



**WORKSHOP MANUAL**

**1989**  
**TROOPER**  
**TROOPER II**  
**SUPPLEMENT**

**V6 ENGINE**

**MECHANICAL, COOLING, ELECTRICAL,  
DRIVEABILITY AND EMISSIONS**

**ISUZU**

# **1989**

# **ISUZU TROOPER V6**

# **SUPPLEMENT**

## **FOREWORD**

This manual includes special notes, important points, service data, precautions, etc. that are needed for the maintenance, adjustments, service, removal and installation of vehicle components.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication.

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**AMERICAN ISUZU MOTORS INC.**

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## ENGINE

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All new Isuzu Motors vehicles are certified by the United States Environmental Protection Agency as conforming to the requirements of the regulations for the control of air pollution from new motor vehicles. This certification is contingent on certain adjustments being set to factory standards. In most cases, these adjustment points either have been permanently sealed and/or made inaccessible to prevent indiscriminate or routine adjustment in the field. For this reason, the factory procedure for temporarily removing plugs, caps, etc., for purposes of servicing the product must be strictly followed and, wherever practicable, returned to the original intent of the design.

### GENERAL DESCRIPTION

#### STATEMENT ON CLEANLINESS AND CARE

- An engine is a combination of many machined, hone, polished and lapped surfaces with very fine tolerances.
- Whenever valve train components, cylinder head, cylinder, 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 air cleaner or TBI unit is removed, the intake opening must be covered. 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. A liberal coating of engine oil should be applied 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.
- It should be kept 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, the ground cable of the battery should be disconnected at the battery.

- Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnected 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 or 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 the 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 Vehicle Emission Control Label. This label is located in the engine compartment.

- Spark plug type and gap.
- Ignition timing.
- Idle, fast idle and solenoid screw speeds, as applicable.
- The proper sequence for making the adjustments.
- Vacuum hose routing diagram (sometimes on a separate label).

#### 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 when 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.

Attempting to pry or pull components apart may result in damage to the part.

3. Surfaces to be resealed must be clean and dry. Remove all traces of oil and RTV. Clean with a chlorinated solvent such as carburetor spray cleaner. Don't use petroleum cleaners such as mineral spirits; they leave a film onto which RTV won't stick.
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. Torque bolts to specifications. Don't over-torque.

### **USING ANAEROBIC GASKET ELIMINATOR**

1. Clean surfaces to be resealed with a chlorinated solvent to remove all oil, grease and old material.
2. Apply a continuous bead of gasket eliminator to one flange.
3. Assemble parts in the normal manner and torque to specifications.

## **GASOLINE ENGINE MECHANICAL DIAGNOSIS**

The following information pertains to the basic assembly only. For more diagnosis information, refer to the following:

- Overheating or other cooling system problems: Refer to "Engine Cooling" (Section "6B1").
- Cranking and ignition system problems: Refer to "Engine Electrical" (Section "6D").
- Starting, driveability, fuel economy, etc. problems: Refer to the DRIVEABILITY AND EMISSIONS (SECTION 6E2).

## **GASOLINE ENGINE COMPRESSION CHECK**

1. Disconnect the primary terminal from the coil. Refer to "Engine Electrical" (Section "6D").
  2. Remove all spark plugs.
  3. Block the throttle plate wide open.
  4. Make sure the battery is fully charged.
  5. Starting with the compression gage at zero, crank the engine through four compression strokes (four "puffs").
  6. Make the compression check 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% 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). ( $1035 \times 70\% = 725$ ) ( $150 \times 70\% = 105$ ).
- Normal - Compression builds up quickly and evenly to specified compression on each cylinder.
  - Piston Rings Leaking - Compression low on first stroke tends to build up on following strikes 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.

## GASOLINE ENGINE MECHANICAL DIAGNOSIS (CONTINUED)

| PROBLEM                                          | POSSIBLE CAUSE                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | CORRECTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Engine Will Not Turn Over</b>                 | <ol style="list-style-type: none"> <li>1. Battery, cranking system or other electrical problems.</li> <li>2. Liquid in combustion chamber.</li> <li>3. Seized engine.</li> </ol>                                                                                                                                                                                                                                                                                                      | <ol style="list-style-type: none"> <li>1. Refer to "Engine Electrical" (Section "6D").</li> <li>2. Remove with suction gun.</li> <li>3. Repair.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Engine Cranks Normally But Does Not Start</b> | <ol style="list-style-type: none"> <li>1. Fuel or ignition system problem.</li> <li>2. Restricted exhaust system.</li> <li>3. Low compression due to stuck or burned valves, stuck rings, blown head gasket etc.</li> </ol>                                                                                                                                                                                                                                                           | <ol style="list-style-type: none"> <li>1. Refer to the "Fuel and Emissions Service Manual" and "Engine Electrical" (Section "6D").</li> <li>2. Repair.</li> <li>3. Perform a compression test, as outlined in this section. Repair engine as necessary.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Rough Idle</b>                                | <ol style="list-style-type: none"> <li>1. Fuel, ignition system or emissions system problem.</li> <li>2. Uneven cylinder compression.</li> <li>3. Bent pushrod or broken valve spring.</li> <li>4. Faulty engine mount.</li> </ol>                                                                                                                                                                                                                                                    | <ol style="list-style-type: none"> <li>1. Refer to the "Fuel and Emissions Service Manual" and "Engine Electrical" (Section "6D").</li> <li>2. Perform a compression test, as outlined in this section. Repair engine as necessary.</li> <li>3. Repair.</li> <li>4. Repair or replace.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                |
| <b>White Smoke</b>                               | Usually caused by water vapor, which is a normal byproduct of combustion. Usually seen on cold days.                                                                                                                                                                                                                                                                                                                                                                                  | None required.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Black Smoke</b>                               | Usually caused by rich fuel mixture.                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Refer to "Fuel System" (Section "6C") and/or the "Driveability and Emissions" (Section 6E2).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Blue Smoke</b>                                | Usually caused by oil burning in the combustion chambers.                                                                                                                                                                                                                                                                                                                                                                                                                             | Refer to Excessive Oil Loss diagnosis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Excessive Oil Loss</b>                        | <ol style="list-style-type: none"> <li>1. External oil leaks.</li> <li>2. Improper reading of dipstick.</li> <li>3. Improper oil viscosity.</li> <li>4. Continuous high speed driving and/or severe usage.</li> <li>5. Crankcase ventilation or PCV system malfunctioning.</li> <li>6. Valve guides and/or valve stem seals worn, or seals missing.</li> <li>7. Piston rings not seated.</li> <li>8. Broken or worn piston rings.</li> <li>9. Piston improperly installed.</li> </ol> | <ol style="list-style-type: none"> <li>1. Tighten bolts and/or replace gaskets and seals as necessary.</li> <li>2. Check oil with vehicle on a level surface and allow adequate drain down time.</li> <li>3. Use recommended viscosity for prevailing temperatures.</li> <li>4. Continuous high speed operation and/or severe usage will normally cause decreased oil mileage.</li> <li>5. Service as necessary.</li> <li>6. Ream guides and install oversize service valves and/or new valve stem seals.</li> <li>7. Allow adequate time for rings to seat.</li> <li>8. Replace broken or worn rings as necessary.</li> <li>9. Replace piston or repair as necessary</li> </ol> |

## GASOLINE ENGINE MECHANICAL DIAGNOSIS (CONTINUED)

| PROBLEM                                                                                        | POSSIBLE CAUSE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | CORRECTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Low Oil Pressure</b>                                                                        | <ol style="list-style-type: none"> <li>1. Slow idle speed.</li> <li>2. Incorrect or faulty oil pressure switch or sensor.</li> <li>3. Incorrect or faulty oil pressure gage.</li> <li>4. Improper oil viscosity.</li> <li>5. Diluted engine oil.</li> <li>6. Oil pump worn or dirty.</li> <li>7. Plugged oil filter.</li> <li>8. Oil pickup screen loose or plugged.</li> <li>9. Hole in oil pickup tube.</li> <li>10. Excessive bearing clearance.</li> <li>11. Cracked, porous or plugged oil galley.</li> <li>12. Galley plugs missing or mis-installed.</li> </ol> | <ol style="list-style-type: none"> <li>1. Set idle speed to specifications.</li> <li>2. Replace with proper switch or sensor.</li> <li>3. Replace with proper gage.</li> <li>4. Replace with proper oil.</li> <li>5. Change engine oil and filter. Repair cause of dilution (rich mixture, etc.).</li> <li>6. Clean pump and replace worn parts as necessary.</li> <li>7. Replace filter and oil.</li> <li>8. Clean or replace screen as necessary.</li> <li>9. Replace tube.</li> <li>10. Replace as necessary.</li> <li>11. Repair or replace block.</li> <li>12. Install plugs or repair as necessary.</li> </ol> |
| <b>Valve Train Noise</b>                                                                       | <ol style="list-style-type: none"> <li>1. Low oil pressure.</li> <li>2. Loose rocker arm attachments.</li> <li>3. Worn rocker arm and/or pushrod.</li> <li>4. Broken valve spring.</li> <li>5. Sticking valves.</li> <li>6. Lifters worn, dirty or faulty.</li> <li>7. Camshaft worn or faulty.</li> <li>8. Worn valve guides.</li> </ol>                                                                                                                                                                                                                              | <ol style="list-style-type: none"> <li>1. Repair as necessary. (See diagnosis for low oil pressure).</li> <li>2. Inspect and repair as necessary.</li> <li>3. Replace as necessary.</li> <li>4. Replace spring.</li> <li>5. Free valves.</li> <li>6. Refer to "Diagnosis of Hydraulic Lifters".</li> <li>7. Replace camshaft.</li> <li>8. Repair as necessary.</li> </ol>                                                                                                                                                                                                                                            |
| <b>Engine Knocks Cold And Continues For Two To Three Minutes. Knock Increases With Torque.</b> | <ol style="list-style-type: none"> <li>1. EFE equipped engines may have valve knock.</li> <li>2. Flywheel contacting splash shield.</li> <li>3. Loose or broken torsional damper or drive pulleys.</li> <li>4. Excessive piston to bore clearance.</li> <li>5. Bent connecting rod.</li> </ol>                                                                                                                                                                                                                                                                         | <ol style="list-style-type: none"> <li>1. Replace EFE valve.</li> <li>2. Reposition splash shield.</li> <li>3. Tighten or replace as necessary.</li> <li>4. Replace piston.</li> <li>5. Replace connecting rod.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Engine Has Heavy Knock Hot With Torque Applied</b>                                          | <ol style="list-style-type: none"> <li>1. Broken balancer or pulley hub.</li> <li>2. Loose torque converter bolts.</li> <li>3. Accessory belts too tight or nicked.</li> <li>4. Exhaust system grounded.</li> <li>5. Flywheel cracked or loose rivets on flywheel.</li> <li>6. Excessive main bearing clearance.</li> <li>7. Excessive rod bearing clearance.</li> </ol>                                                                                                                                                                                               | <ol style="list-style-type: none"> <li>1. Replace parts as necessary.</li> <li>2. Tighten bolts.</li> <li>3. Replace and/or tension to specs as necessary.</li> <li>4. Reposition as necessary.</li> <li>5. Replace flywheel.</li> <li>6. Repair as necessary.</li> <li>7. Repair as necessary.</li> </ol>                                                                                                                                                                                                                                                                                                           |
| <b>Engine Has Light Knock Hot In Light Load Conditions</b>                                     | <ol style="list-style-type: none"> <li>1. Faulty EST or ESC system.</li> <li>2. Improper timing.</li> <li>3. Poor quality fuel.</li> <li>4. Loose torque converter bolts.</li> <li>5. Exhaust leak at manifold.</li> <li>6. Excessive rod bearing clearance.</li> </ol>                                                                                                                                                                                                                                                                                                | <ol style="list-style-type: none"> <li>1. Refer to the "Fuel Driveability and Emissions Service Manual".</li> <li>2. Adjust to specifications.</li> <li>3. Use fuel of recommended grade.</li> <li>4. Tighten bolts.</li> <li>5. Tighten bolts and/or replace gaskets.</li> <li>6. Replace bearings as necessary.</li> </ol>                                                                                                                                                                                                                                                                                         |

**GASOLINE ENGINE MECHANICAL DIAGNOSIS (CONTINUED)**

| <b>PROBLEM</b>                                                        | <b>POSSIBLE CAUSE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>CORRECTION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Engine Knocks On Initial Start Up But Only Lasts A Few Seconds</b> | <ol style="list-style-type: none"> <li>1. Fuel pump.</li> <li>2. Improper oil viscosity.</li> <li>3. Hydraulic lifter bleed down.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                          | <ol style="list-style-type: none"> <li>1. Replace pump.</li> <li>2. Install proper oil viscosity for expected temperatures.</li> <li>3. Refer to "Diagnosis of Hydraulic Lifters".</li> </ol>                                                                                                                                                                                                                                                                                            |
| <b>Engine Knocks At Idle Hot</b>                                      | <ol style="list-style-type: none"> <li>1. Loose or worn drive belts.</li> <li>2. A/C compressor or generator bearing.</li> <li>3. Fuel pump.</li> <li>4. Valve train.</li> <li>5. Improper oil viscosity.</li> <li>6. Excessive piston pin clearance.</li> <li>7. Connecting rod alignment.</li> <li>8. Insufficient piston to bore clearance. (Cold engine piston knock usually disappears when the cylinder's spark plug is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.)</li> <li>9. Loose torsional damper.</li> </ol> | <ol style="list-style-type: none"> <li>1. Tension and/or replace as necessary.</li> <li>2. Replace as necessary.</li> <li>3. Replace pump.</li> <li>4. Refer to "Valve Train Noise".</li> <li>5. Install proper viscosity oil for expected temperature.</li> <li>6. Install new piston, pin and/or connecting rod as needed.</li> <li>7. Check and replace rods as necessary.</li> <li>8. Hone and fit new piston, if required.</li> <li>9. Torque any or replace worn parts.</li> </ol> |

## DIAGNOSIS OF HYDRAULIC LIFTERS

| PROBLEM                                                                                   | POSSIBLE CAUSE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CORRECTION                                                                                 |
|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Momentarily Noisy When Engine Is Started</b>                                           | 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.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | None needed.                                                                               |
| <b>Intermittently Noisy On Idle Only, Disappearing When Engine Speed Is Increased</b>     | 1. Dirt in hydraulic lifter.<br>2. Pitted or damaged check ball.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1. Disassemble and clean.<br>2. Replace the hydraulic lifter.                              |
| <b>Noisy At Slow Idle Or With Hot Oil; Quiet At Higher Engine Speeds Or With Cold Oil</b> | High leak down rate.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Replace the hydraulic lifter.                                                              |
| <b>Noisy At High Vehicle Speeds, Quiet At Low Speeds</b>                                  | 1. High oil level - Oil level above the "Full" mark allows crankshaft counterweight 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.<br>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.<br>3. Oil pan bent against oil pump pickup screen.<br>4. Oil pump screen bent or loose.                                                                                                                                                                                                                        | 1. Drain oil to proper level.<br><br>2. Add oil as needed.<br><br>3. Repair.<br>4. Repair. |
| <b>Noisy At Idle, Becoming Louder As Engine Speed Is Increased To 1500 RPM</b>            | 1. This noise is not connected with lifter malfunction. It becomes most noticeable in the vehicle at 10 to 15 mph "L" (Low) range, or 30 to 35 mph (Drive) range and is best described as a "hashy" sound. At slow idle, it may be entirely gone or appear as light ticking noise in one or more valves. It is caused by one or more of the following:<br><ul style="list-style-type: none"> <li>• Badly worn or scuffed valve tip and rocker arm pad.</li> <li>• Excessive valve stem to guide clearance.</li> <li>• Excessive valve seat runout.</li> <li>• Off square valve spring.</li> <li>• Excessive valve face runout.</li> <li>• Valve spring damper clicking on rotator.</li> </ul> | 1. Repair as necessary.                                                                    |

## DIAGNOSIS OF HYDRAULIC LIFTERS (CONTINUED)

| PROBLEM                                                                                    | POSSIBLE CAUSE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | CORRECTION                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Noisy At Idle, Becoming Louder As Engine Speed Is Increased To 1500 RPM (Continued)</b> | 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 also rotate valve. Repeat until valve becomes quiet. If correction is obtained, check for an off square valve spring.                                                                                                                                                                                                                                                                                                          | 2. If the valve spring is more than 1.6 mm (0.063") off square, it should be replaced.                                                                                                                                                                                |
| <b>Noisy Regardless Of Engine Speed</b>                                                    | 1. Incorrect valve adjustment (excessive lash) (engines with adjustable valve lash).<br>2. Excessive valve lash. Check for valve lash by turning the engine so 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 rocker arm held against valve. Excessive lash can be caused by:<br>a. Worn pushrod upper end ball.<br>b. Bent pushrod.<br>c. Improper lubrication of the pushrod.<br><br>d. Loose or damaged rocker arm.<br>e. If pushrod and rocker arm are OK, trouble in the hydraulic lifter is indicated. | 1. Adjust as specified.<br>2. Repair engine as needed.<br><br>a. Replace pushrod and rocker arm.<br>b. Replace pushrod.<br>c. Replace pushrod and rocker arm. Check lubrication system feed to the pushrod.<br>d. Replace rocker arm.<br>e. Replace hydraulic lifter. |

## SECTION 6A2

# 2.8L V6 ENGINE

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| <b>FRONT COVER REPLACEMENT</b> .....    | <b>6A2-11</b> | <b>SPECIFICATIONS</b> .....                  | <b>6A2-26</b> |
| <b>FRONT CRANKSHAFT SEAL REPL.</b> .... | <b>6A2-12</b> |                                              |               |

### GENERAL DESCRIPTION

2.8L engines are 60° V6 type, overhead valve, water cooled, with cast iron block and heads.

The crankshaft is supported by four precision insert main bearing, with crankshaft thrust taken at the number three bearing.

The camshaft is supported by four plain type bearings and is chain driven. Motion from the camshaft is transmitted to the valves hydraulic lifters, pushrods and ball type rocker arms. The valve guides are integral in the cylinder head.

The connecting rods are forged steel, with precision insert type crankpin bearings. The piston pins are a press fit in the connecting rods.

The pistons are cast aluminum alloy. The piston pins are a floating fit in the piston.

### ENGINE LUBRICATION

Lubrication schematics are shown in Figures 1 - 4. The gear type oil pump is driven from the camshaft. Oil is drawn into the oil pump through a pickup screen and pipe.

Pressurized oil is routed to the oil filter. In case of excessive oil pressure, a bypass valve is provided. From the filter, oil is routed to the main oil gallery which supplies the left bank valve lifters with oil. From the left gallery, oil is directed to the camshaft bearing and the right oil gallery.

Oil flows from the hydraulic lifters through the hollow pushrods to the rocker arms. Oil from the overhead drains back to the crankcase through oil drain holes.

The timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

### ON-VEHICLE SERVICE

#### ROCKER ARM COVER REPLACEMENT

##### Right Side Rocker Arm Cover

##### Remove or Disconnect (Figure 5)

1. Battery negative cable.
2. Air cleaner.
3. Ignition coil and bracket.
4. Spark plug wires from the bracket at the rocker arm cover stud.
5. PCV valve.
6. Vacuum pipe at the manifold.
7. Throttle, cruise control and TVS cables and bracket at the TBI unit.
8. Generator, and lay aside.
9. Rocker arm cover nuts and reinforcements.
10. Rocker arm cover and gasket.
  - If the cover sticks to the head, bump the end of the cover. If the cover still does not come loose, carefully pry until loose. **DO NOT DISTORT THE SEALING FLANGE.**

##### Clean

- All traces of the old gasket from the rocker arm cover and cylinder head.

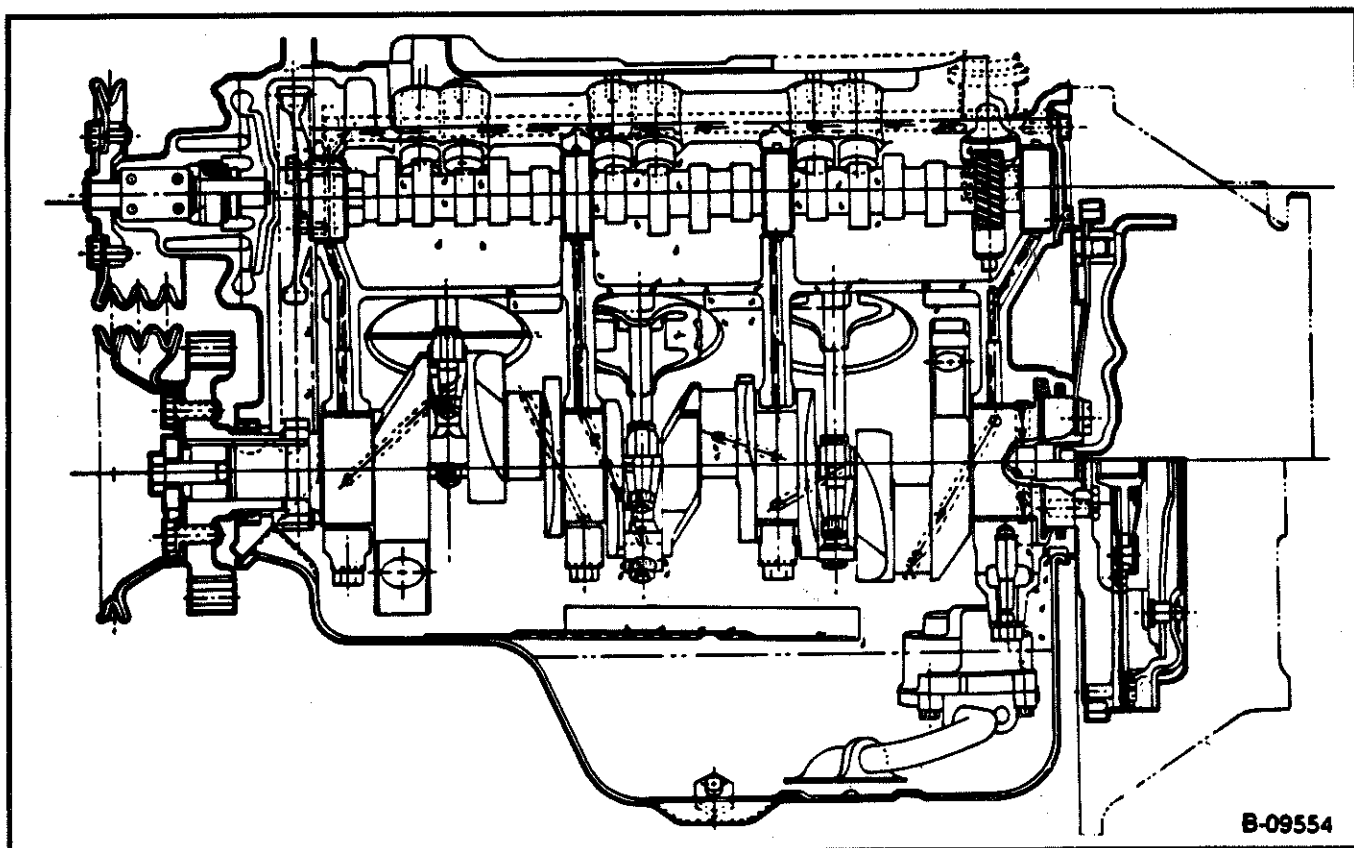


Figure 1 - Engine Lubrication Diagram

### Inspect

- Rocker arm cover sealing surfaces for distortion. Replace if necessary.

### Install or Connect (Figure 5)

- Apply a dab of RTV sealant at the point where the sealing area of the head meets the sealing area of intake manifold.
1. Rocker arm cover and new gasket.
  2. Reinforcements (2) and nuts (1).

### Tighten

- Nuts (1) to 8.0 N·m (72 lb. in.).
3. Generator.
  4. Throttle, cruise control and TVS cables and bracket.
  5. Vacuum pipe.
  6. PCV valve.
  7. Spark plug wires.
  8. Coil and bracket.
  9. Air cleaner.
  10. Battery negative cable.

### Left Side Rocker Arm Cover

#### Remove or Disconnect (Figure 5)

1. Battery negative cable.
2. Crankcase ventilation pipe.
3. Hoses, wires and pipe bracket.
4. Spark plug wires and clips from two retaining studs.
5. Rocker arm cover nuts (1) and reinforcements (2).
6. Rocker arm cover and gasket.
  - If the cover sticks to the head, bump the end or the cover. If the cover still does not come loose, carefully pry until loose. **DO NOT DISTORT THE SEALING FLANGE.**

#### Clean

- All traces of old gasket from the rocker arm cover and cylinder head.

#### Inspect

- Rocker arm cover sealing surfaces for distortion. Replace if necessary.

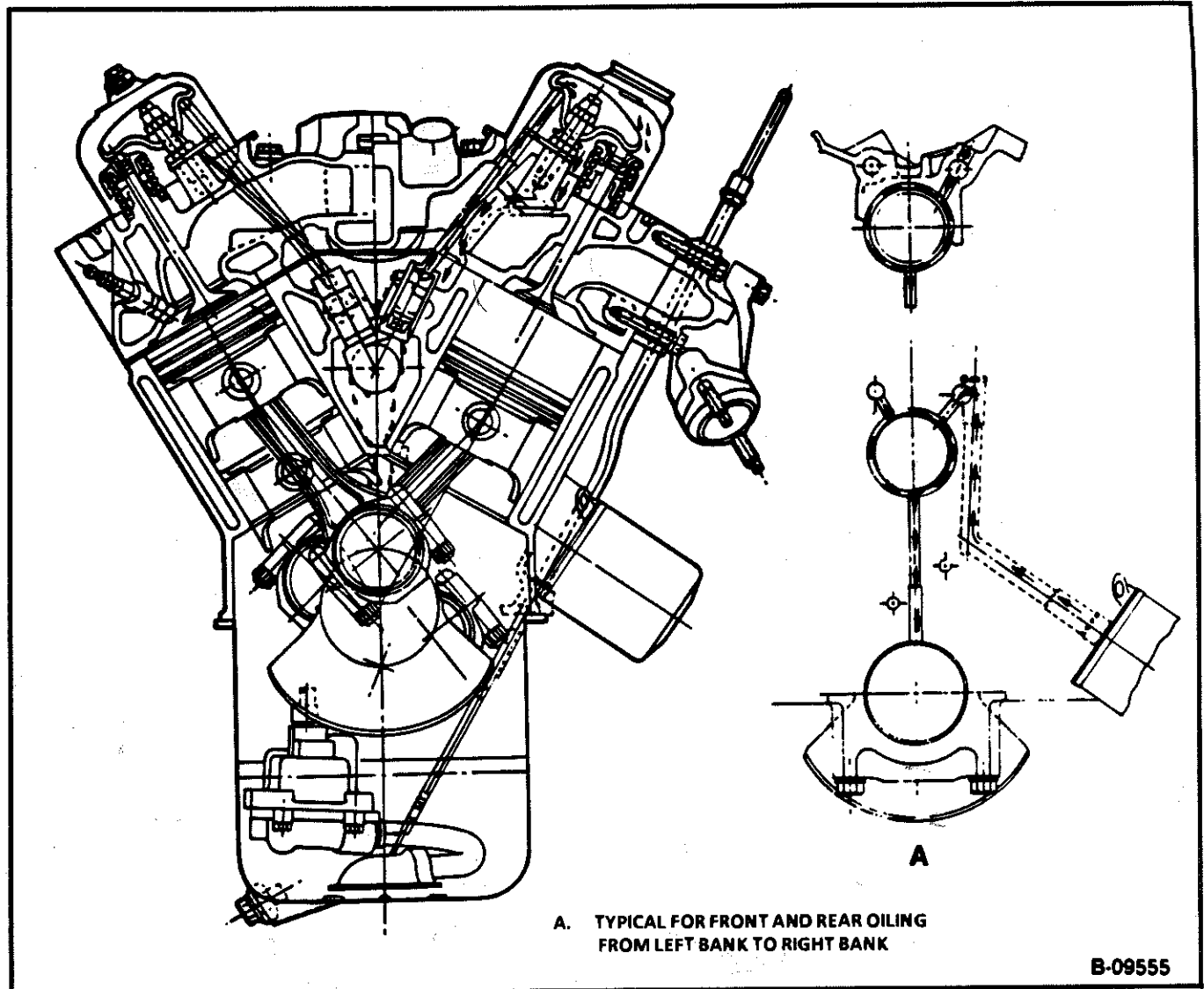


Figure 2 - Engine Lubrication Diagram

### Install or Connect (Figure 5)

- Apply a dab of RTV sealant at the point where the sealing area of the head meets the sealing area of intake manifold.
- 1. Rocker arm cover and gasket.
- 2. Rocker arm cover nuts (1) and reinforcements (2).

### Tighten

- Nuts (1) to 8.0 N·m (72 lb. in.).
- 3. Spark plug wires and clips to the retaining studs.
- 4. Hoses, wires and pipe bracket.
- 5. Crankcase ventilation pipe.
- 6. Battery negative cable.

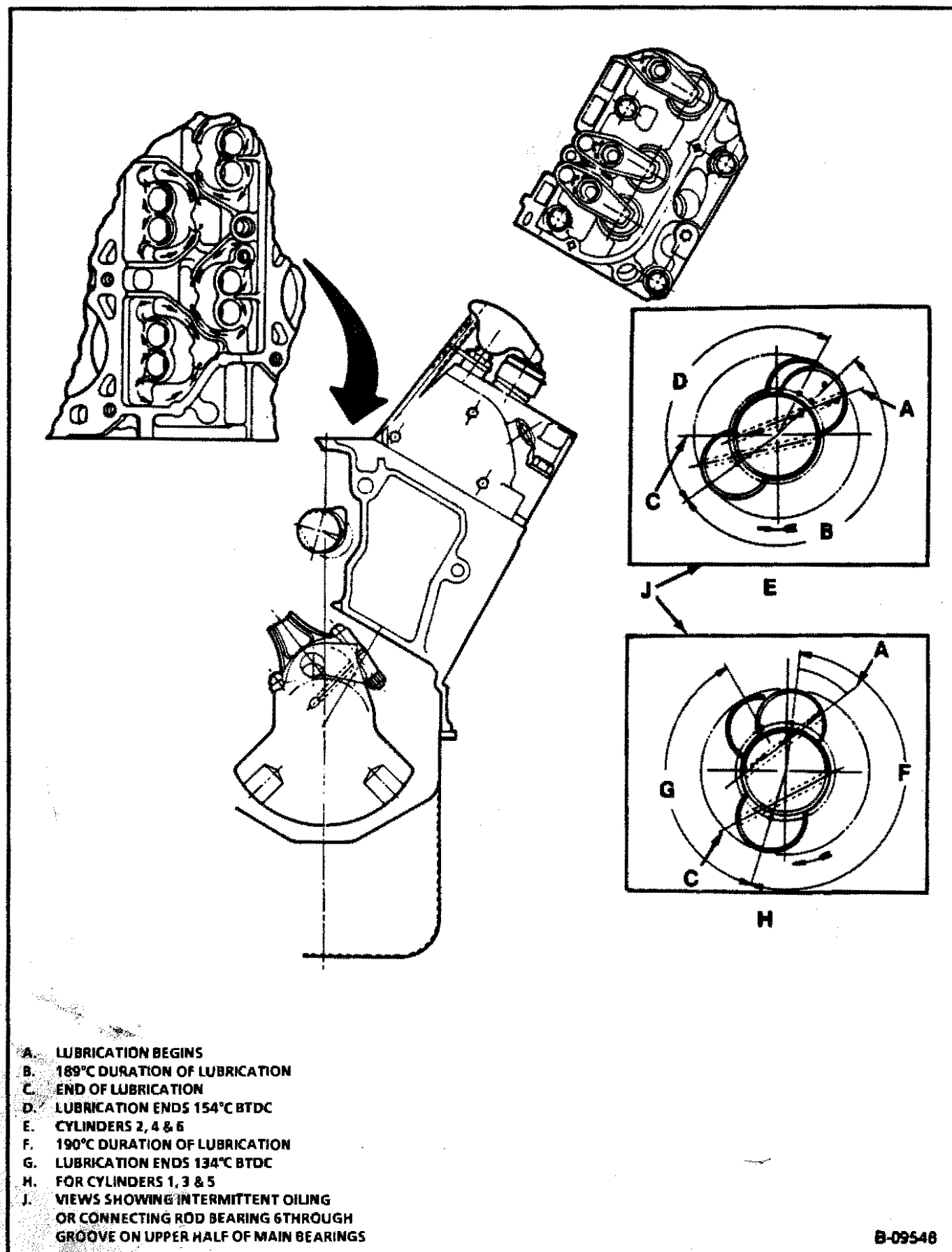
### ROCKER ARM AND PUSHROD REPLACEMENT

#### Remove or Disconnect (Figures 5 and 6)

1. Rocker arm cover, as outlined previously.
2. Rocker arm nut (6).
  - If only the pushrod is to be replaced, back the rocker arm nut off until the rocker arm can be swung away from the pushrod. Then pull the pushrod out.
3. Rocker arm (7) with ball (8).
4. Pushrod (9).

#### Important

- Store used components in order so they can be reassembled in the same location.



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Figure 3 - Engine Lubrication Diagram

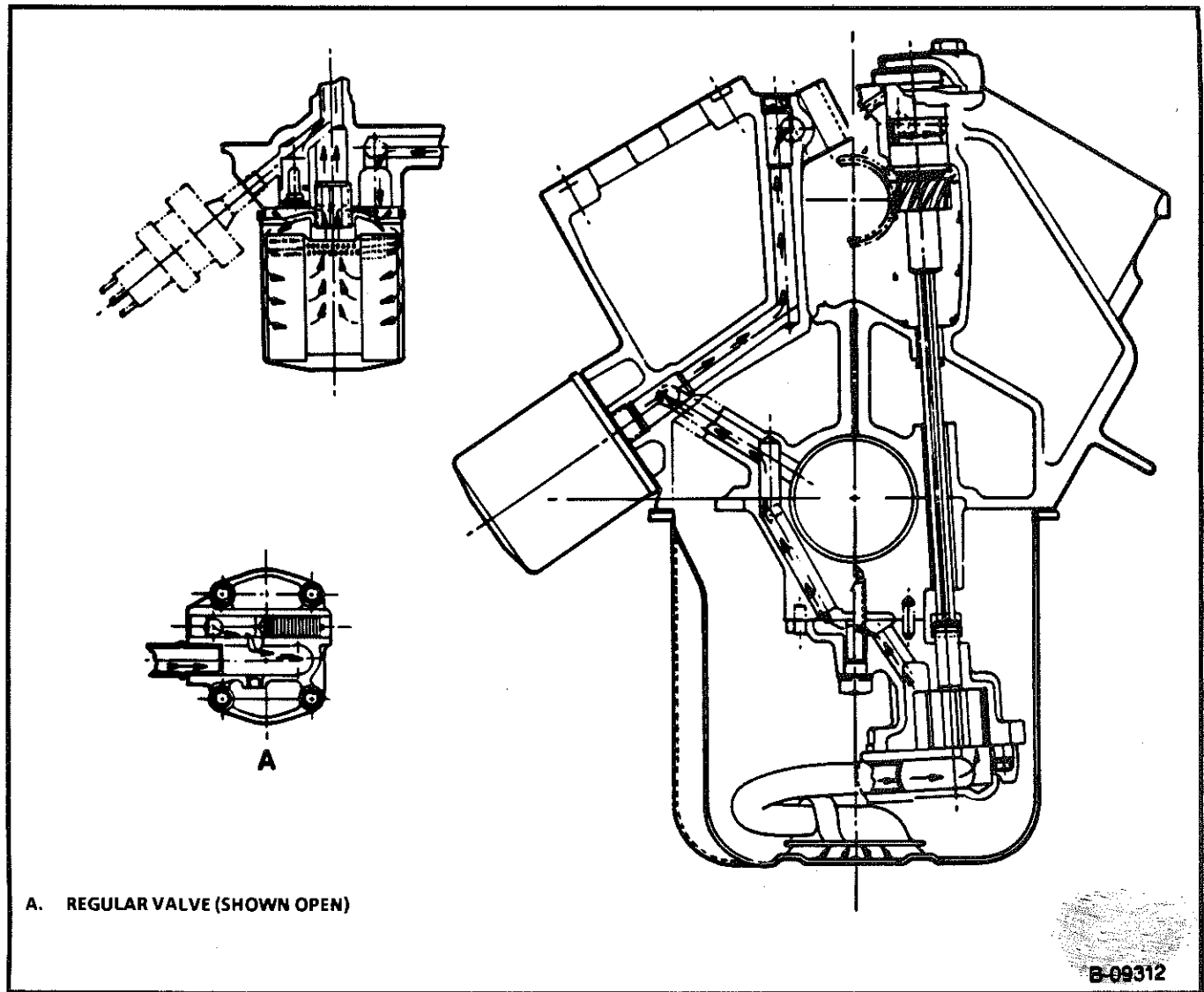


Figure 4 - Engine Lubrication Diagram

### Inspect

- Rocker arms and balls at their mating surfaces. These surfaces should be smooth and free from scoring or other damage.
- Rocker arm areas which contact the valve stems and the sockets which contact the pushrods. These areas should be smooth and free of damage and wear.
- Pushrods for bending. Roll the pushrod on a flat surface to determine if it is bent. Replace it necessary.
- Ends of the pushrods for scoring or roughness.

### Install or Connect (Figures 5 and 6)

1. Pushrod. Make sure the pushrod seats properly in the hydraulic lifter.
2. Rocker arm with ball.

### Important

- When new rocker arms and/or balls are installed, coat their bearing surfaces with Molybdenum grease.
3. Rocker arm nuts.

### Adjust

- Valves as outlined later.
4. Rocker arm cover, as outlined previously.

## VALVE ADJUSTMENT

1. Remove the rocker arm cover as outlined previously.
2. Crank the engine until the mark on the torsional damper lines up with the "O" mark on the timing tab and the engine in the number one firing position.

This may be determined by placing fingers on the number one valve as the mark on the damper comes near the "O" mark on the timing table. If the rocker arms are not moving the engine is in the number one firing position. If the rocker arms move as the mark comes up to the timing tab, the engine is in the number four firing position and should be turned over one more time to reach the number one position.

3. With the engine in the number one firing position as determined above, the following valves may be adjusted:

- Exhaust: 1, 2, 3
- Intake: 1, 5, 6

(Even numbered cylinders are in the left bank; odd numbered cylinders are in the right bank; when viewed from the rear of the engine).

4. Back out the adjusting nut until lash is felt at the pushrod then turn in the adjusting nut until all lash is remove. This can be determined by rotating the pushrod while turning the adjusting nut (Figure 7). When the play has been removed, turn the adjusting nut on one and one-half additional turns (to center the lifter plunger).

5. Crank the engine one revolution until the timing tab "O" mark and vibration damper mark are again in alignment. This is the number four firing position. The following valves may be adjusted:
  - Exhaust: 4, 5, 6
  - Intake: 2, 3, 4
6. Install the rocker arm covers.

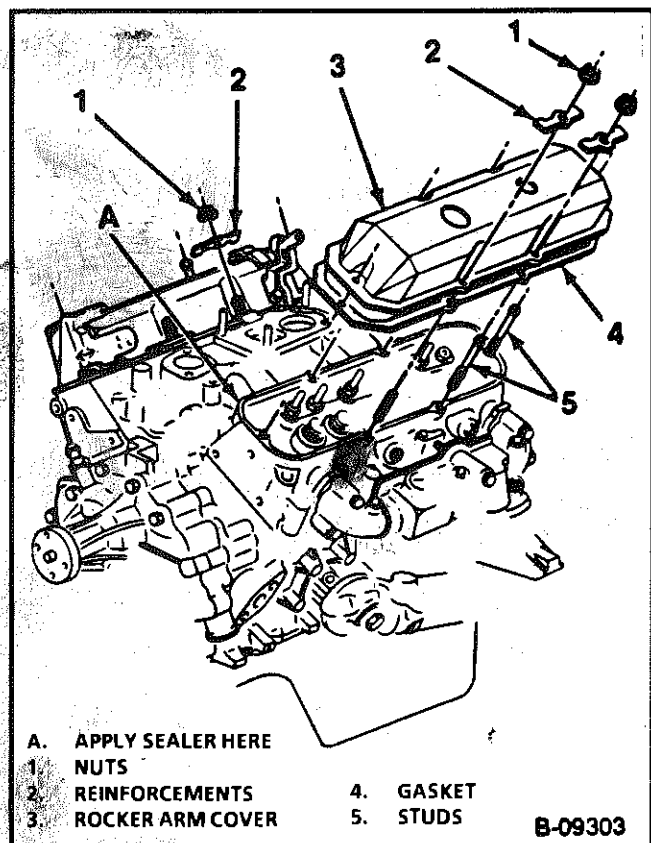


Figure 5 - Rocker Arm Cover Installation

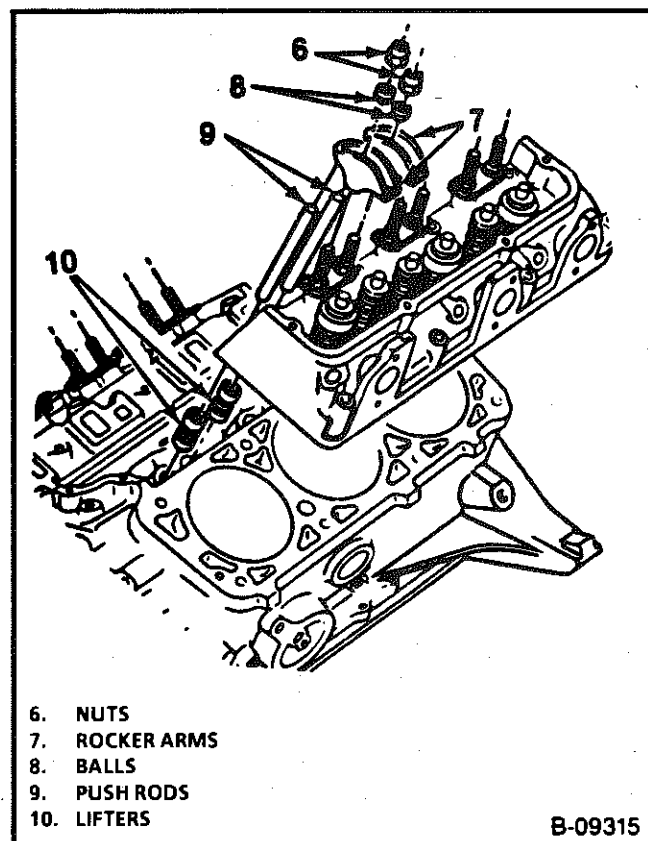


Figure 6 - Rocker Arms and Pushrods

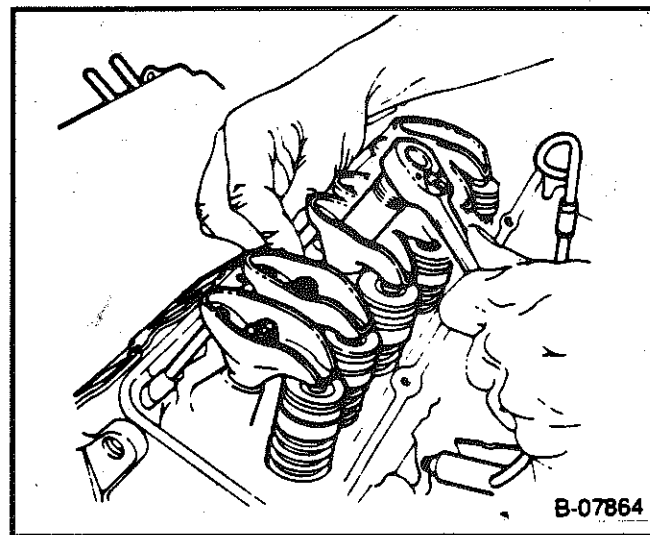


Figure 7 - Adjusting the Valves

## VALVE STEM OIL SEAL AND/OR VALVE SPRING REPLACEMENT

### Remove or Disconnect (Figures 8 and 9)

Tools Required:

J 5892-A, Spring Compressor

J 23590, Air Adapter

1. Rocker arm cover.
2. Spark plug, rocker arm and pushrod from the cylinder(s) to be serviced.
3. Valve keepers (22), valve cap (23), oil shedder (24) (exhaust only), and valve spring and damper.
  - Install J 23590 to the spark plug hole and apply compressed air to hold the valves in place.
  - Use J 5892-A to hold the valve spring.
4. Valve stem seal (25).

### Install or Connect (Figures 8 and 9)

Tools Required:

J 5892-A, Spring Compressor

J 23590, Air Adapter

1. Valve spring and damper to the valve guide boss.
2. Valve stem seal over the valve stem and valve guide boss (intake valve only).
3. Oil shedder (24) and valve rotator over the exhaust valve.

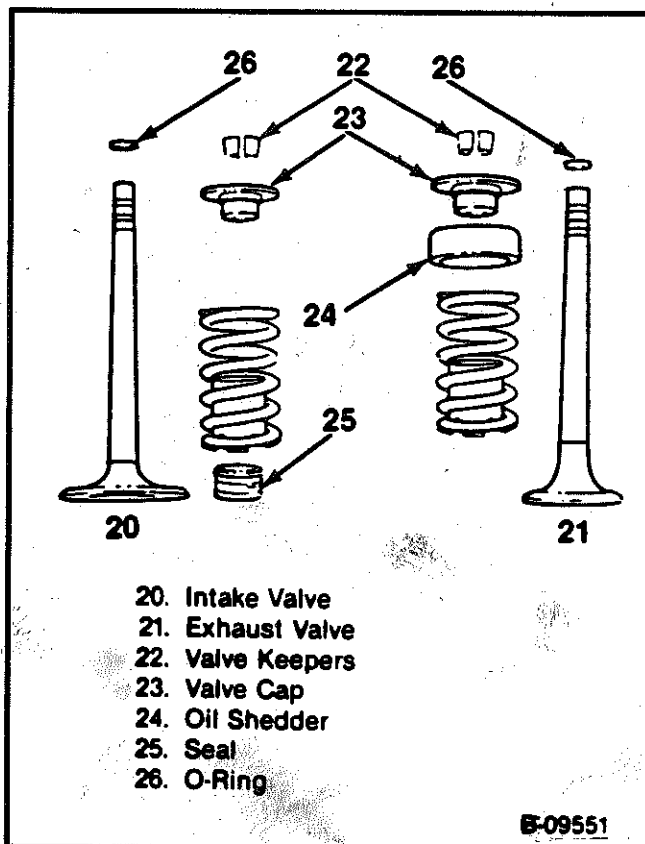


Figure 8 - Valves and Components

4. Valve spring cap over the valve spring.
  - Compress the valve spring using J 5892-A.
5. O-ring (26) around the valve stem in the lower groove.
  - Lubricate the O-ring with engine oil.
  - Make sure the O-ring is not twisted.
6. Valve keepers (22).
  - Use grease to hold the valve keepers in place.
  - Carefully release spring pressure and make sure the valve keepers stay in place.
7. Spark plugs.
8. Rocker arms.

### Adjust

- Valves, as outlined previously.
9. Rocker arm cover.

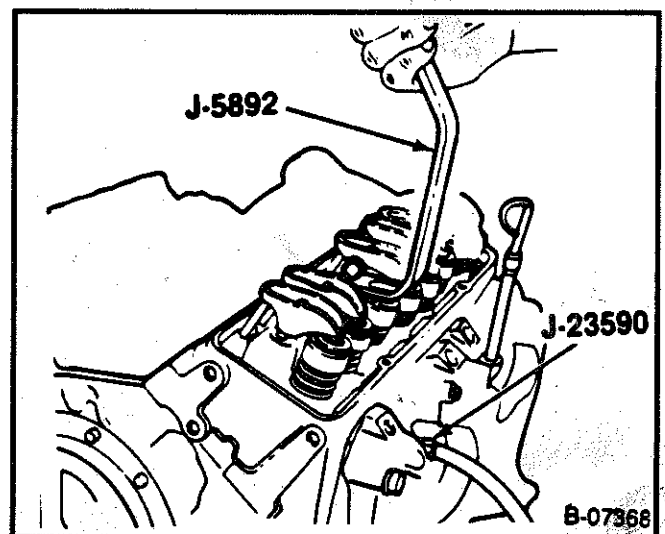


Figure 9 - Compressing the Valve Springs

## INTAKE MANIFOLD REPLACEMENT

### Remove or Disconnect (Figure 10)

- Drain the coolant.
1. Battery negative cable.
  2. Air cleaner.
  3. Wires and hoses at the TBI unit and manifold.
  4. Fuel lines at the TBI unit.
  5. Cables from the TBI unit.
  6. Spark plug wires at the spark plugs.
  7. Wires at the coil.
  8. Distributor cap with spark plug wires.
  9. Distributor hold down bracket.
  10. Distributor. Refer to "Engine Electrical" (Section "6D").
  11. EGR vacuum line.
  12. Evaporative emission hoses.
  13. Pipes brackets from the rocker arm covers.
  14. Rocker arm covers.
  15. Upper radiator hose.
  16. Heater hose.

## 6A2-8 2.8L V6 ENGINE

17. Coolant sensor connectors.
18. Intake manifold bolts and nuts.
19. Intake manifold.
20. Gaskets.

### Clean

- Old gasket and RTV from the block, heads and intake manifold. Remove all RTV that is loose or will cause interference at assembly.
- Excessive carbon deposits from the exhaust and EGR passages.
- Excessive scale and deposits from the coolant passages.

### Inspect

- Manifold for cracks and gasket surface damage.

### Install or Connect (Figure 10)

1. RTV to the front and rear sealing surfaces on the block (Figure 10). Apply a 5 mm (0.197") bead of RTV to the front and rear of the block as shown.
  - Make sure that no oil or water is present on the surfaces to be sealed.
2. Gaskets to the cylinder head.
  - Gaskets are marked right side or left side. Use them only as indicated to maintain design efficiency of the engine.
  - Hold the gaskets in place by extending the bead of RTV 6 mm (0.236") up onto the gasket ends from the block sealing surfaces.
  - The new gaskets will have to be cut where indicated to install behind the pushrods. Cut only the areas where necessary.
3. Intake manifold.
  - Make sure the areas between the case ridges and the intake manifold are completely sealed.
4. Intake manifold bolts and nuts.

### Tighten

- Nuts and bolts to 31 N·m (23 lb. ft.) in the sequence shown in Figure 10. Then re-torque using the same sequence.
5. Heater hose and radiator hose to the manifold.
  6. Rocker arm covers.
  7. Coolant sensor connectors.
  8. Pipe brackets.
  9. Distributor, cap and wires. Refer to "Engine Electrical" (Section "6D9").
  10. Fuel lines.
  11. Cables at the TBI unit.
  12. All necessary wires and hoses.
  13. Air cleaner.
  14. Battery cables.
  15. Proper quantity and grade of coolant.

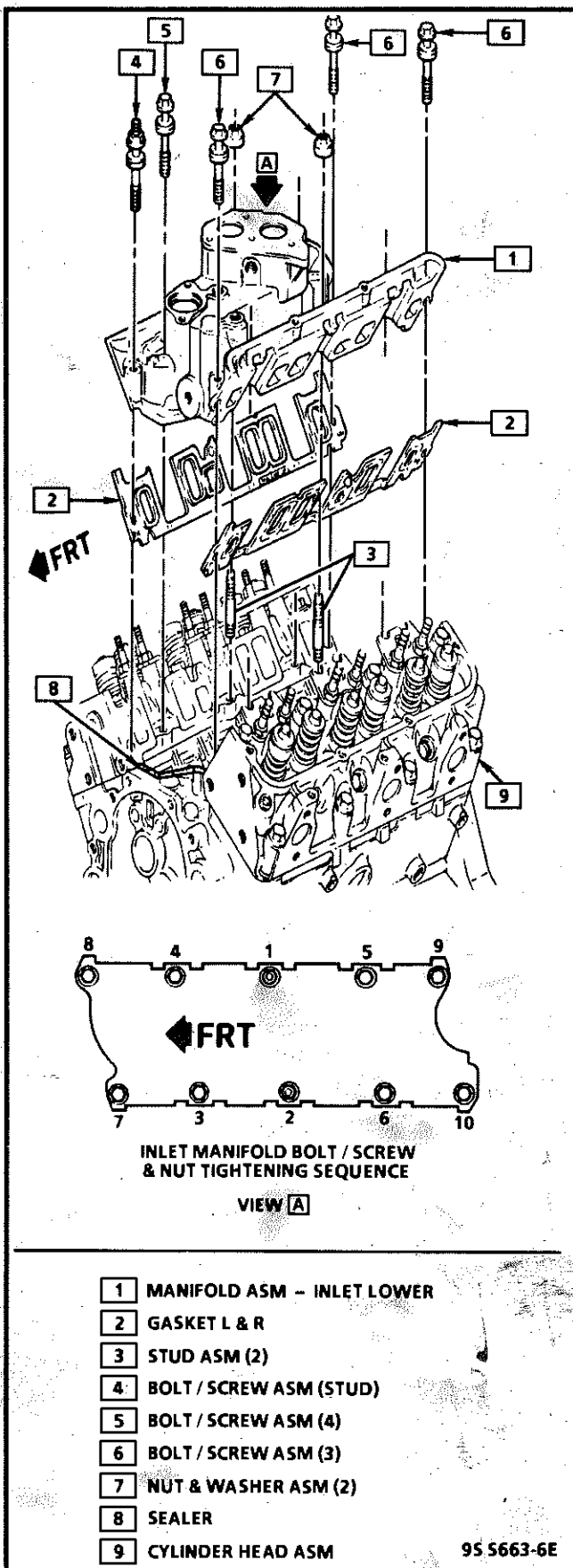


Figure 10 - Intake Manifold Installation

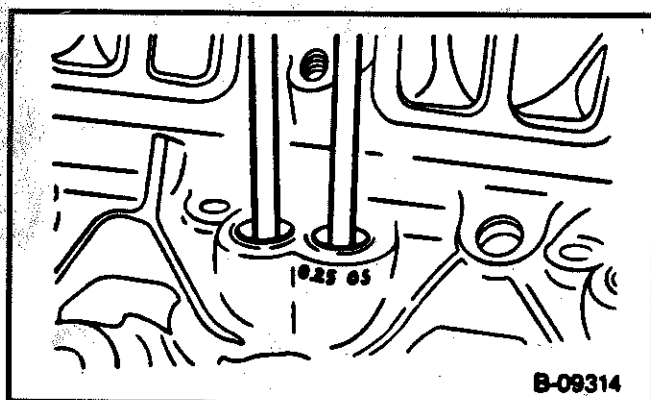


Figure 11 - Oversize Lifter Marking

## HYDRAULIC LIFTER REPLACEMENT

Some engines have both standard and 0.25 mm (0.010") oversize valve lifters. The cylinder case will be marked with a white paint mark and 0.25 mm O. S. stamp where the oversize lifters are used (Figure 11).

If lifter replacement is necessary, use new lifters with a narrow flat along the lower 3/4 of the body length. This provides additional oil to the cam lobe and lifter surfaces.

### ↔ Remove or Disconnect (Figures 6, 12, 13)

Tools Required:

J 3049, Hydraulic Lifter Remover (Plier Type)  
or  
J 9290-1, Hydraulic Lifter Remover (Slide Hammer Type)

1. Rocker arm covers.
2. Intake manifold.
3. Rocker arm nuts, balls, rocker arms and pushrods.
  - Place the components in a rack so they can be installed in the same location.
4. Lifters (10).
  - Remove the lifters one at a time and place them in an organized rack. The lifters must be installed into the same bore from which they were removed.
  - A stuck lifter can be removed using J 3049 (Figure 12) or J 9290-01 (Figure 13).

### 🔍 Inspect

- Hydraulic lifter body for scuffing or scoring. If the lifter body wall is worn or damaged, the mating bore in the block should also be checked.
- Check the fit of each hydraulic lifter in its mating bore in the block. If the clearance is excessive, try a new lifter.
- The hydraulic lifter foot must be smooth and slightly convex. If worn, pitted or damaged, the mating camshaft lobe should also be checked.

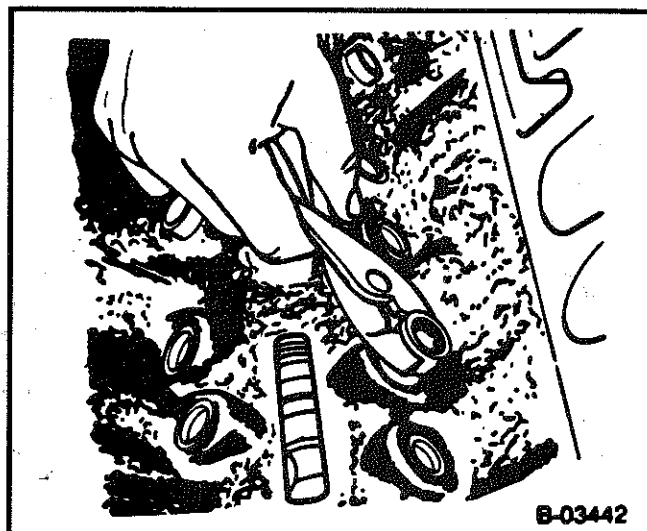


Figure 12 - Removing the Hydraulic Lifter

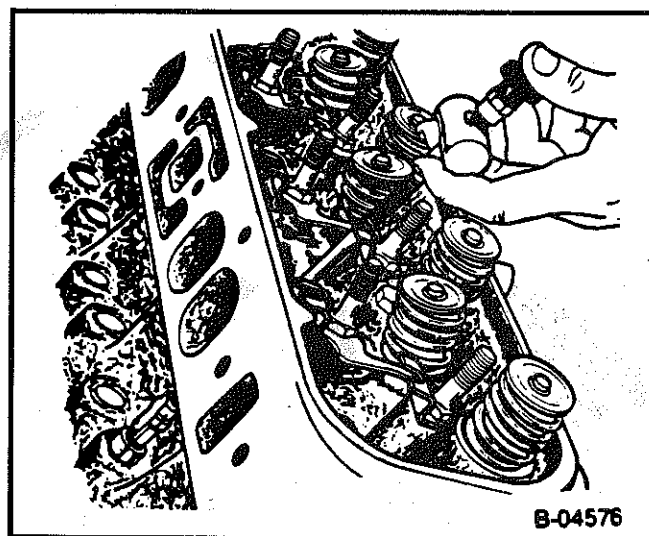


Figure 13 - Removing the Hydraulic Lifter (Typical)

### → Install or Connect

1. Hydraulic lifters into the block.

### ! Important

- Lubricate the lifter foot and body with Molybdenum grease.
  - Make sure the lifter foot is convex by holding a good straight edge to the surface and looking into a light source.
  - When any new hydraulic lifters or a new camshaft is installed, Engine Oil Supplement (or equivalent) should be added to the crankcase oil.
  - Replace all hydraulic lifters when a new camshaft is installed.
2. Intake manifold as outlined previously.

3. Pushrods, rocker arms, ball and rocker arm nuts.

## Adjust

- Valves as outlined previously.
4. Rocker arm covers, as outlined previously.

## ROCKER ARM STUDS

Cylinder heads use threaded rocker arm studs. Rocker arm studs that have damaged threads should be replaced with new studs. If the threads in the head are damaged or stripped, the head can be re-tapped and a helical type insert added. If such an insert is not available, the head should be replaced.

## EXHAUST MANIFOLD REPLACEMENT

### Remove or Disconnect

1. Battery negative cable.
  - Raise the vehicle. Support with suitable safety stands.
2. Exhaust pipe from the manifold.
3. Four rear manifold bolts.
  - Lower the vehicle.
4. Diverter valve and heat shield (right side manifold).
5. AIR pump and generator brackets (right side manifold).
6. Heat stove tube (left side manifold).
7. Power steering pump bracket (left side manifold).
8. Remaining manifold bolts.
9. Manifold.

### Clean

- Mating surfaces of manifold and cylinder head.

### Install or Connect (Figure 14)

1. Manifold and bolts.

## Tighten

- Bolts to 34 N·m (25 lb. ft.).
2. Power steering pump bracket and heat stove tube (left side manifold).
  3. AIR pump and generator brackets, and diverter valve and heat shield (right side manifold).
    - Raise the vehicle. Support with suitable safety stands.
  4. Exhaust pipe to the manifold.
    - Lower the vehicle.
  5. Battery negative cable.

## CYLINDER HEAD REPLACEMENT

### Remove or Disconnect

1. Intake manifold as outlined previously.
2. Coolant from the engine block.
  - Raise the vehicle. Support with suitable safety stands.
3. Exhaust pipe from the manifold.
  - Lower the vehicle.
4. Dipstick tube (left side only).
5. Ground strap at rear of head and sensor connector at front of head (left side only).
6. Drive belt, generator and AIR pump with mounting bracket (right side only).
7. Pushrods as outlined previously.
8. Head bolts.
9. Cylinder head.
10. Head gasket.

### Clean

- Carbon deposits from combustion chambers.
- All traces of old head gasket from the cylinder head and block.
- Cylinder head bolt threads and threads in the block.

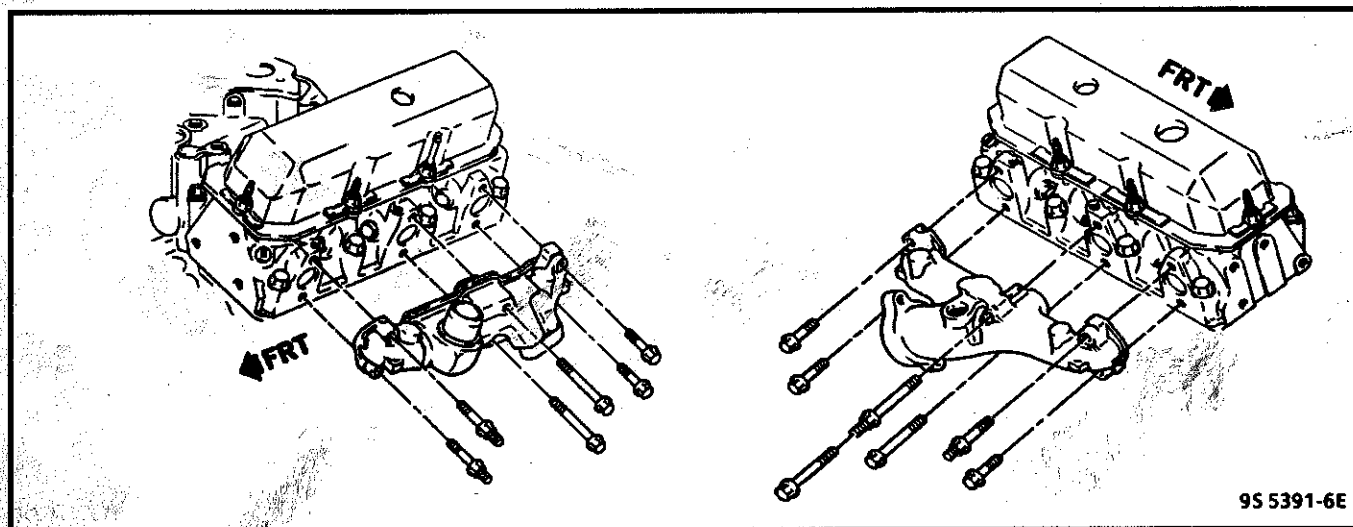


Figure 14 - Exhaust Manifold Installation

 **Inspect**

- Sealing surfaces of the block and cylinder head for nicks, heavy scratches, or other damage.

 **Install or Connect**

1. Gasket in place over the dowel pins with the note "This Side Up" showing.
2. Cylinder head.
  - Gasket must be fully seated on the block before head installation.
3. Head bolts.
  - Coat the bolt threads with sealing compound.
  - Install all bolts finger tight.

 **Tighten**

- All bolts to 55 N·m (40 lb. ft.), using the sequence shown in Figure 15.
  - In sequence, tighten all bolts an additional 90° (1/4-turn).
4. Pushrods, as outlined previously.

 **Adjust**

- Valves, as outlined previously.
5. Generator and AIR pump with mounting bracket and drive belt (right side only).
  6. Ground strap and sensor connector (left side only).
  7. Dipstick tube (left side only).
    - Raise the vehicle.
  8. Exhaust pipe.
    - Lower the vehicle.
  9. Intake manifold, as outlined previously.
  10. Proper quantity and grade of coolant.

**TORSIONAL DAMPER REPLACEMENT**

**NOTICE:** The inertial weight section of the torsional damper is assembled to the hub with a rubber sleeve. The removal and installation procedures must be followed (with proper tools) or movement of the inertia weight section of the hub will destroy the tuning of the torsional damper and the engine timing reference.

The torsional damper has three timing notches on the inertia ring. The number one cylinder timing reference mark will be identified by a dab of white paint. If a new damper assembly is installed, mark the new assembly in the same place for future reference. Number one cylinder reference is the first clockwise mark from the keyway when viewing the engine from the front.

 **Remove or Disconnect**

Tool Required:

J 23523-E or J 24420-B, Puller

1. Negative battery cable.
2. Accessory drive belt.
3. Torsional damper retaining bolt.
4. Drive pulley from the damper.
  - Raise the vehicle. Support with suitable safety stands.
5. Damper using J 23523-E or J 24420-B.

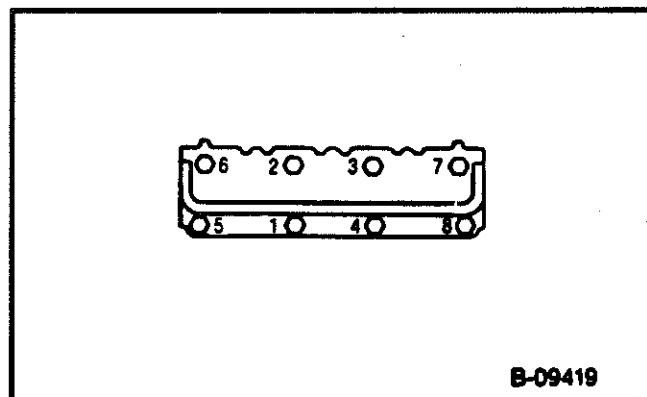


Figure 15 - Cylinder Head Bolt Tightening Sequence

 **Install or Connect**

Tool Required:

J 29113, Torsional Damper Installer

1. Engine oil to the front cover seal contact area on the damper.
2. Use sealing compound on the key and the key way.
  - Clean the key and the key way.
3. Damper over the key on the crankshaft.
4. Pull the damper onto the crankshaft.
  - Install J 29113 into the crankshaft so at least 6 mm (0.236") of thread is engaged.
  - Pull damper into position and remove J 29113 from the damper.
5. • Drive pulley to the damper.
6. Torsional damper retaining bolt.

 **Tighten**

- Bolt to 95 N·m (70 lb. ft.).
  - Lower the vehicle.
7. Drive belt.
  8. Battery negative cable.

**FRONT COVER REPLACEMENT** **Remove or Disconnect**

1. Water pump. Refer to "Engine Cooling" (Section "6B").
2. Power steering pump bracket (if equipped).
3. Torsional damper.

4. Lower radiator hose from the front cover.
  - Drain the cooling system.
5. Remaining front cover bolts.
6. Front cover.
7. Gasket.

## Clean

- Old gasket from the front cover and block.

## Install or Connect

1. New gasket.
  - Make sure sealing surfaces are clean.
  - Take care not to damage sealing surfaces.
  - Lightly coat both sides of the gasket with anaerobic sealer.
2. Front cover.
3. Water pump.
4. Bolts and stud.

## Tighten

- Bolts and stud to specifications.
5. Lower radiator hose to the front cover.
  6. Torsional damper.
  7. Power steering pump mounting bracket (if equipped).
  8. Accessory drive belt.
  9. Negative battery cable.
  10. Proper quantity and grade of coolant.

## FRONT CRANKSHAFT SEAL REPLACEMENT

### With Front Cover Removed

## Remove or Disconnect

- Oil seal out of the front cover.
  - Pry the seal out with a large screw driver.

## Install or Connect

Tool Required:

J 35468, Seal Installer

- New seal so that the open end or the seal is toward the inside of the cover.
  - Drive the seal into position with J 35468.
  - Support the cover at the seal area.
- Lubricate the seal with engine oil before installing the torsional damper.

### With The Front Cover Installed

## Remove or Disconnect

1. Torsional damper.
2. Seal from the front cover.
  - Pry the seal out of the cover with a large screw driver being careful not to damage the surface on the crankshaft.

## Install or Connect

Tool Required:

J 35468, Seal Installer

1. New seal so the open end of the seal is toward the inside of the cover.
  - Drive the seal into place using J 35468.
2. Torsional damper.
  - Lubricate the seal with engine oil.

## TIMING CHAIN AND SPROCKET REPLACEMENT

## Remove or Disconnect

Tool Required:

J 5825-A, Crankshaft Sprocket Puller

1. Crankcase front cover.
  - Place number one piston at top dead center with the marks on the camshaft and crankshaft sprockets aligned (number four firing) (Figure 16).

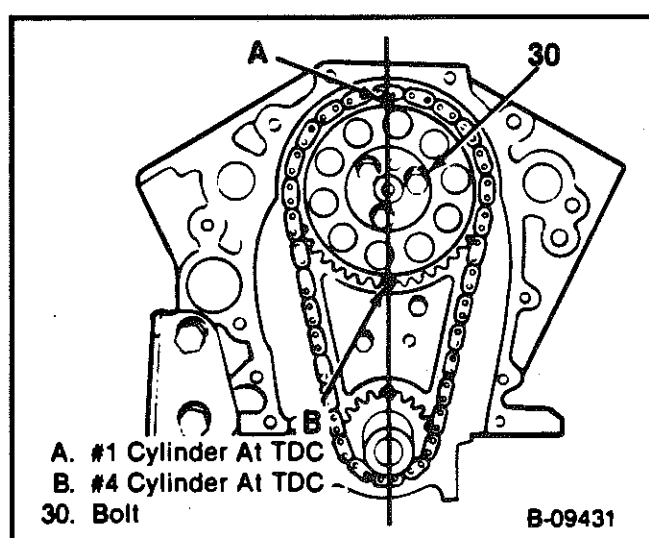


Figure 16 - Camshaft Timing

## Inspect

- Sprockets for chipped teeth and wear.
  - Timing chain for wear.
    - If the chain can be pulled out more than 9.5 mm (0.374"), from the damper, replace the chain.
2. Bolts (30).
  3. Camshaft sprocket and chain.
    - If the sprocket does not come off easily, a light blow on the lower edge of the sprocket (with a plastic mallet only) should dislodge the sprocket.
  4. Crankshaft sprocket (if required) using J 5825-A (Figure 17).

**↔ Install or Connect (Figure 16)**

Tool Required:

J 5590, Crankshaft Sprocket Installer

1. Crankshaft sprocket (if removed) using J 5590 (Figure 17).
  - Make sure the timing mark faces outward.
2. Timing chain onto the camshaft sprocket.
  - Lubricate the thrust surface with "Molykote" or equivalent.
3. Sprocket onto the camshaft.
  - Hold the sprocket vertically with the chain hanging down and align the marks on the camshaft and crankshaft sprockets.
  - Align the dowel in the camshaft with the dowel hole in the sprocket.
4. Bolts (30).
  - Draw the camshaft sprocket onto the camshaft using the mounting bolts.

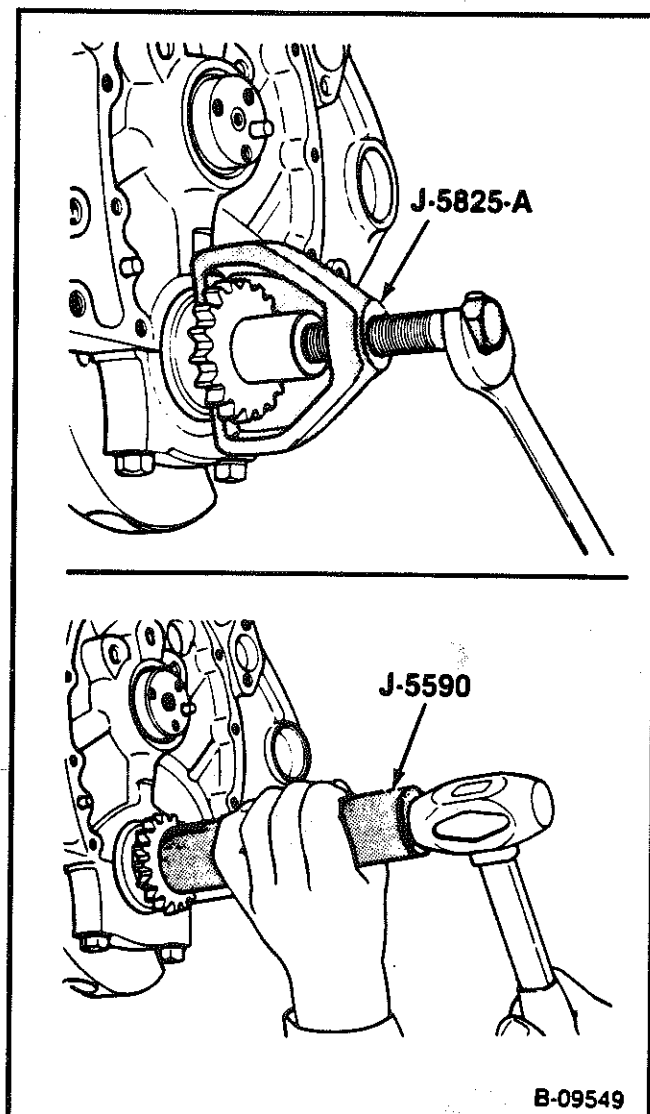


Figure 17 - Replacing the Crankshaft Sprocket

**⌚ Tighten**

- Bolts (30) to 23 N·m (17 lb. ft.).
5. Crankcase front cover.
    - Lubricate the timing chain with engine oil.

**OIL PAN REPLACEMENT****Four Wheel Drive Models****↔ Remove or Disconnect (Figure 18)**

1. Negative battery cable.
2. Dipstick.
  - Raise/support vehicle by frame.
3. Front skid plates assembly (6 bolts).
4. Front crossmember.
5. Catalytic bolts.
6. Y-pipe bolts at manifolds.
7. Front prop-shaft at drive pinion (4 bolts).
8. Braces at flywheel cover.
9. Starter motor bolt
10. Starter motor.
11. Flywheel inspection cover.
  - Reference pitman arm to pitman shaft for reassembly.
12. Pitman arm from pitman shaft.
13. Idler arm from shaft.
14. Rubber tube from front axle vent.
  - Support front axle housing assembly.
15. 2 bolts from left axle housing isolator.
16. 2 bolts from right axle housing isolator.
  - Lower front axle housing assembly.
17. Oil from oil pan.
18. Oil pan bolts.
19. Oil pan.
20. Gasket.

**↔ Install or Connect**

**NOTICE:** Before installing the oil pan, check that the seal surfaces on the pan, cylinder case and front cover are clean and free of oil. Make sure that all RTV is removed from blind attaching holes.

1. Gasket.
  - Apply sealer to the area shown in Figure 18.
2. Oil pan to the cylinder block.
3. Reinforcements (37), nuts, bolts and studs.

**⌚ Tighten**

- Bolts (36) to 25 N·m (18 lb. ft.).
  - Bolts and studs (35) and nuts (38) to 10 N·m (7 lb. ft.).
  - Raise front axle housing assembly.
4. Front axle housing bolts.
  5. Rubber vent tube to front axle housing assembly.
  6. Pitman arm to shaft.
  7. Idler arm to shaft.

### Tighten

- Pitman arm 215 N·m (159 lb. ft.).
- Idler arm 117 N·m (86 lb. ft.).

8. Flywheel inspection cover.
9. Starter motor.
10. Starter motor bolts.
11. Braces at flywheel cover.
12. Front drive shaft and bolts.

### Tighten

- Front drive shaft bolts 62 N·m (46 lb. ft.).

13. Y-pipe to manifold.
14. Converter bolts.
15. Front crossmember and bolts.

### Tighten

- Front crossmember bolts.

16. Front skid plate assembly.
  - Remove supports and lower vehicle.
17. Proper quantity and grade of crankcase oil.
18. Negative battery cable.
19. Dipstick.
  - Start engine and check for leaks.

## OIL PUMP REPLACEMENT

### Remove or Disconnect (Figure 19)

1. Oil pan.
2. Bolt (40).
3. Pump (41).
4. Shaft (42).

### Inspect

- Oil pump pickup tube for looseness. If the tube is loose in the oil pump body, it should be replaced. A loose pickup tube can result in an air leak and loss of oil pressure.

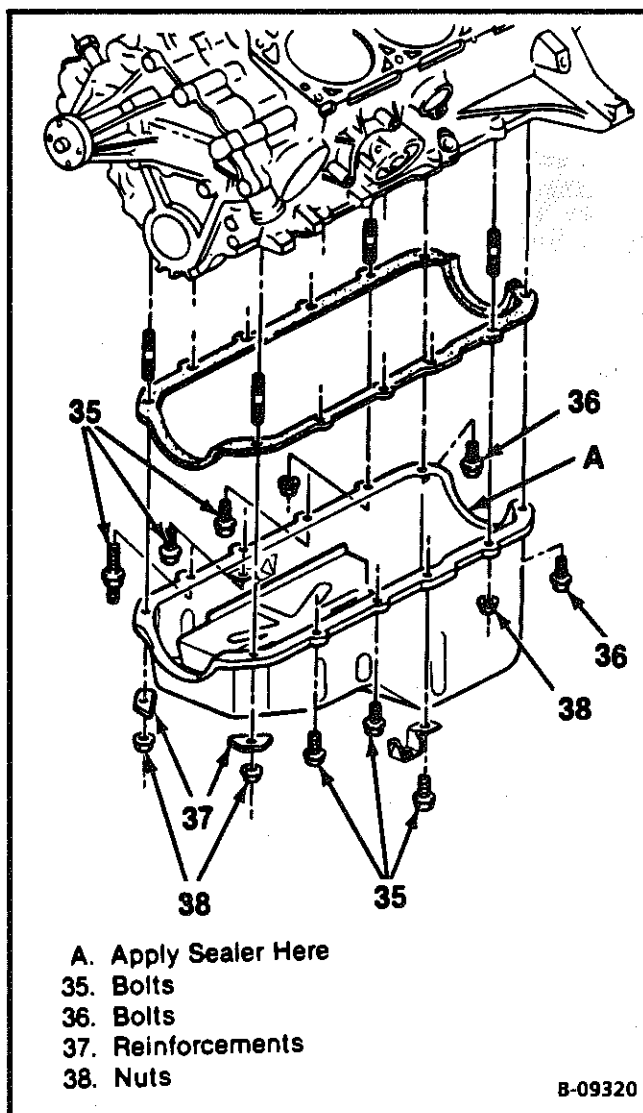
### Install or Connect (Figure 19)

1. Pump (41) and shaft (42) with retainer to the rear main bearing cap.
  - Align the top end or the hexagon extension shaft with the hexagon socket on the lower end of the distributor drive gear.
2. Bolt (40).

### Tighten

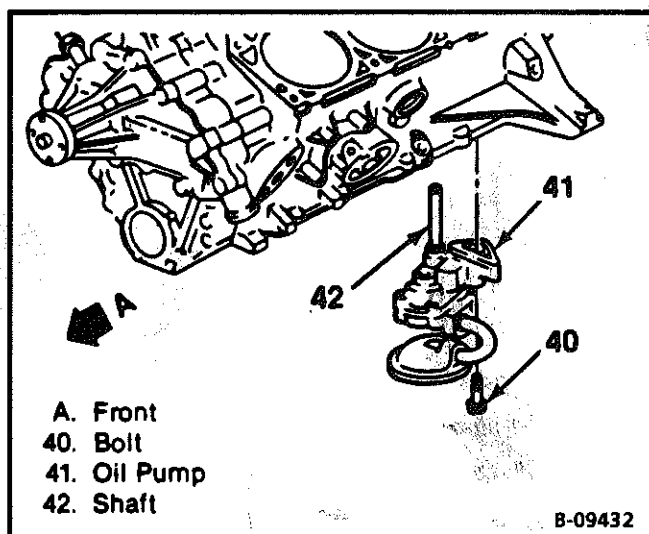
- Bolt (40) to 41 N·m (30 lb. ft.).

3. Oil pan.



B-09320

Figure 18 - Oil Pan Installation



B-09432

Figure 19 - Oil Pump Installation

## REAR CRANKSHAFT OIL SEAL REPLACEMENT

### Remove or Disconnect

1. Transmission.
2. Flexplate.
3. Oil seal.
  - Insert a screwdriver or similar tool through the dust lip at an angle (Figure 20).
  - Pry the seal out and be careful not to damage the outside diameter of the crankshaft.

### Inspect

- Inside diameter of the ore for burrs or nicks.
- Crankshaft for burrs or nicks on the seal contact surface. Repair or replace crankshaft as necessary.

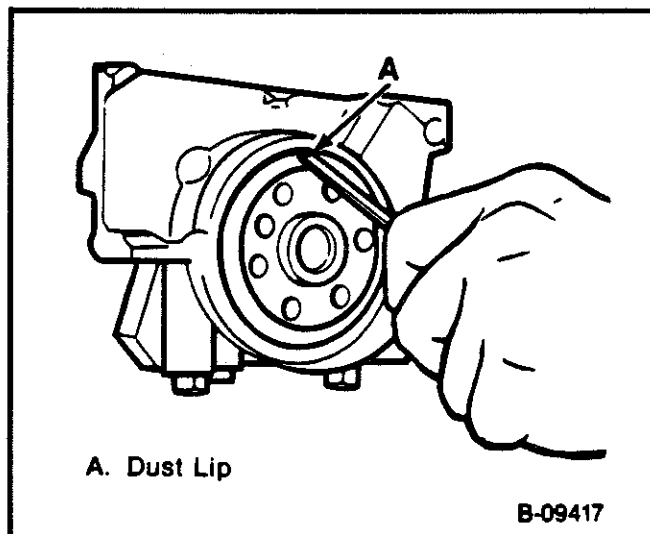


Figure 20 - Removing the Rear Crankshaft Oil Seal

### Install or Connect

Tool Required:

J 34686, Seal Installer

1. Light coat of oil to the inside diameter of the new seal.
2. New seal over the mandril of J 34686 until the dust lip (back of the seal) bottoms against the collar of the tool (Figure 21).
3. J 34686 to the crankshaft by hand or torque the attaching screws to 4.0 N·m (36 lb. in.).
  - Align the dowel pin of J 34686 with the dowel pin hole in the crankshaft.
4. Light coat of oil to the outside diameter of the seal.
5. Seal into the bore.
  - Turn the "T" handle of the tool so the collar pushes the seal into the bore.
  - Turn the handle unit the collar of J 34686 is tight against the cylinder block to seat the seal properly.

- Loosen the "T" handle until it comes to a stop.
  - Remove the attaching screws.
6. Flywheel.
  7. Transmission.
    - Start the engine and check for leaks.

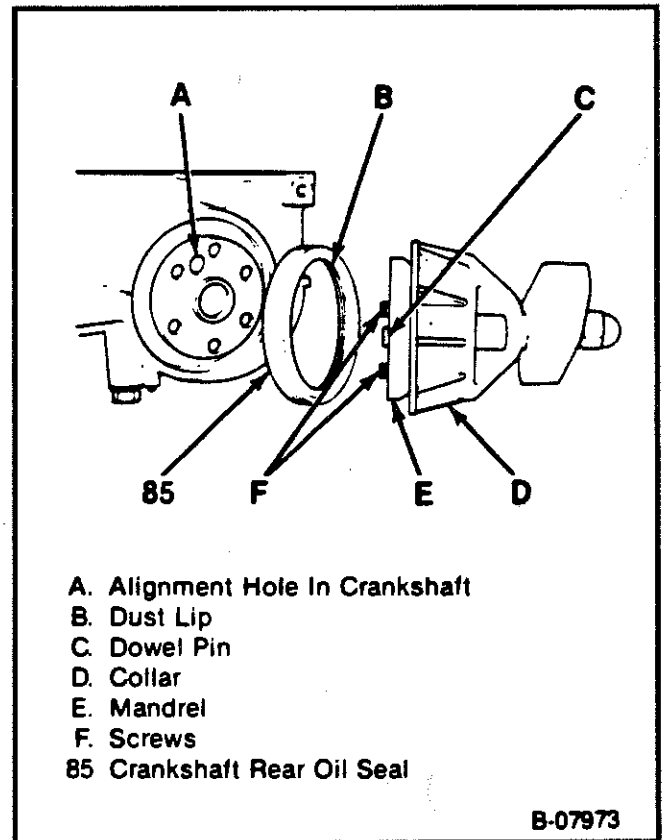


Figure 21 - Installing the Crankshaft Oil Seal

## MEASURING THE CAMSHAFT LOBE LIFT

Measuring lobe lift is similar to checking valve timing. If improper valve operation is indicated, measure the lift of each pushrod in consecutive order and record the readings.

Tool Required:

J 8520 Camshaft Lobe Lift Indicator

1. Remove the rocker arm as outlined previously.
2. Refer to Figure 22. Position the dial indicator (part of J 8520) so the plunger rests on the pushrod end, as shown. Make sure the pushrod is in the lifter socket.
3. Rotate the crankshaft slowly in the direction of rotation until the lifter is on the heel of the cam lobe. At this point, the pushrod will be in its lowest position.
4. Set dial indicator on zero, then rotate the crankshaft slowly, or attach an auxiliary starter switch and "bump" the engine over, until the pushrod is in fully raised position.

**! Important**

- Whenever the engine is cranked remotely at the starter, with a special jumper cable or other means, the distributor primary lead should be disconnected from the coil.
5. Compare the total lift recorded from the dial indicator with specifications.
  6. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
  7. Install the rocker arm and adjust the valves as previously outlined.

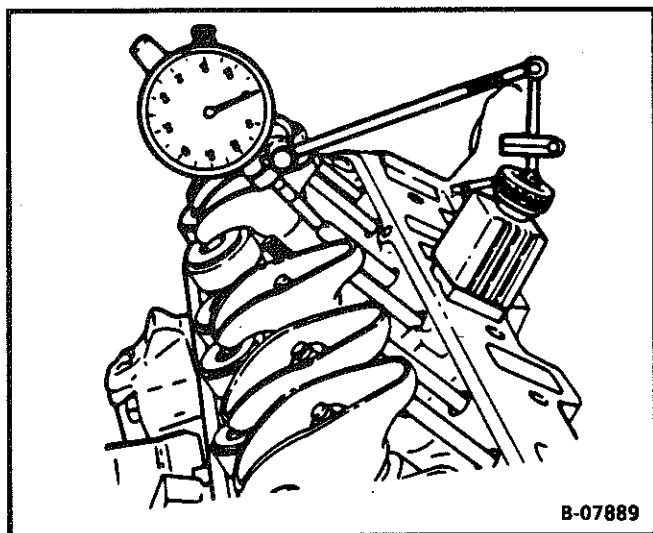


Figure 22 - Measuring Camshaft Lobe Lift

**CAMSHAFT REPLACEMENT****↔ Remove or Disconnect**

1. Upper fan shroud.
2. Radiator.
3. Valve lifters as outlined previously.
4. Crankcase front cover as outlined previously.

**! Important**

- All camshaft bearing journals are the same diameter and care must be exercised in removing the camshaft to avoid bearing damage.
5. Timing chain and sprocket.
  6. Camshaft (Figure 23).

**↔ Install or Connect**

- Coat the camshaft lobes and journals with engine oil according to the Isuzu engine oil recommendation.

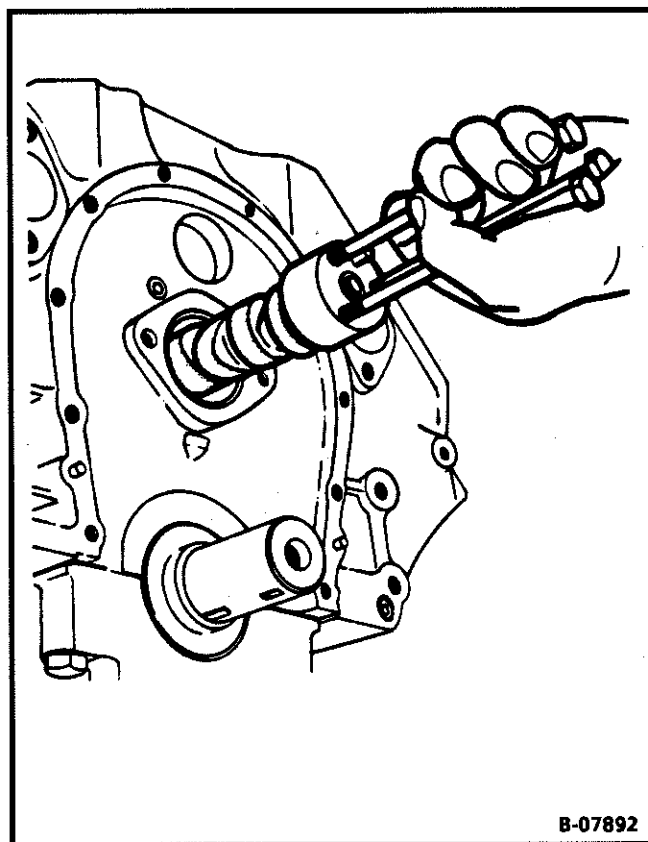


Figure 23 - Replacing the Camshaft (Typical)

- When a new camshaft is installed, install new oil and filter. It is also recommended that all valve lifters be replaced to insure durability of the camshaft lobes and lifter feet.
1. Camshaft.

**! Important**

- All camshaft bearing journals are the same diameter and care must be exercised in installing the camshaft to avoid bearing damage.
2. Timing chain and sprocket as outlined previously.
  3. Crankcase front cover as outlined previously.
  4. Valve lifters as outlined previously.

**CONNECTING ROD AND PISTON REPLACEMENT****↔ Remove or Disconnect**

1. Cylinder heads as outlined previously.
2. Oil pan as outlined previously.
3. Ridge or deposits from the upper end of the cylinder bores.

- Turn the crankshaft until the piston is at BDC.
  - Place a cloth on top of the piston.
  - Perform the cutting operation with a ridge reamer.
  - Turn the crankshaft until the piston is at TDC.
  - Remove the cloth and cuttings.
  - Use a silver pencil or quick drying paint to mark the cylinder number on all pistons, connecting rods and caps. Starting at the front of the crankcase, the cylinders in the right bank are numbered 1-3-5 and the left bank is numbered 2-4-6.
4. Connecting rod cap and bearing.
  5. Connecting rod and piston (Figure 24).
    - Install guide hose over the threads of the rod studs to prevent damage to the bearing journal and rod studs.
  6. Connecting rod bearing

### Cleaning, Inspection And Repair

Clean, inspect and repair or replace the components as necessary. Measure connecting rod bearing clearance, piston clearance, ring clearances, etc. Refer to "Specifications" at the end of this section for information on:

- Connecting rod and piston.
- Piston rings.
- Connecting rod and crankpin.
- Cylinder bores.

### Install or Connect

Tool Required:

J 8037, Ring Compressor

- Make sure the cylinder walls are clean. Lubricate pistons, rings and cylinder walls lightly with engine oil.
1. Connecting rod bearings.
    - Be certain that the bearing inserts are of the proper size.
    - Install the bearing inserts in the connecting rod and connecting rod cap.
    - Lubricate the bearings with engine oil.
  2. Guide hose over the connecting rod studs to protect the crankpin journal.
  3. Connecting rod and piston assemblies into the proper bores.
    - Notch on top of the piston must be toward the front of the engine.
    - Make sure the gap in the oil ring rails is in the up position toward the center of the engine and the gaps of the compression rings are positioned as shown in Figure 25.

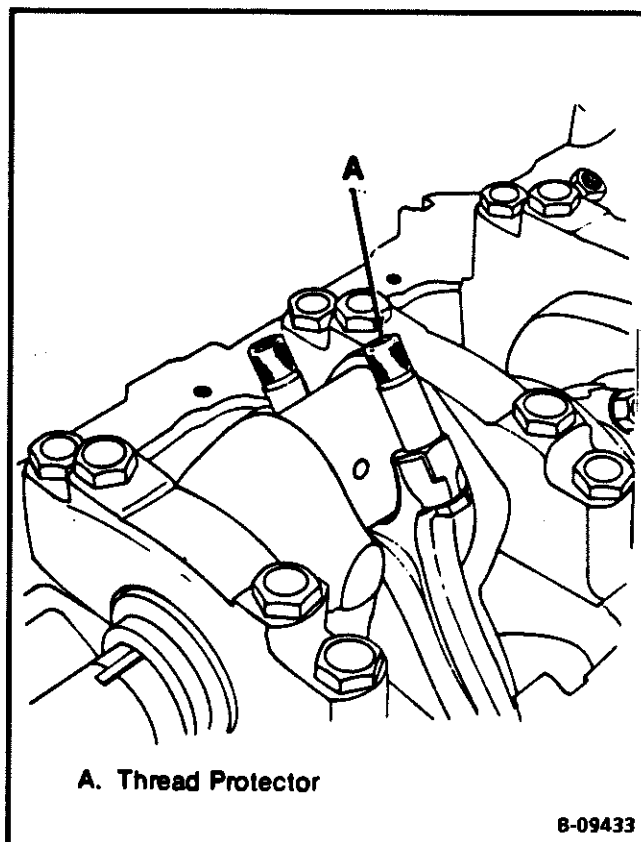


Figure 24 - Replacing the Piston and Connecting Rod (Typical)

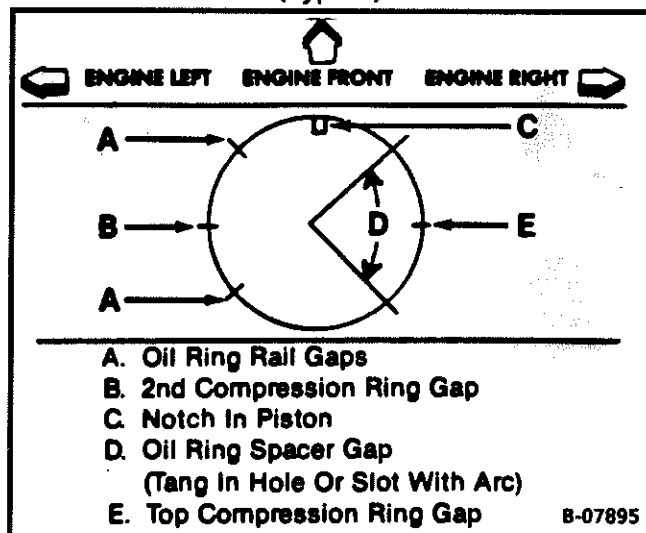


Figure 25 - Piston Ring End Gap Location

- Install with the connecting rod bearing tang slots on the side opposite the camshaft.
- Use J 8037 to compress the rings.
- Use light blows with a hammer handle to tap the piston into its bore (Figure 26). At the same time, guide the connecting rod to the crankpin.
- Hold the ring compressor against the block until all rings have entered the cylinder bore.

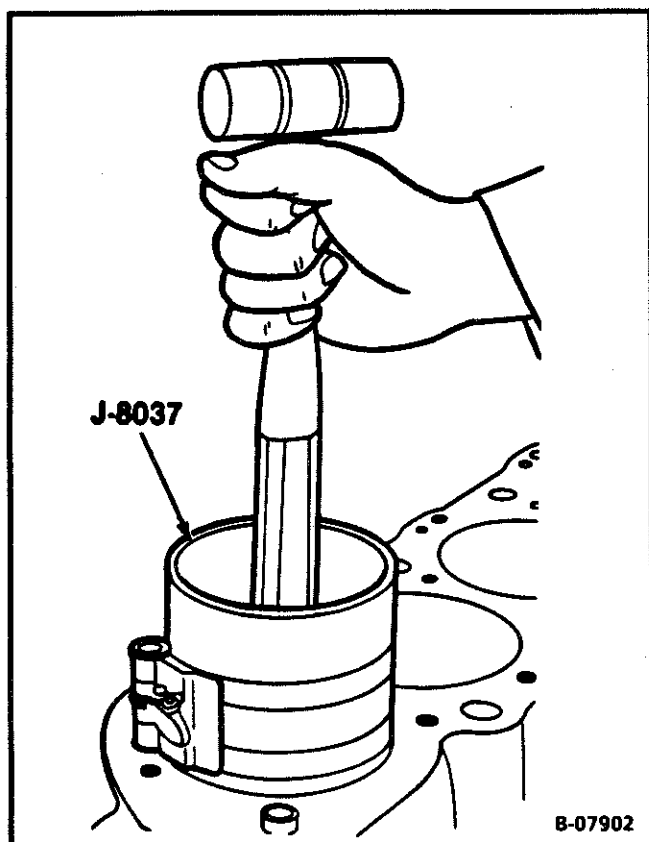


Figure 26 - Installing the Piston

### Important

- Each connecting rod and bearing cap should be marked, beginning at the front of the engine. Cylinders 2, 4 and 6 are at the left bank and 1, 3 and 5 are the right bank. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from block or cylinder to another, new connecting rod bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.

### Measure

- Connecting rod bearing clearance. Refer to the proper unit repair manual.
- Connecting rod cap and bearing.
  - Connecting rod cap nuts.

### Tighten

- Connecting rod cap nuts to 53 N-m (39 lb. ft.).

### Measure

- Connecting rod side clearance. Use a feeler gage between the connecting rod and crankshaft (Figure 27). The correct clearance is 0.006" to 0.025".

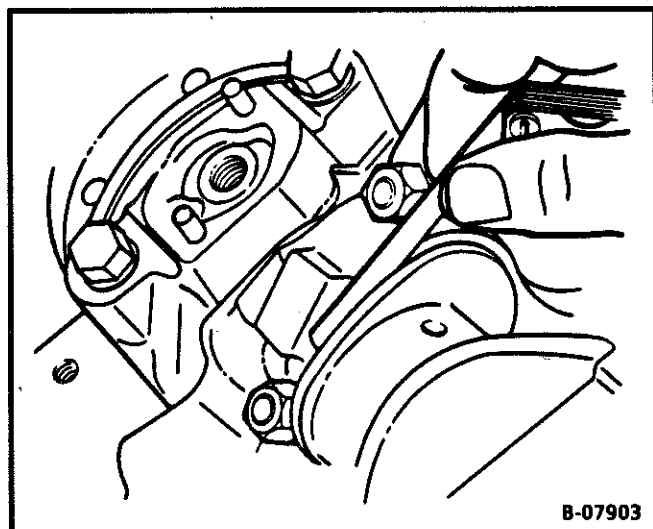


Figure 27 - Measuring Connecting Rod Side Clearance

- Oil pan as outlined previously.
- Cylinder heads as outlined previously.

## MAIN BEARING REPLACEMENT

Main bearings may be replaced without removing the crankshaft.

### Remove or Disconnect

Tool Required:

J 8080, Main Bearing Remover/Installer

- Oil pan as outlined previously.
- Oil pump as outlined previously.
- Spark plugs.
- Main bearing caps.
  - Check the main bearing caps for location marking. Mark the caps if necessary. The caps must be returned to their original locations during assembly.
- Lower main bearing inserts from the main bearing caps.
- Upper main bearing inserts.
  - Insert J 8080 into the crankshaft oil hole (Figure 28).
  - Rotate the crankshaft to turn the bearing insert out of the block.

## Cleaning, Inspection And Repair

Clean, inspect and repair or replace the components as required. Refer to "Specifications" at the end of this section for information on:

- Crankshaft.
- Main and connecting rod bearings.

## ↔ Install or Connect

Tool Required:

J 8080, Main Bearing Remover/Installer

1. Engine oil to bearing inserts of the proper size.
2. Upper main bearing insert.
  - Insert J 8080 into a crankshaft main bearing oil hole (Figure 28).
  - Insert the plain end (without the bearing tang) of the insert between the crankshaft and the notched side of the block.
  - Rotate the crankshaft to roll the insert into the block.
  - Remove J 8080.
  - Inspect for burrs at the oil hole.
3. Lower main bearing inserts to the main bearing caps.
  - Make sure the inserts are of the proper size.
  - Apply engine oil to the bearing inserts.
4. New O-ring into the rear main bearing cap.
5. Thin coat of anaerobic sealant to the rear of the block mating surface or corresponding surface of the rear main bearing cap only.
  - Do not allow sealer on the crankshaft or the seal.
6. Main bearing caps with arrows pointing toward the front of the engine.
7. Main bearing cap bolts.

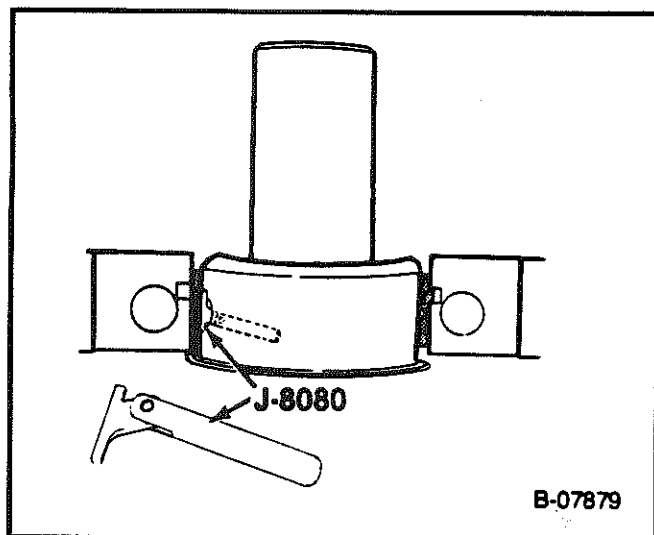


Figure 28 - Removing the Main Bearing Insert

## ⌚ Tighten

- All main bearing caps (except number three cap) to 95 N·m (70 lb. ft.).
- Number three main bearing cap to 15 N·m (11 lb. ft.). Then tap the end of the crankshaft rearward and then forward with a lead hammer to line up the rear main bearing and crankshaft thrust surfaces.
- All main bearing caps to 95 N·m (70 lb. ft.).

## OIL FILTER ADAPTER REPLACEMENT

### ↔ Remove or Disconnect (Figure 29)

1. Wheel and tire.
2. Oil filter.
3. Air cleaner duct.
4. Power steering pump (if equipped).
5. Engine mount through bolt.
6. Engine mount bracket at the block.
  - Raise the engine. Block in position.
7. Oil sending unit connectors.
8. Bolt.
9. Gasket.
10. Oil filter adapter.
11. Gasket.

