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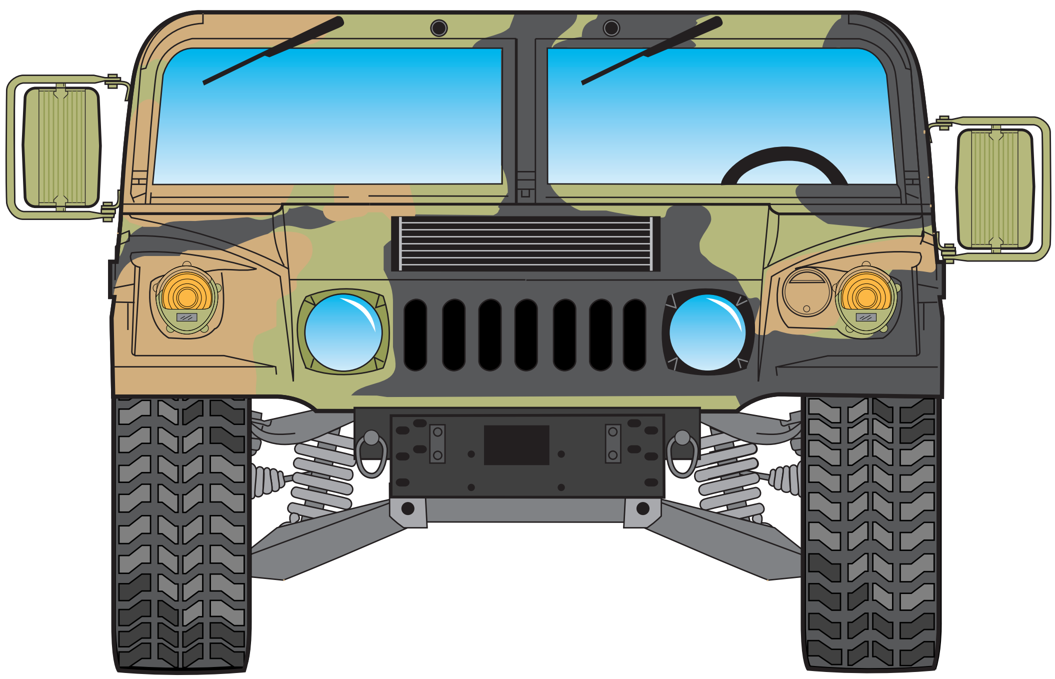
AM General Corporation

MILITARY HMMWV



Component Testing and Troubleshooting

M998A1 Series Vehicles

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SECTION 1
COOLING SYSTEM

A. FAN CLUTCH TEST PROCEDURE

With engine off, attempt to turn fan by hand. If fan can be turned independently of clutch, replace or repair fan drive.

B. FAN THERMOSTATIC SWITCH TESTING (Figure 1-1)

1. With engine running disconnect engine harness leads 458A (1) and 458B (2) from fan thermostatic switch harness leads (3) located on the left side of the water crossover pipe (4). Fan should engage and operate.

2. With engine running momentarily connect engine harness leads 458A & 458B together. Fan should disengage.

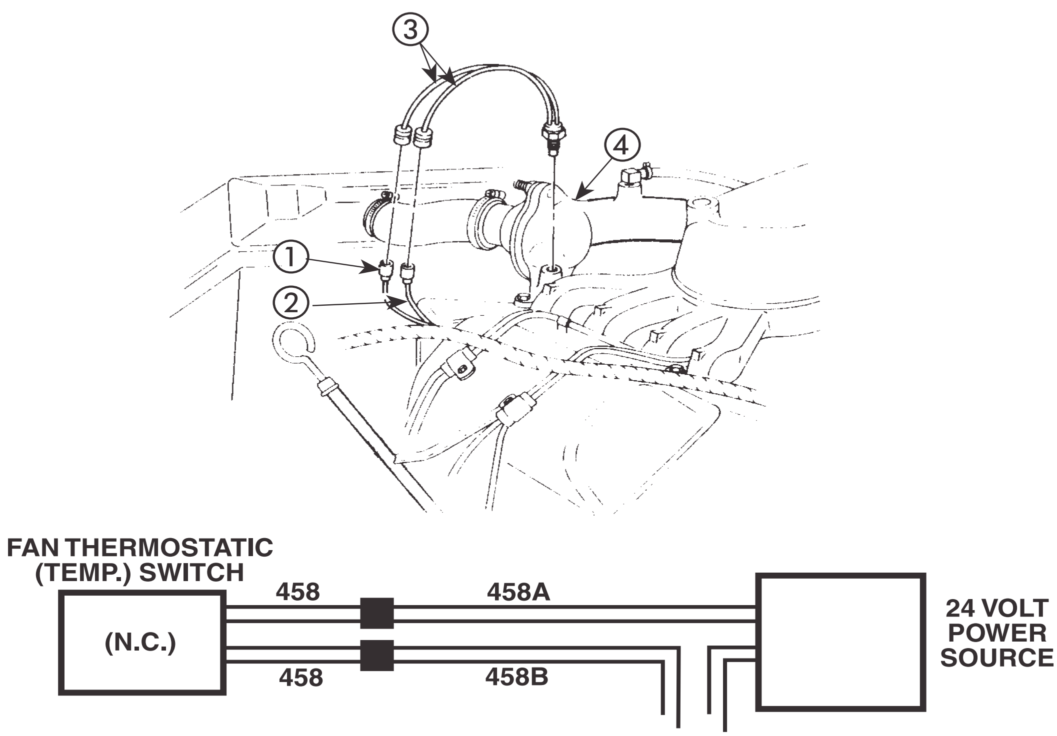


Figure 1-1. Fan Thermostatic Switch Testing Hookup.

C. FAN CLUTCH SOLENOID RESISTANCE TEST (Figure 1-2)

Test for clutch control valve solenoid resistance. Using a multimeter, check resistance between connector terminals (1). Check resistance both ways. Resistance should be 58 ohms to 78 ohms both ways. If not, replace drive solenoid and hydraulic control valve assembly and check for operation while engine is running.

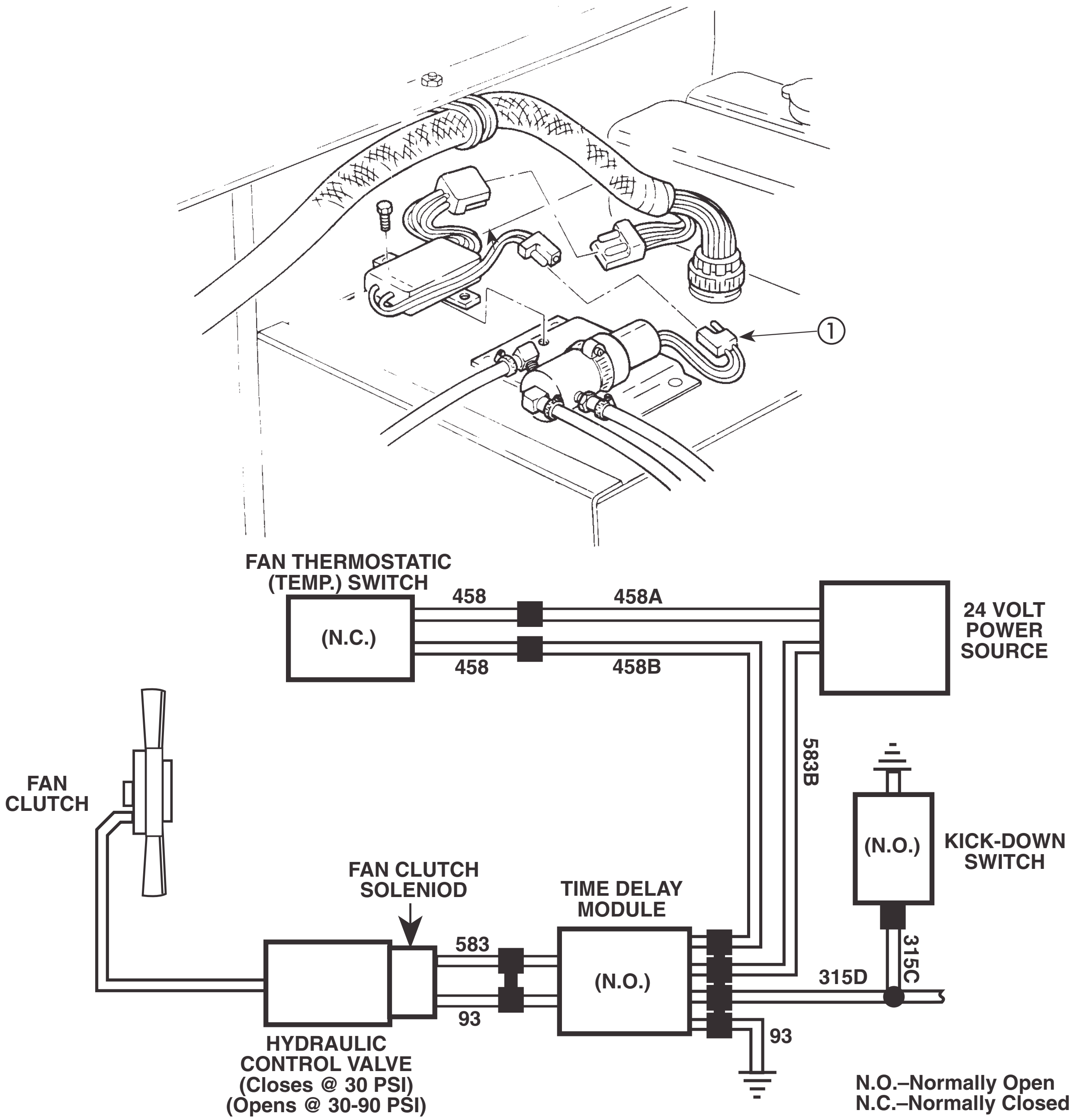


Figure 1-2. Fan Clutch Solenoid Resistance Test Hookup.

D. FAN CLUTCH VALVE PRESSURE TEST (Figure 1-3)

With the engine running, measure pressure at hydraulic hose (1) from fan control valve to fan shroud fitting. Coolant temperature must be below 210°F (99°C). If pressure is below 90 psi (620 kPa), remove hydraulic control valve. Check valve openings for debris which would interfere with control valve operation. Clean control valve openings. Replace control valve if unserviceable.

With engine running, disconnect and measure pressure at hydraulic hose (1) from fan control valve to fan shroud fitting. Pressure should be below 30 psi (206 kPa). If pressure is above 30 psi (206 kPa), remove hydraulic control valve. Check valve openings for debris which would interfere with control valve operation. Clean control valve openings. Replace control valve if unserviceable.

Normal operating pressure for the fan clutch hydraulic control valve is between 90-165 psi (620-1137 kPa).

CAUTION

Pressure required to override fan clutch spring, and allow fan to free-spin is between 30-90 psi (260-620 kPa). Pressure in the fan clutch line however, could go up to 165 psi (1137 kPa).

E. FAN CLUTCH PRESSURE TEST (Figure 1-3)

Check fan drive operation. Disconnect hose (1) at fan shroud fitting. Apply 90 psi (620 kPa) air pressure to fan shroud fitting. Fan clutch should disengage. If fan clutch does not disengage, replace or repair fan drive.

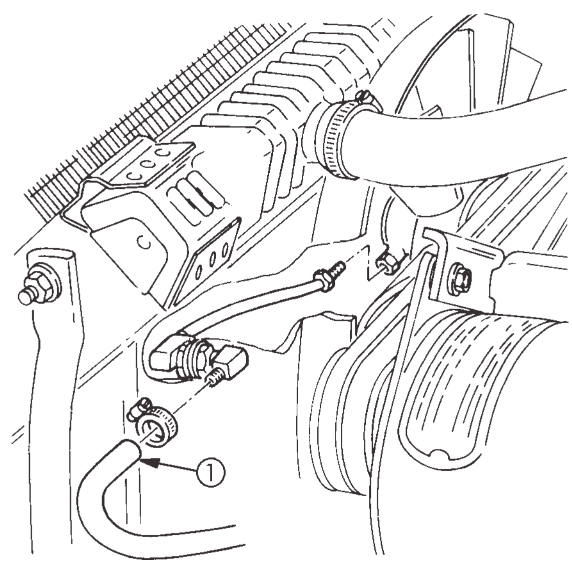


Figure 1-3. Fan Clutch Valve Pressure Test Hookup.

F. ATTACHING COOLANT PRESSURE TESTER (Figure. 1-4 and 1-5)

1. Carefully remove the radiator pressure cap from the surge (overflow) tank.

2. Make sure coolant is at recommended level in surge tank.

3. Wipe out the inside of the filler neck. Examine the lower inside sealing seat of the filler neck for dirt.

4. Inspect the overflow tube for dents or internal obstruction. Pressure released by the pressure cap during operation of the truck must pass through this tube. An obstructed tube may cause the radiator or some portion of the cooling system to burst if pressure builds up excessively.

5. Inspect the cams on the outside of the filler neck. If cams are bent down or up, the seating of the pressure cap valve and the Tester seal will be affected. Bent cams can be reformed if it is done carefully. DO NOT BREAK THE SOLDER JOINT BETWEEN THE NECK AND THE RADIATOR TOP TANK.

6. Attach the Pressure Tester to the filler neck as shown in Figure 1-4. Set the Tester on the filler neck with the locking ears in line with the entrance notches of the filler neck. Press down slightly and rotate clockwise until the locking ears are stopped by the stop lugs on the filler neck. DO NOT FORCE.

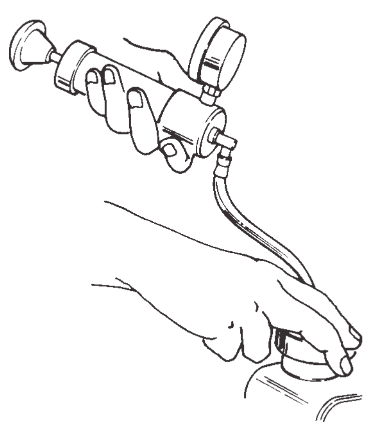


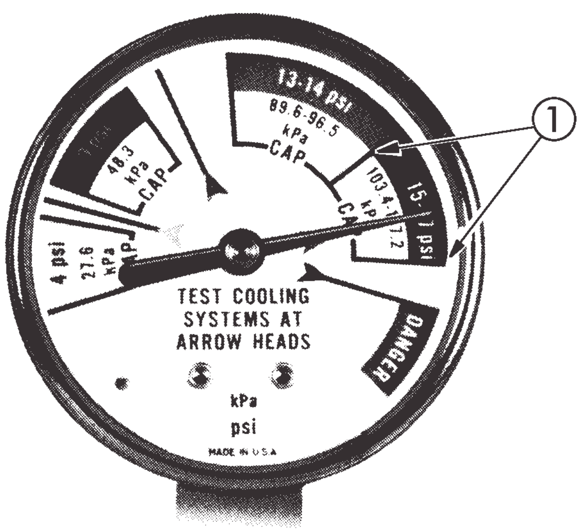
Figure 1-4. Attaching Coolant Pressure Tester

7. After attaching the Tester to the surge tank filler neck, operate the pump until the indicator hand on the gauge reaches the proper arrow just beyond the end of each color band.

The Hummer 15-17 POUND SYSTEM, should be pumped up to the lines indicating the 15–17 pound system (1), Figure 1-5. DO NOT EXCEED THIS POINT.

WARNING

Never exceed the arrow points of the recommended pressure of the system being tested, as it is not necessary to go beyond the arrow to determine if leaks exist. Excessive pressure can rupture radiator, hose, etc. Never pressurize into the red danger area for any cooling system as serious damage to it may occur.



15 -17 lb. CAP

Figure 1-5. Coolant Tester Gauge.

G. RADIATOR EXTERNAL PRESSURE LEAK TESTING (Figure 1-5)

After pumping the proper amount of pressure into the radiator, observe the gauge.

1. ARROW HOLDS STEADY

   If the hand holds steady for two minutes, there are no serious leaks in the system. Nevertheless, examine all points for seepage or slight leakage with a flashlight.

2. ARROW DROPS SLOWLY

   Indicates the presence of small leaks or seepage. Check radiator, hose, gaskets, and heater. After repairing leaks, the system should be rechecked for minor leaks as these will quickly become major leaks. If radiator hose swells excessively while testing system, it indicates it is in a weakened condition and should be replaced.

3. ARROW DROPS QUICKLY

   Indicates that serious leakage is present. Large radiator leaks should be repaired.

H. RADIATOR INTERNAL PRESSURE LEAK TESTING (Figure 1-5)

WHEN THE GAUGE SHOWS A PRESSURE DROP AND THERE IS NO VISIBLE LEAKAGE. Remove tester and replace pressure cap. Run the engine to churn up the oil and examine the dipstick for water globules. Another method would be to remove the crankcase drain plug and drain out a small amount of oil; water being the heaviest should drain out first.

I. HEAD GASKET LEAK TEST (Figure 1-5)

Compression or combustion leakage into the cooling system can be detected as follows:

1. Carefully remove the pressure cap and apply the Pressure Tester to the filler neck when the engine is cool.

2. Let engine idle and warm up to normal operating temperature. WATCH CAREFULLY, IF GAGE INDICATES PRESSURE IS BUILDING UP FAST, RELEASE PRESSURE BY TURNING OFF ENGINE AND CAREFULLY REMOVING TESTER.

3. Do not allow pressure to build up past arrow indicating maximum for the system. When pressure builds up fast, a leak exists as a result of a blown gasket. Replace head gasket.

J. COMPRESSION OR COMBUSTION LEAK TEST (Figure 1-5)

If pressure does not build up immediately then operate the Pressure Tester pump until the gage reads within the range for the system being tested. If the gage hand vibrates, this indicates a compression or combustion leak into the cooling system. Location of compression leak is determined by shorting out each injector; gage hand will stop or decrease vibrating when the injector of the leaking cylinder is shorted out. Retest with Pressure Tester after repairing leak.

Remove Tester From Radiator Neck. (Figure 1-6)

Release pressure in cooling system by pressing stem to one side, (Figure 1-6) then remove Tester from filler neck.

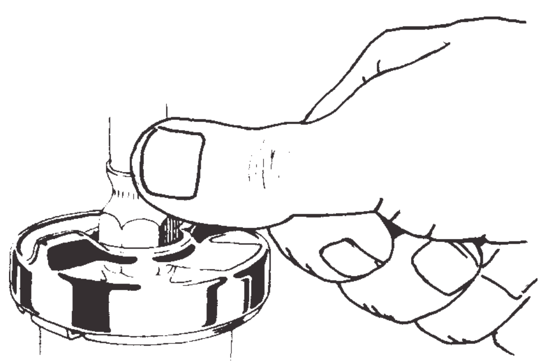


Figure 1-6. Releasing Cooling System Pressure Tester.

K. TESTING THE PRESSURE CAP (Figures 1-7 thru 1-9)

The Pressure Cap functions as a safety valve to keep the pressure within the desired safe limits as designed by the truck manufacturer. The filler cap is stamped or otherwise marked with a figure indicating the approximate operating pressure. (See Figure 1-7).

Pressure Caps are designed to operate within a predetermined range as follows:

Pressure Marking on Cap	Operating Range
4 (lb)	3–4 lb
7 (lb)	6–8 lb
13-14 (lb)	12–16 lb
HMMWV 15-17 (lb)	14 –18 lb

This means that the pressure valve should NOT OPEN below the low limit of the range (i.e. 3 lb for 4 lb cap) but MUST OPEN at or below the top limit of the range (i.e. 4 lb for a 4 lb cap). A slight allowance is made on the gage dial of the Tester at the lower end of the color band to eliminate the possibility of rejecting caps that are otherwise satisfactory as a result of the newness of the seating gasket. The gasket will soften and develop a satisfactory seat after it is put in operation on the vehicle filler neck for a short time.

For the same reason, caps removed from vehicles and tested should be removed from the tester adaptor and reapplied several times as the gasket will retain the seat impression of the filler neck for sometime which may not coincide exactly with the seat in the adaptor on one application.

All Pressure Caps are equipped with a vacuum relief valve which open automatically as the vehicle engine is cooling off to prevent the formation of a vacuum in the system. This prevents the collapse of radiator upper and lower tanks, hose, etc.

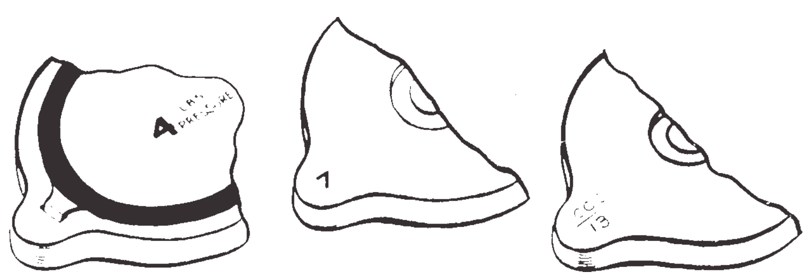


Figure 1-7. Pressure Cap Markings

K. TESTING THE PRESSURE CAP (Cont.) (Figures 1-7 thru 1-9))

1. Carefully remove cap and check the pressure as marked on the top of the cap. Compare it with recommended rating of 14-18 lb (96-124 kPa).

2. Make sure all parts and seating surfaces of cap and adapter are clean. On safety type caps be sure lever is in down or closed position.

3. On new caps, wet the rubber gasket in water. NOTE: Due to the newness of the gasket, it may be necessary to remove the pressure cap several times to get a proper sealing seat on the gasket. The gasket softens in actual operation and will work perfectly.

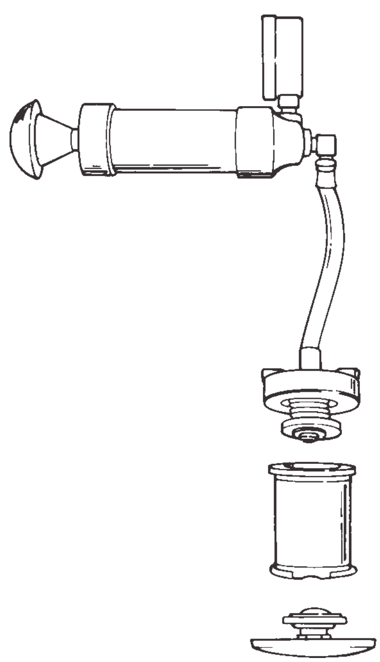


Figure 1-8. Pressure Cap Test Hookup.

4. Attach the pressure cap to be tested, as shown in Figure 1-8, to one end of adapter. Attach opposite end of the adapter to the pressure tester by pressing together and rotating adapter until the locking ears contact the stops on the adapter cams.

5. Hold Tester with gage facing you as shown in Figure 1-9.

6. Operate the pump until needle reaches its highest point

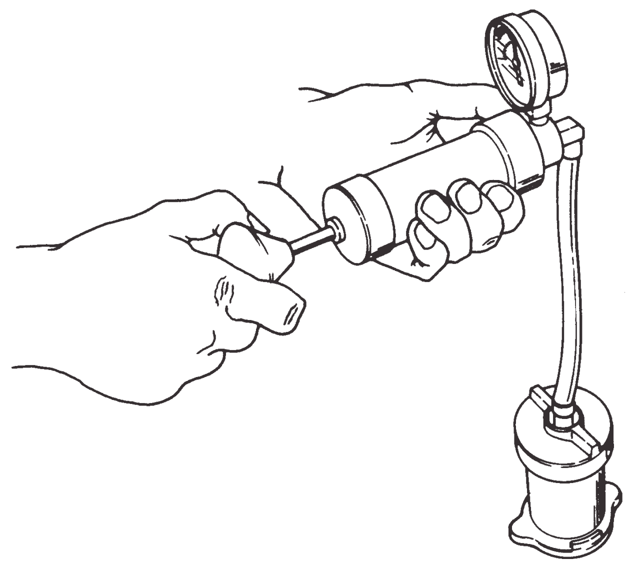


Figure 1-9. Pressure Cap Test.

NOTE

Remember that a cap that has been in use on a radiator for some time will have a slight seat impression in the gasket; therefore, the cap (if it leaks) should be removed and applied several times to the adapter to be sure that leakage is not caused by the impression not seating properly. After the cap is reinstalled on the vehicle, the continuous spring pressure will reseat the gasket properly in a short time.

L. READING THE GAGE (Figures 1-9 & 1-10)

Stop pumping when the valve opens and read the gage (See Figure 1-9) as follows: The gage hand must be within the proper color band for the pressure rating of the cap being tested when the pressure valve opens. The cap is satisfactory when the pressure holds steady or falls very slowly, but holds within the band for 30 seconds or more. If the gage hand falls comparatively fast which indicates serious leakage, reject the pressure cap.

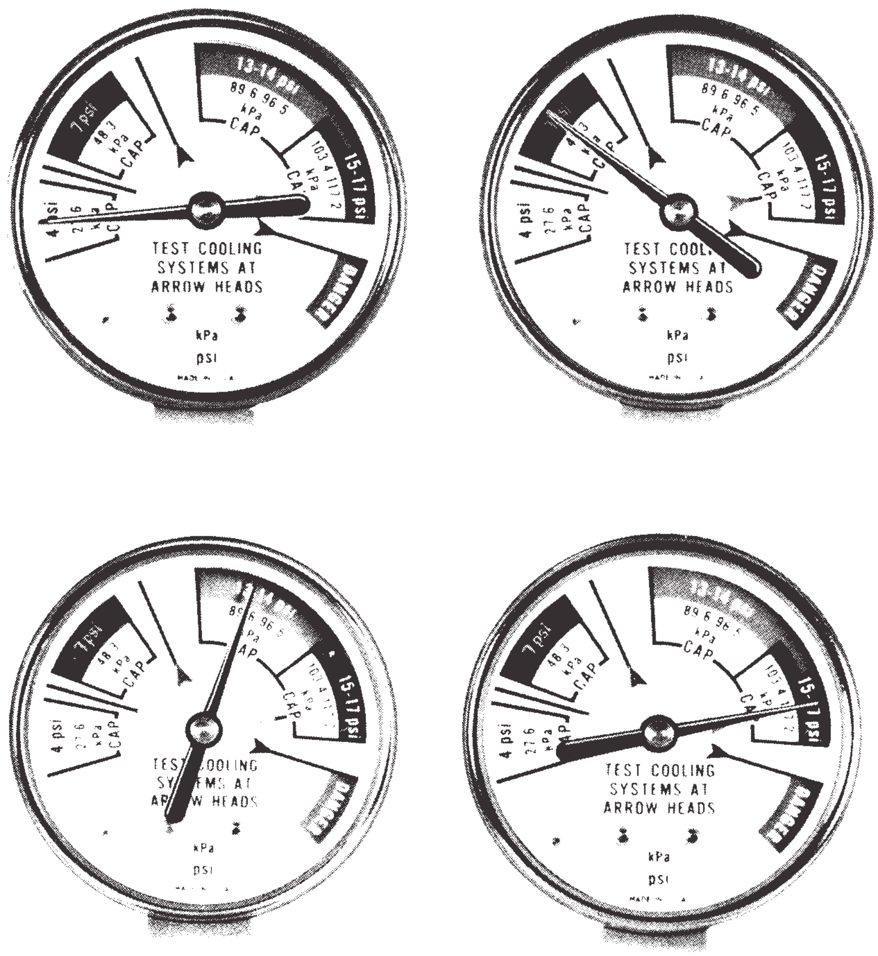


Figure 1-10. Tester Gage Readings.

M. FAN SHROUD ADJUSTMENT (Figure 1-11)

NOTES

Fan shroud should be alined so the following dimensions are maintained. Adjustments may be made by tilting the radiator/shroud assembly. Clearance between top of fan blade and fan shroud must be 1/2 inch (12.7 mm). Distance "A" from the edge of shroud ring and rear edge of fan must be 1-1/2 inch (38.1 mm).

NOTE

If there is evidence of fan blades hitting on fan shroud, check for loose or damaged engine mounts.

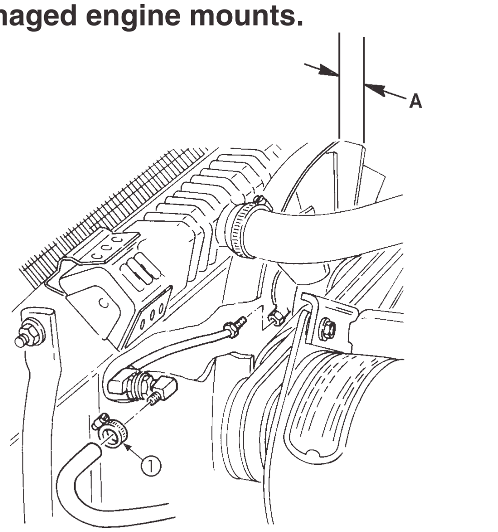


Figure 1-11. Fan Shroud Adjustment.

N. ENGINE COOLING SYSTEM FLOW OIL/COOLANT (Figure 1-12)

1. **Engine Oil** – Engine oil is pumped from the engine pan (10-50 psi), through the engine oil cooler lines to the engine oil cooler where it is cooled by air flowing through the cooler fins and is returned to the engine through the engine oil cooler return line.

2. **Transmission Fluid** – Transmission fluid is pumped from the transmission to the transmission oil cooler through an external transmission cooler line and is cooled by air flowing through the transmission oil cooler fins. From the transmission oil cooler, fluid is routed to the transfer case internal finned cooler and on to the transmission through a return line. The transfer case finned cooler acts as a secondary cooler for transmission oil and the two oils do not mix.

3. **Coolant** – engine coolant is pumped from the coolant pump through the engine internal cooling jackets, through the thermostat (when open) and returned to the radiator for cooling. When the heater is turned on, coolant is also pumped through lines to the heater and returned to the radiator

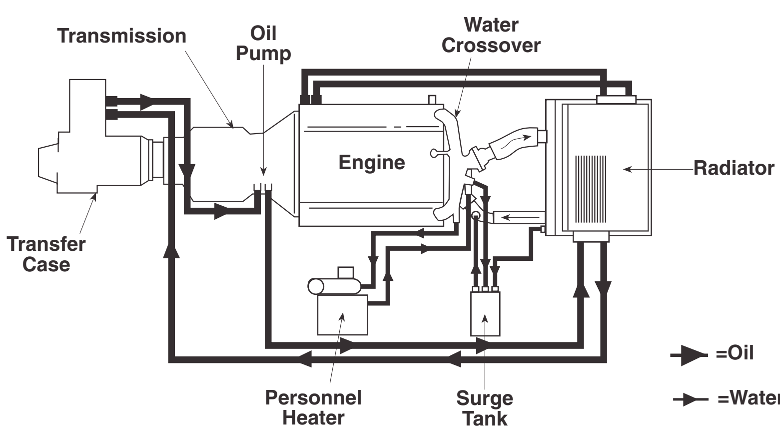


Figure 1-12. Cooling System Schematic.

O. ENGINE NORMAL OIL FLOW SCHEMATIC (Figure 1-13)

1. The lubricating system of this engine is a pressure feed type which means that a pump forces oil through the galleries to the necessary parts. The pump is mounted on the bottom side of the rear main bearing cap. Oil is picked up by the oil pickup tube and pumped through the oil pump. The oil pump is driven by the engine camshaft by means of an intermediate shaft.

2. The oil is then pumped through an oil cooler which cools the oil and helps remove engine heat. From the cooler the oil passes through a filter. This filter is a cartridge type and all oil going to the engine should pass through this filter. The filter is called a full flow filter, because all engine oil normally flows through it.

3. Normal average engine oil pressure at stable conditions is 40-50 PSI @ 2000 RPM. The engine oil filter bypass valve opens at 16-19 PSI above normal high (50 PSI), when increased pump pressure tries to pump oil through a clogged filter. When the bypass valve opens, the oil bypasses the filter and the engine continues to receive lubrication.

4. The engine oil cooler also has a bypass valve. It works the same as the oil filter bypass valve and opens to allow an alternate route for the oil if the cooler should become clogged. The oil cooler bypass valve opens at 9-11 PSI above normal high (50 PSI).

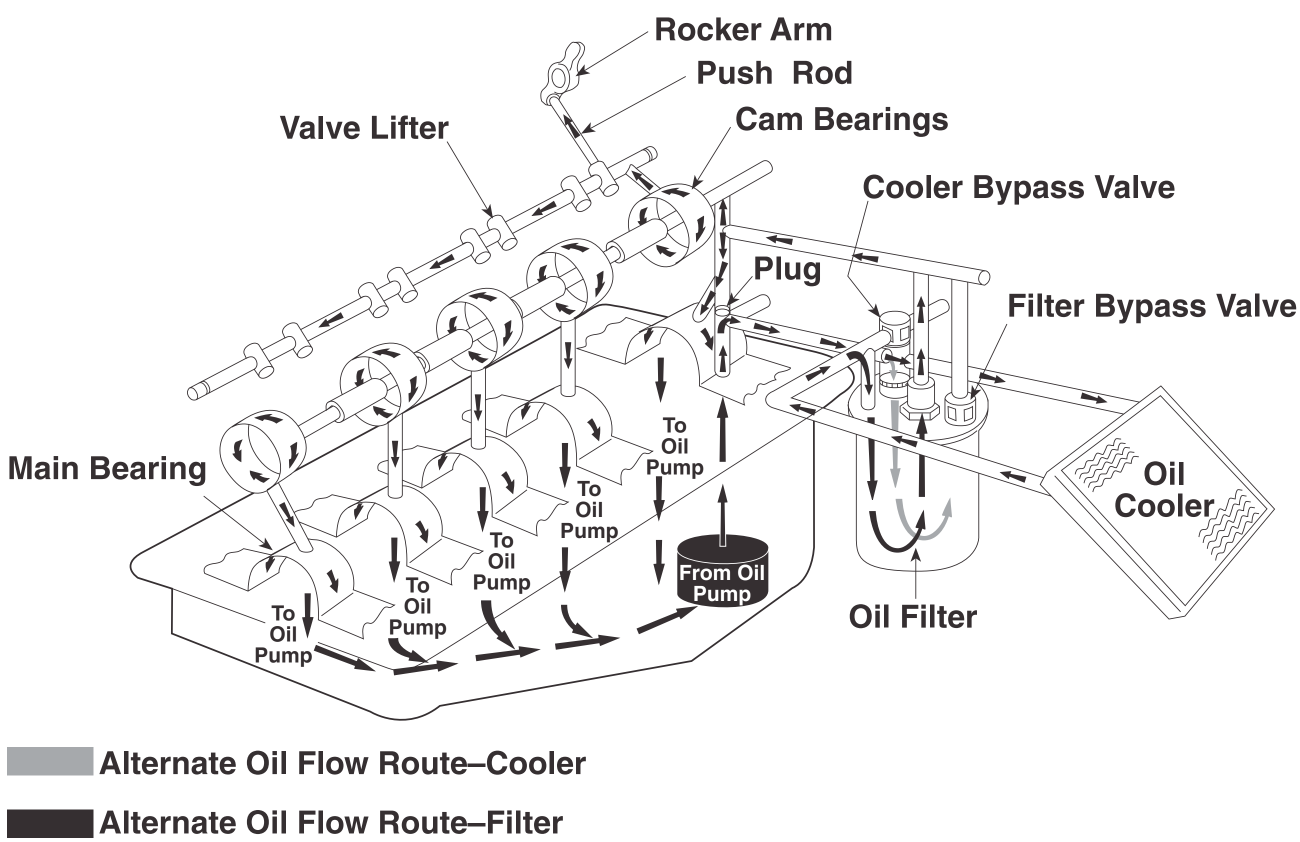


Figure 1-13. Engine Lubrication System Schematic.

SECTION 2
AIR INTAKE AND EXHAUST SYSTEMS

A. MANOMETER INTAKE RESTRICTION TEST (Figure 2-1)

Connect manometer tube to air cleaner vent line (1) pipe (Fig. 2-1). Run engine at approximately 1000 RPM. Water travel should not exceed 3 inches of water travel. If water travel exceeds 3 inches, check for restriction in air intake system.

B. ENGINE STOPS DURING NORMAL OPERATION

a. Check for restriction in air intake system. Check gage on instrument panel. Indicator should be in the yellow range. If reading is in the red range, clean and service air cleaner.

b. Check cleaner to air horn elbow and air horn for damage that would restrict air flow.

c. To test air indicator gage, remove air hose (2) and create a vacuum on tubing. Gage (3) should move into the red position.

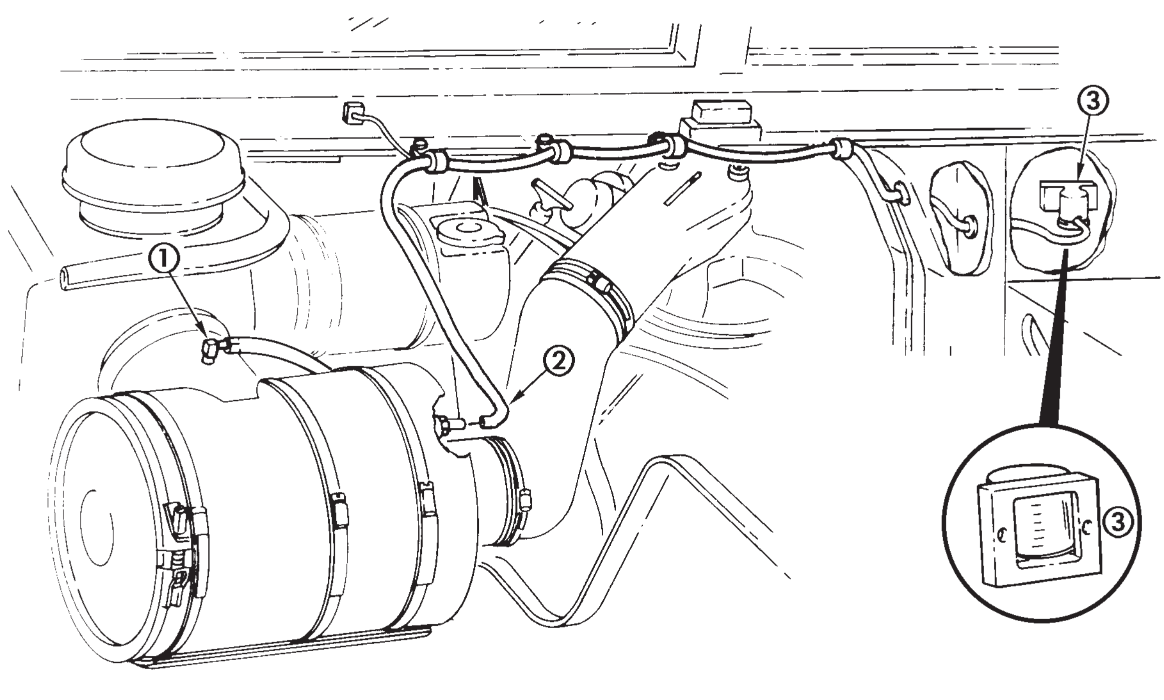


Figure 2-1. Manometer Intake Restriction Test.

C. EXHAUST (Figure 2-2)

Leaking Exhaust Gases or Exhaust Noises

1. Check for rusted through or damaged exhaust pipe or muffler.

2. Check for loose or missing exhaust pipe and crossover pipe fasteners.

3. Check for leaking exhaust gaskets.

Exhaust Restrictions

1. Check for bent exhaust pipe.

2. Check for damaged muffler.

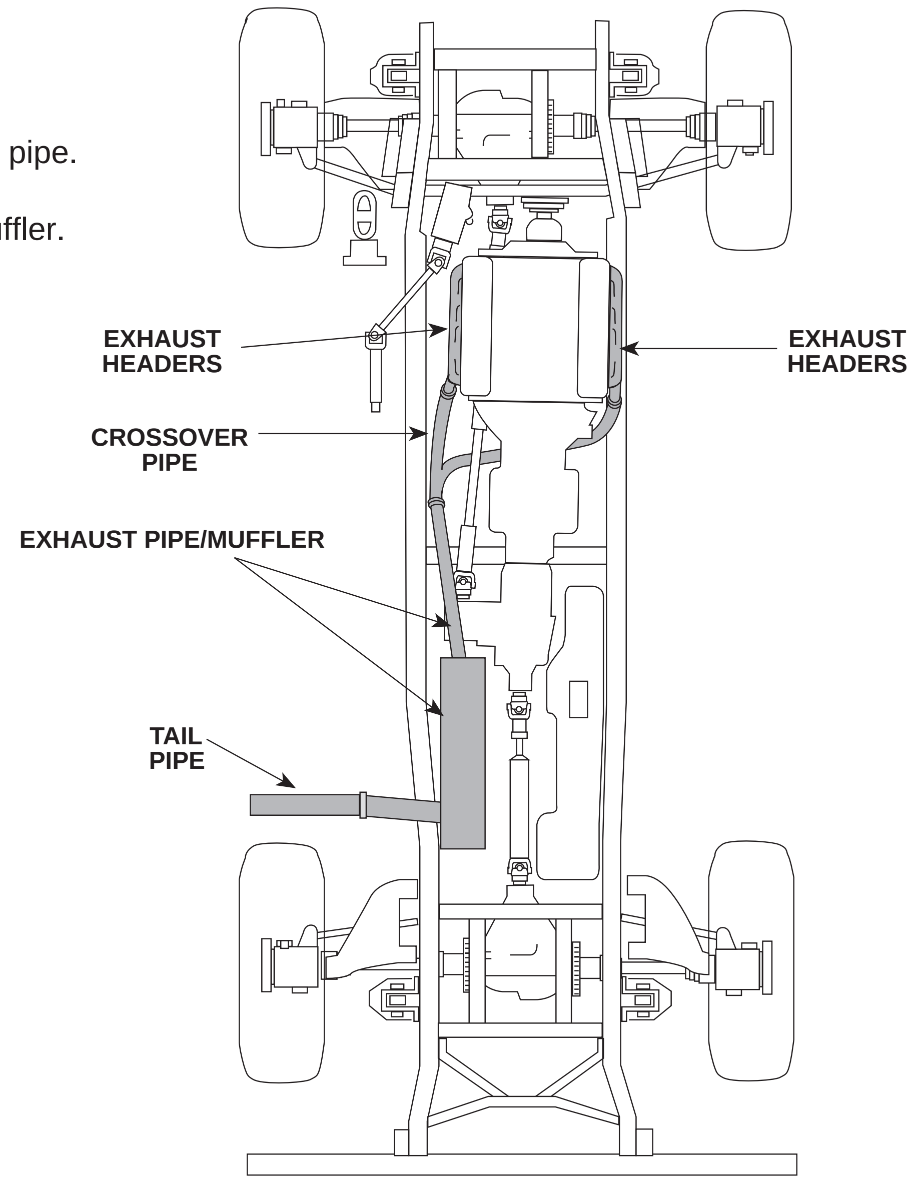


Figure 2-2. Exhaust System.

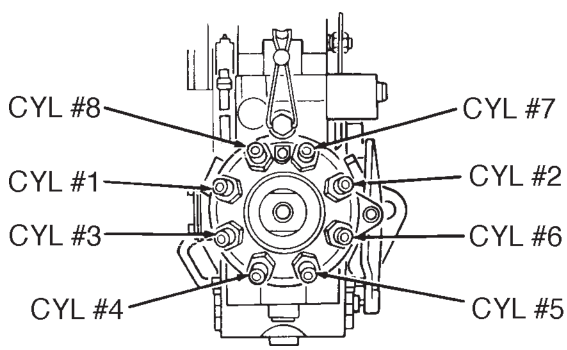
SECTION 3
FUEL SYSTEM

A. 6.2L V8 DIESEL ENGINE (Figure 3-1)

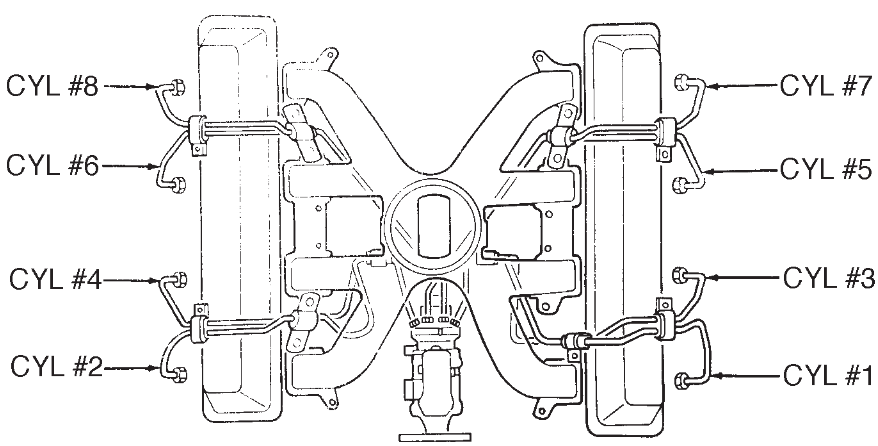
This engine is a 6.2L, 6217 cc (379.4 cu. in.) V8 diesel.

The injection pump used with the 6.2L is the same basic unit as that used on the Oldsmobile/GMC passenger car and light pickup trucks, namely the Roosa Master Stanadyne model DB2.

The engine cylinders are numbered 1, 3, 5, and 7 on the left bank, and cylinders 2, 4, 6, and 8 on the right bank with a firing order of 1-8-7-2-6-5-4-3. The odd-numbered cylinders are on your right-hand side when viewing the engine from the front. Both the cylinder arrangement and the injection pump fuel line routing are illustrated in Figure 3-1.



Cylinder Arrangement



Fuel Line Routing

Figure 3-1. Cylinder Arrangement and Fuel Line Routing.

B. DIAGNOSING ABNORMAL ENGINE OPERATION

1. Engine starts, idles roughly without abnormal noise or smoke.

   - Check engine idle.
   - Inspect fuel injection lines for leaks.
   - Inspect fuel return lines for restrictions or leaks.
   - Check for air in the fuel system.
   - Inspect fuel system for contamination.

2. Engine cold starts and idles roughly, but idles smoothly after warm-up.

   - Check for air in the fuel system.
   - Check glow plug operation.
   - Check the cold start advance system.

3. Engine idles smoothly but misfires at higher RPM.

   - Inspect fuel filters for contamination or restriction of flow.
   - Check for proper fuel.

4. Engine smokes excessively during normal operation.

   - Make sure all injectors are same length.
   - Remove and test fuel injectors.
   - Check fuel system for contamination or restriction.
   - Check for restrictions in air intake system.
   - Check for clogged crankcase depression regulator valve.
   - Black exhaust smoke may indicate excess fuel or restricted air supply.
   - Blue smoke may indicate oil is being burned by the engine.
   - White smoke may indicate unburned fuel or water vapor.

5. Engine will not return to idle.

   - Check external fuel linkage for binding or misadjustment.
   - Check fuel injection pump min-max governor.

6. Engine will not shut off.

   - Check injection pump fuel shutoff solenoid. If shutoff solenoid is inoperative, pinch the pump rubber fuel return line.

7. Excessive engine vibration.
    - Check for air in the fuel lines.
    - Check for broken engine mounts and insulators.
    - Check for loose or damaged vibration damper.
    - Check for sticking injector(s).

8. Engine loses power.
    - Check air intake system for restriction or blockage.
    - Check for obstructed exhaust system.
    - Check for clogged fuel filter and fuel lines.
    - Check for incorrect fuel or contamination.
    - Check for plugged fuel tank.
    - Check for restricted fuel flow from fuel tank.
    - Check for external compression leaks.
    - Check engine/pump timing.
    - Check mechanical lift pump.

9. Engine will not crank.
    - Check for mechanical or hydraulic engine seizure.
    - Check the starting system.

10. Engine cranks, but will not start.
    - Check engine cranking speed.
    - Check for incorrect engine oil.
    - Inspect starting system.
    - Inspect fuel system.
    - Check operation of glow plug system.

11. Excessive oil loss or consumption.
    - Ensure that proper procedures are used to check oil.
    - Make sure that proper grade of oil is used.
    - Inspect engine for leaks at the following:
        - oil pan
        - oil filter
        - dipstick
        - valve covers
        - oil cooler and, cooler lines
        - oil pressure sensor
        - tighten any loose connections or replace damaged parts

C. BLACK OR WHITE SMOKE COMING FROM EXHAUST

1. Black Smoke:

Black smoke is the most common smoking complaint. Diesels are usually rated according to the maximum horsepower developed at the “smoke limit.” At a certain speed, a definite amount of air enters the cylinder. This amount of air is sufficient to produce complete combustion of a given quantity of fuel. If more fuel is injected, overloading the engine beyond the rated horsepower, there will not be sufficient air for complete combustion and black smoke will result. Under these conditions, the black smoke contains a large quantity of unburned carbon (soot) formed by thermal decomposition of the fuel in the over-rich mixture in the cylinder.

Some sources of black smoke directly related to improper burning of fuel are:

- Air into injection pump
- Fuel return restricted
- Pump timing advanced (usually will be accompanied by excess combustion noise)
- Wrong fuel
- Excess fuel delivery from nozzles due to low opening pressure or stuck nozzle
- Restricted exhaust
- Low compression
- Clogged air inlet

2. White Smoke:

At light loads, the average temperature in the combustion chamber may drop 500°F, due to the decreased amount of fuel being burned. As a result of the lower temperature, the fuel ignites so late that combustion is incomplete at the time the exhaust valve opens and fuel goes into the exhaust in an unburned or partially burned condition producing the white smoke. Under these conditions, a higher cetane fuel or a more volatile fuel will tend to promote better combustion and reduce smoke. Any operating variable (jacket temperature, inlet air temperature, etc.) that increases compression temperature or reduces ignition delay will improve the white smoke problem. White smoke is considered normal when the vehicle is first started, but should stop as the vehicle warms up. A continuing white smoke condition could indicate a loss of compression. Retarded timing and plugged fuel return can also cause white smoke.

Some sources of white smoke directly related to improper burning of fuel are:

- Coolant in combustion chamber:
  - blown head gasket(s)
  - crack in block or cylinder head
- Fuel:
  - fuel contaminated (with gasoline)
  - condensation (water) in fuel
- Injection pump timing advanced
- Light load advance piston stuck.
- H.P.C.A.–housing pressure cold advance inoperable.
- Excessive white smoke on start-up:
  - faulty glow plug(s) or glow plug circuit.

D. BLUE SMOKE COMING FROM EXHAUST

Blue smoke indicates that engine oil is burning in the cylinder or cylinders and may be accompanied by excessive oil consumption.

Some mechanical conditions which should be considered are:

- Stuck piston rings
- Worn piston rings
- Failed valve seals, worn valve stems and/or guides
- Faulty crankcase vent valve
- Cylinder walls out of round

Some non-mechanical checks include:

- Oil level too high (overfilled crankcase)
- Fuel oil in crankcase
- Improper oil viscosity (too thin)
- Clogged CDR valve

E. DIESEL ENGINE KNOCK

Diesel engine knock may be caused by a piston. The piston knock sounds very similar to combustion knock. To assist in the diagnosis, with the engine off, retard the injection pump timing as far as the slot in the pump flange will allow. This will quiet down a combustion knock. If the knocking is not substantially reduced, the noise is most likely a mechanical problem. Crack the fuel injection lines one by one to identify the cylinder with the knock. The knock tone will change when the line is cracked feeding the cylinder with the problem.

