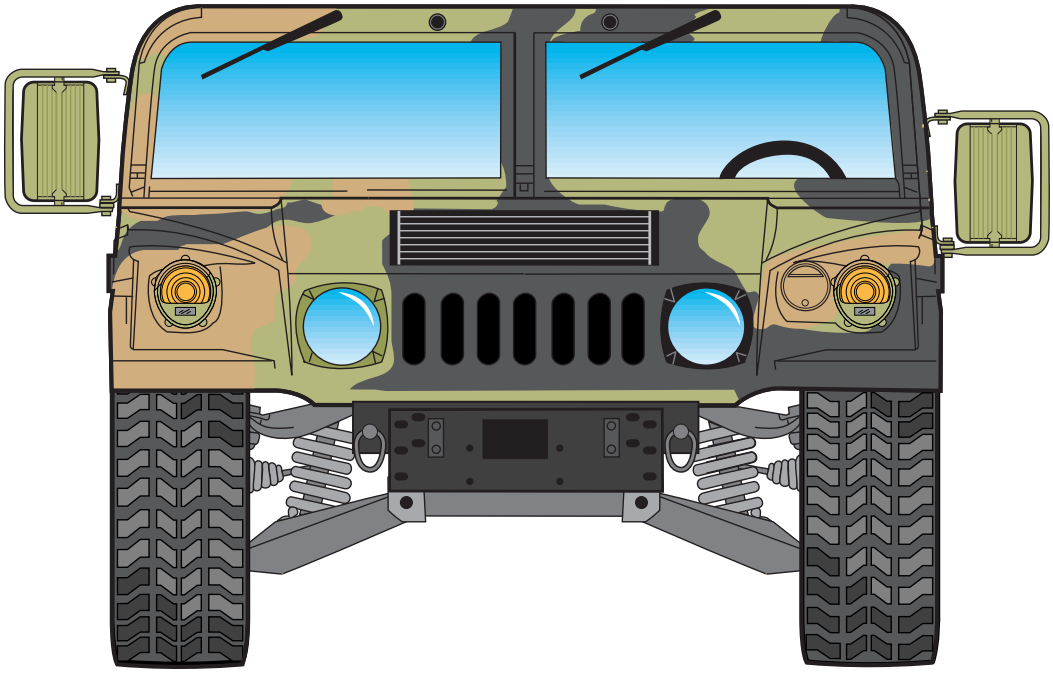
5715084

# AM General Corporation

# MILITARY HMMWV



# Stanadyne DB2 Fuel Injection Pump System

## M998A2 Series Vehicles

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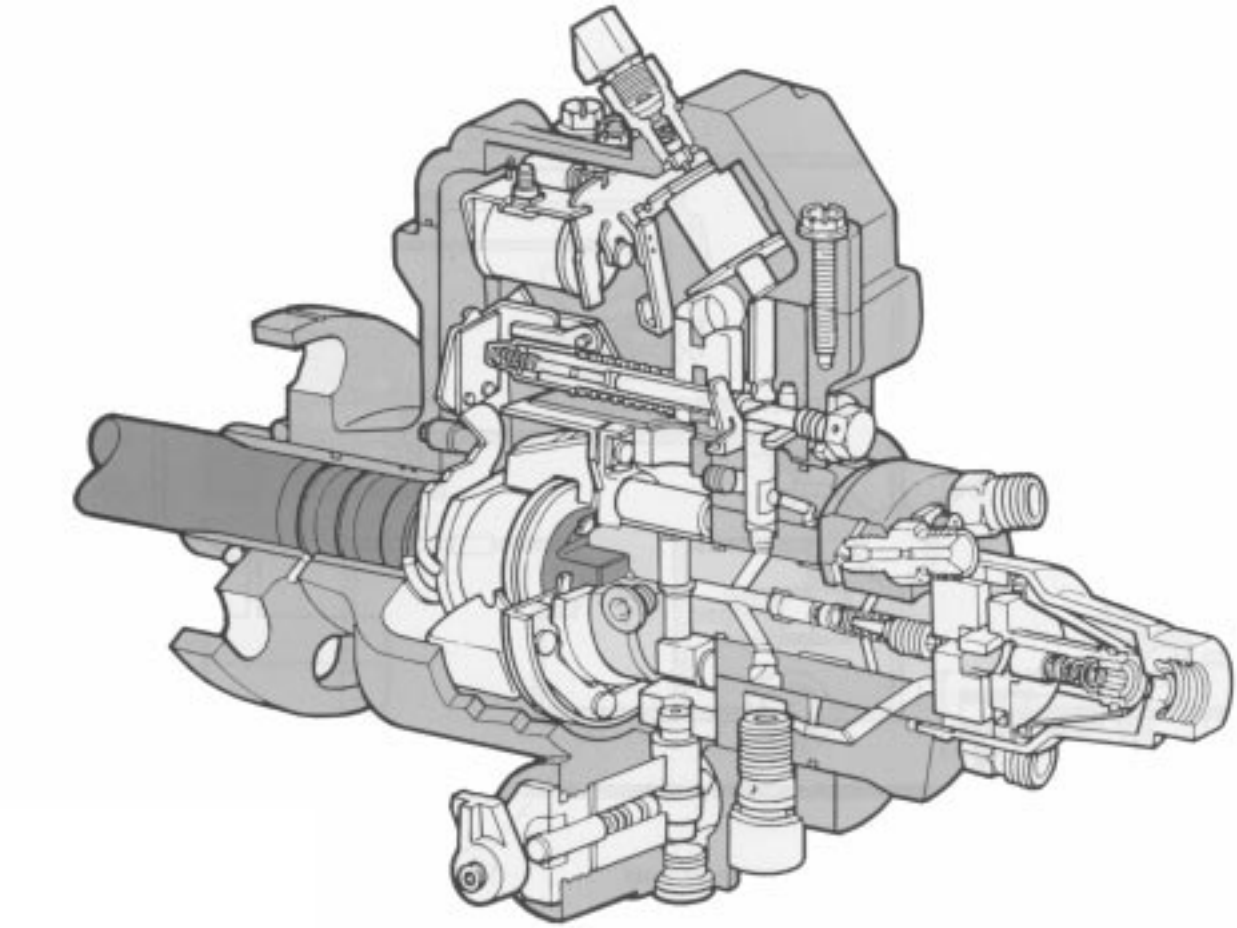
# FUEL INJECTION PUMP SYSTEM
# FOR THE MILITARY
# M998A2 SERIES VEHICLES



# PUMP OPERATION
# INSPECTION/DIAGNOSIS
# AND
# FUEL INJECTION NOZZLE
# DESCRIPTION

# Diagnostic Worksheet

## CUSTOMER INFORMATION

Customer Complaint Statement _____

Customer's Name _____ VIN _____ Date _____

Model Number _____ Technician's Name _____

Pump Model Number _____

## ENGINE CONDITION

**Perform diagnostic check in the numerical order indicated after each "engine condition".**

Engine Cranks- Will Not/or Hard Start Cold
3, 1, 4, 9, 5, 2, 10, 7, 6.

Engine Cranks- Will Not/or Hard Start Hot
3, 2, 4, 5, 7, 16, 6.

Rough Idle/Misfire-Cold
9, 15, 7, 5, 1, 6, 10.

Rough Idle/Misfire-Hot
8, 15, 9, 4, 16, 7, 5, 10, 6.

Black Exhaust Smoke
7, 9, 11, 18, 10.

Blue/White Exhaust Smoke
1, 7, 9, 5, 6, 18.

Engine Stalls
8, 4, 9, 16, 5, 7, 3.

Lack Of Power
5, 9, 7, 12, 11, 4, 16, 6, 17.

Poor Fuel Economy
16, 11, 13, 7, 5, 12, 14.

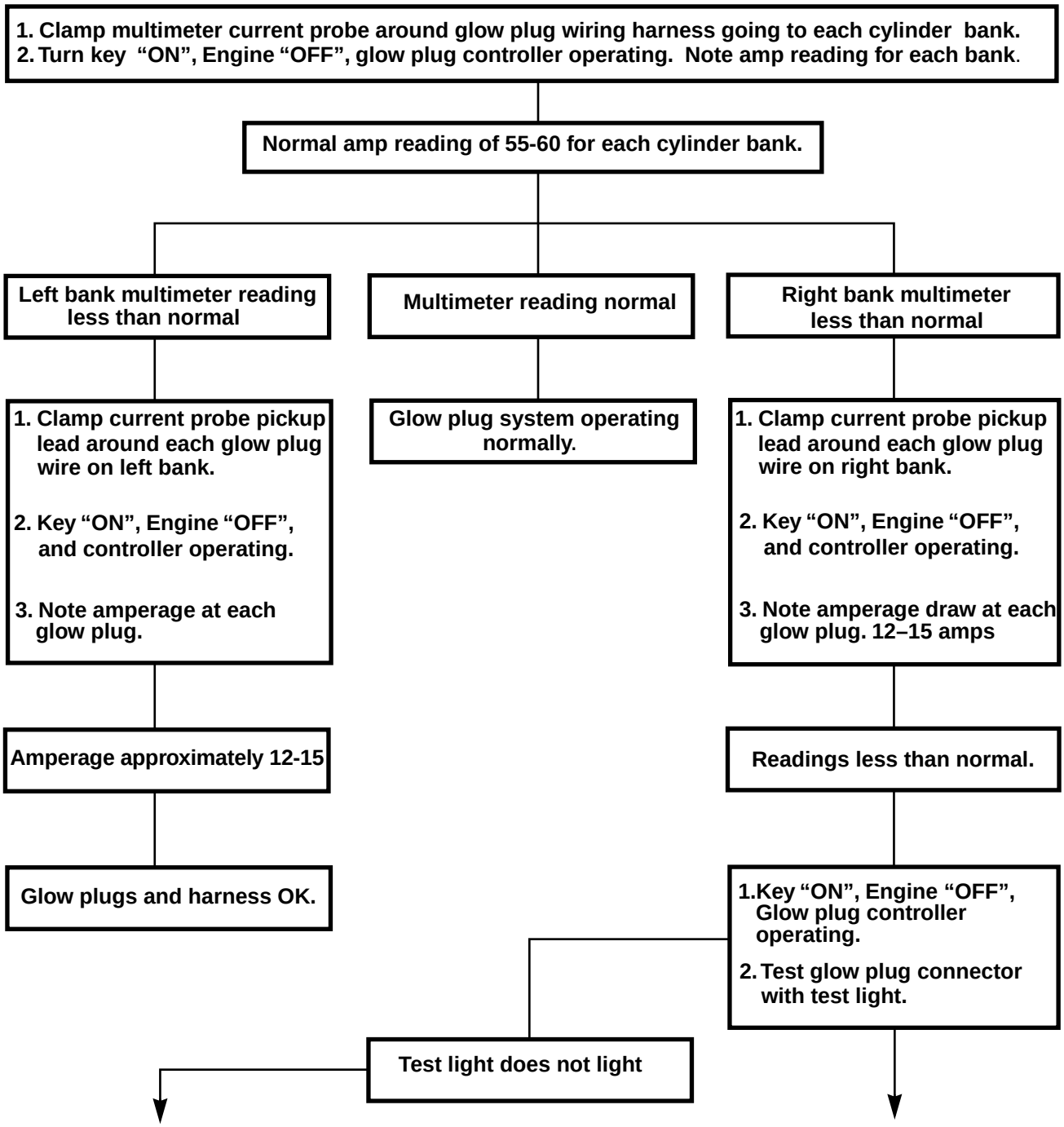
Engine Noisy
7, 9, 10, 18, 17.

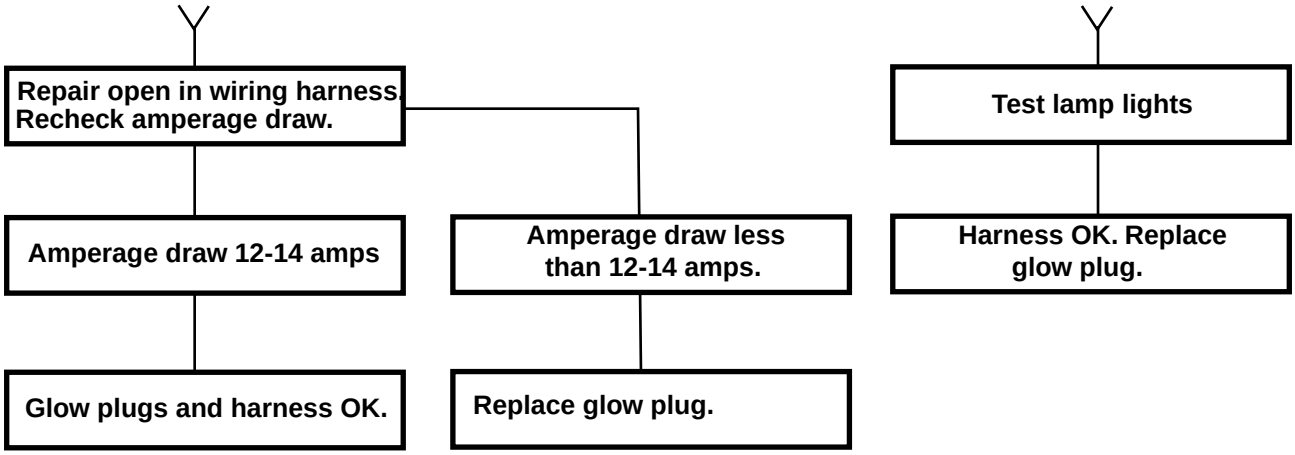
## Diagnostic Checks

| Yes | No | |
|---|---|---|
| ❑ | ❑ | 1. Glow Plug System OK? |
| ❑ | ❑ | 2. Cranking Speed OK? |
| | | Cold RPM_____Hot RPM_____ |
| ❑ | ❑ | 3. (a) Shutoff Solenoid Operation OK? |
| ❑ | ❑ | (b) Continuous Voltage to Shutoff Solenoid? |
| ❑ | ❑ | 4. Air in Fuel Return Line? |
| ❑ | ❑ | 5. Fuel Pressure & Volume to Injection Pump OK? |
| ❑ | ❑ | 6. Compression OK? |
| ❑ | ❑ | 7. (a) Injection Pump Timing OK? |
| | | (b) Advance Function OK? |
| ❑ | ❑ | 8. (a) Injection Pump Housing Pressure OK? |
| ❑ | ❑ | (b) Housing Pressure Cold Advance OK? |
| ❑ | ❑ | 9. Idle Speed Set Correctly? (700 ± 25 RPM) |
| ❑ | ❑ | 10. Defective Nozzle? |
| ❑ | ❑ | 11. Air Cleaner OK? |
| ❑ | ❑ | 12. Throttle Travel OK? |
| ❑ | ❑ | 13. Torque Converter Clutch Functioning? |
| ❑ | ❑ | 14. Speedometer Functioning Properly? |
| ❑ | ❑ | 15. Fuel Injection Lines Leaking? |
| ❑ | ❑ | 16. Fuel OK? |
| ❑ | ❑ | 17. Exhaust System Check OK? |
| ❑ | ❑ | 18. Starting Procedure Correct? |

# Glow Plug System Check

- Batteries Fully Charged and Serviceable
- Engine is Cold 27° C (80°F)
- Glow Plug Controller Operating




Repair open in wiring harness. Recheck amperage draw.
Amperage draw 12-14 amps
Glow plugs and harness OK.
Amperage draw less than 12-14 amps.
Replace glow plug.
Test lamp lights
Harness OK. Replace glow plug.

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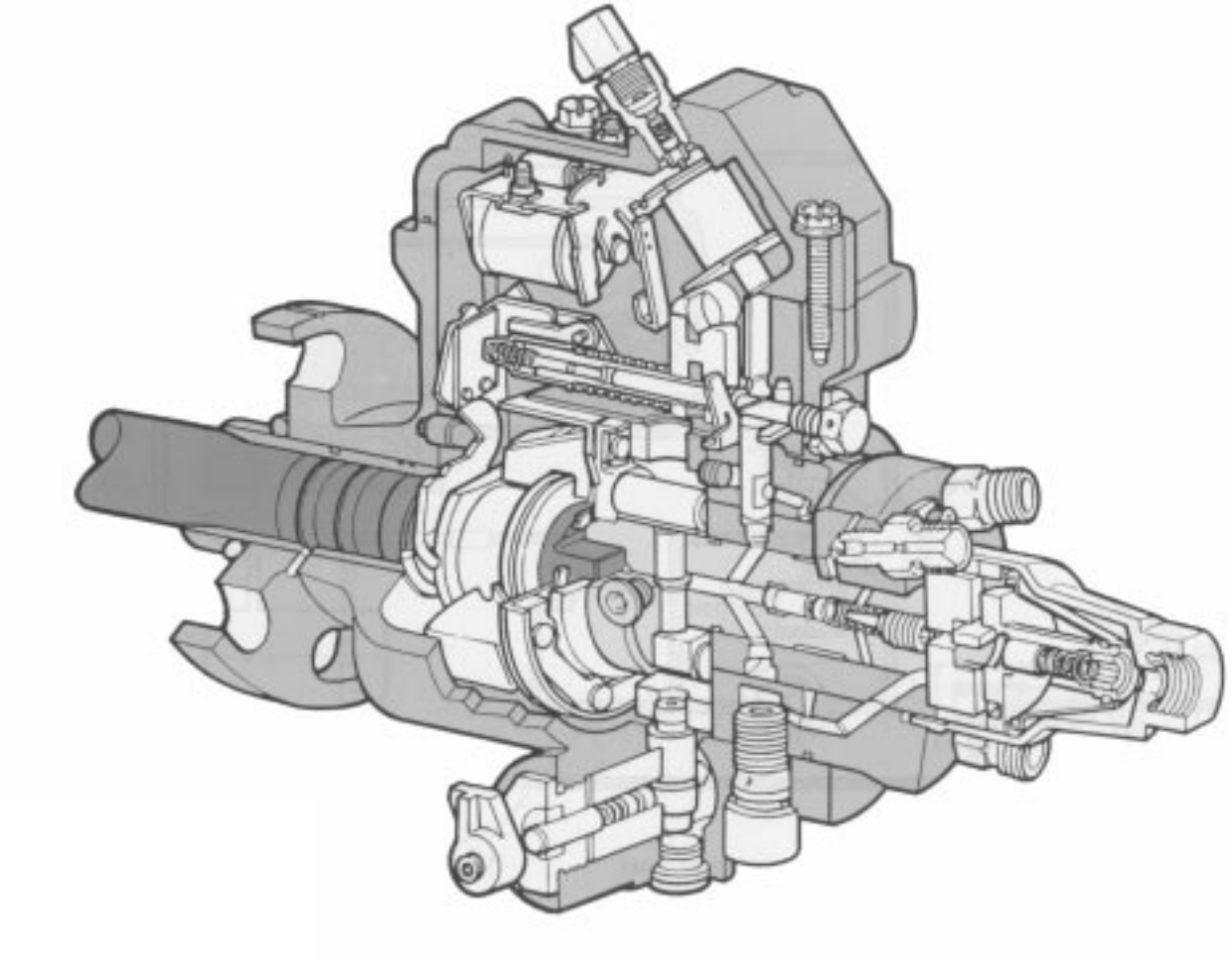
# OPERATION

## 1. Stanadyne DB2 Fuel Injection Pump

This slide program is intended to provide information for qualified technicians experienced in diesel engines and diesel injection equipment, to make adjustments and parts replacement as needed to the Stanadyne DB2 type fuel injection pump. It is recommended that an inexperienced person refrain from making adjustments and repairs, as such actions may result in very extensive damage to the pump and possibly to the engine.

Service should not be performed on the pump until a careful study of this program and the appropriate technical manual has been made. Since several critical adjustments of the injection pump are required which cannot be made on the engine, it is necessary that service be performed in a facility equipped with the proper special tools and equipment, i.e. Test Stand.

This program covers the operating principles of the pump. Only through a thorough knowledge of these principles can the technician locate and correct possible operational defects.



Stanadyne DB2 Fuel Injection Pump

**2. Model Number System**

It is necessary for the technician to understand the model numbering system for reference to the proper technical manuals and bulletins covering operation and maintenance of the pump.

**Example**:

| Model Number | a | b | c | d | e |
|---|---|---|---|---|---|
| | DB2 | 8 | 33 | JN | 3000 |

**a. DB2= D-Series pump, B-Rotor, 2- 2nd. Generation pump**

**b. 8= Number of cylinders (available in 2,3,4,6 & 8 cylinders).**

**c. 33= Abbreviation of plunger diameter.**

| | |
|---|---|
| **25= .250” (6.35mm)** | **31= .310” (7.87mm)** |
| **27= .270” (6.86mm)** | **33= .330” (8.38mm)** |
| **29= .290” (7.37mm)** | **35= .350” (8.89mm)** |

**d. JN= Accessory code: This code pertains to combinations of special accessories such as electrical shutoff, automatic advance, etc.**

**e. 3000= Specification Number. Determines selection of parts and adjustments for a given application.**

Model Numbering System

## 3. Components and Functions

It is necessary that the technicians become familiar with the function of the main components to understand the basic operating principles of the Stanadyne model DB2 pump.

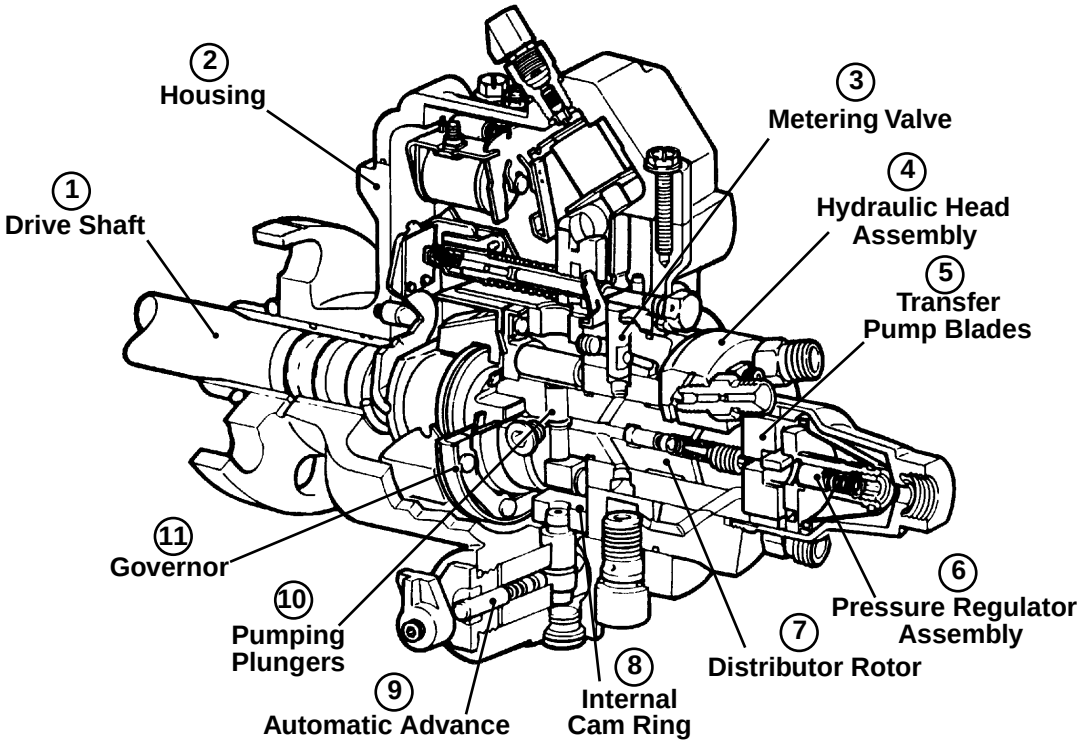
Main Components:

1. Drive Shaft
2. Housing
3. Metering Valve
4. Hydraulic Head Assembly
5. Transfer Pump Blades
6. Pressure Regulator Assembly
7. Distributor Rotor
8. Internal Cam Ring
9. Automatic Advance
10. Pumping Plungers
11. Governor

The main rotating components are the drive shaft (1), transfer pump blades (5), distributor rotor (7), and governor (11).

The plungers (10), are actuated toward each other simultaneously by an internal cam ring (8), through rollers and shoes which are carried in slots at the drive end of the rotor. The number of lobes on the cam equals the number of engine cylinders.

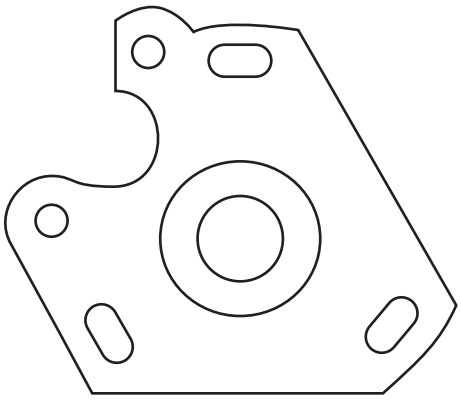
The transfer pump at the rear of the rotor is a positive displacement vane type and is enclosed in the end cap. The end cap also houses the fuel inlet filter and transfer pump pressure regulator valve.




Components and Functions

## 4. Mounting Flanges

This slide shows the DB2 mounting flange configuration for the for the military HMMWV.



HMMWV

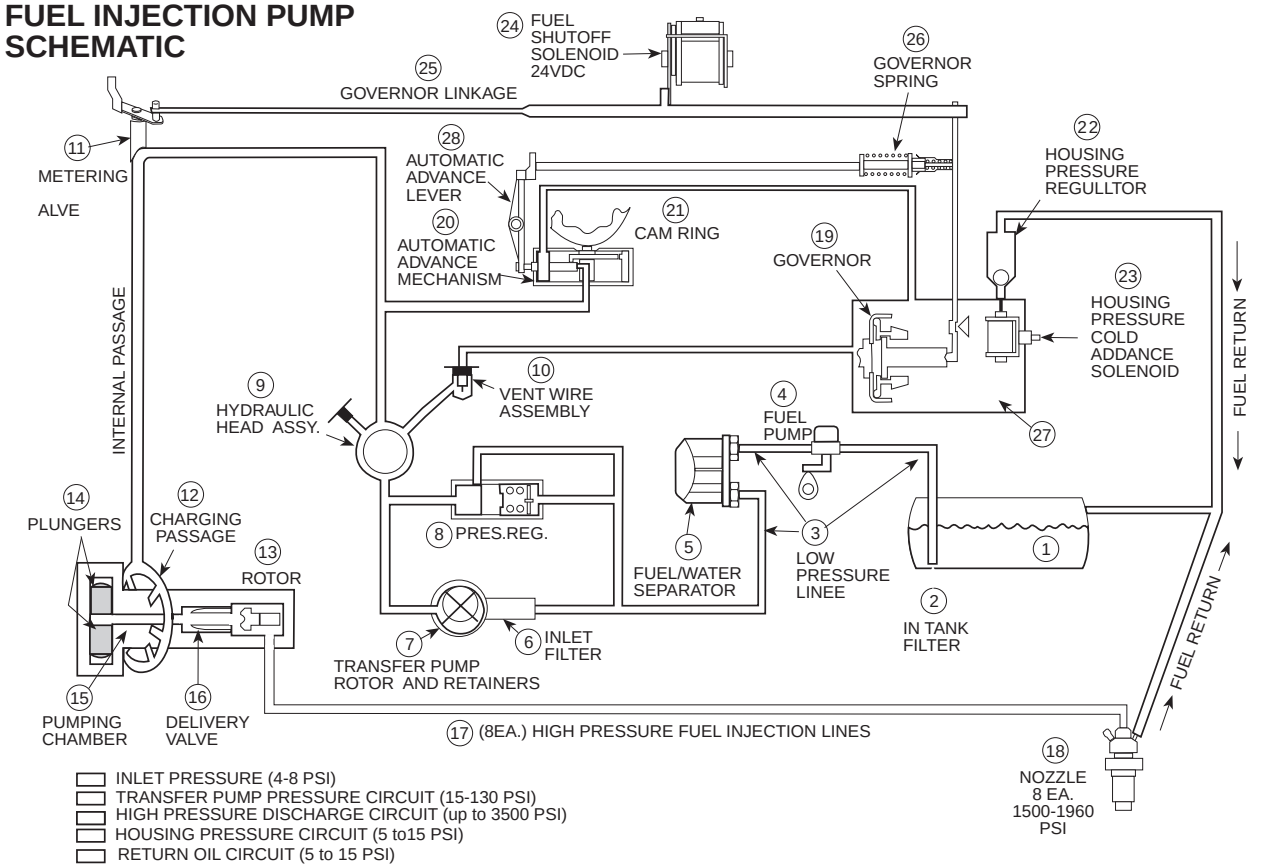
Mounting Flanges

## 5. Fuel Schematic

Fuel is pumped from the supply tank through filters into the pump inlet through the inlet filter (6) by the fuel lift pump (4). Some fuel is bypassed through the pressure regulator assembly (8) to the low pressure side.

Fuel under transfer pump pressure (15-130 psi) flows through the center of the transfer pump rotor, past the rotor retainers (7) into a circular groove. It then flows through a connecting passage in the head to the automatic advance (20) and up through a radial passage, then through a connecting passage to the metering valve. The radial position of the metering valve, controlled by the governor, regulates flow of fuel into the radial charging passage (12) which incorporates the head charging ports.

