

ENGINE

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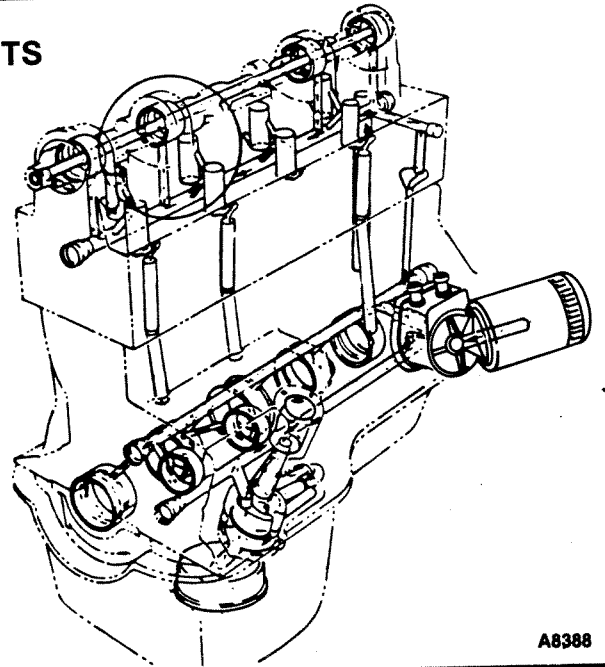
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GENERAL INFORMATION

This section addresses diagnostic procedures on the base engine. Where additional causes could be responsible for a given condition, they will be referred to that section of the manual. The section is divided into two parts.

- Troubleshooting Charts—The engine conditions that are included in this part include engine misfiring, low power, stalling, noises,

smoking, high fuel consumption, etc., or conditions that a driver or operator would recognize as abnormal.

- Diagnostic Procedures—The purpose of the procedures is to confirm the causes of the conditions perceived by the driver/operator or technician.

TROUBLESHOOTING CHARTS

ENGINE CONDITIONS

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Engine will not crank	Hydrastatic (hydraulic) lock in cylinders	Remove spark plugs and rotate engine with a wrench. Spark plug removal is covered in Section 23-01.
	Seized piston(s)	Remove cylinder head and oil pan. Refer to Base Procedures 23 and 26 in Section 21-05. Attempt to rotate engine with a wrench. Look for non-moving piston. Remove piston(s) as necessary.

TROUBLESHOOTING CHARTS

ENGINE CONDITIONS (Continued)

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Engine will not crank (Continued)	Broken crankshaft or connecting rod	Remove oil pan and parts as necessary. Refer to Base Procedure 26 in Section 21-05.
	Starter locking flywheel	Remove starter. Refer to Section 28-01 or 28-02.
	Flywheel damaged	Inspect flywheel. Refer to Base Procedure 28 in Section 21-05.
	Starting system	Refer to Section 28-01.
Engine cranks but will not start	Low compression	Check compression. Refer to Diagnostic Procedures in this section.
	Camshaft out of time	Refer to Base Procedure 2, Section 21-05.
	Ignition system	Refer to Section 23-01.
	Fuel system	Refer to Section 24-01.
Engine starts but fails to stay running	Fuel system	Refer to Section 24-01.
	Idle speed set too low	Refer to Diagnostic Procedures in this section.
	Ignition system	Refer to Section 23-01.
	Exhaust system restricted	Refer to Section 26-01.
	Loose intake manifold or damaged gasket	Perform intake manifold Vacuum Test. Refer to Diagnostic Procedures in this section. Removal and Installation of manifold is covered in Section 24-29.
Engine runs but misfires	Sticking intake or exhaust valve(s)	Perform an Intake Manifold Vacuum Test. Refer to Diagnostic Procedures in this section. Remove cylinder head and valves. Clean and inspect valve stems and guides. Refer to Base Procedure 23 and to Cleaning, Inspection and Overhaul in Section 21-05.

TROUBLESHOOTING CHARTS

ENGINE CONDITIONS (Continued)

