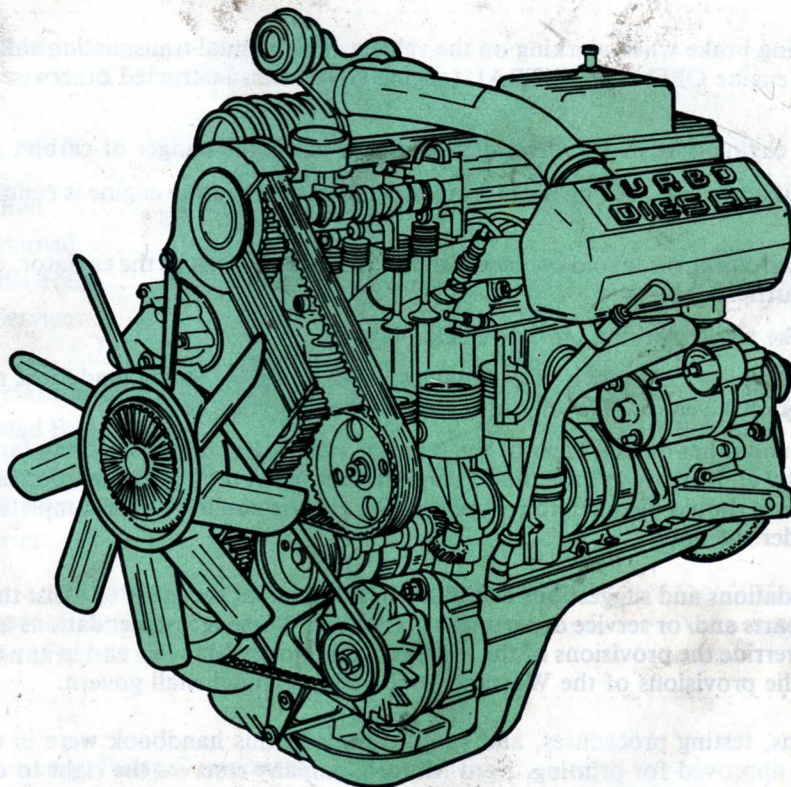


# 2.4L Diesel Engine



**Ford Parts and Service Division  
Training and Publications Department**



## IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as for the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools, or parts.

As you read through the procedures, you will come across **NOTES, CAUTIONS, AND WARNINGS**. Each one is there for a specific purpose. **NOTES** give you added information that will help you to complete a particular procedure. **CAUTIONS** are given to prevent you from making an error that could damage the vehicle. **WARNINGS** remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general **WARNINGS** that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. The manual transmission shifter lever should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.



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# OBJECTIVES

## AFTER STUDYING THIS MANUAL, YOU SHOULD BE ABLE TO CORRECTLY:

- Identify and locate engine components and describe their function.
- Locate engine accessories and describe their function.
- Diagnose and correct fuel and glow plug system problems.
- Check and adjust valve clearance.
- Check cylinder compression.
- Check engine oil pressure.
- Replace and adjust drive belts.
- Describe the operation of the fuel injection system.
- Check and adjust fuel injection pump timing.
- Adjust engine idle speed.
- Diagnose, repair, and adjust the cold-start accelerator.
- Remove and install fuel injection nozzles.
- Clean, test, and adjust fuel injection nozzles.
- Remove and install air, oil, and fuel filters.
- Drain water from the fuel conditioner.
- Describe the glow plug system.
- Remove and install glow plugs.
- Check glow plugs and glow plug system.
- Describe the turbocharger system.
- Check turbocharger charging pressure.
- Determine the cause of incorrect charging pressure and replace the component(s) responsible for the incorrect reading.

**WARNING:** Never use ether or any other starting fluid in the 2.4L engine. The glow plugs may ignite the starting fluid causing an explosion which could result in severe engine damage or personal injury.

**NOTE:** Many of the illustrations in this book contain basic part numbers for the components shown. Use these numbers to assist in ordering parts.



# INTRODUCTION

Beginning with the 1984 model year, Ford Motor Company will be offering the 2.4L diesel engine, built by BMW of Germany, as an option in some luxury automobiles. The 2.4L engine is an in-line six-cylinder, four-stroke cycle, overhead cam engine that incorporates many notable features such as:

- Turbocharging
- Mechanical lifters
- Dual, low restriction exhaust
- Mounting at a 20 degree lean to the right
- EGR
- Fuel conditioner containing a water/fuel separator and fuel heater
- Bosch fuel injection system
- Aluminum cross flow cylinder head
- Finger follower rocker arms
- Belt-driven fuel injection pump

- Engine-driven fan plus an auxiliary electric fan
- External engine oil cooler
- Canister-type oil filter with replaceable element
- Deep skirt block
- Camshaft-driven vacuum pump
- Glow plug system
- Electric fuel supply pump
- 110 volt electric block heater

You will find that this engine is one of the most heavily monitored diesel engines used by Ford Motor Company. This can be attributed mainly to the fact that this engine is turbocharged, has EGR, and a glow plug system. While the component layout beneath the hood is clean and functional (Fig. 1), it is rather compact. Therefore, in the service portions of this book, you are asked to pay particular attention to the directions on the best way to service the components.

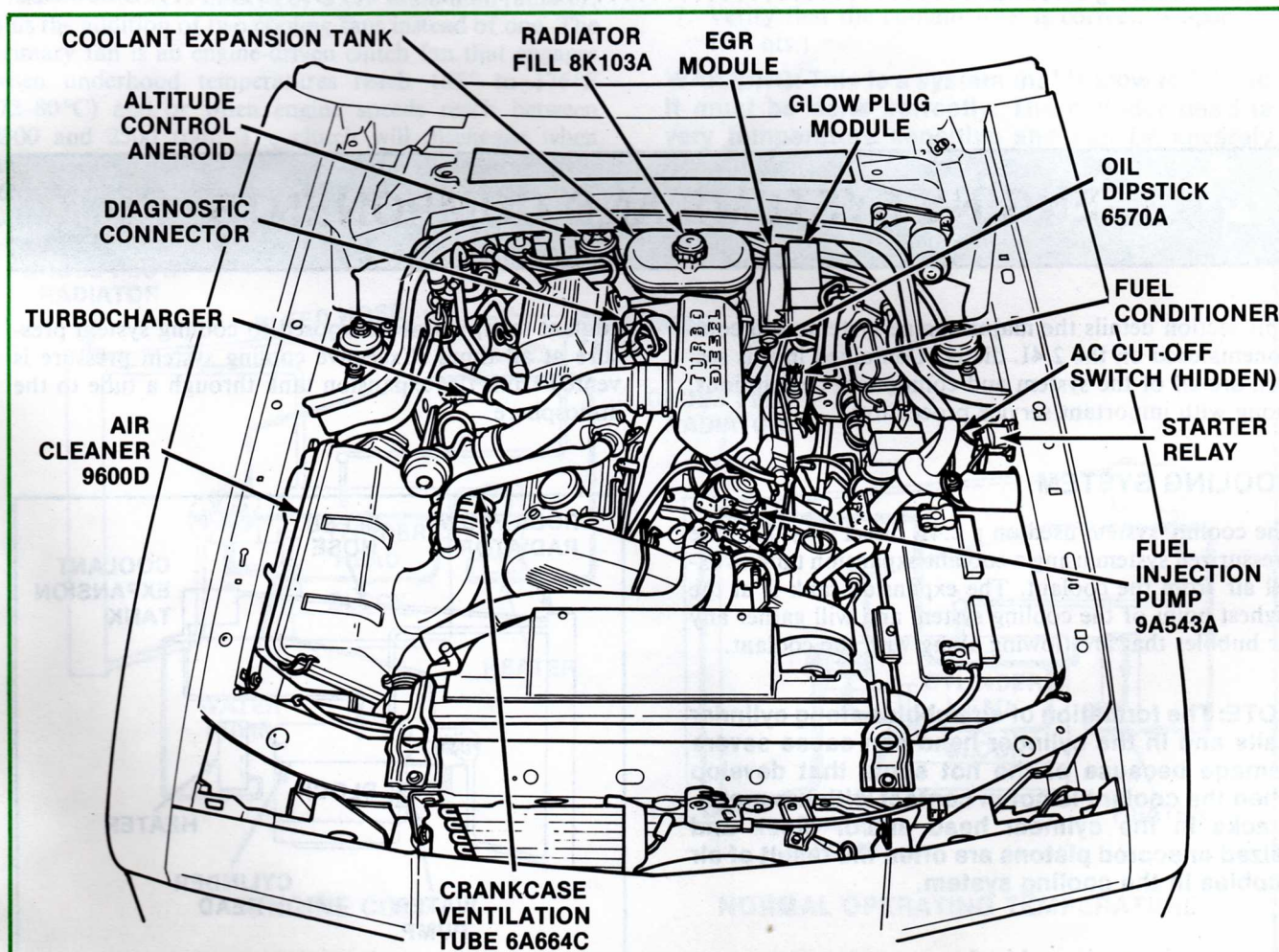


Figure 1. Underhood Component Layout



## GENERAL SPECIFICATIONS

Engine Model .....	2.4L Turbo Diesel
Valve Arrangement.....	OHC
Cylinder Arrangement .....	In-line, 6 cylinders
Bore x Stroke .....	3.15 in x 3.19 in (80 x 81 mm)
Displacement .....	149 cu in (2442.9 cc)
Compression Ratio .....	22:1
Horsepower .....	114 (85 kw)
Maximum Engine Speed .....	5350 ± 100 rpm
Rated Engine Speed .....	4800 rpm
Minimum Torque .....	150 lb-ft (210 N·m) at 2400 rpm
Compression Pressure .....	Minimum 348 psi (2400 kPa) at 200 rpm
Combustion Chamber .....	Swirl type—Indirect injection
Fuel Injection Pump—49 State .....	Bosch VE—Distributor-type with Altitude and Boost Compensation
Fuel Injection Pump—California .....	Bosch VP-20 Distributor-type with Altitude and Boost Compensation
Firing Order .....	1-5-3-6-2-4
Engine Rotating Direction .....	Clockwise

## ENGINE SYSTEMS AND COMPONENTS

This section details the major engine systems and components used on the 2.4L diesel. Contained in this section are all of the system and component descriptions, along with important service procedures.

### COOLING SYSTEM

The cooling system used on a 2.4L diesel (Fig. 2) is the pressurized system using a coolant expansion tank to expel air from the coolant. The expansion tank is at the highest point of the cooling system and will gather any air bubbles that are flowing along with the coolant.

**NOTE: The formation of air bubbles along cylinder walls and in the cylinder head can cause severe damage because of the hot spots that develop when the coolant is not in contact with the metal. Cracks in the cylinder head and/or block and seized or scored pistons are often the result of air bubbles in the cooling system.**

The expansion tank used in this system is not the same as a coolant recovery tank because there is a flow of

coolant to it, and it is exposed to cooling system pressure at all times. Excessive cooling system pressure is vented from the expansion tank through a tube to the atmosphere.

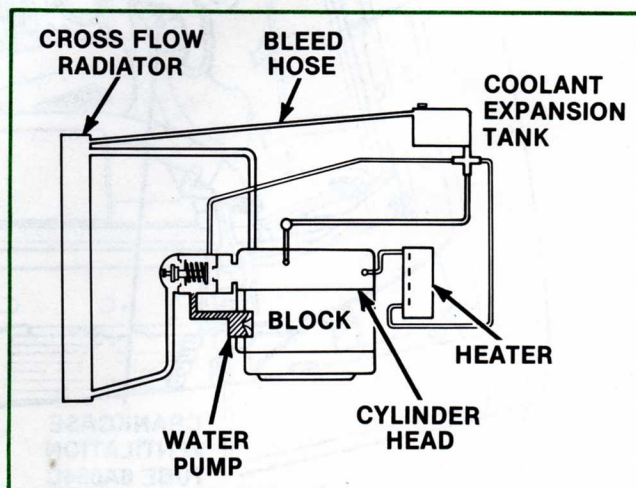


Figure 2. 2.4L Diesel Cooling System



# ENGINE SYSTEMS AND COMPONENTS

**NOTE: The cooling system is filled at the expansion tank in this system.**

The water pump used on the 2.4L diesel is a centrifugal type that is belt-driven off the crankshaft. Coolant flow is controlled by a dual-acting thermostat that is located on the inlet side of the engine on the lower part of the block. Coolant flow during warm and cold operation is shown in Figure 3. Note that coolant flow through this engine is longitudinal rather than up and down. This assures more uniform temperatures through the engine. Opening temperature of this thermostat is approximately 176°F (80°C).

Coolant used in this engine must meet Ford Spec ESE-M97B44-A; it should be mixed in a 50/50 ratio with water.

**CAUTION: Use of coolants that do not meet Ford Spec ESE-M97B44-A, could cause damage to the aluminum cylinder head and to other aluminum engine components.**

Efficient cooling is ensured by a new aluminum radiator, plus the addition of two cooling fans instead of one. The primary fan is an engine-driven clutch fan that engages when underhood temperatures reach 162° to 176°F (72–80°C) and/or when engine speeds reach between 2300 and 2500 rpm. The clutch will disengage when underhood temperatures fall below 149° to 158°F (65°–70°C) or when engine speed falls below 800 rpm.

The other fan is an electric “pusher” fan mounted in front of the radiator. The pusher fan is designed to push air through the radiator whenever the air conditioning is on.

## Filling the Cooling System

One of the most important procedures in servicing the cooling system on the 2.4L diesel engine is the filling procedure on a dry system. To properly fill the cooling system, use the following method:

1. Fill the expansion tank with coolant.
2. Loosen the bleed screw on the thermostat housing, and maintain coolant level in the expansion tank.
3. When coolant appears at the bleed screw, close it off.
4. Start the engine and turn on the heater.
5. Maintain the coolant level in the expansion tank.
6. Run the engine at operating temperature until it won't take any more coolant, then take the vehicle for a test drive.
7. Verify that the coolant level is correct. (Capacity: 11.8 qts.)

**WARNING: This is a system that is slow to fill, but it must be done correctly. The cylinder head is very temperature sensitive and can be severely damaged if the engine is run without sufficient coolant.**

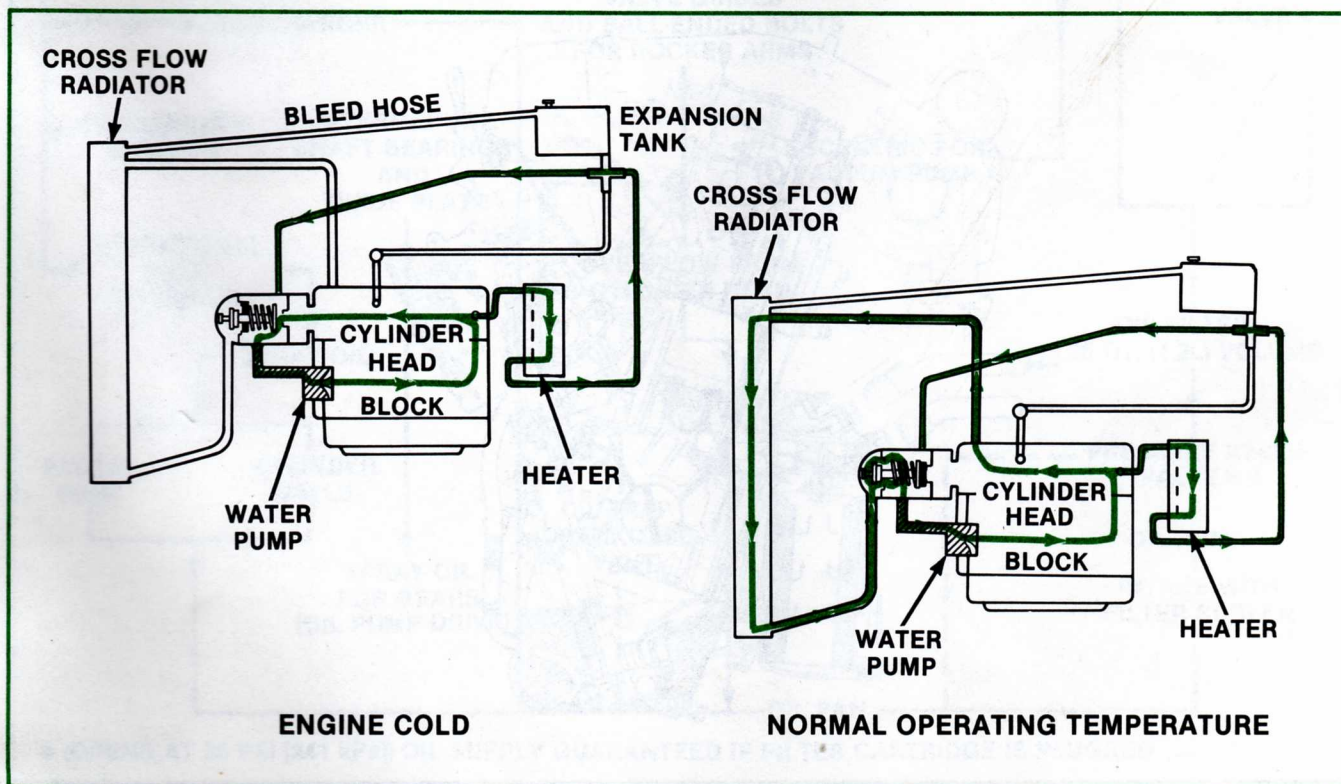


Figure 3. Coolant Flow During Cold and Normal Operating Conditions (Heater On)



# ENGINE SYSTEMS AND COMPONENTS

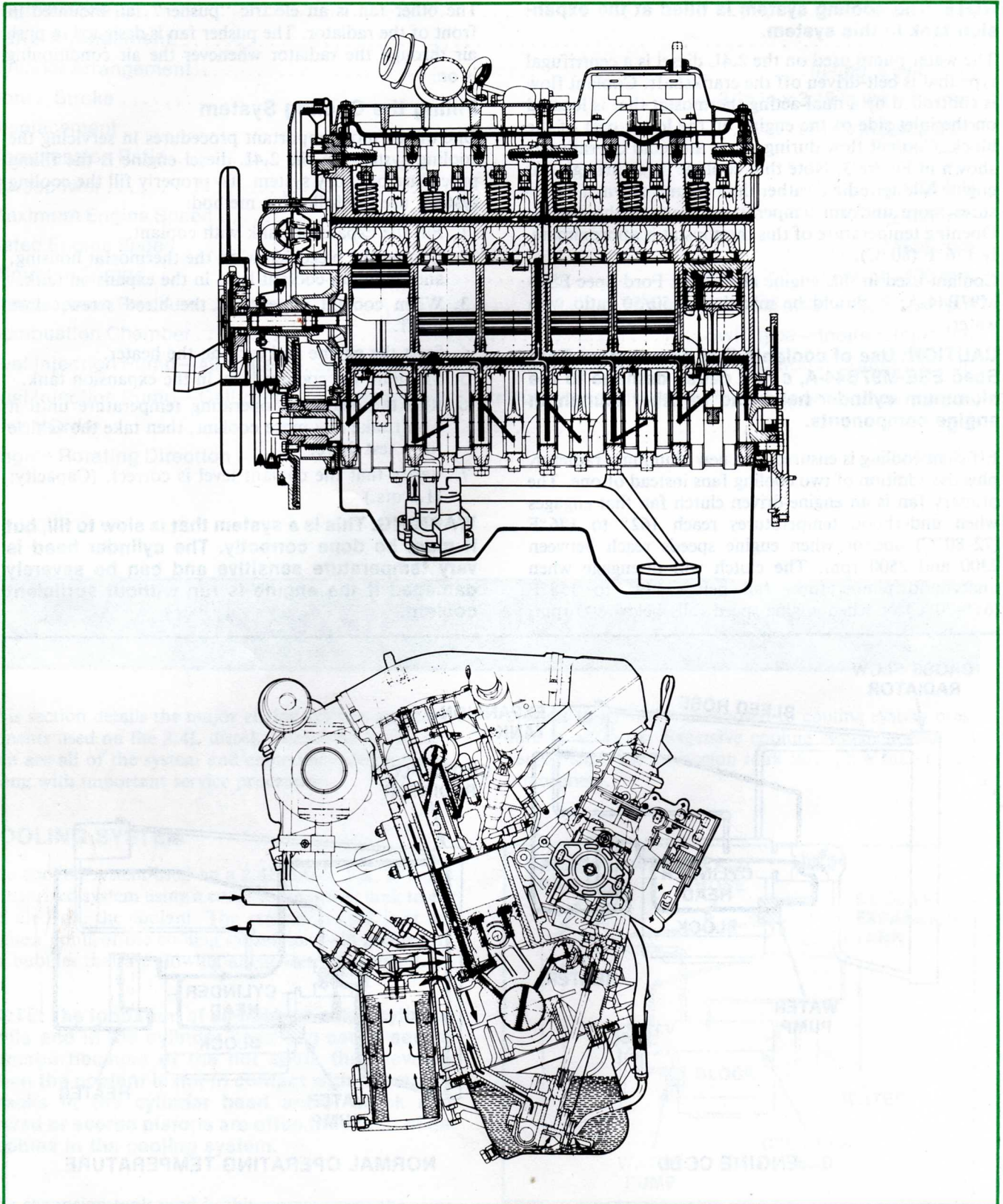
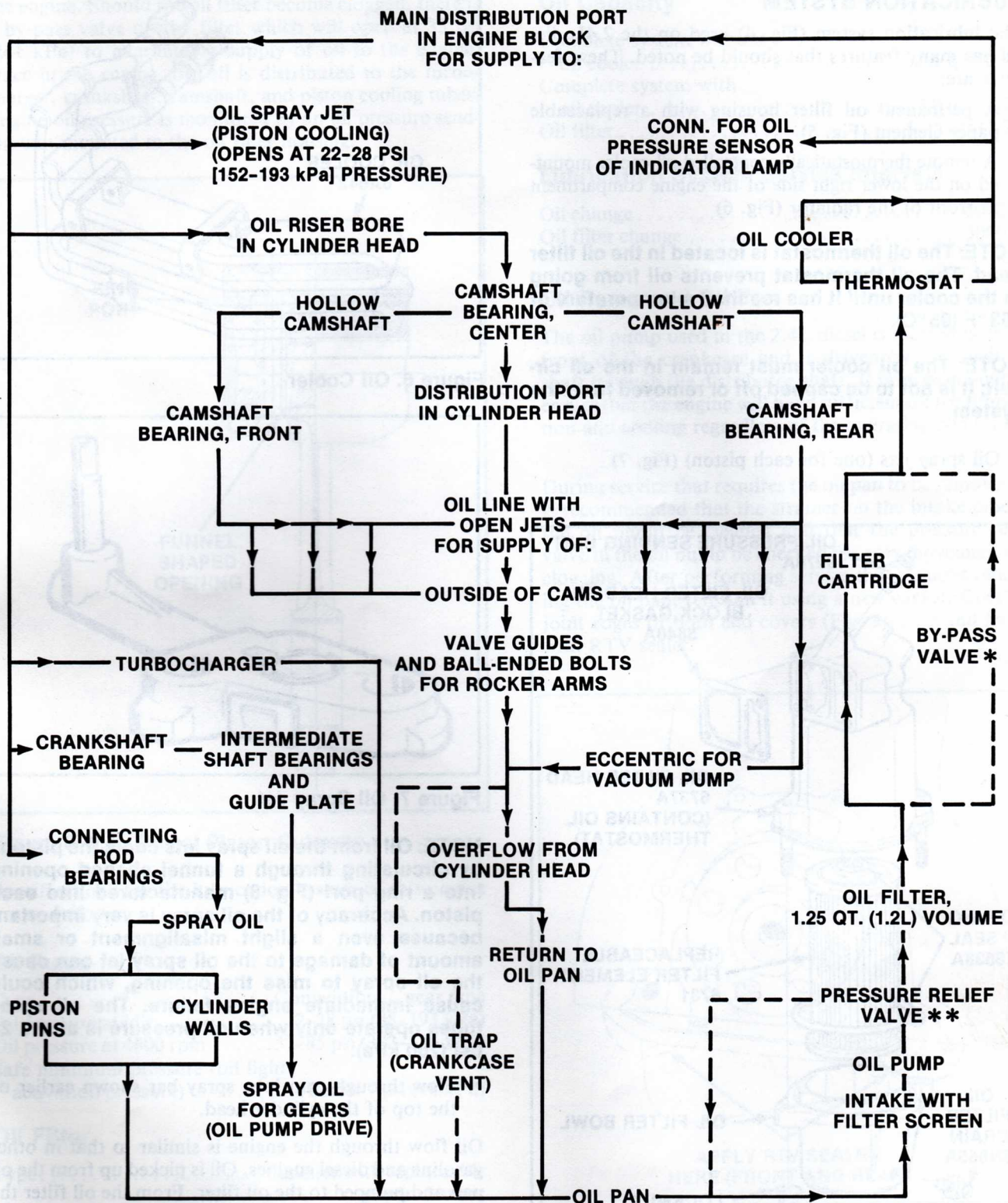


Figure 4. 2.4L Diesel Lubrication System



# ENGINE SYSTEMS AND COMPONENTS



\* (OPENS AT 35 PSI [241 kPa]) OIL SUPPLY GUARANTEED IF FILTER CARTRIDGE IS PLUGGED

\*\* (OIL PUMP) WITH COLD OIL (OPENS WITH 79-92 PSI [544-648 kPa] PRESSURE)



# ENGINE SYSTEMS AND COMPONENTS

## LUBRICATION SYSTEM

The lubrication system (Fig. 4) used on the 2.4L diesel has many features that should be noted. These features are:

- A permanent oil filter housing with a replaceable paper element (Fig. 5)
- A remote thermostatically controlled oil cooler mounted on the lower right side of the engine compartment in front of the radiator (Fig. 6)

**NOTE:** The oil thermostat is located in the oil filter head. The oil thermostat prevents oil from going to the cooler until it has reached a temperature of 203°F (95°C).

**NOTE:** The oil cooler must remain in the oil circuit; it is not to be capped off or removed from the system.

- Oil spray jets (one for each piston) (Fig. 7)

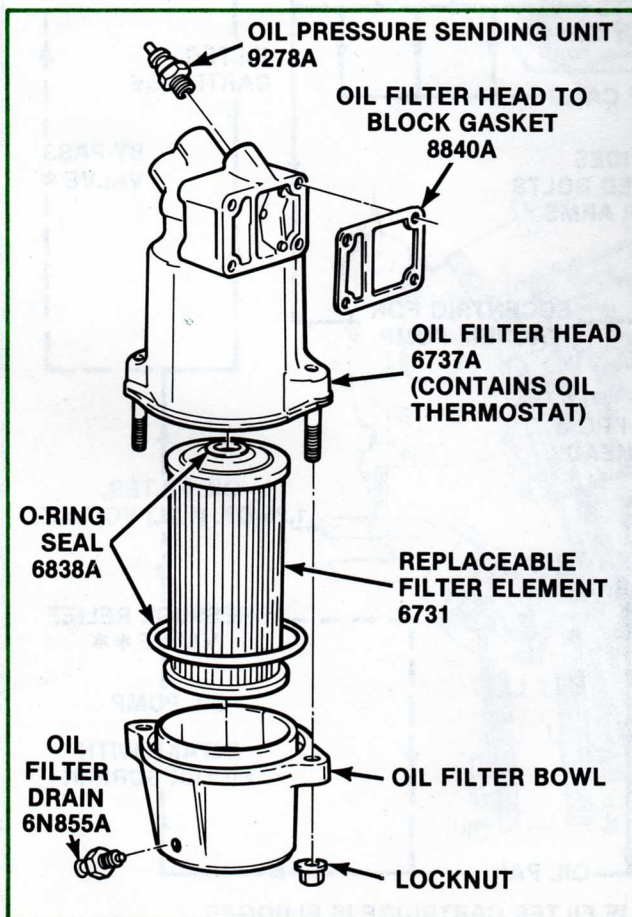


Figure 5. Oil Filter Housing and Replaceable Element

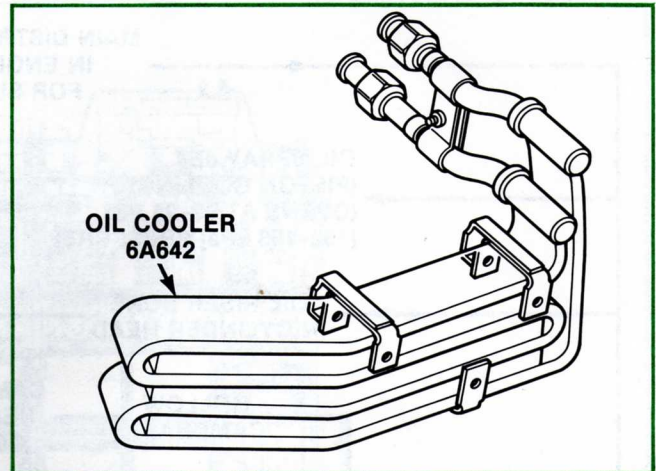


Figure 6. Oil Cooler

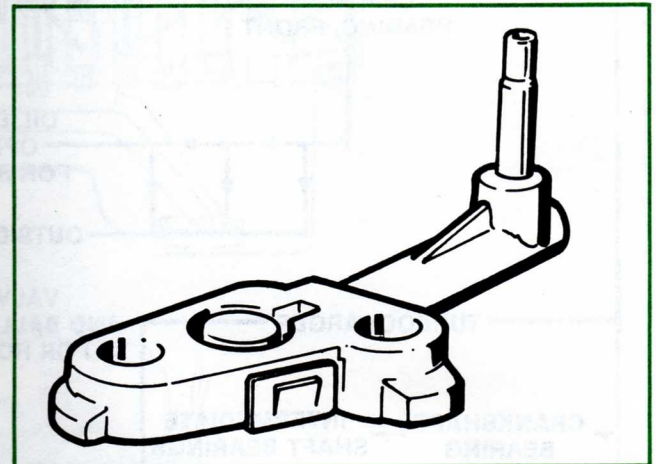


Figure 7. Oil Spray Jet

**NOTE:** Oil from the oil spray jets cools the pistons by circulating through a funnel shaped opening into a ring port (Fig. 8) manufactured into each piston. Accuracy of the oil spray is very important because even a slight misalignment or small amount of damage to the oil spray jet can cause the oil spray to miss the opening, which could cause immediate engine failure. The oil spray tubes operate only when oil pressure is above 29 psi (200 kPa).

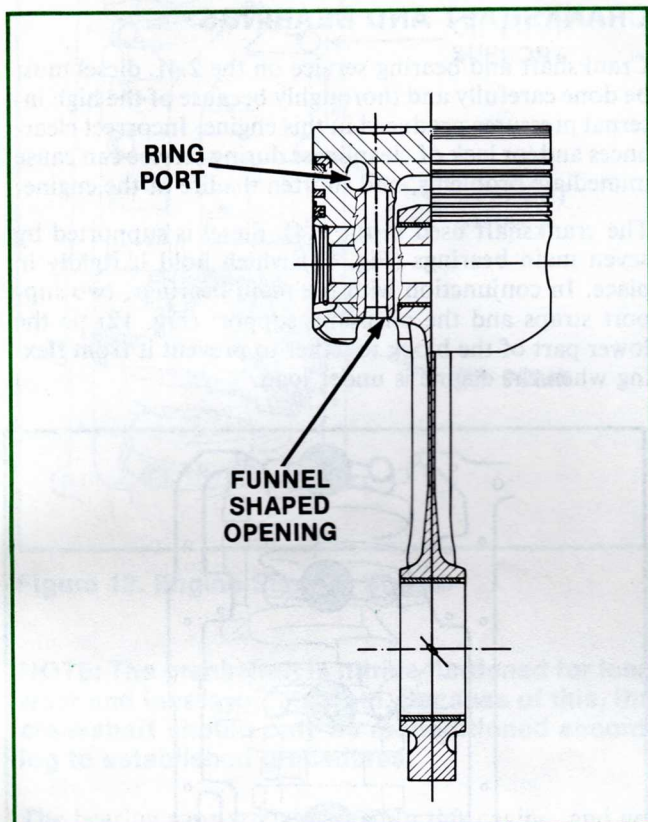
- Flow-through cam lobe spray bar shown earlier on the top of the cylinder head.

Oil flow through the engine is similar to that in other gasoline and diesel engines. Oil is picked up from the oil pan and pumped to the oil filter. From the oil filter the oil goes either to the engine or to the oil cooler, depending on the oil temperature. If the oil temperature is above 203°F (95°C), the oil is routed to the oil cooler; below this temperature, the oil is circulated directly to



# ENGINE SYSTEMS AND COMPONENTS

the engine. Should the oil filter become clogged, there is a by-pass valve on the filter which will open at 35 psi (241 kPa) to guarantee a supply of oil to the engine. Once in the engine, the oil is distributed to the turbo-charger, crankshaft, camshaft, and piston cooling tubes. Engine oil pressure is monitored by an oil pressure sending unit mounted in the oil filter housing.



