SECTION 6

ENGINE

CONTENTS

GENERAL INFORMATION

Following are brief outlines of the information contained in SECTION 6. Use them as a guide to help locate information quickly.

SECTION 6A ENGINE, DRIVEABILITY, AND DIAGNOSIS

This section contains information common to all engines, including:

- Use of gasket sealers
- Diagnosis (for engine mechanical)
- Compression check procedure
- Oil leak diagnosis

SECTIONS 6A3 THROUGH 6A6 4.3L V6, 5.0L AND 5.7L V8, 7.4L V8, AND 6.5L DIESEL

These sections contain information for on-vehicle servicing of the basic engine, such as manifold, cylinder head, camshaft, and piston replacement.

Detailed repair information on components such as oil pump, cylinder head, etc. is not included. Refer to the Light Duty Truck Unit Repair Manual for this information.

SECTION 6B1 ENGINE COOLING

This section has information on cooling system components, including:

- Diagnosis
- Coolant Pump
- Fan and Fan Clutch
- Auxiliary Fan
- Belt
- Thermostat

SECTION 6B2 RADIATOR

This section contains information on radiators and shrouds, including aluminum radiator repair procedures.

SECTION 6C
FUEL SYSTEM

This section contains information on diesel engine fuel system components, including:

- Accelerator controls
- Fuel tanks
- Air cleaners

For information on gasoline engine fuel systems and diesel engines with electronic engine controls (ECM). Refer to the Driveability, Emissions, and Electrical Diagnosis Manual.

SECTION 6C2
DIESEL FUEL INJECTION

This section contains information on the mechanical fuel injection system used on some diesel engines, including:

- Timing adjustment and other adjustment procedures.
- Injection nozzle replacement and testing.
- Injection pump replacement and repairs.

For information on diesel engines with electronically controlled fuel injection systems, refer to the Driveability, Emissions, and Electrical Diagnosis Manual.

SECTION 6D
ENGINE ELECTRICAL

This section contains information on electrical components associated with engine operation, including:

- Spark plug wires
- Battery
- Glow plug system
- Starters
- Generators
- Distributors
- Engine Wiring

On-vehicle service procedures are given. For overhaul information, refer to the Light Duty Truck Unit Repair Manual.

SECTION 6E
EMISSIONS

For information on throttle body fuel injection (TBI) emissions systems, refer to the Driveability, Emissions, and Electrical Diagnosis Manual.

SECTION 6E2
DIESEL EMISSIONS

This section contains information on the emissions systems of diesel engines with mechanical injection pumps, including component repair. Driveability diagnosis can be found in SECTION 6A.

For diesel engines with electronically controlled injection pumps, refer to the Driveability, Emissions, and Electrical Diagnosis Manual.

SECTION 6F
EXHAUST SYSTEM

This section contains information on the exhaust system, including component replacement.

SECTION 6H
VACUUM PUMPS

This section contains information on vacuum pumps, including replacement procedures and diagnosis.

SECTION 6J
TURBOCHARGER

This section contains information on the diesel engine turbocharger, including diagnosis and component replacement.

For information on the diesel engine turbochargers with electronic controls (if equipped), refer to the Driveability, Emissions, and Electrical Diagnosis Manual.

SECTION 6A

ENGINE, DRIVEABILITY, AND DIAGNOSIS

NOTICE: Always use the correct fastener in the correct location. Use the correct fastener part number to replace a fastener. If the correct fastener part number is not available, a fastener of equal size and strength may be used. Do not use a fastener that is stronger when the correct fastener part number is not available in the following applications:

- *Some bolts are designed to permanently stretch, and if a stronger fastener is used, the part will not be tightened correctly. These permanently stretching bolts will be called out. The correct part number fasteners must be used to replace this type of fastener because there is no available equivalent.*
- *Other bolts are designed to break if over tightened to prevent part damage. If a stronger fastener is used part damage may occur.*

Fasteners that need to be replaced when removed will be called out. Fasteners that require thread lockers or thread sealant will be called out. The correct tightening specification and sequence must be used when installing fasteners. Part or system damage may occur if the above instructions are not followed.

CONTENTS

GENERAL INFORMATION

STATEMENT ON CLEANLINESS AND CARE

- An engine is a combination of many machined, honed, polished, and lapped surfaces with very fine tolerances.
- Whenever valve train components, cylinder head, cylinder block, crankshaft, or connecting rod components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.
- Any time the air cleaner or TBI unit is removed, the intake opening must be covered. If a diesel engine is being serviced, the recommended cover set (J 29664) should be used. This will protect against the entrance of foreign material which could follow the intake passage into the cylinder and cause extensive damage when the engine is started.
- When any internal engine parts are serviced, care and cleanliness are important. Apply a liberal coating of engine oil to friction areas during assembly to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- On diesel engines, whenever the fuel injection pump or lines are removed or disconnected, take care to prevent the entry of dirt into the pump, lines, and injectors. The entry of even a small amount of dirt or other foreign material into the fuel injection system may cause serious damage.
- Keep in mind, while working on the engine, that the 12-volt electrical system is capable of violent and damaging short circuits. When performing any work where electrical terminals could possibly be grounded, disconnect the battery ground cable at the battery.
- Disconnect battery cables before any major work is performed on the engine. Failure to disconnect cables may result in damage to wire harness or other electrical parts.
- Cover or otherwise protect exposed electrical connections to prevent damage from oil and fuel.
- When raising and supporting the engine for any reason, do not use a jack under the oil pan. Due to the small clearance between the oil pan and oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen resulting in a damaged oil pickup unit.

TUNE-UP INFORMATION

All information required to tune up the vehicle's engine is given in the Engine Emission Control Label located in the engine compartment.

Information that can be found on the label includes:

- Engine displacement.
- Timing specifications.
- Spark plug gap.
- Timing adjustment procedures.
- Emission hose routing.

USE OF RTV SEALER AND ANAEROBIC GASKET ELIMINATOR

Two types of sealer are commonly used in engines covered by this manual. These are RTV sealer and anaerobic "gasket eliminator" sealer.

It is important that these sealers be applied properly and in the proper place to prevent oil leaks. THE TWO TYPES OF SEALER ARE NOT INTERCHANGEABLE. Use the sealer recommended in the procedure.

- RTV (room temperature vulcanizing) sealer is used where a non-rigid part is assembled to a rigid part. Common examples are oil pans and rocker arm covers.
- Anaerobic gasket eliminator hardens in the absence of air. This sealer is used where two rigid parts (such as castings) are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using gasket eliminator.

USING RTV SEALER

1. Don't use RTV where extreme temperatures are expected, such as exhaust manifold, head gasket, or where gasket eliminator is specified.
2. When separating components sealed with RTV, use a rubber mallet and "bump" the part sideways to shear the RTV sealer. "Bumping" should be done at bends or reinforced areas to prevent distortion of parts. RTV is weaker in shear (lateral) strength than in tensile (vertical) strength.

NOTICE: Attempting to pry or pull components apart may cause damage to the part.

3. Surfaces to be resealed must be clean and dry. Remove all gasket material from the part using a plastic or wood scraper. Use Loctite brand "Chisel Gasket Remover" (P/N 79040), Permatex brand "Gasket Remover" (P/N 4MA) or equivalent. Follow all safety recommendations and directions that are on the can. Do not use any other method or technique to remove gasket material from a part. Do not use abrasive pads, sand paper, or power tools to clean gasket surfaces. These methods of cleaning can damage the part. Abrasive pads also produce a fine grit that the oil filter can not remove from the oil. This grit is abrasive and has been known to cause internal engine damage.
4. Apply RTV to one of the clean surfaces. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer in any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.
5. Assemble while RTV is still wet (within 3 minutes). Don't wait for RTV to skin over.
6. Tighten bolts to specifications. Don't over-tighten.

