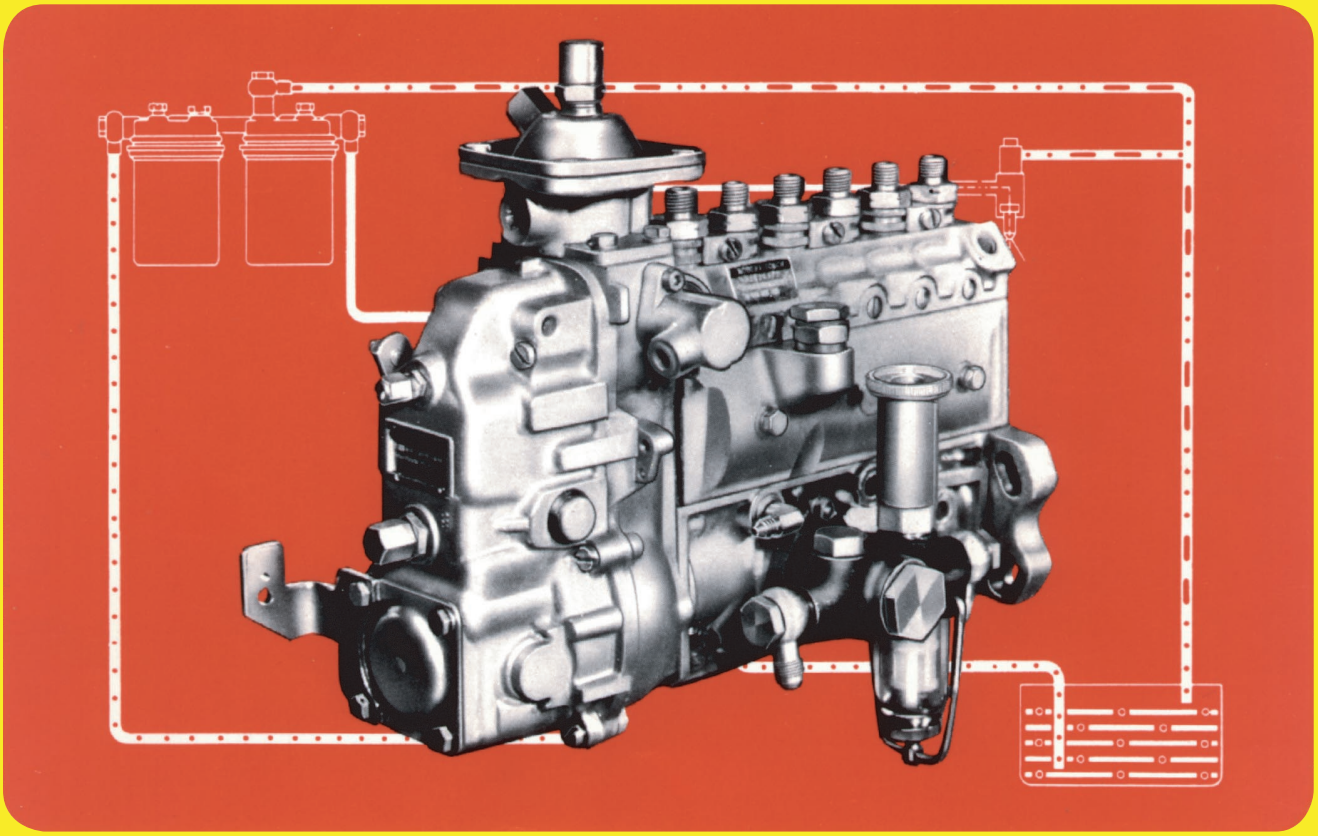
BOSCH

Module 6
Injector Operation, Service and Testing



Pre-Tech Service Training

MODULE 6

INJECTOR OPERATION, SERVICE, AND TESTING

STPR IN
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INJECTOR OPERATION

INTRODUCTION

This is Module 6 of PRE-TECH, **Injector Operation, Service, and Testing.** You should have completed Modules 1 through 5 before beginning to study this module.

This module consists of four audio-visual programs: **Injector Operation; Injector Servicing; Injector Reconditioning;** and **Injector Testing.** This review guide contains a review exercise for each program. The audio-visual programs explain what injectors do and how they operate and, describe the different types of nozzles and nozzle holders. In addition, you will be shown how to service and troubleshoot injectors on the engine; how to disassemble, clean, inspect, and reassemble injectors; and you will be shown how to use the diesel nozzle tester.

PROGRAM OBJECTIVES: INJECTOR OPERATION

When you have finished the audio-visual program, Injector Operation, you will be able to:

1. Describe injectors and injector operation.
2. List the jobs injectors perform.
3. Identify injector applications.
4. Describe how nozzles operate.
5. Identify the purposes of the nozzle holder.
6. Describe how injectors are fitted into a cylinder head.
7. Describe precision delivery and the importance of cleanliness.

NOTE: The Bosch Microfiche referenced in this Module is not included on this CD-ROM. Please contact your supervisor or instructor.

SPECIAL EQUIPMENT

To complete this module you will need the four audio-visual programs identified in the INTRODUCTION, the appropriate play-back equipment, and this review guide. In addition, you will need the following tools and equipment to complete the final review exercise.

KCA Nozzle Holder Assembly	NOT a GM application
Equipment List Microfiche	From Module 2
Common Metric Hand Tools	To disassemble and assemble nozzle holder assembly
Metric Micrometer	To measure shim thickness
Bench Vice	To hold nozzle holder assembly
Torque Wrench (To 80 Nm)	To assemble nozzle holder assembly
Nozzle Tester EFEP60H (or equivalent)	PN 0 681 200 502
Test Line EF8040/24 (or equivalent)	PN 1 680 750 000
Nozzle Cleaning Kit	KDEP 2900 (or equivalent)
Special Cleaning Needle (as required)	
0.13 mm diameter	KDEP 2900/3 (or equivalent)
0.15 mm diameter	KDEP 2900/4 (or equivalent)
0.18 mm diameter	KDEP 2900/5 (or equivalent)
Commercial Parts Cleaning Solvent and facilities	For cleaning nozzle holder parts
Test Oil	For cleaned nozzle parts and nozzle tester

The different types of audio-visual presentations (formats) and the types of required equipment to view each format are listed below. Read the operating instructions for the equipment you will be using before attempting to view the programs.

Slide/Tape Format

You will need either an automatic slide/tape player or a manual slide projector and separate tape player. Side A of the cassette tape has inaudible pulses which trigger the advance mechanism of automatic slide/tape players. Side B of the tape has tone pulses which you can hear to indicate when you should advance to the next slide. Before you begin, be sure that you are using the correct side of the cassette tape for the equipment you are using and rewind the tape completely to be sure you are at the start of the program.

Filmstrip/Cassette Tape Format

You will need either an automatic filmstrip/tape player or a manual filmstrip projector and separate tape player. Side A of the cassette tape has inaudible pulses which trigger the advance mechanism of automatic filmstrip projectors. Side B of the tape has tone pulses which you can hear to indicate when you should advance the filmstrip to the next scene. Before you begin, be sure that you are using the correct side of the cassette tape for the equipment you are using and rewind the tape completely to be sure you are at the start of the program.

Film/Tape Cartridge Format

Because of the variety of film/tape cartridge players available, we have not included instructions for this equipment. Be sure to read the operating instructions that come with the equipment you are using before viewing the audio-visual program.

If you have any questions about how to use the audio-visual equipment, see your supervisor or instructor.

SPECIAL INSTRUCTIONS

DO NOT use or refer to the review guide until you have finished viewing the audio-visual program or you are instructed to do so. The visuals in the program are produced in colors which present important information. The black and white reproductions of these visuals used in the review guide may not show the discrimination between these colors and, therefore, may not completely present the information from the color visual. In addition, the audio-visual program may have been revised with updated visuals which may not be reflected in the review guide. These changes in visuals will not alter the meaning or content of the information contained in the review guide.

Start the audio-visual program, **Injector Operation**, at this time. Sit back and let the colors, motion, and sound help you learn. When the program ends, turn to page 4 and continue as instructed.

NOTE

The audio-visual program will STOP from time to time when viewed using automatic playback equipment. These stops are included to provide an opportunity to review the information that has been presented to that point. When you are ready to continue, press the START button on the playback equipment.

REVIEW EXERCISE: INJECTOR OPERATION

Now that you have finished viewing the audio-visual program, complete this review exercise. If you have a problem answering any of the questions, use the review guide, pages 7 through 26 to locate the correct answer. The numbers following each question indicate the range of scenes where the correct answer can be found.

Select the most correct answer to complete these statements.

1. The injector sprays _____ into the combustion chamber. (8-10)

___ a. air and fuel

___ b. low pressure fuel

___ c. high pressure fuel

2. The injector is also called a _____. (10-12)

___ a. nozzle

___ b. nozzle holder

___ c. nozzle holder assembly

3. A nozzle holder assembly is composed of a/an _____. (10-12)

___ a. injector and nozzle

___ b. nozzle and nozzle holder

___ c. injector and nozzle holder

4. To atomize the fuel means to _____. (15-17)

___ a. break up the fuel into very fine particles

___ b. break up the fuel into a continuous stream

___ c. break up the fuel into very coarse particles

5. A pintle nozzle delivers a _____ spray pattern. (18-20)

___ a. narrow

___ b. star shape

___ c. constantly changing

6. Indirect injection means to inject the fuel into a/an _____. (20-22)

___ a. intake manifold

___ b. combustion chamber

___ c. precombustion chamber

7. _____ type nozzles, producing wide spray angles, are used in direct injected engines. (20-22)

___ a. Hole

___ b. Pintle

___ c. Throttling

8. When high pressure fuel from the pump lifts the spring loaded needle in the nozzle, the nozzle_____ fuel. (29-31)

___ a. delivers

___ b. shuts off

___ c. fills with

9. When pressure_____ at the injector, the needle snaps shut. (31-33)

___ a. rises

___ b. drops

___ c. remains constant

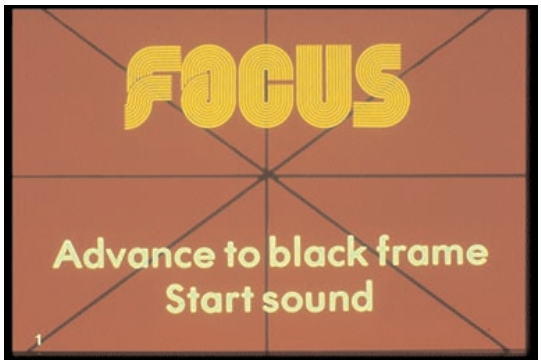
10. Nozzle opening pressure is determined by _____. (43-45)

___ a. fuel density

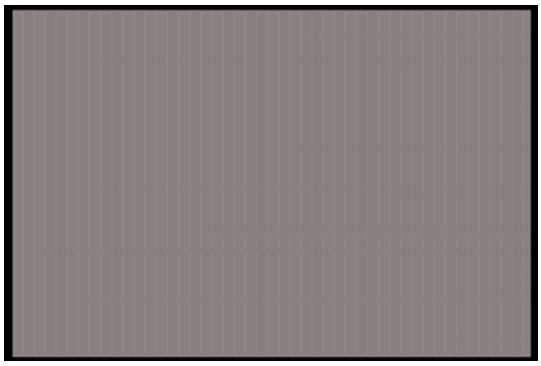
___ b. spring force

___ c. fuel pressure

When you have finished this exercise and reviewed your answers, show the completed exercise to your instructor or supervisor. Have your instructor or supervisor record your progress on your Student Progress Sheet. Then turn to page 29 of this review guide and begin Program 2, **Injector Servicing.**



1. FOCUS

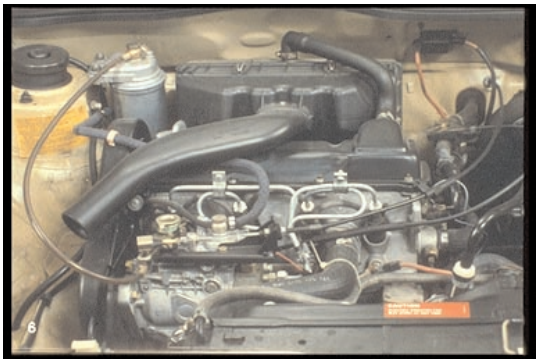


2. BLANK

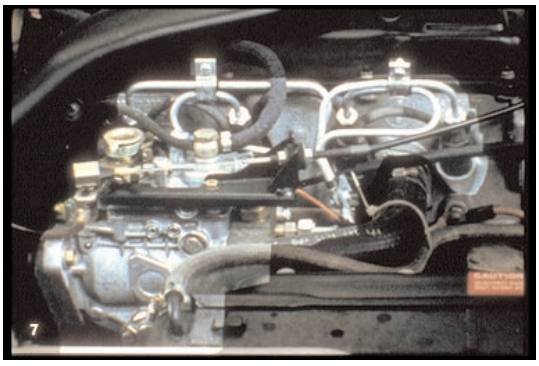
3. Whether you call them "injectors," or "nozzles" or "tips," when you finish this program, you'll know how they operate, these precision parts,

4. . . . brought to you by Robert Bosch. In the life of the unit, injectors operate millions of times with little attention.

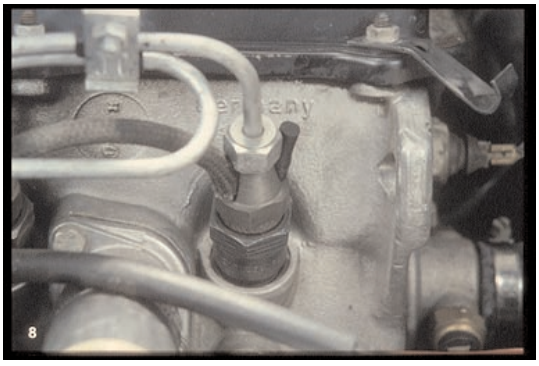
5. Each time they operate -- from start to finish of delivery -- injection duration can be as little as one-thousandth of a second, one millisecond!



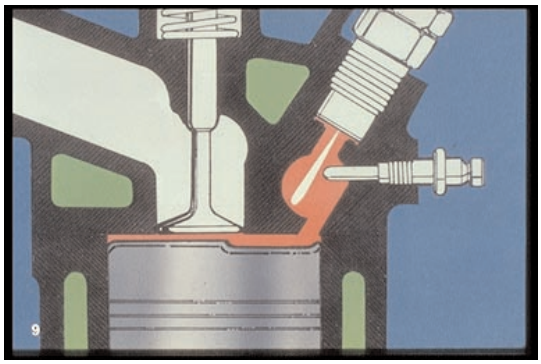
6. Precision operation will maintain the famous fuel efficiency of diesel engines, and help control emissions and smoke.



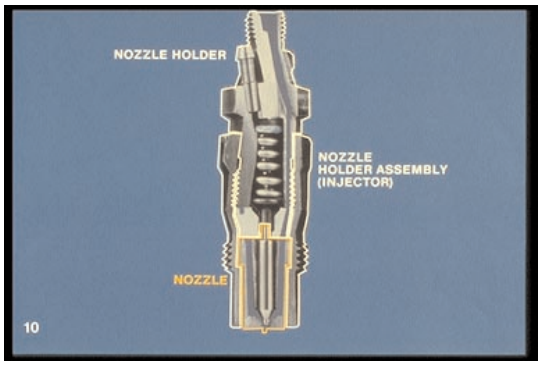
7. That means precision operation of the entire diesel injection system, but most particularly, the injectors.



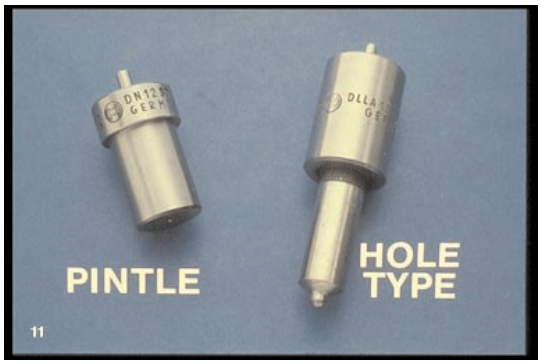
8. Each line leads from the pump to an injector mounted in the cylinder head.



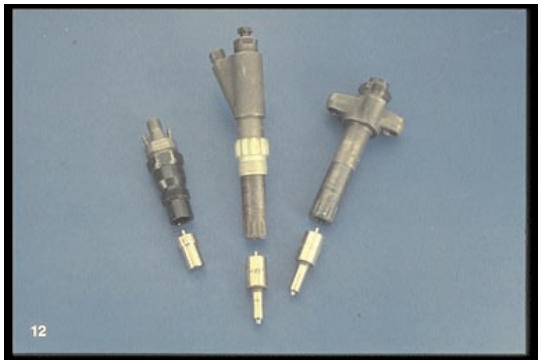
9. The injector sprays high-pressure fuel into the combustion chamber; it must provide accurate delivery, and good atomization.



10. Each injector is made up of a nozzle holder and a nozzle; the whole thing is sometimes called a nozzle-holder assembly.



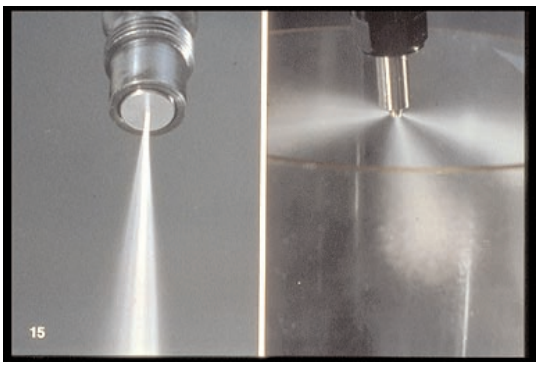
11. In this program, you'll learn about two popular types of inward opening nozzles -- the pintle type and the hole type. Different nozzles are used depending on the engine-combustion-chamber -- different nozzles require different nozzle-holders.



12. Whatever the type nozzle, whatever the type of nozzle-holder, every injector must operate reliably and with great accuracy within the heat and combustion gases of the engine.

13. First, take a look at what nozzles do.

14. Nozzles atomize the fuel into the combustion chamber against high compression pressures.

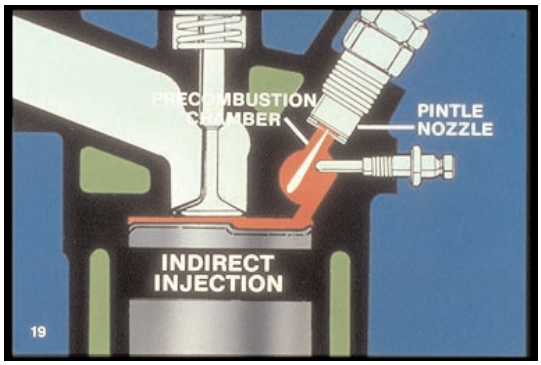


15. Whether pintle or hole type, to atomize means to begin delivery only after the pressure is high enough; (PAUSE) it means to break up the liquid into tiny particles so fine that all the fuel can mix with hot air for compression-ignition. Without good atomization,

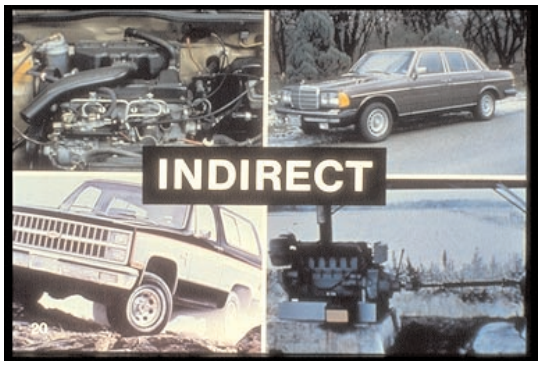
16. . . . you'll see engine smoking from dribble at the tip, and the injector spray will worsen from coking -- from carbon build-up at the tip.

17. Good atomizing can depend on the rate of injection. As the throttling pintle is lifted from closed, the pintle shapes the initial spray for easy injection. Further lift delivers the main-spray -- wider, more finely atomized for complete burning. Good atomizing means a smoother-running engine with reduced emissions and smoke.

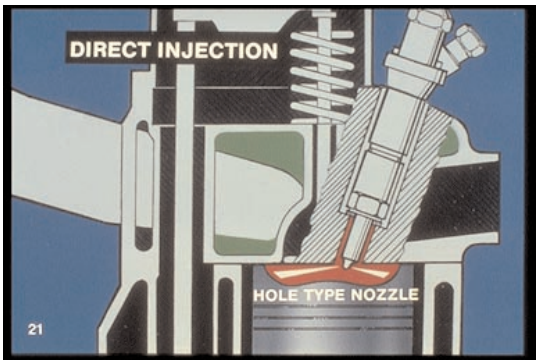
18. The second job of the injector is to distribute the fuel -- in the right place -- at the right instant.



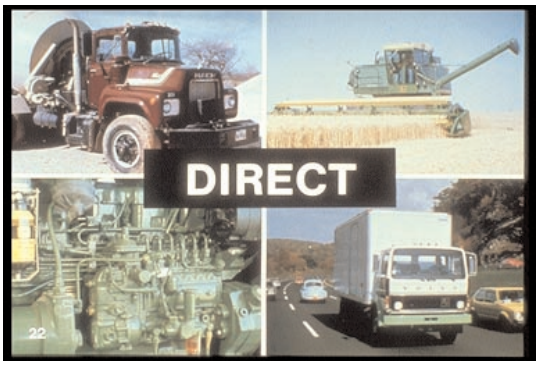
19. To distribute fuel into the precombustion chamber of this indirect-injection automobile engine, the pintle nozzle delivers a narrow spray-pattern; injected fuel ignites in the prechamber; the burning air-fuel mixture spreads to the main chamber above the piston. Stop now for review of what nozzles do.



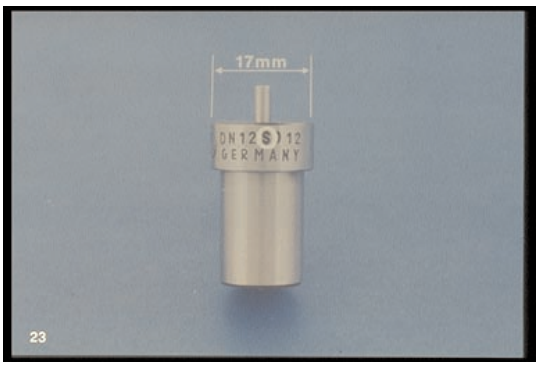
20. You'll find pintle-type nozzles and indirect injection in most passenger car engines, as well as some light truck, industrial, and small marine engines. Indirect injection is usually smoother and quieter than direct injection.



