SECTION 20

Diesel Diagnostics — 6.6L and 7.8L Engines

Contents

Preliminary Checkout

This Section covers Adjustments, Diagnosis, and Test procedures for the 6.6L and 7.8L diesel engines. The areas included are the low-pressure fuel system, high-pressure (fuel injection) fuel system, air induction system, turbocharger, lubrication and cooling systems.

Before Starting

Efficient diagnosis must take place in an organized manner with a plan or procedure which starts with the obvious and goes on to the more difficult. Eliminate all the obvious and easy-to-do items first. Do not start by jumping to conclusions. The job worked on last week might have been caused by an entirely different problem than the one today.

Get All The Information Available

Check out all sources of information. Talk to the operator. Sometimes asking a question will cause the operator to remember something that is useful.

The following list is a set of basic questions. Get the answers to these in order to learn what the true complaint is, and what the basic problem is.

Operating Conditions:

1. Did the problem occur suddenly or over a long period of time?
2. Were there any abnormal noises before the failure?
3. Was the engine under heavy or light load? Decelerating or accelerating?
4. Did the water temperature or oil pressure vary?
5. Were weather conditions a factor?
6. What type of road grade was the vehicle on when the trouble was first noticed?
7. How was the trouble first noticed (felt, heard, etc.)?
8. What was the amount of oil consumption? Fuel? Coolant? Had there been a recent change?
9. What was the exhaust smoke like? Light or dense? Color?
10. Does the engine have good throttle response?
11. Is deceleration normal?
12. Does the engine shut off properly?
13. Does the engine start correctly when cold?
14. Does the engine ever miss?
15. What kind of fuel is being used? Grade and source?
16. Does the engine surge at idle or wide-open throttle?
17. Is the engine subjected to periods of extended idling?
18. Has the vehicle or equipment been in an accident or collision?

Preliminary Checkout

Maintenance History:

1. Has the engine been serviced recently? What was done?
2. Has this complaint occurred before? If so, what was done then?
3. When was the last tune-up?
4. When were the oil and fuel filters last changed?
5. Who normally performs the maintenance and adjustments?
6. Is the maintenance schedule followed closely?
7. How is fuel obtained and stored?
8. What type service designation (CC/CD), and what grade oil is used?
9. How many miles or hours has the engine operated since the last service?

Observed Information:

1. Is the engine clean or dirty?
2. Are the belts in good condition? Loose?
3. Is there evidence of external oil, coolant or fuel leaks?
4. Does the engine appear to have overheated?
5. Are there any make-shift repairs on the engine (loose parts, wired-on parts, etc.)?
6. How does the engine sound at idle?
7. Are any pulleys wobbling?
8. Do any parts appear to have been altered or serviced recently?
9. Are there any aftermarket or unapproved parts on the engine?
10. Have any of the lines been altered or re-routed?
11. Are oil level, coolant level and fuel level satisfactory? (If the problem concerns bearings, notice the condition of the oil).
12. During disassembly, does the engine have unusual odors, carbon accumulations, dirt or other conditions under the rocker cover?

Test Equipment

The following test equipment (Figures 1 through 4) is required for adjusting idle speed and timing.

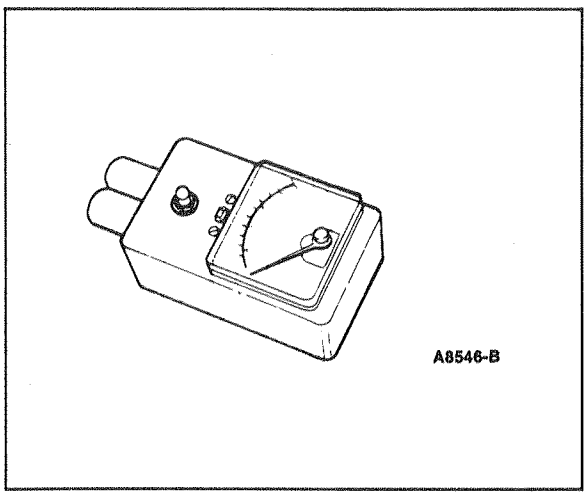


Figure 1 Photoelectric Tachometer, Rotunda 099-00001 Checking Engine

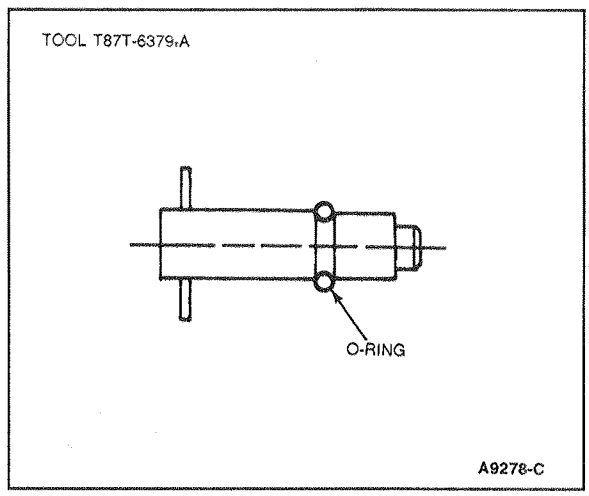


Figure 3 Timing Lock Pin — Damper T87T-6379-A

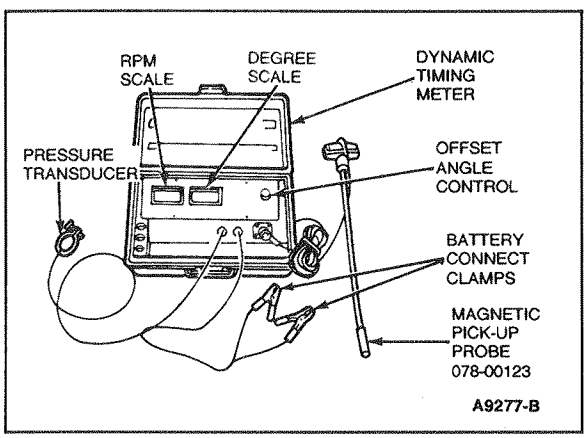


Figure 2 Dynamic Timing Meter, Rotunda 078-00200

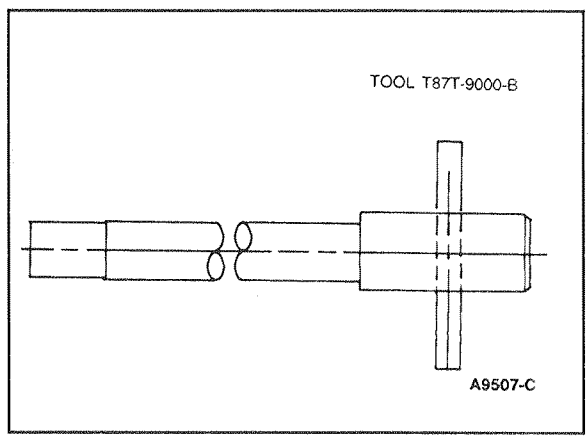


Figure 4 Timing Lock Pin — Injector Pump T87T-9000-B

Test Equipment

The following test equipment (Figures 5 and 6) is required for performing the Engine Performance Diagnostic procedure.

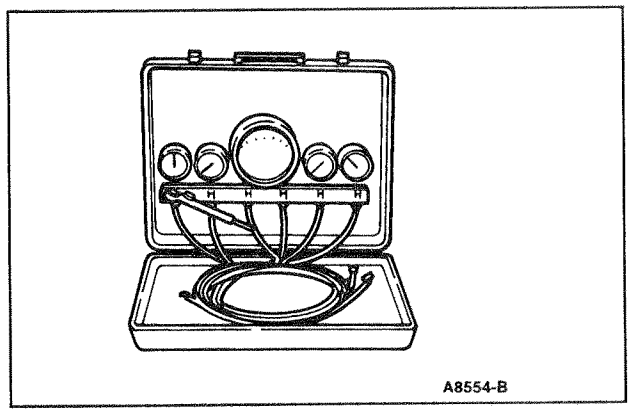


Figure 5 Rotunda 014-00702 Pressure Test Kit Used with Rotunda Adapter Kit 014-00733, 014-00734

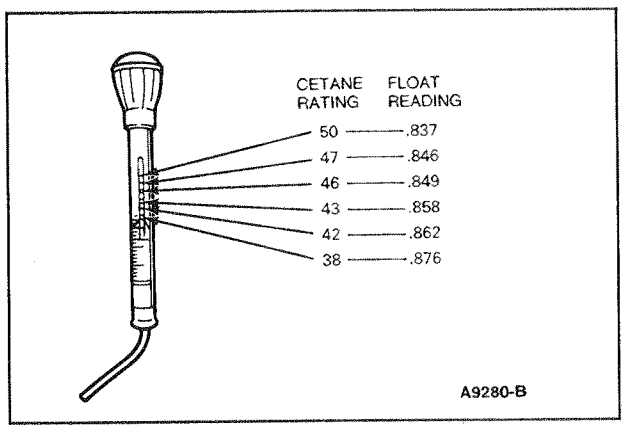


Figure 6 Fuel Quality (Cetane) Tester, Rotunda 078-00121

Test Equipment

The following test equipment (Figure 7) is used to test engine compression.

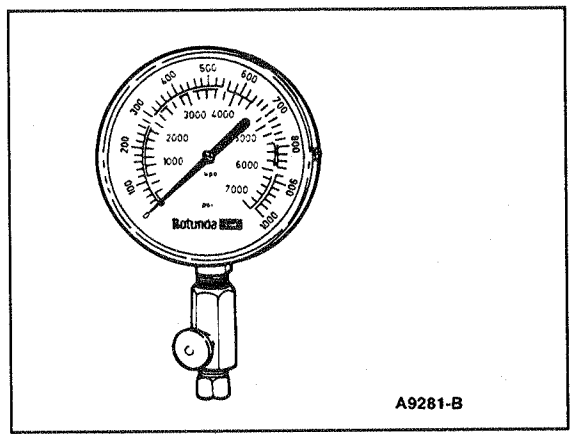


Figure 7 Rotunda Compression Tester 014-00701 Requires Adapter 014-00731

The following test equipment (Figure 8) is required for injection nozzle testing and cleaning.

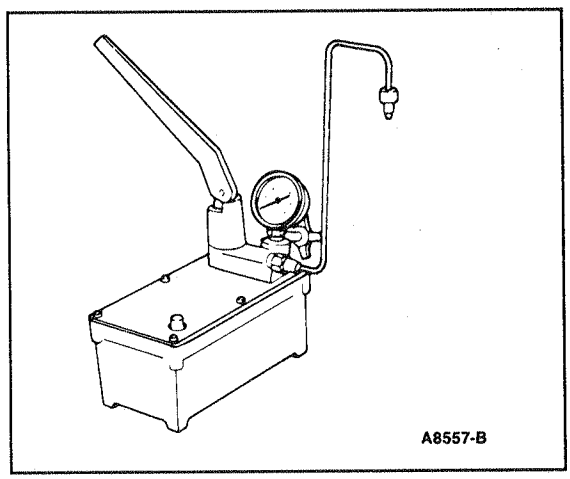


Figure 8 Rotunda Injector Nozzle Tester 014-00300 (Special Service Tool D83T-9000-F)

Engine Performance Specifications

	6.6L Turbo		7.8L Turbo				
	165	**170**	**185**	**210**	**215**	**215**	**240**
Engine Model	49	50	49	50	49	Calif.	50
Engine Rating (BHP @ 2400 rpm)			185	210	215	215	240
Engine Rating (BHP @ 2600 rpm)	165	170					
Firing Order	1-5-3-6-2-4						
Injection Pump Make and Model — Robert Bosch	A-2000	P-3000	P-3000	P-3000	P-3000	P-3000	P-3000
Turbocharger Make and Model — Garret Airesearch	T04E						
Injection Nozzle Make	Robert Bosch						
Injection Nozzle Opening Pressure — PSI	3100-3220	3680-3800	3680-3800				
Minimum Allowable Opening Pressure (Service) — PSI	2870	3390	3390				
Injection Pump Static Timing — BTDC	20°	10°	16°	10°	17°	10°	11°
Injection Pump Dynamic Timing — (No Load) @ 1000 rpm	①	①	①	①	①	①	①
Low Idle Speed — Man. and Auto. Transmission	700-750						
High Idle Speed	2930-3010	2880-2990	2740-2820	2740-2820	2740-2820	2740-2820	2760-2840
Intake and Exhaust Valve Clearance (cold) — Intake	0.015 in (0.38mm)						
Intake and Exhaust Valve Clearance (cold) — Exhaust	0.018 in (0.46mm)						
Intake Manifold Pressure — Full Load @ 2600 rpm	16 ± 1 psi (110 ± 7kPa)	20 ± 1 psi (103 ± 7kPa)	12 ± 1 psi (103 ± 7kPa) @2400 rpm	17 ± 1 psi (138 ± 7kPa) @2400 rpm	11 ± 1 psi (75 ± 7kPa) @2400 rpm	14 ± 1 psi (110 ± 7kPa) @2400 rpm	16 ± 1 psi (124 ± 7kPa) @2400 rpm
Crankcase Pressure (max allowable), no load		3in. H_2O (.7 kPa) @2600 rpm	3 in H_2O (.7 kPa) @2400 rpm				

① Not available at time of publication.