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Engine runs but misfires (Continued)	Weak or broken valve spring(s)	Perform an Intake Manifold Vacuum Test. Refer to Diagnostic Procedures in this section. Inspect valve springs. Refer to Base Procedure 11 and to Cleaning, Inspection and Overhaul in Section 21-05.
	Loose intake manifold	Perform an Intake Manifold Vacuum Test. Refer to Diagnostic Procedures in this section. Removal and Installation of manifold is covered in Section 24-29.
	Ignition system Fuel system	Refer to Section 23-01. Refer to Section 24-01.
Rough engine idle	Engine compression low	Test compression. Refer to Diagnostic Procedures in this section.
	Intake or exhaust valves leaking	Perform Intake Manifold Vacuum Test. Refer to Diagnostic Procedures in this section.
	Worn camshaft lobes	Inspect camshaft. Refer to Cleaning, Inspection and Overhaul in Section 21-05.
	Loose or worn engine mounts	Refer to Engine Removal and Installation in Section 21-05.
	Intake manifold or gasket loose or damaged	Perform Intake Manifold Vacuum Test. Refer to Diagnostic Procedures in this section. Removal and Installation of manifold is covered in Section 24-29.
	Fuel system Ignition system	Refer to Section 24-01. Refer to Section 23-01.
Poor acceleration	Engine compression low	Test compression. Refer to Diagnostic Procedures in this section.
	High engine friction Valve timing incorrect	Continue engine break-in. Perform Base Procedure 2, and if necessary, Base Procedure 3 in Section 21-05.

TROUBLESHOOTING CHARTS

ENGINE CONDITIONS (Continued)

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Poor acceleration (Continued)	Fuel system	Refer to Section 24-01.
	Ignition system	Refer to Section 23-01.
	Brakes dragging	Refer to Section 21-01.
	Automatic transmission	Refer to Section 17-01.
	Vehicle overloaded	Test with vehicle unloaded or trailer disconnected.
	Turbocharger	Test with vehicle unloaded. Refer to Section 24-01.
	High-altitude or high-ambient temperature	Normal to lose some acceleration and power.
Low power or poor high-speed performance	Engine compression low	Test compression. Refer to Diagnostic Procedures in this section.
	Worn camshaft lobes	Inspect camshaft. Refer to Cleaning, Inspection and Overhaul in Section 21-05.
	Fuel system	Refer to Section 24-01.
	Ignition system	Refer to Section 23-01.
	Automatic transmission	Refer to Section 17-01.
	Turbocharger	Refer to Section 24-01.
	Exhaust system	Refer to Section 26-01.
Engine overheats	Defective thermostat	Refer to Section 27-01.
	Loose water pump drive belt	Refer to Section 27-01 or 27-02.
	Restricted coolant passages in cylinder block, cylinder head or radiator	Refer to Section 27-01.
	Obstructed radiator air flow	Clean with water or compressed air.
	Blown cylinder head gasket or cracked cylinder head or block	Test compression. Refer to Diagnostic Procedures in this section.
	Engine cooling or A/C fan(s) not operating	Refer to Section 27-01.
	Defective water pump	Refer to Base Procedure 8 in Section 21-05 and Section 27-01.
	Lower radiator hose collapsed	Refer to Section 27-01.
	Retarded ignition timing	Refer to Section 23-01.

REMOVAL AND INSTALLATION

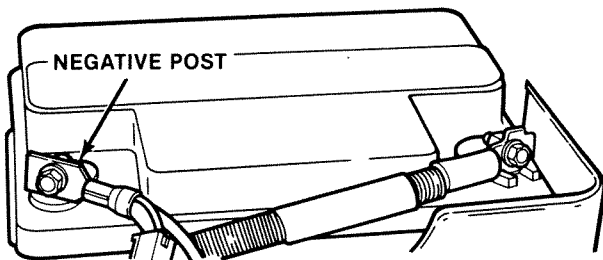
ENGINE ASSEMBLY

Removal

SPECIAL SERVICE TOOLS REQUIRED:

Vacuum Pump	D80P-250-A
Quick Connect Remover/Replacer	T82L-9500-AH

1. Open the hood and disconnect the battery negative cable.



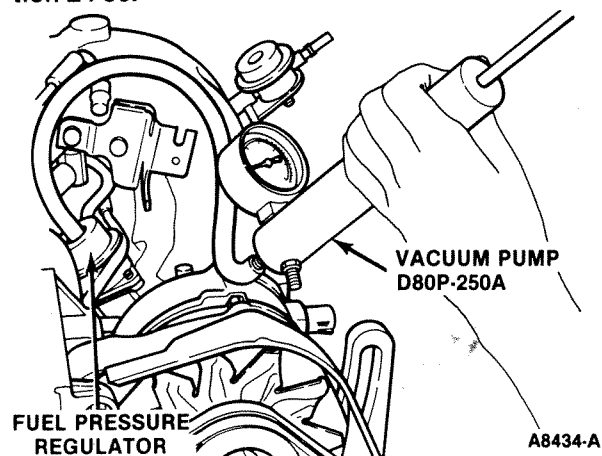
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ORIGINAL EQUIPMENT BATTERY SHOWN

2. Mark the hinge location and remove the hood. Make sure the ground strap near the right hinge is disconnected before removing the hood.

