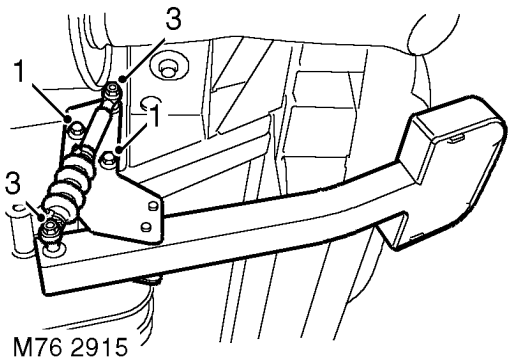
1. Clean front wing body mounting brackets.
2. Fit and secure the front wheel arch finisher to the front wing.
3. Position lower support bracket to the front wing, fit nut and tighten to 8 Nm (6 lbf.ft).
4. Position front wing to body, fit bracket and bolts but do not tighten at this stage.
5. Check and adjust alignment of the front wing to the bonnet and door.
6. Tighten the front wing retaining bolts to 8 Nm (6 lbf.ft).
7. Fit bonnet sealing rubber to the front wing flange.
8. Fit bolt securing lower support bracket to the body and tighten to 8 Nm (6 lbf.ft).
9. Fit nut securing sill finisher to the front wing lower support bracket and tighten to 8 Nm (6 lbf.ft).
10. Fit bolt securing front wing to the front support bracket and tighten to 8 Nm (6 lbf.ft).
11. Fit side repeater lamp to the front wing and connect the multiplug.

12. Fit front wheel arch liner extension panel to the front bumper and secure with screws.
13. Fit and tighten screw securing front wheel arch liner extension panel to the inner wing.
14. Fit the front wheel arch liner.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - front.**
15. Fit the headlamp assembly.
    ☞ **LIGHTING, REPAIRS, Headlamp - from 03MY.**

Rear folding step

🔧 ***76.10.41***

Remove



1. Remove 2 bolts securing step and damper assembly to chassis.
2. Remove step and damper assembly.
3. Remove 2 patch lock nuts securing damper to step and discard nuts.
4. Remove damper from step.

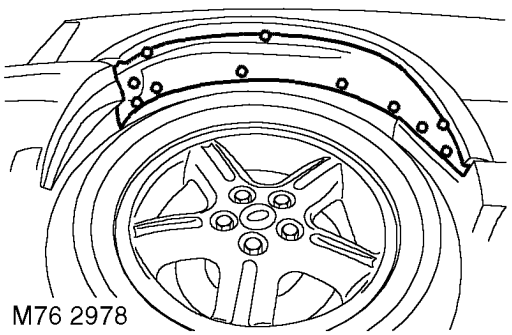
Refit

1. Fit damper to step and secure with new patch lock nuts. Tighten nuts to 17 Nm (13 lbf.ft).
2. Position step and damper assembly to chassis and secure with bolts. Tighten bolts to 45 Nm (33 lbf.ft).

Liner - wheel arch - front

76.10.48

Remove


M76 2978

1. Remove 3 screws securing wheel arch liner to wing.
2. Remove 2 screws securing wheel arch liner to wheel arch liner extension.
3. Remove centres of 6 trim clips securing wheel arch liner to body.
4. Remove outers of trim clips.
5. Remove wheel arch liner.

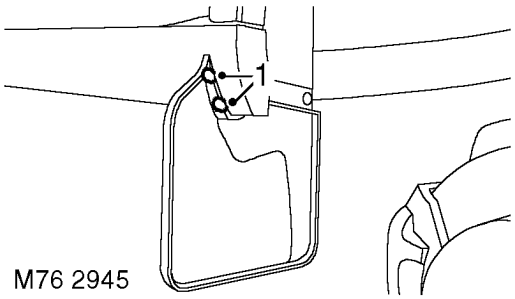
Refit

1. Position wheel arch liner to body.
2. Fit trim clip outers to liner.
3. Fit centres to trim clips.
4. Fit and tighten screws securing wheel arch liner to wing and wheel arch liner extension.

Liner - wheel arch - rear

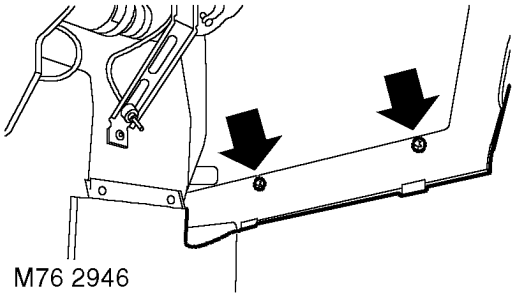
76.10.49

Remove

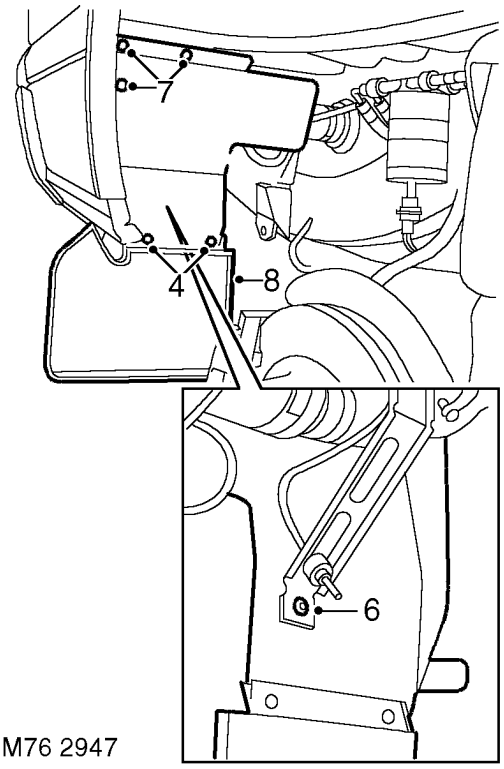


M76 2945

1. Remove 2 trim clips securing rear mud flap to bumper side section.


M76 2946

2. Remove 2 screws securing bumper side section to body.
3. Remove bumper side section.



M76 2947

4. Drill out 2 rivets securing mud flap to wheel arch liner.
5. Remove mud flap.
6. Drill out rivet securing wheel arch liner to support bracket.
7. Drill out 3 rivets securing wheel arch liner to body.
8. Remove wheel arch liner.

Refit

1. Position wheel arch liner to vehicle and secure to body with rivets.
2. Fit rivet securing wheel arch liner to support bracket.
3. Fit mud flap to wheel arch liner and secure with rivets.
4. Fit rear bumper side section to body and secure with screws.
5. Fit trim clips securing mud flaps to side section.

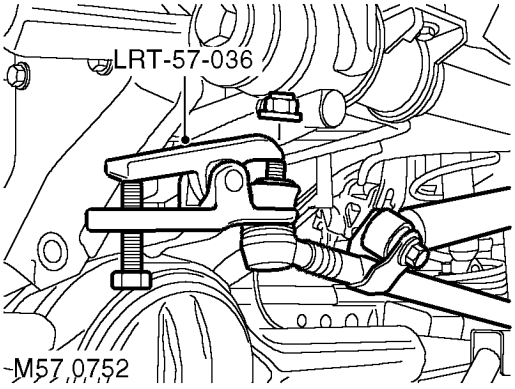
Panel - underbelly

76.10.50

Remove

1. Raise front of vehicle, support underbody and lower front axle

   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



2. Remove nut securing drag link to drop arm.
3. Using tool **LRT-57-036** break taper joint and release drag link from drop arm.
4. Remove nut and bolt securing steering damper to chassis and remove damper.
5. Remove 7 screws securing underbelly panel.
6. Remove underbelly panel.
7. Remove 7 studs securing sound deadening to underbelly panel.
8. Remove sound deadening.

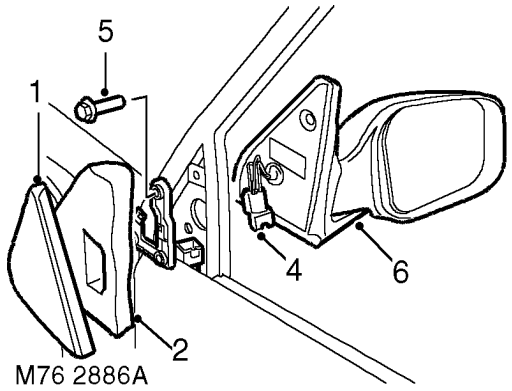
Refit

1. Position sound deadening to underbelly panel and secure with studs.
2. Fit underbelly panel and secure with screws.
3. Position steering damper, fit nut and bolt and tighten to 125 Nm (92 lbf.ft)
4. Fit drag link to drop arm and tighten nut to 80 Nm (59 lbf.ft).
5. Lower front of vehicle.

Mirror - exterior - electric

76.10.57

Remove



1. Release cheater panel from front door.
2. Remove anti-rattle foam pad from front door.
3. Release mirror multiplug from mounting plate.
4. Disconnect multiplug from mirror.
5. Remove 3 bolts securing mirror to door.
6. Remove mirror and collect mounting plate.

Refit

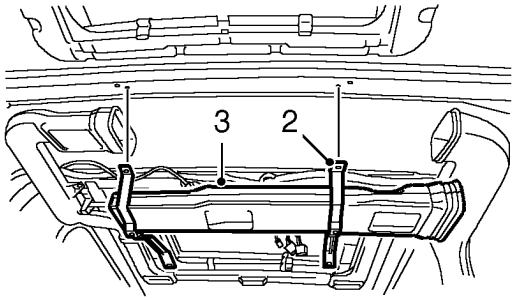
1. Fit mirror and mounting plate to door.
2. Fit bolts securing mirror to door and tighten to 4 Nm (3 lbf.ft).
3. Connect multiplug to mirror.
4. Secure multiplug to mounting plate.
5. Fit anti-rattle foam pad to front door.
6. Secure cheater panel to front door.

Roof bars

76.11.31

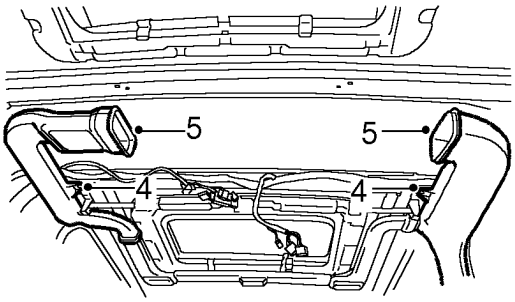
Remove

1. Remove headlining.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**



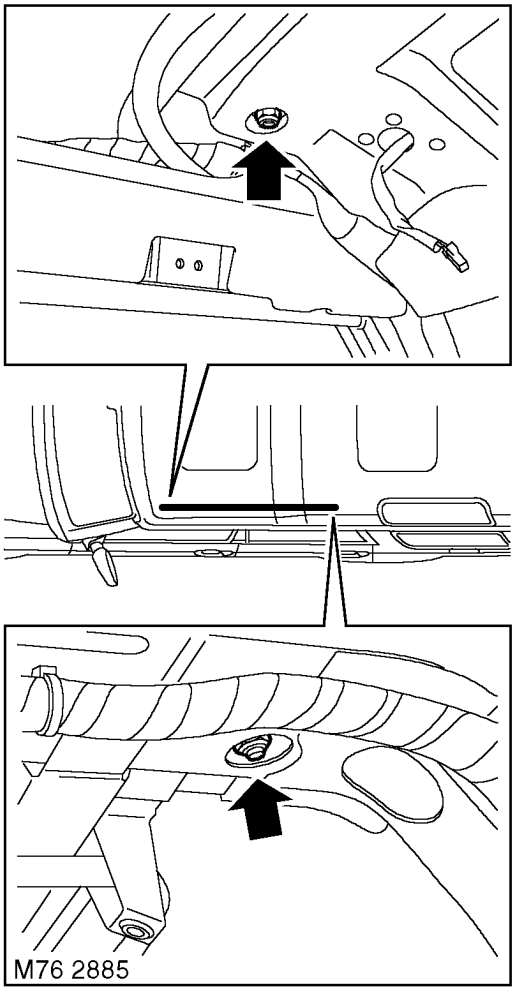
M76 2883

2. **Models with rear A/C:** Drill out 4 rivets securing rear centre duct to roof.
3. **Models with rear A/C:** Release and remove rear centre duct.



M76 2884

4. **Models with rear A/C:** Drill out 2 rivets securing each upper side duct to roof.
5. **Models with rear A/C:** Remove upper side ducts.



6. Remove 2 nuts securing each roof bar to roof.
7. Remove roof bars and collect foam pads from each end.

Refit

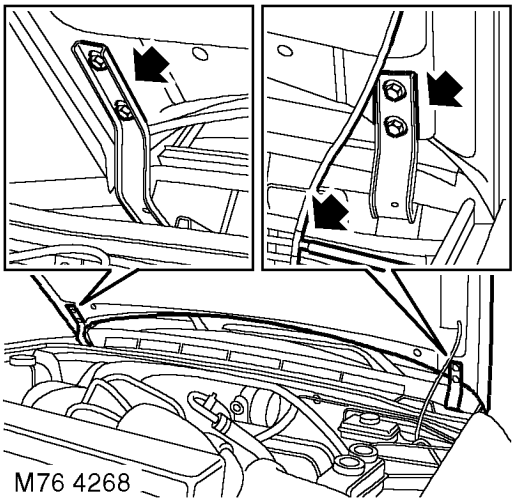
1. Fit roof bars to roof, ensuring foam pads are correctly located.
2. Fit nuts securing roof bars to roof and tighten to 32 Nm (24 lbf.ft).
3. **Models with rear A/C:** Fit upper side ducts and secure with rivets.
4. **Models with rear A/C:** Fit rear centre duct and secure with rivets.
5. Fit headlining.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**

Bonnet

🔧 ***76.16.01.99***

Remove

1. Support bonnet in open position.



2. Fit protection covers to wings and mark hinge outline on bonnet if bonnet is to be refitted.
3. Disconnect windscreen washer tube at elbow joint.
4. With assistance, remove bolts securing hinges to bonnet and remove bonnet.

Refit

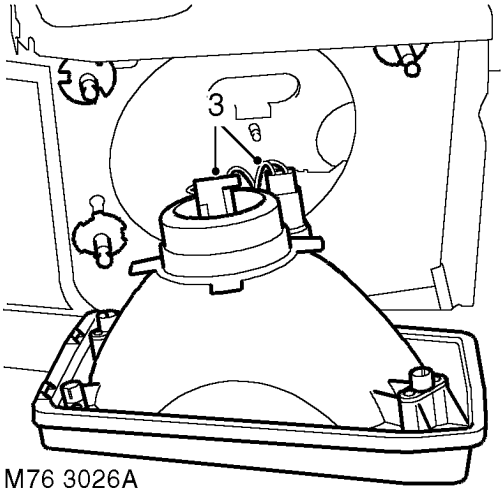
1. With assistance, position bonnet to hinges. Fit and lightly tighten bolts.
2. Connect windscreen washer tube.
3. Close bonnet. Check that bonnet is aligned to both front wings and that gaps are equal. If necessary, adjust bonnet alignment and/or gaps.
4. Finally tighten hinge bolts to 25 Nm (18 lbf.ft).

Cable - bonnet release - up to 03MY

76.16.29

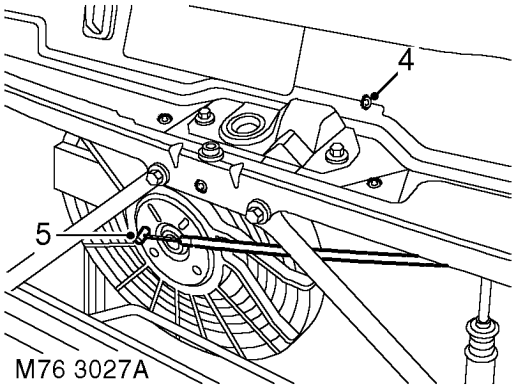
Remove

1. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



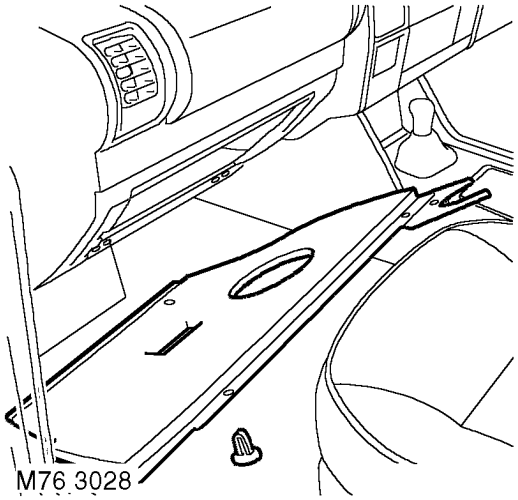
M76 3026A

2. Release LH headlamp from adjuster pin sockets.
3. Disconnect 2 multiplugs from headlamp and remove headlamp.

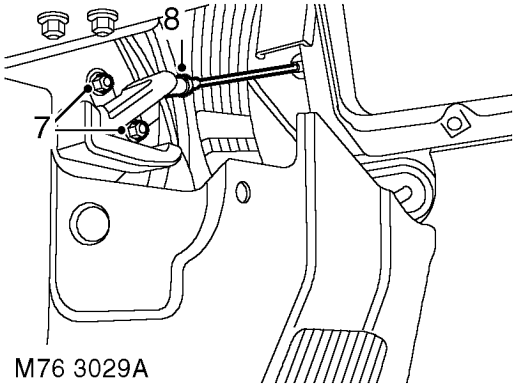


M76 3027A

4. Drill out 4 rivets securing bonnet lock shield to bonnet platform and remove shield.
5. Disconnect bonnet release cable inner and outer from lock.

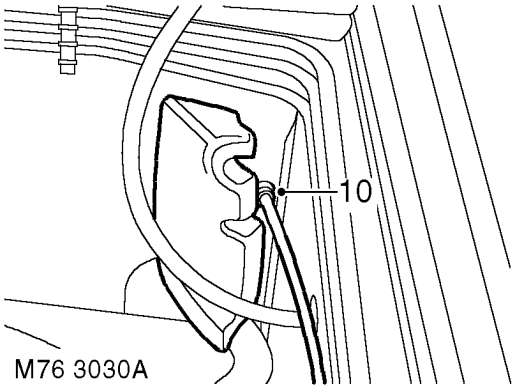

M76 3028

6. Remove 4 fasteners securing LH fascia closing panel to fascia and remove panel.



M76 3029A

7. Remove 2 nuts securing bonnet release lever assembly to body.
8. Remove bonnet release cable from lever assembly.
9. **Diesel models:** Pull sound insulation away from bulkhead for access to bonnet release cable grommet.



10. Remove grommet from engine bulkhead.
11. Tie a draw string to end of bonnet release cable in passenger compartment.
12. Pull bonnet release cable, from bonnet lock end, until whole of cable is released.
13. Untie draw string from bonnet release cable and remove cable.
14. Remove grommet from cable.

Refit

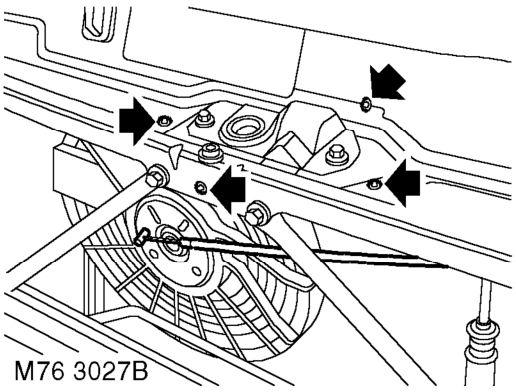
1. Fit grommet to bonnet release cable.
2. Tie draw string to passenger compartment end of bonnet release cable.
3. Use draw string to pull bonnet release cable into position.
4. Fit grommet to engine bulkhead.
5. Untie draw string from bonnet release cable.
6. Position bonnet release lever assembly and connect bonnet release cable to lever.
7. Fit release lever assembly to body and tighten nuts to 10 Nm (7 lbf.ft) .
8. Connect bonnet release cable to lock.
9. With assistance, operate bonnet release lever and check for correct operation of lock.
10. Fit fascia closing panel and secure with fasteners.
11. Fit bonnet lock shield and secure with rivets.
12. Position headlamp to body, connect multiplugs and fit headlamp to sockets.
13. Fit front grille.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**

Cable - bonnet release - from 03MY

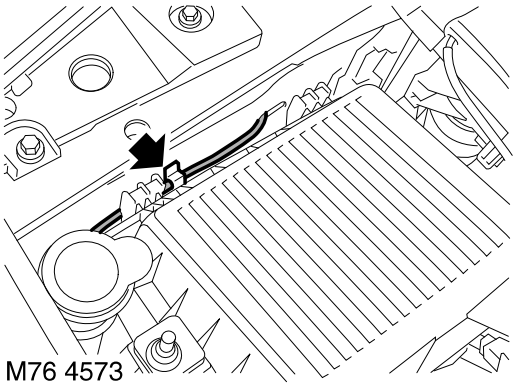
🔧 ***76.16.29***

Remove

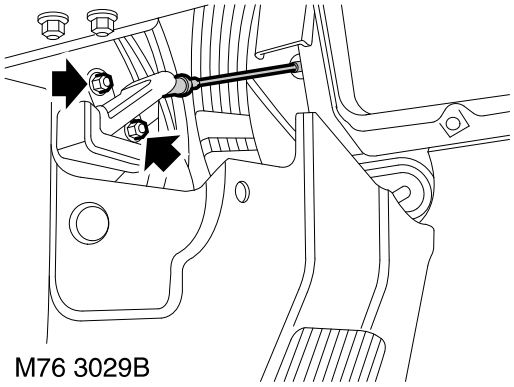
1. Remove the front grille.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - from 03MY.**



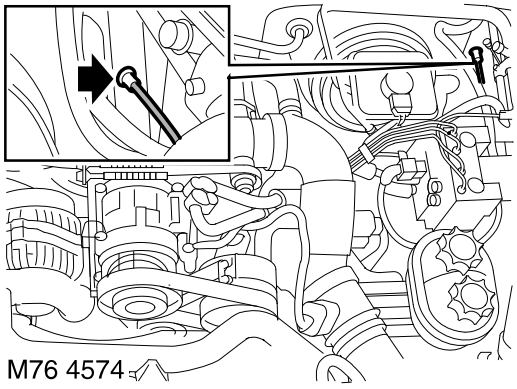
2. Drill out 4 rivets securing bonnet lock shield to the bonnet locking platform and remove the shield.
3. Disconnect bonnet release cable from the bonnet lock.



4. Disconnect bonnet release cable from the front panel retaining clip.


M76 3029B

5. Remove 2 nuts securing bonnet release lever to the 'A' post.
6. Disconnect bonnet release cable from the bonnet release lever.


M76 4574

7. Remove bonnet release cable grommet from the bulkhead.
8. Remove the bonnet release cable.
9. Remove grommet from the bonnet release cable.

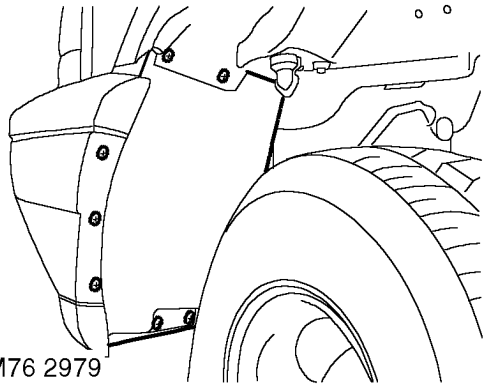
Refit

1. Fit grommet to the bonnet release cable.
2. Position bonnet release cable to body and connect to the bonnet release lever.
3. Position bonnet release lever to 'A' post, fit nuts and tighten to 10 Nm (7 lbf.ft).
4. Fit bonnet release cable grommet to the bulkhead.
5. Connect bonnet release cable to the bonnet lock.
6. Secure bonnet release cable to the front panel retaining clip.
7. With assistance operate bonnet release lever and check for the correct operation of the lock.
8. Fit bonnet lock shield and secure with rivets
9. Fit the front grille.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - from 03MY.**

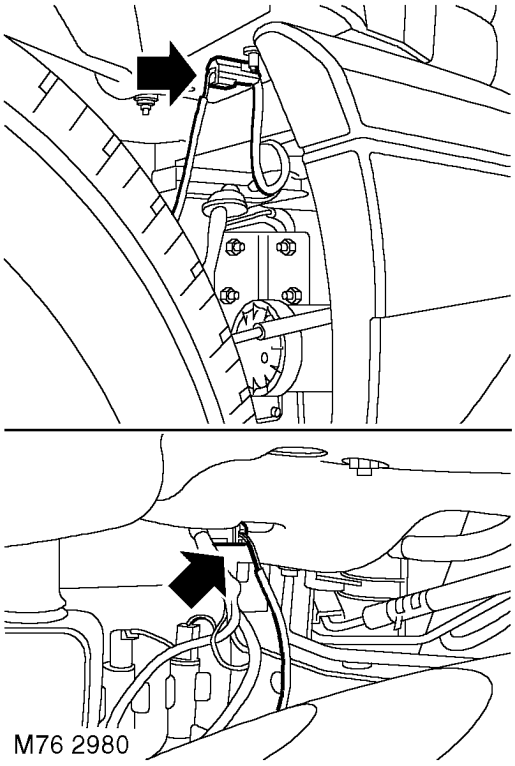
Bumper assembly - front

⊸ ***76.22.08***

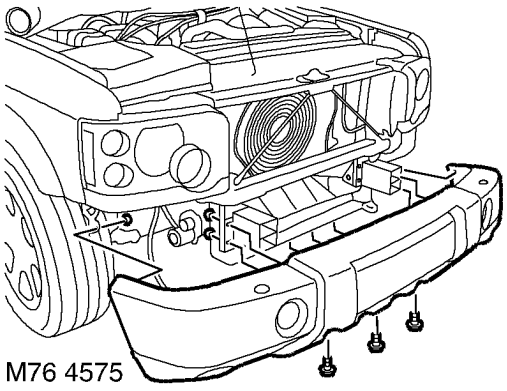
Remove


M76 2979

1. Remove 14 screws securing LH and RH wheel arch liner extensions to wheel arch liners and bumper valance and remove extensions.
   Note: 18 screws are used on 03 MY onwards.

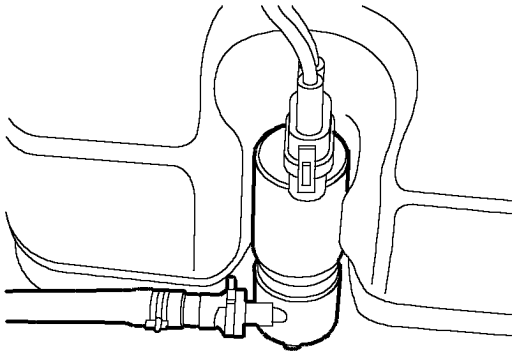

M76 2980

2. Disconnect multiplugs from fog lamps.



M76 4575

3. Remove 2 nuts securing bumper valance side mountings to body.
4. Remove 4 nuts securing bumper to crush cans and remove bumper from body.
5. Remove 3 screws securing bumper to front cross bar.



M76 2982

6. **Models with headlamp wash:** Position container to collect screen washer fluid and disconnect hose from headlamp washer pump.

Refit

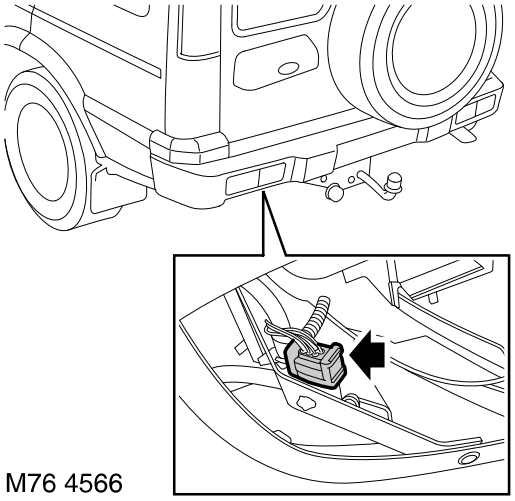
1. **Models with headlamp wash:** Connect hose to headlamp washer pump. Refill washer reservoir with fluid.
2. With assistance position bumper to body.
3. Fit and tighten 3 screws securing bumper to front cross bar.
4. Tighten nuts securing bumper to crush cans to 13 Nm (10 lbf.ft).
5. Tighten nuts securing bumper to side mountings to 13 Nm (10 lbf.ft).
6. Connect multiplugs to fog lamps.
7. Fit wheel arch liner extensions and secure with screws.

Bumper assembly - rear - from 03MY

76.22.15

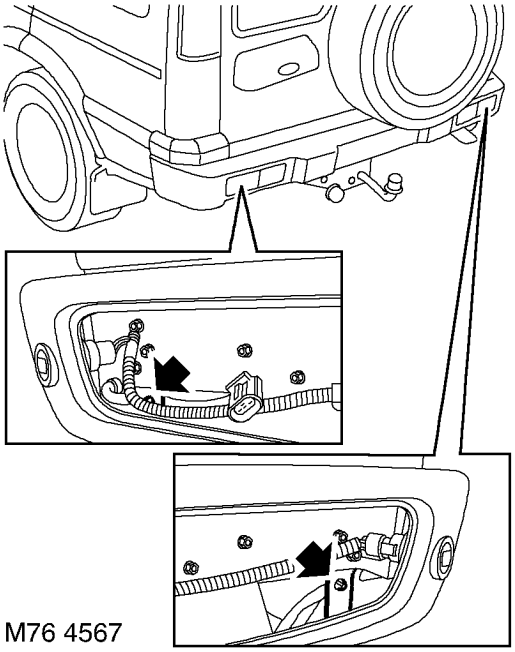
Remove

1. Remove both rear tail lamps.
   LIGHTING, REPAIRS, Lamp - tail/ flasher - bumper.



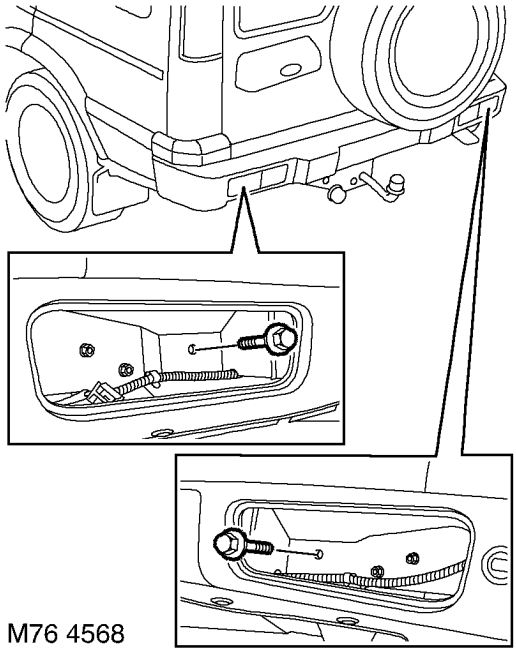
M76 4566

2. Disconnect park distance control harness multiplug.



M76 4567

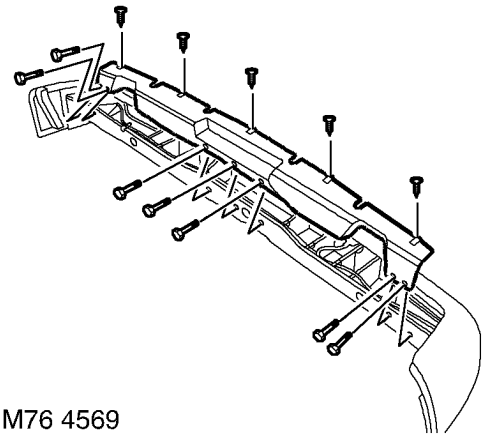
3. Release rear lamp harness clips.



M76 4568

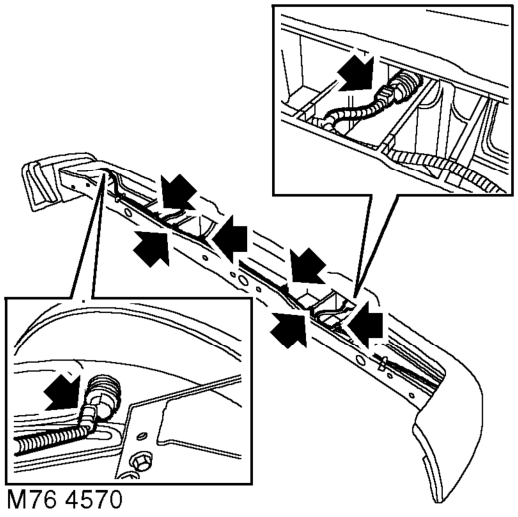
4. Remove 2 bolts securing bumper.
5. With assistance remove bumper.

NOTE: Do not carry out further dismantling if component is removed for access only.



M76 4569

6. Remove 7 bolts and 5 screws securing closing panel and remove panel.



M76 4570

7. Disconnect 4 park distance control sensor harness multiplugs and remove 6 clips retaining harness.
8. Release 3 clips retaining harness and remove harness.
9. Noting their fitted positions, release and remove 4 park distance control sensors and sensor housings.

Refit

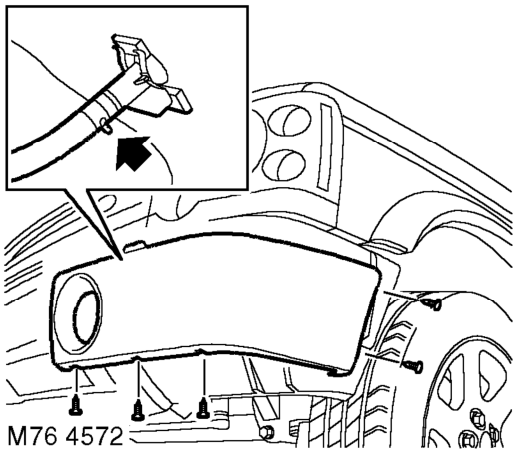
1. Fit sensor housings to bumper, ensuring lugs on housings are aligned with cut-outs in bumper.
2. Fit and secure sensors to housings.
3. Fit harness, secure with clips and connect multiplugs
4. Fit closing panel and secure with bolts and screws.
5. With assistance, fit bumper assembly to body.
6. Fit bolts securing bumper and tighten to 45 Nm (33 lbf.ft).
7. Secure rear lamp harness clips and connect park distance control sensor harness multiplug.
8. Fit both rear tail lamps.

☞ **LIGHTING, REPAIRS, Lamp - tail/ flasher - bumper.**

Trim finisher - bumper - front - from 03MY

76.22.19

Remove



1. Remove 5 screws securing front bumper finisher to bumper and position the finisher aside.
2. Release clip securing washer hose to headlamp washer jet and disconnect the hose.
3. Remove the bumper finisher.
   NOTE: Do not carry out further dismantling if component is removed for access only.
4. Remove clip securing headlamp washer jet to bumper finisher and remove the washer jet.

Refit

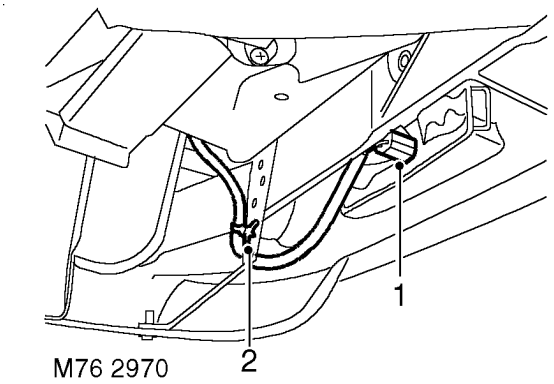
1. Fit and secure headlamp washer jet to bumper finisher.
2. Position bumper finisher to bumper, fit washer hose to washer jet and secure with clip.
3. Fit bumper finisher to bumper and secure with screws.

Bumper assembly - rear - up to 03MY

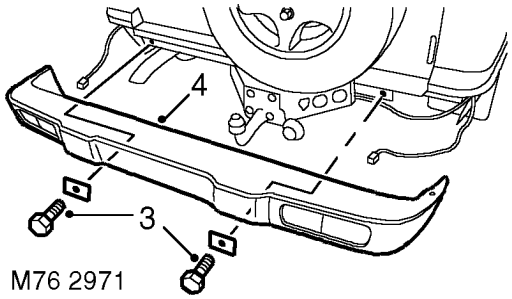
76.22.52

Remove

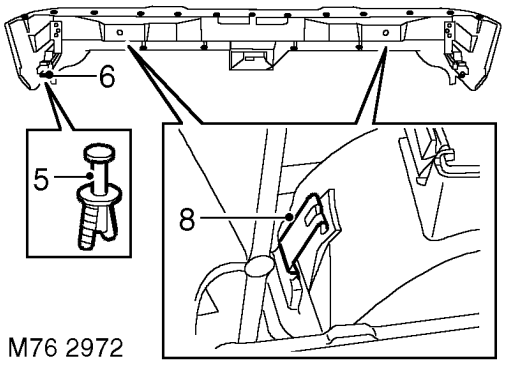
1. Remove both rear tail lamps.
   LIGHTING, REPAIRS, Lamp - tail/ flasher - bumper.



2. Release 2 clips securing rear lamp harnesses to rear bumper.



3. Remove 2 bolts securing rear bumper to chassis and collect 2 plates.
4. With assistance, remove bumper assembly.
   NOTE: Do not carry out further dismantling if component is removed for access only.



M76 2972

5. Remove centres of 19 trim clips securing bumper armature to bumper valance.
6. Remove outers of trim clips.
7. Remove bumper armature from bumper valance.
8. Release clips and remove rear lamps from bumper valance.

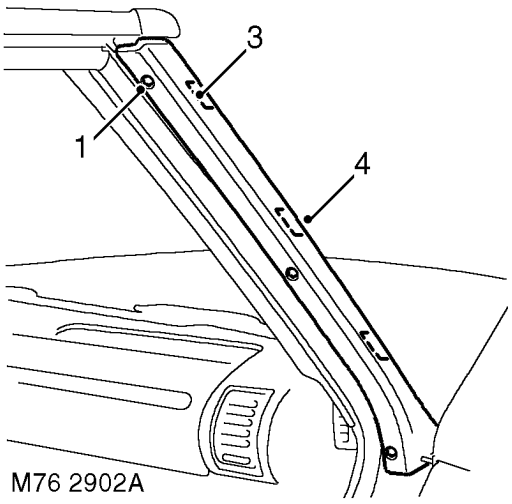
Refit

1. Fit rear lamps to bumper valance.
2. Fit armature to bumper valance and secure with trim clip outers.
3. Fit centres to trim clips.
4. With assistance, fit bumper assembly to body.
5. Position plates to rear bumper.
6. Fit and tighten bolts securing rear bumper to chassis to 45 Nm (33 lbf.ft).
7. Fit 2 clips securing rear lamp harnesses to rear bumper.
8. Connect multiplugs to rear lamps.

Side finisher - windscreen

76.43.39

Remove



M76 2902A

1. Push centres from 3 trim clips securing finisher to 'A' post.
2. Remove trim clip outers from finisher.
3. Release finisher from 3 spring clips.
4. Remove finisher.

Refit

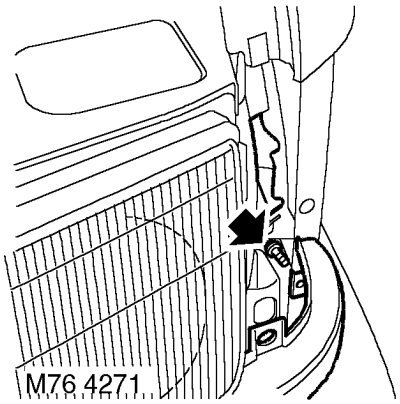
1. Fit finisher to 'A' post and secure with spring clips.
2. Fit trim clip outers to finisher.
3. Fit centres to trim clips.

Grille - front - up to 03MY

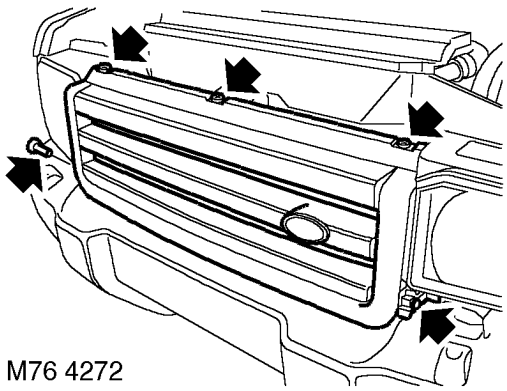
76.55.03

Remove

1. Remove repeater lamps.
   LIGHTING, REPAIRS, Lamp - front repeater.


M76 4271

2. Via access hole in wheel arch liners, remove screws securing headlamp finishers.
3. Remove headlamp finishers from grille.


M76 4272

4. Remove 2 screws securing lower corners of grille.
5. Remove 3 scrivets and remove grille.

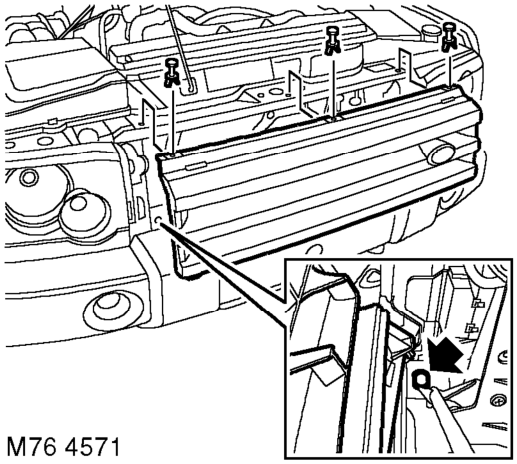
Refit

1. Fit grille and secure with scrivets and screws.
2. Fit headlamp finishers and secure with screws.
3. Fit repeater lamps.
   LIGHTING, REPAIRS, Lamp - front repeater.

Grille - front - from 03MY

76.55.03

Remove


M76 4571

1. Remove 3 scrivets securing front grille to bonnet locking platform.
2. Remove front grille.
   NOTE: Do not carry out further dismantling if component is removed for access only.
3. Remove motif from front grille.

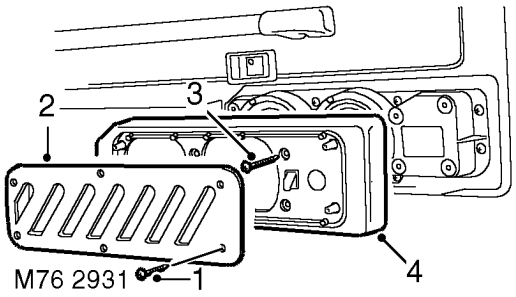
Refit

1. Clean front grille to motif mating face.
2. Fit and secure motif to front grille.
3. Fit front grille and secure with scrivets.

Trim casing - tail door speaker

76.13.11

Remove



1. Remove 6 screws securing grille to speaker trim casing.
2. Remove grille.
3. Remove 4 screws securing trim casing to speaker assembly.
4. Remove trim casing.

Refit

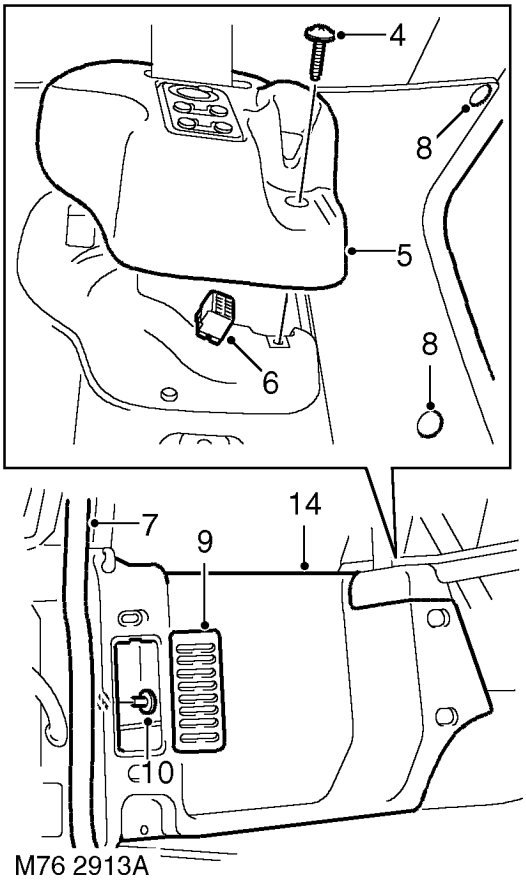
1. Fit trim casing to speaker assembly and secure with screws.
2. Fit grille to trim casing and secure with screws.

Trim casing - side - loadspace

76.13.12

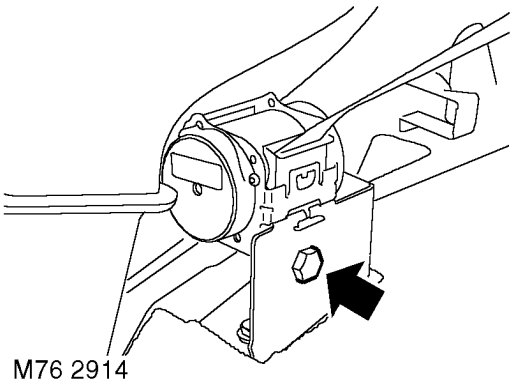
Remove

1. **Models with third row seats:** Remove third row seat.
   SEATS, REPAIRS, Seat - third row.
2. **For LH trim casing:** Remove accessory socket.
   LIGHTING, REPAIRS, Socket - accessory.
3. Remove 'D' post trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.



4. Remove screw securing trim cap to trim casing.
5. Release trim cap from trim casing.
6. **Models with ICE headphone control panels:** Disconnect multiplug from headphone control panel and remove trim cap.
7. Partially remove rear door aperture seal.
8. Remove 2 trim clips securing trim casing to body.
9. Remove access panel.
10. Remove trim clip securing trim casing to lower 'D' post.

11. **Models without third row seats:** Remove trim clip from bottom rear corner of trim casing.
12. Release trim casing to gain access to rear seat belt reel.



13. Remove bolt securing rear seat belt reel to body.
14. Remove trim casing.

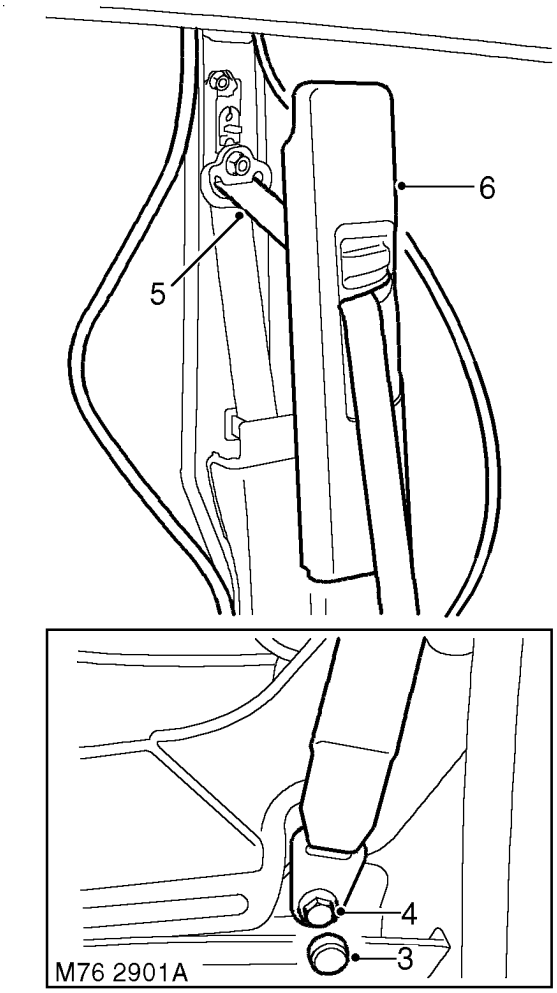
Refit

1. Position trim casing.
2. Fit rear seat belt reel to body and tighten bolt to 50 Nm (37 lbf.ft).
3. **Models without third row seats:** Fit trim clip securing bottom rear corner of trim casing.
4. Fit trim clip securing trim casing to lower 'D' post.
5. Fit access panel to trim casing.
6. Fit trim clips securing trim casing to body.
7. Fit rear door aperture seal.
8. **Models with ICE headphone control panels:** Position trim cap and connect multiplug to headphone control panel.
9. Fit trim cap to trim casing and secure with screw.
10. Fit 'D' post trim casing.
    INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.
11. Fit accessory socket.
    LIGHTING, REPAIRS, Socket - accessory.
12. **Models with third row seats:** Fit third row seat.
    SEATS, REPAIRS, Seat - third row.

Trim casing - upper - 'B' post

76.13.28

Remove



1. Release front door aperture seal from 'B' post.
2. Release rear door aperture seal from 'B' post.
3. Remove cap from front seat belt lower anchorage bolt.
4. Remove front seat belt lower anchorage bolt.
5. Feed seat belt through trim casing.
6. Remove trim casing.
7. Remove sound insulation from trim casing.

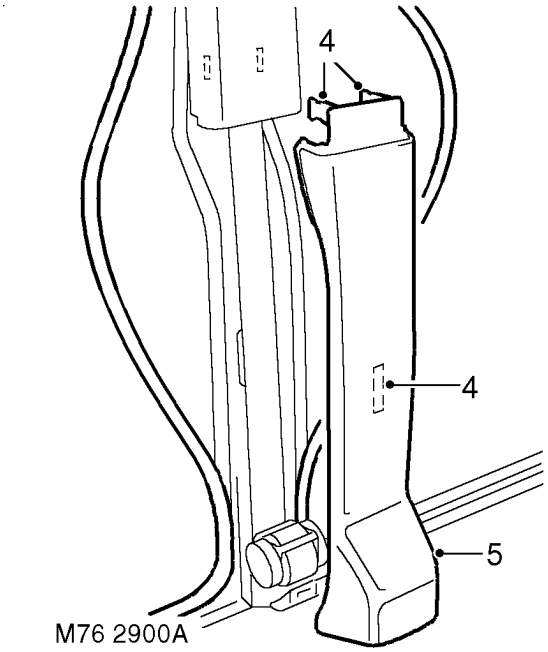
Refit

1. Fit sound insulation to trim casing.
2. Feed front seat belt through trim casing.
3. Fit front seat belt lower anchorage and tighten bolt to 32 Nm (24 lbf.ft).
4. Fit cap to front seat belt lower anchorage bolt.
5. Fit trim casing to 'B' post.
6. Fit front door aperture seal to 'B' post.
7. Fit rear door aperture seal to 'B' post.

Trim casing - lower - 'B' post

76.13.29

Remove



1. Release front door aperture seal from 'B' post.
2. Release rear door aperture seal from 'B' post.
3. Move 'B' post upper trim casing aside.
4. Release 3 clips securing lower trim casing to 'B' post.
5. Remove lower trim casing.

Refit

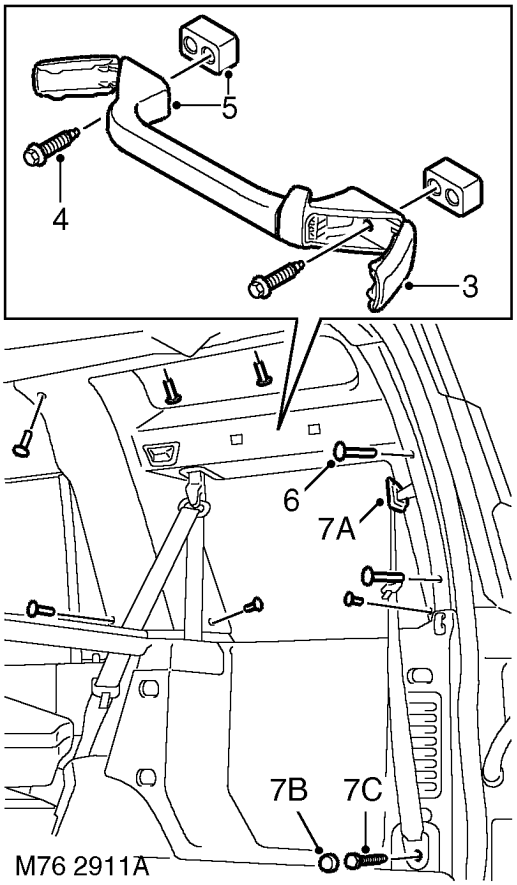
1. Fit lower trim casing to 'B' post and secure with clips.
2. Position 'B' post upper trim casing to 'B' post.
3. Fit front door aperture seal to 'B' post.
4. Fit rear door aperture seal to 'B' post.

Trim casing - 'D' post

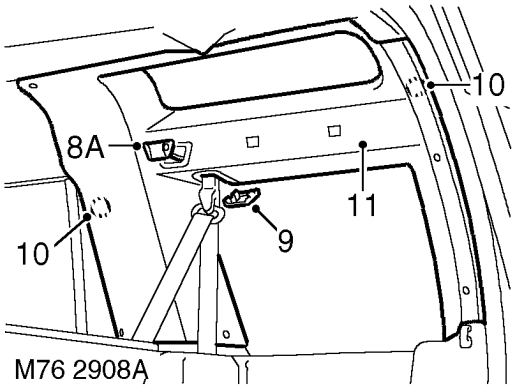
76.13.73

Remove

1. Fold rear seat forward.
2. Remove tail door aperture upper trim casing.



3. Release caps from end of grab handle.
4. Remove 2 bolts securing grab handle to body.
5. Remove grab handle and collect two spacers.
6. Remove 8 trim clips securing trim casing to body.
7. **Models with third row seats:**
   - **a** Remove third row seat belt escutcheon.
   - **b** Remove cap from lower anchorage of third row seat belt.
   - **c** Remove lower anchorage bolt.



8. **Models with volumetric alarm:**
   - **a** Release volumetric sensor from trim casing.
   - **b** Disconnect multiplug from volumetric sensor.
   - **c** Remove volumetric sensor.
9. Remove rear seat belt blanking plate.
10. Release 2 clips securing trim casing to body.
11. Remove trim casing.

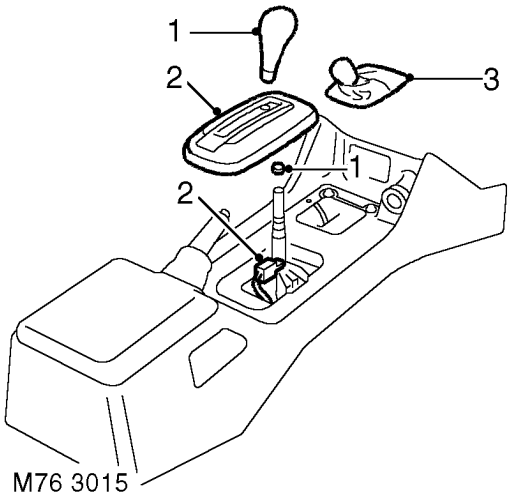
Refit

1. Fit trim casing and secure with clips.
2. Fit rear seat belt blanking plate.
3. **Models with volumetric alarm:**
   - **a** Position volumetric sensor to trim casing and connect multiplug.
   - **b** Fit volumetric sensor to trim casing.
4. **Models with third row seats:**
   - **a** Fit lower anchorage of third row seat belt and tighten bolt to 32 Nm (24 lbf.ft).
   - **b** Fit cap to lower anchorage bolt.
   - **c** Fit third row seat belt escutcheon to trim casing.
5. Fit trim clips securing trim casing to body.
6. Position grab handle and spacers to trim casing.
7. Fit and tighten bolts securing grab handle to body to 3 Nm (2.2 lbf.ft).
8. Close caps on ends of grab handle.
9. Fit tail door aperture upper trim casing.
10. Reposition rear seat.

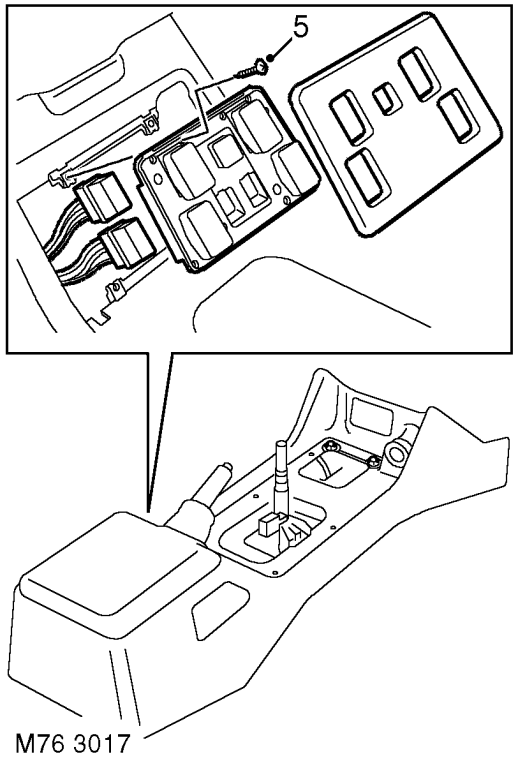
Console - centre - automatic models

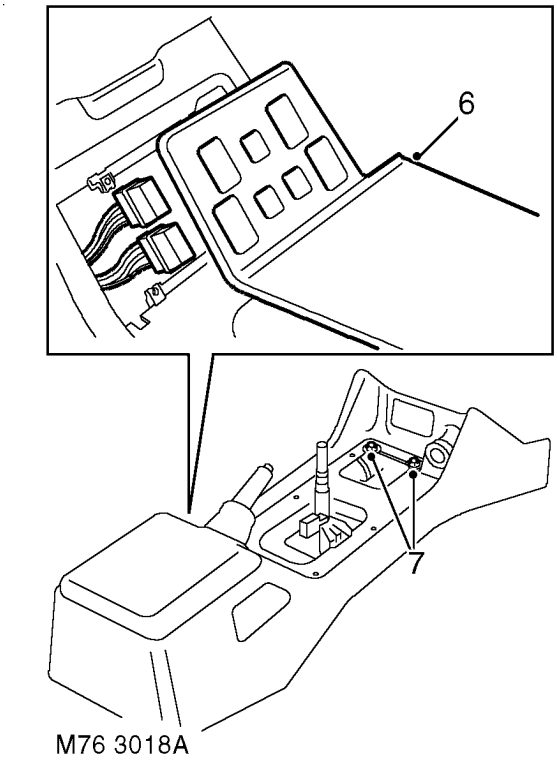
76.25.01

Remove

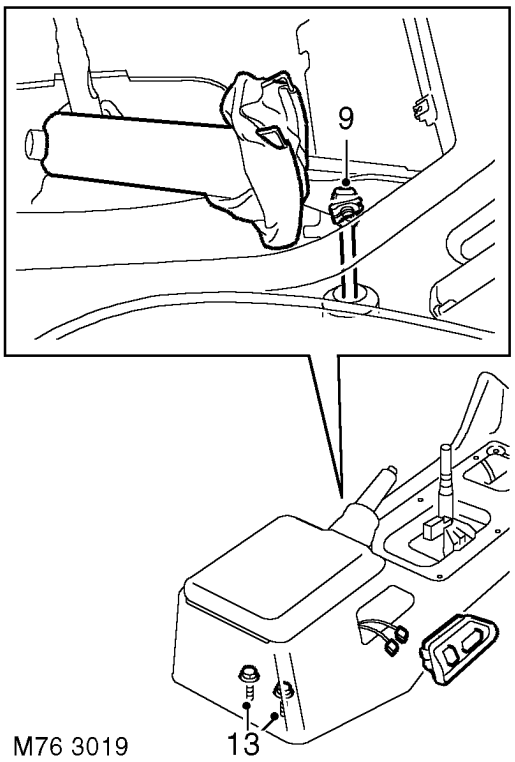


1. Select position 'D', remove gear selector knob and collect spacer.
2. **Models from 03MY:**Remove both centre console cup holders.
3. Release selector panel, disconnect multiplug and remove panel .
4. Release clips securing transfer box lever gaiter to centre console and remove knob and gaiter.



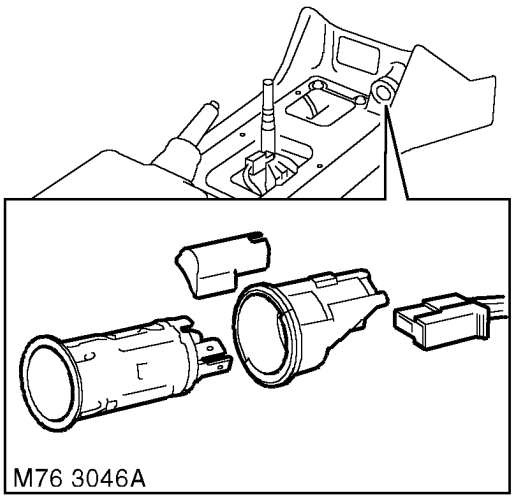


5. **Models with base trim:** Remove rubber mat from centre console and remove cover plate from switch pack.
6. **Models with base trim:** Remove 4 screws securing switch pack to centre console, disconnect multiplugs and remove switch pack.
7. **Models with veneer trim:** Release veneered console cover and remove cigar lighter element. Disconnect multiplugs from switch pack and remove veneered console cover.
8. Remove 2 bolts securing forward edge of console to transmission tunnel.



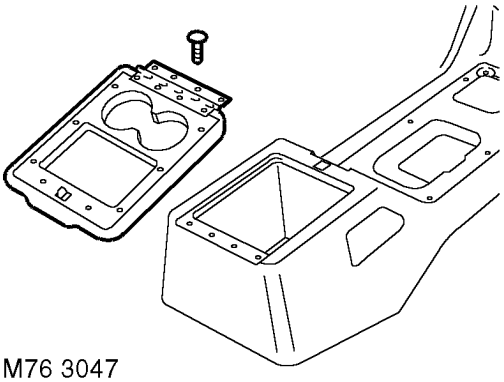
M76 3019

9. Release handbrake gaiter from console.
10. Remove clip and clevis pin securing cable to handbrake lever.
11. Move handbrake to fully upward position.
12. Release electric seat switches from console.
13. Disconnect multiplugs from switches and remove.
14. Remove 2 bolts securing rear of console to transmission tunnel.
15. Release centre console from fascia.


M76 3046A

16. Disconnect multiplug and bulb from cigar lighter.
17. Remove console.

NOTE: Do not carry out further dismantling if component is removed for access only.


M76 3047

18. Remove 4 screws securing storage bin lid to console and remove lid.
19. Release cigar lighter body from console and remove.

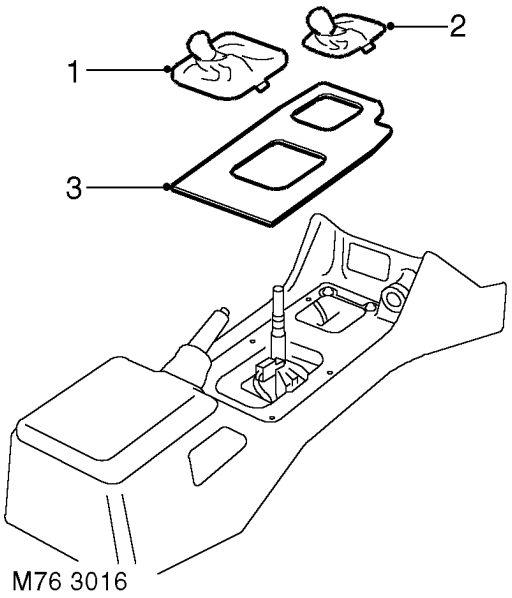
Refit

1. Fit and secure cigar lighter body to console.
2. Fit lid to console and secure with screws.
3. Fit console.
4. Connect multiplug and bulb to cigar lighter.
5. Fit centre console to fascia.
6. Fit 2 bolts securing rear of console to transmission tunnel.
7. Connect multiplugs to seat switches.
8. Fit switches to console.
9. Move handbrake to lowered position.
10. Fit cable to handbrake and secure with clevis pin and clip.
11. Fit handbrake gaiter to console.
12. Fit bolts securing forward edge of console to transmission tunnel.
13. **Models with veneer trim:** Position veneered console cover and connect multiplugs to switch pack. Fit cigar lighter element and secure veneered console cover to console.
14. **Models with base trim:** Connect multiplugs to switch pack, fit switch pack to console and secure with screws.
15. **Models with base trim:** Fit cover plate to switch pack, and rubber mat to console.
16. Fit transfer box gaiter and knob to lever.
17. Secure transfer box gaiter to console.
18. Connect multiplug to selector panel, fit and secure panel to centre console.
19. Fit spacer and knob to gear selector lever.
20. **Models from 03MY:**Fit both centre console cup holders.

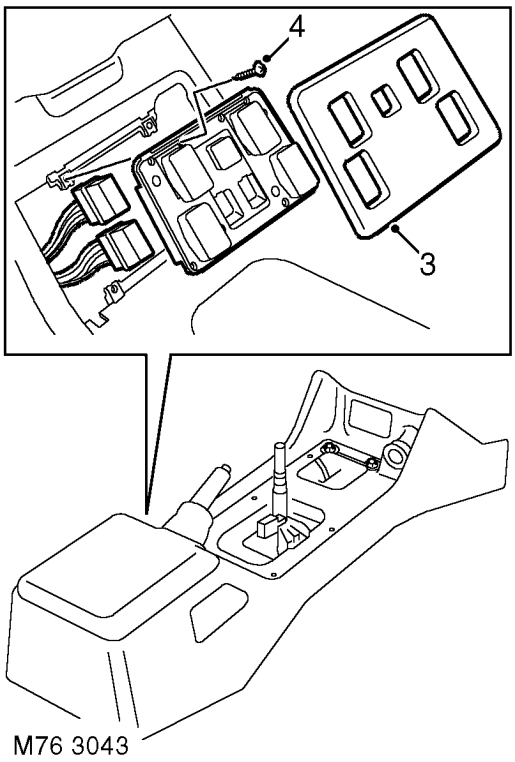
Console - centre - manual models

76.25.01

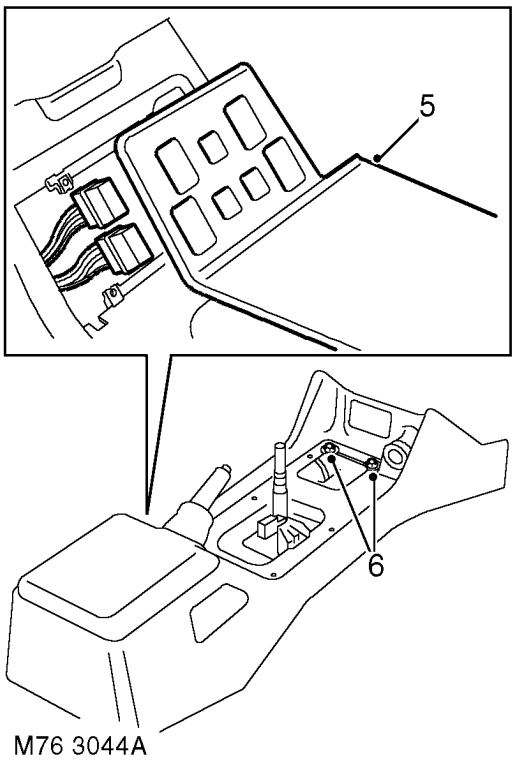
Remove



1. Release clips securing gear lever gaiter to centre console and remove knob and gaiter.
2. **Models from 03MY:**Remove both centre console cup holders.
3. Release clips securing transfer box lever gaiter to centre console and remove knob and gaiter.

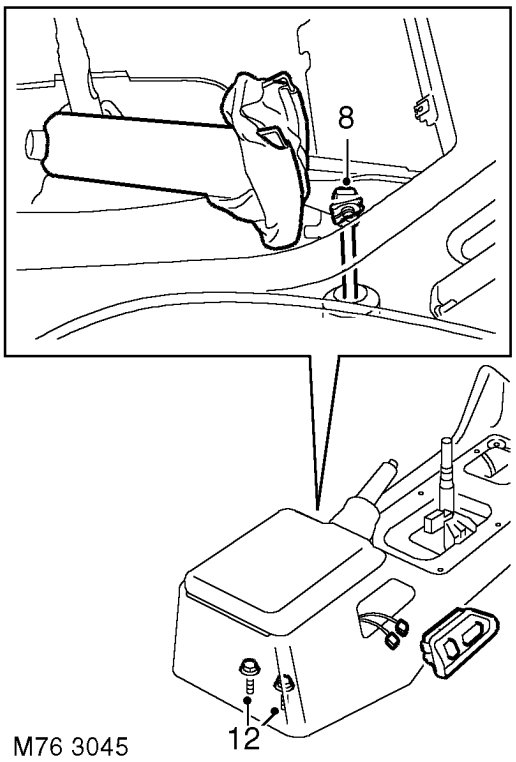


4. **Models with base trim:** Remove rubber mat from console and remove cover plate from switch pack.
5. **Models with base trim:** Remove 4 screws securing switch pack to centre console, disconnect multiplugs and remove switch pack.



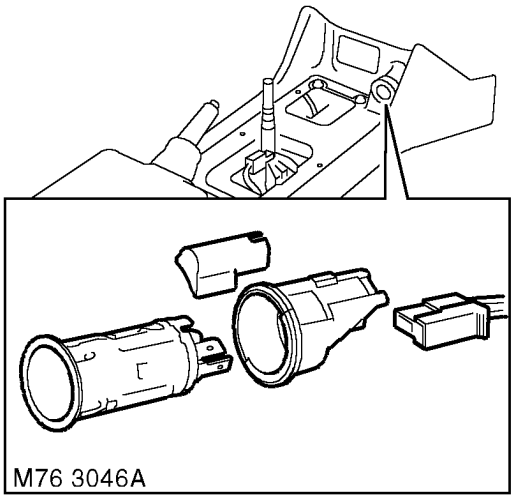
M76 3044A

6. **Models with veneer trim:** Release veneered console cover from console and remove cigar lighter element. Disconnect multiplugs from switch pack and remove veneered console cover.
7. Remove 2 bolts securing forward edge of console to transmission tunnel.



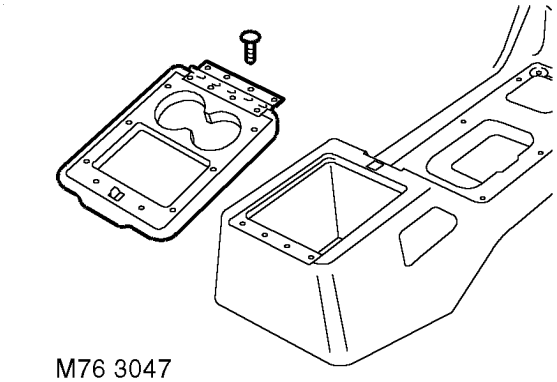
M76 3045

8. Release handbrake gaiter from console.
9. Remove clip and clevis pin securing cable to handbrake.
10. Move handbrake to fully upward position.
11. Release electric seat switches from console.
12. Disconnect multiplugs from switches and remove.
13. Remove 2 bolts securing rear of console to transmission tunnel.
14. Release centre console from fascia.


M76 3046A

15. Disconnect multiplug and bulb from cigar lighter.

16. Remove console.
    NOTE: Do not carry out further dismantling if component is removed for access only.



M76 3047

17. Remove 4 screws securing storage bin lid to console and remove lid.
18. Release cigar lighter body from console and remove.

Refit

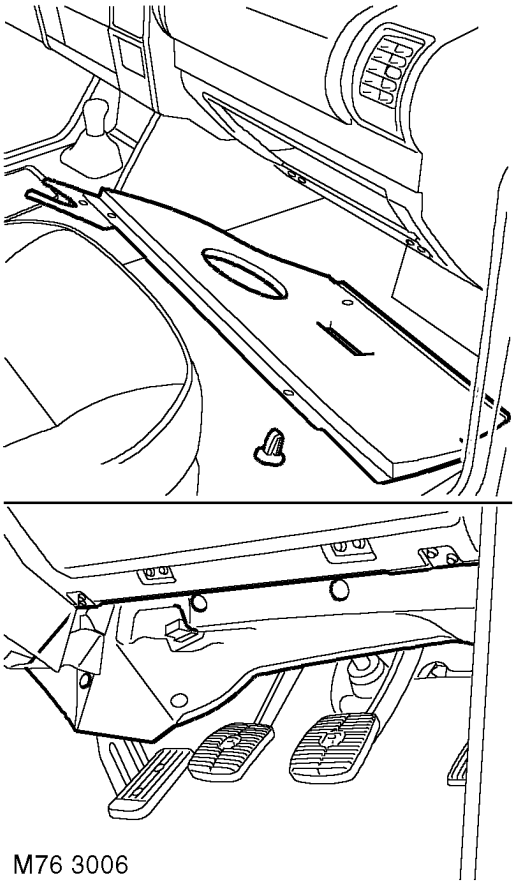
1. Fit and secure cigar lighter body to console.
2. Fit lid to console and secure with screws.
3. Fit console.
4. Connect multiplug and bulb to cigar lighter.
5. Fit centre console to fascia.
6. Fit 2 bolts securing rear of console to transmission tunnel.
7. Connect multiplugs to seat switches.
8. Fit switches to console.
9. Move handbrake to lowered position.
10. Fit cable to handbrake and secure with clevis pin and clip.
11. Fit handbrake gaiter to console.
12. Fit bolts securing forward edge of console to transmission tunnel.
13. **Models with veneer trim:** Position veneered console cover and connect multiplugs to switch pack. Fit cigar lighter element and secure veneered console cover to console.
14. **Models with base trim:** Connect multiplugs to switch pack, fit switch pack to console and secure with screws.
15. **Models with base trim:** Fit cover plate to switch pack, and rubber mat to console.
16. Fit transfer gearbox gaiter and knob to lever.
17. Secure gaiter to console.
18. Fit knob and gaiter to gear lever and secure gear lever gaiter to console with clips.
19. **Models from 03MY:**Fit both centre console cup holders.

Fascia

76.46.23/99

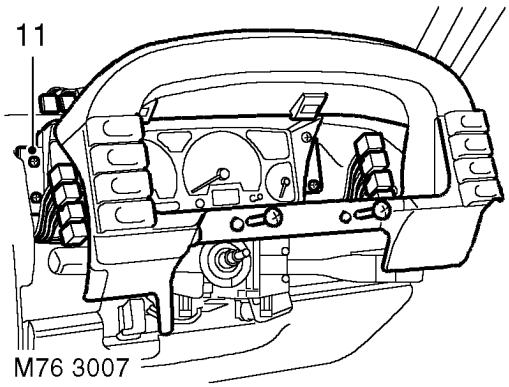
Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove radio cassette player.
   IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.
3. Remove steering wheel.
   STEERING, REPAIRS, Steering wheel.
4. Remove steering column nacelle.
   STEERING, REPAIRS, Nacelle - steering column.
5. Remove centre console.
   - For models with automatic gearbox:
     INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.
   - For models with manual gearbox:
     INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.
6. Remove 'A' post trim panels.



M76 3006

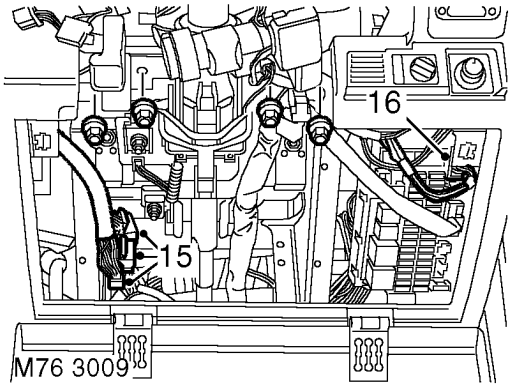
7. Remove 6 clips securing both lower closing panels to fascia and remove closing panels.
8. Remove mats from fascia.



M76 3007

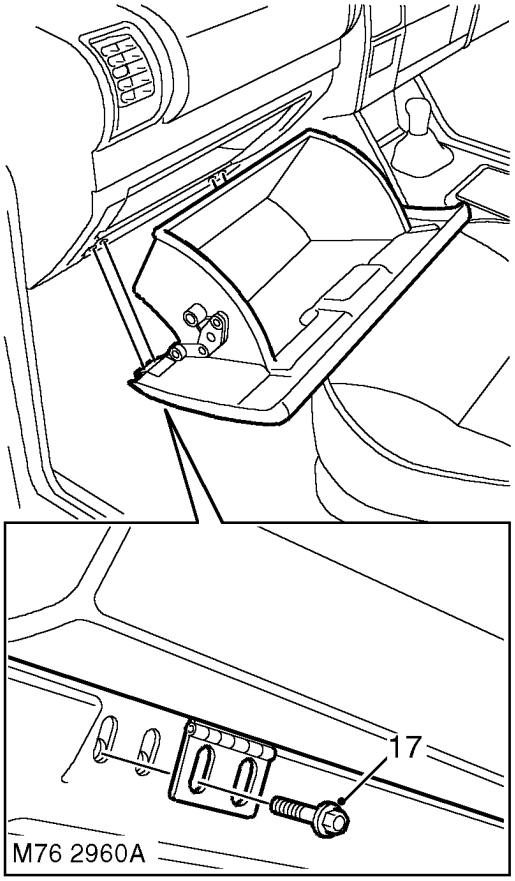
9. Remove 2 screws and release instrument cowl from 2 clips on fascia.
10. Disconnect multiplugs from switches in instrument cowl and remove cowl.
11. Remove 4 screws securing instrument pack to fascia.
12. Disconnect 2 multiplugs from instrument pack and remove pack.

13. Remove fascia access panel.
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Panel - fascia access - driver's side.**



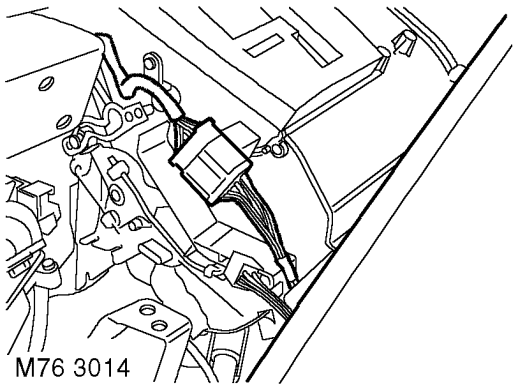
M76 3009

14. Remove 4 nuts securing fascia to steering column bracket.
15. Disconnect 3 multiplugs connecting main body harness to fascia harness.
16. Disconnect fascia harness multiplug from fuse box.

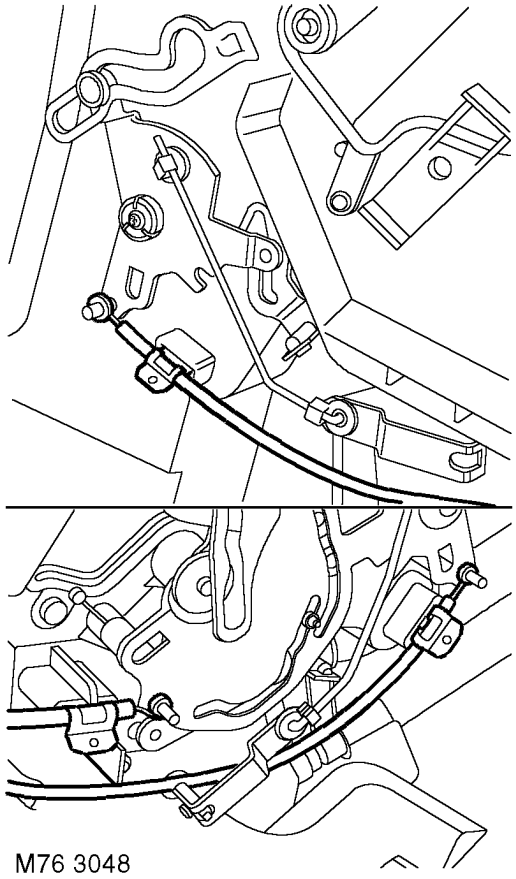


M76 2960A

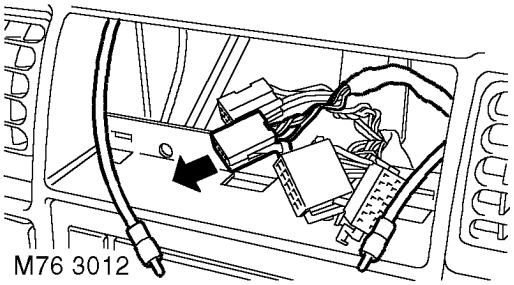
17. Remove 4 bolts securing glove box and remove glove box.


M76 3014

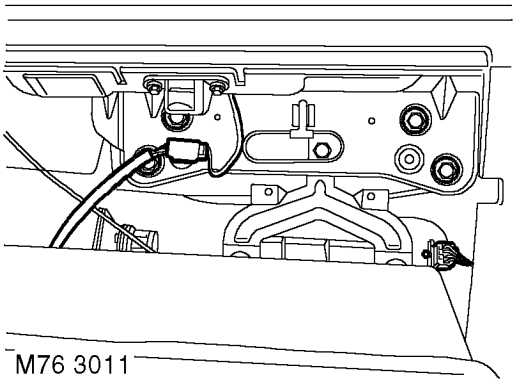
18. **Models with A/C:** Disconnect multiplug from heater controls.


M76 3048

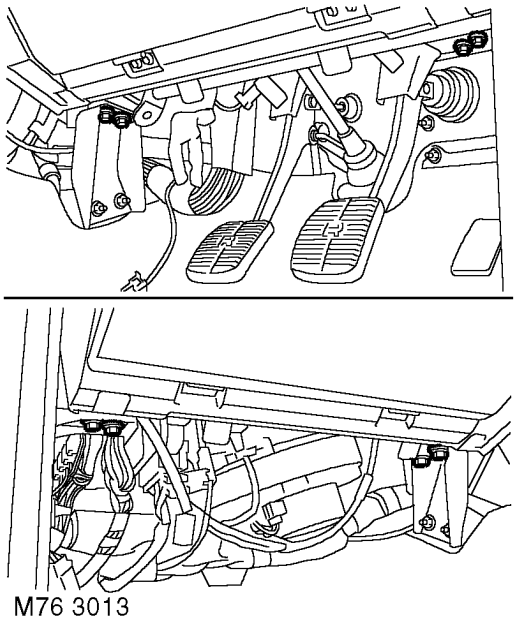
19. **Models without A/C:** Release temperature and air distribution control outer cables from clips on heater casing and disconnect inner cables from levers.


M76 3012

20. Separate blue section from ICE multiplug.
21. Release coaxial cables from fascia panel.


M76 3011

22. Disconnect multiplug from passenger air bag.
23. Disconnect multiplug from blower motor.
24. Working through glove box aperture remove 2 bolts, or 4 bolts if passenger airbag module is fitted, securing fascia to body.



M76 3013

25. Remove 4 bolts securing lower edge of fascia to mounting brackets on transmission tunnel.
26. Remove 4 bolts securing lower edge of fascia to brackets on 'A' post.
27. With assistance carefully remove fascia from vehicle.
28. If renewing fascia, transfer components to new fascia as necessary.

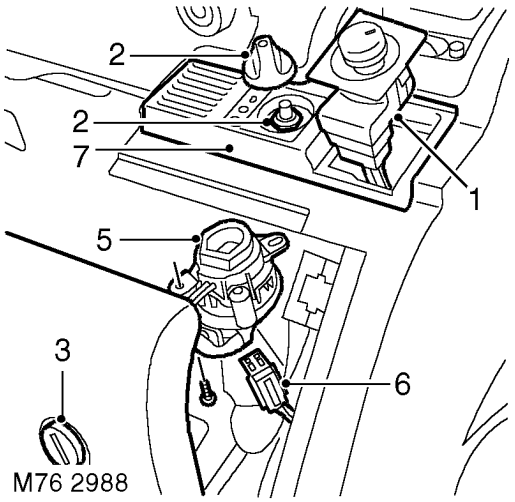
Refit

1. With assistance carefully fit fascia and tighten bolts securing lower edge of fascia to 26 Nm (19 lbf.ft).
2. Tighten bolts securing fascia to body to 26 Nm (19 lbf.ft).
3. Fit nuts securingfascia to steering column bracket to 11 Nm (8 lbf.ft).
4. Secure coaxial cables to fascia and secure blue multiplug to main ICE multiplug.
5. **Models with A/C:** Connect heater control multiplug.
6. **Models without A/C:** Connect temperature and air distribution inner cables to heater control levers. Set temperature control knobs to fully hot, distribution knob to demist position and, with flap levers fully closed, secure outer cables to clips on heater casing.
7. Connect multiplugs to blower motor and passenger air bag (where fitted).
8. Fit glove box and secure with bolts.
9. Connect fascia harness multiplugs to main harness and fuse box.
10. Position instrument pack and connect multiplugs.
11. Fit instrument pack to fascia and secure with screws.
12. Position instrument cowl and connect multiplugs to switches.
13. Fit cowl to clips on fascia and secure with screws.
14. Fit fascia access panel.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Panel - fascia access - driver's side.**
15. Fit fascia lower closing panels and secure with clips.
16. Fit fascia mats.
17. Fit 'A' post trim panels.
18. Fit centre console
    - For models with automatic gearbox:
      ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.**
    - For models with manual gearbox:
      ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.**
19. Fit steering column nacelle.
    ☞ **STEERING, REPAIRS, Nacelle - steering column.**
20. Fit steering wheel.
    ☞ **STEERING, REPAIRS, Steering wheel.**
21. Fit radio cassette player.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.**
22. Connect battery.

Panel - auxiliary switch

76.46.38

Remove



1. Carefully remove electric exterior mirror switch from auxiliary switch panel and disconnect multiplug.
2. **Models with headlamp levelling:** Release knob and remove nut securing headlamp levelling switch to auxiliary switch panel.
3. Release 2 fasteners and open fascia access panel.
4. **Models with headlamp levelling:** Remove headlamp levelling switch from auxiliary switch panel and disconnect multiplug.
5. **Models with A/C:** Remove 2 screws securing in-car temperature sensor to auxiliary switch panel.
6. **Models with A/C:** Disconnect multiplug from in-car temperature sensor and remove from auxiliary switch panel.
7. Release 2 clips securing auxiliary switch panel to fascia and remove panel.

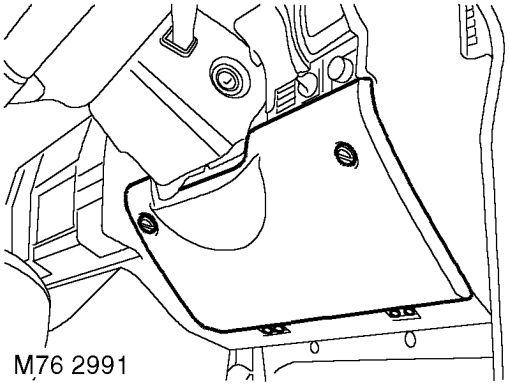
Refit

1. Position auxiliary switch panel to fascia and clip into position.
2. **Models with A/C:** Connect multiplug to in-car temperature sensor.
3. **Models with A/C:** Position in-car temperature sensor to auxiliary switch panel and secure with screws.
4. **Models with headlamp levelling:** Position headlamp levelling switch to auxiliary switch panel and secure with nut.
5. **Models with headlamp levelling:** Replace cap and connect multiplug to headlamp levelling switch.
6. Connect multiplug to exterior mirror switch and fit switch to auxiliary switch panel.

Panel - fascia access - driver's side

76.46.40

Remove



1. Remove 4 bolts securing fascia access panel to fascia.
2. Release 2 quarter turn screws securing fascia access panel to fascia.
3. Remove fascia access panel.

Refit

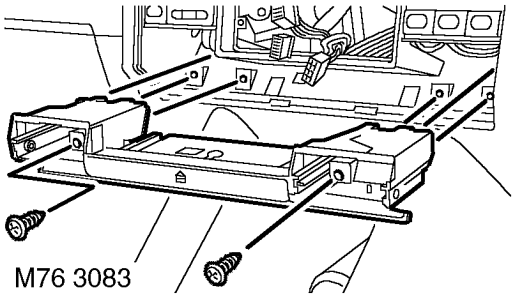
1. Position fascia access panel to fascia and secure with quarter turn screws.
2. Position base of fascia access panel to fascia and secure with bolts.

Drink tray assembly - centre fascia

76.46.41

Remove

1. Remove coin tray and ash tray.



2. Remove 6 screws securing drink tray assembly to fascia.
3. Remove drink tray.

Refit

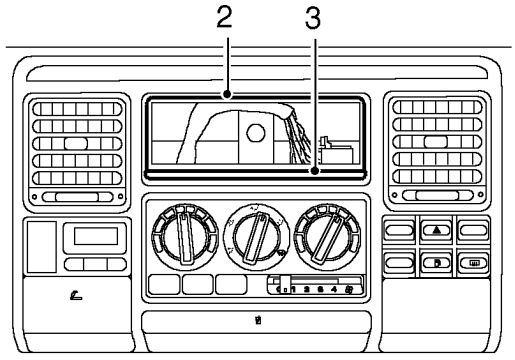
1. Position drink tray assembly to fascia and secure with screws.
2. Fit ash tray and coin tray to drink tray assembly.

Louvre panel assembly - centre fascia

76.46.42

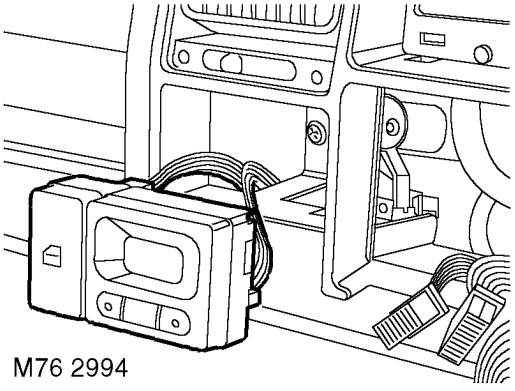
Remove

1. Remove radio cassette player from fascia.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.**



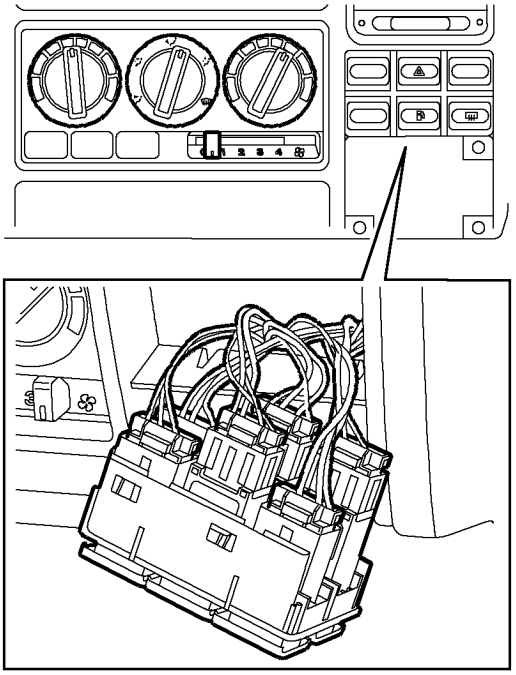
M76 2992A

2. Carefully release and remove radio DIN socket from louvre panel.
3. Remove screw cover from radio aperture.
4. Remove drink tray assembly.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Drink tray assembly - centre fascia.**



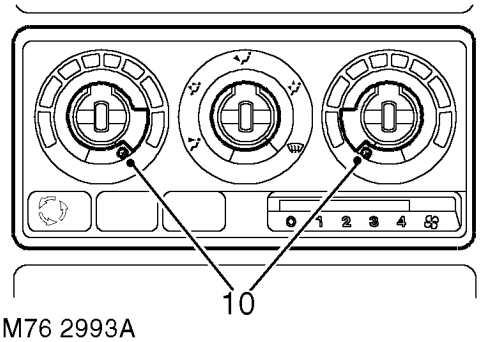
M76 2994

5. Carefully release clock assembly from louvre panel.
6. Disconnect multiplugs from clock and door locking switch. Remove clock assembly.



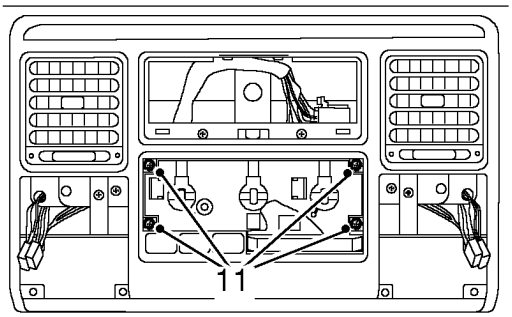
M80 0312

7. Carefully release switch pack from louvre panel.
8. Disconnect multiplugs from switches and remove switch pack.
9. **Models without A/C:** Carefully remove blower speed and heater control knobs.



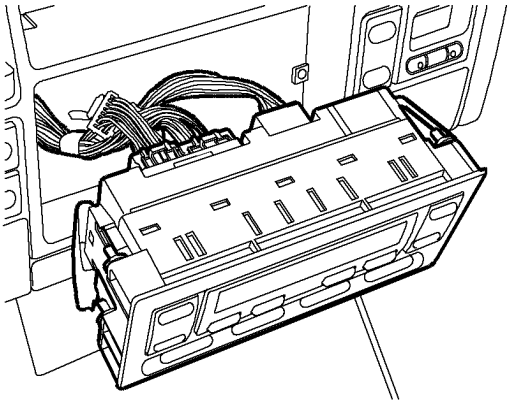
M76 2993A

10. **Models without A/C:** Remove 2 screws securing heater control panel graphic plate and remove graphic plate.



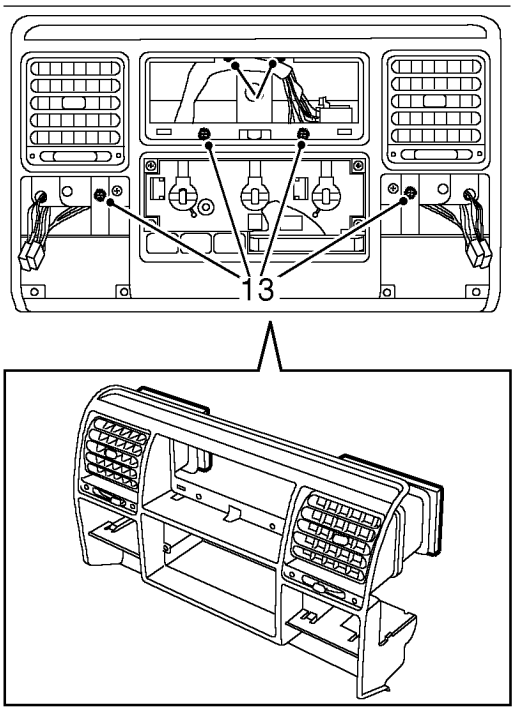
M76 3050

11. **Models without A/C:** Remove 4 screws securing heater control panel to louvre panel.



M82 0538

12. **Models with A/C:** Carefully release ATC ECU from louvre panel, disconnect multiplugs and remove ATC ECU.



M76 2996A

13. Loosen 2 upper screws and remove 4 remaining screws securing louvre panel to fascia.
14. Remove louvre panel assembly.
15. Remove seals from face level vents.

Refit

1. Fit seals to face level vents on new louvre panel.
2. Fit louvre panel to fascia and secure with screws.
3. **Models with A/C:** Connect multiplugs to ATC ECU and fit ATC ECU to fascia.
4. **Models without A/C:** Fit screws securing heater control panel to louvre panel.
5. **Models without A/C:** Fit heater control panel graphic plate and secure with screws.
6. **Models without A/C:** Fit blower speed and heater control knobs.
7. Position switch pack, connect multiplugs to switches and fit switch pack to louvre panel.
8. Position clock assembly, connect multiplug to clock and door locking switch and fit clock assembly to louvre panel.

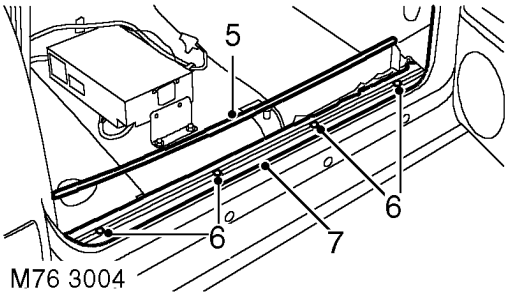
9. Fit drinks tray.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Drink tray assembly - centre fascia.**
10. Fit and secure radio DIN socket.
11. Fit screw cover to radio aperture.
12. Fit radio cassette player.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.**

Carpet - front

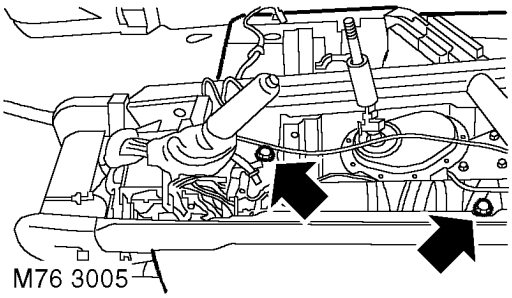
⊸ ***76.49.02***

Remove

1. **Models with premium ICE:** Remove power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
2. **Models with premium ICE:** Remove CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
3. Remove centre console.
   - For models with manual gearbox:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.**
   - For models with automatic gearbox:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.**
4. Remove both lower 'A' post trim panels.



5. Remove finisher from both front carpet retainers.
6. Remove 8 screws securing front carpet retainers to floor.
7. Remove front carpet retainers.



8. Remove 2 nuts securing main body harness to transmission tunnel.
9. With assistance release and remove carpet.

Refit

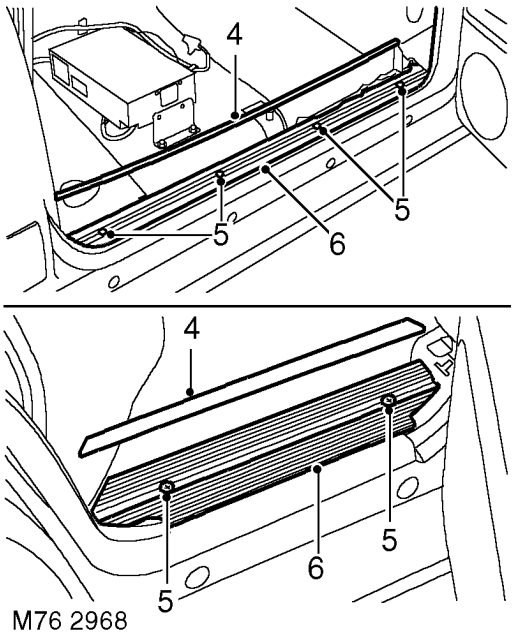
1. With assistance position carpet.
2. Secure main body harness to transmission tunnel with nuts.
3. Position front carpet retainers and secure to floor with screws.
4. Fit finishers to front carpet retainers
5. Fit both lower 'A' post trim panels.
6. Fit centre console.
   - For models with manual gearbox:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - manual models.**
   - For models with automatic gearbox:
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Console - centre - automatic models.**
7. **Models with premium ICE:** Fit CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
8. **Models with premium ICE:** Fit power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**

Carpet - rear

76.49.03

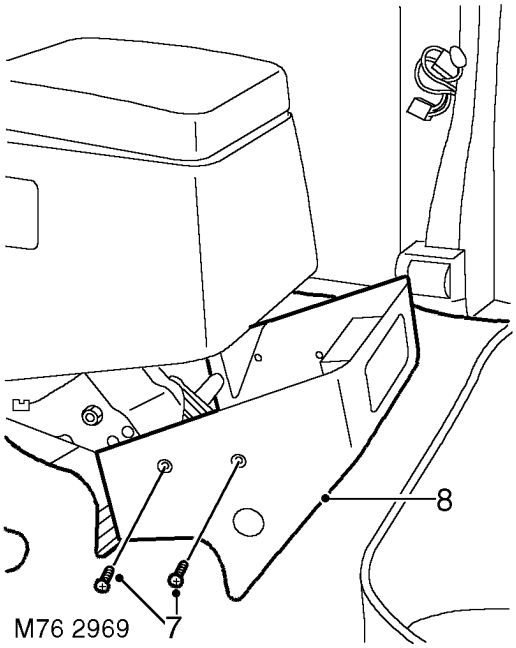
Remove

1. **Models with premium ICE:** Remove power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
2. Remove RH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
3. Remove both 'B' post lower trim panels.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**



M76 2968

4. Remove finishers from front and rear carpet retainers.
5. Remove 12 screws securing front and rear carpet retainers to floor.
6. Remove front and rear carpet retainers.



7. Remove 4 screws securing trim panel to rear of centre console.
8. Remove trim panel.
9. Position harnesses clear of rear carpet.
10. Remove rear carpet.

Refit

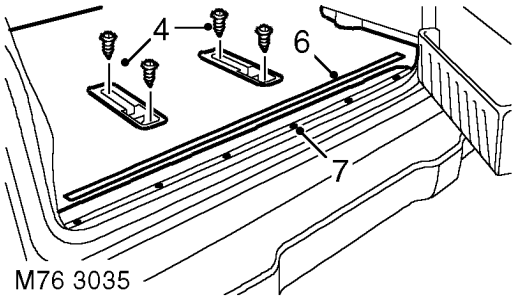
1. Position new rear carpet.
2. Fit front and rear carpet retainers to floor and secure with screws.
3. Fit finishers to front and rear carpet retainers
4. Position trim panel to rear of centre console and secure with screws.
5. Fit lower 'B' post trim panels.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**
6. Fit RH front seat to floor.
   ☞ **SEATS, REPAIRS, Seat - front.**
7. **Models with premium ICE:** Fit power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**

Carpet - loadspace

76.49.04

Remove

1. Remove both rear seat belt lower fixings.
2. **Models with third row seats:** Remove both third row seats.
   ☞ **SEATS, REPAIRS, Seat - third row.**
3. Remove both loadspace side trim casings.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**



4. **Models with third row seats:** Remove 4 screws and remove both seat lower mounting escutcheons.
5. Recline rear seats fully forward.
6. Remove finisher from loadspace carpet retainer.
7. Remove 6 screws securing loadspace carpet retainer to floor and remove retainer.
8. Remove loadspace carpet.

Refit

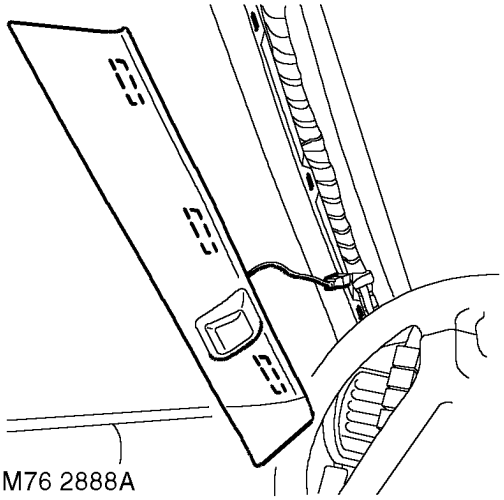
1. Position loadspace carpet to floor.
2. Position loadspace carpet retainer to floor and secure with screws.
3. Fit finisher to loadspace carpet retainer
4. Return rear seats to their normal position.
5. **Models with third row seats:** Position both third row seats lower mounting escutcheons to floor and secure with screws.
6. Fit both loadspace side trim casings.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
7. **Models with third row seats:** Fit both third row seats.
   ☞ **SEATS, REPAIRS, Seat - third row.**
8. Position both rear seat belt lower mountings and secure with bolts tightened to 32 Nm (24 lbf.ft).

Headlining

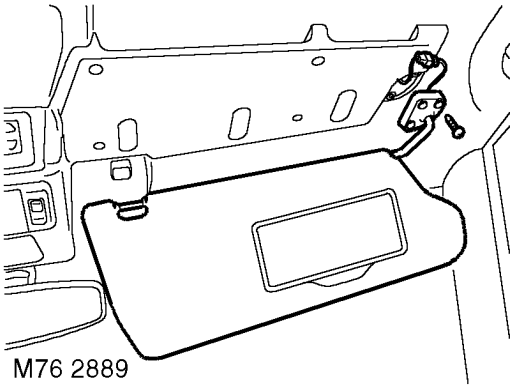
76.64.15.21

Remove

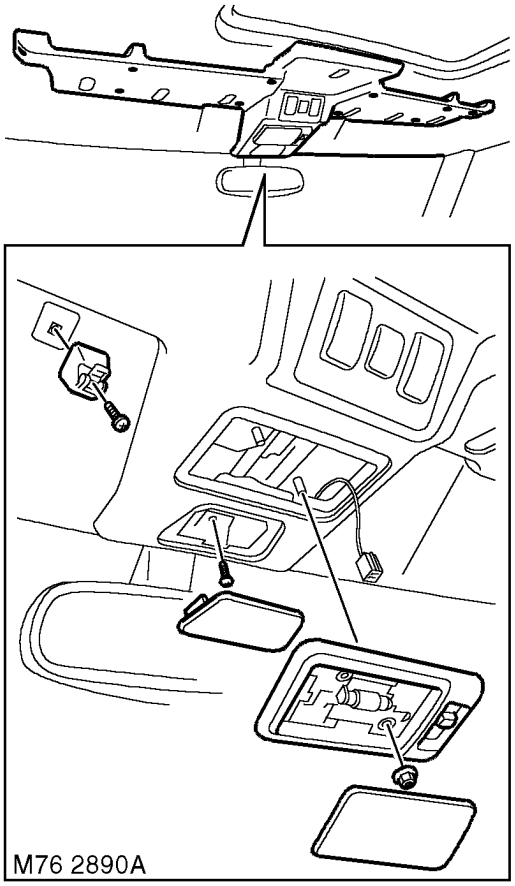
1. Remove both 'D' post trim casings.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.
2. Remove both 'B' post upper trim casings.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - upper - 'B' post.


M76 2888A

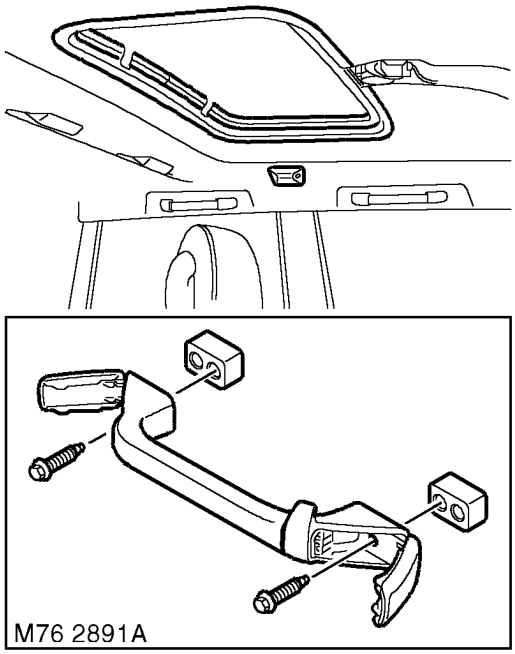
3. Release clips securing both 'A' post trim casings.
4. **Models with premium ICE:** Disconnect multiplugs from 'A' post speakers.
5. Remove both 'A' post trim casings.


M76 2889

6. Remove 3 screws securing sun visor to headlining.
7. Release sun visor from clip.
8. Disconnect multiplug from sun visor.
9. Remove sun visor.
10. Repeat process for second sun visor.

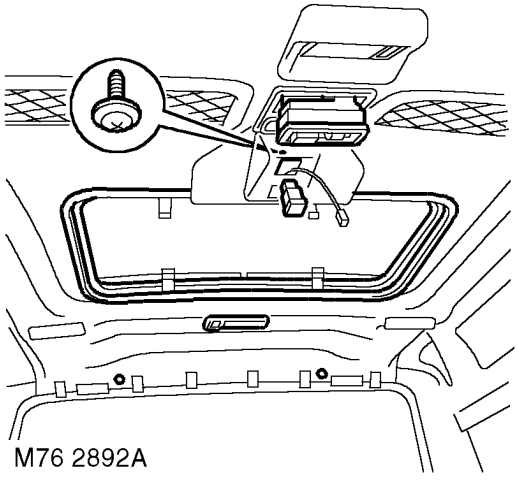

M76 2890A

11. Remove access panel from front edge of front stowage pocket.
12. Remove screw securing front stowage pocket to headlining.
13. Remove lens from front interior lamp.
14. Remove 2 nuts securing front interior lamp to headlining.
15. Disconnect multiplug from front interior lamp.
16. Remove front interior lamp.
17. Remove 10 screws securing front stowage pocket to headlining.
18. Disconnect 3 multiplugs from sunroof switches.
19. Remove front stowage pocket.
20. Remove caps from sun visor clips.
21. Remove screws and release both sun visor clips.
22. Remove tail door aperture upper trim casing.
23. Remove rear sunroof aperture trim.



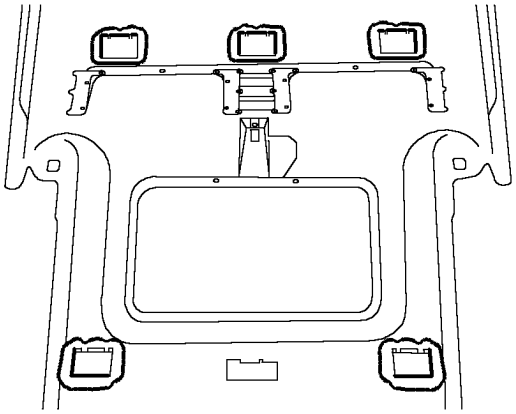
M76 2891A

24. Remove front sunroof aperture trim.
25. Release end caps from all grab handles.
26. Remove 2 bolts securing each grab handle to roof.
27. Remove all 4 grab handles.
28. **Models with volumetric alarm:** Release front volumetric sensor from headlining and disconnect multiplug.



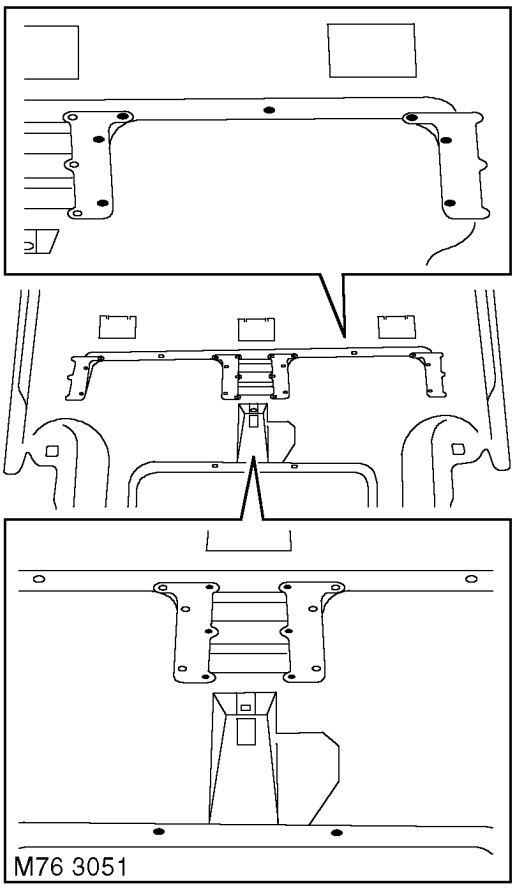
M76 2892A

29. **Models with rear A/C:**
    - **a** Release rear A/C control panel from headlining.
    - **b** Disconnect 2 multiplugs and 2 Lucar connectors from rear A/C control panel.
    - **c** Remove rear A/C control panel.
30. Release rear interior lamp from headlining and disconnect multiplug.
31. Remove rear interior lamp.
32. Remove 2 clips securing rear of headlining to roof.
33. Release rear sunroof switch from headlining.
34. Disconnect multiplug and remove rear sunroof switch.
35. Remove screw securing headlining to roof.
36. With assistance, remove headlining.



M76 2893

37. **Models with rear A/C:**
    - **a** Remove foam pads from air vents.
    - **b** Release 2 rear air vents from headlining.
    - **c** Release 3 central air vents from headlining.



38. Remove 7 nuts securing each stowage pocket to headlining and collect mounting plates.
39. Remove both pockets from headlining.
40. Remove 8 screws securing rear console to headlining and collect 3 mounting plates.
41. Remove rear console from headlining.

Refit

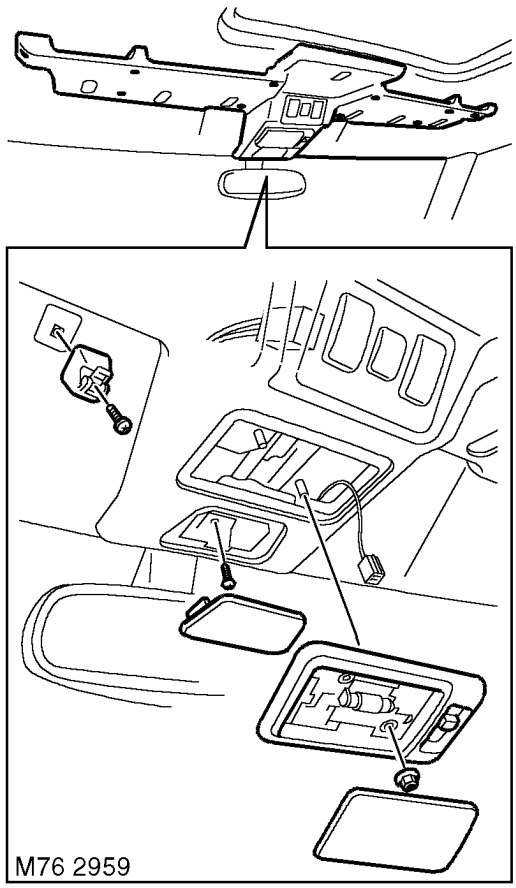
1. Fit rear console and mounting plates to headlining.
2. Fit and tighten nuts securing rear console to headlining.
3. Fit both stowage pockets and mounting plates to headlining.
4. Fit and tighten nuts securing stowage pockets to headlining.
5. **Models with rear A/C:**
   - **a** Fit 3 central air vents to headlining.
   - **b** Fit 2 rear air vents to headlining.
   - **c** Fit foam pads to air vents.
6. With assistance, position headlining in vehicle.
7. Fit and tighten screw securing centre of headlining to roof.
8. Connect multiplug to rear sunroof switch.
9. Fit rear sunroof switch to rear console.
10. Fit clips securing rear edge of headlining to sunroof.
11. Position rear interior lamp to headlining and connect multiplug.
12. Fit rear interior lamp to headlining.
13. **Models with rear A/C:**
    - **a** Position rear A/C control panel to headlining and connect multiplugs and Lucar connectors.
    - **b** Fit rear A/C control panel to headlining.
14. **Models with volumetric alarm:** Connect multiplug to front volumetric sensor and fit sensor to headlining.
15. Fit grab handles to headlining and secure with bolts.
16. Fit end caps to grab handles.
17. Fit front sunroof aperture trim.
18. Fit rear sunroof aperture trim.
19. Fit tail door aperture upper trim casing.
20. Fit sun visor clips to headlining and secure with screws.
21. Fit caps to sun visor clips.
22. Position front stowage pocket to headlining and connect multiplugs to sunroof switches.
23. Fit and tighten 10 screws securing front stowage pocket to headlining.
24. Connect multiplug to front interior lamp.
25. Fit front interior lamp to headlining and secure with nuts.
26. Fit lens to front interior lamp.
27. Fit and tighten screw securing front stowage pocket to headlining.
28. Fit access panel to front edge of front stowage pocket.
29. Position sun visor to headlining and secure to clip.
30. Connect multiplug to sun visor.
31. Fit and tighten screws securing sun visor to headlining.
32. Repeat process for second sun visor.
33. **Models with premium ICE:** Position both 'A' post trim casings and connect multiplugs to speakers.
34. Fit both trim casings to 'A' posts and secure with clips.
35. Fit both 'B' post upper trim casings.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - upper - 'B' post.**
36. Fit both 'D' post trim casings.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**

Stowage pocket - front

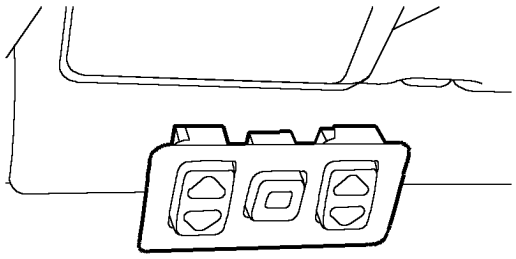
76.67.26

Remove

1. Remove access panel from front edge of front stowage pocket.



2. Remove screw securing front stowage pocket to headlining.
3. Remove lense from front interior lamp.
4. Remove 2 nuts securing front interior lamp to headlining.
5. Disconnect multiplug from front interior lamp.
6. Remove front interior lamp.
7. Remove 10 screws securing front stowage pocket to headlining.
8. Disconnect 3 multiplugs from sunroof switches.
9. Remove front stowage pocket.


M76 3022

10. Release clips securing sunroof switch pack.
11. Remove switch pack.

Refit

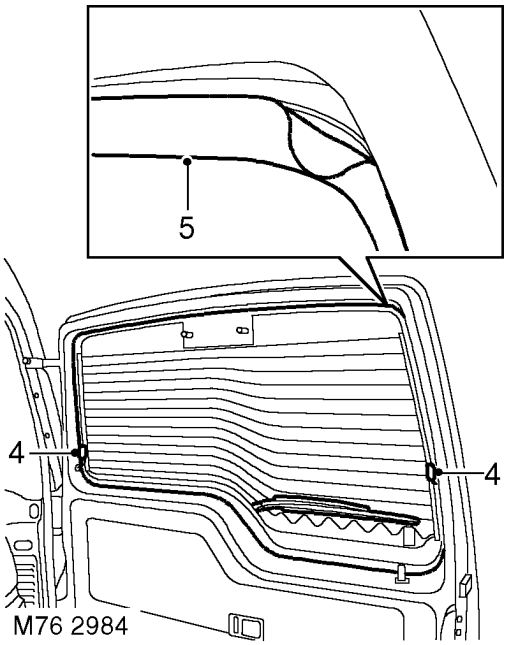
1. Fit sunroof switch pack to front stowage pocket and secure with clips.
2. Position front stowage pocket to headlining and connect multiplugs to sunroof switches.
3. Fit and tighten 10 screws securing front stowage pocket to headlining.
4. Connect multiplug to front interior lamp.
5. Fit front interior lamp to headlining and secure with nuts.
6. Fit lense to front interior lamp.
7. Fit and tighten screw securing front of front stowage pocket to headlining.
8. Fit access panel to front stowage pocket.

Glass/sealing rubber - tail door

76.31.22

Remove

1. Remove spare wheel from rear door.
2. Remove centre high mounted stop lamp.
   LIGHTING, REPAIRS, Lamp - stop - centre high mounted (CHMSL).



3. Pull the rear wiper arm away from the glass.
4. Disconnect leads from rear window heater.
5. Ease glass sealing rubber from tail door flange and with assistance, from inside push the glass and sealing rubber out.
6. Remove sealing rubber from glass.

Refit

1. Thoroughly clean the tail door glass mounting flange.
2. Clean glass and fit sealing rubber. Ensure sealing rubber is fully located onto glass.
3. Fit a draw cord into the outside groove of the sealing rubber with cord ends situated on top corner of bend at bottom of glass.
4. To aid assembly, lubricate the tail door glass mounting flange with liquid soap.
5. Position the assembled glass and rubber to outside of flange.
6. With assistance from second operator pushing glass into door, hold one end of cord and pull the other end carefully around the aperture, easing the rubber seal over the flange.
7. Connect leads to rear window heater.
8. Fit centre high mounted stop lamp.
   LIGHTING, REPAIRS, Lamp - stop - centre high mounted (CHMSL).
9. Fit rear wiper onto glass.
10. Fit spare wheel.

Windscreen

76.81.01

Introduction

The following equipment is required:

- Cutting wire and handles.
- Kent cutting knife.
- Glazing knife.
- Windscreen repair kit.
- Sealant applicator gun.
- Suction cups.
- A felt covered table or stand to support glass.

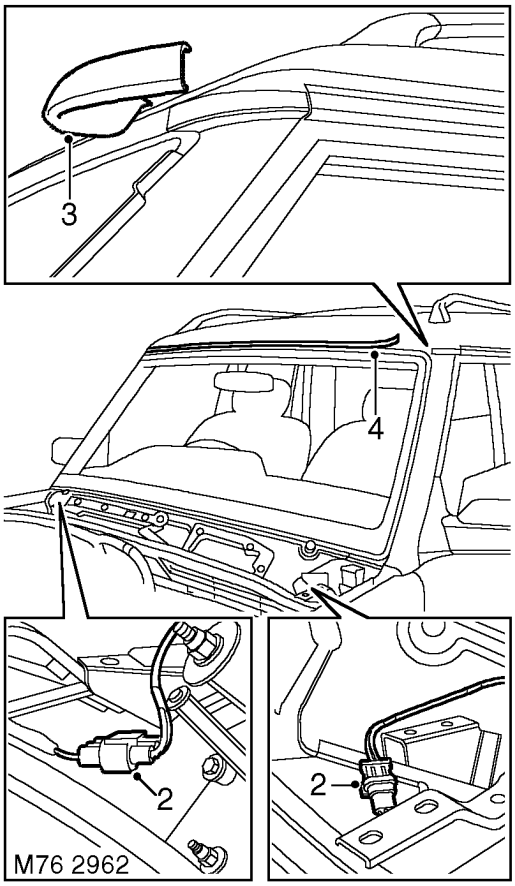
WARNING: Wear protective gloves when handling glass, solvents and primers.

WARNING: Wear suitable eye protection when removing and refitting glass.

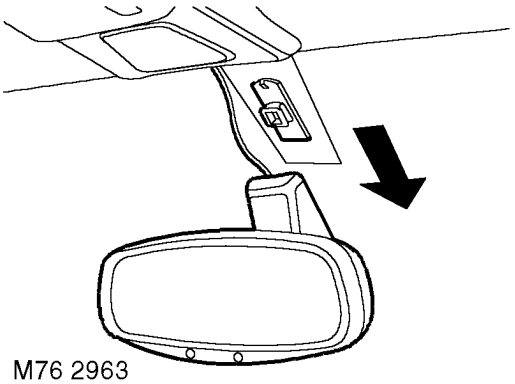
WARNING: If glass has splintered, protect eyes and operate demister blower to remove glass from heater ducts. Use a vacuum cleaner to remove glass from fascia, carpet and seats.

Remove

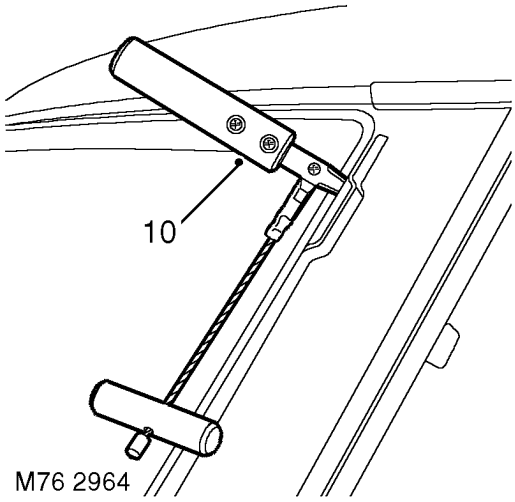
1. Remove air intake plenum.
   ☞ **HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.**



2. If fitted, disconnect screen heater multiplugs.
3. Remove top corner trim finishers from body.
4. Remove windscreen top finisher and discard.



5. Release interior mirror from slug and tie aside.
6. Fit protection to exterior body work adjacent to screen.
7. Cover body panels adjacent to glass.
8. Cover heater ducts with masking tape.
9. Cover interior of vehicle with protective sheet.



M76 2964

10. From outside of vehicle, use a Kent knife and carefully cut through sealant securing sides of screen to body.
11. Using suitable cutting wire, with assistance if required, carefully cut through sealant securing top of screen to body and any remaining sealant at sides.

    CAUTION: Hold the cutting wire as close to the glass as possible to prevent damage to the body and surrounding trim.

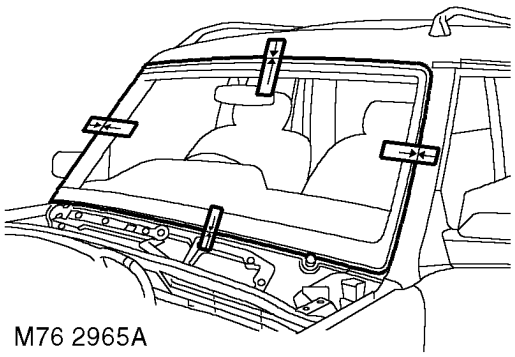
12. Cut through sealant securing lower edge of screen to body with glazing knife.
13. Attach suction cups and use assistance to remove glass from body.

    CAUTION: Lay glass on felt covered supports and be careful not to damage the obscuration band. Do not stand on edge as this can cause chips which subsequently develop into cracks.

14. Collect screen support block.

Refit

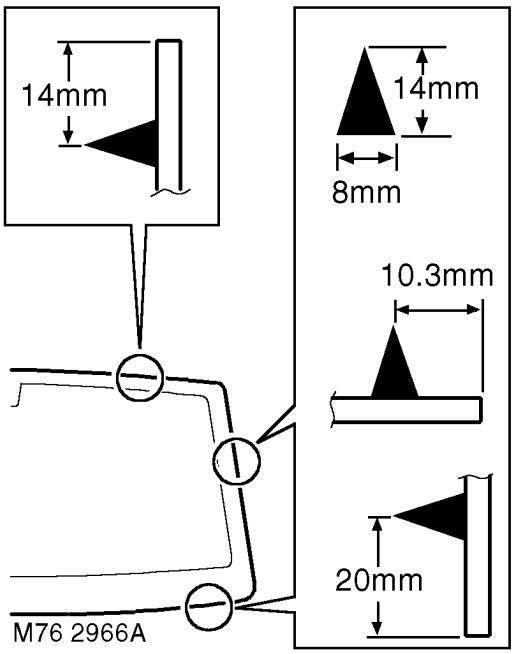
1. Carefully remove sealant from body to leave a smooth surface.
2. Use a vacuum cleaner to clear away any waste.
3. **Original glass:** Carefully cut back old sealer to obtain a smooth surface without damaging obscuration band on glass. Fit new top finisher to screen.


M76 2965A

4. Fit screen support block to body.
5. With assistance, locate screen to body.
6. Apply masking tape to establish reference marks as an alignment aid.
7. With assistance, remove screen and place aside.
8. Clean body and sealant face on screen with solvent.

   CAUTION: Do not touch cleaned or primed surfaces with fingers.

9. Apply etch primer to any bare metal on frame.
10. Apply screen primer to sealant face on screen and allow to cure.
11. Apply primer over etch primer on body.
12. Apply activator over old sealant on body.
13. Allow activator to cure.
14. Fit pre-cut nozzle to sealer cartridge, remove lid, shake out crystals and fit cartridge to applicator gun. If necessary modify the nozzle to achieve required bead section.



15. Apply a continuous bead of sealant to sealant face on screen as shown.
16. With assistance, lift screen into place and align to screen supports and tape. Ensure top finisher is located into correct position. Lightly press glass to fully seat sealer.

    CAUTION: Do not apply heavy pressure to the sides of the windscreen. Lightly press windscreen from centre outwards until edges are to required gap. Pushing sides into position can bend windscreen and lead to cracking in service.

17. Remove protective covers and tape.
18. Test sealer for leaks, apply additional sealer if necessary. If water is used, allow sealer to dry before testing. Spray water around glass and check for leaks. Mark any area that leaks. Dry glass and sealer then apply additional sealer.
19. Fit interior mirror to slug.
20. If applicable, connect screen heater multiplugs.
21. Fit air intake plenum.

    HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.

    CAUTION: A curing time of 6 hours is desirable. During this time leave a window open to ventilate the vehicle interior. If the vehicle must be used before the curing time has elapsed, do not drive at speed or slam the doors with the windows closed.

    CAUTION: Vehicles fitted with a passenger airbag should not be driven for 24 hours.

Glass - body side - rear

76.81.18

Introduction

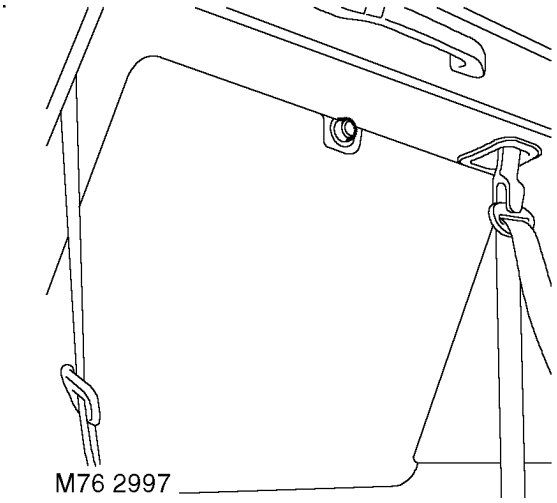
The following equipment is required:

- Cutting wire and handles.
- Kent cutting knife.
- Glazing knife.
- Windscreen repair kit.
- Sealant applicator gun.
- Suction cups.
- A felt covered table or stand to support glass.

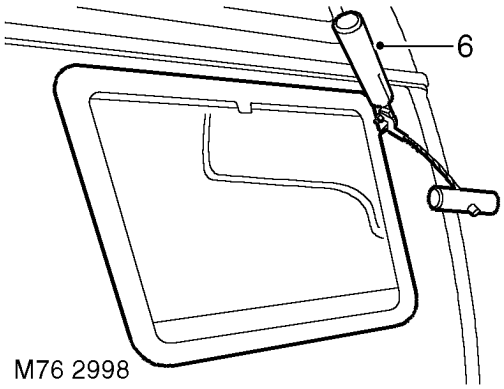
WARNING: Wear protective gloves when handling glass, solvents and primers.

WARNING: Wear suitable eye protection when removing and refitting glass.

Remove



1. If fitted, disconnect coaxial cable from terminal on glass.
2. Fit protection to exterior body work adjacent to glass.
3. Cover body panels adjacent to glass.
4. Fit protection to internal trim adjacent to glass.
5. Cover interior of vehicle with protective sheet.



M76 2998

6. From outside of vehicle, use a Kent knife and carefully cut through sealant to release glass from body. Any remaining sealant not accessible with Kent knife can be severed using cutting wire or knife.

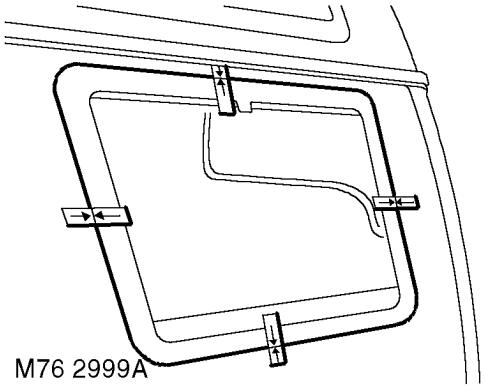
   CAUTION: Hold the cutting wire as close to the glass as possible to prevent damage to the body and surrounding trim.

7. Remove glass.

   CAUTION: Lay glass on felt covered supports and be careful not to damage the obscuration band. Do not stand on edge as this can cause chips which subsequently develop into cracks.

Refit

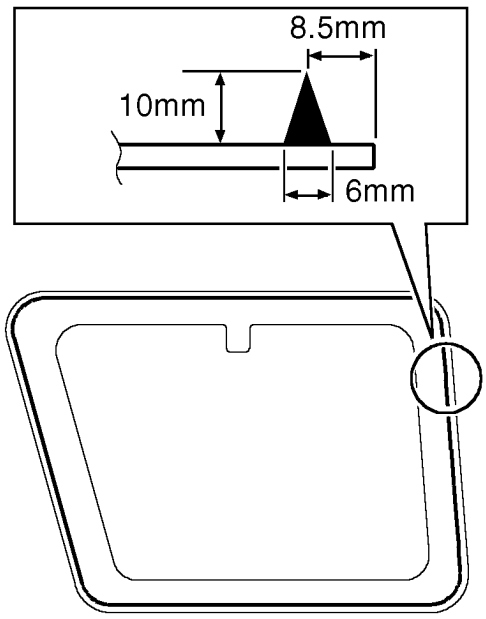
1. Carefully remove sealant from body to leave a smooth surface.


M76 2999A

2. With assistance, fit glass without sealant to body and apply masking tape to establish reference marks as an alignment aid.
3. Remove glass and place aside.
4. Clean body and sealant face on glass with solvent.

   CAUTION: Do not touch cleaned or primed surfaces with fingers.

5. Apply etch primer to any bare metal on body.
6. Apply glass primer to sealant face on glass and allow to cure.
7. Apply primer over etch primer on body.
8. Apply activator over old sealant on body.
9. Allow activator to cure.
10. Fit pre-cut nozzle to sealant cartridge, remove lid, shake out crystals, and fit cartridge to applicator gun. If necessary modify the nozzle to achieve required bead section.



M76 3000A

11. Apply a continuous bead of sealant to sealant face on glass as shown.
12. Position glass to body and align to reference tape.
13. Lightly press glass to ensure correct profile.
14. Secure glass with tape until sealer has cured.
15. Remove protective covers and tape.
16. If applicable, connect coaxial cable to terminal on glass
17. Test sealer for leaks, apply additional sealer if necessary. If water is used, allow sealer to dry before testing. Spray water around glass and check for leaks. Mark any area that leaks. Dry glass and sealer then apply additional sealer.

    CAUTION: A curing time of 6 hours is desirable. During this time leave a window open to ventilate the vehicle interior. If the vehicle must be used before the curing time has elapsed, do not drive at speed or slam the doors with the windows closed.

Glass - alpine light

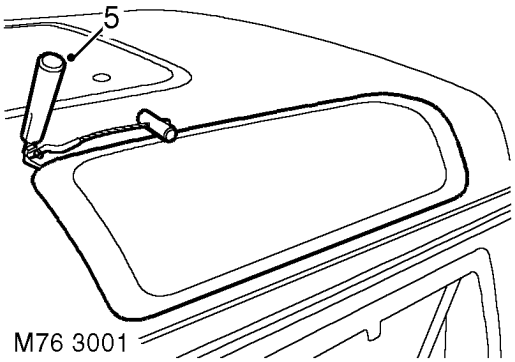
76.81.52

Introduction
The following equipment is required:
- Cutting wire and handles.
- Kent cutting knife.
- Glazing knife.
- Windscreen repair kit.
- Sealant applicator gun.
- Suction cups.
- A felt covered table or stand to support glass.

WARNING: Wear protective gloves when handling glass, solvents and primers.

WARNING: Wear suitable eye protection when removing and refitting glass.

Remove
1. Fit protection to exterior body work adjacent to glass.
2. Fit cover over adjacent body work.
3. Fit protection to internal trim adjacent to glass.
4. Cover interior of vehicle with protective sheet.

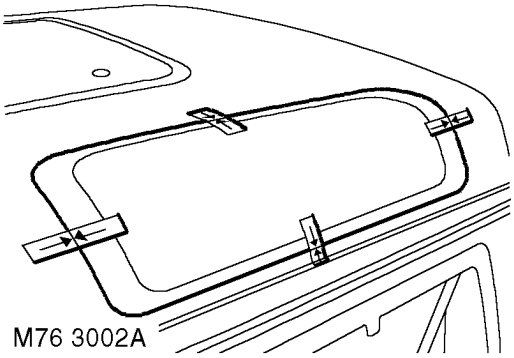


M76 3001

5. From outside of vehicle, use a Kent knife and carefully cut through sealant to release glass from body. Any remaining sealant not accessible with Kent knife can be severed using cutting wire or knife.
   CAUTION: Hold the cutting wire as close to the glass as possible to prevent damage to the body and surrounding trim.

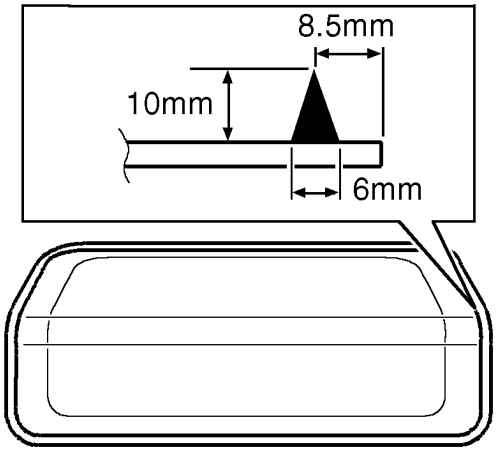
6. Remove glass.
   CAUTION: Lay glass on felt covered supports and be careful not to damage the obscuration band. Do not stand on edge as this can cause chips which subsequently develop into cracks.

Refit
1. Carefully remove sealant from body to leave a smooth surface.


M76 3002A

2. With assistance, fit glass without sealant to body and apply masking tape to establish reference marks as an alignment aid.
3. Remove glass and place aside.
4. Clean body and sealant face on glass with solvent.
   CAUTION: Do not touch cleaned or primed surfaces with fingers.

5. Apply etch primer to any bare metal on body.
6. Apply glass primer to sealant face on glass and allow to cure.
7. Apply primer over etch primer on body.
8. Apply activator over old sealant on body.
9. Allow activator to cure.
10. Fit pre-cut nozzle to sealant cartridge, remove lid, shake out crystals, and fit cartridge to applicator gun. If necessary modify the nozzle to achieve required bead section.



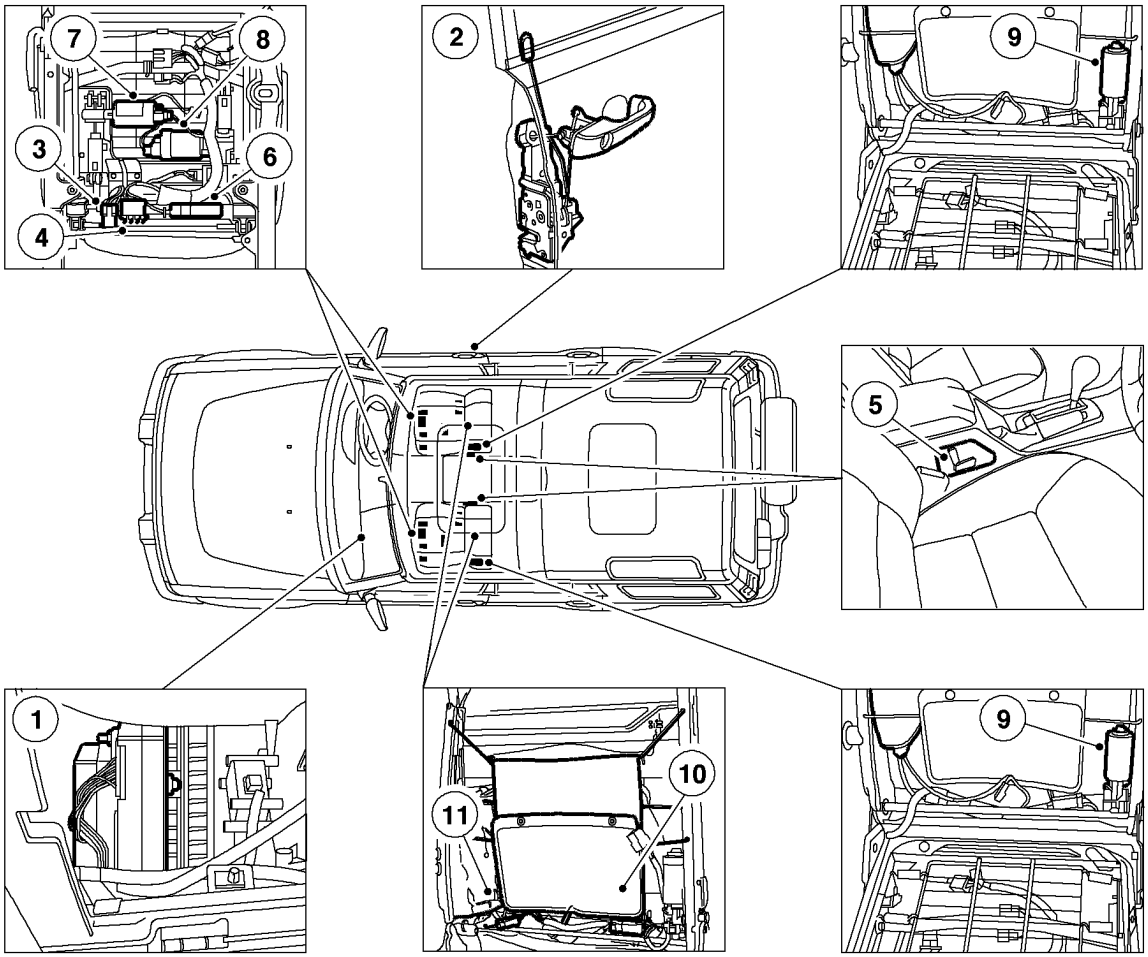
M76 3003A

11. Apply a continuous bead of sealant to sealant face on glass as shown.

12. Position glass to body and align to reference tape.
13. Lightly press glass to ensure correct profile.
14. Secure glass with tape until sealer has cured.
15. Remove protective covers and tape.
16. Test sealer for leaks, apply additional sealer if necessary. If water is used, allow sealer to dry before testing. Spray water around glass and check for leaks. Mark any area that leaks. Dry glass and sealer then apply additional sealer.

    CAUTION: A curing time of 6 hours is desirable. During this time leave a window open to ventilate the vehicle interior. If the vehicle must be used before the curing time has elapsed, do not drive at speed or slam the doors with the windows closed.

Electric seat component location

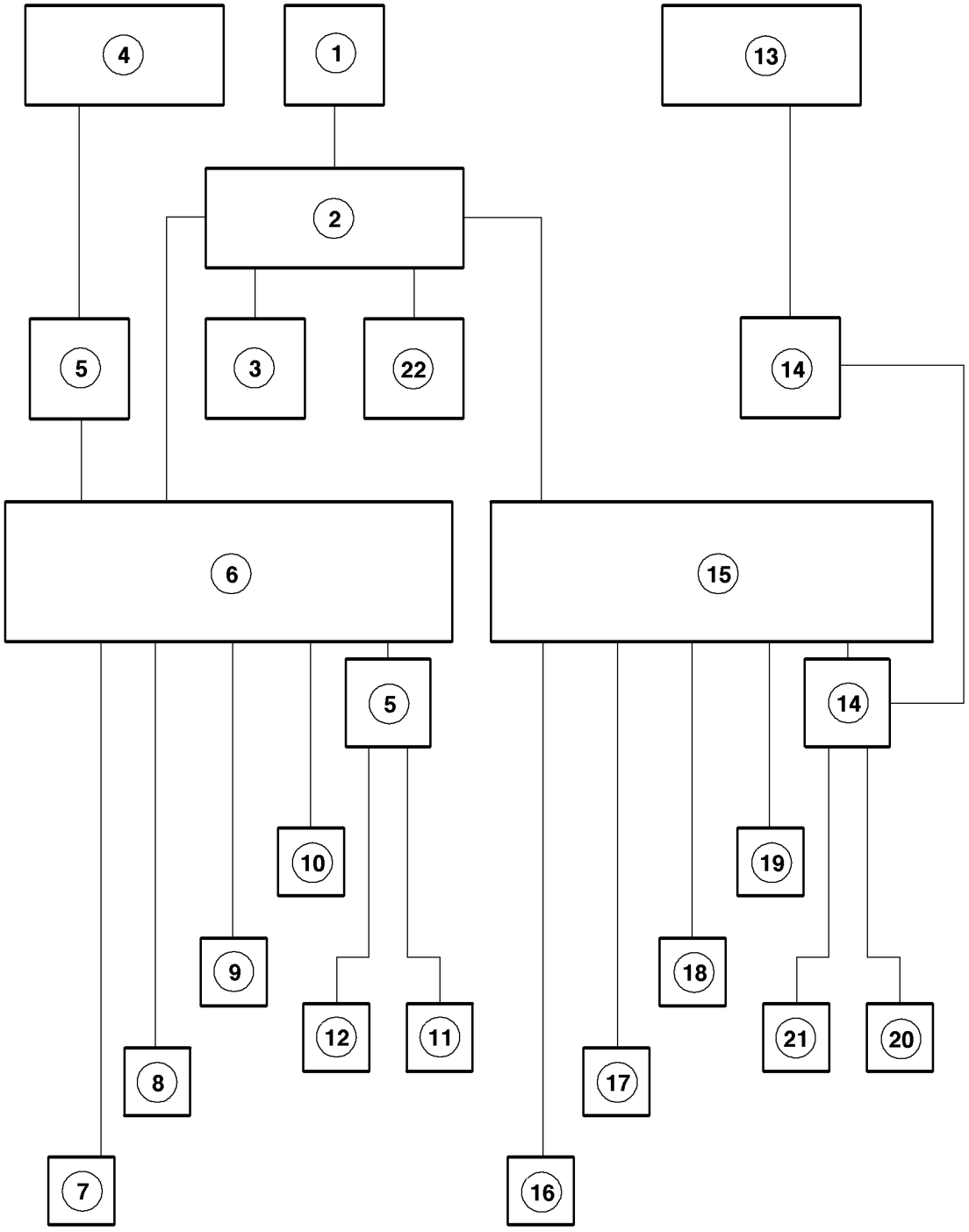


M780317

RHD shown, LHD similar

1 BCU
2 Drivers door switch
3 Power relay
4 Satellite fuse box
5 Switch pack
6 Fore/aft motor
7 Cushion front up/down motor
8 Cushion rear up/down motor
9 Squab fore/aft motor
10 Lumbar support bladder
11 Lumbar pump

Electric seat block diagram



M780370

1 Ignition switch
2 BCU
3 Driver door switch
4 Left seat power relay
5 Left seat satellite fuse box
6 Left seat switch pack
7 Left seat fore/ aft motor
8 Left seat cushion front up/ down motor
9 Left seat cushion rear up/ down motor
10 Left seat squab fore/ aft motor
11 Left seat lumbar pump
12 Left seat lumbar deflate solenoid
13 Right seat power relay
14 Right seat satellite fuse box
15 Right seat switch pack
16 Right seat fore/ aft motor
17 Right seat cushion front up/ down motor
18 Right seat cushion rear up/ down motor
19 Right seat squab fore/ aft motor
20 Right seat lumbar pump
21 Right seat lumbar deflate solenoid
22 Passenger front door switch

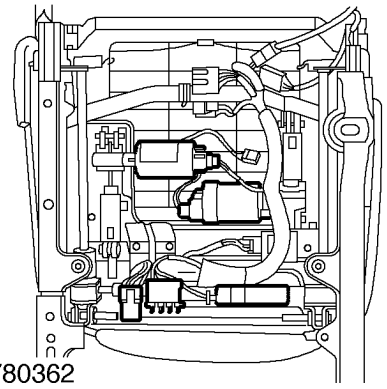
Description - electric seats

General
All markets use the same electric seat system. Electically operated lumbar support is optional. The system consists of an electrical sub-system and a mechanical sub-system.

The electrical sub-system consists of the following components:
- BCU.
- Seat power relays.
- Seat switch packs.
- Seat fore/ aft motors.
- Seat cushion front up/ down motors.
- Seat cushion rear up/ down motors.
- Seat squab motor.
- Lumbar pump.
- Lumbar deflate solenoid.

The mechanical sub-system consist of the following components:
- Gear wheels.
- Rack and pinion assemblies.

Seat power relay


M780362

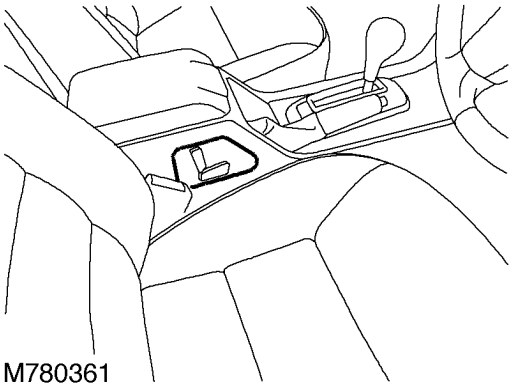
Located beneath the seat, the seat power relay supplies battery voltage to the satellite fuse box. Operation of the relays is controlled by the BCU.

Voltage to the seat power relays is from fuse 5 in the engine compartment fuse box. The BCU controls the earth for the relay coils. Operating the seat power relays provides voltage to the satellite fuse box under each seat.

Satellite fuse box
Located beneath the seat, the satellite fuse box provides circuit protection for the wiring to the seat switches and motors. It also protects the lumbar inflate and deflate circuits.

The seat power relay provides voltage directly to the 40A fuse in the satellite fuse box. Voltage from this fuse feeds the seat switch pack. The 3A fuses in the satellite fuse box protect the wiring to the lumbar pump and lumbar deflate solenoid. Voltage to the 3A fuses comes from the seat switch pack.

Seat switch pack



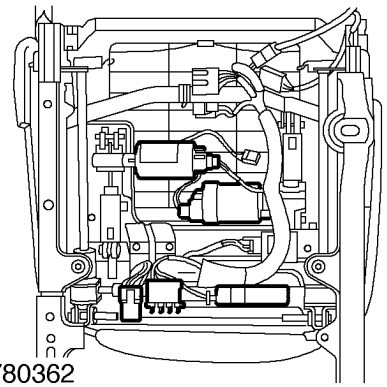
M780361

Each seat switch pack contains two switches representing the seat cushion and the seat squab. The switches provide the following adjustments:

- Seat fore/ aft.
- Cushion front up/ down.
- Cushion rear up/ down.
- Squab fore/ aft.
- Lumbar inflate.
- Lumbar deflate.

The voltage supply to the seat switch pack is from the 40A fuse in the satellite fuse box. A pair of switches controls the operation of each seat motor, the lumbar pump and the lumbar deflate relay.

Seat fore/ aft motor



M780362

The seat fore/ aft motor is a permanent magnet motor coupled to a rack and pinion assembly. Should the motor seize or stick for 6 seconds or more, an internal thermal cut out switch will trip to remove voltage from the motor. Reset time for the switch is 35 seconds.

Two pins within the seat switch pack control the seat fore/ aft motor. Both pins are normally earthed. Operating the backward switch applies voltage to that pin while the other pin remains earthed. Operating the forward switch reverses power and earth to the motor allowing the motor to run in the opposite direction.

Seat cushion front up/ down motor
The seat cushion front up/ down motor is a permanent magnet motor coupled to a rack and pinion assembly. Should the motor seize or stick for 6 seconds or more an internal thermal cut out switch will trip to remove voltage from the motor. Reset time for the switch is 35 seconds.

Two pins within the seat switch pack control the seat cushion front up/ down motor. Both pins are normally earthed. Operating the up switch applies voltage to that pin while the other pin remains earthed. Operating the down switch reverses power and earth to the motor allowing the motor to run in the opposite direction.

Seat cushion rear up/ down motor
The seat cushion rear up/ down motor is a permanent magnet motor coupled to a rack and pinion assembly. Should the motor seize or stick for 6 seconds or more, an internal thermal cut out switch will trip to remove voltage from the motor. Reset time for the switch is 35 seconds.

Two pins within the seat switch pack control the seat cushion rear up/ down motor. Both pins are normally earthed. Operating the up switch applies voltage to that pin while the other pin remains earthed. Operating the down switch reverses power and earth to the motor allowing the motor to run in the opposite direction.

Seat squab fore/ aft motor
The squab fore/ aft motor is a permanent magnet motor coupled to a rotary rack and pinion assembly. Should the motor seize or stick for 6 seconds or more, an internal thermal cut out switch will trip to remove voltage from the motor. Reset time for the switch is 35 seconds.

Two pins within the seat switch pack control the squab fore/ aft motor. Both pins are normally earthed. Operating the fore switch applies voltage to that pin while the other pin remains earthed. Operating the aft switch reverses power and earth to the motor allowing the motor to run in the opposite direction.

Lumbar pump
The lumbar pump inflates a bladder in the squab which provides extra support for the seat occupant. With no load on the seat it takes approximately 10 seconds to completely inflate the bladder. With a load of 25 kg (55 lb) it takes approximately 15 seconds to inflate the bladder. A pressure cut off switch in the system will operate at 0.12 to 1.93 bar (1.8 to 28 lbf.in^2). If a problem occurs with the lumbar bladder, e.g. a rupture, the whole lumbar system must be replaced. The components are not serviceable.

Power comes from the seat switch pack through a 3A fuse in the satellite fuse box. The lumbar pump and the lumbar deflate solenoid share an earth.

Lumbar deflate solenoid
The lumbar deflate solenoid vents the lumbar bladder to atmosphere to allow air to evacuate the bladder. The average time to evacuate the bladder with a load of 25 kg (55 lb) is 9 seconds.

Power comes from the seat switch pack through a 3A fuse in the satellite fuse box. The lumbar deflate solenoid and the lumbar pump share an earth.

Operation - electric seats

Seat power relay enable line
The BCU provides the seat power relays with an earth supply to the relay coil that enables the relay operation. When this seat power relay enable line is active, the seat power relay energises allowing seat operation.

In order for the seat power relay to be active the BCU must detect either of the following condition options:
- Ignition switch in position II.
- Ignition switch in position II or driver's door within 45 seconds of opening.

Seat fore/ aft movement
When the cushion switch is operated and the seat power relay enable line is operating, power and earth are supplied to the motor in the seat, allowing the seat to move forward or backward depending on switch position. The motor drives a gear wheel along a gear rack connected to the seat base. Sliding the cushion switch forward causes the motor to drive the seat forward. Sliding the cushion switch rearward reverses polarity of the voltage at the seat motor, driving the seat rearward.

Seat cushion front up/ down movement
When the cushion switch is operated and the seat power relay enable line is operating, power and earth are supplied to the motor in the seat, allowing the front of the seat cushion to move upward or downward depending on switch position. The motor drives a gear wheel along a gear rack connected to the seat base. Sliding the front of the cushion switch upward causes the motor to drive the seat upward. Sliding the front of the cushion switch downward reverses polarity of the voltage at the seat motor driving the seat downward.

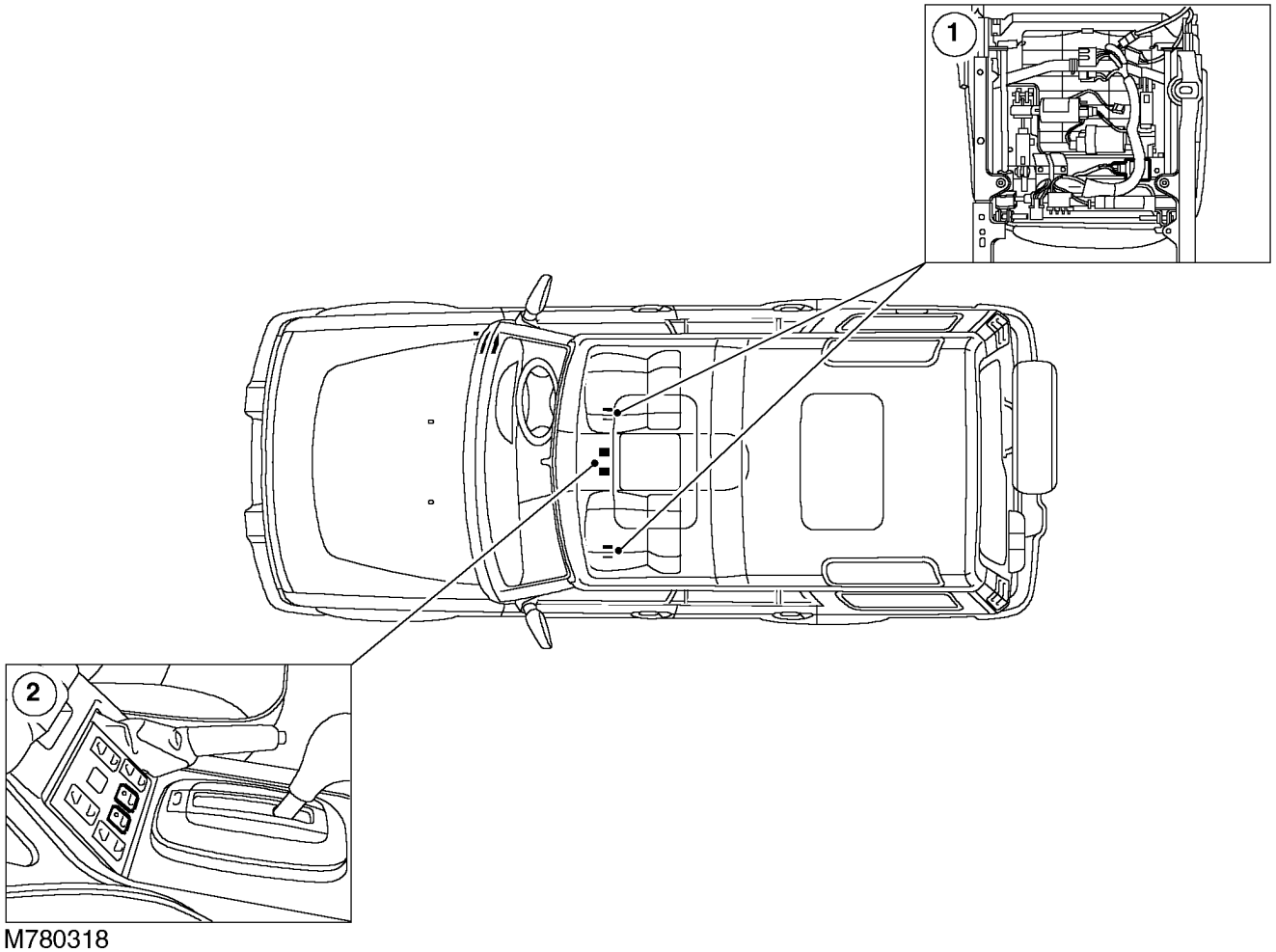
Seat cushion rear up/ down movement
When the cushion switch is operated and the seat power relay enable line is operating, power and earth are supplied to the motor in the seat, allowing the seat to move upwards or downwards depending on switch position. The motor drives a gear wheel along a gear rack connected to the seat base. Sliding the rear of the cushion switch upward causes the motor to drive the seat upward. Sliding the rear of the cushion switch downward reverses polarity of the voltage at the seat motor driving the seat downward.

Squab fore/ aft movement
When the squab switch is operated and the seat power relay enable line is operating, power and earth is supplied to the motor in the squab, allowing the squab to move forward or backward depending on switch position. The motor drives a gear wheel along a rotary gear rack connected to the squab. Sliding the squab switch forward causes the motor to drive the squab forward. Sliding the squab switch rearward reverses polarity of the voltage at the seat motor driving the squab rearward.

Lumbar inflate/ deflate
Sliding the squab switch upwards when the seat power relay enable line is operating applies voltage to the lumbar pump. The lumbar pump inflates the lumbar bladder, increasing lumbar support. The lumbar pump and the normally closed lumbar deflate solenoid hold the air in the bladder. Sliding the squab switch downwards applies voltage to the deflate solenoid, venting the air in the lumbar bladder to atmosphere, decreasing lumbar support.

Diagnostics
TestBook can only verify that the seat power relay line is enabled. It cannot determine the status of the system or any of the components.

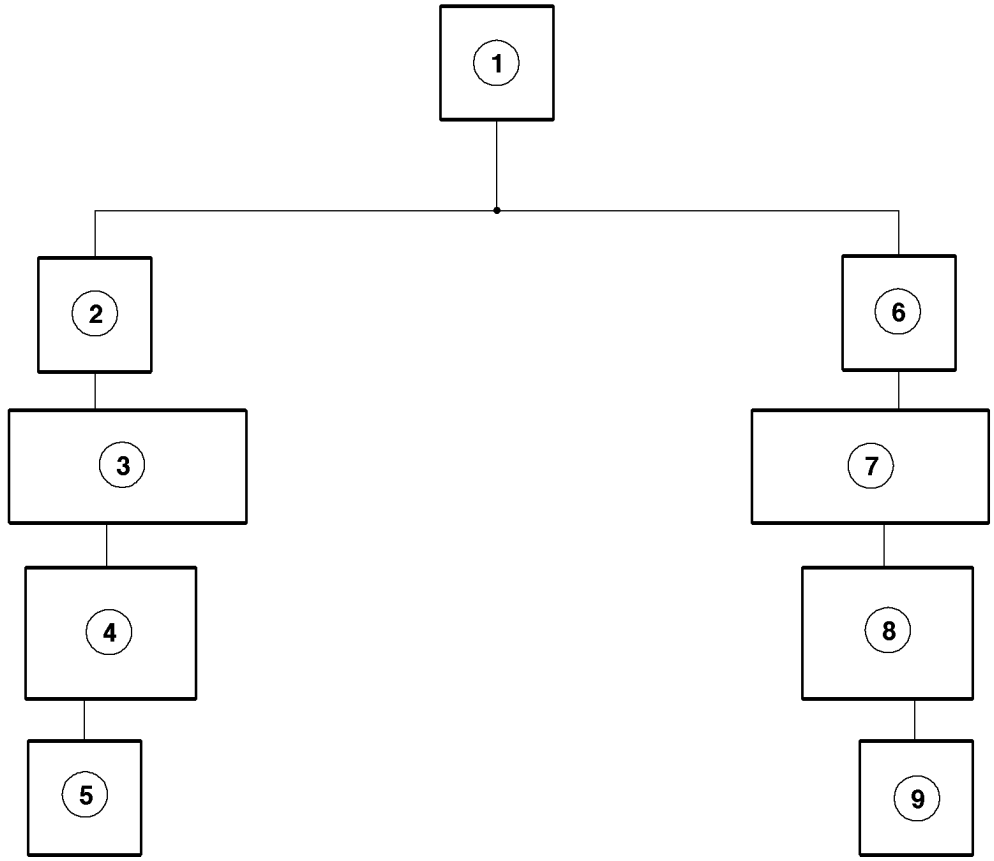
Heated seat component location



M780318

1 Heater module
2 Seat heater switches

Heated seat block diagram (electric seats)



M780364

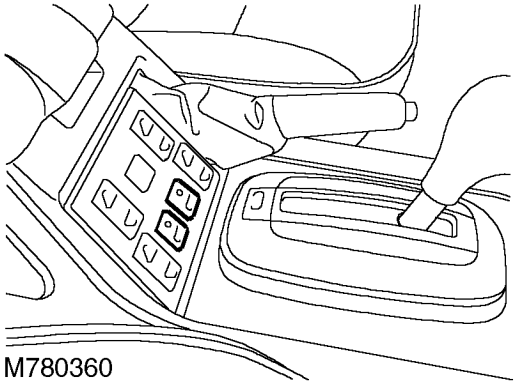
1 Passenger compartment fuse box
2 Left seat heater switch
3 Left seat heater module
4 Left seat cushion heater element
5 Left seat squab heater element
6 Right seat heater switch
7 Right seat heater module
8 Right seat cushion heater element
9 Right seat squab heater element

Description - heated seats

Heated seats
The heated seat system is available on both manual seats and electric seats. The electrical sub-system consists of the following components:

- Seat heater switches.
- Seat heater elements.
- Temperature control unit (if electric seats are fitted).
- Temperature sensor (if electric seats are fitted).
- Thermostat (if manual seats are fitted).

Seat heater switches


M780360

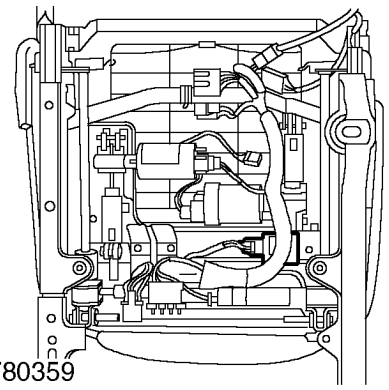
The seat heater switches supply an ignition feed to either the temperature control unit (vehicles with electric seats) or directly to the seat heater elements (vehicles with manual seats). When a seat heater switch is operated, current flows to the seat heater elements causing them to heat the seat.

The ignition feed comes from fuse 15 in the passenger compartment fuse box.

Seat heater elements
The seat heater elements are located in the seat cushion and squab. The cushion and squab heater elements are wired in series. Total power consumption at 13.5 volts is approximately 115 Watts.

The cushion heater element has an input feed from the temperature control unit or heater switch and an output to the squab heater element, which outputs to earth.

Temperature control unit


M780359

The temperature control unit is only fitted to vehicles with electric seats. Feed back of the seat temperature is via a Negative Temperature Coefficient (NTC) sensor within the seat cushion. Resistance of this sensor changes with the temperature of the seat cushion allowing the temperature control unit to lower or raise the voltage to the seat heater elements to raise or lower their temperature.

An ignition feed is supplied via the seat heater switch. The temperature sensor supplies an input. Output is a supply to the cushion heater element and an earth.

Thermostat

On vehicles with non electric seats, the temperature is controlled by a thermostat located in the seat cushion. The thermostat interrupts the power supply when it reaches a pre-determined temperature.

Operation - heated seats

When the seat heater switch is operated, power is supplied to the heater elements in the seat, causing the seat to heat up. On vehicles fitted with non electric seats, the thermostat switches the power supply to the heater elements on and off. On vehicles fitted with electric seats, the temperature control unit senses seat temperature via the sensor in the cushion and regulates voltage to the seat heater elements to maintain a constant temperature.