USING ANAEROBIC GASKET ELIMINATOR

1. Surfaces to be resealed must be clean and dry. Remove all gasket material from the part using a plastic or wood scraper. Use Loctite brand "Chisel Gasket Remover" (P/N 79040), Permatex brand "Gasket Remover" (P/N 4MA) or equivalent. Follow all safety recommendations and directions that are on the can. Do not use any other method or technique to remove gasket material from a part. Do not use abrasive pads, sand paper, or power tools to clean gasket surfaces. These methods of cleaning can damage the part. Abrasive pads also produce a fine grit that the oil filter can not remove from the oil. This grit is abrasive and has been known to cause internal engine damage.
2. Apply a continuous bead of gasket eliminator to one flange.
3. Spread bead evenly with your finger to get a uniform coating on the complete flange.
4. Assemble parts in the normal manner and tighten fasteners to specifications.

REPLACING ENGINE GASKETS

CAUTION: Composite type gaskets are used in some areas of the engine assembly. These gaskets have a thin metal core. Use caution when removing or handling composite gaskets to help avoid personal injury.

COMPRESSION/CRANKING SPEED TESTS

GASOLINE ENGINE COMPRESSION TEST

1. Disconnect the primary lead from the distributor or ignition coil. Refer to SECTION 6D4.
2. Remove all spark plugs.
3. Block the throttle plate wide open.
4. Be sure the battery is fully charged.
5. Starting with the compression gage at zero, crank the engine through four compression strokes (four "puffs").
6. Perform the compression test at each cylinder and record each reading.
7. If some cylinders have low compression, inject about 15 ml (one tablespoon or about 3 squirts from a pump type oil can) of engine oil into the combustion chamber through the spark plug hole.
8. Minimum compression recorded in any one cylinder should not be less than 70 percent of highest cylinder, and no cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1035 x 70%=725) (150 x 70%=105).

   - Normal—Compression builds up quickly and evenly to specified compression in each cylinder.
   - Piston Rings Leaking—Compression low on first stroke tends to build up on following strokes but does not reach normal. Improves considerably with addition of oil.
   - Valves Leaking—Low on first stroke. Does not tend to build up on following strokes. Does not improve much with addition of oil.
   - If two adjacent cylinders have lower than normal compression, and injecting oil into cylinders does not increase the compression, the cause may be a head gasket leak between the cylinders.

6.5L DIESEL ENGINE COMPRESSION TEST

Tools Required:
J 29664 Cover Set
J 26999 Compression Gage
J 26999-10 Compression Gage Adapter

1. Remove the air cleaner. Cover the opening in the intake manifold with J 29664.
2. Disconnect the pink wire from the fuel solenoid terminal of the injection pump. Refer to figure 1.
3. Disconnect wires from glow plugs then remove all glow plugs.
4. Screw J 26999-10 into the glow plug hole of the cylinder that is being checked. Connect to J 26999 (figure 2).
5. Be sure the batteries are fully charged, and the engine is fully warmed up (engine oil hot).
6. Crank the engine. Allow six "puffs" per cylinder.
7. Take the compression test at each cylinder and record the readings.

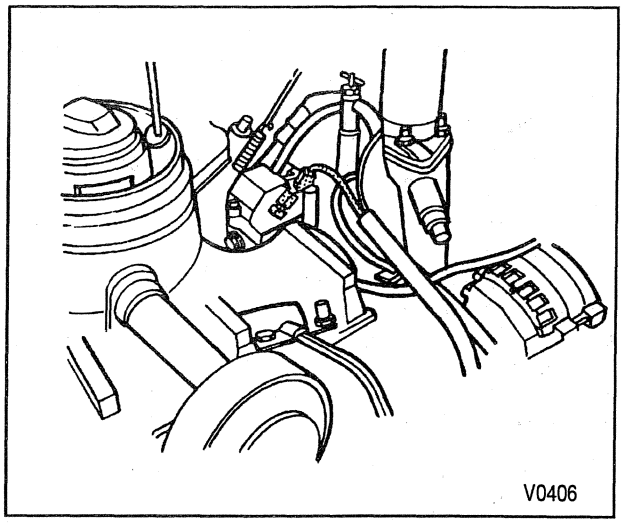


Figure 1—Fuel Solenoid Wire

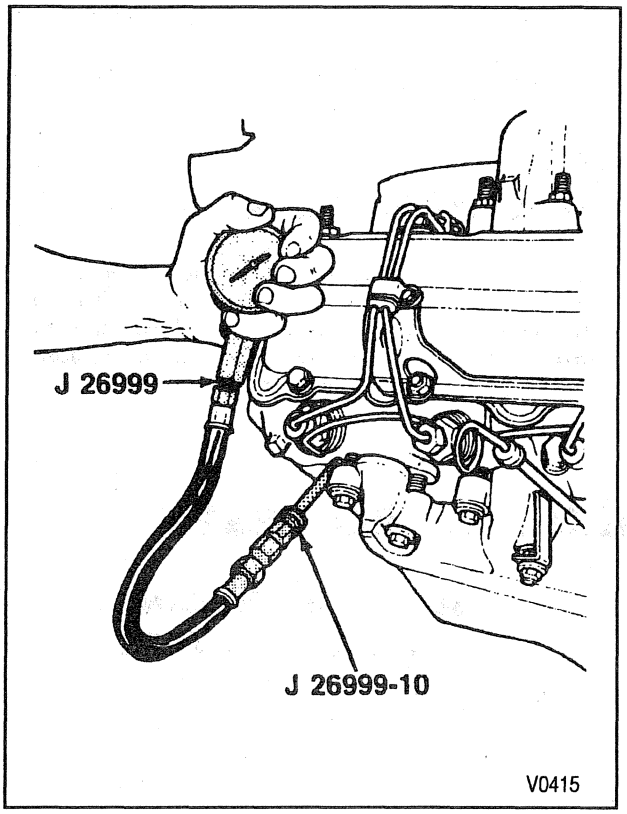


Figure 2—Checking Diesel Engine Compression

NOTICE: Do not add oil to any cylinder during a compression test as extensive engine damage can result.

8. The lowest reading cylinder should not be less than 80 percent of the highest reading cylinder. No cylinder should read less than 2625 kPa (380 psi).
   - Normal: Compression builds up quickly and evenly to specified compression on each cylinder. Reading should be in the 2625-2760 kPa (380-400 psi) range.
   - Leaking: Compression low on first stroke, tends to build up on following strokes, but does not reach normal.

CRANKING SPEED TEST (6.5L DIESEL ENGINE)

Tool Required:
J 26999 Compression Gage
J 26999-10 Compression Gage

Cranking speed is critical for a diesel engine to start, either hot or cold. Some tachometers are not accurate at cranking speed. An alternate method of testing cranking speed or determining the accuracy of a tachometer follows:

1. Screw J 26999-10 into any cylinder and connect J 26999.
2. Disconnect the injection pump fuel solenoid lead on the top of the injection pump. See figure 1.
3. Install the digital tachometer to be tested (if desired).
4. Depress the pressure release valve on the compression gage.
5. With aid of an assistant, crank the engine for 2 or 3 seconds to allow the starter to reach full speed. Then, without stopping, count the number of "puffs" at the compression gage that occur in the next 10 seconds. Multiply the number of "puffs" in the 10 second period by 12 and the resulting number will be the engine speed.
   Example:
   10 seconds= 1/6 of a minute
   1 puff= Engine speed of 2
   Engine speed= No. of puffs x 2 x 6 or
   Engine speed= No. of puffs x 12

Minimum cranking speed on the 6.5L diesel engine is 100 cold and 180 hot. The actual cranking speed needed will vary depending on the condition of the engine (compression) and nozzles.