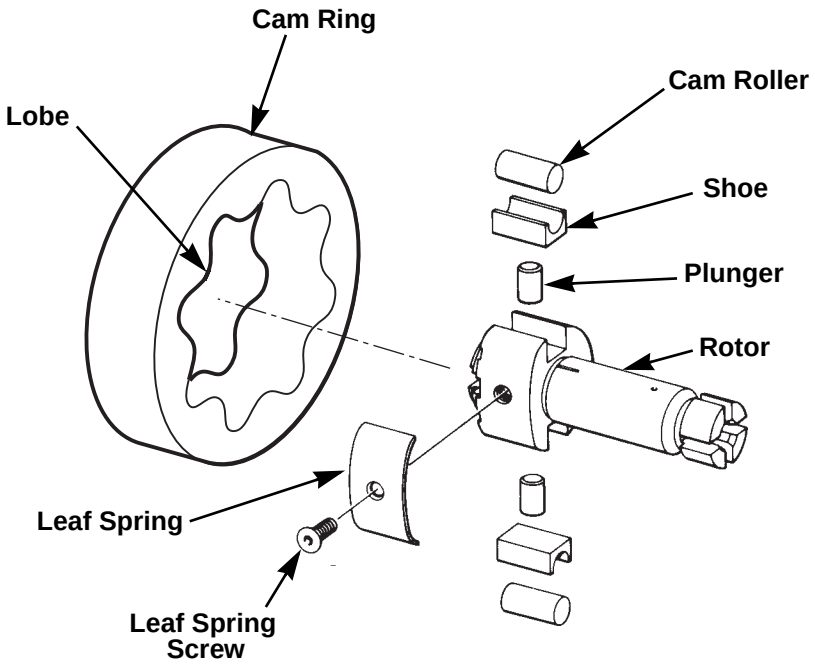
As the rotor revolves, the two rotor inlet filter passages register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber (15). With further rotation, the inlet passages move out of registry, and the discharge port of the rotor registers with one of the head outlets. While the discharge port is open, the rollers contact the cam lobes forcing the plungers (14) together. Fuel trapped between the plungers is the pressurized and delivered by the nozzle to the combustion chamber.




Fuel Schematic

## 6. Rotor Operation

As the rotor revolves, the two rotor inlet passages register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber. With further rotation, the discharge port of the rotor registers with one of the head outlets. While the discharge port is open, the rollers contact the cam lobes forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.



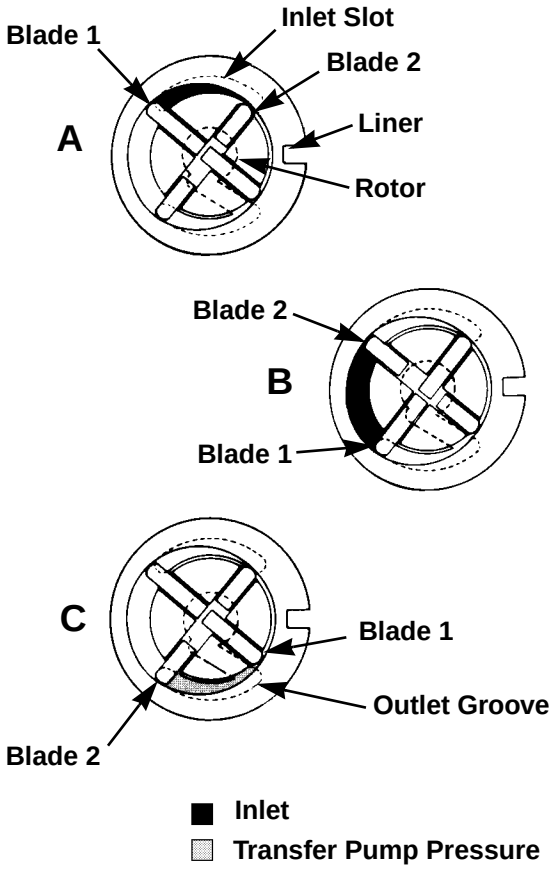

Rotor Operation

## 7. Transfer Pump

A. Transfer pump output volume and pressure increase as pump speed increases. In position 'A', the quadrant is in registry with a kidney shaped inlet slot in the top portion of the regulator assembly. The increasing volume causes fuel to be pulled through the inlet fitting and filter screen into the transfer pump liner. Volume between the two blades continues to increase until blade 2 passes out of registry with the inlet slot.

B. At this point the rotor has reached a point where outward movement of blades 1 and 2 is negligible and volume is not changing. The fuel between the blades is being carried to the bottom of the transfer pump liner.

C. In this position blade 1 passes the edge of the kidney shaped groove in the lower portion of the regulator assembly. The liner, whose inside diameter is eccentric to the rotor, compresses blades 1 and 2 in an inward direction. The volume between the blades is reduced as pressurized fuel is delivered to the head assembly. Volume between the blades continues to decrease, pressurizing the fuel in the quadrant, until blade 2 passes the outlet groove in the regulator assembly.



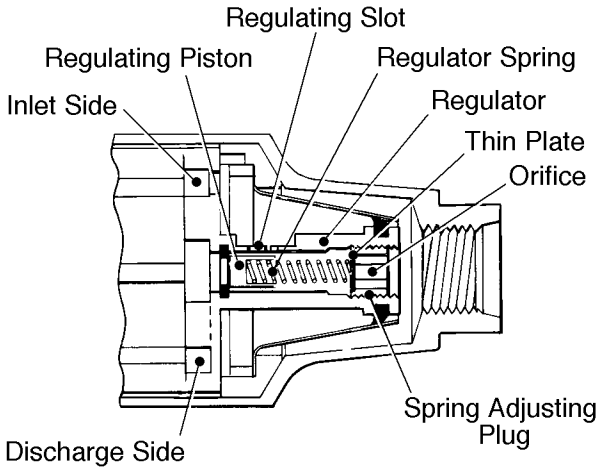

Transfer Pump

## 8. Regulator Assembly Operation/Viscosity Compensation

A. This slide shows the operation of the pressure regulating piston while the pump is running. Fuel output from the discharge side of the transfer pump forces the piston in the regulator against the regulating spring. As flow increases, the regulating spring is compressed until the edge of the regulating piston starts to uncover the regulating slot.

B. Since fuel pressure on the piston is opposed by the regulator spring, the delivery pressure of the transfer pump is controlled by the spring rate and size of the regulating slot.

C. The DB2 transfer pump works equally well with different grades of diesel fuel and varying temperatures, both of which affect fuel viscosity. A unique and simple feature of the regulating system offsets pressure changes caused by viscosity difference. Located in the spring adjusting plug is a thin plate incorporating a sharp-edged orifice. This orifice allows fuel leakage past the piston to return to the inlet , (low pressure) side of the pump.

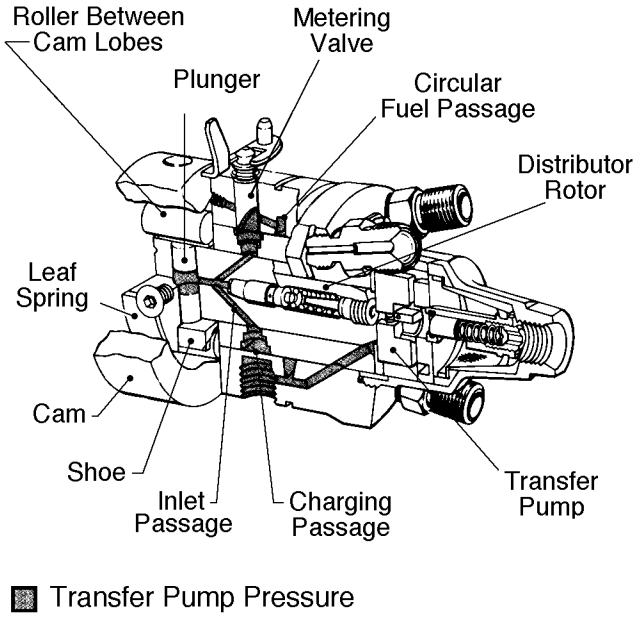



Regulator Assembly Operation.

## 9. Charging Cycle

As the rotor revolves, the two inlet passages in the rotor register with ports of the circular charging passage. Fuel under pressure from the transfer pump, controlled by the opening of the metering valve, flows into the pumping chamber forcing the plungers apart.

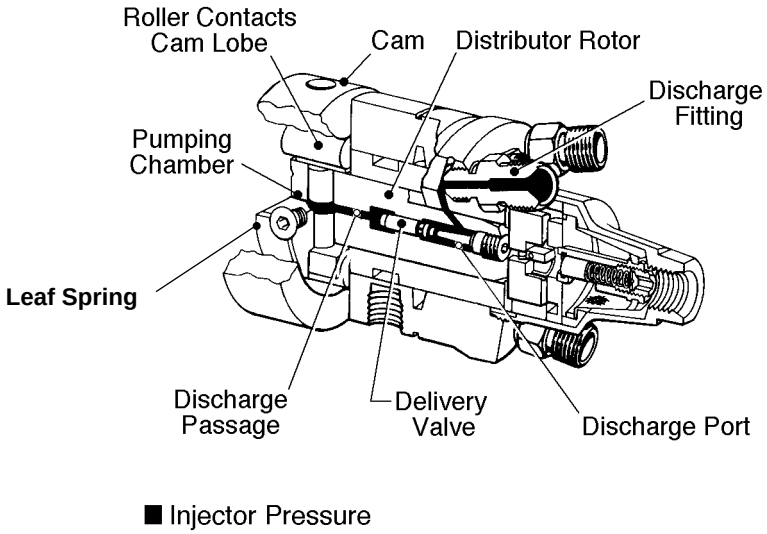
The plungers move outward a distance proportionate to the amount of fuel required for injection on the following stroke. If only a small amount of fuel is admitted into the pumping chamber, as at idling, the plungers move out a short distance. Maximum plunger travel and, consequently, maximum fuel delivery is limited by the leaf spring which contacts the edge of the roller shoes. Only when the engine is operating at full load will the plungers move to the most outward position.




Charging Cycle

## 10. Discharge Cycle

As the rotor continues to revolve the inlet passages move out of registry with the charging ports. The rotor discharge port opens to one of the head outlets. The rollers then contact the cam lobes forcing the shoes in against the plungers and high pressure pumping begins.




Discharge Cycle

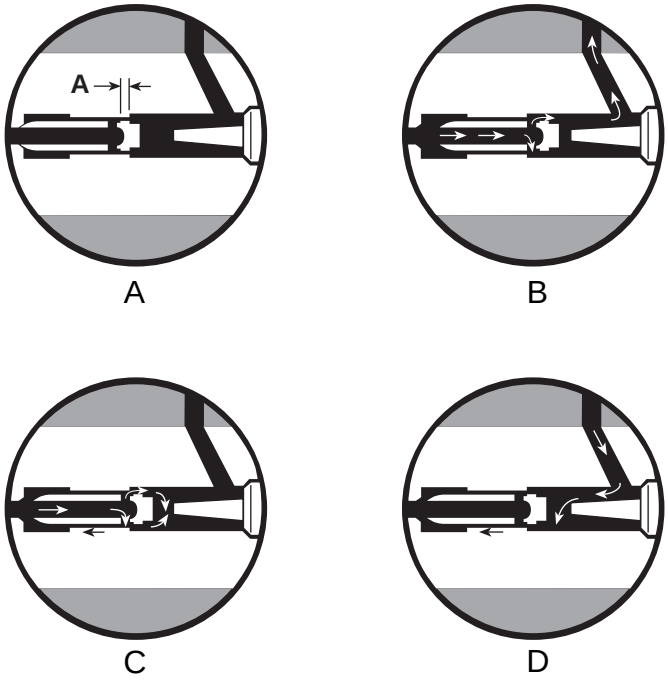
## 11. Delivery Valve

The delivery valve rapidly decreases injection line pressure after injection to a predetermined value lower than that of the nozzle closing pressure, approximately 500 psi. This reduction in pressure permits the nozzle valve to return to its seat, achieving sharp delivery cut-off and preventing improperly atomized fuel from entering the combustion chamber. Following fuel delivery, the rotor discharge port closes completely and a residual injection line pressure is maintained.

The delivery valve operates in a bore in the center of the distributor rotor. Note that the valve requires no seat - only a stop to limit travel. Sealing is accomplished by the close clearance between the valve and bore into which it fits. Since the same delivery valve performs the function of retraction for each injection line, the result is a smooth running engine at all loads and speeds.

When injection starts, fuel pressure moves the delivery valve slightly out of its bore and adds the volume of its displacement, section "A", to the delivery valve spring chamber. Since the discharge port is already opened to a head outlet, the retraction volume and plunger displacement volume are delivered under high pressure to the nozzle. Delivery ends when the pressure on the plunger side of the delivery valve is quickly reduced, due to the cam rollers passing the highest point on the cam lobe.

Following this, the rotor discharge port closes completely and a residual injection line pressure is maintained. Note that the delivery valve is only required to seal while the discharge port is opened. Once the port is closed, residual line pressures are maintained by the seal of the close fitting head and rotor.

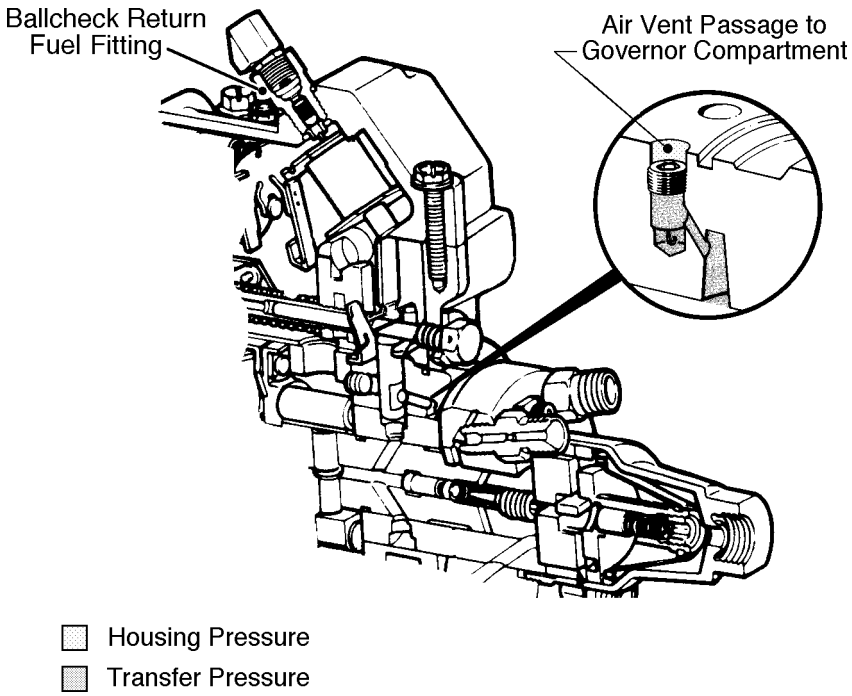



Delivery Valve

## 12. Fuel Return Circuit

Fuel under transfer pump pressure is discharged into a vent passage in the hydraulic head. Flow through the passage is restricted by a vent wire assembly to prevent excessive return fuel and undue pressure loss. The amount of return fuel is controlled by the size of vent wire used. Fuel pressure at this point is reduced to approximately 15 psi.

Should a small amount of air enter the transfer pump, it is broken down and immediately passes to the governor housing. Air and a small quantity of fuel then flow from the housing to the fuel tank via the fuel return line. Housing pressure is maintained by a spring loaded ballcheck fitting in the fuel return valve located on the governor housing.

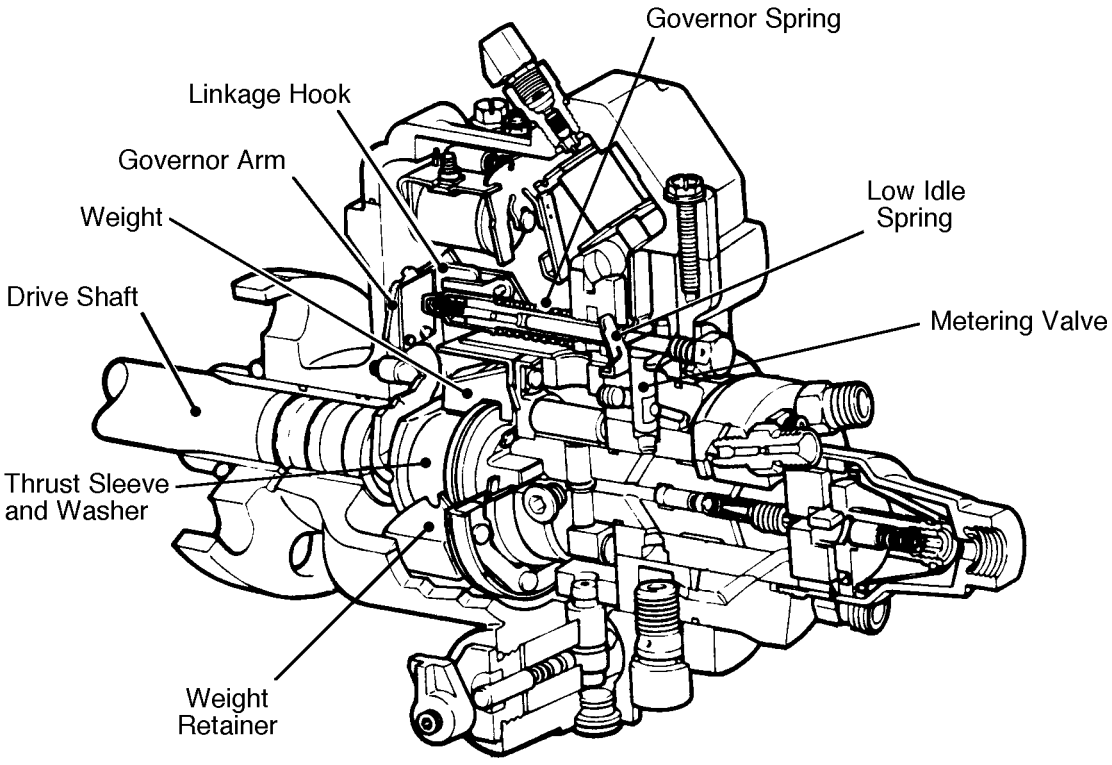



Fuel Return Circuit

## 13. Mechanical Governor

The governor assembly's function is to control minimum engine speed and prevent engine overspeeding at wide-open throttle. Because it controls minimum and maximum engine speeds, it is known as a "min-max" governor. The complete governor assembly consists of the governor weights and retainer cage, a pivot arm, a linkage arm connected to the metering valve and the min-max governor assembly hooked to the throttle shaft.

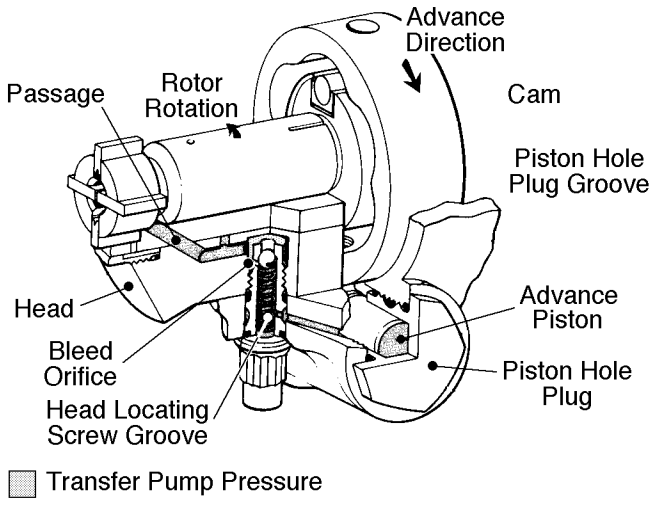
At idle speed, the governor weights exert very little force against the thrust sleeves as they rotate. The spring on the min-max governor keeps the metering valve almost closed, and engine speed is low. At excessive engine rpm, the weights push the thrust sleeve along the shaft, moving the pivot arm; the min-max governor spring is compressed and the linkage rotates the metering valve to an almost closed position. Fuel flow is reduced and engine speed drops. At intermediate speeds, the force of the governor weights and the min-max spring tension are balanced. The min-max governor acts as a rigid mechanical link between the throttle shaft and the metering valve through the pivot arm.




Mechanical Governor

## 14. Automatic Advance

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. The advance mechanism advances or retards start of fuel delivery in response to engine speed changes.




Automatic Advance

## 15. Detailed Inspection

Replace all O-ring seals and gaskets. Examine all springs for wear, distortion or breakage.

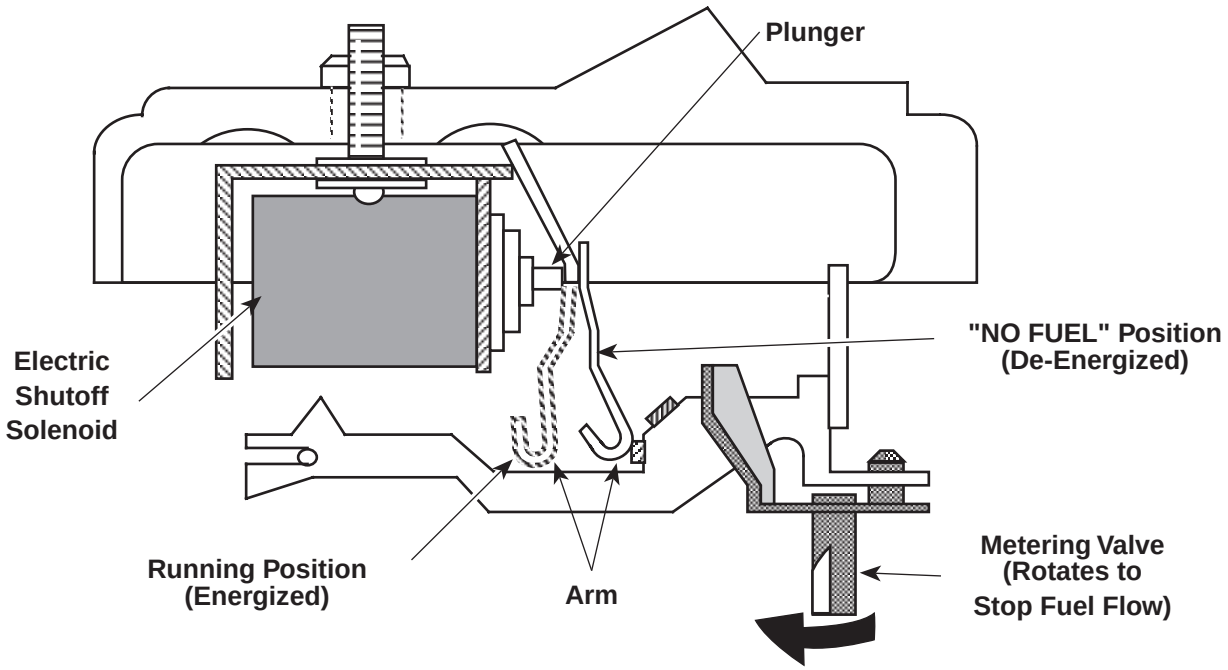
Clean and check all bores, grooves, and seats for damage or wear of any kind. Replace all worn or damaged parts as necessary.

| | Examine For: | Excessive Wear | Foreign Material or Rust | Nicks or Chipping | Scratches or Scores | Thread Damage | Cracks | Distortion | Freedom of Movement | |
|---|---|---|---|---|---|---|---|---|---|---|
| Housing & Drive | Housing | X | X | X | X | X | X | X | | |
| | Drive Shaft | X | X | X | X | X | X | X | | |
| Hydraulic Head & Rotor | Hydraulic Head | X | X | X | X | X | X | | | |
| | Vent Wire Assembly | | X | | | | | | X | |
| | Discharge Fittings | X | X | X | X | X | X | | | |
| | Distributor Rotor | X | X | X | X | X | X | | X | |
| | Delivery Valve | X | X | X | X | | X | | X | |
| | Plungers | X | X | X | X | | X | | X | |
| | Cam Rollers & Screws | X | X | X | X | | X | | X | |
| | Leaf Springs & Screw(s) | X | X | X | X | | X | | X | |
| | Cam | X | X | X | X | X | X | | | |
| | Governor Weight Retainer | X | X | X | | | X | | X | Where weights pivot in retainer socket |
| | Governor Weights | X | X | X | X | X | X | X | X | |
| | Governor Thrust Washer | X | X | X | X | X | X | X | X | Contact areas for excessive wear |
| | Governor Thrust Sleeve | X | X | X | X | X | X | X | X | Points of contact with governor arm for excessive wear |
| Hydraulic Head & Rotor | End Cap | | X | | | X | X | X | X | |
| | Inlet Screen | | X | | | | X | X | | Screen and soldered area for breakage |
| | End Plate / Adj. Plug | X | X | | | X | | | | Tightness in regulator, loose plate |
| | Regulating Piston | | X | X | X | | | | X | |
| | Regulator | X | X | X | X | X | X | X | | |
| | Blades | X | X | X | X | | X | | X | |
| | Liner | X | X | X | X | | | | | Inside diameter in high pressure area for wear |
| | Rotor Retainers | X | X | X | X | | | | | |
| Governor | Pivot Shaft | X | X | X | | X | | X | | Chipped or worn Knife edge |
| | Arm | X | X | X | | | X | X | X | Points of contact with thrust sleeve & pivot shaft for excessive wear |
| | Metering Valve | X | X | X | X | | X | | X | Contact area of body for excessive wear |
| | Metering Valve Arm | X | X | X | X | | X | X | | Inspect pin for wear or loosness |
| Linkage | Linkage Hook | X | X | X | X | X | X | X | X | Metering valve pin hole |
| Advance | Piston | X | X | X | X | | | | X | Bore for excessive wear |
| | Cam Advance Screw | X | X | X | X | X | X | | X | Orifice |
| | Plugs | X | X | X | X | X | X | X | X | |
| | Head Locating Screw | | X | X | X | X | X | | | |

Detailed Inspection

## 16. Fuel Shutoff Solenoid

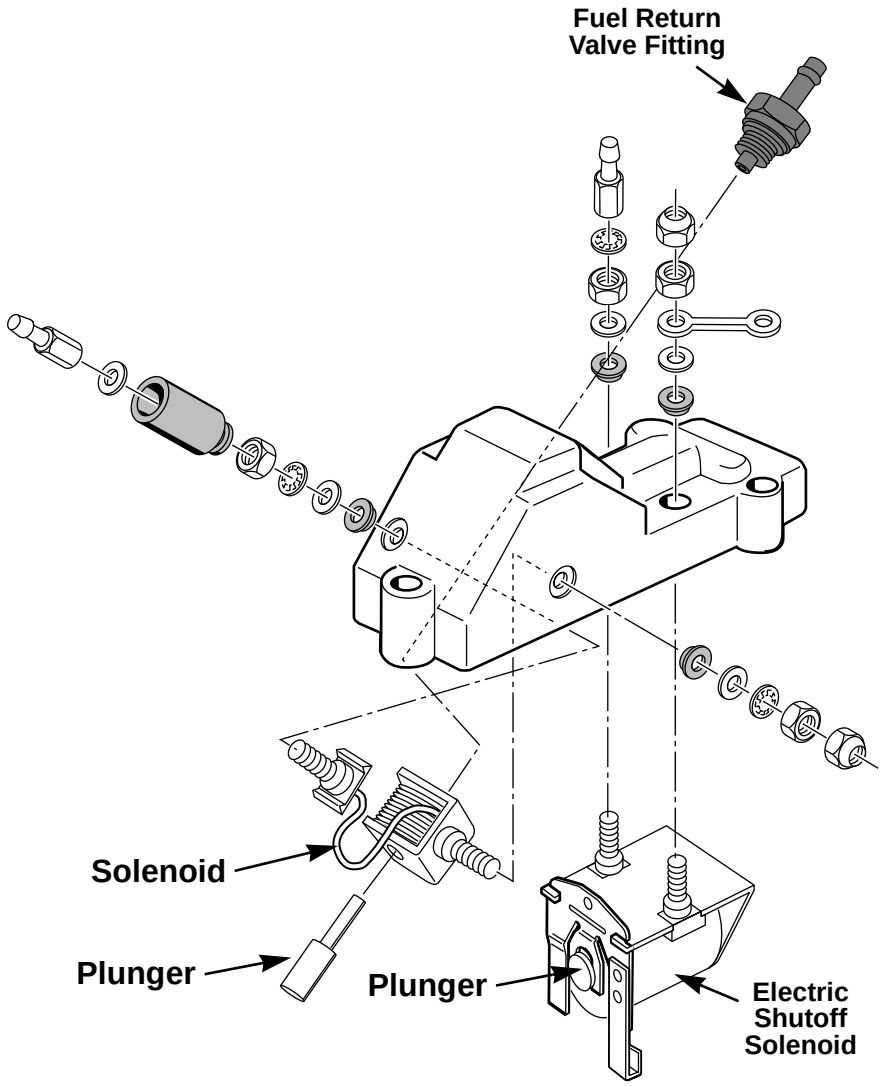
A diesel engine is stopped by cutting off the fuel flow. The fuel-shutoff solenoid is located inside the pump housing. When the ignition is turned off, the solenoid is de-energized. It pushes the metering valve linkage forward, rotating the metering valve to a completely closed position and shutting off the flow of fuel.




Fuel Shutoff Solenoid

## 17. (HPCA) Housing Pressure Cold Advance Solenoid

The HPCA solenoid is activated through the engine coolant temperature switch located in the right cylinder head. The HPCA solenoid is located inside the fuel pump governor housing under the fuel return valve fitting. For cold starts, when the coolant temperature is low, the solenoid plunger lifts a check ball off its seat. This reduces housing pressure to almost zero by allowing fuel and housing pressure to return to the fuel tank. With no housing pressure in the advance mechanism, the fuel at transfer pump pressure can advance the cam ring more easily when the engine is cranking. Injection timing is advanced about 3° to reduce white smoke and improve cold-idle smoothness.