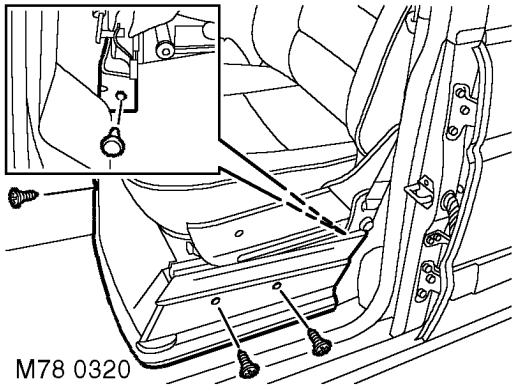
On both electric and non electric seats, the heater elements increase and then maintain the seat at a temperature between 26 and 36 °C (79 and 97 °F).

Seat - front

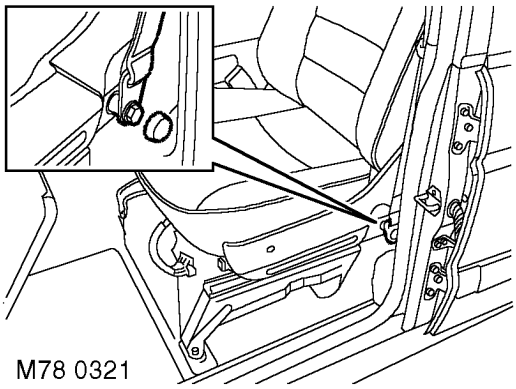
78.10.43.99

Remove

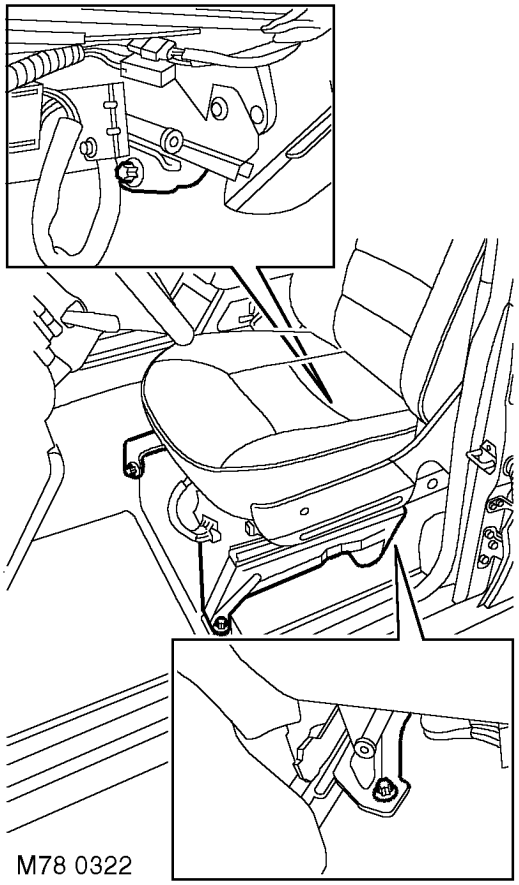
1. Disconnect battery earth lead.


M78 0320

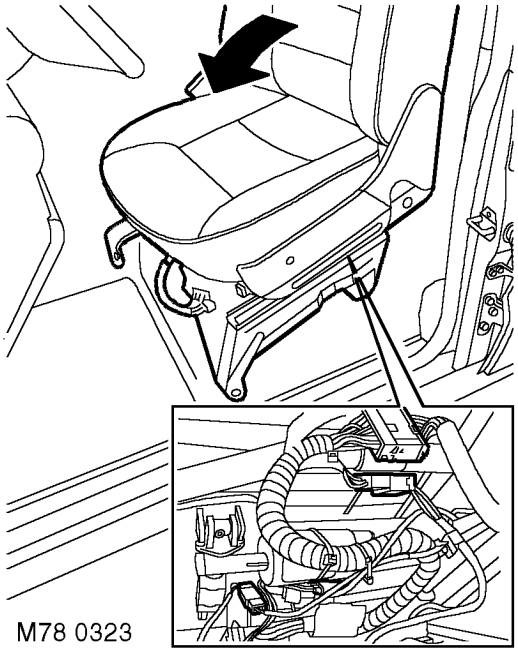
2. Remove 3 screws and 1 trim clip securing lower trim casing to seat.
3. Remove lower trim casing.


M78 0321

4. Remove cap from front seat belt lower anchorage bolt.
5. Remove front seat belt lower anchorage bolt.


M78 0322

6. Remove 4 Torx bolts and nut securing front seat to floor.
7. Lean seat forward to gain access to multiplugs.


M78 0323

8. Release pretensioner multiplug from seat frame and disconnect.
9. **Electrically operated seats:** Disconnect 2 seat motor multiplugs.
10. Remove front seat.

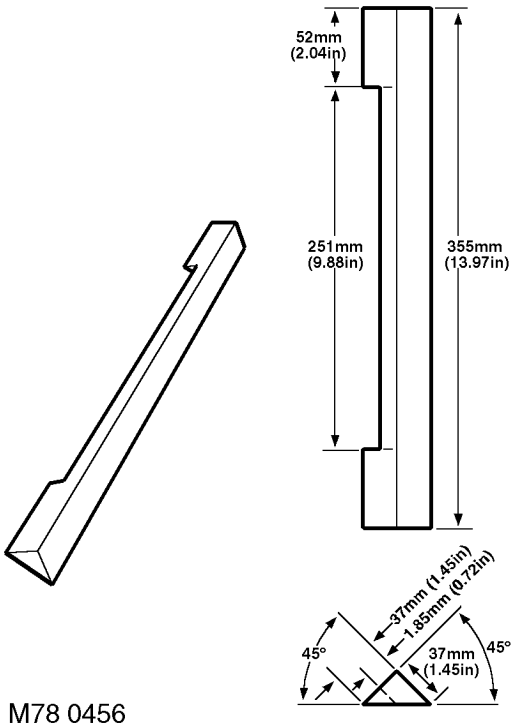
Refit

1. Fit front seat in vehicle.
2. **Electrically operated seats:** Connect seat motor multiplugs.
3. Connect pretensioner multiplug and secure to seat frame.
4. Fit Torx bolts and nut securing front seat to floor and tighten to 45 Nm (33 lbf.ft).
5. Fit front seat belt lower anchorage bolt to front seat and tighten to 32 Nm (24 lbf.ft).
6. Fit cap to lower anchorage bolt.
7. Fit lower trim casing to seat and secure with screws and trim clip.
8. Connect battery earth lead.

Seat - third row

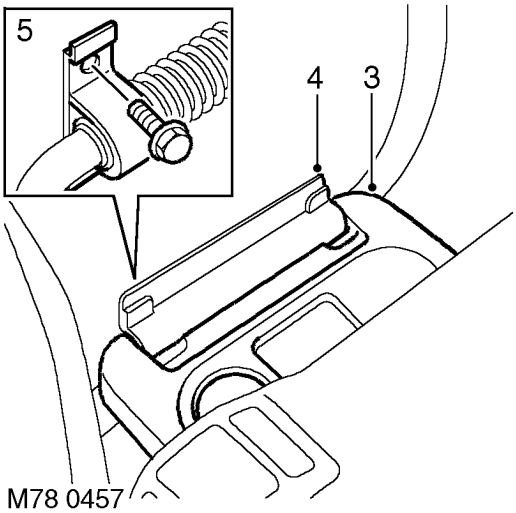
78.10.45

Remove



M78 0456

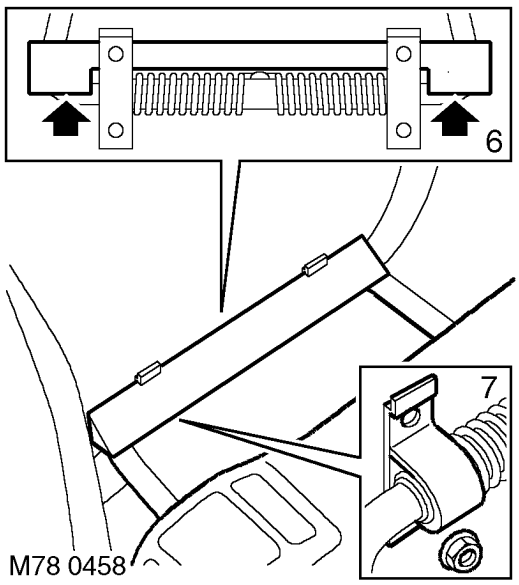
1. Manufacture a spring retainer bracket to the dimensions given above.
2. Position third row seat in deployed position.



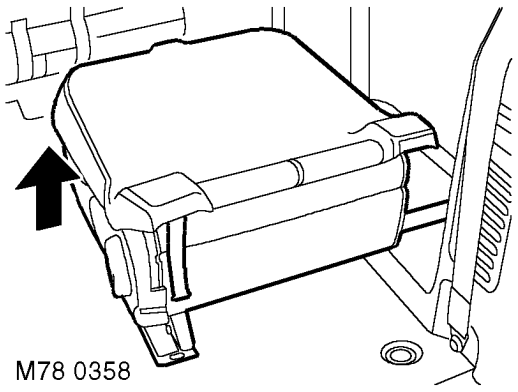
M78 0457

3. Remove the cup holder (where applicable).

4. Remove saddle bracket cover from lower rear quarter to allow access to third row seat securing bolts and nuts.
5. Remove top 2 bolts securing seat to lower rear quarter panel.



6. Position the locally manufactured retainer bracket across the seat mounting. Ensure that the lugs on the end of the retainer fit below the seat mounting bar, then partially fold the seat so that the retainer bracket is held in position.
7. Remove lower 2 nuts securing seat to lower rear quarter panel. The action of the spring will now hold the retainer bracket in place.



8. Remove seat.

Refit

1. Ensuring that the retainer bracket is in position on the spring, position third row seat to its mounting studs.
2. Fit nuts securing third row seat to lower rear quarter panel and tighten to 22 Nm (16 lbf.ft).
3. Remove the retainer bracket, fit bolts securing third row seat to lower rear quarter panel and tighten to 22 Nm (16 lbf.ft).
4. Fit saddle bracket cover to third row seat securing bolts, fit the cup holder (where applicable) and stow the seat.

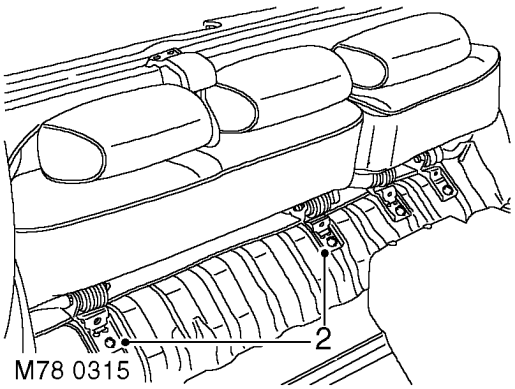
Seat - rear

78.10.48.99

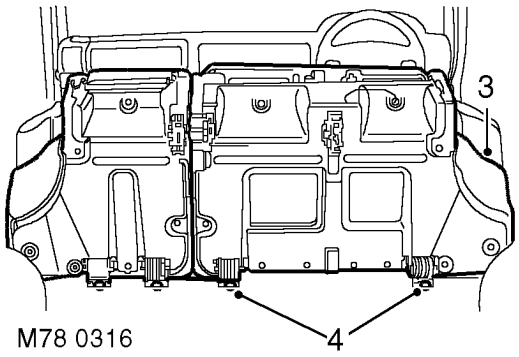
This procedure is applicable to both rear seats.

Remove

1. Carefully pull carpet away from the rear seat base to gain access to mounting brackets.



2. Remove 2 Torx bolts securing front of mounting brackets to floor.



3. Fold rear seats fully forward.
4. Remove the 2 Torx bolts securing rear of mounting brackets to floor.
5. Remove rear seat.

Refit

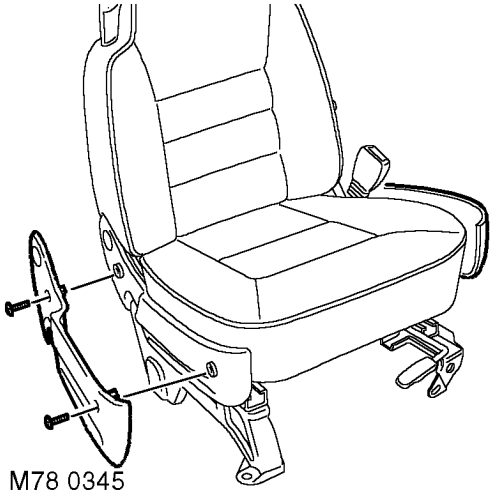
1. Position rear seat to floor in the fully folded position. Fit Torx screws to rear of mounting brackets and tighten to 45 Nm (33 lbf.ft).
2. Position rear seat in upright position. Fit Torx bolts to front of mounting brackets and tighten to 45 Nm (33 lbf.ft).
3. Position front carpet.

Cover - cushion - front seat

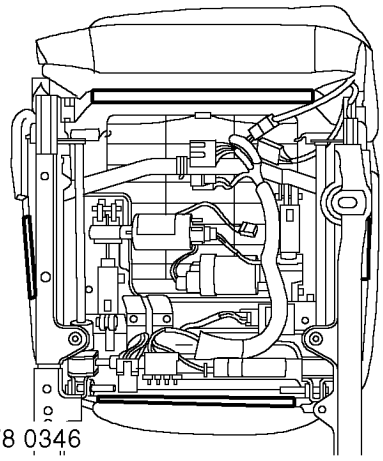
78.30.01/81

Remove

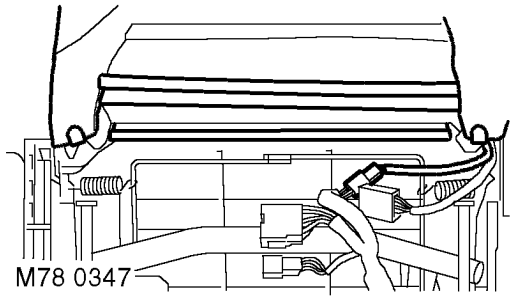
1. Remove front seat.
   SEATS, REPAIRS, Seat - front.
2. Place seat on a suitable work bench.



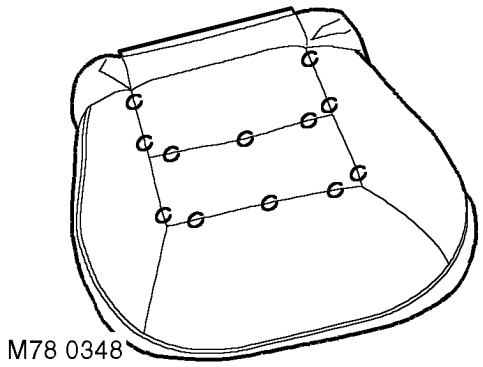
3. Remove 2 screws securing outer edge trim casing to seat frame.
4. Remove trim casing.
5. Release inner edge trim casing from seat frame.
6. Remove trim casing.



7. Position seat upside down on table.
8. Release clip securing front edge of cushion cover to seat frame.
9. Release clips securing side edges of cushion cover to seat frame.



10. Release clip securing lower edge of squab cover to seat frame.
11. Remove 2 end clips securing rear edge of cushion cover to seat frame.
12. Release main central clip securing rear edge of cushion cover to seat frame.
13. **Models with seat heaters:** Disconnect seat heater multiplug.
14. Release bonded rear edge of cushion from seat frame.



15. Remove seat cushion and cover assembly.
16. Release outer edges of cover from cushion to gain access to hog rings.
17. Remove 12 hog rings securing cover to cushion.
18. Remove cover.

Refit

1. Fit cover to cushion.
2. Fit and clamp hog rings securing cover to cushion.
3. Fit outer edges of cover over cushion.
4. Fit cushion and cover assembly to seat frame.
5. **Models with seat heaters:** Connect seat heater multiplug.
6. Secure rear edge of cushion cover with clip.
7. Fit end clips over rear edge of cushion cover.
8. Secure lower edge of squab cover to seat frame.
9. Secure edges of cushion cover with clips.
10. Secure front edge of cushion cover with clip.
11. Position seat correct way up on work bench.
12. Secure inner edge trim casing to seat frame.
13. Fit outer edge trim casing to seat frame and secure with screws.
14. Fit front seat.

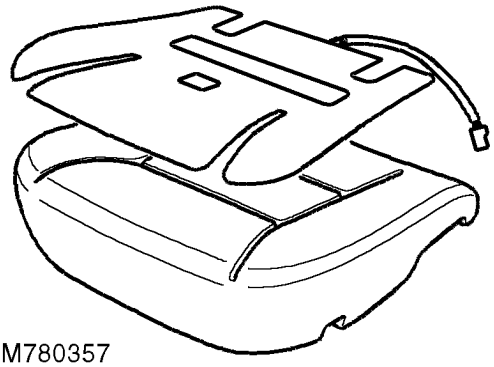
☞ **SEATS, REPAIRS, Seat - front.**

Heating element - cushion - front seat

78.30.24

Remove

1. Remove front seat cushion cover.
   SEATS, REPAIRS, Cover - cushion - front seat.



M780357

2. Carefully release heating element from cushion pad, ensuring adhesive does not tear cushion pad.

Refit

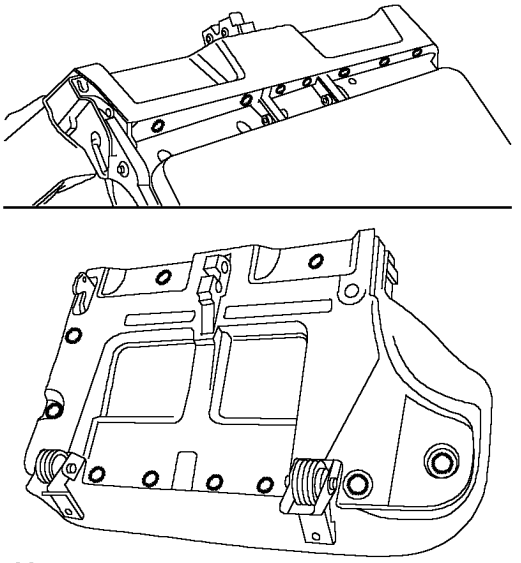
1. Ensure cushion pad is free of adhesive.
2. Remove adhesive cover from new heating element, position element and secure to cushion pad.
3. Fit front seat cushion cover.
   SEATS, REPAIRS, Cover - cushion - front seat.

Cover - cushion - rear seat

78.40.04

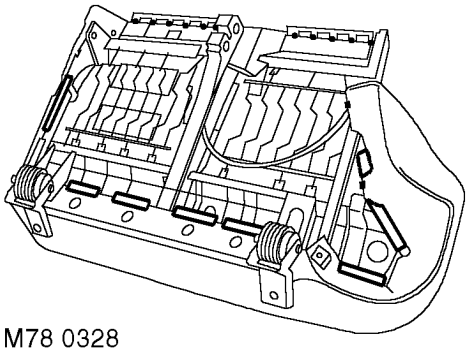
Remove

1. Remove rear seat.
   SEATS, REPAIRS, Seat - rear.



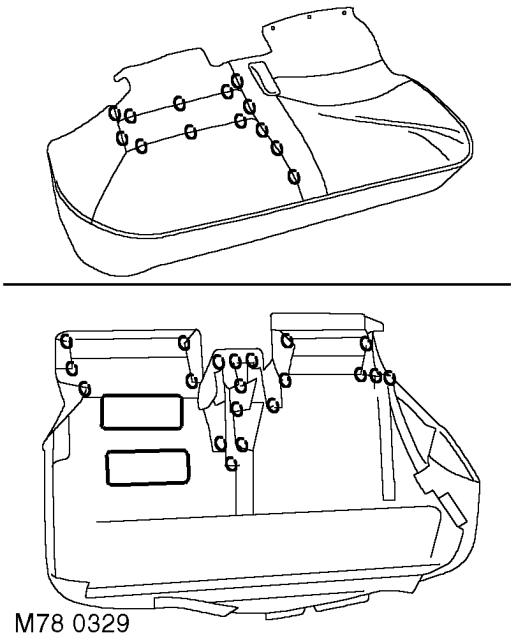
M78 0327

2. Remove 17 studs securing cushion under tray and remove tray.



M78 0328

3. Release cushion from 11 hooks at rear of frame.
4. Remove 2 spring clips securing cushion.
5. Release 8 side clips securing cushion, release and remove cushion assembly.



M78 0329

6. Push 2 retaining bars through pad.
7. Release cushion from sides of pad to access hog rings.
8. Remove 33 hogs rings and remove cushion from pad.

Refit

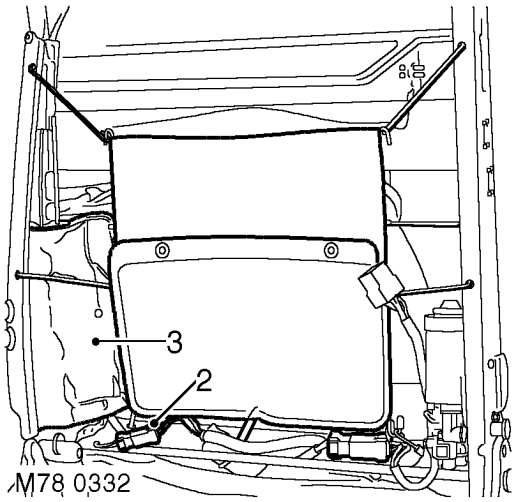
1. Position cushion to pad and secure with hog rings.
2. Push retaining bars through pad and fit cover to sides of pad.
3. Position cushion assembly to frame and secure side clips.
4. Fit spring clips and secure to hooks at rear of frame.
5. Position under tray and secure with studs.
6. Fit rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**

Bladder - lumbar support

78.60.01

Remove

1. Remove squab cover.
   ☞ **SEATS, REPAIRS, Cover - squab - front seat.**



M78 0332

2. Disconnect lumbar support pump multiplug.
3. Release lumbar support pump from bladder retainers.
4. Release bladder from 8 retainers and remove bladder and lumbar support pump.
5. Collect bladder retainers.

Refit

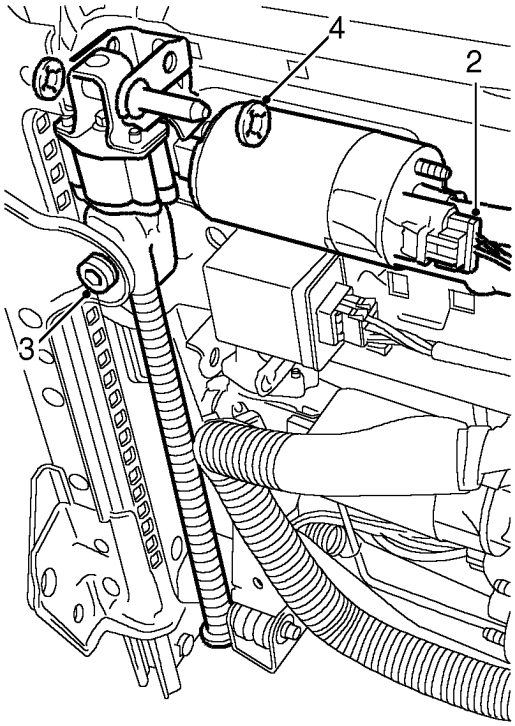
1. Position bladder retainers to seat frame.
2. Position bladder and secure to bladder retainers
3. Position pump in bladder retainers and connect multiplug.
4. Fit squab cover.
   ☞ **SEATS, REPAIRS, Cover - squab - front seat.**

Motor - fore and aft - front seat

78.70 25

Remove

1. Remove front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**



M78 0333

2. Disconnect multiplug from fore and aft motor.
3. Remove Allen screw securing RH screw thread to seat frame.
4. Remove 2 retainers from RH fore and aft gearbox roll pin. Remove roll pin.
5. Remove spacers.
6. Position RH screw thread retainer clear of seat frame and remove fore and aft motor.

Refit

1. Clean gearbox and motor drive tube.
2. Position motor drive tube to LH gearbox and align fore and aft motor to seat frame.
3. Fit new gearbox spacers, roll pin and retainers.
4. Align RH screw thread retainer to seat frame and secure with Allen screw.

   Ensure retainer is correctly aligned or damage may occur when seat motor is operated.

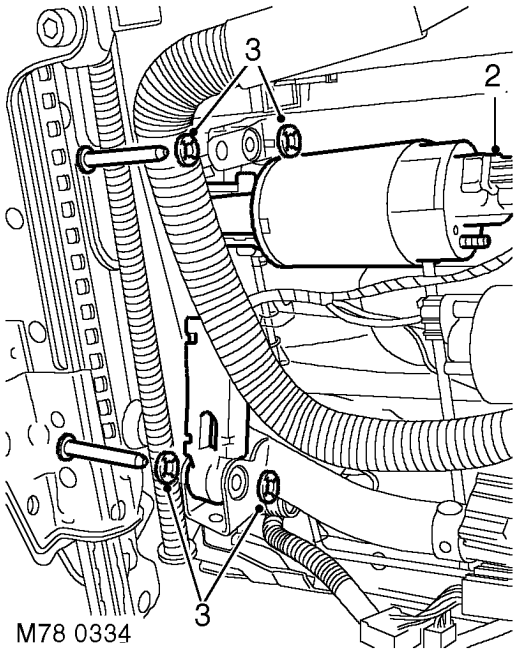
5. Connect fore and aft motor multiplug.
6. Fit front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**

Motor - rise and fall - front seat

78.70.27

Remove

1. Remove front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**



2. Disconnect multiplug from rise and fall motor.
3. Remove retainers from roll pins.
4. Using a suitable drift remove roll pins securing rise and fall motor and operating lever to seat frame.
5. Remove rise and fall motor.

Refit

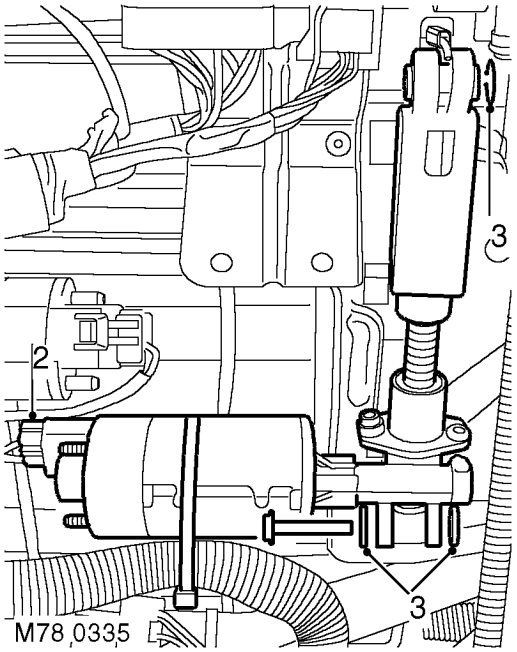
1. Position and align rise and fall motor to seat frame.
2. Fit new roll pins to secure rise and fall motor and operating lever.
3. Fit new retainers to roll pins.
4. Connect multiplug to rise and fall motor.
5. Fit front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**

Motor - tilt - front seat

78.70.29

Remove

1. Remove front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**



2. Disconnect multiplug from tilt motor.
3. Remove 2 retainers and 'C' clip from roll pins securing tilt motor.
4. Using a suitable drift remove roll pins securing tilt motor and operating lever to seat frame.
5. Remove tilt motor.

Refit

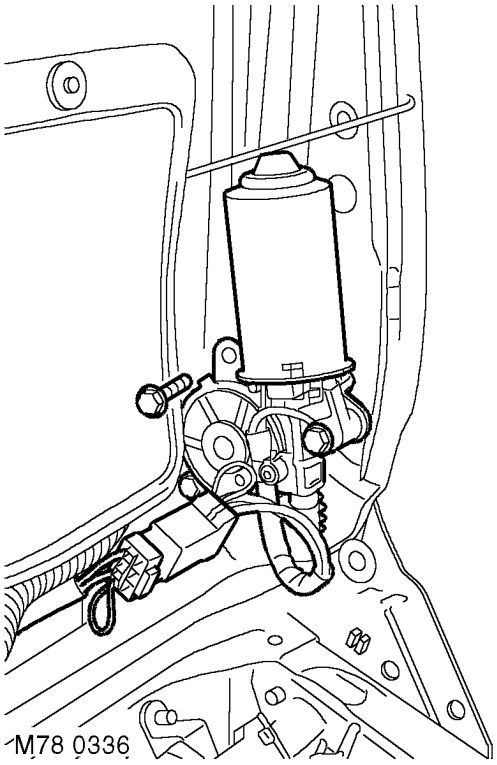
1. Position and align tilt motor to seat frame.
2. Fit new roll pins to secure motor and operating arm.
3. Fit new retainers and 'C' clip to roll pins.
4. Connect multiplug to tilt motor.
5. Fit front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**

Motor - recline

78.70.34

Remove

1. Remove squab cover.
   SEATS, REPAIRS, Cover - squab - front seat.



2. Disconnect recline motor multiplug.
3. Remove 2 bolts securing recline motor and remove motor.

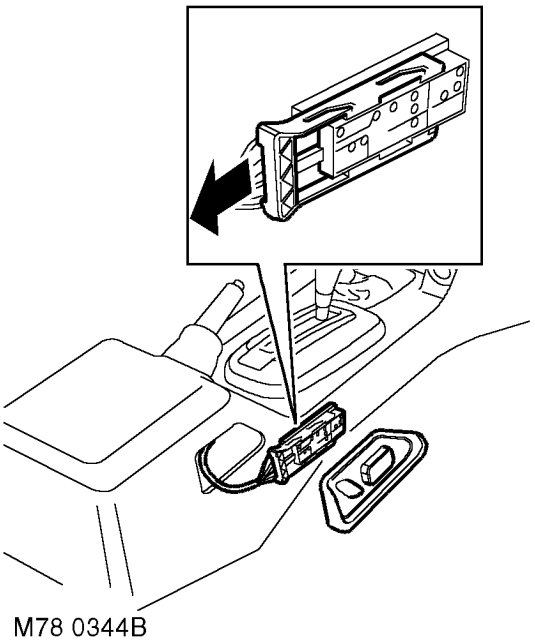
Refit

1. Position recline motor and ensure gear and gear spigot are engaged.
2. Fit and tighten bolts securing recline motor to frame.
3. Connect recline motor multiplug.
4. Fit squab cover.
   SEATS, REPAIRS, Cover - squab - front seat.

Switch - electric seats

78.70.88

Remove



1. Release switch from centre console.
2. Pull the connector retaining bar outwards to the limit of its travel and carefully disconnect the connector from the switch.

Refit

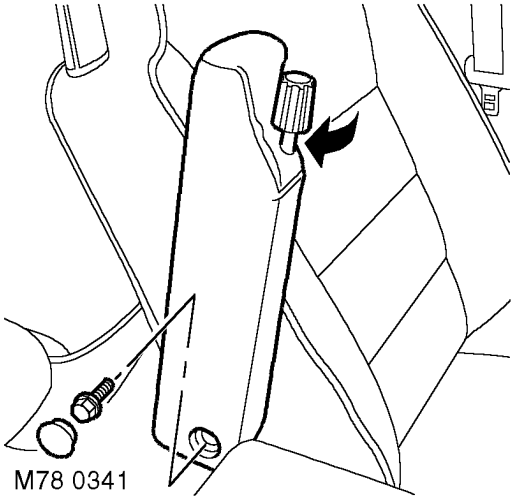
1. Connect multiplug to rear of switch and slide the retaining bar fully home.
2. Fit switch to centre console.

Cover - squab - front seat

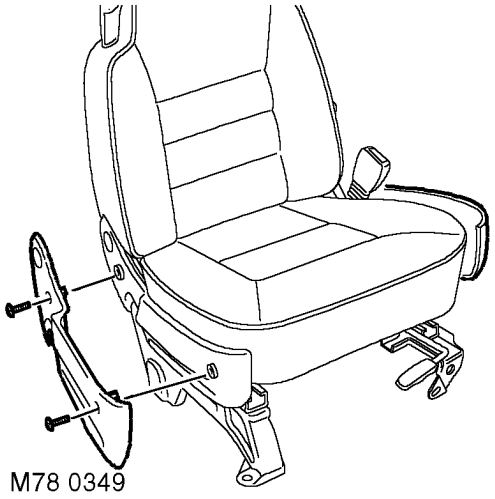
78.90.08/81

Remove

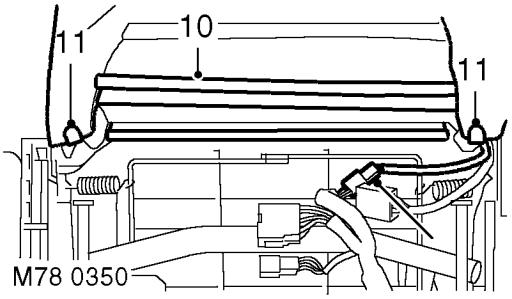
1. Remove front seat.
   SEATS, REPAIRS, Seat - front.
2. Place seat on a suitable work bench.


M78 0341

3. Tighten arm rest adjuster fully clockwise and remove screw cover.
4. Remove screw securing arm rest to seat and remove arm rest.

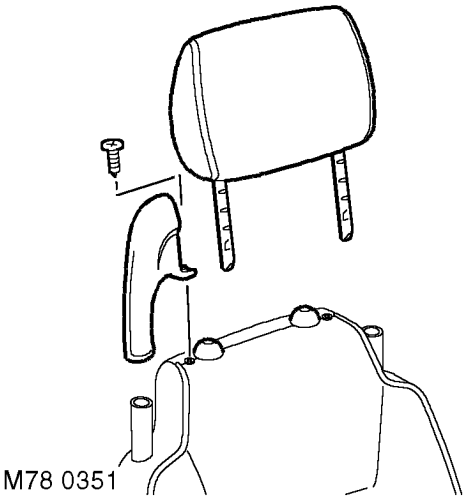

M78 0349

5. Remove 2 screws securing outer edge trim casing to seat frame.
6. Remove trim casing.
7. Release inner edge of trim casing from seat frame.
8. Remove trim casing.

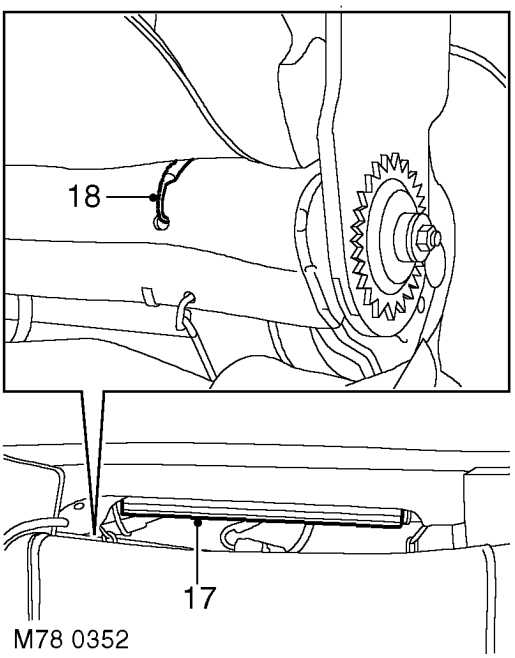


M78 0350

9. Position seat upside down on table.
10. Release clip securing lower edge of squab cover to seat frame.
11. Remove 2 clips securing either end of cover to squab frame.

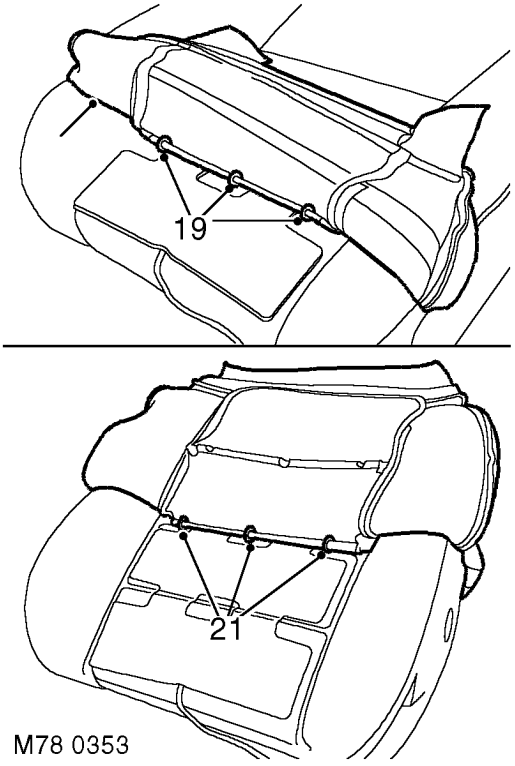

M78 0351

12. Position seat in upright position.
13. Raise headrest to maximum height.
14. Turn both guides through 90°.
15. Remove headrest from seat.
16. Remove screws securing grab handles to seat frame and remove grab handles.



M78 0352

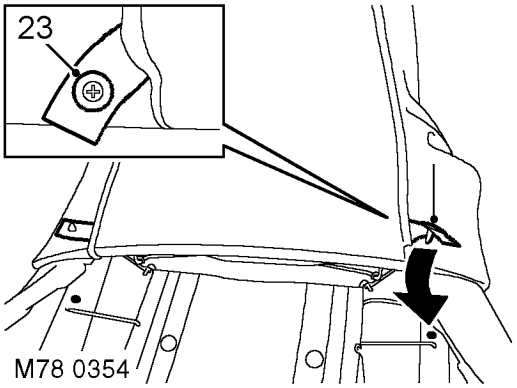
17. Release clip securing front of cover to squab frame.
18. Release hooks from squab frame.



M78 0353

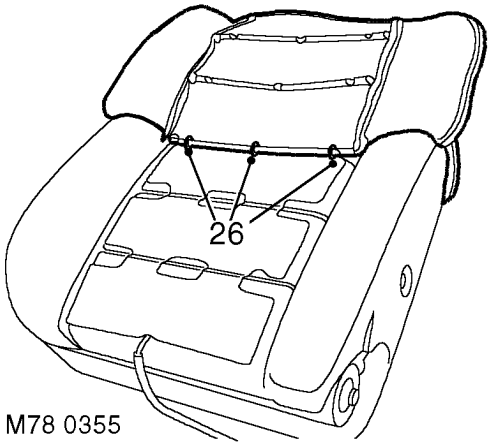
19. Fold cover upwards over squab until first row of hog rings are visible.
20. Remove first row of hog rings.

21. Fold cover upwards over squab until second row of hog rings are visible.
22. Remove second row of hog rings.



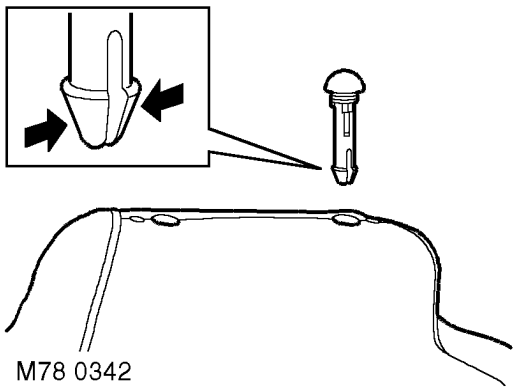
M78 0354

23. Push out centres of trim clips securing stowage pocket elastic to seat frame.
24. Remove trim clip outers.
25. Release hooks from seat frame and feed though to front of foam.



M78 0355

26. Fold cover upwards until third row of hog rings are visible.
27. Remove third row of hog rings.
28. Remove hog rings securing rear of squab cover to seat frame.
29. Release bar from seat frame.



30. Remove headrest guides.
31. Fold cover fully upwards and remove.

Refit

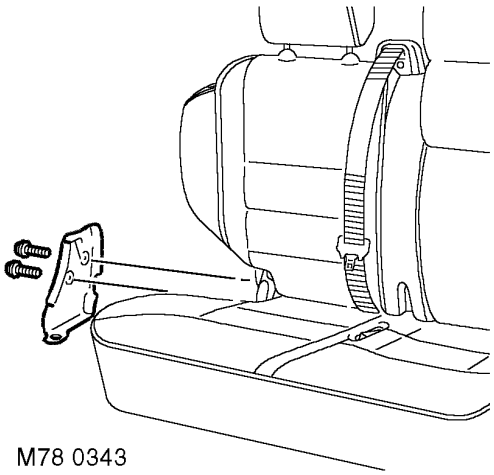
1. Fit squab cover to top of seat. Do not fold down too far onto seat.
2. Fit headrest guides.
3. Fit grab handles to seat and secure with screws.
4. Ensure top of cover fits correctly around grab handles.
5. Fit bar securing rear of squab cover to seat frame.
6. Fit hog rings securing rear of squab cover to seat frame.
7. Pull cover down tight and align hog ring location points.
8. Fit third row of hog rings.
9. Pull cover down tight and feed hooks though foam.
10. Connect hooks to rear of squab frame.
11. Align stowage pocket elastic to seat frame and secure with trim clips.
12. Pull cover down tight and align hog ring location points.
13. Fit second row of hog rings.
14. Pull cover down tight and align hog ring location points.
15. Fit first row of hog rings.
16. Pull cover down tight and connect hooks to squab frame.
17. Feed front of cover through to rear.
18. Secure bottom of cover to frame with clip.
19. Fit clips securing ends of cover to frame.
20. Fit headrest to seat.
21. Turn seat upside down.
22. Secure rear edge of squab cover to frame with clip.
23. Turn seat correct way up.
24. Fit inner edge trim casing to seat frame.
25. Fit outer edge trim casing and secure with screws.
26. Position arm rest to seat, secure with screw and loosen arm rest adjuster to the required position.
27. Fit front seat.
☞ **SEATS, REPAIRS, Seat - front.**

Cover - squab - RH rear seat

78.90.13

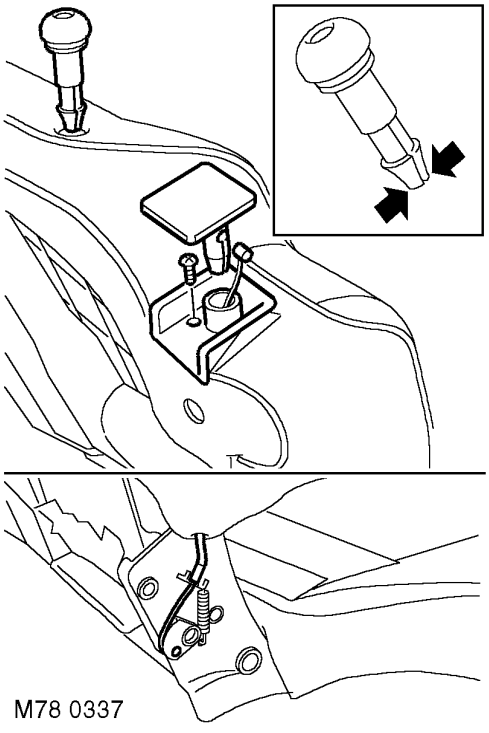
Remove

1. Remove rear seat.
   SEATS, REPAIRS, Seat - rear.
2. Remove centre rear seat belt.
   RESTRAINT SYSTEMS, REPAIRS, Seat belt - rear - centre.



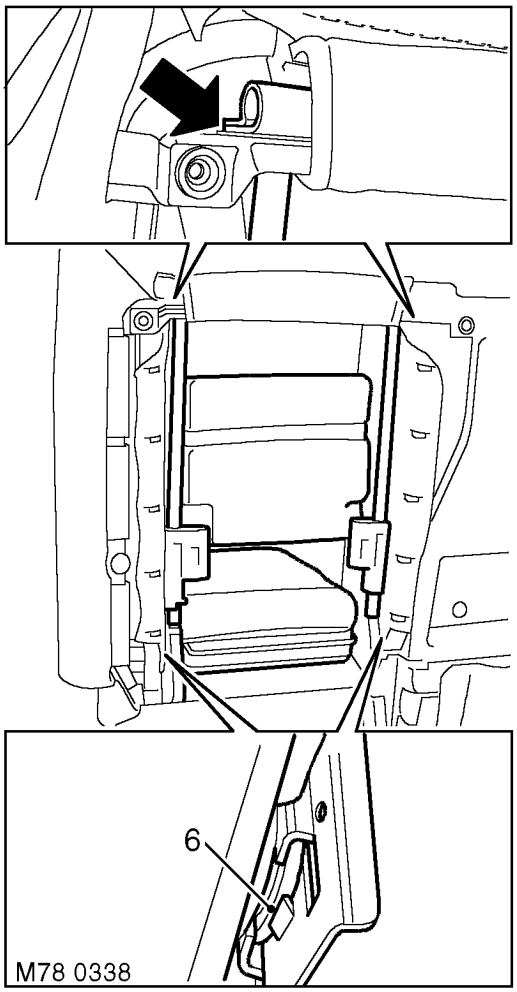
M78 0343

3. Remove 2 screws securing end cover and remove end cover.



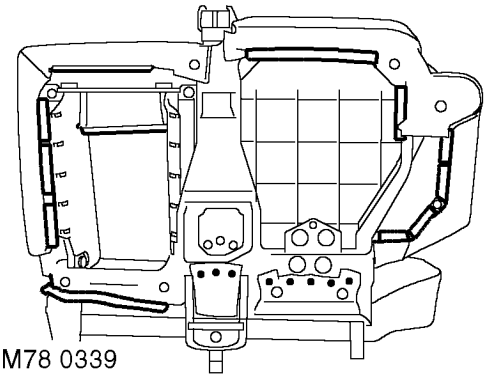
M78 0337

4. Remove both head restraint guide tubes.
5. Remove 2 screws securing squab release lever, release cable and remove lever assembly.



M78 0338

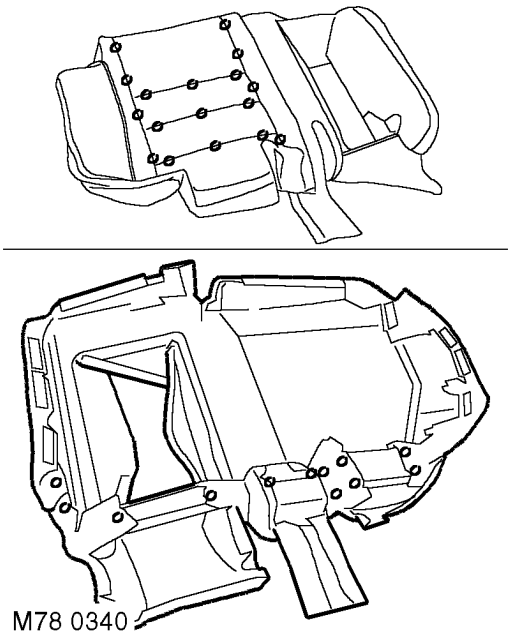
6. Release catches securing arm rest supports, lower arm rest, release arm rest hinge catches and remove arm rest assembly.



M78 0339

7. Release squab from 10 hooks in arm rest recess.

8. Release top and bottom rap round clips in arm rest recess.
9. Remove 3 studs securing squab to centre of frame.
10. Release squab from 5 studs securing RH side.
11. Release 9 side clips securing squab to frame, release and remove squab assembly.



M78 0340

12. Release squab from sides of pad to access hog rings.
13. Remove 29 hogs rings and remove squab cover from pad.

Refit

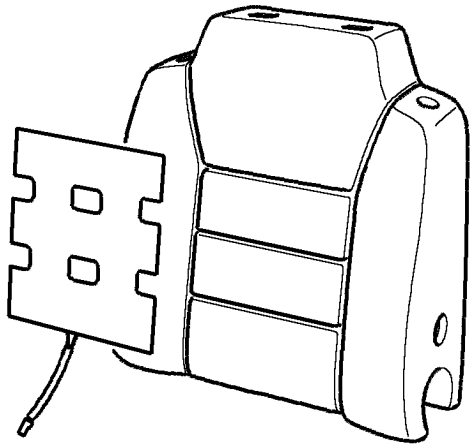
1. Position squab to pad and secure with hog rings.
2. Position squab assembly to frame and secure side clips.
3. Secure squab to hooks at RH side and fit studs to centre of frame.
4. Fit top and bottom rap round clips and hooks in arm rest recess.
5. Fit and secure arm rest assembly.
6. Position squab release lever, connect cable and secure with screws.
7. Fit head restraint guide tubes.
8. Position end cover and secure with screws.
9. Fit centre rear seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - rear - centre.**
10. Fit rear seat.
    ☞ **SEATS, REPAIRS, Seat - rear.**

Heating element - squab - front seat

⊸ ***78.90.36***

Remove

1. Remove front seat squab cover.
   ☞ **SEATS, REPAIRS, Cover - squab - front seat.**



M78 0356

2. Disconnect heating element multiplug.
3. Carefully release heating element from squab pad, ensuring adhesive does not tear squab pad.

Refit

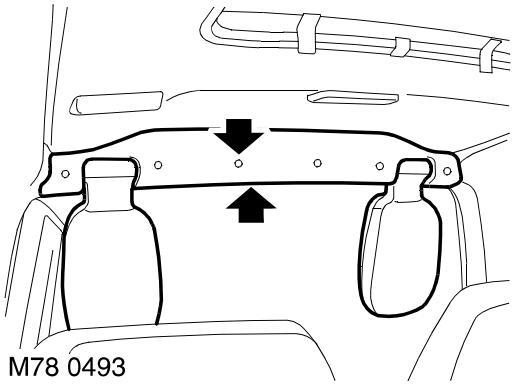
1. Ensure squab pad is free of adhesive.
2. Remove adhesive cover from new heating element, position element and secure to squab pad.
3. Fit front seat squab cover.
   ☞ **SEATS, REPAIRS, Cover - squab - front seat.**

Head restraint - third row seat

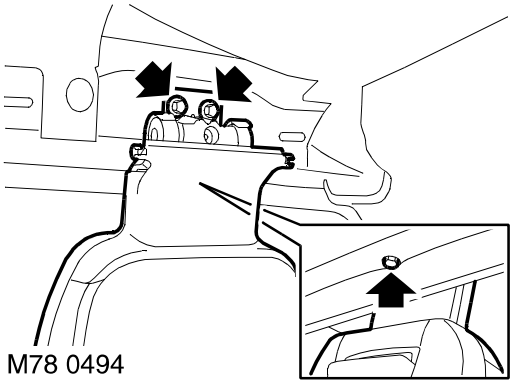
78.50.10

Remove

1. Fold down both third row head restaints.


M78 0493

2. Release upper tail gate finisher from 6 clips and remove finisher.

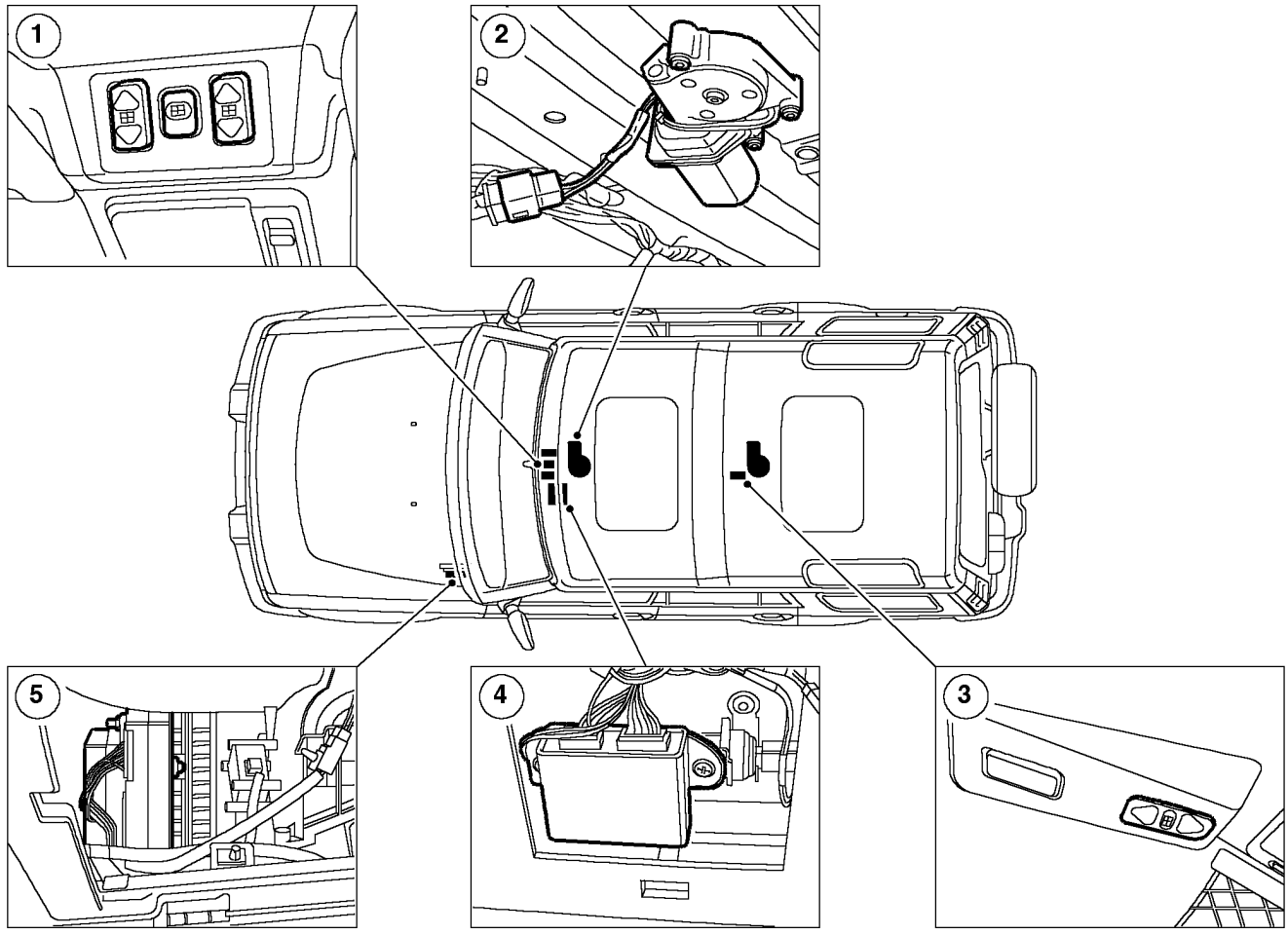

M78 0494

3. Remove 3 bolts securing head restraint and remove head restraint.

Refit

1. Position head restraint, fit and tighten bolts.
2. Position upper tail gate finisher and secure in clips.

Electric sunroof component location

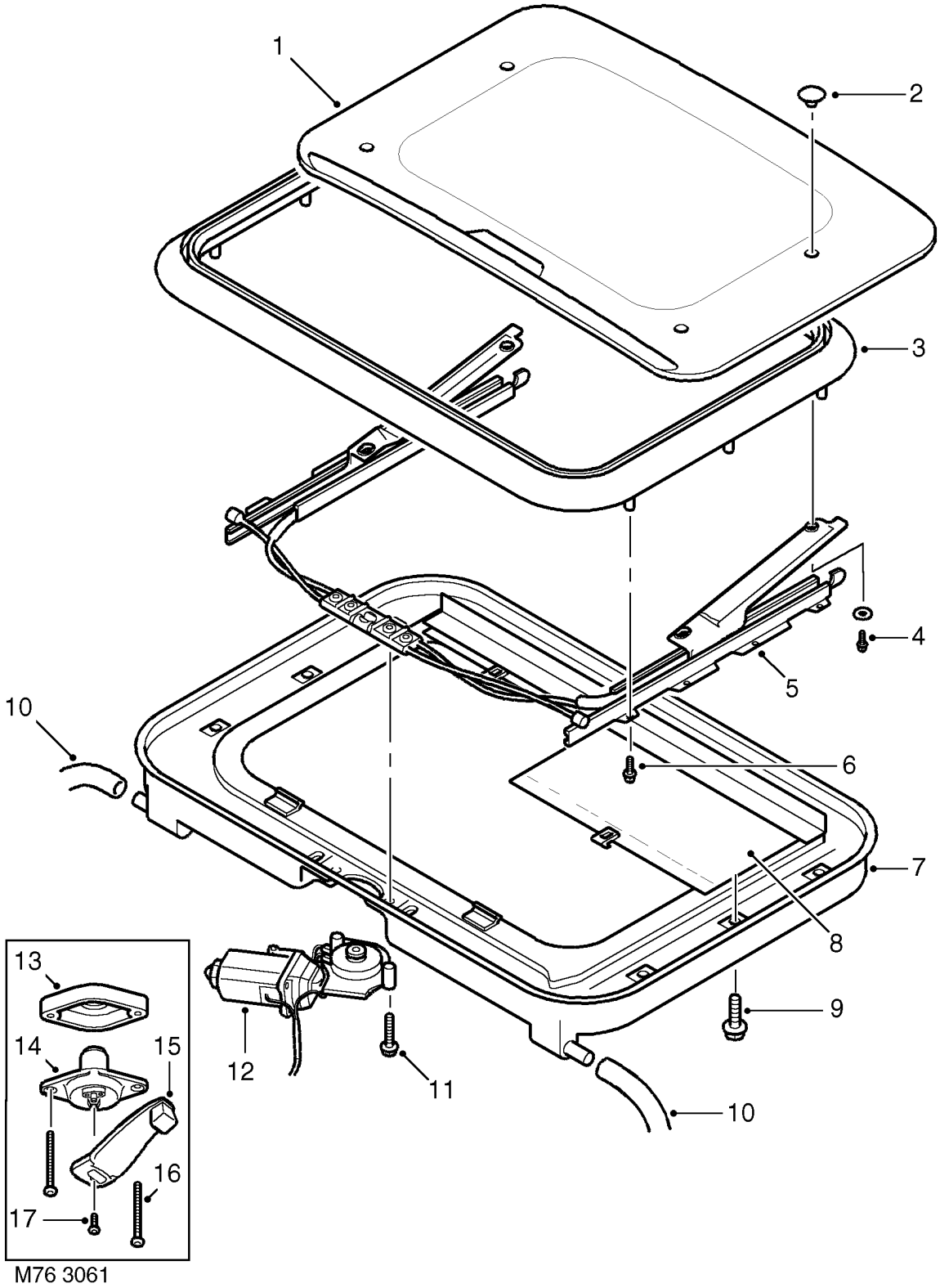


M864466

RHD shown, LHD similar

1 Sunroof front switches
2 Front sunroof motor and microswitch
3 Rear sunroof - rear switch
4 Sunroof ECU
5 BCU

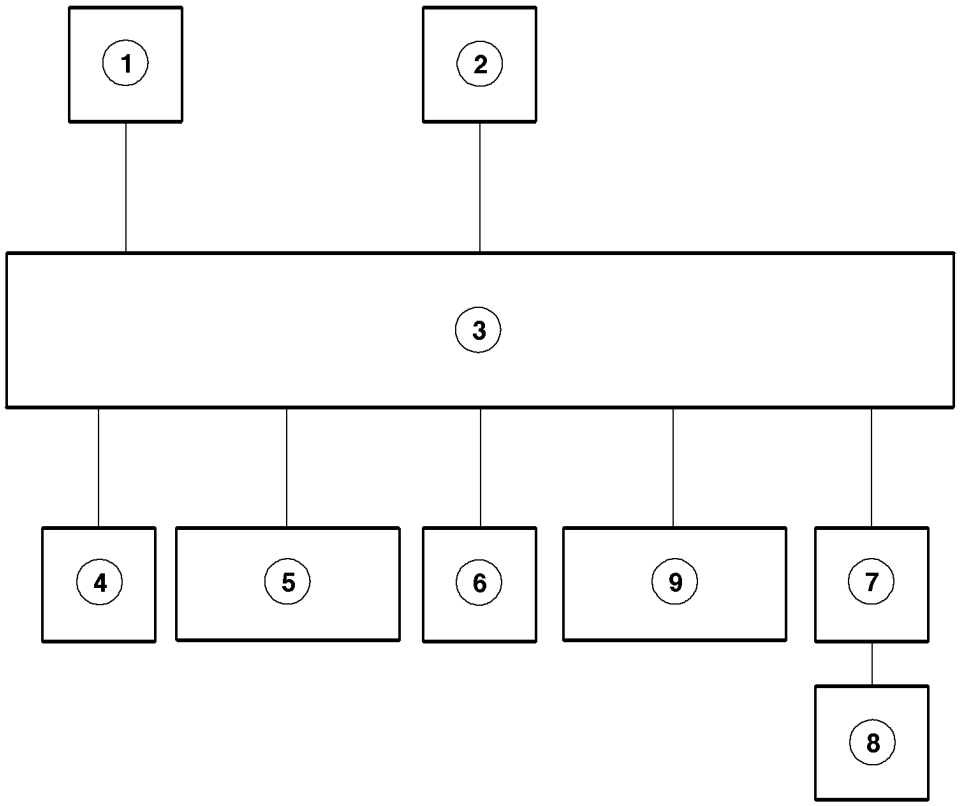
Sunroof components



M76 3061

1 Glass panel
2 Nut - glass panel
3 Frame - glass panel
4 Bolt - glass panel
5 Drive cables and lifting assembly
6 Screw - glass panel frame
7 Sunroof frame
8 Sunroof blind
9 Screw - sunroof frame
10 Drain tubes
11 Screw - motor
12 Motor and gearbox
13 Spacer - manual sunroof regulator
14 Regulator - manual sunroof
15 Handle - manual sunroof
16 Screw - manual sunroof regulator
17 Screw - manual sunroof handle

System block diagram



M862639

1 Passenger compartment fuse box
2 BCU
3 Sunroof ECU
4 Front sunroof switch
5 Front sunroof motor and microswitch
6 Rear sunroof - front switch
7 Rear sunroof isolation switch
8 Rear sunroof - rear switch
9 Rear sunroof motor and microswitch

Description

General

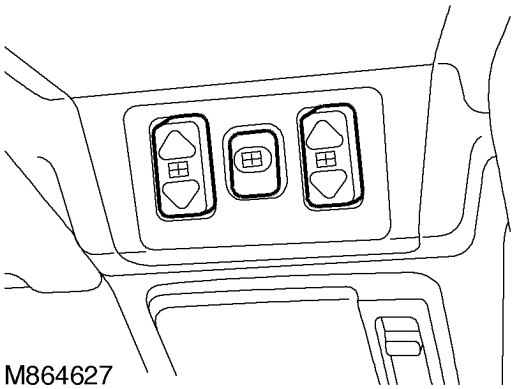
The sunroof system consists of a front and a rear sunroof assembly. Both sunroof assemblies slide and tilt to open. The sunroof system consists of the following components:

- Sunroof ECU.
- BCU.
- Front sunroof switch.
- Front sunroof motor and microswitch.
- Rear sunroof - front switch.
- Rear sunroof - rear switch.
- Rear sunroof isolation switch.
- Rear sunroof motor and microswitch.

The BCU enables operation of the sunroof ECU. If the sunroof ECU does not receive an enable signal from the BCU, neither sunroof assembly operates. The BCU is located behind the glovebox. The sunroof ECU is located above the headlining next to the front sunroof assembly.

TestBook diagnoses the sunroof ECU.

Front sunroof switch


M864627

The front sunroof switch is located in the roof console above the windscreen in front of the front sunroof. It controls the front sunroof motor via the sunroof ECU.

The front sunroof switch supplies an earth signal to the sunroof ECU. The pin at the ECU that receives the earth signal determines whether ECU causes the sunroof to open or close.

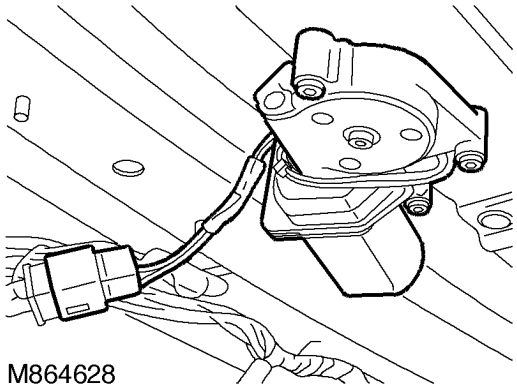
TestBook cannot monitor the state of the front sunroof switch.

The following table lists the values which can be measured at the listed ECU pins when the conditions outlined are met:

Signal values (connector connected)

Connector/Pin No.	Condition	Resistance, ohms
C0784-2	Ignition in position II, front sunroof switch released	> 10,000
C0784-2	Ignition in position II, front sunroof switch open	< 0.5
C0785-7	Ignition in position II, front sunroof switch released	> 10,000
C0785-7	Ignition in position II, front sunroof switch closed	< 0.5

Front sunroof motor and microswitch



The front sunroof motor is located within the front sunroof assembly. The sunroof ECU controls the front sunroof motor.

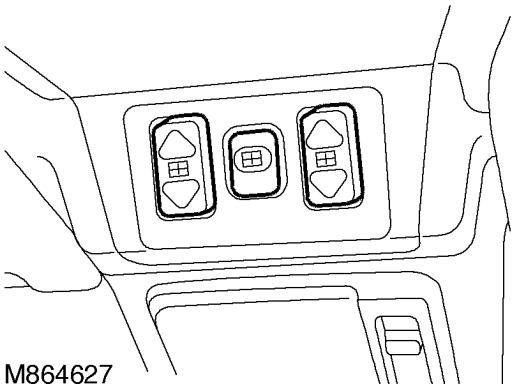
The sunroof ECU determines the direction the sunroof motor runs. A battery signal to one side of the motor and an earth to the other side of the motor causes the motor to turn in one direction, reversing the polarity through the same pins causes the motor to turn in the opposite direction.

The following table lists the values which can be measured at the listed ECU pins when the conditions outlined are met:

Signal values (connector connected)

Connector/Pin No.	Condition	Voltage	Resistance, ohms
C0785-5	Ignition in position II, rear of front sunroof switch pressed	+voltage to C0785-5	
C0785-1	Ignition in position II, front of front sunroof switch pressed	+voltage to C0785-1	< 0.5
C0784-8	Ignition in position II, sunroof fully closed	+V Batt	
C0784-8	Ignition in position II, sunroof not closed		> 10,0000

Rear sunroof - front switch



The rear sunroof front switch is located in the roof console above the windscreen in front of the front sunroof. It controls the rear sunroof motor via the sunroof ECU.

The rear sunroof front switch supplies an earth signal to the sunroof ECU. The pin at the ECU that receives the earth signal determines whether ECU causes the sunroof to open or close.

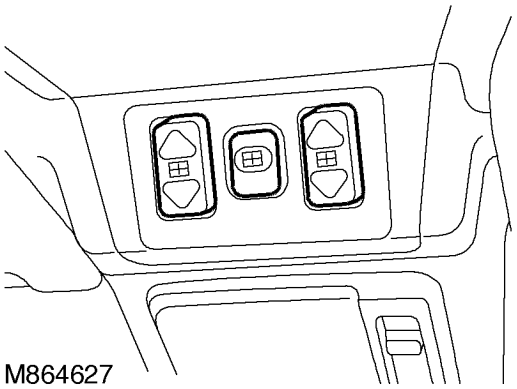
TestBook cannot monitor the state of the rear sunroof front switch.

The following table lists the values which can be measured at the listed ECU pins when the conditions outlined are met:

Signal values (connector connected)

Connector/Pin No.	Condition	Ohms
C0784-7	Ignition in position II, rear sunroof front switch released	> 10,000
C0784-7	Ignition in position II, rear sunroof front switch open	< 0.5
C0785-8	Ignition in position II, rear sunroof front switch released	> 10,000
C0785-8	Ignition in position II, rear sunroof front switch closed	< 0.5

Rear sunroof isolation switch



The rear sunroof isolation switch is located in the roof console above the windscreen in front of the front sunroof. It prevents the rear sunroof rear switch from operating the rear sunroof.

The rear sunroof isolation switch is in the earth path between the rear sunroof rear switch and the sunroof ECU. Operating the rear sunroof isolation switch opens the circuit and prevents the rear sunroof rear switch from operating the rear sunroof.

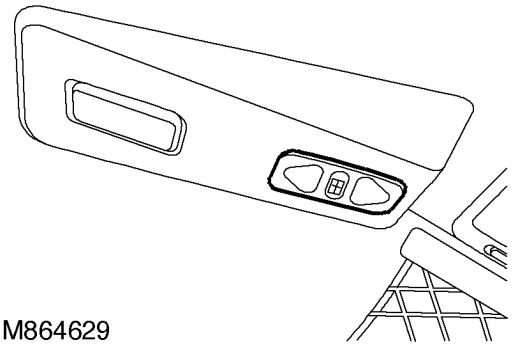
TestBook cannot monitor the state of the rear sunroof isolation switch.

The following table lists the values which can be measured at the listed ECU pins when the conditions outlined are met:

Signal values (connector connected)

Connector/Pin No.	Condition	Resistance, ohms
C0784-6	Ignition in position II, rear sunroof rear switch open, rear sunroof isolation switch pressed	> 10,000
C0784-6	Ignition in position II, rear sunroof rear switch open, rear sunroof isolation switch released	< 0.5
C0785-9	Ignition in position II, rear sunroof rear switch closed, rear sunroof isolation switch pressed	> 10,000
C0785-9	Ignition in position II, rear sunroof rear switch closed, rear sunroof isolation switch released	< 0.5

Rear sunroof rear switch



The rear sunroof rear switch is located in the roof console in front of the rear sunroof. It controls the rear sunroof motor via the sunroof ECU.

The rear sunroof front switch supplies an earth signal through the rear sunroof isolation switch to the sunroof ECU. The pin at the ECU that receives the earth signal determines whether ECU causes the sunroof to open or close.

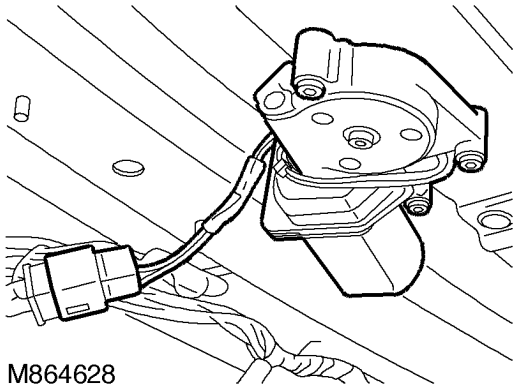
TestBook cannot monitor the state of the rear sunroof rear switch.

The following table lists the values which can be measured at the listed ECU pins when the conditions outlined are met:

Signal values (connector connected)

Connector/Pin No.	Condition	Resistance, ohms
C0784-6	Ignition in position II, rear sunroof isolation switch closed, rear sunroof rear switch released	> 10,000
C0784-6	Ignition in position II, rear sunroof isolation switch closed, rear sunroof front switch open	< 0.5
C0785-9	Ignition in position II, rear sunroof isolation switch closed, rear sunroof front switch released	> 10,000
C0785-9	Ignition in position II, rear sunroof isolation switch closed, rear sunroof front switch closed	< 0.5

Rear sunroof motor and microswitch



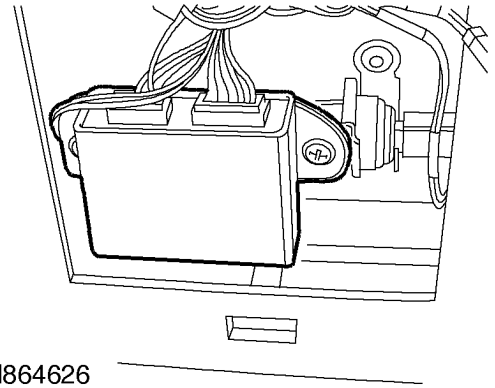
The rear sunroof motor and microswitch are located within the rear sunroof assembly. The sunroof ECU controls the rear sunroof motor.

The sunroof ECU determines the direction the sunroof motor runs. A battery signal to one side of the motor and an earth to the other side of the motor causes the motor to turn in one direction, reversing the polarity through the same pins causes the motor to turn in the opposite direction.

Operating Parameters (connector connected)

Connector/Pin No.	Condition	Voltage	Resistance, ohms
C0785-4	Ignition in position II, rear of rear sunroof switch pressed	+voltage to C0785-6	
C0785-6	Ignition in position II, front of rear sunroof switch pressed	+voltage to C0785-4	< 0.5
C0784-2	Ignition in position II, sunroof fully closed	+V Batt	
C0784-2	Ignition in position II, sunroof not closed		> 10,0000

Sunroof ECU



The sunroof ECU is located behind the head lining above the rear view mirror. Most functions of the sunroof ECU are covered under other components.

Sunroof ECU connector pin details - C0784

Pin No.	Description	Input/Output
1	Rear sunroof microswitch	Input
2	Front sunroof switch - open	Input
3	Not used	-
4	Sunroof microswitches - common	Input
5	Not used	-
6	Rear sunroof, rear switch - open	Input
7	Rear sunroof, front switch - open	Input
8	Front sunroof microswitch	Input

Sunroof ECU connector pin details - C0785

Pin No.	Description	Input/Output
1	Front sunroof motor forward	Output
2	ECU earth	Input
3	Battery power supply	Input
4	Rear sunroof motor backwards	Output
5	Front sunroof motor backwards	Output
6	Rear sunroof motor forwards	Output
7	Front sunroof switch - close	Input
8	Rear sunroof, front switch - close	Input
9	Rear sunroof, rear switch - close	Input
10	Sunroof enable	Input

Operation

Ignition switched-off timeout
There are three timeout modes for operating the sunroof assemblies after the ignition is switched off. The BCU determines the vehicle's timeout mode. The three modes are:

- When the ignition is switched off, no sunroof operation is permitted.
- When the ignition is switched off, sunroof remains functional for 45 seconds or until the driver door is opened.
- When the ignition is switched off, sunroof remains functional for 45 seconds or until any door is opened.

Sunroof open and close
Both sunroof assemblies operate in the same manner. The front sunroof assembly has one switch while there are two switches to control rear sunroof assembly, a rear sunroof front switch and a rear sunroof rear switch.

The sunroof ECU monitors the position of the sunroof microswitch to determine if the sunroof is to be tilted or opened.

In order for the sunroof to operate, either of the following conditions must exist:

- Ignition switch in position II.
- Ignition switched from on to off, doors closed (this may enable the system to operate for 45 seconds after the ignition is switched off, or until a door is opened).

When the sunroof is closed, pressing the rear of the sunroof switch causes the sunroof ECU to operate the sunroof motor and open the sunroof. When the sunroof opens, the sunroof microswitch opens. The sunroof continues to open until the switch is released or the sunroof reaches the fully open position.

When the sunroof is open, pressing the front of the sunroof switch causes the sunroof ECU to operate the sunroof motor and close the sunroof. The sunroof ECU continues to operate the motor until the sunroof microswitch closes. This indicates to the sunroof ECU that the sunroof is fully closed.

Sunroof tilt
Both sunroof assemblies operate in the same manner. The front sunroof assembly has one switch while there are two switches to control rear sunroof assembly, a rear sunroof front switch and a rear sunroof rear switch.

The sunroof ECU monitors the position of the sunroof microswitch to determine if the sunroof is to be tilted or opened.

In order for the sunroof to operate, either of the following conditions must exist.

- Ignition in position II.
- Ignition switched from on to off, doors closed (this may enable the system to operate for 45 seconds after the ignition is switched off, or until a door is opened).

When the sunroof is closed and the front of the sunroof switch is pressed, the sunroof ECU detects the combination of closed microswitch and front of sunroof switch being pressed and tilts the rear of the sunroof. This causes the microswitch to open. The sunroof continues to open until the switch is released or the sunroof reaches the fully open position.

When the sunroof is tilted and the rear of the sunroof switch is pressed, the sunroof ECU detects the combination of open microswitch and rear of sunroof switch and closes the sunroof until the microswitch closes. This indicates to the sunroof ECU that the sunroof is fully closed.

Rear sunroof isolation
The rear sunroof isolation switch prevents the rear sunroof rear switch from operating the rear sunroof. This can be used to prevent small children sitting in the rear seat from playing with the rear sunroof.

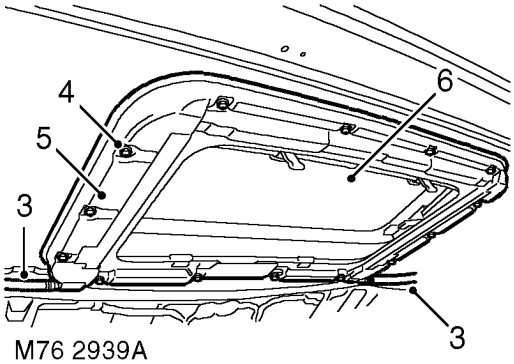
Pressing the rear sunroof isolation switch opens the circuit between the rear sunroof rear switch and the sunroof ECU. The sunroof ECU ignores the rear sunroof switch until the rear sunroof isolation switch is pressed and the circuit closes.

Sunroof - front

76.84.01

Remove

1. Remove headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.
2. Remove front sunroof motor.
   SUNROOF, REPAIRS, Motor - sunroof.

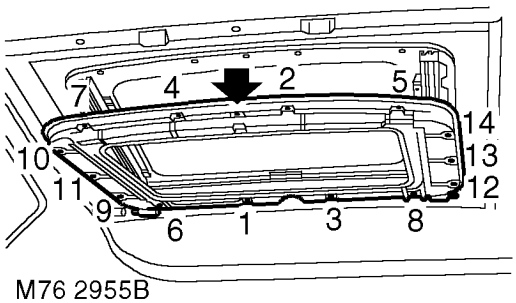


M76 2939A

3. Disconnect drain tubes from sunroof tray.
4. Remove 14 screws securing sunroof tray to sunroof frame.
5. Carefully remove sunroof tray.
6. With assistance, remove sunroof frame and glass assembly.

Refit

1. With assistance, fit sunroof frame and glass assembly.



M76 2955B

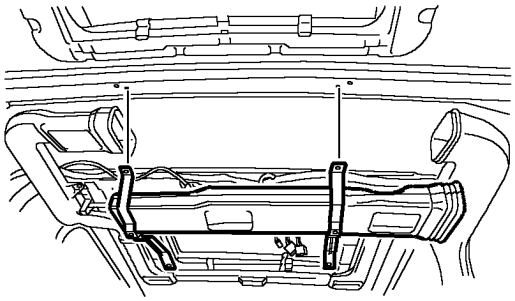
2. Position sunroof tray to roof and locate on front edge and on rear location pin, arrowed in illustration.
3. Fit Torx screws securing sunroof tray to frame and tighten to 2 Nm (1.5 lbf.ft) in the order shown.
4. Connect drain tubes to sunroof.
5. Fit sunroof motor. Do not fit headlining at this stage.
   SUNROOF, REPAIRS, Motor - sunroof.
6. Check operation of sunroof.
7. Pour water over sunroof and check for water leaks.
8. Fit headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.

Sunroof - rear

76.84.02

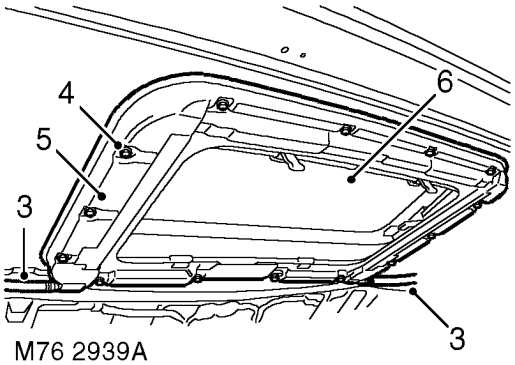
Remove

1. Remove sunroof motor.
   SUNROOF, REPAIRS, Motor - sunroof.



M82 0489

2. **Models with rear A/C:**
   - **a** Drill out 4 rivets securing rear centre duct to roof.
   - **b** Release and remove rear centre duct.
   - **c** Drill out 2 rivets securing each upper side duct to roof.
   - **d** Remove upper side ducts.

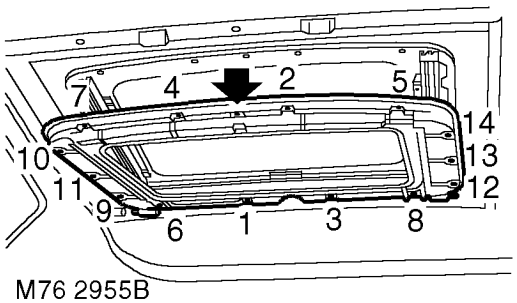


M76 2939A

3. Disconnect drain tubes from sunroof tray.
4. Remove 14 screws securing sunroof tray to sunroof frame.
5. Carefully remove sunroof tray.
6. With assistance, remove sunroof frame and glass assembly.

Refit

1. With assistance, fit sunroof frame and glass assembly.



M76 2955B

2. Position sunroof tray to roof and locate on front edge and on rear location pin, arrowed in illustration.
3. Fit Torx screws securing sunroof tray to frame and tighten to 2 Nm (1.5 lbf.ft) in the order shown.
4. Fit sunroof motor. Do not fit headlining at this stage.
   SUNROOF, REPAIRS, Motor - sunroof.
5. **Models with rear A/C:**
   - **a** Fit upper side ducts and secure with rivets.
   - **b** Fit rear centre duct and secure with rivets.
6. Connect drain tubes to sunroof.
7. Check operation of sunroof.
8. Pour water over sunroof and check for water leaks.
9. Fit headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.

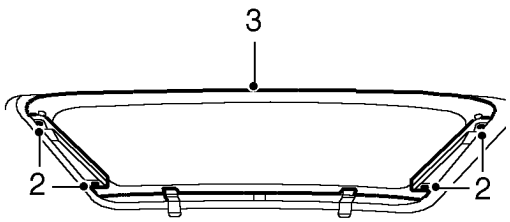
Glass panel - sunroof

76.84.03

The procedure for replacing the rear sunroof glass panel is exactly the same as for the front

Remove

1. Partially open sunroof.



M76 2896

2. Remove 4 Torx screws securing glass to sunroof frame.
3. Remove sunroof glass.

Refit

1. Position glass to frame.
2. Fit Torx screws securing glass to sunroof frame. Do not fully tighten screws at this stage.
3. Adjust position of sunroof glass in relation to roof panel until a 6.5 mm (0.25 in) gap is produced between the front edge of the glass and the sunroof frame.
4. Tighten sunroof glass retaining screws to 3 Nm (2.2 lbf.ft).

Motor - sunroof

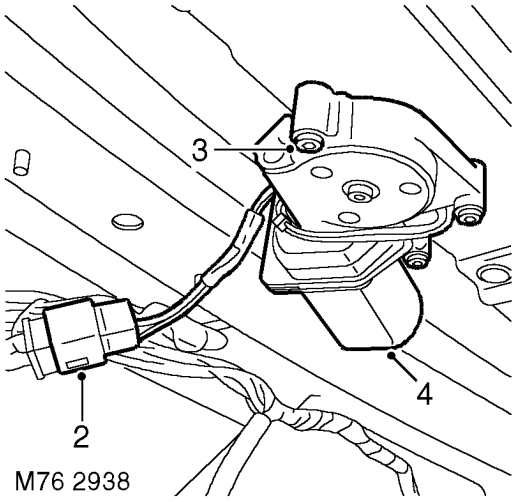
76.84.07

This procedure is applicable to the motor of both sunroofs.

Remove

1. Gain access to the sunroof motor:
   - For front sunroof motor, remove front stowage pocket.
     INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.
   - For rear sunroof motor, remove headlining.
     INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.

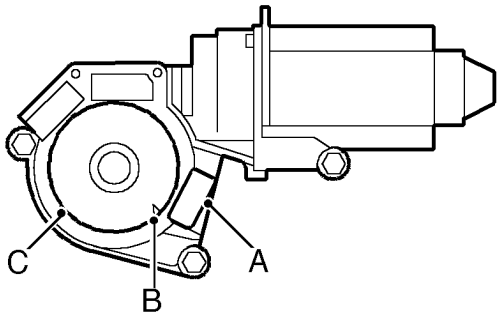
CAUTION: The sunroof must be fully closed before removing the sunroof motor.



M76 2938

2. Disconnect sunroof motor multiplug.
3. Remove 3 Torx screws securing motor to sunroof tray.
4. Remove sunroof motor.

Refit



M76 2956

1. Check sunroof motor timing notch (A) aligns with edge of microswitch (B). If motor is out of alignment, rotate counting wheel (C) to correct position using an Allen key.
2. Ensure sunroof drive cables are in fully closed position.
3. Fit motor to sunroof frame.
4. Fit Torx screws securing motor to sunroof tray and tighten to 2 Nm (1.5 lbf.ft).
5. Connect sunroof motor multiplug.
6. Fit interior trim:
   - For front sunroof motor, fit front stowage pocket.
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.**
   - For rear sunroof motor, fit headlining.
     ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**

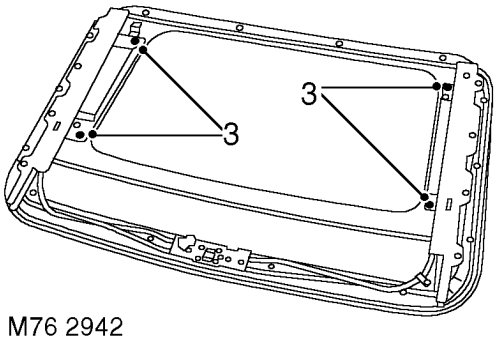
Drive cable assembly

🔧 ***76.84.09***

This procedure is applicable to the drive cable assembly of both sunroofs.

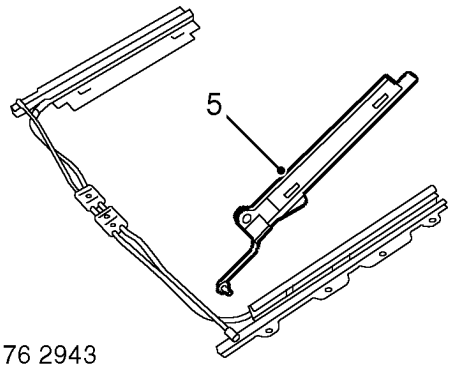
Remove

1. Remove sunroof:
   - For front drive cable assembly:
     ☞ **SUNROOF, REPAIRS, Sunroof - front.**
   - For rear drive cable assembly:
     ☞ **SUNROOF, REPAIRS, Sunroof - rear.**
2. Position sunroof assembly on suitable work bench.



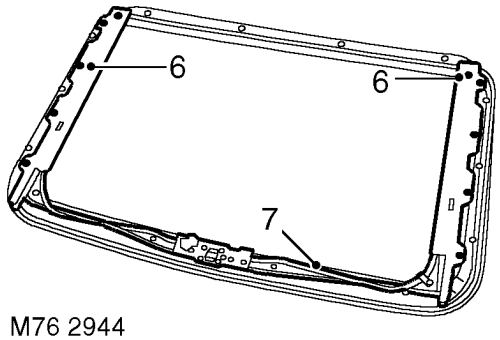
M76 2942

3. Remove 4 Torx screws securing glass to sunroof frame.
4. Remove sunroof glass.



M76 2943

5. Release both glass carriers from cables and remove.



M76 2944

6. Remove 10 Torx screws securing frame to drive cable assembly.
7. Remove drive cable assembly from frame.

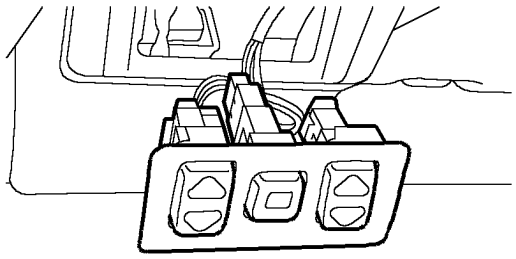
Refit

1. Fit drive cable assembly to frame.
2. Fit Torx screws securing frame to drive cable assembly and tighten to 2.5 Nm (1.8 lbf.ft).
3. Fit glass carriers to cables.
4. Fit glass to sunroof frame and secure with Torx screws. Do not fully tighten screws at this stage.
5. Fit sunroof.
   - For front drive cable assembly:
     ☞ **SUNROOF, REPAIRS, Sunroof - front.**
   - For rear drive cable assembly:
     ☞ **SUNROOF, REPAIRS, Sunroof - rear.**
6. Remove timing pegs supplied with drive cables.
7. Adjust position of sunroof glass in relation to sunroof panel until a 6.5 mm (0.25 in) gap is produced between the front edge of the glass and the sunroof frame.
8. Tighten sunroof glass retaining screws to 3 Nm (2.2 lbf.ft).

Switch pack - sunroof

⊸ ***76.84.44***

Remove



M76 2897

1. Release switch pack from front stowage pocket.
2. Disconnect multiplugs from 3 sunroof switches.
3. Remove switches from switch pack.

Refit

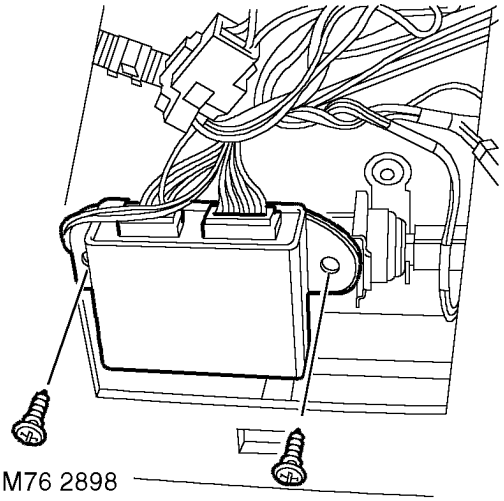
1. Fit switches to switch pack.
2. Connect multiplugs to switches.
3. Fit switch pack to front stowage pocket.

ECU - sunroof

76.84.46

Remove

1. Remove front stowage pocket.
   INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.



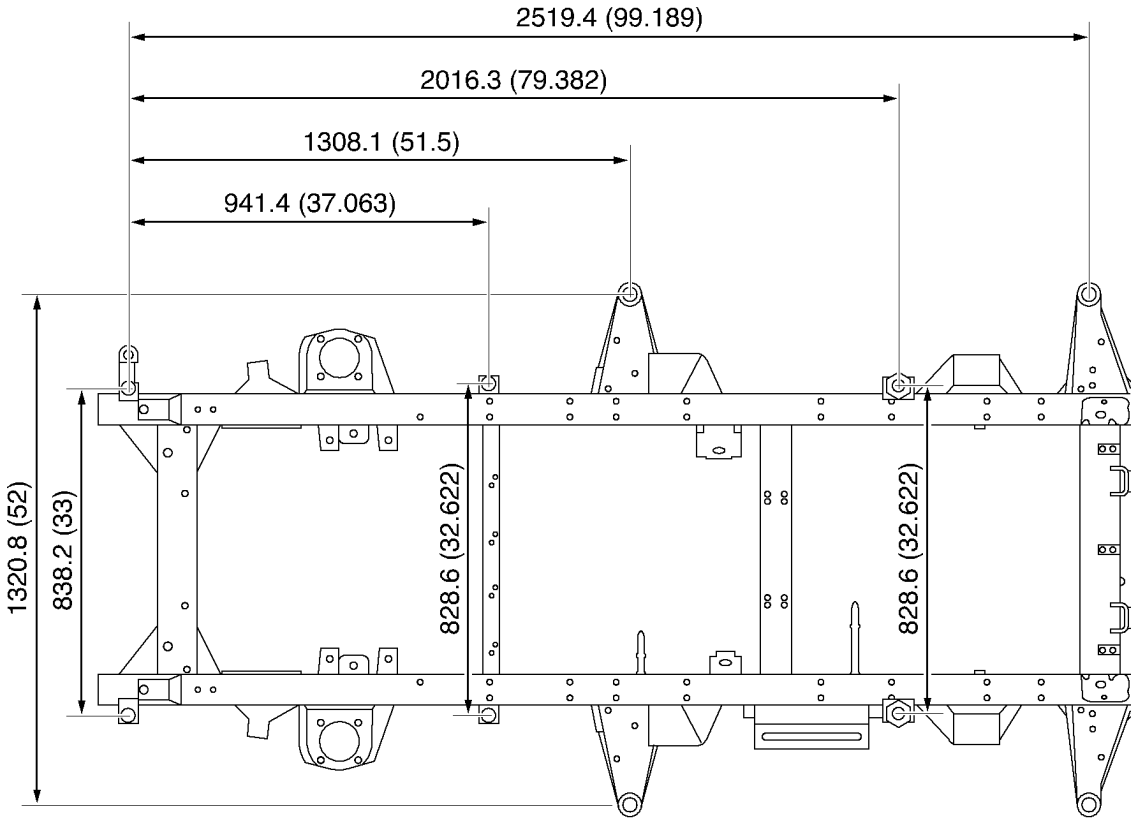
2. Remove 2 screws securing ECU to roof.
3. Disconnect 2 multiplugs from ECU.
4. Remove sunroof ECU.

Refit

1. Position sunroof ECU and connect multiplugs.
2. Fit and tighten screws securing ECU to roof.
3. Fit front stowage pocket.
   INTERIOR TRIM COMPONENTS, REPAIRS, Stowage pocket - front.

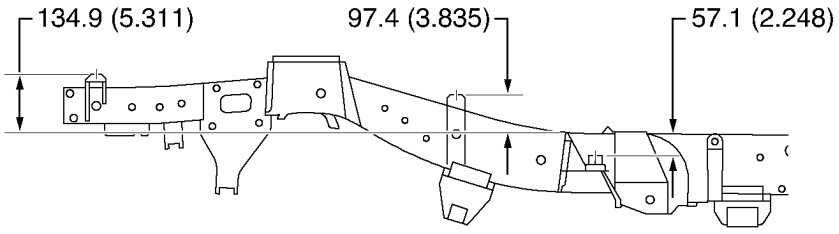
Chassis body mounting points - front end

Plan view



M77 1725

Side view

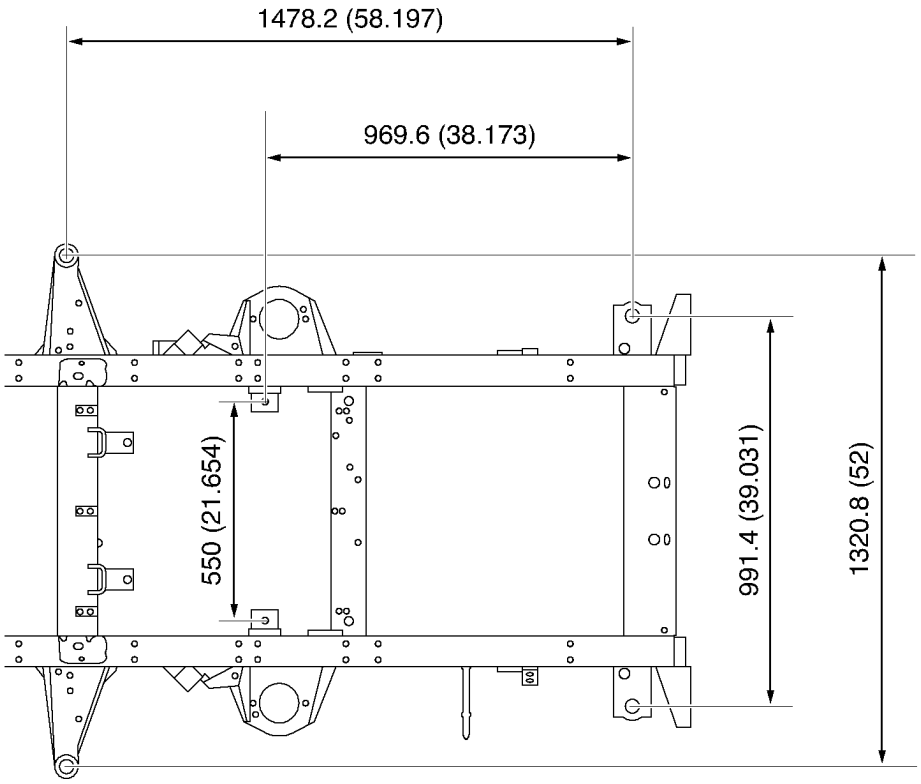


M77 1726

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

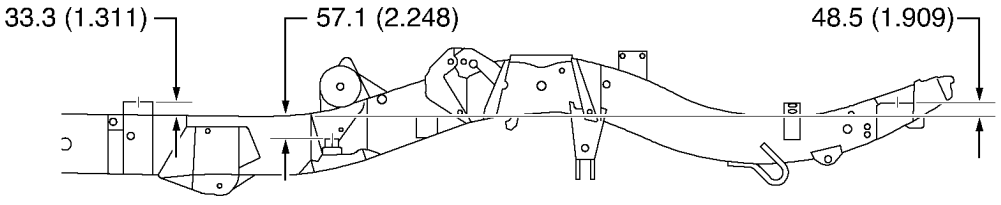
Chassis body mounting points - rear end

Plan view



M77 1729

Side view

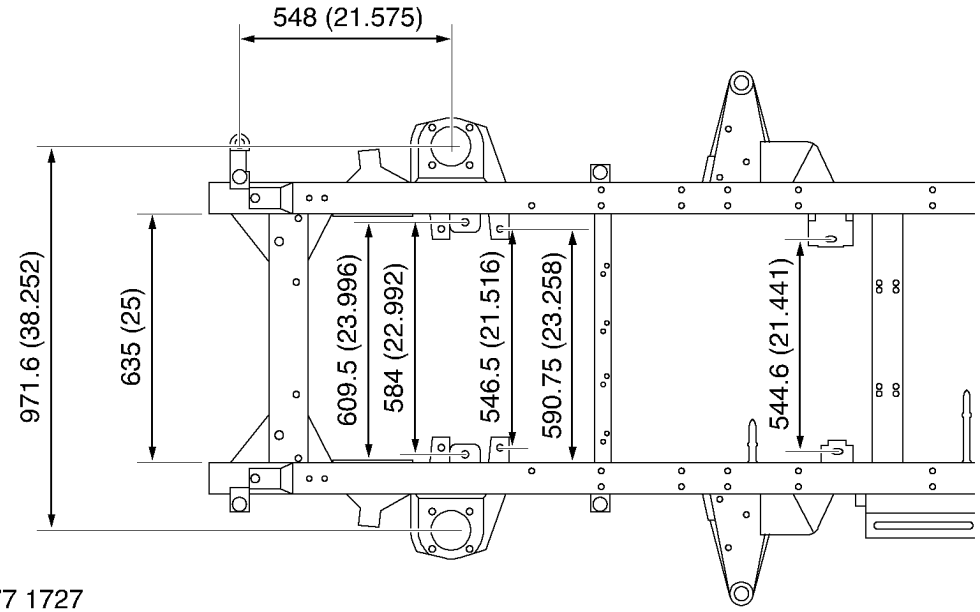


M77 1739

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

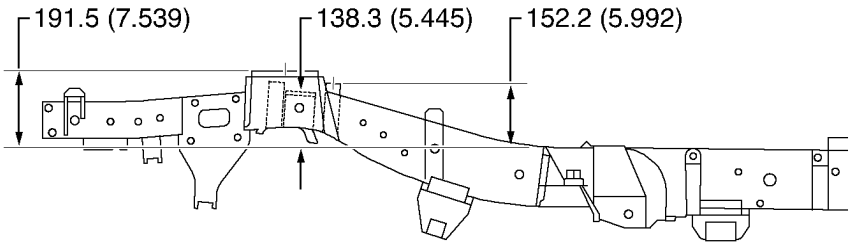
Chassis dimensions - front end

Plan view



M77 1727

Side view

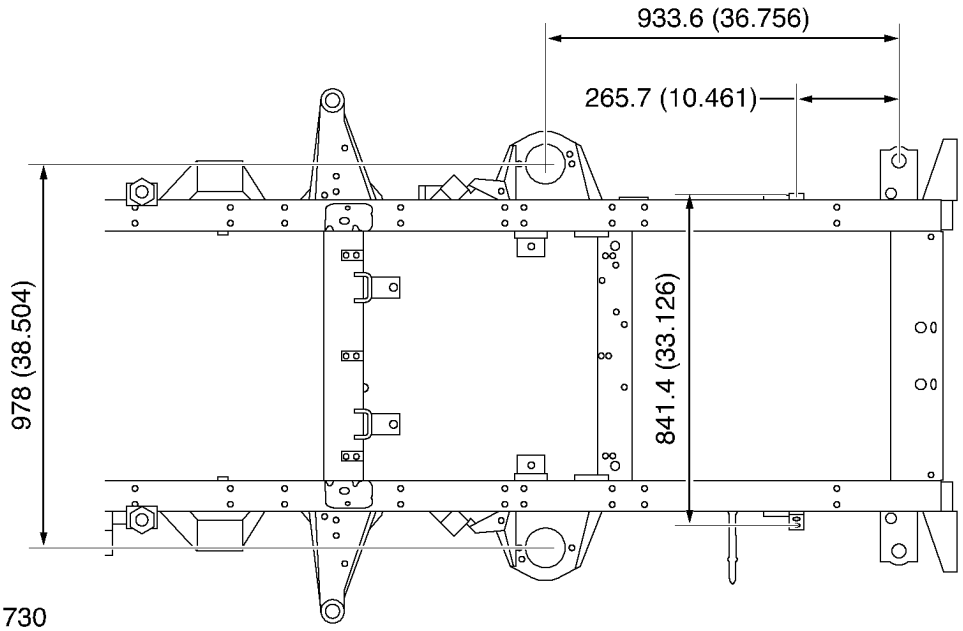


M77 1728

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

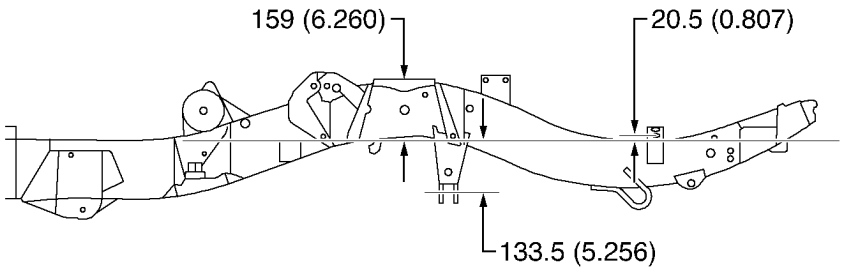
Chassis dimensions - rear end

Plan view



M77 1730

Side view



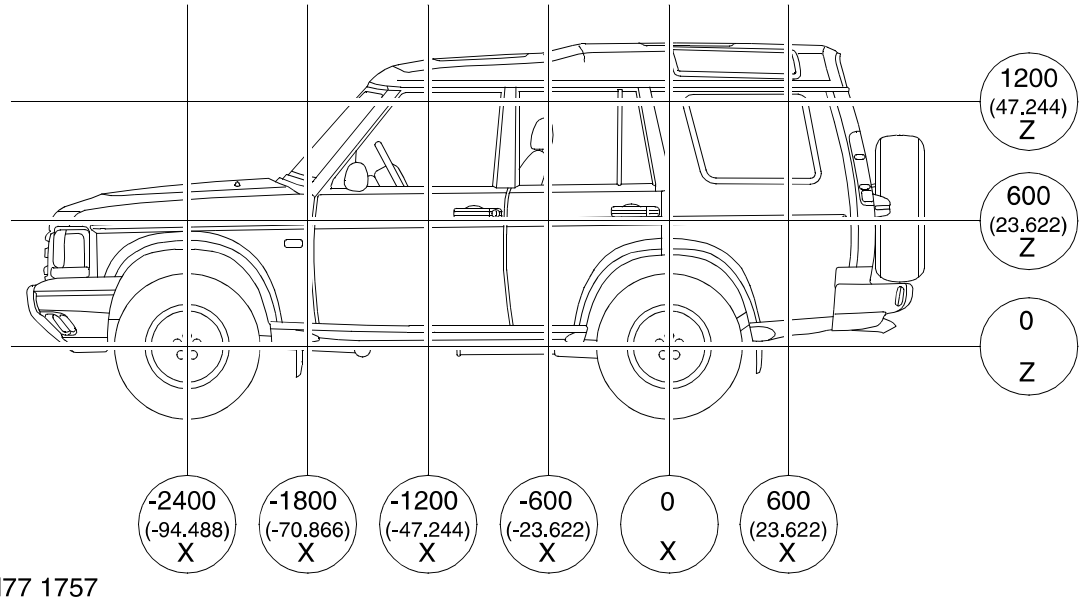
M77 1738

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

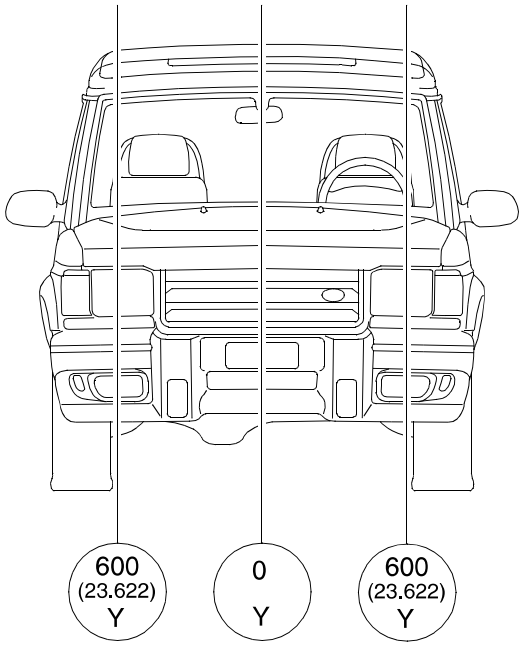
Body Dimensions

The following dimensional information is shown to assist the technician in the diagnosis and repair of body panels. The information is shown in two different forms. In the first part of the information X,Y and Z dimensions are shown and in the second part actual point to point dimensions are shown.

The X,Y,Z dimensions are the planes used by Land Rover for the measurement of body panels. The whole bodyshell lies within a parallel grid system. See following illustrations.



M77 1757



M77 1756

The 'X' plane is an imaginery vertical plane which measures distances along the length of the vehicle. The start point for this plane is through the centre of the rear wheels.

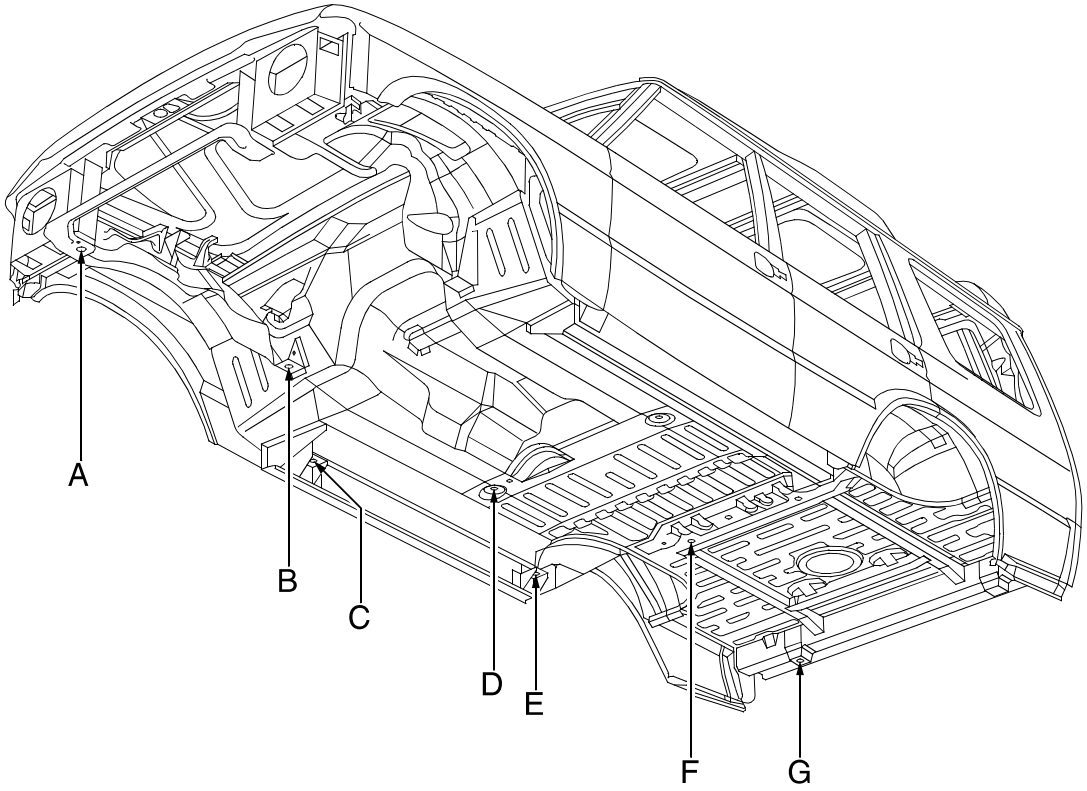
The 'Y' plane is an imaginery plane through the centre of the vehicle and measures distances across the vehicle. As a rule, body dimensions are symmetrical about the centre line.

The 'Z' plane is an imaginery horizontal plane which measures distances in height of the vehicle. The start point for this plane is through the centre of the rear wheels.

The point to point dimensional information shown are actual distances between two points. These points used are either intersection points or holes. Where holes are taken, the point of measurement is always from the hole centre.

X,Y,Z dimensional information
Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

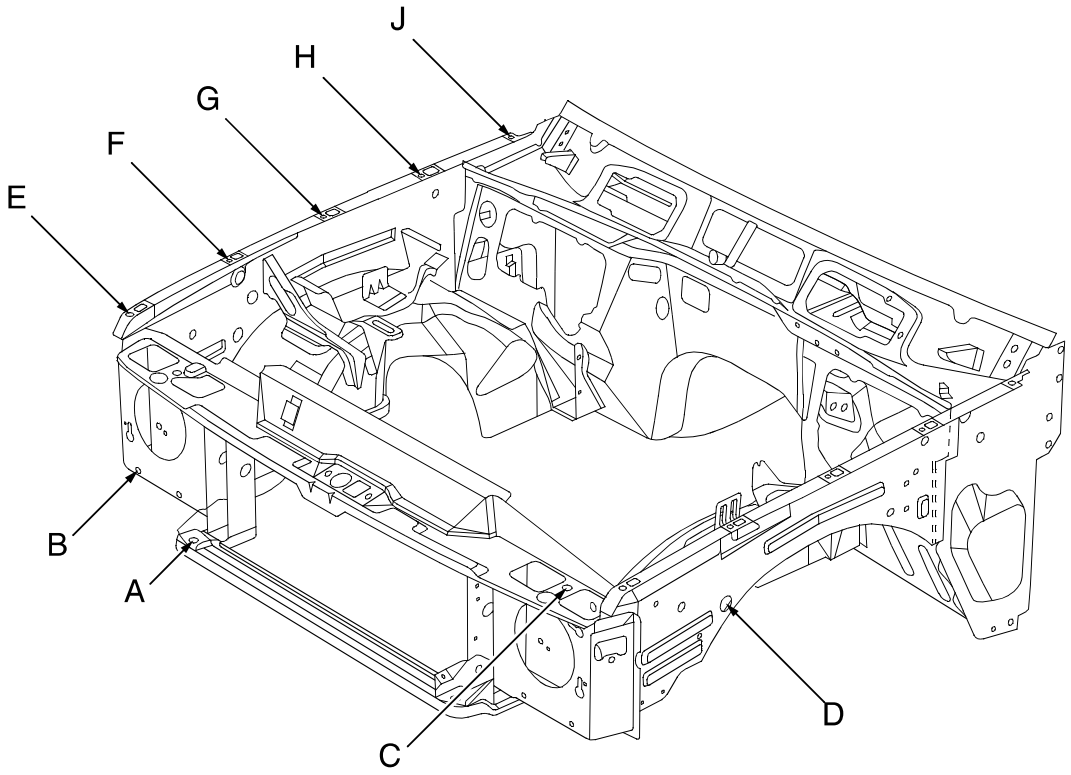
Body to chassis mounting holes



M77 1759

I.D	Description	X	Y	Z
A	Front mounting hole	-3071.6 (-120.929)	419.1 (16.500)	271.5 (10.688)
B	Second mounting hole	-2130.5 (-83.877)	414.3 (16.311)	233.4 (9.188)
C	Third mounting hole	-1763.7 (-69.437)	660.4 (26.000)	78.0 (3.070)
D	Fourth mounting hole	-1055.6 (-41.559)	414.3 (16.311)	169.8 (6.685)
E	Fifth mounting hole	-552.3 (-21.744)	660.4 (26.000)	78.0 (3.070)
F	Sixth mounting hole	-44.000 (-1.732)	275.0 (10.826)	296.4 (11.669)
G	Rear mounting hole	925.6 (36.440)	495.3 (19.500)	184.6 (7.267)

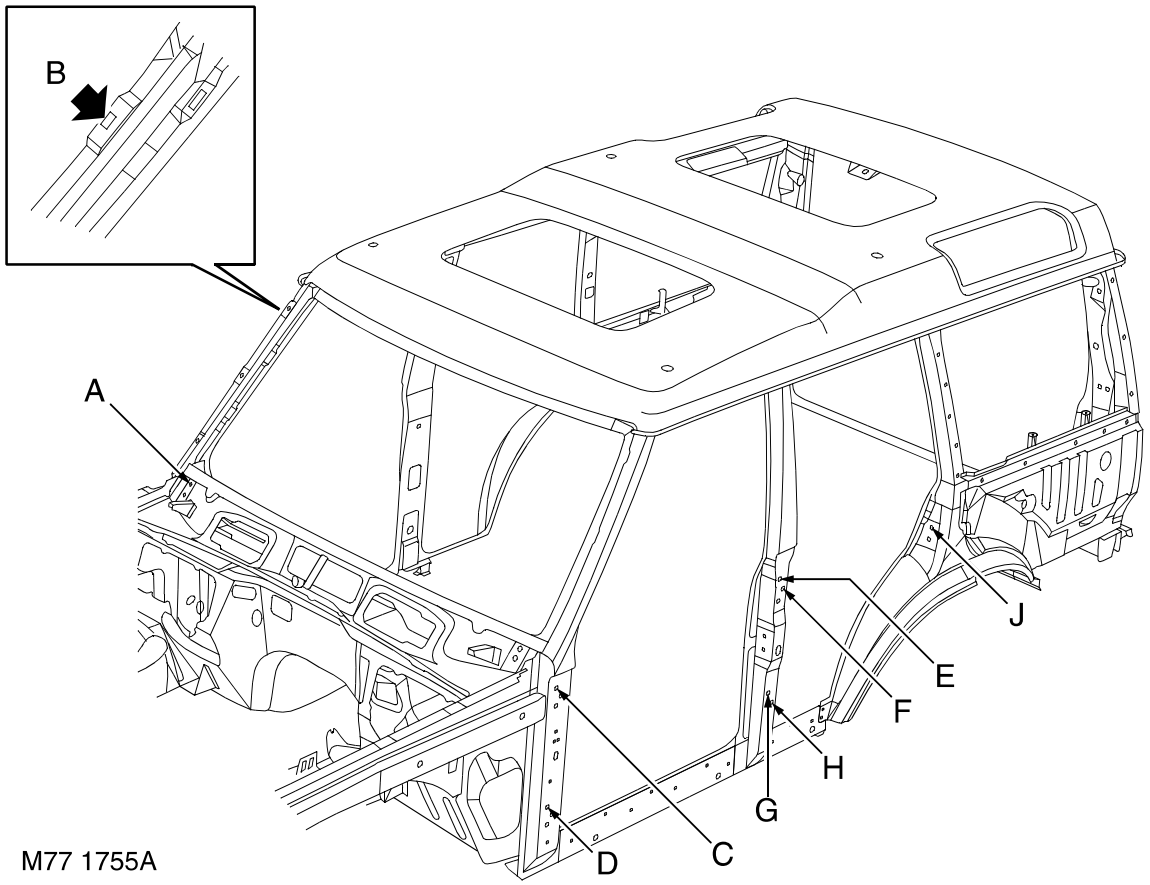
Front end information



M77 1753

I.D	Description	X	Y	Z
A	Grille mounting slot	-3190.5 (-125.610)	413.9 (16.295)	303 (11.929)
B	Headlamp mounting panel, slot	-3124 (-122.992)	686.6 (27.031)	335 (13.188)
C	Bonnet locking platform, jig location hole	-3065.8 (-120.700)	611 (24.055)	584.7 (23.019)
D	Valance upper, jig location hole	-2789.4 (-109.818)	770.5 (30.334)	507.1 (19.964)
E	First wing fixing hole	-3064.8 (-120.661)	768 (30.236)	650.4 (25.606)
F	Second wing fixing hole	-2787.9 (-109.759)	778.7 (30.657)	686.1 (27.011)
G	Third wing fixing hole	-2523.9 (-99.366)	785.4 (30.921)	704.5 (27.736)
H	Fourth wing fixing hole	-2259 (-88.937)	789.6 (31.086)	718.4 (28.283)
J	Fifth wing fixing hole	-1993.9 (-78.5)	793 (31.220)	728.9 (28.696)

Front end/side information



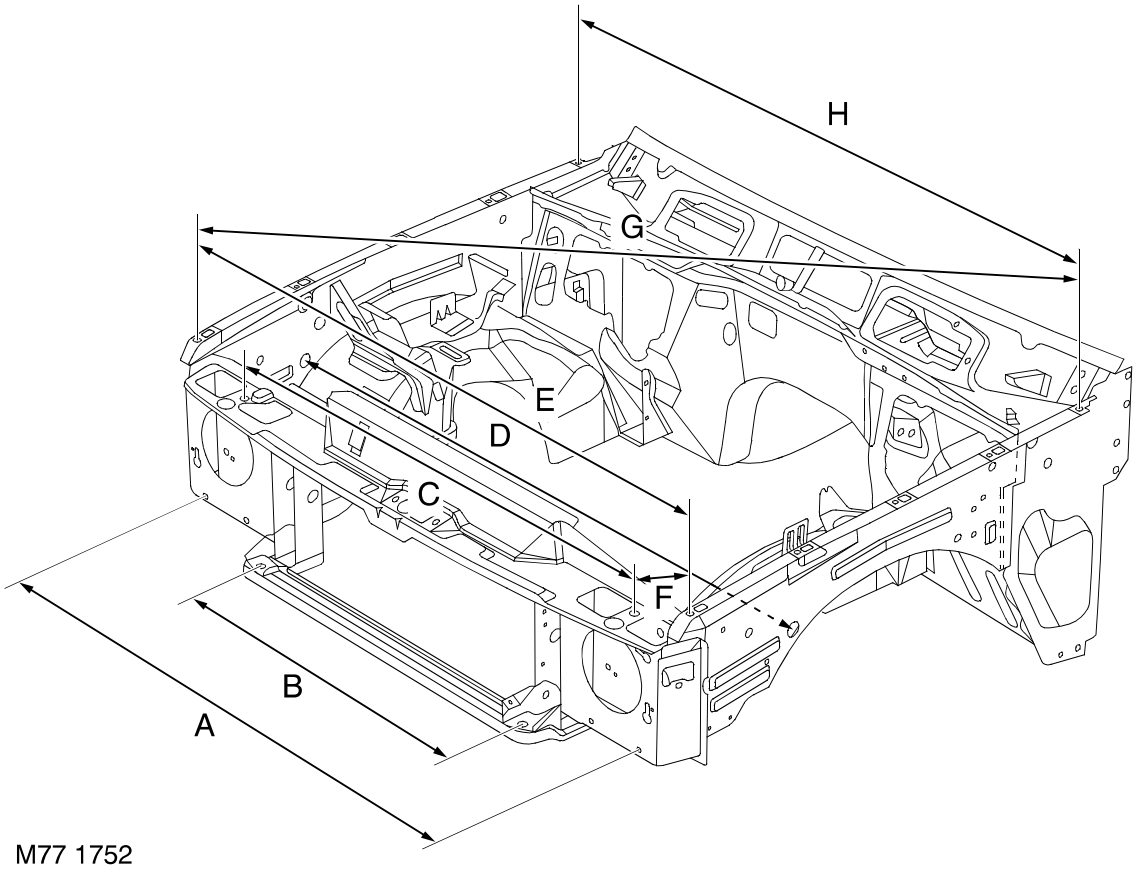
I.D	Description	X	Y	Z
A	Bonnet hinge fixing, top hole	-1906.3 (-75.051)	706 (27.795)	742.9 (29.248)
B	Windscreen finisher, top slot	-1508.9 (-59.405)	715 (28.147)	1229 (48.385)
C	'A' post top, top hinge fixing hole	-1859 (-120.700)	809.6 (24.055)	584.7 (23.019)
D	'A' post bottom, top hinge fixing hole	-1859 (-120.700)	809.6 (24.055)	289.1 (11.381)
E	'B/C' post top, top hinge fixing	-860.5 (-33.877)	809.8 (31.881)	680.5 (26.791)
F	'B/C' post top, jig location hole	-841.5 (-33.129)	809.8 (31.881)	644.5 (25.374)
G	'B/C' post bottom, top hinge fixing hole	-860.5 (-33.877)	809.8 (31.881)	290.3 (11.429)
H	'B/C' post bottom, jig location hole	-841.5 (-33.129)	809.8 (31.881)	254.2 (10.007)
J	'D' post, door striker fixing, top hole	-75.4 (-2.968)	782.3 (30.799)	619.1 (24.374)

Point to point dimensional information

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

All dimensions are to hole/slot centres.

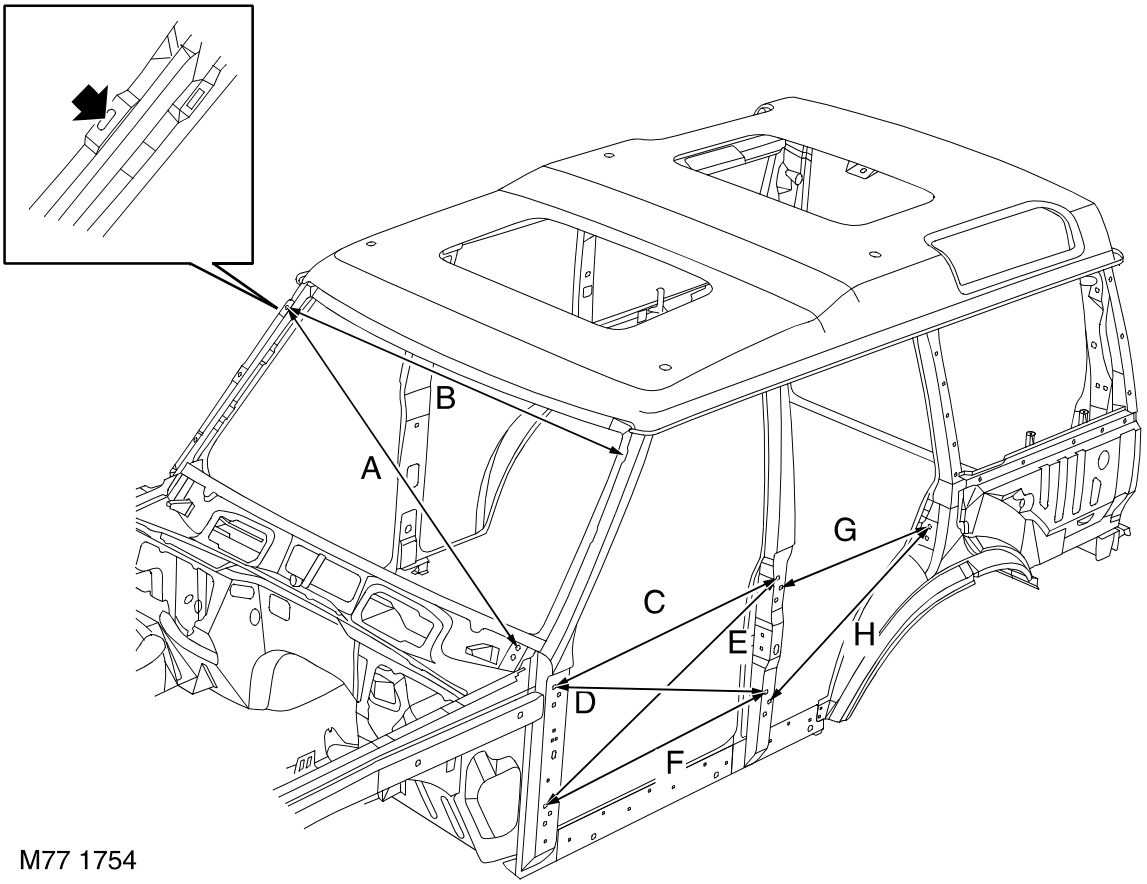
Front end information



M77 1752

I.D	Description	Length
A	Distance between headlamp mounting panel slots	1373.2 (54.062)
B	Distance between grille locating slots	827.8 (32.590)
C	Distance between bonnet locking platform jig location holes	1222 (48.110)
D	Distance between valance upper assembly jig location holes	1541 (60.669)
E	Distance between wing, front fixing holes	1536 (60.472)
F	Distance between bonnet locking platform jig location hole and wing, front fixing hole	170.2 (6.700)
G	Distance between wing, front fixing hole and wing, rear fixing hole	1894.7 (74.594)
H	Distance between wing, rear fixing holes	1586 (62.440)

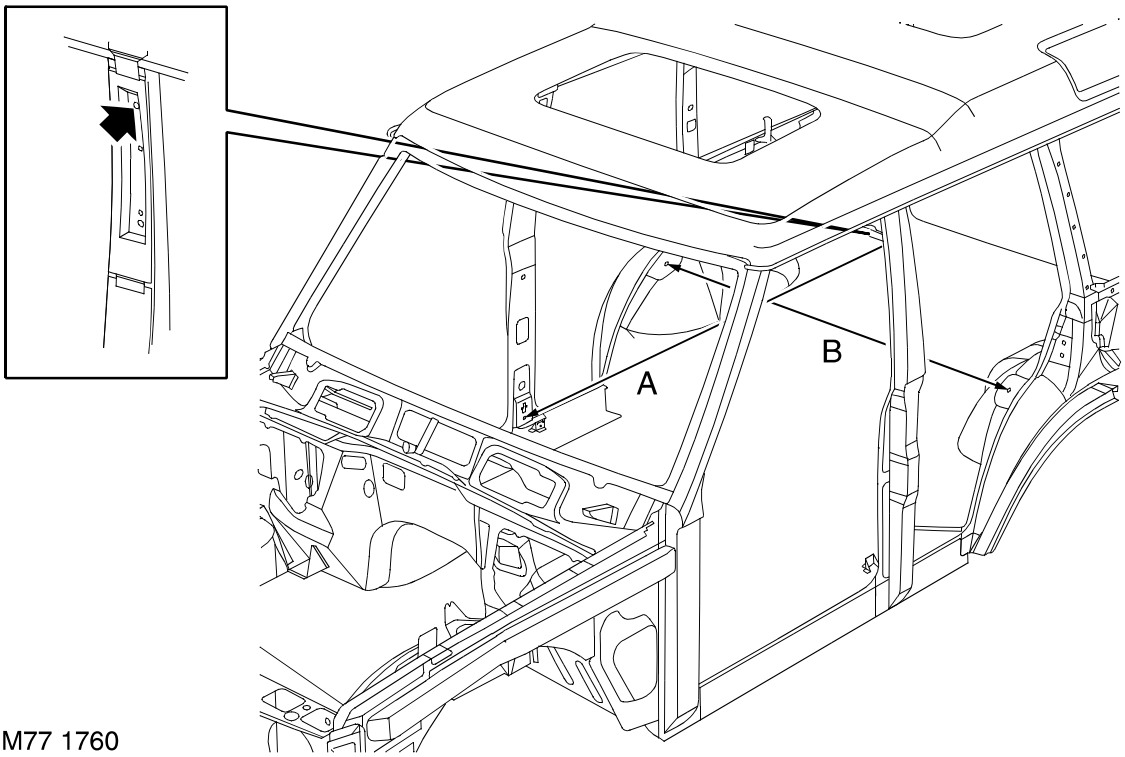
Front end/side information



M77 1754

I.D	Description	Length
A	Distance between bonnet hinge fixing top hole and windscreen side finisher top fixing slot	1553.5 (61.161)
B	Distance between windscreen side finisher top fixing slots	1430 (56.299)
C	Distance between front door top hinge fixing hole and rear door top hinge fixing hole	998.5 (39.311)
D	Distance between front door top hinge fixing hole and rear door bottom hinge fixing hole	1067.7 (42.035)
E	Distance between front door bottom hinge fixing hole and rear door top hinge fixing hole	1072.5 (42.224)
F	Distance between front door bottom hinge fixing hole and rear door bottom hinge fixing hole	998.5 (39.311)
G	Distance between 'B/C' post top jig location hole and 'D' post top door striker fixing hole	767 (30.196)
H	Distance between 'B/C' post bottom jig location hole and 'D' post top door striker fixing hole	849.1 (33.429)

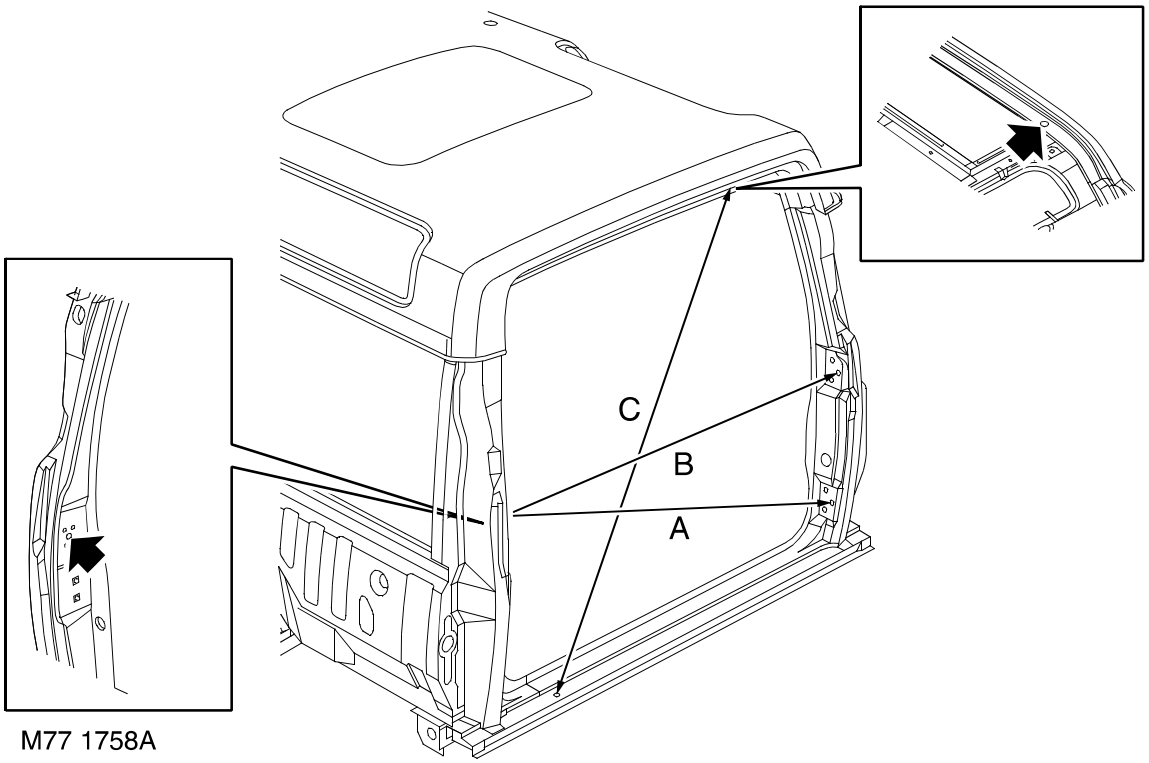
Internal information



M77 1760

I.D	Description	Length
A	Distance between seat belt anchorage top fixing and seat belt reel lower fixing	1814.5 (71.437)
B	Distance between seat belt anchorage lower fixings on wheel arch inner	1430.2 (56.307)

Rear end information



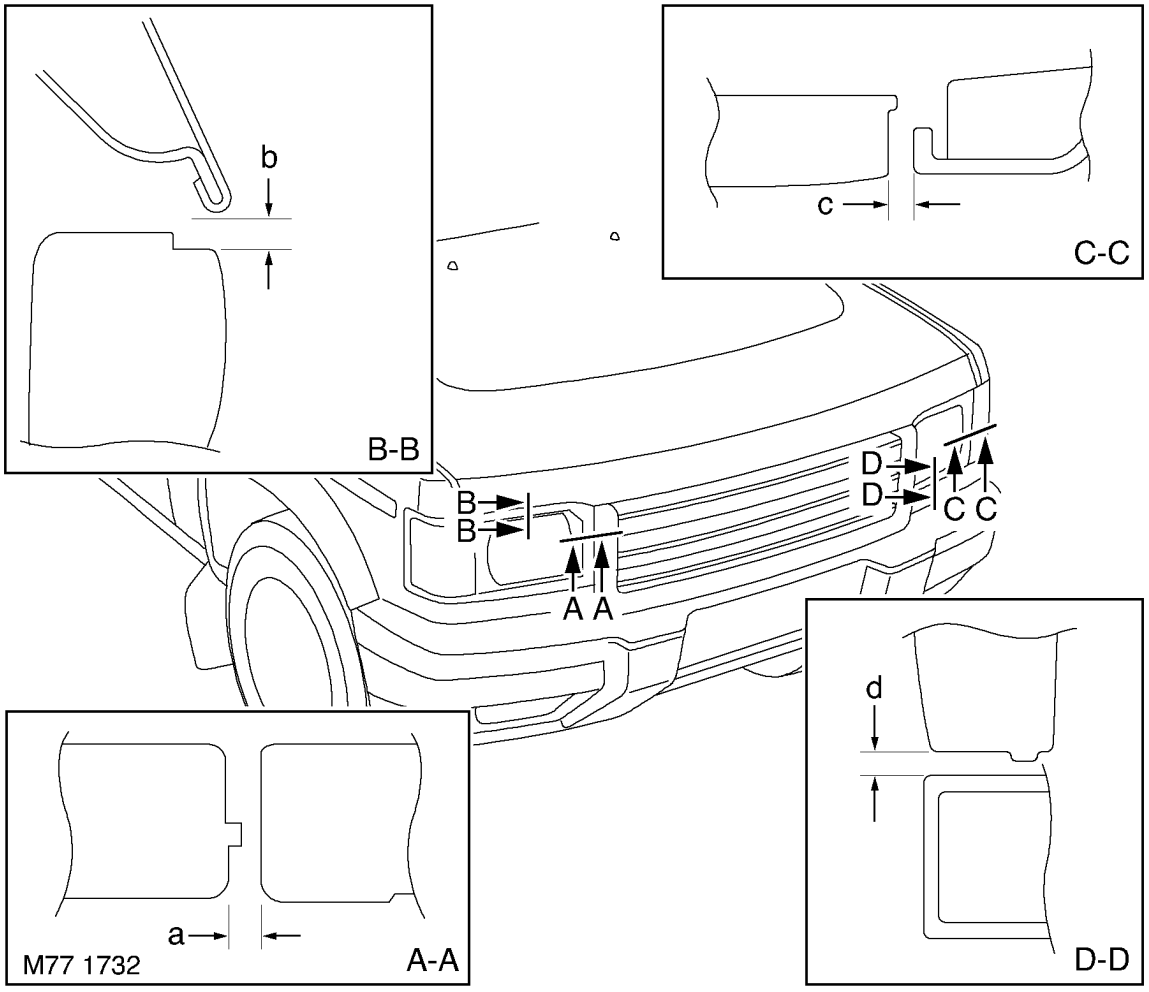
M77 1758A

I.D	Description	Length
A	Distance between taildoor setting block, jig location hole and taildoor bottom hinge, middle fixing hole	1364.4 (53.716)
B	Distance between taildoor setting block, jig location hole and taildoor top hinge, middle fixing hole	1319.8 (51.960)
C	Distance between crossmember outer rear panel, jig location hole and rear headrest fixing hole	1413 (55.629)

Gaps and profiles

Figures shown outside brackets are metric measurements (millimetres) and those inside brackets are imperial measurements (inches).

Front end information

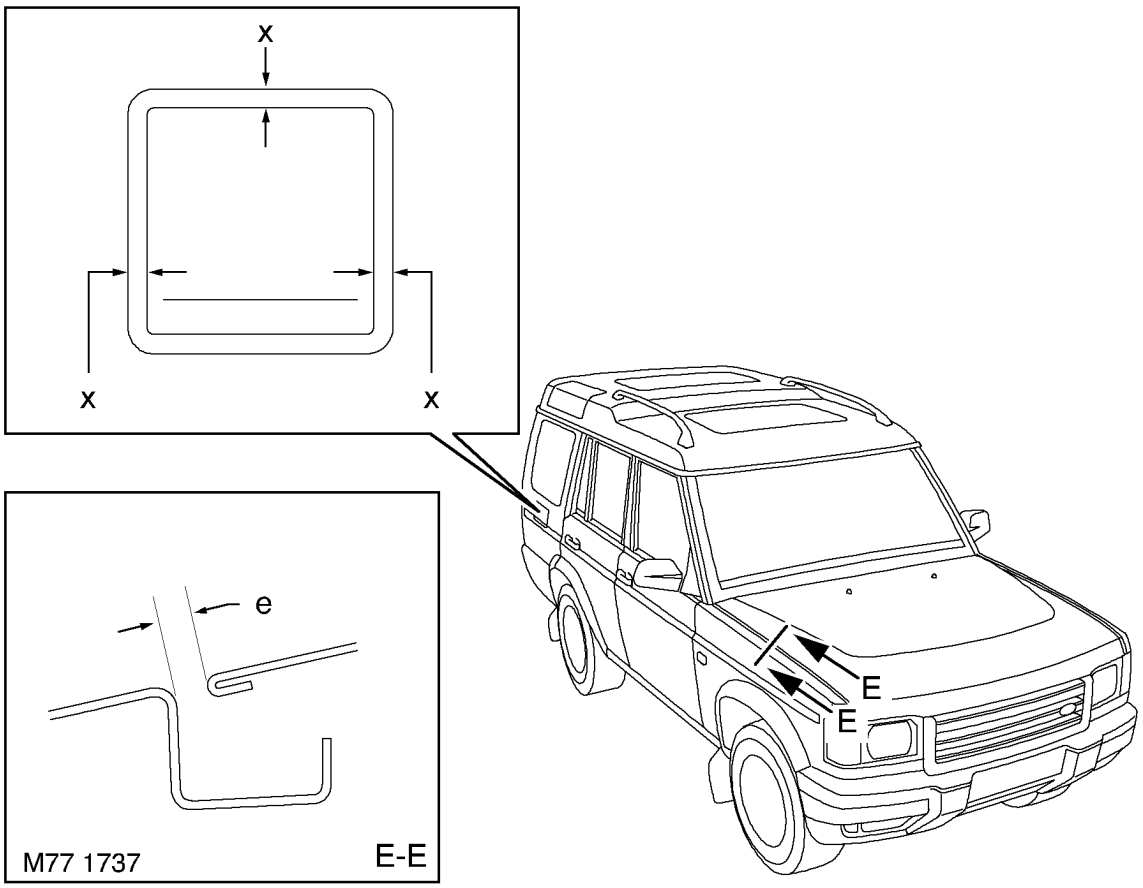


Gaps

Section	Gap	Description	Dimension
A-A	a	Headlamp to grille	9.5 (0.374)
B-B	b	Headlamp to bonnet	14.0 (0.551)
C-C	c	Headlamp to indicator lamp	6.0 (0.236)
D-D	d	Headlamp to headlamp surround panel	9.5 (0.374)

The tolerance for the above figures is ± 1.0 (0.039).

Front end/side information



Gaps

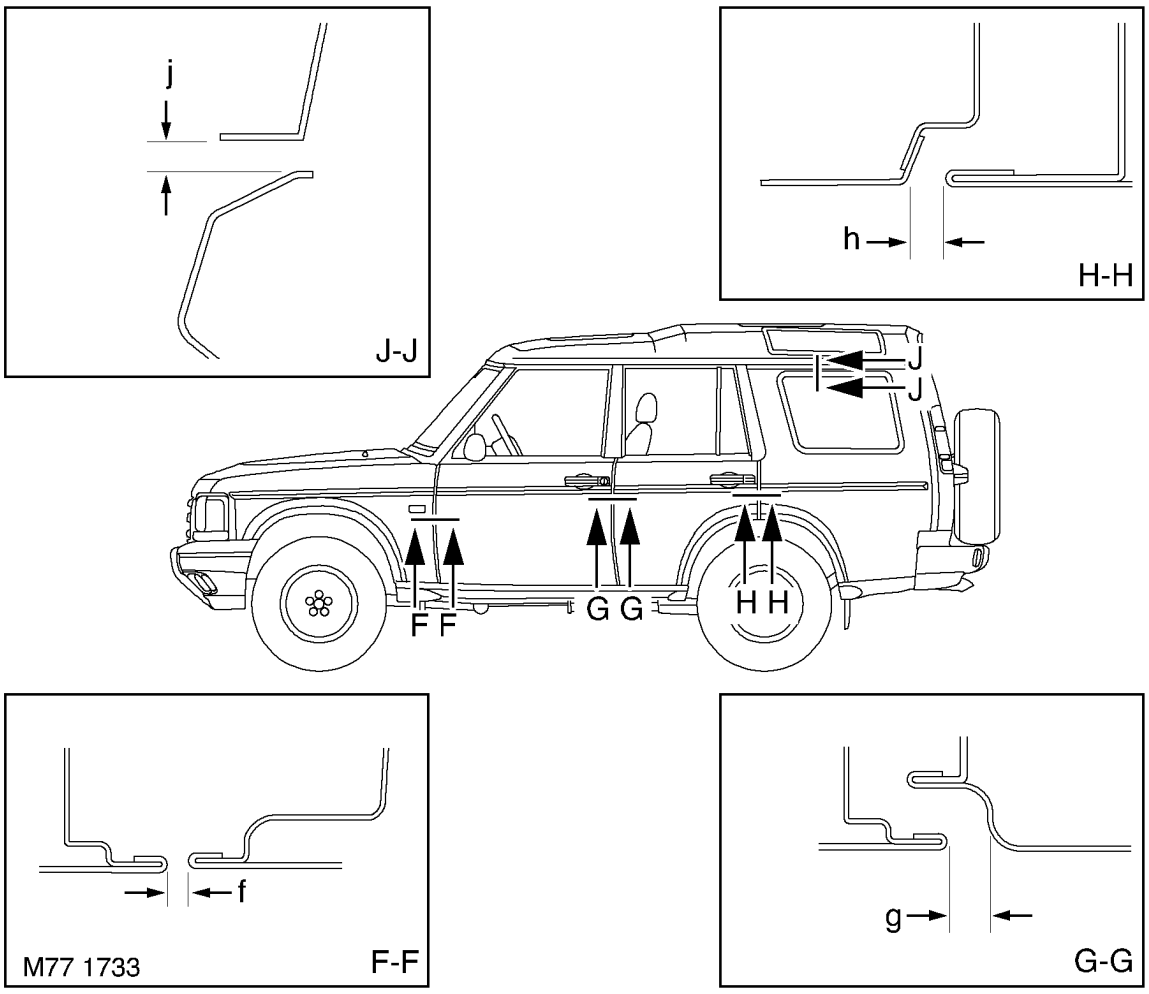
Section	Gap	Description	Dimension
E-E	e	Bonnet to wing	6.0 (0.236)
	x	Fuel filler lid to body side panel	3.0 (0.118)

The tolerance for gap **'e'** is ± 1.0 (0.039), and for gap **'x'** is ± 0.5 (0.019).

Profile

Section	Description	Dimension
E-E	Profile of bonnet to wing	+1.0 (0.039) -0.0

Side information



Gaps

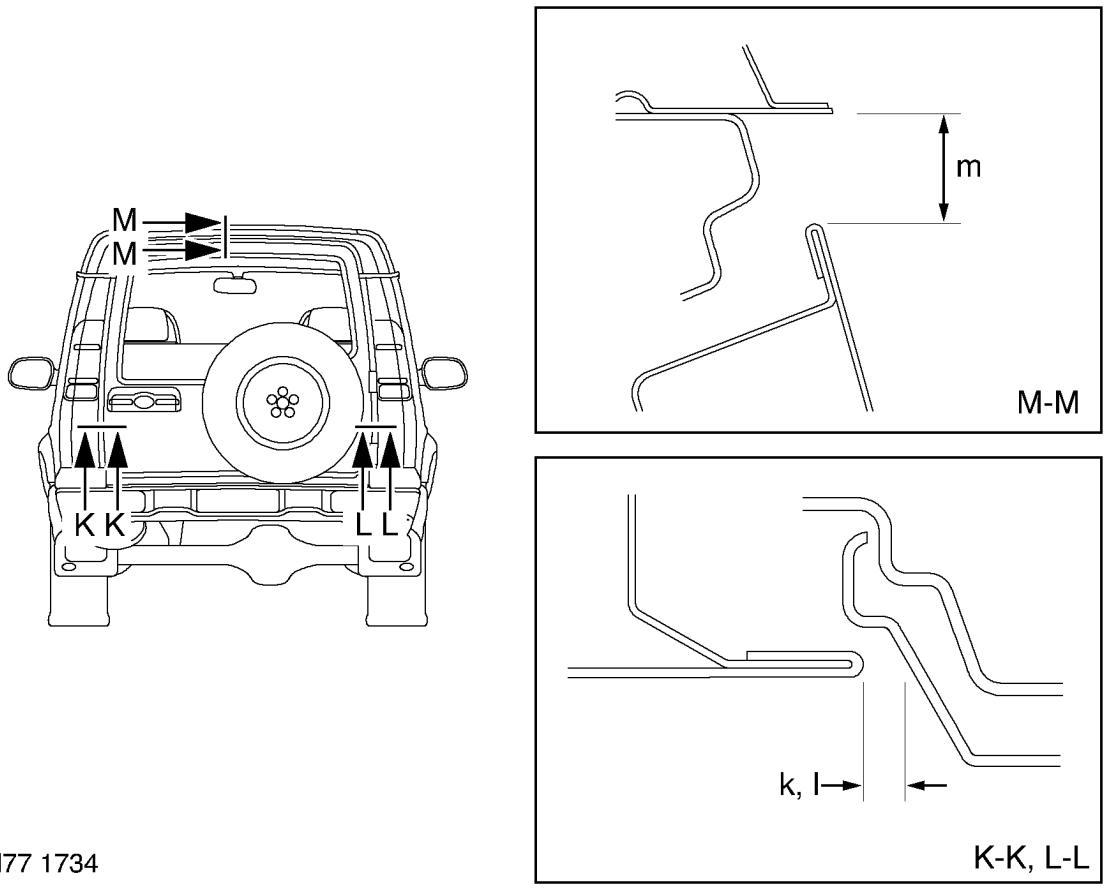
Section	Gap	Description	Dimension
F-F	f	Wing to front door	6.0 (0.236)
G-G	g	Front door to rear door	6.0 (0.236)
H-H	h	Rear door to panel body side	6.0 (0.236)
J-J	j	Panel body side to roof	3.0 (0.118)

The tolerance for gap 'f', 'g' and 'h' is ± 1.0 (0.039), and for gap 'j' is ± 2.0 (0.078).

Profiles

Section	Description	Dimension
F-F	Profile of wing to front door	+1.0 (0.039) -0.0
G-G	Profile of front door to rear door	+1.0 (0.039) -0.0
H-H	Profile of rear door to panel body side	+1.0 (0.039) -0.0

Rear end information



M77 1734

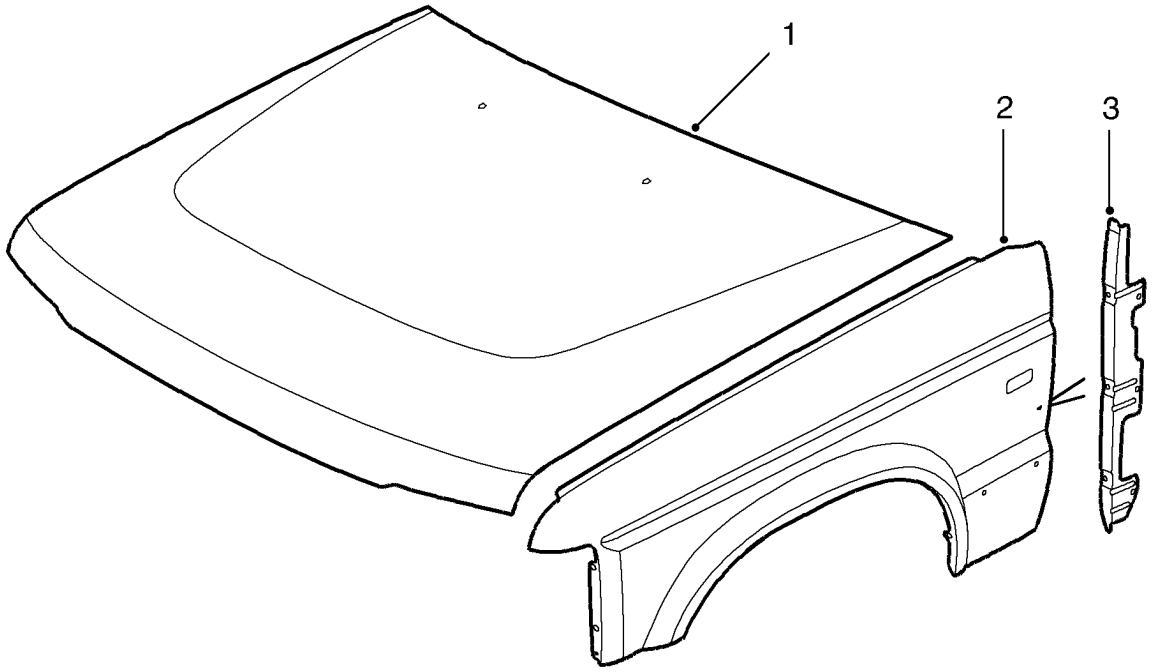
Gaps

Section	Gap	Description	Dimension
K-K	k	Taildoor to body side panel	7.0 (0.275)
L-L	l	Taildoor to body side panel	7.0 (0.275)
M-M	m	Taildoor to roof	23.0 (0.905)

The tolerance for gap 'k' and 'l' is ± 1.0 (0.039), and for gap 'm' is ± 2.0 (0.078).

Replacement panels

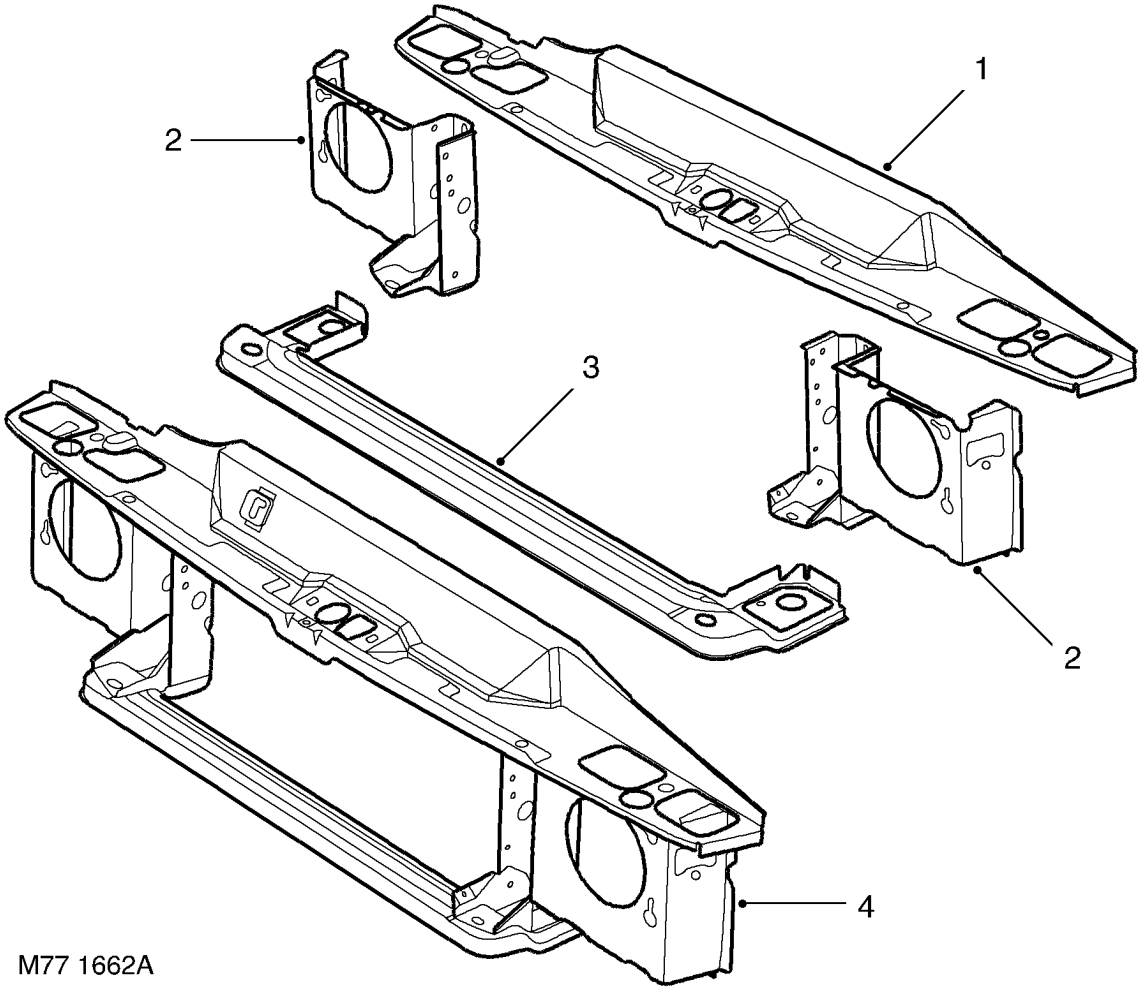
Front end outer panels



M77 1661A

1 Bonnet assembly
2 Front wing
3 Wing support bracket

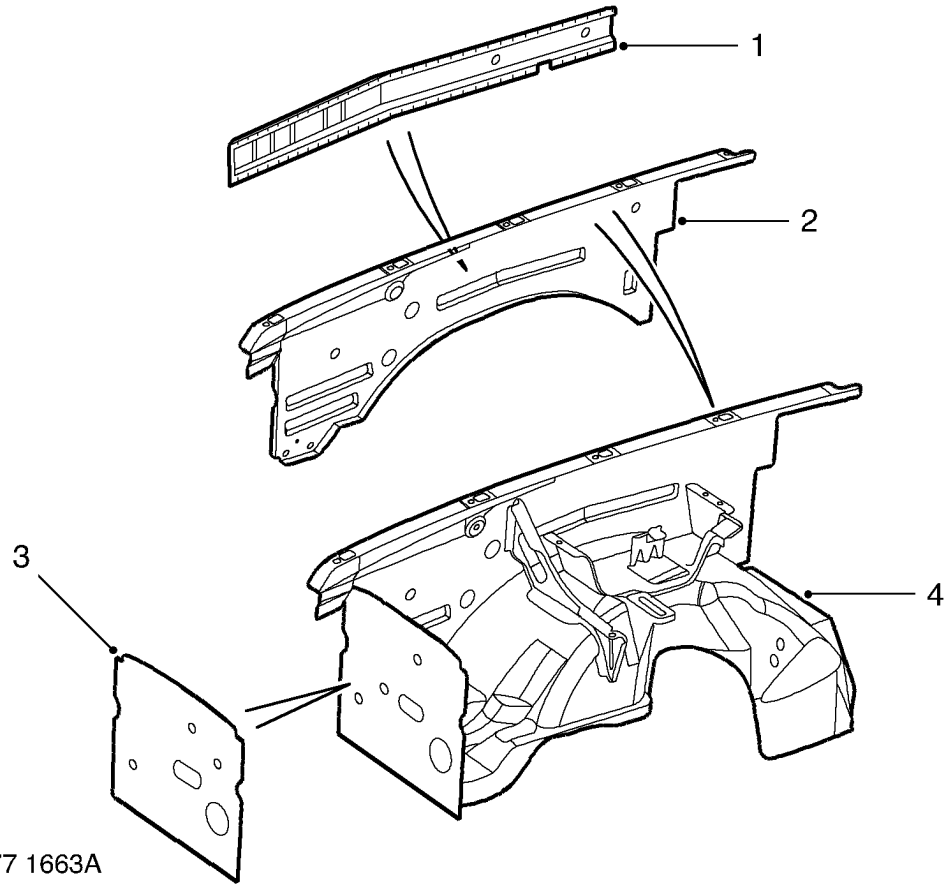
Front end inner panels



M77 1662A

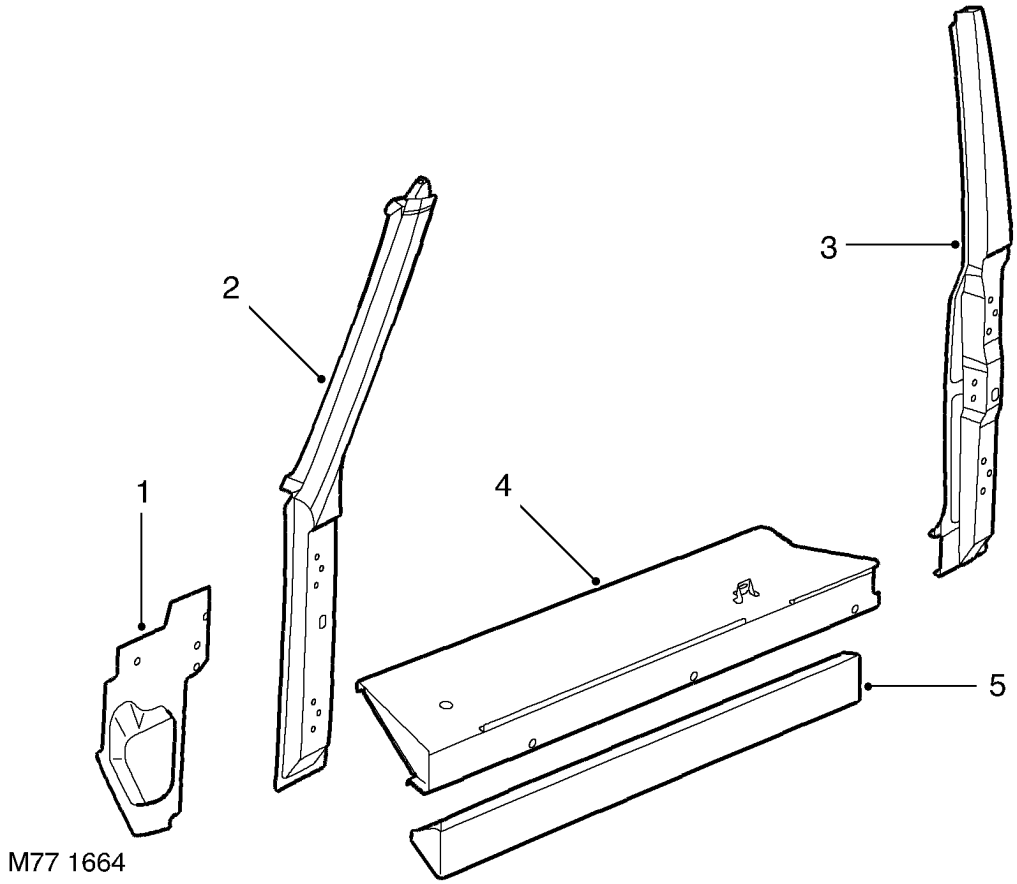
1 Bonnet locking platform
2 Headlamp mounting panels
3 Front crossmember
4 Front bulkhead assembly

Valance panels



1 Reinforcement valance outer
2 Valance upper assembly
3 Headlamp closing panel
4 Front valance assembly

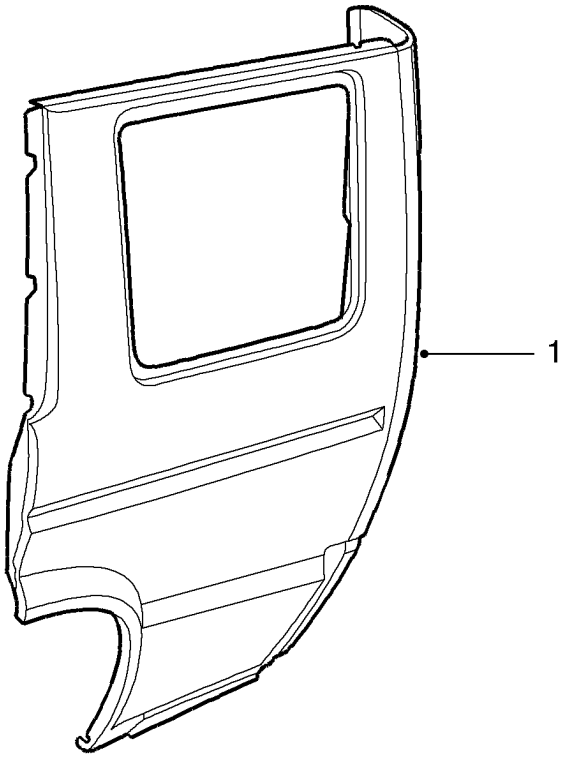
Body side panels



M77 1664

1 Dash side assembly
2 'A' post assembly
3 'B/C' post assembly
4 Sill inner assembly
5 Sill outer assembly

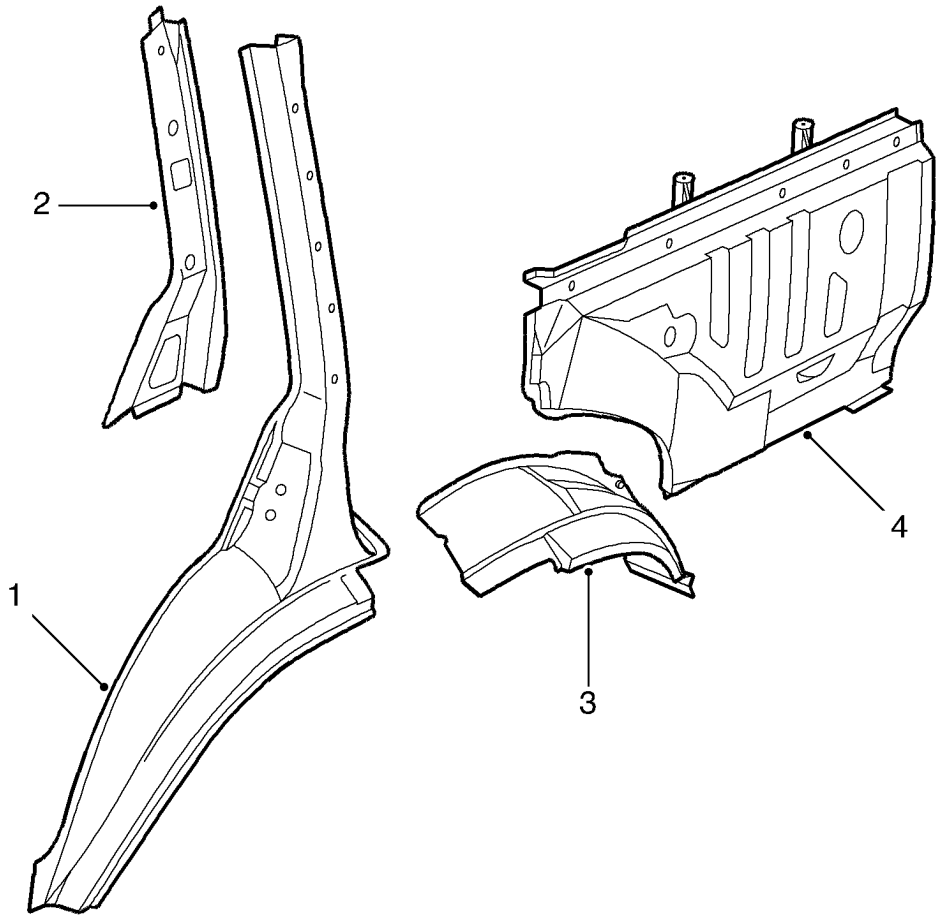
Body side assembly



M77 1679

1 Panel body side assembly

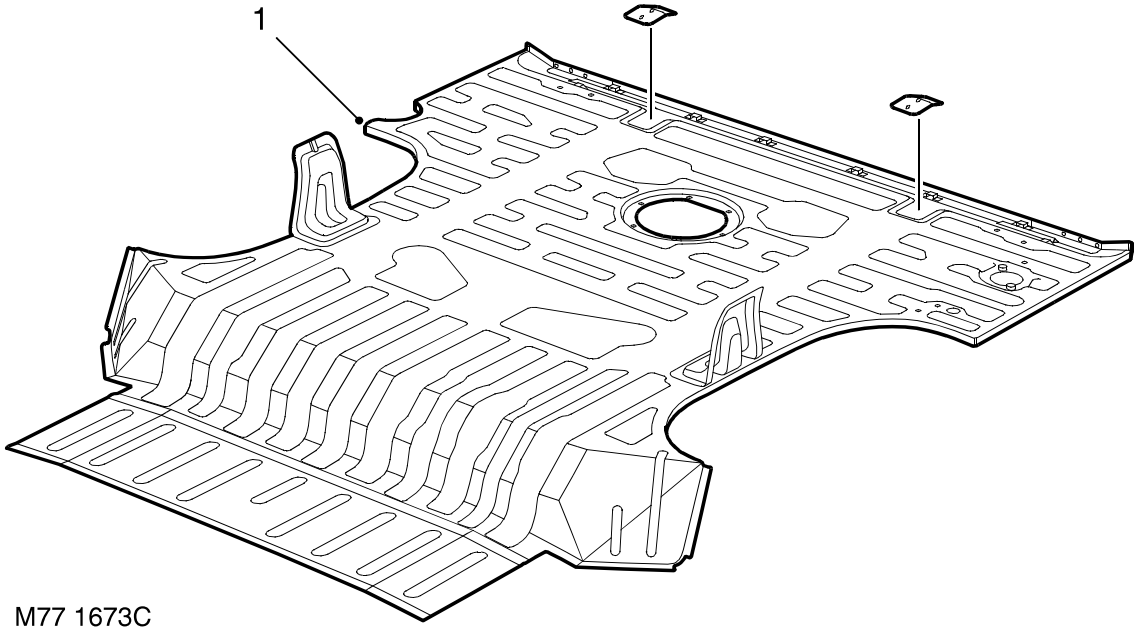
'D'-post assembly



M77 1678

1 'D' post outer assembly
2 'D' post closing assembly
3 Wheelarch rear outer assembly
4 Bodyside inner rear assembly

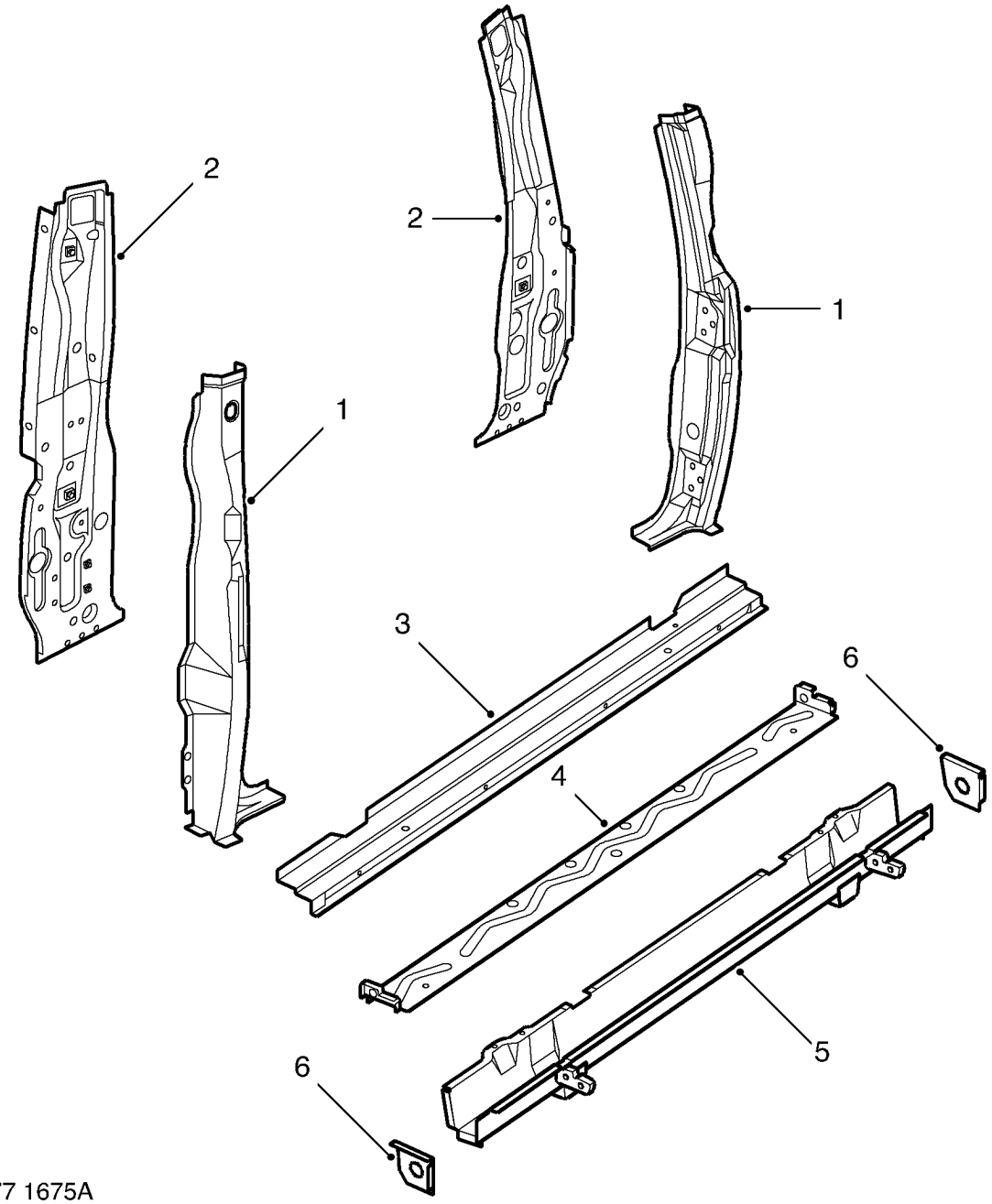
Rear floor assembly.