CAMSHAFT GEAR TIMING TEST

This procedure is a test for proper camshaft gear timing without removing the front cover of the engine.

Important

The following test will not work with the rocker arms on the heads because the valve spring pressure causes the hydraulic lifters to bleed down and not give true lobe lift readings. Also, it is important that the crankshaft is rotated only in a clockwise direction so that the timing chain slack does not effect the position of the maximum lobe lift.

Remove or Disconnect

1. All of the spark plugs (glow plugs on diesels).
2. Valve cover and rocker arms for the number 1 cylinder and mount a dial indicator on the exhaust pushrod to read camshaft exhaust lobe lift.
   - Rotate the crankshaft slowly clockwise until the dial indicator shows maximum exhaust lobe lift.
   - Place a chalk mark on the torsional damper (harmonic balancer) next to the timing tab.
   - Reposition the dial indicator over the intake pushrod and slowly rotate the crankshaft clockwise until maximum lobe lift is obtained.
   - Place a second chalk mark on the torsional damper (harmonic balancer) next to the timing tab.

- Measure the distance from each of the chalk marks to the factory timing groove in the torsional damper (harmonic balancer). If the camshaft gear is properly indexed (positioned) to the crankshaft gear, the distance of each chalk mark to the factory gear timing groove (TDC) will be roughly the same. If the gears are out of position by one tooth or more, the distance from the chalk marks to the (TDC) mark will differ by roughly 50.8 mm (2 inches) or more.

DIAGNOSIS CHARTS

DIESEL ENGINE DIAGNOSIS

The diesel engine diagnosis charts cover the areas of mechanical/maintenance, electrical/emissions, and air system (figures 3, 4, 5, and 6).

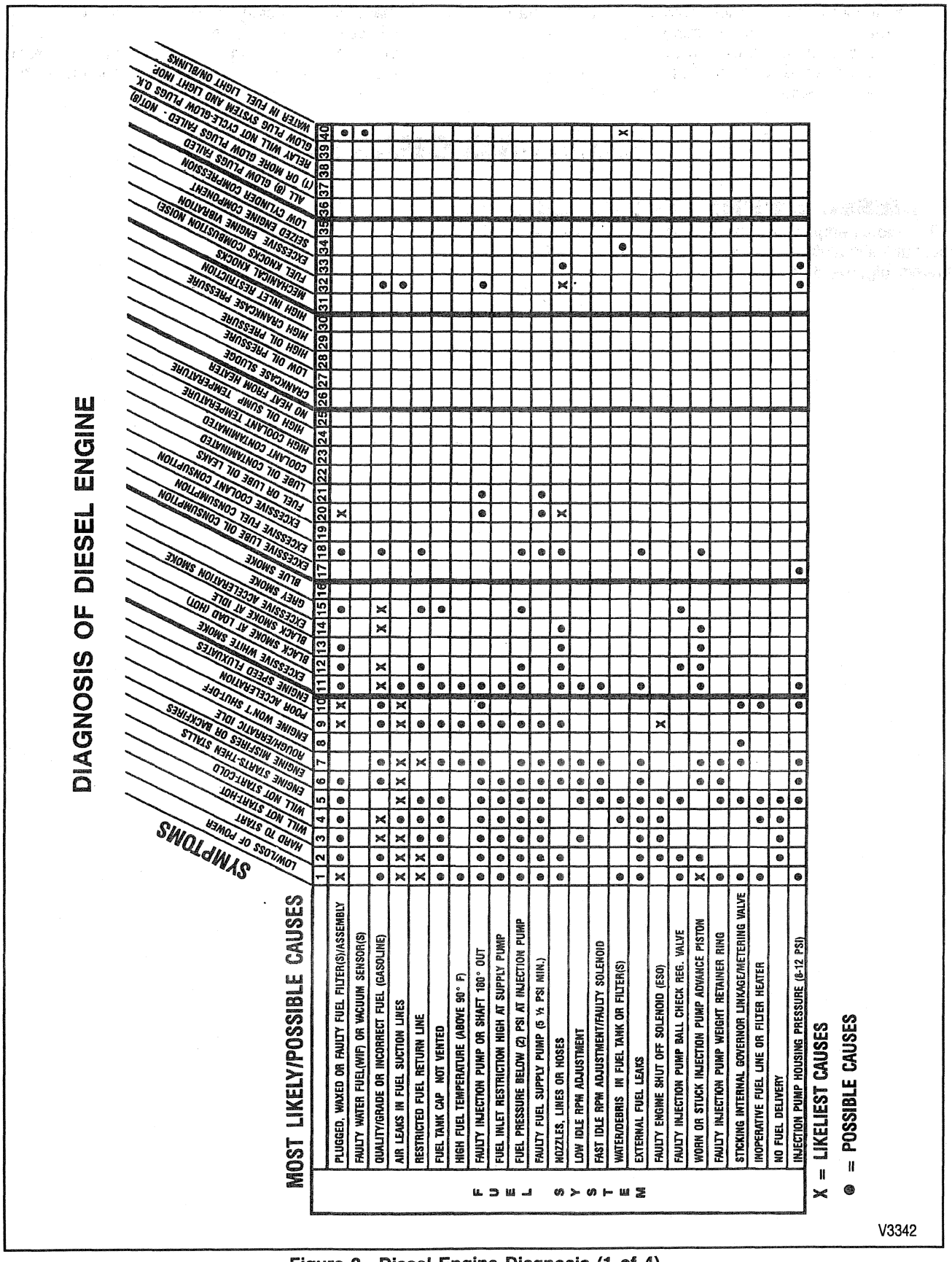


Figure 3—Diesel Engine Diagnosis (1 of 4)