(HPCA) Housing Pressure Cold Advance Solenoid

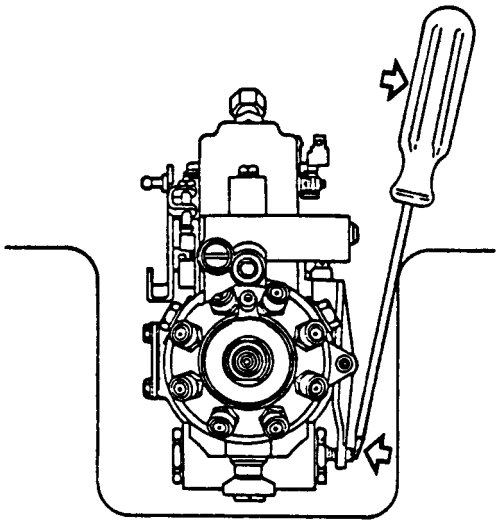
**18. Defective Nozzle Check (Engine knocking due to nozzle stuck open).**

1. Run engine at idle speed. Check cylinder number 1 nozzle first by loosening the injection line nut to the nozzle body 1 to 1-1/2 turns. Listen if knock stops or reduces in density.
2. If knocking continues, retighten line nut on nozzle body to proper torque and proceed to nozzle next in firing order.
3. If knocking stops when injection line is loosened, raise engine speed to approximately 2000 RPM and listen for knock. If knock does not resume, remove nozzle, test and replace as needed.
4. If engine knocking resumes in step 3, retighten line to nozzle body. Proceed to the nozzle next in the firing order and repeat steps #1, #2, and #3.
5. If engine knock is intermittent or does not occur at idle, vary engine speed to determine where knock is audible and note engine RPM. Maintain that speed and loosen injection nut as outlined above. (When checking for knock above idle, it may be necessary to hold RPM for 4-5 seconds for knock to occur.)
6. After all nozzles have been checked, ensure all connections are torqued to proper torque and visually inspect for fuel leaks.

Defective Nozzle Check (Engine knocking due to nozzle stuck open)

## 19. Mechanical Light Load Advance Check

1. With engine at about 2,000 RPM depress the rocker lever with a screwdriver.
2. Timing should retard approximately 5°, RPM should decrease. Engine should sound different (i.e.: run rough).
3. If no change occurs in engine RPM or sound, proceed to next step.
4. Disconnect #569 wire from cold advance solenoid on fuel injection pump.
   - Run engine at 2,000 RPM.
   - Touch a fused jumper wire from the battery positive post to the cold advance solenoid terminal on the fuel injection pump.
   - Engine timing should advance approximately 3°, RPM should increase and engine should sound different.
5. If no change occurs in engine RPM or sound, pump removal for repair is necessary.



Mechanical Light Load Advance Check

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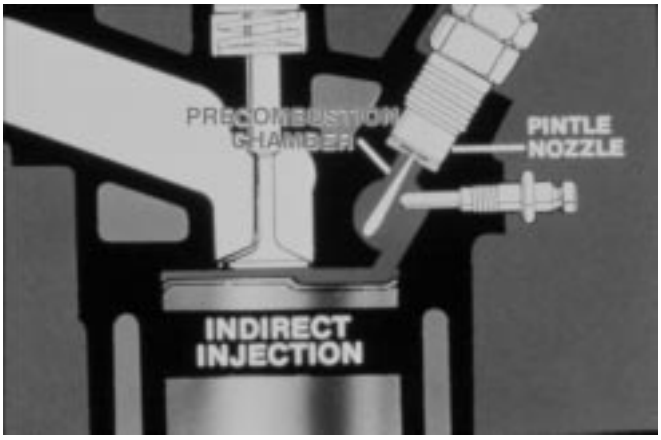
# Fuel Injector Nozzles

### 20. Fuel Injectors

The following slides will cover operation of the Bosch injectors in the M998A2 Series HMMWV 6.5 Liter diesel engine.


### 21. Main Purpose of Injector Nozzle

The main purpose of the nozzle is to direct and atomize the metered fuel into the pre-combustion chamber. Fuel from the injection pump enters and pressurizes the supply passages in the injector. When the force on the lift area is greater than the spring pressure on the needle valve spindle, the needle valve is lifted off its seat and rests with its upper shoulder against a stop.

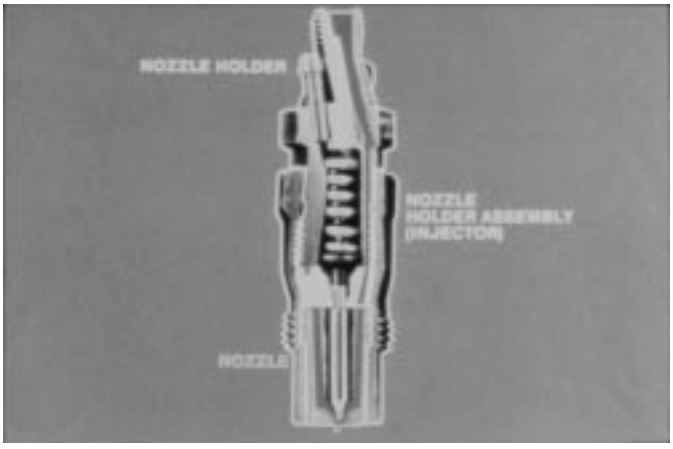


### 22. Types of Needle Valves

Shown here are some of the different needle valves used for other vehicles.

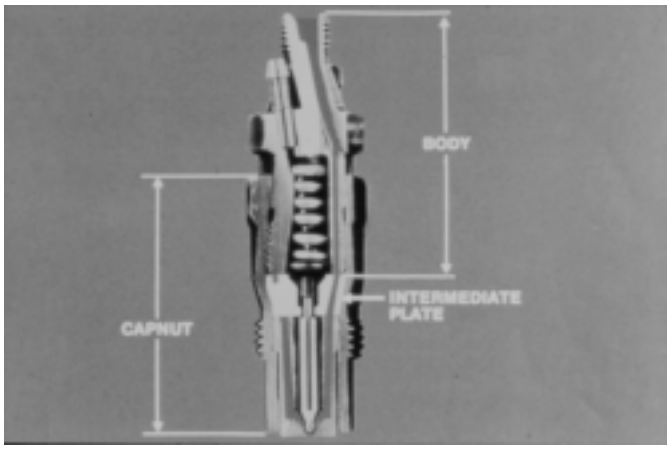

### 23. Purpose of Nozzle Holder Assembly

The purpose of the nozzle holder assembly is to position and to hold the injector nozzle to the nozzle holder, to provide fuel passage to and from the injector nozzle, to provide a pressure adjustment mechanism, and to provide a means to position the injector securely to the cylinder head.



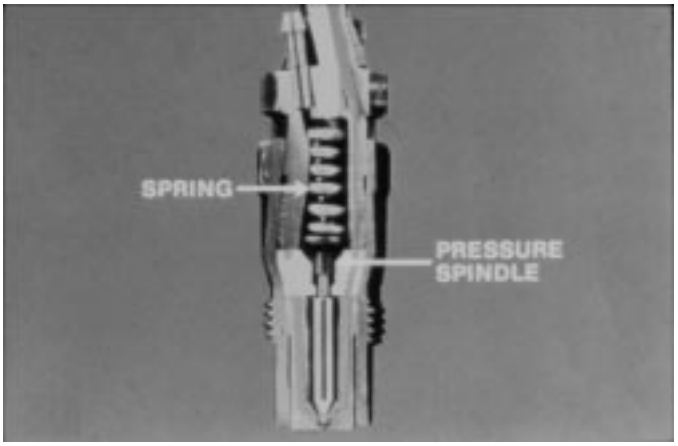
## 24. Body, Cap-Nut and Intermediate Plate

This slide shows some of the different parts of the nozzle holder: Body, Cap-Nut and Intermediate plate.



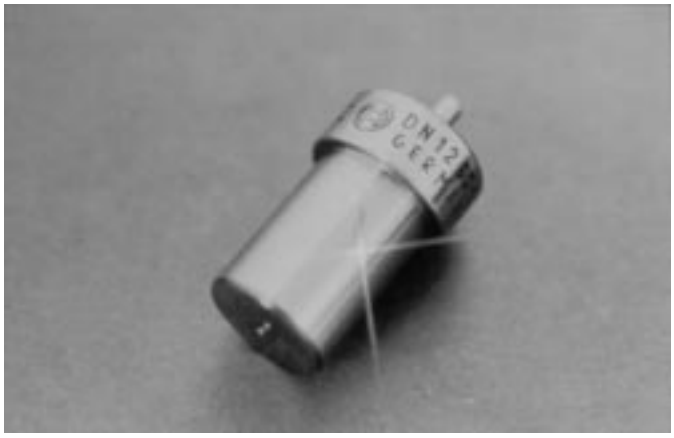

## 25. Additional Parts of Nozzle Holder

More internal parts are shown on this slide.



## 26. HMMWV Type Nozzle

The HMMWV nozzle is a pintle type having an initial rate-flow valve of 680 cm3/minute at 0.1mm lift, and overlap length of 0.7mm and a maximum lift of 97mm. The nominal opening pressure is 1885 psi.

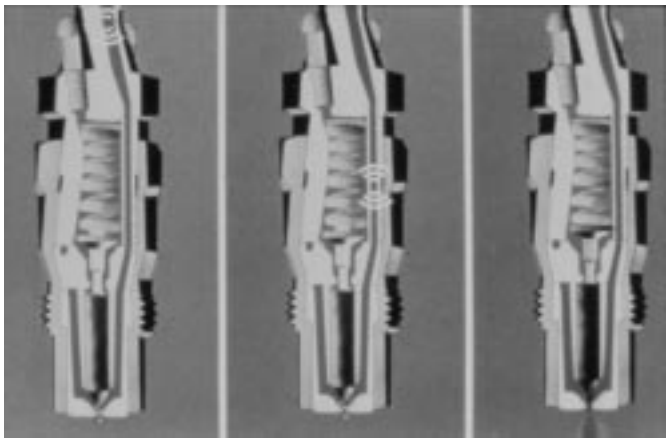


## 27. Internal Heat Shield

The pintle nozzle has an internal heat shield. The main purpose of this heat shield is to dissipate heat from the nozzle to the nozzle holder.

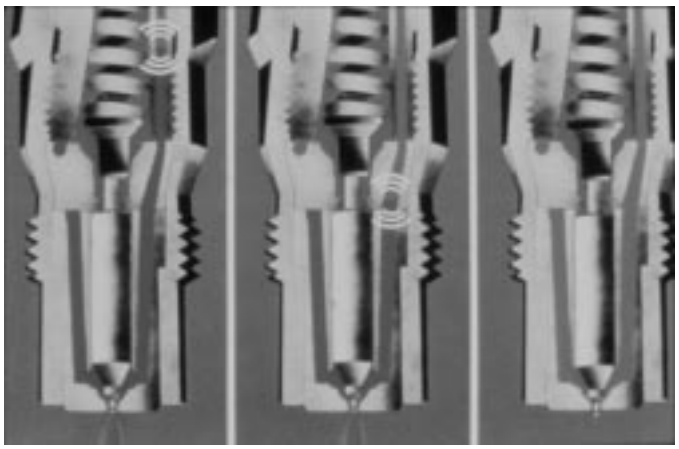
## 28. Nozzle Operation

Here is a sequential graphic view of the nozzle operation. Fuel is pumped under high pressure to the injector (1), pressurizing the internal supply passages (2). When the fuel pressure overcomes spring pressure, the needle valve is lifted off its seat and injection occurs.



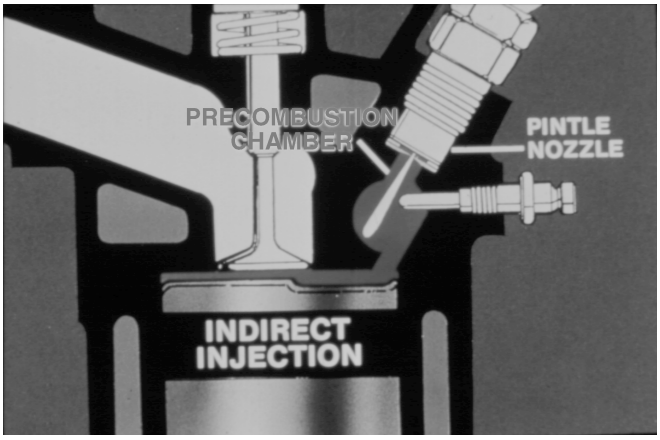
## 29. Nozzle Operation

The first figure on the left shows the needle valve open and injection occurring. The center figure shows fuel pressure decreasing. The figure on the right shows a fuel pressure drop and spring pressure closing the needle valve, shutting off injection.



## 30. Stages of Operation


## 31. Precombustion Chamber



## 32. Specifications

This sheet gives you all the specifications and information you will need to test the Stanadyne DB2 military fuel injection pump on a test stand stand

**M998A2 Series**

**STANADYNE DB2 FUEL INJECTION PUMP SPECIFICATIONS**
(SERVICE/ASSEMBLY)

Full Load RPM: 3400 AM General Part # 05743796 Model # DB28331-5149
Gov. Regulation: % MFG. Part # 12550433
Engine: 6.5L-170 BHP
Application: Heavy duty–Military (1.2 CST Min.)

TEST STAND: ISO 4008:

1. CALIBRATING HIGH PRESSURE PIPES..SAE J1418/ISO 4093: 098" (2.5 mm) ID x 25" (635 mm) LONG.
2. CALIBRATING INJECTORS....SAE J968.ISO 7440: 0.5 mm ORIFICE PLATE.....1700 PSI OPENING PRESSURE.

NOTE: INJECTORS SPECIFIED AT 1700 PSI OPENING PRESSURE MUST USE SPRING P/N WSF 2044 A 5X OR EQUIVALENT.

3. CALIBRATION FLUID...SAE J967/ISO 4113 (REF. S.B.201):
   A. TEMPERATURE AT INLET: 110°-115°F (43°-46°C)
   B. SUPPLY PRESSURE (S.B.334): 5.0 ± 0.5 PSI (34 ± 3 kPa) AT PUMP INLET.
4. CAM MOVEMENT READ OUT DEVICE: #23745.

| PUMP INSTALLATION: | LEVER ANGLES (REF) | |
|---|---|---|
| ROTATION -C'C-* | THOT MIN. (≤B) | N/A |
| NAME PLATE –L– SIDE** | THOT TOTAL (≤C) | N/A |
| #1 CYL.–10– O'CLOCK** | S.O. (≤E) | N/A |
| THROTTLE–K–SIDE** | S.O. (≤F) | N/A |
| TIMING MARK N/A | | |

*VIEWED FROM DRIVE END **VIEWED FROM TRANS. PUMP END

AIR TIMED TO HOUSING (PER S.B.177) (SEE SPECIAL NOTES).
PUMP OPERATING SPEED...HALF...ENGINE SPEED.
PUMP ACCESSORIES:

1. E.S.O. (24V E.T.R.)
2. M/LL ADVANCE
3. MIN.-MAX. GOVERNOR IV
4. HOUSING PRESSURE COLD ADV.
5. TRAILING PORT ROTOR
6. ACCUMULATORS
7. THIN FUEL COMPONENTS

PUMP CALIBRATION CHECKS: AS RECEIVED FOR SERVICE:
(REF. SL-222)

1. 1000 RPM (WOT): OPERATE PUMP FOR 10 MINUTES TO BRING TO OPERATING TEMPERATURE AND CLEAR AIR FROM SYSTEM.
2. 400 RPM: CHECK E.S.O. FOR PULL–IN WITH 17.6 VOLTS MAX., WITH THROTTLE IN LOW IDLE POSITION.
3. CHECK POINTS:

| | RPM | THRTL. POS. | mm3/STROKE | CAM MOVEMENT | (PSI) MSG |
|---|---|---|---|---|---|
| a. | 150 | L.I. | 27 MIN. | – – – | 0-12 |
| b. | 400 | WOT | 43 MIN. | – – – | – – – |
| c. | 400 | WOT* | 4 MAX. | – – – | – – – |
| d. | 700 | L.I. | 12-16*** | 0.5° MIN | 8-12 |
| e. | 700 | L.I. | – – – | **** | 0–1** |
| f. | 2000 | WOT | 56 MAX. | – – – | – – – |
| g. | 3200 | ADJ. | 21.5–23.5 | 3.75°–6.25° | – – – |
| h. | 3400 | WOT | 48-53 | 3.00°–5.00° | – – – |
| i. | 3500 | WOT | 43 MIN. | – – – | – – – |
| j. | 3650 | WOT | 30 MIN. | – – – | – – – |
| k. | 3900 | WOT | 15 MAX. | – – – | – – – |

* E.S.O. DE-ENERGIZED. **HPCA ENERGIZED

*** RESET USING LOW IDLE SCREW **** MIN. OF 1.25° MORE THAN READING OBTAINED IN STEP 3d.

4. a. USE GAGE #23716, SET THROTTLE WITH LOW IDLE SCREW TO 34° ± 2° AS MEASURED BETWEEN VERTICAL CENTER-LINE OF THROTTLE SHAFT BUSHING BORE AND THROTTLE CONNECTION STUD.

   b. ADJUST LOW IDLE SCREW UNTIL THROTTLE CONNECTION STUD MAKES CONTACT WITH GAGE.

5. a. OPERATE PUMP FOR 10 MINUTES TO BRING TO OPERATING TEMPERATURE AND CLEAR AIR FROM SYSTEM.

   b. CHECK FOR MINIMUM LIFT OF 18"HG. AT 400 RPM.

6. 2000 RPM (WOT):

   a. SET TRANSFER PUMP PRESSURE FOR 60-62 PSI, (414-427 kPa). (SUPPLY SET PER TEST STAND NOTE 38)

   b. SET RETURN OIL 225-375 CC/MIN.

7. 700 RPM (L.I.):

   a. CHECK HOUSING PRESSURE FOR 8-12 PSI, (55–83 kPa).

   b. WITH HOUSING PRESSURE COLD ADVANCE SOLENOID ENERGIZED WITH 17.6 VOLTS, HOUSING PRESSURE SHOULD BE 0–1 PSI, (0–7 kPa).

   c. WITH GOVERNOR COVER REMOVED AND THROTTLE IN LOW IDLE POSITION, SET MIN,–MAX. GOVERNOR ASSEMBLY FOR 7-9mm3/STROKE. (FUEL READING WITH COVER INSTALLED).

PUMP SETTINGS:

7. 700 RPM (L.I.): (CONT'D)
   d.ADJUST LOW IDLE SCREW FOR 13–15mm3/STROKE, (NOTE 16c) FOR THE REMAINDER OF THE SETTING AND CHECKING PROCEDURES, CONTROL FACE CAM AND THROTTLE SHAFT END PLAY TO .004"–.006" AS MEASURED BETWEEN SPACER #22900 AND HOUSING.

8. 3400 RPM (WOT):
   a. ROTATE FACE CAM TO ITS MAXIMUM LIFT POSITION IN CONTACT WITH THE CAM ROLLER.
   b. SET TRIMMER SCREW FOR 4.0 ADVANCE.
   c. SET FUEL DELIVERY TO 50–51 mm3/STROKE.

9. 3650 RPM (WOT):
   a. SET GUIDE STUD FOR 35.5–37.5 mm3/STROKE.
   b. AFTER SETTING IS OBTAINED, TORQUE NUT #23585 TO 80–90 IN–LBS.
   c. CHECK DIMENSION FROM TOP OF NUT TO TOP OF GUIDE STUD FOR .425" MAX.

10. 3200 RPM:
   a. ADJUST THROTTLE TO 21.5–23.5 mm3/STROKE.
   b. ROTATE FACE CAM TO OBTAIN 5.0° ADVANCE.
   c. AFTER SETTING IS OBTAINED, TORQUE SCREW #22398 TO 28–30 IN–LBS.
   d. CHECK FACE CAM RETENTION PER S.B.361.

11. SET TOTAL THROTTLE TRAVEL:
   a. 1500 RPM: SET THROTTLE FOR 22.5 ± 3 mm3/STROKE.
   b. LOCK THROTTLE LEVER IN POSITION AND INSTALL THROTTLE LEVER PROTRACTOR #22089 ONTO SHAFT.
   c. ALIGN 0° ON PROTRACTOR WITH CENTER OF RIB ON ROCKER LEVER #28937. UNLOCK THROTTLE LEVER AND ROTATE TO WOT POSITION. ADJUST MAX. TRAVEL SCREW TO 60°.
   d. CHECK TOTAL THROTTLE TRAVEL: WITH THROTTLE IN LOW IDLE POSITION, ALIGN 0° ON PROTRACTOR WITH CENTER OF RIB ON ROCKER LEVER. MOVE THROTTLE TO WOT READING SHOULD BE BETWEEN 75° AND 84°.

12. CHECK POINTS:
   a. 1500 RPM (WOT): DE–ENERGIZE ELECTRIC SHUT-OFF. FUEL SHOULD BE 4 mm3/STROKE, MAX. RE-ENERGIZE E.S.O.

| | RPM | THRTL. POS. | mm3/STROKE | CAM MOVEMENT | PRESSURE (PSI) T.PUMP | MSG |
|---|---|---|---|---|---|---|
| b. | 150 | L.I. | 28 MIN. | – – – | 16 MIN. | 0-12 |
| c. | 400 | WOT | 43 MIN. | – – – | – – – | – – – |
| d. | 400 | WOT* | 4 MAX. | – – – | – – – | – – – |
| e. | 400 | L.I.** | – – – | – – – | – – – | – – – |
| f. | 700 | L.I. | 12-161.0° | MIN. | – – – | 8-12 |
| g. | 700 | L.I. | – – – | **** | – – – | 0–1 |
| h. | 2000 | WOT. | 56 MAX. | – – – | 60–62 | – – – |
| i. | 3200 | ADJ. | 21.5°–23.5° | 4.0°–6.0° | – – – | – – – |
| j. | 3400 | WOT | 49-52 | 3.50°–4.50° | – – – | – – – |
| k. | 3500 | WOT | 45 MIN. | – – – | – – – | – – – |
| l. | 3650 | WOT | 31.5 MIN. | – – – | – – – | – – – |
| m. | 3900 | WOT | 15 MAX. | – – – | 125 MAX | – – – |

*E.S.O. DE-ENERGIZED** CHECK E.S.O. FOR PULL-IN WITH 8.8

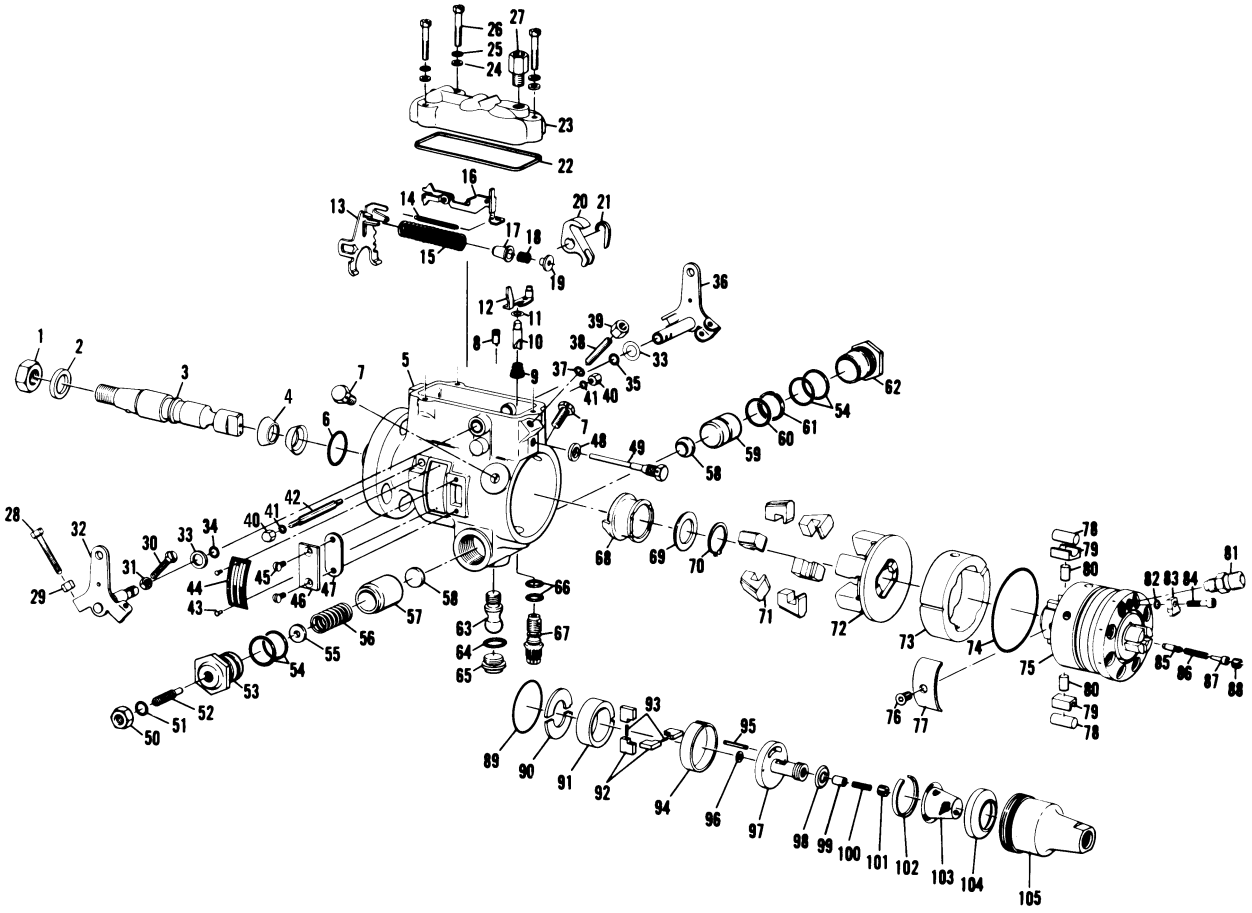
VOLTS MAX. WITH THROTTLE IN LOW IDLE POSITION, CHECK

E.S.O. 4 mm3/STROKE , MAX. **** MIN. OF 1.25° MORE THAN READING OBTAINED IN STEP 13f.

13. AIR-TIME PUMP USING GAGE #23715 SET TO –1.0° ± 0.5°.
   a. TORQUE ALL FASTENERS PER S.B.106.
   b. SECURE MAXIMUM TRAVEL ADJUSTING SCREW, ADVANCE TRIMMER SCREW, AND FACE CAM SCREW WITH RETAINING COMPOUND #21915.
   c. IF ADJUSTMENT IS REQUIRED, USE L.I. SCREW. CHECK CENTERLINE OF THROTTLE STUD TO VERTICAL CENTERLINE OF SHAFT AT 32°–36°. ADJUSTMENT IS ± 1 TURN FROM POINT IN STEP 4a.
   d. INSTALL GUIDE STUD TAMPER PROOFING CAP #26961 (FIELD SERVICE P/N) ON GUIDE STUD #26495 (REF. S.B.365A).
   e. SEAL PUMP FASTENERS PER S.B.365.