M77 1673C

1 Rear floor assembly

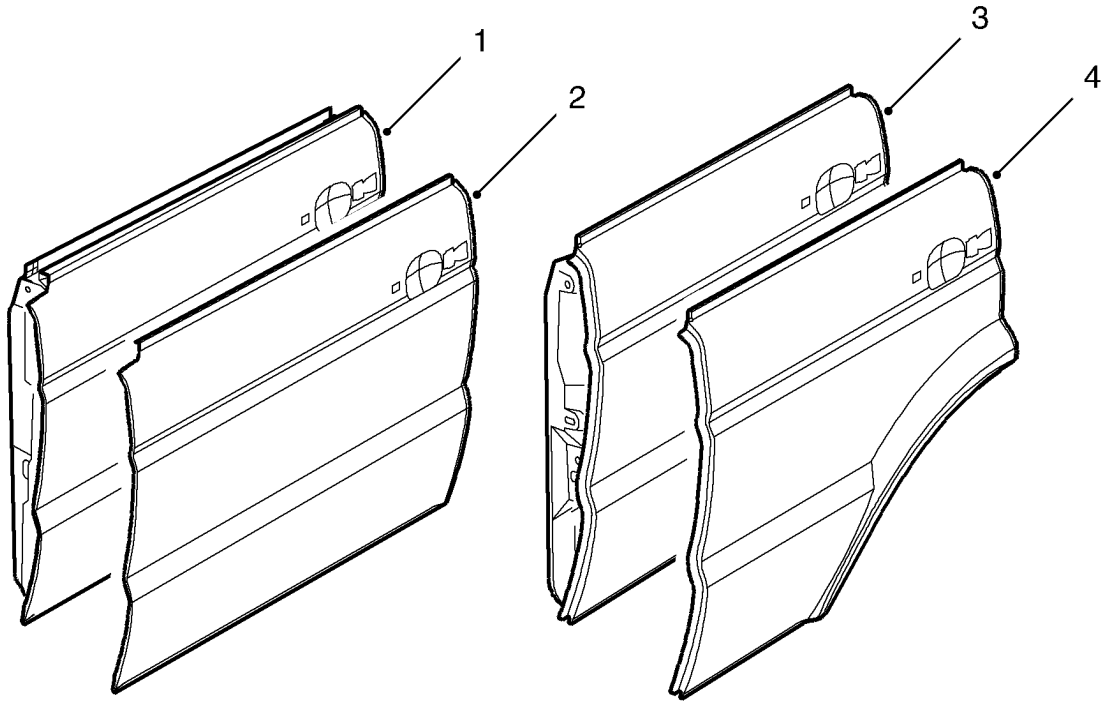
Rear end panels



M77 1675A

1 'E' post assemblies
2 'E' post closing assemblies
3 Crossmember outer rear panel
4 Crossmember closing rear panel
5 Crossmember rear assembly
6 Crossmember closing rear brackets

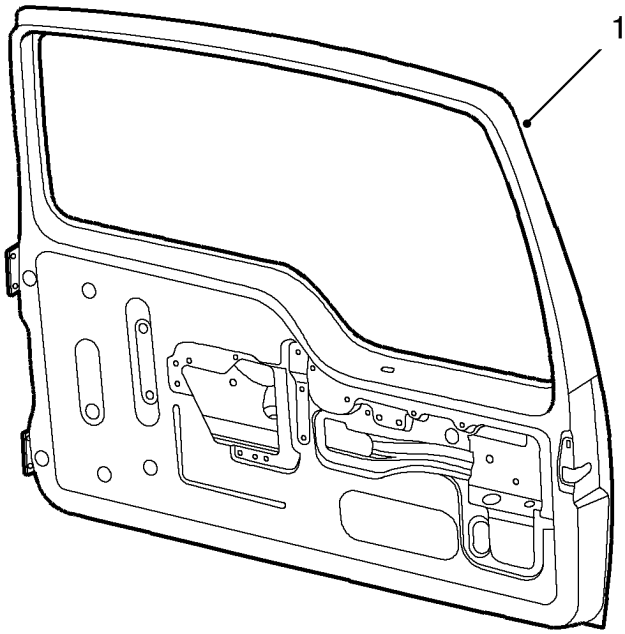
Front and rear doors



M77 1676

1 Front door assembly
2 Front door skin panel
3 Rear door assembly
4 Rear door skin panel

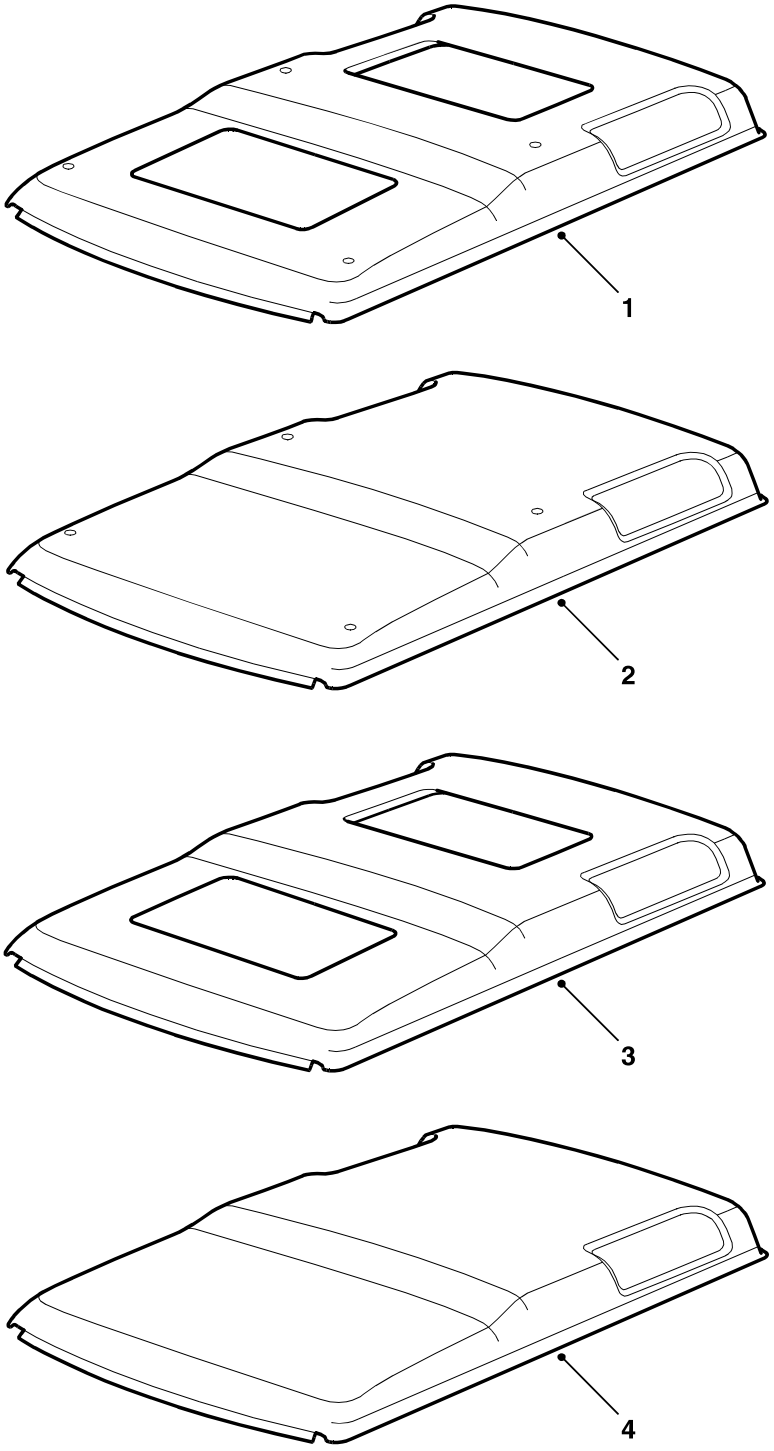
Taildoor



M77 1677A

1 Taildoor complete assembly

Roof panels



M77 1674A

1 Roof panel with sunroofs and roof bar holes
2 Roof panel with roof bar holes only
3 Roof panel with sunroofs only
4 Roof panel

Replacement panels

The previous illustrations show some of the service panels which feature in the Body Repairs procedures. Additional panels and full body shells are also available. **See Parts Fiche for details.**

General welding precautions

General
For ease of reference, the diagrams on the following pages show only the type of weld used in repair where it varies from that used in production.

The replacement welds in the welding diagrams are denoted by the following symbols:

77M1657

a = Single/Multiple thickness plug welds
b = MIG seam weld

When NOT carrying out welding operations the following criteria must be observed:

- Where resistance spot welds have been used in production, these must be reproduced with new spot welds in replacement where possible. All such reproduction spot welds must be spaced 30 mm (1.181 in) apart;
- When spot welding, it is recommended that test coupons of the same metal gauges and materials are produced to carry out peel tests to ensure that welding equipment being used can produce a satisfactory joint. Plug welds must be used if a satisfactory spot weld cannot be produced;
- The electrode arms on hand-held spot welding guns must not exceed 300 mm (11.811 in) in length;
- Single-side spot welding is not acceptable;
- Brazing and gas welding are not acceptable EXCEPT where they have been specified in production;
- Where 3 metal thicknesses or more are to be welded together it is imperative to use MIG plug welds to ensure joint strength;
- MIG plug welds must be used in repair joints where there is no access for a resistance spot welder. To replace each production spot weld a hole must be drilled and/or punched, and a MIG plug weld then made in its place. The number of plug welds must match exactly the number of spot welds which have been removed;
- Where holes are left in an existing panel after removal of the spot welds, a single MIG plug weld will be made in each hole as appropriate.

Seat belt anchorages
Seat belt anchorages are safety critical. When making repairs in these areas, it is essential to follow design specifications. Note that High Strength Low Alloy (HSLA) steel may be used for seat belt anchorages.

Where possible, the original production assembly should be used, complete with its seat belt anchorages, or the cut line should be so arranged that the original seat belt anchorage is not disturbed.

All welds within 250 mm (9.842 in) of seat belt anchorages must be carefully checked for weld quality, including spacing of spot welds.

Electronic control units

The electronic control units (ECU) fitted to vehicles make it advisable to follow suitable precautions prior to carrying out welding repair operations. Harsh conditions of heat and vibration may be generated during these operations which could cause damage to the units.

In particular, it is essential to follow the appropriate precautions when disconnecting or removing the airbag DCU.

Supplementary Restraint System Precautions
Any work undertaken which involves the removal or replacement of any item of the Supplementary Restraint System (SRS), requires extreme caution and the appropriate precautions must be followed.
☞ **GENERAL INFORMATION, Supplementary Restraint System Precautions.**

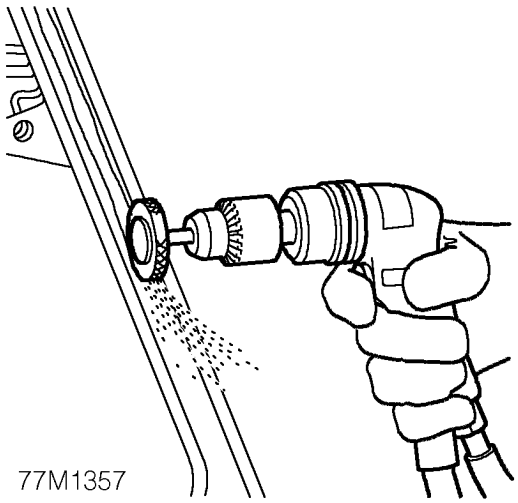
Equipment
Prior to commencing any test procedure on the vehicle, ensure that the relevant test equipment is working correctly and any harness or connectors are in good condition. This particularly applies to electronic control units.

Panel replacement procedure

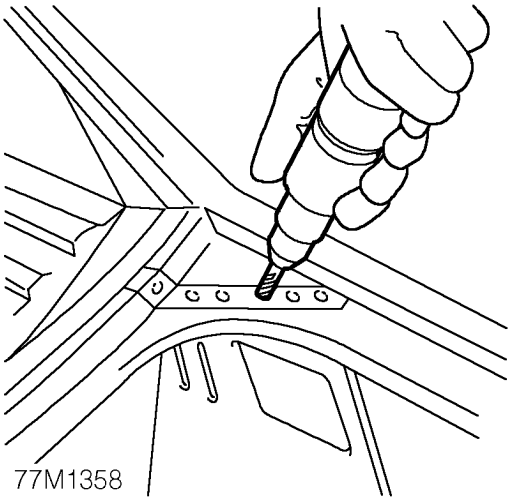
This procedure is designed to explain the basic panel removal and replacement method. The main criterion in removal and replacement of body panels is that the original standard is maintained as far as possible. While individual repairs will differ in detail, this procedure has been devised placing emphasis on ease of repair and the elimination of unnecessary work.

Body panels are being increasingly manufactured in high strength steels to meet design requirements for safety and weight saving. As panels in high strength steels cannot be visually identified, and as they are more sensitive to excess heat than panels manufactured from low carbon steel, it is advisable that the following procedure be observed at all times.

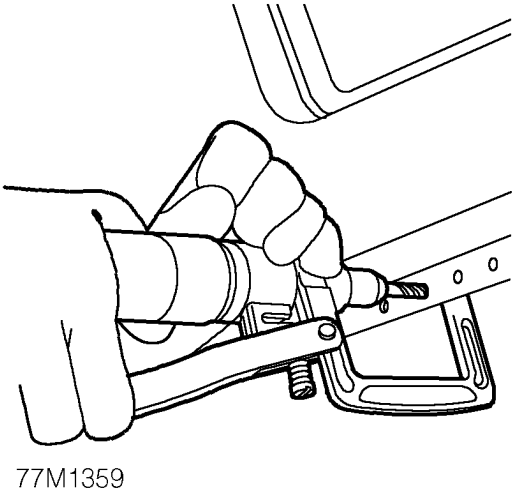
Remove panel



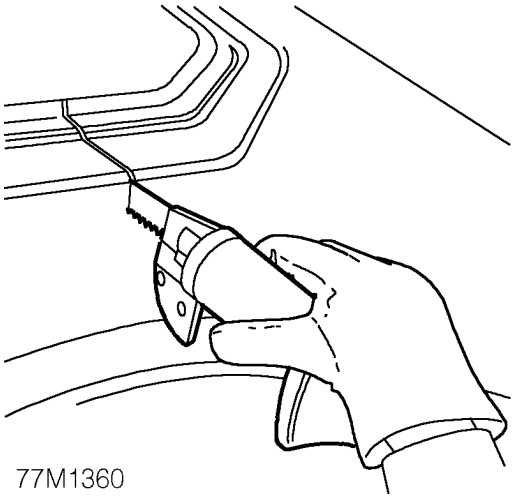
1. Expose resistance spot welds. For those spot welds which are not obviously visible, use a rotary impregnated wire brush fitted to an air drill, or alternatively a hand held wire brush.
   NOTE: In wheel arch areas it may be necessary to soften underbody coating, using a hot air gun, prior to exposing spot welds.



2. Cut out welds using a cobalt drill.



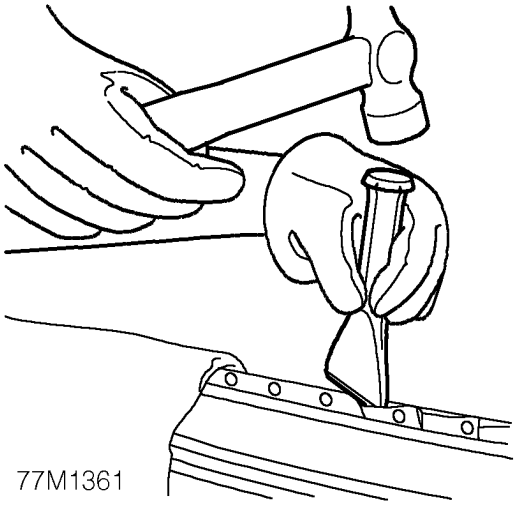
3. Alternatively, use a clamp-type spot weld remover.



77M1360

4. Cut away the bulk of the panel as necessary using an air saw.

   NOTE: On certain panel joints MIG welds and braze should be removed using a sander where possible, before cutting out the panel bulk.



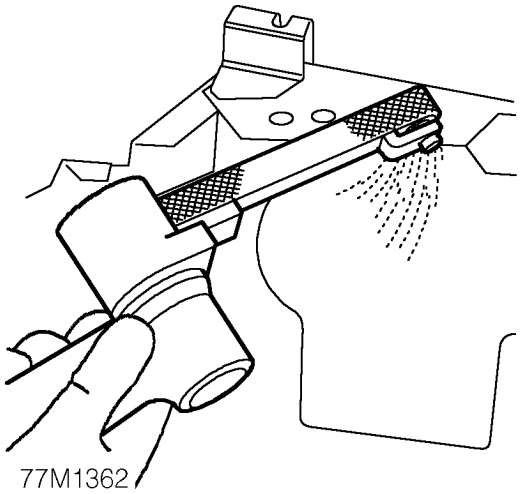
77M1361

5. Separate spot welded joints and remove panel remnants using hammer, bolster chisel and pincers.

Prepare old surfaces

1. Remove any remaining sealant using a hot air gun to minimise the risk of toxic fumes caused by heat generated during welding.

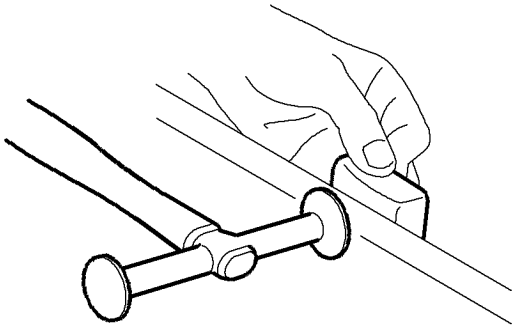
   CAUTION: Care must be taken to avoid excessive heat build-up when using the hot air gun.



77M1362

2. Clean all panel joint edges to a bright smooth finish, using a belt-type sander.

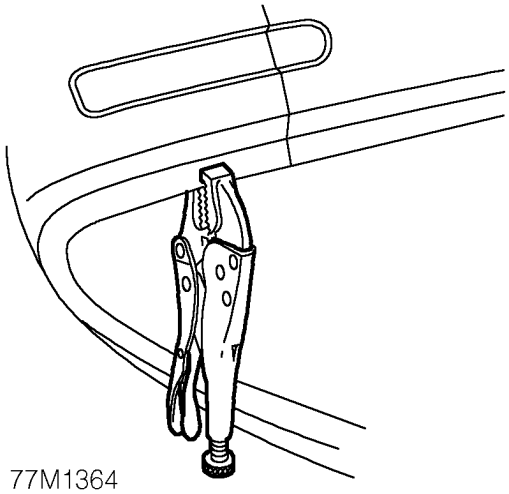
   NOTE: As an alternative, a disc sander may be used.



M77 1720

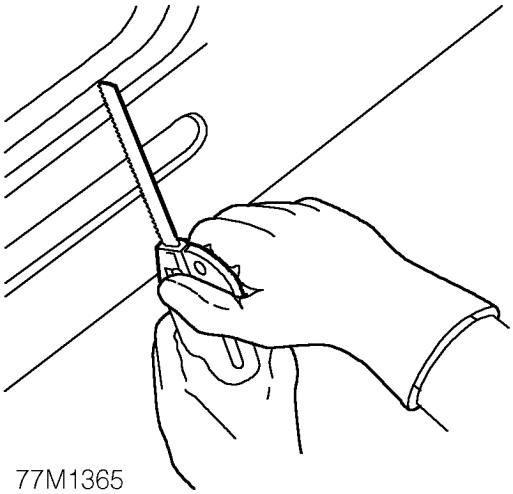
3. Straighten existing panel joint edges using a shaping block and hammer.

Prepare new surfaces



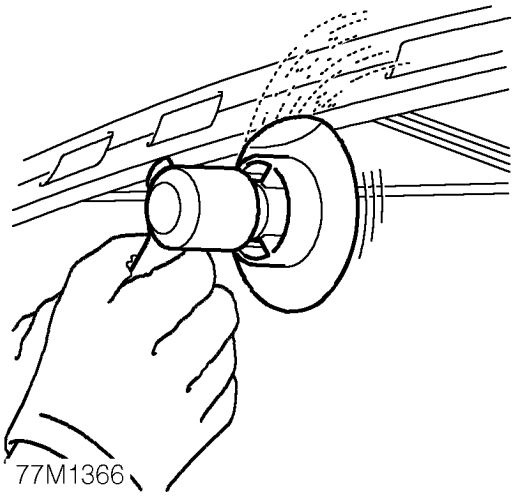
77M1364

1. Mark out bulk of new panel and trim to size, leaving approximately 50 mm (1.968 in) overlap with existing panel. Offer up new panel/section, align with associated panels (e.g. new body side panel aligned with door and taildoor). Clamp into position.



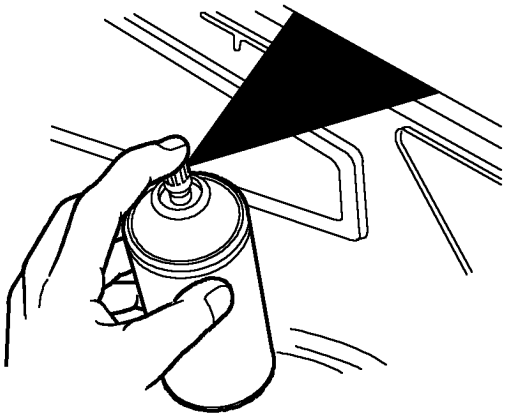
77M1365

2. Cut new and existing panels as necessary to form butt, joggle or brace joint as required. Remove all clamps and metal remnants.



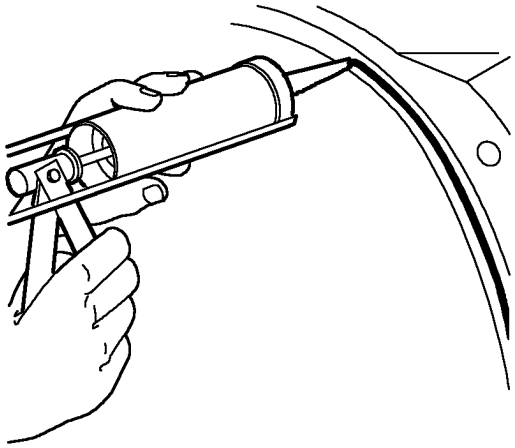
77M1366

3. Prepare new panel joint edges for welding by sanding to a bright finish. This must include inner as well as outer faces.



77M1367

4. Apply suitable weld-through primer, to panel joint surfaces to be welded, using brush or aerosol can.



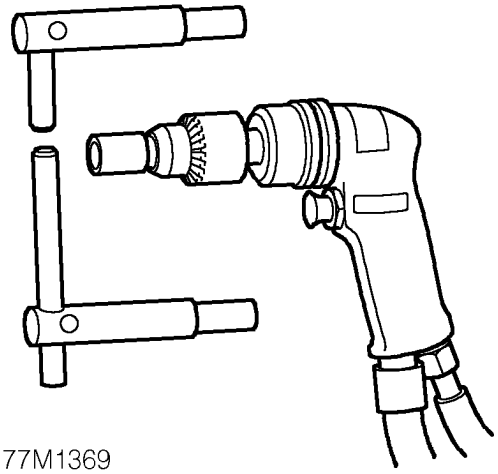
77M1368

5. Apply correct sealant or adhesive, as applicable, to panel joint surfaces.
   ☞ **CORROSION PREVENTION AND SEALING, SEALING, Body Sealing.**

Offer up and align

1. Offer up new panel and align with associated panels. Clamp into position using welding clamps or Mole grips. Where a joggle or brace joint is being adopted, make a set in the original panel joint edge or insert a brace behind the joint.
   NOTE: In cases where access for welding clamps is difficult, it may be necessary to use tack welds.

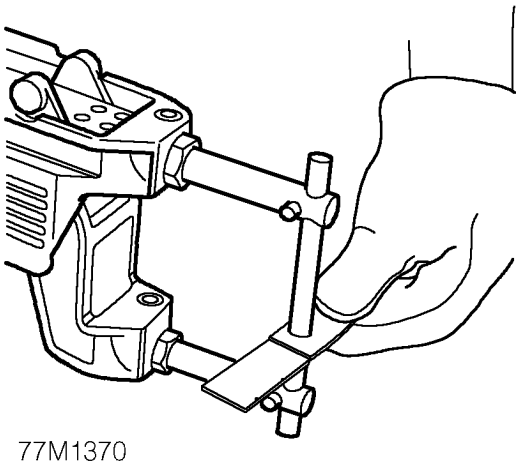
Welding



77M1369

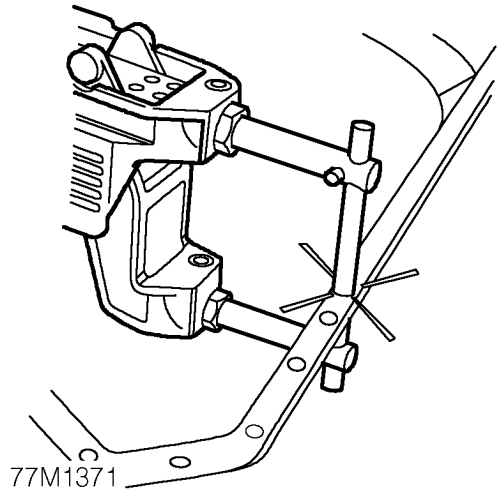
1. Select arms for resistance spot welding and shape electrode tips using a tip trimmer.
   CAUTION: Use arms not exceeding 300 mm (11.81 in) in length.

   NOTE: To maintain weld efficiency, the tips will require regular cleaning and dressing.

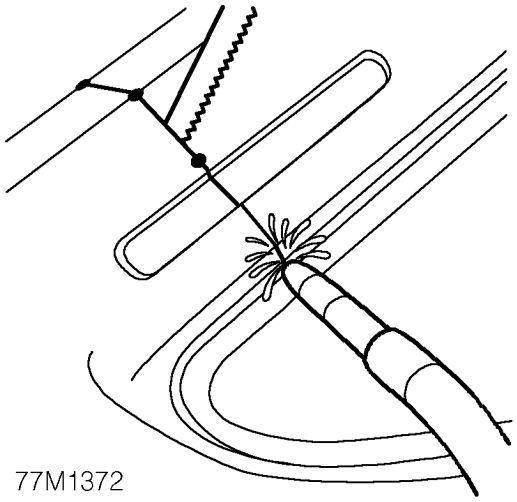


77M1370

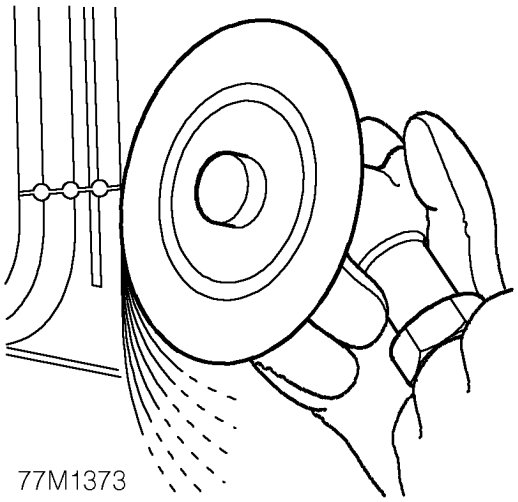
2. Fit resistance spot welding arms and test equipment for satisfactory operation, using test coupons. Where monitoring equipment is not available, verify weld strength by checking that metal around the weld puddle pulls apart under tension during pulling.



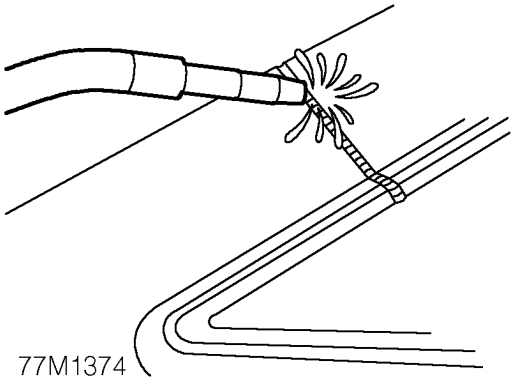
3. Use a resistance spot welder where access permits. Try to ensure weld quality by using a welding monitor where possible.



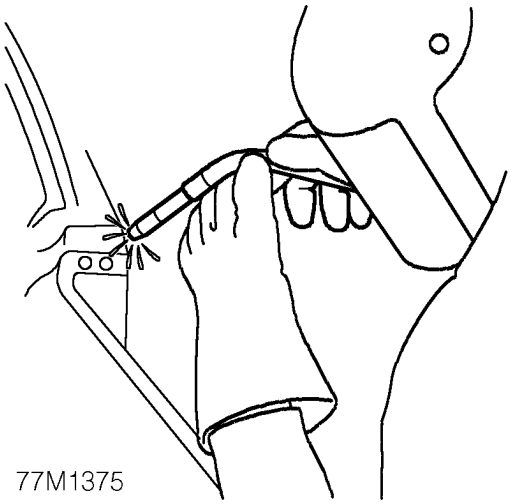
4. MIG tack weld butt joints and re-check alignment and panel contours where necessary. Ensure that a gap is maintained to minimise welding distortion, by inserting a hacksaw blade as an approximate guide.



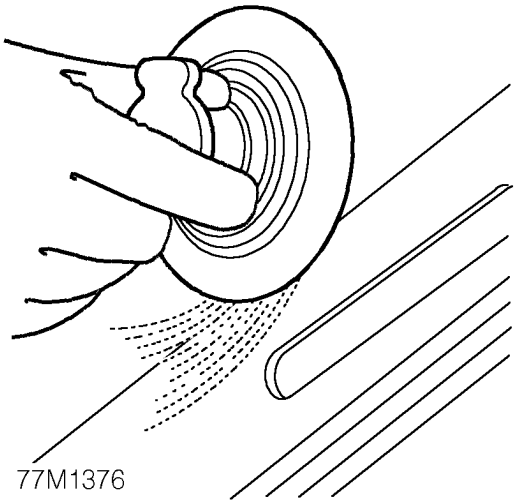
5. Dress MIG tack welds using a sander with 36 grit disc, or a belt-type sander where access is limited.



6. MIG seam weld butt joints.



7. Always use MIG plug welds where excessive metal thickness or limited access make resistance spot welding impractical. Make plug welds either by using holes left by the spot weld cutter, or through holes punched and drilled for the purpose.



8. Dress all welds using either a sander with 36 grit disc, or a belt-type sander and/or impregnated wire brush.

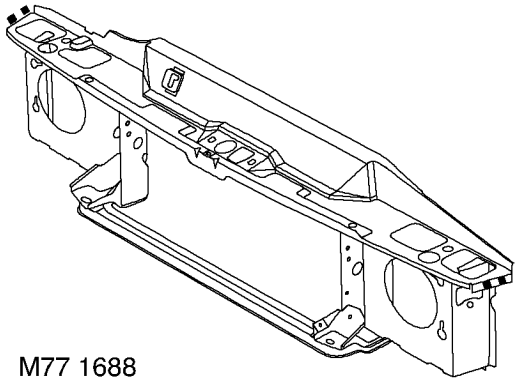
NOTE: Brazing operations, if required, must be carried out at this point.

Front bulkhead assembly

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove washer reservoir.
   ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**
5. **Models with A/C:** Remove condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
6. **Diesel models:** Remove gearbox fluid cooler.
7. Remove RH and LH headlamps.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
8. Release headlamp levelling motors and position aside.
9. Release headlamp wiring and position aside.
10. Remove battery.
    ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
11. Remove battery tray.
12. Remove air filter assembly.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
13. Remove 2 earth leads from LH of front bulkhead.
14. Remove RH horn.
    ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
15. **Models with A/C:** Release and remove A/C pipes.
16. Remove RH and LH crush cans.
17. Remove bonnet release cable.
18. Support bonnet in open position
19. Remove bonnet locking mechanism.
20. Remove VIN plate.
21. Remove 2 bolts securing front bulkhead assembly to chassis.
22. Remove centre braces.

Repair



M77 1688

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit centre braces.
2. Fit 2 bolts securing bulkhead to chassis and tighten to 45 Nm (33 lbf.ft).
3. Fit VIN plate.
4. Fit bonnet locking mechanism.
5. Fit bonnet release cable.
6. Fit crush cans.
7. **Models with A/C:** Fit A/C pipes.
8. Fit RH horn.
   ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
9. Fit 2 earth leads to LH of front bulkhead.
10. Fit air filter assembly.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
11. Fit battery tray.
12. Fit battery. Do not connect leads.
    ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
13. Fit headlamp wiring and headlamp levelling motors.
14. Fit RH and LH headlamps.
    ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
15. **Diesel models:** Fit gearbox fluid cooler.
16. **Models with A/C:** Fit condensor.
    ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
17. Fit washer reservoir.
    ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**

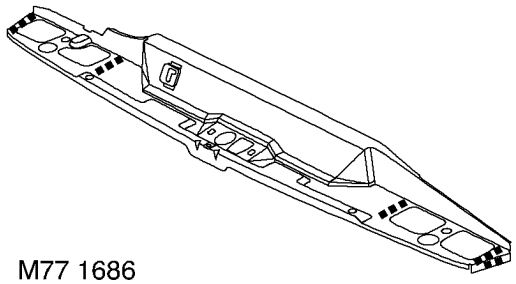
18. Fit front wing.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
19. Connect leads/multiplug to alternator.
20. Connect battery leads, negative lead last.

Bonnet locking platform

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
4. **Models with A/C:** Remove condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
5. **Diesel models:** Remove gearbox fluid cooler.
6. Remove RH and LH headlamps.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
7. Remove RH and LH repeater lamps.
   ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
8. Release headlamp wiring and position aside.
9. Remove battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
10. Remove battery tray.
11. Remove air filter assembly.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
12. Remove RH horn.
    ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
13. Remove bonnet release cable.
14. Support bonnet in open position
15. Remove bonnet locking mechanism.
16. Remove VIN plate.
17. Remove centre braces.

Repair



M77 1686

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

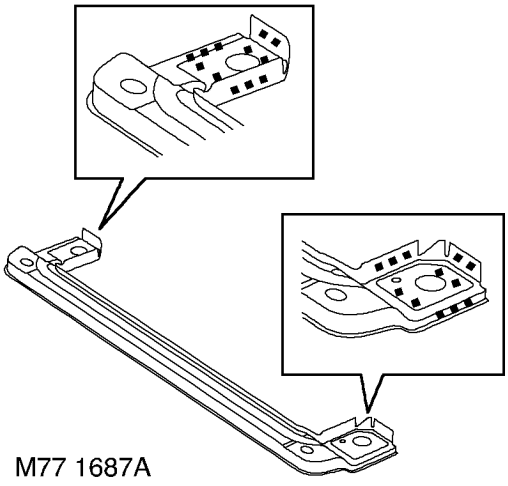
1. Fit centre braces.
2. Fit VIN plate.
3. Fit bonnet locking mechanism.
4. Fit bonnet release cable.
5. Fit RH horn.
   ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
6. Fit air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
7. Fit battery tray.
8. Fit battery. Do not connect leads.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
9. Fit headlamp wiring.
10. Fit RH and LH repeater lamps.
    ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
11. Fit RH and LH headlamps.
    ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
12. **Diesel models:** Fit gearbox fluid cooler.
13. **Models with A/C:** Fit condensor.
    ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
14. Fit bumper assembly.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
15. Connect leads/multiplug to alternator.
16. Connect battery leads, negative lead last.

Front cross member

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove washer reservoir.
   ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**
4. **Models with A/C:** Remove condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
5. **Diesel models:** Remove gearbox fluid cooler.
6. Remove RH and LH headlamps.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
7. Release headlamp levelling motors and position aside.
8. Release headlamp wiring and position aside.
9. Remove RH horn.
   ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
10. **Models with A/C:** Release and remove A/C pipes.
11. Remove RH and LH crush cans.
12. Remove 2 bolts securing front bulkhead assembly to chassis.
13. Remove centre braces.

Repair



M77 1687A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

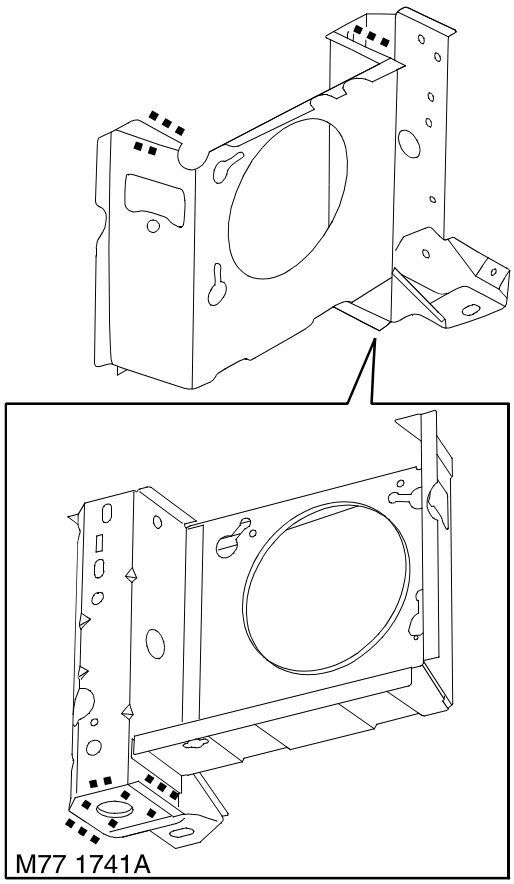
1. Fit centre braces.
2. Fit 2 bolts securing bulkhead to chassis and tighten bolts to 45 Nm (33 lbf.ft).
3. Fit crush cans.
4. **Models with A/C:** Fit A/C pipes.
5. Fit RH horn.
   ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
6. Fit headlamp wiring and headlamp levelling motors.
7. Fit RH and LH headlamps.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
8. **Diesel models:** Fit gearbox fluid cooler.
9. **Models with A/C:** Fit condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
10. Fit washer reservoir.
    ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**
11. Connect leads/multiplug to alternator.
12. Connect battery leads, negative lead last.

Headlamp mounting panel - RH

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
4. **Models with A/C:** Remove condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
5. **Diesel models:** Remove gearbox fluid cooler.
6. Remove RH headlamp.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
7. Remove RH repeater lamp.
   ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
8. Release headlamp levelling motor and position aside.
9. Release headlamp wiring and position aside.
10. Remove battery and battery tray.
    ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
11. Remove horn.
    ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
12. Remove RH crush can.
13. Remove 2 bolts securing front bulkhead assembly to chassis.
14. Remove RH centre brace.

Repair


M77 1741A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

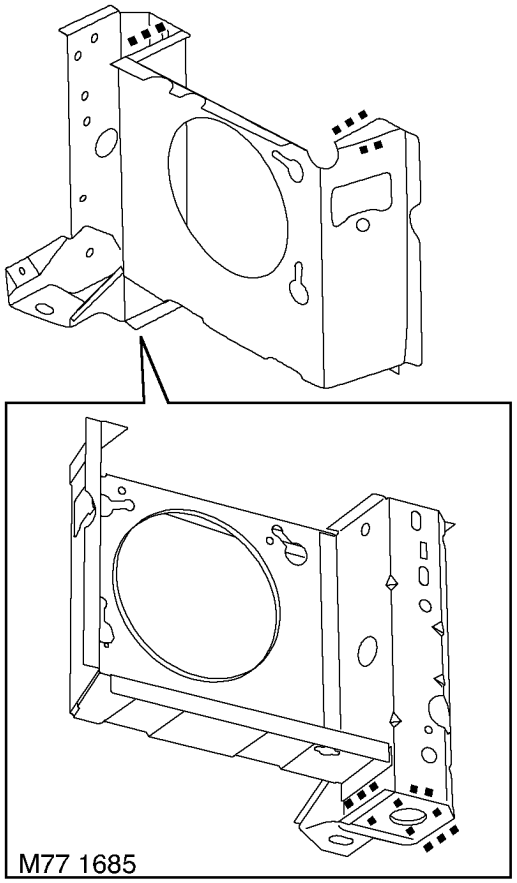
1. Fit centre brace.
2. Fit 2 bolts securing bulkhead to chassis and tighten bolts to 45 Nm (33 lbf.ft).
3. Fit crush can.
4. **Models with A/C:** Fit A/C pipes.
5. Fit horn.
   ☞ **ALARM SYSTEM AND HORN, REPAIR, Vehicle horn.**
6. Fit battery and battery tray. Do not connect leads.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
7. Fit headlamp wiring and headlamp levelling motors.
8. Fit repeater lamp.
   ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
9. Fit headlamp.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
10. **Diesel models:** Fit gearbox fluid cooler.
11. **Models with A/C:** Fit condensor.
    ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
12. Fit bumper assembly.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
13. Connect leads/multiplug to alternator.
14. Connect battery leads, negative lead last.

Headlamp mounting panel - LH

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove washer reservoir.
   ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**
4. **Models with A/C:** Remove condensor.
   ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
5. **Diesel models:** Remove gearbox fluid cooler.
6. Remove headlamp.
   ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
7. Remove repeater lamp.
   ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
8. Release headlamp levelling motor and position aside.
9. Release headlamp wiring and position aside.
10. Remove air filter assembly.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
11. Remove 2 earth leads from LH of front bulkhead.
12. Release and remove A/C pipes.
13. Remove crush can.
14. Remove bonnet release cable.
15. Remove 2 bolts securing front bulkhead assembly to chassis.
16. Remove centre brace.

Repair



1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit centre brace.
2. Fit 2 bolts securing bulkhead to chassis and tighten bolts to 45 Nm (33 lbf.ft).
3. Fit bonnet release cable.
4. Fit crush can.
5. **Models with A/C:** Fit A/C pipes.
6. Fit 2 earth leads to LH of front bulkhead.
7. Fit air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
8. Fit battery tray.
9. Fit headlamp wiring and headlamp levelling motors.
10. Fit repeater lamp.
    ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**

11. Fit headlamp.
    ☞ **LIGHTING, REPAIRS, Headlamp - up to 03MY.**
12. **Diesel models:** Fit gearbox fluid cooler.
13. **Models with A/C:** Fit condensor.
    ☞ **AIR CONDITIONING, REPAIRS, Condenser.**
14. Fit washer reservoir.
    ☞ **WIPERS AND WASHERS, REPAIRS, Reservoir - washer - up to 03MY.**
15. Connect leads/multiplug to alternator.
16. Connect battery leads, negative lead last.

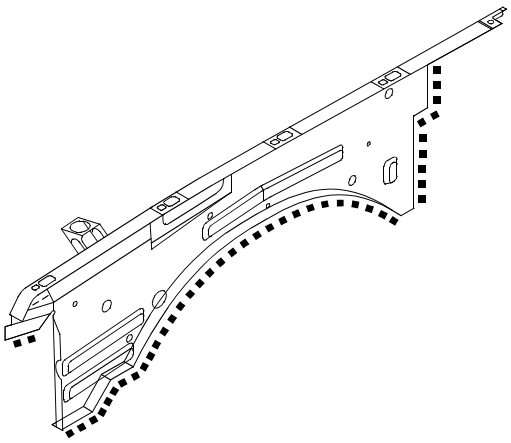
Valance upper assembly - LH

In this procedure, the front wing, the valance outer reinforcement and the bonnet alarm switch mounting bracket are replaced in conjunction with the LH valance upper assembly.

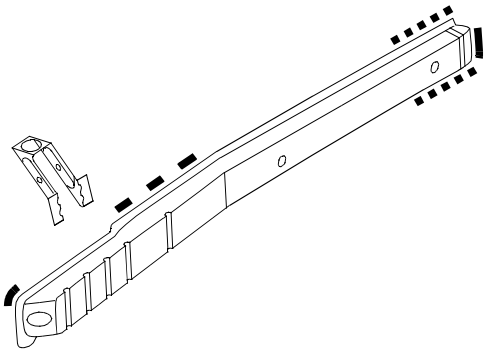
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
5. Remove PAS/ACE reservoir.
6. Remove ABS modulator.
   ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
7. Remove brake pipes from valance.
8. Release harness from valance and position aside.
9. **Models with A/C:** Depressurise A/C system and remove pipes from valance.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

Repair



M77 1743



M77 1690A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. **Models with A/C:** Fit A/C pipes and recharge A/C system.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
2. Fit harness to valance.
3. Fit brake pipes to valance.
4. Fit ABS modulator.
   ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
5. Fit PAS/ACE reservoir, refill fluids to correct levelsand bleed ACE system.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**
6. Fit air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
7. Fit front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
8. Connect leads/multiplug to alternator.
9. Connect battery leads, negative lead last.

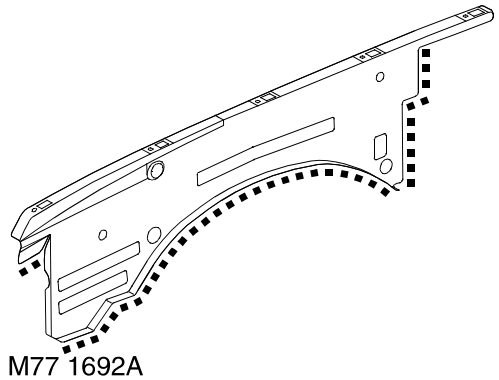
Valance upper assembly - RH

In this procedure, the front wing and the valance outer reinforcement are replaced in conjunction with the RH valance upper assembly.

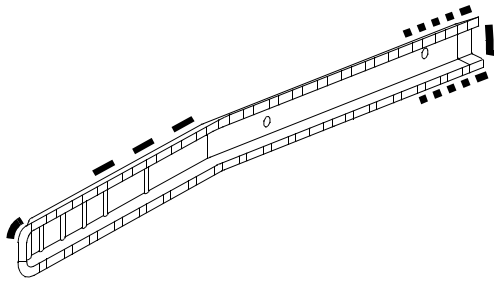
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
5. Remove battery tray.
6. Remove fuse box.
7. Release expansion tank from fixings and position aside.
8. Release harness from valance and position aside.

Repair



M77 1692A



M77 1750

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit harness to valance.
2. Fit and secure expansion tank to fixings.
3. Fit fuse box.
4. Fit battery tray.
5. Fit battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
6. Fit front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
7. Connect leads/multiplug to alternator.
8. Connect battery leads, negative lead last.

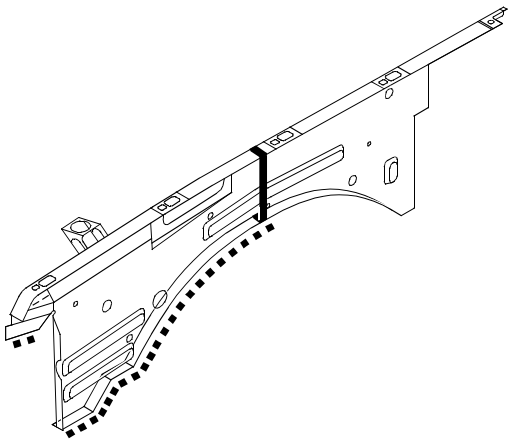
Valance upper assembly (front section) - LH

In this procedure, the front wing, the valance outer reinforcement (front section) and the bonnet alarm switch mounting bracket are replaced in conjunction with the LH valance upper assembly (front section).

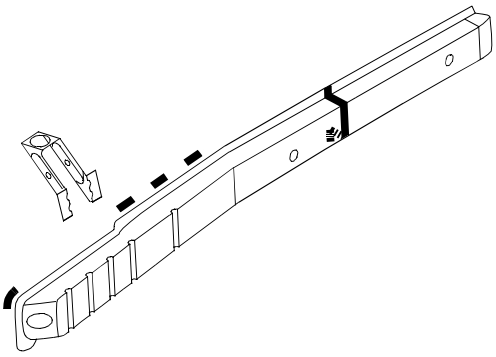
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
5. Remove PAS/ACE reservoir.
6. Remove ABS modulator.
   ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
7. Release harness from valance and position aside.
8. **Models with A/C:** Depressurise A/C system and remove pipes from valance.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

Repair



M77 1744



M77 1689A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. **Models with A/C:** Fit A/C pipes and recharge A/C system.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
2. Fit harness to valance.
3. Fit ABS modulator.
   ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
4. Fit PAS/ACE reservoir and refill fluids to correct levels.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, ACE hydraulic system bleeding.**
   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Fluids.**

5. Fit air filter assembly.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Air filter assembly.**
   ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
6. Fit front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
7. Connect leads/multiplug to alternator.
8. Connect battery leads, negative lead last.

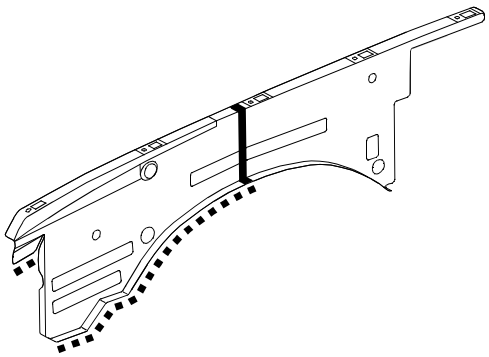
Valance upper assembly (front section) - RH

In this procedure, the front wing and the valance outer reinforcement (front section) are replaced in conjunction with the RH valance upper assembly (front section).

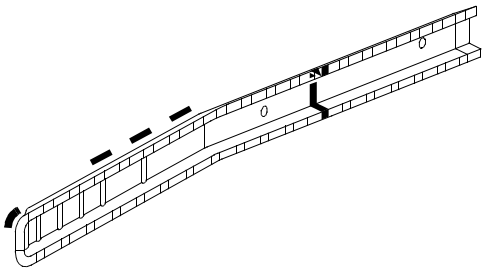
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
5. Remove battery tray.
6. Remove fuse box.
7. Release expansion tank from fixings and position aside.
8. Release harness from valance and position aside.

Repair



M77 1693A



M77 1749

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

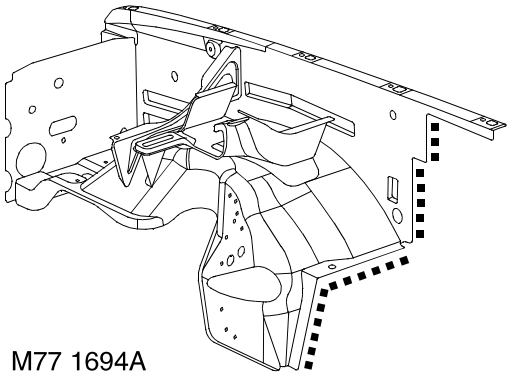
1. Fit harness to valance.
2. Fit and secure expansion tank to fixings.
3. Fit fuse box.
4. Fit battery tray.
5. Fit battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**
6. Fit front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
7. Connect leads/multiplug to alternator.
8. Connect battery leads, negative lead last.

Front valance assembly - RH

Remove

1. Disconnect battery eath lead.
2. Remove front bulkhead assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Front bulkhead assembly.**
3. Remove engine compartment fusebox and related wiring.
4. Remove radiator expansion tank from mountings and position aside.
5. **Petrol models:** Remove cruise control actuator mounting bracket.
6. **Diesel models:** Remove EGR modulator mounting bracket.
7. **RHD models:** Remove brake servo.
   ☞ **BRAKES, REPAIRS, Servo - brake.**
8. Remove brake pipes from valance assembly.
9. Remove RH road wheel.
10. Remove RH front mud flap.
11. Remove insulation pad from engine bulkhead.
12. Remove windscreen side finisher.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.**

Repair



M77 1694A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit windscreen side finisher.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.**
2. Fit insulation pad to engine bulkhead.
3. Fit front mud flap.
4. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
5. Fit brake pipes to valance assembly.

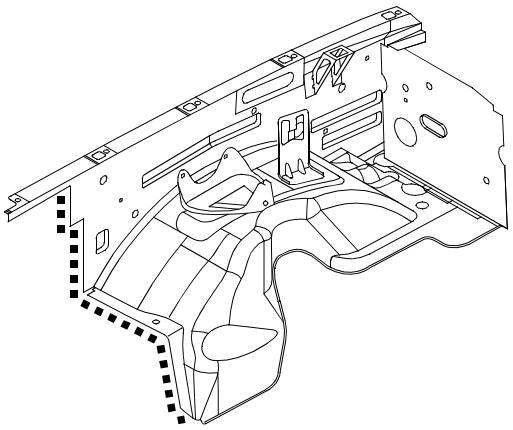
6. **RHD models:** Fit brake servo.
7. **Diesel models:** Fit EGR modulator mounting bracket.
8. **Petrol models:** Fit cruise control actuator mounting bracket.
9. Fit radiator expansion tank.
10. Fit fusebox and secure wiring.
11. Fit front bulkhead assembly.
    ☞ **PANEL REPAIRS, REPAIRS, Front bulkhead assembly.**
12. Connect battery leads, negative lead last.

Front valance assembly - LH

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove front bulkhead assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Front bulkhead assembly.**
4. Remove ABS modulator unit.
   ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
5. **LHD models:** Remove brake servo.
   ☞ **BRAKES, REPAIRS, Servo - brake.**
6. Remove brake pipes from valance assembly.
7. Remove PAS/ACE reservoir.
8. **Models with A/C:** Remove A/C pipes from valance assembly.
9. Remove wiring harness from valance assembly.
10. Remove LH front road wheel.
11. Remove LH front mud flap.
12. Remove insulation pad from engine bulkhead.
13. Remove windscreen side finisher.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.**

Repair



M77 1742

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit windscreen side finisher.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.**
2. Fit insulation pad to engine bulkhead.
3. Fit front mud flap.
4. Fit road wheel and tighten nuts to 140 Nm (103 lbf.ft).
5. Fit wiring harness to valance assembly.
6. **Models with A/C:** Fit A/C pipes to valance assembly.
7. Fit PAS/ACE reservoir.
8. Fit brake pipes to valance assembly.
9. **LHD models:** Fit brake servo.
   ☞ **BRAKES, REPAIRS, Servo - brake.**
10. Fit ABS modulator unit.
    ☞ **BRAKES, REPAIRS, Modulator unit - ABS.**
11. Fit front bulkhead assembly.
    ☞ **PANEL REPAIRS, REPAIRS, Front bulkhead assembly.**
12. Connect leads/multiplug to alternator.
13. Connect battery leads, negative lead last.

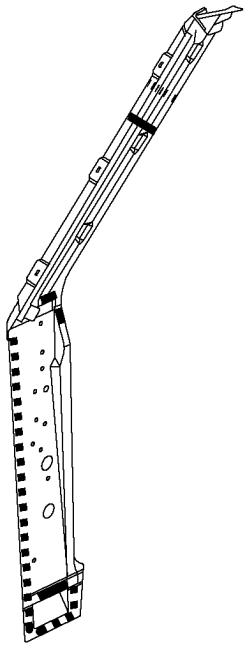
'A' post assembly

In this procedure, the front wing and the valance outer reinforcement (rear section) are replaced in conjunction with the 'A' post assembly. The dash side assembly can also be replaced in this procedure if required.

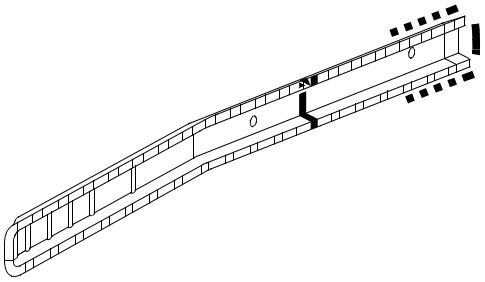
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove bonnet.
4. Remove front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
5. Remove RH or LH front door.
   ☞ **DOORS, REPAIRS, Door - front.**
6. Remove RH or LH sill finisher.
7. Remove windscreen.
   ☞ **SCREENS, REPAIRS, Windscreen.**
8. **Diesel models:** Remove ECM.
   ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Engine control module (ECM).**
9. Remove RH or LH 'A' post inner finishers and disconnect speaker multiplug (if fitted).
10. Release sunroof drain tube and position aside.
11. Remove RH or LH front seat.
    ☞ **SEATS, REPAIRS, Seat - front.**
12. **RH side:** Remove CD autochanger.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
13. Remove fascia.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.**
14. **Driver's side:** Remove steering column support bracket.
15. Remove relevant wiring from 'A' post.
16. Remove tread plate from front door aperture.
17. Release front carpet and position aside.
18. Remove front door aperture seal.
19. Remove engine bulkhead insulation.

Repair



M77 1695



M77 1751

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit insulation pad to engine bulkhead.
2. Fit front door aperture seal.
3. Position front carpet and fit tread plate to front door aperture.
4. Fit wiring to 'A' post.
5. **Driver's side:** Fit steering column support bracket.
6. Fit fascia.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.**
7. **RH side:** Fit CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
8. Fit RH or LH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
9. Fit sunroof drain tube.
10. Connect multiplug to speaker (if fitted) and fit finisher to 'A' post.
11. **Diesel models:** Fit ECM.
    ☞ **ENGINE MANAGEMENT SYSTEM - Td5, REPAIRS, Engine control module (ECM).**
12. Fit windscreen.
    ☞ **SCREENS, REPAIRS, Windscreen.**
13. Fit sill finisher.
14. Fit front door.
    ☞ **DOORS, REPAIRS, Door - front.**
15. Fit front wing.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
16. Fit bonnet.
17. Connect leads/multiplug to alternator.
18. Connect battery leads, negative lead last.

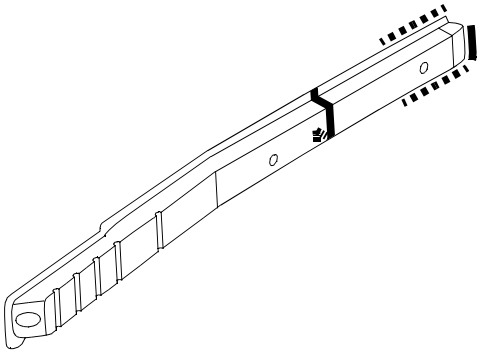
Dash side assembly

NOTE: In this procedure, the front wing, 'A' post assembly and the valance outer reinforcement (rear section) are replaced in conjunction with the dash side assembly.

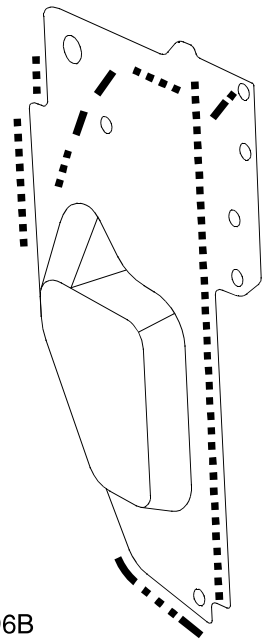
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove 'A' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'A' post assembly.**

Repair



M77 1691



M77 1696B

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

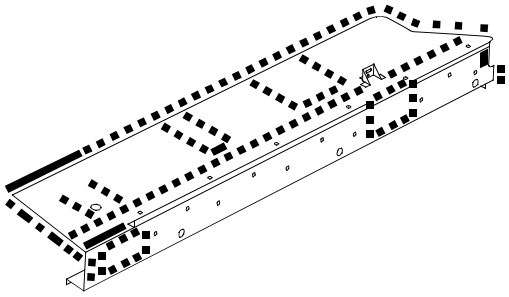
1. Fit 'A' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'A' post assembly.**
2. Connect leads/multiplug to alternator.
3. Connect battery leads, negative lead last..

Sill outer assembly

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove RH or LH front wing.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
4. Remove RH or LH front door.
   ☞ **DOORS, REPAIRS, Door - front.**
5. Remove RH or LH rear door.
   ☞ **DOORS, REPAIRS, Door - rear.**
6. Remove RH or LH sill finisher.
7. Remove RH or LH 'A' post inner lower finishers.
8. Remove RH or LH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
9. **LH side:** Remove power amplifier and EAT ECU.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
10. **RH side:** Remove CD autochanger.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
11. Remove rear seats.
    ☞ **SEATS, REPAIRS, Seat - rear.**
12. Remove RH or LH front seat belt.
    ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - front.**
13. Remove tread plates from front and rear door apertures.
14. Release carpet and position aside.
15. Remove front and rear door aperture seals.
16. Release relevant wiring from 'A' post, 'B/C' post and sill areas, and position aside.
17. Remove loadspace lower trim casing.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
18. **RH side:** Remove lower ACE accelerometer.
    ☞ **FRONT SUSPENSION, REPAIRS, Accelerometer - ACE - lower.**
19. **LH side:** Remove SLS air compressor unit.
    ☞ **REAR SUSPENSION, REPAIRS, Compressor unit - air - SLS.**
20. **Models with rear A/C:** Recover refrigerant from A/C system and remove A/C pipes from LH sill.
    ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
21. Remove 2 bolts securing body to chassis.

Repair



M77 1716A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit 2 bolts securing body to chassis and tighten to 45 Nm (33 lbf.ft).
2. **Models with rear A/C:** Fit A/C pipes to sill and recharge A/C system.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
3. **LH side:** Fit SLS air compressor unit.
   ☞ **REAR SUSPENSION, REPAIRS, Compressor unit - air - SLS.**
4. **RH side:** Fit lower ACE accelerometer.
   ☞ **FRONT SUSPENSION, REPAIRS, Accelerometer - ACE - lower.**
5. Fit loadspace lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
6. Fit relevant wiring to 'A' post, 'B/C' post and sill areas.
7. Fit front and rear door door aperture seals.
8. Fit carpet and secure into position.
9. Fit tread plates to front and rear door apertures.
10. Fit front seat belt.
    ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - front.**
11. Fit rear seats.
    ☞ **SEATS, REPAIRS, Seat - rear.**
12. **LH side:** Fit CD autochanger.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
13. **RH side:** Fit power amplifier and EAT ECU.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
14. Fit front seat.
    ☞ **SEATS, REPAIRS, Seat - front.**
15. Fit 'A' post inner lower finishers.

16. Fit sill finisher.
17. Fit rear door.
    ☞ **DOORS, REPAIRS, Door - rear.**
18. Fit front door.
    ☞ **DOORS, REPAIRS, Door - front.**
19. Fit front wing.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Wing - front - up to 03MY.**
20. Connect leads/multiplug to alternator.
21. Connect battery leads, negative lead last.

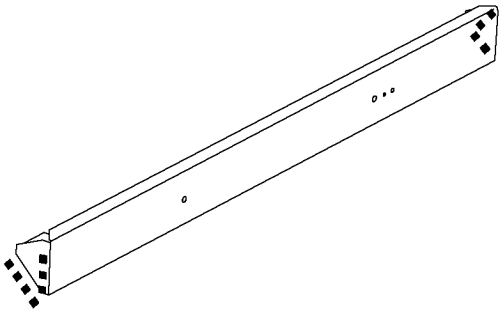
Sill inner assembly

NOTE: In this procedure, the sill outer assembly is replaced in conjunction with the sill inner assembly.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove sill outer assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Sill outer assembly.**

Repair



M77 1717

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

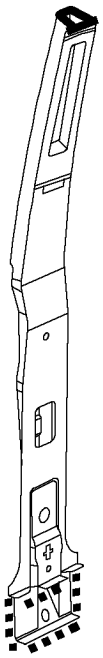
1. Fit sill outer assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Sill outer assembly.**
2. Connect leads/multiplug to alternator.
3. Connect battery leads, negative lead last.

'B/C' post assembly

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove RH or LH rear door.
   ☞ **DOORS, REPAIRS, Door - rear.**
4. Remove front door striker from 'B/C' post.
5. Remove RH or LH sill finisher.
6. Remove RH or LH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
7. **RH side:** Remove power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
8. **LH side:** Remove CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
9. Remove RH or LH front seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - front.**
10. Remove RH or LH rear seat.
    ☞ **SEATS, REPAIRS, Seat - rear.**
11. Remove head lining.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**
12. Remove tread plate from front and rear door apertures.
13. Release carpet from fixings and position aside.
14. Remove front and rear door door aperture seals.
15. Release relevant wiring from 'B/C' post and sill areas and position aside.
16. Remove side drip rail finisher.

Repair



M77 1697

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.
2. **Before welding 'B/C' post to roof, apply 'Heat shrink paste' to roof area to avoid heat damage to paintwork.**

Refit

1. Fit side drip rail finisher.
2. Fit wiring to 'B/C' post and sill areas.
3. Fit front and rear door door aperture seal.
4. Position carpet and secure with fixings.
5. Fit tread plates to front and rear door apertures.
6. Fit head lining.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**
7. Fit rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
8. Fit front seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - front.**
9. **LH side:** Fit CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
10. **RH side:** Fit power amplifier.
    ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
11. Fit RH or LH front seat.
    ☞ **SEATS, REPAIRS, Seat - front.**
12. Fit sill finisher.

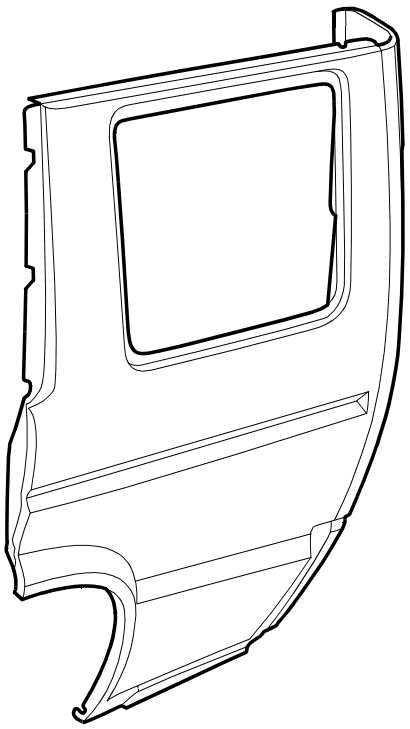
13. Fit front door striker to B/C post, fit Torx bolts and tighten to 26 Nm (19 lbf.ft).
14. Fit rear door.
    ☞ **DOORS, REPAIRS, Door - rear.**
15. Connect leads/multiplug to alternator.
16. Connect battery leads, negative lead last.

Panel body side assembly

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove loadspace side trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
4. Remove head lining rear trim finisher.
5. Remove rear head rests, if fitted.
6. Remove body side rear glass.
   ☞ **SCREENS, REPAIRS, Glass - body side - rear.**
7. Remove rear bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
8. Remove rear bumper finisher.
9. Remove rear wheel arch liner.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - rear.**
10. Remove mud flap.
11. Remove tread plate from rear door aperture.
12. Remove rear door aperture seal.
13. Remove rear door striker from 'D' post.
14. Remove 'D' post outer trim finisher.
15. Remove wheel arch trim finisher.
16. Remove side drip rail finisher.
17. **RH side:** Remove tail door.
18. **LH side:** Remove tail door striker and setting block from 'E' post.
19. Remove tail door tread plate.
20. Remove loadspace carpet retainer.
21. Remove tail door aperture seal.
22. Remove tail lamp.
    ☞ **LIGHTING, REPAIRS, Lamp - tail.**
23. **RH side:** Remove fuel filler flap.
24. **RH side:** Remove fuel filler tube.
    ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Filler tube - fuel.**
25. Remove aerial amplifier.
26. Remove relevant wiring from body side area.

Repair



M77 0000

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. The panel body side assembly does not require any welding, as it is bolted into position.

Refit

1. Position and secure wiring.
2. Fit aerial amplifier.
3. **RH side:** Fit fuel filler tube.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Filler tube - fuel.**
4. **RH side:** Fit fuel filler flap.
5. Fit tail lamp.
   ☞ **LIGHTING, REPAIRS, Lamp - tail.**
6. Fit tail door aperture seal.
7. Fit loadspace carpet retainer.
8. Fit tail door tread plate.
9. **LH side:** Fit tail door striker and setting block to 'E' post, fit Torx bolts and tighten to 26 Nm (19 lbf.ft).
10. **RH side:** Fit tail door.
11. Fit side drip rail finisher.
12. Fit wheel arch trim finisher.
13. Fit 'D' post outer trim finisher.
14. Fit rear door striker.
15. Fit rear door aperture seal.
16. Fit tread plate to rear door aperture.
17. Fit mud flap.
18. Fit rear wheel arch liner.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Liner - wheel arch - rear.**
19. Fit rear bumper finisher.
20. Fit rear bumper assembly.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
21. Fit body side rear glass.
    ☞ **SCREENS, REPAIRS, Glass - body side - rear.**
22. Fit rear head rests, if fitted.
23. Fit head lining rear trim finisher.
24. Fit loadspace side trim casing.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
25. Connect leads/multiplug to alternator.
26. Connect battery leads, negative lead last.

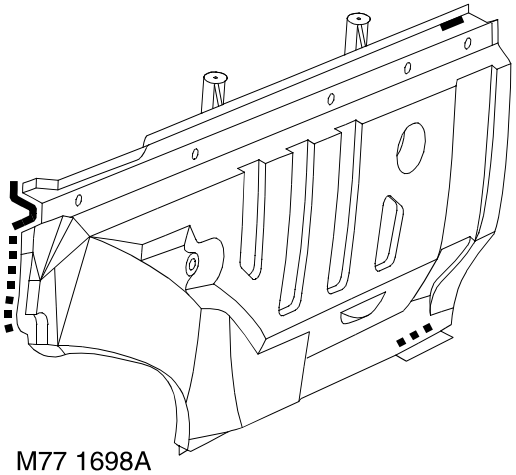
Body side inner rear assembly

In this procedure, the panel body side assembly is replaced in conjunction with the body side inner rear assembly.

Remove

1. Disconnect battery eath lead.
2. Disconnect leads/multiplug from alternator.
3. Remove panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
4. Remove RH or LH rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
5. Remove loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
6. Remove rear side seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - rear - side.**
7. Remove third row seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belts - third row.**
8. Remove fuel tank.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Tank - fuel.**
   ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Tank - fuel.**
9. Remove fuel filler tube.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Filler tube - fuel.**
10. **RH side:** Remove fuel flap release solenoid.
    ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Solenoid - fuel filler flap release.**
    ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Solenoid - fuel filler flap release.**
11. **RH side:** Remove air extractor vent.
12. Remove relevant wiring.

Repair



M77 1698A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit and secure wiring.
2. **RH side:** Fit air extractor vent.
3. **RH side:** Fit fuel flap release solenoid.
   ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Solenoid - fuel filler flap release.**
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Solenoid - fuel filler flap release.**
4. Fit fuel filler tube.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Filler tube - fuel.**
5. Fit fuel tank.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Tank - fuel.**
   ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Tank - fuel.**
6. Fit third row seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belts - third row.**
7. Fit rear side seat belt.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belt - rear - side.**
8. Fit loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
9. Fit rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
10. Fit panel body side assembly.
    ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
11. Connect leads/multiplug to alternator.
12. Connect battery leads, negative lead last.

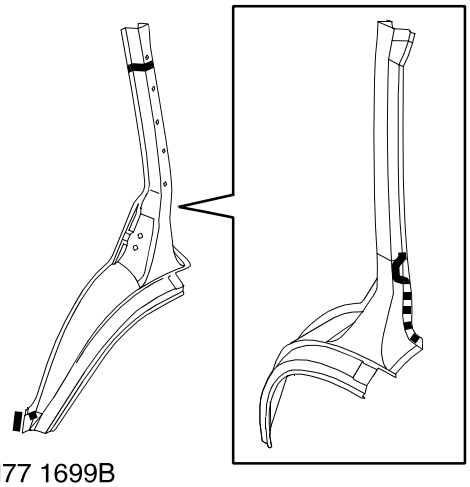
'D' post outer assembly

In this procedure, the panel body side assembly is also replaced in conjunction with the 'D' post assembly. The 'D' post inner closing panel can also be replaced in this procedure, if required.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
4. Remove RH or LH sill finisher.
5. Remove front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
6. **RH side:** Remove power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
7. **LH side:** Remove CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
8. Remove 'B/C' post lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**
9. Remove rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
10. Remove loadspace carpet.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
11. Release carpet for access to 'D' post assembly and position aside.
12. Remove relevant wiring.

Repair



M77 1699B

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit and secure wiring.
2. Position and secure carpet into position.
3. Fit loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
4. Fit rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
5. Fit 'B/C' post lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**
6. **LH side:** Fit CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
7. **RH side:** Fit power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
8. Fit front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
9. Fit RH or LH sill finisher.
10. Fit panel body side assembly.
    ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
11. Connect leads/multiplug to alternator.
12. Connect battery leads, negative lead last.

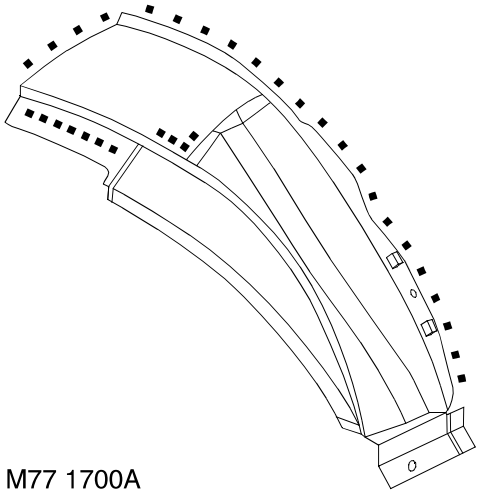
Wheelarch rear outer assembly

In this procedure, the panel body side assembly is replaced in conjunction with the wheelarch rear outer assembly.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
4. Remove front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
5. **RH side:** Remove power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
6. **LH side:** Remove CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
7. Remove 'B/C' post lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**
8. Remove rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
9. Remove loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
10. Release carpet for access to 'D' post assembly and position aside.
11. Remove relevant wiring.

Repair



M77 1700A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit and secure wiring.
2. Position and secure carpet into position.
3. Fit loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
4. Fit rear seat.
   ☞ **SEATS, REPAIRS, Seat - rear.**
5. Fit 'B/C' post lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - lower - 'B' post.**
6. **LH side:** Fit CD autochanger.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, CD autochanger.**
7. **RH side:** Fit power amplifier.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Amplifier - power.**
8. Fit front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**
9. Fit panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
10. Connect leads/multiplug to alternator.
11. Connect battery leads, negative lead last.

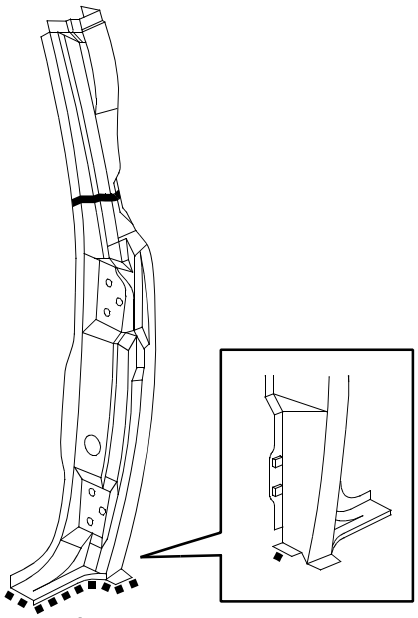
'E' post assembly

In this procedure, the panel body side assembly and tail door are replaced in conjunction with the 'E' post assembly. If required the 'E' post closing assembly can also be replaced.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
4. Remove rear seats.
   ☞ **SEATS, REPAIRS, Seat - rear.**
5. Remove loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
6. Remove third row seat belts.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belts - third row.**
7. Remove relevant wiring.
8. Remove rear drip rail finisher.

Repair



M77 1701A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit rear drip rail finisher.
2. Fit and secure wiring.
3. Fit third row seat belts.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Seat belts - third row.**
4. Fit loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
5. Fit rear seats.
   ☞ **SEATS, REPAIRS, Seat - rear.**
6. Fit panel body side assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Panel body side assembly.**
7. Connect leads/multiplug to alternator.
8. Connect battery leads, negative lead last.

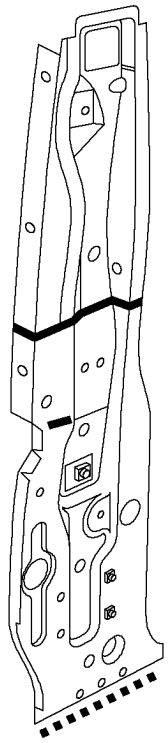
'E' post closing assembly

In this procedure, the panel body side assembly, tail door and 'E' post assembly are replaced in conjunction with the 'E' post closing assembly.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**

Repair



M77 1702

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**
2. Connect leads/multiplug to alternator.
3. Connect battery leads, negative lead last.

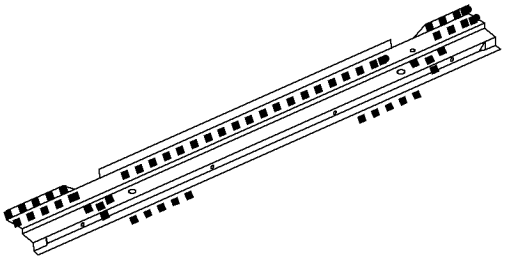
Cross member outer rear panel

In this procedure, the panel body side assembly and the 'E' post assembly are replaced in conjunction with the cross member outer rear panel.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**
4. Remove rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
5. Remove exhaust tailpipe heatshield.
6. Remove relevant wiring.

Repair



M77 1704

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

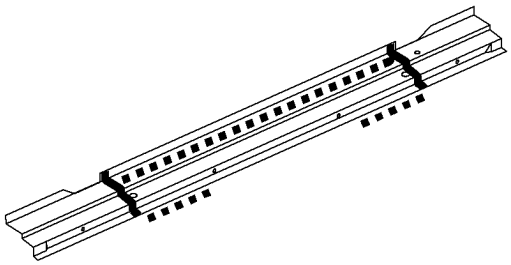
1. Fit and secure wiring.
2. Fit exhaust tailpipe heatshield.
3. Fit rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
4. Fit 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**
5. Connect leads/multiplug to alternator.
6. Connect battery leads, negative lead last.

Cross member outer rear panel (centre section)

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
4. Remove rear bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
5. Remove rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
6. Remove exhaust tailpipe heatshield.
7. Remove tail door tread plate.
8. Remove head lining rear trim finisher.
9. Remove tail door aperture seal.
10. Remove relevant wiring.

Repair



M77 1703

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit and secure wiring.
2. Fit tail door aperture seal.
3. Fit head lining rear trim finisher.
4. Fit tail door tread plate.
5. Fit exhaust tailpipe heatshield.
6. Fit rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
7. Fit rear bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
8. Fit loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
9. Connect leads/multiplug to alternator.
10. Connect battery leads, negative lead last.

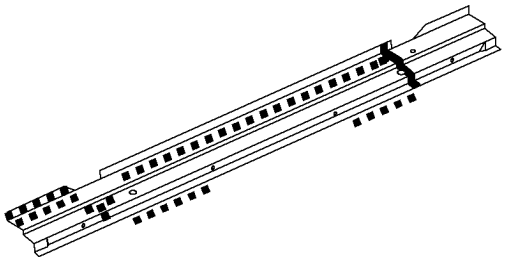
Cross member outer rear panel (RH/LH section)

In this procedure, the panel body side assembly and the 'E' post assembly are replaced in conjunction with either the RH or LH section of the cross member outer rear panel.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**
4. Remove rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
5. **LH side:** Remove exhaust tailpipe heatshield.
6. Remove relevant wiring.

Repair



M77 1706

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit and secure wiring.
2. **LH side:** Fit exhaust tailpipe heatshield.
3. Fit rear folding step.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Rear folding step.**
4. Fit 'E' post assembly.
   ☞ **PANEL REPAIRS, REPAIRS, 'E' post assembly.**
5. Connect leads/multiplug to alternator.
6. Connect battery leads, negative lead last.

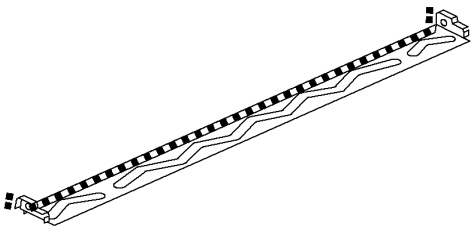
Cross member closing rear panel

In this procedure, the cross member outer rear panel is replaced in conjunction with the cross member closing rear panel. The cross member rear assembly can also be replaced, if required.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove cross member outer rear panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member outer rear panel.**
4. Remove fuel tank.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Tank - fuel.**
   ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Tank - fuel.**
5. Remove 2 rear bolts securing body rear to chassis.

Repair



M77 1705

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit 2 rear bolts securing body rear to chassis and tighten to 45 Nm (33 lbf.ft).
2. Fit fuel tank.
   ☞ **FUEL DELIVERY SYSTEM - V8, REPAIRS, Tank - fuel.**
   ☞ **FUEL DELIVERY SYSTEM - Td5, REPAIRS, Tank - fuel.**
3. Fit cross member rear outer panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member outer rear panel.**
4. Connect leads/multiplug to alternator.
5. Connect battery leads, negative lead last.

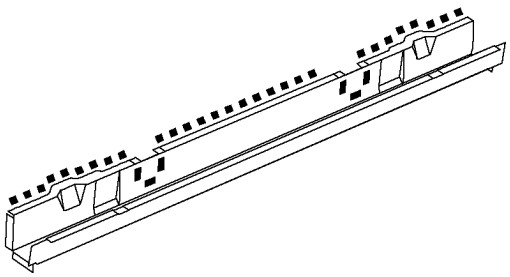
Cross member rear assembly

In this procedure, the cross member outer rear panel, cross member closing rear panel, 'E' post assembly and the panel body side assembly are replaced in conjunction with the cross member rear assembly.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove cross member closing rear panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member closing rear panel.**

Repair



M77 1707

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Fit cross member closing rear panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member closing rear panel.**
2. Connect leads/multiplug to alternator.
3. Connect battery leads, negative lead last.

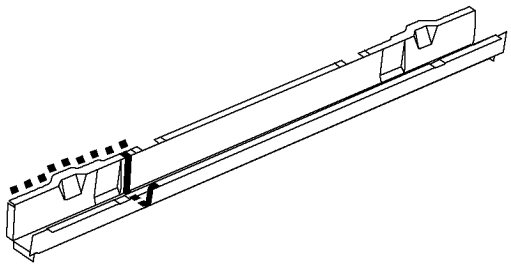
Cross member rear assembly (RH/LH section)

In this procedure, the cross member outer rear panel, cross member closing rear panel, 'E' post assembly and the panel body side assembly are replaced in conjunction with the cross member rear assembly.

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove cross member closing rear panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member closing rear panel.**

Repair



M77 1708

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

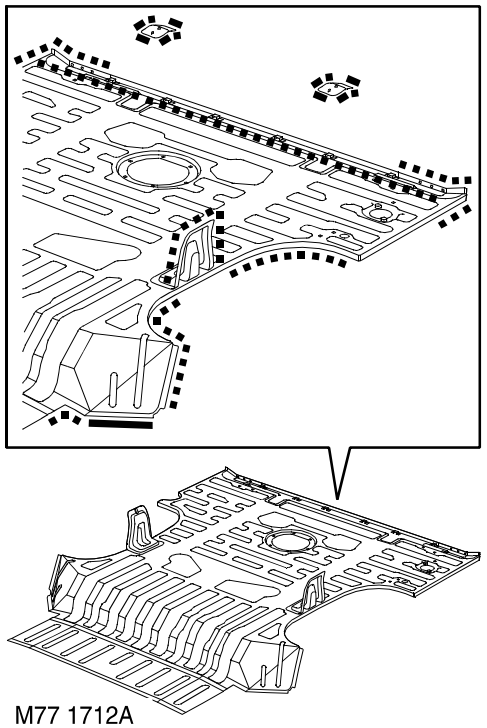
1. Fit cross member closing rear panel.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member closing rear panel.**
2. Connect leads/multiplug to alternator.
3. Connect battery leads, negative lead last.

Rear floor complete assembly

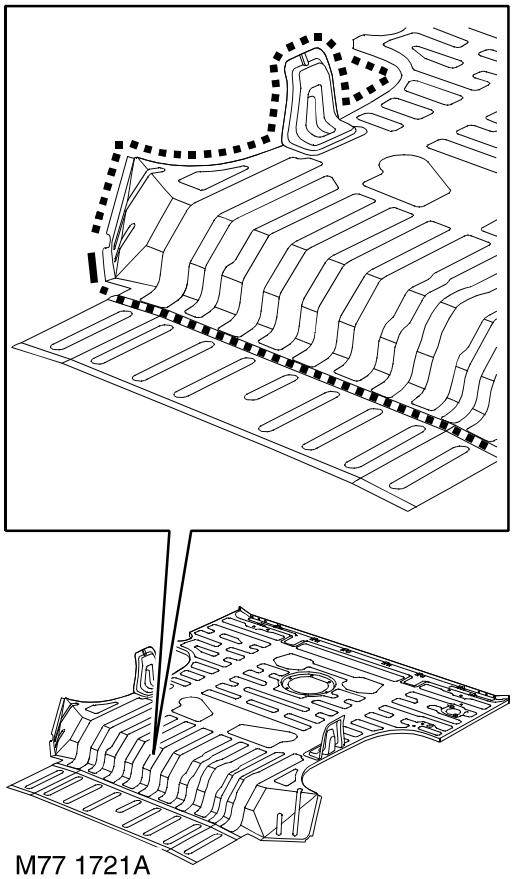
Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove loadspace carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
4. Remove rear seats.
   ☞ **SEATS, REPAIRS, Seat - rear.**
5. Remove rear carpet.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - rear.**
6. Remove rear bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
7. Remove RH and LH mud flap and brackets.
8. Remove exhaust tail pipe heatshields.
9. Remove tread plates from rear door apertures.
10. Remove rear door aperture seal.
11. Remove tail door tread plate.
12. Remove loadspace carpet retainer.
13. Remove head lining rear trim finisher.
14. Remove tail door aperture seal.
15. Remove bolts securing body to chassis.
16. Remove relevant wiring from floor area.

Repair



M77 1712A



M77 1721A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

1. Position and secure wiring.
2. Fit and tighten bolts securing body to chassis to 45 Nm (33 lbf.ft).
3. Fit tail door aperture seal.
4. Fit head lining rear trim finisher.
5. Fit loadspace carpet retainer.
6. Fit tail door tread plate.
7. Fit rear door aperture seals.
8. Fit tread plate to rear door apertures.
9. Fit exhaust tail pipe heatshields.
10. Fit mud flap bracklets and mud flaps.
11. Fit rear bumper assembly.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - up to 03MY.**
12. Fit rear carpet.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - rear.**
13. Fit rear seats.
    ☞ **SEATS, REPAIRS, Seat - rear.**
14. Fit loadspace carpet.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - loadspace.**
15. Connect leads/multiplug to alternator.
16. Connect battery leads, negative lead last.

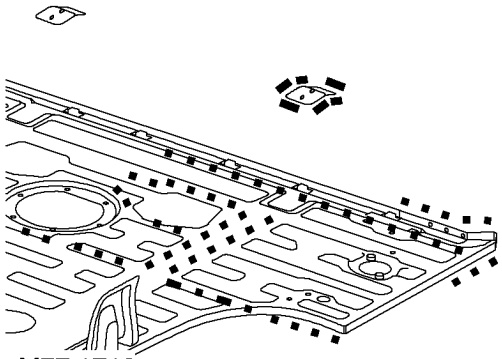
Rear floor (rear section)

In this procedure, the cross member rear assembly, cross member outer rear panel, cross member closing rear panel, 'E' post assembly, 'E' post closing assembly and the panel body side assembly are replaced in conjunction with the rear floor (rear section).

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove cross member rear assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member rear assembly.**
4. Remove mud flap mounting brackets.
5. **LH side:** Remove exhaust heatshield from rear floor.

Repair


M77 1713

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown. Welds for RH side are symmetrically opposite to those shown.

Refit

1. **LH side:** Fit exhaust heatshield to rear floor.
2. Fit mud flap mounting brackets.
3. Fit cross member rear assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member rear assembly.**
4. Connect leads/multiplug to alternator.
5. Connect battery leads, negative lead last.

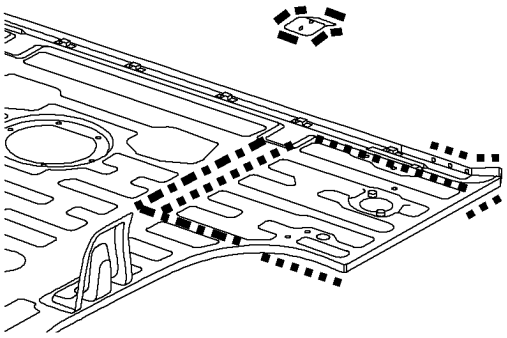
Rear floor (RH/LH section)

In this procedure, the cross member rear assembly, cross member outer rear panel (RH/LH section), cross member closing rear panel, 'E' post assembly, 'E' post closing assembly and the panel body side assembly are replaced in conjunction with the rear floor (RH/LH section).

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. Remove cross member rear assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member rear assembly.**
4. Remove mud flap mounting brackets.
5. **LH side:** Remove exhaust heatshield from rear floor.

Repair



M77 1714

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.

Refit

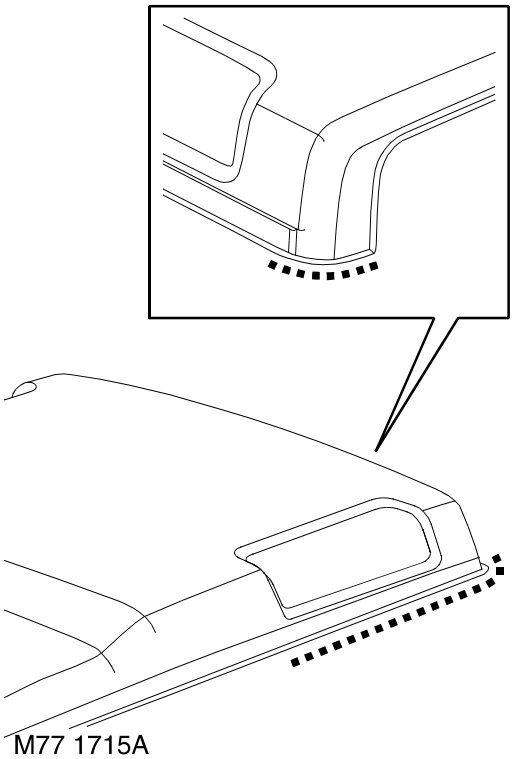
1. **LH side:** Fit exhaust heatshield to rear floor.
2. Fit mud flap mounting brackets.
3. Fit cross member rear assembly.
   ☞ **PANEL REPAIRS, REPAIRS, Cross member rear assembly.**
4. Connect leads/multiplug to alternator.
5. Connect battery leads, negative lead last.

Roof assembly

Remove

1. Disconnect both battery leads, negative lead first.
2. Disconnect leads/multiplug from alternator.
3. **Models with sunroof:** Remove front sunroof.
   ☞ **SUNROOF, REPAIRS, Sunroof - front.**
4. **Models with sunroof:** Remove rear sunroof.
   ☞ **SUNROOF, REPAIRS, Sunroof - rear.**
5. **Models with sunroof:** Release sunroof drain tubes and position aside.
6. **Models with fixed roof:** Remove head lining.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**
7. Remove front seats.
   ☞ **SEATS, REPAIRS, Seat - front.**
8. Remove rear seats.
   ☞ **SEATS, REPAIRS, Seat - rear.**
9. Remove rear headrests, if fitted.
10. Remove roof bars, if fitted.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Roof bars.**
11. Remove tread plates from front door apertures.
12. Remove 'A' post lower trim panels.
13. Remove front door aperture seals.
14. Remove tread plates from rear door apertures.
15. Remove rear door aperture seals.
16. Remove 'D' post outer trim finisher.
17. Remove windscreen.
    ☞ **SCREENS, REPAIRS, Windscreen.**
18. Remove alpine light glass.
    ☞ **SCREENS, REPAIRS, Glass - alpine light.**
19. Remove side and rear drip rail finishers.
20. Release relevant wiring and position aside.

Repair


M77 1715A

1. Remove existing panel(s), prepare panel joint faces and install new panel(s) in accordance with Panel Replacement Procedure. Punch or drill holes in new panel for plug welding as shown.
2. **During welding operations, apply 'Heat shrink paste' to roof and body side panel to avoid heat damage to paintwork.**

Refit

1. Fit and secure wiring.
2. Fit side and rear drip rail finishers.
3. Fit alpine light glass.
   ☞ **SCREENS, REPAIRS, Glass - alpine light.**
4. Fit windscreen.
   ☞ **SCREENS, REPAIRS, Windscreen.**
5. Fit 'D' post outer trim finishers.
6. Fit rear door aperture seals.
7. Fit tread plates to rear door apertures.
8. Fit front door aperture seals.
9. Fit 'A' post lower trim panels.
10. Fit tread plates to front door apertures.
11. Fit roof bars.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Roof bars.**
12. Fit rear headrests.
13. Fit rear seats.
    ☞ **SEATS, REPAIRS, Seat - rear.**
14. Fit front seats.
    ☞ **SEATS, REPAIRS, Seat - front.**
15. **Models with fixed roof:** Fit head lining.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**
16. **Models with sunroof:** Fit sunroof drain tubes.
17. **Models with sunroof:** Fit rear sunroof.
    ☞ **SUNROOF, REPAIRS, Sunroof - rear.**
18. **Models with sunroof:** Fit front sunroof.
    ☞ **SUNROOF, REPAIRS, Sunroof - front.**
19. Connect leads/multiplug to alternator.
20. Connect battery leads, negative lead last.

TIME SCHEDULES

The following information shows the time taken to replace damaged panels and assemblies. This time includes removal of Mechanical, Electrical and Trim (MET) parts, and also time for painting, based on using Clear Over Base (COB) Metallic paint.

The times shown were generated by Thatcham (the Motor Insurance Repair and Research Centre) and are to be used as a **guide only.**

All times shown are in decimal hours.

Single panel/assembly replacement times

Panel Description	Total times	
	Petrol	Diesel
Bonnet	7.4	7.4
Bonnet locking platform	8.4	8.4
Front cross member	9.3	8.1
Front bulkhead assembly	10.5	9.3
Headlamp mounting panel RH	9.3	–
Headlamp mounting panel LH	9.4	–
Front wing RH	7.2	7.2
Front wing LH	7.1	7.1
Front door – skin	10.8	10.8
Front door	7.9	7.9
Rear door – skin	10.0	10.0
Rear door	7.6	7.6
'A' post assembly RH	11.4	–
'A' post assembly LH	11.3	–
'B/C' post assembly	11.3	–
Sill outer assembly RH	14.8	–
Sill outer assembly LH	13.9	–
Panel body side assembly RH	15.5	15.5
Panel body side assembly LH	13.4	13.4
Cross member outer rear panel (centre section)	13.4	13.4
Tail door	9.3	9.3
Roof	30.3	30.3

Combination panel replacement times - Front end panels

Panel Description	Total time	
	Petrol	Diesel
Front bumper Bonnet locking platform Headlamp mounting panel Front wing	18.5 RH 18.8 LH	17.3 RH 17.5 LH
Front bumper Front bulkhead assembly Front wing RH & LH	19.7	18.5
Front bumper Front bulkhead assembly		

Panel Description	Total time	
	Petrol	Diesel
Front wing Front valance assembly Wing support bracket Valance outer reinforcement	 24.0 RH 24.2 LH	 22.7
Front bumper Front bulkhead assembly Front wing Wing support bracket Headlamp closing panel Valance upper assembly (front section) Valance outer reinforcement (front section)	 22.4 RH 23.1 LH	 21.1 RH 21.6 LH

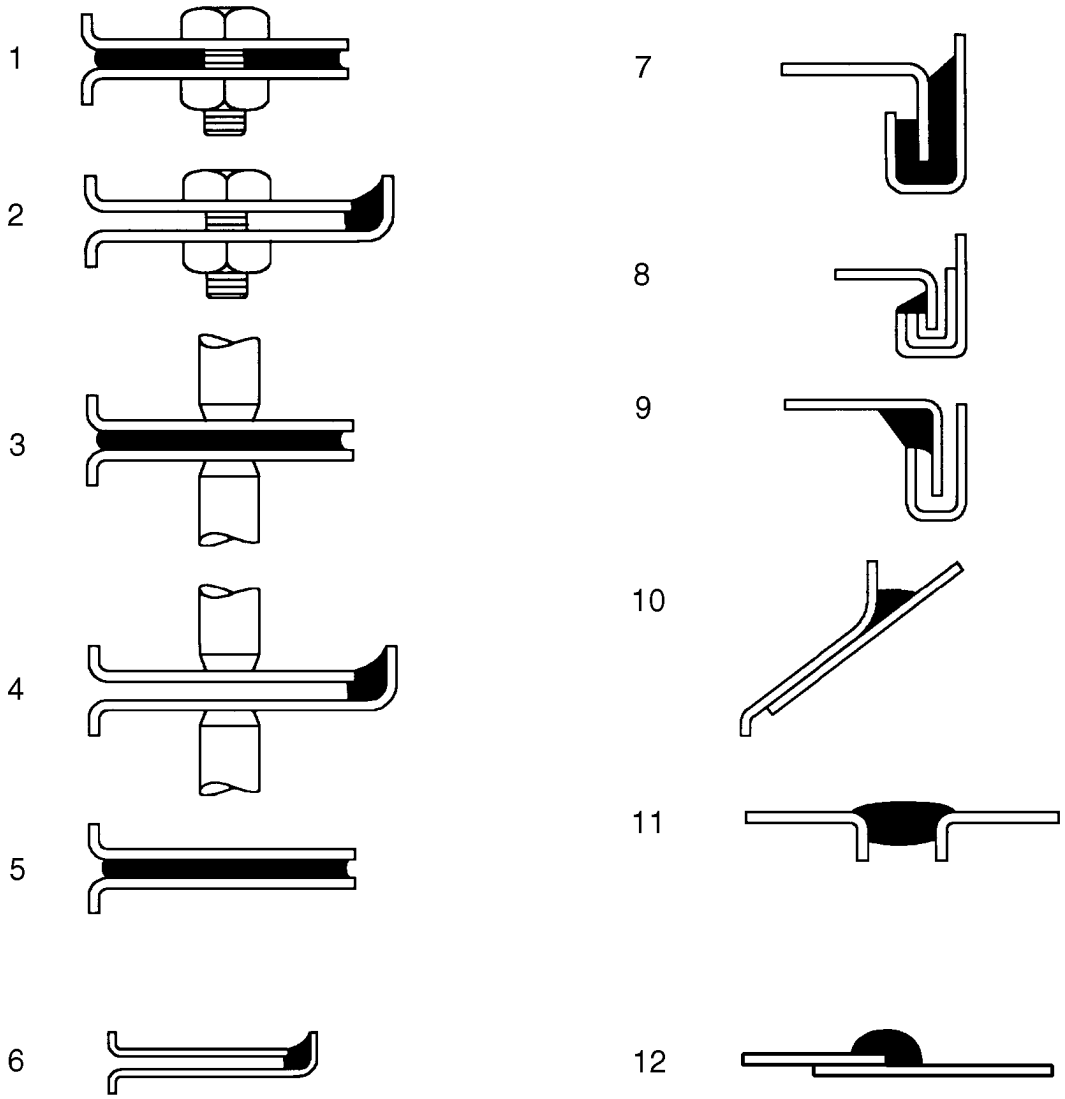
Combination panel replacement times - Side panels

Panel Description	Total time	
	Petrol	Diesel
Front wing Front door	 11.2	 11.2
Rear door Panel bodyside assembly	 19.2 RH 17.1 LH	 19.1 RH 17.1 LH
Front door Rear door 'B/C' Post	 19.9 RH 19.8 LH	 19.8
Front door Rear door 'B/C' Post Front wing Panel bodyside assembly	 33.9 RH 31.8 LH	 33.9 RH 31.7 LH
Front door Front wing Front wing support bracket 'A' post	 23.1 RH 22.9 LH	 23.0 RH 22.8 RH

Combination panel replacement times - Rear end panels

Panel Description	Total time	
	Petrol	Diesel
Rear bumper Panel bodyside assembly 'E' post assembly Crossmember outer rear panel (RH/LH section) Crossmember closing rear panel	31.9 RH 30.1 LH	31.9 RH 30.1 LH
Rear bumper Panel bodyside assembly Bodyside inner rear assembly 'E' post assembly 'E' post closing assembly Crossmember outer rear panel (RH/LH section) Crossmember closing rear panel Crossmember rear assembly (RH/LH section) Rear floor (RH/LH section) Crossmember closing rear brackets	42.9 RH 41.1 LH	42.6 RH 40.7 LH
Rear bumper Panel bodyside assembly RH & LH Bodyside inner rear assembly RH & LH 'E' post assembly RH & LH 'E' post closing assembly RH & LH Crossmember outer rear panel Crossmember closing rear panel Crossmember rear assembly Rear floor (rear section) Crossmember closing rear brackets RH & LH	65.9	65.6

Materials applications



77M1584

1 Between panels - bolted
2 Panel edges - bolted
3 Between panels - spot welded
4 Panel edges - spot welded
5 Between panels - bonded
6 Panel edges - bonded
7 Clinch joints - type (a)
8 Clinch joints - type (b)
9 Clinch joints - type (c)
10 Gaps between panels - type (a)
11 Gaps between panels - type (b)
12 Lap joint

Approved materials

The following is a table of materials approved by Land Rover for use during body repairs.

Description - Usage	Supplier	Part Number
Cavity waxes		
Inner Cavity Wax (Amber)	3M	08901/11/21
Inner Cavity Wax (Transparent)	3M	08909/19/29
Cavity Wax	Croda	PW57
Engine bay waxes/lacquers		
Astrolan Engine Bay Wax and Cosmetic Wax	Astors	DA3243/1
Engine Bay Cosmetic Wax/Lacquer	Croda	PW197
Engine Bay Cosmetic Wax/Lacquer	Dinol	4010
Miscellaneous materials		
Aerosol Auto Adhesive (Trim) - impact adhesive for trim parts	3M	08080
Flexible Parts Repair Material - rubber modified polypropylene parts	3M	05900
Waterproof Cloth Tape - sealing panel apertures	3M	Y387/Y3998
Sound Dampening Foam	Gurit-Essex	Betacore 7999
Water Shedder Repair (Aerosol)	Teroson	
Seam sealers		
Body Caulking - type (b) gaps between panels	3M	08568
Bolted Panel Sealer - between bolted panels	3M	08572
Drip Chek Clear - bolted, spot welded and bonded panel edges; type (a) and (b) gaps between panels; type (c) clinch joints	3M	08401
Drip Chek Heavy - type (b) gaps between panels; type (c) clinch joints	3M	08531
Polyurethane Seam Sealer - bolted, spot welded and bonded panel edges; type (a) and (b) gaps between panels; type (b) clinch joints	3M	08684/89/94
Polyurethane Sealer (Sachet) - bolted panel edges; type (b) clinch joints	3M	08703/83/88
Sprayable Sealer - lap joints	3M	08800/23
Super Seam Sealer - lap joints; type (b) clinch joints	3M	08537
Weld Thru' Sealer - between spot welded panels	3M	08626
Betafill Clinch and Brushable Sealer - type (b) clinch joints	Gurit-Essex	10211/15/20
Clinch, Joint and Underbody Coating - lap joints	Gurit-Essex	10101/10707
Leak Chek Clear - between bolted panels; spot welded and bonded panel edges; type (c) clinch joints; type (a) gaps between panels	Kent Industries	10075
Putty - type (b) gaps between panels	Kent Industries	
Polyurethane Seam Sealer - bolted, spot welded and bonded panel edges; between bonded panels; type (a) and (b) gaps between panels	PPG	6500
Polyurethane Seam Sealer - bolted, spot welded and bonded panel edges; between bonded panels; type (b) gaps between panels	Teroson	92
Terolan Light Seam Sealer - bolted, spot welded and bonded panel edges; type (a) and (b) gaps between panels; between bonded panels; type (c) clinch joints	Teroson	

Description - Usage	Supplier	Part Number
Terolan Special Brushable Seam Sealer - lap joints	Teroson	
Terostat Sprayable Seam Sealer - bolted, spot welded and bonded panel edges; between bonded panels; type (b) gaps between panels	Teroson	9320
Terostat 1K PU Seam Sealer (SE 20) - type (a) and (b) gaps between panels; spot welded and bonded panel edges	Teroson	
Sealing Compound - bolted, spot welded and bonded panel edges; between bonded panels; type (b) gaps between panels	Wurths	8901001/-/6
Structural adhesives		
Automotive Structural Adhesive - between bonded panels; type (a) clinch joints	3M	08122
Two Part Structural Epoxy - between bonded and spot welded panels; type (a) clinch joints	Ciba-Geigy	XB5106/7
Underbody sealers		
Body Schutz	3M	08861
Spray Schutz	3M	08877
Crodapol Brushable Underbody Sealer	Croda	PV75
Terotex Underseal (CP 02)	Teroson	9320
Underbody waxes		
Bodyguard (Aerosol)	3M	08158/9
Underbody Wax	Croda	PW61
Underbody Wax	Dinol	Tectacote 205
Weld-through primers		
Weld Thru' Coating	3M	05913
Zinc Spray	3M	09113
Zinc Rich Primer	ICI	P-565 634

Application equipment

Manufacturers and suppliers
Suitable application equipment is available from the following manufacturers and suppliers:

3M
Automotive Trades Group
3M UK Plc
3M House
PO Box 1
Market Place
Bracknell
Berks
RG 12 1JU
☎ (01344) 858611

Cooper Pegler
Burgess Hill
Sussex
RH15 9LA
☎ (014 446) 42526

SATA Spray Equipment
Minden Industrial Ltd
16 Greyfriars Road
Moreton Hall
Bury St. Edmunds
Suffolk
IP32 7DX
☎ (01284) 760791

3M Body Schutz Pistol Spraygun 08996
A pistol type spraygun constructed from case and machined light alloy and designed for use with 3M screw fit Body Schutz containers.

3M Caulking Gun MKIII 8002
A lightweight, robust metal skeleton gun designed to accept 325 mm (13 in) cartridge for dispensing sealants etc. This gun provides rapid cartridge insertion and loading, with a quick-release lever for accurate control of material ejection and shut-off.

3M Pneumatic Cartridge Gun 08012
Air line-fed gun for applying 3M cartridge products. Excellent for ease of application to obtain a smooth bead. Regulator valve for additional control.

3M Pneumatic Applicator Guns
Air line-fed gun for application of 3M sachet sealers (Part Number 08006 for 200 ml and 310 ml sachet applications, and Part Number 08007 for all size sachets including 600 ml).

Also available: **Heavy Duty Manual Gun 08013.**

3M Applicator Gun 08190.
For the application of 3M Structural Adhesive 08120.

3M Inner Cavity Wax Applicator Gun 08997
This equipment accepts 1-litre canisters and has a 750 mm (29.572 in) flexible tube.

The approved system is available from all 3M refinishing factors.

Cooper Pegler Falcon Junior Pneumatic Gun (Airless)
Intended primarily for applying transit wax, this pneumatic sprayer has a 5-litre container with integral hand pump and provides an effective means of wax spraying without the need for compressed air or additional services.

A selection of nozzles, lances, hose lengths and a trigger valve assembly with integral filter allows flexibility in use. Additional applications include general maintenance, wax injection and paint application. Heavy-bodied materials may also be applied. All parts are fully replaceable and a wide range of nozzle configurations is available.

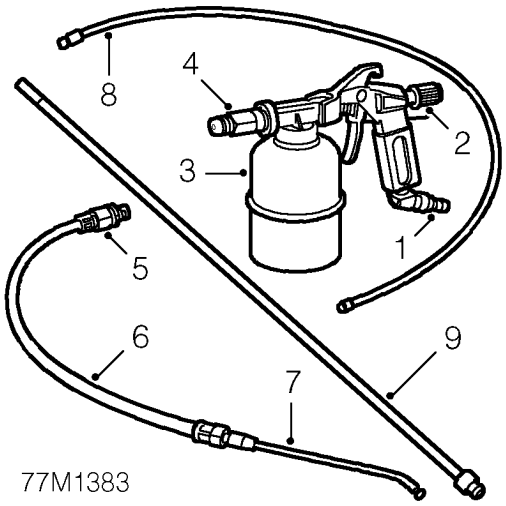
SATA Schutz Gun Model UBE
The SATA Schutz Gun is approved for the retreatment of vehicle underbody areas with protective coatings as supplied in 1 litre, purpose-designed 'one-way' containers. The screw thread fitting (female on the gun) is standard to most Schutz-type packs.

Specifications of Model UBE:	
Air consumption	7 ft^3/min (200 litres/min) @ 45 $lbf.in^2$
Weight:	23.3oz (220 grams)

SATA HKD1 Wax Injection Injection Equipment
This equipment is approved for carrying out cavity wax re-treatment. The SATA HKD1 set comprises a high quality forged gun with 1-litre pressure feed container, a flexible nylon lance, a straight 1100 mm (43.307 in) steel lance and hooked- wand lance. A quick-change coupling is provided as a standard fitting to allow lances to be easily interchanged. Each lance has an integral, machined nozzle with specialised spray characteristics to suit the type of box section to be treated.

NOTE: Always clean gun after use with appropriate solvent to maintain efficiency.

Cavity wax application equipment and techniques



1 Air inlet
2 Flow control (spray pattern adjustment)
3 Pressure cup (1 litre capacity). Maximum pressure 140PSI (9.7 bar, 9.84 kg/cm^3)
4 Gun connector
5 Lance nipple connection
6 Flexible lance
7 Rigid directional hook wand (forward cone spray pattern)
8 Flexible nylon lance 1100 mm (43.307 in) with 360° spray pattern
9 Rigid lance 1100 mm (43.307 in) with 360° spray pattern

When re-treating wax-injected areas which have been disturbed during repairs, it is necessary to use a compressed air spray gun with integral pressure cup and a selection of interchangeable lances.

The following points must be observed during use, according to the attachments fitted:

- Use the rigid or flexible lance attachments with 360° spray dispersal when treating enclosed areas, to ensure maximum coverage;
- Where openings are restricted, use the hook nozzle to provide a more directional spray (e.g. inside narrow or short box sections);
- Spray exposed underbody surfaces directly from the gun less lance attachment and without disconnecting the fluid coupling.

1100 mm (43.307 in) rigid lance

The nozzle on the rigid lance produces a 360° circular spray pattern combined with a forward-directed spray. Although wax is distributed to all box section surfaces in a single stroke, effective and complete coverage is obtained in long straight structures and box section cavities by spraying on both inward and outward strokes of the lance.

The rigid lance also provides the positional accuracy required in shaped sections, by allowing visual assessment.

CAUTION: Do not force the lance into access holes when using this attachment.

1100 mm (43.307 in) flexible nylon lance

This lance is similar in pattern to the rigid version, but provides the additional penetration required for curved sections or in places where access is difficult. Its main limitation is a lack of positional accuracy inside box sections.

Carry out all spraying on the outward stroke of the lance. Withdraw the lance slowly to ensure sufficient coverage. **Do not withdraw the lance too quickly.**

Ensure that the nylon tube of the lance is kept away from the edges of the access hole to eliminate abrasion and extend the life of the tube. Take care to ensure that spraying ceases just before the nozzle emerges from the access hole. To assist in this process paint the final 30 mm (1.181 in) of the nozzle with RED paint.

Hook nozzle on flexible lance

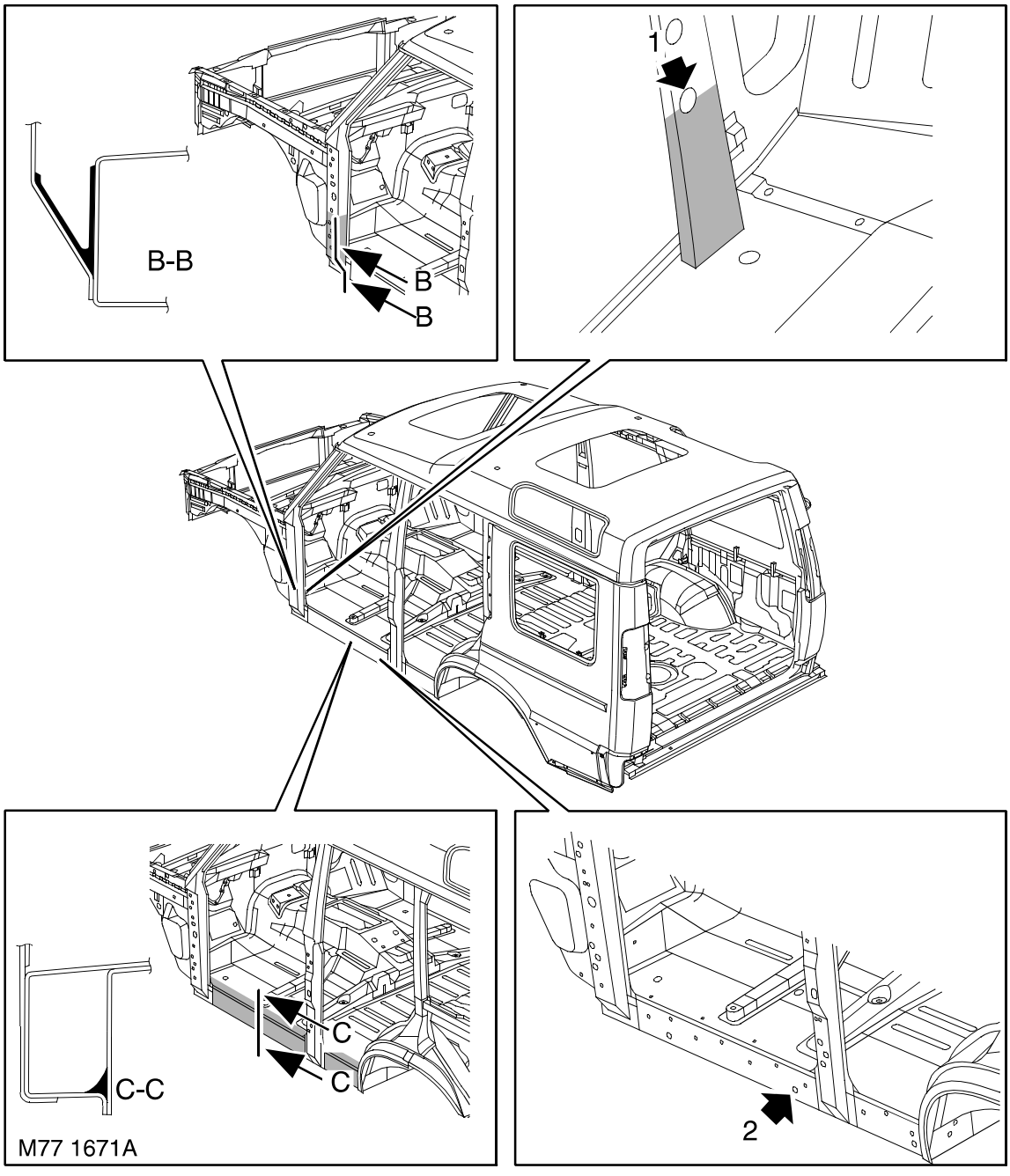
The rigid hook produces a highly atomised, forward-directed, fully conical spray pattern having long range and good dispersion characteristics. This combination has good directional capabilities for treating short, narrow sections, and may also be used for direct spraying of inner wheel arches etc.

In use, position the flat area at the end of the lance at 180° to the nozzle spray direction. This will help to guide the spray more accurately when it is concealed in a box section or access hole.

For general spraying, move the nozzle in an arc from side to side as required, to ensure full coverage.

NOTE: Always clean gun after use with appropriate solvent to maintain efficiency.

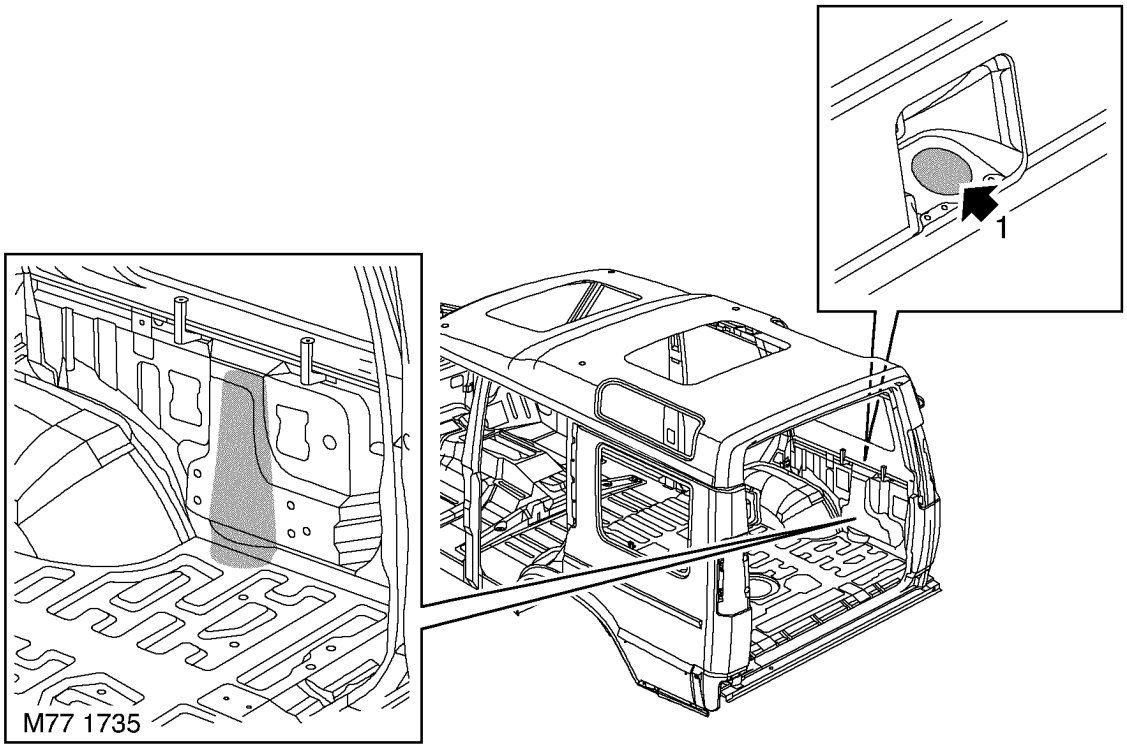
Cavity wax treatment areas and injection holes - 'A' post and sill



All areas symmetrically opposite to those shown are also treated.

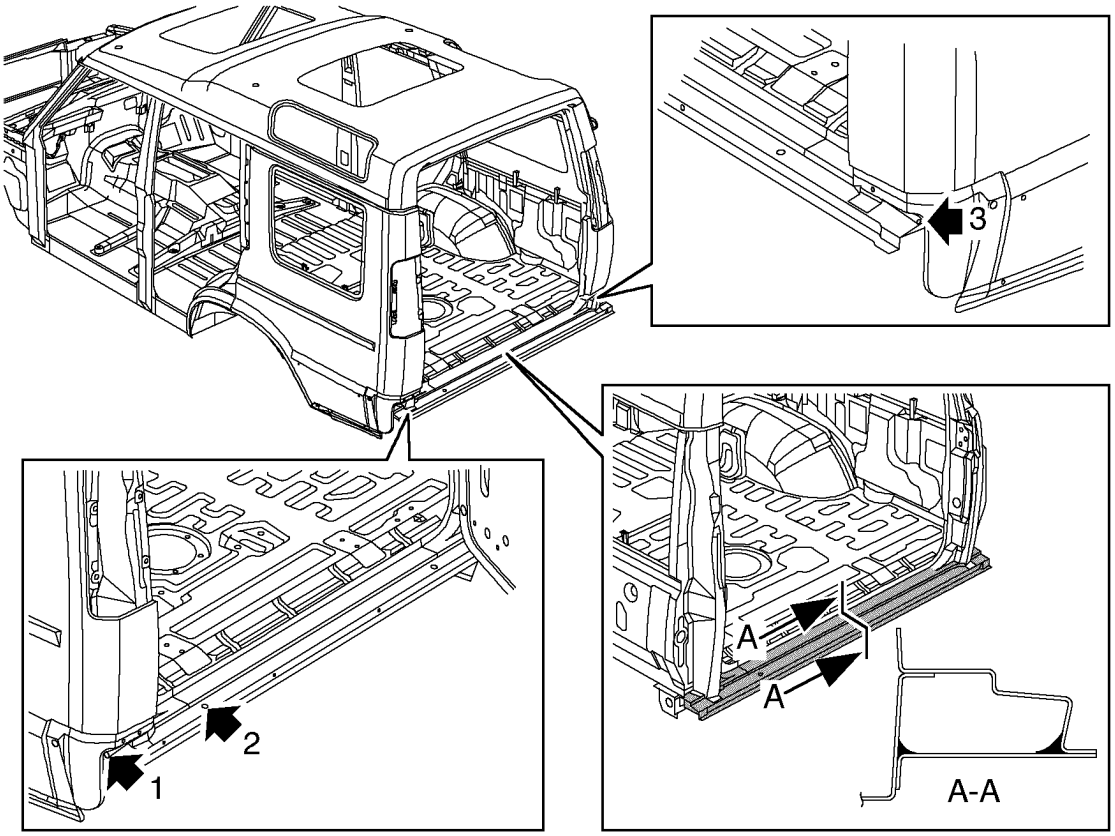
1 Injection hole for 'A' post
2 Injection hole for sill

Cavity wax treatment area and injection hole - fuel filler neck



1 Injection hole for fuel filler neck

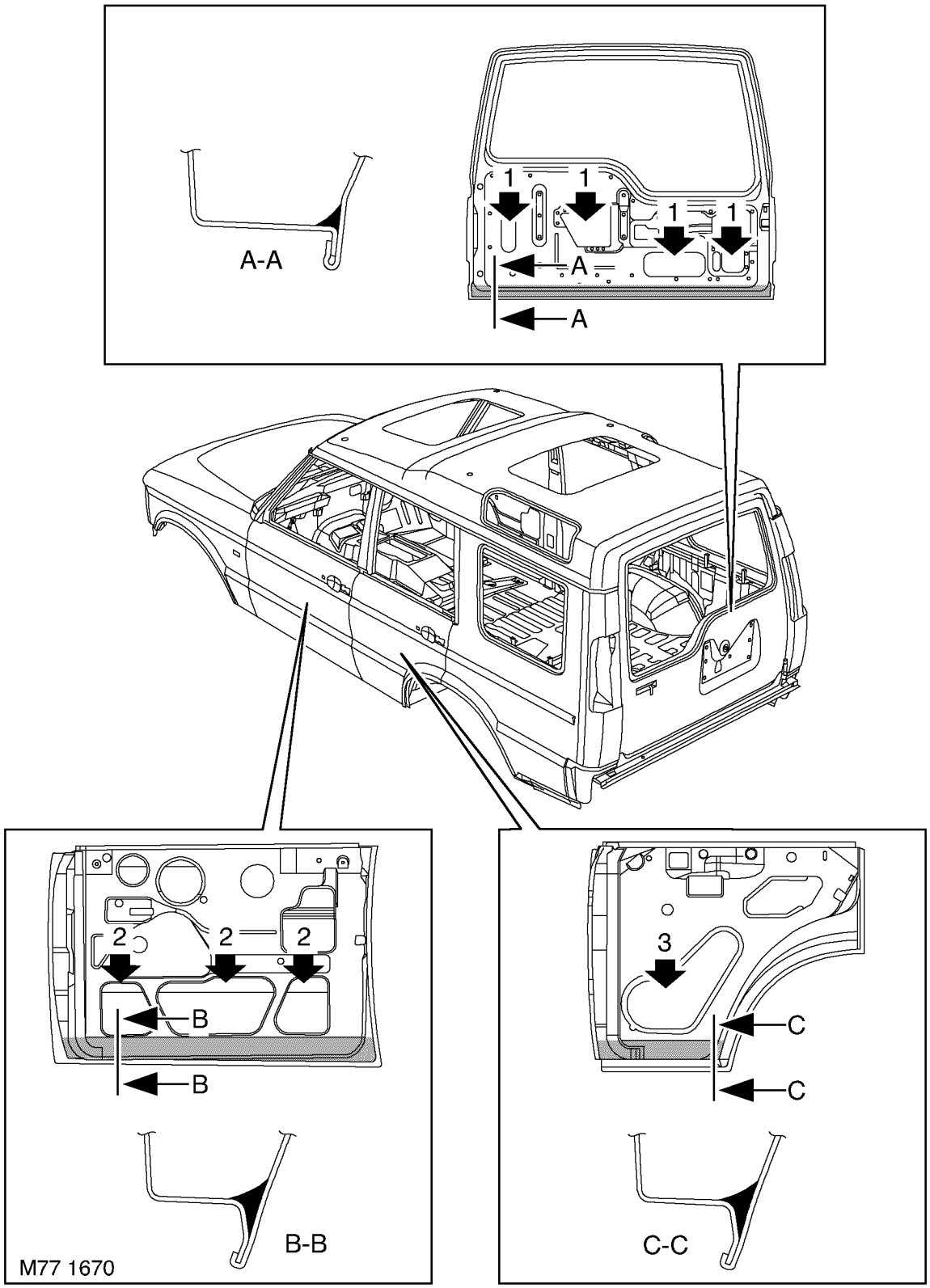
Cavity wax treatment areas and injection holes - rear cross member



M77 1736

1 LH Injection hole for rear cross member
2 Top injection hole for rear cross member
3 RH Injection hole for rear cross member

Cavity wax treatment areas and injection holes - front door, rear door and tail door



All areas symmetrically opposite to those shown are also treated.

1 Injection holes for tail door
2 Injection holes for front door
3 Injection hole for rear door

Corrosion prevention

Factory treatments
During production, vehicle bodies are treated with the following anti-corrosion materials:

- A PVC-based underbody sealer which is sprayed onto the underside of the main floor, rear floor, front and rear wheelarches and the front valance assembly;
- An application of cavity wax which is sprayed into the sill panels, 'A' post, 'B-C' post, fuel filler aperture, body rear panel and the lower areas of the door panels;
- A coating of underbody wax which is applied to the entire underbody inboard of the sill vertical flanges, and covers all moving and flexible components EXCEPT for wheels, tyres, brakes and exhaust;
- A coat of protective wax applied to the engine bay area.

Whenever body repairs are carried out, ensure the anti-corrosion materials in the affected area are repaired or renewed as necessary using the approved materials.

☞ **BODY SEALING MATERIALS, MATERIALS AND APPLICATIONS, Approved materials.**

Precautions during body repairs and handling
Take care when handling the vehicle in the workshop. Underbody sealers, seam sealers, underbody wax and body panels may be damaged if the vehicle is carelessly lifted.

☞ **LIFTING AND TOWING, LIFTING.**

Proprietary anti-corrosion treatments
The application of proprietary anti-corrosion treatments, in addition to the factory-applied treatment, could invalidate the Corrosion Warranty and should be discouraged. This does not apply to Rover approved, compatible, preservative waxes which may be applied on top of existing coatings.

Fitting approved accessories
When fitting accessories ensure that the vehicle's corrosion protection is not affected, either by breaking the protective coating or by introducing a moisture trap.

Do not screw self-tapping screws directly into body panels. Fit suitable plastic inserts to the panel beforehand. Always ensure that the edges of holes drilled into panels, chassis members and other body parts are protected with a suitable zinc rich or acid etch primer, and follow with a protective wax coating brushed onto the surrounding area.

Do not attach painted metal surfaces of any accessory directly to the vehicle's bodywork unless suitably protected. Where metal faces are bolted together always interpose a suitable interface material such as weldable zinc rich primer, extruded strip, or zinc tape.

Steam cleaning and dewaxing
Due to the high temperatures generated by steam cleaning equipment, there is a risk that certain trim components could be damaged and some adhesives and corrosion prevention materials softened or liquified.

Adjust the equipment so that the nozzle temperature does not exceed 90° C (194° F). Take care not to allow the steam jet to dwell on one area, and keep the nozzle at least 300 mm (11.811 in) from panel surfaces.

DO NOT remove wax or lacquer from underbody or underbonnet areas during repairs. Should it be necessary to steam clean these areas, apply a new coating of wax or underbody protection as soon as possible.

Inspections during maintenance servicing
It is a requirement of the Corrosion Warranty that the vehicle body is checked for corrosion by an authorised Land Rover Dealer at least once a year, to ensure that the factory-applied protection remains effective.

Service Job Sheets include the following operations to check bodywork for corrosion:

- With the vehicle on a lift, carry out visual check of underbody sealer for damage;
- With the vehicle lowered, inspect exterior paintwork for damage and body panels for corrosion.

It will be necessary for the vehicle to be washed by the Dealer prior to inspection of bodywork if the customer has offered the vehicle in a dirty condition.

The checks described above are intended to be visual only. It is not intended that the operator should remove trim panels, finishers, rubbing strips or sound-deadening materials when checking the vehicle for corrosion and paint damage.

With the vehicle on a lift, and using an inspection or spot lamp, visually check for the following:

- Corrosion damage and damaged paintwork, condition of underbody sealer on front and rear lower panels, sills and wheel arches;
- Damage to underbody sealer. Corrosion in areas adjacent to suspension mountings and fuel tank fixings.

NOTE: The presence of small blisters in the underbody sealer is acceptable, providing they do not expose bare metal.

Pay special attention to signs of damage caused to panels or corrosion protection material by incorrect jack positioning.

WARNING: It is essential to follow the correct jacking and lifting procedures.

With the vehicle lowered, visually check for evidence of damage and corrosion on all visible painted areas, in particular the following:

- Front edge of bonnet;
- Visible flanges in engine compartment;
- Lower body and door panels.

Rectify any bodywork damage or evidence of corrosion found during inspection as soon as is practicable, both to minimise the extent of the damage and to ensure the long term effectiveness of the factory-applied corrosion prevention treatment. Where the cost of rectification work is the owner's responsibility, the Dealer must advise the owner and endorse the relevant documentation accordingly.

Where corrosion has become evident and is emanating from beneath a removable component (e.g. trim panel, window glass, seat etc.), remove the component as required to permit effective rectification.

Underbody protection repairs

Whenever body repairs are carried out, ensure that full sealing and corrosion protection treatments are reinstated. This applies both to the damaged areas and also to areas where protection has been indirectly impaired, as a result either of accident damage or repair operations.

Remove corrosion protection from the damaged area before straightening or panel beating. This applies in particular to panels coated with wax, PVC underbody sealer, sound deadening pads etc.

WARNING: DO NOT use oxy-acetylene gas equipment to remove corrosion prevention materials. Large volumes of fumes and gases are liberated by these materials when they burn.

NOTE: Equipment for the removal of tough anti-corrosion sealers offers varying degrees of speed and effectiveness. The compressed air-operated scraper (NOT an air chisel) offers a relatively quiet mechanical method using an extremely rapid reciprocating action. Move the operating end of the tool along the work surface to remove the material.

The most common method of removal is by means of a hot air blower with integral scraper.

Another tool, and one of the most efficient methods, is the rapid-cutting 'hot knife'. This tool uses a wide blade and is quick and versatile, able to be used easily in profiled sections where access is otherwise difficult.

Use the following procedure when repairing underbody coatings:

1. Remove existing underbody coatings
2. After panel repair, clean the affected area with a solvent wipe, and treat bare metal with an etch phosphate material
3. Re-prime the affected area

CAUTION: DO NOT, under any circumstances, apply underbody sealer directly to bare metal surfaces.

4. Replace all heat-fusible plugs which have been disturbed. Where such plugs are not available use rubber grommets of equivalent size, ensuring that they are embedded in sealer
5. Mask off all mounting faces from which mechanical components, hoses and pipe clips, have been removed. Underbody sealer must be applied **before** such components are refitted
6. Brush sealer into all exposed seams
7. Spray the affected area with an approved service underbody sealer
8. Remove masking from component mounting faces, and touch-in where necessary. Allow adequate drying time before applying underbody wax

After refitting mechanical components, including hoses and pipes and other fixtures, mask off the brake discs and apply a coat of approved underbody wax.

NOTE: Where repairs include the application of finish paint coats in the areas requiring underbody wax, carry out paint operations before applying wax.

Cavity wax injection
Areas treated with cavity wax are shown in the previous figures. After repairs, always re-treat these areas with an approved cavity wax. In addition, treat all interior surfaces which have been disturbed during repairs whether they have been treated in production or not. This includes all box members, cavities and door interiors. It is permissible to drill extra holes for access where necessary, provided these are not positioned in load-bearing members. Ensure that such holes are treated with a suitable zinc rich primer, brushed with wax and then sealed with a rubber grommet.

Before wax injection, ensure that the cavity to be treated is free from any contamination or foreign matter. Where necessary, clear out any debris using compressed air.

Ensure that cavity wax is applied AFTER the final paint process and BEFORE refitting any trim components.

During application, ensure that the wax covers all flange and seam areas and that it is adequately applied to all repaired areas of both new and existing panels.

It should be noted that new panel assemblies and complete body shells are supplied without wax injection treatment. Ensure that such treatment is carried out after repairs.

Effective cavity wax protection is vital. Always observe the following points:
- Complete all paint refinish operations before wax application;
- Clean body panel areas and blow-clean cavities if necessary, before treatment;
- Maintain a temperature of 18° C (64° F) during application and drying;
- Check the spray pattern of injection equipment;
- Mask off all areas not to be wax coated and which could be contaminated by wax overspray;
- Remove body fixings, such as seat belt retractors, if contamination is at all likely;
- Move door glasses to fully closed position before treating door interiors;
- Treat body areas normally covered by trim before refitting items;
- Check that body and door drain holes are clear after the protective wax has dried;
- Keep all equipment clean, especially wax injection nozzles.

Underbody wax
The underbody wax must be reinstated following all repairs affecting floor panels. The wax is applied over paints and underbody sealers.

Remove old underbody wax completely from a zone extending at least 200 mm (7.874 in) beyond the area where new underbody sealer is to be applied.

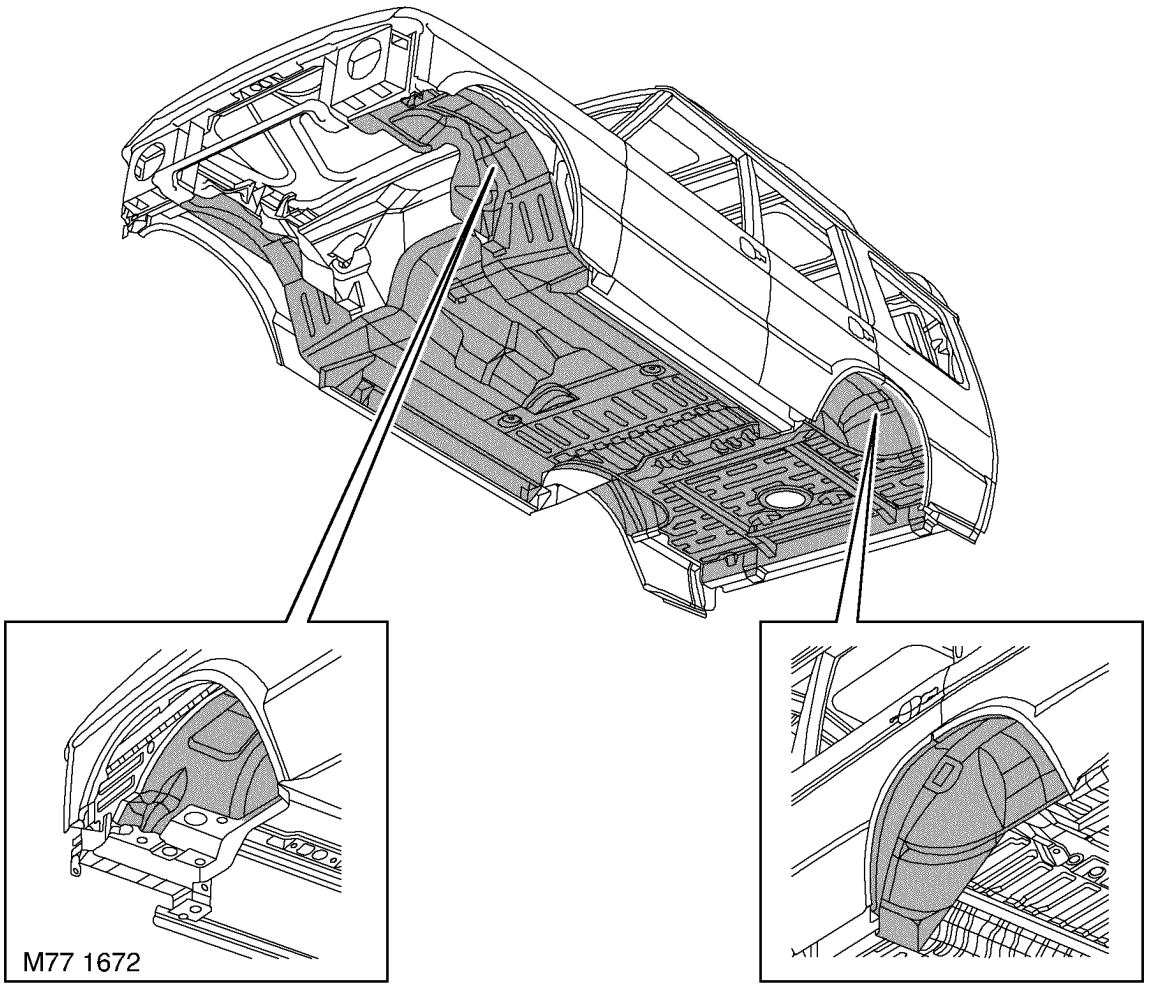
Engine bay wax
Reinstate all protective engine bay wax disturbed during repairs using an approved material.

Where repairs have involved replacement of engine bay panels, treat the entire engine compartment including all components, clips and other fixtures with an approved underbonnet lacquer or wax.

☞ **BODY SEALING MATERIALS, MATERIALS AND APPLICATIONS, Approved materials.**

Body Sealing

Underbody sealer treatment areas

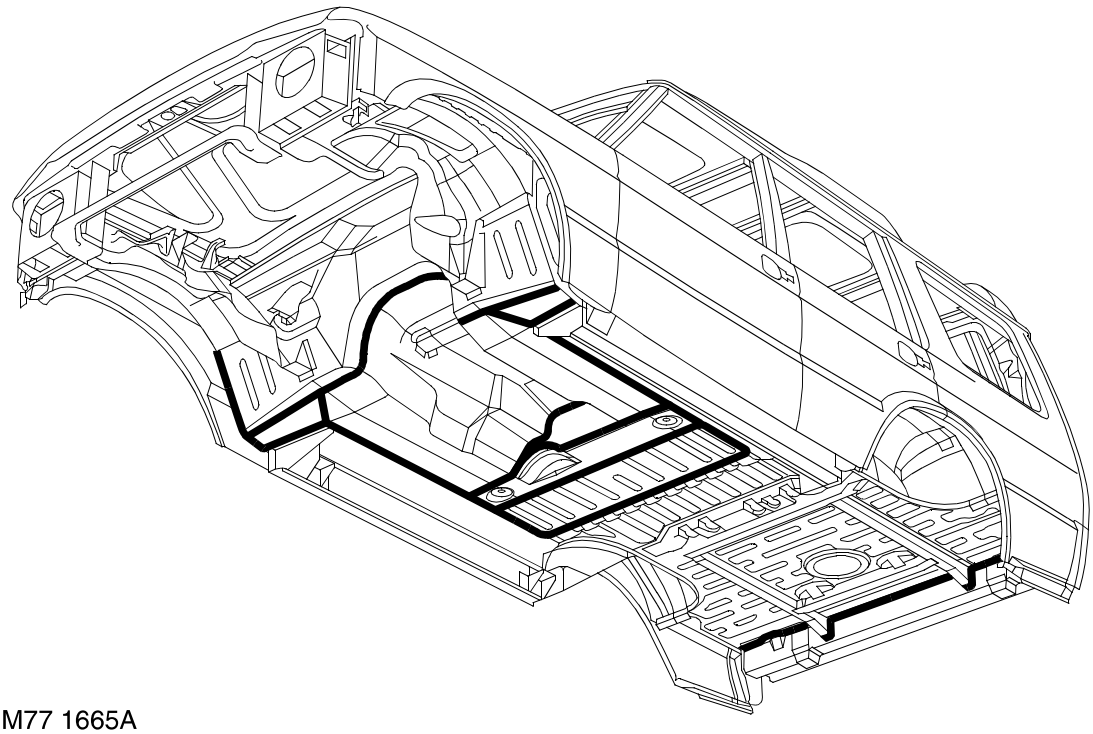


Underfloor areas and sill outer panels are treated with a Plastisol PVC underbody sealer. This material is not suitable for re-treatment. When repairing areas of underbody sealer, strip the factory-applied underbody sealer back to a suitable break point. Ensure that a clean metal surface is exposed and that the edge of the existing sealer adheres soundly to the panel.

Apply new underbody sealer between primer and surfacer paint operations. Apply seam sealer as necessary before application of underbody sealer. Ensure that blanking plugs and grommets in the floor pan (except those used for wax injection) are fitted before underbody sealer application. Refit any heat-fusible plugs which have been disturbed in repair with the aid of a hot air blower, or replace with rubber grommets.

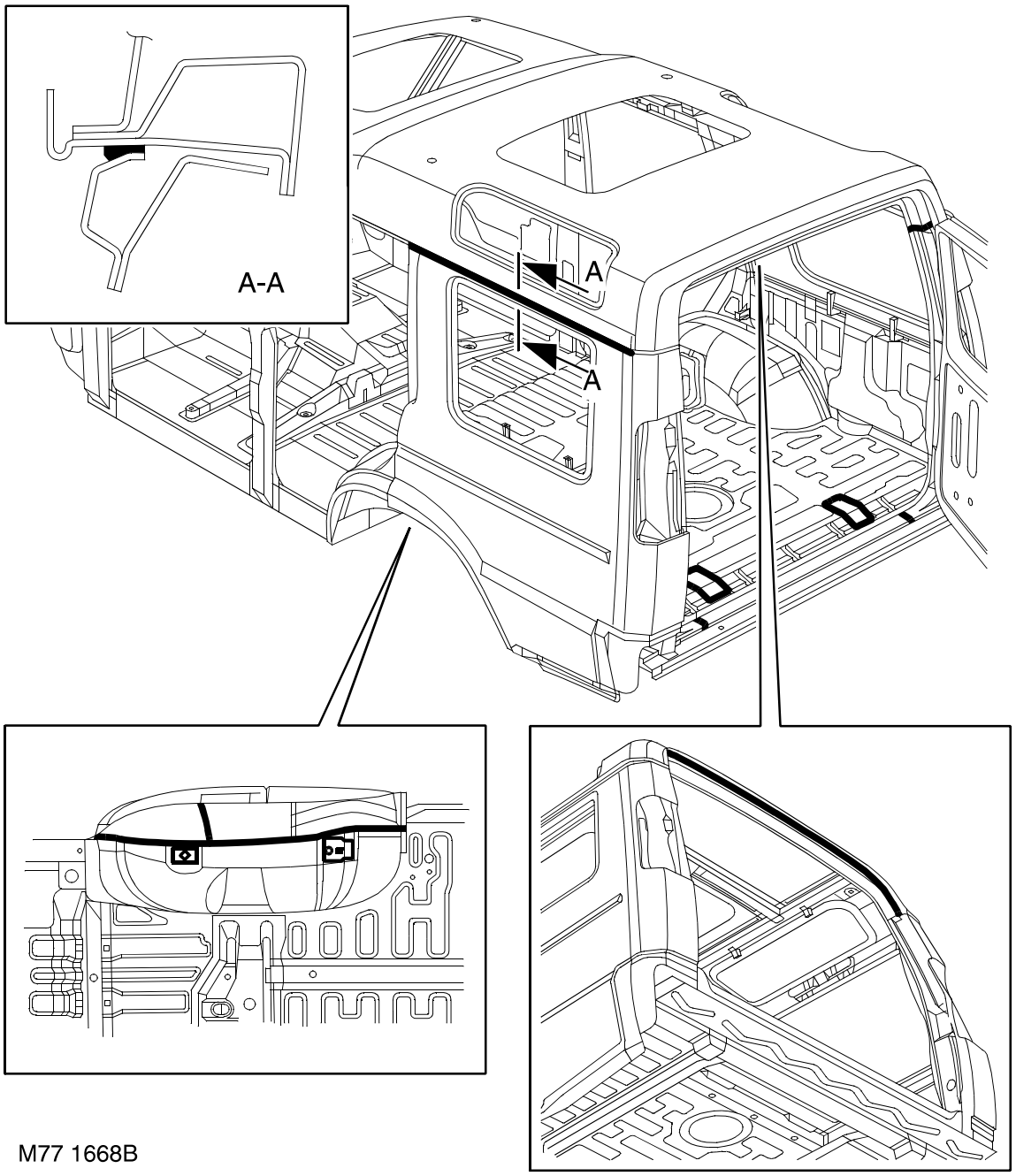
CAUTION: Ensure that suspension units, wheels, tyres, power unit, propeller shafts, exhaust and brakes (including all mounting points) are shielded prior to application of fresh underbody sealer.

Seam sealers



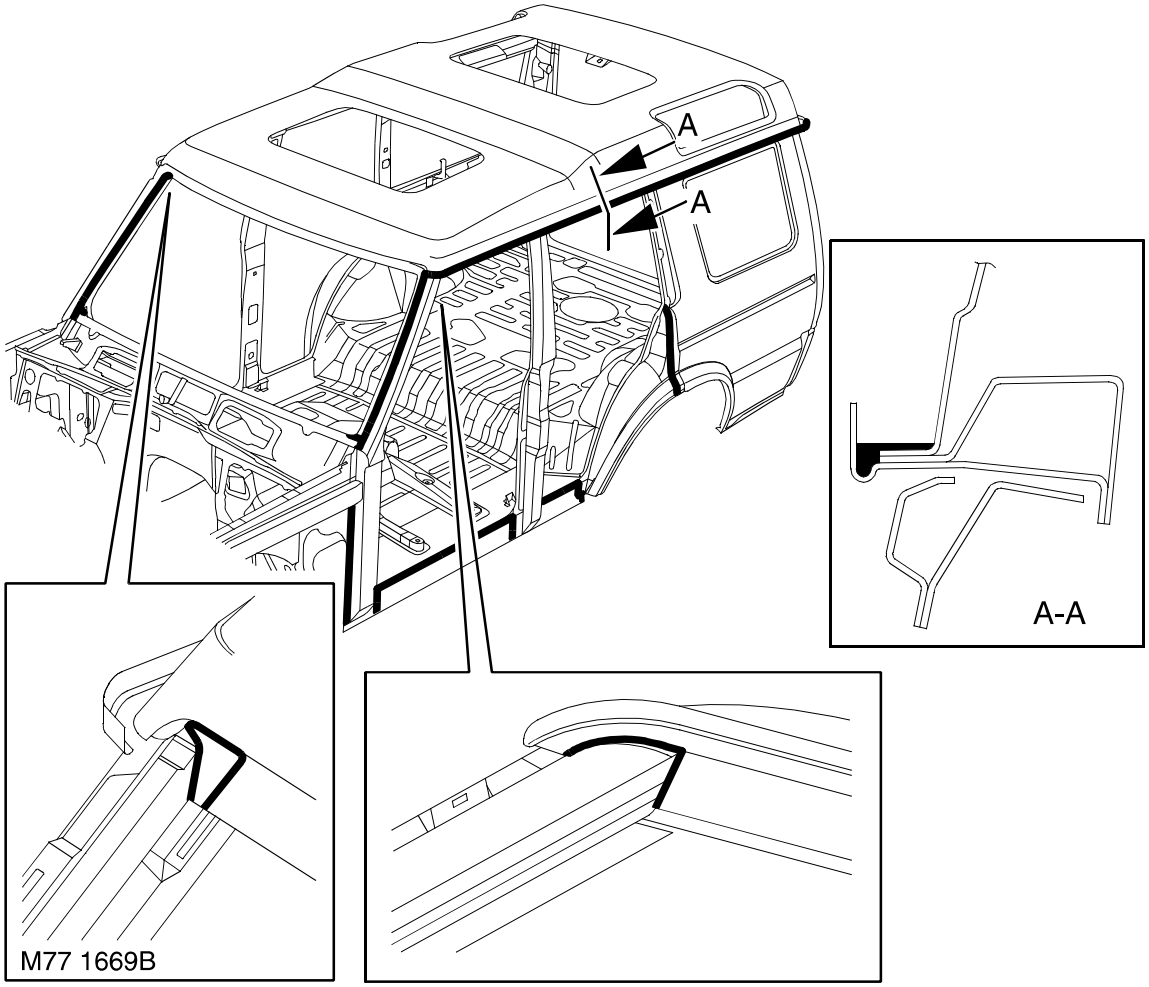
M77 1665A

Seam sealer - underside of vehicle.

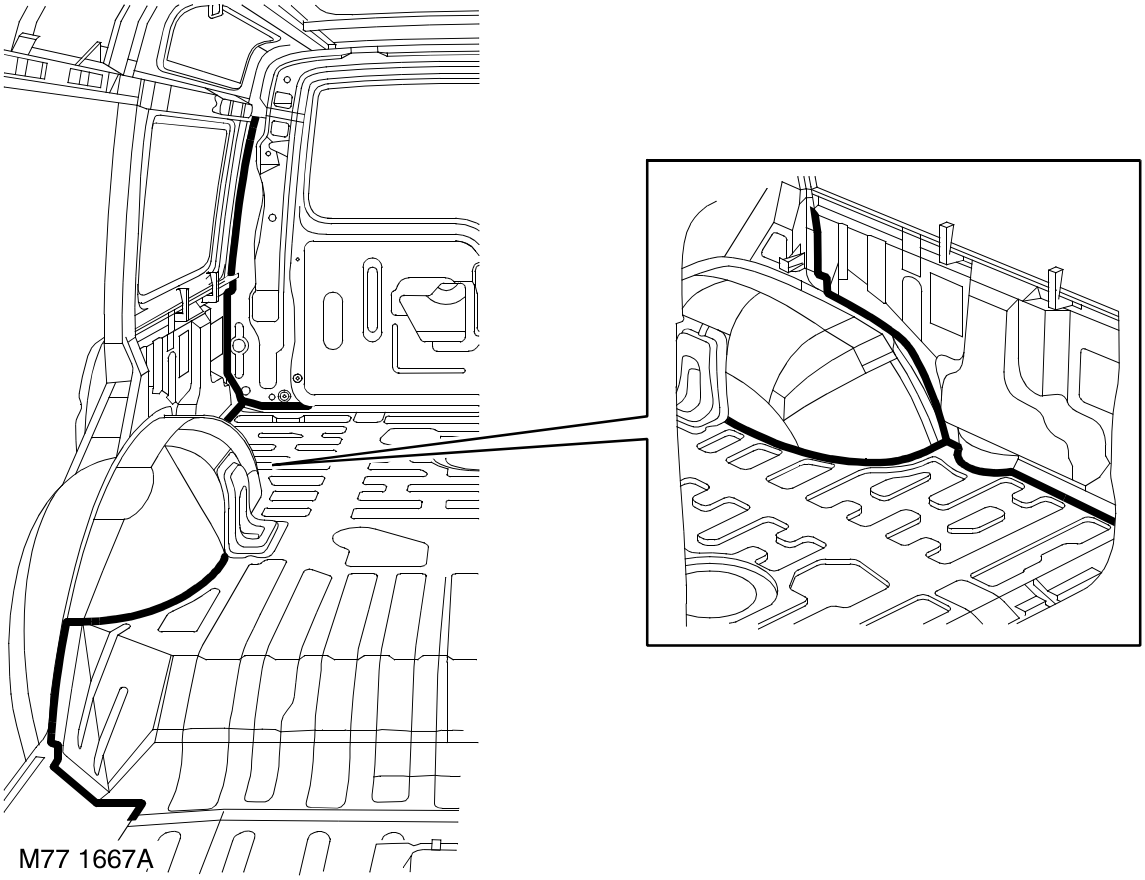


M77 1668B

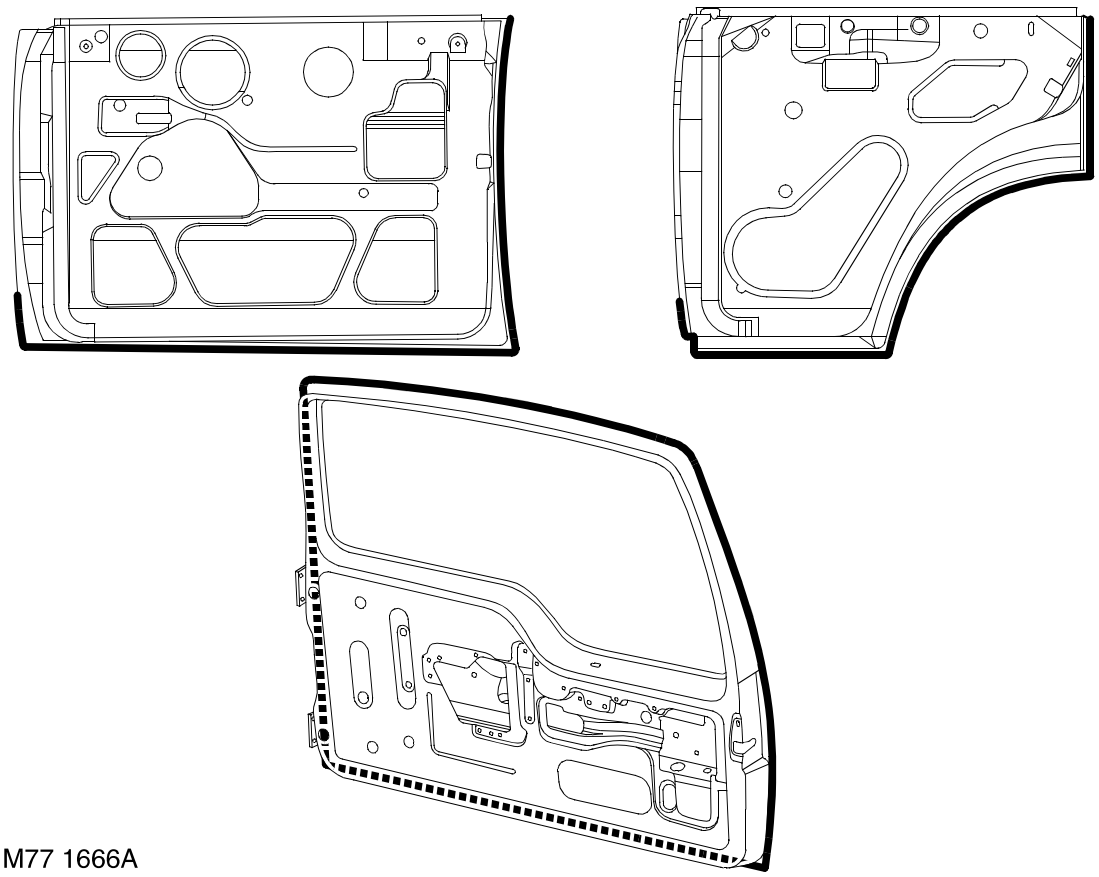
Seam sealer - rear end and underside of vehicle. Seams symmetrically opposite to those shown are also treated.



Seam sealer - exterior of vehicle. Seams symmetrically opposite to those shown are also treated. On roof seams, sealant to be wiped to a smooth finish



Seam sealer - interior of vehicle. Seams symmetrically opposite to those shown are also treated. Sealant to be wiped to a smooth finish.



M77 1666A

Seam sealer - doors. Seams symmetrically opposite to those shown are also treated. Ensure drain holes in doors are not blocked by sealant.

A heat cured, PVC based sealant is applied to specific joint seams during factory assembly. This material is not suitable for service use and, during repair, should be substituted by an approved Seam Sealer.

☞ **BODY SEALING MATERIALS, MATERIALS AND APPLICATIONS, Approved materials.**

Seams to which seam sealer is applied during factory assembly are detailed in the previous illustrations.

Apply seam sealers after the application of primer and before the application of surfacer and top coat. The seam sealer must form a continuous bead, with the profile of the bead dependant on the type of seam. If seam sealer is applied with a brush, take particular care to maintain the required coverage of the seam. Where shaping of the seam sealer is required, use a cloth soaked with solvent such as white spirit or Shell SBP3 to achieve the required finish.

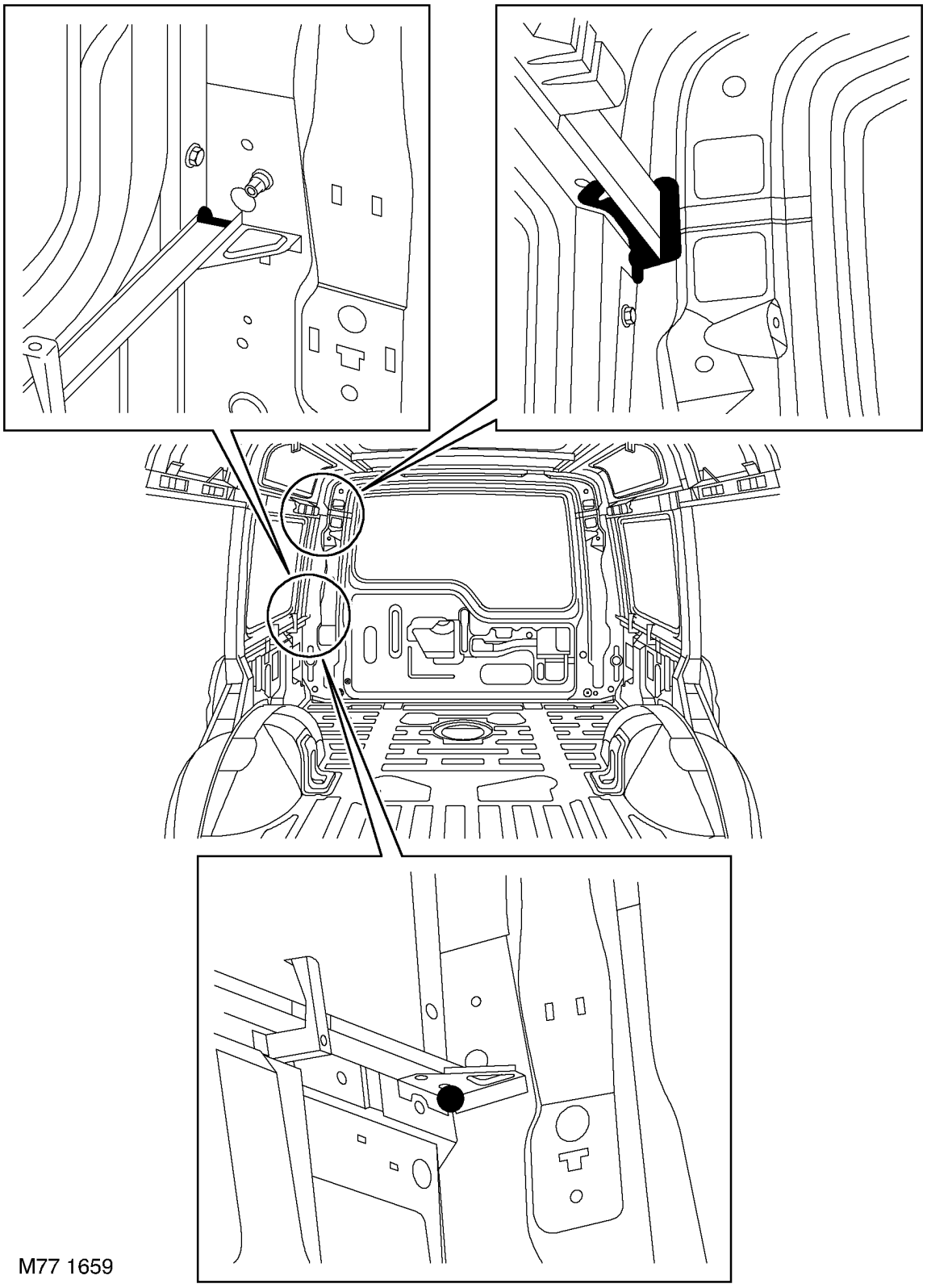
Ensure that ALL accessible repair seams are sealed following a repair. Damage to a vehicle often flexes areas of the body remote from the impact. As a result, the seam sealer in these areas may be disturbed by subsequent straightening and repair operations. Check all seams in the vicinity of the area undergoing repair for evidence of cracked seam sealer, then clean out as required and apply fresh seam sealer using the following procedure:

- Clean the affected seam and re-treat any exposed metal areas with a suitable etch phosphate primer;
- Apply appropriate seam sealer as necessary;
- Treat affected area with an acid-etch prime (and underbody sealer as applicable);
- Apply appropriate colour coat.