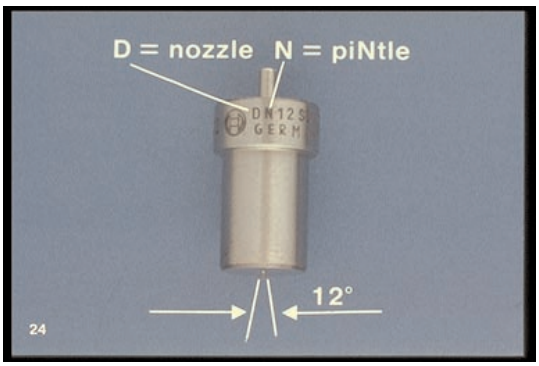
21. In this direct-injected engine, notice the wide spray-angle patterns of the hole-type nozzle required to distribute fuel directly into the cylidner.



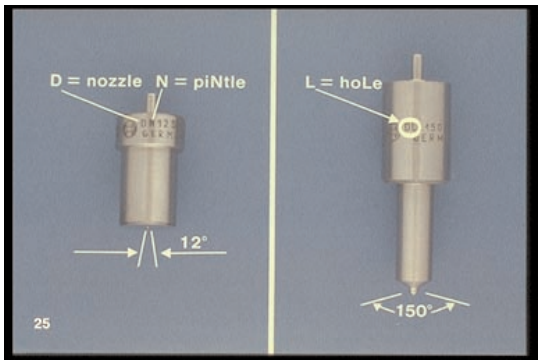
22. You'll find direct injection and hole-type nozzles in truck, agricultural, and industrial applications -- all requiring higher injection pressures and different spray patterns. When you service and test nozzles, you'll need to be able to tell them apart.



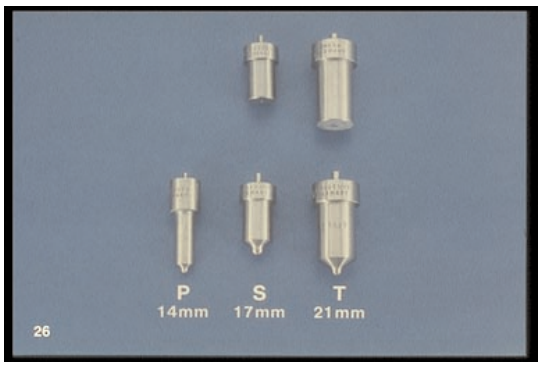
23. You can tell the size by this code letter. For example, a 17 millimeter nozzle -- the most common size -- is indicated by this letter, S.



24. The other codes are valuable also: D for nozzle valve, N tells you this is a pintle type; and 12 indicates the spray angle. Other letters and numbers define applications or variations of design.

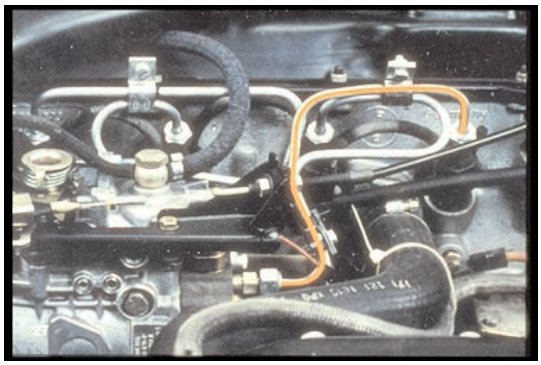


25. Compare the pintle-type to the hole-type. On a hole-type nozzle, you'll see D for nozzle, and L for hole. The 1-50 indicates the spray angle; notice it's much wider for direct injection.

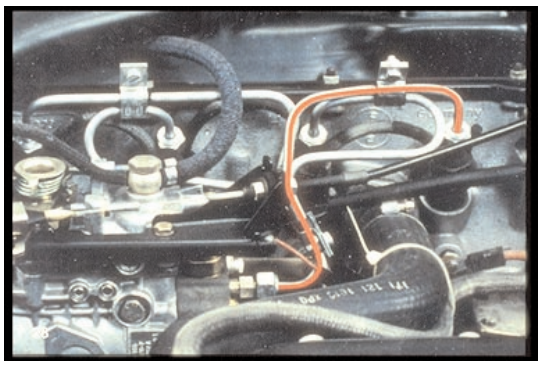


26. In pintle types and in hole types, you'll find nozzle sizes to match different fuel delivery requirements. As you have seen, different letters indicate the size of the nozzle, generally bigger nozzles for bigger engines.

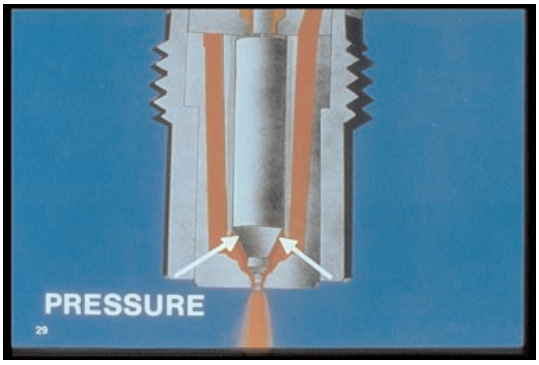
    Stop now for review of applications and sizes of pintle-type and hole-type nozzles.



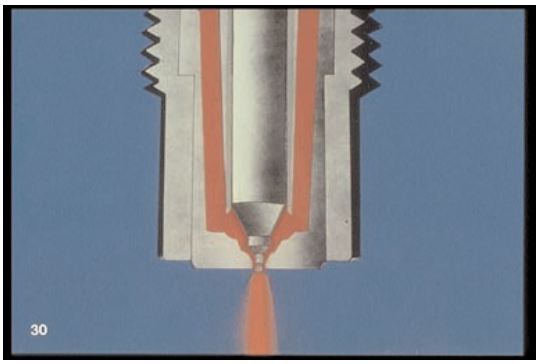
27. Now, take a look at how nozzles operate. Start with fuel at less than injection pressure. We've shown that in orange in one line, from pump to injector. When the pump plunger strokes,



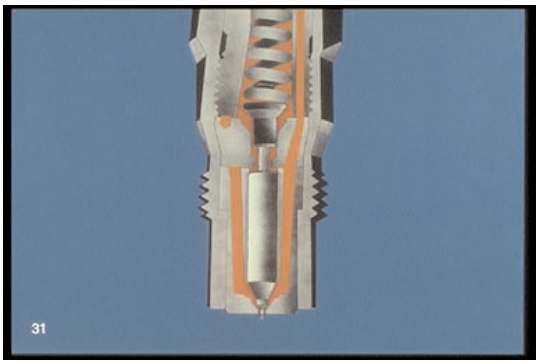
28. . . . high pressure fuel, shown in red, is delivered to the injector in a fraction of a millisecond.



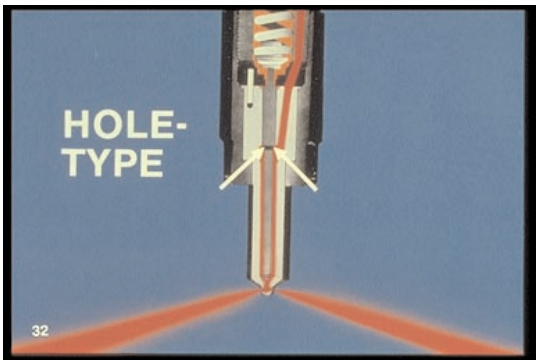
29. In this pintle nozzle, high-pressure fuel applies lifting pressure here against the spring-loaded needle. When fuel pressure is greater than downward pressure, it lifts the needle . . .



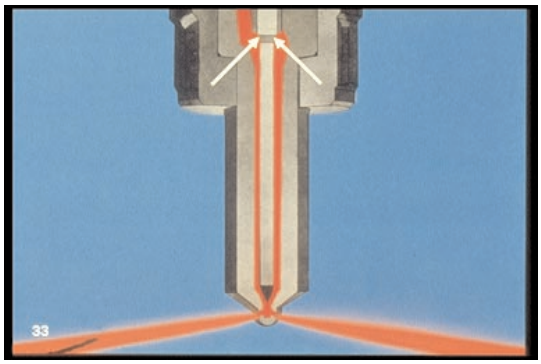
30. . . . and delivers fuel. When pressure at the pump is relieved by port-opening,



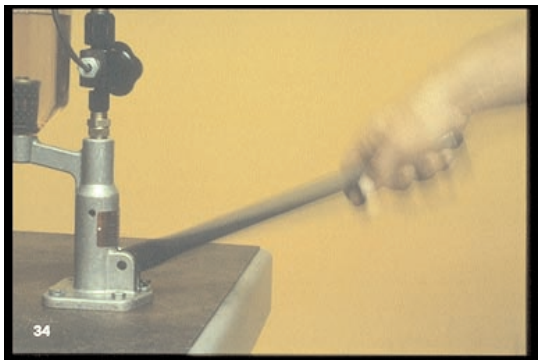
31. . . . pressure drops at the injector so the needle can snap shut, seating the valve with a sharp cut-off -- no drip, no dribble. That's how a pintle nozzle operates. Compare that,



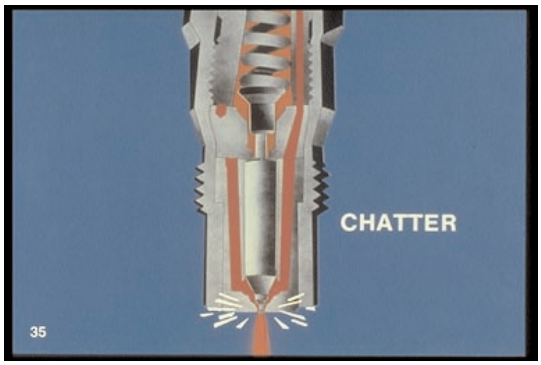
32. . . . to the operation of the hole-type nozzle. High-pressure applies lifting force here -- on this part of the valve.



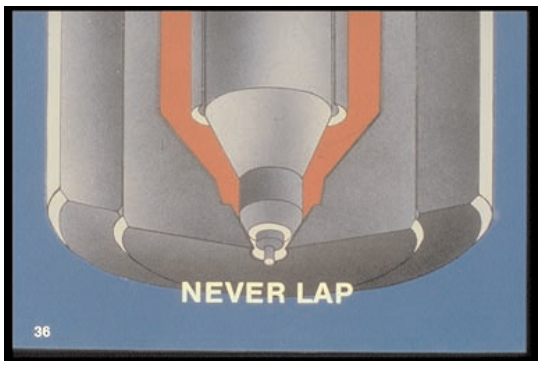
33. When high-pressure from the pump is applied here, the needle-valve lifts to deliver fuel in the broad angle of hole-type nozzles.



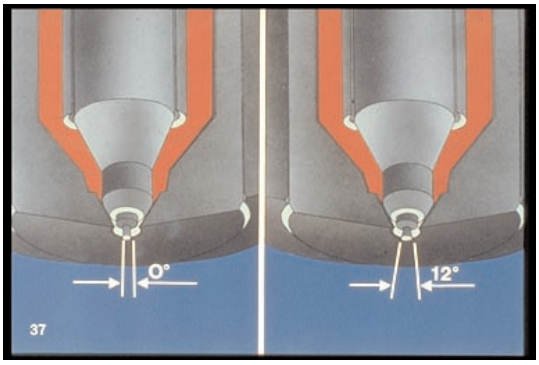
34. When you pressure-test a nozzle on the nozzle-tester, you should hear a chatter sound, depending on how fast you're stroking the tester handle.



35. Chatter is the sound of the needle, tapping rapidly.

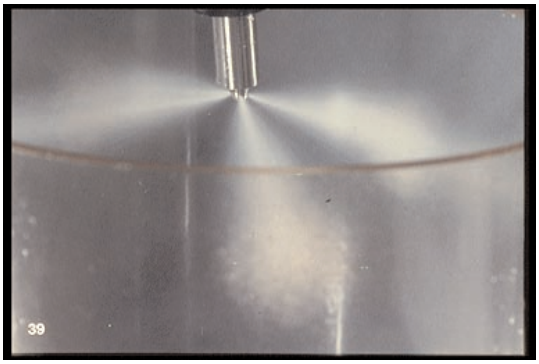


36. You can see that the needle seats precisely in the nozzle body. Never lap a nozzle needle or seat; you could change an OK nozzle into a drip!

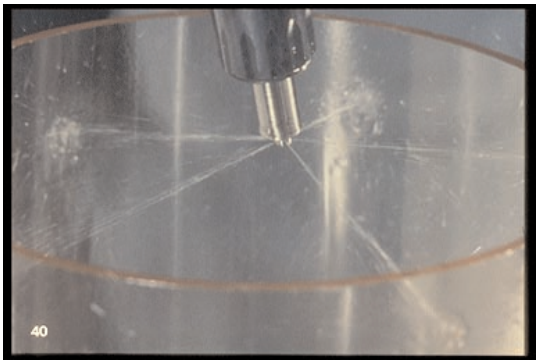


37. The angle of the pintle determines the spray angle. Zero degree means straight, almost no spray angle, in contrast to a typical 12 degree angle.

38. An off-center spray pattern is the result of a bent pintle, probably mishandled; fuel may not burn well. Or the spray pattern may be ruined from contamination of a pintle; the nozzle should be cleaned or replaced.



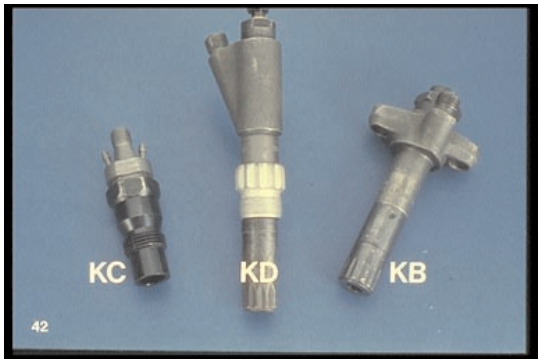
39. In a hole-type nozzle, a good spray pattern like this is determined by the holes. When you clean the holes, you must never change the size or the angle; you must never round the edges of the holes. Compare the fine atomization and distribution from nozzles properly handled,



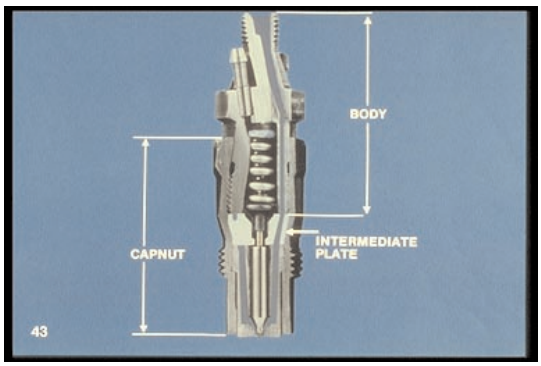
40. . . . with this poor spray performance. What began as a good nozzle has been damaged by improper handling, perhaps by being lapped, or contaminated -- perhaps by improper cleaning of the needle seat and spray holes. Result -- poor engine performance: smoke, loss of power, poor economy.

Stop now for review of nozzle operation.

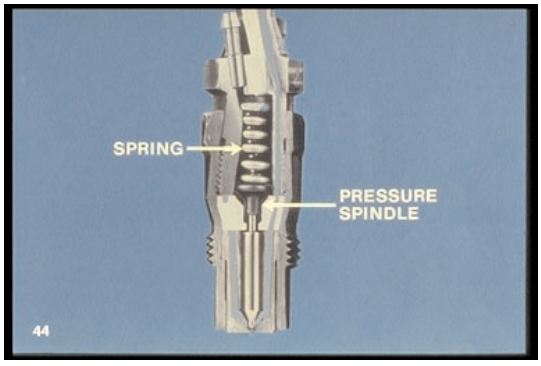
41. Nozzle holders are an important part of injectors. They can vary in size and shape according to application.



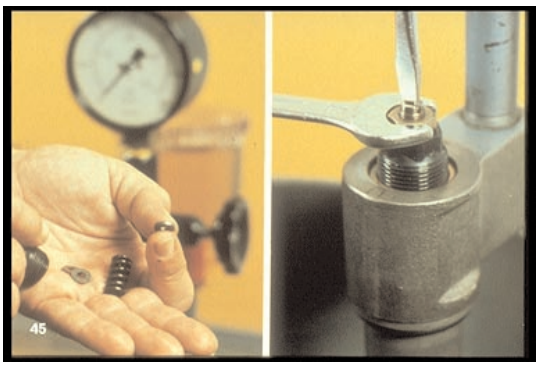
42. Among the most important are the KC holder for pintle-type nozzles; the KD with nut, and the KB with hold-down flanges. The KD and KB are used mostly for hole-type nozzles.



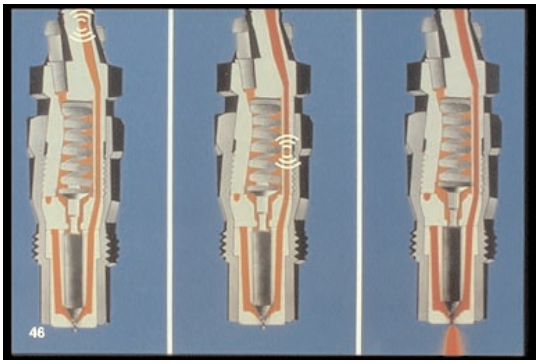
43. Here's how the KC holder holds the DN pintle nozzle. The capnut secures the nozzle against the intermediate plate and the nozzle-holder body.



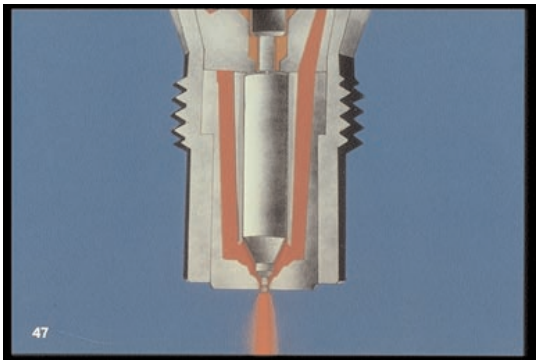
44. Inside this KC holder the spring applies force thru the pressure-spindle, tending to close the needle-valve. Spring force determines nozzle opening pressure. How do you change opening preload-pressure?



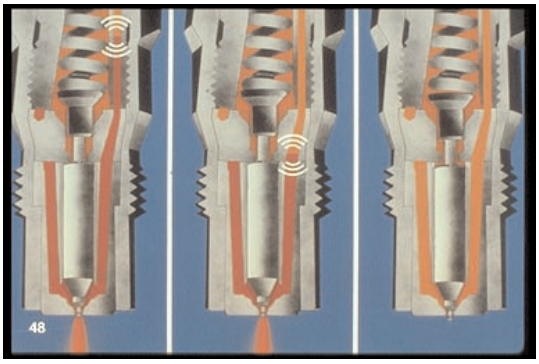
45. With shims, in some injectors. The thicker the shim, the greater the spring pressure. In other injectors, spring pressure is adjusted with a screw. So one job of the nozzle-holder is to apply adjustable spring pressure on the nozzle-needle.



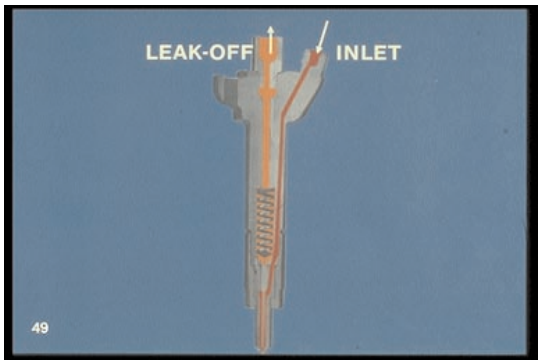
46. Another job is to deliver the fuel. In a fraction of a millisecond, high-pressure from the pump reaches the tip and overcomes the spring-force to lift the needle.



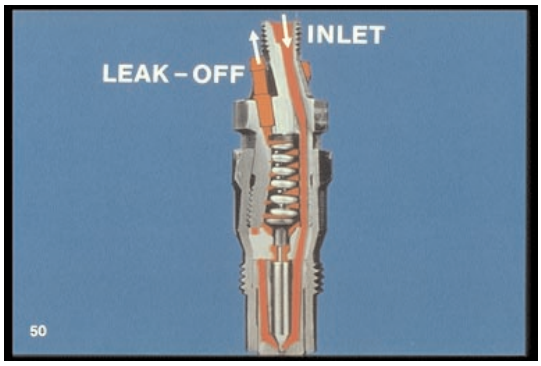
47. When pressurized fuel lifts the needle, fuel is delivered. Delivery continues until pressure drops.



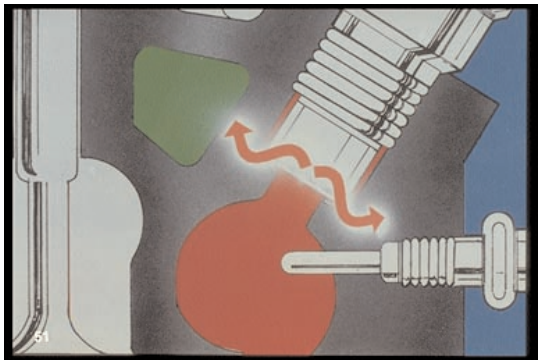
48. At port-opening in the pump, in a fraction of a millisecond, pressure drops at the tip. The spring snaps the needle shut. The valve seats with a sharp cut-off -- no drip, no dribble.



49. Still another job of the holders is to provide fuel connections for inlet, or high-pressure fuel -- and leak-off, or return-fuel. Be sure you know which is which -- sometimes, as in this KB holder, the high-pressure inlet is on the side,

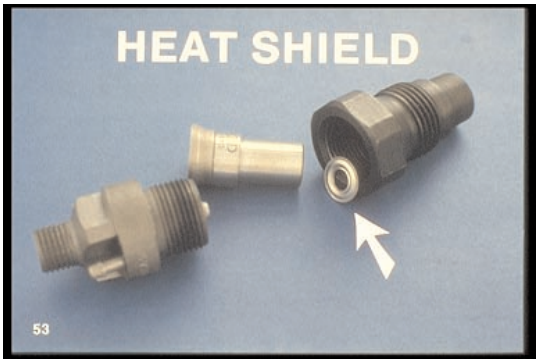


50. . . . and sometimes, as in this KC holder, the high-pressure inlet is in the center. Leak-off fittings connect the injectors in series to each other and return fuel to the tank.