3. Depressurize the EFI fuel system using a hand-operated vacuum pump. Connect the pump hose to the fuel system pressure regulator and apply at least 25" of vacuum.

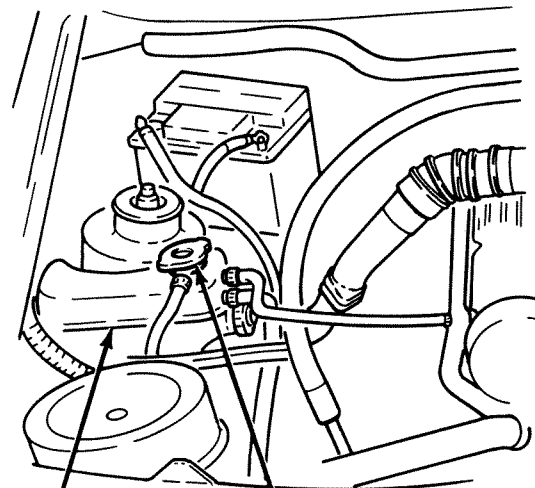
NOTE: It takes at least three minutes for the system to depressurize. If necessary, refer to the Fuel System Pressure Relief Procedure in Section 24-50.



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Use Vacuum Gauge D80P-250-A, or equivalent.

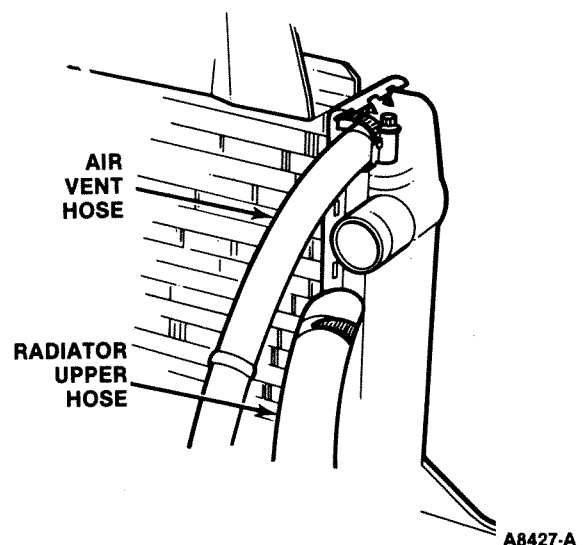
4. Remove the cap from the cooling system expansion tank and drain the radiator. If necessary, refer to Section 27-01 for the radiator drain location.

EXPANSION
TANK

PRESSURE CAP

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5. Disconnect the radiator upper hose at the radiator.



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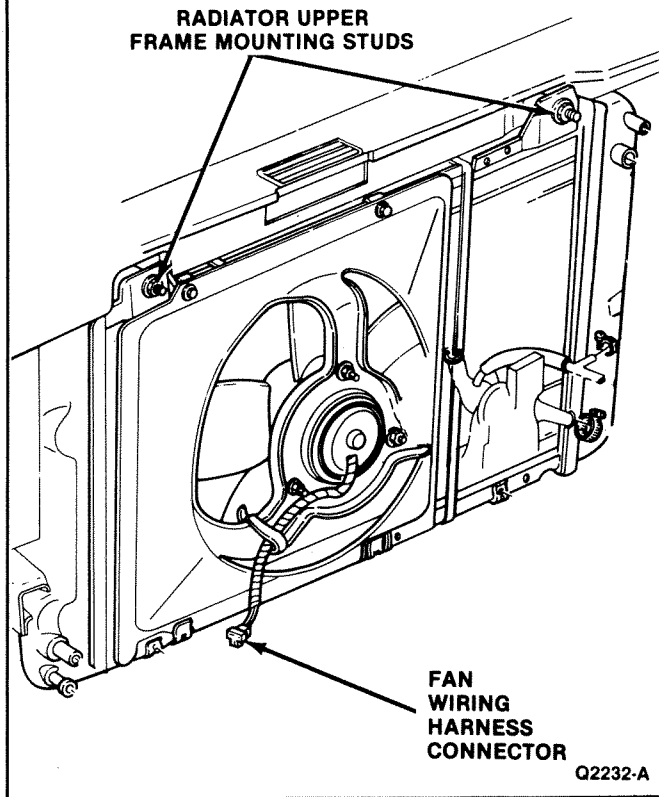
6. Disconnect the radiator air vent hose at the radiator (manual transmission only).