15. FURTHER INFORMATION SUPPLEMENTING THE ABOVE PROCEDURES SHOULD BE OBTAINED FROM S.B.375.

## 33. Exploded View



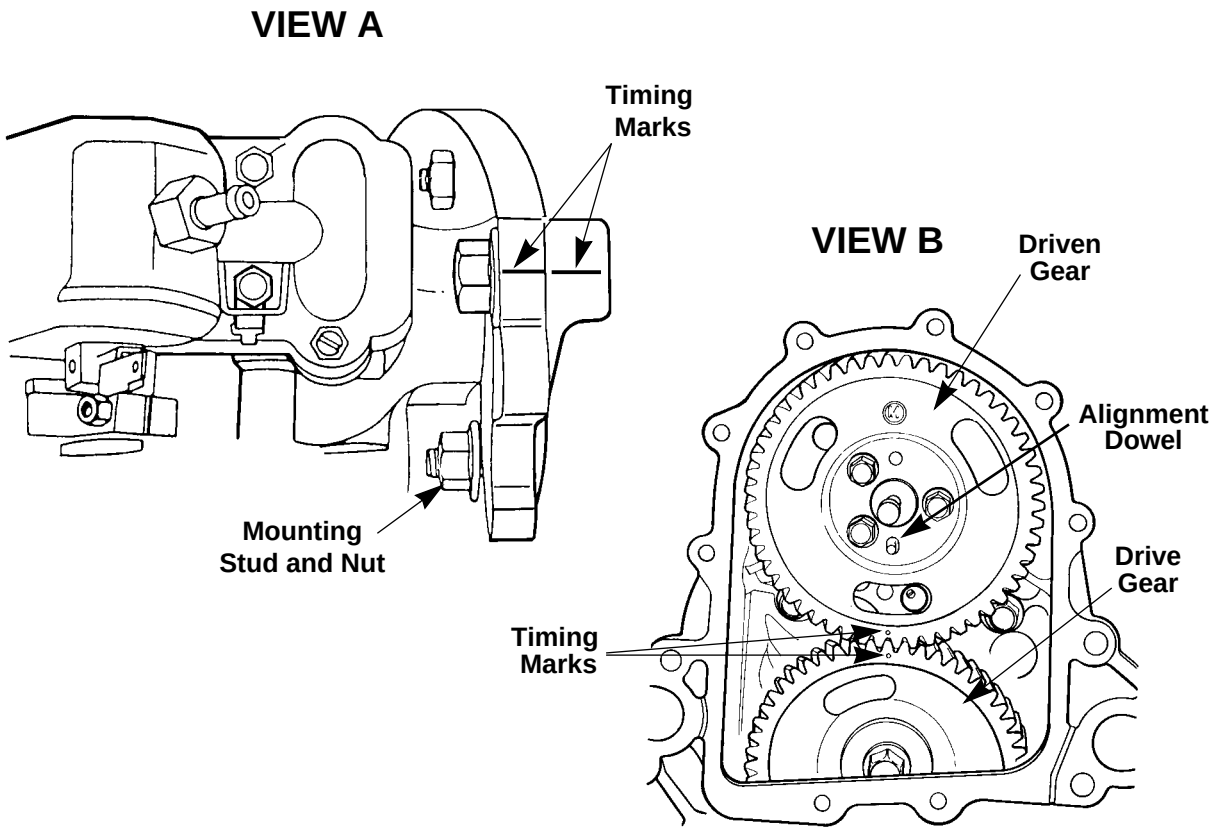
| | | |
|---|---|---|
| 1. NUT, driveshaft | 36. SHAFT ASSY., shut-orr | 37. WEIGHT, governor |
| 2. WASHER, driveshaft | 37. SEAL, torque screw | 72. RETAINER ASSY., gov. weight |
| 3. SHAFT, drive | 38. SCREW, torque | 73. CAM RING |
| 4. SEAL, driveshaft | 39. NUT, torque screw | 74. SEAL, hydraulic head |
| 5. HOUSING ASSY., pump | 40. NUT, pivot shaft | 75. HEAD AND ROTOR ASSY. |
| 6. SEAL, pump flange | 41. SEAL, pivot shaft | 76. SCREW, leaf spring |
| 7. SCREW, head locking | 42. SHAFT. gov. arm pivot | 77. SPRING, leaf |
| 8. SCREW ASSY., vent | 43. SCREWS, nameplate | 78. ROLLER, cam |
| 9. SPRING, metering valve | 44. PLATE, name | 79. SHOE, cam roller |
| 10. VALVE, metering | 45. SCREW, timing line cover | 80. PLUNGERS, discharge |
| 11. SHIM, metering valve | 46. COVER, timing line | 81. FITTING, discharge |
| 12. ARM ASSY., metering valve | 47. GASKET, timing line cover | 82. SEAL, locking plate |
| 13. ARM, governor | 48. WASHER, guide stud | 83. PLATE, locking |

| | | |
|---|---|---|
| 14. SPRING, linkage book | 49. STUD, guide | 84. SCREW, locking plate |
| 15. SPRING, governor | 50. NOT, adv. adj. screw | 85. VALVE, delivery |
| 16. LINKAGE ASSY., gov. hook adj. | 51. SEAL, adv. adj. screw | 86. SPRING, delivery valve |
| 17. RETAINER, spring | 52. SCREW, advance adjusting | 87. STOP, delivery valve |
| 18. SPRING, idling | 53. PLUG, piston hole (trimmer side) | 88. SCREW, delivery valve |
| 19. GUIDE, idling spring | 54. SEAL, piston hole plug | 89. SEAL, transfer pump |
| 20. LEVER, throttle shaft | 55. GUIDE, adv. adj. spring | 90. RETAINERS, rotor |
| 21. CAM, shut-off | 56. SPRING, advance adjusting | 91. LINER, transfer pump |
| 22. GASKET, governor cover | 57. PISTON, spring | 92. BLADES, transfer pump |
| 23. COVER, governor control | 58. WASHER, slide | 93. SPRINGS, transfer pump blade |
| 24. WASHER, cover screw | 59. PISTON, power | 94. RING, liner locating |
| 25. LOCKWASHER, cover screw | 60. RING, piston | 95. ROLLPIN, regulator |
| 26. SCREW, cover hold-down | 61. Ring, piston | 96. SEAL. inlet filter screen |
| 27. SCREW, low idle adjusting | 62. Plug, piston hole (power side) | 97. REGULATOR ASSY., transfer pump |
| 28. SCREW, low idle adjusting | 63. SCREW, cam advance | 98. SEAL, inlet filter screen |
| 29. NUT, low idle adjusting | 64. SEAL, advance screw hole plug | 99. PISTON, regulating |
| 30. SCREW, high idle adjusting | 65. PLUG, advance screw hole plug | 100. SPRING, regulating |
| 31. NUT, high idle screw | 66. SEAL, head locating screw | 101. PLUG ASSY., end plate adjusting |
| 32. SHAFT ASSY., throttle | 67. SCREW, ASSY., head locating | 102. RING, filter screen retaining |
| 33. WASHER, throttle shaft seal | 68. SLEEVE, governor thrust | 103. SCREW, inlet filter |
| 34. SEAL, throttle shaft | 69. WASHER, gov. thrust sleeve | 104. PLATE, transfer pump pressure |
| 35. SEAL, shut-off shaft | 70. Ring, gov. cage retaining | 105. CAP, transfer pump end |

## 34. Injection Pump Mounting and Drive

The fuel injection pump assembly mounts on the rear of the front cover, using a pilot bore, three stud/nut fasteners and a gasket. The injection pump mounting flange has a timing mark that aligns with a timing mark on the front cover during the installation procedure (view A).

The injection pump drive gear is held on the front of the camshaft with a bolt alignment dowel, and rotates a driven gear with a 1:1 ratio. The drive and driven gears have alignment marks for installation to assure correct timing, (view B).



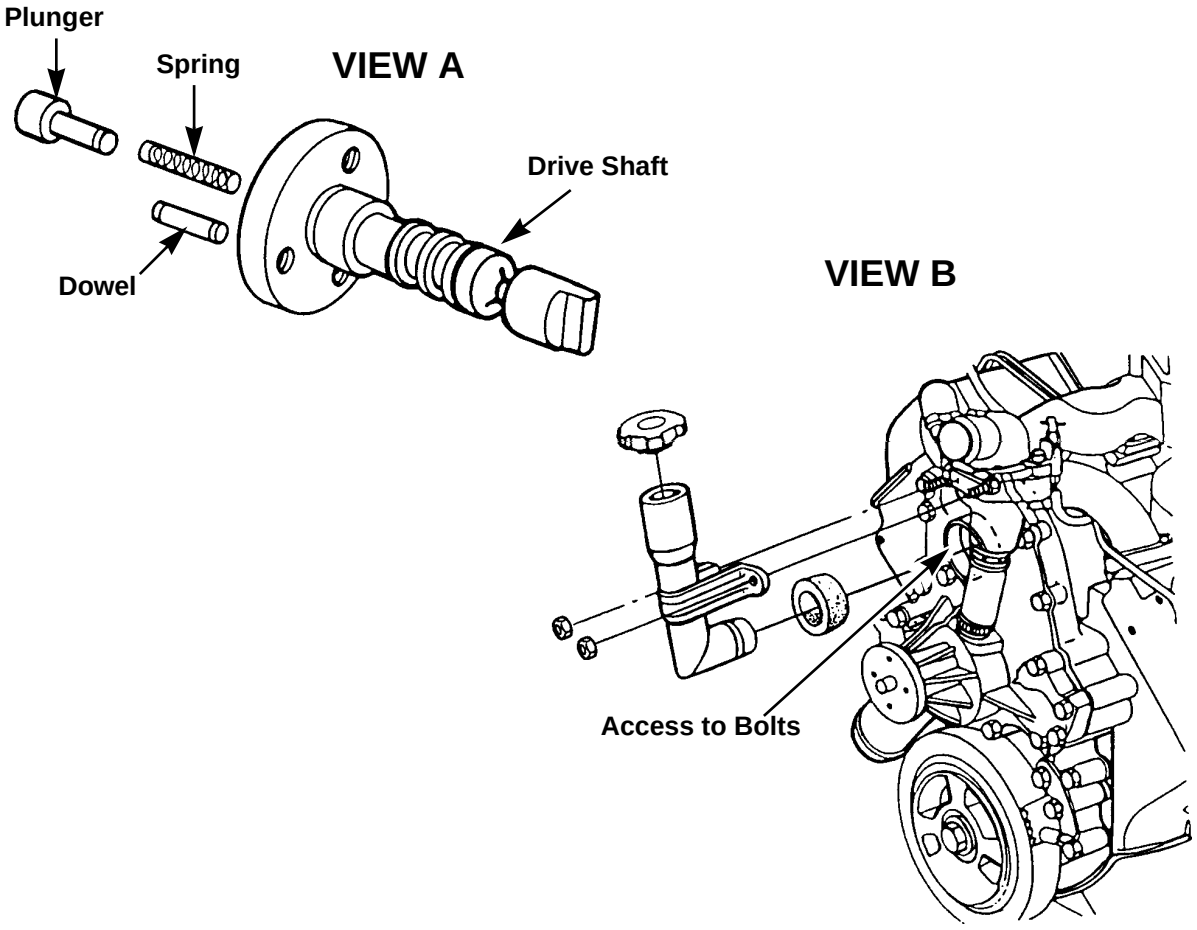

Injection Pump Mounting and Drive

## 35. Injection Pump Mounting and Drive

The fuel injection pump driven gear mounts on the injection pump drive shaft flange, using a pilot bore, and alignment dowel and three bolts coated with thread-locking compound. The injection pump drive shaft has a center bore that allows a spring-loaded plunger to contact a metal finger on the back side of the water pump plate (view A).

Because the gears use teeth cut in a helical pattern, end-play causes changes in fuel injection timing. The spring-loaded plunger provides thrust force on the injection pump drive shaft to control the end-play of internal parts. It also keeps the timing between the drive and driven gears from changing as the result of driven gear endwise movement.

During injection pump replacement, access to the three driven gear mounting bolts is possible after the oil fill pipe and grommet are removed, (view B). The crankshaft must be rotated for access to each of the bolts.



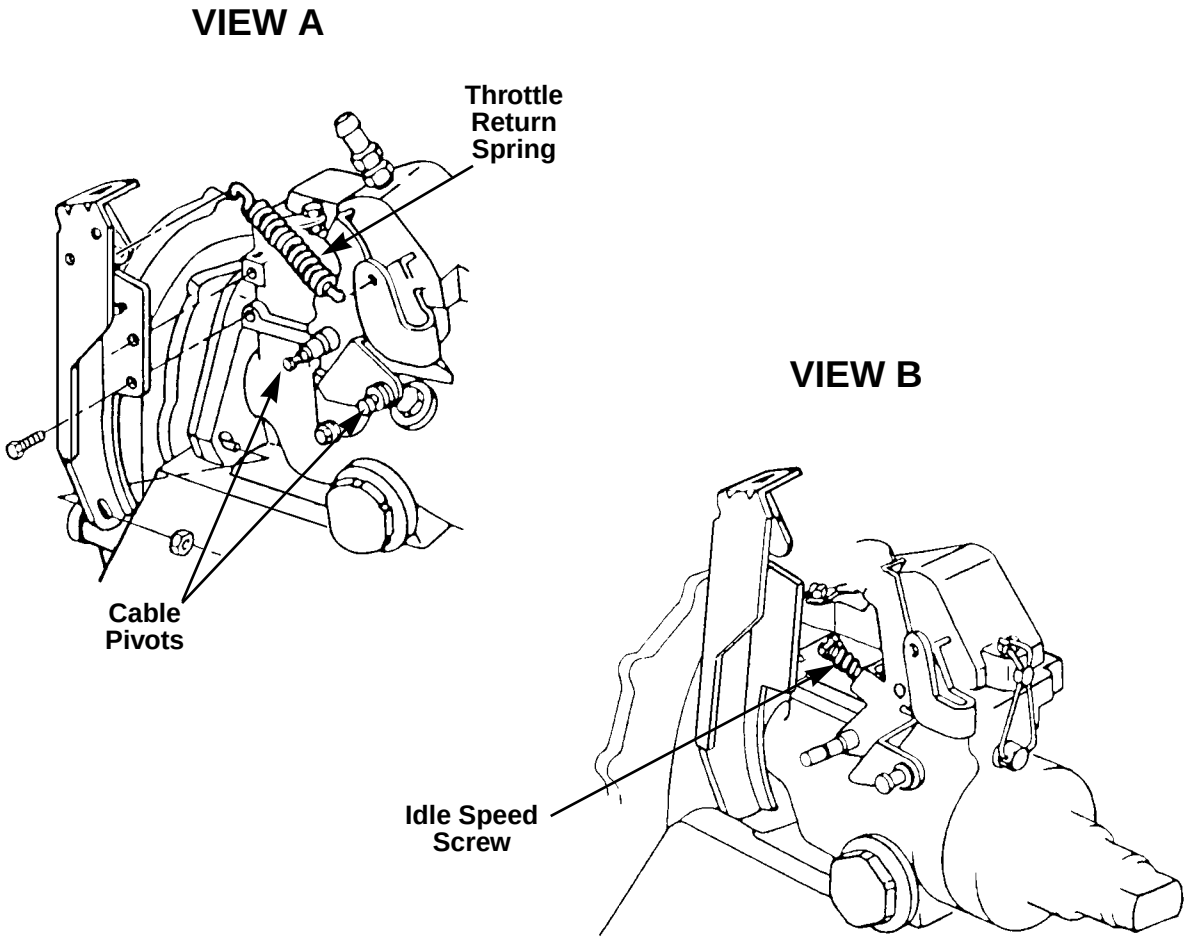

Injection Pump Mounting and Drive

### 36. Injection Pump External Linkage

The fuel injection pump has an external bracket and pivots that support the throttle cable assembly, (view A). The throttle cable attaches to the injection pump throttle shaft and connects with the accelerator pedal in the driver compartment.

A throttle return spring fastened between the bracket and injection pump keeps the throttle shaft in a closed position for engine idling, (view A).

The injection pump throttle shaft has a full-throttle stop screw that is pre-adjusted during calibration, as well as an idle speed screw that provides adjustment during service, (view B)..



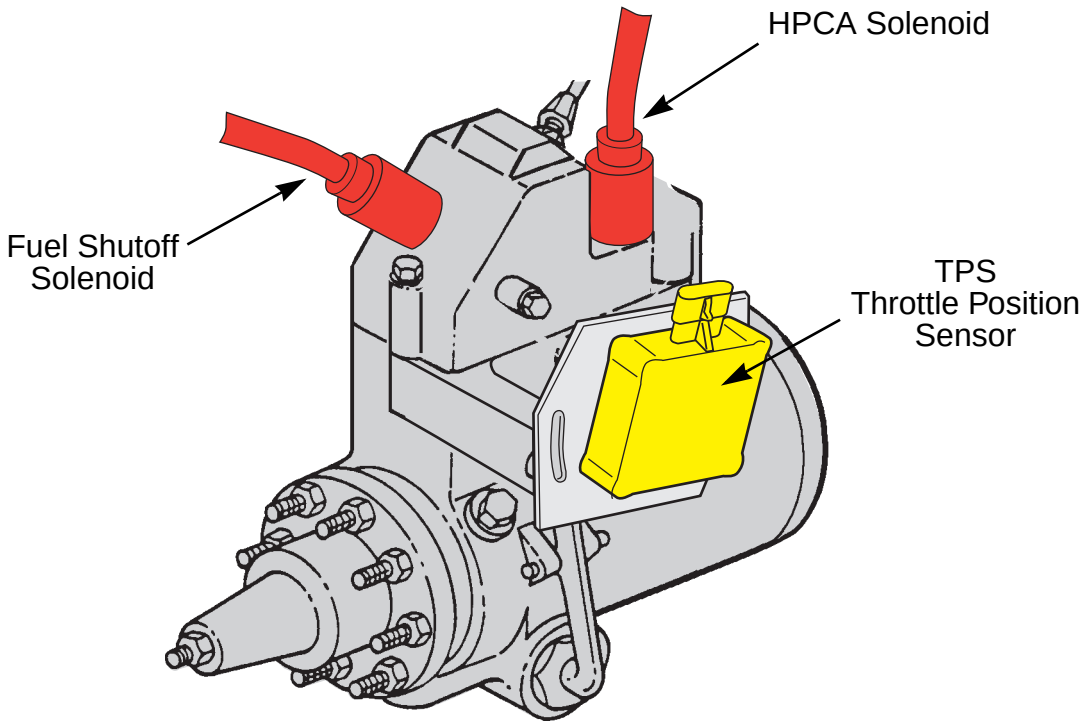

Injection Pump External Linkage

## 37. Injection Pump Electrical Connections

The fuel injection pump has electrical connectors for three devices. The top of the injection pump (called the governor cover) contains an internal fuel shut-off solenoid with a terminal that receives power when the ignition switch is in either the START or RUN position. The shut-off solenoid ground is provided through the injection pump housing mounting to the engine.

Another electrical control inside the injection pump governor cover is the Housing Pressure Cold Advance (HPCA) solenoid. Like the shut-off solenoid, it has a terminal and ground connection through the housing.

The third electrical device is the Throttle Position Sensor (TPS), an input to the Transmission Control Module (TCM).



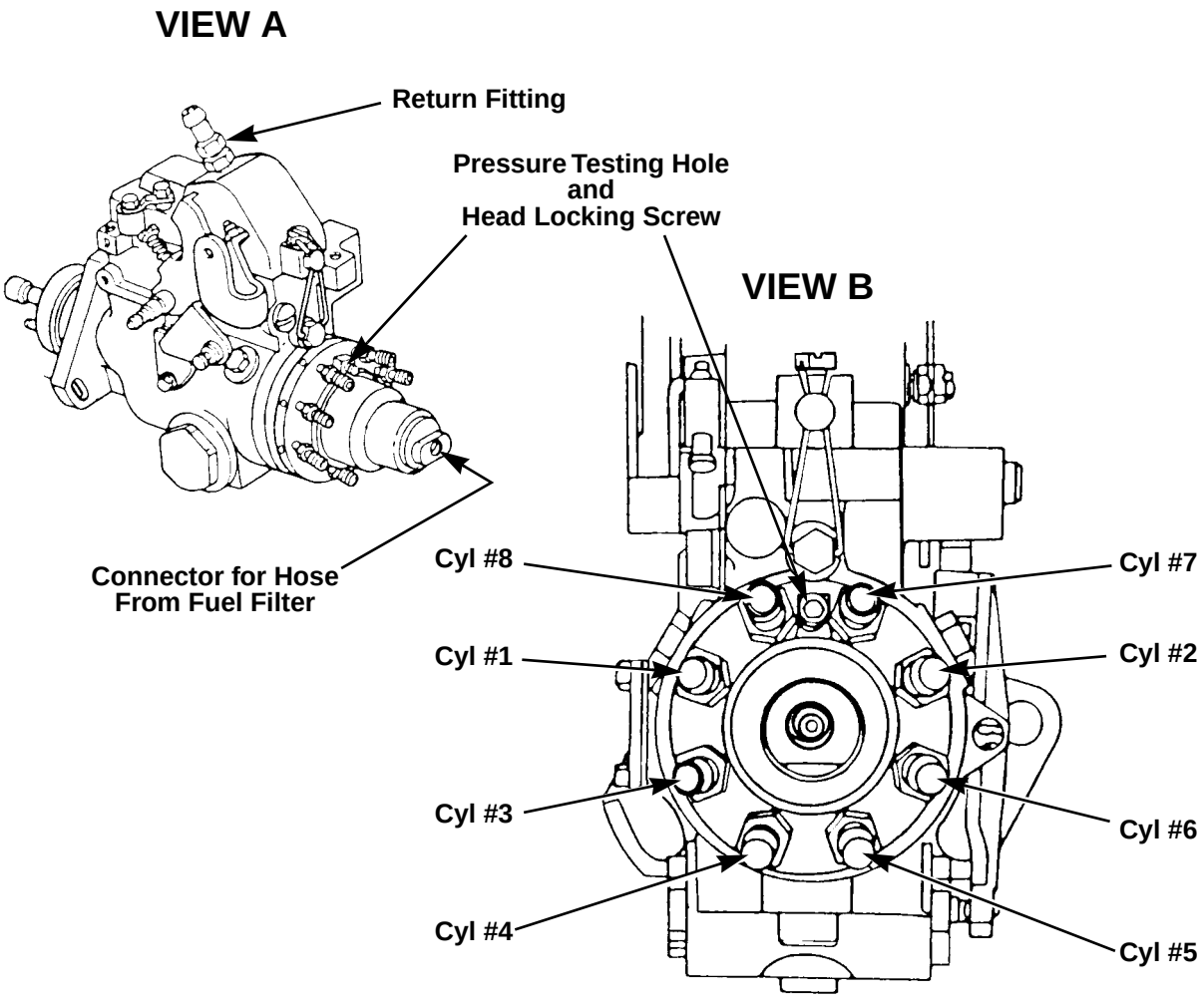

Injection Pump Electrical Connections

## 38. Injection Pump Fuel System Connections

The fuel injection pump has a fitting on ithe transfer pump end cap for the hose from the fuel filter assembly. Fuel under lift pump pressure enters the injection pump at this location. There is also a threaded hole at the head locking screw for pressure testing the pump.

The governor cover of the injection pump has a fitting at its housing pressure regulator for a hose connecting to the fuel return system (view A). The return system sends fuel heated by internal part movement inside the injection pump and injection nozzles to the fuel tank.

The injection pump head assembly has eight high-pressure outlet fittings for the lines connecting to nozzles in the cylinders (view B). Each fitting connects with a specific cylinder.

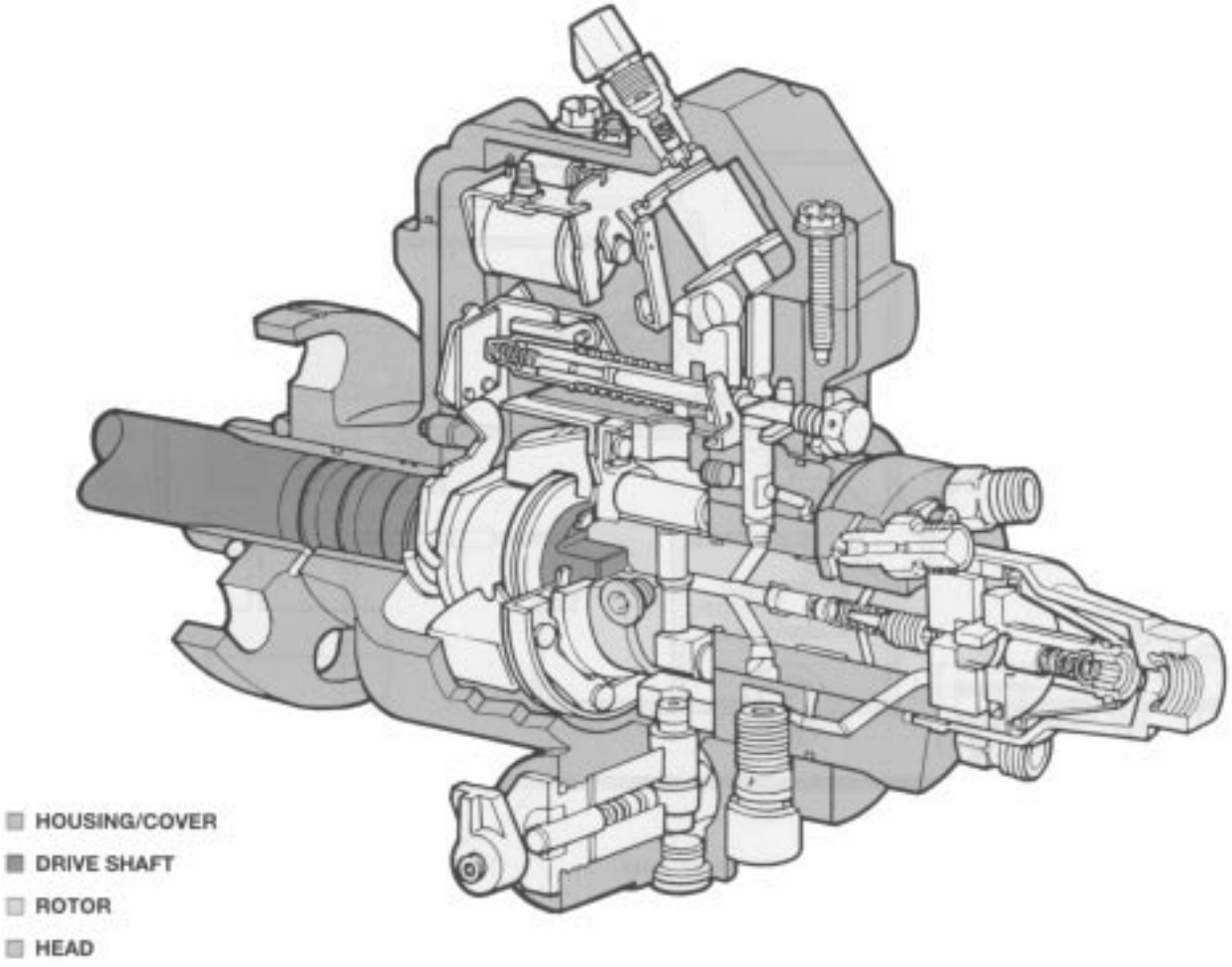



Injection Pump Fuel System Connections

## 39. Injection Pump Construction

The fuel injection pump pressurizes and distributes a metered amount of fuel to each cylinder nozzle at the proper time, based on the calibrated needs of the engine. The injection pump uses a variety of internal components that require lubrication from the very highly filtered fuel flowing around them.

Some parts have surfaces with machining tolerances measured in microns (millionths of an inch) and require handling by skilled technicians operating in a “clean room” environment with a ventilation system using temperature, humidity and dust control. Other internal injection pump parts have adjustments that are made during a calibration procedure with a special test stand.



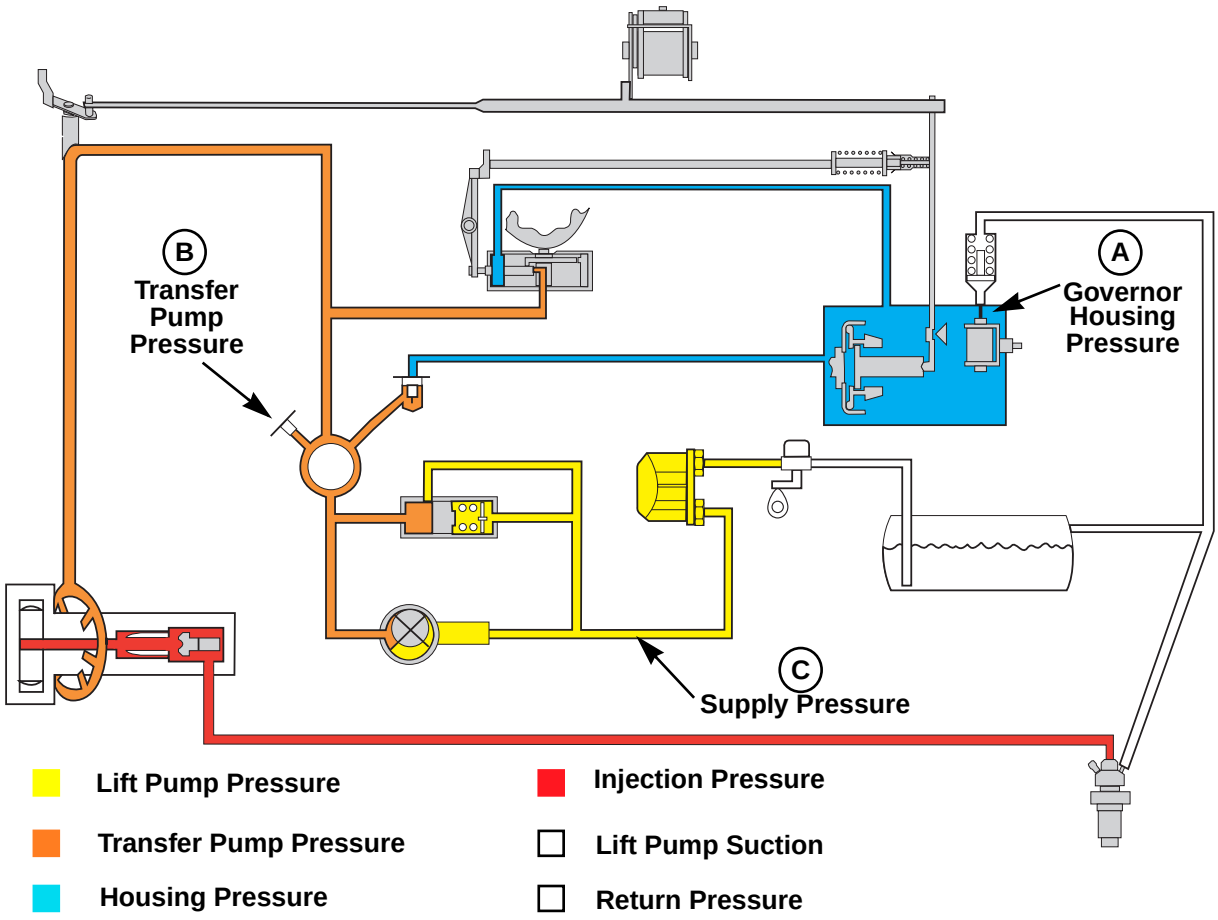

Injection Pump Cutaway View – Major Parts

## 40. Injection Pump Operation

The operation of the fuel injection pump has four functions related to the delivery of fuel to the injection lines and nozzles:

- Metering
- Pressurization and distribution
- Lubricating
- Timing

The injection pump accomplishes its functions using fuel as a hydraulic fluid. Several different pressures exist in the injection pump as it operates. During service, test gauges may be installed to diagnose the fuel system.