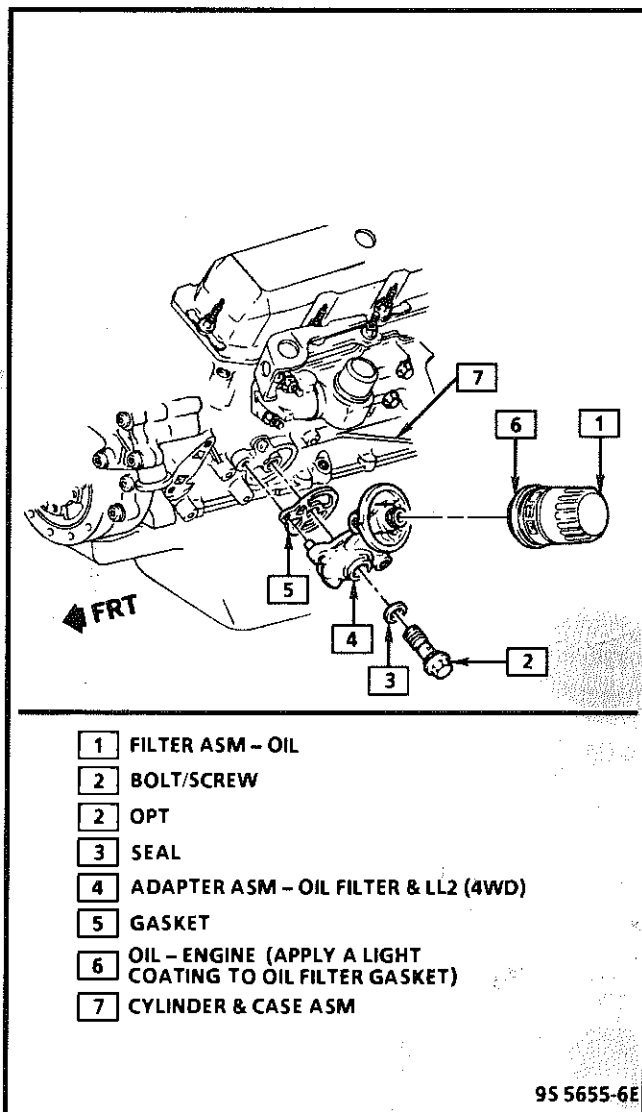


Figure 29 - Oil Filter Adapter Installation

### ↔ Install or Connect (Figures 29)

1. New gasket.
2. Adapter.
3. Gasket.

## 4. Bolt.

### Tighten

- Bolt (50) to 85 N·m (63 lb. ft.).
- 5. Oil sending unit connectors.
- 6. Engine mount bracket.
- 7. Engine mount through bolt.
  - Lower the engine.
- 8. Power steering pump (if equipped).
- 9. Air cleaner duct.
- 10. Oil filter.
- 11. Wheel and tire.

## CRANKSHAFT REPLACEMENT

1. Engine as outlined later.
2. Flywheel (if equipped).
  - Mount the engine in a suitable engine stand.
3. Spark plugs.
4. Crankshaft pulley and torsional damper.
5. Oil pan and oil pump as outlined previously.
6. Timing chain and sprocket as outlined previously.
7. Connecting rod caps.
  - Check the connecting rod caps for cylinder number identification. Mark the caps if necessary.
8. Connecting rods from the crankshaft.
  - Install guide hose over the threads of the rod studs to prevent damage to the bearing journal and rod studs.
9. Main bearing caps as outlined previously.
10. Crankshaft from the cylinder block.

## Cleaning, Inspection And Repair

Clean, inspect and repair or replace the parts as required. Refer to "Specifications" at the end of this section for information on:

- Crankshaft.
- Main and connecting rod bearings.
- Measuring bearing clearance.

### Install or Connect

1. Rear main bearing oil seal in cylinder block and rear bearing cap grooves.
2. Engine oil onto the seal.
  - Keep oil off of the parting line surface.
3. Gasket.
4. Main bearing inserts.
5. Crankshaft.

- Be careful not to damage the bearing surfaces.
- 6. Thin coat of anaerobic sealant (or equivalent) to the rear of the block mating surface or corresponding surface of the rear main bearing cap only.
  - Do not allow sealer on the crankshaft or the seal.
- 7. New O-ring to the rear main bearing cap.
- 8. Main bearing caps with arrows pointing toward the front of the engine.
- 9. Main bearing cap bolts.

### Tighten

- All main bearing caps (except number three cap) to 95 N·m (70 lb. ft.).
- Number three main bearing cap to 15 N·m (11 lb. ft.). Then tap the end of the crankshaft rearward and then forward with a lead hammer to line up the rear main bearing and crankshaft thrust surfaces.
- All main bearing caps to 95 N·m (70 lb. ft.).

## FLYWHEEL REPLACEMENT

### Remove or Disconnect

1. Clutch.
  - Refer to "Clutch" (Section "7C").
2. Bolts.
3. Flywheel.

### Clean

- Mating surfaces or crankshaft and flywheel. Remove any burrs.

### Inspect

- Flywheel for burning, scoring, warping and wear. Replace the flywheel if necessary. Do not machine the flywheel.
- Flywheel ring gear for broken teeth.

### Install or Connect

1. Flywheel.
2. Bolts.

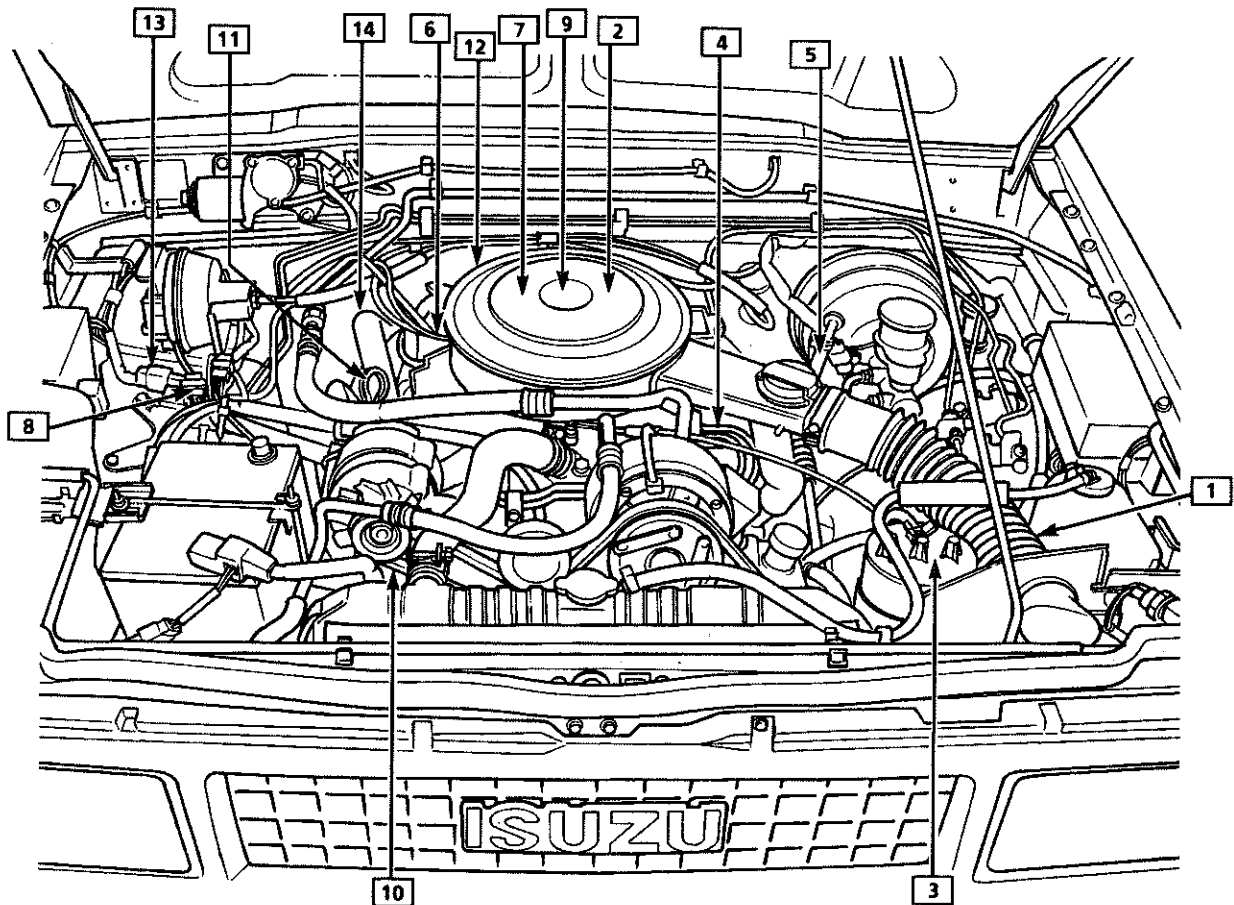
### Tighten

- Bolts to 70 N·m (52 lb. ft.).
- 3. Clutch.
  - Refer to "Clutch" (Section "7C").

## V6 - ENGINE ASSEMBLY

### REMOVAL AND INSTALLATION

#### ENGINE COMPARTMENT PARTS LOCATION



**1** AIR CLEANER DUCT HOSE

**2** AIR CLEANER

**3** CANISTER

**4** FUEL LINES AND HOSES  
(UNDER THE AIR CLEANER DUCT)

**5** MASTER VAC VACUUM HOSE

**6** VACUUM HOSES  
(BEHIND ENGINE AND OTHER)

**7** THROTTLE CABLE AND BRACKET  
(NEAR THROTTLE BODY)

**8** ENGINE HARNESS BULK HEAD CONNECTORS

**9** THROTTLE BODY INJECTION CONNECTOR AND WIRES  
(UNDER THE AIR CLEANER DUCT)

**10** GROUND STRAP  
(UNDER THE GENERATOR)

**11** GENERATOR HARNESS AND CONNECTOR

**12** MAIN HARNESS AND CONNECTOR  
(BEHIND THE AIR CLEANER)

**13** VACUUM SWITCHING VALVE CONNECTOR

**14** HEATER HOSES, BRACKET AND CLIPS  
(ENGINE SIDE)

12-8-88  
95 6284-6E

Figure 30 - V6 Engine Assembly

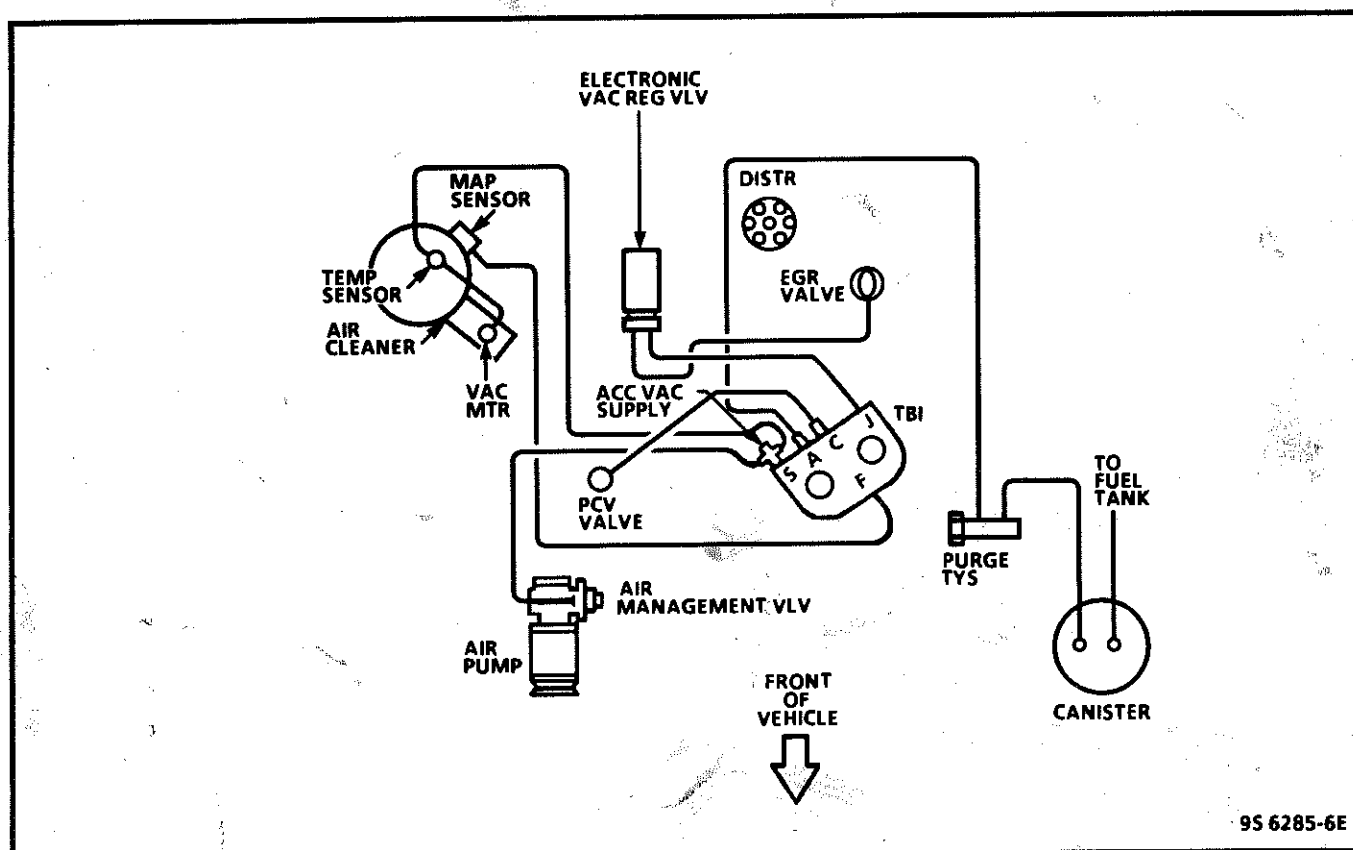


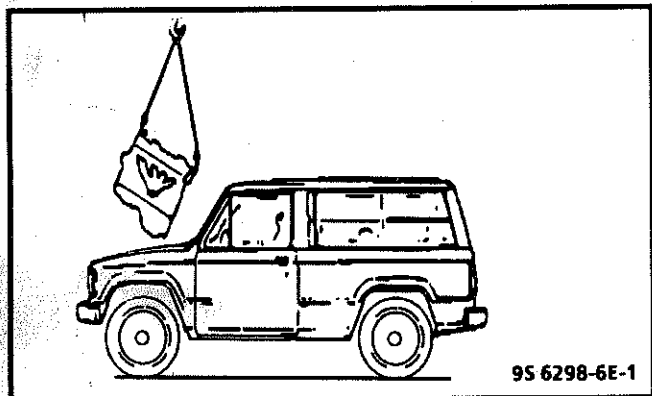
Figure 31 - Vacuum Hose Touting Diagram

## ENGINE REPLACEMENT

### ! Important

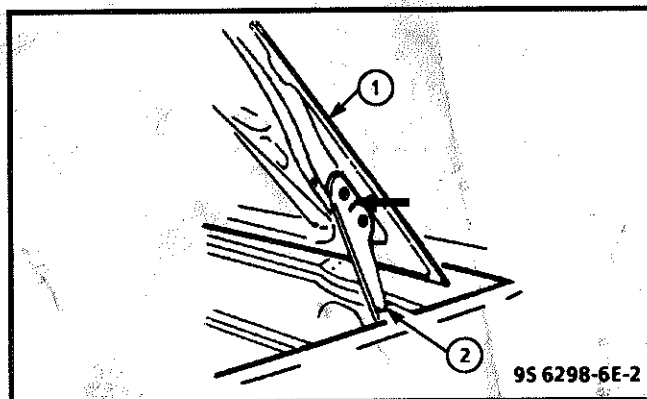
#### Operations - Removal

- Carefully remove the piping, hose, wiring harness connectors, control cables and control rods from the engine.  
When disconnecting vacuum hoses, use tags to identify how they should be reconnected.
- Remove the clutch slave cylinder, the back up lamp switch connector and the speedometer cable from the transmission.
- Separate transmission from engine before removing engine from vehicle.



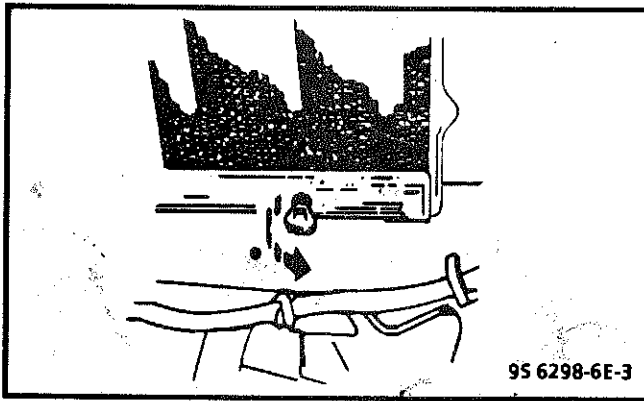
#### 1. Engine hood.

- Mark the engine hood (1) and the engine hood hinge (2) before removing the engine hood. This will facilitate installation of the engine hood to its original position.



#### 2. Coolant.

- Remove three bolts and one nut to remove the cover from under the chassis.
- Remove the water drain plug (at the left side of engine) and the radiator drain cock and allow the coolant to drain completely.

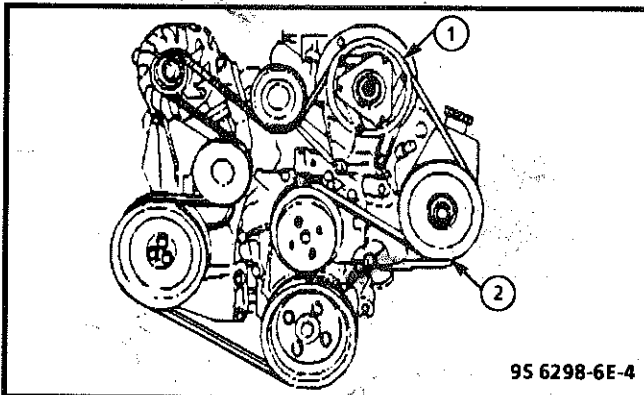


If long life coolant is used, drain the coolant into a clean plastic container for reuse.

### 3. Radiator.

- Disconnect the radiator upper hose from the radiator side.
- Disconnect the radiator lower hose from the engine side.
- Remove the cooling fan and the fan clutch nuts.
- Remove the radiator together with cooling fan. Be careful not to damage the radiator core.
- Cooling fan belt and the fan pulley.

### 4. Air compressor with bracket and hoses.



### 5. Power steering oil pump with bracket and hoses.

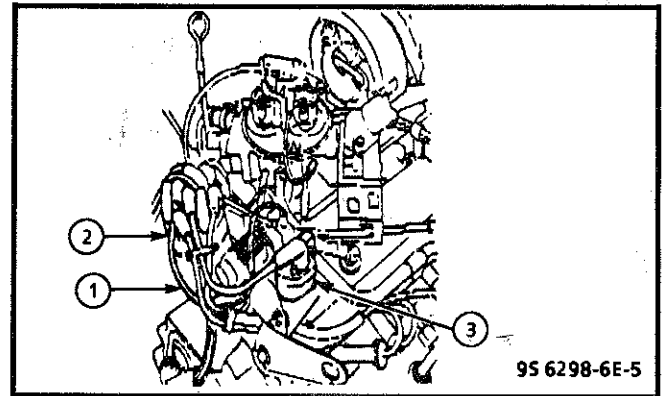
- Remove the air compressor hoses from the air compressor (1).
- Remove the air compressor and the bracket from the engine.
- Remove the power steering oil pump hoses from the oil pump (2).
- Remove the oil pump and the bracket from the engine.

### 6. Distributor cap with spark plug wire.

- Disconnect the spark plug wire (1) from the spark plug.
- Remove the distributor cap (2) together with spark plug wire from the distributor.
- Remove the ignition coil (3) from the engine.

### 7. Gear shift lever.

- Place the gear shift lever in the neutral position.
- Remove the floor mat (if required).
- Pull the gear shift lever grommet (1) and the dust cover (2) to the top of the gear shift lever.
- Remove the gear shift lever cover bolt (3).
- Remove the gear shift lever (4).

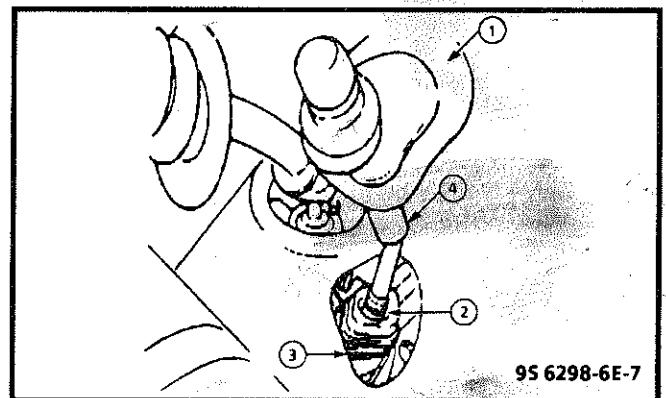


**NOTE:** Cover the gear shift lever hole to prevent the entry of foreign material into the transmission case.

### 8. Transfer change lever.

Perform this procedure after removing the gear shift.

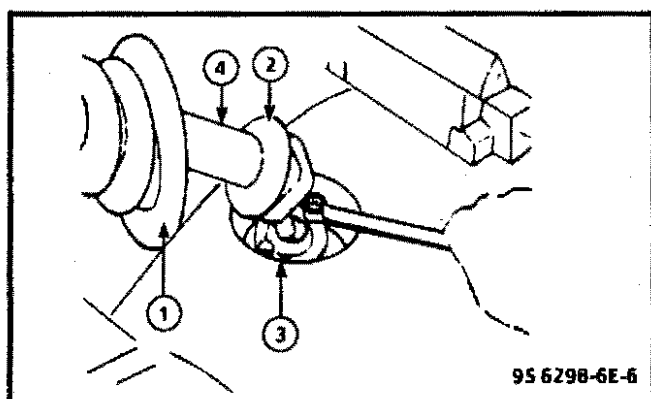
- Place the transfer change lever in the "2H" position.
- Pull the transfer change lever grommet (1) and the dust cover (2) to the top of the transfer change lever.
- Remove the retainer change lever (4) along with the retainer and ball seat cover.



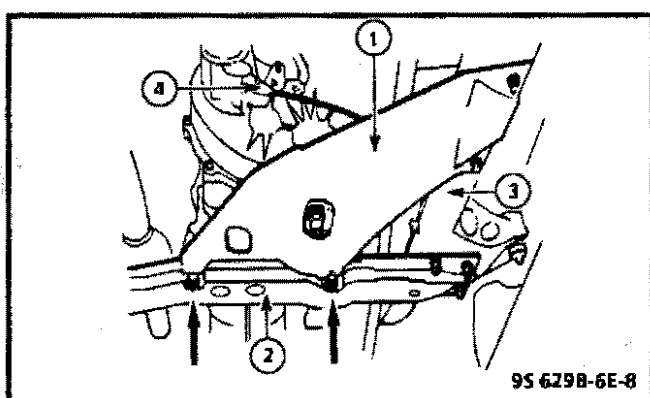
**NOTE:** Cover the transfer change lever hole to prevent the entry of foreign material into the transfer case.

### 9. Transfer under cover.

- Remove the transfer under cover (1) from the transmission mounting member (2) and the side member (3).



- b. Disconnect the speedometer cable (4) from the transmission side.
- c. Remove the transmission harness and the connectors.



10. Front exhaust pipe.

- a. Remove the O<sub>2</sub> sensor from the center exhaust pipe.
- b. Disconnect the front exhaust pipe at the exhaust manifold side and the center exhaust pipe side (Catalytic converter side).

It is not necessary to pull out the exhaust pipe from the chassis.

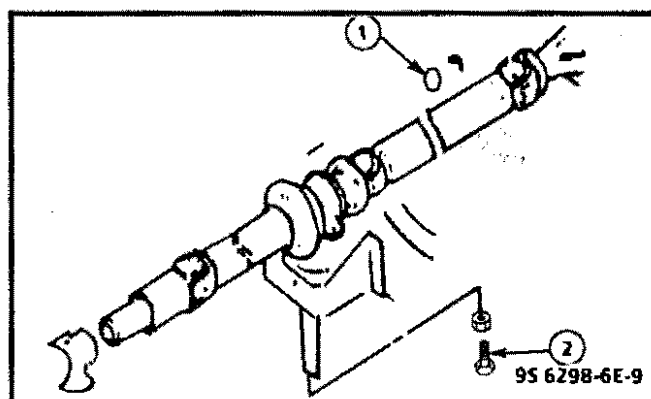
11. Rear propeller shaft.

- a. Remove the 2nd propeller shaft flange yoke bolts at the differential side (1).
- b. Remove the center bearing retainer bolts (2).
- c. Remove the 1st and 2nd propeller shaft with the center bearing.

Pull the 1st and 2nd propeller shaft assembly toward the rear of the vehicle until the 1st propeller shaft spline yoke is free of the No. 4 crossmember.

Insert the rear cover plug to the rear cover.

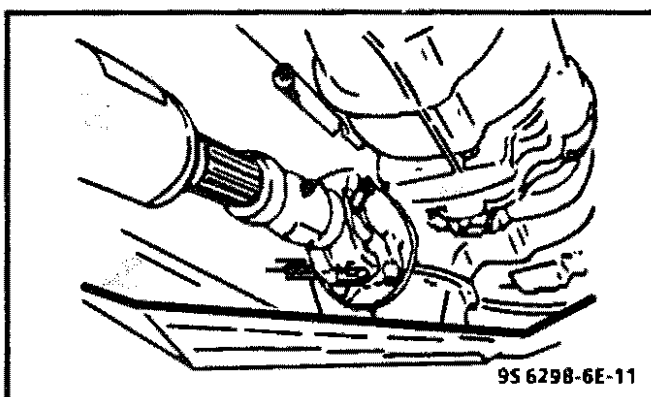
This will prevent oil leak from the transmission rear cover.



12. Front propeller shaft.

Remove the splined yoke flange bolt at the transfer case side.

Do not allow the splined yoke to fall away from the front propeller shaft.



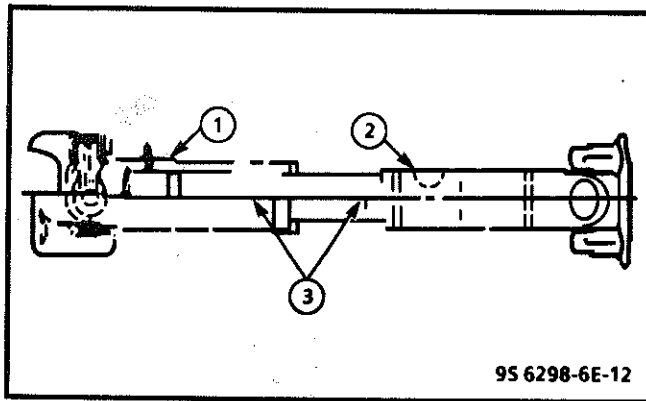
If the splined yoke should fall away from the front propeller shaft, align the setting marks (3) on the splined yoke (1) and the front propeller shaft (2) to reassemble the two parts.

The setting marks are punched circles approximately 3mm (0.12") in diameter.

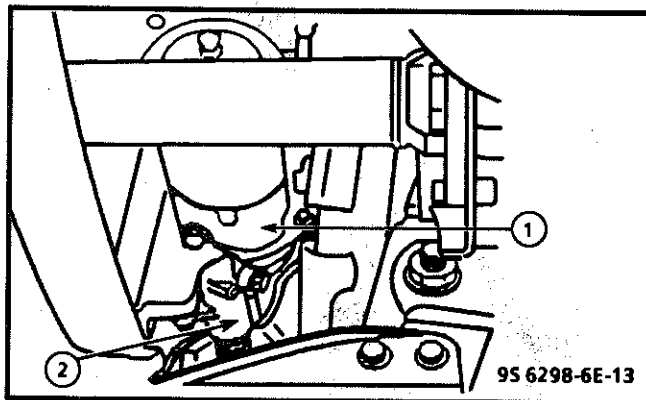
13. Starter motor.

14. Clutch slave cylinder.

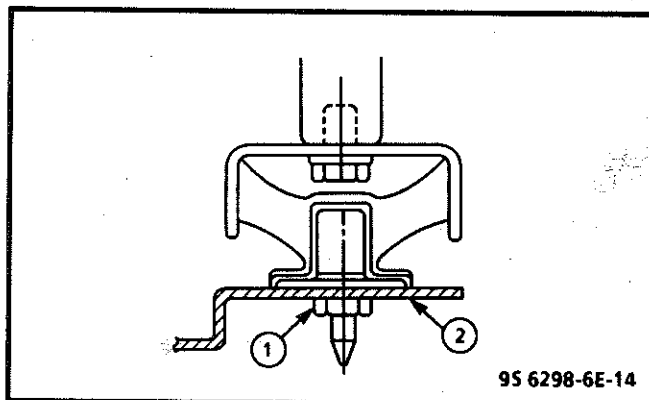
- a. Remove the starter motor from the transmission case.



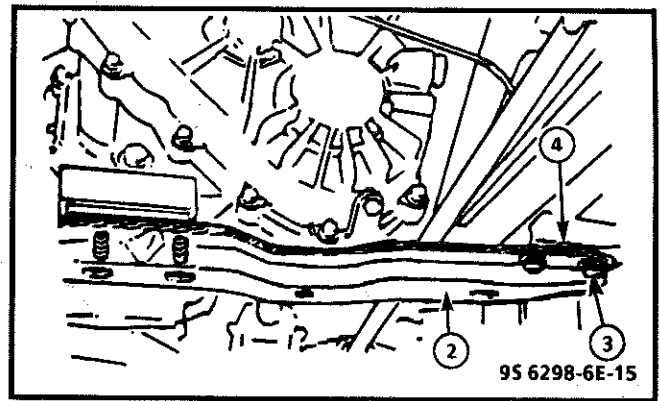
- b. Remove the clutch slave cylinder from the transmission case.



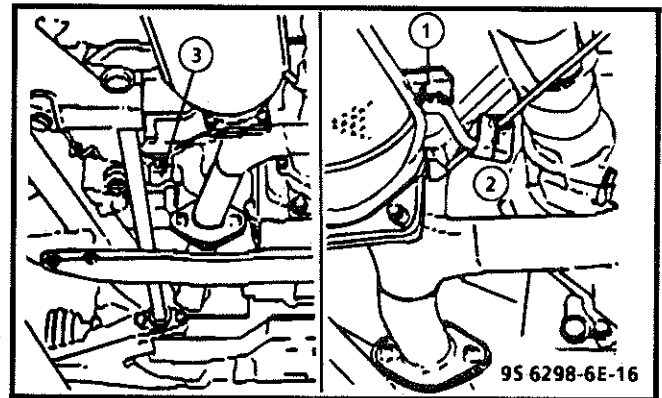
15. Engine rear mounting.
- Attaching the lifting wire to both ends of the engine lifting hanger.
  - Support the transmission with a transmission jack.
  - Remove the rear engine mounting nuts (1) from the transmission mounting member (2).



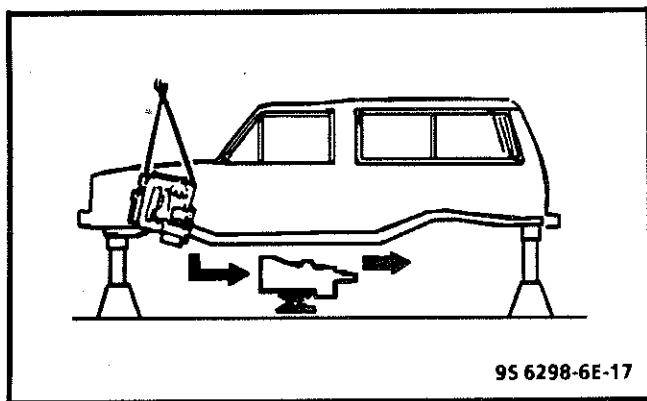
- Loosen the mounting member bolts (3).
- Remove the mounting member from the sidemembers (4).



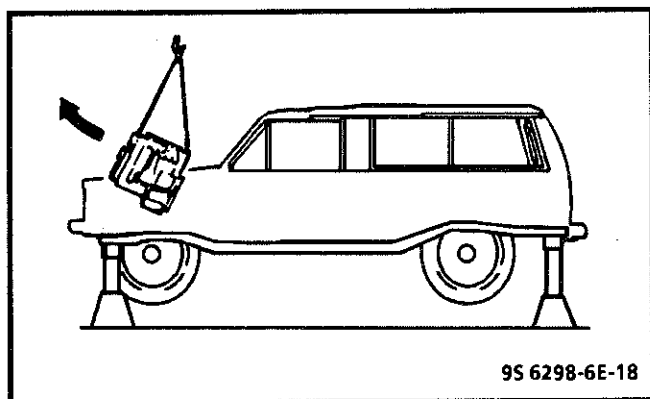
16. Catalytic converter mounting.
17. Parking brake cable bracket.
- Disconnect the catalytic converter mounting rubber (1) and the parking cable grommet (2).
  - Remove the parking brake cable bracket (3).



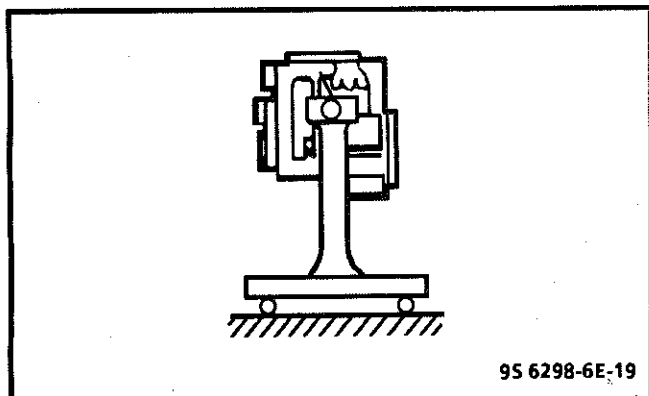
18. Transmission with transfer case.
- The removal of the transmission will require the cooperative efforts of two mechanics.
- Operate the transmission jack to slowly lower the transmission.
  - Remove the transmission nuts and bolts from the engine rear plate.
  - Carefully pull the transmission with the transmission jack toward the rear of the vehicle.
  - Remove the transmission with the transfer case from the engine.
  - Carefully pull the transmission jack with the transmission from the beneath the vehicle.
19. Engine.
- Remove the engine rear plate.
  - Remove the engine front mounting nuts and the bolts attaching the mounting to the sidemembers.
  - Operate the hoist to slightly raise the engine. The front of the engine should be held slightly higher than the rear. Be careful not to damage the brake pipe and the fuel pipe.



- d. Continue to slowly raise the engine from the engine compartment. Hold the front of the engine higher than the rear.



- e. Place the engine on an engine stand.



## Important

Operation - Installation

- To install the engine in the vehicle, reverse the removal procedure.

## Inspect

Preparation for engine installation.

- Check the harness for damage and correct or replace with new ones as necessary.
- Check the engine mounting rubber for looseness or damage and tighten or replace with new ones as necessary.

## Inspect

Steps to be followed after engine installation.

- Fill the engine cooling system.
- Fill the engine crankcase with engine oil.
- Start and let the engine run at idle and check for leakage.

## SPECIFICATIONS

### TORQUE SPECIFICATIONS

| Item                             | N·m | Lb. Ft. |
|----------------------------------|-----|---------|
| Rocker Arm Cover Bolts and Studs | 8   | 6       |
| Intake Manifold Bolts            | 31  | 23      |
| Exhaust Manifold Bolts           | 34  | 25      |
| Cylinder Head Bolts              | 55  | 40      |
| Torsional Damper Bolt            | 95  | 70      |
| Timing Chain Damper              | 21  | 15      |
| Front Cover Bolts                | 24  | 18      |
| Oil Pan Bolts (Rear Two)         | 25  | 18      |
| Oil Pan Bolts, Studs and Nuts    | 10  | 7       |
| Oil Pump Bolt                    | 41  | 30      |
| Camshaft Sprocket Bolts          | 23  | 17      |
| Connecting Rod Cap Nut           | 53  | 39      |
| Oil Filter Adapter               | 85  | 63      |
| Main Bearing Cap Bolts           | 95  | 70      |
| Flywheel Bolts                   | 70  | 52      |
| Spark Plugs                      | 30  | 22      |
| Water Outlet Bolts               | 21  | 15      |
| Water Pump Nut                   | 10  | 7       |
| Water Pump Bolt (M6 × 1.0)       | 10  | 7       |
| Water Pump Bolts (m8 × 1.25)     | 24  | 18      |
| EGR Valve                        | 25  | 18      |

## SPECIFICATIONS ENGINE SPECIFICATIONS

All Specifications are in MILLIMETERS unless otherwise noted

| GENERAL DATA:                                       |                     |                                                                                      |                 |
|-----------------------------------------------------|---------------------|--------------------------------------------------------------------------------------|-----------------|
| Type                                                |                     | 60° V-6                                                                              |                 |
| Displacement                                        |                     | 2.8L                                                                                 |                 |
| RPO                                                 |                     | LL2                                                                                  |                 |
| Bore                                                |                     | 89.0                                                                                 |                 |
| Stroke                                              |                     | 76.0                                                                                 |                 |
| Compression Ratio                                   |                     | 8.9:1                                                                                |                 |
| Firing Order                                        |                     | 1-2-3-4-5-6                                                                          |                 |
| Oil Pressure                                        |                     | 69 kPa @ 500 RPM; 205-380 kPa @ 2000 RPM<br>(10 psi @ 500 RPM; 30-55 psi @ 2000 RPM) |                 |
| CYLINDER BORE:                                      |                     |                                                                                      |                 |
| Diameter                                            |                     | 88.992-89.070                                                                        |                 |
| Out Of Round                                        |                     | 0.02 (Maximum)                                                                       |                 |
| Taper—Thrust Side                                   |                     | 0.02 (Maximum)                                                                       |                 |
| PISTON:                                             |                     |                                                                                      |                 |
| Clearance                                           |                     | 0.017-0.043                                                                          |                 |
| PISTON RING:                                        |                     |                                                                                      |                 |
| C<br>O<br>M<br>P<br>R<br>E<br>S<br>S<br>I<br>O<br>N | Groove<br>Clearance | Top                                                                                  | 0.030-0.070     |
|                                                     |                     | Second                                                                               | 0.040-0.095     |
|                                                     | Gap                 | Top                                                                                  | 0.25-0.50       |
|                                                     |                     | Second                                                                               | 0.25-0.50       |
| O<br>I<br>L                                         | Groove<br>Clearance |                                                                                      | 0.199 (Maximum) |
|                                                     | Gap                 |                                                                                      | 0.51-1.40       |
| PISTON PIN:                                         |                     |                                                                                      |                 |
| Diameter                                            |                     | 22.9937-23.0015                                                                      |                 |
| Clearance                                           |                     | 0.0065-0.0091                                                                        |                 |
| Fit In Rod                                          |                     | 0.0187-0.0515 (Press)                                                                |                 |

F-05523

# **SPECIFICATIONS** **ENGINE SPECIFICATIONS (CONTINUED)**

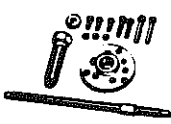
All Specifications are in MILLIMETERS unless otherwise noted

## **CRANKSHAFT**

|                                |                    |        |                                               |
|--------------------------------|--------------------|--------|-----------------------------------------------|
| Main Journal                   | Diameter - 3 Dots  |        | 67.241-67.249                                 |
|                                | Diameter - 2 Dots  |        | 67.249-67.257                                 |
|                                | Diameter - 1 Dot   |        | 67.257-67.265                                 |
|                                | Taper              |        | 0.005 (Maximum)                               |
|                                | Out of Round       |        | 0.005 (Maximum)                               |
| Main Bearing Clearance         |                    |        | 0.041-0.081                                   |
| Crankshaft End Play            |                    |        | 0.06-0.21                                     |
| Crankpin                       | Diameter — 2 Dots  |        | 50.758-50.771                                 |
|                                | Diameter — 1 Dot   |        | 50.771-50.784                                 |
|                                | Taper              |        | 0.005 (Maximum)                               |
|                                | Out of Round       |        | 0.005 (Maximum)                               |
| Rod Bearing Clearance          |                    |        | 0.035-0.095                                   |
| Rod Side Clearance             |                    |        | 0.16-0.64                                     |
| CAMSHAFT:                      |                    |        |                                               |
| Lift                           | Intake             |        | 6.65                                          |
|                                | Exhaust            |        | 6.94                                          |
| Journal Diameter               |                    |        | 47.44-47.49                                   |
| Journal Clearance              |                    |        | 0.026-0.101                                   |
| VALVE SYSTEM:                  |                    |        |                                               |
| Lifter                         |                    |        | Hydraulic                                     |
| Rocker Arm Ratio               |                    |        | 1.50:1                                        |
| Valve Lash                     | Intake             |        | One And One Half Turns<br>Down From Zero Lash |
|                                | Exhaust            |        |                                               |
| Face Angle (Intake & Exhaust)  |                    |        | 45°                                           |
| Seat Angle (Intake & Exhaust)  |                    |        | 46°                                           |
| Seat Runout (Intake & Exhaust) |                    |        | 0.05                                          |
| Seat Width                     | Intake             |        | 1.25-1.50                                     |
|                                | Exhaust            |        | 1.60-1.90                                     |
| Stem Clearance                 |                    |        | 0.026-0.068                                   |
| Valve Spring                   | Free Length        |        | 48.5                                          |
|                                | Pressure<br>N @ mm | Closed | 391 @ 40                                      |
|                                |                    | Open   | 867 @ 30                                      |
|                                | Installed height   |        | 40                                            |
| Valve Spring Damper            | Free Length        |        | 47.2                                          |
|                                | Approx. # of Coils |        | 4                                             |

F-05525

## SPECIAL TOOLS

- |    |                                                                                     |          |     |                                                                                       |           |
|----|-------------------------------------------------------------------------------------|----------|-----|---------------------------------------------------------------------------------------|-----------|
| 1. |    | J-3049   | 9.  |    | J-23523-E |
| 2. |    | J-5590   | 10. |    | J-23590   |
| 3. |    | J-5825-A | 11. |    | J-24420-B |
| 4. |    | J-5892-A | 12. |    | J-29113   |
| 5. |   | J-8037   | 13. |   | J-34686   |
| 6. |  | J-8080   | 14. |  | J-35468   |
| 7. |  | J-8520   |     |                                                                                       |           |
| 8. |  | J-9290-1 |     |                                                                                       |           |
- 
1. Hydraulic Lifter Remover (Plier Type)
  2. Crankshaft Sprocket Installer
  3. Crankshaft Sprocket Puller
  4. Valve Spring Compressor
  5. Ring Compressor
  6. Main Bearing Remover/Installer
  7. Camshaft Lobe Lift Indicator
  8. Hydraulic Lifter Remover (Slide Hammer Type)
  9. Puller
  10. Air Adapter
  11. Puller
  12. Torsional Damper Installer
  13. Seal Installer
  14. Seal Installer

B-09306

## SECTION 6B1

# ENGINE COOLING

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## GENERAL DESCRIPTION

### COOLING SYSTEM

These vehicles have a pressure type engine cooling system with thermostatic control of the coolant circulation. The cooling system is sealed by a pressure type radiator cap that causes the system to operate at a higher than atmospheric pressure. The high pressure operation raises the boiling point of the coolant, thereby increasing the cooling efficiency of the radiator. The 105 kPa (15 psi) pressure cap raises the boiling point of the coolant to about 125°C (257°F) at sea level.

The pressure-vacuum valve radiator cap allows the coolant to expand through the pressure valve in the center of the cap without building unnecessary pressure. The expanding coolant flows into the coolant reservoir. The vent valve closes due to expansion and coolant flow (the nominal 105 kPa (15 psi) pressure will not be reached until the system is working at maximum capacity). Any air or vapor in the cooling system will be forced to the coolant reservoir and out through the vent tube at the top of the reservoir. As the system cools, the extra coolant in the reservoir will be drawn back to the radiator through the vent valve. In this manner, the radiator will keep itself full at all times.

### COOLANT RECOVERY TANK

A "see-through" plastic reservoir, similar to the familiar windshield washer jar, is connected to the radiator by a hose. As the vehicle is driven, the coolant is heated and expands. The portion of the fluid displaced by this expansion flows from the radiator into the recovery bottle. When the vehicle is topped and the coolant cools and contracts, vacuum draws the displaced coolant back into the radiator. Thus, the radiator is kept filled with coolant to the desired level at all times resulting in increased cooling efficiency. Keep the coolant level between "ADD" and "FULL" marks on the recovery bottle. These marks are about one liter (one quart) apart. Use a 44/56 (50/50 in Canada) mixture of ethylene glycol anti-freeze and water to keep the system at the "FULL" mark when hot.

### WATER PUMP

#### 2.8L

The die cast pump is of the centrifugal vane impeller type. The impeller turns on a steel shaft that rotates in a permanently lubricated ball bearing.

The pump inlet is connected to the bottom of the radiator by means of a rubber hose. From the pump, coolant passes through the engine front cover into the coolant passages in the block to pick-up excess engine heat.

## THERMOSTAT

A peller-type thermostat in the coolant outlet passage controls the flow of engine coolant to provide fast engine warm-up and to regulate coolant temperatures. A wax pellet element in the thermostat expands when heated and contracts when cooled. The pellet is connected through a piston to a valve. When the pellet is heated, pressure is exerted against a rubber diaphragm which forces the valve to open. As the pellet cools, the contraction allows a spring to close a valve. Thus, a valve remains closed while the coolant is cold, preventing circulation of coolant through the radiator. At this point, coolant circulates throughout the engine to warm it quickly and evenly.

As the engine warms, the pellet expands and the thermostat valve opens permitting coolant to flow through the radiator where heat is passed through the radiator walls. This opening and closing of the thermostat permits enough coolant to enter the radiator to keep the engine within operating limits.

## GENERAL DIAGNOSIS

### SYSTEM CHECKS

#### Exhaust Leaks

To check for exhaust leaking into the cooling system, drain the system until the coolant level stands just above the top of the cylinder heads, then disconnect the radiator upper hose and remove the thermostat and fan belt. Start the engine and accelerate several times. At the same time note any appreciable coolant rise or the appearance of bubbles which may indicate that exhaust gases are leaking into the cooling system.

**NOTICE:** A worn head gasket may allow exhaust gases to leak into the cooling system. This can damage the cooling system as the gases combine with the water to form acids which are harmful to the radiator and engine.

#### Water Pump

Check water pump operation by running the engine while squeezing the upper radiator hose. When the engine warms a pressure surge should be felt. Check for a plugged vent hole in the pump.

#### Radiator

Test for restrictions in the radiator by warming the engine up and then turning the engine "OFF" and feeling the radiator. The radiator should be hot along the left side and warm along the right side, with an even temperature rise from right to left. Cold spots in the radiator indicated clogged sections.

## Thermostat

Make an operational check of the thermostat by hanging the thermostat on a hook in a 33% glycol solution, -12°C (10°F) below the temperature indicated on the valve. With the valve submerged and the coolant agitated, the valve should close.

## Overheat and/or Noise

Restrictions in the cooling system can cause engine overheating and/or cooling system noise.

Components prone to this condition are the cylinder head, water pump, block, thermostat housing and inlet manifold. Symptoms are:

- Engine may make snapping/cracking noises.
- Heater core may gurgle or surge.
- Radiator hoses may collapse and expand.
- Overheat light may or may not come "ON".

Symptoms are caused by coolant boiling at some localized area and may be noticed after extended idling and/or while driving. Determine which side of the engine is involved and whether it is at the front or rear of the engine.

## Diagnosis/Inspection

1. Isolate the area by probing the engine with a sounding bar (large screwdriver).

**CAUTION:** The radiator cap should be removed from a cool engine only. If the radiator cap is removed from a hot cooling system, serious personal injury may result.

2. With the radiator cap removed, observe the coolant being circulated in the radiator. Feel the front area of the radiator for cold spots which indicate blockage. Blocked radiators generally occur on units that have accrued miles and not on new vehicles.
3. Inspect the thermostat to see if it opens.
4. Inspect the thermostat housing to make sure it is free of obstructions.
5. Remove the water pump from the vehicle and remove the back cover on the pump. Inspect all internal passages using a flashlight.
6. Inspect the crossover at the front of the inlet manifold. This entire passage can be seen only with the thermostat removed.
7. Remove the heads and check the block with a pen light flashlight. Never replace a block unless the restricted area can be SEEN.
8. Inspect the heads if the problem is not found. Heads with blocked coolant passages generally have more than one area that is blocked. Look for signs of overheat discoloration (a dark blue or black are).

If none are found, look in the coolant passages for blockage and probe all accessible passages.

The head is intricate and all the passages cannot be reached. Use a substantial wire to go through or around a partially blocked area. If nothing is found by visual inspection and probing, inspect the passages for a rough, ragged appearance. The roughest internal passages are probably the ones that are blocked.

Replace a blocked or suspect head and inspect the replacement head before installation.

## FAN CLUTCH DIAGNOSIS

### NOISE

Fan noise is sometimes evident under the following normal conditions.

- When the clutch is engaged for maximum cooling.
- During the first few minutes after start-up until the clutch can re-distribute the silicone fluid back to its normal disengaged operating condition (after overnight settling).

Fan noise or an excessive roar will occur continuously. If the fan cannot be rotated by hand or there is a rough grating feel as the fan is turned, replace the clutch.

### LOOSENESS

Check a loose fan assembly for wear and replace as necessary. Under various temperature conditions, there is a visible lateral movement at the tip of the fan blade. Approximately 6.5 mm ( $\frac{1}{4}$ " maximum lateral movement measured at the fan tip is allowable. This is not cause for replacement.

### SILICONE FLUID LEAKS

The fan clutch operation is not affected by small fluid leaks which may occur in the area around the bearing assembly. If leakage appears excessive, replace the fan clutch (see below).

### ENGINE OVERHEATING

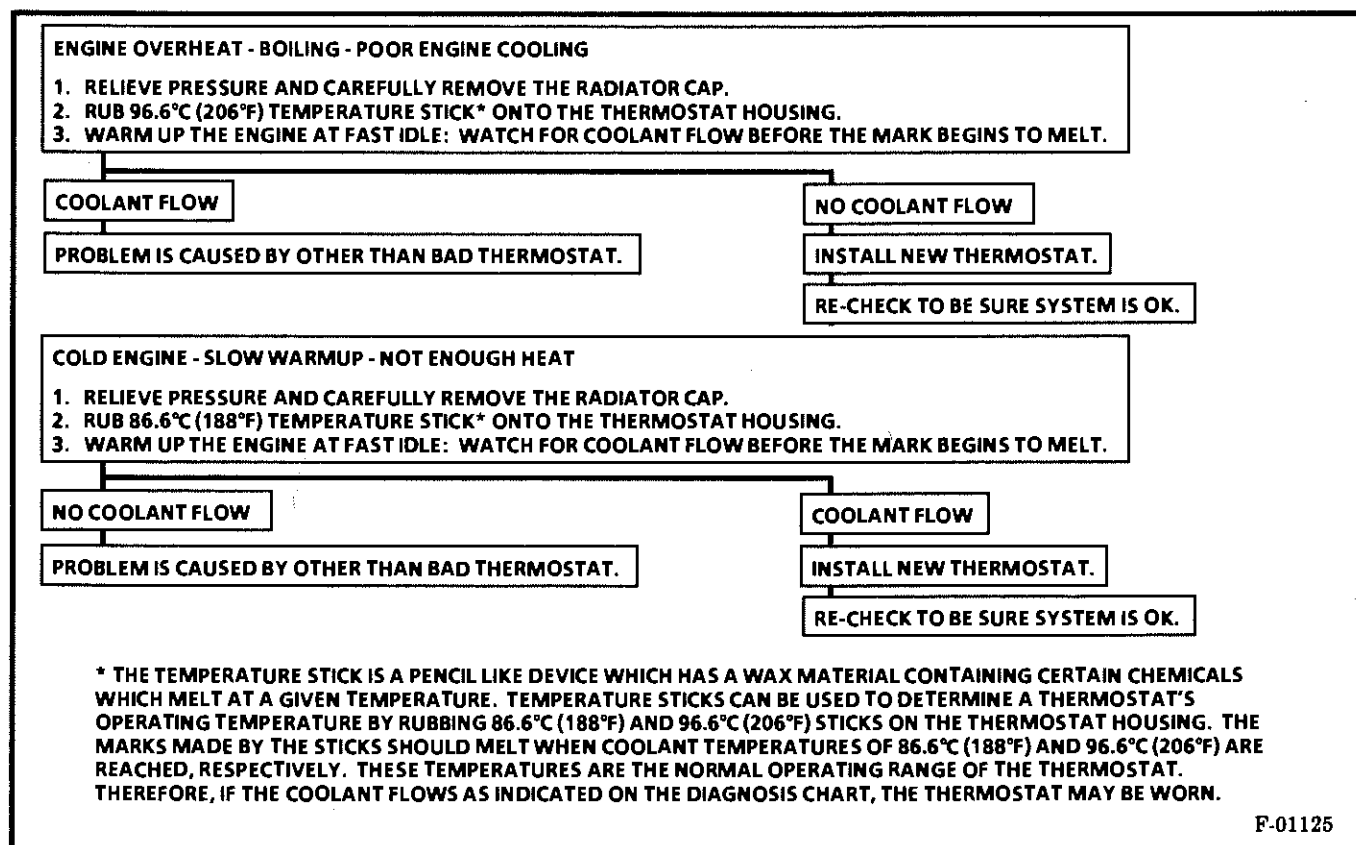
If the fan and clutch assembly free-wheels with no drag (revolves more than five times when spun by hand), replace the clutch.

## THERMOSTAT DIAGNOSIS

Refer to the thermostat diagnosis chart for detailed thermostat diagnostic procedures (Figure 1).

### COOLANT DIAGNOSIS

To determine the freezing point of the coolant, perform a hydrometer test.



F-01125

Figure 1 - Thermostat Diagnosis

## HYDROMETER TEST

Before using a hydrometer, make sure the hydrometer markings are correct. Unless the hydrometer has a provision for temperature correction, test the temperature at which the hydrometer is calibrated. If the coolant is warmer or cooler, the reading may be incorrect.

Most good hydrometers are equipped with a thermometer and a temperature correction scale which permits an accurate test of the freezing point over a range of temperatures. Follow the manufacturer's directions on using the hydrometer.

## COOLANT TESTER

Coolant testers J 26568 (Centigrade Scale) and J 23688 (Fahrenheit Scale) can be used to check the anti-freeze protection of the coolant.



### Clean

- Before each use, swing back the plastic cover at the slanted end of the tester exposing the measuring window and the bottom of the plastic cover. WIPE BOTH CLEAN AND DRY with tissue or clean soft cloth. Close the plastic cover (Figure 2).

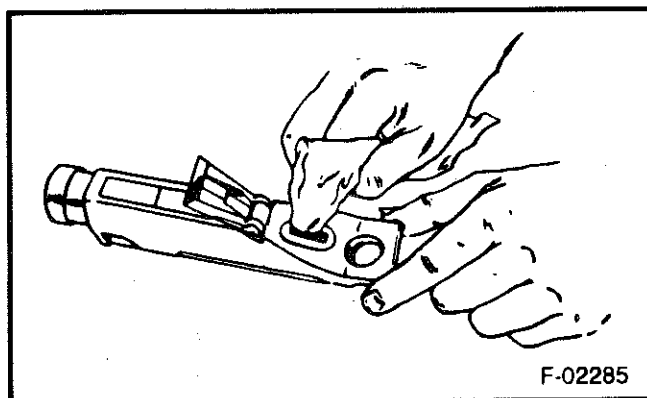


Figure 2 - Cleaning the Coolant Tester

### Testing

Do not remove the clear plastic pump from the tester. Release the tip of the pump from the tester housing and insert the tip into the radiator filler neck. Insert the tip below the level of the coolant (Figure 3).

Press and release the bulb to draw a sample. Bend the plastic tube around and insert the tip into the cover plate opening. Press the bulb and inject a few drops of coolant onto the measuring surface. Do not open the plastic cover when taking the readings because water evaporation can change the reading.

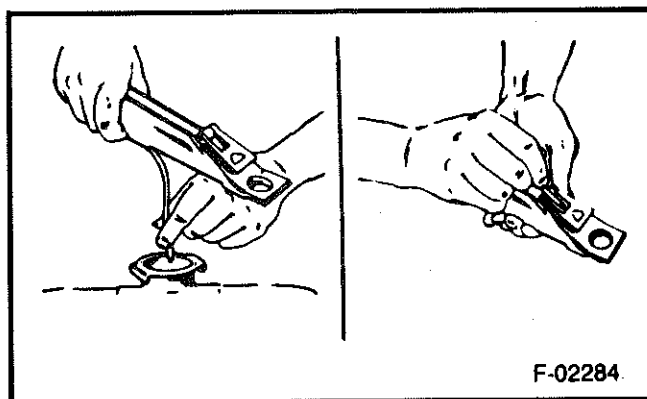


Figure 3 - Collecting the Coolant

### Reading

Point the tester toward any light source and look into the eyepiece (Figure 4). The anti-freeze protection reading is at the point where the dividing line between light and dark (edge or the shadow) crosses the scale: the anti-freeze protection is the right scale, battery charge is on the left.

The tester temperature scale is reversed from a standard thermometer scale; below zero readings are on upper half of scale. Readings on lower half of scale (above zero readings) indicate solutions without enough anti-freeze concentration to provide adequate rust protection.

Tilt the tester toward the light source to obtain the best results. If the "edge of the shadow" is not sharp, the measuring surfaces were not clean or dry. Wipe dry and make a new test.

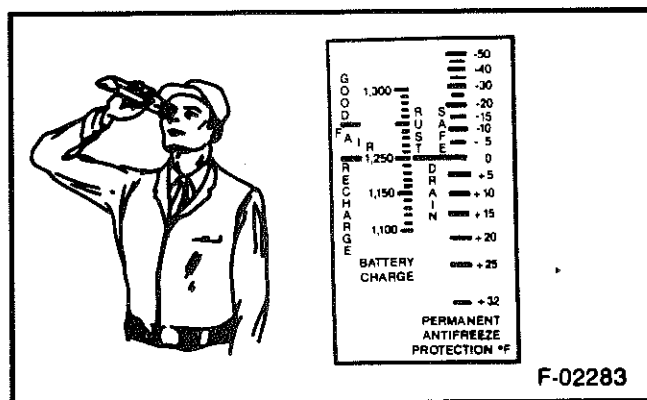


Figure 4 - Reading the Coolant Tester

## COOLANT LEVEL INDICATOR DIAGNOSIS

### INDICATOR LAMP WILL NOT ILLUMINATE

- Turn the ignition switch to the START position.
  - If the lamp illuminates, the lamp is OK and the connector is properly installed on the module. Go to Step 2.

- If the lamp does not illuminate, check the bulb, socket and wiring between the socket and the module connector. Check the connector on the module. Replace or repair as required.
- 2. Turn the ignition switch to the "ON" position and disconnect the electrical lead at the coolant level sensor on the radiator.
  - If the lamp fails to illuminate, check the wiring between the coolant level sensor connector and the module for a short circuit to ground. If the circuit is OK, replace the module.

### INDICATOR LAMP REMAINS ILLUMINATED

1. Turn the ignition switch to "ON".
  - Check the coolant level. Add coolant if necessary.
  - If the lamp remains illuminated, go to Step 2.
2. Disconnect the electrical lead at the coolant level sensor on the radiator (use a jumper wire and "G" type electrical connector).
  - If the lamp remains illuminated, connect the electrical lead and go to Step 3.
3. Check for an open circuit between the sensor and the module.
  - If an open circuit is found, repair it.
  - If no open circuit is found, replace the module.

### COOLING SYSTEM DIAGNOSIS

Refer to the cooling system diagnosis chart for detailed cooling system diagnostic procedures (Figures 5 and 6).

### UNCOMMON COOLING SYSTEM PROBLEMS

#### Problems Not Requiring Disassembly of the Cooling System

1. Remove large obstructions blocking the radiator or condenser.
  - Spare tires.
  - Ice, mud or snow obstructing the grille.
2. Engine oil is overfilled.
3. Incorrect radiator for the application.
  - Check the part number.
4. Loose, damaged or missing air seals.
5. Missing or damaged lower air baffle.
6. Incorrect ignition timing.

#### Problems Requiring Disassembly of the Cooling System

1. Incorrect or damaged fan.
2. Worn or damaged emission system components.

- Could cause overheating at idle.
  - Damaged PCV valve, TVS or TCS.
3. Pressure check the cooling system with the pressure cap installed.
    - Shows if the pressure cap leaks because of radiator filler neck damage.
  4. Worn or damaged water pump.
    - Impeller vanes eroded or broken.
    - Worn or damaged bearing and/or seal-check for shaft or bearing play.
  5. Plugged radiator tubes.
    - Perform a flow check.
  6. Internal system leaks.
    - Head gasket.
    - Cracked block.
    - Timing chain cover.
    - Intake manifold gasket.
  7. Plugged coolant passages in the cylinder heads.
    - Visual check.

### FLUSHING THE COOLING SYSTEM

Follow the manufacturer's instructions when using flushing equipment.



#### Important

- Remove the thermostat before flushing the cooling system.

### COOLANT RECOVERY TANK REPLACEMENT



#### Remove or Disconnect

1. Hose from the coolant tank.
2. Remove coolant tank.



#### Install or Connect

- Reverse procedure.

### FAN/FAN CLUTCH REPLACEMENT



#### Remove or Disconnect (Figure 7)

1. Four nuts from fan clutch to pulley.
2. Remove fan and fan clutch assembly.
3. Four bolts from fan clutch to fan.
4. Spacer from the pulley.

**CAUTION:** Do not use or repair a damaged fan assembly. An unbalanced fan assembly could fly apart and cause personal injury and/or property damage. Replace damaged assemblies with new assemblies.

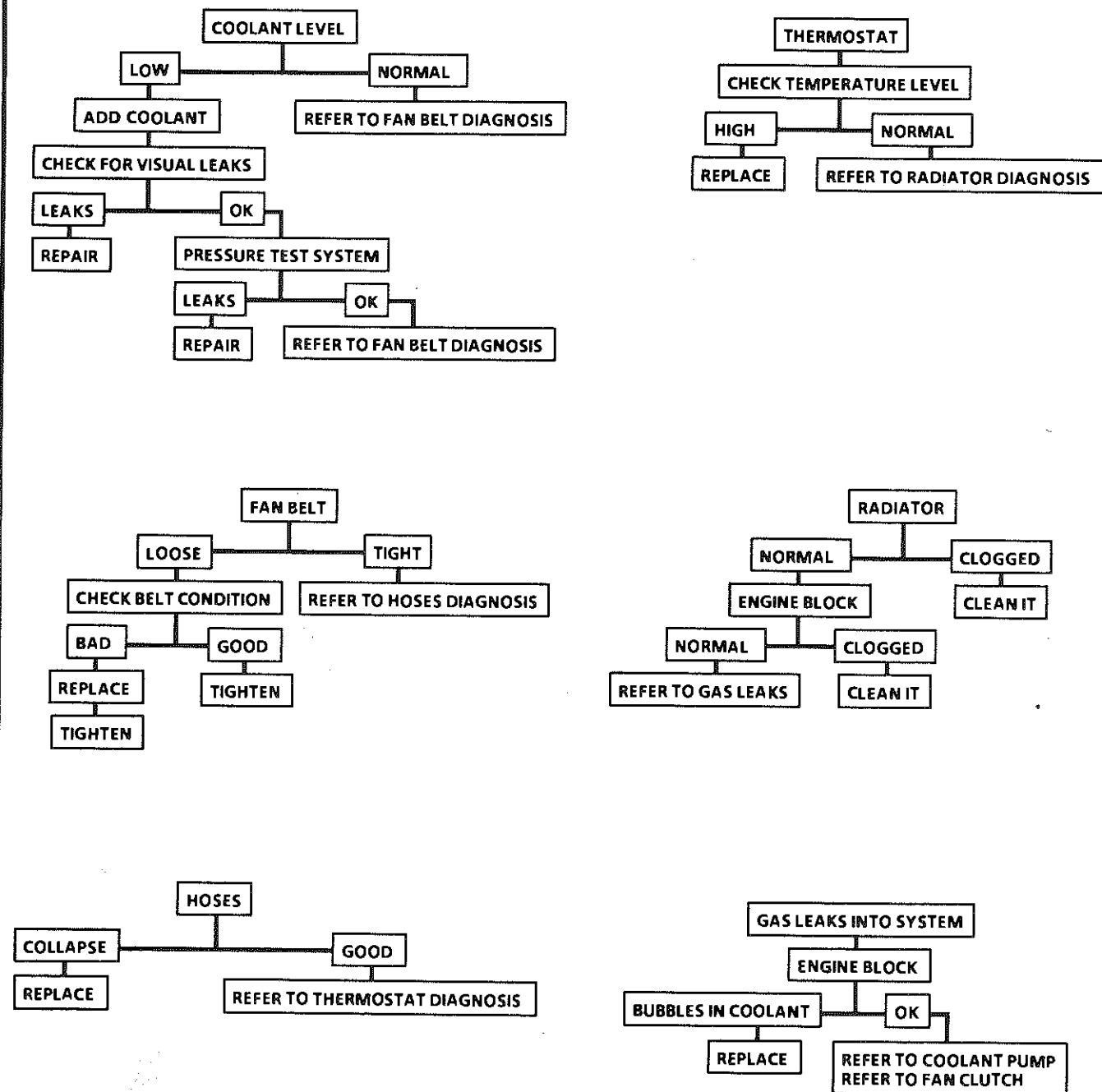


#### Install or Connect

- Reverse procedure.

## OVERHEATING

(HOT LIGHT "ON", HISSING, RUMBLE, STEAM, POWER LOSS)



F-6950

Figure 5 - Overheating Diagnosis

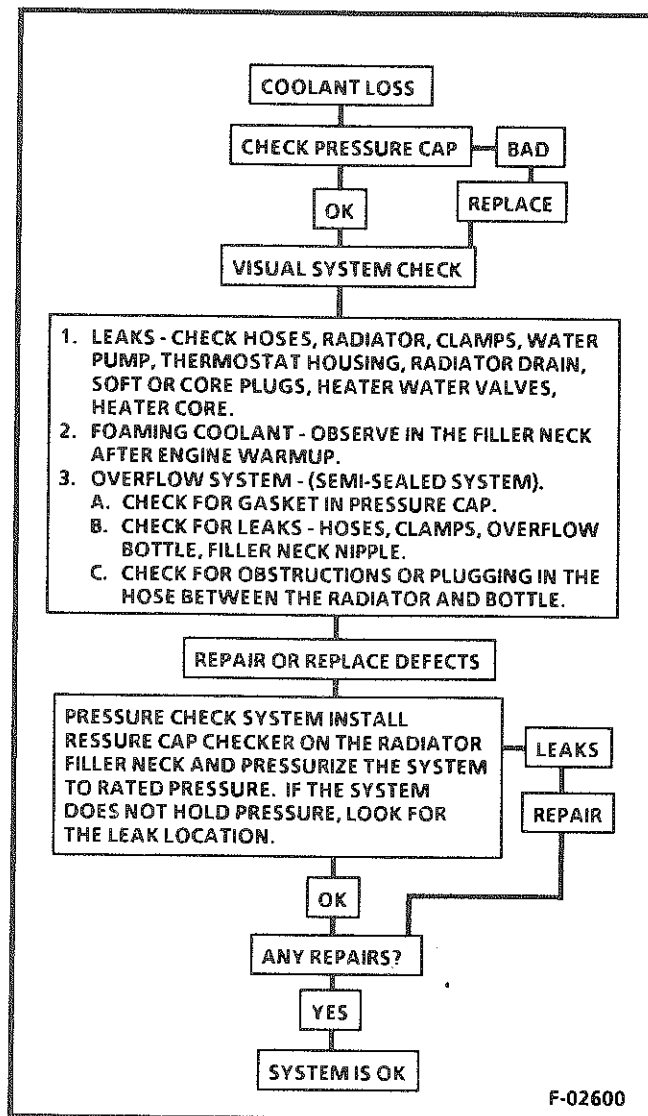


Figure 6 - Coolant Recovery System CHART B

## THERMOSTAT REPLACEMENT

## Remove or Disconnect (Figure 9)

1. Coolant from the radiator.
2. Bolt (72).
3. Outlet (73).
4. Gasket (74).
5. Thermostat (75).

## Clean

- All parts and sealing surfaces.

## Install or Connect (Figure 9)

1. 3 N·m (1/8") bead of RTV sealer 1052289 or equivalent to the groove on the water outlet sealing surface.
2. Thermostat.
3. New gasket.
4. Outlet.
5. Bolt.

## Tighten

- Bolt (72) to 28 N·m (21 lb. ft.).

7. Coolant to the radiator.

## Inspect

- For leaks at the sealing surface after starting the engine.

## SERPENTINE DRIVE BELT REPLACEMENT

Maintain the serpentine drive belt and pulleys can extend the normal life of a drive belt.

## PULLEY INSPECTION

Examine the pulleys for chips, nicks, tool marks, cracks, bent sidewalls, corrosion or other damage.

1. Place a straightedge or position a cord across the two pulleys so they touch at all points.
2. Turn each pulley one half revolution and recheck with a straightedge or cord. Full contact at all points must be made. If contact is not made at all points, the pulley may be warped or its shaft could be bent. Replace any parts found to be damaged.

## DRIVE BELT INSPECTION

Replace a frayed or cracked belt. Do not use drive belt dressings to extend belt life.

## BELT INSTALLATION

Install a serpentine belt following the belt routing (Figure 10). The grooves in the belt must match the grooves in the pulleys.

The tensioner is spring loaded. After removing the belt, the tensioner will return the tension position.

## DRIVE BELT REPLACEMENT

## Remove or Disconnect (Figure 8)

1. Place a tool over the tensioner pulley axis bolt.
2. Rotate the tool counterclockwise.
3. Belt.
4. Tool.

## Install or Connect

1. Route the belt over all the pulleys except the belt tensioner.
2. Place a tool over the tensioner pulley axis bolt.
3. Rotate the tool counterclockwise.
4. Install the belt over the belt tensioner pulley.
5. Remove tool.
6. Check the belt for correct tracking.

## WATER PUMP REPLACEMENT

 Remove or Disconnect (Figure 10)

1. Coolant from the radiator.
2. Serpentine drive belt.
3. Upper fan shroud.
4. Fan and fan clutch assembly.
5. Water pump pulley.
6. Clamps and hoses.
7. Bolts and nut.
8. Water pump.
9. Gasket.

 Inspect

- All parts and replace as necessary.

 Important

- Be sure all mating surfaces are free of burrs or other imperfections.

 Install or Connect (Figure 10)

1. Gasket in place.
2. Water pump.
3. Bolts and nut.
  - Coat the bolt threads with sealant 1052080 or equivalent.

 Tighten

- Bolts to 30 N·m (22 lb. ft.).
  - Nut to 30 N·m (22 lb. ft.).
4. Clamps and hoses.
  5. Water pump pulley.
  6. Fan and fan clutch assembly.
  7. Serpentine drive belt.
  8. Fan shroud.
  9. Coolant to the radiator.

 Important

- Start the engine and check for leaks.

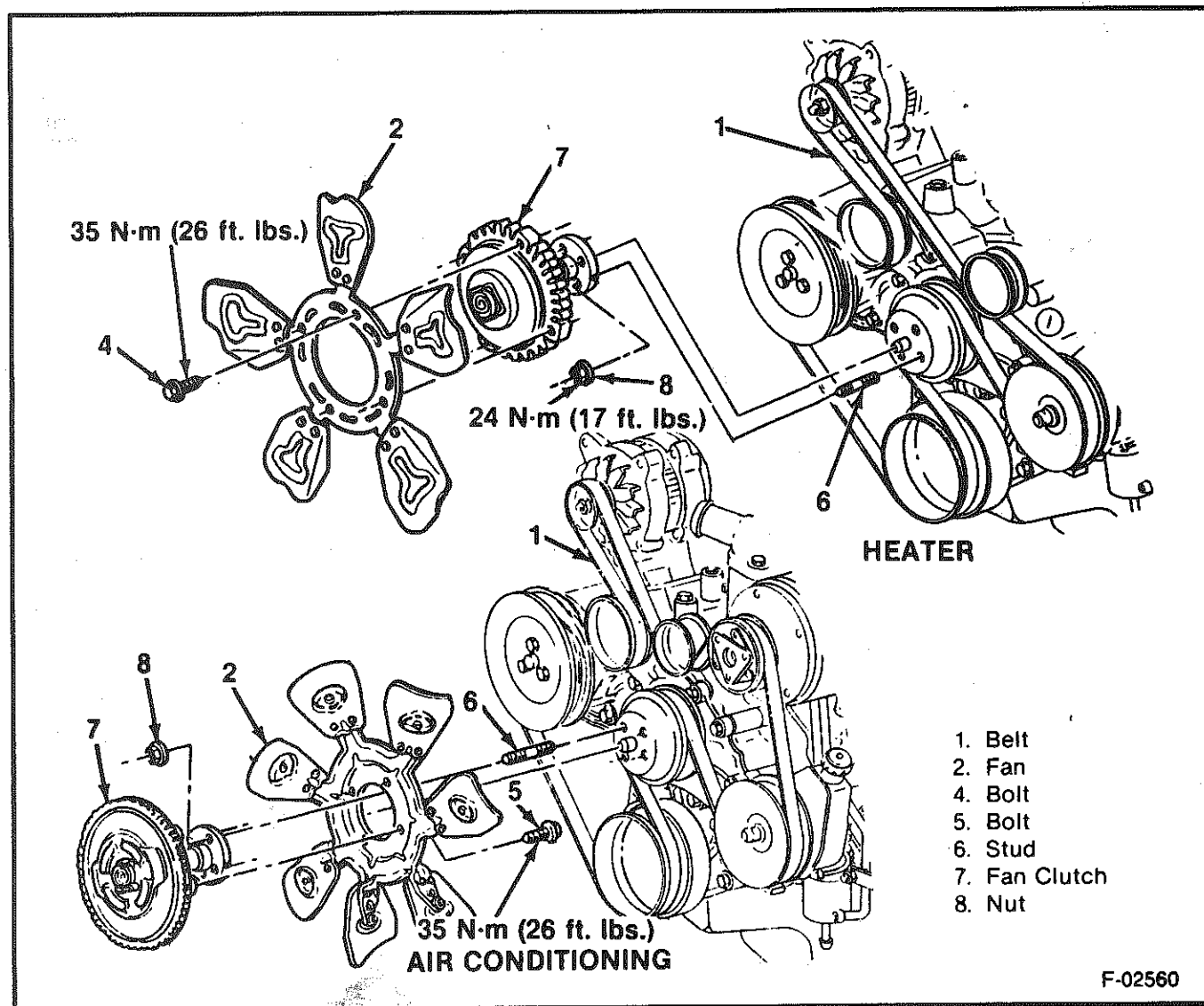


Figure 7 - Fan/Fan Clutch Replacement 2.8L

F-02560

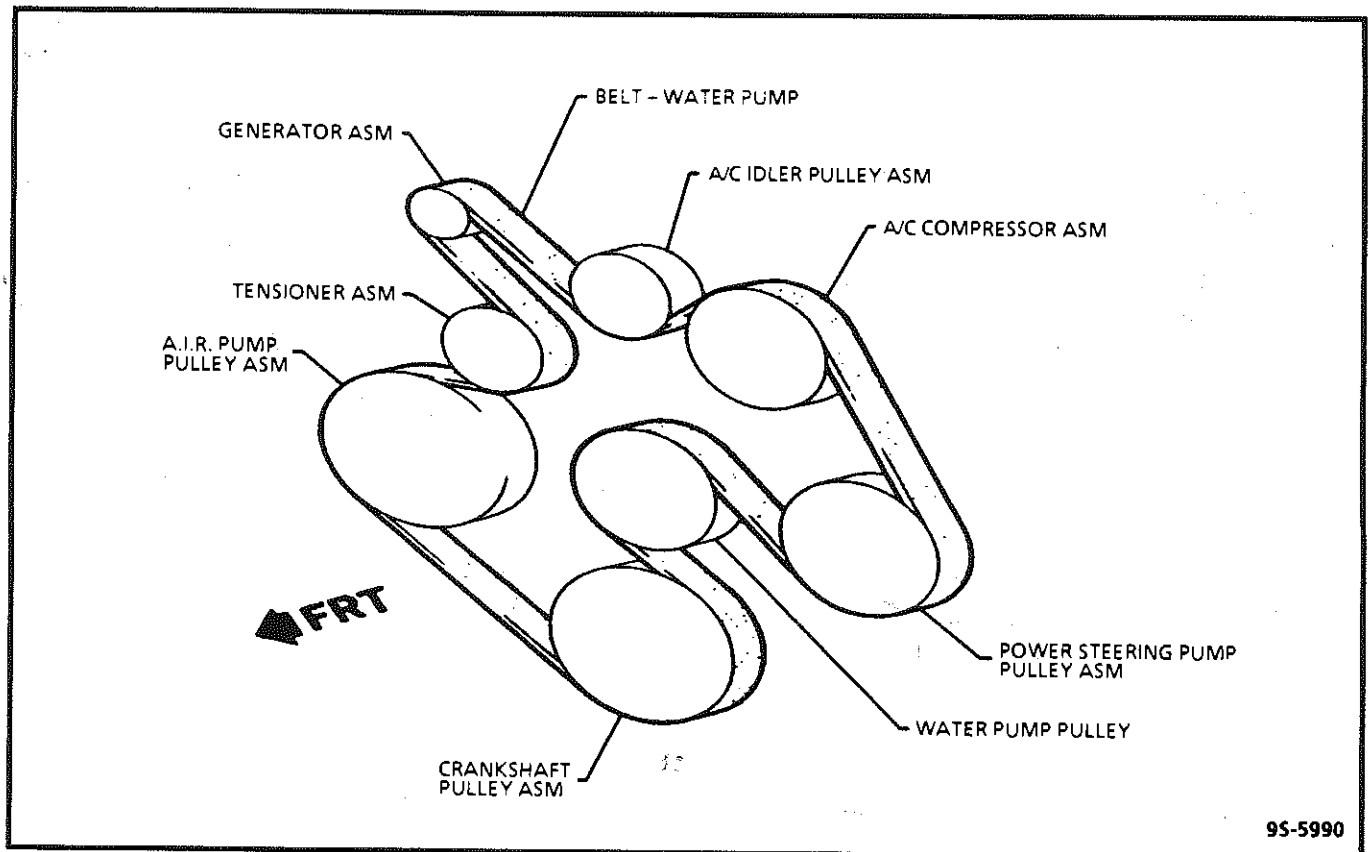


Figure 8 - Serpentine Drive Belt Routing 2.8L

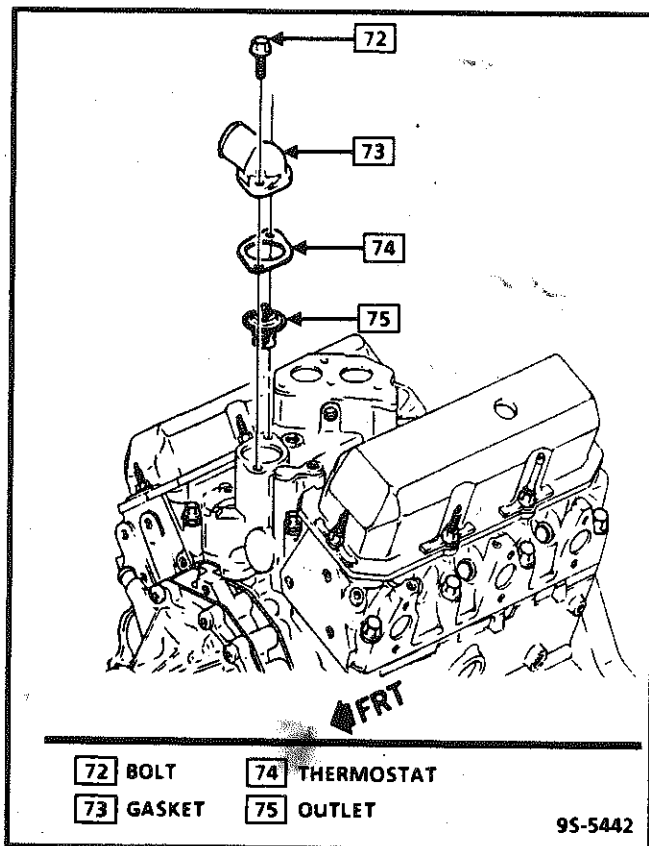


Figure 9 - Water Outlet

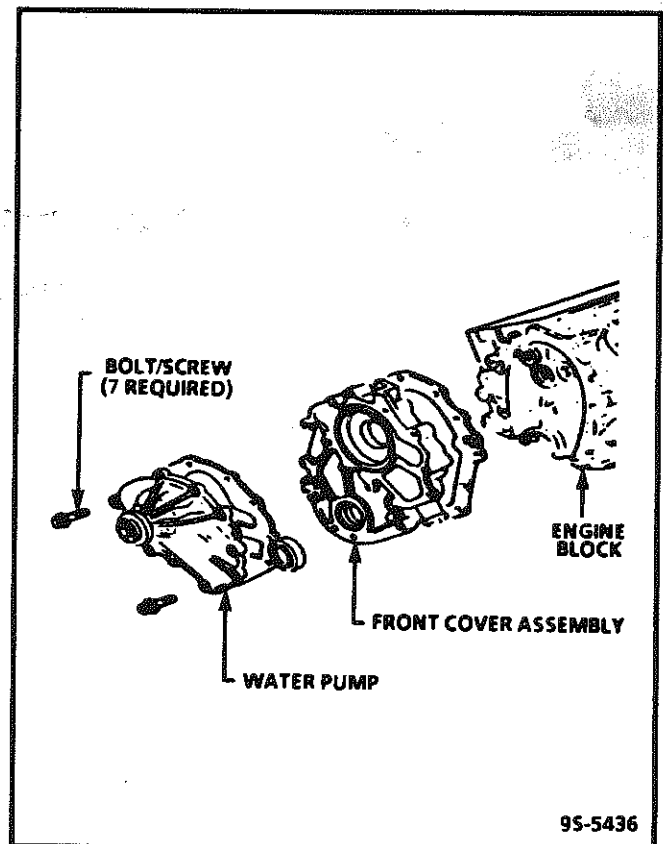


Figure 10 - Water Pump Replacement 2.8L

## COOLANT TEMPERATURE SENSOR OR SWITCH REPLACEMENT

### ↔ Remove or Disconnect (Figure 11)

1. Negative battery cable.
2. Coolant from the radiator below the level of the switch or sensor.
3. Electrical connector.
4. Sensor or switch.

### ↔ Install or Connect

1. Switch or sensor.
  - Apply sealant 1052080 or equivalent to the switch or sensor threads.

### Tighten

- Switch or sensor to 23 N·m (17 lb. ft.).
2. Electrical connector.
3. Coolant to the radiator.
4. Negative battery cable.

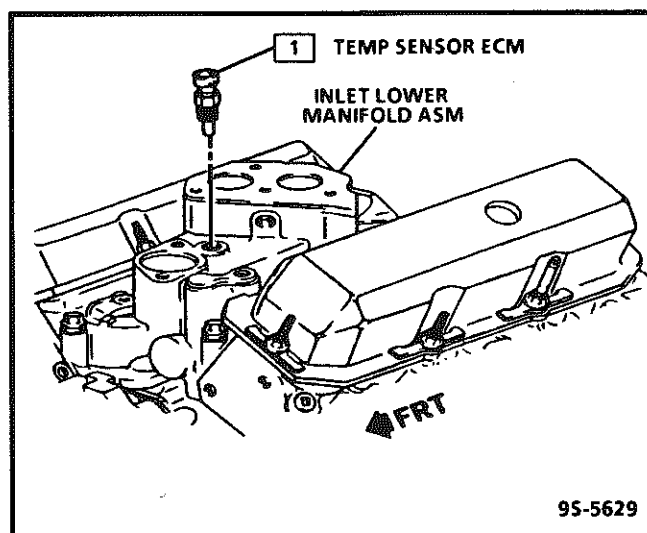
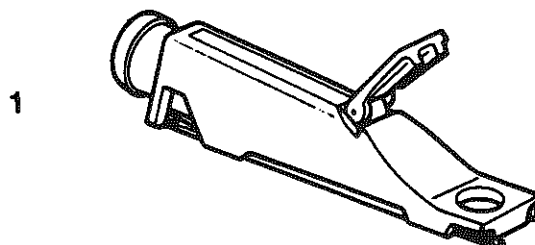


Figure 11 - Coolant Temperature Sensor

## SPECIAL TOOLS

J-23688 (Fahrenheit Scale)  
J-26568 (Centigrade Scale)



1. Coolant Tester

F-02603

## SPECIFICATIONS

### FASTENER TORQUE

|                                                    |                     |
|----------------------------------------------------|---------------------|
| Coolant Tank Screw .....                           | 9 N·m (6.3 lb. ft.) |
| Water Pump Hub Stud - 2.8L .....                   | 8 N·m (6.0 lb. ft.) |
| Fan to Clutch - 2.8L .....                         | 27 N·m (20 lb. ft.) |
| Fan and Clutch Assembly to Pulley Nut - 2.8L ..... | 27 N·m (20 lb. ft.) |
| Thermostat Outlet Housing Bolt - 2.8L .....        | 28 N·m (21 lb. ft.) |
| Water Pump to Engine Block Bolt - 2.8L .....       | 30 N·m (22 lb. ft.) |
| Water Pump to Engine Block Stud - 2.8L .....       | 30 N·m (22 lb. ft.) |
| Coolant Temperature Switch or Sensor .....         | 23 N·m (17 lb. ft.) |

## SECTION 6B2

# RADIATOR

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## GENERAL DESCRIPTION

### RADIATOR

The radiator is a cross-flow, tube and center type. (Refer to Figure 1).

All radiators are fitted with a shroud designed to assist the fan in directing air flow through the radiator core and to also serve as a fan guard. Provision for coolant expansion is achieved with a coolant recovery tank. This retards coolant overflow, and reduces frequent refills.

Pressure is maintained in the radiator and system by a pressure cap. The pressure cap has two valves; one relieves pressure and the other compensates for coolant contraction when the engine is stopped. Radiator caps are provided in 105 kPa (15 psi) rating on all models.

Manual transmission vehicles use radiators without oil coolers. Vehicles equipped with air conditioning use a radiator with extra cooling capacity for greater cooling demands.

### RADIATOR CAP

A pressure-vent cap is used on the cross-flow radiator to allow a build-up of 105 kPa (15 psi) in the cooling system. This pressure raises the boiling point of the coolant to about 125°C (257°F) at sea level. Do not remove the radiator cap to check the engine coolant level; check the coolant visually at the see-through coolant reservoir. Coolant should be added only to the reservoir.

**CAUTION:** As long as there is pressure in the cooling system, the temperature can be considerably higher than the boiling temperature of the solution in the radiator without causing the solution to boil. Removal of the radiator cap while the engine is hot and the pressure is high will cause the solution to boil instantaneously and possibly

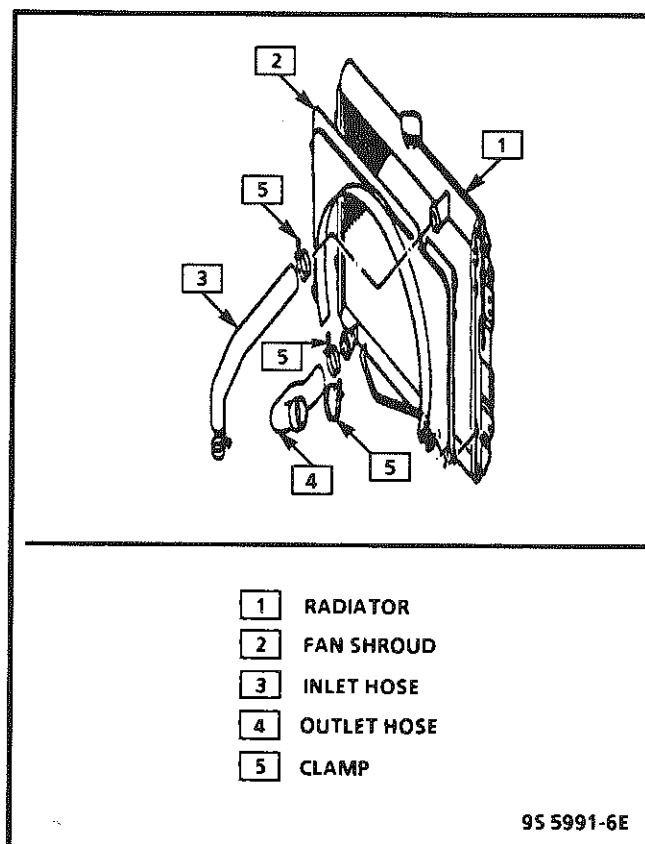


Figure 1 - Radiator

with explosive force, spewing the solution over the engine, fenders and person removing the cap. If the solution contains flammable anti-freeze such as alcohol (not recommended for use at any time), there is also the possibility of causing serious fire.

The pressure-type radiator filler cap contains a blow off or pressure valve and a vacuum or atmospheric valve. The pressure valve is held against its seat by a spring of pre-determined strength which protects the radiator by relieving the pressure if an extreme case of internal pressure should exceed that for which the cooling system is designed. The vacuum

## 6B2-2 RADIATOR

valve is held against its seat by a light spring which permits opening of the valve to relieve vacuum created in the system when it cools off and which otherwise might cause the radiator to collapse (Figure 2).

The design of the radiator cap is to discourage inadvertent removal. It must be pushed downward before it can be removed. A rubber asbestos gasket is added to the diaphragm spring at the top of the cap. Also, embossed on the cap is a caution against its being opened and arrows indicating the proper closed position (Figure 3).

The seal of the filler cap and the operation of the pressure relief valve can be checked using a conventional cooling system testing kit (Figure 4).

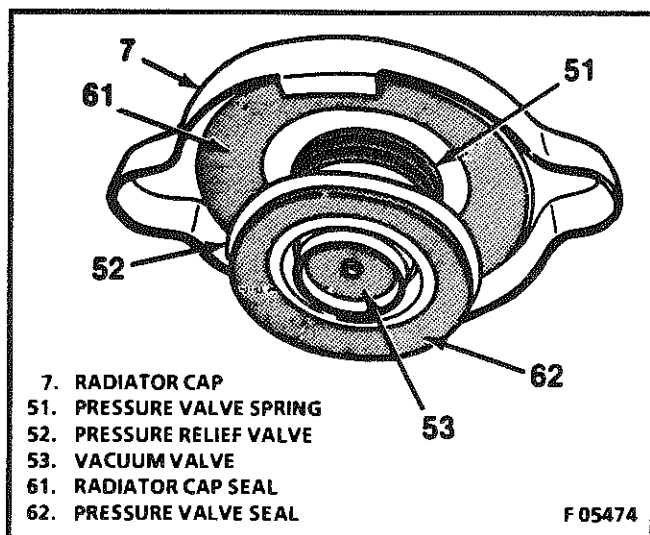


Figure 2 - Radiator Cap Pressure and Vacuum Valves

### RADIATOR MAINTENANCE

Check the outside of the radiator for bent fins or signs of leakage. Repair leaking radiator cores.

Do not seal temporarily with a sealer type antifreeze or coolant additive. Remove any stones between the fins. At least once a year, clean loose debris and road film from the radiator core with a quality grease solvent and compressed air. Direct the stream of solvent at the rear of the core for more efficient cleaning.

To insure thorough cleaning, remove the grille, fan guard, and fan shroud.

Remove the radiator cap and look for plugging and scale on the inside of the tank. Replace a badly plugged radiator. Test the radiator and system as described in "Engine Cooling" (Section "6B1").

1. Check the coolant level. If low, add recommended coolant as required.
2. Check the hose conditions and tighten the clamps if leakage is evident. Replace cracked, stripped, or corroded clamps.

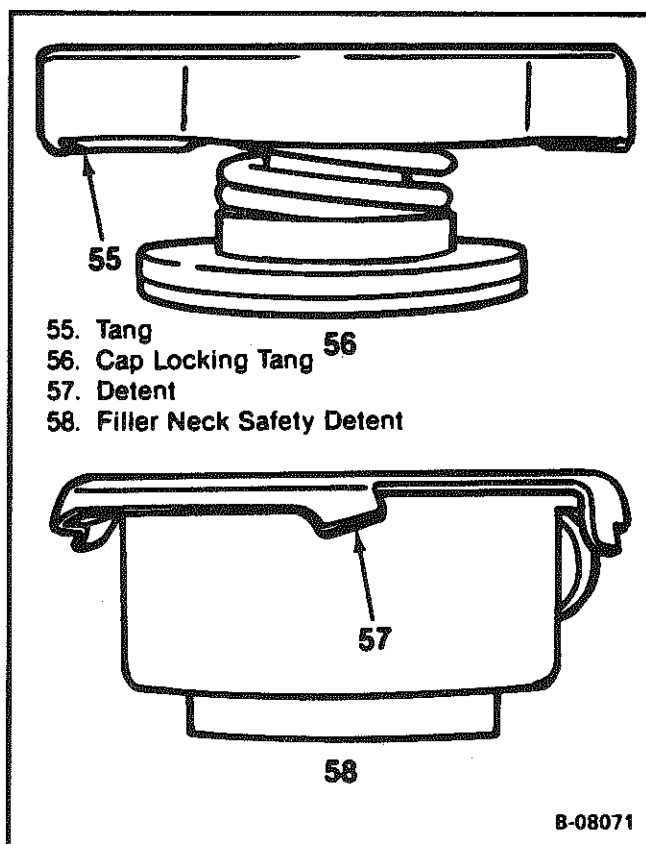


Figure 3 - Radiator Cap and Filler Neck

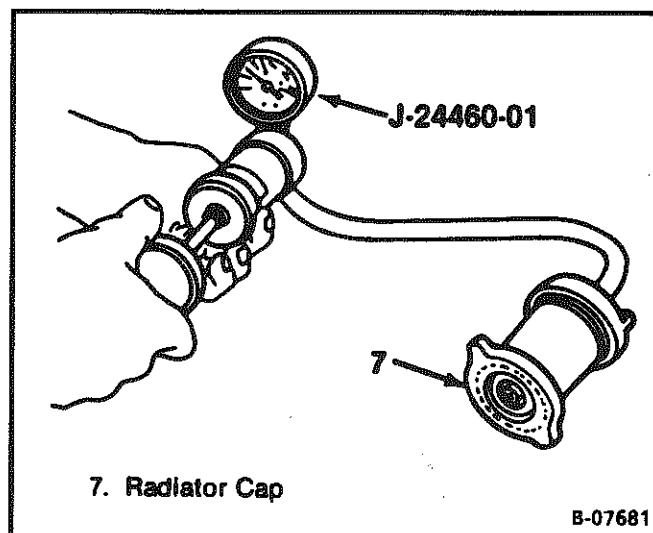


Figure 4 - Radiator Cap and Filler Cap

3. Check the coolant hoses for spongy or check appearances. Replace deteriorated hoses or bursting could occur which would result in coolant loss and extensive damage due to overheating.
4. Check the radiator core for leaks and for accumulation of dirt which may obstruct the air passages and reduce heat transfer.
5. Check the surge tank or recovery tank for leaks. Plastic bottles may develop cracks from being damaged by flying objects. Metal tanks should be checked at weld seams.

6. Inspect the radiator rubber mountings and bumpers for deterioration and replace as necessary. Check the mounting bolts, supports, braces, tie rods and stabilizer rods. Components should be securely fastened in place if mounting bolts are missing, loose or stripped. Also check for damage to core, side flanges and supporting components.
7. Check for clearance between the fan blades, core and shroud. Check the fan attaching bolts for tightness and that none are missing. Replace the fan if any blade is bent. The distance between the blades and shroud should be equal around the entire perimeter of the shroud. Adjust as necessary after any adjustment has been made to the fan or the fan mounting bracket and hub.
8. Inspect the filler cap seal for evidence of cracking, separation or deterioration. Replace as required.
9. To assist in maintaining efficient heat dissipation, an occasional external flushing with water will remove the majority of dirt accumulation and foreign matter from between the core fins. Direct water under moderate pressure from behind the core to force debris out in the opposite direction of its entry. Direct the water stream in line with the fins to reduce the possibility of bending fins.

## RADIATOR INTERNAL DEPOSITS

A radiator that has a dirty, obstructed core or is leaking will cause the engine to overheat. A scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water caused the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water will produce a slit-like deposit which restricts the flow of water.

## SCALE REMOVAL

To remove the hardened scale, a direct chemical action is necessary. A flushing compound at the specified rate of 30 grams per liter (4 oz. per gallon) or radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for 15 minutes, then drain and flush the system with clean water.

There are various types of flushing compounds commercially available and should be obtained from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a descaling solvent is used.

For extremely hard, stubborn coatings, such as lime scale, use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, drain the entire system and fill it with clean, soft water plus a rust inhibitor or high boiling type antifreeze. After filling the cooling system check for radiator, hose and engine coolant leaks.

## ON-VEHICLE SERVICE

### LEAK TESTING

Some core leaks can be detected by adding water to the radiator. Clean the core so that the damaged area can be found.

1. Remove dirt and insects from the fins with a common water hose without a nozzle. Excessive water pressure could damage the fins.
2. Scrub the core with a soft-bristle brush using clean, hot water or hot water with a mild detergent.

### PRESSURE TESTING

The radiator can be pressure tested with J 24460-01 and J 23699 (Figure 5). With the system at a cool temperature, remove the radiator cap, connect the gage, and apply normal system operating pressure.

Repair hose and hose connections as required. Check the radiator cap to ensure that it will maintain the correct pressure.

If the radiator leaks during the pressure test, mark the leak area. Repair or replace if necessary.

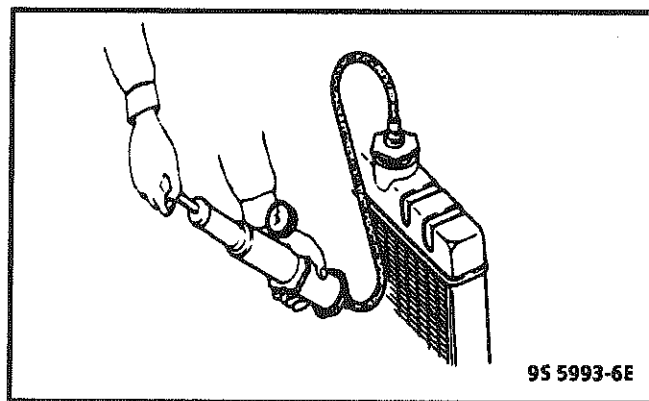


Figure 5 - Pressure Testing

## DIAGNOSIS OF RADIATOR

| PROBLEM          | POSSIBLE CAUSE                                                                                    | CORRECTION                                                                                                                                                                                                 |
|------------------|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Engine Overheats | 1. Cooling area obstructed.<br>2. Radiator fins plugged.<br>3. Leaking radiator.<br>4. Bent fins. | 1. Remove or relocate added on parts that may block air to the radiator.<br>2. Remove any debris (bugs, leaks, etc.) from the radiator fins.<br>3. Repair leaks or replace seals.<br>4. Repair or replace. |
| Radiator Loose   | 1. Loose screws.<br>2. Missing insulators.                                                        | 1. Tighten screws.<br>2. Replace insulators.                                                                                                                                                               |

## OFF-VEHICLE LEAK TESTING

1. Install test fittings or rubber test caps in the inlet and outlet necks.
2. Attach the pressure tester and gradually apply air pressure until 138 kPa (20 psi) is attained. Do not exceed 138 kPa (20 psi). Check the pressure gage to see if there is a pressure loss. To ensure that there are no small leaks, run water over the repair area and look for bubbles. (A mild detergent is helpful).

If a large water tank is available, submerge the radiator and check for air bubbles. If a leak is found, repair or replace.

## RADIATOR REPLACEMENT

 Remove or Disconnect (Figure 1)

1. Coolant from radiator.
2. Overflow hose.
3. A/C condenser inlet bracket bolt to radiator shroud.
4. Upper radiator hose.
5. Lower radiator hose.

6. Four fan shroud screws move fans and engine.
7. Five radiator bolts from radiator support.
8. Remove radiator.

 Inspect

- All parts and connections for leaks and wear. Replace if necessary.

 Install or Connect (Figure 1)

1. In reverse order.

## RECORE

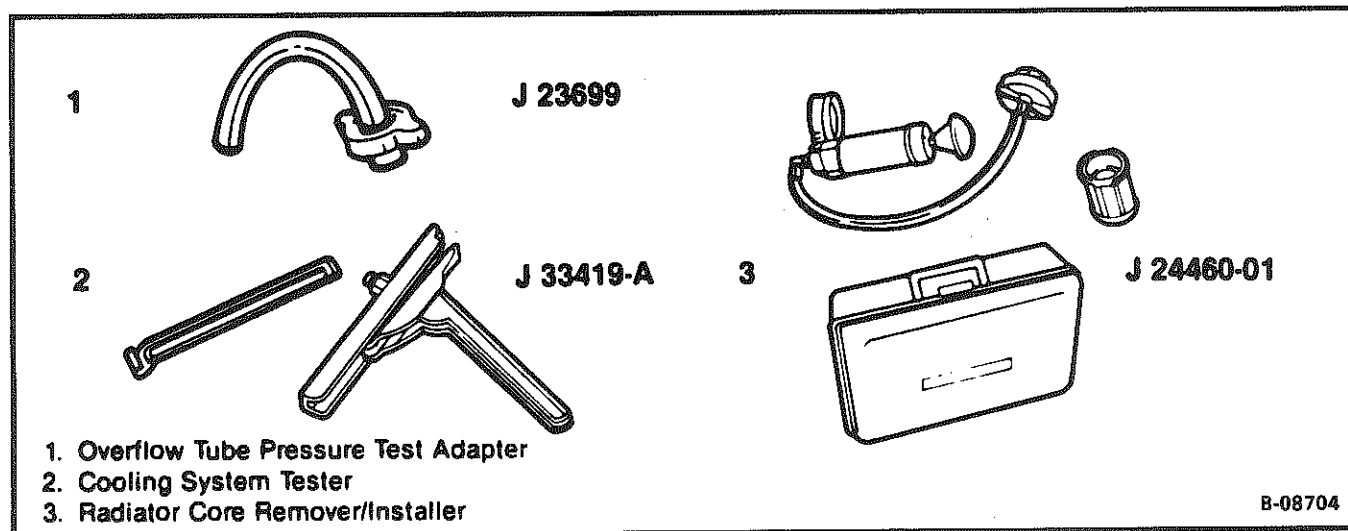
If the radiator core is damaged beyond repair and the other parts are serviceable, install the original inlet and outlet tanks, radiator cap and drain valve, along with the new core and new gaskets.