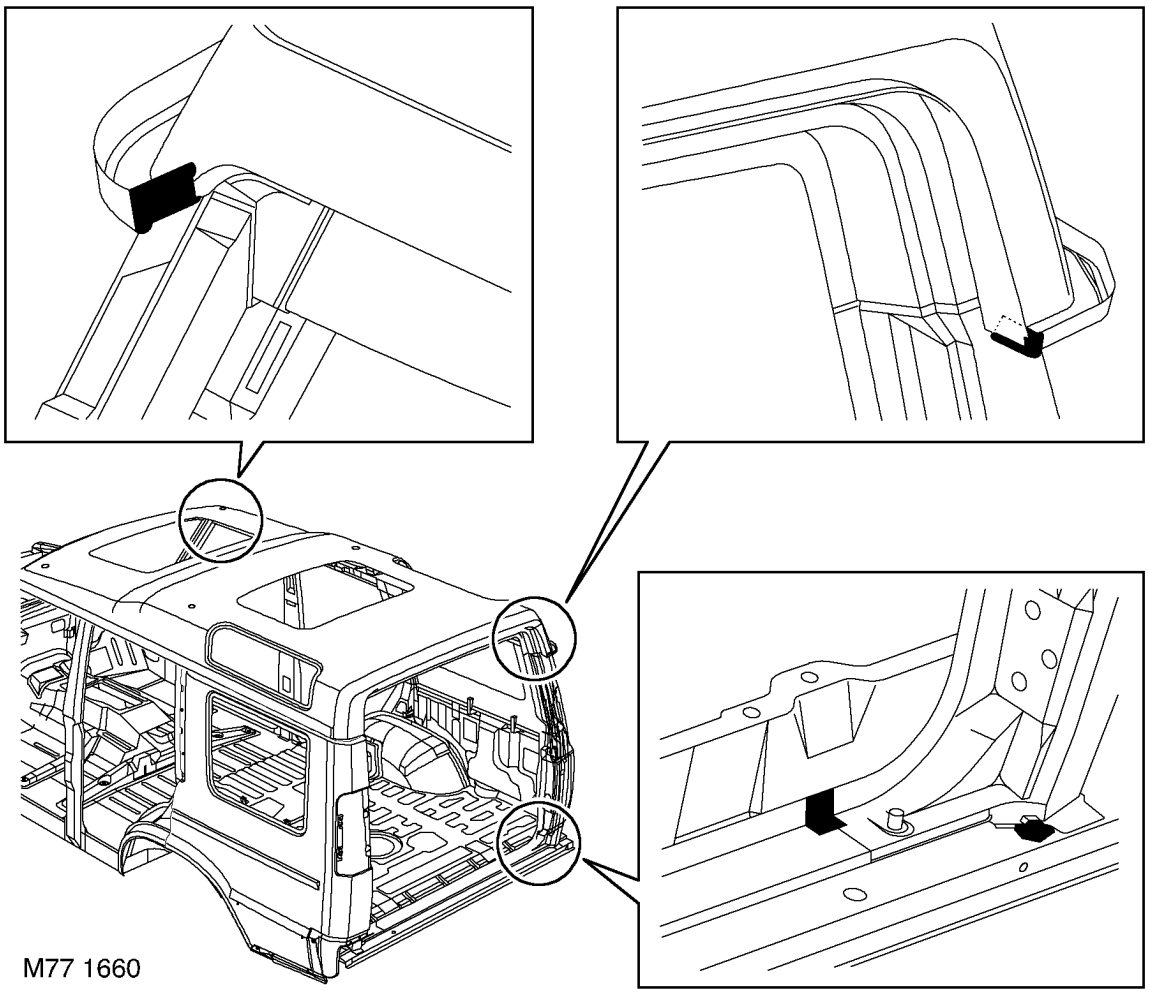
Where seams are inaccessible following the reassembly or fitting of components, ensure that a paste-type seam sealer is applied to such seams. Certain seams also become inaccessible after the completion of panel repairs. In such instances apply seam sealer and paint before final assembly.

Provided access is adequate, apply seam sealer to both sides of a repair joint. Where access is limited to one side only (e.g. box sections), treat the affected box member with cavity wax.

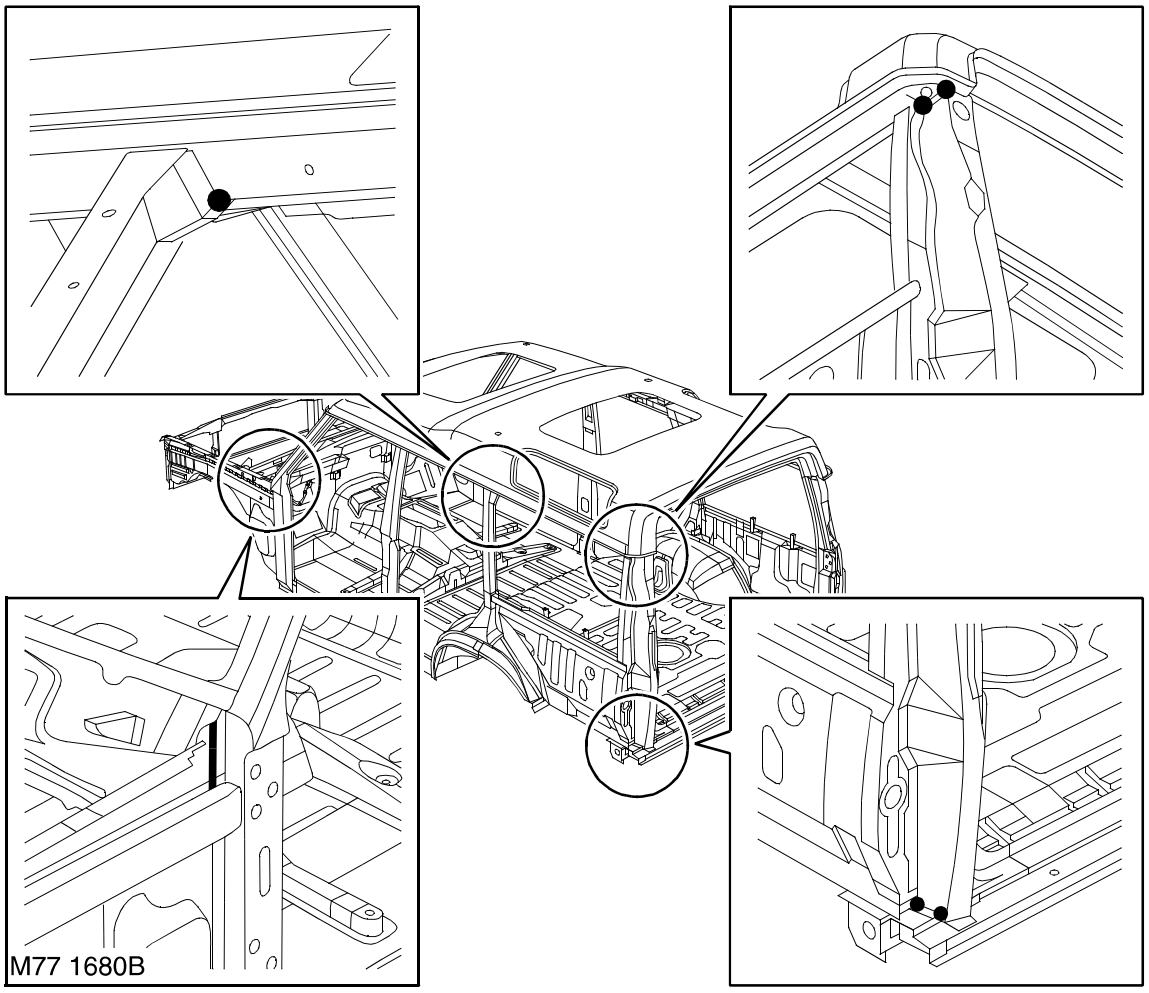
Putty



Putty location - vehicle interior



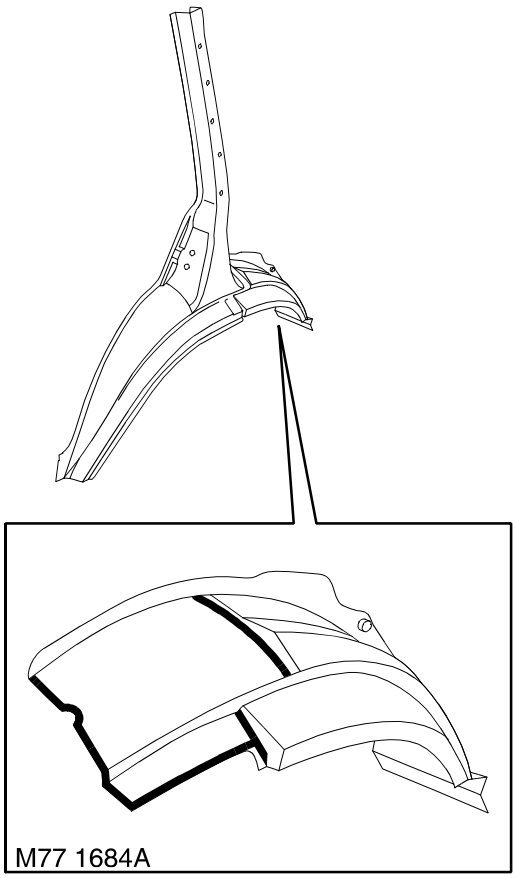
Putty location - vehicle exterior



Putty location - vehicle exterior

The previous illustrations show the areas where putty is applied. Putty is applied to areas to act as a gap filler and for sealing seams. When applying putty ensure that correct area is filled and where necessary, is smoothed to give a cosmetically acceptable condition.

Structural adhesive



Adhesive on rear wheel arch outer assembly.
Joints symmetrically opposite to those shown are also treated. Apply 3 mm diameter beads to all joints shown.

Metal-to-metal adhesive is applied to critical joint areas during factory assembly. The material used is a high-temperature, heat cured, nitrile phenolic which serves to bond two metal surfaces and also to seal the joint against ingress of dust, moisture and fumes. This material is not suitable for service use and, during repair, should be substituted by an approved Structural Adhesive.

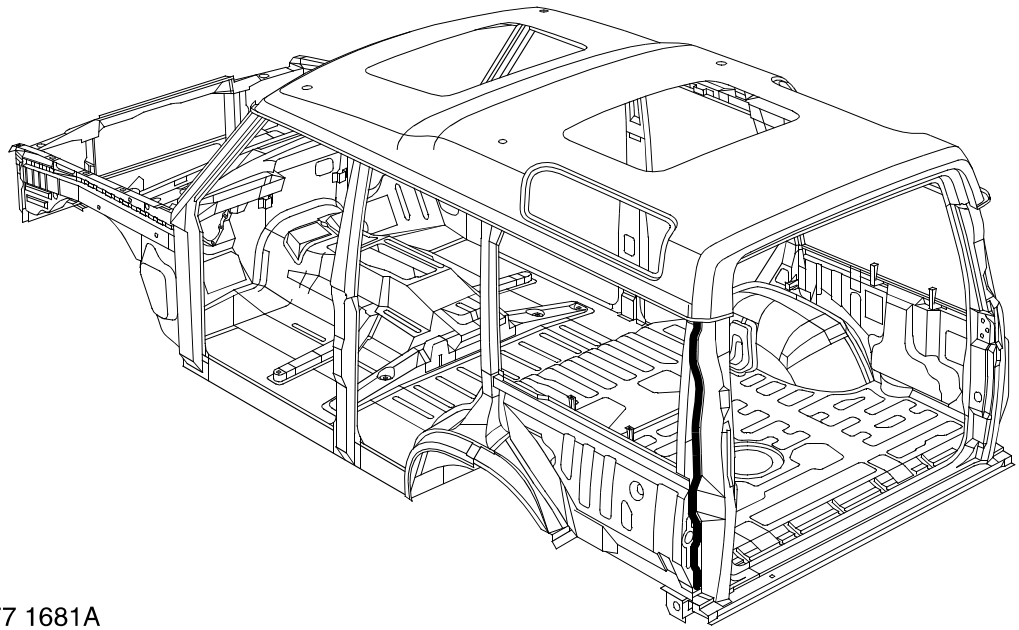
☞ **BODY SEALING MATERIALS, MATERIALS AND APPLICATIONS, Approved materials.**

Those joints which require the application of structural adhesive are detailed in the following figures. Only joints applicable to service panels are included. Apply structural adhesive where indicated or to the mating panel surface.

CAUTION: When separating a joint treated with metal-to-metal adhesive, it is important to avoid distortion. Heat the joint gradually until the bond weakens sufficiently to permit panel separation.

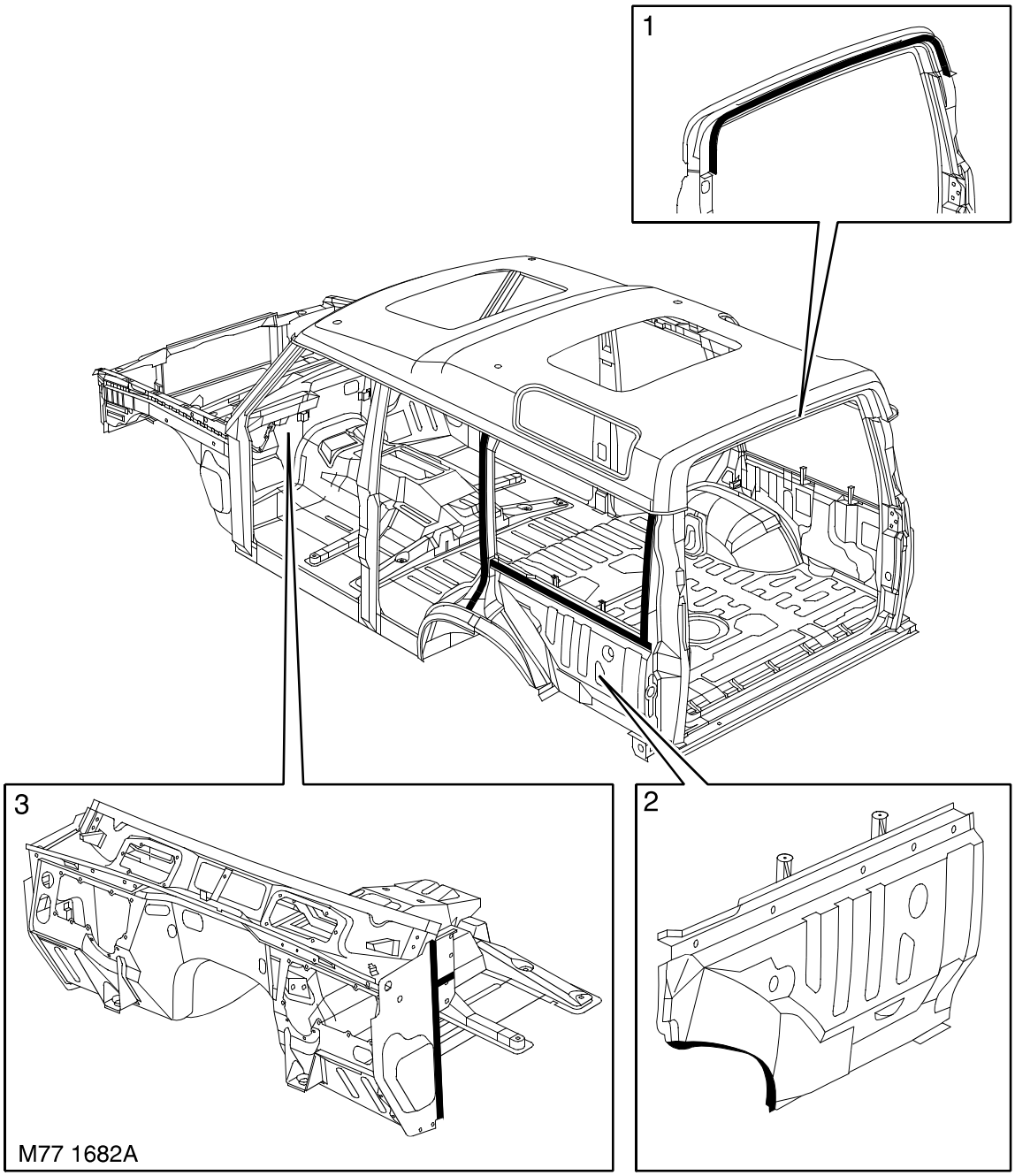
NOTE: When spot welding through metal-to-metal adhesive, take particular care to adjust the transformer setting to ensure a reliable weld.

Interweld sealer



M77 1681A

Interweld sealing areas - rear end. Seams symmetrically opposite to those shown must also be treated.



Interweld sealing areas. Seams symmetrically opposite to those shown must also be treated.

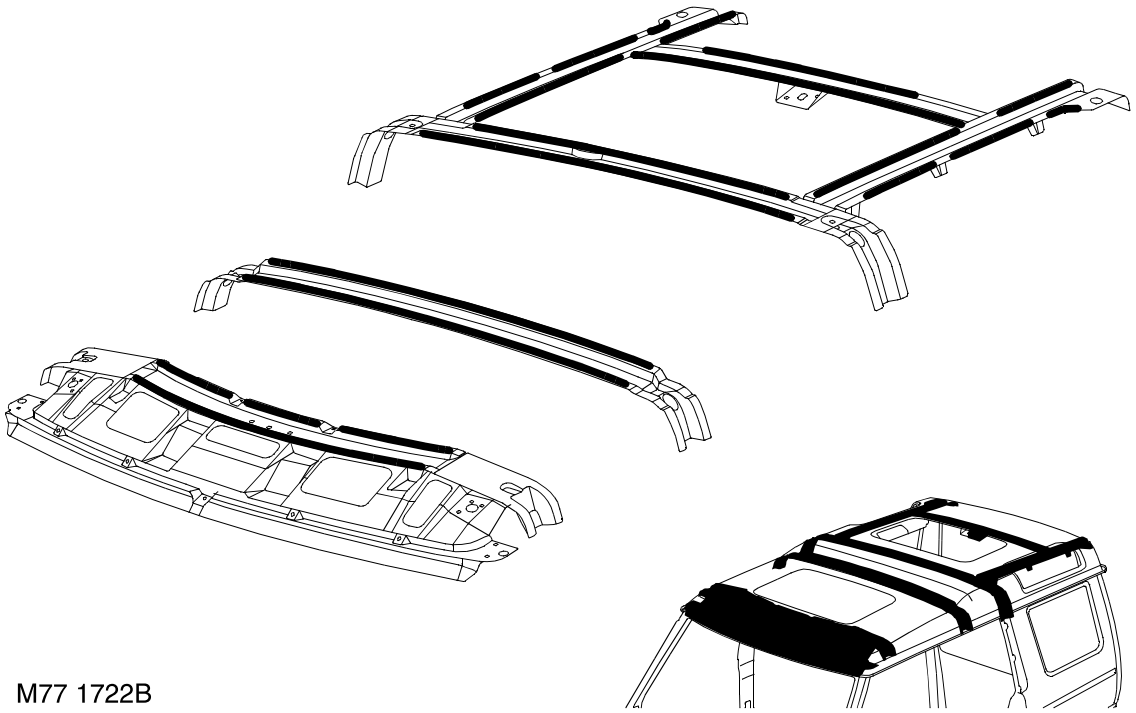
1 10 mm (0.393 in) x 2 mm (0.078 in) 'Butyl strip'
2 10 mm (0.393 in) x 1 mm (0.039 in)'Butyl strip'
3 Interweld sealant

Butyl tape is also applied to the bodyside rear glass aperture flanges. On the forward edge of the aperture a 15 mm (0.590 in) x 2 mm (0.078 in) strip is applied, and on the lower and rearward edges a 10 mm (0.393 in) x 2 mm (0.078 in) strip is applied.

During production, interweld sealer is applied to critical joint areas. The material used is a heat cured, rubber based sealant which serves to seal two metal surfaces and prevent the ingress of moisture, dust and fumes. Before refitting a replacement panel, apply interweld sealer to areas indicated or to the mating panel face.

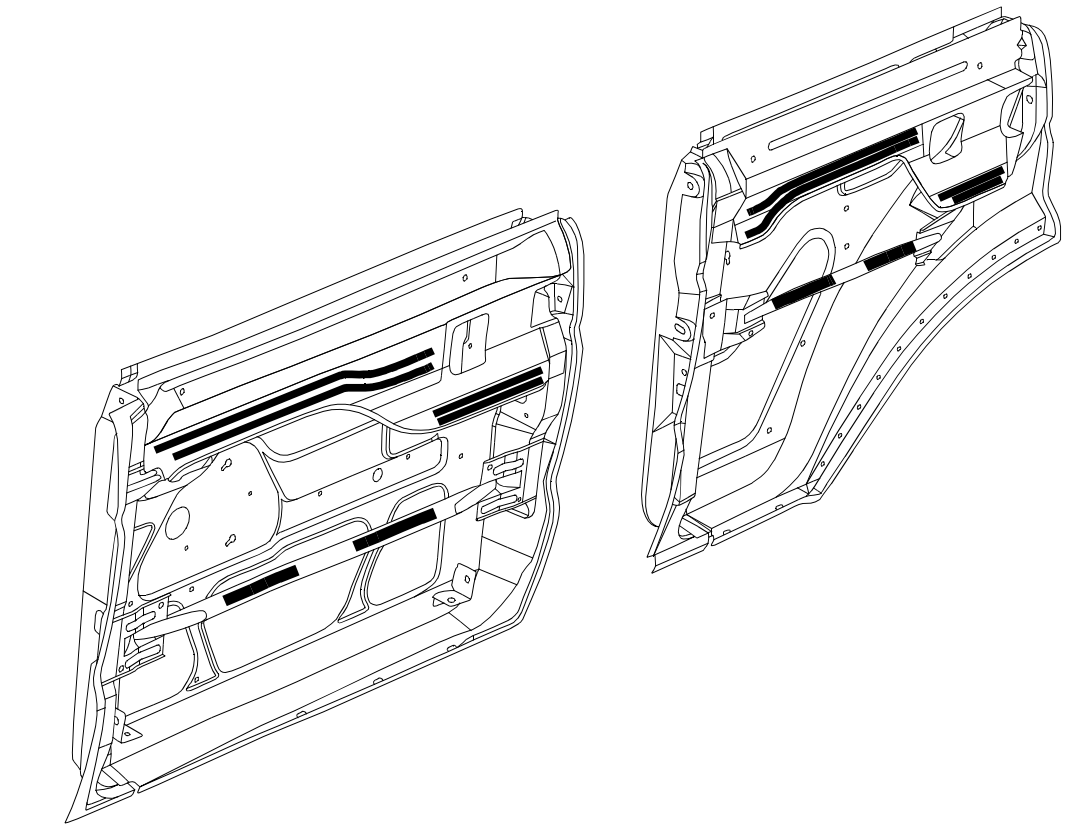
Those joints which require the application of interweld sealers are detailed in the previous illustrations. Only joints applicable to service panels are included.

Gap fill sealer



M77 1722B

Gap fill sealer - front header and roof bows



M77 1724B

Gap fill sealer - front and rear doors

The previous illustrations show the areas where gap-fill (anti-flutter) sealer is applied. The material bonds two surfaces together but allows for a certain amount of movement between the two bonded surfaces.

Water leaks

Where water leakage is involved, always adopt a logical approach to the problem using a combination of skill, experience and intuition. Do not reach a conclusion based only on visual evidence, such as assuming that a wet footwell is caused by a leak emanating from the windscreen. It will often be found that the source of the leak is elsewhere. Use of the correct procedure will increase the chance of locating a leak, however obscure it may seem.

Tools and equipment

The following tools and equipment are recommended for the purpose of detection and rectification of water leaks:

1. Garden sprayer (hand-operated)
2. Wet/dry vacuum cleaner
3. Dry, absorbent cloths
4. Battery torch
5. Small mirror
6. Weatherstrip locating tool
7. Trim panel remover
8. Small wooden or plastic wedges
9. Dry compressed air supply
10. Hot air blower
11. Sealer applicators
12. Ultrasonic leak detector

During leak detection, the vehicle should be considered in three basic sections:

- The front interior space;
- The rear passenger space;
- The loadspace or boot.

Testing

From the information supplied by the customer it should be possible for the bodyshop operator to locate the starting point from which the leak may be detected. After the area of the leak has been identified, find the actual point of entry into the vehicle.

A simple and effective means in the first instance is an ordinary garden spray with provision for pressure and jet adjustment, which will allow water to be directed in a jet or turned into a fine spray. Use a mirror and a battery-powered torch (NOT a mains voltage inspection lamp) to see into dark corners.

The sequence of testing is particularly important. Start at the lowest point and work slowly upwards, to avoid testing in one area while masking the leak in another. For example, if testing started at the level of the windscreen, any water cascading into the plenum chamber could leak through a bulkhead grommet and into the footwells. Even at this point it could still be wrongly assumed that the windscreen seal was at fault.

Another important part of identifying a water leak is by visual examination of door aperture seals, grommets and weatherstrips for damage, deterioration or misalignment, together with the fit of the door itself against the seals.

Sealing

When the point of the leak has been detected, it will then be necessary to rectify it using the following procedure:

1. Renew all door aperture seals and weatherstrips which have suffered damage, misalignment or deterioration
2. Check all body seals to ensure that they are correctly located on their mounting flanges/faces using a lipping tool if necessary
3. Dry out body seams to be treated using compressed air and/or a hot air blower as necessary
4. Apply sealant on the outside of the joint wherever possible to ensure the exclusion of water
5. When rectifying leaks between a screen glass and it's weatherstrip (or in the case of direct glazing, between the glass and bodywork), avoid removing the glass if possible. Apply the approved material at the appropriate location (i.e. glass to weatherstrip or glass to body)

Panel preparation

General
Replacement panels are supplied with a cathodic primer coating as part of the panel protection and in compliance with the vehicle's Corrosion Warranty, where applicable. **DO NOT remove the primer before paint refinishing. In the event of localised surface damage or imperfections, ensure that only the minimum of primer is removed during rectification work for effective repair.**

Rectify damage as far as possible by panel beating or straightening. To remove corrosion or paint runs on outer surfaces, abrade the primer coat in the affected area as necessary, then follow the procedure below:

1. Clean the panel using a solvent wipe
2. Treat exposed areas of metal with an etch phosphate process
3. Re-treat the affected area using either a separate acid-etch primer and two-pack surfacer, or an integrated etch primer/filler

Panel preparation
The following procedures should be followed when repairing panels.

Welded panels
When replacing welded panels the following procedure must be observed:

1. Remove primer from the immediate vicinity of new and existing panel flanges, cleaning to bright metal finish
2. On joints to be spot welded, apply weld-through zinc rich primer to joint faces of both flanges. Make spot welds while primer is still wet or according to the manufacturer's instructions
3. Dress accessible weld joints
4. Clean panel using solvent wipe
5. Treat bare metal with an etch phosphate process
6. Re-treat repaired areas

Sectioned panels
When replacing part or sectioned panels, the basic procedure is the same as for welded panels described above, with the following variations:

1. Remove primer from both new and existing joint faces, cleaning to a bright metal finish
2. Where an overlap joint with the existing panel is to be spot welded, apply weld-through, zinc rich primer to both joint faces and spot weld while the primer is still wet, or according to the manufacturer's instructions
3. MIG weld butt joints where applicable
4. Dress weld joints
5. Clean the panel with a solvent wipe.
6. Treat bare metal areas using an etch phosphate process
7. Re-treat the affected area using either a separate acid-etch primer and two-pack surfacer, or an integrated etch primer/filler
8. Treat the inner faces of lap or butt joints with a suitable cavity wax

☞ **PANEL REPAIRS, PROCEDURES, Panel replacement procedure.**

Clinched panels
When replacing clinched panels the following procedure must be observed:

1. Abrade primer on new and existing panel joint faces, and clean using a solvent wipe
2. Apply metal-to-metal adhesive where applicable
3. Where joints are to be spot welded, apply suitable weld-through, zinc rich primer to weld areas
4. Where joints are to be MIG, arc or gas welded, apply zinc rich primer in adjacent areas **but leave the welded area untreated**
5. To retain the panel while clinching the flanges, tack spot weld or plug weld as appropriate
6. Clean the panel with a solvent wipe
7. Treat bare metal areas with a suitable etch phosphate process
8. Re-treat the affected area using either a separate acid-etch primer and two-pack surfacer, or an integrated etch primer/filler

Paint preparation

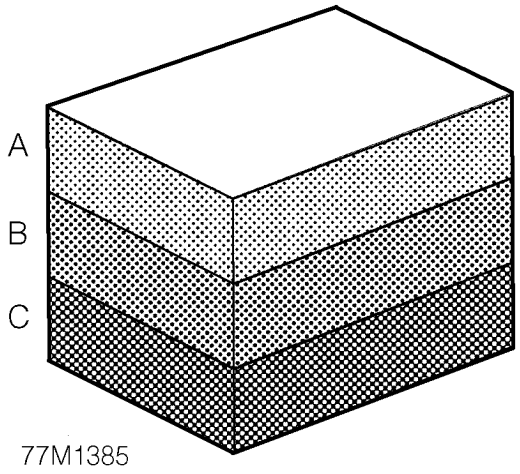
Paint refinishing
The following process must be adhered to for paint refinishing operations.

1 Seal required exterior and interior seams with an approved seam sealer
   ☞ **BODY SEALING MATERIALS, MATERIALS AND APPLICATIONS, Approved materials.**
2 Repair any damage to underbody sealers
   ☞ **CORROSION PREVENTION AND SEALING, CORROSION PREVENTION, Corrosion prevention.**
3 Apply a two-pack paint refinishing system
4 Apply cavity wax to all interior surfaces which have not received refinish paint

Paint repairs
Before carrying out paintwork repairs, clean the vehicle thoroughly using either a steam cleaner or high-pressure washer.

Wash locally repaired areas using a mild water-mixable detergent and wipe them clean with solvent, immediately before paint application.

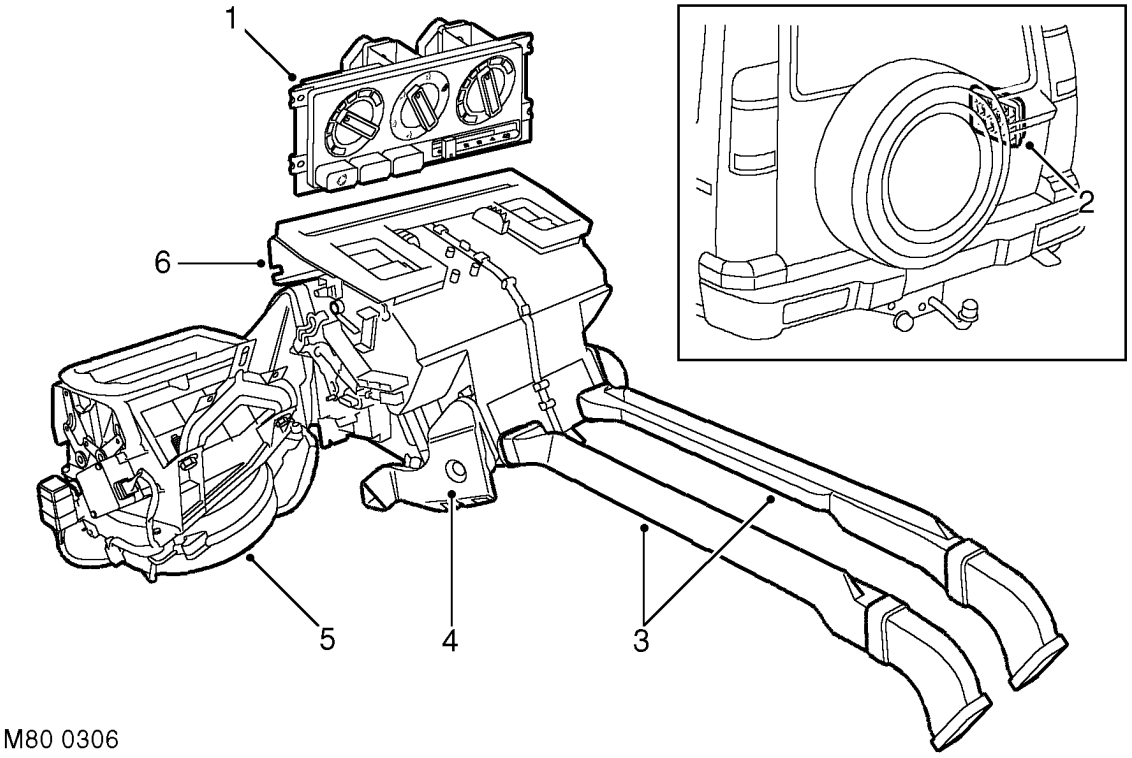
Ensure that damaged paintwork which has led to exposed metal is abraded until the metal is clean, extending beyond the area of the original damage. Treat the bare metal with an etch phosphate to remove all traces of rust and to provide a key for new paint coats. Re-treat the affected area using either a separate acid-etch primer and two-pack surfacer or an integrated etch primer/filler, and follow with a two-pack paint system. Treat those surfaces not receiving paint using an approved cavity wax, following paint operations.



a Two-pack top coat
b Two-pack primer filler and etch primer
c Etch phosphate

When heat curing paint repairs, the temperature must not exceed 65°C (149°F). Temperatures above this figure will cause the reflective elements within the headlamps and taillamps to distort.

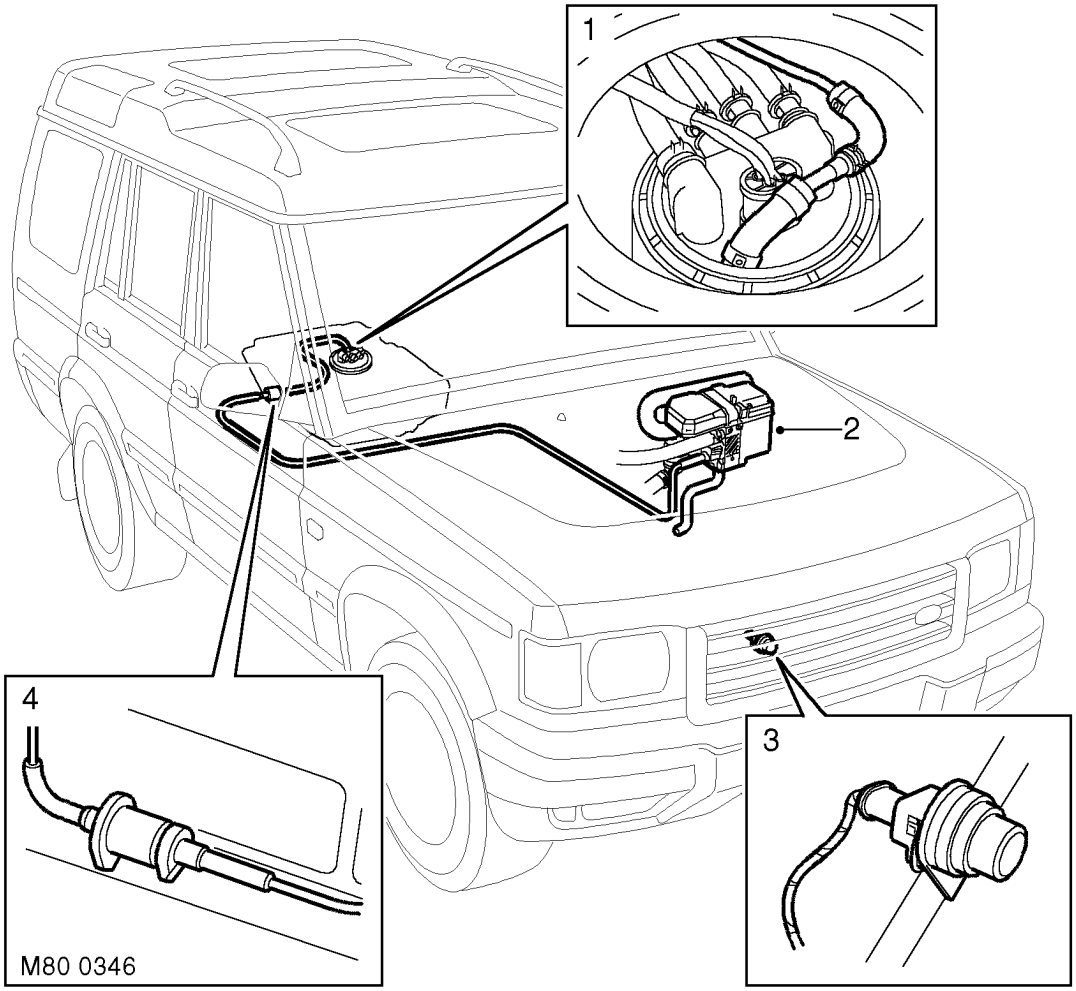
Heating and ventilation component layout



RH drive shown, LH drive similar

1 Control panel
2 Outlet vent
3 Rear footwell ducts
4 Front footwell duct
5 Air inlet duct
6 Heater assembly

Fuel burning heater component layout



RH drive shown, LH drive similar

1 FBH fuel line connection
2 FBH unit
3 Air temperature sensor
4 FBH pump

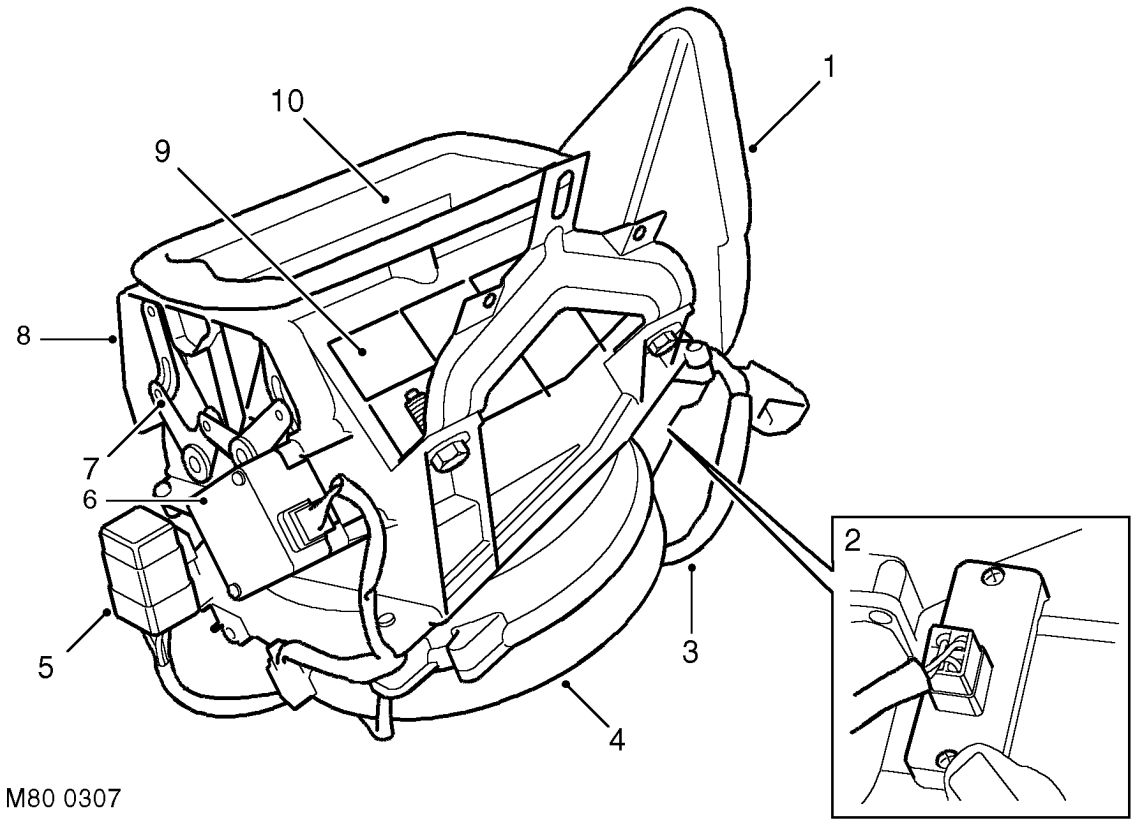
Description

General

The heating and ventilation system controls the temperature and distribution of air supplied to the vehicle interior. The system consists of an air inlet duct, heater assembly, distribution ducts and a control panel. An outlet vent is incorporated at the rear of the cabin. Some diesel models also incorporate a fuel burning heater (FBH) system in the engine coolant supply to the heater assembly.

Fresh or recirculated air flows into the heater assembly from the inlet duct. An electrical variable speed blower in the inlet duct, and/or ram effect, forces the air through the system. Depending on the settings on the control panel, the air is then heated and supplied through the distribution ducts to fascia and floor level outlets.

Air inlet duct



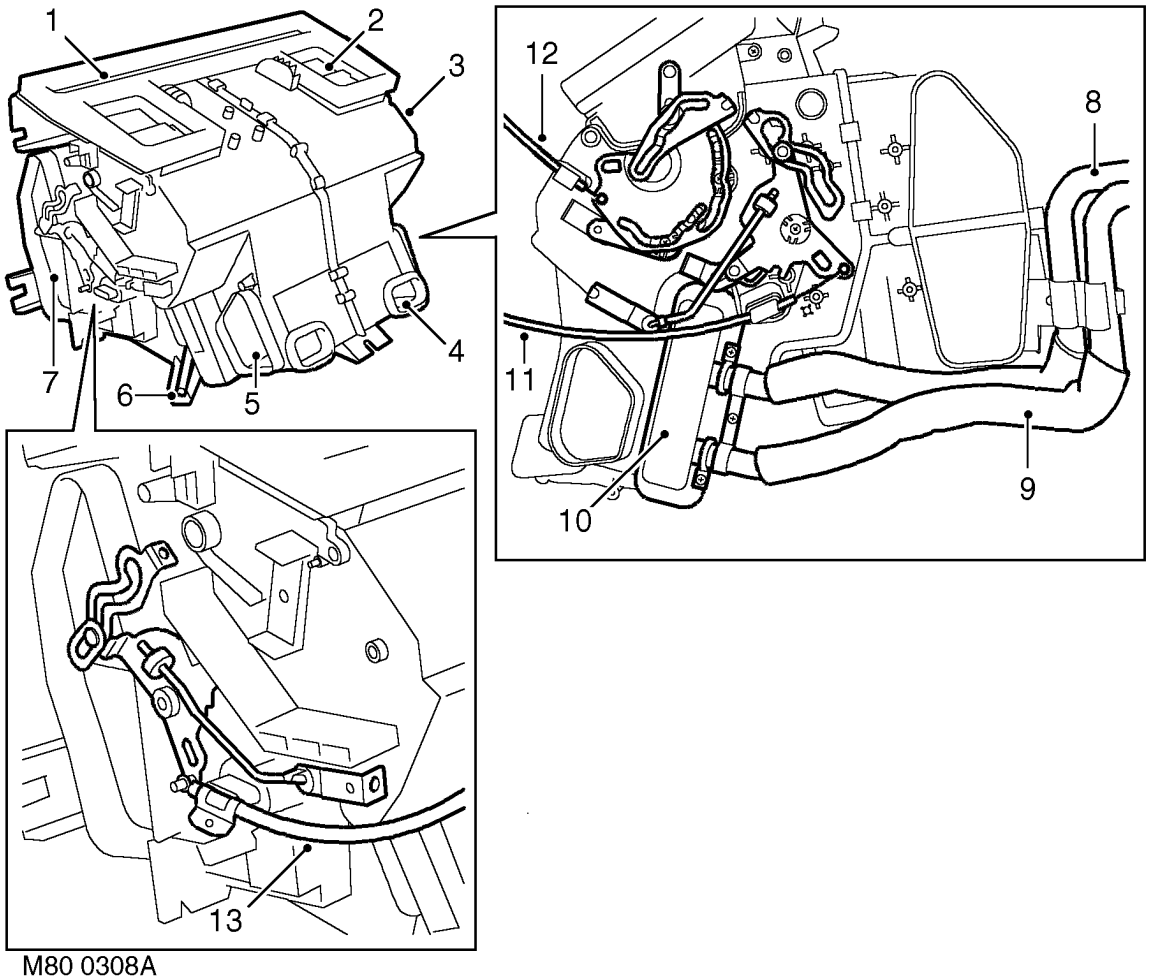
RH drive shown, LH drive similar

1 Air outlet
2 Resistor pack
3 Wiring harness
4 Blower
5 Blower relay
6 Recirculated air servo motor
7 Recirculated air inlet
8 Recirculated air inlet
9 Fresh air inlet
10 Control flap operating mechanism

The air inlet duct is installed behind the fascia, on the passenger's side. The air inlet duct is connected to the plenum to provide the fresh air inlet. Two grilles in the air inlet duct provide recirculated air inlets from the cabin. Two control flaps, operated by a servo motor, open and close the fresh and recirculated air inlets to control the source of incoming air. Operation of the servo motor is controlled by a switch on the control panel.

The blower is installed between the air inlets and the outlet to the heater assembly, and consists of an open hub, centrifugal fan powered by an electric motor. Operation of the blower is controlled by a slider switch on the control panel, via a blower relay mounted on the air inlet duct and a resistor pack. The resistor pack is installed in the air outlet from the blower fan, so that any heat generated is dissipated by the air flow. A wiring harness on the air inlet duct connects the servo motor, blower motor, blower relay and resistor pack to the vehicle wiring.

Heater assembly



M80 0308A

1 Windscreen and side window air outlet
2 Face level air outlet
3 Casing
4 Rear footwell air outlet
5 Front footwell air outlet
6 Drain outlet
7 Air inlet
8 Engine coolant return
9 Engine coolant feed
10 Heater matrix
11 RH temperature control cable
12 Distribution control cable
13 LH temperature control cable

The heater assembly heats and distributes air as directed by selections made on the control panel. The assembly is installed on the vehicle centre-line, between the fascia and the engine bulkhead. The heater assembly consists of a casing, formed from a series of plastic moldings, which contains a heater matrix and control flaps. Internal passages integrated into the casing guide the air through the casing and separate it into two flows, one for the LH outlets and one for the RH outlets. Two drain outlets at the bottom of the casing connect to overboard drain tubes installed in the sides of the transmission tunnel.

Heater matrix

The heater matrix provides the heat source to warm the air being supplied to the distribution outlets. The heater matrix is an aluminium two pass, fin and tube heat exchanger, installed in the RH side of the casing. Two aluminium tubes attached to the heater matrix extend through the engine bulkhead to connect the heater assembly to the engine coolant system. When the engine is running, coolant is constantly circulated through the heater matrix by the engine coolant pump. On diesel models, the coolant flow is assisted by an electric pump while the FBH system is active.

Control flaps

Control flaps are installed in the heater assembly to control the temperature and distribution of air. Blend flaps control the temperature and distribution flaps control the distribution.

Temperature and distribution control

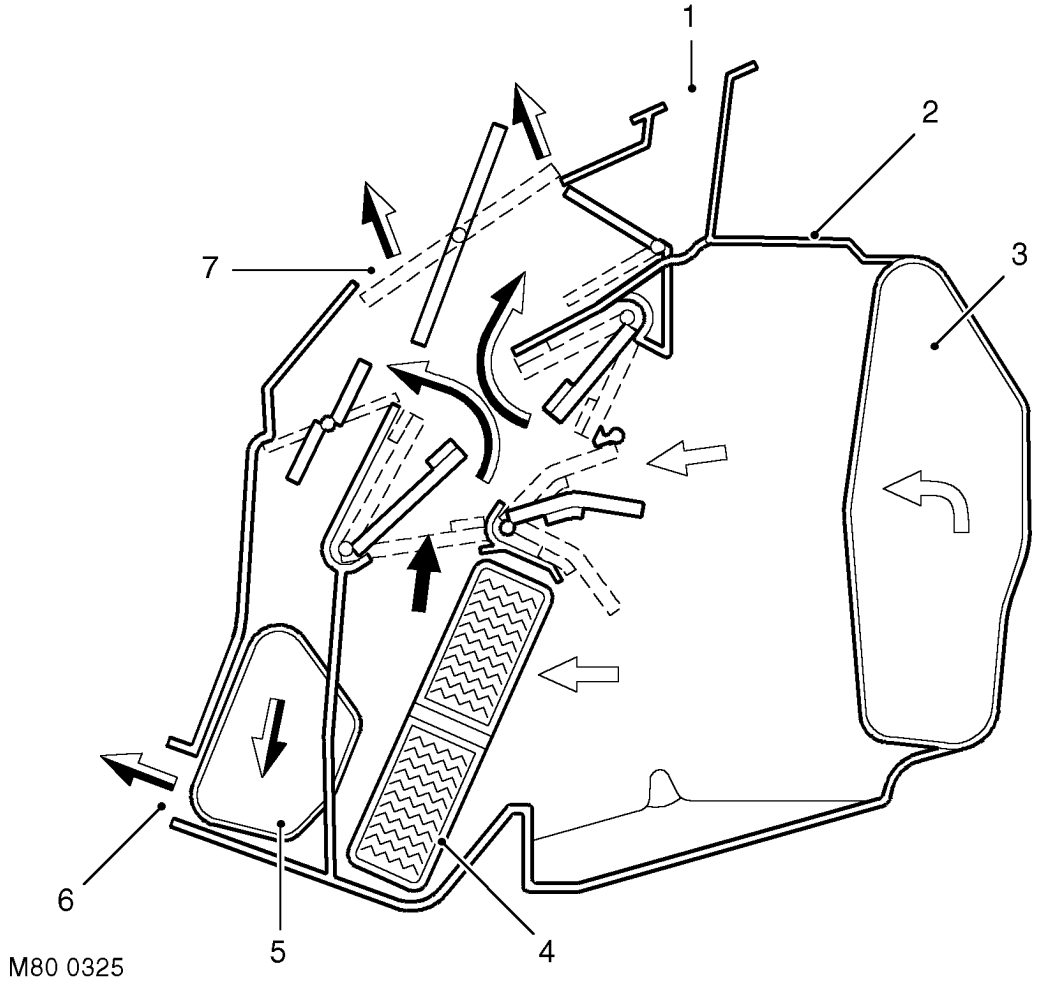


Figure shows flaps set for medium heat to face level and footwell outlets

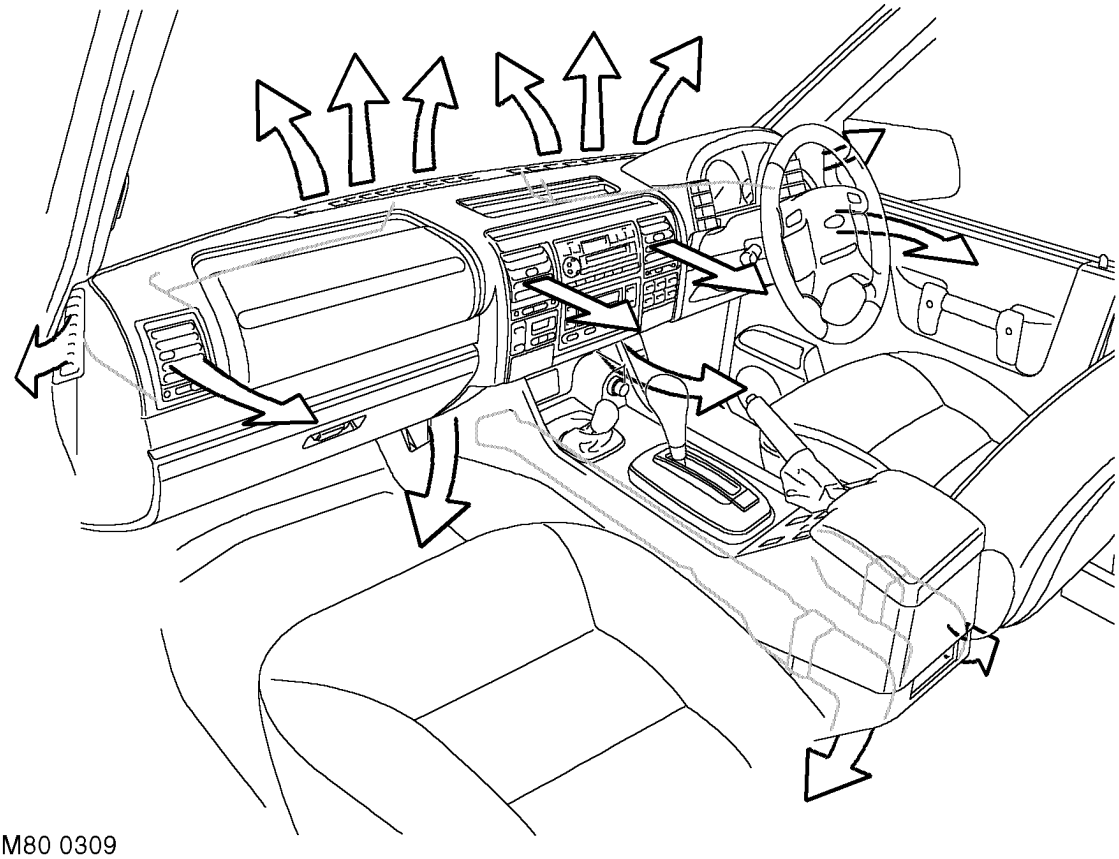
1 Windscreen/Side windows outlet
2 Heater assembly casing
3 Air inlet
4 Heater matrix
5 Front footwells outlet
6 Rear footwells outlet
7 Face level outlet

*Blend flaps:*Two sets of three blend flaps, one LH and one RH, regulate the flow of air through the heater matrix and a heater matrix bypass, to control the temperature of the air leaving the heater assembly. The two sets of blend flaps operate independently to allow different temperatures to be set for the LH and RH outlets.

Each blend flap is attached to a spindle. The end of each spindle extends through the side of the heater casing and is attached to a common lever mechanism on the related side of the casing. A control cable is installed between the lever mechanism and the related temperature knob on the control panel. When the flow is split between the bypass and the heater matrix, the two flows mix downstream of the heater matrix to produce an even air temperature at the individual outlets.

Distribution flaps: Separate distribution flaps are installed to control the flow of air to the footwells, windscreen/side windows and the LH and RH face level outlets. The distribution flaps are attached to spindles that extend through the RH side of the heater casing and are attached to a common lever mechanism. A control cable is installed between the lever mechanism and the distribution knob on the control panel.

Distribution ducts

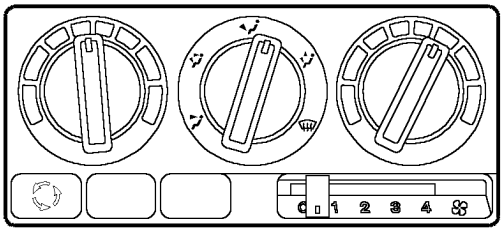


M80 0309

Separate distribution ducts are installed for the front and rear footwell outlets. Distribution ducts for the face level, windscreen and side windows outlets are integrated into the fascia. The front footwell ducts are attached to ports at the sides of the heater assembly. The rear footwell ducts locate in ports at the rear of the heater assembly and extend along each side of the centre console to vent into the rear footwells from below the cubby box.

Vent assemblies in the fascia allow occupants to control the flow and direction of face level air. Each vent assembly incorporates a thumbwheel to regulate flow and moveable vanes to control direction.

Control panel



M80 0310

The controls for heating and ventilation are installed on a control panel in the centre of the fascia, below the radio. Three rotary knobs control the LH and RH outlet temperatures and distribution. A slider switch controls blower speed. A latching pushswitch controls the selection of fresh/recirculated air; an amber LED in the switch illuminates when recirculated air is selected.

Graphics on the panel and the controls indicate the function and operating positions of the controls.

Outlet vent
The outlet vent promotes the free flow of heating and ventilation air through the cabin. The outlet vent is installed in the RH rear quarter body panel and vents cabin air into the sheltered area between the rear quarter body panel and the outer body side panel. The vent consists of a grille covered by soft rubber flaps and is effectively a non-return valve. The flap opens and closes automatically depending on the differential between cabin and outside air pressures.

FBH system (diesel models only)
The FBH system is an auxiliary heating system that compensates for the relatively low coolant temperatures inherent in the diesel engine. At low ambient temperatures, the FBH system heats the coolant supply to the heater assembly, and maintains it within the temperature range required for good in-car heating performance. Operation is fully automatic, with no intervention required by the driver.

The system consists of an air temperature sensor, a FBH fuel pump and a FBH unit. Fuel for the FBH system is taken from the fuel tank, through a line attached to the fuel tank's fuel pump, and supplied via the FBH fuel pump to the FBH unit. The connection on the fuel tank's fuel pump incorporates a tube which extends down into the tank. At the FBH unit connection, the fuel line incorporates a self-sealing, quick disconnect coupling. In the FBH unit, the fuel delivered by the FBH fuel pump is burned and the resultant heat output is used to heat the coolant. An ECU integrated into the FBH unit controls the operation of the system at one of two heat output levels, 2.5 kW at part load and 5 kW at full load

Ambient temperature sensor
The ambient temperature sensor controls a power supply from the alternator to the FBH unit. The sensor is installed on the RH support strut of the bonnet closing panel and contains a temperature sensitive switch that is closed at temperatures below 5 °C (41 °F) and open at temperatures of 5 °C (41 °F) and above.

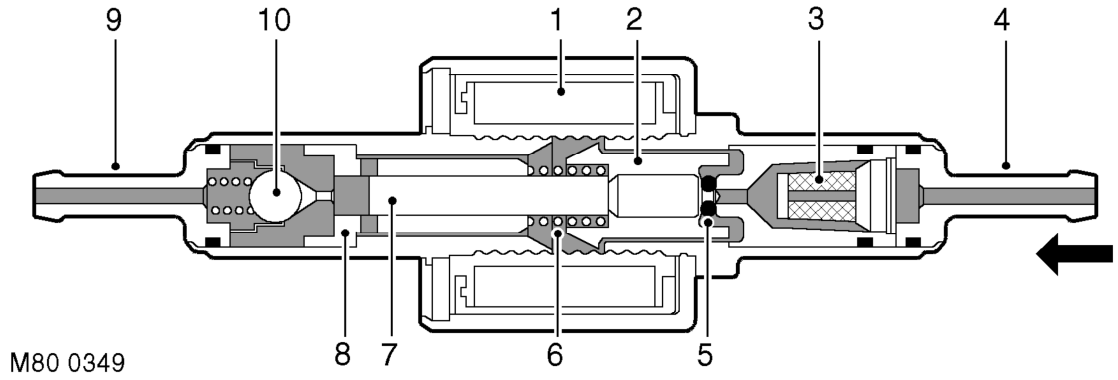
FBH fuel pump

The FBH fuel pump regulates the fuel supply to the FBH unit. The FBH fuel pump is installed in a rubber mounting on the chassis crossmember immediately in front of the fuel tank. The pump is a self priming, solenoid operated plunger pump, with a fixed displacement of 0.063 ml/Hz. The ECU in the FBH unit outputs a pulse width modulated signal to control the operation of the pump. When the pump is de-energised, it provides a positive shut-off of the fuel supply to the FBH unit.

FBH fuel pump nominal operating speeds/outputs

Operating phase	Speed, Hz	Output, l/h (US galls/h)
Start sequence	0.70	0.159 (0.042)
Part load	1.35	0.306 (0.081)
Full load	2.70	0.612 (0.163)

Sectioned view of FBH fuel pump

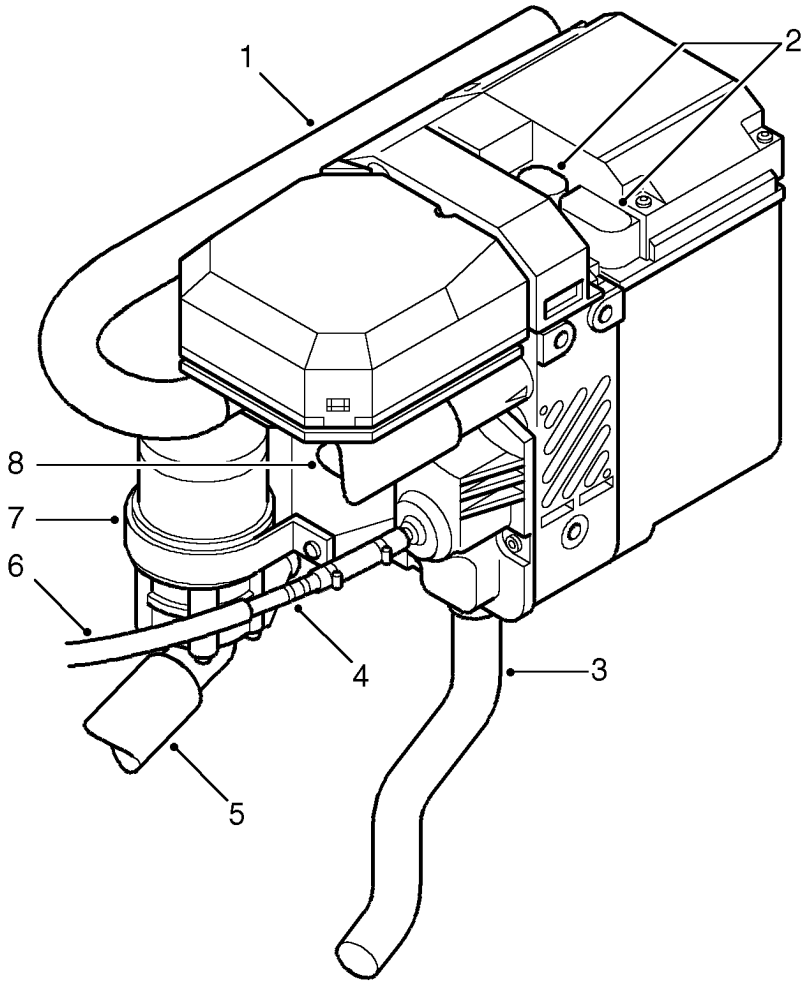


1 Solenoid coil
2 Plunger
3 Filter insert
4 Fuel line connector
5 'O' ring seal
6 Spring
7 Piston
8 Bush
9 Fuel line connector
10 Non return valve

The solenoid coil of the FBH fuel pump is installed around a housing which contains a plunger and piston. The piston locates in a bush, and a spring is installed on the piston between the bush and the plunger. A filter insert and a fuel line connector are installed in the inlet end of the housing. A non return valve and a fuel line connector are installed in the fuel outlet end of the housing.

While the solenoid coil is de-energised, the spring holds the piston and plunger in the 'closed' position at the inlet end of the housing. An 'O' ring seal on the plunger provides a fuel tight seal between the plunger and the filter insert, preventing any flow through the pump. When the solenoid coil is energised, the piston and plunger move towards the outlet end of the housing, until the plunger contacts the bush, and draw fuel in through the inlet connection and filter. The initial movement of the piston also closes transverse drillings in the bush and isolates the pumping chamber at the outlet end of the housing. Subsequent movement of the piston then forces fuel from the pumping chamber through the non return valve and into the line to the FBH unit. When the solenoid coil de-energises, the spring moves the piston and plunger back towards the closed position. As the piston and plunger move towards the closed position, fuel flows passed the plunger and through the annular gaps and transverse holes in the bush to replenish the pumping chamber.

FBH unit



M80 0311

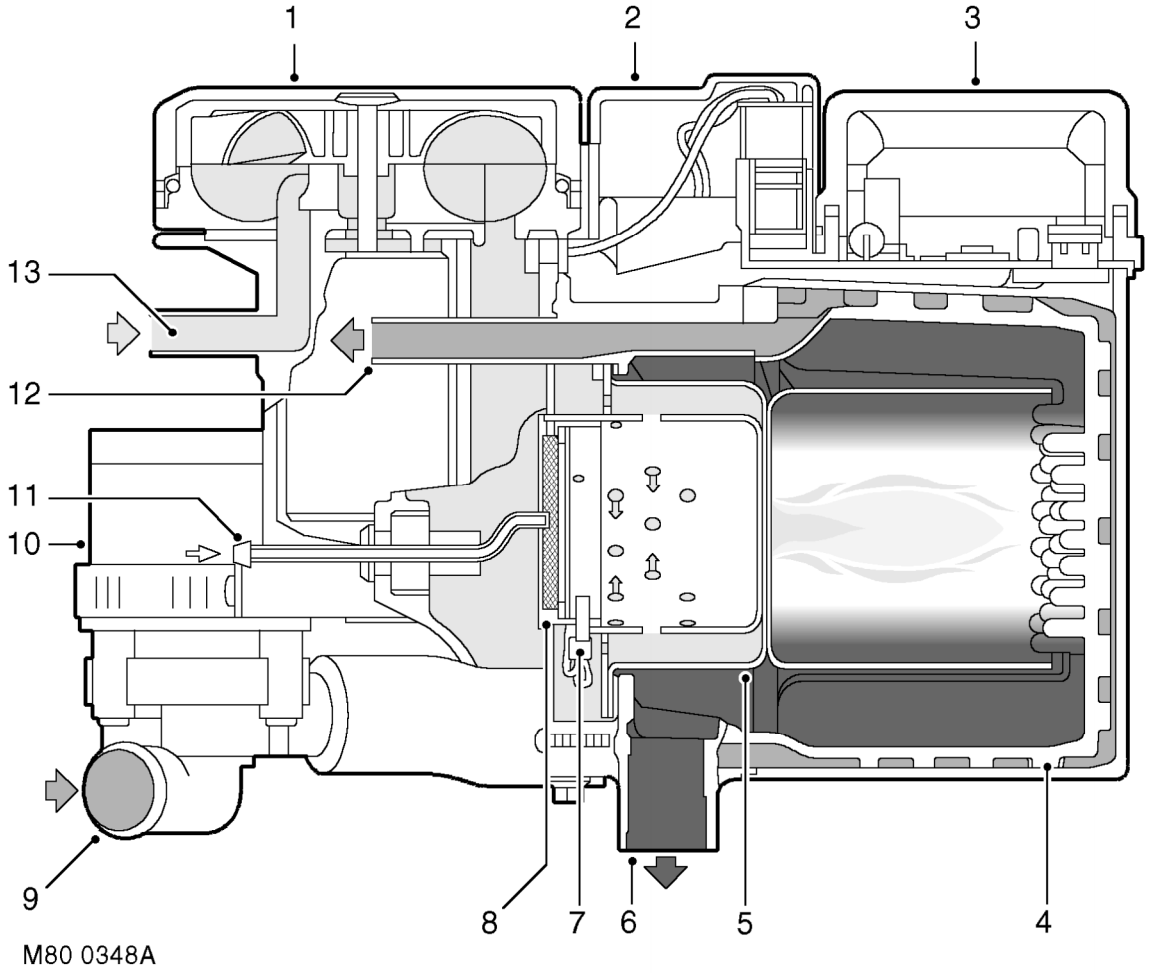
1 Air inlet hose
2 Electrical connectors
3 Exhaust pipe
4 Quick disconnect coupling
5 Coolant inlet hose
6 Fuel supply line
7 Circulation pump
8 Coolant outlet hose

The FBH unit is installed on the bulkhead in the engine compartment, on the side opposite the brake servo, and is connected in series in the coolant supply to the heater assembly. Two electrical connectors on the top of the FBH unit connect to the vehicle wiring.

FBH unit connector pin details

Connector/Pin No.	Description	Input/Output
C0925		
2	K line (diagnostics)	Input/Output
3	Alternator power supply	Input
6	FBH fuel pump	Output
C0926		
1	Battery power supply	Input
2	Earth	-

Sectioned view of FBH unit



1 Combustion air fan
2 Burner housing
3 ECU
4 Heat exchanger
5 Burner insert
6 Exhaust
7 Glow plug/flame sensor
8 Evaporator
9 Coolant inlet
10 Circulation pump
11 Fuel inlet
12 Coolant outlet
13 Air inlet

The FBH unit consists of:

- A circulation pump.
- A combustion air fan.
- A burner housing.
- An ECU/heat exchanger.
- An air inlet hose.
- An exhaust pipe.

Circulation pump. The circulation pump is installed at the coolant inlet to the FBH unit to assist the coolant flow through the FBH unit and the heater assembly. The pump runs continuously while the FBH unit is in standby or active operating modes. While the FBH unit is inactive, coolant flow is reliant on the engine coolant pump.

Combustion air fan. The combustion air fan regulates the flow of air into the unit to support combustion of the fuel supplied by the FBH pump. It also supplies the air required to purge and cool the FBH unit. Ambient air is supplied to the combustion air fan through an air inlet hose containing a sound deadening foam ring.

Burner housing. The burner housing contains the burner insert and also incorporates connections for the exhaust pipe, the coolant inlet from the circulation pump and the coolant outlet to the heater assembly. The exhaust pipe directs exhaust combustion gases to atmosphere at the bottom of the engine compartment.

The burner insert incorporates the fuel combustion chamber, an evaporator and a glow plug/flame sensor. Fuel from the FBH fuel pump is supplied to the evaporator, where it evaporates and enters the combustion chamber to mix with air from the combustion air fan. The glow plug/flame sensor provides the ignition source of the fuel:air mixture and, once combustion is established, monitors the flame.

ECU/heat exchanger. The ECU controls and monitors operation of the FBH system. Ventilation of the ECU is provided by an internal flow of air from the combustion air fan. The heat exchanger transfers heat generated by combustion to the coolant. A sensor in the heat exchanger provides the ECU with an input of heat exchanger casing temperature, which the ECU relates to coolant temperature and uses to control system operation. The temperature settings in the ECU are calibrated to compensate for the difference between coolant temperature and the heat exchanger casing temperature detected by the sensor. Typically: as the coolant temperature increases, the coolant will be approximately 7 °C (12.6 °F) hotter than the temperature detected by the sensor; as the coolant temperature decreases, the coolant will be approximately 2 °C (3.6 °F) cooler than the temperature detected by the sensor.

Operation

Air distribution
Turning the distribution knob on the control panel turns the control flaps in the heater assembly to direct air to the corresponding fascia and footwell outlets.

Air temperature
Turning the LH or RH temperature knob on the control panel turns the related blend flaps in the heater assembly. The blend flaps vary the proportion of air going through the cold air bypass and the heater matrix. The proportion varies, between full bypass no heat and no bypass full heat, to correspond with the position of the temperature knob.

Blower speed
The blower can be selected off or to run at one of four speeds. While the ignition is on, when the blower switch is set to positions 1, 2, 3, or 4, ignition power energises the blower relay, which supplies battery power to the blower. At switch positions 1, 2 and 3, the blower switch also connects the blower to different earth paths through the resistor pack, to produce corresponding differences of blower operating voltage and speed. At position 4, the blower switch connects an earth direct to the blower, bypassing the resistor pack, and full battery voltage drives the blower at maximum speed.

Fresh/Recirculated inlet air
When the recirculated air switch is latched in, the amber indicator LED in the switch illuminates and an earth is connected to the recirculated air side of the fresh/recirculated air servo motor. The fresh/recirculated air servo motor then turns the control flaps in the air inlet duct to close the fresh air inlet and open the recirculated air inlets.

When the latch of the recirculated air switch is released, the amber indicator LED in the switch extinguishes and the earth is switched from the recirculated air side to the fresh air side of the fresh/recirculated air servo motor. The fresh/recirculated air servo motor then turns the control flaps in the air inlet duct to open the fresh air inlet and close the recirculated air inlets.

FBH system (where fitted)
The FBH system operates only while the engine is running and the ambient temperature is less than 5 °C (41 °F). With the engine running and the ambient temperature below 5 °C (41 °F), the air temperature sensor connects the alternator power supply to the ECU in the FBH unit. On receipt of the alternator power supply, the ECU starts the circulation pump and, depending on the input from the temperature sensor in the heat exchanger, enters either a standby or active mode of operation. If the heat exchanger casing temperature is 65 °C (149 °F) or above, the ECU enters a standby mode of operation. If the heat exchanger casing temperature is below 65 °C (149 °F), the ECU enters an active mode of operation. In the standby mode, the ECU monitors the heat exchanger casing temperature and enters the active mode if it drops below 65 °C (149 °F). In the active mode, the ECU initiates a start sequence and then operates the system at full or part load combustion to provide the required heat input to the coolant.

Start sequence
At the beginning of the start sequence the ECU energises the glow plug function of the glow plug/flame sensor, to preheat the combustion chamber, and starts the combustion air fan at slow speed. After 30 seconds, the ECU energises the FBH fuel pump at the starting sequence speed. The fuel delivered by the FBH fuel pump evaporates in the combustion chamber, mixes with air from the combustion air fan and is ignited by the glow plug/flame sensor. The ECU then progressively increases the speed of the FBH fuel pump and the combustion air fan to either part or full load speed, as required by the system. Once full or part load speed is achieved, the ECU switches the glow plug/flame sensor from the glow plug function to the flame sensing function to monitor combustion. From the beginning of the start sequence to stable combustion takes approximately 90 seconds for a start to part load combustion and 150 seconds for a start to full load combustion.

Coolant temperature control

When the ECU first enters the active mode, it initiates a start to full load combustion. Full load combustion continues until the heat exchanger casing temperature reaches 60 °C (140 °F), when the ECU decreases the speed of the FBH fuel pump and the combustion air fan to half speed, to produce part load combustion. The ECU maintains part load combustion while the heat exchanger casing temperature remains between 54 and 65 °C (129 and 149 °F). If the heat exchanger casing temperature decreases to 54 °C (129 °F), the ECU switches the system to full load combustion again. If the heat exchanger casing temperature increases to 65 °C (149 °F), the ECU enters a control idle phase of operation.

On entering the control idle phase, the ECU immediately switches the FBH fuel pump off, to stop combustion, and starts a timer for the combustion air fan. After a 2 minute cooldown period, the ECU switches the combustion air fan off and then remains in the control idle phase while the heat exchanger casing temperature remains above 59 °C (138 °F). If the heat exchanger casing temperature decreases to 59 °C (138 °F), within 15 minutes of the ECU entering the control idle phase, the ECU initiates a start to part load combustion. If more than 15 minutes elapse before the heat exchanger casing temperature decreases to 59 °C (138 °F), the ECU initiates a start to full load combustion.

In order to limit the build-up of carbon deposits on the glow plug/flame sensor, the ECU also enters the control idle phase if the continuous part and/or full load combustion time exceeds 72 minutes. After the cooldown period, if the heat exchanger casing is still in the temperature range that requires additional heat, the ECU initiates an immediate restart to part or full load combustion, as appropriate.

Shutdown

The FBH system is de-activated when the alternator power supply to the FBH unit is disconnected, either by the engine stopping or, if the ambient temperature increases to 5 °C (41 °F) or above, by the contacts in the air temperature sensor opening. If the system is active when the alternator power supply is disconnected, the ECU de-energises the FBH fuel pump to stop combustion, but continues operation of the combustion air fan and the circulation pump to cool down the FBH unit. The cool down time depends on the combustion load at the time the alternator power input is disconnected.

Cool down times

Combustion load	Cool down time, seconds
Part	100
Full	175

Diagnostics

The ECU in the FBH unit monitors the system for faults. Any faults detected are stored in a volatile memory in the the ECU, which can be interrogated by Testbook. A maximum of three faults and associated freeze frame data can be stored at any one time. If a further fault is detected, the oldest fault is overwritten by the new fault.

The ECU also incorporates an error lockout mode of operation that inhibits system operation to prevent serious faults from causing further damage to the system. In the error lockout mode, the ECU immediately stops the FBH fuel pump, and stops the combustion air fan and circulation pump after a cool down time of approximately 2 minutes. Error lockout occurs for start sequence failures and/or combustion flameouts, heat exchanger casing overheat and out of limit input voltage. The error lockout mode can be cleared using Testbook, or by disconnecting the battery power supply for a minimum of 10 seconds.

Start failure/flameout. If a start sequence fails to establish combustion, or a flameout occurs after combustion is established, the ECU immediately initiates another start sequence. The start failure or flameout is also recorded by an event timer in the ECU. The event timer is increased by one after each start failure or flameout, and decreased by one if a subsequent start is successful. If the event timer increases to three (over any number of drive cycles), the ECU enters the error lockout mode.

Heat exchanger casing overheat. To protect the system from excessive temperatures, the ECU enters the error lockout mode if the heat exchanger casing temperature exceeds 105 °C (221 °F).

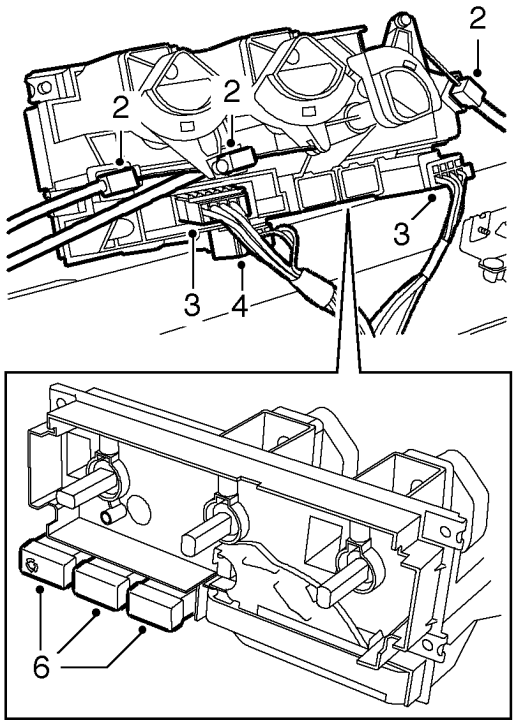
Out of limit voltage. The ECU enters the error lockout mode if the battery or alternator power input is less than 10.5 ± 0.3 V for more than 20 seconds, or more than 15.5 ± 0.5 V for more than 6 seconds.

Heater control and fan switch

80.10.02

Remove

1. Remove louvre panel assembly.
   INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.



M80 0326

2. Release temperature and air distribution cable abutments from heater control housing and disconnect inner cables from controls.
3. Disconnect multiplugs from switches.
4. Disconnect multiplug from control illumination.
5. Remove heater control.
6. Remove 3 switches from heater control.

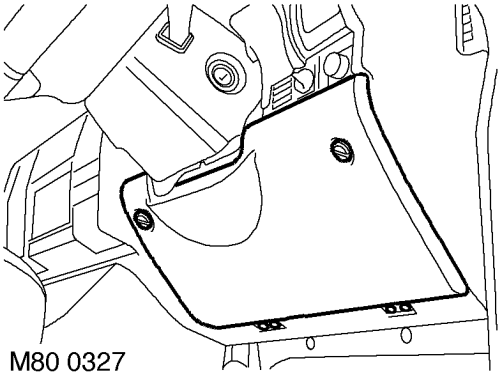
Refit

1. Fit switches to heater control housing.
2. Position heater control assembly and connect multiplugs to switches and illumination.
3. Connect heater control cables and secure outer cable abutments to casing.
4. Fit louvre panel assembly.
   INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.

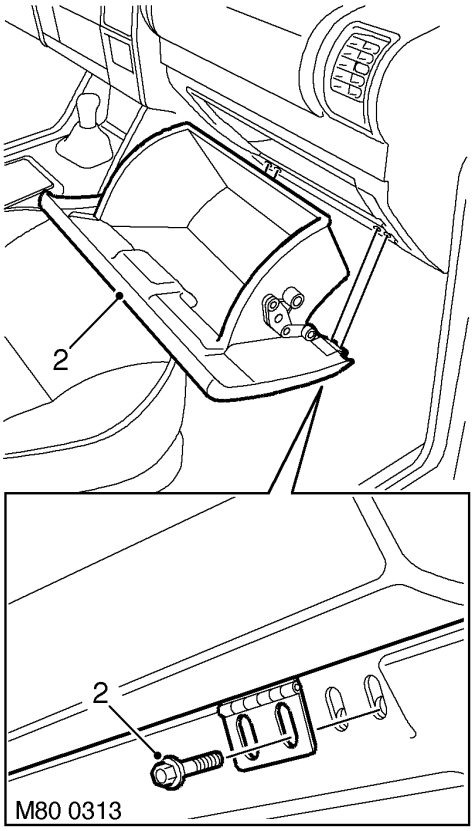
Cables - heater control

80.10.06

Remove


M80 0327

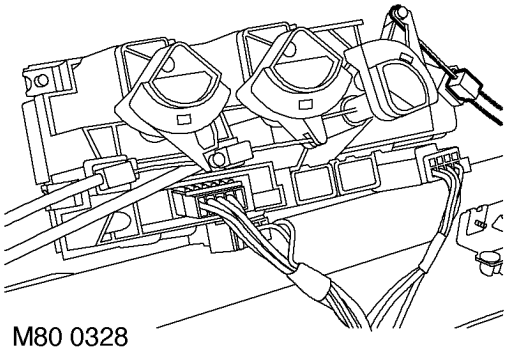
1. **Driver temperature control and air flow control cables:** Release fixings and lower fascia fuse box access cover.



M80 0313

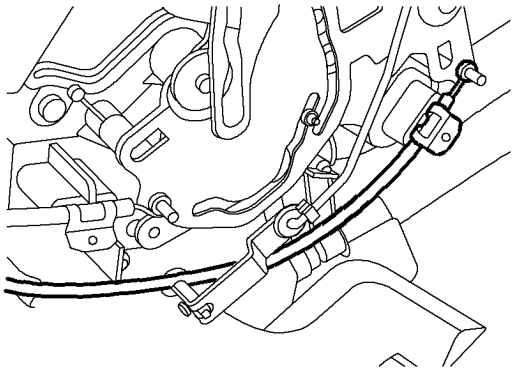
2. **Passenger temperature control cable:** Remove 4 screws securing glove box, release catch and remove glove box.

3. Remove louvre panel assembly.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.**



M80 0328

4. Release control cable abutment from control housing and disconnect inner cable from control.



M80 0329

5. Release clip securing control outer cable to heater case and disconnect inner cable from flap lever.
6. Remove control cable.

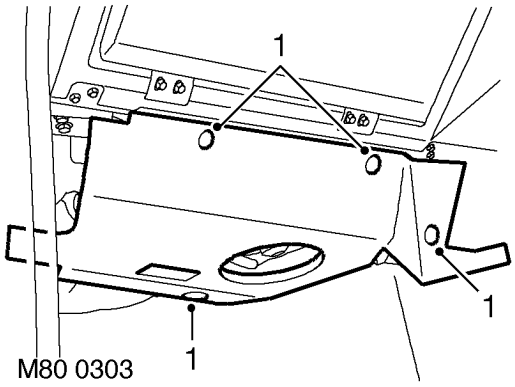
Refit

1. Fit new control cable, connect inner cable to control and secure abutment to control housing.
2. Fit other end of inner cable to flap lever.
3. Position control to maximum heat for temperature control cables or demist for air flow control cable, hold flap lever in fully closed position and secure outer cable in clip on heater casing.
4. Refit louvre panel assembly.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.**
5. **Driver temperature and air flow control cables:** Close fuse access cover and secure fixings.
6. **Passenger temperature control cable:** Refit glove box and secure with bolts.

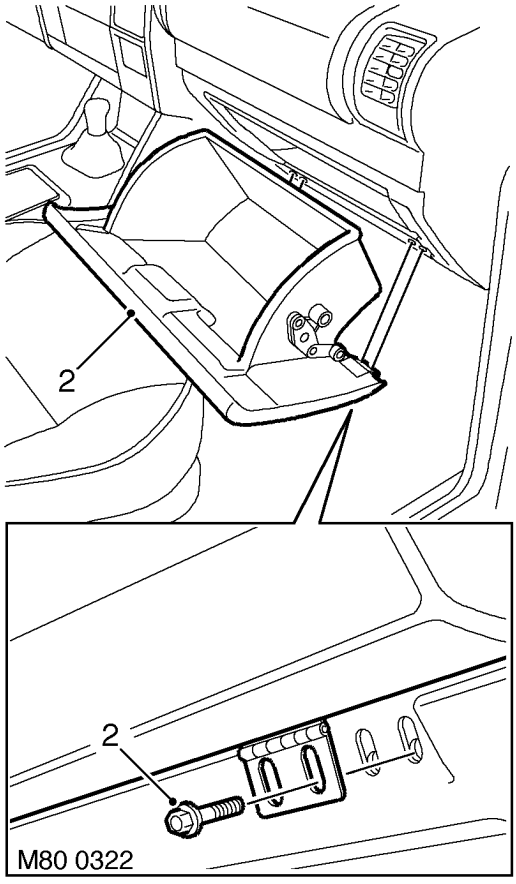
Servo - recirculation flap

80.10.18

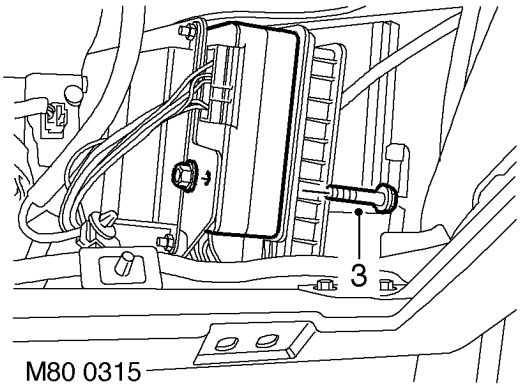
Remove



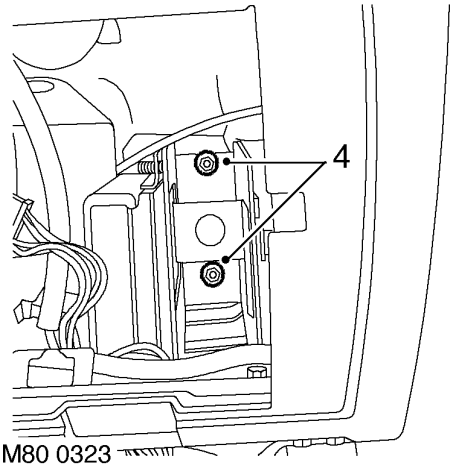
1. Remove 4 studs securing passenger toe board and remove toe board.



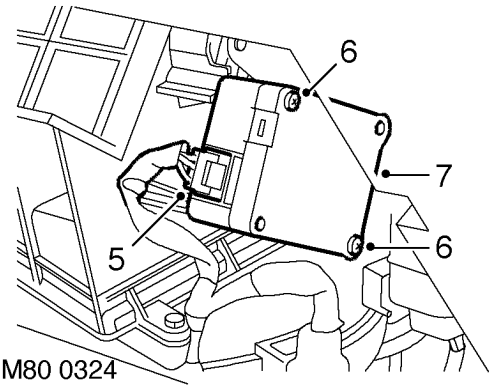
2. Remove 4 screws securing glove box, release catch and remove glove box.



3. Remove bolt securing BCM, release BCM from retaining peg and lower BCM.



4. Remove 2 nuts securing ECU assembly and lower ECU assembly to gain access to servo screws.



5. Disconnect multiplug from servo.
6. Remove 2 screws securing servo.
7. Release servo, disconnect operating lever and remove servo.

Refit

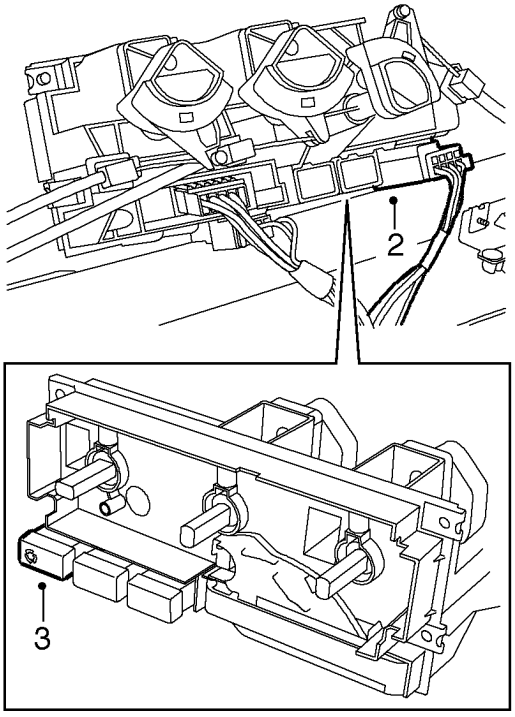
1. Position servo and connect operating lever.
2. Fit and tighten screws securing servo.
3. Connect multiplug to servo.
4. Position ECU assembly, fit and tighten nuts.
5. Position BCM, fit and tighten bolt.
6. Position toe board and secure with studs.
7. Position glove box, fit and tighten screws.

Switch - recirculation control

80.10.21

Remove

1. Remove louvre panel assembly.
   INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.



M80 0345

2. Disconnect multiplug from recirculation switch.
3. Remove recirculation switch from heater control panel.

Refit

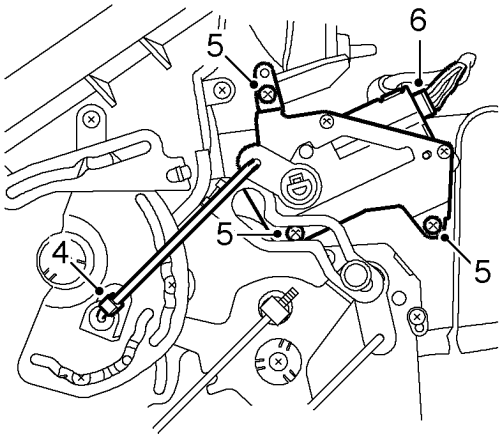
1. Fit recirculation switch to heater control panel and connect multiplug.
2. Fit louvre panel assembly.
   INTERIOR TRIM COMPONENTS, REPAIRS, Louvre panel assembly - centre fascia.

Servo - air distribution control

80.10.30

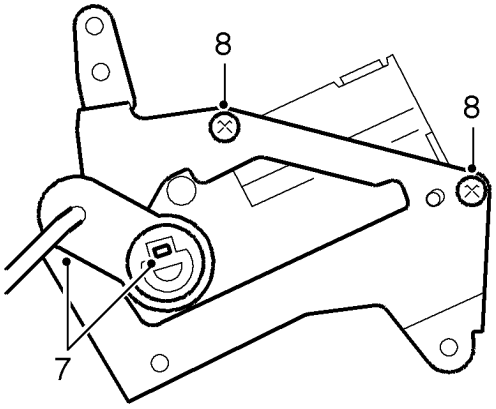
Remove

1. Disconnect battery earth lead.
2. **RHD models:** Remove heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.
3. **LHD models:** Remove heater motor assembly.
   HEATING AND VENTILATION, REPAIRS, Blower assembly.



M80 0301

4. Release clip securing operating lever and release the lever from linkage.
5. Remove 3 screws securing servo support bracket to casing and release servo.
6. Disconnect multiplug from servo and remove servo.



M80 0302

7. Release clip securing operating lever to servo and remove lever.
8. Remove 2 screws securing support bracket and remove support bracket.

Refit

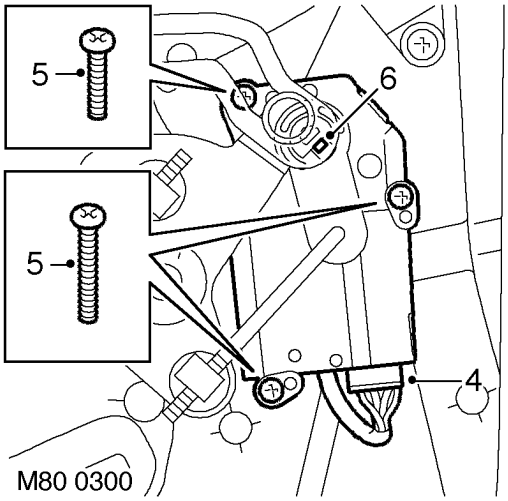
1. Position support bracket to servo and secure with screws.
2. Position servo lever to servo and secure clip.
3. Connect multiplug to servo.
4. Position servo to casing and secure with screws.
5. Connect operating lever to servo and secure with clip.
6. **RHD models:** Fit heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.
7. **LHD models:** Fit heater motor assembly.
   HEATING AND VENTILATION, REPAIRS, Blower assembly.
8. Connect battery earth lead.

Servo - air temperature control

80.10.42

Remove

1. Disconnect battery earth lead.
2. **Driver side:** Remove heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.
3. **Passenger side:** Remove blower assembly.
   HEATING AND VENTILATION, REPAIRS, Blower assembly.



4. Disconnect multiplug from servo.
5. Remove 3 screws securing servo to casing and release servo.
6. Release clip securing operating lever, release the lever and remove servo. lever.

Refit

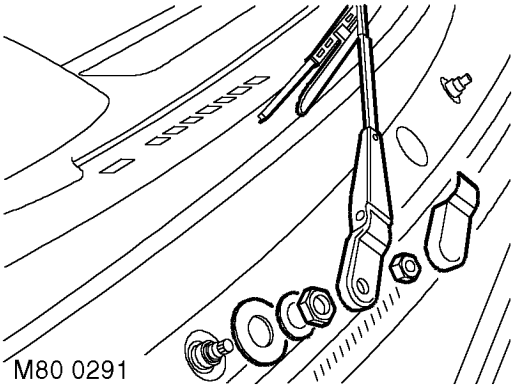
1. Connect operating lever to servo and secure with clip.
2. Position servo to casing, engage locating pegs and secure with screws.
3. Connect multiplug to servo.
4. **Driver side:** Fit heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.
5. **Passenger side:** Fit blower assembly.
   HEATING AND VENTILATION, REPAIRS, Blower assembly.
6. Connect battery earth lead.

Plenum Air Intake

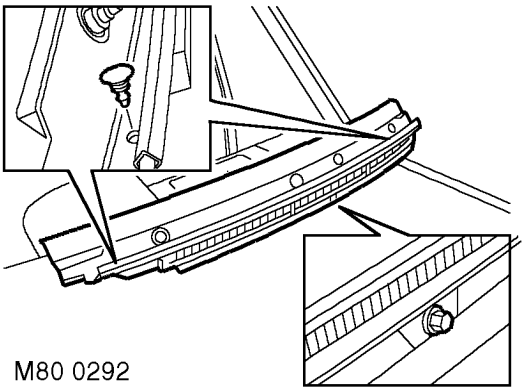
80.15.62

Remove

1. Remove both windscreen side finishers.
   EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.



2. Remove caps from windscreen wiper arms.
3. Remove nuts securing wiper arms to wiper linkage.
4. Remove both wiper arms.
5. Remove lock nuts from wiper linkage and collect washer and rubber spacers.



6. Remove 2 trim clips and centre bolt securing plenum air intake to body.
7. Remove plenum air intake.

Refit

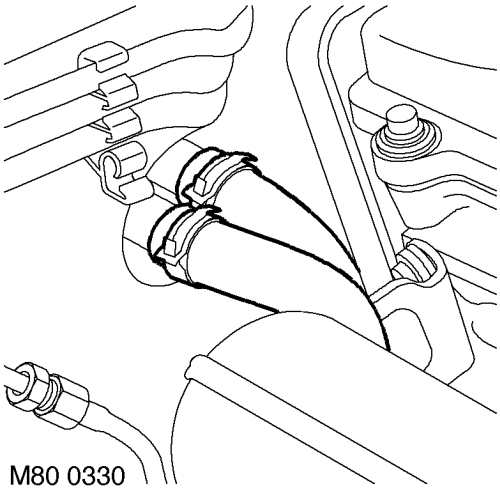
1. Fit plenum air intake.
2. Fit trim clips and centre bolt securing plenum air intake to body.
3. Fit rubber spacers and washers to wiper linkage.
4. Fit locknuts to wiper linkage and tighten to 7 Nm (5.2 lbf.ft).
5. Fit wiper arms to wiper linkage.
6. Fit nuts securing wiper arms to wiper linkage and tighten to 15 Nm (11 lbf.ft).
7. Fit caps to wiper arms.
8. Fit both windscreen side finishers.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Side finisher - windscreen.**

Heater assembly - models without air conditioning

🔧 ***80.20.01.99***

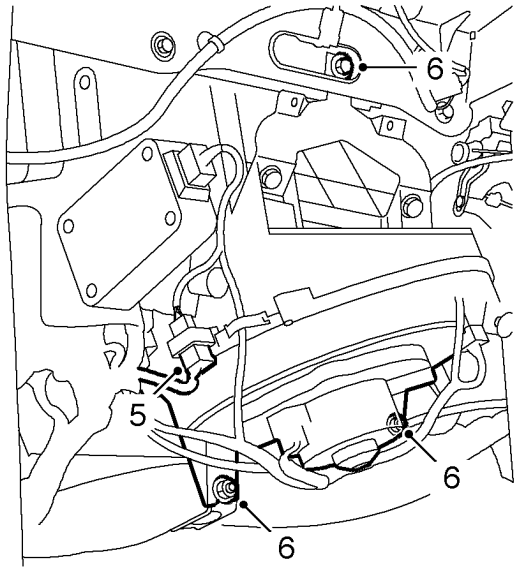
Remove

1. Drain cooling system.
   - ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
   - ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**
2. **Diesel models:** Remove 3 bolts and remove engine cover.



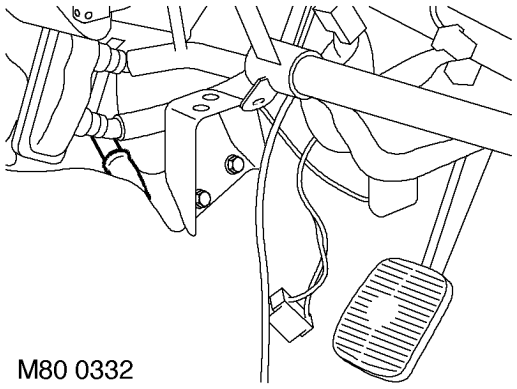
M80 0330

3. Release clips and disconnect coolant hoses from heater pipes.
   CAUTION: Always fit plugs to open connections to prevent contamination.
4. Remove facia assembly.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.**

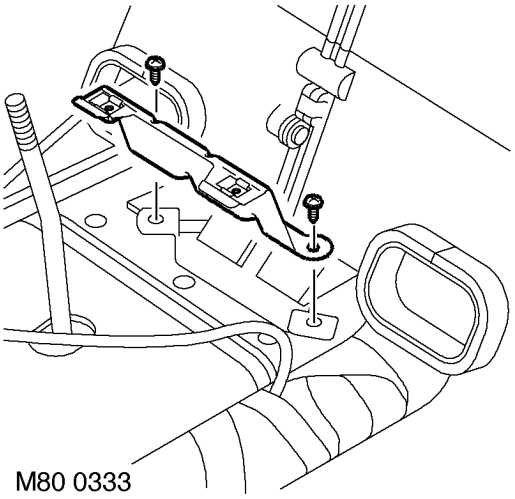


M80 0331

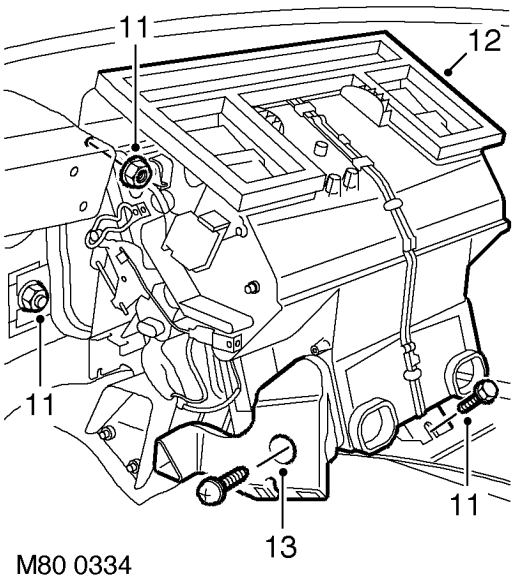
5. Disconnect harness multiplug from heater blower motor.
6. Remove bolt and 2 nuts securing heater blower housing assembly to body and remove blower.


M80 0332

7. Disconnect 2 drain tubes from base of heater.

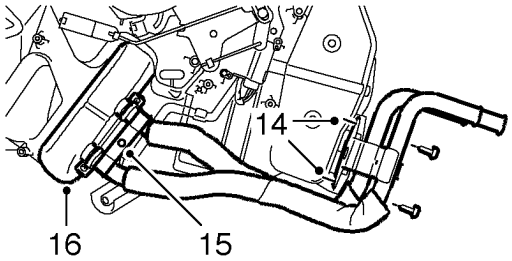

M80 0333

8. Remove 2 screws securing console bracket to tunnel and remove bracket.
9. Release radio coaxial cable from behind heater pipes.
10. Protect the carpet from coolant spillage.



M80 0334

11. Remove 4 nuts and 1 bolt securing heater to body.
12. Remove heater from vehicle.
13. Remove 2 screws securing heater RH and LH footwell outlet duct to heater casing and remove ducts.



M80 0355

14. Remove 2 screws securing matrix pipe bracket to heater casing.
15. Remove screw securing pipe clamp to heater casing and remove clamp.
16. Carefully remove matrix from heater.

Refit

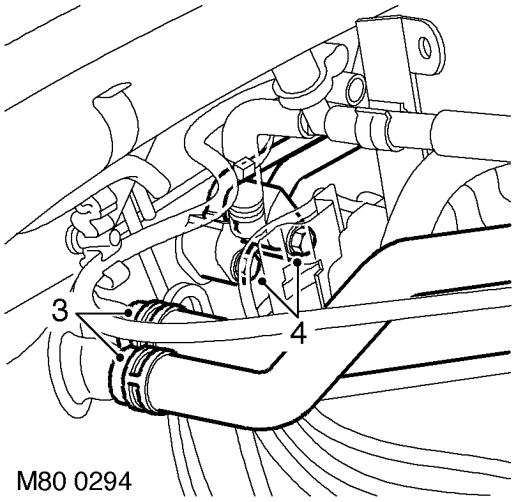
1. Fit matrix into heater casing.
2. Fit screws securing pipe bracket to heater casing.
3. Fit pipe clamp and secure with screw.
4. Fit heater ducts and secure with screws.
5. Position heater assembly to vehicle, ensure heater coolant pipe grommet is correctly located in bulkhead and secure with nuts and bolt.
6. Fit radio coaxial cable behind heater pipes.
7. Fit console bracket and secure with screws.
8. Connect drain tubes to base of heater.
9. Fit blower unit to heater and secure to body with nuts and bolt.
10. Connect harness multiplug to blower motor.
11. Fit facia assembly
    ☞ INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.
12. Connect heater hoses and secure with clips.
13. **Diesel models:** Fit engine cover and secure with bolts.
14. Refill cooling system
    - **☞ COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
    - **☞ COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Heater assembly - models with air conditioning

80.20.01.98

Remove

1. Drain cooling system.
   - **☞ COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**
   - **☞ COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**
2. Evacuate air conditioning system.
   ☞ AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.

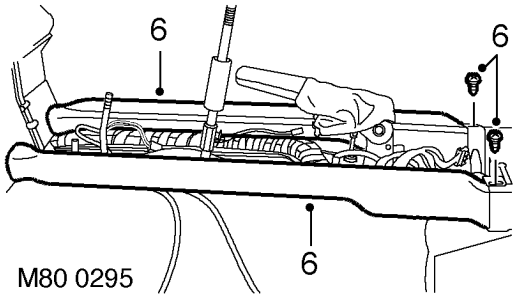


M80 0294

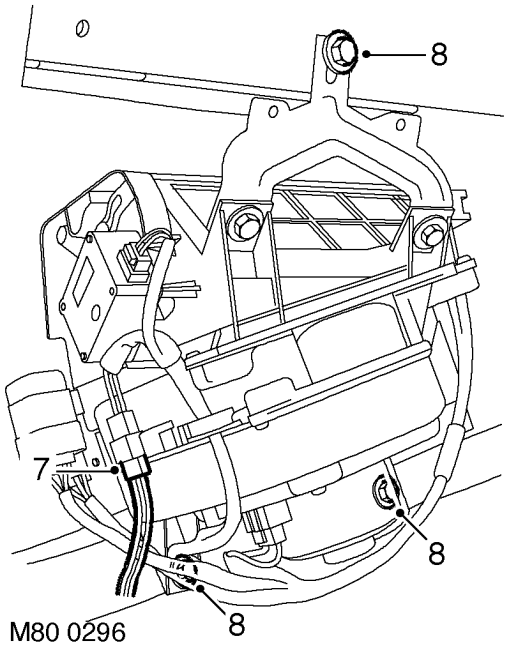
3. Release 2 clips securing heater hoses to heater and release hoses.
4. Remove 2 bolts securing air conditioning pipes to evaporator, release pipes and discard 'O' rings.

   CAUTION: Always fit plugs to open connections to prevent contamination.

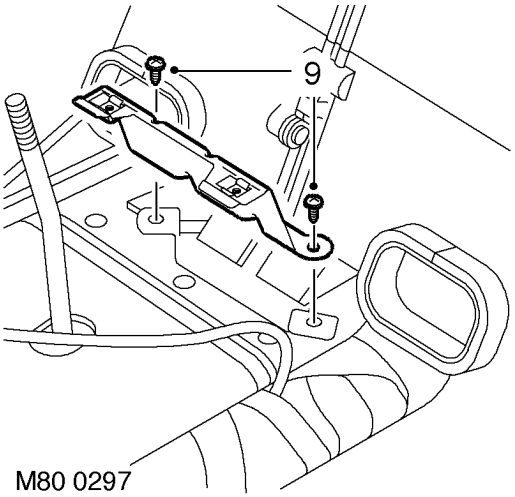
5. Remove fascia.
   ☞ INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.



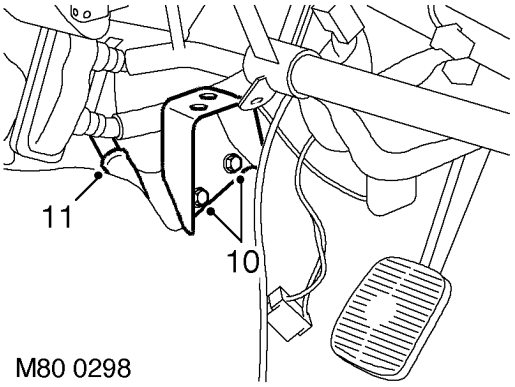
6. Remove screws securing rear heater ducting and remove ducting.

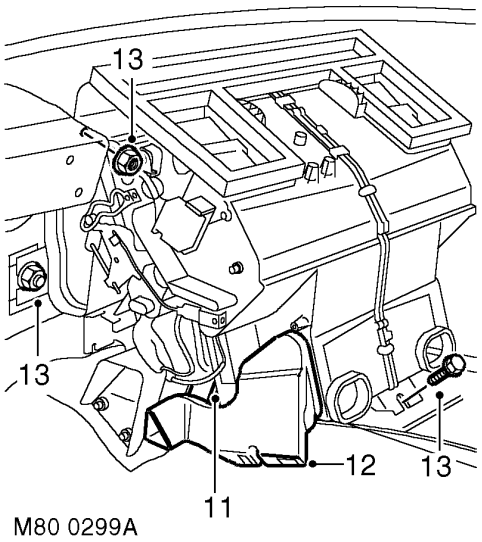


7. Disconnect multiplug from heater motor.
8. Remove 2 nuts and bolt securing heater motor assembly and remove motor assembly from heater casing.



9. Remove 2 screws securing centre console support bracket and remove bracket.





10. Remove 2 nuts securing RH fascia support bracket and remove bracket.

11. Disconnect both evaporator drain hoses.
12. Remove front heater ducting.
13. Remove 4 nuts and bolt securing heater assembly, release heater assembly from bulkhead grommet and remove from vehicle.

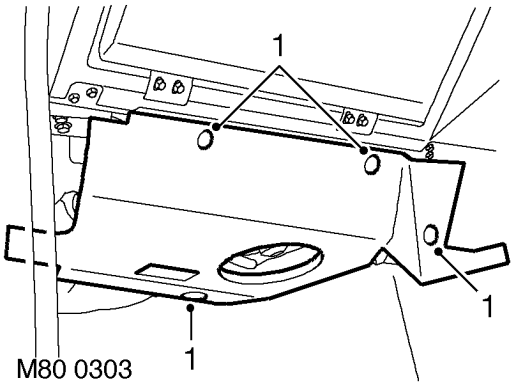
Refit

1. Position heater assembly to bulkhead, locate heater in bulkhead grommet.
2. Fit nuts and bolt securing heater and tighten to 16 Nm (12 lbf.ft).
3. Position RH fascia support bracket, fit and tighten nuts.
4. Fit front heater ducting.
5. Position centre console support bracket, fit and tighten screws.
6. Connect evaporator drain hoses.
7. Position heater motor to heater casing, fit nuts and bolt and tighten to 19 Nm (14 lbf.ft).
8. Connect multiplug heater motor.
9. Position rear heater ducting and secure with screws.
10. Fit fascia.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.**
11. Using new 'O' rings, position air conditioning pipes to evaporator fit bolts and tighten to 5 Nm (3.7 lbf.ft).
12. Position heater hoses and secure hose clips.
13. Recharge air conditioning system.
    ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
14. Refill cooling system.
    - ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**
    - ☞ **COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.**

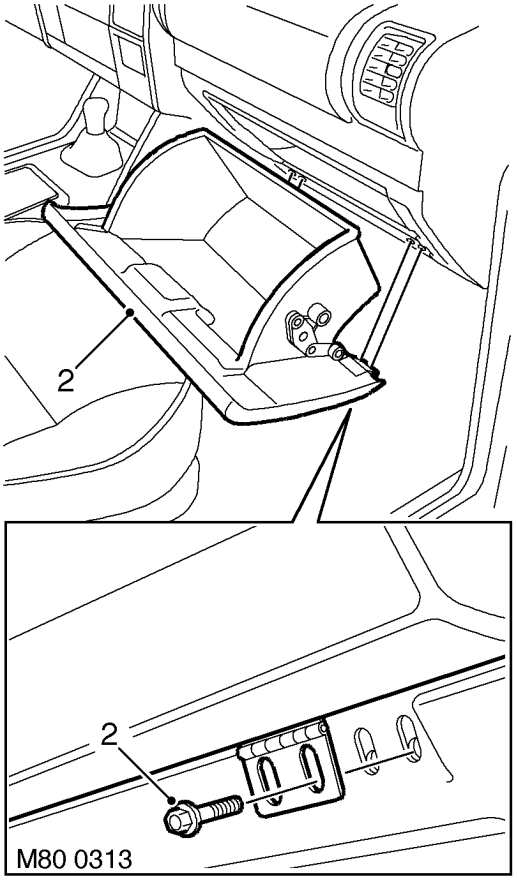
Blower assembly

80.20.12

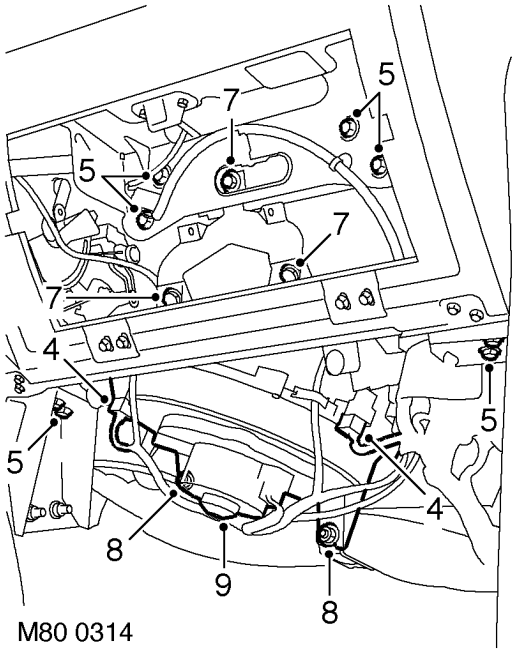
Remove



1. Remove 4 studs securing toe board and remove toe board.



2. Remove 4 screws securing glove box, release catch and remove glove box.
3. Disconnect battery earth lead.



M80 0314

4. Disconnect multiplugs from blower motor.
5. Remove 8 bolts securing passenger side of fascia panel.
6. Carefully ease fascia away from bulkhead
7. Remove 3 bolts securing blower motor support bracket and remove bracket.
8. Remove 2 nuts securing motor assembly.
9. Release blower motor assembly from heater and manoeuvre from under fascia.

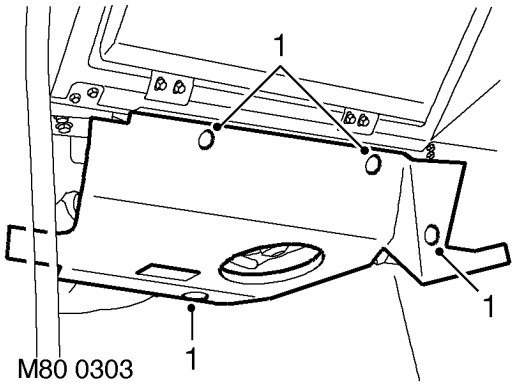
Refit

1. Position blower motor assembly under fascia and locate to heater casing.
2. Position support bracket, fit and tighten nuts and bolts.
3. Align fascia, fit bolt to support bracket and tighten to 26 Nm (19 lbf.ft).
4. Connect multiplugs to blower motor.
5. Connect battery earth lead.
6. Fit glove box, align hinges and tighten screws.
7. Position toe board and secure with studs.

Motor - blower

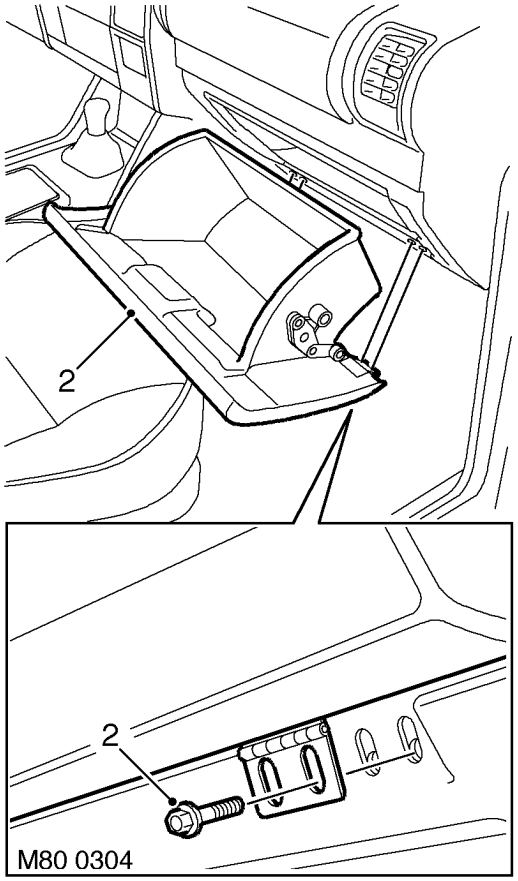
80.20.15

Remove



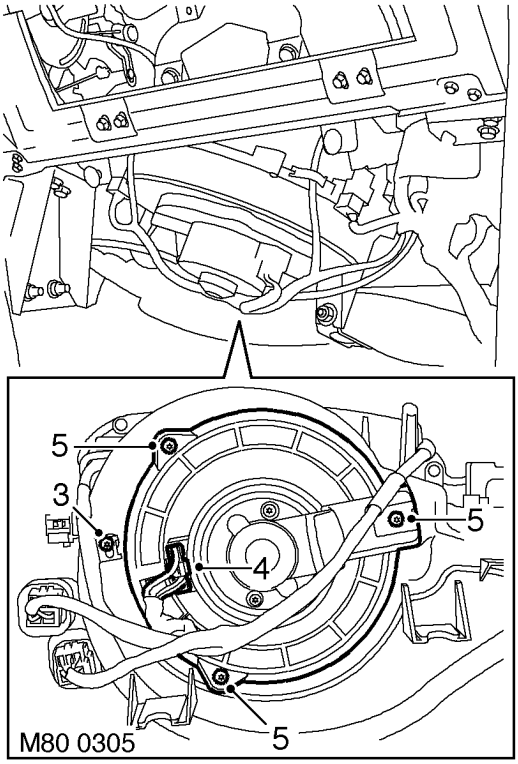
M80 0303

1. Remove 4 studs securing toe board and remove toe board.



M80 0304

2. Remove 4 screws securing glove box, release catch and remove glove box.



3. Remove screw securing harness to blower motor and release harness.
4. Disconnect multiplug from blower motor.
5. Remove 3 screws securing blower motor to casing and remove blower motor.

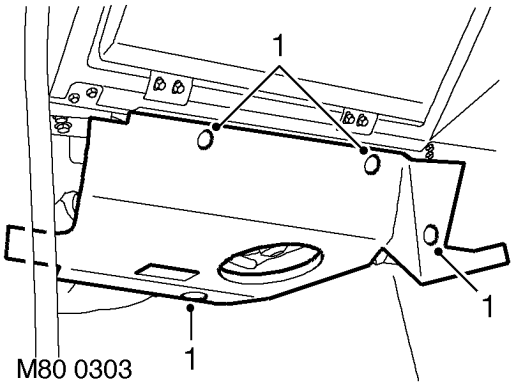
Refit

1. Position blower motor to casing and secure with screws.
2. Connect multiplug to blower motor.
3. Position harness and secure clip with screw.
4. Fit glove box, align hinges and tighten screws.
5. Position toe board and secure with studs.

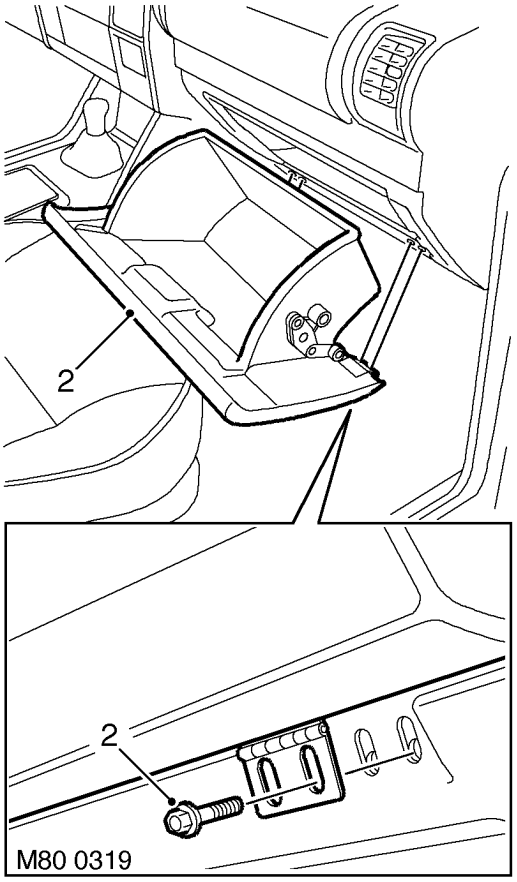
Resistor pack - power resistor A/C

80.20.17

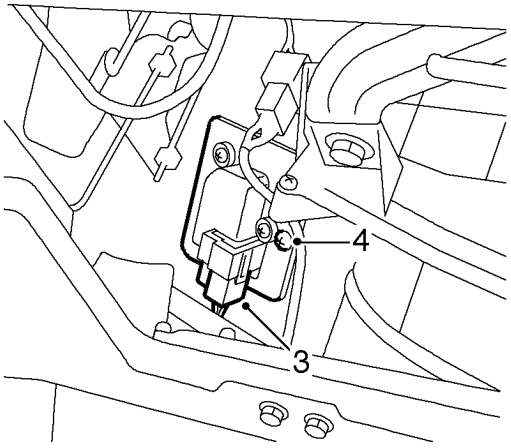
Remove



1. Remove 4 studs securing toe board and remove toe board.



2. Remove 4 screws securing glove box, release catch and remove glove box.



M80 0320

3. Disconnect multiplug from resistor.
4. Remove screws securing resistor, release and remove resistor.

Refit

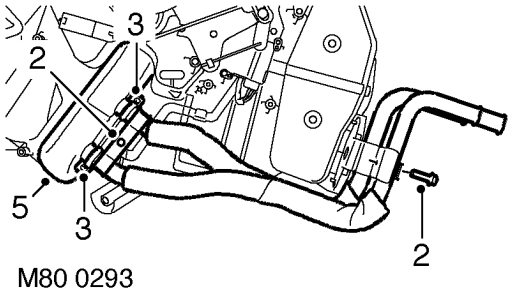
1. Position resistor and secure with screw.
2. Connect multiplug to resistor.
3. Position glove box, fit and tighten screws.
4. Position toe board and secure with studs.

Heater matrix

80.20.29

Remove

1. Remove heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.



M80 0293

2. Remove 2 screws securing coolant pipe saddles and remove saddles.
3. Loosen screws securing coolant pipes to matrix, release clamps and remove coolant pipes.
4. Remove and discard 'O' rings.
5. Remove heater matrix.

Refit

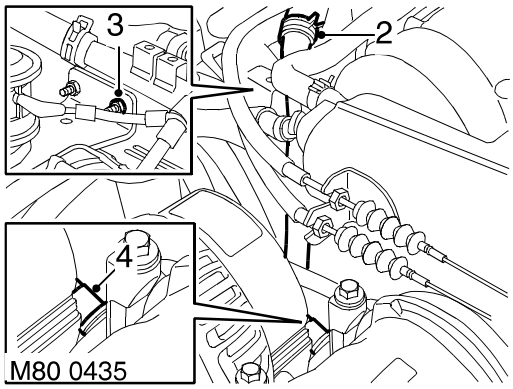
1. Position heater matrix, using new 'O' rings fit coolant pipes and align clamps.
2. Fit saddle clamps and secure with screws
3. Tighten coolant pipe clamp screws.
4. Fit heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.

Pipe - Heater - Feed

80.25.07

Remove

1. Remove heater return pipe.
   HEATING AND VENTILATION, REPAIRS, Pipe - Heater - Return.



2. Release clip securing heater feed hose to heater feed pipe and disconnect hose from pipe.
3. Remove nut securing heater feed pipe to plenum chamber.
4. Press quick release connector and release heater feed pipe from plenum chamber.
5. Remove and discard 'O' ring from pipe.

Refit

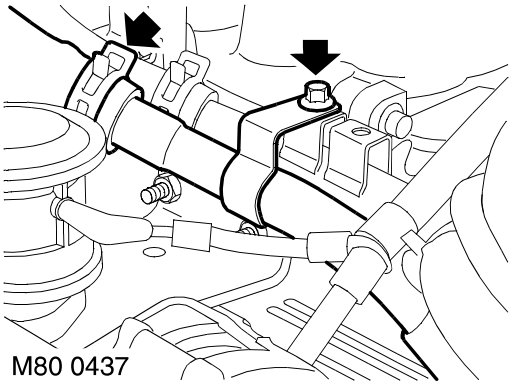
1. Fit new 'O' ring to heater feed pipe and lubricate with castor oil.
2. Secure heater feed pipe to plenum chamber.
3. Fit and tighten nut securing heater feed pipe to plenum chamber.
4. Connect heater feed hose to heater feed pipe and secure with clip.
5. Fit heater return pipe.
   HEATING AND VENTILATION, REPAIRS, Pipe - Heater - Return.

Pipe - Heater - Return

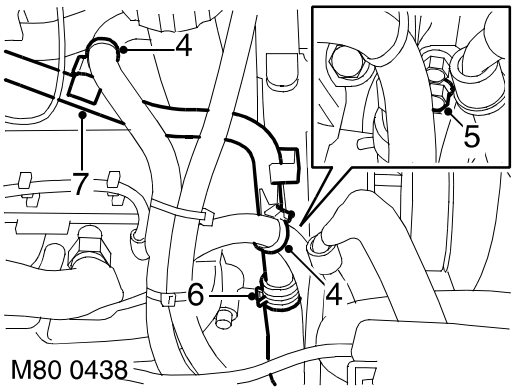
80.25.12

Remove

1. Drain engine coolant.
   COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.



2. Release clip securing heater return hose to heater return pipe and disconnect hose from pipe.



3. Remove bolt securing heater return pipe to heater feed pipe.
4. Release clips securing engine harness and vacuum pipe to heater return pipe.
5. Remove bolt securing heater return pipe to cylinder head.
6. Release clip securing engine coolant hose to heater return pipe.
7. Release engine coolant hose from heater return pipe and collect pipe.

Refit

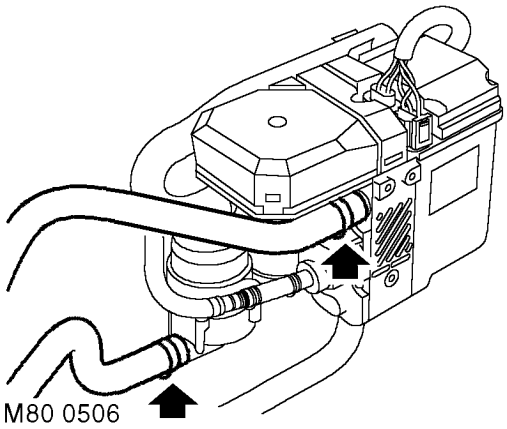
1. Connect engine coolant hose to heater return pipe and secure with clip.
2. Position heater return pipe to cylinder block and secure with bolt.
3. Secure engine harness and vacuum pipe to heater return pipe and secure with clips.
4. Fit and tighten bolt securing heater return pipe to heater feed pipe.
5. Connect heater return hose to heater return pipe and secure with clip.
6. Refill engine coolant.
   ☞ **COOLING SYSTEM - V8, ADJUSTMENTS, Drain and refill.**

Fuel burning heater - (FBH) - Td5

🔧 ***80.40.01.99***

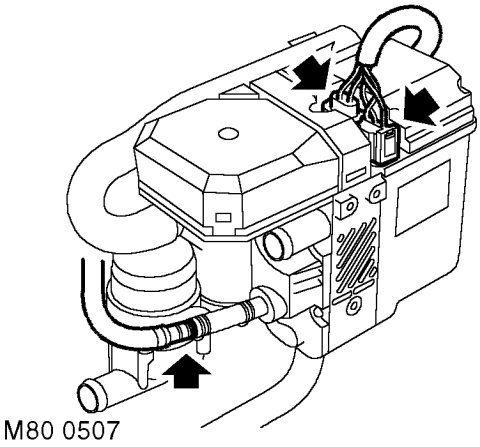
Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Clamp feed and return coolant hoses at FBH.
4. Position container to collect spillage.


M80 0506

5. Release clips, disconnect coolant feed and return hoses from FBH.

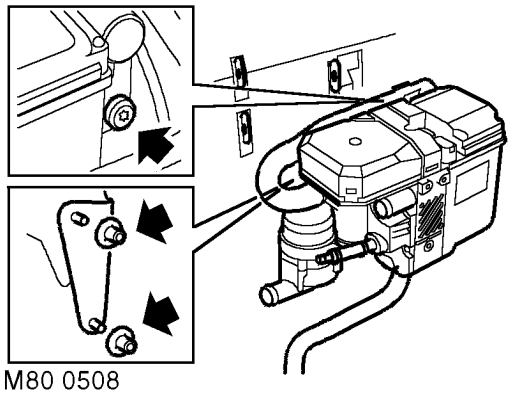
   CAUTION: Before disconnecting or removing components, ensure the immediate area around joint faces and connections are clean. Plug open connections to prevent contamination.


M80 0507

6. Disconnect 2 multiplugs from FBH.

7. Position container to collect spillage and disconnect quick release fuel pipe from FBH.

CAUTION: Before disconnecting any part of the fuel system, it is imperative that all dust, dirt and debris is removed from around components to prevent ingress of foreign matter into fuel system.



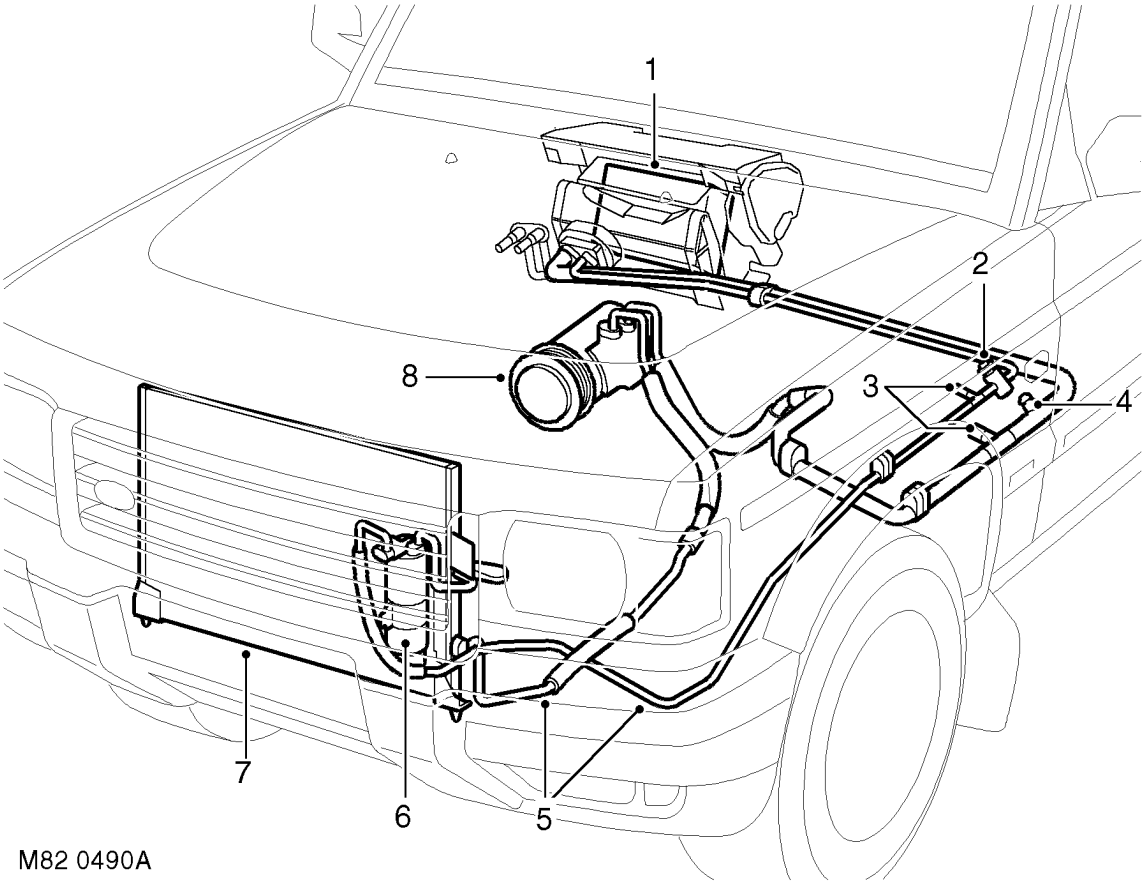
M80 0508

8. Remove Torx bolt securing FBH to bulkhead mounting bracket.
9. Release and remove FBH.
10. Collect locating bushes from pegs.

Refit

1. Fit bushes to pegs.
2. Align FBH to pegs, fit Torx bolt and tighten to 25 Nm (18 lbf.ft).
3. Clean quick release connection and fit fuel pipe to FBH.
4. Connect multiplugs to FBH.
5. Connect coolant hoses to FBH and secure with clips.
6. Release clamps from hoses.
7. Connect battery earth lead.
8. Fit and secure battery cover.
9. Top-up cooling system.
   ☞ **MAINTENANCE, PROCEDURES, Cooling system.**

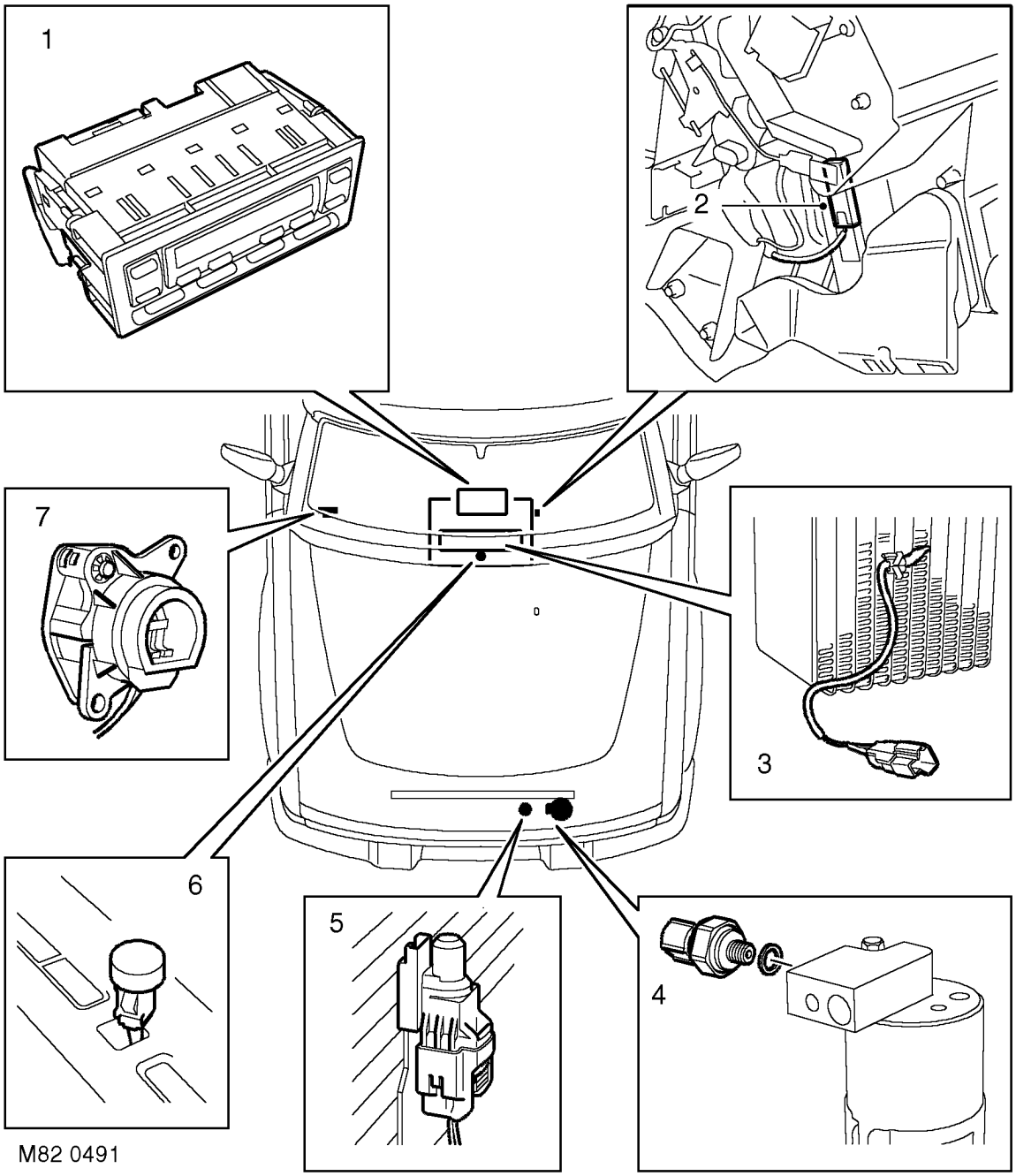
A/C refrigerant system component layout



Diesel installation shown, V8 similar

1 Evaporator and thermostatic expansion valve
2 High pressure servicing connection
3 To rear A/C system (where fitted)
4 Low pressure servicing connection
5 Refrigerant lines
6 Receiver drier
7 Condenser
8 Compressor

A/C control system component layout



RH drive shown, LH drive similar

1 Air temperature control ECU
2 Heater coolant temperature sensor
3 Evaporator temperature sensor
4 Dual pressure switch
5 Ambient temperature sensor
6 Sunlight sensor
7 In-car temperature sensor

Description

General

The air conditioning system controls the temperature, distribution and volume of air supplied to the vehicle interior to provide a comfortable cabin environment. The system is electronically controlled and features automatic and manual modes of operation, with separate temperature control of the LH and RH air outlets. The automatic modes provide optimum control of the system under most ambient conditions and require no manual intervention. The manual modes allow individual functions of automatic operation to be overridden, to accommodate personal preferences.

The air conditioning system consists of a refrigerant system, a heater assembly and a control system. It also uses the same air inlet duct and distribution ducts as the Heating and Ventilation system on non air conditioned vehicles.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**

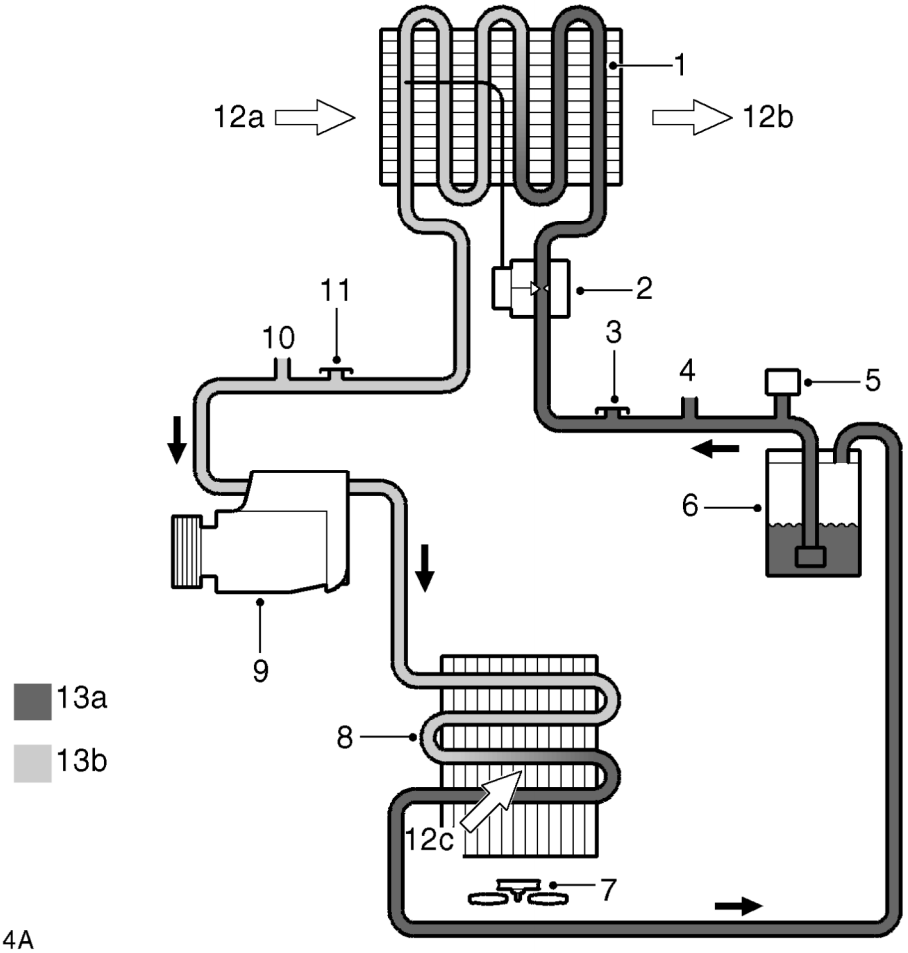
Fresh or recirculated inlet air flows into the heater assembly from the blower in the air inlet duct. In the heater assembly, the air is cooled and/or heated, depending on the selected cabin temperature and ambient conditions, then directed to selected air outlets.

On vehicles with rear air conditioning, additional cooling is provided by recirculating air through a second evaporator and distributing it to outlets in the roof.

☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**

Refrigerant system

Schematic of air conditioning system



M82 0514A

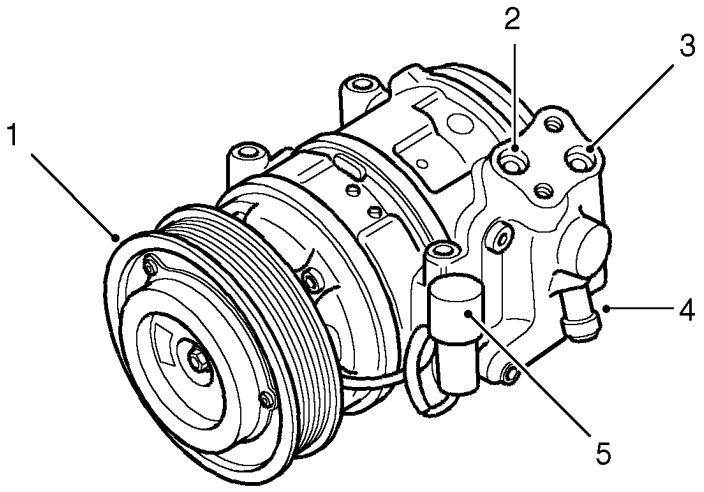
1 Evaporator
2 Thermostatic expansion valve
3 Low pressure servicing connection
4 Outlet to rear A/C system (where fitted)
5 Dual pressure switch
6 Receiver drier
7 Cooling fan
8 Condenser
9 Compressor
10 Inlet from rear A/C system (where fitted)
11 High pressure servicing connection
12 Air flows
- **a** Ambient air
- **b** Cooled air
- **c** Ambient air through condenser

13 Refrigerant
- **a** Liquid
- **b** Vapour

The refrigerant system transfers heat from the vehicle interior to the outside atmosphere to provide the heater assembly with dehumidified cool air. The system comprises a compressor, condenser, receiver drier, thermostatic expansion valve and evaporator, joined together by refrigerant lines. The system is a sealed, closed loop, filled with a charge weight of R134a refrigerant as the heat transfer medium. Oil is added to the refrigerant to lubricate the internal components of the compressor.

To accomplish the transfer of heat, the refrigerant is circulated around the system, where it passes through two pressure/temperature regimes. In each of the pressure/temperature regimes, the refrigerant changes state, during which process maximum heat absorption or release occurs. The low pressure/temperature regime is from the thermostatic expansion valve, through the evaporator to the compressor; the refrigerant decreases in pressure and temperature at the thermostatic expansion valve, then changes state from liquid to vapour in the evaporator, to absorb heat. The high pressure/temperature regime is from the compressor, through the condenser and receiver drier to the thermostatic expansion valve; the refrigerant increases in pressure and temperature as it passes through the compressor, then releases heat and changes state from vapour to liquid in the condenser.

Compressor



M82 0492

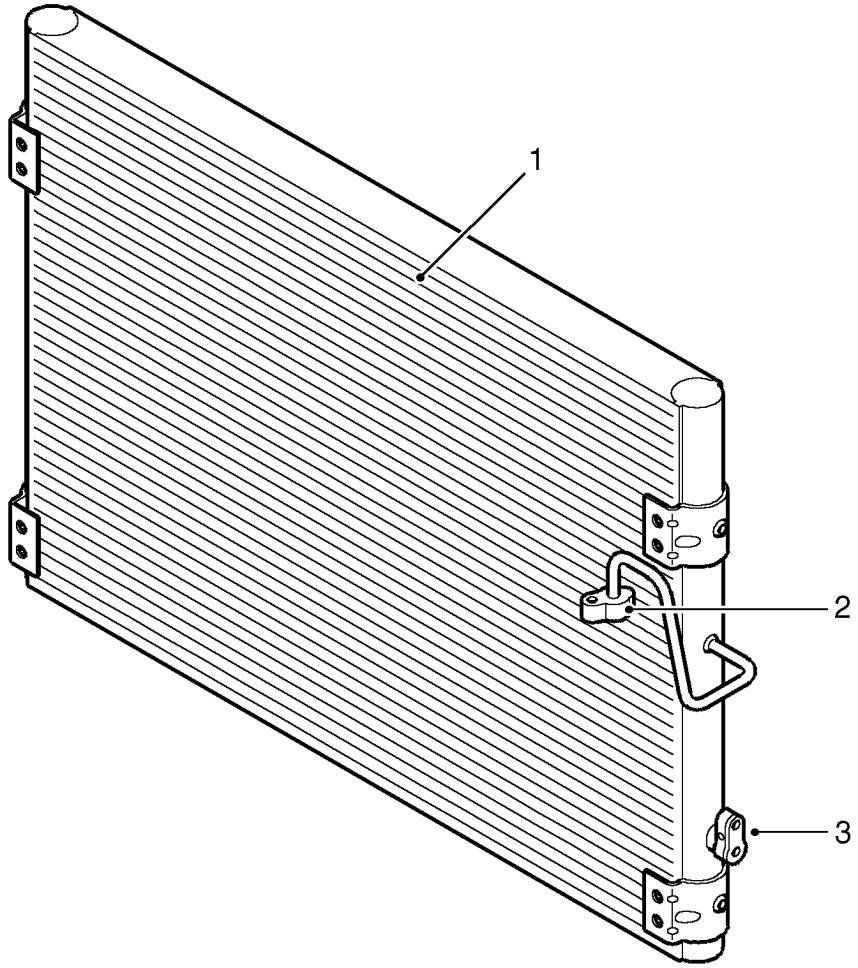
1 Pulley
2 Inlet connection
3 Outlet connection
4 Pressure relief valve
5 Clutch connector

The compressor circulates the refrigerant around the system by compressing low pressure, low temperature vapour from the evaporator and discharging the resultant high pressure, high temperature vapour to the condenser.

The compressor is attached to a mounting bracket on the engine, and is a ten cylinder swash plate unit with a fixed displacement of 177 ml/rev (0.19 US qt/rev). The auxiliary drive belt drives the compressor via a pulley and an electrically actuated clutch. Operation of the clutch is controlled by the Engine Control Module (ECM).

To protect the refrigerant system from unacceptably high pressure, a pressure relief valve is installed in the outlet side of the compressor. The pressure relief valve is set to operate at 34.3 to 41.4 bars (497 to 600 lbf.in^2) and vents excess pressure into the engine compartment.

Condenser



M82 0493

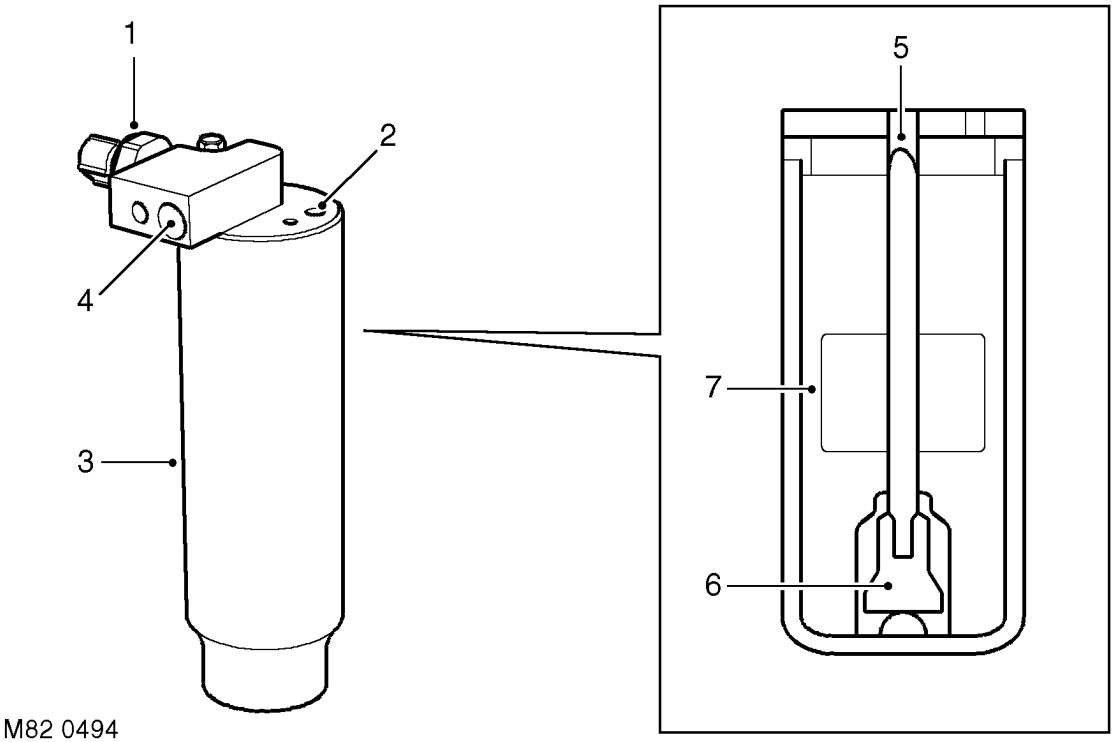
1 Condenser matrix
2 Outlet connection
3 Inlet connection

The condenser transfers heat from the refrigerant to the surrounding air.

The condenser is installed immediately in front of the oil coolers. Rubber mounting bushes are used to mount the condenser to the chassis sidemembers and brackets on the headlamp panels.

Ambient air, passing through the condenser matrix due to ram effect and/or the cooling fan, absorbs heat from the refrigerant, which changes state from a vapour to a liquid.

Receiver drier



M82 0494

1 Dual pressure switch
2 Inlet connection
3 Housing
4 Outlet connection
5 Outlet tube
6 Screen
7 Desiccant

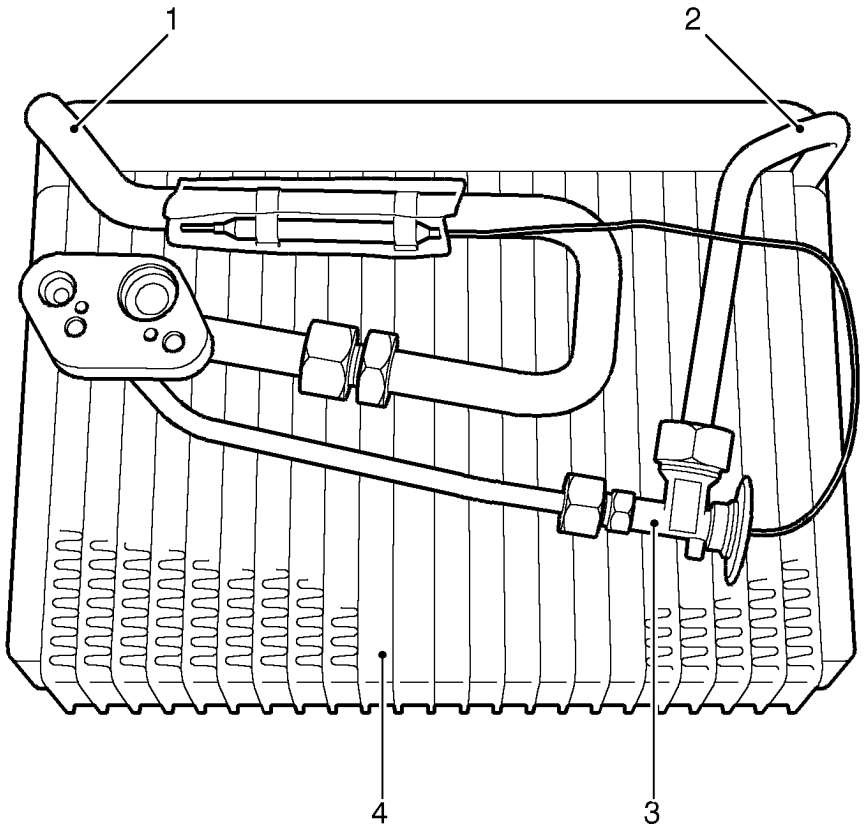
The receiver drier removes moisture and solid impurities from the refrigerant and also acts as a refrigerant reservoir.

The receiver drier is clamped to a bracket in front of the condenser. The receiver drier housing is manufactured in aluminium and contains a desiccant to absorb moisture. A mesh screen in the housing removes solid impurities. Inlet, outlet and dual pressure switch connections are located in the top of the housing.

Liquid refrigerant enters the receiver drier, passes through the desiccant and mesh screen, and through a tube to the outlet connection.

Thermostatic expansion valve

Thermostatic expansion valve and evaporator



M82 0546

1 Refrigerant outlet
2 Refrigerant inlet
3 Thermostatic expansion valve
4 Evaporator

The thermostatic expansion valve meters the flow of refrigerant into the evaporator to match the refrigerant flow with the heat load of the air passing through the evaporator matrix.

The thermostatic expansion valve is installed in the heater assembly, in the refrigerant inlet line to the evaporator. Liquid refrigerant flows through the valve to the evaporator. The restriction across the valve reduces the pressure and temperature of the refrigerant and changes it to a fine spray, which improves the evaporation process. Valve opening is controlled by the pressure in a capillary tube containing a temperature sensitive fluid. One end of the capillary tube is connected to a diaphragm housing on the thermostatic expansion valve, the other end of the capillary tube is sealed and attached to the refrigerant outlet line of the evaporator. As the temperature of the refrigerant leaving the evaporator changes, a corresponding change of capillary tube pressure and valve opening are produced. The warmer the refrigerant leaving the evaporator becomes, the greater the volume of refrigerant allowed through the valve.

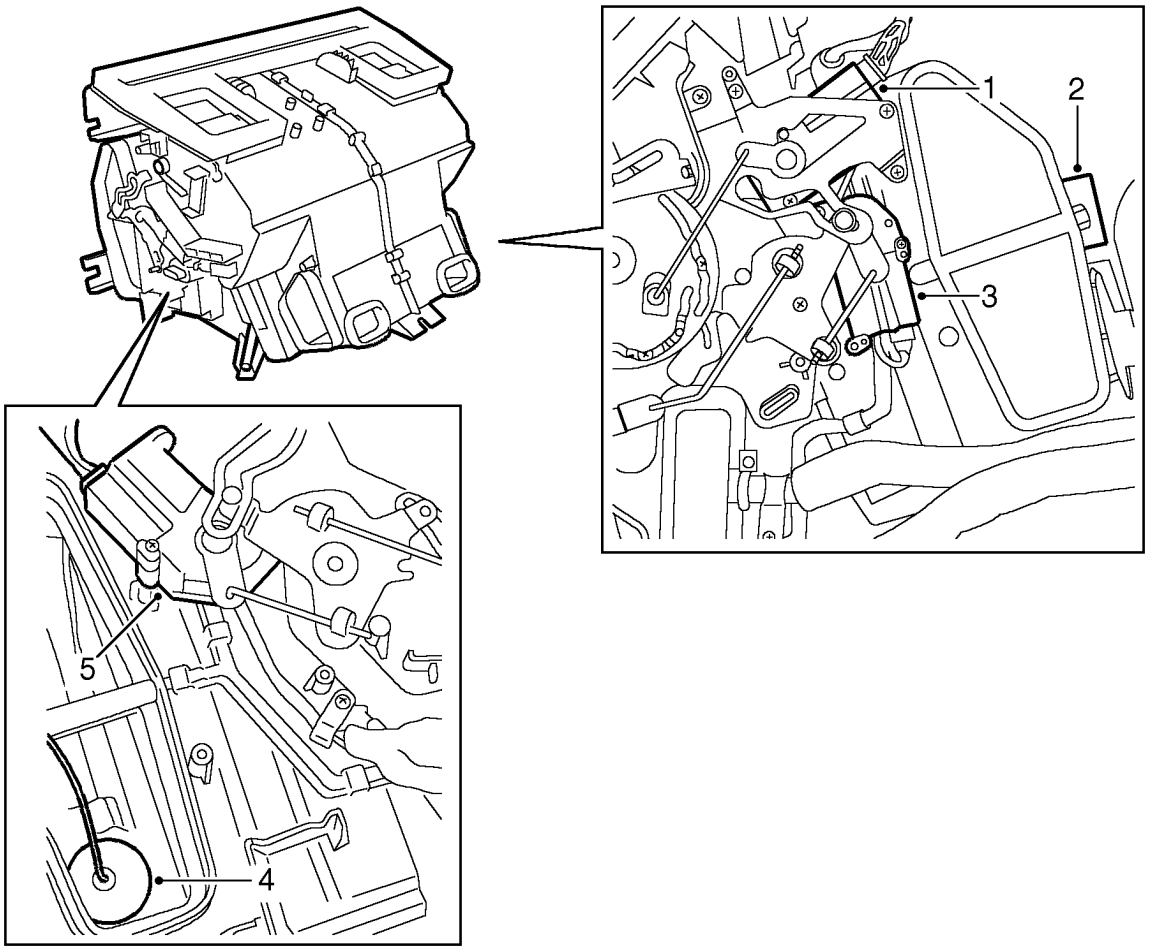
Evaporator

The evaporator is installed in the air inlet of the heater assembly and absorbs heat from the exterior or recirculated inlet air. Low pressure, low temperature refrigerant changes from liquid to vapour in the evaporator, absorbing large quantities of heat as it changes state.

Refrigerant lines

To maintain similar flow velocities around the system, the diameter of the refrigerant lines varies to suit the two pressure/temperature regimes. The larger diameters are installed in the low pressure/temperature regime and the smaller diameters are installed in the high pressure/temperature regime. Low and high pressure charging connections are incorporated into the refrigerant lines for system servicing. Where rear AC is installed, connections for the rear refrigerant lines are incorporated next to the charging connections.

Heater assembly



M82 0545A

1 Distribution servo motor
2 Refrigerant inlet and outlet connector block
3 RH blend flap servo motor
4 Thermostatic expansion valve
5 LH blend flap servo motor

The heater assembly controls the temperature and distribution of air supplied to the distribution ducts, and is similar to the heater assembly installed in non A/C vehicles.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.** The only differences from the heater assembly in non A/C vehicles are as follows:

- The thermostatic expansion valve, evaporator and evaporator temperature sensor are installed at the air inlet side of the casing.
- Three servo motors operate the control flaps instead of control cables.
- A coolant temperature sensor is installed against the heater matrix.

The servo motors are controlled by the ATC ECU. Feedback potentiometers in the servo motors provide the ATC ECU with flap position signals.

Temperature and distribution control

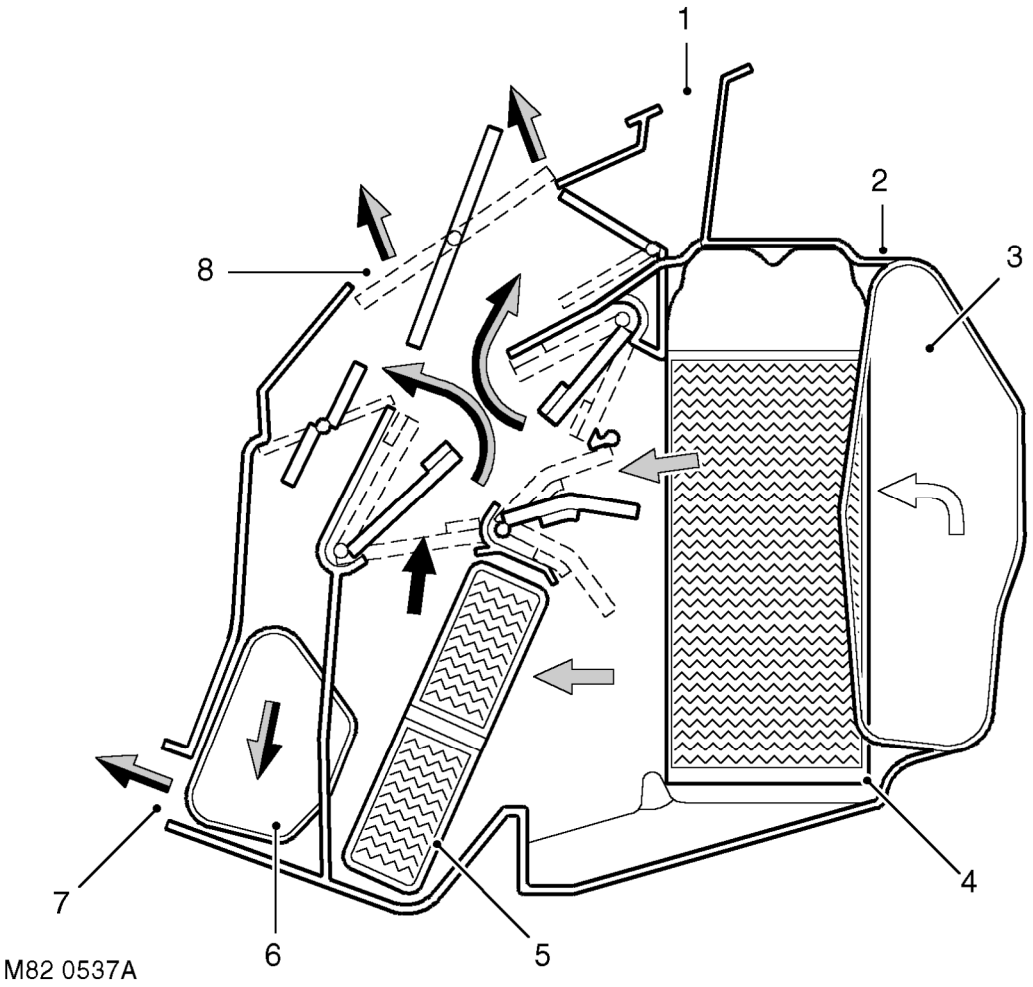


Figure shows flaps set for medium heat to face level and footwell outlets

1 Windscreen/Side windows outlet
2 Heater assembly casing
3 Air inlet
4 Evaporator
5 Heater matrix
6 Front footwells outlet
7 Rear footwells outlet
8 Face level outlet

Control system

The control system operates the refrigerant system and the control flaps in the heater assembly to control the temperature and distribution of air in the vehicle interior. It also outputs signals to the fresh/recirculated air servo motor and the blower to control the volume and source of inlet air. The control system consists of:

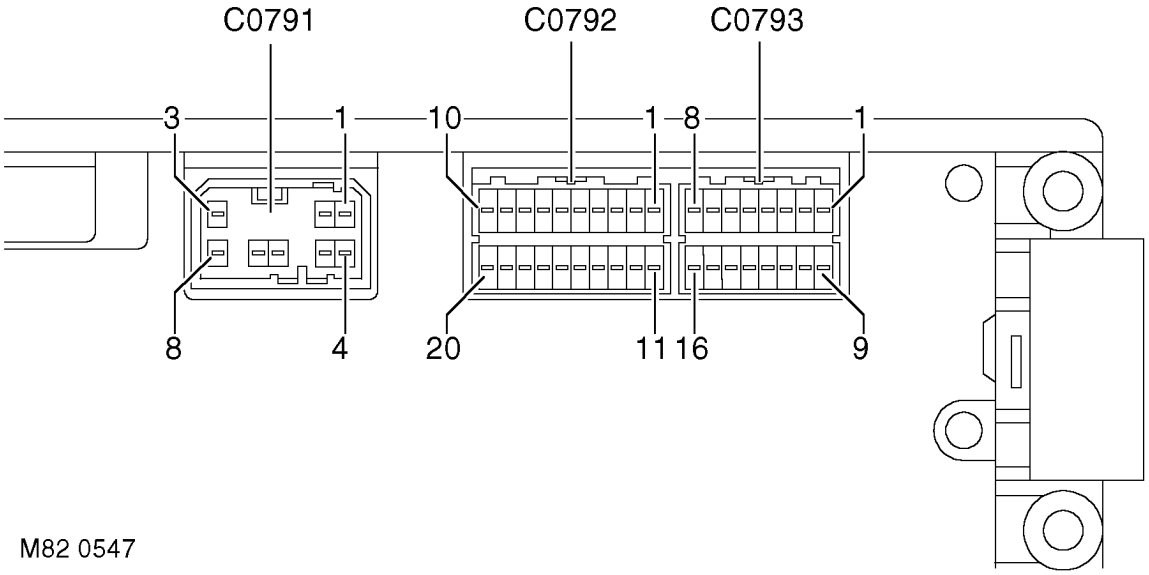
- An Air Temperature Control (ATC) ECU.
- A dual pressure switch.
- An evaporator temperature sensor.
- An in-car temperature sensor.
- A sunlight sensor.
- A heater coolant temperature sensor.
- An ambient temperature sensor.

ATC ECU

The ATC ECU is installed in the centre of the fascia, below the radio. An integral control panel on the ATC ECU contains switches for system control inputs and a LCD to provide system status information.

Inputs from sensors and the control panel switches are processed by the ATC ECU, which then outputs the appropriate control signals.