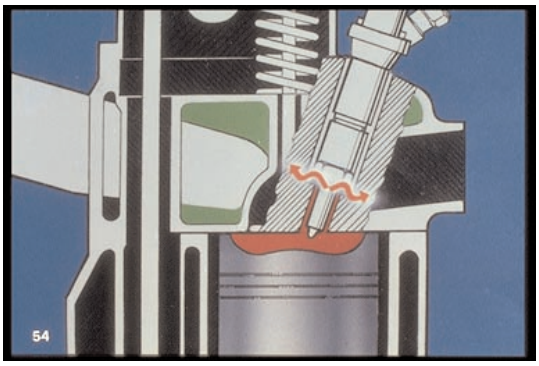


51. Cooling the nozzle is an important job of the holder. Nozzle-tips are exposed to the heat and pressure of combustion -- heat which is carried away to the cooling system by the holder.

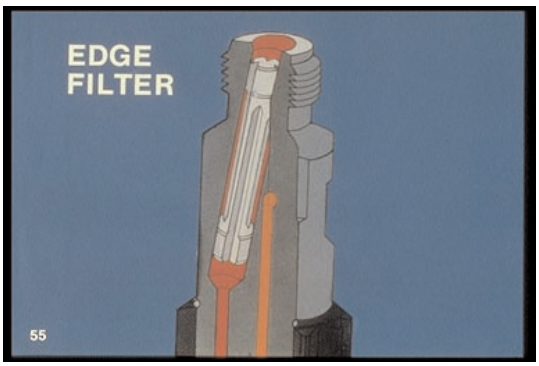
52. In this KC-type nozzle holder, a properly-torqued heat-shield provides heat transfer from the nozzle to the cylinder head; it also applies pressure from the cylinder head to the holder instead of to the nozzle. Contrast this location of the heat shield.



53. . . . with this holder, also KC, used on Chevrolet six-point-two liter engines; the heat shield goes inside the capnut -- on the right.

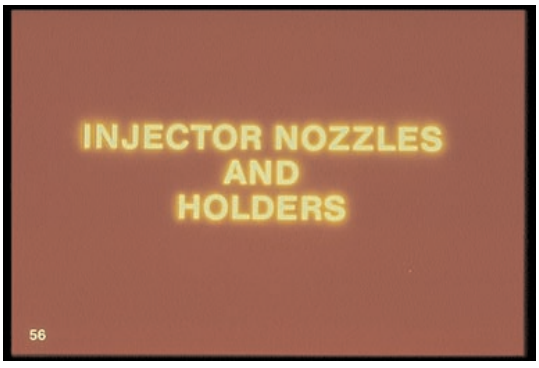


54. In other type nozzle holders, heat from combustion is carried away like this through heat shields and gaskets to the cylinder head. You can see why good contacts of gaskets, or heat shields, are important to the job of the nozzle holder -- cooling the nozzle.

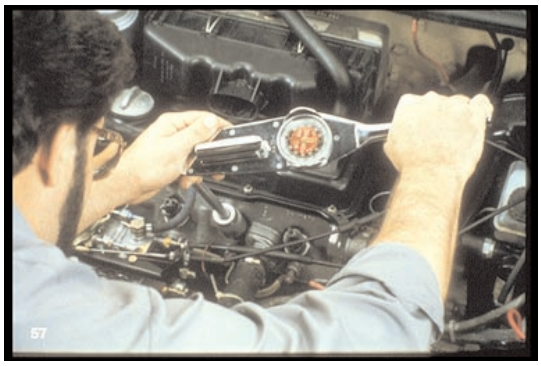


55. Some holders do another job; they contain an edge filter for incoming fuel. The filter is not removable so it must be cleaned as part of the holder.

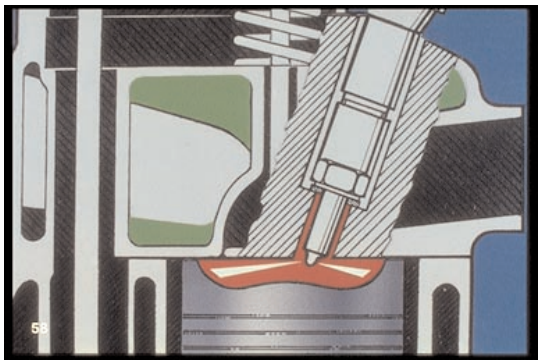
Stop now for review of nozzle holders.



56. The injector -- the injection nozzle with its holder -- is what some people call a nozzle and holder assembly. Let's see how injectors fit into the engine cylinder head.

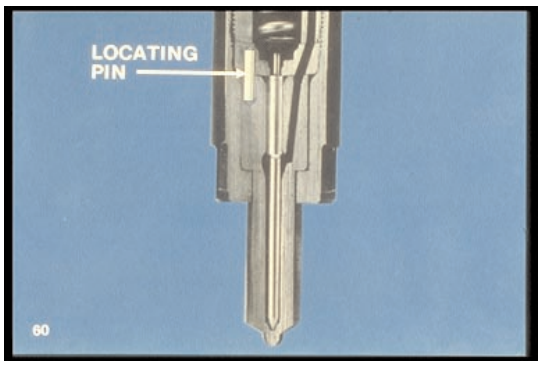


57. The KC holder, for pintle nozzles, is simply screwed into the cylinder head. Provided it's properly torqued, it will spray in the right direction. The direction of the spray is straight in line with the nozzle axis.

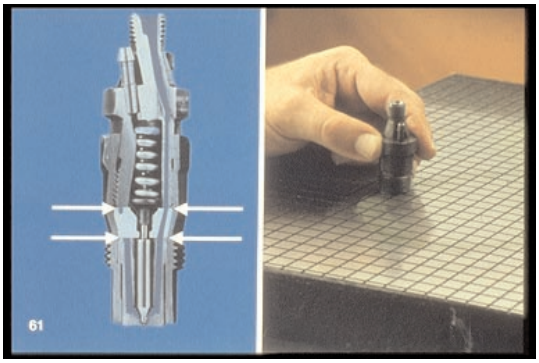


58. In contrast, with direct injection, the KB and KD holders are usually positioned at an angle to the combustion chamber and the piston. If the nozzle is not vertical, the spray holes must be angled to match the piston crown.

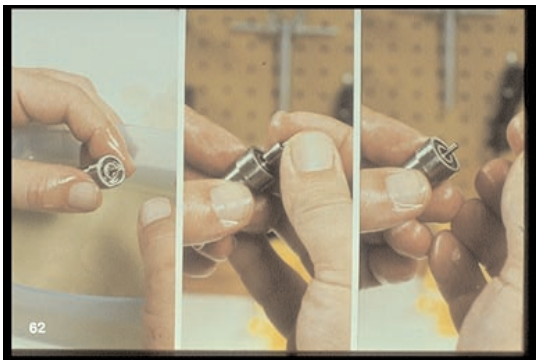
59. The nozzle-holder is positioned in the head by the mounting flanges. And within the holder,



60. . . . the nozzle is positioned by locating pins in the intermediate plate. When servicing injectors, you'll want to take good care of these locating pins.

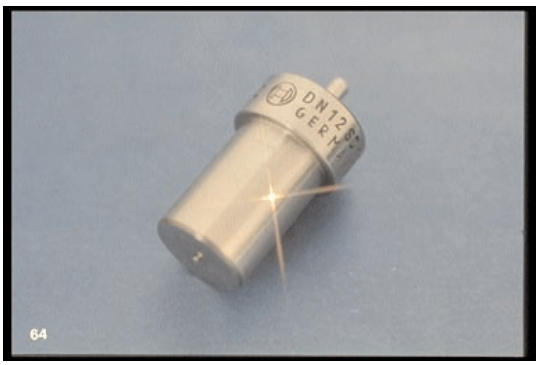


61. You'll find precision lapped surfaces between the nozzle-holder body, the intermediate plate and the nozzle. These are high pressure seal-areas, so each part should be clean an and perfectly flat.

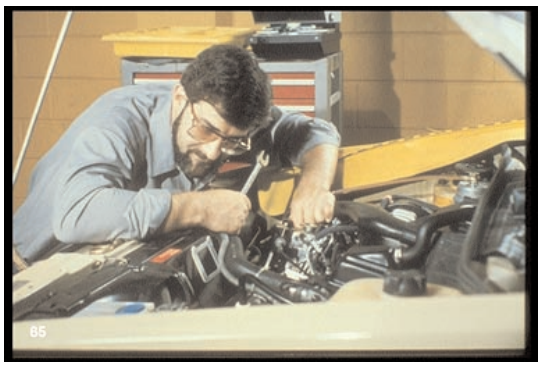


62. Precision manufacture of mated parts -- with tolerances too fine to be measured with ordinary gauges.

63. Precision delivery. In some idling engines, one stroke of an injector must deliver only one-fifth of a drop of fuel, no more, no less!



64. No wonder these gems need clean fuel, clean air, and clean service facilities. Unlike spark plugs, injectors should not be pulled just to be looked at.

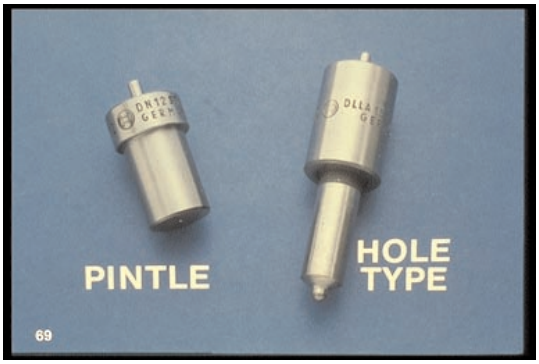


65. Don't break into the fuel system until you've done proper engine diagnosis. Be sure you have good reason to remove injectors from the engine.

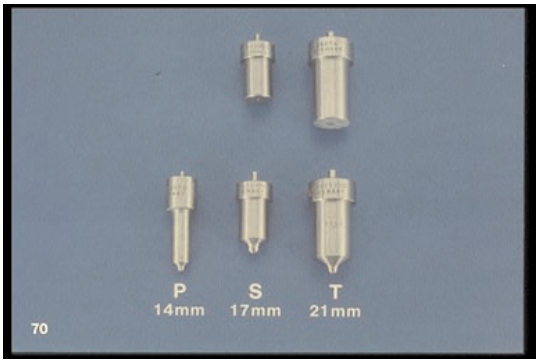
66. If you must remove an injector (to test or replace it), be sure your shop is good and clean -- on a scale of good, better, best.

67. Have a better clean shop if you must test an injector.

68. Be sure you have the best clean shop if you disassemble an injector. You really need separate "clean room" facilities before disassembly. Dirt is the enemy of injectors! Stop now for review.



69. In this program, you've seen the important nozzle types: the pintle nozzle, and the hole-type nozzle.

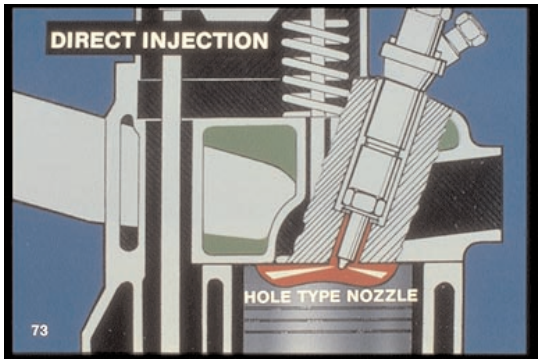


70. You know how these letters identify their sizes. You know how to use the codes to identify nozzles and their spray angles.

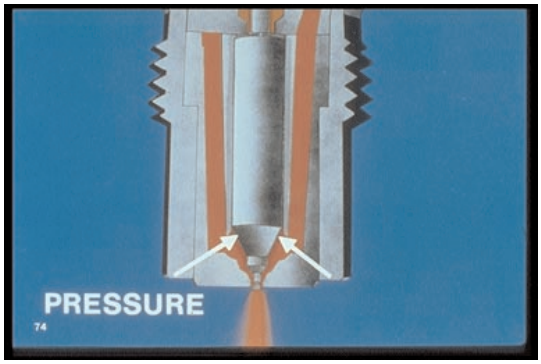
71. You've seen the jobs of the nozzle:

    Atomize the fuel into tiny particles that can ignite in compression-ignition.

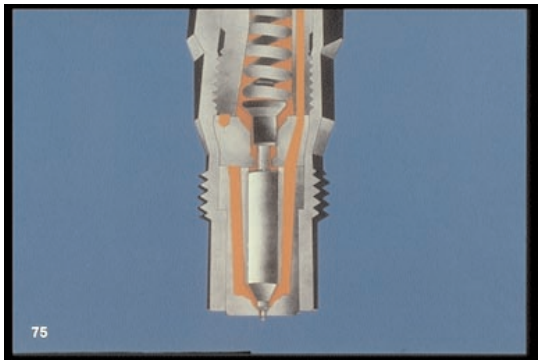
72. Distribute the fuel -- a pintle nozzle into a precombustion chamber, indirect injection --



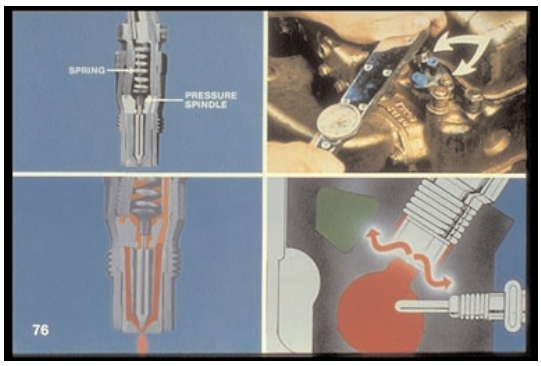
73. . . . a hole-type nozzle with its wider spray-pattern -- direct-injection into the cylinder.



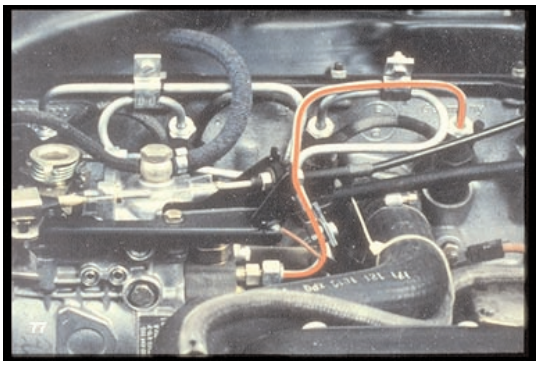
74. You've seen how high-pressure fuel lifts the needle valve so the nozzle can deliver fuel;



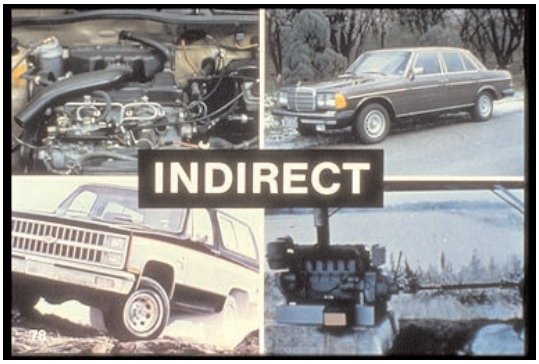
75. . . . and, on pressure drop, the spring and pressure-spindle snap the needle shut without dribble or smoke.



76. You've seen what nozzle holders do for nozzles,



77. . . . what injectors -- given the proper engine conditions and clean fuel, can do for diesel engines.



78. Injectors deliver fuel into a growing number of indirect-injected diesel engines, providing new standards of passenger car economy and clean air;

79. . . . they also deliver fuel into direct injected engines which are the standard of heavy-duty power, in either case, saving fuel and lasting longer, with fuel injection systems,

80. . . . brought to you by Robert Bosch.

SERVICING INJECTORS

INTRODUCTION

Now that you have seen what injectors do and how they operate, it's time to see how to troubleshoot injector problems and service injectors on the engine.

PROGRAM OBJECTIVES: SERVICING INJECTORS

When you have finished the audio-visual program, Servicing Injectors, you will be able to:

1. Describe troubleshooting procedures to determine if injectors are faulty.
2. List the correct procedures for removing injectors from an engine.
3. Describe how to clean assembled injectors.
4. Identify when to replace injectors.
5. List the correct procedure for installing injectors in an engine.

SPECIAL EQUIPMENT

To complete this program you need the **Injector Servicing** audio-visual program and the appropriate playback equipment (described at the beginning of this review guide) and this review guide.

SPECIAL INSTRUCTIONS

DO NOT use or refer to the review guide until you have finished viewing the audio-visual program or you are instructed to do so. The visuals in the program are produced in colors which present important information. The black and white reproductions of these visuals used in the review guide may not show the discrimination between these colors and, therefore, may not completely present the information from the color visual. In addition, the audio-visual program may have been revised with updated visuals which may not be reflected in the review guide. These changes in visuals will not alter the meaning or content of the information contained in the review guide.

Start the audio-visual program, **Injector Servicing**, at this time. Sit back and let the colors, motion, and sound help you learn. When the program ends, turn to page 30 and continue as instructed.

NOTE

The audio-visual program will STOP from time to time when viewed using automatic playback equipment. These stops are included to provide an opportunity to review the information that has been presented to that point. When you are ready to continue, press the START button on the playback equipment.

REVIEW EXERCISE: INJECTOR SERVICING

Now that you have finished viewing the audio-visual program, complete this review exercise. If you have a problem answering any of the questions, use this review guide, pages 33 through 50, to locate the correct answer. The numbers following each question indicate the range of scenes where the correct answer can be found.

Select the most correct answer to complete the following statements

1. _____ smoke can be caused by overfueling; _____ smoke means incomplete combustion or water in the combustion chamber. (9-11)

___ a. Grey, white

___ b. Black, white

___ c. White, black

2. Bad_____ may cause engines to loose power, overheat, knock, or start poorly. (10-14)

___ a. pumps

___ b. injectors

___ c. either a or b

3. If you loosen a high pressure fuel line to an injector and the engine stumbles, you could have_____ . (14-16)

___ a. bad valves

___ b. a bad injector

___ c. a good injector

4. Before you remove the injectors you should_____ around the nozzle holder assembly. (18-20)

___ a. clean

___ b. apply oil

___ c. put a rag

5. Bending the high pressure lines to remove the injectors _____ . (20-23)

___ a. is ok.

___ b. can make it easier to remove the injectors.

___ c. can cause particles to flake off inside the lines.

6. Disassemble injectors _____ . (31-33)

___ a. only in the service bay

___ b. only in the best clean room

___ c. only place you can find that is convenient

7. Clean the carbon from the nozzle tip with a _____ brush. (33-35)

___ a. brass

___ b. steel

___ c. high speed

8. When you install an injector, use a new _____ to assure proper heat transfer from the nozzle to the cylinder head. (46-48)

___ a. nozzle

___ b. heat shield

___ c. nozzle holder

9. Overtorquing an injector may cause the nozzle needle to _____ . (52-54)

___ a. bind

___ b. bend

___ c. crack

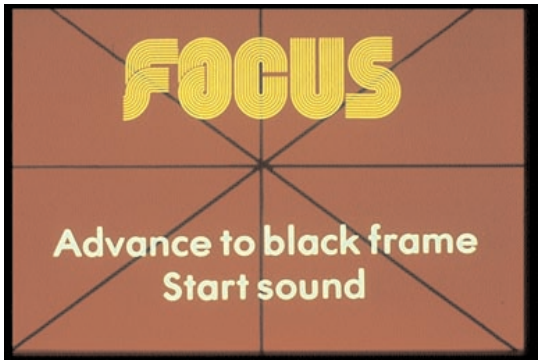
10. You should _____ before you tighten the injector fittings. (57-59)

___ a. bleed the lines

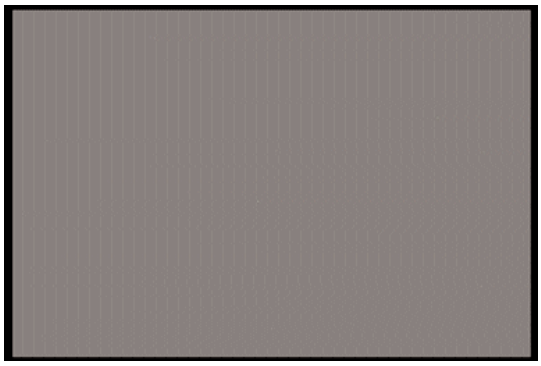
___ b. get a torque wrench

___ c. check pump to engine timing

When you have finished this exercise and reviewed your answers, show the completed exercise to your instructor or supervisor. Have your instructor or supervisor record your progress on your Student Progress Sheet. Then turn to page 53 of this review guide and begin Program 3, **Injector Reconditioning.**



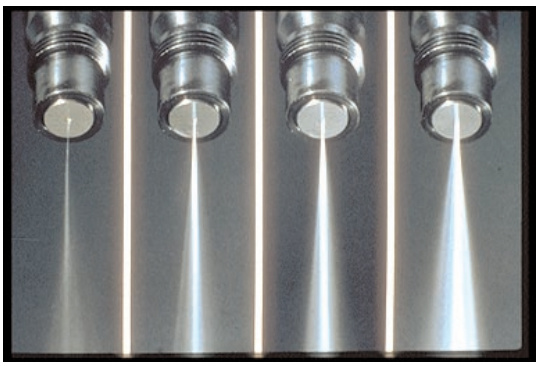
1. FOCUS



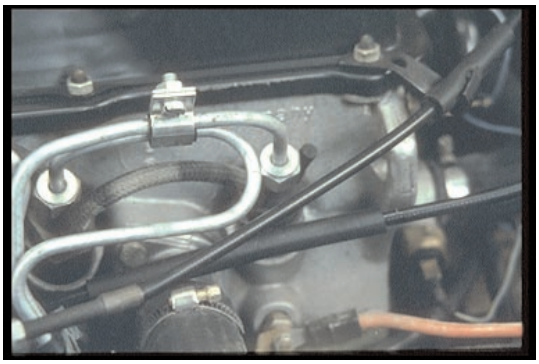
2. BLACK

3. Injector servicing, on the engine—you'll know when to do it—and how to do it when you finish this program in the series,

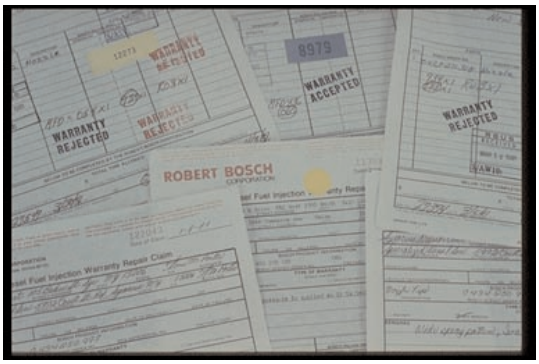
4. . . . brought to you by Robert Bosch. You should have already seen the earlier program describing operation.