F. ENGINE HARD STARTING (HOT)

- Compression (min. 380 PSI) hot
- Excessive starter draw when hot
- Cranking speed hot
- Leaking injector(s) nozzles:
  - fuel in cylinder
  - air from cylinder in pump
- Fuel leaks:
  - pump
  - lines
  - filters
- Injection pump timing
- Stuck advance piston
- Injector pump solenoid
- Governor weight retainer ring
- Improper fuel
  - water in fuel
  - gasoline in fuel

G. ENGINE HARD STARTING (COLD)

- Battery/batteries condition and connections (cables)
- Check charging/starting systems
- Cranking speed (min. 150 RPM’s)
  - excessive starter draw
  - oil viscosity (to heavy)
- Fuel contamination
  - improper type
  - water in fuel
  - gasoline in fuel
- Glow plug(s)
  - glow plug circuit – 1.5 to 5.0 ohms
- Amps 110 amps draw
- Operator uses improper starting procedure
- Housing pressure cold advance - check ball contacts
- Injection pump timing - incorrect
- Injection pump solenoid (at least 24 volts to actuate)
- Fuel line leak (filter leak) drawing air into system
- Advance piston (stuck)
- Broken advance pin
- Fuel-lift pump (low pressure)
- Fuel leaks (major)
  - injector lines
  - pump
  - injector(s) leaking down

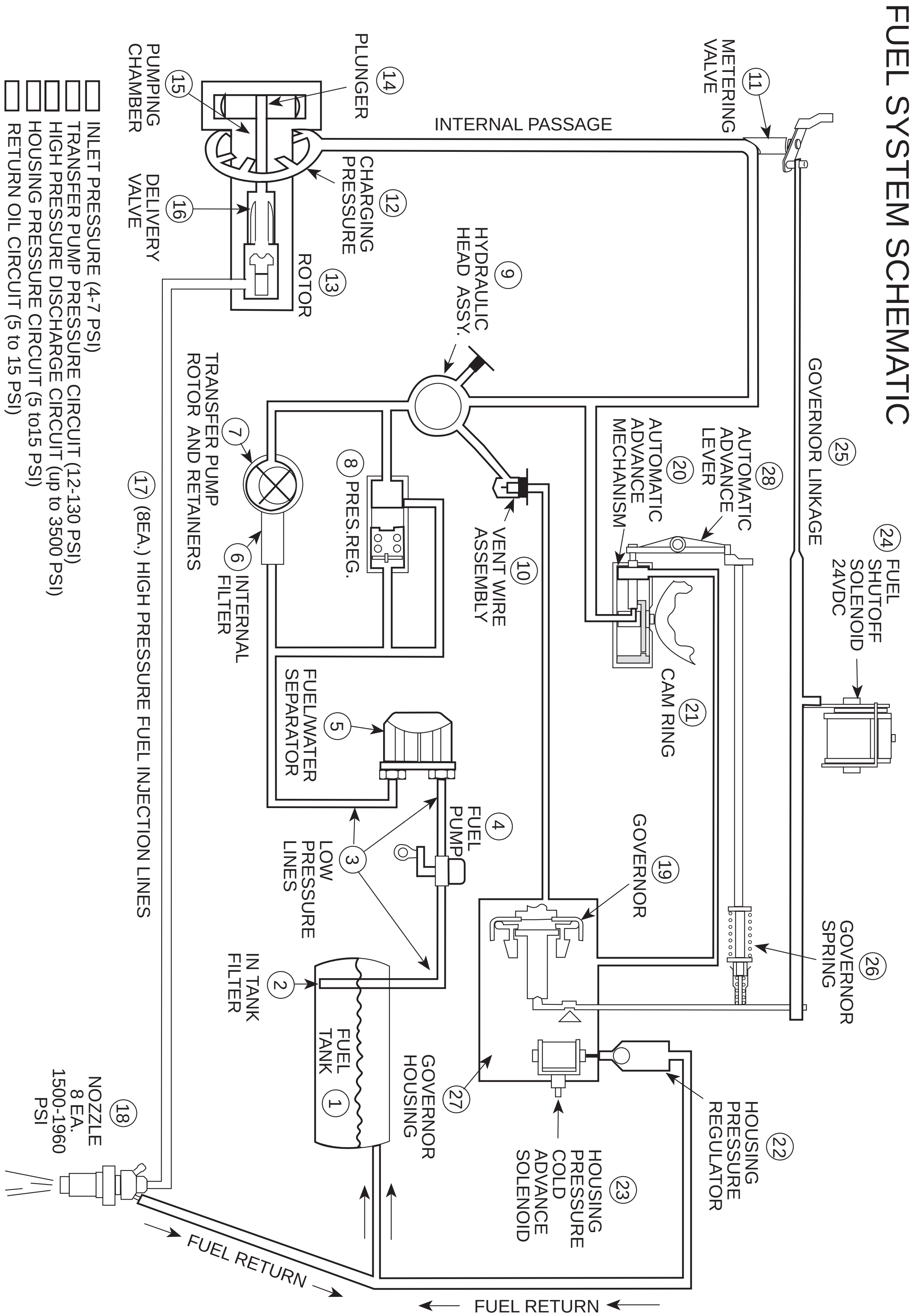


Figure 3-2. Fuel System Schematic.

H. FUEL SYSTEM FLOW SCHEMATIC (Figure 3-2)

1. Inlet Pressure-
   1. Fuel Tank
   2. Fuel Tank Screen (Filter)
   3. Fuel Lines (Low Pressure)
   4. Fuel/Water Separator
   5. Mechanical Lift Pump
   6. Internal Filter
   7. Pressure Regulator Assembly

Fuel is drawn from the fuel supply tank (1), through the in-tank filter (2), and low-pressure line (3) by the mechanical fuel pump (4), mounted on the lower right-front side of the engine. The fuel is then pumped (4-7 psi), through a low-pressure supply line to the fuel/ water separator (5) where water and contaminants are filtered out. Clean fuel is then pumped to the fuel injection pump internal filter (6) mounted in the back of the fuel injection pump and to the back side of the pressure regulator valve assembly (8). At each of these points the fuel pressure should be between 4 and 7 psi.

2. Transfer Pump Pressure-
   1. Transfer pump
   2. Pressure Regulator Valve
   3. Metering Valve
   4. Charging Passage

NOTE

Transfer pump output volume and pressure increase as pump speed increases.

Fuel under transfer pump pressure (12-130 psi), flows through the center of the transfer pump rotor (7), past the rotor retainers into a circular groove on the rotor. It then flows through a connecting internal passage in the hydraulic head (9) to the automatic advance mechanism (20) and up through an internal passage to the metering valve (11). Some fuel is bypassed through the pressure regulator assembly (8) back to the low pressure (inlet) side.

The radial position of the metering valve (11), controlled by the governor linkage (25), regulates flow of the fuel into the radial charging passage which incorporates the head charging passages and ports (12). At each of these points, fuel pressure should be between 12 and 130 psi.

NOTE

As the pump speed increases, the transfer pump pressure increases causing the automatic advance mechanism to rotate changing pump timing.

At low speeds, because transfer pump pressure is comparatively low, the cam remains in the retarded position. When engine speed increases, transfer pump pressure rises and moves the piston in the advanced direction. Advance piston movement is related to engine speed.

3. Housing Pressure Circuit:
   1. Vent wire Assembly
   2. Governor Housing
   3. Governor weights
   4. Governor Springs
   5. Automatic Advance Mechanism
   6. Advance Cam Ring

In addition, an air vent passage in the hydraulic head (9) connects the outlet side of the transfer pump with the pump housing. This allows air and some fuel to be bled back to the governor housing (27). This fuel fills the housing, lubricates internal components, cools the pump and allows small air bubbles to be bled off to the fuel tank (1). A vent wire assembly (10) is installed in the governor housing radial passage.

The vent wire (10) spins freely breaking large air bubbles into small ones. Fuel under governor housing pressure flows through a radial passage to the automatic advance mechanism (20) applying governor housing pressure to the back side of the advance mechanism. The pump operates with the housing completely full of fuel; there are no dead air spaces anywhere within the pump.

4. Housing Pressure Cold Advance System:

This system consists of a housing pressure cold advance solenoid (23), a housing pressure regulator (22), and a housing pressure cold advance switch mounted on the rear of the right head assembly. When the engine is cold, (below 90°F), the housing pressure cold advance switch is closed. With the switch closed, current flows across the switch to the housing pressure cold advance solenoid (23), activating and opening the housing pressure regulator valve (22).

The HPCA solenoid (23) is activated through a temperature switch located at the rear of the right cylinder head assembly. The HPCA solenoid is located in the governor housing cover. For cold starts ,when engine coolant temperature is low , (below 90°F), the solenoid plunger lifts the check ball off its seat. This reduces housing pressure to almost zero. With no housing pressure in the advance mechanism (20), the fuel at transfer pressure can advance the cam ring (21), more easily when the engine is cranking. Injection timing is advanced about **3**° to reduce white smoke and improve cold-idle smoothness. Now that the engine is warmed up, it will run smoothly. The switch operates similar to an automatic choke on automobiles.

5. Fuel Return Circuit:
   1. Injection Pump Fuel Return Lines: (metal) 2Injector Nozzle Fuel Return Lines: (rubber)
   3. Return Circuit Through Nozzle:

The purpose of the fuel return circuit is to maintain a constant pressure within the pump body. It vents air from the charging circuit. Excess fuel, unburned fuel, and air bubbles in the fuel injection pump and nozzles is returned to the fuel storage tank through rubber and metal fuel return lines. Fuel injector nozzles bleed back from nozzle to nozzle, to the tank.\

6. Fuel Shutoff Solenoid: 24 VDC:

The fuel shutoff solenoid (24) is fastened to the inside of the governor housing cover and electrically connected to the ignition switch. When the ignition switch is placed in the start or run position the fuel solenoid (24) is energized pulling the linkage (25) forward rotating the metering valve (11) to the run, (fuel-on) position allowing fuel to flow through the metering valve (11) to the rotor (13) and injectors (18).
When the fuel shutoff solenoid coil (24) is de-energized, the shutoff arm spring pivots the top of the arm to the left, and the bottom of the arm to the right, thus forcing the linkage hook to move rearward and the metering valve (11) to rotate to the no-fuel position.
If the solenoid (24) fails to operate and prevents a shutoff or run condition, disconnect the electrical wire # 54a at the fuel injection pump and check for the presence of battery voltage. If battery voltage is present check for a defective solenoid. If battery voltage is not present, troubleshoot electrical ignition system.

I. TROUBLESHOOTING AND TESTING

NOTE

Now that you understand the principles of operation you can use the schematics to assist you in troubleshooting the diesel fuel injection pump.

a. Check pump advance operation by pushing the advance mechanism lever (28) in while the engine is running at an idle. A drastic change in engine RPM's will occur if the advance system (20) is operating properly.

b. Check fuel pressure at the fuel lift pump (4) outlet hose. The easiest point to check is at the inlet hose on the fuel/ water separator (5). Pressure must be between 4 & 7 psi.

c. Check fuel filter/water separator condition. After checking lift pump pressure remove filter outlet hose and connect a pressure gage. Start the engine. Outlet pressure should be the same as lift pump pressure. If the pressure is lower, it is an indication of filter blockage.

d. Fuel Pump Advance Mechanism Check: Crimp the rubber fuel return line on top of the fuel injection pump cover. The engine should shut-down. If engine continues to run, indication is that the automatic advance timing mechanism inside the pump is malfunctioning.

J. ELECTRICAL FUEL SOLENOID

With the ignition switch in the run position, disconnect the fuel shutoff solenoid (24) electrical lead # 54a. Connect and disconnect this wire several times. An audible clicking sound will be heard each time the solenoid activates if it is good.

K. COLD ADVANCE SOLENOID TEST

With the ignition switch in the run position, Disconnect the #569a and #569b wires from the cold advance switch mounted on the rear of the right head assembly. Connect #569a and #569b wires together. If the housing pressure cold advance solenoid (23) and regulator (22) are good, an audible click will be heard.

L. CHECKING HOSING PRESSURE COLD ADVANCE SWITCH

To check the housing pressure cold advance switch, disconnect the #569a & 569b wires from the switch located on the rear of the right head assembly. Set an ohm meter to RX1. When the engine is cold, (below 75°F), there will be continuity across the switch if the switch is good.

M. FUEL INJECTION PUMP TEST

If you have fuel at the fuel injection pump inlet port and no fuel at the injectors, indication is that the pump has internal malfunctions.

N. UNDERSTANDING DIESEL FUEL

1. Diesel Fuel:

To understand how a diesel injection pump operates, a knowledge of diesel fuel characteristics is required. Diesel fuel can be blended to suit different kinds of diesel engines, just like different blends of gasoline for a spark-ignition engine. Three terms used to describe diesel fuel are (1) viscosity, (2) cloud point, and (3) cetane rating.

2. Viscosity:

Diesel fuel has a higher viscosity than gasoline, that is, it's thicker or heavier. The following sections show how the viscosity of diesel fuel can affect combustion and injection pump operation. There are two grades of fuel in general use, called No. 1 and No. 2. No. 1 diesel fuel has a lower viscosity than No. 2 fuel, so it flows better at low temperatures. No. 2 fuel provides more heat energy than No. 1, so a diesel engine operates a little more efficiently on No. 2 fuel. (Heat energy is measured in British Thermal Units, or BTUs).

The choice of which fuel to use is usually determined by the temperature in an area at any given time of year. The fuel characteristics relating to temperature are cloud point and pour point.

3. Cloud Point and Pour Point:

Diesel fuel contains paraffin wax. The paraffin gives diesel fuel its heat energy. Cold temperatures can cause the paraffin to separate and form wax crystals. These crystals can eventually block the fuel filter. The cloud point of diesel fuel is the temperature at which the wax starts to separate, and the fuel turns milky white, or cloudy. Because No. 2 contains more paraffin than No.1, its cloud point is higher, around 20°F (–7°C). The cloud point of No.1 fuel is about –20°F (–29°C). The temperature at which the fuel stops flowing is known as the pour point. To lower the cloud point of the fuel and prevent fuel filter blockage, a winterized blend of No.1 and No. 2 fuels is sold in cold climates. It is also possible to use an in-line fuel heater, located between the fuel pump and the fuel filter. The heater is actuated thermostatically at about 20°F (–7°C) and is designed to prevent wax crystal formation in the fuel filter.

4. Cetane:

A cetane rating for diesel fuel is similar to an octane rating for gasoline. The cetane number indicates how quickly ignition will take place when the fuel is injected into the cylinder. If the cetane number is too low, ignition is slow , and the engine may knock and emit black smoke. But if the cetane number is too high, ignition may occur too quickly and the fuel is not completely burned, again causing black smoke. You cannot alter the cetane rating of a particular fuel, but you should know what symptoms can be caused by using incorrect or poor quality fuel.

5. Diesel Combustion:

It's also helpful to understand the combustion process in a diesel engine, because it's controlled differently than in a gasoline engine.

A diesel engine does not use a throttle plate to regulate air flow to the engine, so engine speed is controlled by the amount of fuel injected. Injection is explained in detail in the section on Injection Pump Operation. Since the amount of air is relatively constant, the air-fuel ratio of a diesel engine can be as low as 100:1 at idle, rising to 20:1 at wide-open throttle. These ratios are leaner than in a gasoline engine and are one of the reasons for a diesel engine's higher fuel economy.

A diesel engine does not have an electrical ignition system. The heat of the air compressed in the cylinder ignites the fuel injected into the engine. Diesel engine compression ratios are often higher than 20:1, and the temperature of the compressed air may reach 1,000°F. The fuel is injected at or just before the end of the compression stroke, it mixes with the hot air, vaporizes, and ignition starts.

Ignition is not instantaneous everywhere in the cylinder. The fuel burns only where it has been vaporized by the hot air, and this takes longer than in a gasoline engine. This process is called controlled combustion. Two additional reasons for the diesel engine's greater efficiency are (1) the high compression ratio, and (2) the longer combustion period.

The viscosity of the fuel can affect combustion. If the fuel is too heavy (high viscosity), it does not vaporize properly in the cylinder. It's too rich to burn. If the fuel is too light (low viscosity), it may not be injected far enough into the cylinder to mix properly. Both conditions can cause poor combustion and result in loss of engine power.

O. TYPICAL FUEL PROPERTIES (Figure 3-3)

- Pour point and cloud point determine minimum temperature engine can operate with waxy type fuel.
- Diesel fuel pour point is temperature where fuel stops flowing.
- Diesel fuel cloud point is temperature at which wax separates from fuel.
- The No.1 Diesel cloud point is about –20°F (-29°C).
- The No. 2 Diesel cloud point is about 20°F (-7°C).

PROPERTIES \ FUEL	GASOLINE	JP4	#1 DIESEL	#2 DIESEL
LB/GAL	5.9	6.5	6.9	7.2
BTU/LB	18,700	18,400	19,583	19,855
BTU/GAL	110,330	119,600	137,000	141,000
VISCOSCITY, CENTISTOKES	0,5	0.7	2.0	2.7
FLASH POINT	-40°	100°	100°	125°

Figure 3-3. Typical Fuel Properties.

P. ENGINE CRANKING SPEED TEST

Using a tachometer, check engine cranking speed. Ensure speed is 150 RPM minimum. If cranking speed is too low, check battery voltage. If battery voltage is OK, check for incorrect engine oil. Drain and refill with recommended oil. If battery voltage is correct and correct oil is in the engine, check for starter dragging.

Q. FUEL PUMP PRESSURE TEST

Check pressure at fuel pump outlet; if pressure is not at least 4 psi (28 kPa), replace fuel pump.

R. FUEL FILTER (Figure 3-15)

The following illustration depicts the fuel filtering capabilities in the HMMWV.

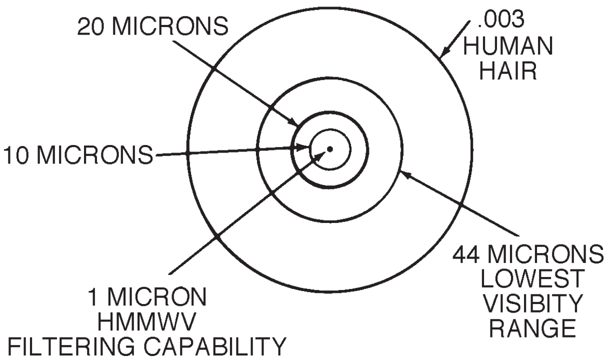


Figure 3-15. Relative Size of Micron Particles

S . FUEL ECONOMY

On the highway, in the 50-75 M.P.H. range, the fuel economy will go down about 3 M.P.G. for each 10 M.P.H. increase in speed. M.P.G. will increase with the use of a steady foot, easy acceleration and light braking. Fuel economy may vary as much as 5 M.P.G. with different drivers.

T. FUEL FILTER PRESSURE TEST (Figure 3-4)

Check fuel supply pressure (1) using pressure gage. Pressure should be 4 psi (28kPa) minimum. If pressure is not at least 4 psi (28kPa), clean fuel filter (2) and repeat test. If pressure is still not at least 4 psi (28 kPa), check fuel supply lines and hoses for restrictions and obvious damage. Replace any damaged lines or hoses. If lines and hoses are not damaged, check fuel pressure at lift pump outlet. Normal pressure is 4–8 psi (28–55 kPa).

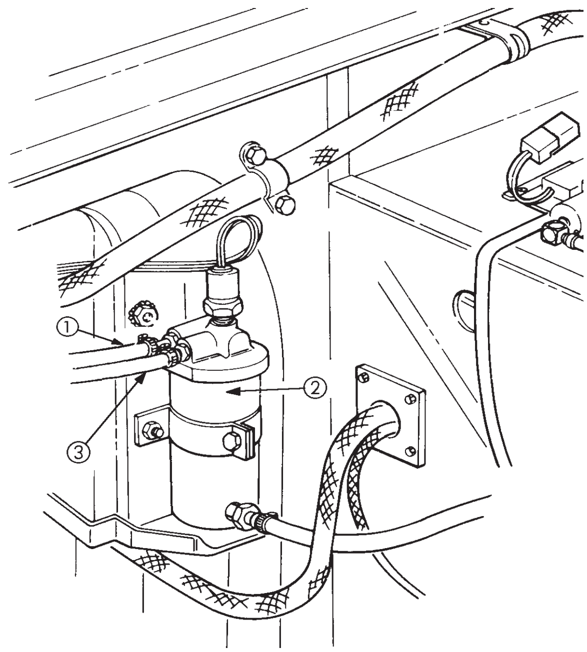


Figure 3-4. Fuel Filter Pressure Test Hook-up
.

U. FUEL FILTER FLOW TEST (Figure 3-4)

Disconnect fuel filter outlet hose (3) and route into quart capacity container. Crank engine for 30 seconds. Container should be at least half-full or contain 1 pint (0.51 liter). If volume is not sufficient, check fuel supply and return lines and hoses for restriction and obvious damage. Replace any damaged lines or hoses. If no restrictions or obvious damage is found, replace fuel pump.

V. FUEL TANK CONTAMINATION TEST

Drain fuel filter while cranking engine a maximum of 30 seconds. If water and contamination is present, wait two minutes and repeat test twice. If water and contamination is still present, drain and clean fuel tank and refuel vehicle.

NOTE

Bubbles in fuel stream may indicate the presence of air in the fuel system, and white exhaust smoke will be seen during cranking.

W. FUEL INJECTION PUMP TEST (Figure 3-5)

If there is fuel at the fuel injector pump inlet line and engine will not run, loosen fuel injection lines (1) at injection nozzles and crank engine. If no fuel leaks from fuel injection lines while cranking engine, replace fuel injection pump.

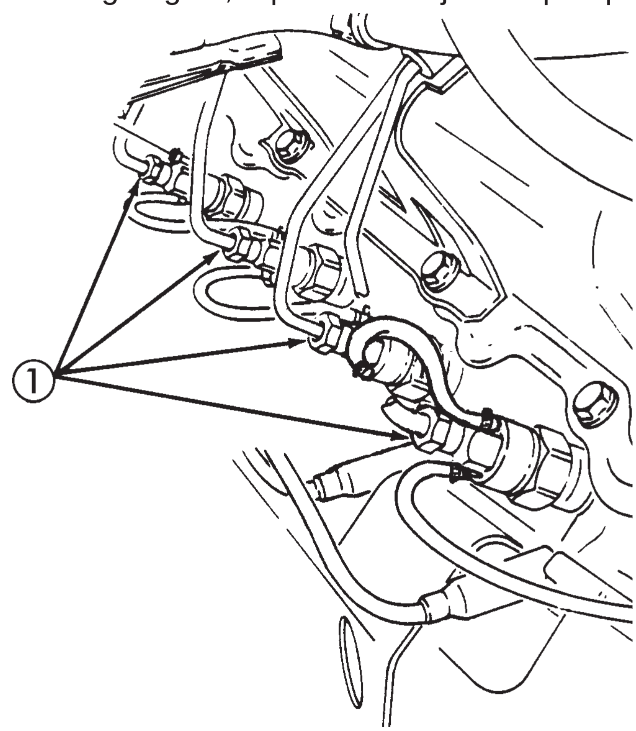


Figure 3-5. Fuel Injection Pump Test.

FUEL INJECTION NOZZLE IDENTIFICATION					
APPLICATION	NOZZLE TYPE	SPRING	COLOR RING	OPENING PRESSURE	
				NEW	USED
1995 L57, 6.5L (M998A2)Military	304	150-266	Purple	1783-1960 psi 123-135 bar	1500-1960 psi 103-135 bar
1991 & Above LL4, 6.2L Military M998/M998A1	253	200	Green AMG P/N 05742548	1783-1960 psi 123-135 bar	1500-1960 psi 103-135 bar
1990 & Below 6.2L Military M998/M998A1	304	200	White	1783-1960 psi 123-135 bar	1500-1960 psi 103-135 bar
1994 L57, 6.5L Commercial	304	150-266	Orange	2030-2204 psi 140-152 bar	
1994 6.5L Military Turbo only	304	200	Red	2030-2204 psi 140-152 bar	

WARNING

Use of any injector other than the one specified for a particular engine could cause serious damage to the engine and / or performance

X. FUEL INJECTOR NOZZLE TEST (TEST STAND) (Figure 3-6)

1. Testing Preparation:

a. Connect fuel injection nozzle (2) to tester.

b. Connect lines to return line nipples (1).

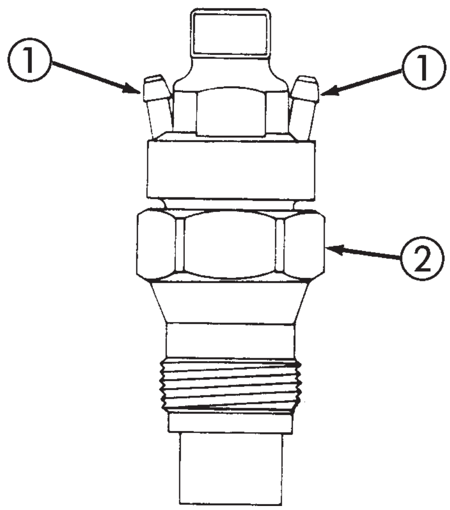


Figure 3-6. Fuel Injector Nozzle.

WARNING

Do not place hands or arms near nozzle during testing. Penetrating force of oil may cause serious injury or death.

c. Close shutoff valve to pressure gage on tester.

d. Operate tester to prime nozzle (2).

2. Obtaining pressure check:

a. Open shutoff valve to pressure gage 1/4 turn.

b. Depress lever on tester slowly. Note at what pressure the needle on pressure gage stops. Opening pressure must be between 1,500 psi (10,343 kPa) and 1,960 psi (13,514 kPa). Replace nozzle (2) if opening pressure does not meet specifications.

3. Leak Test:

a. Open shutoff valve to pressure gage an additional 1 turn.

WARNING

Compressed air used for cleaning purpose will not exceed 30 psi (207 kPa). Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

b. Blow-dry end of nozzle (2).

NOTE

1,400 psi (9,653 kPa) must be maintained for 10 seconds while checking for nozzle leakage.

c. Depress lever on tester until pressure gage reads 1,400 psi (9,653 kPa) and observe tip of nozzle (2). If a droplet forms and drops off the nozzle (2) in 10 seconds or less, replace nozzle (2).

4. Chatter Test:

a. Close shutoff valve to pressure gage.

b. Depress lever on tester slowly, noting whether a chattering noise can be heard.

NOTE

Faster lever movement may cause nozzle to hiss or squeal rather than chatter, this is acceptable.

c. If no chatter is heard, increase speed of lever movement on tester until nozzle (2) chatters. If no chatter is heard, replace nozzle (2).

5. Spray Pattern:

a. Depress lever on tester quickly. Spray pattern must be cone-shaped with no streamers. Replace nozzle if streamers in spray pattern are present.

b. Remove nozzle from tester.

Y. FUEL INJECTOR NOZZLE TEST (IN VEHICLE)

A quick check of the nozzle's condition while it is still on the engine is performed as follows:

1. Run the engine until it is at operating temperature.

2. With the engine running at an idle RPM, loosen the fuel line nut at the nozzle (place a rag around it). The engine should decrease in RPM (similar to shorting out a spark plug in a gasoline engine) if the nozzle is operating properly. If there is no change in engine RPM, then the nozzle is not operating correctly and should be removed.

Z. 6.2L INJECTION NOZZLE RETURN HOSE (Figure 3-10)

Conditions may arise where the fuel return hose or nipple cap is disconnected from the fuel injection nozzle.

The purpose of the fuel hose is to return the fuel which leaks past the pintle in the injector nozzle, back to the fuel tank. This is a relatively small amount of fuel. Starting with the end cylinders on each side of the engine, the fuel passes through each succeeding nozzle. If a blockage occurs in this flow path, pressure will build up and result in a fuel leak at the cap or hose.

One cause of blockage is the leak-off nipple on the nozzle being plugged on the bottom end. During assembly of the nipple into the nozzle body, the epoxy sealant may have flowed over the hole in the nipple on the bottom end. If this happens, the return flow of fuel is restricted.

To determine if the hose or nipple cap fall off was caused by a blocked nozzle passage:

1. Remove the hoses from all nozzle nipples on the side of the engine involved.

2. Using a vacuum gage, attach it to one nipple on a nozzle. If the nozzle nipple end is plugged, a vacuum reading will result. Check each nozzle.

3. Nozzles that indicate a plugged or partially plugged opening will generate some reading on the vacuum scale.

4. **To unplug a suspected plugged nipple, insert a small drill bit into the nozzle nipple and turn by hand to break the epoxy covering.**

5. Recheck with vacuum. If unable to break the epoxy barrier, the nozzle should be replaced.

6. Replace hoses and nipple.

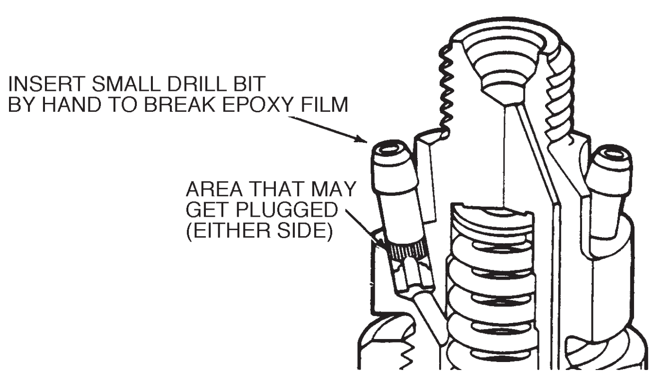


Figure 3-10. Fuel Injection Nozzle Blockage Check.

AA.FUEL SOLENOID TEST - ENGINE CRANKS BUT WILL NOT START (Figure 3-7)

Check electrical connections at injection pump. Ensure lead 54A (1) is connected to fuel solenoid terminal (front terminal) and 569B (2) is connected to cold advance solenoid terminal (rear terminal).

Check for power to fuel solenoid. Disconnect lead 54A (1) from fuel solenoid terminal. Using multimeter, check for voltage at lead 54A with rotary switch in “RUN” position. If voltage is present, but less than 17 volts, check batteries. If no voltage is present, disconnect engine wiring harness connector from protective control box and check for continuity between pin A in engine wiring harness connector and lead 54A.

1. If no continuity is present, repair engine wiring harness. Connect engine harness connector to protective control box.

2. If continuity is present, check for battery voltage (approximately 24 volts) at lead 29C in body wiring harness connector, at protective control box, with rotary switch in “RUN”. If battery voltage is present, replace protective control box. If no voltage is present, repair body wiring harness.

Check operation of fuel solenoid. Disconnect lead 54A from terminal on top of injection pump. Turn rotary switch to “RUN”. Touch lead to fuel solenoid terminal and remove. An audible clicking sound should be heard from within the pump each time contact is made.

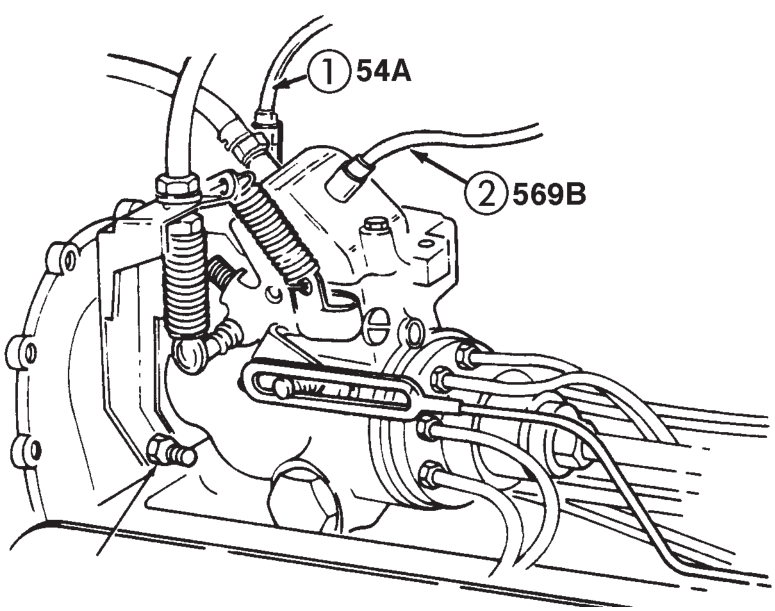


Figure 3-7. Fuel Solenoid Test Hook-up.

BB.COLD ADVANCE SOLENOID-SWITCH TEST (Figure 3-8)

Remove engine access cover. Disconnect leads 569A (1) and 569B (2) from cold advance switch (3). Using a multimeter, check for battery voltage at lead 569A with the rotary switch in "RUN" position and engine coolant below 85°F (29°C). If battery voltage is not present, repair engine wiring harness.

Disconnect lead 569B from fuel injection pump. Using a multimeter, check for continuity through lead 569B at the fuel injection pump to lead 569B at the cold advance switch. If continuity is not present, repair engine wiring harness.

Using a multimeter, check for continuity through the cold advance switch with engine temperature below 85°F (29°C). If continuity is not present, replace cold advance switch. Check for continuity through cold advance switch with engine temperature above 85°F (29°C). If continuity is present, replace cold advance switch. Connect lead 569B to injection pump and leads 569B and 569A to cold advance switch.

NOTE

A bad switch will cause engine to run rough at idle speed until engine warms up to operating temperature. It will also produce white smoke at exhaust outlet.

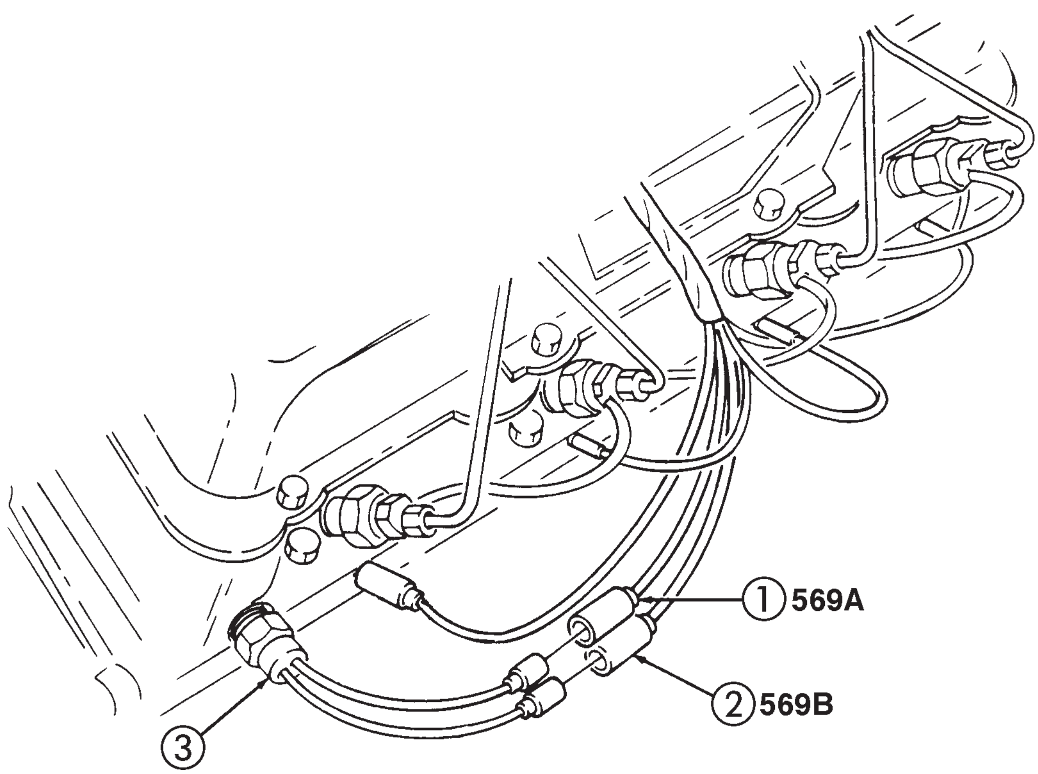


Figure 3-8. Cold Advance Solenoid and Switch Hook-up.

CC. INJECTION PUMP AIR PRESSURE TEST

If leaking injection pump seals are suspected but the location of the seal(s) is unknown, or if injection pump seals have been replaced, it is a good practice to pressure check the injection pump before reinstalling it onto the engine.

Procedure:

1. If the pump has been removed for the pressure check or is already off of the engine, drain all diesel fuel from the pump.

CAUTION

Air will be used to pressure check the pump; therefore, it is imperative that shop air be routed through a filter before hooking it up to the injection pump. The air must be clean and moisture free (dry).

2. Connect an air line to the injection pump inlet.
3. Seal off the injection pump return line fitting.
4. Immerse the injection pump assembly completely in a bath of clean test oil (preferably diesel calibrating fluid) that has been heated to normal test temperature, usually between 110–115°F (43–46°C).
5. Allow the injection pump to sit in the test oil for at least 10 minutes, then apply air pressure to the pump at a maximum of 20 psi (137.91kPa). Let the pump sit for another 10 minutes to allow any trapped air to escape.
6. If no leaks are apparent after this time period, reduce the air pressure to 2 psi (13.8 kPa) for 30 seconds. If no leaks exist, increase the pressure to 20 psi (137.9kPa) again. If no leaks are evident, the pump is satisfactory.

DD. INJECTOR LINE LENGTH

Fuel within the injection pump is routed through each of the high-pressure injector lines in the engine firing order sequence to each cylinder nozzle.

Although each injector line is a different shape, they are all the same length. Any differences in length would cause a change in the injection timing. A longer line would retard the timing, while a shorter line will advance the timing.

EE. WATER IN INJECTOR PUMP

The presence of water in diesel fuel can be disastrous. Water is a non-compressible liquid, and if forced through a injector, can actually blow the tip off of the injector nozzle. In addition, water will corrode internal injection system components if left in the system. One function of diesel fuel is to cool and lubricate the internal operating components of the injection pump. Most diesel fuels used in high-speed automotive applications have a viscosity rating of between 33 to 40 SSU (Saybolt Seconds Universal) at 100°F (37.7°C). The presence of water greatly reduces the lubricating ability of the fuel resulting in little or no lubrication between the moving parts. Seizure can result.

FF. FUEL RETURN VALVE TEST

Procedure:

1. Connect a rubber hose and fitting to fuel return valve outlet on pump top cover.
2. Connect a 24 volt lead to cold start advance solenoid connector on pump top cover.
3. Blow through the rubber hose. If there is no restriction, the fuel return valve is satisfactory.

GG.FUEL SHUTOFF SOLENOID TEST (Figure 3-9)

Connect a 24 volt lead to fuel shutoff solenoid connector on pump top cover and remove. Repeat this step two or three times. Each time the lead is removed an audible clicking sound should be heard from within the cover and the arm on the solenoid should move.

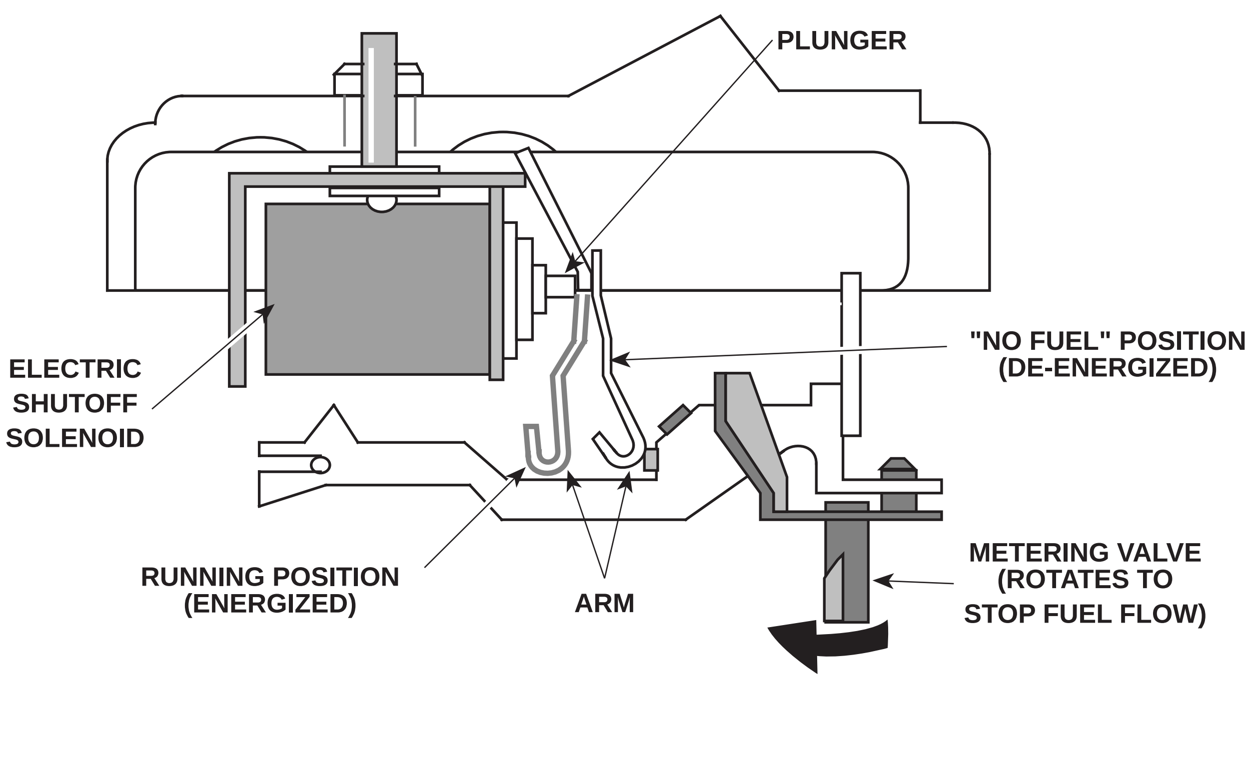


Figure 3-9. Electrical Shutoff Solenoid.

HH. DIESEL FUEL QUALITY (Figure 3-12)

The diesel fuel hydrometer J-34352 can be used to measure specific gravity of fuel. When testing fuel, fuel temperature should be 60°F for best accuracy. Fuel specific gravity is an indication of the Cetane Number, and thus, the quality of a fuel. A poor quality fuel can impair diesel engine performance. The following procedure outline how to measure diesel fuel quality.

NOTE

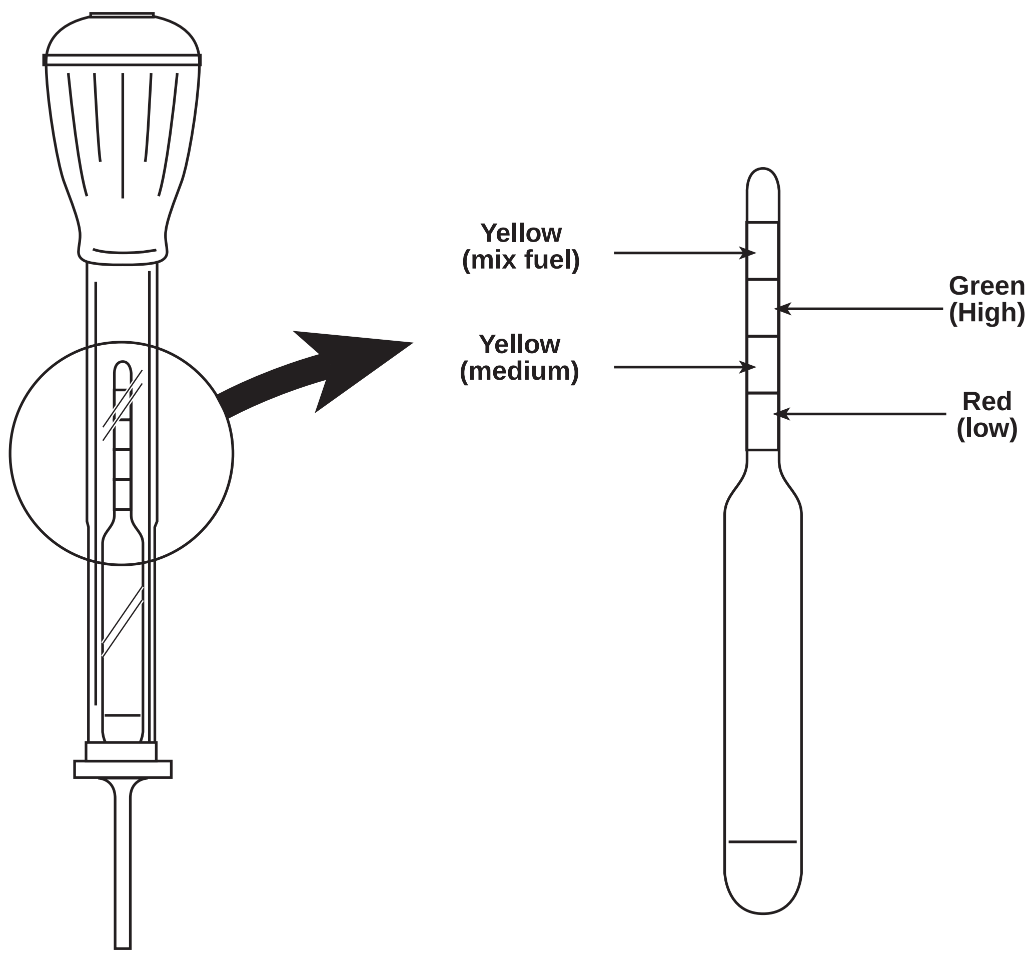
The glass hydrometer, including float portion, is very delicate. Extreme care must be taken when using this tool.

1. Fill a clean quart jar 3/4 full of diesel fuel.
2. Fill the glass hydrometer container with fuel until the hydrometer floats.
3. Gently spin the tool to break the surface tension.
4. Read scale where the fuel level contacts the hydrometer float.
5. Scale code:

   Green = High quality fuel
   *Yellow = Medium quality fuel
   Red = Possible low quality fuel

NOTE

The yellow band above the green band indicates a possible gasoline diesel fuel mixture.



Diesel Fuel Quality Tester.

JJ. DIESEL FUEL CONTAMINATION

Various malfunctions in diesel engines often lead to injection pump replacement. Before replacing the injection pump, determine if water or an excessive amount of gasoline is the cause of the malfunction. If water or gasoline is found to be the cause of the malfunction, injection pump and injection nozzle replacement may be necessary. The following procedure should help to eliminate unnecessary pump and nozzle replacement in the event of fuel contamination.

1. Remove the engine fuel filter and inspect the contents for the presence of water or gasoline. If water or gasoline is found, flush the system.

2. **Fuel contamination should be expected if the vehicle stalls, performance is poor or in the case of gasoline, the engine will knock loudly.**

3. If gasoline is suspected, remove the fuel fill cap and check for the presence of gasoline fumes.

4. Gasoline will not harm the injection system. Flush the gasoline out of the system as outlined. Do not remove any injection equipment unless engine operation is unsatisfactory after the system has been flushed.

5. **For water, remove the engine fuel filter and inspect the contents for the presence of water.** If water is found, remove the injection pump cover. If the pump is full of water, flush system.

6. Small quantities of surface rust in the injection pump will not create a problem. **If the vehicle stalls as a result of contamination, remove the metering valve and polish it lightly with 600 grit paper to remove the contaminant.** If the advance piston is stuck as evident by poor performance, smoke or noise, it may be necessary to remove the pump to free it up.

7. Occasionally contamination may enter the system that becomes so severe that physical damage has occurred to the springs and linkage in the pump.

8. These pumps must be replaced.

KK. DIESEL FUEL SYSTEM CLEANING PROCEDURE

NOTE

You should remove the fuel tank for cleaning when water is detected, because of the current understanding that a small amount of water is potentially damaging to the fuel system. Remove all of it.

CAUTION

Never drain of store diesel fuel in an open container due to possibility of fire, explosion, or contamination.

1. Drain the fuel tank.
2. Remove the tank gage unit.
3. Thoroughly clean the fuel tank. If the tank is rusted internally, it should be replaced. Clean or replace the fuel pickup filter and check valve assembly.
4. Reinstall the fuel tank but leave the lines disconnected at fuel tank area (above the rear axle).
5. Disconnect the main fuel hose at the fuel pump. Using low air pressure, blow out line towards rear of vehicle. Disconnect the return fuel line at the injector pump, with low air pressure, blow out the line towards the rear of the vehicle. NOTE: IF RUST IS PRESENT IN PIPES, THEY MUST BE REPLACED.
6. Reconnect the main fuel and return line hoses at the tank. Fill the tank at least 1/4 full with clean diesel fuel. Reinstall fuel tank cap.
7. Remove and discard the fuel filter.
8. Connect the fuel hose to the fuel pump.
9. Reconnect battery cable.
10. Purge the fuel pump and pump to filter line by cranking the engine until clean fuel is pumped out, catching the fuel in a closed metal container.
11. Install a new fuel filter.
12. Install a hose from the fuel return line (from the injection pump) to a closed metal container with a capacity of at least two gallons.
13. If the engine temperature is above 125°F (52°C), activate the injection Pump Housing Pressure Cold Advance (H.P.C.A.). This can be done by disconnecting the two lead connectors at the engine temperature switch (located at the rear of the right cylinder head), and bridging the connector with a jumper.
14. Crank the engine until clean fuel appears at the return line. Do not crank the engine for more than 30 seconds at one time. Repeat cranking if necessary with 3 minute intervals between crankings.
15. Remove the jumper from the engine temperature switch connector and reconnect the connector to the switch.
16. Crack open each high pressure line at the nozzles using two wrenches to prevent nozzle damage.
17. Disconnect the lead to the H.P.C.A. solenoid (on the injection pump).
18. Crank the engine until clean fuel appears at each nozzle. Do not crank for more than 30 seconds at one time. Repeat cranking if necessary, with 3 minute intervals between crankings.

LL. CLEANING PROCEDURE: GASOLINE IN FUEL SYSTEM

1. Drain fuel tank and fill with diesel fuel.

2. Remove fuel line between fuel filter and injection pump.

3. Connect a short pipe and hose to the fuel filter outlet and run it to a closed metal container.

4. Crank the engine to purge gasoline out of the fuel pump and fuel filter. Do not crank engine more than 30 seconds with three minutes between cranking intervals.

5. Remove the short pipe and hose and install fuel line between fuel filter and injection pump.

6. Attempt to start engine. If it does not start, purge the injection pump.

7. Crack injector lines.

8. Purge the injection pump and lines by cranking the engine with accelerator held to the floor, crank until the gasoline is purged and clear diesel fuel leaks out of the fittings. Tighten fittings. Limit cranking to 30 seconds with three minutes between cranking intervals.

9. Start engine and run at idle for 15 minutes.

NOTE

If gasoline is inadvertently pumped into the tank, there will be no damage to the fuel system or the engine. The engine will not run on gasoline. Gasoline has a feature called octane which defined is the ability of the fuel to resist ignition under high temperatures. Gasoline is a fuel that has high octane and it resists ignition under high heat. It will only ignite by a spark. Gasoline in the fuel at small percentages, (0–30%), will not be noticeable to the driver. At greater percentages, the engine noise will become louder. Gasoline at any percentage will make the engine hard to start when hot. In the summer time, this could be a cause of a hot start problem.

MM. FUEL FLOW TEST (Figure 3-13)

1. Disconnect fuel line at the filter inlet.

2. Disconnect #54 wire at the fuel injection pump electric shut-off solenoid. Place a suitable container at end of pipe and crank engine a few revolutions. If little or no fuel flows from open end of pipe, then fuel pipe is clogged or pump is inoperative.

3. **If fuel flows in a good volume from pipe at filter (1 pint in 30–45 seconds), fuel delivery pressure may be checked. This test is necessary because a weak pump can still produce an adequate volume of fuel when it is not under pressure. Fuel pressure should be in the 4 to 8 psi range.**

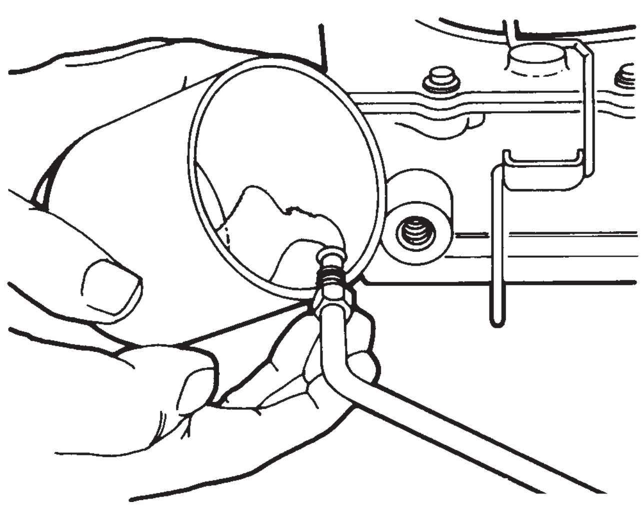


Figure 3-13. Fuel Flow Test.

NN. VACUUM TEST. FUEL LIFT PUMP INLET (Figure 3-14)

Low vacuum or complete loss of vacuum provides insufficient fuel to the injection pump to operate the engine throughout normal speed range. The vacuum test will determine if the pump has the ability to pump fuel and is the best indication of the quality performance of the pump.

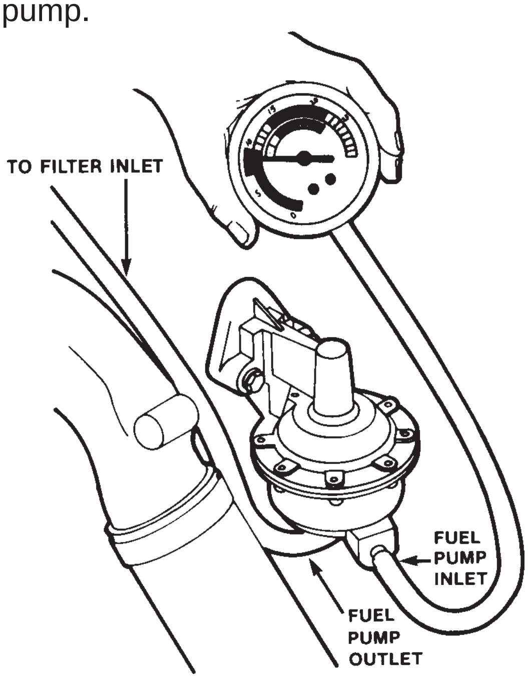


Figure 3-14. Vacuum Gauge.