ATC ECU connectors

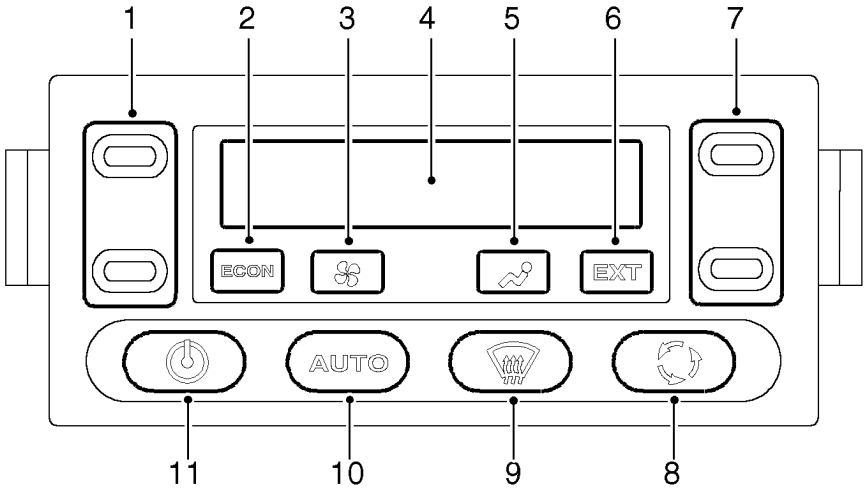


ATC ECU connector pin details

Connector/Pin No.	Description	Input/Output
C0791		
1	Battery power supply	Input
2	Ignition power supply	Input
3	Sensor power supply	Output
4	Earth	-
5	Display illumination	Input
6	Not used	-
7	Not used	-
8	Sensor earth	-
C0792		
1	Night lighting/dimming	Input
2	Vehicle speed	Input

Connector/Pin No.	Description	Input/Output
3	Hand of drive	Input
4	Distribution flaps position	Input
5	Heater coolant temperature	Input
6	External air temperature	Input
7	In-car air temperature	Input
8	Blower power transistor collector voltage	Input
9	Not used	-
10	Not used	-
11	Windscreen heater status	Input
12	Rear screen heater status	Input
13	Not connected	-
14	Driver's blend flaps position	Input
15	Passenger's blend flaps position	Input
16	LH solar heating load	Input
17	RH solar heating load	Input
18	Evaporator	Input
19	Not used	-
20	Not used	-
C0793		
1	Blower power transistor base current	Output
2	Blower relay	Output
3	Windscreen heater request	Output
4	Rear screen heater request	Output
5	Passenger's blend flaps servo motor, drive to hot	Output
6	Driver's blend flaps servo motor, drive to hot	Output
7	Distribution flaps servo motor, drive to windscreen and side windows demist	Output
8	Fresh/Recirculated air servo motor, drive to recirculated air	Output
9	Cooling fan request (diesel models)	Output
10	Power relay	Output
11	Compressor clutch request	Output
12	Cooling fan request (V8 models)	Output
13	Passenger's blend flaps servo motor, drive to cold	Output
14	Driver's blend flaps servo motor, drive to cold	Output
15	Distribution flaps servo motor, drive to footwells	Output
16	Fresh/Recirculated air servo motor, drive to fresh air	Output

Control panel



M82 0495

1 LH temperature switch
2 Economy mode (ECON) switch
3 Blower switch
4 Display
5 Distribution switch
6 External air temperature (EXT) switch
7 RH temperature switch
8 Fresh/Recirculated air switch
9 Defrost mode switch
10 Automatic mode (AUTO) switch
11 A/C on/off switch

The control panel switches are all non-latching pushswitches except for the LH and RH temperature switches, which are centre-off rocker switches. The switches have the following functions:

LH and RH temperature switches. Enabled only while the system is on:

- Each press increases or decreases the related temperature setting, in steps of 1 °C (2 °F), between 16 and 28 °C (60 and 84 °F).
- If the decrease side of the switch is pressed when a temperature of 16 °C (60 °F) is set, the display changes to LO (maximum cold).
- If the increase side of the switch is pressed when a temperature of 28 °C (84 °F) is set, the display changes to HI (maximum hot).
- If a switch is kept depressed, step changes occur every 0.4 seconds.

A/C on/off switch. Switches the system on and off. When used to switch the system on, the system resumes the configuration in use prior to the previous off selection.

Blower switch. Enabled only while the system is on. Provides manual control of blower speed:

- Each press changes the blower speed, in sequence, through off (only available if economy mode is selected on) and five incremental speeds.
- If the switch is kept depressed, after 1 second subsequent speed increments occur every 0.4 second until blower reaches high speed. Releasing and then pressing the switch again changes blower back to off or low speed.

Distribution switch. Enabled only while the system is on. Provides manual control of air distribution:

- Each press changes the air distribution, in sequence, through footwells only, footwells and windscreen/side windows demist, windscreen/side windows demist only, face level only, face level and footwells.
- If the switch is kept depressed, after 1 second subsequent distribution changes occur every 0.4 seconds until distribution reaches face level and footwells. Releasing and then pressing the switch again changes distribution back to footwells only.

External air temperature (EXT) switch. Enabled while the system is on or off. Switches the external temperature output on and off:

- If the system is already on, the temperature output overrides the system outputs for approximately 7 seconds, then the display reverts to system outputs.
- If the system is switched on while the external temperature output is on, the system outputs override the external temperature output.

Fresh/Recirculated air switch. Enabled only while the system is on. Provides manual control of inlet air selection.

Defrost mode switch. Starts the system in, or switches the system to and from, defrost mode.

Automatic mode (AUTO) switch. Starts the system in, or switches the system to and from, the automatic mode.

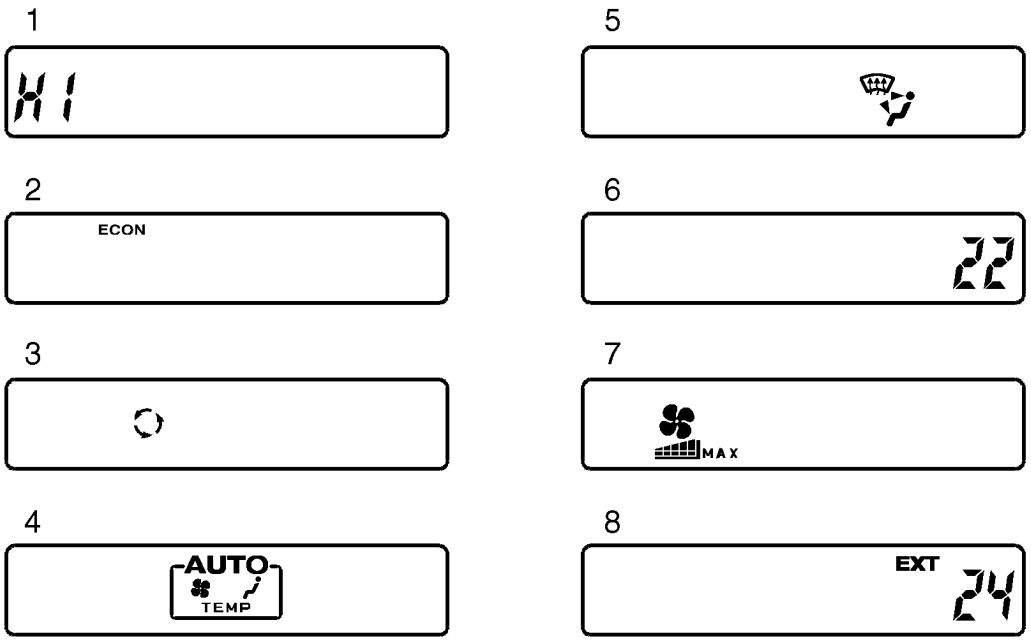
Economy mode (ECON) switch. Enabled only while the system is on. Provides manual on/off control of the refrigerant system compressor, to reduce fuel consumption when there is no requirement for cool or dehumidified air, e.g. when the ambient temperature is lower than the LH and RH temperature settings.

Temperature settings: The LH and RH temperature settings are reference inputs used by the control system and give an approximation of the temperatures that will be established in the cabin. They are not necessarily actual distribution outlet temperatures, or the temperatures at specific points in the cabin.

Audible warning: A 'beep' is emitted from the ATC ECU each time it receives a control switch input. This audible warning can be switched off and on by pressing and holding the AUTO switch, then pressing and holding the A/C on/off switch until the audible warning sounds (approximately 3 seconds). While switched off, the audible warning still sounds when:

- Switching between °F and °C on the display.
- Switching the audible warning from off to on.
- Switching the timed feet function on and off.
- Switching the timed recirculated inlet air on and off.
- Switching the latched recirculated inlet air on and off.
- When there is a fault warning.
- Running the self diagnostic routine.

Display outputs



M82 0496

1 LH temperature
2 Economy mode
3 Recirculated air
4 Automatic mode
5 Manual distribution
6 RH temperature
7 Blower speed
8 External air temperature

Outputs on the display are shown at full brightness when the exterior lights are off, and dimmed when the exterior lights are on.

LH temperature. Illuminates to show the LH temperature selection, the temperature scale or that the ATC ECU is in diagnostic mode.

Economy mode. Illuminates when the compressor is manually selected off with the ECON switch.

Recirculated air. Illuminates when the inlet air is manually selected to recirculated mode.

Automatic mode. Illuminates the AUTO legend and related symbol(s) when the blower speed, air distribution or temperature control are in the automatic mode.

Manual distribution. Illuminates the appropriate symbol(s) to show the manually selected air distribution. Also illuminates in the automatic modes when one of the temperatures is set to LO or HI.

RH temperature. Illuminates to show the RH temperature selection, external air temperature or diagnostic fault code.

Blower speed. Illuminates when the blower speed is manually selected. Also illuminates in the automatic modes when one of the temperatures is set to LO or HI.

External air temperature. EXT illuminates to show that external air temperature is selected on.

All temperature indications on the display are in either °C or °F. For 1 second after the system is first switched on, the display shows only °C or °F, in the LH temperature window, to indicate which temperature scale is in use. After 1 second, the °C or °F indication goes off and the display shows all relevant outputs.

Temperature conversion: While the system is on, the temperature indications on the display can be switched between the two scales by pressing and holding the fresh/recirculated air switch, then pressing and holding the A/C on/off switch until the audible warning sounds (approximately 3 seconds).

Dual pressure switch

The dual pressure switch protects the refrigerant system from extremes of pressure. The normally closed switch is installed in the top of the receiver drier. If minimum or maximum pressure limits are exceeded the switch contacts open, causing the compressor clutch to be disengaged. The minimum pressure limit protects the compressor, by preventing operation of the system unless there is a minimum refrigerant pressure (and thus refrigerant and lubricating oil) in the system. The maximum pressure limit keeps the refrigerant system within a safe operating pressure.

Dual pressure switch nominal operating pressures

Limit	Opening pressure, bar (lbf.in^2)	Closing pressure, bar (lbf.in^2)
Minimum	2.0 (29.0), pressure decreasing	2.3 (33.4), pressure increasing
Maximum	32 (464), pressure increasing	26 (377), pressure decreasing

Evaporator temperature sensor

The evaporator temperature sensor is an encapsulated thermistor that provides the ATC ECU with an input of the evaporator air outlet temperature. The evaporator temperature sensor is installed in a clip which locates in the evaporator matrix in the heater assembly. The ATC ECU uses the input to prevent the formation of ice on the evaporator.

In-car temperature sensor

The in-car temperature sensor is an encapsulated thermistor that provides the ATC ECU with an input of cabin air temperature. The sensor is integrated into the inlet of an electric fan, which is installed behind a grille in the fascia outboard of the steering column. The fan runs continuously, while the ignition is on, to draw air through the grille and across the sensor.

Sunlight sensor

The sunlight sensor consists of two diodes that provide the ATC ECU with inputs of light intensity, one as sensed coming from the left of the vehicle and one as sensed coming from the right. The inputs are used as a measure of the solar heating effect on vehicle occupants. The sensor is installed in the centre of the fascia upper surface.

Heater coolant temperature sensor

The heater coolant temperature sensor is an encapsulated thermistor that provides the ATC ECU with an input related to heater matrix coolant temperature. The sensor is installed in the casing of the heater assembly and presses against the end tank of the heater matrix.

Ambient temperature sensor

The ambient temperature sensor is an encapsulated thermistor that provides the ATC ECU with an input of external air temperature. The sensor is attached to the cooling fan mounting bracket in front of the condenser.

Operation

General
While the system is on, the ATC ECU operates the refrigerant system and the inlet air, blower speed, air temperature and air distribution functions to produce the conditions requested on the control panel. When the system is first switched on, the ATC ECU resumes the control outputs in use when the system was last switched off. If conditions have changed, or a different mode is selected to switch the system on, the control outputs are then changed to produce the required new settings.

The system operates in automatic, economy and defrost modes, with manual overrides of the inlet air source, blower speed and air distribution. The air temperature is automatically controlled in all operating modes.

In the automatic mode, the ATC ECU operates the system to warm-up or cool down the cabin to establish and maintain the temperature selections on the control panel, while directing the air to those outlets most comfortable for the occupant(s). If a difference between the LH and RH temperature selections causes a conflict of the required inlet air source, blower speed or air distribution settings, priority is given to achieving the temperature requested on the driver's side of the control panel.

The ATC ECU enters the economy mode when the refrigerant compressor is selected off while the system is in the automatic mode, which reduces the load on the engine. Economy mode operation is similar to the automatic mode, but without the ability to cool the cabin if the ambient temperature is higher than the temperature selections made on the control panel, or to dehumidify the air in the cabin.

In the defrost mode, the ATC ECU sets the inlet air source to fresh air, the blower to maximum speed, the air distribution to windscreen and side windows, and outputs signals to the BCU to operate the rear window heater and (where fitted) the windscreen heater. The BCU starts or, if the heaters are already on, resets the heater timers and energises the rear window and windscreen heaters for a complete on cycle.

Air temperature control
To determine the amount of heat or cooling required by the cabin, the ATC ECU uses the sensor inputs and the temperatures selected on the control panel to calculate target air outlet temperatures for the driver's and the front passenger's side of the heater assembly. The ATC ECU then signals the servo motors controlling the respective blend flaps in the heater assembly to move to the flaps to the appropriate position. The target temperatures are constantly updated and, in the automatic mode, also used in further calculations to determine the inlet air source, the blower speed and the air distribution.

Inlet air control
The inlet air source is automatically controlled while the system is off or on. While the system is on, the inlet air source can also be manually controlled to give timed recirculated air or latched recirculated air.

While the system is off, the ATC ECU uses vehicle speed to determine the inlet air source. With the vehicle at rest, the inlet air source is set to recirculated air. When vehicle speed reaches 17.5 mph (28 km/h), the inlet air source changes to fresh air. The inlet air source then remains at fresh air until the vehicle speed decreases to 5 mph (8 km/h), when it returns to recirculated air.

While the system is on, the ATC ECU uses the LH and RH temperature selections, vehicle speed, ambient air temperature and coolant temperature to determine the inlet air source. In the automatic mode:

- If one temperature selection is set to LO and one is set to a specific temperature or HI, the inlet air is set to recirculated air.
- If one temperature selection is set to HI and one is set to a specific temperature or HI, the inlet air is set to fresh air.
- When specific LH and RH temperature selections are set, the inlet air source remains at fresh air except when the air distribution function is set to face level only or face level and footwell outlets. If the air distribution function is set to face level only or face level and footwell outlets, at 56 mph (90 km/h) the inlet air source changes to recirculated air (to exclude ram effect, which becomes excessive at speed). When the vehicle speed decreases to 37.5 mph (60 km/h), the inlet air source returns to fresh air.

In the defrost mode, the inlet air source is set to fresh air except at low ambient air and coolant temperatures. If, within 5 minutes of the ignition being switched on, the vehicle speed is less than 5 mph (8 km/h) while the external air temperature is –16 °C (3 °F) or less and the heater coolant temperature is –10 °C (14 °F) or less, then the inlet air source is automatically set to the timed recirculated air mode. The timed recirculated air mode is cancelled immediately the vehicle speed reaches 8 km/h or more .

Timed recirculated air

The timed recirculated air mode sets the inlet air source to recirculated air for 5 ± 1 minutes, after which it automatically reverts to fresh air. Timed recirculated air can be manually selected:

- In the automatic mode, by pressing the fresh/recirculated air switch for 1.5 seconds or more; the audible warning sounds twice.
- In the economy or defrost modes, by pressing the fresh/recirculated air switch for less than 1.5 seconds; the audible warning sounds once.

Latched recirculated air

The inlet air source can be latched to recirculated air:

- In the automatic mode, by pressing the fresh/recirculated air switch for less than 1.5 seconds; the audible warning sounds once.
- In the economy or defrost modes, by pressing the fresh/recirculated air switch for 1.5 seconds or more; the audible warning sounds twice.

Blower control

The ATC ECU operates a blower relay, power transistor and power relay to run the blower at one of 31 stepped speeds. All speed steps are available in the automatic modes of blower control. In the manual mode, speed steps 3, 10, 16, 22 and 31 are used to provide slow, three intermediate and fast blower speeds. The ATC ECU energises the blower relay and modulates the power transistor to operate the blower for speed steps 1 to 30. For speed step 31, the ATC ECU energises the power relay, which switches the earth side of the blower motor direct to earth, bypassing the power transistor.

In the automatic, economy and defrost modes, blower speed is corrected for vehicle speed to compensate for the increase in ram effect on the inlet air as the vehicle speed increases. Correction begins at approximately 50 km/h, when blower speed is progressively decreased as vehicle speed increases, until a maximum decrease of 13 steps occurs at 123 km/h. Similarly, blower speed increases as vehicle speed decreases down to approximately 50 km/h.

In the automatic and economy modes, if the LH or RH temperature is set to LO or HI, the blower runs at maximum speed with correction only for vehicle speed. If both the LH and RH outlet air temperatures are set to a specific temperature, blower speed corrections are added to compensate for the heater coolant temperature, external air temperature, and the solar load acting on the vehicle:

- During warm-up, the blower speed is set to 3 while the heater coolant temperature is below approximately 20 °C (68 °F). From approximately 20 °C (68 °F), the blower speed is progressively increased as the coolant temperature increases, until maximum speed is set at approximately 50 °C (122 °F).
- During cool down, blower speed is set to 3, for 5 seconds after the system is switched on. Over the following 6 seconds, the blower speed is progressively increased up to maximum speed.
- As the temperature in the cabin approaches the selected temperatures, blower speed is progressively reduced until, once the selected temperatures have been established, blower speed stabilises at approximately 6.
- Solar heating correction is employed when air distribution is set to face level or to face and footwells. The correction progressively increases the blower speed, up to a maximum of 9 steps, with increasing values of solar heating.

Air distribution control
To control the air distribution within the cabin the ATC ECU signals the servo motor controlling the distribution flaps in the heater assembly to move to the flaps to the appropriate position.

In the automatic and economy modes, if the LH or RH temperature selections are set to LO or HI, air distribution is fixed as follows:

- If one is set to LO and one is set to a specific temperature, to face level only.
- If one is set to HI and one is set to a specific temperature, to footwells only.
- If one is set to LO and one is set to HI, to face level and footwells.

When specific LH and RH temperature selections are set, air distribution is determined from the target air outlet temperatures. For higher target air outlet temperatures, air distribution is set to footwells only. For lower target air outlet temperatures, air distribution is set to face level only. For intermediate target air outlet temperatures, air distribution is set to face level and footwells. When the air distribution is set to face level and footwells, the ATC ECU varies the bias between the footwells and the face level outlets, in three stages, to provide a gradual transition of air distribution from footwells only to face level only. The three stages of bias are also employed when the air distribution is manually selected to face level and footwells.

During warm-up, the air distribution changes to face level and footwells for a period, then reverts to footwells only. The period of air distribution at face level and footwells can be cancelled by pressing and holding the on/off and defrost mode switches, then turning the ignition switch from off to on. Pressing and holding the AUTO and defrost switches, then turning the ignition switch from off to on, restores the period of air distribution at face level and footwells.

Compressor control
To engage the compressor clutch, the ATC ECU outputs a compressor clutch request to the ECM, which then energises the A/C compressor clutch relay. Compressor operation is governed by the evaporator outlet air temperature, at one of two settings, dependent on the amount of cooling required. When more cooling is required, the compressor clutch request is output if evaporator outlet air temperature increases to 4 °C (39 °F) and cancelled when it decreases to 3 °C (37 °F). When less cooling is required, the compressor clutch request is output if evaporator outlet air temperature increases to 11 °C (52 °F) and cancelled when it decreases to 10 °C (50 °F).

Engine cooling fan control
While the A/C system is on, operation of the electric engine cooling fan, to assist refrigerant condenser operation, is determined by a combination of vehicle speed and external air temperature. When cooling fan operation is required, the ATC ECU outputs a cooling fan request to the ECM, which then energises the cooling fan relay. The cooling fan request is output if vehicle speed is 80 km/h or less while the external air temperature is 28 °C (82 °F) or more. The request is cancelled, and the cooling fan switched off, if either the vehicle speed increases to 100 km/h, or the external air temperature decreases to 25 °C (77 °F).

Default settings
If the battery power supply to the ATC ECU is disrupted for any reason, e.g. battery disconnected, the system reverts to default settings when the battery power supply is restored. Default settings are:

- Temperature indications in °C (in some markets a conversion connector is fitted to the ATC ECU to change the default temperature scale to °F).
- LH and RH outlet temperatures of 22 °C (72 °F).
- audible warning switched on.
- Warm-up air distribution (to face level and footwells) function switched on.
- If the system is first switched on using the A/C on/off switch, the automatic mode is engaged, regardless of the settings in use when the battery was disconnected.

Diagnostics

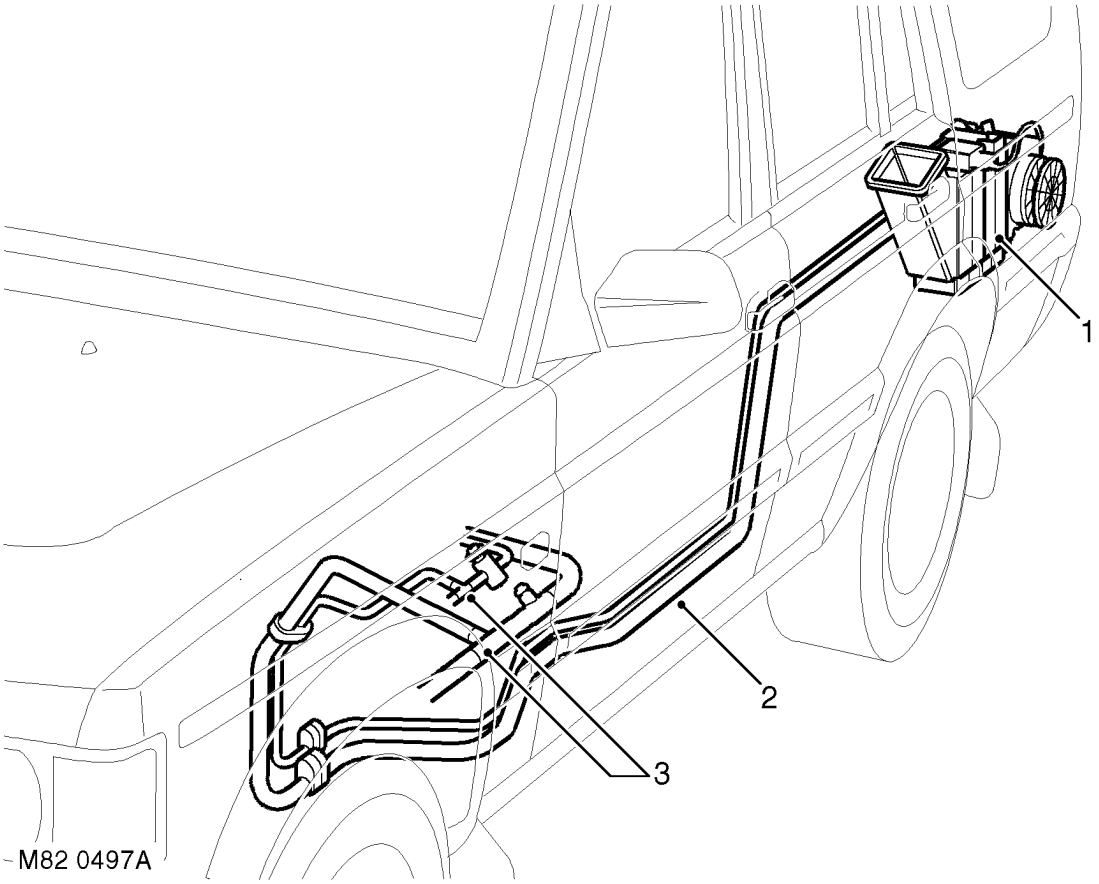
The ATC ECU performs a diagnostic check each time the ignition is switched on. To avoid nuisance fault indications at low light levels, the sunlight sensor is omitted from the diagnostic check. If a fault is detected, the audible warning sounds three times and the AUTO window on the control panel display flashes for 20 seconds. The ATC ECU then reverts to normal control but uses a default value or strategy for the detected fault. Faults are identified by performing a manual diagnostic check of the system.

A manual diagnostic check includes a check of the sunlight sensor, and is initiated by pressing and holding the AUTO switch and the air distribution switch, then turning the ignition switch from off to on. The audible warning sounds once and the indications on the control panel display illuminate. FC is shown in the LH temperature window and the results of the check are shown as a two digit fault code in the RH temperature window. If a fault is detected, the audible warning sounds three times and the AUTO window on the display flashes on and off for 20 seconds. If more than one fault is detected, the fault codes cycle in numerical order, at 1 Hz. The audible warning sounds as each fault code is shown. In low light conditions, to avoid false sunlight sensor fault indications, the sunlight sensor should be illuminated with a strong light source.

Diagnostic fault codes and fault descriptions

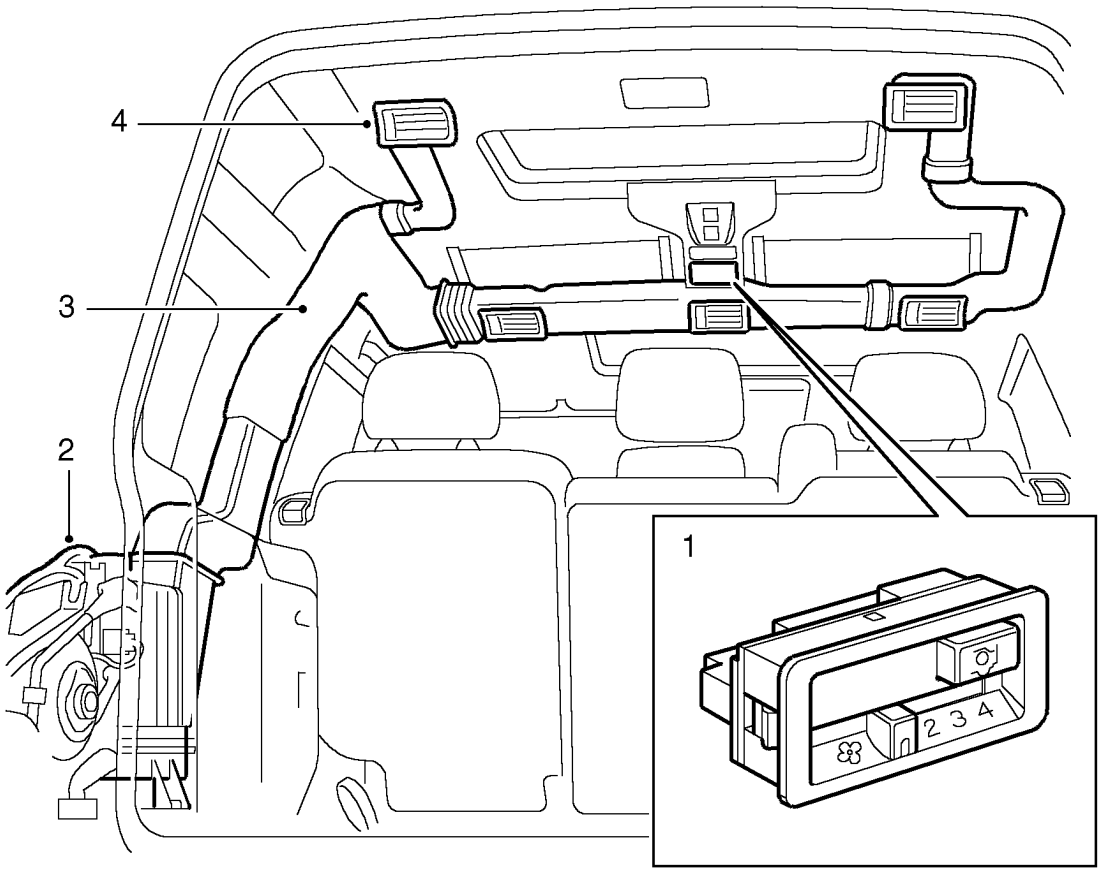
Code	Component	Fault	Default value/strategy
00	-	No fault found	-
11	In-car temperature sensor	Open or short circuit	25°C (77°F)
12	Ambient temperature sensor	Open or short circuit	10°C (50°F) Cooling fan permanently on Display shows "- -" if external air temperature selected
13	Thermistor	Open or short circuit	0°C (32°F)
14	Heater coolant temperature sensor	Open or short circuit	70°C (158°F)
21	Sunlight sensor, left output	Open or short circuit	No solar heating correction
22	Sunlight sensor, right output	Open or short circuit	No solar heating correction
31	LH temperature servo motor	Open or short circuit Motor or flap mechanism seized	Servo motor locked in position
32	RH temperature servo motor	Open or short circuit Motor or flap mechanism seized	Servo motor locked in position
33	Distribution servo motor	Open or short circuit Motor or flap mechanism seized	Servo motor locked in position

Rear A/C refrigerant system component layout



1 Rear evaporator/blower assembly
2 Refrigerant lines
3 Connections to front A/C system

Rear A/C distribution and control component layout



M82 0498

1 Control panel
2 Rear evaporator/blower assembly
3 Air distribution ducts
4 Vent assembly

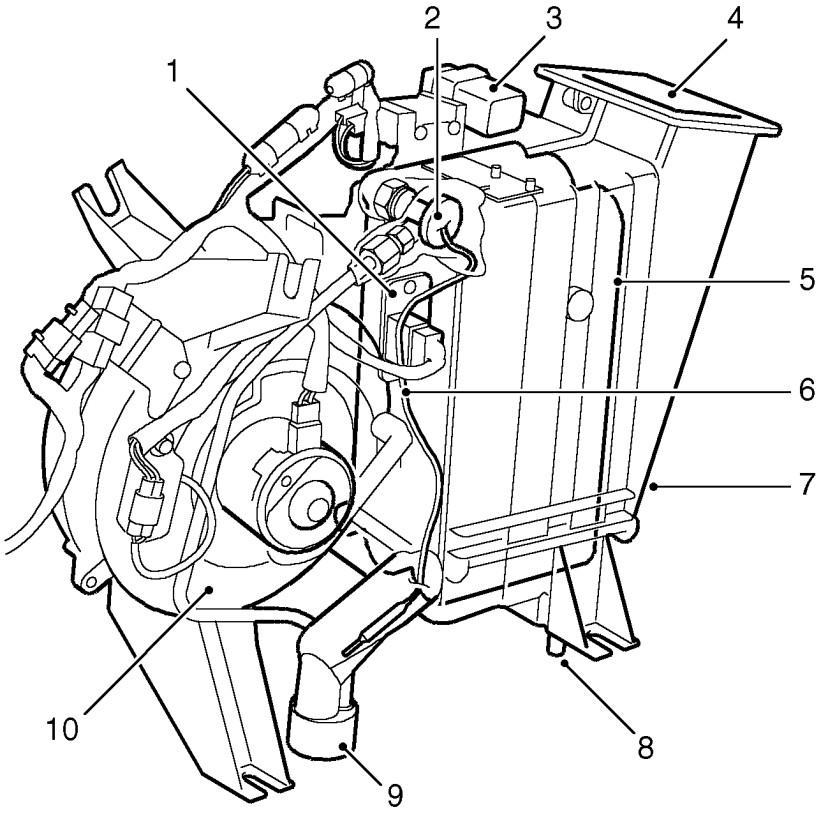
Description

The rear air conditioning system cools and recirculates air at the rear of the cabin. The system consists of refrigerant lines, a rear evaporator/blower assembly, a distribution system and a control panel.

Cooled air from the rear evaporator/blower assembly is supplied by the distribution system to vent outlets above each second and third row seat. The system is controlled by two switches on the control panel.

Refrigerant lines
Two refrigerant lines connect the rear evaporator/blower assembly to the front A/C refrigerant system. The lines are routed along the LH underside of the vehicle and secured to a connector block in the floor. A heat shield protects the lines where they pass above the rear silencer.

Rear evaporator/blower assembly



M82 0544

1 Resistor pack
2 Thermostatic expansion valve
3 Rear blower relay
4 Air outlet
5 Evaporator
6 Capillary tube
7 Housing
8 Condensate drain outlet
9 Refrigerant lines
10 Blower

The rear evaporator/blower assembly cools and dehumidifies air from the cabin and supplies it to the rear distribution system. The unit is installed on the left side of the loadspace, behind the quarter trim. A grille in the quarter trim allows air to flow from the loadspace into the evaporator/blower. Refrigerant lines for the evaporator and a condensate drain tube are attached to the rear floor.

The evaporator and blower are installed in a common housing, which also incorporates the resistor pack for the blower. A thermostatic expansion valve is integrated into the inlet refrigerant line. A rear blower relay is attached to the top of the housing.

Evaporator
The evaporator absorbs heat from the recirculated air being supplied to the distribution ducts.

Thermostatic expansion valve
The thermostatic expansion valve meters the flow of refrigerant into the evaporator to match the heat load of the air passing through the evaporator matrix. A capillary tube, attached to the outlet pipe of the evaporator and connected to the thermostatic expansion valve, automatically adjusts the valve opening in relation to the refrigerant temperature at the evaporator outlet.

Blower
The blower controls the volume of air being supplied to the distribution outlets. The blower is an open hub, centrifugal fan powered by an electric motor. A dust filter is installed over the fan inlet. The blower switch on the control panel and the resistor pack control the operation of the blower, which can be selected to run at one of four speeds.

Resistor pack
The resistor pack supplies reduced voltages to the blower motor for blower speeds 1, 2 and 3. For blower speed 4, the resistor pack is bypassed and battery voltage drives the motor at full speed. The pack is installed in the air outlet from the blower fan, so that any heat generated is dissipated by the air flow.

Distribution system

Air ducts
Ducts connected to the rear evaporator/blower motor assembly distribute air to five vent assemblies in the roof.

Vent assemblies
The vent assemblies allow occupants to control the flow and direction of air. Each vent assembly incorporates a thumbwheel to regulate flow and moveable vanes to control direction.

Rear control system
The control system operates the blower to control the operation of the rear A/C. The control system consists of two control switches and a rear blower relay.

Control switches
A rear A/C switch and a blower speed switch are installed on a control panel in the roof lining. The A/C switch is a latching pushswitch with an amber indicator lamp which illuminates when rear A/C is selected on. The blower speed switch is a slide switch with a positive detent at each of four speed positions (there is no off position).

Rear blower relay
The rear blower relay controls the electrical supply to the blower.

Operation

The rear A/C only operates if the front A/C is on to pump refrigerant through the rear evaporator/blower assembly. When the rear A/C switch is selected on, the indicator lamp in the switch illuminates and the rear blower relay is energised. The rear blower relay switches battery power to the blower motor, which runs at the speed selected on the blower speed switch.

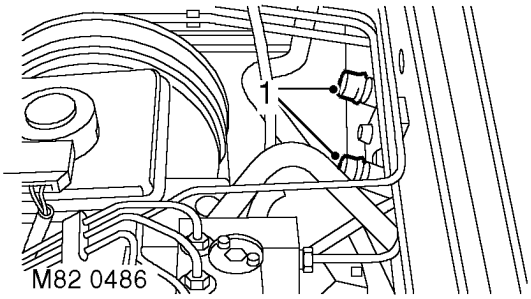
The air from the blower passes through the evaporator matrix, which absorbs heat from the air. The cooled air is then supplied to the roof vents through the distribution ducts. The heat absorbed by the refrigerant in the evaporator is sensed by the thermostatic expansion valve. The thermostatic expansion valve then opens and regulates the flow of refrigerant through the evaporator in proportion to the amount of heat being absorbed from the air.

When the rear A/C switch is selected off, the blower stops. The thermostatic expansion valve senses the subsequent decrease in temperature of the refrigerant in the evaporator. The thermostatic expansion valve then closes and stops the flow of refrigerant, except for a minimal bleed flow.

Refrigerant recovery, recycling and recharging

82.30.02

Recovery



1. Remove dust caps from high and low pressure connectors.
2. Connect high and low pressure hoses to appropriate connections.
3. Open valves on connectors.
4. Turn valves on refrigerant station to correct positions.

   Operate the refrigerant station in accordance with the manufacturers instructions.

5. Turn Process switch to correct position.
6. Turn Main switch to 'ON'.
7. Allow station to recover refrigerant from system.

   WARNING: Refrigerant must always be recycled before re-use to ensure that the purity of the refrigerant is high enough for safe use in the air conditioning system.

   Recycling should always be carried out with equipment which is design certified by Underwriter Laboratory Inc. for compliance with SAE J1991. Other equipment may not recycle refrigerant to the required level of purity.

   A R134a Refrigerant Recovery Recycling Recharging Station must not be used with any other type of refrigerant.

   Refrigerant R134a from domestic and commercial sources must not be used in motor vehicle air conditioning systems.

8. Close valves on refrigerant station.
9. Turn Main switch to 'OFF'.
10. Close valves on connectors.
11. Disconnect connectors high and low pressure hoses from connectors.
12. Fit dust caps to connectors.
13. Open tap at rear of station to drain refrigerant oil.
14. Measure and record quantity of refrigerant oil recovered from system.
15. Close tap at rear of station.

Evacuation

WARNING: Servicing must only be carried out by personnel familiar with both the vehicle system and the charging and testing equipment. All operations must be carried out in a well ventilated area away from open flame and heat sources.

1. Remove dust caps from high and low pressure connectors.
2. Connect high and low pressure hoses to appropriate connections.
3. Open valves on connectors.
4. Turn valves on refrigerant station to correct positions.
5. Turn Process switch to correct position.
6. Turn Main switch to 'ON'.
7. Allow station to evacuate system.

Recharging

NOTE: When recharging, always make allowance for refrigerant in the line between the charging station and the vehicle. This is calculated at 30 grammes/metre of charging line. System charge weights are 700 ± 25 grammes for front A/C system only and 900 ± 25 grammes for combined front and rear A/C system.

1. Close valves on refrigerant station.
2. Close valve on oil charger.
3. Disconnect yellow hose from refrigerant station.
4. Remove lid from oil charger.
5. Pour same quantity of refrigerant oil into oil charger as collected during recovery. If the following components have been renewed, add the following additional quantity of lubricating oil:
   - Condenser = 40 cm^3
   - Evaporator = 40 cm^3
   - Pipe or hose = 5 cm^3/metre
   - Receiver/dryer = 15 cm^3.
6. Fit lid to oil charger.
7. Connect yellow hose to refrigerant station.
8. Open valve on oil charger.
9. Move pointer on refrigerant gauge to mark position of refrigerant charge quantity.

   ☞ **CAPACITIES, FLUIDS AND LUBRICANTS, Capacities.**

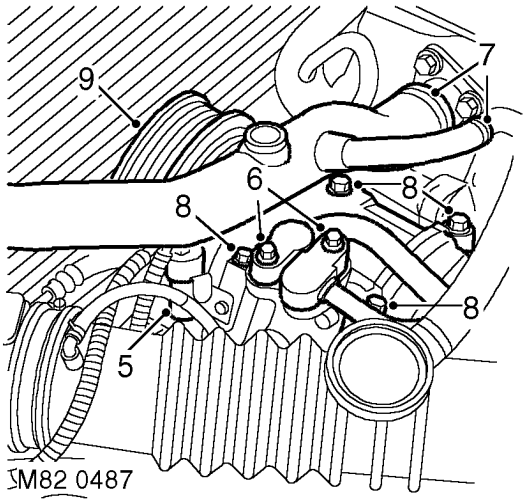
10. Slowly open correct valve on refrigerant station and allow vacuum to pull refrigerant into system.
11. Close valve on refrigerant station when correct amount of refrigerant has been drawn into air conditioning system.
12. Turn Main switch to 'OFF'.
13. Close valves on connectors.
14. Disconnect high and low pressure hoses from connectors.
15. Fit dust caps to connectors.

Compressor - diesel

82.10.20

Remove

1. Remove engine acoustic cover.
2. Depressurise air conditioning system.
   AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.
3. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.
4. Drain cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.



5. Disconnect multiplug from compressor.
6. Remove 2 bolts securing air conditioning pipes to compressor and discard 'O' rings.

   CAUTION: Always fit plugs to open connections to prevent contamination.

7. Release clips and disconnect top hose from coolant elbow and heater pipe.
8. Remove 4 bolts securing compressor to mounting bracket.
9. Remove compressor.

Refit

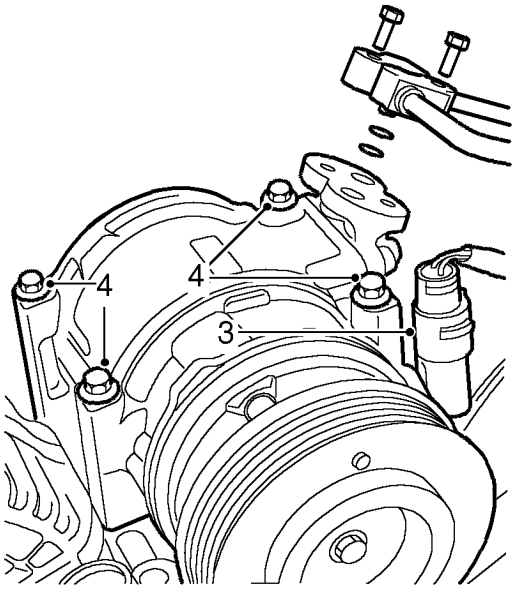
1. Calculate the quantity of refrigerant oil required.
   GENERAL INFORMATION, Air Conditioning Compressor Replacement.
2. Position compressor to mounting bracket and tighten bolts to 25 Nm (18 lbf.ft).
3. Remove caps from compressor and pipe connections.
4. Clean compressor and pipe connections.
5. Lubricate new 'O'rings with refrigerant oil and fit to compressor.
6. Position A/C pipes to compressor and tighten bolts to 10 Nm (7 lbf.ft) .
7. Connect multiplug to compressor.
8. Position top hose and secure with clips.
9. Refill cooling system.
   COOLING SYSTEM - Td5, ADJUSTMENTS, Drain and refill.
10. Fit auxiliary drive belt.
    CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.
11. Recharge air conditioning system.
    AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.
12. Fit engine acoustic cover.

Compressor - V8

82.10.20

Remove

1. Depressurise air conditioning system.
   AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.
2. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



M82 0488

3. Disconnect multiplug from compressor.
4. Remove 2 bolts securing air conditioning pipes to compressor and discard 'O' rings.

   CAUTION: Always fit plugs to open connections to prevent contamination.

5. Remove 4 bolts securing compressor to mounting bracket.
6. Remove compressor.

Refit

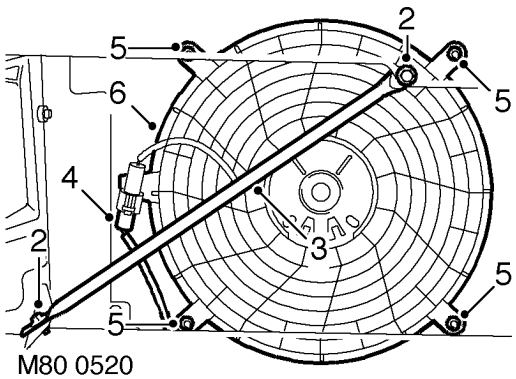
1. Calculate the quantity of refrigerant oil required.
   GENERAL INFORMATION, Air Conditioning Compressor Replacement.
2. Clean compressor dowels and dowel holes.
3. Position compressor to mounting bracket and tighten bolts to 25 Nm (18 lbf.ft).
4. Remove caps from compressor and pipe connections.
5. Clean compressor and pipe connections.
6. Lubricate new 'O' rings with refrigerant oil and fit to compressor.
7. Position A/C pipes to compressor and tighten bolts to 10 Nm (7 lbf.ft).
8. Connect multiplug to compressor.
9. Fit auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.
10. Recharge air conditioning system.
    AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.

Fan - condenser

82.15.01

Remove

1. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



M80 0520

2. Remove 2 bolts securing bonnet platform RH support stay.
3. Remove support stay.
4. Disconnect multiplug from condenser cooling fan motor.
5. Remove 4 screws securing cooling fan cowl to mounting bracket.
6. Remove cooling fan assembly and collect spacing washers.

Refit

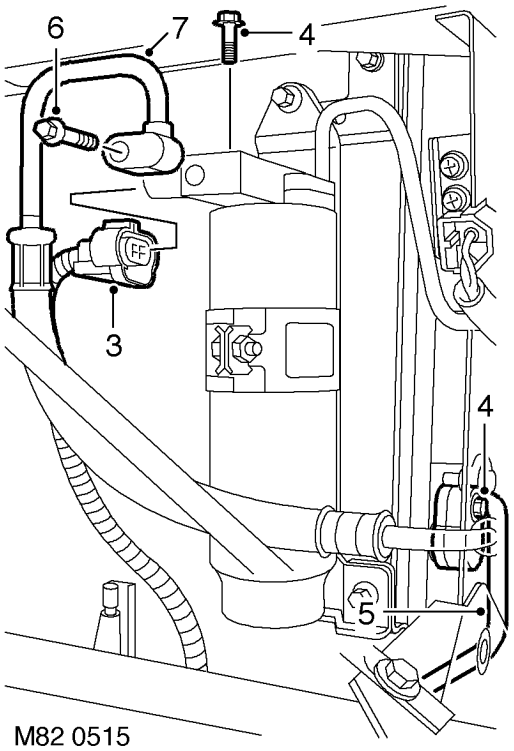
1. Fit condenser fan.
2. Fit spacing washers between fan cowl and mounting bracket and secure with screws.
3. Connect multiplug to motor.
4. Fit bonnet platform support stay and secure with bolts.
5. Fit front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.

Condenser

82.15.07

Remove

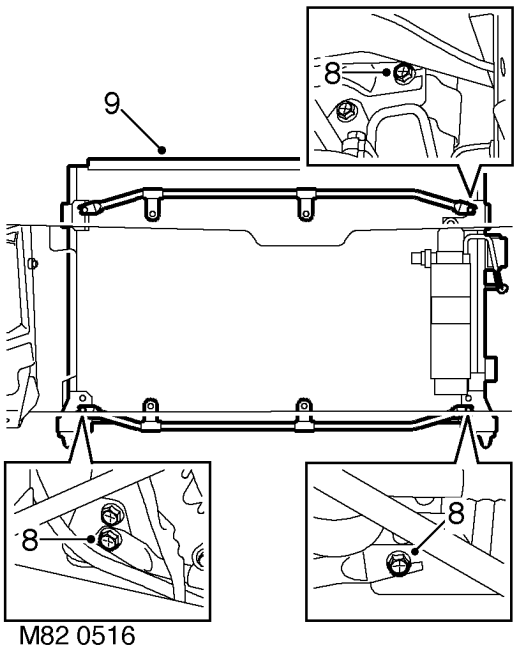
1. Recover refrigerant from A/C system.
   AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.
2. Remove radiator.
   - **COOLING SYSTEM - Td5, REPAIRS, Radiator.**
   - **COOLING SYSTEM - V8, REPAIRS, Radiator.**



M82 0515

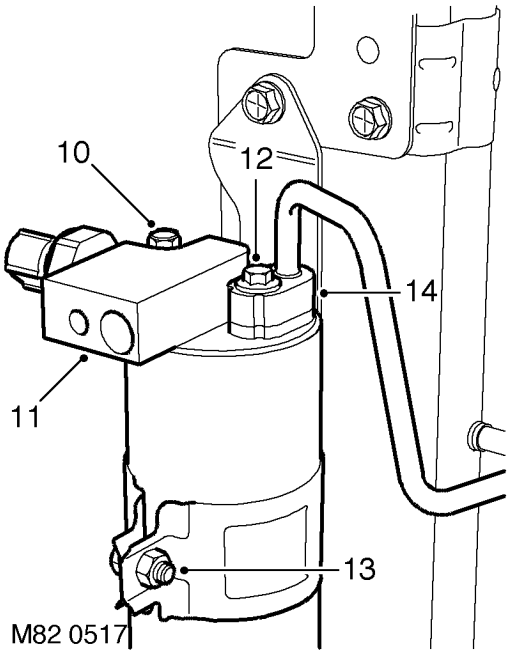
3. Disconnect multiplug from dual pressure switch.
4. Remove bolt securing evaporator pipe to condenser.
5. Disconnect evaporator pipe from condenser and discard 'O' ring.
6. Remove bolt securing evaporator pipe to receiver drier.
7. Disconnect evaporator pipe from receiver drier and discard 'O' ring.

CAUTION: Always fit plugs to open connections to prevent contamination.



M82 0516

8. Remove 3 remaining bolts securing cooling fan support rails to condenser.
9. Remove condenser.



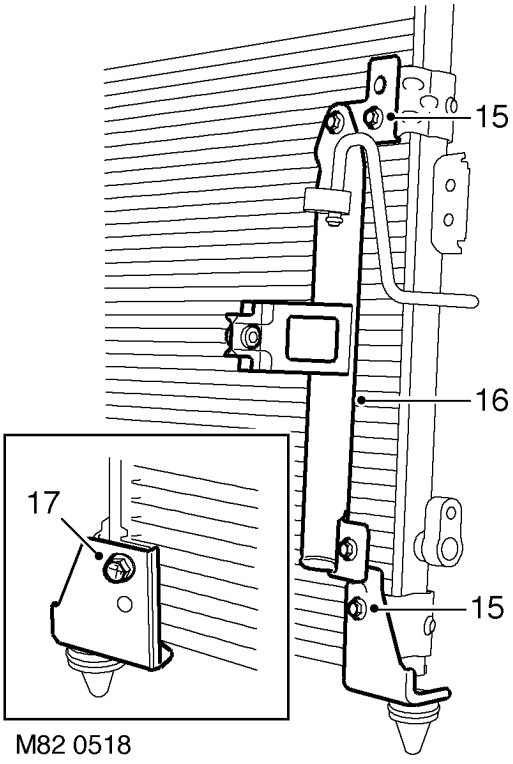
M82 0517

10. Remove bolt securing adaptor block to receiver drier.
11. Remove adaptor block from receiver drier and discard 'O' ring.

CAUTION: Always fit plugs to open connections to prevent contamination.

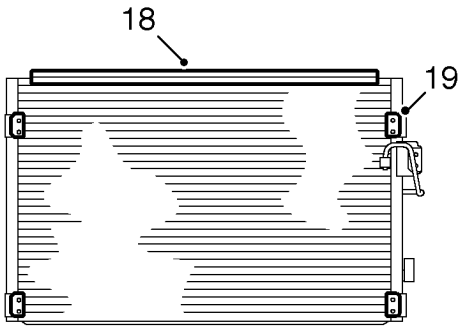
12. Remove bolt securing condenser pipe to receiver drier.
13. Remove clamp bolt receiver drier to bracket and remove drier from bracket.
14. Remove and discard 'O' ring from condenser pipe.

CAUTION: Always fit plugs to open connections to prevent contamination.



M82 0518

15. Remove 2 remaining bolts securing receiver drier brackets and condenser LH mounting bracket to condenser.
16. Remove mounting bracket assembly.
17. Remove remaining bolt securing condenser RH mounting and remove mounting.



M82 0519

18. Remove sealing strip from outer upper seam of condenser.
19. Remove captive nut plates from condenser.

Refit

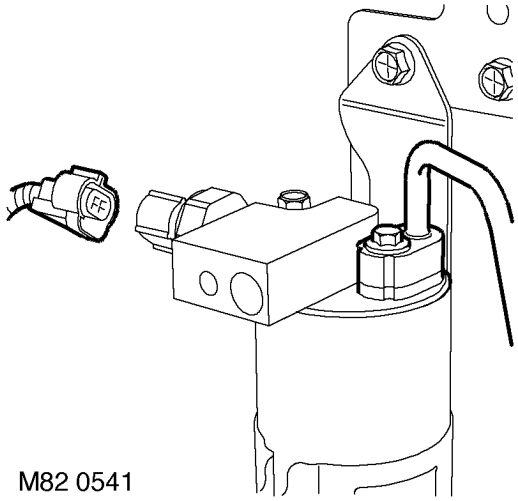
1. Fit captive nut plates to new condenser.
2. Fit seal to condenser.
3. Fit RH mounting bracket to condenser and secure with bolt.
4. Fit receiver drier bracket assembly and secure with bolts.
5. Ensure condenser pipe and new receiver drier connections are clean.
6. Lubricate new 'O' ring with refrigerant oil and fit to condenser pipe.
7. Fit receiver drier to bracket and condenser pipe. Tighten bolt securing condenser pipe to 5 Nm (3.7 lbf.ft). Fit clamping bolt securing receiver drier to bracket and tighten to 5 Nm (3.7 lbf.ft).
8. Ensure adaptor block and receiver drier connections are clean.
9. Lubricate new 'O' ring with refrigerant oil and fit to adaptor block.
10. Fit adaptor block to receiver drier and tighten bolt to 5 Nm. (3.7 lbf.ft).
11. Fit condenser assembly.
12. Fit cooling fan to condenser and fit bolts to secure support rails to condenser brackets.
13. Ensure connections of condenser, receiver drier and evaporator pipes are clean.
14. Lubricate new 'O' ring seals with refrigerant oil and fit one seal to each evaporator pipe.
15. Connect evaporator pipes and tighten bolts to 5 Nm (3.7 lbf.ft).
16. Connect multiplug to dual pressure switch.
17. Fit radiator.
    - ☞ **COOLING SYSTEM - Td5, REPAIRS, Radiator.**
    - ☞ **COOLING SYSTEM - V8, REPAIRS, Radiator.**
18. Recharge A/C system.
    ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

Receiver drier and dual pressure switch

82.17.03

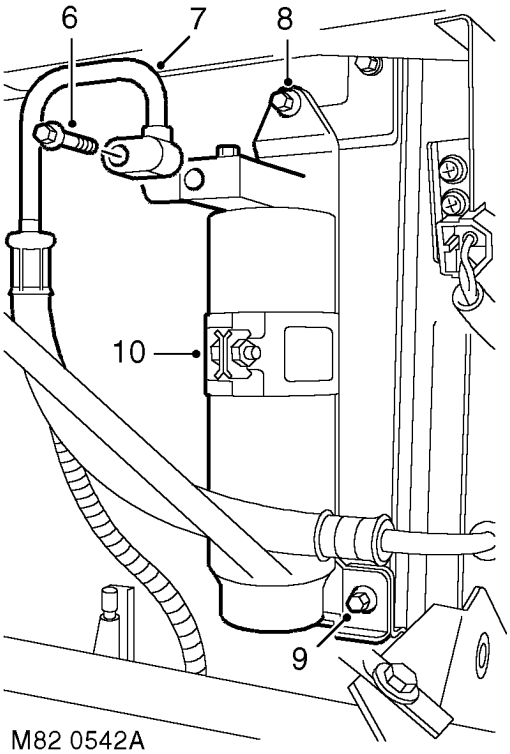
Remove

1. Recover refrigerant from air conditioning system.
   AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.
2. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



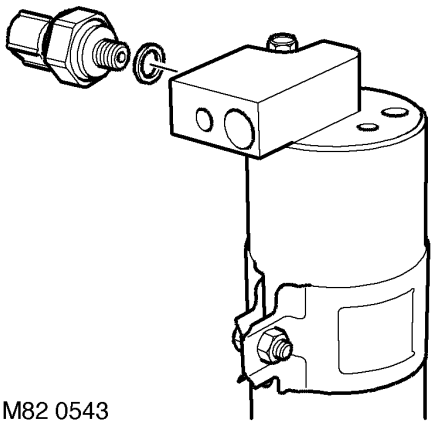
M82 0541

3. Disconnect multiplug from dual pressure switch.
4. Remove bolt securing condenser pipe to receiver drier.
5. Disconnect condenser pipe from receiver drier.
   CAUTION: Always fit plugs to open connections to prevent contamination.



M82 0542A

6. Remove bolt securing evaporator pipe to receiver drier.
7. Disconnect evaporator pipe from receiver drier.
   CAUTION: Always fit plugs to open connections to prevent contamination.
8. Remove bolt securing top of receiver drier mounting bracket to condenser.
9. Remove bolt securing bottom of receiver drier mounting bracket to condenser.
10. Remove receiver drier assembly.



M82 0543

11. Loosen mounting bracket clamping bolt.

12. Remove receiver drier from mounting bracket.
13. Remove dual pressure switch from receiver drier

Refit

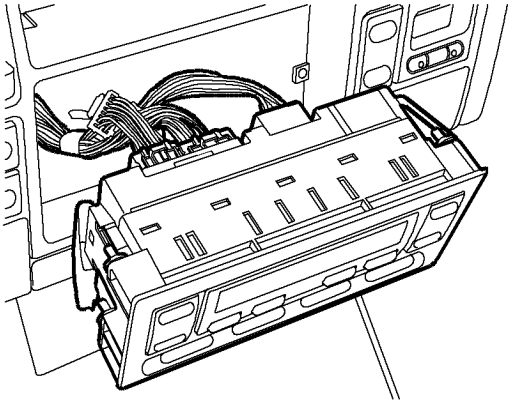
1. Fit dual pressure switch to receiver drier and tighten to 10 Nm (7 lbf.ft).
2. Fit receiver drier to mounting bracket and tighten clamping bolt.
3. Fit receiver drier assembly to condenser.
4. Fit bolts securing receiver drier mounting bracket to condenser and tighten to 5 Nm (3.7 lbf.ft).
5. Remove caps from air conditioning pipes and receiver drier.
6. Remove old 'O' rings from pipes.
7. Fit new 'O' rings to pipes and lubricate with refrigerant oil.
8. Connect air conditioning pipes to receiver drier.
9. Fit bolts securing air conditioning pipes to receiver drier and tighten to 5 Nm (3.7 lbf.ft).
10. Connect multiplug to dual pressure switch.
11. Fit front grille.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**
12. Recharge air conditioning system.
    ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

ECU - air temperature control

⊸ ***82.20.90***

Remove

1. Release radio from fascia.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.**



M82 0538

2. Working through radio aperture, release control unit from fascia.
3. Disconnect 3 multiplugs and remove control unit.
4. Collect bushes from control unit location pegs.

Refit

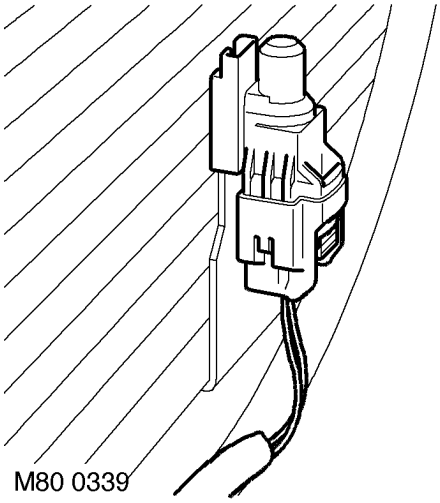
1. Fit bushes to new control unit.
2. Position control unit and connect multiplugs.
3. Fit control unit to fascia.
4. Fit radio to fascia.
   ☞ **IN CAR ENTERTAINMENT, REPAIRS, Radio cassette player.**

Sensor - ambient air temperature

82.20.91

Remove

1. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



2. Release ambient air temperature sensor from support bracket, disconnect multiplug and remove sensor.

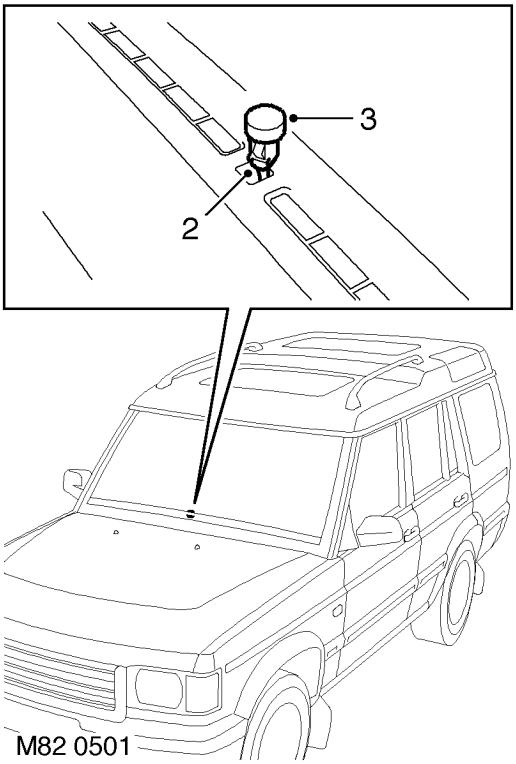
Refit

1. Position sensor, connect multiplug and secure sensor to support bracket
2. Fit front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.

Sensor - solar light

82.20.92

Remove



1. Carefully remove solar light sensor from fascia.
2. Disconnect multiplug from solar light sensor.
3. Remove solar light sensor.

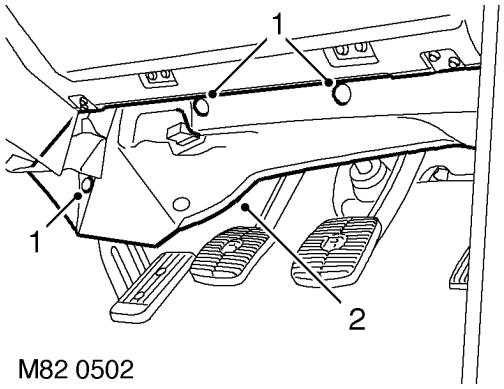
Refit

1. Connect multiplug to solar light sensor.
2. Position solar light sensor to fascia and push to secure.

Sensor - air temperature

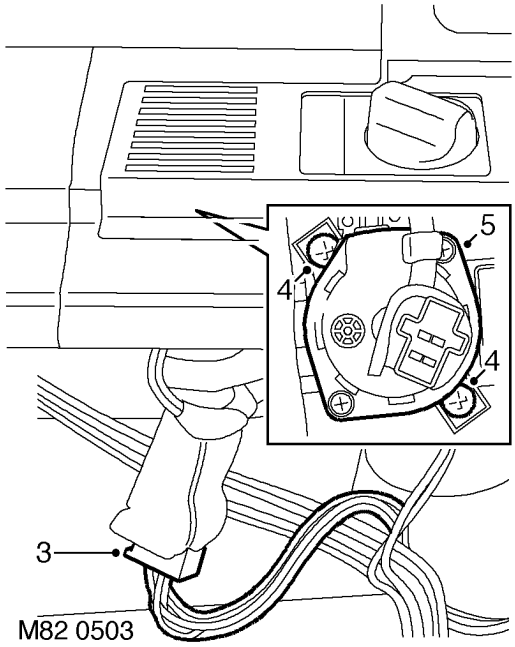
82.20.93

Remove



M82 0502

1. Release 2 quarter turn screws to release fascia access panel.
2. Lower fascia access panel.



M82 0503

3. Disconnect multiplug from air temperature sensor.
4. Remove 2 screws securing air temperature sensor to fascia.
5. Remove air temperature sensor from fascia.

Refit

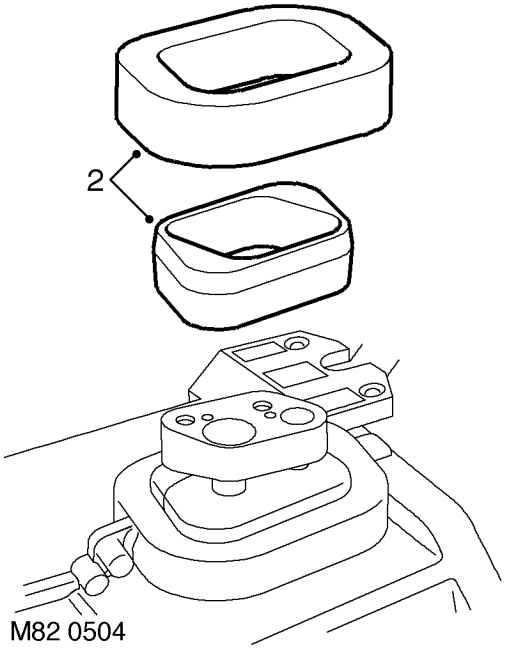
1. Position air temperature sensor to fascia and secure with screws.
2. Connect multiplug to air temperature
3. Position and secure fascia access panel with quarter turn screws.

Evaporator, evaporator thermistor and thermal expansion valve (TXV)

82.25.20

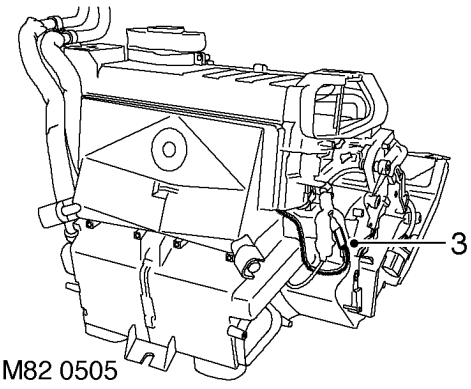
Remove

1. Remove heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.



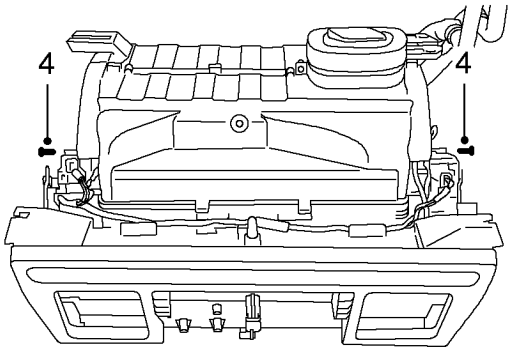
M82 0504

2. Remove bulkhead and evaporator pipe seals.



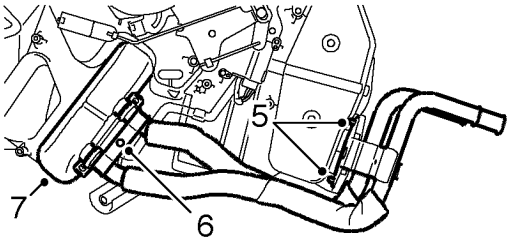
M82 0505

3. Disconnect multiplug from evaporator thermistor.



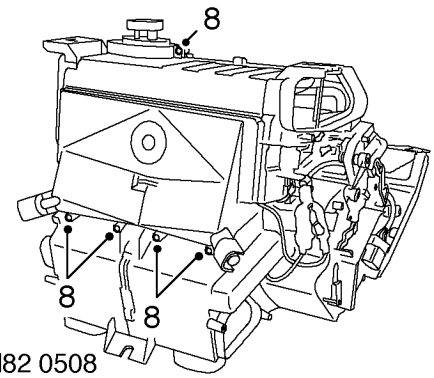
M82 0506

4. Remove 2 screws securing temperature control servos to evaporator casing.



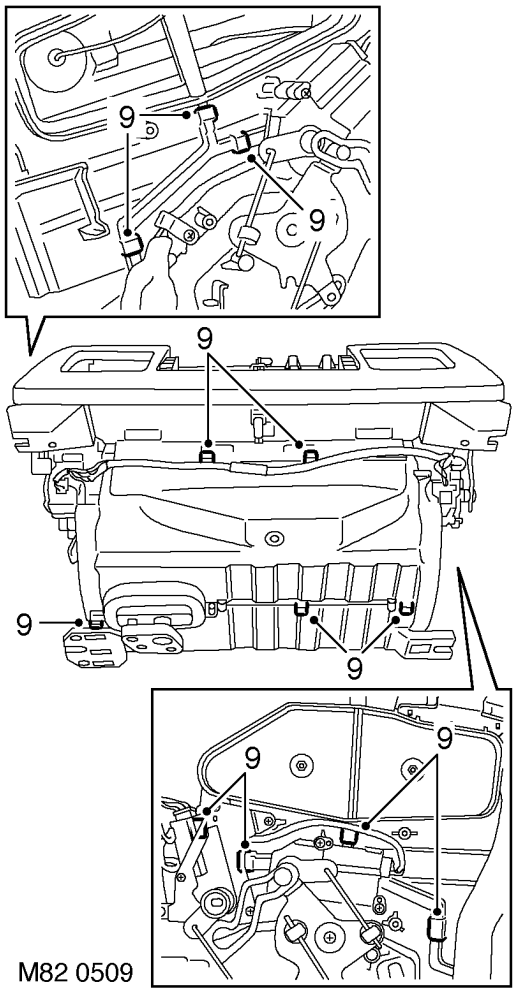
M82 0507

5. Remove 2 screws securing coolant pipe support bracket to casing.
6. Remove screws securing coolant pipe saddle clamp to casing and remove saddle.
7. Remove heater matrix.



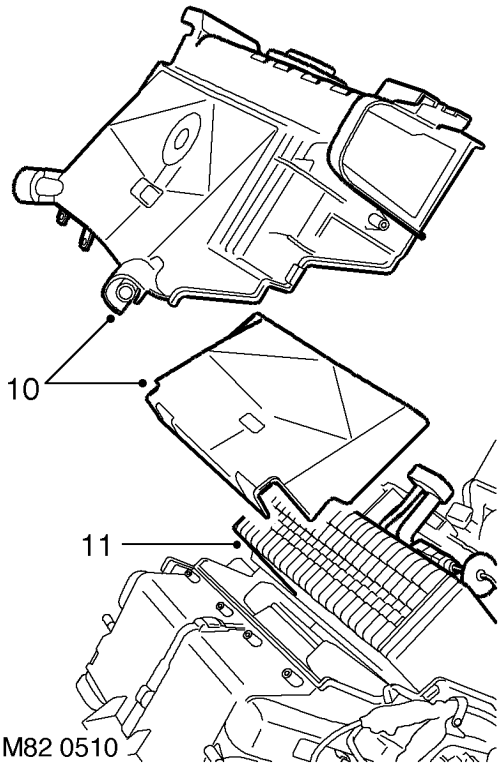
M82 0508

8. Remove 5 screws securing casings.



M82 0509

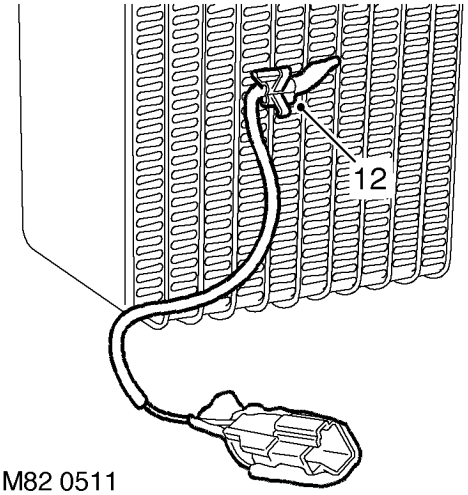
9. Remove 12 spring clips securing casings.



M82 0510

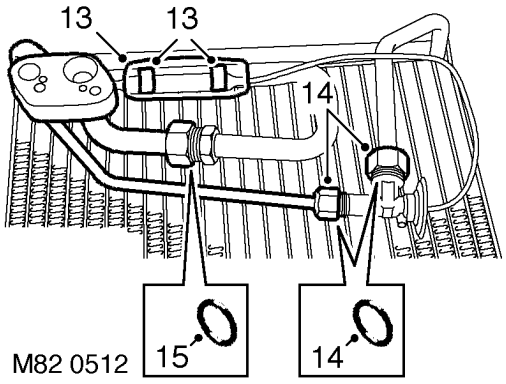
10. Remove evaporator casing and collect insulation.

11. Remove evaporator assembly.



M82 0511

12. Remove evaporator thermistor.



13. Remove covering from TX valve, release 2 clips securing TX valve to pipe.
14. Release 2 unions securing TX valve, remove TX valve, remove and discard 'O' rings.
15. Release pipe union, remove pipe and discard 'O' ring.

Refit

1. Using a new 'O' ring, position pipe to evaporator and tighten union.
2. Using new 'O' rings, position TX valve. Connect pressure pipe union and tighten to 22 Nm (16 lbf. ft). Connect evaporator pipe and tighten to 32 Nm (24 lbf.ft).
3. Position TX valve sensor to pipe and secure with clips.
4. Fit sensor covering.
5. Fit evaporator thermistor.
6. Fit evaporator assembly.
7. Fit insulation to evaporator casing and fit casing.
8. Secure spring clips.
9. Fit and tighten casing screws.
10. Fit heater matrix, ensuring matrix temperature is correctly positioned.
11. Fit coolant pipe saddle, fit and tighten screws securing saddle and pipe bracket.
12. Fit and tighten temperature servo screws.
13. Connect multiplug to evaporator thermistor.
14. Clean any bulk head seal from casing.
15. Fit bulkhead and evaporator pipe seals.
16. Fit heater assembly.

☞ **HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.**

Expansion valve - (TXV) - rear

82.26.01

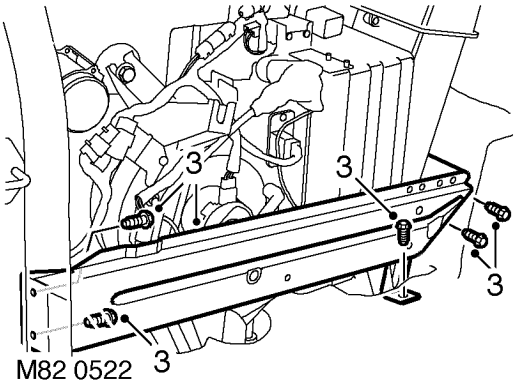
Remove

1. Depressurise air conditioning system.

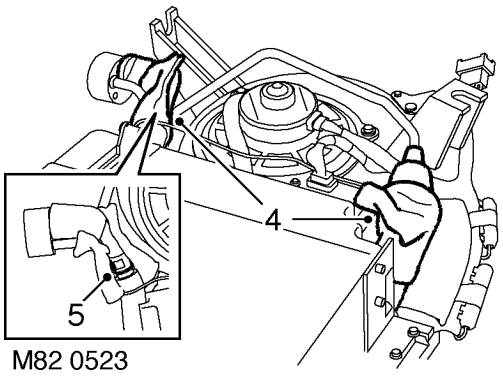
☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

2. Remove rear lower trim casing.

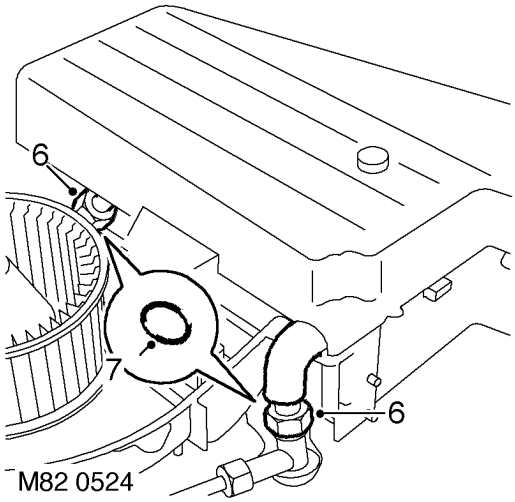
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**



3. Remove 5 bolts securing seat support bracket and remove bracket.



4. Release insulation from TXV pipe unions and sensor.
5. Remove clip securing sensor to pipe and release sensor.



6. Loosen TXV pipe unions, release pipes and remove TXV.
7. Remove and discard 'O' rings.

Refit

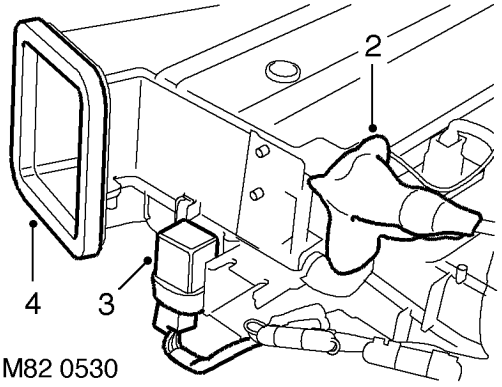
1. Lubricate new 'O' rings with clean refrigerant oil and fit to TXV pipes.
2. Position TXV, align pipes and tighten unions.
3. Connect sensor and secure with clip.
4. Fit insulation to TXV valve and sensor.
5. Position seat support bracket, fit bolts and tighten to 24 Nm (18 lbf.ft)
6. Repressurise air conditioning system.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
7. Fit rear lower trim casing .
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**

Evaporator - rear

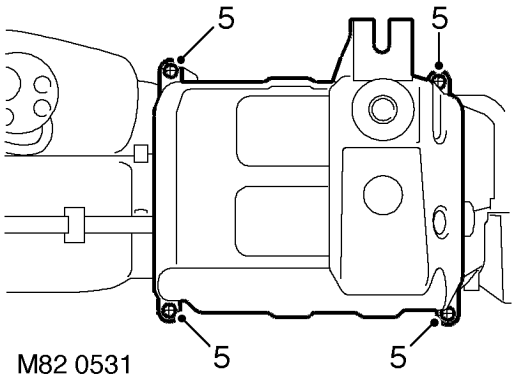
⊸ ***82.26.20***

Remove

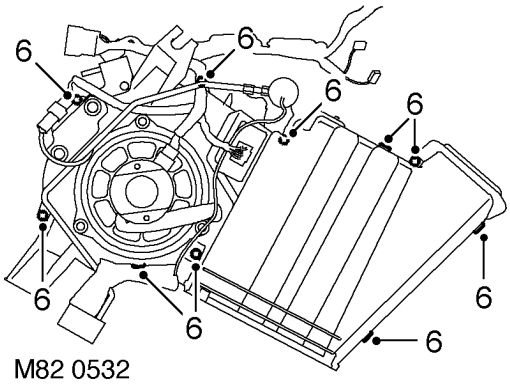
1. Remove evaporator assembly.
   ☞ **AIR CONDITIONING, REPAIRS, Evaporator and motor assembly - rear.**



2. Remove insulation from TXV.
3. Release relay from support bracket.
4. Remove ducting seal.

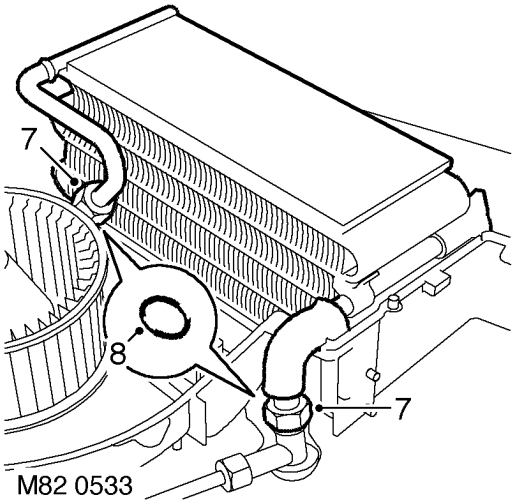


5. Remove 4 screws securing lower part of casing, release and remove lower casing.



M82 0532

6. Remove 6 screws and 4 clips securing main casing and remove top half of casing.



M82 0533

7. Loosen and release evaporator pipes unions, release pipes and remove evaporator.
8. Remove and discard evaporator pipe 'O' rings.

Refit

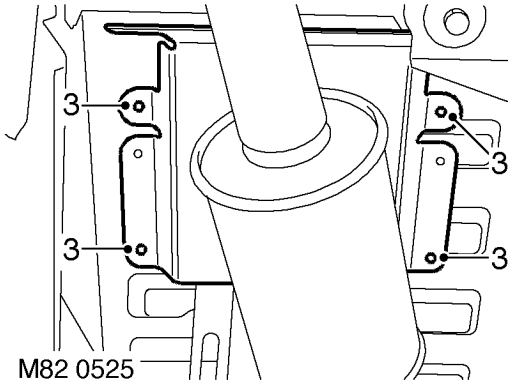
1. Lubricate new 'O' rings with clean refrigerant oil and fit to evaporator pipes
2. Position evaporator, connect pipes and tighten unions.
3. Position main casing and secure with clips and screws.
4. Position lower part of casing and secure with screws.
5. Fit ducting seal
6. Secure relay to support bracket.
7. Fit insulation to TXV.
8. Fit evaporator assembly.
   ☞ **AIR CONDITIONING, REPAIRS, Evaporator and motor assembly - rear.**

Evaporator and motor assembly - rear

🔧 ***82.26.21***

Remove

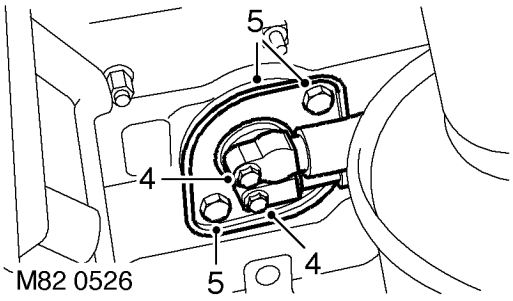
1. Depressurise air conditioning system.
   ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**
2. **V8 models:** Remove 4 clips securing rear exhaust heat shield and remove heat shield.



M82 0525

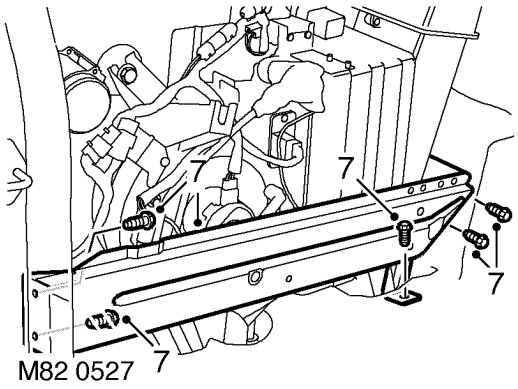
3. Remove 2 bolts securing high and low pressure pipes, release pipes and discard 'O' rings.

CAUTION: Always fit plugs to open connections to prevent contamination.



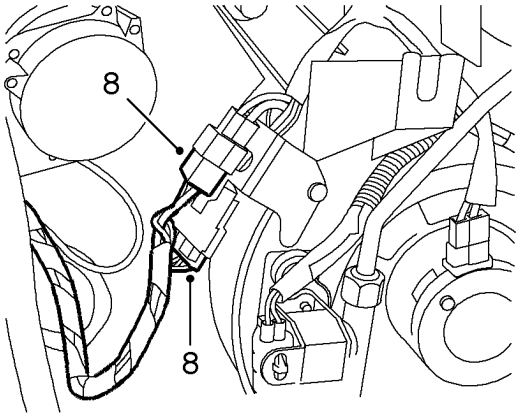
M82 0526

4. Remove 2 bolts securing grommet flange to body and remove flange.
5. Remove LH rear lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
6. Remove 5 bolts securing seat support bracket and remove bracket.



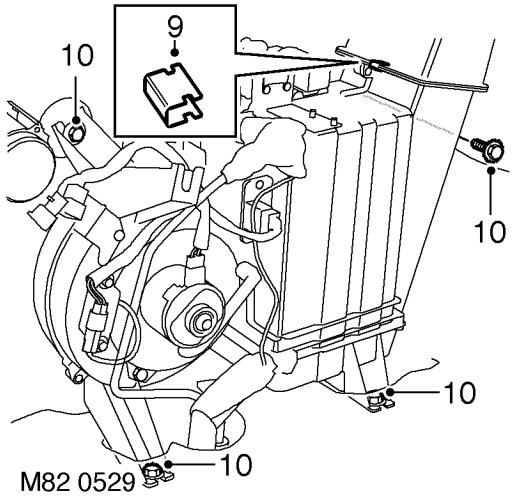
M82 0527

7. Disconnect A/C harness multiplugs from body harness.



M82 0528

8. Remove 2 clips securing ducting to A/C assembly and release ducting.



M82 0529

9. Remove 4 bolts securing evaporator assembly and remove assembly.

Refit

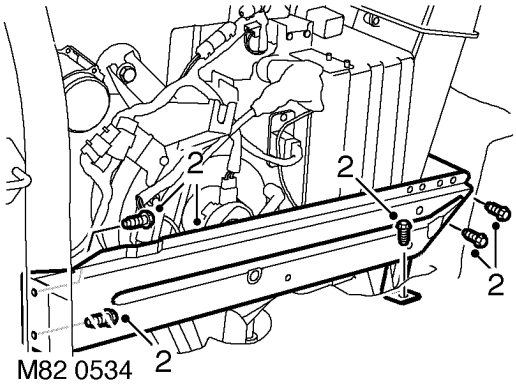
1. Position evaporator assembly to body fit bolts and tighten to 16 Nm (12 lbf.ft).
2. Position ducting to evaporator assembly and secure with clips.
3. Connect harness multiplugs.
4. Position seat support bracket, fit bolts and tighten to 24 Nm (18 lbf.ft).
5. Fit LH rear lower trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
6. Position grommet flange and tighten bolts.
7. Lubricate new 'O' rings with clean refrigerant oil and fit to high and low pressure pipes.
8. Position high and low pressure pipes, fit bolts and tighten to 10 Nm (7 lbf.ft).
9. **V8 models:** Position exhaust heat shield and secure with clips.
10. Repressurise air conditioning system.
    ☞ **AIR CONDITIONING, REFRIGERANT RECOVERY, RECYCLING AND RECHARGING, Refrigerant recovery, recycling and recharging.**

Blower motor assembly - rear

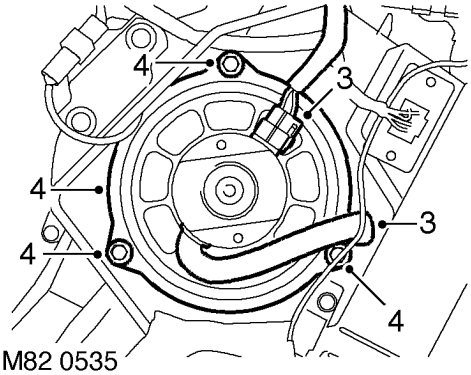
82.26.33

Remove

1. Remove rear lower trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.



2. Remove 5 bolts securing third row seat support bracket and remove bracket.



3. Disconnect blower motor multiplug and release hose from casing.
4. Remove screws securing blower motor and remove motor from casing.

Refit

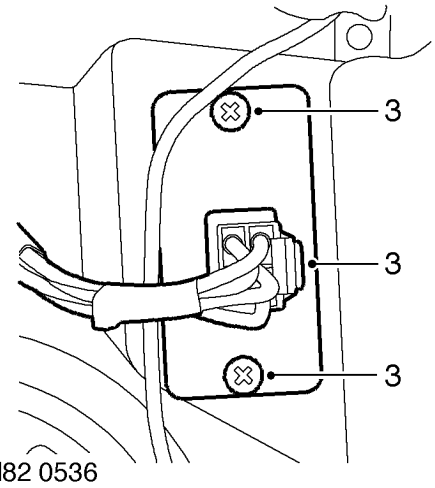
1. Position motor, align to casing and secure with screws.
2. Connect motor multiplug and secure hose to casing.
3. Position seat support bracket, fit bolts and tighten to 24 Nm (18 lbf.ft)
4. Fit rear lower trim casing .
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.

Resistor - blower motor

82.26.48

Remove

1. Remove rear lower trim casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.
2. Disconnect resistor multiplug.



3. Remove 2 screws securing resistor pack to casing. Remove resistor from casing.

Refit

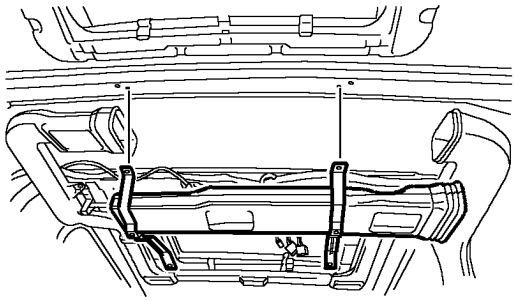
1. Position resistor and secure with screws.
2. Connect resistor multiplug.
3. Fit rear lower trim casing .
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.

Duct - centre - rear

82.26.70

Remove

1. Remove headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.



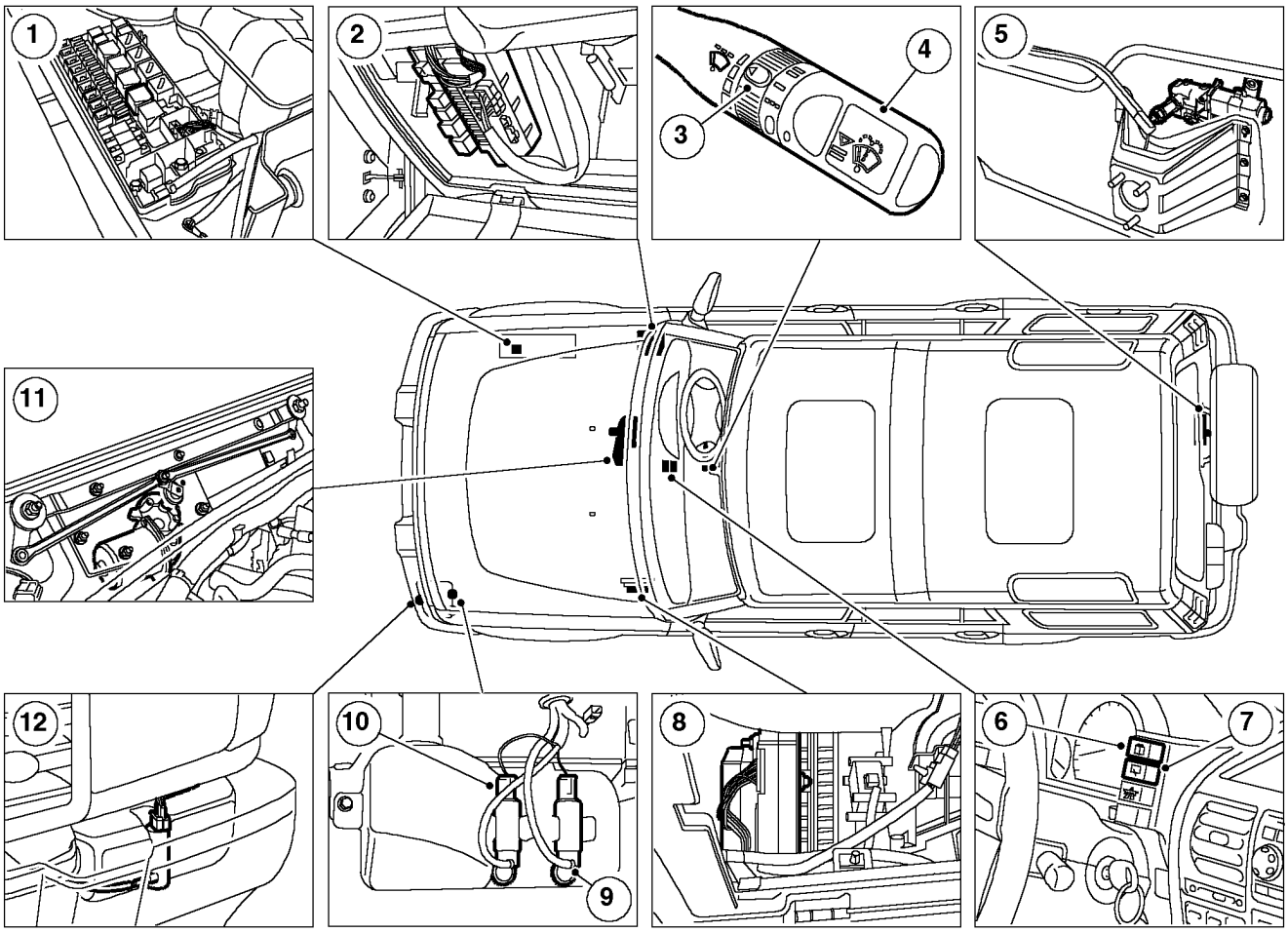
M82 0489

2. Drill out 4 rivets securing centre duct to roof.
3. Release centre duct from upper side duct and remove.
4. Drill out 2 rivets securing mounting braces to duct.
5. Remove braces.

Refit

1. Position braces to duct and secure with rivets.
2. Fit centre duct between upper side ducts.
3. Fit rivets securing centre duct to roof.
4. Fit headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.

Wipers and washers component layout

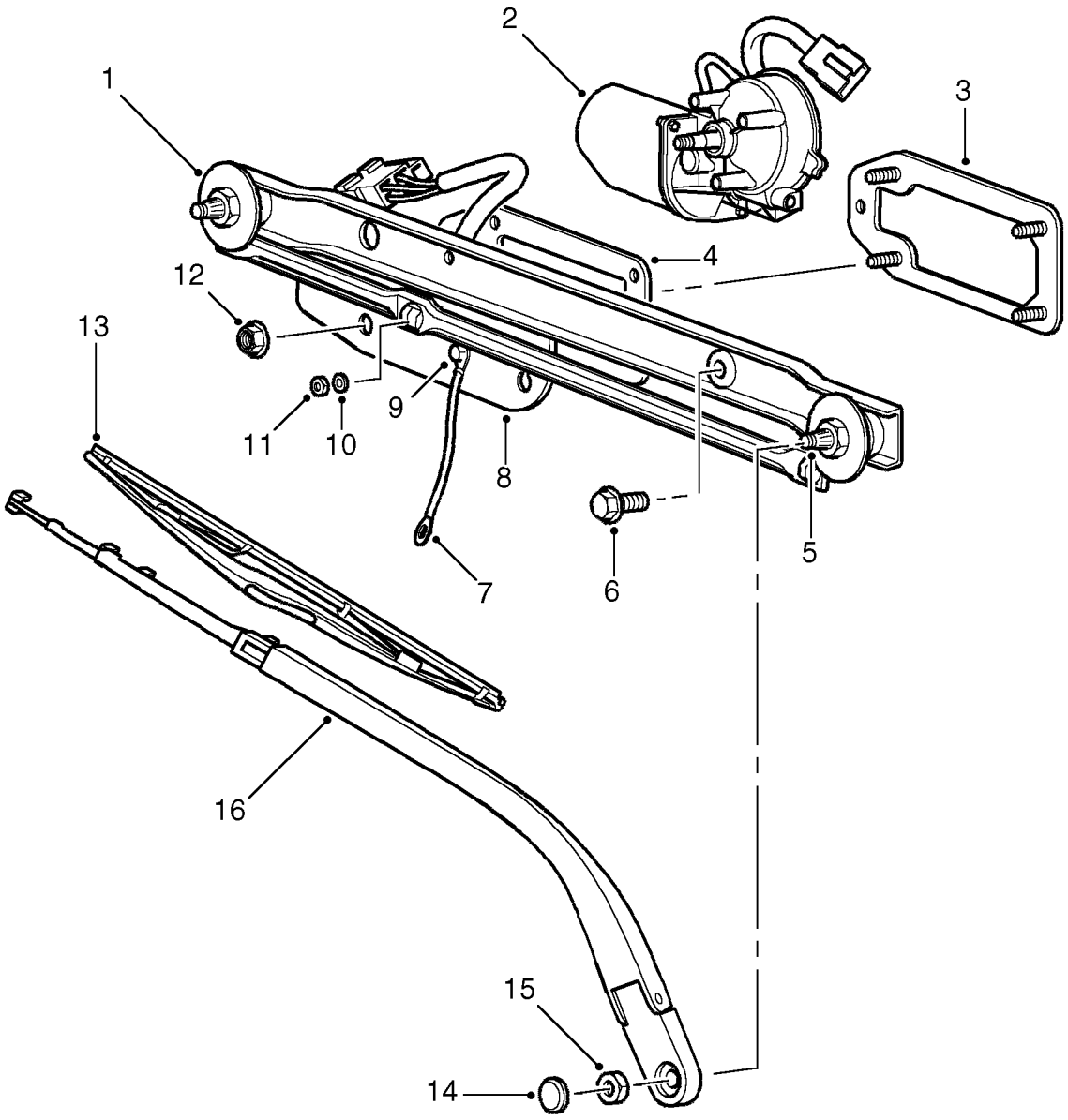


M840292

RHD shown, LHD similar

1 Headlamp power wash relay
2 Passenger compartment fuse box (rear wiper relay, front wiper relay and IDM)
3 Variable Delay Switch
4 Front wash/ wipe switch
5 Rear wiper motor
6 Rear washer switch
7 Rear wiper switch
8 Body Control Unit (BCU)
9 Front washer pump
10 Rear washer pump
11 Front wiper motor assembly
12 Headlamp power wash pump

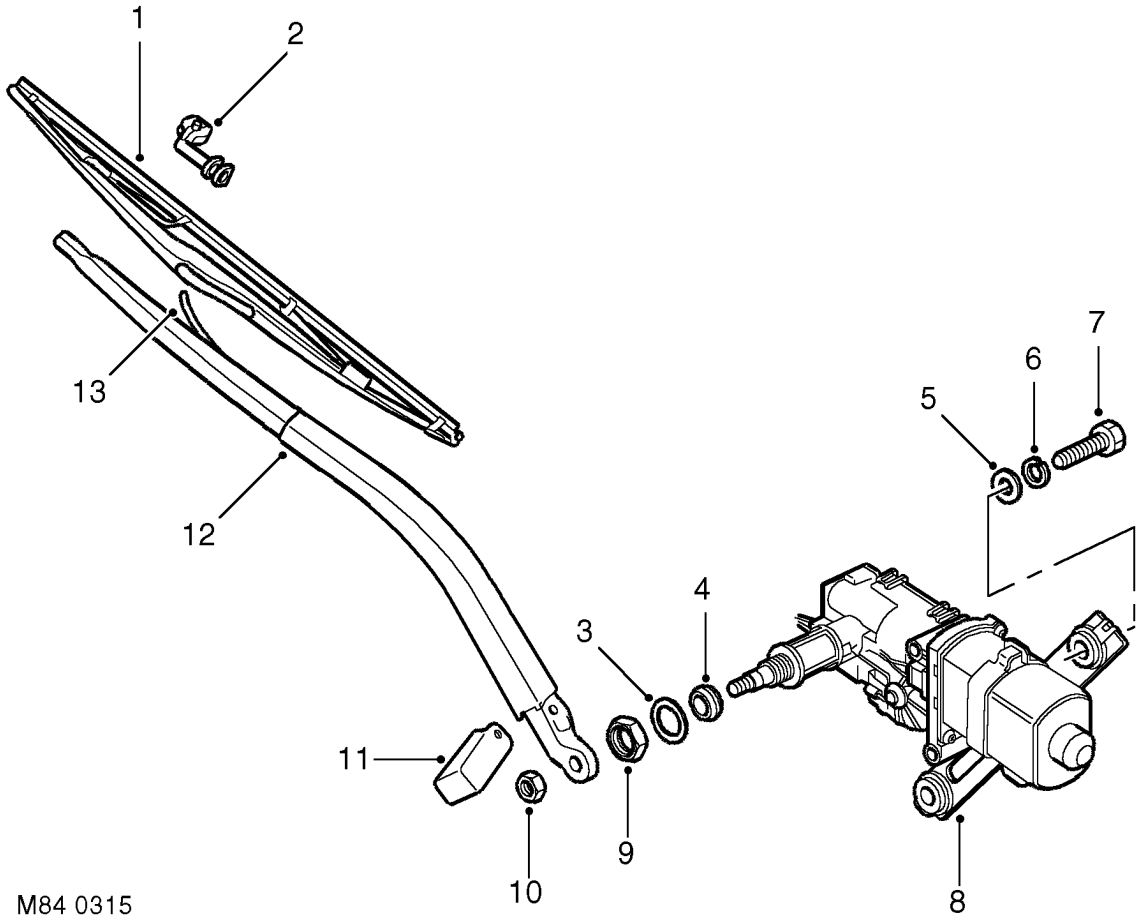
Front wiper components



M84 0314

1 Linkage assembly
2 Wiper motor
3 Stud plate
4 Gasket
5 Wheel box 2 off
6 Bolt 2 off
7 Earth strap
8 Cover plate
9 Bolt 3 off
10 Lock washer
11 Nut
12 Flanged nut 5 off
13 Wiper blade 2 off
14 Cover
15 Nut
16 Wiper arm 2 off

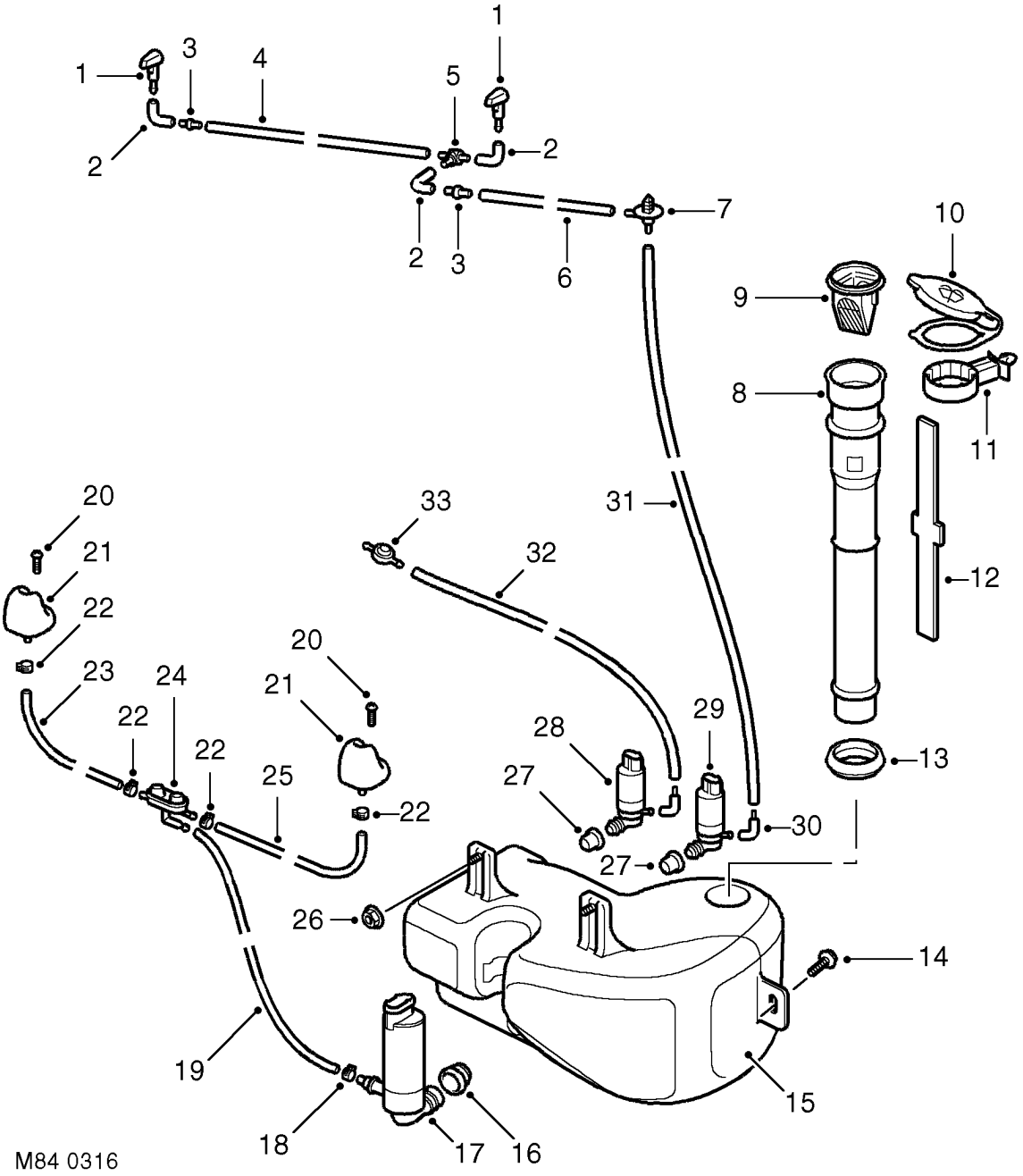
Rear wiper components



M84 0315

1 Wiper blade
2 Washer jet
3 Washer
4 Seal
5 Washer 2 off
6 Lock washer 2 off
7 Bolt 2 off
8 Wiper motor
9 Nut
10 Nut
11 Cover
12 Wiper arm
13 Washer tube

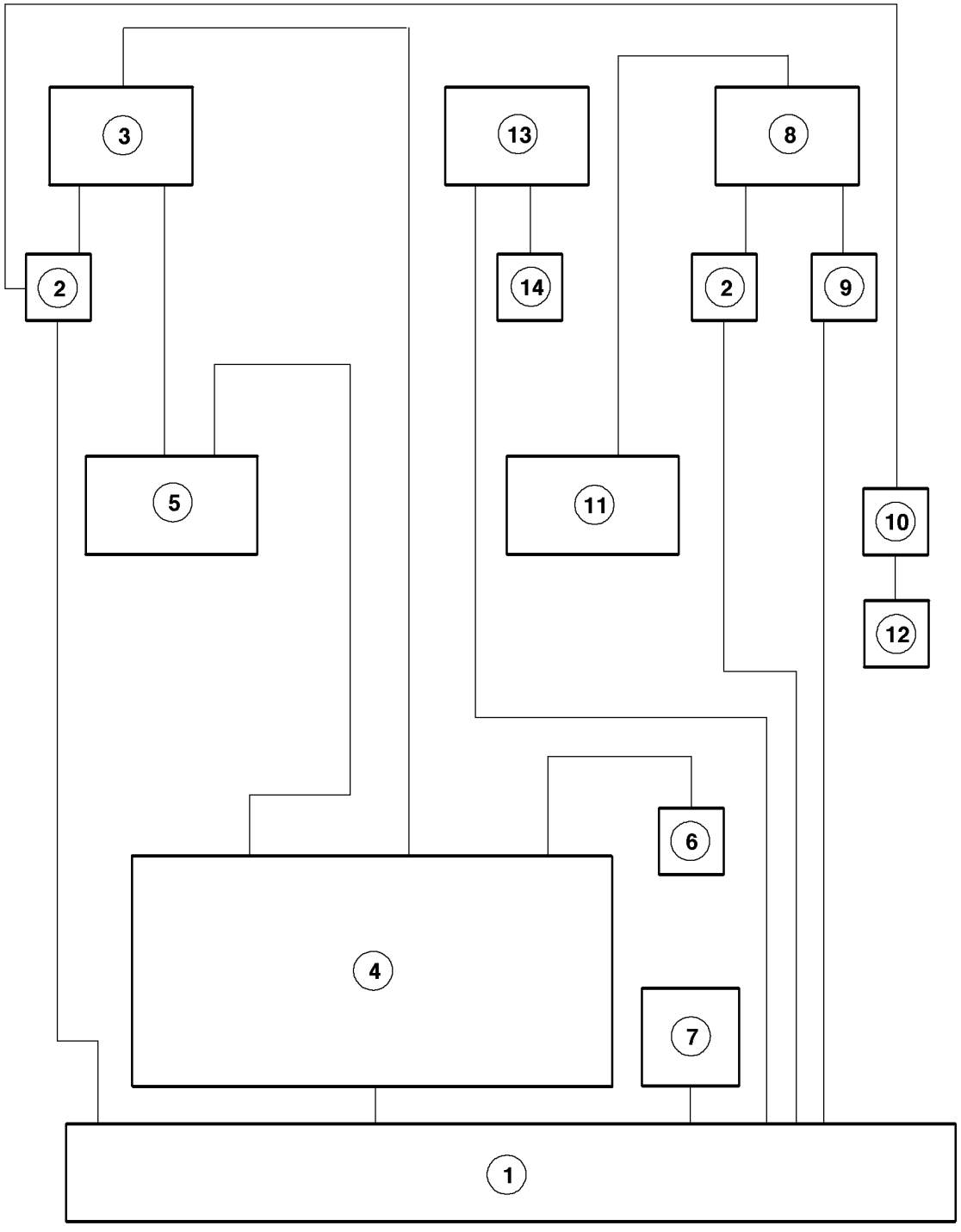
Washer components



Reservoir with headlamp power wash shown

1 Windscreen washer jet 2 off
2 Elbow 3 off
3 In-line non-return valve
4 Tube
5 'T' connector
6 Tube
7 Connector
8 Filler neck tube
9 Filter
10 Cap
11 Bracket
12 Level float
13 Filler neck seal
14 Bolt
15 Reservoir
16 Pump sealing grommet (if fitted)
17 Powerwash pump (if fitted)
18 Clip
19 Tube
20 Screw 2 off
21 Powerwash jet 2 off
22 Clip 4 off
23 Tube
24 'T' connector
25 Tube
26 Nut 2 off
27 Pump sealing grommet 2 off
28 Rear washer pump
29 Front windscreen washer pump
30 Elbow 2 off
31 Tube - front windscreen
32 Tube - rear tail door window
33 Non-return valve

Wipers and washers block diagram



M840313

1 BCU
2 IDM
3 Front wiper relay
4 Front wash / wipe switch
5 Front wiper motor assembly
6 Front washer pump motor
7 Variable delay switch
8 Rear wiper relay
9 Rear wiper switch
10 Rear washer switch
11 Rear wiper motor
12 Rear washer pump motor
13 Headlamp power wash relay
14 Headlamp power wash pump motor

Description

General

All markets have a common wiper system with headlamp powerwash as an option.

The wipers system comprises two front wipers and one rear wiper which are powered by electric motors. A washer reservoir is located in the front left hand wheel arch and is fitted with two electric pumps. Each pump supplies washer fluid to either the front or rear screens. On certain models, a third pump can be fitted to operate a headlamp power wash function. Operation of the front and rear wipers and washers is controlled by the driver using switches located on a steering column stalk and push button switches on the fascia.

Control of the wipers and washers is achieved by the following components:

- BCU.
- IDM.
- Front wiper relay.
- Front wash/ wipe switch.
- Variable delay switch.
- Front wiper motor assembly.
- Front washer pump motor.
- Rear wiper relay.
- Rear wiper switch.
- Rear washer switch.
- Rear wiper motor.
- Rear washer pump motor.

Both the Body Control Unit (BCU) and the Intelligent Driver Module (IDM) control the wiper system. The BCU controls the time delay function of the wiper system and is located below and behind the passenger glovebox. During engine cranking the BCU prevents wiper functions. Two relays are located in the passenger compartment fusebox. The relays control the delay operation of the front and rear wipers. The relays are an integral part of the fusebox and cannot be renewed separately.

Power for the wiper system is supplied by the IDM, which is integral with the passenger fusebox and cannot be renewed as a component. A serial communication link allows communication between the IDM and the BCU.

The system has diagnostic capabilities through TestBook.

Front wipers

The two front windscreen wipers are operated by a linkage assembly and an electric motor located under the plenum grill below the windscreen. The linkage and motor assembly is handed for left and right hand drive vehicles. The motor is an integral part of the linkage and cannot be replaced separately.

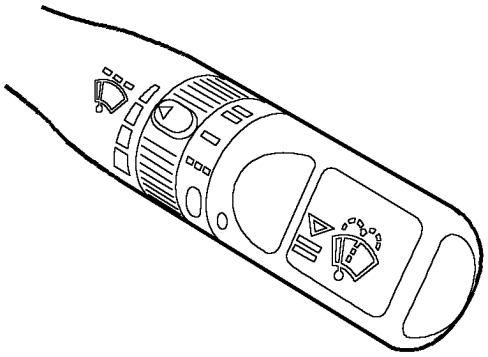
The linkage comprises a pressed steel mounting plate which provides for the attachment of a wheel box at each end. The mounting plate is secured to the bulkhead with flanged nuts which attach to a stud plate located behind the bulkhead. A link arm is attached to each wheel box by a short link and secured with circlips. The link arm has an attachment hole centrally located along its length for the electric motor drive link.

The electric motor is mounted in a recess in the bulkhead below a sealed cover plate. The drive spindle of the motor protrudes through the cover plate and is fitted with a link. The link is attached to a tapered spline on the motor spindle and is secured with a lock washer and nut. The opposite end of the link is attached to the central attachment point on the link arm and secured with a circlip.

Each wheel box has a taper splined shaft which allows for the attachment of the wiper arm which is secured with a washer and nut. The shaft of each wheel box is passed through a rubber sealed aperture in the plenum. The wiper arm attachment to the splined shaft has a pivot to which the remainder of the arm is attached. The two parts of the arm are connected by a spring which controls the pressure of the blade on the screen to a predetermined amount.

The wiper blades are attached to the wiper arms with a clips that allow the blade to pivot. Each wiper blade comprises a number of levers and yokes to which the rubber wiper is attached. The levers and yokes ensure that the pressure applied by the arm spring is distributed evenly along the full length of the blade. The rubber wiper is held in the yokes by a pair of stainless steel strips which also contribute to the even distribution of spring pressure along the blade. The driver's side wiper blade is fitted with an aerofoil which presses the blade onto the screen at high speed. This prevents the blade from lifting off the screen and maintains the wiping performance.

Front wash/ wipe switch



M840306

The front wash/ wipe switch is located on a stalk on the RH side of the steering column and allows the driver to control the operation of the front wipers and the front washer pump.

Operating the washer switch provides battery voltage from fuse 19 in the passenger compartment fusebox to the washer pump motor.

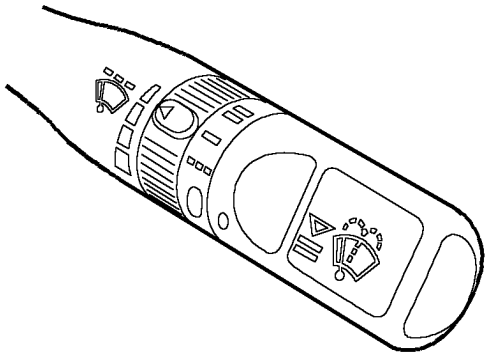
Operating the flick wipe function provides battery voltage from fuse 19 in the passenger compartment fuse box to the high-speed brushes of the wiper motor.

Operating the intermittent function provides a battery voltage signal to the BCU. The BCU determines the wipe interval from the variable delay switch and signals the IDM to activate the front wiper relay, which provides battery voltage to the wiper motor.

Operating the low-speed function provides battery voltage from fuse 19 in the passenger compartment fuse box to the low-speed brushes of the wiper motor.

Operating the high-speed function provides battery voltage from fuse 19 in the passenger compartment fuse box to the high-speed brushes of the wiper motor

Variable delay switch



M840306

A rotary type variable delay switch, integral with the front wash/ wipe switch, controls the interval between windscreen wipes for intermittent wipe variable delay operation.

The variable delay switch is integral with the front wash/ wipe switch.

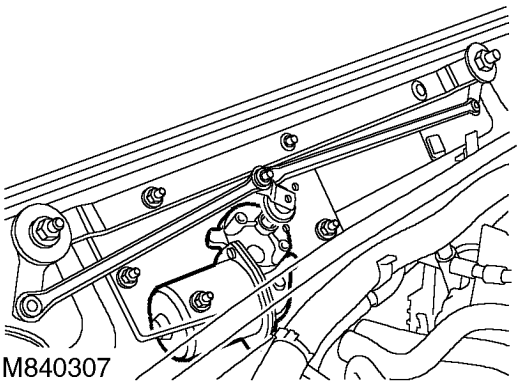
The input from the front variable delay switch to the BCU ranges from battery voltage to zero Volts.

The resistance values and associated time intervals of the variable delay switch are shown in the following table:

Resistance, ohms	Time interval, seconds	
	Front	Rear
0	3.5	6.5
1500	5.5	10.5
3000	7.5	14.5
4500	9.5	18.5
6000	11.5	22.5

TestBook has the ability to monitor the timer function within the BCU from which it can determine the position of the variable delay switch.

Front wiper motor assembly



M840307

The front wiper motor assembly is located on the bulkhead beneath the plenum.

The dc motor contains two permanent magnets, three brushes and a park switch. The smaller third brush is utilised for high-speed operation. Attached to the brush pack are 3 capacitors, which minimise radio interference during wiper operation. A thermal trip switch attached to the brush plate prevents thermal overload of the motor.

The motor incorporates a worm drive gear unit to transfer the rotary motion into a linear motion of the wiper linkage assembly.

The front wiper motor receives battery voltage from fuse 19 of the passenger compartment fuse box. For low-speed operation, including intermittent variable delay operation, the battery voltage to move the wiper motor from the park position passes through the front wiper relay. When the park switch moves to the closed when operating position, fuse 19 of the passenger compartment fuse box provides battery voltage directly to the wiper motor.

For high-speed operation, including flick wipe, fuse 19 in the passenger compartment fuse box provides the battery voltage to move the wiper motor from the park position through the front wash/ wipe switch to the front wiper motor. To achieve high-speed wiper operation, power is supplied to a third brush that provides a closer distance between the motor poles. Because the poles of the motor are closer together, the motor operates faster.

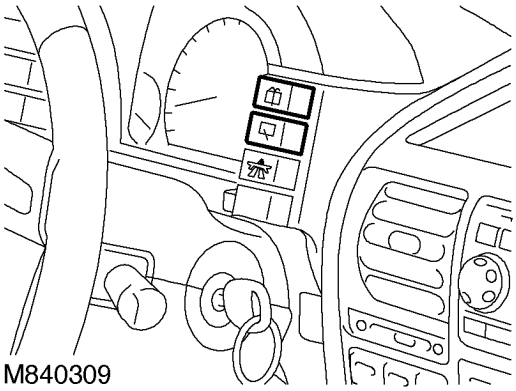
Rear wiper

The rear wiper is driven directly from an electric motor located inside the tail door. The motor is mounted inside the tail door with two bolts, lock washers and washers. The motor mounting brackets have rubber inserts to prevent motor operating noise being transferred to the door structure. The motor spindle is fitted with a seal and protrudes through a hole in the tail door outer skin panel. The motor spindle is secured to the tail door with a washer and nut.

The motor output spindle has a taper splined shaft which allows for the attachment of the wiper arm which is secured with a nut. The wiper arm attachment to the splined shaft has a pivot to which the remainder of the arm is attached. The two parts of the arm are connected by a spring which controls the pressure of the blade on the window to a predetermined amount.

The wiper blade is attached to the wiper arms with a clip which allows the blade to pivot. The wiper blade comprises of a number of levers and yokes to which the rubber wiper is attached. The levers and yokes ensure that the pressure applied by the arm spring is evenly distributed along the full length of the blade. The rubber wiper is held in the yokes by a pair of stainless steel strips which also contribute to the even distribution of spring pressure along the blade.

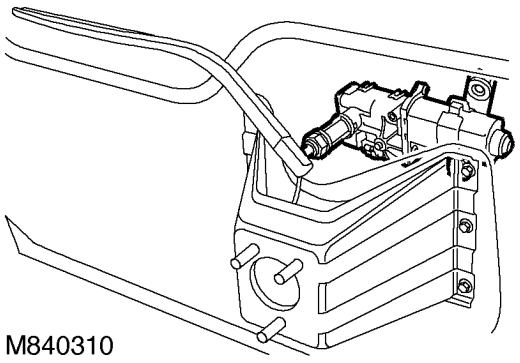
Rear wiper switch


M840309

The rear wiper switch is a latching pushbutton switch and is located on the right hand side of the instrument pack.

Activating the rear wiper switch provides an earth signal to the BCU. The BCU signals the IDM to energise the rear wiper relay, which provides battery voltage to the rear wiper motor.

Rear wiper motor



The DC motor contains two permanent magnets and a park switch. An earth braid attached between the motor casing and the brush pack is utilised to minimise radio interference during wiper functions.

The rear wiper switch provides an earth signal to the BCU, which determines the delay interval, if appropriate. The BCU then signals the IDM to activate the rear wiper motor relay, which provides power to the rear wiper motor.

To allow the rear wiper to park when the rear wiper is switched off, power flows through the park switch until a cam in the wiper motor assembly breaks the contact of the park switch. Triggering the park switch grounds the positive side of the wiper motor causing it to stop abruptly

Washers

The washer system comprises a reservoir, washer pumps, hoses and washer jets. The front washers are controlled from a stalk switch on the steering column and the rear washers are operated by a non-latching pushbutton switch on the fascia adjacent to the instrument pack.

Reservoir

The reservoir is located behind the front bumper in the inner wheel arch and has a capacity of 6.0 litres (12.5 US pints). A filler neck tube is connected to the reservoir with a seal and extends into the engine compartment on the front left hand side. The filler neck tube contains a removable filter to prevent particle contamination and a yellow float to show reservoir contents. The washer filler neck tube is sealed with a cap which is coloured blue for identification.

Two electric washer pumps are located on the rear face of the reservoir and supply washer fluid to the front windscreen and the tail door window. Each pump is sealed to the reservoir with a rubber sealing grommet.

On vehicles with headlamp powerwash fitted, a third pump is fitted with a sealing grommet to the front face of the reservoir.

The reservoir and filler neck tube are manufactured from moulded opaque nylon. The reservoir has moulded lugs for attachment to the vehicle body. A bracket is attached to the top of the filler neck tube and locates in a hole in the body to secure the top of the tube.

Front screen washer jets

Two washer jets for the front windscreen are fitted to the top surface of the bonnet and held in place with plastic clips. Each washer jet is connected via a hose to an in-line valve. The in-line valve prevents the washer fluid draining back to the reservoir and ensures that the washers operate immediately the washer pump is operated. From each in-line valve the washers are connected via a short hose to a 'T' connector. From the 'T' connector a single hose connects to the outlet of the front washer pump. Each jet has two jets which can be adjusted to allow full fluid coverage of the windscreen.

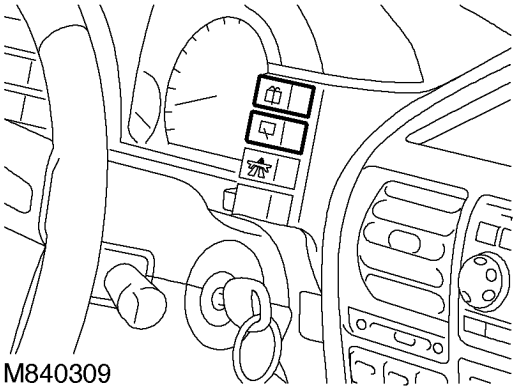
Rear screen washer jet

A single washer jet for the tail door window is fitted to the rear wiper blade. The jet has four spray orifices which direct washer fluid to either side and along the length of the wiper blade. The jet is connected by a hose from the wiper blade, through a sealing grommet in the tail door and connects with the rear washer hose from the rear washer pump. A non-return valve is used to join the feed hose from the pump to the washer jet hose. The non-return valve prevents fluid draining to the reservoir and ensures that the washer operates immediately the washer pump is operated. The hose from the pump to the tail door is located inside the main harness.

Headlamp power washer jets

When fitted, a powerwash jet for each headlamp is located in a housing on the top surface of the front bumper. The jets are fed with fluid at high pressure from the powerwash pump. A large diameter hose connects each jet to the pump. Each connection is secured with a metal clip to secure the hose due to the high pressure from the pump. Each jet directs the high pressure fluid in a wide spray onto the headlamp lens.

Rear washer switch

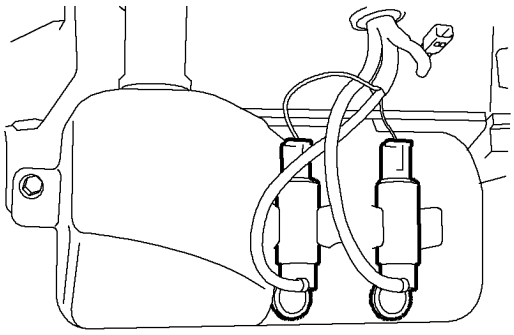


M840309

The rear washer switch is a non-latching pushbutton switch and is located on the RH side of the instrument pack.

Activating the rear washer switch provides battery voltage from fuse 30 in the passenger compartment fusebox to the rear washer pump.

Front washer pump

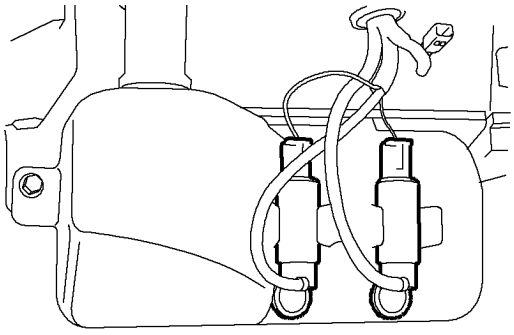


M840311

The front washer pump consists of a DC motor with an impeller. It is located in the rear of the washer fluid reservoir and can be identified by its black top.

Operating the front washer switch provides battery voltage to the front washer pump. This same battery voltage signal also goes to the BCU and increments the headlamp powerwash counter providing the headlamps are switched on.

Rear washer pump

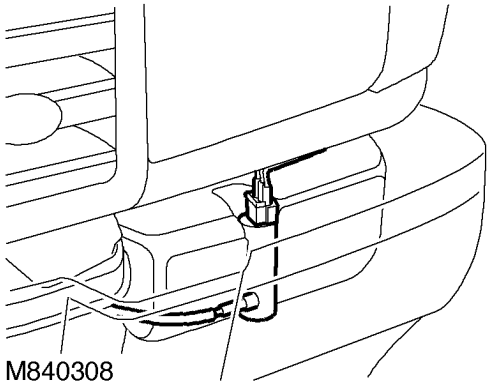


M840311

The rear washer pump consists of a DC motor with an impeller. It is located in the rear of the washer fluid reservoir and can be identified by its red top.

Operating the rear washer switch provides battery voltage to the rear washer pump.

Headlamp powerwash pump



The headlamp power wash pump consists of a DC motor with an impeller. It is located on the front of the washer fluid reservoir.

The BCU controls operation of the headlamp power wash relay, which supplies battery voltage from fuse 4 located in the engine compartment fuse box to the headlamp power wash pump. When the BCU determines headlamp power wash is to be activated, it provides a ground path for the coil of the headlamp power wash relay. The auxiliary relay located in the engine compartment fuse box supplies the headlamp power wash relay coil with battery voltage.

Operation

Front intermittent wipe variable delay
The front intermittent wipe variable delay operation allows the driver to adjust the interval between wipes to suit local conditions. Front variable delay operation activates when the following conditions are met:

- Ignition switch in position I or II.
- Front wash/ wipe switch is in the intermittent position.

The BCU receives the front intermittent wipe signal from the front wash/ wipe switch. The BCU receives a separate signal from the variable delay switch, determines the delay interval from the front wash/ wipe switch position and passes it on to the IDM. The IDM energises the front wiper relay to activate the front wiper motor.

If the delay duration is decreased during front variable delay operation, the wipers immediately operate once and then the delay cycle is reset to the new duration.

If the delay duration is increased during front variable delay operation, the delay cycle is automatically increased by the BCU.

Front low speed
Front low-speed operation activates when the following conditions are met:

- Ignition switch is in position I or II.
- Front wipe/ wash switch is in low speed position.

Selecting low-speed on the front wash/ wipe switch signals the IDM to energises the front wiper relay, which provides power to the front wiper motor assembly.

Front high speed
Front high-speed operation activates when the following conditions are met:

- Ignition switch is in position I or II.
- Front wipe/ wash switch is in high speed position.

Selecting high speed on the front wash/ wipe switch allows power to flow from the switch directly to the wiper motor. The high-speed input goes to a set of brushes in the wiper motor that are closer together than the low speed brushes. These brushes allow the motor to run at a faster speed but with less torque.

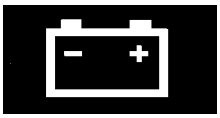
Front washer
Front washer operation will only activate when the following conditions are met:

- Ignition switch is in position I or II.
- Front washer switch operated.

Flicking the front washer switch energises the front washer pump motor for 0.4 second. Holding the front washer switch for longer than 0.4 second allows the front washer pump motor to run as long as the switch is held.

There are two front washer configurations. If the vehicle is fitted with programme wash/ wipe, and the front washer pump motor is active for more than 0.5 second, the front wipers operate at low speed. The wipers continue to operate for 4 seconds after the washer switch is released. In some markets, the driver must activate the front wipers after a front washer operation.

The front washer operation has a higher priority than the variable delay operation. This means that if intermittent wipe is active when a front washer operation is initiated, the wash cycle executes and the intermittent wipe is re-instated at the end of the wash operation.



Front flick wipe

Flick wipe operation will only activate when the following conditions are met:

- Ignition switch is in position I or II.
- Front flick switch is operated.

Pressing the flick wipe switch operates the front wiper motor at high speed. The front wiper motor operates as long as the flick switch is activated. Releasing the flick switch causes the front wiper motor to run through the park switch circuitry. The park switch only permits low speed operation. Thus if the flick switch is pressed and immediately released, the wipers operate at low speed.

Rear intermittent wipe variable delay

The rear intermittent wipe variable delay operation allows the driver to adjust the interval between wipes to suit local conditions. Rear variable delay operation only activates if the following conditions are met:

- Ignition switch in position I or II.
- Front wash/ wipe switch on intermittent.
- Rear wipe switch is operated.

The BCU determines the desired delay interval based on the setting of the variable delay switch. The rear wash/ wipe delay is nominally twice as long as that of the front. This information passes from the IDM to the rear wiper relay and activates the rear wiper motor.

If the delay duration is decreased during operation of the rear wiper, the wipers immediately operate once and the delay cycle is reset.

If the delay duration is increased during operation of the rear wiper, the delay cycle is automatically increased by the BCU.

Reverse wiping

Reverse wiping operates the rear wiper motor when reverse gear is selected. The transmission must be in reverse for longer then 0.5 seconds before reversing wipe activates. Reversing wipe activates if the following conditions are met:

- Ignition switch is in position II.
- Reverse gear is selected.
- Rear wiper or front wipers operating.

If the rear wiper is active in any mode when reverse gear is selected, the rear wiper activates for 4 second. After 4 seconds the rear wiper operates in a delay operation at the same delay interval set by the variable delay switch until reverse gear is deselected.

If the front wipers are operating on either low or high speed when reverse gear is selected, the rear wiper activates continuously until reverse gear is deselected.

In order to enable reversing wipe functions, the BCU utilises the reversing light switch located within the transmission to determine when reverse gear has been selected.

If the front intermittent wipe is active when reverse gear is selected, the rear wiper completes 2 cycles before operating at the same intermittent delay as the front wipers.

Rear wipe
Rear wipe operation will only activate when the following conditions are met:
- Ignition switch is in position II.
- Rear wipe switch is operated.

Operating the rear wiper switch provides an earth input to the BCU. The BCU tells the IDM to activate the rear wiper relay, which provides battery voltage to the wiper motor through the normally closed contacts of the park switch.

Rear wash
Rear wash will only operate when the following conditions are met:
- Ignition switch is in position II.
- Rear wash switch operated.

Operating the rear washer switch for longer than 0.4 second allows the rear washer pump motor and rear wipers to run as long as the switch is held. The wipers run for 4 seconds after the rear washer switch is released. Flicking the rear washer switch energises the rear washer pump motor for 0.4 second.

The rear washer operation has a higher priority than the intermittent wipe operation. If the intermittent wipe is active when a rear washer operation is initiated, the wash cycle executes and the intermittent wipe is re-instated at the end of the washer operation.

Wiper park switch
The park switch allows the wipers to come to rest in the park position when the wipe switch is turned off in mid-wipe.

The park switch consists of a positive and a negative contact. These two contacts are described as closed at park and closed when operating. When the wipers first start, the park switch is in the closed at park position. A relay controls battery voltage to the motor. Battery voltage passes through this relay contact to move the wiper motor from the park position.

When the motor moves, the park switch moves to the closed when operating position. Battery voltage to this relay contact is direct from fuse 19. Battery voltage passes through this contact to keep the wiper motor running. The wiper motor operates for one complete revolution until the park switch moves to the closed at park position again.

Switching off the wipers removes battery voltage from the closed at park contact. When the wipers reach the closed at park switch an earth is applied and the motor stops abruptly.

Headlamp power wash
Headlamp power wash activates when the following conditions are met:
- Ignition switch in position II.
- Headlamps switched on.
- Front wash switch operated.
- BCU counter allows headlamp power wash.

Operating the front washer switch with the headlamps switched on energises the IDM, supplying a voltage to the headlamp powerwash relay, which operates the headlamp powerwash pump and increments a counter within the BCU. This counter prevents the headlamp powerwash pump from operating every time the front washer switch is activated. Headlamp powerwash is only operational every third front wash cycle, providing the headlamps are on. The counter resets when the ignition switch is turned off.

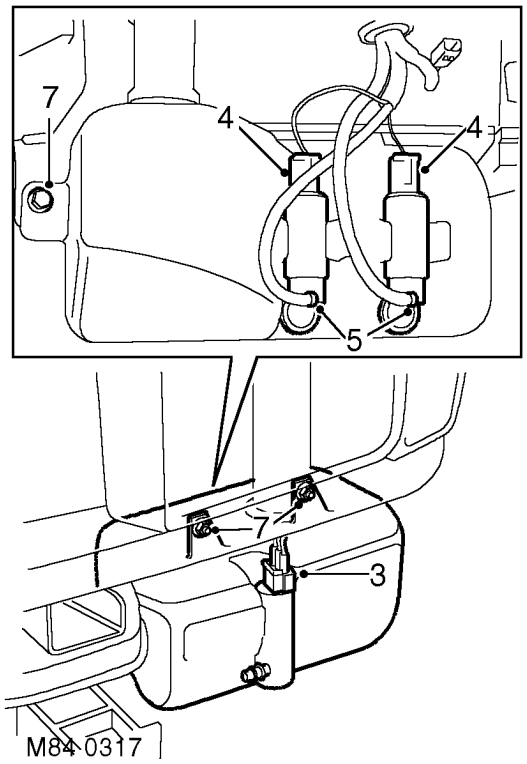
When the BCU permits headlamp power wash operation, the pump motor operates only for 0.5 second.

Reservoir - washer - up to 03MY

84.10.03

Remove

1. Remove front grille.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**
2. Remove front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**



3. Disconnect multiplug from headlamp washer pump.
4. Identify multiplugs for refit and disconnect from rear screen and windscreen washer pumps.
5. Identify hoses for refit and disconnect hoses from rear screen and windscreen washer pumps.
6. Release clip securing washer hose to headlamp washer pump.
7. Remove 2 nuts and 1 bolt securing reservoir, release reservoir from filler neck and remove reservoir assembly.
8. Remove filler neck grommet.

   NOTE: Do not carry out further dismantling if component is removed for access only.

9. Remove fluid level indicator.
10. Remove washer pumps from reservoir, remove and discard pump seals.

Refit

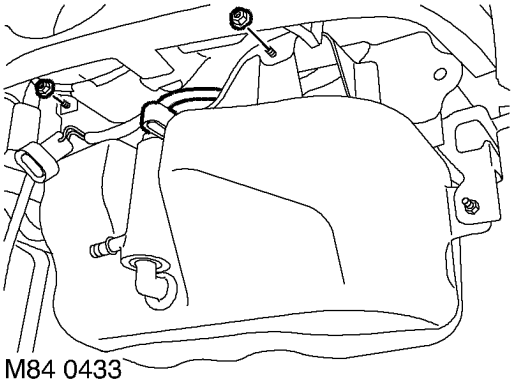
1. Use new seals and fit washer pumps to new reservoir.
2. Fit filler neck grommet to reservoir.
3. Fit level indicator into filler neck.
4. Fit reservoir assembly and secure with nuts and bolt.
5. Connect hoses to rear screen pump, windscreen washer pump and headlamp washer pump. Secure hoses with clips.
6. Identify and connect multiplugs to washer pumps.
7. Fit front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
8. Fit front grille.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.**
9. Refill reservoir
   ☞ **MAINTENANCE, PROCEDURES, Wipers and washers.**

Reservoir - washer - from 03MY

84.10.03

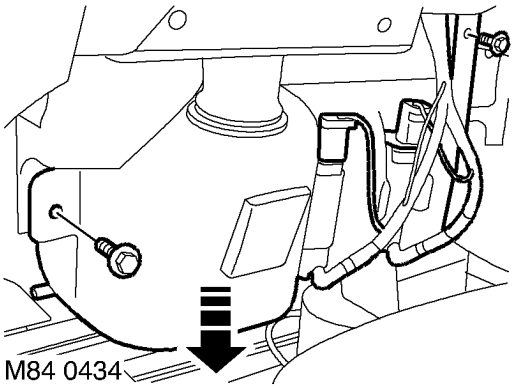
Remove

1. Remove the front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**



M84 0433

2. Disconnect multiplug from the headlamp washer pump.
3. Place a container beneath vehicle to collect any spillage.



M84 0434

4. Noting fitted position disconnect multiplugs and washer hoses from the front and rear windscreen washer pumps.
5. Remove 2 nuts and 2 bolts securing the washer reservoir to the body.
6. Release washer reservoir from filler neck. Remove the washer reservoir.
7. Remove and discard the washer reservoir filler neck seal.

   NOTE: Do not carry out further dismantling if component is removed for access only.

8. Remove washer pumps from washer reservoir and discard the seals.

Refit

1. Clean washer pump and filler neck seal recesses.
2. Fit new washer pump and filler neck seals to the washer reservoir.
3. Fit and secure washer pumps to the washer reservoir.
4. Fit washer reservoir to the filler neck, fit and tighten the nuts and bolts.
5. Connect multiplugs and washer hoses to the windscreen washer pumps.
6. Remove container from beneath the vehicle.
7. Fit the front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**

Jet - washer - windscreen

84.10.08

Remove

1. Carefully pull the elbow from the washer jet.
2. Place a protective covering around the washer jet, then release and remove washer jet.

Refit

1. Fit washer jet to its location in the bonnet, and remove the protective material.
2. Connect the washer tube, ensuring that it is pushed fully onto the stub pipe.

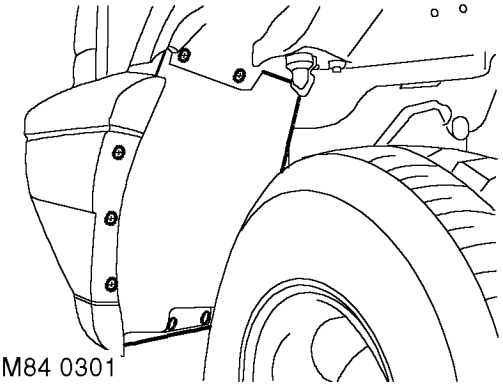
Pump - washer - screen and headlamp

84.10.21

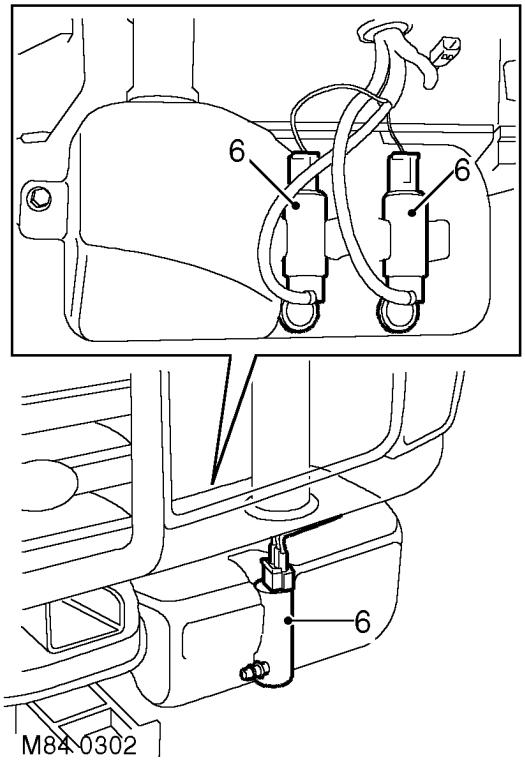
The following procedure also covers removal of the rear screen washer pump and the headlamp washer pump.

Remove

1. **Headlamp washer pump:** Remove front bumper.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**


M84 0301

2. **Front and rear screen washer pumps:** Remove 7 screws securing LH front wheel arch liner extension to liner and bumper valance and remove liner extension.
3. Position container under washer reservoir to collect fluid spillage.



4. Disconnect multiplug from washer pump.
5. Release clip and disconnect washer hose from washer pump.
6. Remove washer pump from reservoir and remove and discard pump seal.

Refit

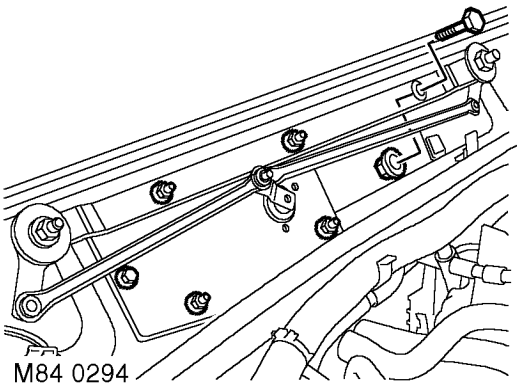
1. Use a new seal and fit pump to reservoir.
2. Connect hose to pump and secure with clip.
3. Connect multiplug to pump.
4. **Front and rear screen washer pumps:** Fit wheel arch liner extension, secure to bumper valance and liner with screws.
5. **Headlamp washer pump:** Fit front bumper. ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
6. Fill reservoir with washer fluid.

Motor and linkage - wiper - windscreen

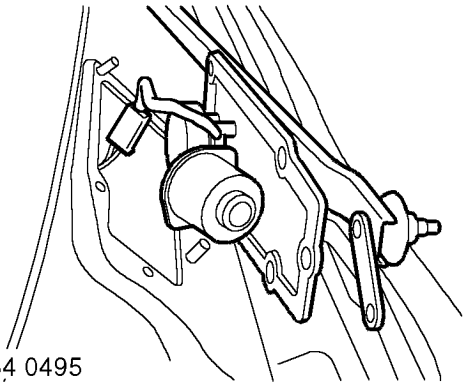
⊸ ***84.15.11***

Remove

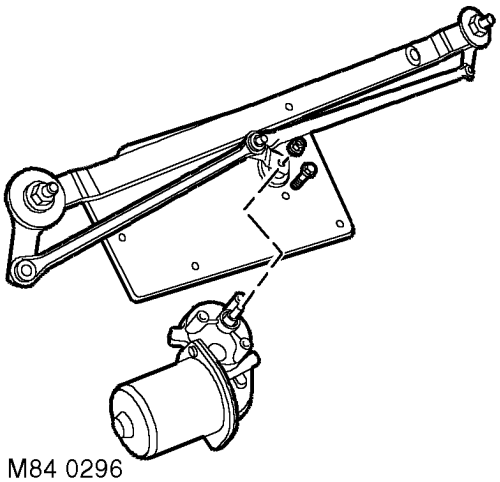
1. Remove plenum air intake. ☞ **HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.**



2. Remove 4 nuts and one bolt securing motor mounting plate to body.
3. Remove nut and bolt securing linkage to body.



4. Release motor and linkage from body and disconnect multiplug from windscreen wiper motor.
5. Remove motor and linkage.



M84 0296

6. Remove nut securing linkage connecting rod to wiper motor spindle.
7. Release link from motor spindle.
8. Remove 3 bolts securing motor to mounting plate and remove motor.

Refit

1. Fit new wiper motor to mounting plate and secure with bolts.
2. Connect link to motor spindle and tighten nut to 7 Nm (5.2 lbf.ft).
3. Fit motor and linkage to body, connect multiplug. Tighten all fixings to 2.5 Nm (1.8 lbf.ft).
4. Fit plenum air intake.
   ☞ **HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.**

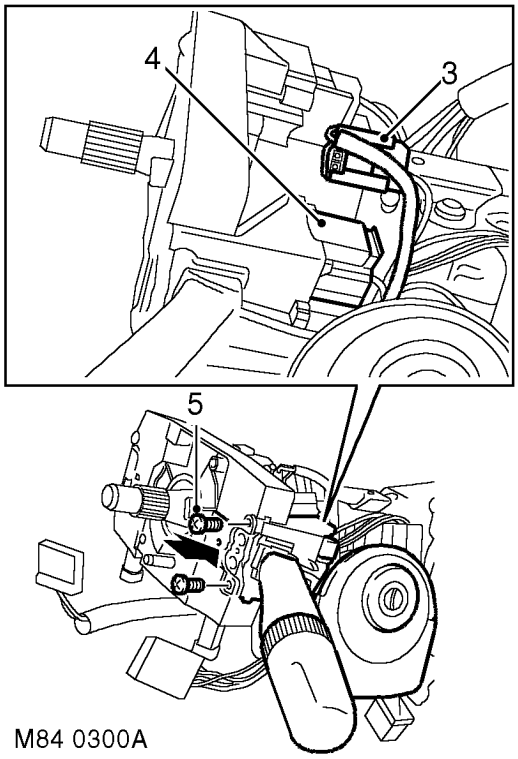
Switch - wiper and washer - windscreen

⊸ ***84.15.34***

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

Remove

1. Remove rotary coupler.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.**



M84 0300A

2. Release passive coil from steering column lock and lower the coil without disconnecting the harness.
3. Release front wiper delay multiplug from column switch mounting bracket and disconnect from harness.
4. Disconnect harness multiplug from wiper switch.
5. Remove 2 screws securing switch, carefully raise edge of switch bracket to clear location peg and remove switch.

Refit

1. Fit new switch to bracket and secure with screws.
2. Connect harness multiplug to switch.

3. Connect front wiper delay multiplug and fit multiplug to switch bracket.
4. Fit passive coil to column lock.
5. Fit rotary coupler.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.**

Jet - washer - headlamp

🔧 ***84.20.08***

The procedure to remove the headlamp washer jet on 03MY vehicles is detailed in the front bumper finisher job.
☞ **EXTERIOR FITTINGS, REPAIRS, Trim finisher - bumper - front - from 03MY.**

Remove

1. Remove retaining screw cover from jet housing.
2. Remove screw securing jet to bumper.
3. Release jet and withdraw sufficiently to gain access to washer tube. Disconnect tube from jet and remove jet.

Refit

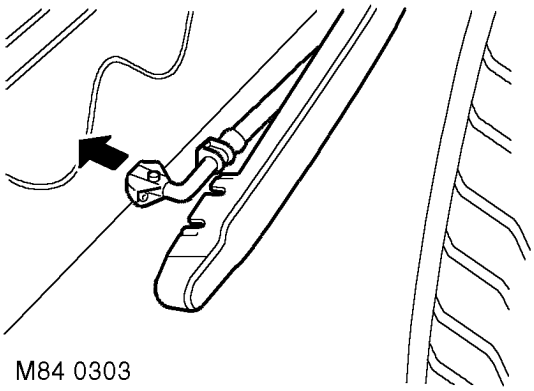
1. Connect jet to washer tube, ensuring it is pushed fully home.
2. Locate jet in bumper, retain with screw and fit screw cover.

Jet - washer - rear screen

84.30.09

Remove

1. Remove spare wheel.
2. Remove rear screen wiper blade.



M84 0303

3. Release washer jet and washer jet tube from wiper arm.
4. Release washer jet from washer jet tube and remove jet.

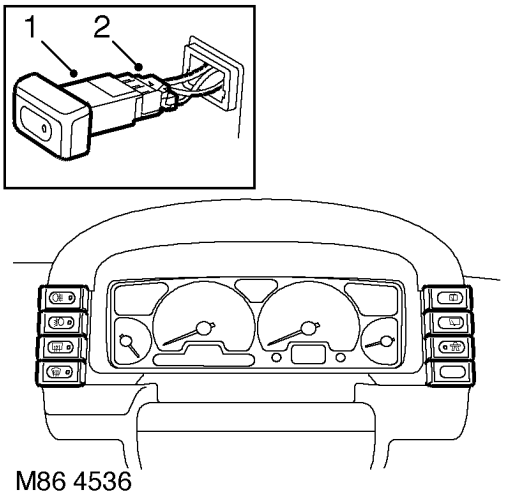
Refit

1. Fit new washer jet to washer jet tube and fit to wiper arm.
2. Fit rear screen wiper blade.
3. Fit spare wheel.

Switch - rear wash

84.30.27

Remove



M86 4536

1. Carefully remove switch from instrument cowl.
2. Disconnect multiplug and remove switch.

Refit

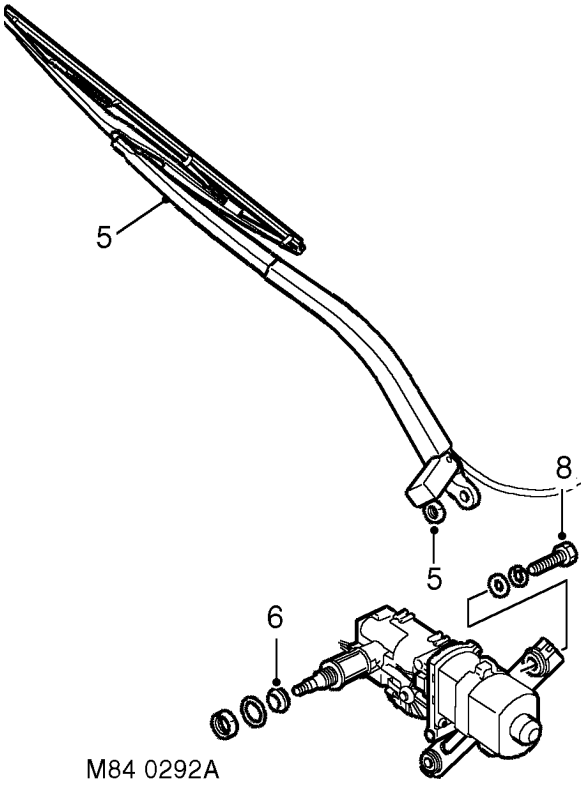
1. Position new switch and connect multiplug.
2. Carefully push switch into instrument cowl.

Motor - wiper - rear screen

84.35.12

Remove

1. Remove spare wheel from taildoor.
2. Remove tail door trim casing.
   DOORS, REPAIRS, Trim casing - tail door.
3. Remove tail door water shedder.
4. Disconnect washer tube



5. Raise nut cover, remove nut and release wiper arm.
6. Remove spindle nut and flat washer and discard rubber seal.
7. Disconnect taildoor harness multiplug from wiper motor.
8. Remove 2 bolts securing wiper motor to tail door.
9. Remove wiper motor.

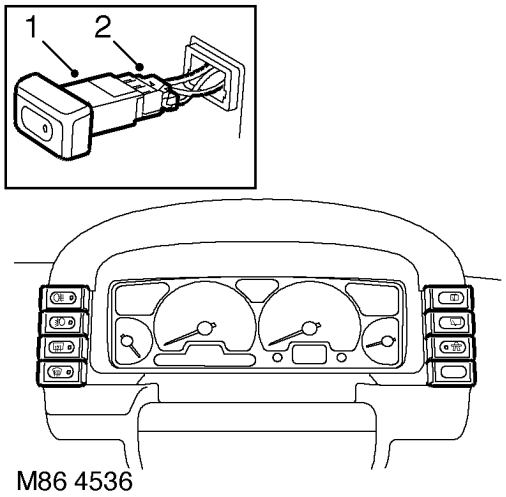
Refit

1. Position wiper motor to door and secure with bolts.
2. Connect tail door harness multiplug to wiper motor.
3. Fit rubber seal, flat washer and spindle nut. Tighten spindle nut to 3 Nm (2.2 lbf.ft).
4. Position wiper arm to tail door and connect washer tube.
5. Tighten wiper arm nut to 20 Nm (15 lbf.ft) and fit nut cover.
6. Fit tail door water shedder.
7. Fit tail door trim casing.
   DOORS, REPAIRS, Trim casing - tail door.
8. Fit spare wheel to tail door.

Switch - wiper - rear - up to 03MY

84.35.33

Remove



M86 4536

1. Carefully remove switch from instrument cowl.
2. Disconnect multiplug and remove switch.

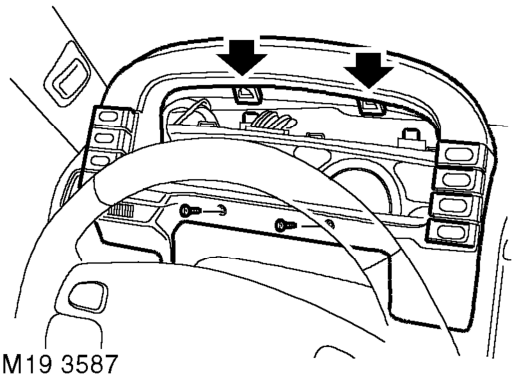
Refit

1. Position new switch and connect multiplug.
2. Carefully push switch into instrument cowl.

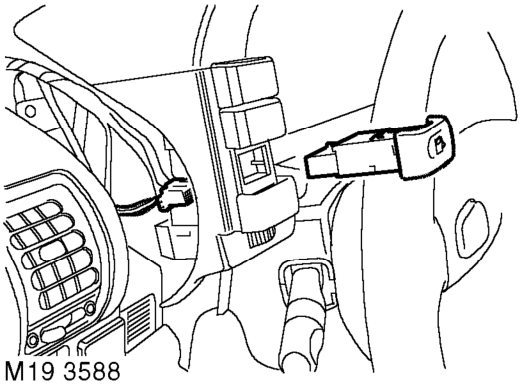
Switch - wiper - rear - from 03MY

843533

Remove


M19 3587

1. Remove 2 screws securing instrument cowl to fascia and release the cowl from the retaining clips.


M19 3588

2. Disconnect multiplug from the rear wiper switch.
3. Remove the rear wiper switch from the instrument cowl.

Refit

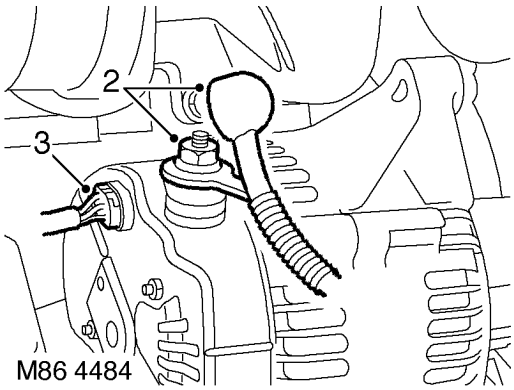
1. Fit and secure the rear wiper switch to the instrument cowl and connect the multiplug.
2. Fit the instrument cowl to the fascia and secure with screws.

Alternator - diesel

86.10.02

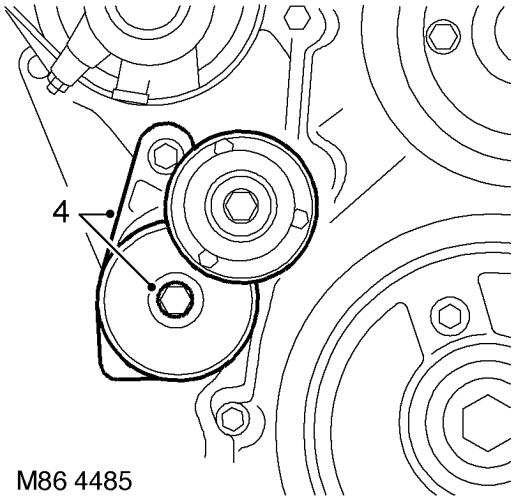
Remove

1. Remove auxiliary drive belt.
   CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.



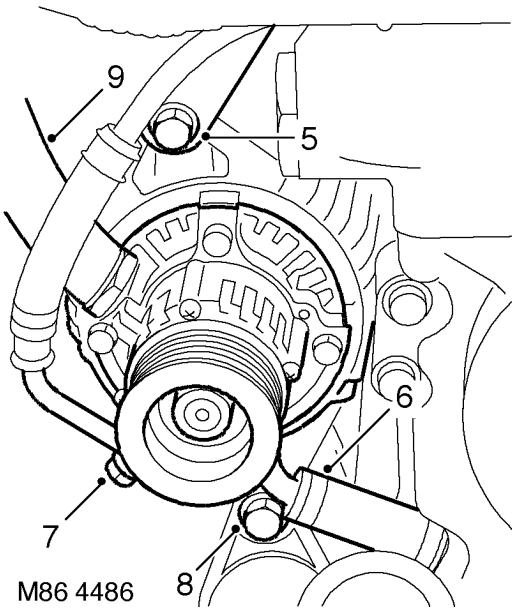
M86 4484

2. Release cover and remove nut securing lead to alternator.
3. Disconnect alternator multiplug.



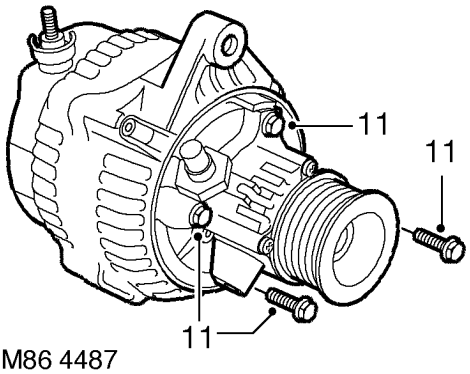
M86 4485

4. Remove bolt (LH thread) and remove auxiliary drive belt tensioner.



M86 4486

5. Remove bolt securing support stay to alternator.
6. Release clip and disconnect oil drain hose from vacuum pump.
7. Disconnect vacuum pump oil supply pipe from cylinder head and discard 'O' ring.
8. Remove bolt securing alternator and release from mounting bracket.
9. Disconnect vacuum hose from vacuum pump.
10. Remove alternator. Take care not to damage radiator cooling fins.



M86 4487

11. Remove 4 bolts, and remove vacuum pump from alternator.

CAUTION: Always fit plugs to open connections to prevent contamination.

Refit

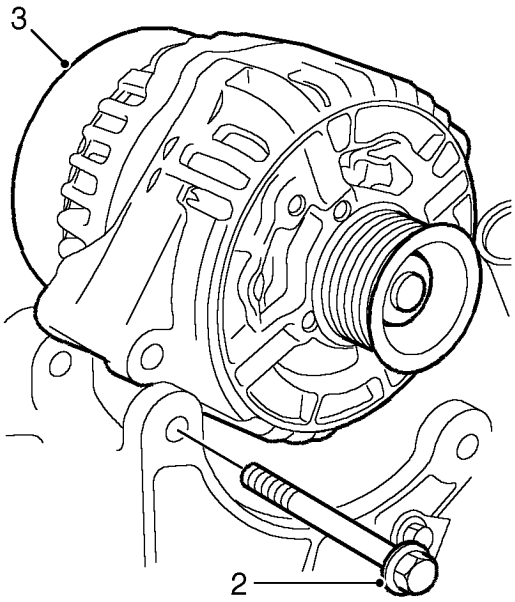
1. Clean mating faces of alternator and vacuum pump.
2. Fit vacuum pump to alternator and tighten bolts to 8 Nm (6 lbf.ft).
3. Position alternator to engine and connect multiplug.
4. Connect vacuum hose and oil drain hose to vacuum pump and secure clips.
5. With assistance align alternator to mounting bracket and fit but do not tighten bolt.
6. Fit bolt securing support stay to alternator and tighten to 25 Nm (18 lbf.ft) .
7. Tighten bolt securing alternator to mounting bracket to 45 Nm (33 lbf.ft).
8. Using new 'O' ring, connect oil supply pipe to cylinder head and tighten to 10 Nm (7 lbf.ft).
9. Connect lead to alternator and tighten nut to 6 Nm (4.4 lbf.ft).
10. Fit auxiliary drive belt tensioner and tighten bolt to 50 Nm (37 lbf.ft).
11. Fit auxiliary drive belt.
    ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

Alternator - V8

⊸ ***86.10.02***

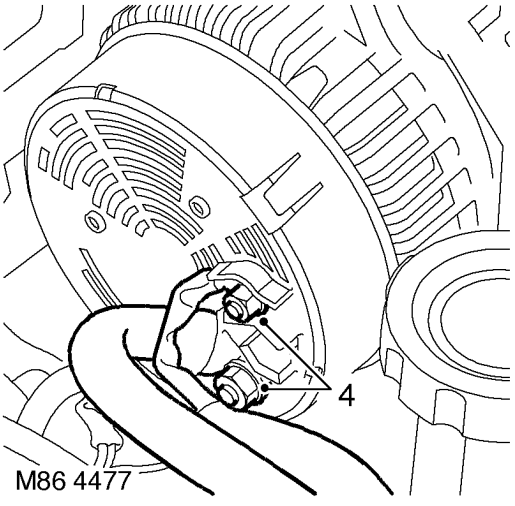
Remove

1. Remove auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**



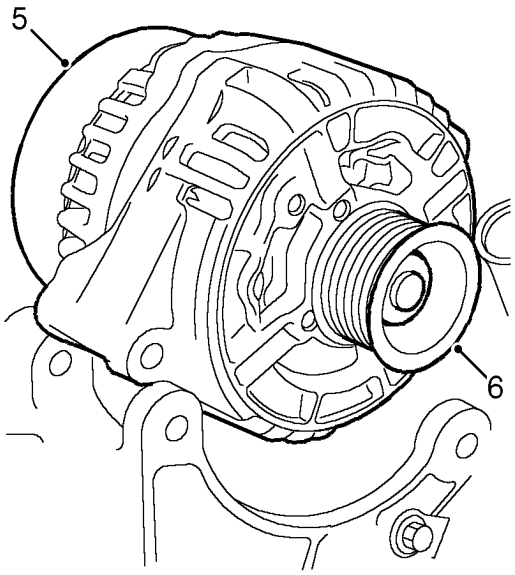
M86 4478

2. Remove 2 bolts securing alternator to mounting bracket.
3. Release alternator from mounting bracket



M86 4477

4. Remove nuts securing alternator cables, and release cables.



M86 4540

5. Remove alternator from mounting bracket.
6. Remove pulley from alternator.

Refit

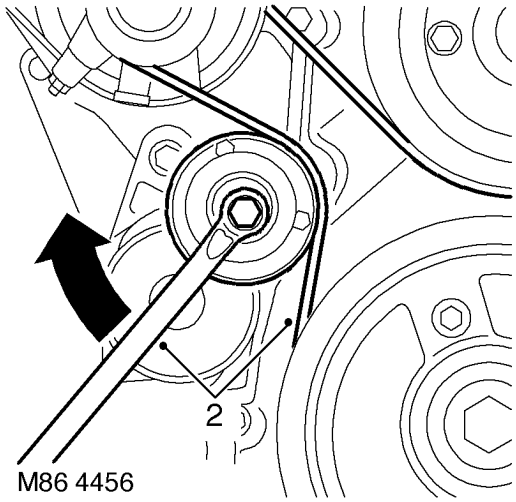
1. Fit alternator pulley and tighten nut to 80 Nm (59 lbf.ft).
2. Position alternator to mounting bracket.
3. Connect alternator cables and tighten B+ nut to 18 Nm (13 lbf.ft), and D+ nut to 5 Nm (3.7 lbf.ft).
4. Locate alternator in mounting bracket.
5. Fit alternator mounting bolts and tighten to 45 Nm (33 lbf.ft).
6. Fit auxiliary drive belt.
   ☞ **CHARGING AND STARTING, REPAIRS, Belt - auxiliary drive.**

Belt - auxiliary drive

⊸ ***86.10.03***

Remove

1. Remove viscous fan:
   - ☞ **COOLING SYSTEM - V8, REPAIRS, Fan - viscous.**
   - ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**



M86 4456

2. Turn drive belt tensioner using a 15 mm ring spanner and release belt from pulleys.

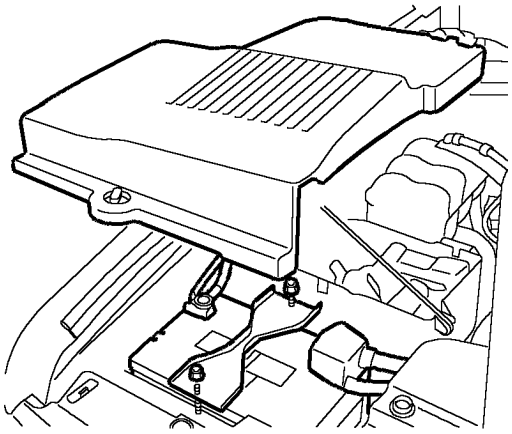
Refit

1. Clean drive belt pulley grooves and ensure grooves are not damaged.
2. Fit new drive belt around pulleys, ensure belt is correctly aligned in pulley grooves.
3. With assistance, hold tensioner fully clockwise and fit drive belt around remaining pulley. Release tensioner.
4. Fit viscous fan:
   - ☞ **COOLING SYSTEM - Td5, REPAIRS, Fan - viscous.**
   - ☞ **COOLING SYSTEM - V8, REPAIRS, Fan - viscous.**

Battery

86.15.01

Remove



M86 4452

1. Release fixings and remove battery cover.
2. Disconnect both battery leads, negative lead first.
3. Remove lock nuts and retaining nuts securing battery clamp.
4. Remove battery clamp.
5. Remove battery.

Refit

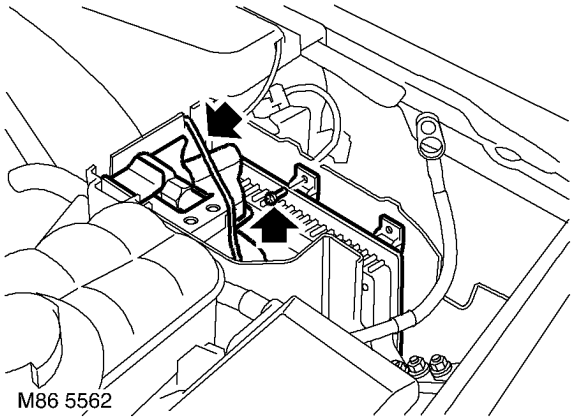
1. Clean battery terminals and coat with petroleum jelly.
2. Fit battery.
3. Fit battery clamp and tighten retaining nuts and lock nuts.
4. Fit both battery leads, negative lead last.
5. Fit battery cover and secure fixings.

Battery carrier

86.15.11

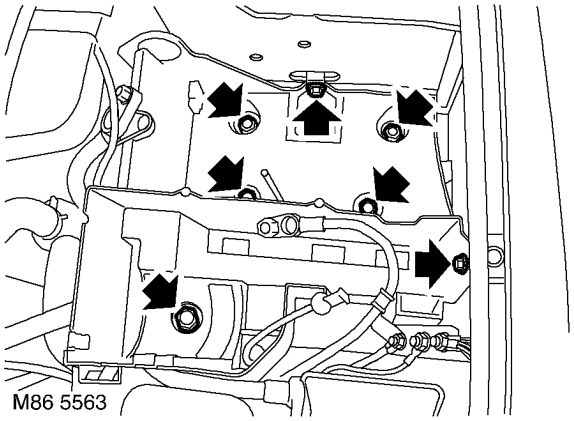
Remove

1. Remove battery.
   CHARGING AND STARTING, REPAIRS, Battery.



M86 5562

2. Release strap and remove jack.
3. Release coolant hose from clip.
4. **Diesel models:** Remove screw securing ECM, release ECM and position aside.