Engine Performance Specifications

	6.6L Turbo		7.8L Turbo				
	165	170	185	210	215 (CAL)	215 (49S)	240
Fuel Pressure (filter inlet)	(Min) 15 psi (103.43 kPa) (Max) 30 psi (206.85 kPa)						
Fuel Pressure (filter outlet)	(Min) 15 psi (103.43 kPa) (Max) 28 psi (193.06 kPa)						
Pressure Drop Across Fuel Filter	(Max) 7 psi (48.27 kPa)						
Air Filter Restriction @ 2600 rpm, no load	(Max) 10 in H_2O (2.5 kPa)						
	@ 2600 rpm		@ 2400 rpm				
Lift Pump Suction @ 2600 rpm, no load	(Max) 10 in H_2O (2.5 kPa)						
Fuel Return Line Pressure — no load	(Max) 6 psi (41.37 kPa)						
Lubricating Oil Pressure at Operating Temperature	Low Idle: (Min) 15 psi (103 kPa)						
	High Idle: 65-95 psi (488-655 kPa)						

Engine Lubrication System

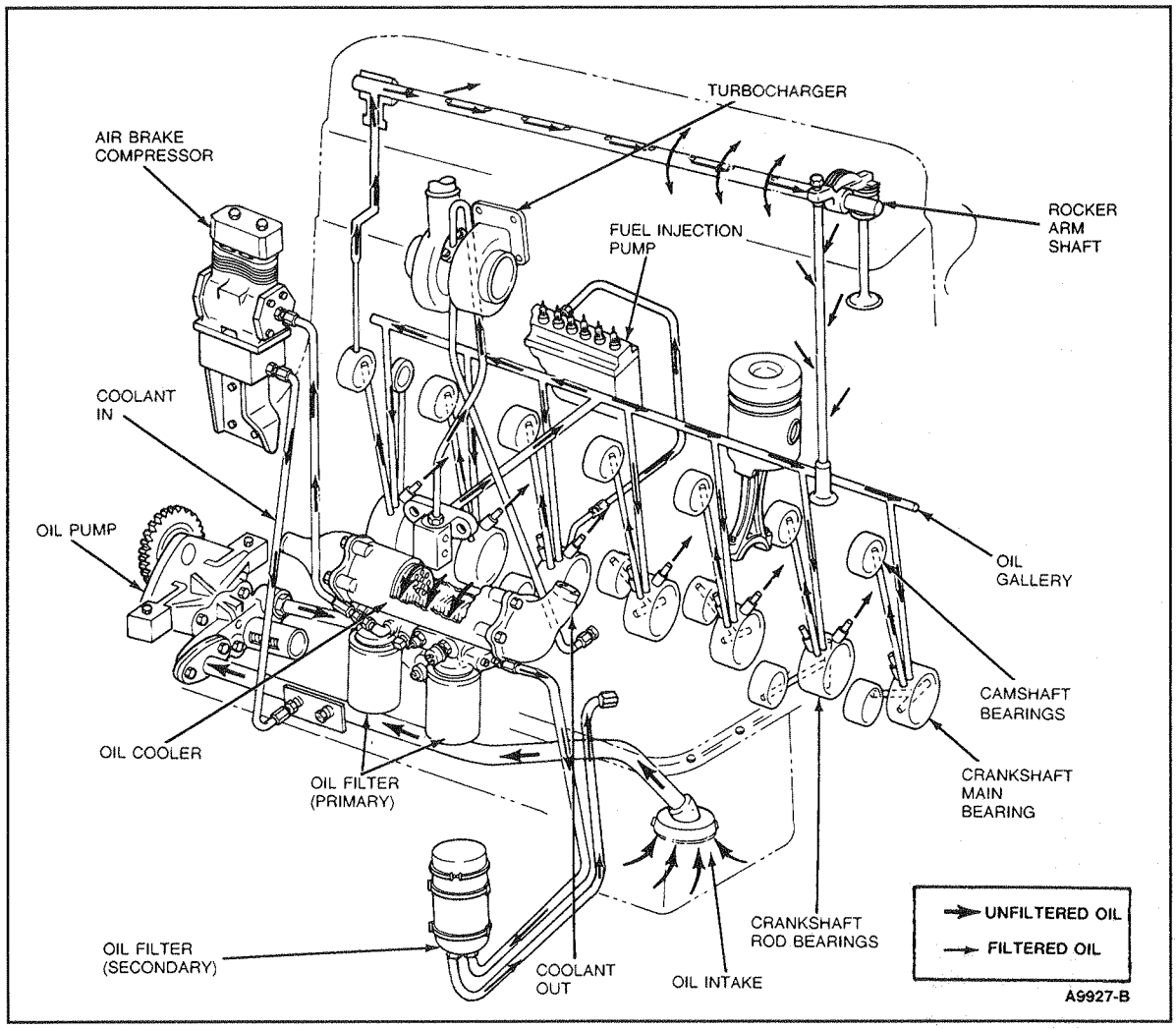


Figure 9 Phase 2 6.6L and 7.8L Lubrication System

Engine Lubrication System

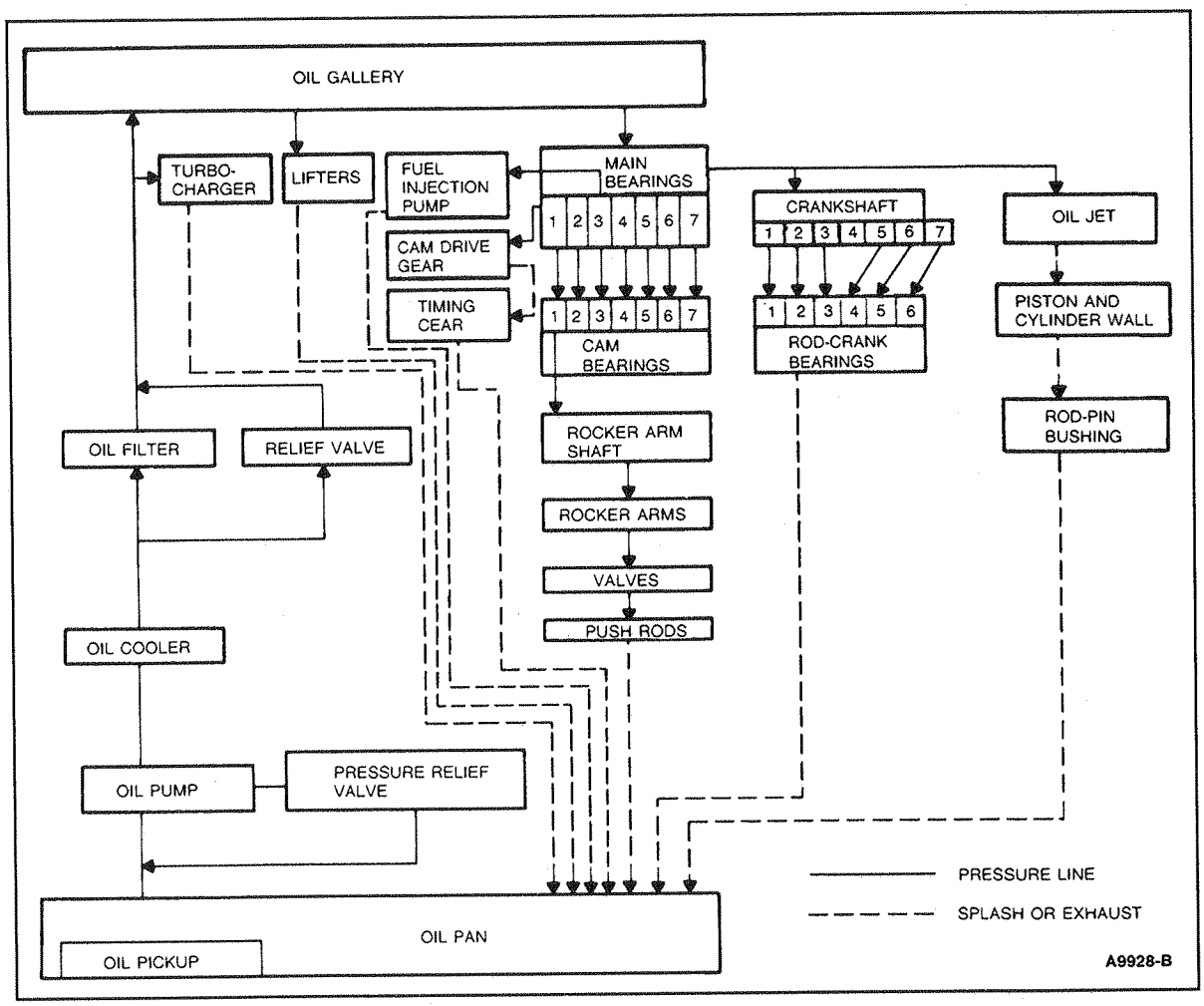


Figure 10 Phase 2 6.6L and 7.8L

High and Low Idle Speed Check and Adjustment

1. Clean crankshaft vibration damper and apply reflective tape at point shown in Figure 11.

NOTE: If dynamic timing meter is being used to check engine rpm, application of reflective tape on vibration damper is not necessary. Refer to Dynamic Timing for instructions on meter hookup.

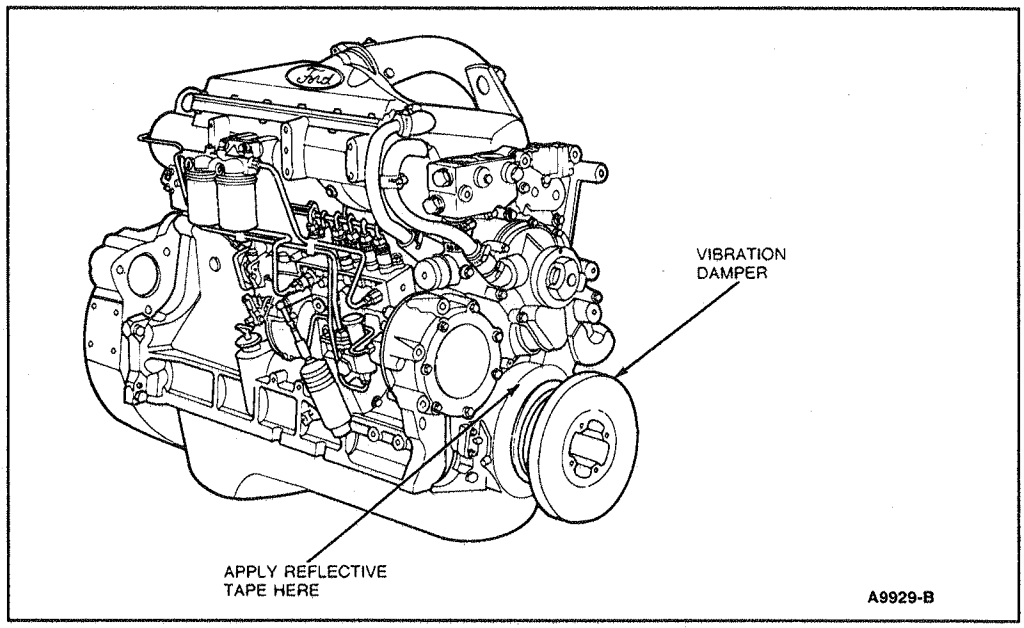


Figure 11 Reflective Tape Application

2. Place transmission in NEUTRAL or PARK and set the parking brake.
3. Bring engine to normal operating temperature. The engine must have been running at least 10 minutes prior to any adjustment.
4. Low idle speed is measured with manual transmission in NEUTRAL and automatic transmission in PARK.
5. Ensure that the throttle lever is against the low idle stop. If not, adjust linkage. Refer to Shop Manual, Section 25-60.

High and Low Idle Speed Check and Adjustment

6. Check idle speed using Rotunda Photoelectric Tachometer 099-00001 or equivalent. Low idle speed is specified on the Vehicle Emission Control Information (VECI) decal. Turn adjusting screw (Figure 12) counterclockwise to increase speed, clockwise to decrease speed.

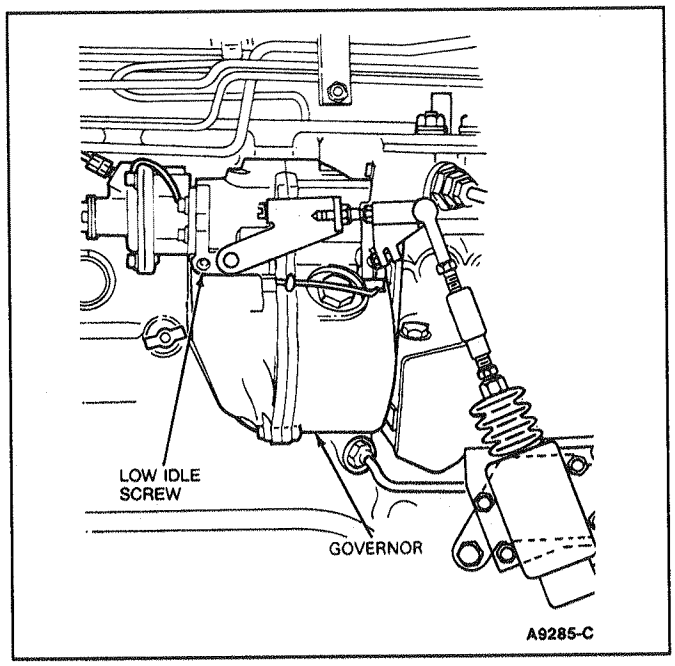


Figure 12 Adjusting Screw

7. Place transmission in NEUTRAL or PARK. Rev engine momentarily. Place transmission in specified gear (automatic transmission only) and recheck curb idle rpm. Adjust if necessary.
8. High idle speed is measured with manual transmission in NEUTRAL and automatic transmission in PARK or NEUTRAL.
9. Ensure that the throttle lever is against the high idle stop when the accelerator pedal is fully depressed. If not, adjust the linkage. Refer to Shop Manual, Section 25-60.
10. Check high idle speed using Rotunda Photoelectric Tachometer 099-00001 or equivalent.
11. If high idle speed is not correct, determine the problem. If the high idle is too low, go to the Engine Performance Diagnosis procedure. If the engine is overspeeding, the fuel injection pump should be sent to an authorized service center for inspection and diagnosis.

CAUTION: High idle speed is not to be adjusted. Breaking the seal on the high idle stop screw will void the warranty.

Dynamic Timing

Engine timing is verified by using the timing bracket (Figure 13) located beside the crankshaft damper. The timing bracket contains holes for checking dynamic timing and static timing. Positioning of the bracket is very important because if it is loosened or moved, timing will not be correct. The bracket is accurately positioned and chisel marked to the front cover during engine production. These chisel marks must always be aligned. Never loosen or remove the timing bracket.

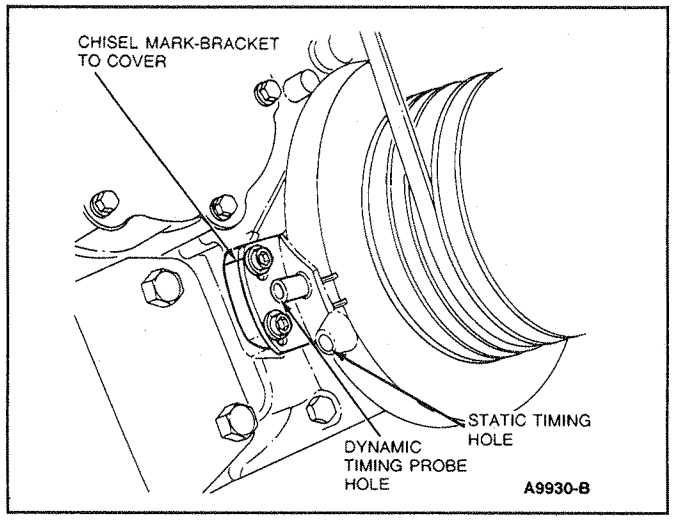


Figure 13 . Timing Pin and Probe Bracket

Dynamic timing is used as a quick check for proper timing. Do not, under any circumstances, change or set engine timing based only on dynamic timing readings. Timing is to be set only with the Timing Lock Pins T87T-9000-B and T87T-6379-A or equivalent using the static timing method.