## SPECIFICATIONS

## FASTENER TORQUE

Shroud and Radiator Screws . 25 N·m (18 lb.ft.)

## SPECIAL TOOLS



B-08704

## SECTION 6D

# ENGINE ELECTRICAL

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### ELECTRICAL SYSTEM

The engine electrical system includes the battery, charging system (generator and related wiring,) cranking system (starter motor and related wiring,) and ignition system (distributor, spark plugs and wiring.)

These vehicles are equipped with an electronic Computer Command Control system and have a "Check Engine" lamp on the instrument panel. Refer to the "Driveability and Emissions" Section "6E" for a detailed description of the lamp's operation and use as a diagnostic indicator.

### DESCRIPTION

The battery has three major functions in the electrical system: First, it provides a source of energy for cranking the engine; second, it acts as a voltage stabilizer for the electrical system; and third, it can, for a limited time, provide energy when the electrical load used exceeds the output of the generator.

The sealed battery as shown in Figure 1 is standard. Refer to "Specifications" at the end of this section for specific application.

## BATTERY

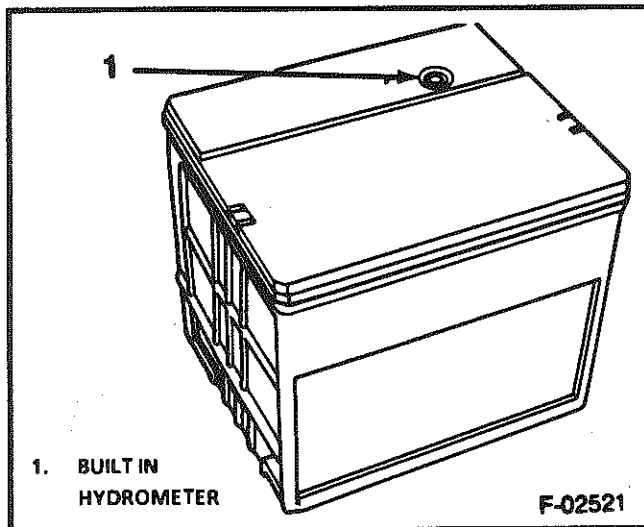


Figure 1 - Sealed Battery with Side Terminals

Water never needs to be added to the sealed battery. There are no filler caps in the cover. The battery is sealed, except for small vent holes in the cover. The vents allow what small amount of gasses that are produced in the battery to escape. The special chemical composition inside the battery reduces gassing to a very small amount at normal charging voltages. Besides reducing gassing, the special chemistry greatly reduces the possibility of overcharge damage.

Keep the battery in an upright position to prevent electrolyte leakage. Tipping the battery beyond a 45 degree angle in any direction can allow a small amount of electrolyte to leak out the vent hole.

Do not exceed this 45 degree angle when carrying or installing the battery.

Evidence of electrolyte leakage does not always mean the battery is defective.

## Ratings

Batteries are rated according to their reserve capacity in minutes and their cold cranking power in amperes. Both methods involve measuring the battery terminal voltage after a specified time period and discharge current.

The "reserve capacity" is defined as the maximum length of time it is possible to travel at night with minimum electrical load and no generator output. Expressed in minutes, it is the time required for a fully charged 12 volt battery, at a temperature of 27°C (80°F), being discharged at a constant current of 25 amperes, to reach a terminal voltage of 10.5 volts.

The Cold Cranking Ampere (CCA) test measures the amperage delivered by the battery at -18°C (0°F) for 30 seconds.

Refer to the "Specifications" at the end of this section for battery ratings.

## Built-In Hydrometer

The sealed battery has a special temperature compensated hydrometer built into the cover to show at a glance the battery's state-of-charge. The hydrometer has a green ball within a cage which is attached to a clear plastic rod. The green ball will float at a predetermined specific gravity of the electrolyte. When the green ball floats, it rises within the cage and positions itself under the rod. Visually a green dot then shows in the center of the hydrometer (Figure 2). The built-in hydrometer provides a guide for battery testing and charging.

When looking at the hydrometer, make sure that the battery has a clean top. A lamp may be needed in some poorly-lit areas.

1. **GREEN DOT VISIBLE:** The state of charge is 65 percent or more of the full charge.
2. **DARK; GREEN DOT NOT VISIBLE:** The state of charge is below 65 percent. Charge the battery until the green dot appears. (Shake the battery slightly to make the green dot appear after charging.)
3. **CLEAR OR LIGHT YELLOW:** The fluid level has dropped below the bottom of the hydrometer. This can be caused by a broken case, tipping of the battery, normal wearout, or overcharging because of a problem in the electrical system. Check the system and replace the battery.

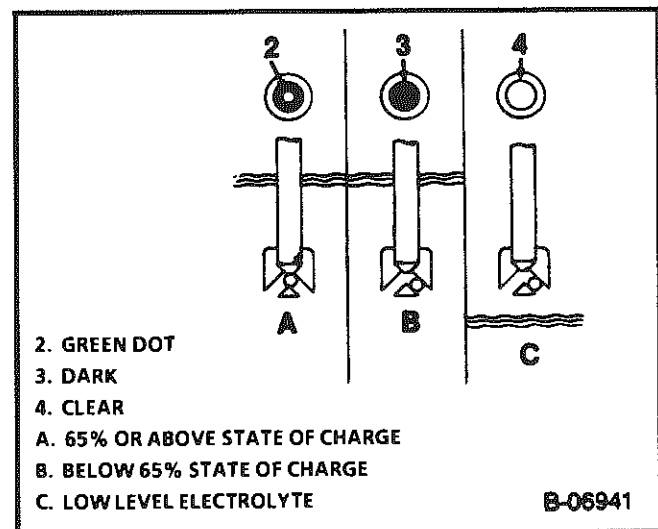


Figure 2 - Built-In Hydrometer

## GENERAL INFORMATION

### Common Causes of Malfunction

If testing shows the battery to be in good condition but the battery doesn't perform satisfactorily, check for the following:

1. Vehicle accessories left on overnight.
2. Extended slow-speed driving with many accessories turned on.
3. The vehicle electrical load is more than the generator output, particularly with the addition of aftermarket equipment.
4. Problems in the charging system such as shorts, slipping fan belt, or worn generator or regulator parts.
5. Loose or poor battery cable-to-post connections, previous improper charging of a rundown battery, or loose hold-downs.
6. High-resistance connections in the cranking system.
7. Electronic devices draining the battery when the vehicle is parked for a long period of time. Disconnect the negative cable if the vehicle will be stored for more than 30 days.

### Electrolyte Freezing

The freezing point of electrolyte depends on its specific gravity. Since freezing may ruin a battery, protect it against freezing by keeping it in a charged condition.

### Carrier and Hold-Down

The carrier and hold-down should be clean and free from corrosion before battery installation.

The carrier should be in a sound mechanical condition so that it will support the battery securely and keep it level. Make certain there are no foreign objects in the carrier before installation.

To prevent the battery from shaking in its carrier, tighten the hold-down bolts. However, do not tighten the bolts to where the battery case or cover is placed under a severe strain.

## DIAGNOSIS OF BATTERY

### VISUAL INSPECTION

Check for obvious damage such as a cracked or broken case or cover that could permit loss of electrolyte. If damaged, replace the battery. Determine the cause of the damage and correct.

## HYDROMETER TEST

**GREEN DOT VISIBLE:** If the hydrometer has a GREEN DOT visible, the battery is ready for testing. Proceed to "Load Test."

**DARK; GREEN DOT NOT VISIBLE:** Charge the battery as outlined under the heading "Battery Charging Procedure" later in this section.

**LIGHT OR BRIGHT INDICATOR:** Do not charge, test, or jump start the battery. Replace the battery.

## LOAD TEST

If the battery is in the vehicle, make sure the engine control switch is "OFF." If there is more than one battery, check each separately.

1. Disconnect the battery cables from the terminals.
2. Install a voltmeter and battery load tester to the adapters.
3. Remove the surface charge from recently charged batteries by applying a 300-ampere load for 15 seconds.
4. Do not remove the surface charge from batteries which have been in storage.
5. Turn the load "OFF" and wait 15 seconds for the battery to recover.
6. Apply the specified load selected from the chart in "Specifications." Observe the battery voltage after 15 seconds with load connected, then turn "OFF" the load.
7. If the battery voltage does not drop below the minimum voltage as shown in the "Voltage and Temperature Chart" following, the battery is good and should be returned to service. (The battery temperature must be estimated by feel and by the temperature the battery has been exposed to for the preceeding few hours.) If the battery voltage drops below the minimum voltage listed, replace the battery.

## VOLTAGE AND TEMPERATURE CHART

| TEMPERATURE               | MINIMUM VOLTAGE |
|---------------------------|-----------------|
| 21°C (70°F & Above) ..... | 9.6             |
| 10°C (50°F) .....         | 9.4             |
| -1°C (30°F) .....         | 9.1             |
| -10° (15°F) .....         | 8.8             |
| -18°C (0°F) .....         | 8.5             |

## BATTERY ON-VEHICLE SERVICE

### BATTERY CHARGING PROCEDURES

The following basic rules apply to any sealed battery charging situation:

1. Do not charge a battery if the hydrometer is clear or light yellow-replace the battery.
2. Charge rates between 3 and 50 amperes are satisfactory as long as spewing of electrolyte does not occur or the battery does not feel over 52°C (125°F). If spewing occurs or temperature exceeds 52°C (125°F), the charging rate must be reduced or temporarily halted to permit cooling. Estimate battery temperature by touching or feeling the battery case.
3. Some chargers feature polarity protection circuitry which prevents charging unless the charger leads are connected to the battery terminals correctly. A completely discharged battery may not have enough voltage to activate this circuitry, even though leads are connected properly making it appear that the battery will not accept charging current.
4. The battery is sufficiently charged if the green dot in the built-in hydrometer is visible. No further charging is required. Shake or tilt the battery at hourly intervals during charging to mix the electrolyte and see if the green dot appears.
5. Battery charging consists of a charge current in amperes for a period of time in hours. Thus a 25 ampere charging rate for 2 hours would be 50 ampere-hour charge to the battery. In most cases, batteries whose load test values are less than 200 amperes will have the green dot visible after at least a 50 ampere-hour charge. Most batteries whose load test values are greater than 200 amperes will have the green dot visible after at least a 75 ampere-hour charge. In the event that the green dot does not appear after this amount of charging, continue charging for another 50 or 75 ampere-hours. If the green dot still does not appear, replace the battery.
6. The time required for a charge will vary according to:
  - a. Size of battery - Example: A discharged large heavy-duty battery requires more than twice the recharging as a discharged small passenger car battery.
  - b. Temperature - Example: A longer time will be needed to charge any battery at -18°C (0°F) than at 27°C (80°F). When a fast charger is connected to a cold battery, the current accepted by the battery will be very low at first; then, as the battery warms, it will accept a higher rate.

- c. State-of-charge - Example: A discharged battery requires more than twice as much charge as a one-half-charged battery. Because the electrolyte is nearly pure water and therefore a poor conductor, the current accepted is low at first. Later, as the charging current causes the electrolyte acid content to increase, the charging current will likewise increase.
- d. Charger Capacity - Example: A charger which can supply only 5 amperes will require a much longer period of charging than a charger that can supply 30 amperes or more.

### EMERGENCY STARTING DUE TO A DISCHARGED BATTERY

If the vehicle will not start due to a discharged battery, it can be started by using energy from another battery - a procedure called "jump starting."

**NOTICE:** Do not push or tow the vehicle to start it. Under some conditions this may damage the catalytic converter or other parts of the vehicle. Also, since this vehicle has a 12 volt battery, be sure the vehicle or equipment used to jump start the engine is also 12 volt. Use of any other type system may damage the vehicle's electrical components.

### Jump Starting Instructions (Figure 3)

**CAUTION:** Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:

- Always shield your eyes and avoid leaning over the battery whenever possible.
- Do not expose the battery to open flames or sparks.
- Do not allow battery acid to contact the eyes or skin. Flush any contacted areas with water immediately and thoroughly, and get medical help.
- Follow each step in the jump starting instructions.

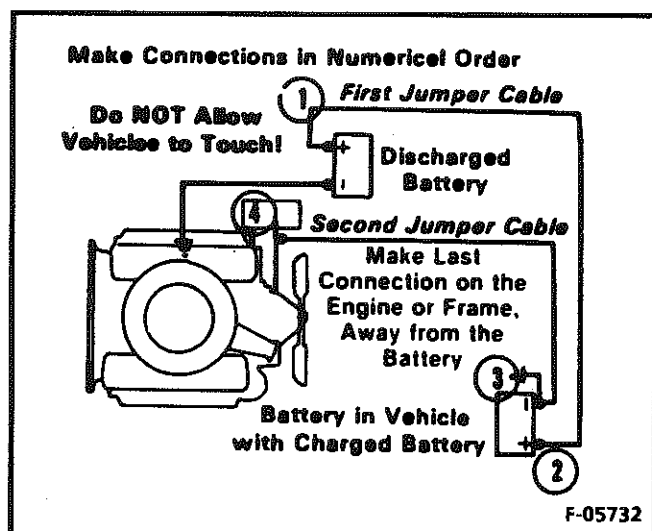


Figure 3 - Jump Starting Connection

1. Position the vehicle with the good (charged) battery so that the booster (jumper) cables will reach, but never let the vehicles touch. Also, be sure booster cables do not have loose or missing insulation.
2. In both vehicles:
  - Turn off the ignition and all lamps and accessories except the hazard flasher or any lamps needed for the work area.
  - Apply the parking brake firmly, and shift the transmission to Neutral.
3. Making sure the cable clamps do not touch any other metal parts, clamp one end of the first booster cable to the positive (+) terminal on one battery, and the other end to the positive terminal on the other battery (figure). Never connect (+) to (-).
4. Clamp one end of the second cable to the negative (-) terminal of the good (charged) battery and make the final connection to a heavy metal bracket such as the mounting bracket of the generator or air conditioner compressor (if so equipped) on the engine about 450 millimeters (18 inches) from the discharged battery. Make sure the cables are not on or near pulleys, fans or other parts that will move when the engine is started.
5. Start the engine of the vehicle with the good (charged) battery and run the engine at a moderate speed for several minutes. Then, start the engine of the vehicle that has the discharged battery.
6. Remove the booster cables by reversing the above installation sequence exactly. While removing each clamp, take care it does not touch any other metal while the other end remains attached.

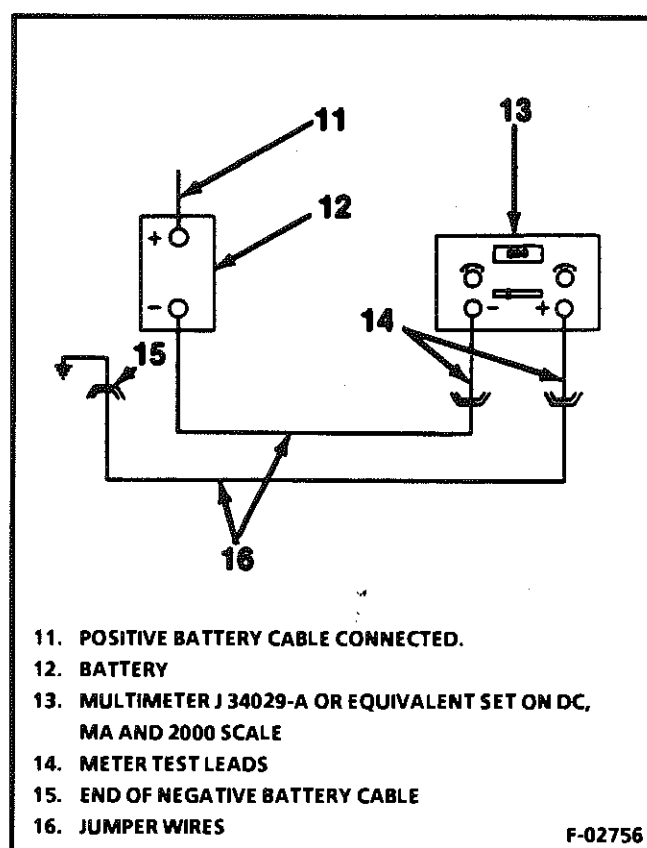


Figure 4 - Battery Drain Test Circuit

## CURRENT DRAIN TEST

If a battery needs recharging and no cause is evident, check the vehicle for excessive current drain.

### Remove or Disconnect

1. Negative battery cable.

### Install or Connect

Tool Required:

J 34029-A Multimeter.

1. Clip of a jumper wire to the negative battery terminal adapter (Figure 4).
2. Clip at the other end of the jumper wire to digital multimeter J 34029-A or equivalent.
3. Clip from the second jumper wire to the end of the negative battery cable.
4. Clip at the other end of the wire to the multimeter.
  - Set the multimeter on the DC, MA and 2000 scale.
  - Take the reading with the engine control switch and all accessories "OFF."
5. If current draw is more than 50 milliamps, check the system for causes such as a shorted wire or a compartment lamp that does not shut "OFF" when it should.

## BATTERY CABLES

Excessive resistance caused by poor terminal connections and partial short circuits through defective cable insulation will result in an abnormal voltage drop in the starter cable. Low voltage at the starter will prevent normal starter operation and cause hard starting.

**CAUTION:** To prevent possible personal injury from a moving vehicle or operating engine do the following before performing the checks:

1. Engage the parking brakes and block the wheels.
  2. Place the manual transmission in the neutral position.
  3. Disconnect the battery feed at the distributor.
1. Check the voltage drop between ground (negative battery terminal) and the vehicle frame. Place one prod of the test voltmeter on the grounded battery post (not on the cable clamp) and the other on the frame. Operate the starter and note the voltage reading.
  2. Check the voltage drop between the positive battery terminal and starter terminal stud with starter operating.

3. Check the voltage drop between the starter housing and frame with the starter operating.
4. If the voltage drop in any of the above is more than 1.0 volt, there is excessive resistance in the circuit. To eliminate resistance, the cables should be disconnected and connections cleaned. If cables are frayed or the clamps corroded, the cables should be replaced. When selecting new cables, be sure they are at least as large as the ones being replaced.

Battery cable routing is shown in Figure 5.

## BATTERY REPLACEMENT

When handling a battery, observe the following safety precautions.

1. Hydrogen gas is produced by the battery. A flame or spark near the battery may cause the gas to ignite.
2. Battery fluid is highly acidic. Avoid spilling on clothing or skin. Any spilled electrolyte should be flushed with large quantities of water and cleaned immediately.

### Remove or Disconnect (Figure 5)

1. Negative cable from the negative battery terminal.
2. Positive cable from the positive battery terminal.

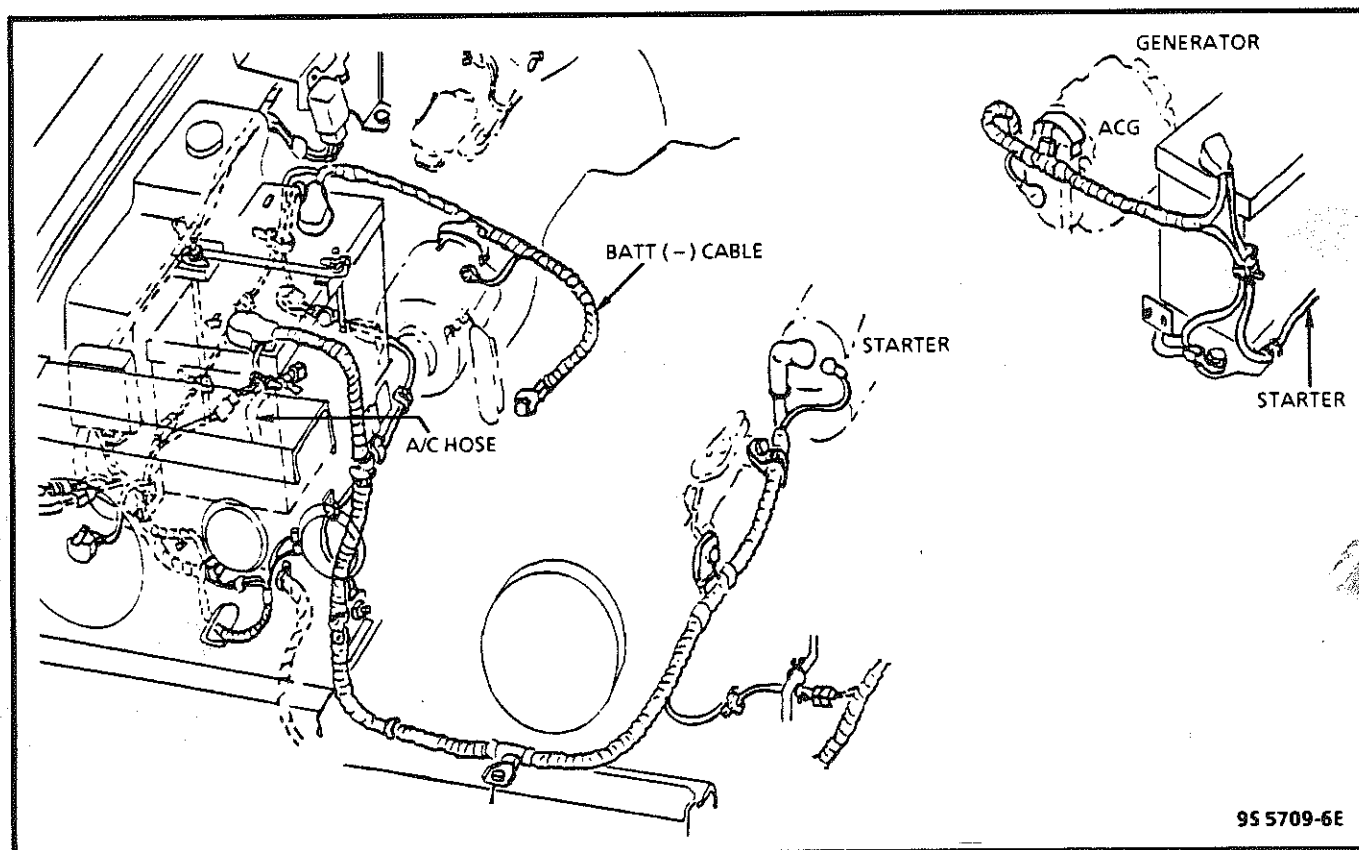


Figure 5 - Battery Cable Routing for the 2.8L Engine

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3. Battery hold-down clamp.
4. Battery.

### Inspect

1. Battery for damage.
2. Cables and connectors.
3. Carrier for damage or foreign objects.
  - If damage is noted, find and correct the cause.

### Install or Connect

1. Battery into cleaned carrier.
2. Hold-down retainer.

### Tighten

- Retainer to 17 N·m (13 lb. ft.)
  - Retainer on right-hand drive vehicle to 11 N·m (100 lb. in.).
1. Positive cable to the positive terminal.
  2. Negative cable to the negative terminal.

## CHARGING SYSTEM

### DESCRIPTION

The charging system consists of the battery, the generator, the regulator, and the charging system

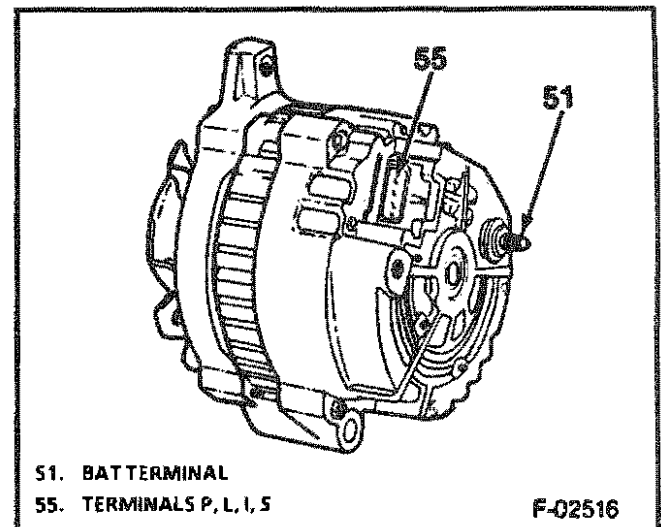


Figure 6 - CS-130 Generator

indicator lamp circuitry. The generator supplies electrical power for charging the battery and operating accessories.

The CS-130 (Figures 6 & 7) is a generator featuring a high ampere output per pound of weight. The CS stands for charging system and 130 is the measurement in millimeters of the outside diameter of the stator laminations.

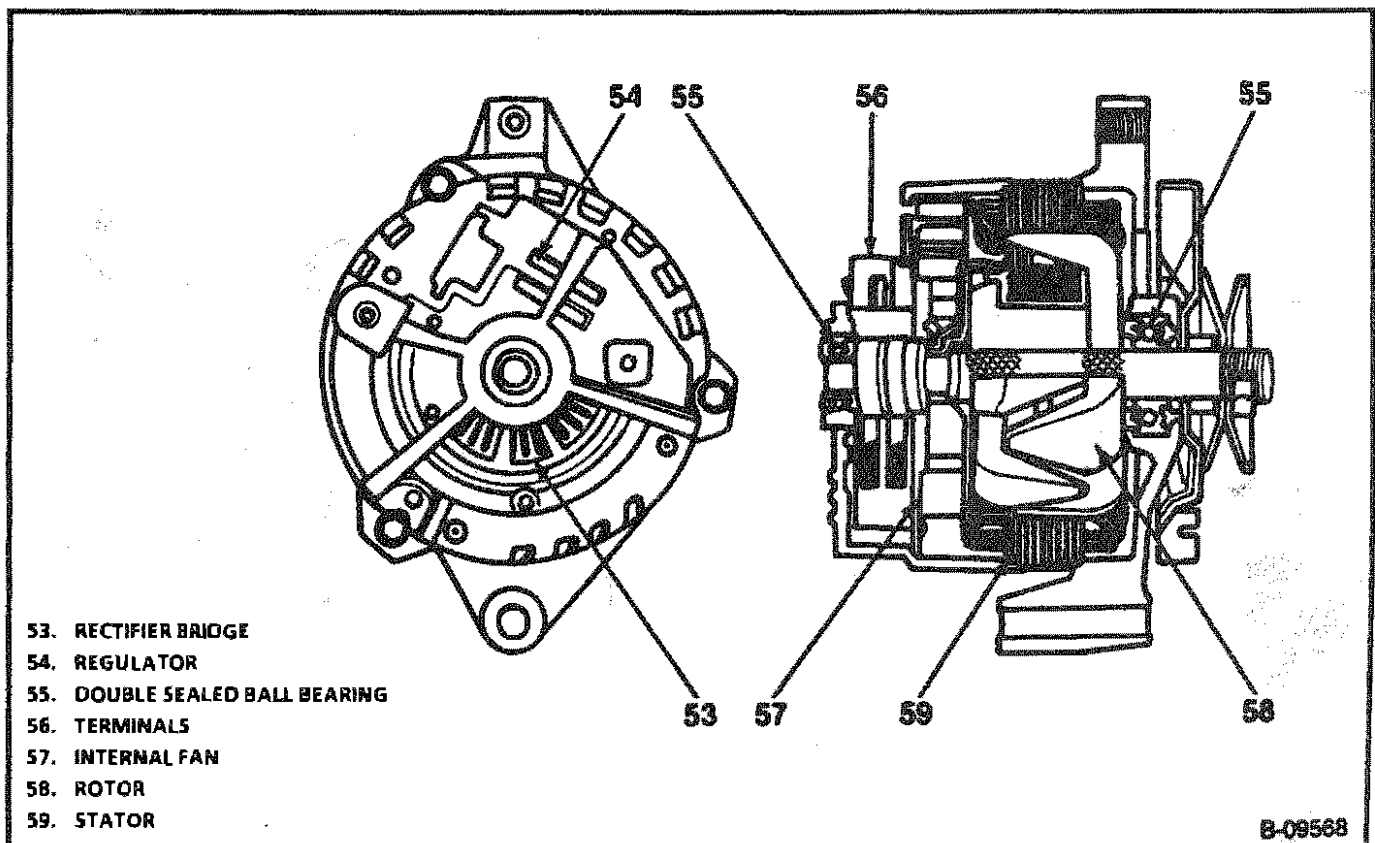


Figure 7 - Generator Components

This generator with integral regulator does not have a diode trio. The delta stator, rectifier bridge, and rotor with slip rings and brushes are electrically similar to other generators. A conventional fan and pulley are used, and an internal fan cools the slip rings, end frame, rectifier bridge and regulator.

The charge indicator, which appears on the instrument panel as a battery symbol, lights when the engine control switch is closed and goes out when the engine is running. If the charge indicator is on with the engine running, a charging system problem is indicated. This indicator will glow at full brilliance, not half lit, if any charging problem occurs or if the system voltage is too high or too low.

The regulator voltage setting varies with temperature, and limits system voltage by controlling rotor field current on and off at a fixed frequency of about 400 cycles per second. By varying the on-off time, correct average field current for proper system voltage control is obtained. At high speeds, the on-time may be 10 percent and the off-time 90 percent. At low speeds, with high electrical loads, on-off time may be 90 percent and 10 percent respectively.

The regulator has four terminals "P", "L", "I" and "S" (Figure 6). The use of the "P", "L" and "S" terminals is optional. The "P" terminal is connected to the stator, and may be wired to a tachometer or other device. The "S" terminal may be wired to the battery to sense voltage to be controlled. The "L" and "I" terminals serve to turn on the regulator and allow field current to flow when the switch is closed. The "I" terminal may be connected directly to the switch, or through a resistor. The "I" circuit may be used with or without the "L" circuit. Refer to the "Light Duty Truck" wiring diagrams for specific application.

The generator is not serviceable, and no periodic maintenance is required.

### DIAGNOSIS OF THE CHARGING SYSTEM

#### NOISY GENERATOR

Noise from a generator may be caused by a loose drive pulley, loose mounting bolts, worn or dirty bearings, or a worn stator. If the pulley and mounting bolts are snug and the noise continues, replace the generator. Refer to "Generator Replacement" later in this section.

#### ELECTRICAL TESTS

Before performing the diagnosis procedures on the vehicle, be certain that the system wiring is good and generator belts are not slipping. Also, the battery must be fully charged for a valid test of the charging system.

**NOTICE:** To avoid damage to the vehicle electrical system, observe the following precautions:

- Do not polarize the generator.
- Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.
- NEVER operate the generator with the output terminal open-circuited.
- Make sure the generator and battery have the same ground polarity.
- When connecting a charger or booster battery to the vehicle battery, connect negative to negative and positive to positive.

### CIRCUIT DIAGNOSIS

Trouble in the charging system will show up as one or more of the following conditions:

- Abnormal indicator lamp operation.
- An undercharged battery as evidenced by slow cranking or dark hydrometer.
- An overcharged battery as evidenced by excessive spewing of electrolyte from the vents.

A basic wiring diagram for the charging system is shown in Figure 8. When the system is operating normally, the indicator lamp will come "ON" when the engine control switch is turned "ON" and go out when the engine starts. If the lamp operates abnormally, or if an undercharged or overcharged battery condition occurs, the following procedure may be used to diagnose the charging system. Remember that an undercharged battery is often caused by accessories being left "ON" overnight, or by a switch stuck closed which allows a lamp, such as a glove box lamp, to stay "ON." This generator does not have a test hole.

### DIAGNOSTIC TEST FOR CS-130

1. Check belt for wear and tension. Check wiring.
2. Go to Step 5 for vehicles without a charge indicator lamp.
3. With the engine control switch "ON" and the engine stopped, the lamp should be "ON." If not, detach the wiring harness at the generator and use a fused (5 amp) jumper to ground the "L" terminal lead.
  - If the lamp lights, replace the generator.
  - If the lamp does not light, locate the open circuit between the grounding lead and the engine control switch. The lamp may be open.

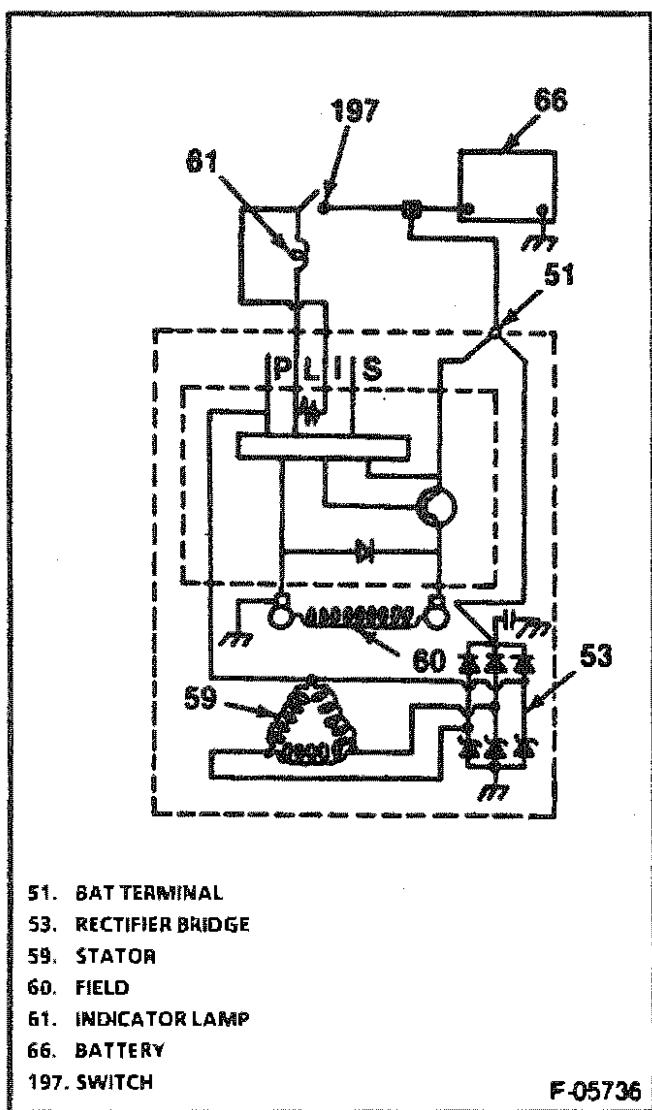


Figure 8 - CS Generator Schematic

4. With the switch "ON," and the engine running at moderate speed, the lamp should be "OFF." If not, detach the wiring harness at the generator.
  - If the lamp goes out, replace the generator.
  - If the lamp stays "ON," check for a grounded "L" terminal wire in the harness.
5. If the battery is undercharged or overcharged:
  - Detach the wiring harness connector from the generator.
  - With the switch "ON" and the engine not running, connect a voltmeter from ground to the "L" terminal in the wiring harness, and to the "I" terminal, if used. The wiring harness may connect to either "I" or to both.
  - A zero reading indicates an open circuit between the terminal and the battery. Correct as required.
  - Connect the harness connector to the generator and run the engine at moderate speed with accessories "OFF."

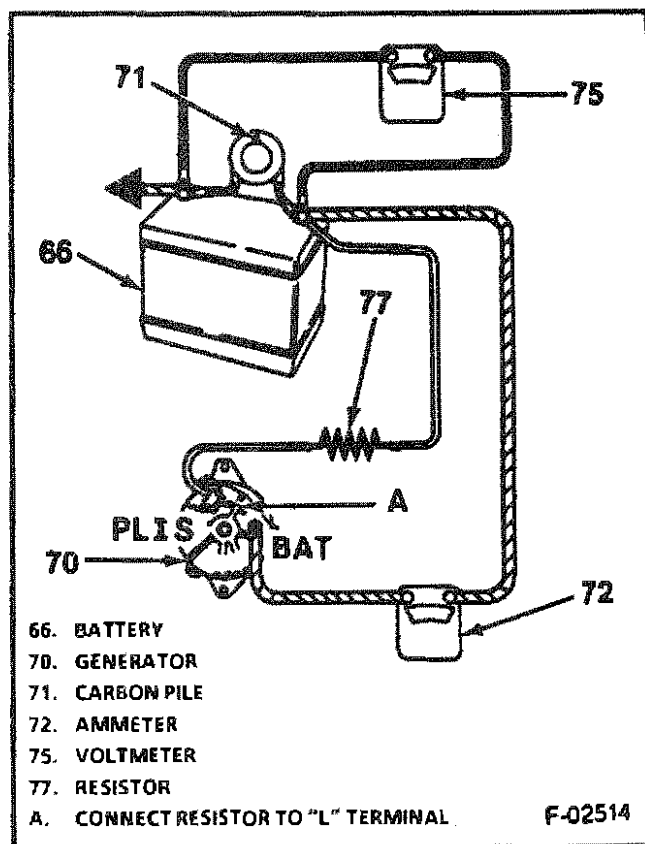


Figure 9 - Connections for Generator Output Test

- Measure the voltage across the battery. If above 16 volts, replace the generator.
- Connect an ammeter at the generator output terminal, connect a voltmeter across the generator, turn "ON" the accessories and load the battery with a carbon pile to obtain maximum amperage. Maintain voltage at 13 volts or above.
  - If the output in amperes is within 15 amperes of the rated output, the generator is OK. (Refer to "Specifications" at the end of this section.)
  - If the output is not within 15 amperes of the rated output, replace the generator.

### GENERATOR BENCH CHECK

1. Make connections as shown in Figure 9, except leave the carbon pile disconnected. The ground polarity of the generator and battery must be the same. The battery must be fully charged. Use a 30 to 500 ohm resistor between the battery and the "L" terminal.
2. Slowly increase generator speed and observe the voltage.

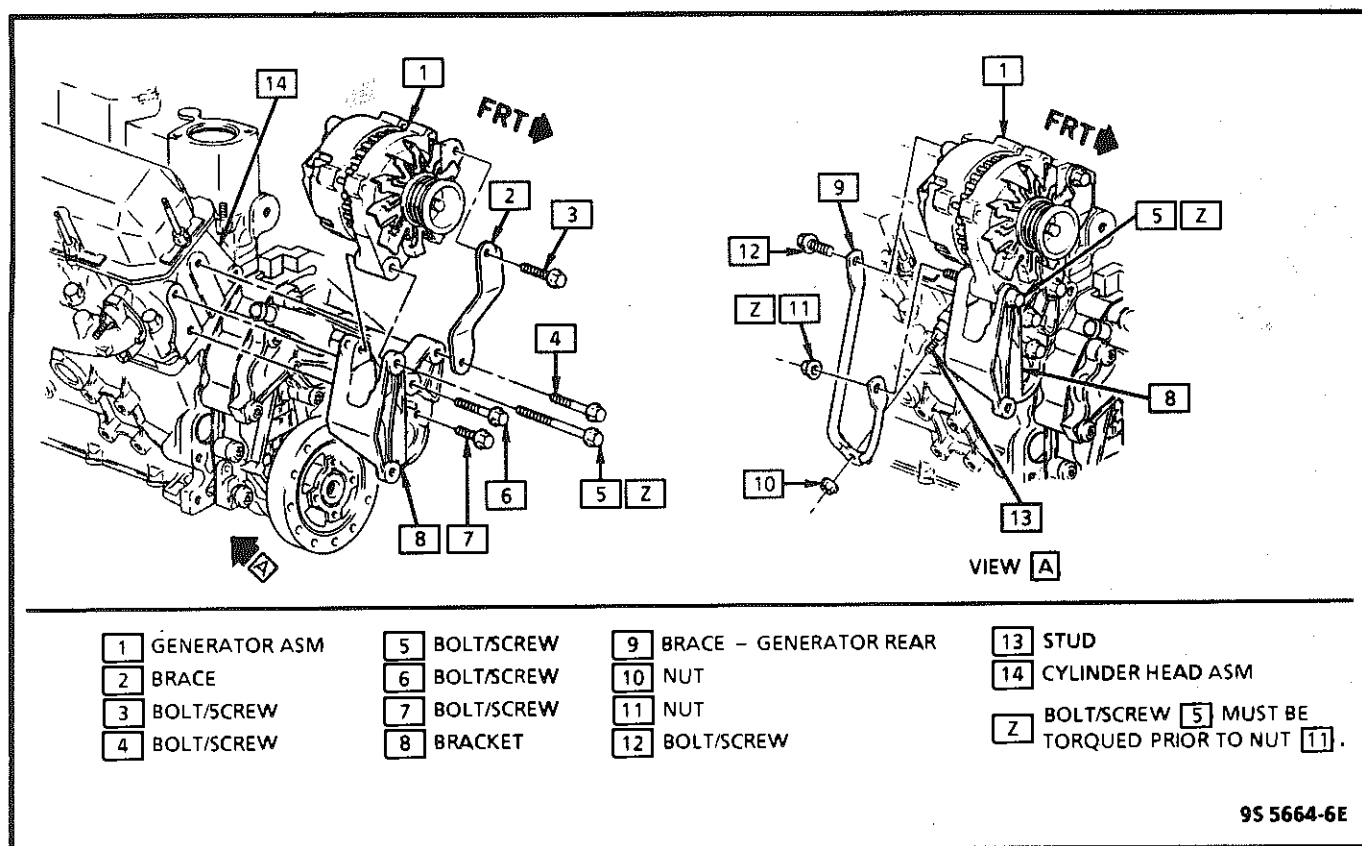


Figure 10 - Generator Mounting for the 2.8L Engine

3. If the voltage is uncontrolled and increases above 16 volts, the rotor field is shorted, the regulator is not working properly, or both. A shorted rotor field coil can cause problems in the regulator.
4. If the voltage is below 16 volts, increase speed and adjust the carbon pile to obtain maximum amperage output. Maintain the voltage above 13 volts.
5. If the output is within 15 amperes of the rated output, the generator is good.
6. If the output is not within 15 amperes of the rated output, replace the generator.

## GENERATOR ON-VEHICLE SERVICE

### GENERATOR REPLACEMENT

The removal and installation instructions serve only as a guide. Additional operations may be required on some vehicles to remove other equipment to gain access to the generator, drive belts and brackets.

**CAUTION:** Failure to observe Step 1 in this procedure may result in an injury from the hot battery lead at the generator.

### Remove or Disconnect (Figure 10)

1. Negative battery cable at the battery.
2. Terminal plug and battery lead from the back of the generator.
3. Drive belt.
4. Bolt at the back of the generator.
5. Two mounting bolts.
6. Generator from the mounting bracket.

### Install or Connect

1. Generator to the mounting bracket with two bolts.
2. Bolt to the back of the generator.
3. Drive belt.

### Tighten

- Lower mounting bolt to 35 N·m (26 lb. ft.)
  - Upper mounting bolt to 25 N·m (18 lb. ft.)
  - Air pump bracket bolt to 25 N·m (18 lb. ft.)
4. Terminal connector and battery lead to the back of the generator.
  5. Negative battery cable.

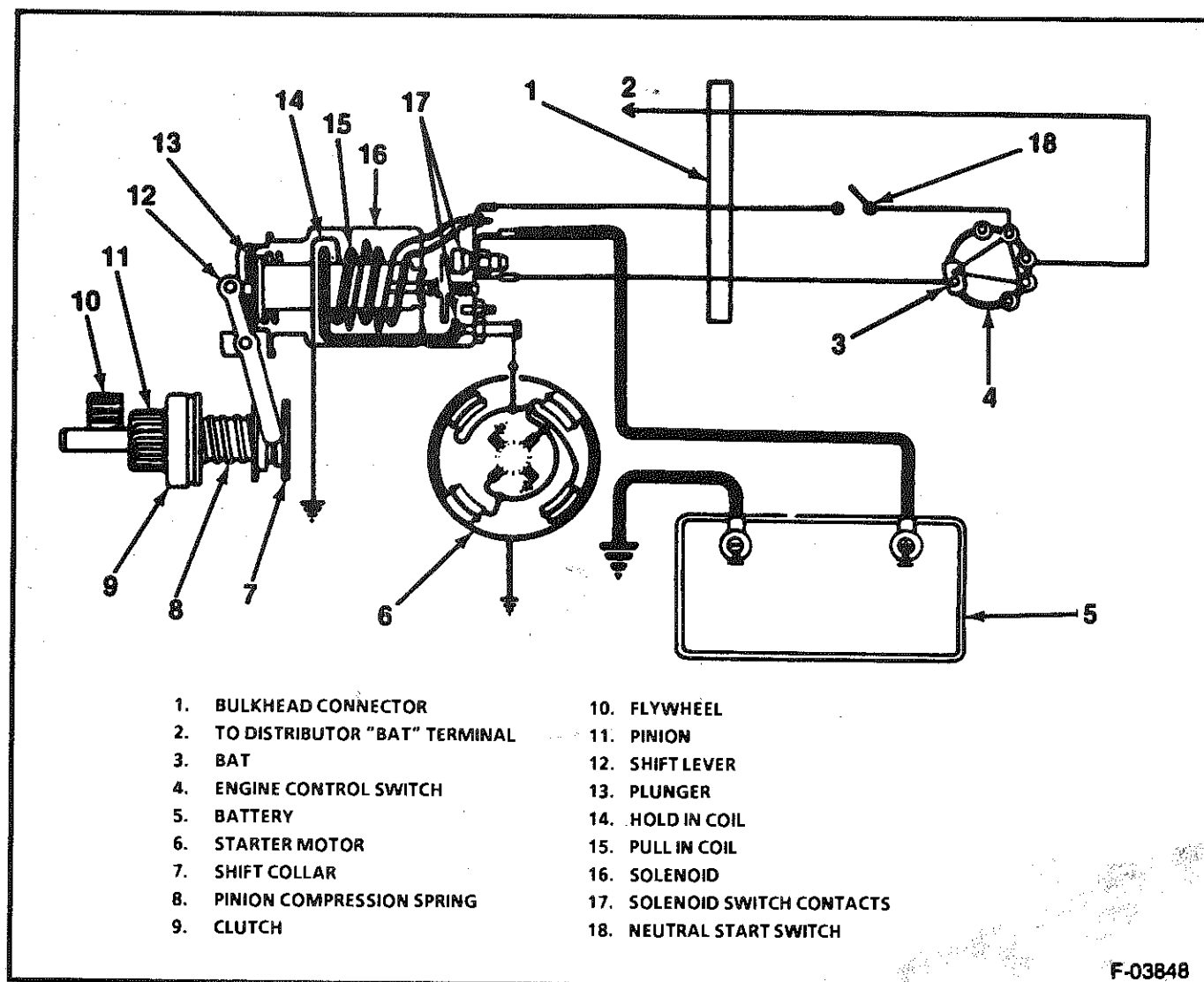


Figure 11 - Cranking Circuit

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## DESCRIPTION

### Cranking Circuit

The basic cranking circuit consists of the battery, starter motor, engine control switch, neutral sensing or neutral start switch, and related electrical wiring (Figure 11).

### Starter Motor

Wound field starter motors have pole pieces, arranged around the armature that are energized by wound field coils (Figure 12).

### Solenoid

Enclosed shift lever cranking motors have the shift lever mechanism and the solenoid plunger enclosed in the drive housing, protecting them from exposure to dirt, icing conditions and splash.

In the basic circuit shown in Figure 12, solenoid windings are energized when the switch is closed. The resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened at which time the return spring causes the pinion to disengage. To prevent excessive overrun, open the engine control switch (release from the "start" position) immediately when the engine starts.

## DIAGNOSIS OF CRANKING SYSTEM

Refer to Figures 13, 14 and 15 for a diagnosis of the cranking system. Before removing any unit in the system for repair, make the following checks.

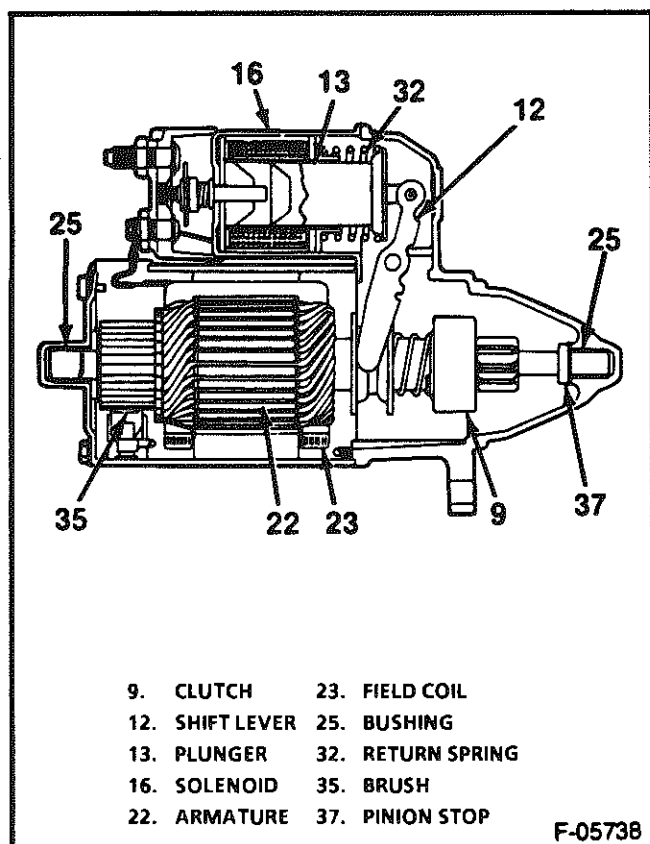


Figure 12 - 5MT Starter Motor

## CRANKING CIRCUIT

### Battery

Determine the condition of the battery. Refer to "Battery" earlier in this section for battery diagnosis and testing.

### Wiring

Inspect the circuit wiring for damage. Inspect all connections to the starter motor, solenoid, engine control switch, and battery, including all ground connections. Clean and tighten all connections as required.

### Solenoid and Control Switches

Check all switches to determine their condition. A vehicle with a manual transmission has a neutral start switch attached to the clutch.

## STARTER MOTOR NOISE

Refer to the starter noise diagnostic chart. Shims are available to adjust the pinion clearance.

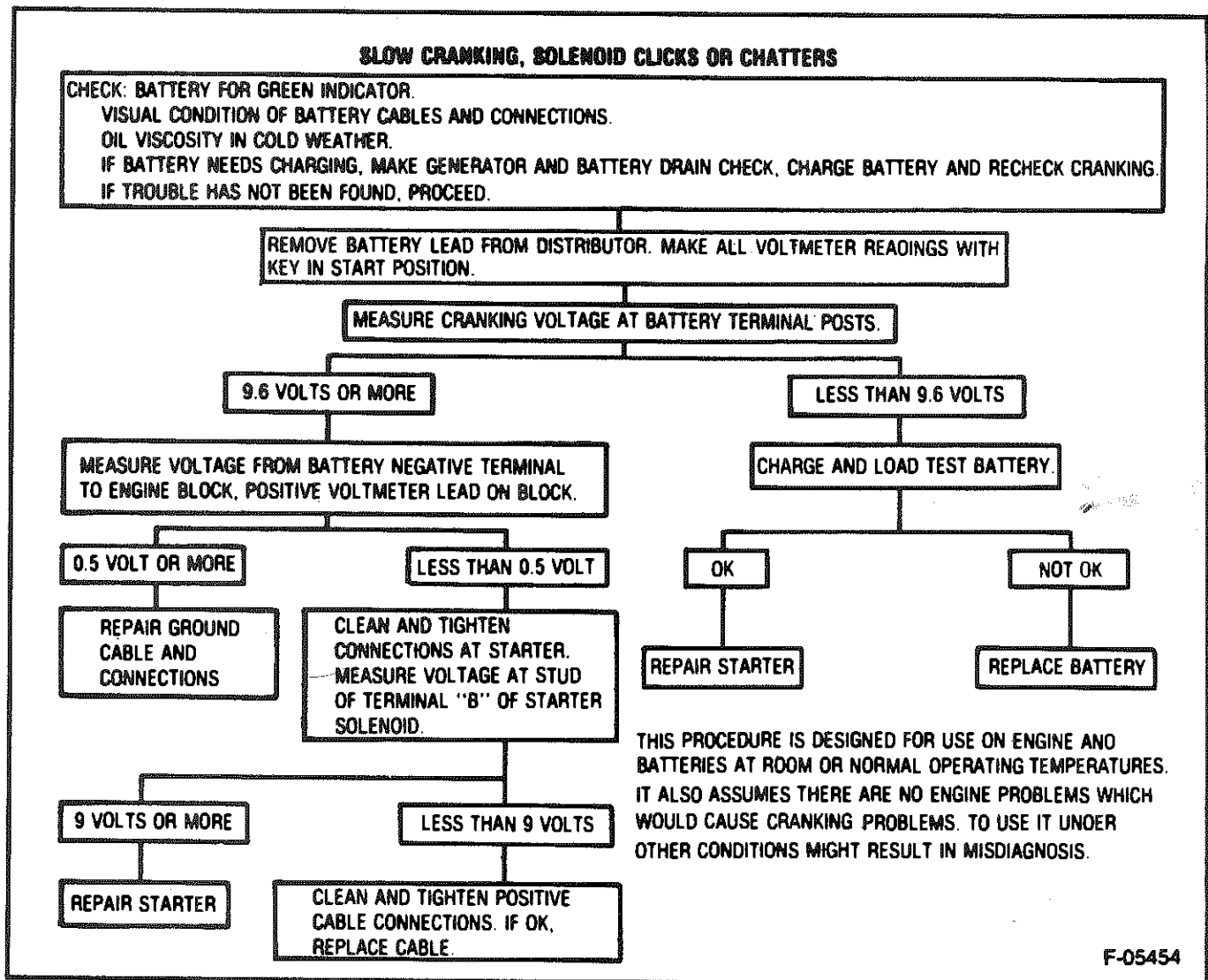
## Pinion Clearance

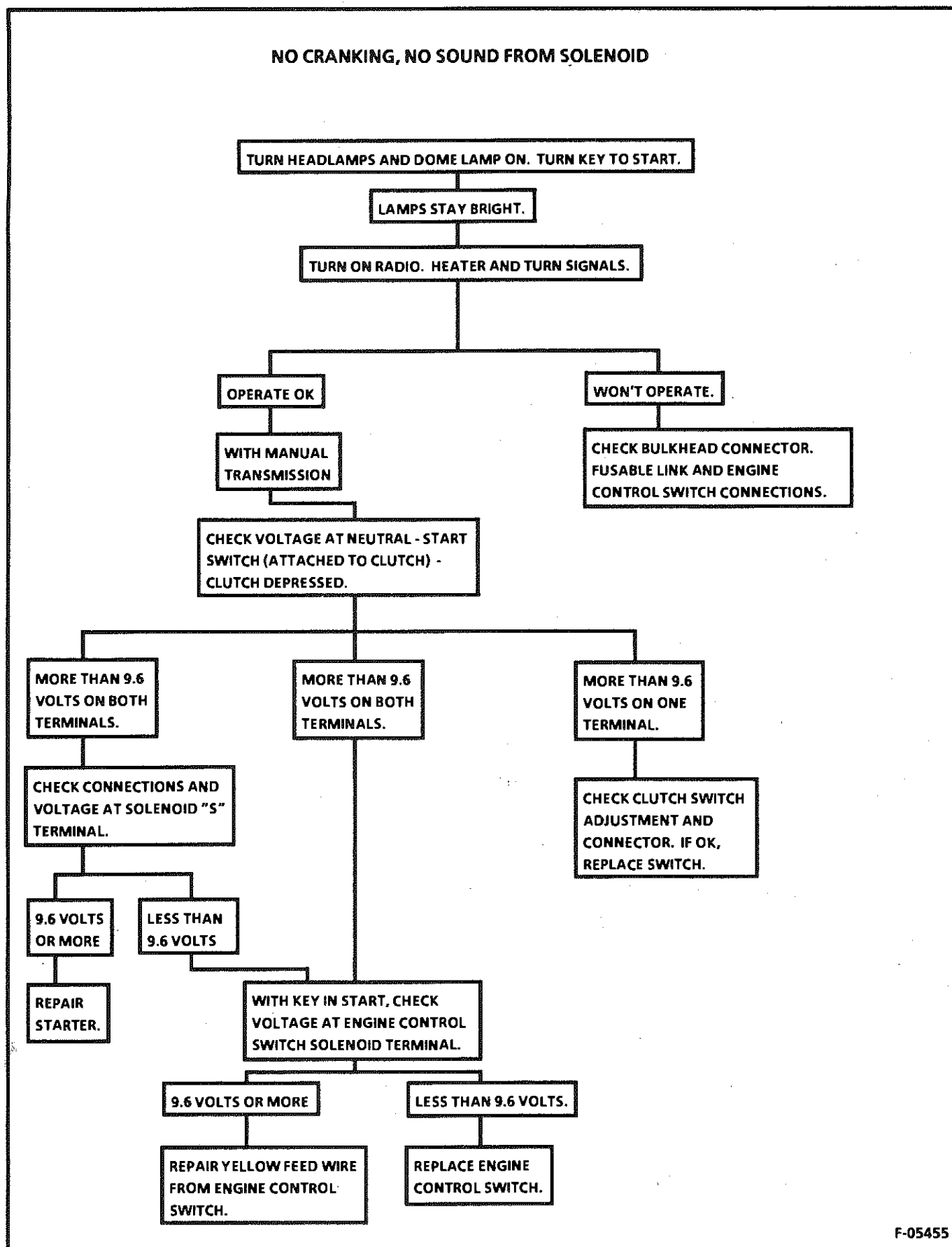
1. Remove negative battery cable.
2. Remove starter.
3. Flywheel inspection cover.
4. Inspect the flywheel for signs of unusual wear such as chipped or missing gear teeth or the flywheel being bent. If the flywheel needs replacing, refer to "Engine Mechanical" earlier in this manual.
5. Install starter motor and negative battery cable.
6. Start the engine and gently touch the outside diameter of the rotating flywheel ring gear with chalk or crayon to show the high point of toothrunout after the engine is turned "OFF". Turn the engine "OFF" and rotate the flywheel so that the marked teeth are in the area of the starter pinion gear.
7. Disconnect the negative battery cable to prevent accidental cranking of the engine.
8. Insert a screwdriver in the small hole in the bottom of the starter (shown by the arrow in Figure 17) and move the starter pinion and clutch assembly so that the pinion teeth and flywheel teeth are meshed. If necessary, rotate the flywheel so that a pinion tooth is directly in the center of two flywheel teeth and on the centerline of the two gears (Figure 18).
9. Measure the clearance between the top of the pinion tooth and the bottom of the flywheel tooth using the width of the wire gage (Figure 18). Normal clearance is 0.5 to 1.5 mm (0.02 to 0.06 in.).
10. If the clearance is less than 0.5 mm (0.02 in.) and the starter whines after firing, shim the starter away from the flywheel (Figure 18). Add 1.0 mm (0.04 in.) shims, one at a time, between the starter mounting pads and the engine until the noise problem is corrected. Do not use more than 4 shims on the 2.8L engine.
11. If the pinion clearance is more than 1.5 mm (0.06 in.) and the starter whines during cranking, shim the starter towards the flywheel. Reduce shim thickness by removing the existing shim and replace it with a 1.0 mm (0.04 in.) shim. If noise persists, remove the shim.
12. When shimming is done, torque the mounting bolts.
13. Install flywheel inspection cover.



### Tighten

- Bolts to 40 N·m (30 lb. ft.).





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Figure 14 - Cranking System Diagnosis

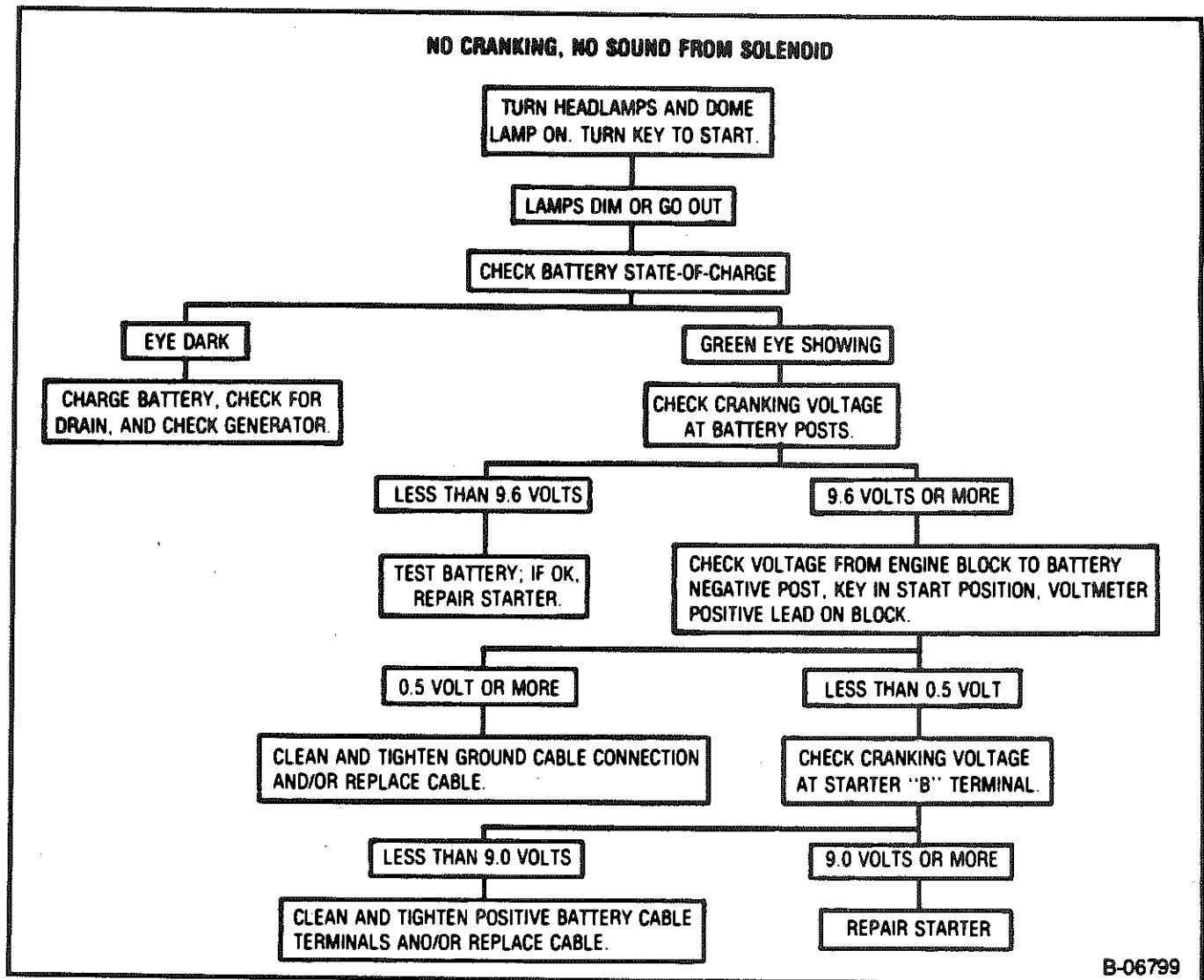


Figure 15 - Cranking System Diagnosis

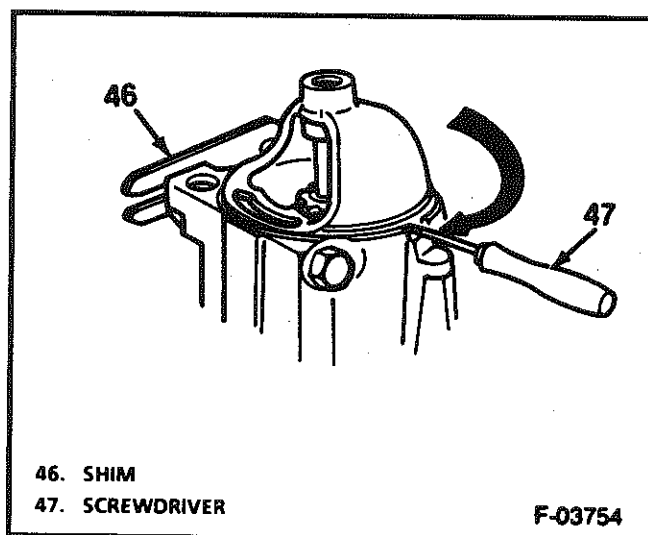


Figure 16 - Meshing Starter and Flywheel Teeth

6. Two bolts and washers holding the starter to the engine.
7. Starter and the shim (if present).

#### Install or Connect

1. Starter and the shim (if present) to the engine with bolts and washers.

#### Tighten

- Mounting bolts on the 2.8L engines to 40 N·m (30 lb. ft.).
1. Skid plate (if equipped).
  2. Wires to the solenoid terminals.
    - Lower the vehicle.
  3. Negative battery cable.

#### Tighten

- Mounting bracket nuts to 8 N·m (75 lb. in.).

## ENGINE BLOCK HEATER

## DESCRIPTION

The optional engine block heater is used to preheat engine coolant for cold weather starting. The unit consists of a heating element that fits into the engine block. It attaches to an electrical cord with a plug. If the element fails to heat the coolant, check the cord and connections before replacing the element.

## ON-VEHICLE SERVICE

 Remove or Disconnect

1. Engine coolant. Refer to "Engine Cooling" Section "6B".
2. Plug end from the heater.
  - Loosen the heater screw
3. Heater from the engine block.

## Installation

1. Apply a coating of lubricant to the O-ring and to the cleaned surface of the plug opening in the block.
2. Insert the element of the heater into the block.
3. Turn the heater to the left as far as possible, and then rotate it slightly to the right so the element clears the wall of the cylinder.
4. Position the heater as shown in Figure 19.

 Tighten

- Screw to 1.8 N·m (16 lb. in.).
5. Route the heater cord so that it does not touch the engine, hot pipes, manifold, or any moving parts.
  6. Add engine coolant. Refer to "Engine Cooling," Section "6B".

## IGNITION SYSTEM

## DESCRIPTION

All ignition systems includes a battery, a distributor, an engine control switch, spark plugs, and the primary and secondary wiring. Information on the battery is located earlier in this section.

## DISTRIBUTOR

A distributor with a separate coil is used on these engines (Figures 22, 23). The coil connects to the rotor through a high tension wire.

The distributor uses a magnetic pickup assembly located inside the distributor which contains a permanent magnet, a pole piece with internal teeth, and pickup coil (Figure 23). When the teeth of the timer core rotating inside the pole piece line up with the teeth of the pole piece, an induced voltage in the pickup coil signals the electronic module to trigger the coil primary circuit.

The primary current decreases and a high voltage of up to 35,000 volts is induced in the ignition coil secondary winding which is directed through the rotor and secondary leads to fire the spark plugs. The capacitor in the distributor is for radio noise suppression.

The distributor also features a longer spark duration, made possible by the higher amount of energy stored in the coil primary. This is desirable for firing lean mixtures.

No periodic lubrication is required. Engine oil lubricates the lower bushing and an oil-filled reservoir provides lubrication for the upper bushing.

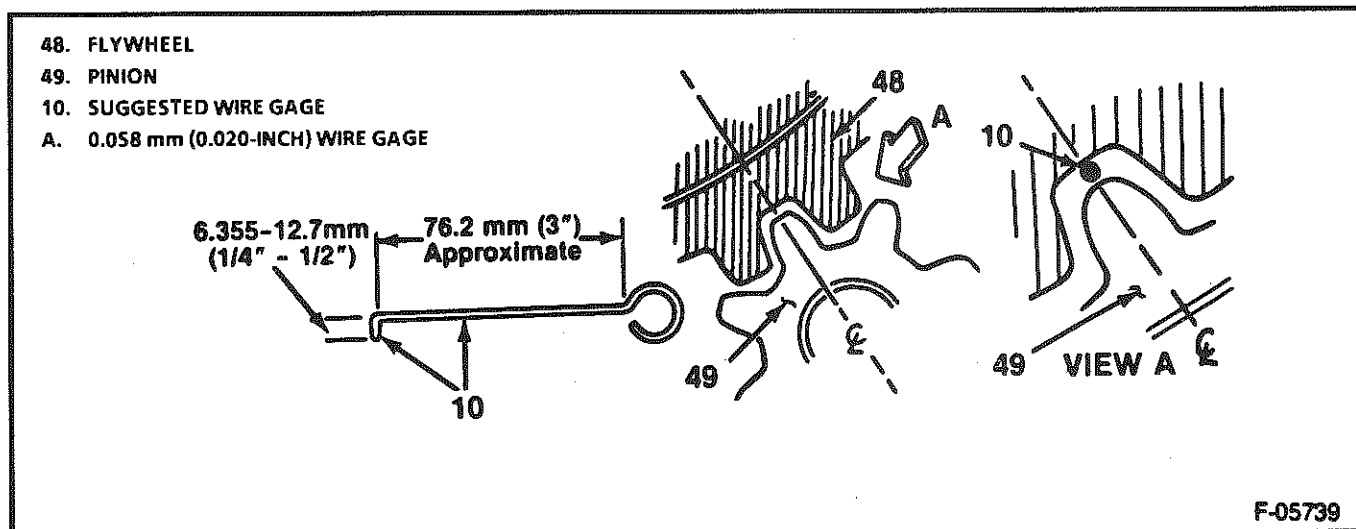


Figure 17 - Flywheel to Pinion Clearance

## ELECTRONIC SPARK TIMING (EST) SYSTEM

EST is part of most Computer Command Control systems. The computer, called an ECM (Electronic Control Module), monitors information from various engine sensors, computes the desirable spark timing, and signals the distributor to change the timing.

The distributor does not contain centrifugal advance weights, springs, or a vacuum advance unit.

For information on the Electronic Spark Timing system, system components and their locations, and diagnostic charts, refer to the "Driveability and Emissions" Section 6E.

## Electronic Spark Control (ESC)

The 2.8L engine is equipped with Electronic Spark Control (Figure 24). A knock sensor is mounted in the engine block. It is connected by a blue wire to the electronic spark control module, mounted on the RT fender in the engine compartment or bracket mounted on the block. The sensor, in response to engine knock, sends a signal to the module (called a "half function box"). This sends a signal to the ECM, located in the passenger compartment. The ECM sends a signal to the distributor to retard spark timing. Information and diagnostic material on ESC are located in the "Drivability and Emissions" Section 6E of the service manual.

## IGNITION TIMING

Timing specifications are listed on the Vehicle Emissions Control Information label on the engine hood. Always follow Vehicle Emissions Control Information label procedures when adjusting timing. When using a timing light, connect an adapter between the No. 1 spark plug and the No. 1 spark plug wire, or use an inductive type pickup. Do not pierce the plug lead. Once the insulation of the spark plug cable has been broken, voltage will jump to the nearest ground, and the spark plug will not fire properly.

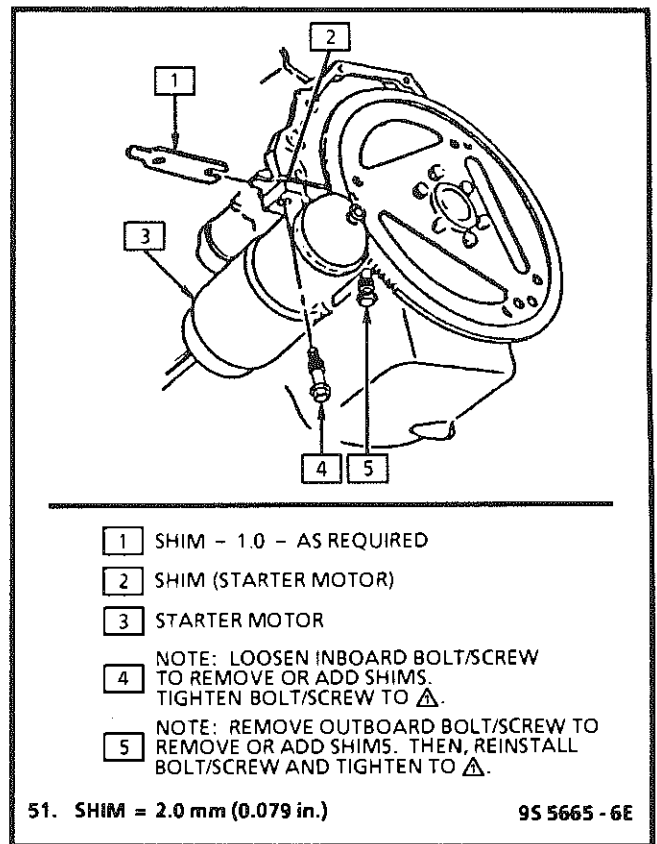


Figure 18 - Shimming the Starter Motor

Some engines incorporate a magnetic timing probe hole for use with special electronic timing equipment. Consult manufacturer's instructions for use of this equipment.

## SPARK PLUG WIRES

The 7 mm (0.276 in.) wire used on the 2.8L engines has an outer layer of silicone. The silicone spark plug boots form a tight seal on the plugs. Refer to "Spark Plug Wiring and Boots" later in this section for service precautions.

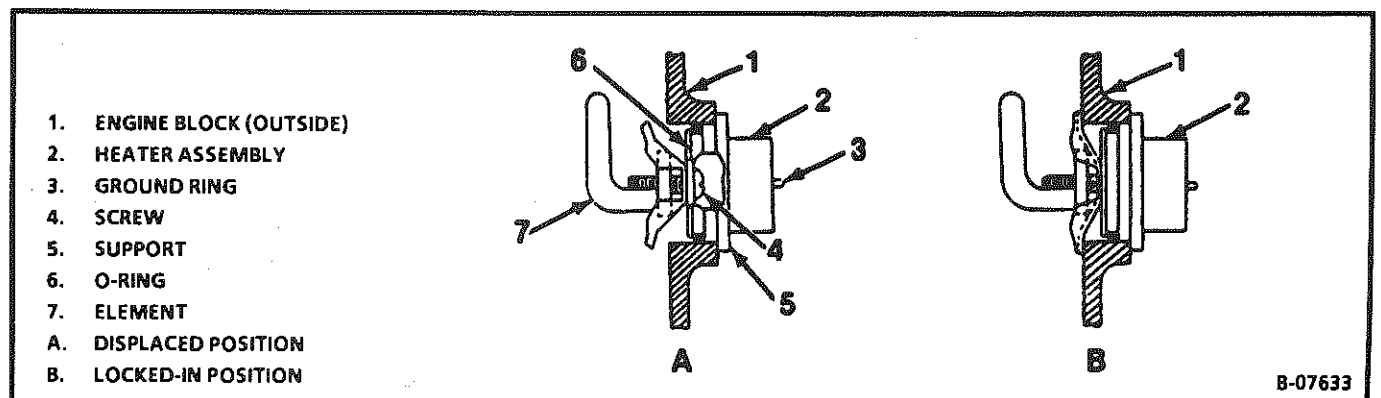


Figure 19 - Engine Block Heater

## SPARK PLUGS

Resistor type, tapered seat spark plugs are used. No gasket is used on these tapered seat plugs. Refer to Figure 25 for an explanation of letter coding on spark plugs. A dot before the spark plug code or the letter "C" after the number in the code indicates the plug has a copper core. Refer to the "Vehicle Emissions Control Information" label on the engine hood for correct gap information.

Normal or average service is assumed to be a mixture of idling, slow speed, and high speed operation with some of each making up the daily total driving. Occasional or intermittent high-speed driving is essential to good spark combustion heat that burns away any excess deposits of carbon or oxide that may have accumulated from frequent idling or continual stop-and-go or slow-speed driving. Spark plugs are protected by an insulating boot made of special heat-resistant material which covers the spark plug terminal and extends downward over a portion of the plug insulator. These boots prevent flash-over with resultant missing of engine, even though a film is allowed to accumulate on the exposed portion of plug porcelains.

Do not mistake corona discharge for flash-over or a shorted insulator. Corona is a steady blue light appearing around the insulator, just above the shell crimp. It is the visible evidence of a high-tension field, and has no effect on ignition performance. Usually it can be detected only in darkness. This discharge may repel dust particles, leaving a clear ring on the insulator just above the shell. This ring is sometimes mistakenly regarded as evidence that combustion gases have blown out between shell and insulator.

## DIAGNOSIS OF IGNITION SYSTEM

### ELECTRONIC SPARK TIMING SYSTEM

The "Driveability and Emissions" Section "6E" covers this system, including the diagnostic use of the "Check Engine" lamp.

Refer to the "Engine Electrical" Section "6D" for distributor component checks.

## DIAGNOSIS OF STARTER-MOTOR NOISE

| 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 starter mount. Refer to "Starter Motor Noise."                                   |
| 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 starter mount. Refer to "Starter Motor Noise."                                      |
| A loud "whoop" after the engine fires 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 starter motor and check clutch. Refer to the "Light Duty Truck Unit" Repair Manual.       |
| 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 starter motor and check the armature. Refer to the "Light Duty Truck Unit" Repair Manual. |

## 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 output.                                                                                                                                                                         | Check distributor to coil connections. Refer to the Fuel and Emissions Service Manual.                                                                                                                                                                                                                                                                                                                                                                                 |
| Wet, oily deposits with very little electrode wear.                                                                                | <ol style="list-style-type: none"> <li>1. "Break-in" of new or recently overhauled engine.</li> <li>2. Excessive valve stem guide clearances.</li> <li>3. Worn intake valve seals.</li> </ol> | <ol style="list-style-type: none"> <li>1. Degrease, clean and reinstall the plugs.</li> <li>2. Refer to "Engine" Section "6A".</li> <li>3. Replace the seals.</li> </ol>                                                                                                                                                                                                                                                                                               |
| 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.                                                                                                                                                                                                                                                                                                                                                                                          |
| Shiny yellow glaze coating on insulator.                                                                                           | Melted by-products of combustion.                                                                                                                                                             | Avoid sudden acceleration with wide-open throttle after long periods of low speed driving. Replace the plugs.                                                                                                                                                                                                                                                                                                                                                          |
| Burned or blistered insulator tips and badly eroded electrodes.                                                                    | Overheating.                                                                                                                                                                                  | <ol style="list-style-type: none"> <li>1. Check the cooling system.</li> <li>2. Check for sticking heat riser valves. Refer to "Engine" Section "6A".</li> <li>3. Lean air-fuel mixture. Refer to the "Fuel and Emissions" service manual.</li> <li>4. Check the heat range of the plugs. May be too hot.</li> <li>5. Check ignition timing. May be over-advanced.</li> <li>6. Check the torque value of the plugs to ensure good plug-engine seat contact.</li> </ol> |
| Broken or cracked insulator tips.                                                                                                  | Heat shock from sudden rise in tip temperature under severe operating conditions. Improper gapping of plugs.                                                                                  | Replace the plugs. Gap correctly.                                                                                                                                                                                                                                                                                                                                                                                                                                      |

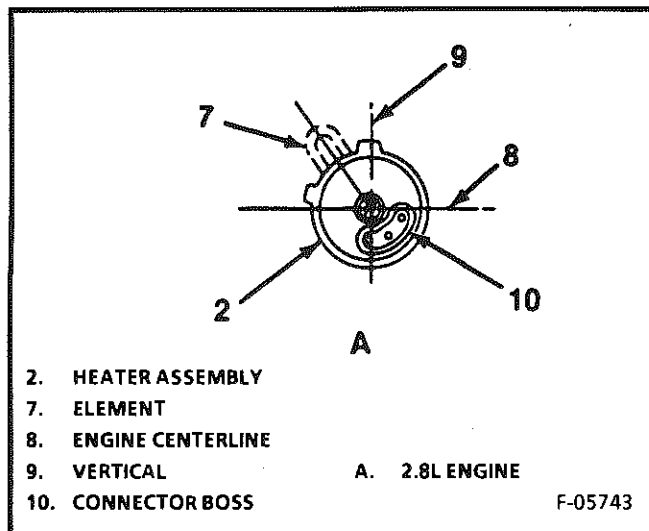


Figure 20 - Element Position

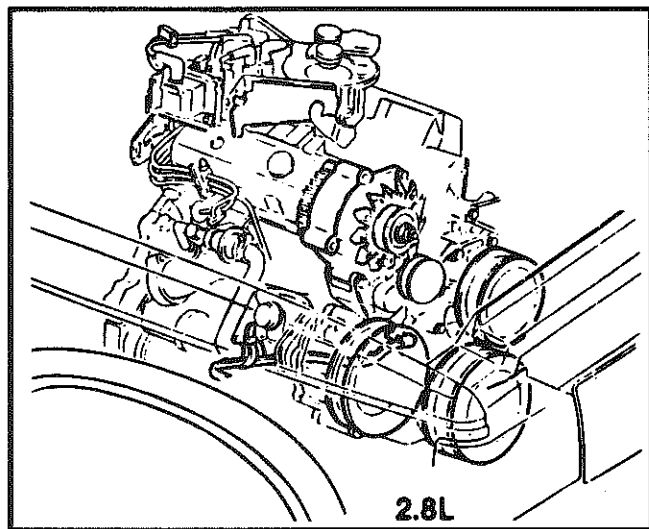


Figure 21 - Engine Block Heaters and Cords

## IGNITION SYSTEM ON-VEHICLE SERVICE

### SERVICE PRECAUTIONS

Some service tachometers and electronic diagnostic equipment may NOT be compatible with this ignition system. Consult your representative of such equipment.

1. When making compression checks, disconnect the engine control switch feed wire at the distributor. When disconnecting this connector, release the locking tab while pulling downward on the connector body; do not use a screwdriver or tool to release the locking tab as it may break the tab.
2. No periodic lubrication of the distributor is required. Engine oil lubricates the lower bushing and an oil-filled reservoir provides lubrication for the upper bushing.

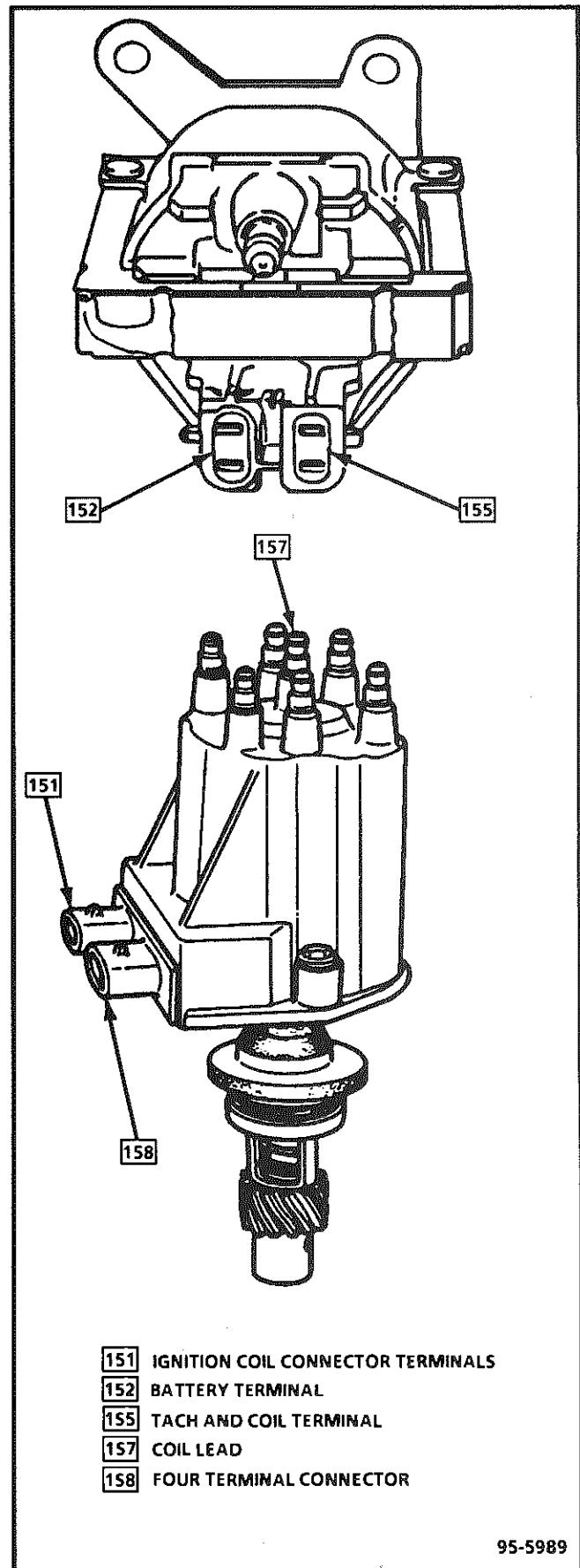


Figure 22 - EST Distributor with Sealed Module Typical Connector and Separate Coil

3. The tachometer (TACH) terminal is next to the engine control switch (BAT) connector on the distributor cap.

**NOTICE:** The tachometer terminal must NEVER be allowed to touch ground, because damage to the module inside the distributor and/or ignition coil can result.

4. There is no manual dwell adjustment.
5. The material used to construct the spark plug wires is very pliable and soft. This wire will withstand more heat and carry a higher voltage. Due to the more pliable wire, scuffing and cutting become easier. It is therefore extremely important that the spark plug wires be routed correctly to prevent chaffing or cutting. When removing a spark plug wire from a spark plug, twist the boot on the spark plug and pull on the boot to remove the wire.

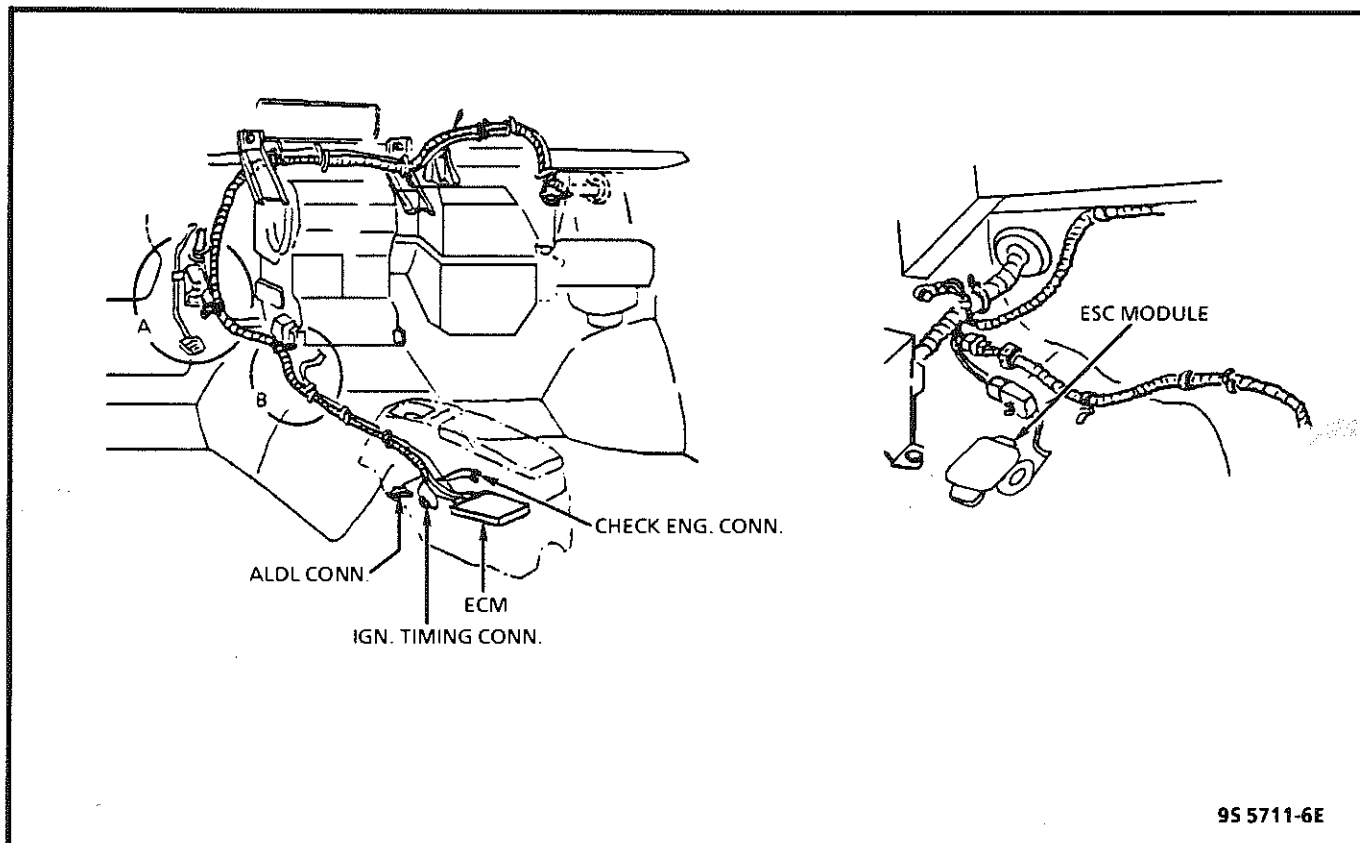
### IGNITION COIL CHECK

1. Disconnect the distributor lead and wiring from the coil.
2. Connect an ohmmeter as shown in Figure 27, Step 1. Use the high scale. The reading should be infinite. If not, replace the coil.

3. Connect the ohmmeter as shown in Step 2 (Figure 27). Use the low scale. The reading should be very low or zero. If not, replace the coil.
4. Connect the ohmmeter as shown in Step 3. Use the high scale. The meter should not read infinite. If it does, replace the coil.
5. Reconnect the distributor lead and wiring to the coil.

### PICKUP COIL CHECK

1. Disconnect the negative battery cable.
2. Remove the distributor cap.
3. Disconnect the pickup coil connector from the module.
4. Check the resistance of the coil with an ohmmeter.
  - Connect an ohmmeter to either pickup coil lead and the housing as shown in Figure 28, Step 1. The reading should be infinite. If not, replace the coil.
  - Connect an ohmmeter to both pickup coil leads as shown in Figure 27, Step 2. Flex the leads by hand at the coil and the connector to locate any intermittent opens. The ohmmeter should read a constant unchanging value in the 500 to 1500 ohm range. If not, replace the coil.



95 5711-6E

Figure 23 - Electronic Spark Control Wiring for the 2.8L Engine

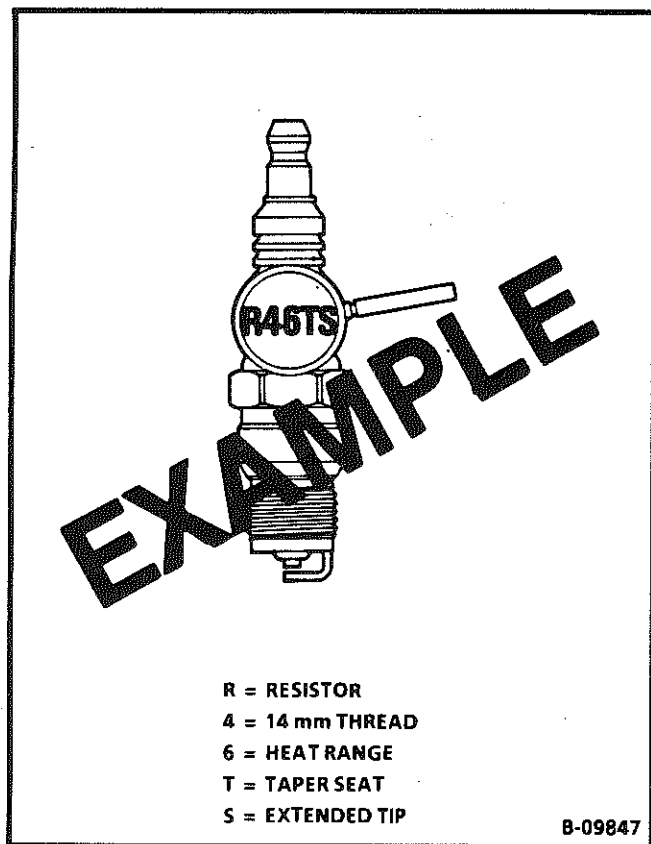


Figure 24 - Spark Plug Coding

Numbers relate to thread size as follows:

1st number denotes THREAD SIZE

|            |                    |
|------------|--------------------|
| 4 = 14 mm  | 2 = 1/2-inch taper |
| 8 = 18 mm  | 5 = 1/2-inch       |
| 10 = 10 mm | 6 = 3/4-inch       |
| 12 = 12 mm | 7 = 7/8-inch       |

2nd number denotes HEAT RANGE

0-1-2-3-4-5-6-7-8-9

COLD-----HOT

Figure 25 - Spark Plug Coding Chart

### Install or Connect

- To ensure correct timing of the distributor it must be installed with the rotor correctly positioned as noted in the removal procedure.
  - If the distributor shaft won't drop into the engine, insert a screwdriver into the hole for the distributor and turn the oil pump driveshaft.
1. Distributor.
  2. Hold-down nut and clamp.
  3. Distributor cap.
  4. Wiring harness connector at the side of the cap.
  5. Air cleaner and hoses.
  6. Negative battery cable.

### Ignition Coil

#### Remove or Disconnect

1. Negative battery cable.
2. Engine control switch and tachometer terminals at the coil.
3. Coil to distributor lead at the coil.
4. Nuts holding the coil bracket and coil to the engine bracket or manifold.
5. Coil bracket and coil.
  - Drill and punch out the two rivets holding the coil to the bracket.
6. Coil from bracket.

#### Install or Connect

1. Coil to the bracket or manifold with two screws.
2. Coil bracket to the engine bracket with studs and nuts.
3. Coil to the distributor lead at the coil.
4. Engine control switch and tachometer connectors to the coil.
5. negative battery cable.

## DISTRIBUTOR AND COIL REPLACEMENT

The distributor has a separate coil which is mounted on the right side of the engine.

### Distributor

#### Remove or Disconnect

1. Negative battery cable.
2. Air cleaner and hoses.
3. Wiring harness connectors at the side of the distributor cap.
4. Distributor cap and move it out of the way.
  - Scribe a mark on the engine in line with the rotor.
  - Note the position of the distributor housing in relation to the engine.
5. Distributor hold-down nut and clamp.
6. Distributor.

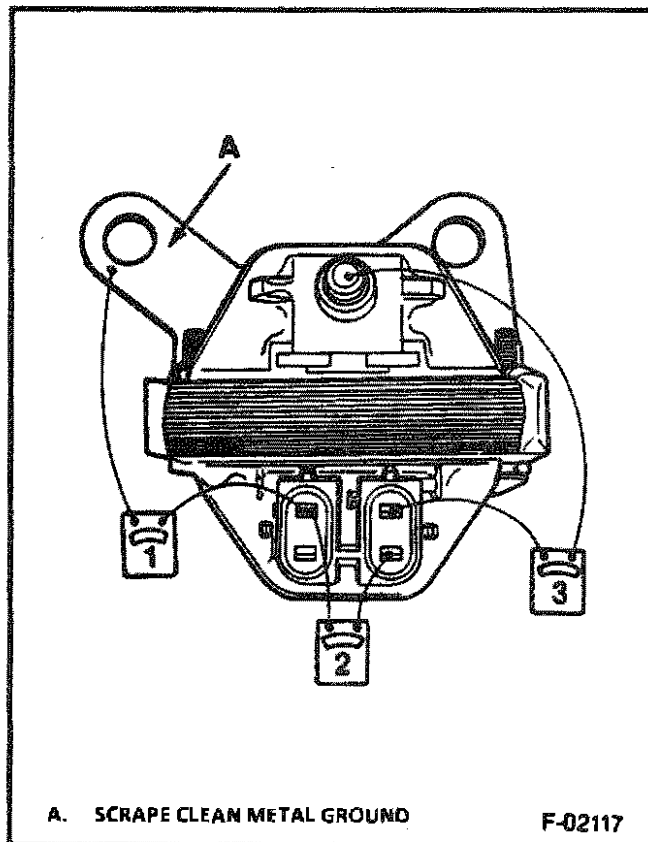


Figure 26 - Testing the Ignition Coil

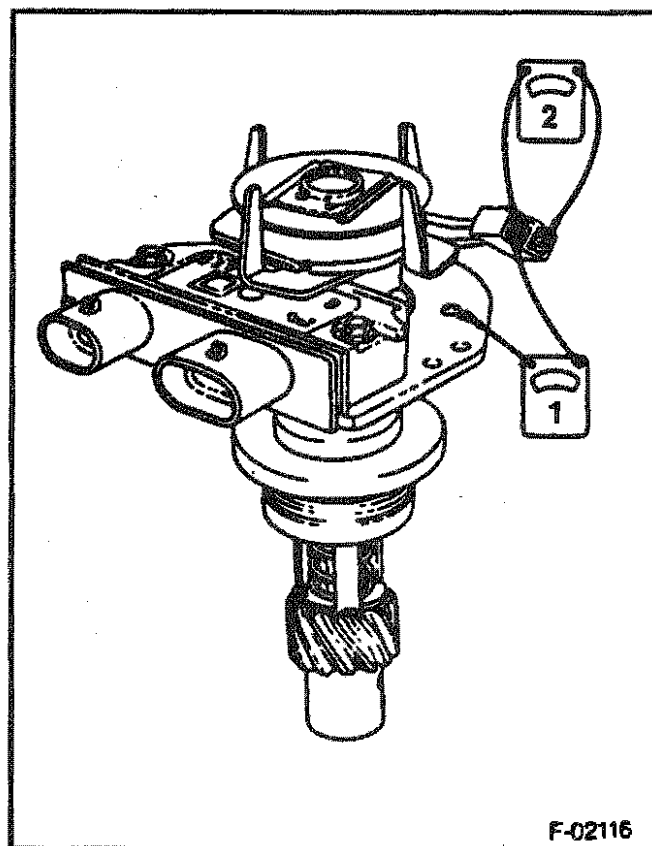


Figure 27 - Testing the Pickup Coil (Typical)

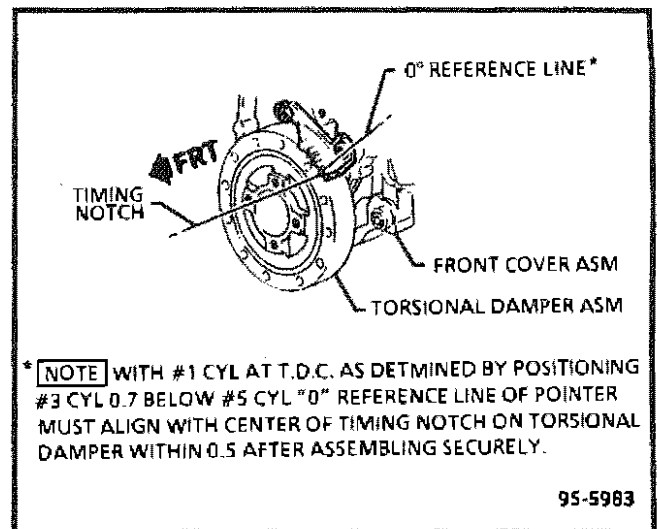


Figure 28 - Typical Timing Mark

### IGNITION TIMING

**CAUTION:** To prevent possible personal injury from a moving vehicle or operating engine do the following before performing the checks:

1. Engage the parking brake and block the wheels.
2. Place the manual transmission in neutral.

1. Refer to the "Vehicle Emissions Control Information" label located on the engine hood. Follow all instructions on the label.
2. Refer to the "Driveability and Emissions" Section "6E" for information on the bypass timing mode.
3. With the engine control switch "OFF," connect the pickup lead of the timing light onto the number one spark plug. Use a jumper lead between the wire and plug or an inductive type pick up. DO NOT pierce the wire or attempt to insert a wire between the boot and the wire. Connect the timing light power leads according to manufacturer's instructions.
4. Follow all instructions on the Vehicle Emission Control Information label. Start the engine, and aim the timing light at the timing mark (Figure 28). The line on the balancer or pulley will line up at the timing mark. If a change is necessary, loosen the distributor hold-down clamp bolt at the base of the distributor. While observing the mark with the timing light, slightly rotate the distributor until the line indicates the correct timing. Tighten the hold-down bolt, and recheck the timing.
5. Turn "OFF" the engine and remove the timing light. Reconnect the number one spark plug wire, if removed.