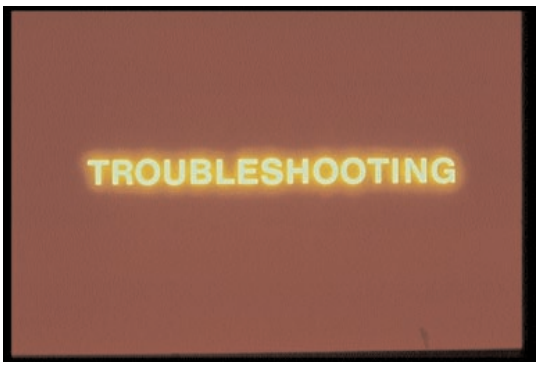
5. You've seen how the nozzle delivers the metered fuel, atomizes and distributes it for power, economy and emission-control.



6. In the life of the vehicle, each injector will operate hundreds of millions of times—and with accuracies measured in milliseconds.



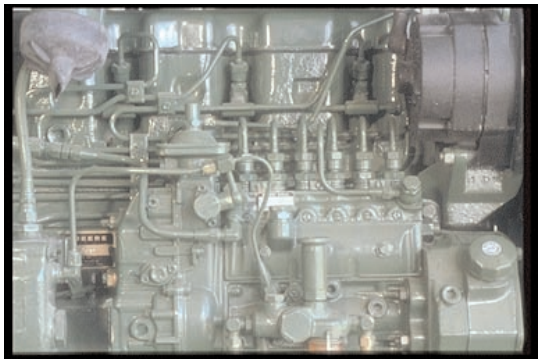
7. A study shows that four out of five warranty injectors are OK. This should tell you that injectors are being pulled for what are really engine and pump problems. But if injectors do not operate properly, how can you tell?



8. When you're troubleshooting an engine, what might lead you to suspect injectors?

9. Smoke—black smoke which could also come from overfueling; white smoke which could also come from incomplete combustion, or water in the combustion chamber.

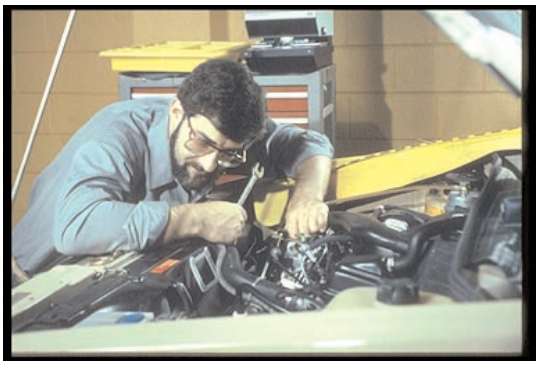
10. Loss of power. You can't keep up with traffic; performance is sluggish. You know many causes for this, one of which could be injectors.



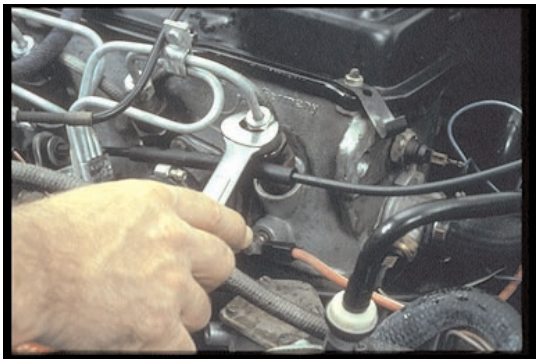
11. Knocking—or overheating—or both. Is it injectors, or pump or engine?

12. Poor starting—prolonged cranking or perhaps no start at all.

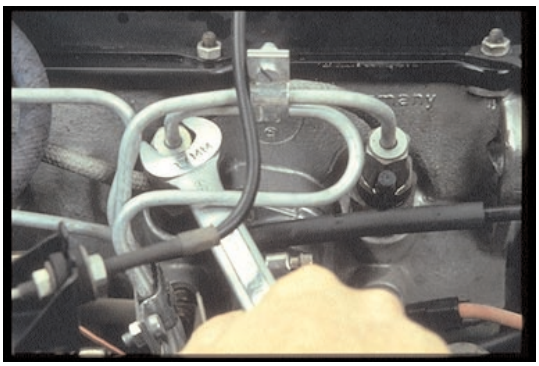
13. Most likely, engine problems are causing these symptoms—but these can also be injector symptoms. How would you check out whether injectors are at fault—and which ones?



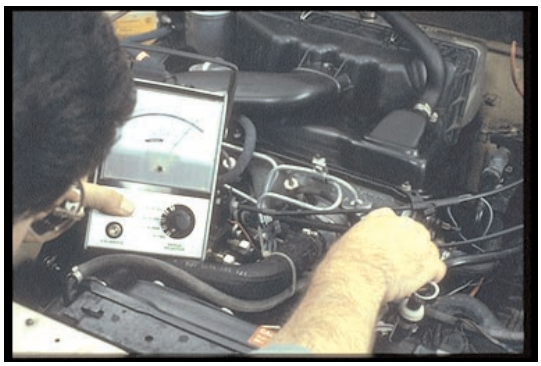
14. One way is to listen to the idling engine as you cut out injectors, one at a time. This may not work with all injection pumps, but with Robert Bosch pumps,



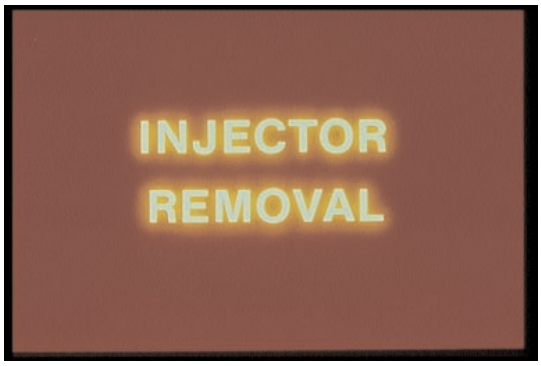
15. . . . loosen one high-pressure fuel line fitting, a little like this—Listen: When the speed drops, you know it's not that injector. So retighten the line.



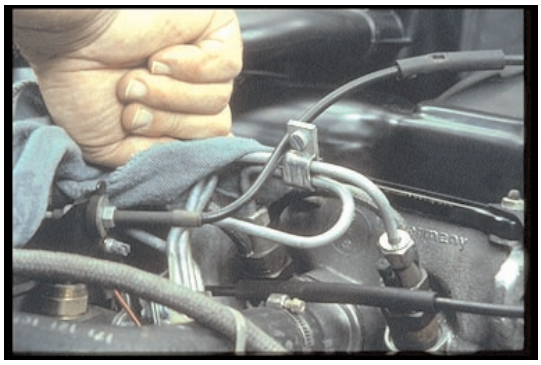
16. With idle speed recovered, loosen the next fitting and listen. When speed does not change or changes very little, you've probably found a faulty injector; it's a little like shorting out spark plugs on a gasoline engine. With other pumps, you may have to use a pyrometer instead of loosening fittings.



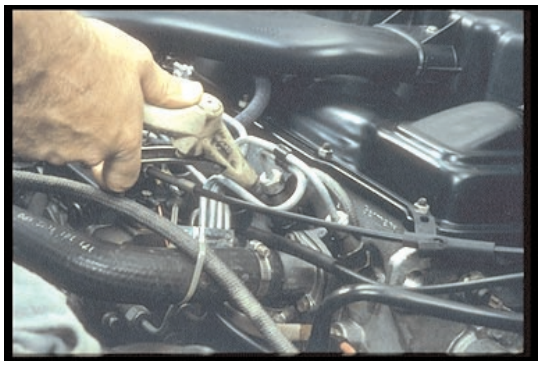
17. If you're not sure, use a diesel tachometer. As you loosen one fitting, check the RPM drop. This one's OK. If you get the same RPM drop on all of them, it's likely the problem is in the engine. With some exceptions, removing a good injector can do more harm than good. Stop now for review of troubleshooting.



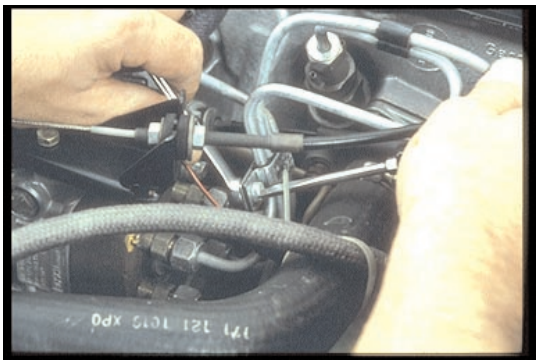
18. Injector removal—whether you are removing one of them, or all of them,



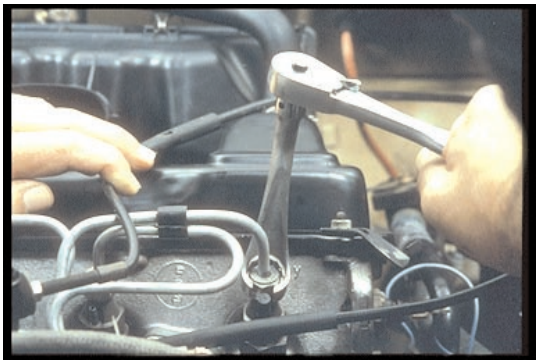
19. . . . clean up before you start. You don't want to let any dirt into the injector or into the pump.



20. Be sure to clean around the nozzle-holder assembly; you don't want dirt to fall into the engine when you remove the injector. After removing the return lines,

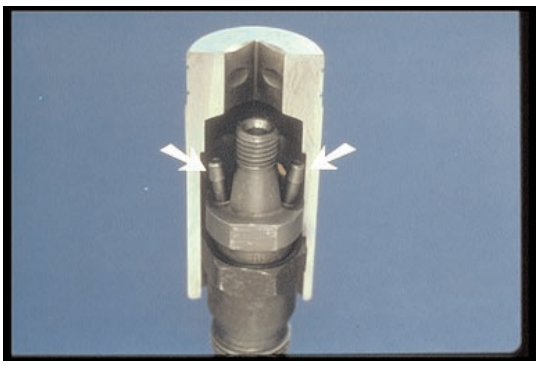


21. . . . loosen the clamps before you disconnect the high-pressure lines, even if you are pulling only some of the injectors.

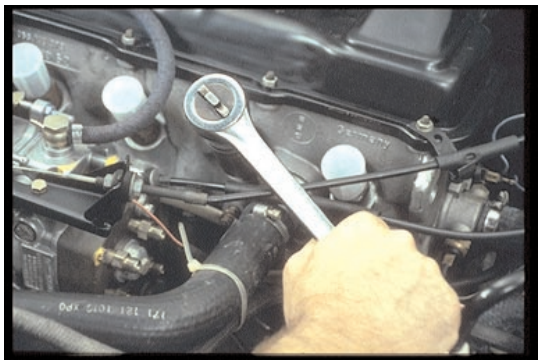


22. That means you'll have to disconnect all the fittings (notice the special wrench). But don't bend the high-pressure lines because inside particles could flake off and get into the injectors.

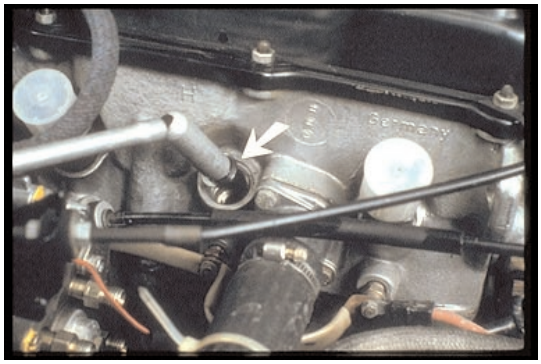
23. At the pump, hold the delivery-valve holder while you loosen the line fitting. Once removed, the lines should be capped to keep the insides clean.



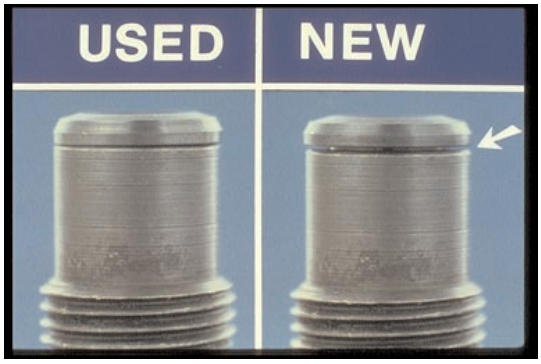
24. On this widely-used nozzle holder, the proper socket will clear the return line fittings like this. If the socket is not properly relieved, it will probably break them off.



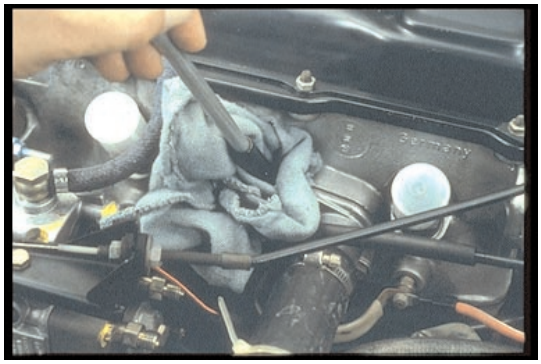
25. Some injectors unscrew—like this. Others come out by removing their clamp nuts and using a puller. Cap all injectors not being removed.



26. With the injector removed, use a magnet like this to remove a steel heat shield. Some engines use copper gaskets—non-magnetic; you'll have to fish them out. And in some engines, such as the Chevrolet 6.2 liter, you won't find a separate heat shield in the recess—it's inside the injector.

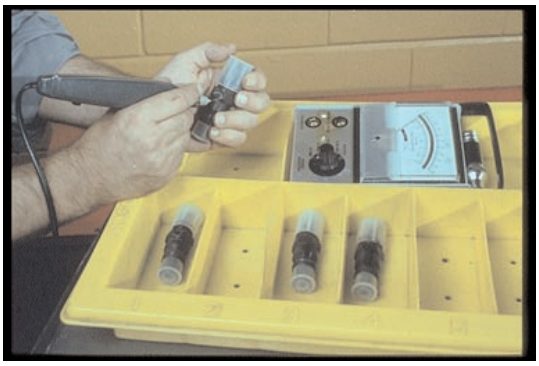


27. A separate used heat shield should be thrown away. When you torque a new one in place, it will crush this space properly to provide good heat-transfer and to seal the pressures.

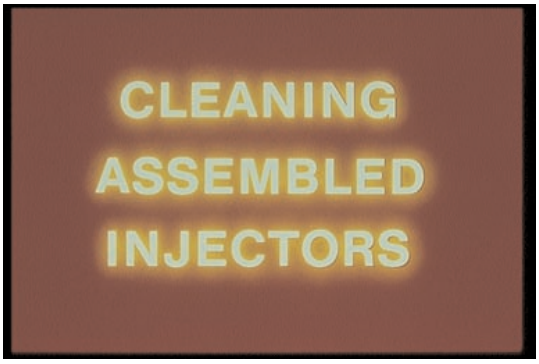


28. Before you leave the engine, stuff a rag in the openings to keep dirt out of the cylinders.

29. Be sure to cap removed injectors—all openings. Don't damage the needle at the tip.

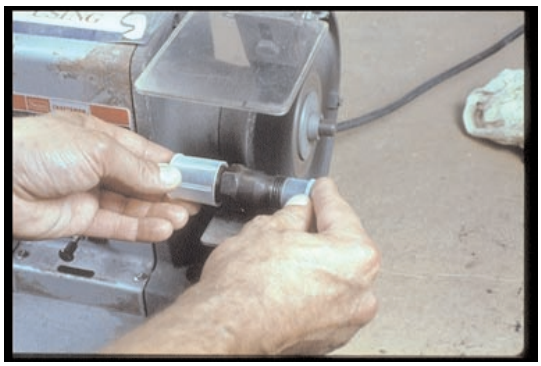


30. Numbering injectors now may help you find an engine problem later, such as a bad valve in one cylinder which shows up on that injector. Stop now for review of injector removal.



31. In this section, you'll see cleaning of assembled injectors.

32. Don't disassemble injectors in the service-bay. Disassemble only in the best clean room facilities and using the right tools, as shown in the recondition-program.



33. In the shop, you can clean the outside if you're going to test injectors or inspect the outside.

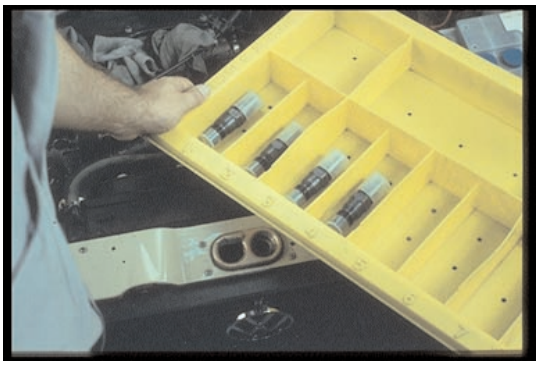
34. Using a brass brush, clean the carbon from the nozzle tip. And be careful of the pintle needle.

35. With the injector clean, inspection may show you the problem. But more likely,

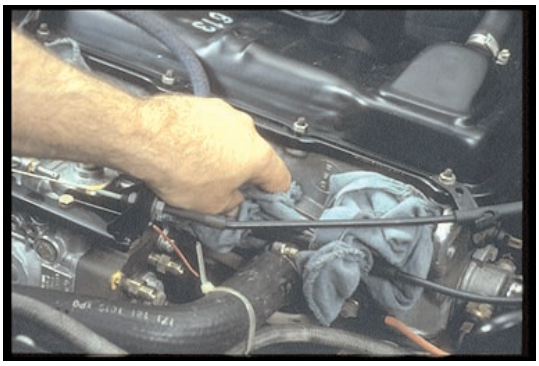
36. . . . you will test it, as shown in another program in this series. If it checks out, reinstall it in the engine. If it does not, replace it, or send it to a diesel specialist for reconditioning.

37. You can recondition it yourself if you have the cleanest of facilities, the right tools and the know-how. Stop now for review of removal.

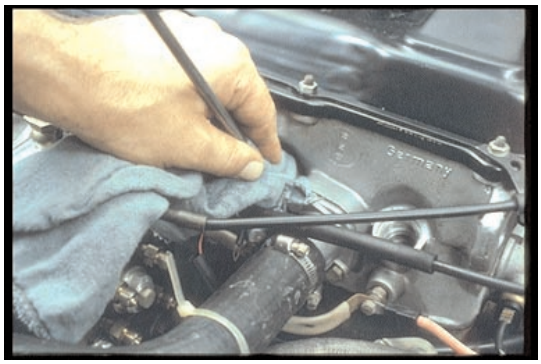
38. Installation is just about the same whether for new injectors, reconditioned, or the removed injectors.



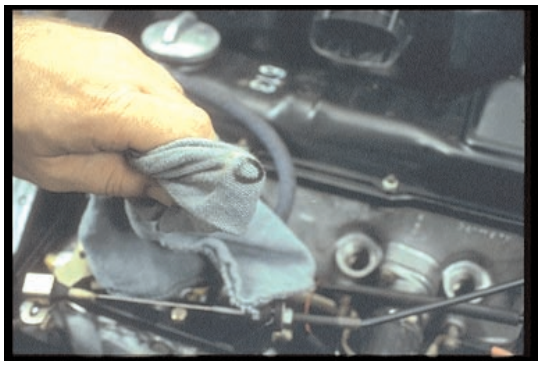
39. The important point is you are satisfied they test out OK. They should only go into clean injector recesses.



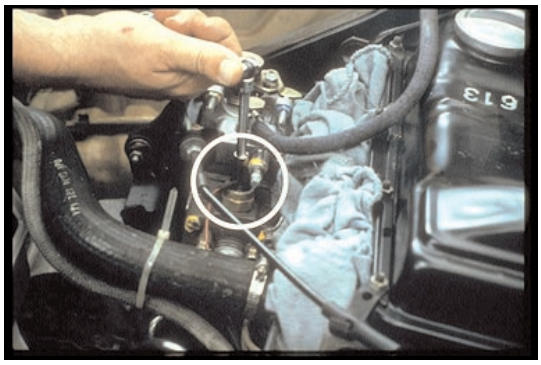
40. Remove the rags that plugged these openings to keep outside dirt away. But you want to clean inside those openings.



41. Usually, your magnetic tool will help your cloth do a good job.

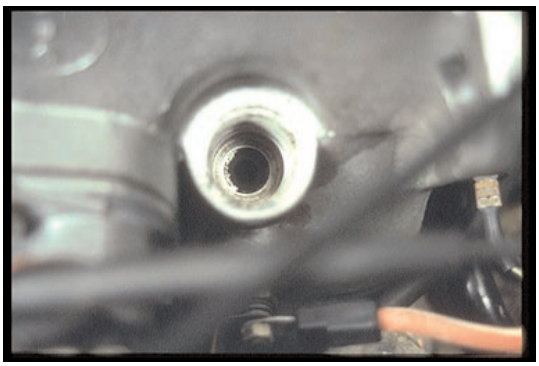


42. You want to remove this kind of dirt. But to be sure you've got it really clean, you'll want to blow it out.

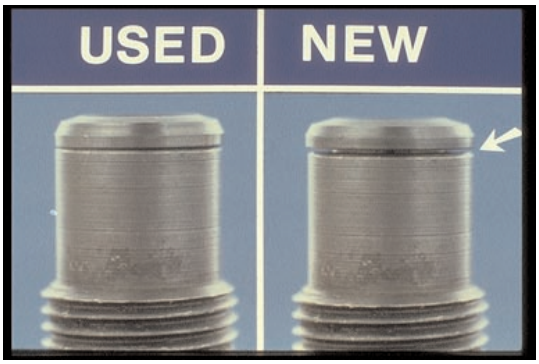


43. First, shut off the fuel (in this engine by disconnecting the electric fuel shut-off).

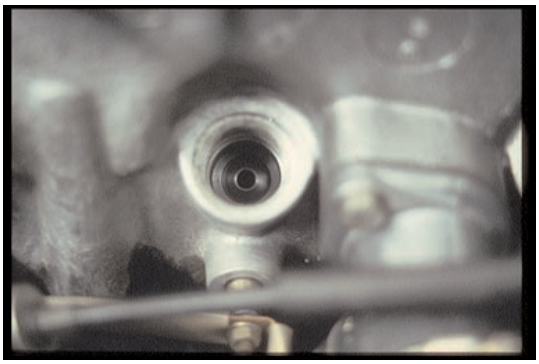
44. Then crank it a few turns to blow out the dirt.