1. Disconnect hose from fuel tank to fuel pump at fuel pump. Plug or position hose to prevent fuel leakage.

2. Connect a vacuum gage to the fuel pump inlet and attach a vacuum gage to the pump inlet.

3. Disconnect #54A wire at the fuel injection pump electric shut-off solenoid, so that the engine will not start. Crank the engine until you obtain a reading in the vacuum gage. If vacuum is less than 12 inches Hg (2.98 kPa) replace fuel pump.

OO. MECHANICAL FUEL PUMP TESTS

NOTE

Perform the following tests or inspections before removing pump.

Preliminary Inspection:

1. Check fittings and connections to insure tightness. If insufficiently tight, leaks of air and/or fuel may occur.

2. Check for fuel line bends or kinks in hoses.

3. With engine idling look for:

   - Leaks at pressure (outlet) side of the pump.

   - A leak on suction (inlet) side will reduce the volume of fuel on the pressure side of the pump and suck in air.

   - Also check for leaks at diaphragm, flange, and at breather holes in pump casting.

   - Check fuel pump steel cover and its fittings for leaks. Tighten or replace fittings as necessary. If fuel pump leaks (diaphragm, flange, steel cover, or pump casting breathing holes), replace pump.

SECTION 4
ENGINE

A. GENERAL ENGINE DATA (Figure 4-1)

The 6.2 liter diesel is designed, engineered, tested and manufactured specifically as a truck engine for tough, light-duty truck applications.

The 6.2 liter is a V-8 with a 90-degree configuration. It is a four-cycle operation engine and naturally aspirated (not requiring a turbo for air induction). Its oversquare design, the bore being larger than the stroke, assists in reducing engine friction.

As with all IDI-type engines, this unit also employs a glow plug in each cylinder to facilitate engine starting. Both the glow plugs and the injectors are threaded into the cylinder head with the injector nozzles being spring loaded and calibrated to open at a specified psi of fuel pressure.

NOTE

The compression ratio of this engine is 21.5:1.

CAUTION

Due to the high compression ratio of this engine and the use of glow plugs, do not at any time attempt to use starting fluids to start the engine in cold weather. The use of such highly volatile liquids (ether) can result in serious engine damage due to the explosive nature of this fluid within the cylinder as the piston is coming up on its compression stroke. This condition creates extremely high pressures that attempt to oppose the piston's upward movement. If the glow plugs are in the heated position and ether is sprayed into the engine, this can cause severe explosions within the cylinder and glow plug damage. In addition, ether tends to act as a drying agent and will cause lack of upper cylinder lubricant, which can also cause engine damage.

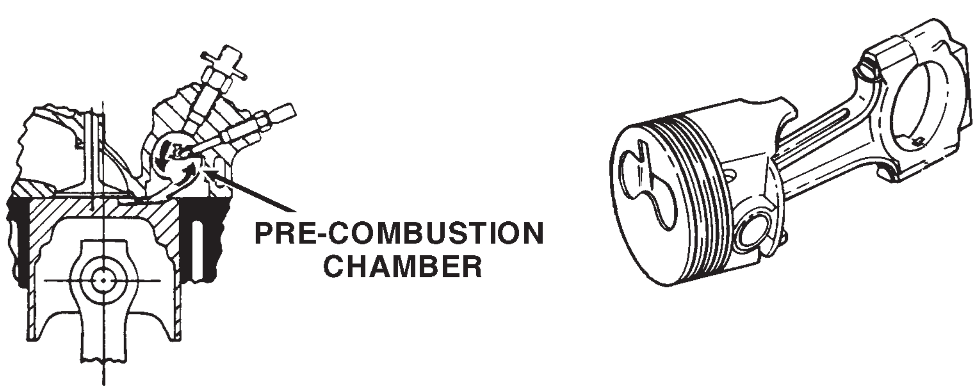


Figure 4-1. Pre-combustion Chamber and Piston Crown Shape.

B. MANOMETER - BLOW-BY TEST

1. Run the engine at idle. Record water pressure. The crankcase pressure at idle should indicate zero inches of water or a slight vacuum.

2. Increase engine RPM to 2,000 RPM and record water pressure. The crankcase pressure at 2,000 RPM should be between 1/2 inch and 4 inches of water vacuum.

NOTE

If water travel is one inch, you must add one inch for travel at other end of manometer scale.

C. GLOW PLUG TIP REMOVAL (DAMAGED OR BROKEN) (Figure 4-2)

1. Remove fuel injector nozzle.

2. Using socket wrench and breaker bar on torsion damper bolt, rotate crankshaft clockwise to bring piston (in affected cylinder) to top dead center (TDC) position to ensure intake and exhaust valves are closed.

WARNING

Compressed air used for cleaning purposes may exceed 100 psi (688 kPa). Use only with effective chip guarding and personnel protective equipment (goggles, shield, gloves, etc.).

3. Direct compressed air into glow plug port (1) to expel broken tip from prechamber through injector nozzle opening (2).

NOTE

In some cases it may be necessary to remove cylinder head to remove expanded glow plug tip.

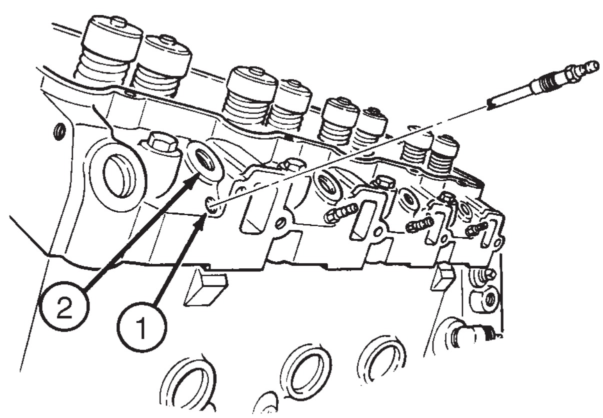


Figure 4-2. Damaged Glow Plug Removal

D. ENGINE INJECTION PUMP TIMING PROCEDURES USING KENT-MOORE TACH-N-TIME METER (Figures 4-3 through 4-7)

NOTE

Magnetic pickup receptacle (8) on timing bracket (1) must be correctly positioned or timing meter will not register correctly.

1. Insert timing bracket gauge into magnetic pickup receptacle (8) on timing bracket (1).

2. Rotate timing bracket gauge so pointer on gauge fits into TDC notch (9) in timing bracket (1).

3. If pointer on gauge does not fit exactly into TDC notch (9), bend magnetic pickup receptacle (8) until pointer on timing bracket gauge fits exactly into TDC notch (9).

4. Remove timing bracket gauge from pick-up receptacle (8) on timing bracket (1).

NOTE

End of magnetic pickup (7) must be 1/16 in. (1.6 mm) from torsional dampener.

5. Install magnetic pickup (7) into magnetic pickup receptacle (8) and connect pickup lead (6) to timing meter.

NOTE

Clamp-on pickup (4) must be used on a straight section of tube no further than 4 in. (10 cm) from injection nozzle.

6. Clean cylinder number one injection line (2) with metallic wool.

CAUTION

Do not overtighten clamp-on pickup or damage to pickup will result.

7. Install pickup (4) on injection line (2).

8. Connect ground clip (3) to fuel injection line (2) and connect pickup lead (5) to timing meter.

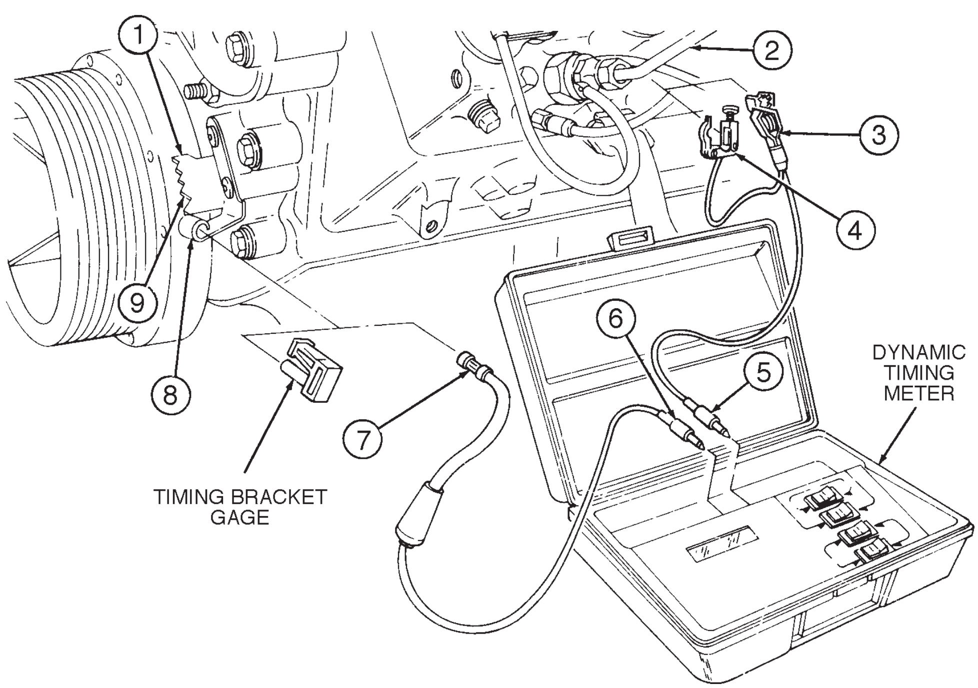


Figure 4-3. Engine Injection Pump Timing Meter Hook-up.

a. Connecting Power Leads (Figure 4-4)

9. Route power leads of timing meter into battery compartment and connect red power lead (11) to rear battery + (plus) terminal (12).

10. Connect black ground lead (10) to negative battery terminal (13). Display should light up and read: SE-120.0.

NOTE

On 24 volt systems, do not connect the Tach-N-Time to each battery. Power should be derived from the positive and negative terminals on the 12 volt system source (one battery).

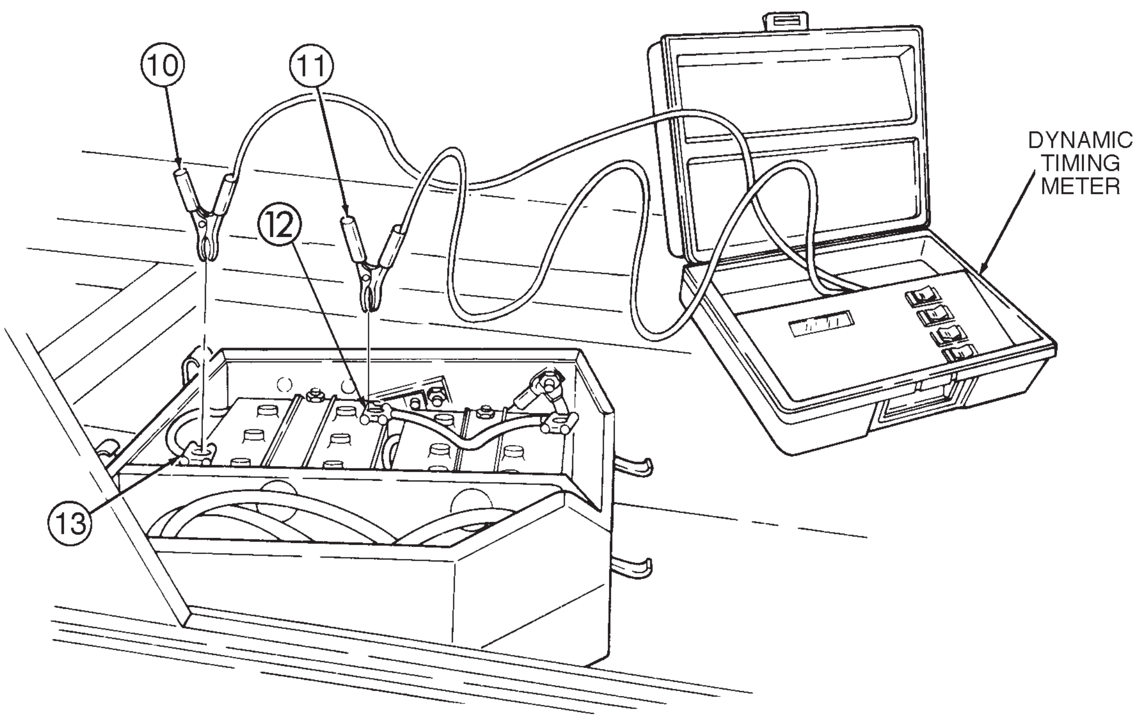


Figure 4-4. Timing Meter Power Hook-up

b. Enter Offset Chart (Figure 4-5)

1. Cylinder Number in the Firing Order – The numbers 1 thru 8 do not correspond to the cylinder numbers on the engine. They represent the cylinder numbers in firing order. For example: When the engines firing order is 1-8-7-2-6-5-4-3, “1” refers to cyl. #1 (the first cylinder in the firing order), “2” refers to cyl. #8 (the second cylinder in the firing order), “3” refers to cyl. #7 (the third cylinder in the firing order), etc.

2. Offset Entries – The offset entries are listed in crankshaft degrees, and correspond to the position of the magnetic pick-up receptacle in relation to TDC for the individual cylinders.

Figure 4-5. Enter Offset Chart.

c. Injection Pump Timing Adjustment TACH-N-TIME (Figure 4-6)

WARNING

Never adjust injection pump timing with engine running or injury to personnel or damage to equipment may result.

1. Loosen three nuts (1) securing injection pump (2) to timing cover (3).

NOTE

Moving injection pump 1/32 inch (1 mm) is equal to approximately 1° of injection pump timing.

2. Move injection pump (2) clockwise to retard timing or counterclockwise to advance timing.

3. Tighten three nuts (1) securing injection pump (2) to timing gear cover (3) and recheck timing.

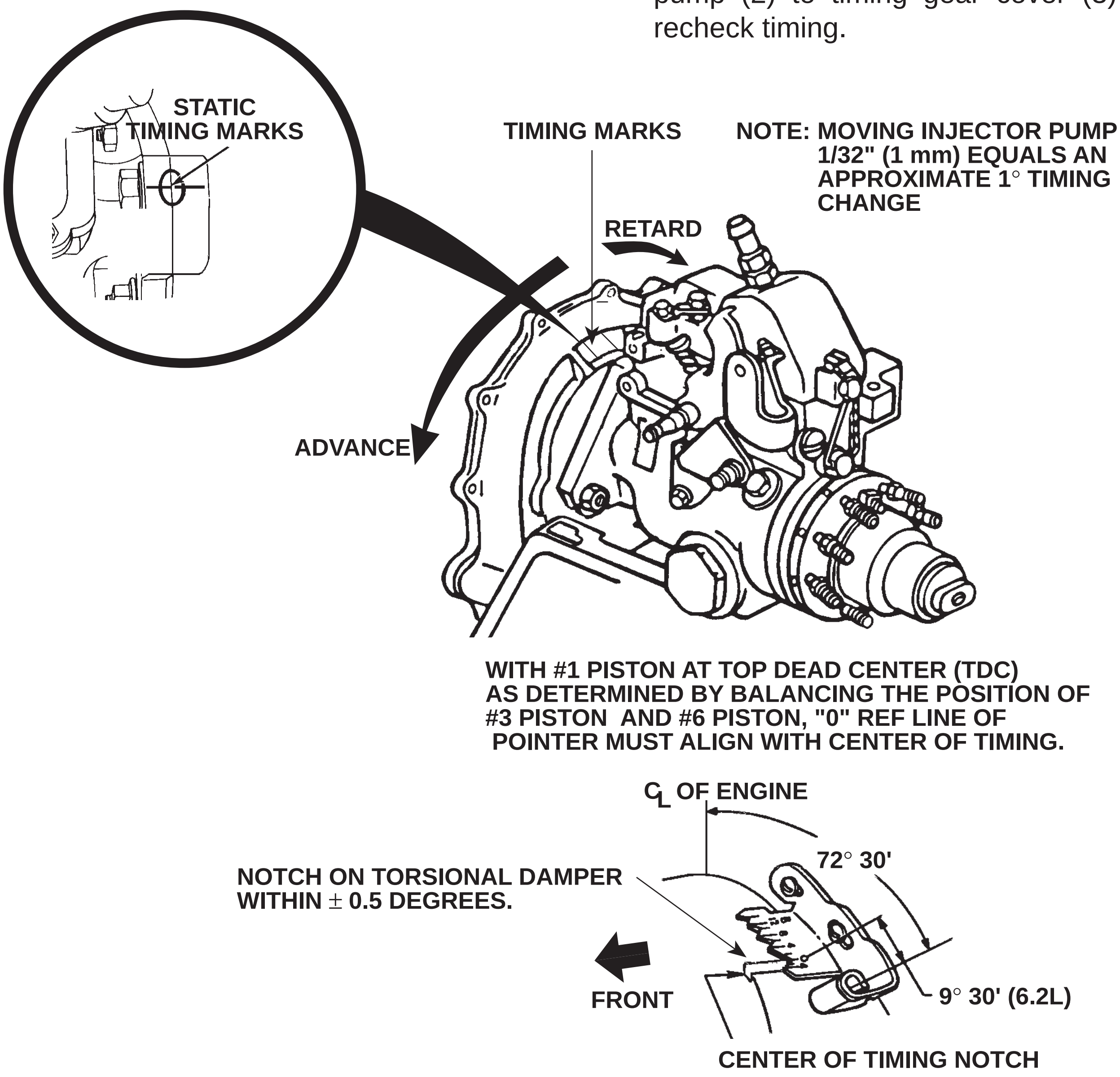


Figure 4-6. Timing Adjustment.

d. Engine Injection Pump Timing (Figure 4-7)

CAUTION

Make sure all cables and wires are clear from fan, belts, and exhaust manifolds before starting engine, or damage to equipment will result.

NOTE

If sensor light is not blinking, check clamp-on pickup on fuel injection line for proper installation.

1. Depress offset adjustment switch (3) and hold.
2. Operate increase/decrease switch (2) until offset adjustment reads 9.5 on display (4) and release offset adjustment switch (3). Display (4) should now read: 0000...0.0.
3. Start engine and warm up to operating temperature.
4. Position sensor switches (1) to clamp-on and magnetic pickup position.
5. Raise engine speed to 1300 RPM and read injection pump timing on display (4). Timing must be 4 before top dead center. If timing is not 4 before top dead center, stop engine and adjust timing.
6. Disconnect timing meter.

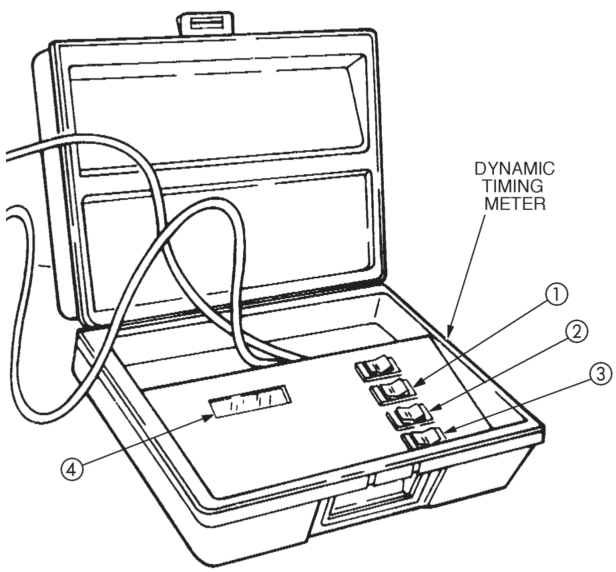


Figure 4-7. Timing with Dynamic Timing Meter.

E. ENGINE INJECTION PUMP TIMING PROCEDURES USING SNAP-ON LUMY/MAG II TIMING METER 12-VOLT DC (Figure 4-8)

1. **Power Leads**. These leads have color-coded clip boots. Red lead is connected to positive (+) terminal of 12 volt battery, and black to negative (-) terminal or a good vehicle ground.

2. **Magnetic Pick-up Lead**. This lead features the male half of a "quick disconnect" coupling which attaches to either of the two magnetic pick-up assemblies included with the MT1480.

3. **Magnetic Pick-ups**. The MT88A pick-up, with convenient handle and flexible extension, is designed for general use, while the MT89 is intended for use on vehicles with restricted access to the magnetic pick-up receptacle. Magnetic pick-ups are used with both diesel and gasoline engines equipped with compatible pick-up receptacles. The magnetic pick-up senses a groove or protrusion on a harmonic balancer, and provides precise crankshaft or piston position and RPM data to the meter. Magnetic pick-ups are carefully calibrated to detect proper grooves or protrusions and to reject minor surface imperfections that may cause improper meter readings. However, if an improper RPM reading occurs, use the optical or inductive pick-up to obtain the proper RPM reading.

4. **Optical Pick-up Lead**. The optical pick-up is connected to this lead at the locking coupling. The optical pick-up is used when working on diesel engines. The pick-up monitors the start of combustion within an engine cylinder.

5. **Luminosity Probe**. The luminosity probe is installed in a diesel engine glow plug hole. The probe has a quartz core which serves as a "window" to the cylinder. Light pulses, caused by combustion in the cylinder, pass through the "window" and are detected by the optical pick-up.

6. **Optical Pick-up**. The optical pick-up connects to the luminosity probe. A photo detector inside the pick-up senses light pulses that pass through the probe and changes the light pulses to electrical signals.

7. **RPM LED Display**. The MT1480 has an RPM range of 40 to 8000 RPM and displays in increments of 10 RPM. Just one pick-up connection is required if only an RPM reading is desired. For a diesel engine RPM reading, either the magnetic or optical pick-up can be used.

   Diesel engine "cranking RPM" tests are performed using the magnetic pick-up. For user convenience, the RPM display will hold the "cranking RPM" reading for about five seconds after cranking is stopped.

8. **Degrees LED Display**. The MT1480 displays engine timing to within 99° (in increments of .5°) of engine offset settings of 0° to 359.5°. This allows timing to be performed from any engine cylinder.

   The luminosity probe, optical pick-up and magnetic pick-up are used for diesel engine timing.

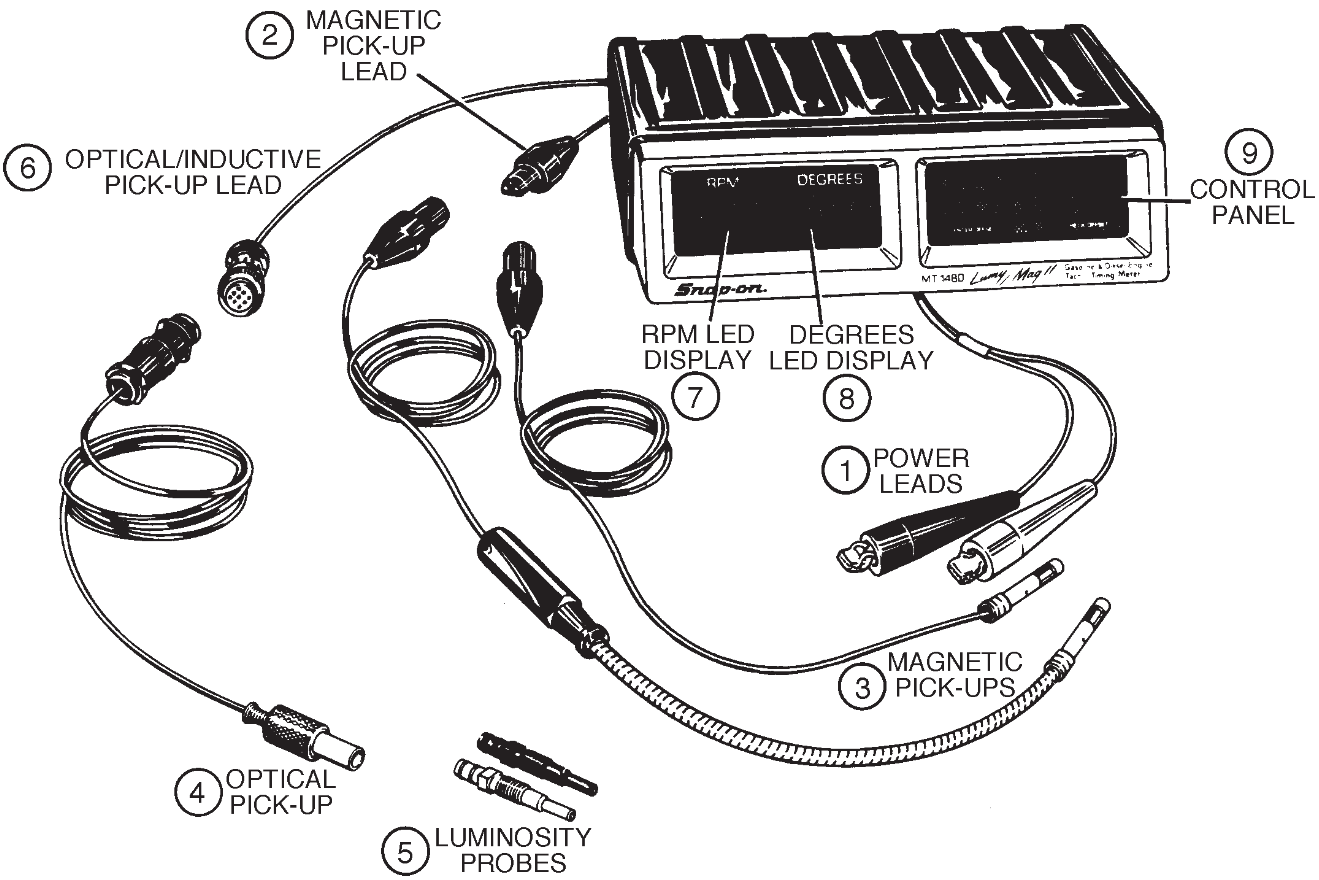


Figure 4-8. Snap-on Lumy/Mag II.

9. **Control Panel**. The MT1480 features a touch control panel with ten digits (0–9), a decimal point (.) and two function controls - ENTER OFFSET and CHECK OFFSET.

   The ten digits, decimal point, and enter offset controls are used to enter the desired degrees of offset. Offsets of .5°–359.5° may be entered in .5° (1/2°) increments, such as 1, 1.5, 2, 2.5, etc. This is termed a “valid” offset. Offsets entered that are greater than 359.5 or not in .5 increments are “invalid” and will be rejected by the meter.

   CHECK OFFSET is used to verify the degree of offset entered. The degrees entered are displayed by touching CHECK OFFSET.

a. Accessories Included with the MT-1480

MT95 Timing Bracket Gauge — The MT95 is used to check and align the position of HUMMER 6.2L diesel engine magnetic pick-up receptacles. Instructions are packaged with the MT95.

b. Display Codes

The RPM and DEGREES displays provide valuable meter operation information in addition to RPM and timing readouts. An understanding of the following display codes is necessary for efficient use of the MT 1480.

"E" will appear when power leads are connected to the battery. It indicates that the meter is waiting for an offset to be entered.

If anything other than the "E" is displayed, press ENTER OFFSET to display the "E".

"1480 READY" will move across the displays after a valid offset is entered. It indicates that the meter is ready, but no signals are going to the meter. In other words, the engine has not been started and/or the pick-ups have not been connected.

"SNAP-ON" also indicates that the meter is ready and no signals are going to the meter. It will appear after a valid offset is entered if pick-up leads are disconnected and/or engine is shut off.

Cranking RPM tests can not be performed if the displays read "SNAP-ON". A valid offset must be reentered first.

"OFFS. Err." (offset error) will be displayed if an invalid offset is entered. If this occurs, press ENTER OFFSET and reenter a valid offset. "OFFS. Err." indicates one of the following errors has occurred:

1. An offset greater than 359.5° was entered.
2. An offset using a decimal point not followed by a "O" or "5" was entered. Offsets must be entered as whole numbers or in increments of .5° (1/2°).
3. No offset was entered.
4. An offset with more than one number to the right of the decimal point was entered, such as 9.50 or 9.05.

5. A four digit offset was entered, such as 0100, or 0200.
6. An offset was entered using the decimal point but no number was entered after the decimal point.

Displays show RPM reading, but no timing reading. It indicates that only one pick-up is connected. Only one pick-up connection is required to monitor RPM on a diesel engine. Two pick-up connections are necessary to monitor engine timing. The optical and magnetic pick-ups are required for diesel engines.

When timing an engine and only an RPM reading is displayed, check for the following potential problems:

1. No magnetic pick-up signal — Check by disconnecting optical pick-up (diesel engine). If RPM reading is still displayed the magnetic pick-up is functioning properly.

2. No optical pick-up signal — Check by disconnecting the magnetic pick-up. If RPM reading is still displayed the meter is receiving a signal from the optical or inductive pick-up and the pick-up is working properly.

   If the optical pick-up is connected, and no RPM reading is displayed when the magnetic pick-up is disconnected, the problem may be a dirty luminosity probe and not a bad connection or faulty pick-up.

3. Timing of engine is not within ±99° of offset entered — Verify that the offset entered is correct for the engine and engine cylinder being tested. Press CHECK OFFSET and make sure the correct offset degree was entered.

4. RPM is too low — If the RPM reading is less than 400, no timing degrees will be displayed.

If anything other than a tach reading, timing reading, or one of the display codes mentioned appears, press ENTER OFFSET or disconnect and reconnect a battery power lead.

c. Operator Tips

Familiarize yourself with the following Operator Tips before doing any testing with the LUMY-MAG II. Tips are divided into two sections — Equipment Tips and Testing Tips.

d. Equipment Tips

1. When installing a luminosity probe in a glow plug hole, take care not to overtighten it. Follow torque specifications in testing sections.

2. Handle the luminosity probe with care. Dropping it may fracture the quartz. Do not use a damaged probe.

3. Use a wet toothpick or wooden matchstick to remove carbon buildup from a luminosity probe. Also, an ultrasonic cleaning unit, with a solution used for cleaning injector nozzles, will help to loosen deposits. Do not place hot probe in liquid.

4. Sooty, dirty or broken probes will result in retarded readings. The luminosity probe will soot up very fast when used in a cold engine.

5. Use a dry cotton swab to clean the lens in an optical pick-up. Do not use solvent or an ultrasonic cleaner.

6. Clean any spills, such as gasoline, brake fluid, cleaning solvents, etc. from the meter's exterior immediately to protect the finish.

7. When not in use, the inductive pick-up should be stored in the open position. This will help to protect it if it is dropped.

8. Periodically check external lead connections to make sure they are secure.

9. For convenience, keep the enclosed quick reference ENTER OFFSET CHART near the meter.

10. The MT1480 is a highly sensitive and versatile test instrument. Yet, if handled with care it should provide years of dependable trouble-free service.

e. Checking Cranking Speed

Cranking speed is extremely critical for a diesel to start, either hot or cold. Some tachometers are not accurate at cranking speed. An alternate method of checking cranking speed or determining the accuracy of a tachometer is to perform the following procedure:

1. Install a compression gauge into any cylinder.
2. Disconnect the injection pump fuel shut off solenoid lead on the top of the injection pump or at the harness connector.
3. Install the digital tachometer to be checked.
4. Depress the pressure release valve on the compression gauge.
5. With the aid of an assistant, crank the engine for 2 or 3 seconds to allow the starter to reach full speed, then without stopping, count the number of “puffs” at the compression gauge that occur in the next 10 seconds. Multiply the number of “puffs” in the 10 second period by 12 and the resulting number will be the cranking speed in revolutions per minute (RPM).

f. Hookkup Procedures and Testing Tips (Figure 4-9)

1. Engine must be in good running order before timing adjustments can be done correctly.
2. Test engine must be at normal operating temperature for accurate test results.
3. Make sure that manufacturer’s preliminary test procedures are followed to ensure accurate test results.
4. When test readings are first displayed, allow a few seconds for display readings to stabilize.
5. Clean any dirt from the engine probe holder and crankshaft balancer rim.
6. A cylinder misfire can cause a momentary increase in the timing reading. If this occurs, allow the meter reading to stabilize.
7. If magnetic pick-up signal is lost when you let go of an inserted magnetic pick-up, it may be due to a spring-like return of the magnetic pick-up receptacle caused by a too snug fit. A spray lubricant applied to the pick-up or receptacle may solve this problem.

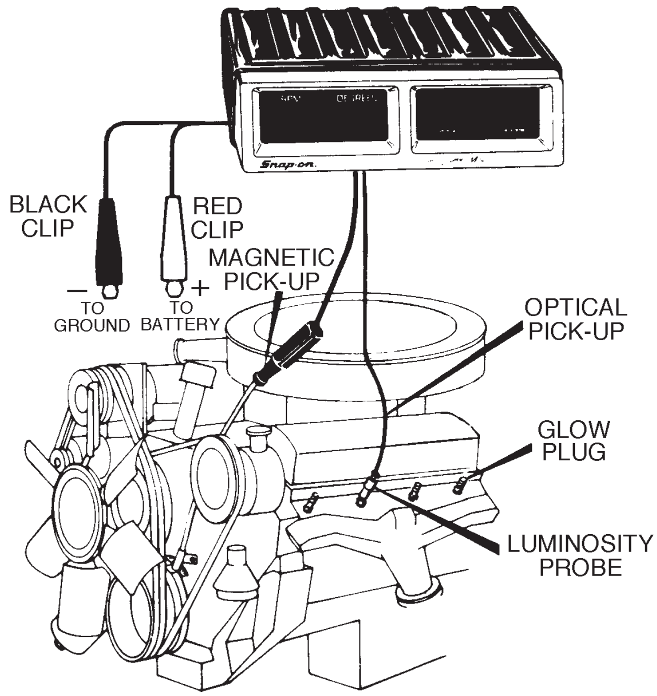


Figure 4-9. Hookup

g. Diesel Engine Timing

1. Place transmission selector in neutral, apply parking brake and block the drive wheels.
2. Clean timing marks located on pump flange, if needed, and check the position of the marks.

h. Injection Pump Timing Adjustment LUMY/MAG II (Figure 4-10)

WARNING

Never adjust injection pump timing with engine running or injury to personnel or damage to equipment may result.

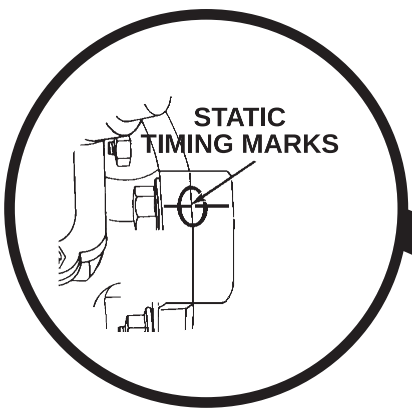
1. Loosen three nuts (1) securing injection pump (2) to timing cover (3).

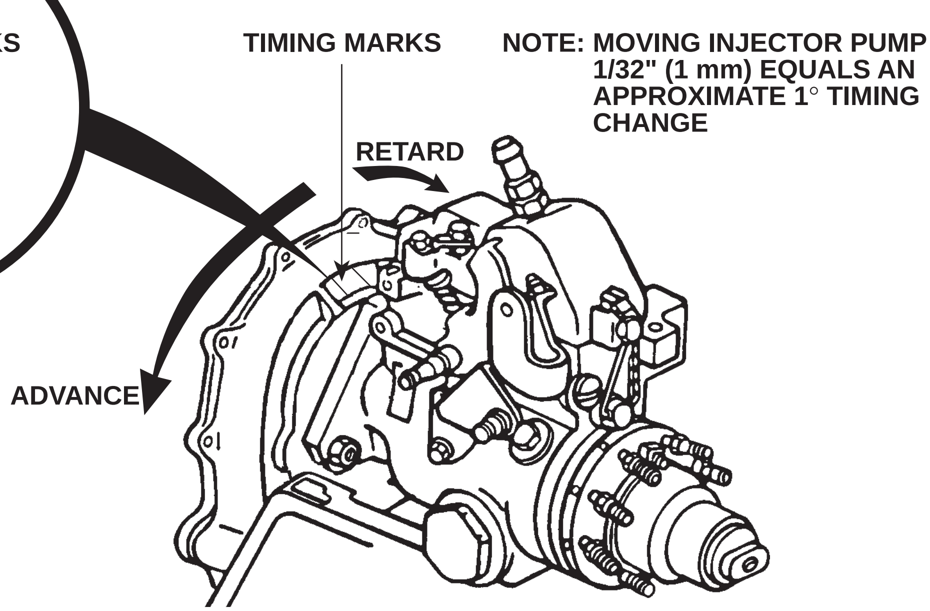
NOTE

Moving injection pump 1/32 inch (1 mm) is equal to approximately 1° of injection pump timing.

2. Move injection pump (2) clockwise to retard timing or counterclockwise to advance timing.

3. Tighten three nuts (1) securing injection pump (2) to timing gear cover (3) and recheck timing.





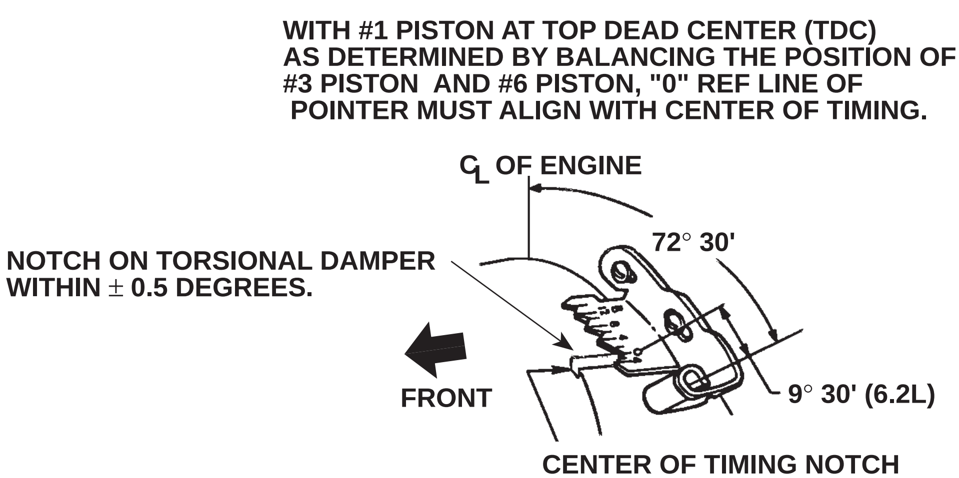


Figure 4-10. Timing Adjustment.

NOTE

Normally the alignment of the marks will be quite close. If they are not, a variation in timing from the manufacturer's specifications can be expected.

3. Clean the magnetic pick-up receptacle and the harmonic balancer or flywheel as required.

4. Start the engine and allow it to idle until it reaches normal operating temperature. Shut off the engine.

NOTE

Failure to fully warm the engine may result in erroneous readings and improper pump adjustment. Combustion timing will vary until the temperature stabilizes.

5. Select cylinder to be used for testing.

NOTE

Select the correct offset to be entered for cylinder selected.

6. Clean dirt from around the glow plug of cylinder selected.

7. Remove glow plug.

NOTE

If a carbon buildup around the glow plug heater element causes difficulty in removing the glow plug, remove the buildup. This will help to keep the luminosity probe's "window" clean.

8. Install proper luminosity probe in glow plug hole and torque to 8–9 lb ft (10–12 N•m).

<u>CAUTION</u>

Do not overtighten luminosity probe. Do not install a luminosity probe in an engine it is not specified for use on, as it may result in insufficient thread engagement.

9. Insert magnetic pick-up into pick-up receptacle, making sure it is in far enough to make contact with harmonic balancer, flywheel or crankshaft pulley.

   If the pickup will be monitoring a protrusion, rotate the engine slowly and position the protrusion in line with the pick-up receptacle hole. Insert the pick-up until it contacts the top of the protrusion, and then back it out slightly.

10. Connect MT1480 power leads to battery (12 volts DC); red to positive (+) and black to negative (–). "E" should be displayed on RPM display. If not, press "ENTER OFFSET" switch until "E" appears.

11. Enter the proper offset for the cylinder used for testing.

12. Start engine and adjust RPM to manufacturer's specification 650 RPM ±25. Make sure that lead wires are clear of all moving or hot engine parts.

13. Observe light pulses for steadiness through luminosity probe window. If pulses are steady, continue testing. Irregular pulses indicate a malfunction that must be corrected before timing adjustments can be properly made.

14. Connect optical pick-up to luminosity probe.

15. After engine has run several minutes at the specified RPM, observe the timing reading. Recheck timing reading at two minute intervals until reading stabilizes. This usually takes 4–6 minutes. Do not accept a reading that does not repeat at two minute intervals.

    Timing must be 3° ±2° after top dead center at 1300–1400 RPM.

16. Shut off the engine.

    A. If timing is within specifications, go to step 22.

    B. If timing is not within specifications, go to step 17.

17. Loosen fuel injection pump bolts (or retaining nuts) to allow the pump to be rotated.

18. Rotate the pump to advance or retard the timing as needed. See page 4-6.

19. Retorque the pump bolts.

20. Start the engine and recheck the timing.

21. Repeat steps 15 to 20 until timing is to specifications.

    If the timing marks are far apart after resetting the timing and the engine still has a problem, the dynamic timing could still be incorrect because of a malfunctioning cylinder. When this occurs, check timing from any other cylinder. If there is still a difference in timing between cylinders, try averaging the timing by adding the timing readings and dividing by the number of cylinders checked.

22. Reset the idle to specifications and shut off the engine.

23. Remove the meter and its attachments from the vehicle.

24. Replace and retorque the glow plug. Connect wire.

i. Cranking RPM Test (Min. 180 RPM)

1. Place the transmission selector in neutral, apply parking brake and block drive wheels.

2. Disable the engine to prevent it from starting. Disconnect the fuel shut-off solenoid wire (#54).

3. Connect MT1480 power leads to battery (12 volt DC); first red to positive (+) and the black to negative (-). "E" should be displayed on RPM display. If not, press "ENTER OFFSET" until "E" appears.

4. Insert the magnetic pick-up into the pick-up receptacle until it contacts the surface of the harmonic balancer, flywheel or pulley.

5. Enter any valid offset and press "ENTER OFFSET". "1480 ready" should now move across the displays.

NOTE

If the display is blank or anything other than "1480 ready" is displayed, disconnect leads at battery and then repeat steps 3 thru 5.

6. Crank engine and monitor RPM. The meter will hold the RPM reading for about five seconds after cranking is stopped. (Min. 180 RPM).

j. Enter Offset Chart (Figure 4-11)

Using the ENTER OFFSET CHART:

1. CYLINDER NUMBER IN THE FIRING ORDER - The numbers 1 through 8 do not correspond to the cylinder numbers on the engine. They represent the cylinder number in the firing order. Example: if the engine's firing order is 1-8-7-2-6-5-4-3, "1" refers to cylinder, #1 (the first cylinder in the firing order), "2" refers to cylinder #8 (the second cylinder in the firing order), "3" refers to cylinder #7 (the third cylinder in the firing order), etc.

2. OFFSET ENTRIES - The offset entries are listed in crankshaft degrees, and correspond to the position of the magnetic pick-up receptacle in relation to TDC for the individual cylinders.

Figure 4-11. Enter Offset Chart.

F. USE OF TORQUE COMPUTER (Figure 4-12)

1. Using torque adapters, tighten engine to engine mount capscrews to 37 lb ft (50 N•m). Tighten insulator to engine mount capscrews to 37 lb ft (50 N•m). Tighten frame bracket to insulator nuts to 60 lb ft (82 N•m).

2. Using a 3/4 inch torque adapter, tighten transmission mount to transfer case adapter capscrews to 65 lb ft (88 N•m).

To approximate the correct torque setting when using a click-type torque wrench with an adaptor follow the directions as follows:

a. Adjust the micrometer to the desired torque setting.

b. Determine the effective length “A” from the center of handle to center of square drive.

c. Determine “A + B”.

d. Compute corrected toque setting.

e. Adjust micrometer to corrected torque setting.

f. Redetermine effective length “A” for new torque setting.

g. Redetermine “A + B”.

h. Compute final corrected torque setting.

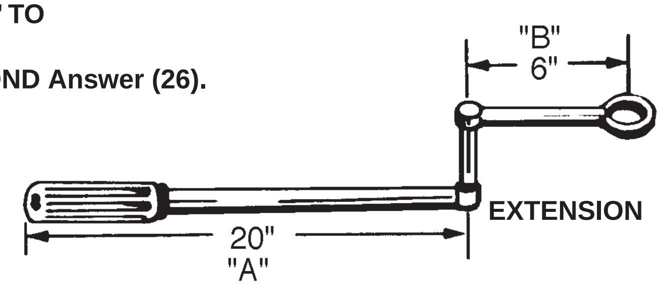
i. Adjust micrometer to final corrected torque setting.

The final derived torque setting is an approximation only of the true setting. Steps (f) through (i) must be repeated if greater accuracy is required.

For use with adapters ONLY. Handle extensions NOT recommended.

EXAMPLE:
1. **MULTIPLY LENGTH OF TORQUE WRENCH 20" BY DESIRED TORQUE 200 FT LBS 20 x 200=4000.**
2. **ADD LENGTH OF TORQUE WRENCH 20" TO LENGTH OF ADAPTER 6" 20 + 6=26.**
3. **DIVIDE FIRST ANSWER (4000) BY SECOND Answer (26). 4000/26=APPROXIMATELY 154 FT LBS.**

154 FT LBS WILL BE THE READING ON THE TORQUE WRENCH WHEN THE DESIRED TORQUE OF 200 FT LBS IS ACHIEVED AT THE NUT.



TORQUE WRENCH IS MEASURED FROM CENTER OF SOCKET END TO PIVOT POINT IN HANDLE OR IF SOLID TO END OF HANDLE.

TORQUE WRENCH AND ADAPTER MUST BE USED ONLY IN A STRAIGHT LINE.

Figure 4-12. Computing Torque when using Extensions.

G. ENGINE COMPRESSION TEST

- **Engine must be up to normal operating temperature.**
- **No reading should be lower than 380 psi (2625 kPa).**
- **Cranking speed must be at least 180 RPM.**
- **The lowest reading should not be less than 80% of the highest.**
- **In order to receive an accurate compression reading, the batteries must be at or near a full state of charge in order to crank the engine over fast enough. A slow cranking rate will result in a low reading. The lowest reading obtained from any engine cylinder should not be less than 380 psi (2625 kPa).**

GMC 6.2L Engine Compression Check. A compression check can be performed at any time on the engine to establish the mechanical condition of the valves and rings.

1. Remove all glow plugs.
2. Remove air cleaner element.
3. Disconnect lead 54A from fuel injection pump.
4. Install compression gauge adapter in glow plug hole of cylinder being tested and connect compression gauge.

CAUTION

Because of the high compression ratio of this engine (21.5:1), do not attempt to add oil to any cylinder as a means of isolating the problem to valves or rings because a hydrostatic lock could occur that can result in extensive engine damage. In extreme cases, connecting rod or piston damage can result.

5. Crank engine, allow engine to crank long enough to accumulate six compression pulses, and record highest reading.
6. Repeat steps (4) and (5) for remaining cylinders.
7. All cylinders should build up quickly and evenly to a minimum of 380–400 psi (2625 to 2760 kPa) and lowest reading should not be less than 80% of highest cylinder reading.

NOTE

Normal Compression - Compression builds up quickly and evenly to specified compression on each cylinder.

Piston Rings Leaking - If the problem is poor piston rings, this is generally evidenced by the fact that the compression reading on the gauge will be low on the first stroke but tends to increase on the remaining cranking strokes to a reading that is still less than the minimum of 380 psi (2625 kPa).

H. CHECK FOR ENGINE MECHANICAL OR HYDRAULIC SEIZURE (Figure 4-13)

Remove all glow plugs. Using socket and breaker bar at crankshaft pulley, rotate crankshaft and check for mechanical or hydraulic seizure. If crankshaft will not turn, replace engine. If crankshaft turns and liquid is discharged determine if liquid is coolant or fuel. If coolant is discharged, remove cylinder heads and check for cracked cylinder heads or leaking head gaskets. Replace cracked cylinder heads. If fuel is discharged, remove and test fuel injection nozzles. Replace defective fuel injection nozzles.

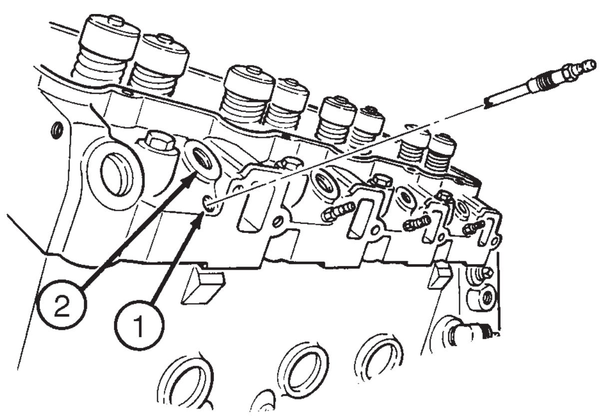


Figure 4-13. Glow Plug Removal
Engine Seizure Check

Remove converter housing cover and check for damaged flywheel. Replace flywheel if damaged.

I. PRE-CHAMBER CRACKS (Figure 4-14)

During the service of 6.2L diesel cylinder heads, the observance of hairline cracks may be noticed in the pre-chamber area.

Cracks on the face of the pre-chamber start at the edge of the fire slot. From the edge, the cracks proceed toward the circular impression of the head gasket bead.

These cracks are a form of stress relief and are completely harmless up to a length of 5mm (3/16"). Cracks longer than this are approaching the head gasket sealing bead and should be replaced with the proper part number.

This illustration of a pre-chamber displays both acceptable and unacceptable cracks.

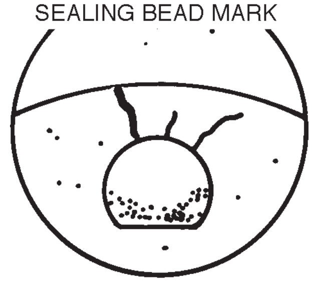


Figure 4-14. Pre-chamber Cracks.

J. NOISY VALVES & VALVE SPRING CHECK (Figure 4-15)

To check valve spring and valve guide clearance, remove the valve covers:

Occasionally this noise can be eliminated by rotating the valve spring and valve. Crank engine until noisy value 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. If spring is off square more than 1/16" in free position, replace spring.

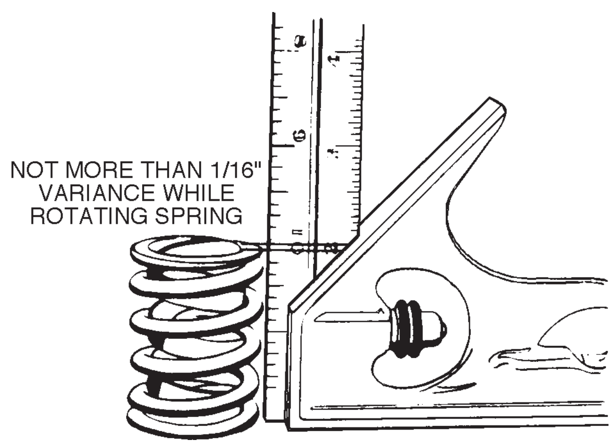


Figure 4-15. Valve Spring Check.

K. VALVE LIFTER DIAGNOSIS

1. Momentarily noisy when engine is started:

   This condition is normal. Oil drains from the lifters which are holding the valves open when the engine is not running. It will take a few seconds for the lifter to fill after the engine is started.

2. Intermittently noisy on idle only, disappearing when engine speed is increased:

   - Intermittent clicking may be an indication of a pitted check valve ball, or it may be caused by dirt.
   - Correction: Clean the lifter and inspect. If check valve ball is defective, replace lifter.

3. Noisy at slow idle or with hot oil, quiet with cold oil or as engine speed is increased:

   High leak down rate. Replace suspect lifter.

4. Noisy at high speeds and quiet at low speeds:

   - High oil level - Oil level above the "Full" mark allows crankshaft counterweights to churn the oil into foam. When foam is pumped into the lifters, they will become noisy since a solid column of oil is required for proper operation.

     Correction: Drain crankcase oil until proper level is obtained.

   - Low oil level - Oil level below the "Add" mark allows the pump to pump air at high speeds which results in noisy lifters.