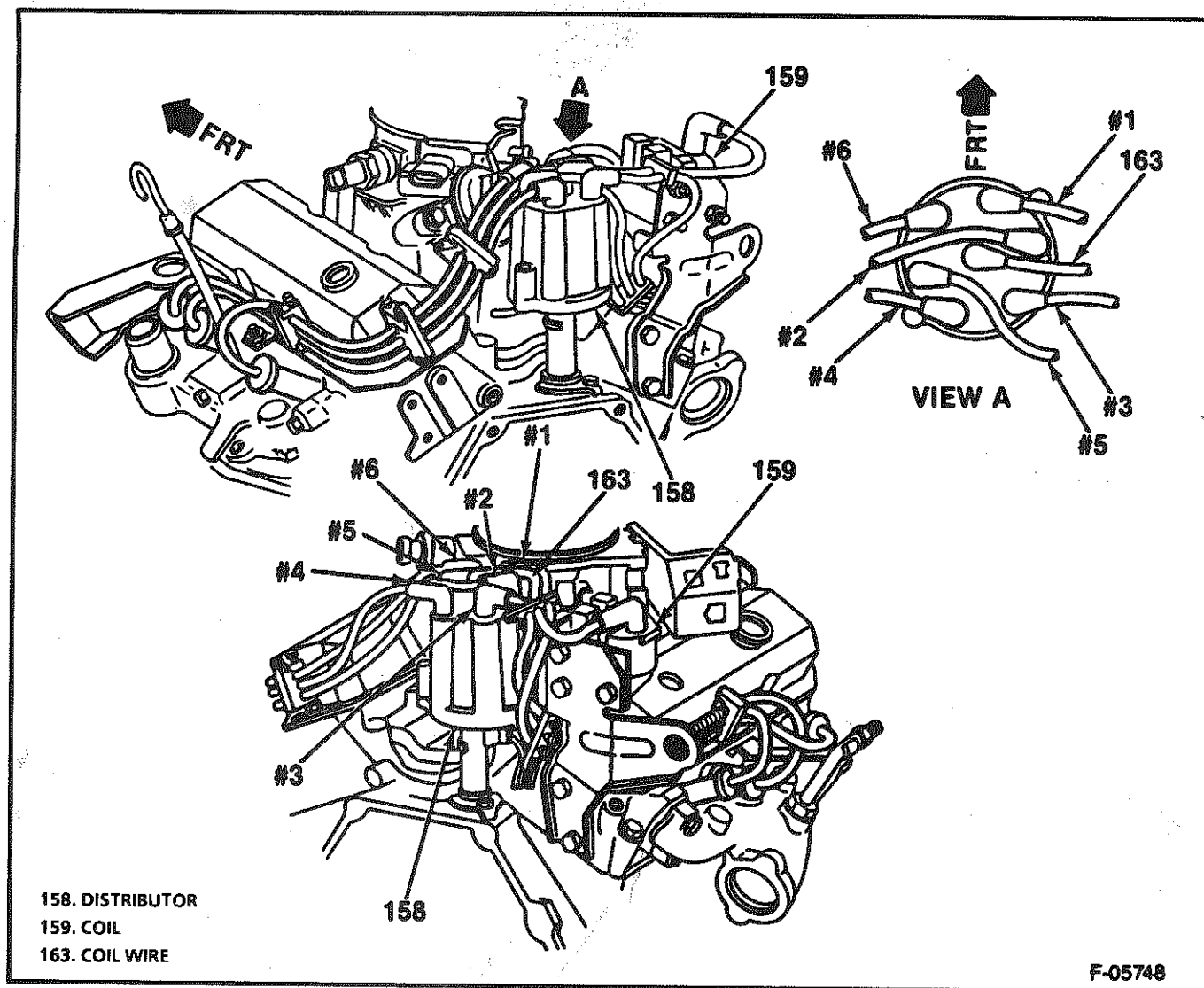


Figure 29 - Spark Plug Wire Routing for the 2.8L Engine

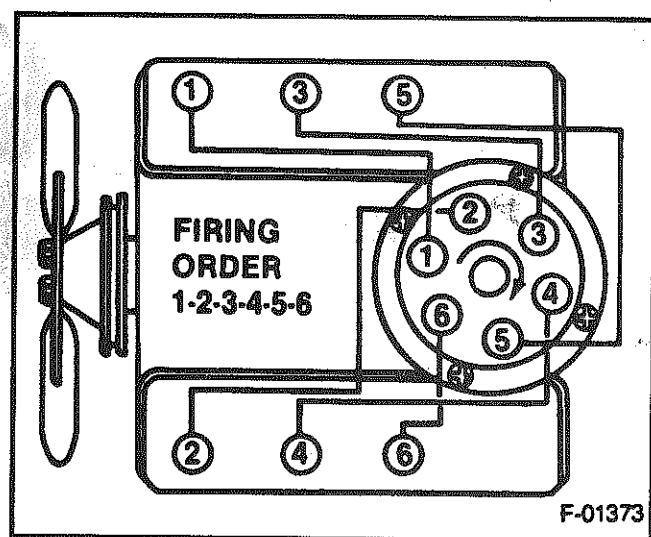


Figure 30 - Spark Plug Wire Schematic

## SPARK PLUG WIRING AND BOOTS

### Precautions

1. Twist boots one-half turn before removing.
2. When removing the boot, do not use pliers or other tools that could tear the boot.
3. Do not force anything between the wire and the boot, or through the silicone jacket of the wiring.
4. Do not pull on the wires to remove the boot. Pull on the boot, or use a tool designed for this purpose.
5. Special care should be exercised when installing spark plug boots to assure that the metal terminal within the boot is fully seated on the spark plug terminal and that the boot has not moved on the wire. If boot to wire movement has occurred, the boot will give a false visual impression of being fully seated.

A good check to assure that boots have been properly assembled is to push sideways on the installed boots. If they have been correctly installed, a stiff boot with only slight looseness will be noted. If the terminal has not been properly seated on the spark plug, only the resistance of the boot will be felt when pushing sideways

6. Be sure to position all plug boots perpendicular to the centerline of the engine.

### SPARK PLUG WIRE REPLACEMENT

Wire routings must be kept intact during service and followed exactly when wires have been disconnected or when replacement of the wires is necessary. Failure to route the wires properly can lead to radio ignition noise and crossfiring of the plugs, or shorting of the leads to ground. The correct routing for each engine is shown in Figure 29.

Some distributors have spark plug wire retainer harness assemblies with the engine firing order marked on them. If the firing order is not indicated, install the plug wires according to the firing order as shown in Figure 30.

### ENGINE WIRING

When it is necessary to move any of the wiring, whether to lift wires away from their harnesses or move harnesses to reach some component, take care that all wiring is replaced in its original position and all harnesses routed correctly. If clips or retainers break, replace them. Electrical problems can result from wiring or harnesses becoming loose and moving from their original positions or from being rerouted. Refer to Figures 31,32,33 for correct routing of engine wiring.

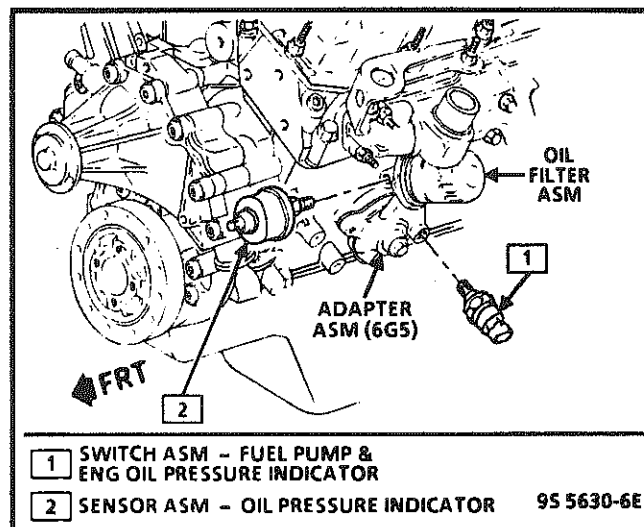
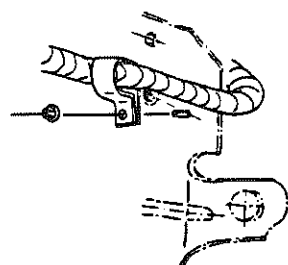
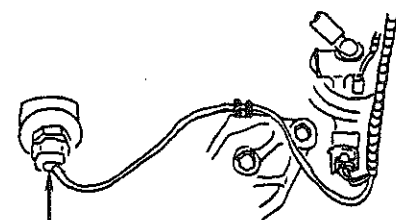
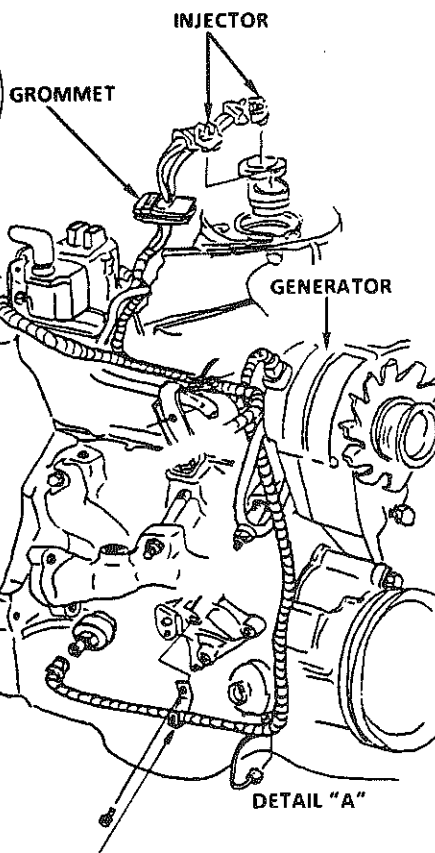


Figure 31 - Engine Wiring, Left Side, 2.8L Engine



DETAIL "B"



KNOCK  
SENSOR

DETAIL "A"

95 5744-6E

Figure 32 - Engine Wiring, Right Side, 2.8L Engine

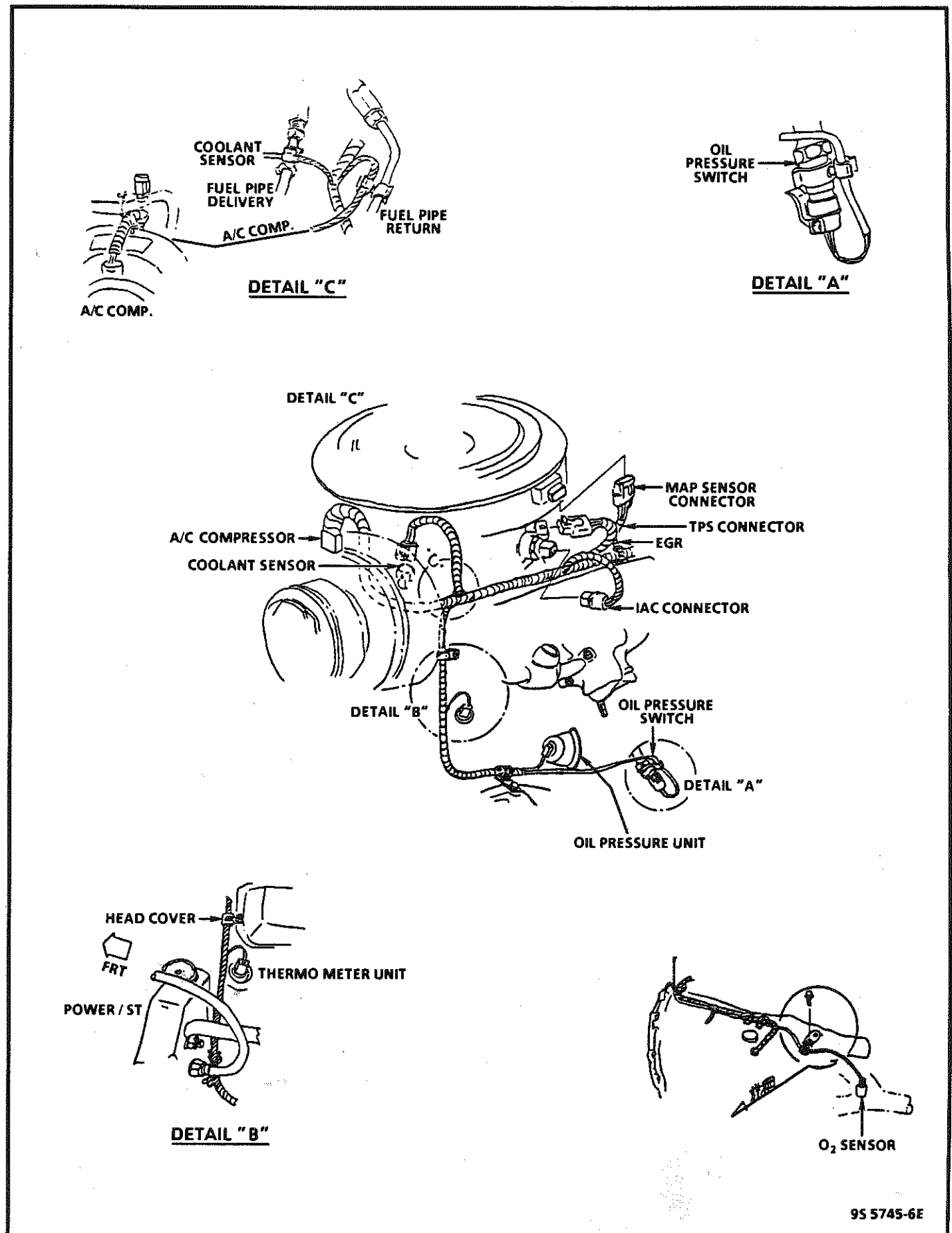


Figure 33 - Engine Wiring, Left Side, 2.8L Engine

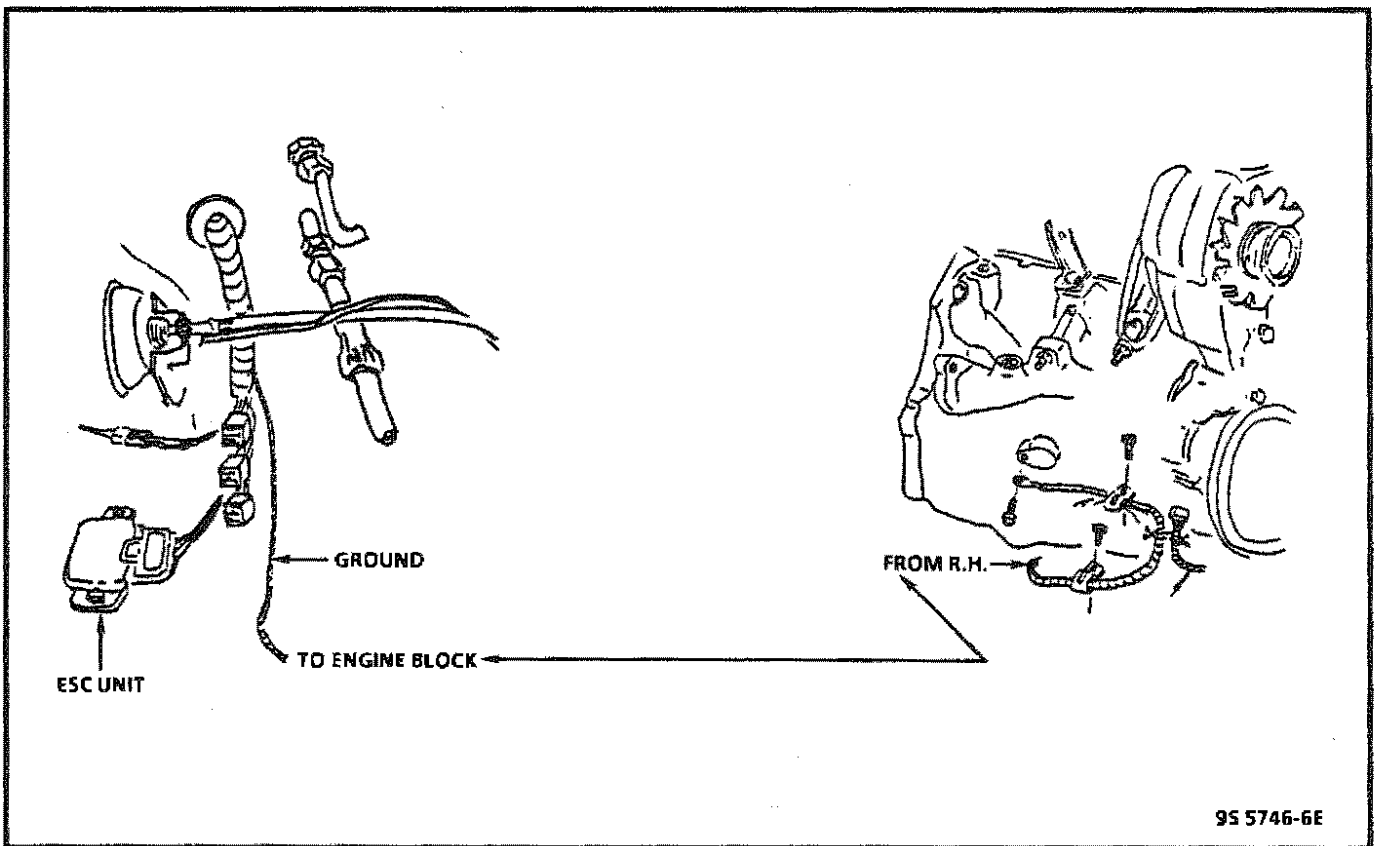


Figure 34 - Engine Ground Strap, 2.8L Engine

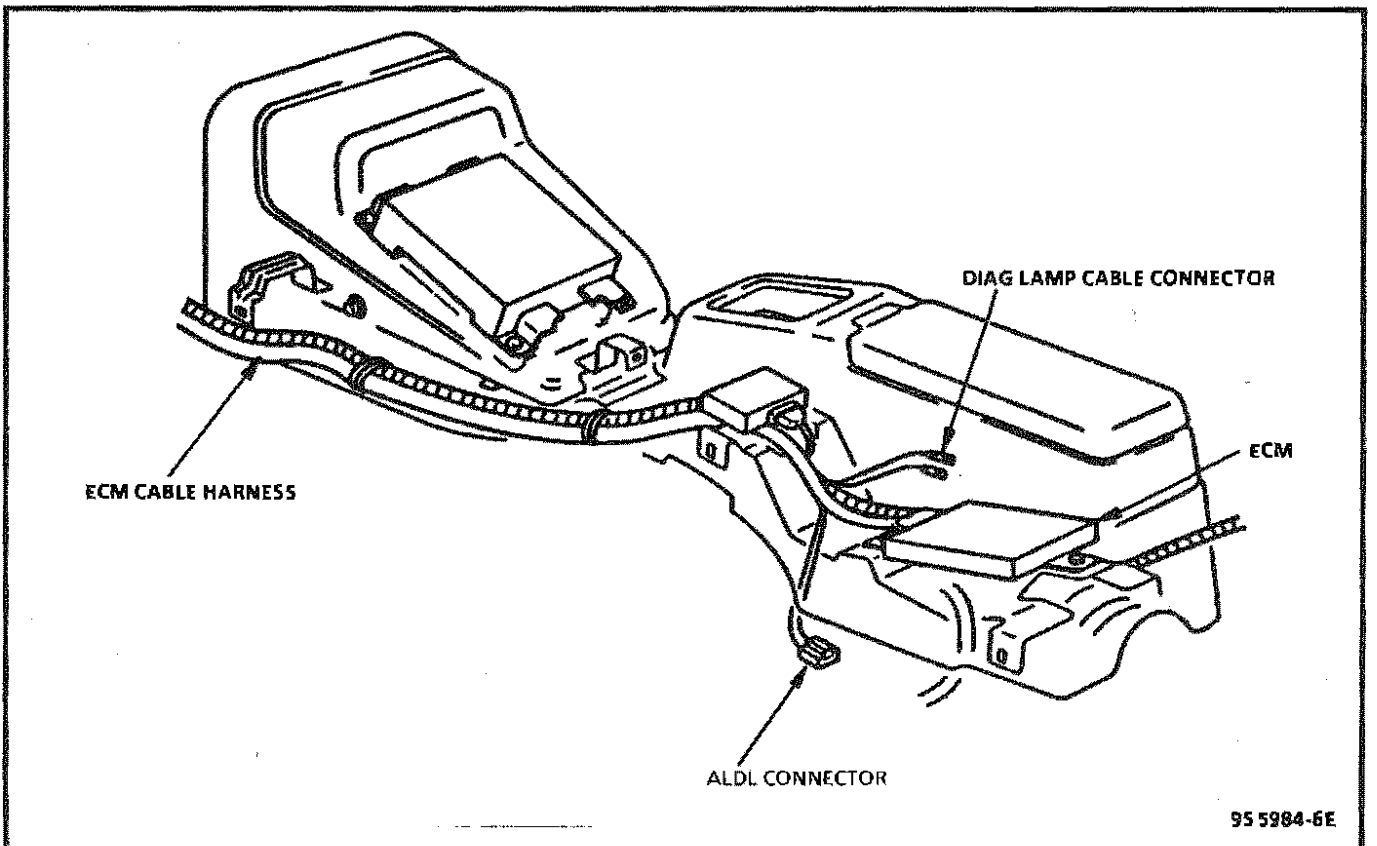


Figure 35 - ECM Wiring

## SPECIFICATIONS

## GENERATOR SPECIFICATIONS

| Engine | Rotation | Field Current<br>(80°F) |       | Cold Output |      | Rated Hot<br>Output |      |
|--------|----------|-------------------------|-------|-------------|------|---------------------|------|
|        |          | Amps                    | Volts | Amps        | RPM  | Amps                | RPM  |
| 2.8L   | CW       | 4.8-5.7                 | 12    | 30          | 1600 | 85                  | 6500 |

## STARTER SPECIFICATIONS

| Engine Application | Rotation | No Load Test @ 10 Volts |     |      |        | Solenoid |
|--------------------|----------|-------------------------|-----|------|--------|----------|
|                    |          | AMPS                    |     | AMPS |        |          |
|                    |          | Min                     | Max | Min  | Max    |          |
| 2.8L               | CW       | 50                      | 70  | 6000 | 11,900 |          |
|                    | CW       | 50                      | 75  | 6000 | 11,900 |          |

\* Drive Speed

## STARTER SHIMS

| Engine<br>Application | mm  | inch |
|-----------------------|-----|------|
| 2.8L                  | 1.0 | 0.04 |

## MOUNTING TORQUE VALUES

|                           | N.m | ft. lb. | in. lb. |
|---------------------------|-----|---------|---------|
| BATTERY                   |     |         |         |
| Retainer                  | 17  | 13      |         |
| Terminals                 | 15  | 11      |         |
| GENERATOR                 |     |         |         |
| 2.8L Engine               |     |         |         |
| Lower Mounting Bolt       | 35  | 26      |         |
| Upper Mounting Bolt       | 25  | 18      |         |
| STARTER                   |     |         |         |
| 2.8L                      |     |         |         |
| Mounting Bolts            | 40  | 30      |         |
| ENGINE BLOCK HEATER SCREW | 1.8 |         | 16      |

## SECTION 6E

DRIVEABILITY AND EMISSIONS  
GENERAL INFORMATION

## CONTENTS

|                                    |      |                                     |       |
|------------------------------------|------|-------------------------------------|-------|
| DRIVEABILITY AND EMISSIONS CONTROL | 6E-1 | ECM Learning Ability                | 6E-6  |
| EMISSIONS CONTROL INFORMATION      |      | DIAGNOSTIC CIRCUIT CHECK            | 6E-6  |
| LABEL                              | 6E-1 | ALDL "SCAN" TOOLS                   | 6E-7  |
| MAINTENANCE SCHEDULE               | 6E-2 | Normal (Open) Mode                  | 6E-7  |
| BLOCKING DRIVE WHEELS              | 6E-2 | ALDL Mode                           | 6E-7  |
| WHAT THIS SECTION CONTAINS         | 6E-2 | Factory Test Mode                   | 6E-7  |
| VISUAL/PHYSICAL UNDERHOOD          |      | "SCAN" TOOL USE WITH                |       |
| INSPECTION                         | 6E-4 | INTERMITTENTS                       | 6E-7  |
| BASIC KNOWLEDGE AND TOOLS          |      | WIRING HARNESS SERVICE              | 6E-7  |
| REQUIRED                           | 6E-4 | WIRING CONNECTOR SERVICE            | 6E-8  |
| Electrostatic Discharge Damage     | 6E-4 | Metri-Pack - Series 150 Terminals   | 6E-9  |
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| Reading Codes                      | 6E-5 | SPECIAL TOOLS                       | 6E-11 |
| Clearing Codes                     | 6E-5 | GENERAL SPECIFICATIONS              | 6E-15 |
| Diagnostic Mode                    | 6E-5 | DRIVEABILITY AND EMISSIONS SECTIONS |       |
| Field Service Mode                 | 6E-6 | FUEL INJECTION (TBI)                | 6E2-1 |

## DRIVEABILITY AND EMISSIONS CONTROL

The computer command control system, which is controlled by the Electronic Control Module (ECM), is designed to maintain exhaust emission levels at federal standards while providing good driveability and fuel efficiency. The functions of the system are based on data gathered by sensors and switches located throughout the vehicle. The ECM maintains control over fuel delivery, ignition, idle air flow, the fuel pump and other system components, while monitoring the system for faulty operation with its diagnostic capabilities. See Figure 1.

It is important to review the component sections and wiring diagrams in Section "6E2" to determine which systems are controlled by the ECM.

## EMISSIONS CONTROL INFORMATION LABEL

The underhood Vehicle Emissions Control Information label (Figure 2) contains important emission specifications and setting procedures. In the upper left corner is exhaust emission information which identifies the year, the manufacturing division of the engine, the displacement of the engine in liters, the class of vehicle, and type of fuel metering. There is also an illustrated emission component and vacuum hose schematic.

This label is located in the engine compartment of every Isuzu vehicle. If the label has been removed, it can be ordered from American Isuzu Parts Distribution Network (AIPDN).

**ALL NEW ISUZU VEHICLES ARE CERTIFIED BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AS CONFORMING TO THE REQUIREMENTS OF THE REGULATIONS FOR THE CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES. THIS CERTIFICATION IS CONTINGENT ON CERTAIN ADJUSTMENTS BEING SET TO FACTORY STANDARDS. IN MOST CASES, THESE ADJUSTMENT POINTS EITHER HAVE BEEN PERMANENTLY SEALED AND/OR MADE INACCESSIBLE TO PREVENT INDISCRIMINATE OR ROUTINE ADJUSTMENT IN THE FIELD. FOR THIS REASON, THE FACTORY PROCEDURE FOR TEMPORARILY REMOVING PLUGS, CAPS, ETC., FOR PURPOSES OF SERVICING THE PRODUCT, MUST BE STRICTLY FOLLOWED AND, WHEREVER PRACTICABLE, RETURNED TO THE ORIGINAL INTENT OF THE DESIGN.**

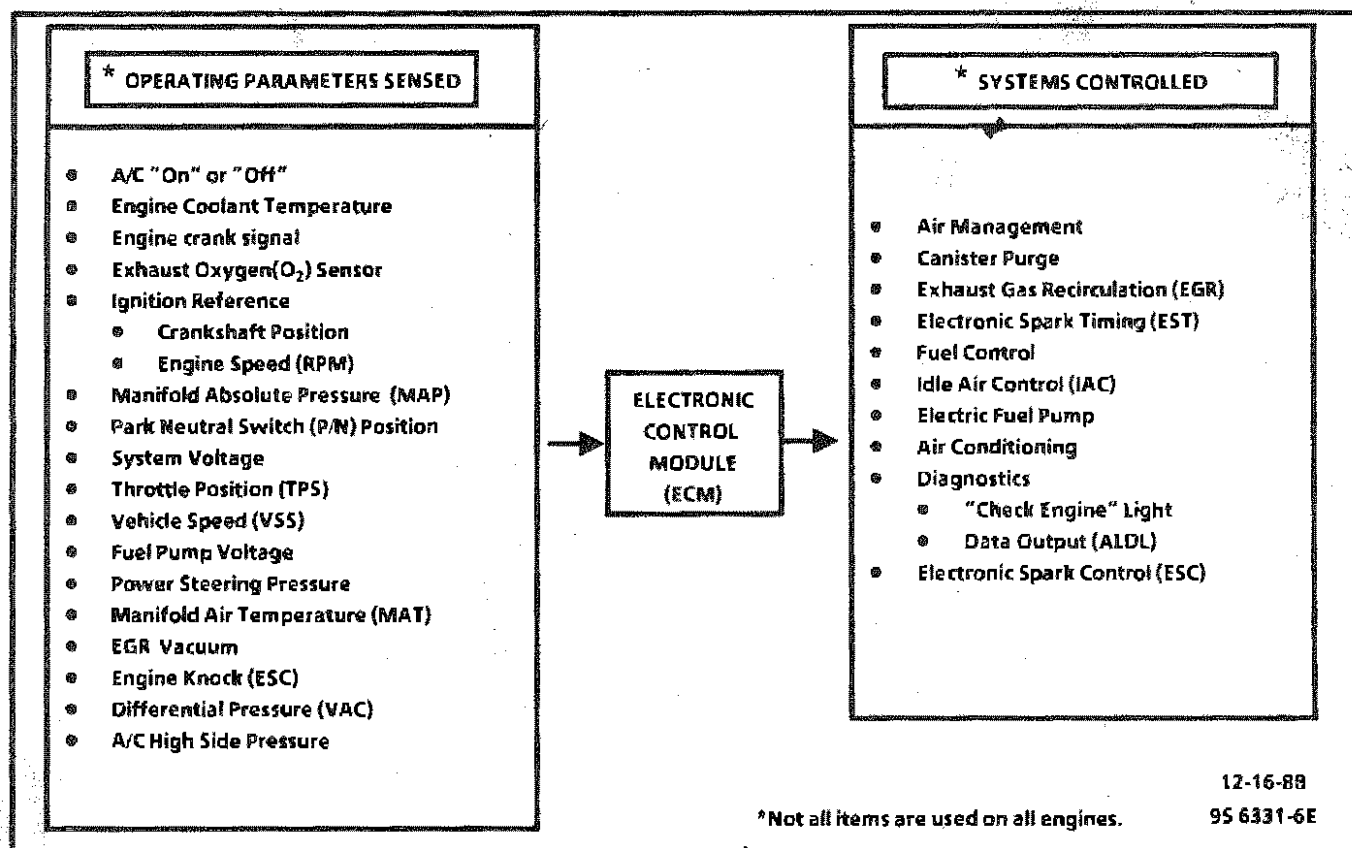


Figure 1 - ECM Inputs and Outputs

## MAINTENANCE SCHEDULE

Refer to the Isuzu Maintenance Schedule in Section "00" of the Workshop Manual for the maintenance service that should be performed to retain emission control performance.

## BLOCKING DRIVE WHEELS

The vehicle drive wheels always should be blocked and parking brake firmly set while checking the system.

## WHAT THIS SECTION CONTAINS

This section of the Workshop Manual has been developed to describe the function and operation of the electronic engine control system that controls the driveability and emissions of the vehicle. Emphasis is placed on the diagnosis and repair of problems related to the system.

Section "6E" provides general diagnostic procedures, diagnostic "Scan" tool use, wiring and terminal repair procedures, and descriptions of special tools. It then leads into Section "6E2." Section "6E2" deals with engine control systems using throttle body injection for fuel delivery.

Section "6E2" are divided into three major sub-sections dealing with diagnosis and repair. They can be summarized as follows.

### SECTION A: CIRCUIT INFORMATION & DIAGNOSIS

- Component Locations
- Wiring Diagrams
- ECM Terminal End View and Terminal Definitions
- Diagnostic Circuit Check. This must be the first step of any diagnostic procedure.
- Diagnostic Trouble Code Charts with facing pages containing circuit diagrams, circuit operation information, and helpful diagnostic information.

### SECTION B: DRIVEABILITY & EMISSIONS SYMPTOMS

- This sub-section assists in diagnosis of intermittent problems or problems which don't result in the storing of diagnostic trouble codes. It is arranged by symptoms of poor driveability and emissions and lists possible causes of the problems.

### SECTION C: COMPONENT CHECKS & SERVICE

- Component and Circuit Descriptions
- On-Vehicle Service
- Functional Checks/Diagnostic Charts

LABEL CODE

ADJUSTMENT  
PROCEDURE

LDT  
CALIFORNIA

**VEHICLE EMISSION CONTROL INFORMATION**  
**ISUZU MOTORS LIMITED**

CATALYST  
AIP, EGR, FI, OS  
AND TWC

**SET PARKING BRAKE AND BLOCK DRIVE WHEEL**

TIMING ADJUSTMENT: MAKE ADJUSTMENT WITH ENGINE AT NORMAL OPERATING TEMPERATURE AND AIR CONDITIONING OFF (IF EQUIPPED)

1. VERIFY NO "CHECK ENGINE" LIGHT
2. PUT EST (ELECTRONIC SPARK TIMING) IN BYPASS MODE BY DISCONNECTING THE TIMING CONNECTOR.

**NOTE** THIS IS A SINGLE WIRE CONNECTOR. THE CONNECTOR IS LOCATED UNDER THE CENTRE CONSOLE IN THE PASSENGER COMPARTMENT. DO NOT DISCONNECT FOUR-WIRE CONNECTOR AT DISTRIBUTOR.

3. CONNECT A TIMING LIGHT INDUCTIVE PICK-UP TO #1 SPARK PLUG WIRE AND SET TIMING TO SPECIFICATION WITH ENGINE RUNNING AT IDLE SPEED.
4. RECONNECT TIMING CONNECTOR AND CLEAR ECM TROUBLE CODE.

|                     |                         |
|---------------------|-------------------------|
| EVAPORATIVE FAMILY  | CAN-H                   |
| ENGINE FAMILY       | KSZ173T5FGB5            |
| ENGINE DISPLACEMENT | 173 C.I.C. (2.8 LITER)  |
| IDLE SPEED          | 800 RPM                 |
| IGNITION TIMING     | 10° BTDC UNDER 1000 RPM |
| SPARK PLUG GAP      | 0.045 IN. (1.14 MM)     |

SEE SHOP MANUAL AND MAINTENANCE SCHEDULE FOR ADDITIONAL INFORMATION.

**VACUUM HOSE ROUTING DIAGRAM**

**THIS VEHICLE CONFORMS TO U.S. EPA AND STATE OF CALIFORNIA REGULATION APPLICABLE TO 1989 MODEL YEAR NEW LIGHT-DUTY TRUCKS.**

PT. NO. 8943434951

ENGINE SIZE AND  
AJUSTMENT  
SPECIFICATIONS

ENGINE COMPONENT  
AND VACUUM HOSE  
SCHEMATIC

AREA OF  
CERTIFICATION

LABEL PART  
NUMBER

Vehicle Emission Control Information Isuzu Motors Limited

12-13-88  
95 6330-6E

Figure 2 - Vehicle Emission Control Information Label

## VISUAL/PHYSICAL UNDERHOOD INSPECTION

A careful visual and physical underhood inspection must be performed as part of any diagnostic procedure or in finding the cause of an emissions test failure. This can often lead to fixing a problem without further steps. Inspect all vacuum hoses for correct routing, pinches, cuts, or disconnects. Be sure to inspect hoses that are difficult to see beneath the air cleaner, compressor, generator, etc. Inspect all the wires in the engine compartment for proper connections, burned or chafed spots, pinched wires, or contact with sharp edges or hot exhaust manifolds. This visual/physical inspection is very important. It must be done carefully and thoroughly.

## BASIC KNOWLEDGE AND TOOLS REQUIRED

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. One should be familiar with wiring diagrams, the meaning of voltage, ohms, amps, the basic theories of electricity, and understand what happens in an open or shorted wire.

To perform system diagnosis, the use of a diagnostic "Scan" tool is required. A tachometer, test light, ohmmeter, digital voltmeter with 10 megohms impedance, vacuum gauge, and jumper wires are also required. Please become acquainted with the tools and their use before attempting to diagnose a vehicle. Special tools which are required for system service and the ones described above are illustrated at the end of this section.

## Electrostatic Discharge Damage

Electronic components used in control systems are often designed to carry very low voltage, and are very susceptible to damage caused by electrostatic discharge. It is possible for less than 100 volts of static electricity to cause damage to some electronic components. By comparison, it takes as much as 4,000 volts for a person to even feel the zap of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage, therefore, it is important to use care when handling and testing electronic components.

**NOTICE:** To prevent possible Electrostatic Discharge damage:

- Do Not touch the ECM connector pins or soldered components on the ECM circuit board.
- When handling a PROM, CALPAK or MEM-CAL, Do Not touch the component leads, and Do Not remove integrated circuit from carrier.

## DIAGNOSTIC INFORMATION

The diagnostic "trouble tree" charts and functional checks in this manual are designed to locate a faulty circuit or component through logic based on the process of elimination. The charts are prepared with the requirement that the vehicle functioned correctly at the time of assembly and that there are no multiple failures.

The ECM performs a continual self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of diagnostic trouble codes. The codes are two digit numbers that can range from 12 to 99. When a malfunction is detected by the ECM, a code is set and the "Check Engine" light is illuminated.

## "Check Engine" Light

This light is on the instrument panel and has the following functions.

- It informs the driver that a problem has occurred and that the vehicle should be taken for service as soon as reasonably possible.
- It displays "Trouble Codes" stored by the ECM which help the technician diagnose system problems.
- It indicates "Open Loop" or "Closed Loop" operation.

As a bulb and system check, the light will come "ON" with the key "ON" and the engine not running. When the engine is started, the light will turn "OFF." If the light remains "ON," the self-diagnostic system has detected a problem. If the problem goes away, the light will go out in most cases after 10 seconds, but a Trouble Code will remain stored in the ECM.

When the light remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability or emissions problem, a "Diagnostic Circuit Check" must be performed. The procedures for these checks are given in Section "A" of "6E2". These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

## Intermittent "Check Engine" Light

In the case of an "intermittent" problem, the "Check Engine" light will light for ten (10) seconds and then will go out. However, the corresponding trouble code will be stored in the memory of the ECM until the battery voltage to the ECM has been removed. When unexpected codes appear during the code reading process, one can assume that these codes were set by an intermittent malfunction and could be helpful in diagnosing the system.

An intermittent code may or may not re-set. If it is an intermittent failure, a Diagnostic Trouble Code Chart is not used. Consult the "Diagnostic Aids" on the page facing the diagnostic chart corresponding to the intermittent trouble code. Section "B" also covers the topic of "Intermittents." A physical inspection of the applicable sub-system most often will resolve the problem.

## Reading Codes

The provision for communicating with the ECM is the Assembly Line Diagnostic Link (ALDL) connector (See Figure A-4). The ALDL is usually located in the center console and is sometimes covered by a plastic cover labeled "DIAGNOSTIC CONNECTOR." It is used in the assembly plant to receive information in checking that the engine is operating properly before it leaves the plant. The code(s) stored in the ECM's memory can be read either through a hand-held diagnostic scanner plugged into the ALDL connector or by counting the number of flashes of the "Check Engine" light when the diagnostic terminal of the ALDL connector is grounded. The ALDL connector terminal "B" (diagnostic terminal) is the second terminal from the right of the ALDL connector's top row. The terminal is most easily grounded by connecting it to terminal "A" (internal ECM ground), the terminal to the right of terminal "B" on the top row of the ALDL connector.

Once terminals "A" and "B" have been connected, the ignition switch must be moved to the "ON" position, with the engine *not* running. At this point, the "Check Engine" light should flash Code 12 three times consecutively. This would be the following flash sequence: "flash, pause, flash-flash, long pause, flash, pause, flash-flash, long pause, flash, pause, flash-flash." Code 12 indicates that the ECM's diagnostic system is operating. If Code 12 is not indicated, a problem is present within the diagnostic system itself, and should be addressed by consulting the appropriate diagnostic chart in Section "A".

Following the output of Code 12, the "Check Engine" light will indicate a diagnostic trouble code three times if a code is present, or it will simply continue to output Code 12. If more than one diagnostic trouble code has been stored in the ECM's memory, the codes will be output from the lowest to the highest, with each code being displayed three times.

## Clearing Codes

To clear the codes from the memory of the ECM, either to determine if the malfunction will occur again or because repair has been completed, the ECM power feed must be disconnected for at least thirty (30) seconds. Depending on how the vehicle is equipped, the ECM power feed can be disconnected at the positive battery terminal "pigtail," the inline fuseholder that originates at the positive connection at the battery, or the ECM fuse in the fuse block. (The negative battery terminal may be disconnected, but other on-board memory data, such as preset radio tuning, will also be lost.)

**CAUTION:** To prevent ECM damage, the key must be "OFF" when disconnecting or reconnecting ECM power.

When using a hand-held diagnostic scanner, or "Scan" tool to read the codes, clearing the diagnostic trouble codes is done in the same manner as in the above procedure.

## Diagnostic Mode

When the Diagnostic terminal is grounded with the ignition "ON" and the engine "OFF," the system will enter what is called the Diagnostic Mode. In this mode the ECM will

1. Display a Code 12 by flashing the "Check Engine" light (indicating the system is operating correctly).
2. Display any stored trouble codes by flashing the "Check Engine" light. Each code will be flashed three times, then Code 12 will be flashed again.
3. Energize all ECM controlled relays and solenoids except fuel pump relay. This allows checking circuits which may be difficult to energize without driving the vehicle and being under particular operating conditions.
4. The IAC valve moves to its fully extended position on most models, blocking the idle air passage. This is useful in checking the minimum idle speed.

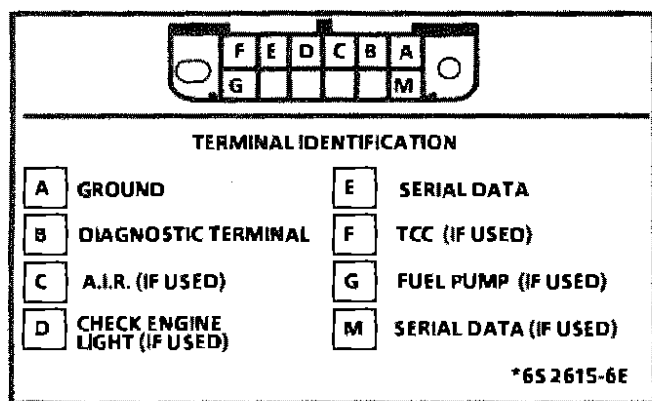


Figure 3 - ALDL Connector

### Field Service Mode

If the diagnostic terminal is grounded with the engine running, the system will enter the Field Service mode. In this mode, the "Check Engine" light will indicate whether the system is in "Open Loop" or "Closed Loop."

In "Open Loop" the "Check Engine" light flashes two and one-half times per second.

In "Closed Loop," the light flashes once per second. Also, in "Closed Loop," the light will stay "OFF" most of the time if the system is running lean. It will stay "ON" most of the time if the system is running rich.

While the system is in Field Service Mode, new trouble codes cannot be stored in the ECM and the "Closed Loop" timer is bypassed.

### ECM Learning Ability

The ECM has a "learning" ability which allows it to make corrections for minor variations in the fuel system to improve driveability. If the battery is disconnected, to clear diagnostic codes or for other repair, the "learning" process resets and begins again. A change may be noted in the vehicle's performance. To "teach" the vehicle, ensure that the engine is at operating temperature. The vehicle should be driven at part throttle, with moderate acceleration and idle conditions until normal performance returns.

### DIAGNOSTIC CIRCUIT CHECK

After the visual/physical underhood inspection, the "Diagnostic Circuit Check" is the starting point for all diagnostic procedures or finding the cause of an emissions test failure.

The correct procedure to diagnose a problem is to follow three basic steps.

1. Are the On-Vehicle Diagnostics working? This is determined by performing the "Diagnostic Circuit Check." Since this is the starting point for the diagnostic procedures or finding the cause of an emissions test failure, *always begin here.*

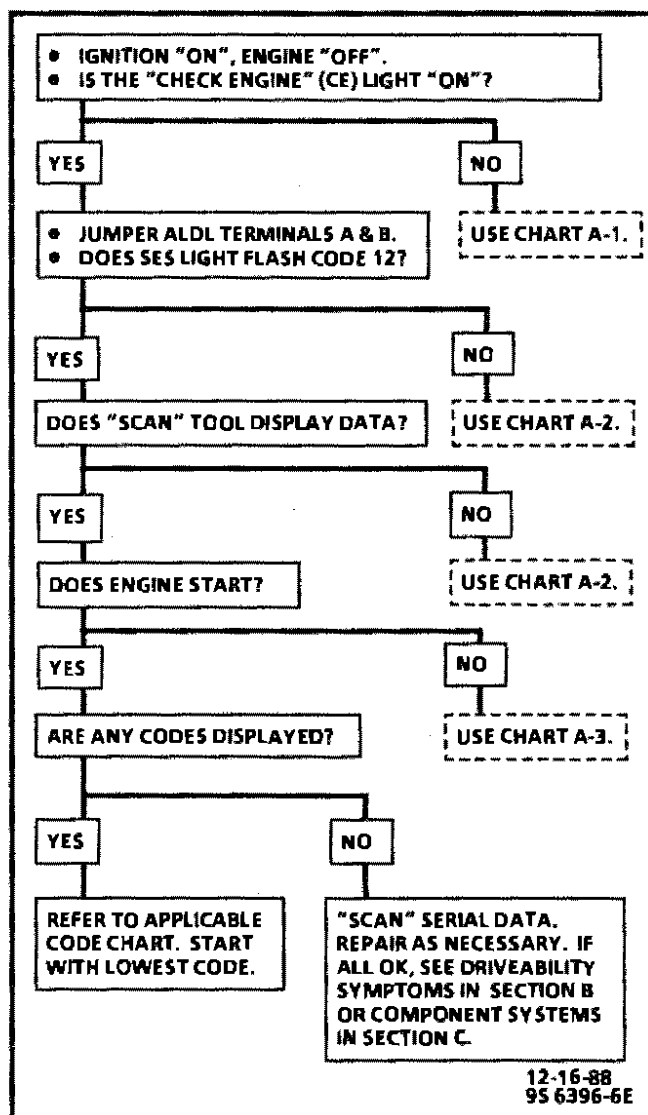


Figure 4 - Diagnostic Circuit Check

If the On-Vehicle Diagnostics aren't working, the "Diagnostic Circuit Check" will lead to a diagnostic chart in Section "A" to correct the problem. If the On-Vehicle Diagnostics are working correctly, the next step is

2. Is there a Trouble Code stored? If a trouble code is stored, go directly to the numbered code chart in Section "A". This will determine if the fault is still present. If no trouble code is stored, then
3. "Scan" Serial Data transmitted by the ECM. This involves reading the information available on the Serial Data Stream with one of the tools available for that purpose. Information on these tools and the meaning of the various displays can be found in the succeeding paragraphs. Expected readings under a particular operating condition can be found on the facing page of the Diagnostic Circuit Check.

## ALDL "SCAN" TOOLS

The ECM can communicate a variety of information through ALDL connector terminals "E" or "M" (depending on the engine). This data is transmitted at a high frequency which requires a "Scan" tool for interpretation. There are several "Scan" tools available for reading this information.

With an understanding of the data which the tool displays, and knowledge of the circuits involved, the tool can be very useful in obtaining information which would be more difficult or impossible to obtain with other equipment.

"Scan" tools do not make the use of diagnostic charts unnecessary, nor can they indicate exactly where a problem is in a particular circuit. Trouble Tree Charts incorporate diagnosis procedures using a "Scan" tool where possible and most charts *require* the use of a "Scan" tool when it is applicable.

**A "SCAN" TOOL THAT DISPLAYS FAULTY DATA SHOULD NOT BE USED AND THE PROBLEM SHOULD BE REPORTED TO THE MANUFACTURER. THE USE OF A FAULTY "SCAN" TOOL CAN RESULT IN MISDIAGNOSIS AND UNNECESSARY PARTS REPLACEMENT.**

ECM's have three modes for transmitting information. The following information will describe the system operation in each of the three modes.

### Normal (Open) Mode

On engines that can be monitored in the "Open" mode, certain parameters can be observed without changing the engine operating characteristics. The parameters capable of being read vary with engine families. Most "Scan" tools are programmed so that the system will go directly into the ALDL mode if the "Open" mode is not available.

### ALDL Mode (Also Called 10K or Special)

In this mode, all obtainable data is readable. However, in this mode, the system operating characteristics are modified as follows.

- "Closed Loop" timers are bypassed.
- EST (spark) is advanced.
- IAC valve controls engine idle to 1000 rpm  $\pm$  50 rpm (if applicable).
- On some engines, canister purge solenoid is enabled.

### Factory Test Mode (Also Called Back-up or 3.9 K)

In this mode, the ECM is operating on the fuel back-up logic used to control the fuel delivery if the ECM fails. This mode verifies that the back-up feature is OK. The parameters that can be read on a "Scan" tool in this mode are not of much use for service.

### "SCAN" TOOL USE WITH INTERMITTENTS

In some "Scan" tool applications, the data update rate makes the tool less effective than a voltmeter, such as when trying to detect an intermittent problem which lasts for a very short time. However, the "Scan" tool does allow one to manipulate wiring harnesses or components under the hood with the engine not running, while observing the "Scan" tool's readout.

The "Scan" tool can be plugged in and observed while driving the vehicle under the condition when the "Check Engine" light turns "ON" momentarily or when the engine driveability is momentarily poor. If the problem seems to be related to certain parameters that can be checked on the "Scan" tool, they should be checked while driving the vehicle. If there does not seem to be any correlation between the problem and any specific circuit, the "Scan" tool can be checked on each position, watching for a period of time to see if there is any change in the readings that indicates intermittent operation.

The "Scan" tool is also an easy way to compare the operating parameters of a poorly operating engine with those of a known good one. For example, a sensor may shift in value but not set a trouble code. Comparing the sensor's readings with those of a known good vehicle may uncover the problem.

The "Scan" tool has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the "Scan" tool successfully for diagnosis lies in the technician's ability to understand the system he is trying to diagnose as well as an understanding of the "Scan" tool's operation and limitations. The technician should read the tool manufacturer's operating manual to become familiar with the tool's operation.

### WIRING HARNESS SERVICE

Wire harnesses should be replaced with proper part number harnesses. When signal wires are spliced into a harness, use wire with high temperature insulation only. See Figure 5 for instructions.

With the low current and voltage levels found in the system, it is important that the best possible bond be made at all wire splices by soldering the splices as shown.

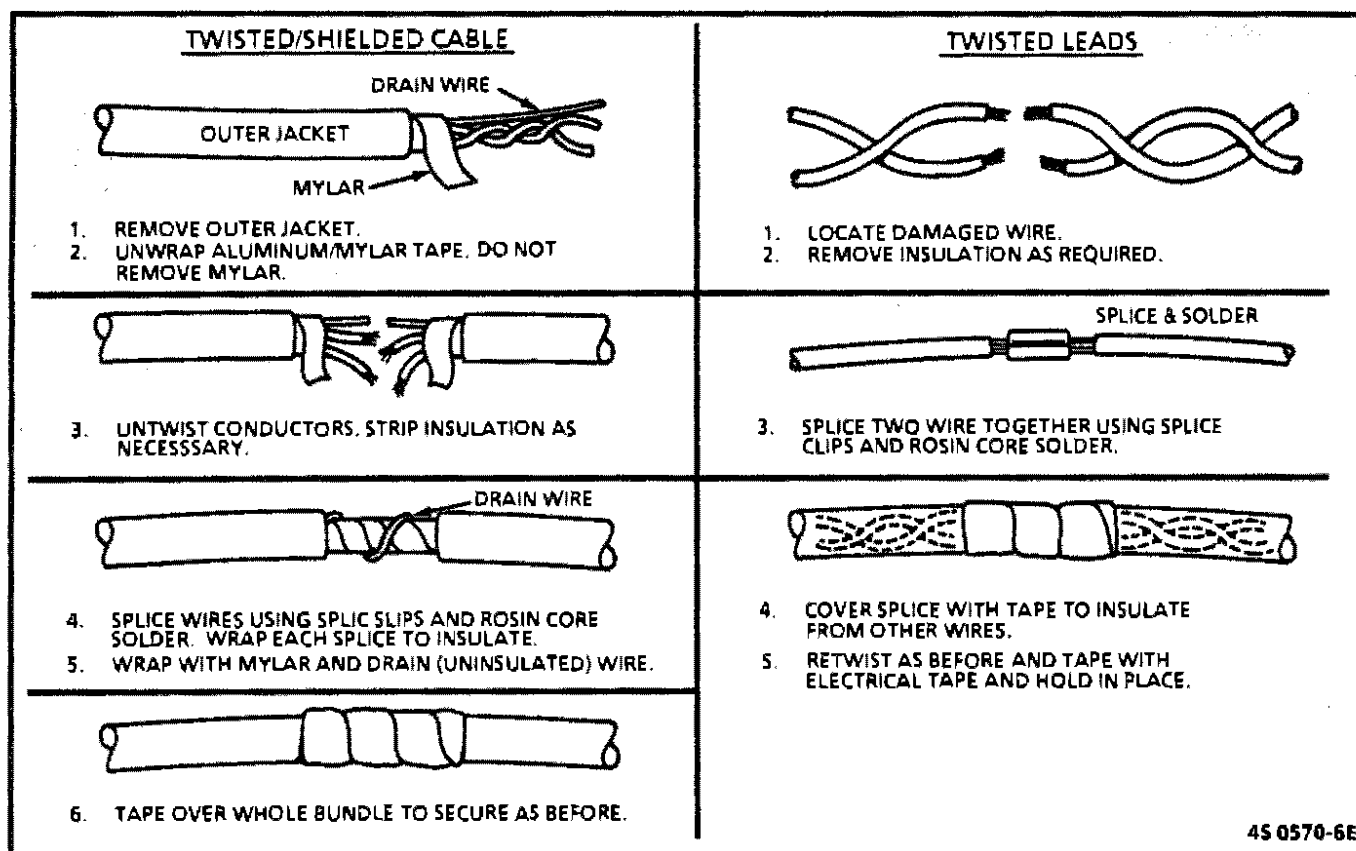


Figure 5 - Wiring Harness Repair

Use care when probing a connector or replacing connector terminals. It is possible to short between opposite terminals. If this happens, certain components can be damaged. Always use jumper wires between connectors for circuit checking. **NEVER** probe through connector seals, wire insulation, secondary ignition wires, boots, nipples, or covers. Even microscopic damage or holes may result in eventual water intrusion, corrosion and/or component or circuit failure.

## WIRING CONNECTOR SERVICE

Most connectors in the engine compartment are protected against moisture and dirt which could create oxidation and deposits on the terminals. This protection is important because of the very low voltage and current levels found in the electronic system. The connectors have a lock which secures the male and female terminals together. A secondary lock holds the seal and terminal into the connector.

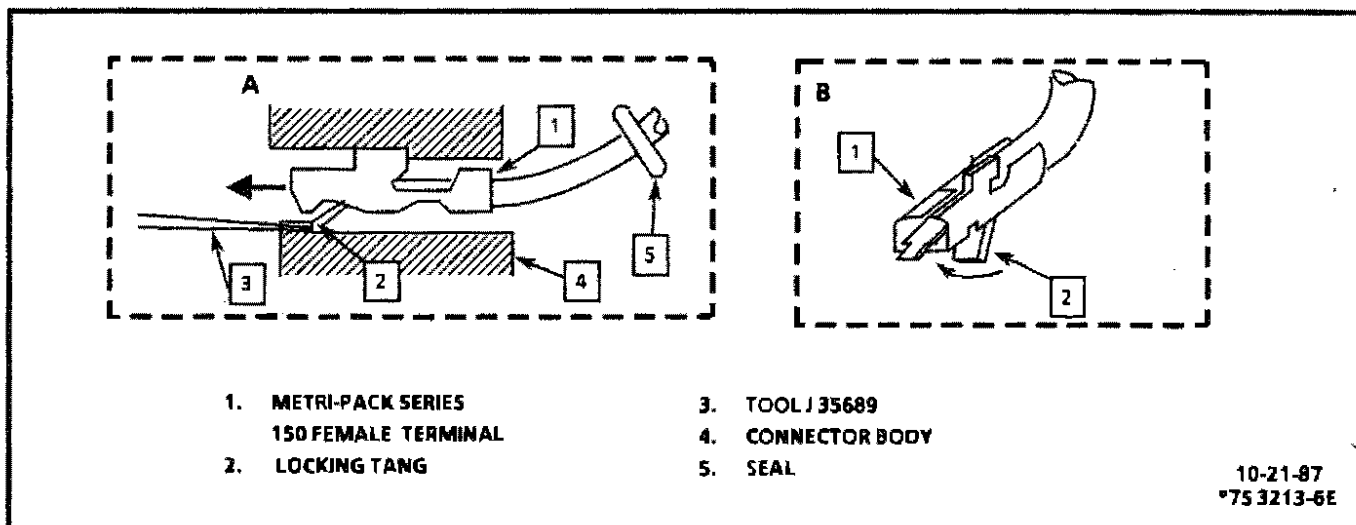


Figure 6 - Metri-Pack Series 150 Terminal Removal

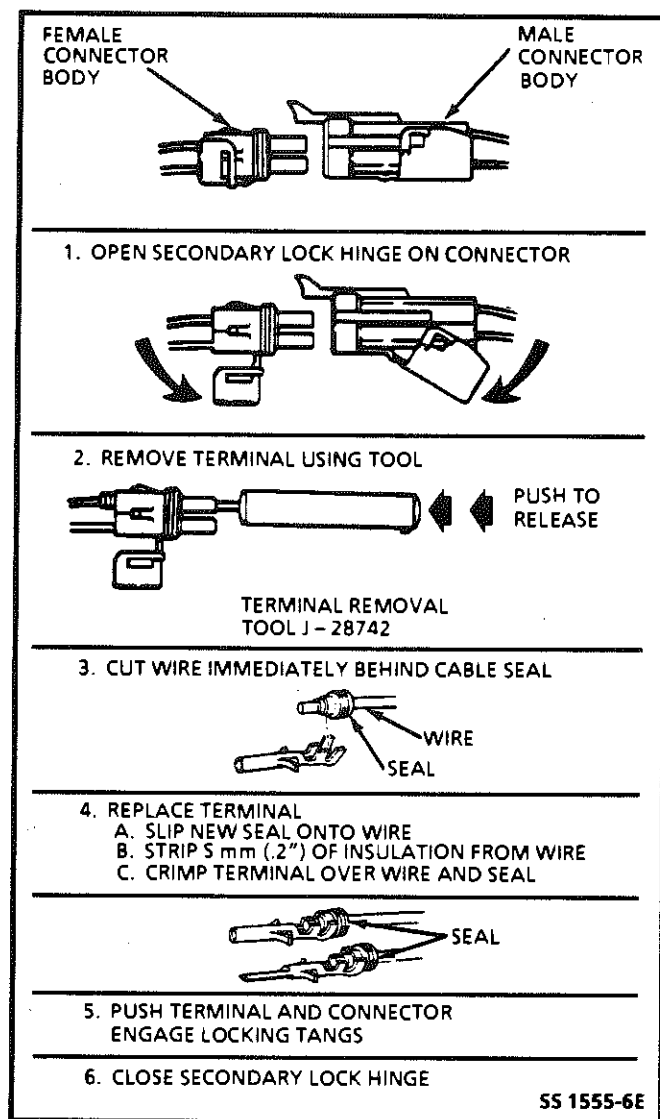


Figure 7 - Weather-Pack Terminal Repair

When diagnosing, open circuits are often difficult to locate by sight because oxidation or terminal misalignment are hidden by the connectors. Merely wiggling a connector on a sensor or in the wiring harness may locate the open circuit condition. This should always be considered when an open circuit or failed sensor is indicated. Intermittent problems may also be caused by oxidized or loose connections.

Before making a connector repair, be certain of the type of connector. Weather-Pack and Compact Three connectors look similar but are serviced differently. Replacement connectors and terminals are listed in Isuzu Parts Catalog.

### Metri-Pack Series 150 Terminals

Some ECM harness connectors contain terminals called Metri-Pack (Figure 6). These may be used at the coolant sensors as well as at ignition modules.

Metri-Pack terminals are also called "Pull-To-Seat" terminals because to install a terminal on a wire, the wire is first inserted through the seal (5) and connector (4). The terminal is then crimped on the wire, and the terminal pulled back into the connector to seat it in place.

To remove a terminal:

1. Slide the seal back on the wire.
2. Insert tool (3) J 35689, or equivalent as shown in insert "A" and "B" to release the terminal locking tang (2).
3. Push the wire and terminal out through the connector.

If the terminal is being reused, reshape the locking tang (2).

### Weather-Pack Connectors

Figure 7 shows a Weather-Pack connector and the tool (J 28742, or equivalent) required to service it. This tool is used to remove the pin and sleeve terminals. If terminal removal is attempted with an ordinary pick, there is a good chance that the terminal will be bent or deformed, and unlike standard blade type terminals, these terminals cannot be straightened once they are bent.

Make certain that the connectors are properly seated and all of the sealing rings in place when connecting leads. The hinge-type flap provides a secondary locking feature for the connector. It improves the connector reliability by retaining the terminals if the small terminal lock tangs are not positioned properly.

Weather-Pack connections cannot be replaced with standard connections. Instructions are provided with Weather-Pack connector and terminal packages.

### Compact Three Connectors

The Compact Three connector, which looks similar to a Weather-Pack connector, is not sealed and is used where resistance to the environment is not required. This type of connector most likely is used at the AIR control solenoid. Use the standard method when repairing a terminal. Do not use the Weather-pack terminal tool J 28742.

### Micro-Pack Connectors

Micro-Pack terminal (Figure 8) replacement requires the use of special tool J 33095, or equivalent.

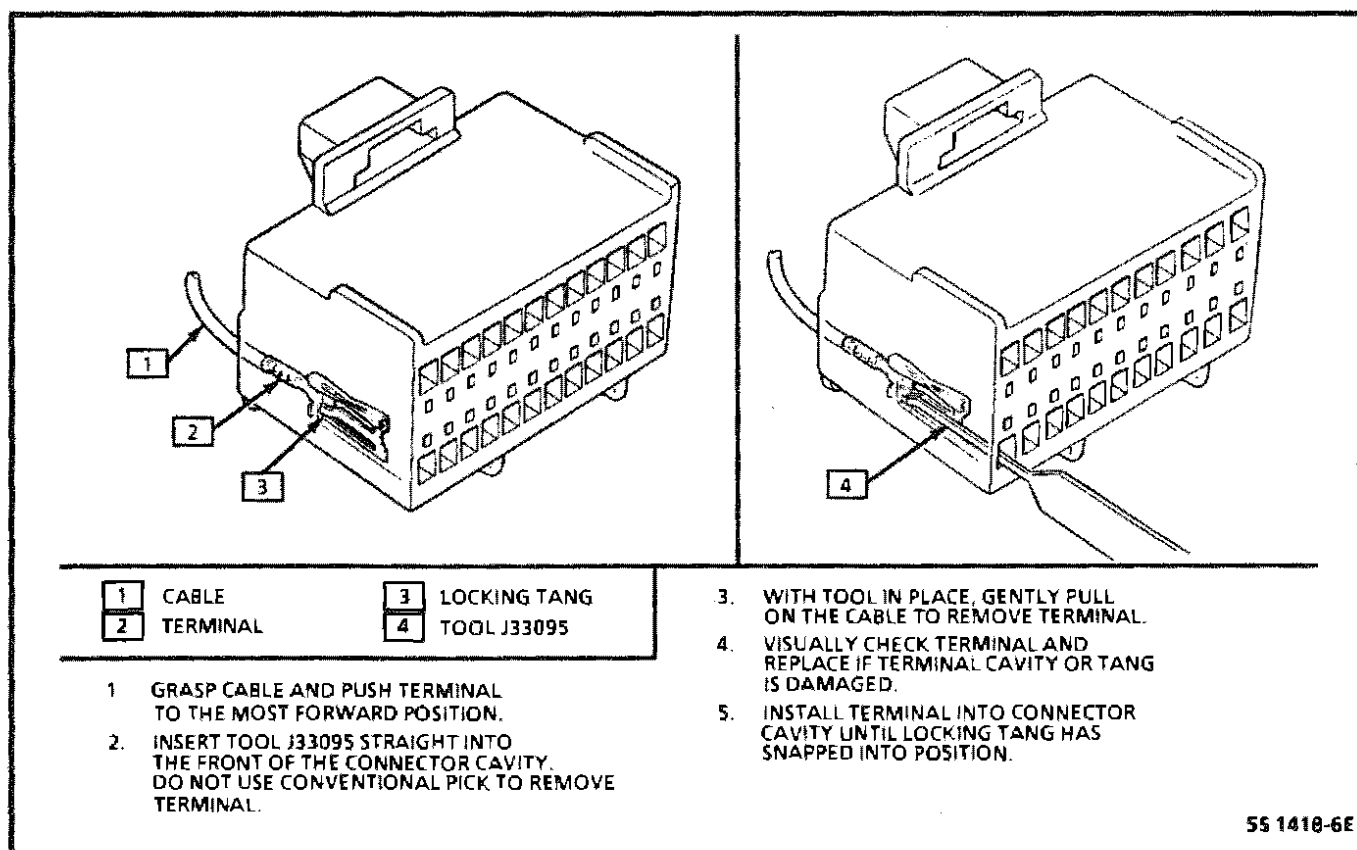
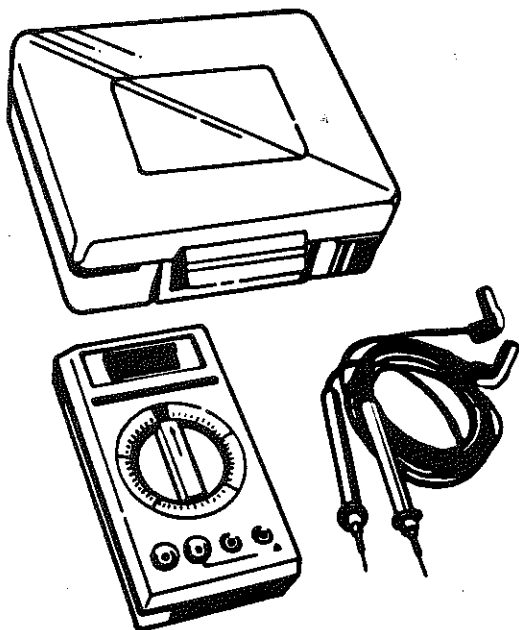


Figure 8 - Micro-Pack Terminal Replacement

## TOOLS NEEDED TO SERVICE THE SYSTEM

The system requires an "Scan" tool, tachometer, test light, ohmmeter, digital voltmeter with 10 megohms impedance (J 29125A, J 34029A or equivalent), vacuum gage and jumper wires for diagnosis. A test light or voltmeter must be used when specified in the procedures. See Figures 9 through 13 for Special Tools needed to diagnosis or repair a system. For more complete information on the operation of these tools, consult the tool manufacturer's instructions.



HIGH IMPEDANCE MULTIMETER  
(DIGITAL VOLTMETER-DVM)  
J 34029-A

**VOLTMETER** - Voltage position measures magnitude of voltage when connected in parallel to an existing circuit. A digital voltmeter with a 10 meg ohm input impedance is used because this type of meter will not load down the circuit and result in faulty readings. Some circuits require accurate low voltage readings because they have a very high resistance.

**AMMETER** - When used as an ammeter, this meter accurately measures extremely low current flow. Refer to meter instructions for more information.

- Selector must be set properly for both function and range. DC is used for most automotive measurements.

**OHMMETER** - Measures resistance of circuit directly in ohms. Refer to meter instructions for more information.

- OL display in all ranges indicates open circuit.
- Zero display in all ranges indicates a short circuit.
- An intermittent connection in a circuit may be indicated by a digital reading that will not stabilize on the circuit.
- Range Switch.

- ☐ 200 $\Omega$  - Reads ohms directly
- 2K, 20K, 200K $\Omega$  - Reads ohms in thousands
- 2M and 20M $\Omega$  - Reads ohms in millions



J 23738

**VACUUM PUMP WITH GAGE (20 IN. HG. MINIMUM)**

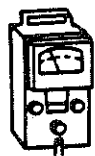
Use the gage to monitor manifold engine vacuum and use the hand pump to check vacuum sensors, solenoids and valves.



J 34142-A

**UNPOWERED TEST LIGHT**

Used for checking wiring for complete circuit, short to ground, or voltage.

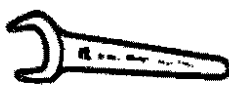
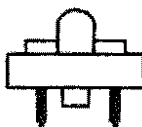
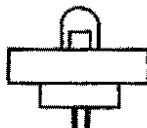
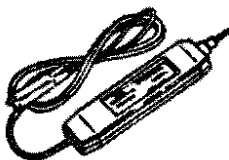


**TACHOMETER**

Must have inductive trigger signal pickup.

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\*7S 3382-6E

# 6E-12 DRIVEABILITY AND EMISSIONS - FUEL INJECTION

|                                                                                                      |                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>J 29533A</p>    | <p><b>OXYGEN SENSOR WRENCH</b><br/>Used for removing or installing the oxygen sensor.</p>                                                                                                                                                                                                     |
|  <p>J 33031</p>     | <p><b>IDLE AIR CONTROL WRENCH</b><br/>Used for removing or installing IAC valve on throttle body.</p>                                                                                                                                                                                         |
|  <p>BT8320</p>      | <p><b>INJECTOR TEST LIGHT</b><br/>Used for checking the electrical circuit to a TBI fuel injector (except TBI 700).</p>                                                                                                                                                                       |
|  <p>BT8329A</p>     | <p><b>INJECTOR TEST LIGHT</b><br/>Used for checking the electrical circuit to a TBI 700 fuel injector and a port fuel injector.</p>                                                                                                                                                           |
|  <p>J 26792</p>    | <p><b>SPARK TESTER</b><br/>Used for checking available secondary ignition voltage. Also called an ST125.</p>                                                                                                                                                                                  |
|  <p>J 35616</p>   | <p><b>CONNECTOR TEST ADAPTER KIT</b><br/>Used for making electrical test connections in current Weather Pack, Metri-Pack and Micro-Pack style terminals.</p>                                                                                                                                  |
|  <p>J 34636</p>   | <p><b>CIRCUIT TESTER</b><br/>Used for checking all relays and solenoids before connecting them to a new ECM. Measures the circuit resistance and indicates pass or fail via green or red LED. Amber LED indicates current polarity. Can also be used as a non-powered continuity checker.</p> |
|  <p>J 28687-A</p> | <p><b>OIL PRESSURE TRANSDUCER WRENCH</b><br/>Used for removing or installing oil pressure transducer on engine.</p>                                                                                                                                                                           |

12-8-88  
95 6376-6E

|                                                                                                      |                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>J 35689</p>     | <p><b>METRI-PACK TERMINAL REMOVER</b><br/>Used for removing 150 series Metri-Pack "pull-to-seat" terminals from connectors. Refer to wiring harness service in Section "6E" for removal procedure.</p> |
|  <p>J 28742</p>     | <p><b>WEATHER PACK TERMINAL REMOVER</b><br/>Used for removing terminals from Weather Pack connectors. Refer to wiring harness service in Section "6E" for removal procedure.</p>                       |
|  <p>J 33095</p>     | <p><b>ECM CONNECTOR TERMINAL REMOVER</b><br/>Used for removing terminals from Micro-Pack connectors. Refer to wiring harness service Section "6E" for removal procedure.</p>                           |
|  <p>J 29698-A</p>   | <p><b>FUEL LINE WRENCH</b><br/>Used for disconnecting or connecting fuel lines at throttle body unit by holding fuel nut at throttle body.</p>                                                         |
|  <p>J 33179-20</p> | <p><b>MINIMUM AIR RATE ADJUSTING WRENCH</b><br/>Used for adjusting throttle stop screw on TBI unit.</p>                                                                                                |

12-8-88  
95 6377-6E

**GENERAL SPECIFICATIONS**

Many of the specifications used in this section are located on the Vehicle Emission Control Information label under the hood.

Listed on the chart below are locations of specifications used in this Section.

| SPECIFICATION                                                      | LOCATION OF INFORMATION                     |
|--------------------------------------------------------------------|---------------------------------------------|
| Engine Timing                                                      | Vehicle Emission Control information label. |
| Idle Speed, ECM Controlled                                         | Not adjustable. ECM controls idle.          |
| Spark Plug Gap                                                     | Vehicle Emission Control Information Label. |
| Engine Code                                                        | 8th digit of VIN number.                    |
| Engine Family                                                      | Vehicle Emission Control Information label. |
| Part Numbers of<br>Major Components                                | AIPDN.                                      |
| Replacement of<br>Vehicle Emission<br>Control Information<br>Label | AIPDN.                                      |

## SECTION 6E2

# DRIVEABILITY AND EMISSIONS

### 2.8L (VIN R) "KT" (TBI)

## CONTENTS

### 2.8L (VIN R) "KT"

|                                                                    |                |
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| Section B Symptoms                                                 | 6E2-B-1        |
| Section C Component Systems                                        | 6E2-C-1        |
| C1 Electronic Control Module (ECM) and Sensors                     | 6E2-C1-1       |
| C2 Fuel Metering System                                            | 6E2-C2-1       |
| C3 Evaporative Emission Control System (EECS)                      | 6E2-C3-1       |
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| C6 Air Management System 2.8L Engine                               | 6E2-C6-1       |
| C7 Exhaust Gas Recirculation (EGR) System                          | 6E2-C7-1       |
| C10 ECM Controlled Air Conditioning                                | 6E2-C10-1      |
| C13 Positive Crankcase Ventilation (PCV)                           | 6E2-C13-1      |
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| <b>INDEX</b>                                                       | END OF SECTION |

ALL NEW ISUZU VEHICLES ARE CERTIFIED BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AS CONFORMING TO THE REQUIREMENTS OF THE REGULATIONS FOR THE CONTROL OF AIR POLLUTION FROM NEW MOTOR VEHICLES. THIS CERTIFICATION IS CONTINGENT ON CERTAIN ADJUSTMENTS BEING SET TO FACTORY STANDARDS. IN MOST CASES, THESE ADJUSTMENT POINTS EITHER HAVE BEEN PERMANENTLY SEALED AND/OR MADE INACCESSIBLE TO PREVENT INDISCRIMINATE OR ROUTINE ADJUSTMENT IN THE FIELD. FOR THIS REASON, THE FACTORY PROCEDURE FOR TEMPORARILY REMOVING PLUGS, CAPS, ETC., FOR PURPOSES OF SERVICING THE PRODUCT, MUST BE STRICTLY FOLLOWED AND, WHEREVER PRACTICABLE, RETURNED TO THE ORIGINAL INTENT OF THE DESIGN.

## INTRODUCTION

### GENERAL DESCRIPTION

This section applies to engines which have a fuel injector mounted above a throttle body assembly. The entire assembly is mounted to the intake manifold and is referred to as "Throttle Body Injection."

These engines have controls to reduce exhaust emissions, while maintaining good driveability and fuel economy.

An engine control module (ECM) is the heart of this control system and has sensors used to provide information about engine operation and the various systems it controls. Details of basic operation, diagnosis, functional checks, and on-vehicle service are covered in Section "C", Component Systems.

The ECM has the ability to do some diagnosis of itself, and of other parts of the system. When it finds a problem, it lights a "Check Engine" light on the instrument panel and a trouble code will be stored in the ECM memory. This does not mean that the engine should be stopped right away, but that the cause of the light coming on should be checked as soon as reasonably possible.

### DIAGNOSIS PROCEDURE

The following sections(s) are written for specific engine applications and are clearly identified. Be sure to use only the section which applies to the engine family being diagnosed.

Before using this section of the manual, you should be familiar with the information and the proper diagnosing procedures as described in Section "6E". If the proper diagnosis procedures are not followed, as described in Section "6E", it may result in unnecessary replacement of good parts.

Trouble Tree Charts incorporate diagnosis procedures using an ALDL "Scan" tool, where possible. The "Scan" tool has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the "Scan" tool successfully for diagnosis lies in the technician's ability to understand the system he is trying to diagnose, as well as an understanding of the "Scan" tool's limitations. See Section "6E" for more information.

## SECTION A

### 2.8L ENGINE

#### DIAGNOSTIC CIRCUIT CHECK

The "Diagnostic Circuit Check" verifies the system is functioning correctly. Some special considerations to keep in mind while making the "Diagnostic Circuit Check" are:

##### Blocking Drive Wheels

The vehicle drive wheels should always be blocked while checking the system.

##### Idle "Open Loop"

Operation at idle will put the system in "Open Loop" to restore "Closed Loop" operation, run the engine at 1000 rpm or greater.

#### Cold Oxygen Sensor

The Oxygen Sensor may cool off after only a short period of operation at idle. This will put the system into "Open Loop." To restore "Closed Loop" operation, run the engine at part throttle several minutes and accelerate from idle to part throttle a few times.

#### BASIC PROCEDURE

If you have not reviewed the basic information on how to use the diagnostic procedures, go to the Introduction of this section.

## SECTION A

### ENGINE COMPONENTS / WIRING DIAGRAMS / DIAGNOSTIC CHARTS

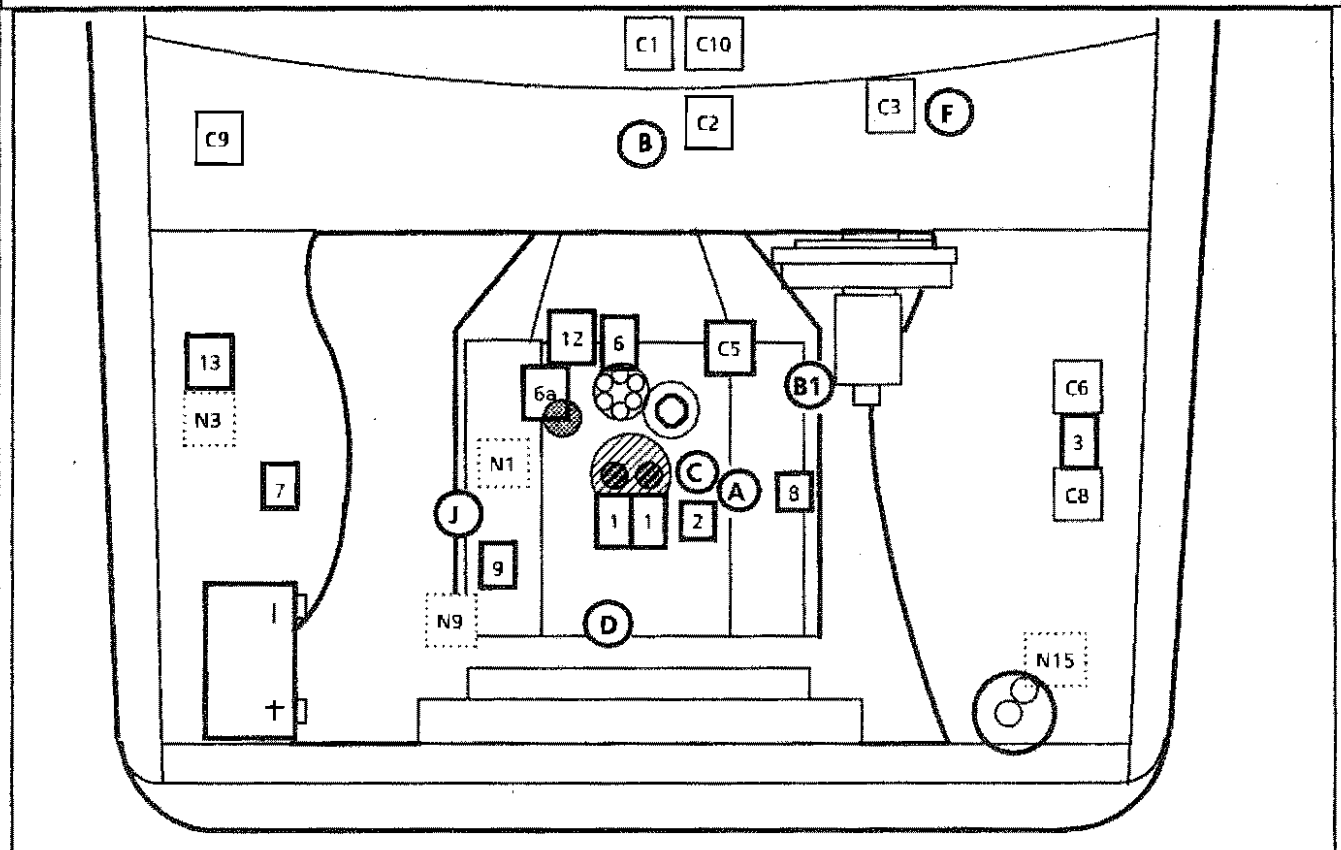
|                                                                                                |           |
|------------------------------------------------------------------------------------------------|-----------|
| Engine Component Locations .....                                                               | Page A-2  |
| ECM Wiring Diagrams .....                                                                      | Page A-3  |
| ECM Connector Terminal End View .....                                                          | Page A-6  |
| Diagnostic Circuit Check .....                                                                 | Page A-8  |
| No "Check Engine" Light - Chart A-1 .....                                                      | Page A-10 |
| No ALDL Data or Won't Flash Code 12, "Check Engine" Light "On" Steady - Chart A-2 .....        | Page A-12 |
| Engine Cranks But Will Not Run - Chart A-3 (1 of 2) .....                                      | Page A-14 |
| Fuel System Diagnosis - Chart A-7 (1 of 2) .....                                               | Page A-18 |
| Code 13 Oxygen Sensor Circuit (Open Circuit) .....                                             | Page A-22 |
| Code 14 Coolant Temperature Sensor Circuit (High Temperature Indicated) .....                  | Page A-24 |
| Code 15 Coolant Temperature Sensor Circuit (Low Temperature Indicated) .....                   | Page A-26 |
| Code 21 Throttle Position Sensor (TPS) Circuit (Signal Voltage High) .....                     | Page A-28 |
| Code 22 Throttle Position Sensor (TPS) Circuit (Signal voltage Low) .....                      | Page A-30 |
| Code 24 Vehicle Speed Sensor (VSS) Circuit .....                                               | Page A-32 |
| Code 32 EGR System Failure .....                                                               | Page A-34 |
| Code 33 Manifold Absolute Pressure (MAP) Sensor Circuit (Signal Voltage High-Low Vacuum) ..... | Page A-36 |
| Code 34 Manifold Absolute Pressure (MAP) Sensor Circuit (Signal Voltage Low-High Vacuum) ..... | Page A-38 |
| Code 42 Electronic Spark Timing (EST) Circuit .....                                            | Page A-40 |
| Code 43 Electronic Spark Control (ESC) Circuit .....                                           | Page A-42 |
| Code 44 Oxygen Sensor Circuit (Lean Exhaust Indicated) .....                                   | Page A-44 |
| Code 45 Oxygen Sensor Circuit (Rich Exhaust Indicated) .....                                   | Page A-46 |
| Code 54 Fuel Pump Circuit (Low Voltage) .....                                                  | Page A-48 |
| Code 51 Prom Error (Faulty or Incorrect Prom) .....                                            | Page A-50 |
| Code 52 Calpak Error (Faulty or Incorrect Calpak) .....                                        | Page A-50 |
| Code 55 ECM Error .....                                                                        | Page A-50 |

"KT" SERIES

RPO:LL2

ENGINE CODE:R

2.8L V6



☐ **COMPUTER COMMAND CONTROL**

- C1 Electronic Control Module (E.C.M.)
- C2 ALDL diagnostic connector
- C3 Check engine light
- C5 ECM harness ground
- C6 Fuse panel
- C8 Fuel pump test connector
- C9 Elapsed Timer Module
- C10 Set Timing Connector

☐ **ECM INFORMATION SENSORS**

- A Manifold Absolute Pressure (M.A.P.)
- B Exhaust oxygen (Federal)
- C Throttle position (T.P.S.)
- D Coolant temperature
- F Vehicle speed (V.S.S.)
- J Electronic Spark Control Knock (E.S.C.)

☐ **EMISSION COMPONENTS (NOT ECM CONTROLLED)**

- N1 Crankcase vent valve (PCV)
- N3 Main Relay
- N9 Air Pump
- N15 Fuel Vapor Canister

☐ **ECM CONTROLLED COMPONENTS**

- 1 Fuel injector
- 2 Idle air control
- 3 Fuel pump relay
- 6 Electronic Spark Timing Distributor (E.S.T.)
- 6a Remote ignition coil
- 7 Electronic Spark Control module (E.S.C.)
- 8 Oil pressure switch
- 9 Electric Air Control solenoid (E.A.C.)
- 12 Exhaust Gas Recirculation Vacuum Solenoid
- 13 A/C Relay

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Figure A-1 - Engine Component Locations 2.BL

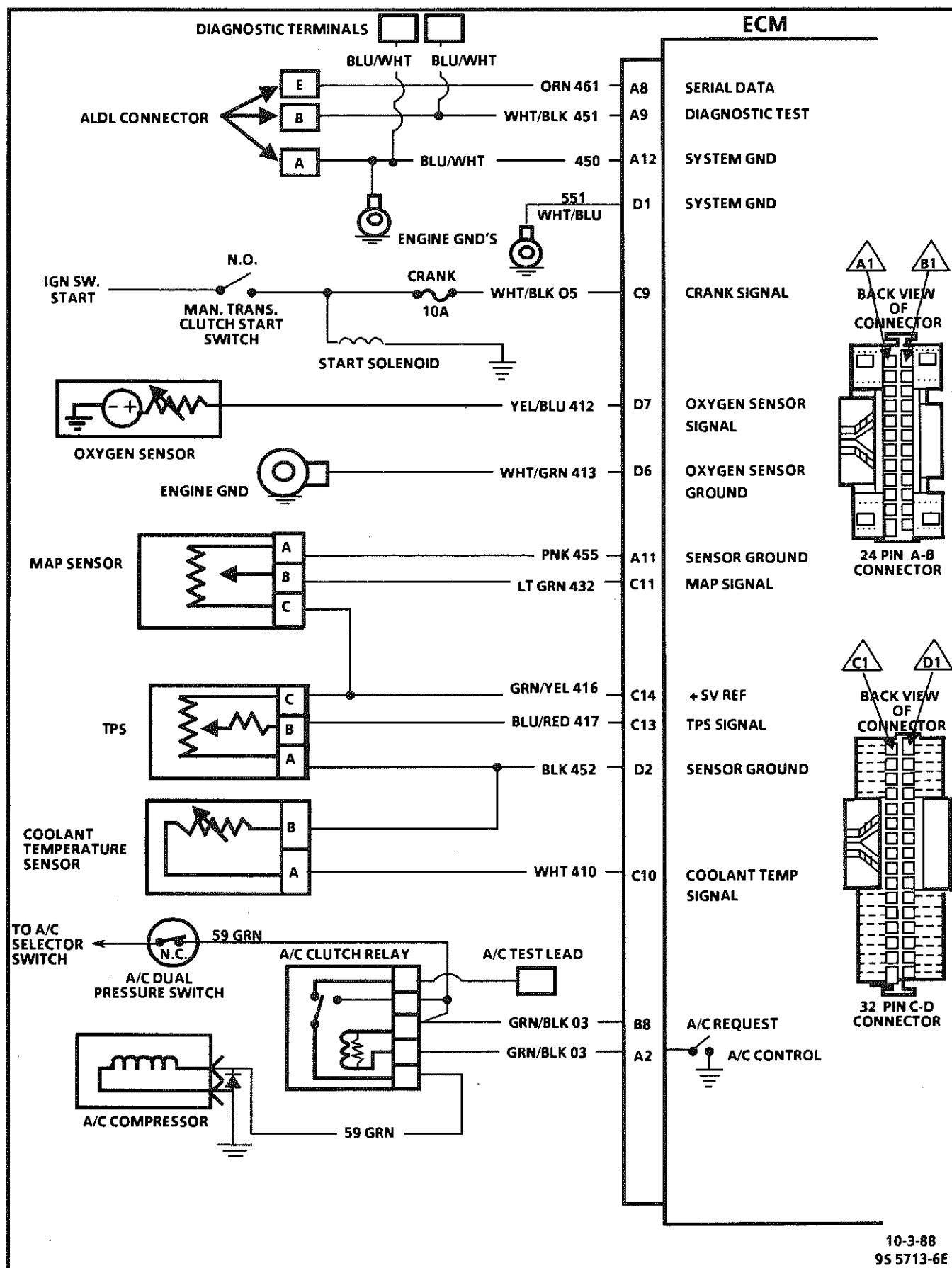


Figure A-2 - ECM Wiring Diagram 2.8L (1 of 3)

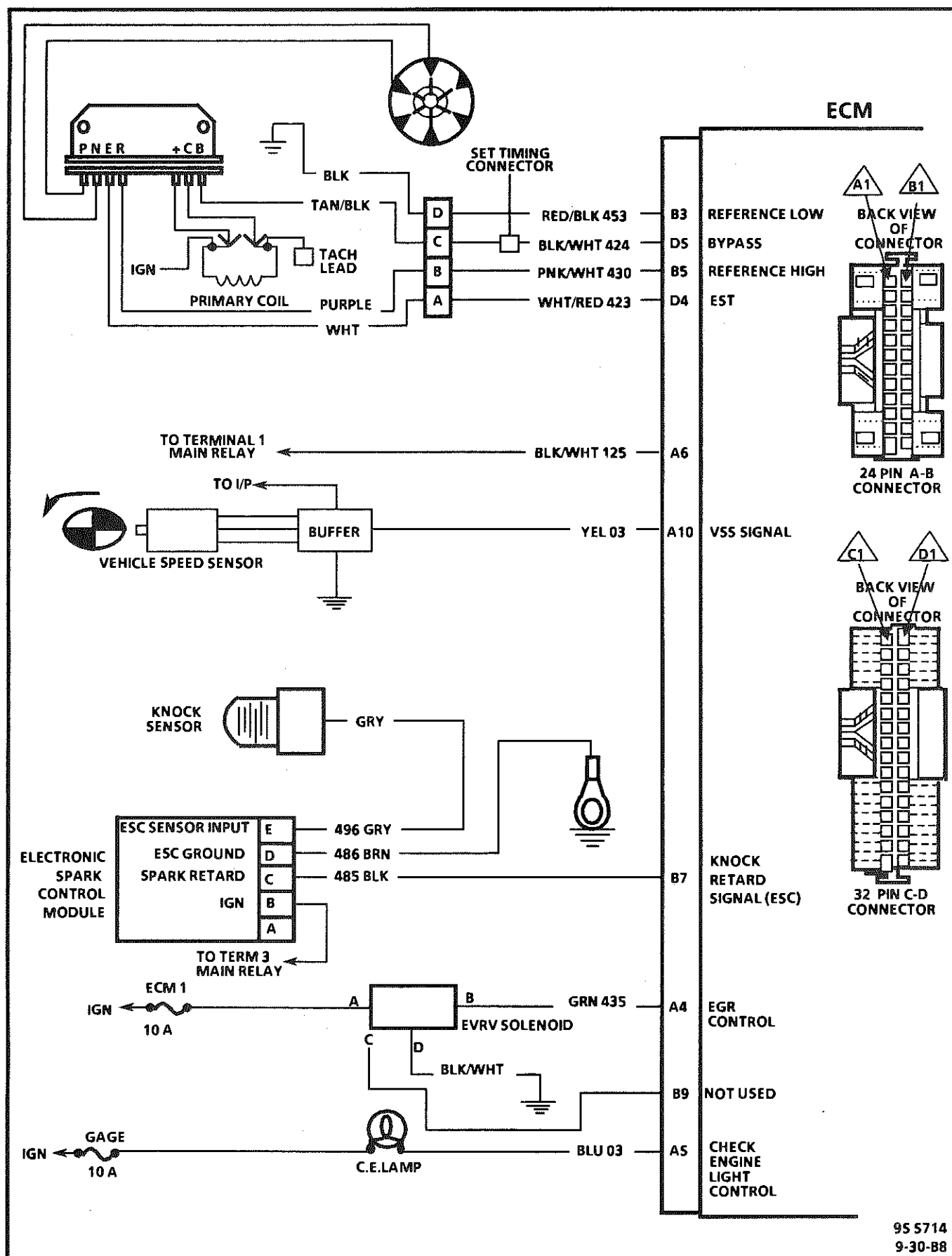


Figure A-3 - ECM Wiring Diagram 2.8L (2 of 3)

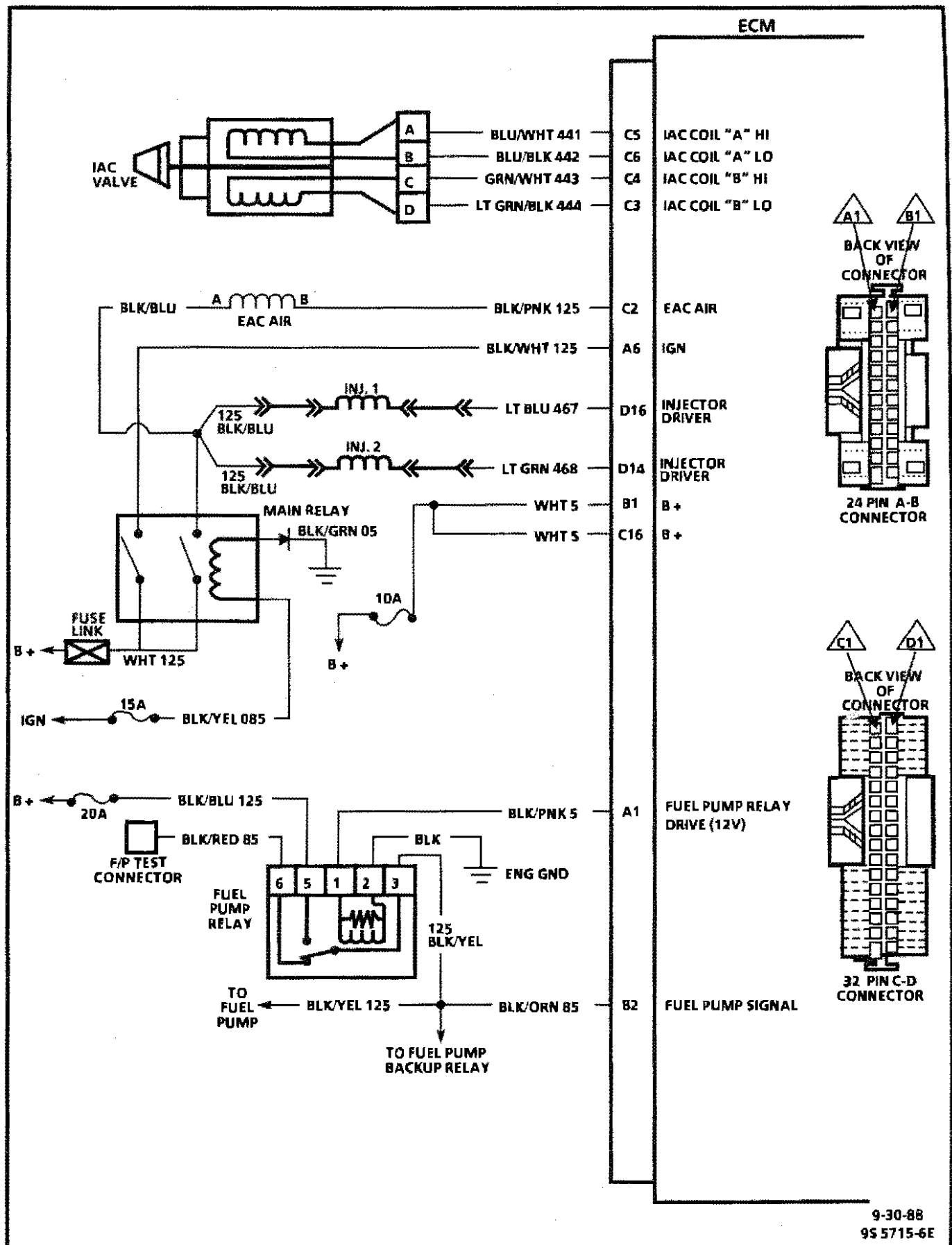


Figure A-4 - ECM Wiring Diagram 2.8L (3 of 3)

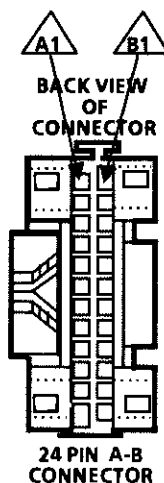
## TBI FUEL INJECTION ECM CONNECTOR IDENTIFICATION

**This ECM voltage chart is for use with a digital voltmeter to further aid in diagnosis. The voltages you get may vary due to low battery charge or other reasons, but they should be very close.**

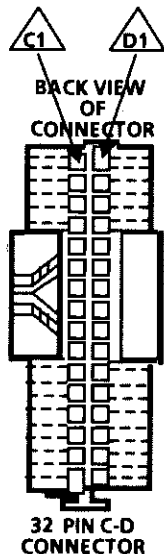
**THE FOLLOWING CONDITIONS MUST BE MET BEFORE TESTING:**

- Engine at operating temperature ● Engine idling in closed loop (for "Engine Run" column)  
● Test terminal not grounded ● ALCL tool not installed

| VOLTAGE     |             |                         |     |                    |
|-------------|-------------|-------------------------|-----|--------------------|
| KEY<br>"ON" | ENG.<br>RUN | CIRCUIT                 | PIN | WIRE<br>COLOR      |
| 0           | 14          | FUEL PUMP RELAY         | A1  | BLK/PNK            |
| 12          | 14          | A/C CLUTCH<br>CONTROL   | A2  | GRN/BLK            |
|             |             | NOT USED                | A3  |                    |
| 12          | 14          | EGR CONTROL             | A4  | GRN                |
| 0           | 14          | "CHECK ENGINE"<br>LIGHT | A5  | BLU<br>BLK/<br>WHT |
| 12          | 14          | IGN - ECM FUSE          | A6  |                    |
|             |             |                         | A7  |                    |
| 2-5         | 2.5         | SERIAL DATA             | A8  | ORN<br>WHT/<br>BLU |
| 5           | 5           | DIAG. TERM.<br>SPEED    | A9  |                    |
| ①           | ①           | SENSOR SIGNAL           | A10 | YELLOW             |
| 0           | 0           | MAP GROUND              | A11 | PNK<br>WHT/<br>BLK |
| 0           | 0           | SYSTEM GROUND           | A12 |                    |



|             |     |                         |     |                |
|-------------|-----|-------------------------|-----|----------------|
|             |     | NOT USED                | C1  |                |
| 12          | 14  | FAC SOL                 | C2  | BLK/PNK        |
| NOT USEABLE |     | IAC "B" LO              | C3  | LT GRN/<br>BLK |
| NOT USEABLE |     | IAC "B" HI              | C4  | GRN/<br>WHT    |
| NOT USEABLE |     | IAC "A" HI              | C5  | BLU/<br>WHT    |
| NOT USEABLE |     | IAC "A" LO              | C6  | BLU/<br>BLK    |
|             |     | NOT USED                | C7  |                |
|             |     | NOT USED                | C8  |                |
| 0           | 0   | CRANK SIGNAL            | C9  | WHT/BLK        |
| 1.9         | 1.7 | COOLANT<br>TEMP. SIGNAL | C10 | WHT            |
| 4.9         | 2.0 | MAP SIGNAL              | C11 | LT GRN         |
|             |     | NOT USED                | C12 |                |
| .48         | .48 | TPS SIGNAL              | C13 | BLU/RED        |
| 5           | 5   | 5 VOLT<br>REFERENCE     | C14 | GRN/YEL        |
|             |     | NOT USED                | C15 |                |
| 12          | 14  | BATTERY                 | C16 | WHT            |



|               |     |                     | VOLTAGE     |             |
|---------------|-----|---------------------|-------------|-------------|
| WIRE<br>COLOR | PIN | CIRCUIT             | KEY<br>"ON" | ENG.<br>RUN |
| WHT           | B1  | BATTERY             | 12          | 14          |
| BLK/<br>ORN   | B2  | FUEL PUMP SIGNAL    | 0           | 14          |
| RED/<br>BLK   | B3  | EST REF LOW         | 0           | 0           |
|               | B4  | NOT USED            |             |             |
| PNK/<br>WHT   | B5  | EST<br>REFERENCE HI | 0           | 1.6         |
|               | B6  | NOT USED            |             |             |
| BLK           | B7  | ESC SIGNAL          | 9           | 9           |
| GRN/<br>BLU   | B8  | A/C SIGNAL          | 0           | 0/12        |
| BRN           | B9  | NOT USED            |             |             |
|               | B10 | NOT USED            |             |             |
|               | B11 | NOT USED            |             |             |
|               | B12 | NOT USED            |             |             |

|             |     |                               |    |      |
|-------------|-----|-------------------------------|----|------|
| WHT/<br>BLU | D1  | SYSTEM GROUND                 | 0  | 0    |
| BLK         | D2  | 5V RETURN                     | 0  | 0    |
|             | D3  | NOT USED                      |    |      |
| WHT/<br>RED | D4  | EST CONTROL                   | 0  | 1.0  |
| BLK/<br>WHT | D5  | EST BYPASS                    | 0  | 4.75 |
| WHT/<br>GRN | D6  | SENSOR GRD. (0 <sub>2</sub> ) | 0  | 0    |
| YEL/<br>BLU | D7  | O <sub>2</sub> SENSOR SIGNAL  | 0  | ③    |
|             | D8  | NOT USED                      |    |      |
|             | D9  | NOT USED                      |    |      |
|             | D10 | NOT USED                      |    |      |
|             | D11 | NOT USED                      |    |      |
|             | D12 | NOT USED                      |    |      |
|             | D13 | NOT USED                      |    |      |
| GRN         | D14 | INJECTOR B                    | 12 | 14   |
|             | D15 | NOT USED                      |    |      |
| BLU         | D16 | INJECTOR A                    | 12 | 14   |

- 1 Varies from .60 to battery voltage depending on position of drive wheels.
- 2 Varies with temperature.
- 3 Varies. (toggles)
- 4 12V First two seconds.

- 5 Measured between terminals C13 and D2 ( $\pm .06V$ ).  
6 12 V in gear  
7 0 V with A/C "on"  
8 12 V with A/C "on"  
9 12 V when cold

**ENGINE 2.8L LL2**

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95 5612-6E

**Figure A-5 - ECM Connector Terminal End View**

**BLANK**

## DIAGNOSTIC CIRCUIT CHECK

The Diagnostic Circuit Check is an organized approach to identifying a problem created by an electronic engine control system malfunction. It must be the starting point for any driveability complaint diagnosis, because it directs the service technician to the next logical step in diagnosing the complaint.

The "Scan Data" listed in the table may be used for comparison, after completing the diagnostic circuit check and finding the on-board diagnostics functioning properly and no trouble codes displayed. The "Typical Values" are an average of display values recorded from normally operating vehicles and are intended to represent what a normally functioning system would typically display.

**A "SCAN" TOOL THAT DISPLAYS FAULTY DATA SHOULD NOT BE USED, AND THE PROBLEM SHOULD BE REPORTED TO THE MANUFACTURER. THE USE OF A FAULTY "SCAN" CAN RESULT IN MISDIAGNOSIS AND UNNECESSARY PARTS REPLACEMENT.**

Only the parameters listed below are used in this manual for diagnosis. If a "Scan" tool reads other parameters, the values are not recommended by Isuzu for use in diagnosis. For more description on the values and use of the "Scan" to diagnosis ECM inputs, refer to the applicable diagnosis section in Section "C". If all values are within the range illustrated, refer to "Symptoms" in Section "B".