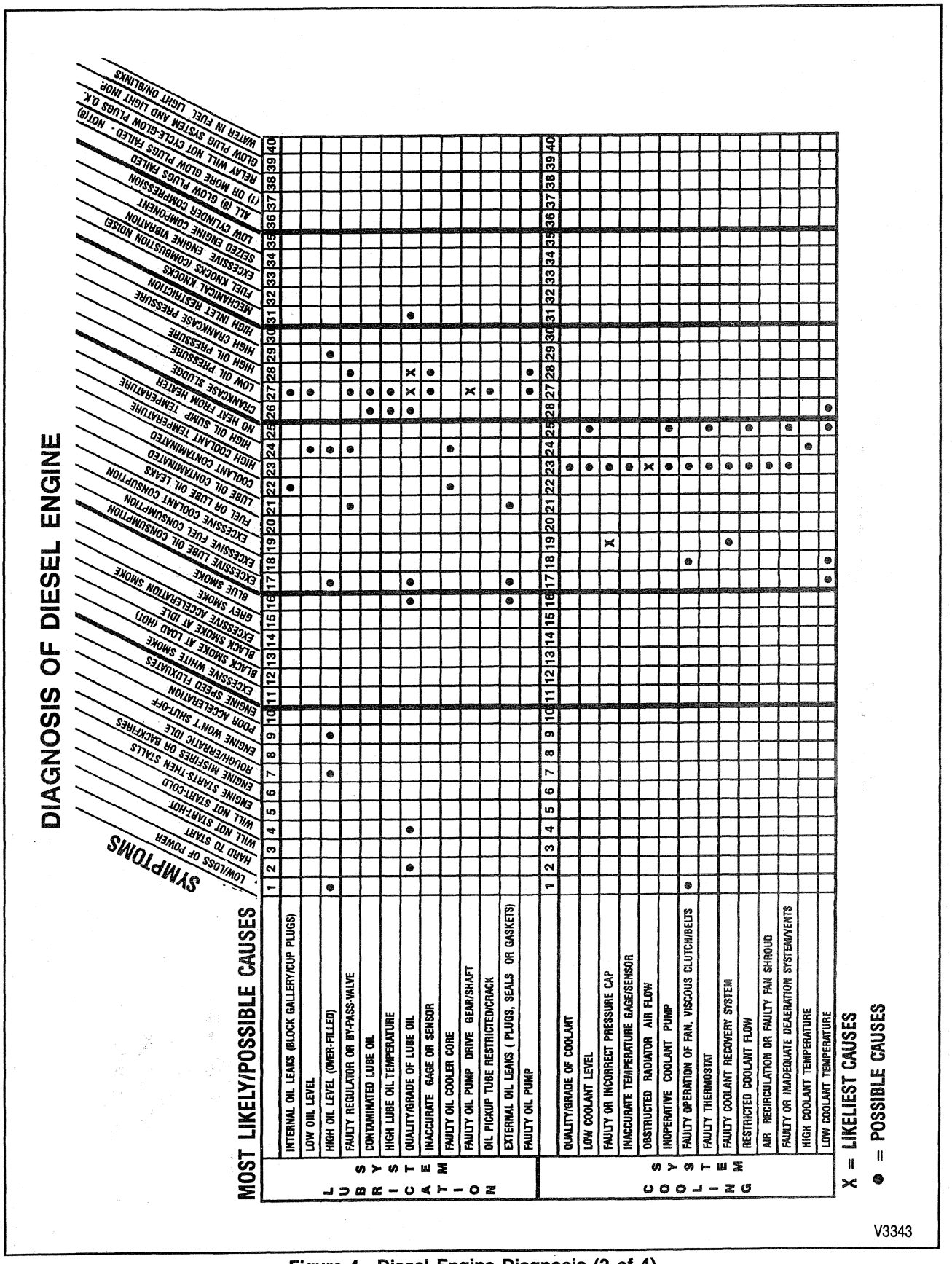


Figure 4—Diesel Engine Diagnosis (2 of 4)

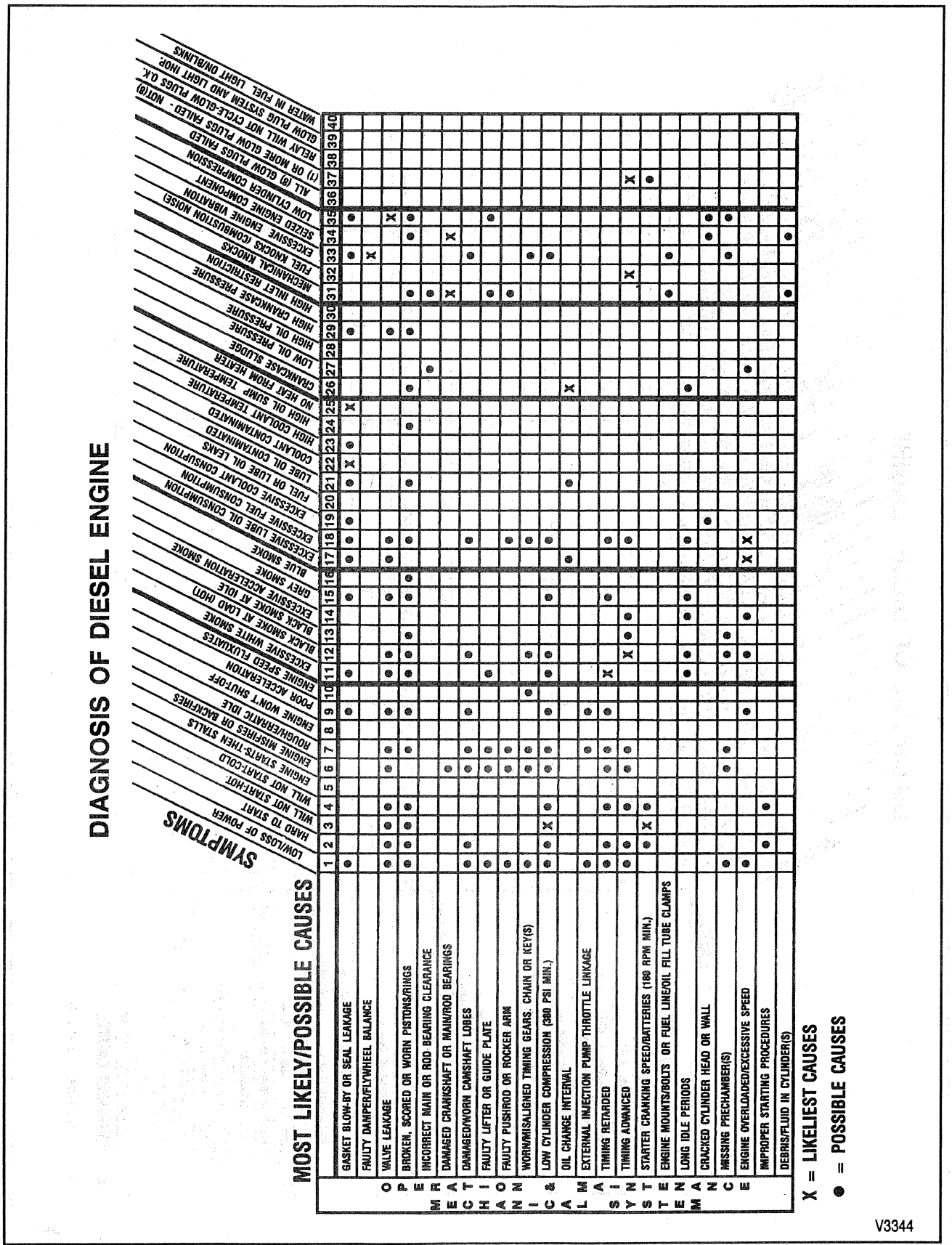
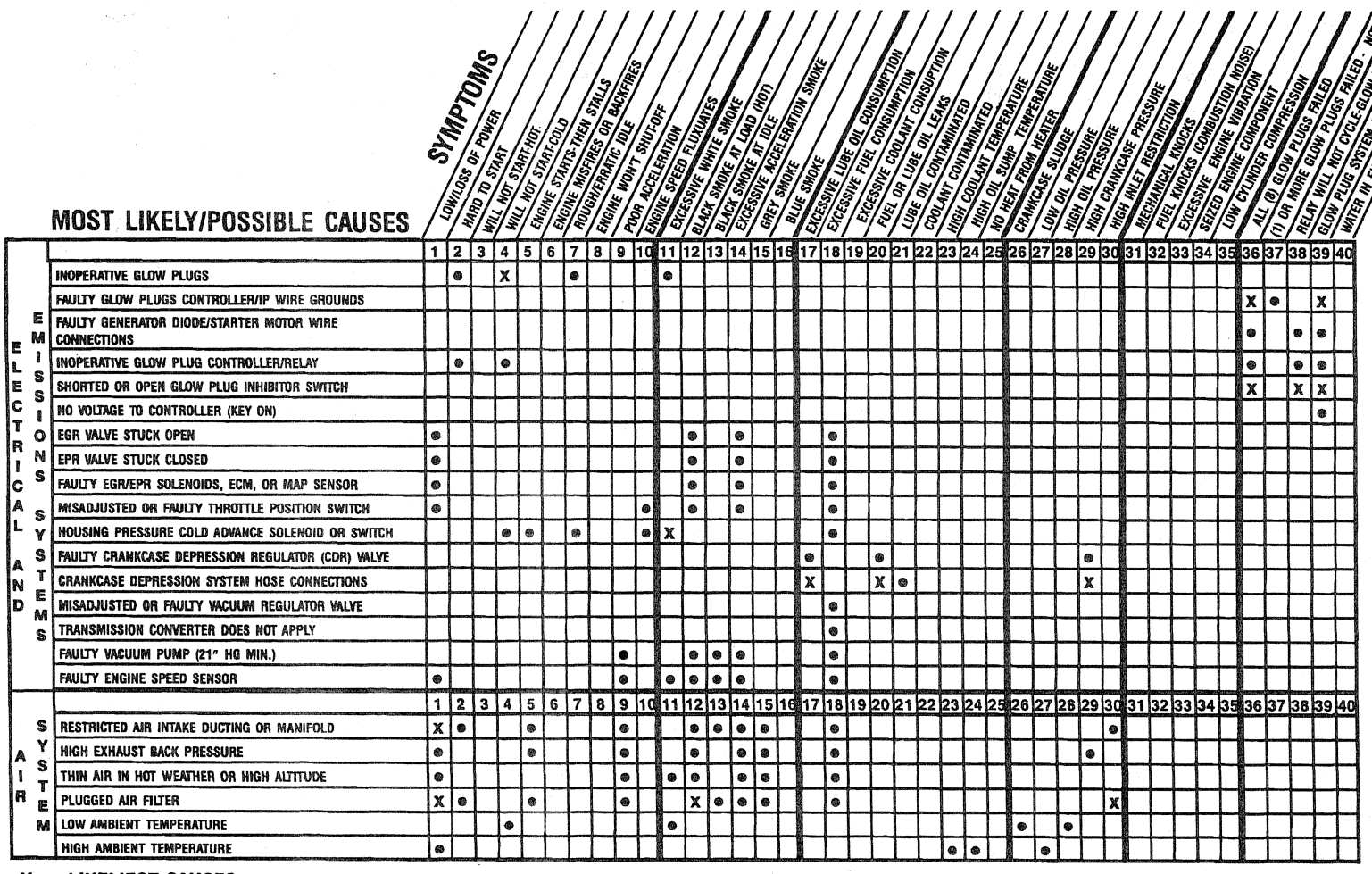