**NOTE: Circled Letters Indicate Pressure Check Points.**

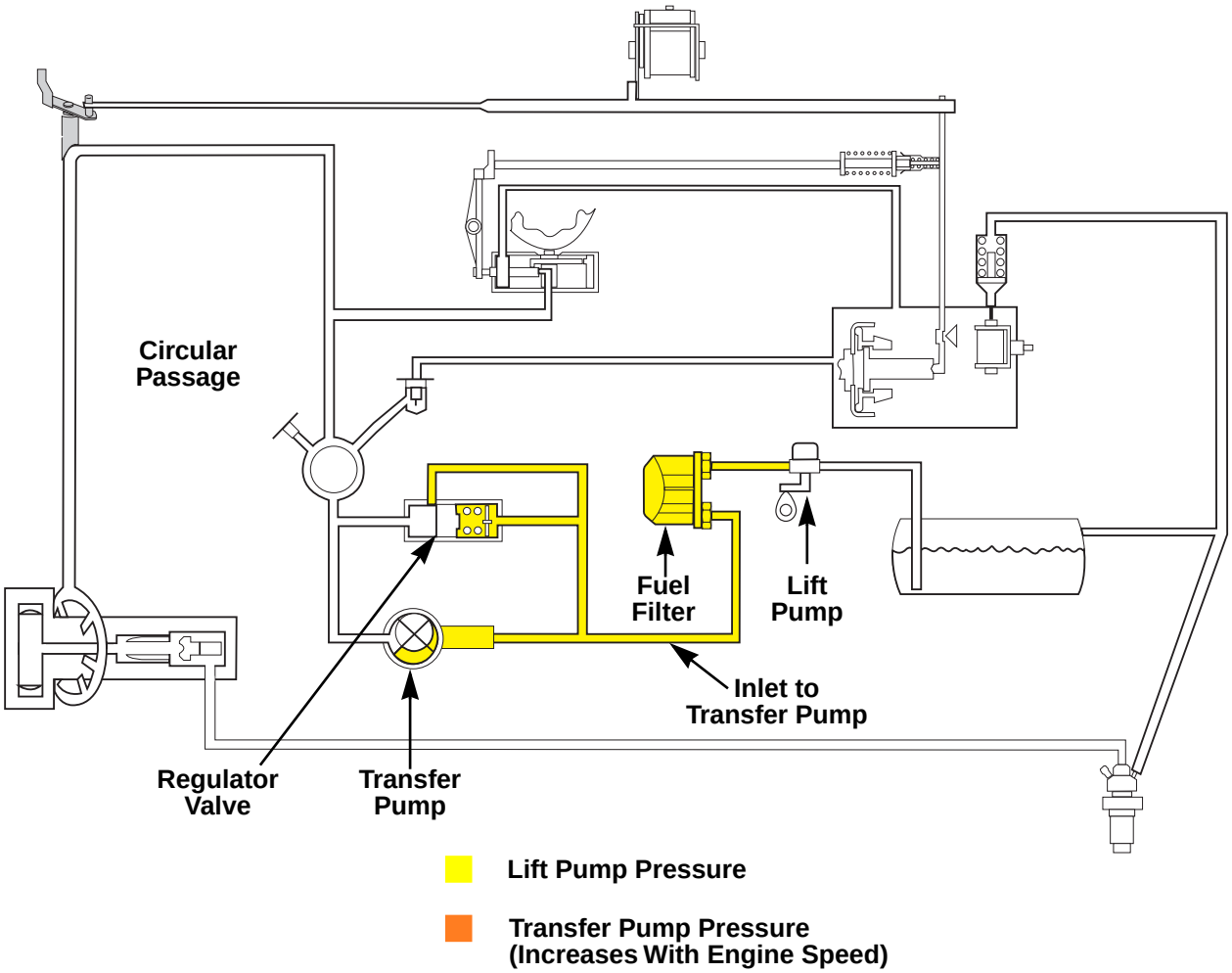
Fuel System Diagram – Injection Pump Hydraulic Pressures

## 41. Transfer Pump Flow

Fuel under lift pump pressure enters the inlet of the transfer pump. The drive shaft rotates the rotor, which has slots in its end to operate the blades of the transfer pump inside a stationary cam ring.

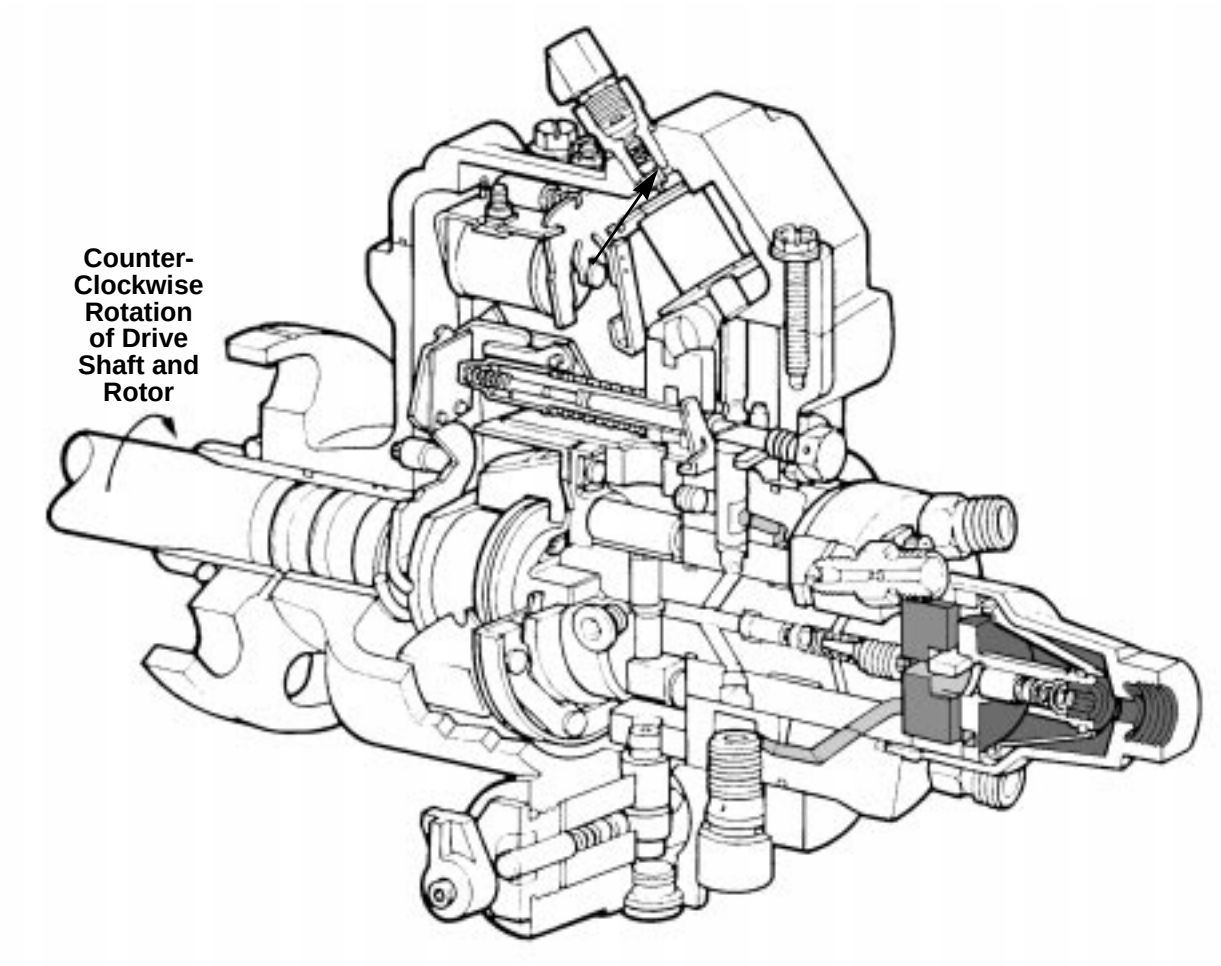
The transfer pump varies the pressure of the fuel, depending on the speed of the engine. At idle, the transfer pump outlet pressure is approximately 8-15 psi. At full engine speed, the transfer pump outlet pressure may be as high as 130 psi.

A regulator valve controls the transfer pump outlet pressure and has an adjustment made during injection pump calibration.




Fuel System Diagram – Transfer Pump Flow

## 42. Transfer Pump Operation




**Lift Pump Pressure**

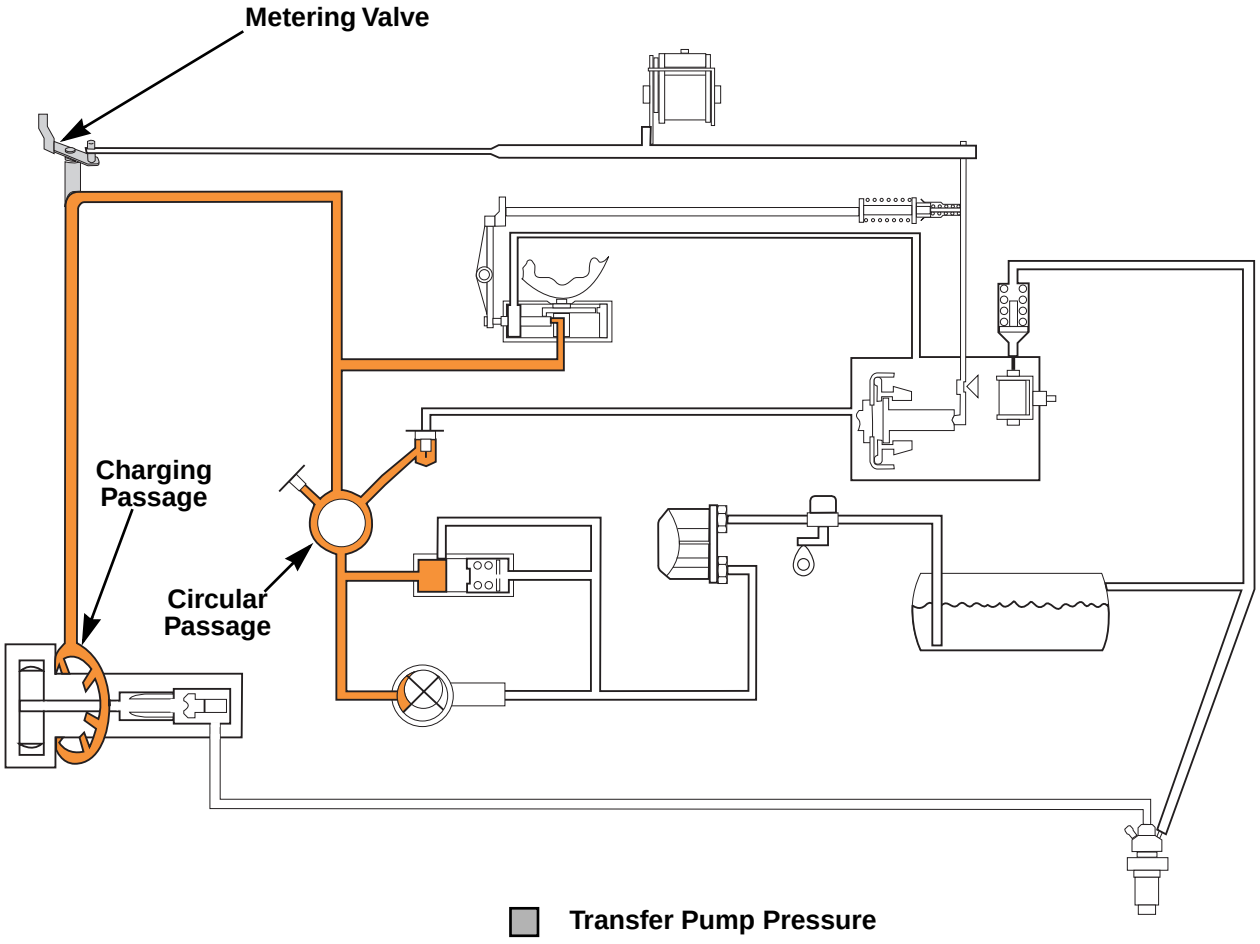
**Transfer Pump Pressure**

Injection Pump Cutaway View – Transfer Pump Operation

## 43. Metering Valve Flow

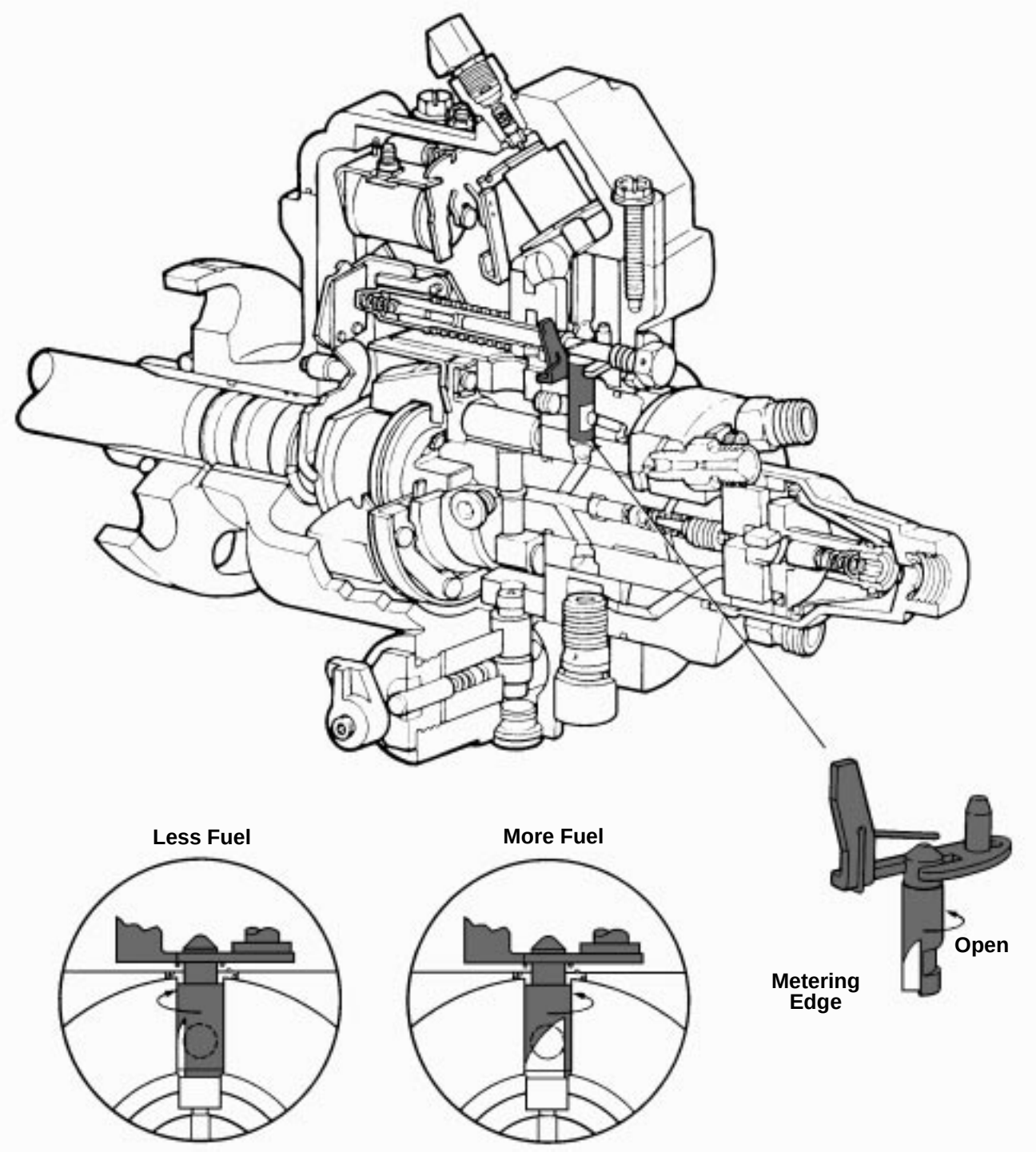
Fuel under transfer pump pressure travels through passages to several components, including a metering valve. The metering valve directly affects the speed and power of the engine.

The metering valve controls how much fuel under transfer pump pressure enters a circular charging passage in the high-pressure part of the injection pump. When the valve rotates in a clockwise direction, less fuel enters the charging passage. As the valve rotates in a counterclockwise direction, more fuel enters the charging passage.




Fuel System Diagram – Metering Valve Flow

## 44. Metering Valve Operation




Injection Pump Cutaway View – Metering Valve Operation

### 45. Governor Mechanism Parts

A governor mechanism positions the metering valve by balancing the opposing forces of the throttle shaft position and the speed of the injection pump. The governor mechanism includes the following parts.

- The metering valve
- Linkage connected to the metering valve (not shown)
- The governor arm, connected to the linkage and pivoting on a pin in the injection pump housing
- Two parts that contact the governor arm:

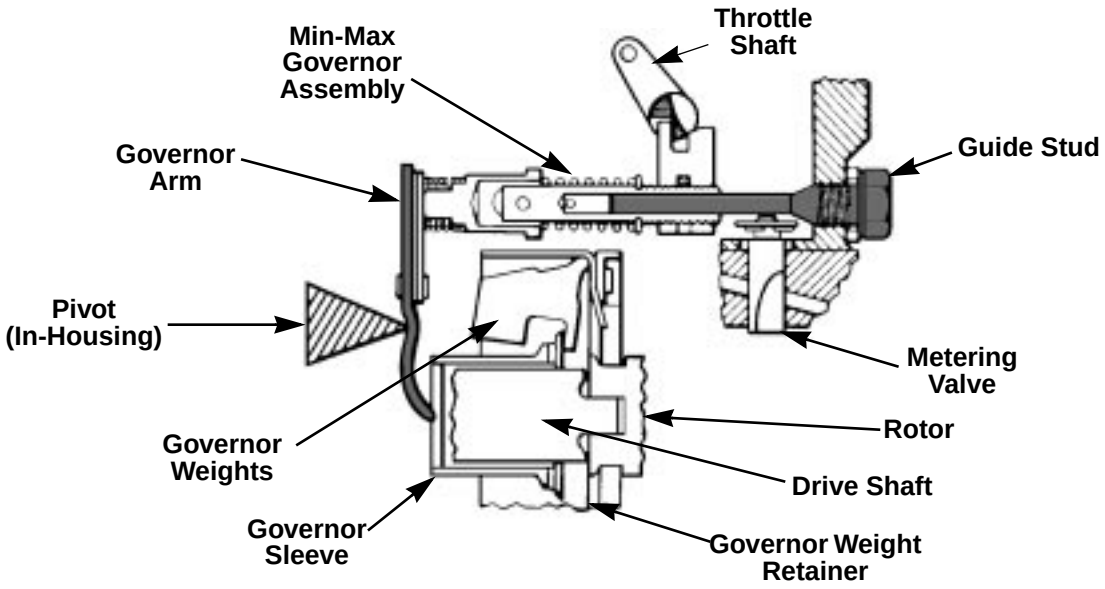
  A governor weight assembly

  A min-max governor assembly

The governor weight assembly has these parts:

- A weight retainer, mounted on the rotor and rotated by the drive shaft
- Six weights that pivot further outward as injection pump speed increases
- A governor sleeve that is moved by the action of the weights and in turn moves the bottom end of the governor arm

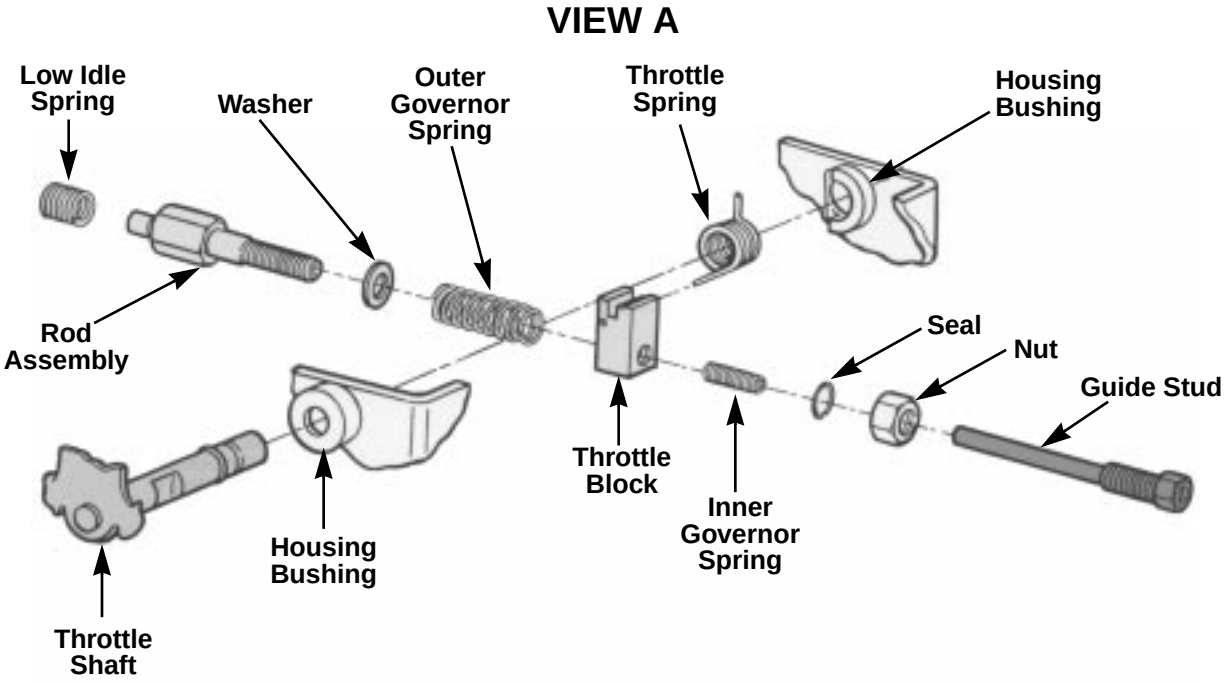
.

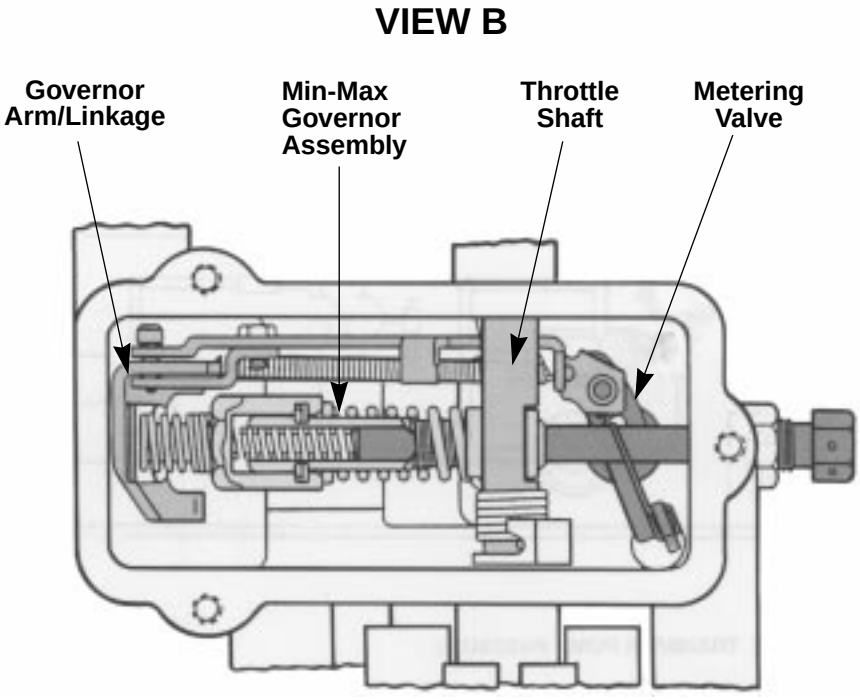



Governor Mechanism Parts

## 46. Min-Max Governor Assembly

The min-max governor assembly has the parts shown in the next slide (view A). It mounts in the injection pump housing by sliding on a guide stud and connects the throttle shaft to the upper end of the governor arm, (view B).



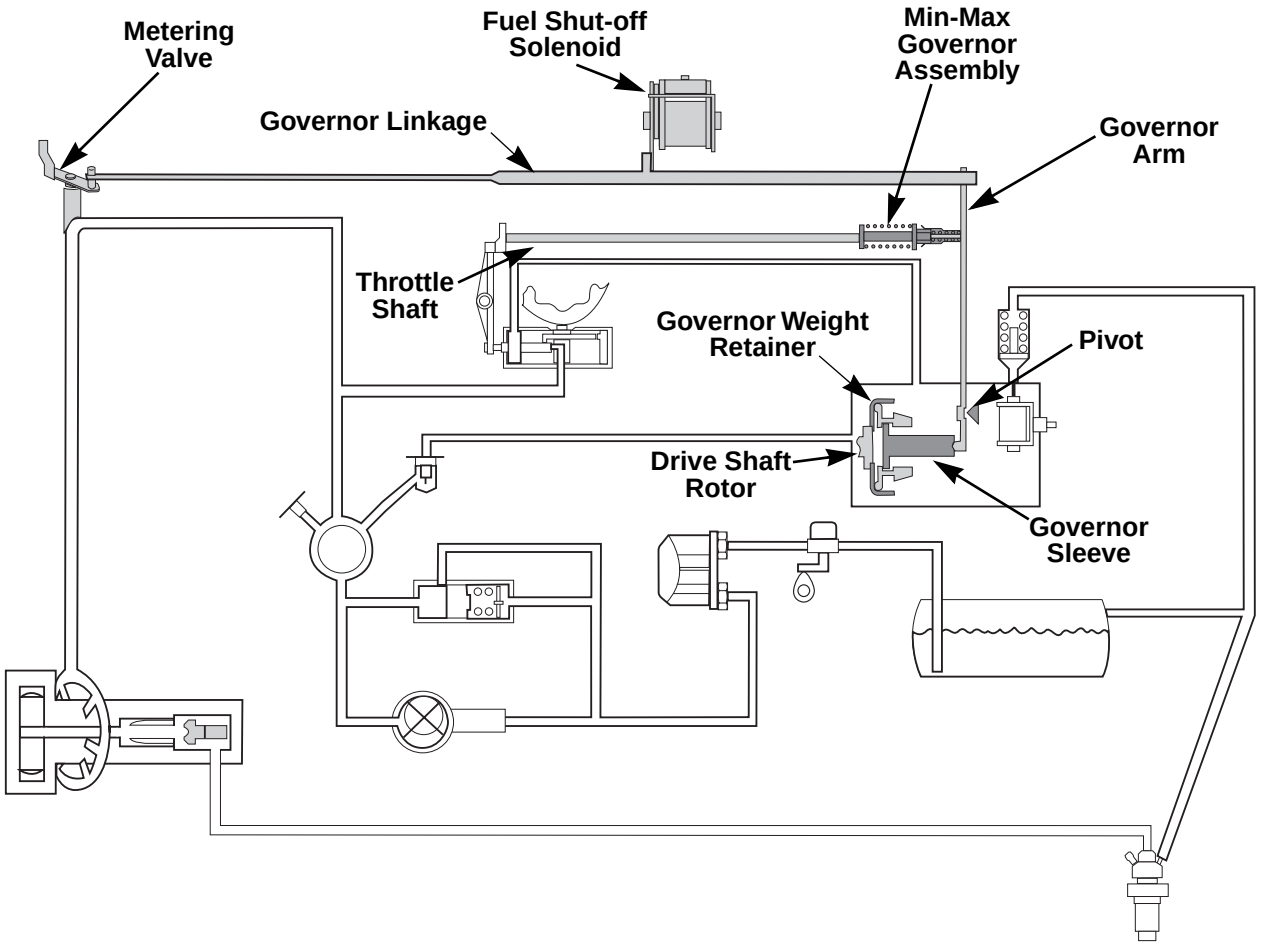

Min-Max Governor Assembly

## 47. Governor Mechanism Operation

The governor mechanism operates as follows:

- A fuel shut-off solenoid contacts the metering valve linkage when it is OFF, blocking fuel from entering the charging passage and stopping engine operation.
- At any engine speed, the metering valve is positioned by opposing forces:

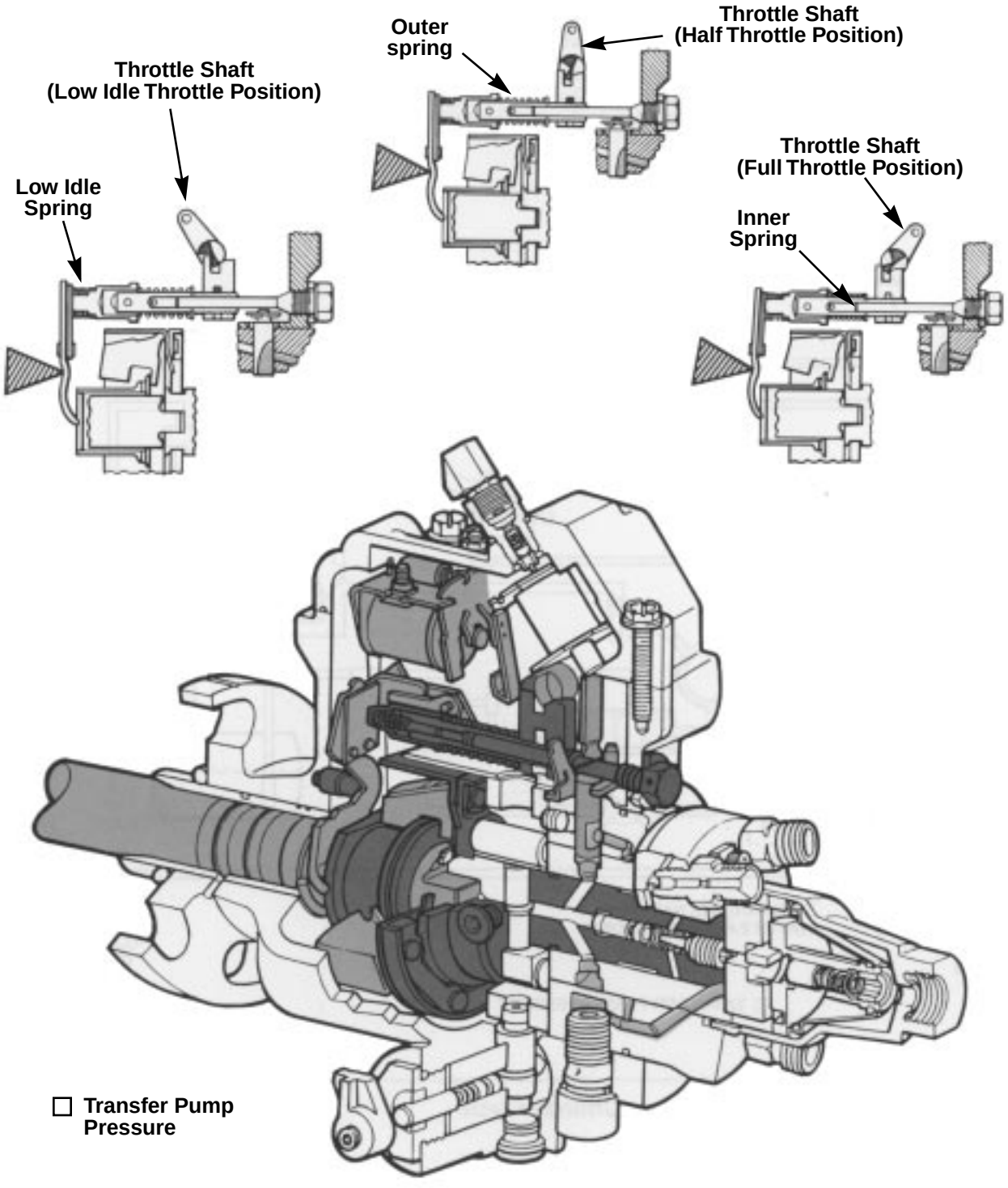
  The throttle shaft position and injection pump drive shaft speed.