Dynamic Timing

1. With engine stopped, install Rotunda Dynamic Timing Meter 078-00200 or equivalent. Place the magnetic pickup into the timing bracket pointer hole (Figure 14). Attach the connector from the pickup to the meter lead.

   NOTE: To prevent incorrect readings, make sure that the vibration damper grooves are clean and free of debris and rust. The pickup groove in the damper must not be plugged, or readings will be inaccurate.

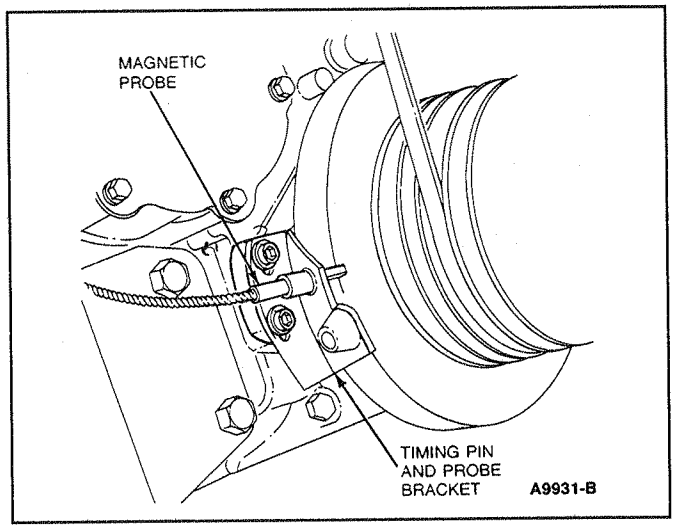


Figure 14 Inserting Magnetic Pickup Into Timing Bracket

2. Attach the pressure transducer to the No. 1 injector line (Figure 15) at the injector. Be sure the injector line is clean and free of paint where transducer is attached. Tighten the thumbscrew on the transducer finger-tight when attaching to the injector line.

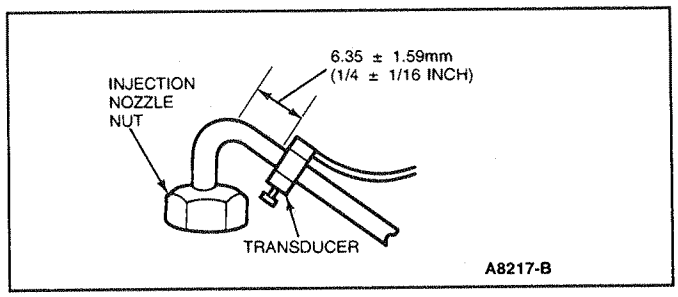


Figure 15 Pressure Transducer Attachment

NOTE: Cracks or other damage to the pressure transducer can cause incorrect timing readings. Follow these procedures carefully when working with pressure transducers.

- Do not over-tighten the transducer; snug fit is all that is needed. Do not use hand tools to tighten.
- Attach the transducer at the same location along the high-pressure line each time a check is made. The timing reading will change if the transducer is placed at a different location along the injector line.

Dynamic Timing

- The transducer should be dry; wet conditions will give erratic readings. If erratic readings are observed, remove transducer, wipe line and transducer with a clean, dry cloth. Spray the transducer and line with a water-displacing material, and clamp on the injector line.

3. Connect the timing meter to the battery and adjust the offset angle on the meter to zero degrees.

CAUTION: Be sure that all wire leads are located away from the front accessory drive belts and cooling fan.

4. With the transmission in NEUTRAL or PARK and the parking brake set, start the engine. Set the engine speed at 1000 rpm with no load, and observe the timing meter.
5. Check the Engine Performance Specifications for the correct timing specification for the engine being serviced and compare with observed reading.
6. Turn the engine off and remove the dynamic timing components.
7. If timing is off more than 2 degrees and there are indications of incorrect timing, such as poor performance or smoke, check the static timing using the lock pins. If the engine is performing normally and there is no evidence of excessive smoke or poor performance, check all meter connections and, if necessary, have meter calibration verified.

Static Timing

Pump On Engine (Check Timing)

1. Rotate engine clockwise. Set engine at correct static timing angle with No. 1 piston on the compression stroke. Fit Timing Lock Pin T87T-6379-A through the timing bracket into the correct crankshaft damper groove (Figure 16).

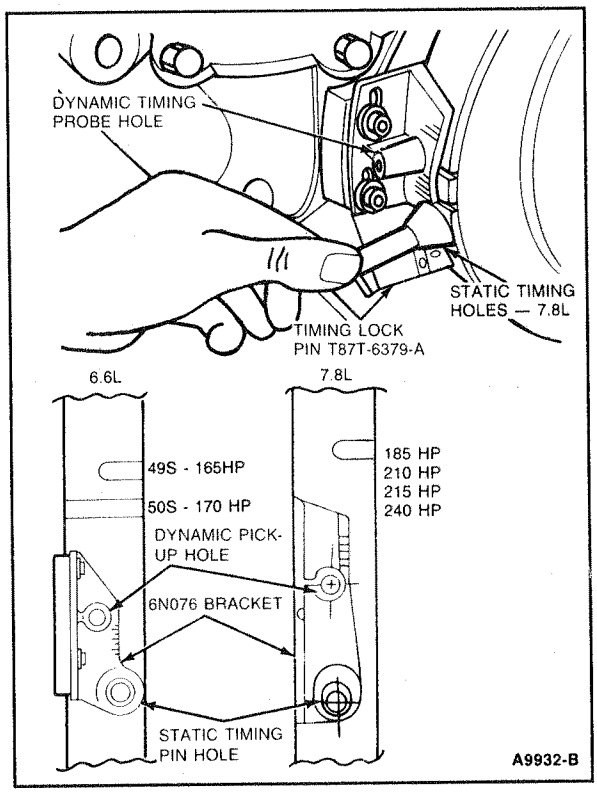


Figure 16 Fitting Timing Pin Into Crankshaft Damper

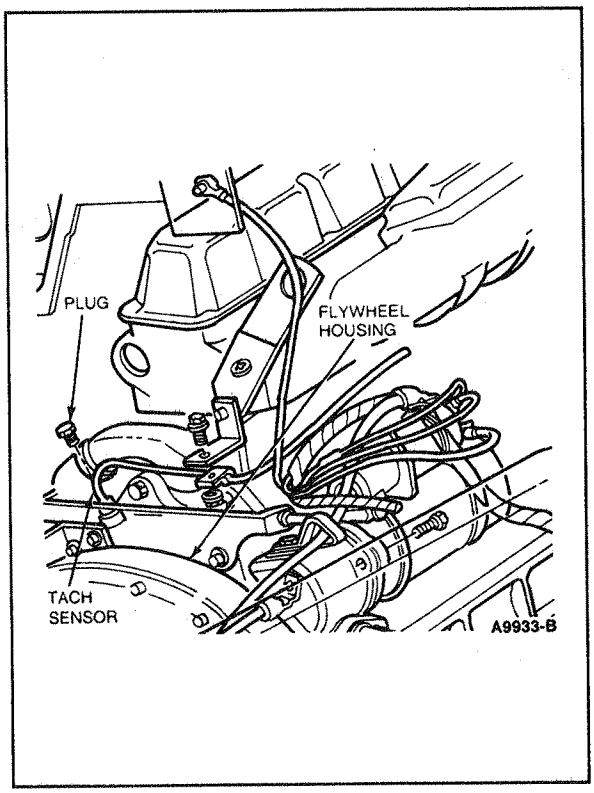


Figure 17 Tach Sensor or Plug Location

NOTE: The proper timing angle on the compression stroke of No. 1 cylinder is indicated by removing No. 1 injector and feeling for compression while turning the engine in the direction of rotation. When compression is felt, continue turning the engine until the alignment pin drops into the appropriate groove in the crankshaft damper cover. This indicates that the engine crankshaft is at the correct static timing angle with No. 1 piston on the compression stroke. Always approach the lock pin groove while turning the engine clockwise to ensure that gear backlash will not affect timing.

NOTE: When unable to access front damper mounting bolt to rotate engine, remove plug or tach sensor at top of flywheel housing to rotate flywheel ring gear with large screwdriver.

CAUTION: Do not, under any circumstances, loosen or remove the timing bracket.

Static Timing

2. Remove the plug from the injector pump adapter plate timing pin location and install timing lock pin into the adapter plate (Figure 18).
3. It is important that the lock pin seats fully in the slot in the injection pump hub (to within 3mm (1/8-inch) of the shoulder of the lock pin) to shoulder of eccentric pin lock screw. This verifies proper engine timing. If the lock pin is not fully seated the timing will be incorrect.

CAUTION: Do not turn crankshaft with timing lock pins in place.

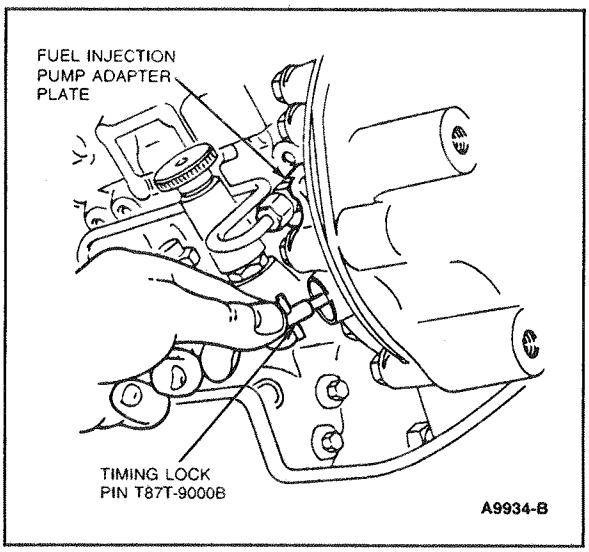


Figure 18 Lock Pin in Adapter Plate Installation

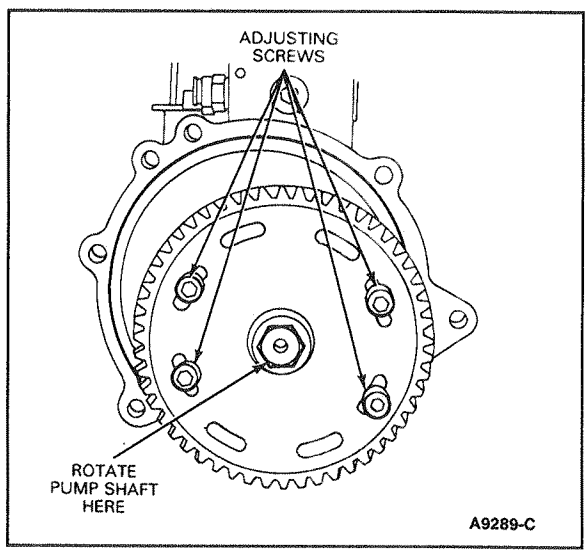


Figure 19 Injection Pump Gear Hub Adjusting Screws

NOTE: To properly adjust timing, be sure the damper timing pin is installed in the proper location with the No. 1 piston on the compression stroke.

4. To adjust timing, loosen the four adjusting screws on the injection pump gear hub (Figure 19). Rotate the pump shaft until the pump timing lock pin can be pushed into position and fully seated.
5. Turn gear counterclockwise by hand to remove backlash (it will move slightly). Tighten the four adjusting screws to 7 N•m (5 lb-ft). Remove the lock pins and tighten the adjusting screws to 22-26 N•m (16-19 lb-ft). Replace plug and sealing washer in adapter plate timing pin hole. Tighten to 9-12 N•m (7-9 lb-ft).
6. Rotate engine counterclockwise 90 degrees and then clockwise to the point where timing lock pin can be inserted in crankshaft damper. Insert timing lock pins into crankshaft damper and into fuel injection pump hub. If pin seats in injection pump gear hub, timing is correct. If it does not seat, repeat timing procedure.

Injection Pump Removed From Engine — Timing Bracket Removed or Loosened

1. Align timing bracket chisel mark with chisel mark on engine front cover. Tighten the timing bracket screw to 9-12 N•m (7-9 lb-ft).

NOTE: If a new timing bracket is being installed, it is necessary to accurately position the timing bracket with the damper timing groove. This requires a special procedure found in Shop Manual, Section 22-12.

Static Timing

2. Lock the fuel injection pump at port closure by inserting the lock pin into the fuel injection pump adapter housing so that it locks into the slot in the injection pump hub.
3. Set the engine, with No. 1 cylinder on the compression stroke, at static timing angle using the timing bracket and lock pin. Rotate the engine at least 20 degrees counterclockwise, then clockwise until the lock pin in the timing bracket engages the correct groove in the damper cover.
4. Loosen the four adjusting screws on injection pump gear hub.
5. Install the injection pump on the engine and align the adapter bolt holes to holes on engine. Install pump bolts and tighten to 27-34 N•m (20-25 lb-ft).
6. Rotate the pump gear counterclockwise to remove the pump gear backlash. Tighten the four adjusting screws on the hub to 7 N•m (5 lb-ft). Remove the timing lock pin from the pump. Tighten the four adjusting bolts to 22-26 N•m (16-19 lb-ft). Install the lock pin hole plug to 9-12 N•m (7-9 lb-ft).
7. Install engine components and check dynamic timing as outlined.

Injection Pump Off Engine — Timing Bracket Undisturbed

- Perform Steps 2 through 7 of Static Timing: Injection Pump Off Engine — Timing Bracket Removed or Loosened.

Fuel System Description

Figure 20 shows the two sides of the fuel system. In the low-pressure side, fuel pressure does not normally rise above 206 kPa (30 psi). In the high-pressure side, fuel pressure can be over 68,950 kPa (10,000 psi).

In the low-pressure side, fuel is supplied to the injection pump by the lift pump. Fuel flows from the fuel tank to the fuel block, to the lift pump, through the dual filters to the injection pump.

In the high-pressure side, the injection pump plungers raise the pressure to over 68,950 kPa (10,000 psi) and distributes fuel to the injector nozzles by way of the high-pressure fuel lines.

Approximately 40% of the fuel reaching the fuel injection pump and injectors is used for combustion. The remaining fuel cools and lubricates the fuel injection pump and injectors and returns to the fuel tank through a fuel return line.