**Figure 8. 2.4L Diesel Piston Cutaway**

Specifications for the lubrication system of this engine are as follows:

## Oil Pump

Type ..... Conventional, gear type  
 Oil pressure at idle ..... 7–28 psi (48–193 kPa)  
 Oil pressure at 4800 rpm ..... 57–85 psi (393–586 kPa)  
 Safe minimum pressure (oil light activation pressure) ..... Below 7 psi (48 kPa)

## Oil Filter

Type ..... Canister with replaceable paper element  
 By-Pass valve opens ..... 35 psi (241 kPa)

## Oil Capacity

Complete system without  
 oil cooler ..... 7.1 qts (6.7L)  
 Complete system with  
 oil cooler ..... 7.9 qts (7.5L)  
 Oil filter ..... 1.25 qts (1.2L)

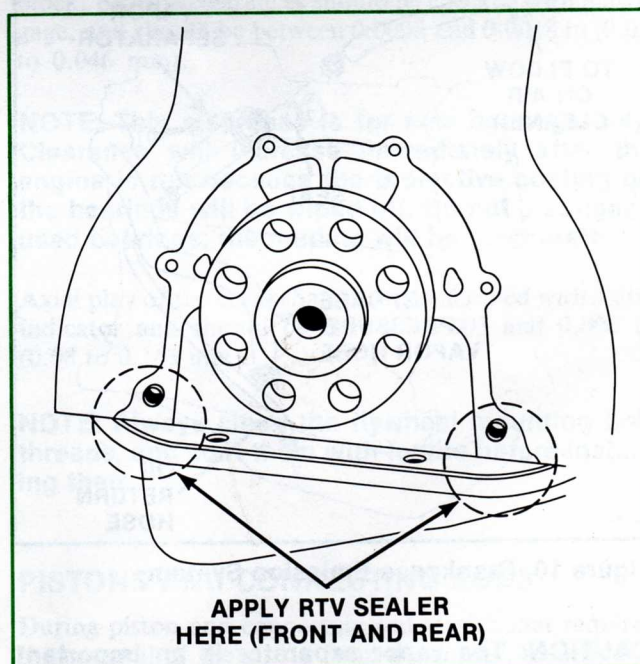
## Lubrication System Service Intervals

Oil change ..... 5000 mi  
 Oil filter change ..... 5000 mi

## Oil Pump and Oil Pan

The oil pump used in the 2.4L diesel is located near the front of the crankcase and is driven by the auxiliary shaft through the distributor shaft. It is large enough to ensure that the engine will have sufficient oil for lubrication and cooling regardless of the operating conditions.

During service that requires the oil pan to be removed, it is recommended that the strainer on the intake pipe of the oil pump be cleaned and that the pressure relief valve in the oil pump be checked for easy movement and clogging. After performing service that requires removing the oil pan, reinstall it using a new gasket. Coat the joint edges of both end covers (Fig. 9), rear and front, with RTV sealer.



**Figure 9. Oil Pan RTV Application Points**



# ENGINE SYSTEMS AND COMPONENTS

## Important Lubrication System Service Instructions

- After a cold start, never race the engine before the oil indicator lamp has gone out.
- Empty the large volume oil filter through the oil drain before removing the filter.
- Never stop an engine running at high speed, because the turbocharger will continue running and its oil supply will be interrupted. Shutting the engine off at high speeds is very hard on turbocharger bearings!
- Oil change intervals must conform to the Scheduled Maintenance Chart, which states that both the oil and filter should be changed every 5000 miles.
- Only use oil with an A.P.I. rating of SF/CD.

## Crankcase Emission System

Crankcase emissions from the 2.4L diesel engine are controlled by the crankcase emission system (Fig. 10) located on the left side of the engine. The vapor separator directs crankcase and cylinder head fumes to the elbow behind the air cleaner, without allowing any oil to get by. The fumes then go through the turbocharger and into the engine where they are burned.

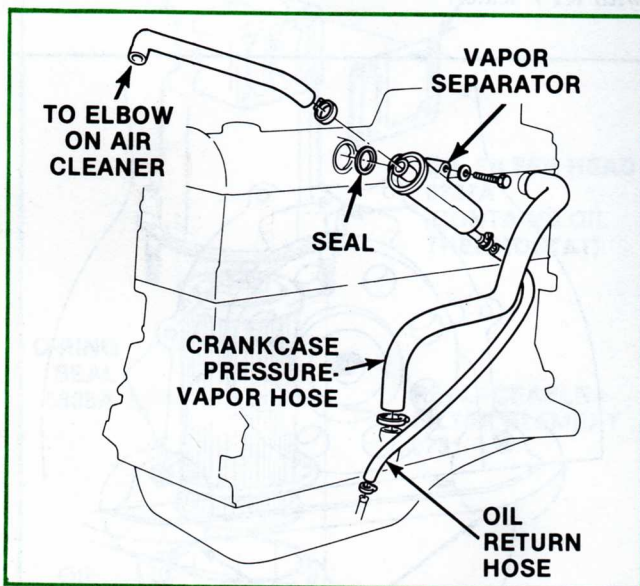


Figure 10. Crankcase Emission System

**CAUTION:** The vapor separator is an important safety feature on diesel engines because it prevents oil from getting to the combustion chamber. A diesel engine can actually run on its own crankcase oil, and an unrestricted supply of

crankcase oil would cause the engine to run away and destroy itself. If this happened, even shutting off the fuel wouldn't stop the engine. Therefore, never remove, disable, or modify the vapor separator system unless it is specifically recommended by Ford Motor Company.

## CRANKSHAFT AND BEARINGS

Crankshaft and bearing service on the 2.4L diesel must be done carefully and thoroughly because of the high internal pressures produced in this engine. Incorrect clearances and/or lack of cleanliness during service can cause immediate problems, and shorten the life of the engine.

The crankshaft used in the 2.4L diesel is supported by seven main bearings (Fig. 11) which hold it rigidly in place. In conjunction with the main bearings, two support straps and the oil pump support (Fig. 12) tie the lower part of the block together to prevent it from flexing when the engine is under load.

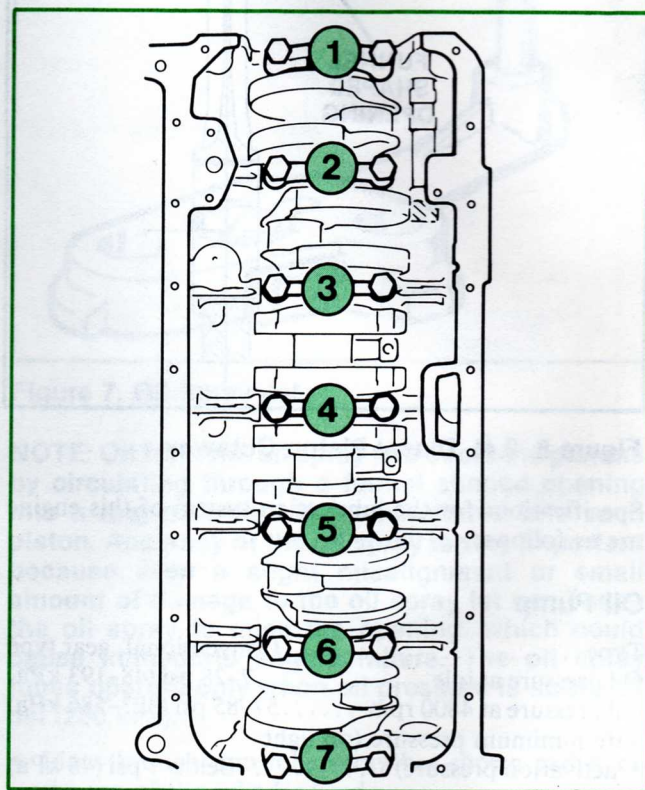
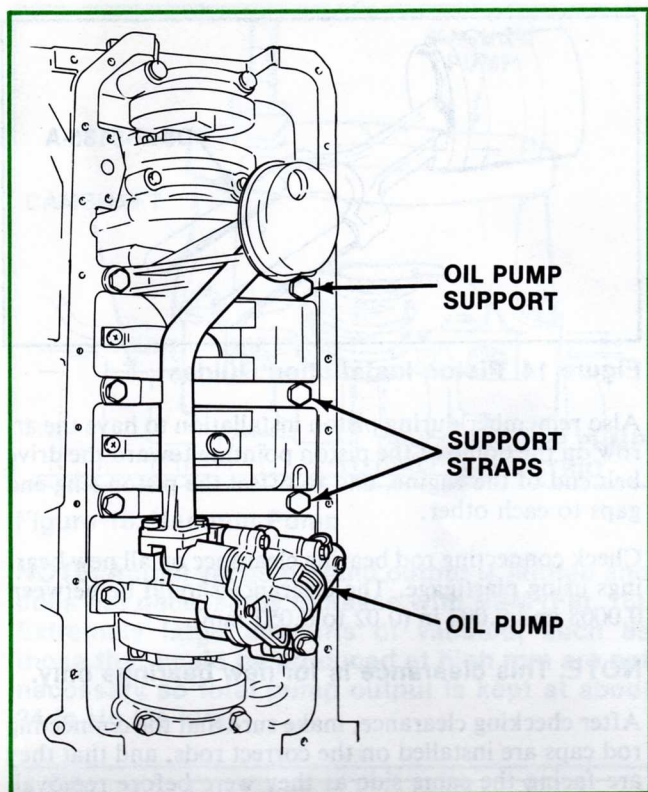


Figure 11. Main Bearings

**NOTE:** There is also a special brace used to connect the cylinder block to the lower portion of the transmission torque converter housing for added powertrain rigidity and noise reduction.



# ENGINE SYSTEMS AND COMPONENTS



**Figure 12. Engine Support Straps**

**NOTE: The crankshaft is nitride-hardened for long wear and increased strength. Because of this, the crankshaft should only be reconditioned according to established procedures.**

The bearing caps are numbered in this engine, and are not to be mixed up. Bearing cap 1 is on the drive belt end of the engine. Bearing cap 7 is on the flywheel side of the engine. Bearing cap 6 carries the thrust bearing.

To maintain precise tolerances within the 2.4 diesel engine there are three different main bearing thicknesses available for standard, first undersize, and second undersize crankshafts.

The different main bearing thicknesses are identified by a color code on the edge of the bearing shell. The correct bearings to use for each journal are determined during production and are shown by paint swatches in the crankcase for bearings in the block; and by paint swatches on the counterweights of the crankshaft, for bearings in the main caps. The paint swatches will not always be the same color. What this means is that bearings in the block and main caps can be purposely mismatched to take up any variations in the crankshaft journals.

The following chart shows all of the main bearings available for the 2.4L diesel standard crankshaft, and how they are used in conjunction with each other to make up for variations in the crankshaft journals.

**BEARING SELECTION CHART—  
STANDARD CRANKSHAFT**

CRANKSHAFT	BLOCK DIAMETER	ENGINE BLOCK MAIN BEARING THICKNESS	CRANKSHAFT MAIN JOURNAL SIZE	MAIN CAP MAIN BEARING THICKNESS	BEARING TO CRANKSHAFT CLEARANCE
STANDARD	Y 2.5590-2.5592 in (65.000-65.006 mm)	0.0980-0.0983 in (2.491-2.498 mm)	Y 2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
			G 2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 mm)	
			W 2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	
STANDARD	G 2.5593-2.5595 in (65.007-65.013 mm)	0.0983-0.0986 in (2.498-2.505 mm)	Y 2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
			G 2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 mm)	
			W 2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	
STANDARD	W 2.5596-2.5598 in (65.014-65.019 mm)	0.09862-0.0988 in (2.505-2.512 mm)	Y 2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
			G 2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 mm)	
			W 2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	

BEARING Y — YELLOW  
BEARING G — GREEN  
BEARING W — WHITE

NOTE: BEARING TO CRANKSHAFT CLEARANCE CAN ONLY BE CHECKED WITH NEW BEARINGS.

**NOTE: This chart is only part of the full chart. See page 64 for the full chart.**

**NOTE: Always replace both the upper and lower shells when replacing bearings.**

Note also that there is a lubricating groove in one of the bearing shells for each set. The bearing shell containing the lubricating groove should be installed in the engine block. Bearing clearances should be checked with plastigage, and should be between 0.0008 and 0.0018 in (0.02 to 0.046 mm).

**NOTE: This clearance is for new bearings only. Clearance will increase immediately after the engine is run because the protective coating on the bearings will be wiped off. Do not plastigage used bearings; the reading will be inaccurate.**

Axial play of the crankshaft must be checked with a dial indicator and should be between 0.003 and 0.006 in (0.08 to 0.163 mm).

**NOTE: Always clean the flywheel mounting bolt threads, and coat them with loctite before installing them.**

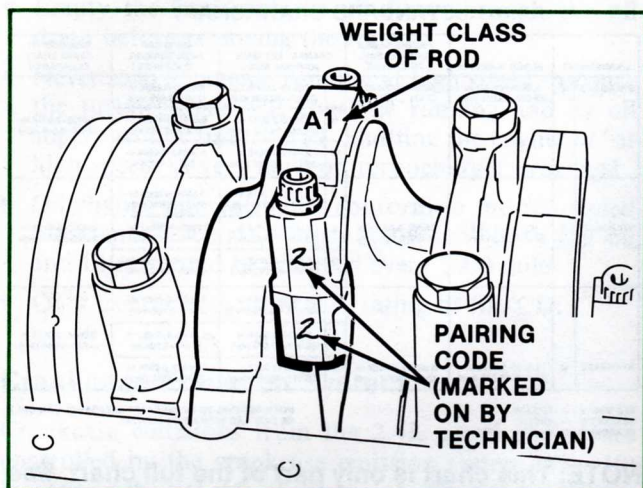
## PISTONS AND CONNECTING RODS

During piston and connecting rod service that requires the removal of the piston from the engine, identify the connecting rod and cap as a matched set (Fig. 13), and identify the cylinder they were in. This is very important! The weight class of the rod is identified on the rod



# ENGINE SYSTEMS AND COMPONENTS

cap (shown in Figure 13) by a code. This code must be the same for all of the rods in a particular engine. Do not use rods of different weight classes in the same engine because of the possibility of excessive engine vibration and/or durability problems.



**Figure 13. Connecting Rod Cap Identification**

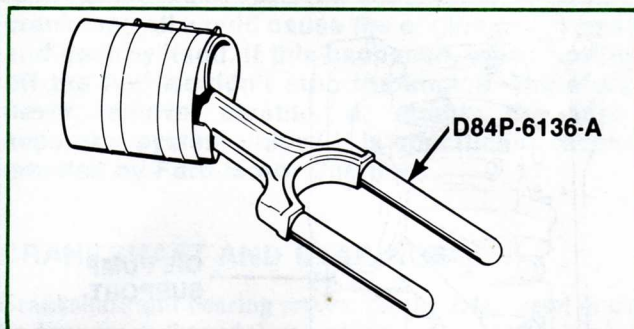
Like the main bearings, the rod bearings are also identified by color code. The colors used for rod bearing identification are red and blue. These colors are located on the edge of the bearings, and on the crankshaft counterweights. Unlike the main bearings, colors are not to be mixed on individual rods. If the paint swatch is blue on the crankshaft, then the bearings installed on that particular journal will both be blue.

During rod and piston service the oil spray tubes mounted in the crankcase should be examined. Check these tubes for damage or dirt that could interfere with proper operation. Oil spray tubes are rigid castings, and cannot be bent except at the tip, which can be knocked out of alignment or even pinched shut. For this reason it is extremely important that the spray tubes be handled carefully.

**NOTE: In the event of severe engine damage such as seized pistons or spun bearings it is recommended that the oil spray tubes and cam lobe spray bar be replaced.**

To help prevent damage to the spray tubes during engine assembly, use special tool D84P-6136-A (Fig. 14) to guide the connecting rod over the crankshaft journal without touching the piston cooling tubes. This tool also retains the cam bearing on the rod and protects the crankshaft from being damaged.

**CAUTION: Failure to use this tool for installation may cause damage on the oil spray tubes, which, in turn, may lead to engine failure.**



**Figure 14. Piston Installation Guides**

Also remember during piston installation to have the arrow on the dome of the piston pointing toward the drive belt end of the engine, and to offset the piston ring end gaps to each other.

Check connecting rod bearing clearance on all new bearings using plastigage. The clearance should be between 0.0008 and 0.002 in (0.02 to 0.053 mm).

**NOTE: This clearance is for new bearings only.**

After checking clearance, make sure that the connecting rod caps are installed on the correct rods, and that they are facing the same side as they were before removal. This is made easier by marking a pairing code on both the rod and cap before disassembly.

Use the torque angle method when tightening the connecting rod caps. Tighten each connecting rod nut to 15 lb-ft (20 N·m) initially, and then tighten another 70° of additional rotation.

**NOTE: Connecting rod bolts are not to be reused.**

## VACUUM PUMP

Since diesel engines do not produce vacuum because of the unrestricted intake of air into the cylinders, they must be equipped with a vacuum pump to provide vacuum for power brakes, climate control, emission controls, and other duties. The vacuum pump (Fig. 15) used on the 2.4L diesel is located beneath the valve cover, and is driven by an eccentric on the camshaft.

**NOTE: The Mark VII and Continental are equipped with Hydro-boost brakes.**

**NOTE: The vacuum pump eccentric is covered by a hardened steel ring which must be in place when the vacuum pump is in place. Never attempt to start or crank the engine without the vacuum pump and eccentric in place.**

The vacuum pump is attached by lines to a vacuum reservoir located on the fender. The minimum allowable vacuum from the pump is 16 in Hg (53 kPa) at idle.



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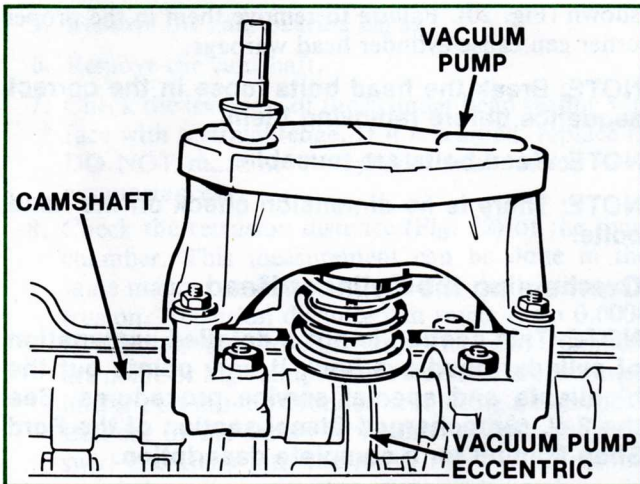


Figure 15. Vacuum Pump

**NOTE:** Actual vacuum pump output is limited and does not necessarily increase with RPM (Fig. 16). Extremely large amounts of vacuum, such as those that could be produced at high rpm are not necessary so total pump output is kept at about 24 in Hg (81 kPa).

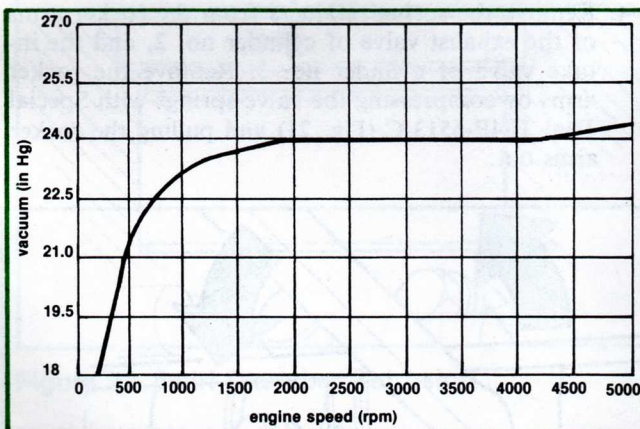


Figure 16. Maximum Vacuum vs. Engine Speed

Minimum vacuum is checked at the vacuum pump output hose on top of the valve cover. This is the point where the vacuum pump can be isolated from the system. Should the pump be unable to draw more than 16 in Hg (53 kPa) at idle it must be replaced.

To remove the vacuum pump the eccentric should be fully down, and the nuts should be loosened in a cross ways pattern a few threads at a time.

## CYLINDER HEAD SERVICE

The aluminum cylinder head used on the 2.4L diesel requires the following special service procedures:

- Determining cylinder head gasket thickness
- Determining swirl chamber retraction
- Determining valve retraction
- Tightening head bolts using torque angle method
- New method for adjusting rocker arms

Each of these procedures will be described in the following pages.

## Setting TDC

Many of the following procedures require the removal of the cylinder head. Before removing the cylinder head or the timing belt, always set the engine to Number 1 TDC using special tool T84P-6400-A (Fig. 17). It is inserted through a hole at the lower left side of the block, into a hole in the flywheel. The engine should not move when the pin is inserted; if it does then the pin has not contacted the proper hole in the flywheel. When the engine is at TDC the "OT" mark on the crankshaft damper should be aligned with the notch on the front cover (Fig. 18).

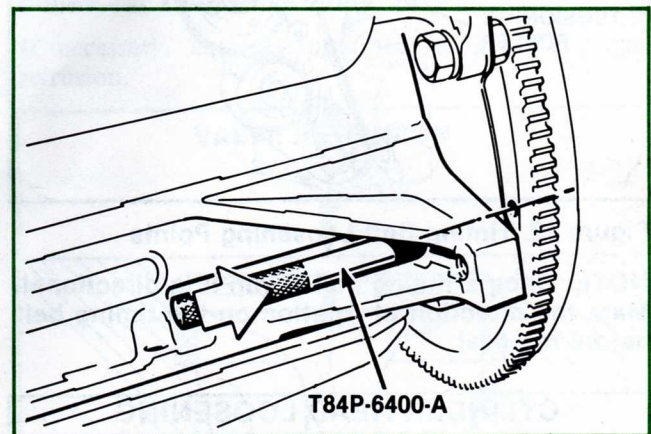


Figure 17. Fixing TDC on Cylinder No. 1

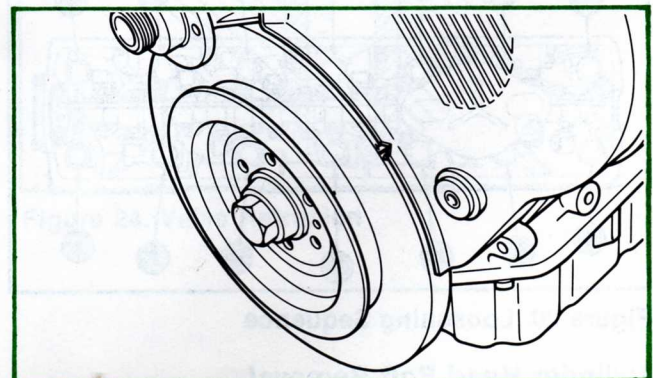


Figure 18. "OT" Mark and Notch



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**NOTE:** The hole for the alignment tool is below the position sensor.

**NOTE:** Coat the alignment tool with lubricant before inserting it. The hole in the block is a tight fit so the lubricant will probably make insertion easier.

**CAUTION:** Don't turn the engine over with the pin installed. If the tip gets bent, it's very hard to remove.

## Removing the Timing Belt

After setting the engine to Number 1 TDC the timing belt can be removed by loosening the belt at these points (Fig. 19).

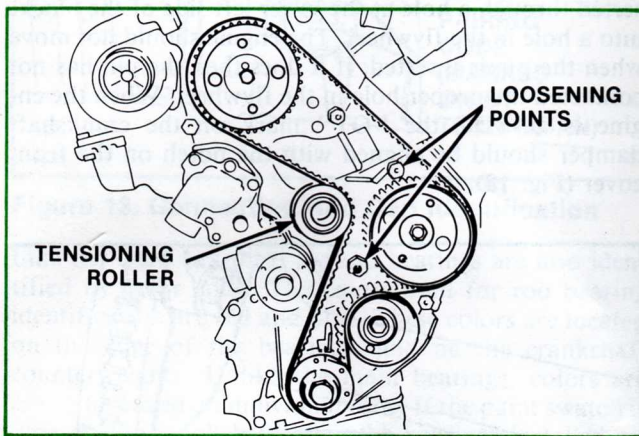


Figure 19. Timing Belt Loosening Points

**NOTE:** Once a timing belt is run it is directional. Mark the direction of rotation on the timing belt before removal.

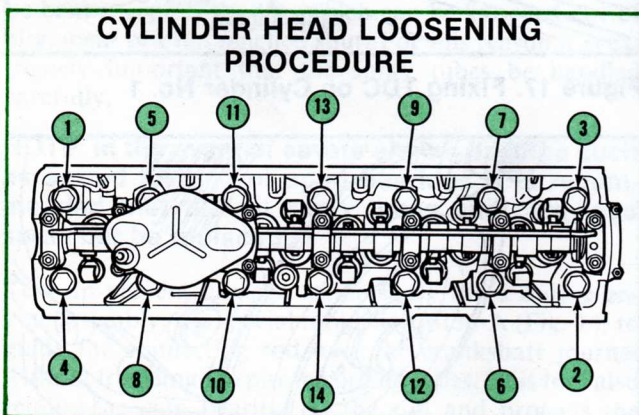


Figure 20. Loosening Sequence

## Cylinder Head Bolt Removal

Cylinder head bolts should be removed in the order

shown (Fig. 20). Failure to remove them in the proper order can cause cylinder head warpage.

**NOTE:** Break the head bolts loose in the correct sequence before removing them.

**NOTE:** Head bolts are reusable.

**NOTE:** There is no dimension check on the head bolts.

## Overhauling the Cylinder Head

**NOTE:** This section is not a detailed explanation of cylinder head overhaul; it only points out the highlights and special service procedures. See the 2.4L turbocharged Diesel section of the Ford Shop Manual for a complete description.

1. Detach the cylinder head. Remove the intake manifold and the exhaust manifold.
2. Place the cylinder head on holding fixture number D83L-500-A. Turn the camshaft until the vacuum pump eccentric faces down, relaxing the vacuum pump spring.
3. Loosen the nuts uniformly in a crosswise manner to take off the vacuum pump.
4. Remove the spring retainers from the rocker arms of the exhaust valve of cylinder no. 2, and the intake valve of cylinder no. 3. Remove the rocker arms by compressing the valve springs with Special Tool T84P-6513-C (Fig. 21) and pulling the rocker arms out.

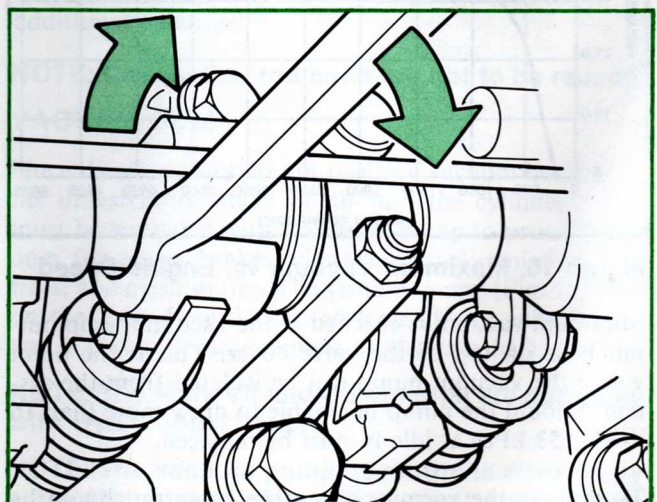


Figure 21. Compressing Valve Spring

**NOTE:** These rocker arms must be removed because of the valve spring tension on the cam at these two points when the engine is at TDC, as it should be when the head is removed.



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5. Remove the cam bearing caps.
6. Remove the camshaft.
7. Check the levelness of the cylinder head sealing surface with a straightedge. If it is warped, replace it. DO NOT machine the cylinder head under ANY circumstances.
8. Check the retraction distance (Fig. 22) of the swirl chamber. This measurement can be done in the same manner as that used to determine piston protrusion. Retraction distance can range from 0.0008 to 0.003 in (0.02 to 0.07 mm). The swirl chambers are made of high temperature steel and are mounted into the aluminum cylinder head using a shrink fit. Because of the shrink fit method of mounting the swirl chambers into the head, there is no recommended service procedure for servicing the swirl chambers individually. If one of them should become loose or damaged, the entire cylinder head must be replaced.

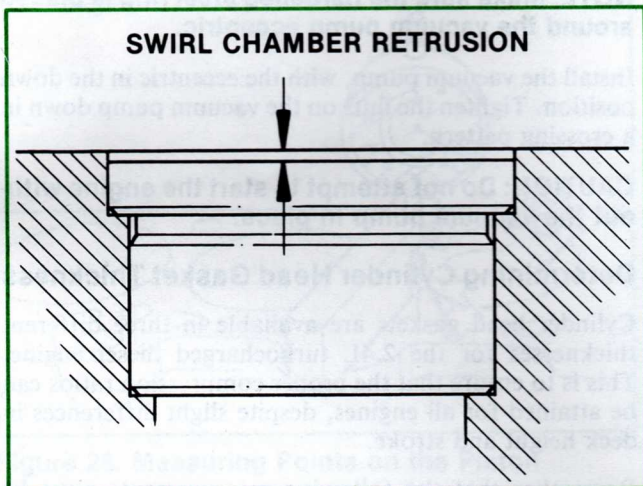


Figure 22. Swirl Chamber Retraction

## Valve and Valve Seat Service

Do not grind or machine the valves used in the 2.4L diesel engine. This would take off the hardened coating on the face of the valve and severely shorten its life. Valve seats must be cut, and repair size valves with higher valve heads are available. Cut the valve seats as shown in Figure 23.

On completion of valve seat service, check the amount of valve retraction (Fig. 24). This is a very important

measurement, which must be performed accurately on all of the valves. It is done with a dial indicator, using the same method explained earlier for checking piston protrusion. The amount of retraction should be:

Intake Valve = 0.025 to 0.033 in (0.65 to 0.85 mm)

Exhaust Valve = 0.033 to 0.041 in (0.85 to 1.05 mm)

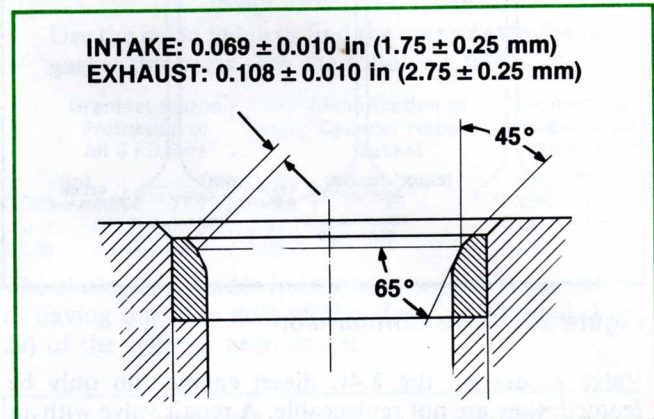


Figure 23. Valve Seat Information

If necessary, cut the valve seat to get the proper retraction.

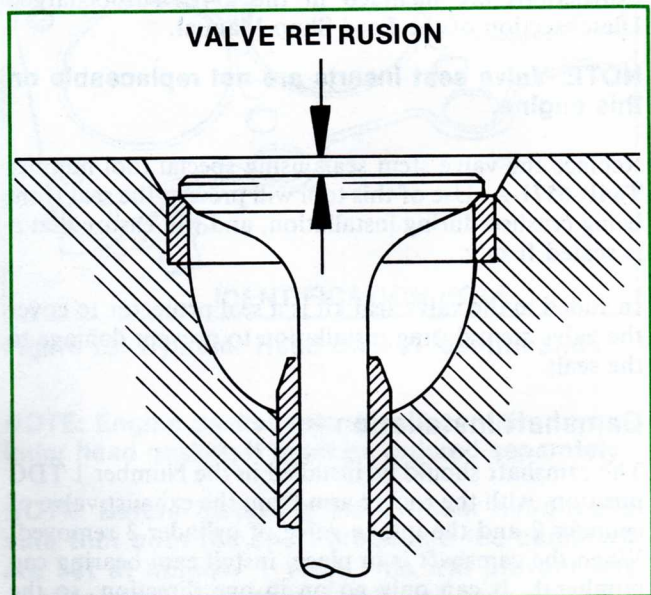


Figure 24. Valve Retraction



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In cases where there is too much retrusion, use a replacement valve with a higher head.

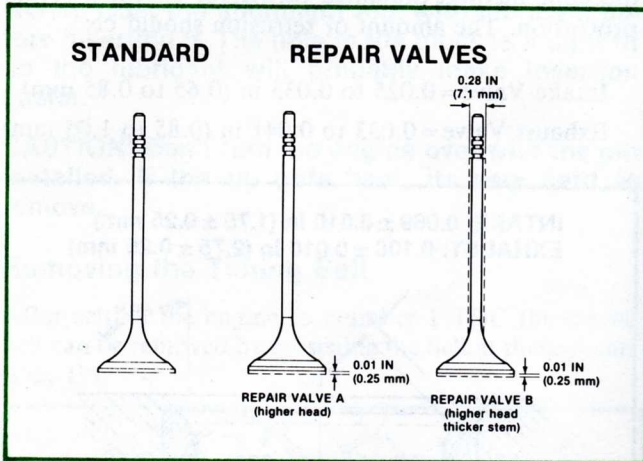


Figure 25. Valve Comparison

Valve guides on the 2.4L diesel engine can only be reamed, they are not replaceable. A repair valve with an oversize stem is available to take up extra clearance caused by reaming. Note that the repair valve with the larger stem also has a higher head, so retrusion will have to be checked and the valve seat cut if needed. Reaming instructions are included in the 2.4L Turbocharged Diesel section of the Ford Shop Manual.

**NOTE: Valve seat inserts are not replaceable on this engine.**

Replace the valve stem seals using special tool number T84P-6571-A. Use of this tool will prevent the seal from being crushed during installation, and will ensure that it is seated firmly.

Included in the valve seal kit is a seal protector to cover the valve stem during installation to prevent damage to the seals.

## Camshaft Installation

The camshaft should be installed in the Number 1 TDC position, with the rocker arm from the exhaust valve of cylinder 2 and the intake valve of cylinder 3 removed. When the camshaft is in place, install cam bearing cap number 1. It can only go on in one direction, so the

number will obviously be on the correct side; toward the intake. Install the rest of the cam bearing caps with their numbers pointing in the same direction (Fig. 26).

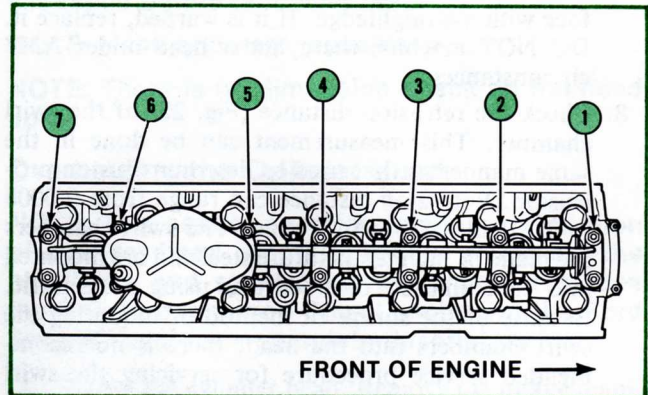


Figure 26. Cam Bearing Cap Numbering

**NOTE: Make sure the hardened steel ring is placed around the vacuum pump eccentric.**

Install the vacuum pump, with the eccentric in the down position. Tighten the nuts on the vacuum pump down in a crossing pattern.