❑ **Transfer Pump Pressure**

Fuel System Diagram – Governor Mechanism Operation

## 48. Governor Mechanism Operation

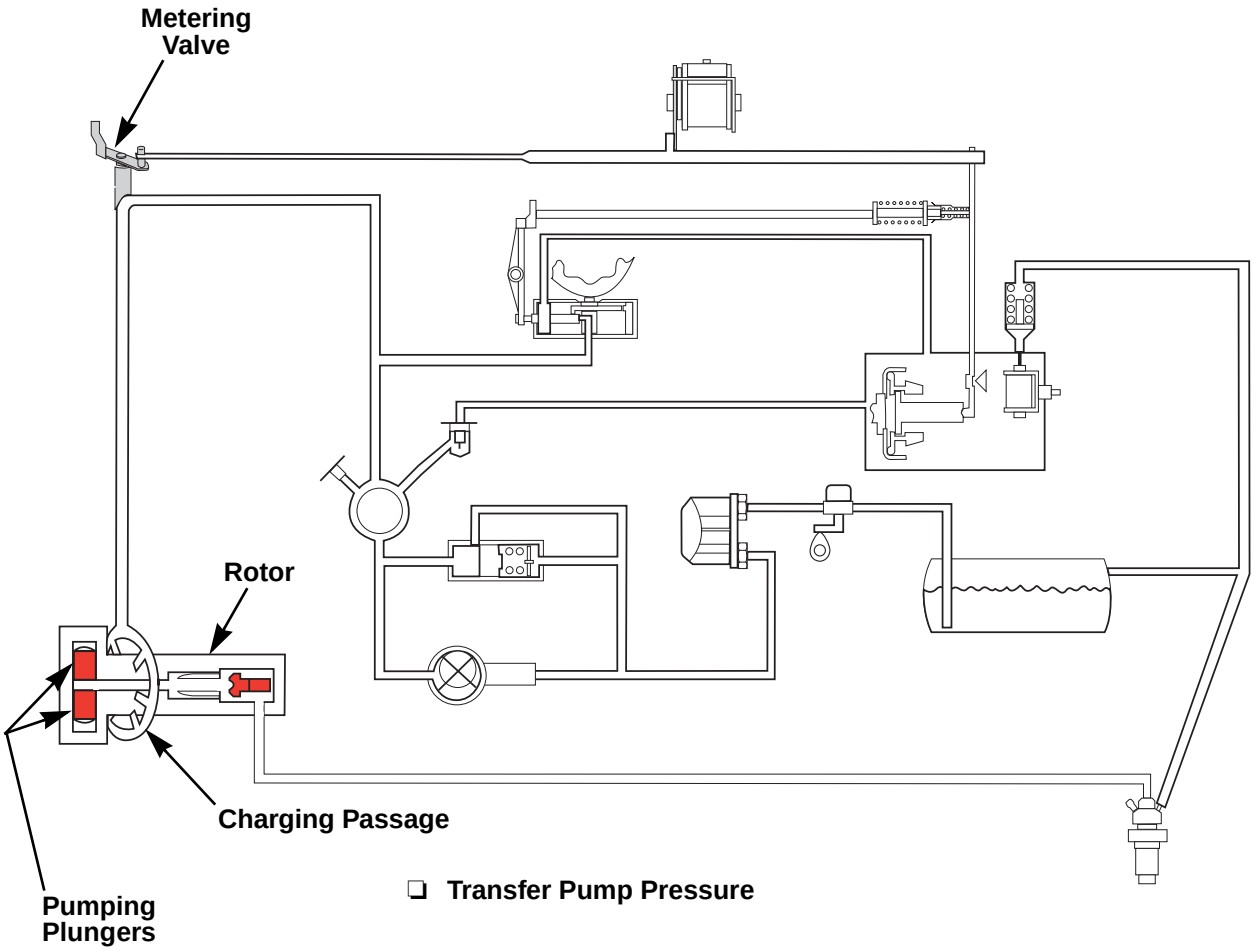



Injection Pump Cutaway View – Governor Mechanism Operation

## 49. Pressurizing and Distributing

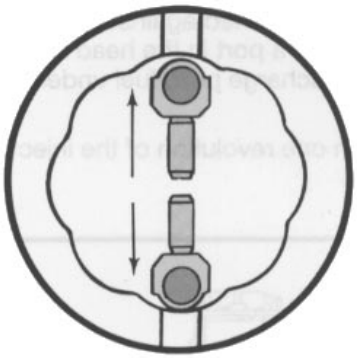
The circular charging passage in the head of the injection pump has eight ports that align in pairs with the two ports of the rotor pumping chamber. Metered fuel under transfer pump pressure travels through the charging passage and enters the rotor, pushing two pumping plungers outward as it fills the chamber.

Each pumping plunger contacts a shoe/roller assembly. The two shoe/roller assemblies contact the inner surface of a cam ring, which has eight lobes and valleys. During the charging of the pumping chamber, the valleys of the cam ring allow the pumping plungers and shoe/roller assemblies to move outward at a distance controlled by how much fuel fills the pumping chamber.

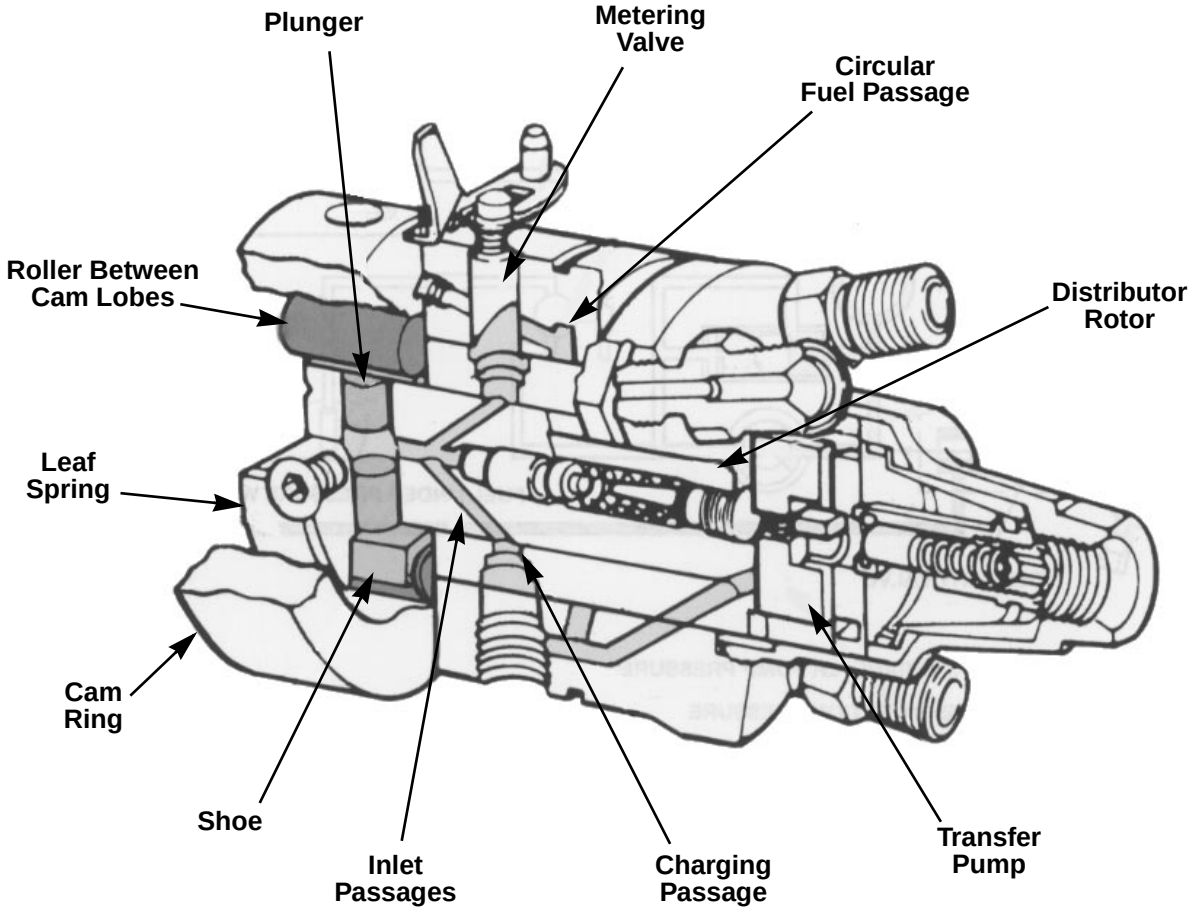



Fuel System Diagram – Charge Cycle

## 50. Charge Cycle



**Plunger Movement**



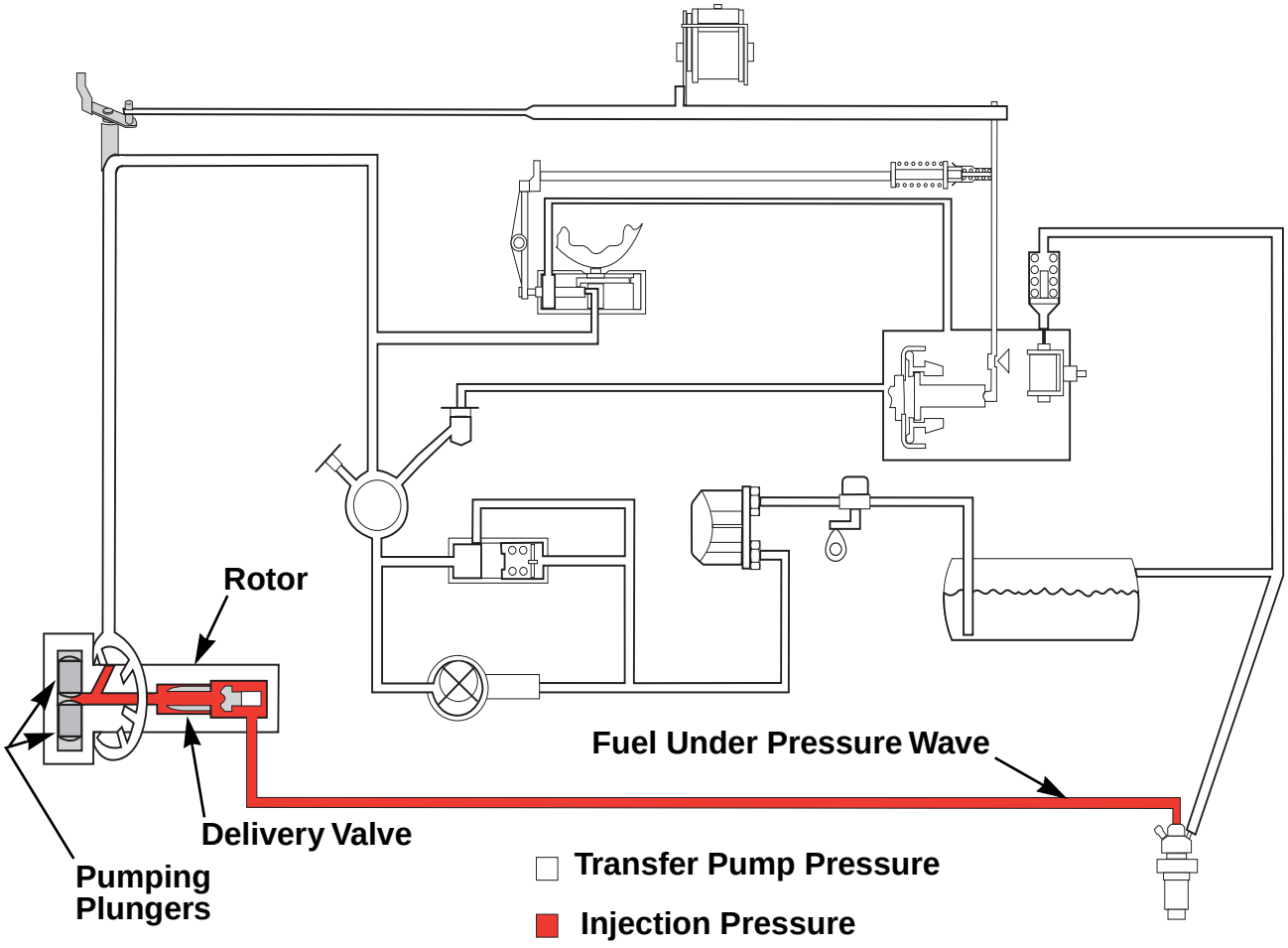

Injection Pump Cutaway View – Charge Cycle

## 51. Discharge Cycle

As the injection pump rotor continues its rotation, two ports of the pumping chamber are blocked from the charging passage. At the same time, two of the cam ring lobes push the shoe/roller assemblies and pumping plungers inward, increasing fuel pressure in the pumping chamber to an amount approximately 100 times greater than the transfer pump pressure.

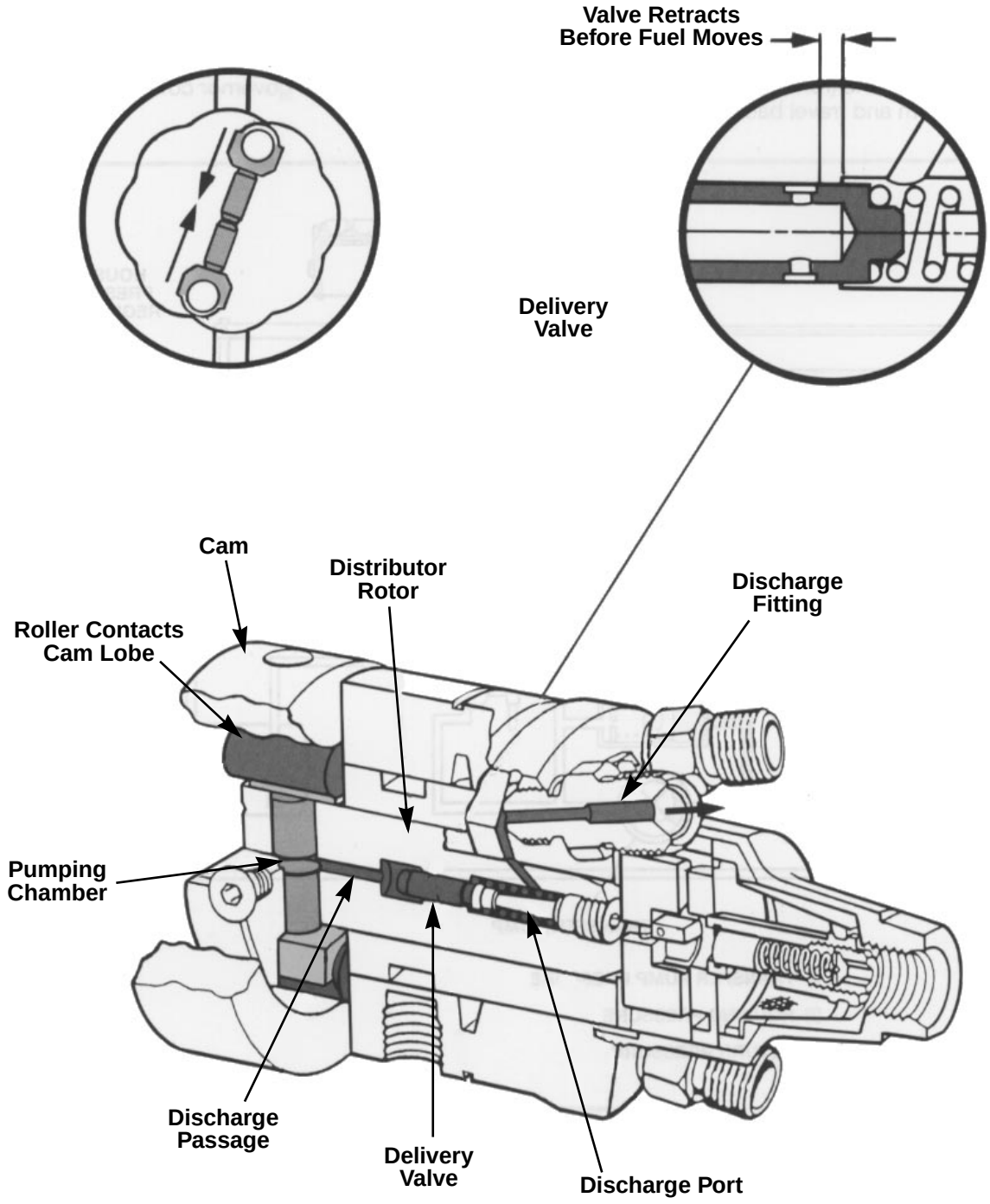
When the fuel pressure in the pumping chamber rises, a delivery valve is pushed against spring force. The fuel then moves past the delivery valve to a discharge port of the rotor. When a port in the head connecting to the injection line and nozzle for a particular cylinder aligns with the rotor discharge port, fuel under a pressure wave exits the injection pump.

The process of pressurizing and distributing fuel occurs eight time in one revolution of the injection pump drive shaft and rotor.




Fuel System Diagram – Discharge Cycle

## 52. Discharge Cycle

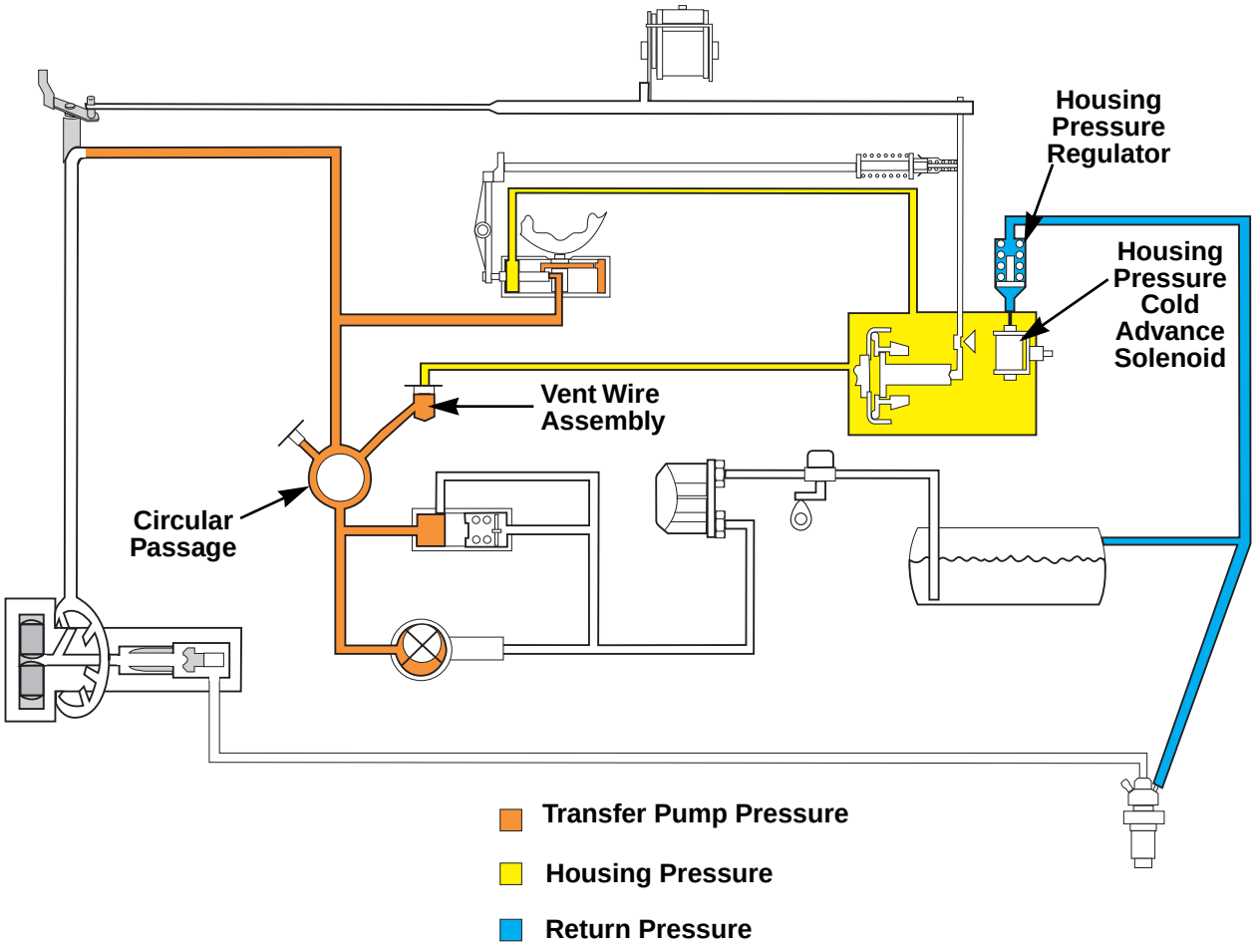



Injection Pump Cutaway View – Discharge Cycle.

## 53. Lubrication Flow

The outlet of the transfer pump connects to a threaded restrictor known as the vent wire assembly. This component causes fuel under transfer pump pressure to undergo a pressure decrease. It also vents the pump of air and uses a wire with hooked ends to assist in this task.

The fuel passing through the vent wire assembly flows inside the pump housing to cool and lubricate most of the injection pump internal parts. An outlet port in the governor cover allows fuel to enter the return system and travel back to the fuel tank.



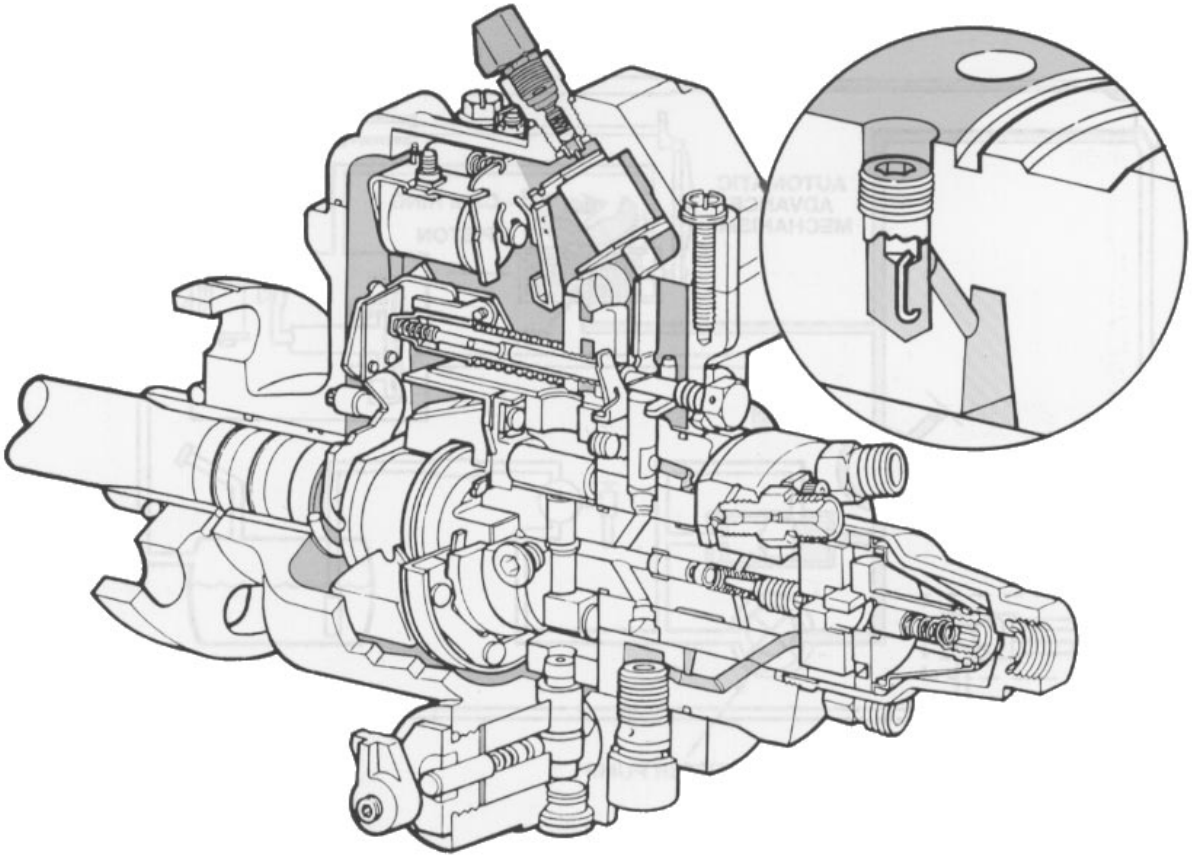

Fuel System Diagram – Lubrication Flow

## 54. Lubrication

The outlet port has a spring-loaded valve that regulates the flow of fuel from the injection pump housing into the return system. This valve, known as the housing pressure regulator, works with the vent wire assembly to provide a housing pressure of approximately 15 psi.

The vent wire assembly has several sizes, based on the amount of restriction required. The selection of this component is a part of the injection pump calibration procedure.

A solenoid in the governor cover uses a plunger to unseat the valve in the housing pressure regulator, causing housing pressure to drop to 0 psi. This component, known as the Housing Pressure Cold Advance (HPCA) solenoid, is ON during cold engine operation to cause a change in fuel injection timing.

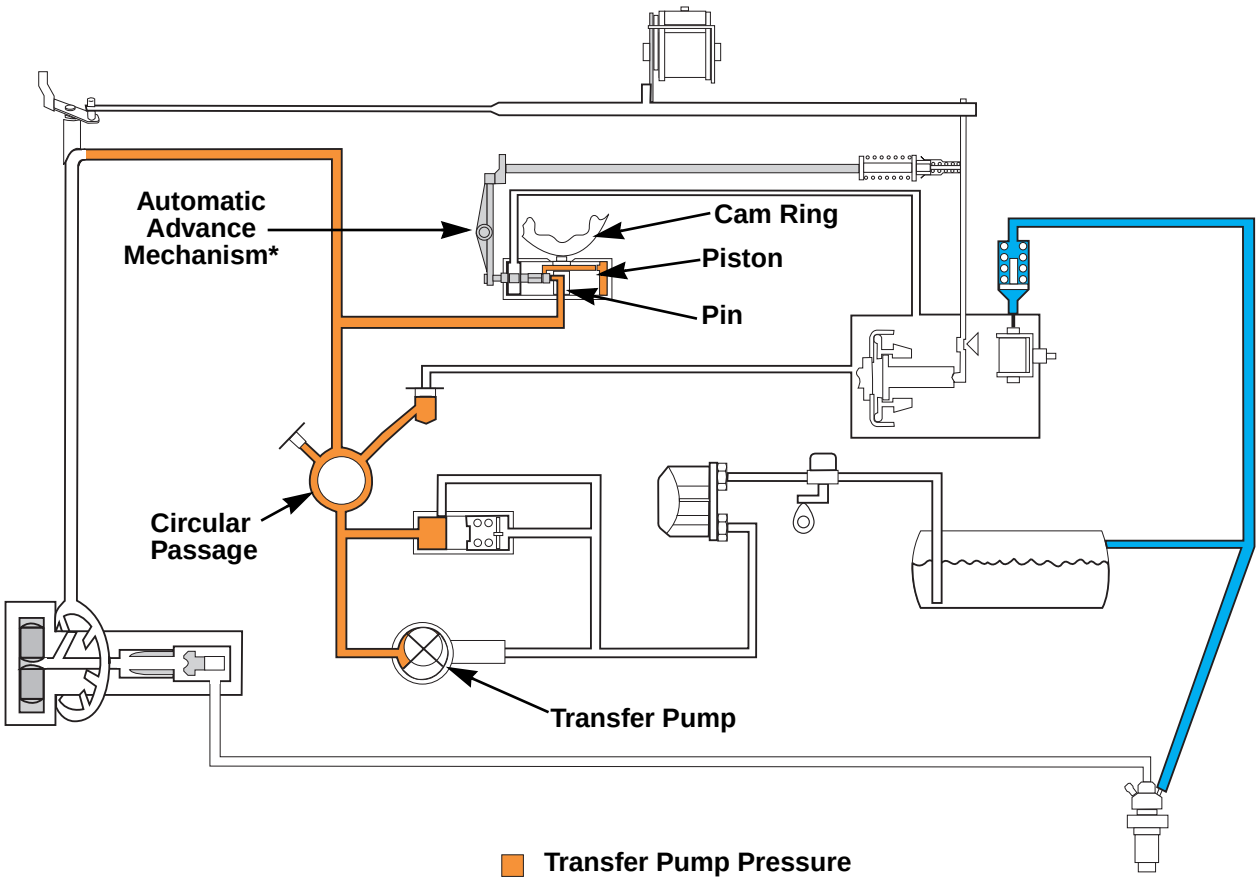


Injection Pump Cutaway View – Lubrication.