     Correction: Fill crankcase until proper oil level is obtained.

   - Oil pan bent on bottom or pump screen cocked or loose; replace or repair as necessary.

L. V-8 DIESEL HEAD GASKET LEAKAGE

There are various reasons why a cylinder head may not seal, that should be detected before a head gasket is replaced. Some may not be readily apparent to the technician because the theory of sealing is not fully understood.

First get an understanding of what is going on in the engine and what the gasket must accomplish. The pressure within the diesel engine cylinder is much higher than a gasoline engine, 1000 vs.. 600 psi.

The sealing concept is to use most of the clamping load, about 75%, to seal the compression. This is accomplished by placing a round wire ring inside of a thin metal shield that surrounds the cylinder bore. When the bolts are tightened there is line contact around the bore between the cylinder head and the block. Because it is line contact, the pressure exerted by the ring to the head and block is extremely high. The clamping load is used to compress the metal ring. The body of the gasket is a few thousands of an inch thinner than the ring after it is crushed. Therefore none of the clamping load is used to crush the body. The colored rings around the various holes in the gasket are a cured RTV sealer. The sealer is about .005 inches in thickness, on each side. It is thick enough so that it gets crushed between the head and block. The sealer keeps the combustion gases from going into the coolant and keeps the coolant from leaking out through the gasket.

The gasket has another feature that needs explanation. The wire ring must cross over the pre-chamber which should be flush with the head.

M. LEAKING CYLINDER HEAD GASKET

Pre-chambers must not be recessed into the cylinder head or protrude out of the cylinder head by more than .002" or a head gasket leak may result.

This measurement should be made at two or more points on the pre-chamber where the pre-chamber seats on the head gasket heat shield and sealing ring. Using a straight edge and a thickness gage or dial indicator, measure the difference between the flat of the pre-chamber and the flat surface of the cylinder head. A slight variance from one side of the pre-chamber to the other provided both sides are within the tolerance will result in a good seal.

The sealing surface is the wire ring in the gasket where it contacts the block and head. Any damage to these surfaces will result in gasket leaks. Use of the motorized wire brush or grinder could remove a few thousands of metal. The head may then clamp the body of the gasket rather than the sealing ring.

While the cylinder heads are off the engine, they should be carefully inspected for a number of possible conditions, one of which is warpage, if any cylinder head is warped more than .006" longitudinally, .003" transversely, it should be replaced; resurfacing is not recommended.

Minor surface cracks in the valve port area of the cylinder head, especially between the intake and exhaust valve ports, are not a normal condition. These surface cracks may affect the function of the cylinder heads and they may require replacement for this condition. The use of magnaflux or dye check is recommended as cracks in the cylinder head that affect performance are not always readily visible to the naked eye, checking is necessary.

There is an indentation in the block and head surface where the sealing ring contacts both parts. While this appears to be quite deep, actual measurements have shown that the groove is only one or two thousands deep and does not affect sealing. There are gaskets available that are used with .030 inch oversize pistons. Use of these head gaskets will move the sealing bead outboard of the existing groove. These gaskets will be used in the various kits.

Another condition is one that is evident by looking at the gasket once it is located on the dowel pins on the block. The sealing bead is only slightly larger in diameter than the bore. The bead may extend into the chamfer at the top of the cylinder which results in an uneven crush of the wire and after a few miles will result in a leak.

To check for this lay the old gasket on the block. Look at each cylinder, the gasket should be concentric with the bore. It may help to pull the metal ring out of the gasket so the block is more readily visible.

Make sure that the bolt holes in the cylinder block are drilled and tapped deep enough. The head should be placed on the block without a head gasket. Then run a .005 feeler gauge around the edge of the head. There should be no clearance, this indicates that dowel pins are not holding the head off the block. Then by hand, screw each of the bolts in. The bolts should screw in far enough to contact the head. This will indicate that the holes are drilled deep enough.

The bolt threads should be wire brushed to clean them and then coated with a sealant lubricant. This should be on the threads and under the heads of the bolts. This is critical so that the friction on the bolt is reduced during installation. Do not put the oil in the bolt hole, an excessive amount of oil could cause a hydraulic lock and prevent the bolt from tightening up. Do not paint the head gasket with a sealant. Sealants will sometimes attack the RTV sealer which results in a leak.

N. DIESEL HEAD GASKET PRE-INSTALLATION INSPECTION

Check for the following contitions:

- See if dowel pins hold head off block.
- Dowel pins missing.
- Cylinder heads are not warped more than .006 inches longitudinally and .003" transversely.
- Pre-chamber + .002" inches from head.
- Damage in sealing ring area.
- Damage in seal area around water passage.
- Water passage seal surrounds all water passages.
- Chips in bolt holes.
- Bolt holes in cylinder block drilled and tapped deep enough.

Wire brush head bolts to clean threads.

Apply sealant to bolt threads and under head of bolt.

Follow torque sequence and installation torque procedure.

SECTION 5
BRAKES

A. WHAT IS HYDRO-BOOST?

Hydro-boost is a hydraulically operated power assist mechanism that is used to increase fluid pressure in the brake system while at the same time decreasing pedal effort. This unit does the same job as a vacuum booster and is connected in the brake system much the same way.

The major difference between the two is that the hydro-boost unit uses pressurized power steering fluid to obtain its assist power, the vacuum unit depends on manifold vacuum and atmospheric pressure for its assist power.

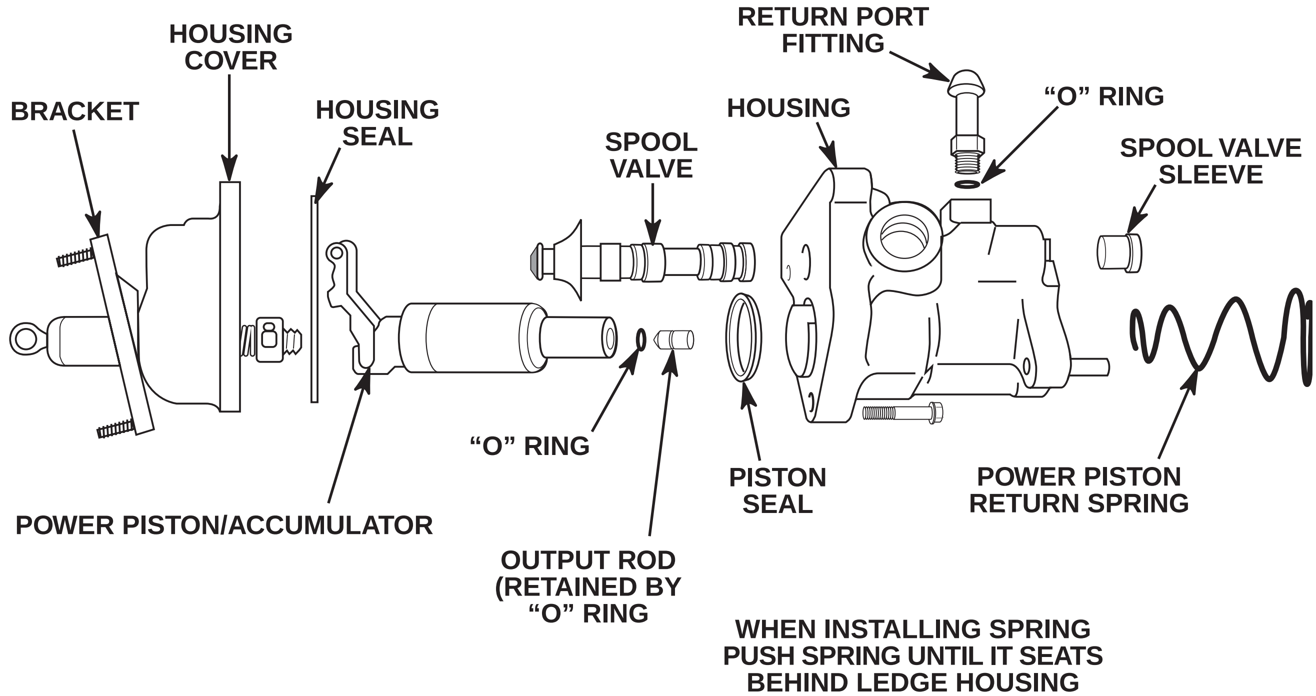
B. WHY HYDRO-BOOST?

If the hydro-boost does the same job as the vacuum booster, why change?

One reason why the hydro-boost unit is being used is that Federal regulations are requiring that vehicles stop in a fewer number of feet while at the same time using less pedal pressure to do it. This could be done with a larger vacuum unit but its great size would be a problem.

The unit's smaller size has made it easier to fit in the engine compartment and has eliminated the need for a remote or frame mounted booster previously used on some truck applications.

Another reason for Hydro-boost application is the lack of adequate vacuum produced in diesel and turbocharged engines. The reliance on the power steering pump for assist is independent of vacuum supply.



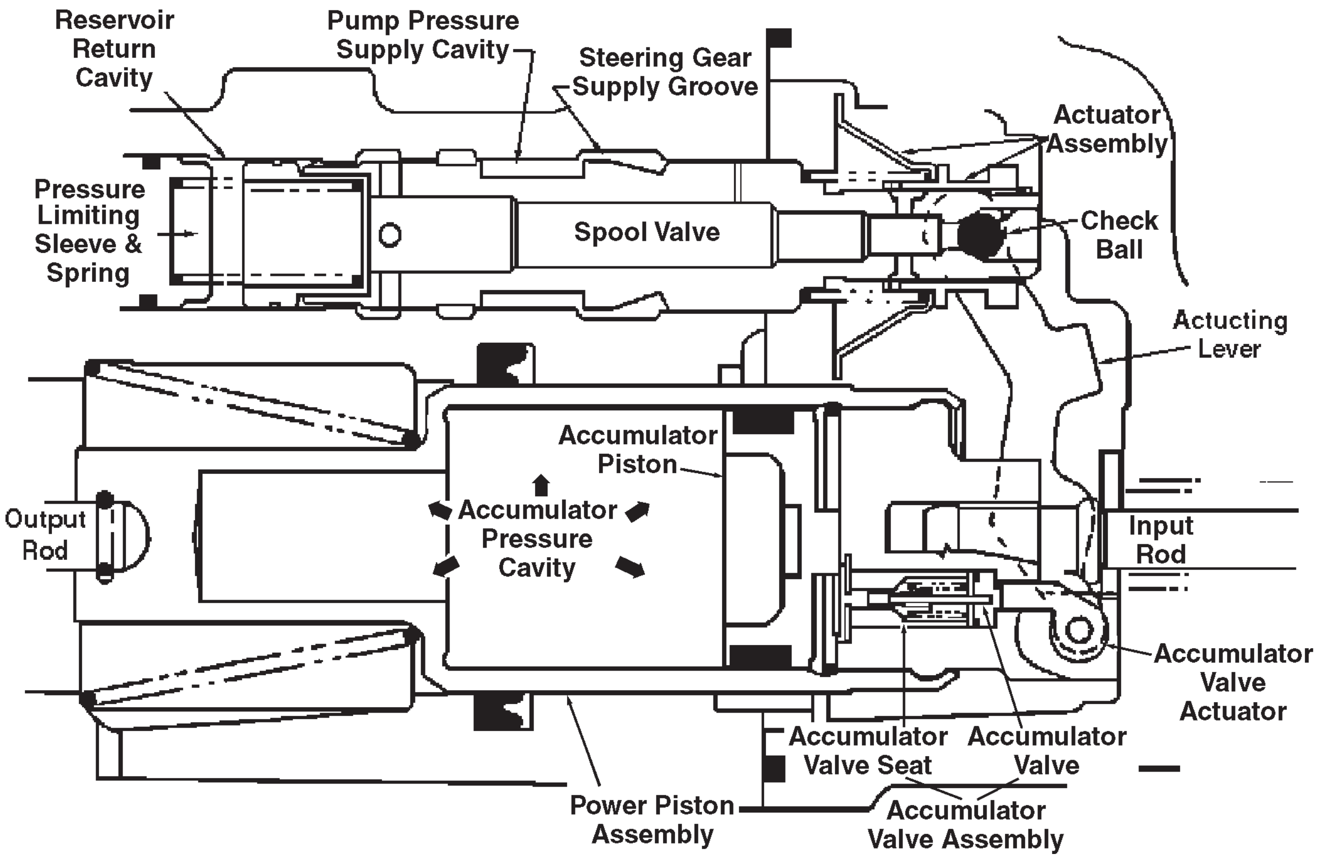


Figure 5-2. Cutaway.

C. HYDRO-BOOST II

Hydro-boost II is constructed much the same as Hydro-boost with an open center spool valve and hydraulic cylinder combined with a gas filled accumulator. The difference between Hydro-boost and Hydro-boost II is the location and size of the accumulator which makes the power unit itself smaller than previous designs.

Hydro-boost II has a reserve accumulator system which stores sufficient fluid under pressure to provide one power assisted brake application in the event normal oil pressure is lost.

Normal application of the brake system in Hydro-Boost II is as follows: With pressure from the steering pump entering and passing through the Hydro-boost housing, high pressure oil is always present for brake application . See figure 5-2.

Pushing on the brake pedal presses the input rod forward into the cavity at the cowl end of the accumulator/power piston.

The anchoring point at the bottom of the lever is spring-loaded against the power piston; it transfers the forward movement of the apply lever to the spool valve actuator sleeve. The actuator sleeve on the cowl end of the spool valve begins moving forward pushing against the spring which reacts against the spool valve moving it toward the apply position.

This uncovers the sealing land allowing high pressure oil to pass through the interior of the spool valve exiting at the rear past the check ball.

The movement of the spool valve first closes the reservoir port, then opens the pump port to allow pressurized fluid into the power cavity. This pressurizes the power section and forces the power piston forward applying the brakes.

As the high pressure oil enters the boost cavity, it presses on the rear of the power piston forcing the piston toward the engine compartment and applying pressure through the master cylinder to the brakes.

This movement of the spool valve also reduces the opening of the gear port. This restricts the flow of fluid to the gear, but at no time is the flow completely stopped.

By restricting the flow of the fluid the power steering pump increases the pressure in the hydraulic lines.

As pressure is applied to the power piston, high pressure oil enters between the bore end and the input rod, in effect moving the power piston farther and faster than the input rod. This provides pedal braking feel to the driver and requires less pedal travel to move the power piston.

Pressure is increased because the power steering pump is a constant displacement type.

With no restriction the pump will maintain a pressure of 100 to 150 PSI.

With full restriction the power steering pump will produce 1450 PSI; a relief valve limits the buildup to that pressure.

The pressure in Hydro-boost II is limited at 1100 PSI. A pressure limiting sleeve and spring are installed on the engine compartment end of the spool valve. Pressure limiting takes place as the actuator sleeve assembly compresses its spring which compresses the spring at the pressure limiting sleeve end and the spool valve travels into the bore. As oil pressure mounts, oil presses on the pressure limiting sleeve end opposing the direction of spool application. At 1100 PSI, the hydraulic pressure combined with limiter spring pressure will overcome movement of the spool valve and limit its travel. At this point, a controlled bleed situation exists limiting pressure.

The pressure limiting sleeve prevents the reservoir port from complete passage cut off. Pressure limiting sleeve is .006 in. larger than the spool valve opposing hydraulic area. Therefore, it has the hydraulic pressure advantage.

Note the undercut area and through passage in the spool between the steering gear supply groove and cowl end of the spool valve. This is a safety passage which supplies gear pressure in case the normal supply route becomes shut off.

D. TROUBLESHOOTING

The hydro-boost differs from vacuum brake boosters not only in the source of power (hydraulic versus vacuum) but in the fact that it is also a part of another major subsystem of the vehicle—the-power steering system. Therefore, problems or malfunctions in the steering system may affect the operation of the booster, just as a problem in the booster may affect the steering system. The following noises are associated with the Hydro-Boost system and may or may not be cause for customer complaint. Some are normal and for the most part temporary in nature. Others may be a sign of excessive wear or the presence of air in either the booster or the steering system.

1. Moan or low frequency hum usually accompanied by a vibration in the pedal and/or steering column may be observed during parking maneuvers or other very low speed maneuvers. This may be caused by a low fluid level in the power steering pump or by air in the power steering fluid due to holding the pump at relief pressure (steering wheel held all the way in one direction) for an excessive amount of time (more than 5 seconds). Check the fluid level and fill to mark. System must sit for I hour with the cap removed to remove the air. If the condition persists this may be a sign of excessive pump wear and the pump should be checked following the shop manual procedure.

2. At or near power runout (brake pedal near fully depressed position), a high speed fluid noise (faucet type) may be heard. This is a normal condition and will not be heard except in emergency braking conditions.

3. Whenever the accumulator pressure is used, a slight hiss may be noticed. It is the sound of the hydraulic fluid escaping through the accumulator valve, and is completely normal.

4. After the accumulator has been emptied, and the engine is started again, another hissing sound may be heard during the first brake application or the first steering maneuver. This is caused by the fluid rushing through the accumulator charging orifice. It is normal and will only be heard once after the accumulator is emptied. However, if this sound continues, even though no apparent accumulator pressure assist was made, it could be an indication that the accumulator is not holding pressure and should be checked using the procedure for Accumulator Leakdown Test.

5. After bleeding, a "gulping" sound may be present during brake applications as noted in the bleeding instructions in the service manual.

Prior to performing the booster function tests, or the accumulator leakdown test, the following preliminary checks must be made.

1. Check all power steering and brake lines and connections for leaks and/or restrictions.

2. Check and fill brake master cylinder with brake fluid. CAUTION: *Power steering fluid and brake fluid cannot be mixed. If brake seals contact steering fluid or steering seals contact brake fluid, seal damage will result.*

3. Check and fill power steering pump reservoir with power steering fluid. Insure fluid is not aerated (air mixed with fluid).

4. Check power steering pump belt for tension and/or damage. Adjust if necessary.

5. Check engine idle speed and adjust if necessary.

6. Check steering pump pressure.

CONDITION	CAUSE	CORRECTION
Excessive Brake Pedal Effort	Loose or broken power steering pump belt.	Tighten or replace the belt.
	No fluid in power steering reservoir.	Fill reservoir and check for external leaks.
	Leaks in Hydro-Boost 11.	Replace faulty pans.
	Leaks in Hydro Boost 11.	Tighten fittings or replace O" ring seal.
	Faulty booster piston seal causing leakage at booster flange vent	Overhaul with new seal or power piston/ accumulator
	Faulty booster input rod seal with leakage at input rod end.	Overhaul with input assembly kit.
	Faulty booster cover seal with leakage between housing and cover.	Overhaul with new seal kit.
	Faulty booster spool plug seal	Overhaul with spool plug seal kit.
Slow Brake Pedal Return	Excessive seal friction in booster.	Overhaul with new seal kit.
	Faulty spool action.	Disassemble and clean steering system and Hydro-Boost II.
	Restriction in return line from booster to pump reservoir.	Replace line.
	Damaged input rod end.	Overhaul with input assembly kit.
Grabby Brakes	Faulty spool action caused by contamination in system.	Disassemble and clean steering system and Hydro-Boost II.
Booster Chatters Pedal Vibrates	Power steering pump belt slips.	Tighten belt.
	Low fluid level in power steering pump reservoir.	Fill reservoir and check for external belts
Accumulator Leak Down-System does not hold charge	Faulty spool operation caused by contamination in system.	Disassemble and clean steering system and Hydro-Boost II.
	Contamination in steering and Hydro-Boost 11 system.	Disassemble and clean steering system and Hydro-Boost II.
	Internal leakage in accumulator system.	Overhaul with power piston/ accumulator kit.

E. SEAL LEAKS

1. Input Rod Seal: A damaged seal will show up as a fluid leak onto the drip pan from the mounting bracket vent hole.

2. Power Piston Seal: Power piston seal damage will be noticed by fluid leaking out at the common master cylinder-brake booster vent and a possible reduction in power assist. The booster must be removed from the vehicle and disassembled. The piston should be checked for any scratches that may be the cause of the leak. If scratches are present, then the power piston must be replaced. If no excessive scratches are present, replace the appropriate seals.

3. Housing Seal: If the housing seal is damaged, fluid will leak out from between the two housings onto the drip pan. The booster must be removed from the vehicle and disassembled. Replace the housing and power piston seals.

4. Spool Valve Plug ‘’O” Ring Seal: Damage to this seal will be noticed by fluid leaking out past the plug The master cylinder should be disconnected from the booster. Insert a small punch into the hole in the front housing and remove the retaining ring from the bore. Some models do not have this hole in the front housing. On these units, use a small screwdriver to remove the retaining ring. Using pliers, withdraw the plug from the bore. Remove the “O” ring from the plug and replace with a new one. Clean any dirt or rust from the plug bore using fresh power steering fluid. Insure that no dirt or rust is introduced into the booster. Push the end plug back into the bore and secure with a new retaining ring

5. Accumulator Piston Seals. Plunger Seat Seal Ring& and Check Valve Seal Ring: Any damage to these seals would cause internal leakage. This would cause the accumulator to leak down resulting in the loss of reserve stopping. Seals must be replaced with their assemblies.

6. Accumulator “O” Ring Seal: Damage to this seal will result in fluid leakage past the accumulator spring cap.

F. HYDRO-BOOST DIAGNOSIS

a. Booster Functional Tests

1. With the engine stopped; depress the brake pedal several times to eliminate all accumulator reserve from the system.

2. Hold the brake pedal depressed with medium pressure (25 to 35 Ibs.), start the engine. If the unit is operating correctly, the brake pedal will fall slightly and then push back against the driver’s foot, remaining at about the same position. If the booster is not operating correctly, the trouble may be one of the following causes.

No Boost Hard Pedal

CAUSE	CORRECTION
Loose or broken power steering pump belt.	Tighten or replace the belt.
No fluid in power steering reservoir.	Fill reservoir and check for external cracks.
Leaks in power steering, booster or accumulator hoses.	Replace defective parts.
Leaks at tube fittings, power steering, booster or accumulator connections.	Tighten fittings or replace tube seats, if defective.
External leakage at accumulator.	Replace accumulator (replace booster on integral units).
Faulty booster piston seal causing leakage at booster flange vent.	Replace all booster seals.
Faulty booster input rod seal with leakage at input rod end.	Replace all booster seals.
Faulty booster cover seal with leakage between housing and cover.	Replace all booster seals.
Faulty booster spool plug seal.	Replace all booster seals.
Internal leakage in booster.	Replace booster.
Contamination in power steering fluid.	Flush power steering system and replace with new fluid.
Hydraulic lines routed incorrectly.	Reroute lines.

Slow Brake Pedal Return

CAUSE	CORRECTION
Excessive seal friction in booster.	Replace all booster seals.
Faulty spool action.	Clean spool and replace all booster seals.
Broken piston return spring.	Replace spring.
Restriction in return line from booster to pump reservoir.	Replace line.
Broken spool return spring.	Replace spring.
Excessive pedal pivot friction.	Lubricate pivot bushings with Delco Brake Lube #S450032 (or equivalent) or replace bushings.

Grabby Brakes

CAUSE	CORRECTION
Broken spool return spring.	Replace spring.
Faulty spool action caused by contamination in system.	Inspect, clean and replace all booster seals.
No cargo body on chassis.	Normal condition.

Booster Chatter —Pedal Vibrates

CAUSE	CORRECTION
Power steering pump belt slips.	Tighten belt.
Low fluid level in power steering *pump* reservoir.	Fill reservoir and check for external leaks.
Faulty spool operation caused by contamination in system.	Inspect, clean and replace all booster seals.
Excessive contamination in power steering fluid.	Flush power steering fluid from system and replace with new power steering fluid.
Air in power steering fluid.	Allow vehicle to stand for approximately one hour; then bleed power steering hydraulic system as described in the appropriate service manual.
External leakage at accumulator welds.	Replace accumulator (entire booster assembly on integral units).
External leakage at accumulator fittings.	Tighten or replace fittings, as necessary.
Internal leakage in accumulator (past piston seal or relief valve).	Perform accumulator leakage test as described on following page (except on integral unit—replace booster).
Internal leakage at booster accumulator valve (if accumulator is not leaking externally or internally).	Replace all booster seals ant accumulator valves.

Power Steering Pump Noise on Brake Apply

CAUSE	CORRECTION
Insufficient fluid in pump reservoir.	Fluid level decreases approximately K" on brake apply — refill to proper level. If fluid is foamy, let vehicle stand for approximately one hour; then bleed power steering hydraulic system as outlined in the service manual.

Brake Pedal Pulls Down Slightly on engine Start

CAUSE	CORRECTION
Restriction in gear or booster return lines.	Replace lines or reposition lines to eliminate restriction.
	Accumulator Leakdown—System Does Not Hold Charge

b. Leakdown Test

1. Start engine and turn the steering wheel until the wheels contact the wheel stops lightly. Hold for a maximum of five seconds. Then release the steering wheel and turn off the engine.

2. Depress and release the brake pedal. There should be a minimum of three power assisted brake applications before a hard pedal is obtained.

3. Restart the engine and turn the steering wheel until the wheels contact the wheel stops lightly. There should be a light hissing sound as the accumulator is charged. Hold steering wheel lightly against stop for a maximum of five seconds. Then release the steering wheel, and turn off the engine.

4. Wait one hour and apply brake pedal (do not restart the engine). There should still be a minimum of three power assisted brake applications before obtaining a hard pedal;

5. If either of these preliminary checks shows that the accumulator is not holding its charge, the trouble may be one of the following causes.

G. PARKING BRAKE LIGHT SWITCH TEST (Figure 5-3)

Disconnect leads 67C and 67E from parking brake switch. Using multimeter, check for continuity between each terminal on parking brake switch with parking brake engaged. If continuity is not present, replace parking brake switch. Reconnect leads 67C and 67E.

Disconnect lead 67D from parking brake warning lamp. Using multimeter check for continuity between lead 67D and ground with parking brake engaged. If continuity is not present, repair body wiring harness.

Disconnect lead 27L from parking brake warning lamp. Using multimeter, check for battery voltage at lead 27L with rotary switch in “RUN”. If battery voltage is present, replace brake warning lamp. If battery voltage is not present, repair body wiring harness.

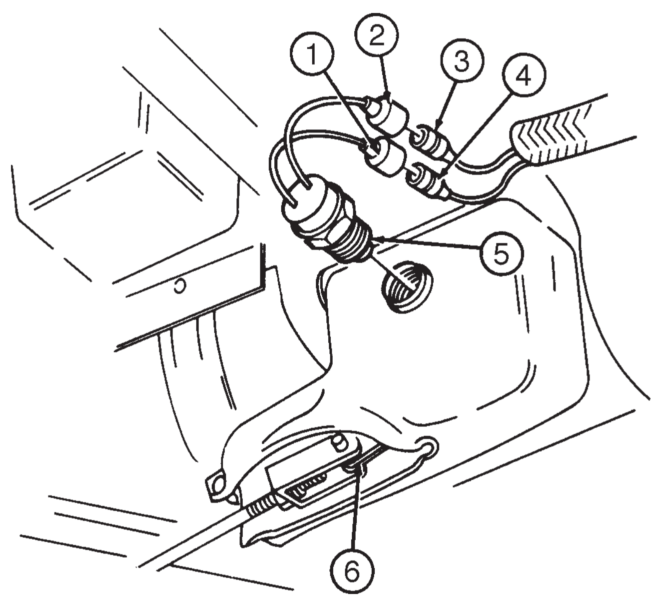


Figure 5-3. Parking Brake Switch.

H. BLEEDING THE HYDRO-BOOST SYSTEM

Whenever the booster is removed and installed, the steering system should be bled.

NOTE

The power steering fluid and brake fluid cannot be mixed. If the brake seals contact steering fluid or the steering seals contact brake fluid, seal damage will result.

1. Fill the power steering pump reservoir to the proper level and let the fluid remain undisturbed for at least two minutes.
2. Start the engine and run momentarily. Add fluid it necessary.
3. Repeat steps 1 and 2 until the fluid level remains constant after running the engine.
4. Raise the front of the vehicle so the wheels are off the ground. Support the vehicle with suitable safety stands.
5. Turn the wheels from stop to stop light contacting the stops. Add fluid if necessary.
6. Lower the vehicle.
7. Start the engine and depress the brake pedal several times while rotating the steering wheel from stop to stop.
8. Turn the engine off and pump the brake pedal 4 to 5 times.
9. Check brake fluid level. Add fluid if necessary.
10. If the fluid is extremely foamy allow the vehicle to stand a few minutes with the engine on. Then repeat steps 7, 8 and 9.
11. Check for the presence of air in the oil. Air in the oil will give the fluid a milky appearance. Air in the system will also cause the fluid level in the pump to rise when the engine is turned off.

I. BRAKE FLUID

Silicone brake fluid (BFS) in your vehicle should be purple. Sometimes, though, the dye that gives it the purple color breaks down, and the fluid in the master cylinder becomes brown or amber.

There's no cause for alarm if the color changes. The dye does not affect the performance of the brake fluid.

If the fluid is not purple however, you can't tell what kind of fluid is in your brake system. You might have a vehicle with the older HB brake fluid, and you shouldn't mix the brake fluids. Here are two ways to tell what kind of brake fluid you have:

1. Mix a few tablespoons of the unknown fluid with a little BFS.
2. If the two mix, it's BFS. If the two fluids separate into layers, the unknown fluid is HB, and the vehicle brake fluid needs to be changed.
3. Put some of the unknown fluid in a jar with a little water and shake it. BFS does not mix with water, and distinct layers **will** be visible. Water mixes with HB, on the other hand, and will remain mixed. Separate layers **will not** be visible.

SECTION 6
TRANSMISSION

A. MODULATOR MAINTENANCE AND ADJUSTMENT (Figure 6-1 and 6-2))

Removal:

WARNING

Allow transmission to cool before performing this task. Failure to do this may cause injury.

1. Pull off cable clip from modulator control rod head.
2. Loosen mounting nuts and securing modulator cable to cable bracket and remove cable and washer from bracket .
3. Underneath vehicle, remove capscrew and modulator retaining clip from transmission.

NOTE

Have drainage container ready to catch fluid.

4. Remove modulator and “O” ring seal from transmission. Discard “O” ring seal.
5. Adjust to 1-1/2" (3.18 cm) maximum travel from idle to wide open throttle.
6. Tighten mounting nuts and and recheck alignment. Readjust if alignment has changed.
7. Pull modulator cable core outward and connect cable clip to modulator control rod head.
8. Check modulator cable for ease and smoothness of operation and ensure cable returns to the idle position.

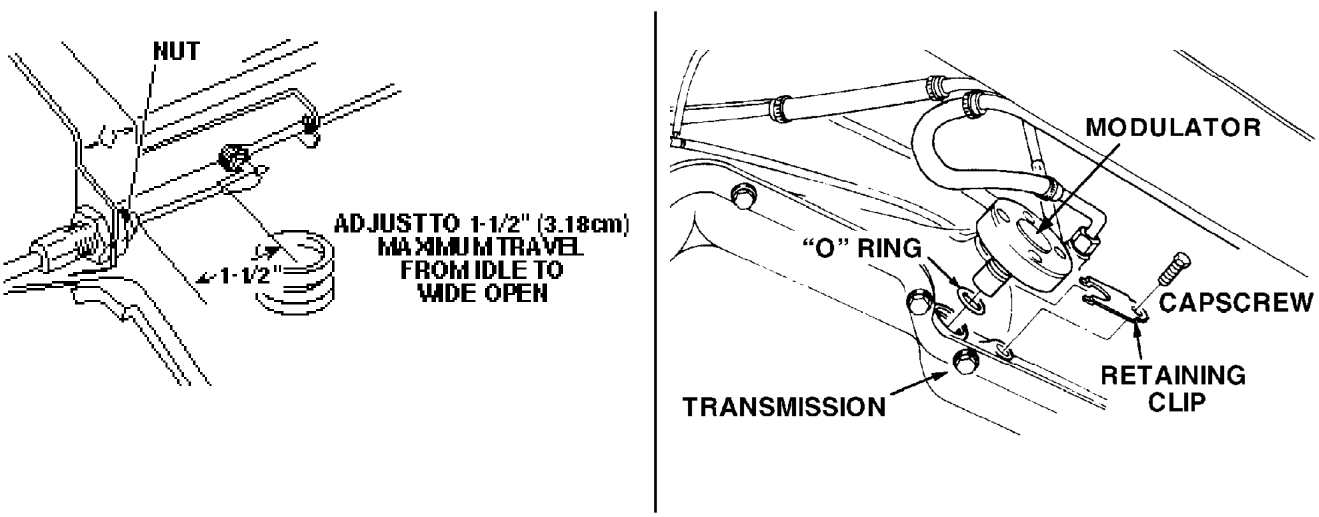


Figure 6.3. Modulator Maintenance and Adjustment.

9. Remove modulator cable at transmission and measure depth of cable pinch pin. Depth must be 0.590-0.600 inch (14.98-15.24 mm). Replace modulator if pin depth is not within specifications.

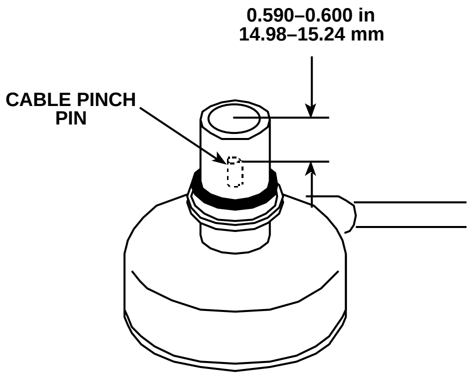


Figure 6-2. Moudlator Pinch Pin Depth.

10. Check modulator valve for damage and freedom of movement in its bore. Replace modulator valve if damaged.

11. Check transmission case for damage or porosity at modulator valve. Replace transmission case if damaged or porous.

B. TRANSMISSION OIL PRESSURE TESTS (Figures 6-6 and 6-7)

Oil Pressure Diagnostic Test

1. Remove pipe plug (3) from line pressure port (2) on left side of transmission (1).

2. Connect oil pressure gage to line pressure port (2).

WARNING

Direct all personnel to stand clear of vehicle before starting engine. Transmissions slipping into gear may cause injury.

3. Start engine and check for leaks at connections.

4. Bring engine to operating temperature. Check and adjust modulator cable if needed.

5. Place transmission shift lever in “N” (neutral) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 55-70 psi (379-483 kPa).

CAUTION

Total running time for next five tests should not exceed two minutes.

6. Apply service brakes and place transmission shift lever in “D” (drive), and allow engine to idle, note pressure reading. Pressure should be 60-85 psi (414-586 kPa).

7. Apply service brakes and place transmission shift lever in “D” (drive) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 60-90 psi (414-621 kPa).

8. Apply service brakes and place transmission shift lever in “2” (low 2) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 135-160 psi (931-1103 kPa).

9. Apply service brakes and place transmission shift lever in “1” (low 1) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 135-160 psi (931-1103 kPa).

10. Apply service brakes and place transmission shift lever in “R” (reverse) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 95-100 psi (655-1034 kPa).

11. Activate kickdown switch manually or through the use of an electrical jumper lead. Apply service brakes and place transmission shift lever in “D” (drive) and operate engine at 1,000 RPM, note pressure reading. Pressure should be 90-110 psi (621-758 kPa).

NOTE

Next pressure test must be performed during a road test or with vehicle raised and tires off the ground. Pressure must be recorded at RPM specified with closed throttle.

12. Place transmission shift lever in “D” (drive) and take foot off brake. Operate engine at 2,000 RPM, close throttle (foot off accelerator) and take pressure reading when engine RPM is between 2,000-1,200. Pressure should be 55-70 psi (379-483 kPa).

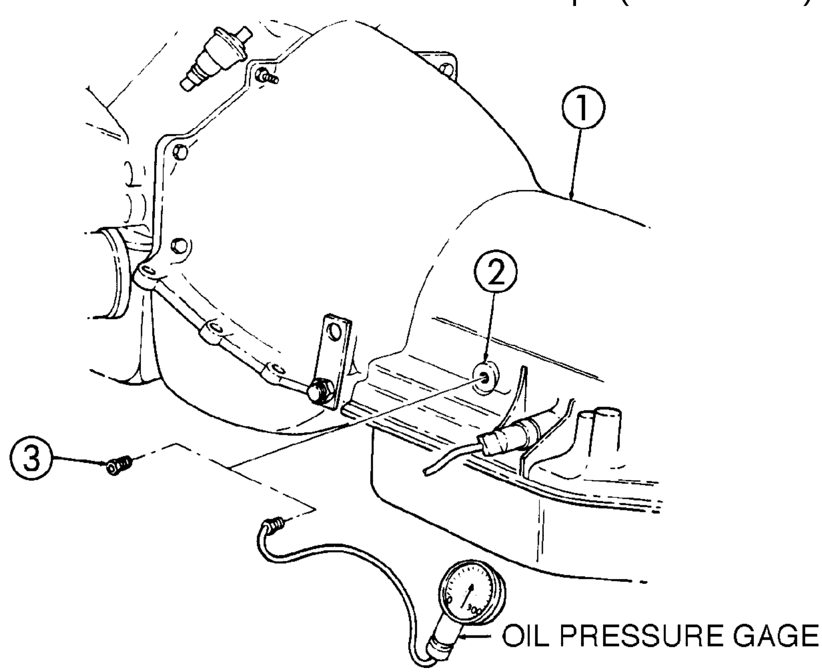


Figure 6-6. Transmission Oil Pressure Test Hook-up.

Compare oil pressure test results to information in Table 1.

TABLE 6-1

NOTE

Make sure that the modulator cable is properly adjusted. An improperly adjusted cable will give false pressure readings.

	TEST CONDITIONS 1	2	3	4	5	6	7	8	
	Neutral 1000 RPM	Drive Idle RPM	Drive 1000 RPM	Low 2 1000 RPM	Low 1 1000 RPM	Reverse 1000 RPM	Drive 1000 RPM Kick-Down Switch Activated	Road Test Only Drive * 2000 RPM Closed Throttle	Check Transmission For Malfunctions In:
Normal Pressure	55-70	60-85	60-90	135-160	135-160	95-150	90-110	55-70	
Test Results	Normal	High	High	Normal	Normal	Normal	Normal	High	Detent System
	High	High	High	Normal	Normal	High	**	**	Modulator System
	Normal	Normal	Normal	Normal	Normal	Low	Normal	Normal	Direct Clutch Oil Feed
	Normal	Low To Normal	Low To Normal	Low To Normal	Low To Normal	Normal	Low To Normal	Low To Normal	Forward Clutch Oil
	Normal	Normal	Normal	Normal	Normal	Normal	Low	Normal	Feed Detent System

* Modulator cable and linkage held in full throttle position.
** Oil pressure not important under test conditions indicated.

Table 1. Oil Pressure Diagnosis.

13. Remove oil pressure gage from transmission (1) and install pipe plug (3) in line pressure port (2).

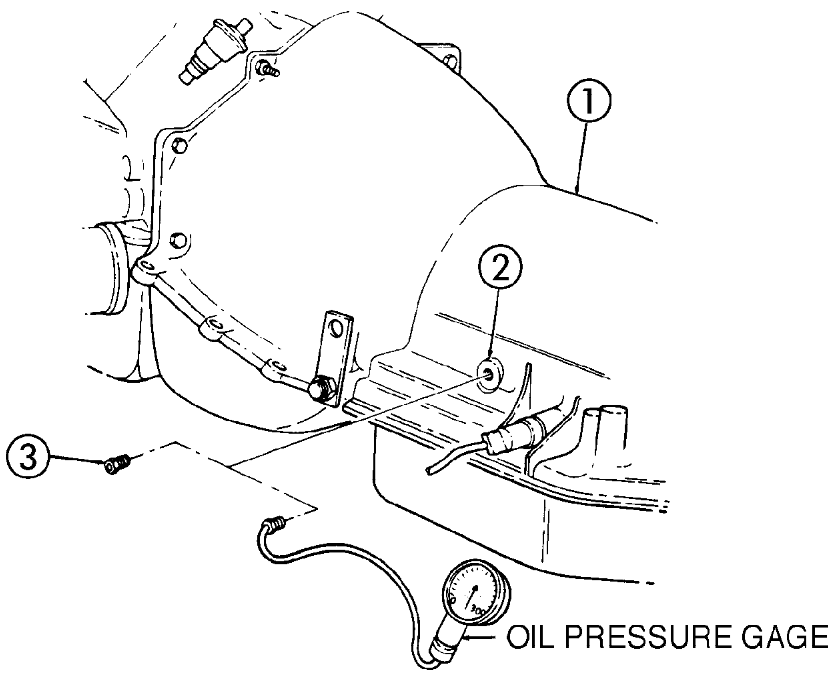


Figure 6-7. Transmission Oil Pressure Gage Removal.

C. TRANSMISSION CONTROL VALVE AND GOVERNOR PRESSURE TEST (Figure 6-7)

Control Valve and Governor Line Pressure Test

1. Remove pipe plug (3) from line pressure port (2) on left side of transmission (1).

2. Connect oil pressure gage to line pressure port (2).

WARNING

Direct all personnel to stand clear of vehicle before starting engine. Transmission slipping into gear may cause injury.

NOTE

This test must be performed with vehicle raised and tires off the ground.

3. Start engine and check for leaks at connections.

4. Bring engine to operating temperature.

5. Hold modulator linkage in the full extended position during testing.

6. Apply service brakes, place transmission shift lever in “D” (drive) and take foot off brake. Operate engine at 1,000 RPM and note pressure reading.

7. Slowly increase engine speed to 3,000 RPM and determine if line pressure drops below the reading recorded in step 6.

8. If line pressure drops more than 10 psi (69 kPa) remove control valve and inspect for damage. Replace control valve if damaged.

9. If line pressure drops less than 10 psi (69 kPa):

   a. Remove governor and inspect for damage, replace governor if damaged.

   b. Check governor pipes, screen, and transmission case for obstructions to fluid flow. Replace damaged components.

10. Remove oil pressure gage from transmission (1) and install pipe plug (3) in line pressure port (2).

D. TRANSMISSION ROAD TEST

1. Position transmission shift lever in “D” (drive) and accelerate vehicle from 0 m.p.h.. A 1-2 and 2-3 shift should occur at all throttle openings. Shift points will vary with throttle openings. Allow vehicle to decrease in speed to 0 m.p.h. and 3-2 and 2-1 shifts should occur.

2. Position transmission shift lever in “2” (low 2) and accelerate vehicle from 0 m.p.h.. A 1-2 shift should occur at all throttle openings (no 2-3 shift can be obtained in this range). The 1-2 shift in “2” (low 2) is somewhat firmer than in “D” (drive). This is normal.

3. Position transmission shift lever in “1” (low 1) and accelerate vehicle from 0 m.p.h.. No upshift should occur in this range.

4. Position transmission shift lever in “D” (drive) and with the vehicle speed at approximately 35 m.p.h., close throttle and move transmission shift lever to “2” (low 2). Transmission should downshift to 2nd gear. An increase in engine RPM and an engine braking effect should be noticed.

5. Position transmission shift lever in “2” (low 2) and with vehicle speed at approximately 25 m.p.h., close throttle and move transmission shift lever to “1” (low 1). Transmission should downshift to 1st gear. An increase in engine RPM and engine braking effect should be noticed.

6. Position transmission shift lever in “R” (reverse) and check for reverse operation.

E. TRANSMISSION DETENT SOLENOID RESISTANCE TEST (Figure 6-8)

Check for damaged detent solenoid. Using multimeter, test solenoid coil resistance. Resistance should be 60-70 ohms. Replace solenoid if damaged.

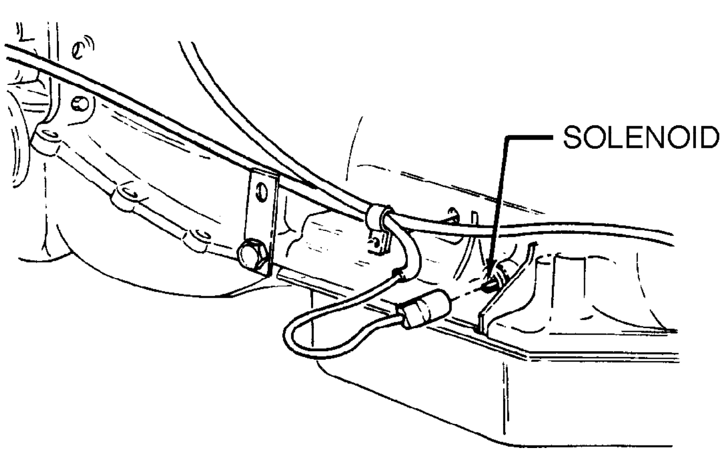


Figure 6-8. Transmission Detent Solenoid Resistance Test.

F. TRANSMISSION KICK-DOWN SWITCH TEST & ADJUSTMENT (Figure 6-9)

NOTE

Prior to removal, tag leads for installation.

a. Removal

1. Disconnect engine harness leads 315A (5) and 315B (4) from kick-down switch (3).
2. Remove two capscrews (1) securing switch (3) to fuel injection pump (2).
3. Remove switch (3) from injection pump (2).

b. Installation

1. Install kick-down switch (3) to injection pump (2), and secure with two capscrews (1).
2. Connect leads 315A (5) and 315B (4) to kick-down switch (3).

c. Adjustment

NOTE

Kick-down switch must be adjusted whenever it is replaced or, when injection pump is replaced.

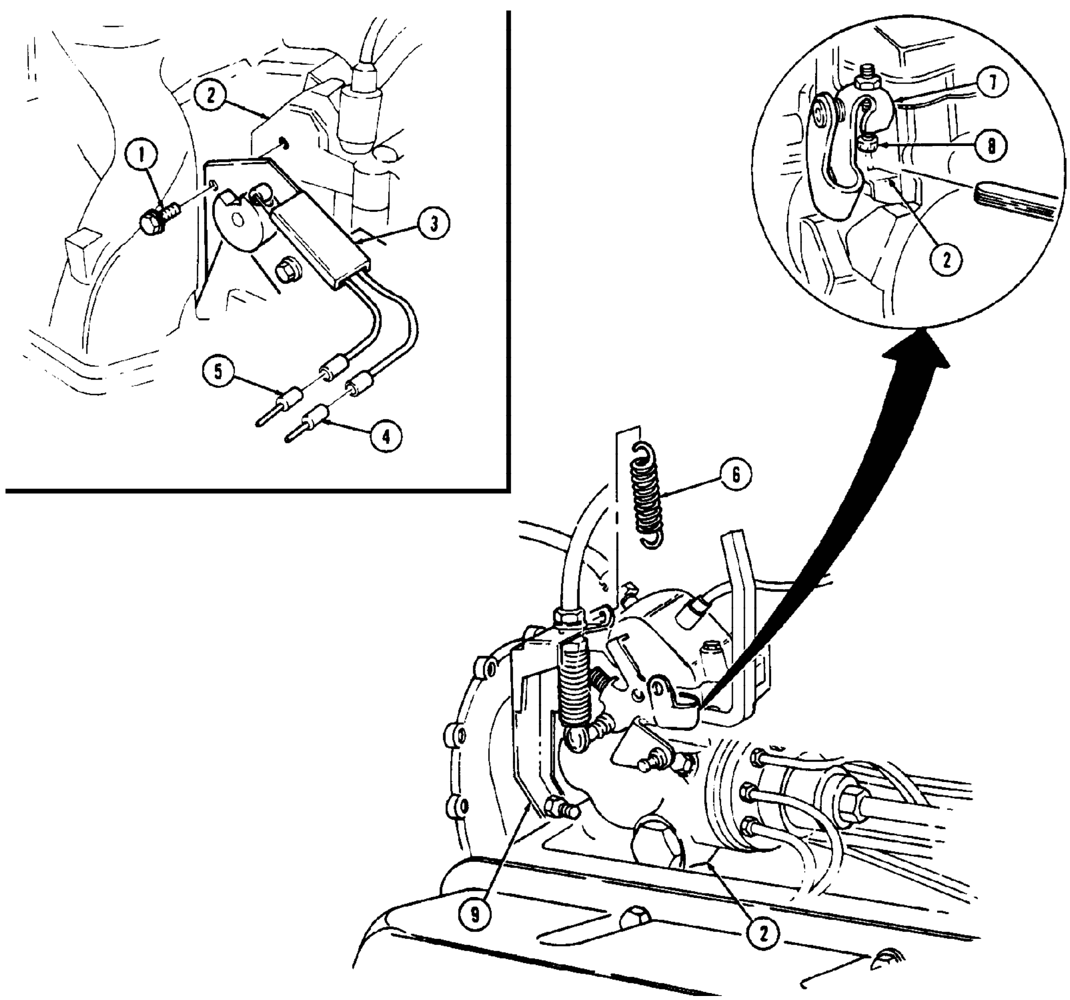


Figure 6-9. Kick-down Switch Adjustment.

1. Disconnect throttle return spring (6) from throttle shaft lever (7) and accelerator cable bracket (9).

2. Disconnect engine harness leads 315A (5) and 315B (4) from kick-down switch (3).

3. Connect multimeter to leads on kick-down switch (3) to read continuity.

4. Loosen two capscrews (1) to allow movement of kick-down switch (3).

5. Position feeler gage set at 0.295 inch (7.493 mm) between throttle shaft lever (7) and injection pump (2) ensuring feeler gage does not touch screw (8).

6. Move throttle shaft lever (7) to wide open position so throttle shaft lever (7) rests on feeler gage.

7. Rotate kick-down switch (3) slowly until multimeter reads continuity through kick-down switch (3) and tighten capscrews (1).

8. Position feeler gage set at 0.310 inch (7.874 mm) between throttle shaft lever (7) and injection pump (2) ensuring feeler gage does not touch screw (8).

9. Move throttle shaft lever (7) to wide open position so throttle shaft lever (7) rests on feeler gage. Note multimeter, no continuity should be present. If continuity is present, repeat steps 3 through 8.

10. Connect leads 315A (5) and 315B (4) to kick-down switch (3).

11. Connect throttle return spring (6) to accelerator cable bracket (9) and throttle shaft lever (7).

G. TRANSMISSION MALFUNCTIONS

NOTES

- **In the event of a major transmission malfunction involving the torque converter or oil pump, replace filter, flush oil cooler and lines before replenishing fluid.**
- **Perform the oil pressure tests and record the readings for use during troubleshooting.**
- **Perform a road test.**

Malfunction 1.
No 1-2 Upshift or Delayed Upshift

1. If oil pressure in “D” (drive) at 1000 RPM is normal, proceed to step 2. If oil pressure is high, proceed to step 3.

2. Check results of control valve and governor line pressure test.

3. If oil pressure in “N” (neutral) at 1000 RPM was normal, proceed to step 4. If oil pressure was high. Proceed to step 7.

4. Check for damaged detent solenoid. Using multimeter, test solenoid coil resistance. Resistance should be 60-70 ohms. Replace solenoid if damaged.

5. Check control valve spacer plate for obstructions. Clean or replace spacer plate.

6. Check detent valve train for stuck valves or incorrect assembly. Replace control valve if necessary.

7. Check modulator cable and linkage for damage or obstruction to movement. Cable core should move freely in its housing. Replace modulator or linkage if damaged.

8. Check adjustment of modulator cable. Adjust modulator cable.

END OF TESTING!

Malfunction 2.
1-2 Shift or Slips

1. Check transmission oil pressure response to varying throttle openings. Pressure should respond rapidly to quick changes in throttle opening. If oil pressure response is poor, proceed to step 2. If oil pressure response is normal, proceed to step 3.

2. Perform steps 7 through 10 of malfunction 1.

3. If oil pressure in “D” (drive) at 1000 RPM is low, proceed to step 4. If oil pressure is normal, proceed to step 10.

4. Check oil pump for obstructed oil passages or damage. Repair oil pump.

5. Check forward clutch seals for damage. Replace damaged seals.

6. Check center support oil seal rings for damage. Replace damaged seals.

7. Check rear servo piston and oil seal rings for damage. Repair rear servo if damaged.

8. Check front accumulator piston and oil seal rings for damage. Replace control valve if accumulator piston components are damaged.

9. Check transmission case for internal damage or porosity. Replace transmission if case is damaged or porous.

10. Inspect control valve for nicks on machined surfaces or voids in casting; check 1-2 accumulator valve train for stuck valves or incorrect assembly; check front accumulator piston and oil seal rings for damage. Replace control valve if any damage is found.