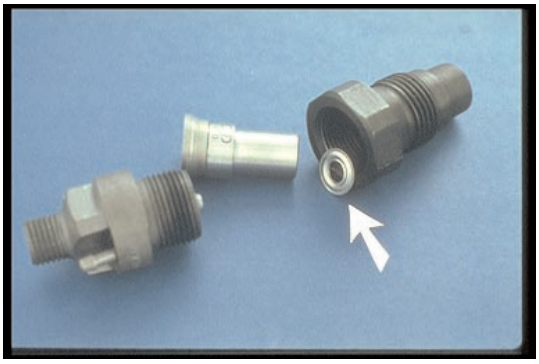
45. This injector recess is clean, especially around the inside where the heat-shield touches. If it were not, it might need reaming to remove the carbon; check instructions from the engine manufacturer.



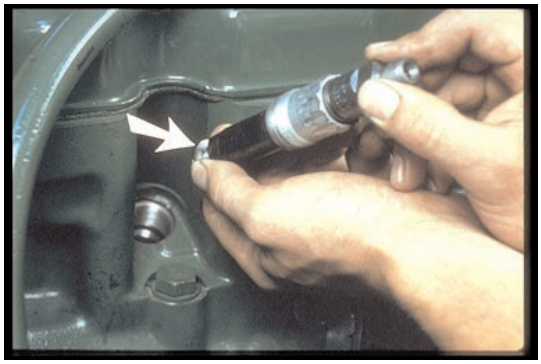
46. Never put in a used heat shield. Remember only a new heat shield can be properly crushed to insure good seal and good heat transfer from the nozzle tip to the cylinder-head. And be sure you install it the right way.



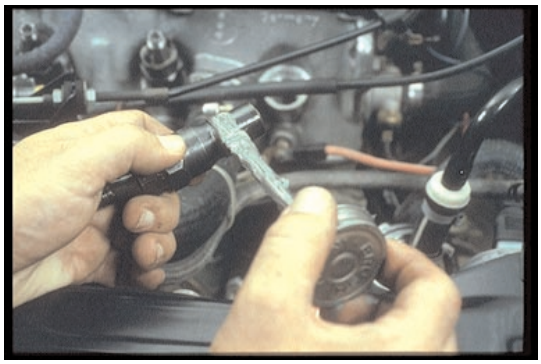
47. This kind of heat shield looks like this when it's properly installed, the flat outer-rim facing you. When you install the injector, be careful not to strike the nozzle tip or the pintle.



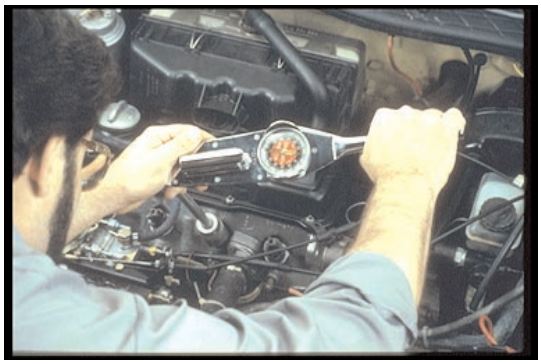
48. In some injectors like this, the heat-shield is inside the injector so don't add another heat-shield in the recess.



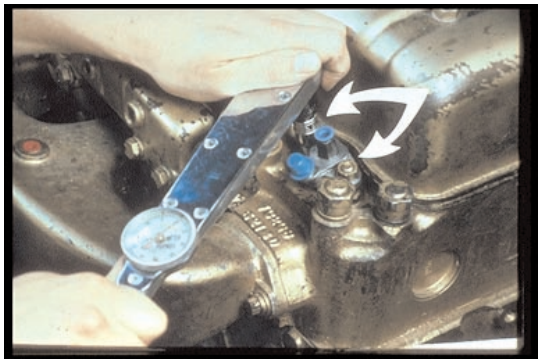
49. On some nozzles, you'll need a new washer to be sure it will seal the nozzle, as well as position and cool the injector in the head.



50. Use an anti-sieze type compound to make the next removal easier—a long way down the road. When you start threading by hand you can be sure you're not cross-threading.



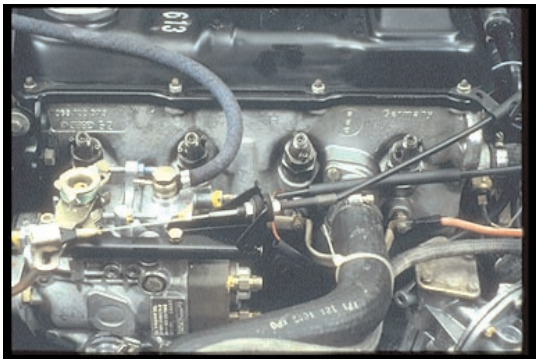
51. Screw in and torque the injector according to specifications.



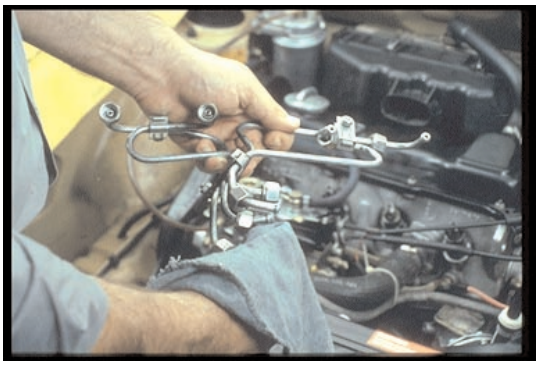
52. With these KB nozzle holders, be sure to alternate from one hold-down nut to the other to prevent cocking the injector; that could cause jamming of the nozzle.

53. With most injectors, if you overtorque the injector, you may cause needle binding.

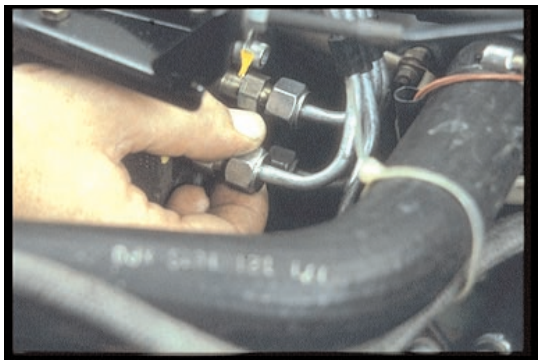
54. If you undertorque, you will fail to seat the heat shield; combustion gases may leak and burn the nozzle tip.



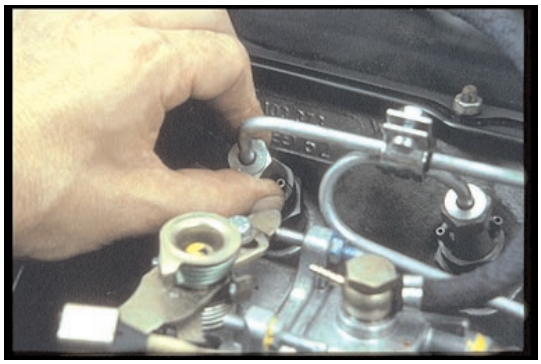
55. With all injectors properly torqued in place, you're ready to reinstall the lines.



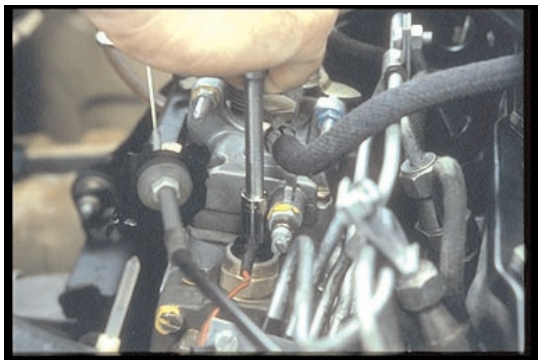
56. Keep the high-pressure lines clean, and wipe the ends before installation, just to be sure.



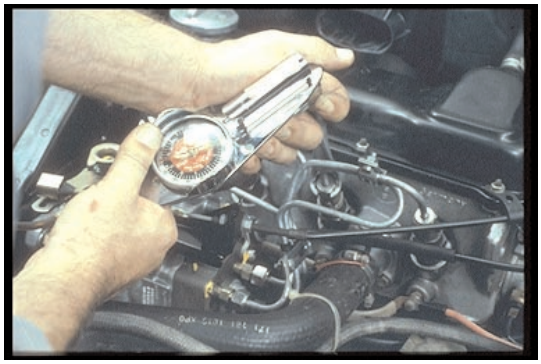
57. Run the threads up by hand to be sure you don't cross-thread, and leave them a little loose.



58. That way, you'll find it easier to thread the fittings onto the injectors. But before you tighten the injector fittings,

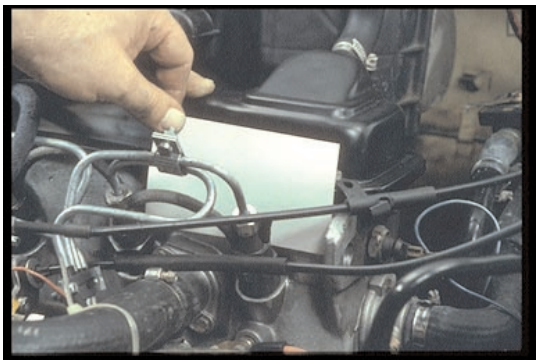


59. . . . reconnect the electric fuel shut-off or turn on the fuel and crank the engine to bleed the lines.



60. Now, torque all fittings, injectors and pump. Don't forget to replace the leakoff lines.

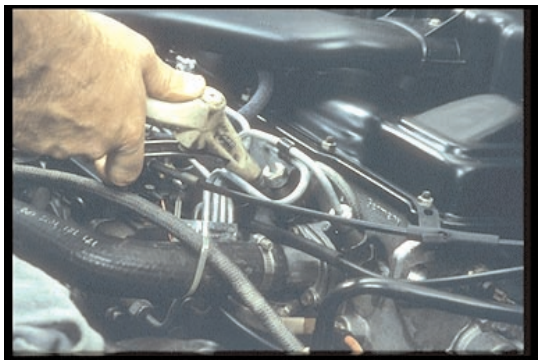
61. When you crank the engine, if you haven't bled the lines, it might take a minute to start up.



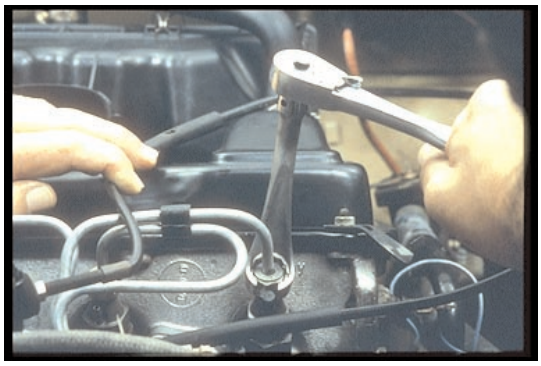
62. Then, with a card like this near each fitting in turn, you can check all lines for leaks. If you remember the kind of high-pressure in those lines, you won't feel for leaks with your hands as you complete injector servicing on the engine.

63. In this program, you have seen how to troubleshoot—how to separate engine problems from injector problems; when not to pull injectors that are working OK.

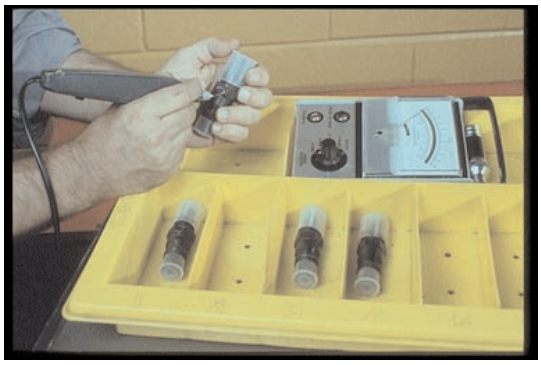
64. If you're checking injectors, you know how to check for rpm drop, with a tach or by ear as you loosen each injector in turn.



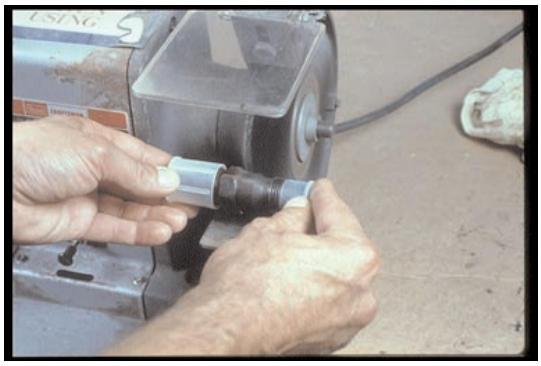
65. Before you remove anything, blow and wipe to be sure you don't add dirt inside injectors or fuel-lines.



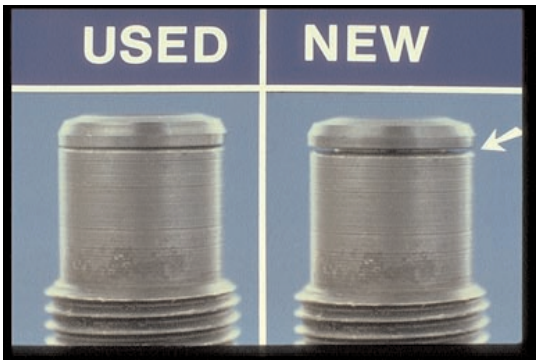
66. When removing lines, you don't want to bend them so you loosen line clamps first.



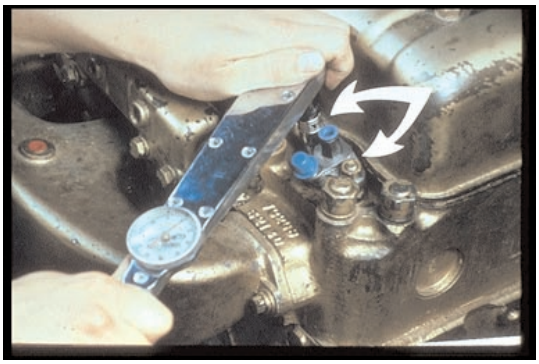
67. You know that keeping track of injectors can be important to engine diagnosis.



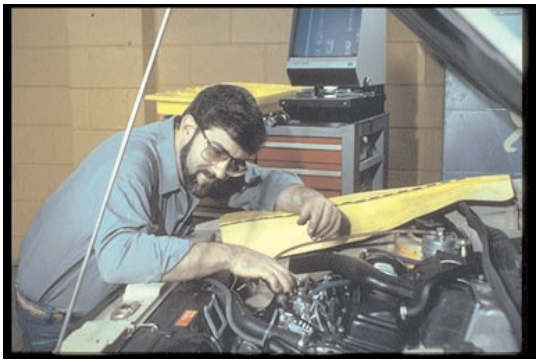
68. You know how to clean the outside for inspection or testing—and know that, without the best-clean room, you do not disassemble the injector.



69. You've learned the importance of replacing a separate used heat-shield or washer with a new one to insure a good seal and good heat-transfer.



70. The differences between installing and torquing the different kinds of nozzle holders as well as what happens if you under-torque or overtorque.



71. By the sound of the engine, you know you won't have any problems with these injectors,

72. . . . brought to you by Robert Bosch.

RECONDITIONING INJECTORS

INTRODUCTION

If you find a faulty injector on an engine, reconditioning the injector will usually restore it to "like new" operation. In this program we will show you how to disassemble, clean, inspect, and reassemble an injector.

PROGRAM OBJECTIVES: INJECTOR RECONDITIONING

When you have finished the audio-visual program, **Injector Reconditioning** you will be able to:

1. Describe how to prepare the work area and the injectors for disassembly.
2. Describe how to disassemble typical injectors and identify the correct tools required.
3. Explain how to properly clean injectors.
4. Identify inspection requirements for nozzles and nozzle holders.
5. Describe correct injector reassembly procedures.

SPECIAL INSTRUCTIONS

DO NOT use or refer to the review guide until you have finished viewing the audio-visual program or you are instructed to do so. The visuals in the program are produced in colors which present important information. The black and white reproductions of these visuals used in the review guide may not show the discrimination between these colors and, therefore, may not completely present the information from the color visual. In addition, the audio-visual program may have been revised with updated visuals which may not be reflected in the review guide. These changes in visuals will not alter the meaning or content of the information contained in the review guide.

Start the audio-visual program, **Injector Reconditioning**, at this time. Sit back and let the colors, motion, and sound help you learn. When the program ends, turn to page 54 and continue as instructed.

NOTE

The audio-visual program will STOP from time to time when viewed using automatic playback equipment. These stops are included to provide an opportunity to review the information that has been presented to that point. When you are ready to continue, press the START button on the playback equipment.

REVIEW EXERCISE: INJECTOR RECONDITIONING

Now that you have finished viewing the audio-visual program, complete this review exercise. If you have a problem answering any of the questions, use this review guide, pages 57 through 76, to locate the correct answer. The numbers following each question indicate the range of scenes where the correct answer can be found.

Choose the most correct answer to complete the following statements.

1. On a scale of good, better, best, injector reconditioning should be done in a _____ clean room. (5-8)

___ a. good

___ b. better

___ c. best

2. On many injectors, before you loosen the nozzle nut you should _____ to prevent damaging the threads. (21-23)

___ a. soak it in penetrating oil

___ b. release adjusting spring pressure

___ c. hit it sharply with a leather or plastic mallet

3. Acids from your skin can ruin a nozzle needle. (26-28)

___ a. true

___ b. false

4. Use a _____ to clean the holes in a hole type nozzle. (37-39)

___ a. ream

___ b. brush

___ c. cleaning needle

5. To clean the non-removable edge filter, blow compressed air from the _____ side of the holder. (41-43)

___ a. inlet

___ b. nozzle

___ c. outlet

6. You should clean new nozzles in solvent and dip them in test oil before you assemble them. (43-45)

___a. true

___b. false

7. The nozzle body and nozzle needle are individual parts and can be replaced separately. (48-50)

___a. true

___b. false

8. High pressure fuel sealing is accomplished by_____. (60-62)

___a. lapping

___b. gaskets

___c. using Permatex

9. Replace the nozzle if it fails the_____ test. (66-68)

___a. drop

___b. slide

___c. pressure

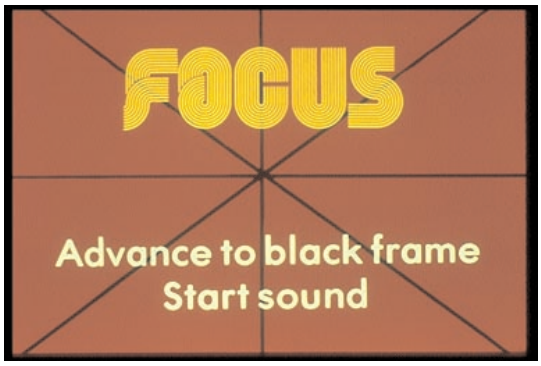
10. Make sure the parts are_____ as you assemble the injector. (70-72)

___a. clean and dry

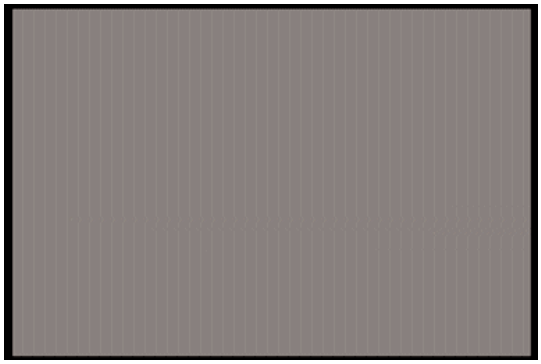
___b. new replacements

___c. wet with test oil

When you have finished this exercise and reviewed your answers, show the completed exercise to your instructor or supervisor. Have your instructor or supervisor record your progress on your Student Progress Sheet. Then turn to page 79 of this review guide and begin Program 4, **Injector Testing.**



1. FOCUS

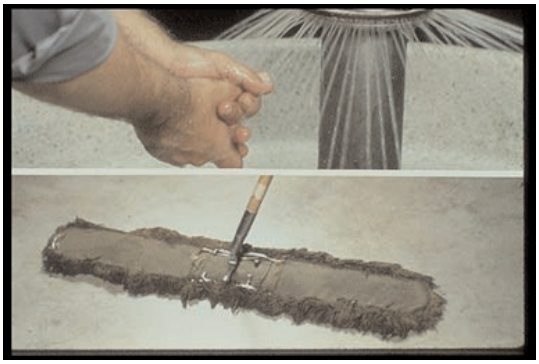


2. BLACK

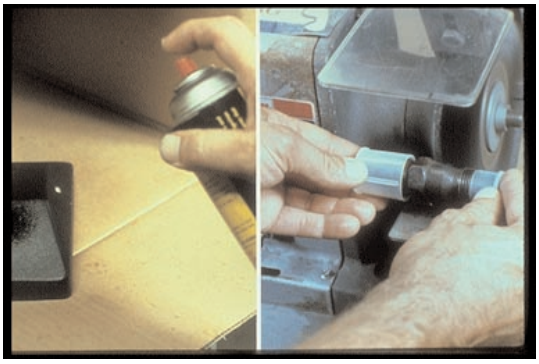
3. Injector reconditioning – disassembly, cleaning, inspection, and reassembly – that's what you'll be able to do when you finish this third program in the series,

4. . . . brought to you by Robert Bosch. You should have already seen the first programs in this injector series.

5. Preparation starts with the right tools and specifications. And with a clean facility; on a scale of good, better, best, this should be the best.



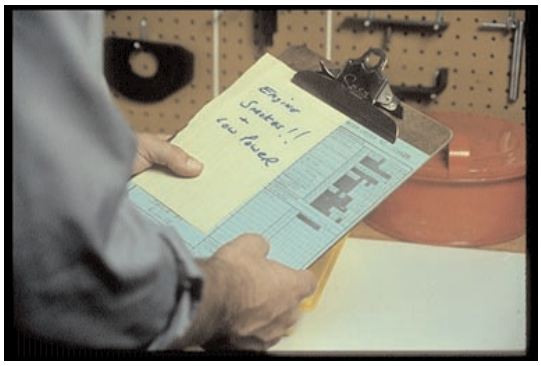
6. Strange as it may sound, your hands should be clean, and your clothing, too. Clean the floor with an oil mop, and keep cement floors painted to reduce dust. In your best clean room,



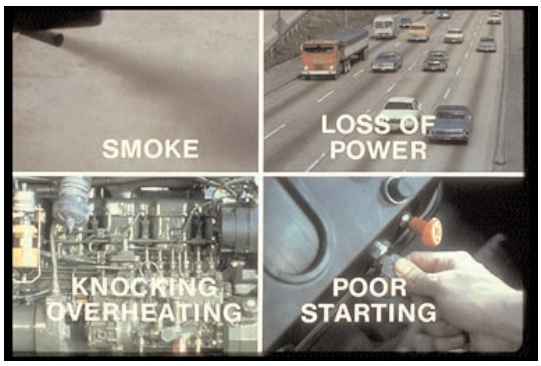
7. . . . no spray-painting and no grinding. Your best clean rooms have an air-filtering system and are separate from dust-making service operations.