## 55. Timing

The cam ring that controls the pressurizing of fuel in the pumping chamber of the rotor can be rotated in the pump housing to change fuel injection timing. The automatic advance mechanism for the injection pump is a sliding piston connected to the cam ring with a pin. As the piston slides in its housing bore, the cam ring rotates to change injection timing.

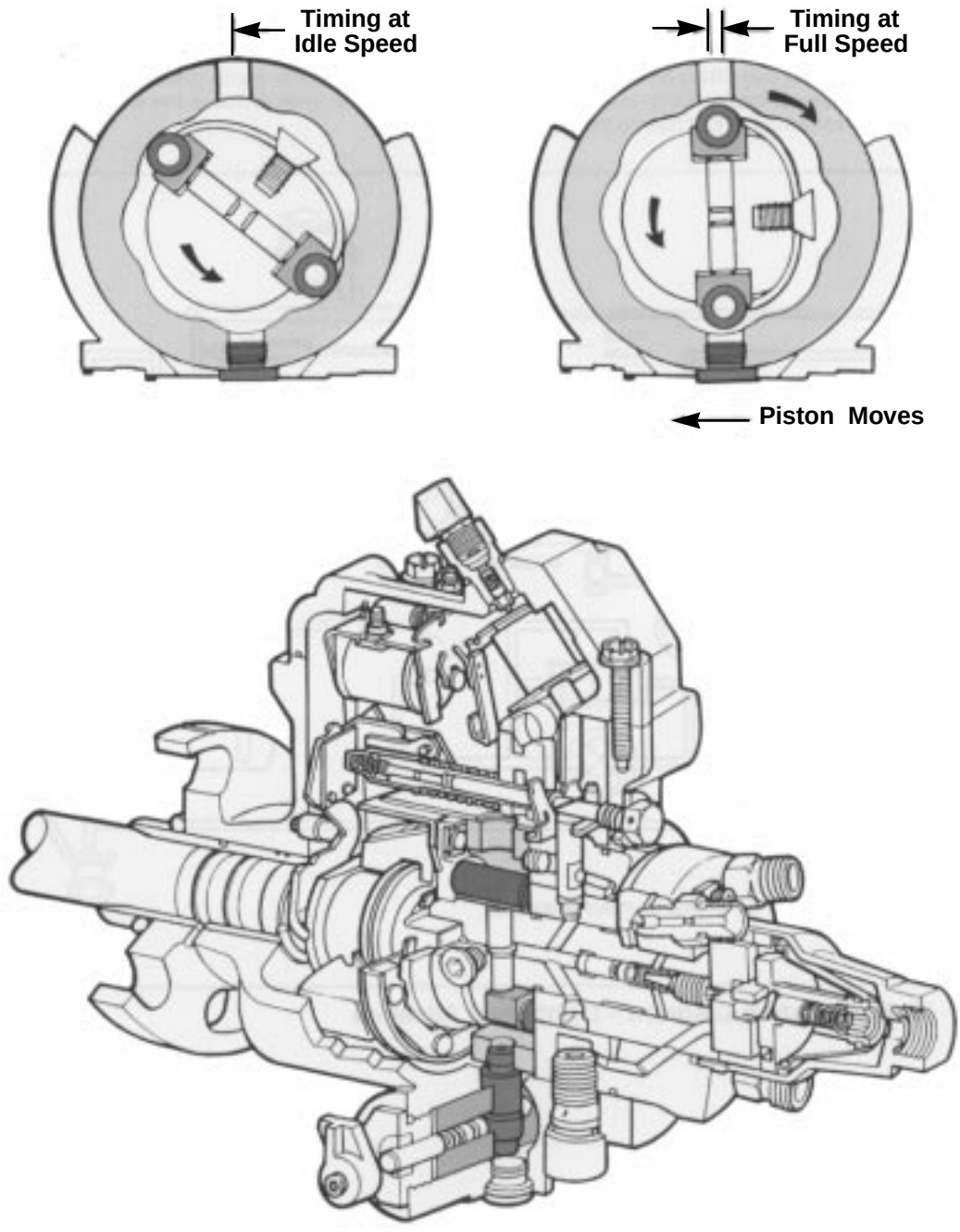
One of the outlet passages of the transfer pump connects to the piston of the automatic advance mechanism, following a passage in the head of the injection pump, through a hollow head locating screw and into a housing passage. Fuel under transfer pump pressure pushes the piston, causing the injection timing to advance automatically in relation to engine speed.




***View of Parts From Drive Shaft End of Injection Pump**

Fuel System Diagram – Basic Injection Timing

## 56. Timing

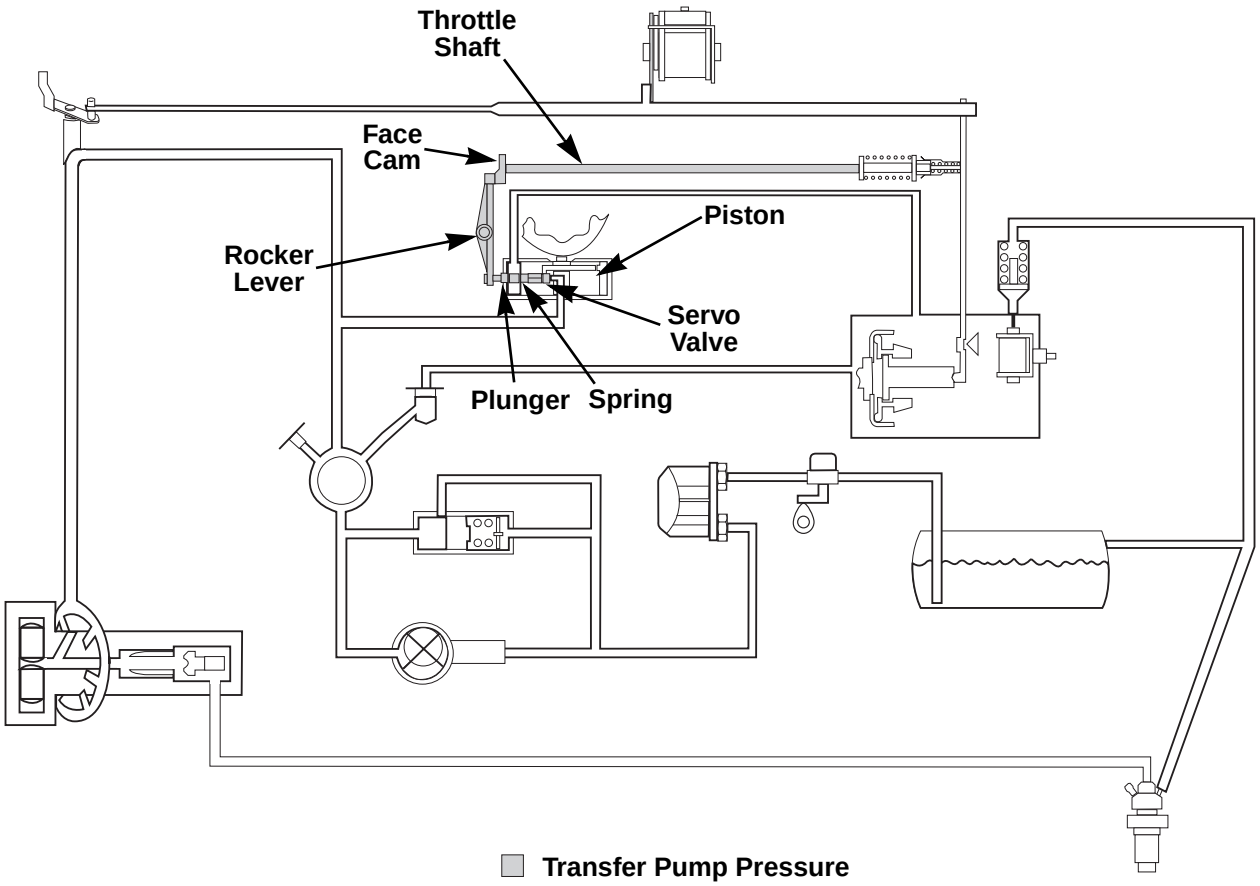



Injection Pump Cutaway View – Basic Injection Timing

## 57. Light Load Advance

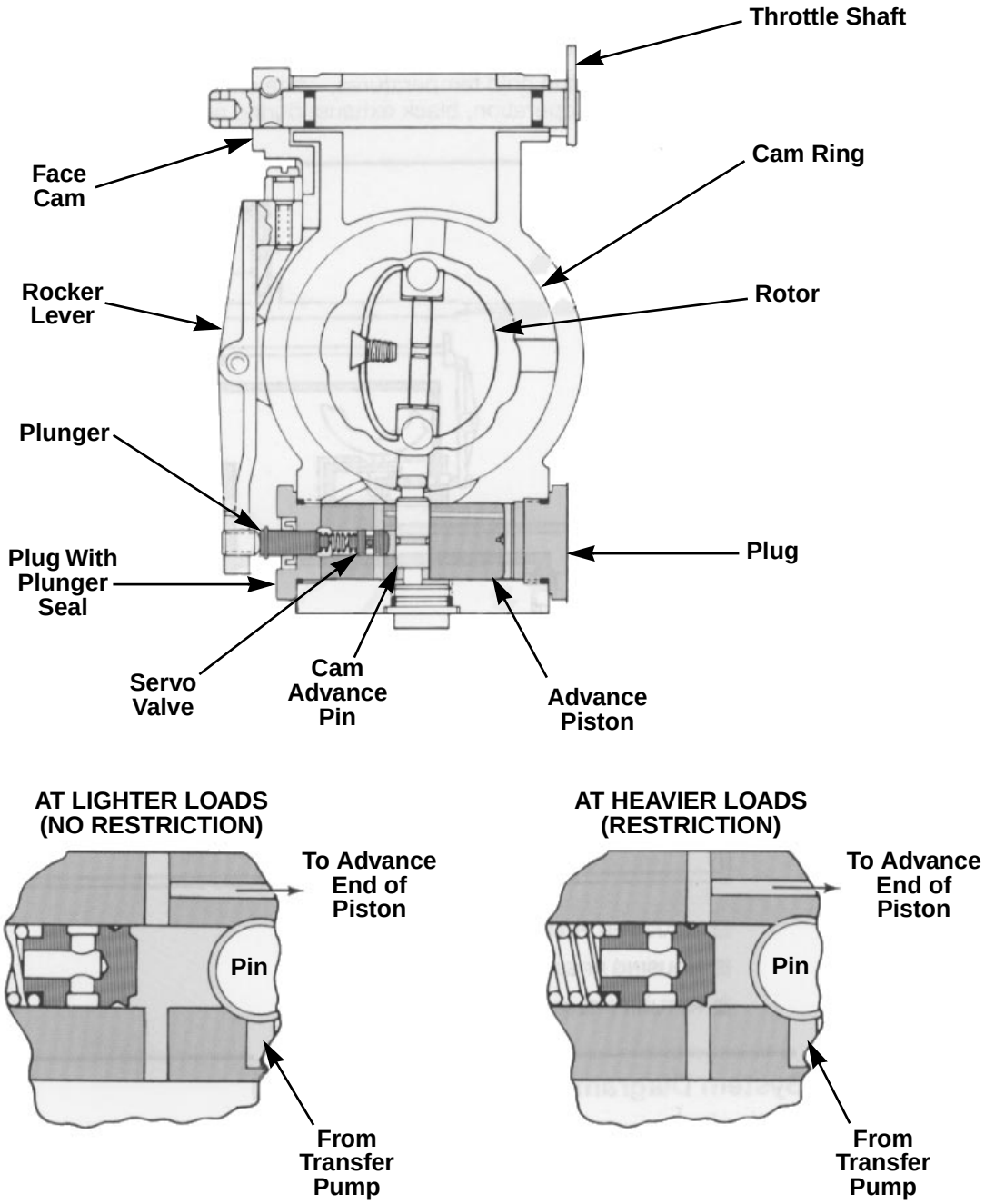
The throttle shaft has a face cam mounted on the outside of the injection pump that operates a servo valve inside the bore of the advance piston. The face cam contacts a lever arm, which changes the spring force acting on the valve by pushing a plunger in contact with the spring. In this way, the timing of fuel delivery can be varied to correspond to engine requirements.

The mechanical action of the throttle shaft, face cam and rocker lever allows a more rapid advance of injection timing under light loads by permitting an unrestricted flow of fuel under transfer pump pressure to the advance end of the piston. Under heavier loads, the throttle shaft, face cam and rocker lever increase the servo valve spring force, resulting in a restriction of fuel flow to the advance piston.




Fuel System Diagram – Light Load Advance

## 58. Light Load Advance

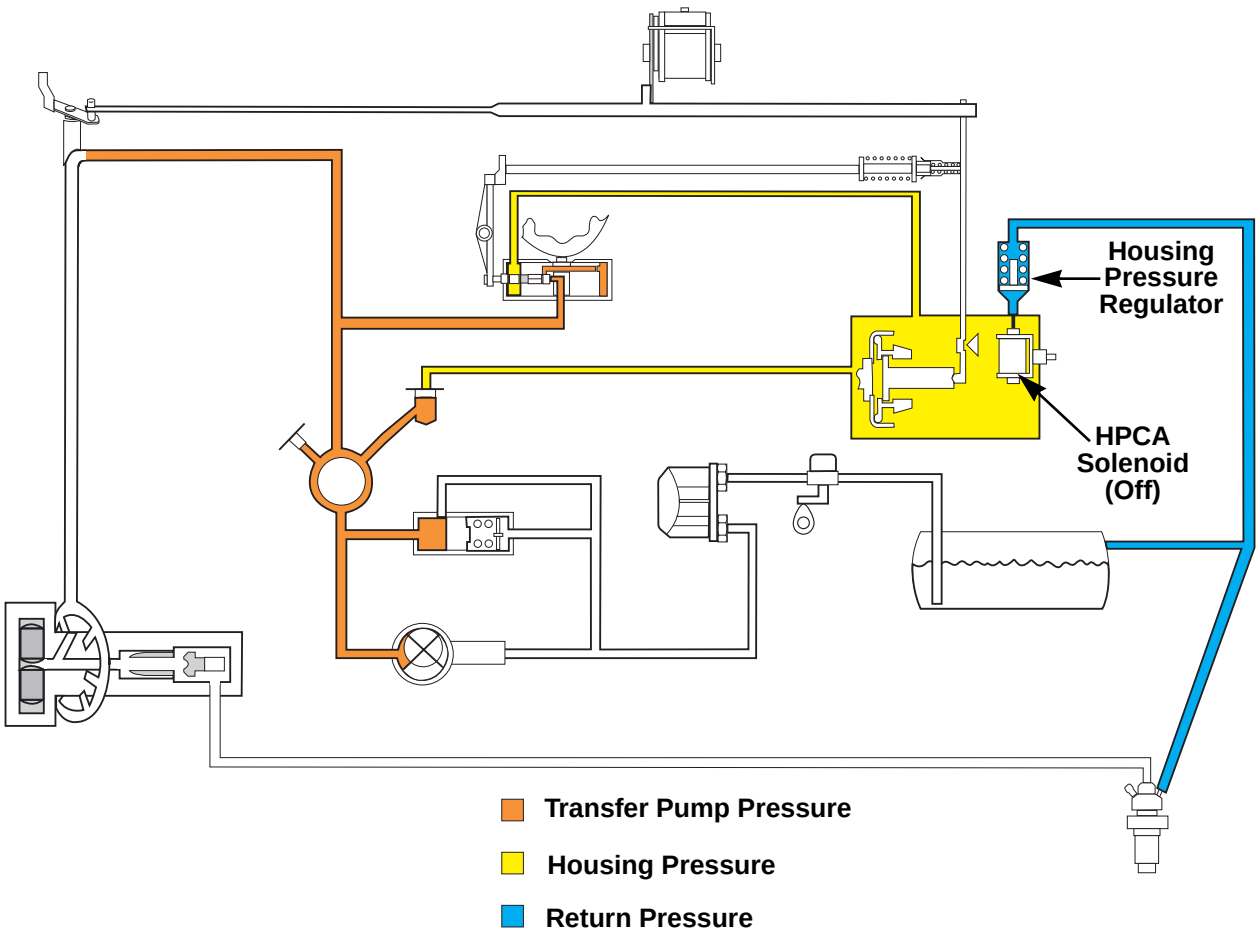



Injection Pump Cutaway View – Light Load Advance

## 59. HPCA (Warm Engine)

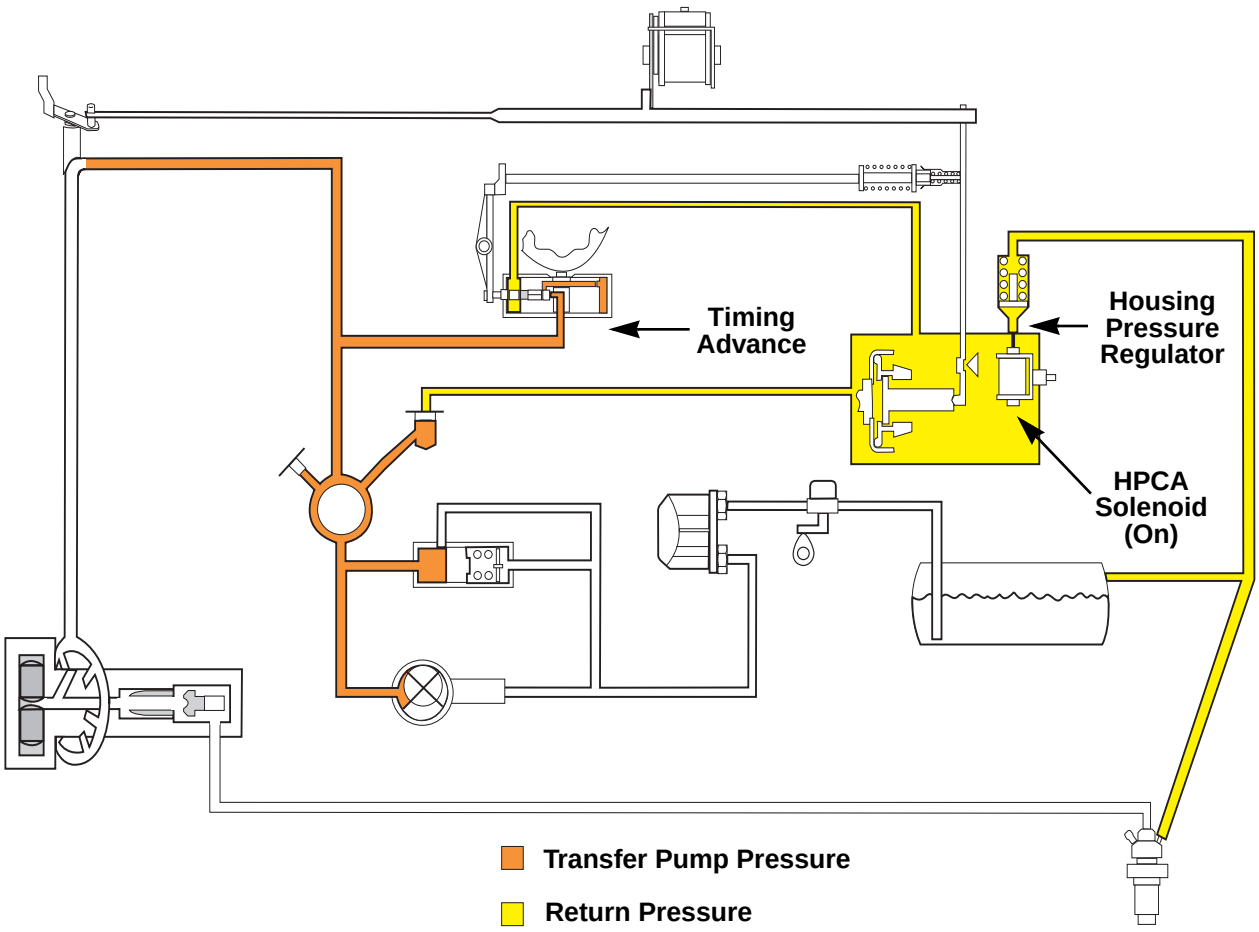
During warm engine operation, fuel under housing pressure pushes on the retard end of the advance mechanism piston, providing lubrication and a fluid cushion.

When the HPCA solenoid is ON (during cold engine operation), a drop in housing pressure causes transfer pump pressure to push the advance piston farther. This results in smoother engine operation during warm-up and temporarily increase engine idle speed. If the HPCA solenoid is OFF during starting in cold temperatures, white exhaust smoke may result. If the HPCA solenoid is ON during warm or hot engine operation, black exhaust during acceleration may result.




Fuel system Diagram – HPCA (Warm Engine)

## 60. HPCA (Cold Engine)




Fuel System Diagram – HPCA (Cold Engine)

## 61. Fuel Supply Checks

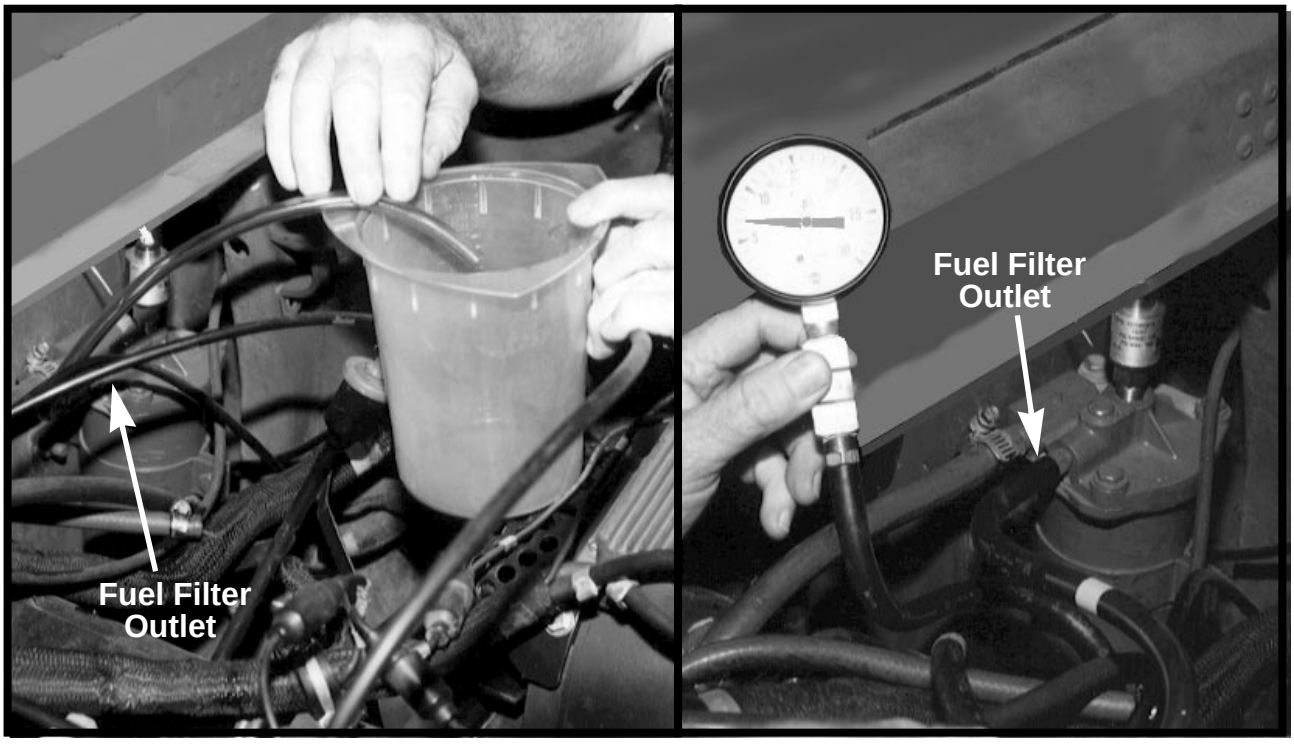
Diagnosis of the fuel injection pump includes the following diagnostic steps.

1. Check the fuel supply to the injection pump. (Check at fuel filter outlet).

- Check that the output of the lift pump is correct:

  Volume of at least 0.24 liter (1/2 pint) in 15 seconds

- Pressure of 40 to 60 kPa (4 to 8 psi)
- Check that the restriction of the fuel filter is not excessive: (Check pressure in and out of filter).
  Lift pump volume and pressure should be present at the inlet of the injection pump.
- Check the fuel entering the injection pump for the presence of air, using a transparent hose:
- If air bubbles appear, check the lift pump suction line for air leakage under a vacuum.
- Check the quality of the fuel:




Injection Pump Fuel Supply Checks.

## 62. Fuel Return Pressure Checks

2. Check the fuel return from the injection pump.

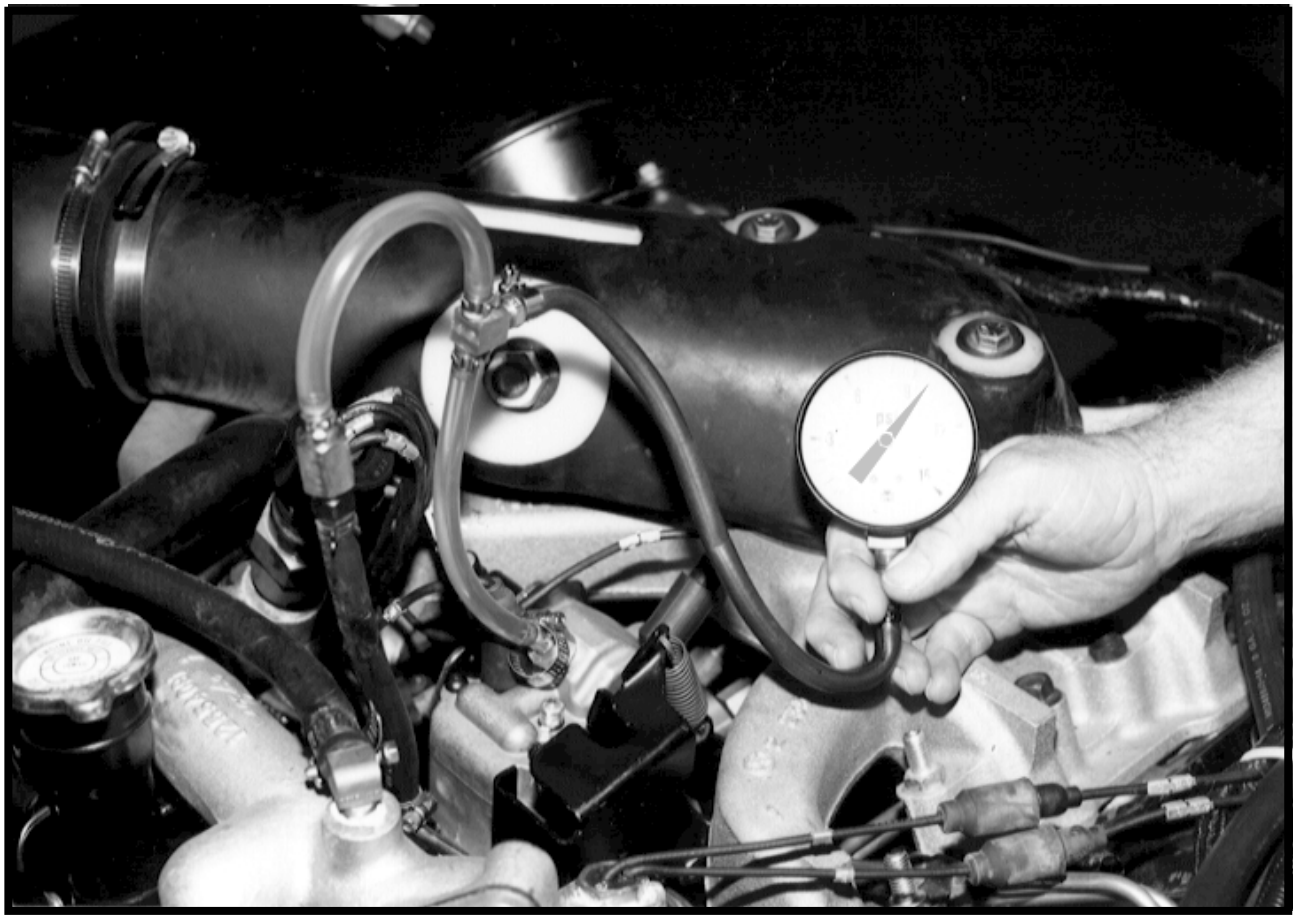
   - Check the injection pump housing pressure:

     If pressure is not within 8 to 15 psi, do one of these things:

     - Check the return line for a restriction.

     - Check the housing pressure regulator for a restriction.