11. Check rear servo and rear accumulator pistons and oil seal rings for damage. Repair rear servo if damaged.

12. Check center support bolt for looseness. Tighten to 20-25 lb-ft (27-34 N•m).

13. Air check intermediate clutch piston for proper operation. If operation is normal, proceed to step 15.

14. Check intermediate clutch piston, plates, and release springs for damage or incorrect assembly. Repair intermediate clutch piston if damaged.

15. Check center support for missing orifice plug. Replace transmission if plug is missing.

END OF TESTING!

Malfunction 3.
1-2 Shift Firm or Rough

1. Perform steps 7 through 10 of malfunction 1.

2. If oil pressure in "D" (drive) at 1000 RPM is normal, proceed to step 3. If oil pressure is high, proceed to step 7.

3. Check 1-2 accumulator valve train for stuck valves or incorrect assembly. Replace control valve if any damage is found.

4. Check rear accumulator piston and oil seal rings for damage. Repair rear servo if damaged.

5. Check transmission case for restricted oil passages; damage, or porosity. Remove obstructions or replace transmission if case is damaged or porous.

6. Check for missing or incorrectly installed check balls. Replace missing check balls.

7. Check for damaged detent solenoid. Using multimeter, test solenoid coil resistance. Resistance should be 60-70 ohms. Replace solenoid if damaged.

8. Check control valve spacer plate for obstructions and damaged or misaligned gasket. Clean or replace spacer plate.

9. Check detent valve train for stuck valves or incorrect assembly. Replace control valve if damaged.

10. Check oil pump for obstructed oil passages or damage. Repair oil pump if damaged.

END OF TESTING!

Malfunction 4.
No 2-3 Upshift or Delayed Upshift

NOTE

If malfunction only occurs at or near full throttle, check engine timing for proper adjustment and check exhaust system for restrictions.

1. Perform steps 7 through 10 of malfunction 1.

2. Check control valve for a stuck 2-3 valve, and misaligned or damaged gaskets. Replace control valve if damaged.

3. Check direct clutch for damage or burned clutch plates. Repair direct clutch if damaged.

END OF TESTING!

Malfunction 5.
2-3 Shift Soft or Slips

1. If oil pressure in "D" (drive) at 1000 RPM is low, proceed to step 2. If oil pressure is normal, proceed to step 4.

2. Perform steps 7 through 10 of malfunction 1.

3. Perform steps 4 through 9 of malfunction 2.

4. Perform steps 8 and 9 of malfunction 3.

5. Check front servo for broken or missing spring and leak at servo pinch Repair front servo if damaged.

6. Air check direct clutch piston for proper operation. If piston exhibits excessive leakage, proceed to step 7. If operation is normal, proceed to step 8.

7. Check direct clutch piston, plates, and release springs for damage or incorrect assembly. Repair intermediate clutch if damaged.

8. Check transmission case passages for leaks. Replace transmission if case is damaged.

END OF TESTING!

Malfunction 6.
2-3 Shift Firm or Rough

1. If oil pressure in "D" (drive) at 1000 RPM is normal, proceed to step 2. If oil pressure is high, proceed to step 5.

2. Check front accumulator for damaged piston, rings, and broken or missing spring; check valve to accumulator feed for obstructions. Replace control valve if damaged.

3. Air check direct clutch piston for leak to outer area of clutch piston; check center piston seal for damage. Repair direct clutch if damaged.

4. Check center support and second oil ring for damage. Repair center support if damaged.

5. Perform steps 7 through 10 of malfunction 1. Step 6. Perform steps 7 through 10 of malfunction 3.

END OF TESTING!

Malfunction 7.
No Engine Braking - Second Gear

1. Check front servo piston for leaking oil rings and damaged piston. Replace damaged components.

2. Check front accumulator piston for leaking oil rings and damaged piston. Replace control valve if damaged.

3. Check front band for damage and proper installation. Replace front band if damaged.

END OF TESTING!

Malfunction 8.
No Engine Braking - First Gear

1. Check for missing or incorrectly installed check balls. Replace missing check balls.

2. Check transmission case for damage at check ball locations. Replace transmission if case is damaged.

3. Check rear servo for leaking oil seal rings and damaged piston. Repair rear servo if damaged.

4. Check rear band apply pin for proper length. Replace pin if length is not correct.

5. Check rear band for damage and proper installation. Replace rear band if damaged.

END OF TESTING!

Malfunction 9.
No Detent Downshifts

1. Check for damaged detent solenoid. Using multimeter, test solenoid coil resistance. Resistance should be 60-70 Ohms. Replace solenoid if damaged.

2. Check detent valve train for stuck valves and incorrect assembly. Replace control valve if necessary.

END OF TESTING!

Malfunction 10.
No Drive or Drive Slips

1. If oil pressure in “D” (drive) at 1000 RPM is low, proceed to step 2. If oil pressure is normal, proceed to step 4.

2. Perform steps 7 through 10 of malfunction 1.

3. Perform steps 4, 5, and 9 of malfunction 2.

4. Check forward clutch for damage and burned clutch plates. Repair forward clutch if damaged.

5. Check roller clutch for damage and proper installation. Replace roller clutch if damaged.

END OF TESTING!

Malfunction 11.
No Reverse or Reverse Slips

1. If oil pressure in “D” at 1000 RPM is low, proceed to step 2. If oil pressure is normal, proceed to step 4.

2. Perform steps 7 through 10 of malfunction 1.

3. Perform step 4 and steps 6 through 9 of malfunction 2.

4. Check control valve spacer plate for obstructions and misaligned gasket. Clean or replace spacer plate if necessary.

5. Check control valve for damaged or leaky passages and stuck valves or incorrect assembly. Replace control valve if damaged.

6. Check rear servo and accumulator piston for damaged oil seal rings, pistons, and band apply pinch Check for correct length band apply pinch Repair rear servo and accumulator if damaged.

7. Check center support and oil seal rings for damage and wear. Repair center support if damaged or worn.

8. Check direct clutch for damage and burned clutch plates. Repair direct clutch if damaged.

9. Check rear band for damage and proper installation. Replace band if damaged.

10. Check forward clutch for damage and binding (will not release). Repair forward clutch if damaged.

END OF TESTING!

Malfunction 12.
Vehicle Moves in Neutral

1. Check manual valve for damage and proper installation. Replace manual valve if damaged.

2. Check detent lever and pin for damage and proper installation. Replace lever or pin if damaged.

3. Check oil pump for leaking oil passages and damage. Repair oil pump if damaged.

4. Check forward clutch for damage and burned clutch plates. Repair forward clutch if damaged.

Malfunction 13.
Transmission Noisy

NOTE

Check engine accessory drive components; water pump, power steering pump, alternator, and air conditioner compressor (if installed) for the source of "noise" before checking transmission.

a. Noise in Neutral and All Driving Ranges

1. Check torque converter for loose mounting capscrews and damage. Tighten capscrews or replace torque converter if damaged.

2. Check flywheel for damage. Replace flywheel if damaged. Step 3. Check oil pump for obstructed oil passages, damage, and proper assembly. Repair oil pump if damaged.

b. Noise in First, Second, and Reverse.

1. Check gear unit thrust bearings and races for damage. Replace bearing(s) and races if either is damaged.

2. Inspect gears for damage and wear. Replace damaged or worn components. Step 3. Inspect front internal gear ring for damage. Replace gear ring if damaged.

c. Noise During Acceleration - Any Gear.

Check engine and transmission mounts for looseness or damage. Secure or replace mounts.

H. TORQUE CONVERTER END PLAY CHECK (Figure 6-11)

1. Screw upper and lower knurled knobs together. Be sure collet end is not expanded.

2. Insert J 35138 into the torque converter hub.

3. Slide tapered plug into torque converter hub. Plug is for alignment of tool.

4. Hold upper knurled knob and turn wing nut clockwise until hand tight to expand collet into converter turbine hub. Then loosen wing nut (counter clockwise) 2 turns, or until tool is loose (will move up and down) while not removable from converter.

5. Hold upper knurled knob and turn lower knurled knob clockwise until hand tight to clamp tool in the converter turbine hub.

6. Attach magnetic base (J 26900-13) to torque converter and set up dial indicator (J 8001) so that indicator tip is in center of tool wing nut.

7. To make end play check, push upper knurled knob down, zero out dial indicator and pull lower knurled knob up. Be sure tapered plug stays seated in converter hub. End play is the difference between up and down positions. DO NOT ALLOW WING NUT TO TURN WHEN MEASURING.

8. Remove tool by holding upper knurled knob and turning wing nut counter

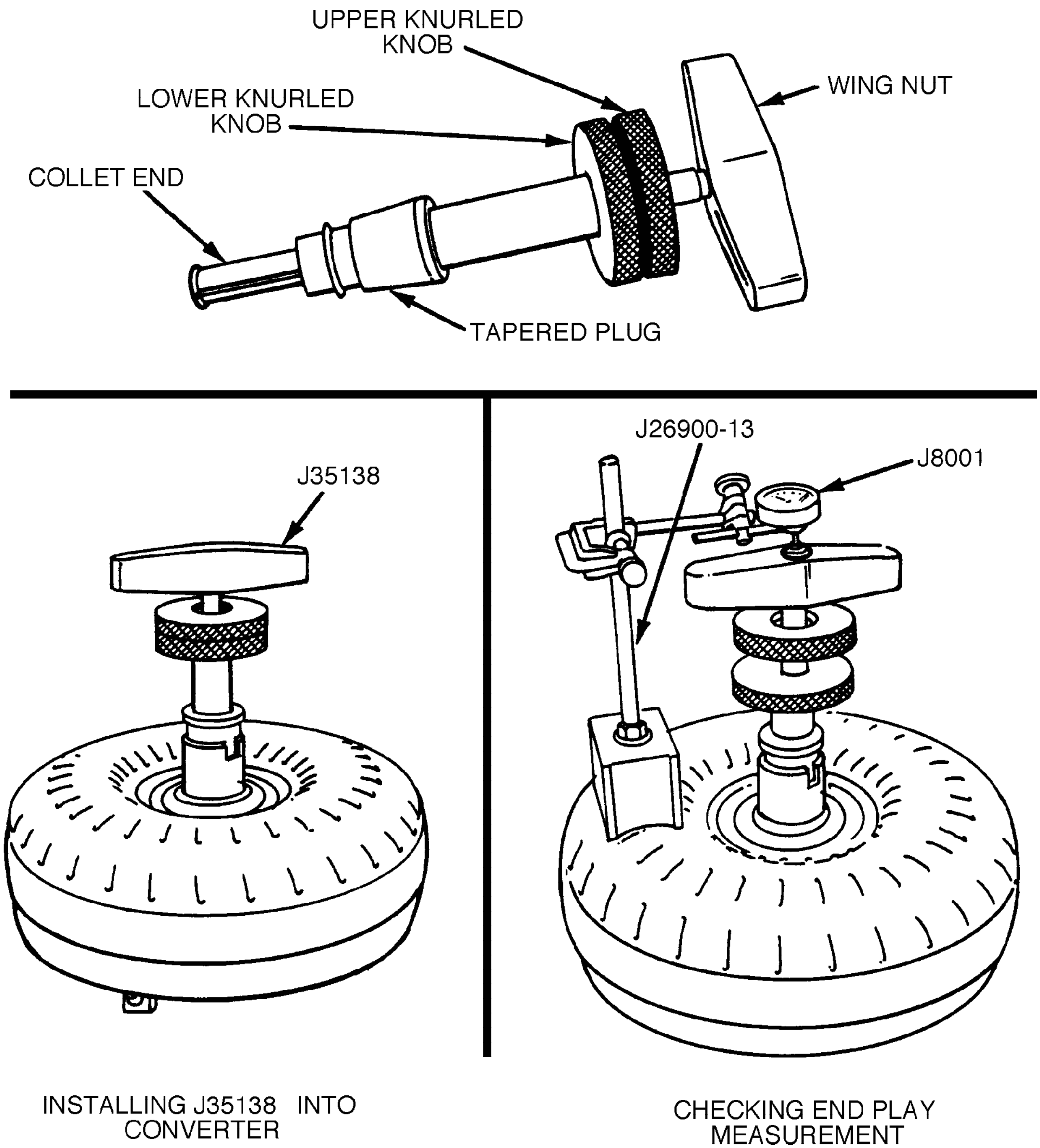


Figure 6-11.Torque Converter Checks.

Refer to the following chart for torque converter end play specifications. Torque converters that exceed the maximum end play specitfications ahould be replaced.

OPEN CONVERTER (NON-T.C.C.).	ALL SIZES	0-0.50" (0-1.30 MM)

I. TORQUE CONVERTER LEAK TEST (Figure 6-12)

WARNING

Wear protective goggles during this test to prevent accidental damage to eyes.

1. Select proper plug and insert into torque converter opening.
2. Install converter leak test fixture onto torque converter and tighten securely.
3. Apply 60 psi air pressure into the torque converter.
4. The torque converter passes the air test if there is no drop in pressure during a 60 second period.

WARNING

Release air pressure slowly to avoid spraying of oil from the leak tester.

5. Remove torque converter leak test fixture and plug.

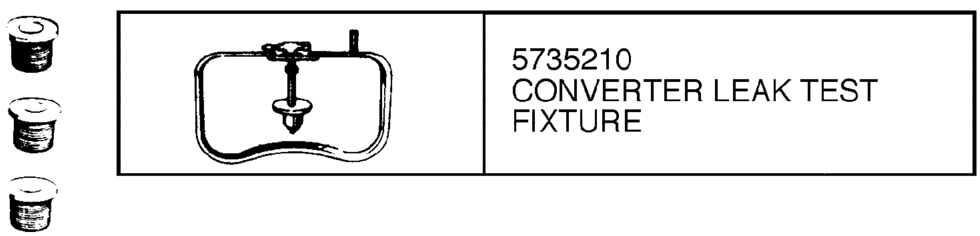


Figure 6-12. Converter Leak Tst Fixture.

SECTION 7
ALIGNMENT PROCEDURES

A. TOE-IN/FRONT WHEEL CHECK AND INSPECTION (Figures 7-1, 7-2, 7-3, 7,4 and 7-5)

NOTE

- **It is not necessary to perform front wheel toe-in alignment prior to the scheduled semiannual or 3,000 mile (4,827 km) maintenance interval unless abnormal vehicle handling or control is reported.**
- **Front wheel alignment adjustments other than toe-in are performed by DS maintenance.**
- **Vehicle must be at normal operating weight during toe-in check and/or adjustment to ensure proper alignment.**
- **Make sure models M1037 and M1042 have S250 shelter installed before performing front wheel toe-in alignment.**

a. Preliminary Inspection (Figure 7-1)

1. Check all tires (6) for uniform tread wear.
2. Raise vehicle and support under lower control arm (9).
3. Check geared hubs (4) for output spindle end play by grasping edges of tires (6) and attempting to move tires (6) up and down. Adjust spindle bearings if any spindle movement is apparent.
4. Check for looseness of upper ball joints (3) by grasping top of tires (6), and attempting to move tires (6) in and out. Replace upper ball joints (3) if tire (6) movement at top outer edge of tires (6) is 3/8 inch (9 mm) or more.

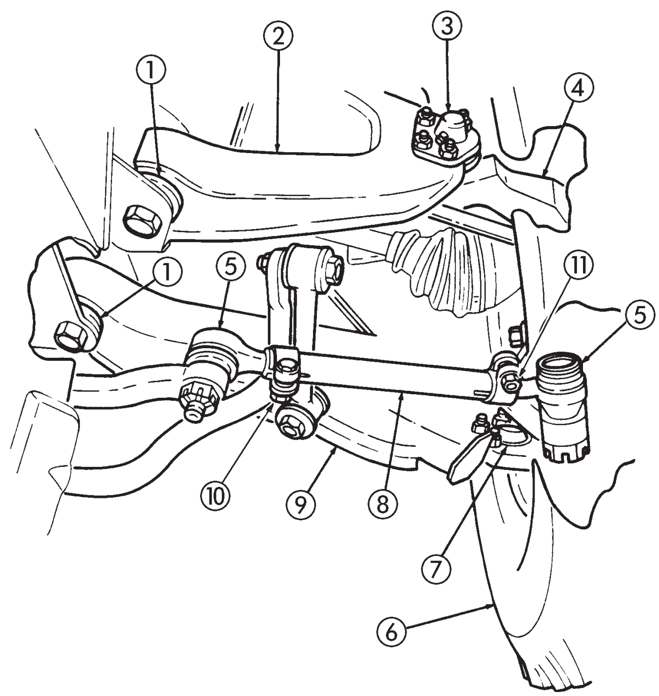


Figure 7-1.
Toe-in Front Wheel Check and Adjustment.

b. Ball Joint Inspection (Figure 7-2)

Check for looseness of lower ball joints. With lower control arms supported.

1. Inscribe a reference point on geared hub capscrew (1) parallel with lower control arm (2) to obtain an accurate measurement.
2. Position prybar between lower control arm (2) and geared hub (3).
3. Hold a 6 inch ruler between the lower control arm (2) and the capscrew (1) on geared hub (3).
4. Push down on the prybar to try and move the geared hub (3).
5. Measure any movement in geared hub assembly. If Movement is more than 1/8 inch (0.3175 cm), replace the lower ball joint(s).
6. If ball joint makes a squeaking noise, replace it.

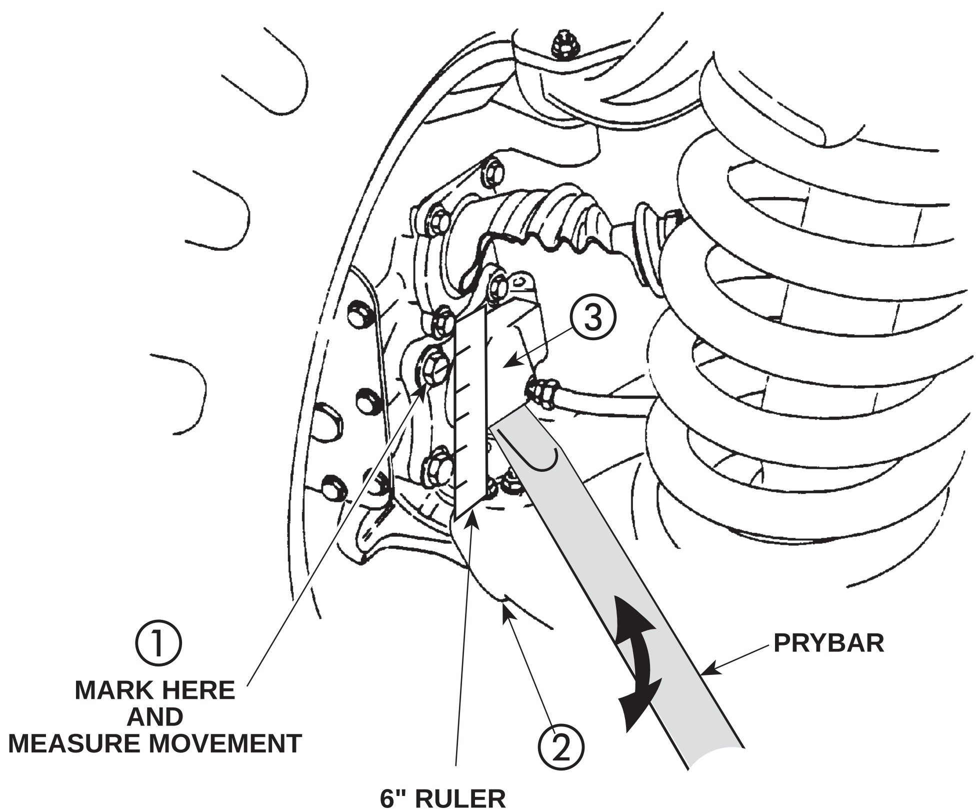


Figure 7-2. Lower Ball Joint Inspection.

c. Idler Arm Inspection (Figure 7-3, 7-4, and 7-5)

Perform an Idler arm inspection. Use the following procedure to determine idler arm free play. Measurements can be made using a spring scale dial indicator.

1. Park vehicle on a flat surface, and make sure parking brake is engaged.

2. Block rear wheels.

3. Raise front wheels off surface, and place supports under frame rails.

4. Set front wheels in a straight-ahead position.

5. Check idler arm for visible damage, such as breaks and cracks. If breaks or cracks are found, replace idler arm.

NOTE

Use a flat steel plate or scrap metal to perform step (f).

6. Secure steel plate or scrap metal (10) to front crossmember (2) with clamp (9) as shown in Figure 7-3.

7. Pull center link (1) in downward direction to seat ball and socket of idler arm (3) as shown in Figure 7-3.

8. Use flat surface (7) of center link (1) as a guide, mark reference line one (8) on steel plate or scrap metal (10) as shown in Figure 7-3.

9. Position spring scale (3) on center link (1) and pull in an upward direction to obtain 25 lb reading on spring scale (3) as shown in Figure 7-4.

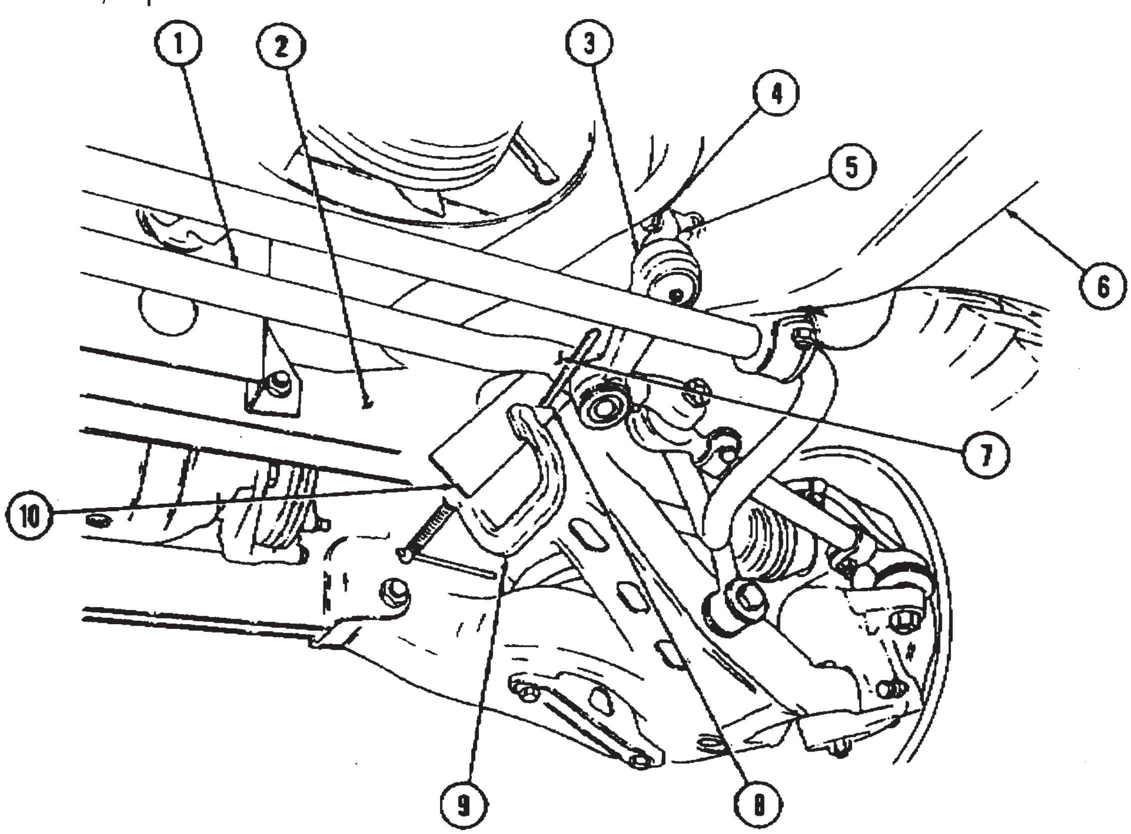


Figure 7-3. Idler Arm Inspection and Check.

NOTE

During marking of reference line two, maintain 25 lb reading on spring scale.

10. Use flat surface (4) of center link (1) as a guide, mark reference line two (5) on steel plate or scrap metal (7) as shown in figure 2. Remove spring scale (3) from center link (1).

11. Remove clamp (6) and steel plate or scrap metal (7) from front crossmember (2) as shown in Figure 7-4.

12. Measure distance between marked reference line one (3) and reference line two (2) on steel plate or scrap metal (1) as shown in Figure 7-5. If measurement exceeds 0.25 inch, replace idler arm.

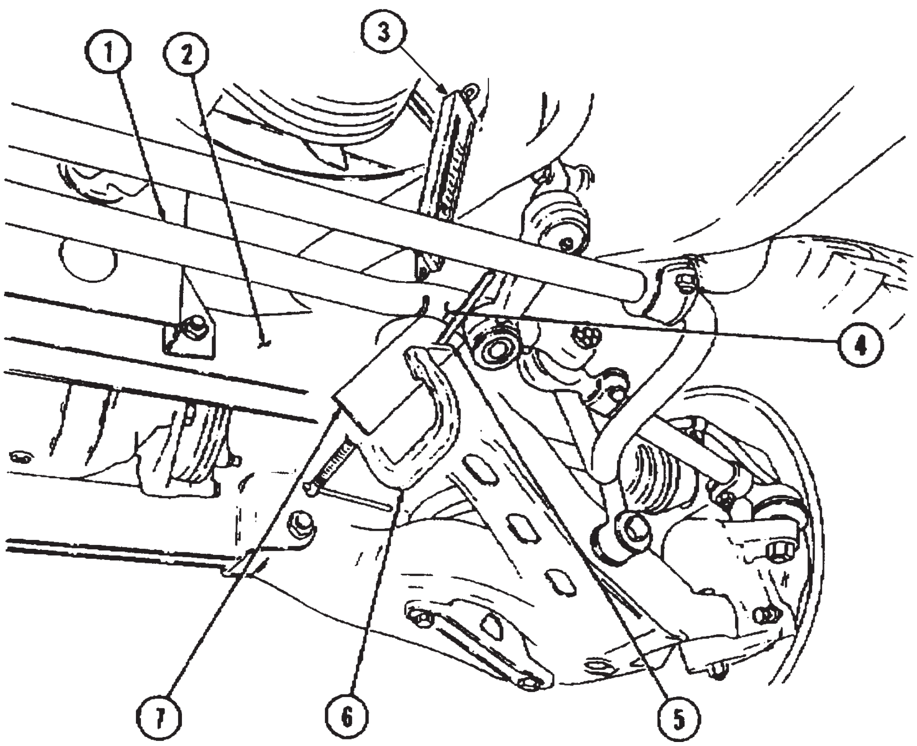


Figure 7-4.
Using a Spring Scale Dial Indicator to Check Idler Arm Free Play.

13. Remove supports from under frame rails.

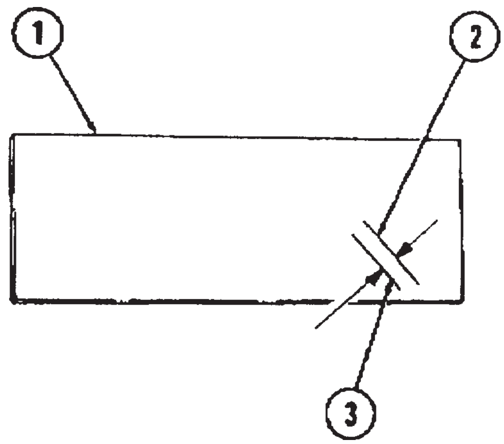


Figure 7-5.
Measuring Idler Arm Free Play.

14. Remove rear wheel blocks.

15. Check for looseness of tie rod ends (5) by attempting to move tie rods (8) vertically and horizontally. Replace tie rod end(s) (5) if any movement is apparent.

16. Check for damaged control arm bushings (1). Replace upper control arms (2) or lower control arms (9) if bushings (1) are damaged.

d. Toe-In Check

NOTE

- **Vehicle must be on level ground with wheels set straight ahead.**
- **Check and adjust tire pressure**
- **Steps 1 through 3 will determine centerline of tire.**
- **"Point of Measurement" for checking toe-in will be where lines marked in steps 1 and 3 intersect.**

1. Mark line (4) on center tread (1) of tire (2) 16 inch (42 cm) from ground.
2. Measure total width of tire tread (3) and record.
3. Mark line (5) on center tread (1) at one-half total tread width (3).
4. Repeat steps 1 through 3 for opposite tire.
5. Measure distance between "Points of Measurement" on front side of tires (2) and record.
6. Rotate tires (2) by moving vehicle forward until "Points of Measurement" are 16 inch (42 cm) above ground at rear side of tires (2).
7. Measure distance between "Points of Measurement" on rear side of tires (2) and record.

NOTE

- **If measurement is larger on front side of tires than measurement on rear side of tires, tires have toe-out.**
- **During vehicle operation, suspension system movement may cause slight alignment changes. For this reason, Table 7-1 provides an inspection specification that allows a larger toe-in tolerance during inspection. If, after inspection, the toe-in is outside inspection specifications, set toe-in to the adjustment specifications in Table 7-1.**
- **If toe-in alignment does not meet inspection specifications, repeat checking procedures to eliminate any possible reading errors.**

8. Subtract measurement from front side of tires (2) step 5, from measurement from rear side of tires (2) step 7. The result of this subtraction represents inches of toe-inch Refer to Table 7-1 for toe-in inspection specifications. If toe-in does not meet inspection specifications, adjust toe-in.

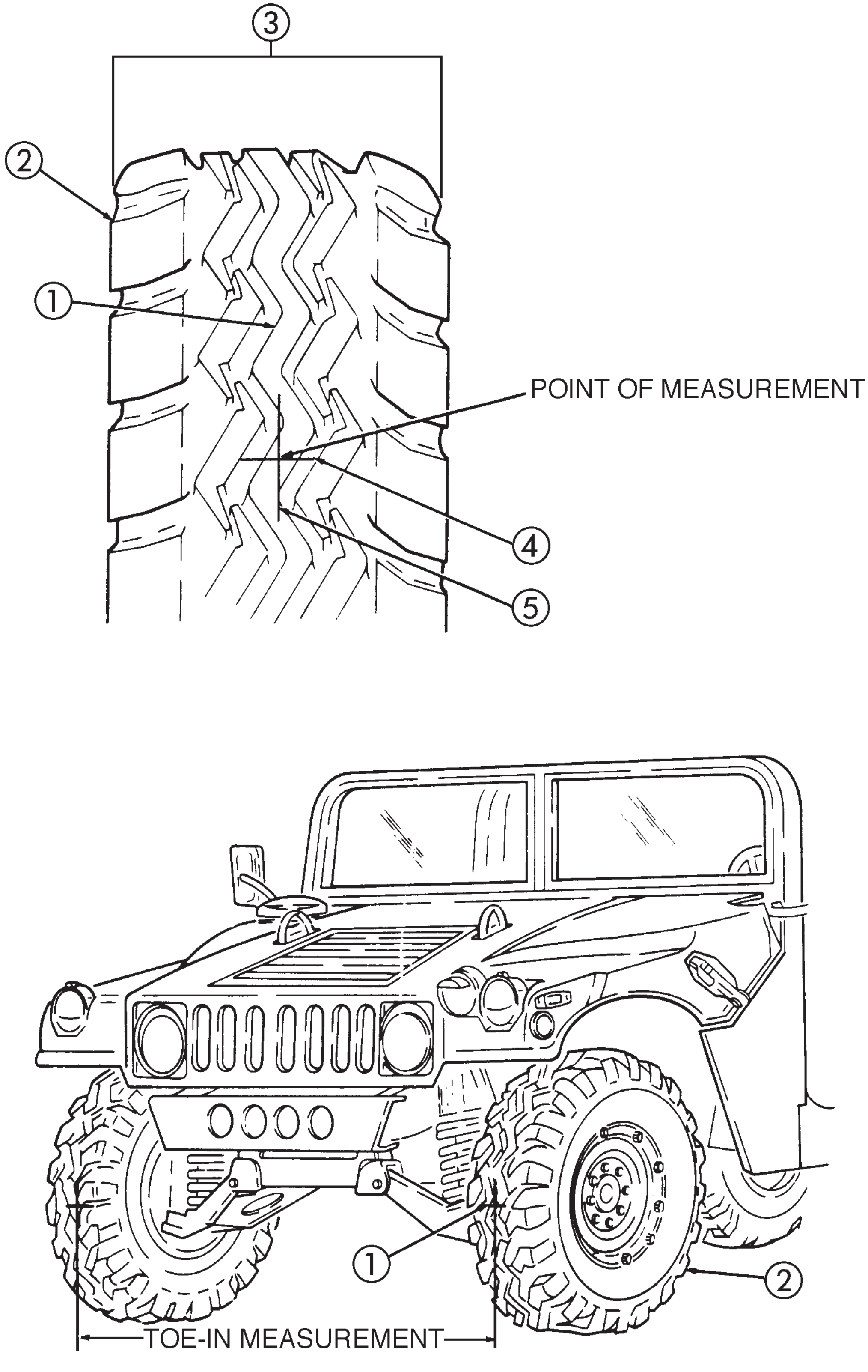


Figure 7-5. Toe-in Measurement Check.

NOTE

- Vehicles should be at curb weight to ensure proper alinement. Refer to Table 7-1(a.) for adjustment specifications.
- Table 7-1(b.) is optional and can be used when the vehicle's average operation is at less than gross vehicle weight. Vehicle is to be loaded to its average operating weight when using this table.

Table 7-1. Toe-In Alignment Specifications.

e. Toe-in Adjustment (Figure 7-6)

1. Loosen two locknuts securing two clamps on each adjusting sleeve.

NOTE

Toe-in can be increased or decreased by changing length of tie rods. A threaded sleeve is provided for this purpose. Both tie rods must be the same length 1/8 inch (3 mm) after adjustment.

2. Turn each adjusting sleeve (8) equally, but in opposite directions.

3. Roll vehicle rearward then forward to original position.

4. Repeat toe-in check and adjustment procedures until correct adjustment is indicated.

CAUTION

Ensure bolt and nut on adjusting sleeve clamp nearest to geared hub is facing halfshaft. Bolt and nut on adjusting sleeve clamp nearest to frame must be facing away (180°) from stabilizer bar, to prevent damage to equipment.

5. Secure two clamps (10) on each adjusting sleeve (8) with two locknuts (11). Tighten locknuts (11) to 30 lb-ft (40 N•m).

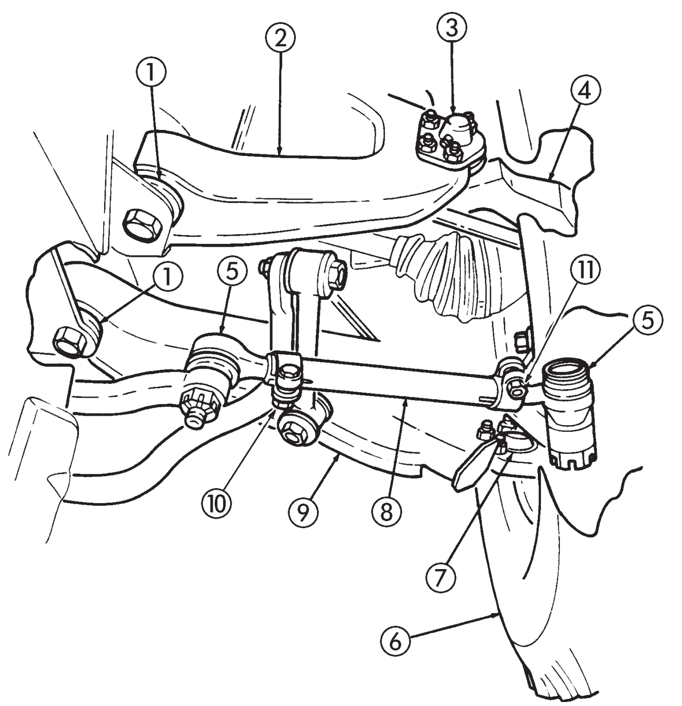


Figure 7-6. Toe-in/Front Wheel Check

B. TOE-OUT REAR WHEEL CHECK ADJUSTMENT (Figures 7-7, through 7-9)

NOTE

- **It is not necessary to perform rear wheel toe-out alignment prior to the scheduled semi-annual or 3,000 mile (4,827 km) maintenance interval unless abnormal vehicle handling or control is reported.**
- **Rear wheel alignment adjustments other than toe-out are performed by DS maintenance.**
- **Vehicle must be at normal operating weight during toe-out check and/or adjustment to ensure proper alignment.**
- **Make sure models M1037 and M1042 have S250 shelter installed before performing rear wheel toe-out alignment.**

a. Preliminary Inspection

1. Check all tires for uniform tread wear.
2. Raise vehicle and support under lower control arms (1).
3. Check geared hubs (2) for output spindle end play by grasping edges of tires and attempting to move tires up and down. Adjust spindle bearings if any spindle movement is apparent.
4. Check for looseness of upper ball joints (3) by grasping top of tires, and attempting to move tires in and out. Replace upper ball joints (3) if tire movement at top outer edge of tires is 3/8 inch (9 mm) or more.
5. Check for looseness of lower ball joints by grasping bottom of tires, and attempting to move tires in and out. Replace lower ball joints if tire movement at bottom outer edge of tires is 1/2 inch (13 mm) or more.
6. Lower vehicle.
7. Check for looseness of radius rod ends (4) by attempting to move adjusting sleeve (5) vertically and horizontally. Replace radius rod end(s) (4) if any movement is apparent.
8. Check for damaged control arm bushings. Replace upper control arms or lower control arms if bushings are damaged.

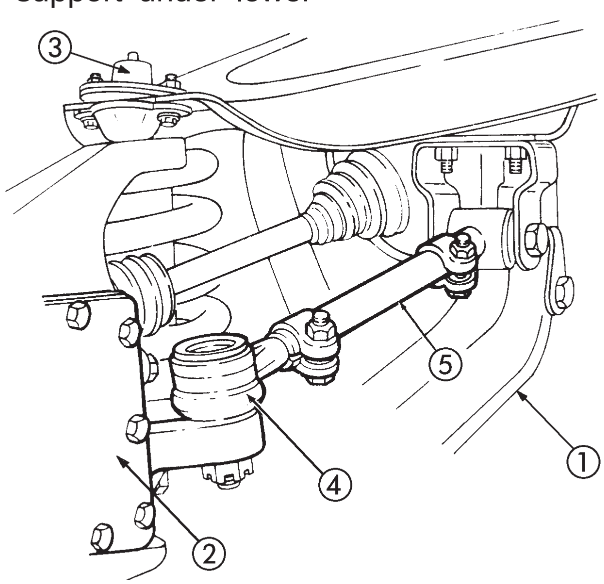


Figure 7-7. Toe-0ut Rear Wheel Check Adjustment.

b. Toe-Out Check

NOTE

- **Vehicle must be on level ground with wheels set straight ahead.**
- **Steps 1 through 3 will determine centerline of tire.**
- **"Point of Measurement" for checking toe-out will be where lines marked in steps 1 and 3 intersect.**

1. Mark line (4) on center tread (1) of tire (2) 16 inches (42 cm) from ground.
2. Measure total width of tire tread (3) and record.
3. Mark line (5) on center tread (1) at one-half total tread width (3).
4. Repeat steps 1 through 3 for opposite tire.
5. Measure distance between "Points of Measurement" on front side of tires (2) and record.
6. Rotate tires (2) by moving vehicle forward until "Points of Measurement" are 16 inch (42 cm) above ground at rear side of tires (2).
7. Measure distance between "Points of Measurement" on rear side of tires (2) and record.

NOTE

- **If measurement is larger on rear side of tires than measurement on front side of tires, tires have toe-in.**
- **During vehicle operation, suspension system movement may cause slight alignment changes. For this reason, Table 7-2 provides an inspection specification that allows a larger toe-out tolerance during inspection. If, after inspection, the toe-out is outside inspection specifications, set toe-out to the adjustment specifications in Table 7-2. If toe-out alignment does not meet inspection specifications, repeat checking procedures to eliminate any possible reading errors.**

8. Subtract measurement from rear side of tires (2) step 7, from measurement from front side of tires (2) step 5. The result of this subtraction represents inches of toe-out. Refer to Table 7-2 for toe-out inspection specifications. If toe-out does not meet inspection specifications, adjust toe-out.

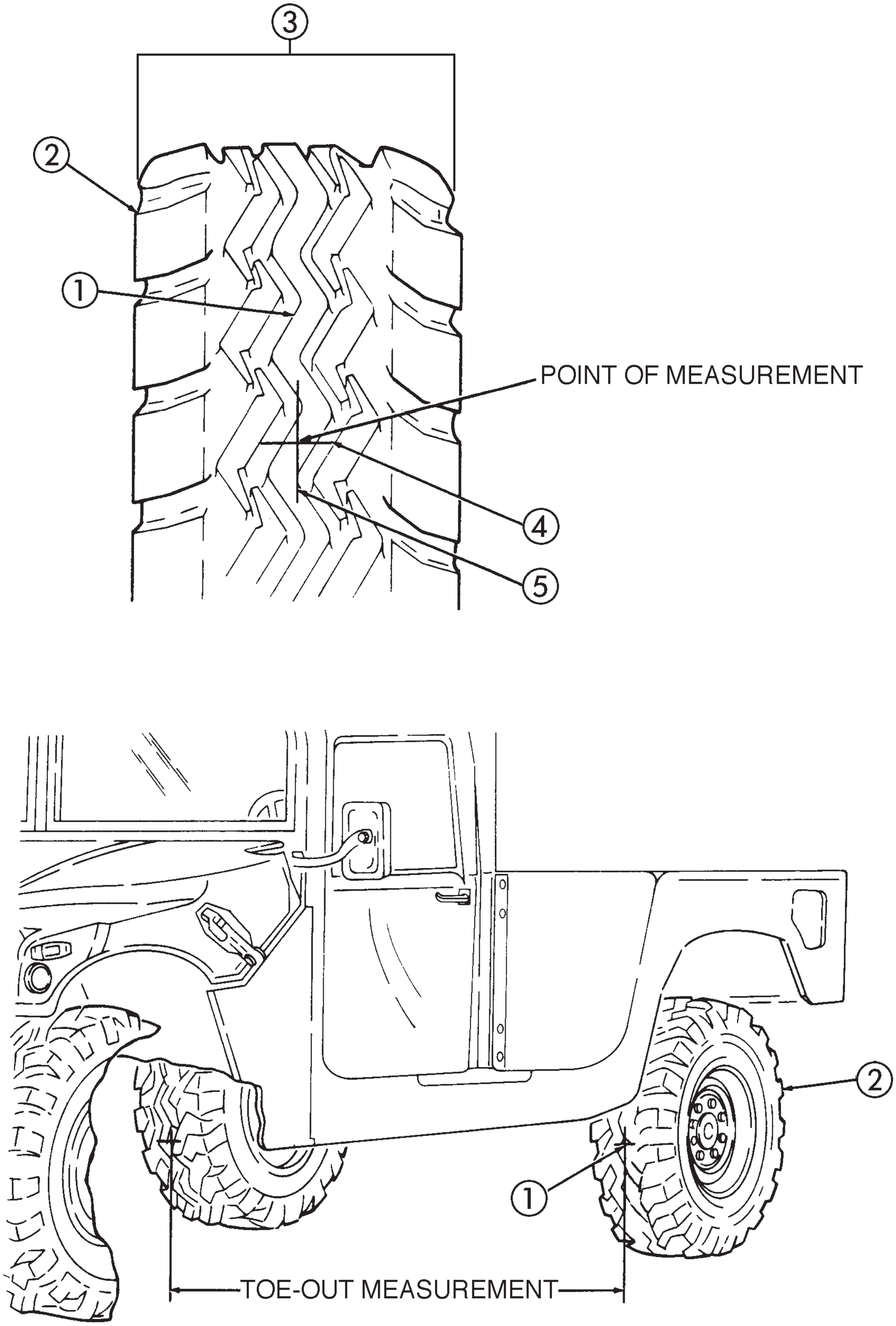


Figure 7-8. Toe-0ut Points of Measurement.

NOTE

- Vehicles should be at curb weight to ensure proper alinement. Refer to Table 7-1(a.) for adjustment specifications.
- Table 7-1(b.) is optional and can be used when the vehicle's average operation is at less than gross vehicle weight. Vehicle is to be loaded to its average operating weight when using this table.

	TOE-OUT (REAR) ADJUSTMENT SPECIFICATIONS				
	BIAS TIRE		RADIAL TIRE		
VEHICLE PAYLOAD	MODELS: M998, M1025, M1026, M1035, M1038, M1043, M1044	MODELS: M996, M997, M1036, M1037, M1042, M1045, M1046	MODELS: M996, M996A1, M998, M998A1, M1025, M1025A1, M1026, M1026A1, M1035, M1035A1, M1036, M1038, M1038A1, M1043, M1043A1, M1044, M1044A1, M1045, M1045A1, M1046, M1046A1	MODEL: M997, M997A1, M1037, M1042	MODELS: M1097, M1097A1,
a. Vehicle @ curbweight	7/16 ± 1/8 in. (11 mm ± 3 mm)	5/16 ± 1/8 in. (8 mm ± 3 mm)	1/2 ± 1/16 in. (12.5 mm ± 1.5 mm)	1/2 ± 1/16 in. (12.5 mm ± 1.5 mm)	1/2 ± 1/16 in. (12.5 mm ± 1.5 mm)
b. Vehicle @ normal operating weight (Optional)	1/4 ± 1/8 in. (6 mm ± 3 mm)	1/4 ± 1/8 in. (6 mm ± 3 mm)	1/16 ± 1/16 in. (1.5 mm ± 1.5 mm)	1/16 ± 1/16 in. (1.5 mm ± 1.5 mm)	1/16 ± 1/16 in. (1.5 mm ± 1.5 mm)

Table 7-2. Toe-Out Alignment Specifications.

c. Toe-Out Adjustment

1. Loosen two locknuts (1) securing two clamps (3) on each adjusting sleeve (2).

NOTE

Toe-out can be increased or decreased by changing length of radius rods. A threaded sleeve is provided for this purpose.

2. Turn each adjusting sleeve (2) equally, but in opposite directions.

3. Roll vehicle rearward then forward to original position.

4. Repeat toe-out check and adjustment procedures until correct adjustment is indicated.

5. Secure two clamps (3) on each adjusting sleeve (2) with two locknuts (1). Tighten locknuts (1) to 30 lb-ft (40 N•m).

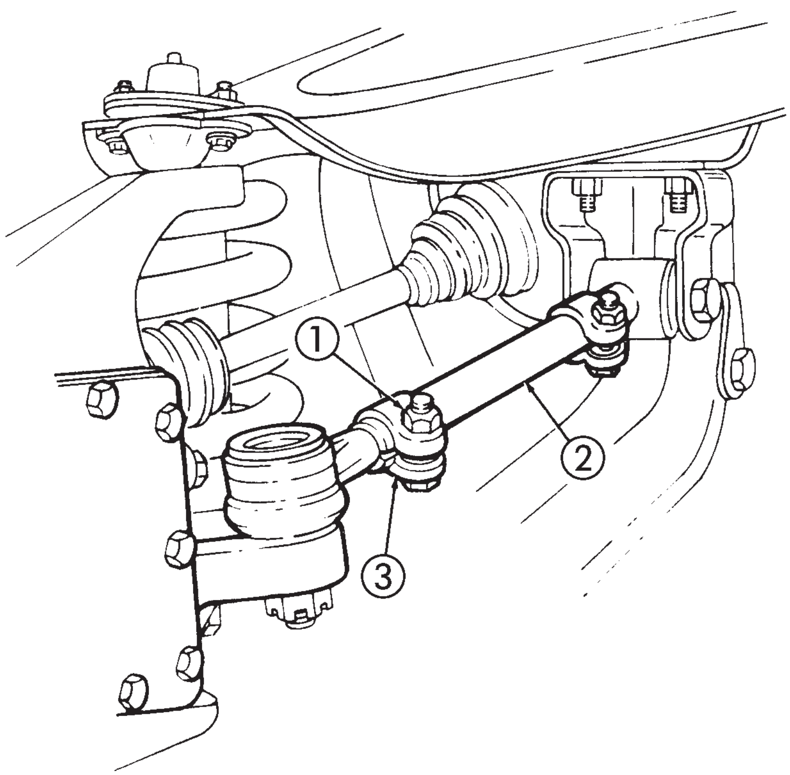


Figure 7-9. Toe -out Adjustment.

C. STEERING STOP CHECK & ADJUSTMENT (Figure 7-10 through 7-13)

a. Removal

1. Loosen jamnut (2) and remove steering stop capscrew (3) and jamnut (2) from geared hub (1). See Figure 7-10.

2. Remove jamnut (2) from capscrew (3).

b. Installation

1. Apply sealing compound to capscrew (3).

2. Install jamnut (2) on capscrew (3).

3. Install capscrew (3) and jamnut (2) on geared hub (1). Tighten capscrew (3) finger tight.

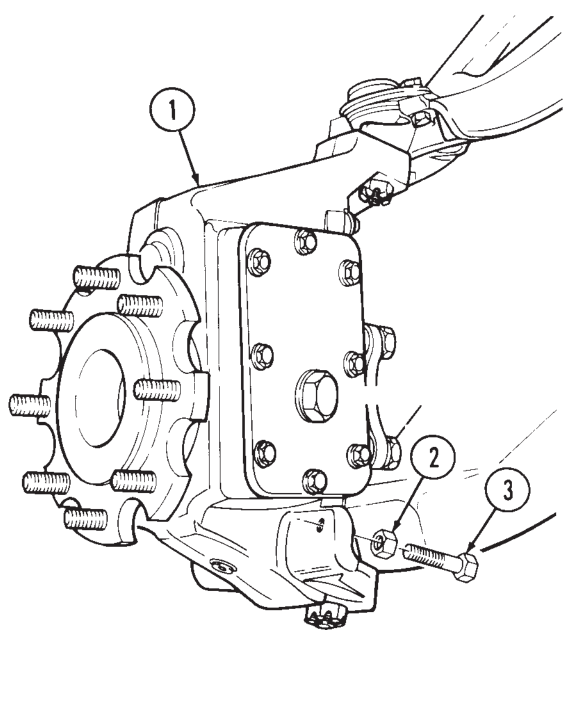


Figure 7-10.
Steering Arm Capscrew Adjustment.

c. Adjustment

NOTE

Prior to adjustment ensure length of each tie rod is the same. If tie rod lengths are not the same 1/8 inch (3 mm), check toe-in alignment.

1. Draw a reference chalk line (6) 30 feet long. Mark this line “A”.

2. Draw another reference line perpendicular to line “A” approximately 10 feet from the end of line “A” and mark this line “D”.

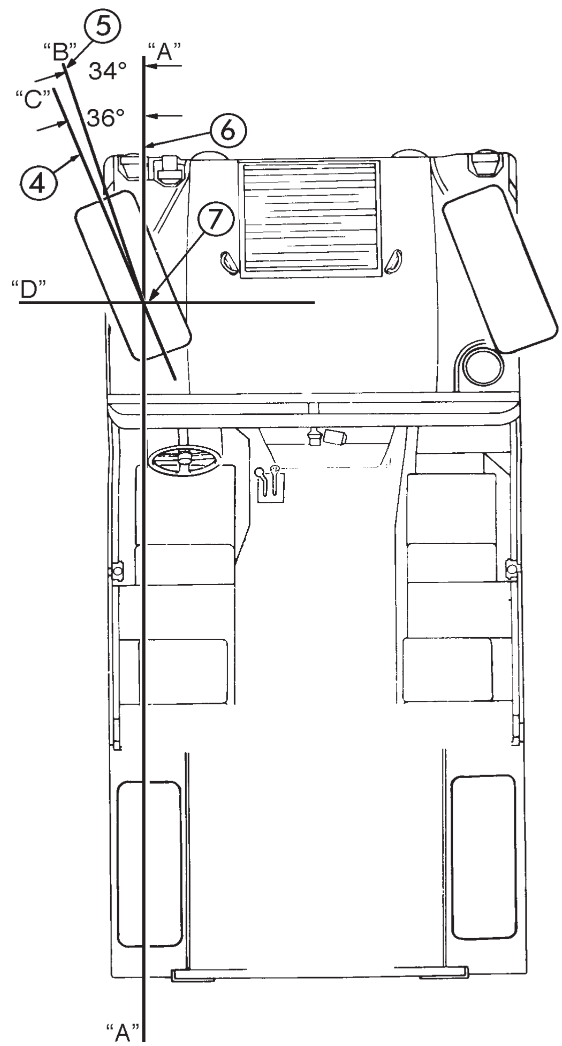


Figure 7-11. Steering Stop Reference line

2. Position vehicle so that center of left rear and left front tires are positioned directly on reference line “A” (6).

3. Using a protractor, draw a second reference line “B” (5) at 34° where lines “A” and “D” intersect. Mark this line “B”.