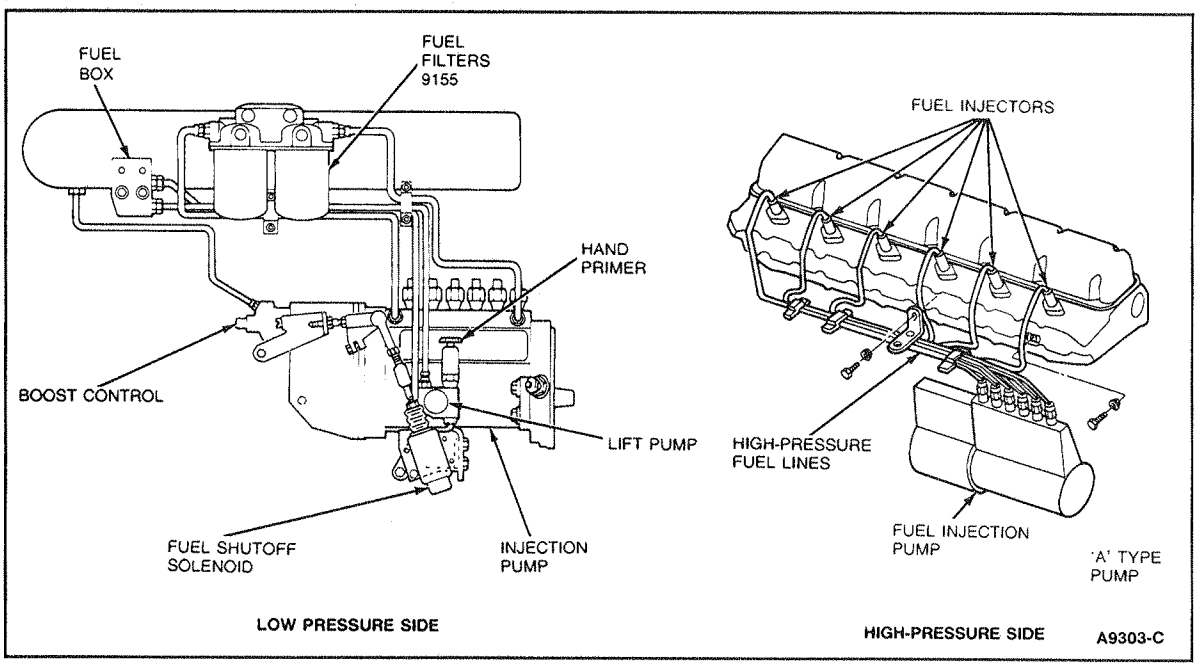


Figure 20 Typical 6.6L, 7.8L Diesel Engine Fuel System

Symptom Analysis

Consult the Symptom Analysis Pinpoint Diagnosis procedures first. These will direct you to a service to be performed or they will direct you to the Engine Performance Diagnosis procedure.

If the problem is low power and/or increased fuel consumption, go directly to the Engine Performance Diagnosis procedure.

Evaluating "Normal" Diesel Engine Exhaust Smoke

The following is a description of what is "normal" and expected exhaust smoke for a vehicle with a diesel engine. Diesel exhaust smoke can vary in color and consistency. The following chart should help in determining what causes certain types and colors of exhaust smoke and what should be done. Normal diesel exhaust smoke can be classified into two categories according to the color of the smoke.

The first category is blue-white smoke. Blue-white smoke may be observed at all ambient temperatures but should not occur after the vehicle is warmed and being driven. Blue-white smoke may occur after engine warm-up during extended idling due to the combustion chambers cooling down.

NOTE: Chassis fuel system air leaks also may cause continuous heavy blue-white smoke. Service fuel system as required.

The second category of diesel exhaust smoke is black smoke. Black smoke is caused by an overrich mixture, and normally occurs whenever the engine is working hard. The engine works hard when it is going up a steep grade, carrying a heavy load, or during heavy acceleration. More black smoke will be observed when operating the vehicle at higher altitudes because the air is thinner. If black smoke is observed while the engine is idling (at low altitude) or under normal driving conditions, the problem should be diagnosed as soon as possible.

There is a third category of diesel exhaust smoke which is not normal; blue smoke. Blue smoke occurs when oil is entering the combustion chamber and is burning along with the fuel. Smoke of this color usually indicates a definite problem which should be corrected as soon as possible.

Symptom Analysis

Hard Starting/No Start	Pinpoint Test A
Engine Surges	Pinpoint Test B
Engine Misses	Pinpoint Test C
Excessive Black Smoke	Pinpoint Test D
Fog-Like Exhaust (White or Blue) in Full-Load Range	Pinpoint Test E
Engine Cannot Reach Governed rpm	Pinpoint Test F
Engine Knocks	Pinpoint Test G
Turbocharger Noisy	Pinpoint Test H
Cyclic Sound From Turbocharger	Pinpoint Test J
Oil Leak From Turbocharger Compressor or Turbine Seal	Pinpoint Test K
Low Oil Pressure with Proper Oil Level	Pinpoint Test L
Excessive Oil Consumption	Pinpoint Test M
Fuel Dilution in Lubricating Oil	Pinpoint Test M
Excessive Coolant Temperature-Temperature Above 105°C (220°F)	Pinpoint Test P
Fuel Injection Pump Overheating	Pinpoint Test Q
Low Power	Go to Engine Performance Diagnosis Procedure.
Increased Fuel Consumption	Go to Engine Performance Diagnosis Procedure.

Hard Starting/No Start

Pinpoint Test **A**

TEST STEP	RESULT ▶	ACTION TO TAKE
A0 CHECK STARTING PROCEDURE		
• Check and follow correct starting procedure.	(OK) ▶	RETURN vehicle to customer.
	(OK) ▶	GO to A1.
A1 CHECK CRANKING SPEED		
• Check engine cranking rpm. • Cranking speed should be a minimum of 110 rpm.	(OK) ▶	GO to A2.
	(OK) ▶	SERVICE cranking system. REFER to Shop Manual, Group 28.
A2 CHECK FUEL FLOW		
• Check for fuel in fuel tank. • Loosen one injection line nut slightly while cranking engine. Fuel should discharge. **WARNING: BE EXTREMELY CAREFUL TO PREVENT BEING STRUCK BY DIESEL FUEL UNDER PRESSURE. DIESEL FUEL AT INJECTION PRESSURE CAN EASILY PIERCE THE SKIN, POSSIBLY CAUSING SEVERE SKIN POISONING. IF STRUCK BY DIESEL FUEL, SEEK MEDICAL HELP IMMEDIATELY.**	(OK) ▶	GO to A4.
	(OK) ▶	GO to A3.

Hard Starting/No Start	Pinpoint Test	A

TEST STEP	RESULT ▶	ACTION TO TAKE
A3 CHECK FUEL SHUTOFF SOLENOID • Check fuel shutoff solenoid linkage for binding. • Check fuel solenoid shutoff electrical terminals for dirt or corrosion and loose or broken electrical connections. • With ignition in RUN position, measure voltage at fuel shutoff solenoid. Voltage should be a minimum of 9 volts.	(OK) ▶ (OK) ▶	GO to A4 . SERVICE or REPLACE linkage or fuel shutoff solenoid. REFER to Shop Manual, Section 25-02. REPEAT Step A2 .
A4 CHECK STARTING AID • Check that starting aid is operating properly. Refer to Shop Manual, Section 25-02.	(OK) ▶ (OK) ▶	GO to Engine Performance Diagnosis procedure. SERVICE starting aid. REFER to Shop Manual, Section 25-02. REPEAT Step A4 . **NOTE: REVIEW proper cold-starting procedure with customer, if necessary.**

Engine Surges	Pinpoint Test	B

TEST STEP	RESULT ▶	ACTION TO TAKE
B0 CHECK FUEL TANK		
• Check to see if fuel tank is empty or if tank vent is blocked.	(OK) ▶	GO to Engine Performance Diagnosis procedure.
	(OK) ▶	FILL fuel tank. BLEED air from fuel system. CHECK tank vent. REFER to Shop Manual, Sections 25-02 and 25-50.

Engine Misses	Pinpoint Test	C

TEST STEP	RESULT ▶	ACTION TO TAKE
C0 ISOLATE MISS		
• Loosen each injector nozzle line nut (one at a time) while engine is running. Refer to On-Vehicle Injector Nozzle Testing. **WARNING: BE EXTREMELY CAREFUL TO PREVENT BEING STRUCK BY DIESEL FUEL UNDER PRESSURE. DIESEL FUEL AT INJECTION PRESSURE CAN EASILY PIERCE THE SKIN, POSSIBLY CAUSING SEVERE SKIN POISONING. IF STRUCK BY DIESEL FUEL, SEEK MEDICAL HELP IMMEDIATELY.**	Miss not isolated to specific cylinder ▶ Miss isolated to specific cylinder ▶	GO to Engine Performance Diagnosis procedure. GO to C1.
C1 CHECK NOZZLE FUEL DELIVERY		
• Check injector nozzle fuel line(s) for damage or restrictions. • Perform injector nozzle test as outlined under On Bench Injection Nozzle Testing.	(OK) ▶ (OK) ▶	GO to C2. CLEAN or REPLACE restricted or damaged line(s). REFER to Shop Manual, Section 25-02. REPLACE nozzle(s) as outlined under On Bench Injection Nozzle Testing.
C2 CYLINDER COMPRESSION CHECK		
• Perform cylinder compression test as outlined.	(OK) ▶ (OK) ▶	GO to Engine Performance Diagnosis procedure. GO to C3.
C3 CHECK CRANKCASE PRESSURE		
• Perform Engine Performance Diagnosis procedure Test Step **EPC.11B.**	(OK) ▶ (OK) ▶	SERVICE valve train as necessary. REFER to Shop Manual, Section 22-12. OVERHAUL problem cylinder(s). REFER to Shop Manual, Section 22-12.

Excessive Black Smoke

Pinpoint Test **D**

TEST STEP	RESULT ▶	ACTION TO TAKE
D0 VERIFY SMOKE LEVEL • Verify under what conditions black smoke occurs. **NOTE: Excessive black smoke may be accompanied by poor performance or low power.** **NOTE: Refer to Symptom Analysis.**	Light load or low altitude ▶	GO to D1. **NOTE: For warranty claim approval, Engine Performance Chart must be filled out.**
	Under heavy load ▶	A certain amount of black smoke is normal when going up steep grades, under maximum load, maximum boost, maximum acceleration or at high altitude.
D1 EXHAUST RESTRICTION CHECK • Inspect exhaust system for kinks or restriction. • Disconnect exhaust system at turbo and check performance.	(OK) ▶	GO to D2.
	(OK) ▶	SERVICE or REPLACE exhaust system components as necessary. REFER to Shop Manual, Section 26-01.
D2 CHECK AIR INTAKE RESTRICTION • Perform Engine Performance Diagnosis Test Step **EPC.7.**	(OK) ▶	GO to D3.
	(OK) ▶	REPLACE air filter or other components as required.
D3 CHECK DYNAMIC TIMING • Check dynamic engine timing as outlined.	(OK) ▶	GO to D5.
	(OK) ▶	GO to D4.

Excessive Black Smoke	Pinpoint Test	D

TEST STEP	RESULT ▶	ACTION TO TAKE
D4 CHECK STATIC TIMING		
• Check static engine timing as outlined.	(OK) ▶	Check dynamic timing meter for accuracy. If accurate, GO to Engine Performance Diagnosis Test Step **EPC.10.**
	(OK) ▶	Set static engine timing as outlined.
D5 CHECK NOZZLE FUEL DELIVERY		
• Check injector nozzle fuel line(s) for damage or restrictions. • Perform On-Vehicle Injector Nozzle test as outlined. **WARNING: BE EXTREMELY CAREFUL TO PREVENT BEING STRUCK BY DIESEL FUEL UNDER PRESSURE. DIESEL FUEL AT INJECTION PRESSURE CAN EASILY PIERCE THE SKIN, POSSIBLY CAUSING SEVERE SKIN POISONING. IF STRUCK BY DIESEL FUEL, SEEK MEDICAL HELP IMMEDIATELY.**	(OK) ▶	GO to **EPC.11.**
	(OK) ▶	REPLACE restricted or damaged line(s). REFER to Shop Manual, Section 25-02 or REPLACE nozzle(s) as outlined under On Bench Injection Nozzle Testing. If problem still exists, REPLACE the injection pump. REFER to Shop Manual, Section 25-02. **NOTE: For warranty claim approval, Engine Performance chart must be filled out.**

Fog-Like Exhaust (White or Blue) In Full-Load Range

Pinpoint Test **E**

TEST STEP	RESULT ▶	ACTION TO TAKE
E0 CHECK COOLING SYSTEM • Check to see that engine is reaching operating temperature.	(OK) ▶ (OK) ▶	GO to E2 . GO to E1 .
E1 THERMOSTAT OPERATION • Remove thermostats and test for proper operation. Refer to Shop Manual, Section 22-11.	(OK) ▶ (OK) ▶	GO to E3 . REPLACE thermostat(s). REFER to Shop Manual, Section 22-12. REPEAT Step E0 .
E2 EXCESSIVE OIL LEVEL • Check engine oil level indicator for excessive oil fill.	(OK) ▶ (OK) ▶	GO to E3 . DRAIN excess oil from oil pan. If problem still exists, GO to E3 .
E3 CHECK CRANKCASE BREATHER/ROAD DRAFT TUBE • Check for restricted crankcase breather element or plugged crankcase road draft tube.	(OK) ▶ (OK) ▶	GO to E4 . When obstruction is removed, RUN engine for 30 minutes to burn off accumulated oil in exhaust system.
E4 CHECK FUEL RETURN • Perform Engine Performance Diagnosis Test Step **EPC.8E.** **NOTE: If the fuel injection pump overflow valve is stuck shut, it will simulate a clogged fuel return line. To check this valve, measure inlet pressure to the injection pump. If the pressure exceeds 193 kPa (28 psi) at 2600 rpm the valve must be removed and cleaned or replaced. Refer to Shop Manual, Section 25-02.**	(OK) ▶ (OK) ▶	PERFORM Engine Performance Diagnosis procedure. SERVICE or REPLACE fuel return line(s). REFER to Shop Manual, Section 25-02. REPEAT Step E3 .

Engine Cannot Reach Governed RPM	Pinpoint Test	F

TEST STEP	RESULT ▶	ACTION TO TAKE
F0 VEHICLE OVERLOADED		
• Check to see if vehicle is being overloaded (above specified GVW).	Vehicle is overloaded ▶	INFORM customer to reduce loads.
	Vehicle load normal ▶	GO to F1.
F1 THROTTLE LINKAGE		
• Check throttle adjustment as outlined under Engine Performance Diagnosis Test Step **EPC.3.**	(OK) ▶	PERFORM Engine Performance Diagnosis procedure.
	(OK) ▶	ADJUST the throttle adjustment. REFER to Shop Manual, Section 25-60.