Figure 5—Diesel Engine Diagnosis (3 of 4)

DIAGNOSIS OF DIESEL ENGINE



X = LIKELIEST CAUSES

● = POSSIBLE CAUSES

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Figure 6—Diesel Engine Diagnosis (4 of 4)

DIAGNOSIS OF "SERVICE FUEL FILTER" LIGHT

PROBLEM	POSSIBLE CAUSE	CORRECTION
Intermittent Light	Water in fuel filter.	Drain water from the fuel filter.
Light Stays On With Engine Running (Temperature Above Freezing)	Fuel filter is clogged or contains water.	Drain the fuel filter. If no water is drained and the light stays on, replace the filter element.
Light Stays On With Engine Running (Temperature Below Freezing)	Fuel filter is clogged with ice.	Drain the fuel filter. If no water is drained, open the air bleed and check for fuel pressure. Replace the filter element if there is no pressure.
Light Comes On At High Speed Or During Heavy Acceleration	Plugged fuel filter.	Replace the filter element.
Light Stays On Continuously And Engine Stalls And Will Not Restart (After Initial Start-Up)	Fuel filter or lines plugged.	Replace the filter element or check the lines.
Light Stays On Continuously And Engine Stalls and Will Not Restart (After Refueling)	Large amounts of water pumped into the tank.	Purge the fuel tank.
		D0250

DIAGNOSIS OF NOISES

PROBLEM	POSSIBLE CAUSE	CORRECTION
High-Pitched Whine During Cranking (Before Engine Fires) But Engine Cranks And Fires Normally	Distance too great between starter pinion and flywheel.	Remove shims at the starter mount. Refer to SECTION 6D2.
High-Pitched Whine After The Engine Fires As Key Is Being Released. The Engine Cranks And Fires Normally. This Complaint Is Often Diagnosed As "Starter Hang-In" Or "Solenoid Weak".	Distance too small between starter pinion and flywheel. Flywheel runout contributes to the intermittent nature of the problem.	Add shims at the starter mount. Refer to SECTION 6D2.
A Loud "Whoop" After The Engine Fires But While The Starter Is Still Held Engaged. Sounds Like A Siren If The Engine Is Revved While The Starter Is Engaged.	Usually due to a worn starter motor clutch.	Remove the starter motor and check the starter clutch. Refer to the Light Duty Truck Unit Repair Manual.

DIAGNOSIS OF NOISES (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
A "Rumble", "Growl", Or (In Severe Cases) A "Knock" As The Starter Is Coasting Down To A Stop After Starting The Engine	Usually due to a bent or unbalanced starter armature.	Remove the starter motor and check the armature. Refer to the Light Duty Truck Unit Repair Manual.
Engine Noisy On Initial Start Up But Only Lasts A Few Seconds	1. Hydraulic lifter bleed down. This condition is normal. Oil drains from the lifters, which are holding the valves open, when the engine is not running. It will take a few seconds for the lifter to fill after the engine is started. 2. Improper oil viscosity.	1. None needed. 2. Install proper oil viscosity for expected temperatures. Refer to Owner's Manual.
Intermittently Noisy On Idle Only, Disappearing When Engine Speed Is Increased.	1. Dirt in hydraulic lifter. 2. Pitted or damaged lifter check ball.	1. Replace the hydraulic lifter. 2. Replace the hydraulic lifter.
Engine Knocks Cold And Continues For Two To Three Minutes. Knock Increases With Torque	1. Flywheel contacting splash shield. 2. Loose or broken torsional damper or drive pulleys. 3. Excessive piston to bore clearance. 4. Bent connecting rod.	1. Reposition splash shield. 2. Tighten or replace as necessary. 3. Replace piston; inspect bore. 4. Replace connecting rod.
Noisy At Idle, Becoming Louder As Engine Speed Is Increased To 1500 RPM	1. This noise is not connected to hydraulic valve lifter malfunction. It becomes most noticeable in the vehicle at 10 to 15 mpg in "L" (Low) range, or 30 to 35 mph in "D" (Drive) range and is best described as a "ticking" sound. At slow idle, it may be entirely gone or appear as a light ticking noise in one or more valves. It is caused by one or more of the following: • Badly worn or scuffed valve tip and rocker arm pad • Excessive valve stem to guide clearance. • Excessive valve seat runout. • Off-square valve spring. • Excessive valve face runout. • Valve spring damper clicking on rotator. 2. Off-square valve spring. Occasionally this noise can be eliminated by rotating the valve spring and valve. Crank engine until noisy valve is off its seat. Rotate spring. This will rotate valve. Repeat until valve is quiet. If correction is obtained, Check for off-square valve spring.	1. Repair as necessary. 2. If the valve spring is more than 1.6 mm (1/16 inch) off-square, it should be replaced.