**CAUTION: Do not attempt to start the engine without the vacuum pump in place.**

## Determining Cylinder Head Gasket Thickness

Cylinder head gaskets are available in three different thicknesses for the 2.4L turbocharged diesel engine. This is to ensure that the proper compression ratios can be attained for all engines, despite slight differences in deck height and stroke.

Remember that the following measurements must be taken whenever the head gasket is replaced, and must be extremely accurate.

1. Mount the dial indicator (part no. D82L-4201-A) into the base (part no. D84P-6100-A) and set to zero with pre-load on the cleaned cylinder head sealing surface (Fig. 27).
2. Apply dial indicator at measuring point A (Fig. 28) on the cleaned piston and find the highest point by turning the crankshaft to bring the piston to TDC. Note the value on the dial indicator.



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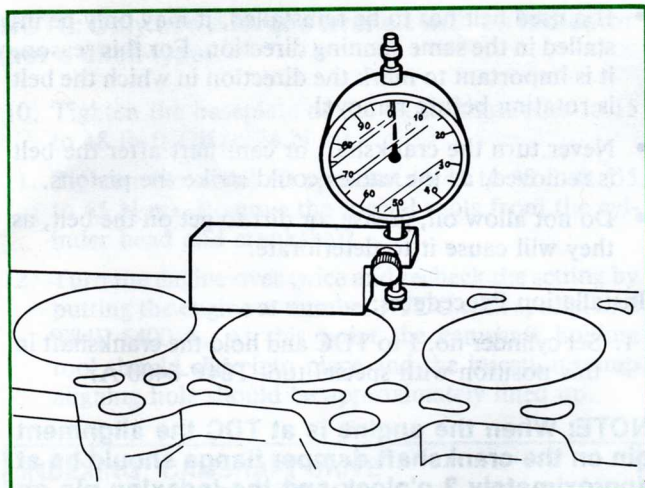


Figure 27. Setting Dial Indicator to Zero

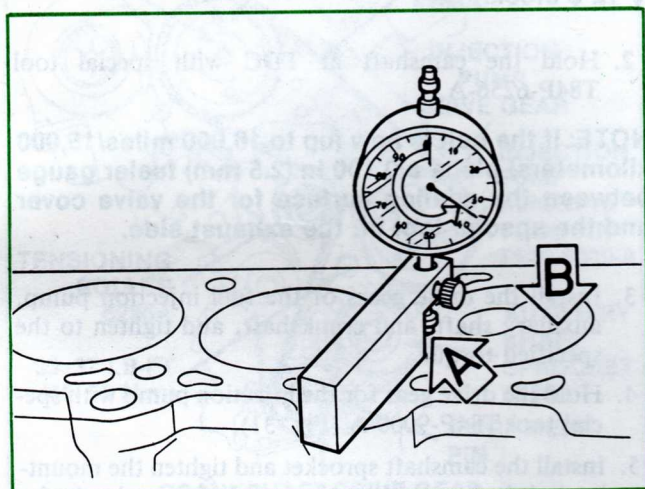


Figure 28. Measuring Points on the Piston

**NOTE:** It is extremely important to clean the surfaces that are being measured to ensure accuracy of measurement.

3. Repeat Step 2 at measuring point B (Fig. 28).
4. Perform Steps 2 and 3 for all of the other pistons and note the distances for each. For example:

**NOTE:** Measuring points A and B should be as close to the centerline of the piston as possible.

Cylinder No.	Distance A (mm)	Distance B (mm)
1	0.73	0.74
2	0.70	0.72
3	0.74	0.76
4	0.73	0.73
5	0.72	0.73
6	0.72	0.74

5. The piston with the greatest protrusion is used to determine the cylinder head gasket thickness. In this case it is cylinder no. 3 which has a protrusion of 0.74 mm at point A and 0.76 mm at point B.

Determine the mean value of distance A and distance B. For example:

Distance A = 0.74 mm      Distance B = 0.76 mm

Mean Value = 0.75 mm

Use the mean value to find the correct cylinder head gasket thickness with the following table:

Greatest Piston Protrusion of All 6 Pistons		Identification of Cylinder Head Gasket	Thickness of Cylinder Head Gasket	
(in)	(mm)		(in)	(mm)
0.025 ... 0.030	0.64 ... 0.78	1	0.056	1.43
0.031 ... 0.035	0.79 ... 0.91	2	0.060	1.54
0.036 ... 0.042	0.92 ... 1.08	3	0.067	1.70

The choice of cylinder head gasket would be identified as having only one hole on the identification pad (Fig. 29) of the cylinder head gasket.

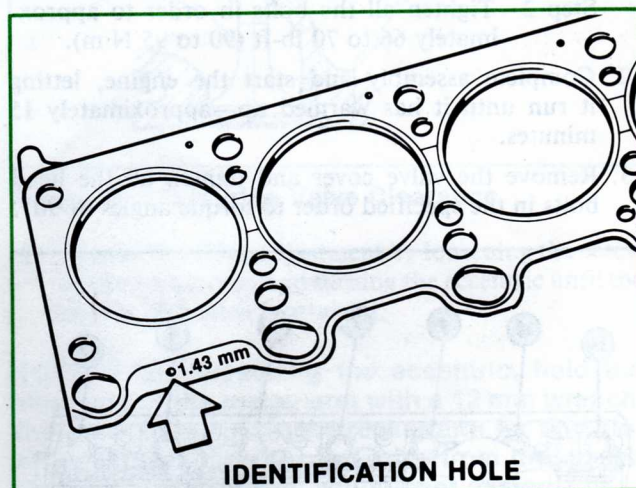


Figure 29. Cylinder Head Gasket Identification

**NOTE:** Engine gasket sets do not contain the cylinder head gasket; it must be ordered separately.

**NOTE:** Before installing the cylinder head make sure that both the short block and the camshaft are set at number 1 TDC. This will prevent any chance of the valves striking the pistons while the head is being installed, and will make timing belt installation easier.

## Tightening Cylinder Head Bolts

Tightening the cylinder head bolts is not a part of the service maintenance schedule, nor is it part of normal



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inspection procedure; but, should the cylinder head be removed or loosened for any reason, the bolts will have to be tightened according to this procedure:

**NOTE: Make sure there is no oil in any of the head bolt holes. Hydraulic pressure created by tightening the bolt onto oil can cause improper torque readings, or could even crack the block. Do not lubricate the threads of the head bolts, just make sure they are clean.**

1. With a torque wrench, tighten cylinder head bolts in the specified order (Fig. 30) from inside to outside.

Step 1—Tighten all the bolts in order to approximately 37 to 44 lb-ft (50 to 60 N·m).

Wait approximately 15 minutes.

**NOTE: Install the timing belt and adjust the valves during this time.**

Step 2—Tighten all the bolts in order to approximately 66 to 70 lb-ft (90 to 95 N·m).

2. Complete assembly and start the engine, letting it run until it has warmed up—approximately 15 minutes.
3. Remove the valve cover and tighten all the head bolts in the specified order to torque angles of 90°.

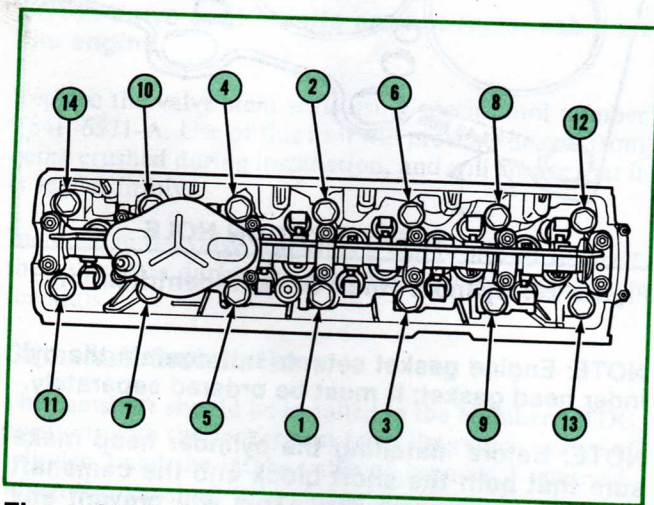


Figure 30. Cylinder Head Tightening Sequence

## Timing Belt Installation

Proper engine operation can be guaranteed only by correct installation of the timing belt. Improper installation of the timing belt can lead to engine failure, because it is possible for the valves to strike the pistons even if there is only a slight belt misadjustment. Here are some important points to remember about timing belt service:

- If a used belt has to be reinstalled, it may only be installed in the same running direction. For this reason, it is important to mark the direction in which the belt is rotating before removal.
- Never turn the crankshaft or camshaft after the belt is removed, as the valves could strike the pistons.
- Do not allow oil, grease, or dirt to get on the belt, as they will cause it to deteriorate.

### Installation Procedures:

1. Set cylinder no. 1 to TDC and hold the crankshaft in this position with special tool T84P-6400-A.

**NOTE: When the engine is at TDC the alignment pin on the crankshaft damper flange should be at approximately 3 o'clock and the indexing pin on the camshaft sprocket should be at approximately 12 o'clock.**

2. Hold the camshaft at TDC with special tool T84P-6256-A.

**NOTE: If the belt is new (up to 10,000 miles/15,000 kilometers) place a 0.100 in (2.5 mm) feeler gauge between the sealing surface for the valve cover and the special tool on the exhaust side.**

3. Install the drive gears of the fuel injection pump, auxiliary shaft, and crankshaft, and tighten to the specified torque.
4. Hold the drive gear for the injection pump with special tool T84P-9000-A (Fig. 31).
5. Install the camshaft sprocket and tighten the mounting bolt by hand. Move the camshaft sprocket in the direction of engine rotation toward the pin against the stop.
6. Install the tensioning roller. Tighten the mounting bolt and nuts by hand.
7. Install the belt in this order: Start at the crankshaft, go around the auxiliary shaft and the injection pump sprockets, over the cam drive gear, then over the tensioner.
8. Remove the special tool on the injection pump sprocket.
9. Swing the tensioning roller against the back of the timing belt with 33 to 37 lb-ft (45–50 N·m) for a new belt, or 22 to 26 lb-ft (30–35 N·m) for a used belt at the point shown in Figure 31, and tighten the mounting nut.

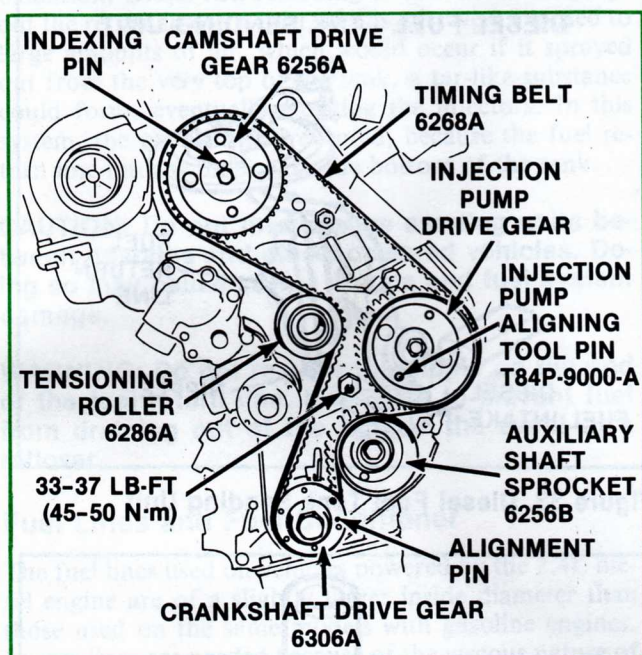
**CAUTION: The belt must not be allowed to jump out.**



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**NOTE:** Only use a torque wrench with an indicator (not a click-type).

10. Tighten the baseplate of the tensioning roller to 15 to 18 lb-ft (20 to 24 N·m).
11. Tighten the camshaft sprocket to 41 to 48 lb-ft (55 to 65 N·m). Remove the special tools from the cylinder head and crankshaft.
12. Turn the engine over twice and recheck the setting by putting the engine at number 1 TDC with special tool T84P-6400-A. At this point the camshaft holding tool should slide into place and the injection pump aligning hole should be approximately lined up.



**Figure 31. Timing Belt**

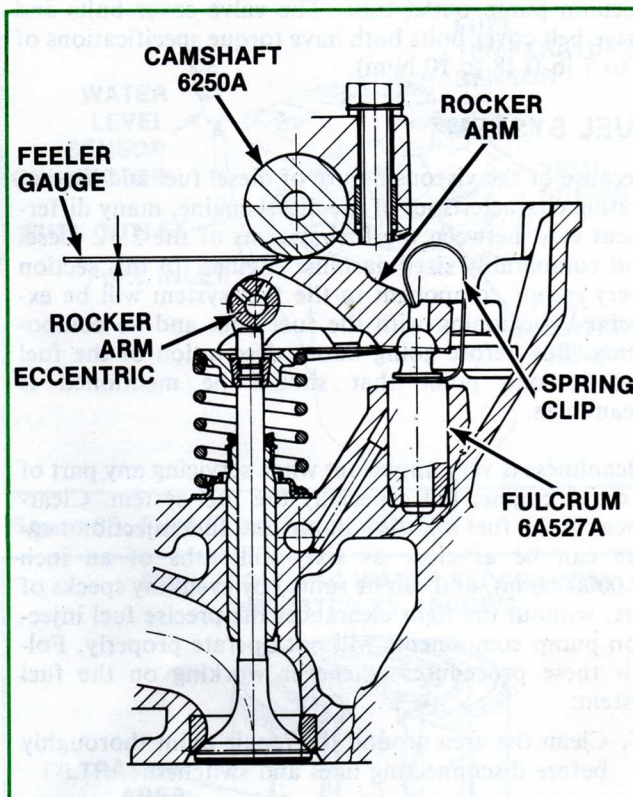
## Adjusting Valve Clearance

Perform valve adjustment when the engine is cold (coolant temperature below 95°F [35°C]), and is not running. Adjust the valves according to the following procedure:

1. Measure the clearance between the camshaft (Fig. 32) and the rocker arm sliding surface with a feeler gauge blade when the piston is at TDC on the compression stroke.

Valve Clearance: Intake = 0.012 in (0.30 mm)  
Exhaust = 0.012 in (0.30 mm)

**NOTE:** Adjust only one valve at a time.



**Figure 32. Measuring Valve Clearance**

2. Correct the valve adjustment by loosening the screw on the rocker arm and turning the eccentric until the correct clearance is attained.

**NOTE:** When loosening the eccentric, hold the other end of the rocker arm with a 12 mm wrench. There are flats cut on the rocker arm for this purpose. This will prevent the valve from hitting the piston and also makes adjustment easier.

3. Lock the adjusting screw and recheck the clearance.

**NOTE:** Whenever a rocker arm is replaced the fulcrum must also be replaced. Use special tool D84P-6564-A and a slide hammer to remove the fulcrum. Tap the new fulcrum in with a plastic hammer after cleaning the cavity and coating the shaft with loctite.

## Installing the Valve Cover

Proper installation of the valve cover is important in preventing oil leaks. Before installing the valve cover, unscrew the bolts holding the drive belt cover. Fit the valve cover with a new gasket, and an O-ring for the



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vacuum pump outlet tube. The valve cover bolts and drive belt cover bolts both have torque specifications of 6 to 7 lb-ft (8 to 10 N·m).

## FUEL SYSTEM

Because of the viscous nature of diesel fuel and the operating characteristics of the diesel engine, many differences exist between the fuel systems of the 2.4L diesel and comparably sized gasoline engines. In this section every major component in the fuel system will be examined, beginning with the fuel tank and its components. But before going into a description of the fuel system, one point that should be mentioned is cleanliness.

Cleanliness is very important when servicing any part of a diesel engine, but especially the fuel system. Clearances in the fuel injection pump and fuel injection nozzles can be as close as sixty-millionths of an inch (0.0000060 in), and can be ruined by even tiny specks of dirt; without the tight clearances the precise fuel injection pump components will not operate properly. Follow these procedures whenever working on the fuel system:

1. Clean the area around the repair point thoroughly before disconnecting lines and switches.
2. Lay removed parts only on clean surfaces and cover them with a plastic sheet. Never use cloths that leave lint.
3. Cover or insert plugs in open lines and components immediately.
4. Install only cleaned parts; do not remove new parts from their packaging until immediately before installing.
5. Keep diesel fuel off of rubber parts.

## Fuel Tank and Components

The fuel tank used on vehicles equipped with the 2.4L diesel engine is the same as that used on gasoline-powered models. The interior components, however—in particular, the diesel fuel intake and sending unit—are specifically designed for diesel engine applications.

The diesel fuel sending unit (Fig. 33) used in the 2.4L diesel uses a Ford-designed diesel fuel intake that is unique. The diesel intake maintains constant contact with the bottom of the fuel tank. The reason for keeping the fuel intake constantly drawing from the bottom of the tank is to prevent buildup of contaminants such as water and microbiological organisms in the fuel tank. The contaminants are simply moved through the system and are removed by the water/fuel separator.

**NOTE:** Microbiological organisms have a tendency to grow in fuel tanks that contain water in the fuel and have been stored for a lengthy period of time, especially in warm climates. The slimy, gelatin-like growths will clog a fuel system, and will also produce an acid that has a corrosive effect on precise fuel system components such as the injection pump and injectors. For this reason, it is important to have a filter and water/fuel separator that can effectively remove water and other contaminants from the fuel system. It is also very important to use only clean, fresh fuel in a diesel engine.

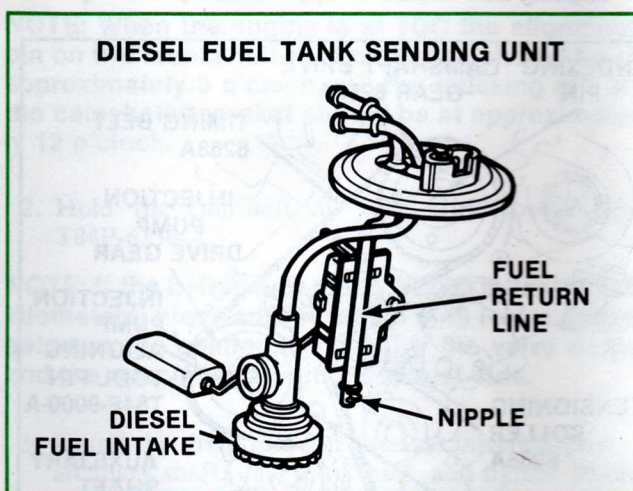


Figure 33. Diesel Fuel Tank Sending Unit

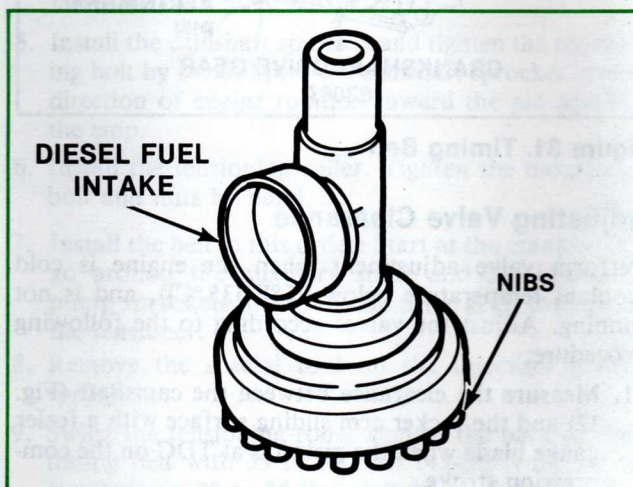


Figure 34. Diesel Fuel Intake

The diesel fuel intake (Fig. 34) actually draws water to it by creating a pressure differential between itself and the fuel tank. The “nibs” on the bottom of the intake set up



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a restriction in the fuel flow and create a venturi-type effect on the fuel. Fuel going past the nibs accelerates and the pressure drops. This pressure drop attracts the water. Water contained in the fuel is drawn, along with the fuel, into the diesel fuel intake and is accelerated and forced to the fuel conditioner where the water is removed.

Buildup of ice and/or waxed fuel around the diesel fuel intake is prevented by depositing the returning fuel directly above it. This warm fuel returning to the tank will dissolve the ice and/or wax, and will allow the fuel to flow normally through the diesel fuel intake.

The placement of the fuel return line also prevents fuel oxidation. Diesel fuel returning to the fuel tank sprays out the return line in a mist. If this mist were exposed to large amounts of air, which would occur if it sprayed out from the very top of the tank, a tar-like substance could form, eventually clogging the injectors. In this system, the problem is prevented, because the fuel return line returns the fuel to the bottom of the tank.

**CAUTION:** Do not interchange sending units between gasoline-and diesel-powered vehicles. Doing so may cause severe engine and fuel system damage.

**WARNING:** Do not remove the nipple on the end of the fuel return line. It is there to prevent fuel from draining out of the tank in the event of a rollover.

## Fuel Lines and Fuel Conditioner

The fuel lines used on vehicles powered by the 2.4L diesel engine are of a slightly larger inside diameter than those used on the same models with gasoline engines. Larger lines are needed because of the viscous nature of diesel fuel and its tendency to thicken in cold weather. Fuel line routing is located on the left side of the vehicle, which is the exact opposite of that found on gasoline-powered models. The diesel is also equipped with a fuel return line.

The fuel conditioner (Fig. 35) used on vehicles equipped with the 2.4L diesel performs five different functions:

1. Filters the fuel. The replaceable filter element (Fig. 36) of the fuel conditioner efficiently filters extremely small particles from the fuel. The reason for having such a fine filtering system is that clearances within the fuel injection pump and injector nozzles can be as close as sixty-millionths of an inch, and any abrasive particle that gets past the filter can cause severe damage to these components. The capacity of this filter is 600 cc, and its replacement interval is 30,000 miles.

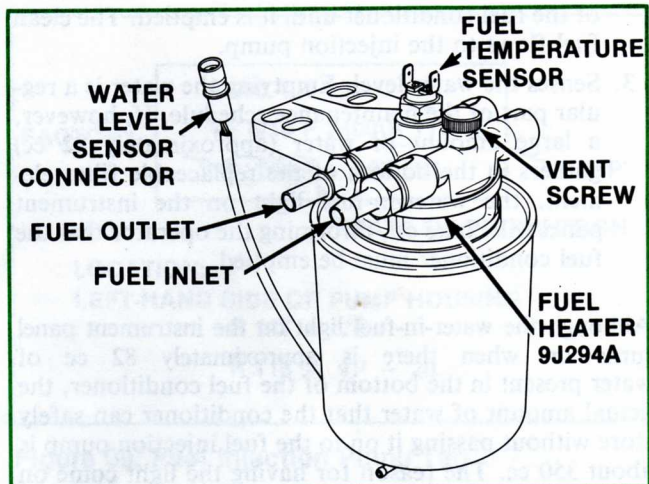


Figure 35. Fuel Conditioner (9155A)

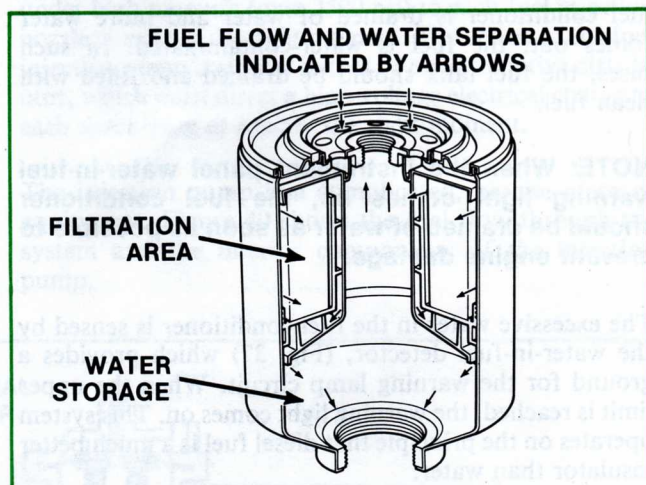


Figure 36. Replaceable Filter Element Cutaway (9365A)

**CAUTION:** Never bypass the fuel conditioner for any reason, because severe damage to the fuel injection pump may occur.

**NOTE:** The fuel filter portion of the fuel conditioner is replaceable. It is a spin-on type which should be replaced every 30,000 miles, or sooner if needed. The water purge button and water level sensor that screw into the bottom of the filter are reusable and should be removed from the old filter and installed in the new one.

2. Separates the water and fuel. Water, which is heavier than diesel fuel, is separated from the fuel as the fuel passes through the fuel conditioner. After being separated from the fuel, the water collects in the bottom of the replaceable filter element



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of the fuel conditioner until it is emptied. The clean fuel flows to the injection pump.

3. Senses the water level. Emptying the water is a regular part of the maintenance schedule. If, however, a large amount of water (approximately 82 cc) gathers in the bottom of the replaceable filter element, the water-in-fuel light on the instrument panel will come on, informing the operator that the fuel conditioner must be emptied.

Although the water-in-fuel light on the instrument panel turns on when there is approximately 82 cc of water present in the bottom of the fuel conditioner, the actual amount of water that the conditioner can safely store without passing it on to the fuel injection pump is about 350 cc. The reason for having the light come on quickly is to inform the operator immediately of a bad load of fuel. If the light keeps coming on soon after the fuel conditioner is drained of water and more water comes out, the fuel is water-contaminated. In such cases, the fuel tank should be drained and filled with clean fuel.

**NOTE: When the instrument panel water-in-fuel warning light comes on, the fuel conditioner should be drained of water as soon as possible to prevent engine damage.**

The excessive water in the fuel conditioner is sensed by the water-in-fuel detector, (Fig. 37) which provides a ground for the warning lamp circuit. When the upper limit is reached, the warning light comes on. This system operates on the principle that diesel fuel is a much better insulator than water.

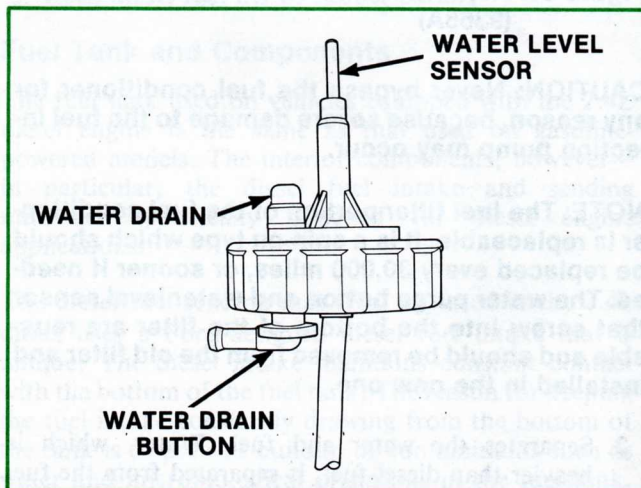


Figure 37. Water Level Sensor

4. Heats the fuel. The electric fuel heater is standard equipment on vehicles equipped with the 2.4L diesel engine. It is located between the top of the fuel conditioner and the filter element, and is serviced independently of the rest of the system. Power (approximately 200 watts) is available to the fuel heater whenever the key is in the ON position, but is used only when the fuel is cold. A fuel temperature sensor is located on the top of the fuel conditioner, and is exposed to diesel fuel contained in the fuel conditioner. The sensor senses fuel temperature and operates within a temperature range between 30 and 55°F (-1 and 13°C). This means that the heater must be operating at fuel temperatures of 30°F (-1°C) or lower, and must cease operating at fuel temperatures 55°F (13°C) and above.

When the sensor snaps into the ON position, it supplies current via a relay (mounted on the firewall) to a positive temperature coefficient (PTC) heater. This heater is self-regulating because as its temperature goes up, so too does its resistance to electrical flow, thereby limiting the maximum temperature. For this reason, there is no control module for the fuel heater.

5. Purges water from the fuel system. Water that is captured by the water/fuel separator is removed from the fuel conditioner by loosening the vent screw on top of the fuel conditioner and pressing the button, shown in Figure 37, on the bottom of the replaceable filter element and draining the water into a container until clear diesel fuel comes out.

**NOTE: Water removed from the fuel conditioner is generally milky in appearance, whereas diesel fuel is usually clear with an amber tint.**

Performance of these five functions by one component—the fuel conditioner—simplifies maintenance and service.

## Electric Lift Pump

An electric lift pump (Fig. 38) is used on the 2.4L diesel fuel system. It is located between the fuel conditioner and the fuel injection pump. The purpose of the lift pump is to get the fuel from the fuel tank to the fuel injection pump and to maintain adequate fuel pressure to the fuel injection pump.

## Fuel Injection Pump

The fuel injection pump used on the 2.4L diesel is located at the left front of the engine. It is a distributor type Bosch VE (49-state) or VP-20 (California). The



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major difference between the two is that the injection pump timing on the California version is controlled electronically, whereas the 49-state version is controlled mechanically. To determine which pump is which, there is a tag on the left hand side of the pump (Fig. 39). The information on the tag is not really important for service, only for identification.

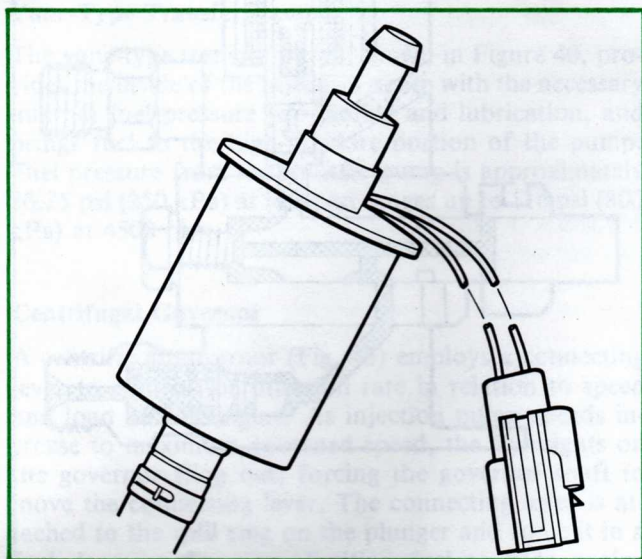


Figure 38. Electric Lift Pump

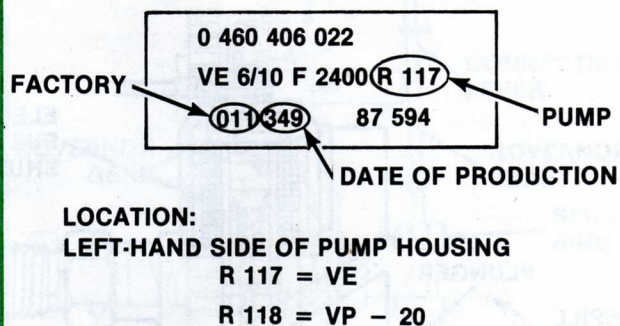


Figure 39. Fuel Injection Pump Tag

The fuel injection pump delivers a precise amount of fuel under high pressure (over 2500 psi) to each fuel injection nozzle at exactly the right moment. The action of the fuel injection pump is similar to that of an automotive distributor, which must direct a high-voltage electrical charge to each spark plug at exactly the right moment.

The injection pump is a complicated, precise piece of equipment. Figure 40 shows the fuel flow through the system and the interior components of the injection pump.