REMOVAL AND INSTALLATION

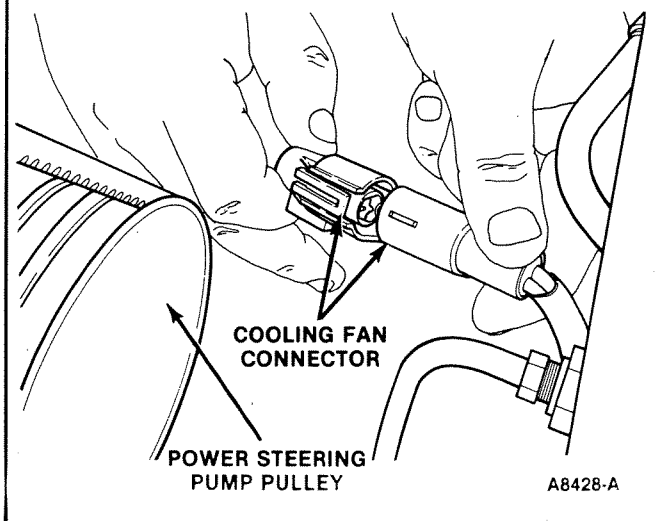
ENGINE ASSEMBLY

Removal (Continued)

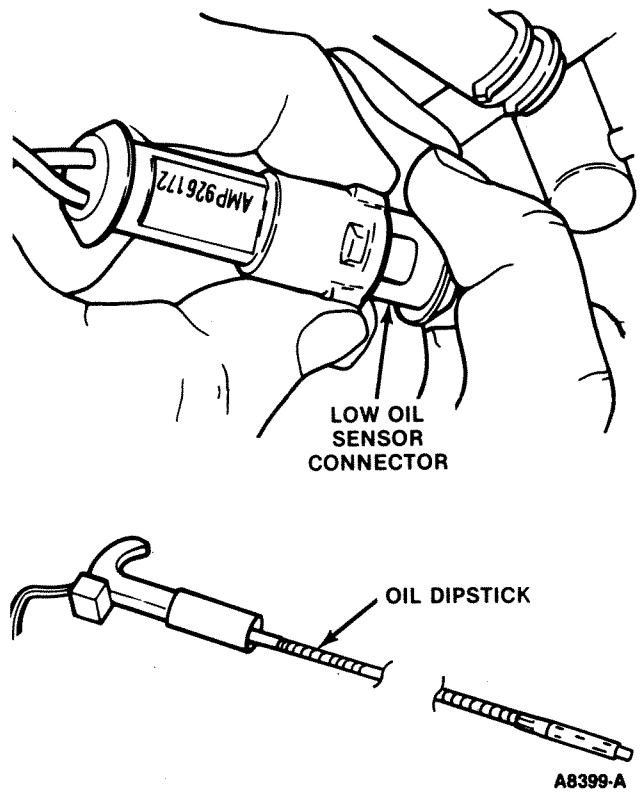
7. Remove the radiator upper attaching bolts.



8. Disconnect the wiring at the cooling fan connector.



9. Separate the oil level sensor wiring connector and remove the engine oil level dipstick.



TROUBLESHOOTING CHARTS

ENGINE RELATED NOISES		
CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Miscellaneous noises: grinding, scraping, howling, squeaking and rattles	Many noises are located in or caused by the engine accessories such as the alternator, A/C compressor, water pump, power steering pump or cooling fan	Remove the drive belts and run the engine for a short time. Do not overheat the engine. Refer to Base Procedures 5R & I in Section 21-05. Also, refer to Section 27-02.
	The exhaust system and transmission are also possible noise sources	Refer to Sections 26-01, 16-01 and 17-01.
Light tapping at one-half engine speed and non-varying frequency	Excessive valve train clearance at cam follower, valve stem, hydraulic lash adjuster or camshaft lobe(s)	Refer to Diagnostic Tests and to Cleaning, Inspection and Overhaul in Section 21-05.
Light tapping as above but with varying frequency—comes and goes	Sticking valve(s) or hydraulic lash adjusters	Perform compression and manifold vacuum tests. Refer to Diagnostic Procedures in this section. Also, refer to Cleaning, Inspection and Overhaul in Section 21-05.
Light to medium rap; most noticeable when engine is cold and at mid-range of engine speed. Noise temporarily reduced when oil is added to affected cylinder	Excess piston to cylinder bore clearance (piston slap)	Measure piston to bore clearance. Refer to Base Procedure 29 and to Cleaning, Inspection and Overhaul in Section 21-05.
Light to medium double rap each engine revolution. More noticeable at engine idle. Shorting out the affected cylinder increases noise	Excess piston-to-piston pin clearance	Measure piston-to-piston pin clearance. Refer to Base Procedure 29 and to Cleaning, Inspection and Overhaul in Section 21-05.
Medium-to-heavy sharp knock at medium engine speed and at a no load or "float" condition. Shorting out cylinder reduces noise	Connecting rod bearing(s)-to-crankshaft clearance excessive	Measuring connecting rod bearing clearance. Refer to Base Procedure 29 and to Cleaning, Inspection and Overhaul in Section 21-05.
Heavy, dull knock or thud at any engine speed. More severe under load. Sound will change when spark plug is shorted in area of worn bearing	Main bearing-to-crankshaft clearance excessive	Measure main bearing clearance. Refer to Base Procedure 30 and to Cleaning, Inspection and Overhaul in Section 21-05.