DIAGNOSIS OF NOISES (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Noisy At Slow Idle Or With Hot Oil; Quiet At Higher Engine Speeds Or with Cold Oil	High hydraulic lifter leak down rate.	Replace the hydraulic lifter.
Engine Knocks At Idle Hot	1. Loose or worn drive belts. 2. Air conditioning compressor or generator bearing. 3. Valve train. 4. Improper oil viscosity. 5. Excessive piston pin clearance. 6. Connecting rod alignment. 7. Insufficient piston to bore clearance. (Cold engine piston knock usually disappears when the cylinder's spark plug wire is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.) 8. Loose torsional damper.	1. Tension and/or replace as necessary. 2. Replace as necessary. 3. Refer to "Valve Train Noise" in this chart. 4. Install proper oil viscosity for expected temperatures. Refer to Owner's Manual. 5. Install new piston, pin and/or connecting rod as needed. 6. Check and replace rods as necessary. 7. Hone cylinder and fit new piston, if required. 8. Torque damper or replace worn parts.
Noisy At High Vehicle Speeds, Quiet At Low Speeds	1. High oil level—Oil level above the "Full" mark allows crankshaft counterweights to churn the oil into foam. When foam is pumped into the lifters, they will become noisy since a solid column of oil is required for proper operation. 2. Low oil level—Oil level below the "Add" mark allows the oil pump to pump air at high speeds, which results in noisy lifters. 3. Oil pan bent against oil pump pickup screen. 4. Oil pump pickup screen bent or loose.	1. Drain oil to proper level. 2. Add oil as needed. 3. Repair. 4. Repair.
Noisy Regardless Of Engine Speed	1. Incorrect valve adjustment (excessive lash) (engines with adjustable valve lash.) 2. Excessive valve lash. Check for valve lash by turning the engine so that the piston in that cylinder is on TDC of the firing stroke. If valve lash is present, the pushrod can be freely moved up and down a certain amount with the rocker arm held against the valve. Excessive lash can be caused by: a. Worn pushrod upper end ball. b. Bent pushrod. c. Improper lubricaton of the pushrod. d. Loose or damaged rocker arm. e. If pushrod and rocker arm are OK, trouble in the hydraulic lifter is indicated.	1. Adjust as specified. 2. Repair engine as needed. a. Replace pushrod and rocker arm. b. Replace pushrod. c. Replace pushrod and rocker arm. Check lubrication system feed to the pushrod. d. Replace rocker arm. e. Replace hydraulic lifter.

DIAGNOSIS OF NOISES (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Has Light Knock Hot In Light Load Conditions	1. Faulty Ignition Control or Knock Sensor Circuit system. 2. Improper timing. 3. Poor quality fuel. 4. EGR valve malfunction. 5. Loose torque converter bolts. 6. Exhaust leak at manifold. 7. Excessive rod bearing clearance.	1. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 2. Adjust to specifications. 3. Use fuel of recommended grade. 4. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 5. Tighten bolts. 6. Tighten bolts and/or replace gaskets. 7. Replace bearings as necessary.
Engine Has Heavy Knock Hot With Torque Applied	1. Broken balancer or pulley hub. 2. Loose torque converter bolts. 3. Accessory belts too tight or nicked. 4. Exhaust system touching vehicle. 5. Flywheel cracked or loose flywheel rivets. 6. Excessive main bearing clearance. 7. Excessive rod bearing clearance.	1. Replace parts as necessary. 2. Tighten bolts. 3. Replace and/or tension to specs. as necessary. 4. Reposition as necessary. 5. Replace flywheel. 6. Repair as necessary. 7. Repair as necessary.
Valve Train Noise	1. Low oil pressure. 2. Loose rocker arm attachments. 3. Worn rocker arm and/or pushrod. 4. Broken valve spring. 5. Sticking valves. 6. Lifters worn, dirty, or faulty. 7. Camshaft worn or faulty. 8. Worn valve guides.	1. Repair as necessary. (Refer to diagnosis for "Low Oil Pressure" in previous chart). 2. Inspect as necessary. 3. Replace as necessary. 4. Replace spring. 5. Free valves. 6. Refer to other hydraulic lifter-related causes and corrections in this chart. 7. Replace camshaft. 8. Repair as necessary.
Vibrating Or Rattling From Exhaust System	Loose and/or misaligned exhaust components.	Align, then tighten connections. Check for damaged hangers or mounting brackets and clamps.
Exhaust Leakage And/Or Noise	1. Leakage at exhaust component joints and couplings. 2. Improperly installed or misaligned exhaust system. 3. Exhaust manifold cracked or broken. 4. Leak between exhaust manifold or cylinder head. 5. Damaged or worn exhaust seals or packing. 6. Burned or rusted out exhaust pipe heat tube extension. 7. Burned or rusted out exhaust pipe. 8. Burned or blown out muffler. 9. Broken or loose exhaust clamps and/or brackets.	1. Tighten clamps or couplings to specified torque. 2. Align, then tighten connections. 3. Replace the manifold. 4. Tighten the manifold to cylinder head nuts and bolts to specifications. 5. Replace the seals or packings as necessary. 6. Replace the heat tube extensions as required. 7. Replace the exhaust pipe. 8. Replace the muffler assembly. 9. Repair or replace as necessary.

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DIAGNOSIS OF POWER PROBLEMS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Hesitates During Normal Acceleration **Hesitates During Cold Engine Operation**	1. Engine Control Module malfunction. 2. Ignition timing misadjusted.	1. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 2. Adjust timing. Refer to Emission Control Information Label on vehicle.
Engine Has Less Than Normal Power At Normal Acceleration	1. Ignition system malfunction. 2. Ignition timing misadjusted. 3. Plugged air cleaner element. 4. Exhaust system restricted. 5. Engine Control Module malfunction. 6. Transmission malfunction. 7. Fuel filter(s) partially plugged. 8. Faulty fuel pump, or leaking or restricted fuel lines.	1. Check ignition system. Refer to SECTION 6D4. 2. Adjust timing. See Emission Control Information Label on vehicle. 3. Replace element. 4. Check for restrictions. See diagnosis for "Restricted Exhaust System" in this chart. 5. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 6. Refer to SECTION 7. 7. Inspect fuel filter(s). Replace as necessary. 8. Check fuel pump pressure and volume. Replace pump if necessary. Inspect fuel lines for leaks and restrictions.
Less Than Normal Power On Heavy Acceleration Or At High Speed	1. Ignition system malfunction. 2. Ignition timing misadjusted. 3. Plugged air cleaner element. 4. Exhaust system restricted. 5. Engine Control Module malfunction. 6. Transmission malfunction. 7. Fuel filter(s) partially plugged. 8. Faulty fuel pump or leaking or restricted fuel lines.	1. Check ignition system. Refer to SECTION 6D4. 2. Adjust timing. See Emission Control Information Label on vehicle. 3. Replace element. 4. Check for restrictions. See diagnosis for "Restricted Exhaust System" in this chart. 5. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 6. Refer to SECTION 7. 7. Inspect fuel filter(s). Replace as necessary. 8. Check fuel pump pressure and volume. Replace fuel pump if necessary. Inspect fuel lines for leaks and restrictions.
Engine Surges	1. Ignition system malfunction. 2. Exhaust system restricted. 3. Engine Control Module malfunction. 4. Contaminated fuel. 5. Fuel filter(s) partially plugged. 6. Faulty fuel pump or leaking or restricted fuel lines.	1. Check ignition system. Refer to SECTION 6D4. 2. Check for restrictions. Correct as necessary. See diagnosis for "Restricted Exhaust System" in this chart. 3. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 4. Check for water or excessive alcohol in fuel. 5. Inspect fuel filter(s). Replace as necessary. 6. Check fuel pump pressure and volume. Replace pump if necessary. Inspect fuel lines for leaks and restrictions.