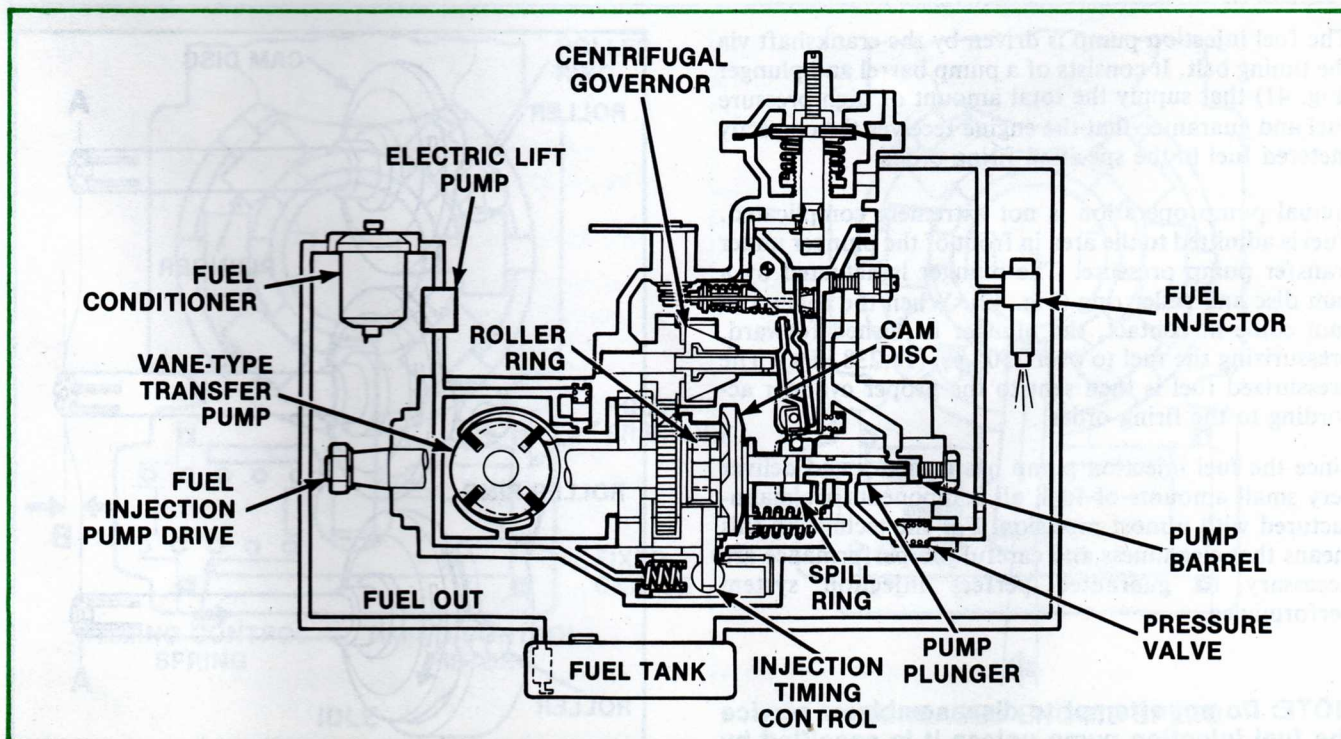
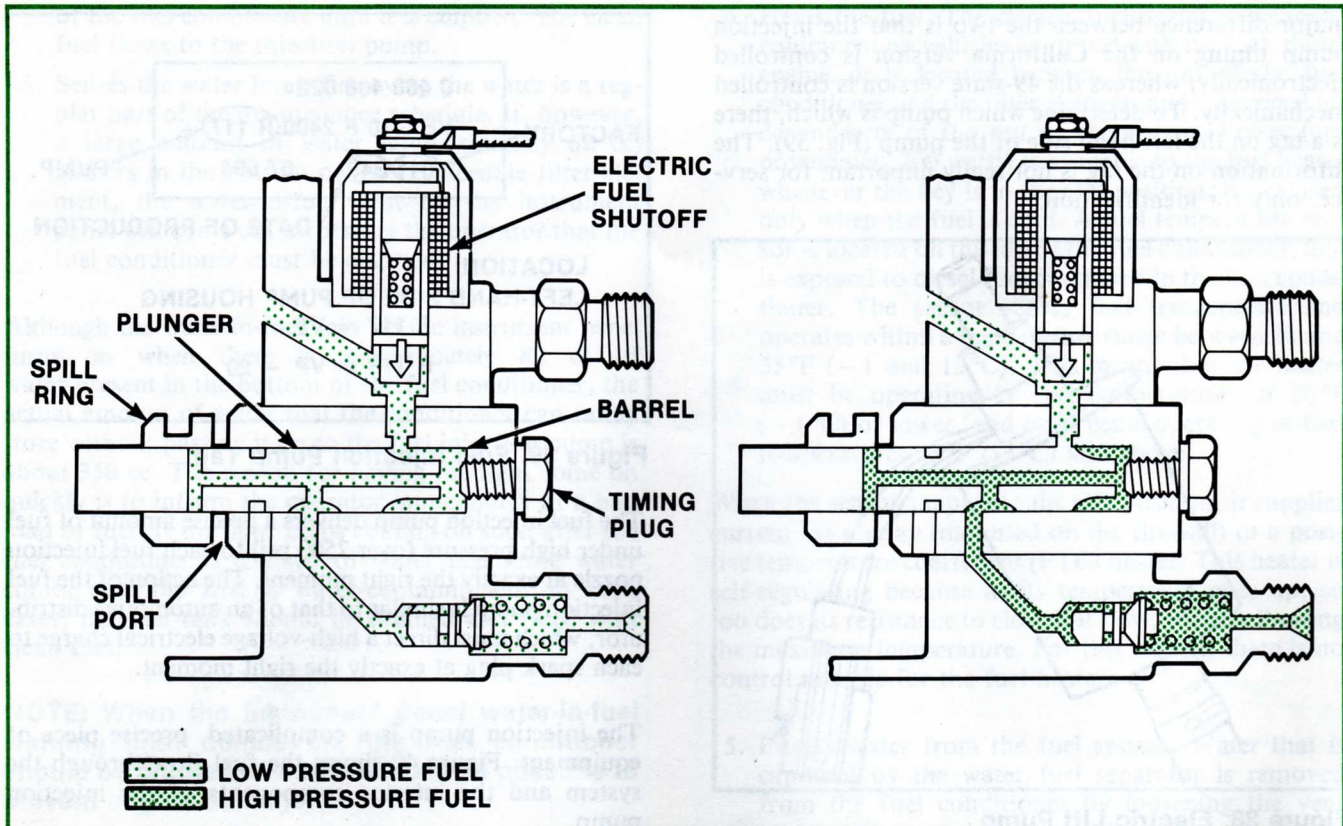


Figure 40. Fuel System Flow and Injection Pump Components



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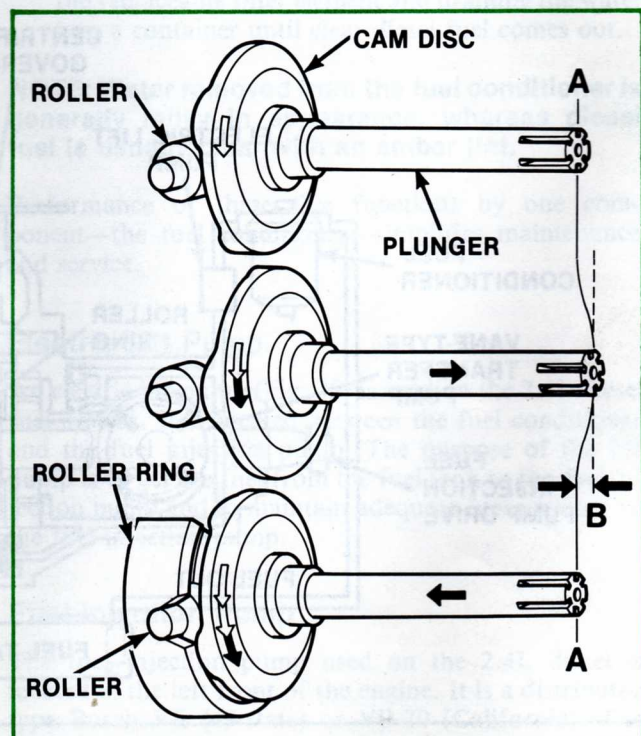
**Figure 41. Pump Barrel and Plunger**

The fuel injection pump is driven by the crankshaft via the timing belt. It consists of a pump barrel and plunger (Fig. 41) that supply the total amount of high-pressure fuel and guarantee that the engine receives the correctly metered fuel in the specified firing order.

Actual pump operation is not extremely complicated. Fuel is admitted to the area in front of the plunger under transfer pump pressure. The plunger is actuated by a cam disc and roller ring (Fig. 42). When the roller and cam come in contact, the plunger is pushed forward, pressurizing the fuel to over 2500 psi (17,238 kPa). The pressurized fuel is then sent to the proper cylinder according to the firing order.

Since the fuel injection pump has to meter and deliver very small amounts of fuel, all components are manufactured with utmost precision. For the technician this means that cleanliness and careful job performance are necessary to guarantee perfect injection system performance.

**NOTE: Do not attempt to disassemble or service the fuel injection pump unless it is specified by the Ford Motor Company. Tampering with the fuel injection pump will void the warranty.**



**Figure 42. Cam Disc with Roller Ring**



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**CAUTION:** Never wash or spray the injection pump when it is warm or the engine is running as it may cause the pump to seize.

## Performance of Fuel Injection Pump Components

### Vane-Type Transfer Pump

The vane-type transfer pump, shown in Figure 40, provides the inside of the injection pump with the necessary internal fuel pressure for cooling and lubrication, and brings fuel to the high-pressure portion of the pump. Fuel pressure from the transfer pump is approximately 36.25 psi (250 kPa) at idle and ranges up to 116 psi (800 kPa) at 4500 rpm.

### Centrifugal Governor

A centrifugal governor (Fig. 43) employs a connecting lever to control the injection rate in relation to speed and load on the engine. As injection pump speeds increase to maximum governed speed, the flyweights on the governor fling out, forcing the governor shaft to move the connecting lever. The connecting lever is attached to the spill ring on the plunger and force it in a fuel decrease direction, limiting fuel to keep engine speeds within the governed limits.

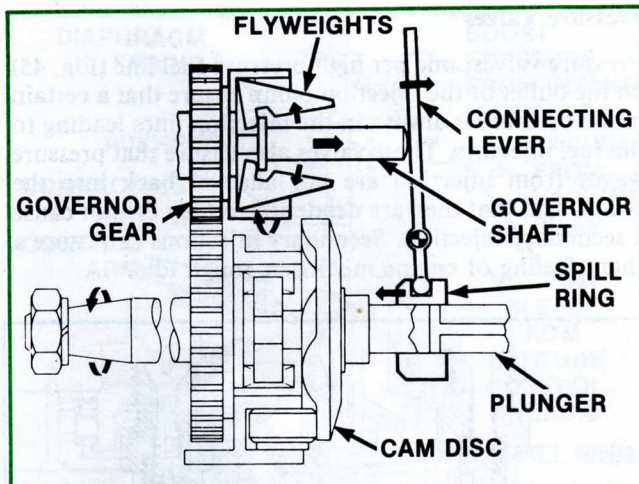


Figure 43. Centrifugal Governor

### Injection Timing Control

An injection timing control (Fig. 44) changes the beginning of injection according to fuel pressure in the pump, in much the same way that a distributor changes spark timing in a gasoline engine by means of centrifugal advance. Injection is advanced or retarded by moving the roller ring in relation to the cam disc. Internal injection pump pressure is used to change timing because it is an excellent indicator of engine speed.

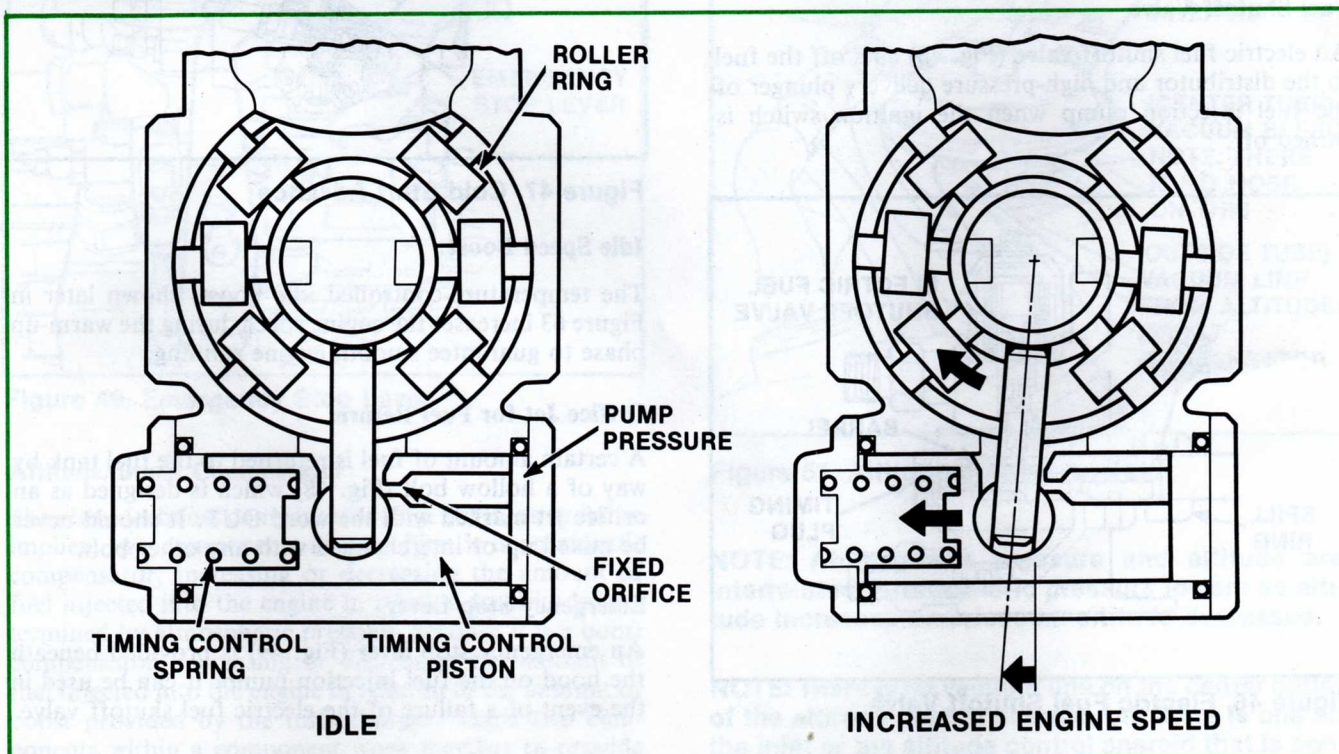


Figure 44. Injection Timing Control



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## Pressure Valves

Pressure valves, one per high pressure fuel line (Fig. 45) on the outlet of the injection pump ensure that a certain initial pressure is always in the injection lines leading to the fuel injectors. These valves also ensure that pressure waves from injection are not allowed back into the pump, and that they are deadened so they cannot cause a secondary injection. Secondary injections can cause a slight feeling of engine misfire or rough idle.

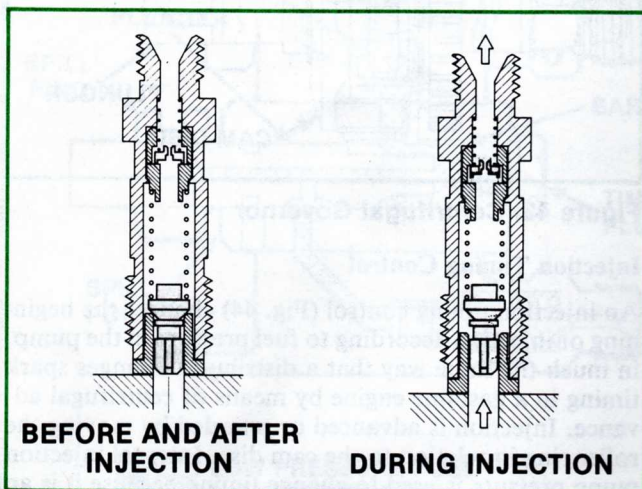


Figure 45. Pressure Valves

## Fuel Shutoff Valve

An electric fuel shutoff valve (Fig. 46) cuts off the fuel to the distributor and high-pressure delivery plunger of the fuel injection pump when the ignition switch is turned off.

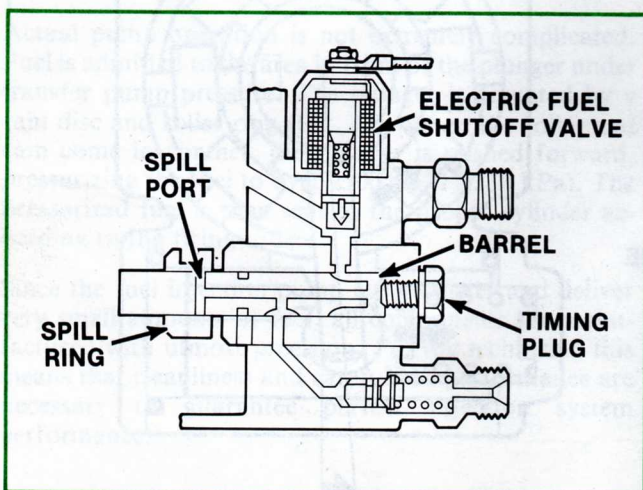


Figure 46. Electric Fuel Shutoff Valve

**NOTE: When performing service operations that require cranking the engine without having it start, the fuel shutoff valve should be disconnected to prevent the engine from starting.**

## Cold Start Advance

An automatic cold start advance (Fig. 47) provides the engine with better starting and warm-up properties. The beginning of injection is advanced by the automatic cold start accelerator working with the injection timing control. A solenoid valve, which is activated electrically by a temperature switch in the cylinder head, increases the pressure inside of the injection pump (which advances timing) at temperatures below 86°F (30°C). By using this method, correct injection timing is always guaranteed for both cold and warm starts.

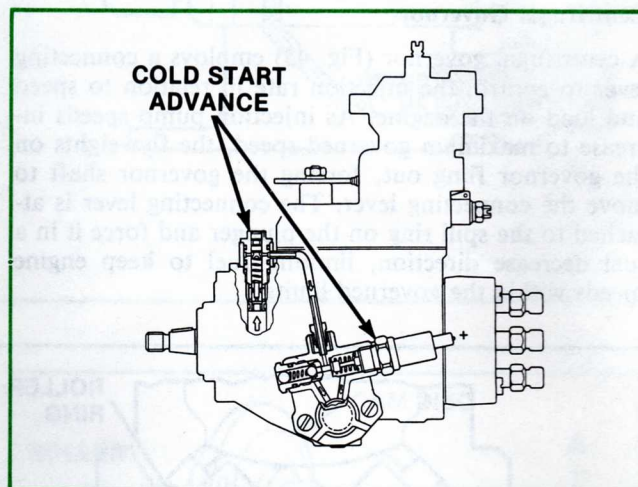


Figure 47. Cold Start Advance

## Idle Speed Boost

The temperature-controlled idle boost, shown later in Figure 63 increases the engine speed during the warm-up phase to guarantee smooth engine running.

## Orifice Jet for Fuel Return

A certain amount of fuel is returned to the fuel tank by way of a hollow bolt (Fig. 48) which is designed as an orifice jet marked with the word OUT. It should never be mixed up or interchanged with any other bolt.

## Emergency Stop Lever

An emergency stop lever (Fig. 49) is provided beneath the hood on the fuel injection pump. It can be used in the event of a failure of the electric fuel shutoff valve.



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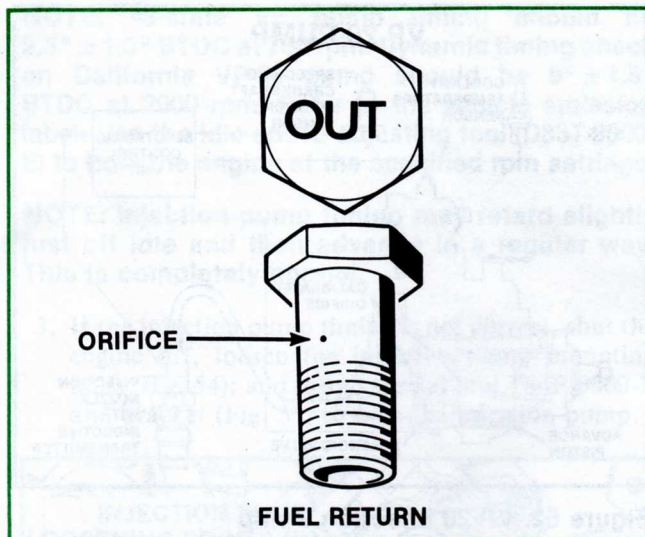


Figure 48. Fuel Return Orifice Jet

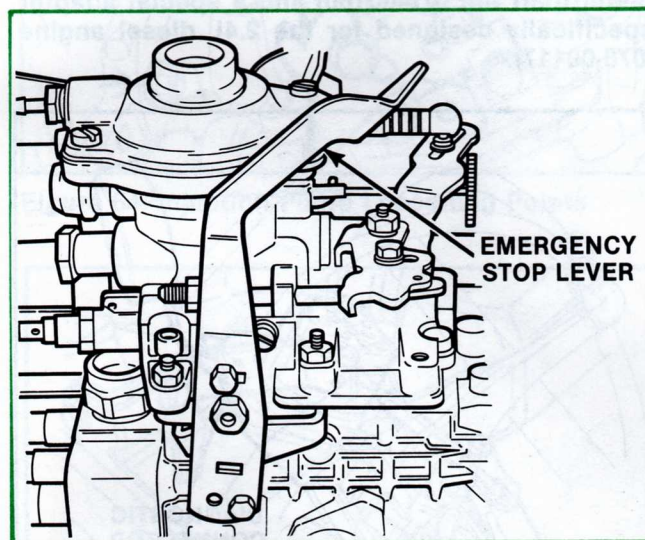


Figure 49. Emergency Stop Lever

## Altitude/Boost Compensator

The altitude/boost compensator (Fig. 50) is, as its name implies, two components in one. First it is an altitude compensator, increasing or decreasing the amount of fuel injected into the engine in relation to altitude, determined by atmospheric pressure. Second, it is a boost compensator, increasing or decreasing the amount of fuel injected into the engine in relation to the amount of boost provided by the turbocharger. These two components within a component work together to provide maximum performance with minimal emissions.

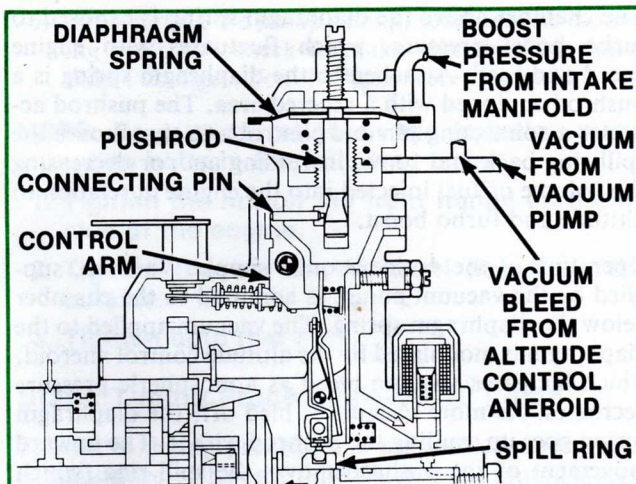


Figure 50. Altitude/Boost Compensator

The components that make up the boost compensator include a diaphragm spring mounted horizontally in the housing that is exposed to a reference vacuum beneath it. The reference vacuum is modulated by an altitude control aneroid (Fig. 51), mounted on the cowl, that bleeds vacuum in relation to atmospheric pressure.

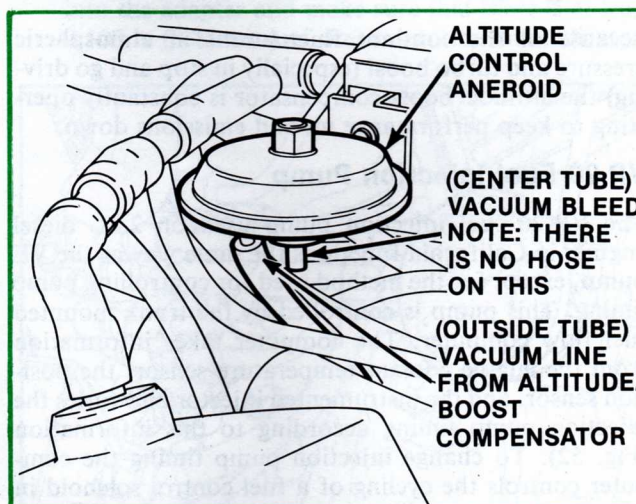


Figure 51. Altitude Control Aneroid

**NOTE: Atmospheric pressure and altitude are interrelated. Atmospheric pressure lowers as altitude increases and rises as altitude decreases.**

**NOTE: There is no vacuum line on the center outlet of the altitude control aneroid, but there is one on the inlet of the altitude control aneroid that is connected to the altitude/boost compensator.**



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The chamber above the diaphragm spring is exposed to turbo boost pressure, which fluctuates with engine speed and load. Attached to the diaphragm spring is a pushrod equipped with a tapered area. The pushrod actuates a connecting pin and control arm that moves the spill ring back and forth, increasing and/or decreasing the volume of fuel injected into the engine in relation to altitude and turbo boost.

Operation of the device is quite simple. Vacuum, supplied by the vacuum pump, is admitted to the chamber below the diaphragm spring. The vacuum applied to the diaphragm is modulated by the altitude control aneroid, which increases vacuum bleed as atmospheric pressure decreases. As more vacuum is bled off, the diaphragm spring goes up, pulling the pushrod with it. The upward movement of the pushrod moves the spill ring (which controls fuel volume from the fuel injection pump to the engine) in a fuel-decreasing direction by rotating the control arm through the connecting pin.

During periods of high turbo boost (high engine speed/high load situations) extra fuel is needed in the engine. Boost pressure is applied to the upper chamber of the altitude/boost compensator against the top of the diaphragm spring. As boost pressure goes up, it forces the diaphragm spring and pushrod down, causing the spill ring to go in a fuel-increase direction.

Because of the constant fluctuations in atmospheric pressure and turbo boost (especially in stop and go driving) the altitude/boost compensator is constantly operating to keep performance up and emissions down.

## VP-20 Fuel Injection Pump

The VP-20 fuel injection pump used on 2.4L diesel engines in California functions the same way as the VE pump, except for the method used for controlling pump timing. This pump is controlled by the trunk mounted fuel flow computer. The computer takes information from the engine coolant temperature sensor, the position sensor, and the instrumented injector and varies the injection pump timing according to this information (Fig. 52). To change injection pump timing the computer controls the cycling of a fuel control solenoid in the injection pump. The solenoid varies the amount of fuel pressure available to the advance piston by providing an additional bleed whenever it is open. By cycling the solenoid, fuel pressure at the advance piston can be precisely controlled thereby controlling timing.

## Fuel Injection Pump Service

### Checking and Adjusting Injection Pump Timing

Setting timing on this engine is very important, since engine performance and emissions will suffer if the timing is not correct. The method used for setting injection pump timing on the 2.4L diesel engine is the dynamic (engine running) procedure.

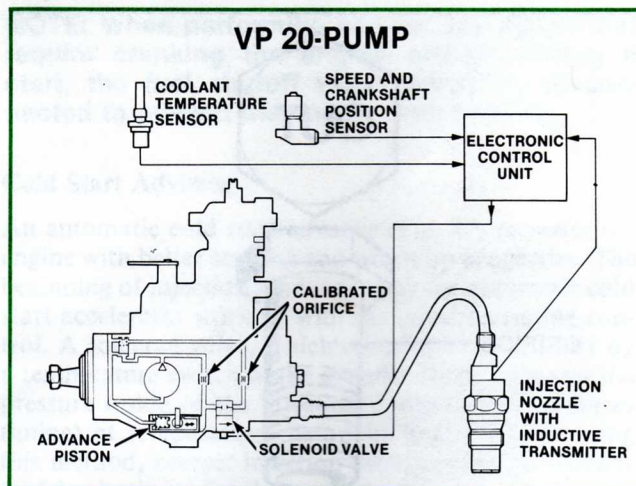


Figure 52. VP-20 Injection Pump

**NOTE:** The 2.4L diesel engine is equipped with a diagnostic connector (Fig. 53) for use in checking engine rpm and setting dynamic timing. It is used in conjunction with the Rotunda dynamic timing meter (part no. 078-00100) and a special adapter specifically designed for the 2.4L diesel engine (078-00117).

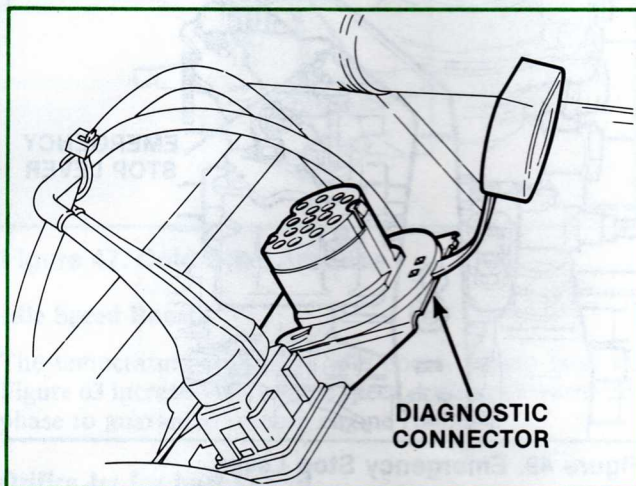


Figure 53. Diagnostic Connector

The meter and adapter are also available together (part no. 078-00116).

Setting the fuel injection pump dynamic timing is made much easier by the addition of the diagnostic connector, which speeds the hookup of the meter and makes a luminosity probe unnecessary. To set the dynamic pump timing:

1. Run the engine at operating temperature.
2. Plug the tester into the diagnostic connector and check the pump timing.



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**NOTE:** 49-state VE pump timing should be  $2.5^\circ \pm 1.0^\circ$  BTDC at 750 rpm. Dynamic timing check on California VP-20 pump should be  $6^\circ \pm 1.5^\circ$  BTDC at 2000 rpm. Refer to the vehicle emission label. Use the idle speed adjusting tool (D83T-9000-E) to hold the engine at the specified rpm settings.

**NOTE:** Injection pump timing may retard slightly just off idle and then advance in a regular way. This is completely normal.

3. If the injection pump timing is not correct, shut the engine off, loosen the injection pump mounting bolts (Fig. 54); and install special tool T84P-9000-B and bracket (Fig. 55) to turn the injection pump.

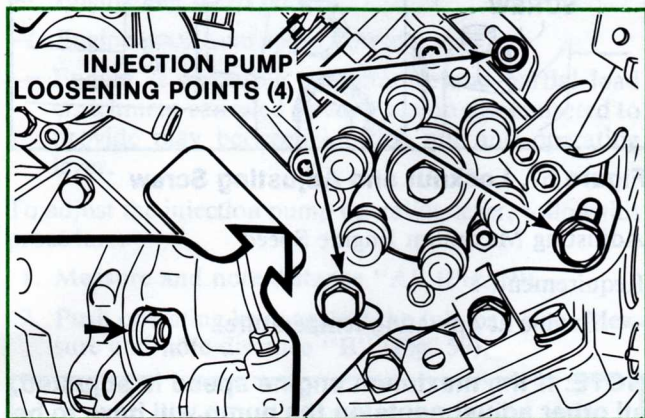


Figure 54. Injection Pump Loosening Points

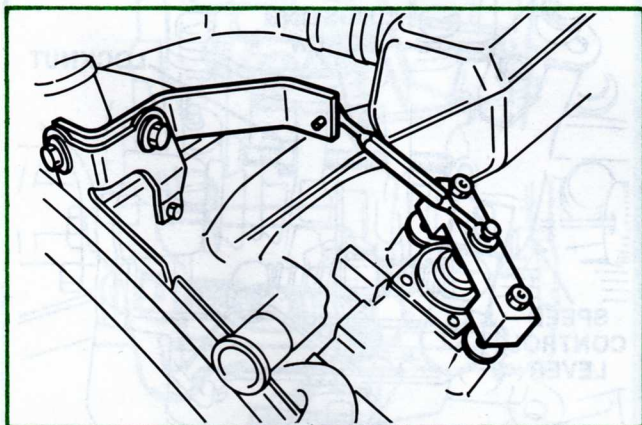


Figure 55. Injection Pump Rotating Tool

4. Restart the engine and turn the injection pump to correct the timing.  
To advance timing—Rotate the pump toward the engine  
To retard timing—Rotate the pump away from the engine

5. After setting the pump timing, retighten the mounting bolts and check to make sure that the timing didn't change when the bolts were tightened.

**NOTE:** Be sure to retighten the injection pump mounting bolts in the following order:

1. Tighten the nut on the front flange on the inside of the engine.
2. Tighten the nut on the front flange on the outside.
3. Tighten both rear bolts.

## Static Timing Procedure—VP-20 Pump

The static timing procedure is not needed under most circumstances. The only time which static timing is set is when a new fuel injection pump is installed; and this is **only in California** on the VP-20 pump. Use the following procedure to set the static timing.

1. Turn the engine to number 1 TDC.
2. Remove the timing plug in the injection pump head.
3. Install the adapter D84P-9000-D (Fig. 56) into the injection pump. The plunger portion of the adapter must project into the pump so it can contact the fuel injection pump plunger. Mount the dial indicator into the adapter and make sure that there is at least 0.100 in (0.25 mm) of preload on the dial indicator.

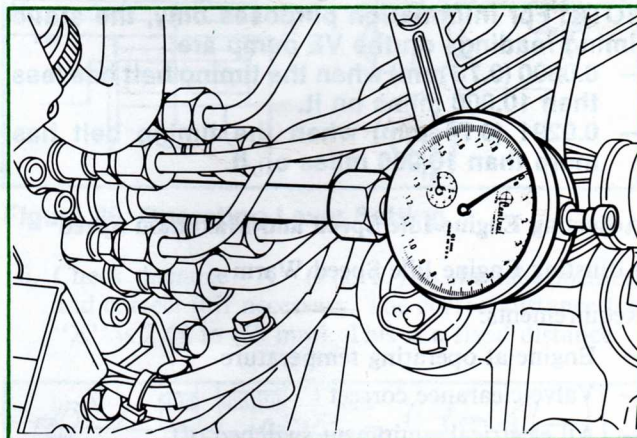


Figure 56. Static Timing Adapter and Dial Indicator

4. Turn the crankshaft in the direction of engine rotation until the dial gauge displays the lowest value. Set the dial gauge to zero.
5. Continue turning the crankshaft in the direction of rotation until cylinder 1 is at TDC on the compression stroke. Hold the engine at number 1 TDC using special tool T84P-6400-A.



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6. The measurement on the dial indicator should read:
  - $0.0256 \pm .0015$  in ( $0.65 \pm 0.04$  mm) when the timing belt has less than 10,000 miles on it.
  - $0.0248 \pm .0015$  in ( $0.63 \pm 0.04$  mm) when the timing belt has more than 10,000 miles on it.

If the measurement is not correct, the proper measurement can be attained by loosening the injection pump and turning it using special tool T84P-9000-B until the specified measurement is reached.

- Measurement too small—swing the pump toward the engine
  - Measurement too large—swing the pump away from the engine
7. Tighten the injection pump mounting nuts in the specified order, and remove special tools T84P-6400-A and T84P-9000-B.
  8. Turn the engine over twice and recheck the measurement with the engine at number 1 TDC. If the measurement is correct, remove the dial indicator and adapter and reinstall the plug in the injection pump. If the measurement is not correct, static timing will have to be reset by repeating steps 1-8.

**NOTE: Dynamic timing should be checked on the 2.4L diesel after setting static timing to assure that the trunk mounted fuel flow computer is operating correctly.**

**NOTE: For information purposes only, the static timing readings on the VE pump are:**

- 0.0300 (0.76 mm) when the timing belt has less than 10,000 miles on it.
- 0.0291 (0.74 mm) when the timing belt has more than 10,000 miles on it.