TROUBLESHOOTING CHARTS

ENGINE RELATED NOISES (Continued)

CONDITION	POSSIBLE CAUSE	CORRECTIVE ACTION
Heavy, dull knock or thud. Manual transmission clutch operation will change noise. Automatic transmission stall condition will increase noise	Flywheel loose or cracked	Inspect flywheel for cracks and secure attachment. Refer to Base Procedure 28 in Section 21-05.
Light ping or sharp clank depending on throttle opening, engine speed and loading. Lower engine speeds and heavier loading produce louder knock	Detonation or spark knock caused by combination of high advanced spark timing, low octane fuel, high engine temperature, high engine loading at low engine speeds, high compression, carboned engine and high ambient temperature. Other reasons for detonation are hot spots in the cylinder, spark plug heat range too hot or lean fuel mixture	Refer to Section 23-01.
Dieseling or engine running after ignition is shut off	High idle speed	Lower idle speed to specification. Refer to Diagnostic Procedures in this section.
	Low octane fuel	Change fuel to specified fuel.
	Excess carbon in combustion chambers	Clean carbon.
	Hot spots in combustion chamber such as sharp valve edge, too hot a spark plug, heat range or glowing carbon	Clean combustion chamber or source of hot spot. Change spark plugs to proper heat range.
	Intake system air leak	Test intake manifold vacuum. Refer to Diagnostic Procedures in this section.

DIAGNOSTIC PROCEDURES

INTAKE MANIFOLD VACUUM TEST

Bring the engine to normal operating temperature. Connect vacuum gauge to the intake manifold. Run engine at specified idle speed.

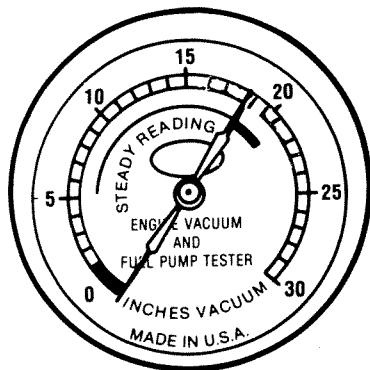
The vacuum gauge should read between 15 and 22 inches depending upon the engine condition and the altitude at which the test is performed. **SUBTRACT ONE INCH FROM THE SPECIFIED READING FOR EVERY 1,000 FEET OF ELEVATION ABOVE SEA LEVEL.**

The reading should be quite steady. It may be necessary to adjust the gauge damper control (where used) if the needle is fluttering rapidly. Adjust damper until needle moves easily without excessive flutter.

Interpreting Vacuum Gauge Readings

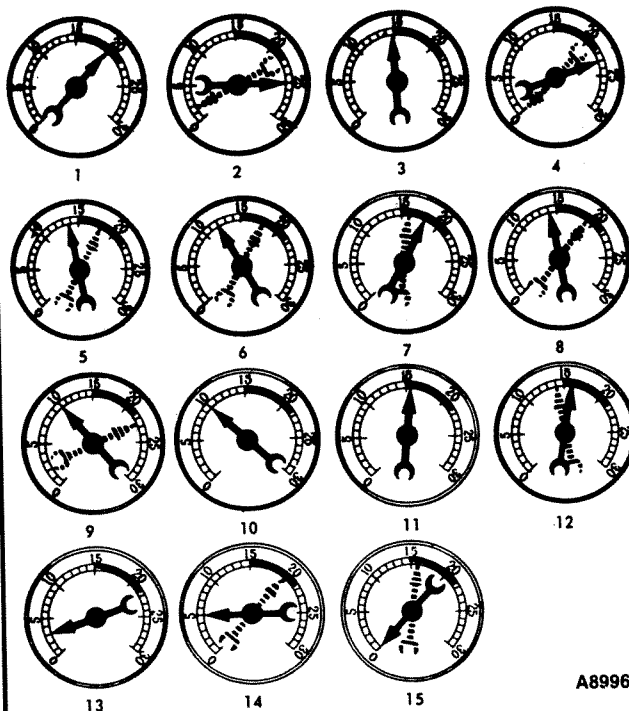
A careful study of the vacuum gauge reading while the engine is idling will help to pinpoint trouble areas. Always conduct other appropriate tests before arriving at a final diagnostic decision. Remember that vacuum gauge readings, although helpful, must be interpreted with care.