DIAGNOSIS OF POWER PROBLEMS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Fuel Starvation	1. Fuel filter(s) plugged. 2. Fuel lines leaking, restricted or misrouted. 3. Faulty fuel pump.	1. Inspect fuel filter(s). Replace as necessary. 2. Repair/replace, clean, or reroute as required. 3. Check fuel pump pressure and volume. Replace pump if necessary.
Restricted Exhaust System	1. "Kinked" exhaust tubing. 2. Restriction inside the muffler. 3. End of tail pipe obstruction. 4. Plugged three way catalytic converter (may result from serious engine malfunction).	1. If possible, repair the damaged condition, otherwise replace the component. 2. If restriction is suspected, remove the muffler and visually check it. Replace muffler if condition is doubtful. 3. Remove the obstruction, or if end is crimped, straighten outlet. 4. Replace the three way catalytic converter.
		D0263

DIAGNOSIS OF STARTING/IDLING/SHUTOFF PROBLEMS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Will Not Turn Over	1. Battery, cranking system, or other electrical problem. 2. Liquid in combustion chamber. 3. Seized engine.	1. Refer to SECTION 6D2. 2. Remove with suction gun. 3. Repair.
Engine Cranks Normally—Will Not Start Or Starts Hard	1. Improper starting procedure used. 2. Ignition system malfunction. 3. Engine loaded with fuel. (Improper starting procedure used). 4. No fuel. 5. Restricted exhaust system. 6. Low compression due to stuck or burned valves, sticking piston rings, blown head gasket, etc. 7. Engine Control Module malfunction.	1. Check with the customer to determine if proper starting procedure, outlined in the Owner's Manual, is used. 2. Check ignition system. Refer to SECTION 6D4. 3. Check with the customer to determine if proper starting procedure, outlined in Owner's Manual, is used. 4. Inspect fuel filter(s) for plugging. Replace as necessary. Check fuel pump pressure and volume. Replace pump if necessary. Inspect fuel lines for leaks and restrictions. 5. Repair. Refer to diagnosis for "Restricted Exhaust system" in "Power Problems" chart. 6. Perform a compression test, as outlined in this section. Repair engine as necessary. 7. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.

DIAGNOSIS OF STARTING/IDLING/SHUTOFF PROBLEMS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Starts—Will Not Keep Running	1. Air leaks at intake manifold gasket. Vacuum hoses disconnected or installed improperly.	1. Use a pressure oil can to spray light oil or kerosene around manifold to head mounting surfaces. If engine RPM changes, torque intake manifold bolts to specification. If necessary, replace the intake manifold gasket(s). Check condition and routing of vacuum hoses. Correct or replace as necessary. Refer to Emission Control Information Label on vehicle for correct routing.
	2. Not enough fuel.	2. Inspect fuel filter(s) for being partially plugged. Replace as necessary. Check fuel pump pressure and volume. Replace pump if necessary. Inspect fuel lines for leaks and restrictions.
	3. Engine Control Module malfunction.	3. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
Engine Idles Abnormally (Too Fast Or Too Slow)	1. Engine Control Module malfunction.	1. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
	2. Throttle linkage or throttle shaft sticking or binding.	2. Check throttle linkage and throttle shaft(s) for smooth and free operation. Clean with suitable solvent. Replace throttle body if necessary.
	3. Air leaks at intake manifold gasket, Vacuum hoses disconnected or improperly installed.	3. Use a pressure oil can to spray light oil or kerosene around manifold to head mounting surfaces. If engine RPM changes, torque intake manifold bolts to specification. If necessary, replace the intake manifold gasket(s). Check condition and routing of vacuum hoses. Correct or replace as necessary. Refer to Emission Control Information Label on vehicle for correct routing.
	4. Restricted air cleaner element.	4. Replace if necessary.
Rough Idle	1. Engine Control Module malfunction.	1. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
	2. Uneven cylinder compression.	2. Perform a compression test, as outlined in this section. Repair engine as necessary.
	3. Bent pushrod or broken valve spring.	3. Repair.
	4. Faulty engine mount.	4. Repair or replace.

DIAGNOSIS OF STARTING/IDLING/SHUTOFF PROBLEMS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
Engine Diesels (After Run) Upon Shut Off	1. Air leaks at intake manifold gasket(s). Vacuum hoses disconnected or improperly installed.	1. Use pressure oil can to spray light oil or kerosene around manifold to head mounting surfaces. If engine RPM changes, torque intake manifold bolts to specification. If necessary, replace the intake manifold gasket(s). Check condition and routing of vacuum hoses. Correct or replace as necessary. Refer to Emission Control Information Label for correct routing.
	2. PCV system malfunctioning.	2. Check PCV system. Clean or replace PCV valves and hoses as necessary.
	3. Ignition timing retarded (causes throttle valve to be opened farther than normal to obtain correct idle speed).	3. Adjust timing. See Emission Control Information Label.
	4. Engine Control Module malfunction.	4. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
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DIAGNOSIS OF POOR FUEL ECONOMY/SMOKE/OIL/ODORS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Poor Gas Mileage *Black Smoke From Tail Pipe	1. Customer driving habits.	1. Run mileage test, with customer driving if possible. Make sure engine has at least 2,000-3,000 miles (3,200-4,800 km) for the "break-in" period.
	2. Wrong speedometer gear.	2. Check odometer against measured mile. Replace speedometer gear if necessary. Refer to SECTION 7.
	3. Low tire pressure or incorrect tire size.	3. Inflate tires to specifications and use correct tire sizes. Refer to label on driver's door.
	4. Transmission malfunction or in wrong gear.	4. Refer to SECTION 7.
	5. Fuel leaks.	5. Inspect fuel tank, fuel lines and fuel pump for any fuel leakage.
	6. Plugged air cleaner element.	6. Replace element.
	7. Ignition system malfunction.	7. Check ignition system. Refer to SECTION 6D4.
	8. Ignition timing misadjusted.	8. Adjust timing. Refer to Emission Control Information Label.
	9. Engine Control Module malfunction.	9. Check operation. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
	10. Air leaks at intake manifold gasket. Vacuum hoses disconnected or improperly installed.	10. Use a pressure oil can to spray light oil or kerosene around manifold to head mounting surfaces. If engine RPM changes, torque intake manifold bolts to specification. If necessary, replace the intake manifold gasket(s). Check condition and routing of vacuum hoses. Correct or replace as necessary. Refer to Emission Control Information Label on vehicle for correct routing.
	11. Engine in need of service	11. Check engine compression.
	12. Restricted exhaust system.	12. Check for restrictions and correct as necessary.
Low Oil Pressure	1. Incorrect or faulty oil pressure switch or sensor.	1. Replace with correct/new switch or sensor.
	2. Incorrect or faulty oil pressure gage.	2. Replace with correct/new gage.
	3. Improper oil viscosity.	3. Replace with proper oil. Refer to Owner's Manual.
	4. Diluted engine oil.	4. Change engine oil and filter. Repair cause of dilution (rich mixture, etc.).
	5. Oil pump worn or dirty.	5. Clean pump and replace worn parts as necessary.
	6. Plugged oil filter.	6. Replace filter and oil.
	7. Oil pickup screen loose or plugged.	7. Clean or replace screen as necessary.
	8. Hole in oil pickup tube.	8. Replace pickup tube.
	9. Excessive bearing clearance.	9. Replace as necessary.
	10. Cracked, porous or plugged oil galleries	10. Repair or replace block.
	11. Oil gallery plugs missing or mis-installed.	11. Install plugs or repair as necessary.
Blue Smoke	Usually caused by oil burning in the combustion chambers.	Refer to diagnosis for "Excessive Oil Loss" in this chart.