## Adjusting Engine Idle Speed and Maximum Speed

### Adjusting Engine Idle Speed Warm

#### Requirements:

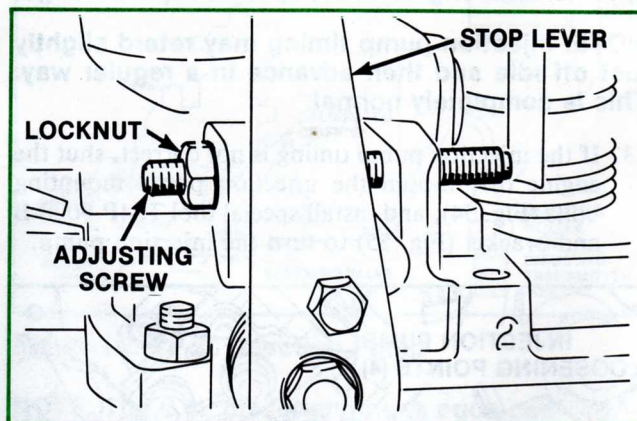
- Engine at operating temperature
- Valve clearance correct
- All electrical equipment switched off
- Tachometer connected
- Play between knurled nut and lever

To adjust the warm idle speed:

1. Loosen the locknut (Fig. 57) on the adjusting screw and adjust the idle speed. The correct idle speed is 750-800 rpm.
2. Start the engine.
3. Tighten the locknut.

4. Check the knurled nut for play between the lever and knurled nut. Play should be 0.020 to 0.040 in (0.5 to 1.0 mm).

5. Check and, if necessary, correct linkage adjustment after adjusting idle speed.



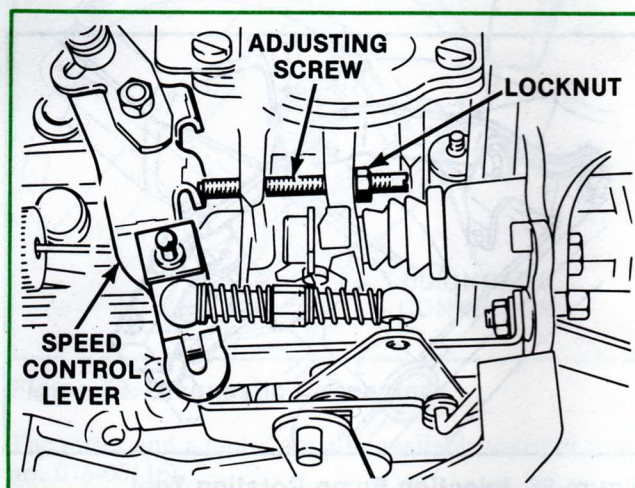
**Figure 57. Locknut and Adjusting Screw**

### Adjusting Maximum Engine Speed

#### Requirement:

- Engine at operating temperature.

**NOTE: If the maximum engine speed is adjusted, all other adjustments on the pump will have to be checked.**



**Figure 58. Maximum Speed Setting**

To adjust the maximum engine speeds:

1. Start the engine
2. Move the speed control lever (Fig. 58) to the W.O.T. position.



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- Loosen the locknut and adjust the maximum speed with the adjusting screw shown in Figure 58. The maximum top speed of the engine without a load at its normal operating temperature is  $5,350 \pm 100$  rpm.
- Check the throttle cable adjustment so that the speed control lever rests on the stop screw when it is in the W.O.T. position.
- Check and, if necessary, correct the linkage adjustment after finishing adjustments of the maximum speed.

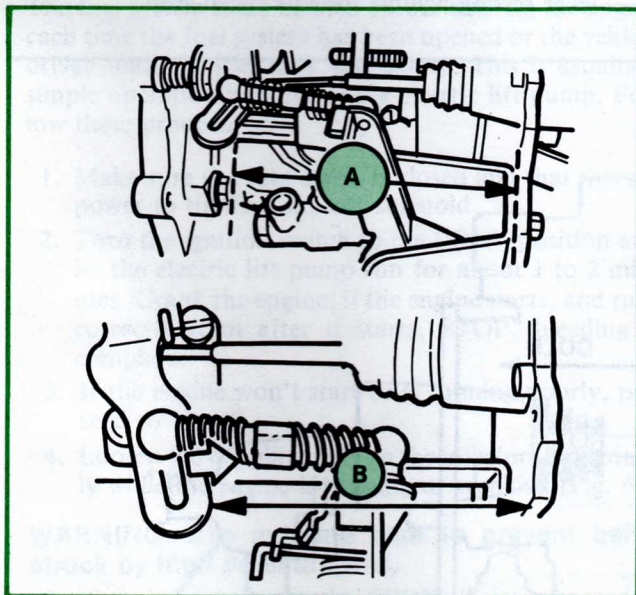
## Adjusting the Injection Pump Operating Lever

### Requirements:

- Engine idle speed correct
- Engine maximum speed correct
- Engine at operating temperature and partial load enrichment canceled or cable clamp disconnected to provide play between knurled nut and operating lever.

To adjust the injection pump operating lever, follow this procedure:

- Measure and note distance "A" (Fig. 59).
- Push operating lever against the full load stop. Measure and note distance "B" (Fig. 59).



**Figure 59. Operating Lever Setting**

- Subtract distance "B" from distance "A".

$$A - B = Y$$

Example: A = 3.6 in (92.0 mm)

B = 1.9 in (48.5 mm)

Y = 1.70 in (43.5 mm)

- Find distance "C" for adjusting linkage in the following table.

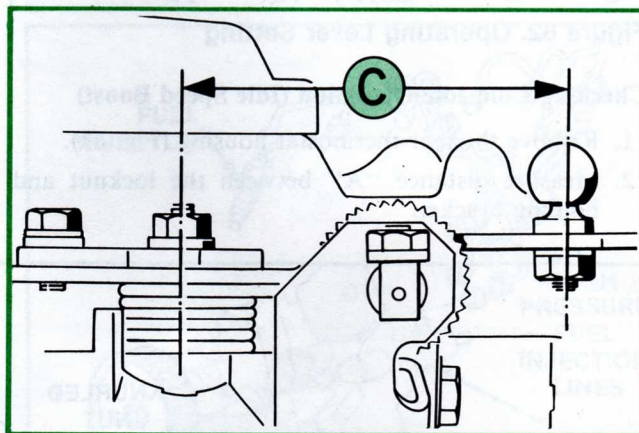
### Adjusting Table: English

Y (in.)	1.61	1.63	1.65	1.67	1.69	1.71	1.73	1.75	1.77	1.79	1.81	1.83
C (in.)	3.07	3.03	3.00	2.94	2.90	2.87	2.83	2.79	2.76	2.73	2.70	2.66
Y (in.)	1.85	1.87	1.89	1.91	1.93	1.95	1.97	1.99	2.01	2.03	2.05	2.07
C (in.)	2.64	2.61	2.58	2.55	2.53	2.50	2.47	2.45	2.42	2.40	2.38	2.35
Y (in.)	2.09	2.11	2.13	2.15	2.17	2.19	2.20					
C (in.)	2.33	2.31	2.29	2.27	2.26	2.24	2.22					

### Adjusting Table: Metric

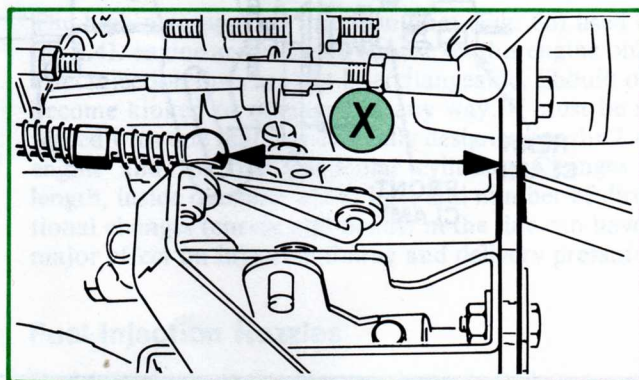
Y (mm)	41	41.5	42	42.5	43	43.5	44	44.5	45	45.5	46	46.5
C (mm)	78.1	77.0	76.0	74.9	73.9	73.0	72.0	71.1	70.3	69.4	68.6	67.8
Y (mm)	47	47.5	48	48.5	49	49.5	50	50.5	51	51.5	52	52.5
C (mm)	67.0	66.3	65.6	64.9	64.2	63.5	62.9	62.3	61.6	61.0	60.5	59.9
Y (mm)	53	53.5	54	54.5	55	55.5	56					
C (mm)	59.4	58.8	58.3	57.8	57.3	56.8	56.4					

- Disconnect linkage and measure distance "C" (Fig. 60). Compare the measurement with those in the table, and correct the distance if necessary.



**Figure 60. Operating Lever Setting**

- Check distance "X" (Fig. 61) in the idle position and correct it if necessary. The correct distance for "X" is 2.68 in (68 mm). This is a fixed distance.

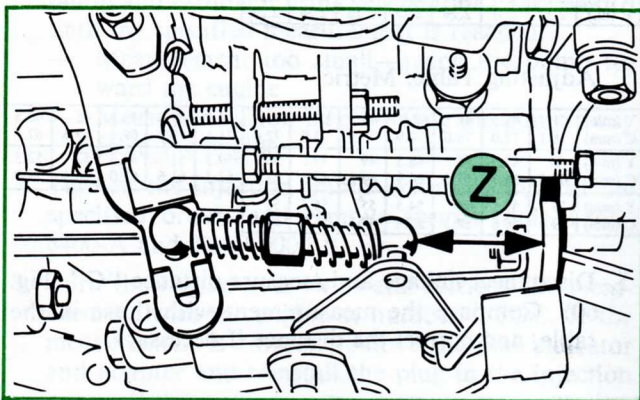


**Figure 61. Operating Lever Setting**



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7. Check the adjustment at W.O.T. In the W.O.T. position, distance "Z" (Fig. 62) must be  $1.14 \pm 0.20$  in ( $29.0 \pm 0.5$  mm). If distance "Z" is not correct, repeat adjustments 1-4.
8. Check and, if necessary, correct throttle cable adjustment.



**Figure 62. Operating Lever Setting**

## Checking Cold Idle Operation (Idle Speed Boost)

1. Remove the rear thermostat housing (Fig. 63).
2. Measure distance "A" between the locknut and holding bracket.

The measurement should be  $0.216 \pm 0.015$  in ( $5.5 \text{ mm} \pm 0.4 \text{ mm}$ ).

**NOTE: During this measurement the lever should rest against the knurled nut.**

### Adjustment:

This is a factory sealed adjustment which should not be tampered with. If the seal has been broken, and the adjustment tampered with; use the following method to correct the adjustment:

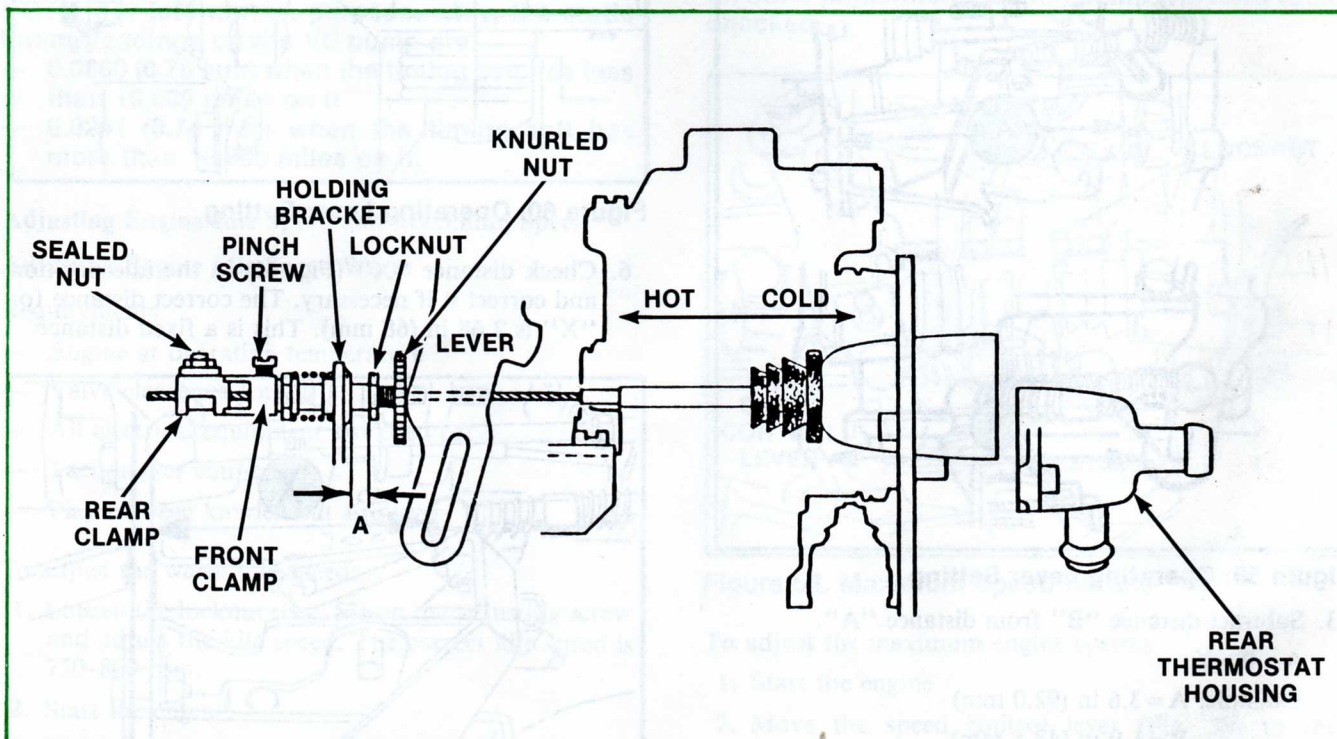
1. Loosen both the front and rear clamps.
2. Adjust measurement "A" by moving the clamps. Tighten the rear clamp first.
3. Tighten the pinch screw on the front clamp.
4. Recheck the adjustment at point "A" and seal the nut on the rear clamp with yellow paint.

### Adjusting the Knurled Nut

Warm engine adjustment (Fig. 64).

### Requirements:

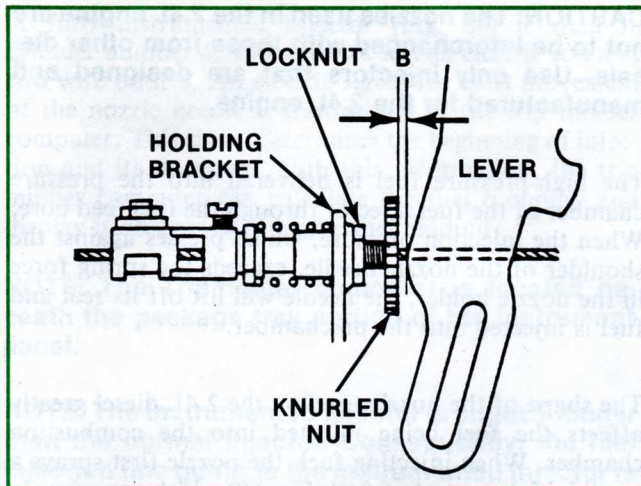
- correct warm engine idle speed
- coolant temperature above  $77^\circ\text{F}$  ( $25^\circ\text{C}$ )
- locknut resting against the holding bracket
- lever resting against the idle speed stop



**Figure 63. Idle Speed Boost Adjustment**



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**Figure 64. Knurled Nut Adjustment**

1. Measure distance "B" (Fig. 64) between the lever and knurled nut. The measurement should be  $0.020 \pm 0.011$  in ( $0.5 \pm 0.3$  mm).
2. To adjust "B" loosen the locknut and move the knurled nut to set the correct distance.
3. Tighten the locknut and recheck the adjustment.

## Bleeding the Fuel System

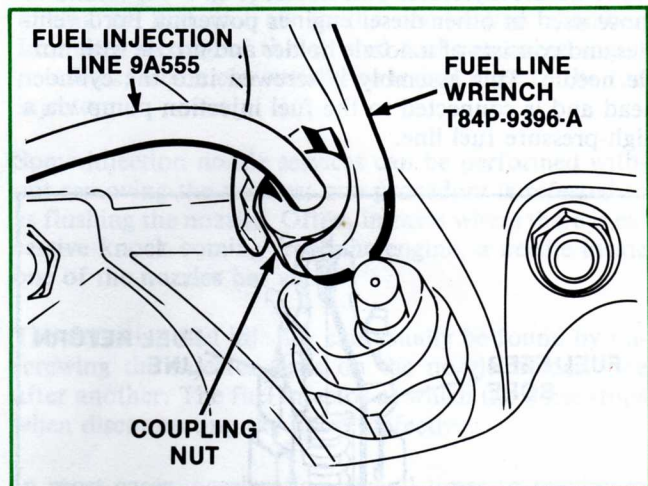
The fuel system must be bled before starting the engine each time the fuel system has been opened or the vehicle driven until the fuel tank was empty. This is usually a simple operation because of the electric lift pump. Follow these procedures:

1. Make sure the vent screw is closed and that there is power to the fuel shutoff solenoid.
2. Turn the ignition switch to the "ON" position and let the electric lift pump run for about 1 to 2 minutes. Crank the engine, if the engine starts, and runs correctly soon after it starts, STOP, bleeding is complete.
3. If the engine won't start or is running poorly, proceed to step 4.
4. Loosen the coupling nuts on the injectors individually while the engine is running or cranking (Fig. 65).

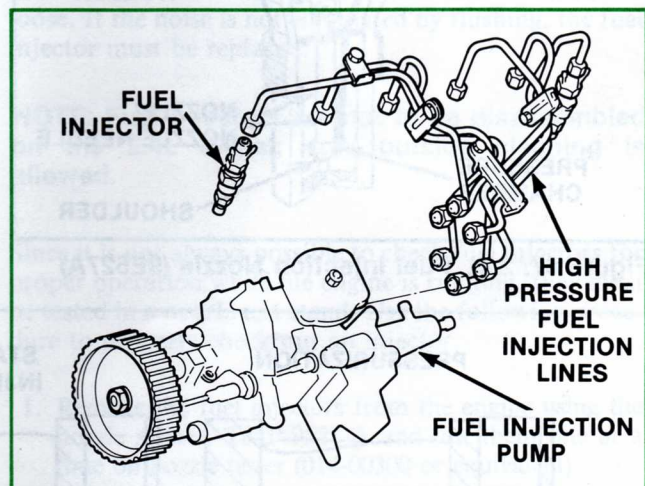
**WARNING: Use extreme care to prevent being struck by high pressure fuel.**

5. If engine runs correctly, STOP, if not, proceed to step 6.
6. If additional bleeding is required it should be done in the following order with a cranking or running engine.
  - fitting labeled "OUT"
  - timing plug
  - fuel shutoff solenoid
  - injector pressure outlet valves

7. If the engine will still not start, replace the fuel shut-off solenoid, it is probably defective.



**Figure 65. Loosening Coupling Nuts**



**Figure 66. High-Pressure Fuel Injection Lines**

## High-Pressure Fuel Injection Lines

The high-pressure fuel injection lines (Fig. 66) used on the 2.4L engine are designed for use on this engine only. Fuel injection lines are **not** interchangeable. Should one become kinked or damaged in any way, it must be replaced with one that is specifically designed for the 2.4L engine and for that particular cylinder. Changes in length, inside diameter of the line, and number of directional changes (curves and bends) in the line can have a major effect on injection timing and delivery pressures.

## Fuel Injection Nozzles

Fuel injection nozzles have an important duty to perform in all diesel engines. How well the fuel is atomized and how efficiently the energy contained in the fuel is



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used during combustion depend on the injector nozzles. The 2.4L diesel employs liquid-controlled, throttling pintle-nozzle injectors. This nozzle (Fig. 67) is similar to those used in other diesel engines powering Ford vehicles and consists of a nozzle holder and nozzle with nozzle needle. This assembly is screwed into the cylinder head and is connected to the fuel injection pump via a high-pressure fuel line.

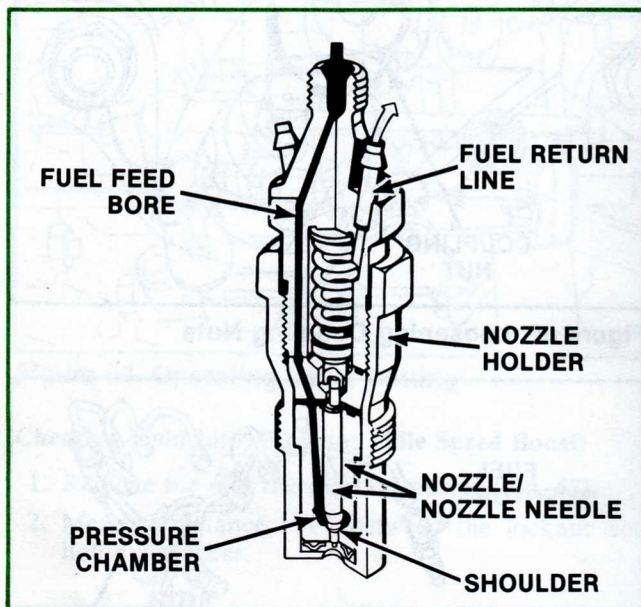


Figure 67. 2.4L Fuel Injection Nozzle (9E527A)

**CAUTION:** The nozzles used in the 2.4L engine are not to be interchanged with those from other diesels. Use only injectors that are designed and manufactured for the 2.4L engine.

The high-pressure fuel is delivered into the pressure chamber of the fuel injector through the fuel feed bore. When the injection pressure, which presses against the shoulder of the nozzle needle, exceeds the spring force in the nozzle holder, the needle will lift off its seat and fuel is injected into the prechamber.

The shape of the nozzle used on the 2.4L diesel greatly affects the fuel being injected into the combustion chamber. When injecting fuel, the nozzle first sprays a small initial amount of fuel (Fig. 68) which vaporizes in the prechamber and ignites. Immediately afterward, the main amount of fuel is injected and the combustion can be started. This type of injector guarantees smooth engine running and minimal engine noise.

All fuel injectors are connected with each other via a fuel return line, so that fuel leaking past the nozzle needle can be returned to the fuel tank.

**NOTE:** A certain amount of internal leakage is designed into every fuel injector for lubrication purposes.

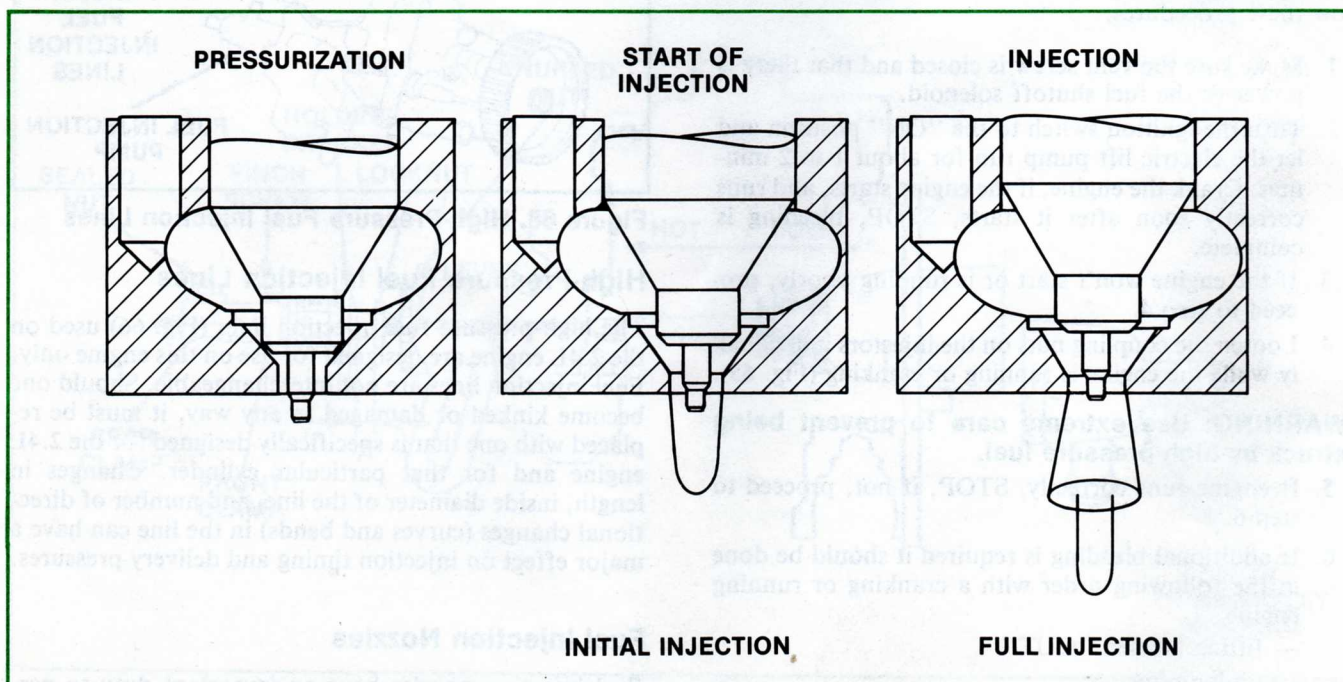


Figure 68. Fuel Injection



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A fully instrumented injector (Fig. 69) is used in cylinder number 4. This injector has an electric coil and two wire outlets. An electric signal for each movement of the nozzle needle is transmitted to the trip minder computer. This signal determines the beginning of injection and its duration. With this information, the trip minder computer can calculate the fuel economy and display it on the instrument panel readout.

**NOTE: The Tripminder computer is located beneath the package tray portion of the instrument panel.**

**NOTE: The instrumented injector is slightly longer than the normal injector. Consequently, the fuel injection line going to the instrumented injector is slightly shorter than the others.**

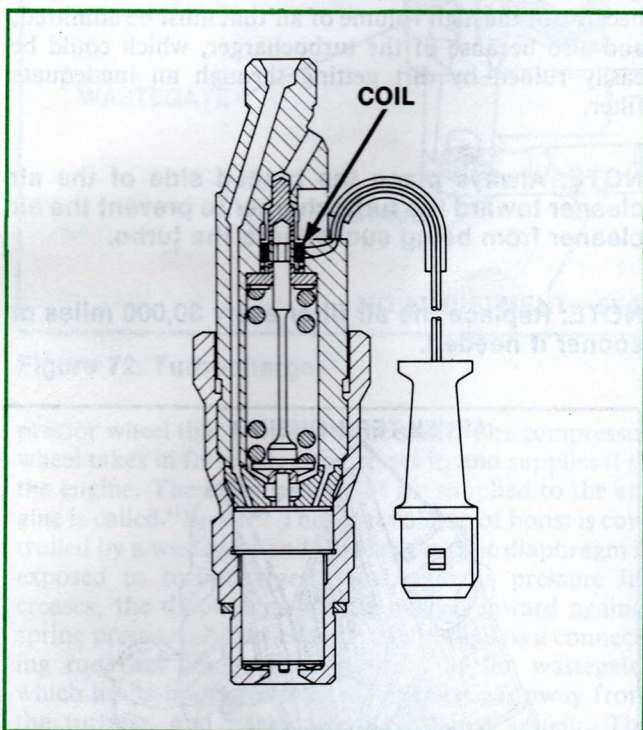


Figure 69. Instrumented Injector (9E527B)

**NOTE: 2.4L diesel vehicles that are sold in California will be equipped with two fully instrumented injectors. In cylinder 4, the injector will send signals to a trunk-mounted computer that monitors fuel flow and engine timing; using information from the injector, the computer will change engine timing for the best engine performance with the smallest amount of emissions. In cylinder 5, the injector will send signals to the trip minder as in 49-state vehicles.**

## Fuel Injection Nozzle Service

Proper engine operation is dependent on the correct mixing of fuel and air in the combustion chamber. Improper mixing of the air and fuel can cause engine problems, which can usually be traced back to the fuel injector.

Some injection nozzle services can be performed without removing the nozzles; one procedure is referred to as flushing the nozzles. Often, in cases where there is excessive knock coming from the engine, a needle inside one of the nozzles has seized.

The defective fuel injector can usually be found by unscrewing the injector lines on the nozzle holder, one after another. The fuel injector at which the noise stops when disconnecting the line is defective.

In most cases, accelerating several times to maximum speed in an unloaded condition (car stopped and in park or neutral) will be sufficient to flush the nozzle needle loose. If the noise is not eliminated by flushing, the fuel injector must be replaced.

**NOTE: Fuel injectors are not to be disassembled on the 2.4L diesel; only outside cleaning is allowed.**

Since it is not always possible to check fuel injectors for proper operation while the engine is running, they must be tested in a nozzle test stand. Use the following procedure to properly check out an injector.

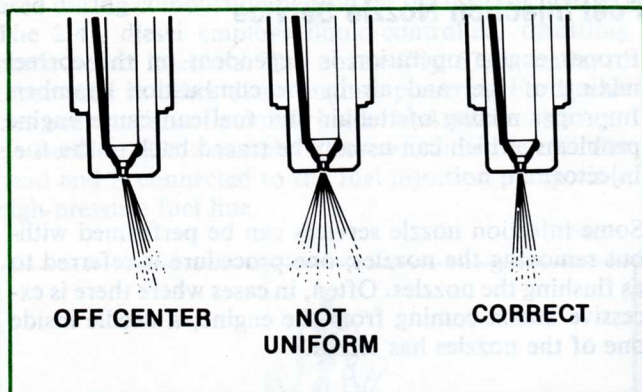
1. Remove the fuel injectors from the engine using the nozzle socket, T84P-9527-A and test them one at a time on nozzle tester (014-00300 or equivalent).

**NOTE: Test the injection nozzles using SAE-approved calibration oil 208629, SAE J967D, or ISO 4173 fluid rather than diesel fuel.**

2. After connecting a nozzle to the pressure line of the nozzle tester, air bleed the line and nozzle by pumping the tester handle several times.
3. Perform the SPRAY PATTERN TEST
  - Operate the lever of the tester in short, fast strokes.
  - The injected fuel should have a rather tight and cone-shaped pattern (Fig. 70).
  - The fuel stream should break off cleanly at the end of each stroke.



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**Figure 70. Injection Nozzle Spray Patterns**

## 4. Perform the CHATTER TEST

- Operate the lever of the tester slowly and completely (1 to 2 strokes per second)
- A properly operating nozzle will “chatter” when fuel is injected.

## 5. Perform the INJECTION PRESSURE TEST

- Press down the lever of the tester slowly. Read the pressure on the pressure gauge when injection begins.

Nominal pressure for a  
new injector ..... 2175 + 116 psi  
(15,000 + 800 kPa)

Minimum allowable injection  
pressure ..... 1957.5 psi (13,500 kPa)

Maximum difference among nozzles  
in one engine ..... 145 psi (1000 kPa)

## 6. Perform the VALVE SEAT SEALING TEST:

- Press down the lever of the tester slowly and hold it 10 seconds at approximately 290 psi (2000 kPa) below opening pressure. The nozzle must not drip fuel.

## 7. Fuel injectors may not be repaired. Always replace fuel injectors when the nozzle is defective or leaks, spray pattern is wrong, or opening (injection) pressure is wrong.

## 8. Remember that the nozzle holding nut has a copper seal which must be replaced whenever an injector is removed and installed. Also, the injector threads should be coated with anti-seize compound before installation.

## Fuel Return Line

The fuel return line used on the vehicles powered by the 2.4L diesel runs from the fuel injection pump and nozzles back to the fuel tank, parallel to the supply line, and down the left side of the vehicle. The purpose of this line is to return unused fuel from the injection pump and

nozzles to the fuel tank. The fuel system used with the 2.4L diesel is referred to as a “high flow” system, because only about 10 percent of the fuel that is transferred from the fuel tank to the injection pump and nozzles is actually burned. The remaining 90 percent is used to cool and lubricate the pump and nozzles before being returned to the fuel tank. Fuel returning to the tank is filtered and conditioned, and should contain very little, if any, contaminants. Since this return fuel is warm, it helps prevent the buildup of ice or wax on the diesel fuel intake in the tank during cold weather.

## AIR INTAKE SYSTEM

Air entering the 2.4L diesel engine must first go through the high volume air cleaner (Fig. 71) before it can be admitted to the turbocharger. It is very important that only the recommended air cleaner be used on this engine because of the high volume of air that must be admitted, and also because of the turbocharger, which could be easily ruined by dirt getting through an inadequate filter.