8. In your clean room, use clean, smooth paper as a work surface. If you don't have a dust-free place to work, you probably should not be disassembling injectors.

9. After cold-soaking nozzles in solvent, use the brass brush to clean the tip, removing any carbon residue.



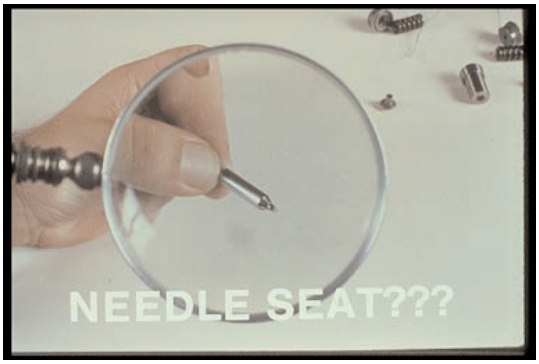
10. Check the work order for engine complaints. Most injector complaints are not injector-problems — they're probably engine-related. That's a good reason to keep track of injectors by cylinder number.



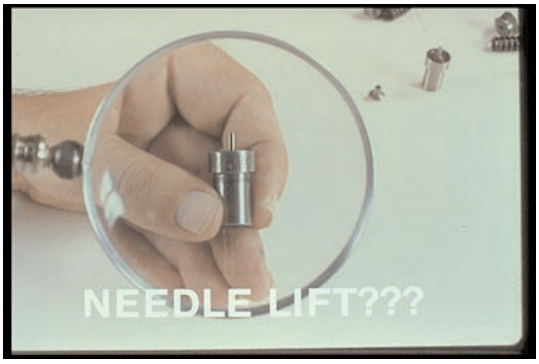
11. Whether the complaint is smoking, loss of power, overheating or knocking, or poor starting, you may be able to relate a specific injector to a specific cylinder or injection pump element.

12. Before disassembly, test the injector, as shown in another program. You may find it's not an injector problem at all — or the injector needs a new nozzle.

13. In this program, you'll learn how to recondition — up to certain limits. Do not lap the needle seat; do not grind the needle valve. If you do, without highly specialized equipment,



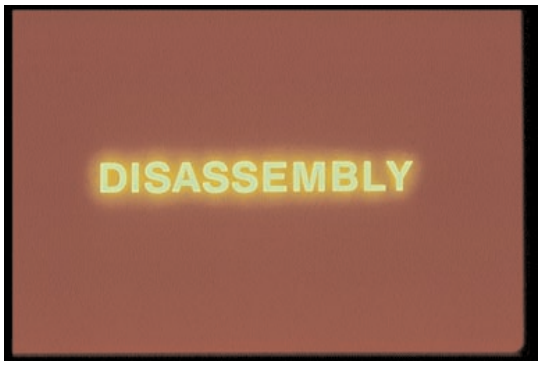
14. . . . you won't know whether the needle-seat is too large, changing peak-pressure.



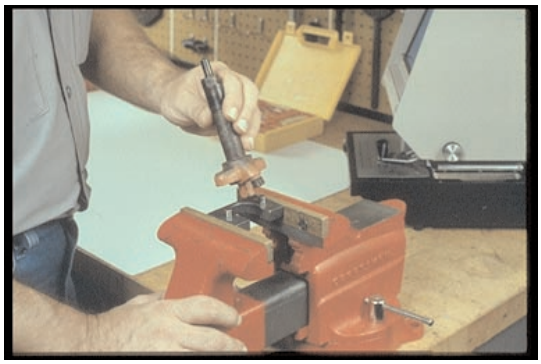
15. Without such equipment, excess needle lift might cause increased flow-rate and you wouldn't know it.

16. You won't know if excess needle play will increase leakoff fuel, changing delivery. You won't know about deliver-rates — you get the idea:

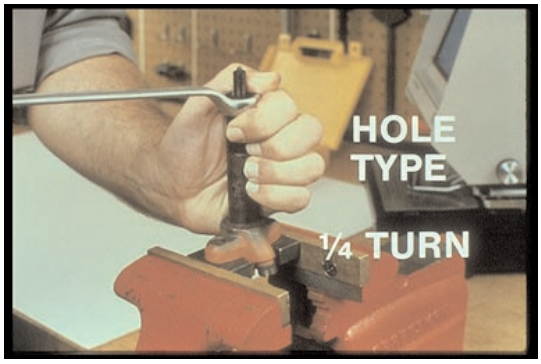
17. You'll know a reconditioned injector will do the job for the customer. If an injector doesn't test out, don't lap or grind the nozzle. Replace it. Stop now for review or preparation for reconditioning.



18. Disassembly procedure includes knowing injectors and how they're put together; otherwise, in your first step, you could ruin one.

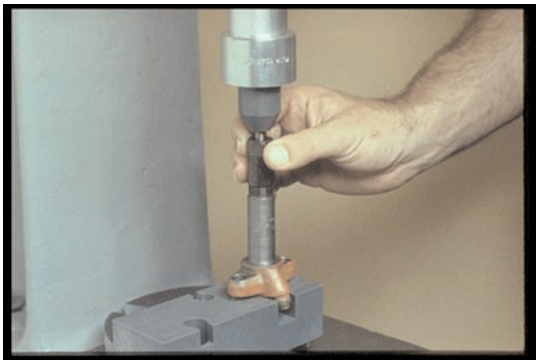


19. For most injector types, using a fixture in your vise, hold the injector upside down, like this.



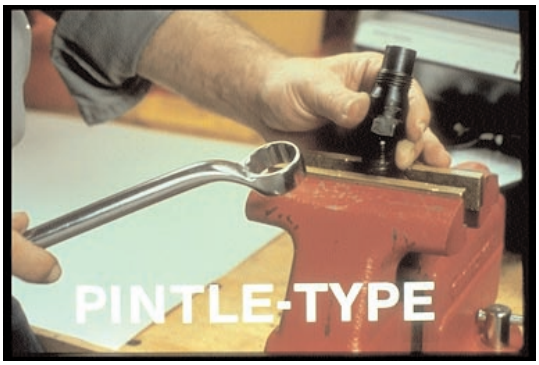
20. Loosen the nozzle nut. But for this hole type injector, and for some specified pintle nozzles, only one-quarter turn, no more — not yet!

21. For many injectors, including all hole-types, you have to relieve the pressure of the adjusting spring by applying downward pressure like this on the injector in this fixture.



22. Now as you remove the nut, you're keeping spring pressure from damaging the nozzle nut threads — and you won't shear off the pins.

23. In the same way, some pintle type injectors should be relieved by pressure on the nozzle to avoid contamination with metal chips.



24. For this kind of pintle-type nozzle such as used on V-W and Mercedes, it's simpler. Clamp it in brass jaws, loosen the nozzle nut and remove it.

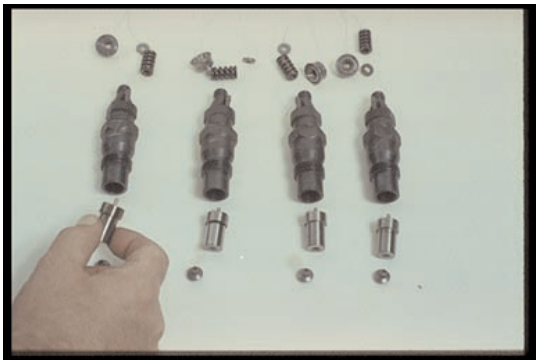
25. In your parts tray, keep parts from each unit together; wiring spring and shims like this helps a lot.

26. Of course, you hold the needle valve by the stem unless you have wet your fingers in test oil to protect the lapped surfaces from skin acid. Is that really a problem?

27. In this demonstration, a reject needle is handled by dry fingers — clean, normal skin-acid, dry. If you were to just touch it like this,

28. . . . in a few hours, you'd have a ruined needle! You'd have to throw it away, along with its mated nozzle body — just because of a careless fingerprint!

29. So wet your fingers with test oil. And when you join these mated parts, dip them in test oil; avoid damage from finger-acid or from any tiny dust particle in the air.

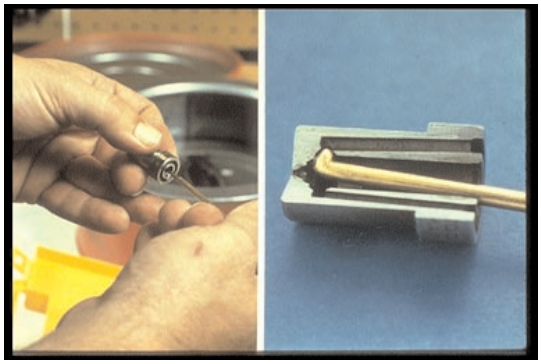


30. You may spread them like this, organized on clean paper, or in a pan of clean test oil, with nozzle nuts reinstalled to protect the lapped surfaces of the nozzle holder. Stop now for review of disassembly.

31. Cleaning includes the outside, the inside and all orifices.

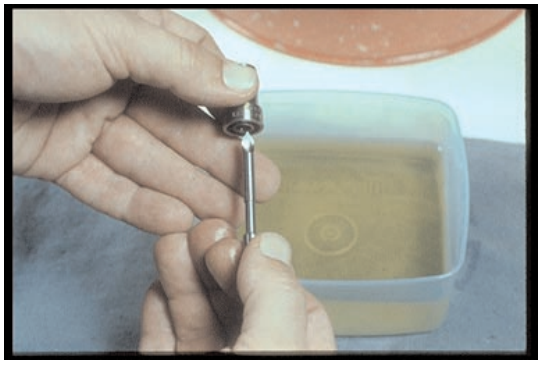
32. To clean burnt-on combustion deposits, use a commercially-available parts solvent.

33. With the brass brush, remove any carbon from the outside of the nozzle body and needle tip, especially the needle seat. Never use emery paper or any abrasive to clean the nozzle.

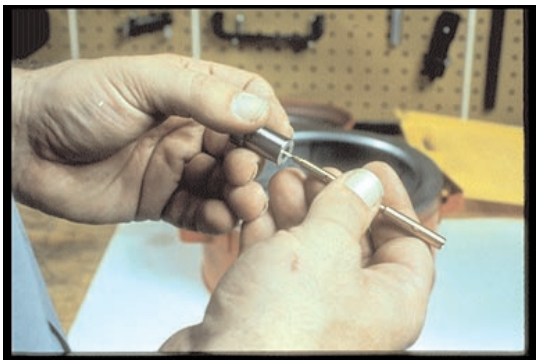


34. When you clean the ring groove, the scraper loosens the dirt like this.

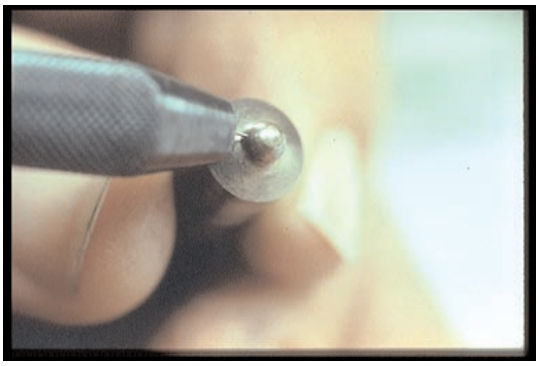
35. When you've finished scraping, rinse in clean solvent to remove the dirt and carbon you've loosened.



36. Use the scraper dipped in test oil to clean the seat.



37. Select the proper size cleaning needle to clean the pintle bore.

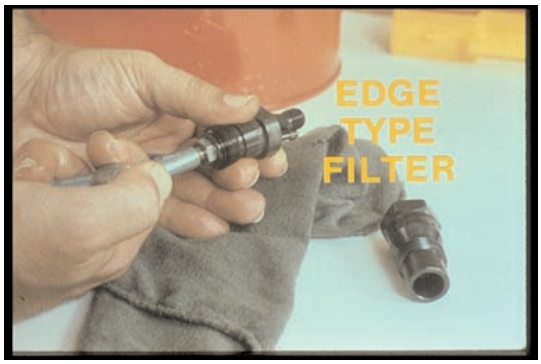


38. Same thing for these orifices in the hole-type nozzles. Be sure the wire is just small enough to fit in the hole without forcing. Never use a ream; you might enlarge the hole and ruin the nozzle.

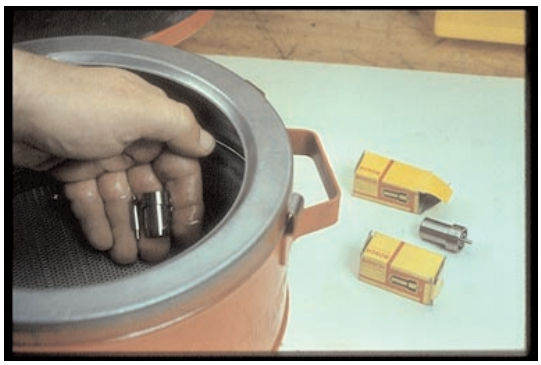
39. With the nozzles clean, remove your nozzle holders from the solvent, keeping them in order.

40. With carbon loosened, clean the nozzle-nut. Don't sand-blast — that's too abrasive.

41. After washing in solvent, blow the parts dry and dip in clean test oil.



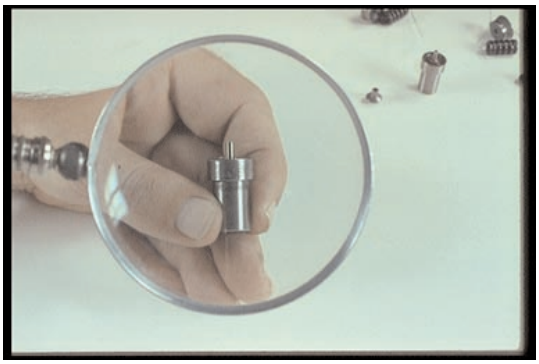
42. Use compressed air to clean the edge-type filters, blowing from the nozzle side of the holder; the filter is not removable.



43. New replacement parts need cleaning too. Solvent removes the protective coating. And new or re-used, when the parts are completely clean,

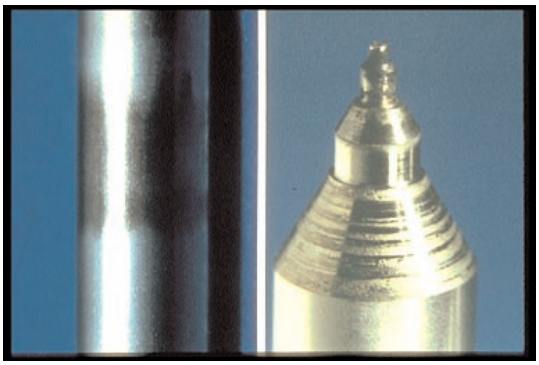
44. . . . dip the nozzles and holders in clean test oil. Stop now for review of cleaning operations.

45. Inspection applies to used nozzles and holders; your new nozzles are inspected thoroughly before shipping.



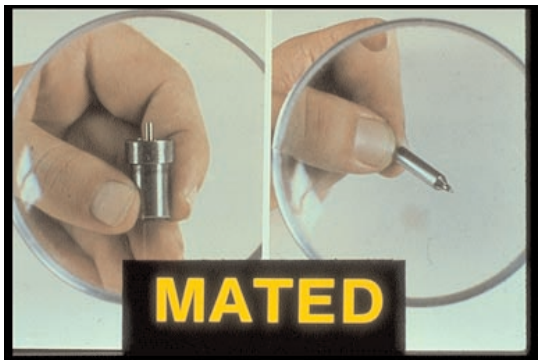
46. The nozzle body should also be inspected for signs of damage. This body is OK.

47. Inspect the needle valve for signs of damage. Remember these are hard-working pieces; don't expect them all to look shiny-new.



48. On the finished surface, you'll probably find marks like this; the pressure-shoulder is normally rough. This needle valve is OK.

49. On the nozzle-tip, you may find normal, hard carbon, which can be removed. This nozzle-body is OK.



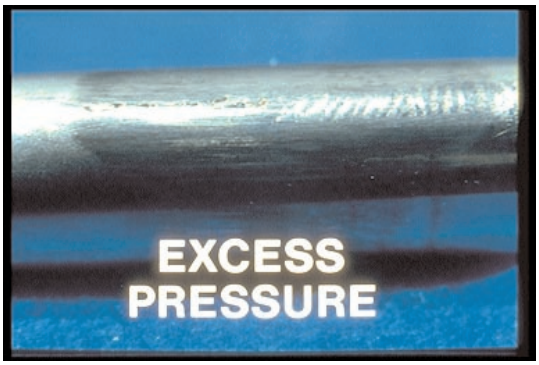
50. You know what mated means; if either one has a problem, they will both be replaced. Now that you know what good nozzles look like,

51. . . . try a little nozzle diagnosis — what went wrong?

52. When you see this, you're seeing the evidence of contaminated fuel. Contamination damaged this needle valve; and could cause nozzle-seat damage. Contaminated fuel is a problem the operator's got to deal with.

53. Suppose you find a needle valve with a broken pintle like this — or a bent pintle? You'll know the nozzles were dropped or mishandled during assembly or installation. Improper handling is a problem for service technicians.

54. Some technician's improper handling — incorrect gaskets or excessive torque — caused excess pressure on the nozzle body distorted the body, causing pressure marks, and leading to nozzle failure.

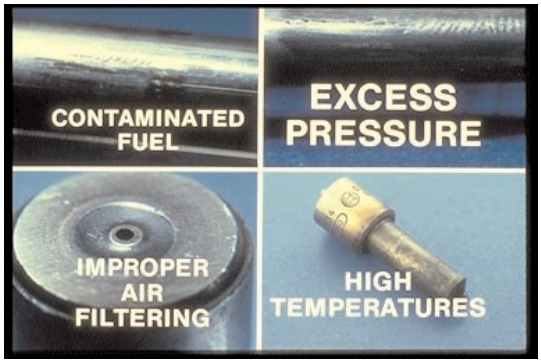


55. Another improper handling — score marks from scuffing in a deformed nozzle body as a result of excess torqueing pressure on the nozzle.

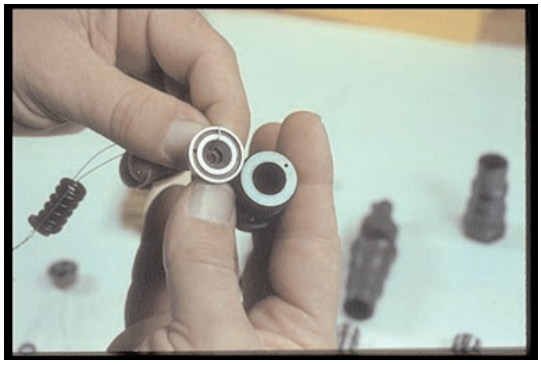
56. These combustion residues collected because the nozzle-spring pressure was less than combustion pressures. Adjust opening-pressure so the cylinder gas can't blow back inside the nozzle.

57. Improper air filtering allowed dirty air to erode and ruin this nozzle. A torn filter should be changed without delay.

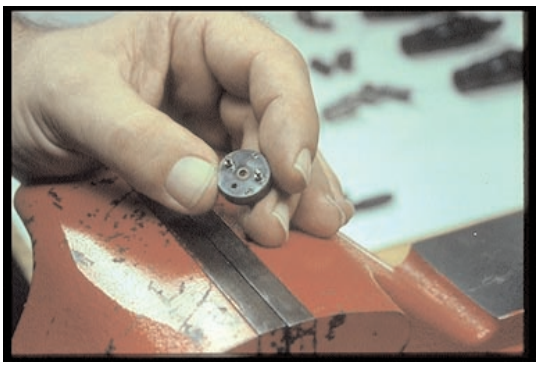
58. When you see color changes like this, high-temperatures have been at work on the nozzles; replace them, but more important — find the engine problem.



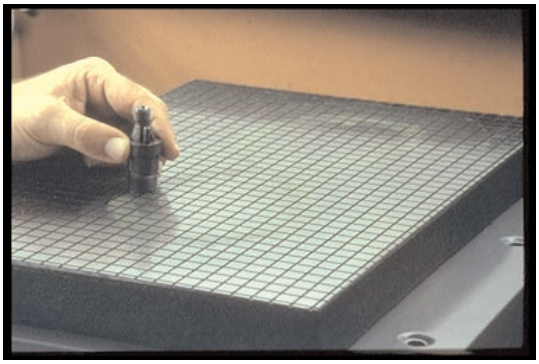
59. And so you've seen some of the factors which could cause nozzle problems you may observe in your inspection.



60. These lapped surfaces seal high-pressure fuel; they must be flawless in fit.

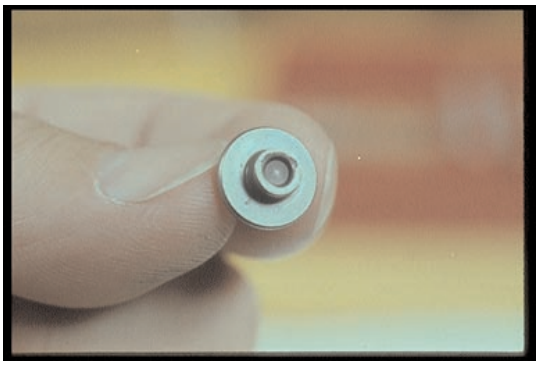


61. If you want to lap these machined surfaces of the nozzle-holder, the locating pins must be removed; and replaced after lapping.



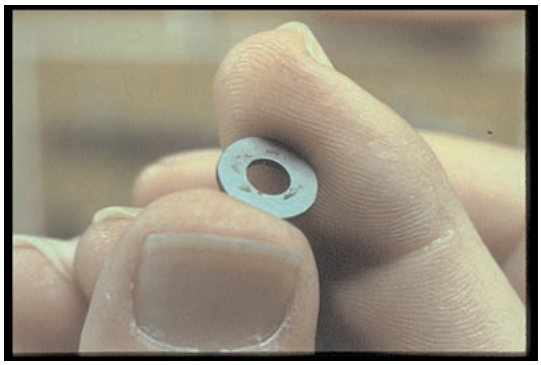
62. You may polish the seating surfaces on a lapping block like this; otherwise, you'll need to replace the part.