DIAGNOSIS OF POOR FUEL ECONOMY/SMOKE/OIL/ODORS (cont'd)

PROBLEM	POSSIBLE CAUSE	CORRECTION
White Smoke	Usually caused by water vapor, which is a normal by-product of combustion. Usually seen on cold days.	None required.
Excessive Oil Loss	1. Improper reading of dipstick. 2. External oil leaks. 3. Improper oil viscosity. 4. Continuous high speed driving and/or severe usage. 5. Crankcase ventilation or PCV system malfunction. 6. Valve guides and/or valve stem seals worn, or seals missing. 7. Piston rings not seated. 8. Broken or worn piston rings. 9. Piston improperly installed.	1. Check oil with vehicle on a level surface and allow adequate drain down time. 2. Tighten bolts and/or replace gaskets and seals as necessary. 3. Use recommended viscosity for prevailing temperature. Refer to Owner's Manual. 4. Continuous high speed operation and/or severe usage will normally cause decreased oil mileage. 5. Check PCV system. Clean or replace PCV valves and hoses as necessary. 6. Ream guides and install oversize service valves and/or new valve stem seals. 7. Allow adequate time for rings to seat. 8. Replace broken or worn rings as necessary. 9. Replace piston or repair as necessary.
Gasoline Odor	1. Fuel feed, fuel return, or vapor return line leaking. 2. Leak in fuel tank. 3. Disconnected or leaking fuel tank vent lines or hoses to canister(s). 4. Purge lines not connected, improperly routed, plugged or pinched. 5. Evaporative Emission Control System carbon canister(s) loaded. 6. Faulty fuel tank fill cap.	1. Repair/replace as required. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 2. Purge tank and repair or replace tank as required. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 3. Connect, repair or replace lines as required. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 4. Connect, clean or reroute lines as required. Refer to Emission Control Information Label on vehicle for correct routing. 5. Compare weight of canister with a new one. Replace if necessary. Refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model. 6. Install new fuel filler cap. Be sure to use a cap designed for gasoline and evaporation systems.

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DIAGNOSIS OF SPARK PLUGS

PROBLEM	POSSIBLE CAUSE	CORRECTION
Brown to Grayish-Tan Deposits And Slight Electrode Wear.	Normal wear.	Clean, regap, reinstall.
Dry, Fluffy Black Carbon Deposits.	Poor ignition system output.	Check the distributor to coil connections, as discussed in SECTION 6D4 or refer to the Driveability, Emissions, and Electrical Diagnosis Manual for this model.
Wet, Oily Deposits With Very Little Electrode Wear.	1. "Break-in" of new or recently overhauled engine. 2. Excessive valve stem to guide clearance. 3. Worn intake valve seals.	1. Degrease, clean, and reinstall the plugs. 2. Refer to specific engine section for procedure. 3. Replace the seals.
Red, Brown, Yellow and White Colored Coatings on Insulator. Engine Misses Intermittently Under Severe Operating Conditions.	By-products of combustion.	Clean, regap, and reinstall. If heavily coated, replace.
Colored Coatings Heavily Deposited on the Portion of the Plug Projecting into the Chamber and on the Side Facing the Intake Valve.	Leaking seals if condition is found in only one or two cylinders.	Check the seals. Replace if necessary. Clean, regap, and reinstall the plugs.
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OIL LEAK DIAGNOSIS

Most oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair. The following procedure may help in locating and repairing most leaks.

FINDING THE LEAK

1. Identify the fluid, determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
2. From what point is the fluid leaking? After running the vehicle at normal operating temperature, park the vehicle over a large sheet of paper. After a few minutes, you should be able to find the approximate loccation of the leak by the drippings on the paper.
3. Visually check around the suspected component. Check around all gasket mating surfaces for leaks. Use a mirror for finding leaks that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam, or spray solvent. Clean the area, then dry the area. Operate the vehicle for several miles at normal operating temperature and varying speeds. After operating the vehicle, visually check the suspected component. If you still cannot find the leak, try using the powder or black light and dye method.

Powder Method

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) on the suspected area.
3. Drive the vehicle under normal operating conditions.
4. Visually inspect the suspected component. You should be able to trace the leak path over the white powder surface to the source.

Black Light and Dye Method

A dye and light kit is available for finding leaks. Refer to the manufacturer's directions when using the kit.

1. Pour specified amount of dye into leaking component.
2. Drive the vehicle under normal operating conditions as directed in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

REPAIRING THE LEAK

Once the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must also be repaired. Before attempting to repair a leak, make sure the following conditions are correct as they may cause a leak.

Gasket Leaks

Check for:

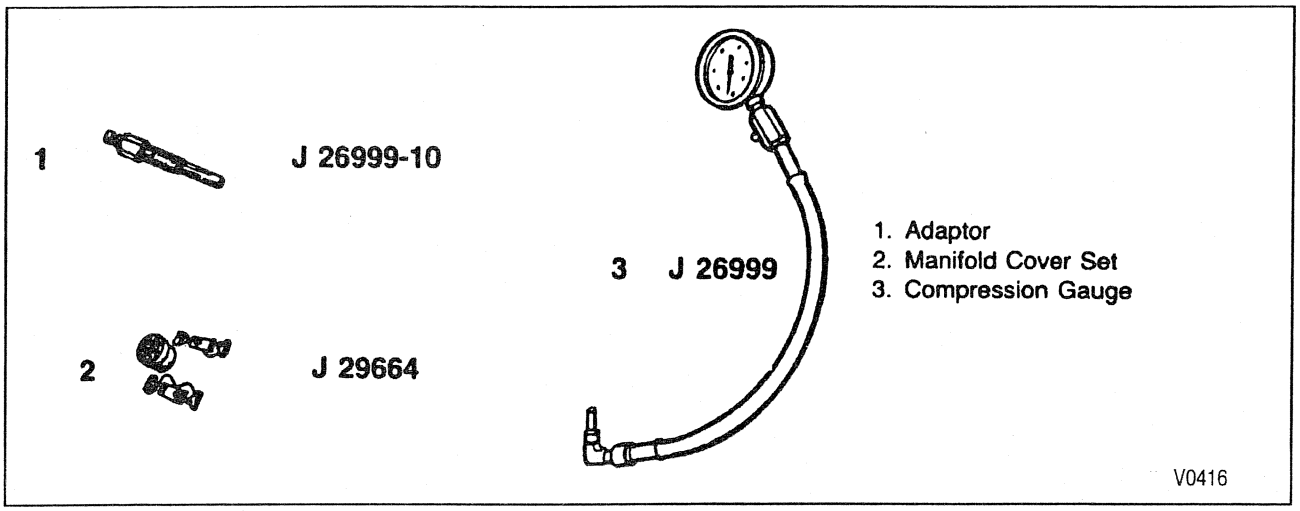
- High fluid level or high oil pressure.
- Plugged ventilation filter or valve.
- Improperly tightened fasteners or dirty/damaged threads.
- Warped flanges or sealing surface.
- Scratches, burrs, or other damage to the sealing surface.
- Damaged or worn gasket.
- Cracking or porosity of the component.
- Improper sealant, or no sealant where required.

Seal Leaks

Check for:

- High fluid level or high oil pressure.
- Plugged ventilation filter, or valve.
- Damaged seal bore (scratched, burred, or nicked).
- Damaged or worn seal.
- Improper installation.
- Cracks in component.
- Shaft surface scratched, nicked, or damaged.
- Loose or worn bearing causing excess seal wear.

SPECIAL TOOLS



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