**NOTE: Always place the braced side of the air cleaner toward the turbocharger to prevent the air cleaner from being sucked into the turbo.**

**NOTE: Replace the air filter every 30,000 miles or sooner if needed.**



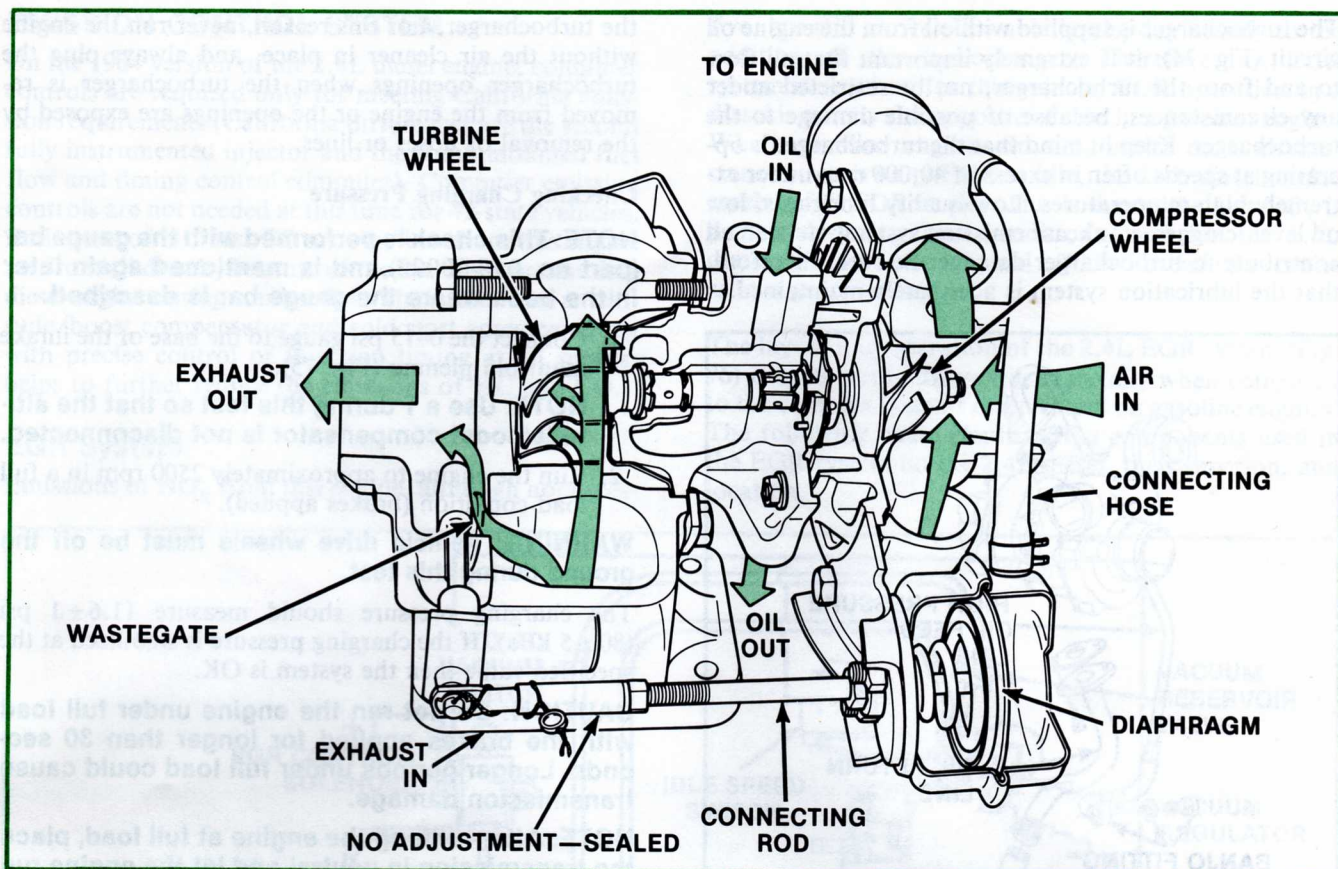
**Figure 71. High Volume Air Cleaner**

## Turbocharger

A turbocharger (Fig. 72) is used on the 2.4L diesel engine to improve its efficiency and performance. During operation, the turbine wheel of the turbocharger is driven by exhaust gas heat. The turbine drives a com-



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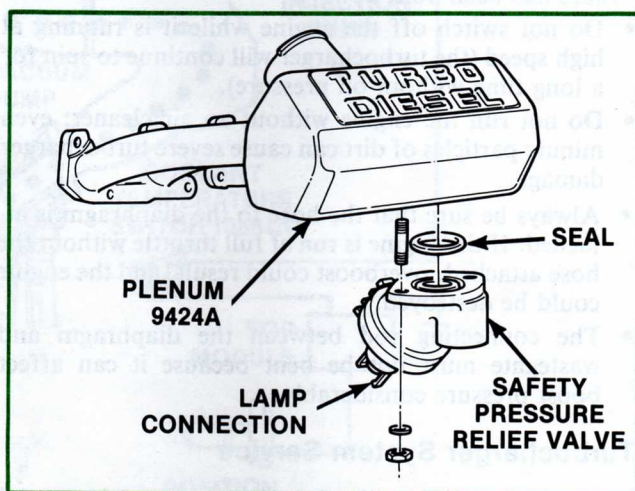


**Figure 72. Turbocharger**

pressor wheel that is on the same shaft. The compressor wheel takes in fresh air, compresses it, and supplies it to the engine. The extra volume of air supplied to the engine is called "boost." The total volume of boost is controlled by a wastegate and diaphragm. The diaphragm is exposed to turbocharger boost, and as pressure increases, the diaphragm will be pushed inward against spring pressure. Attached to the diaphragm is a connecting rod that controls the opening of the wastegate, which limits boost by diverting exhaust gas away from the turbine, and back into the exhaust system. The wastegate should open at approximately 12 psi (81 kPa) and keep turbocharger boost from going beyond this point.

In the event that the wastegate cannot divert enough exhaust gas away from the turbine to keep boost down or there is a malfunction in the diaphragm or wastegate, a safety pressure relief valve (Fig. 73) will divert excess boost to the atmosphere. It is located on the bottom of the intake manifold plenum, and will open when turbocharger boost reaches approximately 13 psi (90 kPa). The safety pressure relief valve is hooked into the

"check engine" lamp circuit and will cause this lamp to come on when the valve opens, indicating an overboost condition. The lamp will go out when boost goes below 13 psi and the valve closes.



**Figure 73. Safety Pressure Relief Valve**



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The turbocharger is supplied with oil from the engine oil circuit (Fig. 74). It is extremely important that oil flow to and from the turbocharger, not be restricted under any circumstances, because of possible damage to the turbocharger. Keep in mind that the turbocharger is operating at speeds often in excess of 40,000 rpm under extremely high temperatures. Low-quality lubricants, low oil level, clogged crankcase emission system, etc. can all contribute to turbocharger damage. Be sure, therefore, that the lubrication system is adequately maintained.

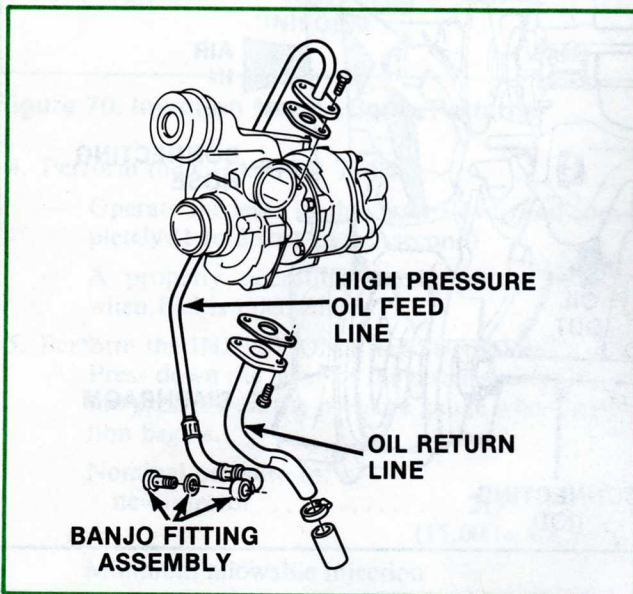


Figure 74. Turbocharger Lubrication

Other important points about turbocharged engines are as follows:

- Do not accelerate the engine before engine oil pressure has been built up.
- Do not switch off the engine while it is running at high speed (the turbocharger will continue to spin for a long time without oil pressure).
- Do not run the engine without an air cleaner; even minute particles of dirt can cause severe turbocharger damage.
- Always be sure that the hose to the diaphragm is attached. If the engine is run at full throttle without the hose attached, overboost could result, and the engine could be destroyed.
- The connecting rod between the diaphragm and wastegate must not be bent because it can affect boost pressure considerably.

## Turbocharger System Service

When servicing the turbocharger, be extremely careful not to let dirt get into it. Remember that even the most minute particle of dirt could lead to the destruction of

the turbocharger. For this reason, never run the engine without the air cleaner in place, and always plug the turbocharger openings when the turbocharger is removed from the engine or the openings are exposed by the removal of hoses or lines.

## Checking Charging Pressure

**NOTE:** This check is performed with the gauge bar (part no. 019-00022) and is mentioned again later in the book where the gauge bar is described.

1. Connect the 0-15 psi gauge to the base of the intake manifold plenum (Fig. 75).

**NOTE:** Use a T during this test so that the altitude/boost compensator is not disconnected.

2. Run the engine to approximately 2500 rpm in a full load condition (brakes applied).

**WARNING:** Vehicle drive wheels must be off the ground during this test.

The charging pressure should measure  $11.6 \pm 1$  psi ( $80 \pm 5$  kPa). If the charging pressure is stabilized at the specified value then the system is OK.

**CAUTION:** Do not run the engine under full load with the brakes applied for longer than 30 seconds. Longer periods under full load could cause transmission damage.

**NOTE:** After running the engine at full load, place the transmission in neutral and let the engine run for about a minute at 1000 rpm. This will cool the transmission.

If the value on the vehicle does not conform to these specifications, then check (and, if necessary, replace) the following components:

- wastegate diaphragm
- hose connections
- turbocharger
- safety pressure regulator

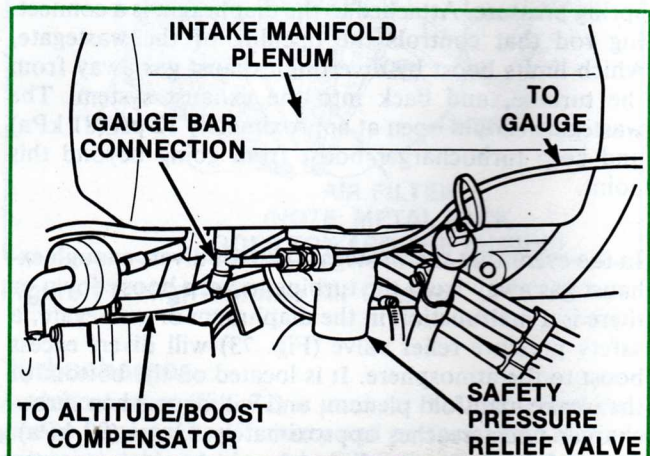


Figure 75. Checking Charging Pressure



# ENGINE SYSTEMS AND COMPONENTS

## EMISSION CONTROL SYSTEM

On the 1984 version of the 2.4L diesel engine, computer controls are required only for meeting California emission requirements (California differences are the second fully instrumented injector and the trunk mounted fuel flow and timing control computer). Computer emission controls are not needed at this time for 49-state vehicles. Emissions of HC and CO are very low from this engine (as from all diesels) because of the excess air present in a diesel engine during combustion. The addition of an altitude/boost compensator and cold start advance, along with precise control of injection timing at all speeds, helps to further reduce the emissions of HC and CO.

## EGR System

Emissions of  $\text{NO}_x$  from this engine, although not exces-

sive, are still above allowable levels, due mainly to the addition of the turbocharger. Therefore, an EGR system is required for this vehicle. EGR operation in a diesel is exactly the opposite of that in a gasoline engine. Where gasoline engines do not, under most circumstances, receive any EGR at idle, the 2.4L diesel engine receives full EGR at idle. This is due to the fact  $\text{NO}_x$  is produced during lean conditions, and for the 2.4L diesel, this occurs at idle and off idle instead of at cruise as in a gasoline engine.

The layout and operation of the 2.4L EGR system (Fig. 76) is quite straightforward, especially when compared to the complex systems often found on gasoline engines. The following chart identifies the components used in the EGR system on the 2.4L diesel, their function, and location.

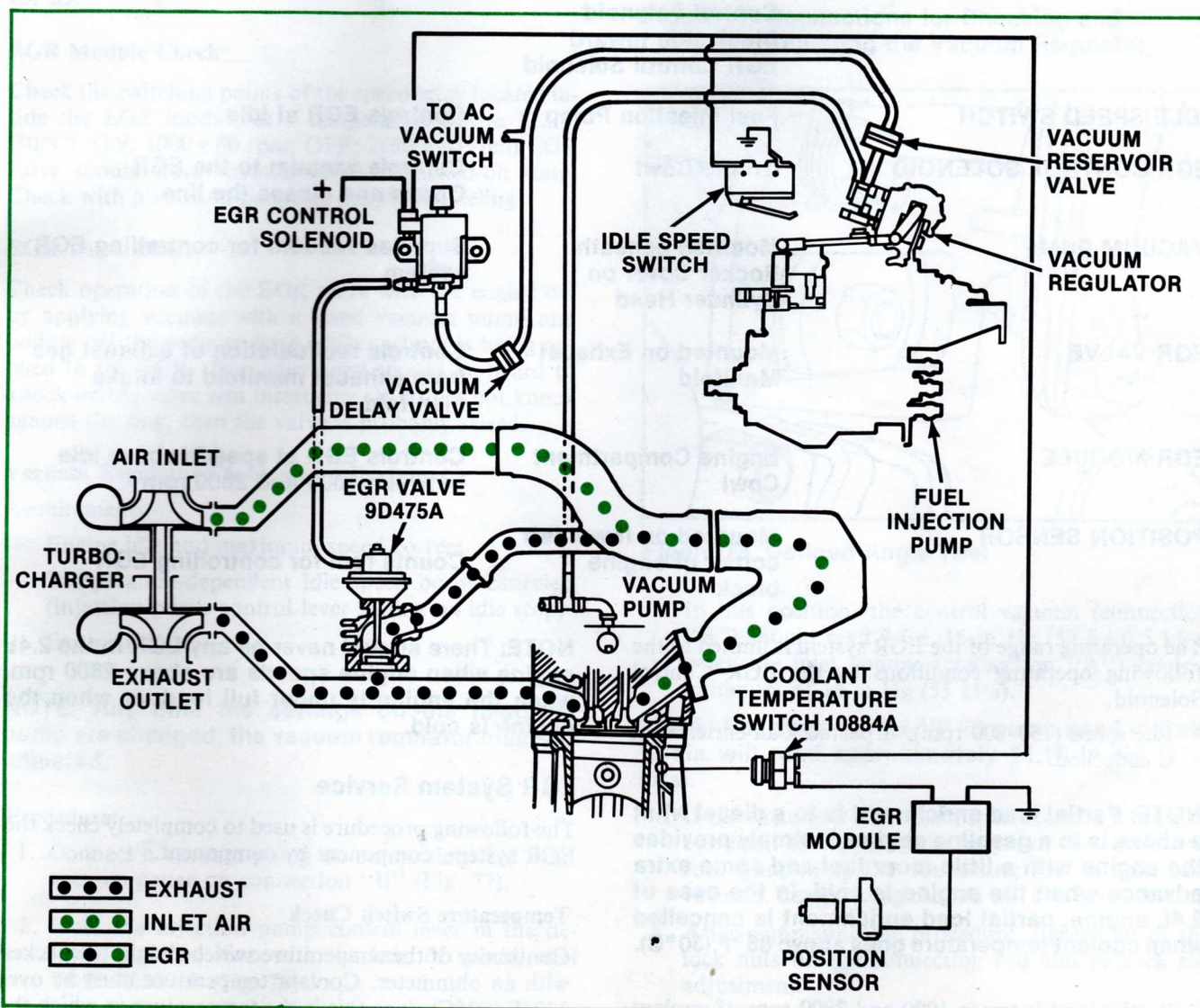


Figure 76. 2.4L EGR System



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COMPONENT	LOCATION	FUNCTION
TEMPERATURE SWITCH	Cylinder Head	Senses coolant temperature Closes above 50°C
VACUUM REGULATOR	Top of Fuel Injection Pump	Controls amount of EGR in relation to the amount of fuel being injected
VACUUM RESERVOIR VALVE (White)	Top of the Fuel Injection Pump Must be within 3 inches of Vacuum Regulator	Prevents Pulsations to the Vacuum Regulator
VACUUM DELAY VALVE (White/Black)	In the Vacuum Line between the Vacuum Regulator and EGR Control Solenoid— Black side toward EGR Control Solenoid	Improves driveability by soft initiation of EGR
IDLE SPEED SWITCH	Fuel Injection Pump	Controls EGR at idle
EGR CONTROL SOLENOID	On the Cowl	Controls vacuum to the EGR Opens and closes the line
VACUUM PUMP	Mounted beneath Rocker Cover on Cylinder Head	Supplies vacuum for controlling EGR system
EGR VALVE	Mounted on Exhaust Manifold	Controls recirculation of exhaust gas from exhaust manifold to intake manifold
EGR MODULE	Engine Compartment Cowl	Controls EGR at speeds above idle between 1000 and 2800 rpm
POSITION SENSOR	Mounted on lower left corner of engine block	Counts rpm for controlling EGR

The operating range of the EGR system is limited to the following operating conditions by the EGR Control Solenoid.

- Idle speed (750–800 rpm), if partial load enrichment is cancelled.

**NOTE: Partial load enrichment is to a diesel what a choke is to a gasoline engine. It simply provides the engine with a little more fuel and some extra advance when the engine is cold. In the case of 2.4L engine, partial load enrichment is cancelled when coolant temperature goes above 86°F (30°C).**

- Partial load between 1000 and 2800 rpm, if coolant temperature is above 122°F (50°C).

**NOTE: There should never be any EGR in the 2.4L engine when engine speeds are above 2800 rpm, when the engine is under full load, or when the engine is cold.**

## EGR System Service

The following procedure is used to completely check the EGR system, component by component.

### Temperature Switch Check

Continuity of the temperature switch should be checked with an ohmmeter. Coolant temperature must be over 122°F (50°C) since this is the temperature at which the switch closes. The ohmmeter should indicate continuity.



# ENGINE SYSTEMS AND COMPONENTS

## Idle Speed Switch

Check the continuity of the idle speed switch with an ohmmeter. The switch will open with a clearance of approximately .040 in (1 mm) between the idle stop screw and control lever when operating the injection pump control lever. The ohmmeter should show continuity at warm idle. The ohmmeter should show no continuity when the throttle is opened more than .040 in (1 mm).

## EGR Control Solenoid

Check air flow in the switching valve at idle (750 to 800 rpm), and at a speed range of 1000 to 2800 rpm with a temperature greater than 122°F (50°C). At this point, there should be vacuum in the connecting line between the EGR Control Solenoid and the EGR valve. This can be checked with a vacuum gauge, or simply by feeling for it.

## EGR Module Check

Check the switching points of the speed relay located inside the EGR module at a temperature above 122°F (50°C) (ON:  $1000 \pm 60$  rpm; OFF:  $2880 \pm 80$  rpm) EGR valve should have vacuum in the switched-on state. Check with a vacuum gauge or simply by feeling.

## EGR Valve Check

Check operation of the EGR valve with the engine off by applying vacuum with a hand vacuum pump and pulling off the vacuum hose while vacuum is being applied to the EGR. The valve head should be heard to knock on the valve seat insert ring. If it does not knock against the ring, then the valve is probably seized.

## Vacuum Regulator Check and Adjustment

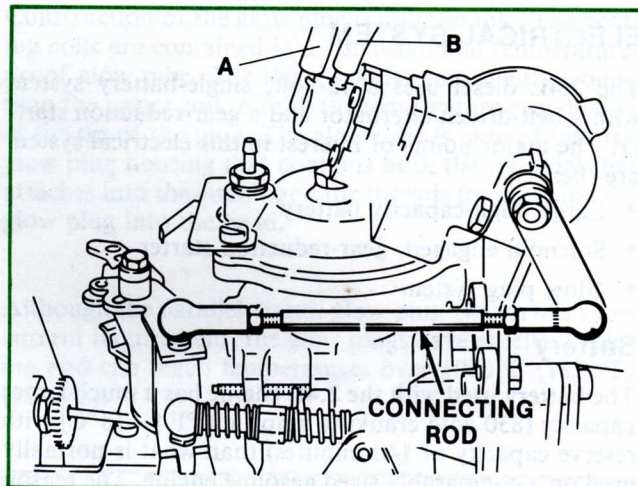
### Requirements:

- Engine idle and maximum speed correct
- Temperature-dependent idle speed boost canceled (injection pump control lever resting on idle stop)
- Engine Off

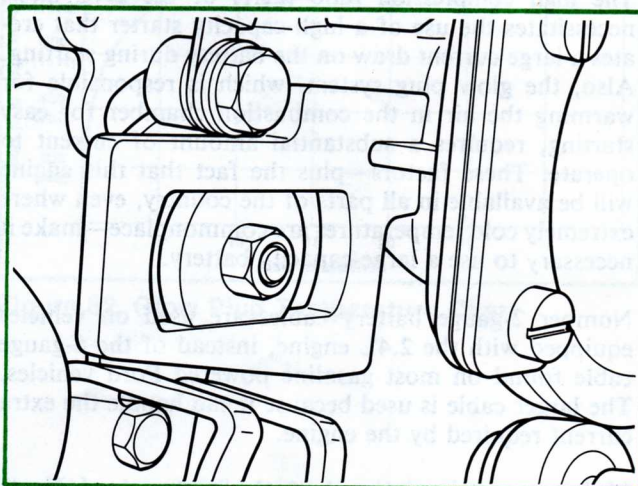
**NOTE: Any time the settings on the injection pump are changed, the vacuum regulator must be adjusted.**

### Procedure:

1. Connect a vacuum pump on connection "A" and vacuum gauge on connection "B" (Fig. 77).
2. Hold the injection pump control lever in the defined angle position with the help of special tool T84P-7B200-A (Fig. 78).



**Figure 77. Connections for Checking and Adjusting the Vacuum Regulator**



**Figure 78. Defined Angle Tool**

3. In this position, the control vacuum (connection "B") should read  $9.6 \pm .15$  in Hg ( $32.5 \pm 0.5$  kPa) when the inlet volume (connection "A") reads a minimum of 16 in Hg (55 kPa).

**NOTE: Readings on the VP-20 pump used in California will read approximately 11.10 in Hg (37.5 kPa).**

4. If the vacuum is not within specification, it must be corrected by changing the length of the connecting rod. Shortening the connecting rod will increase vacuum. Lengthening the rod will decrease vacuum.
5. After completing the procedure, tighten all of the lock nuts on the connecting rod and recheck the adjustment.



# ENGINE SYSTEMS AND COMPONENTS

## ELECTRICAL SYSTEM

The 2.4L diesel uses a 12-volt, single-battery system with a belt-driven alternator and a gear-reduction starter. The major points of interest in this electrical system are the:

- Large, high-capacity battery
- Solenoid engaged, gear-reduction starter
- Glow plug system

### Battery

The battery used with the 2.4L engine has a much larger capacity (850 cold cranking amps at 0°F [-18°C] with reserve capacity of 140 minutes) than what is normally used on a comparably sized gasoline engine. The reason for using this large-capacity battery with such a small-displacement engine is that diesels, in general, because of their design, are more difficult to start when cold. The high compression ratio (22:1) of the 2.4L diesel necessitates the use of a high-capacity starter that creates a large current draw on the battery during starting. Also, the glow plug system, which is responsible for warming the air in the combustion chamber for easy starting, requires a substantial amount of current to operate. These factors—plus the fact that this engine will be available in all parts of the country, even where extremely cold temperatures are commonplace—make it necessary to use a large-capacity battery.

Number 2-gauge battery cables are used on vehicles equipped with the 2.4L engine, instead of the 6-gauge cable found on most gasoline powered Ford vehicles. The larger cable is used because it can handle the extra current required by the engine.

The starter relay used on the 2.4L diesel engine is located on the left inner fender, just back from the battery. It is used only to energize the pull-in solenoid on the starter when the key is turned to the “START” position. The starter relay does not handle starter current, as there is a direct cable connection between the battery and starter.

### Starter

The starter (Fig. 79) used on the 2.4L diesel is different from those used on gasoline powered, Ford/Lincoln-Mercury vehicles. This starter has the following features:

- Solenoid engaged
- Internal gear reduction
- Needle bearings instead of bushings

Although this starter is fully serviceable, note the following points on its service and testing:

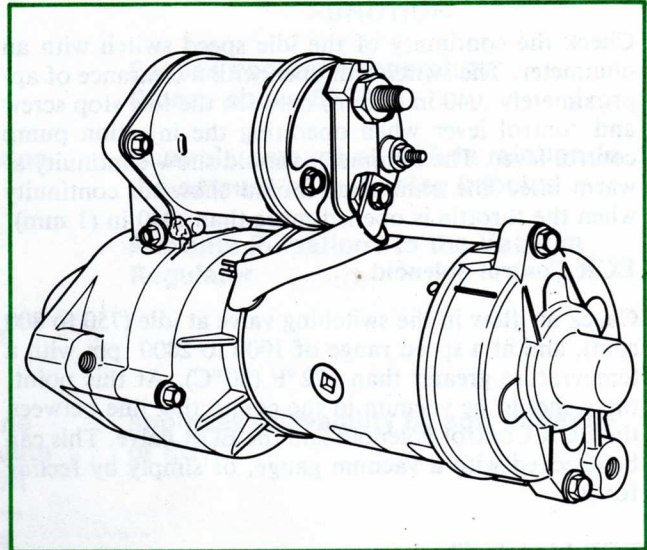


Figure 79. Starter (11001)

- Should the plastic cap on the solenoid become cracked during service procedures, the entire solenoid must be replaced.
- Starter free-spin speed can be as high as 20,000 rpm (the free-spin of other starters used by Ford is normally about 10,000 rpm).
- Current draw during the free-spin test is approximately 170 amps (new) down to 130 amps (used).
- Starter draw should be about 300 amps at dead crank (the fuel is shut off and the engine can't start) at room temperature.
- Following the torque specifications on the bolts and nuts on this starter is very important, especially those for attaching wires and cables to the plastic cap of the starter solenoid. Figure 80 shows the different torque specifications.

**WARNING: There is battery voltage at the starter relay at all times.**

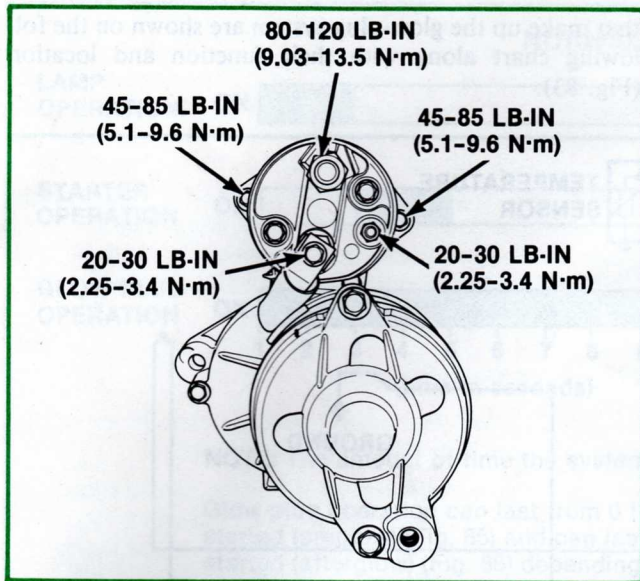
### Glow Plugs

The glow plugs (Fig. 81) used in the 2.4L diesel engine are the small, single-pole type, and are hooked up in a parallel circuit. A parallel circuit is used in favor of a series circuit for two reasons:

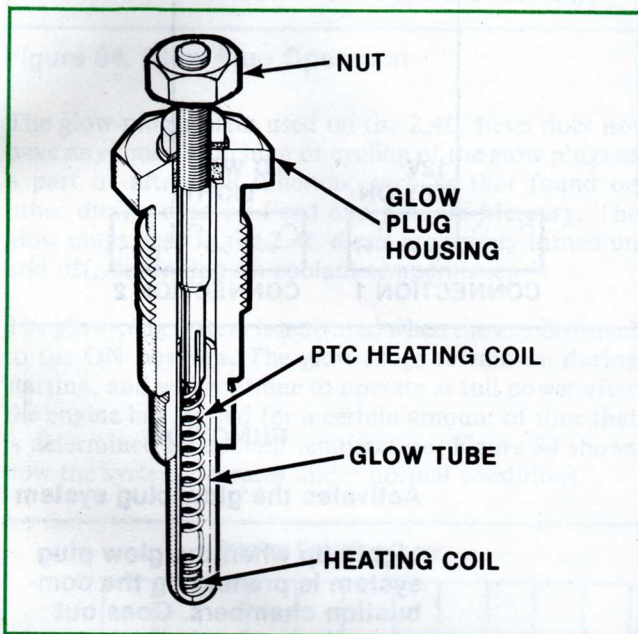
1. Parallel glow plug circuits do not require as much current to operate as series glow plug circuits.
2. If one glow plug in a series circuit ceases to operate, the entire circuit is inoperative. Whereas, in a parallel circuit, if one glow plug ceases to operate, the others can still function normally.



# ENGINE SYSTEMS AND COMPONENTS



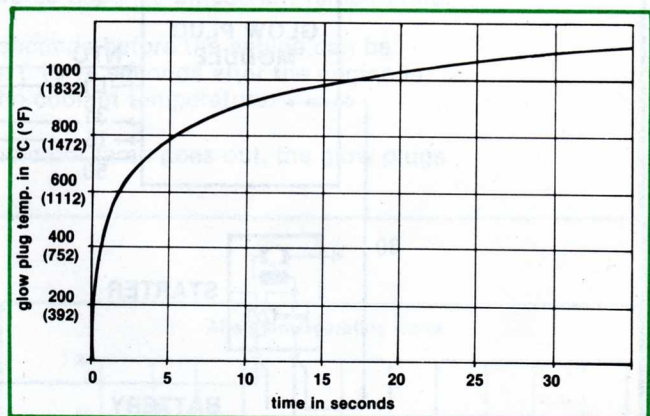
**Figure 80. Starter Solenoid Torque Specifications**



**Figure 81. Glow Plug**

Construction of the glow plug is quite simple. The heating coils are contained in a corrosion and temperature-proof glow tube. The lower coil is more tightly wound than the upper coil to raise the temperature even higher at the tip of the plug. The glow tube is pressed into the glow plug housing that contains both the terminal that attaches into the circuit and the threads for screwing the glow plug into the head.

Although the parallel-circuit glow-plug system has a low current requirement, the glow plugs have excellent heating and can reach temperatures over 1000°C (1832°F) (Fig. 82).



**Figure 82. Glow Plug Temperature Chart**

The higher part of the heating coil that is not as tightly wound is actually a PTC (positive temperature coefficient) heater. This means that as its temperature rises, so too does its resistance. This increase in resistance limits the heating capacity of the glow plug which extends its lifetime and makes the addition of extra timing and electronic glow plug cycling components unnecessary. Under normal circumstances this glow plug should not burn out.



# ENGINE SYSTEMS AND COMPONENTS

Operation of the glow-plug system is based on time and temperature, with the operating time of the glow-plug system based on coolant temperature. The components

that make up the glow-plug system are shown on the following chart along with their function and location (Fig. 83).