Most vacuum gauges have a "normal" band indicated on the gauge face.



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Following are potential gauge readings. Some should be considered as normal; others should be investigated further.



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1. **NORMAL READING:** Needle between 15 and 22 inches and holding steady.
 2. **NORMAL READING DURING RAPID ACCELERATION AND DECELERATION:** When engine is rapidly accelerated (dotted needle) needle will drop to a low (not to 0) reading. When throttle is suddenly released, the needle will snap back up to a higher than normal figure.
- NOTE:** The rapid acceleration and deceleration must be done very quickly by hand to avoid turbocharger boost.
3. **NORMAL FOR HIGH LIFT CAM WITH LARGE OVERLAP:** Needle will register as low as 15 inches but will be relatively steady. Some oscillation is normal.
 4. **WORN RINGS OR DILUTED OIL:** When engine is accelerated (dotted needle) needle drops to 0 inch. Upon deceleration, needle runs slightly above 22 inches.
 5. **STICKING VALVE OR VALVES:** When the needle (dotted) remains steady at a normal vacuum but occasionally flicks (sharp, fast movement) down and back about 4 inches, one or more valves may be sticking.

DIAGNOSTIC PROCEDURES

INTAKE MANIFOLD VACUUM TEST (Continued)

6. **BURNED OR WARPED VALVES:** A regular, evenly spaced downscale flicking of the needle indicates one or more burned or warped valves. Insufficient hydraulic lash adjuster clearance will also cause this action.
7. **POOR VALVE SEATING:** A small but regular downscale flicking can mean one or more valves are not seating.
8. **WORN VALVE GUIDES:** When the needle oscillates (swings back and forth), over about a 4-inch range at idle speed, the valve guides could be worn. As engine speed is increased, needle will become steady if guides are responsible.
9. **WEAK VALVE SPRINGS:** When the needle oscillation becomes more violent as engine rpm is increased, weak valve springs are indicated. The reading at idle could be relatively steady.
10. **LATE VALVE TIMING:** A steady but low reading could be caused by late valve timing.
11. **IGNITION TIMING RETARDING:** Retarded ignition timing will produce a steady but somewhat low reading.
12. **INSUFFICIENT SPARK PLUG GAP:** When plugs are gapped too close, a regular, small pulsation of the needle can occur.
13. **INTAKE LEAK:** A low, steady reading, can be caused by an intake manifold or throttle body mounting flange gasket leak.
14. **BLOWN HEAD GASKET:** A regular drop of fair magnitude can be caused by a blown head gasket or warped head to block surface.
15. **CLOGGED EXHAUST SYSTEM:** When the engine is first started and is idled, the reading may be normal but as the engine rpm is increased, the back pressure caused by a clogged muffler, kinked tail pipe, etc., will cause the needle to slowly drop to 0. The needle then may rise slowly. Excessive exhaust clogging will cause the needle to drop to a low point even if the engine is only idled.

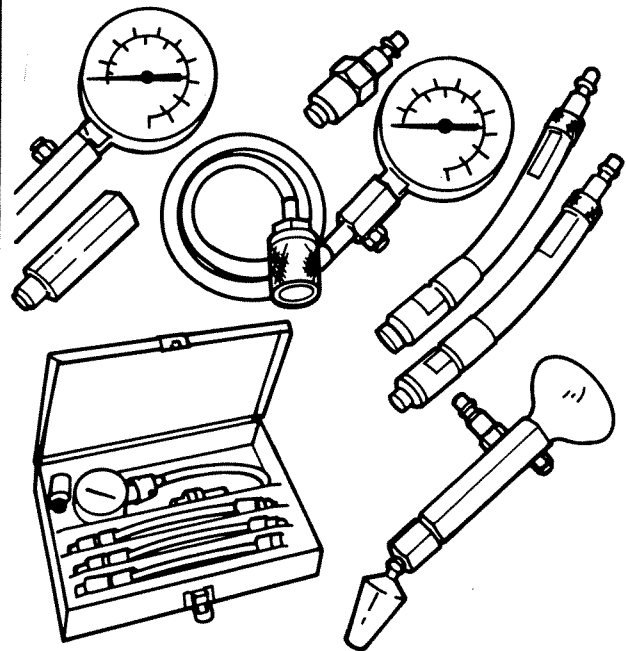
When vacuum leaks are indicated, search out and correct the cause. Excess air leaking into the system will upset the fuel mixture and cause trouble such as rough idle, missing on acceleration, burned valves. If the leak exists in some accessory unit, such as the power brake, the unit will not function correctly. **ALWAYS FIX VACUUM LEAKS.**

ENGINE COMPRESSION TEST

Operate the engine until normal operating temperature is reached. Remove the spark plugs (see Section 23-02 for correct removal and installation technique). Remove the air cleaner. Block the throttle body valve in the wide open position.