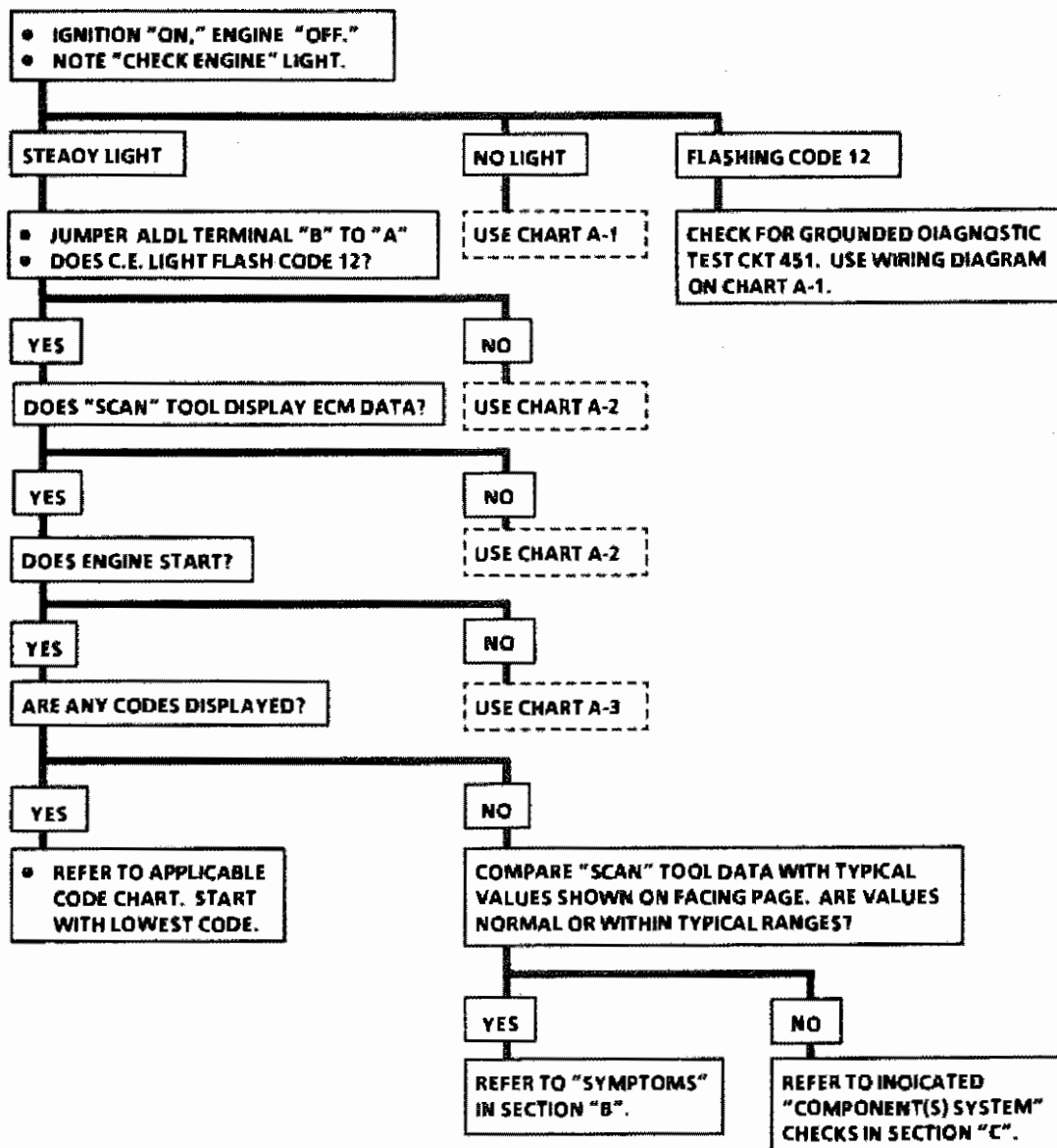
### "SCAN" DATA

Idle / Upper Radiator Hose Hot / Closed Throttle / Park or Neutral / Closed Loop / Acc. off

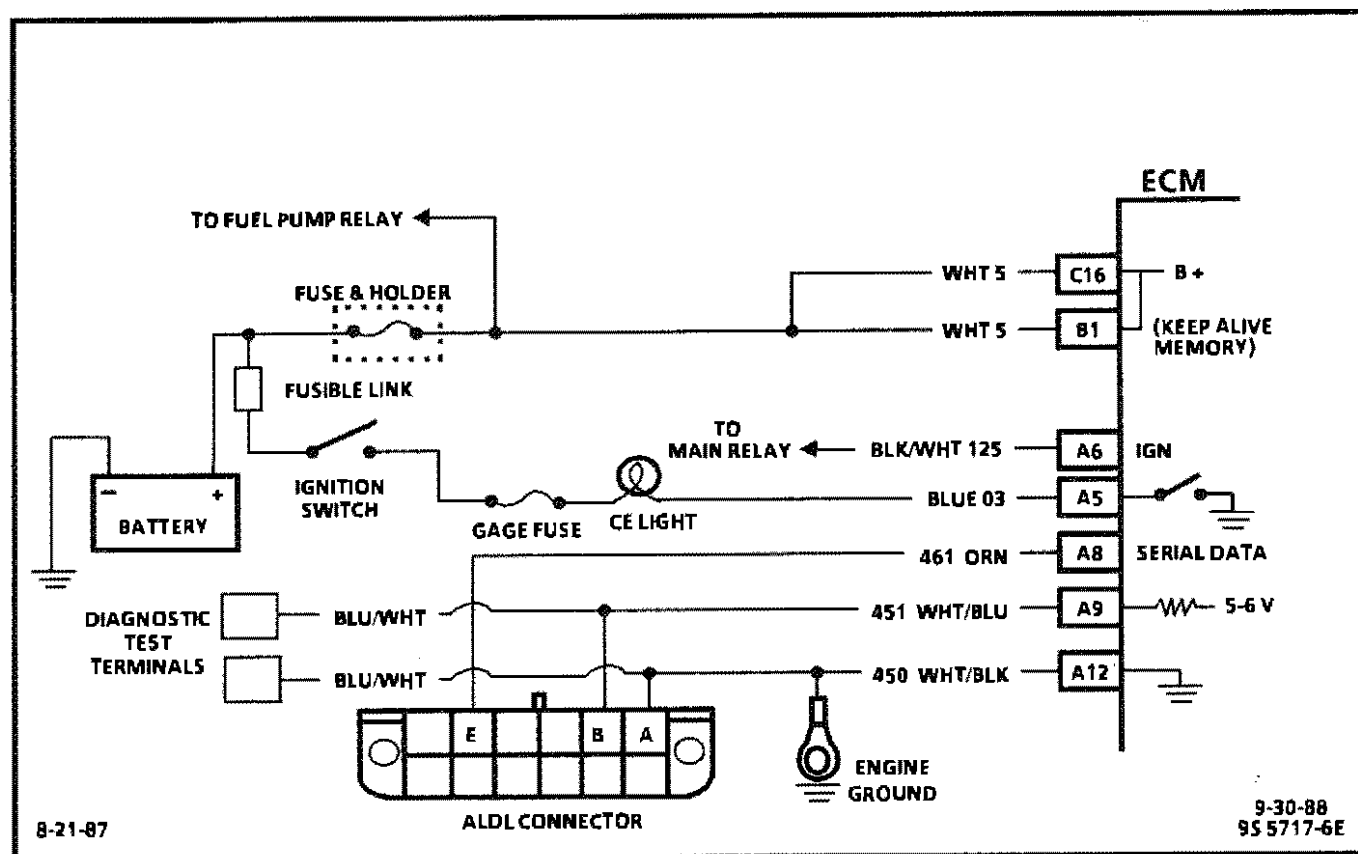
| <u>"SCAN" Position</u> | <u>Units Displayed</u> | <u>Typical Data Value</u>               |
|------------------------|------------------------|-----------------------------------------|
| Coolant Temp.          | C°                     | 85° - 105°                              |
| TPS                    | Volts                  | .48 +/- .06                             |
| MAP                    | Volts                  | 1 - 2 (depends on Vac. & Baro pressure) |
| INT (Integrator)       | Counts                 | Varies                                  |
| BLM (Block Learn)      | Counts                 | 118 - 138                               |
| IAC                    | Counts (steps)         | 1 - 50                                  |
| RPM                    | RPM                    | 650 ± 100 RPM                           |
| O <sub>2</sub>         | Volts                  | .001 - 999 and varies                   |
| Open/Closed Loop       | Open/Closed            | Closed Loop (will go open at idle)      |
| A/C Request            | Yes/No                 | No (yes, with A/C requested)            |
| VSS                    | MPH                    | 0                                       |
| Battery                | Volts                  | 13.5 - 14.5                             |
| Air Divert             | Normal/Divert          | Normal                                  |
| Air Switch             | Converter/Port         | Converter                               |
| Knock Signal           | Yes/No                 | No                                      |

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9-30-88

**DIAGNOSTIC CIRCUIT CHECK****2.8L (VIN R) "KT" (TBI)**

9-27-88  
• 95 5978-6E



## CHART A-1

### NO "CHECK ENGINE" LIGHT 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

There should always be a steady "Check Engine" light, when the ignition is "ON" and engine stopped. Ignition voltage is supplied directly to the light bulb. The electronic control module (ECM) will control the light and turn it "ON" by providing a ground path through CKT 03 to the ECM.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Battery feed CKT 5 is protected by a 10A in-line fuse. If this fuse was blown, refer to wiring diagram on the facing page of Code 54.
2. Using a test light connected to 12 volts, probe each of the system ground circuits to be sure a good ground is present. See ECM terminal end view in front of this section for ECM pin locations of ground circuits.

#### Diagnostic Aids:

Engine runs OK, check:

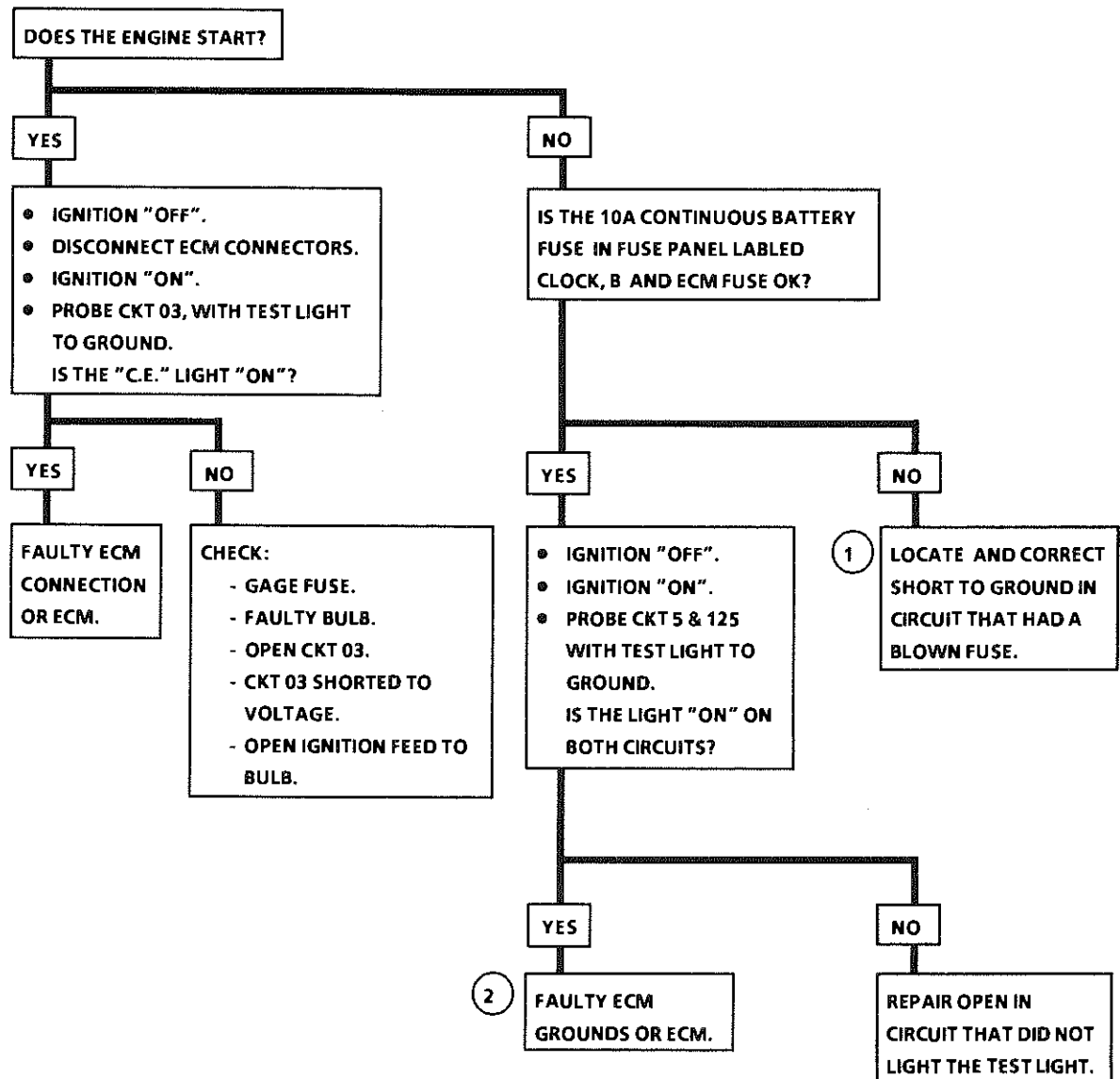
- Faulty light bulb
- CKT 03 open
- Gage fuse blown. This will result in no oil, or generator lights, seat belt reminder, etc.

Engine cranks, but will not run.

- Continuous battery - fuse or fusible link open
- ECM ignition fuse open
- Battery CKT 5 to ECM open
- Ignition CKT 125 to ECM open
- Poor connection to ECM

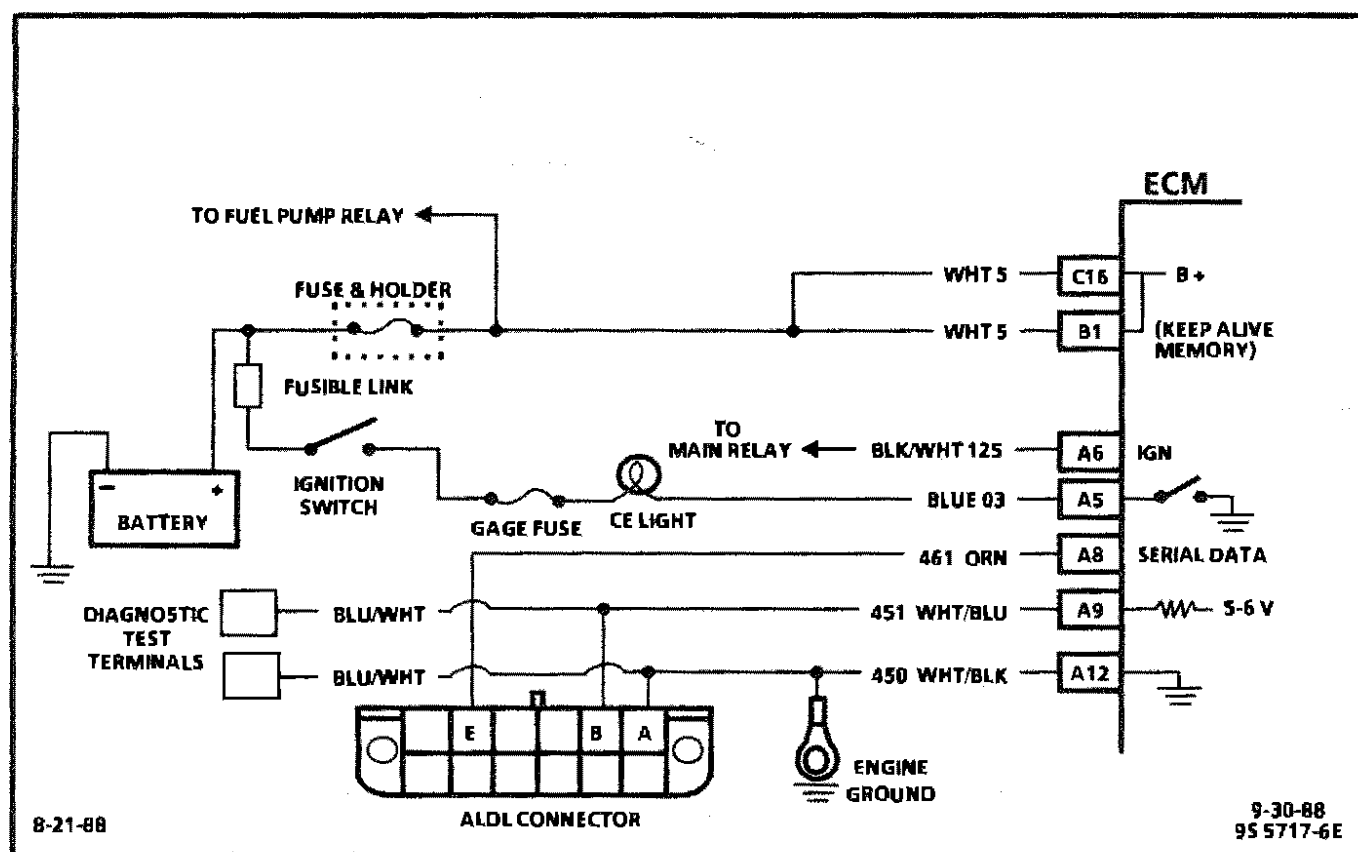
**CHART A-1**

**NO "CHECK ENGINE" LIGHT  
2.8L (VIN R) "KT" (TBI)**



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 5718-6E



## CHART A-2

### NO ALDL DATA OR WON'T FLASH CODE 12 "CHECK ENGINE" LIGHT "ON" STEADY 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

There should always be a steady "Check Engine" light, when the ignition is "ON" and engine stopped. Ignition voltage is supplied directly to the light bulb. The electronic control module (ECM) will turn the light "ON" by grounding CKT 03 at the ECM.

With the diagnostic terminal grounded, the light should flash a Code 12, followed by any trouble code(s) stored in memory.

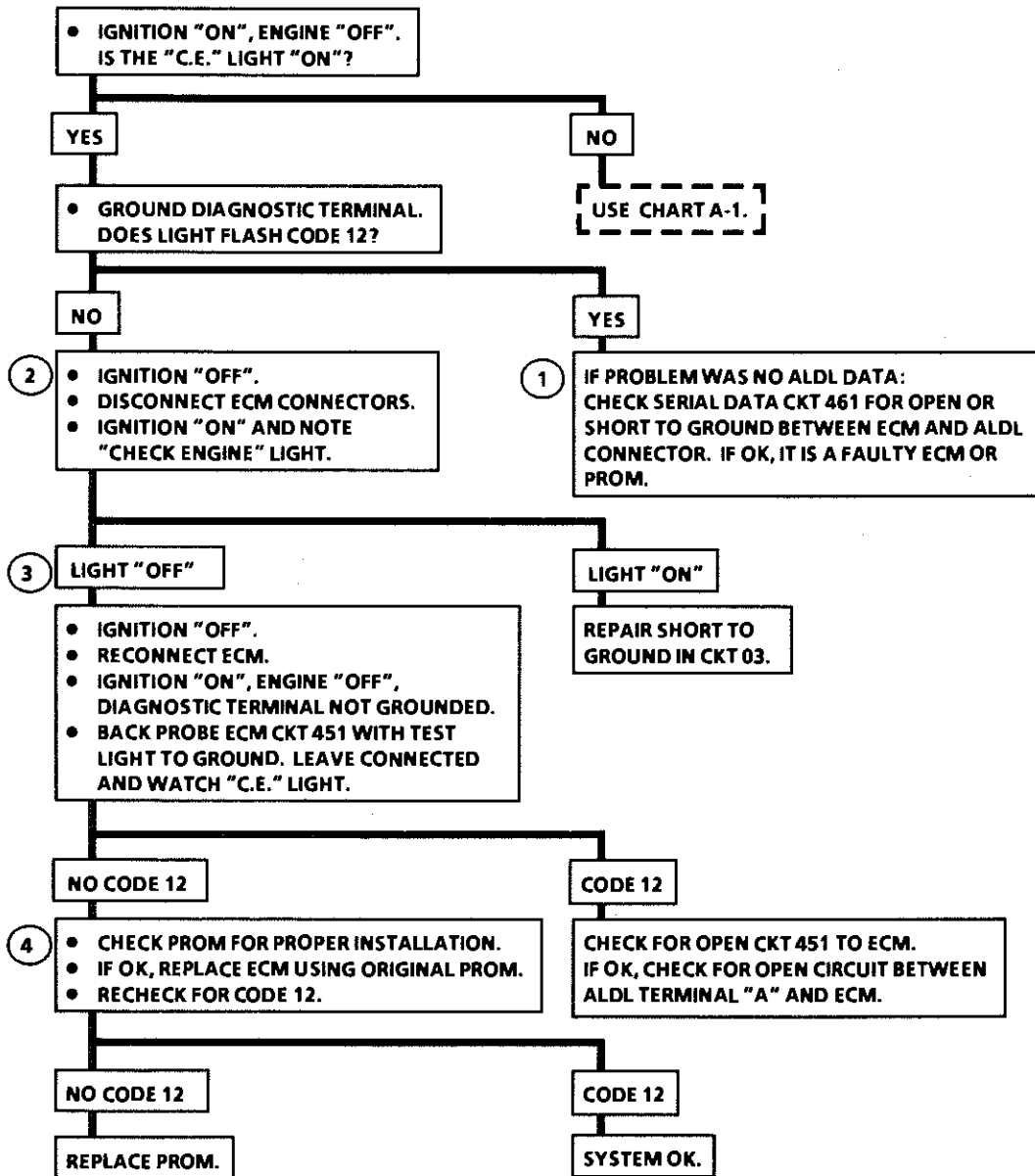
A steady light suggests a short to ground in the light control CKT 03, or an open in diagnostic CKT 451.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. If there is a problem with the ECM that causes a "Scan" tool to not read serial data, then the ECM should not flash a Code 12. If Code 12 does flash, be sure that the "Scan" tool is working properly on another vehicle. If the "Scan" is functioning properly and CKT 461 is OK, the Mem-Cal or ECM may be at fault for the NO ALDL symptom.
2. If the light goes "OFF," when the ECM connector is disconnected, then CKT 03 is not shorted to ground.
3. This step will check for an open diagnostic CKT 451.
4. At this point, the "Check Engine" light wiring is OK. The problem is a faulty ECM or PROM. If Code 12 does not flash, the ECM should be replaced using the original PROM. Replace the PROM only after trying an ECM, as a defective PROM is an unlikely cause of the problem.

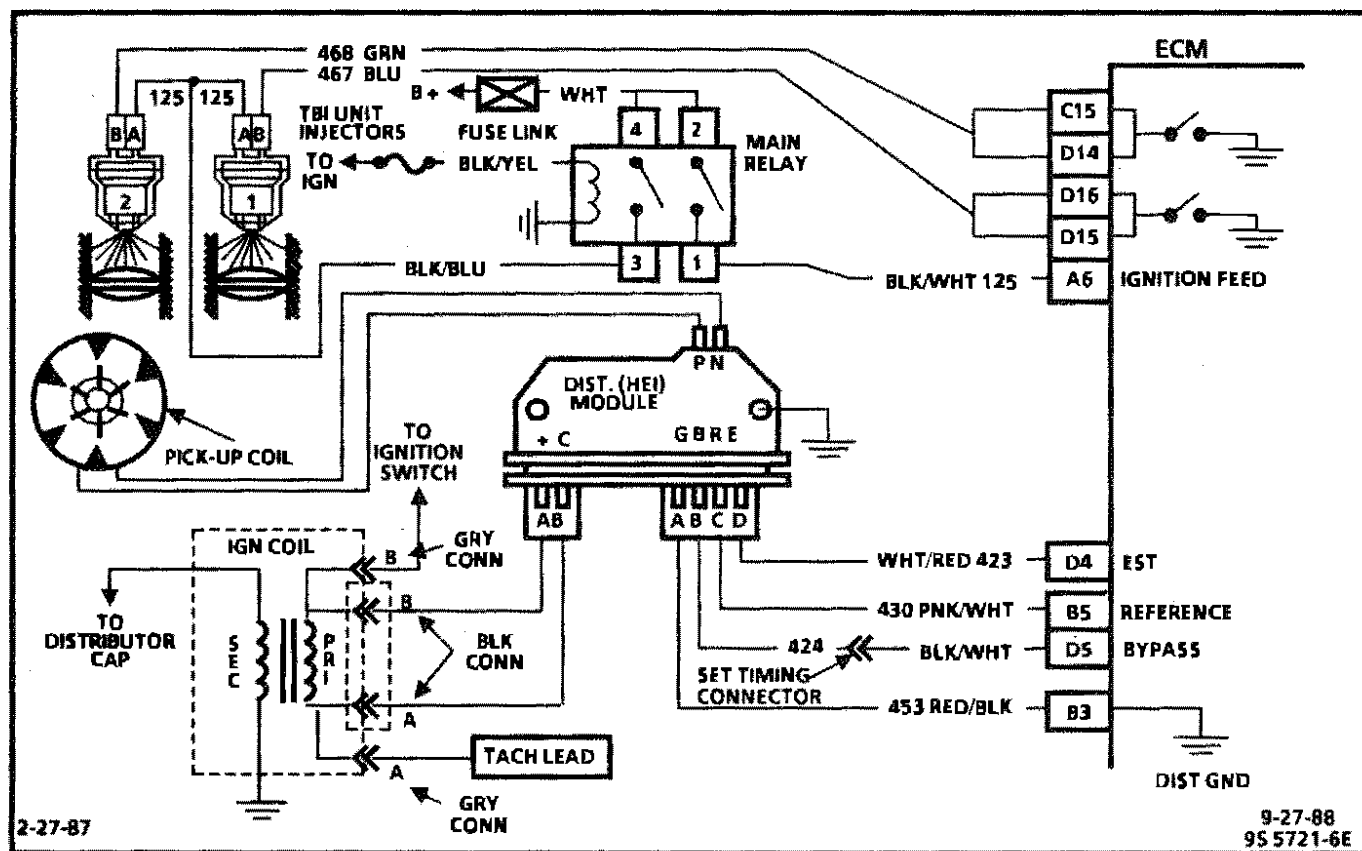
**CHART A-2**

**NO ALDL DATA OR WON'T FLASH CODE 12  
"CHECK ENGINE" LIGHT "ON" STEADY  
2.8L (VIN R) "KT" (TBI)**



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-26-88  
95 5720-6E



## CHART A-3

(Page 1 of 2)

### ENGINE CRANKS BUT WILL NOT RUN 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

This chart assumes that battery condition and engine cranking speed are OK, and there is adequate fuel in the tank.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. A "Check Engine" light "ON" is a basic test to determine if there is a 12 volt supply and ignition 12 volts to ECM. No ALDL may be due to an ECM problem and CHART A-2 will diagnose the ECM. If TPS is over 2.5 volts, the engine may be in the clear flood mode which will cause starting problems. The engine will not start without reference pulses and therefore, the "Scan" should read rpm (reference) during crank.
2. No spark may be caused by one of several components related to the ignition system. CHART C-4 will address all problems related to the causes of a no spark condition.
3. Fuel spray from the injector(s) indicates that fuel is available, however, the engine could be severely flooded due to too much fuel.
4. While cranking engine, there should be no fuel spray with injector disconnected. Replace an injector if it sprays fuel or drips like a leaking water faucet.
5. The fuel pressure will drop after the fuel pump stops running due to a controlled bleed in the fuel system. Use of the fuel pressure gage will determine if fuel system pressure is enough for engine to start and run.
6. No fuel spray from injector indicates a faulty fuel system or no ECM control of injector.
7. This test will determine if the ignition module is not generating the reference pulse, or if the wiring or ECM are at fault. By touching and removing a test light to 12 volts on CKT 430, a reference pulse should be generated. If injector test light blinks, the ECM and wiring are OK.

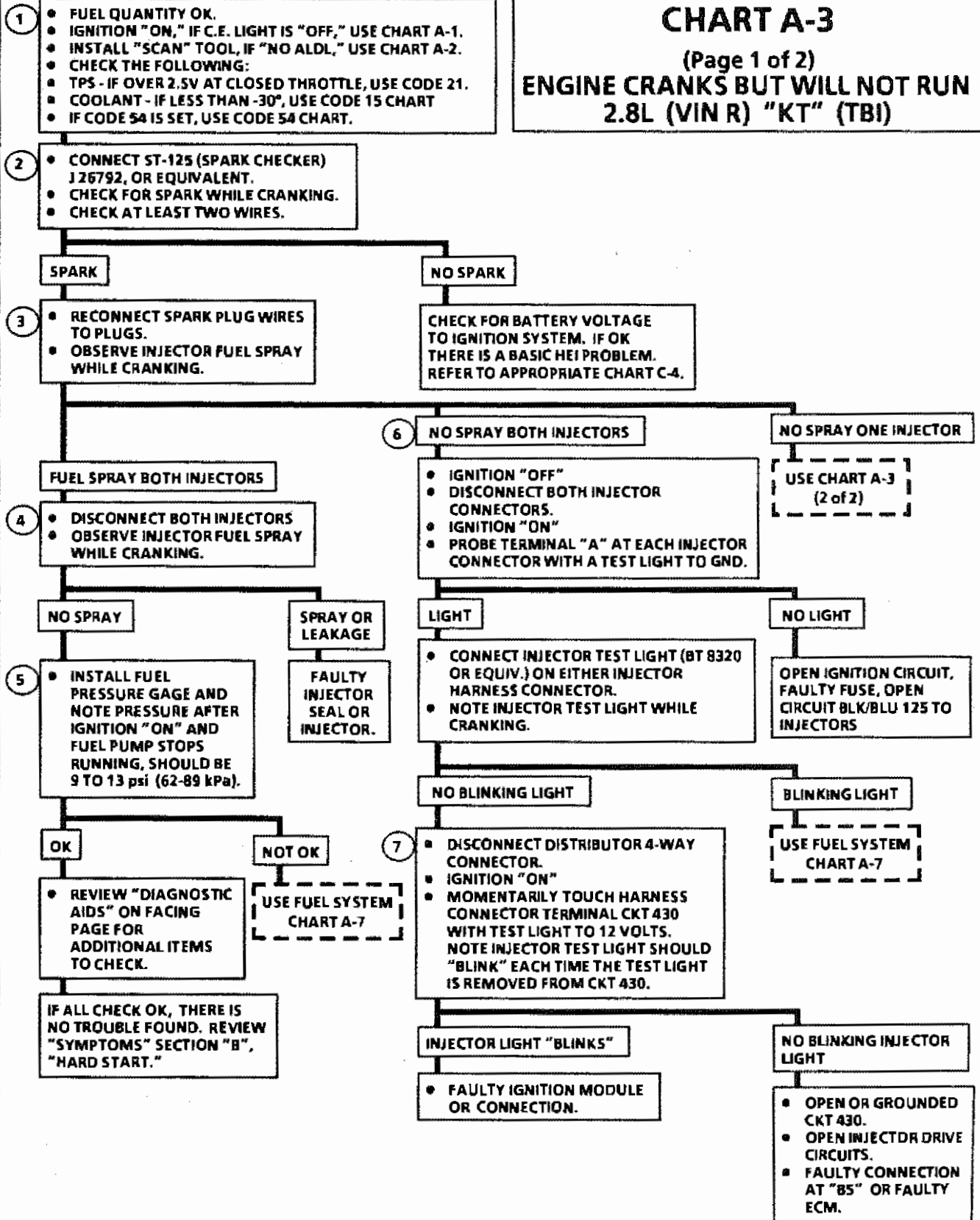
#### Diagnostic Aids:

- Water or foreign material can cause a no start during freezing weather.
- An EGR sticking open can cause a low air/fuel ratio during cranking.
- Fuel pressure: Low fuel pressure can result in a very lean air/fuel ratio. See CHART A-7.
- A grounded CKT 423 (EST) may cause a "No-Start" or a "Start then Stall" condition.

# CHART A-3

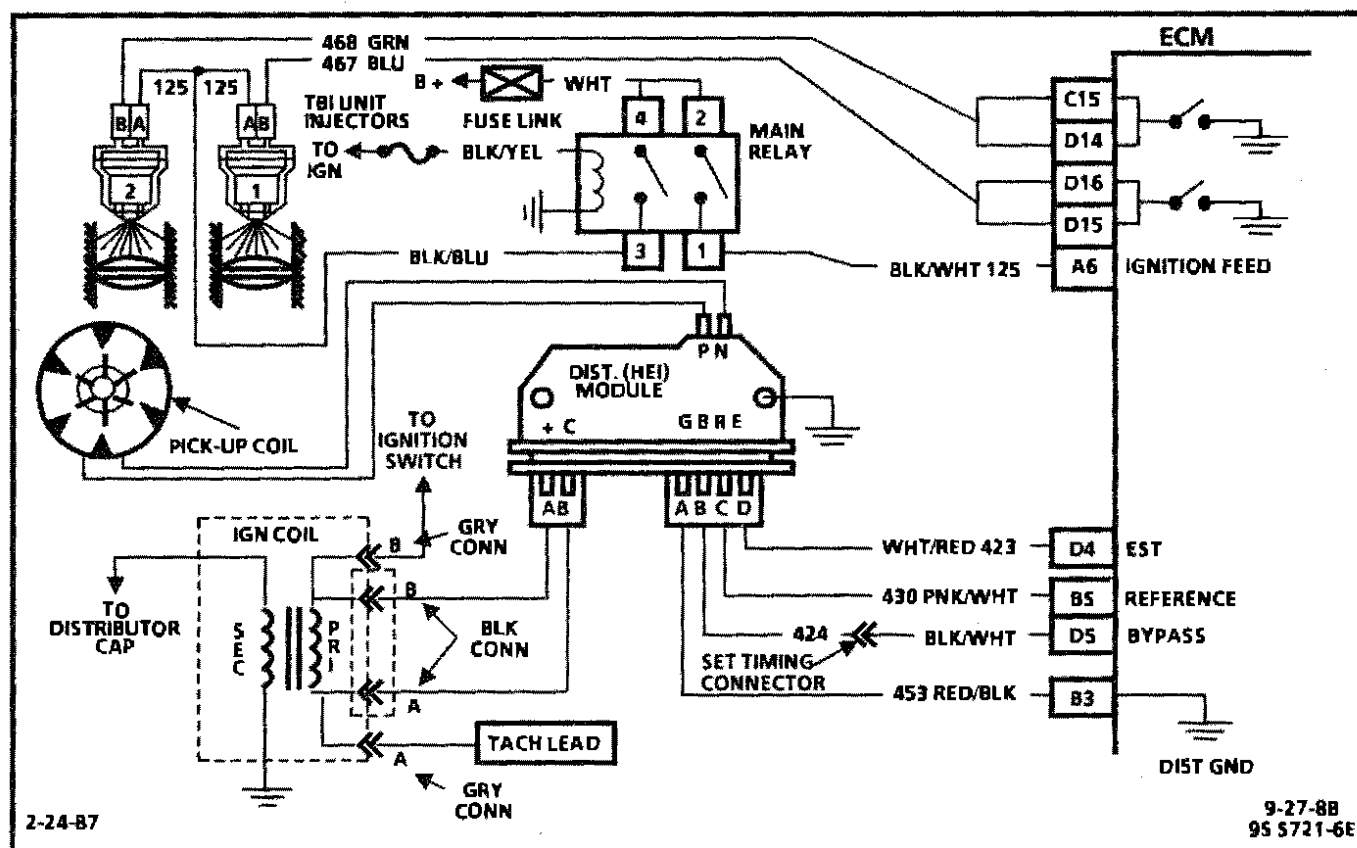
(Page 1 of 2)

## ENGINE CRANKS BUT WILL NOT RUN 2.8L (VIN R) "KT" (TBI)



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-29-88  
95 5722-6E



## CHART A-3

(Page 2 of 2)

### ENGINE CRANKS BUT WILL NOT RUN 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

This chart assumes that battery condition and engine cranking speed are OK, and there is adequate fuel in the tank.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- No fuel spray from one injector indicates a faulty fuel injector or no ECM control of injector. If the test light "blinks" while cranking, then ECM control should be considered OK. Be sure test light makes good contact between connector terminals during test. The light may be a little dim when "blinking." This is due to current draw of the test light. How bright it "blinks" is not important. The test light bulb should be a J 36400-1 or equivalent.
- CKTs BLK/BLU 125 supply ignition voltage to the injectors. Probe each connector terminal with a test light to ground. There should be a light "ON" at one terminal. If the test light confirms ignition voltage at the connector, the ECM injector control CKT 467 or 468 may be open. Reconnect the injector and using a test light connected to ground, check for a light at the applicable ECM connector terminal "D14" or "D16". A light at this point indicates that the injector drive circuit involved is OK. If an ECM repeat failure has occurred, the injector is shorted. Replace the injector and ECM.

**CHART A-3**

(Page 2 of 2)

**ENGINE CRANKS BUT WILL NOT RUN  
2.8L (VIN R) "KT" (TBI)**FROM  
CHART A-3  
(Page 1 of 2)

NO SPRAY ONE INJECTOR

①

- DISCONNECT INOPERATIVE INJECTOR CONNECTOR
- CONNECT TEST LIGHT ACROSS HARNESS CONNECTOR.
- NOTE LIGHT WHILE CRANKING.

"BLINKING LIGHT"

FAULTY INJECTOR  
CONNECTOR OR  
INJECTOR.

NO "BLINKING LIGHT"

②

- IGNITION "ON", ENGINE "OFF."
- PROBE EACH CONNECTOR  
TERMINAL WITH A TEST LIGHT  
TO GROUND.

LIGHT "ON"  
ONE  
TERMINAL.OPEN CKT 467, OR 468,  
FAULTY ECM  
CONNECTION, OR  
FAULTY ECM.LIGHT "OFF"  
BOTH  
TERMINALS.REPAIR OPEN  
IN CKT  
BLK/BLU 125  
TO INJECTORSLIGHT "ON"  
BOTH  
TERMINALS.CKT 467 INJECTOR "1"  
OR CKT 468 INJECTOR  
"2" SHORTED TO  
VOLTAGE.

STEADY LIGHT

CHECK FOR SHORT TO GROUND  
IN CKT 467 INJECTOR "1" OR  
CKT 468 INJECTOR "2".CKT 467 OR CKT 468 OK.  
CHECK RESISTANCE ACROSS  
INJECTOR TERMINALS.  
SHOULD BE OVER 1.2 OHMS.

OK

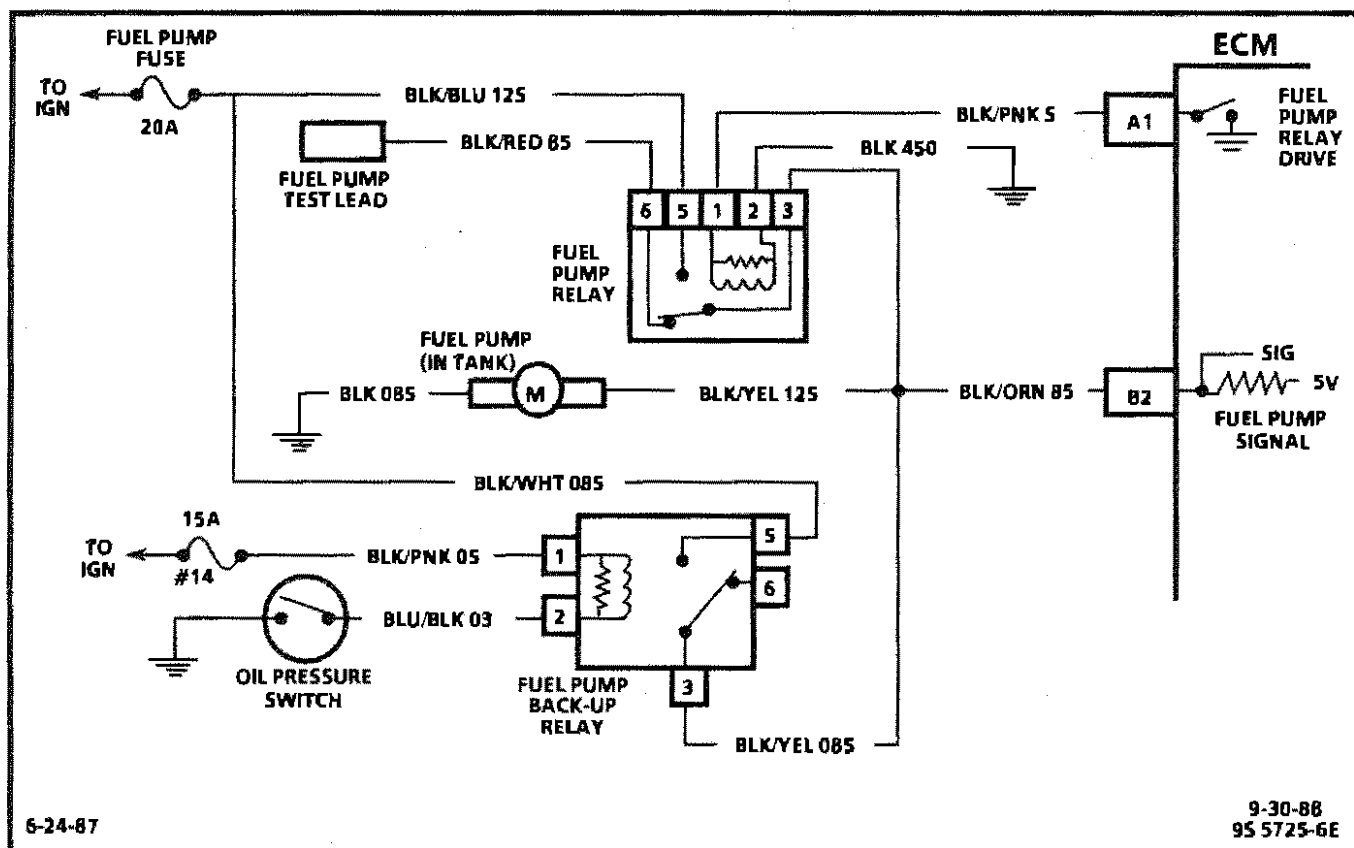
FAULTY  
ECM

NOT OK

FAULTY  
INJECTOR  
AND ECM

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
9S 5724-6E



## CHART A-7

(Page 1 of 2)

### FUEL SYSTEM DIAGNOSIS 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

When the ignition switch is turned "ON," the electronic control module (ECM) will turn "ON" the in-tank fuel pump. It will remain "ON" as long as the engine is cranking or running, and the ECM is receiving ignition reference pulses.

If there are no reference pulses, the ECM will shut "OFF" the fuel pump within 2 seconds after key "ON."

The pump will deliver fuel to the TBI unit, where the system pressure is controlled to 62 to 90 kPa (9 to 13 psi). Excess fuel is then returned to the fuel tank.

The fuel pump test terminal is located in the left side of the engine compartment. When the engine is stopped, the pump can be turned "ON" by applying battery voltage to the test terminal.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Fuel pressure should be noted while fuel pump is running. Fuel pressure will drop immediately after fuel pump stops running due to a controlled bleed in the fuel system.

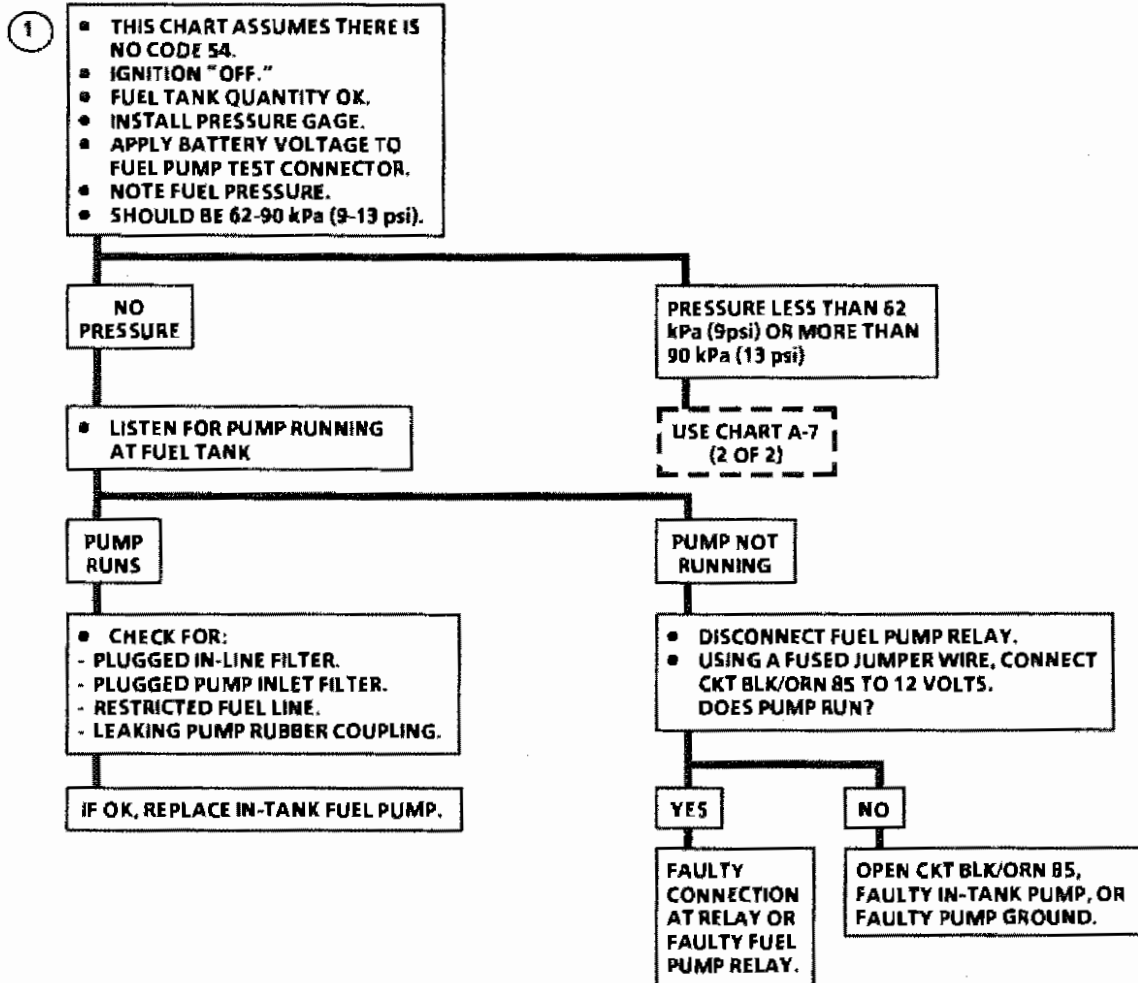
#### Diagnostic Aids:

Improper fuel system pressure can result in one of the following symptoms:

- Cranks, but won't run.
- Code 44.
- Code 45.
- Cuts out, may feel like ignition problem.
- Poor fuel economy, loss of power.
- Hesitation.

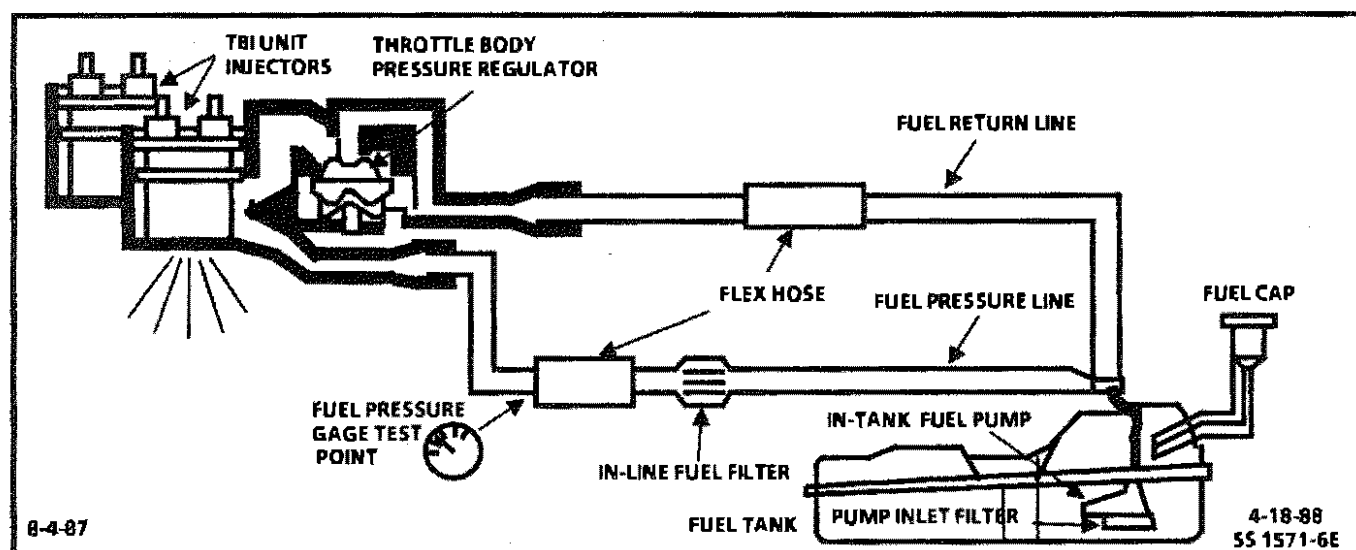
**CHART A-7**

(Page 1 of 2)  
**FUEL SYSTEM DIAGNOSIS**  
 2.8L (VIN R) "KT" (TBI)



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-27-88  
 95 5726-6E



## CHART A-7

(Page 2 of 2)

### FUEL SYSTEM DIAGNOSIS 2.8L (VIN R) "KT" (TBI)

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

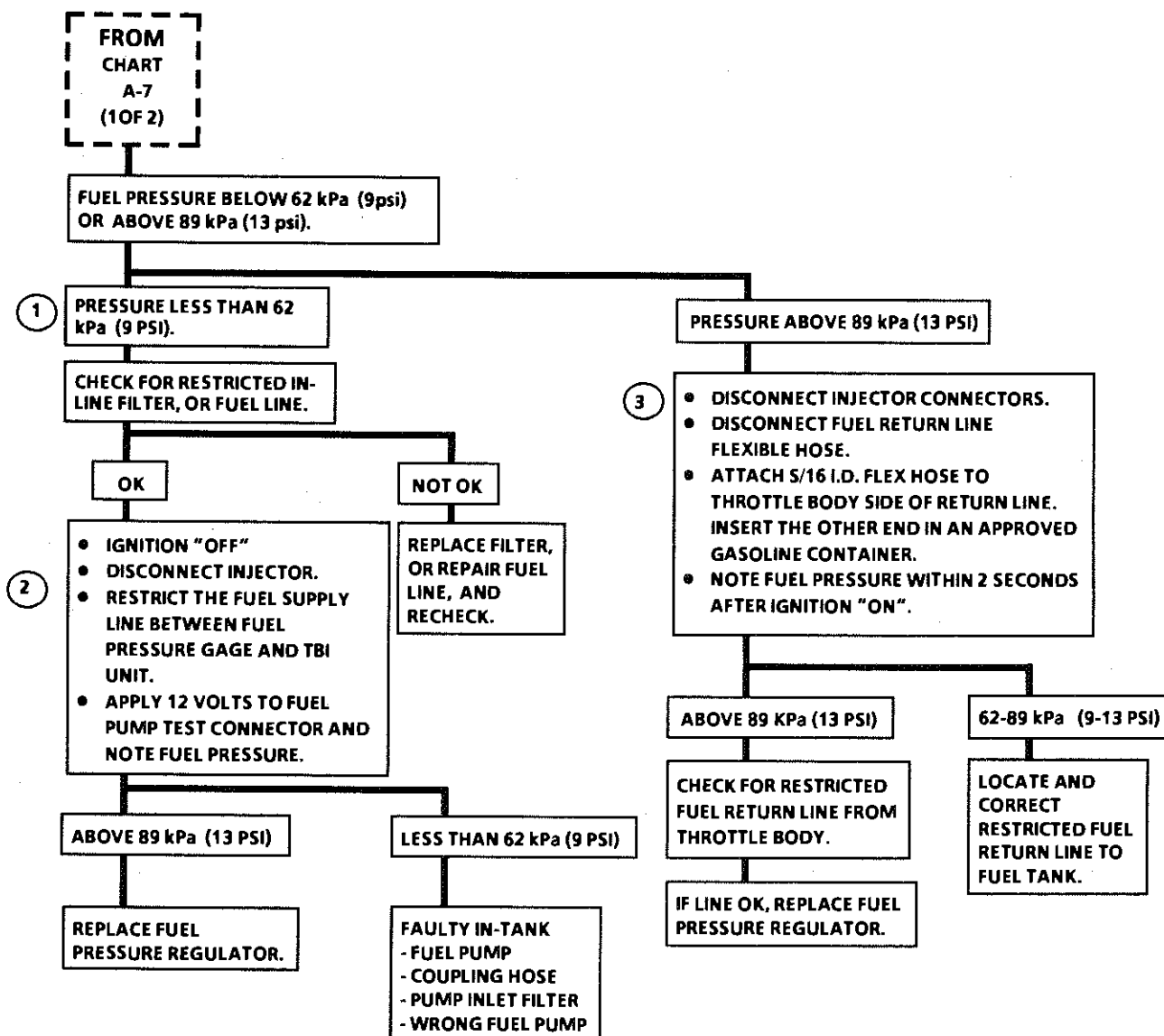
1. Pressure than 62 kPa (9 psi) falls into two areas:

- Regulated pressure than 62 kPa (9 psi). Amount of fuel to injectors OK but pressure is too low. System will be lean and may set Code 44. Also, hard starting cold and poor overall performance.
- Restricted flow causing pressure drop. Normally, a vehicle with a fuel pressure of less than 62 kPa (9 psi) at idle will not be driveable. However, if the pressure drop occurs only while driving, the engine will normally surge then stop as pressure begins to drop rapidly.

2. Restricting the fuel return line allows the fuel pump to develop its maximum pressure (dead head pressure). When battery voltage is applied to the pump test terminal, pressure should be from 90 to 124 kPa (13 to 18 psi).
3. This test determines if the high fuel pressure is due to a restricted fuel return line or a throttle body pressure regulator problem.

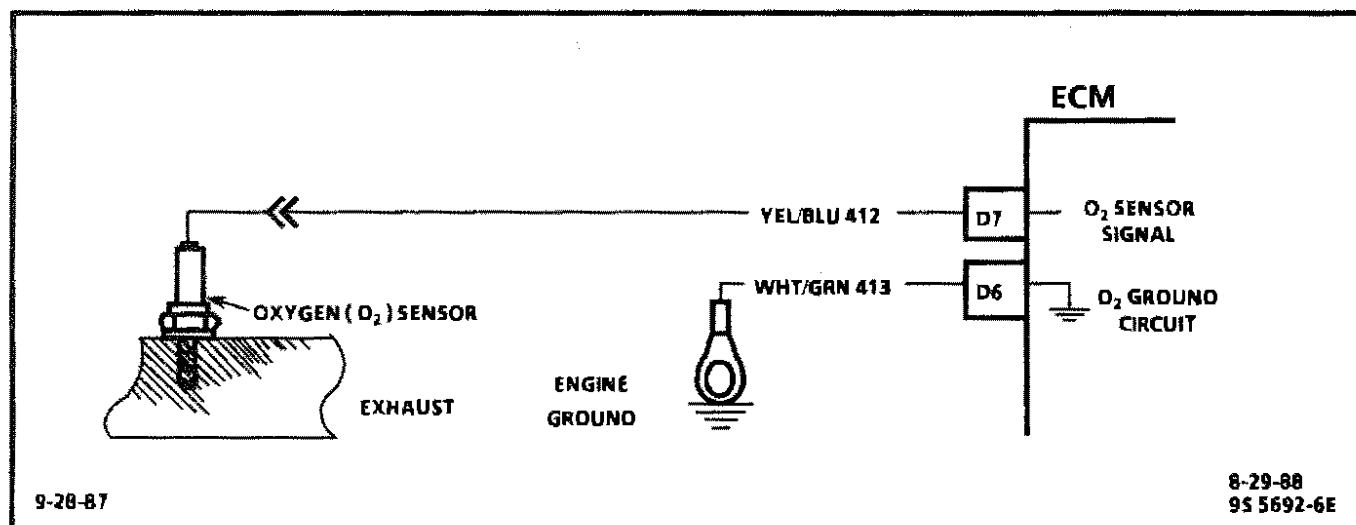
**CHART A-7**

(Page 2 of 2)  
**FUEL SYSTEM DIAGNOSIS**  
 2.8L (VIN R) "KT" (TBI)



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
 95 6029-6E



## CODE 13

### OXYGEN SENSOR CIRCUIT (OPEN CIRCUIT) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM supplies a voltage of about .45 volt between terminals "D7" and "D6". (If measured with a 10 megohm digital voltmeter, this may read as low as .32 volt). The O<sub>2</sub> sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about .10 volt if exhaust is lean.

The sensor is like an open circuit and produces no voltage when it is below 315°C (600°F). An open sensor circuit or cold sensor causes "Open Loop" operation.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Code 13 will set:
  - Engine at normal operating temperature.
  - At least 2 minutes engine time after start.
  - O<sub>2</sub> signal voltage steady between .35 and .55 volt.
  - rpm above 1600.
  - Throttle position sensor signal above 5% (about .3 volt above closed throttle voltage).
  - All conditions must be met for about 60 seconds.

If the conditions for a Code 13 exist, the system will not go "Closed Loop."
2. This will determine if the sensor is at fault or the wiring or ECM is the cause of the Code 13.

3. In doing this test, use only a high impedance digital volt ohmmeter. This test checks the continuity of CKT(s) 412 and 413. If CKT 413 is open, the ECM voltage on CKT 412 will be over .6 volt (600 mV).

#### Diagnostic Aids:

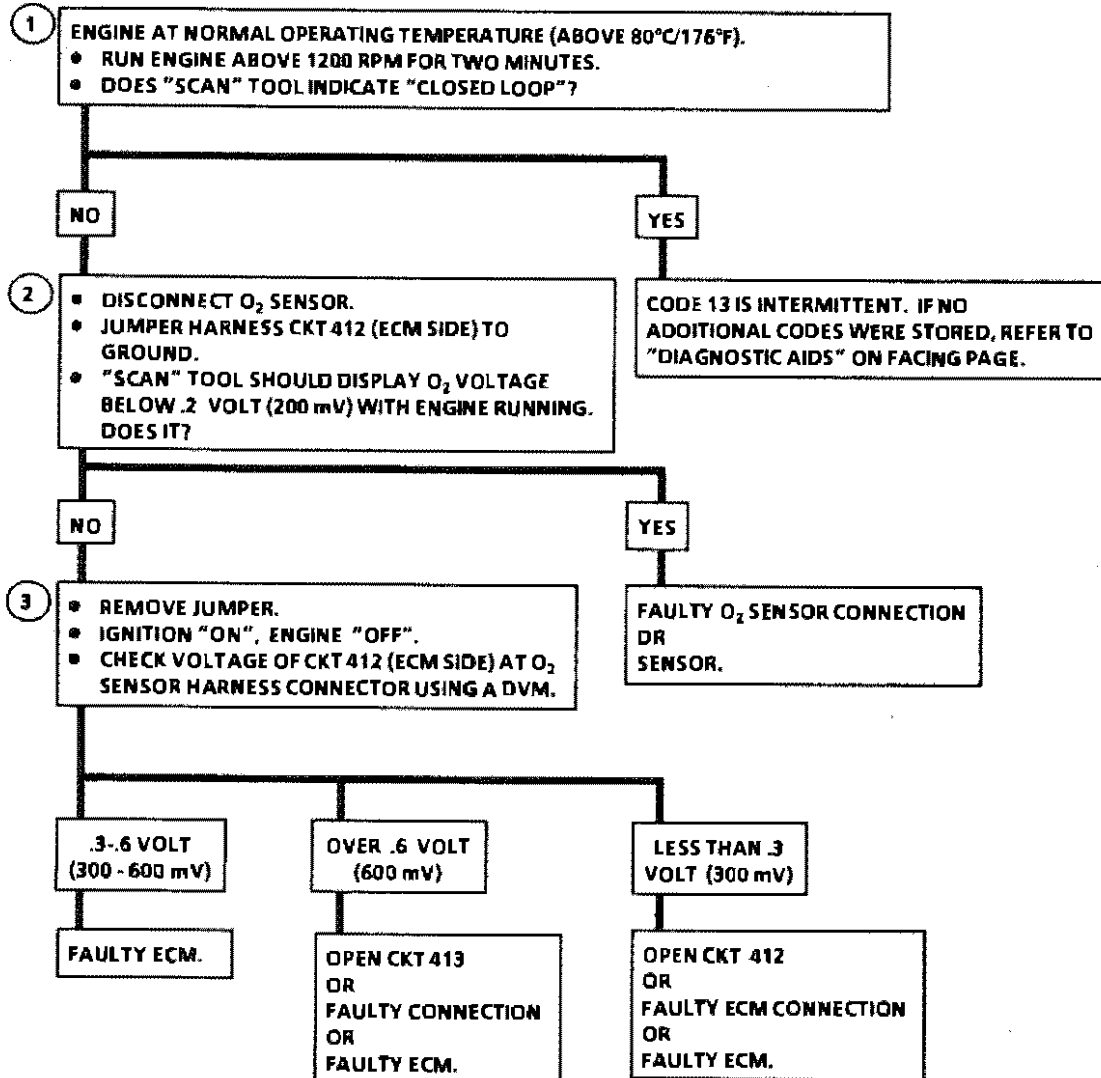
Normal "Scan" voltage varies between 100 mv to 999 mV (.1 and 1.0 volt), while in "Closed Loop." Code 13 sets in one minute, if voltage remains between .35 and .55 volt, but the system will go "Open Loop" in about 15 seconds.

Refer to "Intermittents" in Section "B".

# CODE 13

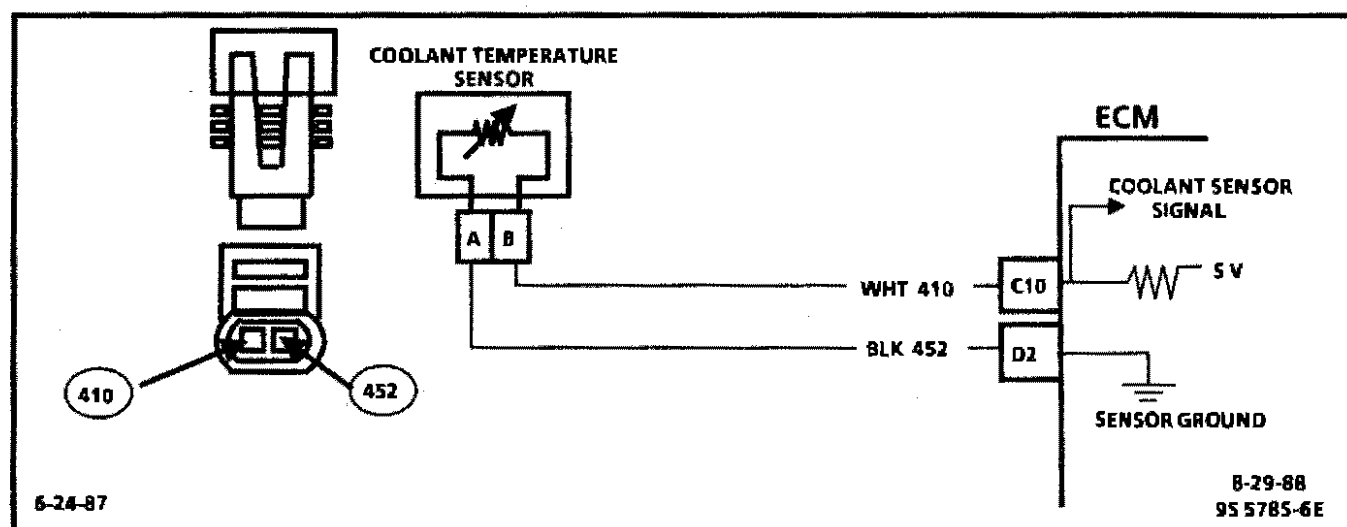
## OXYGEN SENSOR CIRCUIT (OPEN CIRCUIT)

### 2.8L (VIN R) "KT" (TBI)



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 5997-6E



## CODE 14

### COOLANT TEMPERATURE SENSOR CIRCUIT (HIGH TEMPERATURE INDICATED) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The coolant temperature sensor uses a thermistor to control the signal voltage to the ECM. The ECM applies a voltage on CKT 410 to the sensor. When the engine is cold the sensor (thermistor) resistance is high, therefore the ECM will see high signal voltage.

As the engine warms, the sensor resistance becomes less, and the voltage drops. At normal engine operating temperature (85°C to 95°C) the voltage will measure about 1.5 to 2.0 volts.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

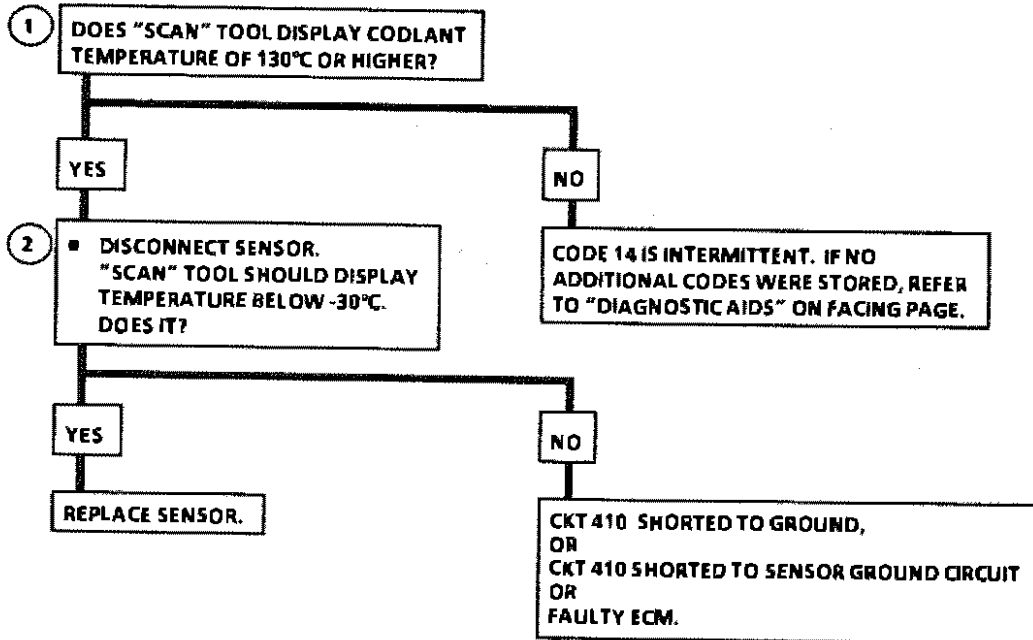
- Code 14 will set if:
  - Signal voltage indicates a coolant temperature above 135°C (275°F) for 2 seconds.
- This test will determine if CKT 410 is shorted to ground which will cause the conditions for Code 14.

#### Diagnostic Aids:

Check harness routing for a potential short to ground in CKT 410.

"Scan" tool displays engine temp. in degrees centigrade. After engine is started, the temperature should rise steadily to about 90°C then stabilize when thermostat opens.

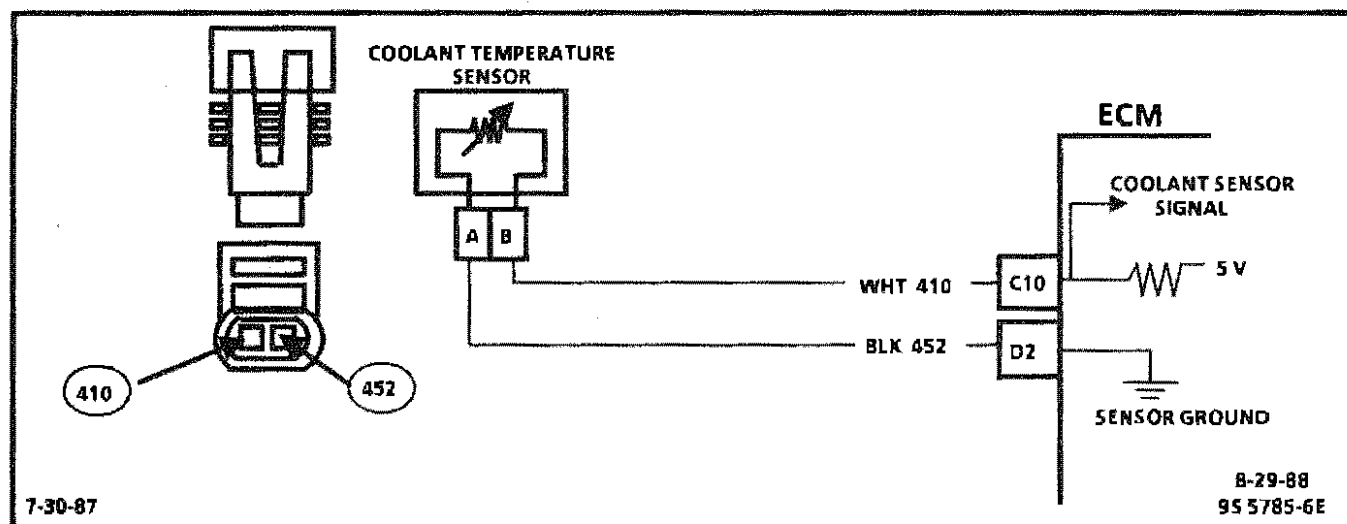
Refer to "Intermittents" in Section "B".

**CODE 14****COOLANT TEMPERATURE SENSOR CIRCUIT  
(HIGH TEMPERATURE INDICATED)  
2.8L (VIN R) "KT" (TBI)****DIAGNOSTIC AID**

| COOLANT SENSOR                                     |     |         |
|----------------------------------------------------|-----|---------|
| TEMPERATURE VS. RESISTANCE VALUES<br>(APPROXIMATE) |     |         |
| °F                                                 | °C  | OHMS    |
| 210                                                | 100 | 185     |
| 160                                                | 70  | 450     |
| 100                                                | 38  | 1,800   |
| 70                                                 | 20  | 3,400   |
| 40                                                 | 4   | 7,500   |
| 20                                                 | -7  | 13,500  |
| 0                                                  | -18 | 25,000  |
| -40                                                | -40 | 100,700 |

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 5999-6E



## CODE 15

### COOLANT TEMPERATURE SENSOR CIRCUIT (LOW TEMPERATURE INDICATED) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The coolant temperature sensor uses a thermistor to control the signal voltage to the ECM. The ECM applies a voltage on CKT 410 to the sensor. When the engine is cold the sensor (thermistor) resistance is high, therefore the ECM will see high signal voltage.

As the engine warms, the sensor resistance becomes less, and the voltage drops. At normal engine operating temperature (85°C to 95°C) the voltage will measure about 1.5 to 2.0 volts at the ECM.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

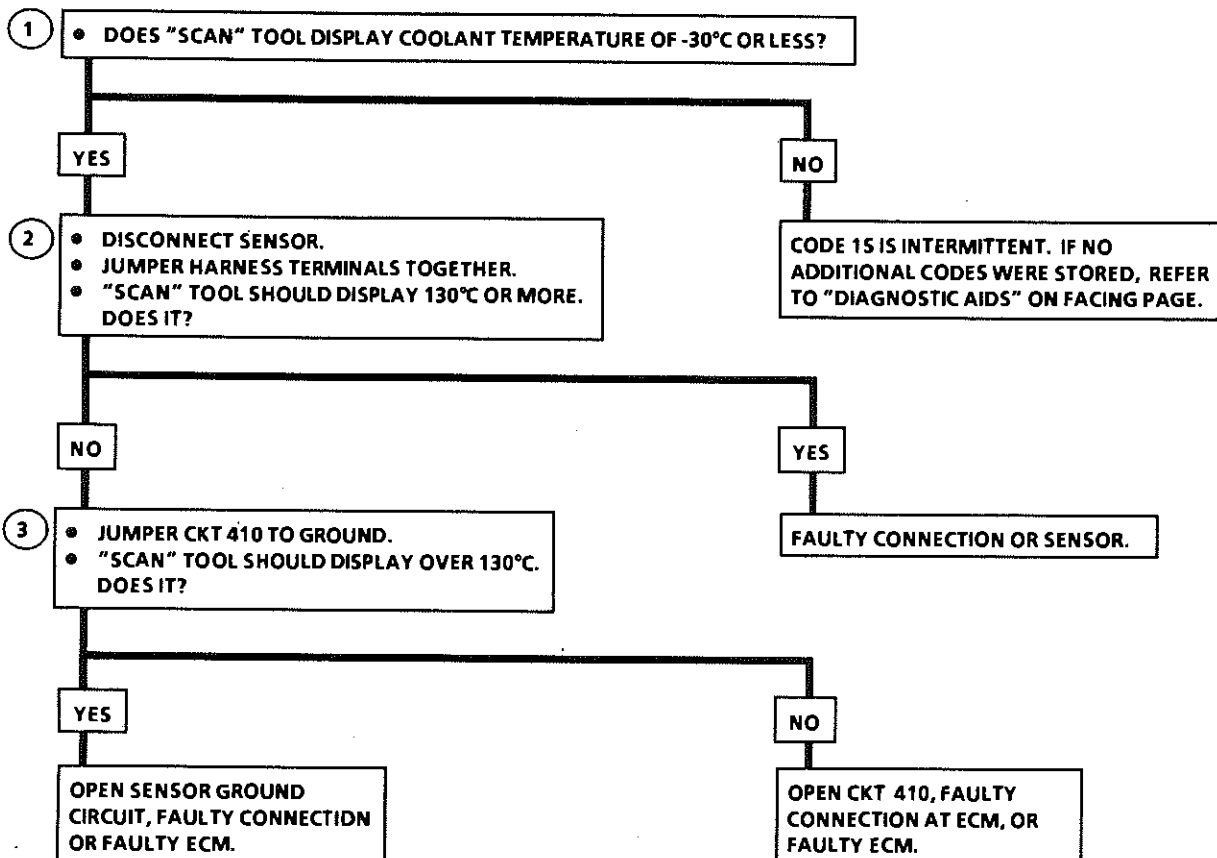
- Code 15 will set if:
  - Engine running longer than 30 seconds.
  - Coolant temp. less than -30°C (-22°F), for 3 seconds.
- This test simulates a Code 14. If the ECM recognizes the low signal voltage, (high temperature) and "Scan" reads 130°C or above, the ECM and wiring are OK.
- This test will determine if CKT 410 is open. There should be 5 volts present at sensor connector if measured with a DVM.

#### Diagnostic Aids:

A "Scan" tool reads engine temperature in degrees centigrade. After engine is started the temperature should rise steadily to about 90°C then stabilize when thermostat opens.

If Code 21 is also set, check CKT 452 for faulty wiring or connections. Check terminals at sensor for good contact.

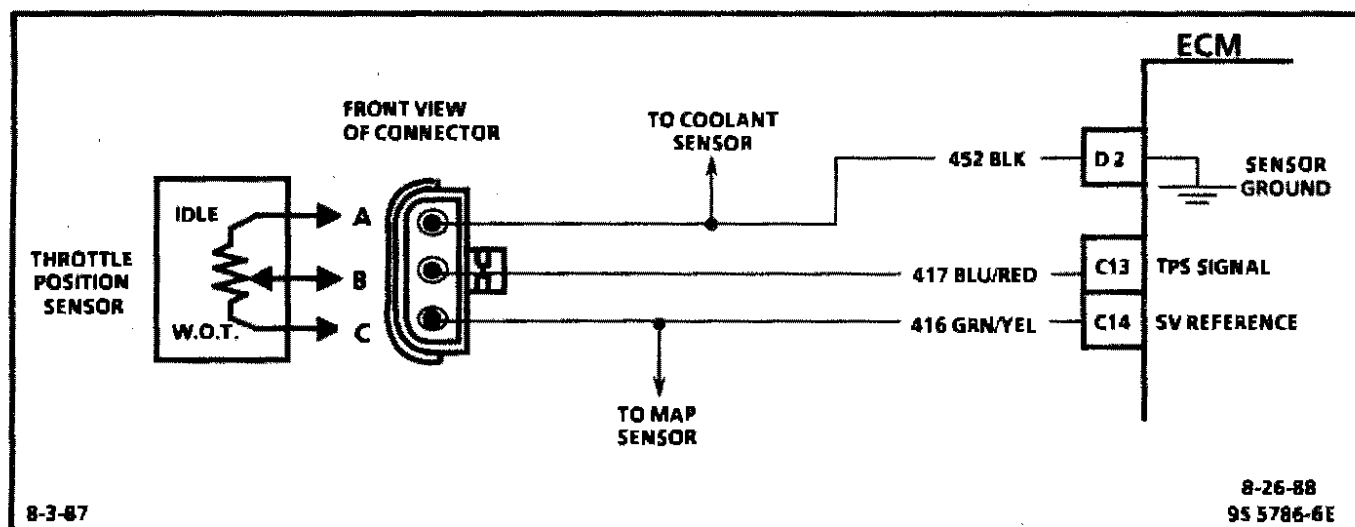
Refer to "Intermittents" in Section "B".

**CODE 15****COOLANT TEMPERATURE SENSOR CIRCUIT  
(LOW TEMPERATURE INDICATED)  
2.8L (VIN R) "KT" (TBI)****DIAGNOSTIC AID**

| COOLANT SENSOR                                    |     |         |
|---------------------------------------------------|-----|---------|
| TEMPERATURE TO RESISTANCE VALUES<br>(APPROXIMATE) |     |         |
| °F                                                | °C  | OHMS    |
| 210                                               | 100 | 185     |
| 160                                               | 70  | 450     |
| 100                                               | 38  | 1,800   |
| 70                                                | 20  | 3,400   |
| 40                                                | 4   | 7,500   |
| 20                                                | -7  | 13,500  |
| 0                                                 | -18 | 25,000  |
| -40                                               | -40 | 100,700 |

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
9S 6026-6E



## CODE 21

### THROTTLE POSITION SENSOR (TPS) CIRCUIT (SIGNAL VOLTAGE HIGH) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The throttle position sensor (TPS) provides a voltage signal that changes relative to the throttle blade. Signal voltage will vary from about .5 at idle to about 5 volts at wide open throttle.

The TPS signal is one of the most important inputs used by the ECM for fuel control and for most of the ECM control outputs.

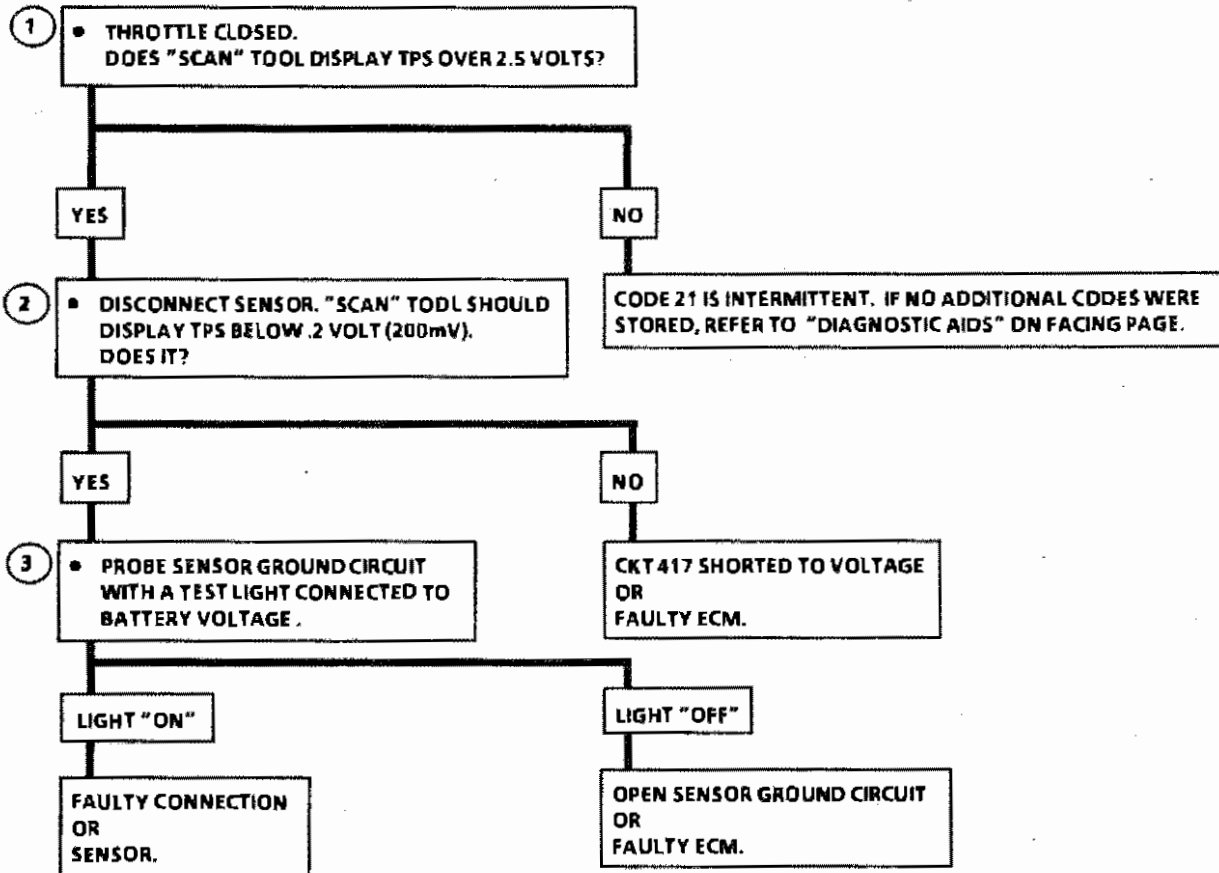
**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 21 will set if:
  - TPS signal voltage is greater than 2.5 volts.
  - All conditions met for 8 seconds.
  - MAP less than 52 kPa.
- With the TPS sensor disconnected, the TPS voltage should go low if the ECM and wiring are OK.
- Probing CKT 452 with a test light to 12 volts checks the sensor ground CKT. A faulty sensor ground will cause a Code 21.

#### Diagnostic Aids:

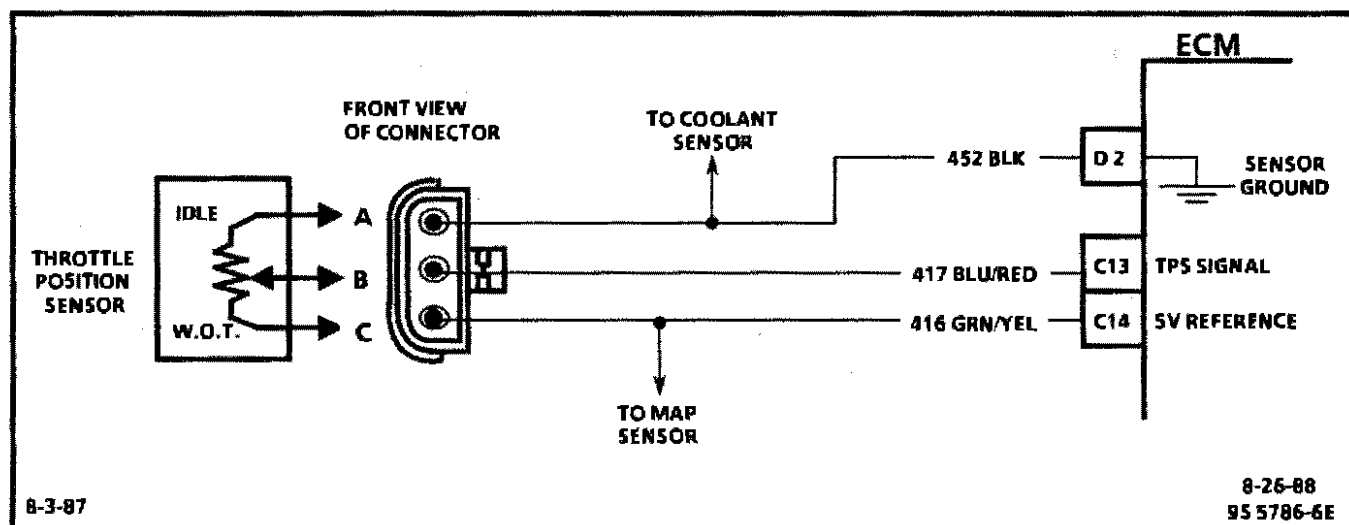
A "Scan" tool reads throttle position in volts. Should read less than 1.25 volts with throttle closed and ignition "ON" or at idle. Voltage should increase at a steady rate as throttle is moved toward WOT.

An open in CKT 452 will result in a Code 21. Refer to "Intermittents" in Section "B".

**CODE 21****THROTTLE POSITION SENSOR (TPS) CIRCUIT  
(SIGNAL VOLTAGE HIGH)  
2.8L (VIN R) "KT" (TBI)**

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 6000-6E



## CODE 22

### THROTTLE POSITION SENSOR (TPS) CIRCUIT (SIGNAL VOLTAGE LOW) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The throttle position sensor (TPS) provides a voltage signal that changes relative to the throttle blade. Signal voltage will vary from about .5 at idle to about 5 volts at wide open throttle.

The TPS signal is one of the most important inputs used by the ECM for fuel control and for most of the ECM control outputs.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 22 will set if:
  - Engine is running
  - TPS signal voltage is less than about .2 volt for 2 seconds.
- Simulates Code 21: (high voltage) If the ECM recognizes the high signal voltage then the ECM and wiring are OK.
- This simulates a high signal voltage to check for an open in CKT 417. The "Scan" tool will not read up to 12 volts, but what is important is that the ECM recognizes the signal on CKT 417.
- There should be 5 volts at terminal "C" if measured with a DVM when ignition is "ON."

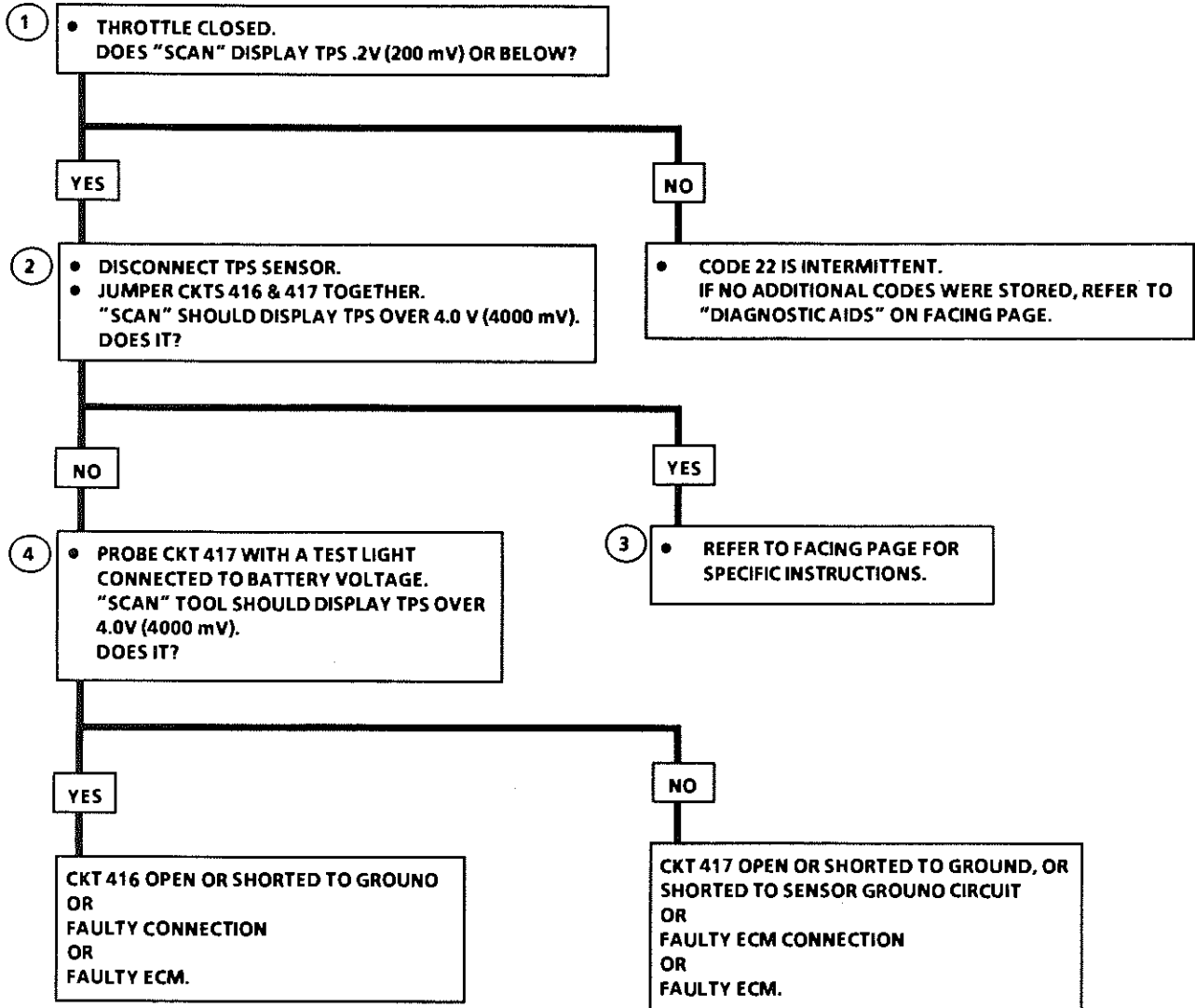
#### Diagnostic Aids:

A "Scan" tool reads throttle position in volts. Should read less than 1.25 volts with throttle closed and ignition "ON" or at idle. Voltage should increase at a steady rate as throttle is moved toward WOT.

An open or short to ground in CKTs 416 or 417 will result in a Code 22.

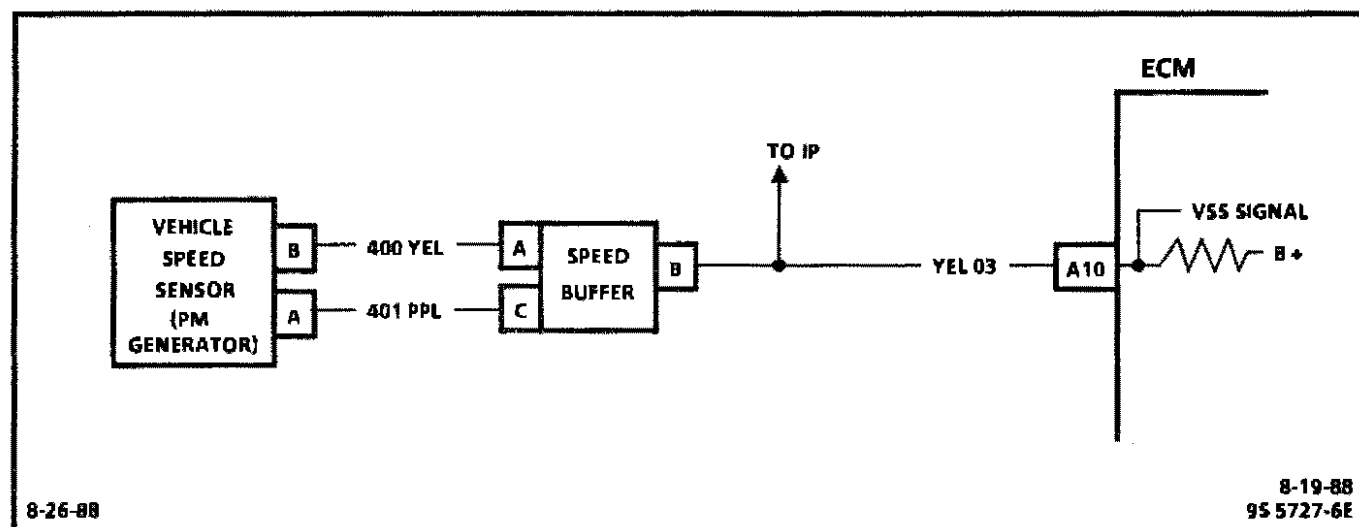
If a Code 22 is also set check CKT 416 carefully for open or short to ground.

Refer to "Intermittents" in Section "B".

**CODE 22****THROTTLE POSITION SENSOR (TPS) CIRCUIT  
(SIGNAL VOLTAGE LOW)  
2.8L (VIN R) "KT" (TBI)**

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-29-88  
95 6030-6E



## CODE 24

### VEHICLE SPEED SENSOR (VSS) CIRCUIT 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM applies and monitors 12 volts on CKT yellow 03. CKT yellow 03 connects to the vehicle speed sensor which alternately grounds CKT yellow 03 when drive wheels are turning. This pulsing action takes place about 2000 times per mile and the ECM will calculate vehicle speed based on the time between "pulses."

"Scan" reading should closely match with speedometer reading with drive wheels turning. Disregard a Code 24 set when drive wheels are not turning.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 24 will set if vehicle speed equals 0 mph when:
  - Engine speed is between 1200 and 4400 rpm
  - TPS is less than 2% (closed throttle)
  - Low load condition (high vacuum). Less than 25 kPa.
  - All conditions met for 5 seconds.

These conditions are met during a road load deceleration. Disregard Code 24 that sets when drive wheels are not turning.

- 8-12 volts, at the I/P connector, indicates CKT yellow 03 is open between the I/P connector and the VSS, or there is a faulty vehicle speed sensor. A voltage of less than 1 volt, at the I/P connector, indicates that CKT yellow 03 wire is shorted to ground. If, after disconnecting CKT yellow 03 at the vehicle speed sensor, the voltage reads above 10 volts, the vehicle speed sensor is faulty. If voltage remains less than 8 volts, then CKT yellow 03 wire is grounded. If yellow 03 is not grounded, there is a faulty connection at the ECM, or a faulty ECM.

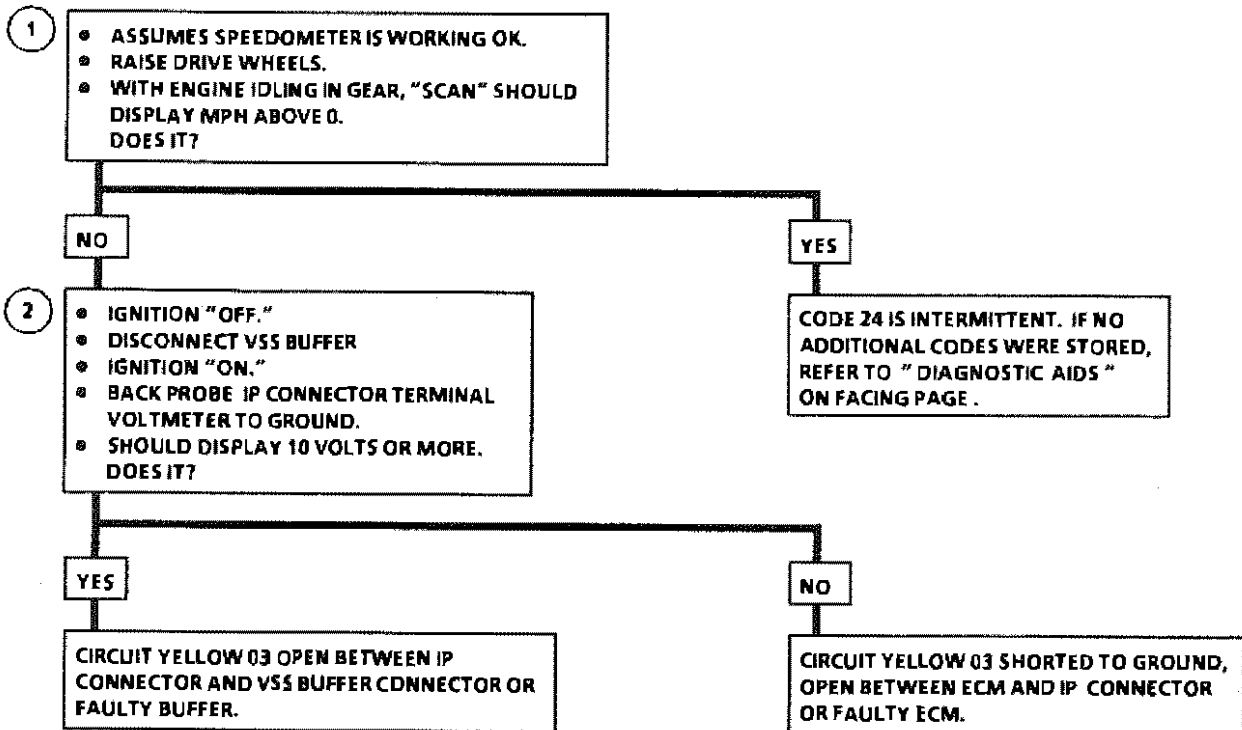
#### Diagnostic Aids:

"Scan" should indicate a vehicle speed whenever the drive wheels are turning.

If all OK, refer to "Intermittents" in Section "B".

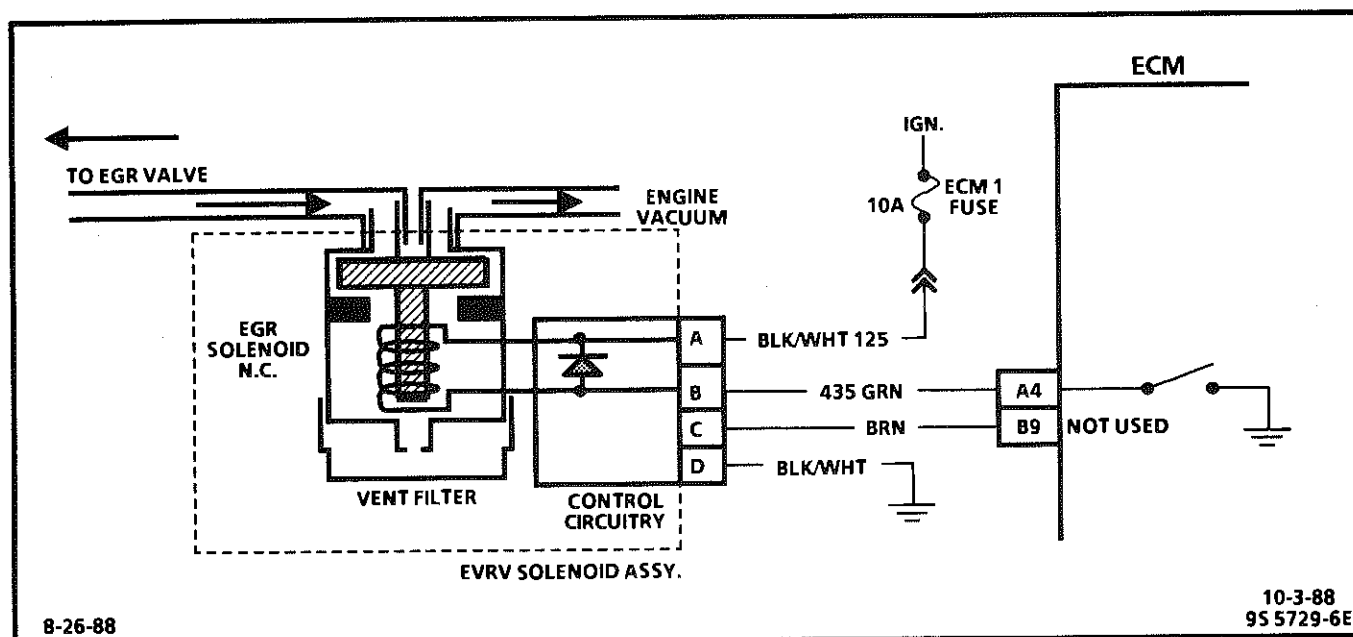
**CODE 24****VEHICLE SPEED SENSOR (VSS) CIRCUIT  
2.8L (VIN R) "KT" (TBI)**

**NOTE:** DISREGARD CODE 24 IF SET WHEN DRIVE WHEELS ARE NOT TURNING.



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

11-21-88  
95 5728-6E



## CODE 32

### EGR SYSTEM FAILURE 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM operates a solenoid to control the exhaust gas recirculation (EGR) valve. This solenoid is normally closed. By providing a ground path, the ECM energizes the solenoid which then allows vacuum to pass to the EGR valve.

The ECM monitors EGR effectiveness by de-energizing the EGR control solenoid thereby shutting "OFF" vacuum to the EGR valve diaphragm. With the EGR valve closed, fuel integrator counts will be greater than they were during normal EGR operation. If the change is not within the calibrated window, a Code 32 will be set.

The ECM will check EGR operation when:

- Vehicle speed is above 50 mph.
- Engine vacuum is between 40 and 51 kPa.
- No change in throttle position while test is being run.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. With the ignition "ON," engine stopped, the solenoid should not be energized and vacuum should not pass to the EGR valve. Grounding the diagnostic terminal will energize the solenoid and allow vacuum to pass to valve.
2. Checks for plugged EGR passages. If passages are plugged, the engine may have severe detonation on acceleration.
3. The vehicle must be driven during this test in order to produce sufficient engine load to operate the EGR. Lightly accelerating (approximately 1/4 throttle) will produce a large and stable enough reading to determine if the ECM is commanding the system "ON."