Engine Knocks — Pinpoint Test G

TEST STEP	RESULT ▶	ACTION TO TAKE
G0 VEHICLE OVERLOADED • Check to see if vehicle is being overloaded (above specified GVW).	Vehicle is overloaded ▶	INFORM customer to reduce load.
	Vehicle load normal ▶	GO to **G1**.
G1 BELT DRIVE ACCESSORIES • Check engine front drive components for proper operation.	(OK) ▶	GO to **G2**.
	(OK) ▶	SERVICE or REPLACE components as necessary. REFER to specific accessory Shop Manual Section.
G2 ENGINE COOLANT TEMPERATURE • Verify engine coolant temperature is below 105°C (220°F).	(OK) ▶	GO to **G3**.
	(OK) ▶	GO to Pinpoint Test **Q.**
G3 ISOLATE ENGINE KNOCK • Loosen each injector nozzle line nut (one at a time) while running engine. **WARNING: BE EXTREMELY CAREFUL TO PREVENT BEING STRUCK BY DIESEL FUEL UNDER PRESSURE. DIESEL FUEL AT INJECTION PRESSURE CAN EASILY PIERCE THE SKIN, POSSIBLY CAUSING SEVERE SKIN POISONING. IF STRUCK BY DIESEL FUEL SPRAY, SEEK MEDICAL HELP IMMEDIATELY.**	Engine knock not isolated to specific cylinder ▶	GO to Engine Performance Diagnosis procedure.
	Engine knock isolated to specific cylinder(s) ▶	GO to **G4**.
G4 CHECK NOZZLE FUEL DELIVERY • Check injector nozzle fuel line(s) for damage or restrictions. • Perform injector nozzle test as outlined under On Bench Injector Nozzle Testing.	(OK) ▶	GO to Engine Performance Diagnosis procedure.
	(OK) ▶	SERVICE or REPLACE restricted or damaged line(s). REFER to Shop Manual, Section 25-02 or REPLACE nozzle(s) as outlined under On Bench Injector Nozzle Testing.

Turbocharger Noisy	Pinpoint Test	H

TEST STEP	RESULT ▶	ACTION TO TAKE
H0 AIR INTAKE OBSTRUCTION • Check for obstruction or restriction in: a. Duct between air cleaner and compressor inlet. b. Duct between the compressor outlet and intake manifold. c. Intake manifold.	(OK) ▶ (OK) ▶	GO to **H1**. REMOVE obstruction or REPLACE damaged parts. REFER to Shop Manual, Section 22-12.
H1 AIR INTAKE LEAKS • Check for air leaks in: a. Duct between the air cleaner and compressor inlet. b. Duct between the compressor outlet and intake manifold. c. Intake manifold to engine connection.	(OK) ▶ (OK) ▶	GO to **H2**. REPLACE seals or tighten fasteners. REFER to Shop Manual, Section 22-12.
H2 EXHAUST SYSTEM RESTRICTION • Check for restricted or damaged exhaust system.	(OK) ▶ (OK) ▶	GO to **H3**. SERVICE or REPLACE exhaust system components. REFER to Shop Manual, Section 26-01.
H3 EXHAUST GAS LEAK • Check for exhaust gas leak at: a. Exhaust manifold-to-engine connection. b. Turbine inlet to exhaust manifold.	(OK) ▶ (OK) ▶	GO to **H4**. REPLACE gaskets or TIGHTEN fasteners. REFER to Shop Manual, Section 25-45.

Turbocharger Noisy	Pinpoint Test	H

TEST STEP	RESULT ▶	ACTION TO TAKE
H4 COMPRESSOR WHEEL		
• Check for dirt caked on turbocharger compressor wheel or obvious signs of foreign object ingestion. **NOTE: If there is damage to compressor wheel or turbine wheel, the turbocharger will have to be replaced.**	(OK) ▶ (OK) ▶	GO to H5 . CLEAN the compressor wheel with a non-caustic cleaner and soft brush. FIND and CORRECT source of unfiltered air. CHANGE engine oil and oil filter.
H5 TURBOCHARGER		
• Remove turbocharger from engine. Check turbocharger for damage. Perform failure analysis. Refer to Shop Manual, Section 25-45.	(OK) ▶ (OK) ▶	INSTALL turbocharger on engine. GO to Step **EPC.12.** REPLACE turbocharger. REFER to Shop Manual, Section 25-45.

Turbocharger Noisy or Cyclic Sound From Turbocharger

Pinpoint Test **J**

TEST STEP	RESULT ▶	ACTION TO TAKE
J0 AIR INTAKE DUCT		
• Check for a restriction in air intake duct into turbo compressor inlet.	(OK) ▶	GO to J1.
	(OK) ▶	REMOVE obstruction or REPLACE damaged parts. REFER to Shop Manual, Section 25-41.
J1 COMPRESSOR WHEEL		
• Check for dirt caked on compressor wheel of turbocharger.	(OK) ▶	GO to Pinpoint Test Step H5.
	(OK) ▶	CLEAN compressor wheel with a non-caustic cleaner and a soft brush. LOCATE and CORRECT source of unfiltered air. CHANGE engine oil and oil filter.

Oil Leak From Turbocharger Compressor Or Turbine Seal

Pinpoint Test **K**

TEST STEP	RESULT ▶	ACTION TO TAKE
K0 CHECK AIR INTAKE RESTRICTION • Perform Engine Performance Diagnosis Test Step **EPC.7.**	(OK) ▶ (OK) ▶	GO to K1. REPLACE air filter or other components as needed. REFER to Shop Manual, Section 25-41.
K1 EXHAUST SYSTEM RESTRICTION • Inspect exhaust system for kinks or restriction. • Disconnect the exhaust system at the turbo and check performance.	(OK) ▶ (OK) ▶	GO to K2. SERVICE or REPLACE exhaust system components as necessary. REFER to Shop Manual, Section 26-01.
K2 EXHAUST GAS LEAK • Check exhaust manifold-to-engine gaskets for leaks at ports.	(OK) ▶ (OK) ▶	GO to K3. REPLACE exhaust manifold-to-engine gasket(s). REFER to Shop Manual, Section 22-12.
K3 CHECK TURBINE INLET • Check turbine inlet-to-exhaust manifold gasket for leaks.	(OK) ▶ (OK) ▶	GO to K4. REPLACE exhaust manifold-to-turbocharger gasket. REFER to Shop Manual, Section 22-12.
K4 OIL DRAIN LINE OBSTRUCTION • Check oil drain line for restriction.	(OK) ▶ (OK) ▶	GO to K5. SERVICE or REPLACE oil drain line. REFER to Shop Manual, Section 25-45.

Oil Leak From Turbocharger Compressor Or Turbine Seal

Pinpoint Test **K**

TEST STEP	RESULT ▶	ACTION TO TAKE
K5 CRANKCASE VENT OBSTRUCTION • Check crankcase vent tube for damage or restriction.	OK ▶ OK ▶	GO to K6. SERVICE or REPLACE crankcase vent tube. REFER to Shop Manual, Section 22-12.
K6 TURBOCHARGER CENTER HOUSING • Check turbocharger center housing for sludge or coke deposits.	OK ▶ OK ▶	GO to K7. CHANGE engine oil and oil filter. REPLACE turbocharger, if necessary. REFER to Shop Manual, Section 25-45.
K7 EXCESSIVE BLOW-BY • Perform Engine Performance Diagnosis procedure Test Step **EPC.11B.**	OK ▶ OK ▶	GO to K8. SERVICE engine as required. REFER to Shop Manual, Section 22-12.
K8 INTERNAL ENGINE PROBLEM • Perform compression test as outlined.	OK ▶ OK ▶	GO to K9. SERVICE engine as required. REFER to Shop Manual, Section 22-12.

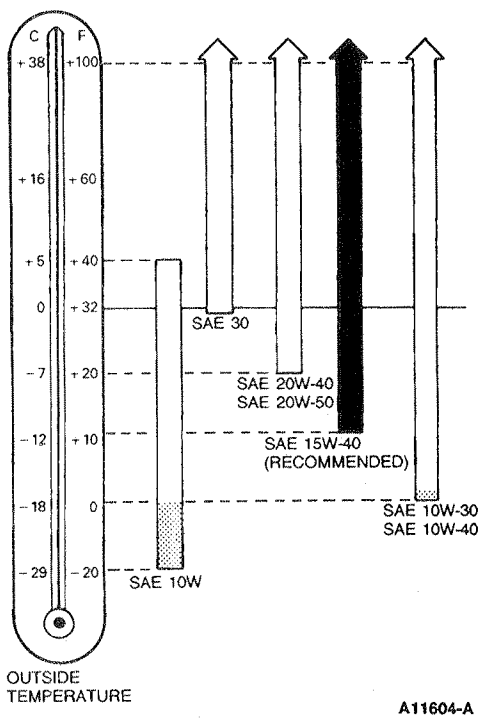
Oil Leak From Turbocharger Compressor Or Turbine Seal

Pinpoint Test **K**

TEST STEP	RESULT ▶	ACTION TO TAKE
K9 COMPRESSOR WHEEL		
• Check for dirt caked on turbocharger compressor or turbine wheel for obvious signs of foreign object ingestion. **NOTE: If there is damage to compressor wheel or turbine wheel, the turbocharger will have to be replaced.**	(OK) ▶ (OK) ▶	GO to K10. CLEAN compressor wheel with a non-caustic cleaner and soft brush. FIND and CORRECT source of unfiltered air. CHANGE engine oil and oil filter.
K10 TURBOCHARGER		
• Check turbocharger for damage. Perform failure analysis. Refer to Shop Manual, Section 25-45.	(OK) ▶ (OK) ▶	CHECK for oil leakage from other sources. REPLACE turbocharger. REFER to Shop Manual, Section 25-45.

Low Oil Pressure With Proper Oil Level

Pinpoint Test **L**

TEST STEP	RESULT ▶	ACTION TO TAKE
L0 CHECK OIL PRESSURE		
• Remove oil pressure sending unit. Connect Rotunda Pressure Test Kit 014-00702 or equivalent 11706 to engine. Refer to Pressure Test Kit Hook-up, Figure 18. • Run engine until normal operating temperature is reached and check oil pressure. • Engine oil pressure should be 103 kPa (15 psi) minimum at Low Idle — 65-95 psi (488-655 kPa) at High Idle.	(OK) ▶ (OK) ▶	CHECK oil pressure gauge and/or sending unit. REFER to Shop Manual, Section 33-32. INSTALL sending unit. GO to L1.
L1 CHANGE ENGINE OIL AND FILTER		
• Change engine oil and filter. Use engine oil that meets API specification SF/CD (recommended), or CD. Determine viscosity according to ambient temperature.  • Run engine until normal operating temperature is reached. • Check oil pressure reading.	(OK) ▶ (OK) ▶	RETURN vehicle to customer. GO to L2.

Low Oil Pressure With Proper Oil Level

Pinpoint Test **L**

TEST STEP	RESULT ▶	ACTION TO TAKE
L2 CHECK OIL PUMP DRIVE GEARS • Remove oil pan. • Check oil pump drive gears for damage or wear. • Check drive gear backlash. Refer to Shop Manual, Section 22-12.	(OK) ▶ (OK) ▶	GO to L3. REPLACE oil pump drive gears. REFER to Shop Manual, Section 22-12.
L3 CHECK OIL PUMP INLET TUBE • Check oil pump inlet tubes for cracks. • Check that oil pump inlet tube attaching bolts are tightened to specification. Refer to Shop Manual, Section 22-12.	(OK) ▶ (OK) ▶	GO to L4. REPLACE oil pump inlet tube or TIGHTEN attaching bolts to specification. REFER to Shop Manual, Section 22-12. CHECK engine oil pressure.
L4 CHECK OIL PRESSURE TUBE • Check oil pressure tube for cracks. • Check that oil pressure tube attaching bolts are tightened to specification. Refer to Shop Manual, Section 22-12.	(OK) ▶ (OK) ▶	SERVICE or REPLACE oil pump assembly as necessary. REFER to Shop Manual, Section 22-12. REPLACE oil pressure tube or REPLACE oil pressure tube-to-engine block gasket and TIGHTEN attaching bolts to specification. REFER to Shop Manual, Section 22-12.

Excessive Oil Consumption — Pinpoint Test M

TEST STEP	RESULT ▶	ACTION TO TAKE
M0 LEAK CHECK		
• Visually inspect for external oil leaks.	(OK) ▶	GO to M1.
	(OK) ▶	SERVICE oil leaks. RETURN vehicle to customer.
M1 CHECK AIR INLET SYSTEM		
• Check for air cleaner restriction and check air induction system for leaks. Perform Engine Performance Diagnosis Test Step **EPC.11B.**	(OK) ▶	GO to M2.
	(OK) ▶	SERVICE or REPLACE air inlet system components. REFER to Shop Manual, Section 22-12.
M2 VERIFY PROBLEM		
• Change the oil. Use oil that meets API specification SF/CD (recommended), or CD. Determine viscosity according to ambient temperature as shown on chart in Pinpoint Test Step **L1.**	Oil consumption less than 0.95L (1 quart) per 483 km (300 miles) ▶	RETURN vehicle to customer. Oil consumption is normal.
• Determine oil consumption rate and trend at: 1610 km (1000 miles/50 hours) or 8047 km (5000 miles/250 hours).	Oil consumption more than 9.5L (1 quart) per 483 km (300 miles) ▶	GO to M3.
• Record amount of make-up oil added during test period.		
M3 CHECK VEHICLE LOAD		
• Determine if abnormally heavy loads are being pulled by vehicle (above specified GVW).	Vehicle load normal ▶	GO to M4.
	Vehicles overloaded ▶	INFORM customer to reduce loads.
M4 CHECK VEHICLE OPERATION		
• Check for improper operation (i.e., allowing engine to lug in incorrect gear range) resulting in oil consumption.	Truck being driven correct ▶	GO to M5.
	Engine being lugged ▶	INFORM customer to REVIEW operator habits to be sure engine is not being lugged.