Ground the distributor end of the coil secondary wire. Attach a remote starter switch.

Insert a compression gauge TIGHTLY in the spark plug hole one at a time.



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DIAGNOSTIC PROCEDURES

ENGINE COMPRESSION TEST (Continued)

Crank the engine (battery must be fully charged, in good condition and properly connected). Starter must spin engine as specified until the gauge shows no further rise in pressure, (this will require at least 4 or 5 COMPRESSION strokes).

Normally, the first compression stroke will run the gauge indicator needle a considerable distance up the scale. Succeeding strokes will raise it more until the highest level is shown. Record the highest reading for each cylinder.

For engines having plug holes that are difficult to reach, a compression gauge having an offset tip or one utilizing a flex hose, is useful.

Remember, that the engine must be at operating temperature and the throttle body valves must be open.

Interpreting Compression Readings

Examine the readings for all cylinders. Pressure variation between the highest and lowest cylinders should be within 75 percent of one another. Example: if the highest cylinder reads 134 psi and the lowest cylinder reads 101 psi, then the 101 reading is within 75 percent of the 134 reading.

Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI
134	101	164	123	194	145	224	168
136	102	166	124	196	147	226	169
138	104	168	126	198	148	228	171
140	105	170	127	200	150	230	172
142	107	172	129	202	151	232	174
144	108	174	131	204	153	234	175
146	110	176	132	206	154	236	177
148	111	178	133	208	156	238	178
150	113	180	135	210	157	240	180
152	114	182	136	212	158	242	181
154	115	184	138	214	160	244	183
156	117	186	140	216	162	246	184
158	118	188	141	218	163	248	186
160	120	190	142	220	165	250	187
162	121	192	144	222	166		

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DIAGNOSTIC PROCEDURES

ENGINE COMPRESSION TEST

(Continued)

Variations between cylinders will have a greater effect upon engine performance than overall readings that are even but slightly below specifications.

When taking compression readings, watch the action of the gauge needle. When it raises only a small amount on the first stroke and little more on succeeding strokes, ending up with a very LOW reading, burned, warped or sticky valves are indicated.

A low buildup on the first stroke with a gradual buildup on succeeding strokes, to a moderate reading, can mean worn, stuck or scored rings.

If two adjacent cylinders are low, a blown head gasket or warped head to block surface could be responsible.

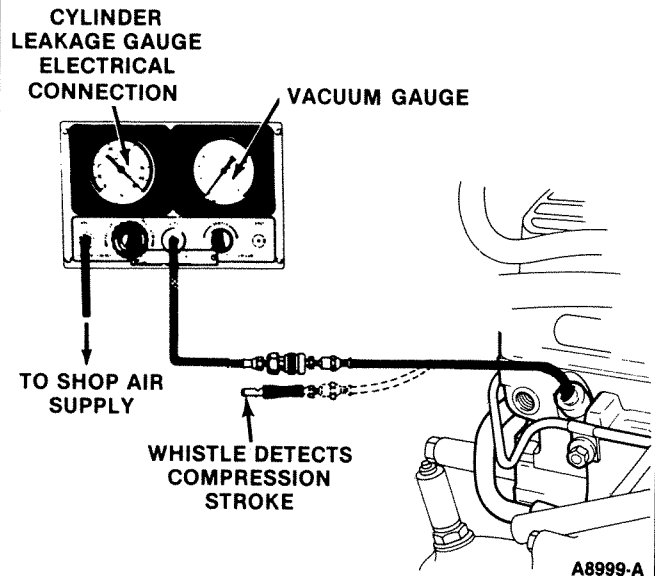
Add one tablespoon of heavy (30W minimum) engine oil to a cylinder with a low reading. Insert the compression gauge and recheck the cylinder. Crank the engine for a few extra compression strokes and watch the gauge. If the compression goes up 10 percent or more, worn rings are indicated. If the addition of the oil produces no significant change, valve trouble, a broken piston or a blown gasket, etc., is probably causing the low reading.