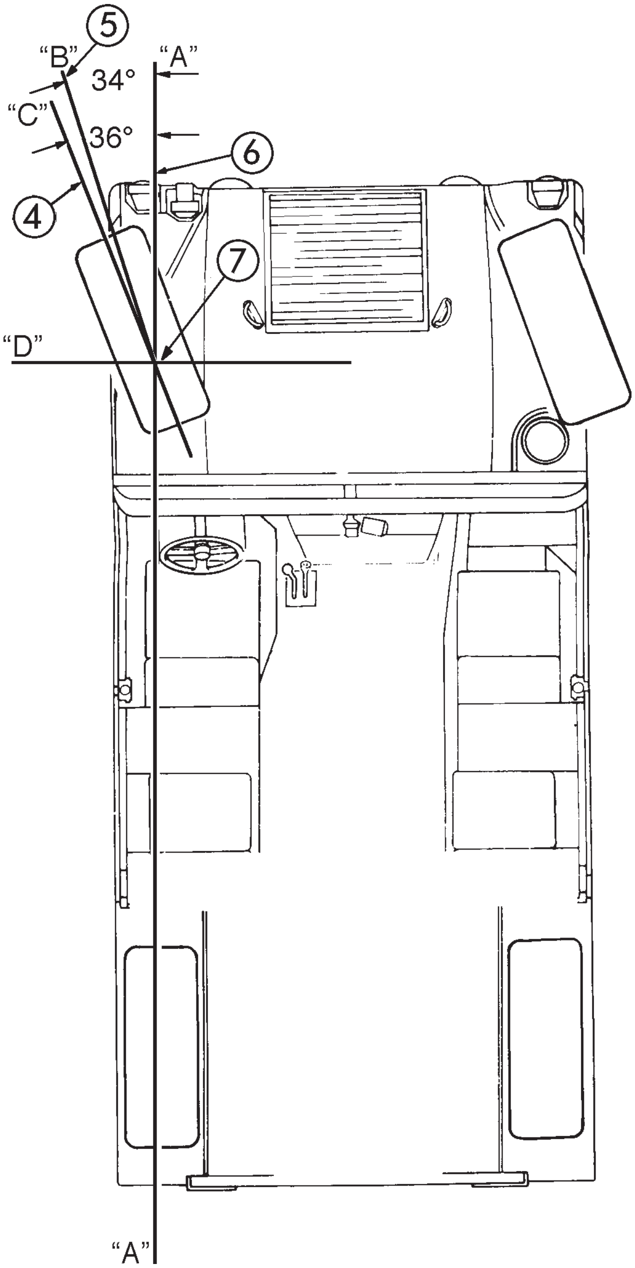


Figure 7-12. Repeat.
Steering stop Check and Adjustment.

4. Again, using a protractor, draw a third reference line “C” (4) at 36° where lines “A”, “B”, and “D” intersect. Mark this line “C”.

5. Roll vehicle forward until center of left front tire is over intersection of lines “A”, “B”, “C” and “D”.

6. Turn steering wheel full left.

7. If the centerline of front and rear of left front tire (7) is over area between lines “B” and “C”, no adjustment is necessary.

8. If centerline of front and rear of left front is not over area between lines “B” and “C”, loosen jamnut (2) and turn capscrew (3) all the way in. See Figure 7-13.

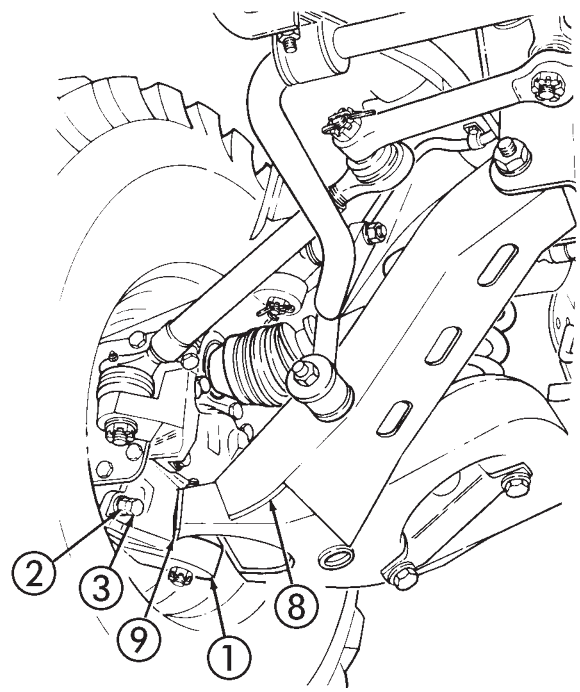


Figure 7-13.
Steering Stop Adjustment and
Lower Contrtol Arm

9. Turn steering wheel until centerline of front and rear of tire (7) is over area between lines “B” and “C”.

10. Unscrew capscrew (3) until head makes contact with wheel stop (9) on lower control arm (8).

11. Secure capscrew (3) with jamnut (2).

12. Repeat adjustment procedure for opposite side.

D. CASTER & CAMBER CHECK AND ADJUSTMENT PROCEDURES (Figure 7-14)

a. Caster and Camber Check

NOTE

The alignment check will be made on a level surface with front tires in the straight ahead position. Vehicles will be checked at curb weight only.

1. Check caster and compare to the specifications in Table 7-3.

2. Check camber and compare to the specifications in Table 7-3.

3. If either caster or camber does not meet specifications, go to caster and camber adjustment.

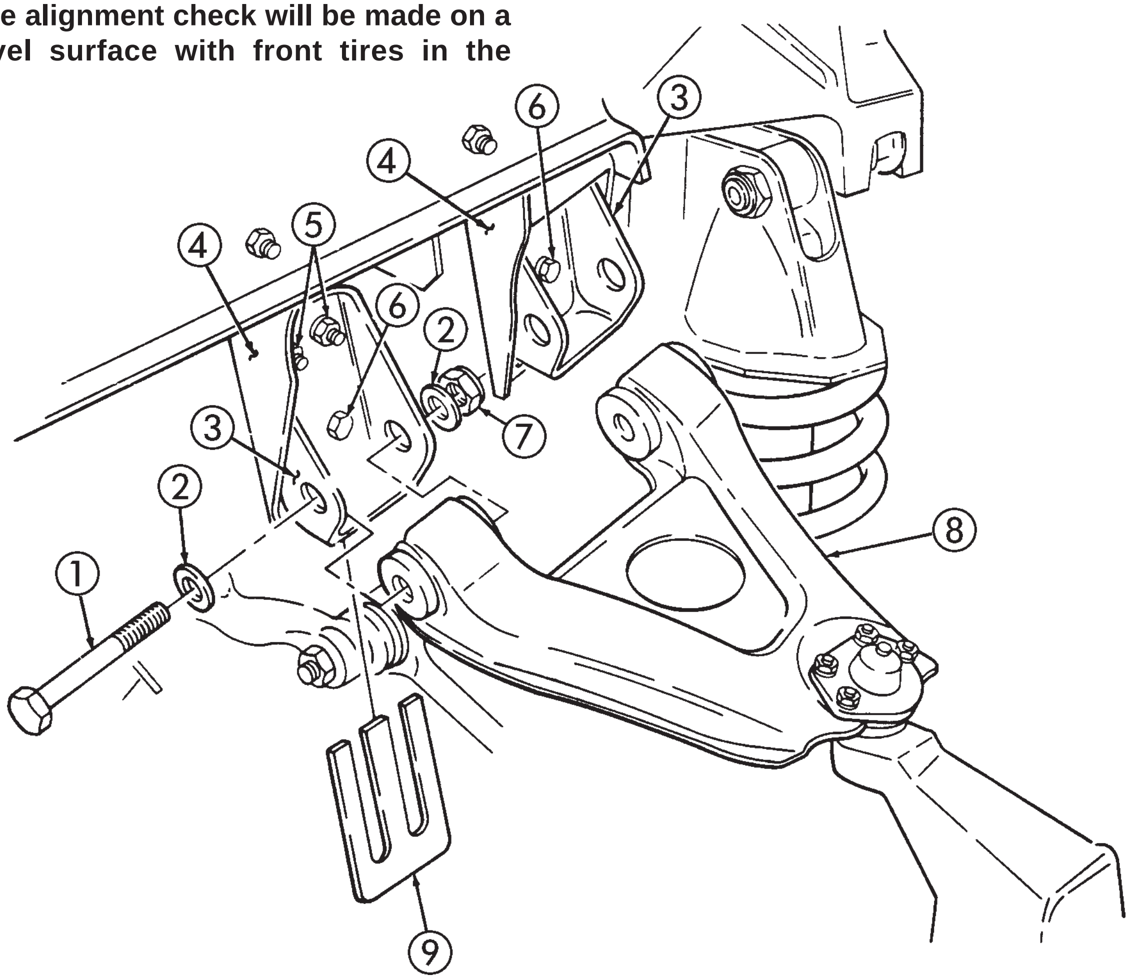


Figure 7-14 . Caster and Camber Adjustment.

b. Caster and Camber Adjustment

NOTE

Caster and camber adjustment is basically the same for all four wheels. This procedure covers the right front wheel.

1. Remove wheel.

2. Remove two locknuts (7), washers (2), capscrews (1), and washers (2) securing upper control arm (8) to mounting brackets (3). Discard locknuts (7).

3. Loosen capscrews (6) and nuts (5) securing each mounting bracket (3) to air lift bracket (4).

NOTE

Shims are available in 0.06 inch (1.52 mm) and 0.12 inch (3.04 mm) thickness.

4. Add or subtract shim(s) (9) as required to bring caster and/or camber within specifications (table 7-3). Suspension alignment change in relation to shim selection is shown in Table 7-4, Suspension Alignment Change.

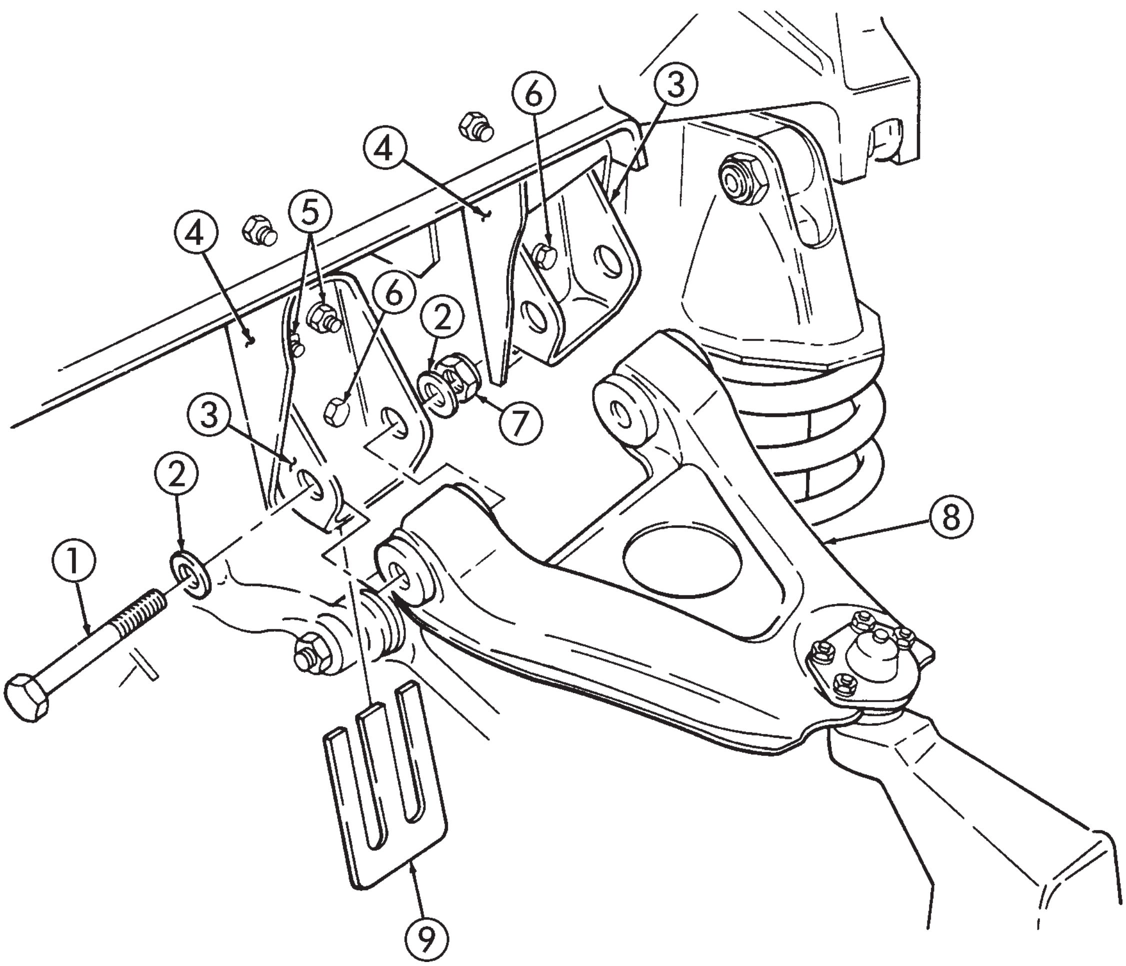


Figure 7-14 (Repeat). Caster and Camber Adjustment.

NOTE

- **Subtracting shims will affect caster/ camber in the opposite direction as compared to adding shims.**
- **For 0.06 inch (1.52 mm) shims, reduce the values in the table by half.**
- **For larger changes, combinations of additions or subtractions will provide desired results.**

5. Tighten capscrews (6) and nuts (5) securing each mounting bracket (3) to 90 lb-ft (122 N•m).

6. Secure upper control arm (8) to mounting brackets (3) with two washers (2), capscrews (1), washers (2), and locknuts (7). Tighten locknuts (7) to 260 lb-ft (353 N.m).

7. Install wheel.

BIAS TIRES

MODEL	CASTER FRONT/REAR (±1.5°)	CAMBER FRONT/REAR (±1.5°, –0.5°)
M998, M1025, M1026, M1035 M1038, M1043, M1044	2.0°/0.0°	0.8°/1.7°
M966, M1036, M1037, M1042 M1045, M1046	2.0°/0.0°	0.8°/1.5°
M996M M997	2.0°/0.0°	0.8°/1.7°

RADIAL TIRES

MODEL	CASTER FRONT/REAR (±1.5°)	CAMBER FRONT/REAR (±1.0°)
M996, M996A1, M998, M998A1, M1025, M1025A1, M1026, M1026A1, M1035, M1035A1, M1036, M1038, M1038A1, M1043, M1043A1, M1044, M1044A1, M1045, M1045A1, M1046, M1046A1	+1.50°/0.0°	+0.68°/+1.50°
M997, M997A1, M1037, M1042	+1.44°/0.0°	+0.68°/+1.44°
M1097, M1097A1	+1.44°/0.0°	+0.38°/+2.12°

Table 7-3. Alignment Specifications.

LOCATION	FRONT SUSPENSION SHIM	CASTER	CAMBER
Front shim only	+0.12 inch (3.04 mm)	+0.6°	–0.5°
Rear shim only	+0.12 inch (3.04 mm)	–0.6°	+0.0°
Front and rear shims	+0.12 inch (3.04 mm)	0.0°	+0.5°
LOCATION	**REAR SUSPENSION SHIM**	**CASTER**	**CAMBER**
Front shim only	+0.12 inch (3.04 mm)	+0.5°	–0.1°
Rear shim only	+0.12 inch (3.04 mm)	–0.5°	+0.6°
Front and rear shims	+0.12 inch (3.04 mm)	0.0°	+0.5°

Table 7-4. Suspension Alignment Change.

SECTION 8
JACKING PROCEDURES

WARNING

Hydraulic jacks are used for raising and lowering, and are not used to support vehicle. Never work under vehicle unless wheels are blocked and it is properly supported. Injury or damage to equipment may result if vehicle suddenly shifts or moves.

A. RAISING CORNER OF VEHICLE (Figure 8-1)

1. Block wheels (2) or (4).
2. Place jack under lower control arm (5) on corner to be raised.
3. Raise vehicle (1) high enough to place trestle (3).
4. Place trestle (3) under flat portion of frame rail (7) and lower jack until weight is supported by trestle (3).

B. LOWERING CORNER OF VEHICLE (Figure 8-1)

1. Raise vehicle (1) and remove trestle (3).
2. Lower vehicle (1).
3. Remove blocks from wheels (2) or (4).

C. RAISING FRONT OF VEHICLE (Figure 8-1)

1. Block rear wheels (2).
2. Center jack under front suspension front crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (7) and lower jack until weight is supported by trestles (3).

D. LOWERING FRONT OF VEHICLE (Figure 8-1)

1. Raise vehicle (1) and remove trestles (3).
2. Lower vehicle (1).
3. Remove blocks from rear wheels (2).

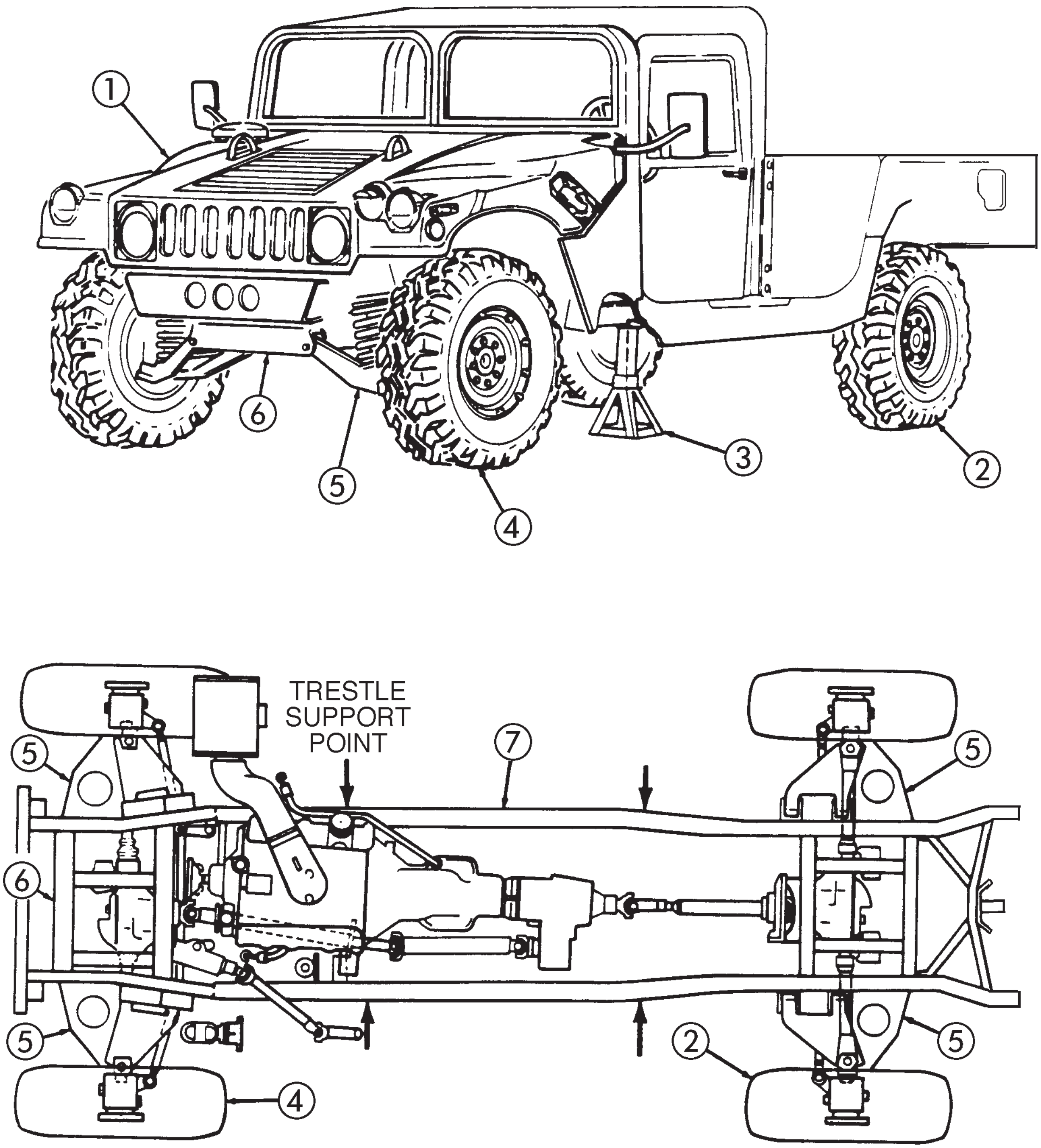


Figure 8-1. Front and Corner Jacking Procedures.

E. RAISING REAR OF VEHICLE (Figure 8-2)

1. Block front wheels (4).
2. Center jack under rear suspension rear crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (5) and lower jack until weight is supported by trestles (3).

F. LOWERING REAR OF VEHICLE (Figure 8-2)

1. Raise vehicle (1) and remove trestles (3).
2. Lower vehicle (1).
3. Remove blocks from front wheels (4).

G. RAISING ENTIRE VEHICLE (Figure 8-2)

1. Raise front of vehicle.
2. Center jack under rear suspension rear crossmember (6). Use a wood block between jack and crossmember (6).
3. Raise vehicle (1) high enough to place trestles (3).
4. Place trestles (3) under flat portion of frame rails (5) and lower jack until weights is supported by trestles (3).
5. Move blocks aside.

H. LOWERING ENTIRE VEHICLE (Figure 8-2)

1. Raise rear of vehicle (1) and remove trestles (3).
2. Lower rear of vehicle (1) and block rear wheels (2).
3. Lower front of vehicle.

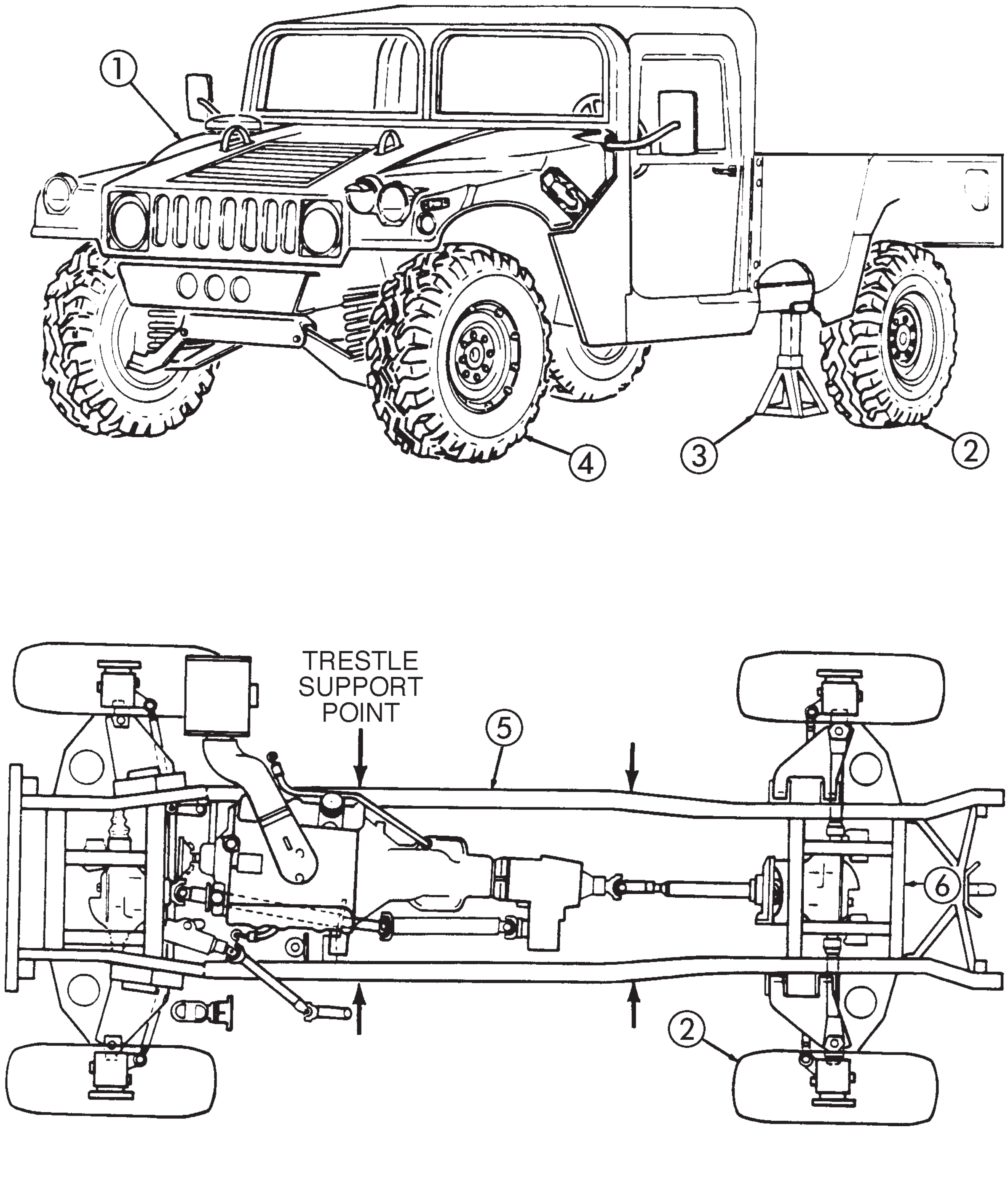


Figure 8-2. Rear and Entire Vehicle Jacking Procedures.

SECTION 9
POWER STEERING

A. POWER STEERING TEST & BLEEDING (Figure 9-1)

Check power steering system using power steering analyzer and analyzer adapter.

1. Disconnect high pressure hose (1) from hydro-boost (4) leading to power steering pump and connect adapter (2) and analyzer (3) to hydro-boost (4). Connect adapter (6) to high pressure hose and to analyzer(3). Open valve (5) on analyzer.

2. Disconnect harness connector at fan drive solenoid. Check fluid level in power steering pump and add if necessary.

3. Connect tachometer for purpose of recording engine RPM.

4. Start engine and allow to idle. Check for leaks at connections.

5. Record pump pressure and flow. Pressure should be 180-220 psi and flow should be 2.50-3.50 gpm. If pressure or flow is too low, check for restriction in pressure line from power steering pump. If pressure is too high, check for restriction in pressure line from hydro-boost to steering gear. If no restrictions are found, replace power steering pump.

6. Partially close valve (5) on analyzer so pressure increases to 300 psi and record flow. Subtract this flow rate from flow rate obtained in step e. If there is more than 1 gpm difference in flow rates, replace power steering pump.

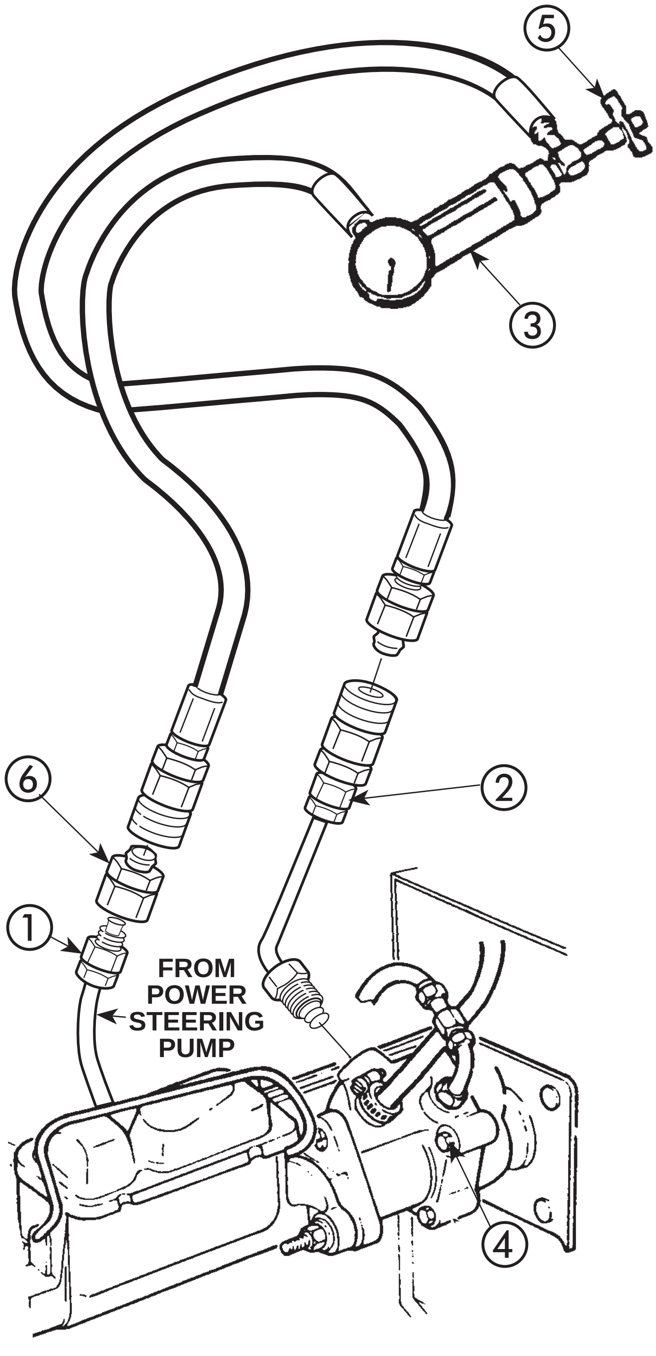


Figure 9-1. Power Steering Test Hook-up

CAUTION

Do not leave valve fully closed for more than 5 seconds or pump damage will result.

7. Close and partially open valve on analyzer three times, record highest pressure reading each time. All three readings must be 1300 psi or above. If not, replace power steering pump.

8. Open valve on analyzer and increase engine speed to 1500 RPM. Record flow. If flow varies more than 1 gpm from flow rate recorded in step f., replace power steering pump.

9. Turn steering wheel all the way to left and right and record flow at each stop. Flow should drop to 1 gpm or less. If flow does not drop to 1 gpm or less, replace steering gear.

10. Push brake pedal to floor and hold, flow should drop to 1 gpm or less. If flow does not drop to 1 gpm or less, replace hydro-boost.

11. Turn steering wheel slightly to left or right, and release wheel quickly while watching pressure gage. Pressure gage should snap back quickly. If pressure gage returns slowly, replace steering gear.

12. Push brake pedal down and release quickly while watching pressure gage. Pressure gage should snap back quickly. If pressure gage returns slowly, replace hydro-boost. Connect harness connector to fan clutch solenoid.

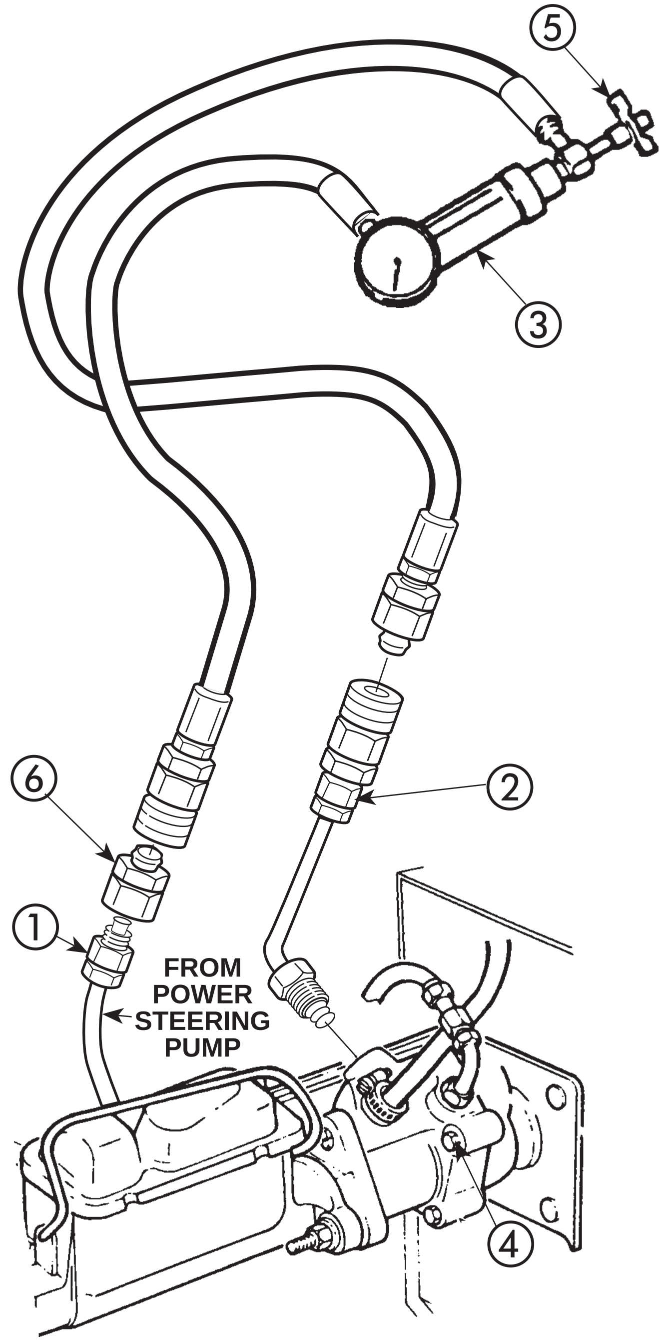


Figure 9-1 Repeat.
Power Steering Test Hook-up.

SECTION 10
TRANSFER CASE

A. TRANSFER CASE HOUSING STUDS (Figure 10-1)

If transfer case will not go into low range after unit repair or replacement of adapter mounting studs (1), check measurement of studs. Studs must be exposed 1.250 inch to 1.300 inch. If not exposed 1.250 inch to 1.300 inch, studs could be preventing transfer case from shifting.

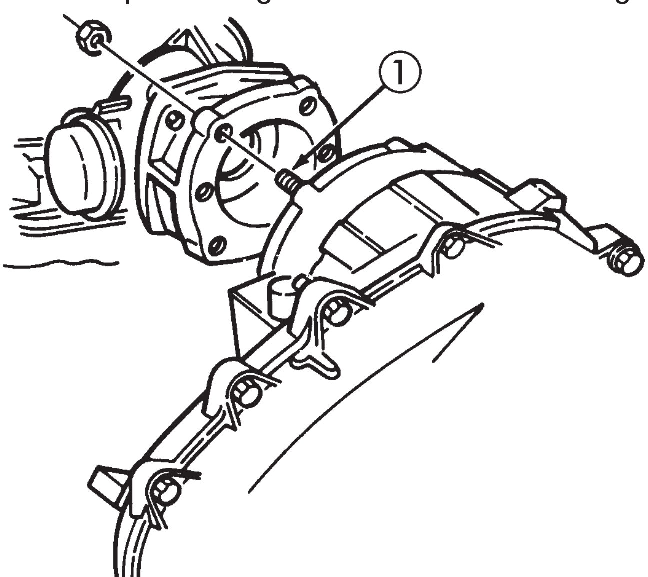


Figure 10-1.
Measuring Adapter Mounting Studs.

B. TRANSFER CASE TOWING INSTRUCTIONS

The recommended methods for towing the vehicle if it becomes disabled are as follows:

1. Flat bed towing (all wheels stationary).

2. All four wheels on the ground with Transfer Case in neutral (towing speeds should be limited to 55 m.p.h. with no distance restrictions).

3. If the Transfer Case is not operational or Transfer Case neutral is not obtainable, tow the vehicle with either the front or rear off the ground and the opposite end on a towing dolly to prevent the wheels from rotating their respective propeller shafts.

NOTE

When towing with all four wheels on the ground, all the tires must be the same size (air pressure equalized and same circumference).

SECTION 11
DIFFERENTIALS

A. AXLE AND DIFFERENTIAL OPERATION (Figure 11-1)

The front and rear axle housings, cast from aluminum, are manufactured by Dana, utilizing conventional hypoid eight bolt ring and pinion gears with a ratio of 2.73:1. Both axle housings are equipped with a ZEXEL Torsen® differential and lubricated with standard 80/90 Hypoid gear oil.

The housings are mounted up, between the frame rails, to minimize drive line vibrations, external damage, and provide increased ground clearance. Each housing is equipped with a disc brake assembly mounted at each side of the output flange, and both housings are interchangeable.

The ZEXEL Torsen® differential provides full time differentiation, full time maximum traction, and “Torque and Load Sensing” capabilities. These features provide improved handling, steering, and enhanced off-road mobility. The differential “torque” senses where power is required and delivers it accordingly. It resists spinout by transferring more torque to the drive wheel with the most resistance to spinout.

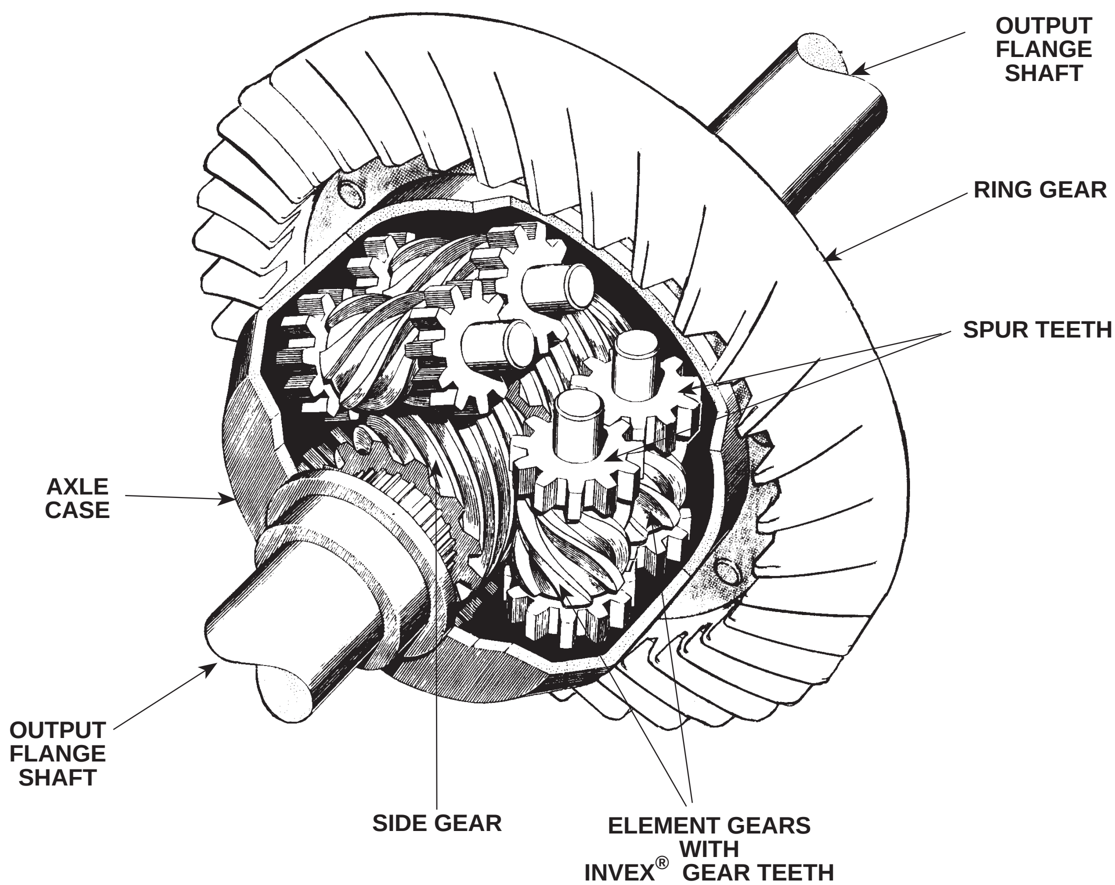


Figure 11-1. ZEXEL Torsen® Differential.

B. OPERATING PRINCIPLE

In the ZEXEL Torsen® differential, as in any conventional differential, power of the engine is transferred to the differential housing by the ring gear. The Torsen differential is assembled with Invex gearing comprised of three pairs of satellite gears (element gears) in mesh and rotation with central helical gears (side gears). The side gears are splined to the axle shafts which provide power to the wheels. Independent rotation (differentiation) of the axle shafts occurs when required.

The pairs of element gears are interconnected with each other by means of the spur teeth. The Torsen® differential provides an increase in the total amount of power supplied to the wheels. Power is transferred to the wheel having the most traction via the combination of the Invex® gear system and the frictional resistance in the differential.

Driving in a straight line, each wheel rotates the same speed. In a turn, each wheel will rotate at a slightly different speed. The inside wheel will slow down at exactly the same rate as the outside wheel speeds up. The difference in RPM is transferred via the 1 to 1 ratio of the spur teeth on the element gears.

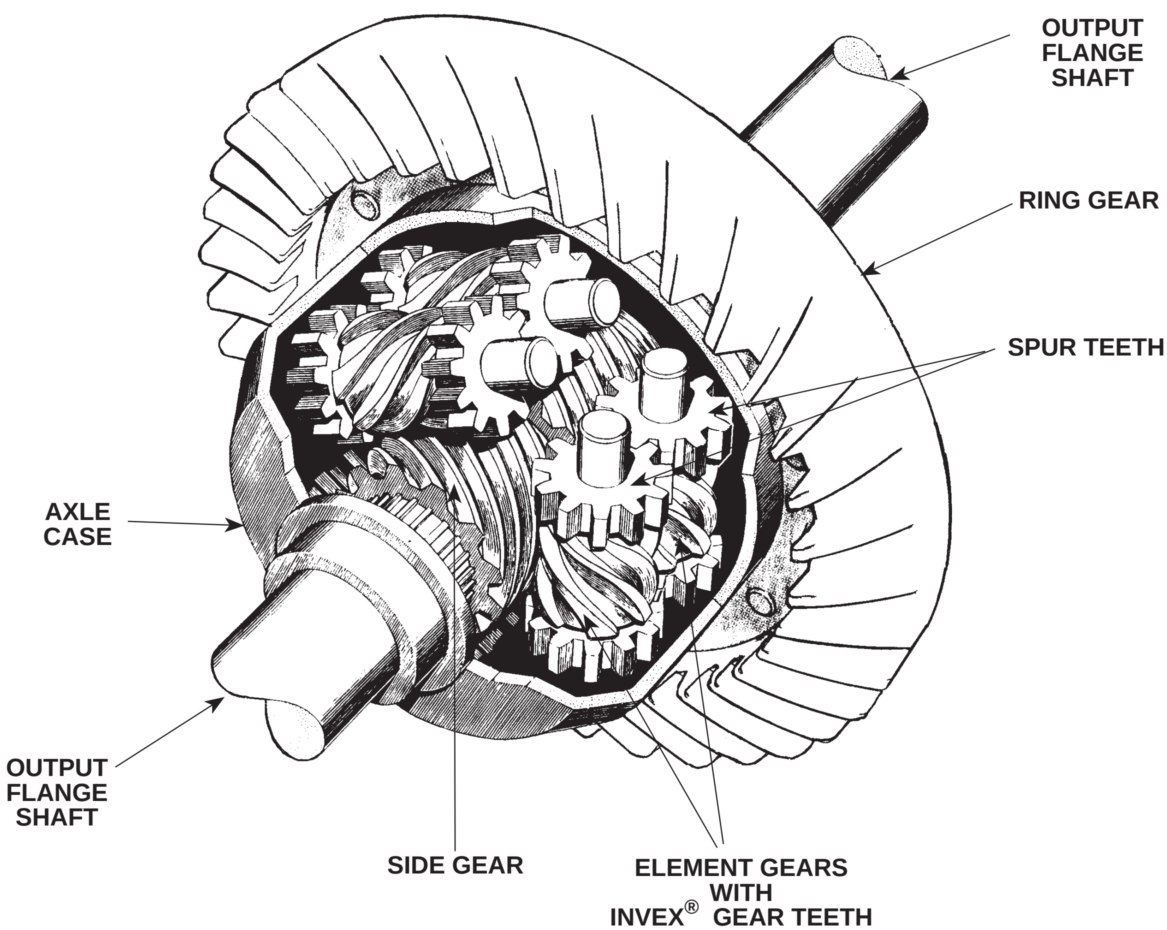


Figure 11-1 Repeat. Torsen Differential.

SECTION 12
ELECTRICAL SYSTEM

A. BATTERY SHUNT TEST AND REPLACEMENT (Figure 12-1)

Using a multimeter, check for continuity across shunt in battery compartment. If continuity is not present, replace shunt.

B. STARTER TESTING (Figure 12-1)

WARNING

Negative battery cable must be disconnected before disconnecting any harness from protective control box. Failure to do so may result in injury to personnel or damage to equipment.

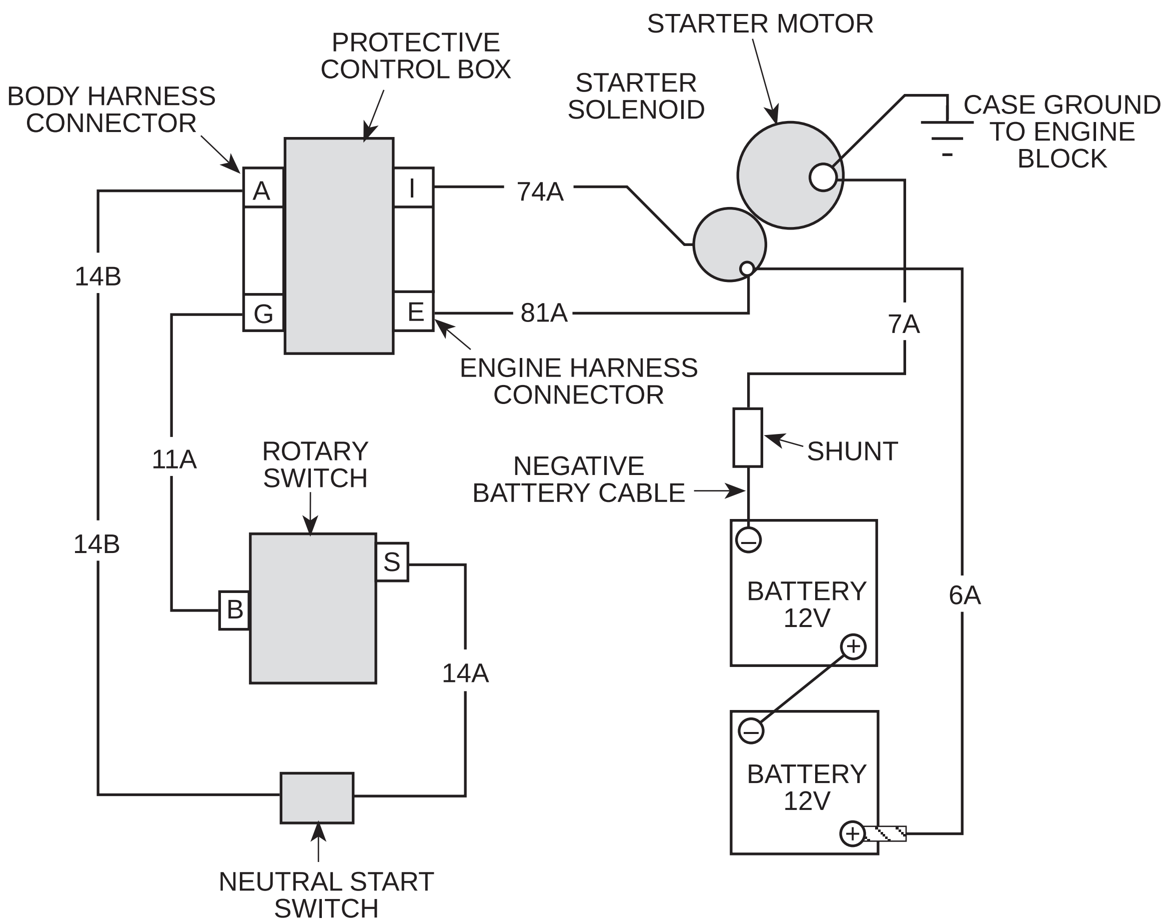


Figure 12-1. Starting System Schematic.

1. With rotary switch held in “START”, check for battery voltage on lead 74A at the starter. If battery voltage is present, replace starter.

2. Disconnect lead 14B from neutral start switch. Check for battery voltage at neutral start switch connector 14 with rotary switch in “START” position. If battery voltage is present continue to step 3. If voltage is not present proceed to step 7.

3. Disconnect negative battery cable and both connector plugs from protective control box. Check continuity of lead 14B at neutral start switch to pin A at the control box body harness connector plug. If continuity is not present repair wiring harness.

4. Disconnect lead 74A from starter. Check continuity of lead 74A at starter to pin I of the control box engine harness connector plug. If continuity is not present, repair wiring harness.

5. Connect neutral start switch lead 14B, starter lead 74A, and both control box connector plugs. Disconnect lead 2A from alternator and connect battery ground cable. Attempt to start vehicle. If starter does not crank, replace protective control box. Check continuity of lead 2A.

6. If starter cranks engine, disconnect negative battery cable, and connect lead 2A to alternator after thoroughly cleaning terminal connection area. Connect negative battery cable and attempt to start vehicle. If starter does not crank replace alternator. If starter does crank, apply sealant to alternator terminal connections.

7. Disconnect lead 14A from neutral start switch. With rotary switch in “START” position, check for battery voltage at lead 14A. If voltage is present, continuity check the neutral start switch. Ensure the neutral start switch is activated mechanically. If continuity is not present, replace neutral start switch. Reconnect neutral start switch leads 14A and 14B.

8. Disconnect the rotary switch lead 14A and with rotary switch in “START” check for battery voltage at terminal S. If voltage is present, repair body wiring harness from rotary switch to neutral start switch.

9. Disconnect lead 11A at the rotary switch, check lead 11A for battery voltage. If voltage is present, replace rotary switch.

10. Disconnect negative battery cable from battery and disconnect protective control box connector plugs from protective control box. Reconnect negative battery cable to battery. Check pin E of engine wiring harness connector plug for battery voltage. If voltage is present, check for continuity from pin G on the control box wiring harness connector plug to lead 11A of rotary switch. If continuity is present, replace protective control box. If no continuity is present, repair body wiring harness.

C. BATTERY CIRCUIT CHECKS (Figure 12-2)

1. Check batteries for loose or dirty connections.

   a. Make sure all connection are clean and tight. This includes the interconnect cables, clamp, shunt, power stud and the slave connector. Also check wire 6A and 7A under vehicle where they enter the shunt.

2. Check batteries fluid level.

   a. There is a ring inside the battery fill plugs. The water level should be at the ring.

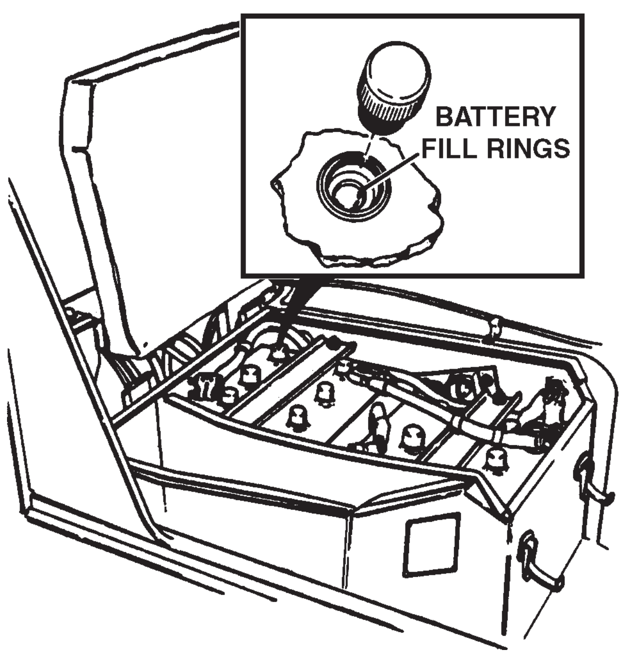


Figure 12-2. Battery Fill Rings.

3. Check batteries voltage for 23.5 to 25.5 volts.

   a. If batteries voltage is low, check each battery individually. Voltage should be between 11to13 volts. (A good battery has 12 volts at 70°F (22°C).

   b. If battery is below 11-13 volts, recharge battery.

   c. If batteries are good, check the voltage drop across cables in battery box. Voltage drop should be less than 0.25 volts maximum.

4. Load test batteries. If batteries fail load test, replace batteries.

Check starter voltage drop from power stud of 6A to starter ground.Voltage drop should be less than 0.25 volts. If voltage drop is more than 0.25 volts replace 6A cable.