Excessive Oil Consumption

Pinpoint Test **M**

TEST STEP	RESULT ▶	ACTION TO TAKE
M5 CHECK AIR CLEANER RESTRICTION • Perform Engine Performance Diagnosis Test Step **EPC.7.** Restriction should be less than 2.5 kPa (10 in) H_2O.	Air cleaner restriction within specification ▶	GO to M6.
	Pulls over oil through turbocharger compressor seal ▶	REPLACE element. REPEAT M5.
M6 CHECK CRANKCASE BREATHER/ ROADDRAFT TUBE • Check for restricted crankcase breather element or plugged crankcase roaddraft tube. • Check crankcase pressure step **EPC.11B.**	(OK) ▶	GO to M7.
	(OK) ▶	SERVICE or REPLACE breather element or vent. RUN engine for 30 minutes to burn off accumulated oil in exhaust system.
M7 CHECK AIR COMPRESSOR • Check air compressor for worn rings causing oil to leak into air system. Refer to Shop Manual, Section 12-41.	(OK) ▶	GO to M8.
	(OK) ▶	SERVICE or REPLACE air compressor. REFER to Shop Manual, Section 12-41.
M8 CHECK VALVE GUIDES/SEALS • Check for worn engine valve guide seals or valve guides. Refer to Shop Manual, Section 22-12.	(OK) ▶	GO to M9.
	(OK) ▶	CLEAN, INSPECT and REPLACE as necessary. REFER to Shop Manual, Section 22-12.
M9 CHECK COMPRESSION • Perform engine compression test as outlined.	(OK) ▶	RETURN vehicle to customer.
	(OK) ▶	SERVICE engine as necessary. REFER to Shop Manual, Section 22-12.

Fuel Dilution in Lubricating Oil	Pinpoint Test	N

TEST STEP	RESULT ▶	ACTION TO TAKE
N0 VERIFY THE PROBLEM		
• Determine if there is fuel present in lubricating oil.	No dilution ▶	RETURN vehicle to customer.
NOTE: If fuel is present, oil will have the odor of diesel fuel.	Fuel diluted ▶	CHECK to see if vehicle has been idled for excessive periods. CHECK for internal fuel injection pump or injection nozzle leakage. REFER to Shop Manual, Section 25-02.

Excessive Coolant Temperature Temperature Above 105°C (220°F)

Pinpoint Test **P**

TEST STEP	RESULT ▶	ACTION TO TAKE
P0 VERIFY CONDITION • Determine conditions when overheating occurs. **NOTE: Ambient temperatures above 43°C (110°F) may cause engine temperatures to exceed 105°C (220°F).**	Ambient temperature above 43°C (110°F) ▶ Ambient temperature below 43°C (100°F) ▶	INFORM customer that condition is normal. GO to P1.
P1 VERIFY OPERATION • Check operator's driving habits (running in improper gear ranges, etc).	OK ▶ OK ▶	GO to P2. INFORM customer to REVIEW operator driving habits.
P2 CHECK ACCESSORIES • Check that all accessory equipment is approved. • Check accessory drive belt tension. Refer to Shop Manual, Section 27-06.	OK ▶ OK ▶	GO to P3. ADJUST belt tension or REPLACE belts. INFORM customer accessories are not approved.
P3 CHECK ENGINE • Check that engine is clean. • Check for engine coolant and/or oil leaks.	OK ▶ OK ▶	GO to P4. CLEAN engine. SERVICE engine coolant and/or oil leaks as necessary.
P4 CHECK ENGINE COOLANT • Check coolant condition. Refer to Shop Manual, Section 27-02.	OK ▶ OK ▶	GO to P5. DRAIN, FILL and BLEED the coolant system using the specified coolant and coolant conditioner. REFER to Shop Manual, Section 27-02.

Excessive Coolant Temperature Temperature Above 105°C (220°F)	Pinpoint Test	P

TEST STEP	RESULT ▶	ACTION TO TAKE
P5 CHECK RADIATOR, HOSES, CLAMPS • Check radiator cap for proper operation. • Check that correct hoses are installed and are properly clamped. • Check that radiator is correct for vehicle and is clean and unobstructed by bent fins, pinched tubes or foreign objects. • Check that correct fan is properly installed.	(OK) ▶ (OK) ▶	GO to P6. SERVICE or REPLACE components as necessary. REFER to Shop Manual, Group 27.
P6 CHECK WATER PUMP • Check water pump for worn bearings or coolant leaks.	(OK) ▶ (OK) ▶	GO to P7. SERVICE or REPLACE water pump. REFER to Shop Manual, Section 22-12.
P7 CHECK THERMOSTATS • Check thermostats for proper operation. Refer to Shop Manual, Section 22-12.	(OK) ▶ (OK) ▶	GO to P8. REPLACE thermostats. REFER to Shop Manual, Section 22-12.
P8 CHECK STATIC TIMING • Check injection pump static timing as outlined.	(OK) ▶ (OK) ▶	GO to P9. ADJUST static timing as outlined.

Excessive Coolant Temperature Temperature Above 105°C (220°F)

Pinpoint Test **P**

TEST STEP		RESULT ▶	ACTION TO TAKE
P9	CHECK FOR BLOWN HEAD GASKET		
• Fill a bucket and suitable bottle with water. • Run engine until normal operating temperature is reached. Stop engine. • Place filled bottle in bucket with neck facing down. • Insert coolant overflow hose into neck of bottle. • Start engine and look for air bubbles in bottle.		No bubbles present ▶ Bubbles present ▶	GO to **P10**. REPLACE blown head gasket. REFER to Shop Manual, Section 22-12.
P10	CHECK COOLING SYSTEM FOR CONTAMINATION		
		No contamination present ▶ Contamination present ▶	RETURN vehicle to customer. REFER to Shop Manual, Section 22-12.

Fuel Injection Pump Overheating

Pinpoint Test Q

TEST STEP		RESULT ▶	ACTION TO TAKE
Q0	OVERFLOW VALVE		
• Verify that fuel flows freely from overflow valve.		(OK) ▶	PERFORM Engine Performance Diagnosis Test Step **EPC.8E.**
		(OK) ▶	CLEAN orifice in overflow valve or REPLACE fitting. REFER to Shop Manual, Section 25-02.

Engine Performance Diagnosis Procedure

The Engine Performance Diagnosis procedure begins with those items which are the high frequency, easy-to-diagnose problems, and progresses to the low frequency, hard-to-diagnose problems. Use of this procedure will promote rapid, as well as accurate diagnosis.

The Engine Performance Diagnosis procedure follows, step-by-step, the Engine Performance Chart. Each test step is labeled to coincide with the Engine Performance Chart steps.

NOTE: Under no circumstances should the fuel injection pump, fuel injectors or turbocharger be replaced until the Engine Performance Chart has been completely filled out. Warranty claims for the fuel injection pump, fuel injectors and turbocharger will not be accepted unless the Engine Performance Chart has been filled out as specified and all tamper-proof seals are intact.

Service each problem detected before going on the next step. If service corrects the original complaint, it will not be necessary to proceed to the next test step. However, if the complaint is not corrected, continue with the procedure until the complaint is corrected.

The following explanations refer to the basic test steps of the Engine Performance Diagnosis procedure and Chart. They give a brief description of the effect on performance these problems can create, giving an understanding of the importance of each test step.

1. **External Leakage:** Fuel leakage can be a reason for diesel fuel smell, poor fuel economy or poor performance. Oil leakage can be a reason for high oil consumption. An air intake system leak can shorten engine and turbocharger life, especially under dusty conditions. Coolant leakage can result in engine overheating. Exhaust gas or boost air leakage can cause poor engine performance and black smoke.

2. **Exhaust System Condition:** Kinks or dents in the exhaust system can cause high exhaust back pressure. This can result in loss of power and high smoke levels. If an aftermarket exhaust brake is installed ensure:

   - Maximum exhaust pressure does not exceed 241 kPa (35 psi) @ 2860 rpm.
   - Exhaust brake assembly is mounted at least 1.7m (5.5 ft) downstream from turbocharger.

3. **Accelerator Linkage:** If the accelerator linkage is improperly adjusted, damaged or worn, low idle speed may be out of specification and the engine may not reach high idle and top speed, causing pulling power to be reduced.

4. **Fuel System Condition:** Kinks in the fuel lines or hoses can block or restrict fuel flow and loose connections can leak air into the fuel. This can result in loss of power, high smoke levels and failure to start.

5. **Fuel Quality:** Diesel engines need clean fuel, free of air, dirt, water and microbiological organisms. Any contamination may result in poor engine performance.

   NOTE: If the fuel is contaminated with water, microbiological organisms are able to grow in a diesel fuel tank, especially in warm, moist climates. Therefore, it is very important to keep water from getting into the fuel.

Engine Performance Diagnosis Procedure

The diesel fuel recommended for use in the 6.6L and 7.8L diesel engines must be either grade 1-D or 2-D. Use No. 2-D fuel when ambient temperatures are above −7°C (20°F). Use No. 1-D when ambient temperatures are below −7°C (20°F). If No. 1-D is not available, use winterized 2-D. Use of regular No. 2-D during cold weather may cause starting and/or driveability problems due to reduced fuel flow caused by fuel waxing.

The use of high sulfur fuel should be avoided. When fuel sulfur content exceeds 0.5 percent by weight, oil change intervals should be shortened. Consult the maintenance schedule for the required intervals.

6. **Engine Idle Speed:** Low engine idle speed may cause stalling or rough running.

7. **Air Cleaner Restriction:** A dirty air filter or restriction in the air cleaner may result in low power, excessive smoke, poor fuel economy and oil leakage from the turbocharger.

8. **Fuel System Pressure and Capacity:** The fuel supply system must deliver the proper quantity of fuel with no pressure loss or air leaks in the chassis fuel system and then return unused fuel to the fuel tank. Restriction in the lines providing fuel to the fuel injection pump will result in low power, smoke problems and generally poor performance. Restrictions in the lines returning fuel to the fuel tank may cause problems of injection pump overheating, smoke problems and generally poor performance.

9. **Injection Timing:** Incorrect timing can be responsible for poor fuel economy, rough idling, hard starting and excessive smoke. Injection timing can be checked either statically or dynamically but can only be set statically.

10. The injector nozzles must be removed from the engine for testing. This is a functional test of injector nozzle performance which checks opening pressure, spray pattern and leakage.

11. **Compression and Crankcase Pressure:** These tests examine the condition of internal components of the engine. Low compression indicates leakage past the piston rings or valves. Crankcase pressure measures the amount of blow-by past the rings. Excessive blow-by past the rings creates high pressure in the crankcase. The crankcase pressure test will also indicate a clogged crankcase ventilation system. Compression testing, crankcase pressure readings and rate of oil consumption should be used to evaluate engine mechanical condition.

12. **Turbocharger:** These tests and checks examine the condition of the turbocharger to determine if it is affecting engine performance. Problems which can be caused by a turbocharger include low power, excessive exhaust smoke, excessive engine oil consumption, noise and oil leaks. Most turbocharger checks are performed with the engine off. Boost pressure, although not included in the Engine Performance Section, can be checked, but it requires a dynomometer since a full load condition must be simulated. Specifications for turbocharger boost are given in the Engine Performance Specifications Section and an adapter is available with the pressure test kit for checking boost pressure.

To perform the Engine Performance Diagnosis procedure, it is necessary to connect the Rotunda Pressure Test Kit 014-00702 or equivalent (Figure 21). Use the explanations outlined under Pressure Testing With the Gauge Bar to help in attaching the gauges and interpreting the readings.

Engine Performance Diagnosis Procedure

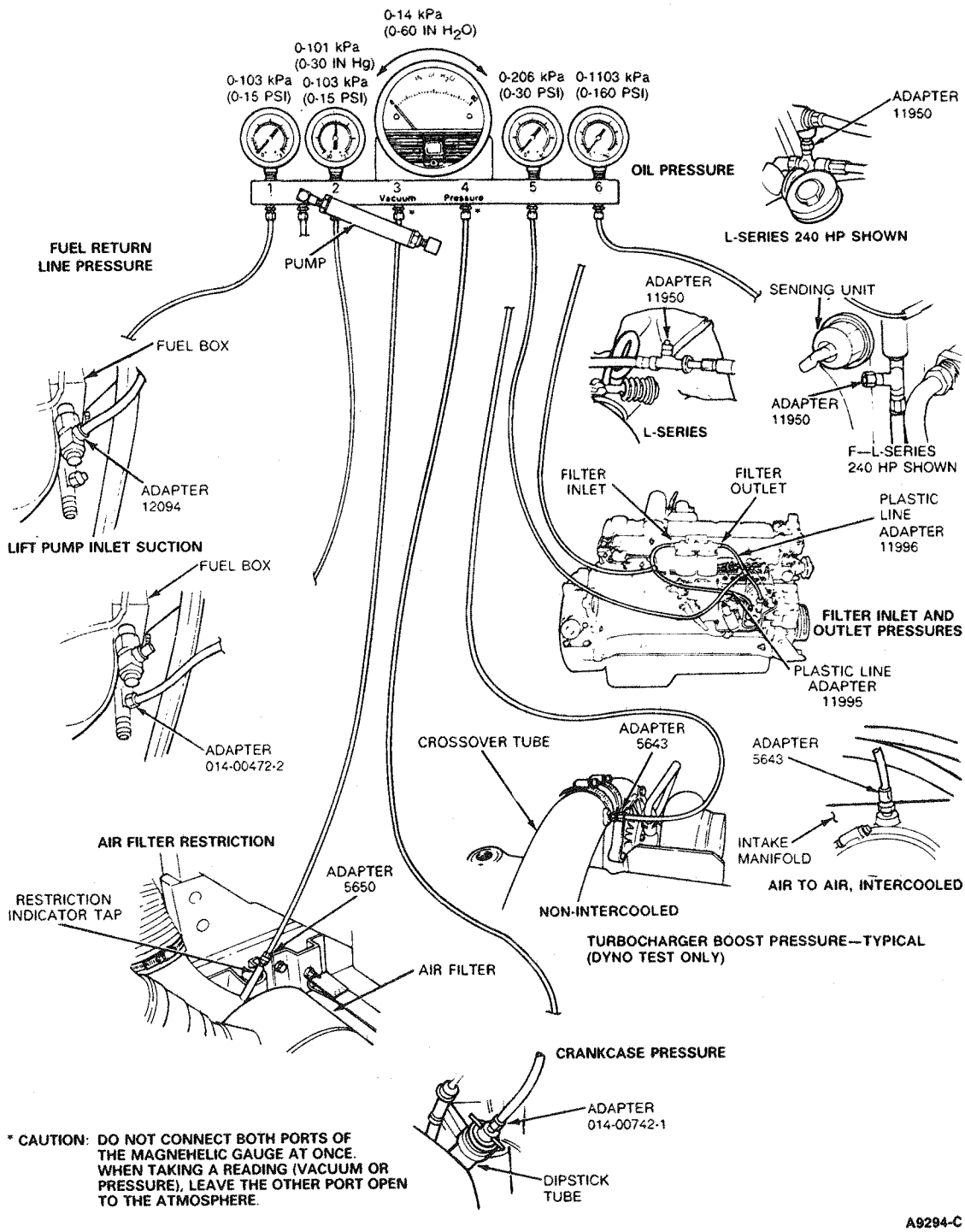


Figure 21 Pressure Test Kit Hookup

Engine Performance Diagnosis Procedure

Pressure Testing With the Gauge Bar

The gauge bar is used for several different pressure checks (Figure 21). Hookups are made using special adapters manufactured specifically for the 6.6L and 7.8L engines.