If the compression pressure exceeds specifications, there is a buildup of carbon on the head of the piston and on the combustion chamber walls. IF CARBON BUILDUP IS PRESENT, AND IS CAUSING PINGING THAT CANNOT BE STOPPED BY RETARDING THE TIMING, OR BY SWITCHING TO A HIGHER OCTANE GASOLINE, THE CARBON SHOULD BE REMOVED.

Another sign of excessive carbon is "dieseling" (the engine continues to run after the ignition is turned off). Dieseling action can be caused by glowing bits of carbon. Hard cranking can also indicate excessive compression from carbon buildup.

Cylinder Leakage Detector

When a cylinder produces a low reading, the use of a cylinder leakage detector will be helpful in pinpointing the exact cause.



The leakage detector is inserted in the spark plug hole, piston brought up to dead center on the compression stroke, and compressed air admitted.

Once the combustion chamber is pressurized, a special gauge will read the percentage of leakage. Leakage exceeding 20 percent is considered excessive.

While the air pressure is retained in the cylinder, listen for the hiss of escaping air. A leak by the intake valve will be audible in the throttle body. A leak by the exhaust valve can be heard at the tail pipe. Leakage past the rings will be audible, at the PCV (positive crankcase ventilation) connection. If air is passing through a blown gasket to an adjacent cylinder, the noise will be evident at the plug hole of the cylinder into which the air is leaking. Cracks in the block or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator.

DIAGNOSTIC PROCEDURES

OIL LEAK AND VALVE GUIDE SEAL TEST

The cylinder leakage detector can be used to test for engine oil leaks and to check the valve seals for leakage.

1. Plug all crankcase openings except the one used for connecting the leakage detector.
2. Connect the detector to a crankcase opening (oil dipstick tube is convenient) and adjust the air pressure to approximately 5 psi.
3. Using a solution of liquid soap and water, brush the solution along gasket sealing surfaces and bearing seals. Look for bubbles or foam.
4. Remove the spark plugs and rotate the engine slowly with a wrench. Check for large amounts of air escaping into the cylinders as each intake and exhaust valve opens.

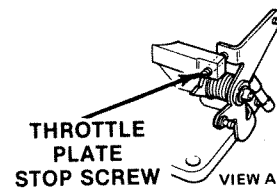
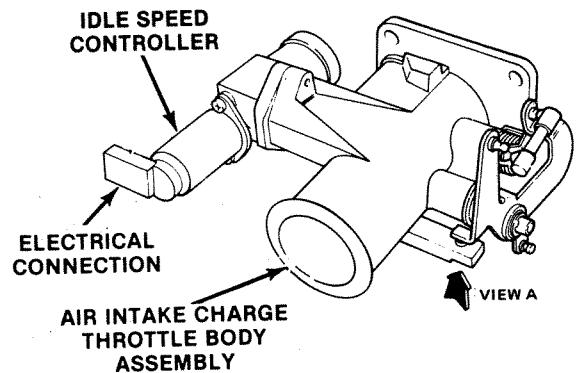
The spark plugs on the leaking cylinders will probably show deposits of burned oil.

ENGINE IDLE SPEED TEST

One of the contributing factors to engine dieseling is excess idle speed. The engine warm curb idle speed should be $900 \text{ rpm} \pm 75$.

1. To check idle speed, place the transmission in neutral and turn the A/C-blower switch to Off. Run the engine until it reaches normal operating temperature and then shut it off. Disconnect the air bypass valve electrical connection.
2. Connect a tachometer to the engine.
3. Start the engine. Check the throttle plate and linkage for sticking by tapping the throttle pedal until it opens approximately $1/4$ of full travel and then release it. Repeat this procedure two or three times. Observe the tachometer to be sure it repeats the rpm reading. Correct sticking condition, if necessary, and recheck.
4. Operate the engine at 2000 rpm for two minutes.

5. If the electric cooling fan comes on during the checking procedure, disconnect it at the electrical connector.
6. Allow the engine to idle and observe the rpm. It should be $750 \pm 50 \text{ rpm}$. Adjust the idle rpm at the throttle plate stop screw.



A9000-A

7. Turn the engine off.
8. Connect the electrical connection to the cooling fan, if necessary.
9. Connect the electrical connection at the air bypass valve.
10. Recheck idle speed. It should now be $900 \text{ rpm} \pm 75$.

NOTE: If, after performing the above procedure, the curb idle is not within specification, it will be necessary to refer to Sections 23-01 and 24-01.

NOTE: If, while driving the vehicle at idle speed throttle position, the engine speed is too great, turn the ignition switch off until the engine has stopped. Restart the engine. If the speed is still excessive, do not drive the vehicle until the condition is repaired.