D. 6.2L ENGINE GLOW PLUG SYSTEM (Figure 12-3 through 12-6)

The glow plug is basically an electric heater that is energized by the operator through the ignition switch. Once energized, electric current flows through the glow plug to cause it to glow or become red hot 1550°F to1650°F (829° to 884°C). After a given time period when the starter motor is engaged, the ambient air that flows into the engine will be rapidly increased in temperature through the use of the hot glow plug within the combustion chamber.

Each cylinder in the 6.2L engine employs a glow plug that is actually a 12-volt unit operated from the 24-volt battery system when the ignition key is turned to the run position prior to engaging the starter motor. They remain pulsing for a short time after starting, then automatically turn off.

Within the instrument panel of the vehicle is a "glow plugs" light that will turn on immediately when the ignition switch is turned to the run position.

The major components of the glow plug system are described in the following paragraphs.

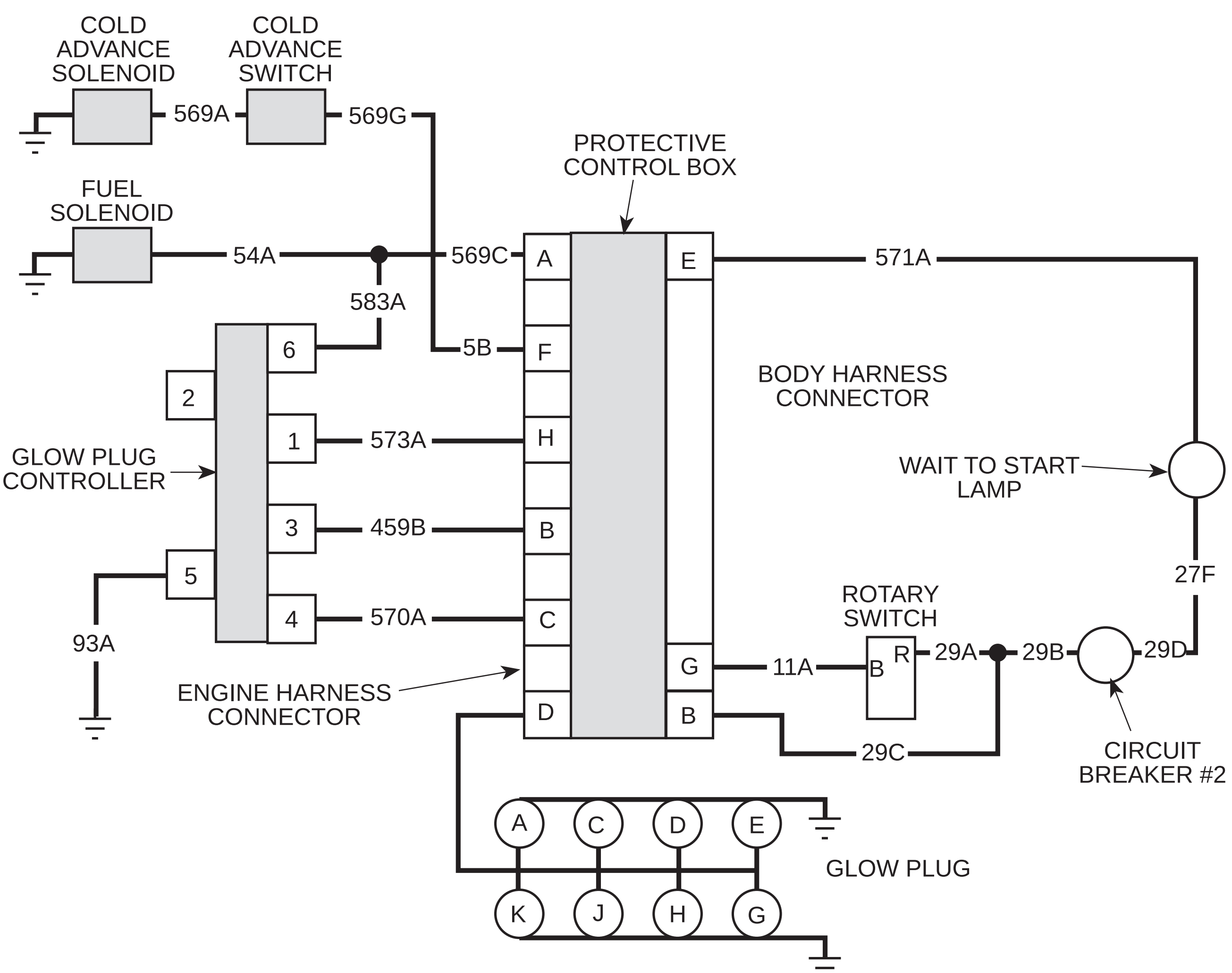


Figure 12-3. Glow Plug Controller Testing

(MALFUNCTION)

a. Glow Plug System Continues To Cycle After Engine Is Warmed Up

Start engine, and check for 12-14 volts DC signal at alternator lead 2A. If no voltage is present or voltage is not within limits, replace the alternator. If 12-14 volts DC is present, replace protective control box.

b. Using multimeter, check glow plug internal resistance (Figure 12-5)

Connect one test lead to terminal (1) and other test lead to threaded area (2).

Glow plug internal resistance should be 1.5-5.0 ohms. If resistance is not 1.5-5.0 ohms, replace glow plug.

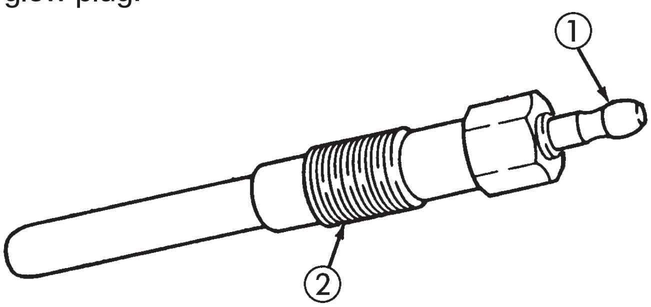


Figure 12-4. HMMWV Glow Plug.

NOTE

- **The following will explain proper operation of glow plug system. When engine is below 120°F (48°C) and rotary switch is positioned to "RUN", "Wait-To-Start" lamplight then goes on for up to fifteen seconds, depending on engine temperature, then goes off, engine can then be started. After engine is started, glow plugs will continue to cycle (for up to 5 minutes) then stop cycling.**

- **Glow plug system is cycling normal when there is an on pulse for approximately 1 second and an off pulse for approximately 15 seconds.**

- **To detect glow plug system cycling, watch voltmeter. The gage needle will move to the left when glow plugs are on, then return to normal position when glow plugs are off. A relay click should be heard from the protective control box as the system switches on and off. Multimeter may be used on any glow plug wire to visually watch operation of glow plug system.**

- **If engine temperature is above 120°F (48°C), glow plugs are not required to start engine.**

- **Each glow plug draws approximately 11.25 amperes. To test system connect AMP meter across batteries. With glow plugs cycling, there should be approximately 90 ampere draw. Each bad glow plug will lower ampere draw approximately 11.25 amperes. (Example) With one bad glow plug, reading will be approximately 78.75 amperes. With two bad glow plugs, reading will be approximately 67.5 amperes etc.**

NOTE

Allow engine to cool for 30 minutes before performing glow plug resistance checks.

1. Remove engine wiring harness connectors from all glow plugs. Using a multimeter, check glow plug resistance. Replace any glow plug not having 1.5-5.0 ohms resistance.

NOTE

Allow engine to cool 2-3 hours before performing glow plug controller resistance checks if continuous controller cycling is suspected.

NOTE

If solid state glow plug controller is being used, no test is available to test the controller. Replace if suspected of being faulty. If symptoms still exist, continue with step 3.

Refer to Figure 12-6 for the following steps.

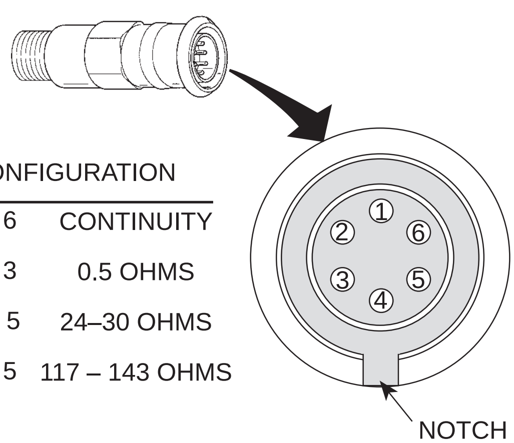
2. Disconnect engine wiring harness connector from glow plug controller. Check the controller connector for dirt or moisture contamination, clean if required. Using multimeter, check controller for the following:

a. Check for continuity between pin 2 and pin 6 (continuity should exist).

b. Check resistance between pin 2 and pin 3. The resistance should be approximately 0.5 ohms.

c. Check resistance between pin 4 and pin 5. The resistance should be 24-30 ohms.

d. Check resistance between pin 1 and pin 5. The resistance should be 117-143 ohms.



PIN CONFIGURATION	
PINS 2 & 6	CONTINUITY
PINS 2 & 3	0.5 OHMS
PINS 4 & 5	24–30 OHMS
PINS 1 & 5	117 – 143 OHMS

Figure 12-5. Glow Plug Controller

If any of the above conditions are not met, replace glow plug controller.

Refer to Figure 12-7 for the following steps.

3. Using a multimeter, check for continuity between terminal 5 at glow plug controller connector (lead 93A) and ground. Repair engine wiring harness if continuity is not present.

WARNING

Negative battery cable must be disconnected before disconnecting any harness from protective control box. Failure to do so may result in injury to personnel or damage to equipment.

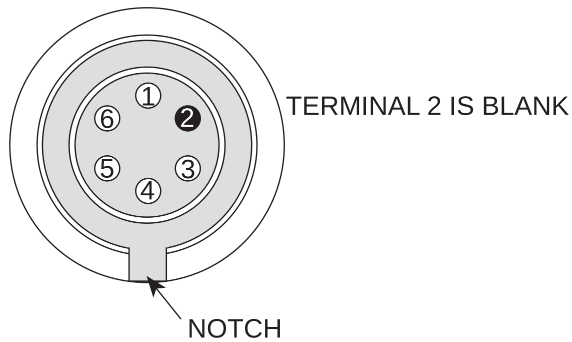


Figure 12-6. Glow Plug Controller Continuity Test.

4. Disconnect negative battery cable and disconnect engine wiring harness connector at protective control box. Inspect the control box and harness connector for dirt, or moisture contamination, clean if required. Using a multimeter, check for continuity between terminal "D" in protective control box engine wiring harness connector and eight glow plug connectors (leads 575). Repair engine harness, if any glow plug leads do not have continuity.

5. Using a multimeter, check for continuity between terminal "G" in engine wiring harness connector at protective control box and lead 2A at alternator. Repair engine wiring harness, if continuity is not present.

6. Using a multimeter, the following continuity checks must be made from engine wiring harness connector at protective control box to engine wiring harness connector at glow plug controller.

   a. Terminal “C” at protective control box connector to terminal 4 at glow plug controller connector (lead 370A).

   b. Terminal “B” at protective control box connector to terminal 3 at glow plug controller connector (lead 459B).

   c. Terminal “H” at protective control box connector to terminal 1 at glow plug controller connector (lead 573A).

   d. Terminal “A” at protective control box connector (lead 54B) to terminal 6 at glow plug controller connector (lead 583A).

If any leads did not have continuity, repair engine wiring harness.

7. If no problem is found in glow plugs, glow plug controller or engine wiring harness, replace protective control box and check system for proper operation.

END OF TESTING!

E. COLD START ADVANCE DOES NOT FUNCTION PROPERLY

1. Remove engine access cover. Disconnect leads 569A and 569B from cold advance switch. Using multimeter, check for battery voltage at lead 569A with rotary switch in “RUN” position. If battery voltage is not present, repair engine wiring harness.

2. Disconnect lead 569B from fuel injection pump. Using multimeter, check for continuity through lead 569B from injection pump to cold advance switch. If continuity is not present, repair engine wiring harness.

3. Using multimeter, check for continuity through cold advance switch with engine temperature below 70°F (21°C). If continuity is not present, replace cold advance switch. Check for continuity through cold advance switch with engine temperature above l00°F (38°C). If continuity is present, replace cold advance switch.

F. NEIHOFF 100 AMP ALTERNATOR TESTING (Figure 12-7 through 12-9.

a. On Vehicle Test

The alternator is examined most easily on the vehicle, where the charging and ignition systems of the vehicle can be examined at the same time.

Equipment:

<u>Belt</u> <u>Tension</u> <u>Gauge</u>
<u>Voltmeter</u>, 0-40 Volt Range
<u>Ammeter</u>, 0-400 Amp Range

b. Preliminary Checks

1. **Check Belt Tension.** Use Belt Tension Gauge to measure belt tension within range for the appropriate belting system: Dual Belt: 80-120 lbs each belt.
2. **Check Battery.** Battery must be in good condition and fully charged. If condition is marginal the battery should be replaced with one which is known to be in good condition.
3. **Check Electrical Connections in Charging Circuit.** Make sure all connections are clean, tight, and free of corrosion. Battery connections are especially important.
4. **Check Ignition Circuit.** If alternator is not charging, check for voltage at the alternator energize terminal (Red Terminal). Refer to Figure 12-7 for energize terminal location on the outside of the regulator. Look for 24V nominal.

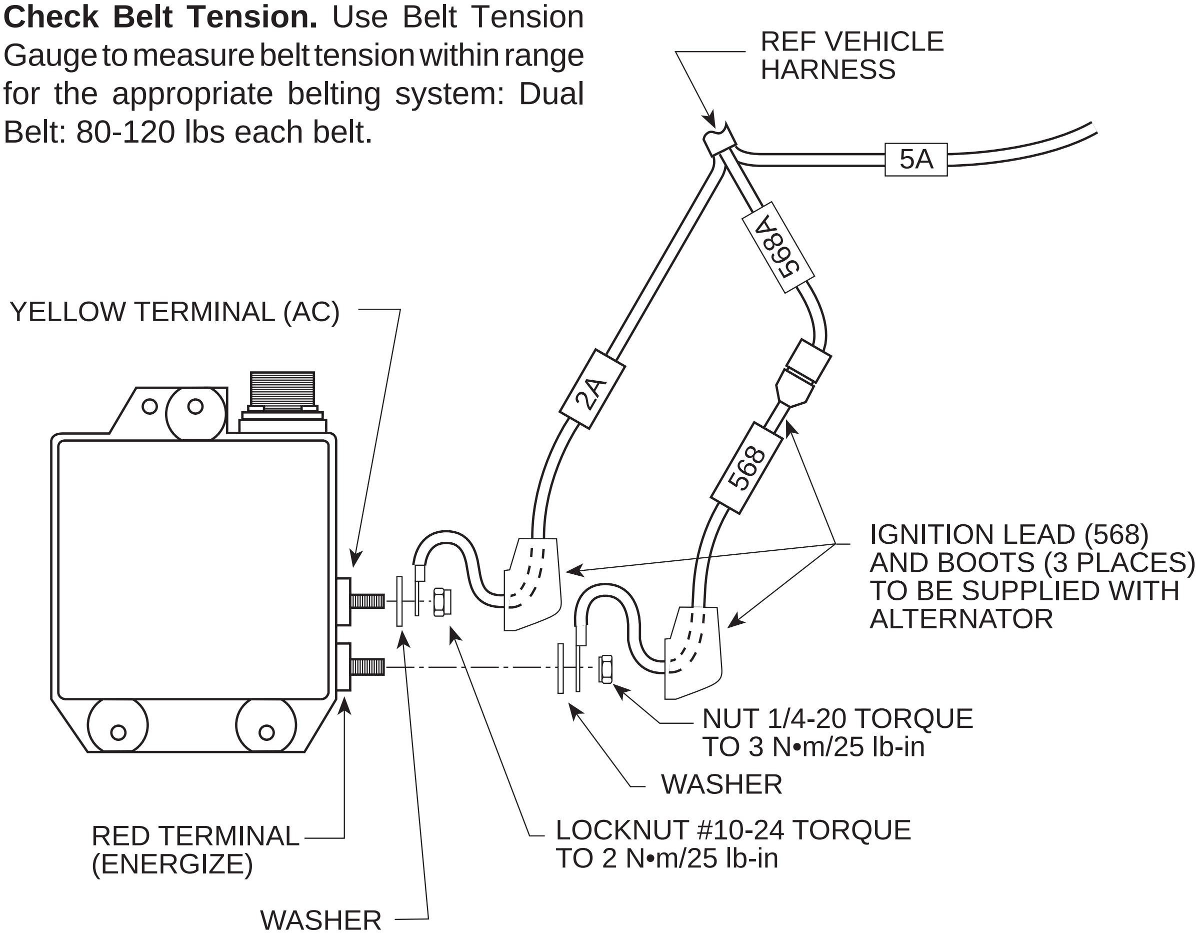


Figure 12-7.
Regulator AC and Energize Terminals

c. Test Setup

1. **Discharge Battery as Follows:**

    1. Remove wire 54A from injection pump.

    2. Turn all lights and accessories. Crank the engine for 10-15 seconds to discharge battery, then stop cranking engine.

    3. Turn all lights and accessories off.

    4. Reconnect wire 54A to injection pump.

2. **Attach meter as indicated by Figure 12-8A.** Be sure to measure voltage and amperage at alternator, not battery or intermediate point.

If an in-line ammeter is used, disconnect battery ground cable before connecting ammeter. Then reconnect battery ground cable. Ammeter connections must carry rated output of alternator.

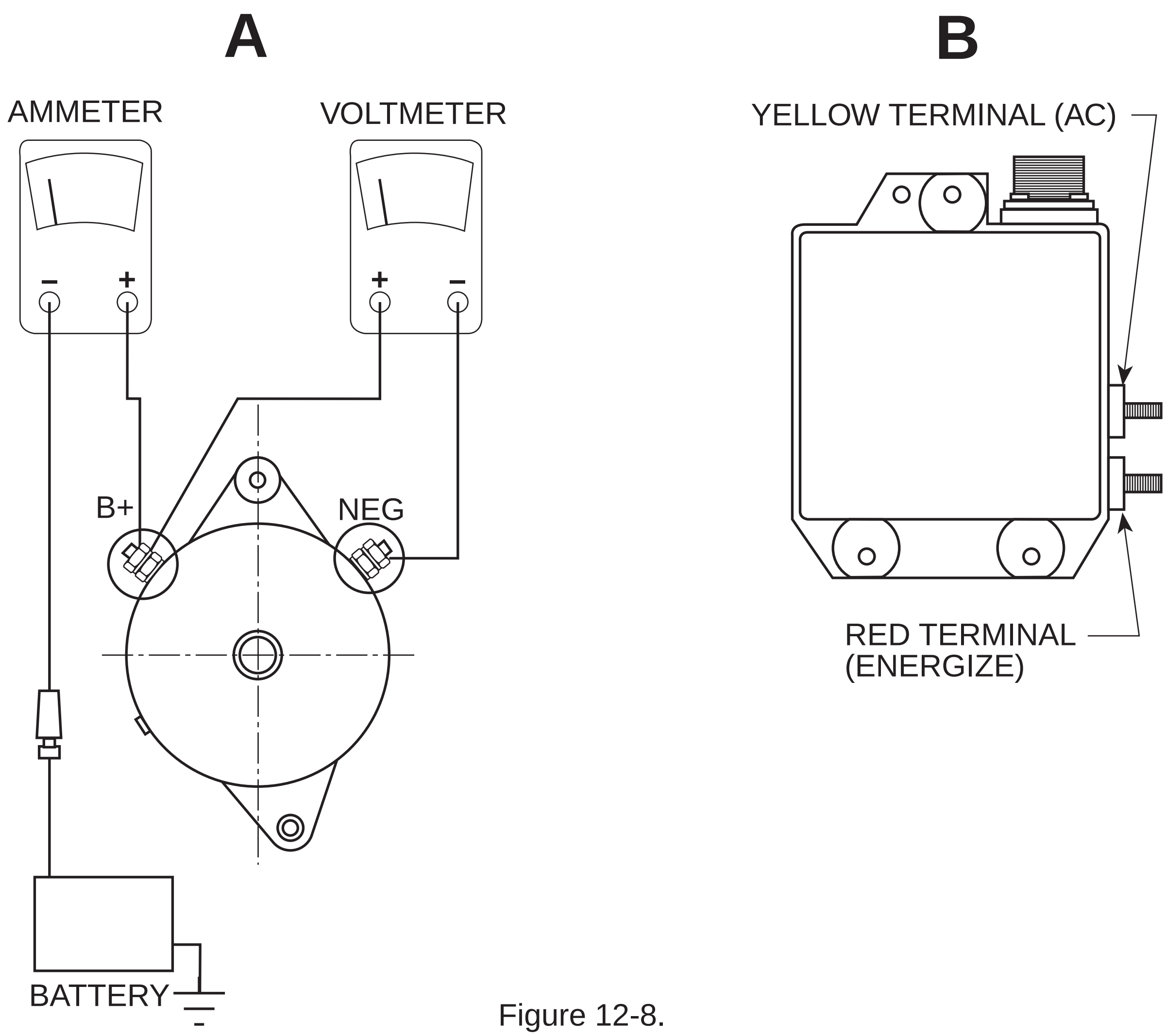


Figure 12-8.
On Vehicle Test.

d. Test Procedure

1. **Start engine.** Accelerate to high idle. **<u>Caution</u>: If voltmeter reading exceeds 30.5V, stop engine immediately and refer to Table 1-1.**

2. **Watch meter reading.** If battery is sufficiently discharged, amps should be "high". Volts should be within or below the "normal range" of Table 1-2, as battery approaches full charge, amps should fall as volts rise. When amps and volts stabilize, note readings and refer to Table 1-1.

AMPS	VOLTS	DIAGNOSIS
HIGH	LOW	Charging system is OK. Battery is not yet fully charged. Wait for charging system to bring to full charge: AMPS should fall and VOLTS should stabilize within normal range (Table 1-2).
HIGH	NORMAL	Watch until AMPS fall or Volts exceed normal range (Table 1-2). If AMP fall and Volts remain normal, charging system is OK. If Volts exceed normal, regulator and/or tube assembly should be replaced. (Go to Static Tests)
HIGH	HIGH	**STOP TEST.** Regulator and/or tube assembly should be replaced. (Go to Static Tests)
LOW	LOW	Make sure voltmeter leads attached at alternator. If connections are OK, alternator and/or regulator must be repaired or replaced.
LOW	NORMAL	Charging system is OK.
LOW	HIGH	**STOP TEST.** If battery and voltmeter check OK, regulator and/or tube assembly must be replaced.

TABLE 1-1.Troubleshooting.

ALTERNATOR (REGULATOR)	SYSTEM VOLTAGE	FACTORY SETTING	NORMAL ADJUSTING RANGE
N3103	28	28.2 ±.2	27.0 – 29.4

Table 1-2.Voltage Regulator Specifications.

NOTE:
Regulator set at 28.2 ±.5 volts at 72°F and compensate for temperature variation of –0.1 volt per 10°F.

e. Static Checks: Partially Disassembled Alternator

Static Tests are performed on the partially disassembled alternator to confirm component failure indicated by On-Vehicle Test and Bench Tests

1. Equipment: Ohmmeter, Simpson 260 or equivalent Regulator Tester, Zetron or equivalent, or Ohmmeter Diode Tester or Ohmmeter.

2. Remove the pulley (refer to Disassembly Procedure).

Disconnect all phase leads attached to the heatsink (“P1” through “P6”) in Figure 12-9. Disconnect alternator connector from voltage regulator.

Before repairing the alternator, perform ALL Static Tests.

f. Field Coil Test

1. Remove both field coil (F+, F-) leads from terminal studs on the front housing. (See Figure 12-9).

2. Check for open field coil. Set ohmmeter to x1 scale and make sure meter is zeroed. Connect ohmmeter leads to each of the two field leads and measure the resistance. Ohmmeter should read less than 3 ohms. If ohmmeter reads above the specified limit, the field coil is open and must be replaced (replace or repair stator, shell assembly or alternator).

3. Check for grounded field coil. Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Connect one ohmmeter lead to either field lead, connect the other ohmmeter lead to the front housing ground stud. The ohmmeter should read very high. If the ohmmeter reads less than 100k ohm the field coil is grounded and must be replaced (replace or repair stator, shell assembly or alternator).

4. Replace both field coil (F+, F–) leads before performing electrical continuity check.

g. Electrical Continuity Check

Note
Make sure coil (F+, F–) leads are connected to terminal studs.

1. Set ohmmeter to x10 scale and make sure meter is zeroed.

2. Probe the alternator connector pins to insure all internal wiring is intact. (Refer to figure 12-9, page 14).

ALTERNATOR HARNESS CONNECTOR	MEASURE TO:	READING
Pin A	B+ Stud	2.3 ± .3
Pin B	"R" Terminal Test Point	Less than 1 ohm
Pin C	GND Stud	Less than 1 ohm
Pin D	B+ Stud	Less than 1 ohm

Table 1.3

h. Diode Heatsink Tests

Remove all phase leads (P1-P6) from front housing (refer to figure 12-9 page 14). Note: Do not allow sleeving on leads to slide down leads; phase terminals without sleeves can short to alternator body.

The diode heatsink assembly is normally checked using a diode tester. If a diode tester is used, refer to manufacturer's instructions for proper connections. When a diode tester is not available, use an ohmmeter and refer to the following procedure. Note: Do not use an AC device, such as a leakage tester to check the diode heatsink.

1. Check positive diodes (Refer to Figure 12-9, page 14). Set ohmmeter to x 100 scale and make sure ohmmeter is zeroed. Connect one ohmmeter lead to the B+ output connector. Connect the other ohmmeter lead to each of the six heatsink phase terminals "S". All six readings should be nearly alike; either less than 600 ohms, or very high. If all six readings are not alike, the diode rectifier assembly is defective and the heatsink assembly or front housing assembly must be replaced.

Reverse ohmmeter leads, and again observe resistance between the “B+” stud of the output connector and each of the six heatsink terminals “S”. All six readings should be nearly alike, and opposite the readings obtained previously; if all readings were less than 600 ohms before, all readings should be very high now, and vice versa. If any reading is not alike the diode rectifier assembly is defective and the heatsink assembly must be replaced.

2. Check negative diodes (Refer to Figure 12-9). Set ohmmeter to x100 scale and make sure ohmmeter is zeroed. Connect ohmmeter lead to the ground terminal located on the outside of the front housing, connect the other ohmmeter lead to each of the six heatsink phase terminals “S”. All six readings should be nearly alike; either less than 600 ohms, or very high. If all six readings are not alike, the diode rectifier assembly is defective and the heatsink assembly is defective, and the heatsink assembly or front housing assembly must be replaced.

   Reverse ohmmeter leads, and again observe resistance between ground terminal and each of the six heatsink phase terminals “S”. All six readings should be nearly alike, and opposite the readings obtained previously; if all readings were between less than 600 ohms before, all readings should be very high now, and vice versa. If any reading is not alike, the diode rectifier assembly is defective and the heatsink assembly or front housing assembly must be replaced.

NOTE

Heatsink diodes are derated for heavy duty performance. If diode failure is detected the entire charging system should be examined for loose connections (especially battery). If diode failure is indicated, stator failure must be suspected.

i . Stator Tests

The alternator has two separate stator assemblies that will be checked individually. Make sure that all phase leads are disconnected from the heatsink (Refer to Figure 12-9).

1. Check front stator. Set ohmmeter to x1 scale and make sure ohmmeter is zeroed. Check for open stator windings by connecting ohmmeter between each successive pair of stator phase leads (Refer to Figure 12-9), (“P1”-”P2", “P2”-”P3", and “P1”-”P3"). Note it may be necessary to probe under the sleeves of the phase leads in order to make electrical contact. Ohmmeter should read less than 1 ohm between each pair of stator phase windings. If ohmmeter reads very high (infinity) the stator is open and must be replaced (replace or repair stator and shell assembly).

   Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Check for shorted stator windings by connecting ohmmeter between each phase lead (“P1”, “P2”, and “P3”) and the ground terminal located on the outside of the front housing. Ohmmeter should read very high (infinity). If ohmmeter reads zero the stator is grounded and must be replaced (replace or repair stator and shell assembly).

Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Check for shorted stator windings by connecting ohmmeter between each phase lead (“P4”, “P5”, and “P6”) and the ground terminal located on the outside of the front housing. Ohmmeter should read very high. If ohmmeter reads zero the stator is grounded and must be replaced (replace or repair stator and shell assembly).

NOTE:
Disassemble alternator only as far as necessary to replace defective part.

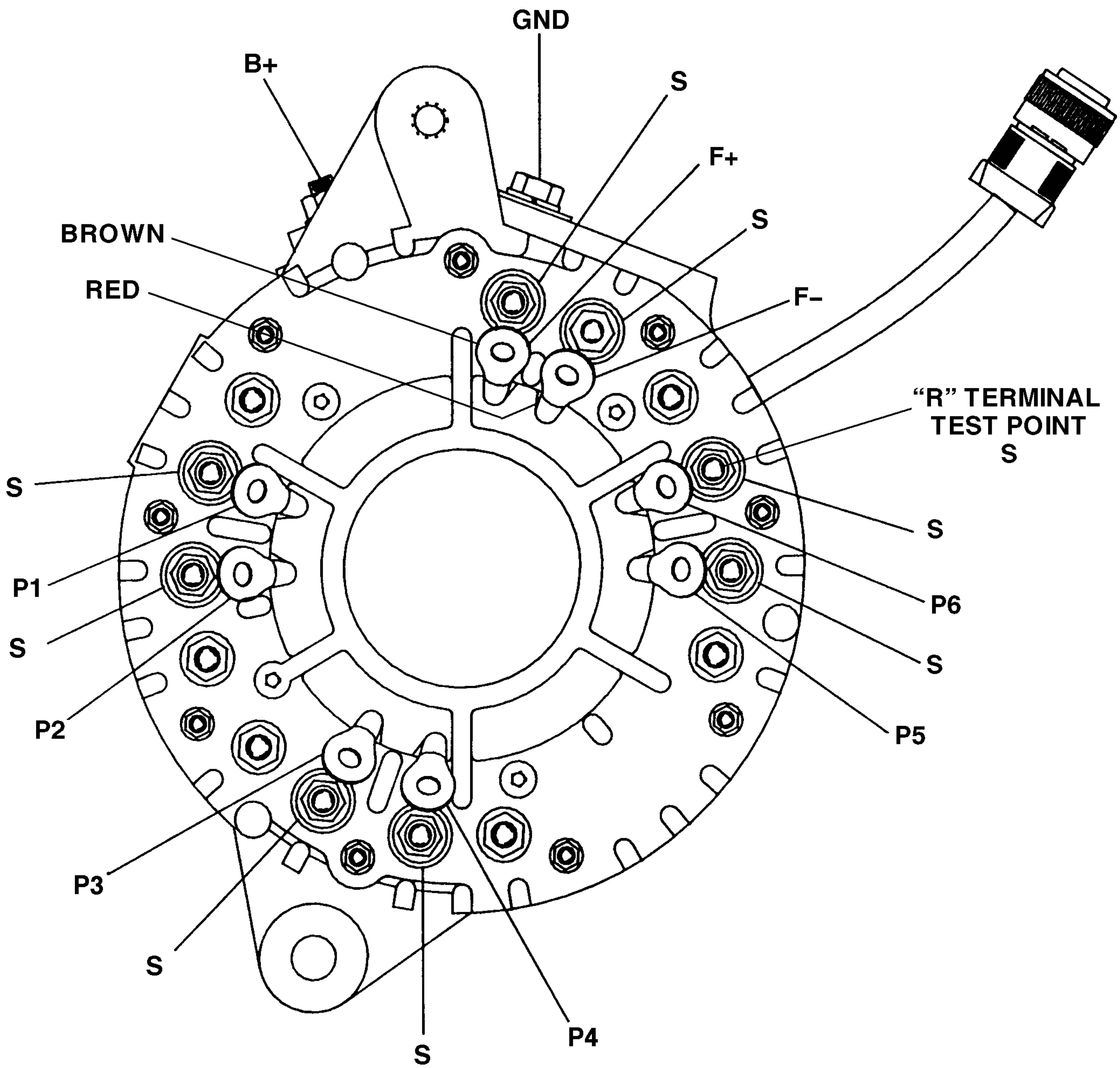


Figure 12-9.

G. PROTECTIVE CONTROL BOX TESTING (Figure 12-10)

WARNING

Negative battery cable must be disconnected before removing any connector from the protective control box, or injury to personnel or damage to equipment may result.

NOTE

During continuity check of pin "A" and pin "G" at the body harness connector, the ignition switch must be in the "START" position.

1. Disconnect body harness connector and engine harness connector from protective control box. Check for continuity between pin "A" and "G" on the body harness connector. Continuity should be between 0.1–0.3 ohms. If the incorrect reading is found go to step 2. If the correct reading is found, go to step 3.

2. Disconnect lead 14B from the neutral start switch. Check for battery voltage at neutral start switch lead 14 with rotary switch in "START". If battery voltage is present, disconnect the negative battery cable from battery, both cannon plugs from protective control box and lead 74A from starter. Ground lead 74A and check pin **I** on the engine wiring harness cannon plug for the control box. If continuity is present, check lead 14B on neutral start switch to pin A on the body wiring harness cannon plug for the control box. If continuity is present, replace the control box. If no continuity is present, repair wiring harnesses. Reconnect

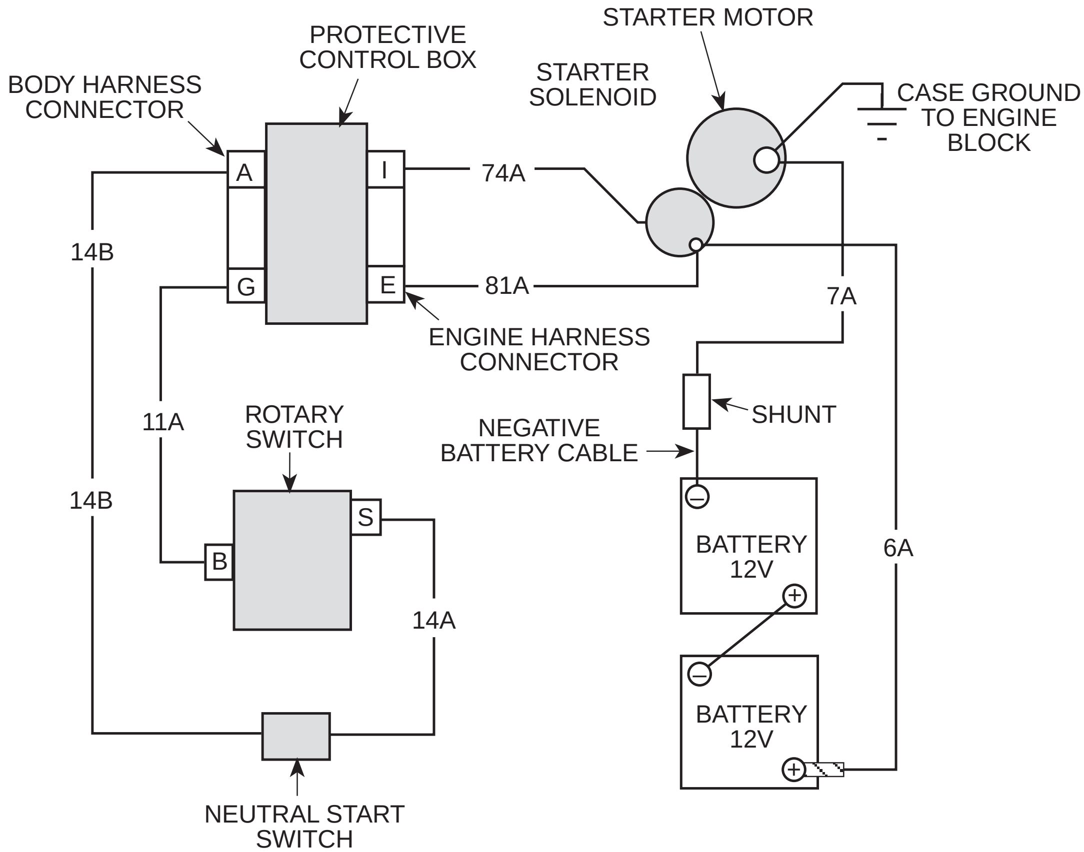


Figure 12-10. Starting System Schematic– Protective Control Box Testing.

protective control box cannon plugs, neutral start switch lead 14B, starter lead 74A to starter, and negative battery cable to battery.

3. Disconnect negative battery cable from battery and disconnect protective control box cannon plugs from protective control box. Reconnect negative battery cable to battery. Check pin E of engine wiring harness cannon plug for battery voltage. If voltage is present, check for continuity from pin G on control box body wiring cannon plug to lead 11A of rotary switch. If continuity is present, replace protective control box. If no continuity is present, repair body wiring harness.

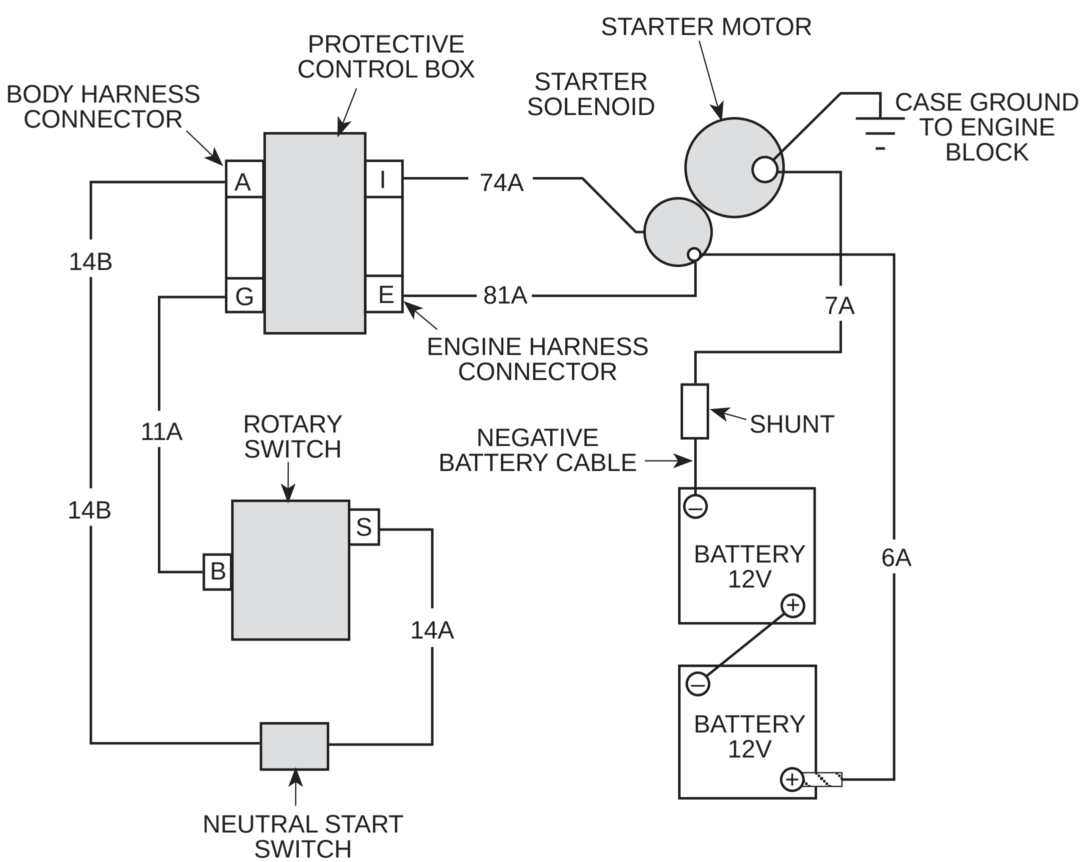


Figure 12-10. Starting System Schematic–
Protective Control Box Testing.

H. LIGHT TESTING

1. Disconnect body wiring harness from light switch. Using multimeter, check for battery voltage at terminal “F” in body wiring harness connector. If battery voltage is not present, repair body wiring harness. If wiring harness cannot be repaired, replace the wiring harness.

2. Working from Table 12-8, Lighting Circuit Chart, connect a jumper wire from terminal “F” to circuit terminal being tested. If lamps light with jumper wire connected, replace main light switch. If lamps do not light, repair or replace hood wiring harness (front lights only), or repair body wiring harness.

3. Working from Table 12-9 light switch continuity chart, position light switch control levers to position indicated for circuit function being tested. Check for continuity between light switch connector pins as shown. If continuity is not present at the appropriate light switch connector pins, replace main light switch.

CIRCUIT CHART

PIN	WIRE NO.	CIRCUIT
B	40A	Panel Lights
C	22A	Directional Control (Service Stoplight)
D	19A	B. O. Driving Light
E	20-24A	B. O. Marker Lights
F	15A	Battery Pos. 24 Volts
H	21A-491A	Service Rear & Parking Lights
J	46C-461A	Directional Indicator
M	16A	Service Headlights
N	23A	B. O. Stoplight

Table 12-8. Lighting Circuit Chart

LIGHT SWITCH CONTINUITY CHART

CIRCUIT FUNCTION BEING TESTED	LIGHT SWITCH LEVER POSITION	CONTINUITY CHECK PINS
	Off	Check all pins (pin to pin) for infinity
Switch	Park	A to B, H to L
Switch	Dim	A to B, H to M
Switch	Panel Bright	A to B, H to M
Service Stoplights	Stoplights	A to F, C to K
Directional Indicators (turn signals)	Service Drive	F to H
Parking, Tail, and Side Marker Lights	Service Drive	F to H
Panel Lights	Service Drive (panel lights bright)	F to B
Headlights	Service Drive (panel lights bright)	F to M
Front and Rear Blackout Marker	Blackout Marker	F to E
Blackout Stoplamps	Blackout Marker	F to A, K to N
Blackout Headlamps	Blackout Drive	F to D

Table 12-9. Light Switch Circuit Chart.

I. HIGH BEAM SELECTOR SWITCH TESTING (Figure 12-12)

Remove high beam selector switch and check for battery voltage at lead 16A. If voltage is present, check high beam selector switch for continuity between leads 16 and 17 in high position, and leads 16 and 18 in low position. If continuity is not present in either position when selected, replace high beam selector switch.

END OF TESTING!

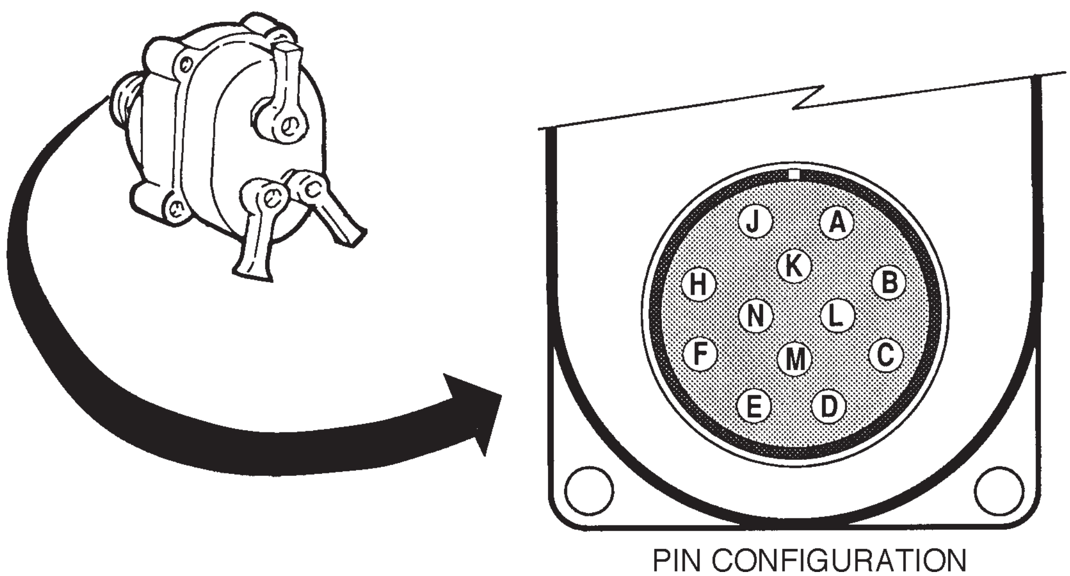


Figure 12-12. Master Lightswitch Pin Configuration.

J. STOPLIGHTS INOPERATIVE OR DO NOT OPERATE PROPERLY (Figure 12-13)

1. Check stoplight switch adjustment. Adjust stoplight switch.

2. Disconnect leads 75A and 75B from stoplight switch. Using multimeter, check leads on stoplight switch for continuity while operating switch. If continuity is not present, replace stoplight switch.

3. Check body wiring harness light switch cannon plug pins A to K for continuity while operating stoplight switch. If no continuity is present, repair body wiring harness.

END OF TESTING!

K . TURN SIGNALS INOPERATIVE OR DO NOT OPERATE PROPERLY (Figure 12-13 and 12-14)

1. Disconnect negative battery cable and body wiring harness connection from turn signal switch. Using multimeter, check continuity of leads 467A and 467B from the body harness light switch connector pin J to body harness turn signal switch connector pin G. If continuity is not present, repair body wiring harness.

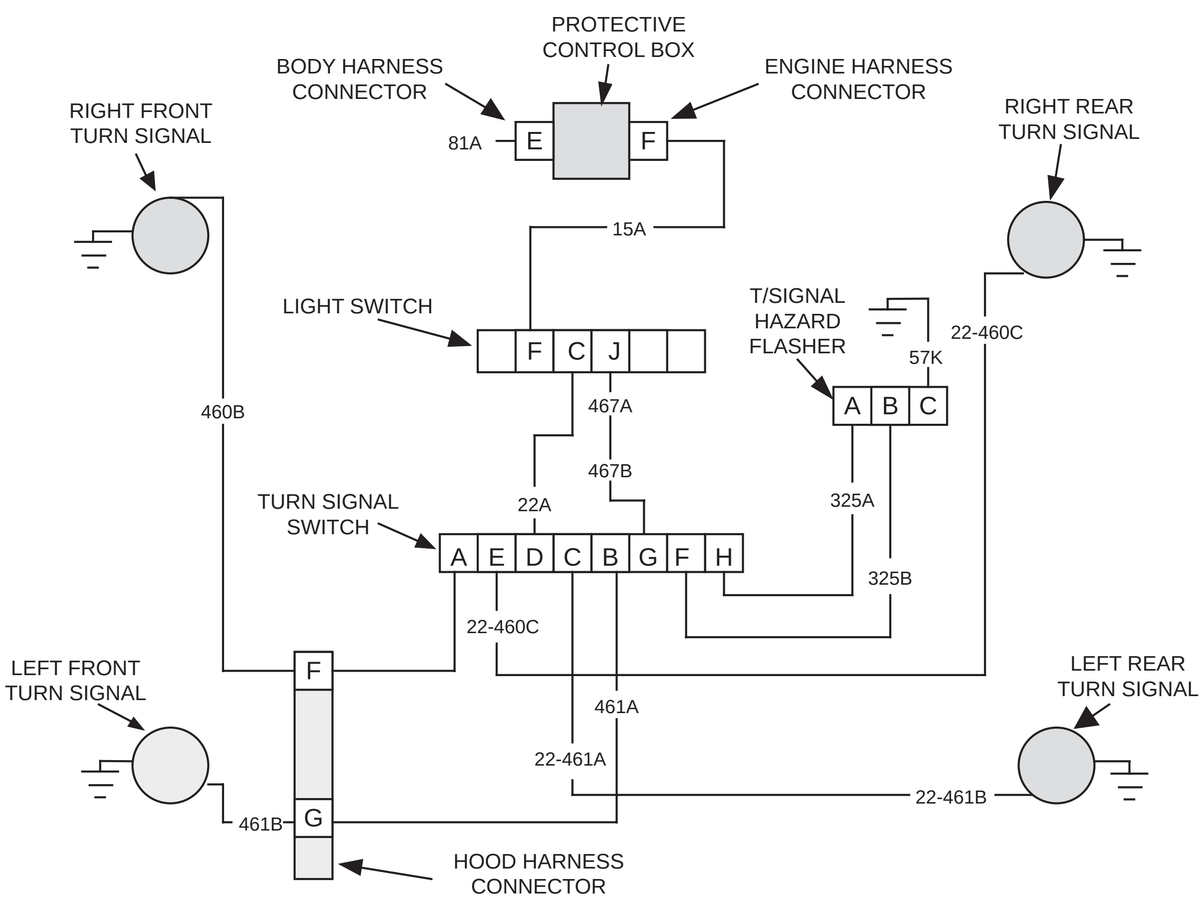


Figure 12-13. Turn Signal System Schematic.

Refer to Figure 12-14 for the following step.

2. Using multimeter, check continuity of turn signal switch from pin G to pin F with turn signal switch in left, right and hazard positions. If continuity is not present, replace turn signal switch.

3. Disconnect wiring harness from turn signal flasher. Using multimeter, check for continuity between lead 57K (terminal C) and ground. If continuity is not present, repair body wiring harness.

4. Set control lever in left hand or right hand positions. Using multimeter, check for battery voltage at lead 325B in turn signal flasher harness connector. If battery voltage is present, connect a jumper from lead 325A (terminal A) to lead 325B (terminal B) in flasher harness connector, if turn signal lamps light, replace flasher.

5. Disconnect wiring harness from directional signal control. Remove indicator lamp from control unit. Using multimeter, test for continuity using Table 12-3 Control Unit Test Chart. If any circuit does not test as shown on chart, replace directional signal control.

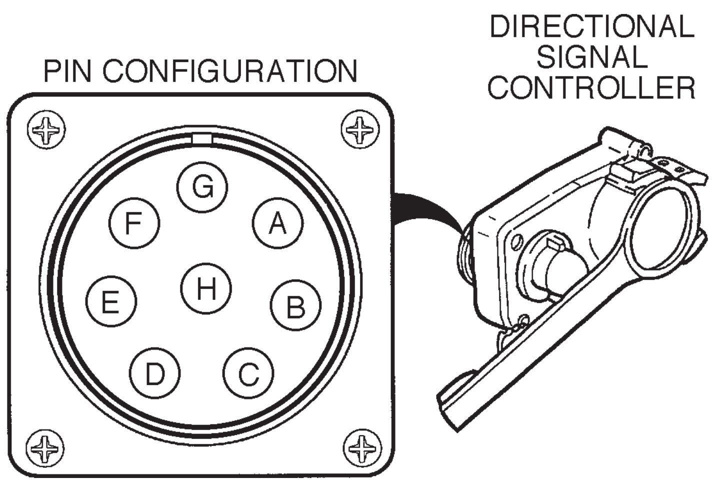


Figure 12-14. Turn Signal Pin Configuration.

CONTROL UNIT TEST CHART

A. DIRECTIONAL SIGNAL CONTROL LEVER IN “NEUTRAL” POSITION			C. DIRECTIONAL SIGNAL CONTROL LEVER IN “RIGHT TURN” POSITION		
FROM PIN	TO PIN	CONTINUITY INDICATION	FROM PIN	TO PIN	CONTINUITY INDICATION
H	A	OPEN	F	G	SHORTED
H	B	OPEN	H	A	SHORTED
H	C	OPEN	H	E	SHORTED
H	E	OPEN	H	B	OPEN
D	C	SHORTED	H	C	OPEN
D	E	SHORTED	D	C	SHORTED
F	G	OPEN	D	E	OPEN

B. DIRECTIONAL SIGNAL CONTROL LEVER IN “LEFT TURN” POSITION			D. DIRECTIONAL SIGNAL CONTROL LEVER IN “HAZARD WARNING” POSITION		
FROM PIN	TO PIN	CONTINUITY INDICATION	FROM PIN	TO PIN	CONTINUITY INDICATION
H	B	SHORTED	H	A	SHORTED
H	C	SHORTED	H	B	SHORTED
H	A	OPEN	H	C	SHORTED
H	E	OPEN	H	E	SHORTED
F	G	SHORTED	D	E	SHORTED
D	E	SHORTED	D	C	SHORTED
D	C	OPEN	F	G	SHORTED

Table 12-10. Control Unit Test Chart.

5. Position main light switch lever to stoplight position. Working from Table 12-4 circuit chart, connect a jumper wire (minimum 14 AWG) from pin G of the turn signal switch body harness connector to theappropriate pin of the circuit being tested. If lamps do not light, repair or replace hood wiring harness.