63. Inspect the nozzle nut for physical damage; check for coking inside the surface or damaged seating surface.

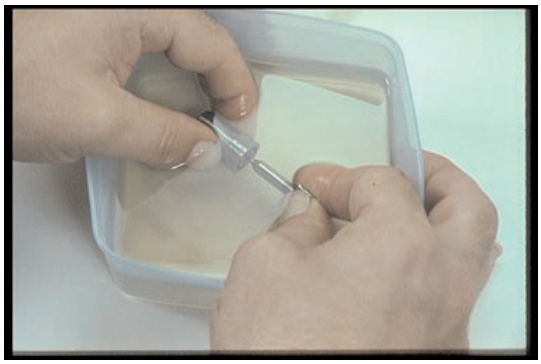


64. Be sure the lower end of the spindle is straight — not cracked or broken. If the spring seat is worn, you'll need to replace the assembly. This one's OK.

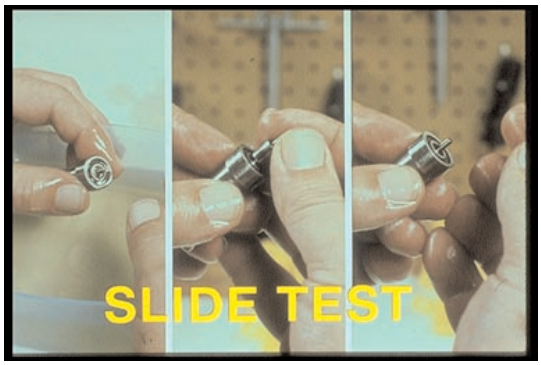
65. Compare spring length to a new spring. If in doubt, replace it. Also, if the spring is pitted or shows excessive wear, replace it.



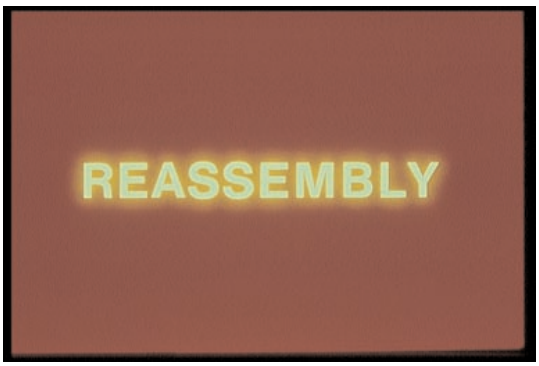
66. The adjusting shim must be smooth and not worn or corroded. Otherwise, replace it.



67. For your final check of the nozzle, assemble the nozzle under the test oil, like this.



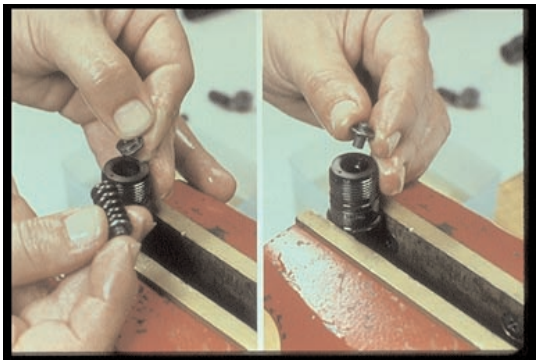
68. In the slide test, wet the needle; pull the needle out about one-third and hold the body at 45 degree slant like this. The needle should slide in of its own weight. If the nozzle fails this test, clean it and try it once more. If it fails again, replace it. Stop now for review of inspection.



69. Reassembly begins with known good parts,

70. . . . as clean as possible. You might think to clean and dry the parts,

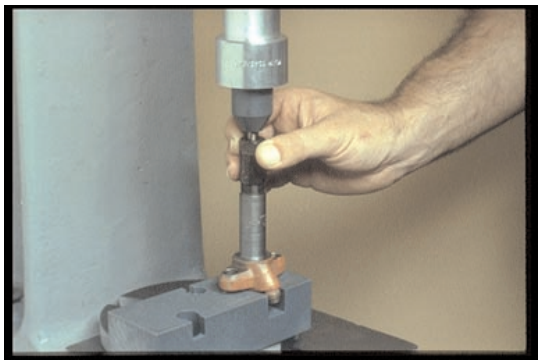
71. . . . with towels and compressed air. But no! This could leave dust particles on the pressure faces of the valve body and the nozzle holder.



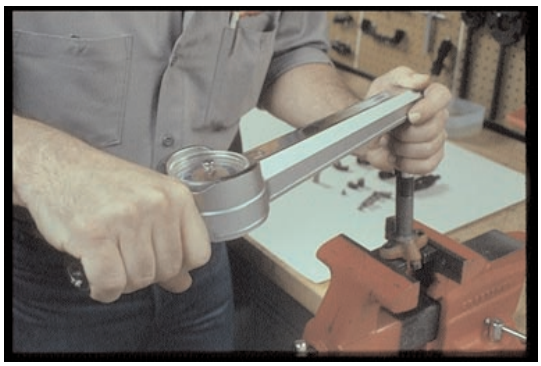
72. With the holder body upside down, be sure these parts are wet with test oil as you assemble the shims, spring and pressure spindle like this.

73. After the intermediate plate, and the nozzle, thread the nozzle nut several turns, but if it's a hole-type injector, do not snug it up yet.

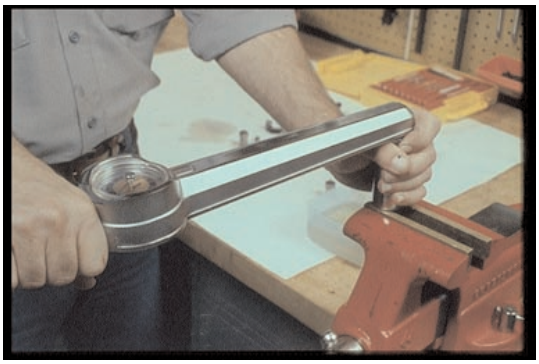
74. Remember hole-type and some pintle injectors need force down against the pressure-spring,



75. . . . while you tighten the nut until you feel considerable resistance.



76. In the vise, tighten the nut the final part of a turn, according to the torque values in your specs.



77. Of course, many pintle type nozzles can be tightened and torqued right in the vise. In this program, you've learned to recondition injectors, precision parts,

78. . . . brought to you by Robert Bosch.

TESTING INJECTORS

INTRODUCTION

In this program you will see how to use a nozzle tester to determine if an injector is good or bad. You will see how to check injector opening pressure, how to perform leak tests, chatter tests, and how to evaluate spray patterns.

PROGRAM OBJECTIVES: INJECTOR TESTING

When you have finished the audio-visual program, **Injector Testing** you will be able to:

1. Demonstrate injector tester safety procedures.
2. Identify the units of measure shown on tester gauges.
3. Identify conditions requiring the use of the injector tester.
4. Check injector opening pressure.
5. Perform injector leak tests.
6. Perform injector chatter tests.
7. Evaluate injector spray patterns.

SPECIAL EQUIPMENT

To complete this program you will need the **Injector Testing** audio-visual program, the appropriate playback equipment (described at the beginning of this review guide), this review guide, and the following tools and equipment.

KCA Nozzle Holder Assembly	NOT a GM application
Equipment List Microfiche	From Module 2
Common Metric Hand Tools	To disassemble and assemble nozzle holder assembly
Metric Micrometer	To measure shim thickness
Bench Vice	To hold nozzle holder assembly
Torque Wrench (To 80 Nm)	To assemble nozzle holder assembly
Nozzle Tester EFEP60H (or equivalent)	PN 0 681 200 502
Test Line EF8040/24 (or equivalent)	PN 1 680 750 000
Nozzle Cleaning Kit	KDEP 2900 (or equivalent)
Special Cleaning Needle (as required)	
0.13 mm diameter	KDEP 2900/3 (or equivalent)
0.15 mm diameter	KDEP 2900/4 (or equivalent)
0.18 mm diameter	KDEP 2900/5 (or equivalent)
Commercial Parts Cleaning Solvent and facilities	For cleaning nozzle holder parts
Test Oil	For cleaning nozzle parts and nozzle tester

SPECIAL INSTRUCTIONS

DO NOT use or refer to the review guide until you have finished viewing the audio-visual program or you are instructed to do so. The visuals in the program are produced in colors which present important information. The black and white reproductions of these visuals used in the review guide may not show the discrimination between these colors and, therefore, may not completely present the information from the color visual. In addition, the audio-visual program may have been revised with updated visuals which may not be reflected in the review guide. These changes in visuals will not alter the meaning or content of the information contained in the review guide.

Start the audio-visual program, **Injector Testing**, at this time. Sit back and let the colors, motion, and sound help you learn. When the program ends, turn to page 81 and continue as instructed.

REVIEW EXERCISE: INJECTOR TESTING

You're on the last leg now. By this time you've been through the identification and operation of many Robert Bosch pumps and governors, waded through their alphanumeric product designations, serial numbers and more. You've also seen how nozzles operate and how to service, recondition, and test them. Now it's time to put some of what you've learned to practical use. Get a KCA nozzle holder assembly, one that is NOT used for a GM application, and complete the following exercise. You may refer to any or all of the review guides for the modules you have completed to help you find your answers.

Locate the following information on the nozzle holder assembly:

1. Nozzle Holder Product Designation _____

2. Factory Code _____

3. Manufacturing Date Code _____

Use the Equipment List Microfiche (from Module 2) to locate the following:

NOTE

> If the nozzle holder assembly you have selected is not listed in the Equipment List Microfiche Cards from Module 2, have your supervisor assist you in locating this information in your shop set of microfiche cards.

4. Engine or Equipment _____

5. Specified Opening Pressure _____

Connect the nozzle to the nozzle tester to determine:

6. Actual Opening Pressure _____

7. Leakage Yes____ No____ (With pressure 20 bar below specified opening pressure, no drop should fall from nozzle tip within 10 seconds.)

8. Chatter Yes____ No____

9. Spray Pattern Good____ Bad____ Why? _____

Disassemble Nozzle Holder Assembly

10. Nozzle Product Designation _____

11. Shim Thickness (Measure with micrometer) _____

Clean and reassemble nozzle holder assembly. Torque nozzle nut to 80 Nm and retest.

12. Opening Pressure _____

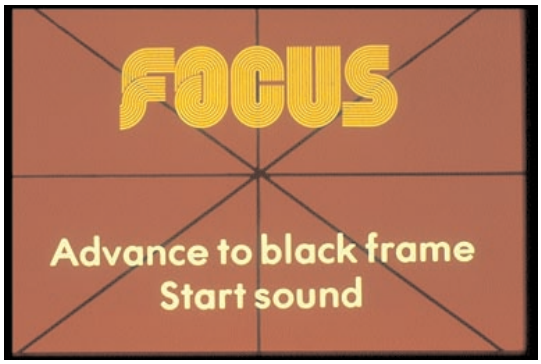
13. Leakage Yes____No____(See Item 7)

14. Chatter Yes____ No____

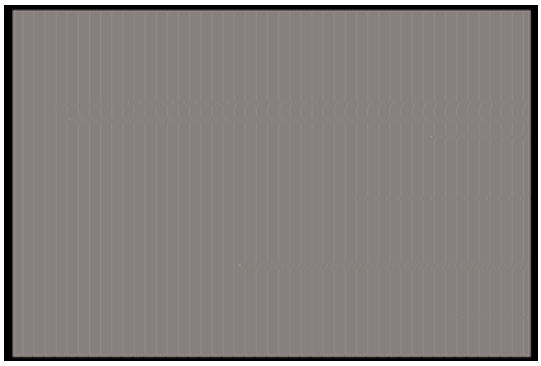
15. Spray Pattern Good____ Bad____ Why? _____

When you have finished this exercise, have your instructor or supervisor confirm your findings. Have your instructor or supervisor record your progress on your Student Progress Sheet and order your final exam.

Congratulations! You've made it through PRE-TECH Phase I. While you are waiting for your final exam to arrive, review the information contained in all of the review guides, especially any areas that are not clear to you. If you have any questions about this material, be sure to ask your instructor or supervisor.



1. FOCUS

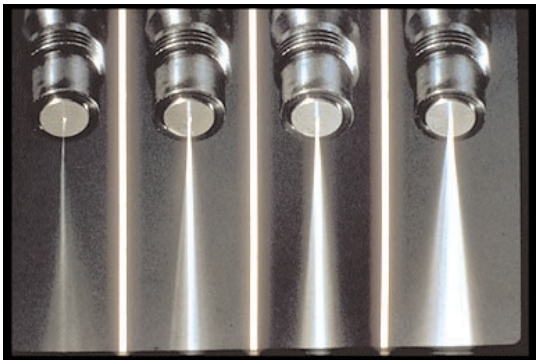


2. BLACK

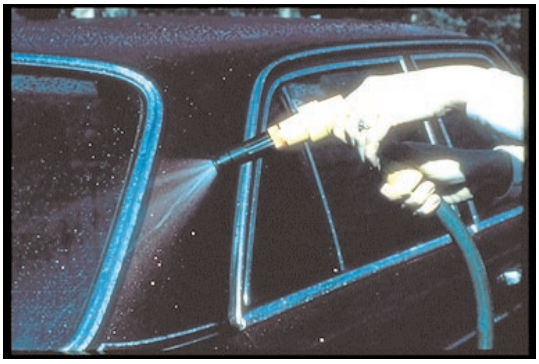
3. Injector testing — for opening pressure, leakage, chatter and spray pattern — that's what you'll be able to do when you finish this program,

4. . . . brought to you by Robert Bosch. This is the fourth in this series covering injectors and nozzles.

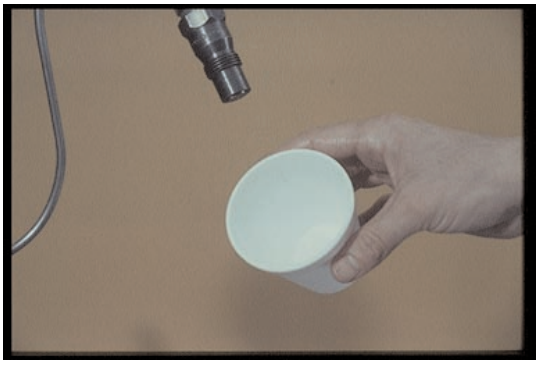
5. When you pump fast with the tester handle, you can build up pressures,



6. . . . to open the nozzle and deliver fuel, as in the engine. The action is slowed by high-speed photography. You should know that these high pressures can be dangerous.

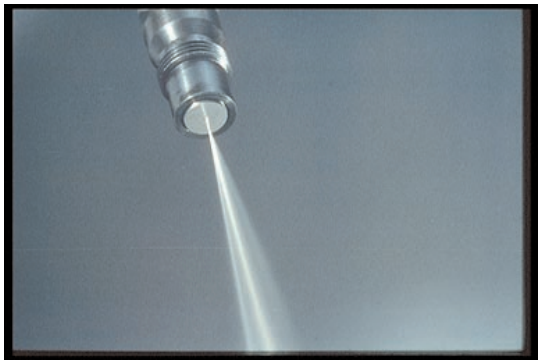


7. Spray from a low-pressure nozzle like this can't hurt you; it may even be fun to put your hand in it. But injection-pressure is another thing.

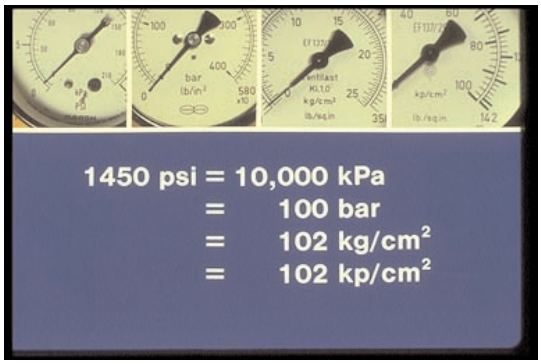


8. Take something like this coffee cup — far thicker than your skin — see what high-pressure fuel injection can do.

9. Just like this, nozzle spray pressure can penetrate your skin; it can destroy skin tissue.

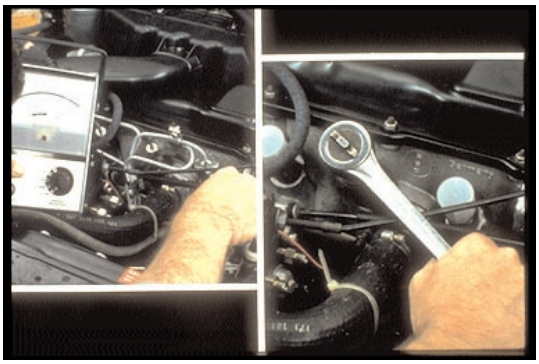


10. In your blood stream, this can cause blood poisoning. Keep your hands out of any spray — and always wear glasses for eye-safety. High-pressure test oil can seriously damage your eyes.

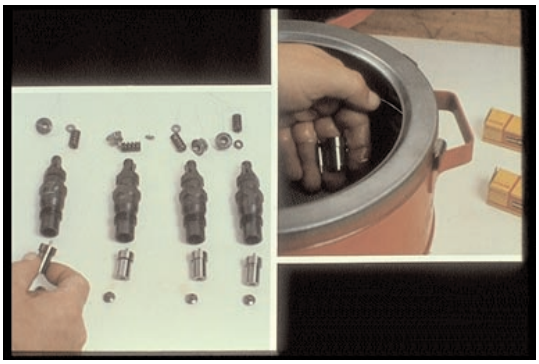


11. You may find pressure gages reading in p-s-i, or in various metric units — easily changed without a lot of math. Most early units will phase out leaving kiloPascals and bar. Now that you know about pressure gages and tester safety,

12. . . . you'll want to know when to use it. You'll use it for diesel nozzles; gasoline testers are for low-pressure nozzles only.



13. Use the injector-tester when you're troubleshooting the engine and you suspect one or more injectors.



14. Use it whenever you have a reconditioned injector and whenever a new nozzle has been installed in a nozzle-holder; also routinely during any overhaul of an engine.

15. Use it only with cleanliness and in your better clean-room facility. Use a lint-free cloth or clean compressed air to clean the fittings.

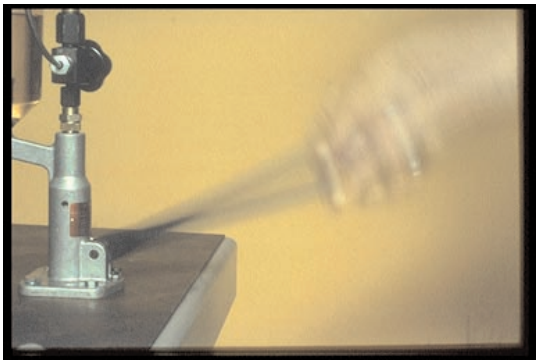
16. Your test oil should be clean filter test oil, or as called for in your specs.

17. Diesel fuel is not recommended; when it gets old, it may form gum. Kerosene is usually forbidden; it's so flammable, it's unsafe in spray-testing.

18. At regular intervals, have your tester checked against a known standard injector — more important than ever with today's tighter tolerances.

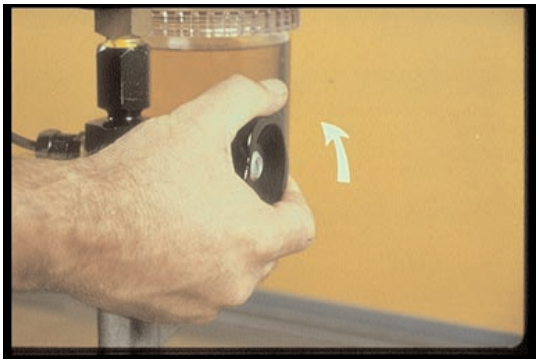
19. When your tester is ready, connect your first injector to be tested and snug it down.

20. Close the valve to protect the gage mechanism. Close it whenever you're going to stroke rapidly.



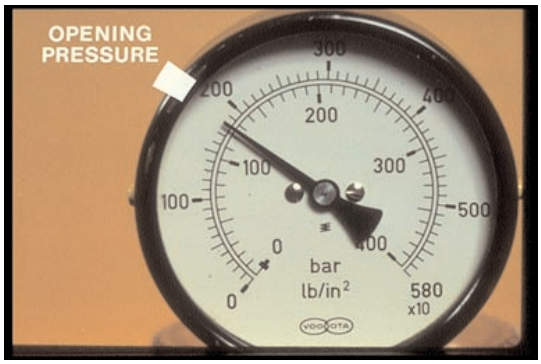
21. Rapid strokes bleed the system; they could also damage the gage. Stop now for review of preparation for testing.

22. You can find opening pressure specs in the microfiche, in the engine manual, and sometimes on the nozzle holder itself.

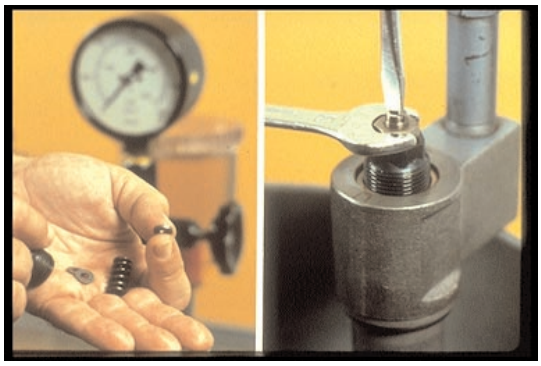


23. To measure the pressure, you'll need to pen the gage valve — open it just slightly.

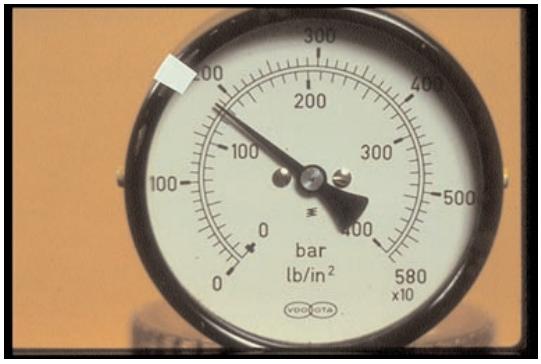
24. Now, slowly apply pressure; using your arm like this, you can control it better. If necessary, pump to maintain the pressure. When the spray starts,



25. . . . that's your opening pressure — in this example (on the inner scale) 125 bar. This one is within checking tolerance from 120 to 130. What if opening pressure were not in spec?