#### Diagnostic Aids:

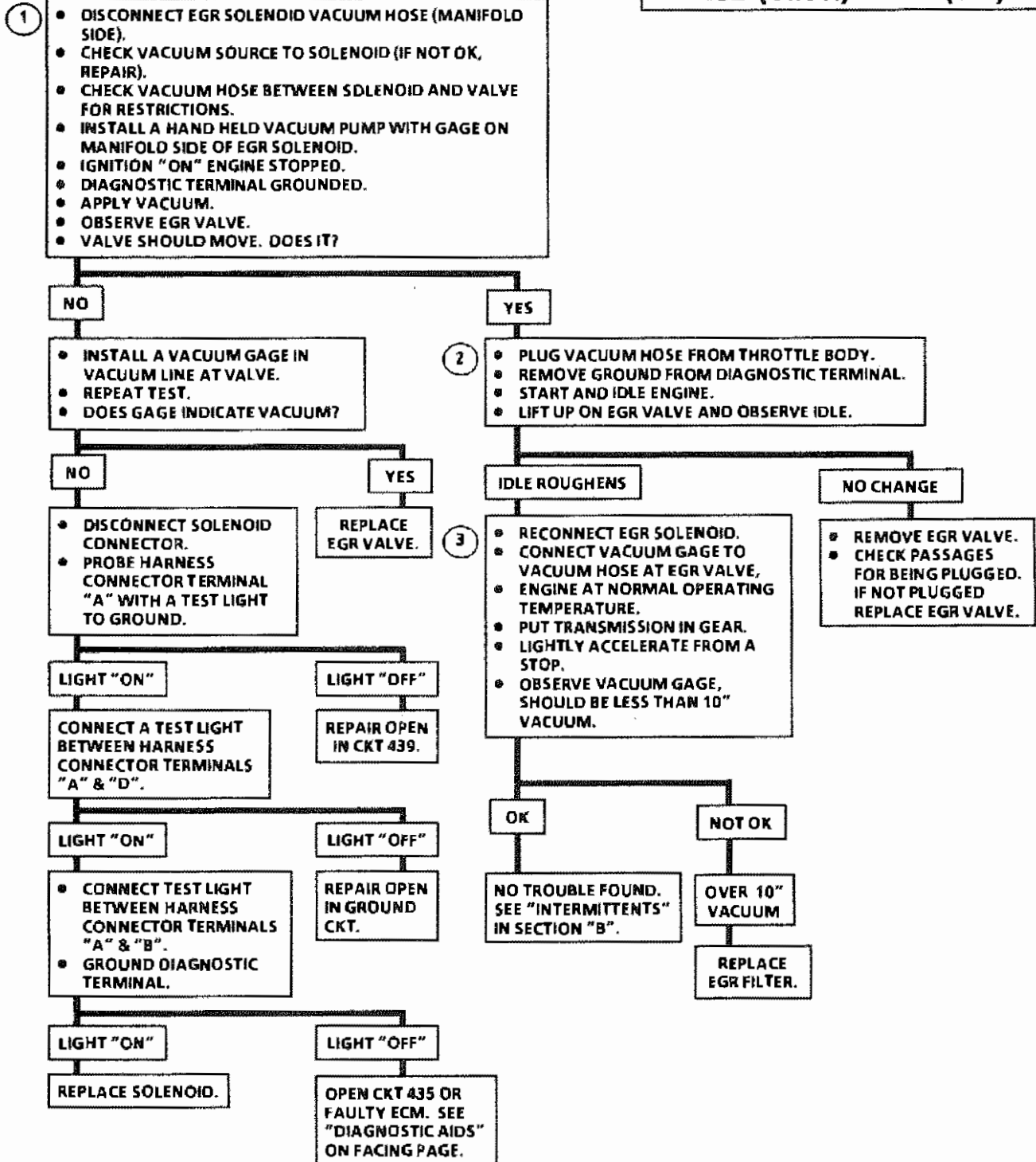
- Before replacing ECM, use an ohmmeter and check the resistance of each ECM controlled relay and solenoid coil.  
See ECM wiring diagram for coil terminal identification of solenoid(s) and relay(s) to be checked.  
Replace any solenoid where resistance measures less than 20 ohms.

# CODE 32

## EGR SYSTEM FAILURE

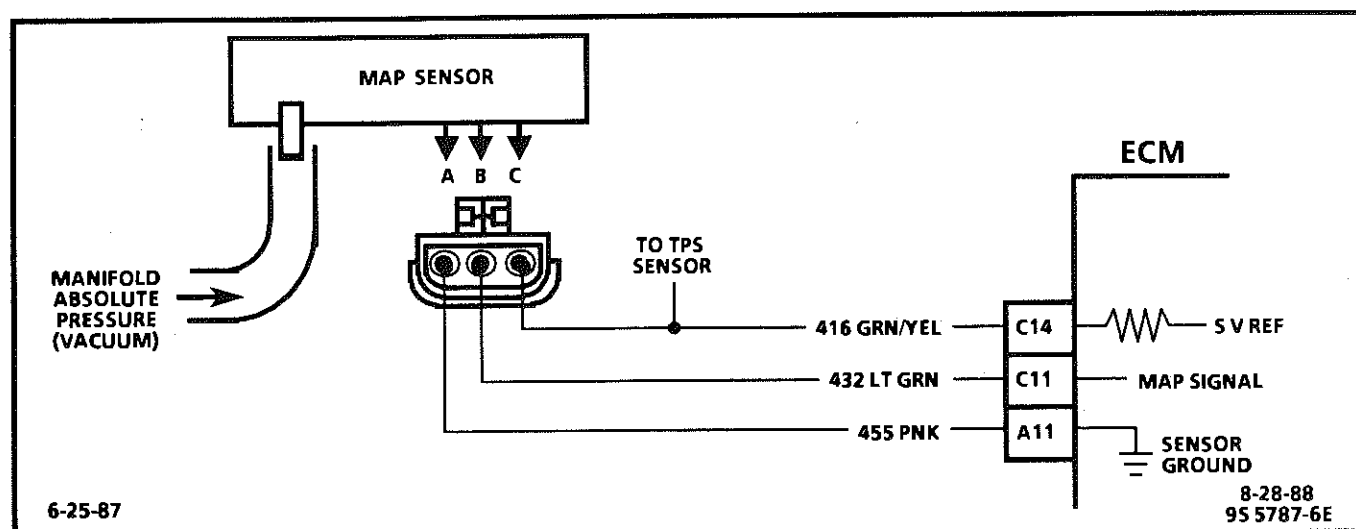
### 2.8L (VIN R) "KT" (TBI)

IF ANY OTHER CODES ARE STORED, DIAGNOSE THEM FIRST.  
IF VEHICLE EXHIBITS A ROUGH OR INCORRECT IDLE, REPAIR  
IDLE COMPLAINT FIRST. SEE SECTION "B".



CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 5619-6E



## CODE 33

### MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT (SIGNAL VOLTAGE HIGH - LOW VACUUM) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The manifold absolute pressure sensor (MAP) responds to changes in manifold pressure (vacuum). The ECM receives this information as a signal voltage that will vary from about 1-1.5 volts at idle to 4-4.5 volts at wide open throttle.

A "Scan" displays manifold pressure in volts. Low pressure (high vacuum) reads a low voltage while a high pressure (low vacuum) reads a high voltage.

If the MAP sensor fails the ECM will substitute a fixed MAP value and use the throttle position sensor (TPS) to control fuel delivery.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 33 will set when:
  - Signal is too high, (kPa greater than 68 kPa), for a time greater than 5 seconds.
  - TPS less than 4%.
 Engine misfire or a low unstable idle may set Code 33. Disconnect MAP sensor and system will go into backup mode. If the misfire or idle condition remains, see "Symptoms" in Section "B".
- If the ECM recognizes the low MAP signal, the ECM and wiring are OK.

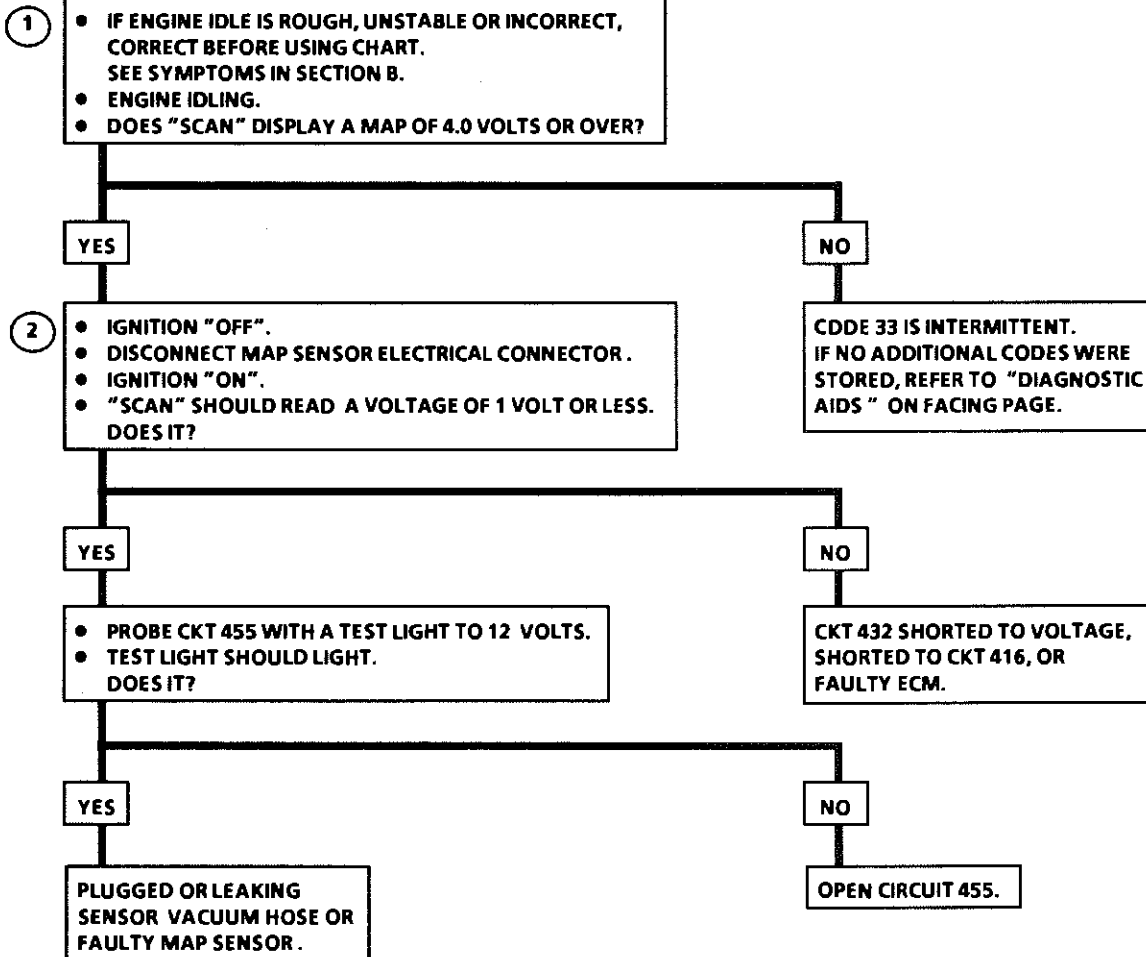
#### Diagnostic Aids:

If idle is rough or unstable refer to "Symptoms" in Section "B" for items which can cause an unstable idle.

An open in CKT 455 or the connection will result in a Code 33.

With the ignition "ON" and the engine stopped, the manifold pressure is equal to atmospheric pressure and the signal voltage will be high. This information is used by the ECM as an indication of vehicle altitude and is referred to as BARO. Comparison of this BARO reading with a known good vehicle with the same sensor is a good way to check accuracy of a "suspect" sensor. Reading should be the same  $\pm .4$  volt.

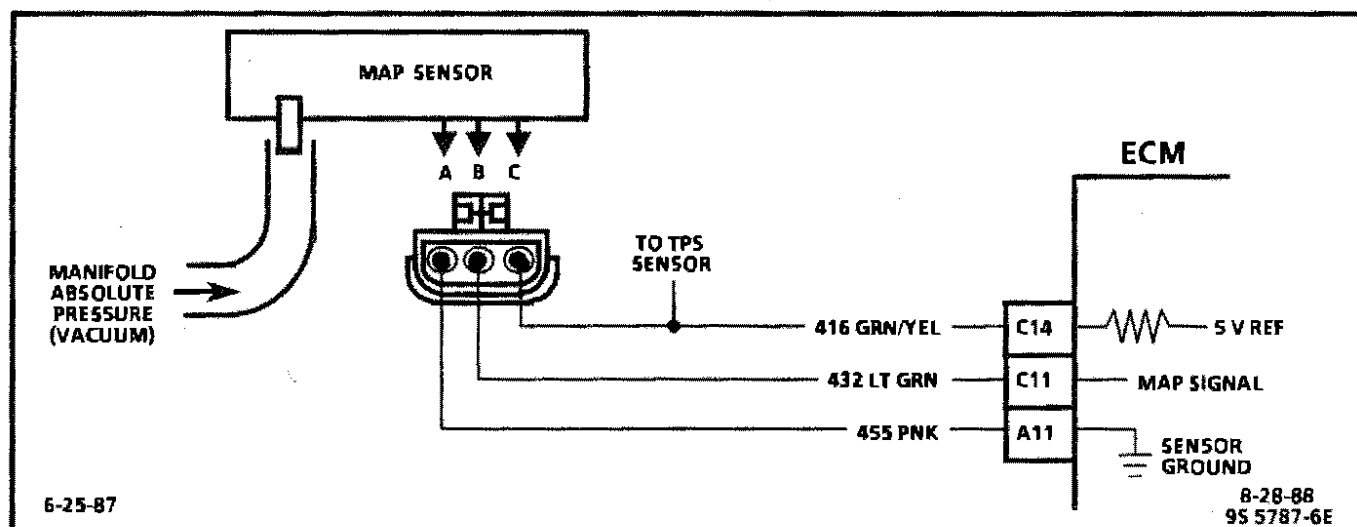
Refer to "Intermittents" in Section "B".

**CODE 33****MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT  
(SIGNAL VOLTAGE HIGH - LOW VACUUM)  
2.8L (VIN R) "KT" (TBI)****IGNITION "ON" ENGINE STOPPED VOLTAGES**

| ALTITUDE   |               | VOLTAGE RANGE |
|------------|---------------|---------------|
| Meters     | Feet          |               |
| Below 305  | Below 1,000   | 3.8---5.5V    |
| 305---610  | 1,000--2,000  | 3.6---5.3V    |
| 610---914  | 2,000--3,000  | 3.5---5.1V    |
| 914--1219  | 3,000--4,000  | 3.3---5.0V    |
| 1219--1524 | 4,000--5,000  | 3.2---4.8V    |
| 1524--1829 | 5,000--6,000  | 3.0---4.6V    |
| 1829--2133 | 6,000--7,000  | 2.9---4.5V    |
| 2133--2438 | 7,000--8,000  | 2.8---4.3V    |
| 2438--2743 | 8,000--9,000  | 2.6---4.2V    |
| 2743--3048 | 9,000--10,000 | 2.5---4.0V    |

LOW ALTITUDE = HIGH PRESSURE = HIGH VOLTAGE

75 3796-6E  
7-22-86



## CODE 34

### MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT (SIGNAL VOLTAGE LOW - HIGH VACUUM) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The manifold absolute pressure sensor (MAP) responds to changes in manifold pressure (vacuum). The ECM receives this information as a signal voltage that will vary from about 1-1.5 volts at idle to 4-4.5 volts at wide open throttle.

If the MAP sensor fails the ECM will substitute a fixed MAP value and use the throttle position sensor (TPS) to control fuel delivery.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 34 will set when:
  - Signal is too low (kPa less than 14) and engine running less than 1200 rpm.
  - OR
  - Engine running greater than 1200 rpm.
  - Throttle position greater than 21% (over 1.5 volts).
- If the ECM recognizes the high MAP signal, the ECM and wiring are OK.
- The "Scan" tool may not display 12 volts. The important thing is that the ECM recognizes the voltage as more than 4 volts, indicating that the ECM and CKT 432 are OK.

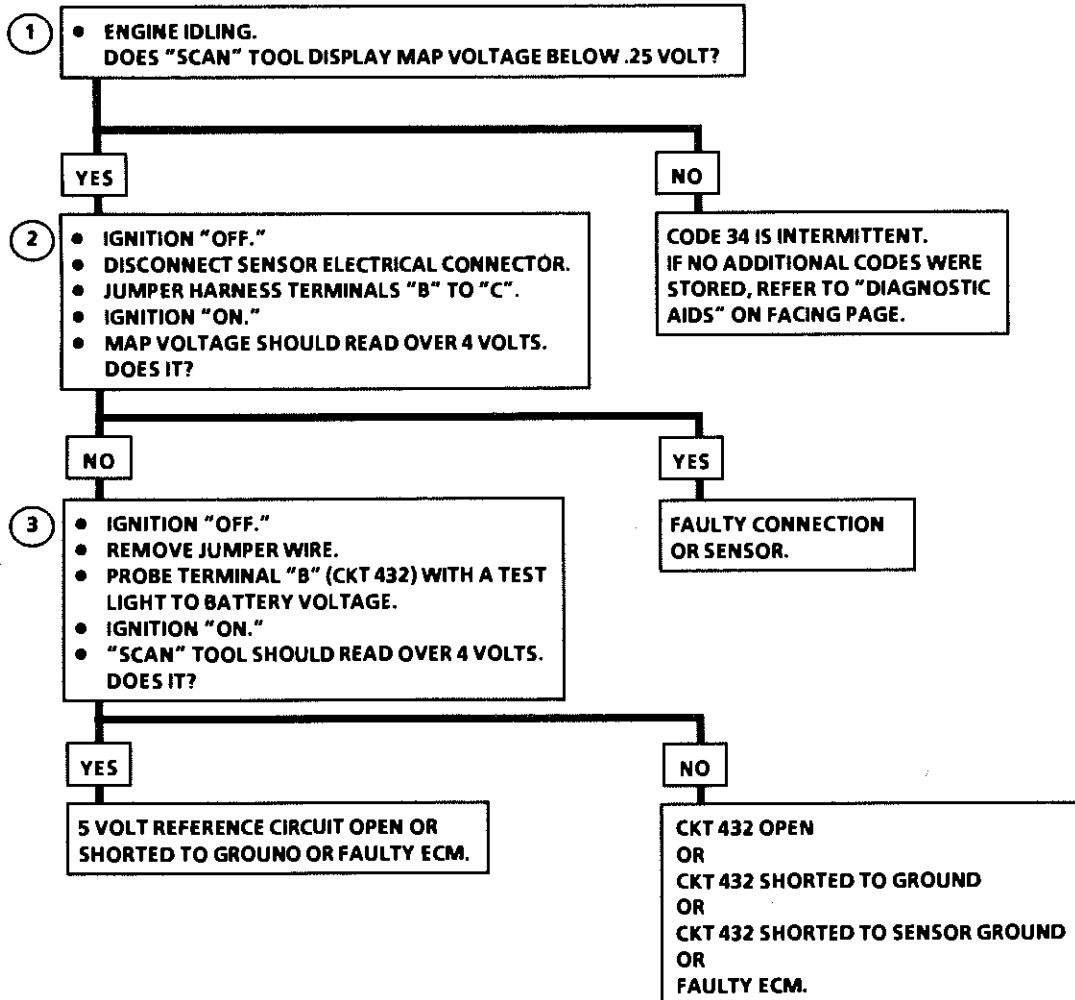
#### Diagnostic Aids:

An intermittent open in CKT's 432 or 416 will result in a Code 34.

With the ignition "ON" and the engine stopped, the manifold pressure is equal to atmospheric pressure and the signal voltage will be high. This information is used by the ECM as an indication of vehicle altitude and is referred to as BARO. Comparison of this BARO reading with a known good vehicle with the same sensor is a good way to check accuracy of a "suspect" sensor. Reading should be the same  $\pm .4$  volt.

Also CHART C-1D can be used to test the MAP sensor.

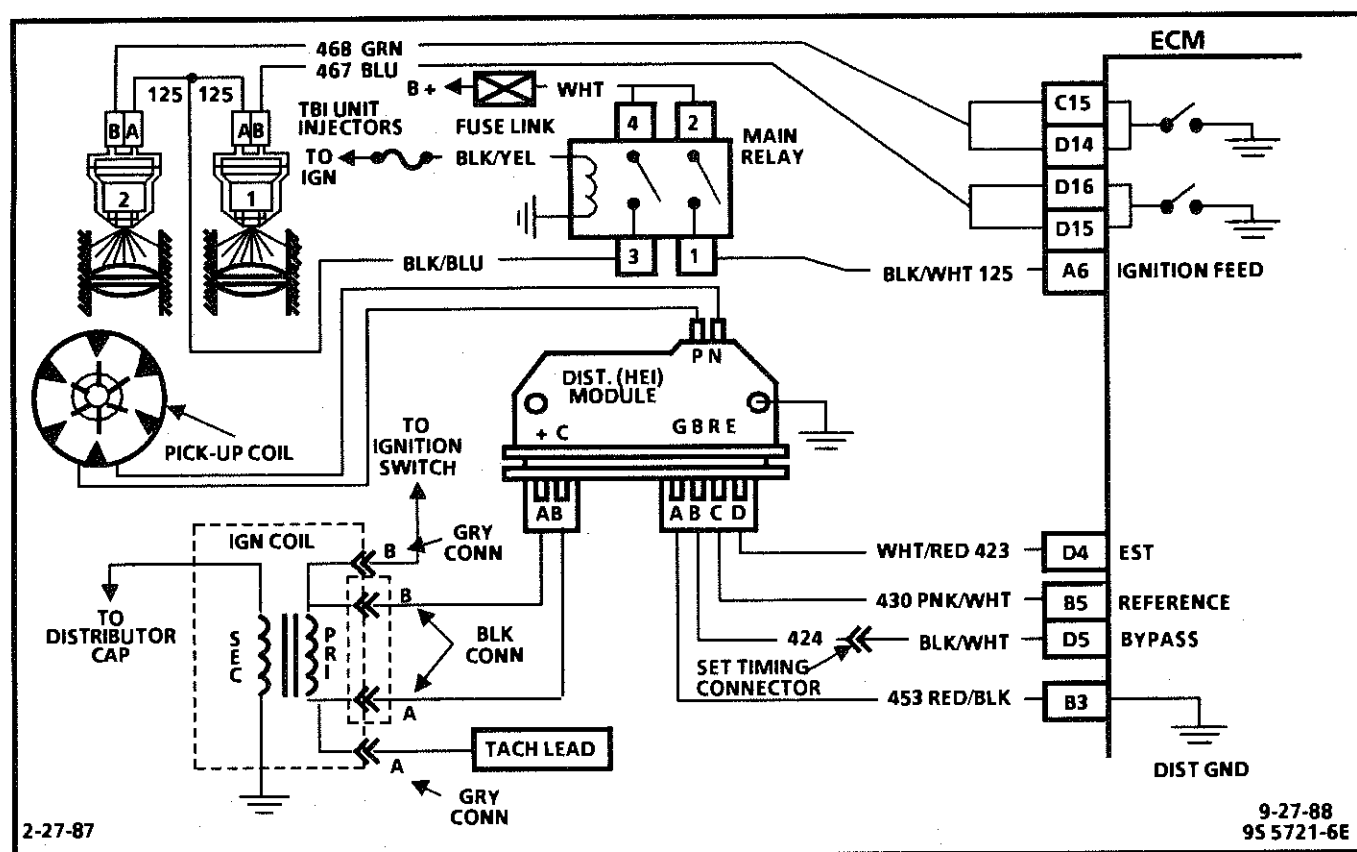
Refer to "Intermittents" in Section "B".

**CODE 34**
**MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT**  
**(SIGNAL VOLTAGE LOW - HIGH VACUUM)**  
**2.8L (VIN R) "KT" (TBI)**

**MAP SENSOR VOLTAGE VS. ALTITUDE WITH  
IGNITION "ON" AND ENGINE "OFF"**

| ALTITUDE   |               | VOLTAGE RANGE |
|------------|---------------|---------------|
| Meters     | Feet          |               |
| Below 305  | Below 1,000   | 3.8---5.5V    |
| 305--- 610 | 1,000--2,000  | 3.6---5.3V    |
| 610--- 914 | 2,000--3,000  | 3.5---5.1V    |
| 914--1219  | 3,000--4,000  | 3.3---5.0V    |
| 1219--1524 | 4,000--5,000  | 3.2---4.8V    |
| 1524--1829 | 5,000--6,000  | 3.0---4.6V    |
| 1829--2133 | 6,000--7,000  | 2.9---4.5V    |
| 2133--2438 | 7,000--8,000  | 2.8---4.3V    |
| 2438--2743 | 8,000--9,000  | 2.6---4.2V    |
| 2743--3048 | 9,000--10,000 | 2.5---4.0V    |

**LOW ALTITUDE = HIGH PRESSURE = HIGH VOLTAGE**

 8-4-88  
 • 75 3211-6E



## CODE 42

### ELECTRONIC SPARK TIMING (EST) CIRCUIT 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

When the system is running on the ignition module, that is, no voltage on the bypass line, the ignition module grounds the EST signal. The ECM expects to see no voltage on the EST line during this condition. If it sees a voltage, it sets Code 42 and will not go into the EST mode.

When the rpm for EST is reached (about 400 rpm), and bypass voltage applied, the EST should no longer be grounded in the ignition module so the EST voltage should be varying.

If the bypass line is open or grounded, the ignition module will not switch to EST mode so the EST voltage will be low and Code 42 will be set.

If the EST line is grounded, the ignition module will switch to EST, but because the line is grounded there will be no EST signal. A Code 42 will be set.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Code 42 means the ECM has seen an open or short to ground in the EST or bypass circuits. This test confirms Code 42 and that the fault causing the code is present.
- Checks for a normal EST ground path through the ignition module. An EST CKT 423 shorted to ground will also read less than 500 ohms; however, this will be checked later.
- As the test light voltage touches CKT 424, the module should switch causing the ohmmeter to "overrange" if the meter is in the 1000-2000 ohms position. Selecting the 10-20,000 ohms position will indicate above 5000 ohms. The important thing is that the module "switched".
- The module did not switch and this step checks for:
  - EST CKT 423 shorted to ground.
  - Bypass CKT 424 open.
  - Faulty ignition module connection or module.
- Confirms that Code 42 is a faulty ECM and not an intermittent in CKTs 423 or 424.

#### Diagnostic Aids:

If a Code 42 was stored and the customer complains of a "hard start," the problem is most likely a grounded EST line (CKT 423).

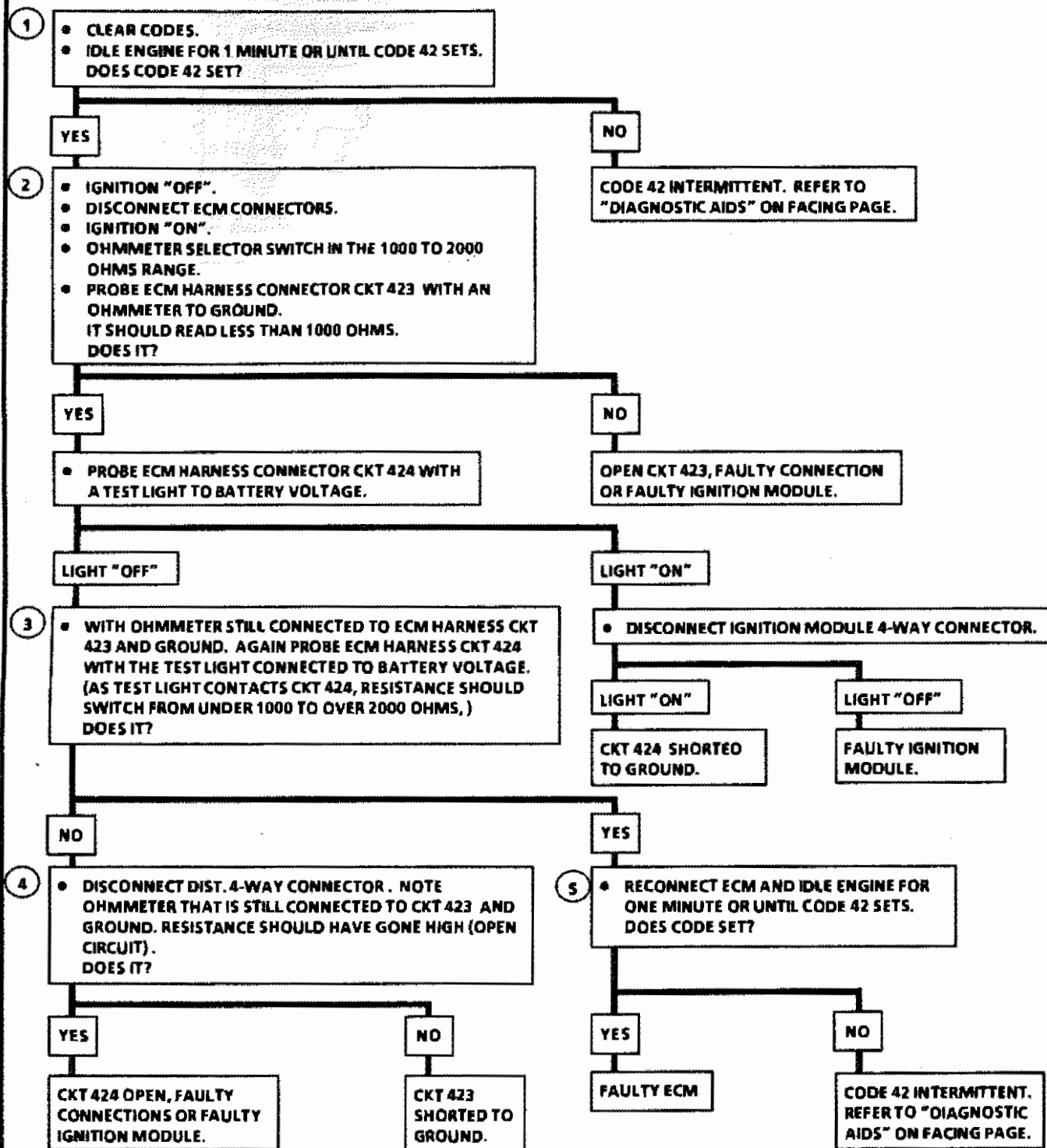
The "Scan" tool does not have any ability to help diagnose a Code 42 problem.

A PROM not fully seated in the ECM can result in a Code 42.

Refer to "Intermittents" in Section "B".

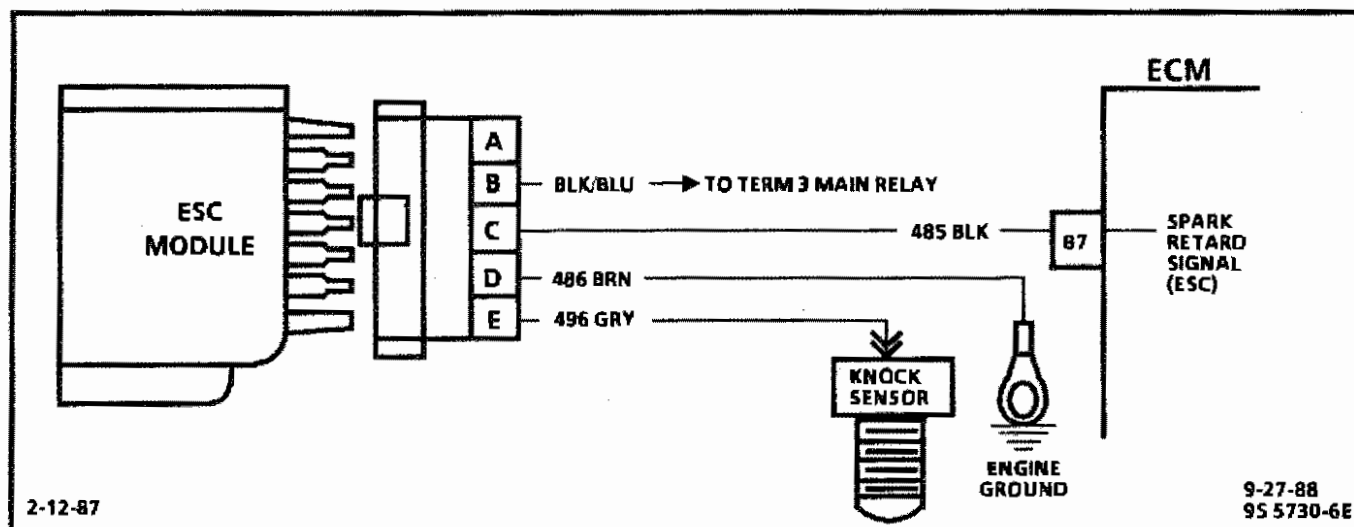
**CODE 42**

## ELECTRONIC SPARK TIMING (EST) CIRCUIT 2.8L (VIN R) "KT" (TBI)



**CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.**

9-28-88  
95 6027-6E



## CODE 43

### ELECTRONIC SPARK CONTROL (ESC) CIRCUIT 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

Electronic spark control is accomplished with a module that sends a voltage signal to the ECM. As the knock sensor detects engine knock, the voltage from the ESC module to the ECM drops, and this signals the ECM to retard timing. The ECM will retard the timing when knock is detected and rpm is above about 900 rpm.

Code 43 means the ECM has been low voltage at CKT 485 terminal "B7" for longer than 5 seconds with the engine running or the system has failed the functional check.

This system performs a functional check once per start up to check the ESC system. To perform this test the ECM will advance the spark when coolant is above 95°C and at a high load condition (near W.O.T.). The ECM then checks the signal at "B7" to see if a knock is detected. The functional check is performed once per start up and if knock is detected when coolant is below 95°C (194°F) the test has passed and the functional check will not be run. If the functional check fails, the "Service Engine Soon" light will remain "ON" until ignition is turned "OFF" or until a knock signal is detected.

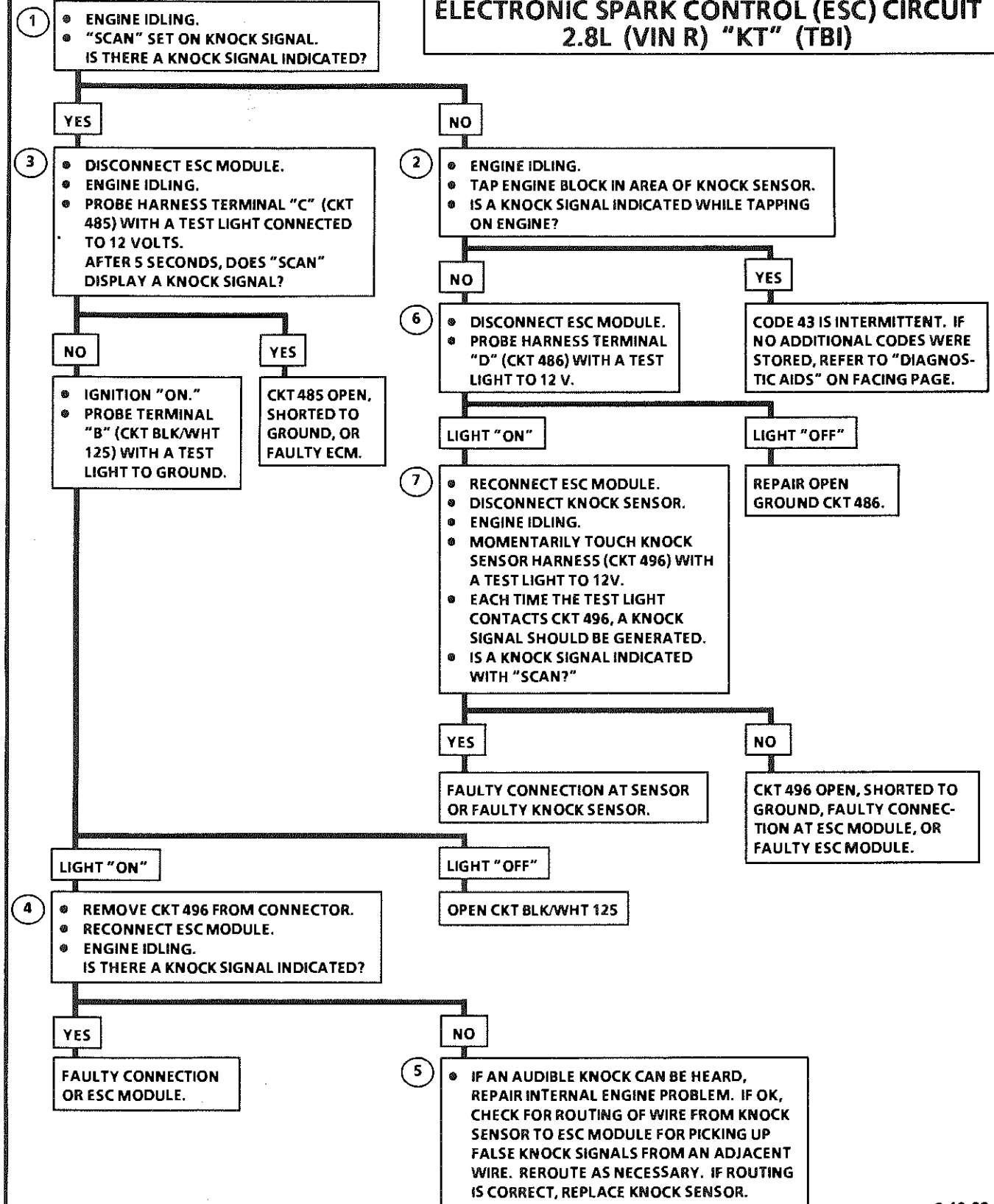
**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

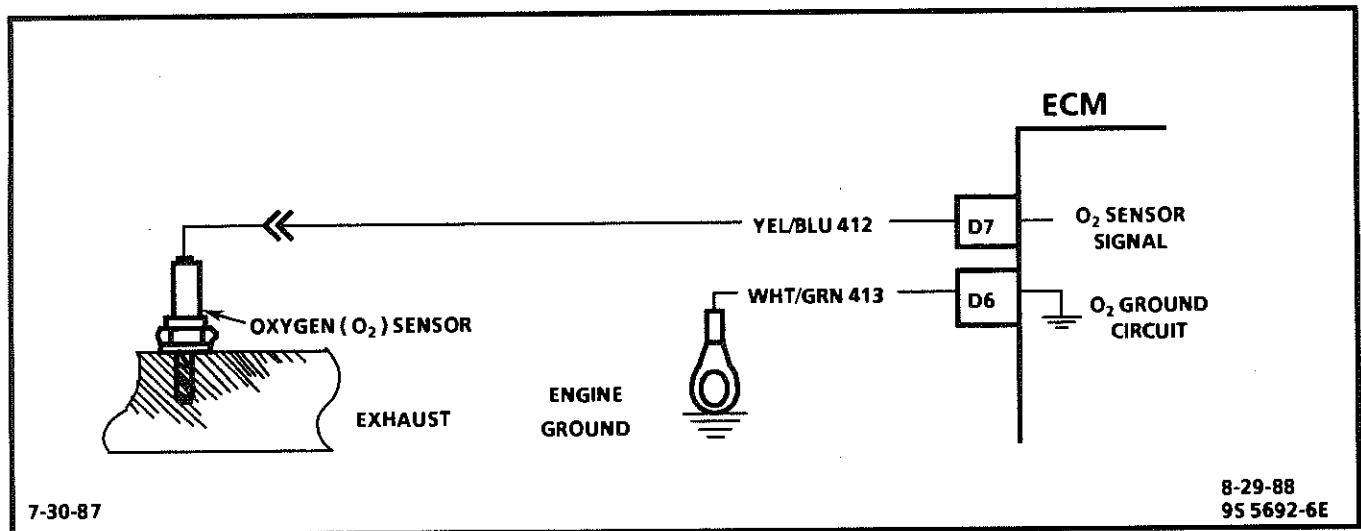
1. If the conditions for a Code 43 are present the "Scan" will always display "yes." There should not be a knock at idle unless an internal engine problem, or a system problem exists.
2. This test will determine if the system is functioning at this time. Usually a knock signal can be generated by tapping on the right exhaust manifold. If no knock signal is generated try tapping on block close to the area of the sensor.
3. Because Code 43 sets when the signal voltage on CKT 485 remains low this test should cause the signal on CKT 485 to go high. The 12 volts signal should be seen by the ECM as "no knock" if the ECM and wiring are OK.
4. This test will determine if the knock signal is being detected on CKT 496 or if the ESC module is at fault.
5. If CKT 496 is routed to close to secondary ignition wires the ESC module may see the interference as a knock signal.
6. This checks the ground circuit to the module. An open ground will cause the voltage on CKT 485 to be about 12 volts which would cause the Code 43 functional test to fail.
7. Contacting CKT 496 with a test light to 12 volts should generate a knock signal. This will determine if the ESC module is operating correctly.

#### Diagnostic Aids:

Code 43 can be caused by a faulty connection at the knock sensor at the ESC module or at the ECM. Also check CKT 485 for possible open or short to ground.

Refer to "Intermittents" in Section "B".

**CODE 43****ELECTRONIC SPARK CONTROL (ESC) CIRCUIT  
2.8L (VIN R) "KT" (TBI)**8-19-88  
9S 5731-6E



## CODE 44

### OXYGEN SENSOR CIRCUIT (LEAN EXHAUST INDICATED) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM supplies a voltage of about .45 volt between terminals "D6" and "D7". (If measured with a 10 megohm digital voltmeter, this may read as low as .32 volt.) The O<sub>2</sub> sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about .10 volt if exhaust is lean.

The sensor is like an open circuit and produces no voltage when it is below about 360°C (600°F). An open sensor circuit or cold sensor causes "Open Loop" operation.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Code 44 is set when the O<sub>2</sub> sensor signal voltage on CKT 412.
  - Remains below .2 volt for 50 seconds.
  - And the system is operating in "Closed Loop."

#### Diagnostic Aids:

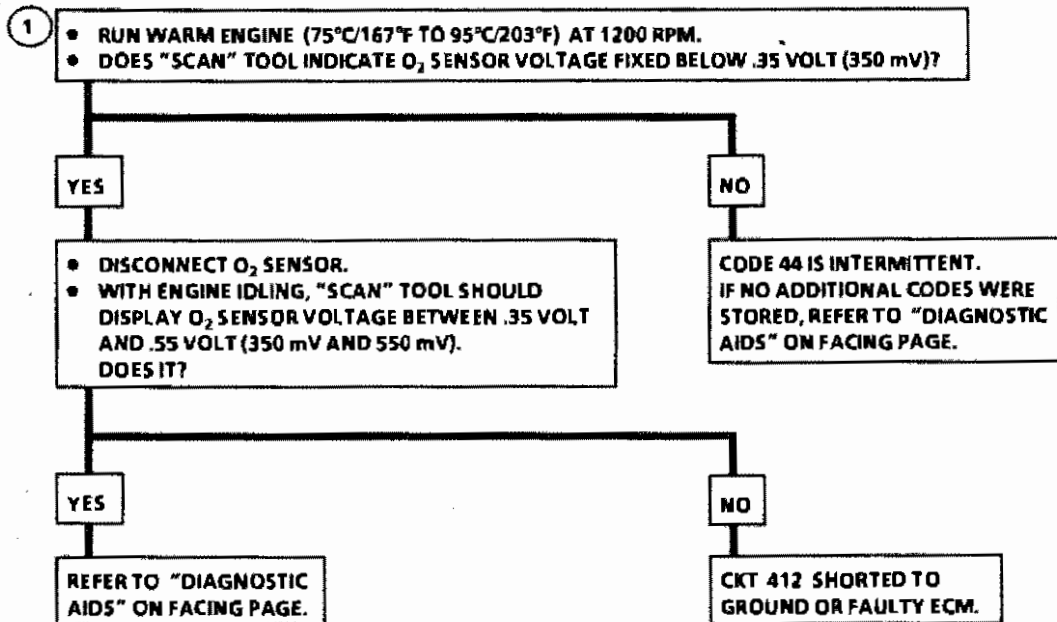
Using the "Scan," observe the block learn values at different rpm and air flow conditions to determine when the Code 44 may have been set. If the conditions for Code 44 exists the block learn values will be around 150.

- O<sub>2</sub> Sensor Wire. Sensor pigtail may be mispositioned and contacting the exhaust manifold.
- Check for intermittent ground in wire between connector and sensor.

- MAP Sensor. A (MAP) sensor output that causes the ECM to sense a higher than normal vacuum will cause the system to go lean. Disconnect the MAP sensor and if the lean condition is gone, replace the sensor.
- Lean Injector(s).
- Fuel Contamination. Water, even in small amounts, near the in-tank fuel pump inlet can be delivered to the injectors. The water causes a lean exhaust and can set a Code 44.
- Fuel Pressure. System will be lean if pressure is too low. It may be necessary to monitor fuel pressure while driving the car at various road speeds and/or loads to confirm. See "Fuel System Diagnosis" CHART A-7.
- Exhaust Leaks. If there is an exhaust leak, the engine can pull outside air into the exhaust and past the sensor. Vacuum or crankcase leaks can cause a lean condition.
- If the above are OK, it is a faulty oxygen sensor.

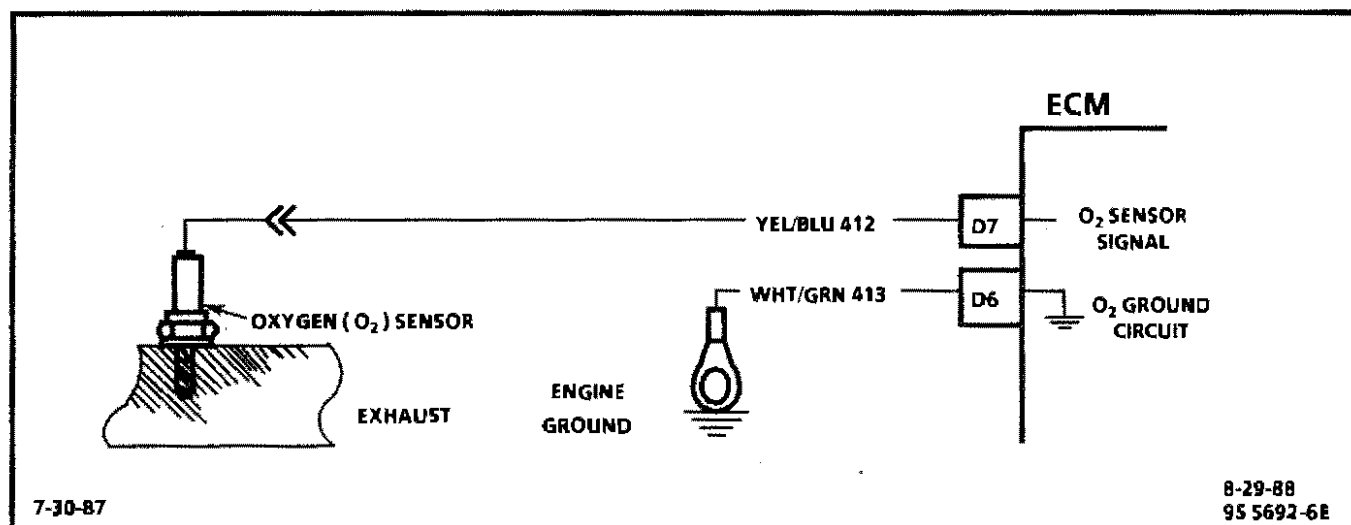
**CODE 44**

**OXYGEN SENSOR CIRCUIT  
(LEAN EXHAUST INDICATED)  
2.8L (VIN R) "KT" (TBI)**



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 6025-6E



## CODE 45

### OXYGEN SENSOR CIRCUIT (RICH EXHAUST INDICATED) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM supplies a voltage of about .45 volt between terminals "D6" and "D7". (If measured with a 10 megohm digital voltmeter, this may read as low as .32 volt.) The O<sub>2</sub> sensor varies the voltage within a range of about 1 volt if the exhaust is rich, down through about .10 volt if exhaust is lean.

The sensor is like an open circuit and produces no voltage when it is below about 360°C (600°F). An open sensor circuit or cold sensor causes "Open Loop" operation.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Code 45 is set when the O<sub>2</sub> sensor signal voltage or CKT 412.
  - Remains above .7 volt for 50 seconds; and in "Closed Loop."
  - Engine time after start is 1 minute or more.
  - Throttle angle greater than 2% (about .2 volt above idle voltage) but less than 25%.

#### Diagnostic Aids:

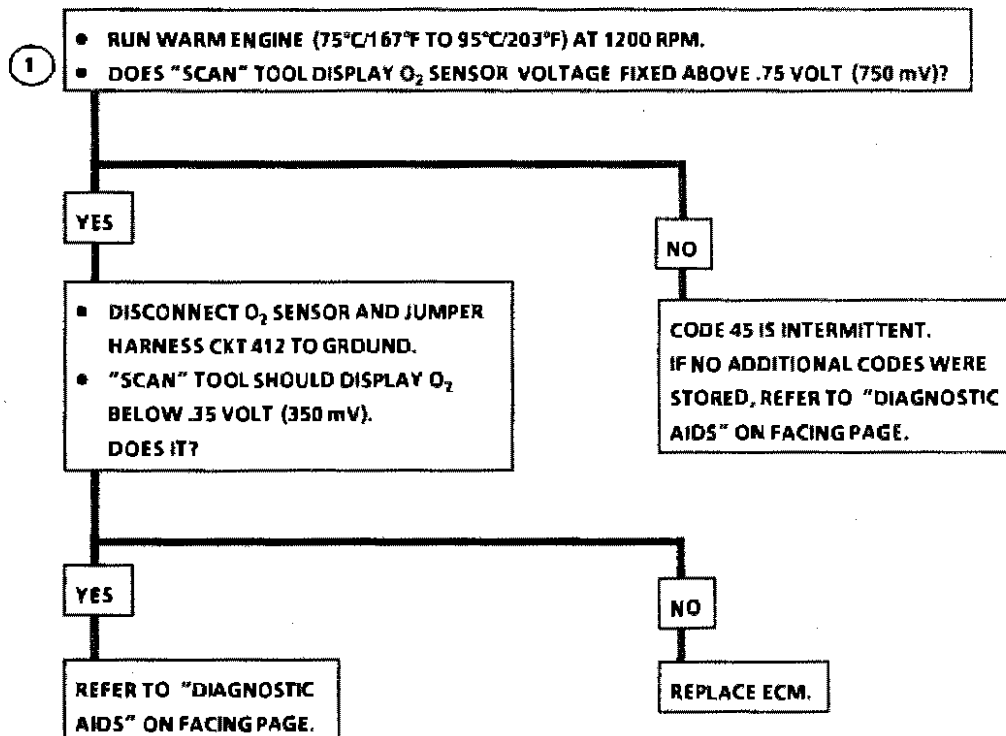
Using the "Scan," observe the block learn values at different rpm conditions to determine when the Code 45 may have been set. If the conditions for Code 45 exists, The block learn values will be around 115.

- **Fuel Pressure.** System will go rich if pressure is too high. The ECM can compensate for some increase. However, if it gets too high, a Code 45 may be set. See "Fuel System Diagnosis" CHART A-7.
- **Leaking injector.** See CHART A-7.
- Check for fuel contaminated oil.

- **HEI Shielding.** An open ground CKT 453 (ignition system ref. low) may result in EMI, or induced electrical "noise." The ECM looks at this "noise" as reference pulses. The additional pulses result in a higher than actual engine speed signal. The ECM then delivers too much fuel, causing system to go rich. Engine tachometer will also show higher than actual engine speed, which can help in diagnosing this problem.
- **Canister purge.** Check for fuel saturation. If full of fuel, check canister control and hoses. See "Canister Purge" Section "C3".
- **MAP sensor.** An output that causes the ECM to sense a lower than normal vacuum can cause the system to go rich. Disconnecting the MAP sensor will allow the ECM to set a fixed value for the sensor. Substitute a different MAP sensor if the rich condition is gone while the sensor is disconnected.
- **TPS.** An intermittent TPS output will cause the system to go rich, due to a false indication of the engine accelerating.

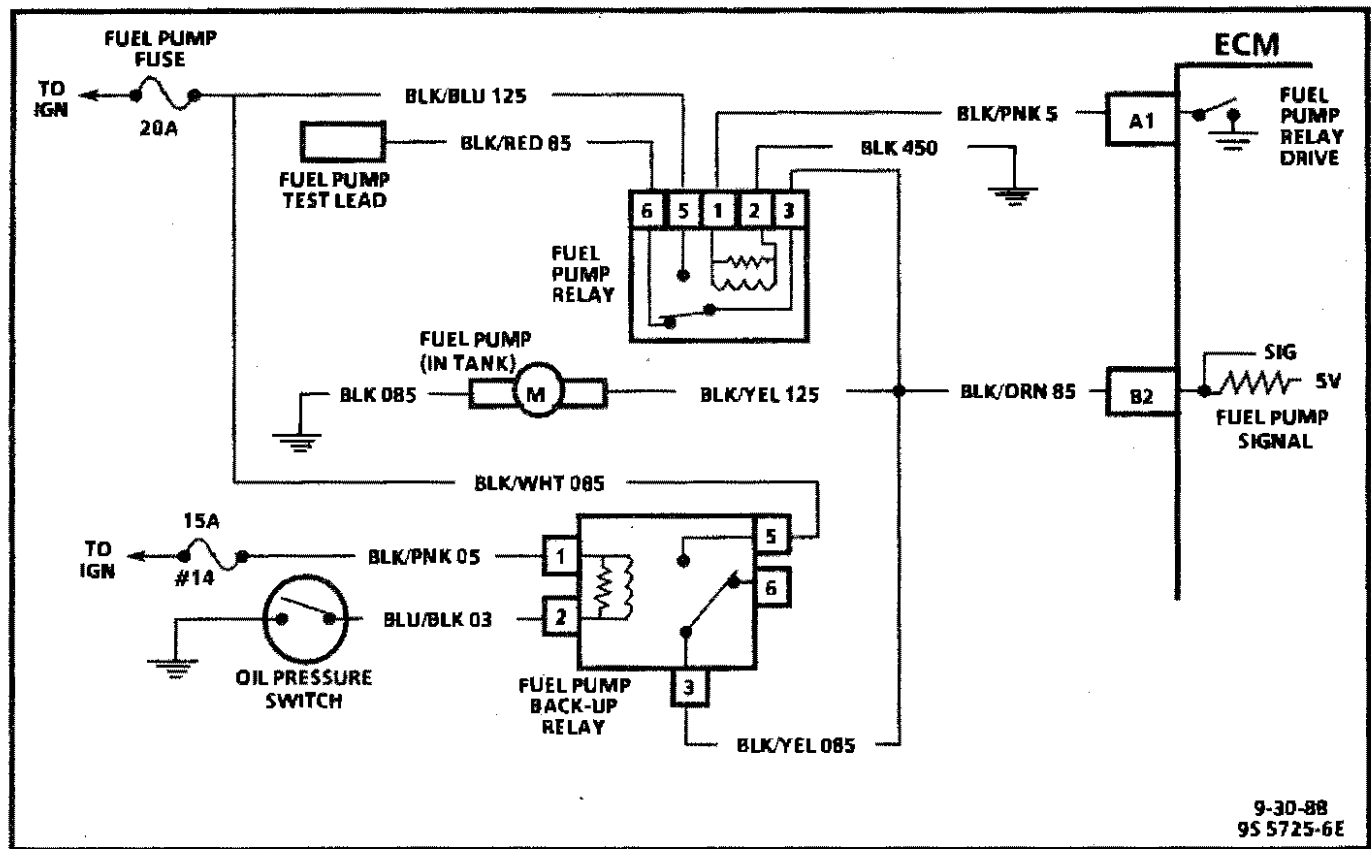
**CODE 45**

**OXYGEN SENSOR CIRCUIT  
(RICH EXHAUST INDICATED)  
2.8L (VIN R) "KT" (TBI)**



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 6024-6E



**CODE 54**

**FUEL PUMP CIRCUIT  
(LOW VOLTAGE)  
2.8L (VIN R) "KT" (TBI)**

### Circuit Description:

When the ignition switch is turned "ON," the electronic control module (ECM) will activate the fuel pump relay and run the in-tank fuel pump. The fuel pump will operate as long as the engine is cranking or running, and the ECM is receiving ignition reference pulses.

**If there are no reference pulses, the ECM will shut "OFF" the fuel pump within 2 seconds after key "ON."**

Should the fuel pump relay, or the 12 volt relay drive from the ECM fail, the fuel pump will be run through an oil pressure switch which activates the back up relay circuit.

### Diagnostic Aids:

An inoperative fuel pump relay can result in long cranking times, particularly if the engine is cold or engine oil pressure is low. The extended crank period is caused by the time necessary for oil pressure to build enough to close the oil pressure switch and turn "ON" the fuel pump.

**Intermittent problems may be caused by:**

- Poor wiring connections
- Corrosion
- All connections should be checked visually

**CODE 54****FUEL PUMP CIRCUIT  
(LOW VOLTAGE)  
2.8L (VIN R) "KT" (TBI)**

- IGNITION "OFF" FOR 10 SECONDS.
- IGNITION "ON".
- LISTEN FOR IN-TANK FUEL PUMP.
- PUMP SHOULD RUN FOR 2 SECONDS AFTER IGNITION "ON". DOES IT?

NO

- IGNITION "OFF".
- USING A FUSED JUMPER WIRE, CONNECT FUEL PUMP TEST CONNECTOR TO 12 VOLTS.
- DOES PUMP RUN?

YES

- IGNITION "OFF".
- FROM BACK SIDE OF FUSE PANEL PROBE CKT BLK/PNK 5 WITH A TEST LIGHT TO GROUND.
- IGNITION "ON"
- SHOULD HAVE LIGHT FOR 2 SECONDS.

LIGHT "ON"

IGNITION "OFF"  
CONNECT TEST LIGHT BETWEEN CKTS WHT 5 & 450 BLK.  
IGNITION "ON"  
LIGHT FOR 2 SECONDS.

LIGHT "OFF"

REPAIR OPEN IN CKT BLK/PNK 5.

NO

- DISCONNECT FUEL PUMP RELAY.
- USING THE FUSED JUMPER WIRE, CONNECT CKT BLK/ORN 85 TO 12 VOLTS. DOES PUMP RUN?

YES

FAULTY RELAY

NO

OPEN CKT BLK/ORN 85, FAULTY IN-TANK PUMP OR FAULTY PUMP GROUND.

YES

- CLEAR CODES.
- START AND RUN ENGINE FOR 10 SECONDS
- ENGINE "OFF" FOR 10 SECONDS
- START ENGINE AND RUN FOR 10 SECONDS. DOES CODE 54 SET?

YES

- AT THE ECM, BACK PROBE BLK/ORN CKT 85 WITH A TEST LIGHT TO GROUND.
- IGNITION "OFF" FOR 10 SECONDS.
- NOTE LIGHT WITHIN 2 SECONDS AFTER IGNITION "ON".

LIGHT "ON"

FAULTY CONNECTION AT ECM OR FAULTY ECM.

NO

CODE 54 IS INTERMITTENT. REFER TO DIAGNOSTIC AIDS.

LIGHT "OFF"

OPEN CKT BLK/ORN 85 TO ECM.

LIGHT "ON"

CODE 54 IS INTERMITTANT  
REFER TO DIAGNOSTIC AIDS ON FACING PAGE.

LIGHT "OFF"

REPAIR OPEN CKT 450.

NOTE: IF ORIGINAL COMPLAINT WAS "EXTENDED CRANKING BEFORE START" MAKE THE FOLLOWING ADDITIONAL CHECKS:

- ENGINE IDLING AT NORMAL OPERATING TEMPERATURE.
- OIL PRESSURE NORMAL.
- DISCONNECT FUEL PUMP MAIN RELAY.
- ENGINE SHOULD CONTINUE TO RUN.
- DOES IT?

YES

- RECONNECT FUEL PUMP RELAY.
- IGNITION "OFF".
- PROBE FUEL PUMP TEST TERMINAL WITH A TEST LIGHT TO GROUND.

LIGHT "OFF"

FUEL PUMP CIRCUIT OK

NO

FAULTY OIL PRESSURE SWITCH OR BACK UP RELAY

LIGHT "ON"

FAULTY OIL PRESSURE SWITCH

9-28-88  
95 5732-6E

**CODE 51**

**PROM ERROR  
(FAULTY OR INCORRECT PROM)**

CHECK THAT ALL PINS ARE FULLY INSERTED IN THE SOCKET. IF OK, REPLACE PROM, CLEAR MEMORY AND RECHECK. IF CODE 51 REAPPEARS, REPLACE ECM.

CLEAR ALL CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT

**CODE 52**

**CALPAK ERROR  
(FAULTY OR INCORRECT CALPAK)**

CHECK THAT ALL PINS ARE FULLY INSERTED IN THE SOCKET. IF OK, REPLACE CALPAK, CLEAR MEMORY AND RECHECK. IF CODE 52 REAPPEARS, REPLACE ECM.

CLEAR ALL CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT

**CODE 55**

**ECM ERROR**

REPLACE ELECTRONIC CONTROL MODULE (ECM).

CLEAR ALL CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT

9-28-88  
95 6028-6E

## SECTION B SYMPTOMS

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### BEFORE STARTING

Before using this section you should have performed the DIAGNOSTIC CIRCUIT CHECK.

Verify the customer complaint, and locate the correct SYMPTOM below. Check the items indicated under that symptom.

If the ENGINE CRANKS BUT WILL NOT RUN, see CHART A-3.

Several of the following symptom procedures call for a careful visual (physical) check.

The importance of this step cannot be stressed too strongly - it can lead to correcting a problem without further checks and can save valuable time.

This check should include:

- Vacuum hoses for splits, kinks, and proper connections, as shown on Emission Control Information label.
- Air leaks at throttle body mounting and intake manifold.
- Ignition wires for cracking, hardness, proper routing, and carbon tracking.
- Wiring for proper connections, pinches, and cuts.

The following symptoms cover several engines. To determine if a particular system or component is used, refer to the ECM wiring diagrams for application.

## INTERMITTENTS

Problem may or may not turn "ON" the "Check Engine" light, or store a code.

DO NOT use the Trouble Code Charts in Section "A" for intermittent problems. The fault must be present to locate the problem. If a fault is intermittent, use of Trouble Code Charts may result in replacement of good parts.

- Most intermittent problems are caused by faulty electrical connections or wiring. Perform careful check of suspect circuits for:
  - Poor mating of the connector halves, or terminals, not fully seated in the connector body (backed out).
  - Improperly formed or damaged terminals. All connector terminals in problem circuit should be carefully reformed or replaced to insure proper contact tension.
  - Poor terminal to wire connection. This requires removing the terminal from the connector body to check as outlined in the Introduction to Section "6E".
- If a visual (physical) check does not find the cause of the problem, the car can be driven with a voltmeter connected to a suspected circuit or a "Scan" tool may be used. An abnormal voltage reading, when the problem occurs, indicates the problem may be in that circuit. If the wiring and connectors check OK, and a Trouble Code was

stored for a circuit having a sensor, except for Codes 44 and 45, substitute a known good sensor and recheck.

- Loss of trouble code memory. To check, disconnect TPS and idle engine until "Check Engine" light comes "ON." Code 22 should be stored, and kept in memory, when ignition is turned "OFF" for at least 10 seconds. If not, the ECM is faulty.
- An intermittent "Check Engine" light, and No Trouble Codes, may be caused by:
  - Electrical system interference caused by a defective relay, ECM driven solenoid, or switch. They can cause a sharp electrical surge. Normally, the problem will occur when the faulty component is operated.
  - Improper installation of electrical options, such as lights, 2-way radios, etc.
  - EST wires should be routed away from spark plug wires, ignition system components, and generator. Wire for CKT 453 from ECM to ignition system should be a good ground.
  - Ignition secondary shorted to ground.
  - CKTs BLU/PNK 03 ("Check Engine" light) or 451 (Diagnostic Test) intermittently shorted to ground.
  - ECM power grounds.

## HARD START

**Definition:** Engine cranks OK, but does not start for a long time. Does eventually run, or may start but immediately dies.

- **CHECK:**
  - For water contaminated fuel.
  - Fuel system pressure CHART A-7.
  - TPS for sticking or binding should read less than 1.25 volts on a "Scan" tool.
  - No crank signal; see CHART C-1B.
  - EGR operation; CHART C-7.
  - Fuel pump relay - Connect test light between pump test terminal and ground. Light should be "ON" for 2 seconds following ignition "ON." If not, refer to CODE 54 CHART.
  - For a faulty in-tank fuel pump check valve, which would allow the fuel in the lines to drain back to the tank after the engine is stopped. To check for this condition:
    1. Ignition "OFF."
    2. Disconnect fuel line at the filter.
    3. Remove the tank filler cap.
- 4. Connect a radiator test pump to the line and apply 103 kPa (15 psi) pressure. If the pressure will hold for 60 seconds, the check valve is OK.
- Check ignition system for:
  - Proper output with ST-125.
  - Worn shaft.
  - Bare and shorted wires.
  - Pickup coil resistance and connections.
  - Loose ignition coil connections.
  - Moisture in distributor cap.
  - Spark plugs, wet plugs, cracks, wear, improper gap, burned electrodes, or heavy deposits.
- If engine starts but then, immediately stalls, open distributor bypass line. If engine then starts, and runs OK, replace distributor pickup coil.
- Check CKT 423 (EST) for short to ground.

## SURGES AND/OR CHUGGLE

**Definition:** Engine power variation, under steady throttle or cruise. Feels like the car speeds up and slows down, with no change in the accelerator pedal.

- Use a "Scan" tool to make sure reading of VSS matches vehicle speedometer. See "Special Information," Section "6E".
- **CHECK:**
  - For intermittent EGR at idle. See appropriate CHART C-7.
  - Ignition timing. See Emission Control Information label.
  - Inline fuel filter for dirt or restriction.
  - Fuel pressure. See CHART A-7.
  - Generator output voltage. Repair, if less than 9, or more than 16 volts.
- Inspect oxygen sensor for silicon contamination from fuel, or use of improper RTV sealant. The sensor may have a white, powdery coating and result in a high but false signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivered to the engine, causing a severe driveability problem.
- Remove spark plugs. Check for cracks, wear, improper gap, burned electrodes, or heavy deposits. Also, check condition of the rest of the Ignition System.

## LACK OF POWER, SLUGGISH, OR SPONGY

**Definition:** Engine delivers less than expected power. Little or no increase in speed, when accelerator pedal is pushed down part way.

- Compare customer's car to similar unit. Make sure the customer's car has an actual problem.
- Remove air cleaner and check air filter for dirt, or for being plugged. Replace as necessary.
- If there is spray from only one injector, then there is a malfunction in the injector assembly, or in the signal to the injector assembly. The malfunction can be isolated, by switching the injector connectors. If the problem remains with the original injector, after switching the connector, then, the injector is defective. Replace the injector. If the problem moves with the injector connector, then, the problem is an improper signal in the injector circuits, see CHART A-3.
- **CHECK:**
  - Ignition timing. See Emission Control Information label.
  - For restricted fuel filter, contaminated fuel or improper fuel pressure. See CHART A-7.
  - ECM grounds.
  - EGR operation for being open, or partly open, all the time - CHART C-7.
  - Generator output voltage. Repair, if less than 9, or more than 16 volts.
- Engine valve timing and compression.
- Engine, for proper or worn camshaft. See Section "6A".
- Secondary ignition voltage, using a scope or ST-125.
- Proper operation of EST. See Section "C4".
- Check exhaust system for restriction, See CHART B-1:
  1. With engine at normal operating temperature, connect a vacuum gage to any convenient vacuum port on intake manifold.
  2. Run engine at 1000 rpm and record vacuum reading.
  3. Increase rpm slowly to 2500 rpm. Note vacuum reading at steady 2500 rpm.
  4. If vacuum at 2500 rpm decreases more than 3" from reading at 1000 rpm, the exhaust system should be inspected for restrictions.
  5. Disconnect exhaust pipe from engine and repeat steps 3 & 4. If vacuum still drops more than 3" with exhaust disconnected, check valve timing.

## DETONATION / SPARK KNOCK

**Definition:** A mild to severe ping, usually worse under acceleration. The engine makes sharp metallic knocks that change with throttle opening.

- CHECK for obvious overheating problems.
  - Low coolant.
  - Loose water pump belt.
  - Restricted air flow to radiator, or restricted water flow through radiator.
  - Faulty or incorrect thermostat.
  - Coolant sensor, which has shifted in value.
  - Correct coolant solution - should be a 50/50 mix of anti-freeze coolant and water.
- CHECK:
  - For poor fuel quality, proper octane rating.
  - For correct PROM.
  - Spark plugs for correct heat range.
  - Ignition timing. See Vehicle Emission Control Information label.
  - Proper operation of Thermac.
  - Fuel system for low pressure. See CHART A-7.
- Check EGR system for not opening - CHART C-7.
- For incorrect basic engine parts such as cam, heads, pistons, etc.
- Excessive oil entering combustion chamber.
- Remove carbon with top engine cleaner. Follow instructions on can.
- If there is spray from only one injector, then, there is a malfunction in the injector assembly, or in the signal to the injector assembly. The malfunction can be isolated, by switching the injector connectors. If the problem remains with the original injector, after switching the connector, then, the injector is defective. Replace the injector. If the problem moves with the injector connector, then, the problem is an improper signal in the injector circuits, see CHART A-3.

## HESITATION, SAG, STUMBLE

**Definition:** Momentary lack of response as the accelerator is pushed down. Can occur at all car speeds. Usually most severe when first trying to make the car move, as from a stop sign. May cause the engine to stall if severe enough.

- Perform careful visual (physical) check, as described at start of Section "B".
- CHECK:
  - Fuel pressure. See CHART A-7.
  - Water contaminated fuel.
  - TPS for binding or sticking.
  - Ignition timing. See Emission Control Information label.
  - Generator output voltage. Repair if less than 9 or more than 16 volts.
  - For open Ignition System ground, CKT 453.
  - Canister purge system for proper operation. See Section "C3".
  - EGR valve operation CHART C-7.

## CUTS OUT, MISSES

**Definition:** Steady pulsation or jerking that follows engine speed, usually more pronounced as engine load increases. The exhaust has a steady spitting sound at idle or low speed.

- Perform careful visual (physical) check, as described at start of Section "B".
- If ignition system is suspected of causing a miss at idle or cutting, out under load:
- Check for missing cylinder by:
  1. Disconnect IAC motor. Start engine. Remove one spark plug wire at a time, using insulated pliers.
  2. If there is an rpm drop, on all cylinders, (equal to within 50 rpm), go to ROUGH, UNSTABLE, OR INCORRECT IDLE, OR STALLING symptom. Reconnect IAC motor.
  3. If there is no rpm drop on one or more cylinders, or excessive variation in drop,
- check for spark, on the suspected cylinder(s) with J 26792 (ST-125) spark tester or equivalent. If no spark, see Section "6D" for Intermittent Operation or Miss. If there is spark, remove spark plug(s) in these cylinders and check for:
  - Cracks
  - Wear
  - Improper gap
  - Burned electrodes
  - Heavy deposits
  - Perform compression check on questionable cylinder.
- Check wire resistance (should not exceed 30,000 ohms), also, check rotor and distributor cap.

- If the previous checks did not find the problem:
  - Visually inspect ignition system for moisture, dust, cracks, burns, etc. Spray plug wires with fine water mist to check for shorts.
  - Fuel System - Plugged fuel filter, water, low pressure. See CHART A-7.
  - Perform compression check.
  - Valve Timing.
  - Remove rocker covers. Check for bent pushrods, worn rocker arms, broken or weak valve springs, worn camshaft lobes. Repair as necessary. See Section "6A".
- If there is spray from only one injector, then, there is a malfunction in the injector assembly, or in the signal to the injector assembly. The malfunction can be isolated, by switching the injector connectors. If the problem remains with the original injector, after switching the connector, then, the injector is defective. Replace the injector. If the problem moves with the injector connector, then, the problem is an improper signal in the injector circuits, see CHART A-3.

## POOR FUEL ECONOMY

**Definition:** Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, economy is noticeably lower than it was on this car at one time, as previously shown by an actual road test.

- **CHECK:**
  - Engine thermostat for faulty part (always open) or for wrong heat range.
  - Fuel Pressure. See CHART A-7.
- Check owner's driving habits.
  - Is A/C "ON" full time (Defroster mode "ON")?
  - Are tires at correct pressure?
  - Are excessively heavy loads being carried?
  - Is acceleration too much, too often?
  - Suggest driver read "Important Facts on Fuel Economy" in Owner's Manual.
- Perform "Diagnostic Circuit Check."
- Check air cleaner element (filter) for dirt or being plugged.
- Check for proper calibration of speedometer.
- Visually (physically) Check:
  - Vacuum hoses for splits, kinks, and proper connections, as shown on Vehicle Emission Control Information label.
  - Ignition wires for cracking, hardness, and proper connections.
- Check Ignition timing. See Emission Control Information label.
- Remove spark plugs. Check for cracks, wear, improper gap, burned electrodes or heavy deposits. Repair or replace, as necessary.
- Check compression. See Section "6A".
- Check for dragging brakes.
- Suggest owner fill fuel tank and recheck fuel economy.
- Check for exhaust system restriction. See CHART B-1.

## ROUGH, UNSTABLE, OR INCORRECT IDLE, STALLING

**Definition:** The engine runs unevenly at idle. If bad enough, the car may shake. Also, the idle may vary in rpm (called "hunting"). Either condition may be severe enough to cause stalling. Engine idles at incorrect speed.

- **CHECK:**
  - Ignition timing. See Emission Control Information label.
  - For injector(s) leaking. Check Fuel Pressure CHART A-7.
  - IAC - See CHART C-2C.
  - If a sticking throttle shaft or binding linkage causes a high TPS voltage (open throttle indication), the ECM will not control idle. Monitor TPS voltage. "Scan" and/or voltmeter should read less than 1.25 volts with throttle closed.
- Vacuum leaks can cause higher than normal idle.
- EGR "ON," while idling, will cause roughness, stalling, and hard starting. CHART C-7.
- Battery cables and ground straps should be clean and secure. Erratic voltage will cause IAC to change its position, resulting in poor idle quality.
- IAC valve will not move, if system voltage is below 9, or greater than 17.8 volts.
- Use "Scan" tool to determine if ECM is receiving A/C request signal.

- MAP Sensor - Ignition "ON," engine stopped. Compare MAP voltage with known good vehicle. Voltage should be the same  $\pm 400$  mV (.4 volt).  
or  
Start and idle engine. Disconnect sensor electrical connector. If idle improves, substitute a known good sensor and recheck.
- A/C Refrigerant Pressure too high. Check for overcharge or faulty pressure switch.
- PCV valve for proper operation by placing finger over inlet hole in valve end several times. Valve should snap back. If not, replace valve.
- Run a cylinder compression check. See Section "6".
- Inspect oxygen sensor for silicon contamination from fuel, or use of improper RTV sealant. The sensor will have a white, powdery coating, and will result in a high but false signal voltage (rich exhaust indication). The ECM will then reduce the amount of fuel delivered to the engine, causing a severe driveability problem.

### EXCESSIVE EXHAUST EMISSIONS OR ODORS

**Definition:** Vehicle fails an emission test. Vehicle has excessive "rotten egg" smell. Excessive odors do not necessarily indicate excessive emissions.

- Perform "Diagnostic Circuit Check."
- IF TEST SHOWS EXCESSIVE CO AND HC, (or also has excessive odors):
  - Check items which cause car to run RICH.
    - Make sure engine is at normal operating temperature.
- CHECK:
  - Fuel pressure. See CHART A-7.
  - Incorrect timing. See Vehicle Emission Control Information label.
  - Canister for fuel loading. See CHART C-3.
  - PCV valve for being plugged, stuck, or blocked PCV hose, or fuel in the crankcase.
  - Spark plugs, plug wires, and ignition components. See Section "6D".
  - Check for lead contamination of catalytic converter (look for removal of fuel filler neck restrictor).
  - Check for properly installed fuel cap.
- If the system is running rich, (block learn less than 118), refer to "Diagnostic Aids" on facing page of Code 45.
- IF TEST SHOWS EXCESSIVE NOx:
  - Check items which cause car to run LEAN, or to run too hot.
    - EGR valve for not opening. See CHART C-7.
    - Vacuum leaks.
    - Coolant system and coolant fan for proper operation. See CHART C-12.
    - Remove carbon with top engine cleaner. Follow instructions on can.
    - Check ignition timing for excessive base advance. See Emission Control Information label.
- If the system is running lean, (block learn greater than 138), refer to "Diagnostic Aids" on facing page of Code 44.

### DIESELING, RUN-ON

**Definition:** Engine continues to run after key is turned "OFF," but runs very roughly. If engine runs smoothly, check ignition switch and adjustment.

- Check injector for leaking. Apply 12 volts to fuel pump test terminal to turn "ON" fuel pump and pressurize fuel system.
- Visually check injector and TBI assembly for fuel leakage.

### BACKFIRE

**Definition:** Fuel ignites in intake manifold, or in exhaust system, making a loud popping noise.

- CHECK:
  - EGR operation for being open all the time. See CHART C-7.
  - Output voltage of ignition coil(s).
  - For crossfire between spark plugs (distributor cap, spark plug wires, and proper routing of plug wires).
  - Engine timing - See Emission Control Information label.
- For faulty spark plugs and/or plug wires or boots.
- Perform a compression check - look for sticking or leaking valves.
  - For proper valve timing.
  - Broken or worn valve train parts.

## CHART B-1

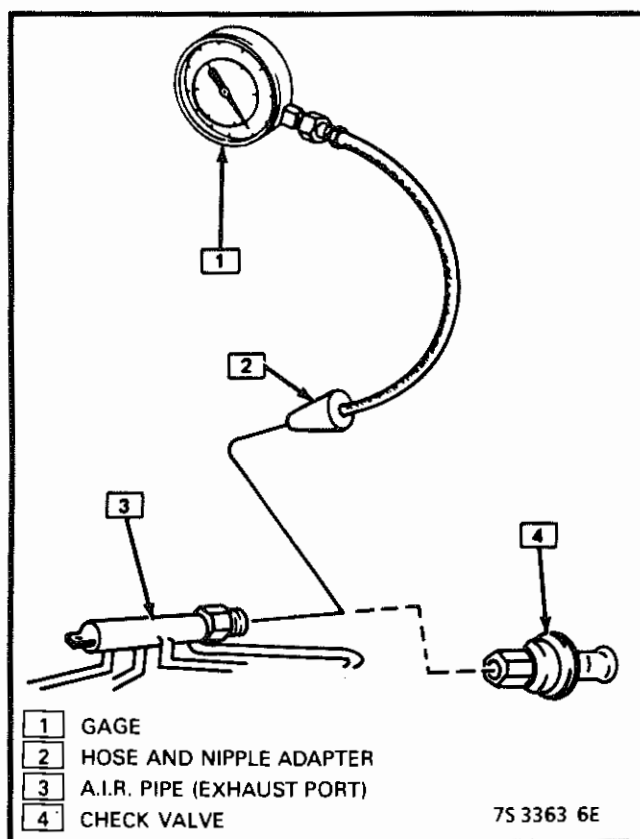
### RESTRICTED EXHAUST SYSTEM CHECK

#### ALL ENGINES

Proper diagnosis for a restricted exhaust system is essential before any components are replaced. Either of the following procedures may be used for diagnosis, depending upon engine or tool used:

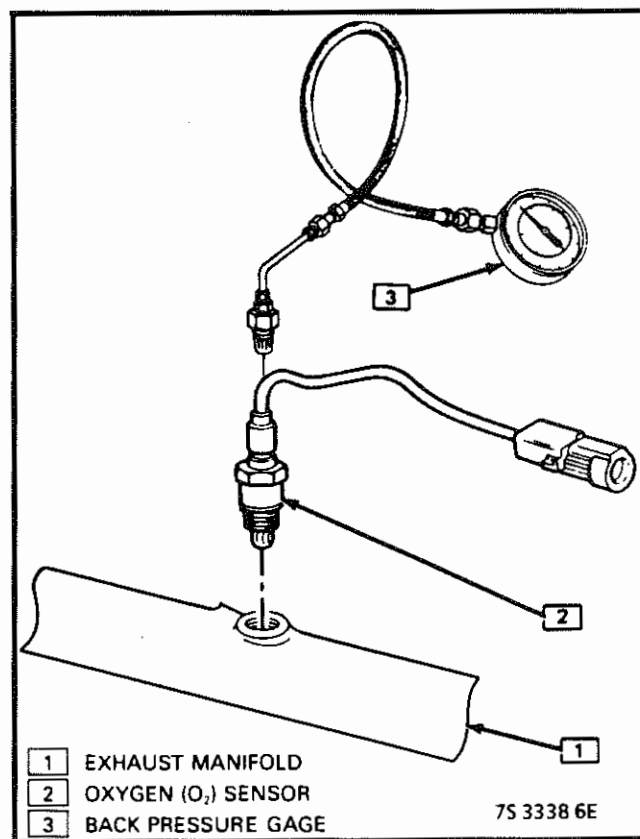
#### CHECK AT A. I. R. PIPE:

1. Remove the rubber hose at the exhaust manifold A.I.R. pipe check valve. Remove check valve.
2. Connect a fuel pump pressure gauge to a hose and nipple from a Propane Enrichment Device (J 26911) (see illustration).
3. Insert the nipple into the exhaust manifold A.I.R. pipe.



#### OR CHECK AT O<sub>2</sub> SENSOR:

1. Carefully remove O<sub>2</sub> sensor.
2. Install Borroughs exhaust backpressure tester (BT 8515 or BT 8603) or equivalent in place of O<sub>2</sub> sensor (see illustration).
3. After completing test described below, be sure to coat threads of O<sub>2</sub> sensor with anti-seize compound prior to re-installation.



#### DIAGNOSIS:

1. With the engine idling at normal operating temperature, observe the exhaust system backpressure reading on the gage. Reading should not exceed 8.6 kPa (1.25 psi).
2. Increase engine speed to 2000 rpm and observe gage. Reading should not exceed 20.7 kPa (3 psi).
3. If the backpressure at either speed exceeds specification, a restricted exhaust system is indicated.
4. Inspect the entire exhaust system for a collapsed pipe, heat distress, or possible internal muffler failure.
5. If there are no obvious reasons for the excessive backpressure, the catalytic converter is suspected to be restricted and should be replaced using current recommended procedures.

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## SECTION C COMPONENT SYSTEMS

Section C provides information on the following:

- General description of components and systems.
- On-vehicle service.
- Part names and group numbers.
- Diagnostic charts. These include a functional check of the system as well as diagnosis of any problem found in the functional check.

For locations of components, wiring diagrams, and ECM terminal end view, refer to the front on the "A" Section of the engine being diagnosed.

Following are the sub-section identification and the system covered:

|       |                                             |            |
|-------|---------------------------------------------|------------|
| • C1  | Electronic Control Module (ECM) and Sensors | Page C1-1  |
| • C2  | Fuel Metering System                        | Page C2-1  |
| • C3  | Evaporative Emission Control System (EECS)  | Page C3-1  |
| • C4  | Ignition System/(EST)                       | Page C4-1  |
| • C5  | Electronic Spark Control (ESC) System       | Page C5-1  |
| • C6  | Air Management System 2.8L Engine           | Page C6-1  |
| • C7  | Exhaust Gas Recirculation (EGR) System      | Page C7-1  |
| • C10 | ECM Controlled Air Conditioning             | Page C10-1 |
| • C13 | Positive Crankcase Ventilation (PCV)        | Page C13-1 |
| • C14 | Thermostatic Air Cleaner (THERMAC)          | Page C14-1 |

## DIAGNOSTIC CHARTS

The Diagnostic Charts for each system are found after the on-car service and parts information at the back of each section. Following are the charts found in this section.

|              |                                                     |            |
|--------------|-----------------------------------------------------|------------|
| • Chart C-1B | Crank Signal                                        | Page C1-10 |
| • Chart C-1D | MAP Output Check                                    | Page C1-12 |
| • Chart C-2C | Idle Air Control (IAC) Valve Check                  | Page C2-16 |
| • Chart C-4B | Ignition System Check                               | Page C4-4  |
| • Chart C-5  | Electronic Spark Control (ESC) System Check         | Page C5-4  |
| • Chart C-6  | Air Management Check (Electronic Air Control Valve) | Page C6-6  |
| • Chart C-7  | EGR System Check                                    | Page C7-4  |
| • Chart C-10 | A/C Clutch Control Circuit Diagnosis                | Page C10-2 |

## SECTION C1

### ELECTRONIC CONTROL MODULE (ECM) AND SENSORS

#### CONTENTS

|                                       |      |                                       |      |
|---------------------------------------|------|---------------------------------------|------|
| <b>GENERAL DESCRIPTION</b> .....      | C1-1 | <b>ECM INPUTS</b> .....               | C1-5 |
| ELECTRONIC CONTROL MODULE (ECM) .     | C1-1 | Coolant Temperature Sensor .....      | C1-5 |
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| Vehicle Speed Sensor (VSS) .....      | C1-4 | CALPAK .....                          | C1-8 |
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| ECM .....                             | C1-5 | O <sub>2</sub> SENSOR .....           | C1-9 |
| PROM .....                            | C1-5 | THROTTLE POSITION SENSOR (TPS) .....  | C1-9 |

### GENERAL DESCRIPTION

#### ELECTRONIC CONTROL MODULE (ECM)

**NOTICE:** To prevent possible Electrostatic Discharge damage to the ECM, Do Not touch the connector pins or soldered components on the circuit board.

The Electronic Control Module (ECM) (Figure C1-1), located under the center console tray, is the control center of the fuel injection system. It constantly looks at the information from various sensors, and controls the systems that affect vehicle performance. The ECM performs the diagnostic function of the system. It can recognize operational problems, alert the driver through the "Check Engine" light, and store a code or codes which identify the problem areas to aid the technician in making repairs. See "Introduction" for more information on using the diagnostic function of the ECM. For service, the ECM has three parts: a controller (the ECM without the PROM), a separate calibrator (PROM), and a CALPAK.

#### PROM

**NOTICE:** To prevent possible Electrostatic Discharge damage to the PROM, CALPAK or Mem-Cal, Do Not touch the component leads, and Do Not remove integrated circuit from carrier.

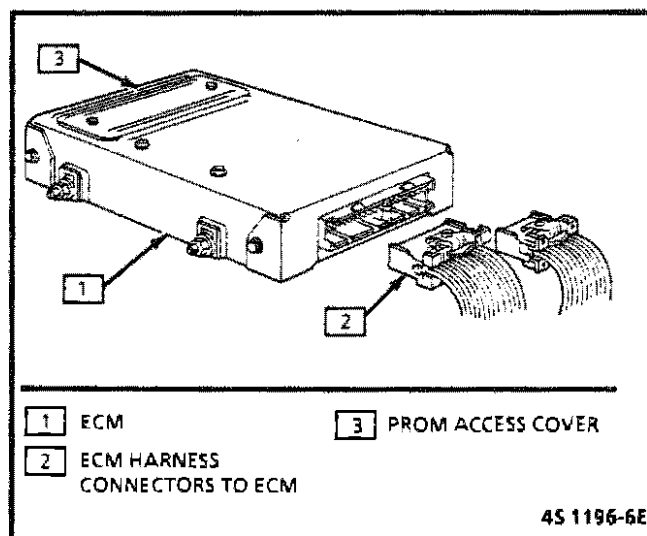
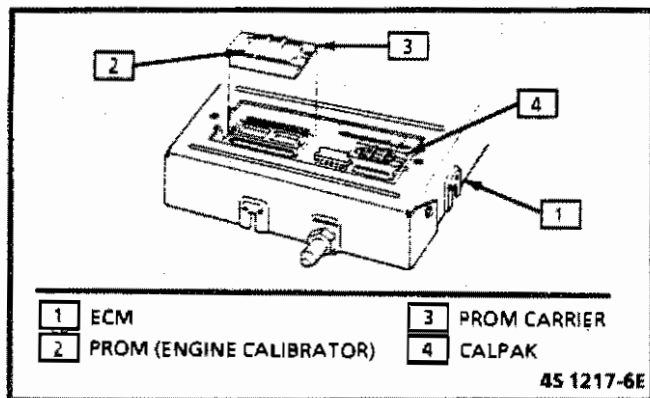


Figure C1-1 - Electronic Control Module (ECM) 2.8L

To allow one model of ECM to be used for many different cars, a device called a Calibrator (or PROM) (Programmable Read Only Memory) is used (see Figure C1-2). The PROM is located inside the ECM, and has information on the vehicle's weight, engine, transmission, axle ratio, and several others. While one ECM part number can be used by many car lines, a PROM is very specific and must be used for the right car. For this reason, it is very important to check the latest parts book and Service Bulletin information for the correct part number when replacing a PROM.

An ECM used for service (called a controller) comes without a PROM. The PROM from the old ECM



**Figure C1-2 - PROM (Calibrator) and CALPAK**

must be carefully removed and installed in the new ECM (see On-Car Service).

## CALPAK

A device called a CALPAK is used to allow fuel delivery if other parts of the ECM are damaged. It has an access door in the ECM, and removal and replacement procedures are the same as with a PROM.

If the CALPAK is missing, it will result in a no start and run condition. The CALPAK must be transferred to a replacement ECM.

## ECM FUNCTION

The ECM supplies either 5 or 12 volts to power various sensors or switches. This is done through resistances in the ECM which are so high in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a 10 megohm input impedance digital voltmeter is required to assure accurate voltage readings.

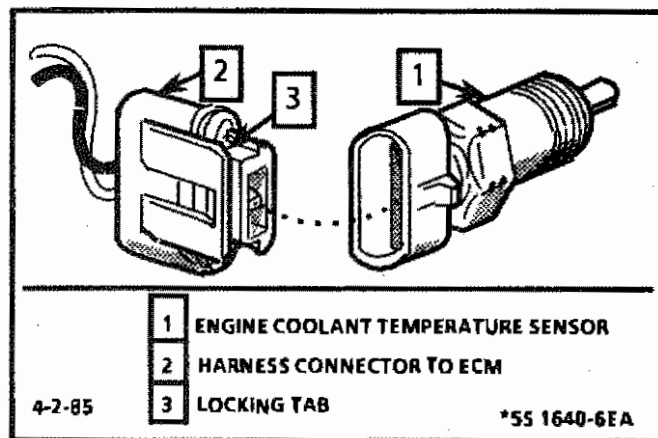
The ECM controls output circuits such as the injector, IAC, etc. by controlling the ground circuit through transistors in the ECM.

## INFORMATION SENSORS

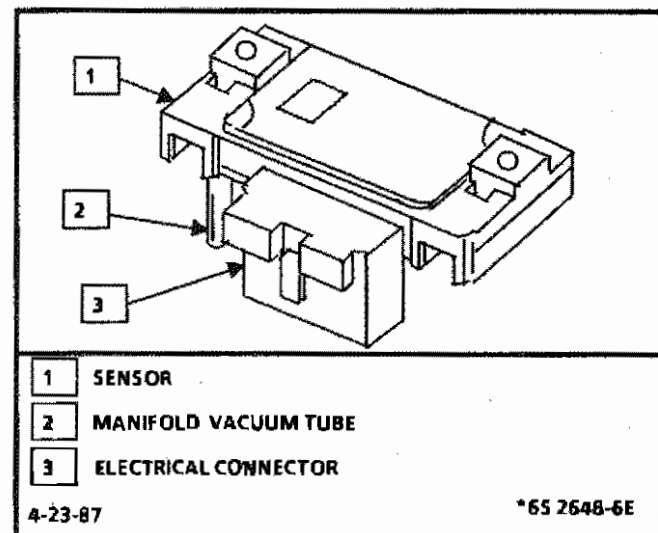
### Engine Coolant Temperature Sensor

The coolant sensor (Figure C1-3) is a thermistor (a resistor which changes value based on temperature) mounted in the engine coolant stream. Low coolant temperature produces a high resistance (100,000 ohms at -40°C/-40°F) while high temperature causes low resistance (70 ohms at 130°C/266°F).

The ECM supplies a 5-volt signal to the coolant sensor through a resistor in the ECM and measures the voltage. The voltage will be high when the engine is cold, and low when the engine is hot. By measuring



**Figure C1-3 - Engine Coolant Temperature Sensor**



**Figure C1-4 - MAP Sensor**

the voltage, the ECM knows the engine coolant temperature. Engine coolant temperature affects most systems the ECM controls.

A failure in the coolant sensor circuit should set either a Code 14 or Code 15. Remember, these codes indicate a failure in the coolant temperature circuit, so proper use of the chart will lead to either repairing a wiring problem or replacing the sensor, to properly repair a problem.

### MAP Sensor

The Manifold Absolute Pressure (MAP) sensor (Figure C1-4) measures the changes in the intake manifold pressure which result from engine load and speed changes, and converts this to a voltage output.

A closed throttle on engine coastdown would produce a relatively low MAP output, while a wide-open throttle would produce a high output. This high output is produced because the pressure inside the manifold is the same as outside the manifold, so you measure 100% of outside air pressure. Manifold Absolute Pressure (MAP) is the OPPOSITE of what you would measure on a vacuum gage. When

manifold pressure is high, vacuum is low. The MAP sensor is also used to measure barometric pressure under certain conditions, which allows the ECM to automatically adjust for different altitudes.

The ECM sends a 5-volt reference signal to the MAP sensor. As the manifold pressure changes, the electrical resistance of the sensor also changes. By monitoring the sensor output voltage, the ECM knows the manifold pressure. A higher pressure, low vacuum (high voltage) requires more fuel, while a lower pressure, higher vacuum (low voltage) requires less fuel. The ECM uses the MAP sensor to control fuel delivery and ignition timing.

A failure in the MAP sensor circuit should set a Code 33 or Code 34.

### Oxygen (O<sub>2</sub>) Sensor

The exhaust oxygen sensor is mounted in the exhaust system where it can monitor the oxygen content of the exhaust gas stream. The oxygen content in the exhaust reacts with the oxygen sensor to produce a voltage output. This voltage ranges from approximately .1 volt (high O<sub>2</sub> - lean mixture) to .9 volt (low O<sub>2</sub> - rich mixture).

By monitoring the voltage output of the O<sub>2</sub> sensor, the ECM will know what fuel mixture command to give to the injector (lean mixture-low voltage-rich command, rich mixture-high voltage-lean command). This voltage can be measured with a digital voltmeter having at least 10 megohms input impedance. Use of standard shop type voltmeters will result in very inaccurate readings.

An open O<sub>2</sub> sensor circuit, should set a Code 13. A shorted sensor circuit should set a Code 44. A high voltage in the circuit should set a Code 45. When any of these codes are set, the car will run in the "Open Loop" mode.

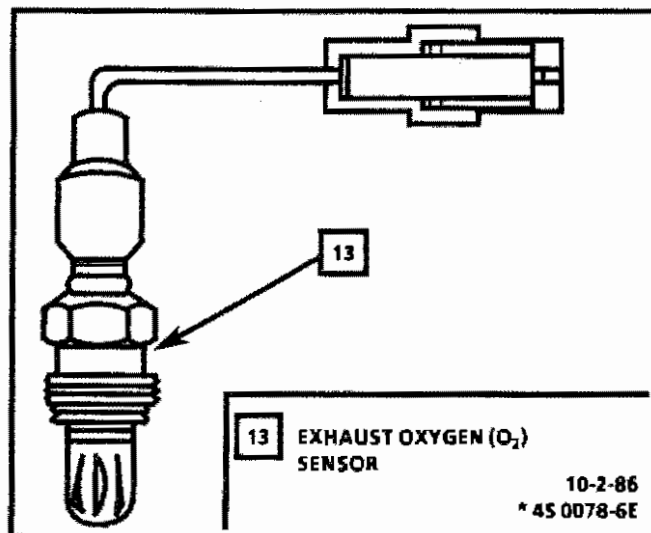


Figure C1-5 - Exhaust Oxygen (O<sub>2</sub>) Sensor

### Throttle Position Sensor (TPS)

The Throttle Position Sensor (TPS) is connected to the throttle shaft on the TBI unit (see Figure C1-6). It is a potentiometer with one end connected to 5 volts from the ECM and the other to ground. A third wire is connected to the ECM to measure the voltage from the TPS. As the throttle valve angle is changed (accelerator pedal moved), the output of the TPS also changes. At a closed throttle position, the output of the TPS is low (approximately .48 volt). As the throttle valve opens, the output increases so that, at wide-open throttle, the output voltage should be approximately 4.5 volts.

By monitoring the output voltage from the TPS, the ECM can determine fuel delivery based on throttle valve angle (driver demand). If the sensor CKT is open, the ECM will set a Trouble Code 22. If the circuit is shorted, the ECM will think the vehicle is at WOT, and a Trouble Code 21 will be set. A broken or loose TPS can cause intermittent bursts of fuel from the injector, and an unstable idle, because the ECM thinks the throttle is moving. Once a Trouble Code is set, the ECM will use an artificial value for TPS, and some vehicle performance will return.

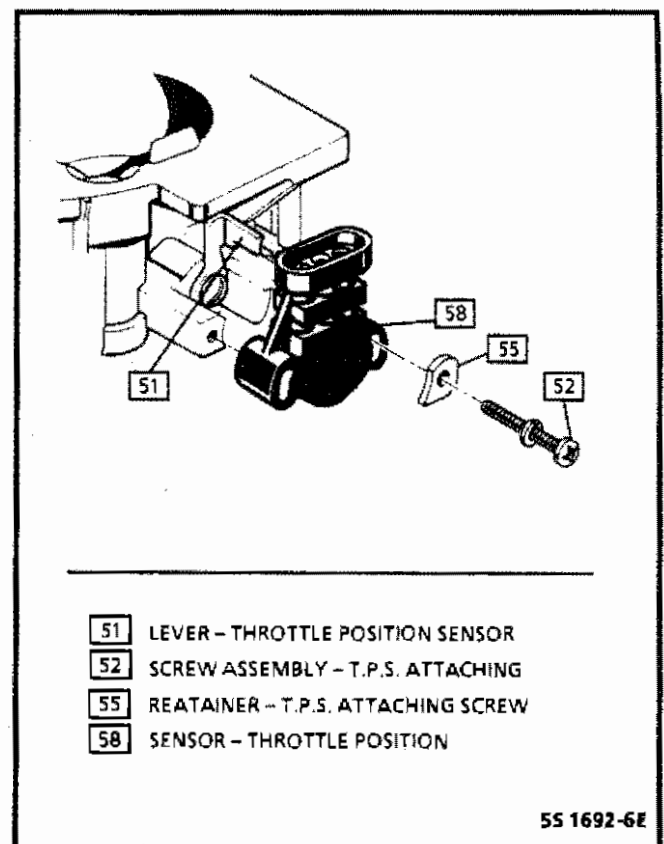


Figure C1-6 - Throttle Position Sensor (Typical)

### Knock Sensor

The knock sensor is mounted in the engine block. When abnormal engine vibrations (spark knock) are present, the sensor produces a voltage signal, which is sent to the ESC module.

See Section "C5" for further information on the electronic spark control (ESC) system.

### Crank Signal

The ECM looks at the starter solenoid to tell when the engine is cranking. It uses this to tell when the car is in the Starting Mode.

If this signal is not available, car may be hard to start in extremely cold weather.

### A/C Request Signal

This signal tells the ECM that the A/C selector switch is turned "ON," and that the high side low pressure switch is closed. The ECM uses this to adjust the idle speed when the air conditioning is working.

### Vehicle Speed Sensor (VSS)

The Vehicle Speed Sensor (VSS) sends a pulsing voltage signal to the ECM, which the ECM converts to miles per hour.

### Distributor Reference Signal

The distributor sends a signal to the ECM to tell it both engine rpm and crankshaft position. See "EST System" for further information.

## DIAGNOSIS

Since the ECM can have a failure which may effect only one circuit, following the diagnostic procedures in this section can reliably tell when a failure has occurred in the ECM. Also, a Code 55 indicates a failure of the ECM.

If a diagnostic chart indicates that the ECM connections or ECM is the cause of a problem, and the ECM is replaced, but does not correct the problem, one of the following may be the reason:

- There is a problem with the ECM terminal connections. - The diagnostic chart will say ECM connections or ECM. The terminals may have to be removed from the connector in order to check them properly.

- The ECM or PROM is not correct for the application. - The incorrect ECM or PROM may cause a malfunction and may or may not set a code.

- The problem is intermittent. - This means that the problem is not present at the time the system is being checked. In this case, refer to the "Symptoms" portion of the manual and make a careful physical inspection of all portions of the system involved.

- Shorted solenoid, relay coil, or harness. - Solenoids and relays are turned "ON" and "OFF" by the ECM, using internal electronic switches called "drivers." Each driver is part of a group of four called "quad-drivers."

A shorted solenoid, relay coil, or harness to the computer will not damage the ECM, but will cause the circuit and controlled component to be inoperative. When the circuit fault is not present or has been repaired, the "quad-driver" will again operate in a normal manner due to its fault protected design. If a fault has been repaired in a circuit controlled by a "quad-driver," the original ECM should be reinstalled and the circuit checked for proper operation. ECM replacement will not be necessary if the repaired circuit or component now operates correctly.

J 34636 tester or equivalent provide a fast, accurate means of checking for a shorted coil or a short to battery voltage.

- The PROM may be faulty. - Although the PROM rarely fails, it operates as part of the ECM. Therefore, it could be the cause of the problem. Substitute a known good PROM.

- The replacement ECM may be faulty. - After the ECM is replaced, the system should be rechecked for proper operation. If the diagnostic chart again indicates the ECM is the problem, substitute a known good ECM. Although this is a rare condition, it could happen.

The components or circuits and the codes or charts, related to them are:

- Code 55 indicates a failure of the ECM.
- PROM - Code 51.
- Coolant Temperature Sensor - Codes 14-15.
- MAP Sensor - Codes 33 or 34. To check the sensor with no code set, use CHART C-1D.
- TPS - Codes 21 or 22.
- Crank Signal - CHART C-1B
- O<sub>2</sub> Sensor - Codes 13, 44, 45.

- A/C Request signal - If the A/C request signal is not reaching the ECM, it can cause rough idle, with A/C "ON." See "Rough Idle" in Section "B", "Symptoms."
- VSS - Code 24.
- Distributor - Code 42 indicates an EST failure.
- Distributor - CHART C-4 ignition system check.

## ECM

A faulty ECM will be determined in the diagnostic charts, or by a Code 55.

## PROM

An incorrect or faulty PROM, which is part of the ECM, may set a Code 51.

## ECM INPUTS

All of the sensors and input switches can be diagnosed by the use of a "Scan" tool. Following is a short description of how the sensors and switches can be diagnosed by the use of "Scan." The "Scan" can also be used to compare the values for a normal running engine with the engine you're diagnosing.

### Coolant Temperature Sensor

A "Scan" tool displays engine temperature in degrees centigrade. After the engine is started, the temperature should rise steadily to about 90°C, then stabilize when thermostat opens. A fault in the coolant sensor circuit should set a Code 14 or 15. The code charts also contain a chart to check for sensor resistance values relative to temperature.

### MAP Sensor

A "Scan" tool reads manifold pressure and will display either volts or kPa of pressure.

Key "ON," engine stopped, (no vacuum), MAP will read high voltage or pressure, while at idle (high vacuum), MAP will read low voltage or pressure. Likewise, on acceleration, MAP will read high and on deceleration, will read low.

A failure in the MAP sensor, or circuit, should result in a Code 33 or 34.

## Oxygen (O<sub>2</sub>) Sensor

The "Scan" has several positions that will indicate the state of the exhaust gases, O<sub>2</sub> voltage, integrator, and block learn. See "Scan" position information in Introduction, Section "6E".