M86 5563

5. Remove 7 bolts securing battery carrier.
6. Remove battery carrier.

   NOTE: Do not carry out further dismantling if component is removed for access only.

7. Remove jack retaining strap, speed nut and clip.

Refit

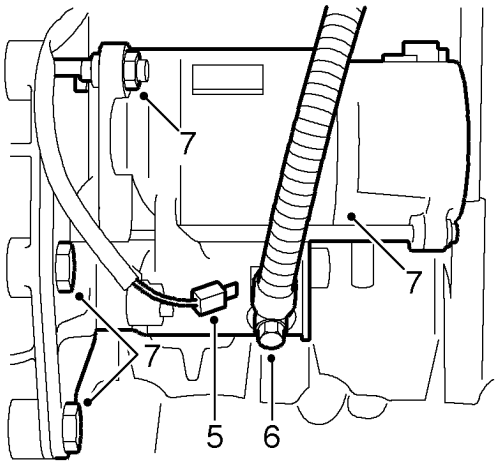
1. Fit jack retaining strap, speed nut and clip.
2. Fit battery carrier, fit bolts and tighten to 28 Nm (21 lbf.ft).
3. **Diesel models:** Fit ECM and secure with screw.
4. Secure coolant hose.
5. Fit and secure jack.
6. Fit battery.
   ☞ **CHARGING AND STARTING, REPAIRS, Battery.**

Starter motor - diesel

86.60.01

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.
   WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.
4. Remove underbelly panel.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**



M86 4488

5. Disconnect Lucar connector from starter solenoid.
6. Remove nut and disconnect battery lead from starter solenoid.
7. Remove nut and 2 bolts securing starter motor and remove starter motor from engine.

Refit

1. Clean starter motor and mating face on engine.
2. Fit starter motor and tighten nut and 2 bolts to 27 Nm (20 lbf.ft).
3. Connect lead to starter solenoid and tighten nut to 10 Nm (7 lbf.ft).
4. Connect Lucar connector to starter solenoid.
5. Fit underbelly panel.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Panel - underbelly.**
6. Remove stand(s) and lower vehicle.
7. Connect battery earth lead.
8. Fit battery cover and secure the fixings.

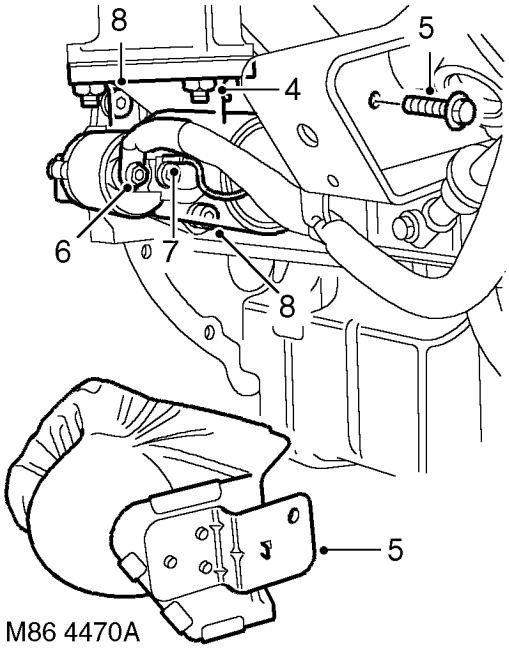
Starter motor - V8

86.60.01

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.
3. Raise front of vehicle.

WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



M86 4470A

4. Remove 3 nuts securing exhaust flange to front pipe, release front pipe and collect gasket.
5. Remove bolt securing heat shield to engine mounting bracket, release heat shield from starter motor and remove from vehicle.
6. Remove nut securing battery lead to starter solenoid and release lead.
7. Disconnect Lucar connector from starter solenoid.
8. Remove 2 Allen bolts securing starter motor and remove starter motor from engine.

Refit

1. Clean starter motor and mating face on engine.
2. Fit starter motor and tighten Allen bolts to 44 Nm (32 lbf.ft).
3. Connect Lucar connector to starter solenoid.
4. Fit battery lead to solenoid and tighten nut.
5. Position heat shield to starter motor, locate tag in engine mounting bracket, fit bolt and tighten to 10 Nm (7 lbf.ft).
6. Clean exhaust manifold and front pipe mating faces.
7. Using a new gasket, position front pipe, fit nuts and tighten to 30 Nm (22 lbf.ft).
8. Remove stand(s) and lower vehicle.
9. Connect battery earth lead.
10. Fit battery cover and secure fixings.

Headlamps beam alignment - up to 03MY

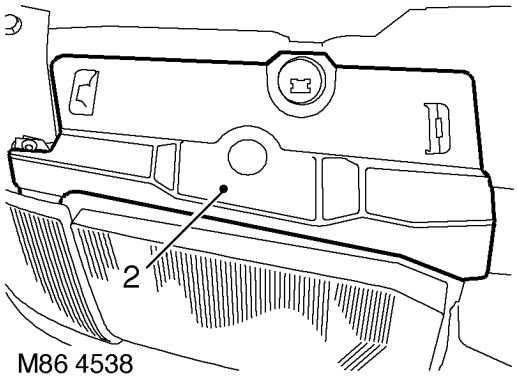
86.40.17

Check

1. Ensure vehicle is unladen and tyres are at correct pressures.
2. **Models with SLS:** Ensure vehicle is at standard ride height.
3. **Models with headlamp levelling:** Ensure headlamp levelling switch is set to '0'.
4. Align suitable beam setting equipment to headlamp.
5. Switch headlamps on and measure main beam settings. Beam must be 1.4% below the horizontal and parallel to the vehicle centre line. If necessary, adjust headlamp to get correct beam settings.
6. Align beam setting equipment to 2nd headlamp and repeat check.
7. Switch off headlamps and remove beam setting equipment.

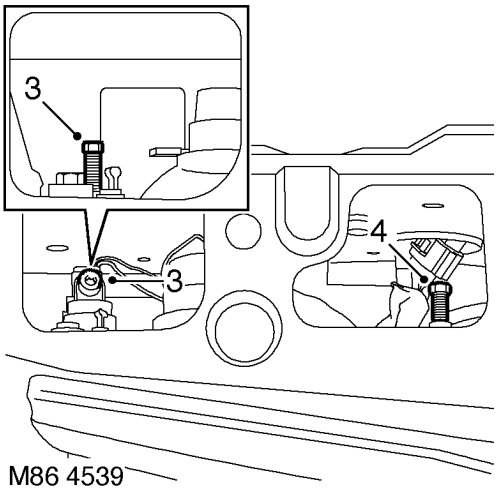
Adjust

1. **For RH headlamps:** Release fixings and remove battery cover



M86 4538

2. Remove headlamp access cover.



M86 4539

3. Turn vertical adjuster as necessary to get correct beam setting. Use a 7 mm Allen key for models with headlamp levelling, or a 10 mm spanner for models without headlamp levelling.
4. Turn horizontal adjuster as necessary to get correct beam setting. Use a 10 mm spanner.
5. Fit headlamp access cover.
6. **For RH headlamp adjustment:** Fit battery cover and secure fixings.

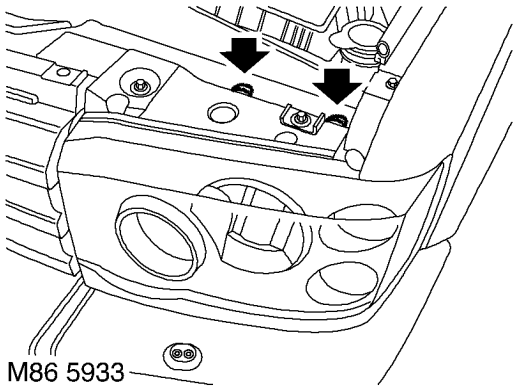
Headlamps beam alignment - from 03MY

86.40.17

Check

1. Ensure vehicle is unladen and tyres are set at the correct pressures.
2. **Models with SLS:** Ensure vehicle is at the standard ride height.
3. **Models without SLS:** Set headlamp leveling switch to zero.
4. Align beam setting equipment to headlamp.
5. Switch on headlamps. Headlamp setting 1.2% below horizontal and parallel.
6. Align beam setting equipment to second headlamp and repeat the check.

Adjust



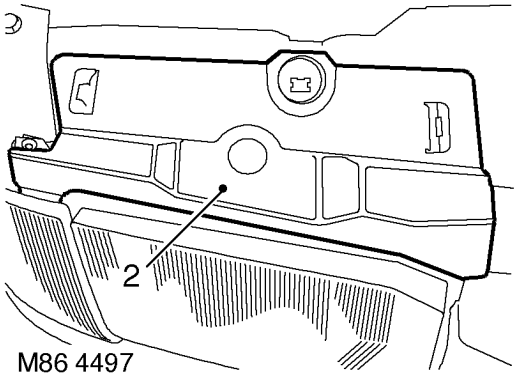
1. Using a flat blade screwdriver rotate the headlamp adjusters until correct alignment is achieved
2. Rotate inboard adjuster for verticle alignment.
3. Rotate outboard adjuster for horizontal alignment.
4. Adjust 2nd headlamp as detailed above.
5. Switch off headlamps and remove beam setting equipment.

Lamp - front repeater

86.40.42

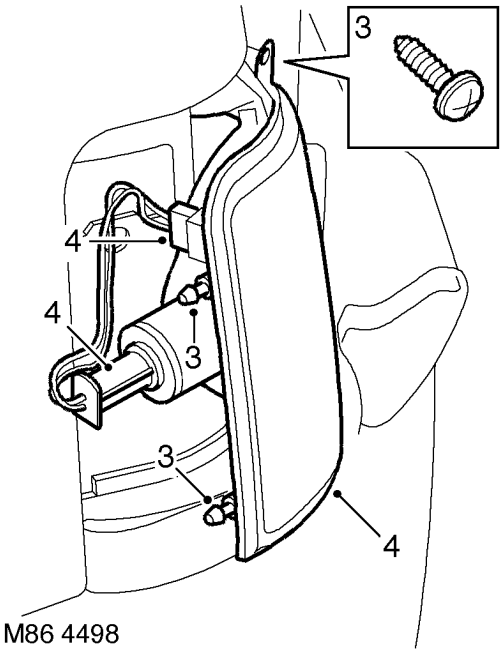
Remove

1. **For RH repeater lamp:** Release fixings and remove battery cover.



M86 4497

2. Remove headlamp access cover from body.



M86 4498

3. Remove screw securing repeater lamp to body and release lamp from 2 locating peg sockets in wing.
4. Disconnect 2 multiplugs from repeater lamp and remove lamp.

Refit

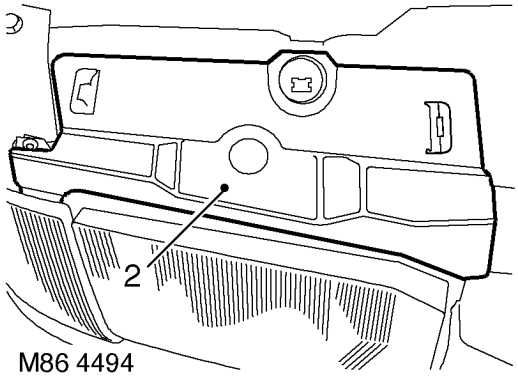
1. Position new repeater lamp and connect multiplugs.
2. Fit repeater lamp to body and tighten screw.
3. Fit headlamp access cover.
4. **For RH repeater lamp:** Fit battery cover and secure fixings.

Headlamp - up to 03MY

86.40.49

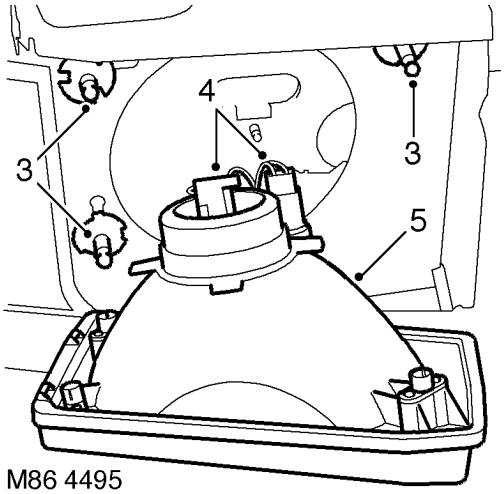
Remove

1. **For RH headlamp:** Release fixings and remove battery cover.



M86 4494

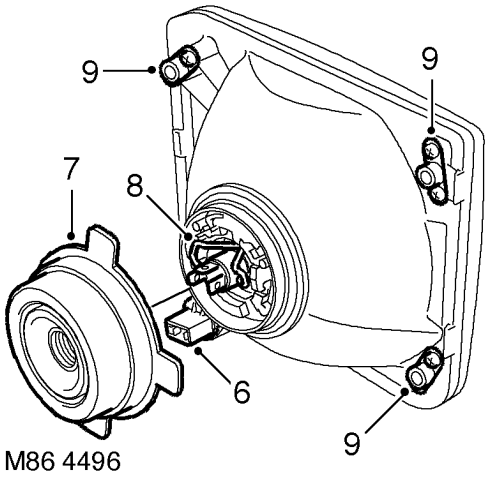
2. Remove headlamp access cover from body.



M86 4495

3. Release headlamp from locating sockets.
4. Disconnect multiplugs from headlamp and side lamp bulbs.
5. Remove headlamp.

NOTE: Do not carry out further dismantling if component is removed for access only.



M86 4496

6. Remove side lamp bulb holder from headlamp.
7. Remove rubber cover from headlamp.
8. Release headlamp bulb retaining clip and remove headlamp bulb.
9. Remove 6 screws and remove headlamp retaining sockets.

Refit

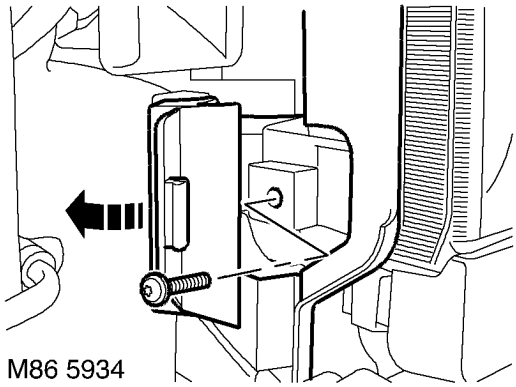
1. Fit retaining sockets to new headlamp and secure with screws.
2. Fit headlamp bulb and secure with clip.
3. Fit rubber cover.
4. Fit side lamp bulb holder.
5. Position headlamp and connect multiplugs.
6. Fit headlamp onto locating pins.
7. Check headlamp beam alignment.
   ☞ **LIGHTING, ADJUSTMENTS, Headlamps beam alignment - up to 03MY.**
8. Fit headlamp access cover.
9. **For RH headlamp:** Fit battery cover and secure with fixings.

Headlamp - from 03MY

86.40.49

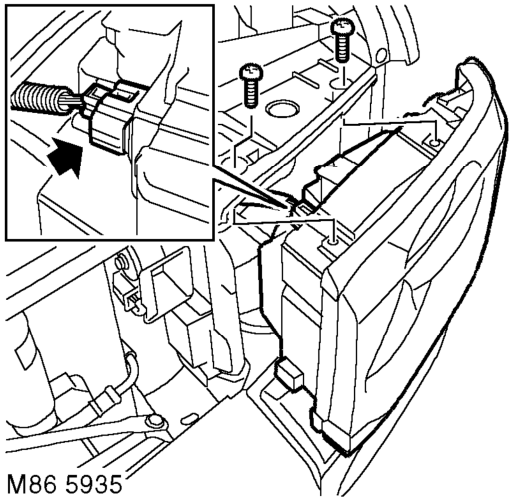
Remove

1. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - from 03MY.
2. Protect bumper.
   CAUTION: Always protect paintwork when removing or refitting any body trims or bumpers.



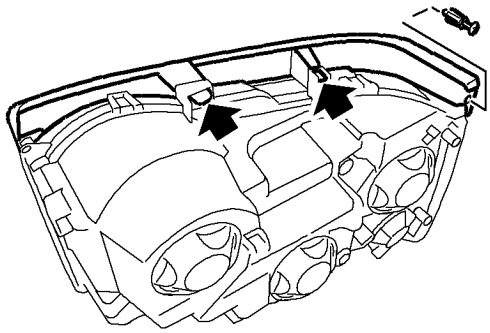
M86 5934

3. Open air deflector access panel and remove Torx screw securing headlamp assembly to the front panel.



M86 5935

4. Remove 2 screws securing headlamp assembly to the bonnet locking platform.
5. Release headlamp assembly from wing, disconnect multiplug and remove the headlamp assembly.
   NOTE: Do not carry out further dismantling if component is removed for access only.



M86 5936

6. Remove scrivet securing headlamp finisher to headlamp assembly, release and remove the finisher.

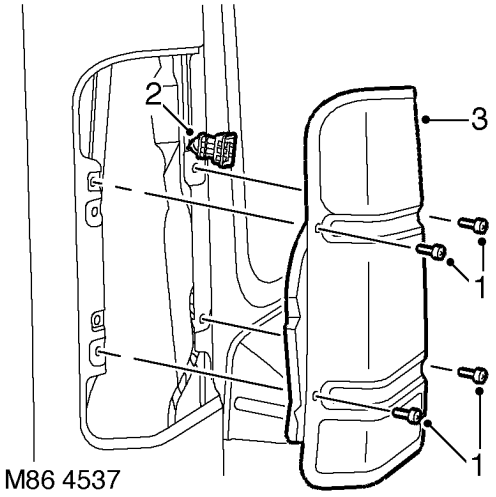
Refit

1. Fit and secure headlamp finisher to the headlamp assembly.
2. Position headlamp assembly to front panel and connect the multiplug.
3. Secure headlamp assembly to the front wing.
4. Fit and tighten screws securing headlamp assembly to the bonnet locking platform.
5. Fit and tighten Torx screw securing headlamp assembly to the front panel. Close the air deflector access panel.
6. Remove bumper protection.
7. Fit front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - from 03MY.
8. Check headlamp alignment - adjust if necessary.
   LIGHTING, ADJUSTMENTS, Headlamps beam alignment - from 03MY.

Lamp - tail

86.40.70

Remove



M86 4537

1. Remove 4 screws securing tail lamp to body.
2. Disconnect multiplug from tail lamp.
3. Remove tail lamp.

Refit

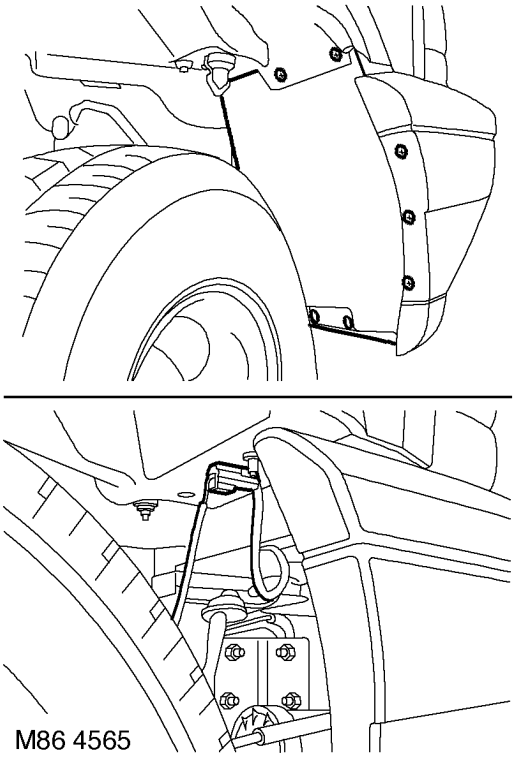
1. Position tail lamp to body and connect multiplug.
2. Secure tail lamp to body with screws.

Lamp - front fog up to 03MY

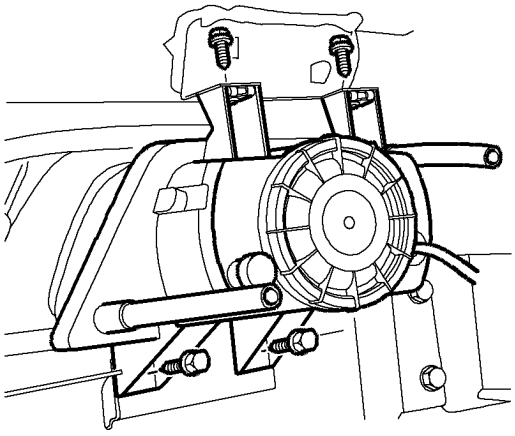
86.40.95

Remove

1. Raise front of vehicle, one side.


M86 4565

2. **For RH lamp:** Remove 7 screws securing wheel arch liner extension to liner and bumper valance and remove liner extension. Disconnect lamp multiplug from harness.
3. **For LH lamp:** Remove front bumper assembly. ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**



M86 4566

4. Remove 4 screws and remove lamp.

Refit

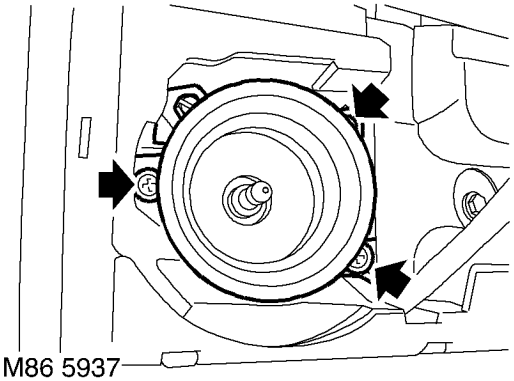
1. Fit new lamp and secure with screws.
2. **For LH lamp:**Fit front bumper assembly.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
3. **For RH lamp:** Connect multiplug to harness. Fit wheel arch liner extension, secure to bumper valance and liner with screws.
4. Lower vehicle.

Lamp - front fog from 03MY

⊸ ***86.40.96***

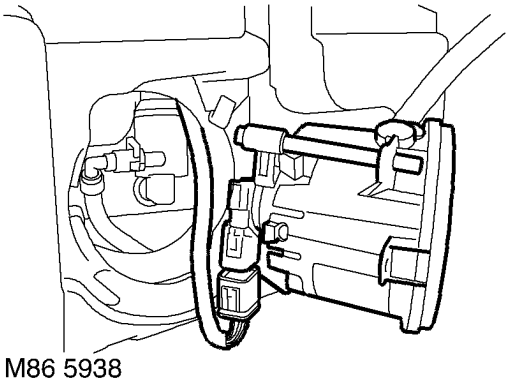
Remove

1. Remove the front bumper finisher.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Trim finisher - bumper - front - from 03MY.**



M86 5937

2. Remove 3 screws securing the fog lamp to the bumper.



M86 5938

3. Disconnect the fog lamp multiplug and remove the fog lamp.

Refit

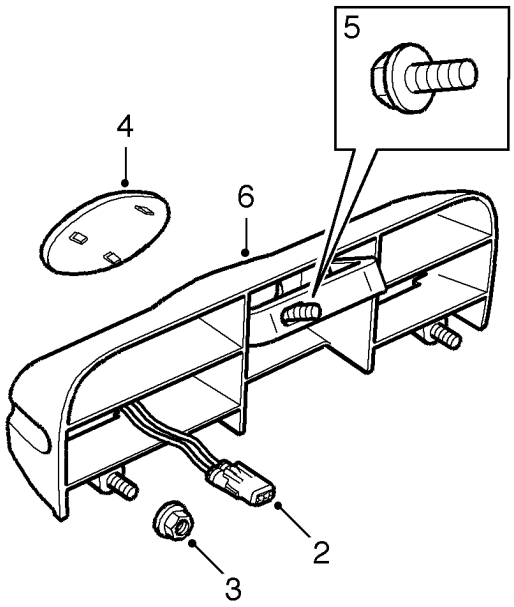
1. Position the fog lamp to the bumper, connect the multiplug and secure with screws.
2. Fit the front bumper finisher.
   ☞ **EXTERIOR FITTINGS, REPAIRS, Trim finisher - bumper - front - from 03MY.**

Housing - number plate lamp

86.40.98

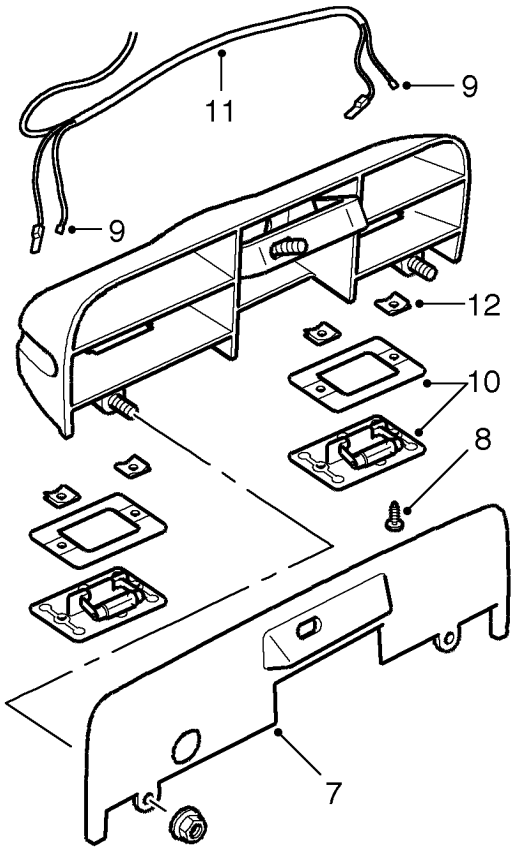
Remove

1. Remove tail door latch and motor.
   DOORS, REPAIRS, Latch and motor - tail door.



M86 4455

2. Disconnect lamps multiplug.
3. Remove 2 nuts securing housing to door.
4. Carefully release and remove Land Rover badge from housing.
5. Remove bolt securing housing to door.
6. Remove housing from door.



M86 4663

7. Remove housing seal.
8. Remove 4 screws securing lamps to housing.
9. Disconnect 4 Lucar connectors from lamps.
10. Remove lamps and lamp seals.
11. Remove lamp harness from housing.
12. Remove 4 speed nuts from housing.

Refit

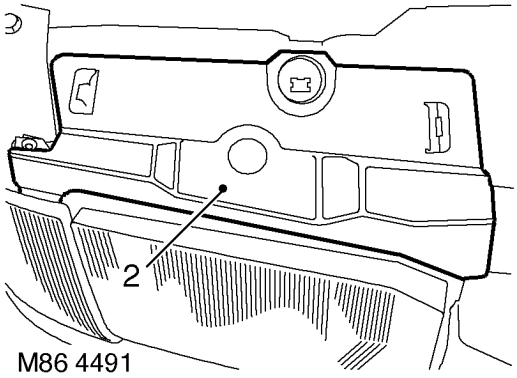
1. Fit 4 speed nuts to housing.
2. Fit lamp harness to housing.
3. Fit lamps and lamp seals.
4. Connect 4 Lucar connectors to lamps.
5. Fit 4 screws securing lamps to housing.
6. Position seal to housing.
7. Position housing and seal to tail door and secure with bolt tightened to 3 Nm (2.2 lbf.ft).
8. Fit Land Rover badge to number plate lamp housing.
9. Fit nuts to number plate housing and tighten to 3 Nm (2.2 lbf.ft).
10. Connect lamps multiplug.
11. Fit tail door latch and motor.
    DOORS, REPAIRS, Latch and motor - tail door.

Motor - headlamp levelling

86.41.16

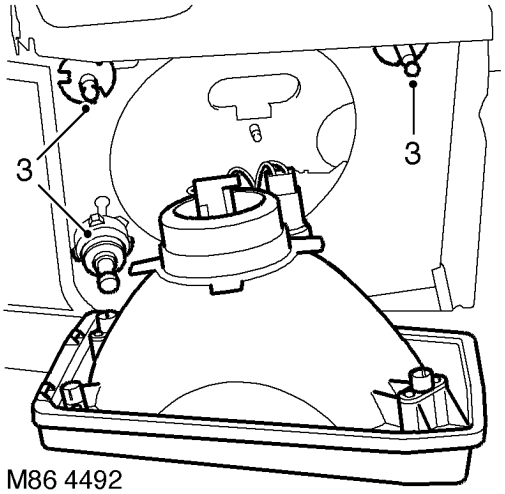
Remove

1. **For RH headlamp levelling motor:** Release fixings and remove battery cover.



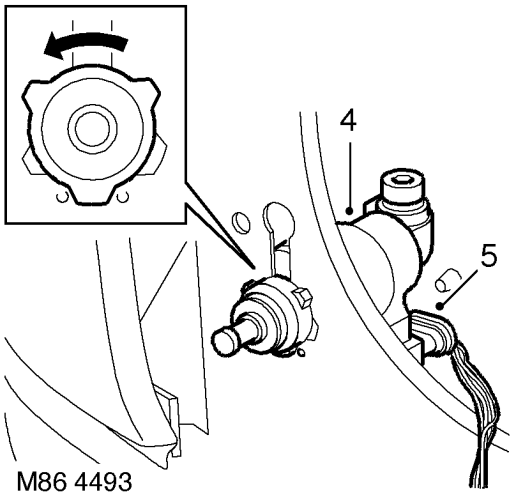
M86 4491

2. Remove headlamp access cover.



M86 4492

3. Release headlamp from adjuster pin sockets.



M86 4493

4. Rotate and remove motor from body panel.
5. Disconnect multiplug from motor.
6. Remove headlamp levelling motor.

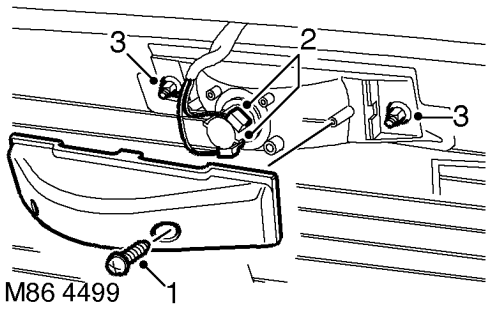
Refit

1. Position new headlamp levelling motor and connect multiplug.
2. Fit motor to body panel.
3. Fit headlamp to adjuster pins.
4. Check headlamp beam alignment.
   ☞ **LIGHTING, ADJUSTMENTS, Headlamps beam alignment - up to 03MY.**
5. Fit headlamp access cover.
6. **For RH headlamp levelling motor:** Fit and secure battery cover with fixings.

Lamp - stop - centre high mounted (CHMSL)

86.41.32

Remove



1. Remove 2 screws securing lamp cover and remove cover.
2. Disconnect Lucar connectors from lamp bulb holder.
3. Remove 2 nuts securing lamp to rear screen and remove lamp.

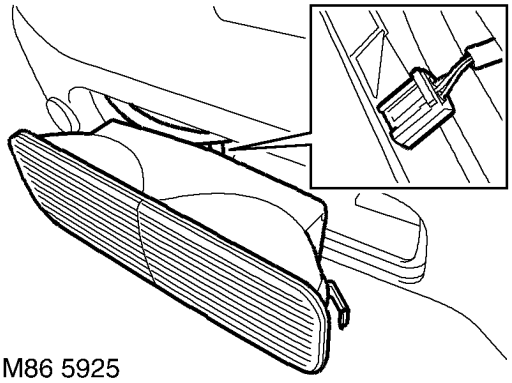
Refit

1. Fit new lamp to screen and secure with nuts.
2. Connect Lucar connectors to lamp bulb holder.
3. Fit lamp cover to lamp and secure with screws.

Lamp - tail/flasher - bumper

86.41.42

Remove


M86 5925

1. Release tail lamp from bumper.
2. Disconnect multiplug and remove lamp.

Refit

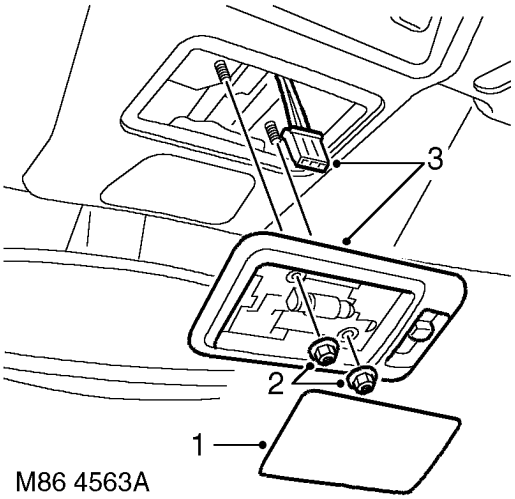
1. Position tail lamp, connect multiplug and secure lamp to bumper.

Lamp - interior - front

86.45.09

Introduction
This procedure is also applicable for removal and fitting of the loadspace lamp.

Remove



M86 4563A

1. Remove interior lamp lens.
2. Remove two nuts securing lamp.
3. Release lamp and disconnect multiplug.
4. Remove lamp.

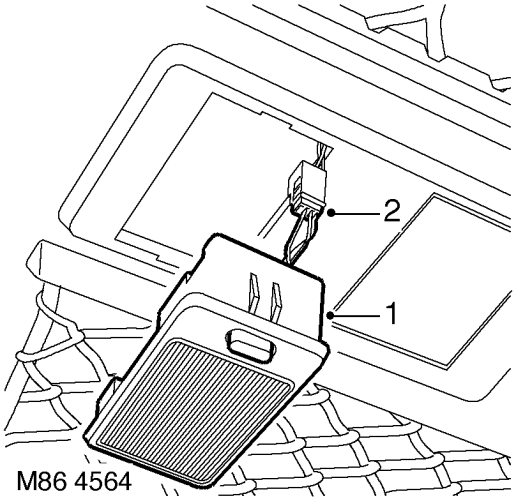
Refit

1. Position new lamp and connect multiplug.
2. Fit lamp and secure with nuts.
3. Fit interior lamp lens.

Lamp - interior - rear

86.45.18

Remove



M86 4564

1. Release lamp from headlining.
2. Disconnect multiplug and remove lamp.

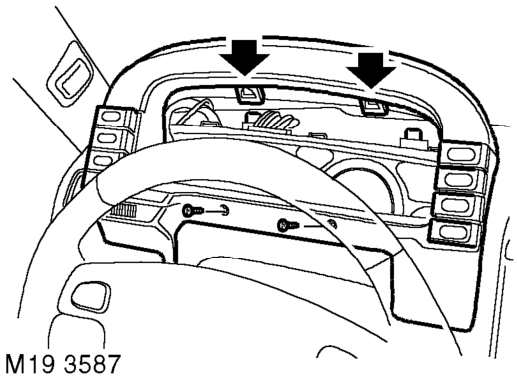
Refit

1. Position interior lamp and connect multiplug.
2. Fit lamp to headlining.

Rheostat - panel lights dimmer

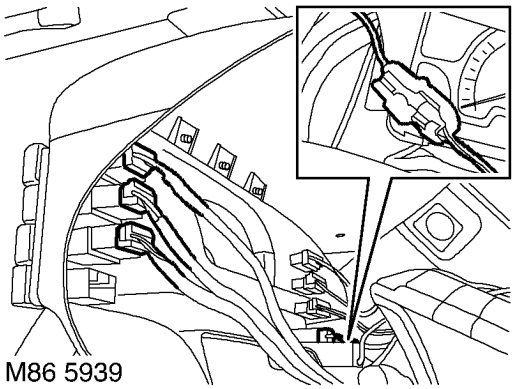
86.65.37

Remove



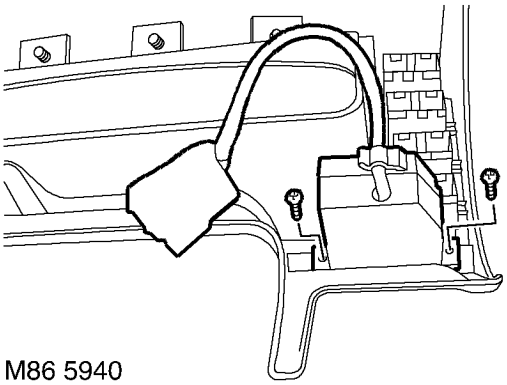
M19 3587

1. Remove 2 screws securing instrument cowl to fascia and release the cowl from the retaining clips.



M86 5939

2. Disconnect 8 multiplugs from the instrument cowl switches.
3. Remove the instrument cowl.



M86 5940

4. Remove 2 screws securing the dimmer switch to the instrument cowl and remove the dimmer switch.

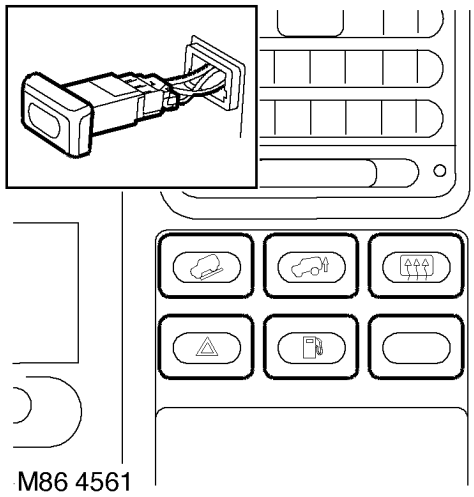
Refit

1. Fit the dimmer switch to the instrument cowl and secure with screws.
2. Position the instrument cowl to the fascia and connect the multiplugs.
3. Fit the instrument cowl to the fascia and secure with screws.

Switch - hazard warning

86.65.50

Remove


M86 4561

1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

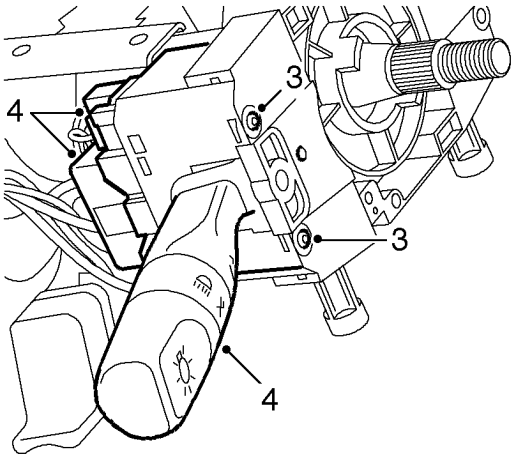
Switch - indicator and exterior lighting - combined

86.65.55

WARNING: Always remove the key from the starter switch, disconnect the vehicle battery and wait 10 minutes before commencing work on the SRS system.

Remove

1. Remove rotary coupler.
   RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.



M86 4490

2. Remove 2 screws securing switch.
3. Carefully raise edge of switch bracket to clear location peg and release switch from bracket.
4. Disconnect 2 multiplugs and remove switch.

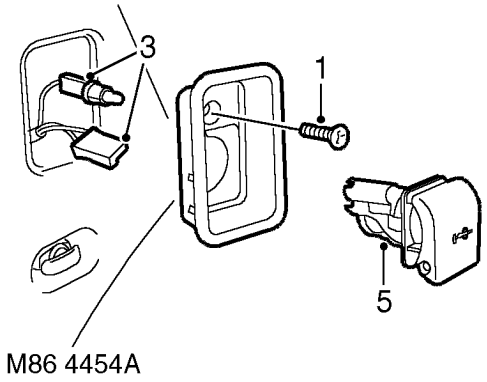
Refit

1. Position switch and connect multiplugs.
2. Fit switch to bracket and secure with screws.
3. Fit rotary coupler.
   RESTRAINT SYSTEMS, REPAIRS, Rotary coupler.

Socket - accessory

86.65.62

Remove



M86 4454A

1. Remove screw securing accessory socket escutcheon to loadspace side trim casing.
2. Release accessory socket assembly from trim casing.
3. Disconnect multiplug and bulb from accessory socket.
4. Remove accessory socket.
5. Release bulb holder from accessory socket. Release accessory socket from escutcheon.

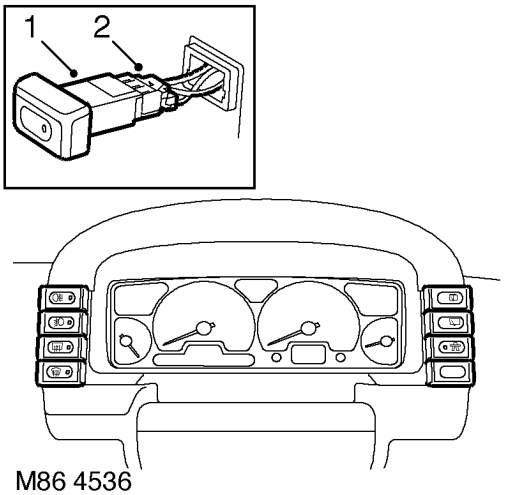
Refit

1. Fit accessory socket to escutcheon.
2. Fit bulb holder to accessory socket.
3. Position accessory socket to trim casing and connect multiplug and bulb.
4. Fit accessory socket to trim casing and secure with screw.

Switch - front/rear fog lamps

86.65.65

Remove



M86 4536

1. Carefully remove switch from instrument cowl.
2. Disconnect multiplug and remove switch.

Refit

1. Position switch and connect multiplug.
2. Carefully push switch into instrument cowl.

Description

General

The Body Control Unit (BCU) is located behind the passenger glovebox and is connected to the main harness by four connectors on its bottom edge and an additional connector located on the side of the BCU casing. Mounting the BCU behind the fascia makes it reasonably inaccessible for intruders to disable the anti-theft system.

The BCU uses solid-state microprocessor control to perform logical operations and timing functions for a variety of the vehicle's electrically operated systems, these include:

- Door locking.
- Anti-theft alarm and immobilisation system.
- Exterior lighting including direction indicators and hazard warning lamps.
- Courtesy lighting.
- Wipers and washers.
- Electric windows and sunroof.
- Heated windows.

The BCU also communicates with several other electronically controlled systems such as the EAT ECU and SLABS ECU and also has a datalink between the Intelligent Driver Module (IDM) and the instrument pack. The datalink is a low speed bus capable of transmitting and receiving messages at a data rate of 10,400 bits per second. Additional inputs and outputs to peripheral devices are included which are necessary for determining vehicle status for particular logical operations e.g. crank, ignition key inserted, fuel flap enable etc.

The BCU receives its power supply from the engine compartment fuse box, and is protected by a 10 A fuse.

The BCU communicates with the IDM to provide the control signals to perform power switching operations in conjunction with dedicated relays.

IDM

The IDM is integrated into the passenger compartment fuse box, which is mounted behind the fascia below the steering column. There are no harnesses between the fuse box and the IDM. The IDM performs the power switching operations for several of the vehicle's electrical systems.

The IDM communicates with the BCU and the instrument pack via a serial interface. If the BCU or the IDM is replaced, the communications link between the two units has to be re-established. This can be done either by switching on the ignition and leaving it on for five minutes, or by using TestBook. The vehicle immobilisation will remain active until the communications link between the BCU and IDM has been re-established.

Transit mode

To prevent excessive battery drain during transit to overseas markets, the vehicle is placed in a transit mode. The following functions are disabled when the vehicle is in transit mode:

- Volumetric sensors.
- Passive immobilisation.
- Immobilisation of the vehicle by use of door lock.
- Ignition key interlock.
- Electric seat enable time-out with driver's door open.

Power supply
Battery supply to the BCU and the IDM is provided through a 10 A fuse located in the engine compartment fuse box.

The BCU unit receives an ignition switched power supply (ignition switch position II) input via a 10 A fuse in the passenger compartment fuse box.

The BCU receives a signal when the ignition switch is turned to the crank position, it then supplies an earth path to the starter relay coil, to enable the crank operation by supplying power through the starter relay contacts to the starter motor.

Battery voltage is monitored and BCU operation will function normally between 8 and 18 volts. Between 5.7 and 8 volts the BCU is in the 'under volts' state. The status of the battery is used to determine which outputs may be driven.

If a voltage supply above 18 volts is experienced, outputs will not normally be driven except for those functions which are required during cranking (robust immobilisation, antenna coil, crank enable relay and feed to gear position switch contacts W, X, Y, Z). In the over voltage state the vehicle can be driven, but all other functions are disabled and outputs are switched off (power windows, heated screen, direction indicators etc.).

All functions are disabled on power up until communications between the BCU and IDM have been established. If communications cannot be established, operation will commence with degraded functionality.

Battery supply to the IDM is provided through the inertia switch and a 10 A fuse in the engine compartment fuse box. If the inertia switch contacts are closed battery voltage is available at the IDM; if the inertia switch contacts are open there is no battery supply to the IDM. The supply condition of the IDM is signalled to the BCU via the serial bus. If the inertia switch is operated (contacts open) the change in state is detected by the BCU which unlocks the doors if the ignition switch is in position II and the alarm is not set.

The BCU is earthed through a hard-wire connection.

Inputs and outputs
The BCU and IDM process inputs and provide the necessary outputs for control and operation of the vehicle's 'body' systems.

BCU inputs
The BCU processes signals received from the following components:
- Door latch switches.
- Driver's door key lock/ unlock switches.
- Bonnet activated security system.
- Volumetric sensors.
- Central Door Locking (CDL) switches.
- Remote transmitter (via receiver unit).
- Inertia fuel cut-off switch.
- Ignition switch.
- Fuel flap release switch.

The input voltages (V_{in}) for BCU digital signals are defined as follows:
- Logic 1 when $V_{in} \geq 6V$.
- Logic 0 when $V_{in} \leq 2V$.

BCU input voltages between 2 and 6 volts are indeterminate and cannot be guaranteed.

Analogue input voltages are measured as a ratio with respect to battery voltage.

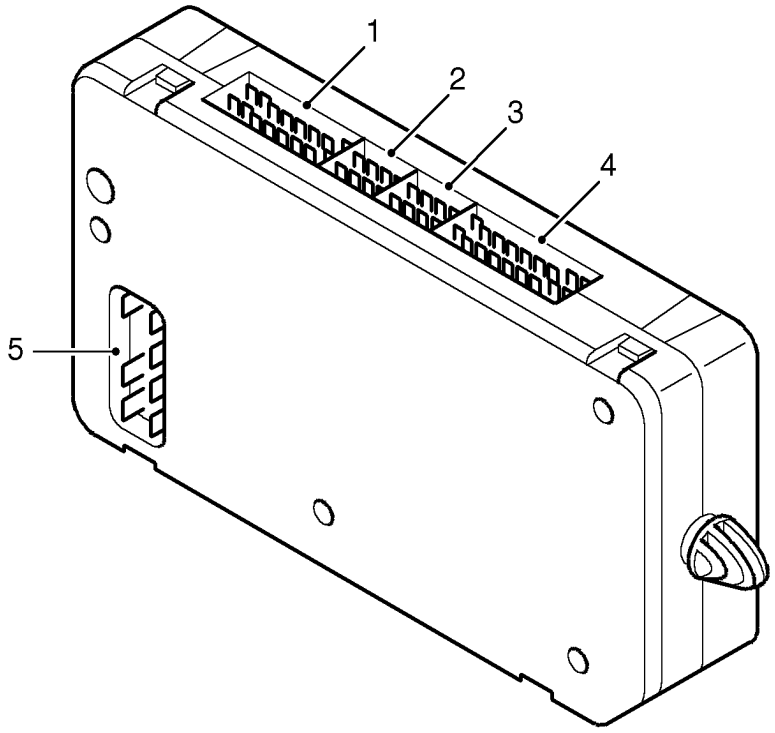
BCU outputs

The BCU processes the input signals it receives and uses the information to determine the control outputs that need to be established for any given set of conditions. The BCU provides controlled outputs for the following systems:

- Interior courtesy lamps.
- Fuel flap release actuator.
- Anti-theft status LED.
- Engine Control Module.
- Door lock actuators.
- Direction indicators and hazard warning lamps.
- Headlamps.
- Alarm sounder.
- Vehicle horns.
- Battery backed sounder.
- Starter relay.
- Passive re-mobilisation exciter coil.

Simultaneous switching of outputs in different units is limited by the bus transfer time, but the skew is no longer than 100 ms for either the BCU or the IDM. When the processor is reset, all outputs are switched off until the inputs have been read for the first time to check current condition.

BCU to harness connectors

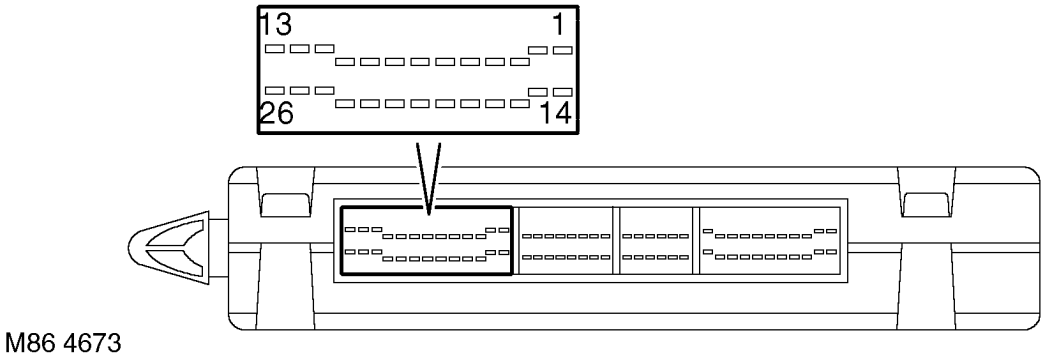


M86 4672

1 Connector C0661
2 Connector C0662
3 Connector C0663
4 Connector C0660
5 Connector C0664

The pinout details for the BCU connectors are defined below:

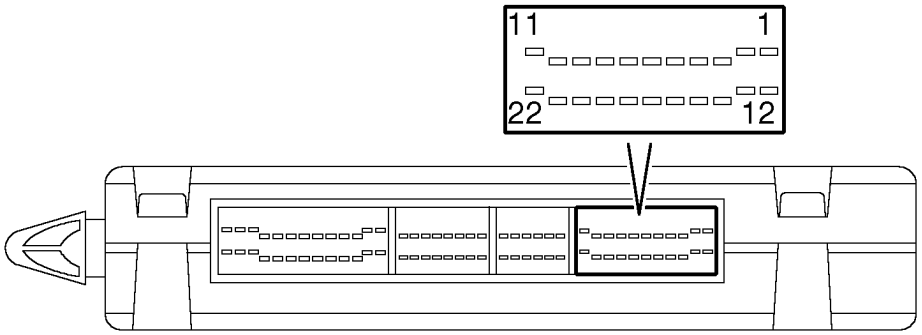
C0660 connector pin details



M86 4673

Pin No.	Description	Input/Output
1	Ignition power supply	Input
2	Right front window - down	Input
3	Auxiliary power supply	Input
4	Passenger or rear door open	Input
5	Driver's door key lock	Input
6	RH indicator selected	Input
7	Front fog lamps selected	Input
8	Gear position feedback 'R'	Output
9	Gear position feedback 'P'	Output
10	SLS too high (audible warning)	Input
11	Earth	-
12	Vehicle raise/lower request	Output
13	Battery power supply	Input
14	Heated front screen selected	Input
15	Bonnet open	Input
16	CDL doors lock	Input
17	Driver's door open	Input
18	Left front window up	Input
19	Right front window up	Input
20	Rear washer pump	Input
21	Front intermittent wiper switch	Input
22	Gear position feedback '1'	Output
23	Gear position feedback '2'	Output
24	Gear position feedback '3'	Output
25	Gear position feedback 'D'	Output
26	Gear position feedback 'N'	Output

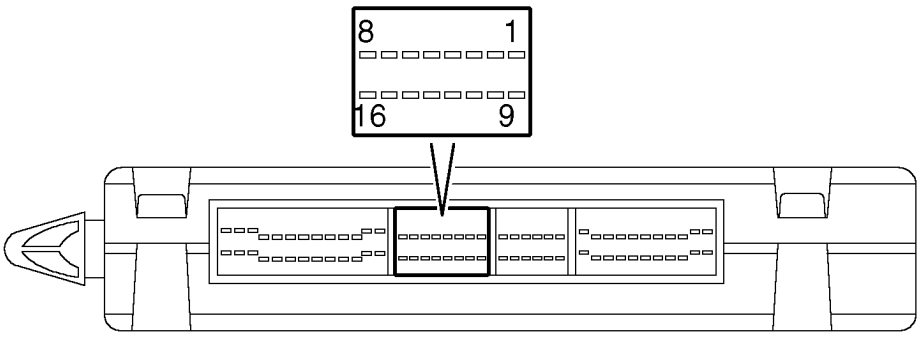
C0661 connector pin details



M86 4674

Pin No.	Description	Input/Output
1	Serial bus to instrument pack and IDM	Input/Output
2	Not used	-
3	Battery backed up sounder code (AL)	Output
4	Diagnostic bi-directional 'K'-line	Input/Output
5	RF regulated power supply	Output
6	RF receiver input	Input
7	Brake switch activated	Input
8	Reverse gear selected	Input
9	Sunroof enable line	Output
10	Robust immobilisation	Output
11	Front washer pump	Input
12	Heated front screen relay	Output
13	Heated front screen active	Output
14	Battery backed up sounder code (ST)	Output
15	Heated rear screen active	Output
16	'N' or 'R' or 'P' or brake selected	Output
17	Not used	-
18	Passive remobilisation exciter coil	Output
19	RF battery supply from fuse 20 in passenger compartment fusebox	Input
20	Security status LED	Output
21	Front intermittent wiper	Input
22	Driver's door key unlock	Input

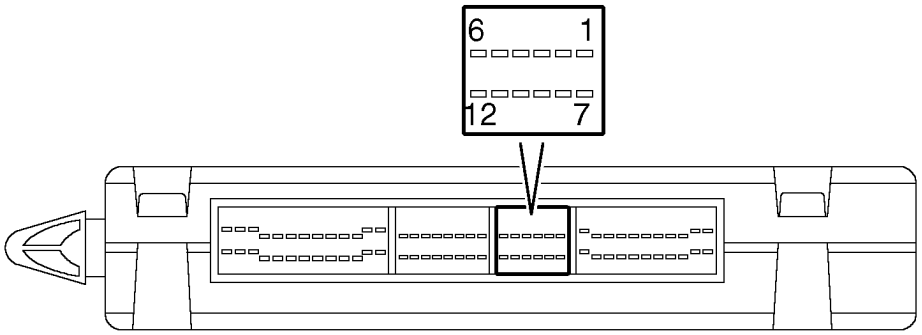
C0662 connector pin details



M86 4675

Pin No.	Description	Input/Output
1	Front left window - down	Input
2	Ignition key inserted	Input
3	Rear wiper	Input
4	Vehicle horns	Input
5	Crank enable	Output
6	Gear position switch (Y contacts)	Input
7	CDL doors unlock	Input
8	Rear fog lamps selected	Input
9	Gear position switch (W contacts)	Input
10	Drive selected (HDC)	Output
11	Ignition key interlock solenoid	Output
12	Headlamp powerwash	Output
13	Gear position switch (X contacts)	Input
14	Not used	-
15	Transfer box - neutral selected	Input
16	Seat buckle fastened	Input

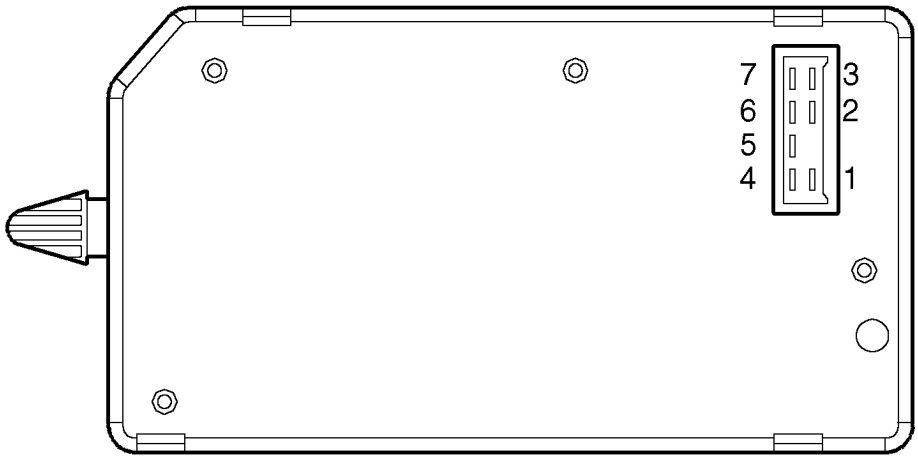
C0663 connector pin details



M86 4676

Pin No.	Description	Input/Output
1	Crank selected	Input
2	LH direction indicator selected	Input
3	Driver/Passenger seat enable	Output
4	Front fog lamps	Output
5	Heated rear screen selected	Input
6	Ultrasonic input	Input
7	Gear position switch (Z contacts)	Input
8	Ultrasonic power supply	Output
9	Courtesy lamps	Output
10	Feed to gear position switch (W, X, Y, Z contacts)	Output
11	Park/Neutral selected	Input
12	Hazard warning lamps	Input

C0664 connector pin details



M86 4677

Pin No.	Description	Input/Output
1	Front left window down	Output
2	Front right window down	Output
3	Fuel flap release	Output
4	Front left window up	Output
5	Earth	-
6	Front right window up	Output
7	Battery power supply	Input

IDM inputs

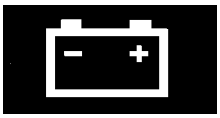
The IDM inputs are communicated to the BCU using the serial datalink so that the BCU can perform the necessary logic operations:

The V_{in} for IDM digital signals are defined as follows:

- Logic 1 when $V_{in} \geq 8V$.
- Logic 0 when $V_{in} \leq 2V$.

IDM input voltages between 2 and 8 volts are indeterminate and cannot be guaranteed.

Description	Signal type	System
Inertia switch	Digital	Locking/ Unlocking/ Alarm
Side lamps	Digital	Exterior lighting
Headlamp dipped beam	Digital	Exterior lighting
Headlamp main beam daylight running lamps	Analogue	Exterior lighting
RH direction indicators current sense	Analogue	Direction indicators/ Hazards/ Alarm
LH direction indicators current sense	Analogue	Direction indicators/ Hazards/ Alarm
Front wiper park sense	Digital	Wipers and washers

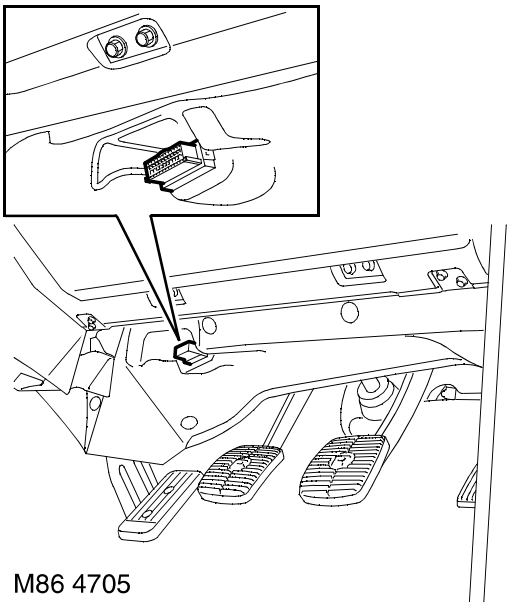


IDM outputs

The IDM receives the following signals from the BCU using the serial datalink to provide power outputs:

Description	Signal type	System
Unlock all doors enable	Digital	Locking/ Unlocking/ Alarm
Lock passenger and rear doors enable	Digital	Locking/ Unlocking/ Alarm
Superlock all doors enable	Digital	Locking/ Unlocking/ Alarm
Lock driver's door	Digital	Locking/ Unlocking/ Alarm
Rear fog lamps enable	Digital	Exterior lighting
Daylight running lamps enable	Digital	Exterior lighting
LH direction indicators enable	Digital	Direction indicators/ Hazard warning/ Alarm
RH direction indicators enable	Digital	Direction indicators/ Hazard warning/ Alarm
Gear position indicator illumination	Digital	Illumination
Headlamp main beam indicator disable	Digital	Illumination
Front wiper enable	Digital	Wipers and washers
Rear wiper enable	Digital	Wipers and washers
Rear window enable	Digital	Power windows
Shift lever solenoid enable	Digital	Automatic gearbox
Transfer box solenoid enable/ Alarm sounder relay	Digital	Gearbox
Heated rear window enable	Digital	Heated screens

Diagnostic socket



M86 4705

RHD illustrated

The BCU has a serial connection to the diagnostic socket to allow unit interrogation using TestBook.

In addition to fault diagnosis, the BCU can be programmed with the following information:

- Plip codes.
- Options.
- VIN code.
- EKA code.
- EEPROM locking.

The following manufacturing details are programmed into the BCU which can be accessed using TestBook:

- Date of manufacture.
- Hardware version number.
- Unit serial number.
- Odometer reading.

It is not possible to use the diagnostic bus to communicate with the BCU via TestBook when the security system is active (except for passive immobilisation). This is a security measure to ensure that no key programming or market configuration can take place if the operator is not in possession of a valid remote transmitter or the vehicle keys.

The BCU is normally programmed to accept two remote transmitters, but a further two remote handsets can be programmed into the BCU and one optional Self Levelling Suspension (SLS) transmitter. All remote transmitters need to be available if TestBook is to be used to re-configure the BCU.

Programmable options

The BCU can be programmed with a number of options to satisfy specific market requirements and customer preferences. The options can be set using TestBook.

Function	Option	Details
Transmission	Manual	The vehicle is fitted with manual transmission.
	Automatic	The vehicle is fitted with automatic transmission.
Front fog lamps	None	The vehicle is not fitted with front fog lamps.
	Main	The front fog lamps will operate if the headlamps are on main beam.
	No main	The front fog lamps will not operate if the headlamps are on main beam.
Interlocks	None	The vehicle is not fitted with key, shift or transfer box interlocks.
	Shift	The vehicle is fitted with key, shift and transfer box interlocks.
	No transfer	The vehicle is fitted with key and shift interlocks, but not a transfer box interlock.
Daylight running lamps	None	The vehicle is not fitted with daylight running lamps.
	No main	The daylight running lamps are on if the headlamp main beams are off.
	No heads	The daylight running lights are on with headlamp main and dipped beams off and the gearbox not in Park.
Programmed wash/ wipe	Normal	The front wipers operate if the front wash is operated.
	No wipe	The front wipers do not operate if the front wash is operated.
Key-in warning	Disabled	The ignition key in audible warning is disabled.
	Enabled	The ignition key in audible warning is generated if the ignition key is in and the driver's door is open.
Electric front seats	None	The vehicle is not fitted with electric front seats.
	Normal	Electric seat adjustment is available for 45 seconds after the driver's door opens or if the ignition is on.
	Ignition II	Electric seat adjustment is available if the ignition is on.
Electric front windows	Driver cancel	The front windows will be disabled 44 seconds after the driver's door is opened.
	All cancel	The front windows will be disabled 44 seconds after any door is opened.
	No cancel	The front windows will be disabled when the ignition is turned off.
Heated front screen	Fitted	The vehicle is fitted with heated front screens.
	None	The vehicle is not fitted with heated front screens.
Rear windows and sunroof	Driver cancel	The rear windows and sunroof will be disabled 44 seconds after the driver's door is opened.
	All cancel	The rear windows and sunroof will be disabled 44 seconds after any door is opened.
	No cancel	The rear windows and sunroof will be disabled when the ignition switch is turned off.
Gear position indicator illumination	Always	The automatic gearbox selector illumination is on when the ignition is on.
	Sidelights	The automatic gearbox selector illumination is on when the ignition is on and the sidelights are off.
Hill descent control	None	The vehicle is not fitted with hill descent control.
	Fitted	The vehicle is fitted with hill descent control.
Courtesy headlamps	Disabled	The vehicle is not fitted with courtesy headlamps.
	Enabled	The vehicle is fitted with courtesy headlamps.
Odometer error warning	Disabled	The odometer will not flash if there is an odometer error.
	Enabled	The odometer will flash if there is an odometer error.

Function	Option	Details
Seatbelt warning lamp	Timed	The warning lamp is on for 6 seconds after the ignition is turned on.
	Buckle	The warning lamp is on for 6 seconds after ignition is turned on or until the buckle is fastened.
	Ignition II	If the buckle is unfastened when the ignition is turned on then the warning lamp comes on for 6 seconds.
	Disable	The warning lamp is not used.
Seatbelt audible warning	Timed	The audible warning is on for 6 seconds after the ignition is turned on.
	Buckle	The audible warning is on for 6 seconds after the ignition is turned on or until the buckle is fastened.
	Ignition II	If the buckle is unfastened when the ignition is turned on then the audible warning is on for 6 seconds.
	Disable	The audible warning is not used.
Bulb failure warning	Disabled	Direction indicator bulb failure detection is disabled.
	Enabled	Direction indicator bulb failure detection is enabled.
Superlocking	None	Superlocking is not available.
	Double	The vehicle will superlock on a double press of the remote transmitter or double key turn.
	Single	The vehicle will superlock on a single press of the remote transmitter or a single key turn.
	No key	The vehicle will superlock on a single press of the remote transmitter but not with the key.
Door unlocking	Not SPE	The SPE (Single Point Entry) function is not used. All doors unlock on a remote transmitter press.
	SPE	Only the driver's door unlocks on the first remote transmitter press, all other doors on the second press.
Alarm disarming	Always	Operation of the key in the driver's door always disarms the vehicle.
	Key only	Operation of the key in the driver's door only disarms the vehicle if it was locked with the key.
	Key never	The security system is not disarmed by the key (except for EKA).
Inertia switch	No hazards	Operation of the inertia switch does not operate the hazard warning lamps.
	Hazards	Operation of the inertia switch operates the hazard warning lamps.
Speed locking	Disabled	Speed related locking is disabled.
	Enabled	Speed related locking is enabled. The door locks are disabled when the vehicle is moving.
Volumetric sensing	Disabled	Volumetric sensing is disabled.
	Enabled	Volumetric sensing is enabled.
Alarm	Disabled	The vehicle is not fitted with a security system.
	Enabled	The vehicle is fitted with a security system.
Passive immobilisation	Disabled	Passive immobilisation is disabled.
	Enabled	Passive immobilisation is enabled.
Hazard warning lamps	Disabled	The hazard warning lamps do not flash on security system arm, disarm or trigger.
	Enabled	The hazard warning lamps flash on security system trigger only.
	All	The hazards flash on security system arm, disarm and trigger.
Mislocking audible warning	Disabled	Mislock audible warnings are disabled.
	Enabled	Mislock audible warnings are enabled.

Function	Option	Details
Alarm sounder	Alarm	Audible warnings are given by the security system sounder only.
	Both	Audible warnings are given by both the security system sounder and the vehicle horn.
	Vehicle	Audible warnings are given by the vehicle horn only.
	BBUS	Audible warnings are given by the security system sounder, vehicle horn and BBUS.
	Disabled	Audible warnings are not given.
Acclimatisation locking	Disabled	The vehicle cannot be locked if the ignition is on.
	Enabled	The vehicle can be locked if the ignition is on and the engine is running.
Alarm tamper	Disabled	The security system LED does not flash when the security system has been tampered with.
	Enabled	The security system LED flashes when the security system has been tampered with.
Engine immobilised	LED off	The security system LED does not flash when the engine is immobilised.
	LED flash	The security system LED flashes when the engine is immobilised.
Low battery warning	Disabled	The security system LED does not flash when the remote transmitter battery is low.
	Enabled	The security system LED flashes when the remote transmitter battery is low.
Emergency Key Access (EKA)	Disabled	EKA is disabled.
	Enabled	EKA is enabled and the door locks operate electrically.
	No unlock	EKA is enabled, but the door locks do not operate electrically.

Anti-theft system

The BCU controls the logical switching operations for enabling and activating the anti-theft system. Features include:

- Perimetric protection – monitors the condition of doors and hinged panels.
- Volumetric protection – monitors the vehicle's interior space.
- Remote locking, superlocking and unlocking functions.
- Engine immobilisation and remobilisation.
- Advanced mislock detection and automatic compensation.
- EKA code functions.
- Customer configuration options.
- Market configuration options.

Immobilisation

The immobilisation system comprises the following components:

- RF receiver.
- RF transmitter/ transponder.
- Transponder coil.
- BCU.
- Door switches, door lock switches and bonnet switch.
- IDM.
- ECM.
- Starter solenoid relay.
- Status LED.

Alarm system

The alarm system comprises the following components:

- RF receiver.
- RF transmitter.
- BCU.
- IDM.
- Door switches, door lock switches and bonnet switch.
- Battery backed-up sounder (BBUS).
- Status LED.

On non NAS vehicles, power supply for the alarm sounder and the battery BBUS is provided through two relays in the passenger compartment fuse box. Each of the coils of the alarm relays are directly connected to the IDM which controls their operation under the direction of BCU signals received via the serial data bus.

On NAS vehicles, an audible warning is provided through operation of the vehicle horns. The BCU provides an earth path for the coil of the horn relay to initiate vehicle horn operation.

☞ **ALARM SYSTEM AND HORN, DESCRIPTION AND OPERATION, Description.**

Central Door Locking (CDL)

The BCU carries out the logic control operation for CDL. A CDL switch is mounted on the fascia panel and has two inputs to the BCU, one for lock and one for unlock.

Door locking and unlocking can be performed using the remote transmitter in the keys and the receiver unit located above the vehicle's headlining, behind the rear sunroof aperture. The receiver detects the signals sent from the remote transmitter and sends a decoded signal to the BCU for processing.

Four methods of door locking are available:

- Remote handset locking.
- Vehicle key locking.
- CDL switch locking.
- Speed related locking.

Two security levels of door locking are available, CDL and Superlocking. The anti-theft alarm system works in conjunction with the CDL system.

Electric windows and sunroof

The BCU controls the logical operations and the timing periods for the electric front windows. The rear windows are hard-wired and the two electric sunroofs are controlled by a dedicated ECU which is enabled by the BCU.

The front windows are electrically operated using two rocker switches located in the centre console. Electric motors are located in each of the front doors.

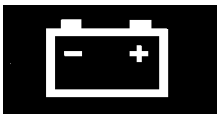
The rear windows are enabled by the IDM controlling the operation of the rear window relay located in the passenger compartment fuse box.

Wipers and washers

The wiper and washer functions are controlled by the BCU and the IDM.

The front wipers and washers are operated from the switch stalk located on the right hand side of the steering column and only operate when the ignition switch is in position I or II. The front wipers are operated by a motor located below the windscreen plenum.

☞ **WIPERS AND WASHERS, DESCRIPTION AND OPERATION, Description.**



The BCU controls the wiper motor frequency of operation via the IDM when intermittent wipe or wash is selected. The front intermittent wipe option features five different intermittent delay periods. The shortest delay period is 3 seconds and this is increased by 2 second increments up to a maximum delay of 11 seconds. The desired delay period for the front wipers is set by the position of the rotary switch located on the wiper column stalk.

The rear wiper switch is located on the instrument pack cowl and is latched when pressed. The rear wiper electric motor is located in the tail door. The rear wiper operation is controlled according to a programmed strategy via the BCU and the IDM. The BCU also checks for a signal from either the reverse lamp switch located in the vehicle gearbox (manual gearbox models) or the gear position switch (automatic gearbox models) for operating the rear wipers when the vehicle is in reverse. The rear wiper and washer only operate when the ignition switch is in position II.

The front and rear washer pumps and the headlamp powerwash (where fitted) are also controlled through the BCU. The washers are operated from electric pumps attached to the washer reservoir located in the left hand wheel arch. The front wash switch is located on the wiper column stalk and is pulled towards the steering wheel to select the washer function. When the front washers are operated, the wipers are also activated for three full cycles. The rear wash switch is located on the instrument pack cowl. The BCU programme can be configured in one of two modes of operation:

- No wiper operation when the wash switch is pressed.
- Wiper action after an initial delay of 400 ms.

Headlamp wash is activated by the BCU via the IDM and operates when the headlamps are on and the front washers function is selected.

Electric seats

The BCU controls the logical operation of the electrically operated front seats. Two modes of operation are available:

☞ **SEATS, DESCRIPTION AND OPERATION, Description - electric seats.**

- Electric seat adjustment is enabled if the ignition is on or the driver's door is opened for a short time period.
- Electric seat adjustment is enabled if the ignition is on and the driver's door is closed.

The seats are operated by four electric motors which control the seat cushion rear up/ down, the seat cushion front up/ down, seat cushion forward/ rearward and seat squab recline. The electrically powered lumbar adjustment in each seat is operated by a single motorised air pump and a solenoid located on the seat squab frame. The air pump inflates a cushion in the seat squab and the solenoid operates a valve to deflate the cushion. The seat squab and cushion may also contain heater elements to provide heated seat operation.

The switches for electrically operated seats are located either side of the centre console.

Direction indicators and hazard warning lamps

The direction indicator lamps are operated from a three position direction indicator switch on the left hand, steering column stalk. The BCU only allows the lamps to work as direction indicators when the ignition switch is in position II. The BCU also controls the lamps to operate as hazard warning lamps and as a visual warning for the anti-theft system, in which cases all lamps flash simultaneously irrespective of the ignition switch position.

System control of the direction indicators and hazard warning lamps is provided by the BCU operating with the IDM and two electronic relays located in the passenger compartment fuse box. The IDM and relays are integral parts of the passenger compartment fuse box and cannot be serviced individually. The serial data bus is used for communication of status and operation requests between the BCU, IDM and instrument pack.

The hazard warning lamps are operated from a latching pushbutton switch located on the fascia.

All direction indicator/ hazard warning lamp bulbs are rated at 5 Watts.

Headlamps
The BCU contains a feature which allow the vehicle headlamps to be turned on when the remote transmitter is pressed (courtesy headlamps).

For markets with daylight running lamps, the BCU controls the logical operation of the daylight running lamps. Options are daylight running lamps are on if the main beam headlamps are off, or the daylight running lamps are on with main and dipped beam off and the gearbox not in Park.

Front fog lamps
For markets with front fog lamps fitted, the BCU controls the operation of the front fog lamps. Options can be selected so that the fog lamps will operate with or without the headlamps on main beam.

Instrument pack
The BCU communicates with the instrument pack via a serial data bus.

☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

- The instrument pack provides the BCU and IDM with details of vehicle speed.
- Signals are provided from the IDM to the instrument pack and BCU when the direction indicator lamps are active.
- For certain markets, the BCU provides a signal to the instrument pack for indicating when the transfer box is in neutral.
- The IDM can signal the instrument pack to illuminate a trailer warning lamp. This operates when the IDM senses that the current drawn by the indicator circuit exceeds a preset threshold.
- The odometer reading displayed on the instrument pack LCD screen is also stored in non volatile memory in the BCU. Whenever the ignition is turned from position I to position II, the instrument pack and the BCU compare their stored values.
- The gear selector position is displayed on the instrument pack LCD screen under the direction of the BCU.

Starting
The starting system comprises a starter motor and solenoid located at the rear right hand side of the engine. A starter relay controlled by the BCU is used to supply battery power for starter solenoid operation. The starter motor receives its feed directly from the battery.

Cruise control
The BCU processes several signals used for cruise control:

- When the brake pedal is pressed, a low voltage brake lamp signal is sent via the BCU to the cruise control ECU.
- The gear position switch sends an input via the BCU to the cruise control ECU if the selector lever is in Park, Neutral or Reverse.
- A voltage supply is fed from the BCU to the cruise control SET+ switch.
- A voltage supply is fed from the BCU to the cruise control RES switch.

On vehicles with automatic transmission, if the BCU receives an input from the gear position switch or the brake pedal switch, the BCU sends a signal to the cruise control ECU to cancel or inhibit cruise control operation.

☞ **ENGINE MANAGEMENT SYSTEM - Td5, DESCRIPTION AND OPERATION, Description.**
☞ **ENGINE MANAGEMENT SYSTEM - V8, DESCRIPTION AND OPERATION, Description - cruise control.**

Shift interlock (where fitted)
On automatic gearbox models, the BCU and IDM combine with an interlock relay located in the passenger compartment fuse box to operate a shift interlock solenoid, so that the gear selector lever cannot be moved out of Park until certain logical conditions have been satisfied. Operation of the interlock may be affected, if the battery becomes discharged.

☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Description.**

Ignition key interlock (where fitted)
On automatic gearbox models, the ignition key interlock solenoid prevents removal of the ignition key from the ignition switch when the transmission gear selector is not in the Park position. The logic control operation for this is performed by the BCU.

Transfer box interlock (where fitted)
On automatic gearbox models, a transfer box interlock solenoid is controlled by the IDM to prevent transfer box shift lever being moved out of high or low range unless certain conditions have been satisfied. The IDM controls the operation of the transfer box relay which is located in the passenger compartment fuse box.

☞ **TRANSFER BOX - LT230SE, DESCRIPTION AND OPERATION, Description.**

Gear position switch
A gear position switch is located on the automatic gearbox and is used to inform the BCU of the gear selector lever position. The BCU has four sensing inputs from the gear position switch contacts W, X, Y, Z, which are used to determine the gearbox drive status at any particular instance. The BCU gives an output corresponding to the gearbox status derived from the gear position switch inputs. The logic states defining the gear selector positions are listed in the table below, where Z1, Z2, Z3 and Z4 represent intermediate states which exist as the selector lever position is changed:

Gear position	Switch contacts			
	W	X	Y	Z
P (Park)	1	0	0	0
Z1	1	1	0	0
R (Reverse)	0	1	0	0
Z1	1	1	0	0
N (Neutral)	1	1	1	0
Z2	1	0	1	0
D (Drive)	1	0	1	1
Z3	1	1	1	1
3	0	1	1	1
Z4	0	0	1	1
2	0	0	0	1
Z4	0	0	1	1
1	0	0	1	0

The existence of an intermediate state causes a fault code to be detected by the BCU. To reduce the chances of the fault condition occurring while changing selector lever position, the inputs are debounced and only considered valid when they have existed for at least 33 ms.

Transmission neutral selector
The transmission neutral sensor provides an earth signal to the BCU when the transfer box is in neutral. The earth signal causes the BCU to operate an audible warning when the transfer box is in neutral with the ignition switched on.

☞ **TRANSFER BOX - LT230SE, DESCRIPTION AND OPERATION, Description.**

Self levelling suspension and ABS
The BCU communicates with the SLABS ECU for several functions:

- An output is provided from the SLABS ECU to the BCU to provide the logic conditions for issuing the SLS audible warning.
- The BCU receives an input from the SLABS ECU relating to the raise/ lower command from the remote handset.

☞ **REAR SUSPENSION, DESCRIPTION AND OPERATION, Description - SLS.**

Hill descent control
The BCU provides an output signal to the SLABS ECU for automatic transmission in neutral for HDC control. The BCU checks the status of the ignition and 'gearbox state' inputs and provides a 'Neutral selected' output. If the ignition is on and 'gearbox state' is Neutral, the 'Neutral selected' output is on, otherwise 'Neutral selected' is off.

☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**

Heated screens
The Heated Front Screen (HFS) is fitted for some market destinations and is operated from a non-latching switch located on the instrument pack cowl. The BCU will only allow the heated front screen to operate when the engine is running and controls the time-out period for switching the circuit off.

The heated front screen operation can also be controlled from the Automatic Temperature Control (ATC) ECU on vehicles fitted with air conditioning.

The heated rear window will only function when the engine is running, and is operated by a non-latching switch on the instrument pack cowl. The heated rear window can also be operated by the ATC ECU on vehicles fitted with air conditioning.

Interior courtesy lamps
The BCU controls the operation of the interior courtesy lamps. The courtesy lamps are situated in the front, mid and rear areas of the headlining.

Fuel flap actuator
The BCU provides an earth path to the fuel flap release solenoid to allow the fuel filler flap to be opened. This is only allowed if the alarm system is not set and all other conditions have been satisfied. The fuel flap release switch is located in the fascia switch pack and it receives a voltage supply from the passenger compartment fuse box.

Audible warnings
The BCU can request the instrument pack to generate an audible warning in response to conditions it has detected and which need to be drawn to the driver's attention. One of six different audible warnings can be requested by the BCU.

Sound request number	Sound functions	Priority (1 = lowest, 6 = highest)
0	Off	1
1	Seat belt warning	6
2	Key-in warning	3
3	SLABS/ HDC warning	4
4	Transfer box in neutral warning	5
5	Lights on warning	2

Operation

For IDM inputs which are also inputs for BCU functions, the delay before the BCU recognises the change in input status is less than 250 ms. The BCU uses a debounce algorithm to ignore changes in input having a duration less than 100 ms with the exception of automatic gearbox W, X, Y, Z inputs, which have a debounce period of 33 ms.

Transit mode
To prevent excessive battery drain during transit to overseas markets, the vehicle is placed in a transit mode.

To exit the transit mode, simultaneously hold down the heated rear window switch and the rear fog lamp switch, turn the ignition switch from 0 to II and, after a minimum of 2 seconds, release the switches.

Transit mode can be entered using TestBook. When TestBook communicates with the BCU for diagnostics related to BCU operation, it first checks that the vehicle is not in transit mode.

Anti-theft system
The BCU uses the driver's door key lock and unlock switches to activate and deactivate the security system. The driver's door lock is also used for entering the EKA.

☞ **ALARM SYSTEM AND HORN, DESCRIPTION AND OPERATION, Description.**

Immobilisation
For immobilisation, the BCU disables the starter motor relay. When the engine is cranking, the ECM looks for a coded signal from the BCU. If the signal is not received within one second of cranking, the fuel supply to the engine is stopped and the injectors are disabled. This also prevents unburnt fuel from entering the catalyst.

If the BCU is disconnected, the engine starter motor will remain isolated by the starter motor relay and the ECM will remain immobilised. The main wiring for the system is contained within the main harness which is relatively inaccessible, so preventing intruders from disabling the system by cutting the wires for the immobilisation system. Once the immobiliser has been activated, destruction of the trigger device or the wiring to it will not disarm the system.

The RF transmitter communicates to the BCU via the RF receiver using a 70 bit code. Pressing the unlock button on the transmitter will re-mobilise the vehicle. The RF transponder is integrated into the metal key assembly, inserting the key into the ignition switch will induce a signal in the exciter coil to re-mobilise the vehicle.

Anti-theft alarm
The alarm system provides a warning of unauthorised access to the vehicle and includes perimetric and volumetric monitoring under the control of the BCU.

The perimetric protection system detects opening of all doors, tail door and bonnet and will also detect the operation of the ignition key switch. The following conditions must be satisfied before the BCU will operate all of the functions of perimetric protection:

- All doors and hinged panels are in the closed position.
- Ignition key out of the ignition switch.
- Inertia switch is not tripped.

If all conditions are not satisfied the BCU will enter a mislock condition.

The volumetric sensor uses two ultrasonic sensors mounted in the headlining to detect movement within the vehicle. The alarm will trigger when the sensor signals the BCU for 200 ms or greater. Within a single setting period the alarm system will allow a maximum of 10 triggers as a result of any combination of sensor inputs. It is possible to lock the vehicle without enabling the volumetric alarm by using the key. The same conditions needed to satisfy enabling of the perimetric protection system is also needed to enable volumetric protection.

When the alarm system is set the BCU checks the status of all the inputs from the door and bonnet switches to ensure the integrity of the vehicle before setting the alarm system into operational mode. In some markets, when the alarm is set the BCU sends a signal to the IDM which will cause the direction indicators to flash three times for a duration of 3 seconds.

If the sensors are triggered the BCU will activate an alarm sounder to provide an audible warning of a theft attempt. The activation period of the alarm sounder is 25 to 30 seconds. The duty cycle of the alarm sounder is 50:50 ± 10%.

In some markets, when the alarm is triggered the BCU also activates the direction indicators, in phase with the audible warning, to provide an optical warning of a theft attempt. The activation period of the optical alarm is 25 to 30 seconds. The duty cycle of the optical warning is 50:50 ± 10%.

The alarm system relies upon the vehicle battery for power. However, the BCU remembers the status of the security system if it loses battery supply. If the security system was in a set condition when battery supply was lost the BCU will trigger the alarm and initiate a visual warning by flashing the hazard lamps when the battery voltage is restored. On vehicles with a BBUS fitted, the BBUS will sound if the battery is disconnected while the alarm system is set.

Door switches
The BCU uses the door latch switches to indicate if a door is open or closed. The BCU provides power to all door latch switches; the switches are in the 'normally open' condition when the doors are shut. When a door is opened, the door switch contacts are closed and the circuit is earthed, signalling a change in state to the BCU. All doors except the driver's doors are connected in parallel, so the BCU will recognise a passenger door has been opened but will not be able to distinguish which one. The driver's door has a dedicated signal line which enables the BCU to detect if the driver's door has been opened or closed.

Door lock actuators
The CDL system has the facility to enable superlocking. All door lock actuators are controlled by the BCU via the IDM. The driver's door is controlled separately from all other doors, enabling functions like single point entry and key access.

Driver's door key lock and unlock switches
The BCU uses the driver's door key lock and unlock switches to activate and deactivate the security system. The driver's door lock is also used for entering the EKA code.

Two separate switches are incorporated into the key lock assembly of the driver's door. The switches are normally open and the BCU provides a separate power supply to each. The BCU is signalled when a circuit is earthed enabling it to determine the direction in which the lock has been turned.

Bonnet switch
The bonnet switch is powered from the BCU and is used as a logical input for operation of the security system. The switch is normally open with the bonnet closed, when the bonnet is opened the switch contacts close to complete a circuit to earth and signal the change in state to the BCU.

Key-in sensor
When the ignition key is inserted into the lock barrel the key-in sensor contacts close and supply a signal to the BCU. The BCU monitors the ignition switch for a change in state and triggers the alarm if it receives an ignition signal before it receives an alarm disarm signal.

Another feed to the ignition switch is provided by the BCU to provide switch illumination.

A key-in warning can be enabled or disabled. When the key-in warning is enabled, an audible warning is generated if the ignition key is in and the driver's door is opened.

Passive coil
The passive coil is located around the ignition key barrel. When the BCU detects that the ignition key has been turned to the crank position, the vehicle's immobilisation system is activated and a signal is sent to the passive coil at a frequency of 125 kHz. The magnetic field generated in the coil is induced in the remote transmitter to trigger a re-mobilisation signal.

BBUS/ alarm sounder/ vehicle horn
The BBUS is an audible warning device which operates under the control of the BCU if the anti-theft system is activated or the vehicle battery is disconnected. The unit contains its own internal battery power source which is charged via a feed from the passenger compartment fuse box. The BBUS will not sound if the battery is disconnected while the security system has not been set.

Some markets utilise an alarm sounder which operates independently or in conjunction with the vehicle horn if the anti-theft system is triggered.

Security system status LED
The LED flashes when the anti-theft system has been set. There are four different flash rates dependent on mode of operation or other system information.

Central door locking
The doors can be locked by the following methods:
- Pressing the lock button on the remote transmitter.
- Locking the vehicle from the driver's door with the key.
- Pressing the lower half of the central door lock switch.
- Pushing the sill button down (will only lock that particular door).
- By driving over 7 km/h (4 mph) – (if the speed related locking function has been enabled).

The BCU will prevent locking if the logical conditions for locking are not satisfied. Conditions which will prevent door locking include:
- Driver's door open.
- Ignition switch on.
- Inertia switch tripped.
- Vehicle is already superlocked.

A mislock may occur if the logical conditions are not met.

The doors can be unlocked by the following methods:
- Pressing the unlock button on the remote transmitter
- Unlocking the vehicle from the driver's door with the key.
- Pressing the upper half of the central door locking switch (not operational if the vehicle is superlocked).
- Pulling the interior door handles (not operational if the vehicle is superlocked).
- Inertia switch being triggered while the ignition is on and the security system is de-activated.

The BCU supplies information via the serial data bus to the IDM to energise the coil of the relays for each of the door lock actuators.

The BCU normally checks the following inputs to determine lock/ unlock requirements:
- Unlock request.
- Lock request.
- Superlock request.
- Single point entry request.
- Lock passenger and rear doors request.

The following outputs are generated by the BCU dependent on the prevailing logic conditions and the input requests the BCU has detected:

- Unlock all doors enable.
- Lock passenger and rear doors enable.
- Superlock all doors enable.
- Lock driver's door enable.

All lock/ unlock pulses have a duration of 800 ms.

Input/Output logic for door lock/unlock

Output/Request	Superlock all doors enable	Unlock all doors enable	Lock driver's door enable	Lock passenger and rear doors enable
Unlock request	0	1	0	0
Lock request	0	0	1	1
Superlock request	1	0	1	1
Single point entry request	0	1	0	1
Lock passenger and rear doors request	0	0	0	1

To determine if the vehicle speed is appropriate for enabling speed related locking, the BCU uses the vehicle speed signal supplied over the serial data bus from the instrument pack.

Electric windows and sunroof

Three modes of operation are available:

- Driver cancel – the front windows, rear windows and sunroof will be disabled 44 seconds after the driver's door is opened.
- All cancel – The front windows, rear windows and sunroof will be disabled 44 seconds after any door is opened.
- No cancel – the front windows, rear windows and sunroof will be disabled when the ignition is turned off.

The BCU will allow window and sunroof operation when the ignition key is in position II. The BCU provides a voltage to the window control switches. When the switches are pressed, they provide a path to earth to complete the circuit and initiate window operation. Window and sunroof operation is suspended when the ignition switch is in the crank position.

For front window operation, the BCU checks the status of the following inputs:

- Ignition state.
- Driver's door open.
- Passenger or rear door open.
- Front right window down.
- Front right window up.
- Front left window down.
- Front left window up.
- Right window stall detect.
- Left window stall detect.

The front window motors are directly connected to the BCU by two wires. Each wire can be used as a feed or return, dependent on the required direction for motor operation (open or close). The BCU provides the following outputs:

- Right window up.
- Right window down.
- Left window up.
- Left window down.

The electric front windows are enabled when the ignition switch is in position II and is disabled if the ignition switch is moved to the crank position.

The BCU checks the status of the following inputs to determine when to provide the rear window enable and sunroof enable output signals:

- Ignition state.
- Driver's door open.
- Passenger or rear door open.

The rear window enable and sunroof enable lines are on when the ignition switch is in position II, and are switched off if the ignition switch is moved to the crank position.

The BCU monitors the circuit current draw when the windows are operating to detect the occurrence of a stall condition. If the BCU determines that the window has stalled, it will cut the power supply to stop the operation of the window motor. The BCU only starts to check for a stall condition after the window has been operating for 500 ms. This delay period enables the initial current surge to pass and eliminates false detections of window stall. A stall condition is activated when a nominal current value is exceeded for a period greater than 300 ms.

If the BCU detects that it has been operating the same window motor in one direction for more than 10 ± 0.2 seconds, without the BCU detecting a stall condition or the control switch being released, it will automatically stop operation of the window motor (timed out). Window operation can resume when the window switch is released and pressed again. If the window was operating in one touch mode, the window operation will resume on the next press of the window switch.

One touch mode automatically lowers the window to its fully open position, without the need for the window switch to be kept pressed for the duration of the window travel. One touch mode is initialised if the window switch is pressed for a period of less than 0.4 ± 0.2 second. One touch mode continues to lower the window until the BCU detects:

- A stall condition exists (window has reached bottom of travel).
- Window switch is repressed in either direction for more than 0.4 ± 0.2 second.
- The BCU has operated the motor for a period greater than 10 ± 0.2 seconds.

A timeout function is included which allows the windows and sunroofs to be operated for a period of 44 ± 1 seconds after the ignition key has been removed from the ignition switch. The timeout function will be cancelled if the BCU detects the following conditions:

- The driver's door has been closed after the ignition has been switched off.
- Any door open after the ignition is switched off.

The preconditions are programmed into the BCU dependent on market specification.

The BCU does not directly control rear window operation, but it can request the IDM to remove the power feed to the rear windows. The IDM enables power supply to be provided to the rear lift relay in the passenger fuse box. When the relay coil is energised the relay contacts close and power is applied to the rear window motor. If the window lift isolation switch located in the centre console is latched out, the earth path from the LH and RH rear door window switches is broken and operation of the rear window motors through the use of the rear window switches is prevented. Rear window operation using the console switches is not affected by the isolation switch.

In the event of a communications link failure occurring while rear window enable is on, the relay remains on until the ignition switch is turned to the off position.

Heated screens
The heated screen time-outs and logical operations are controlled by the BCU.

Heated front screen
The BCU provides an output to the heated front screen relay and a 'heated front screen active signal' for the heated front screen warning lamp. The BCU uses the status of the following inputs to determine the appropriate logical operations for this feature:

- Ignition state.
- Engine running (link from instrument pack).
- Heated front screen selected (non-latched button pressed).

If the ignition switch is not in position II, or the engine running signal is OFF, the heated front screen will not be active.

The heated front screen operation period and voltage supply is controlled by the BCU. The BCU receives a voltage supply feed from the engine compartment fuse box and an ignition switched supply through a fuse in the passenger compartment fuse box. When the heated front screen switch is operated, it completes a path to earth, signalling a request for heated screen operation to the BCU. The BCU then supplies a feed to the heated front screen switch to light the switch indicator, and earths the supply from the coil of the heated screen relay to turn the heated front screen on. The BCU maintains a supply for a predetermined time (5 minutes), then opens the earth path after the time out period to turn the heated screen off. During the timeout period, if the heated front screen switch is pressed a second time, the circuit is also interrupted to turn off the supply to the heated front screen.

On vehicles fitted with air conditioning, the heated front screen is also operated by the ATC ECU when DEF (defrost) is selected. In this case the ATC ECU provides the trigger signal to the BCU to turn the heated front screen circuit on or, if it is already on, to re-start the time out period.

☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**

In the event of a communications link failure occurring while the heated front screen relay is on, the relay and lamp will remain on until the ignition switch is turned off or the time-out period elapses or the heated front screen switch is pressed.

Heated rear window
The heated rear window will only function when the engine is running, and is operated by a non-latching switch on the instrument pack cowl.

The BCU provides a 'heated rear window enable output' and a 'heated rear window active warning lamp signal' based on the logic status of the following inputs:

- Ignition state.
- Engine running (link from instrument pack).
- Heated rear window selected (non-latched button pressed).

If the ignition switch is not in position II, or the engine running signal is OFF, the heated rear window will not be active.

The heated rear window operation period and voltage supply is controlled by the BCU. The BCU receives a voltage supply feed from the engine compartment fuse box and an ignition switched supply through a fuse in the passenger compartment fuse box. When the heated rear window switch is operated, it completes a path to earth, signalling a request for heated rear window operation to the BCU. The BCU then supplies a feed to the heated rear window switch to light the switch indicator, and earths the supply from the coil of the heated rear window relay via the IDM to turn the heated rear window elements on. The BCU maintains a supply for a predetermined time (15 minutes), then opens the earth path after the time-out period to turn the heated rear window operation off. If the heated rear window switch is pressed a second time, the circuit is also interrupted to turn off the supply to the heated front screen.

On vehicles fitted with air conditioning, the heated rear window is also operated by the ATC ECU when DEF (defrost) is selected. In this case the ATC ECU provides the trigger signal to the BCU to turn the heated rear window circuit on or, if it is already on, to re-start the time out period.

☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**

In the event of a communications link failure occurring while the heated rear window enable is on, the relay and lamp will be de-activated.

Wipers and washers
Front and rear wash/ wipe operations are controlled by the BCU via the IDM.

Front wipers and washers
When front intermittent wipe is selected using the wiper switch on the column stalk, the BCU signals the IDM to operate the wiper motor. The IDM then supplies a voltage to the normal speed winding of the wiper motor for a period of no longer than 500 ms. The timed feed ensures the wiper motor operates, but does not complete more than a single wipe of the screen. The BCU checks the position of the delay switch to determine the delay period which should be utilised for the intermittent wipe operation. The delay period of the front intermittent wipe is maintained until the wiper switch is moved to the off, normal or fast speed position, or the delay period is changed.

When front intermittent wipe is selected, a delay period of 500 ms will be incurred before the wipers operate. This delay prevents the occurrence of a wipe action when the wiper switch is changed to the off position from the normal or fast modes of operation.

To enable the front intermittent wipe facility, the BCU checks the state of the following inputs:
- Ignition state.
- Front intermittent wiper switch.
- Front intermittent wiper rate.

If the ignition switch is in the off or crank position, the front wipers are not active and the front wiper enable output is switched off.

If the option to initiate a wipe action in addition to a front screen wash action has been configured in the BCU, the wipers will operate 400 ms after the washer pump becomes active. If the washer switch is released within 400 ms, the wipers will not be activated. If a washer switch is pressed for longer than 400 ms, the BCU will operate the wipers after an initial delay of 400 ms, and will continue to operate for as long as the washer switch is depressed plus an additional 4 seconds.

The front wash/ wipe programme can be configured to operate in one of two ways:
- Option 1 – normal.
- Option 2 – no wipe.

The BCU checks for the following inputs:
- Ignition state.
- Front washer pump switch.

The BCU can provide the following wash / wipe outputs depending on the logic states prevailing:
- Front wiper enable.
- Front wash/ wipe in progress flag.

In the event of a communications link failure occurring while the front wash/ wipe programme is in operation, the front wiper enable output is switched off.

Rear wipers and washers
The rear wiper is initially operated for a period of 4 seconds when the rear wiper switch is pressed, to complete two full cycles. After this, the rear wiper will operate every other time the front wiper completes a wipe operation. During the wipe operation, the front and rear wipers are synchronised, and changes to the delay period during intermittent wipe will change the delay period for both front and rear wipers.

Operation of the rear washer switch causes the washer motor to operate for as long as the switch is operated. The wiper also operates while the switch is depressed and for a further 4 seconds after the switch is released.

The BCU checks for the following inputs to determine when to provide the rear wiper enable signal:
- Ignition state.
- Rear wiper switch.
- Front intermittent wiper rate.
- Front intermittent wiper switch.

If the ignition switch is in the off or crank position, the rear wipers are not active and the rear wiper enable output is switched off.

In the event of a communications link failure occurring while the rear intermittent wipe programme is in operation, the rear wiper enable output is switched off.

Reverse gear wipe

The BCU changes the operation of the rear wiper when the front wiper is active and reverse gear is selected. The rear wiper operation rate used when the preconditions have been satisfied depend on the prevailing front wiper operating mode and the position of the rear wiper switch. If the rear wiper is on or the front wiper is operating at an intermittent rate when reverse gear is selected, the BCU will operate the rear wiper continuously for 4 seconds via the IDM. After the initial period, the rear wiper will operate at the same rate as the front wiper.

The BCU checks for the following inputs to determine when to provide the rear wiper enable signal if the vehicle is in reverse gear:

- Ignition state.
- Rear wiper switch.
- Front intermittent wiper rate.
- Reverse gear selected.
- Front intermittent wiper switch.
- Front wiper switch state.
- Front wash/ wipe in progress flag.

In the event of a communications link failure occurring while the reversing wipe is in operation, the rear wiper enable output is switched off.

Headlamp wash

The headlamp wash will only operate when the headlamps are on, and then only every third time the front windscreen wash button is pressed. When the BCU operates the headlamp washers, it activates the washer pump relay for a period of 500 ms. The BCU supplies an earth path for the coil of the power wash relay located in the engine compartment fuse box when the washer function is selected.

The BCU checks for the following inputs to determine when to provide power to the headlamp power wash relay:

- Ignition state.
- Front washer pump switch.
- Dipped beam.
- Main beam state.

If the ignition switch is in the off position, the headlamp power wash relay is also held off. if the ignition state is crank, the headlamp power wash relay is switched off and the headlamp power wash counter is reset to 0.

In the event of a communications link failure occurring while the headlamp power wash relay in on , the relay remains on until the 500 ms timer has completed, then the relay is switched off.

Electric seats

The BCU can be programmed to operate the electric seats according to one of three options:

- Option 1 – no electric seats.
- Option 2 – normal.
- Option 3 – operates with ignition only.

To determine when to provide an output to the passenger and drivers seat enable relay, the BCU checks the condition of the following inputs:

- Ignition state.
- Transit mode.
- Driver's door open.

The electrically controlled seats are operated when the ignition switch is in position I or II or for a predetermined period when the driver's door is open. If the ignition state is in crank, the seat enable relay is off. If the ignition state is off and the driver's door open input is off, the seat enable relay is off. If the ignition state is off and the driver's door open input is on and transit mode is on, the seat enable relay output is off.

The power supply to each seat switch pack is powered from a power seat relay located on the underside of each seat frame. The feed from the relay is protected by a fuse located in a satellite fuse block located adjacent to the power seat relay. The fuse block also contains two additional fuses which are used to protect the feeds to the lumbar pump and solenoid.

With the ignition switch in position I or II or the driver's door open, the BCU provides an earth path for the coils of the LH and RH power seat relays, energising the relays and closing the contacts. If the driver's door input signal is on for longer than 45 seconds with the ignition switched off, the seat enable relay is switched off.

Direction indicators and hazard warning lamps

The BCU supplies reference voltages for the LH and RH indicators. When the direction indicator switch is used to select the LH or RH indicator position, an earth path is completed which signals the BCU that a request for direction indicator operation has been made. The BCU then communicates this request to the IDM which supplies an earth path for the coil of the relevant relay (LH or RH indicator relay). When the relay coil is energised, the relay contacts close and a voltage supply is provided via a resistor to the relevant direction indicators. The IDM controls the timing of the flash operations by continually removing and restoring the earth path to the direction indicator relay coil.

The BCU checks for the following inputs for performing the logic operations associated with the direction indicator lamps:

- Ignition state.
- RH indicators selected.
- LH indicators selected.
- Hazards selected.
- Inertia switch hazard request.
- One short indicator flash request (anti-theft system arming).
- Two short indicator flash request (superlocking).
- One long indicator flash request (anti-theft system disarming).
- Alarm flashing indicators (anti-theft alarm triggered).

The following outputs are provided by the BCU as a result of the inputs received and the logical operations performed:

- RH indicators enable.
- LH indicators enable.
- Direction indicator left message (link to IDM).
- Direction indicator right message (link to IDM).

Direction indicator lamp failure detection

The BCU uses the following logic inputs to determine if there is a direction indicator bulb failure or if the presence of a trailer is detected. The BCU uses the information to decide which output to enable at any particular instance:

- Right direction indicators requested.
- Left direction indicators requested.
- RH indicators current sense.
- LH indicators current sense.

If a direction indicator bulb failure or a trailer presence is detected, the following outputs can be generated depending on the BCU logic states:

- Trailer detected.
- Bulb failure detected.
- Direction indicator short circuit.
- Direction indicator relay stuck.

The BCU can be configured whether or not to provide bulb failure warnings.

When the direction indicators are operating, instrument pack direction indicators flash in sequence with the exterior direction indicators. If a failure of an indicator bulb occurs, the corresponding instrument pack indication lamp will flash quickly to warn of the problem.

The IDM monitors the current drawn through the circuit to detect for the occurrence of a lamp failure. If an indicator lamp fails, the IDM detects the drop in current drawn through the resistor and operates the indicator relay at a faster speed. The fast flash is demonstrated on the instrument pack direction indicator warning lamps to bring attention to the driver that a direction indicator bulb failure has occurred. The current sense for the related indicator lamps (RH or LH) are checked when a direction indicator request has been made that lasts for at least 160 ms. The current level sensed is relative to the number of working bulbs and determines the request generated by the BCU.

Number of working bulbs	Request generated
3	Trailer detected
2	None (bulbs okay)
1	Bulb failure detected
0	Direction indicator short circuit detected

The output is signalled to the instrument pack using the serial communications link. If the hazard warning lamps are operating, both sets of direction indicators are checked using the current sensing functions to check the number of bulbs on each side of the vehicle.

If the BCU detects that a direction indicator request has not been made, but one or other of the current sense inputs indicate that current is flowing, a 'Relay stuck' output is generated.

Hazard lamps

The BCU controls the operation of the hazard warning lamps via the IDM and dedicated relays. The hazard warning lamps are activated under the following conditions:

- The vehicle is locked and the security system is set (the hazard warning lamps flash three times if the superlocking feature is used, once if not).
- The vehicle is unlocked (the hazard warning lamps flash once for a duration of two seconds).
- The anti-theft alarm system is triggered (the hazard warning lamps flash in phase with and for the duration of the audible warning).
- The hazard warning switch is pressed (the hazard warning lamps flash until the hazard warning switch is pressed for a second time).
- The inertia switch is triggered (the hazard warning lamps flash until the inertia switch has been reset).

The hazard warning lamp operation may differ dependent on market and customer configuration options.

The hazard warning lamps are operated from a latching pushbutton switch located on the fascia. When the switch is pressed, both left and right indicator lamps in the instrument pack flash to show that the hazard warning lamps are operating and all hazard warning lamps flash simultaneously. If a trailer is fitted, the ICM detects this and a trailer symbol in the instrument pack also flashes to show correct operation of the trailer direction indicators and hazard warning lamps.

The BCU supplies a reference voltage to the hazard warning switch. When the hazard warning switch is operated an earth path is completed which signals the BCU that a request for hazard lamp operation has been made. The BCU then sends a signal to the IDM via the serial data bus to communicate the request. The IDM supplies an earth path for both direction indicator relay coils simultaneously so that the hazard warning lamps are turned on concurrently. The IDM controls the timing of the flash operations by continually removing and restoring the earth path to both direction indicator relay coils simultaneously.

Courtesy headlamps
This feature activates the headlamps for 30 seconds when the lock button on the remote transmitter is held down for longer than 1 second. The headlamps will extinguish if the BCU receives either a lock or an unlock signal from the remote transmitter.

The BCU checks the status of the following inputs to determine the correct qualifying conditions for requesting courtesy headlamps:
- Ignition state.
- Remote locking request.
- Remote unlocking request.
- Lazy locking request.

If the ignition is off and a lazy locking request is received, the courtesy headlamps are switched on and an internal timer is turned on in the BCU which operates for 30 seconds. If the 30 second timer expires or a request for remote locking or remote unlocking is received, the courtesy headlamps will be turned off.

When main beam is selected, the IDM also provides a signal to the instrument pack to switch on the main beam warning lamp. An additional signal 'main beam indicator disable' is used to prevent the daylight running lamps illuminating the main beam indicator when the main beam is in the daylight running lamp state and the main beam indicator disable signal is on.

Lights on alarm
The lights on alarm in the instrument pack operates when the driver's door is open and the side lamps or headlamps are on. The system uses inputs from the driver's door switch and the lighting switch to determine the logical conditions that need to occur for switching on the alarm. The BCU carries out the logic operation and communicates with the instrument pack using the serial data bus; the instrument pack will be requested to sound the alarm if the logic inputs indicate that the driver's door is open with the lights still on.

Supply voltage is provided through the lighting switch to the IDM which acts as the signal line to indicate that the lights are on for the logic circuits in the IDM and BCU. When the driver's door is opened, a second feed is supplied to the BCU through the driver's door switch to indicate the condition. In this logic condition (lights on and driver's door open) the BCU signals the instrument pack to operate the audible warning. If the lights are switched off or the driver's door is closed the logic condition will be changed and the audible warning will be switched off.

Daylight running lamps
The BCU operates the daylight running lamps (where fitted) via the IDM. The daylight running lamps option can be programmed in one of three states dependent on market/ customer requirements, these are:
- Option 1– no daylight running lamps.
- Option 2 – on with main beam off.
- Option 3 – on with main and dipped beam off and gearbox not in Park.

The BCU will ensure the logical conditions are satisfied for the lamps to operate under the set conditions. The BCU checks the status of the following inputs to determine the logic action for providing an output to the daylight running lamp relay:
- Main beam state.
- Engine running (link from instrument pack).
- Dipped beam.
- Gearbox state.

A voltage supply is fed to the coil of the daylight running lamp relay and the IDM. When the preconditions are satisfied for daylight running lamp operation, the BCU sends a signal for the IDM to complete the circuit to earth to switch on the daylight running lamps. The logical inputs are checked to ensure that the engine is running before switching the relay to turn on the daylight running lamps. The engine running signal has to be present for at least 2 seconds before the daylight running lamp relay can be switched on.

Fog lamps
The BCU operates the rear fog lamps and the front fog lamps (where fitted) via the IDM. The BCU front fog lamp operation can be programmed to operate under one of three set conditions. The BCU will ensure the logical conditions are satisfied for the lamps to operate under the set conditions.

Front fog lamps
Front fog lamp operation is monitored by the BCU, which allows only the front fog lamps to operate when the side lamps or headlamps are on. When the side lamps, headlamps or ignition switch is turned off, the BCU also switches off the fog lamps. When the side or headlamps are switched on again, the front fog lamps will remain off unless the front fog lamp switch is pressed to resume operation. If the rear fog guard lamps are selected on, switching off the front fog lamps will also switch off the rear fog guard lamps.

When the fog lamp switch is operated, an earth path is completed and the BCU allows the fog lights to be switched on providing the logical preconditions have been satisfied. The BCU then supplies a voltage supply to the fog lamp relay, to illuminate the fog lamps.

The front fog lamps option can be programmed in one of three states dependent on market/ customer requirements, these are:
- Option 1– not fitted.
- Option 2 – main beam no effect.
- Option 3 – off with main beam.

The BCU checks the status of the following inputs to determine the logic action for providing an output to the front fog lamp relay:
- Ignition state.
- Main beam state.
- Side lamps.
- Dipped beam.
- Front fogs selected (press button, not latched).

If the ignition state is crank the state of the front fog relay is memorised and the relay is switched off. Pressing the front fog switch during cranking will not be recognised. When the ignition state returns to Ignition after cranking, the memorised front fog relay state is restored. If the ignition is turned off, the front fog relay is turned off.

For option 3 configuration, if the main beam is turned on the state of the front fog relay is memorised and the relay is switched off. Pressing the front fog switch while main beam is on will not be recognised. When the Main beam state returns to OFF, the memorised front fog relay state is restored.

In the event of a communications link failure while the front fog relay is on, the front fog relay will be switched off.

Rear fog lamps
The rear fog lamps operation is monitored by the BCU, which only allows the rear fog lamps to operate when the side lamps or the headlamps are on. When the side lamps, headlamps or ignition is switched off, the rear fog lamps are also switched off. When the side lamps or headlamps are switched on again, the rear fog lamps will not switch on again unless reselected by operating the rear fog lamps switch. If front fog lamps are fitted, the rear fog lamps will be switched off if the front fog lamps are switched off.

A supply voltage to the rear fog lamps relay is provided from a fuse in the passenger compartment fuse box, then through two electronic switches in the IDM. With the lighting switch in the side lamp or headlamp position, an earth path from the coil of the rear fog lamps relay completes the circuit through the two switches in the IDM to switch the rear fog lamps on when the BCU receives a request signal from the rear fog lamps switch to turn the circuit on.

The BCU checks the status of the following inputs to determine the logic action for providing an output to the rear fog lamp relay:

- Ignition state.
- Main beam state.
- Dipped beam.
- Front fogs relay.
- Rear fogs selected (press button, not latched).

If the ignition state is crank the state of the rear fog relay is memorised and the relay is switched off. Pressing the front fog switch during cranking will not be recognised. When the ignition state returns to Ignition after cranking, the memorised rear fog relay state is restored. If the ignition is turned off, the rear fog relay is turned off.

In the event of a communications link failure occurring while the rear fog relay is on, the rear fog relay will remain on until the ignition is turned off or the dipped/ main beam is turned off.

Interior courtesy lamps

To determine when to provide an interior courtesy lamps enable output, the BCU checks the following input conditions:

- Ignition state.
- Transit mode.
- Driver's door open.
- Passenger or rear door open.

The courtesy lamps operate at full brightness when they are first switched on. The BCU then gradually dims the lamps (fade-out) before completely switching them off. Fade-out occurs over a period of two seconds following the logical control signal to turn off the lights. When a door is opened, the BCU provides earth paths from the interior lamps, the load space lamp and the ignition switch illumination. The following table lists the courtesy lamps operation and duration for holding the lamps on that occurs after the BCU has detected a condition that signals the courtesy lamps should be switched on:

Control signal	Additional conditions	Duration
Door open	-	10 minutes
Unlock signal from remote transmitter	All doors closed and ignition switch not in position III	1 minute
Unlock signal from the driver's door lock	All doors closed and ignition switch not in position III	1 minute
Ignition switch turned from position II or III to position 0	All doors closed	1 minute
Door changed from open to closed	All other doors closed and ignition switch not in position III	15 seconds
Ignition switch in position III	-	Timer cancelled
BCU receives a lock command	-	Timer cancelled
Vehicle has transit mode enabled	-	15 seconds on all occasions

Instrument pack

The BCU communicates with the instrument pack to provide a range of functions.

Odometer update

The BCU can be programmed for one of two options:

- Option 1 – no odometer error warning.
- Option 2 – odometer error warning.

In order to provide an LCD flash request to the instrument pack via the communications link, the following inputs are checked:

- Ignition state.
- Instrument pack odometer value (via the communications link).
- BCU odometer value.

The function is only active when the ignition state is on. The maximum allowed value is 999,999 miles (1,608,999 km).If the instrument pack odometer value is greater than the maximum allowed value, the maximum value is assumed. The BCU odometer value is stored in EEPROM. If 16 identical values of the instrument pack odometer reading is received consecutively, the instrument pack odometer value is compared with the BCU odometer value. If the consecutive readings from the instrument pack differ, the BCU odometer value is incremented accordingly. If the BCU odometer value is less than the instrument pack odometer value by up to 10 km, the BCU odometer value is set equal to the instrument pack odometer value.

If the odometer warning option is enabled, and the contents of the instrument pack odometer value buffer is identical to, or greater than BCU odometer value ± 10 km, the BCU sends an LED flash request to the instrument pack.

In the event of a communications link failure, this function will be unable to operate.

Gear position indicator illumination

On automatic gearbox models, two variations of illumination for the gear position indicators on the selector lever can be programmed into the BCU. In option 1, illumination is provided when the ignition is on. In option 2, illumination is enabled when the ignition is on and the side lamps are off.

Starter relay

The BCU checks the status of the following inputs and internal BCU conditions to determine whether or not to provide an output to enable the starter relay:

- Autostart inhibit (vehicles with automatic gearbox only).
- Security start inhibit (immobilisation check).
- Engine running (link to instrument pack).
- EEPROM locked (internal check).
- IDM and BCU matched.

When the BCU receives a crank signal from the ignition switch, an earth path is completed to the starter relay coil, provided that the security system has been de-activated. If the ECM has not received a valid unlock/ remobilise signal, the starter relay will be disengaged and the engine stopped. The BCU also receives an engine running signal from the instrument pack, so that if the ignition key is turned to the crank position while the engine is running, the starter motor relay will not be engaged.

If the logic conditions are correct to allow starter operation, the completion of the earth path from the starter relay coil to the BCU energises the coil and the relay contacts close to supply battery power to the starter motor.

When the ignition switch is released from the crank position, the power supply feed from the ignition switch to the starter relay coil is interrupted and the relay contacts open to prevent further battery feed to the starter motor.

If a communications link failure is experienced, the BCU will be prevented from detecting the 'engine running' condition and the BCU will default to assume that the engine is not running.

Cruise control
The Neutral/ Reverse/ Park/ Brake selected output is used by the cruise control system. The BCU checks for the following inputs:

- Ignition on.
- Gearbox state.
- Brake switch activated.

For vehicles with manual transmission, Neutral/ Reverse/ Park/ Brake selected output is on if the ignition is on and brake switch activated is on. Otherwise, the Neutral/ Reverse/ Park/ Brake selected output is off.

For vehicles with automatic transmission, the Neutral/ Reverse/ Park/ Brake selected output is on if the ignition is on and brake switch activated is on, or if the ignition is on and 'gearbox state' is in Neutral, Park or Reverse. Otherwise Neutral/ Reverse/ Park/ Brake selected output is off.

Shift interlock (where fitted)
On automatic gearbox models, the BCU and IDM combine to operate a shift interlock solenoid, so that the gear selector lever can only be moved when certain logical conditions have been satisfied. Operation of the interlock may be affected, if the battery becomes discharged.

☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Description.**

When the gear selector lever is in the Park position and the ignition is off, an interlock solenoid is de-energised, locking the gear selector lever in the Park position.

The gear selector lever can only be moved from the Park position when the ignition is switched on and the brake pedal is depressed. When these conditions are satisfied, the brake pedal switch signal is received by the BCU which then signals the IDM to energise the interlock relay. When the interlock relay is energised, the interlock solenoid is operated, unlocking the gear selector lever.

When the brake pedal is released, the feed to the BCU is removed and the shift interlock solenoid is de-energised. The locking mechanism controlled by the solenoid will lock the gear selector lever once it is returned to the Park position.

The shift interlock option can be programmed in one of three states dependent on market/ customer requirements, these are:

- Option 1– not fitted.
- Option 2 – normal operation.
- Option 3 – inhibit transfer box.

The BCU checks the status of the following inputs to determine the logic action for employing the shift interlock solenoid:

- Brake switch activated.
- Ignition state.
- Gearbox state.

In the event of a communications link failure, the shift interlock solenoid enable is switched on for 1 minute every time the ignition is switched on and switched off when the ignition is turned off.

Ignition interlock (where fitted)
On automatic gearbox models, when the ignition key is inserted in the ignition switch, the ignition key-in switch contacts close to supply a signal to the BCU to indicate the presence of the key in the switch and provide a supply feed to the ignition interlock solenoid. If the gear selector lever is in a position other than Park, or the 'transfer box neutral selected' is on, the BCU will supply an earth path to complete the ignition interlock circuit and cause the interlock solenoid to be engaged. With the interlock solenoid engaged, removal of the ignition key is prevented. The BCU will open the circuit, to allow removal of the ignition key, only when the gear selector lever is in the Park position and the transfer box is in either high or low range.

The ignition key interlock option can be programmed in one of three states dependent on market/ customer requirements, these are:

- Option 1– not fitted.
- Option 2 – normal operation.
- Option 3 – inhibit transfer box.

The BCU checks the status of the following inputs to determine the logic action for operating the ignition key interlock solenoid:

- Transfer box neutral selected.
- Gearbox state.
- Transit mode.

When the transit mode is on, the ignition key interlock solenoid is off.

Transfer box interlock (where fitted)

The transfer box interlock is controlled by the IDM to prevent transfer box shifter operation unless certain preconditions have been satisfied.

The transfer box interlock prevents the transfer box being shifted from High or Low to neutral with the ignition key removed from the ignition switch. When the BCU senses that the ignition key is removed from the ignition switch, it signals the IDM via the serial data bus. The IDM then provides an earth path for the coil of the transfer box relay, energising the relay coil and closing the relay contacts to provide a voltage supply to the transfer box interlock solenoid.

A diode is included in the supply line to the solenoid to prevent residual current causing the solenoid to stick in the energised position.

The transfer box solenoid interlock option can be programmed in one of three states dependent on market/ customer requirements, these are:

- Option 1– not fitted.
- Option 2 – normal operation.
- Option 3 – inhibit transfer box.

The BCU checks the status of the following inputs to determine the logic action for employing the transfer box interlock solenoid (transfer box solenoid enable):

- Ignition state.
- Gearbox state.

In the event of a communications link failure occurring while the transfer box enable is on, the output will be switched off.

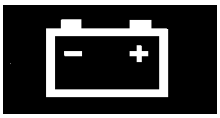
Gear position switch

On automatic gearbox models, the BCU provides an output which supplies power to the automatic gearbox gear position switch. The BCU checks for the following inputs before it supplies power:

- Ignition on.
- Auxiliary.

When the ignition is on, the feed to the gear position switch is on. When the ignition is off and auxiliary is off for more than 30 seconds, feed to the gear position switch is off.

☞ **AUTOMATIC GEARBOX - ZF4HP22 - 24, DESCRIPTION AND OPERATION, Description.**



Fuel flap release
The fuel flap release solenoid only operates when the ignition switch is switched off, the anti-theft system is not activated and the fuel flap release switch is pressed. If the BCU detects that these conditions have been satisfied, it provides a path to earth for the fuel flap solenoid, so allowing the fuel flap to be opened.

To decide the correct conditions for providing a fuel flap enable output, the BCU checks the following input conditions:
- Ignition state.
- Perimetric alarm state.

If the battery state is not normal, the electric fuel flap enable is switched off.

Audible warnings
The BCU can request the instrument pack to generate an audible warning in response to logic conditions which have been detected by the BCU and which need to be drawn to the driver's attention.

☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

Seat belt warning
The BCU can be programmed to include seat belt warning using one of four options:
- Option 1 – warning on for 6 seconds.
- Option 2 – warning on for 6 seconds or until the seat belt is fastened.
- Option 3 – warning on for 6 seconds unless the seat belt is fastened.
- Option 4 – no warning.

The BCU checks the status of the following inputs:
- Ignition on.
- Seat belt fastened.

Depending on the logic conditions of the inputs, the BCU provides the following outputs:
- Audible warning No.1 requested.
- Seat belt not fastened warning on instrument pack (via datalink to the instrument pack).

When programmed for option 1 operation, audible warning No. 1 is requested when the ignition switch is turned from off to position II. The audible warning remains active for 6 seconds and a warning lamp on the instrument pack is illuminated for the same duration.

When programmed for option 2 operation, audible warning No. 1 is requested when the ignition switch is turned from off to position II. The audible warning remains active for 6 seconds or until the seat belt fastened signal is on and a warning lamp on the instrument pack is illuminated for the same duration.

When programmed for option 3 operation, audible warning No. 1 is requested when the ignition switch is turned from off to position II. The audible warning remains active for 6 seconds if the seat belt fastened signal is off; a warning lamp on the instrument pack is illuminated for the same duration.

In the event of a communications link failure occurring, the audible and visual warning requests are not sent to the instrument pack.

Key-in warning

The BCU can be programmed to one of two options:

- Option 1 – no timeout.
- Option 2 – no key-in warning.

The BCU issues an audible warning No. 2 request, depending on the status of the following inputs:

- Ignition state.
- Ignition key inserted.
- Driver's door open.

If the key-in warning is programmed into the BCU for operation, audible warning No.2 will be requested if the ignition switch is off, the ignition key inserted signal is on and the driver's door open signal is ON.

In the event of a communications link failure occurring, the audible warning request is not sent to the instrument pack.

SLABS HDC warning

The BCU issues an audible warning No. 3 request, depending on the status of the following inputs:

- Ignition state.
- SLABS HDC warning.

The SLABS warning transmitted by the SLABS ECU is a 2 Hz signal, audible warning No. 3 is requested on every falling edge of this signal. If the signal from the SLABS ECU stays low for more than 650 ms, audible warning No. 3 is requested every 2 seconds, for 30 seconds, while the signal stays low.

In the event of a communications link failure occurring, the audible warning request is not sent to the instrument pack.

Transfer box in neutral warning

If the transfer box is in the neutral position and the ignition switch is on, the BCU issues an audible warning No. 4 request. The BCU checks for the following inputs:

- Transfer box neutral selected.
- Ignition on.

The transfer box in neutral warning is activated by communicating with the instrument pack via the serial datalink. If a communications link failure occurs while the transfer box in neutral warning is active, the audible warning will not operate.

Lights on warning

If the ignition switch is off while the side lamps or headlamps on and the driver's door is opened, the BCU issues an audible warning No. 5 request.

The BCU checks for the following inputs:

- Driver's door open.
- Ignition on.
- Side lamps.
- Dipped beam state.
- Main beam state.

The lights on warning is activated by communicating with the instrument pack via the serial datalink. If a communications link failure occurs while the lights on warning is active, the audible warning will not operate.

SLABS raise/lower

Before enabling a SLS vehicle raise/ lower request, the BCU checks the logical condition of the following inputs:

- Ignition state.
- SLABS raise request.
- SLABS lower request.

If the ignition switch is in position 0 or I, the vehicle raise/ lower request is off.

With the ignition switch in position II, and the 'SLABS raise' request and 'SLABS lower' request both off, the vehicle raise/ lower request output is driven at 25 Hz with a 50% duty cycle and the vehicle height remains unchanged.

If the 'SLABS lower' request input is on, the vehicle raise/lower request output is driven at 25 Hz with a 25% duty cycle, lowering the vehicle.

If the 'SLABS raise' request input is on, the vehicle raise/lower request output is driven at a 25 Hz with a 75% duty cycle.

Body control unit (BCU)

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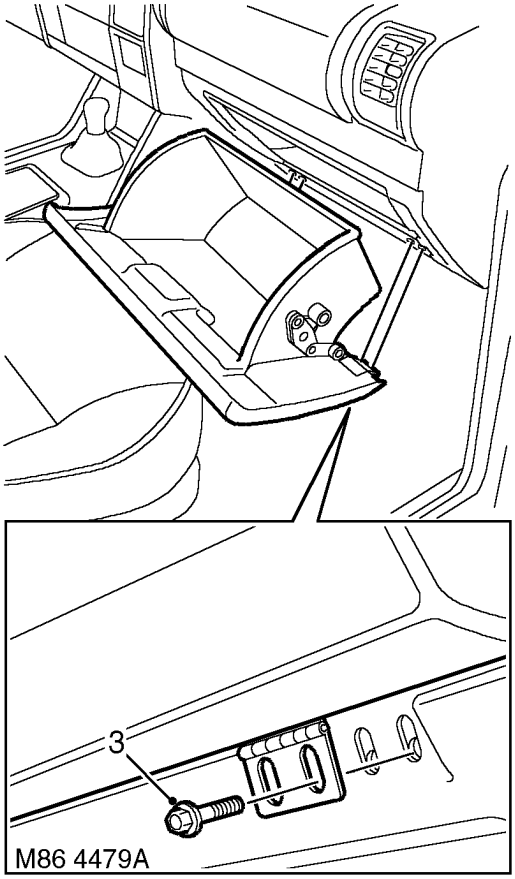
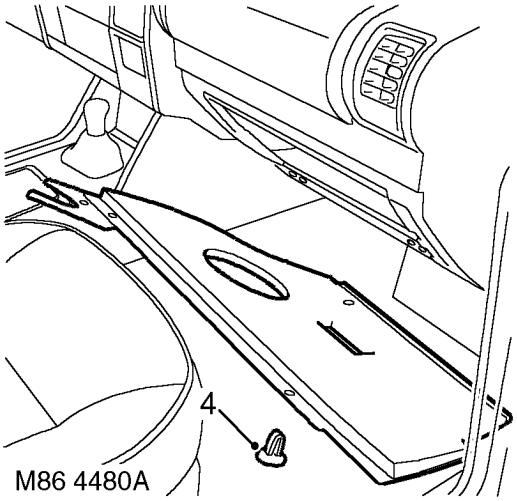
Remove

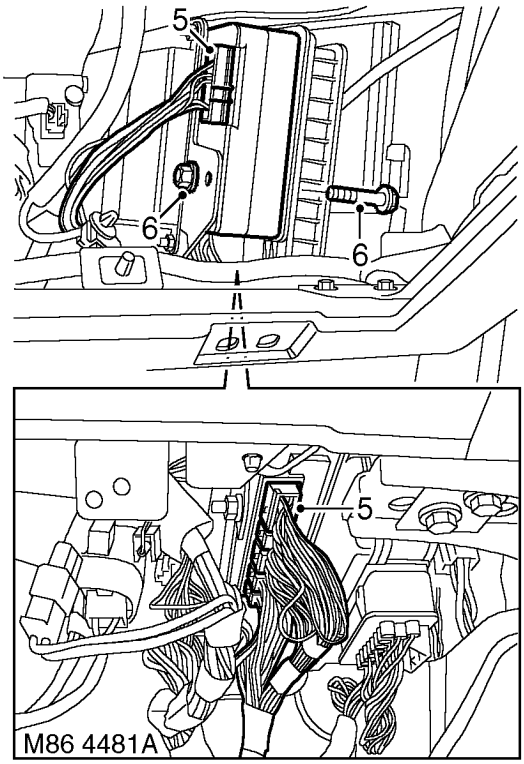
1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.



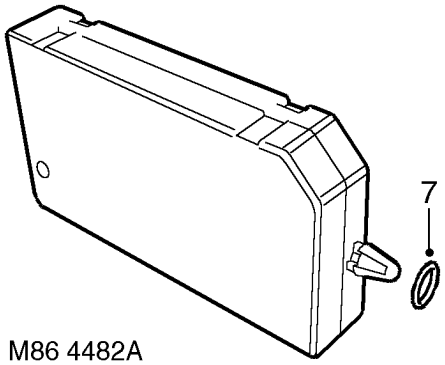
3. Remove 4 bolts securing glove box and remove glove box.



4. Remove 4 fixings securing closing panel and remove panel.



5. Disconnect 5 multiplugs from BCU.
6. Remove nut and bolt securing BCU to bracket and remove BCU.



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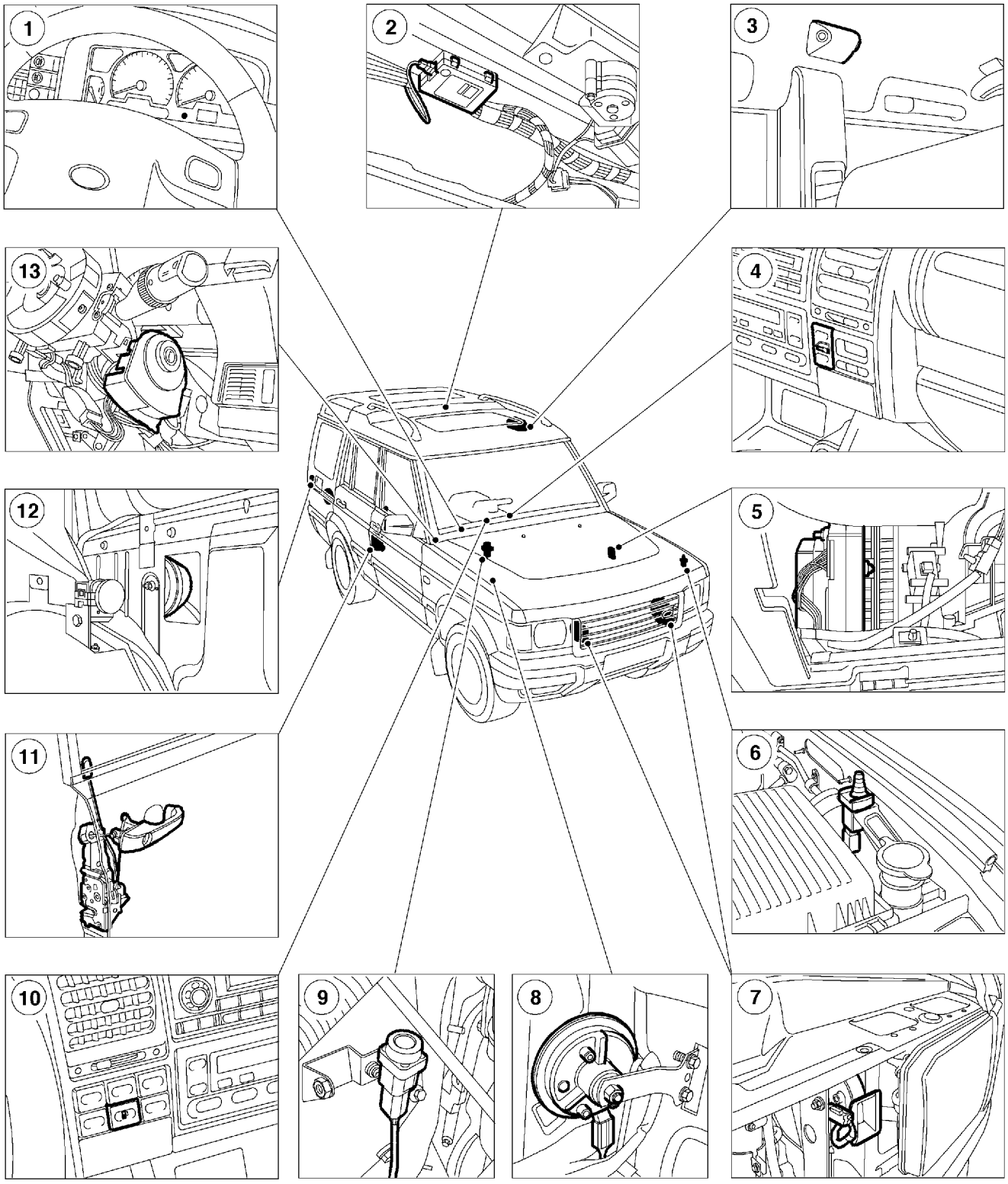
7. Remove rubber ring from locating peg.

Refit

1. Fit rubber ring to new BCU.
2. Fit BCU to bracket and secure with nut and bolt.
3. Connect multiplugs to BCU.
4. Fit closing panel and secure with fixings.
5. Fit glove box and secure with bolts.
6. Connect battery earth lead.
7. Fit battery cover and secure with fixings.
8. Programme and calibrate new BCU using TestBook.

Alarm system component layout



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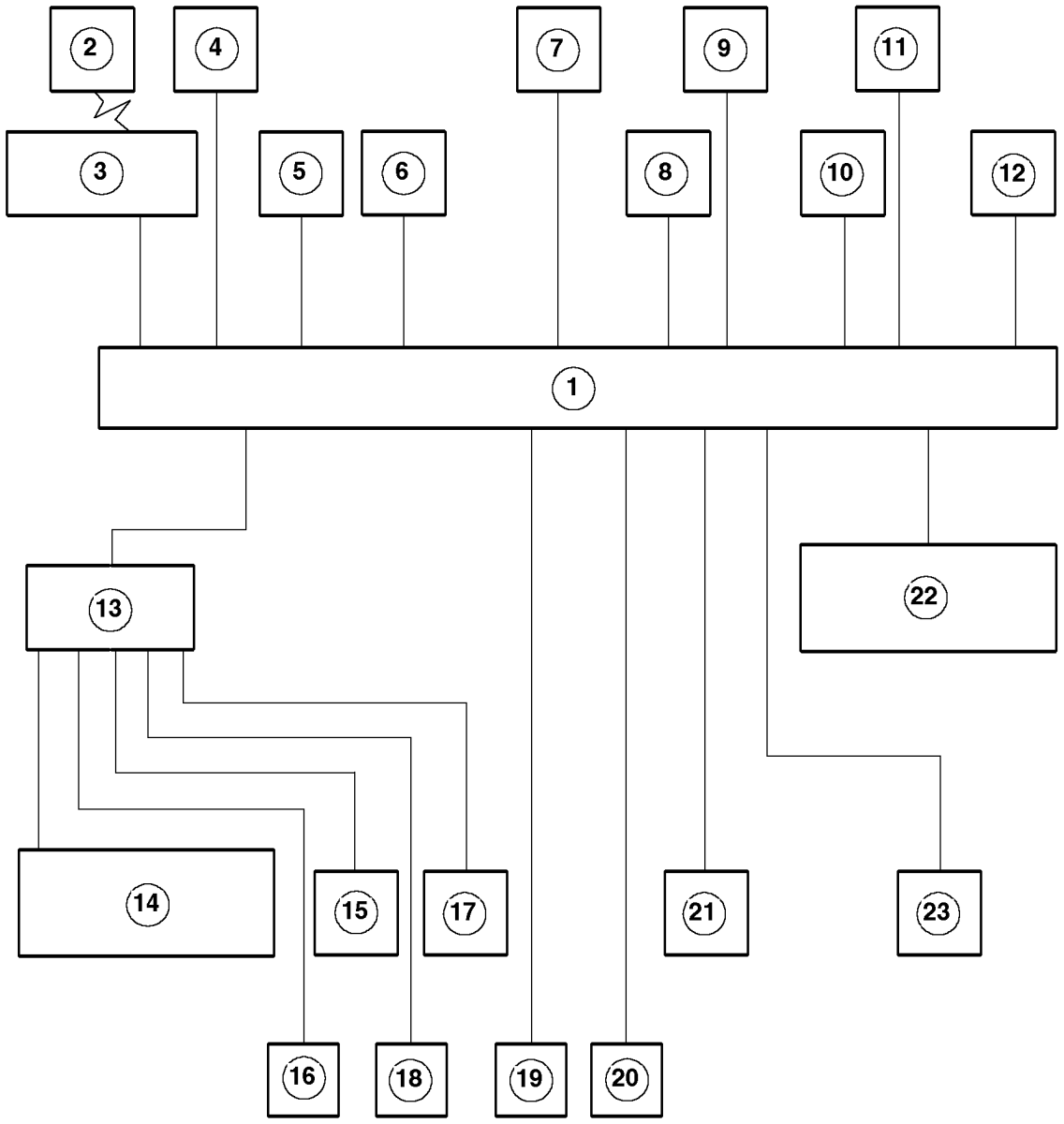
RHD shown, LHD similar

1 Theft deterrent LED
2 Receiver
3 Volumetric sensors
4 Central door locking switch
5 Body Control Unit (BCU)
6 Bonnet activated alarm switch
7 Vehicle horn
8 Alarm sounder
9 Fuel cut off switch
10 Fuel flap release switch
11 Door latch switches, drivers door key lock/ unlock switches
12 Battery Backed Up Sounder (BBUS)
13 Passive remobilisation exciter coil

Alarm system block diagram



M864651

1 Body Control Unit (BCU)
2 Remote handset
3 Receiver
4 Fuel cut off switch
5 Ignition switch
6 Central door locking switch
7 Volumetric sensors
8 Bonnet activated alarm switch
9 Drivers door key lock/unlock switches
10 Door latch switches
11 Fuel flap release switch
12 Intelligent Driver Module (IDM)
13 Battery Backed Up Sounder (BBUS)
14 Alarm sounder
15 Vehicle horns
16 Direction indicators
17 Door lock actuators
18 Engine Control Module (ECM)
19 Starter motor

Description

General

The anti-theft system deters the theft of the vehicle with both active and passive systems. The active systems monitor the vehicle perimeter and, in some markets the vehicle interior, for intrusion. If the system detects intrusion, an alarm sounds. The passive systems include a vehicle immobiliser as well as protection against intrusion through super locking the doors. The vehicle is immobilised whenever the ignition key is removed from the ignition switch. Super locking prevents the interior door handles from opening the doors. In addition, there are many features and functions that enhance system operation.

It is possible to perform the various functions associated with the anti-theft system remotely. To accomplish this, the handset generates a radio frequency when the lock button or unlock button is depressed. This signal is transmitted to the Body Control Unit (BCU) via a receiver located in front of rear sunroof beneath the headlining. Precise alignment of the handset to the receiver is not necessary. The approximate operating range between the handset and the receiver is 10 metres (33 feet).

It is important to understand the configuration of the system on each particular vehicle. There are many different combinations of features with dedicated operating modes. System configuration for each vehicle can be determined using TestBook.

The anti-theft system is controlled centrally by the BCU, which is located below and behind the passenger glovebox. A serial communication link communicates between the Intelligent Driver Module (IDM) located within the fusebox, the BCU and the LED located in the instrument panel.

The state of the alarm is stored in the BCU. If the battery is disconnected while the alarm is armed, the alarm will be triggered when the battery is reconnected.

NOTE: Disconnecting the battery while the alarm is armed triggers the alarm. Always disarm the alarm system before disconnecting the battery.

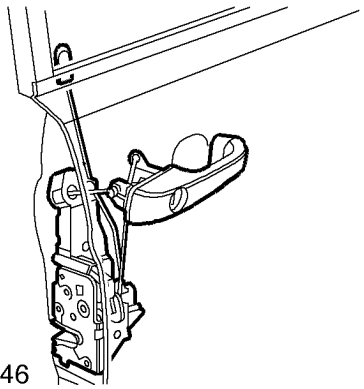
The BCU also receives inputs from the following components:

- Ignition key in sensor.
- Ignition switch.
- Fuel cut off switch.
- Fuel flap release switch.

The BCU also interacts with the following components:

- Starter relay.
- Vehicle horns.
- Direction indicators.
- Fuel flap release actuator.
- Courtesy lamps.

Door latch switches



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The BCU uses the door latch switches to indicate if a door is open or closed. There is a door latch switch within every door latch assembly, including the tail door latch assembly.

Input/Output

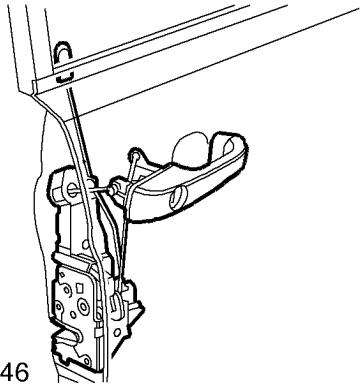
The input from the door latch switches to the BCU is either zero volts or an open circuit. Zero volts indicates the door is open. An open circuit indicates that the door is closed. When the BCU sees an open circuit, it pulls the input high internally.

The driver's door latch switch has a dedicated signal input to the BCU. This allows the BCU to identify the driver's door position.

The BCU use a common signal input for the remaining door latch switches.

TestBook provides the ability to monitor the real time state of the door latch switches. Remember that the driver's door is always in a known state. The remaining doors are combined into a single state. The BCU cannot distinguish the state of the individual doors, other than the driver's door.

Driver's door key lock/unlock switches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The BCU uses the driver's door key lock/unlock switches to activate and deactivate the alarm system. Two separate switches are incorporated into the key lock of the driver's door.

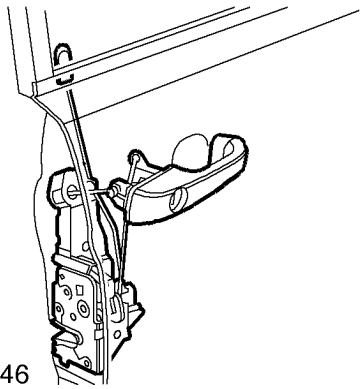
Input/Output

The input from the driver's door key lock/unlock switches to the BCU is either zero volts or an open circuit. Zero volts indicates the key lock is in the lock or unlock position. An open circuit indicates the key lock is in the centre position. When the BCU senses an open circuit, it pulls the input high internally.

The driver's door key lock /unlock switches have a dedicated signal input to the BCU. This allows the BCU to identify the lock/unlock position.

TestBook provides the ability to monitor the real time state of the driver's door key lock/unlock switches.

Door lock actuators



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The door lock actuators are D type latches. The door locks allow the vehicle to be locked/unlocked and super locked to prevent access to the vehicle via the interior door handles.

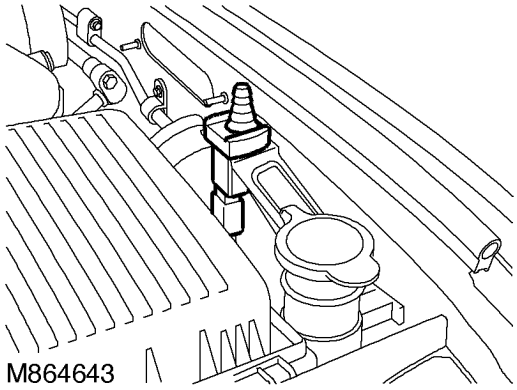
Input/Output

The driver's door lock actuator has a dedicated 12 volts power supply from the passenger compartment fuse box to energise the locking action of the door lock actuator. The passenger and rear door lock actuators share a 12 volts power supply from the passenger compartment fuse box to energise the locking action of the door lock actuator.

To perform the super locking action all the door lock actuators receive a 12 volts power supply from the passenger compartment fuse box.

To perform the unlocking action for all the doors, a 12 volts power supply from the passenger compartment fuse box is supplied to the door lock actuators.

Bonnet switch



The BCU uses a plunger type switch to determine if the bonnet has been forcibly opened when the alarm has been set. The switch is located under the bonnet on the left hand side of the vehicle when viewed from the rear.

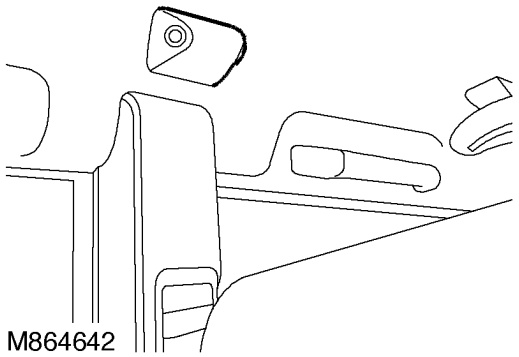
Input/Output

When the bonnet is closed the bonnet activated alarm switch is in an open condition and the input to the BCU is more than 6 volts, in which case the BCU pulls the input high internally. When the bonnet is open the bonnet activated alarm switch is closed and the input to the BCU is less than 2 volts.

The bonnet activated alarm switch has a dedicated signal input to the BCU. This allows the BCU to identify the position of the bonnet.

TestBook provides the ability to monitor the real time state of the switch.

Volumetric sensors



The BCU uses volumetric sensors to detect any change in air movement within the vehicle. There are two sensors located in the headlining of the vehicle.

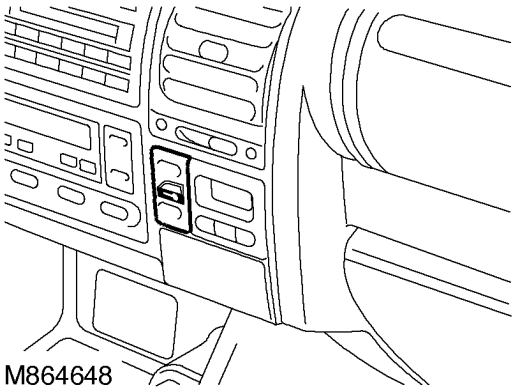
Input/Output

The sensors require a regulated power supply of 12 volts, via the BCU. When a change in air movement is detected the sensors generate a 5 Hz pulse train to the BCU.

Each of the sensors have a dedicated signal input to the BCU. Power to the sensors is supplied by the BCU.

TestBook provides the ability to monitor the real time state of the sensors.

Central door locking switches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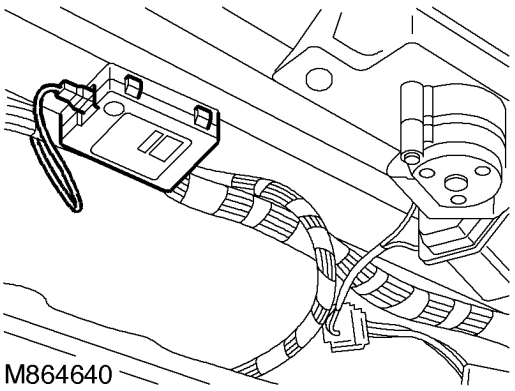
A momentary action switch mounted on the fascia allows for central door locking/unlocking from within the vehicle. The switch is mounted adjacent to the clock.

Input/Output
The input from the central door locking/unlocking switch to the BCU is either zero volts or an open circuit. Zero volts indicates the switch is closed. An open circuit indicates that the switch is open. When the BCU sees an open circuit, it pulls the input high internally.

The central door locking/unlocking switch has a dedicated signal input to the BCU. This allows the BCU to identify the lock/ unlock request.

TestBook provides the ability to monitor the real time state of the central door locking/ unlocking switch.

Handset and receiver
The handset is incorporated in the key. It uses coded radio frequency signals to lock, unlock and super lock the vehicle remotely with a range of up to 10 metres (33 ft). The handset also mobilises the vehicle by transmitting a remobilisation signal when the handset is within range of the passive remobilisation exciter coil.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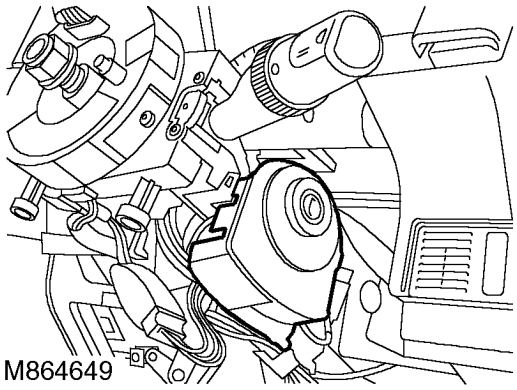
The receiver is located in front of the rear sunroof beneath the headlining. Signals transmitted by the handset are distributed to the BCU via the receiver.

Input/Output
The BCU supplies the receiver with a 12 volts power supply. On receiving a valid signal from the handset, the receiver transmits a 1000 baud signal to the BCU to allow locking/unlocking of the vehicle.

TestBook provides the ability to monitor the real time state of the remote receiver.

Passive remobilisation exciter coil

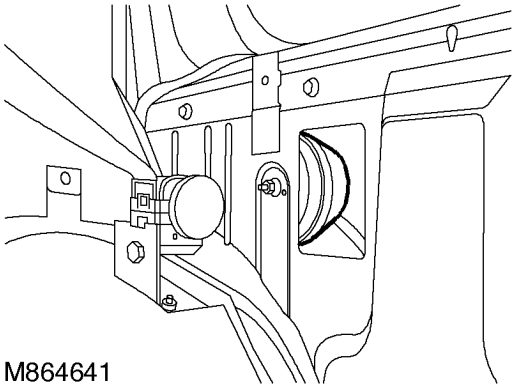


The passive remobilisation exciter coil consists of a coil around the steering column lock. The coil energises to create a magnetic field when the ignition is switched to position II.

This coil activates the handset initiating the mobilisation of the vehicle.

Input/Output
The input to the passive remobilisation exciter coil from the BCU is a 12 volts 125 kHz sinewave. The passive remobilisation exciter coil also receives an ignition controlled power supply via fuse 20 (15 amperes) located in the engine compartment fuse box. On receiving these signals, a magnetic field is generated which activates the handset to produce a remobilisation signal. This remobilisation signal is transmitted to the remote receiver and onto the BCU to allow the engine to start.

Battery Backed-up Sounder (BBUS)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The BBUS is located behind the rear quarter trim panel on the right hand side of the vehicle and is utilised as an additional alarm warning device. It has a self contained power source allowing it to operate when the vehicle battery is disconnected.

NOTE: Always disarm the BBUS before carrying out any procedures related to the BBUS.

Input/Output

The BBUS utilises a 12 volts power supply from fuse 20 (15 amperes) located in the passenger compartment fusebox via a relay to charge the self contained battery.

When the alarm is triggered, the BCU is pulled high internally triggering the BBUS to sound continuously for 30 seconds.

The BCU sets the BBUS to its internal battery backed mode when the vehicle battery is disconnected.

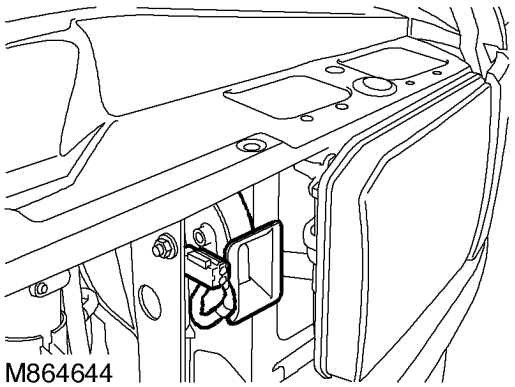
If a mislock occurs the BCU triggers the BBUS for a period of 50 ms.

The BCU triggers the BBUS once for a period of 50 ms when an EKA code is requested.

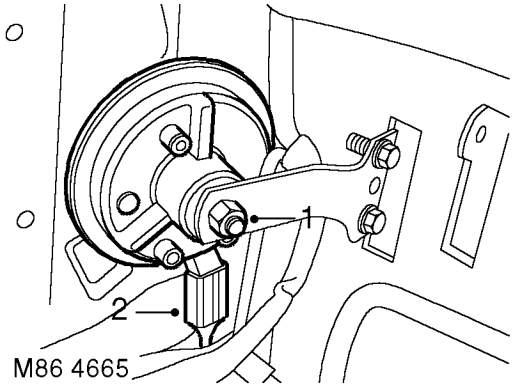
When the EKA code is entered correctly, the BBUS will operate twice for a period of 50 ms on, 200 ms off.

The BBUS utilises a dedicated earth path.

Vehicle horn/alarm sounder



Vehicle horn



Alarm sounder

Depending on system configuration, the alarm sounder will either sound independently or in conjunction with the vehicle horns as an alarm triggered warning. The alarm sounder is located under the bonnet on the bulkhead. If the alarm is triggered, the alarm sounder operates at 0.5 second intervals in phase with the direction indicators.

Input/Output

The BCU provides an earth path for the alarm sounder relay situated in the passenger compartment fuse box.

Fuse 21 supplies battery power to the alarm sounder relay. When an unauthorised entry to the vehicle is detected, the BCU provides an earth path for the alarm sounder relay. This earth path energises the alarm sounder relay, which activates the alarm sounder.

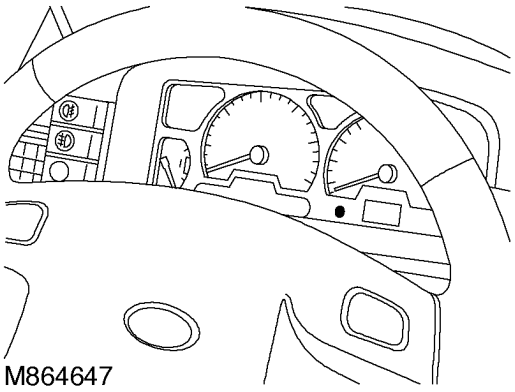
If a mislock occurs the BCU triggers the alarm sounder 2 times for a period of 50 ms on, 200 ms off.

The BCU triggers the alarm sounder once for a period of 50 ms when an EKA code is requested.

When the EKA code is entered correctly, the alarm sounder will operate twice for a period of 50 ms on, 200 ms off.

The alarm sounder relay has a dedicated signal to the BCU.

Anti-theft status LED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A Light Emitting Diode (LED) situated in the instrument cluster indicates the condition of the anti-theft system and acts as a warning to potential thieves that the alarm system is activated.

Input/Output

The LED has a dedicated signal from the BCU to indicate the status of the following:

- Alarm armed: The LED flashes at 10 Hz with a 50:50 duty cycle for 10 seconds, after which the LED flashes 50 ms on, 2 seconds off until the state of the system changes.
- Engine immobilised: If the engine is immobilised and the ignition is on, the LED is illuminated continuously. If the engine is immobilised and the ignition is off, the LED flashes 50 ms on, 2 seconds off.
- Alarm tampered: If the alarm has been triggered, the LED flashes at 10 Hz with a 50:50 duty cycle.
- Handset battery low indicator: If the handset battery is low, the driver's door is open and the ignition is switched off, the LED flashes two pulses of 50 ms on, 50 ms off, every 10 seconds.

Operation

Standard system functions
All vehicles have the following functions as standard.
- Locking.
- Unlocking.
- Fuel cut off switch unlocking.
- Internal locking.
- Electric fuel flap release.

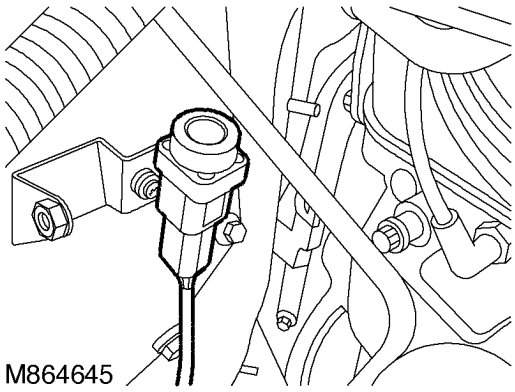
Locking
The doors are locked by pressing the lock button on the handset or by locking the vehicle from the driver's door with the key.

In order to lock the vehicle, the following conditions must be met:
- The driver's door is closed.
- The ignition is off.
- The fuel cut off switch is not tripped.
- The bonnet is closed.
- The vehicle is not super locked.

Depending on system configuration a mislock occurs if these conditions are not met. The doors may lock (depending on condition not met) and the system may not fully arm, depending on configuration of the system. If a mislock occurs an audible warning is emitted and the vehicle becomes partially armed.

Unlocking
The doors are unlocked by pressing the unlock button on the handset or by unlocking the vehicle from the driver's door with the key. This may unlock only the driver's door or it may unlock all doors depending on system configuration.

Fuel cut off switch unlocking

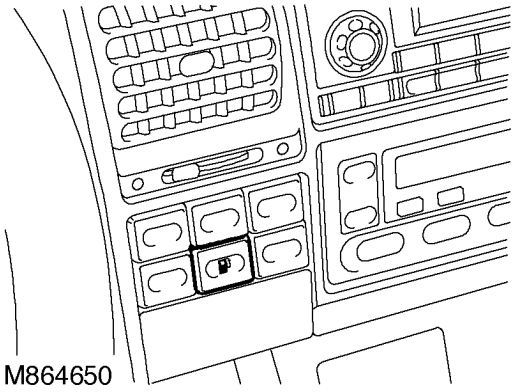

M864645

In the event that the vehicle experiences a force strong enough to actuate the switch, all the doors on the vehicle immediately unlock. The following conditions must be met for this to occur:
- The security system is not armed.
- The ignition is on.

This same action causes the fuel pump to shut off and disables the Engine Control Module (ECM). In some markets, this action may also cause the direction indicators lights to flash.

Internal locking
Internal locking allows the doors to be locked / unlocked from a central position using switches on the instrument panel. The internal unlock switch will not operate if the vehicle is super locked.

Electric fuel flap release



Up to 03 model year shown

The fuel flap is opened by pressing the button on the fascia on vehicles up to 03 model year or on the instrument pack binacle on vehicles from 03 model year. This works only if the anti-theft system is not armed and the ignition is off. In some configurations, it may also be necessary to remove the key from the ignition switch.

Configurable system functions
The following alarm system features are configurable using TestBook.
- Perimetric alarm.
- Volumetric alarm.
- Super locking.
- Partial arming.
- Mislock.
- Passive immobilisation.
- Passive remobilisation.
- Emergency key access.
- Single point entry.
- Speed related locking.
- Acclimatisation related locking.
- Visual warnings.
- Audible warning.
- Theft deterrent led.
- Transit mode.

Perimetric alarm

The perimetric alarm is used by the BCU to detect unauthorised opening of a door or hinged panel. Switches incorporated into the door latch assemblies and the bonnet determine the state of the panels.

There are two perimetric alarm configurations:

- Alarm not active.
- Alarm active.

Arming: To arm the perimetric alarm, press the lock button on the handset or lock the vehicle using the key in the driver's door. Once the alarm has been set, the BCU monitors the state of the doors and the bonnet.

In order to arm the perimetric alarm the following conditions must be met:

- Drivers door closed.
- Key not inserted in ignition switch.
- Fuel cut-off switch not tripped.

Disarming: To prevent the alarm from triggering when entering the vehicle, the alarm system must be disarmed with the key or the handset.

There are two perimetric alarm disarming configurations:

- Always disarm with key.
- Only disarm with key if locked with key.

The perimetric alarm can be disarmed by unlocking the vehicle with the handset or by using the key in the driver's door lock, depending on system configuration.

NOTE: The “only disarm with key if locked with key” configuration prevents the alarm from being disarmed by unlocking the vehicle with the handset if the vehicle has been locked by the key. In this situation the Emergency Key Access (EKA) code must be entered to disarm the alarm.

In order for the alarm to trigger, the following conditions must be met:

- Perimetric alarm armed.
- Bonnet or door opened.

Once triggered, the alarm will remain triggered for 30 seconds before resetting.

Volumetric alarm

The volumetric alarm is used by the BCU to detect movement within the vehicle. This allows the alarm to be triggered if a window is smashed in an attempt to gain access to the vehicle.

There are two volumetric alarm configurations:

- Volumetric alarm not active.
- Volumetric alarm active.

Two sensors, which transmit and receive ultrasonic signals, detect movement within the vehicle. Theses sensors detect any change in air movement within the vehicle and then supply the BCU a signal to activate the alarm. Fifteen seconds after the vehicle is locked with the handset or the key the volumetric alarm is armed. This delay is incorporated into the BCU software to prevent accidental or nuisance triggering of the alarm.

In order to arm the volumetric alarm, the following conditions must be met:

- Driver's door closed.
- Key not inserted in ignition.
- Fuel cut-off switch not tripped.

To prevent the alarm from triggering when entering the vehicle, the alarm system must be disarmed with the key or the handset.

There are two volumetric alarm disarming configurations:

- Always disarm with key.
- Only disarm with key if locked with key.

The volumetric alarm can be disarmed by unlocking the driver's door with the key or the handset, depending on system configuration.

NOTE: The "only disarm with key if locked with key" configuration prevents the alarm from being disarmed by unlocking the vehicle with the handset if the vehicle has been locked by the key. In this situation the EKA code must be entered to disarm the alarm.

In order for the alarm to trigger, the following conditions must be met:
- Volumetric alarm armed.
- Volumetric sensors triggered.

Once triggered, the alarm will remain triggered for 30 seconds before resetting.

Super locking
Super locking prevents the use of the interior door handles to unlock and open the vehicle doors. This prevents the doors from being opened if the window be smashed in an attempt to gain access to the vehicle.

There are four configurations for super locking:
- No super locking.
- Super locking on single handset press only (no key activated super locking).
- Super locking on single handset press or single key turn.
- Super locking on double handset press or double key turn.

To super lock, press the lock button on the handset once or twice within one second depending on system configuration. In some configurations, it is also possible to super lock the vehicle using the key in the driver's door. This also may require one or two turns of the key in the lock direction. If two turns of the key are required to activate super locking, the two turns must occur within one second of each other.

In order to super lock the vehicle, the following conditions must be met:
- All door are closed.
- The ignition is off.
- The fuel cut-off switch is not tripped.

Partial arming
Partial arming allows protection of as much of the vehicle as possible if the alarm is armed with one or more doors or the bonnet open.

Partial arming allows the vehicle alarm to be armed even if the following conditions exist. When the bonnet or door is closed, the BCU activates the perimetric alarm and the volumetric alarm after 15 seconds have elapsed:
- The bonnet is not closed: If the bonnet is open when the alarm is armed, the BCU activates super locking and volumetric sensing. In this condition, the alarm enters a partially armed state. All other functions of the alarm are active and the BCU monitors the bonnet for a change of state. If the bonnet closes, the system is completely armed.
- The passenger door, a rear door or the tail door is not closed: If a door is open when the alarm is armed, the BCU does not activate super locking or volumetric sensing. In this condition the alarm enters a partially armed state. All other alarm functions are armed and the BCU monitors the open door. If the door closes volumetric sensing and super locking become active.
- Failure of a door latch switch: If a short circuit in the door latch switch occurs, the BCU presumes the door is not closed. In this situation the BCU does not activate super locking or volumetric sensing. All other alarm functions are armed.
- Damaged wiring harness: If a short circuit in the wiring harness for the door latch switch occurs, the BCU presumes the door is not closed and does not activate super locking or volumetric sensing; all other alarm functions are armed. If an open circuit in the wiring harness for the door latch switch occurs, the BCU presumes the door is closed and arms the alarm as normal.

Mislock
Mislock alerts the driver that a failed attempt has been made to lock the vehicle because of the doors or the bonnet not being fully closed.

There are six audible configurations for mislock:
- No audible warning.
- Alarm sounder.
- Vehicle horn.
- Alarm sounder and vehicle horn.
- BBUS.
- Alarm sounder, vehicle horn and BBUS.

When a failed attempt has been made to lock the vehicle, the audible warning device is switched on for 50 ms and off for 200 ms. The BCU allows the audible warning device to operate 3 times.

Passive immobilisation
Passive immobilisation prevents the vehicle from being started unless the authorised key is used to start the vehicle.

There are only two configurations for passive immobilisation:
- passive immobilisation not active
- passive immobilisation active

When the ignition is switched off, the vehicle remains mobilised for up to a maximum of 5 minutes. If however the driver's door is opened, after 2 minutes 30 seconds, the vehicle remains in a mobilised state for a further 30 seconds. When the timer in the BCU has expired, the vehicle is immobilised.

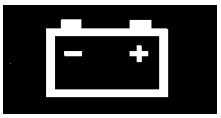
Once the ignition is switched on, the BCU transmits a coded signal to the ECM. If the coded signal does not correspond to the programmed code in the ECM, the ECM is inhibited and the BCU inhibits the starting circuit.

In order for passive immobilisation to occur, the following conditions must be met:
- Driver's door closed.
- Fuel cut-off switch not tripped.
- Key not inserted in ignition.

Passive remobilisation
Whenever the vehicle is immobilised, passive remobilisation of the engine occurs when the ignition is switched on, allowing the vehicle to be started.

There are three configurations for passive remobilisation:
- Passive immobilisation not active.
- Passive immobilisation active.
- EKA with super locking on receiving good passive remobilisation exciter coil signal.

The BCU controls the passive remobilisation exciter coil (located around the ignition barrel) to generate a magnetic field which causes the handset to transmit a remobilisation signal. The BCU receives the signal and allows the vehicle to be started. If a valid signal from the handset is not received within one minute of the ignition being switched to position II, the BCU stops the passive coil from generating the magnetic field.



Emergency key access

If the handset fails to operate, the engine can be remobilised by using the key to enter a unique four digit Emergency Key Access (EKA) code.

There are three configurations for emergency key access:

- EKA not active (no immobiliser fitted).
- EKA active.
- EKA with super locking on receiving good passive remobilisation exciter coil signal.