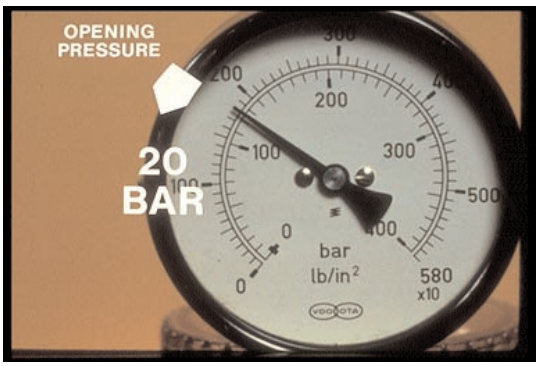


26. Some injectors need disassembly — in the best clean-room facilities — to change the shims; in others, you turn the adjusting screw without disassembly.

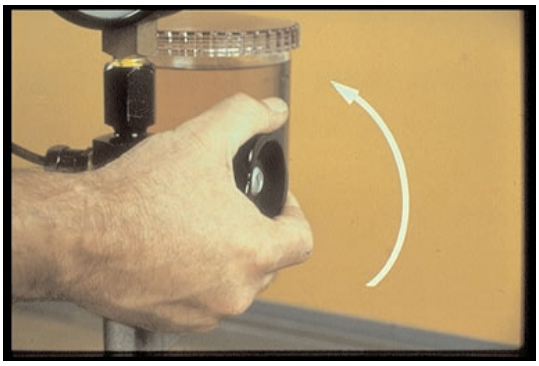


27. Whenever you set opening pressure, set it toward the high-end so it will stay in tolerance after the injector seats in. Stop now for review of the opening pressure test.

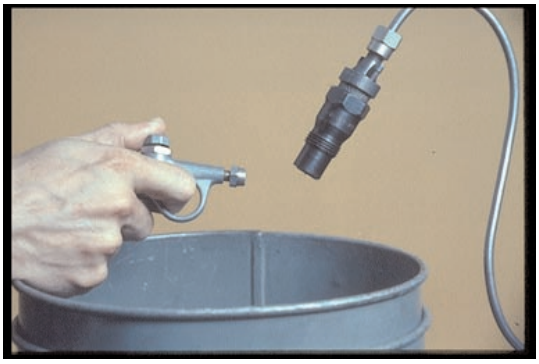
28. The leak-test tells you whether the nozzle will drip below opening pressure — causing engine smoke.



29. At twenty bar below opening pressure of this nozzle, you want to be sure it does not open enough to drip one drop.



30. Open the valve further, about one full turn.

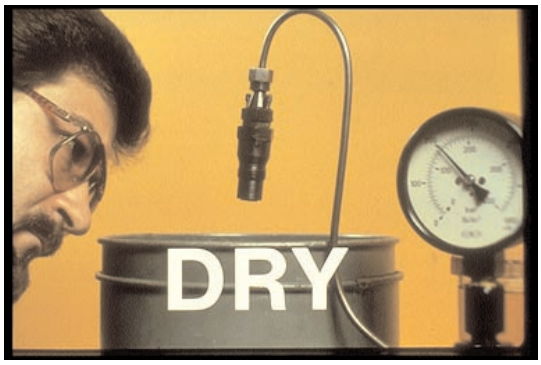


31. You have to start with a dry nozzle tip. Use air or dab it with a lint-free cloth.

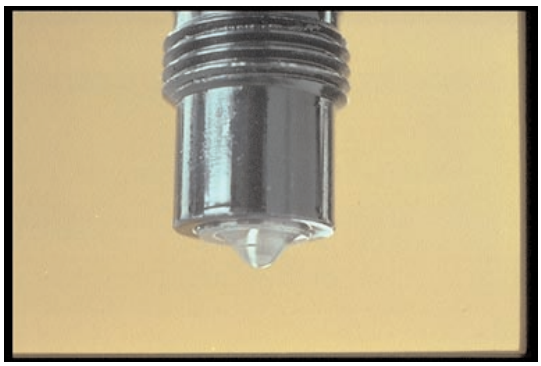
32. Your valve is open so you are stroking slowly just to build pressure and hold it.

33. For your leak test, in this example, you want to build and hold to 20 bar less than opening pressure, or as specified.

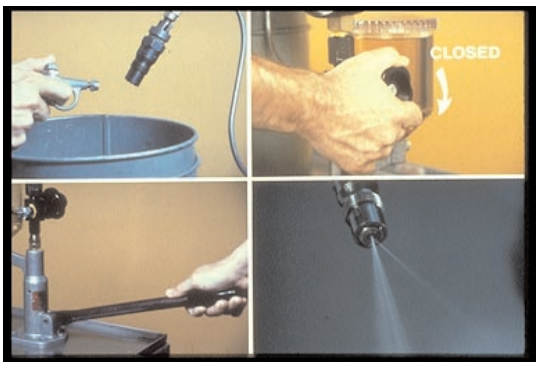
34. Hold pressure and watch the tip for ten seconds, but, of course, only with your eyes protected.



35. Most nozzles will stay dry — you can tell right away they're OK.

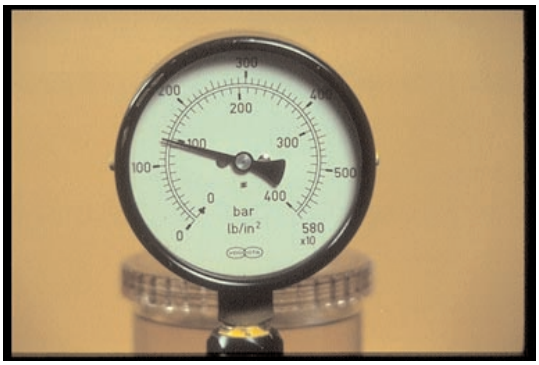


36. If a drop forms, count the time. If the drop falls off in 10 seconds, clean and retest the nozzles; if it still drops one drop, the nozzle should not go back in the engine.



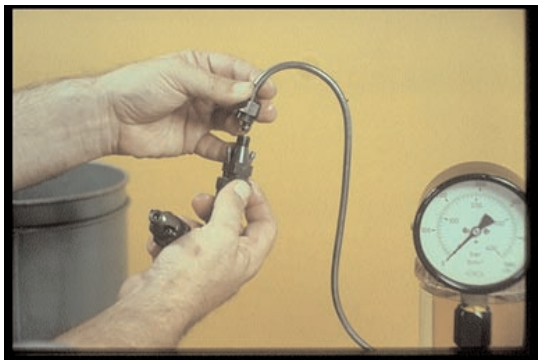
37. See if you can clear it out; dry the tip, close the gage; a few fast strokes may clear it. But if you still see the spray pattern of a contaminated needle, or if fails the leak test, don't try to lap it; replace it.

38. For some nozzles, you'll need to slip on clear plastic lines like this to hold extra leak-off fuel. Otherwise fuel runs down the side and fools you into thinking this nozzle won't pass its leak test.



39. Be sure to check your specs for proper test pressure; here's a special case — use 95 bar to leak-test a nozzle used in Chevrolet 6.2 liter engines. Stop now to review leak test.

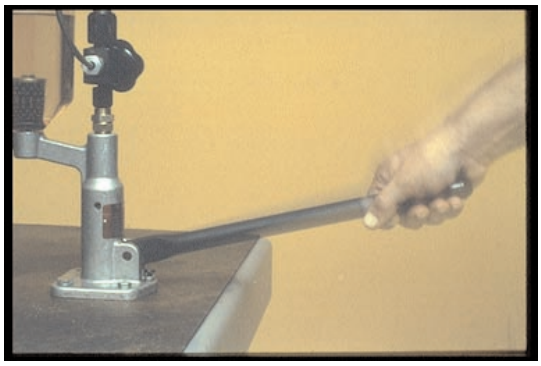
40. The chatter test has changed since the old days. Let's see how. First, you'll see chatter and spray patterns of good pintle nozzles that are OK; perhaps reconditioned or new.



41. Check your specs: some nozzles chatter only softly, depending on how fast you pump the handle. In general, spray patterns should be judged only when pumping the tester handle fast, fast, fast.

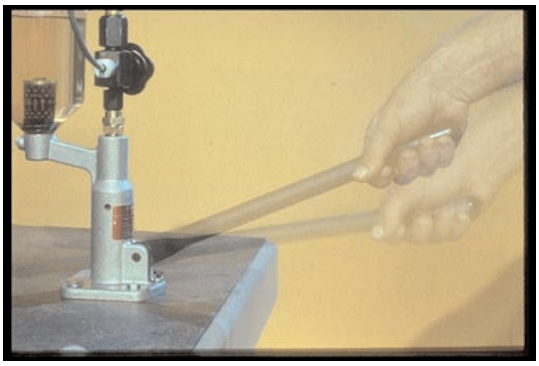
42. You want the valve closed because later, you're going to pump fast enough to damage the gage.

43. You can check the spray angle from the code on the nozzle. On this nozzle, the first numbers after DN — 12 degrees.



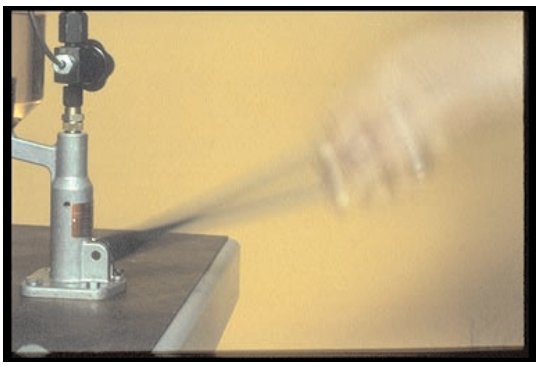
44. For a good D-N nozzle, what is the pattern when you pump slowly — this rate is about one per second?

45. You will hear a soft chatter, very soft. But as you can see in this high-speed photography, the spray pattern is stringy, with split streams. Does this mean a bad injector? No. At slow pumping, neither a bad pattern nor a bad sound means a bad injector.

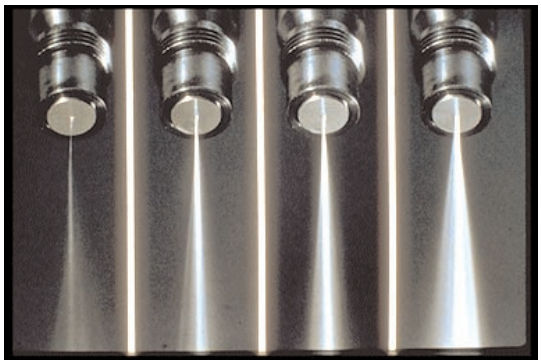


46. Suppose you pump the tester at medium speed, at a rate of about three per second.

47. At this rate, the chatter disappears — changes to a hiss. And the pattern is not good. Is the injector bad?



48. At a faster rate, about 5 per second, you will hear a good chatter. But notice, at this pumping rate, the chatter is high-pitched. So you see, chatter usually depends on how fast you pump.



49. When you pump fast, you should see a good pattern, here slowed by high-speed photography. You have a good nozzle. But you must check your manuals to know what pumping rates should produce what kind of chatter. To judge spray-pattern, be ready to pump fast. Fast pumping is the way to test patterns.

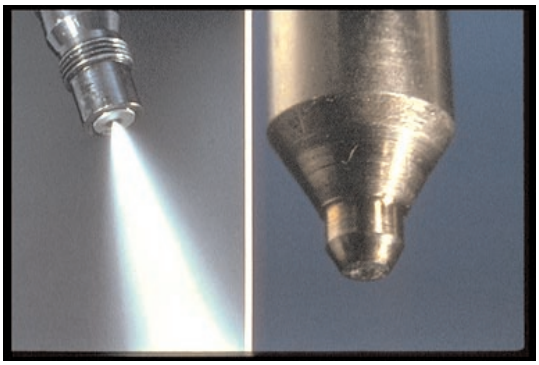
50. What about spray-patterns of pintle nozzles that are used? Fast-pumping is the way to test patterns. If they're not OK, what can they look like before cleaning, just as they came out of the engine?

51. You might see this pattern from the coking of the needle as a result of combustion gases being forced inside the nozzle body. Judge such a nozzle by the pattern, not by the sound.

52. Here's a pattern resulting from contamination. Remember, don't reject a nozzle by its sound.

53. When a nozzle is not seating, its spray-pattern may look like this; or when it's leaking, like this below opening pressure. It's two views of the same problem. Clean the nozzle or replace it.

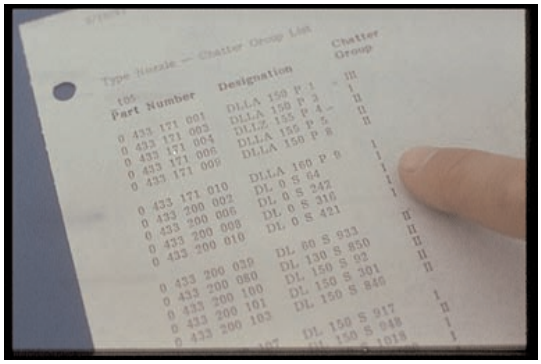
54. This spray-pattern is caused by a bent pintle, the result of careless handling. And if the handling is rougher,



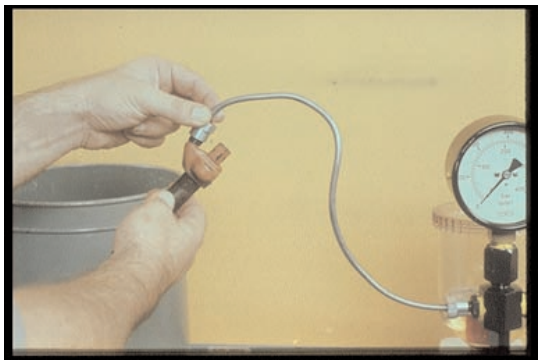
55. . . . the pattern can look like this — from a broken pintle — the tip is gone!

56. So is this one. You've seen a few of the spray patterns of pintle nozzles, used, before cleaning. Stop now for review of pintle nozzle chatter and spray.

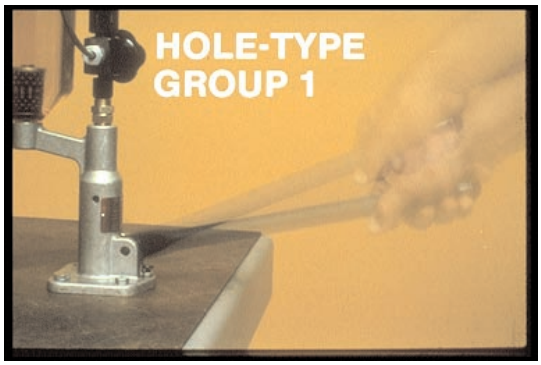
57. In this chapter, you'll see chatter and spray patterns from good hole-type nozzles.



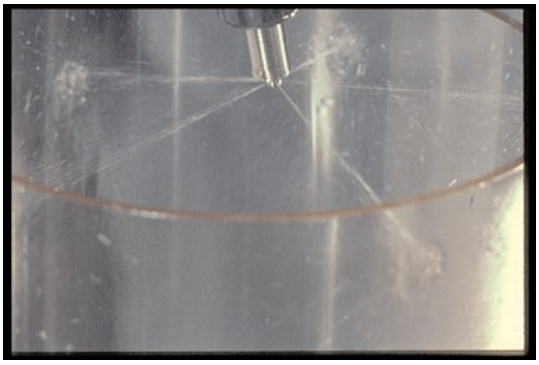
58. When you check the specs for testing, you'll find three chatter groups which define chatter and spray patterns according to pumping rates. Group one is widely used in the United States and Canada. Groups two and three differ mainly in lack of chatter at intermediate pumping speeds.



59. Install the nozzle; snug it tight and be sure to close the gage. Testing hole-type nozzles for opening pressure and leak-testing is the same as for pintle nozzles

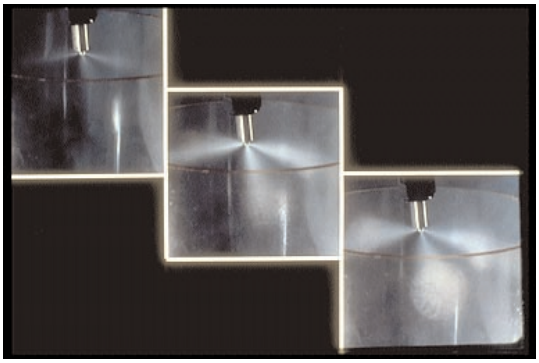


60. In all groups, good nozzles, at low pumping speeds, like this, good chatter.



61. But, at this slow pumping rate, the spray pattern is not good — it is divided, with coarse atomization.

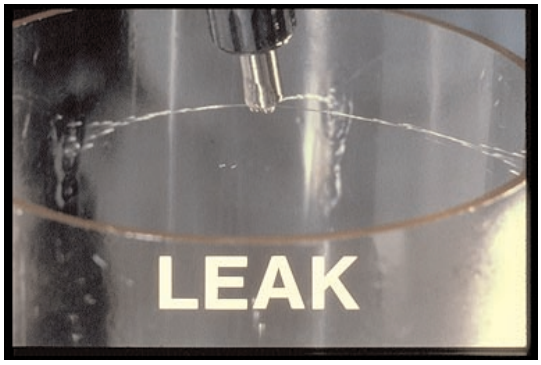
62. What happens when you stroke fast?



63. At fast strokes like this, good chatter and the spray pattern becomes uniform and well atomized for all groups. However, in Groups two and three, at intermediate speeds, you will not hear chatter or see a good pattern like this; check your manual.

In contrast to new nozzles,

64. . . . look at spray-patterns from hole-type nozzles which are used, before cleaning? And fast pumping is the only way to test.



65. A leak at the needle seat could deliver fuel in a pattern like this.

66. In a hole-type nozzle, poor atomization can cause this kind of pattern.

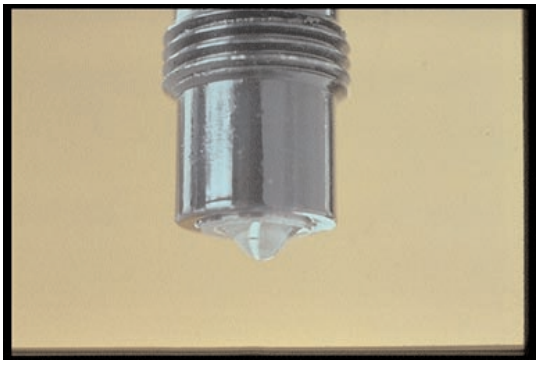
67. Contaminated fuel can clog the delivery holes of this hole-type nozzle, causing this kind of pattern.

68. Coked holes produce this kind of pattern. Remember, you are seeing high-speed photography, a look inside the blurred spray pattern that you would normally see.

69. In this program, you have seen the power of nozzle spray-pressure. You know that high-pressure fuel can severely injure your skin or your eyes.

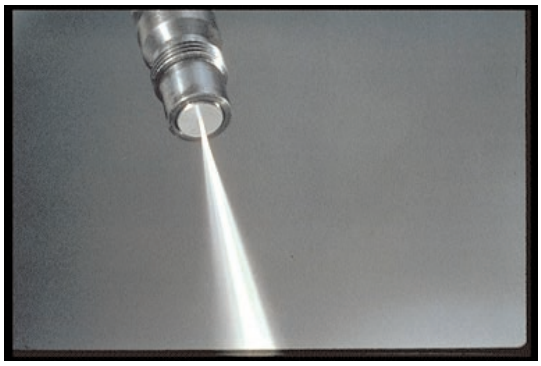
70. You know the importance of clean test oil, in a clean tester, in a clean workplace.

71. You know how to apply measured pressure — for opening pressure or leak testing.



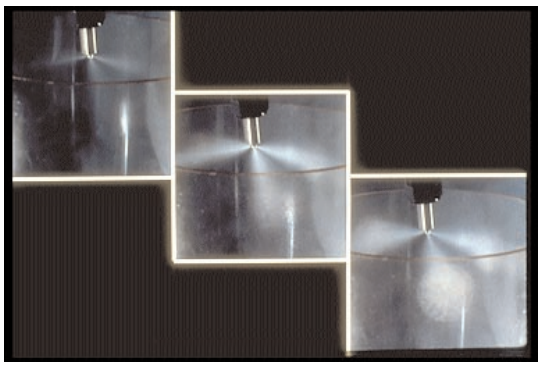
72. You know one drop can form. If it does not fall off in 10 seconds, the nozzle tests OK.

73. You've got the message — at slow tester pumping, you might see a poor spray pattern like this, but that doesn't mean a bad injector. You might hear a good, soft chatter like this. And that doesn't mean a good injector.



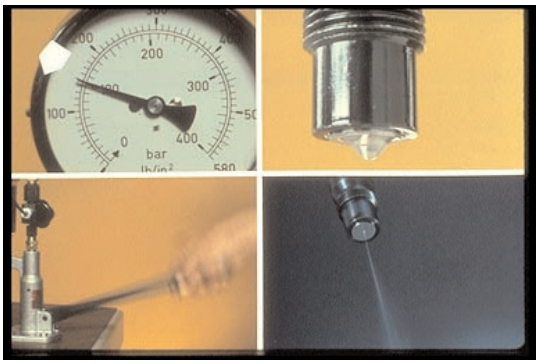
74. But, at fast pumping of a good pintle nozzle, you should generally see a good spray-pattern and hear a high-pitched chatter. Check your manuals for your specific nozzle.

75. Even when you pump fast, a coked nozzle will show a poor spray pattern like this.



76. When you fast-pump a good hole-type nozzle, you expect to see a good spray pattern like this, and hear a good chatter, like this. You know the difference between a good hole-type spray pattern,

77. . . . and a poor pattern, such as from a contaminated nozzle, like this. Judge a nozzle as bad by its pattern, not by its sound.



78. You know how to test injectors for opening-pressure — leak-test — chatter — and spray-pattern.

79. You know how important it is to keep them clean when working with these precision injectors,

80. . . . brought to you by Robert Bosch.

REVIEW EXERCISE ANSWER PAGE

INJECTOR OPERATION

1. c
2. c
3. b
4. a
5. a
6. c
7. a
8. a
9. b
10. b

INJECTOR SERVICING

1. b
2. c
3. c
4. a
5. c
6. b
7. a
8. b
9. a
10. a

INJECTOR RECONDITIONING

1. c
2. b
3. a
4. c
5. b
6. a
7. b
8. a
9. b
10 c

INJECTOR TESTING

Instructor or supervisor to confirm student answers.