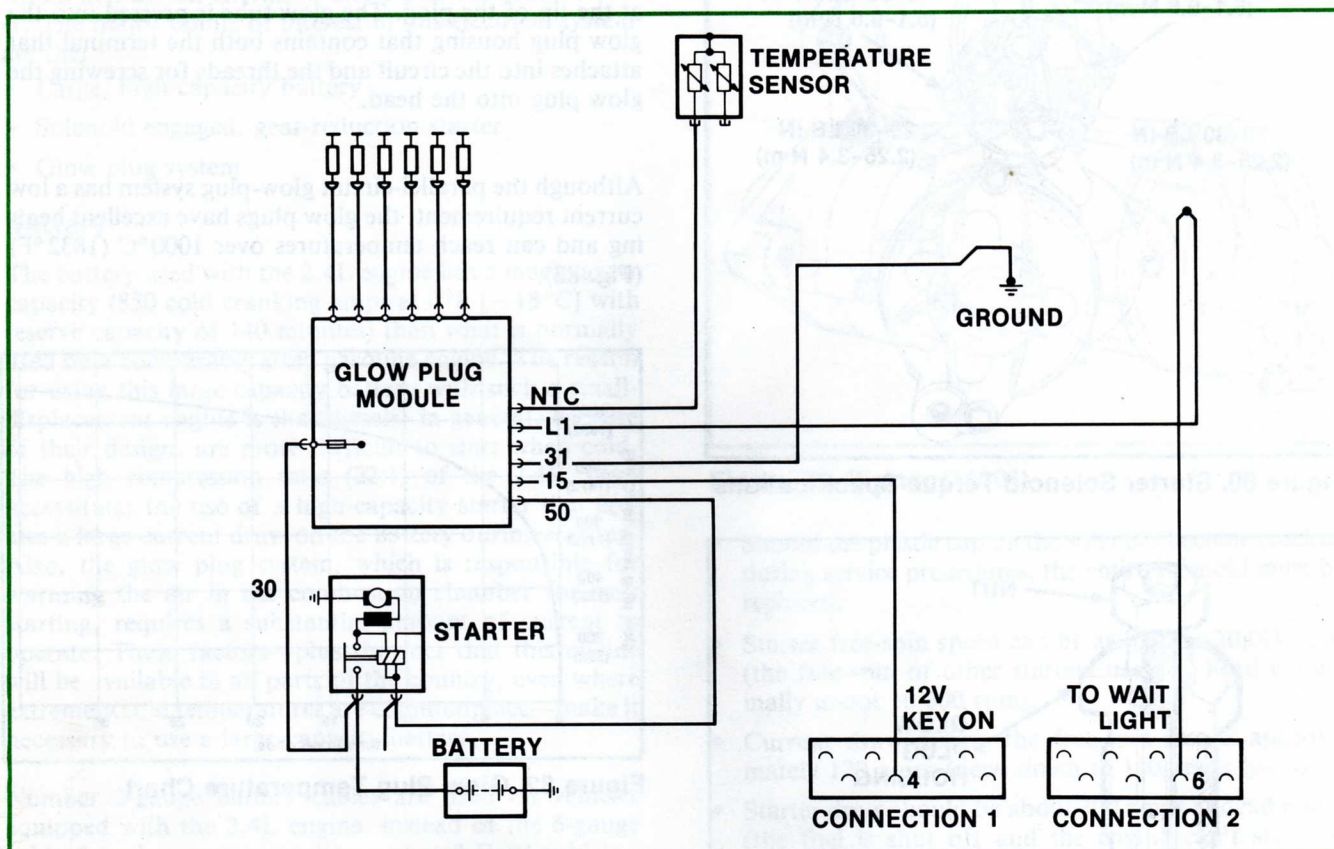
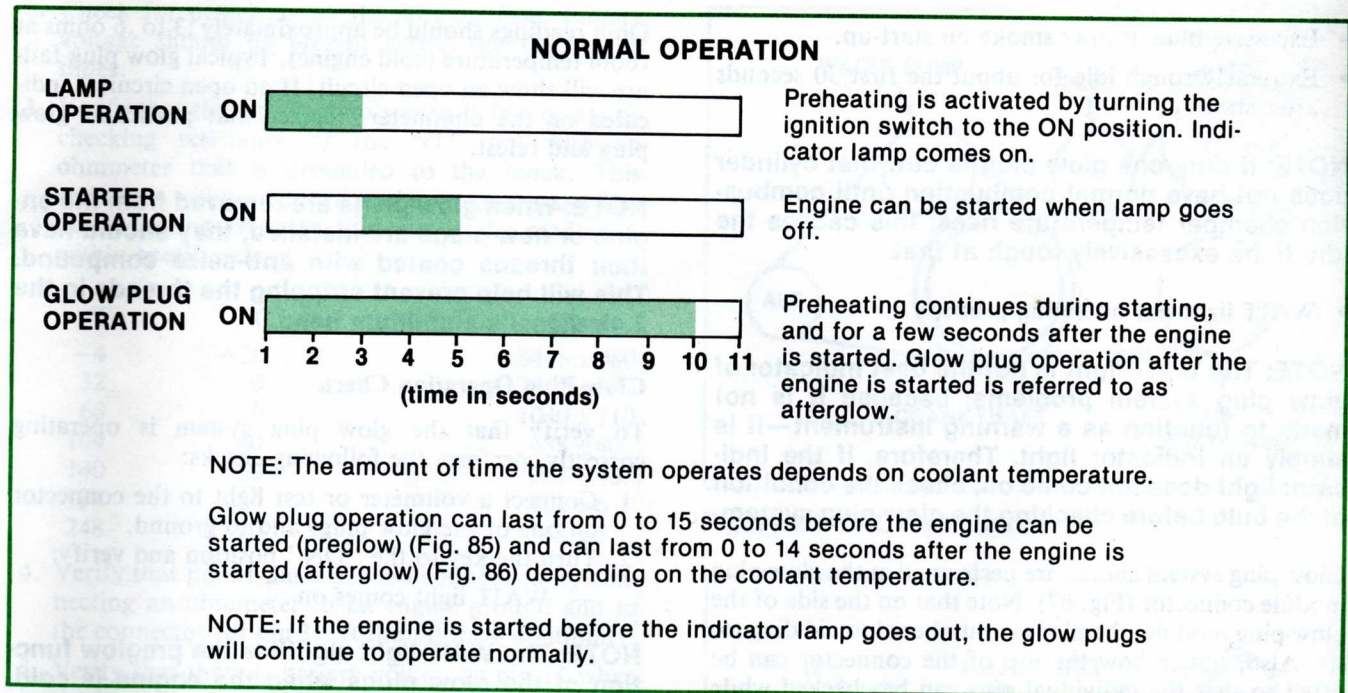


Figure 83. Glow Plug System Layout

COMPONENT	LOCATION	FUNCTION
Ignition Switch	Steering column	Activates the glow plug system
Glow Indicator Lamp	Instrument panel	Lights up when the glow plug system is preheating the combustion chambers. Goes out when the engine is ready to start
Temperature Sensor	Upper water outlet connection	Senses coolant temperature to determine the length of time the glow plugs are on, and turns on the instrument panel warning light if the engine overheats
Glow Plug Control Module	Engine compartment above the steering column	Controls glow plug operation
Glow Plugs	Left side of cylinder head	Heat the combustion chamber air



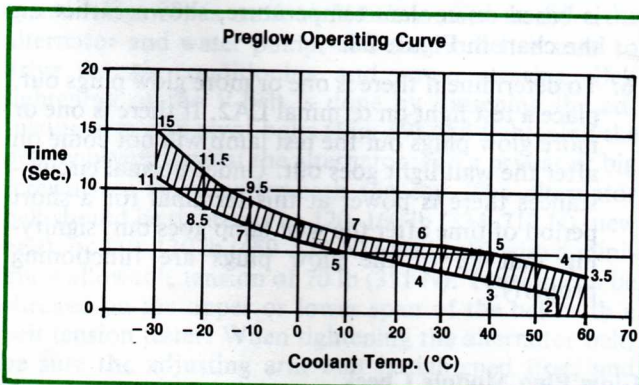
# ENGINE SYSTEMS AND COMPONENTS



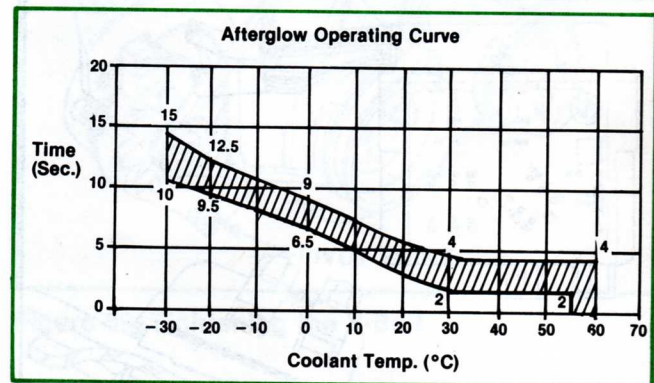
**Figure 84. Glow Plug Operation**

The glow-plug system used on the 2.4L diesel does not have any timed switching or cycling of the glow plugs as a part of afterglow function, such as that found on other diesels used by Ford and Lincoln-Mercury. The glow plugs used in the 2.4L diesel are simply turned on and off, depending on coolant temperature.

The glow-plug system is activated when the key is turned to the ON position. The glow plugs remain on during starting, and will continue to operate at full power after the engine has started for a certain amount of time that is determined by coolant temperature. Figure 84 shows how the system operates under normal conditions.



**Figure 85. Preglow**



**Figure 86. Afterglow**

One thing that is very important to know about the 2.4L diesel glow-plug system is that **the instrument panel indicator lamp will not come on when coolant temperature is above 158°F (70°C)**. In this case, the engine can be started immediately. The glow plugs will still operate during starting and for a few seconds afterward, but not nearly as long as when the engine is cold.

## Glow Plug System Service

Here is a list of the most common symptoms for glow plug system malfunctions.

- Engine will not start.



# ENGINE SYSTEMS AND COMPONENTS

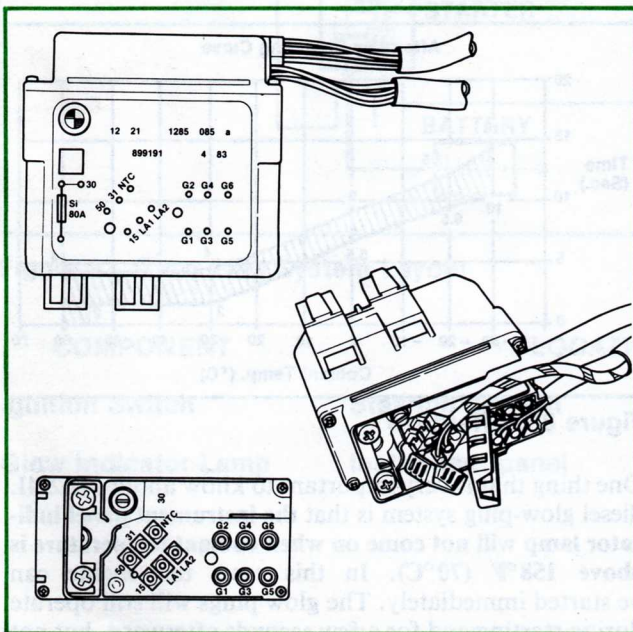
- Excessive blue or gray smoke on start-up.
- Extremely rough idle for about the first 30 seconds after starting.

**NOTE:** If only one glow plug is out, that cylinder does not have normal combustion until combustion chamber temperature rises; this causes the idle to be excessively rough at first.

- WAIT light not operating properly.

**NOTE:** The WAIT light is not the best indicator of glow plug system problems, because it is not made to function as a warning instrument—it is simply an indicator light. Therefore, if the indicator light does not come on, check the condition of the bulb before checking the glow plug system.

Glow plug system checks are performed at the glow plug module connector (Fig. 87). Note that on the side of the glow plug module, the pins are numbered to aid diagnosis. Also, notice how the top of the connector can be lifted so that the individual pins can be checked while the connector is hooked to the module.



### Figure 87. Glow Plug Module and Connector

## Glow Plug Resistance Check

**Glow plug condition is easily checked with an ohmmeter at the glow plug module, located on the cowl of the engine compartment. Follow these procedures:**

1. Remove the glow plug connector from the module.
2. Hook one probe to the engine block as a ground.
3. Insert the other probe onto each terminal in the connector and record the readings.

Ohm readings should be approximately .3 to .6 ohms at room temperature (cold engine). Typical glow plug failure will show an open circuit. If an open circuit is indicated on the ohmmeter, replace that particular glow plug and retest.

**NOTE:** When glow plugs are removed from the engine or new plugs are installed, they should have their threads coated with anti-seize compound. This will help prevent stripping the threads in the 2.4L diesel's aluminum head.

### Glow Plug Operation Check

To verify that the glow plug system is operating correctly, perform the following checks:

1. Connect a voltmeter or test light to the connector on one of the glow plugs and to ground.
2. Turn the key to the "ON" position and verify:
  - WAIT light comes on

**NOTE:** The WAIT light signifies the preglow function of the glow plugs when the engine is cold. This time will vary depending upon coolant temperature. See the preglow time chart shown earlier in Figure 85.

- There is power to the glow plugs
3. After the WAIT light goes out, the glow plugs should remain on for 8 to 13 seconds, at which time the plugs will shut off to prevent excessive battery drain.
4. Turn the key to the "START" position and verify that the glow plugs turn back on when the engine is cranking.
5. Once the engine is running, the glow plugs will remain on briefly. This is called the afterglow function. The length of time that afterglow operates is based on coolant temperature, shown earlier on the chart in Figure 86.
6. To determine if there is one or more glow plugs out, place a test light on terminal LA2. If there is one or more glow plugs out the test lamp will not come on after the wait light goes out. Under normal circumstances there is power at this terminal for a short period of time after the wait lamp goes out, signifying that all of the glow plugs are functioning properly.

### Glow Plug Module Check

**If the glow plug system does not operate in this manner, perform the glow plug module check listed here:**

1. Check for power at the module on the large red wire. There should be battery voltage present here at all times.



# ENGINE SYSTEMS AND COMPONENTS

2. Check for power across the 80 amp fuse. Battery voltage should be present across the fuse at all times.
3. Verify that the temperature sensor is functional by checking resistance of the NTC pin with an ohmmeter that is grounded to the block. This resistance will vary due to coolant temperature. Use the following chart to find out if the reading is within specifications.

°F	°C	Ohms
-4	-20	$6446 \pm 980$
32	0	$2447 \pm 300$
68	20	$1040 \pm 110$
104	40	$488 \pm 40$
140	60	$247 \pm 18.5$
194	90	$102 \pm 6$
248	120	$48 \pm 3$

4. Verify that pin 31 has a ground connection by connecting an ohmmeter to an engine ground and to the connector for pin 31. It should show continuity.
5. Verify that there is battery voltage to pin 15 when the key is in the "ON" and "START" positions.
6. Verify that pin 50 has battery voltage when the key is in the "START" position.

If all these points check out correctly, but the glow plug system is not operating properly, then the glow plug module should be replaced. After replacement, recheck the glow plug system operation to ensure that everything is operating properly.

## ACCESSORIES, ACCESSORY DRIVE AND BELT TIGHTENING

Standard equipment on vehicles equipped with the 2.4L diesel engine includes power steering, power brakes, air conditioning, and the alternator. To power these accessories, except for the power brakes, a dual belt-drive system (Fig. 88) is used. A V-belt is used to drive the alternator and water pump, and a 6-rib belt is used to drive the air conditioning and power steering. Belt tightening of the V-belt is done by loosening the adjusting arm and pivot bolts (Fig. 89) and tightening the belt by prying against the alternator with a prybar or big screwdriver from underneath the car. The alternator belt should be tightened to 120–160 lb (534–712 N) (new belt), or 110–130 lb (489–578 N) (used belt) with a minimum allowable tension of 70 lb (311 N). Tension can be checked on the upper or lower span of the belt with a belt tension tester. When tightening the alternator belt, be sure the adjusting arm bolt is tightened first, and then the alternator pivot bolt.

The 6-rib belt is tightened by means of an idler pulley (Fig. 90) using a  $\frac{1}{2}$  inch drive ratchet. Belt tightness on the six-rib belt should be 150–170 lb (667–845 N) (new),

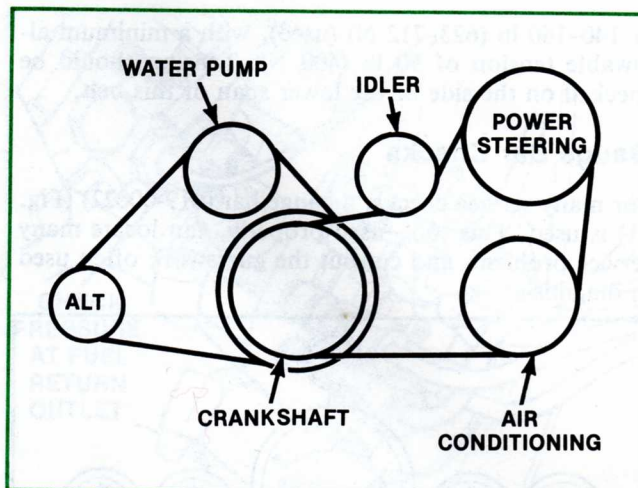


Figure 88. 2.4L Belt Layout

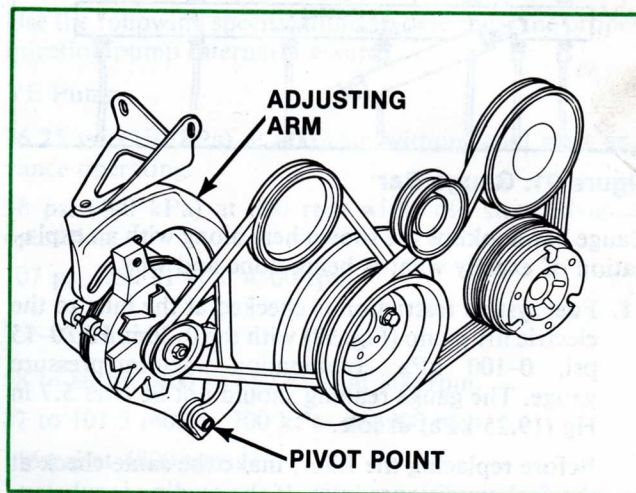


Figure 89. Tightening the V-Belt

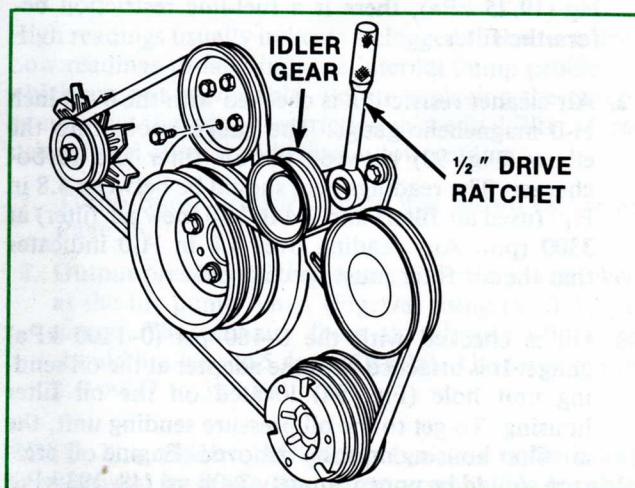


Figure 90. Tightening the 6-Rib Belt

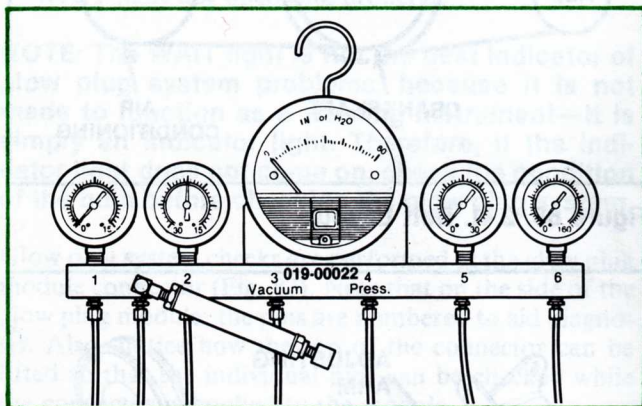


# ENGINE DIAGNOSIS

or 140–160 lb (623–712 N) (used), with a minimum allowable tension of 90 lb (400 N). Tension should be checked on the side or the lower span of this belt.

## Gauge Bar Checks

For many service checks, a gauge bar (019-00022) (Fig. 91) is used. This tool, used properly, can locate many service problems and cut out the guesswork often used in diagnosis.



**Figure 91. Gauge Bar**

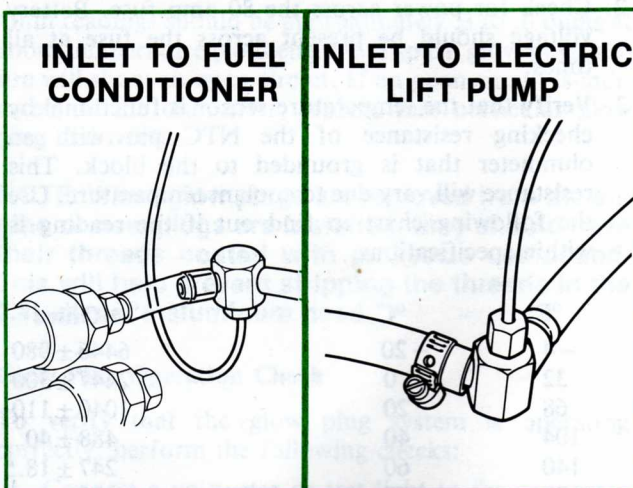
Gauge bar hookups are shown here along with an explanation of exactly what is being done and why.

1. Fuel system restriction is checked at the inlet to the electric lift pump (Fig. 92) with the 0–30 in Hg/0–15 psi, 0–100 kPa combination vacuum/pressure gauge. The gauge reading should not be over 5.7 in Hg (19.25 kPa) at idle.

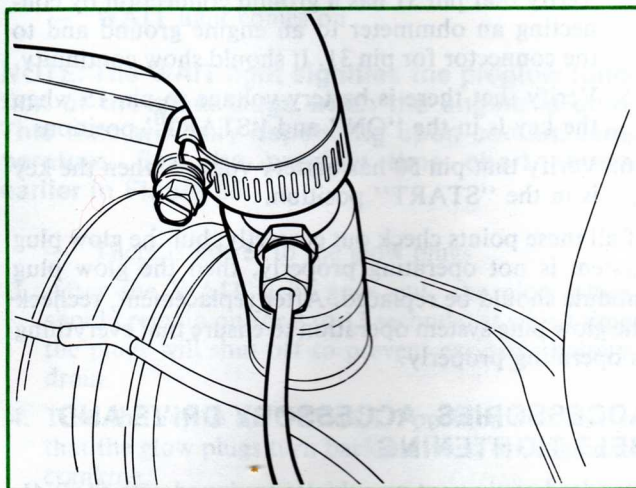
Before replacing the filter, make the same check at the fuel conditioner inlet. If the reading is substantially lower, the filter is bad and should be replaced. If the reading is approximately the same, over 5.7 in Hg (19.25 kPa), there is a fuel-line restriction before the filter.

2. Air cleaner restriction is checked with the 0–60 inch H<sub>2</sub>O manometric gauge. The gauge hooks into the elbow (Fig. 93) between the air filter and turbocharger. The readings here should be between 4.8 in H<sub>2</sub>O (used air filter) and 2.4 in H<sub>2</sub>O (new air filter) at 3300 rpm. Any reading over 4.8 in H<sub>2</sub>O indicates that the air filter must be changed.

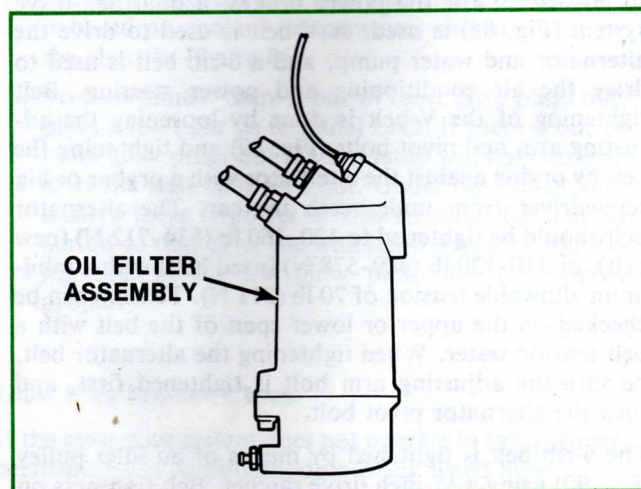
3. Oil is checked with the 0–160 psi (0–1100 kPa) gauge. It is attached with the adapter at the oil sending unit hole (Fig. 94) located on the oil filter housing. To get to the oil pressure sending unit, the air filter housing must be removed. Engine oil pressure should be approximately 7–28 psi (48–193 kPa) at idle, and approximately 57–85 psi (393–586 kPa) at 4800 rpm.



**Figure 92. Fuel System Restriction Check**



**Figure 93. Air Cleaner Restriction Check**

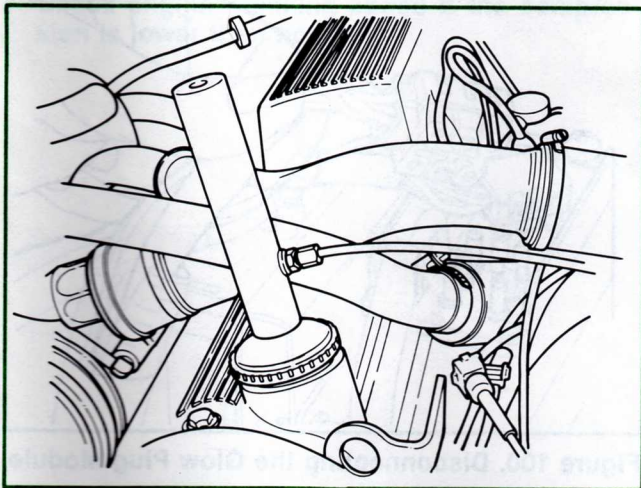


**Figure 94. Oil Pressure Check**



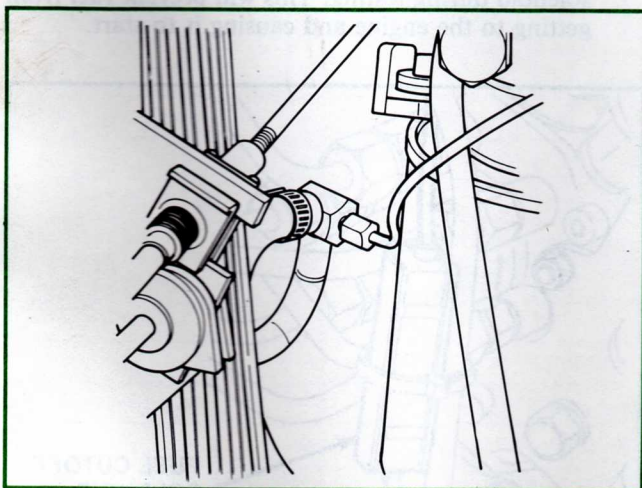
# ENGINE DIAGNOSIS

4. Crankcase pressure is checked at the oil fill hole in the valve cover using the oil cap adapter (Fig. 95) and 0-60 inch H<sub>2</sub>O manometric gauge. The maximum allowable pressure here is 30 inches H<sub>2</sub>O at 3300 rpm. A reading exceeding this indicates cylinder leakage past the rings.



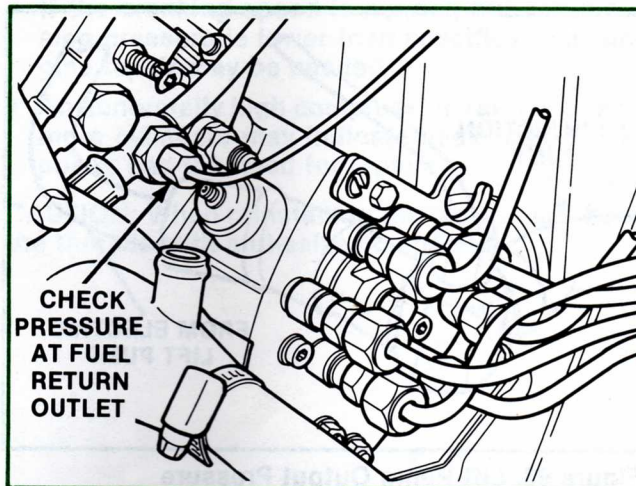
**Figure 95. Crankcase Pressure Check**

5. Fuel return line pressure is checked at the connection between the nylon and plastic fuel lines on the lower part of the fender apron near the fuel conditioner (Fig. 96). The gauge used to check this measurement is a 0-30 in Hg/0-15 psi, 0-100 kPa combination vacuum/pressure gauge. Pressure readings here should be below 2 psi (14 kPa) at all times. If the measurement is higher than this, the fuel return line is restricted in some way and should be repaired.



**Figure 96. Fuel Return Line Pressure Check**

6. Injection pump internal pressure is checked at the banjo fitting for the fuel return line (Fig. 97), using the 0-160 psi (0-1100 kPa) gauge.



**Figure 97. Fuel Injection Pump Internal Pressure Check**

Use the following specifications to determine the proper injection pump internal pressure.

**VE Pump:**

36.25 psi (250 kPa) at 800 rpm without cold start advance operating.

58 psi (400 kPa) at 800 rpm with cold start advance operating.

107 psi (750 kPa) at 4500 rpm.

**VP-20 Pump:**

58 to 80 psi (400 to 550 kPa) at 800 rpm.

87 to 101.5 (600 to 700 kPa) at 3000 rpm.

116 psi at 4800 rpm.

**NOTE: The maximum allowable pressure for the VP-20 pump is 145 psi (1000 kPa).**

High readings usually indicate a clogged fuel return line. Low readings usually indicate internal pump problems, which are not serviceable. Before replacing the pump, be sure that there is no restriction in the fuel filter. A restricted fuel filter could cause a low reading.

7. Turbo-Boost Pressure Check was shown earlier on Page 36.

8. Output pressure of the electric lift pump is checked at the lift pump outlet (Fig. 98) using the 0-15 psi gauge. The pressure from the electric lift pump should not exceed 5.6 psi (39 kPa). The range is 1 to 5.6 psi (7 to 39 kPa).

**NOTE: The electric lift pump bracket bolts must be removed to make the pump accessible for this check.**



# ENGINE DIAGNOSIS

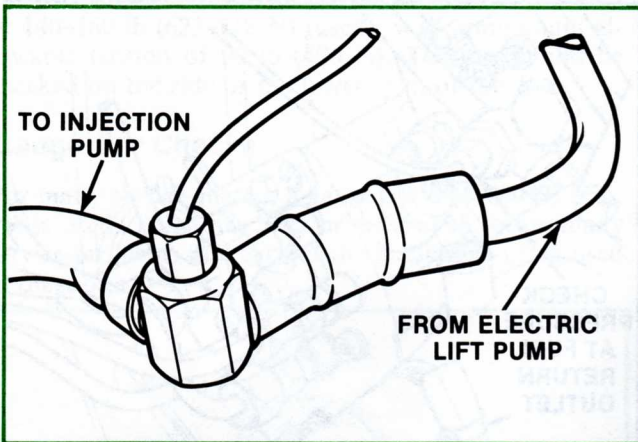


Figure 98. Lift Pump Output Pressure

## Checking Compression

Checking compression on a diesel engine that is not running properly is one of the most important diagnostic procedures. This is because the diesel relies totally on the heat produced by compression to ignite the fuel injected into the combustion chamber. Use the following procedures to check the compression on the 2.4L diesel through the glow plug hole:

1. Do not warm up the engine! The engine must be cold.
2. Stop the engine and remove all six glow plugs. Install the 2.4L adapter (part number 019-00020) and the compression tester (19-00001 or equivalent) on the cylinder to be checked (Fig. 99). Use the right adapter, so that thread damage does not occur.

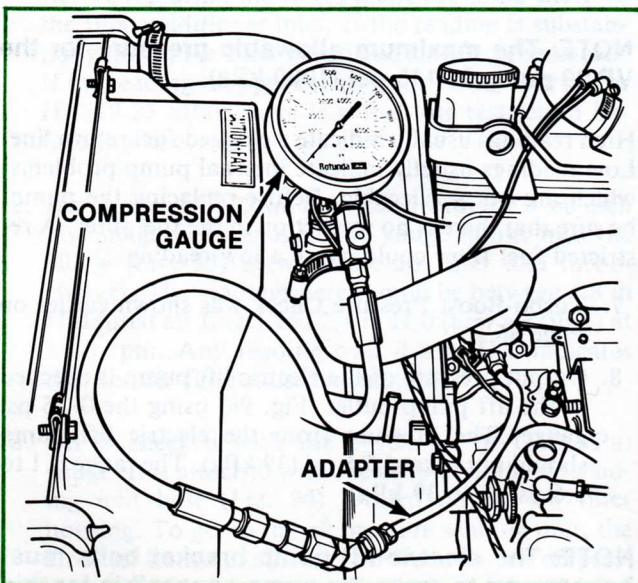


Figure 99. Compression Gauge and Adapter

3. Disconnect the glow-plug circuit at the glow-plug module (Fig. 100) to prevent the glow-plug connectors from shorting to ground when the engine is cranked.

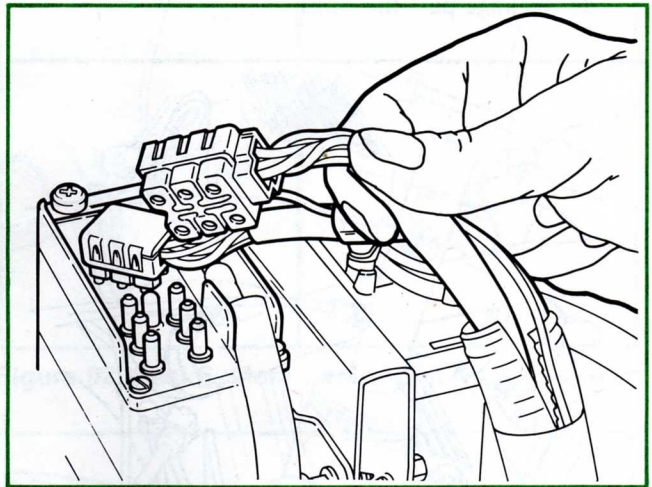


Figure 100. Disconnecting the Glow Plug Module

**CAUTION:** If the glow plug connectors are allowed to ground when the engine is cranked, severe damage to the glow-plug circuit and module may occur. For this reason, the glow-plug circuit must always be disconnected whenever the engine is cranked and the glow-plug terminals are not attached.

4. Disconnect the fuel cutoff solenoid valve wire (Fig. 101) on the fuel injection pump to de-activate the solenoid during testing. This will prevent fuel from getting to the engine and causing it to start.

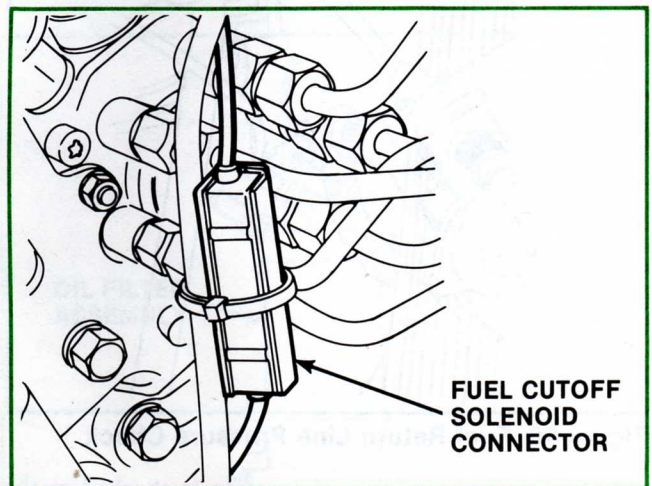


Figure 101. Fuel Cutoff Solenoid Connector



# ENGINE DIAGNOSIS

5. Crank the engine and note the gauge indication when stabilized. Compression pressure must be a minimum of 348 psi (2400 kPa), and should not vary more than 50 psi (345 kPa) between cylinders.

## NOTE:

- Check engine cranking speed if the compression is lower than normal.

- If the cranking speed is normal, but compression pressure is lower than specifications, engine repair may be needed.
- An abnormally high compression ratio in one or more cylinders may indicate heavy carbon deposits and the need for repairs.

**CAUTION:** When reinstalling the glow plugs, coat the threads with anti-seize compound.



1. Engine does not start or starts poorly in warm condition.
2. Engine does not start or starts poorly in cold condition.
3. Irregular idling (hunting).
4. Erratic idling when engine is warm.
5. Engine misfires while driving car.
6. Engine power output insufficient.
7. Fuel consumption too high.
8. Engine is running on.
9. Engine is running rough, blows black smoke.
10. Smoke from exhaust (white, black, blue).
11. Improper warm idle.
12. Engine does not idle properly.
13. Injection pump does not work properly.
14. Smoke from exhaust.