A problem in the O<sub>2</sub> sensor circuit should set a Code 13 (open circuit), Code 44 (lean O<sub>2</sub> indication), Code 45 (rich O<sub>2</sub> indication). Refer to applicable chart, if any of these codes were stored in memory.

## Throttle Position Sensor (TPS)

A "Scan" tool displays throttle position in volts. The 2.8L should read under 1.25 volts, with throttle closed and ignition "ON," or at idle. Voltage should increase at a steady rate as throttle is moved toward WOT.

The ECM has the ability to auto-zero the TPS voltage, if it is below about 1.25 volts. This means that any voltage less than 1.25 volts will be determined by the ECM to be 0% throttle. Some "Scan" tools have the ability to read the percentage of throttle angle and should read 0%, when the throttle is closed. A failure in the TPS, or circuit, should set a Code 21 or 22.

## Vehicle Speed Sensor (VSS)

A "Scan" tool reading should closely match with speedometer reading, with drive wheels turning. A failure in the VSS circuit should set a Code 24.

## A/C Request Signal

If the low pressure switch is closed and A/C is "ON," the "Scan" tool should indicate A/C "ON." See Section "C10" for A/C electrical system diagnosis.

## Distributor Reference Signal

A "Scan" tool will read this signal and is displayed in rpm. See Section "C4", for more information on the ignition system.

## Knock Signal

A "Scan" tool will indicate when the ESC module signals the ECM that knock is present. See Section "C5" for further information on the ESC system.

## ON-CAR SERVICE

## ELECTRONIC CONTROL MODULE (ECM)

**NOTICE:** To prevent possible Electrostatic Discharge damage to the ECM, Do Not touch the connector pins or soldered components on the circuit.

Service of the ECM should normally consist of either replacement of the ECM or a PROM change.

If the diagnostic procedures call for the ECM to be replaced, the engine calibrator (PROM) and ECM should be checked first to see if they are the correct parts. If they are, remove the PROM from the faulty ECM and install it in the new service ECM. THE SERVICE ECM WILL NOT CONTAIN A PROM. Trouble Code 51 indicates the PROM is installed improperly or has malfunctioned. When Code 51 is obtained, check the PROM installation for bent pins or pins not fully seated in the socket. If the PROM is installed correctly and Code 51 still shows, replace the PROM.

### ⚠ Important

When replacing the production ECM with a service ECM (controller), it is important to transfer the Broadcast code and production ECM number to the service ECM label. Please do not record on ECM cover. This will allow positive identification of ECM parts throughout the service life of the vehicle.

**NOTICE:** To prevent internal ECM damage, the ignition must be "OFF" when disconnecting or reconnecting power to ECM (for example, battery cable, ECM pigtail, ECM fuse, jumper cables, etc.).

### ↔ Remove or Disconnect

1. Negative battery cable.
2. Center console.
3. Connectors to ECM.
4. ECM.
5. PROM from ECM.

### ↔ Install or Connect

1. Old PROM in new ECM.
2. ECM into car.
3. Connectors.
4. Center console.
5. Negative battery cable.

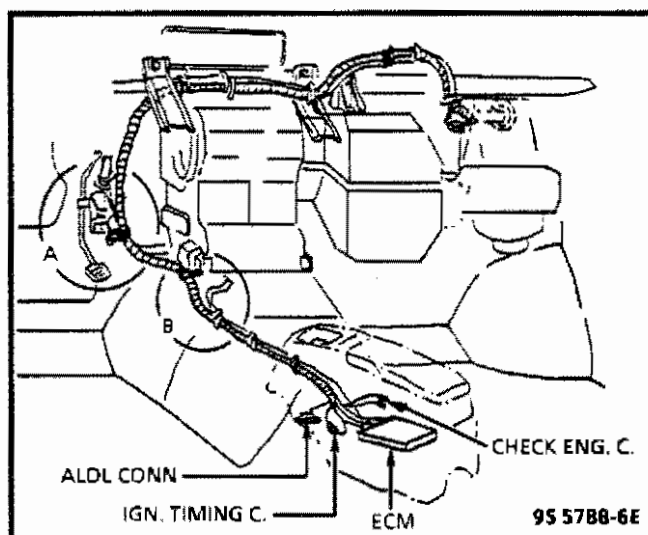


Figure C1-7 - ECM Mounting

## PROM

**NOTICE:** To prevent possible Electrostatic Discharge damage to the PROM, CALPAK or Mem-Cal, Do Not touch the component leads, and Do Not remove integrated circuit from carrier.

Code 51 indicates a faulty PROM, bent pins, or incorrect installation.

### ⚠ Important

It is possible to install a PROM backward. If the PROM is installed backward and the ignition key turned to "ON," the PROM circuitry will be destroyed, requiring PROM replacement.

### ⚠ Important

The ignition should always be "OFF" when installing or removing the ECM connectors.

### ↔ Remove or Disconnect

1. Connectors from ECM.
2. ECM mounting hardware.
3. ECM from center console area.
4. Prom access cover (see Figure C1-8).
5. Remove PROM assembly.

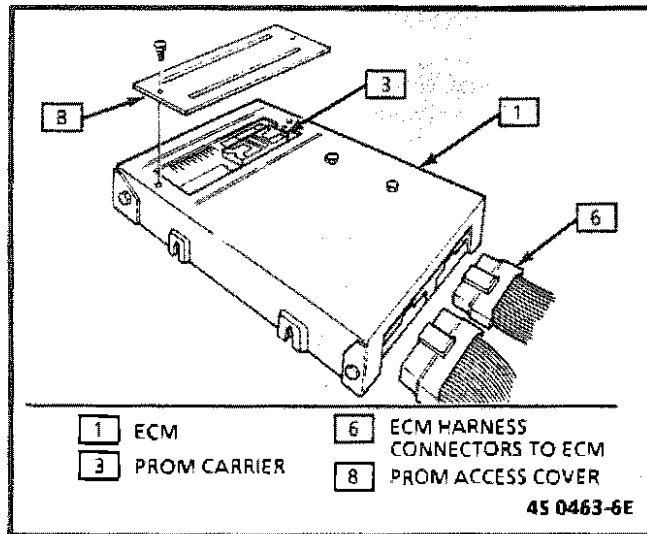


Figure C1-8 - PROM Access Cover

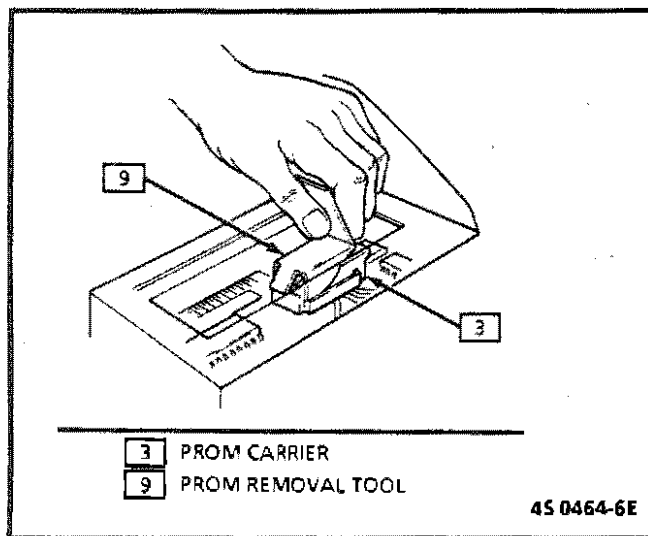


Figure C1-9 - PROM Removal Tool

### Important

Using the rocker-type PROM removal tool, engage one end of the PROM carrier with the hook end of the tool (see Figure C1-9). Press on the vertical bar end of the tool and rock the engaged end of the PROM carrier up as far as possible. Engage the opposite end of the PROM carrier in the same manner and rock this end up as far as possible. Repeat this process until the PROM carrier and PROM are free of the PROM socket. The PROM carrier with PROM in it should lift off of the PROM socket easily. PROM carrier should only be removed by using the pictured PROM removal tool. Other methods could cause damage to the PROM or PROM socket.

### Remove or Disconnect

1. New PROM carrier in PROM socket.

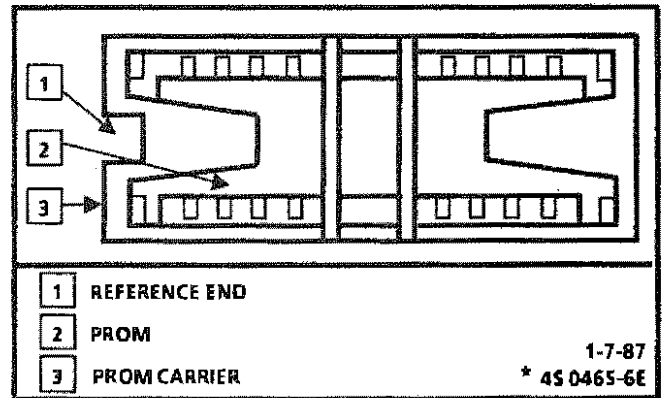


Figure C1-10 - PROM in PROM Carrier

### Inspect

1. New PROM for same part number as old.

### Important

Do Not remove PROM from carrier to check PROM number.  
For correct reference of PROM in carrier, see Figure C1-10.

### Important

Small notch of carrier should be aligned with small notch in socket. Press on PROM carrier until it is firmly seated in the socket. Do not press on PROM; only the carrier.

2. Access cover on ECM.
3. ECM in center console area.
4. Connectors to ECM.

### Functional Check

1. Turn ignition "ON."
2. Enter diagnostics (see "Diagnostic Circuit Check" for procedure).
  - A. Allow Code 12 to flash four times to verify no other codes present. This indicates the PROM is installed properly.
  - B. If trouble Code 51 occurs or if the "Check Engine" light is "ON" constantly with no codes, the PROM is not fully seated, installed backwards, has bent pins, or is defective.
    - If not fully seated, press firmly on PROM carrier.
    - If it is necessary to remove the PROM, follow instructions in steps "A" and "B".
    - If installed backwards, REPLACE THE PROM.
    - If pins bend, remove PROM, straighten pins, and reinstall. If bent pins break or crack during straightening, discard PROM and replace it.

**NOTICE:** Any time the PROM is installed backward and the ignition switch turned "ON," the PROM is destroyed.

## CALPAK

### ↔ Remove or Disconnect

1. Remove ECM access cover.
2. Remove CALPAK (Figure C1-11) using removal tool shown. Grasp the CALPAK carrier at the narrow end only. Gently rock the carrier from end to end while applying a firm upward force.

### 🔍 Inspect

3. Inspect reference end of the CALPAK carrier and carefully set aside. Do not remove CALPAK from the carrier to confirm CALPAK correctness. Notch in CALPAK referenced to smaller notch in carrier and the (1).

### ↔ Install or Connect

4. Install CALPAK. If a service CALPAK is being installed, make sure it has the same part number as the removed CALPAK. Do not press on the CALPAK - only the carrier. Small notch of the carrier must be aligned with small notch in socket. Press on CALPAK carrier until it is firmly seated in the socket.
5. Install ECM access cover.
6. Install ECM in back in proper location and perform a "Diagnostic Circuit Check" to confirm proper installation.

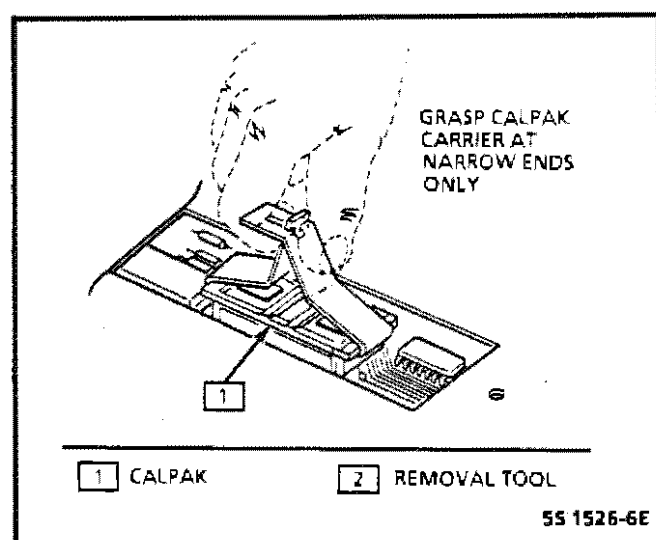


Figure C1-11 - Removing CALPAK

## COOLANT SENSOR

**NOTICE:** Care must be taken when handling coolant sensor. Damage to coolant sensor will affect proper operation of the fuel injection system.

### ↔ Remove or Disconnect

1. Negative battery cable.
2. Electrical connector.
3. Carefully back out coolant sensor.

### ↔ Install or Connect

1. Sensor in engine.
2. Electrical connector.
3. Negative battery cable.

## MAP SENSOR

Other than checking for loose hoses and electrical connections the only service possible is unit replacement if diagnosis shows sensor to be faulty. Figure C1-12 shows location and replacement of MAP sensor.

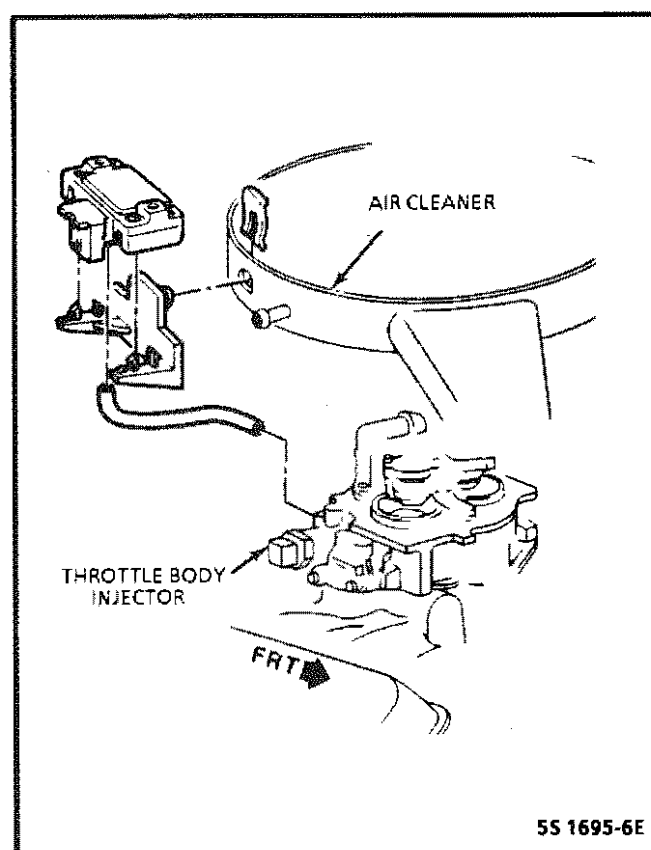


Figure C1-12 - MAP Sensor Service

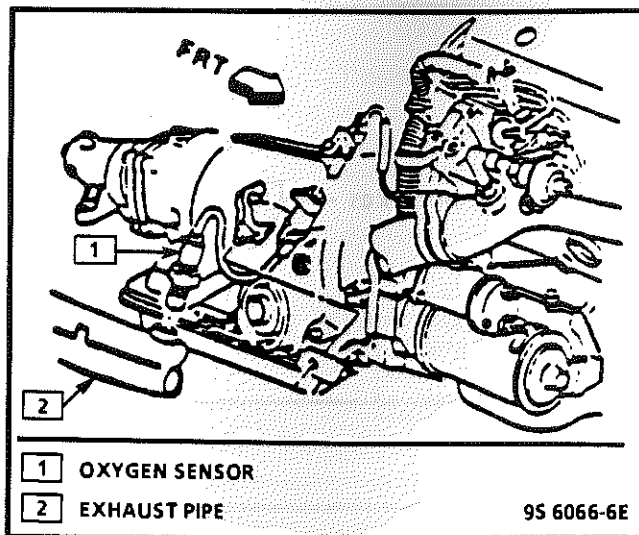


Figure C1-13 - Oxygen Sensor

**O<sub>2</sub> SENSOR**

**NOTICE:** The oxygen sensor uses a permanently attached pigtail and connector. This pigtail should not be removed from the oxygen sensor. Damage or removal of the pigtail or connector could affect proper operation of the oxygen sensor.

**! Important**

Use care when handling the oxygen sensor. The in-line electrical connector and louvered end must be kept free of grease, dirt or other contaminants. Also, avoid using cleaning solvents of any type. Do not drop or roughly handle the oxygen sensor.

**↔ Remove or Disconnect**

1. Negative battery cable.
2. Electrical connector.
3. Carefully back out oxygen sensor.

The oxygen sensor may be difficult to remove when engine temperature is below 48°C (120°F). Excessive force may damage threads in the exhaust pipe.

**→→ Install or Connect****! Important**

A special anti-seize compound is used on the oxygen sensor threads. The compound consists of a liquid graphite and glass beads. The graphite will tend to burn away, but the glass beads will remain, making the sensor easier to remove.

New or service sensors will already have the compound applied to the threads. If a sensor is removed from an engine, and, if for any reason it is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

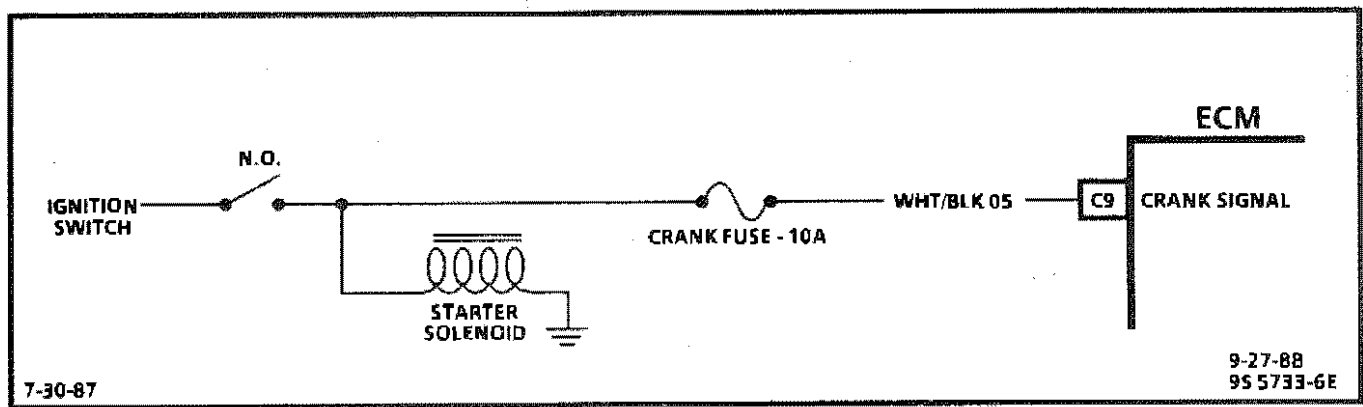
1. Coat threads of oxygen sensor with anti-seize compound or equivalent if necessary.
2. Sensor, and torque to 41 N·m (30 ft. lbs.).
3. Electrical connector.
4. Negative battery cable.

**THROTTLE POSITION SENSOR (TPS)****↔ Remove or Disconnect**

1. Air cleaner.
2. Electrical connector.
3. Two TPS attaching screws, lockwashers and retainers.
4. Sensor.

**→→ Install or Connect**

1. With throttle valve in the normal closed idle position, install throttle position sensor on throttle body assembly, making sure TPS pickup lever is located ABOVE tang on throttle actuator lever.
2. Retainers and two TPS screws and lockwashers using a thread locking compound on the screws. Use loctite 262, or equivalent. Tighten screws.
3. Connector.
4. Air cleaner.



**CHART C-1B**  
**CRANK SIGNAL**  
**2.8L (VIN R) "KT" (TBI)**

**Circuit Description:**

Crank signal is a 12 volt signal to the ECM during cranking to allow enrichment and cancel diagnostics until engine is running 12 volts is no longer on circuit.

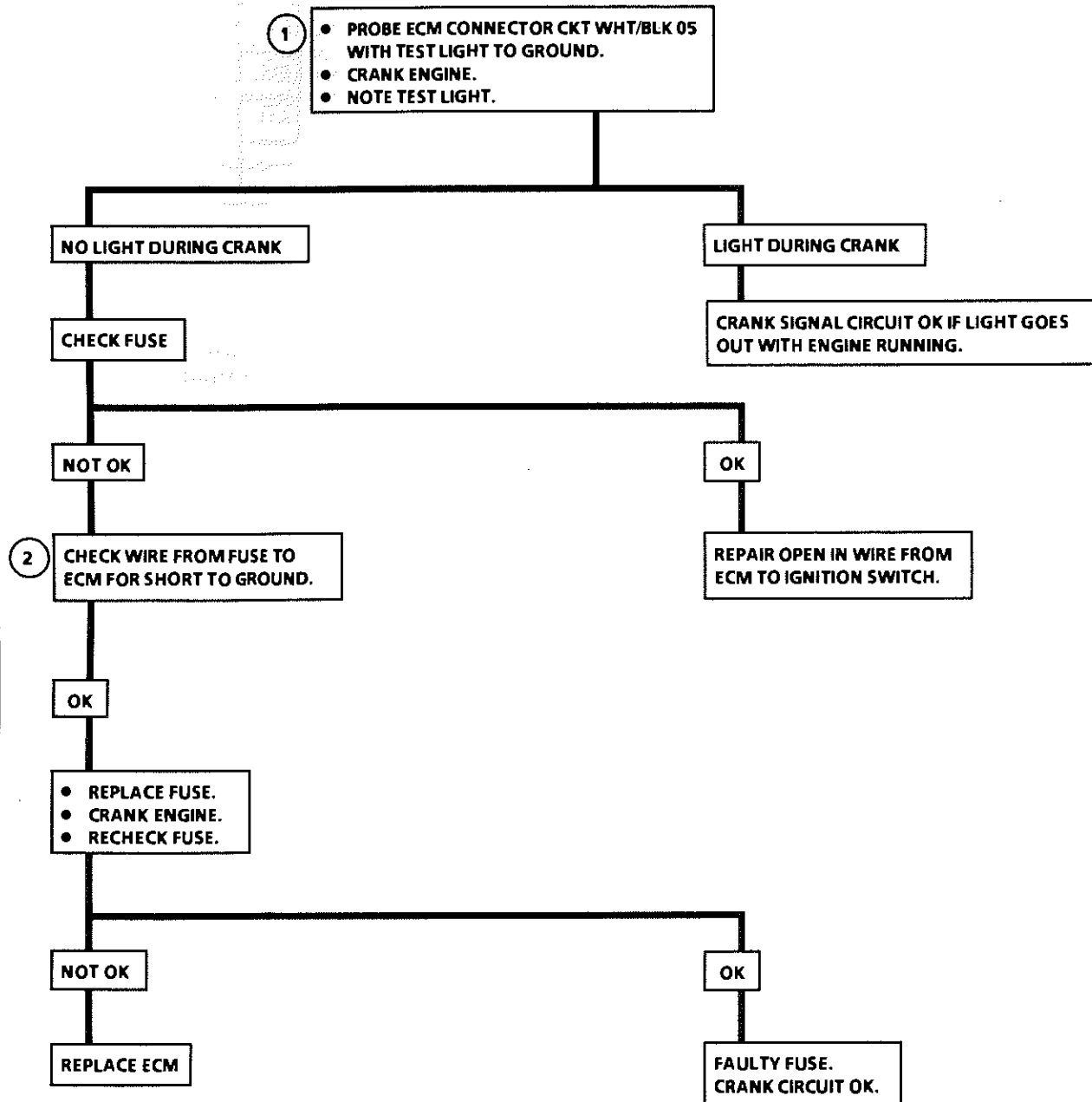
**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Checks for normal (cranking) voltage to terminal "C9" of ECM. Test light should be "ON" during cranking.
2. Checks to determine if source of blown fuse was a faulty ECM.

# CHART C-1B

## CRANK SIGNAL

### 2.8L (VIN R) "KT" (TBI)



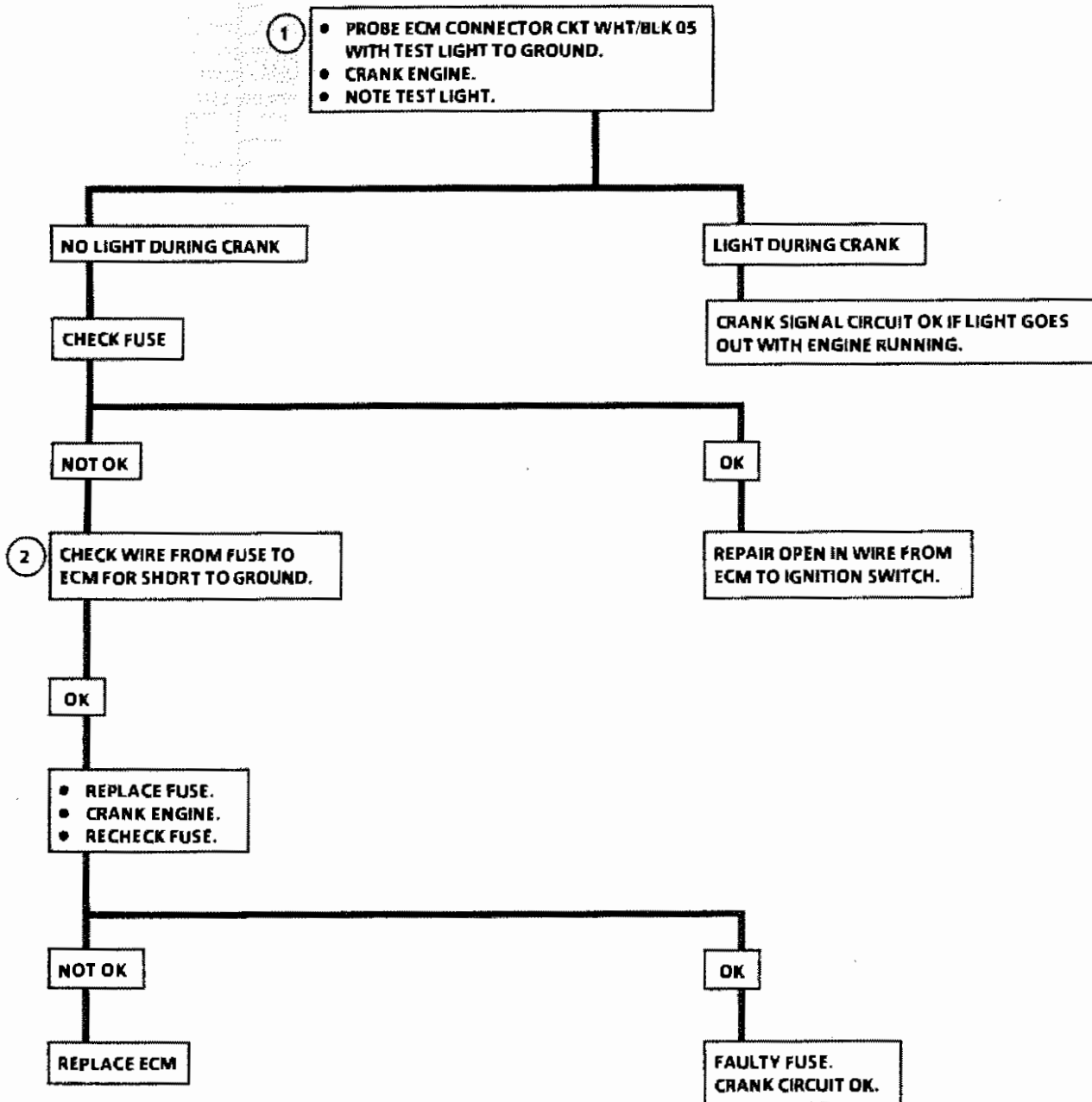
CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
9S 5734-6E

# CHART C-1B

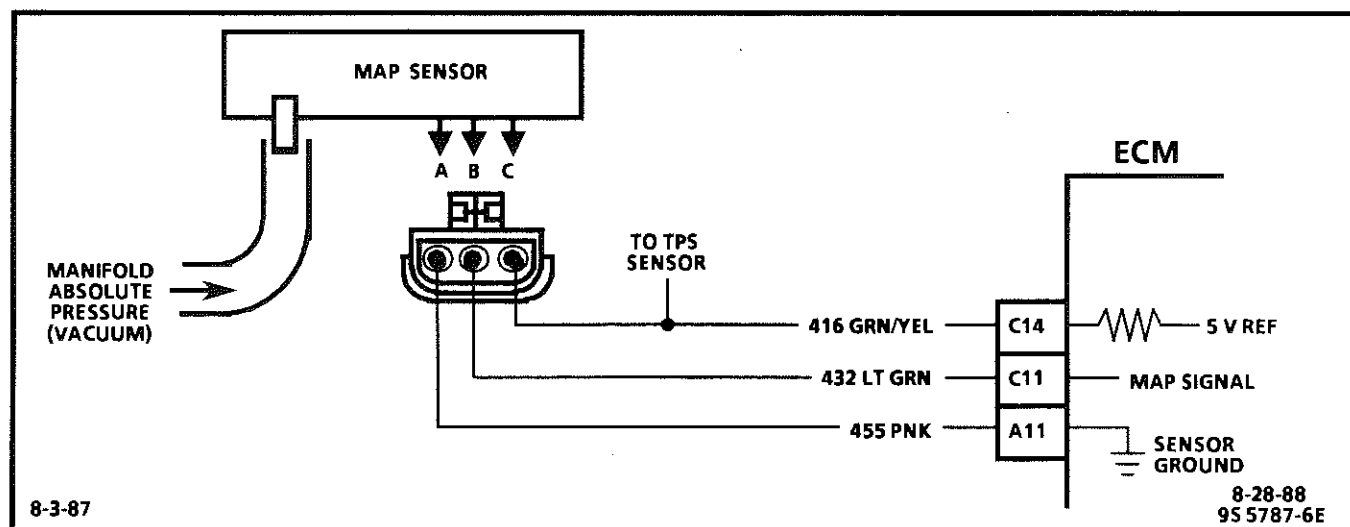
## CRANK SIGNAL

### 2.8L (VIN R) "KT" (TBI)



CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

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### CHART C-1D

#### MAP OUTPUT CHECK 2.8L (VIN R) "KT" (TBI)

##### Circuit Description:

The Manifold Absolute Pressure (MAP) sensor measures manifold pressure (vacuum) and sends that signal to the ECM. The ECM uses this information for fuel and spark control.

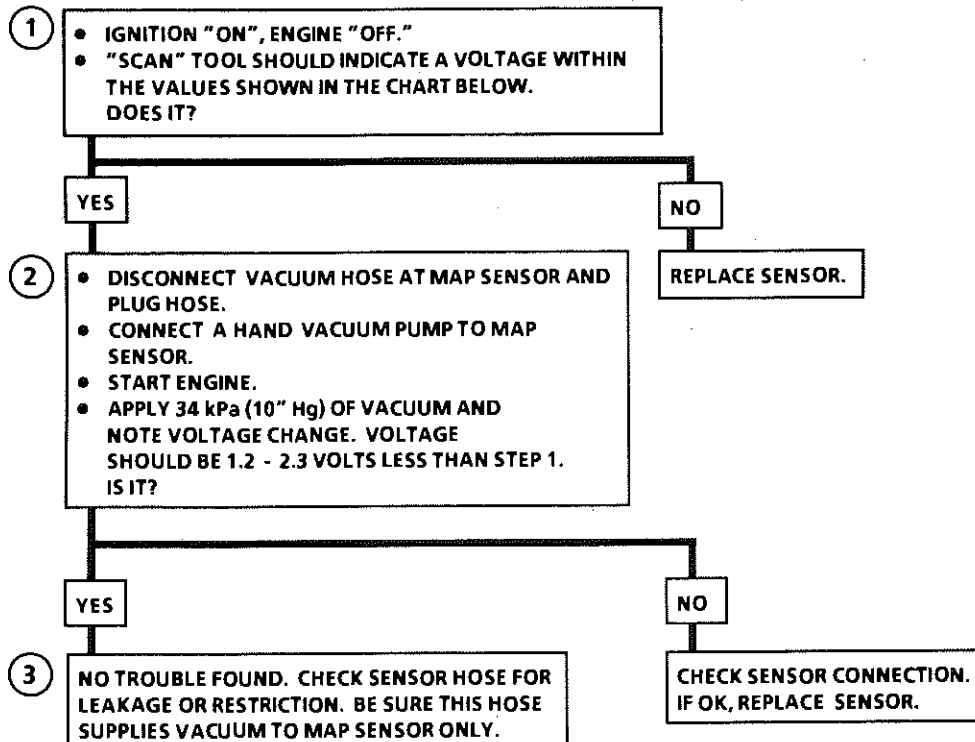
**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

- Checks MAP sensor output voltage to the ECM. This voltage, without engine running, represents a barometer reading to the ECM.
- Applying 34 kPa (10 inches Hg) vacuum to the MAP sensor should cause the voltage to be 1.2 volts less than the voltage at Step 1. Upon applying vacuum to the sensor, the change in voltage should be instantaneous. A slow voltage change indicates a faulty sensor.
- Check vacuum hose to sensor for leaking or restriction. Be sure no other vacuum devices are connected to the MAP hose.  
With the ignition "ON" and the engine stopped, the manifold pressure is equal to atmospheric pressure and the signal voltage will be high. This information is used by the ECM as an indication of vehicle altitude and is referred to as BARO. Comparison of this BARO reading with a known good vehicle with the same sensor is a good way to check accuracy of a "suspect" sensor. Reading should be the same  $\pm .4$  volt.

# CHART C-1D

## MAP OUTPUT CHECK

### 2.8L (VIN R) "KT" (TBI)



| ALTITUDE   |               | VOLTAGE RANGE |
|------------|---------------|---------------|
| Meters     | Feet          |               |
| Below 305  | Below 1,000   | 3.8---5.5V    |
| 305---610  | 1,000--2,000  | 3.6---5.3V    |
| 610---914  | 2,000--3,000  | 3.5---5.1V    |
| 914--1219  | 3,000--4,000  | 3.3---5.0V    |
| 1219--1524 | 4,000--5,000  | 3.2---4.8V    |
| 1524--1829 | 5,000--6,000  | 3.0---4.6V    |
| 1829--2133 | 6,000--7,000  | 2.9---4.5V    |
| 2133--2438 | 7,000--8,000  | 2.8---4.3V    |
| 2438--2743 | 8,000--9,000  | 2.6---4.2V    |
| 2743--3048 | 9,000--10,000 | 2.5---4.0V    |

LOW ALTITUDE = HIGH PRESSURE = HIGH VOLTAGE

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

9-28-88  
95 5998-6E

**BLANK**

## SECTION C2

### FUEL METERING SYSTEM

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### GENERAL DESCRIPTION

#### PURPOSE

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered by the Throttle Body Injection (TBI) unit, which is controlled by the Electronic Control Module (ECM).

The main control sensor is the oxygen ( $O_2$ ) sensor, which is located in the exhaust manifold. The  $O_2$  sensor tells the Engine Control Module (ECM) the amount of oxygen in the exhaust gas, and the ECM changes the air/fuel ratio to the engine by controlling the fuel injector. A 14.7:1 air/fuel ratio is required for efficient catalytic converter operation. Because of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a "Closed Loop" system (Figure C2-1).

#### MODES OF OPERATION

The ECM monitors voltages from several sensors to determine how much fuel to give the engine. The fuel is delivered under one of several conditions, called "modes." All the modes are controlled by the ECM.

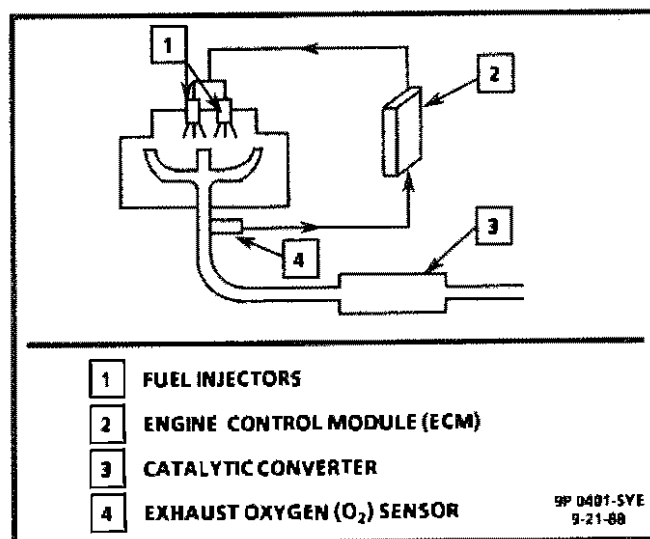


Figure C2-1 - "Closed Loop" System

#### Starting Mode

When the key is first turned "ON," the ECM turns "ON" the fuel pump relay for two seconds, and the fuel pump builds up pressure to the TBI unit. The ECM checks the coolant temperature sensor, Throttle Position Sensor (TPS), Manifold Absolute Pressure (MAP) sensor, and crank signal, then determines the proper air/fuel ratio for starting. This ranges from

## 6E2-C2-2 DRIVEABILITY AND EMISSIONS

1.5:1 at -36°C (-33°F) to 14.7:1, at 94°C (201°F) coolant temperature.

The ECM controls the amount of fuel delivered in the starting mode by changing how long the injector is turned "ON" and "OFF." This is done by "pulsing" the injector for very short times.

### Clear Flood Mode

If the engine floods, clear it by pushing the accelerator pedal down all the way. The ECM then pulses the injector at a 20:1 air/fuel ratio, and holds this injector rate as long as the throttle stays wide open, and the engine is below 600 rpm. If the throttle position becomes less than 80%, the ECM returns to the starting mode.

### Run Mode

The run mode has two conditions called "Open Loop" and "Closed Loop."

#### Open Loop

When the engine is first started, and it is above 400 rpm, the system goes into "Open Loop" operation. In "Open Loop," the ECM ignores the signal from the (O<sub>2</sub>) sensor, and calculates the air/fuel ratio based on inputs from the coolant temperature and MAP sensors.

The system stays in "Open Loop" until the following conditions are met:

1. The O<sub>2</sub> sensor has varying voltage output, showing that it is hot enough to operate properly. (This depends on temperature.)
2. The coolant temperature sensor is above a specified temperature.
3. A specific amount of time has elapsed after starting the engine.
4. The throttle is above idle.

#### Closed Loop

The specific values for the above conditions vary with different engines, and are stored in the programmable read only memory (PROM). When these conditions are met, the system goes into "Closed Loop" operation. In "Closed Loop," the ECM calculates the air/fuel ratio (injector on-time) based on the signal from the O<sub>2</sub> sensor. This allows the air/fuel ratio to stay very close to 14.7:1.

### Acceleration Mode

The ECM looks at rapid changes in throttle position and manifold pressure, and provides extra fuel.

### Deceleration Mode

When deceleration occurs, the fuel remaining in the intake manifold can cause excessive emissions and backfiring. Again, the ECM looks at changes in throttle position and manifold pressure and reduces the amount of fuel. When deceleration is very fast, the ECM can cut off fuel completely for short periods of time.

### Battery Voltage Correction Mode

When battery voltage is low, the ECM can compensate for a weak spark delivered by the distributor by:

- Increasing injector "ON" time of fuel delivered.
- Increasing the idle rpm.

### Fuel Cutoff Mode

No fuel is delivered by the injectors when the ignition is "OFF." This prevents dieseling. Also, fuel is not delivered if no reference pulses are seen from the distributor, which means the engine is not running.

## FUEL METERING SYSTEM COMPONENTS

The fuel metering system (see Figure C2-2) consists of the following:

- Fuel supply components (fuel tank, pump and lines)
- Fuel pump electrical circuit.
- Throttle body injection (TBI) unit.

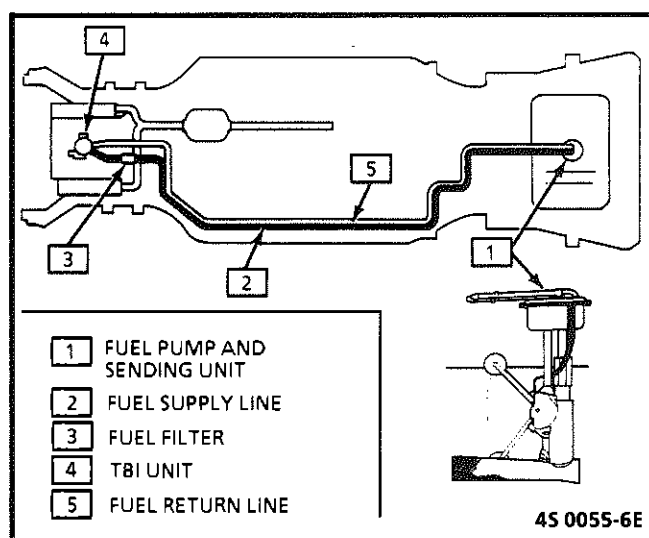


Figure C2-2 - Fuel Metering System

## FUEL SUPPLY SYSTEM

The fuel supply is stored in the fuel tank. An electric fuel pump, located in the fuel tank with the gage sending unit, pumps fuel through an in-line fuel filter to the Throttle Body Injection (TBI) unit. The pump is designed to provide fuel at a pressure above the pressure needed by the injectors. A pressure regulator, an integral part of the TBI assembly, keeps fuel available to the injectors at a regulated pressure. Unused fuel is returned to the fuel tank by a separate line. (See Section "02" for replacement procedures covering the fuel tank, fuel pump, in-line filter and fuel lines.)

## FUEL PUMP ELECTRICAL CIRCUIT

When the ignition switch is turned to the "ON" position (engine not running), the ECM turns the fuel pump relay "ON" for two seconds, causing the fuel pump to pressurize the fuel system. If the ECM does not receive ignition reference pulses (engine cranking or running) within two seconds, it will shut "OFF" the fuel pump relay, causing the fuel pump to stop.

As a backup system to the fuel pump relay, the fuel pump can also be turned "ON" by the oil pressure switch. The oil pressure sender has two internal circuits. One operates the oil pressure indicator or gage in the instrument cluster, and the other is a normally open switch which closes when oil pressure reaches about 28 kPa (4 psi). If the fuel pump relay fails, a Code 54 will be set in the ECM, and the oil pressure switch will run the fuel pump.

An inoperative fuel pump relay can result in long cranking times, particularly if the engine is cold. The oil pressure switch will turn "ON" the fuel pump as soon as oil pressure reaches about 28 kPa (4 psi).

## THROTTLE BODY INJECTION (TBI) UNIT

The Model 220 unit (Figure C2-3) consists of three major assemblies:

- Fuel Meter Cover
  - Fuel pressure regulator
- Fuel Meter Body
  - Fuel injectors
- Throttle Body

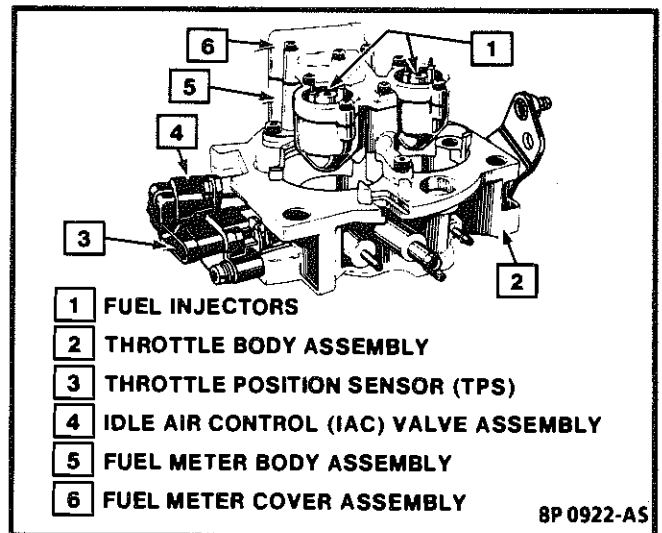


Figure C2-3 - Model 220 Throttle Body Injection Unit

- Two throttle valves to control air flow into the engine
- Idle air control (IAC) valve
- Throttle position sensor (TPS)
- Vacuum ports located at, above, or below the throttle valves to generate vacuum signals to various controls and accessories.

## Fuel Injectors

A fuel injector (Figure C2-4) is a solenoid-operated device controlled by the ECM. When the ECM energizes the solenoid, a normally closed ball valve is lifted off its seat. The pressurized fuel is injected in a conical spray pattern against the walls of the throttle bore above the throttle valve. The fuel which is not used by the injector passes through the pressure regulator before being returned to the fuel tank. Model 220 TBI uses two injectors designed with the flow capacity required for the engine application.

A fuel injector which does not open may cause a no-start condition. An injector which is stuck partly open will cause a loss of pressure after setting, so long crank times would be noticed. Also, dieseling could occur because some fuel would be delivered to the engine after the key is turned "OFF." An injector stuck completely open will cause a stall or no-start condition.

## Pressure Regulator

The pressure regulator (see Figure C2-4) is an integral part of the fuel meter cover, and contains an air chamber and a fuel chamber that are separated by a diaphragm-operated relief valve and a calibrated spring. The function of the regulator is to maintain constant pressure drop across the injector at all times. Fuel pressure is regulated by the difference between fuel pump pressure acting on one side of the diaphragm and the force of the calibrated spring (and air cleaner pressure) acting on the other side. The system operates in an acceptable pressure range of 62 to 90 kPa (9 to 13 psi). The fuel meter cover includes a bleed that relieves system pressure when the engine is turned "OFF." The bleed also helps purge vapors from the injector and regulator after a hot restart.

If the pressure regulator in the TBI supplies pressure which is too low (below 62 kPa or 9 psi), poor performance could result. If the pressure is too high, excess emissions and unpleasant exhaust odor may result.

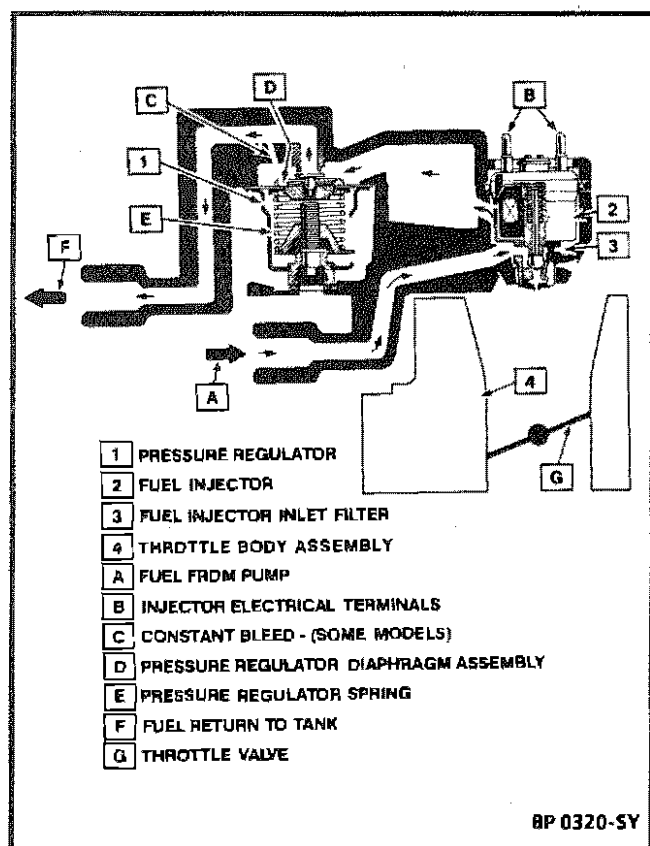


Figure C2-4 - TBI 220 Fuel Flow Diagram

## Idle Air Control (IAC) Valve

Engine idle speed is controlled by the ECM through the idle air control (IAC) valve mounted on the throttle body (Figures C2-5, 6). The ECM sends voltage pulses to the IAC motor windings causing the IAC pintle to move "IN" or "OUT" a given distance (number of steps) for each pulse, called counts. The

pintle movement controls the airflow bypassing the throttle valves, which in turn, controls engine idle speed.

- Engine idle speed is a function of total airflow into the engine based on IACV pintle position + PCV flow + throttle valve opening + calibrated vacuum loss through accessories.
- "Controlled" idle speed is programmed into the ECM, which determines the correct IAC valve pintle position to maintain the desired idle speed for all engine operating conditions and loads.
- The minimum idle air rate is set at the factory with a stop screw. This setting allows enough air flow by the throttle valves to cause the IAC valve pintle to be positioned a calibrated number of steps (counts), from the seat, during "controlled" idle operation.
- If the IAC valve is disconnected and reconnected with the engine running, the idle speed may be wrong. In this case, the IAC valve can be reset by doing the following: depress accelerator pedal slightly, start and run engine for five seconds, then turn ignition "OFF" for ten seconds.

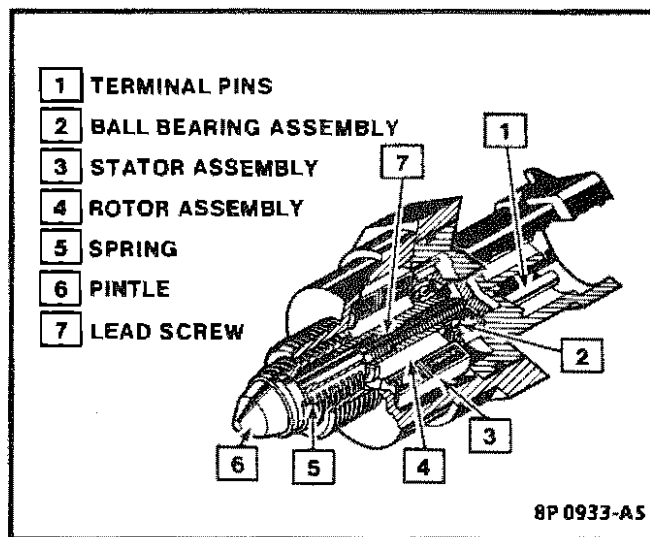


Figure C2-5 - Idle Air Control (IAC) Valve  
Throttle Position Sensor (TPS)

The Throttle Position Sensor (TPS), is mounted on the side of the throttle body opposite the throttle lever assembly. Its function is to sense the current throttle valve position and relay that information to the ECM. Knowledge of throttle position allows the ECM to generate the required injector control signals (pulses). Refer to Section "6E2-C1" for further information.

## DIAGNOSIS

### FUEL METERING SYSTEM

Always start with the "Diagnostic Circuit Check" in Section "6E2-A". This will reduce diagnosis time,

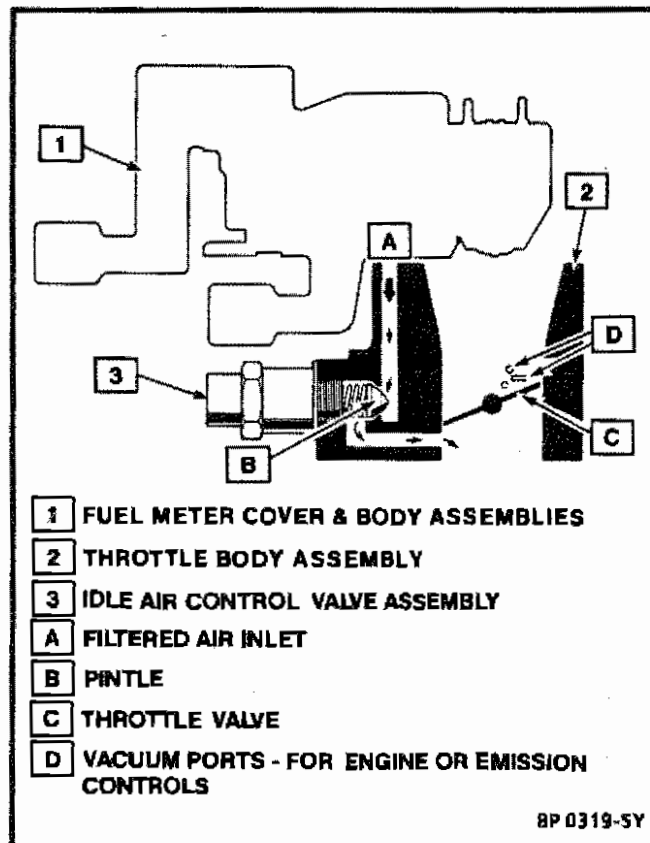


Figure C2-6 - IACV Air Flow Diagram

and prevent unnecessary parts replacement. The diagnosis of the "Fuel Metering System" is covered in CHART A-3, "Engine Cranks but Won't Run," and CHART A-7, "Fuel System Diagnosis." These charts cover the diagnosis of the injectors, pressure regulator, and the fuel pump. Diagnosis of the fuel pump relay and oil pressure switch is covered in the Code 54 Chart.

### Fuel System Pressure Test

#### Tools Required:

- J 29658-B Fuel Pressure Gage
- J 29658-85 Adapter

A fuel system pressure test is part of several of the diagnostic charts and symptom checks. To perform this test, follow this procedure:

- CAUTION:**
- To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before connecting a fuel pressure gage.
  - A small amount of fuel may be released when disconnecting the fuel lines. In order to reduce the chance of personal

injury, cover fuel line fittings with a shop towel before disconnecting, to catch any fuel that may leak out. Place the towel in an approved container when disconnect is completed.

1. Disconnect negative battery terminal to avoid possible fuel discharge if an accidental attempt is made to start the engine.
2. Loosen fuel filler cap to relieve tank vapor pressure.
3. The internal constant bleed feature of TBI Model 220 relieves fuel pump system pressure when the engine is turned "OFF." Therefore, no further pressure relief procedure is required.
4. Disconnect fuel feed hose in engine compartment. Install J 29658B gage and J 29658-85 adapter between steel line and flexible hose.
  - Tighten gage in line to ensure no leaks occur during testing.
5. Connect negative battery terminal.
6. Start car and observe fuel pressure reading. It should be 62 to 90 kPa (9 to 13 psi); if not, refer to CHART A-7.
7. Disconnect negative battery terminal.
8. Loosen fuel filler cap to relieve tank vapor pressure.
9. Remove fuel pressure gage.
10. Install new O-ring on fuel feed line.
11. Reconnect fuel feed line.
12. Connect negative battery terminal.
13. With engine "OFF" and ignition "ON," check for fuel leaks.

### Idle Air Control (IAC) Valve

A "Scan" tool reads IAC position in steps, called "counts." "0" steps indicates the ECM is commanding the IAC to be driven in, to a fully seated position (minimum idle air). The higher the number steps, the more idle air being allowed to pass by the IAC valve.

Refer to CHART C-2C for information to diagnose the function of the IAC valve.

### Driveability

Refer to Section "B" for driveability symptoms related to the fuel control.

## ON-VEHICLE SERVICE

### FUEL PUMP RELAY

The fuel pump relays are located in the fuse box on the left side of engine compartment. For diagnosis of the fuel pump relay circuit, refer to the Code 54 chart.

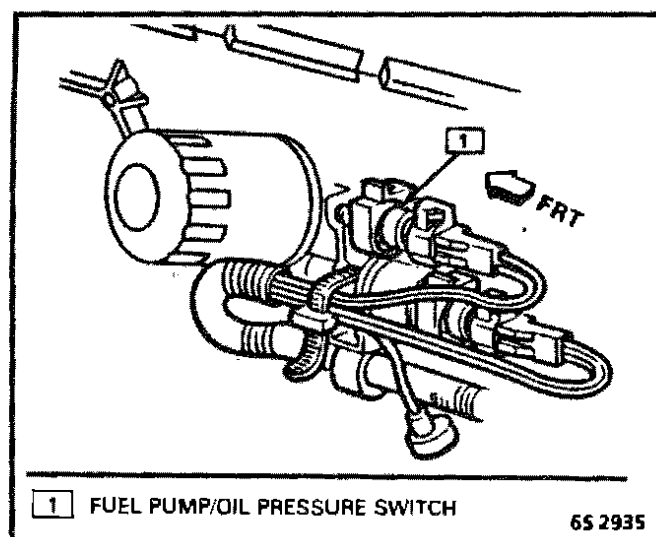


Figure C2-7 - Oil Pressure Switch

### OIL PRESSURE SWITCH

The oil pressure switch is mounted on the engine (Figure C2-7). This switch is a parallel power supply, with the fuel pump relay, and will provide battery voltage to the fuel pump, after approximately 28 kPa (4 psi) oil pressure is reached.

### GENERAL SERVICE INFORMATION

The TBI unit repair procedures cover component replacement with the unit on the vehicle. However, throttle body replacement requires that the complete unit be removed from the engine.

An eight digit part identification number is stamped on the throttle body (Figure C2-8). Refer to this number if servicing or part replacement is required.

Refer to the disassembled view (Figure C2-10) for identification of parts during repair procedures.

- CAUTION:**
- To reduce the risk of fire and personal injury, it is necessary to relieve the fuel system pressure before servicing fuel system components.
  - A small amount of fuel may be released when servicing fuel lines or connections. In order to reduce the chance of personal injury, cover fuel line fittings with a shop towel before disconnecting, to catch any fuel that may leak out. Place the towel in an approved container when disconnect is completed.

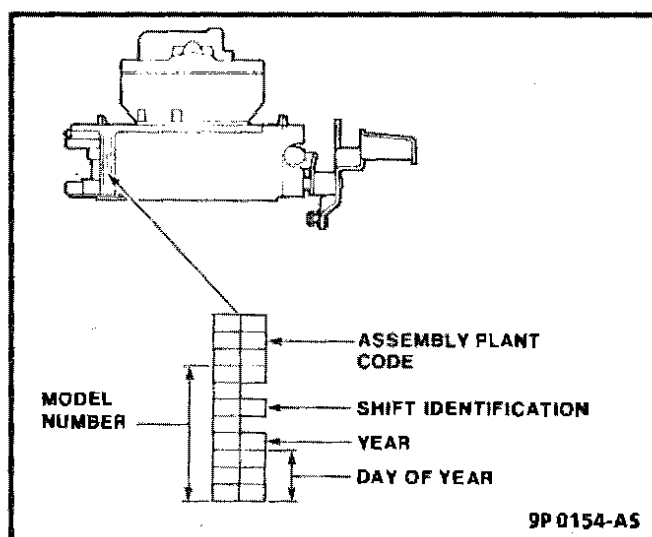


Figure C2-8 - TBI 220 Identification

### Fuel Pressure Relief Procedure

1. Disconnect negative battery terminal to avoid possible fuel discharge if an accidental attempt is made to start the engine.
2. Loosen fuel filler cap to relieve tank vapor pressure.
3. The internal constant bleed feature of TBI Model 220 relieves fuel pump system pressure when the engine is turned "OFF." Therefore, no further pressure relief procedure is required.

### Cleaning Procedures

All TBI component parts, with the exception of those noted below, should be cleaned in a cold immersion cleaner.

**NOTICE:** The Throttle Position Sensor (TPS), Idle Air Control (IAC) valve, fuel meter cover assembly, fuel injectors or other components containing rubber, should NOT be placed in a solvent or cleaner bath. A chemical reaction will cause these parts to swell, harden or distort. Do Not soak the throttle body with the above parts attached. If the throttle body assembly requires cleaning, soaking time in the cleaner should be kept to a minimum. Some models have hidden throttle shaft dust seals that could lose their effectiveness by extended soaking.

## Thread-Locking Compound

Service repair kits are supplied with a small vial of thread-locking compound with directions for use. If material is not available, use Loctite 262 or equivalent.

### TBI UNIT

#### Remove or Disconnect (Figure C2-9)

1. Negative battery terminal.
2. Relieve fuel system pressure.
3. Air cleaner assembly and extension (spacer).
4. Electrical connectors to IAC valve, TPS and fuel injectors.
5. Injector wiring harness.
6. Throttle cable, return spring(s), transmission control cable, and cruise control cable (wherever applicable).
7. Vacuum hoses (noting position of hoses) and bracket.
8. Fuel feed and return lines.
  - Use a back-up wrench on TBI fuel nuts to prevent them from turning.
9. Fuel line O-rings (30, 37) and discard.
10. TBI attaching bolts.
11. TBI unit and flange gasket (70).
  - Discard gasket.

#### Important

- Stuff manifold opening with a shop towel to prevent dirt and other contaminants from entering engine.

#### Clean

**NOTICE:** Use care in cleaning old gasket material from machined aluminum surfaces. Sharp tools may damage sealing surfaces.

- Gasket sealing surfaces.

#### Install or Connect (Figure C2-9)

1. New TBI flange gasket (70).
2. TBI unit.
3. TBI attaching bolts.

#### Tighten

- TBI attaching bolts to 25.0 N·m (18 lb.ft.).
4. New O-rings (30, 37) on fuel lines.
  5. Fuel feed and return lines.

#### Tighten

- Fuel line nuts to 27.0 N·m (20 lb.ft.).
- Use a back-up wrench on the TBI fuel nuts to prevent them from turning.

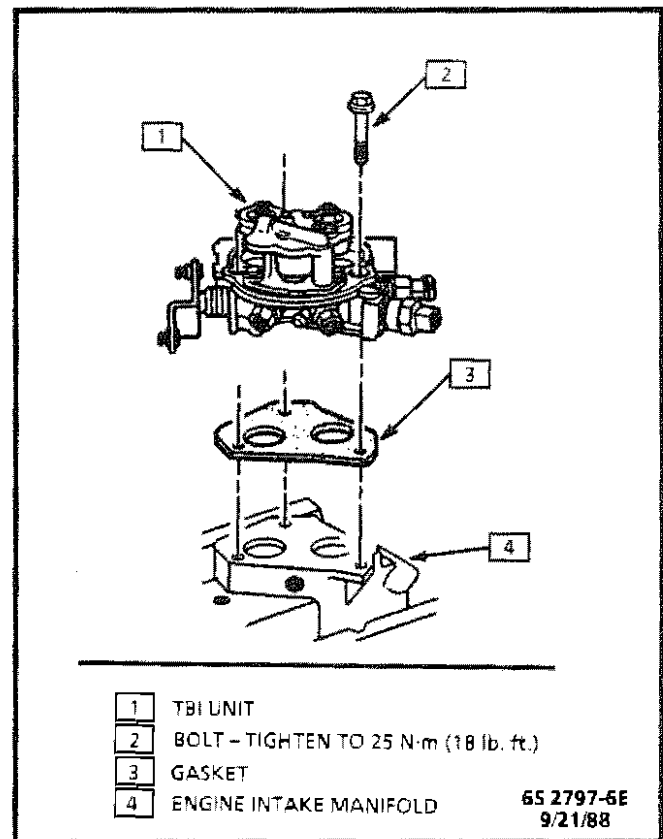


Figure C2-9 - TBI Removal and Installation

6. Vacuum hoses and bracket.
7. Throttle cable, return spring(s), transmission control cable, and cruise control cable (wherever applicable).

#### Important

- Make sure throttle and cruise control cables do not hold throttle open. Refer to Section "6C" "Engine Fuel" for additional information on accelerator controls.

8. Injector wiring harness.
9. Electrical connectors, making sure connectors are fully seated and latched.
10. Negative battery terminal.

#### Inspect

- With engine "OFF," and ignition "ON," check for fuel leaks.
  - With the engine "OFF," check to see that the accelerator pedal is free:
    - Depress pedal to the floor and release.
11. Air cleaner extension, and air cleaner assembly.
  12. Reset IAC valve pintle position:
    - a. Depress accelerator pedal slightly.
    - b. Start and run engine for three seconds.
    - c. Turn ignition "OFF" for ten seconds.
    - d. Restart engine and check for proper idle operation.

## FUEL METER COVER ASSEMBLY

The fuel meter cover and pressure regulator are serviced as a complete assembly only.

**CAUTION:** DO NOT remove the four screws securing the pressure regulator to the fuel meter cover. The fuel pressure regulator includes a large spring under heavy compression which, if accidentally released, could cause personal injury. Disassembly might also result in a fuel leak between the diaphragm and the regulator container.

### Remove or Disconnect (Figure C2-11)

1. Negative battery terminal.
2. Relieve fuel system pressure.
3. Air cleaner assembly and extension (spacer).
4. Electrical connectors to fuel injectors. (Squeeze plastic tabs and pull straight up.)
5. Fuel meter cover attaching screws (1, 2).
6. Fuel meter cover assembly (3).

**NOTICE:** DO NOT immerse the fuel meter cover (with pressure regulator) in cleaner, as damage to the regulator diaphragm could occur.

7. Fuel meter outlet gasket (5), cover gasket (4), and pressure regulator dust seal (6). Discard gaskets and seal.

### Clean

- Gasket sealing surfaces.

### Install or Connect (Figure C2-11)

1. New pressure regulator dust seal (6), fuel meter outlet passage gasket (5), and cover gasket (4).
2. Fuel meter cover assembly (3).
3. Fuel meter cover attaching screws (1, 2), coated with appropriate thread-locking compound.
  - Install short screws next to injectors.

### Tighten

- Fuel meter cover attaching screws to 3.0 N·m (27 lb.in.).
4. Electrical connectors to fuel injectors.
  5. Negative battery terminal.

### Inspect

- With engine "OFF," and ignition "ON," check for fuel leaks.

6. Air cleaner extension, and air cleaner assembly.

## FUEL INJECTORS

Each fuel injector is serviced as a complete assembly only.

**NOTICE:** Use care in removing injectors to prevent damage to the electrical connector terminals, the injector filter, and the fuel nozzle. Also, since the injectors are electrical components, they should not be immersed in any type of liquid solvent or cleaner as damage may occur.

### Remove or Disconnect (Figures C2-11, 12, 13)

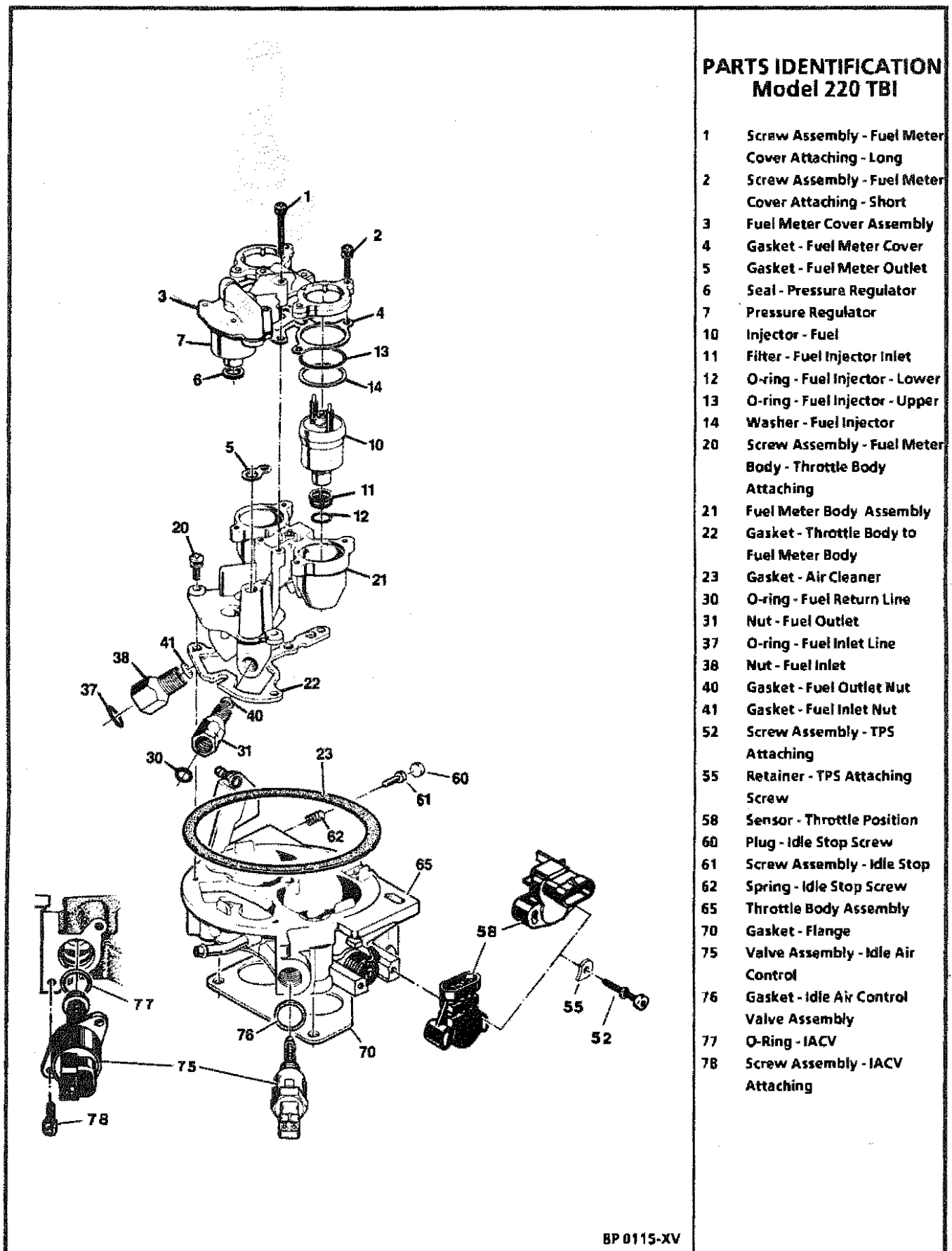
1. Negative battery terminal.
2. Relieve fuel system pressure.
3. Air cleaner assembly and extension (spacer).
4. Electrical connectors to fuel injectors. (Squeeze plastic tabs and pull straight up.)
5. Fuel meter cover attaching screws (1, 2).
6. Fuel meter cover assembly (3).
7. Fuel meter outlet passage gasket (5) and pressure regulator dust seal (6). If fuel meter cover gasket (4) stuck to fuel meter body, leave it in place. If it stuck to fuel meter cover, remove it, and place it on the fuel meter body.
  - The fuel meter cover gasket will be used to protect the fuel meter body in the next step.
8. With fuel meter cover gasket on fuel meter body, use a screwdriver and fulcrum to carefully pry out injector (10).
9. Lower (small) O-ring (12) from nozzle end of injector and discard.
10. Fuel meter cover gasket (4) and discard.
11. Upper (large) O-ring (13) and steel backup washer (14) from top of injector cavity. Discard O-ring.

### Inspect

- Fuel injector filter (11) for evidence of dirt and contamination. If present, check for presence of dirt in fuel lines and fuel tank.

### Important (Figure C2-14)

Be sure to replace the injector with an identical part. Injectors from other models can fit, but are calibrated for different flow rates.



## PARTS IDENTIFICATION Model 220 TBI

- 1 Screw Assembly - Fuel Meter Cover Attaching - Long
- 2 Screw Assembly - Fuel Meter Cover Attaching - Short
- 3 Fuel Meter Cover Assembly
- 4 Gasket - Fuel Meter Cover
- 5 Gasket - Fuel Meter Outlet
- 6 Seal - Pressure Regulator
- 7 Pressure Regulator
- 10 Injector - Fuel
- 11 Filter - Fuel Injector Inlet
- 12 O-ring - Fuel Injector - Lower
- 13 O-ring - Fuel Injector - Upper
- 14 Washer - Fuel Injector
- 20 Screw Assembly - Fuel Meter Body - Throttle Body Attaching
- 21 Fuel Meter Body Assembly
- 22 Gasket - Throttle Body to Fuel Meter Body
- 23 Gasket - Air Cleaner
- 30 O-ring - Fuel Return Line
- 31 Nut - Fuel Outlet
- 37 O-ring - Fuel Inlet Line
- 38 Nut - Fuel Inlet
- 40 Gasket - Fuel Outlet Nut
- 41 Gasket - Fuel Inlet Nut
- 52 Screw Assembly - TPS Attaching
- 55 Retainer - TPS Attaching Screw
- 58 Sensor - Throttle Position
- 60 Plug - Idle Stop Screw
- 61 Screw Assembly - Idle Stop
- 62 Spring - Idle Stop Screw
- 65 Throttle Body Assembly
- 70 Gasket - Flange
- 75 Valve Assembly - Idle Air Control
- 76 Gasket - Idle Air Control Valve Assembly
- 77 O-Ring - IACV
- 78 Screw Assembly - IACV Attaching

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Figure C2-10 - Model 220 TBI

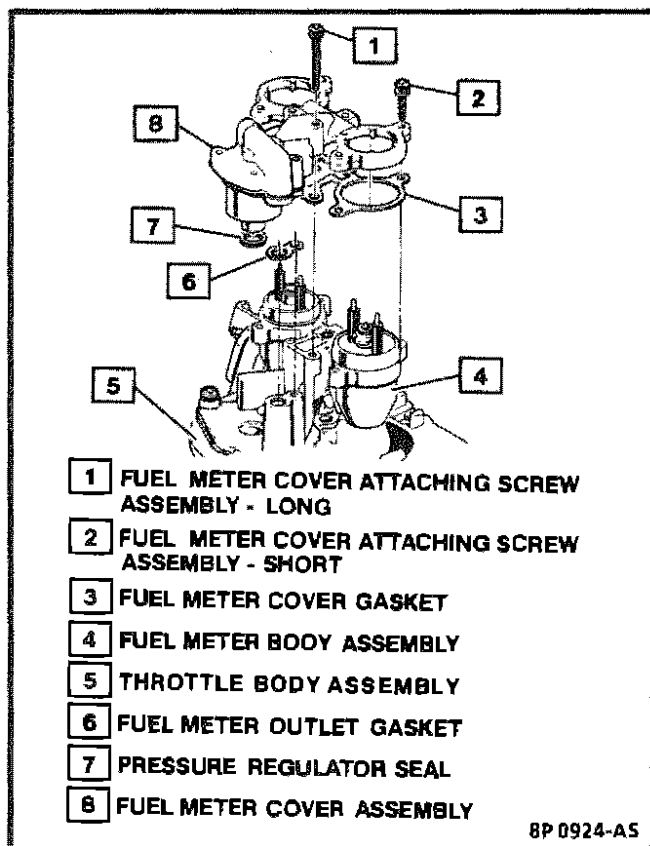


Figure C2-11 - Fuel Meter Cover Assembly

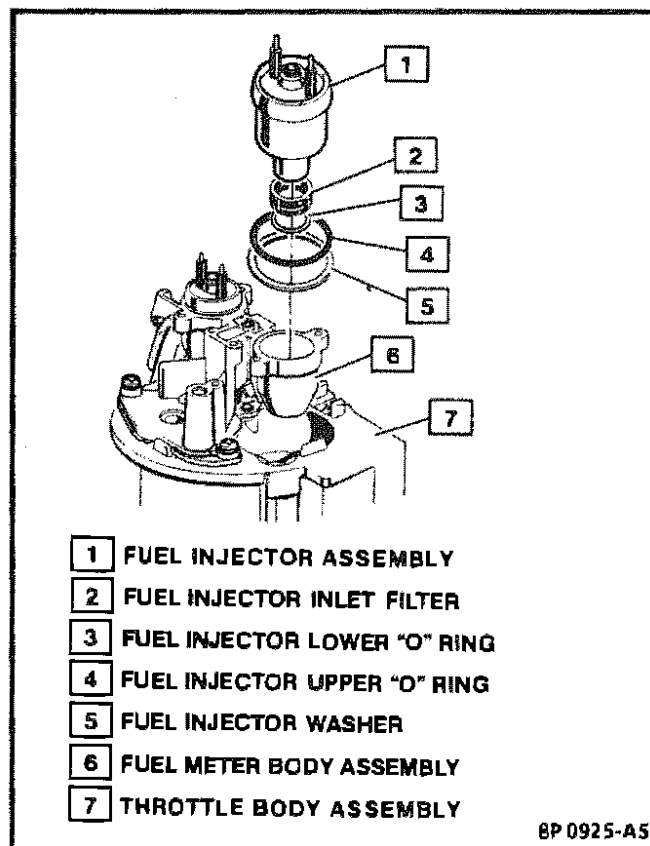


Figure C2-13 - Fuel Injector and O-rings

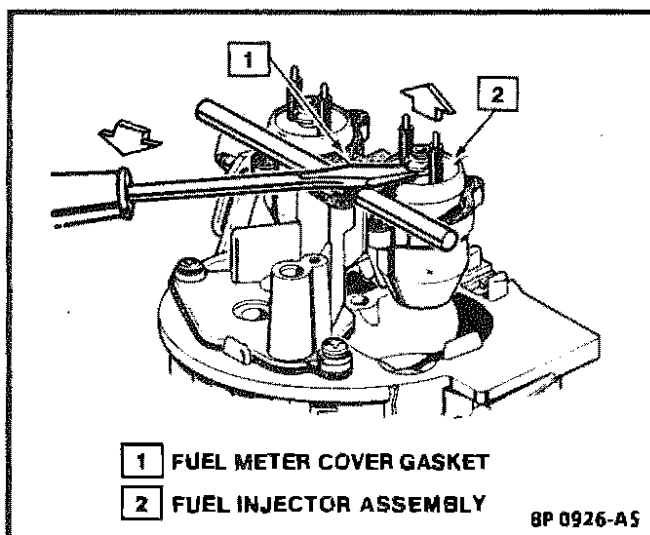


Figure C2-12 - Removing TBI 220 Fuel Injector



### Install or Connect (Figures C2-12, 13, 15)

**CAUTION:** When installing an injector, the backup washer and upper O-ring must be installed before the injector to ensure proper seating of the O-ring. Reversing these steps could result in a fuel leak and possible fire.

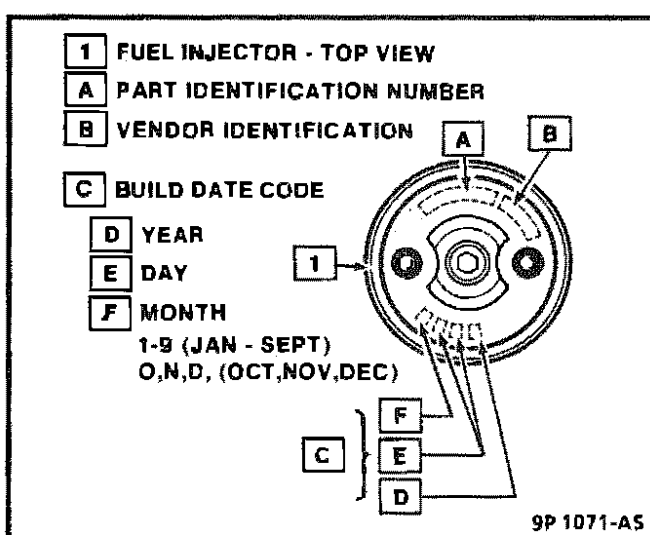


Figure C2-14 - Fuel Injector Part Number Location

1. Steel injector backup washer (14) in counterbore of fuel meter body.
2. Lubricate new upper (large) O-ring (13) with engine oil, and install directly over the backup washer.
  - Be sure O-ring is seated properly, and is flush with top of fuel meter body surface.
3. Lubricate new lower (small) O-ring (12) with engine oil, and install on nozzle end of injector.
  - Push O-ring on far enough to contact filter.
4. Fuel injector (10):

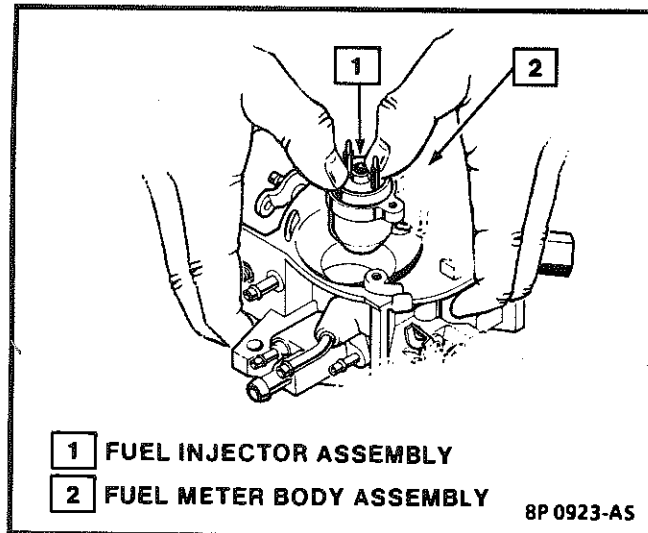


Figure C2-15 - Installing Fuel Injector

- a. Align raised lug on injector base with notch in fuel meter body cavity.
- b. Push down on injector until it is fully seated in fuel meter body. (Electrical terminals of injector should be parallel with throttle shaft.)
5. New pressure regulator dust seal (6), fuel meter outlet gasket (5), and cover gasket (4).
6. Fuel meter cover assembly (3).
7. Fuel meter cover attaching screws (1, 2), coated with appropriate thread-locking compound.



### Tighten

- Fuel meter cover attaching screws to 3.0 N·m (27 lb.in.).
- 8. Electrical connectors to fuel injectors.
- 9. Negative battery terminal.



### Inspect

- With engine "OFF" and ignition "ON," check for fuel leaks.
- 10. Air cleaner extension, and air cleaner assembly.

## FUEL METER BODY ASSEMBLY



### Remove or Disconnect (Figures C2-11, 12, 13 and 16)

1. Negative battery terminal.
2. Relieve fuel system pressure.
3. Air cleaner assembly and extension (spacer).
4. Electrical connectors to injectors. (Squeeze plastic tabs and pull straight up.)
5. Fuel meter cover (3) and fuel injectors (10).
6. Fuel feed and return lines.
7. Fuel line O-rings (30, 37) and discard.
8. Fuel inlet and outlet nuts (31, 38) and gaskets (40, 41) from the fuel meter body assembly.
  - Discard gaskets.

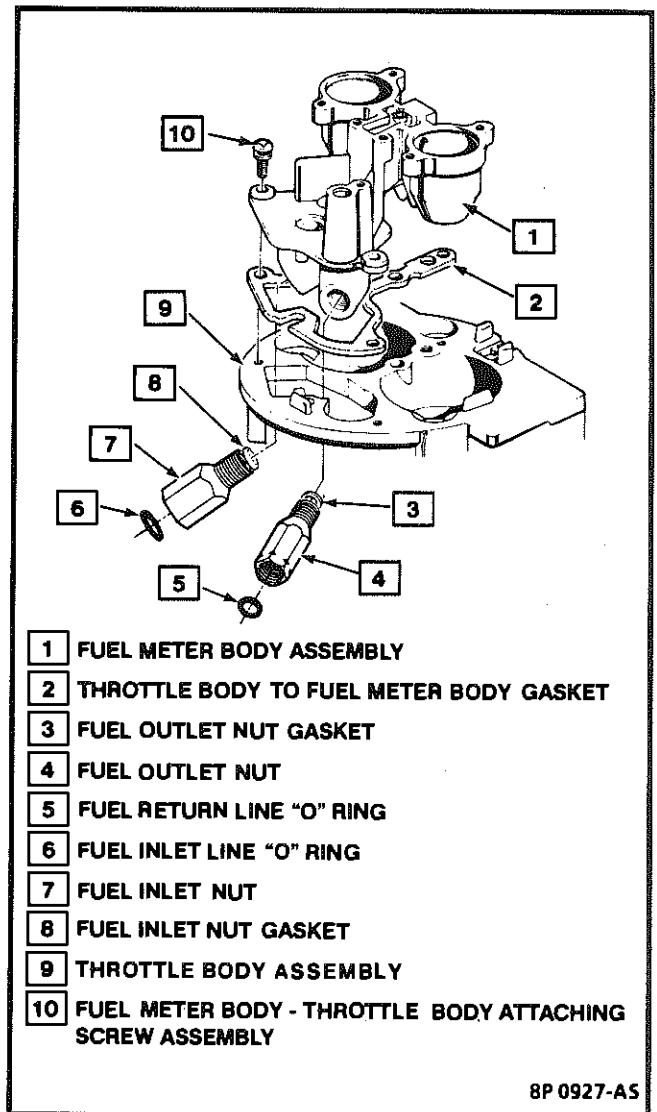


Figure C2-16 - Fuel Meter Body Assembly



### Important

Note locations of nuts, for proper reassembly later. Inlet nut has a larger passage than outlet nut.

9. Fuel meter body to throttle body attaching screws (20).
10. Fuel meter body (21) and gasket (22) from throttle body.
  - Discard gasket.



### Install or Connect (Figures C2-11, 13, 15 and 16)

1. New throttle body to fuel meter body gasket (22).
  - Match cut-out portions in gasket with openings in throttle body.
2. Fuel meter body assembly (21) on throttle body assembly.
3. Fuel meter body-to-throttle body attaching screws (20), coated with appropriate thread-locking compound.



### Tighten

- Fuel meter body attaching screws to 4.0 N·m (35 lb.in.).
4. Fuel inlet and outlet nuts (31, 38) with new gaskets (40, 41).



### Tighten

- Inlet nut to 40.0 N·m (30 lb.ft.).
  - Outlet nut to 29.0 N·m (21 lb.ft.).
5. New O-rings (30, 37) on fuel feed and return lines.
  6. Fuel lines.



### Tighten

- Fuel line nuts to 27.0 N·m (20 lb.ft.).
  - Use a back-up wrench on the TBI fuel nuts to prevent them from turning.
7. Fuel injectors (10) and fuel meter cover (3).
  8. Electrical connectors to injectors.
  9. Negative battery terminal.



### Inspect

With engine "OFF," and ignition "ON," check for fuel leaks.

10. Air cleaner extension, and air cleaner assembly.

## THROTTLE POSITION SENSOR (TPS)



### Remove or Disconnect (Figure C2-17)

1. Air cleaner assembly and extension (spacer).
2. TPS electrical connector.
3. TPS attaching screws (52).
4. Throttle position sensor (58).

**NOTICE:** The TPS is an electrical component and must not be soaked in any liquid cleaner or solvent, as damage may result.



### Install or Connect (Figure C2-17)

1. Throttle position sensor (58).
  - Line up TPS lever with TPS drive lever on throttle body.
2. TPS attaching screws (52).



### Tighten

- TPS attaching screws to 2.0 N·m (18 lb.in.).
3. Electrical connector.
  4. Air cleaner extension, and air cleaner assembly.

## IDLE AIR CONTROL (IAC) VALVE



### Remove or Disconnect (Figure C2-18)

1. Air cleaner assembly and extension (spacer).

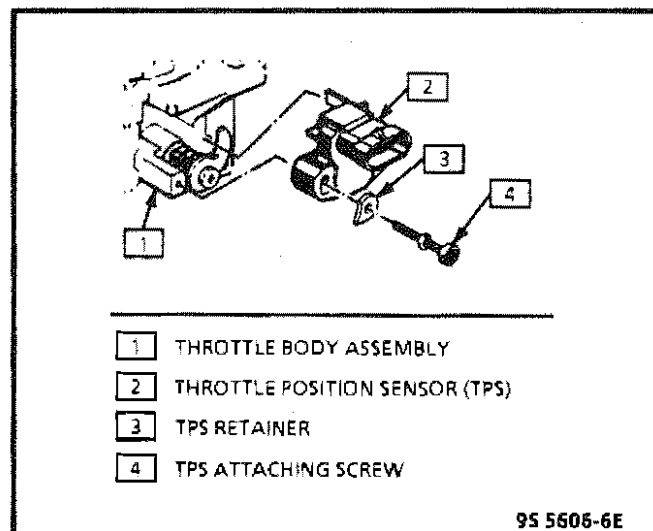


Figure C2-17 - Throttle Position Sensor

2. IAC valve electrical connector.
3. IAC valve assembly (75) and gasket (76).

**NOTICE:** On IAC valves that have been in service: Do Not push or pull on the IAC valve pintle. The force required to move the pintle may damage the threads on the worm drive.

Also, Do Not soak IACV in any liquid cleaner or solvent, as damage may result.



### Cleaning and Inspection

- Both original and replacement IAC valves have a special factory applied thread-locking compound applied to the screw threads. If the valve removed from the throttle body is being reinstalled, Do Not attempt to remove any of the thread locking compound that may be remaining on the threads.
- Clean IACV gasket sealing surface, pintle valve seat and air passage.
  - Use carburetor cleaner to remove carbon deposits. Do Not use a cleaner that contains methyl ethyl ketone. It is an extremely strong solvent, and not necessary for this type of deposit.
  - Shiny spots on the pintle or seat are normal, and do not indicate misalignment or a bent pintle shaft.
  - If air passage has heavy deposits, remove throttle body for complete cleaning.



### Important

- If installing a new IAC valve, be sure to replace with an identical part. IACV pintle shape and diameter are designed for the specific application.

### Measure (If Installing a New IAC Valve) (Figure C2-18)

- Distance between tip of IAC valve pintle and mounting surface.
  - If greater than 28 mm, use finger pressure to slowly retract the pintle. The force required to retract the pintle of a new valve will not cause damage to the valve.

### Install or Connect (Figure C2-18)

- IAC valve assembly (75) and gasket (76).

### Tighten

- IAC valve to 18.0 N·m (13 lb.ft.).
  - Use a socket or box wrench on valve hex.
- IAC valve electrical connector.
  - Air cleaner extension, and air cleaner assembly.
  - Reset IAC valve pintle position:
    - Depress accelerator pedal slightly.
    - Start and run engine for five seconds.
    - Turn ignition "OFF" for ten seconds.
    - Restart engine and check for proper idle operation.

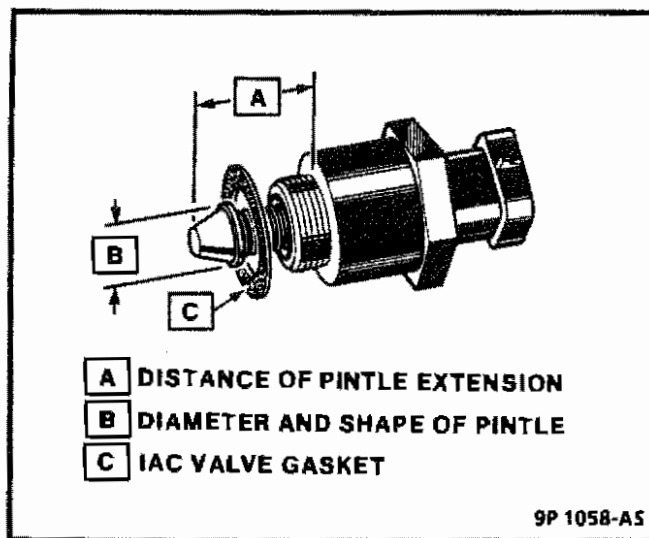


Figure C2-18 - Idle Air Control IAC Valve

## THROTTLE BODY REPLACEMENT

### Remove or Disconnect (Figures 9, 10)

- Negative battery terminal.
- Relieve fuel system pressure.
- TBI unit from engine.
- Fuel inlet and outlet nuts and gaskets from the fuel meter body assembly. Discard gaskets.

### Important

Note locations of nuts, for proper reassembly later. Inlet nut has a larger passage than outlet nut.

- Fuel meter body to throttle body attaching screws.
- Fuel meter assembly and gasket from throttle body.
  - Discard gasket.

### Inspect

- Replacement throttle body for items that will need to be transferred from unit removed from engine.

### Disassemble

- TBI unit, following component repair procedures.

### Assemble

- Replacement throttle body with transferred parts, following component repair procedures.

### Install or Connect (Figures 9, 10)

- New throttle body to fuel meter body gasket. Match cut-out portions in gasket with openings in throttle body.
- Fuel meter assembly on replacement throttle body.
- Fuel meter body-to-throttle body attaching screws, coated with appropriate thread-locking compound.

### Tighten

- Fuel meter body attaching screws to 4.0 N·m (35 lb.in.).
- Fuel inlet and outlet nuts with new gaskets to fuel meter body assembly.

### Tighten

- Inlet nut to 40.0 N·m (30 lb.ft.).
  - Outlet nut to 29.0 N·m (21 lb.ft.).
- TBI unit onto engine.
  - Position air cleaner assembly on TBI unit to allow access to the idle stop screw. Connect Thermac vacuum hose.
  - Negative battery terminal.
  - Adjust minimum idle speed.

### Important

- Minimum idle speed should only be adjusted when installing a replacement throttle body.
- The idle stop screw is used to regulate minimum idle speed of the engine. On original equipment throttle bodies, it is adjusted at the factory, then covered with a plug to discourage unnecessary readjustment.

**NOTICE:** The minimum idle speed adjustment is critical to vehicle performance and component durability. Incorrect minimum idle speed adjustment (too high), will cause the IAC valve pintle to constantly bottom on its seat and result in early valve failure. If minimum idle speed is adjusted too low, the vehicle may not start in cold weather or may stall during warm-up.



### Adjust

1. Block drive wheels, and apply parking brake.
2. Connect a "Scan" tool to the ALDL connector.
3. Turn ignition to "ON" position.
4. Select "TPS" voltage display on "Scan" tool, and adjust TPS to obtain  $0.48 \pm 0.06$  volt.
  - Tighten attaching screws enough to hold TPS in place. Readjustment may be required following minimum idle speed adjustment.
5. Select "Field Service Mode" on "Scan" tool (refer to "Scan" tool instructions). This will cause IAC valve pintle to seat in throttle body (closing air passage). Wait at least 45 seconds, disconnect IAC valve connector, then exit "Field Service Mode."
6. Disconnect distributor set-timing connector.



### Important

- The distributor set-timing connector must be disconnected to fix spark-advance at base timing. This eliminates the possibility of changes in engine speed due to changes in timing.
7. Place transmission in "Neutral" (M/T). Start and run engine until it reaches normal operating temperature, and "Closed Loop" operation as read on the "Scan" tool.
    - It may be necessary to hold throttle open slightly to maintain idle.
  8. Select "Engine rpm" on "Scan" tool, and read engine speed.



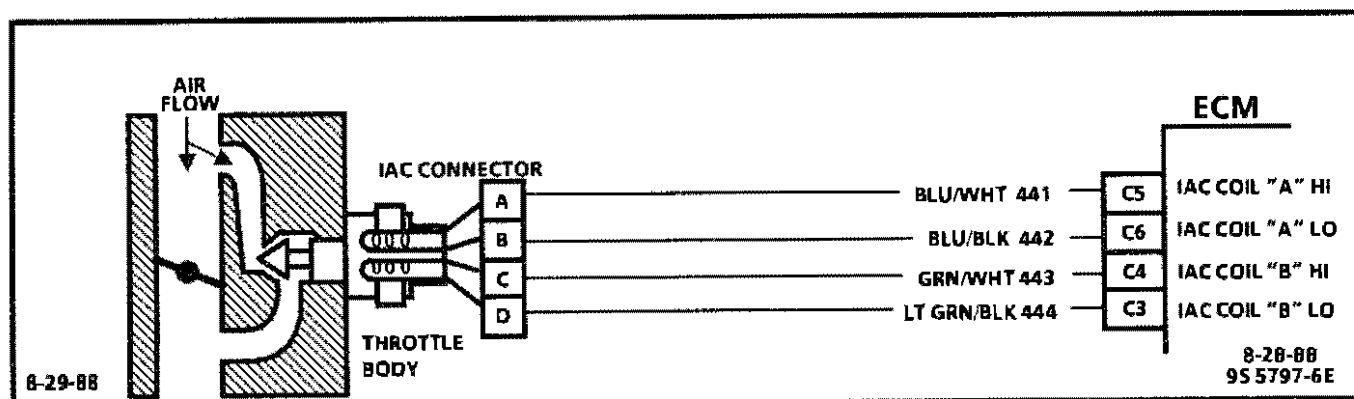
### Important

- Engine should be at normal operating temperature and in "Closed Loop."
  - Accessories (A/C, rear defog, etc.) "OFF."
  - Make sure throttle and cruise control cables do not hold throttle open.
  - Idle speed should be  $700 \pm 50$  rpm.
9. Adjust minimum idle speed if necessary.
  10. Turn ignition "OFF."
  11. Connect IAC valve electrical connector and distributor set-timing connector.
  12. Turn ignition to "ON" position, and recheck TPS voltage on "Scan" tool. Adjust if necessary, to obtain  $0.48 \pm 0.06$  volt.
    - Tighten TPS attaching screws to 2.0 N·m (18 lb.in.). Make sure adjustment did not change after tightening screws.
  13. Reset IAC valve pintle position:
    - a. Depress accelerator pedal slightly.
    - b. Start and run engine for five seconds.
    - c. Turn ignition "OFF" for ten seconds.
    - d. Restart engine and check for proper idle operation.
  14. Disconnect "Scan" tool.
  15. Remove block from drive wheels.

## TORQUE SPECIFICATIONS

|                                   |                      |
|-----------------------------------|----------------------|
| Throttle Body Attach. Bolts . . . | 25.0 N·m (18 lb.ft.) |
| Fuel Line Nuts . . . . .          | 27.0 N·m (20 lb.ft.) |
| Fuel Meter Cover Screws . .       | 3.0 N·m (27 lb.in.)  |
| Fuel Meter Body-Throttle Body     | 4.0 N·m (35 lb.in.)  |
| TBI Fuel Inlet Nut . . . . .      | 40.0 N·m (30 lb.ft.) |
| TBI Fuel Outlet Nut . . . . .     | 29.0 N·m (21 lb.ft.) |
| Throttle Position Sensor . . .    | 2.0 N·m (18 lb.in.)  |
| Idle Air Control Valve . . . .    | 18.0 N·m (13 lb.ft.) |

**BLANK**



## CHART C-2C

### IDLE AIR CONTROL (IAC) VALVE CHECK 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The ECM controls idle rpm with the IAC valve. To increase idle rpm, the ECM moves the IAC valve out, allowing more air to pass by the throttle plate. To decrease rpm, it moves the IAC valve in, reducing air flow by the throttle plate. A "Scan" tool will read the ECM commands to the IAC valve in counts. The higher the counts, the more air allowed (higher idle). The lower the counts, the less air allowed (lower idle).

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Continue with test, even if engine will not idle. If idle is too low, "Scan" will display 80 or more counts, or steps. If idle is high, it will display "0" counts. Occasionally, an erratic or unstable idle may occur. Engine speed may vary 200 rpm, or more, up and down. Disconnect IAC. If the condition is unchanged, the IAC is not at fault.
2. When the engine was stopped, the IAC valve retracted (more air) to a fixed "park" position for increased air flow and idle speed during the next engine start. A "Scan" will display 100 or more counts. When performing this test, immediately note rpm on start up, because, on a warm engine, the rpm will decrease rapidly.
3. Be sure to disconnect the IAC valve prior to this test. The test light will confirm the ECM signals by a steady or flashing light on all circuits.
4. There is a remote possibility that one of the circuits is shorted to voltage, which would have been indicated by a steady light. Disconnect ECM and turn the ignition "ON" and probe terminals to check for this condition.

#### Diagnostic Aids:

A slow unstable idle may be caused by a system problem that cannot be overcome by the IAC. "Scan" counts will be above 80 counts, if engine speed is too low, and "0" counts, if engine speed is too high.

If idle is too high, stop engine. Ignition "ON."

Ground diagnostic terminal. Wait 30 seconds for IAC to seat, then, disconnect IAC. Unground diagnostic terminal and start engine. If idle speed is above 450 rpm in drive, locate and correct vacuum leak. If rpm is less than 450 rpm, refer to "Rough Unstable or Incorrect Idle," in "Symptoms," Section "B".

#### • System too lean (High Air/Fuel Ratio)

Idle speed may be too high or too low. Engine speed may vary up and down, disconnecting IAC does not help. May set Code 44.

"Scan" and/or voltmeter will read an oxygen sensor output less than 300 mV (.3 volt). Check for low regulated fuel pressure or water in fuel. A lean exhaust, with an oxygen sensor output fixed above 800 mV (.8 volt), will be a contaminated sensor, usually silicone. This may also set a Code 45.

#### • System too rich (Low Air/Fuel Ratio)

Idle speed too low. "Scan" counts usually above 80. System obviously rich and may exhibit black smoke exhaust.

"Scan" tool and/or voltmeter will read an oxygen sensor signal fixed above 800 mV (.8 volt).

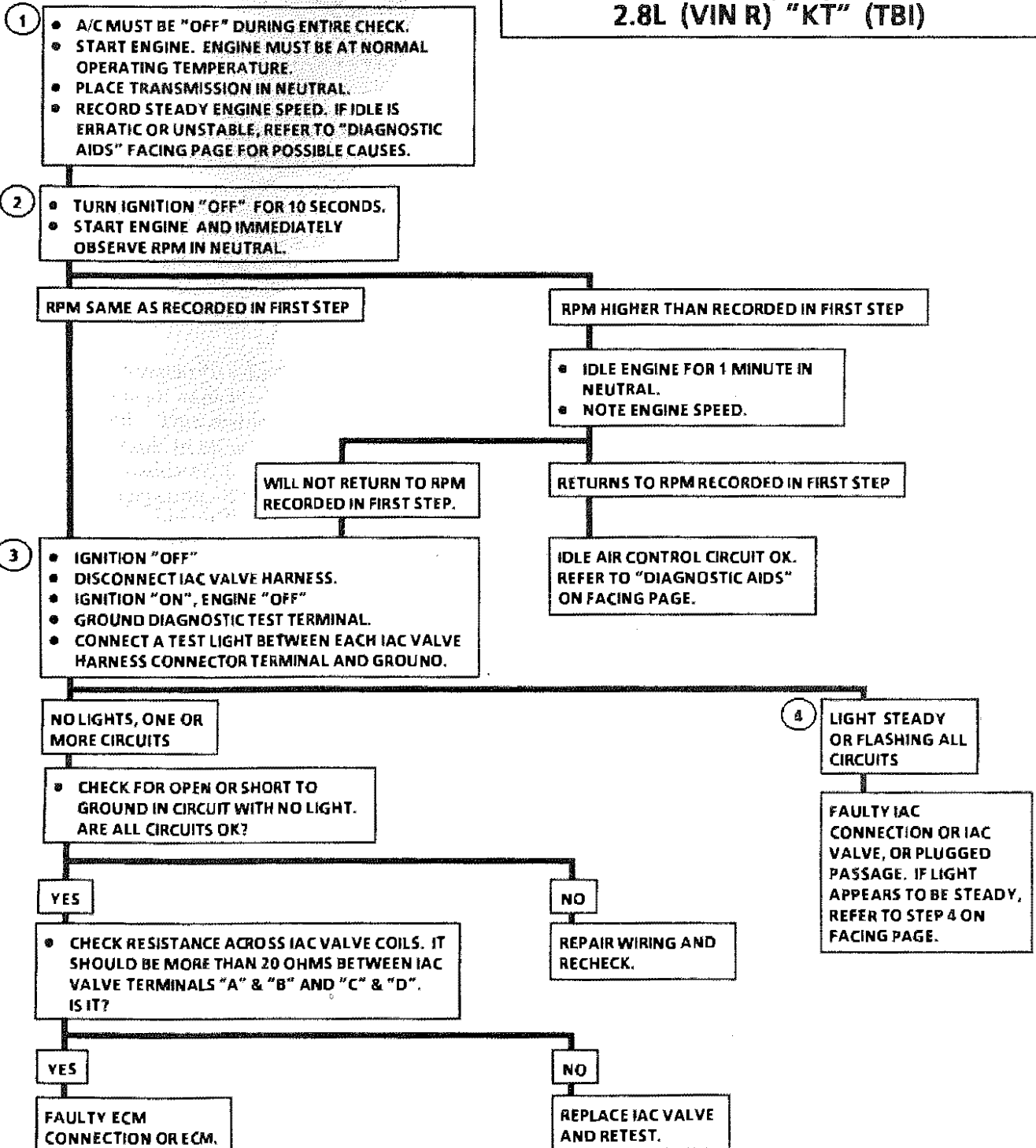
Check:

- High fuel pressure
- Injector leaking or sticking

#### • Throttle Body

Remove IAC and inspect bore for foreign material or evidence of IAC valve dragging the bore.