The code is recorded on the security information card and is entered as follows:

1. Using the key, turn the driver's door lock to the UNLOCK position and hold in this position for at least 5 seconds. An audible warning is then emitted to indicate that the body control unit is ready to accept the code. Return the key to the centre position. It is now possible to use the key to enter the separate numerical values of the four digits that make up the EKA code.
2. Enter the first digit of the code. If the first digit is 4, turn the key to the UNLOCK position 4 times. Ensure the key is fully returned to the centre position after each turn of the key.
3. Enter the second digit of the code. If the second digit is 3, turn the key to the LOCK position 3 times. Ensure the key is fully returned to the centre position after each turn of the key.
4. Enter the third digit of the code. If the third digit is 2, turn the key to the UNLOCK position twice. Ensure the key is fully returned to the centre position after each turn of the key.
5. Enter the fourth digit of the code. If the fourth digit is 1, turn the key to the LOCK position once. Ensure the key is fully returned to the centre position after each turn of the key.
6. Finally, turn the key to the UNLOCK position and back to the centre position, a double bleep will indicate that the code has been entered correctly. A single bleep indicates that the code has been entered incorrectly.

   Then, before opening the door, wait 5 minutes for the alarm and immobiliser to be de-activated. During the 5 minute wait for the alarm and immobiliser to be de-activated, the alarm indicator LED in the instrument pack continues to flash (one flash every 2 seconds). **DO NOT OPEN THE DOOR OR ATTEMPT TO ENTER THE CAR** until the full delay period has elapsed.

   When the 5 minute wait has elapsed, the alarm indicator LED stops flashing. Immediately open the door, insert the key in the ignition switch and turn the switch to position II. If the ignition switch is not turned to position II within 30 seconds of the end of the 5 minute wait, the engine is automatically immobilised again.

The EKA code will not be recognised if there is an interval of 10 seconds or more between key turns or if the key is held turned for 5 seconds or more during the procedure.

In some system configurations a successful EKA code entry is indicated by the audible warning device pulsing twice for a period of 50 ms on, 200 ms off. The theft deterrent LED is switched on for 1 second, all doors unlock, the alarm disarms and the vehicle is remobilised allowing the engine to start.

If an incorrect code is entered, an audible warning is emitted and the procedure must be repeated. Up to a maximum of 10 attempts to enter the code is possible. After 10 attempts, the BCU will not allow any further codes to be entered for a period of 10 minutes.

Single point entry

Single point entry (SPE) allows the driver to unlock the driver's door while leaving all other doors locked.

There are two configurations for single point entry:

- SPE not active.
- SPE active.

To use SPE, press the unlock button on the handset once. Depressing the unlock button a second time in the space of one minute unlocks the remaining doors. SPE is also possible by turning the key in the driver's door lock to the unlock position once. Turning the key to the unlock position again within one minute unlocks the remaining doors.

In order for SPE to operate, the following conditions must be met:

- The ignition is off.
- All doors are locked.

Speed related locking
For added protection the vehicle doors can automatically lock when the vehicle exceeds a specific road speed.

There are two configurations for speed related locking:
- Speed related locking not active.
- Speed related locking active.

Speed related locking causes the doors to automatically lock when the vehicle exceeds a speed of 4 mph (7 km/h). When the ignition is switched off, the doors are automatically unlocked. Depressing the instrument panel mounted central door unlocking switch disables the speed related locking for the duration of the journey.

Speed related locking only activates once per ignition cycle. If speed related locking activates and a door is then unlocked, the door does not automatically re-lock.

In order for speed related locking to activate the following conditions must be met:
- All doors unlocked.
- Engine running.
- Vehicle speed greater than 4 mph (7 km/h).

Acclimatisation related locking
Acclimatisation related locking allows the engine to be started and then the vehicle locked with a spare key and left unattended to allow the vehicle interior to reach the desired temperature.

There are two configurations for acclimatisation related locking:
- Acclimatisation related locking not active.
- Acclimatisation related locking active.

Once the engine is started, the vehicle is locked with a spare key at the driver's door while the engine is running. During these conditions the alarm is not armed.

In order to activate acclimatisation related locking the following conditions must be met:
- Engine running.
- All doors closed.

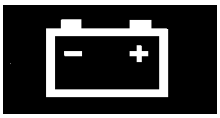
Visual warnings
The direction indicators serve as a visual indication when the alarm is triggered. The direction indicators are also used as a visual indication during lock/unlock procedures.

There are three configurations of alarm armed/disarmed indication:
- No direction indicators on, alarm armed/disarmed/trigger.
- Direction indicators on, alarm trigger only.
- Direction indicators on, alarm armed/disarmed/trigger.

Dependent on system configuration the direction indicators flash one short pulse to confirm that the alarm is armed and flash two short pulses to confirm that the vehicle is super locked. If the alarm is triggered the direction indicators operate in phase with the audible warning. When the alarm is disarmed, the direction indicators flash one long pulse.

Audible warning
An audible warning device is used to indicate that the alarm has been triggered, or a mislock has occurred, or an EKA request has occurred, or the EKA code has been entered.

There are six audible warning configurations:
- No sound (audible warnings disabled).
- Alarm sounder only.
- Vehicle horn only.
- Alarm sounder and vehicle horn.
- BBUS only.
- Alarm sounder, vehicle horn and BBUS.



Depending on which market the vehicle is sold, either the vehicle horn, a specific alarm sounder, or a BBUS operates in phase with the direction indicators when the alarm is triggered. The audible warning device operates for approximately 30 seconds at 0.25 second on, and 0.25 second off. The BCU allows the alarm to be triggered up to 3 times in any armed period.

Theft deterrent LED

An LED located in the instrument pack indicates the status of the alarm system.

There are eight theft deterrent alarm configurations:

- No handset low battery warning.
- Handset low battery warning.
- No passive immobilisation.
- Passive immobilisation.
- Engine immobilised (ignition off, LED off).
- Engine immobilised (ignition off, LED flashes).
- No alarm tampered indication.
- Alarm tampered indication.

The theft deterrent LED utilises a particular flash to show the status of the following:

- Alarm armed.
- Engine immobilised.
- Alarm tampered.
- Handset low battery warning.

Transit mode

To prevent excessive battery drain during transportation to overseas markets, the vehicle is placed in a transit mode at the end of line test.

The following functions are disabled when the vehicle is in transit mode:

- Volumetric sensors.
- Passive immobilisation.
- Mobilisation of the vehicle by use of door lock.
- Ignition key interlock.
- Electric seat enable time-out with drivers door open.

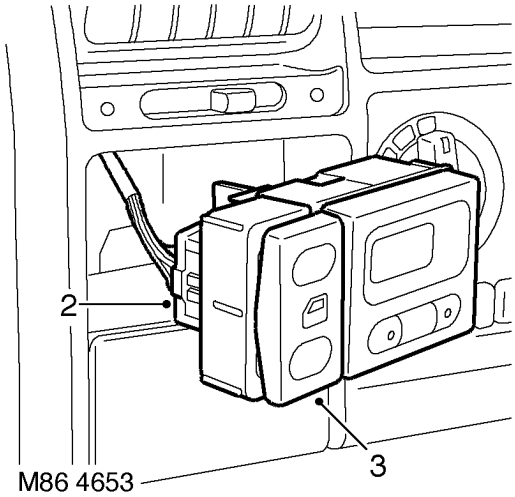
To exit this mode, switch on the ignition and simultaneously hold down the heated rear window and the rear fog lamp switch for 2 seconds.

Transit mode can be entered using Testbook.

Switch - central door locking

86.26.30

Remove



1. Carefully remove clock assembly from louvre panel.
2. Disconnect multiplug from door lock switch.
3. Remove door lock switch from clock.

Refit

1. Fit door lock switch to clock assembly.
2. Connect multiplug to door lock switch.
3. Position clock assembly and push to secure in position.

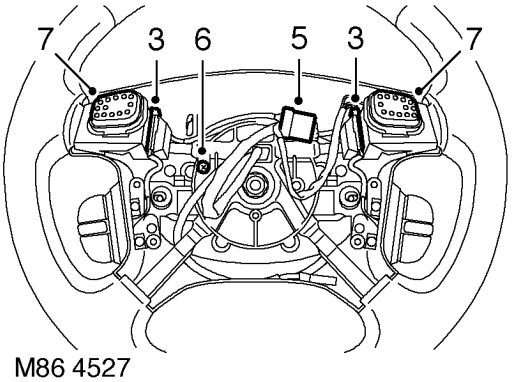
Switches - horn

86.30.01

Remove

WARNING: It is imperative that before any work is undertaken on the SRS system the appropriate information is read thoroughly.

1. Disconnect both battery leads, negative lead first, and wait 10 minutes.
2. Remove driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.



3. Release horn switch multiplugs and leads from steering wheel base.
4. Disconnect horn switch multiplugs from harness.
5. Disconnect horn switch multiplug from rotary coupler harness.
6. Remove screw securing earth leads to steering wheel.
7. Using a broad round edged tool, carefully prise horn switches from steering wheel.

Refit

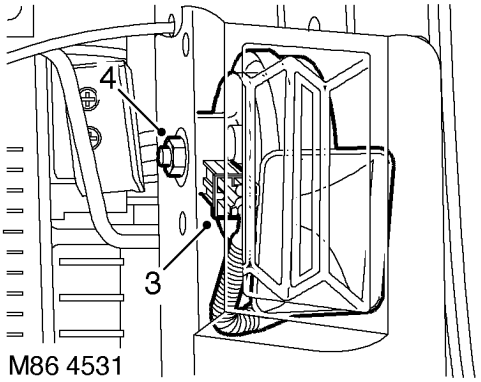
1. Fit to steering wheel and connect multiplugs.
2. Fit earth leads and secure with screw.
3. Secure leads and multiplugs to base of steering wheel.
4. Fit driver's airbag module.
   RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.

Vehicle horn

86.30.10

Remove

1. Remove front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.



2. Disconnect multiplug from horn.
3. Remove nut securing horn to body and remove horn.

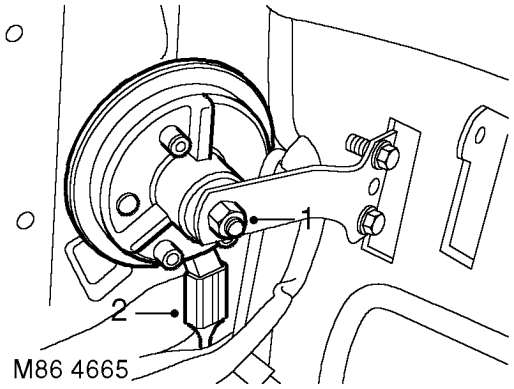
Refit

1. Fit horn to body and tighten nut to 13 Nm (10 lbf.ft).
2. Connect multiplug to horn.
3. Fit front grille.
   EXTERIOR FITTINGS, REPAIRS, Grille - front - up to 03MY.

Sounder - alarm

86.77.10

Remove



1. Remove nut securing sounder to mounting bracket.
2. Release sounder from mounting bracket, disconnect multiplug and remove sounder.

Refit

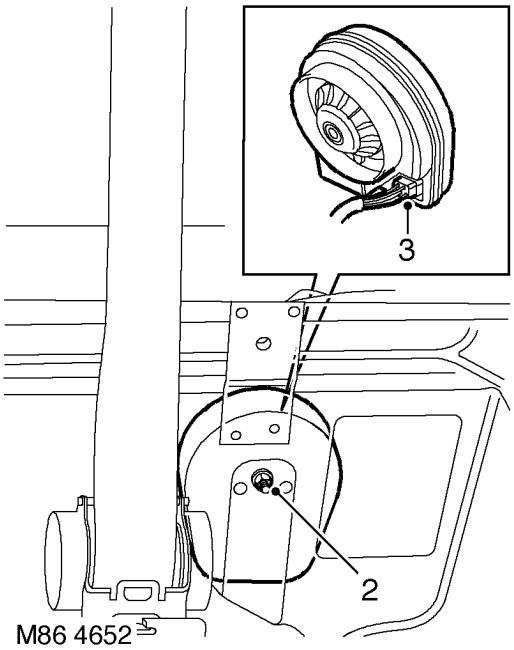
1. Position sounder and connect multiplug.
2. Fit sounder to bracket and secure with nut.

Sounder - battery backed-up (BBUS)

86.77.13

Remove

1. Remove rear quarter lower casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.



2. Remove nut securing BBUS to RH rear body panel.
3. Disconnect multiplug and remove BBUS.

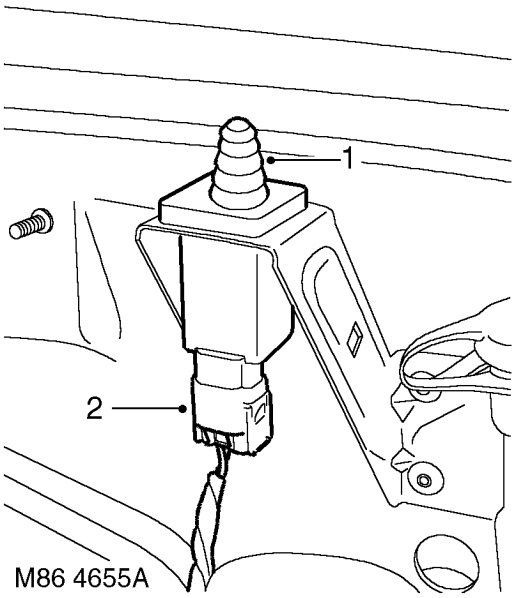
Refit

1. Position BBUS, connect multiplug and tighten securing nut.
2. Fit rear quarter lower casing.
   INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.

Switch - bonnet

86.77.20

Remove



1. Remove rubber cover from bonnet switch.
2. Disconnect multiplug, release switch retainers and remove switch.

Refit

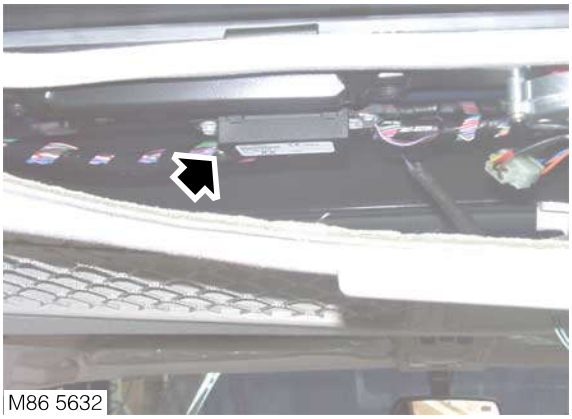
1. Position switch and connect multiplug.
2. Fit rubber cover to switch,

Receiver - alarm system - models with sunroof

86.77.31

Remove

1. Remove trim seal from rear sunroof.
2. Release sunroof switch and remove screw securing headlining.


M86 5632

3. Remove 2 nuts securing receiver to roof panel, disconnect multiplug and remove receiver.

Refit

1. Connect multiplug to receiver, fit to roof panel, tighten nuts to 10 Nm (7 lbf.ft).
2. Fit and tighten screw securing headlining.
3. Fit sunroof switch
4. Fit sunroof trim seal.
5. Connect multiplug to receiver, fit to roof panel and secure with nuts tighten to 10 Nm (7 lbf.ft).

Receiver - alarm system - models without sunroof

86.77.31

Remove

1. Release rear door upper trim finisher.
2. Remove 3 Torx bolts securing rear headrest, remove headrest. Repeat operation on opposite side.
3. Remove both 'D' post trim casings.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**
4. Release rear interior light lens, remove 2 nuts to release light.
5. Release 2 studs securing rear headlining, carefully lower lining.

M86 5762

6. Remove 2 studs securing alarm receiver.
7. Disconnect multiplug from alarm receiver and remove receiver.

Refit

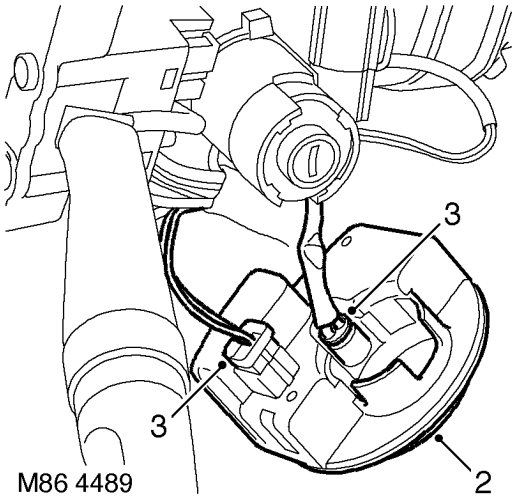
1. Connect multiplug to receiver.
2. Position receiver and secure with studs.
3. Position rear end of headlining, secure with studs.
4. Position interior light fit and tighten nuts.
5. Fit interior light lens.
6. Fit both 'D' post trim casings.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**
7. Fit 3 Torx bolts securing headrest and tighten to 25 Nm (18 lbf.ft). Repeat operation on opposite side.
8. Fit rear door upper finisher

Coil - passive immobilisation

86.77.35

Remove

1. Remove steering column nacelle.
   STEERING, REPAIRS, Nacelle - steering column.

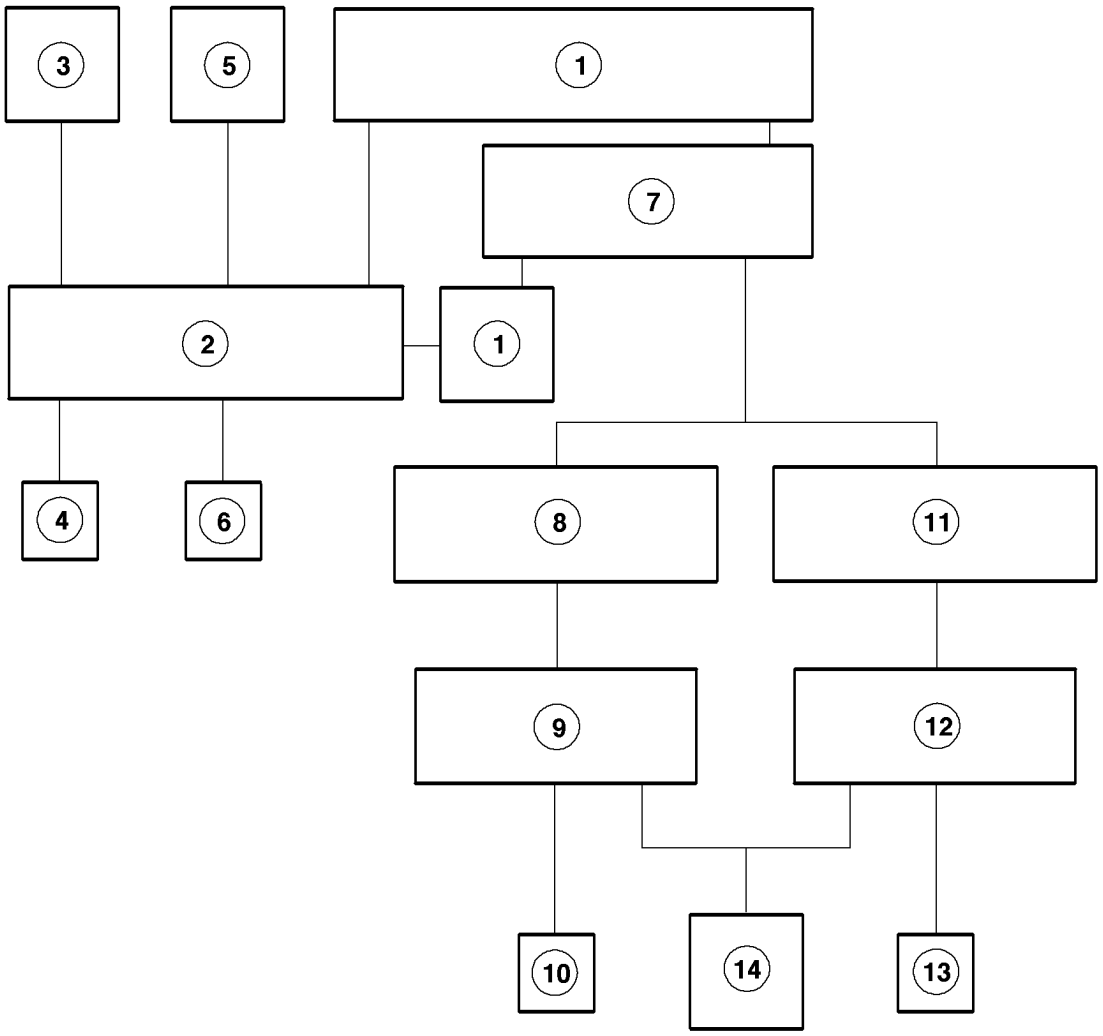


2. Release passive coil from steering lock.
3. Disconnect illumination bulb holder and multiplug and remove passive coil.

Refit

1. Position passive coil, connect multiplug and illumination bulb holder.
2. Fit passive coil to steering lock.
3. Fit steering column nacelle.
   STEERING, REPAIRS, Nacelle - steering column.

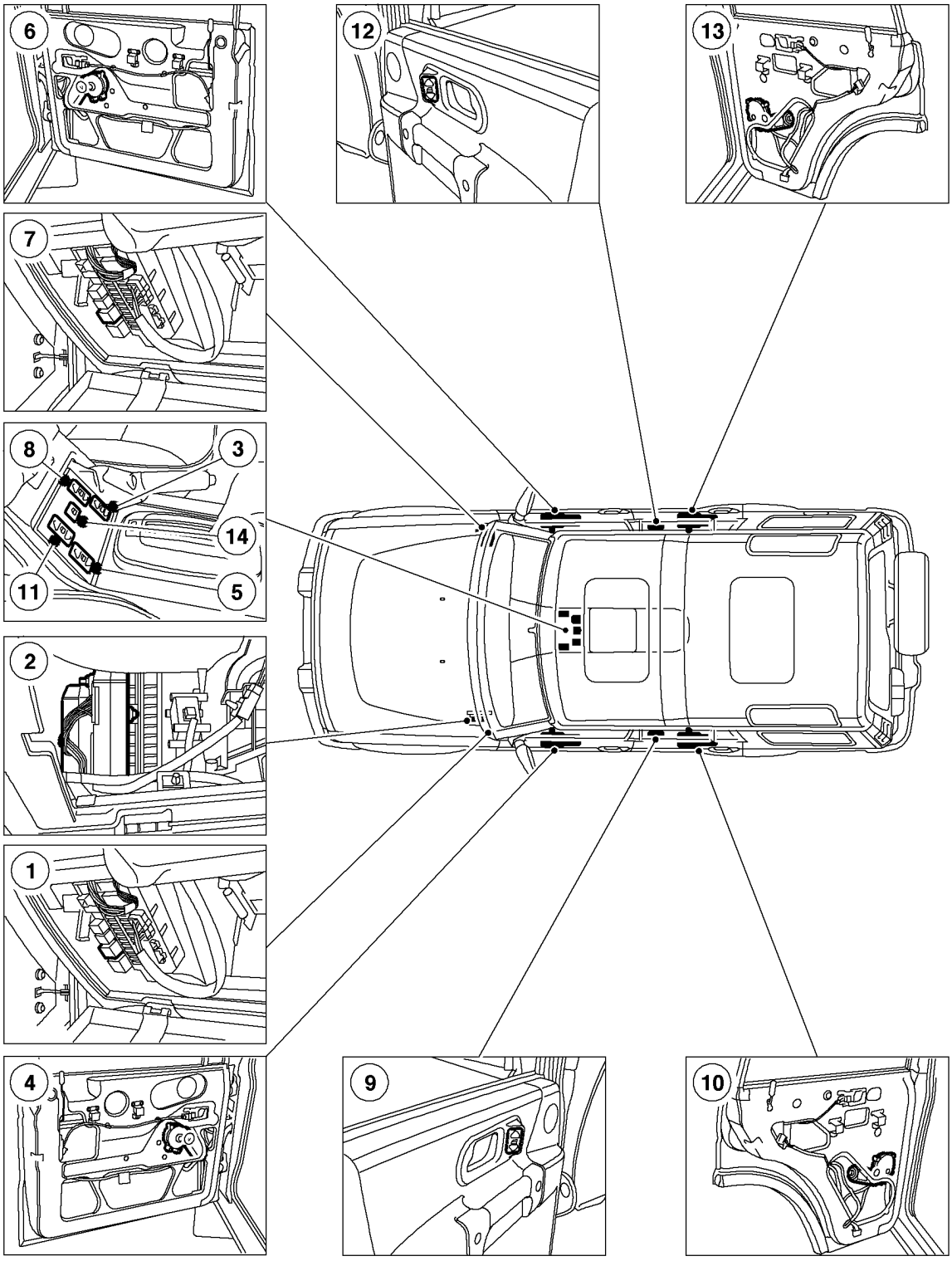
Electric windows block diagram



M864631

1 Passenger compartment fusebox
2 BCU
3 LH front window switch
4 LH front window motor
5 RH front window switch
6 RH front window motor
7 Rear window lift relay
8 Centre console LH rear window switch
9 LH rear door window switch
10 LH rear door window motor
11 Centre console RH rear window switch
12 RH rear door window switch
13 RH rear door window motor
14 Rear window isolation switch

Electric windows component layout



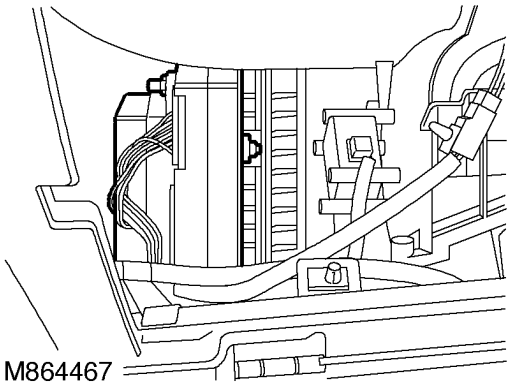
M864465

RHD shown, LHD similar

1 Passenger compartment fusebox
2 Body Control Unit (BCU)
3 LH front window switch
4 LH front window motor
5 RH front window switch
6 RH front window motor
7 Rear window lift relay
8 Centre console LH rear window switch
9 LH rear door window switch
10 LH rear door window motor
11 Centre console RH rear window switch
12 RH rear door window switch
13 RH rear door window motor
14 Rear window isolation switch

Description

Body Control Unit (BCU)



RHD shown, LHD similar

The BCU controls all operations for the front windows. It controls the voltage and the earth paths to the window motors, it controls one-touch down operation and it detects stall conditions. Stall detection protects the system from sustained high current draw that occurs when a window reaches the fully up/down position or becomes stuck. When the BCU detects a stall condition, it disables operation at the stalled window until the window switch is released. Upon releasing the window switch, the BCU allows normal window operation.

The BCU receives power from fuse 34 (30A) of the passenger compartment fusebox. There is a unique earth signal between each pole of the front window switches and the BCU. This allows the BCU to determine which window motor to operate as well as which direction to operate the motor. The BCU operates the front window motors directly. There are no relays or switches between the BCU and the window motors.

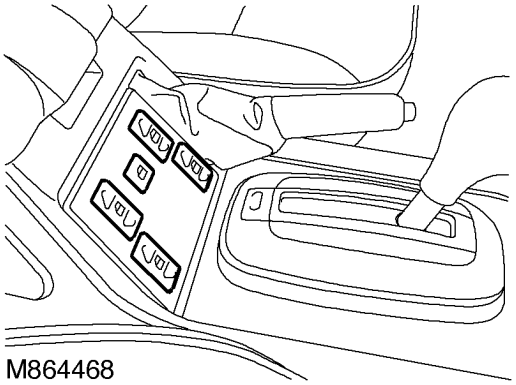
The BCU disables stall detection on the front windows for a period of 500 ms when an electric window operates to allow for initial current surge to the window motor. After this period, if the BCU detects a stall signal (high current draw) for more than 300 ms, it disables the window motor until the window switch is released.

The BCU also contains the ignition switched off timeout information for both the front and the rear windows. It controls the rear window timeout function through the IDM.

TestBook communicates with the BCU and can determine the status of the front window switches. TestBook can also operate both front windows. TestBook can only determine rear window timeout status. It cannot determine the status of the rear windows, nor can it operate the rear windows.

Do not feed TestBook cables through open windows as the windows operate while performing test.

Front window switches

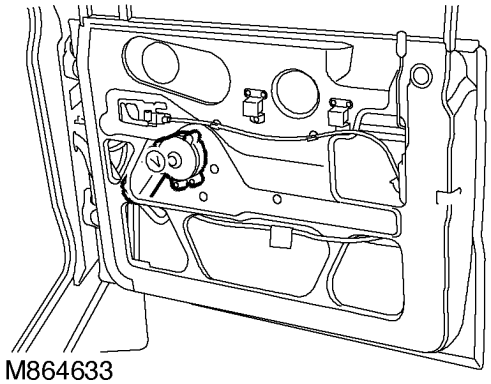

M864468

The front window switches are non-latching rocker switches located in the center console. The front window switches contain illumination bulbs that operate when the side lamps or headlamps are on.

The front window switches provide earth signals to the BCU. The BCU determines which direction to operate the front window motors.

TestBook will monitor the real time status of the front window switches.

Front window motors

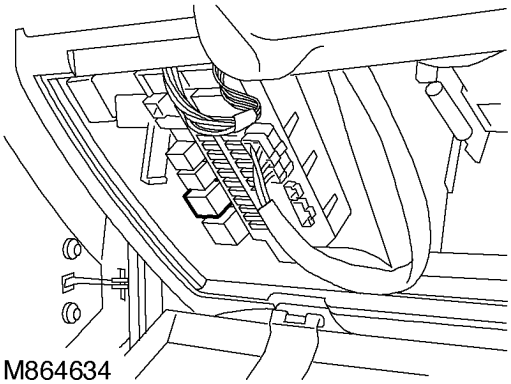

M864633

The front window motors are permanent magnet motors. There is a window motor in each front door. The front window motors are controlled by the BCU.

The BCU provides both the voltage and the earth paths to the front window motors. The BCU reverses the direction the window motor operates by switching the voltage and earth paths to the window motor. The BCU also monitors stall current for the front window motors.

TestBook can operate the front window motors remotely.

Rear window lift relay


M864634

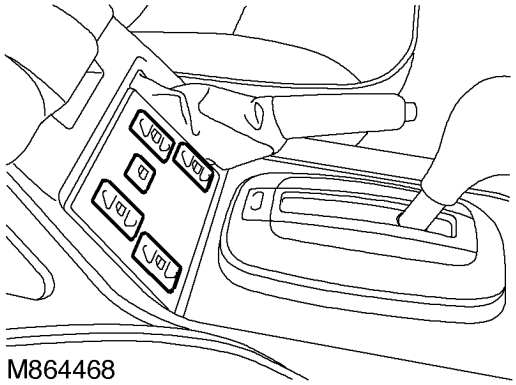
The rear window lift relay is a normally open relay that provides power to the rear window system. It is controlled by the IDM. The IDM receives a rear window enable signal from the BCU to allow operation during the ignition switched-off timeout period.

Both the rear window lift relay and the IDM are located in the passenger compartment fusebox. The IDM is integral to the passenger compartment fusebox.

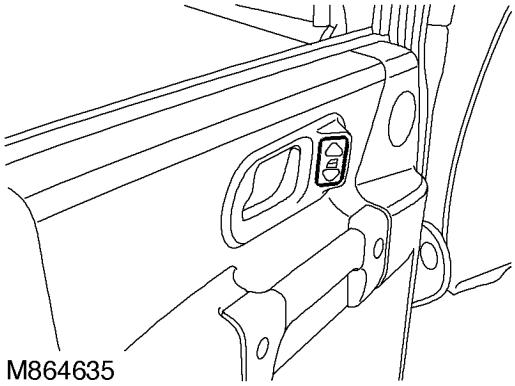
The rear window lift relay receives voltage from fuse 13 (30A) in the passenger compartment fusebox. The IDM controls the earth side of the relay coil.

TestBook cannot monitor the status of the rear window lift relay.

Rear window switches



M864468



M864635

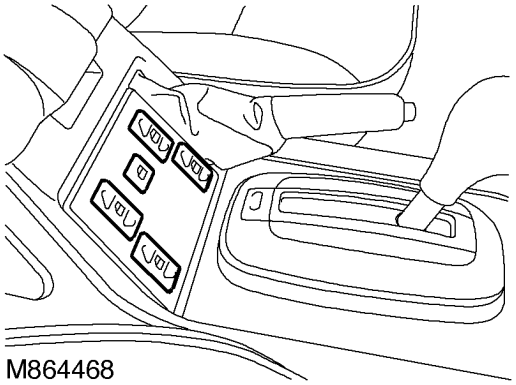
There are two sets of switches that operate the rear windows. There is a set of rear window switches located in the centre console that allow the front seat occupants to operate the rear windows. The second set of switches are located on the rear doors. All rear window switches are non-latching rocker switches.

A conventional window switch circuit controls the rear window system. In the rest position, there is battery voltage at both sides of every switch as well as at the window motors. Operating any switch provides a ground path through the switch to the window motor. Operating the switch in the opposite direction switches the voltage path and the earth path to the motor allowing the motor to run in the opposite direction.

Voltage for the rear windows is from fuse 13 (30A) in the passenger compartment fusebox through the rear window lift relay to the switches and motors.

TestBook cannot monitor the status of the rear window switches.

Rear window isolation switch



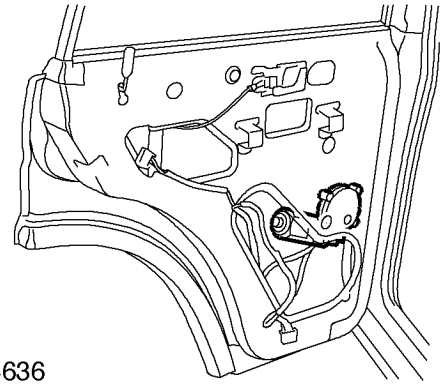
The rear window isolation switch allows the front seat occupants to disable the rear window switches.

The rear window isolation switch is located in the centre console.

The rear window isolation switch is connected in the earth path in series with the rear door window switches. Operating the rear window isolation switch interrupts the earth path to the rear door window switches, preventing the rear door switches from operating the rear window motors. The rear windows can still be operated from the centre console rear window switches.

TestBook cannot monitor the status of the rear window isolation switch.

Rear window motors



M864636

There is a rear window motor located in each rear door. The rear window motors are permanent magnet motors with an integral circuit breaker that provides stall protection.

The rear window switches provide battery voltage and an earth path to the rear window motors. Operating the switch in the opposite direction reverses the voltage and earth paths at the rear window motor, allowing the motor to run in the opposing direction.

TestBook cannot monitor the rear window lift motors.

Operation

Front windows
In order for the windows to operate the ignition switch must either be in position II, or in the off position with the ignition switched-off timeout operational.

The front window switches provide ground signals to the BCU, which operates the windows.

One-touch down operation
The front windows will open completely with a single touch on the window down switch.

In order for the one-touch down to operate, the following conditions must exist:
- Ignition switch in position II, or in the off position with the ignition switched-off time out operational.
- Front window switch pressed for less than 0.4 second.

When the front window down switch is pressed for less than 0.4 second, the window opens completely. Pressing the window up switch for less than 0.2 second stops the movement of the window. The BCU stops one-touch down operation when it detects window stall current or after 10 seconds of window operation.

Depending on market, one-touch down operation can be fitted on both front windows or on the driver's side only.

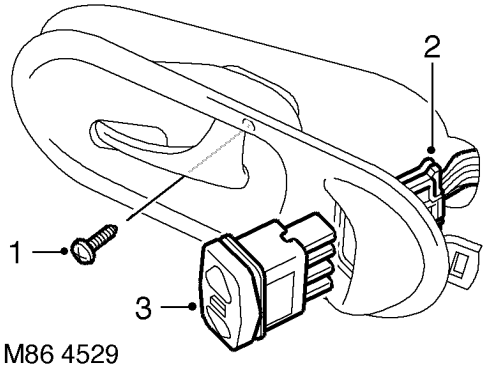
Rear windows
In order for the windows to operate the ignition switch must either be in position II, or in the off position with the ignition switched-off timeout operational.

The rear windows operate by the switch providing both power and ground to the window motor. Pressing one side of the switch provides a power and earth path to the window motor that allows the window motor to operate in one direction. Pressing the other side of the switch reverses the power and earth, which allows the window motor to operate in the opposite direction.

Switch - rear door

86.25.10

Remove



M86 4529

1. Remove screw securing escutcheon to door casing.
2. Release escutcheon, far enough to access switch multiplug, and disconnect multiplug from switch.
3. Remove switch from escutcheon.

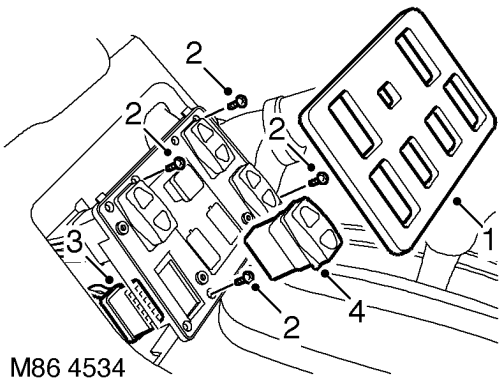
Refit

1. Connect new switch to multiplug and fit to escutcheon.
2. Fit escutcheon to door casing and secure with screw.

Switch - console

86.25.19

Remove



M86 4534

1. Remove console switch cover.
2. Remove 4 screws securing switch mounting plate to console.
3. Release mounting plate from console and disconnect multiplug from switch.
4. Release and remove switch from mounting plate.

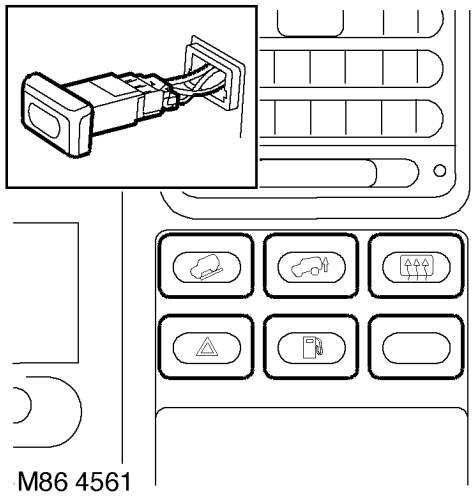
Refit

1. Fit new switch to mounting plate and connect multiplug.
2. Position mounting plate and secure with screws.
3. Fit console switch cover.

Switch - heated rear screen

86.65.36

Remove

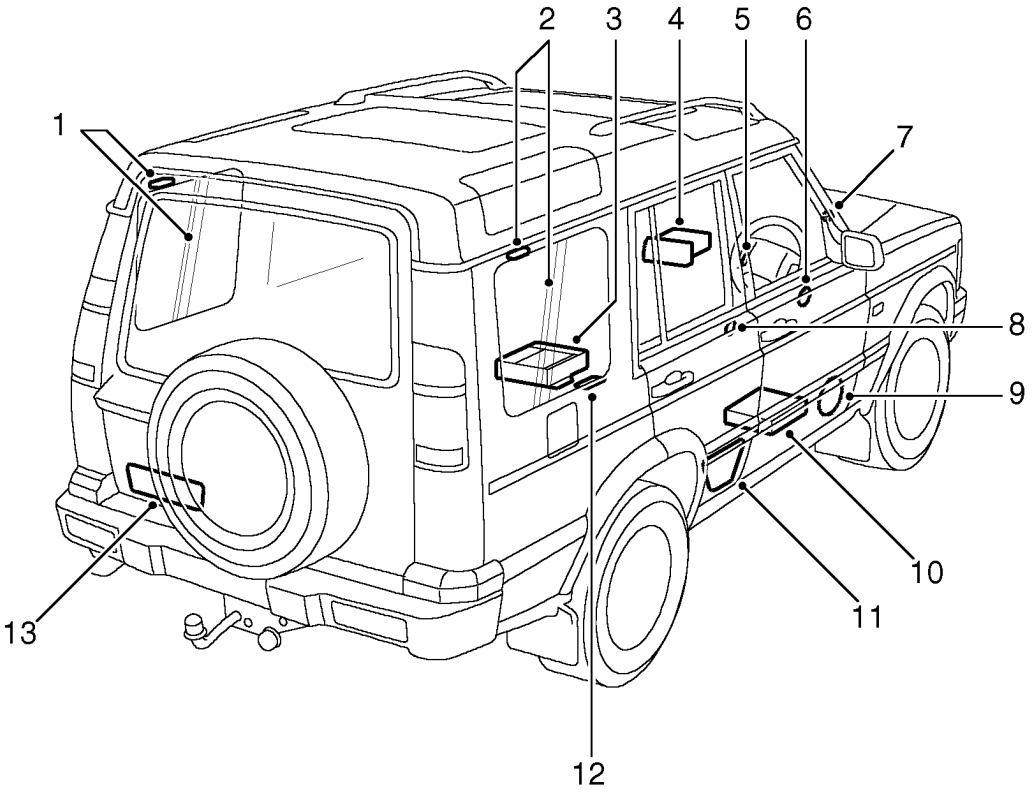


1. Carefully remove switch.
2. Disconnect multiplug from switch.
3. Remove switch.

Refit

1. Connect multiplug switch.
2. Position switch and push to secure.

ICE System Component layout

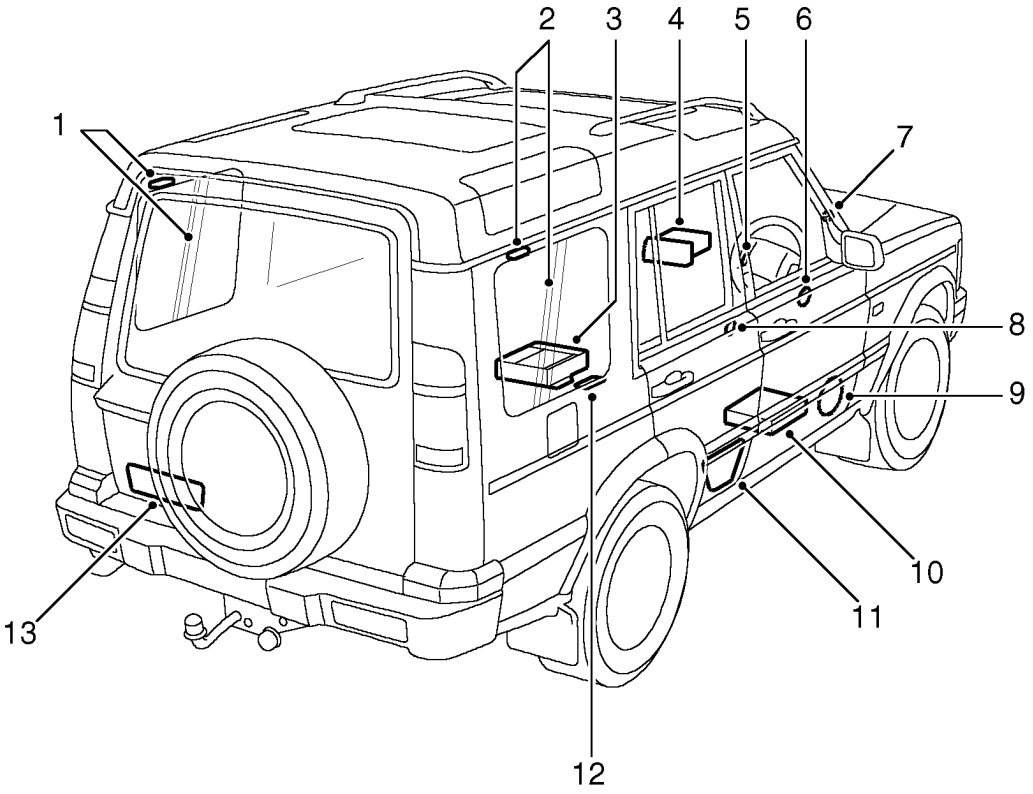


M86 4656

High line RHD system shown (LHD system similar)

1 FM aerial and amplifier (high line only)
2 AM/FM aerial and amplifier
3 Power amplifier (high line only)
4 Radio cassette player
5 Remote radio control switches (mid line and high line only)
6 Upper front door speaker LH/RH (high line only)
7 A post speaker LH/RH (mid line and high line only)
8 Upper rear door speaker, LH/RH (high line only)
9 Lower front door speaker LH/RH
10 CD-autochanger (if fitted)
11 Lower rear door speaker LH/RH
12 Radio headphone amplifier LH/RH (high line only)
13 Tail door speakers (high line only)

ICE System Component layout



M86 4656

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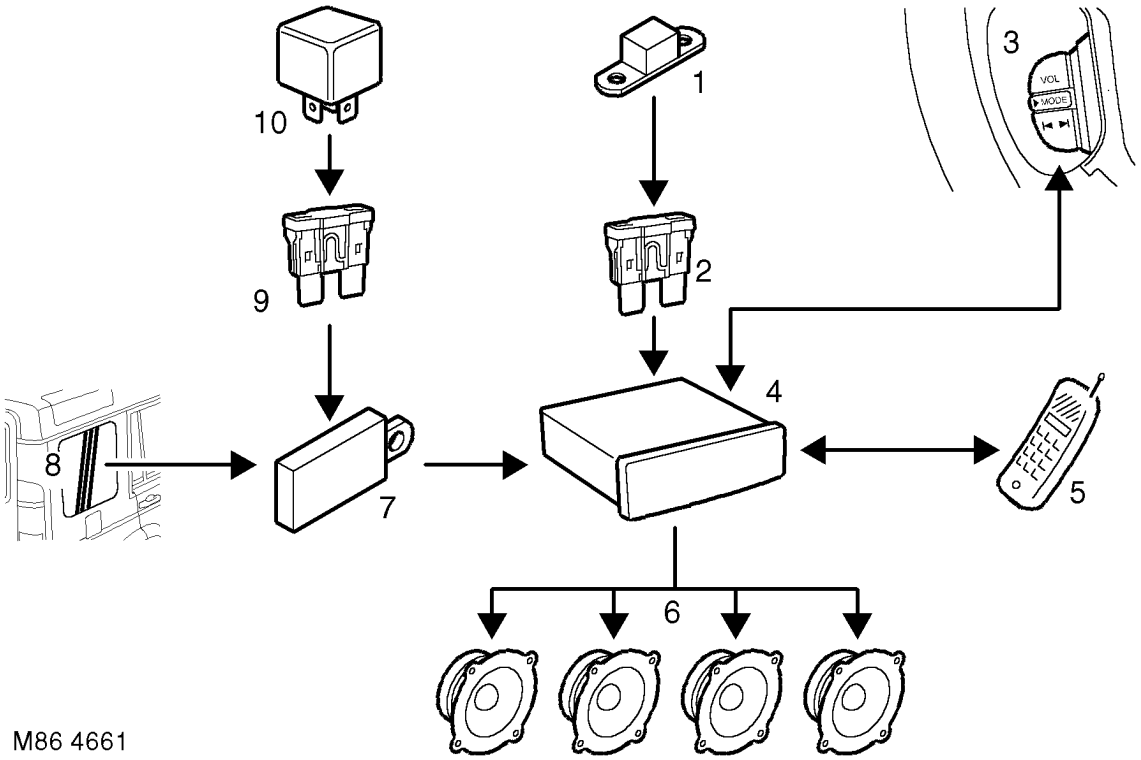
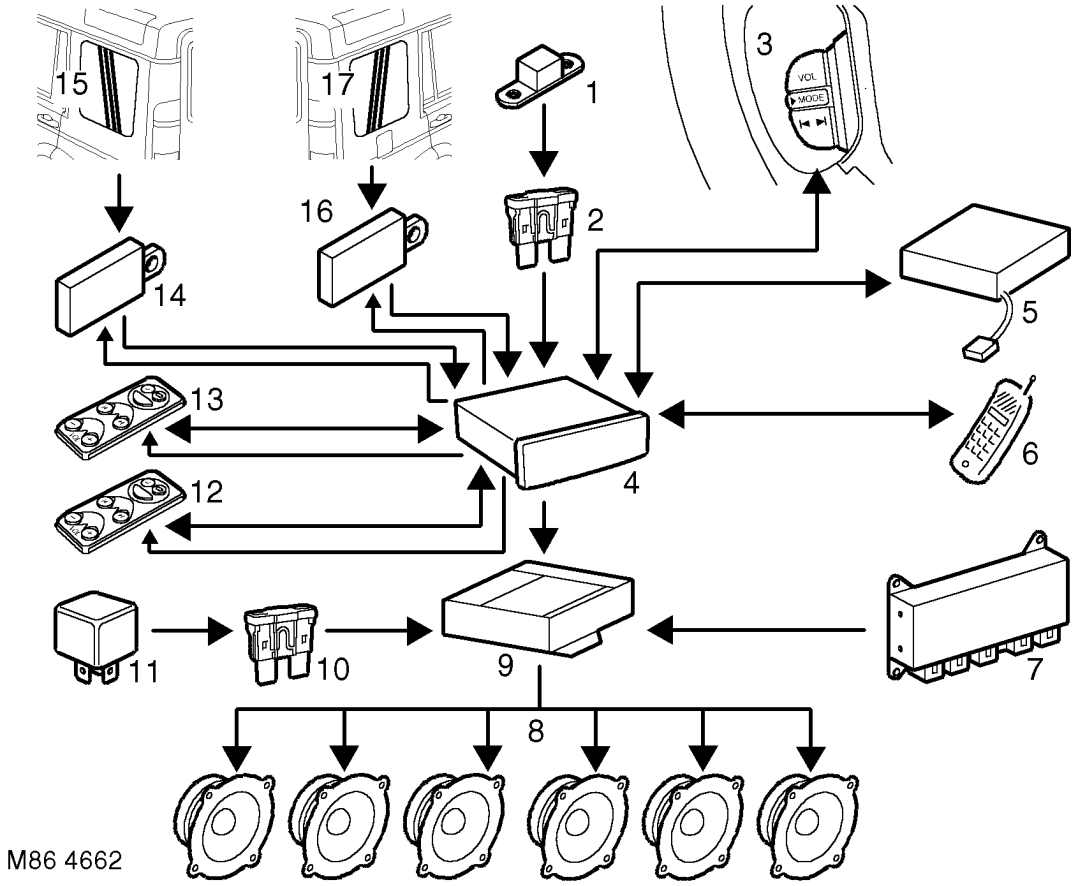
10 CD-autochanger (if fitted)
11 Lower rear door speaker LH/RH
12 Radio headphone amplifier LH/RH (high line only)
13 Tail door speakers (high line only)

Base and mid line ICE system control diagram



1 Fusible link
2 Battery power supply fuse
3 Remote radio control switches (if fitted)
4 Radio cassette
5 Telephone system interface
6 Speakers
7 Amplifier AM/FM aerial
8 AM/FM aerial
9 Auxiliary power supply fuse
10 Auxiliary relay

High line ICE system control diagram



1 Fusible link
2 Battery power supply fuse
3 Remote radio control switches
4 Radio cassette
5 CD-autochanger
6 Telephone system interface
7 Speed signal from SLABS ECU
8 Speakers
9 Power amplifier
10 Auxiliary power supply fuse
11 Auxiliary relay
12 Radio headphone amplifier RH rear
13 Radio headphone amplifier LH rear
14 Amplifier FM aerial
15 FM aerial
16 Amplifier AM/FM aerial
17 AM/FM aerial

Description

General
The in car entertainment (ICE) system allows the driver and passengers to listen to audio output from the speakers or optional headphones inside the vehicle. Buttons or knobs on the radio cassette allow changes of levels or selections during the various modes of operation. The system can be controlled from the fascia mounted radio cassette, or optional remote control switches on the left hand side of the steering wheel. High line systems may also have rear headphone amplifiers that have some control of the system via the radio cassette player.

One or two amplified aerials located in the rear side windows send radio signals to the radio cassette player. On high line systems a power amplifier and a CD-autochanger may be located under the front seats. Speakers are located in the lower door panels, additional speakers may be located in upper door trim, the A-post and the tail door. A display screen shows the user the current system status.

The ICE supplied varies with trim level and market. Vehicles may not have all of the speakers, amplified aerials, CD-autochanger, rear headphone amplifiers or power amplifier.

Base system radio cassette
The base radio cassette has buttons for LD (loudness) AM, FM, EJECT (tape), Reverse, Base/Balance, treble, MAN forward and reverse. The base radio cassette is located in the center of the fascia and contains the radio and tape player, four clips (accessible through holes in the front of the unit) secure the unit in the fascia. To remove the unit the four clips must be released with a special tool. The base system can be controlled from the fascia mounted radio cassette. A logic control circuit in the radio cassette player controls the operation in the various control modes.

The radio cassette has a display screen, the information shown can be the current radio frequency, tape operating, bass or loudness settings. Power for the illumination on the radio cassette is supplied from the passenger compartment fuse box. A main fuse is also located in the connector socket area on the back of the radio cassette.

Security code function
A combination of buttons on the radio cassette are used to input and change security codes. Security codes make the unit unusable if the unit is disconnected from the vehicle without deactivating the security code. The radio cassette has an internal memory chip that stores the code information, if the power is removed from the unit the chip will activate the security code feature. For this reason the security code feature must be deactivated before the unit is removed or the vehicles battery is disconnected.

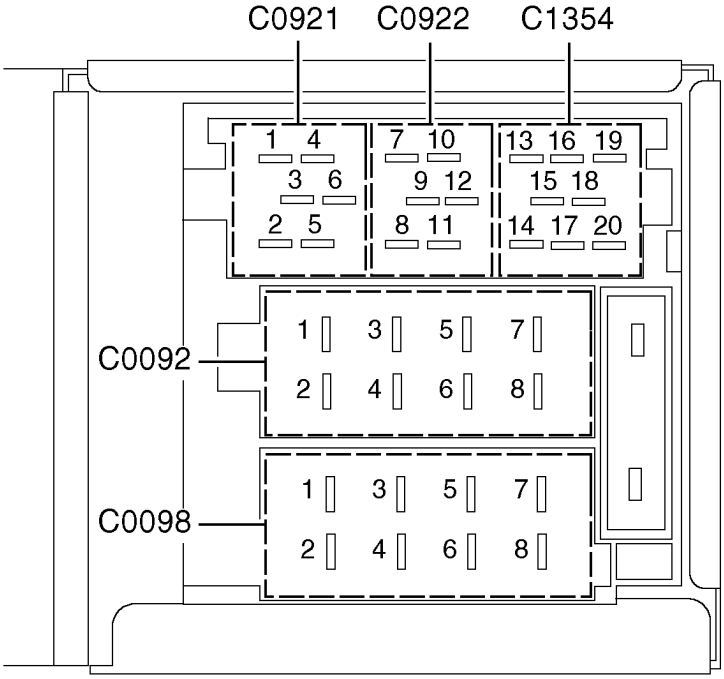
Audio functions
The radio cassette has buttons for the following audio functions: LD (loudness), bass/balance, fader, treble and volume.

Cassette functions
The radio cassette has buttons for the following cassette functions: eject, forward, reverse and tape reversal.

Multi function buttons
The function of presets 1-6 and the MAN button depends on current mode of operation and allows selection of radio band, radio on, tape track and search/seek functions. The MAN button is mode dependent, when pressed the button allows manual operation or alternate mode selections such as manual tuning.

Internal memory
An internal memory chip stores the station presets and security code, power is supplied internally to the chip via a permanent power feed, supplied from the passenger compartment fuse box.

Radio cassette player connector pin details.



M86 4657A

Connector/Pin No.	Description	Input/Output
C0092		
1	Rear RH speaker line	Output +
2	Rear RH speaker line	Output -
3	Front RH speaker line	Output +
4	Front RH speaker line	Output -
5	Front LH speaker line	Output +
6	Front LH speaker line	Output -
7	Rear LH speaker line	Output +
8	Rear LH speaker line	Output -
C0098		
1	Telephone mute	Input
2	Steering wheel remote radio controls	Input
3	Steering wheel remote radio controls	Output
4	Permanent battery feed	Input
5	System enable	Output
6	Illumination	Input
7	Auxilary feed	Input
8	Earth	Input
C0921 (high line systems)		
1	Radio headphone left channel	Output +
2	Radio headphone right channel	Output +
3	Telephone audio	Input +
4	Radio headphone left channel	Output -
5	Radio headphone right channel	Output -
6	Telephone audio	Input -
C0922 (high line systems)		
7	Radio headphone active	Input

8	I-BUS communications	Input/Output
9	Audio amplifier spatial imaging enable	Output
10	Radio headphone LH remote control	Input
11	Radio headphone RH remote control	Input
12	Headphone remote controls feed	Output
C1354 (high line systems)		
13	CD-autochanger audio left channel	Input +
14	CD-autochanger audio right channel	Input +
15	CD-autochanger audio earth	Output
16	CD-autochanger audio left channel	Input -
17	CD-autochanger audio right channel	Input -
18	Not Used	
19	CD-autochanger I-BUS communications link	Input/Output
20	CD-autochanger permanent feed	Output

Midline system radio cassette

The midline radio cassette is located in the center of the fascia and contains the radio and tape player, four clips (accessible through holes in the front of the unit) secure the unit. To remove the radio cassette unit the four clips must be released with a special tool. The midline system can be controlled from the fascia mounted radio cassette, or from remote radio control switches on the left hand side of the steering wheel. The audio signal can be from the radio, cassette player or a optional CD-autochanger. A logic control circuit in the radio cassette player controls the operation in the various control modes.

The radio cassette has a display screen, information shown can include current status, station (radio mode) or cassette tape track or (optional) CD-autochanger track/disc status. Power for illumination on the radio cassette is supplied from the passenger compartment fusebox. A main fuse is also located in the connector socket area on the back of the radio cassette.

Security code function

A combination of buttons on the radio cassette are used to input and change security codes. Security codes make the unit unusable if the unit is disconnected from the vehicle without deactivating the security code. The radio cassette has an internal memory chip that stores the information, if the power is removed from the unit the chip will activate the security code feature. For this reason the security code feature must be deactivated before the unit is removed or the vehicles battery is disconnected.

Audio functions

A rotary knob allows changes of levels or selections during the various modes of operation, this includes volume, bass, treble and fader.

Cassette functions

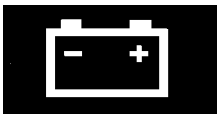
The radio cassette has buttons for the following cassette functions eject, tape, reverse, forward, tape eject/reversal.

Radio functions

The radio cassette has buttons for the selection of AM or FM reception. Selection of the radio station is controlled by the use of the multi-function buttons on the radio cassette player, the radio headphone amplifiers or the remote radio controls on the steering wheel.

Traffic information and news function

A traffic information button (TA/NEWS) allows traffic or news information to be selected on the FM waveband only, in this mode the audio output will mute when traffic or news messages are received. After the traffic or news message the radio, cassette tape or CD will resume play, the traffic and news information varies with the country of use and radio band selected.



Multi function buttons
Rotary controls are located on the front of the radio cassette for adjustment of bass, treble etc, depending on current mode selected. Operation of presets 1-6 depends on current mode of operation and allows selection of radio band (Radio mode on) or CD-autochanger disc (in the CD mode). Scan (Mode dependent) manual or automatic selection of band or track. RND random play, MODE/MUTE (mode dependent) when pressed the button allows manual operation or alternate mode selections such as manual tuning, compact disk cue/review, tape forward/rewind modes.

Internal memory
An internal memory chip stores the station presets and security code, power is supplied internally to the chip via a permanent power feed, supplied from the passenger compartment fuse box.

High line system radio cassette
The high line radio cassette is located in the center of the fascia and contains the radio and tape player. Two clips (accessible through slots in the front of the unit) secure the unit. To remove the radio cassette unit the two clips must be released with a special tool. The high line system can be controlled from the fascia mounted radio cassette, or from remote radio control switches on the left hand side of the steering wheel. In vehicles fitted with radio headphone amplifiers, the rear seat passengers can control their individual audio output using a headphone amplifier control panel. The audio signal can be from the radio, cassette player or a CD-autochanger. A logic control circuit in the radio cassette player controls the operation in the various control modes.

The radio cassette has a display screen, information shown includes current status, station (Radio mode) , CD-autochanger track/disc status or status of headphone amplifier. Power for illumination on the radio cassette is supplied from the passenger compartment fusebox. A main fuse is also located in the connector socket area on the back of the radio cassette. When the radio cassette switch is on, power is made available via internal circuits to the radio headphone amplifiers.

Security code function
A combination of buttons on the radio cassette are used to input and change security codes. Security codes make the unit unusable if the unit is disconnected from the vehicle without deactivating the security code. The radio cassette has an internal memory chip that stores the information, if the power is removed from the unit the chip will activate the security code feature. For this reason the security code feature must be deactivated before the unit is removed or the vehicles battery is disconnected.

Audio functions
A rotary knob allows changes of levels or selections during the various modes of operation, this includes volume, bass, treble, fader and spatial on/off.

Cassette functions
The radio cassette has buttons for the following cassette functions; eject, fast forward, rewind and dolby. The dolby symbol is shown on the dot matrix display screen if dolby mode is selected.

Radio functions
The radio cassette has buttons for the selection of AM or FM reception. Selection of the radio station is controlled by the use of the multi-function buttons on the radio cassette player, the radio headphone amplifiers or the remote radio controls on the steering wheel.

CD-autochanger functions
The CD button on the radio cassette player allows selection of the CD-autochanger. CD disc and track selection is controlled by the use of the multi-function buttons on the radio cassette player, the radio headphone amplifiers or the remote radio controls on the steering wheel.

Traffic information function

A traffic/news information button (I) allows traffic or news information to be selected on the FM waveband only, in this mode the radio will mute when traffic or news messages are received. After the traffic or news message the radio, cassette tape or CD will resume play, the traffic and news information varies with the country of use and radio band selected.

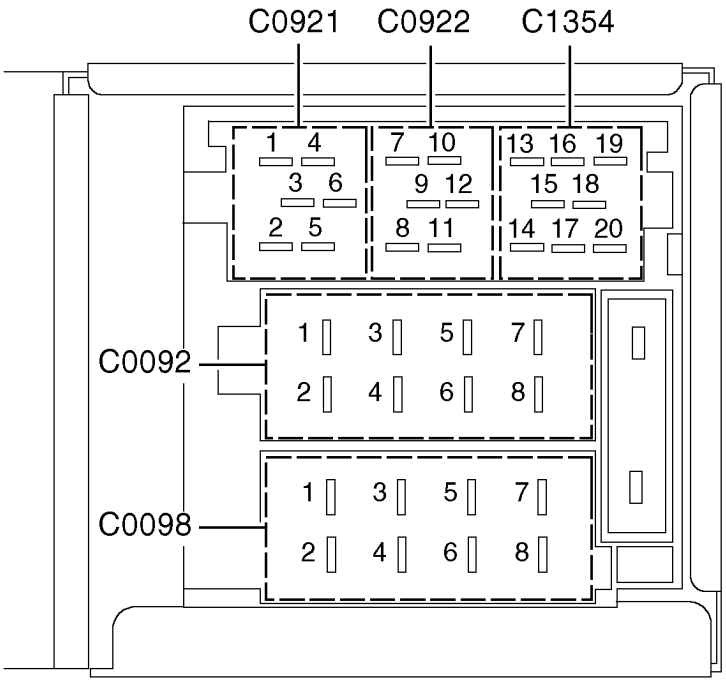
Multi function buttons

The music symbol button is used for mode selection for adjustment of bass, treble etc. depending on current mode selected. Operation of presets 1-6 depends on current mode of operation and allows selection of radio band (Radio mode on) or CD-autochanger disc (in the CD mode). Search/Seek (Mode dependent) manual or automatic selection of band or track. MAN (mode dependent) when pressed the button allows manual operation or alternate mode selections such as manual tuning, compact disk cue/review, tape forward/rewind modes. The mode dependent SCAN button allows automatic searching of radio bands, tape or compact disk tracks.

Internal memory

An internal memory chip stores the station presets and security code, power is supplied internally to the chip via a permanent power feed, supplied from the passenger compartment fuse box.

Radio cassette player connector pin details.



M86 4657A

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C0098		
1	Telephone mute	Input
2	Steering wheel remote radio controls	Input
3	Steering wheel remote radio controls	Output
4	Permanent battery feed	Input
5	System enable	Output
6	Illumination	Input
7	Auxilary feed	Input
8	Earth	Input
C0921 (high line systems)		
1	Radio headphone left channel	Output +
2	Radio headphone right channel	Output +
3	Telephone audio	Input +
4	Radio headphone left channel	Output -
5	Radio headphone right channel	Output -
6	Telephone audio	Input -
C0922 (high line systems)		
7	Radio headphone active	Input
8	I-BUS communications	Input/Output
9	Audio amplifier spatial imaging enable	Output
10	Radio headphone LH remote control	Input
11	Radio headphone RH remote control	Input
12	Headphone remote controls feed	Output
C1354 (high line systems)		
13	CD-autochanger audio left channel	Input +
14	CD-autochanger audio right channel	Input +
15	CD-autochanger audio earth	Output
16	CD-autochanger audio left channel	Input -
17	CD-autochanger audio right channel	Input -
18	Not Used	
19	CD-autochanger I-BUS communications link	Input/Output
20	CD-autochanger permanent feed	Output

Inputs and outputs

The radio cassette player receives a mute signal from the telephone system if a call is received, when the call finishes the mute is removed and the system resumes play. Inputs are also received from the steering wheel control system (mid line and high line sytems). When the system is turned on, the high line systems radio cassette player:

- sends a 'power on enable' to the power amplifier
- sends an 'enable' signal to the radio headphone amplifiers.

On the high line system the radio cassette player also sends and receives signals from the CD-autochanger and rear headphone amplifiers (if fitted). On high line systems the radio cassette player sends audio signals to the power amplifier.

Remote radio steering wheel controls (midline and high line systems)
The remote radio control switch is located on the LH side of the steering wheel and is secured with two screws. The wiring from the remote radio control switch plugs in to a connector that is part of the steering wheel rotary coupler. Operation of the remote radio control switches allow the driver to control the ICE without releasing the steering wheel. Volume, mode and selection functions can be carried out using the steering wheel mounted control switches. Control inputs from the remote radio control switches are sent to the radio cassette player.

Aerial
On base and midline ICE systems an AM/FM aerial is built-in to the side window glass on the RH side of the vehicle. An amplifier is located on the frame above the rear side widow behind the rear quarter trim, and is secured (and earthed) with one bolt. Coaxial leads connect the aerial to the aerial amplifier and radio cassette. Power is supplied from the auxilary relay in the engine compartment fuse box, through a fuse in the passenger compartment fusebox to the amplifier.

On high line ICE systems two amplified aerials are built-in to the side window glass of the vehicle. The two aerials are an AM/FM aerial on the RH side, and an FM aerial on the LH side. The amplifier for each aerial are located on the frame above each rear side widow behind the rear quarter trim, and are each secured (and earthed) with one bolt. Amplified aerials improve the reception quality, the FM aerial gives improved reception in areas of poor signal (diversity) conditions in urban areas. A Power feed from the radio cassette player is connected to the amplified aerials, power is available when the cassette player is operating. The aerials are connected to the radio cassette player by two coaxial cables, a small plug connects the FM only aerial, a larger plug connects the AM/FM aerial.

Power amplifier (high line system)
The amplifier is located on a bracket under the LH front seat and is secured with three screws and washers. The amplifier receives inputs from the radio, radio cassette player or (via the radio cassette player) the CD-autochanger. Power for the amplifier is supplied from the passenger compartment fuse box. The amplifier will power up when an enable logic signal is sent from the radio cassette, this signal is sent by the radio cassette when it is turned on.

CD-autochanger (high line system)
A CD-autochanger is located under the RH front seat, the unit is secured to brackets in the floor with four screws and washers. A tray is used to hold each compact disk (CD), the loaded tray is then inserted in a magazine, the magazine holds six trays and is then inserted into the CD-autochanger. A sliding cover protects the internal components of the CD-autochanger from dirt entry through the magazine opening. An eject button located on the front of the CD-autochanger can be used to release the magazine from the CD-autochanger. The sliding cover has to be opened manually before the magazine eject button is pressed. The operation of the CD-autochanger is controlled by inputs from the radio cassette, the control inputs can be from the radio cassette buttons, the remote radio controls or the rear radio headphone amplifiers if they are fitted. The output from the CD-autochanger are connected to the radio cassette player. The radio cassette player sends the outputs to the power amplifier. Power is supplied to the CD-autochanger by a feed from the radio cassette player.

Radio headphone amplifiers (high line system)
The rear mounted radio headphone amplifiers are located in the lower rear quarter trim casing and are held in position by a clip on the side of the headphone amplifier. Mode and function buttons are located on a control panel, the mode button allows each of the rear seat passengers to independently select from the radio, tape or CD-autochanger. The driver and the rear seat passengers can each listen to any of the audio devices they select. However the radio cassette setting has overall priority e.g:

- If the radio cassette is using a radio wave band (AM or FM), the headphone user will be able to select the cassette tracks or CD-autochanger. The user will be able to listen to same radio band that is selected on the radio cassette, but will not be able to change the station selected.
- If the radio cassette has CD-autochanger selected, the headphone amplifiers will allow listening to the compact disk but will not allow track changes. The headphone user will be able to select on all of the radio bands or cassette tracks.
- If the radio cassette has tape selected, the headphone amplifiers will allow listening to the tape but will not allow track changes. The headphone user will be able to select all radio bands or CD's on the CD-autochanger.

If one headphone amplifier unit has control of the tape player, CD or radio, the other headphone amplifier will be able to listen and be able to change tape tracks or radio bands. Other buttons allow a search seek function of radio band or compact disk track, reversal of the tape, radio station and volume adjustment depending on the current operating mode. If one radio headphone amplifier has control of the radio, tape or CD autochanger the other radio headphone amplifier is able to change the track or radio band selected. A headphone socket with a glow ring is located on the control panel. When a headphone is turned on , a 'headphone-module active' signal is sent to the radio cassette player. The design incorporates panel illumination and a glow-ring to locate the socket in low light conditions. To control the audio output from the radio headphone amplifiers, signals are sent to and received from the radio cassette player.

Automatic volume control (High line system only)
An automatic base and treble volume control feature compensates for increases in interior road/transmission noise. A road speed signal is monitored by the power amplifier, the signal is supplied by the SLABS ECU.
☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**The power amplifier boosts the levels of base and treble as road speed increases. This system ensures that the apparent volume of sound remains constant and is not affected by increases in the background noise in the vehicle.

Speakers
Some vehicles will not have all the speakers, the type and location of speakers fitted depends on the trim level and ICE options specified for the vehicle.

A-post speakers LH/RH (if fitted)
The A-post speakers are located in the A-post trim on each side of the windscreen, and are each protected by a metal grille. The speakers are held from the rear by a bayonet clip that clamps the speaker on to the A-post trim. The A-post speakers are a high range type and have a power rating of:
- Mid line system A-post speakers have a power rating of 15 watts and an impedance of 4 Ω.
- High line system A-post speakers have a power rating of 30 watts and an impedance of 4 Ω.

Upper front and rear door speakers LH/RH (high line system only)
The upper door speakers are located in the upper door trim, the speaker is protected by an integral metal grille. The speaker is held in by a threaded ring that clamps the speaker from the rear onto the door trim. The upper door speaker is a mid-range type and has a power rating of 30 watts and an impedance of 4 Ω.

Lower front door speakers LH/RH
The lower front door speaker is located in the front end of the lower (pocket) trim and is secured by three self tapping screws. The speaker is protected by a clip on circular metal grille. The type of lower front door speakers fitted depends on trim level and market:
- The base and mid line systems are fitted with full-range door speakers with a power rating of 15 watts and an impedance of 4 Ω
- The high line system is fitted with a low-range door speaker with a power rating of 30 watts and an impedance of 4 Ω.

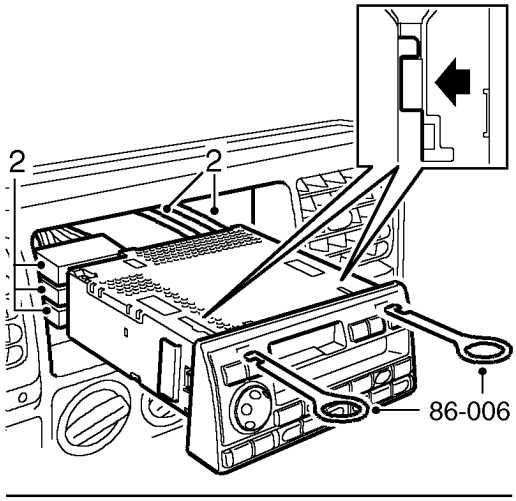
Lower rear door speaker LH/RH
The lower rear door speaker is located in the lower door trim and is secured by three self tapping screws. The speaker is protected by a clip on metal grille. The type of lower rear door speaker fitted depends on trim level and market:
- The base and mid line systems are fitted with full-range door speakers with a power rating of 15 watts and an impedance of 4 Ω
- The high line system is fitted with a low-range door speaker with a power rating of 30 watts and an impedance of 4 Ω.

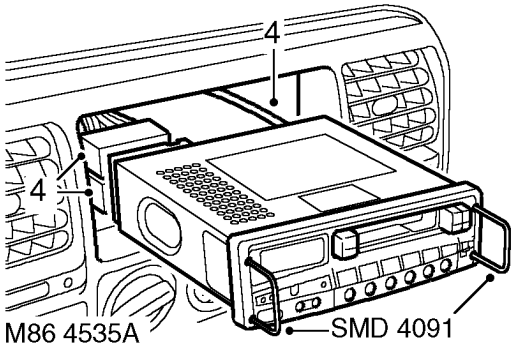
Low range tail door speakers (high line system only)
The low range tail door speaker are located in a plastic casing in the lower door trim. Each of the two speakers is secured to the casing with four self tapping screws. The casing is secured to the lower door structure with eight bolts. The tail door trim surrounds the casing, the front of the casing is covered by a metal grill that is secured with six screws. The low range tail door speakers have a power rating of 30 watts and has an impedance of 4 Ω.

Radio cassette player

86.50.03

Remove





1. **High line models:** Fit tool **86-006**, with cut-outs facing outwards, into slots at top of radio cassette player. Ensure that cut-outs locate correctly with retaining clips (arrowed), and pull radio cassette player from fascia.
2. **High line models:** Disconnect 3 multiplugs and 2 coax cables and remove radio cassette player.
3. **Mid and low line models:** Fit radio removal tools **SMD 4091** to release retaining clips and pull radio cassette player from fascia.
4. **Mid and low line models:** Disconnect 2 multiplugs and coax cable and remove radio cassette player.

Refit

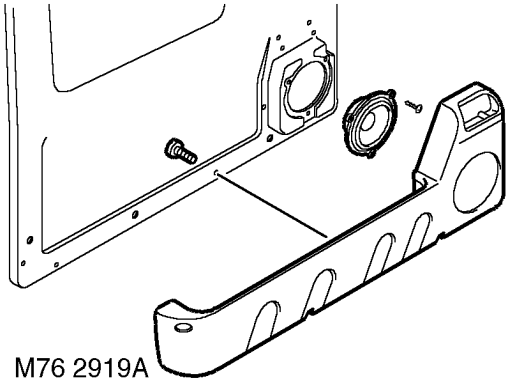
1. Position radio cassette player to fascia aperture and connect multiplugs and coax cable(s).
2. Slide radio into fascia until retaining clips engage.
3. Enter security code and check radio cassette player for correct operation.

Speaker - low/full range - front door

86.50.10

Remove

1. Remove front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.



M76 2919A

2. Remove 10 Torx screws securing front door pocket to door trim casing.
3. Remove 3 screws securing speaker to door trim casing.
4. Remove front door speaker.

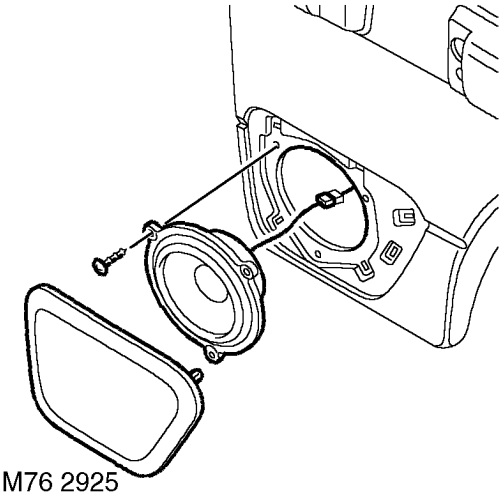
Refit

1. Position speaker and secure to door trim casing with screws.
2. Position front door pocket to trim casing and secure with Torx screws.
3. Fit front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.

Speaker - low range - rear door

86.50.12

Remove



M76 2925

1. Carefully release 6 clips securing speaker grille to door trim casing.
2. Remove speaker grille.
3. Remove 3 screws securing rear door speaker to rear door trim casing.
4. Disconnect multiplug from rear of speaker.
5. Remove speaker.

Refit

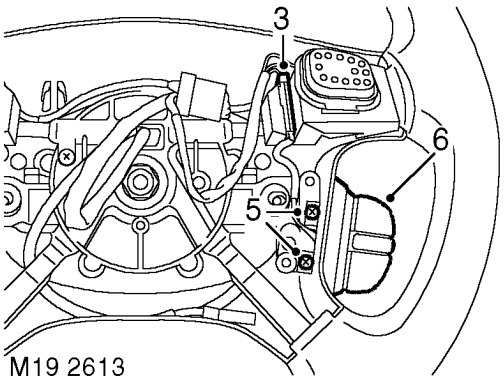
1. Position rear door speaker and connect multiplug.
2. Secure speaker to rear door trim casing with screws.
3. Position grille to trim casing and secure with clips.

Switches - remote control - ICE

86.50.13

Remove

1. Remove the key from the starter switch. Disconnect both battery leads, negative lead first. Wait ten minutes before starting work.
2. Remove driver's airbag module.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.**



M19 2613

3. Release remote control switches multiplug and leads from steering wheel base.
4. Disconnect remote control switches multiplug from harness.
5. Remove 2 screws securing remote control switches to steering wheel base.
6. Release and remove remote control switches from steering wheel.

Refit

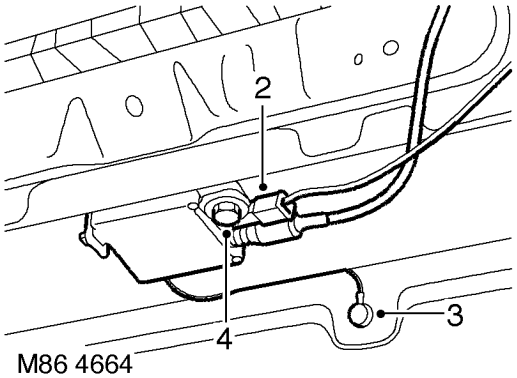
1. Fit remote control switches to steering wheel and secure with screws.
2. Connect remote control switches multiplug to harness.
3. Secure leads and multiplug to base of steering wheel.
4. Fit driver's airbag module.
   ☞ **RESTRAINT SYSTEMS, REPAIRS, Airbag module - drivers.**

Amplifier - aerial

86.50.29

Remove

1. Remove rear quarter upper trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**



M86 4664

2. Disconnect coaxial lead and Lucar connector from amplifier.
3. Disconnect amplifier from aerial.
4. Remove bolt securing amplifier and remove amplifier.

Refit

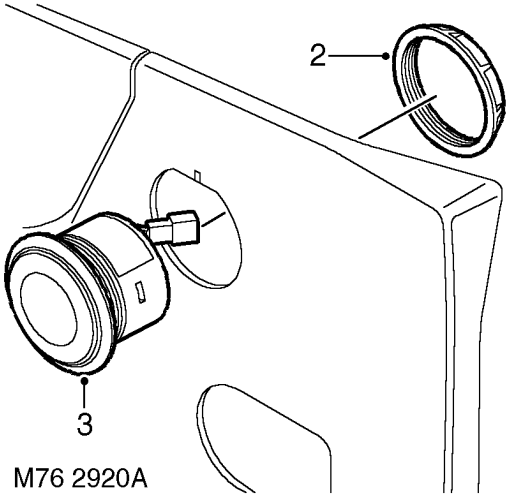
1. Position amplifier and secure with bolt.
2. Connect aerial lead, Lucar connector and coaxial lead.
3. Fit rear quarter upper trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - 'D' post.**

Speaker - mid range - front door

86.50.34

Remove

1. Remove front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.



M76 2920A

2. Remove locknut securing speaker to front door trim casing.
3. Remove speaker.

Refit

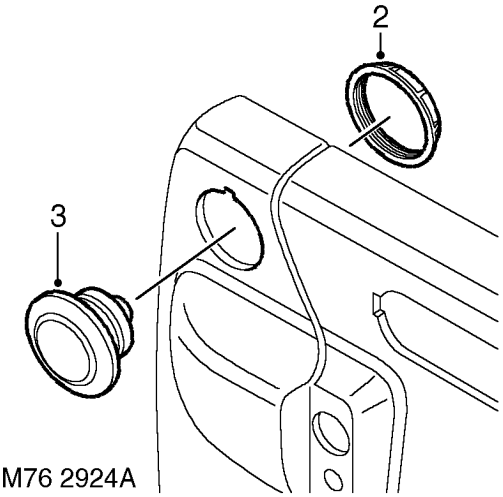
1. Position speaker and secure to door trim casing using locknut.
2. Fit front door trim casing.
   DOORS, REPAIRS, Trim casing - front door.

Speaker - high range - rear door

86.50.35

Remove

1. Remove rear door trim casing.
   DOORS, REPAIRS, Trim casing - rear door.



M76 2924A

2. Remove speaker locknut.
3. Remove speaker from door trim casing.

Refit

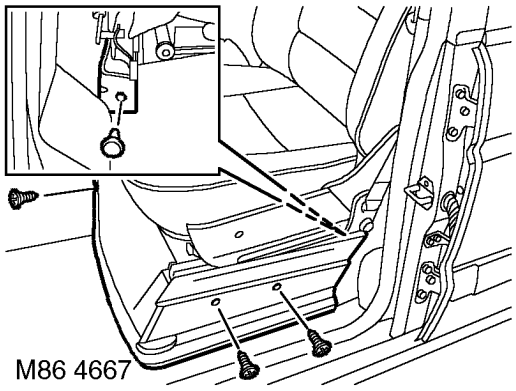
1. Position speaker and secure withlocknut to rear door trim casing.
2. Fit rear door trim casing.
   DOORS, REPAIRS, Trim casing - rear door.

Amplifier - power

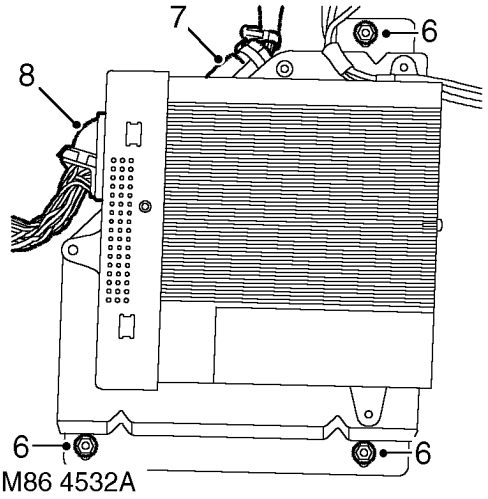
86.50.36

Remove

1. Release fixings and remove battery cover.
2. Disconnect battery earth lead.

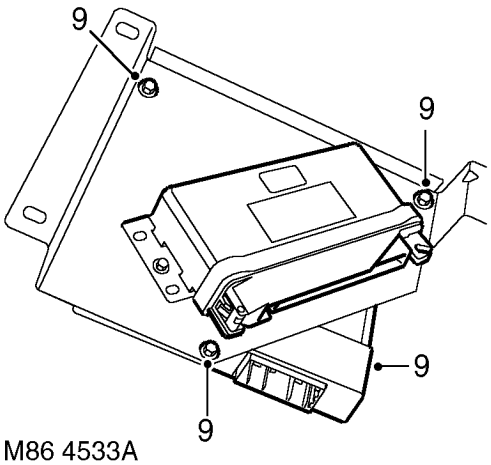

M86 4667

3. Remove 3 screws and 1 trim clip securing lower trim casing to LH front seat.
4. Remove lower trim casing.
5. Move seat fully rearwards.



M86 4532A

6. Remove 3 nuts securing power amplifier mounting bracket to body.
7. Release mounting bracket and, if applicable, disconnect multiplug from EAT ECU on underside of bracket.
8. Disconnect multiplug from power amplifier.



M86 4533A

9. Remove 3 screws securing power amplifier to mounting bracket and remove power amplifier.

Refit

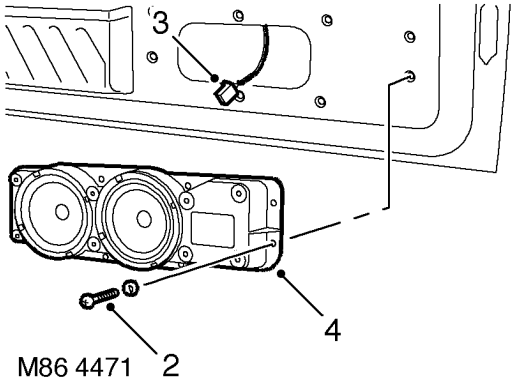
1. Fit power amplifier to mounting bracket and secure with screws.
2. Position power amplifier and mounting bracket to body and connect power amplifier multiplug. If applicable, also connect EAT ECU multiplug.
3. Fit bracket to body mountings and secure with nuts.
4. Position lower trim casing to seat and secure with fixings.
5. Connect battery earth lead.
6. Fit battery cover and secure with fixings.

Speaker - tail door

86.50.42

Remove

1. Remove tail door speaker trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - tail door speaker.**



2. Remove 8 screws securing tail door speaker to tail door trim casing.
3. Disconnect tail door speaker multiplug.
4. Remove tail door speaker.

Refit

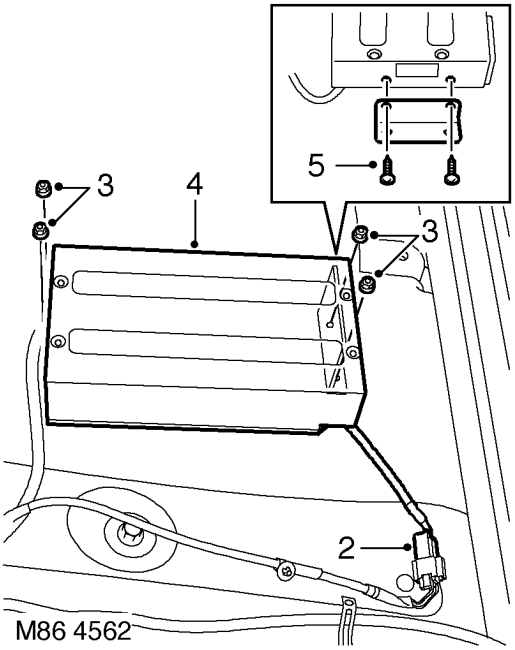
1. Position tail door speaker to tail door and connect multiplug.
2. Fit screws securing tail door speaker to tail door trim casing.
3. Fit tail door speaker trim casing.
   ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - tail door speaker.**

CD autochanger

86.50.60

Remove

1. Remove RH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**



2. Disconnect multiplug from CD autochanger.
3. Remove 4 nuts securing CD autochanger to floor.
4. Remove CD autochanger.
5. Remove 4 screws securing mounting brackets to CD autochanger and remove mounting brackets.

Refit

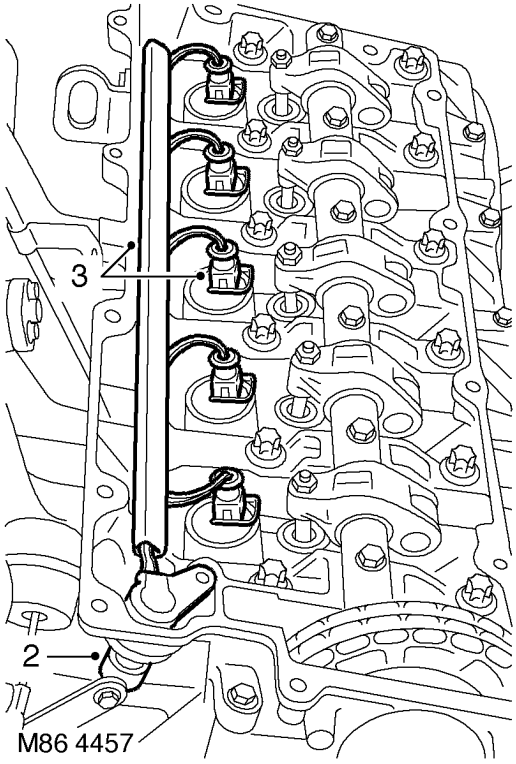
1. Position mounting brackets to CD autochanger and secure with screws.
2. Position CD autochanger to floor and secure with nuts.
3. Connect multiplug to CD autochanger.
4. Fit RH front seat.
   ☞ **SEATS, REPAIRS, Seat - front.**

Harness - injectors - diesel

86.70.22

Remove

1. Remove camshaft cover gasket.
   ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.



2. Disconnect engine harness from injector harness.
3. Disconnect multiplugs from injectors. release injector harness from camshaft carrier and remove harness.

Refit

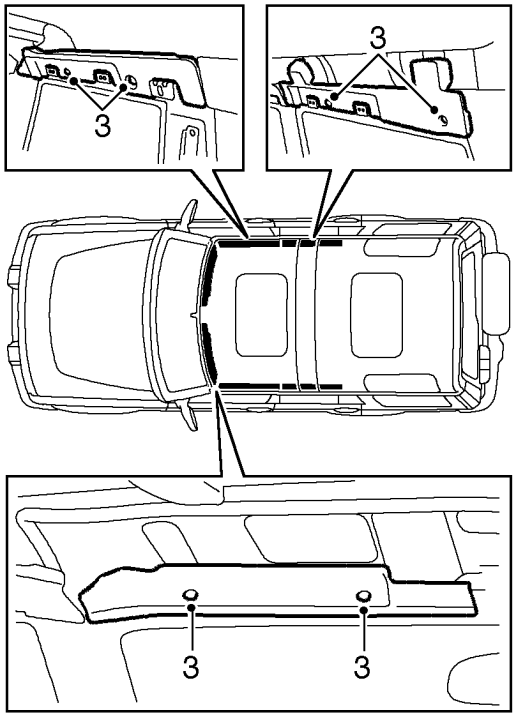
1. Fit new 'O' rings to injector harness connector.
2. Position harness and locate connector to camshaft carrier.
3. Connect injector and engine harness multiplugs.
4. Fit camshaft cover gasket.
   ENGINE - Td5, REPAIRS, Gasket - cover - camshaft.

Harness - body

86.70.11

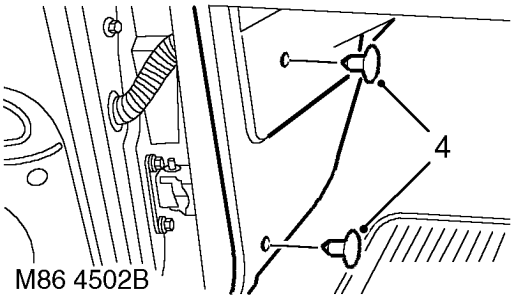
Remove

1. Remove fascia panel.
   INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.
2. Remove headlining.
   INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.

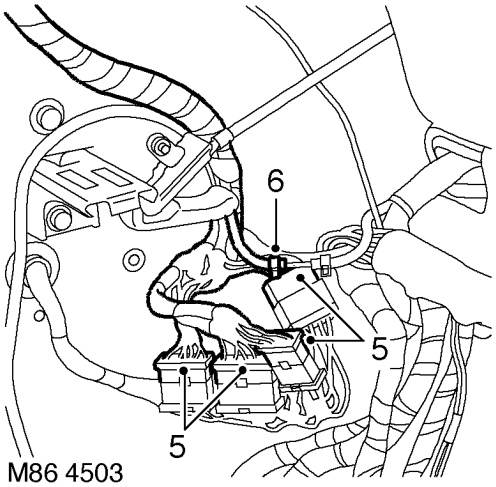


M86 4501

3. Remove 5 studs securing sound deadening and remove 3 sound deadening panels.

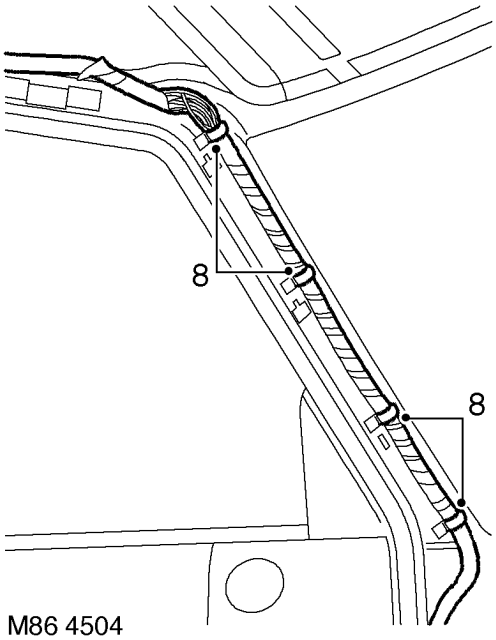


4. Remove 2 studs securing LH lower 'A' post trim panel and remove trim panel.



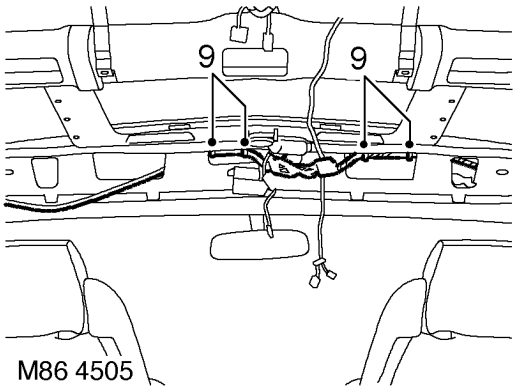
M86 4503

5. Release and disconnect 4 multiplugs from LH lower 'A' post.
6. Release clip and disconnect rear washer pipe from LH lower 'A' post.
7. Release harness from behind bonnet release cable.



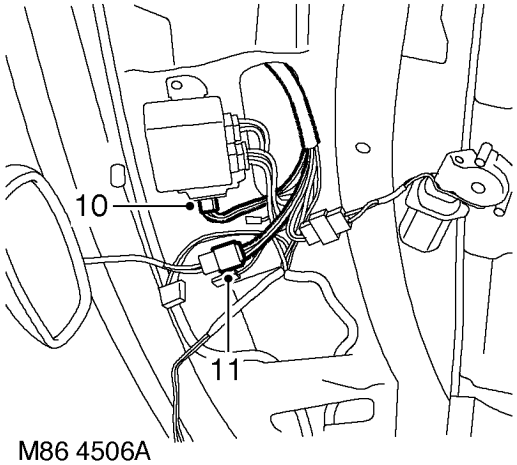
M86 4504

8. Release harness from 4 retainers in LH upper 'A' post and collect protective sleeves.



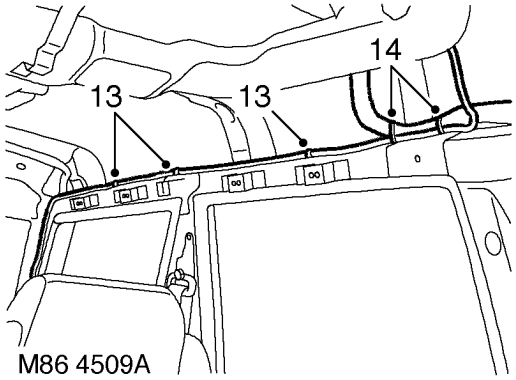
M86 4505

9. Release 4 clips securing harness to centre of roof.



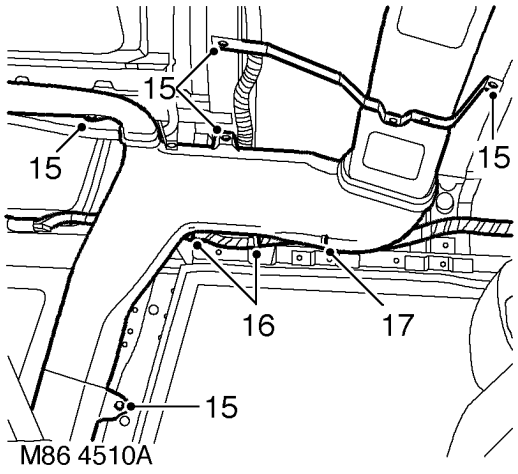
M86 4506A

10. Disconnect multiplug from ACE accelerometer.
11. Disconnect multiplug from interior mirror.
12. Feed harness through roof to upper 'A' post.
13. Release 3 retainers securing harness to RH roof panel.



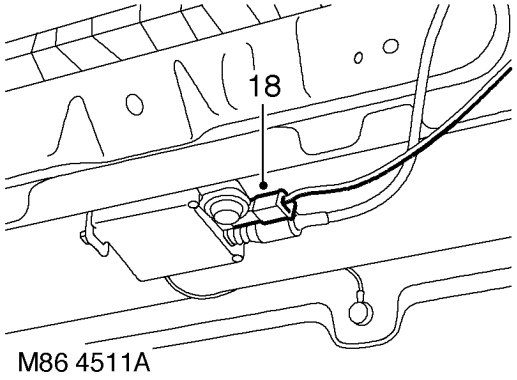
M86 4509A

14. Release 2 cable clips securing body harness to sunroof harness.



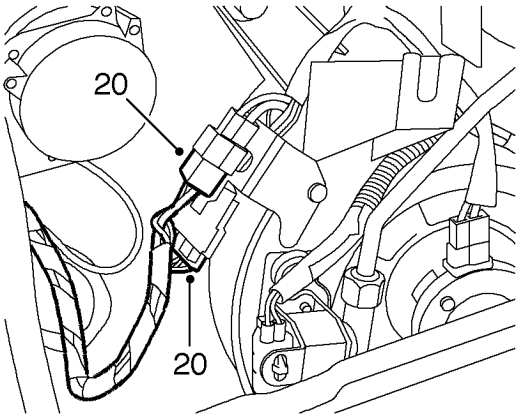
M86 4510A

15. Drill out 4 rivets securing air conditioning ducting to body, release ducting.
16. Release 2 cable ties securing harness to LH side of body.
17. Release retainer securing harness to LH side of body.



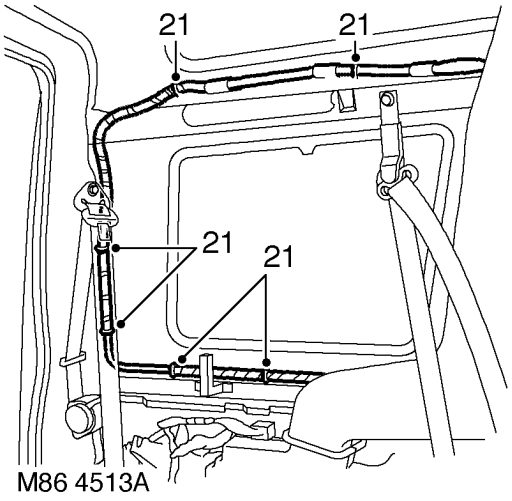
M86 4511A

18. Disconnect Lucar from radio aerial LH amplifier.
19. Remove both luggage compartment trim casings.
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**



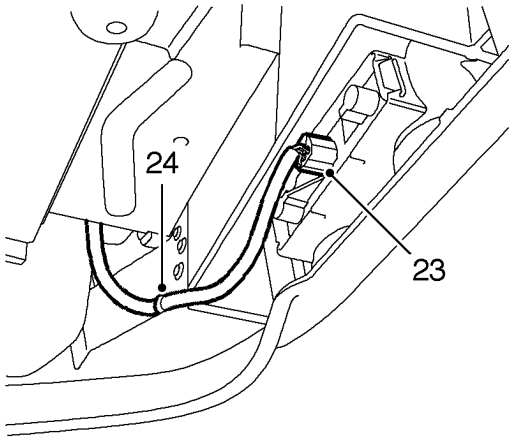
M86 4512A

20. Disconnect 2 multiplugs from rear air conditioning unit.



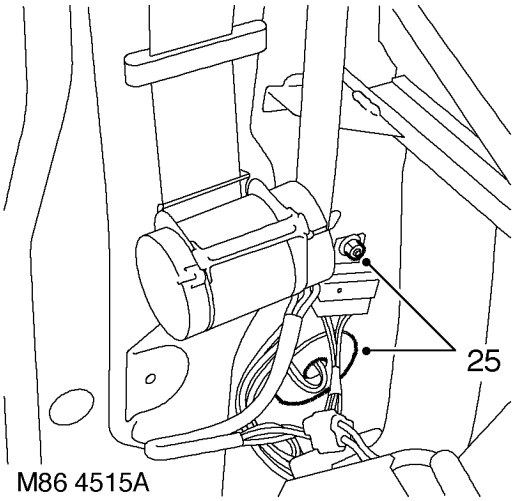
M86 4513A

21. Remove 6 clips securing harness to LH side of body.
22. Remove both rear tail lamps.
☞ **LIGHTING, REPAIRS, Lamp - tail.**



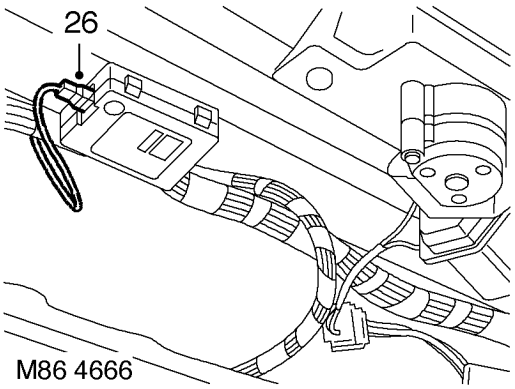
M86 4514A

23. Disconnect multiplugs from both tail/flasher lamps.
24. Release 2 clips securing harness to rear bumper.



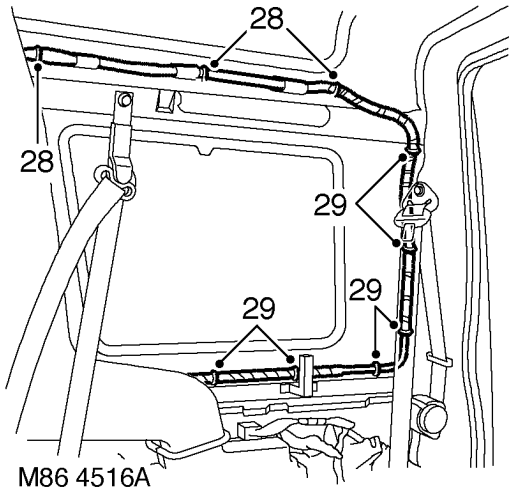
M86 4515A

25. Remove nut securing earth header to LH 'E' post and remove grommet from 'E' post.

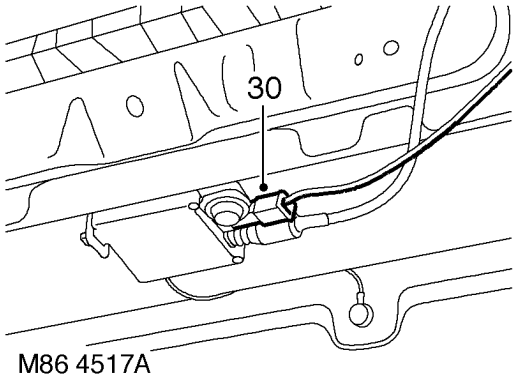


M86 4666

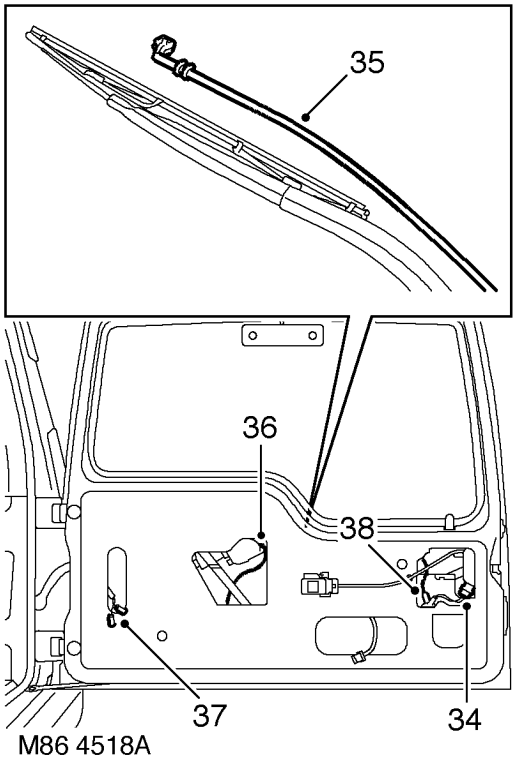
26. Disconnect multiplug from RF receiver.
27. Feed harness back to air conditioning ducting.



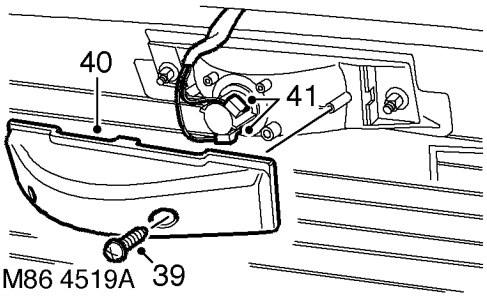
28. Release 3 harness retainers securing harness to RH side of body.
29. Release 6 cable clips securing harness to body.



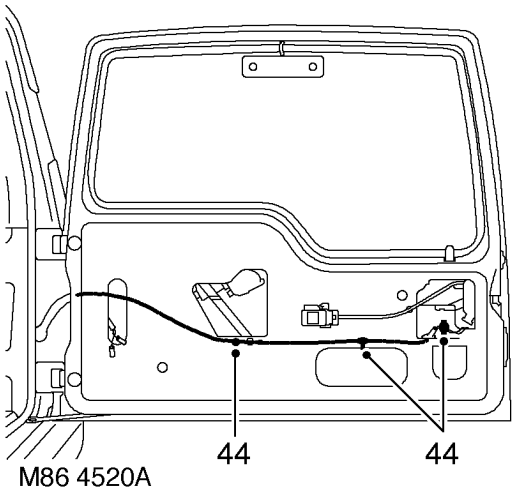
30. Disconnect Lucar from RH aerial amplifier.
31. Release harness from roof and feed to upper 'E' post.
32. Remove tail door trim casing.
☞ **DOORS, REPAIRS, Trim casing - tail door.**
33. Carefully release plastic sheet from tail door.



34. Disconnect multiplug from door latch.
35. Disconnect multiplug and washer tube from rear wiper arm.
36. Disconnect multiplug from rear wiper motor.
37. Disconnect 2 Lucars from heated rear window (HRW).
38. Disconnect multiplug from number plate lamp.

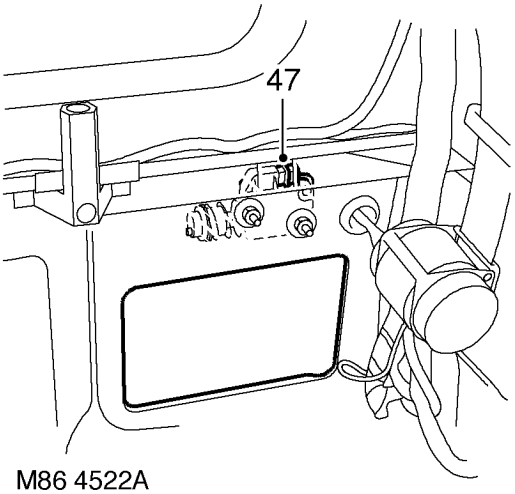


39. Remove 2 screws securing centre high mounted stop lamp (CHMSL) cover to tail door glass.
40. Remove CHMSL cover.
41. Disconnect 2 Lucars from CHMSL.
42. Attach draw string to harness and draw harness through tail door.
43. Disconnect draw string from harness, and tape to the tail door.



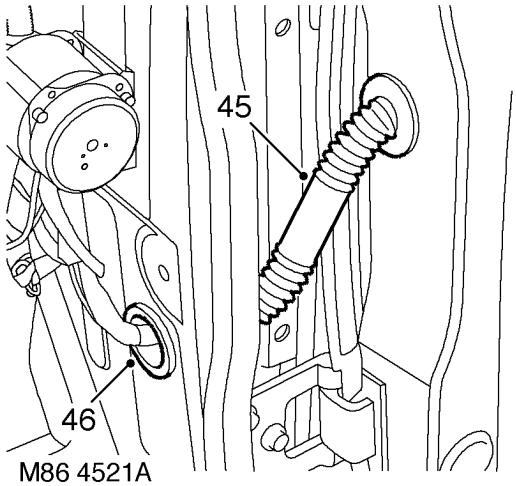
M86 4520A

44. Release 3 clips securing harness to tail door.



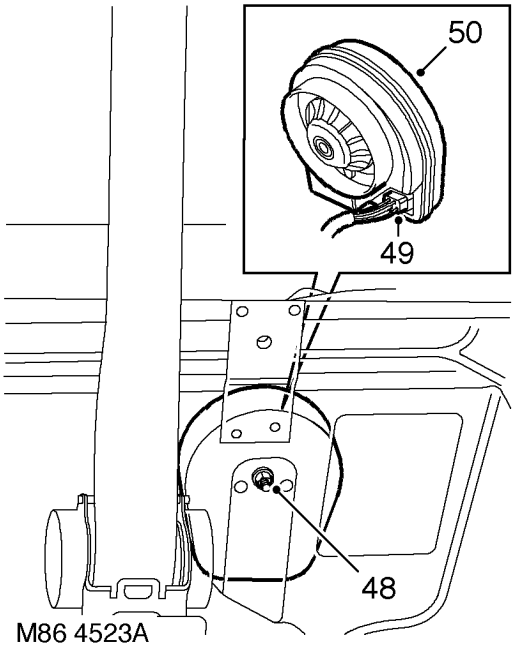
M86 4522A

47. Disconnect multiplug from fuel flap solenoid.



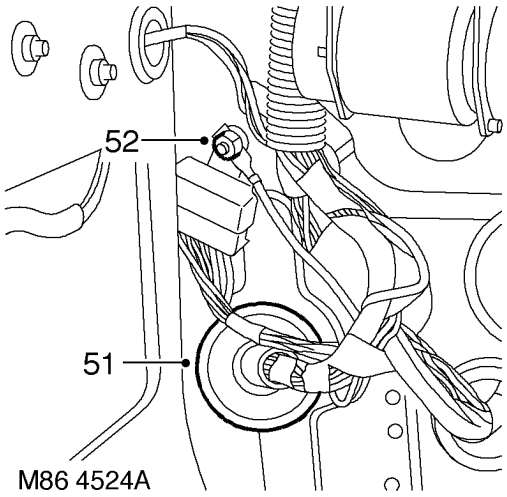
M86 4521A

45. Release harness sleeve from door outer edge and feed harness through door.
46. Release grommet from 'E' post and feed tail door harness back to upper 'E' post.

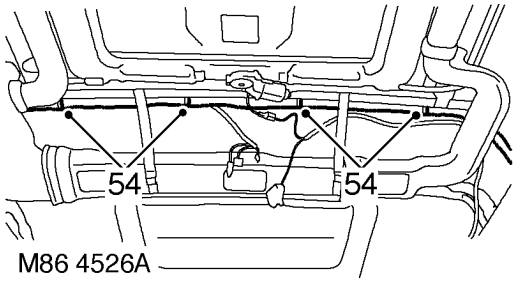


M86 4523A

48. Remove nut securing alarm sounder to RH lower 'E' post.
49. Disconnect multiplug from alarm sounder.
50. Remove alarm sounder.



51. Remove grommet and feed harness from rear bumper to upper 'E' post.
52. Remove nut securing earth headers to RH 'E' post.
53. Feed harness to air conditioning ducting.



54. Remove 4 cable ties securing harness to centre of roof.
55. With assistance, remove harness from air conditioning ducting and remove from vehicle.

Refit

1. With assistance, position harness to air conditioning ducting and secure with cable ties.
2. Secure harness to sunroof harness with cable clips.
3. Connect multiplug to RF receiver.
4. Feed harness to LH and RH upper 'E' posts.
5. Feed harness through 'E' post to tail lamp and rear bumper and secure with grommet.
6. Connect multiplug to fuel flap solenoid and alarm sounder.
7. Position alarm sounder to rear quarter and secure with nut to 9 Nm (7 lbf.ft).
8. Position both RH earth header to 'E' post and tighten nut to 10 Nm (7 lbf.ft).
9. Feed tail door harness through 'E' post and secure with grommet.
10. Position harness sleeve to outer edge of door and pull harness through door.
11. Secure harness to tail door with clips.
12. Connect washer tube to rear of wiper arm.
13. Remove tape from draw string and secure to CHMSL harness.
14. Draw harness through tail door and connect Lucars to CHMSL.
15. Fit CHMSL cover and secure with screws.
16. Connect multiplug to door lock switch.
17. Connect Lucars to HRW.
18. Connect multiplug to rear wiper motor.
19. Connect multiplug to door latch.
20. Fit plastic sheet to tail door, ensuring it aligns with witness marks.
21. Fit tail door trim casing.
☞ **DOORS, REPAIRS, Trim casing - tail door.**
22. Connect Lucar to radio aerial RH amplifier.
23. Secure harness to RH side of body with clips and retainers.
24. Position both LH earth header to 'E' post and tighten nut to 10 Nm (7 lbf.ft).
25. Connect multiplugs to both tail/flasher lamps and secure harness to bumper with clips.
26. Fit both rear tail lamps.
☞ **LIGHTING, REPAIRS, Lamp - tail.**
27. Secure harness to rear LH side of body with 6 cable clips.
28. Connect 2 Lucars to rear air conditioning unit.
29. Fit both luggage compartment trim casings.
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Trim casing - side - loadspace.**
30. Feed harness into position for rear interior light.
31. Connect Lucar to radio aerial LH amplifier.
32. Secure harness to body with cable ties clips and retainers.
33. Secure air conditioning ducting to body with rivets.
34. Feed harness to LH lower 'A' post.

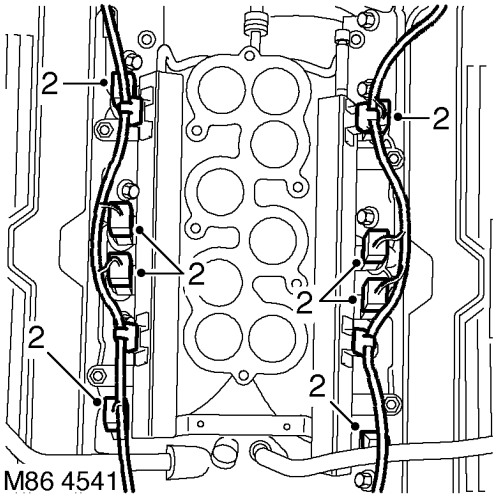
35. Secure harness to LH side of body with cable tie clips and retainers.
36. Connect and secure multiplugs to lower LH 'A' post.
37. Feed harness through roof to centre.
38. Secure harness behind bonnet release cable.
39. Connect rear washer pipe at lower 'A' post and secure with clip.
40. Secure harness to roof with clips.
41. Connect multiplug to interior mirror, ARC accelerometer.
42. Position sound deadening panels and secure with clips.
43. Fit headlining.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Headlining.**
44. Fit fascia panel.
    ☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Fascia.**

Harness - engine - V8

🔧 ***86.70.17***

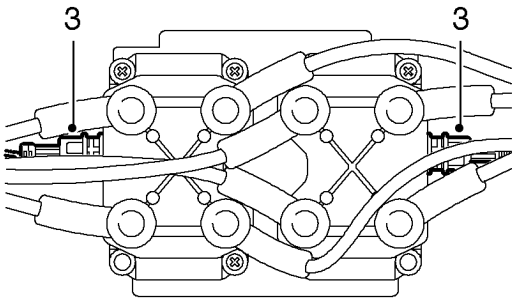
Remove

1. Remove upper inlet manifold.
   ☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**



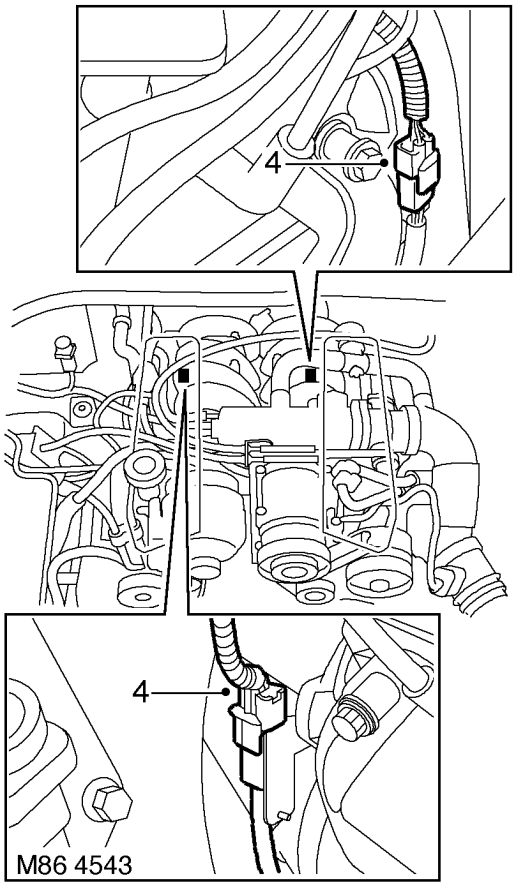
M86 4541

2. Disconnect injector multiplugs, release harness from fuel rail.

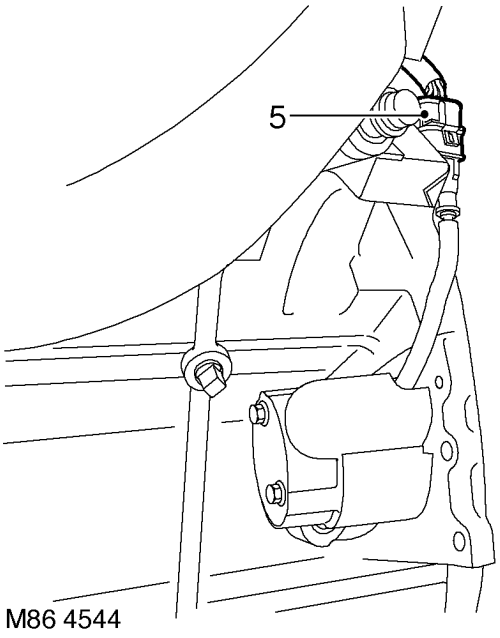


M86 4542

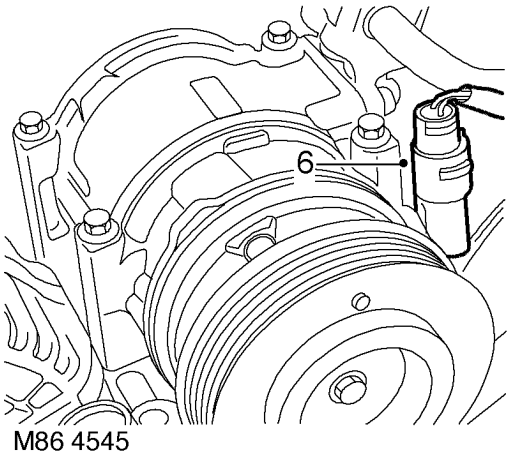
3. Disconnect ignition coil multiplugs.



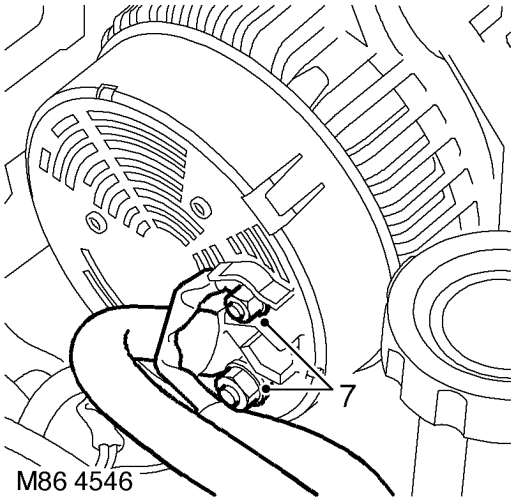
4. Release and disconnect both HS_2O sensor multiplugs.



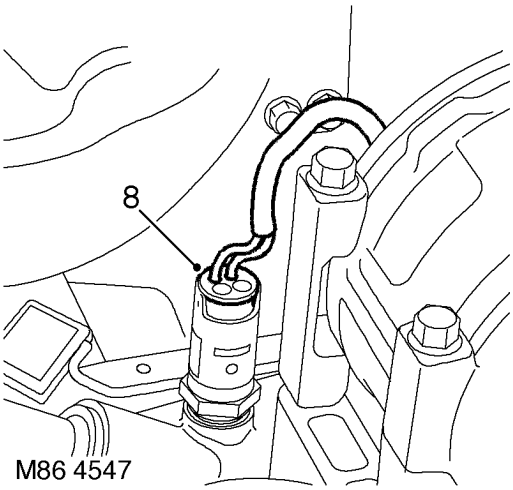
5. Disconnect CKP sensor multiplug.



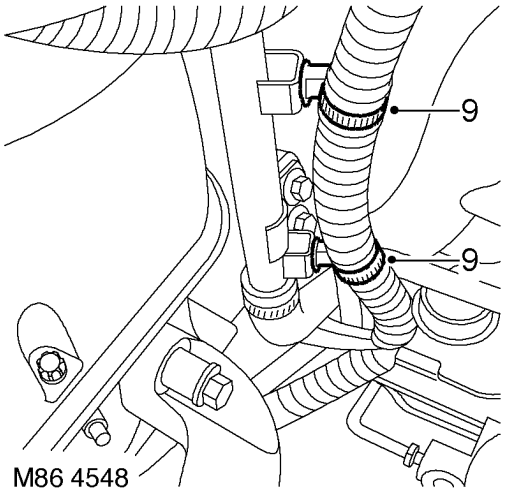
6. Disconnect air conditioning compressor multiplug.



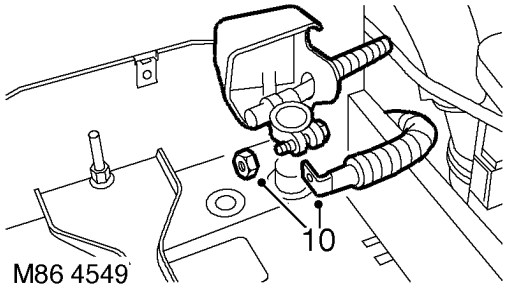
7. Remove 2 nuts securing alternator cables and release cables.



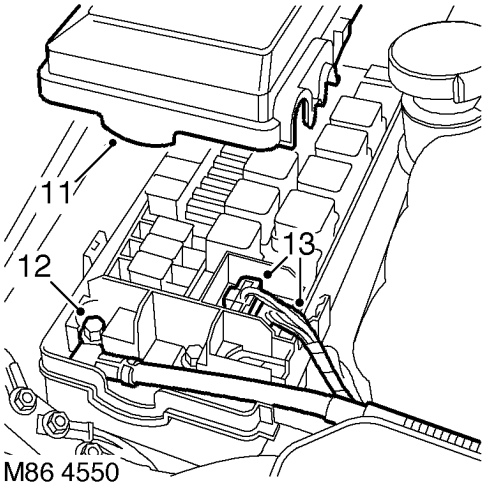
8. Disconnect coolant temperature sensor multiplug.



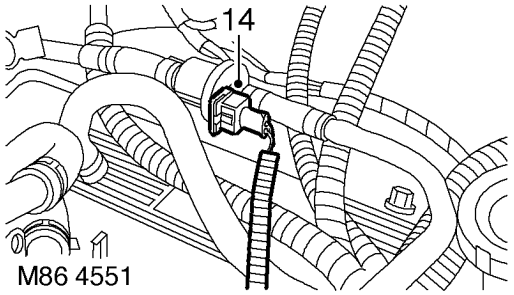
9. Release 2 harness clips from coolant rail.



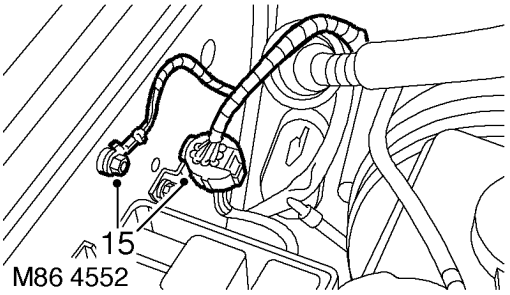
10. Remove nut securing engine harness positive lead to battery, release lead and position aside.



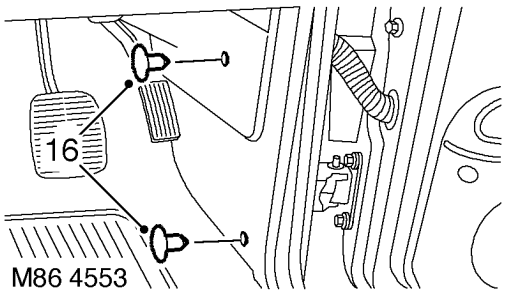
11. Release clips and remove fuse box cover.
12. Remove bolt securing starter lead to fuse box, release lead and position aside.
13. Disconnect 2 engine harness multiplugs from fuse box.



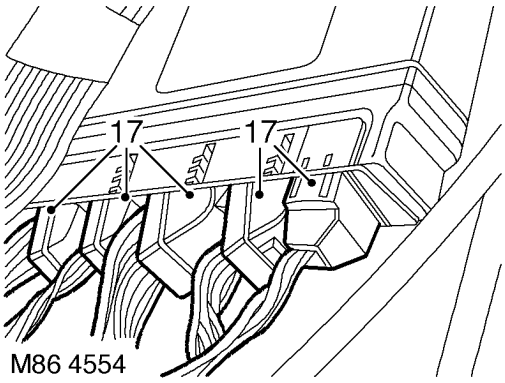
14. Disconnect EVAP solenoid multiplug.



15. Remove nut securing engine harness earth to body and disconnect engine harness to main harness multiplug.

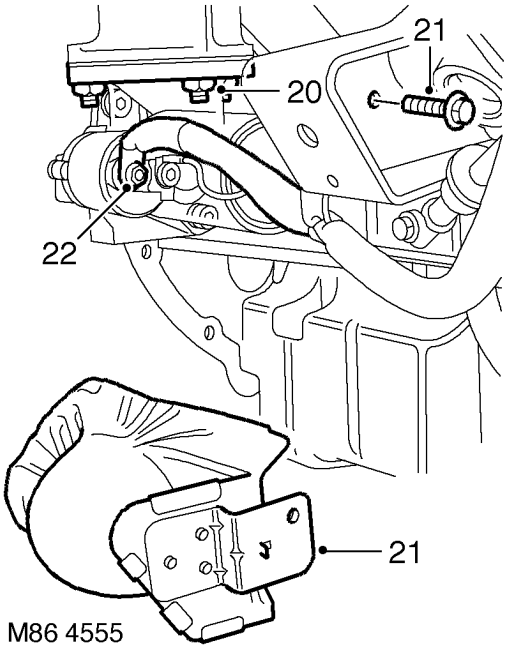


16. Remove trim fixings securing toe board and remove toe board.

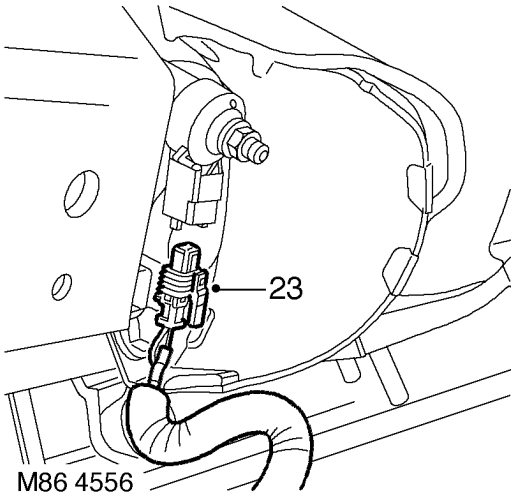


17. Disconnect 5 multiplugs connecting engine harness to ECM.
18. Release engine harness, pull into engine bay.
19. Raise front of vehicle.

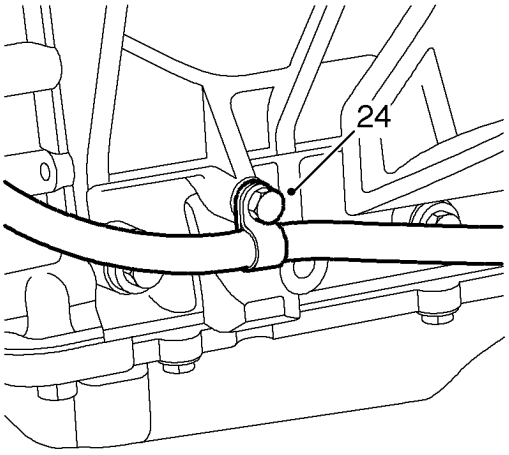
WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.



20. Remove 3 nuts securing RH exhaust front pipe to manifold. Remove and discard gasket.
21. Remove bolt securing starter heat shield and remove heat shield.
22. Remove nut securing battery cable to starter and disconnect solenoid cable.

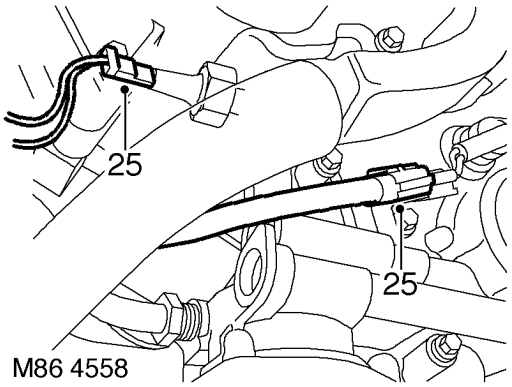


23. Disconnect both knock sensor multiplugs.



M86 4557

24. Remove bolt securing harness clip to LH side of engine.



M86 4558

25. Disconnect camshaft sensor and oil pressure switch multiplugs.
26. Remove engine harness.

Refit

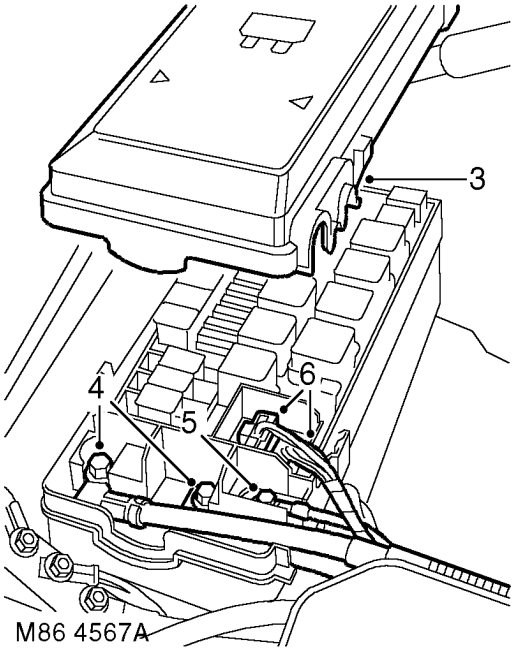
1. Position engine harness around engine.
2. Connect oil pressure switch and camshaft sensor multiplugs.
3. Fit and tighten bolt securing harness to LH side of engine.
4. Connect both knock sensor multiplugs.
5. Connect battery cable and solenoid cable to starter motor.
6. Position starter heat shield and secure with bolt.
7. Clean exhaust flange mating faces, using a new gasket align exhaust fit nuts and tighten to 60 Nm (44 lbf.ft).
8. Remove stand(s) and lower vehicle.
9. Position harness into footwell and secure grommet.
10. Connect ECM multiplugs.
11. Position toe board and secure with trim fixings.
12. Connect engine harness to main harness multiplug and secure earth lead.
13. Connect EVAP solenoid multiplug.
14. Connect both fuse box multiplugs.
15. Position starter lead to fuse box and secure screw.
16. Fit fuse box cover.
17. Position battery positive lead to battery and secure nut.
18. Secure harness to coolant rail.
19. Position alternator cables and tighten terminal B+ to 18 Nm (13 lbf.ft) and terminal D+ to 5 Nm (3.7 lbf.ft)
20. Connect coolant temperature sensor multiplug.
21. Connect A/C compressor multiplug.
22. Secure harness clip to rear of LH cylinder head.
23. Connect CKP sensor multiplug.
24. Secure injector harness and connect injector multiplugs.
25. Connect coil multiplugs.
26. Connect and secure HS_2O sensor multiplug
27. Fit upper inlet manifold.
☞ **MANIFOLDS AND EXHAUST SYSTEMS - V8, REPAIRS, Gasket - inlet manifold - upper - Without Secondary Air Injection.**
28. Connect battery earth lead.

Harness - engine - diesel

86.70.17

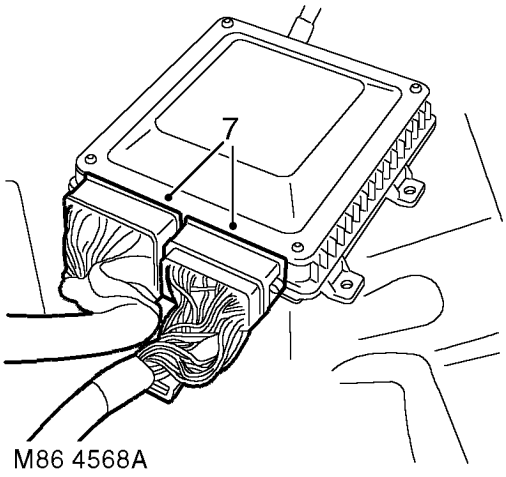
Remove

1. Remove engine acoustic cover.
2. Remove battery carrier.
   CHARGING AND STARTING, REPAIRS, Battery carrier.



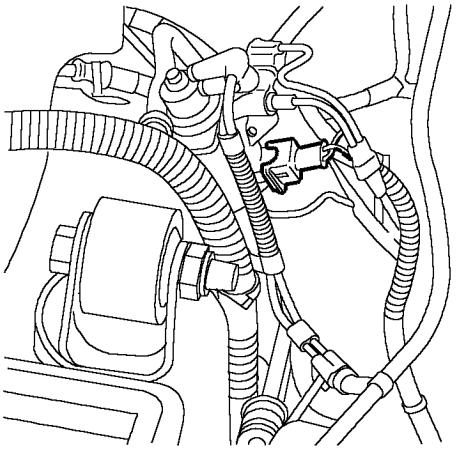
M86 4567A

3. Remove engine compartment fuse box cover.
4. Remove bolts securing battery and alternator leads to fuse box.
5. Remove bolt securing heater plug lead to fuse box.
6. Disconnect 2 engine harness multiplugs from fuse box.

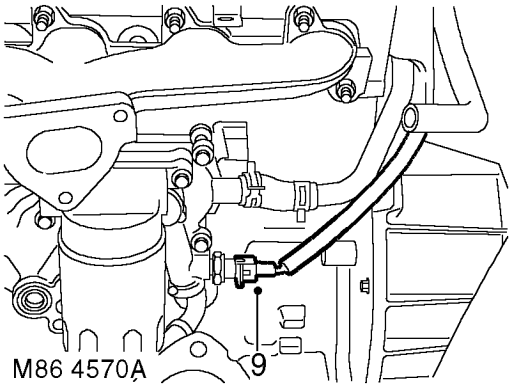


M86 4568A

7. Disconnect 2 engine harness multiplugs from ECM and main harness.

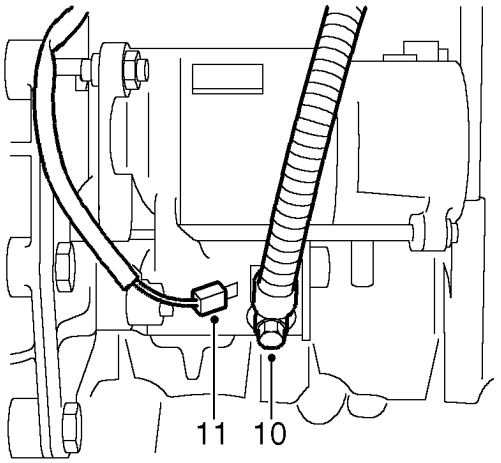

M12 4493A

8. Disconnect multiplug from EGR solenoid.



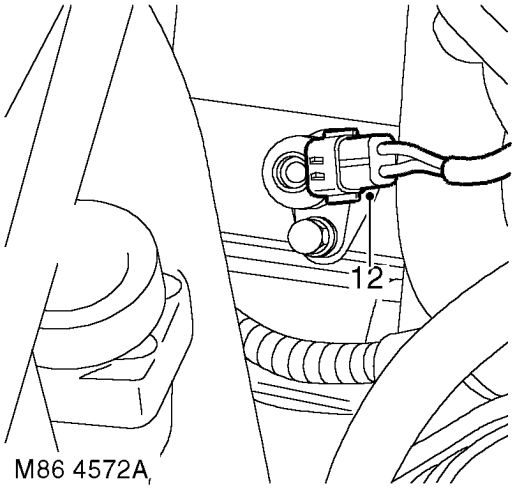
M86 4570A

9. Disconnect multiplug from oil pressure switch.



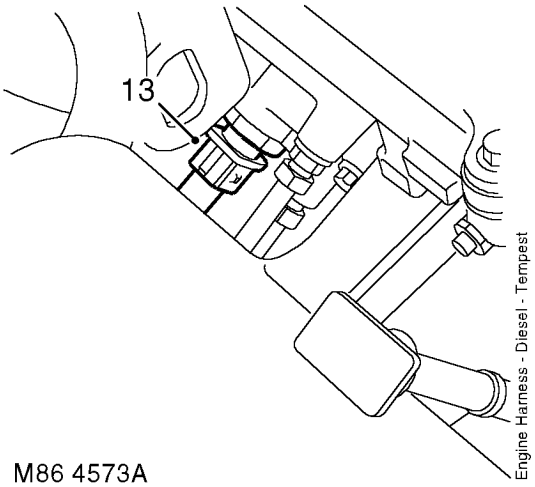
M86 4571A

10. Remove nut and disconnect battery lead from starter solenoid.
11. Disconnect Lucar from starter solenoid.



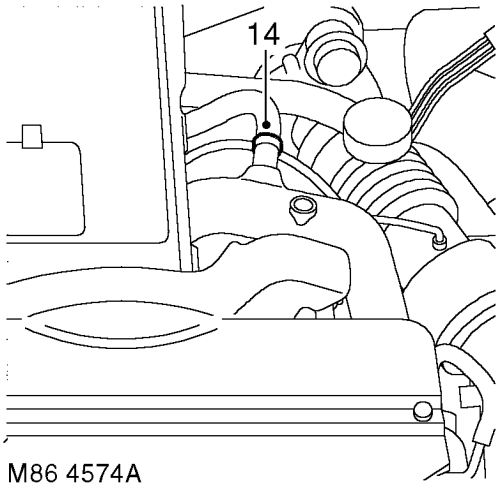
M86 4572A

12. Disconnect multiplug from CKP sensor.



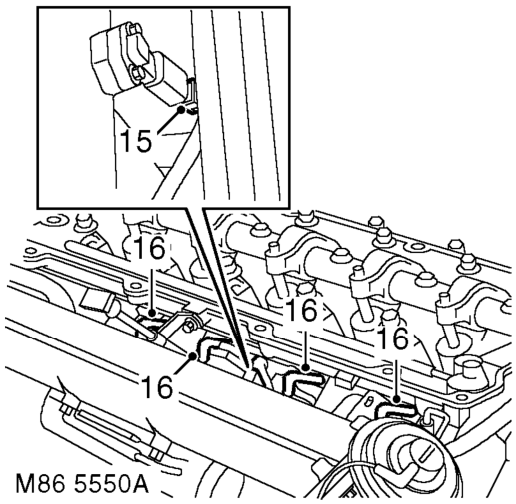
M86 4573A

13. Disconnect multiplug from fuel temperature sensor.

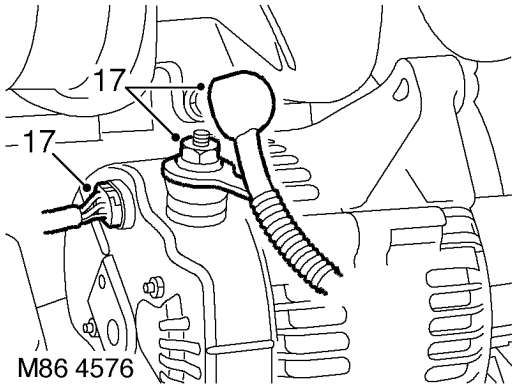


M86 4574A

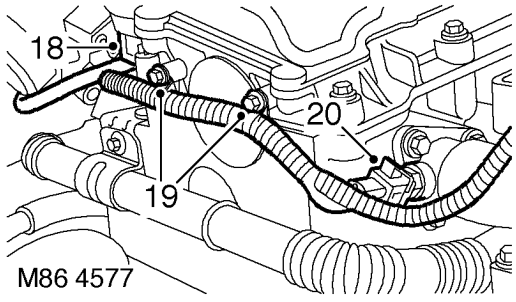
14. Release harness clip from coolant pipe.



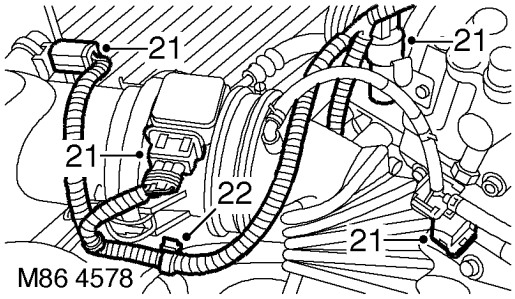
15. Disconnect multiplug from MAP sensor.
16. Disconnect 4 glow plug connectors.



17. Release nut securing battery lead to alternator and disconnect multiplug from alternator.



18. Disconnect injector multiplug.
19. Remove 2 bolts securing harness to front of cylinder head.
20. Disconnect multiplug from ECT sensor.



21. Disconnect multiplugs from A/C compressor, turbocharger solenoid valve, AAP sensor and MAF sensor.
22. Release harness clips from coolant hose and PAS hose.
23. Note the route of the engine harness, release from underneath of inlet manifold and remove from engine.

Refit

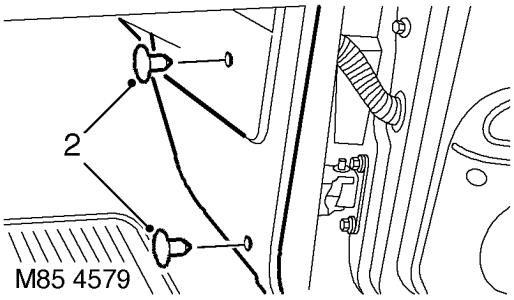
1. Position harness on engine.
2. Connect multiplugs to A/C compressor, turbocharger solenoid valve, AAP and MAF sensors.
3. Position harness clips to coolant and PAS hoses.
4. Connect multiplug to ECT sensor.
5. Position harness to front of cylinder head and tighten bolts to 10 Nm (7 lbf.ft).
6. Connect injector multiplug.
7. Connect multiplug and position battery cable to alternator and tighten nut.
8. Connect multiplug to fuel temperature sensor.
9. Connect multiplug to MAP sensor.
10. Connect glow plugs.
11. Connect CKP sensor multiplug.
12. Connect Lucar to starter solenoid.
13. Connect battery lead to starter solenoid and tighten nut to 10 Nm (7 lbf.ft).
14. Position harness clip to coolant pipe.
15. Locate harness over bell housing and connect multiplug to oil pressure switch.
16. Connect 2 multiplugs to EGR solenoids.
17. Connect engine harness multiplug to ECM and main harness.
18. Connect engine harness multiplugs to fuse box.
19. Position glow plug lead to fuse box and tighten bolt to 3.5 Nm (2.6 lbf.ft).
20. Position battery and alternator leads to fuse box and tighten bolts to 6 Nm (4.4 lbf.ft).
21. Fit engine compartment fuse box cover.
22. Fit battery carrier.
23. Fit engine acoustic cover.

Harness - main

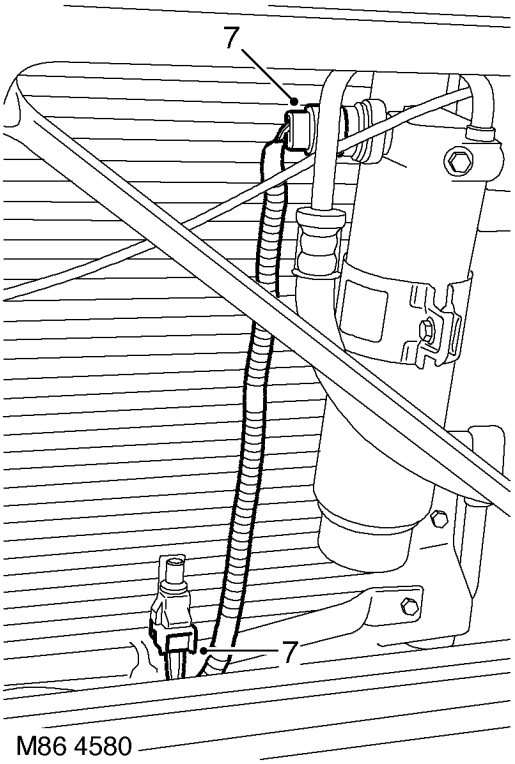
86.70.07

Remove

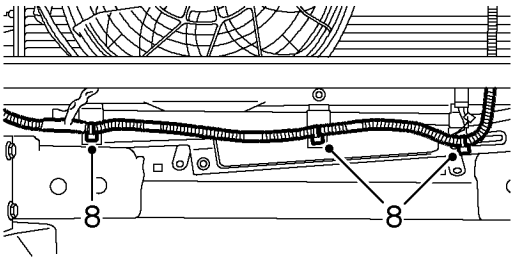
1. Remove heater assembly.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.
   HEATING AND VENTILATION, REPAIRS, Heater assembly - models without air conditioning.



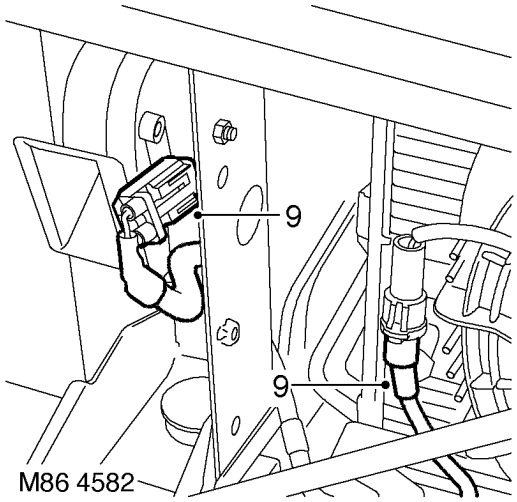
2. Remove 4 clips securing LH and RH trim panels to lower 'A' post.
3. Remove both lower 'A' post trim panels.
4. Remove air filter assembly.
   ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.
5. Remove battery tray.
6. Remove front bumper.
   EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.



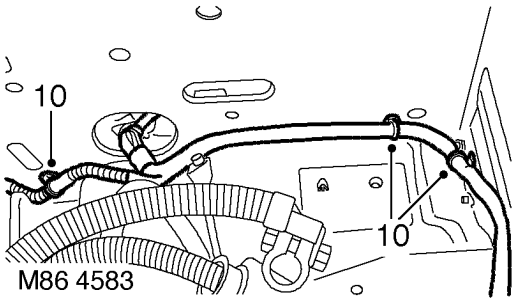
7. Disconnect multiplugs from receiver drier and air temperature sensor.



8. Release 3 cable tie clips securing harness to lower support rail.



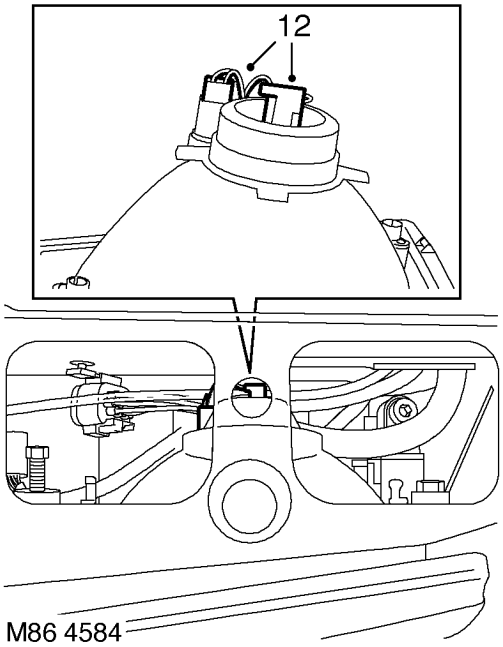
9. Disconnect multiplugs from cooling fan and horn.



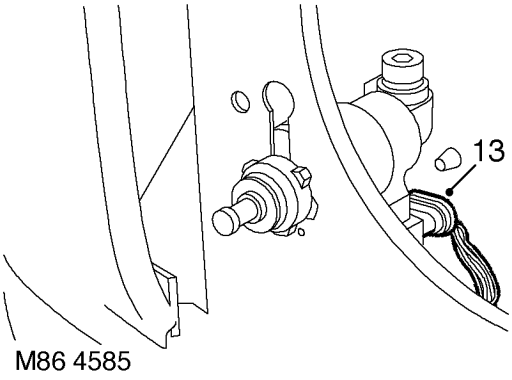
10. Release 3 cable tie clips from front RH panel.

11. Remove RH indicator lamp.

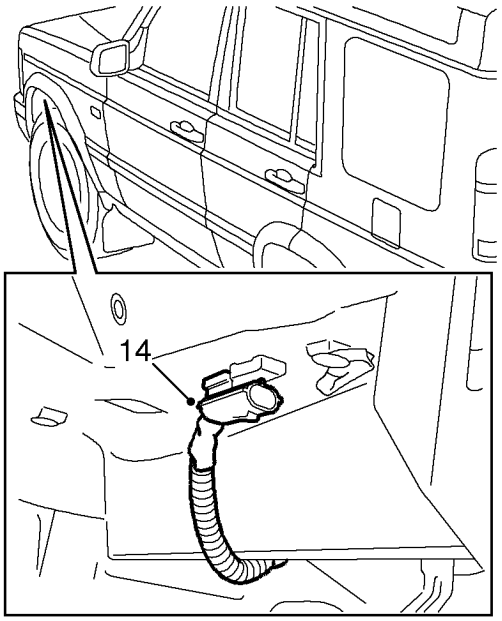
☞ **LIGHTING, REPAIRS, Lamp - front repeater.**



12. Disconnect multiplugs from headlamp and sidelamp.

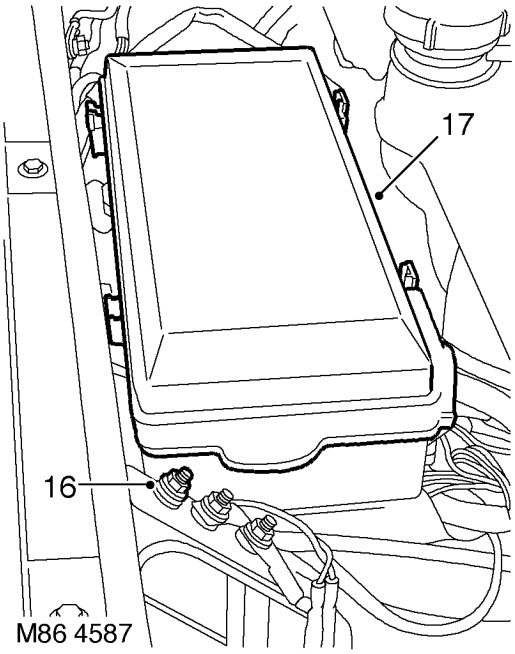


13. Disconnect multiplug from headlamp levelling motor.



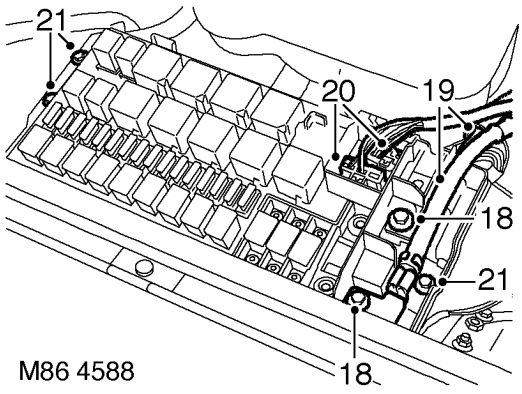
M86 4586

14. Release clip securing fog lamp multiplug.
15. Withdraw harness to engine compartment fuse box.



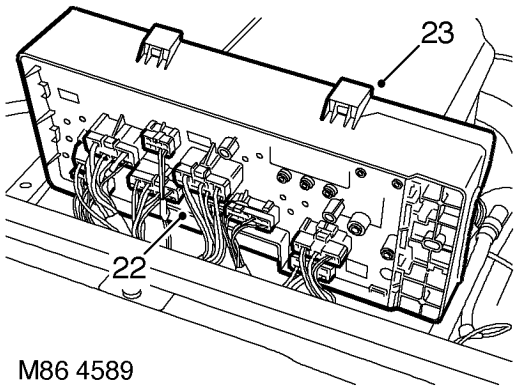
M86 4587

16. Remove nut securing harness earth to body.
17. Release 4 clips and remove engine compartment fusebox cover.



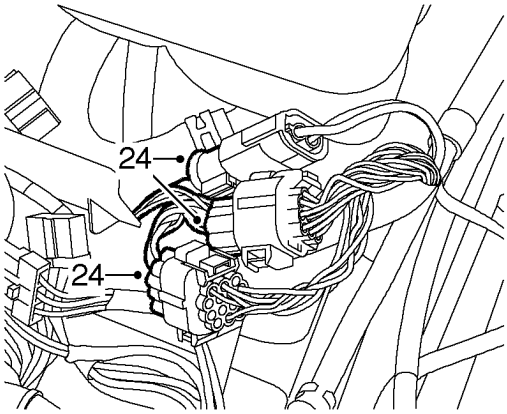
M86 4588

18. Remove 2 bolts securing battery and starter lead to fuse box.
19. Release leads from fusebox.
20. Remove 2 multiplugs from fusebox front.
21. Remove 3 bolts securing fusebox to body.



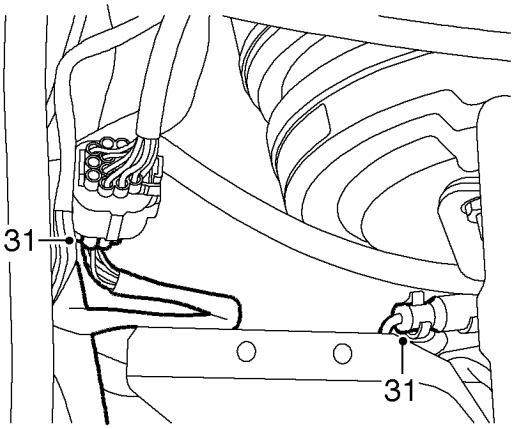
M86 4589

22. Release fuse box and remove 9 multiplugs from rear of fuse box.
23. Remove fuse box.



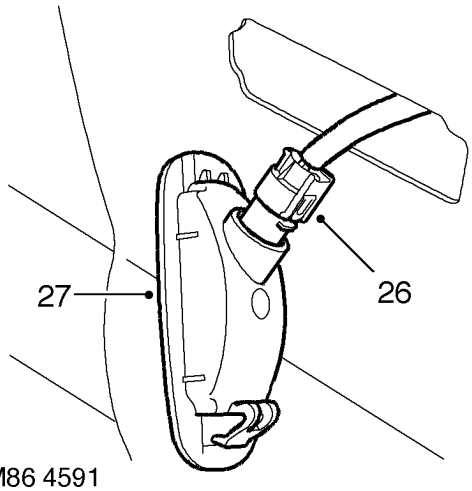
M86 4590

24. Disconnect 3 multiplugs from chassis harness.



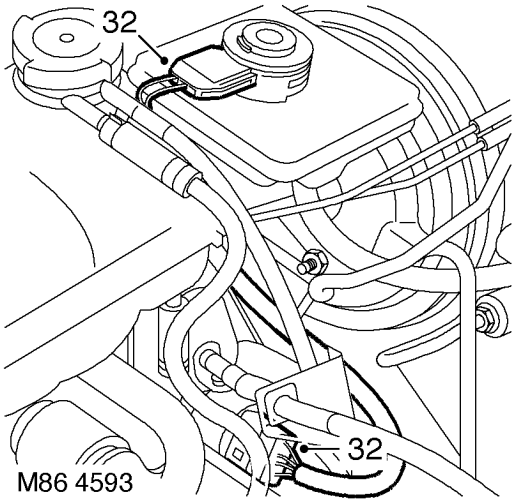
M86 4592

31. Disconnect main harness multiplug from engine harness and ABS sensor.



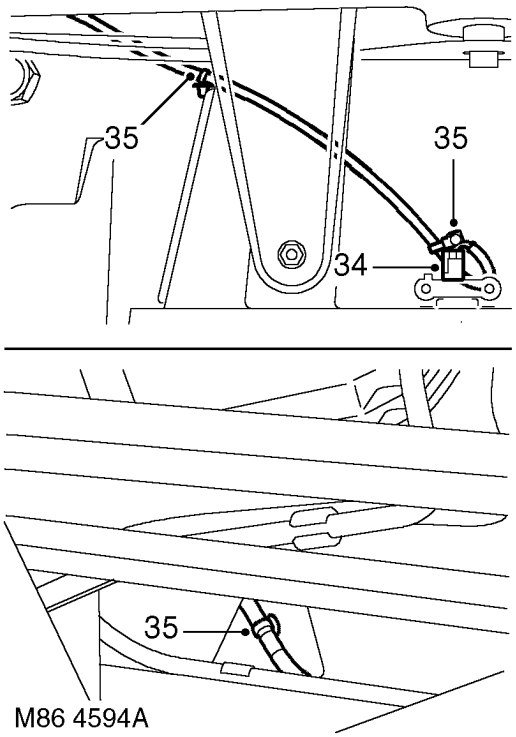
M86 4591

25. Remove RH front indicator repeater lamp from wing.
26. Disconnect multiplug from repeater lamp.
27. Remove repeater lamp.
28. Attach draw string to indicator lamp harness.
29. Withdraw harness to fuse box.
30. Remove draw string and secure.

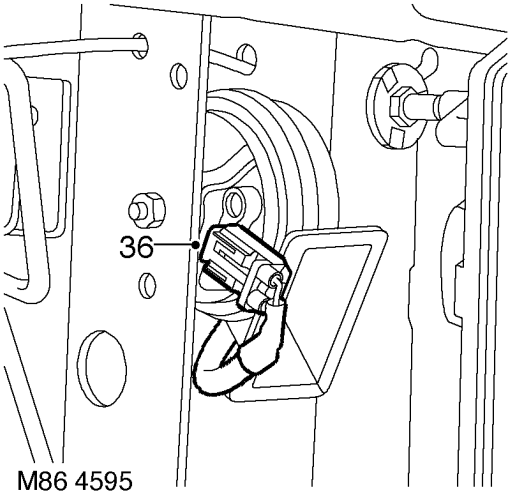


M86 4593

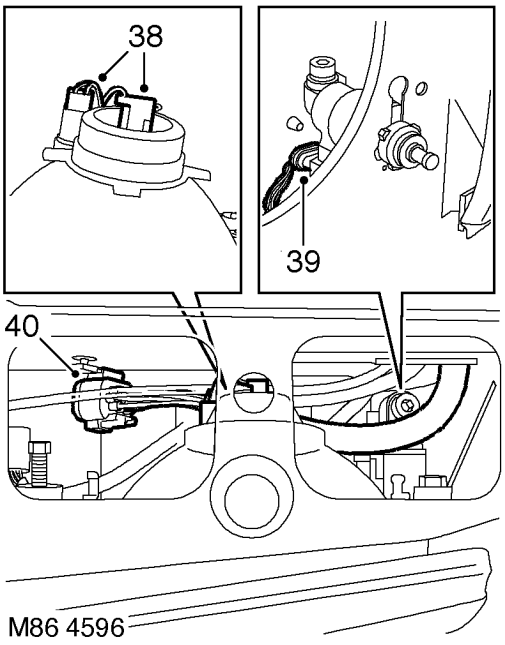
32. Disconnect multiplugs from cruise control actuator and brake fluid level switch.
33. Withdraw harness to bulkhead.



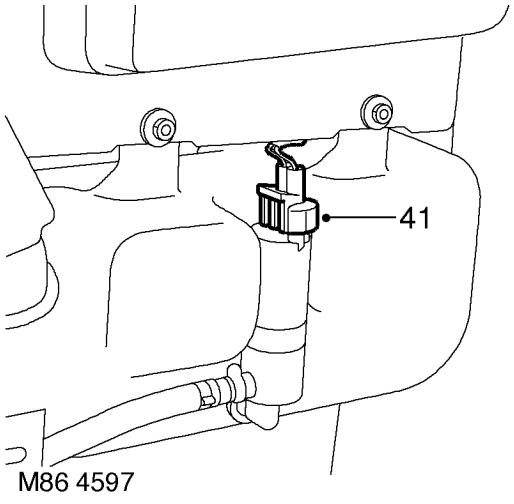
34. Release multiplug from ACE accelerometer.
35. Remove 3 cable tie clips from body and withdraw harness to bulkhead.



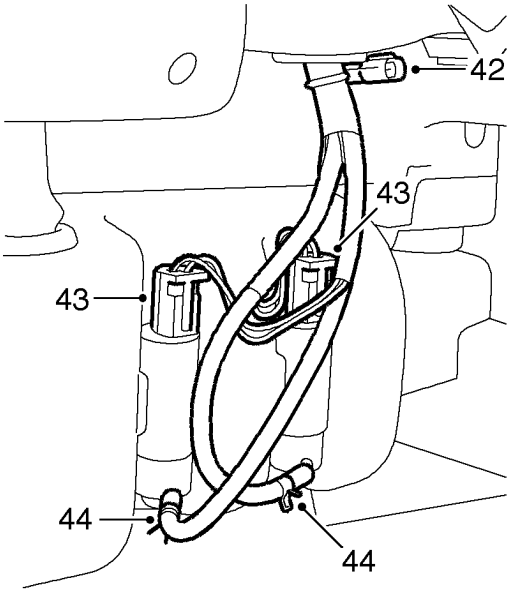
36. Disconnect multiplug from LH horn.
37. Remove LH indicator lamp.
☞ **LIGHTING, REPAIRS, Lamp - front repeater.**



38. Disconnect multiplugs from headlamp and sidelamp.
39. Disconnect headlamp level multiplug from headlamp levelling motor.
40. Release earth header behind headlamp.

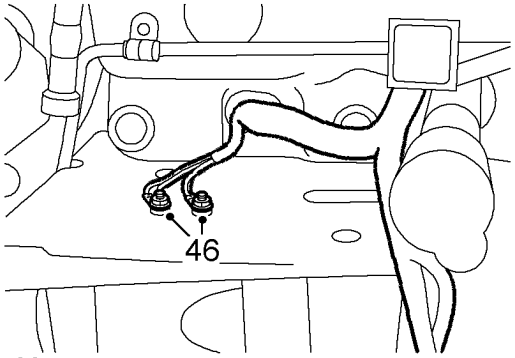


41. Disconnect multiplug from front of washer reservoir.
42. Release clip securing fog lamp multiplug.



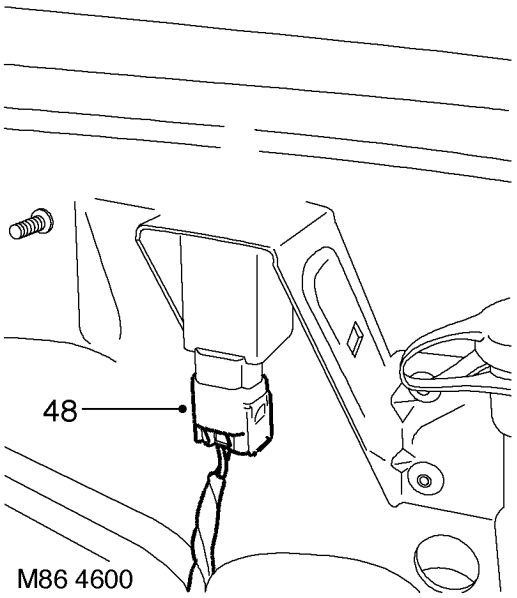
M86 4598

43. Disconnect 2 multiplugs from washer pumps.
44. Remove 2 clips securing washer pipes to washer reservoir motors.
45. Remove washer reservoir pipes.