**The use of this troubleshooting guide requires, that the basic engine adjustment, the boost pressure equipment, the electric and vacuum system are correct.**

14. Smoke at full load higher speeds only.										REFERENCE MANUAL PAGE	
CAUSE:					CORRECTION:						
									Tank empty	Fill up fuel. Bleed fuel system.	31
									Air in fuel system	Bleed/seal fuel system.	31
									Electric shut off valve without current, or faulty	Check electric power supply or replace fuel shutoff.	24
									Fuel filter clogged	Replace fuel filter.	20 & 46
									Injection line clogged (diameter reduced)	Check, clean or replace fuel lines.	31
									Fuel supply line clogged (diameter reduced)	Check, clean or replace fuel lines.	19 & 46
									Connections loose, lines leaking, broken	Test and/or tighten/seal connections, replace fuel lines.	19 & 46
									Extreme paraffine deposits on filter	Test and/or replace fuel filter, use winter fuel.	19 & 46
									Injection, timing not correct	Check and adjust injection timing.	26
									Fuel injector faulty	Test and/or replace fuel injector.	33
									Engine air cleaner clogged	Test and/or replace air cleaner filter.	46
									Glow plug system faulty	Check/replace glow plugs, control unit.	43
									Injection order does not correspond with firing order	Fit injection lines in correct order.	31
									Engine idle speed not correct	Adjust engine idle speed (setting screw on injection pump)	28
									Engine maximum speed not correct	Adjust maximum engine speed.	28
									Wrong hollow bolt on return line	Install correct hollow bolt.	24
									Hollow bolt clogged	Clean hollow bolt.	24
									Cold start advance faulty	Check cold start valve.	24
									Engine compression low or different	Check engine (see Shop Manual).	48
									Injection pump faulty or maladjusted	Check and adjust/replace.	26-31,39,47
									Electric fuel pump faulty	Check and replace electric fuel pump.	20 & 47
									EGR system operating improperly	Check EGR system operation.	37-39



# EXHAUST SMOKE DIAGNOSIS

## Black or Dark Gray Smoke

SYMPTOM	PROBABLE CAUSE	ACTION TO TAKE	COMMENTS
Smoke at full load, particularly at high and medium speeds; engine quieter than normal	Pump timing retarded	Check and adjust timing to specifications	Pump timing changes only if moved intentionally, or if mountings are not properly tightened
Smoke at full load, particularly at low and medium speeds; engine noisier than normal	Pump timing advanced	Check and adjust timing to specifications	
Smoke at full load, particularly at high and medium speeds, probably with loss of power	Injection nozzle(s) discharge hole fully or partly blocked	Clean or replace injection nozzles as required	
Smoke at full load, at higher speeds only	Air cleaner filter restricted; EGR system	Replace air cleaner filter; Check EGR system	Replace filter at scheduled intervals or more often under severe service conditions
Intermittent or puffy smoke, sometimes with white or bluish tinge, usually accompanied by engine knocking	Injector nozzle valve sticks open intermittently	Check injection nozzles for sticking valve, broken spring, or very low opening pressure; also check for cross-threading in head	May be caused by dirt or water in fuel; injection nozzle should screw into head freely and must not be over-tightened
Smoke at all speeds at high loads, mostly at low and medium speeds and probably accompanied by hard starting	Loss of cylinder compression because of stuck rings, bore wear, burning, sticking valves, or incorrect valve setting	Engine requires overhaul if wear indications are present; check valve setting  Check compression	May be caused by improper crankcase oil or incorrect valve clearance
Smoke at full load, mostly at medium and high speeds, and probably accompanied by low power	Injection fuel lines clogged or restricted because of damage	Check injection fuel lines; clean or replace as required	Fuel lines must be clear and unrestricted

## Blue, Bluish Gray or Grayish White Smoke

SYMPTOM	PROBABLE CAUSE	ACTION TO TAKE	COMMENTS
Blue or whitish smoke particularly when cold, and at high speeds and light load, but reducing or changing to black when hot and at full load, with loss of power at least at high speeds	Pump timing retarded	Check and adjust pump timing	Some engines show this symptom for less retard than gives rise to black smoke, but usually substantial retard is required to produce blue smoke when running hot and under load
Blue or whitish smoke when cold, particularly at light loads but persisting when hot, probably accompanied by knocking	Injection nozzle valve stuck open or nozzle tip damaged and leaking	Examine nozzle for valve stuck open or nozzle tip damage	
Blue smoke at all speeds and loads, hot or cold	Engine oil being passed by piston rings because of sticking rings or bore wear	Engine reconditioning as required	May be caused by improper crankcase oil; will be associated with high oil consumption
Blue smoke, particularly when accelerating from period of idling, tending to clear with running	Engine oil being passed by worn inlet valve guides, or valve stem umbrella seals worn or missing	Engine reconditioning as required	
Light blue smoke at high-speed light loads, or running downhill, usually accompanied by sharp odor	Engine running cold; thermostat stuck open	Replace thermostat	Low temperatures also increase bore wear



## COMPRESSION PRESSURE

- Compression pressure should be approximately 348 psi (2,400 kPa) and should not vary more than 50 psi (345 kPa) between cylinders.

Cyl. 1\_\_\_\_ Cyl. 2\_\_\_\_ Cyl. 3\_\_\_\_ Cyl. 4\_\_\_\_ Cyl. 5\_\_\_\_ Cyl. 6\_\_\_\_

- Warm up engine
- Connect test gauge to engine in sending unit hole

Oil pressure should be 7–28 psi (48–193 kPa) at idle and 57–85 psi (393–586 kPa) at 4800 rpm.

Gauge oil pressure idle \_\_\_\_\_ 4800 rpm \_\_\_\_\_

- Opening pressure

Injection nozzle opening pressure should be 2175 + 116 psi (15,000 + 800 kPa) for new nozzles, and 1957.5 psi (13,500 kPa) for used nozzles.

Cyl. 1\_\_\_\_ Cyl. 2\_\_\_\_ Cyl. 3\_\_\_\_ Cyl. 4\_\_\_\_ Cyl. 5\_\_\_\_ Cyl. 6\_\_\_\_

- Valve seat sealing test
- Nozzle spray pattern
- Chatter test

_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

## REMARKS

[illegible]



# SCHEDULED MAINTENANCE

ENGINE SERVICE INTERVALS	INSPECTION INTERVALS — DIESEL/FORD												
	PDI	Oil 5,000	Oil 10,000	Insp. 15,000	Oil 20,000	Oil 25,000	Insp. 30,000	Oil 35,000	Oil 40,000	Insp. 45,000	Oil 50,000	Oil 55,000	Insp. 60,000
Change engine oil		X	X	X	X	X	X	X	X	X	X	X	X
Change engine oil filter		X	X	X	X	X	X	X	X	X	X	X	X
Inspect and adjust valves		X		X			X			X			X
Fuel filter: drain water separation		X	X	X	X	X	X	X	X	X	X	X	X
Check drive belt tension and condition							X						X
Check and adjust timing belt							X						X
Replace timing belt	Replace timing belt at 105,000 miles, or sooner if needed												
Check idle RPM							X						X
Replace air cleaner element							X						X
Replace fuel filter element							X						X
Check coolant	Annually, prior to cold weather if possible												
Replace glow plugs													X <sup>1</sup>
Check fuel injectors													
Replace fuel injectors													
Check dynamic injection setting							X						X

<sup>1</sup> 49 states model, California vehicles are allowed to go to 105,000 miles, but it is recommended in consumer maintenance that the glow plugs be replaced at 60,000 miles.

## ENGINE LUBRICANT SPECIFICATIONS

ALL OILS LISTED BELOW ARE SF/CD GRADE

SAE 20W-20

SAE 30

SAE 40

SAE 15W-40

\*SAE 5W-30

-40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 °F  
-40 -30 -20 -10 0 10 20 30 40 °C

\*RECOMMENDED FOR IMPROVED LOW TEMPERATURE STARTING

## ENGINE OIL REFILL CAPACITIES

	Liters	U.S. Qts.	Imp. Qts.
Complete system w/o oil cooler	6.7	7.1	5.9
Complete system with oil cooler	7.5	7.9	6.5
Oil filter	1.2	1.25	1

## REPLACEMENT ENGINE FILTERS

	Ford Part Number
Oil Filter	E45Y-6731-A FL-798
Fuel Filter	E45Y-9365-A FL-821
Air Filter	E45Y-9601-A FA-1005

## COOLING SYSTEM REFILL CAPACITY

Liters	U.S. Qts.	Imp. Qts.
11.1	11.8	9.8

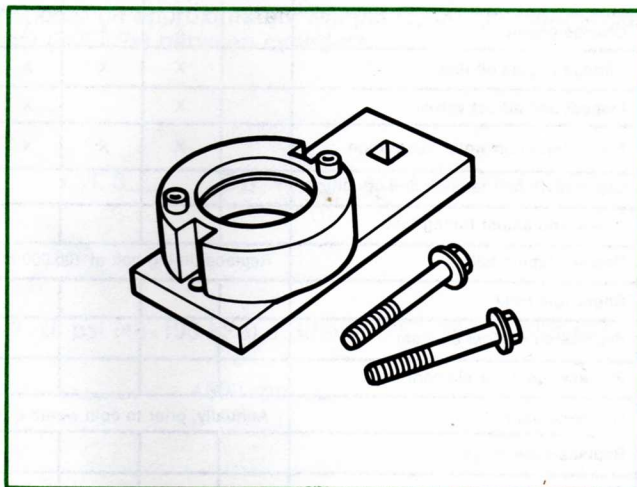


## SPECIAL SERVICE TOOLS AND APPLICATIONS

The following special tools have been developed specifically for use on the 2.4L diesel engine, and are new for the 1984 model year.

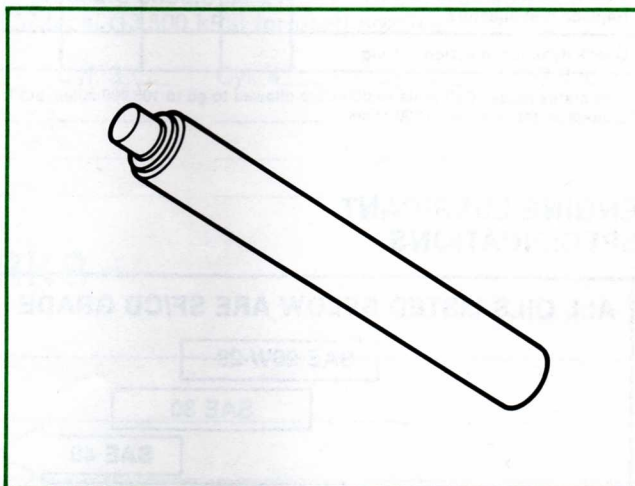
### **DAMPER FLANGE AND PULLEY HOLDING TOOL T84P-6316-A**

Essential when removing or installing the vibration damper bolt. Also used when removing the intermediate shaft sprocket center nut.



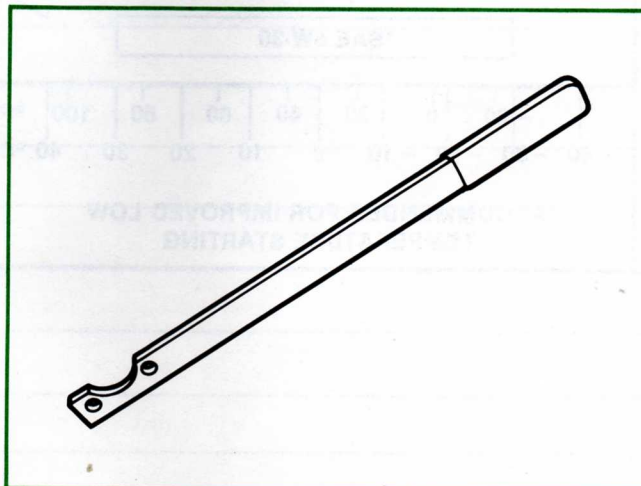
### **OIL PUMP DRIVE BEARING REPLACER T84P-6603-A**

Essential when replacing the two Torrington (needle type) bearings that are mounted on each end of the oil pump shaft. The tool installs the bearings at the proper depth.



### **WATER PUMP HOLDING TOOL T84P-6312-A**

This tool prevents the water pump pulley from turning during removal and installation of the fan clutch. It is used in conjunction with the T84P-6312-B Fan Clutch Wrench.

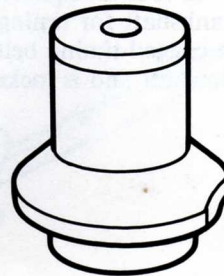




## SPECIAL SERVICE TOOLS AND APPLICATIONS

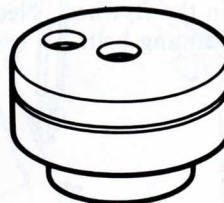
### CRANK FRONT SEAL REPLACER T84P-6019-B

Installs the front seal to the proper depth on-or-off the vehicle. Protects the seal lip during installation. The tool is made of high strength plastic with an integral steel cap.



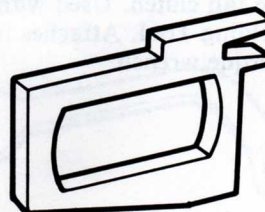
### INTERMEDIATE SHAFT SEAL REPLACER T84P-6020-A

This essential tool has the same quality design features as the Front Seal Replacer (T84P-6019-B). The intermediate shaft on this engine drives the oil pump.



### EGR VACUUM REGULATOR KEY T84P-7B200-A

This "Key" sets the injection pump at a specific throttle position so the EGR vacuum regulator diaphragm can be adjusted properly. This setting also controls the shift points of the automatic transmission.





## SPECIAL SERVICE TOOLS AND APPLICATIONS

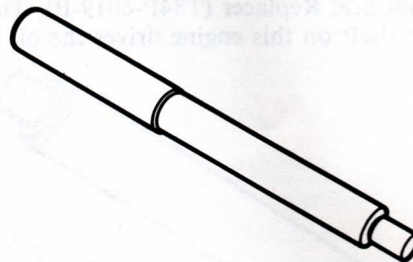
### **CAM POSITIONING TOOL T84P-6256-A**

This precision ground tool is required to index the camshaft to the crankshaft for timing the valves. Used when installing the cogged-timing belt. Mounts over the front of the camshaft and is locked in position to the cylinder head.



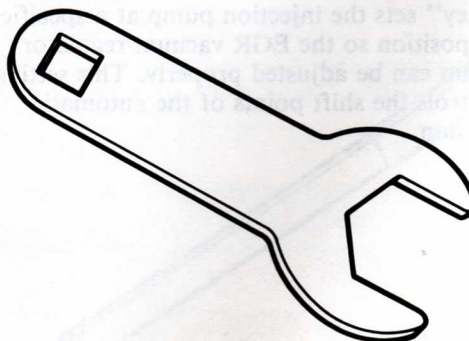
### **TDC ALIGNING PIN T84P-6400-A**

This tool must be used to place the No. 1 piston at TDC. Tool enters through a hole in the block and indexes with a hole in the flywheel. Necessary when installing the cogged-timing belt.



### **FAN CLUTCH WRENCH T84P-6312-B**

This tool is essential in order to remove the left-hand thread nut of the fan clutch. Used with T84P-6312-A Water Pump Holding Tool. Attaches to a 1/2" drive flex handle or torque wrench.

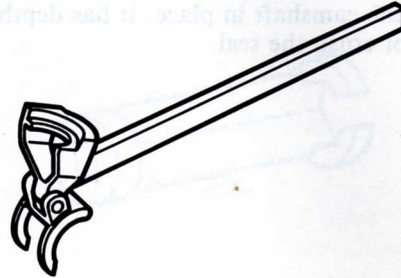
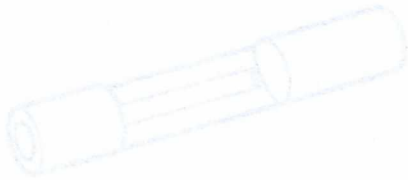




## SPECIAL SERVICE TOOLS AND APPLICATIONS

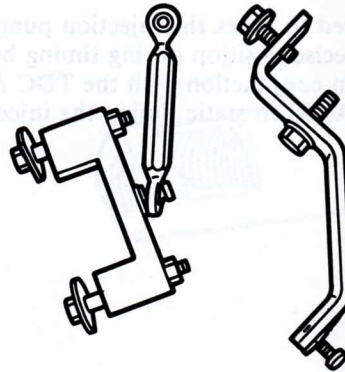
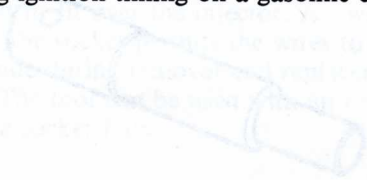
### VALVE SPRING COMPRESSOR T84P-6513-C

Used to compress the valve springs with the camshaft installed. The tool slides under the camshaft which is then used as a fulcrum.



### INJECTION PUMP ROTATING TOOL T84P-9000-B

Essential for dynamic and static timing settings on the engine. Rotating the pump on this 2.4L diesel is similar to setting ignition timing on a gasoline engine.



### VALVE CLEARANCE ADJUSTING WRENCH T84P-6575-A

To adjust valve lash, this wrench must be used to loosen and tighten the eccentric cams located on the cam follower. The tool's unique design permits access to the eccentric cams by getting around the vacuum pump housing which is driven off the camshaft. A torque wrench must be used to tighten the lock nut after making the adjustment.

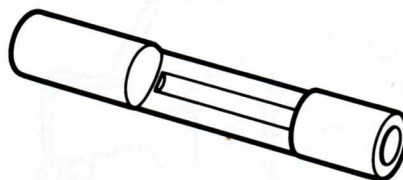




## SPECIAL SERVICE TOOLS AND APPLICATIONS

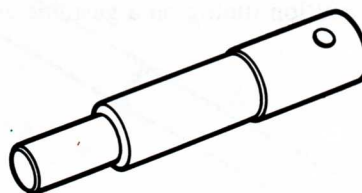
### VALVE STEM SEAL REPLACER T84P-6571-B

This essential tool is designed to install the valve stem seals with the camshaft in place. It has depth control and will not crush the seal.



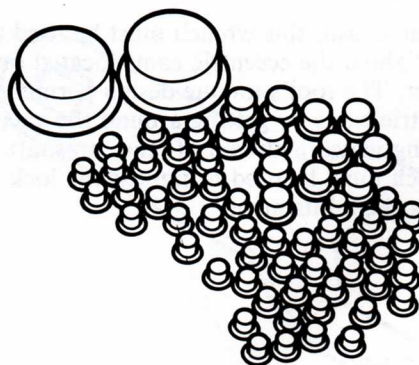
### INJECTION PUMP ALIGNING PIN T84P-9000-A

This pin is required to index the injection pump sprocket in its precise position during timing belt installation. Used in conjunction with the TDC Aligning Pin (T84P-6400-A) when static timing the injection pump.



### FUEL SYSTEM PROTECTOR CAPS T84P-9395-B

These plastic caps prevent foreign material and contamination from entering the fuel lines, the injection pump and the injectors. They also prevent fuel from running out after lines have been disconnected. A cap has also been provided for the intake manifold.



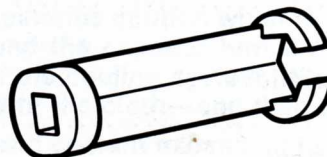


# SPECIAL SERVICE TOOLS AND APPLICATIONS

## FUEL LINE WRENCH

**T84P-9396-A**

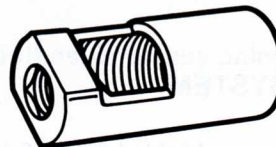
Used to remove or replace fuel lines. Essential because of clearance problems with the cluster of fuel lines at the injection pump.



## INJECTION NOZZLE SOCKET

**T84P-9527-A**

Used to remove and replace injection nozzles from the cylinder head. Certain injectors have an electrical connector with wiring that must be moved aside in order for this socket to fit over the injector. A "window" in the side of the socket permits the wires to protrude through the side during removal and replacement of the injector. The tool can be used with an open end wrench on the socket flats.



## PAST MODEL YEAR TOOLS USED ON THE 2.4L DIESEL

• Steering Wheel Puller .....	T67L-3600-A
• 7/16 Collet .....	D80L-100-M
• Actuator Pin .....	D80L-100-G
• Cylinder Head Holding Fixture .....	D84L-500-A
• Valve Spring Compressor (2.0L Diesel Tool) .....	T84P-6513-A
• Crank Rear Seal Installer .....	T84P-6701-A
• Idle Speed Adjusting Tool .....	D83T-9000-E



# SPECIFICATIONS

## ENGINE

Type .....	6-cylinder, in-line, 4-cycle, overhead valve, water-cooled
Bore .....	3.150 in (80 mm)
Stroke .....	3.189 in (81 mm)
Displacement .....	149 cu in (2442.9 cc)
Compression ratio .....	22:1
Horsepower .....	114 (85 kw) at 4800 rpm
Minimum Torque .....	150 lb ft (210 N·m) at 2400 rpm
Compression pressure .....	348 psi (2400 kPa)
Valve clearance (cold engine) .....	Intake: 0.010 in (0.3 mm) Exhaust: 0.010 in (0.3 mm)
Cam Timing	
Intake valve opens .....	6° BTDC
Intake valve closes .....	34° ABDC
Exhaust valve opens .....	46° BBDC
Exhaust valve closes .....	6° ATDC
Intake valve lift .....	0.374 in (9.5 mm)
Exhaust valve lift .....	0.376 in (9.5 mm)
Weight .....	433 lbs (196.4 kg) dry

## COOLING SYSTEM

Fan ..... Molded nylon, 8-blade, engine driven plus electrically operated “pusher” fan on front of radiator  
 Drive belt tension (lb) ..... Use a belt tension gauge to determine tightness  
 Belt tension figures listed below are for adjustment on a cold engine.

	Alternator	Accessories
New	120-160	150-190
Used (reset)	110-130	140-160
Used (minimum)	70	90

Antifreeze mixture ..... 50% antifreeze/50% water (Use Ford Spec ESE-M97B44-A)  
 Radiator type ..... Cross flow  
 Cooling system pressure test ..... Apply 15 psi (105 kPa) and check for pressure drop  
 Expansion tank cap test ..... Pressure valve should open at 14-17 psi (96.5-117 kPa)  
 Thermostat opening temperature ..... Approx. 176°F (80°C)

## CAUTION:

- Do not use alcohol- or methanol-base coolants.
- Use only soft (demineralized) water in the coolant mixture.



# SPECIFICATIONS

## WARNING:

- Do not attempt to remove the coolant expansion tank cap under any circumstances while the engine is operating. To do so might lead to damage to the cooling system and the engine, and could result in serious injury from hot coolant or steam.

Switch off the engine and wait until it has cooled. Even then, use extreme caution when removing the cap from a hot coolant expansion tank. Wrap a thick cloth around the cap and turn it slowly until pressure releases. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, unscrew the cap—still with the cloth—and then remove it.

- Do not remove the coolant expansion tank cap when the engine and coolant expansion tank are hot. Scalding hot coolant and steam may be blown out under pressure, and could cause serious injury.

## ELECTRICAL SYSTEM

Battery	One 12-volt, cold-cranking amperage: 850 amps @ 0°F; Reserve capacity: 140 minutes
Alternator	Belt-driven, 12-volt; 100 amp
Starter	Gear-reduction type
Glow plug system	Automatic, operating time dependent upon coolant temperature

## WARNING:

- Keep lighted tobacco or any flame away from the battery. Hydrogen, which is a highly combustible gas, is always present in cells.
- Do not get electrolyte (SULFRIC ACID) in your eyes, on your skin or clothes, or on any painted surfaces because damage or personal injury may result.

## CAUTION:

- For emergency starting, use only a 12-volt jumper system with a negative ground. You can damage a 12-volt starting motor and/or glow plug system beyond repair by connecting to a 24-volt power supply (two 12-volt batteries in series or a 24-volt motor-generator set).
- Do not disconnect the battery of the vehicle to be started. Disconnecting the battery when jump starting could damage the vehicle's electrical system.
- Be sure to connect the booster battery cables to the positive terminal and engine ground on the driver's side for lowest circuit resistance. See the operating guide for complete booster battery connecting procedures and precautions.
- To interrupt the battery supply circuit for servicing or emergencies, remember that the circuit must be disconnected at the battery, not at the starter relay.

## LUBRICATION SYSTEM

Complete System w/o oil cooler	7.1 qts (6.7L)
Complete System	7.9 qts (7.5L)
Engine oil pressure	57–85 psi at 4800 rpm

## FUEL SYSTEM

Fuel requirement	No. 2-D or winterized No. 2-D if temperature is below 20°F (–7°C)
Fuel tank capacity	22.6 gal (87L) (18.9 imp. gal)



# SPECIFICATIONS

## CAUTION:

- Do not use home heating oil, gasoline, or other alternate fuels, or additives (unless recommended), in a diesel engine. Also, do not mix any of these substances to diesel fuel.
- Do not use No. 2-D diesel fuel when the temperature is below 20°F (– 7°C) unless it is winterized. Low temperatures can cause wax to form in the No. 2-D fuel, which will clog the system.
- Using a fuel other than those specified can result in a loss of warranty coverage on the related components.
- Never use ether or any other starting fluid in an automotive diesel using glow plugs. The hot glow plugs may ignite the starting fluid causing an explosion which could result in severe engine damage or personal injury.

Injection firing order	1-5-3-6-2-4
Idle speed	750 + 50 – 0 rpm
Fast idle (cold-start) speed	900–1050 rpm
Injection pump timing	VE—2.5° ± 1° BTDC at 750 rpm; VP-20—6° ± 1.5° BTDC at 2000 rpm

## TORQUE SPECIFICATIONS

**LB FT (N·m)**

Main bearing caps	M10 × 21	43–48 (60–67)
Engine support straps	M10 × 21	28–34 (39–47)
Valve cover	M8 × 21	6–7 (8–10)
Oil trap to valve cover	M8 × 21	11–14 (15–19)
Cylinder head bolts	M11 × 21	
Step 1		36–43 (50–60) wait 15 minutes
Step 2		65–69 (90–95) run warm about 15 min.
Step 3 (torque angle)		90 ± 5°
Oil spray bar to cylinder head	M8 × 21	14–17 (20–24)
Oil drain plug	M12 × 21	24–26 (33–36)
Oil pan to cylinder block	M6 × 21	6.5–7 (9–10)
Front/rear end covers to cylinder block	M6 × 21	6–7 (8–10)
	M8 × 21	14–17 (20–24)
Flywheel to crankshaft (installed with Loctite No. 270)	M12 × 21	71–81 (98–112)
Vibration damper hub to crankshaft	M18 × 21	282–311 (390–430)
Pulley / vibration damper to vibration damper hub	M8 × 21	16–17 (22–24)
Connecting rod bolts	M21	
Step 1		14 (20)
Step 2 (torque angle)		70°
Sprocket to camshaft	M10.9 × 21	40–47 (55–65)
Bearing cap of camshaft	M6 × 21	6–7 (8–10)
	M8 × 21	14–17 (20–24)
Tensioning roller holder to cylinder block	M8 × 21	14–17 (20–24)
Clamping bolt in rocker arm	M6 × 21	5–6.5 (7–9)



# SPECIFICATIONS

## TORQUE SPECIFICATIONS (Cont'd.)

Sprocket to auxiliary shaft .....	M10.9 × 21 .....	40-47 (55-65)
Oil pressure switch .....	M21 .....	22-29 (30-40)
Oil pump to crankcase .....	M8 × 21 .....	16-17 (22-24)
Oil pump cover .....	M6 × 21 .....	6-7 (8-10)
Oil filter housing to cylinder block .....	M8 × 21 .....	14-17 (20-24)
Oil filter cover .....	M8 × 21 .....	15-18 (21-25)
Oil filter drain plug .....	M12 × 21 .....	7-9 (10-13)
Oil spray jet to cylinder block .....	M6 × 21 .....	6-7 (8-10)
Oil cooler oil lines to oil filter housing .....	M21 .....	22-29 (30-40)
Oil lines to turbocharger .....	M8 × 21 .....	14-17 (20-24)
Oil line from turbocharger to crankcase 22 mm width across flats hollow bolt .....	M16 × 21 .....	29-33 (40-45)
Water pump to crankcase .....	M8 × 21 .....	14-17 (20-24)
Fan coupling to water pump nut with left-hand threads .....	M21 .....	36 (50)
Fan to fan coupling .....	M6 × 21 .....	6-7 (8-10)
Pulley to water pump .....	M6 × 21 .....	6-7 (8-10)
Thermostat housing .....	M6 × 21 .....	6-7 (8-10)
Bleeder screw .....	M8 × 21 .....	4-7 (6-10)
Temperature sensor / temperature switch .....	M14 × 21 .....	12-14 (17-19)
Intake manifold to cylinder head .....	M8 × 21 .....	14-17 (20-24)
Exhaust manifold to cylinder head (upper row of staybolts installed with Loctite 270) .....	M8 × 21 .....	14-17 (20-24)
Turbocharger to exhaust manifold .....	M10 × 21 .....	17-20 (23-27)
Exhaust manifold to turbocharger .....	M10 × 21 .....	31-35 (43-48)
Vacuum pump .....	M6 × 21 .....	6-7 (8-10)
Pulse sensor to engine (holder) .....		6-7 (8-10)
Glow plugs .....		14-22 (20-30)
Temperature switch to fuel filter housing .....		22 (30)
Wire to glow plug .....		3-4 (4-5)
Fuel filter housing to holder .....		31-35 (43-48)
Injection pump to holder, rear (nuts and bolts) .....		14-17 (20-24)
Injection pump to holder, front .....		14-17 (20-24)
Electric shut-off to injection pump .....		11-18 (15-25)
Electric valve for cold start accelerator to injection pump .....		11-14 (15-20)
Injection pump gear to injection pump .....		33-36 (45-50)
Tensioning torque for tensioning roller holder .....		33-36 (45-50)
Tensioning roller holder to engine (M8 nut and bolt) .....		18 (25)
Combination fuel injector in cylinder head .....		29-33 (40-45)
Injection line (coupling nut) .....		14-18 (20-25)
Nozzle holder to injection pump .....		33 (45)
Spill valve to injection pump (hollow bolt) .....		14-22 (20-30)



# BEARING SELECTION CHART— STANDARD CRANKSHAFT

CRANKSHAFT		CAP DIAMETER	ENGINE BLOCK MAIN BEARING THICKNESS		CRANKSHAFT MAIN JOURNAL SIZE	MAIN CAP MAIN BEARING THICKNESS	BEARING TO CRANKSHAFT CLEARANCE
STANDARD	Y	2.5590-2.5592 in (65.000-65.006 mm)	0.0980-0.0983 in (2.491-2.498 mm)	Y	2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 in)	
				W	2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	
STANDARD	G	2.5593-2.5595 in (65.007-65.013 mm)	0.0983-0.0986 in (2.498-2.505 mm)	Y	2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 mm)	
				W	2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	
STANDARD	W	2.5596-2.5598 in (65.014-65.019 mm)	0.09862-0.0988 in (2.505-2.512 mm)	Y	2.3615-2.3618 in (59.984-59.990 mm)	0.0980-0.0983 in (2.491-2.498 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3613-2.3615 in (59.977-59.983 mm)	0.0983-0.0986 in (2.498-2.505 in)	
				W	2.3610-2.3612 in (59.971-59.976 mm)	0.09862-0.0988 in (2.505-2.512 mm)	
1ST UNDERSIZE - 0.100 in (- 0.25 mm)	Y	2.5590-2.5592 in (65.000-65.006 mm)	0.1029-0.1036 in (2.616-2.623 mm)	Y	2.3517-2.3519 in (59.734-59.740 mm)	0.1029-0.1032 in (2.616-2.623 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3514-2.3516 in (59.727-59.733 mm)	0.1032-0.1035 in (2.623-2.630 mm)	
				W	2.3512-2.3514 in (59.721-59.726 mm)	0.1035-0.1038 in (2.630-2.637 mm)	
1ST UNDERSIZE - 0.100 in (- 0.25 mm)	G	2.5593-2.5595 in (65.007-65.013 mm)	0.1032-0.1035 in (2.623-2.630 mm)	Y	2.3517-2.3519 in (59.734-59.740 mm)	0.1029-0.1032 in (2.616-2.623 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3514-2.3516 in (59.727-59.733 mm)	0.1032-0.1035 in (2.623-2.630 mm)	
				W	2.3512-2.3514 in (59.721-59.726 mm)	0.1035-0.1038 in (2.630-2.637 mm)	
1ST UNDERSIZE - 0.100 in (- 0.25 mm)	W	2.5596-2.5598 in (65.014-65.019 mm)	0.1035-0.1038 in (2.630-2.637 mm)	Y	2.3517-2.3519 in (59.734-59.740 mm)	0.1029-0.1032 in (2.616-2.623 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3514-2.3516 in (59.727-59.733 mm)	0.1032-0.1035 in (2.623-2.630 mm)	
				W	2.3512-2.3514 in (59.721-59.726 mm)	0.1035-0.1038 in (2.630-2.637 mm)	
2ND UNDERSIZE - 0.200 in (- 0.50 mm)	Y	2.5590-2.5592 in (65.000-65.006 mm)	0.1079-0.1081 in (2.741-2.748 mm)	Y	2.3418-2.3421 in (59.484-59.490 mm)	0.1079-0.1081 in (2.741-2.748 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3416-2.3418 in (59.477-59.483 mm)	0.1081-0.1084 in (2.748-2.755 mm)	
				W	2.3413-2.3415 in (59.471-59.476 mm)	0.1084-0.1087 in (2.755-2.762 mm)	
2ND UNDERSIZE - 0.200 in (- 0.50 mm)	G	2.5593-2.5595 in (65.007-65.013 mm)	0.1081-0.1084 in (2.748-2.755 mm)	Y	2.3418-2.3421 in (59.484-59.490 mm)	0.1079-0.1081 in (2.741-2.748 mm)	0.0008-0.0018 in (0.020-0.046 mm)
				G	2.3416-2.3418 in (59.477-59.483 mm)	0.1081-0.1084 in (2.748-2.755 mm)	
				W	2.3413-2.3415 in (59.471-59.476 mm)	0.1084-0.1087 in (2.755-2.762 mm)	
2ND UNDERSIZE - 0.200 in (- 0.50 mm)	W	2.5596-2.5598 in (65.014-65.019 mm)	0.1084-0.1087 in (2.755-2.762 mm)	Y	2.3418-2.3421 in (59.484-59.490 mm)	0.1079-0.1081 in (2.741-2.748 mm)	0.0008-0.0018 in (0.020-0.046 mm)
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				W	2.3413-2.3415 in (59.471-59.476 mm)	0.1084-0.1087 in (2.755-2.762 mm)	

BEARING Y — YELLOW  
BEARING G — GREEN  
BEARING W — WHITE

NOTE: Bearing to crankshaft clearance can only be checked with new bearings.

NOTE: Undersize crankshafts will be identified by slashmarks on the number 7 throw of the crankshaft.

— first undersize /  
— second undersize //





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