NOTE: Use of the gauge bar is not mandatory. Individual gauges can be used, as long as they are accurate and applicable to a particular check. Technicians who own their own set of gauges may find that buying the Adapter Kit 014-00733 will make it easier to hook their gauges into the 6.6L and 7.8L engines and systems.

Diagnostic tests that can be accomplished with the gauge bar along with hookup instructions are listed here:

Filter Inlet Pressure: Filter inlet pressure is measured by disconnecting the fuel line between the lift pump and the fuel filter inlet. In its place, a plastic line (11995) from the pressure test kit is installed. This line is equipped with a T-connection so that a pressure tap to the gauge bar can be made. Attach a line from the T-connection to the 0-1103 kPa (0-160 psi) gauge.

Filter Outlet Pressure: Filter outlet pressure is measured by disconnecting the fuel line between the fuel filter outlet and the inlet to the fuel injection pump. In its place, a plastic line (11996), from the pressure test kit is installed. This line is equipped with a T-connection so that a pressure tap to the gauge bar can be made. Attach a line from the T-connection to the 0-206 kPa (0-30 psi) gauge.

Connect both the Filter Inlet and Filter Outlet Pressure adapters at the same time to check the following:

- Filter Inlet Pressure
- Filter Outlet Pressure
- Pressure Drop Across the Fuel Filters
- Lift Pump Output Pressure
- Injection Pump Inlet Pressure (Fuel Galley Pressure)
- Air Leaks in the Fuel System (look for air bubbles in the plastic fuel lines)

Lift Pump Inlet Suction: To measure lift pump inlet suction, the coupling for the fuel line going into the fuel box from the fuel tank must be disconnected. At this point an adapter is screwed into the fuel box coupling and the fuel line coupling is screwed into the adapter. The adapter is equipped with a pressure tap which must be connected to 1-30 in Hg/0-15 psi gauge.

Fuel Return Line Pressure: To measure fuel return line pressure, the coupling for the fuel line going out of the box to the fuel tank must be disconnected. At this point, adapter 12094 is screwed into the fuel box. The adapter is equipped with a pressure tap which must be connected to the 0-1 bar (0-103 kPa or 0-15 psi) gauge.

Oil Pressure: Oil pressure is checked by tapping into a flexible line between the oil filter support and oil pressure sender switch. Use adapter 11950 to attach to either a coupling in the line or at the oil pressure sender switch at the dash panel.

Air Filter Restriction: Air filter restriction is checked at the same port where the restriction indicator is located. To check air filter restriction, remove the restriction indicator and install the adapter (5650) from the pressure test kit in its place. Connect the adapter to the vacuum side of the magnehelic gauge.

Engine Performance Diagnosis Procedure

Crankcase Pressure: Crankcase pressure is measured from the dipstick tube. To make this check, remove the dipstick and install the adapter (014-00472-1) from the pressure side of the magnehelic gauge.

CAUTION: Do not connect both parts of the magnehelic gauge at once. When taking a reading (vacuum/pressure) leave the other port open to the atmosphere.

Turbo Boost Pressure: Turbo boost pressure is measured from a tap on the crossover tube or inlet manifold. Remove the tap and install the adapter (5643) from the pressure test kit. Connect the adapter to the 0-206 kPa (0-30 psi) gauge.

NOTE: Turbo boost pressure is checked **only on a dynomometer** or where **full load conditions** can be simulated.

Air Leak Testing

The gauge bar is equipped with a pressure pump. This pump can be used to pressurize fuel lines to help locate air leaks. Once an air leak is verified by seeing air bubbles in the fuel going to the injection pump, the exact location can be determined using the pressure pump and the following procedure:

1. Plug the end of the fuel line.
2. Install the pump into the system in front of the suspected air leak.
3. Pressurize the system to a maximum of 104 kPa (15 psi) and maintain pressure.
4. Wipe the fuel lines and connections with a soap and water solution.
5. An air leak will show up as bubbles.
6. Tighten the connection or replace components as needed to eliminate the leak.

Checking Fuel Cetane

Checking fuel is very important in diagnosis. Contaminants in the fuel, like water and microbiological organisms, are easy to see when a fuel sample is placed in a clear container. Diesel fuel should be clear, with an amber tint (actual color may vary). Water or particulates floating in the fuel are indicators of contaminated fuel. Diesel fuel must have a cetane rating of at least 40. Cetane can be checked using Rotunda Cetane Tester 078-00121 or equivalent (Figure 22).

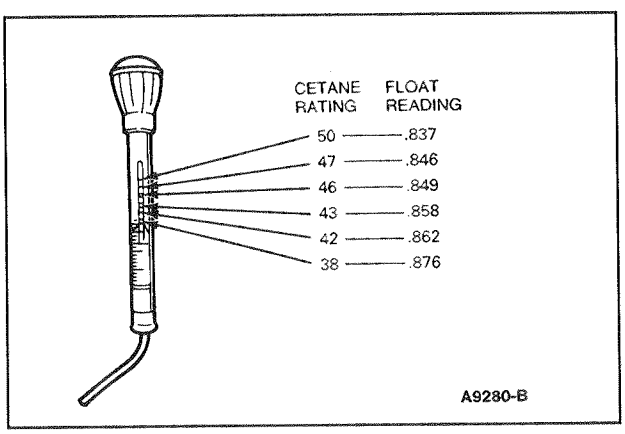


Figure 22 Centane Tester Float Readings, Rotunda 078-00121

Engine Performance Diagnosis	Pinpoint Test	EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.1 CHECK FOR EXTERNAL LEAKAGE • With engine running, visually check for leakage of: 1. Fuel 2. Engine oil 3. Dirt past air cleaner 4. Coolant 5. Exhaust 6. Boost air	(OK) ▶ (OK) ▶	GO to **EPC.2.** SERVICE or REPLACE faulty component(s). If performance problem still exists, GO to **EPC.2.**
EPC.2 CHECK EXHAUST SYSTEM • Visually check exhaust system for dents or kinks which could cause restriction.	(OK) ▶ (OK) ▶	GO to **EPC.3.** SERVICE or REPLACE exhaust system components as required. REFER to Shop Manual, Section 26-01. GO to **EPC.3.**
EPC.3 ACCELERATOR LINKAGE ADJUSTMENT • With engine off, check that control lever contacts injection pump stops. Control lever must contact low idle stop when accelerator pedal is released, and must contact high idle stop when accelerator is fully depressed.	(OK) ▶ (OK) ▶	GO to **EPC.4.** ADJUST or SERVICE vehicle throttle linkage as necessary. REFER to Shop Manual, Section 25-60. GO to **EPC.4.**
EPC.4 FUEL SYSTEM CONDITION • Inspect fuel supply and return lines and hoses for kinks, and all connections for tightness. **NOTE: If problem is "not starting", perform EPC.5A and EPC.5B.**	(OK) ▶ (OK) ▶	GO to **EPC.5A.** SERVICE or REPLACE loose or damaged component(s). If performance problems still exist, GO to **EPC.5A.**

Engine Performance Diagnosis | Pinpoint Test | EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.5A CHECK FUEL FOR CONTAMINATION • Obtain a fuel sample and visually examine fuel in a clear container (including bottom of container), for particles, clouding, or liquid contamination, such as water.	(OK) ▶ (OK) ▶	GO to **EPC.5B.** REPLACE engine and chassis fuel filters. CLEAN and/or SERVICE fuel system. REFER to Shop Manual, Section 25-02. GO to **EPC.5B.**
EPC.5B CHECK FUEL FOR CETANE VALUE • Check cetane value of fuel sample taken in Test Step **EPC.5,** using Rotunda Cetane Tester 078-00121 or equivalent. • Cetane value should be minimum of 40.	More than 40 ▶ Less than 40 ▶	GO to **EPC.6.** GO to **EPC.7.** INFORM owner to change fuel source. **NOTE: Do not replace fuel injection pump because of low cetane problem.**
EPC.6 CHECK ENGINE IDLE SPEED • Check engine speed as outlined under Adjustments. • Bring engine up to normal operating temperature. • Idle speed is measured with manual transmission in NEUTRAL and automatic transmission in PARK. • Idle speed is shown on Vehicle Emission Control Information decal (VECI).	(OK) ▶ (OK) ▶	GO to **EPC.7.** ADJUST idle speed as outlined in this Section. GO to **EPC.7.**
EPC.7 CHECK AIR INTAKE RESTRICTION • Remove air cleaner restriction indicator and install adapter 5650 and Rotunda Pressure Test Kit 014-00702 or equivalent. Refer to Figure 19. • Run engine at 2600 rpm, no load. • Record restriction reading. • Restriction should not exceed 2.5 kPa (10 in of H_2O).	(OK) ▶ (OK) ▶	REMOVE adapter. INSTALL cap on air cleaner port. GO to **EPC.8A.** REPLACE filter element and CHECK intake system for blockage. REPEAT **EPC.7.** If restriction indicator is not functioning correctly, REPLACE it.

Engine Performance Diagnosis | Pinpoint Test | EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.8A FUEL FILTER OUTLET PRESSURE		
• Install adapter 11996 with Rotunda Pressure Test Kit 014-00702 or equivalent. Refer to Figure 19. • Run engine at 2600 rpm with no load, transmission in PARK or NEUTRAL. • Record pressure reading. • Pressure should be 103-193 kPa (15-28 psi) at 2600 rpm.	(OK) ▶	GO to **EPC.8C.**
	Fuel pressure too low or fuel does not appear ▶	GO to **EPC.8B.**
	Fuel pressure too high ▶	GO to **EPC.8G.**
EPC.8B FUEL FILTER INLET PRESSURE		
• Install adapter 11995 with Rotunda Pressure Test Kit 014-00702 or equivalent. Refer to Figure 19. • Run engine at 2600 rpm with no load, transmission in PARK or NEUTRAL. • Record pressure reading. • Pressure should be 103-207 kPa (15-30 psi) with a maximum allowable pressure drop across the filter of 48 kPa (7 psi).	(OK) ▶	GO to **EPC.8C.**
	Pressure drop is greater than 48 kPa (7 psi) ▶	REPLACE fuel filters. REPEAT **EPC.8B.**
	Pressure is below 103 kPa (15 psi) ▶	GO to **EPC.8C.**
EPC.8C CHECK FUEL SYSTEM FOR AIR LEAKS		
• Run engine with adapters 11995 and 11996 installed, and observe clear plastic lines for air bubbles.	No bubbles present ▶	GO to **EPC.8E.**
	Bubbles present ▶	GO to **EPC.8D.**
EPC.8D CHECK CHASSIS FUEL LINES		
• Disconnect fuel supply line at engine and fuel tank. • Plug one end of line and connect pressure pump from Rotunda Pressure Test Kit 014-00702 or equivalent to other end of line. Refer to Figure 19. • Apply a maximum of 103 kPa (15 psi) to line, and hold pressure. • Apply a soap and water solution to all connections and fittings, and look for air bubbles.	Bubbles present ▶	SERVICE or REPLACE any leaking connection or fittings. REFER to Shop Manual, Section 25-50. REPEAT **EPC.8C.**
	No bubbles present ▶	SERVICE ends of fuel supply lines. CHECK fuel tank pickup for leaks. SERVICE or REPLACE fuel tank pickup. REFER to Shop Manual, Section 25-50. REPEAT **EPC.8C.**

Engine Performance Diagnosis | Pinpoint Test | EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.8E CHECK LIFT PUMP • Connect adapter 12094 and Rotunda Pressure Test Kit 014-00702 or equivalent to fuel box. Refer to Figure 19. • Run engine at 2600 rpm with no load, transmission in PARK or NEUTRAL. • Record vacuum reading. • Vacuum must be a maximum of 34 kPa (10 in Hg).	(OK) ▶ (OK) ▶	GO to **EPC.8F.** SERVICE or REPLACE restricted fuel supply line. REFER to Shop Manual, Section 25-50. REPEAT **EPC.8E.**
EPC.8F CHECK LIFT PUMP VOLUME • Disconnect lift pump outlet and connect a clean sample hose. • Disconnect fuel shutoff solenoid. • Place end of sample hose in clean, graduated container and crank engine for 30 seconds. • Volume should be a minimum of 0.47L (1 pint) in 30 seconds.	(OK) ▶ (OK) ▶	GO to **EPC.8G.** REPLACE lift pump. REFER to Shop Manual, Section 25-02. REPEAT **EPC.8F.**
EPC.8G CHECK FUEL RETURN PRESSURE • Disconnect fuel return line at fuel block. Install adapter 11950 and Rotunda Pressure Test Kit 014-00702 or equivalent. Refer to Figure 19. • Run engine at 2600 rpm with no load, transmission in PARK or NEUTRAL. • Record pressure reading. • Pressure should be a maximum of 41 kPa (6 psi) at 2600 rpm.	Fuel return pressure OK, EPC.8A OK ▶ Fuel return pressure OK, but fuel filter outlet pressure in EPC.8A high ▶ Fuel return pressure too high ▶	GO to **EPC.9.** SERVICE or REPLACE injection pump overflow valve. REFER to Shop Manual, Section 25-02. REPEAT **EPC.8A.** SERVICE or REPLACE fuel return line. REFER to Shop Manual, Section 25-50. REPEAT **EPC.8G.**
EPC.9 CHECK STATIC TIMING • Check injection pump static timing as outlined in this Section.	(OK) ▶ (OK) ▶	GO to **EPC.10.** ADJUST static timing as outlined.

Engine Performance Diagnosis	Pinpoint Test	EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.10 CHECK INJECTOR NOZZLES/LINES • Check injector nozzle lines for damage or restriction. • Remove injector nozzles. Refer to Shop Manual, Section 25-02. • Test injector nozzles as outlined.	(OK) ▶ (OK) ▶	GO to **EPC.11A.** REPLACE damaged lines. REFER to Shop Manual, Section 25-02. CLEAN or REPLACE injector nozzles as outlined. REFER to Shop Manual, Section 25-02 for Installation. If performance problem still exists, GO to **EPC.11A.**
EPC.11A CHECK COMPRESSION • Check engine compression as outlined.	(OK) ▶ (OK) ▶	GO to **EPC.11B.** SERVICE engine as necessary. REFER to Shop Manual, Section 22-12.
EPC.11B CHECK CRANKCASE PRESSURE • Remove engine oil dipstick and connect adapter 11949 and Rotunda Pressure Test Kit 014-00702 or equivalent. Refer to Figure 18. • Run engine at 2600 rpm with no load, transmission in PARK or NEUTRAL. • Record pressure reading. • Pressure should be a maximum of 0.7 kPa (3 in H_2O) at 2600 rpm.	(OK) ▶ (OK) ▶	GO to **EPC.12A.** GO to Pinpoint Test **E3** or **M6.** Problem is internal to engine. REFER to Shop Manual, Section 22-11.