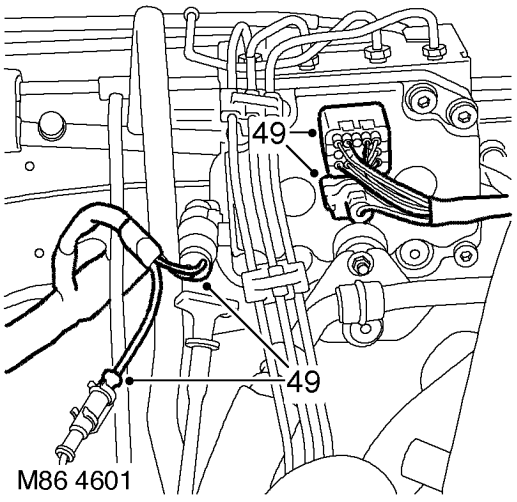
M86 4599

46. Release 2 bolts securing earth points to body.
47. Pull harness into engine bay.



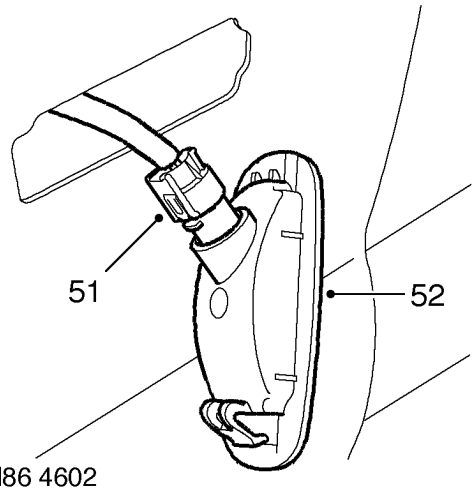
M86 4600

48. Disconnect multiplug from bonnet switch.



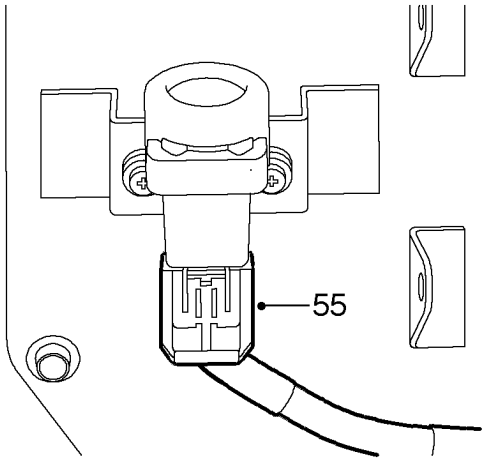
M86 4601

49. Disconnect 3 multiplugs from ABS modulator and multiplug from ABS sensor.



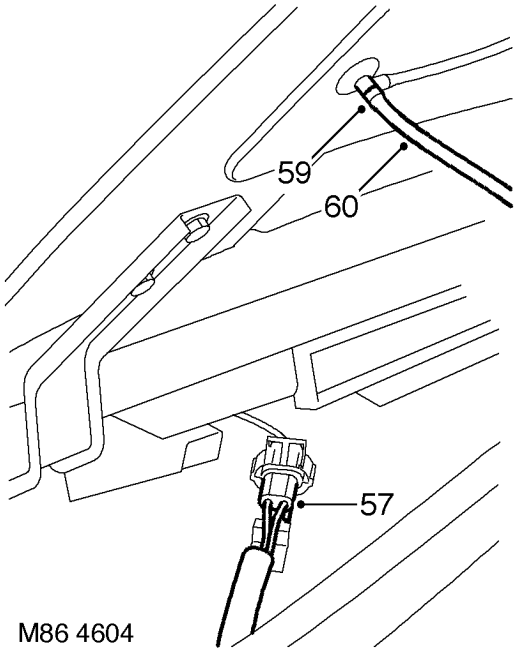
M86 4602

50. Release LH indicator repeater lamp.
51. Disconnect multiplug from repeater lamp.
52. Remove repeater lamp.
53. Attach draw string to repeater lamp harness.
54. Pull harness into engine bay, remove draw string and secure.



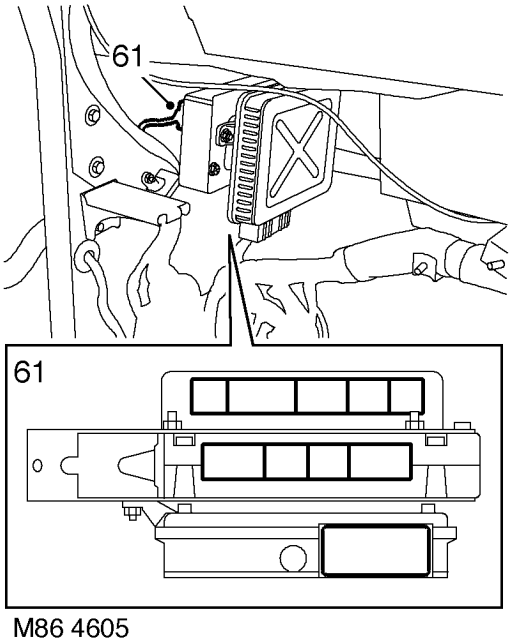
M86 4603

55. Disconnect multiplug from fuel cut-off switch.
56. Remove plenum moulding.
☞ **HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.**



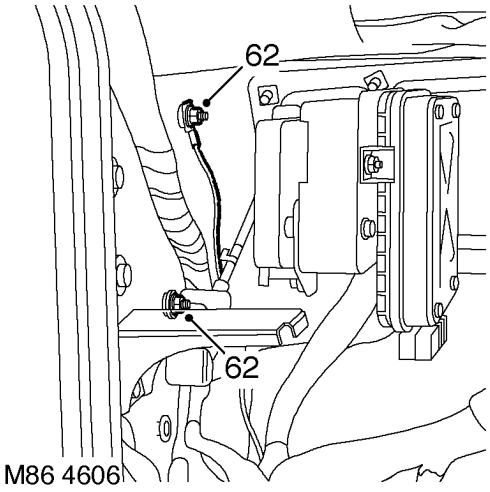
M86 4604

57. Disconnect and release 2 multiplugs from front heated screen element.
58. Pull harness into engine bay.
59. Remove clip securing washer pipes to bonnet.
60. Disconnect pipe from bonnet.

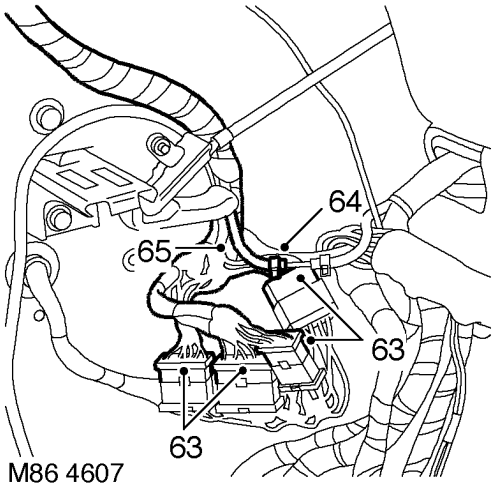


M86 4605

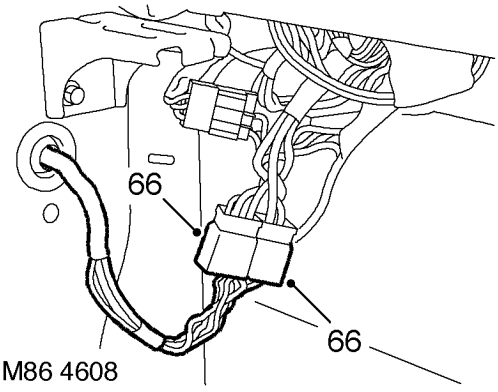
61. Disconnect 11 multiplugs from ECU pack.



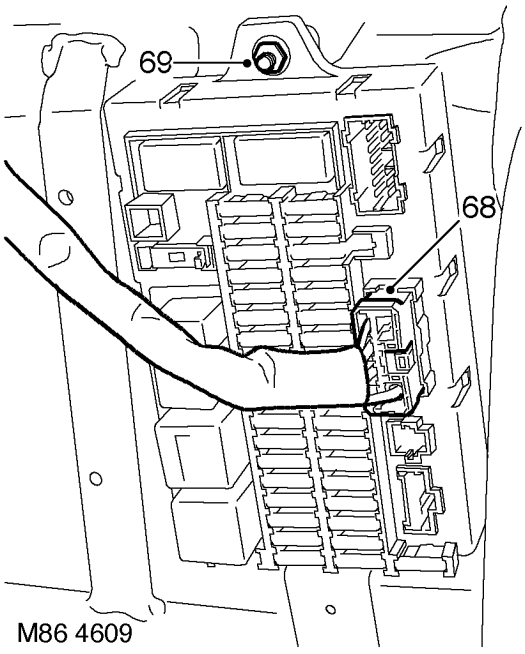
62. Remove 2 nuts securing earth headers to LH lower 'A' post.



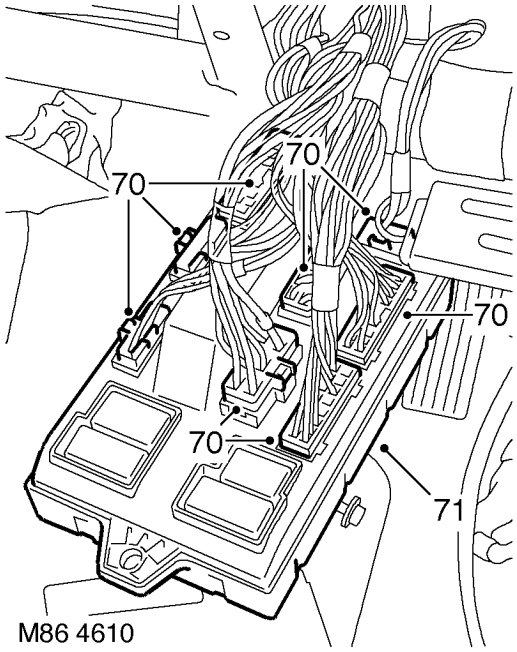
63. Disconnect 4 multiplugs from body harness.
64. Remove clip securing washer pipe located at lower 'A' post
65. Remove pipe.



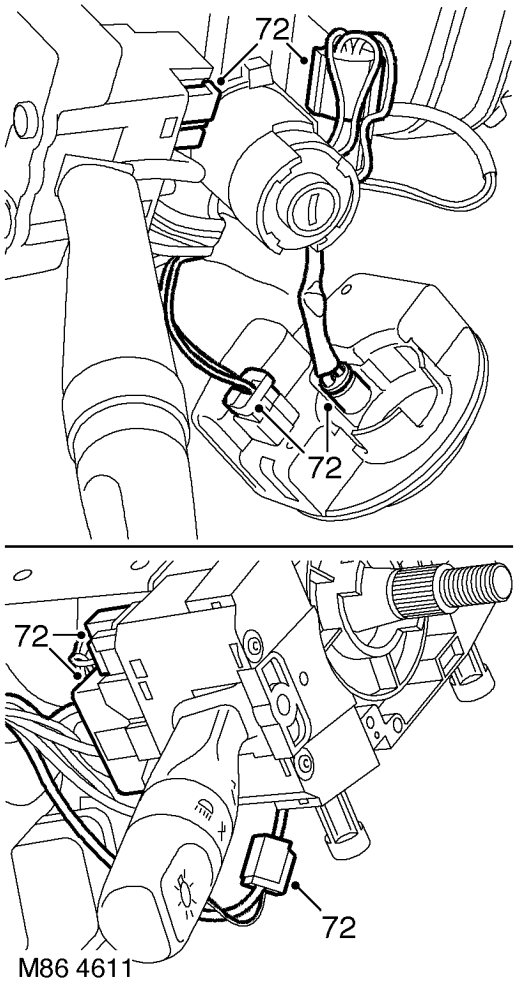
66. Disconnect 2 multiplugs from front door harness.
67. With assistance withdraw LH side harness into interior.



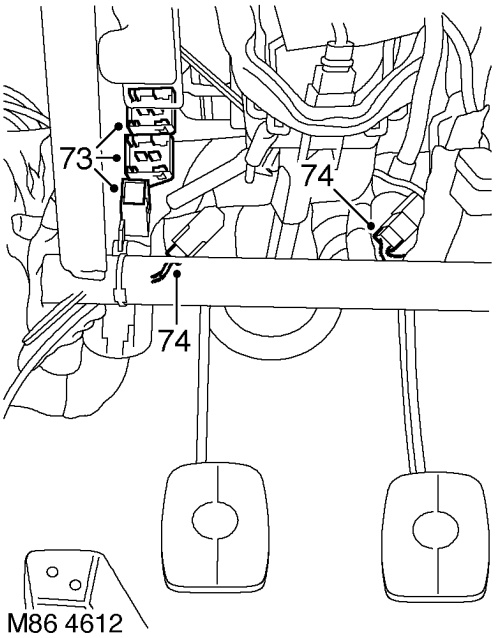
68. Disconnect ignition harness multiplug from passenger compartment fusebox.
69. Remove nut securing passenger compartment fusebox to steering support bracket.



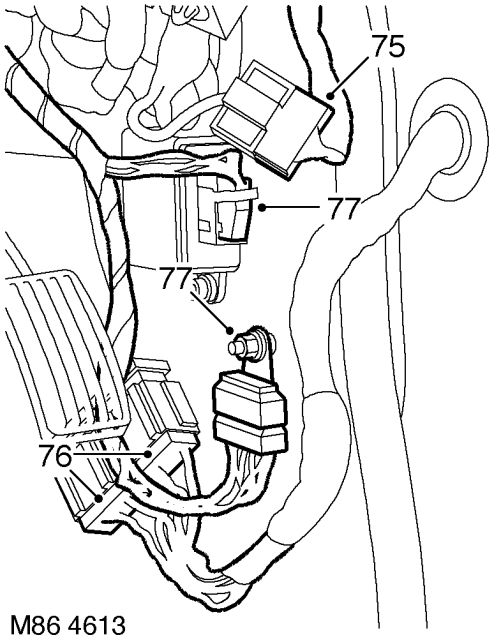
70. Release fusebox and disconnect 8 multiplugs.
71. Remove fusebox.



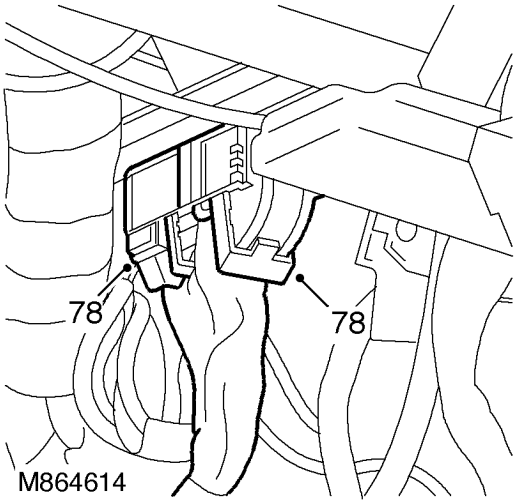
72. Disconnect 7 multiplugs from ignition passive coil and steering column switch assembly.



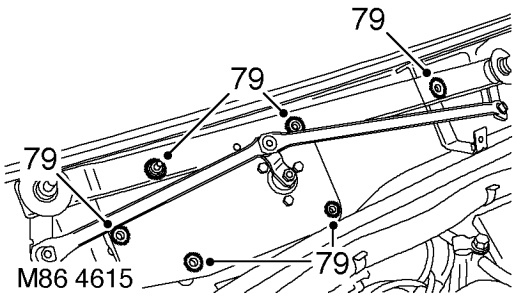
73. Release 3 multiplugs from steering column support.
74. Disconnect multiplugs from brake and clutch pedal.



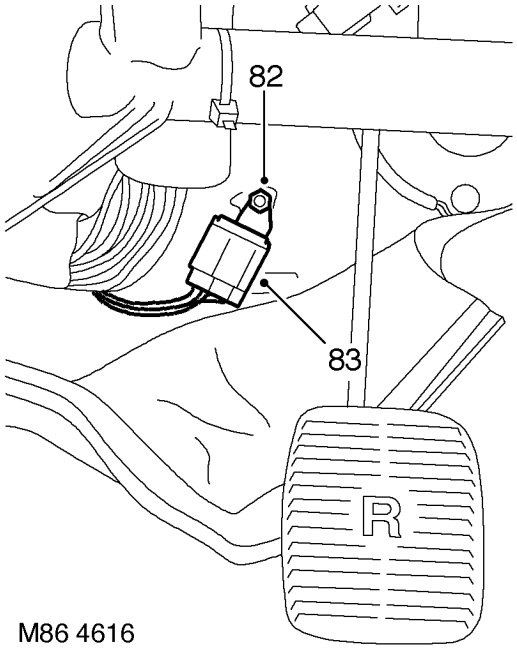
75. Disconnect multiplug from RH side body harness.
76. Disconnect 2 multiplugs from RH door harness.
77. Disconnect multiplugs from cruise control ECU, remove nut securing earth header to body and remove earth header.



78. Disconnect 2 multiplugs from ECM.

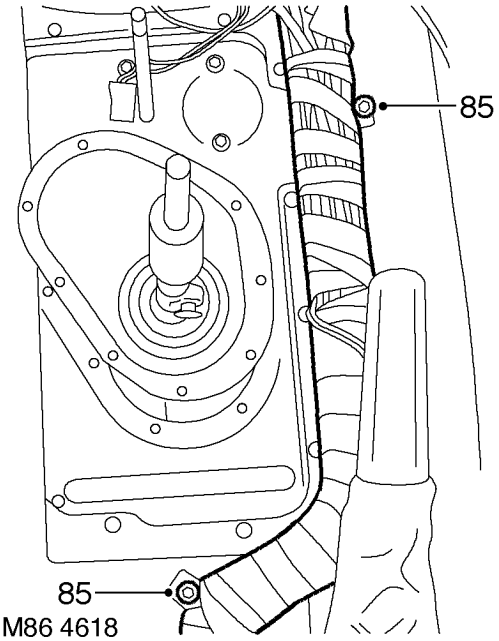


79. Remove 6 nuts and bolts securing wiper mechanism, release mechanism and disconnect multiplug.
80. With assistance withdraw RH side harness into interior.
81. Release RH side front carpet.



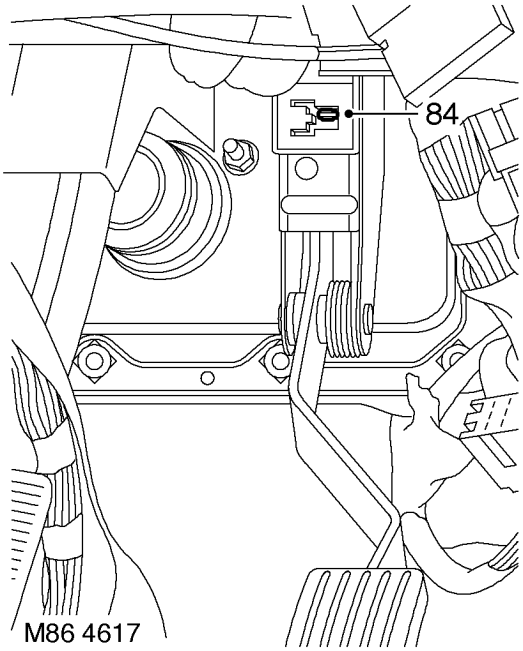
M86 4616

82. Remove nut securing earth header to footwell.
83. Remove earth header.



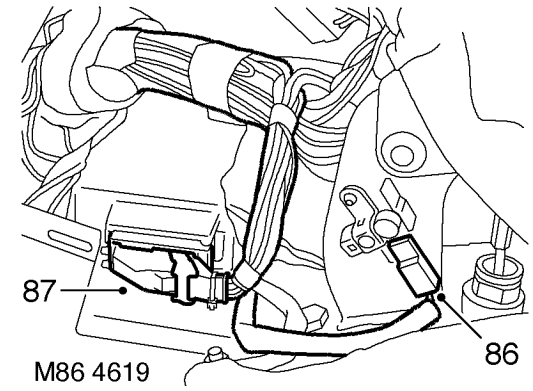
M86 4618

85. Remove 2 nuts securing harness to tunnel.



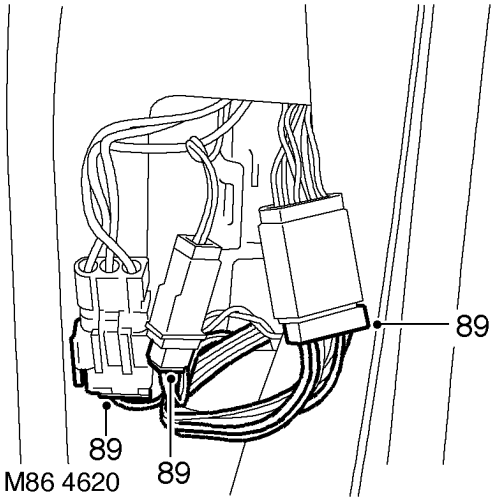
M86 4617

84. Remove clip securing harness to pedal box.

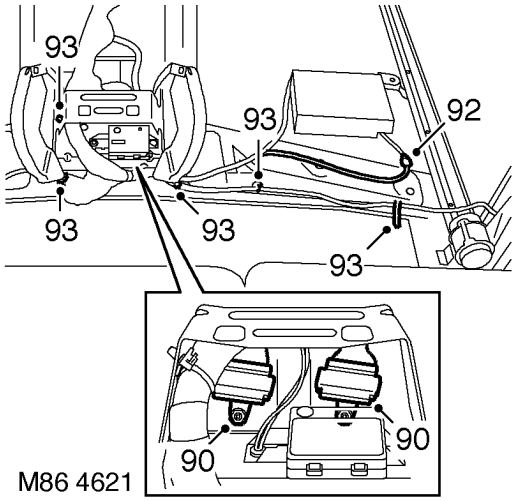


M86 4619

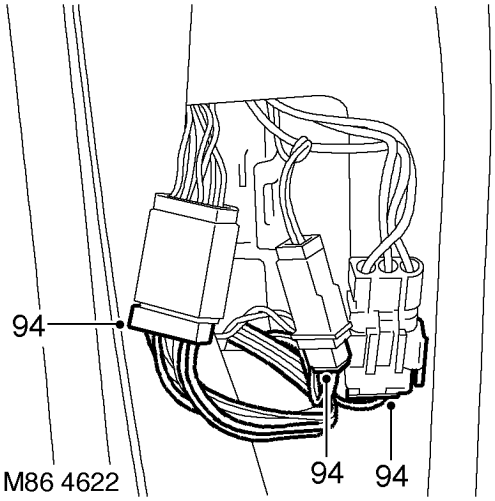
86. Disconnect Lucar from handbrake switch.
87. Disconnect multiplug from DCU.
88. Remove rear carpet.
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - rear.**



89. Disconnect 3 multiplugs from RH rear door harness.



90. Remove 2 nuts securing 2 earth headers to rear centre console tunnel.
91. Remove earth headers from centre console.
92. Disconnect multiplug from CD player.
93. Remove 5 clips and 2 retainers securing harness to floor.



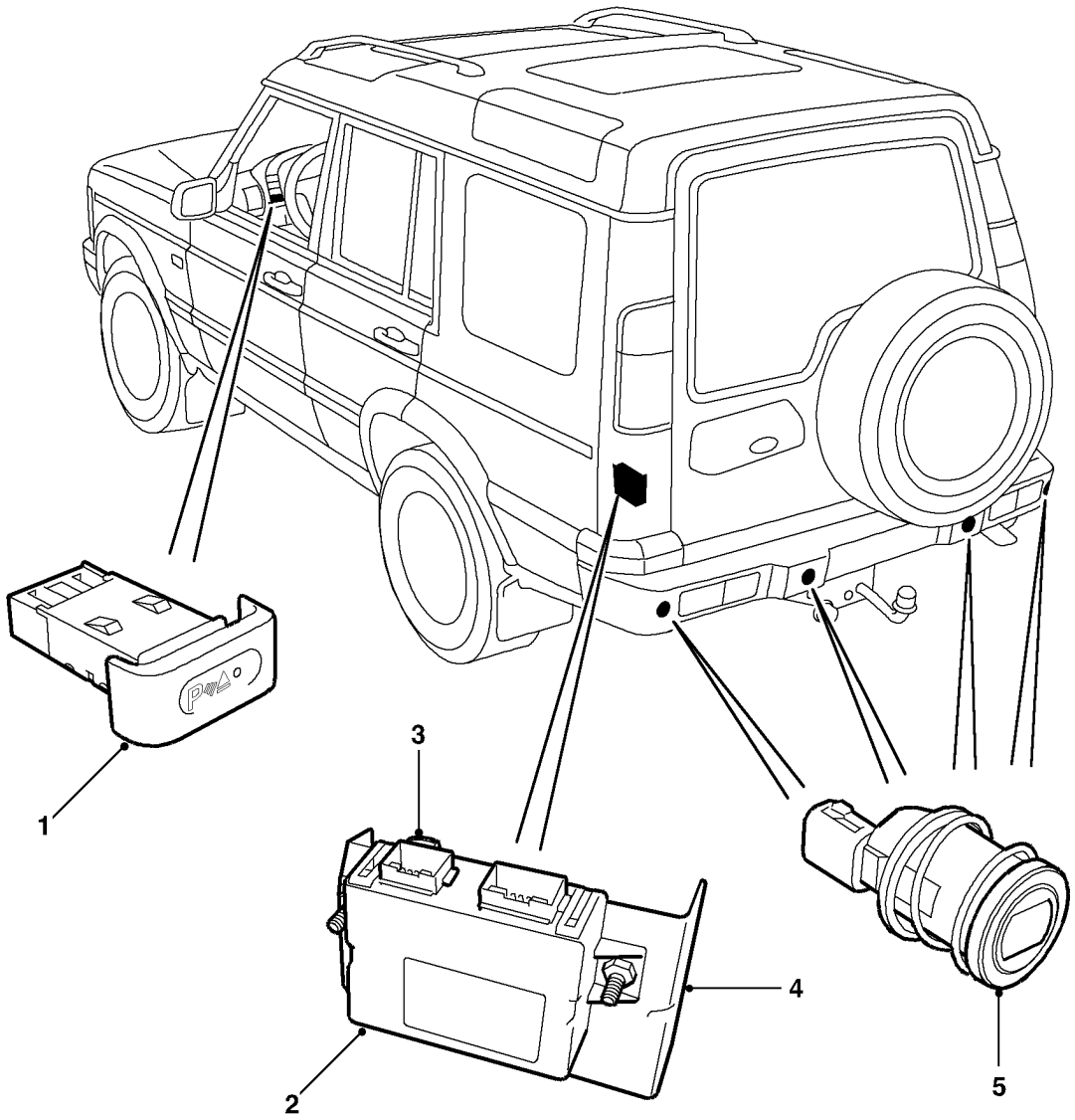
94. Disconnect 3 multiplugs from LH rear door harness.
95. Withdraw harness to interior.
96. Manoeuvre harness over steering column support bracket.
97. With assistance remove main harness.

Refit

1. With assistance position main harness to body and manoeuvre over steering column support bracket.
2. Lay harness in position and secure to floor clips and retainers.
3. Connect LH and RH rear door multiplugs.
4. Connect CD player multiplug.
5. Position centre console earth headers and secure with nuts.
6. Fit rear carpet.
☞ **INTERIOR TRIM COMPONENTS, REPAIRS, Carpet - rear.**
7. Connect DCU multiplug.
8. Connect Lucar to handbrake switch.
9. Fit and tighten nuts securing harness to transmission tunnel.
10. Secure harness to pedal box.
11. Position footwell earth header and secure with nut.
12. Feed RH side of harness into engine bay.
13. Position carpet.
14. Connect wiper motor multiplug, position mechanism and secure with nuts and bolts.
15. Connect ECM multiplug.
16. Position RH lower 'A' post earth header and secure with nut, connect cruise control multiplug.
17. Connect RH front door and RH side body harness multiplugs.

18. Secure multiplugs to steering column support bracket and connect brake and clutch pedal multiplugs.
19. Connect multiplugs to column switch and passive coil.
20. Position passenger compartment fusebox, connect multiplugs, fit fusebox to fascia and secure with nut.
21. Connect ignition switch multiplug to fuse box.
22. With assistance feed LH side of harness into engine bay.
23. Connect multiplugs to front door harness and body harness.
24. Position earth headers to LH lower 'A' post and secure with nuts.
25. Connect multiplugs to ECU pack.
26. Position harness in engine bay.
27. Connect and secure heated front screen multiplugs.
28. Fit plenum molding.
    ☞ **HEATING AND VENTILATION, REPAIRS, Plenum Air Intake.**
29. Connect multiplugs to ABS sensor and fuel cut-off switch.
30. Using draw string feed harness through inner wing, remove draw string, connect repeater lamp multiplug and fit lamp.
31. Connect multiplugs to ABS modulator.
32. Feed harness through to front panel.
33. Position body earth leads and secure with bolts.
34. Connect washer reservoir multiplugs and pipes, secure pipes with clips.
35. Secure fog lamp multiplug.
36. Secure earth header behind headlamp.
37. Connect multiplugs to headlamp level motor, headlamp and side lamp.
38. Fit indicator lamp
    ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
39. Connect multiplug to LH horn.
40. Feed harness to ACE accelerometer, connect multiplug and secure with cable ties.
41. Connect cruise control, ABS sensor and brake fluid level switch multiplugs.
42. Connect engine harness multiplug and feed harness along RH wing to fuse box.
43. Using draw string pull harness through inner wing, remove draw string, connect repeater lamp multiplug and fit lamp.
44. Connect chassis harness multiplugs.
45. Position engine bay fuse box and connect multiplugs, fit fuse box and secure with screws.
46. Connect multiplugs to front of fuse box.
47. Position battery and starter cables and secure with screws.
48. Fit fuse box cover.
49. Position earth lead and secure with nut.
50. Feed harness through to front panel.
51. Secure fog lamp multiplug.
52. Connect headlamp level motor, headlamp and side lamp multiplugs.
53. Fit indicator lamp.
    ☞ **LIGHTING, REPAIRS, Lamp - front repeater.**
54. Secure harness to RH front panel.
55. Connect cooling fan and horn multiplug.
56. Secure harness to lower support rail.
57. Connect receiver drier and air temperature sensor multiplugs.
58. Fit front bumper.
    ☞ **EXTERIOR FITTINGS, REPAIRS, Bumper assembly - front.**
59. Fit battery tray.
60. Fit air filter assembly.
    ☞ **ENGINE MANAGEMENT SYSTEM - V8, REPAIRS, Air cleaner assembly.**
61. Position both lower 'A' post trims and secure with studs.
62. Fit heater assembly.
    ☞ **HEATING AND VENTILATION, REPAIRS, Heater assembly - models with air conditioning.**
    ☞ **HEATING AND VENTILATION, REPAIRS, Heater assembly - models without air conditioning.**

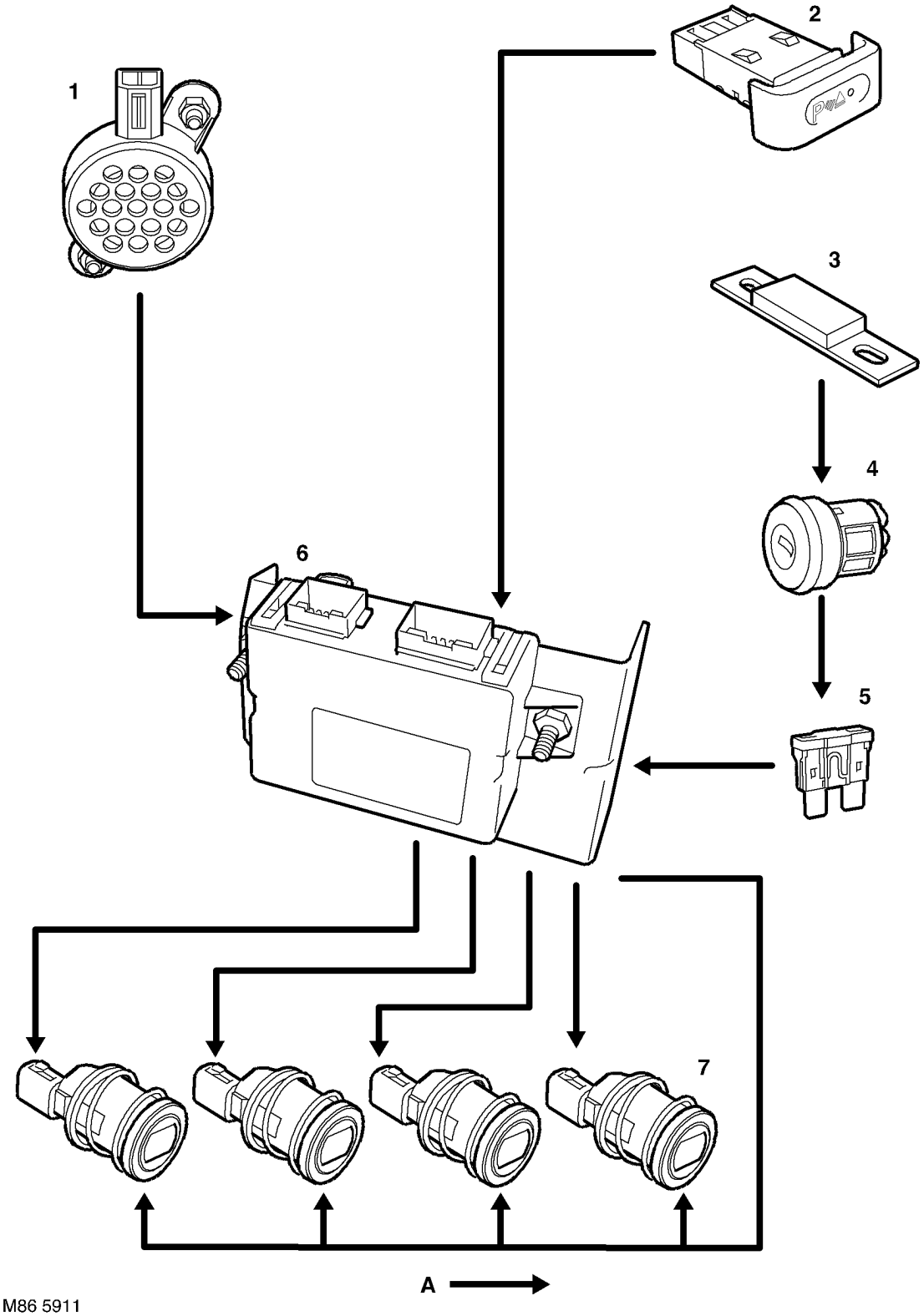
Park Distance Control – Component Location



M86 5910

1 Park Distance Control (PDC) Switch
2 PDC ECU
3 PDC sounder
4 Mounting bracket
5 PDC sensor

Park Distance Control – Control Diagram



***A** = Hardwired*

1 PDC sounder
2 PDC switch
3 Fusible link
4 Ignition switch
5 Fuse
6 PDC ECU
7 PDC sensors

Description

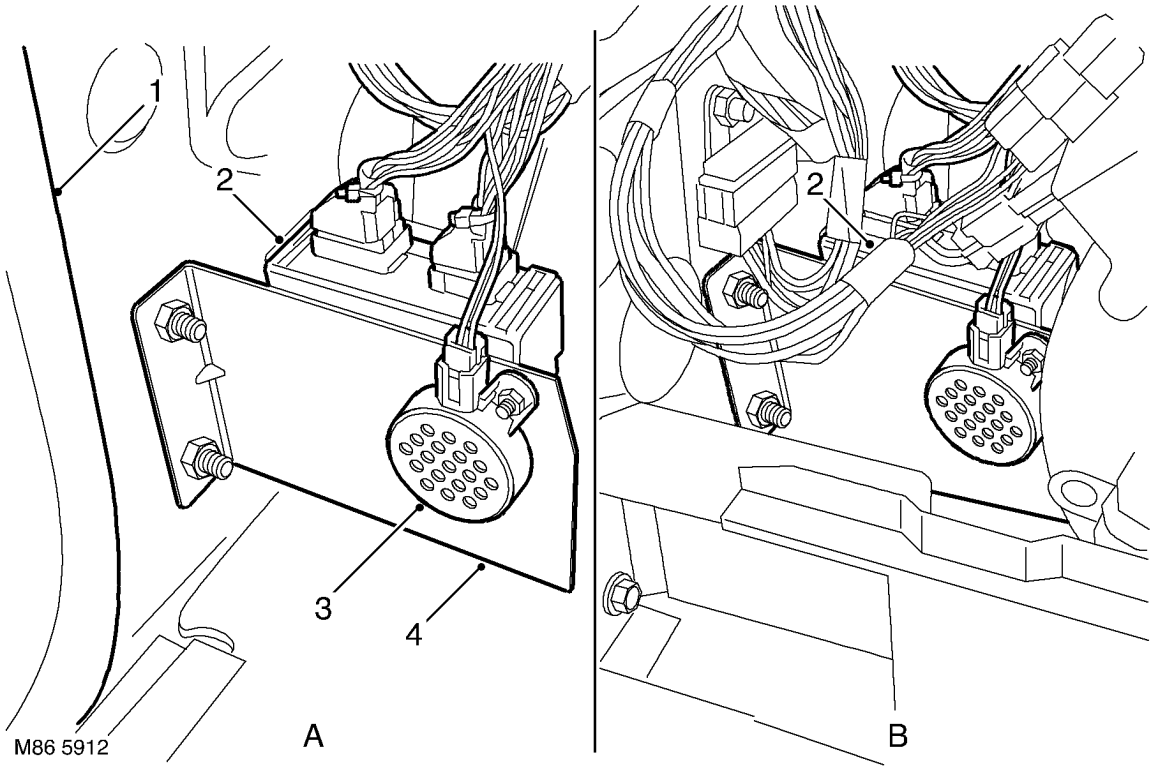
General

Park Distance Control (PDC) is introduced on vehicles from 03 model year. PDC provides an audible warning to the driver when any obstacles are in the path of the vehicle during a reversing manoeuvre. The purpose of the system is to assist the driver when parking and is not designed as a crash avoidance system or a replacement for visual interpretation by the driver.

The system comprises four ultrasonic sensors in the rear bumper, an ECU, a fascia mounted momentary switch and a sounder unit. The system operates using ultrasonic signals which are transmitted by the sensors. The reflected echo from this output is received by the sensors and used by the PDC ECU to calculate the distance from an object.

The fascia mounted switch allows the driver to de-activate the PDC system if operation is not required or the vehicle has a trailer attached.

PDC ECU



***A** = Vehicles without rear air conditioning*
***B** = Vehicles with rear air conditioning*

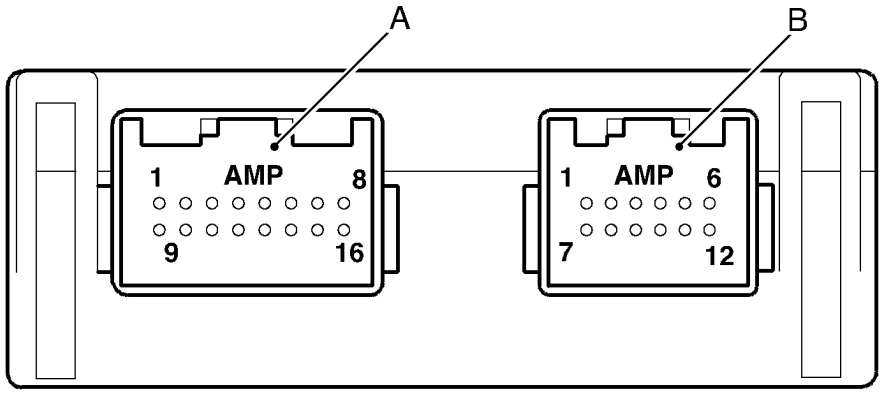
1 Body 'E' post
2 PDC ECU
3 PDC sounder
4 Mounting bracket

The PDC ECU is located in the LH side of the luggage compartment. A bracket is attached to the 'E' post, behind the trim panel and provides for the attachment of the ECU and the PDC sounder.

On vehicles without rear air conditioning, the bracket is located inboard on the LH 'E' post, adjacent to the luggage compartment trim panel. On vehicles with rear air conditioning, the bracket is located outboard on the LH 'E' post, adjacent to the outer body panel.

The bracket has integral studs which provide for the attachment of the ECU with nuts. The ECU is located with the harness connectors uppermost to assist access. The PDC sounder is located on the opposite side of the bracket and is secured with screws, lockwashers and nuts.

PDC ECU Connector Pin Details



M86 5913

a Connector C0958
b Connector C0957

Connector C0958

Pin No.	Description	Input/Output
1	Ignition switch power supply	Input
2	Sounder - Negative	Input
3	Not used	–
4	PDC Switch	Input
5	Not used	–
6	Reverse Gear signal	Input
7	Not used	–
8	Ground	–
9	Not used	–
10	Sounder - Positive 12V supply	Output
11	Not used	–
12	Not used	–
13	PDC Switch LED	Output
14 to 16	Not used	–

Connector C0957

Pin No.	Description	Input/Output
1	Not used	–
2	Sensor - RH Inner - Signal	Input
3	Sensor - Rear LH Inner - Signal	Input
4	Sensor - Rear RH Outer - Signal	Input
5	Sensor - Rear LH Outer - Signal	Input
6 and 7	Not used	–
8	Ground - All sensors	Input
9	Not used	–
10	Power Supply - All sensors	Output
11 and 12	Not used	–

Inputs and Outputs

Two connectors provide the interface between the PDC ECU and the external PDC components.

The ECU receives inputs from the following:

- Reverse lamp circuit – for system activation when reverse gear is selected
- PDC switch – for activation and de-activation of the system
- Ignition switch – power supply for system operation.

The ECU outputs to the following:

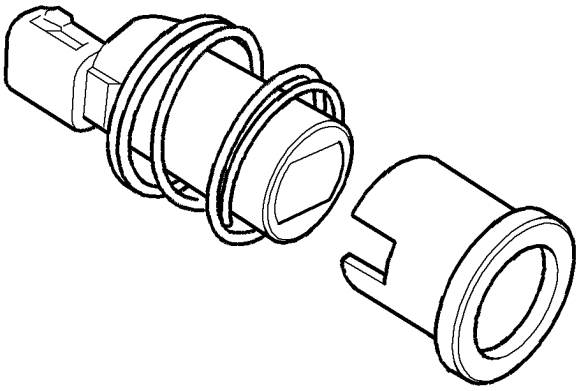
- Sensors – power and ground connections
- Sensor – digital signal transmit and receive signals
- Sounder – signal for sounder operation
- PDC Switch – power supply for switch LED operation.

Diagnostics

The PDC ECU has no diagnostic connection to enable faults to be retrieved using TestBook/T4. An on-board diagnostic routine monitors the system and alerts the driver to a system fault by emitting a tone from the sounder.

If a PDC system fault has occurred, the sounder will emit a continuous tone for 3 seconds and the PDC switch LED will flash continuously when reverse gear is selected.

Sensors



M86 5914

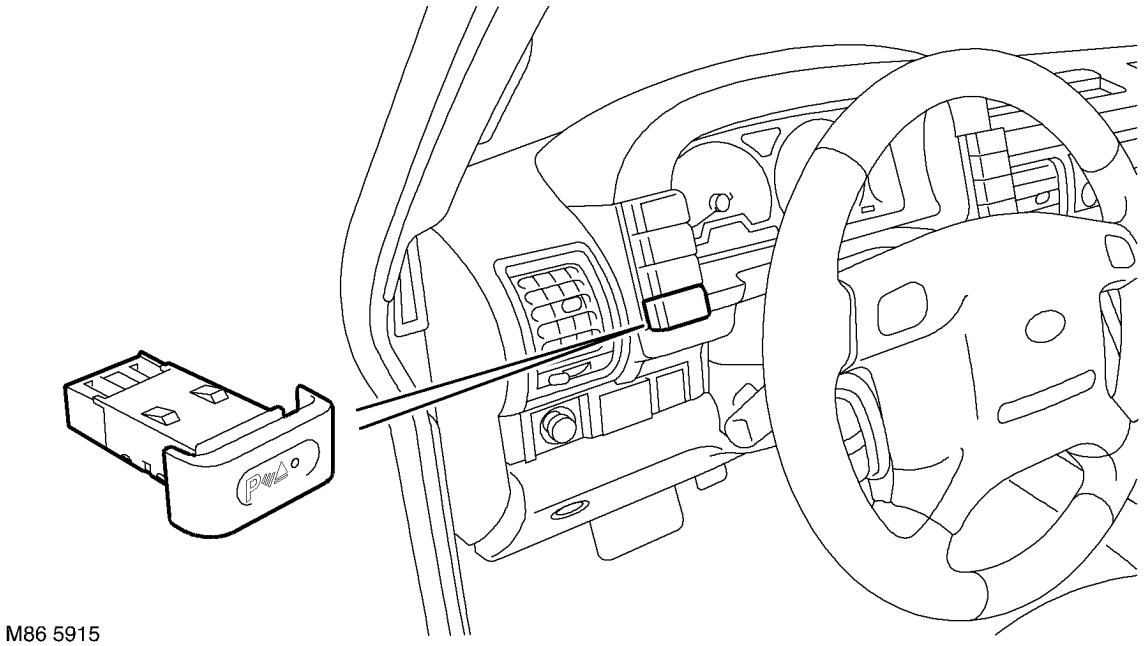
Four sensors are positioned in the rear bumper. Each sensor comprises an outer housing with an angled rubber trim which differs between the inner and outer sensors and the sensor body. The outer housing has a slot which engages with a pin on the sensor body and is locked by rotating the sensor. A coil spring around the sensor is compressed when the sensor is installed in the bumper and maintains the sensor housing engaged on the pin. The sensor housing has a raised lip at the top which locates in a corresponding groove in the bumper mounting hole and sets the correct orientation for the sensor body.

Each sensor has a three pin connector which connects into a common harness linking all four sensors. This harness is connected to the main vehicle body harness. The three pins are for sensor negative and positive feeds and a signal line.

Each sensor comprises a plastic housing which contains a piezoelectric disc. The disc resonates at a frequency of 38.4kHz, producing an ultrasonic signal output. The disc also receives the reflected echo signal.

The PDC ECU controls the operating mode of each sensor by output of a digital signal on the signal line. Each sensor has two modes of operation; combined transmitter and receiver mode or receiver mode only.

PDC Switch



M86 5915

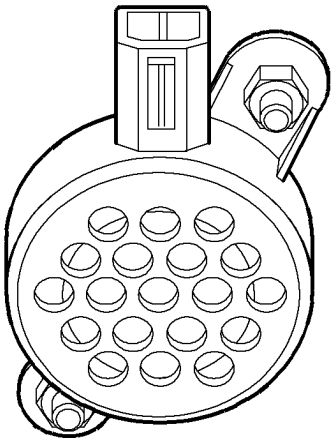
The PDC switch is located in the instrument pack cowl, below the fuel flap release switch. The switch has a momentary, non-latching action, which switches a positive output from the PDC ECU to ground when pressed. This signal is used by the ECU to switch the PDC between the activated and de-activated conditions. The switch is connected to the PDC ECU via a harness connector which is integrated into the vehicle body harness.

The switch contains an LED. The LED illuminates for approximately 3 seconds when the ignition is switched to position II for a bulb check. The bulb check is controlled by logic within the PDC ECU. When the system is active (i.e. obstacle detected), the LED illuminates to show the active condition.

When the PDC is switched from the off condition to the active condition, the LED is illuminated briefly, along with a chime from the sounder, to signal that the system has been activated.

If a fault exists in the PDC system, the ECU flashes the LED continuously, when the switch is pressed to activate the system.

Sounder



M86 5916

The PDC sounder is controlled by the PDC ECU and emits a series of tones of varying frequency to inform the driver of the distance between the vehicle and a detected object.

The PDC sounder is located in the LH side of the luggage compartment. A bracket is attached to the 'E' post, behind the trim panel and provides for the attachment of the PDC sounder and the PDC ECU.

On vehicles without rear air conditioning, the bracket is located inboard on the LH 'E' post, adjacent to the luggage compartment trim panel. On vehicles with rear air conditioning, the bracket is located outboard on the LH 'E' post, adjacent to the outer body panel.

The sounder is located on two screws and lock washers through the bracket and secured with nuts. The sounder is connected to the PDC ECU via a harness connector.

Operation

PDC System Operation
When the ignition switch is in position II and reverse gear is selected, the PDC sensors are automatically activated. The PDC ECU only activates the system if reverse is selected for more than 1 second. This avoids nuisance audible warnings when the gear selector lever is being moved between Drive and Park on vehicles with automatic transmission.

When the system is activated, the PDC ECU illuminates the indicator LED in the PDC switch, switches on the ultrasonic sensors and generates a single chime on the PDC sounder to indicate the system is active. If an object is range of the sensors when the system is activated, a series of audible warnings are emitted by the PDC sounder immediately.

If PDC operation is not required, it can be suspended temporarily by pressing the PDC switch. When reverse is deselected and subsequently reselected, PDC will automatically become active again.

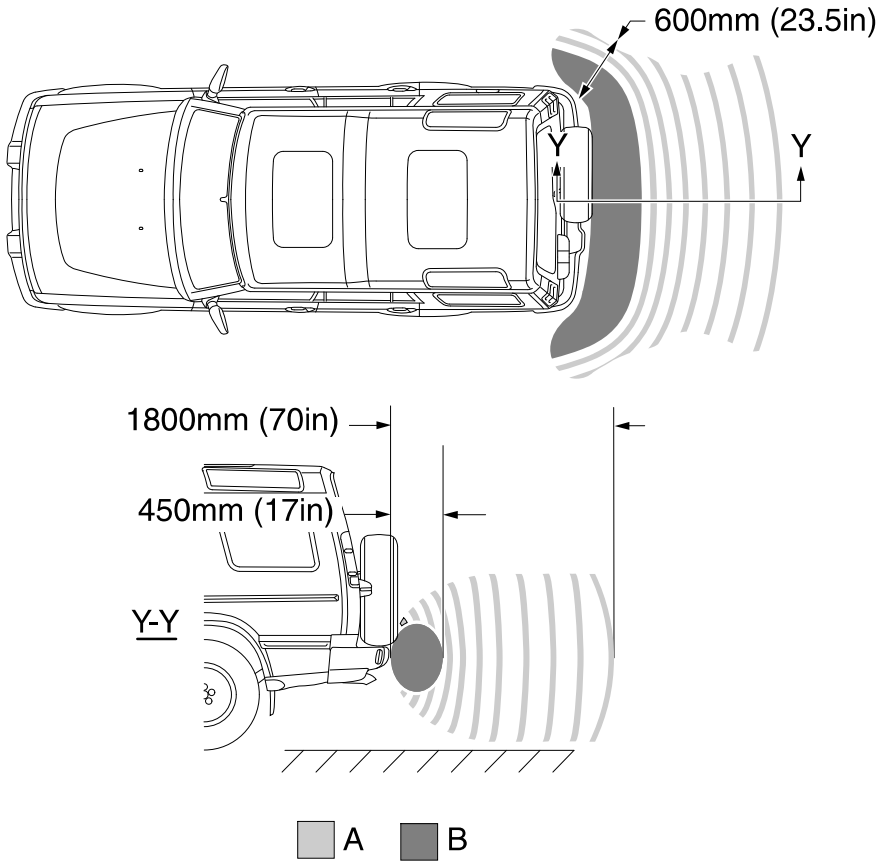
PDC can also be manually selected when not in reverse gear by pressing the PDC switch. A second press of the switch is required to turn off the PDC or the PDC will be deactivated if reverse is selected and then deselected.

Sensor Operation
The PDC ECU processes the distance readings from the ultrasonic sensors to determine if there are any objects within the detection areas. If there are no objects in the detection areas, there are no further audible warnings. If an object is detected, repeated audible warnings are produced on the PDC sounder.

The maximum detection range is 1800 mm (70 in). When an object is detected, the time delay between the audible warning tones decreases as the distance between the detected object and the vehicle decreases until, at approximately 450 mm (17 in), the audible warning tone is continuous.

After the initial detection of an object, if there is no decrease in the distance between an object and the central sensors, the time delay between the audible warnings remains constant. If an object is detected by one of the corner sensors only, the audible warnings stop after about 5 seconds if there is no change in the distance between the object and the corner sensor.

Park Distance Control Detection Areas



M86 5917

a Intermittent Warning Tone
b Continuous Warning Tone

Detection Calculation

When operating in the combined transmitter and receiver mode, the sensor outputs a number ultrasonic pulses and receives the reflected echo signal. The ECU amplifies the received echo signals and compares them with a preprogrammed threshold to calculate the distance to the object. This is achieved by determining the elapsed time between the transmission and reception of the ultrasonic signal.

When operating in receiver mode, the sensor receives echo signals transmitted by an adjacent sensor. This mode is used to improve the accuracy of the system.

The detection cycle consists of the ECU operating one sensor in the combined transmitter and receiver mode and transmitting a number of ultrasonic pulses. The ECU then switches the transmitting sensor and the adjacent sensor(s) to receiver mode. After a short time delay, this sequence is repeated using a different sensor to transmit the ultrasonic pulse and continues until all four sensors have output an ultrasonic signal. This sequence is completed in 100ms. The ECU uses several measurements of the same sensors to remove errors from the calculation.

If the object is directly behind a sensor, the distance is calculated using the time between the transmission and reception of the signal. If the object is positioned between two sensors, the ECU uses both signals to determine the correct distance using triangulation.

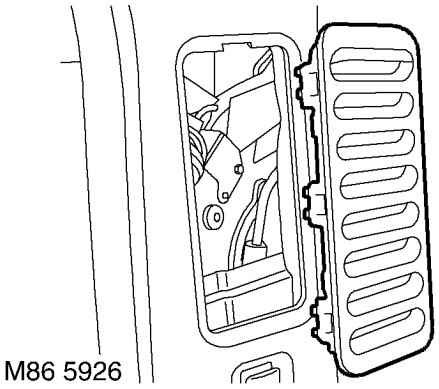
To perform the triangulation calculation, the ECU must know the distance between the individual sensors in the bumper. This information is stored in the ECU memory. From the received distance from each sensor and using the known distance between adjacent sensors, the ECU can calculate the minimum distance from the vehicle to the object.

When approaching several objects, the ECU recognises the distance from the vehicle to the nearest object.

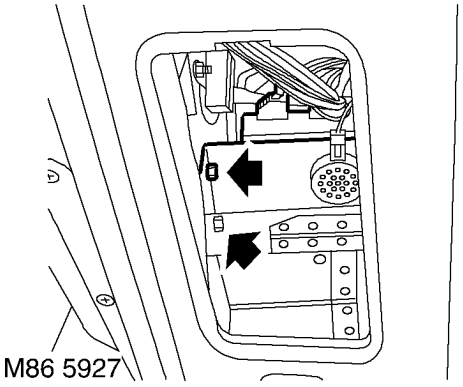
Control unit (ECU) - parking aid

86.54.10

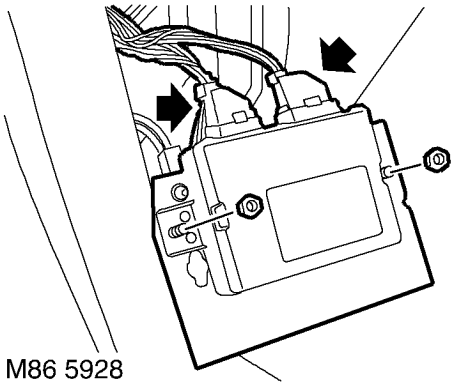
Remove


M86 5926

1. Remove loadspace LH side trim casing access panel.


M86 5927

2. Remove 2 bolts securing parking aid ECU mounting bracket to body and manoeuvre ECU and bracket assembly from behind trim casing.


M86 5928

3. Disconnect multiplug from ECU.
4. Remove 2 nuts securing ECU to bracket.
5. Remove ECU.

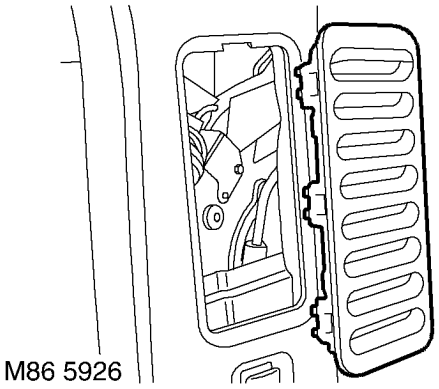
Refit

1. Fit ECU to mounting bracket and fit and tighten nuts.
2. Connect ECU multiplug.
3. Manoeuvre ECU and mounting bracket assembly behind trim casing, align, fit bolts and tighten to 25 Nm (18 lbf.ft).
4. Fit access panel.

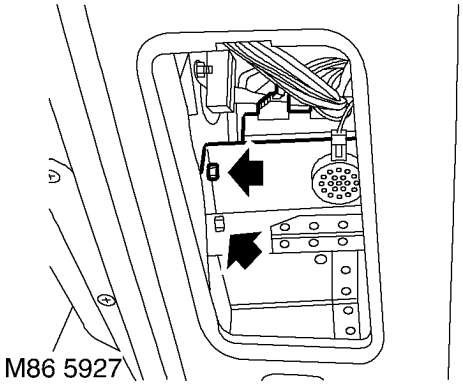
Sounder - parking aid rear

86.54.19

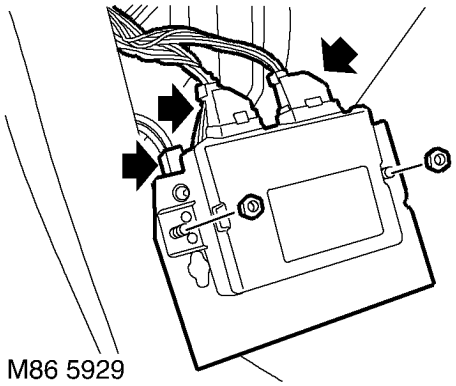
Remove


M86 5926

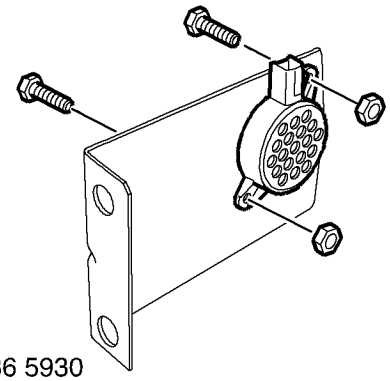
1. Remove loadspace LH side trim casing access panel.


M86 5927

2. Remove 2 bolts securing parking aid ECU mounting bracket to body and manoeuvre ECU and bracket assembly from behind trim casing.


M86 5929

3. Disconnect multiplugs from parking aid ECU and parking aid sounder.
4. Remove 2 nuts and bolts securing parking aid ECU to bracket and remove the ECU.


M86 5930

5. Remove 2 screws securing parking aid sounder to bracket and remove the sounder.

Refit

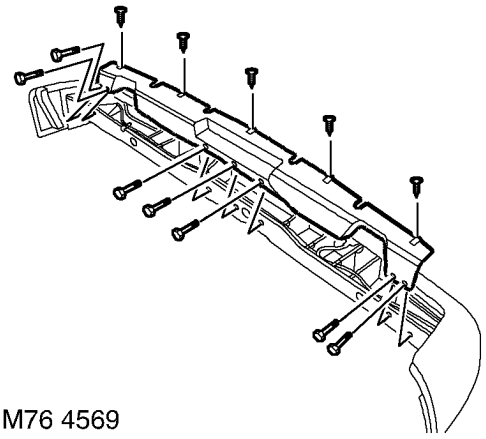
1. Fit parking aid sounder to the bracket and secure with screws.
2. Fit parking aid ECU to the bracket and secure with nuts and bolts.
3. Connect multiplugs to parking aid ECU and parking aid sounder.
4. Manoeuvre ECU and mounting bracket assembly behind trim casing, align, fit bolts and tighten to 25 Nm (18 lbf.ft).
5. Fit and secure loadspace access panel.

Sensor - parking aid - rear - inner

86.54.23

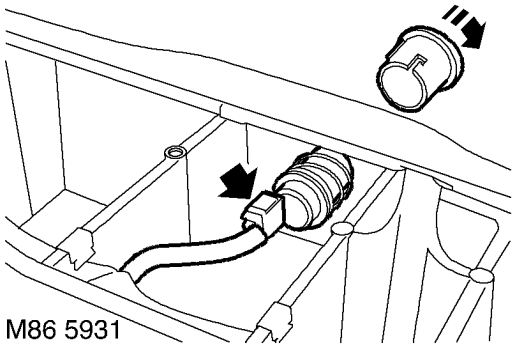
Remove

1. Remove rear bumper assembly.
   EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - from 03MY.



M76 4569

2. Remove 7 bolts and 5 screws securing closing panel and remove panel.



M86 5931

3. Disconnect multiplug from sensor.
4. Release and remove sensor and sensor housing.

Refit

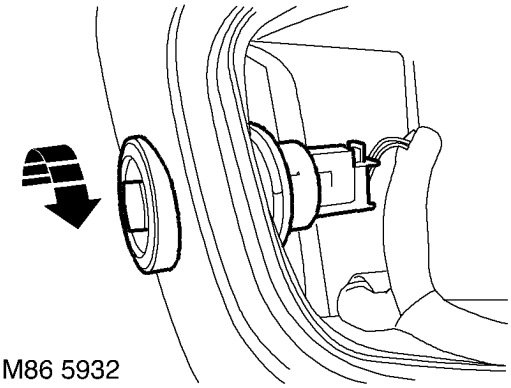
1. Clean sensor location on bumper.
2. Fit sensor housing to bumper, ensuring lug on housing is aligned with cut-out in bumper.
3. Fit and secure sensor to housing.
4. Connect multiplug.
5. Fit closing panel and secure with bolts and screws.
6. Fit bumper assembly.
   EXTERIOR FITTINGS, REPAIRS, Bumper assembly - rear - from 03MY.

Sensor - parking aid - rear - outer

86.54.24

Remove

1. Remove tail lamp from bumper.
   LIGHTING, REPAIRS, Lamp - tail/ flasher - bumper.



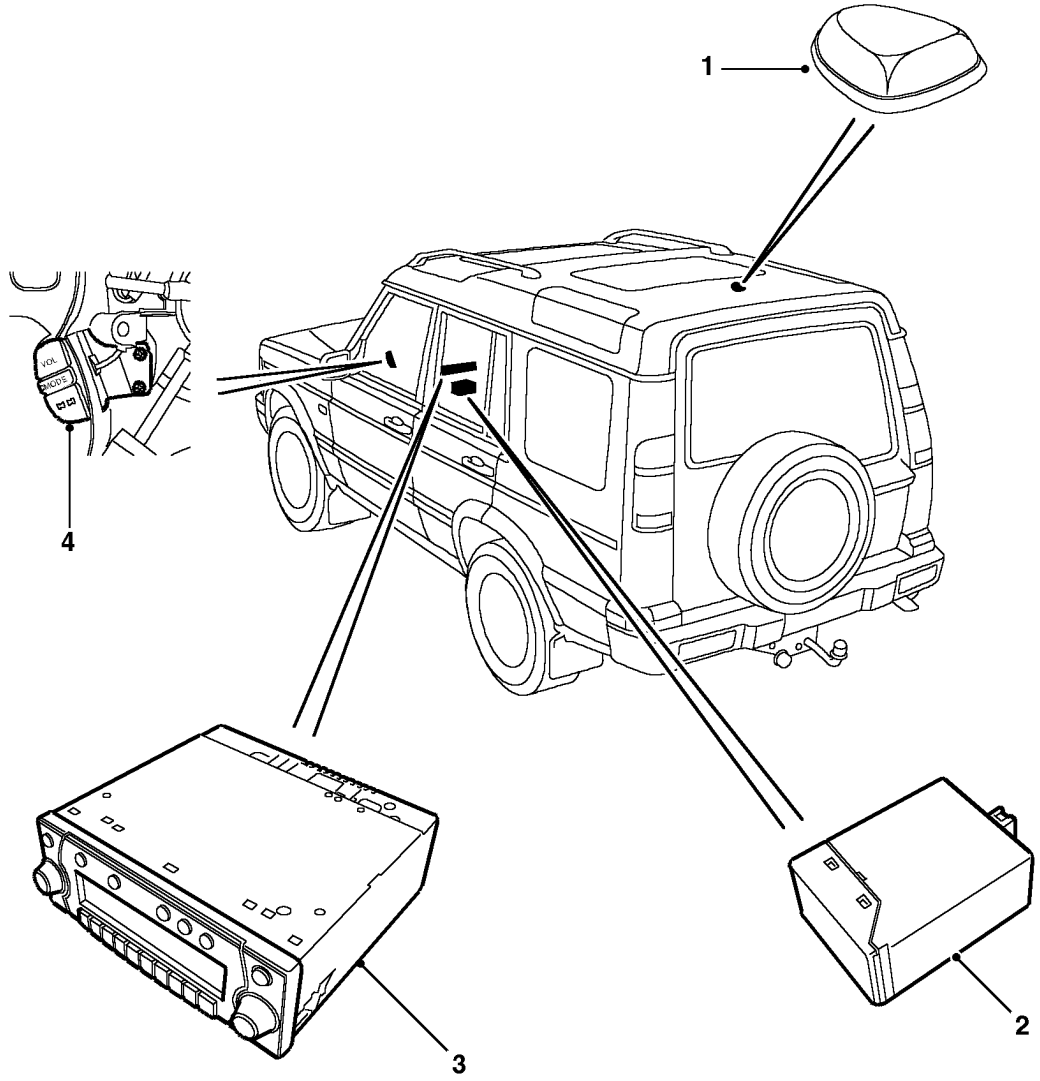
M86 5932

2. Disconnect multiplug from sensor.
3. Release and remove sensor and sensor housing.

Refit

1. Clean sensor location on bumper.
2. Fit sensor housing to bumper, ensuring lug on housing is aligned with cut-out in bumper.
3. Fit and secure sensor to housing.
4. Connect multiplug.
5. Fit tail lamp.
   LIGHTING, REPAIRS, Lamp - tail/ flasher - bumper.

Navigation System Component Location



M86 5731A

1 GPS antenna and diplexer unit
2 Remote control interface unit
3 Navigation computer
4 Steering wheel switches

Description

General
The navigation system provides audio and visual route guidance to help the driver reach a selected destination. The system is an optional fit consisting of a Traffic Pro navigation computer and antenna, manufactured by Harman/ Becker Automotive Systems, which are fitted in place of the In Car Entertainment (ICE) head unit and antenna. Compact Disc (CD) and radio functions are incorporated into the navigation computer.

The navigation system allows the driver to choose between the shortest and fastest routes between the vehicle's current position and a selected destination, and to select a stopover point in the journey and a route that avoids motorways, ferries and toll roads. Directions to Points Of Interest (POI) e.g. airports, hospitals, petrol stations etc, either local, national or in another country, can also be selected. A traffic jam function enables the driver to request diversion instructions, around an obstructed part of the selected route, during the journey. A Traffic Management Control (TMC) function, currently only available in some European countries, monitors traffic broadcasts and automatically selects an alternative route during the journey if the original route is effected by a traffic jam, accident or road works etc.

The position of the vehicle is determined by the navigation computer using a combination of vehicle sensor inputs and radio signals from the 24 Global Positioning System (GPS) satellites orbiting the earth. The position of the vehicle is then plotted on a digitised map, loaded into the navigation computer from a CD-ROM, to determine the journey route and provide the route guidance.

The GPS satellite signals are used for initial determination of the vehicle's position and periodic position updates. The vehicle sensor inputs are used to monitor the vehicle's direction of travel and distance travelled between position updates from the GPS satellite signals. The vehicle sensor inputs consist of:

- A vehicle speed signal from the ABS ECU, to monitor the distance travelled and for automatic volume control.
- A reverse gear signal from the selector and inhibitor switch of the automatic gearbox, or reverse gear switch of the manual gearbox, to enable the navigation computer to differentiate between forward and rearward movement of the vehicle.
- A gyro in the navigation computer, to monitor changes of direction, i.e. steering inputs.

The signal from each GPS satellite contains information about satellite position, almanac data and time (almanac data is the current status of the satellite). Signals from between five and 11 of the GPS satellites can be received at a given point on the earth's surface at any one time. The number and quality of separate GPS satellite signals received also varies with vehicle location. In hilly or tree lined areas, built up areas with tall buildings, multi-storey car parks, garages, tunnels, bridges and during heavy rain/thunderstorms, signal reception of some or all of the GPS satellites will be poor or non existent.

A minimum of three separate GPS satellite signals are required for the navigation computer to calculate a three dimensional (3D) positional fix. When only two signals are being received, the navigation computer will calculate a less accurate two dimensional (2D) positional fix. The more widely dispersed that the GPS satellites are, the more accurate the positional fix. The navigation computer can store information from a maximum of 12 GPS satellites at any one time. When more than three signals are stored, the navigation computer selects the three most widely dispersed signals for the position calculation.

GPS Antenna and diplexer unit
The GPS antenna is installed at the rear of the roof on the centreline. A diplexer unit on the underside of the GPS antenna amplifies the radio signals received from the GPS satellites and transmits them through separate dedicated co-axial cable to the navigation computer for processing.

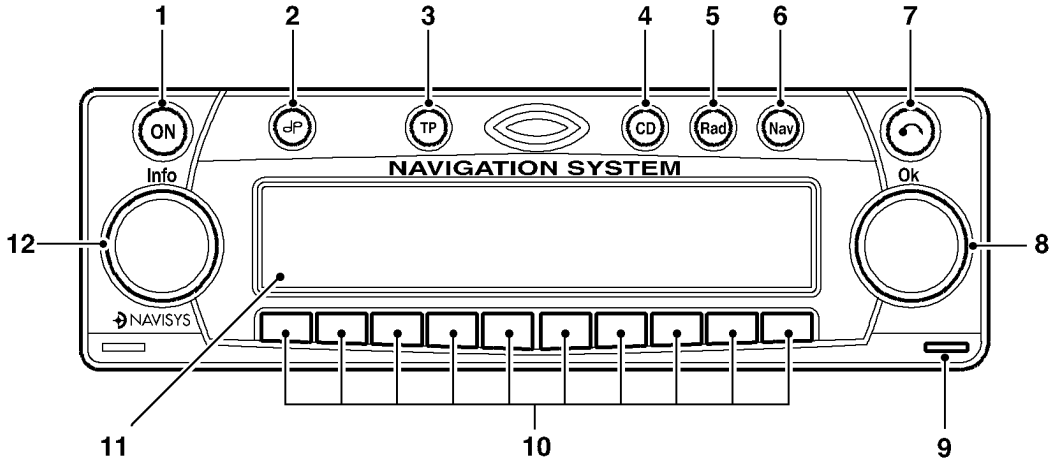
Navigation Computer

The navigation computer is installed in the DIN radio slot in the fascia. A spring loaded catch on each side of the navigation computer secures it in position. Slide tools, installed in slots at the bottom front corners of the navigation computer, are required to unlock the catches during removal.

The navigation computer contains all the hardware and software required for control of the navigation, radio and CD systems, including the GPS receiver and a solid state piezo gyro for the navigation system. The piezo gyro measures the motion of the vehicle around its vertical axis.

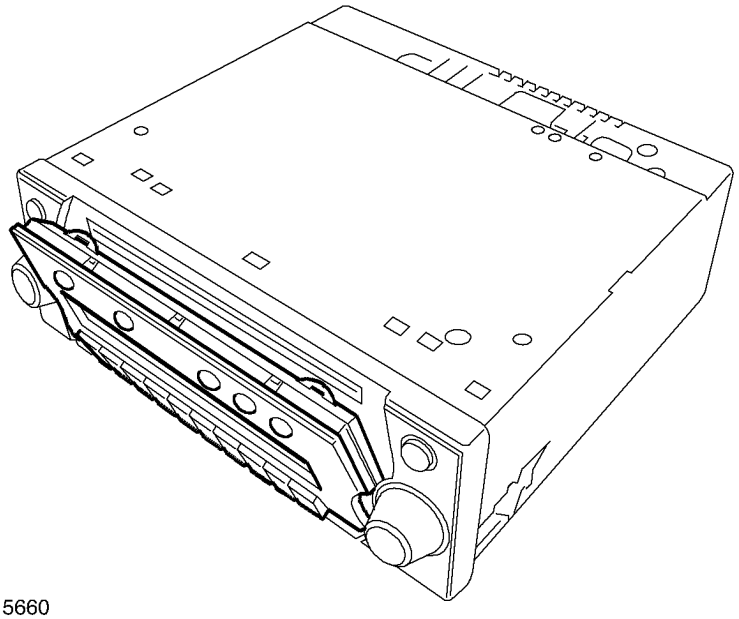
The controls for the navigation computer are all located on the front panel of the unit. The centre section of the front panel hinges to allow access to the CD player and, for security purposes, can be removed from the unit. The controls perform the following functions:

- On/Off (ON) button, for switching the unit on and off.
- Tone button, for activating the tone menu to adjust bass, treble, balance, fade and loudness functions.
- Traffic Programme (TP) button, for activating the traffic information programme menu (Europe only).
- Compact Disc (CD) mode button, for selecting CD operation.
- Radio (Rad) mode button, for selecting radio operation and tuning menus.
- Navigation (Nav) mode button, for entry and exit of the navigation menu and service mode.
- CD eject button, opens the removable panel and ejects the CD.
- RH rotary control, scrolls through menus when turned and enters a selection when pressed. Also mutes audio navigation instructions when pressed in navigation mode.
- Multifunction buttons, for entering the security code and menu selections.
- Liquid Crystal Display (LCD), green screen that displays navigation, radio and CD information.
- LH rotary control, adjusts volume when turned. When pressed, restores, repeats or interrupts audio navigation instructions or provides destination details.



M86 5652

1 On/Off button
2 Tone button
3 Traffic programme button (Europe only)
4 CD mode button
5 Radio mode button
6 Navigation mode button
7 CD eject button
8 RH rotary control
9 Release tool slot
10 Multifunction buttons
11 LCD
12 LH rotary control



M86 5660

Inputs and Outputs

In addition to the vehicle sensor and the antenna inputs, the navigation computer also receives the following:

- A permanent battery feed from the passenger compartment fusebox, to power the navigation function.
- An ignition switched battery feed from the passenger compartment fusebox, to power the navigation, radio and CD functions when the ignition switch is in positions I and II.
- An illumination power feed for switch illumination and LCD backlighting when the exterior lights are on.

Navigation computer outputs consist of those for the ICE system speakers and to the auxiliary CD autochanger, where fitted.

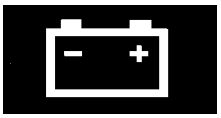
Security Code

The navigation computer is programmed with a five digit security code selected from numbers 1 to 7. If the battery or the navigation computer are disconnected, the code is requested on the LCD the first time the navigation computer is switched on after reconnection; this also occurs if a different removable panel is fitted.

The code is entered using the appropriate multifunction buttons. The navigation computer automatically starts to operate when the fifth digit of the correct code is entered. If an incorrect code is entered, CODE is displayed on the LCD to prompt another entry attempt. If an incorrect code is entered three times in succession, WAIT is displayed on the LCD and the unit is disabled for approximately 60 minutes. If the navigation computer is switched off, the remaining disabled time will resume when the power is restored.

Automatic Volume Control (AVC)

The AVC feature automatically increases and decreases the audio volume with increases and decreases of vehicle road speed. The AVC feature, also known as the GAL setting, uses the vehicle speed signal from the ABS ECU and can be turned off or adjusted to start at a different vehicle speed. The GAL setting is accessed through the User Menu and can be set to between 0 and +15, where 0 is off and +1 to +15 progressively increase the vehicle speed at which AVC starts to operate.



System Settings Menu

The system settings menu provides access to features that can be changed to suit market and personal preferences and to navigation system operating features. On European systems, the system settings menu also includes computer games and a currency converter. While the navigation computer is in the navigation mode, the system settings menu can be accessed by pressing the Nav button. Using the RH rotary control, the following features can be selected and adjusted:

- *TIME* – Allows the navigation system clock to be set to local time as opposed to the Greenwich Mean Time (GMT) transmitted from the GPS satellites. The local time setting is necessary for correct navigation on routes with time restrictions and for Estimated Time of Arrival (ETA) calculations. The time can only be adjusted in 30 minute steps.
- *SAVE POSITION*– Allows the current vehicle position to be saved and allocated a name in the navigation destination memory.
- *GAMES* – Provides access to a selection of computer games.
- *LANGUAGE*– Allows the navigation system language and voice (where applicable) to be changed.
- *ANIMATIONS*– Allows the LCD animations to be switched on and off.
- *MEASURING UNIT* – Allows the route guidance distances displayed on the LCD to be switched between metric and Imperial units.
- *ANNOUNCEMENT ETA* – Allows the route guidance ETA announcement to be switched on and off.
- *CALCULATE EURO* – Provides access to a currency converter.

User Menu

The user menu provides access to further features that can be changed to suit personal preferences. While the navigation computer is in navigation, radio or CD modes, the user menu can be accessed by pressing and holding the tone button for more than 2 seconds. The user menu is displayed over two screens, which can be toggled between using the ⇒ multifunction button. Using the appropriate multifunction button or the RH rotary control, the following settings can be selected and adjusted:

Screen 1

- *Gal* – Automatic volume control setting (see above).
- *Tel* – If a handsfree telephone system is connected to the navigation computer, allows either *mute* (telephone mute mode) or *audio signal* (telephone conversation via the ICE speakers) to be selected.
- *Lcd* – The LCD can be set to appear *negative, positive*or *automatic*. In *automatic*, the display will be positive or negative, depending on the setting of the exterior lamps.
- *Led* – A Light Emitting Diode (LED) in the display can be set to *off* or *blinking*. When set to *blinking*, the LED flashes when the navigation computer is switched off.
- *M/S* – Radio reception can be set to *Stereo, Mono* or *Auto*, to suppress interference and reflections and so optimise reception. *Stereo* is for exceptionally good reception conditions. *Mono* is for poor reception conditions. In *auto*, the normal setting, the navigation computer automatically switches between stereo and mono depending on reception conditions.

Screen 2

- *Nav* – Sets how audio navigation instructions are delivered. In *onl*, other audio sources are suppressed and only the navigation instruction is output to the speakers. In *mixed*, the volume of any other audio source is reduced and the volume of the navigation announcement is the same as the original audio source +/– 6 dB (adjustable). In *independ*, the audio source and navigation announcement can be set to independent volume levels.
- *Aux* – Used to switch auxiliary CD AF connections between *Aux mode on* and *Aux mode off*. If no CD autochanger is installed, an external cassette or CD player can be connected to the navigation computer and powered by switching on the auxiliary CD AF connections.
- *Cmp* – Allows a compass to be shown on the LCD when route guidance is not active.
- *BeV* – Used to adjust the signal tone volume. Signal tones sound to confirm storage confirmation etc. and can be set between 0 (quiet) and +5 (loud).

Service Menu

The service menu provides access to details of the navigation computer hardware and software, and can be accessed when the navigation computer is in radio mode, by simultaneously pressing the *NAV* button and the 10 multifunction buttons. The following items can then be scrolled through by pressing the *Nxt* (next) and *Prv* (previous) multifunction buttons, or turning the RH rotary control:

- *Model No.*
- *Serial No.*
- *Changer Reset*
- *GAL*
- *Radio Software*
- *Radio Bolo*
- *Navi Rom*
- *Navi Flash*
- *RTC Value*

When Changer Reset is displayed, the CD autochanger (where fitted) can be reset by pressing the appropriate multifunction button.

When the End multifunction button is pressed, the navigation computer quits the service menu and returns to radio mode.

Garage Menu

Garage menu enables the navigation system to be tested and calibrated, and also contains a route navigation demonstration. The garage menu is entered from the main navigation menu, as follows:

1. Press the Nav button to access the system settings.
2. Press and hold multifunction button 3, then press multifunction button 5 to display the garage menu.

The garage menu contains the following, which can be accessed using the RH rotary control:

- *CALIBRATION RIDE* – Used to calibrate the navigation computer, to enable route navigation.
- *GPS INFO*– Provides functional test of antenna by checking GPS reception. If functioning correctly, displays the number of satellites being received, the date, time (Greenwich Mean Time) and the type of positional fix currently possible.
- *CALIBRATION*– Allows vehicle specific calibration data to be entered, e.g. tyre size. Also allows current calibration to be deleted prior to re-calibrating.

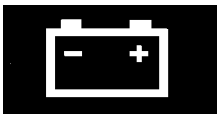
NOTE: Only known calibration data should be entered. The navigation computer cannot make route calculations if incorrect data is entered.

- *SENSORS*– Allows wheel speed, reverse gear and gyro sensor inputs to be checked.
- *VERSION*– Displays navigation computer hardware and software details.
- *SPEECH TEST*– Performs a test of the navigation computer audio output.
- *MODULE TEST*– Performs a test routine on the internal components of the navigation computer.
- *DEMO* – Allows a route navigation demonstration to be run.

To quit the garage menu, press the Nav button.

Calibration

Calibration is required after initial installation or replacement of the navigation computer. It may also be necessary after repairs to system wiring and if route navigation becomes inaccurate or fails to operate. If the navigation computer contains an existing calibration, this must be deleted, using the garage menu, prior to running the new calibration routine. The sensor inputs should also be checked before running the calibration routine.



Sensor Check

1 Call up the SENSORS screen on the LCD:
- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, use the garage menu as detailed above.

2 Drive the vehicle forwards a short distance at a speed greater than 2.5 mph (4 km/h) and ensure the road speed counter on the SENSORS screen starts to increment.

3 Select reverse gear and ensure the direction arrows on the SENSORS screen point rearwards.

4 Ensure the GPS data on the SENSORS screen is displayed and updated.

NOTE: The GPS data will randomly display a GPS MODULE FAILURE message. This is not a fault condition, and no action need be taken, provided the GPS data switches between the GPS MODULE FAILURE message and actual GPS data.

5 Exit the SENSORS screen:
- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, press the Nav button.

Calibration Routine

1 Park the vehicle outside in an area clear of high buildings, trees etc.

NOTE: The more open the surrounding area is, the faster the system will acquire sufficient GPS satellite signals to begin calibration. To minimise the calibration time, the vehicle should not be moved again until the calibration ride.

2 Turn the ignition switch to position II. If the navigation computer does not come on, press the navigation computer ON button.

3 If necessary, use the navigation computer multifunction buttons to enter the security code.

4 Turn the ignition switch to position 0 and remove the ignition key.

5 Press the navigation computer ON button.

6 Call up the SENSORS screen on the LCD:
- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, use the garage menu as detailed above.

7 Turn the LH rotary control to minimum volume.

8 Wait for 30 minutes. If necessary, the vehicle can be left unattended and locked.

NOTE: Land Rover recommend a minimum of 30 minutes be allowed to elapse in order to ensure that only a short distance need be driven to achieve calibration.

9 After the 30 minutes have elapsed, ensure the navigation computer LCD shows a GPS almanac figure of 27 or higher.

10 Start the vehicle engine and allow to idle.

11 Install the navigation CD-ROM.

12 Wait until the navigation computer LCD prompts for a language to be selected. Turn the RH rotary control to scroll through the options, highlight the required language and press the RH rotary control to select.

13 The navigation computer LCD will prompt for a voice to be selected. Turn the RH rotary control to scroll through the options, highlight the required voice and press the RH rotary control to select.

14 Wait until the navigation computer LCD advises "language has been loaded OK". Press the RH rotary control to confirm the language and voice selections.

15 The navigation computer LCD will default to the CALIBRATION RIDE screen and should show the CALIBRATION RIDE CAN START message. The GPS data and the road speed counter will also be shown.

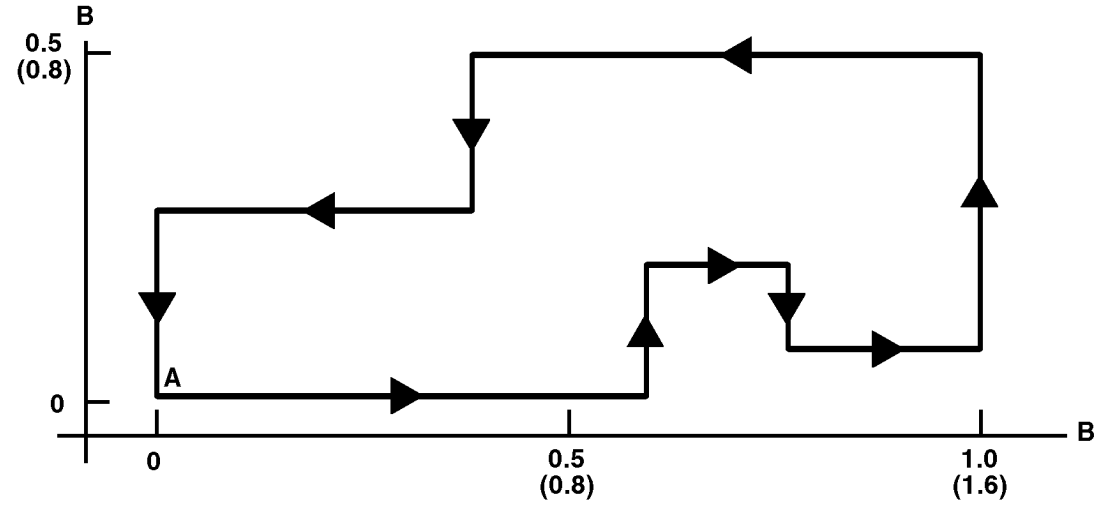
16 Drive the vehicle over a road route approximating that shown below (it is not necessary to copy the route exactly). Calibration is complete when the navigation computer LCD switches to show DESTINATION & POI and the satellite graphic. If all the pre calibration ride conditions were complied with, calibration is typically achieved within 3 miles (5 km) and usually occurs when the vehicle returns to the start point. However, calibration may be achieved earlier in the journey and, if it is, there is no need to complete the remainder of the calibration route.

17 After calibration is achieved, return to the dealership, park the vehicle and stop the engine.
18 Turn the ignition switch to position I.
19 Use the system settings menu to set the navigation computer to local time and the required units of measure:
- **a** Press the Nav button.
- **b** Turn the RH rotary control to scroll through the displayed menu, highlight TIME and press the RH rotary control to select. Press the + or – multifunction button to adjust the time in 30 minute steps. Select the 24 hour clock and confirm by pressing the OK multifunction button.
- **c** If metric units of measure are required, go to step e) (the navigation computer defaults to metric units of measure).
- **d** If Imperial units of measure are required, turn the RH rotary control to scroll through the displayed menu, highlight MEASURING UNIT and press the RH rotary control to select. Turn the RH rotary control to highlight IMPERIAL and press the RH rotary control to select.
- **e** Press the Nav button to return to the destination menu.

20 Calibration is complete. The navigation system is ready for use.

NOTE: The accuracy of the system will automatically be fine tuned when a further journey is made, but this is not required as part of the calibration procedure.

NOTE: In European countries, the territory will have to be set the first time the navigation system is used, and the first time a destination in another country is selected. The first time the navigation system is used or a destination in another country is selected, a map is displayed with the default/current territory highlighted. To change the territory: Press the RH rotary control to display the territory list; turn the RH rotary control to scroll through the list and highlight the required territory; press the RH rotary control to confirm the selection.



M86 5677

A = Distance, miles (km); B = Start/Finish point

Reset

If the navigation system malfunctions, a system reset can be triggered by simultaneously pressing the TP button and multifunction button 1 or 3. The navigation CD will need to be installed after the system reset.

Steering Wheel Switches
The steering wheel switches provide remote control operation for some of the navigation computer functions. The switches can be used to select between the radio/CD/navigation modes, to adjust the volume (in all modes) and to select search/preset up/down for radio and CD operation.

Remote Control Interface Unit
The remote control interface unit converts the analogue signals from the steering wheel switches into digital signals for use by the navigation computer. The remote control interface unit is installed in a bracket immediately below the navigation computer.

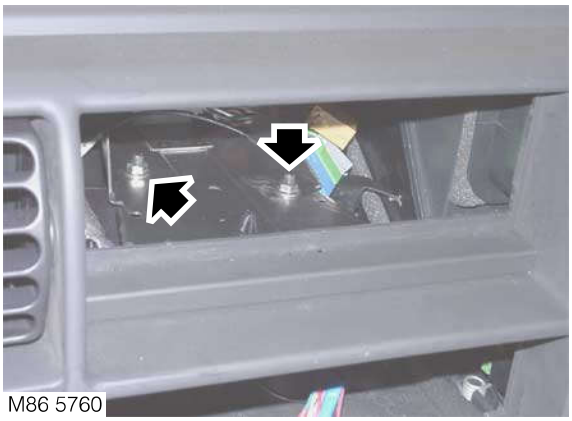
The radio remote switches form a resistance ladder between two wires with the resistance across wires dependent on which switch is pressed. The remote control interface unit monitors the two wires and converts their input into Instrument (I) bus protocol messages, which it outputs on a dedicated serial link to the navigation computer.

Interface electronic control unit (ECU) - remote control

86.53.15

Remove

1. Remove navigation display unit.
   NAVIGATION SYSTEM, REPAIRS, Display unit.
2. Remove automatic temperature control unit.
   AIR CONDITIONING, REPAIRS, ECU - air temperature control.



M86 5760

3. Remove 2 nuts securing interface carrier bracket, carefully pull bracket out of fascia.

M86 5762

4. Release interface ECU from bracket, disconnect multiplug and remove ECU.

Refit

1. Secure interface ECU in bracket and connect multiplug.
2. Carefully position carrier bracket in fascia, secure with nuts and tighten to 10 Nm (7 lbf.ft).
3. Fit automatic temperature control unit.
   AIR CONDITIONING, REPAIRS, ECU - air temperature control.
4. Fit navigation display unit.
   NAVIGATION SYSTEM, REPAIRS, Display unit.

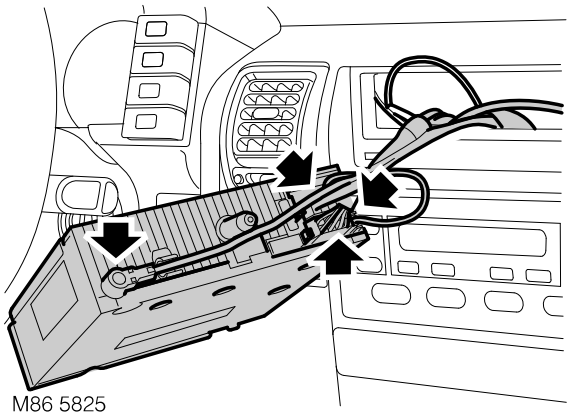
Display unit

86.53.20

Remove

1. Fit tool **LRT-86-009** into slots ensuring correct handed key is in correct slot.
   The tools are stamped either 'TOP L' or 'TOP R', ensure the stamping is facing upwards when removing the unit.

2. Pull display unit from fascia.

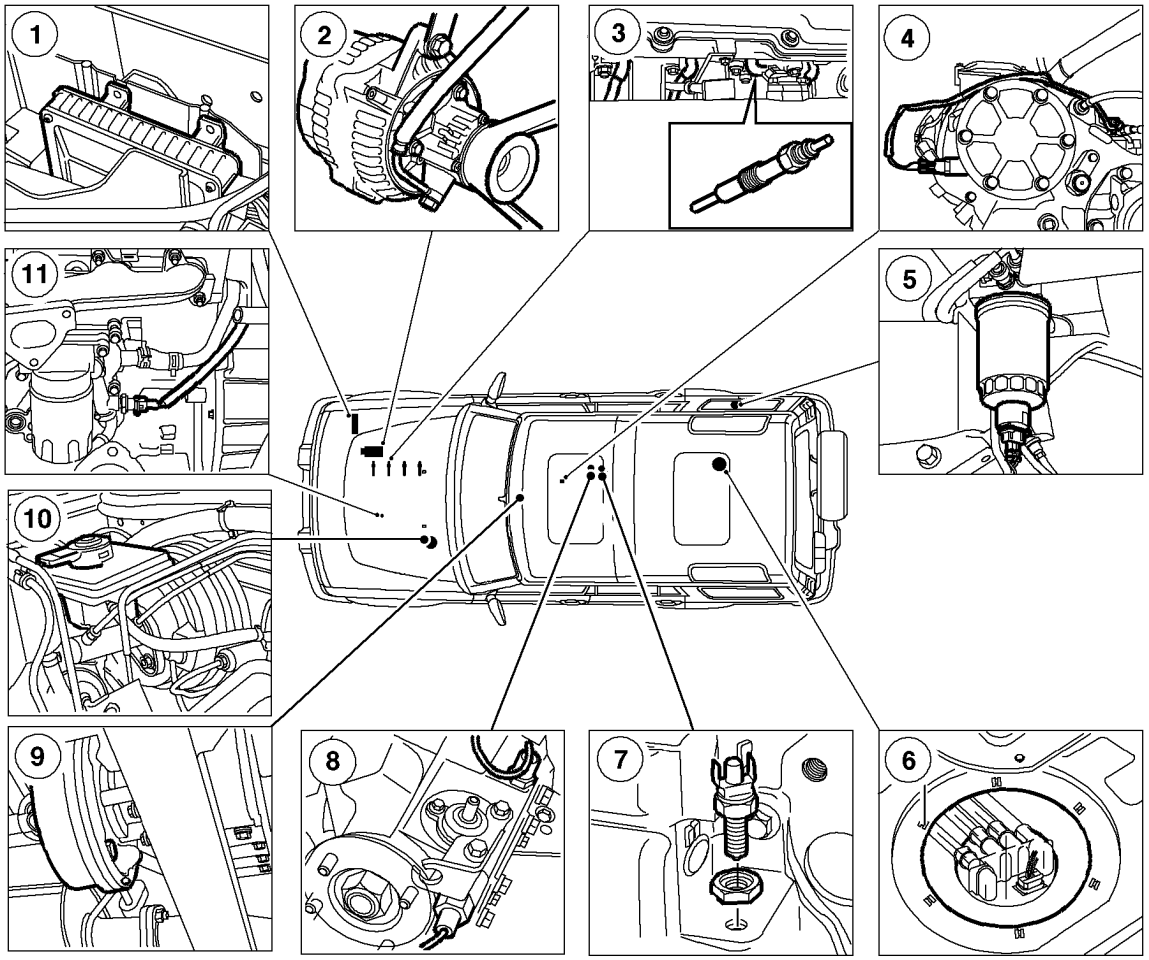


3. Disconnect 3 multiplugs and 2 coax cables from display unit and remove unit.
4. Push display unit retaining clips inwards and remove keys.

Refit

1. Position display unit to fascia, connect multiplugs and coax cables.
2. Push display unit into fascia until retaining clips engage.
3. Enter security code and check system is operational.

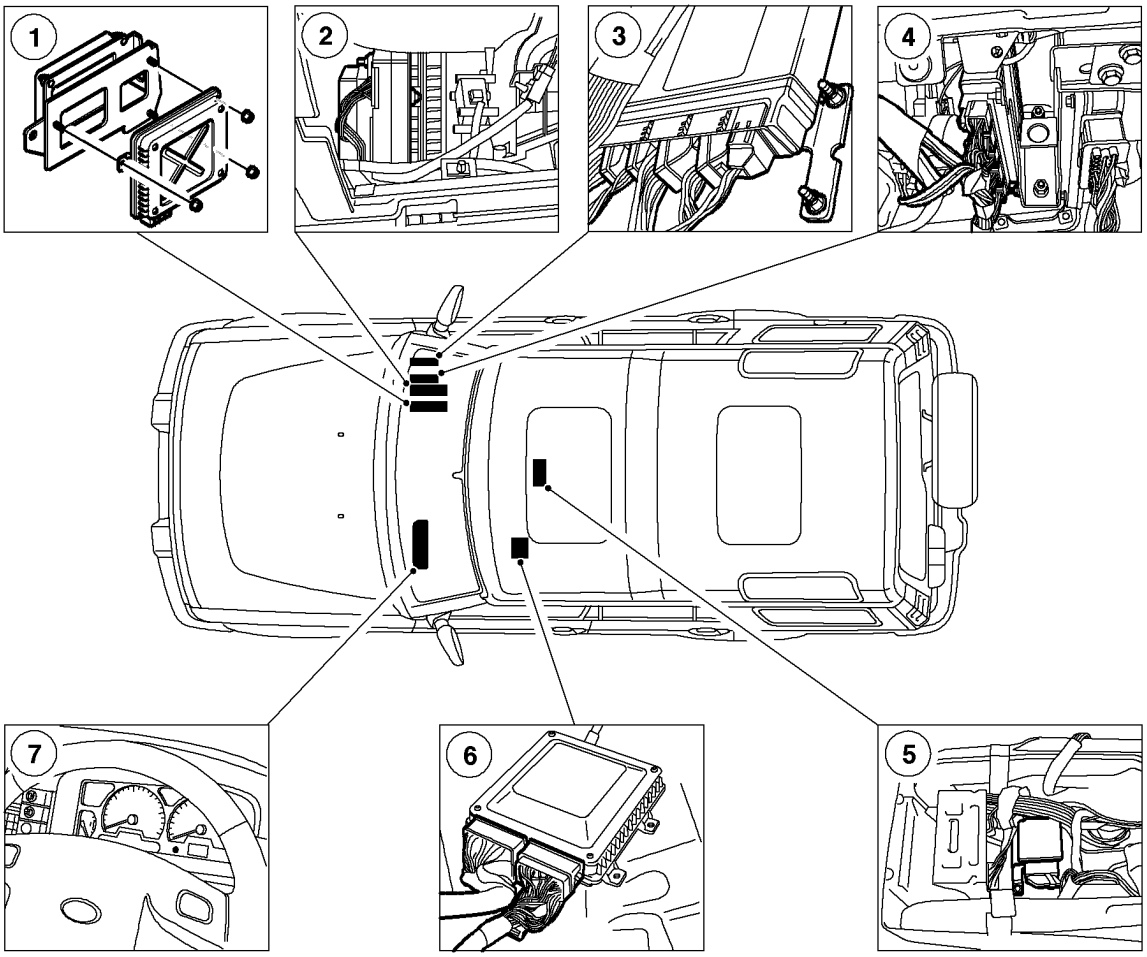
Instrument component location - Engine compartment / underneath vehicle



M88 0205A

1 ECM (diesel models)
2 Alternator
3 Glow plugs
4 Transmission temperature sensor
5 Water in fuel filter sensor
6 Fuel tank sender unit
7 Differential lock switch – vehicles up to 03 model year
8 Differential lock switches – vehicles from 03 model year (where fitted)
9 Parking brake switch
10 Brake fluid level switch
11 Oil pressure switch

Instrument component location - Passenger compartment

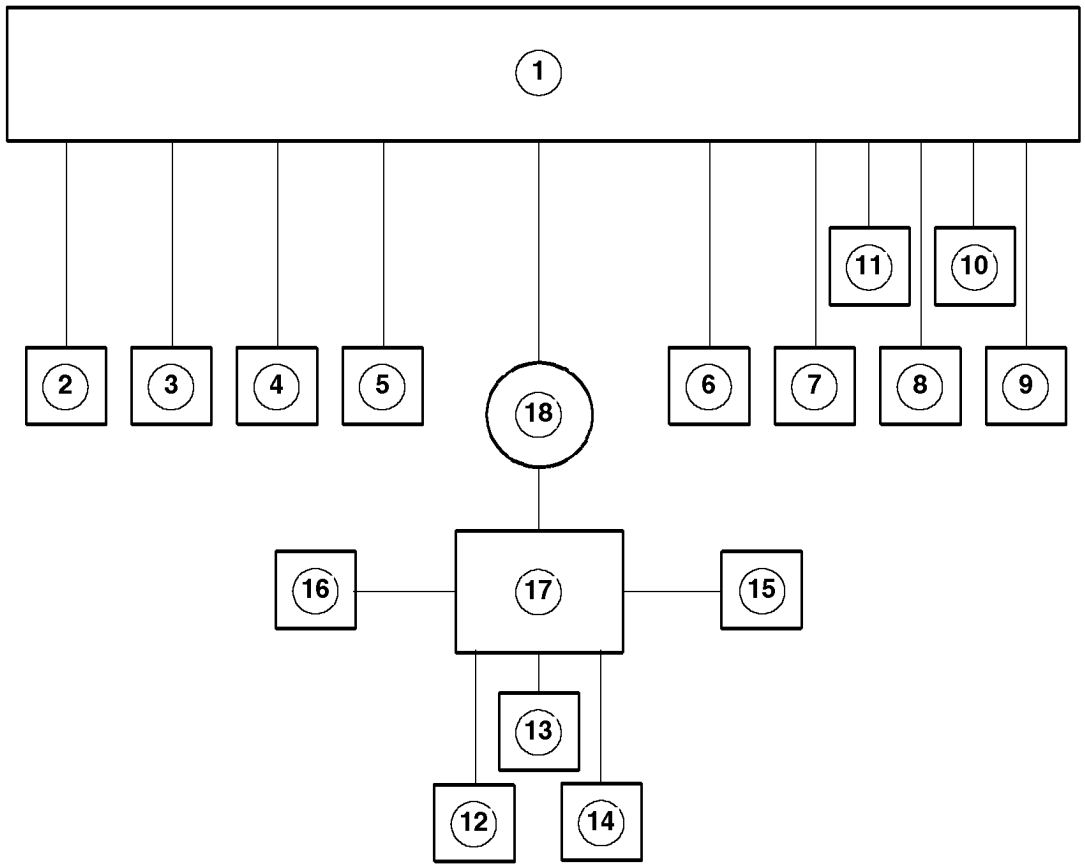


M880245

LHD illustrated

1 ACE ECU
2 BCU
3 ECM (V8 models)
4 SLABS ECU
5 SRS DCU
6 EAT ECU
7 Instrument pack

Instrument block diagram



M880206

1 Instrument pack
2 ECM
3 Brake fluid level switch
4 Parking brake switch
5 Oil pressure switch
6 Alternator
7 Fuel tank sender unit
8 Water in fuel filter sensor
9 Transmission temperature sensor
10 Differential lock switch - vehicles up to 03 model year or Differential lock switches - vehicles from 03 model year
11 Audible warning speaker
12 SRS DCU
13 SLABS ECU
14 BCU
15 ACE ECU
16 EAT ECU
17 Diagnostic connector
18 Serial communications link

Description

General
The instrument pack consists of four analogue dials, four warning lamp packs and a Liquid Crystal Display (LCD) odometer.

The four dials are used to indicate:
- Road speed.
- Engine speed.
- Fuel tank level.
- Engine coolant temperature.

The dials are driven by a microprocessor from information received from the serial communication link. Information input is received as either:
- Digital.
- Analogue.
- Pulse train.
- Pulse Width Modulation (PWM).

The LCD provides information for:
- Odometer.
- Trip distance.
- Selected gear (on vehicles fitted with an automatic gearbox).

A trip reset button is provided to zero the trip display, this button also allows the selection of "miles" or "kilometres" for the display. A photocell controls the illumination of the LCD, maintaining contrast of the display during ambient light changes.

Within the four warning lamp packs there are 28 lamps. A long life bulb illuminates the high beam warning lamp and the rest of the warning lamps are illuminated by Light Emitting Diodes (LED's). All warning lamp legends are invisible until lit. When lit the symbols are illuminated on a black background.

The warning lamps illuminate in one of four colours. The colour indicates the level of importance to the driver, as follows:
- Red = warning.
- Amber = caution.
- Green = system operative.
- Blue = main beam operative.

The first warning lamp pack is located in the top left-hand side of the instrument pack and contains the following warning lamps:
- Traction control warning lamp.
- Transfer box in neutral warning lamp.
- Differential lock warning lamp
- Overspeed warning lamp (activated for gulf market only).
- Brake system warning lamp.
- Hill Descent Control (HDC) information warning lamp.
- Malfunction Indicator Lamp (MIL)/ SERVICE ENGINE SOON warning lamp.

The second warning lamp pack is located in the centre of the instrument pack and contains the following warning lamps:
- Direction indicator warning lamps.
- High beam warning lamp.
- Anti-lock brake system warning lamp.

The third warning lamp pack is located in the top right-hand side of the instrument pack and contains the following warning lamps:

- SRS warning lamp.
- SLS off road mode warning lamp.
- Trailer warning lamp.
- Glow plug warning lamp.
- Water in fuel filter warning lamp.
- Seat belt warning lamp.
- Transmission high temperature warning lamp.

The fourth warning lamp pack is located underneath the tachometer of the instrument pack contains the following warning lamps:

- Oil pressure warning lamp.
- Alternator charge warning lamp.
- HDC fault warning lamp.
- Self Levelling Suspension (SLS) warning lamp.
- Active Cornering Enhancement (ACE) warning lamp.
- Gearbox manual/sport mode warning lamps.

The serial communication link is used to allow information to travel to and from the instrument pack, and it provides the ability to configure the instrument pack to a specific market. It also allows the instrument pack to be controlled by TestBook for diagnostics.

There are five market specific variants of the instrument pack:

- United Kingdom (UK).
- North American Specification (NAS).
- Canada.
- Australia.
- Rest Of the World (ROW), Gulf and Japan.

The main difference between the five markets is that the speedometer will indicate road speed in mph as major figures and km/h as minor figures, km/h as major figures and mph as minor figures or km/h only.

When TestBook is used to diagnose the instrument pack it demands each of the dials and warning lamps to operate in-turn so a visual check of their operation can be made.

CAUTION: The instrument pack must not be stored on its face side at any time. This is because the dials have damping fluid within them to ensure smooth operation of the dials' indicator needles. This fluid will leak out.

Speedometer

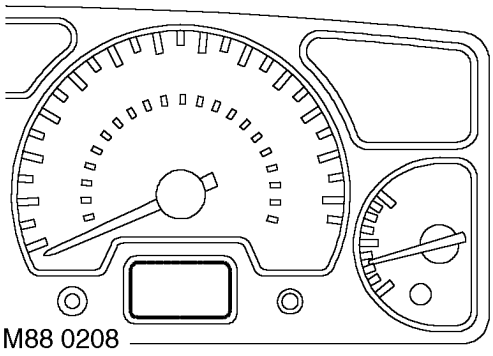
The speedometer informs the driver of the current vehicle road speed. It has a Liquid Crystal Display (LCD) to show odometer, trip meter and, on automatic gearbox models, the selected gear. The speedometer will not show speeds of less than 1.5 mph (2.5 km/h).

There are three different market configurations:

- NAS and UK = mph as major figures km/h as minor figures.
- Canada = km/h as major figures mph as minor figures.
- ROW and Australia = km/h only.

The Self Levelling and Anti-Lock Brake System (SLABS) ECU provides the signal input for the road speed. The signal is at 8000 pulses per mile (1.6 kilometres).

LCD odometer/trip meter



The LCD has 3 different display elements:

- Odometer.
- Trip meter.
- Selected gear (on vehicles with automatic gearboxes).

The odometer displays units in either miles or kilometres. It has a range from 0 to 999,999 units, only full units are displayed irrespective of the type of units selected, the display will stop at 999,999 units. TestBook can be used to reset the odometer. This is allowed only once and must be carried out before 150 miles (240 km) from new, after this distance the feature is disabled. The odometer may lose up to one km (0.6 miles) when the battery is reconnected, this is due to the software incorporated into the instrument pack to prevent anyone tampering with the odometer reading.

The trip meter displays units in either miles or kilometres and has a range of 0.0 to 999.9 units. The display rolls over from 999.9 to 0.0 units. Units down to one tenth of a mile or one tenth of a kilometre are displayed. The trip meter displays 0.0 when the battery is reconnected or charged from a discharged state.

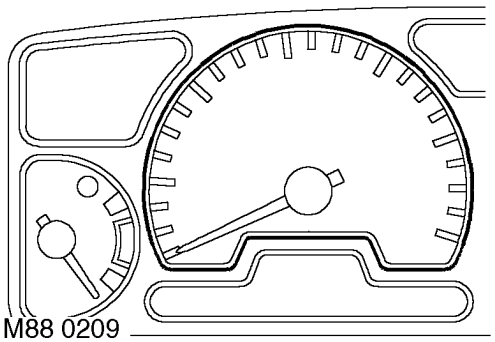
A push button located next to the LCD is utilised to reset the trip meter to zero and to change the units from miles to kilometres. Pressing the button for less than 2 seconds allows the display to reset to zero. Pressing the button for more than 2 seconds changes the units from miles to kilometres and vice versa. The units will only change for UK, NAS and Canadian market vehicles.

The selected gear displays when the automatic gearbox is in park, reverse, neutral, drive 3,2,1, by using the letters or numbers PRND321 in the display.

The data input for the LCD odometer/trip meter is from the SLABS ECU for the distance input and from the BCU for the gear position. The instrument pack provides the earth path to illuminate the gear position warning lamp.

If a replacement instrument pack is required TestBook must be used to retrieve the odometer reading, so that when the new instrument pack is fitted the odometer reading can be programmed in.

Tachometer

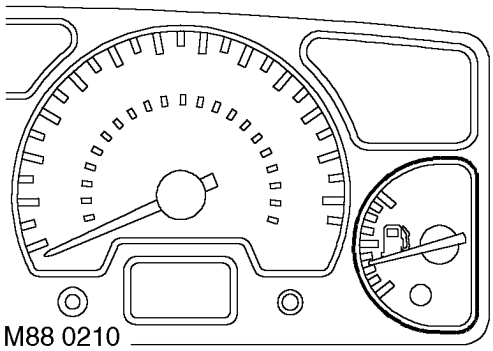


The tachometer is an integral part of the instrument pack. Located next to the speedometer. it displays engine speed in revolutions per minute. It is an analogue gauge with a maximum reading of 6000 rev/min.

V8 and diesel variants use the same gauge.

The input for the tachometer is from the ECM. It is a digital signal at 2 pulses per engine revolution. When the ignition is switched on with the engine not running, the ECM will generates pulses equivalent to 228 rev/min for diagnostic purposes. The tachometer will not register a reading, as it only indicate engine speeds above 228 rev/min.

Fuel gauge

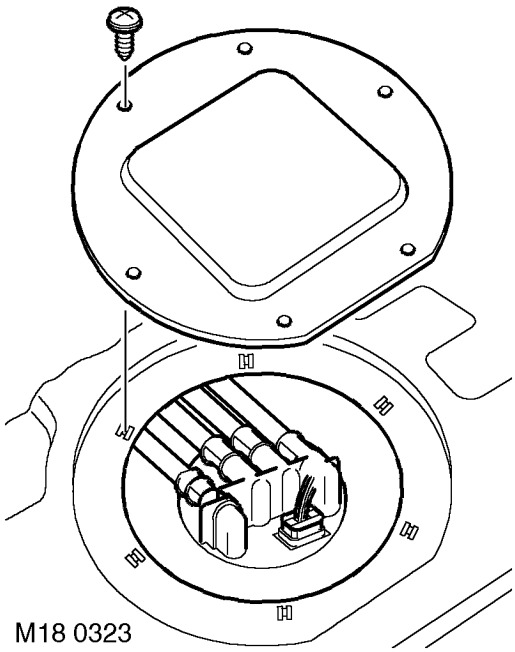


The fuel gauge is an analogue gauge that indicates the level of fuel in the fuel tank with the ignition on. The fuel gauge returns to 0 with ignition off. The gauge reading is proportional to the level of fuel in the tank. It is a damped action gauge to prevent erroneous readings caused by fuel moving in the tank. The damping action is minimised when the ignition is switched on to give an accurate reading within 2.5 seconds.

The signal input for the fuel gauge is from the tank sender unit, it is a variable voltage signal proportional to the level of fuel in the tank. The instrument pack provides the power via fuse 27 to the fuel gauge, then from the gauge on to the fuel tank sender unit. The earth path return circuit of the sender unit is connected to the instrument pack.

A low fuel level signal is provided for the ECM when the sender resistance is greater than 158±8 ohms, this is used to create a fault code indicating low fuel level during misfire diagnosis using TestBook.

Fuel tank sender unit



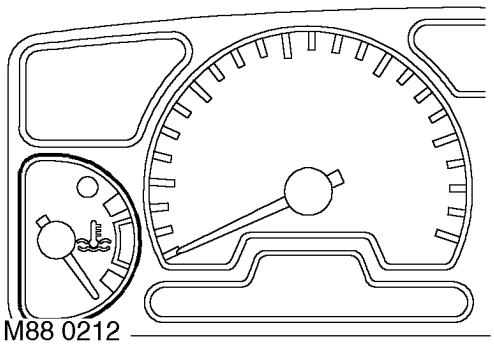
The fuel tank sender unit is combined with the pump. It contains a variable resistor with change in resistance proportional to the change in level of fuel in the tank.

The resistance of the fuel tank sender unit in relation to tank contents and gauge display is shown in the table below:

Tank contents	Sender resistance, ohms	Gauge display
Empty	245	0
Full	19	1

The fuel tank sender unit input voltage feed is supplied from the fuel gauge. The earth path return circuit of the sender unit is connected to the instrument pack.

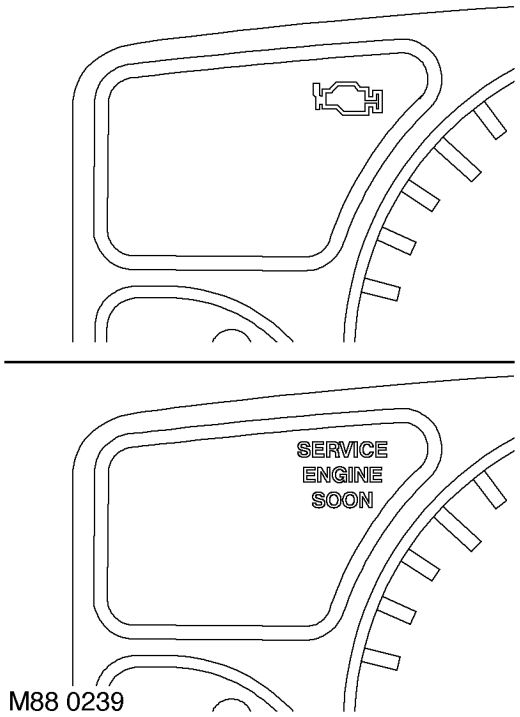
Engine coolant temperature gauge



The engine coolant temperature gauge is an analogue gauge with three sections: cold temperature; normal operating temperature; high temperature. Under normal engine operating temperatures the engine coolant temperature gauge will display in the centre of the gauge. When the engine is cold e.g. from first start-up, the coolant temperature gauge will display in the cold band. When the engine is over heating the temperature gauge will display in the high temperature band. If the engine coolant temperature gauge receives no input or the input is out of range the temperature gauge will read cold and the high coolant temperature warning lamp will be illuminated.

The input signal is a PWM signal from the engine coolant temperature sensor via the ECM. The power input for the high coolant temperature warning lamp is supplied by the instrument pack via fuse 27. The ECM controls the earth path to illuminate the high coolant temperature warning lamp.

Malfunction Indicator Lamp (MIL)/ SERVICE ENGINE SOON warning lamp



The MIL/service engine soon warning lamp within the instrument pack utilises an amber LED and a clear legend. If an emission related fault is detected by the engine management system or, on automatic gearbox models, the EAT ECU, the ECM will illuminate the LED providing the driver with a visible warning.

The warning lamp will illuminate whenever the vehicle is driven until the fault is repaired, and the ECM fault code memory is cleared using TestBook.

When the ignition is switch on the ECM carries out a self-test function of the lamp. The lamp will illuminate for 3 seconds then extinguish if no faults exist. If a fault is present the lamp will be extinguished for 1 second before illuminating again to indicate a fault exists.

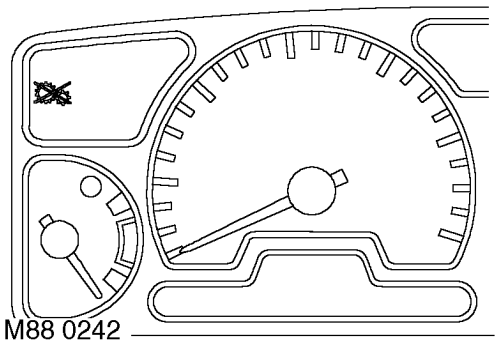
There are two configurations of the legend for the warning lamp:

- NAS and Canada = SERVICE ENGINE SOON text.
- All other markets = MIL SAE J1930 symbol.

The power input for the LED is supplied by the instrument pack via fuse 27. The ECM provides a voltage to the instrument pack Central Processing Unit (CPU) to control the warning lamp:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Transfer box neutral warning lamp



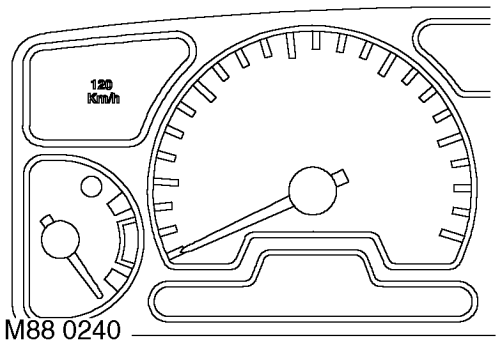
The transfer box neutral warning lamp illuminates to inform the driver that the transfer box is in neutral. The warning lamp utilises an amber LED with a clear legend which is to ISO design standards. There is no self-check for this warning lamp. If the transfer box neutral warning lamp is illuminated the audible warning speaker will also chime.

There are two configurations for this warning lamp:

- NAS, Canada and Japan = warning lamp enabled.
- Rest of World = warning lamp disabled.

The instrument pack provides the power input and the BCU provides the signal to illuminate the warning lamp. The transfer box in neutral information is provided by a switch on the transfer box, this sends an analogue signal to the BCU. The BCU commands the warning lamp on using the serial link to the instrument pack.

Overspeed warning lamp



The overspeed warning lamp within the instrument pack utilises an amber LED and a clear legend. The BCU illuminates the LED when the vehicle speed has exceeded 77 mph (123 km/h) and remains on until the vehicle speed falls below 74 mph (118 km/h), providing the driver with a visible warning. There is no self-check for this warning lamp.

There are two configurations for this warning lamp:

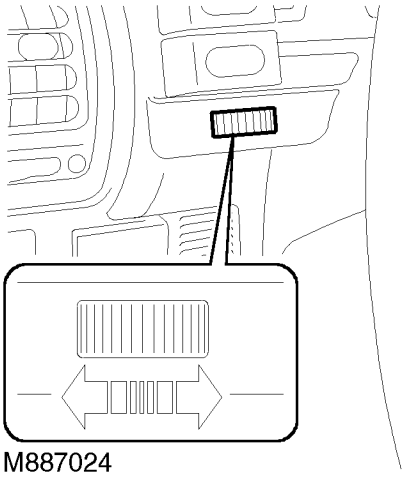
- Gulf = symbol.
- All other markets = disabled.

The instrument pack provides the power input and the warning lamp is controlled by the instrument pack according to PWM signal received from the ECM. The road speed information is derived from the SLABS ECU.

The lamp activation thresholds are shown in the table below

	Lamp on	**Lamp off**
Input pulse, Hz	165.75	158.83
Road speed, mph (km/h)	77 (123)	74 (118.5)

Instrument illumination

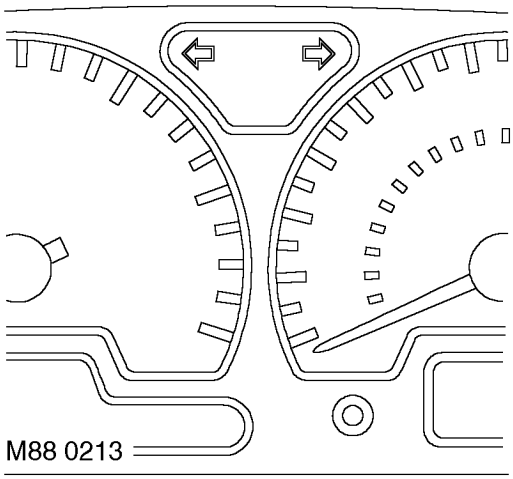


Dimmer switch

The instrument pack contains 3 bulbs to illuminate the dials. Depending on market the bulbs are illuminated either from the side lamps feed with no dimmer control or from a PWM dimmer control located on the dashboard. A PWM dimmer is used so finer control of the instrument illumination can be achieved.

The input is either direct from the side lamp power feed or from the PWM dimmer control. The instrument pack provides the earth path to illuminate the lamps.

Direction indicator warning lamps



The direction indicator warning lamp within the instrument pack utilises a green LED and a clear legend. The LED flashes at the same rate as the external indicators, providing the driver with a visible warning.

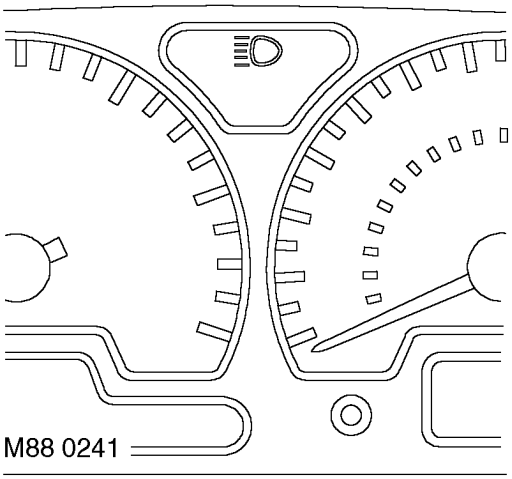
Operating the left-hand indicator switch instructs the BCU to activate the left-hand indicator warning lamp.

Operating the right indicator switch instructs the BCU to activate the right-hand indicator warning lamp.

There is no self-test performed at ignition on for these warning lamps.

The power input for the LED is supplied by the instrument pack via fuse 27. The earth path for the warning lamps is from the BCU.

Main beam warning lamp

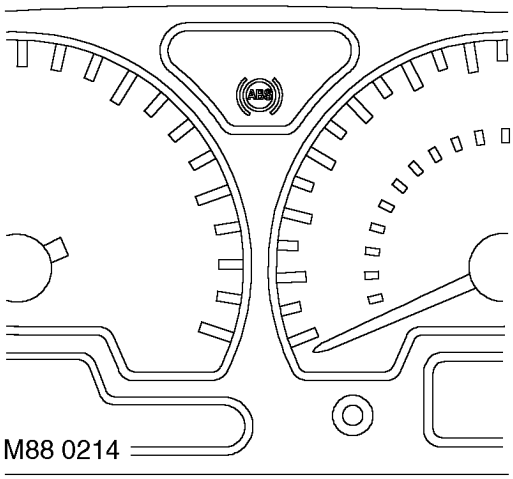


The main beam warning lamp within the instrument pack utilises a clear 14 volt 2 watt long life bulb and a blue legend. The bulb illuminates when the headlamps are switched to main beam, providing the driver with a visible warning.

There is no self-test performed at ignition on for this warning lamp.

Operating the main beam switch provides the Intelligent Driver Module (IDM) with battery voltage. This feed activates the IDM to supply the power for the main beam warning lamp. The earth path is provided through the instrument pack.

Anti-lock Brake System (ABS) warning lamp

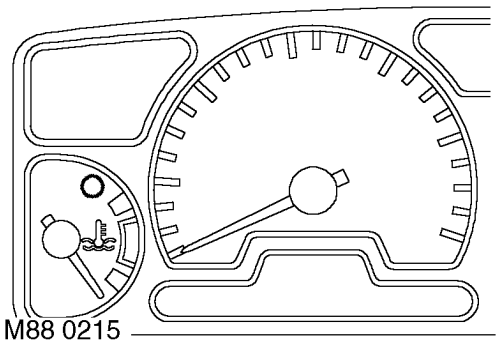


The ABS warning lamp within the instrument pack utilises an amber LED with a clear legend. If a fault within the ABS is detected, the SLABS ECU illuminates the LED, providing the driver with a visible warning.

When the ignition is switched on, the SLABS ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off. If an ABS fault is detected while driving the warning lamp will illuminate to alert the driver.

The power input for the LED is supplied by the instrument pack via fuse 27. The SLABS ECU provides the earth path to illuminate the ABS warning lamp.

High engine coolant temperature warning lamp



The high engine coolant temperature warning lamp within the instrument pack utilises a red LED and a clear legend. The ECM illuminates the LED when it detects the engine coolant has exceeded a temperature of 121 °C (250 °F) and switches it off when the coolant temperature drops below 118 °C (244 °F). The ECM also illuminates the high engine coolant temperature warning lamp when it detects the PWM duty cycle to the temperature gauge is out of range. If it is greater than 94% duty cycle when the engine is hot, or less than 8% duty cycle when the engine is cold, the engine coolant temperature gauge pointer will indicate cold, thus alerting the driver with an additional visible warning.

When the ignition is switched on, the ECM illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The response of the engine high temperature warning lamp varies according to engine type and market, there are three conditions:

- V8 - Gulf.
- V8 - all markets except Gulf.
- Diesel - all markets.

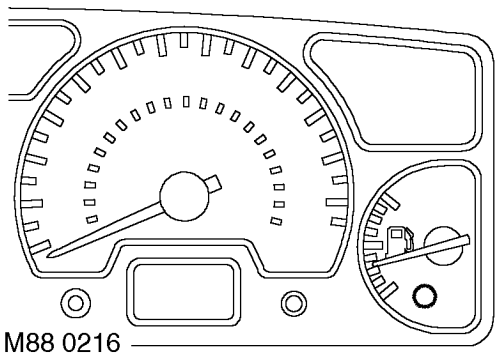
The vehicle configuration determines which condition is set.

The PWM duty cycle thresholds for illuminating and extinguishing the warning lamp are given in the table below.

Market	Lamp on	Lamp off
V8 - Gulf	79.8 ± 2%	77.8 ± 2%
V8 - all markets except Gulf	77.8 ± 2%	75.7 ± 2%
Diesel - all markets	78.8 ± 2%	76.8 ± 2%

The power input for the LED is supplied by the instrument pack via fuse 27. The ECM controls the earth path to illuminate the warning lamp.

Low fuel warning lamp



The low fuel warning lamp within the instrument pack utilises an amber LED and a clear legend. The ECM illuminates the LED when the fuel gauge pointer has reached 8 degrees from zero. The LED remains illuminated until fuel is added to move the fuel gauge pointer past 20 degrees from zero. This provides the driver with a visible warning that the fuel level in the tank is low.

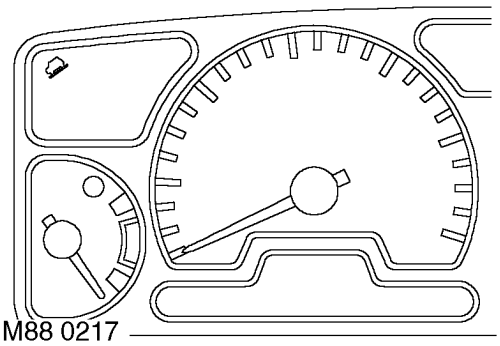
When the ignition is switched on, the ECM illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The sender unit resistance thresholds for switching the lamp on and off are shown in the table below:

	Lamp on	**Lamp off**
Resistance, ohms	158 ± 8	113 ± 6
Fuel gauge pointer angle, degrees	8	20

The power input for the LED is supplied by the instrument pack via fuse 27. The ECM provides the earth path to illuminate the warning lamp.

Hill Descent Control (HDC) information warning lamp



The HDC information warning lamp within the instrument pack utilises a green LED and a clear legend. On vehicles fitted with HDC, the HDC switch provides a hard wired voltage to the SLABS ECU to illuminate the LED when HDC is switched on. This provides the driver with a visible warning that the system is enabled.

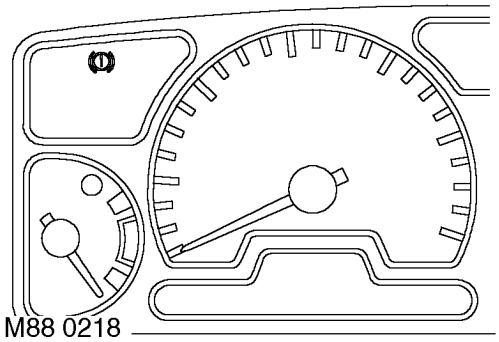
When the ignition is switched on, the SLABS ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 27. The SLABS ECU provides the earth path to illuminate the warning lamp.

The voltage on the SLABS ECU earth path to the instrument pack is as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Brake system warning lamp



The brake system warning lamp within the instrument pack utilises a red LED and a clear legend. If the brake fluid level is low, the hand brake is operated or there is a brake system fault, the LED will be illuminated providing the driver with a visible warning.

When the ignition is switched on, the instrument pack illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

There are two configurations of the legend for the warning lamp:

- NAS only.
- All other markets.

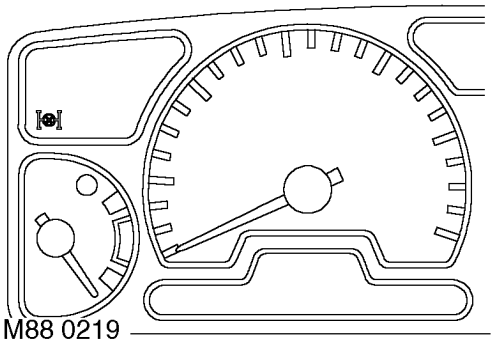
The power input for the LED is supplied by the instrument pack via fuse 27. The hand brake switch, the low brake fluid level switch or the SLABS ECU provides the earth path illuminating the warning lamp.

The hand brake switch has a separate connection to the vehicle body. The low brake fluid switch connects to an earth header joint.

On the earth paths to the instrument pack the warning lamp is controlled according to these voltages:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Differential lock warning lamp (If fitted)



The differential lock is a device used for rolling road testing only on vehicles up to 03 model year. On vehicles from 03 model year, the differential is a driver selectable option which can also be used for off road driving. Refer to the service procedures for details of rolling road testing on vehicles up to and from 03 model year.

CAUTION: Engage the differential lock when testing the vehicle on a two wheel rolling road. The propeller shaft connecting the axle not on the rolling road must also be removed.

Differential lock warning lamp – vehicles up to 03 model year

The differential lock warning lamp within the instrument pack utilises a red LED and a clear legend. When the differential lock is engaged, using the lever on the side of the transfer box, the differential lock switch is operated and the warning lamp is switched on providing the driver with a visible warning.

When the differential lock is engaged, the warning lamp will be illuminated continuously when the ignition switch is in position II.

Differential lock warning lamp – vehicles from 03 model year

The differential lock warning lamp is located in the top left hand corner of the instrument pack and uses an amber LED and a clear legend. When the differential lock is engaged, the warning lamp illuminates when the ignition is on to provide a visual indication to the driver that the differential lock is engaged. The instrument pack, simultaneously emits three audible warning chimes as a confirmation.

When the differential lock is disengaged, the warning lamp is extinguished and the instrument pack simultaneously emits three audible warning chimes as a confirmation.

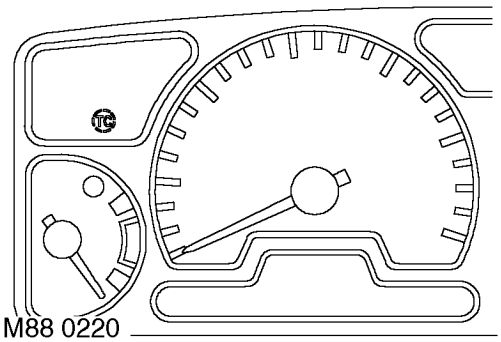
All vehicles

The power input for the LED is supplied by the instrument pack via fuse 13 in the engine compartment fusebox. The differential lock switch or switches provide(s) the earth path illuminating the warning lamp.

The voltage on the differential lock switch or switches to instrument pack earth path produces the following warning lamp functions:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Traction control warning lamp



The traction control warning lamp within the instrument pack utilises a red LED and a clear legend. The traction control warning lamp informs the driver that the traction control system is enabled. The warning lamp is hard wired to the SLABS ECU. The SLABS ECU controls the warning lamp on or off via a high or low voltage signal to the instrument pack.

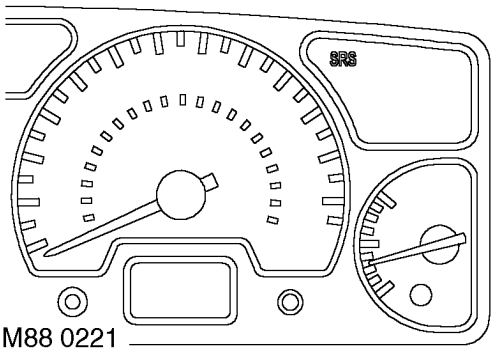
When the ignition is switched on, the SLABS ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 27. The SLABS ECU provides the earth path to illuminate the warning lamp.

The voltage on the SLABS ECU earth path to the instrument pack is as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Supplementary Restraint System (SRS) warning lamp



The SRS warning lamp within the instrument pack utilises a red LED and a clear legend. If a fault within the SRS is detected, the SRS DCU illuminates the LED, providing the driver with a visible warning.

When the ignition is switched on, the SRS DCU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off. The SRS warning lamp does not output fault codes.

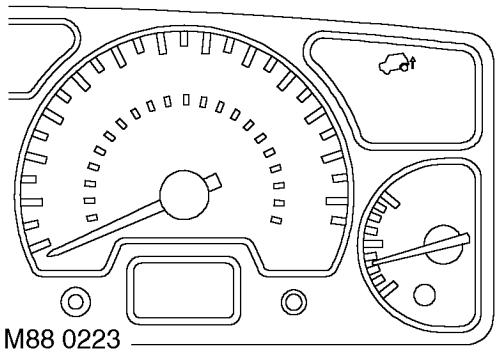
The power input for the LED is supplied by the instrument pack via fuse 35. The SRS DCU provides the earth path to illuminate the SRS warning lamp during the 3 second self-check.

The SRS warning lamp is switched on continuously by the instrument pack if the SRS DCU supply voltage is less than half of the ignition switch voltage, with a tolerance of +2 or -1 volt.

The SRS warning lamp is operated by the SRS DCU if a fault is detected within the supplementary restraint system circuits. The warning lamp is switched on according to the voltage present in the SRS DCU to instrument pack earth path as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Off road mode warning lamp



The off road mode warning lamp is available on vehicles equipped with self levelling suspension. The off road mode warning lamp within the instrument pack utilises an amber LED and a clear legend. On vehicles fitted with self levelling suspension the driver can enable the function using the off road mode fascia switch.

The SLABS ECU illuminates the LED, providing the driver with a visible warning.

When the ignition is switched on the SLABS ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The off road mode is only enabled if the transfer box is in low range.

The off road mode warning lamp will flash at the rate of 2 Hz during the transition phase (up and down), and is illuminated continuously when at full height.

The vehicle may be parked in off road mode the driver is reminded when the ignition is switched on that off road mode is still active by the warning lamp flashing twice at a ratio 2 Hz then illuminates continuously.

The warning lamp will flash at 2 Hz in belly out mode. Belly out mode is if the vehicle grounds out, then the suspension will raise to try and clear the underside of the vehicle.

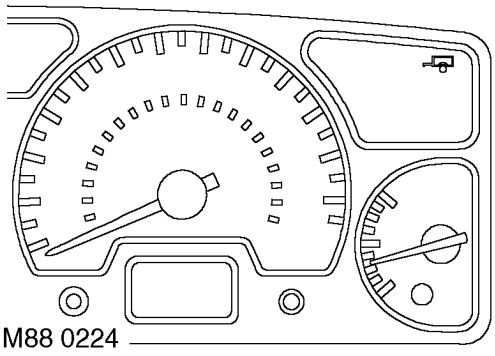
If a new SLABS ECU is fitted the warning lamp remains illuminated until the ECU has been calibrated using TestBook.

The warning lamp will illuminate continuously if the voltage supply is less than 10 volts for 1 second.

The power input for the LED is supplied by the instrument pack via fuse 27. The warning lamp is switched on according to the voltage present in the SLABS ECU to instrument pack earth path as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Trailer warning lamp

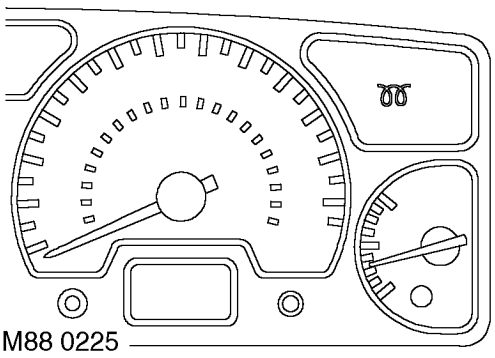


The trailer warning lamp within the instrument pack utilises a green LED and a clear legend. When a trailer is fitted to the vehicle, and the direction indicators are operated, the BCU detects additional current draw and illuminates the LED, providing the driver with a visible warning.

When the ignition is switched on the BCU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off. This self-check is every time the ignition is switched on, not only if a trailer is connected.

The power input for the LED is supplied by the instrument pack via fuse 13. The BCU provides the earth path to illuminate the warning lamp.

Glow plug warning lamp



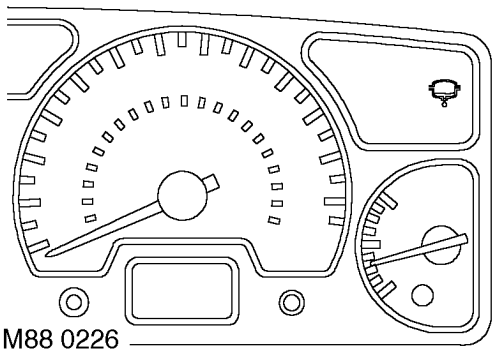
The glow plug warning lamp within the instrument pack utilises an amber LED and a clear legend. On vehicles with diesel engines the LED illuminates when the ECM operates the glow plugs. After a predetermined time calculated by the ECM, dependent on engine temperature, the LED is switched off providing the driver with a visible warning that the engine can be started.

The power input for the LED is supplied by the instrument pack via fuse 27. The ECM provides the earth path to illuminate the warning lamp.

The voltage on the earth path from the ECM to the instrument pack is as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Water in fuel filter warning lamp



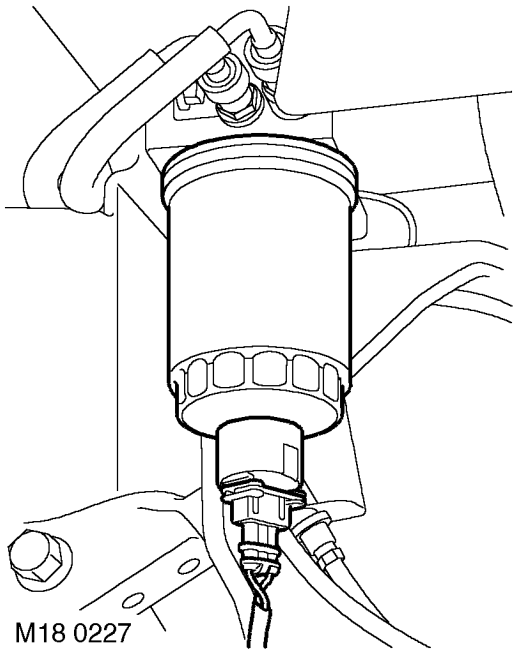
The water in fuel filter warning lamp within the instrument pack utilises an amber LED and a clear legend. On vehicles with diesel engines the LED is illuminated when the water sensor detects water is present in the fuel filter, providing the driver with a visible warning.

When the ignition is switched on, the instrument pack illuminates the LED to provide a self-check, providing there is no water present in the fuel filter it will remain illuminated for 3 seconds or until the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 27. The water sensor provides the earth path to illuminate the warning lamp. The voltage on the earth path from the sensor to the instrument pack is as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Water sensor

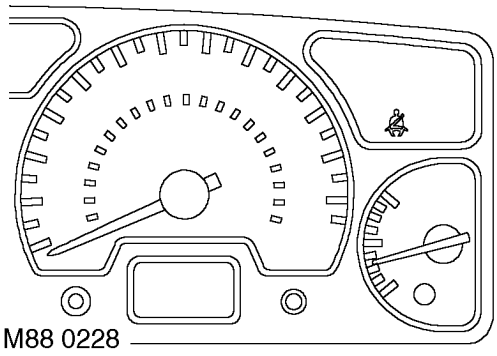


On vehicles with diesel engines a water sensor is located in the bottom of the fuel filter. The sensor utilises the different resistance properties between water and diesel fuel to determines the presence of water in the fuel.

The sensor receives a battery voltage supply from the fuel pump relay. The sensor output is supplied to the instrument pack. The water sensor provides the earth path to illuminate the warning lamp.

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Seat belt warning lamp



The seat belt warning lamp within the instrument pack utilises a red LED and a clear legend. The BCU utilises a switch in each of the front seat belt buckles to determine if a seat belt is not fastened.

When the ignition is switched on, the BCU illuminates the LED for 6 seconds or until the BCU determines that a seat belt is fastened which extinguished the warning lamp. This provides the driver with a visible reminder that the seat belts are not fastened.

The instrument pack provides the self-check if the diagnostic connector fails.

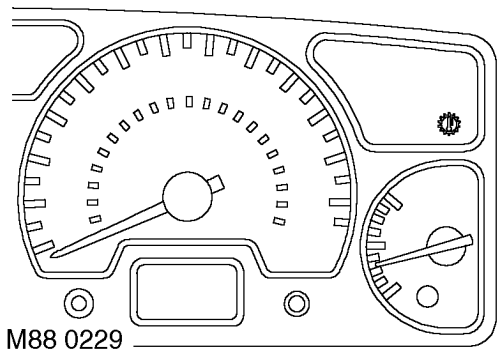
The power input for the LED is supplied by the instrument pack via fuse 13. The BCU provides the earth path to illuminate the seat belt warning lamp.

The seat belt buckle switches complete the earth path in the BCU sensing circuit, the BCU commands the instrument pack to switch on the seat belt warning lamp.

The BCU earth path to the seat belt buckle is as follows:

- < 1.8 volts = warning lamp off.
- > 7.7 volts = warning lamp off.

Transmission high temperature warning lamp



The transmission high temperature warning lamp within the instrument pack utilises a red LED and a clear legend. On vehicles fitted with automatic gearboxes, the transmission high temperature warning lamp is utilised to provide the driver with a visible warning that the automatic gearbox oil has exceeded a normal operating temperature. The warning lamp will extinguish if the gearbox oil returns back to normal operating temperature.

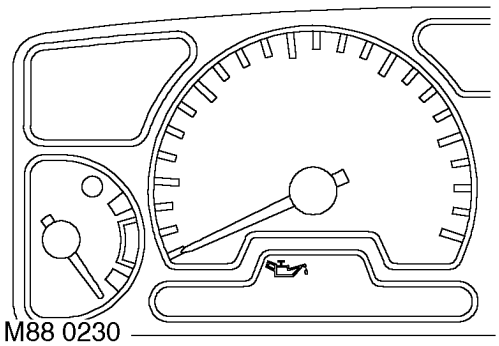
When the ignition is switched on, the instrument pack illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 13. The temperature sensor provides the earth path to illuminate the transmission high temperature warning lamp.

The transmission high temperature warning lamp is controlled according to the voltage present on the temperature sensor to instrument panel earth path:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Engine oil pressure warning lamp



The engine oil pressure warning lamp within the instrument pack utilises a red LED and a clear legend. The LED illuminates when the engine oil pressure is below the specified pressure (see table), providing the driver with a visible warning that the engine oil pressure has fallen below the specified minimum reading.

There is no self-test performed at ignition on for this warning lamp.

The power input for the LED is supplied by the instrument pack via fuse 27. The oil pressure switch located on the engine provides the earth path to illuminate the warning lamp, it will remain illuminated until the engine is started and the oil pressure exceeds the appropriate threshold and opens the switch contacts.

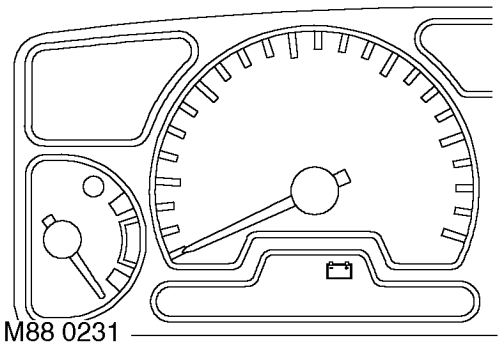
Low oil pressure switch operating pressures

Engine type	Switch opening pressure, bar (lbf.in^2)
V8	0.22 to 0.59 (3.0 to 8.5)
Diesel	0.25 to 0.42 (3.5 to 6.0)

The response to the voltage signal at the instrument pack is as follows:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Alternator charge warning lamp



The alternator charge warning lamp within the instrument pack utilises a red LED and a clear legend. The LED illuminates when the alternator output voltage is less than 2 volts. When the alternator output is greater than 7.6 volts the LED is extinguished, providing the driver with a visible warning that the alternator is charging.

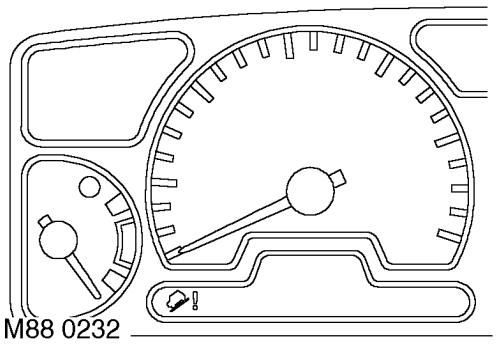
When the ignition is switched on, and the LED illuminates, it will remain illuminated until the engine is started and voltage is above the predetermined parameter, or the ignition is switched off providing there is no fault.

The power input for the LED is supplied by the instrument pack via fuse 27. The alternator provides a signal to illuminate the warning lamp by means of a hard wired connection to the instrument pack.

The response to the voltage signal at the instrument pack is as follows:

- < 2.0 volts = warning lamp on.
- > 7.6 volts = warning lamp off.

Hill Descent Control (HDC) fault warning lamp



The HDC fault warning lamp within the instrument pack utilises an amber LED and a clear legend. On vehicles fitted with hill descent control the SLABS ECU illuminates the LED if a fault within the HDC system is detected, providing the driver with a visible warning.

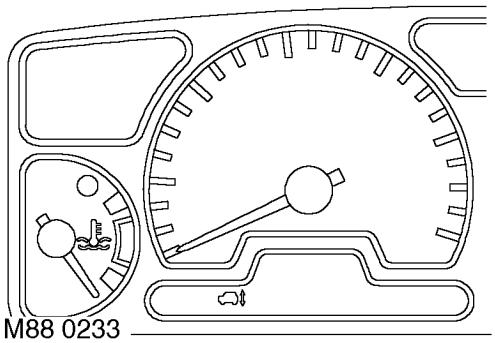
When the ignition is switched on, the SLABS ECU illuminates the LED to provide a self-check, it will remain illuminated for 3 seconds or until the ignition is switched off, providing there is no fault.

The power input for the LED is supplied by the instrument pack via fuse 27. The SLABS ECU provides the earth path to illuminate the HDC fault warning lamp

The voltage on the earth path from the SLABS ECU to the instrument pack has the following functions:

- < 1.8 volts = warning lamp is switched on.
- > 7.7 volts = warning lamp is switched off.

Self Levelling Suspension (SLS) warning lamp



The SLS warning lamp within the instrument pack utilises an amber LED and a clear legend. The SLABS ECU illuminates the LED continuously if a fault within the SLS is detected, providing the driver with a visible warning.

When the ignition is switched on the SLABS ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

On vehicles equipped with coil springs the SLS warning lamp is extinguished after 850 milliseconds if the SLABS ECU configuration of the vehicle is correct.

The SLS warning lamp flashes at 2 Hz when the remote handset control is used to raise or lower the ride height.

If a new SLABS ECU is installed the SLS warning lamp will remain illuminated until the ECU has been calibrated by TestBook.

The warning lamp will illuminate continuously when battery voltage is less than 10 volts for greater than 1 second.

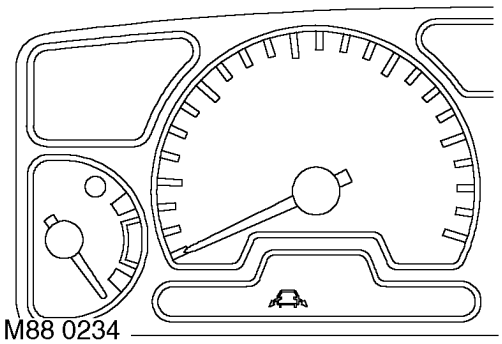
When the vehicle is in transportation mode the SLS warning lamp is illuminated continuously with ignition on, and will flash at 2 Hz frequency as the vehicle rises from bump stop level to transport level on engine start.

The power input for the LED is supplied by the instrument pack via fuse 27. The SLABS ECU provides the earth path to illuminate the warning lamp.

The voltage on the earth path from the SLABS ECU to the instrument pack has the following functions:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Active Cornering Enhancement (ACE) warning lamp



On vehicles fitted with ACE an LED within the instrument pack is used to alert the driver that the ACE ECU has detected a fault in the system, providing the driver with a visible warning. The ACE warning lamp utilises an amber LED and a clear legend.

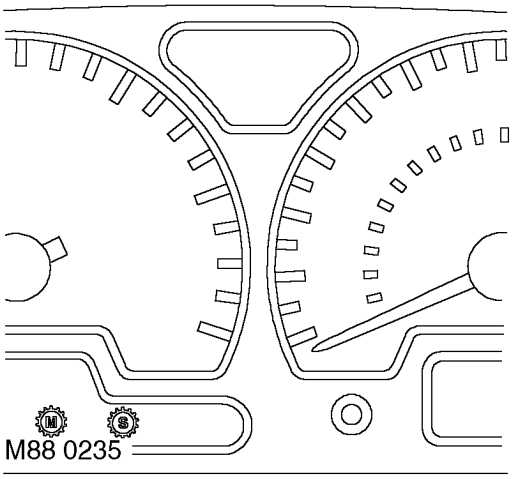
When the ignition is switched on the ACE ECU illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated for 3 seconds or until the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 13. The ACE ECU provides the earth path to illuminate the warning lamp.

The voltage on the earth path from the ACE ECU to the instrument pack has the following functions:

- < 1.8 volts = warning lamp on.
- > 7.7 volts = warning lamp off.

Gearbox manual/sport mode warning lamps



The gearbox manual/sport mode warning lamps within the instrument pack each utilise a green LED and a clear legend. On vehicles fitted with an automatic gearbox, operating the manual mode switch instructs the Electronic Automatic Transmission (EAT) ECU to illuminate the manual mode LED. Operating the sport mode switch instructs the EAT ECU to illuminate the sport mode LED.

There is no self-test performed at ignition on for this warning lamp.

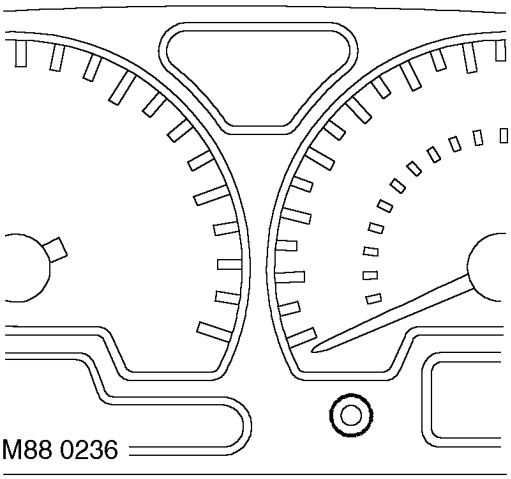
If the EAT ECU detects a fault it will cause both warning lamps to flash.

The power input for the LED's is supplied by the instrument pack. The EAT ECU applies a high or low voltage to the instrument pack microprocessor which measures the applied voltage from the ECU and illuminates the appropriate warning lamp.

The voltage on the earth paths from the EAT ECU to the instrument pack has the following functions:

Warning lamp response	Manual earth path, volts	Sport earth path, volts
No lamps	> 7.7	> 7.7
Sport warning	> 7.7	< 1.8
Manual warning	< 1.8	> 7.7
Both lamps flash	< 1.8	< 1.8

Anti-theft status warning lamp



The anti-theft status warning lamp within the instrument pack utilises a red LED and a clear legend.

The BCU illuminates the LED when the vehicle anti-theft system is active.

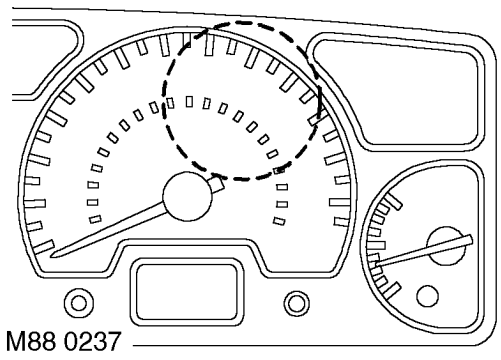
This provides a warning to potential thieves that the vehicle is protected by a security system.

When the ignition is switched on, the ECM illuminates the LED to provide a self-check, providing there is no fault it will remain illuminated until the engine is started or the ignition is switched off.

The power input for the LED is supplied by the instrument pack via fuse 13. The BCU controls the earth path to illuminate the warning lamp.

The voltage on the earth path from the BCU to the instrument pack will be less than 1 volt when the anti-theft status is enabled.

Audible warning speaker



The audible warning speaker is integral with the instrument pack and provides an audible warning to alert the driver of the following situations:

- Seat belt warning lamp.
- Key in/lights on warning.
- SLABS command received warning.
- Transfer box in neutral warning.
- Lights on warning.

It has a maximum pressure level of 87 dB at 1 metre (3.3 ft). The audible warning speaker is located on the rear of the instrument pack.

The power input for the audible warning speaker is supplied by the instrument pack via fuse 27.

The BCU provides the earth paths for the following:

- The seatbelt warning.
- Key in/lights on warning.
- Lights on warning.

The SLABS ECU provides the earth paths for the SLABS commands. The EAT ECU provides the earth path for the transfer box in neutral warning.

The BCU activates the audible warning speaker to produce audible warnings.

The audible warning speaker can operate with the ignition off.

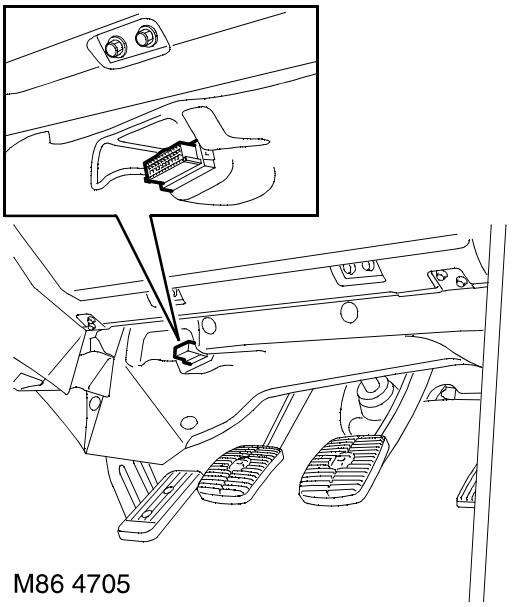
The seatbelt warning will commence at key on, and in the event of a serial link failure, will terminate after 6 seconds.

The SLABS warnings are sounded only once for each received command.

The lights on warning and transfer box in neutral are sounded continuously until a sound off command is received.

Sound request number	Sound functions	Priority (1 = lowest, 6 = highest)
0	Off	1
1	Seat belt warning	6
2	Key-in warning	3
3	SLABS/ HDC warning	4
4	Transfer box in neutral warning	5
5	Lights on warning	2

Diagnostic connector



M86 4705

RHD illustrated

The diagnostic connector allows TestBook to communicate with the vehicle electrical system.

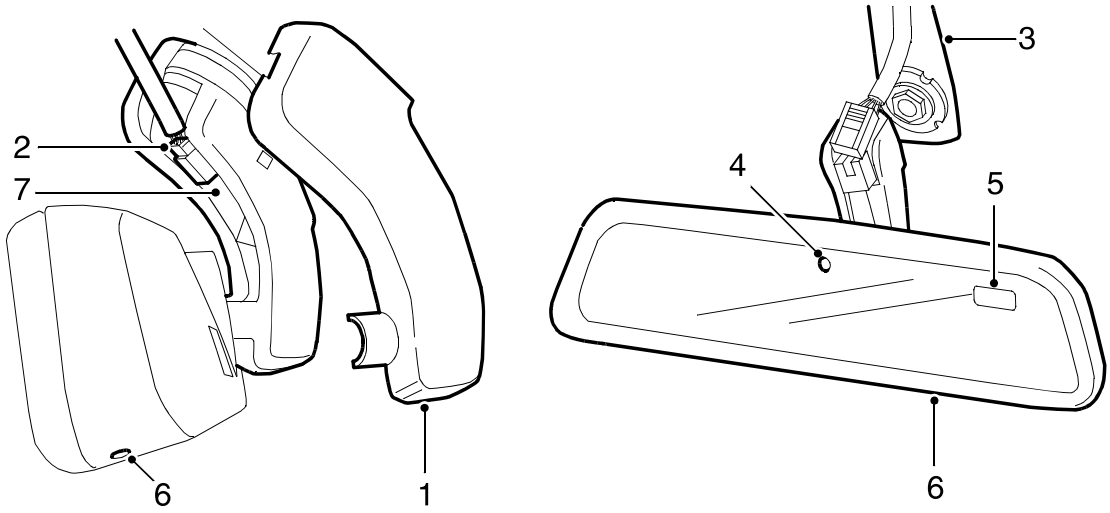
The modules that TestBook can interface with via the diagnostic connector are:
- SLABS ECU.
- BCU.
- ECM (V8 and Td5).
- IDM.
- ACE ECU.
- EAT ECU.
- SRS DCU.

TestBook communicates with the ECM, ECU's and the instrument pack for diagnostic purposes and for configuration for a specific options or market. If communications on the diagnostic connector fail for greater than three seconds after the ignition is in position II the gear selected display in the LCD flashes. This applies to both manual and automatic vehicles in all markets.

The instrument pack options configured by TestBook are:
- Automatic or manual gearbox fitted.
- Diesel or V8 engine fitted.
- ACE fitted.
- SLS fitted.
- Gulf, Japan or ROW markets.
- Service engine reset.
- Odometer reset.
- HDC fitted.
- Traction control fitted.

The serial communications link is a bi-directional communications network providing both input and output on the same pin.

Interior rear view mirror with compass (where fitted)



M88 0297

1 Cover
2 Electrical connector
3 Mounting bracket
4 Light sensor
5 Compass LED display
6 Compass calibration switch
7 Compass printed circuit board

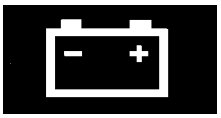
Certain vehicles have an interior rear view mirror that features an automatic photochromatic dimming function and an electronic compass with LED display.

The compass mirror is a self-contained unit and does not interface with any other vehicle system or electronic control unit. The mirror is fixed to a metal bracket attached to the windscreen.

A three pin connector provides the electrical connection to the mirror's internal circuit board. Pin-1 of the connector provides the 12V power supply to the board via the auxiliary relay located in the engine compartment fusebox. When the ignition switch is turned to the 'II' position, a 12V supply is provided to energise the coil of the auxiliary relay via fuse 26 in the passenger compartment fusebox. The auxiliary relay's contact supply voltage is provided from the vehicle battery through fusible links 1 & 7. When the relay's contacts close, a 12V supply is fed to the compass mirror circuit board via fuse 15 in the passenger compartment fusebox. This is the supply voltage feed for the mirror's internal compass.

Pin-2 of the electrical connector provides the path to earth.

Pin-3 of the electrical connector is a 12V ignition switched supply voltage (position 'II' of the ignition switch). The supply voltage is provided to the mirror's circuit board via fuse 25 in the passenger compartment fusebox, and the reverse lamp switch (normally closed) for vehicles with manual transmission or the starter inhibitor / reverse light switch (normally closed) for vehicles with automatic transmission. This is the supply voltage feed for the mirror's photochromatic dimming function.



Compass

The mirror's compass display is activated when the ignition switch is turned to position 'II'. If the compass has been previously calibrated, the current direction of the vehicle will be shown in the LED display at the upper RH side of the mirror's reflective surface. The display is able to indicate one of eight compass points (i.e. N, NE, E, SE, S, SW, W or NW).

The compass mirror circuit board contains a microchip which is able to determine changes in vehicle direction due to the changes in the earth's magnetic field. The circuit board is located in the stem of the mirror so that it follows the changes in the vehicles direction and is not affected by adjustment of the mirror itself.

Because of changes in the lines of magnetic influence, the compass is set for operation in one of fifteen different zones depending on the current location of the vehicle. If the vehicle is to be driven in a different zone, the compass will have to be reset for operation in that zone. **To determine the correct zone for a particular location on the planet, refer to the maps provided in the Owner's Handbook.** The mirror's default setting is zone 8 which is suitable for central European countries (Germany, Austria, Italy etc.).

The compass should be set to the correct zone using the following procedure:

1. Switch the ignition to position 'II'.
   - **a** If the compass displays one of the eight compass point directions, proceed to step '3'.
   - **b** If the compass displays 'C' then proceed to step '2'.
   - **c** If the display does not show either of the above, then the calibration button on the underside of the mirror should be pressed and held for approximately 6 seconds, using a small probe (e.g. paper clip or ballpoint pen). The compass should now enter the set mode and 'C' should be shown in the display.
2. To calibrate the compass, the vehicle must be driven slowly (5 mph (8 km/h) or less) in a circle until the display shows a direction (usually 1 or 2 revolutions). The mirror can calibrate itself during normal driving, but this will take considerably longer.
3. Set the compass to the relevant zone of magnetic influence by pressing the calibration button on the underside of the mirror for approximately 3 seconds, using a small probe, until a number is shown in the display. If the zone is being entered for the first time, the default zone setting '8' should be displayed. If the zone is being reset from a previous entry, the previous zone setting number will be displayed.

   The calibration button should now be pressed and released with single presses, using a small probe, until the desired zone number appears in the display.

   After approximately 10 seconds, the compass display should return correctly set to the required zone.

Note the degree of magnetic variation from one zone to another is only very slight. Recalibration of the compass is not normally necessary unless several zone changes are undertaken.

Automatic dimming

The mirror's automatic dimming function operates when the ignition switch is turned to the 'II' position.

A light sensor is contained at the upper centre of the mirror which detects the intensity of light from the headlights of following vehicles in dark or low light conditions. When the light intensity is sufficiently high, the mirror automatically adjusts the brightness of the reflected light by photochromatically changing the mirror's reflective properties and so preventing glare affecting the driver.

When reverse gear is selected, the power supply for the mirror's photochromatic function is opened so that the mirror defaults to its normal reflective properties while the reversing operation is in progress.

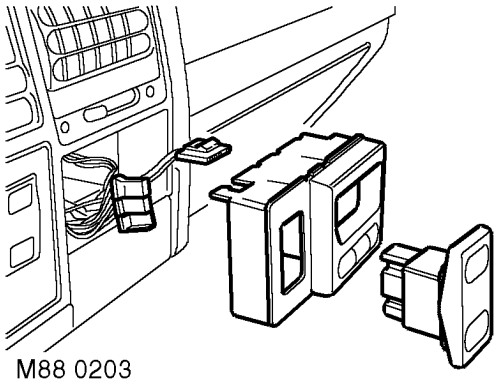
Another light sensor is located on the rear of the mirror so that the unit can detect the difference between strong ambient light and that attributable to following vehicle headlights. To check operation of the light dimming function of the mirror, use the following procedure:

1. Turn ignition switch to position 'II', and ensure reverse gear is not selected.
2. Cover the sensor on the back of the mirror.
3. Shine a bright light on the front (reflective side) of the mirror; the mirror should darken.

Clock

88.15.07

Remove


M88 0203

1. Carefully remove clock assembly from fascia.
2. Disconnect multiplugs from clock and door locking switches.
3. Remove door locking switch from clock assembly and remove clock assembly.

Refit

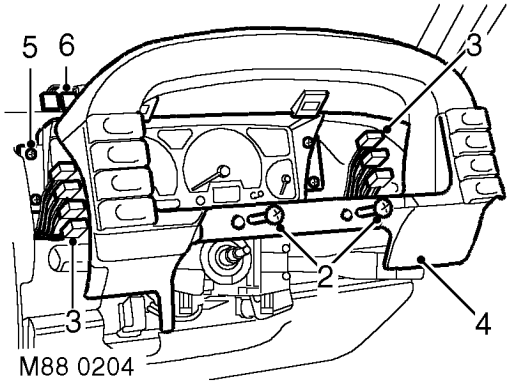
1. Fit door lock switch to clock assembly and connect multiplugs.
2. Position and push to secure clock assembly to fascia.

Instrument pack

88.30.38

Remove

1. Remove steering column nacelle.
   STEERING, REPAIRS, Nacelle - steering column.



M88 0204

2. Remove 2 screws and release instrument cowl from 2 clips on fascia.
3. Disconnect 7 multiplugs from switches.
4. Remove instrument cowl.
5. Remove 4 screws securing instrument pack to fascia.
6. Disconnect 2 multiplugs from instrument pack.
7. Remove instrument pack.

Refit

1. Position new instrument pack and connect multiplugs.
2. Align instrument pack to fascia and secure with screws.
3. Position instrument cowl and connect multiplugs to switches.
4. Fit instrument cowl to clips and secure cowl with screws.
5. Fit steering column nacelle.
   STEERING, REPAIRS, Nacelle - steering column.