CIRCUIT CHART

PIN	WIRE NO.	CIRCUIT
A	460A	Right Front Turn Signal
B	461A	Left Front Turn Signal
C	22-461A	Left Rear Turn Signal
E	22-460A	Rear Rear Turn Signal

Table 12-11. Circuit Chart.

L. ONE OR MORE TRAILER LIGHTS INOPERATIVE (VEHICLE LIGHTING SYSTEM FUNCTIONS NORMALLY) (Figure 12-15)

1. Position light switch to circuit being tested. Check for battery voltage at sockets. If battery voltage is present, replace bulb with bulb known to be operative. If bulb does not light, check for corroded connections, loose lamp sockets, or damaged wire terminals, repair or replace any damaged components.

2. Using multimeter, check for continuity between pins D and L of trailer receptacle to frame. If continuity is not present, repair body wiring harness.

3. Position light switch in circuit being tested. Using multimeter, connect ground lead to terminal L in trailer receptacle. Using Table 12-12 (page 12-26) Trailer Receptacle Circuit Chart, connect positive lead from multimeter to circuit terminal in trailer receptacle being tested. If battery voltage is present, repair trailer wiring harness. If battery voltage is not present, repair body wiring harness.

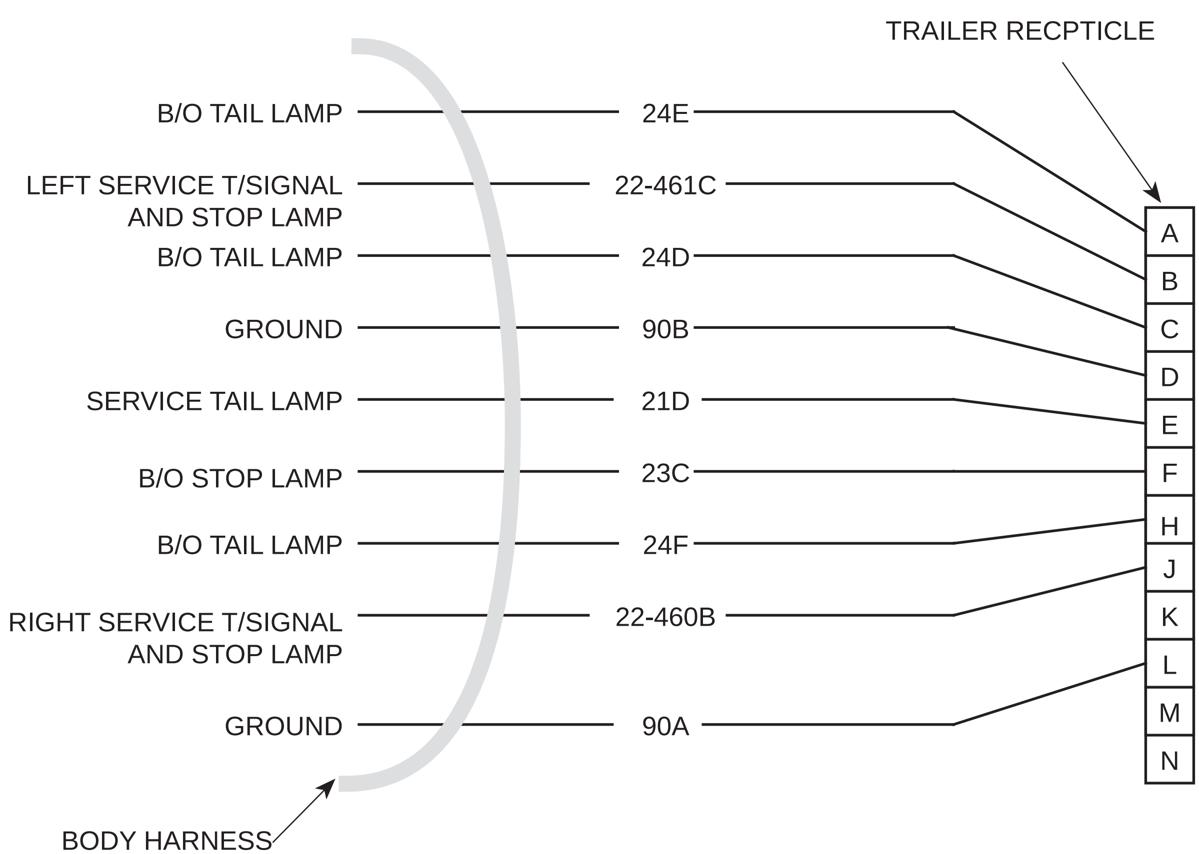


Figure 12-15. Trailer Lighting System Schematic.

TRAILER RECEPAICLE CIRCUIT CHART

PIN	WIRE NO.	CIRCUIT
A	24E	Rear B.O. Marker (LH)
B	22-461A	Service Stoplight (LH)
C	24D	Rear B.O. Marker (RH)
D	90B	Ground to Frame
E	21D	Service Taillight
F	23C	B.O. Stoplight
H	24F	B.O. Marker Lights
J	22-460B	Service Stoplight (RH)
K	None	Not Used
L	90A	Ground to Frame
M	None	Not Used
N	None	Not Used

Table 12-12. Trailer Receptacle Circuit Chart

M. WARN 6000 POUND , 24 VDC WINCH ELECTRICAL TROUBLESHOOTING PROCEDURES

a. Power Supply

Check for tight fit of all connections and use a volt meter to verify battery voltage at the bus bar connecting solenoids #1 and #3 (Figure 12-16). Connect black test lead to ground and red test lead to the hot bus bar, ***(100 amps minimum required for testing, 200 amps minimum required for operation).***

Note

The black insulating coating can sometimes contaminate electrical terminals and may need to be scraped off of contact surfaces.

b. Grounding

The Solenoid mounting plate should be grounded to the motor by means of a band clamp. Newer model winches will also have a ground wire connecting the mounting plate with the motor ground bolt **(-)**. Use an ohm meter to measure resistance between the mounting plate and the motor case; resistance should be less than 1 (ohm).

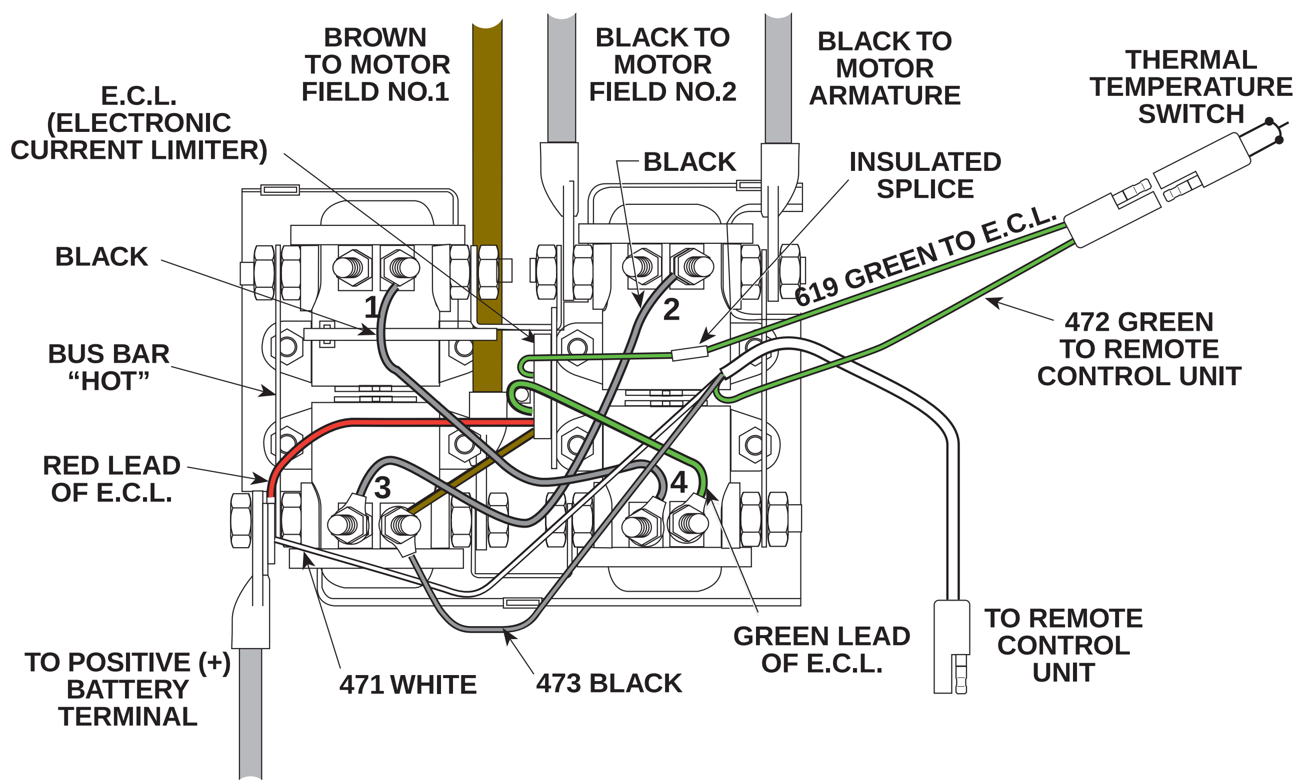


Figure 12-16. Winch Testing.

c. Electronic Current Liiter (ECL)

Note

The ECL can be tripped when first powered 'on' so always reset by powering out the wirerope for ten (10) seconds to reset the limiter.

1. If the winch will power-out but will not power-in, the ECL may be defective. First, check that the red wire coming from the charged bus bar is connected properly and that the mounting L-bracket of the ECL circuit board is cleanly grounded to the solenoid plate.

1. If still no power-in, by-pass the ECL as follows: Cut the green ,(#619) wire coming from the thermal switch to the ECL near the splice on the ECL side (Figure 12-16)**.** Take the cut wire coming from the thermal switch and connect it to solenoid **#4** on the same terminal that the green ECL wire is attached (Figure 12-16). The winch should operate in both directions. If not, continue with the troubleshooting steps.

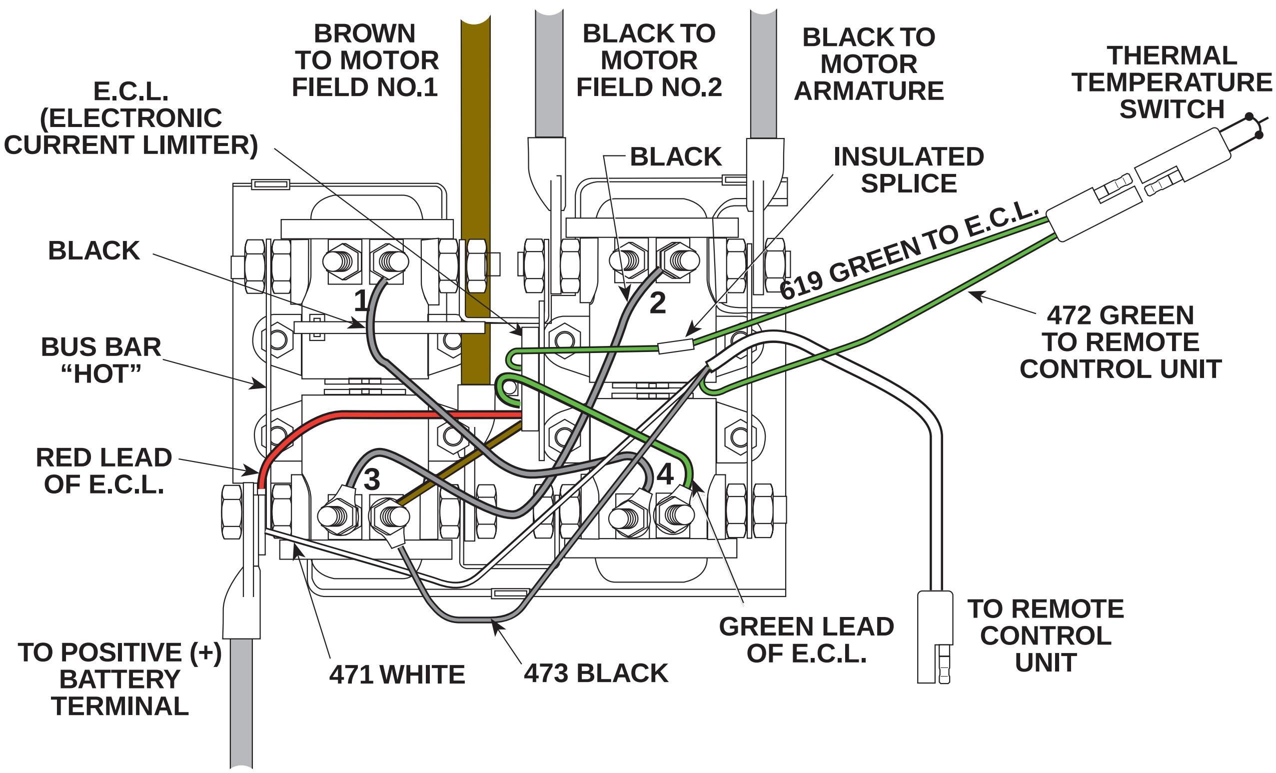


Figure 12-16 Repeat. Winch Testing.

d. Thermal Switch

Note

The motor will not run if the thermal switch is open or if its terminals are in contact with the motor case. The switch should normally open when the temperature at the motor brushes reaches 400+ F.

1. To check a faulting or shorting switch, use an ohm meter and measure the resistance of the thermal switch between the wire cut in the previous step and the socket pin (#472) of the plug, which is connected to the green wire (Figure 12-17). If the butt splice and switch are good, the resistance should be less than 1 (ohm) across the switch. If the switch is open at room

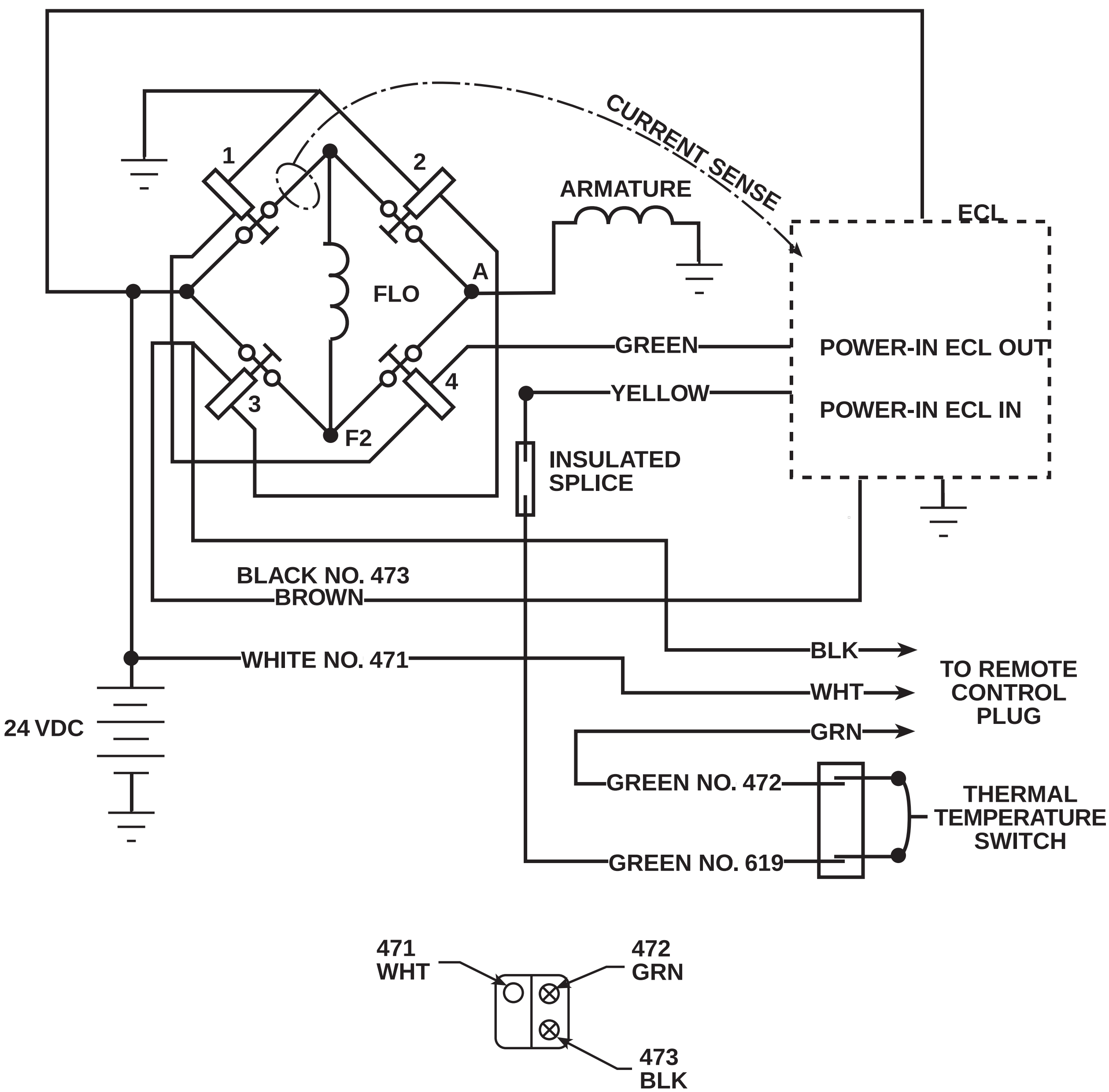


Figure 12-17Figure 12-17.Repeat. Winch Testing.

temperature then the motor should be replaced. Next, check the resistance between the cut wire and the bare motor case. The resistance should be greater than one megaohm. If not, replace motor.

e. Motor

Note

If the motor is suspected to be failing check the following.

Disconnect F1, F2 and A leads from motor. Measure the resistance from'F1' and 'F2' and between 'A' and ground. Resistance should be less than 1 (ohm). The motor brushes could be worn, or the internal wiring could be burned and the motor should be replaced.

Note

If faults were not detected in steps A, B, C, D and E, replace solenoid pack.

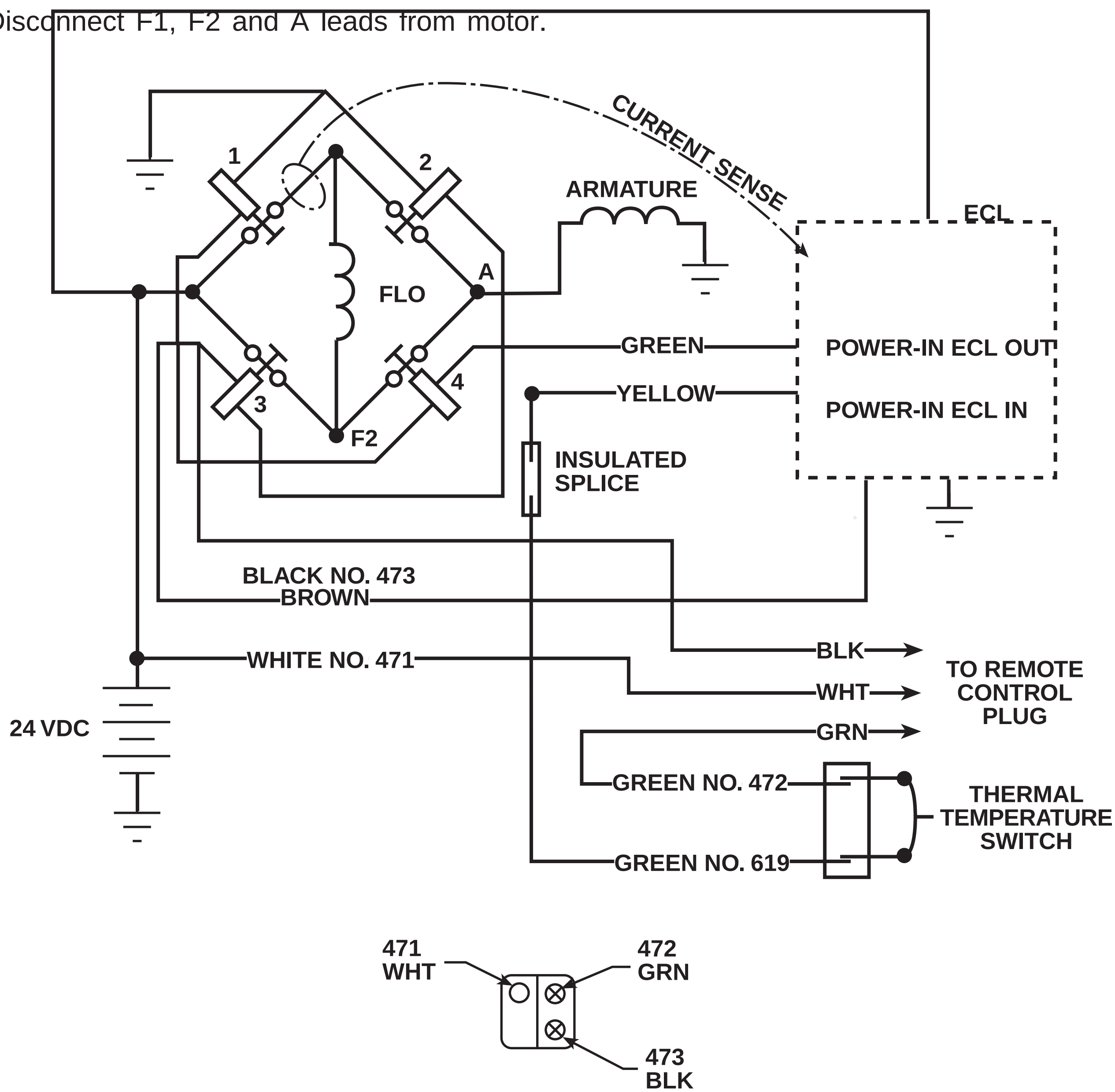


Figure 12-17.Repeat. Winch Testing.

SECTION 13
TIME DELAY MODULE OPERATION

PICTORIAL SCHEMATICS

NOTE

The following group of pictorial schematics are intended to be presented by a qualified instructor who is familiar with the Time Delay System and can properly color-code current and fluid flow.

A. TIME DELAY MODULE OPERATION (Figure 13-1).

a. Fan Temperature Switch Closed Engine Not Running (Figure 13-1)

With the rotary ignition switch (1) in the off position (open) there is no current flow to the fan temperature switch (2) or the time delay module (3) through the #458 wire. Since the electric solenoid (4) is not activated, there is no hydraulic flow through the hydraulic control valve (5) to release the fan clutch. The fan clutch remains engaged, locking the fan to the fan drive unit.

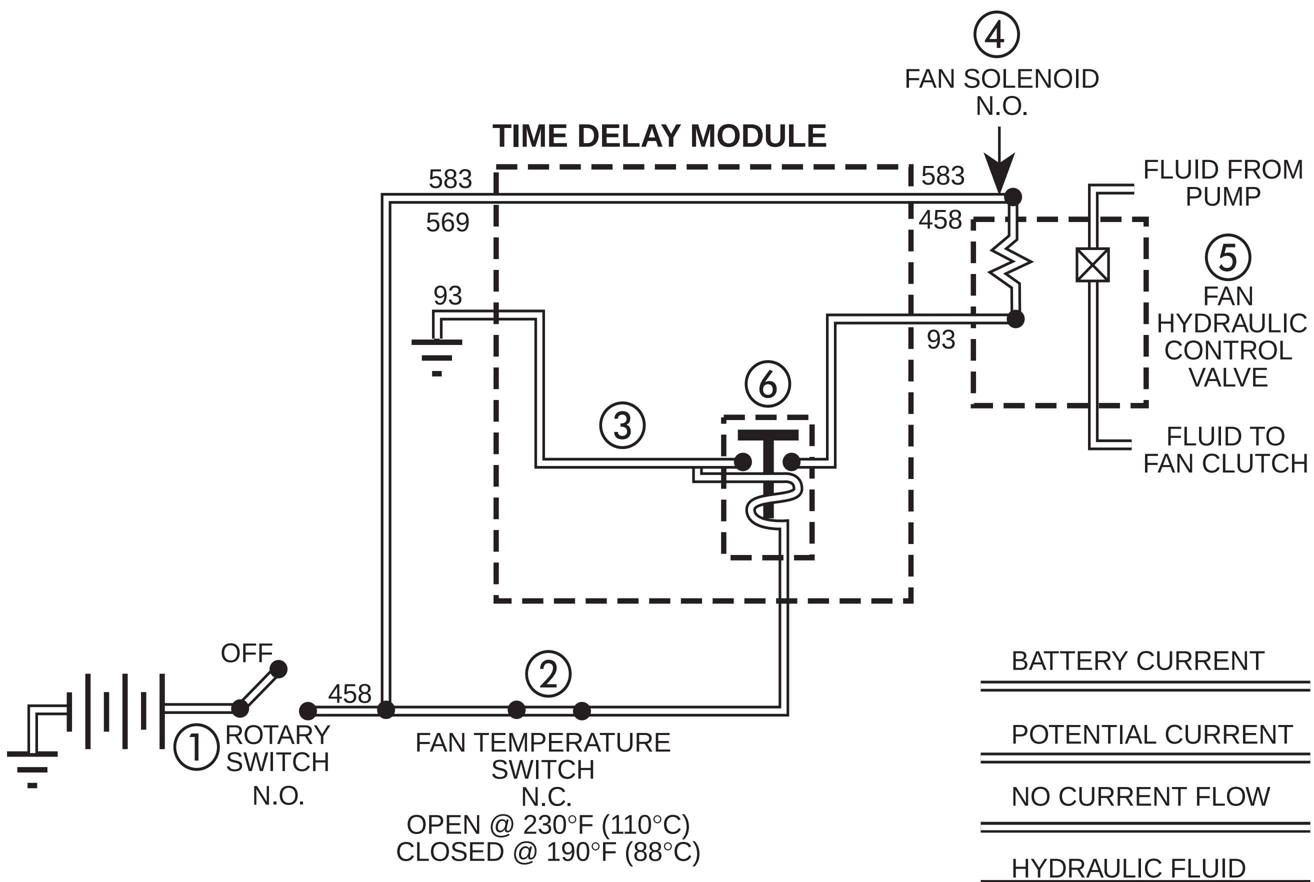


Figure 13-1. Fan Temperature Switch Closed Engine Not Running.

**b. Fan Temperature Switch Closed,
Engine Temperature below 230°F.
Engine Running. (Figure 13-2)**

1. With the rotary ignition switch (1) in the “R” (run position), current flows from the battery through the #458 wire across the normally closed (NC) fan temperature switch (2), through a relay (6), out the #98 wire to ground.

2. The current flowing through the relay (6) closes a set of points in the #93 circuit. This circuit completion now allows current to flow through the #583/569 wire, through the time delay module (3), out the time delay module via the #583/458 wire, through the fan solenoid (4), out the #93 wire, back through the time delay module (3), across the closed points (6) and out to ground.

3. This flow of current activates the fan solenoid (4), which opens the fan hydraulic control valve (5), allowing hydraulic oil to flow up to 160 PSI to the fan clutch, overcoming the spring and disengaging the fan from the fan drive, letting the fan free spin.

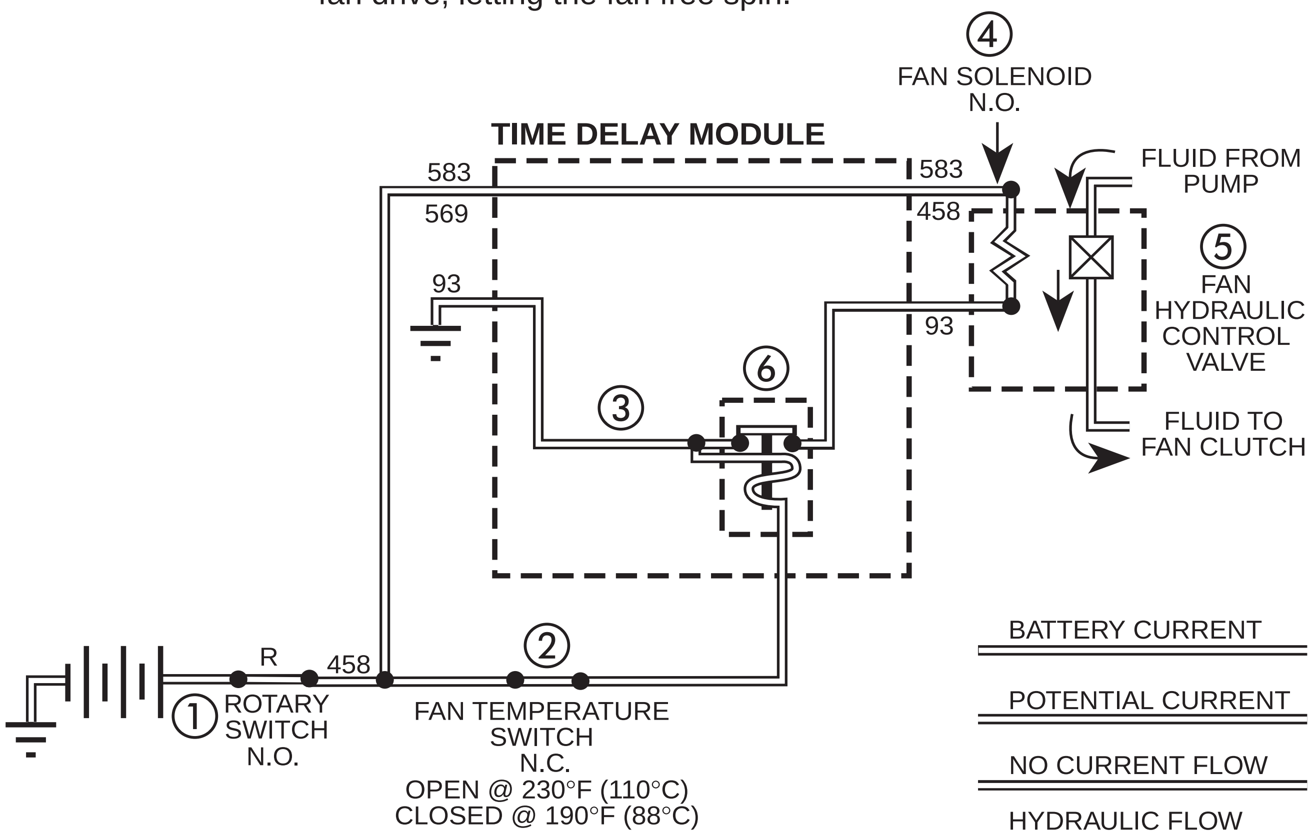


Figure 13-2. Fan Temperature Switch Closed,
Engine Temperature below 230°F.
Engine Running.

c. Fan Temperature Switch Closed
Engine Temperature Below 230°F.
(Figure 13-3)

1. When the engine temperature reaches 220°F, the normally closed fan temperature switch (2) opens. The open switch breaks the completed circuit through the relay (6) to the #93 ground wire.

2. The points opening, break the completed #583/458 circuit through the fan solenoid (4) to ground.

3. When the fan solenoid (4) is de-energized, the fan hydraulic control valve (5) closes, blocking hydraulic fluid flow from the pump to the fan clutch, letting the fan clutch lock the fan to the fan drive for engine cooling.

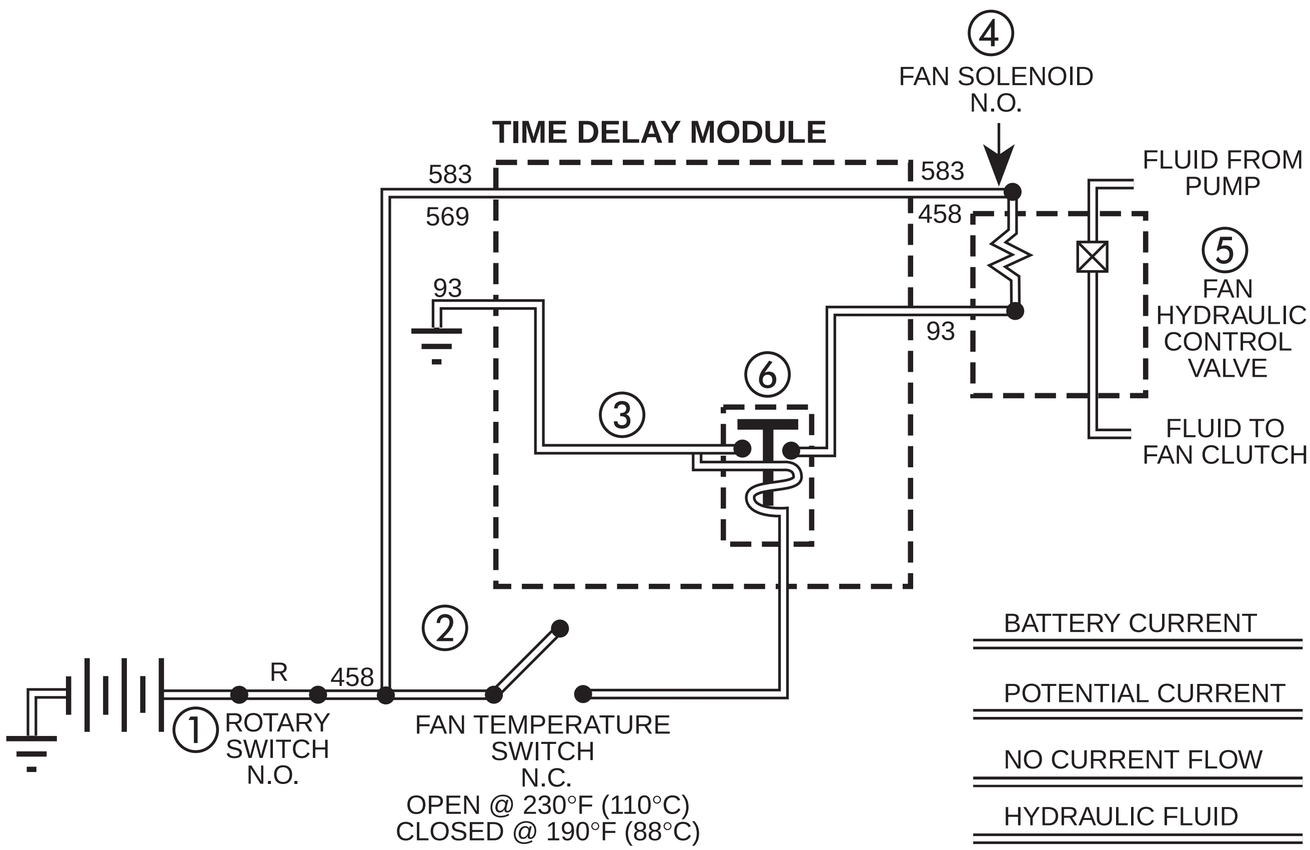


Figure 13-3. Fan Temperature Switch Closed
Engine Temperature Below 230°F.

**d. Fan Temperature Switch Open
Engine Temperature Above 230°F
Kickdown Switch Closed (Figure 13-4)**

1. Engine temperature is above 220°F and the fan clutch is engaged, turning the fan for engine cooling.

2. When extra horsepower is required, the kickdown switch (7) is activated, completing the #315 circuit. Current flows from the batteries through the #458 wire, through the #315 wire, across the closed kickdown switch (7), through the normally open 20 second timer (8) and out the #93 wire to ground.

3. The 20 second timer closes the points (9) in the #93 circuit, letting current flow through the #583/458 circuit to the fan solenoid (4) through the #93 wire, across the closed points (9) and out to ground.

4. This flow of current through the fan solenoid (4) opens the control valve (5) and holds it open as long as the timer (8) is activated. This allows oil to flow to the fan clutch, overriding the spring pressure, disengaging the fan clutch and giving the engine an approximate 12-15 horsepower boost.

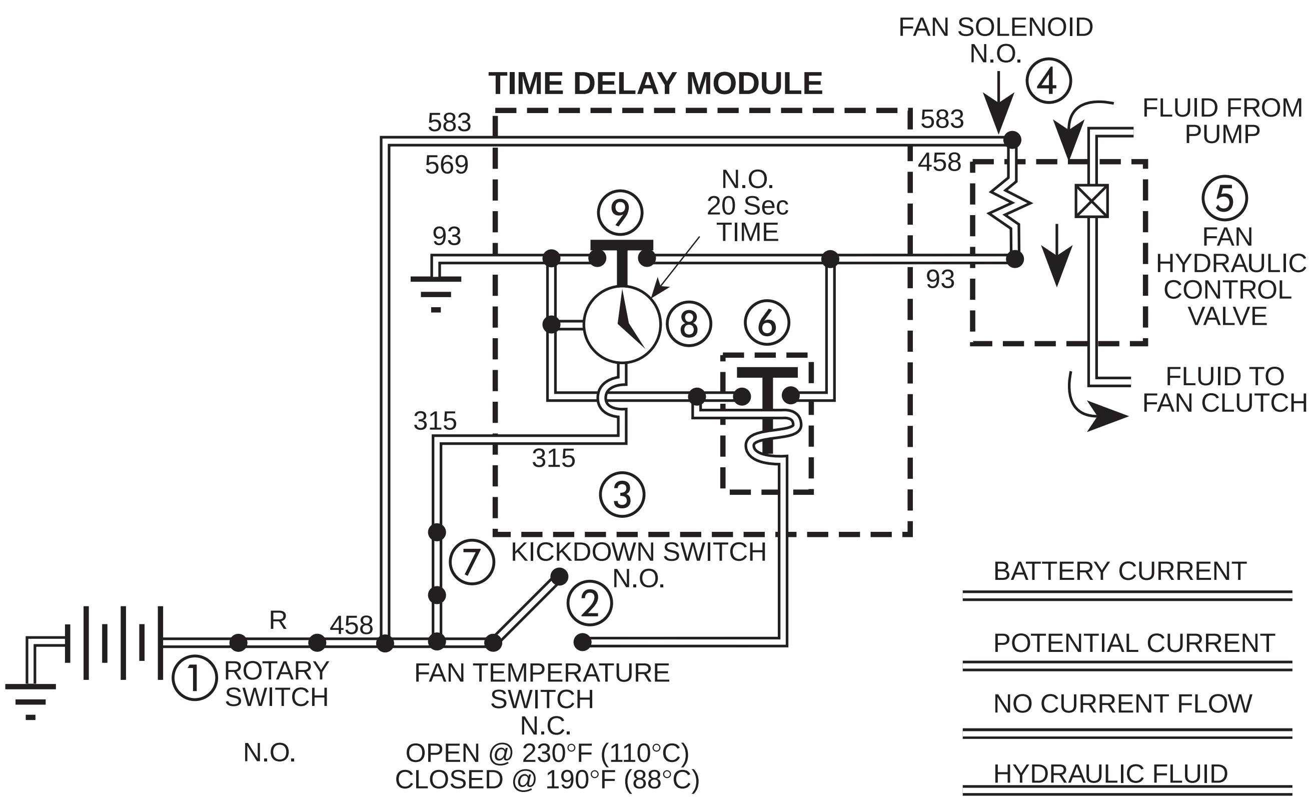


Figure 13-4. Fan Temperature Switch Open
Engine Temperature Above 230°F
Kickdown Switch Closed.

**e. Fan Temperature Switch Open
Engine Temperature Above 230°F
Kickdown Switch Closed (Figure 13-5)**

The first 20 second timer (8) actually operates a dual set of points (9) simultaneously. Current flows across the second set of points (9), into a capacitor (10), charging the capacitor.

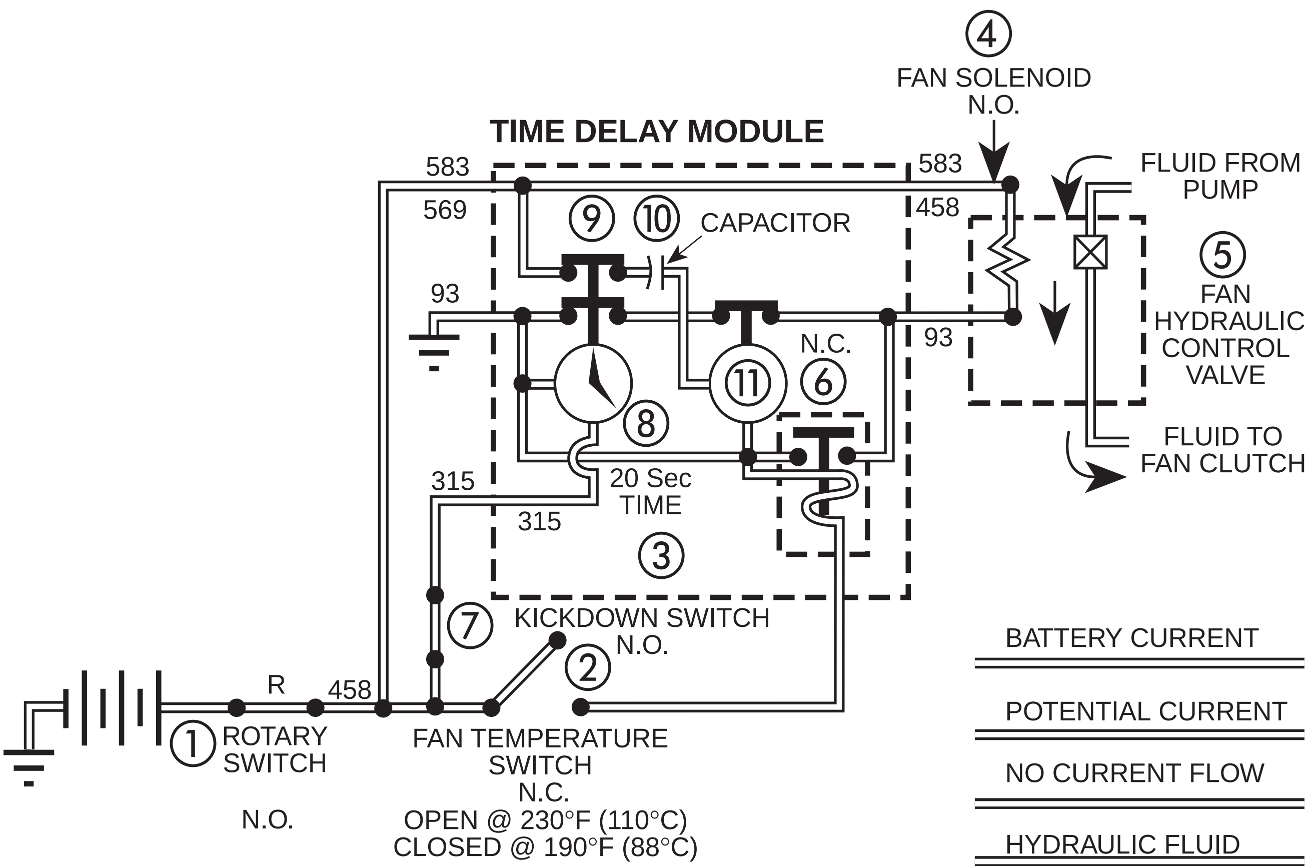


Figure 13-5. Fan Temperature Switch Open
Engine Temperature Above 230°F
Kickdown Switch Closed.

f. Fan Temperature Switch Open Engine Temperature Above 230°F Kickdown Switch Open (Figure 13-6)

1. After the first 20 second timer (8) expires, the dual points (9) open, breaking the completed #93 circuit and the fan clutch is engaged for extra engine cooling.

2. When the current to the capacitor (10) is interrupted, the capacitor (10) discharges its stored current through the second 20 second timer (11) and out the #93 wire to ground. This discharge of current activates the #2 timer (11), opening the points in the #93 circuit (12).

3. If the kickdown switch (7) is activated again (while the #2 timer is in its 20 second cycle) the fan will not disengage. After the #2 timer completes its 20 second cycle, the kickdown switch (7) can be activated and the fan will disengage again, giving the engine an additional gain in horsepower.

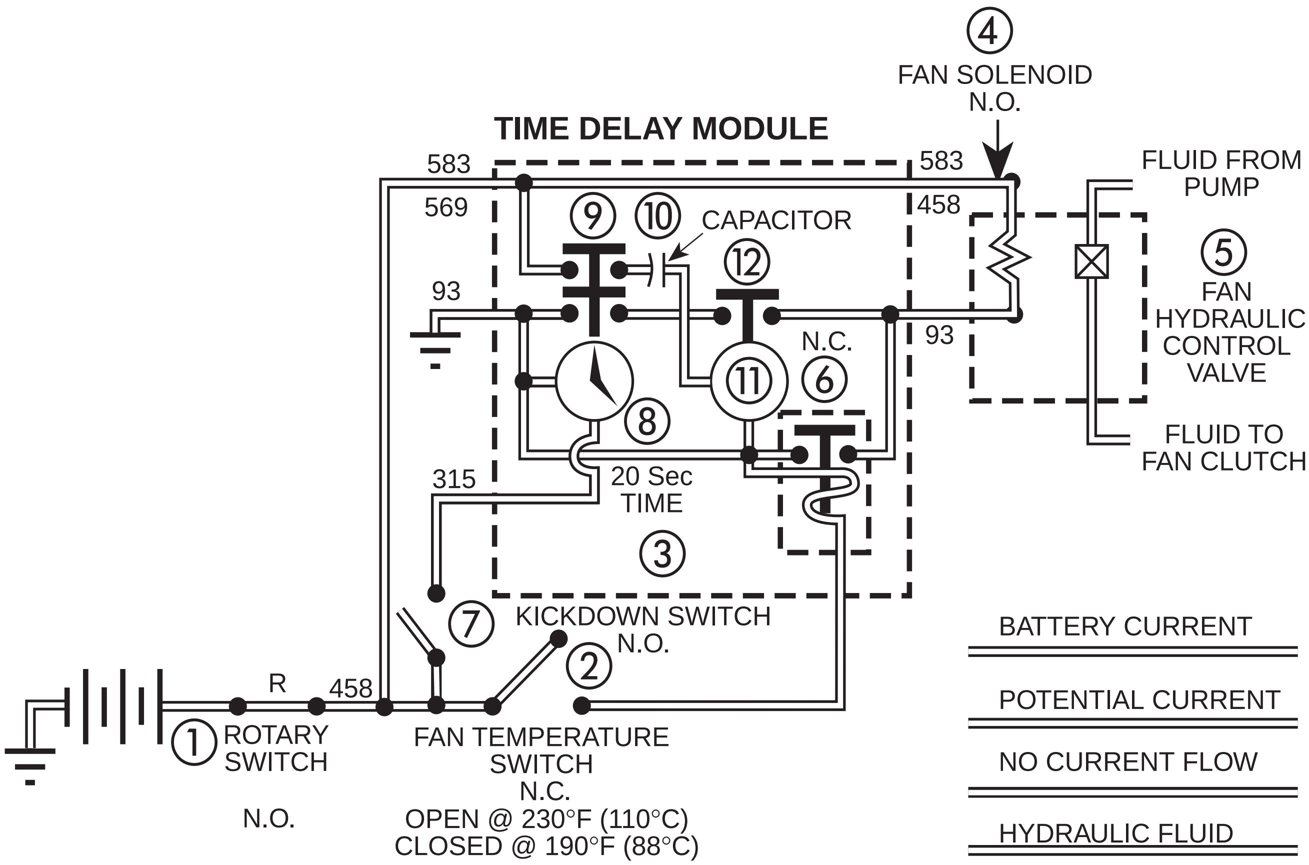


Figure 13-6. Fan Temperature Switch Open Engine Temperature Above 230°F Kickdown Switch Open.

B. TIME DELAY MODULE TESTING

a. Description

The time delay module sends a delayed signal to the fan clutch solenoid for delay of fan actuation to provide needed horsepower for engine acceleration. During normal engine operation [(engine coolant temperature below 230°F) (110°C)], current flows through the time delay module energizing the fan solenoid circuit This provides hydraulic pressure to overcome spring pressure thereby disengaging the fan clutch.

When engine coolant temperature exceeds 230° F(110°C), current is interrupted by the fan temperature switch. This interruption of current causes the time delay relay to open, thereby de-energizing the fan solenoid circuit and allowing the fan to engage for additional cooling. If the kickdown switch is actuated during fan operation, the time delay is activated, disengaging the fan for approximately 20 seconds and providing additional horsepower. If the kickdown switch is activated again, an additional timer within the time delay module prevents the disengagement of the fan until 20 seconds has elapsed allowing for adequate engine cooling. After the timer completes its 20 second cycle, the kickdown switch can be reactivated and the fan will disengage, providing additional horsepower.

b. On-Vehicle Testing (Figure 13-7)

1. Disconnect glow plug controller.

2. Turn rotary switch to the RUN position.

3. Using a multimeter, measure voltage at the four and two prong connector of the time delay module (do not disconnect prongs).

4. Perform continuity test on control valve solenoid. 58 to 78 ohms both ways.

c. Four Prong Connector

a. Leads 458 and 569 should indicate battery voltage. If no voltage is present, repair ignition circuit.

b. Leads 93 and 315 should indicate 0 voltage. If voltage is indicated, repair live short.

d. Two Prong Connector

a. Lead 483 should indicate battery voltage. If no voltage is indicated, replace time delay module.

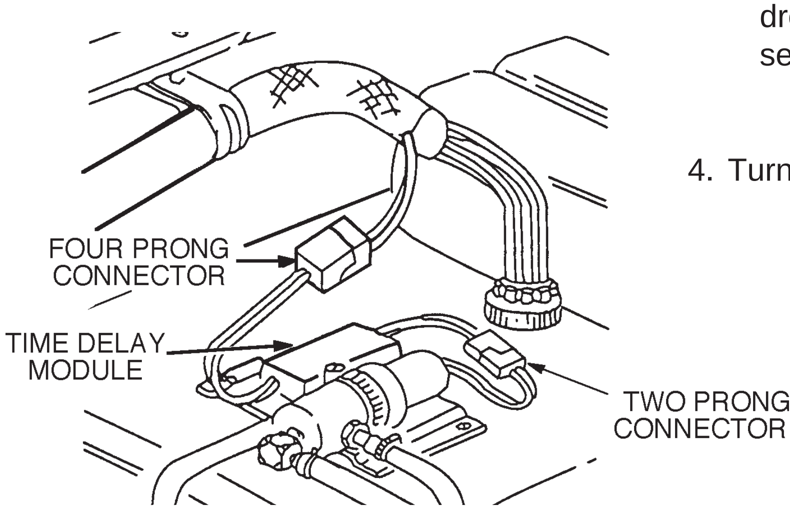


Figure 13-7. Time Delay Module Connector Testing.

b. Lead 93 should indicate 0 voltage. If battery voltage is indicated, replace time delay module.

3. Disconnect either lead (458) at fan temperature switch. [(This simulates engine coolant temperature at 230°F (110°C) or above)]. Using a multimeter, measure voltage at the four and two prong connectors. Leave 458 disconnected.

a. Lead 458 at the four prong connector should measure 0 volts. Replace time delay module if voltage is indicated.

b. Lead 315 at the four prong connector should “momentarily” measure battery voltage when kick down switch is manually actuated. If measured voltage remains, replace time delay module.

c. Lead 93 at the two prong should measure battery voltage with kickdown switch *not* engaged. Momentarily engage kickdown switch, battery voltage should drop to 0 for approximately 20 seconds. If measured voltage remains, replace time delay module. Immediately after test activate kickdown switch again. The time delay switch should not allow the voltage drop for another 20 seconds. After 20 seconds has passed, repeat 1st test.

4. Turn rotary switch to the OFF position.

C. BENCH TESTING (Table 13-1)

NOTE

Time delay module may be bench tested without removing from vehicle.

1. Disconnect four and two prong leads from module.

2. Using a multimeter, check for continuity at the following leads of the time delay module:

   a. Lead 458 at the two prong and 569 at the four prong. If continuity is not present, replace time delay module.

   b. Measure for continuity in the remaining leads at the time delay module. If continuity is detected at any remaining leads, replace time delay module.

3. Using a multimeter, check for resistance at the following leads. Set resistance range switch at R3 (see Table 13-1).

TWO PRONG	FOUR PRONG	
LEAD #	LEAD #	RESISTANCE
93+	458–	∞(Infinity)
93–	458+	∞
93+	569–/583*	∞
93–	569+/583*	∞
93+	93–	∞
93–	93+	∞
93+	315–	∞
93–	315+	∞
458+/583*	458–	∞
458–/583*	458+	∞
458+/583*	569–/583*	Continuity
458–/583*	569+/583*	Continuity
458+/583*	93–	∞
458–/583*	93+	∞
458+/583*	315–	∞
458–/583*	315+	∞

* Wire #458 is superseded by wire #583, and #569 is superseded by #583 on Level III vehicles only.

Table 13-1. Time Delay Module Resistance Tests.