Engine Performance Diagnosis | Pinpoint Test | EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.12A CHECK TURBINE/COMPRESSOR WHEELS • Visually check turbocharger turbine and compressor wheels for evidence of contact with turbocharger housing or foreign object damage (bent, broken, chipped or eroded blades).	(OK) ▶ (OK) ▶	GO to **EPC.12B.** DETERMINE source of foreign object ingestion. SERVICE or REPLACE turbocharger and/or other components as necessary. REFER to Shop Manual, Section 25-45.
EPC.12B OIL LEAKAGE-EXHAUST PIPE ELBOW/TURBINE HOUSING • Check for oil deposits at connection between exhaust pipe elbow and turbine outlet. **NOTE: Slight amount of oil seepage is normal after extended periods of idling.**	(OK) ▶ (OK) ▶	GO to **EPC.12C.** REPLACE turbocharger. REFER to Shop Manual, Section 25-45.
EPC.12C OIL LEAKAGE-EXHAUST MANIFOLD/TURBINE HOUSING • Check for oil deposits in exhaust manifold between engine exhaust ports and turbine inlet.	(OK) ▶ (OK) ▶	GO to **EPC.12D.** Problem is internal to engine. REFER to Shop Manual, Section 22-12.
EPC.12D OIL LEAKAGE-INTAKE MANIFOLD/ COMPRESSOR HOUSING • Check for oil deposits in intake manifold and compressor housing. **NOTE: Slight amount of seepage is normal after extended periods of idling.**	(OK) ▶ (OK) ▶	GO to **EPC.12E.** CHECK for intake restriction. GO to **EPC.7.** If intake restriction is OK, GO to **EPC.12G.**

Engine Performance Diagnosis	Pinpoint Test	EPC

TEST STEP	RESULT ▶	ACTION TO TAKE
EPC.12E OIL LEAKAGE-OIL SUPPLY/DRAIN PIPE FLANGES		
• Check for oil leaks at oil supply and drain pipe flanges. • Check oil drain pipe for clogging.	(OK) ▶ (OK) ▶	GO to **EPC.12F.** SERVICE or REPLACE oil drain pipe. TIGHTEN attaching bolts to specification. REPLACE gaskets as necessary. REFER to Shop Manual, Section 25-45.
EPC.12F CHECK FOR AIR LEAKS		
• Visually check for air and exhaust leaks at following: 1. Exhaust manifold to engine.[a] 2. Exhaust manifold to turbine inlet.[a b] 3. Turbine housing to center housing.[a b] 4. Turbine outlet to exhaust pipe elbow.[a] 5. Compressor housing to center housing. 6. Compressor outlet to intake manifold.[b c] 7. Compressor inlet to air cleaner duct. 8. Air cleaner.	(OK) ▶ (OK) ▶	GO to **EPC.12G.** SERVICE or REPLACE leaking component(s). REFER to Shop Manual, Sections 22-12, 25-41 and/or 25-45.
EPC.12G CHECK BEARING PLAY		
• Check turbocharger axial and radial bearing play. Refer to Shop Manual, Section 25-45.	(OK) ▶ (OK) ▶	REPLACE fuel injection pump. REFER to Shop Manual, Section 25-02. ADJUST static timing as outlined. REPLACE turbocharger. REFER to Shop Manual, Section 25-45.

[a] Possible whistle or scream noise varying with engine speed.

[b] May show signs of carbon buildup.

[c] May cause low boost.

Injector Nozzle Testing

Where ideal conditions of good combustion, specified engine temperature control, and clean quality fuel prevail, nozzles require little attention. Nozzle trouble is usually indicated by one or more of the following symptoms:

- Exhaust smoke (black)
- Low power
- Missing under load
- Rough warm idle
- Excessive fuel consumption
- Engine will not rev up
- Combustion knock
- Overheating

On Vehicle Testing

When faulty nozzle operation is suspected on an engine that is misfiring or puffing black smoke, a simple test can be made to determine the problem nozzle(s).

1. Run the engine at the rpm which makes the problem most pronounced.
2. Momentarily loosen the high-pressure fuel inlet line connection on one nozzle assembly. Listen to see if it has an effect on the engine and look to see if the smoke level changes. Then tighten the connection to specification.

   WARNING: BE EXTREMELY CAREFUL TO PREVENT BEING STRUCK BY DIESEL FUEL UNDER PRESSURE. DIESEL FUEL AT INJECTION PRESSURE CAN EASILY PIERCE THE SKIN, POSSIBLY CAUSING SEVERE INJURY FROM BLOOD POISONING. IF STRUCK BY PRESSURIZED DIESEL FUEL, SEEK MEDICAL HELP IMMEDIATELY.
3. Check each nozzle in the same manner.
4. If one nozzle is found where loosening makes no difference in performance or it causes the smoke level to change, that nozzle should be bench tested.

On Bench Testing

After removing the nozzle(s) from the engine, the injector nozzle pressure test should be performed. This test will provide valuable information regarding the condition of the nozzle(s). A clean workbench, clean washing fluid containers, clean tools and clean hands are essential to produce satisfactory results. Injector nozzles which are not functioning properly, have improper opening pressure, leak down, or spray patterns, should be replaced. Replacement injectors should be tested before assembly to engine.

Injector Nozzle Testing

Figure 23 shows the Rotunda Injector Nozzle Tester 014-00300, used for pressure testing the injector nozzles. Use the following procedure for testing the injector nozzles.

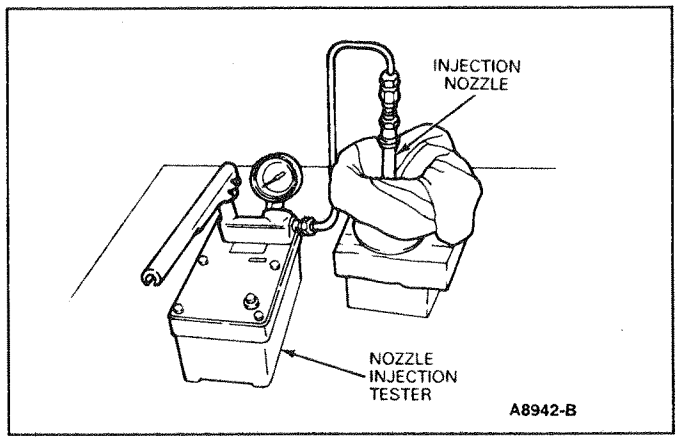


Figure 23 Injector Nozzle Tester

1. Prepare the stand for making tests. Place a container partly filled with shop cloths beneath the outlet pipe to catch the spray. Fill the stand reservoir with clean calibration fluid. Open the tester valve slightly and operate the tester handle to expel the air from the tester and outlet pipe. Operate the tester until solid fuel (no air bubbles) flows from the end of the outlet pipe. Close the tester valve.

   NOTE: Test injector nozzles using SAE approved calibration oil 208629, SAE J967D, or ISO 4113 fluid, rather than diesel fuel.

2. Install the proper adapter for testing the 6.6L and 7.8L diesel injectors on the injector nozzle test stand.

3. Connect the nozzle to the test stand. Take care to avoid cross-threading. Tighten connector nut securely with a wrench.

   WARNING: ALWAYS WEAR APPROVED SAFETY GLASSES WHEN OPERATING THE TESTER. VOLATILE LIQUIDS CAN BE EXTREMELY FLAMMABLE WHEN VAPORIZED. AVOID ANY CONDITIONS (SPARKS, OPEN FLAMES, LIT CIGARETTES, ETC.) WHICH MIGHT IGNITE THE FLUID USED DURING THE TEST PROCEDURE. ENSURE THAT THE INJECTOR IS MOUNTED ON THE TESTER SO THAT THE SPRAY IS DIRECTED AWAY FROM THE OPERATOR AND ANY OTHER PERSONS. THE ONLY LIQUID APPROVED FOR USE IN THIS TESTER IS SAE CALIBRATION NO. 208629 OR EQUIVALENT CALIBRATION FLUID (SAE J967D OR ISO 4113).

   WHEN A NOZZLE IS BEING TESTED OR IS IN OPERATION, KEEP HANDS AND OTHER PARTS OF THE BODY AWAY FROM THE SPRAYING NOZZLE. THE LIQUID SPRAY LEAVES THE NOZZLE TIP WITH SUFFICIENT FORCE TO PENETRATE THE SKIN AND CAUSE SERIOUS INJURY. THE NOZZLE TIP SHOULD BE ENCLOSED IN A TRANSPARENT RECEPTACLE IF AVAILABLE.

Injector Nozzle Testing

4. Bleed air from the nozzle. Open the tester valve and operate tester handle for 8 to 10 quick strokes to expel (bleed) air from the injector nozzle. Test fluid should spray from the spray holes in the nozzle tip. If the nozzle is blocked or the needle jammed, replace the injector. Replacement injectors should be tested before assembly to the engine.

   NOTE: Conduct opening pressure, tip leakage and spray pattern tests separately. Do not attempt to evaluate more than one test step or result at a time.

5. **Check nozzle opening pressure** by pumping the injector nozzle tester and observing the pressure at which the needle valve lifts and fuel is ejected from the nozzle tip. Opening pressure must meet specifications or nozzle should be replaced.

6. **Check the nozzle for tip leakage.** Wipe the nozzle tip dry and operate the tester to maintain pressure at 2068 kPa (300 psi) below opening pressure of the nozzle. Hold the pressure for 10 seconds. If droplets form on the tip of the injector and fall off, the nozzle should be replaced. Wetness on the tip of the injector is acceptable.

   NOTE: Do not wipe the tip with fingers, because it tends to draw a small amount of fluid out of the injector giving a false impression of a leak. Use a clean cloth or blotting paper.

7. **Check the spray pattern of the nozzle** (Figure 24) by pumping the tester handle rapidly and observing the spray pattern coming from the orifices. Spray must come from each orifice and be similar in size and consistency. The spray should be well atomized and cone shaped as it comes from the injector nozzle. Injectors showing poor spray patterns should be replaced.

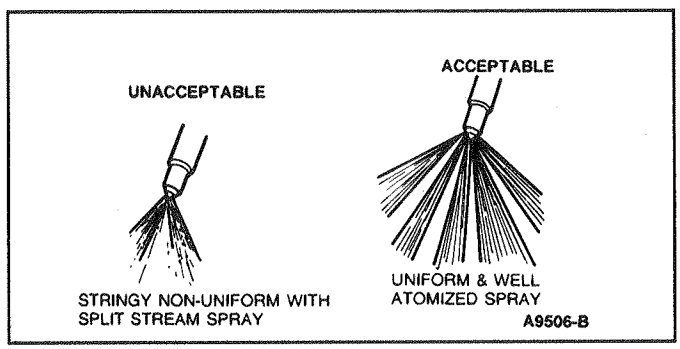


Figure 24 Spray Patterns

8. If the injector fails any of the tests, overhaul or replace the injector. Refer to Shop Manual, Section 25-02.

Checking Compression

To check compression in the 6.6L and 7.8L engines use the following procedure:

1. Be sure battery performance meets specifications.
2. Clean the engine, especially the area around the injectors.
3. Warm up the engine by operating for a minimum of 30 minutes at 1200 rpm.
4. Stop the engine and remove the high-pressure fuel lines and fuel leak-off line from the engine. Cap all the openings in the fuel injection system and fuel injection pump.
5. Remove the injector nozzle and seat washer from each cylinder. Cap the injector nozzle and line to prevent the entry of dirt into the system. Place the injectors in a rack to prevent damage while they are removed from the engine and to keep them in order.

   CAUTION: If an injector is struck in the cylinder head and will not pull straight out, turn the injector in a clockwise direction to break it loose. If it is turned in a counterclockwise direction there is a chance that the nozzle and holder could unscrew from each other, allowing the internal components to fall out.

   NOTE: The lines should not be capped until residual fuel has been removed from them. Otherwise, when the engine is cranked during the compression test, the fuel remaining in the lines will blow the caps off. To remove the residual fuel, crank the engine after the fuel shutoff solenoid has been disconnected, then cap the lines.
6. Disconnect the electrical connector at the bottom of the fuel shutoff solenoid (Figure 25) and cover with tape. This must be done to shut off the flow of fuel to the engine during cranking.

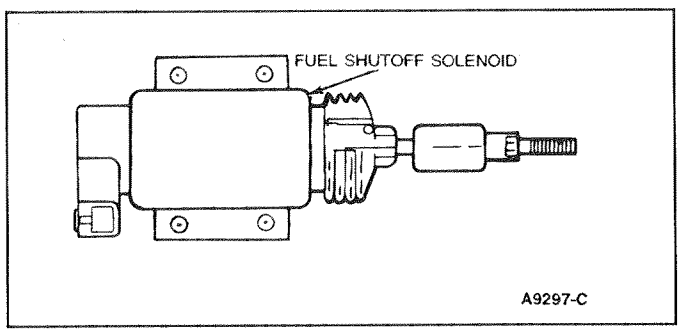


Figure 25 Fuel Shutoff Solenoid Terminals

7. Crank the engine to blow out any loose carbon particles from the injector bores.
8. Install the engine compression tester adapter 12210 into the injector bore of cylinder No. 1, using a new set washer and the injector mounting studs and nuts.
9. Connect Compression Gauge 014-00701 or equivalent and hose to the adapter.
10. Crank the engine (speed must be at least 200 rpm) and observe the gauge reading. Allow about 6-8 puffs per cylinder.
11. Repeat Steps 7 through 10 for each cylinder.
12. After completing the compression check, install the injector nozzles using new seat washers. Connect the injector lines back on the engine and attach the connector at the bottom of the fuel shutoff solenoid.

Checking Compression

Test Conclusions

1. Minimum compression must be at least 1896 kPa (275 psi). Also, compression readings from the lowest cylinder must be at least 75 percent of the highest.
2. If any of the readings do not meet the above specifications, this indicates that there is leakage at the cylinder head gasket, piston rings or valves.

   NOTE: To determine if the rings or valves are at fault, squirt the equivalent of a tablespoon of heavy oil into the combustion chamber, then crank the engine to distribute the oil and repeat the compression test. The oil will temporarily seal leakage past the rings. During a compression test, if the pressure fails to climb steadily and remains the same during the first two succeeding strokes, or fails to climb during the entire test, suspect a sticking valve.
3. A low, even compression in two adjacent cylinders may indicate a cylinder head gasket leak. Check this before blaming the rings or valves.