- If above are all OK, refer to "Rough, Unstable, Incorrect Idle or Stalling," in "Symptoms," Section "B".

**CHART C-2C****IDLE AIR CONTROL (IAC) VALVE CHECK  
2.8L (VIN R) "KT" (TBI)**

CLEAR CODES, CONFIRM "CLOSED LOOP" OPERATION, NO "CHECK ENGINE" LIGHT.

11-21-8B  
9S 5872-6E

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## SECTION C3

### EVAPORATIVE EMISSION CONTROL SYSTEM (EECS)

#### CONTENTS

|                                   |      |
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### GENERAL DESCRIPTION

#### PURPOSE

The basic Evaporative Emission Control System (EECS) used on all vehicles is the charcoal canister storage method. This method transfers fuel vapor from the fuel tank to an activated carbon (charcoal) storage device (canister) to hold the vapors when the vehicle is not operating. When the engine is running, the fuel vapor is purged from the carbon element by intake air flow and consumed in the normal combustion process.

#### VAPOR CANISTER

Gasoline vapors from the fuel tank flow into the tube labeled tank. Any liquid fuel goes into a reservoir in the bottom of the canister to protect the integrity of the carbon bed above (Figure C3-1). These vapors are absorbed into the carbon. The canister is purged when the engine is running above idle speed. Ambient air is allowed into the canister through the air tube in the top. The air mixes with the vapor and the mixture is drawn into the intake manifold.

#### EVAPORATIVE EMISSION SYSTEM

This system has a Thermostatic Vacuum Switch (TVS) installed in the intake manifold coolant passage to sense engine coolant temperature. This TVS has two ports and is located between the canister and the TBI unit. When the engine is below 46°C (115°F), the TVS is closed preventing purge of the canister. When engine temperature is above 46°C (115°F), the TVS opens, allowing purge of the canister.

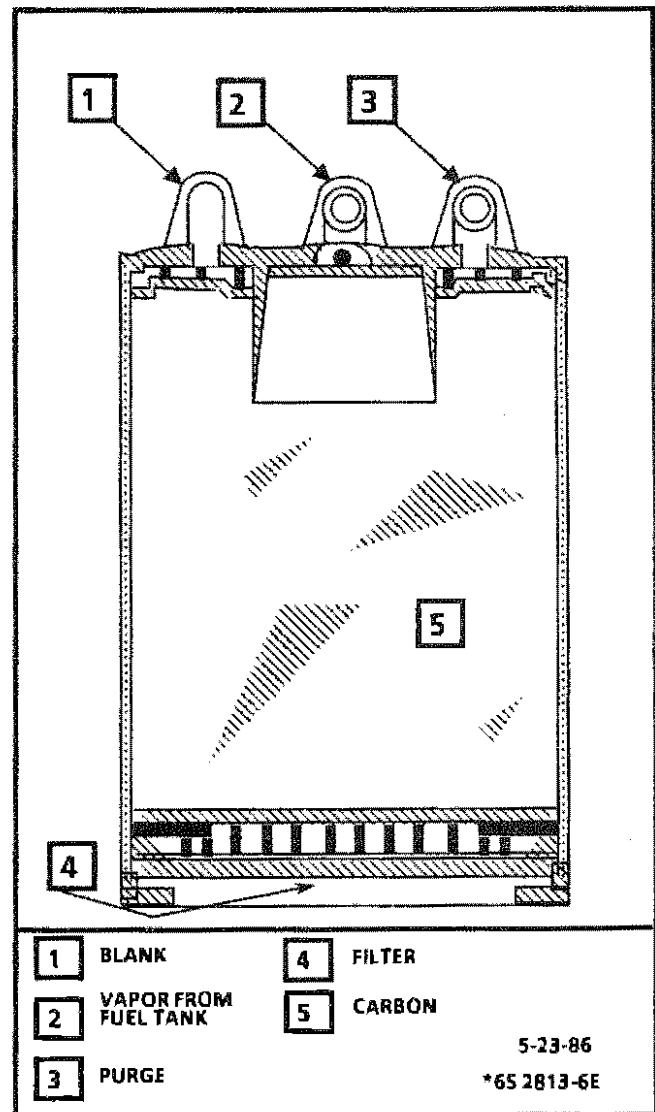


Figure C3-1 - Fuel Vapor Canister

### IN-TANK PRESSURE CONTROL VALVE

The in-tank pressure control valve, a combination roll-over, integral pressure and vacuum relief valve, is located with the fuel sending unit in the fuel tank. When vapor pressure in the tank exceeds 1" Hg (5 kPa) the valve opens and allows vapors to vent to the canister and then be purged. When the tank pressure drops below the opening point of the valve it will close, keeping vapors in the fuel tank. The valve provides vacuum relief to protect against vacuum build up in the fuel tank and roll-over protection to prevent liquid fuel from entering the canister during normal driving maneuvers.

### DIAGNOSIS

#### RESULTS OF INCORRECT OPERATION

- Poor idle, stalling and poor driveability can be caused by:
  - Damaged canister.
  - Hoses split, cracked and/or, not connected to the proper tubes.
- Evidence of fuel loss or fuel vapor odor can be caused by:
  - Liquid fuel leaking from fuel lines or TBI unit.
  - Cracked or damaged vapor canister.
  - Disconnected, misrouted, kinked, deteriorated or damaged vapor pipe, or canister hoses.
  - Air cleaner or air cleaner gasket improperly seated.

### VISUAL CHECK OF VAPOR CANISTER

- Replace vapor canister if cracked or damaged.
- Replace vapor canister if fuel is leaking from bottom and check operation of the total system.

### ON-CAR SERVICE

#### FUEL VAPOR CANISTER

##### Remove or Disconnect

1. Hoses from canister. Mark hoses to install on new canister.
2. Canister.

##### Install or Connect

1. Canister as removed.
2. Hoses. Make sure connections are correct.

#### CANISTER HOSES

Refer to "Vehicle Emission Control Information" label for routing of canister hoses.

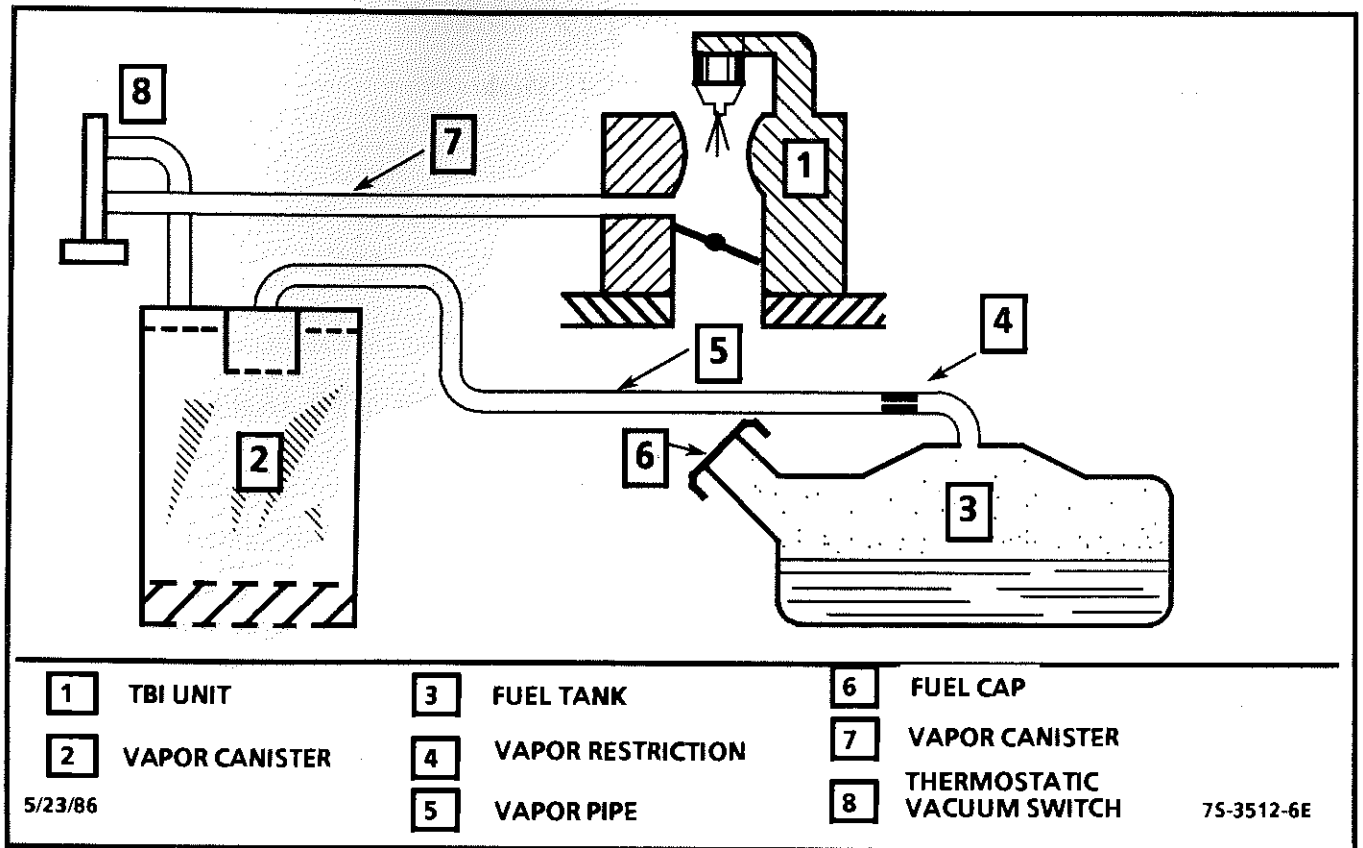


Figure C3-2 - Evaporative Emissions Control System Schematic 2.8L (VIN R)

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## SECTION C4

### IGNITION SYSTEM/(EST)

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### GENERAL DESCRIPTION

#### PURPOSE

The High Energy Ignition (HEI) system controls fuel combustion by providing a spark to ignite the compressed air/fuel mixture at the correct time. To provide improved engine performance, fuel economy, and control of exhaust emissions, the ECM controls distributor spark advance (timing) with the Electronic Spark Timing (EST) system.

Only the Electronic Spark Timing (EST) system will be described here. Additional information on the HEI system is found in Section "6D".

#### OPERATION

The standard High Energy Ignition (HEI) system (described in Section "6D") has a modified distributor module, which is used in connection with EST. The module has eight terminals. (See Figure C4-1).

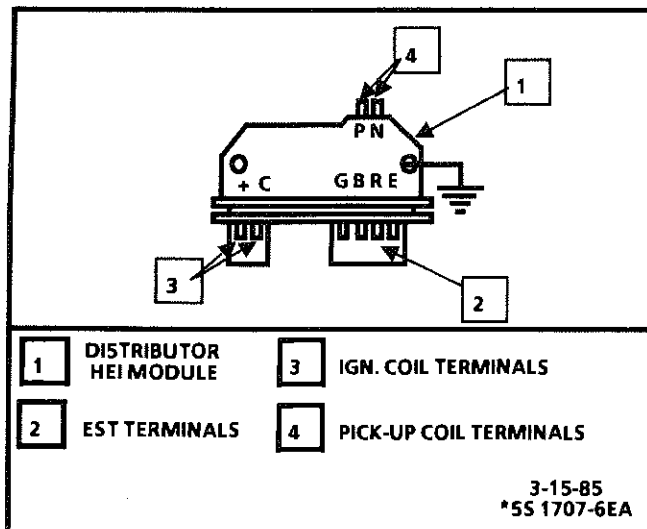


Figure C4-1 - Distributor Module 2.8L

To properly control ignition/combustion timing, the ECM needs to know:

- crankshaft position

- engine speed (rpm)
- engine load (manifold pressure or vacuum)
- atmospheric (barometric) pressure
- engine temperature

The EST system consists of the distributor module, ECM, and connecting wires. The distributor has four wires, from the HEI module, connected to the ECM.

These circuits perform the following functions:

- **Distributor reference.** Terminal "C"  
This provides the ECM with rpm and crankshaft position information.
- **Reference ground.** Terminal "A"  
This wire is grounded in the distributor and makes sure the ground circuit has no voltage drop which could affect performance. If it is open, it may cause poor performance.
- **Bypass.** Terminal "B"  
At about 400 rpm, the ECM applies 5 volts to this circuit to switch spark timing control from the HEI module to the ECM. An open or grounded bypass circuit will set a Code 42 and the engine will run at base timing, plus a small amount of advance built into the HEI module.
- **EST.** Terminal "D"  
After bypass voltage is applied, the ECM uses this circuit to trigger the HEI module. The ECM uses the distributor reference signal to base its calculation of the amount of spark advance needed, under present engine conditions. If the base timing of the engine is incorrect, the entire spark curve will be incorrect.

### DIAGNOSIS

#### RESULTS OF INCORRECT EST OPERATION

An open, or ground, in the EST circuit, will set a Code 42 and cause the engine to run on the HEI module timing. This will cause poor performance and poor fuel economy.

The ECM uses information from the MAP and coolant sensors, in addition to rpm, to calculate spark advance as follows.

Low MAP output voltage = More spark advance

Cold engine = More spark advance

High MAP output voltage, = Less spark advance

Hot engine = Less spark advance

Therefore, detonation could be caused by low MAP output or high resistance in the coolant sensor circuit.

Poor performance could be caused by high MAP output or low resistance in the coolant sensor circuit.

### HOW CODE 42 IS DETERMINED

When the system is running on the HEI module, that is, no voltage on the bypass line, the HEI module grounds the EST signal. The ECM expects to see no voltage on the EST line during this condition. If it sees a voltage, it sets Code 42 and will not go into the EST mode.

When the rpm for EST is reached (about 400 rpm), the ECM applies 5 volts to the bypass line and the EST should no longer be grounded in the HEI module, so, the EST voltage should be varying.

If the bypass line is open, the HEI module will not switch to EST mode, so, the EST voltage will be low and Code 42 will be set.

If the EST line is grounded, the HEI module will switch to EST but, because the line is grounded, there will be no EST signal and the engine will not run. A Code 42 may, or may not, be set.

The description, operation, and diagnosis of the HEI system are found in Section "6D" of this manual. This section will address diagnosis of that portion of the ignition system pertaining to the EST operation.

### CODE 12

Code 12 is used during the "Diagnostic Circuit Check" procedure to test the code display ability of the ECM. This code indicates that the ECM is not receiving the engine rpm (reference) signal. This occurs with the ignition key "ON" and the engine not running.

The "reference" signal, also, triggers the fuel injection system. Without the "reference" signal, the engine cannot run.

### CHECKING EST PERFORMANCE

The ECM will set timing at a specified value, when the diagnostic "test" terminal in the ALDL connector is grounded. To check for EST operation, the timing should be checked at 1500 rpm with the terminal ungrounded. Then, ground the "test" terminal. If the timing changes at 1500 rpm, the EST is operating.

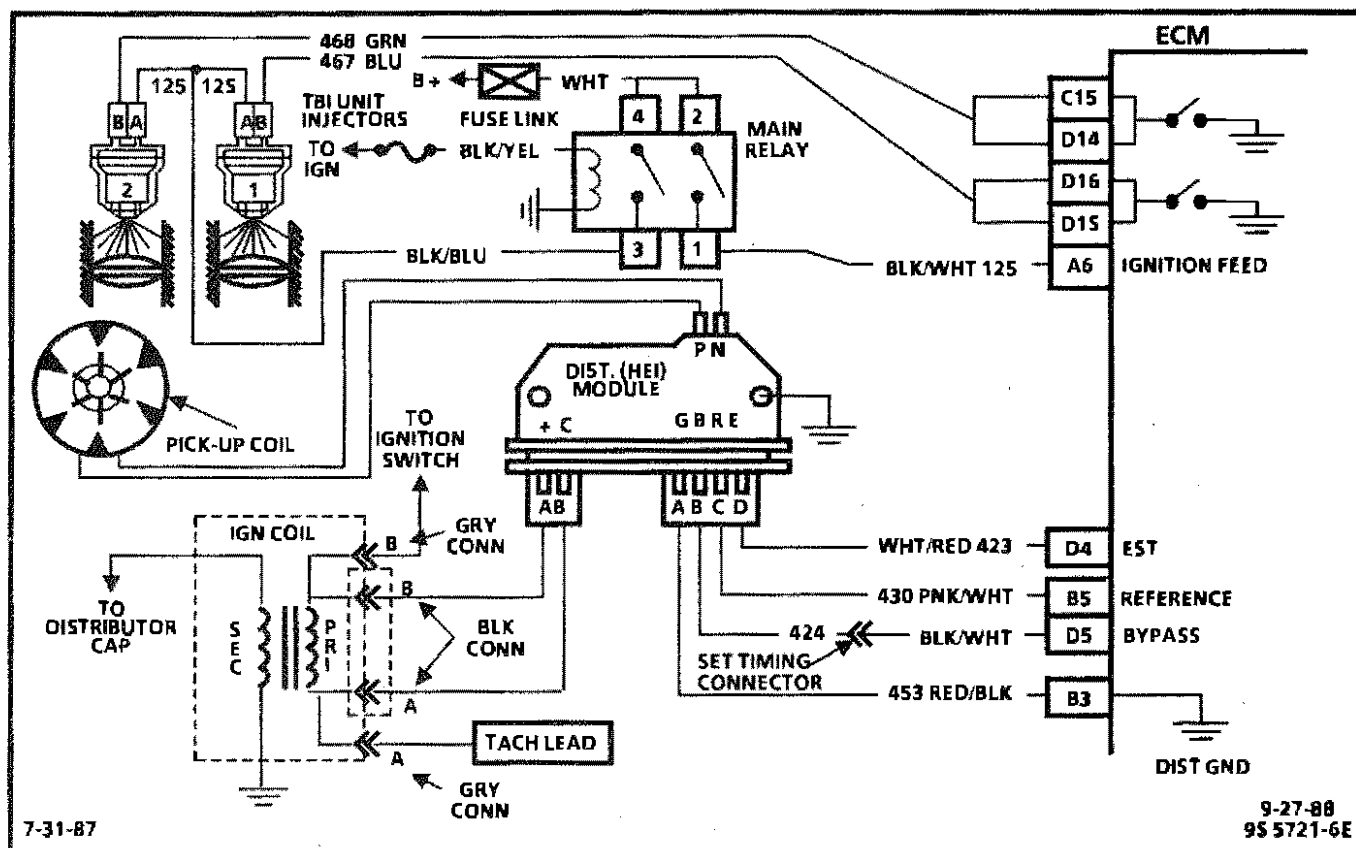
A fault in the EST system will, usually, set a trouble Code 42. Use that chart to diagnose the system.

## ON-CAR SERVICE

### SETTING TIMING

Set timing according to instructions on Vehicle Emission Control Information label.

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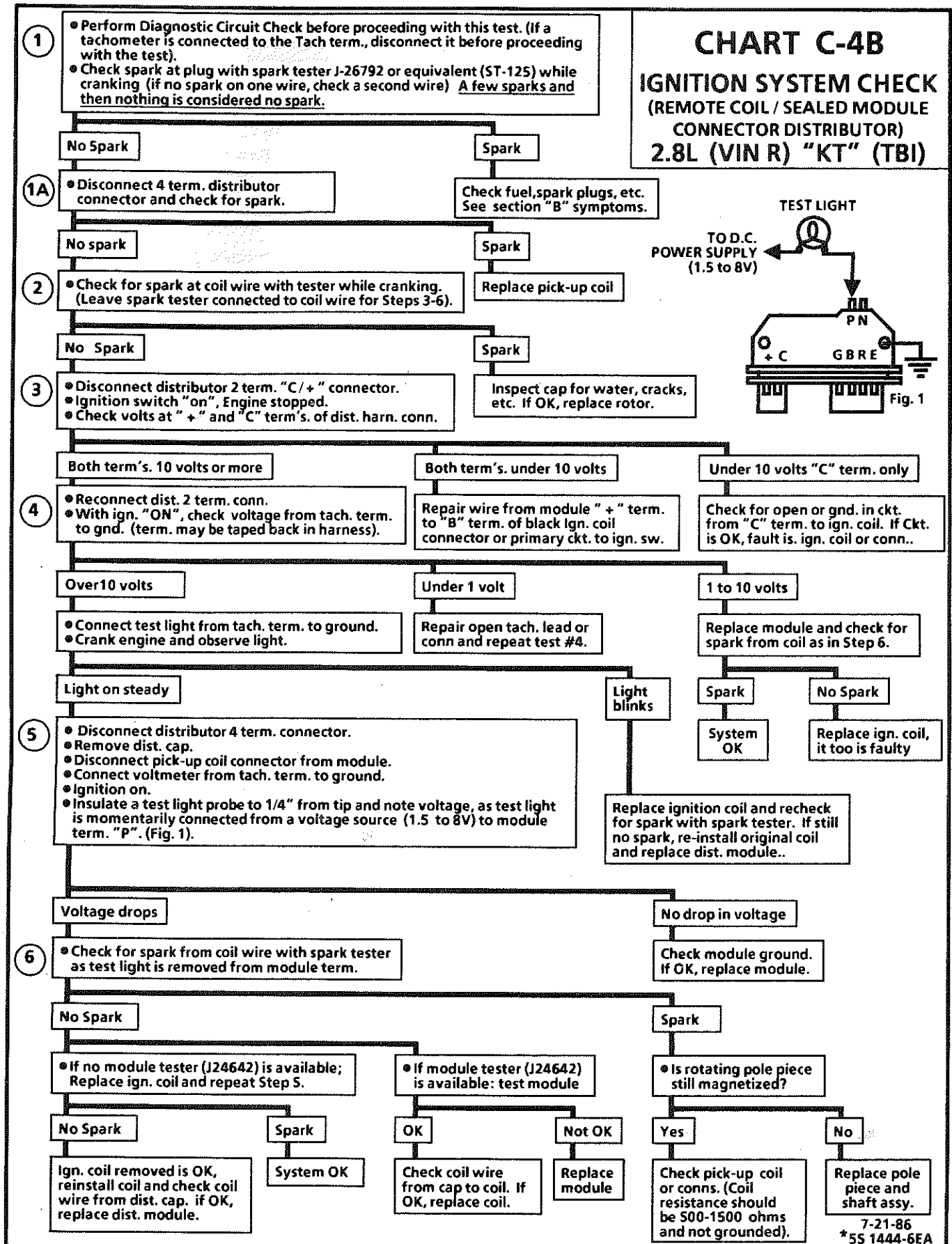


## CHART C-4B

### IGNITION SYSTEM CHECK (REMOTE COIL / SEALED MODULE CONNECTOR DISTRIBUTOR) 2.8L (VIN R) "KT" (TBI)

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. Two wires are checked, to ensure that an open is not present in a spark plug wire.
- 1A. If spark occurs with EST connector disconnected, pick-up coil output is too low for EST operation.
2. A spark indicates the problem must be the distributor cap or rotor.
3. Normally, there should be battery voltage at the "C" and "+" terminals. Low voltage would indicate an open or a high resistance circuit from the distributor to the coil or ignition switch. If "C" term. voltage was low, but "+" term. voltage is 10 volts or more, circuit from "C" term. to ignition coil or ignition coil primary winding is open.
4. Checks for a shorted module or grounded circuit from the ignition coil to the module. The distributor module should be turned "OFF," so normal voltage should be about 12 volts. If the module is turned "ON," the voltage would be low, but above 1 volt. This could cause the ignition coil to fail from excessive heat. With an open ignition coil primary winding, a small amount of voltage will leak through the module from the "Bat." to the tach terminal.
5. Applying a voltage (1.5 to 8 volts) to module terminal "P" should turn the module "ON" and the tach. term. voltage should drop to about 7-9 volts. This test will determine whether the module or coil is faulty or if the pick-up coil is not generating the proper signal to turn the module "ON." This test can be performed by using a DC battery with a rating of 1.5 to 8 volts. The use of the test light is mainly to allow the "P" terminal to be probed more easily. Some digital multi-meters can also be used to trigger the module by selecting ohms, usually the diode position. In this position the meter may have a voltage across it's terminals which can be used to trigger the module. The voltage in the ohm's position can be checked by using a second meter or by checking the manufacturers specification of the tool being used.
6. This should turn "OFF" the module and cause a spark. If no spark occurs, the fault is most likely in the ignition coil because most module problems would have been found before this point in the procedure. A module tester could determine which is at fault.



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## SECTION C5

### ELECTRONIC SPARK CONTROL (ESC) SYSTEM

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| OPERATION .....                    | C5-1 | ESC MODULE .....            | C5-1 |
| <b>DIAGNOSIS</b> .....             | C5-1 |                             |      |
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### GENERAL DESCRIPTION

#### PURPOSE

To control spark knock, an Electronic Spark Control (ESC) system has been added. This system is designed to retard spark timing up to 20°, to reduce spark knock in the engine. This allows the engine to use maximum spark advance to improve driveability and fuel economy.

Varying octane levels in gasoline can cause detonation in engines. Detonation is called spark knock.

#### OPERATION

The ESC system has two major components:

- ESC Module
- ESC Knock Sensor

The sensor is mounted in the engine block near the cylinders, or in the intake manifold at the rear of the engine. When the ESC knock sensor detects abnormal vibration (spark knocking) in the engine, it produced a voltage that is received by the ESC module. As long as the ESC module sees no voltage from the knock sensor (knock not present), it sends a signal voltage (8 to 10 volts) to the ECM and the ECM provides normal spark advance.

When the module detects voltage from the knock sensor (knock present), it turns "OFF" the signal to the ECM and the voltage at terminal "B7" goes to 0 volts. The ECM then retards EST to reduce spark knock.

### DIAGNOSIS

#### RESULTS OF INCORRECT ESC OPERATION

Loss of the ESC knock sensor signal or loss of ground at ESC module would cause the signal to the ECM to remain high. This condition would cause the ECM to control EST, as if no spark knocking were happening. No retard would occur, and spark knocking could become severe under heavy engine load conditions.

Loss of the ESC signal to the ECM would cause the ECM to constantly retard EST. This could result in sluggish performance and cause a Code 43 to set.

A "Scan" tool will read knock signal in A/D counts. When detonation is detected, knock signal counts will increment, as long as knock is present. "Scan" tools will indicate knock being present either by showing A/D counts, or displaying "Yes" (knock present), or "No" (knock not present). If Code 43 is present, use that chart to diagnose system. If no code is present and ESC system is suspected, use CHART C-5.

### ON-CAR SERVICE

#### ESC KNOCK SENSOR

##### Remove or Disconnect

1. Negative battery cable.
2. ESC wiring harness connector from ESC sensor.
3. ESC sensor from engine block.

##### Install or Connect

1. ESC sensor into engine block. Apply thread sealer, such as soft tape, to the ESC sensor threads.
2. ESC wiring harness connector to the ESC sensor.
3. Negative battery cable.

#### ESC MODULE

Refer to Figure C5-1.

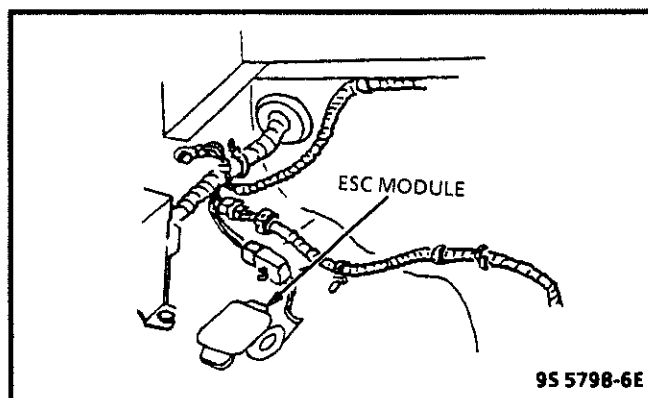
ESC module is mounted to the ECM bracket behind the glove compartment.

##### Remove or Disconnect

1. Negative battery cable
2. ESC module connector.
3. Attaching screws.
4. ESC module.

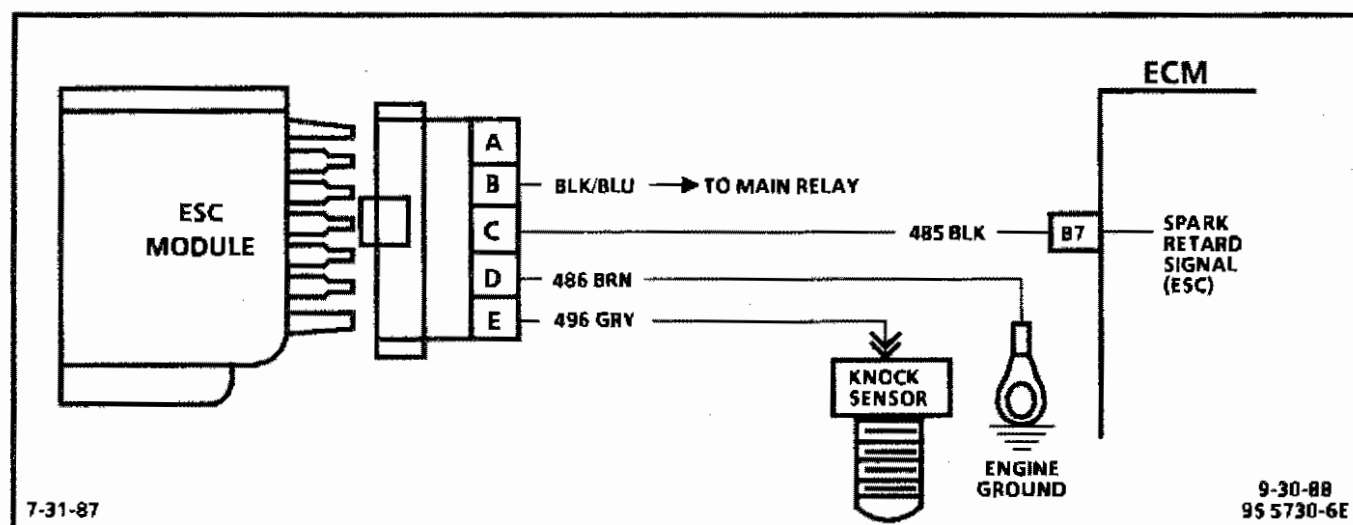
**↔ Install or Connect**

1. ESC module.
2. Attaching screws.
3. ESC module connector.
4. Negative battery cable.



**Figure C5-1 - ESC Module Location**

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## CHART C-5

### ELECTRONIC SPARK CONTROL (ESC) SYSTEM CHECK (ENGINE KNOCK, POOR PERFORMANCE, OR POOR ECONOMY) 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

Electronic spark control is accomplished with a module that sends a voltage signal to the ECM. As the knock sensor detects engine knock, the voltage from the ESC module to the ECM is shut "OFF" and this signals the ECM to retard timing, if engine rpm is over about 900.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. If a Code 43 is not set, but a knock signal is indicated while running at 1500 rpm, listen for an internal engine noise. Under a no load condition, there should not be any detonation, and if knock is indicated, an internal engine problem may exist.
2. Usually a knock signal can be generated by tapping on the right exhaust manifold. This test can also be performed at idle. Test number 1 was run at 1500 rpm, to determine if a constant knock signal was present, which would affect engine performance.
3. This tests whether the knock signal is due to the sensor, a basic engine problem, or the ESC module.

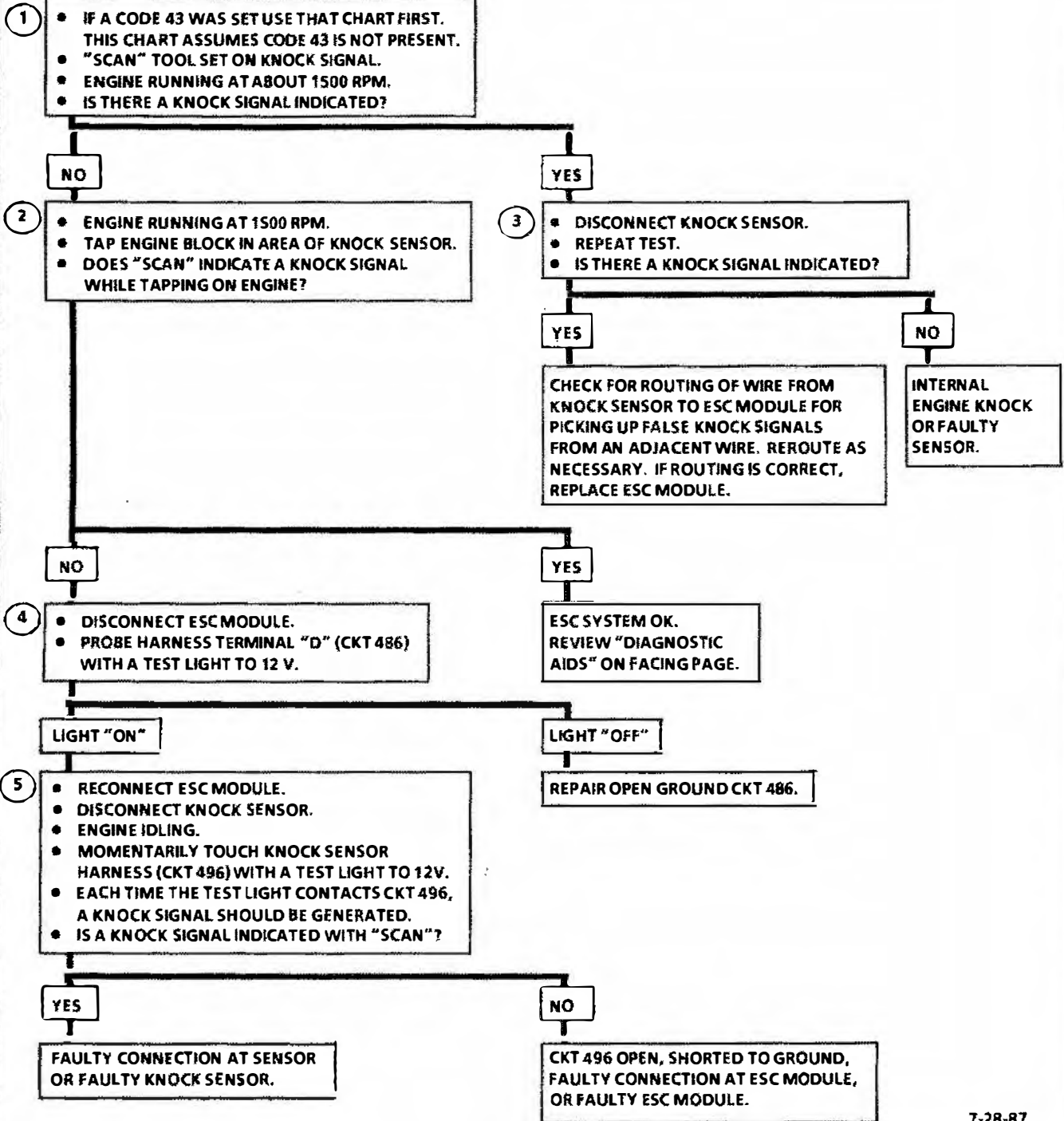
4. If the module ground circuit is faulty, the ESC module will not function correctly. The test light should light indicating the ground circuit is OK.
5. Contacting CKT 496, with a test light to 12 volts, should generate a knock signal to determine whether the knock sensor is faulty, or the ESC module can't recognize a knock signal.

#### Diagnostic Aids:

If the ESC system checks OK, but detonation is the complaint, refer to "Detonation/Spark Knock" symptom in Section "B".

**CHART C-5****ELECTRONIC SPARK CONTROL (ESC) SYSTEM CHECK  
(ENGINE KNOCK, POOR PERFORMANCE, OR POOR ECONOMY)  
2.8L (VIN R) "KT" (TBI)**

THIS CHART SHOULD BE USED AFTER ALL OTHER CAUSES OF SPARK KNOCK HAVE BEEN CHECKED. I.E., TIMING, EGR, ENGINE TEMPERATURE OR EXCESSIVE ENGINE NOISE, ETC. IF CODE 43 IS SET, USE THAT CHART FIRST.



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## SECTION C6

### AIR MANAGEMENT SYSTEM 2.8L ENGINE

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| AIR OPERATION .....              | C6-1        | PUMP CENTRIFUGAL FILTER FAN ..... | C6-3        |
| <b>DIAGNOSIS</b> .....           | <b>C6-1</b> | AIR PUMP .....                    | C6-3        |
| AIR SYSTEM .....                 | C6-1        | AIR CONTROL VALVE .....           | C6-4        |
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| Hoses And Pipes .....            | C6-2        | AIR MANAGEMENT CHECK CHART .....  | C6-7        |

#### GENERAL DESCRIPTION

##### PURPOSE

The air management system is used to reduce carbon monoxide and hydrocarbon emissions.

This system, Air Injection Reaction (AIR), under certain conditions, adds air (oxygen) to the exhaust manifold to continue combustion after the exhaust gases leave the combustion chamber. This added air also brings the catalytic converter up to operating temperature more quickly when the engine is cold.

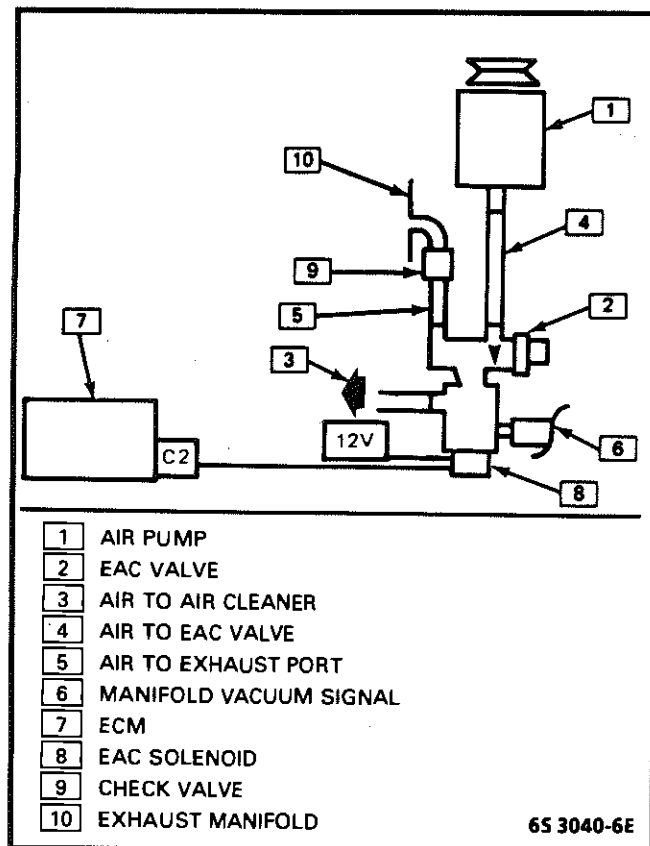


Figure C6-1 - AIR System - 2.8L

##### AIR OPERATION

The system consists of an air pump, an (electric) air control valve with solenoid, check valve(s), and necessary plumbing.

A belt driven air pump supplies air through a centrifugal filter fan to the Electric Air Control (EAC) valve 2.8L. This valve directs the air to either the engine exhaust manifold ports or to the air cleaner.

**NOTICE:** On the EAC valve, the divert and signal tube locations are reversed from the previous model year.

When the engine is cold or in wide open throttle condition, the ECM energizes the solenoid on the valve and air is directed to the exhaust manifold ports. When the coolant temperature increases, the solenoid is de-energized and air goes into the air cleaner which also acts as a silencer. At higher engine speeds, air is directed to the air cleaner through the pressure relief valve even though the solenoid may be energized. There should be no air going to the exhaust ports while operating in the "Closed Loop" mode.

During engine decel, when there is a rise in the manifold vacuum signal, air is directed to the air cleaner.

A check valve, on the air injection pipe, prevents back flow of exhaust into the air pump if there is an exhaust backfire or pump drive belt failure.

If the engine is operating under a rich condition or the "Check Engine" lamp lights, the solenoid is de-energized and air goes to the air cleaner.

#### DIAGNOSIS

##### AIR SYSTEM

Refer to Air Management Check chart for the diagnosis of the AIR system.

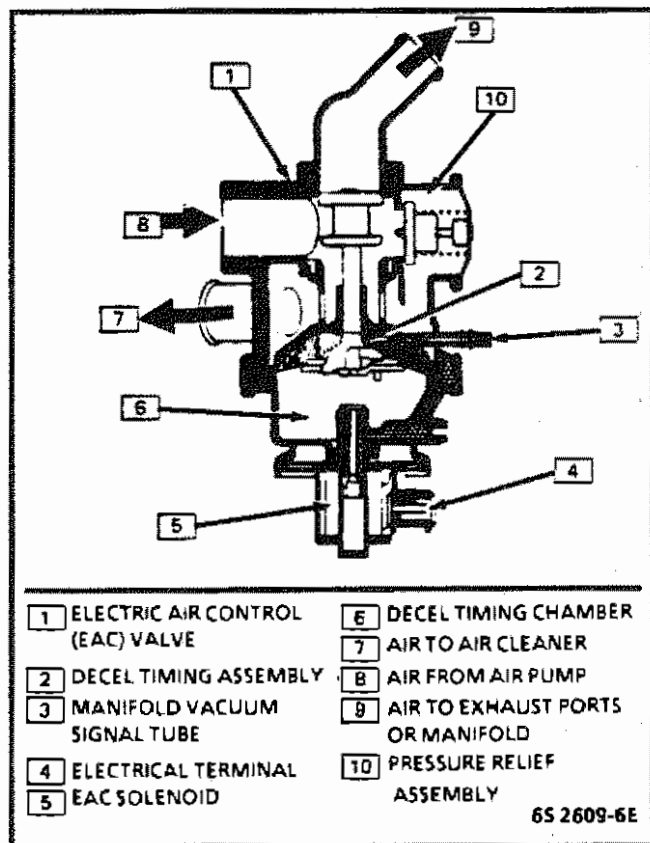


Figure C6-2 - EAC Valve

**NOTICE:** If the engine or underhood compartment is to be cleaned with steam or high-pressure detergent, the centrifugal filter fan should be masked off to prevent liquids from entering the pump.

If no air (oxygen) flow enters the exhaust stream at the exhaust ports, HC and CO emission levels may be too high.

Air flowing to the exhaust ports at all times could cause a rich ECM command and increased temperature of the converter.

The AIR system is not completely noiseless. Under normal conditions, noise rises in pitch as engine speed increases. To determine if excessive noise is the fault of the AIR system pump, momentarily operate the engine with the pump drive belt removed.

If noise is caused by the AIR system pump, check for:

- A seized air pump.
- Proper mounting and bolt torque of pump.
- Proper routine and connections of hoses.

**NOTICE:** Do not oil air pump.

- Replace pump if there is excessive noise.

### Air Pump

The air pump is a positive displacement vane type which is permanently lubricated and requires no periodic maintenance.

Accelerate engine to approximately 1500 rpm and observe air flow from hose. If air flow increases as engine is accelerated, pump is operating satisfactorily. If air flow does not increase or is not present, proceed as follows:

#### Inspect

1. For proper drive belt tension.
2. For a leaky pressure relief valve. Air may be heard leaking with the pump running.

### Check Valve

#### Inspect

1. A check valve should be inspected whenever the hose is disconnected from it or whenever check valve failure is suspected (A pump that had become inoperative and had shown indications of having exhaust gases in the pump would indicate check valve failure).
2. Remove the check valve.
3. Blow through the check valve toward the exhaust manifold side. Air should pass freely. Turn the valve around and attempt to blow through the valve toward the air pump side. No air should pass through the valve.
4. Replace valve which does not operate properly.

### Hoses and Pipes

#### Inspect

1. Hose or pipe for deterioration or holes.
2. All hoses or pipe connections, and clamp tightness.
3. Hose or pipe routing. Interference may cause wear.
4. If a leak is suspected on the pressure side of the system, or if a hose or pipe has been disconnected on the pressure side, the connections should be checked for leaks with a soapy water solution. With the pump running, bubbles will form if a leak exists.

## ON-VEHICLE SERVICE

### DRIVE BELT

#### ↔ Remove or Disconnect

Inspect drive belt for wear, cracks or deterioration and replace if required. When installing new belt, it must be seated and fully secured in grooves of A/C compressor, air pump, generator, and crankshaft pulleys.

### PUMP CENTRIFUGAL FILTER FAN

The centrifugal filter fan should not be cleaned, either with compressed air or solvents.

**CAUTION:** Centrifugal fan should not be removed from pump unless it is damaged, as removal will destroy the fan.

Before starting replacement note the following:

- Do not allow any filter fragments to enter the air pump intake hole.
- Do not remove filter fan by inserting a screwdriver between pump and filter fan. Air damage to sealing lip pump will result.
- Do not remove metal drive hub from filter fan.
- It is seldom possible to remove the filter fan without destroying it.

#### ↔ Remove or Disconnect

(Figure C6-3)

1. Air pump.
2. Pump pulley.
3. Insert needle nose pliers and pull filter fan from pump hub.

#### →+ Install or Connect

1. New filter fan on pump hub.
2. Spacer and pump pulley against centrifugal filter fan.
3. Pump pulley bolts and tighten equal to torque spec. in Figure C6-3. This will compress the centrifugal filter fan onto the pump hole. Do not drive filter fan on with a hammer. A slight amount of interference with the housing bore is normal. After a new filter fan has been installed, it may squeal upon initial operation or until O.D. sealing lip has worn in. This may require a short period of pump operation at various engine speeds.
4. Air pump.

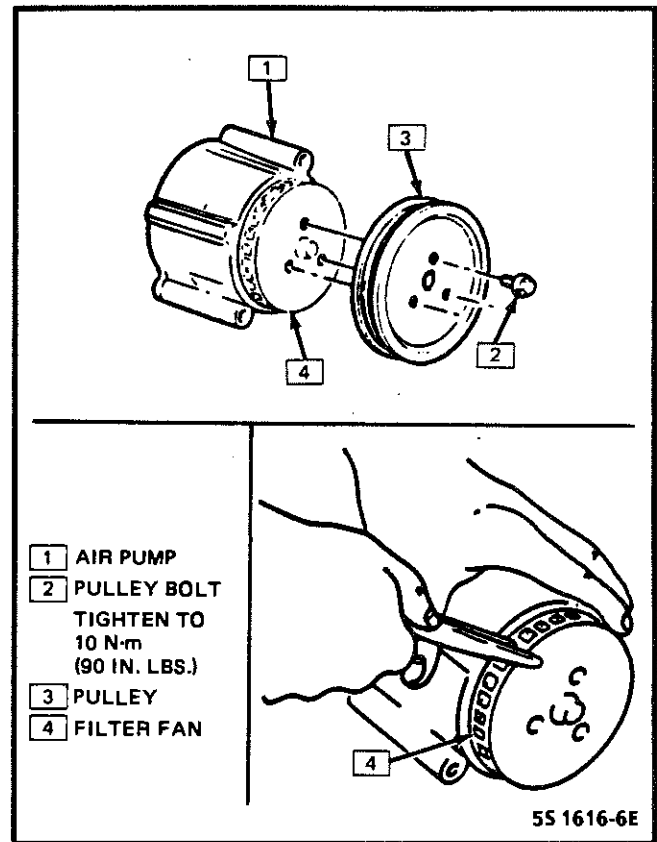


Figure C6-3 - Pump Filter Fan Service

### AIR PUMP

#### ↔ Remove or Disconnect

1. Hold pump pulley from turning by compressing drive belt, then loosen pump pulley bolts.
2. Loosen bolt, holding pump to mounting brackets, release tension on drive belts.
3. Move belts out of the way, then remove pump hoses, vacuum and electrical connections, and control valve.
4. Pulley, then pump.
5. If required, insert needle nose pliers and pull filter fan from hub.

#### →+ Install or Connect

1. Air pump assembly, and tighten mounting bolts.
2. Hose.
3. New filter fan on pump hub.
4. Spacer and pump pulley against centrifugal filter fan.
5. Pump pulley bolts and tighten equally to torque specifications. This will compress the centrifugal filter fan onto the pump hole. Do not drive filter fan on with a hammer. A slight amount of interference with the housing bore is normal.

After a new filter fan has been installed, it may squeal upon initial operation or until O.D. sealing lip has worn in. This may require a short period of pump operation at various engine speeds.

6. Pump drive belt and adjust.
7. Check air management system for proper operation (see Air Management Check chart).

### **AIR CONTROL VALVE**

#### **↔ Remove or Disconnect**

1. Battery ground cable.
2. Electrical connector on control valve.
3. Manifold vacuum signal hose.
4. Air inlet and outlet hoses from valve.
5. Control valve.

#### **→← Install or Connect**

1. Control valve.
2. Air inlet and outlet hoses to valve.
3. Manifold vacuum signal hose.
4. Electrical connector on control valve.
5. Battery ground cable.
6. Check system operation (See Air Management Check chart).

### **CHECK VALVE**

#### **↔ Remove or Disconnect**

1. Any parts required for access.
2. Release clamp and disconnect air hoses from check valve.
3. Unscrew check valve from air injection pipe.

#### **→← Install or Connect**

1. Screw check valve onto air injection pipe.
2. Position air hose on check valve and secure with clamp.
3. Any parts removed for access.

### **AIR INJECTION PIPE ASSEMBLY**

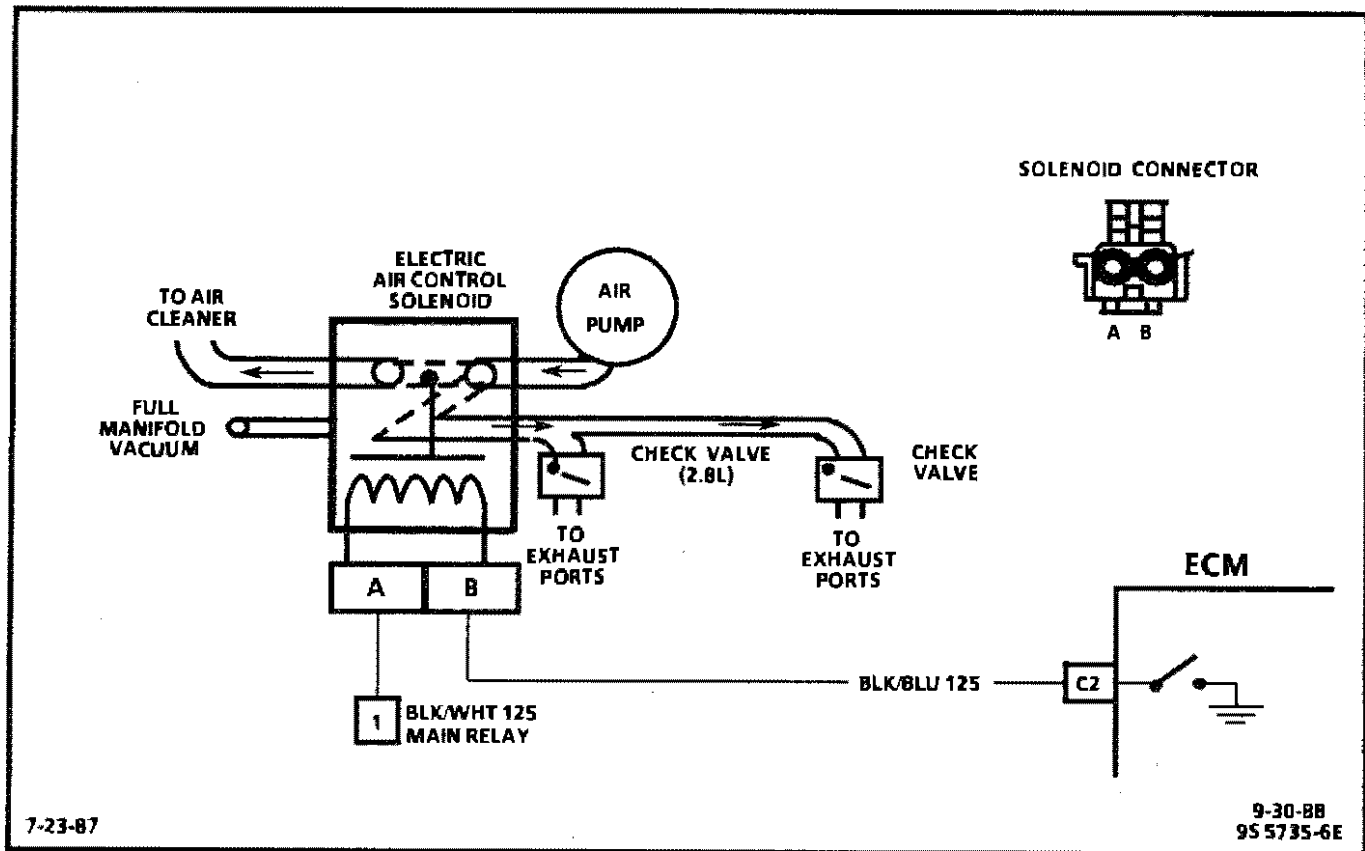
#### **↔ Remove or Disconnect**

1. Hose.
2. Check valve.
3. Nuts attaching pipes-to-manifold.
4. Pipe assembly.

#### **→← Install or Connect**

1. Nuts attaching pipes-to-manifold.
2. Check valve.
3. Hose.

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**CHART C-6**  
**AIR MANAGEMENT CHECK**  
**(ELECTRONIC AIR CONTROL VALVE)**  
**2.8L (VIN R) "KT" (TBI)**

#### Circuit Description:

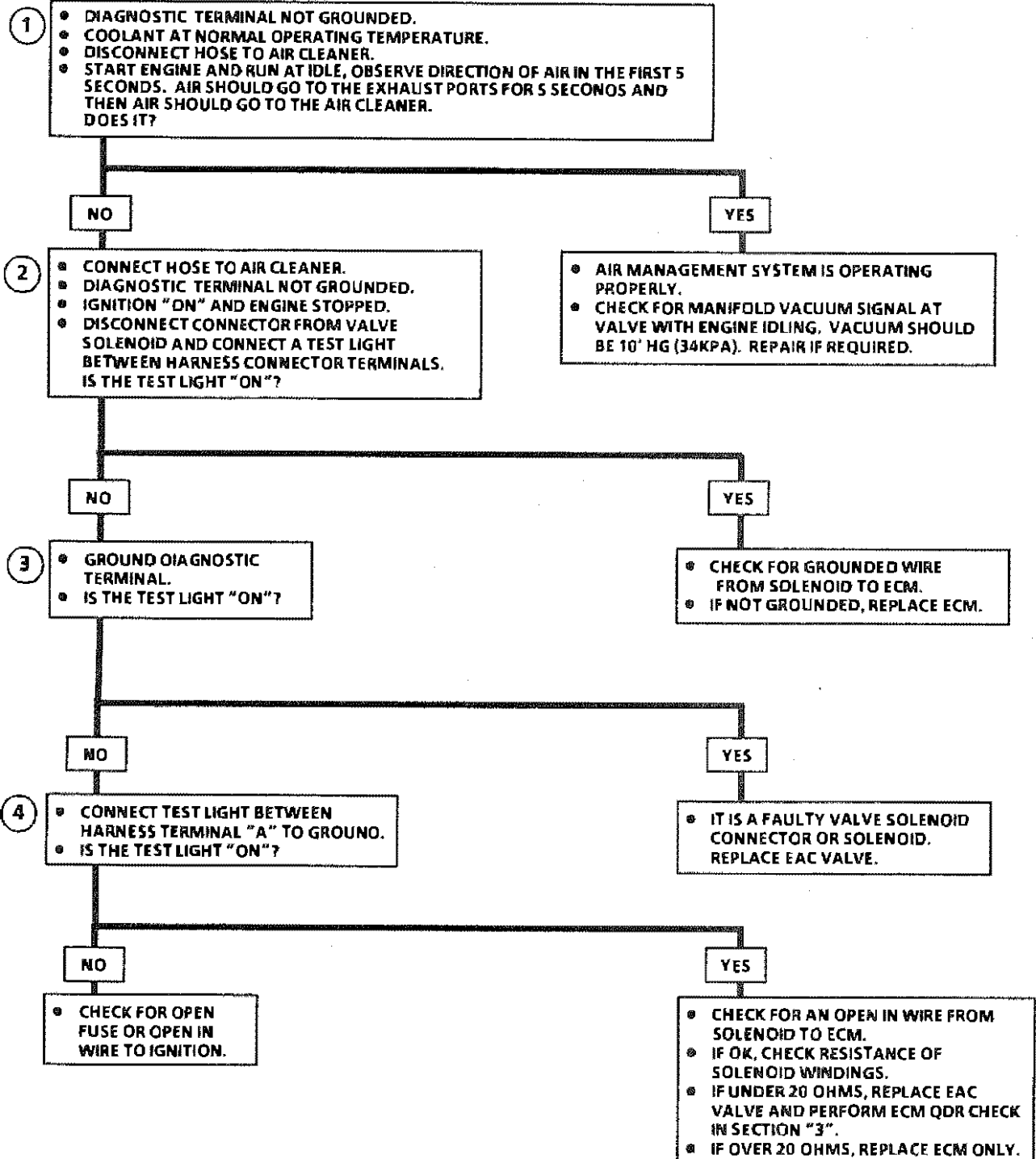
An electric air control valve solenoid directs air into the exhaust ports or the air cleaner. During cold start the ECM completes the ground circuit, the EAC solenoid is energized, and air is directed to the exhaust ports. As "coolant" temperature increases, or system goes to "Closed Loop," the ECM opens the ground circuit, the EAC solenoid is de-energized, and air goes to the air cleaner. If the system is not operating properly, check manifold vacuum signal (10"Hg/34kPa) at the valve and check the electrical circuit from the solenoid to the ECM.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. This is a system performance test. When vehicle goes to "Closed Loop," air will switch from the ports and divert to the air cleaner..
2. Tests for a grounded electric divert circuit. Normal system light will be "OFF."
3. Checks for an open control circuit. Grounding diagnostic terminal will energize the solenoid, if ECM and circuits are normal. In this step, if test light is "ON," circuits are normal and fault is in valve connections or valve.
4. Checks for voltage from battery through a fuse to the solenoid.

# CHART C-6

## AIR MANAGEMENT CHECK (ELECTRONIC AIR CONTROL VALVE) 2.8L (VIN R) "KT" (TBI)



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## SECTION C7

### EXHAUST GAS RECIRCULATION (EGR) SYSTEM CONTENTS

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### GENERAL DESCRIPTION

#### PURPOSE

The EGR system is used to lower NO<sub>x</sub> (oxides of nitrogen) emission levels caused by high combustion temperatures. It does this by decreasing combustion temperature.

The main element of the system is an EGR valve operated by vacuum, and mounted on the intake manifold.

The EGR valve feeds small amounts of exhaust gas back into the combustion chamber as shown in Figure C7-1.

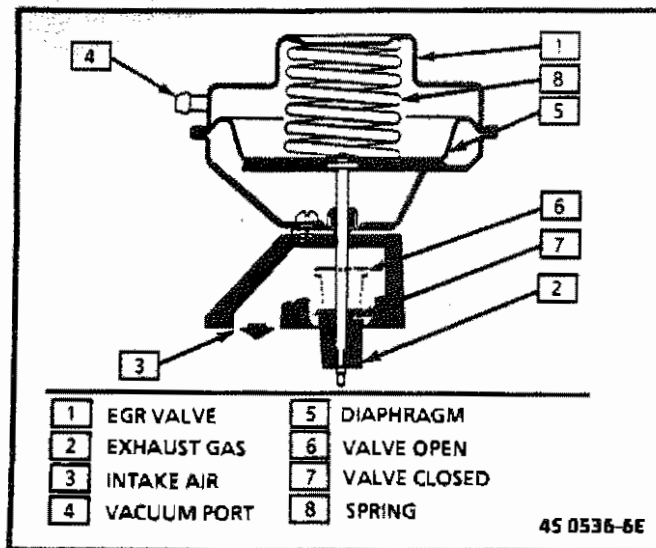


Figure C7-1 - Exhaust Gas Recirculation

### OPERATION

The EGR valve is opened by vacuum to let exhaust gas flow into the intake manifold. The exhaust gas then moves with the air/fuel mixture into the combustion chamber. If too much exhaust gas enters combustion will not occur. For this reason, very little exhaust gas is allowed to pass through the valve especially at idle. The EGR valve is usually open under the following condition:

- Warm engine operation
- Above idle speed

### EGR CONTROL

#### ELECTRONIC VACUUM REGULATOR VALVE (EVRV)

To regulate EGR flow, an ECM controlled electronic vacuum regulator valve (EVRV) solenoid is used in the vacuum line. The ECM uses information from the following sensors to regulate the solenoid:

- Coolant Temperature
- Throttle Position Sensor (TPS)
- Distributor (rpm signal)

The EGR vacuum control has an EVRV solenoid that uses "pulse width modulation." This means the ECM turns the solenoid "ON" and "OFF" many times a second and varies the amount of "ON" time ("pulse width") to vary the amount of EGR.

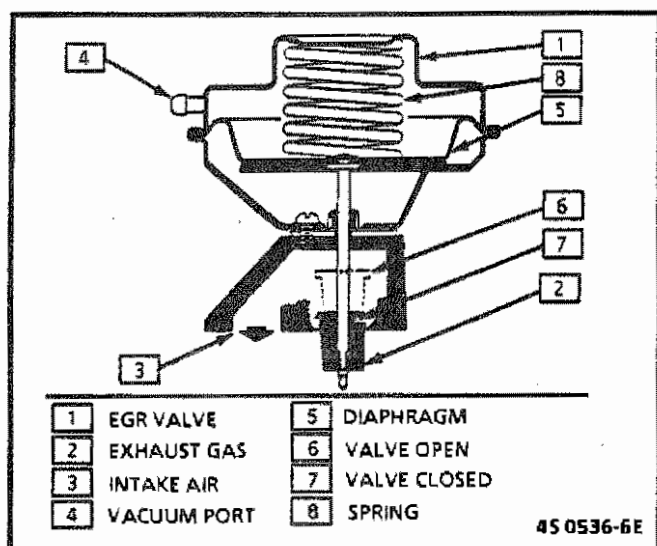


Figure C7-2 - Mounting Valve

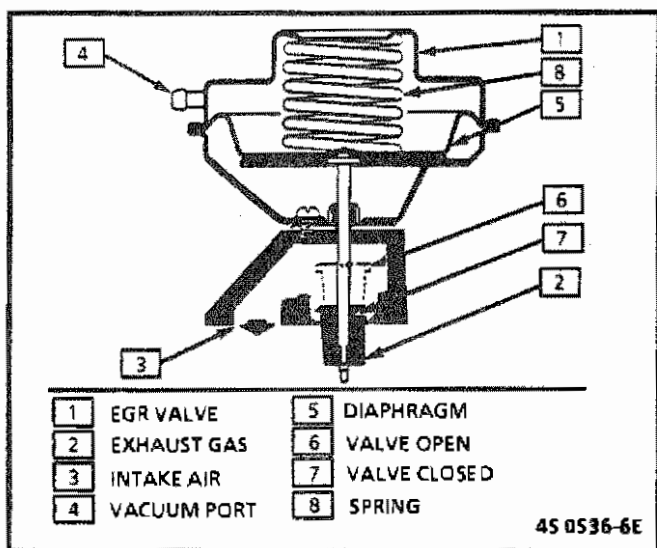


Figure C7-3 - EGR Mounting

## PORT EGR VALVE

This valve is controlled by a flexible diaphragm which is spring loaded to hold the valve closed. Vacuum applied to the top side of the diaphragm overcomes the spring pressure and opens the valve in the exhaust gas port. This allows exhaust gas to be pulled into the intake manifold and enter the engine cylinders.

## EGR VALVE IDENTIFICATION

- Negative backpressure EGR valves will have an "N" stamped on the top side of the valve after the part number (Figure C7-4).

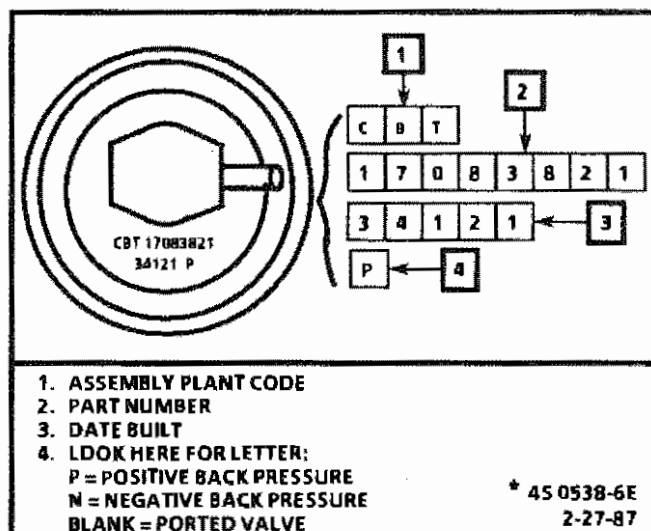


Figure C7-4 - EGR Valve Identification

- Positive backpressure EGR valves will have a "P" stamped on the top side of the valve, after the part number.
- Port EGR valves have no identification stamped after the part number.

When replacing an EGR valve, always check for correct part number in the parts catalog or supplemental bulletin.

## RESULTS OF INCORRECT OPERATION

Too much EGR flow (at idle, cruise, or cold operation) and may result in any of the following conditions:

- Engine stops after cold start.
- Engine stops at idle after deceleration.
- Car surges during cruise.
- Rough idle.

Too little or no EGR flow allows combustion temperatures to get too high during acceleration and load conditions. This could cause:

- Spark knock (detonation).
- Engine overheating.
- Emission test failure.

## ON-CAR SERVICE

### EGR VALVE

#### ↔ Remove or Disconnect

- Air cleaner.
- EGR valve vacuum hose at valve.
- Bolts.
- EGR valve from manifold.

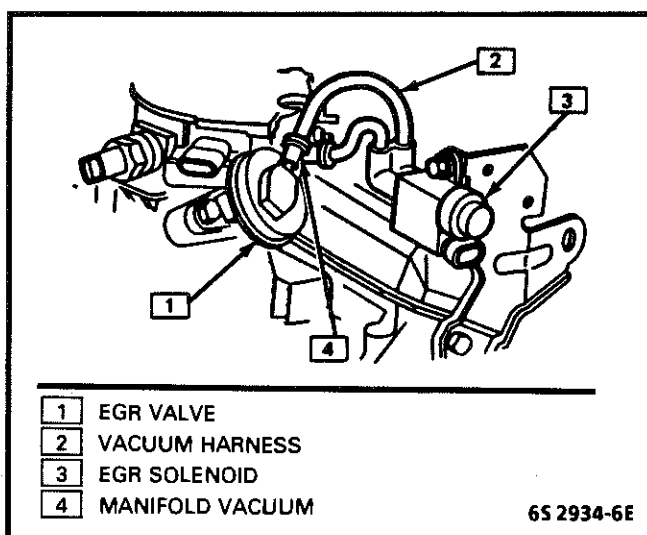


Figure C7-5 - EGR &amp; Solenoid 2.8L

**EGR Manifold Passage****Inspect**

If EGR passages in the inlet manifold indicate excessive build-up of deposits, the passages should be cleaned. Care should be taken to ensure that all loose particles are completely removed to prevent them from clogging the EGR valve or from being ingested into the engine.

**Clean**

1. With a wire wheel, buff the exhaust deposits from the mounting surface and around the valve.
2. Look for exhaust deposits in the valve outlet. Remove deposit build-up with a screwdriver.
3. Clean mounting surfaces of intake manifold and valve assembly.

**Install or Connect**

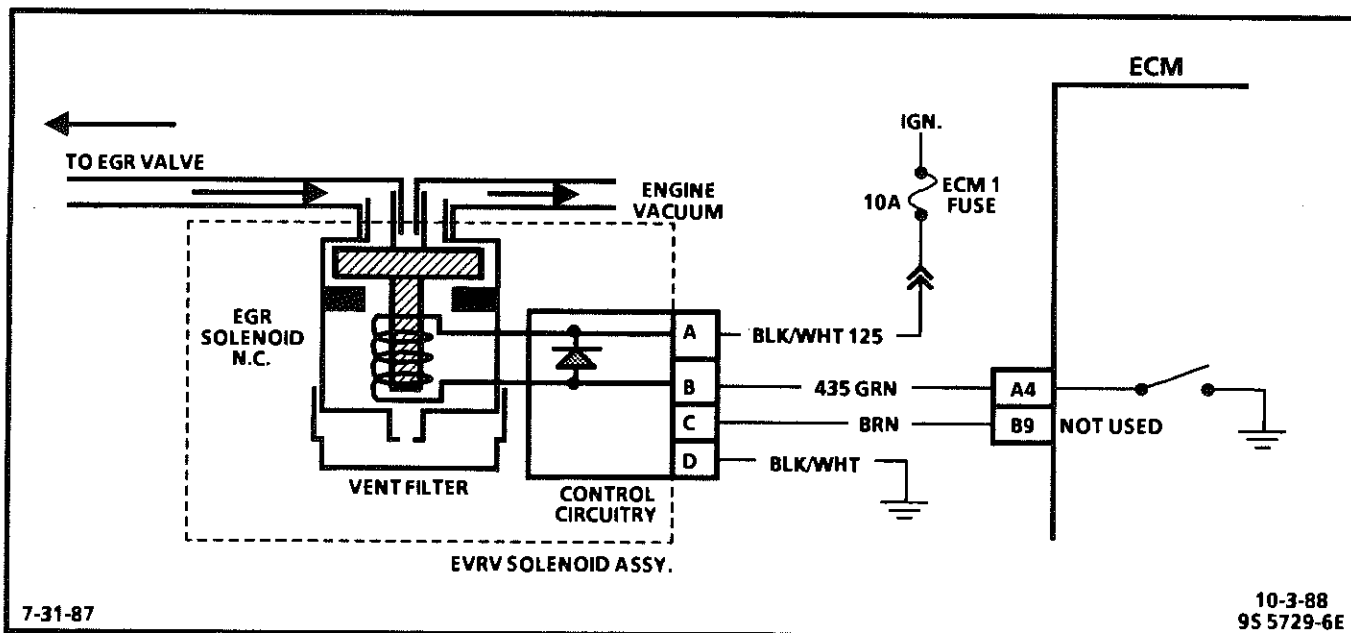
1. EGR valve on intake manifold using new gasket.
2. Bolts and tighten to 22 N·m (16 lb. ft.).
3. Vacuum hose to valve.
4. Air cleaner.

**EGR CONTROL SOLENOID****Remove or Disconnect**

1. Negative battery cable.
2. Air cleaner.
3. Electrical connector at solenoid, (Figure C7-5)
4. Vacuum hoses.
5. Nut and solenoid.

**Install or Connect**

1. Solenoid and bracket. Tighten nut to 24 N·m (17 lb. ft.).
2. Vacuum hoses.
3. Electrical connector.
4. Air cleaner.
5. Negative battery cable.



## CHART C-7

### EGR SYSTEM CHECK 2.8L (VIN R) "KT" (TBI)

#### Circuit Description:

The EGR valve is controlled by a normally closed solenoid (allow a vacuum to pass when energized). The ECM pulses the solenoid to turn "ON" and regulate the EGR. The ECM diagnoses the system using an internal EGR test procedure.

The ECM control of the EGR is based on the following inputs:

- Engine coolant temperature - above 25°C.
- TPS - "OFF" idle
- MAP

If Code 24 is stored, use that chart first.

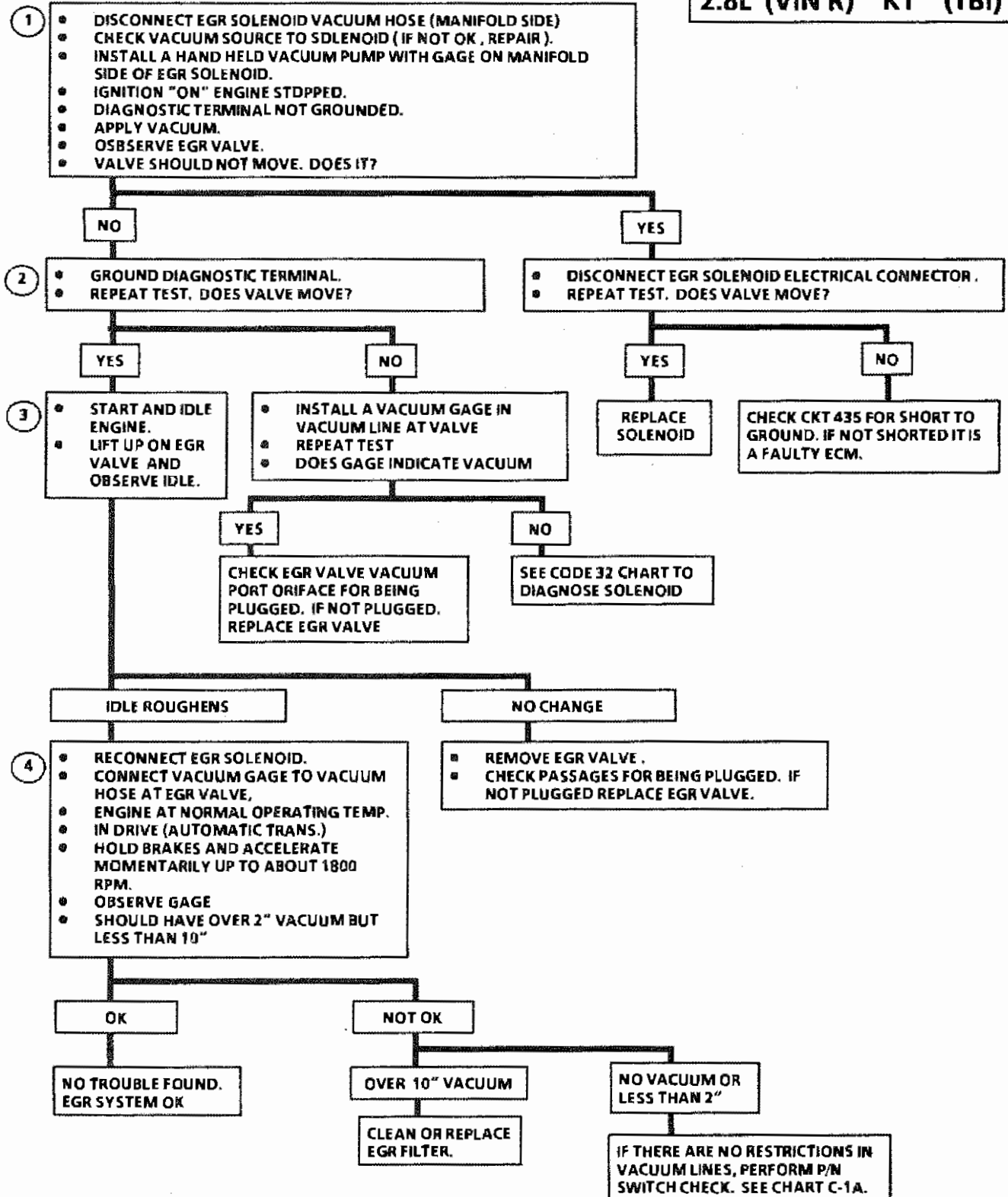
Code 32 will detect a faulty solenoid, vacuum supply, EGR valve or plugged passage. This chart checks for plugged EGR passages, a sticking EGR valve, or a stuck open or inoperative solenoid.

**Test Description:** Numbers below refer to circled numbers on the diagnostic chart.

1. With the ignition "ON," engine stopped, the solenoid should not be energized and vacuum should not pass to the EGR valve.
2. Grounding the diagnostic terminal will energize the solenoid and allow vacuum to pass to valve.
3. Checks for plugged EGR passages. If passages are plugged, the engine may have severe detonation on acceleration.
4. The EGR solenoid will not be energized in park or neutral. This test will determine if the switch input is being received by the ECM.

**CHART C-7****EGR SYSTEM CHECK  
2.8L (VIN R) "KT" (TBI)**

ASSUMES NO CODE 24 OR 32 IS STORED



CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

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## SECTION C10

### ECM CONTROLLED AIR CONDITIONING

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### GENERAL DESCRIPTION

In order to improve idle quality and wide open throttle performance, the A/C compressor is controlled by the ECM.

The KT Trooper uses the expansion valve refrigerant system as described earlier in Section "1". There are five modes of operation available on the control. They are OFF, MAX, A/C, HEAT and DEFROST. Blower speed is manually selected in all modes except OFF. For descriptions of the components used, refer to Section "12" of the service manual.

### OPERATION: EXPANSION VALVE TYPE

This system consists of a dual pressure switch, an evap thermo switch, 3 control relays, and the compressor.

The dual pressure switch, mounted in the receiver dryer, is closed when the system contains a sufficient refrigerant charge. This switch opens when pressure is less than about 40 psi (276 kPa) or over 440 psi (3034 kPa).

The A/C control relays are controlled by the ECM, so that the ECM can increase idle speed before turning "ON" the clutch, to disable the clutch during WOT.

See appropriate C-10 CHART for specific wiring and circuit description.

### DIAGNOSIS

CHARTS C-10 should be used for diagnosing the electrical portion of the A/C circuit. Section "1B" should be used for diagnosing the refrigerant portion of the system.

The "Scan" tool will be used in diagnosing the system, as it has the ability to read the A/C request input to the ECM, as well as displaying when the ECM has commanded the A/C clutch "ON."

### ON-CAR SERVICE

For removal and replacement procedures of A/C components, refer to Section "12" of the service manual.

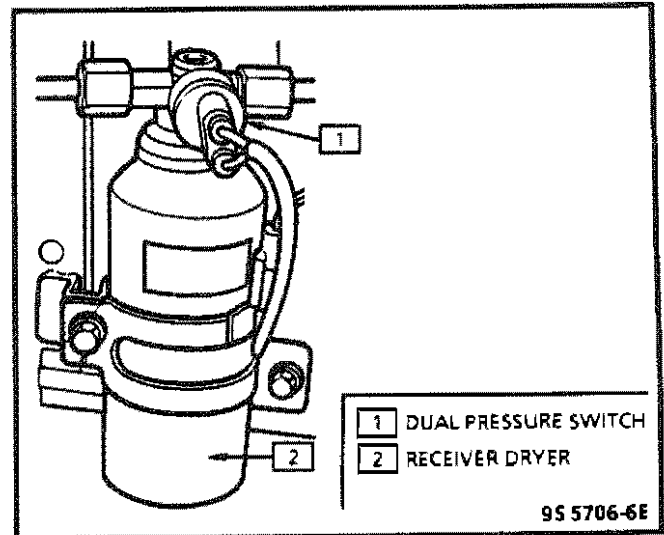


Figure C10-1 - A/C Dual Pressure Switch

## A/C CLUTCH CONTROL CIRCUIT DIAGNOSIS

The A/C clutch control relay is ECM controlled to delay A/C clutch engagement about .4 second after A/C is turned "ON." This allows the IAC to adjust engine rpm before the A/C clutch engages. The ECM also causes the relay to disengage the A/C clutch during WOT, when high power steering pressure is present, or if engine is overheating. The A/C clutch control relay is energized when the ECM provides a ground path for CKT grn/blk 03.

**ECM control of the A/C clutch improves idle quality and performance by:**

- Delaying clutch apply until the idle air rate is increased.
- Releasing clutch when idle speed is too low.
- Releasing clutch at wide open throttle.
- Smooths cycling of the compressor by providing additional fuel at the instant clutch is applied.

**Test Description:** Numbers refer to circled numbers on the diagnostic chart.

1. Checks for low refrigerant or dual pressure switch as cause for no A/C.

2. This and following tests check for faulty A/C control relay.
3. This and following tests check for open ECM wiring or faulty ECM.

**CHART C-10****A/C CLUTCH CONTROL CIRCUIT DIAGNOSIS  
2.8L (VIN R) "KT" (TBI)**

- ENGINE IDLING AT NORMAL TEMP.
- TURN BLOWER SWITCH "ON"
- TURN A/C "ON"
- DOES COMPRESSOR CLUTCH ENGAGE?

NO

YES

NO TROUBLE FOUND

①

- WITH A TEST LIGHT CONNECTED TO GROUND, PROBE BOTH TERMINALS OF A/C DUAL PRESSURE SWITCH.

LIGHT "ON" BOTH

LIGHT "ON" ONE TERMINAL

NO LIGHT

②

- TURN ENGINE "OFF"
- USING FUSABLE JUMPER WIRE, JUMP A/C COMPRESSOR TEST LEAD TO B+.
- DOES COMPRESSOR CLUTCH ENGAGE?

FAULTY DUAL PRESSURE SWITCH OR FAULTY A/C SYSTEM PRESSURE.

- REFER TO HEATING AND COOLING ELECTRICAL SECTION OF MANUAL.

YES

NO

③

- RESTART ENGINE
- ENGINE IDLING AT NORMAL TEMP.
- TURN BLOWER SWITCH "ON"
- TURN A/C "ON"
- WITH TEST LIGHT CONNECTED TO GROUND, BACK PROBE ECM PIN TERM B-8.

- CONNECT FUSABLE JUMPER TO B+ AND CIRCUIT 5 GRN/RED.
- DOES COMPRESSOR CLUTCH ENGAGE?

YES

NO

FAULTY RELAY

OPEN A/C COMPRESSOR CLUTCH CIRCUIT OR FAULTY COMPRESSOR CLUTCH.

LIGHT "ON"

LIGHT "OFF"

WITH TEST LIGHT CONNECTED TO B+, BACK PROBE ECM PIN A-2.

OPEN CIRCUIT BETWEEN DUAL PRESSURE SWITCH AND ECM TERMINAL B-8.

LIGHT "ON"

LIGHT "OFF"

- WITH JUMPER WIRE CONNECTED TO GROUND, PROBE CKT 3 GRN/BLACK AT RELAY. DOES COMPRESSOR CLUTCH ENGAGE?

FAULTY ECM

YES

NO

OPEN CKT 3 GRN/BLACK BETWEEN ECM AND RELAY.

FAULTY RELAY

CLEAR CODES AND CONFIRM "CLOSED LOOP" OPERATION AND NO "CHECK ENGINE" LIGHT.

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## SECTION C13

### POSITIVE CRANKCASE VENTILATION (PCV)

#### CONTENTS

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#### GENERAL DESCRIPTION

A Positive Crankcase Ventilation (PCV) system is used to consume crankcase vapors in the combustion process instead of venting to atmosphere. Fresh air from the air cleaner is supplied to the crankcase, mixed with blow-by gases and then passed through a Positive Crankcase Ventilation (PCV) valve into the intake manifold (Figure C13-2).

The primary control is through the PCV valve which meters the flow at a rate depending on manifold vacuum.

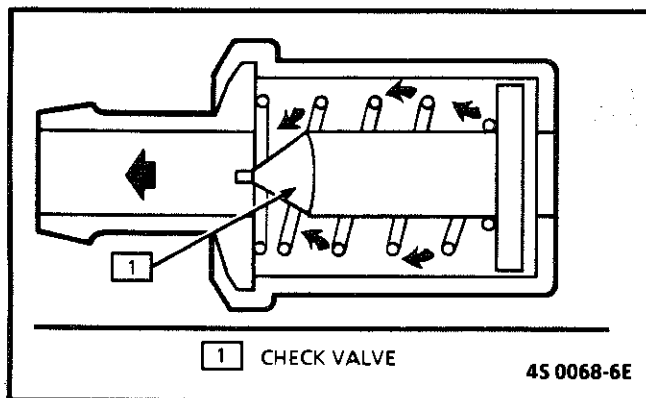


Figure C13-1 - PCV Valve Cross Section

To maintain idle quality, the PCV valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the air cleaner to be consumed by normal combustion.

- A leaking valve or hose would cause:
  - Rough idle.
  - Stalling.
  - High idle speed.

#### DIAGNOSIS

If an engine is idling rough, check for a clogged PCV valve or plugged hose. Replace as required. Use the following procedure:

1. Remove PCV valve from rocker arm cover.
2. Run the engine at idle.

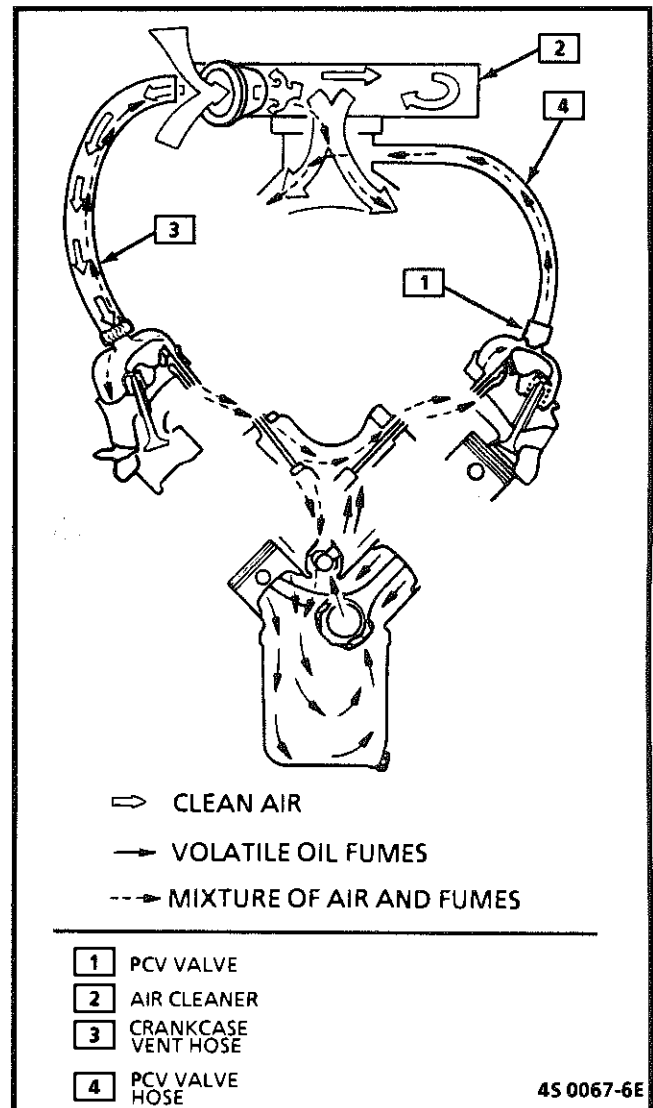


Figure C13-2 - PCV-Flow

3. Place your thumb over end of valve to check for vacuum. If there is no vacuum at valve, check for plugged hoses or manifold port, or PCV valve. Replace plugged or deteriorated hoses.
4. Turn "OFF" the engine and remove PCV valve. Shake valve and listen for the rattle of check needle inside the valve. If valve does not rattle, replace valve.

With this system, any blow-by in excess of the system capacity (from a badly-worn engine, sustained heavy load, etc.) is exhausted into the air cleaner and is drawn into the engine.

Proper operation of the PCV system is dependent upon a sealed engine. If oil sludging or dilution is noted, and the PCV system is functioning properly, check engine for possible cause and correct to ensure that system will function as intended.

### ON-CAR SERVICE

An engine which is operated without any crankcase ventilation can be damaged. Therefore, it is important to replace the PCV valve and air cleaner breather at intervals shown in Section "OO".

Periodically, inspect the hoses and clamps and replace any showing signs of deterioration.

### RESULTS OF INCORRECT OPERATION

- A plugged valve or hose may cause:
  - Rough idle.
  - Stalling or slow idle speed.
  - Oil leaks.
  - Oil in air cleaner.
  - Sludge in engine.

## SECTION C14

### THERMOSTATIC AIR CLEANER (THERMAC)

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### GENERAL DESCRIPTION

#### PURPOSE

A heated intake air system is used to give good driveability under varying climatic conditions. By having a uniform inlet air temperature, the fuel system can be calibrated to reduce exhaust emissions and to eliminate throttle valve icing.

#### OPERATION

The THERMAC air cleaner operates by heated air and manifold vacuum (Figure C14-1). Air can enter the air cleaner from outside the engine compartment or from a heat stove built around the exhaust manifold. A vacuum diaphragm motor, built into the air cleaner snorkel, moves a damper door, to admit hot air from the exhaust manifold, outside air, or a combination of both. Inside the air cleaner is a temperature sensor that reacts to air intake temperature and controls the amount of vacuum going to the motor.

- **Hot Air Delivery Mode.** When the temperature is below 86°F (30°C), the sensor allows vacuum to the motor and the damper door will shut off outside air and allow only heated air from the exhaust manifold to enter the air cleaner.
- **Outside Air Delivery Mode.** When the temperature is above 55°C (131°F), the damper door drops down and only outside air enters the air cleaner.
- **Regulating Mode.** Between 30°C (86°F) and 55°C (131°F) the damper door allows both heated and outside air to enter the air cleaner.

#### THERMAC DELAY VALVE

Some applications use a delay valve on the hose connecting the vacuum motor to the temperature sensor (Figure C14-2). When vacuum in this hose drops for any reason, the check valve will bleed off the vacuum to the vacuum motor slowly.

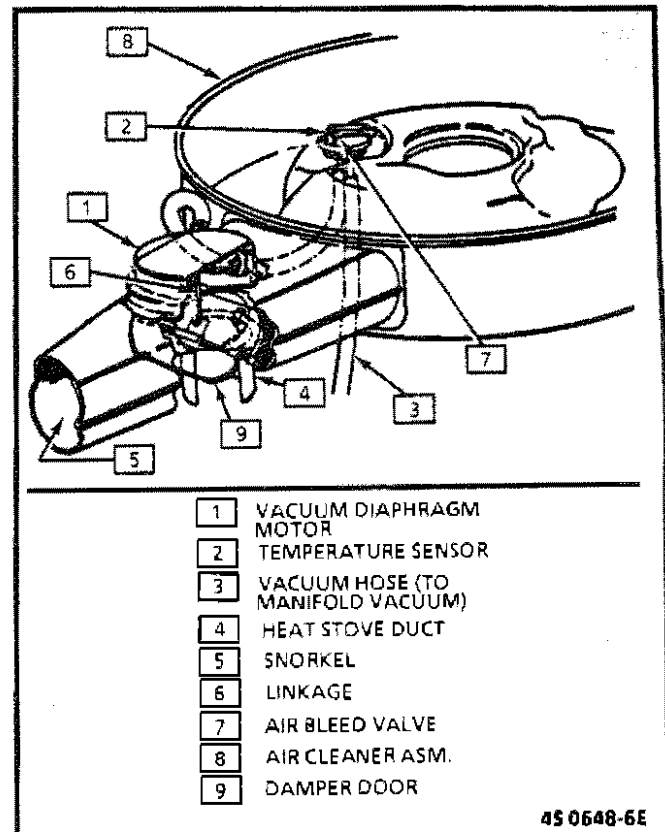


Figure C14-1 - THERMAC Air Cleaner - Typical

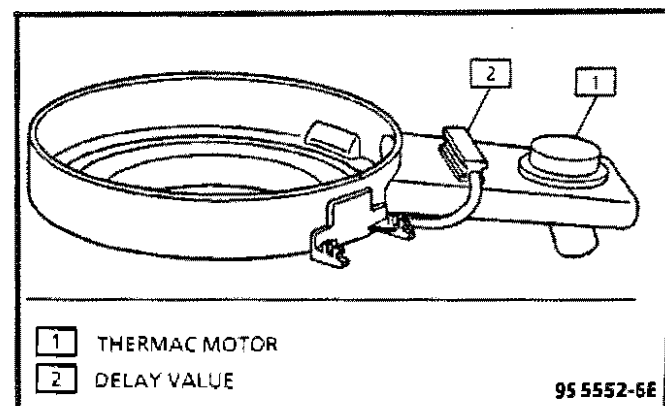


Figure C14-2 - THERMAC Delay Valve

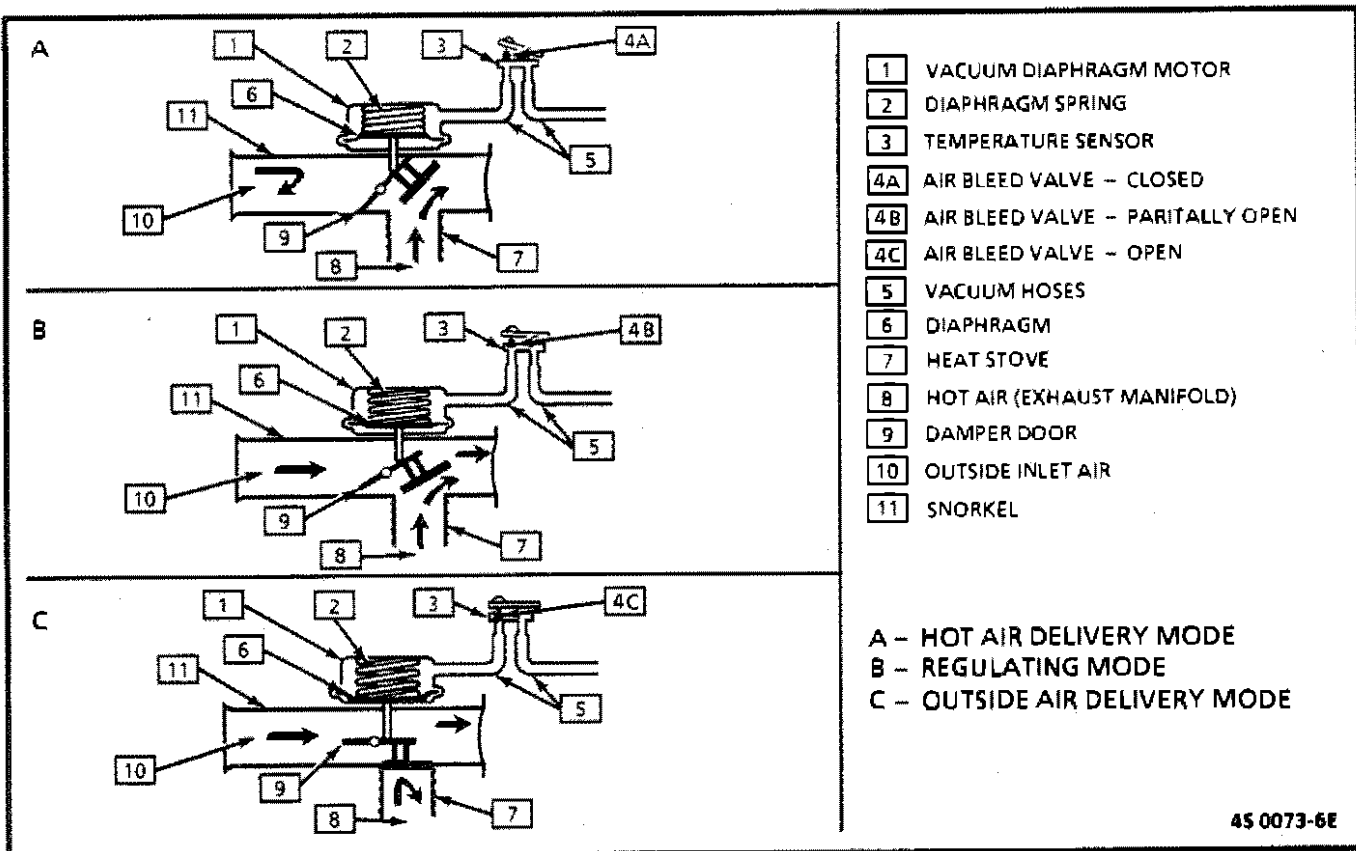


Figure C14-3 - Thermac Operation

## DIAGNOSIS

### RESULTS OF INCORRECT THERMAC OPERATION

- Hesitation during warm-up can be caused by:
  - Heat stove tube disconnected.
  - Vacuum diaphragm motor inoperative (open to snorkel).
  - No manifold vacuum.
  - Damper door does not move.
  - Missing air cleaner to carburetor seal.
  - Missing air cleaner cover seal or loose cover.
  - Loose air cleaner.
- Lack of power, sluggish, spongy, or detonation on a hot engine can be caused by:
  - Damper door does not open to outside air.
- Temperature sensor doesn't bleed off vacuum.

### THERMAC AIR CLEANER CHECK

1. Inspect system to be sure all hoses and heat stove tube are connected. Check for kinked, plugged or deteriorated hoses.
2. Check for presence and condition of air cleaner to carburetor gasket seal.

3. With air cleaner assembly installed, damper door should be open to outside air.
4. Start engine. Watch damper door in air cleaner snorkel. When engine is first started, damper door should move and close off outside air. As air cleaner warms up, damper door should open slowly to outside air.
5. If the air cleaner fails to operate as described above, perform vacuum motor check. If it operates, the door may not be moving at the right temperature. If the driveability problem is during warm-up, make the temperature sensor check below.

### VACUUM MOTOR CHECK

1. With engine "OFF," disconnect vacuum hose at vacuum diaphragm motor.
2. Apply at least 23 kPa (7in.Hg.) of vacuum to the vacuum diaphragm motor. Damper door should completely block off to outside air when vacuum is applied. If not, check to see if linkage is hooked up correctly.
3. With vacuum still applied, trap vacuum in vacuum diaphragm motor by bending hose. Damper door should remain closed. If not, replace vacuum diaphragm motor assembly.

(Failure of the vacuum diaphragm motor assembly is more likely to be caused from binding linkage or a corroded snorkel than from a failed diaphragm. This should be checked first, before replacing the diaphragm.)

4. If vacuum motor checks OK, check vacuum hoses and connections. If OK, replace the temperature sensor.

## TEMPERATURE SENSOR CHECK

1. Start test with air cleaner temperature below 30°C (86°F). If engine has been run recently, remove air cleaner cover and place thermometer as close as possible to the sensor. Let air cleaner cool until thermometer reads below 30°C (86°F) about 5 to 10 minutes. Reinstall air cleaner on engine and continue to Step 2.
2. Start and idle engine. Damper door should move to close off outside air immediately if engine is cool enough. When damper door starts to open the snorkel passage (in a few minutes), remove air cleaner cover and read thermometer. It must read about 55°C (131°F).
3. If the damper door is not open to outside air at temperature indicated, temperature sensor is malfunctioning and must be replaced.

## ON-CAR SERVICE

### AIR CLEANER ELEMENT

#### ↔ Remove or Disconnect

1. Air cleaner cover.
2. Old element.

#### ↔ Install or Connect

1. New element.
2. Air cleaner cover. Do not over-torque nuts (install finger-tight).

### VACUUM DIAPHRAGM MOTOR

#### ↔ Remove or Disconnect

1. Air cleaner.
2. Vacuum hose from motor.
3. Drill out the two spot welds initially with a 1.6mm (1/16") drill, then enlarge as required to remove the retaining strap. Do not damage the snorkel tube.
4. Motor retaining strap.
5. Lift up motor, cocking it to one side to unhook the motor linkage at the control damper assembly.

#### ↔ Install or Connect

1. Drill a 2.8mm (7/64") hole in snorkel tube at center of vacuum motor retaining strap.

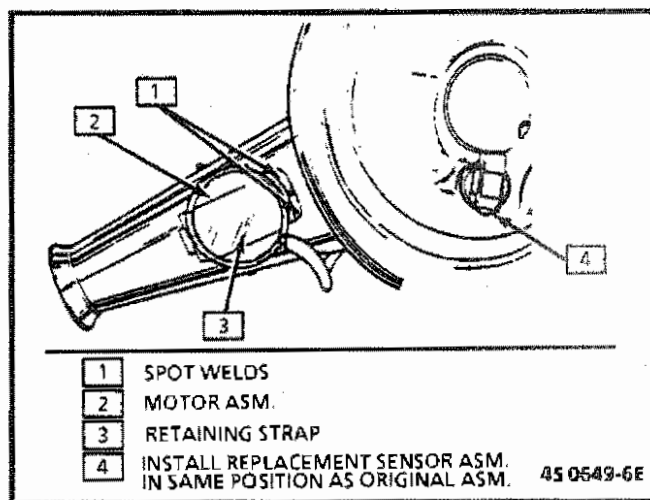


Figure C14-4 - Replacing THERMAC Vacuum Motor

2. Vacuum motor linkage into control damper assembly.
3. Use the motor retaining strap and sheet metal screw provided in the motor service package to secure motor to the snorkel tube. Make sure the screw does not interfere with the operation of the damper assembly. Shorten screw if required.
4. Vacuum hose to motor and install air cleaner.

### SENSOR

#### ↔ Remove or Disconnect

1. Air cleaner.
2. Hoses at sensor.
3. Pry up tabs on sensor retaining clip. Remove clip and sensor from air cleaner. Note position of sensor for installation.

#### ↔ Install or Connect

1. Sensor and gasket assembly in original position.
2. Retainer clip on hose connectors.
3. Vacuum hoses and air cleaner on engine.

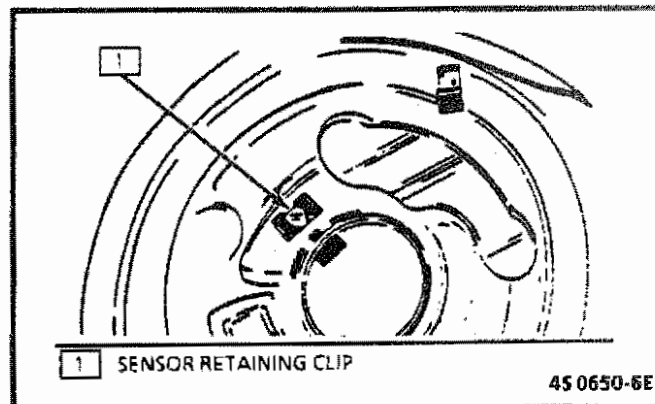


Figure C14-5 - Replacing THERMAC Sensor

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