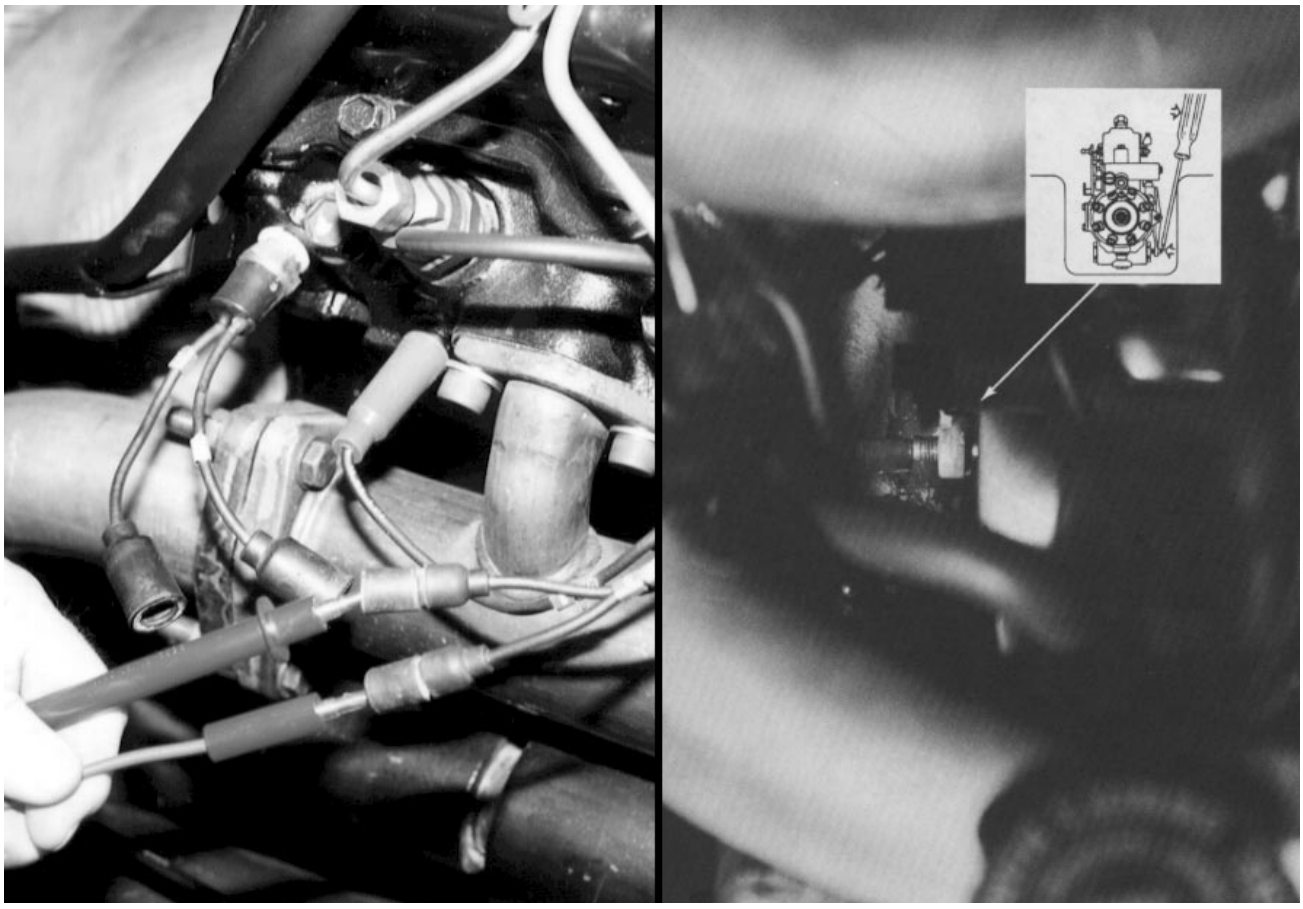
   - Check the fuel exiting the injection pump for the presence of air, using a transparent hose: If air bubbles appear, remove the injection pump for service.



Fuel Return Pressure Check

**63. Advance Mechanism Checks**

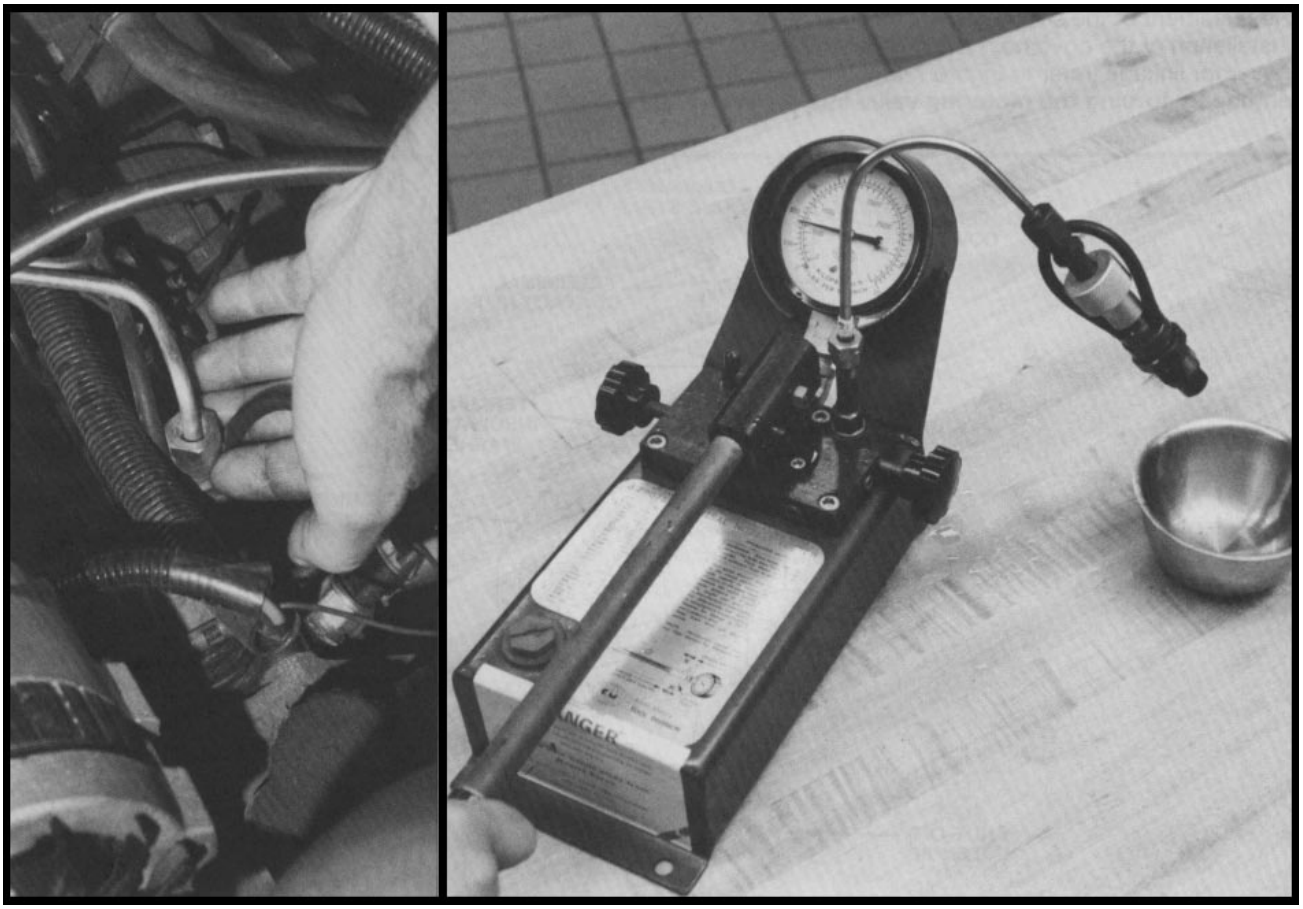
4. Check the Housing Pressure Cold Advance (HPCA) solenoid operation:
    - With the engine at approximately 700 rpm, jumper the fast idle/cold advance temperature switch to energize the HPCA solenoid circuit.
    - Observe that the engine speed increases, indicating an advance in injection timing.
    - If no change in engine speed occurs, diagnose the cold advance circuit.
5. Check the injection pump automatic advance mechanism piston for movement:
    - With the engine at 2,000 rpm, press the lower end of the mechanical light load advance rocker arm toward the injection pump.
    - Observe that the engine speed decreases, indicating a retard on injection timing.
    - If no change in engine speed occurs, remove the injection pump for service.



Injection System Advance Mechanism Checks

## 64. Injection Line & Nozzle Checks

6. Check the operation of the injection lines and nozzles:
   - Check all nozles using tester as shown.
   - Inspect the injection lines for external damage and evidence of fuel leakage.
   - Replace any damaged injection line.
   - Replace faulty nozzles and install the nozzles with new compression gaskets.



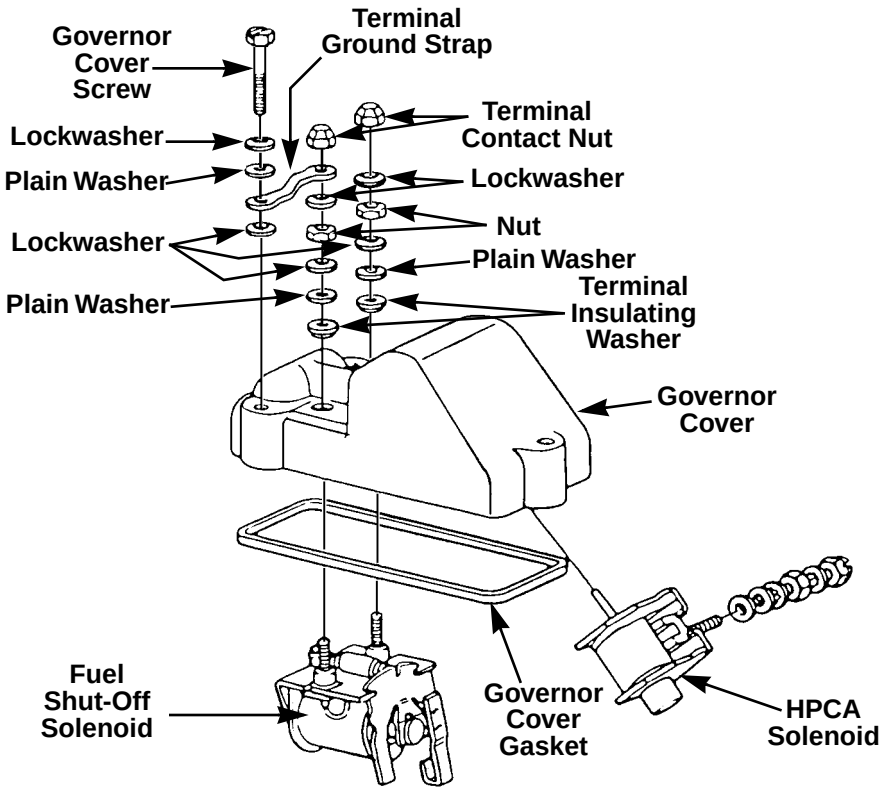
Injection Line and Nozzle Checks

## 65. Injection Pump Governor Cover & Parts

Since several calibration adjustments are disturbed during disassembly, most injection pump repairs are made by General Support Level Maintenance technicians. Repairs to the injection pump that can be made by Direct Support technicians include replacement procedures for the following parts:

- Governor cover seal (in-vehicle)
- Fuel shut-off solenoid (in-vehicle)
- HPCA solenoid (in-vehicle)
- Timing window cover gasket (out-of-vehicle)

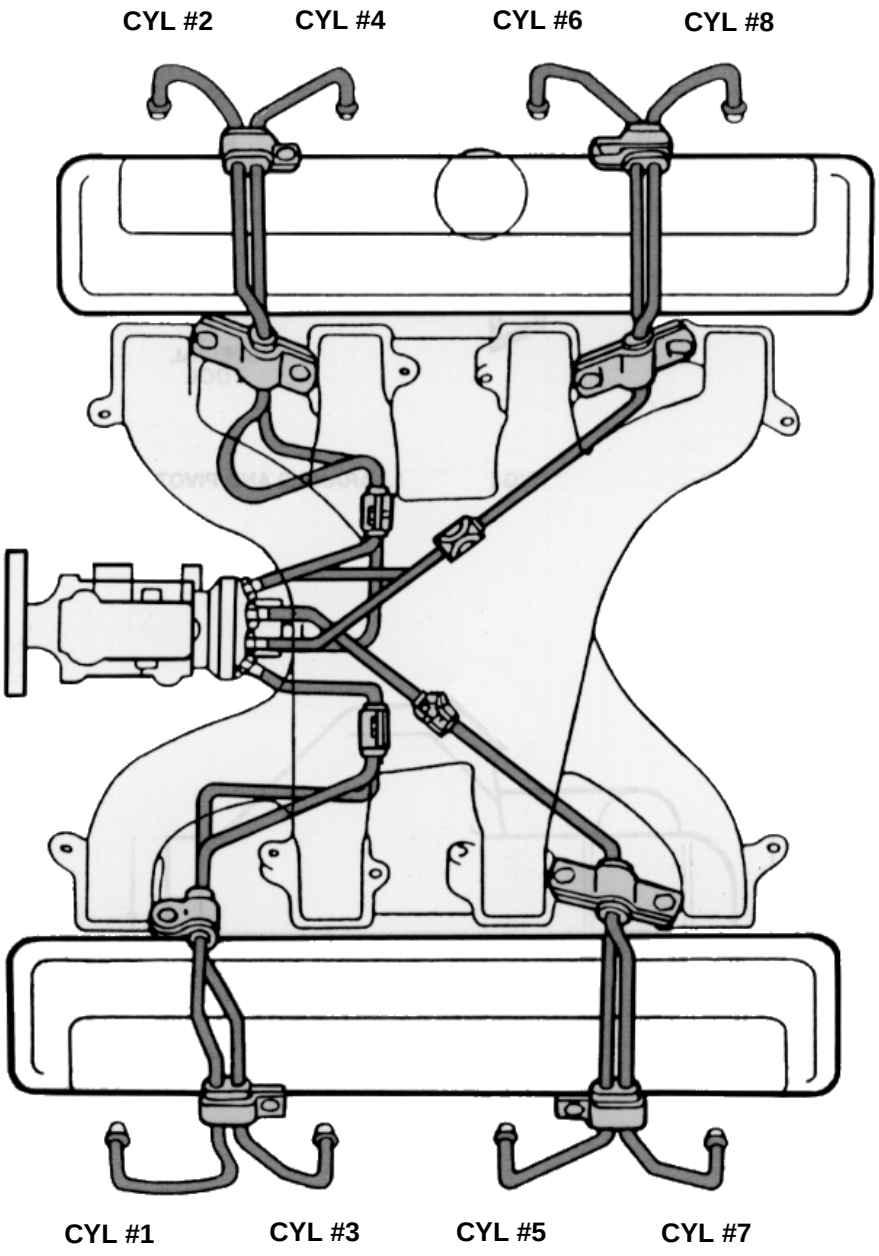
Replacement of the seal and two solenoids involves removal of the governor cover, as shown.




Injection Pump Governor Cover and Parts

## 66. Injection Lines

The high-pressure discharge fittings on the head of the injection pump connect to the injection nozzles with steel lines of equal length and interior volume. The ends of the injection lines have special fittings and nuts.




Injection Lines

## 67. Injection Lines

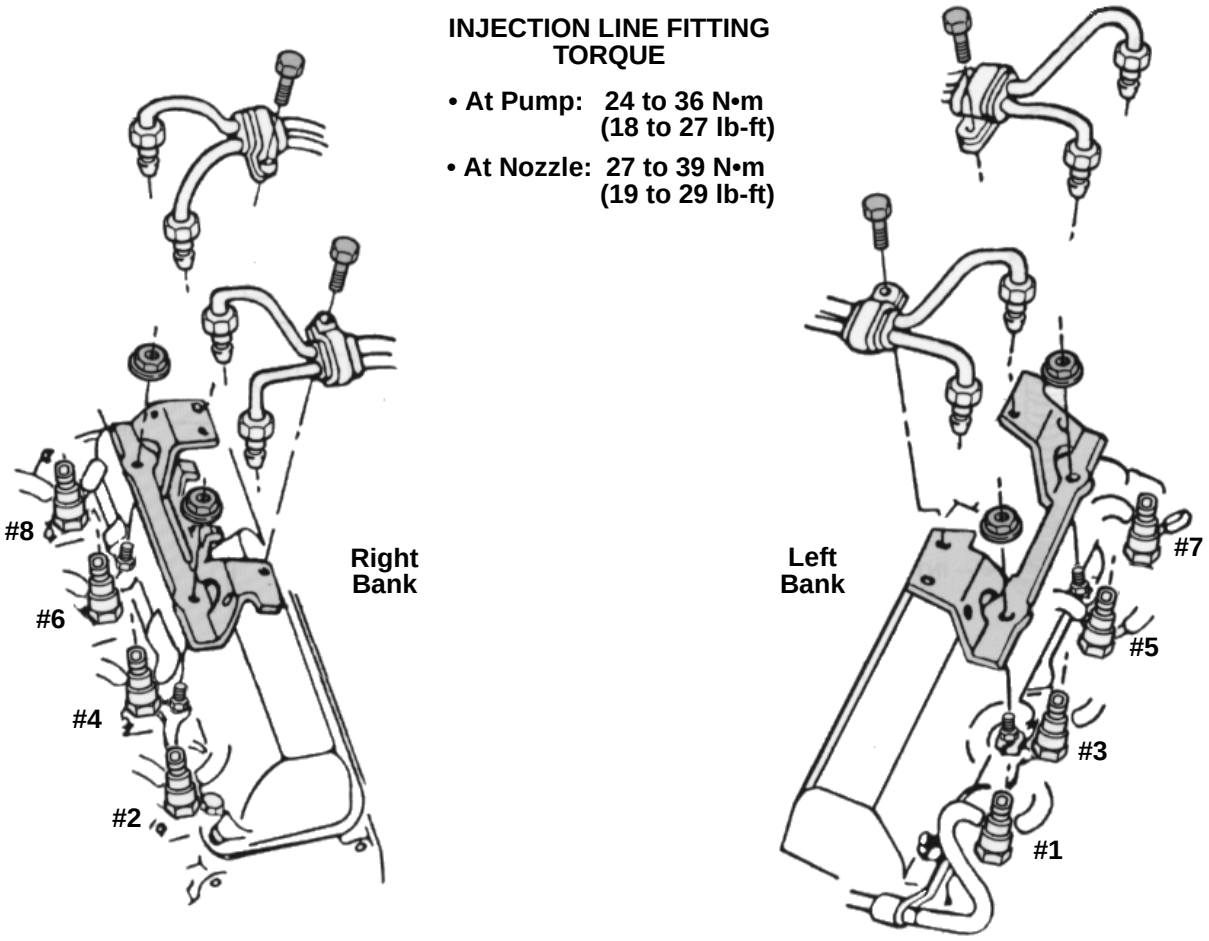
Intake manifold mounting bolts and studs secure the injection lines, using straps and soft isolators. Each injection line is clamped in three locations to prevent breakage due to vibration from the engine and from injection pressure pulses.

When the engine is not running, fuel is contained in the injection lines. During engine operation, a residual pressure of approximately 500 psi is maintained in each injection line. As injection occurs in each line, a small amount of fuel enters the line, pushing a similar amount into the nozzle at the other end with a pressure wave.

During service, injection lines are serviced by replacement. Diagnosis includes an inspection for tubing and fitting end damage that causes restrictions or leakage.

**INJECTION LINE FITTING TORQUE**

- **At Pump: 24 to 36 N•m (18 to 27 lb-ft)**
- **At Nozzle: 27 to 39 N•m (19 to 29 lb-ft)**

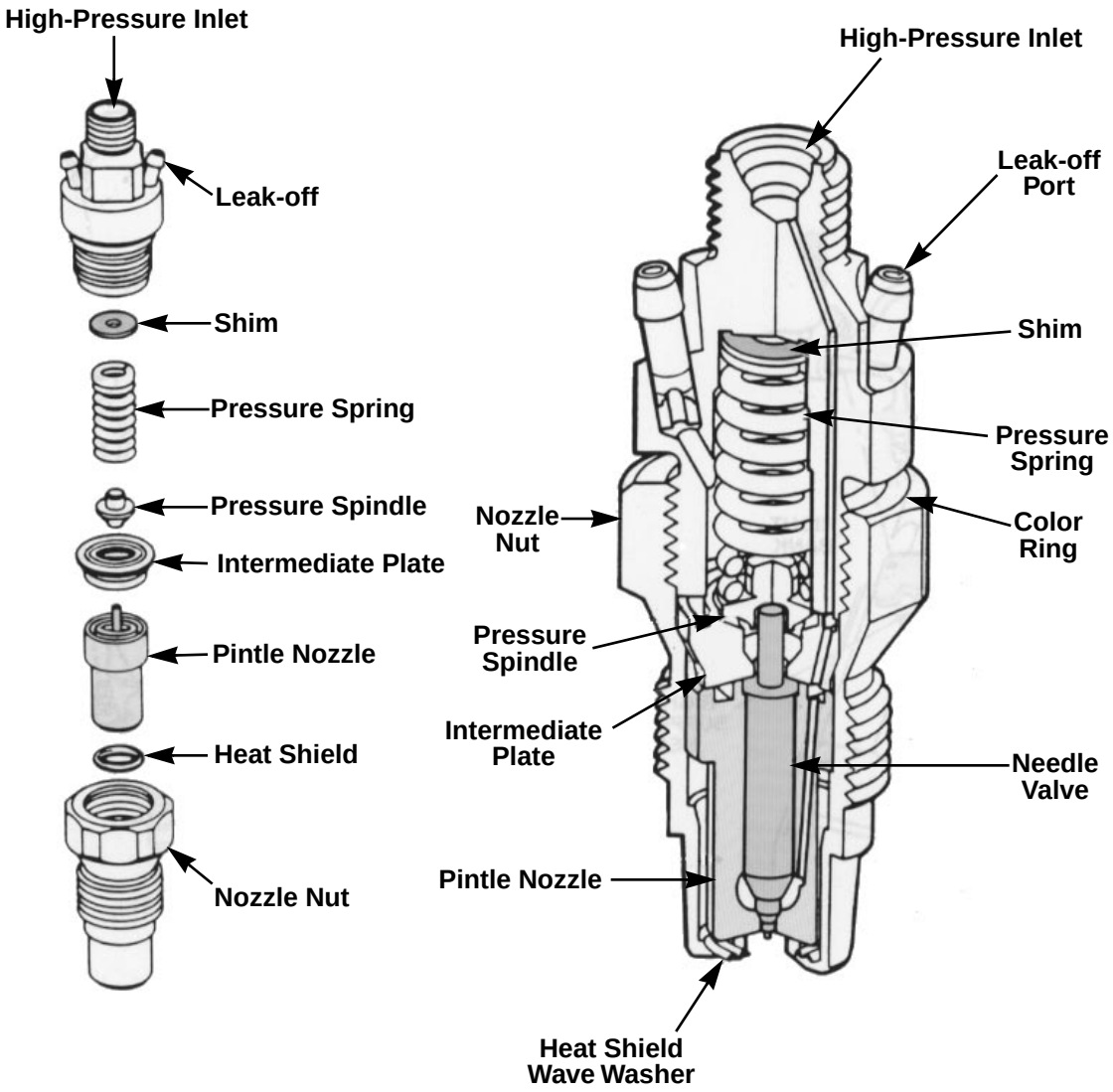



Injection Lines

## 68. Construction and Operation

Each cylinder has an identical fuel injection nozzle mounted in the pre-combustion chamber, using threads and a copper sealing gasket. A specific injection line connects to each nozzle, using a special fitting and nut.

Each nozzle is an assembly containing a two-piece body, a needle valve/pintle nozzle assembly, a pressure spring and other parts. During the manufacturing process, a selective thickness shim is used to adjust the nozzle opening pressure.



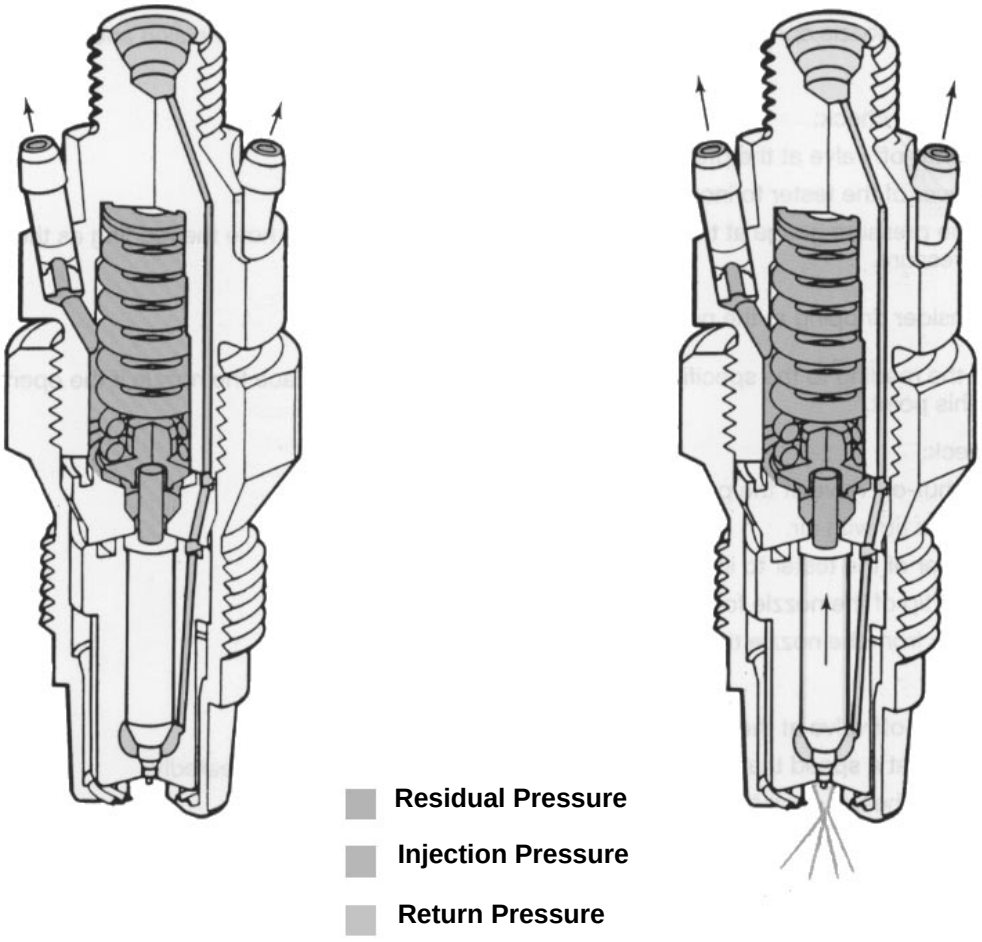

Injection Nozzle Parts

## 69. Injection Nozzle Operation

As the pressure wave of injection reaches a nozzle, the needle valve is lifted against spring force and fuel exits into the pre-combustion chamber of the cylinder as a highly atomized spray. A small amount of fuel travels between the needle valve and pintle nozzle, providing lubrication.

Two passages inside the upper half of the nozzle body allow fuel that has lubricated the needle valve to exit into the fuel return system. Fittings on the nozzle connect with hoses and clamps to the return system pipes.

During service, nozzles are serviced by replacement. Installation involves the use of a new compression gasket, anti-seize compound on the cylinder head threads. Tighten and torque using a special 30mm socket.




Injection Nozzle Operation

## 70. Injection Nozzle Testing

During diagnosis, each injection nozzle may be tested after it is removed from the engine. Nozzle tests include the following checks:

1. Preparation
    - Position a nozzle tester on a workbench.
    - Install one nozzle on the tester fitting.
    - Place a container under the nozzle that will deflect the nozzle spray and absorb the test fluid.
    - Install two clear plastic hoses (1-1/2 in. long) over the leak-off fittings.
    - Close the shut-off valve at the pressure gauge.
    - Operate the lever of the nozzle tester repeatedly and briskly to fill and flush the nozzle with test oil.

Note: Never allow the nozzle spray to contact you hands, since it can penetrate the skin and cause blood poisoning.

2. Opening pressure check:
    - Open the shut-off valve at the pressure gauge 1/4-turn.
    - Push the lever of the tester to increase pressure slowly.
    - Observe the pressure gauge at the point which the nozzle sprays, and note the reading of the opening pressure.

Note: Do not consider dripping at the nozzle during this check as a fault.

    - Compare the reading to the specification for this nozzle, and replace the nozzle if the opening pressure is below this point.

3. Leakage check:
    - Open the shut-off valve at the pressure gauge 1/2 to 1-1/2 turns.
    - Dry the nozzle tip with air.
    - Push the lever of the tester to increase pressure to 1400 psi.
    - Observe the tip of the nozzle for drops of test oil.
    - If a drop falls from the nozzle tip within 10 seconds, replace the nozzle.

4. Chatter check:
   - Close the shut-off valve at the pressure gauge.
   - Push the lever at a speed that causes the nozzle to chatter as it sprays repeatedly.
   - If chatter is not heard, push the lever at a faster speed.
   - If no chatter is heard, replace the nozzle.

Note: New and used nozzles have different sound characteristics during the chatter check.

5. Spray pattern check:
   - Close the shut-off valve at the pressure gauge.
   - Push the lever of the tester abruptly and quickly.
   - Observe the spray pattern of the nozzle:
   - Do not be too critical of the spray pattern since it is not tested properly with this check.

Injection Nozzle Testing

## 71. Fuel Return System

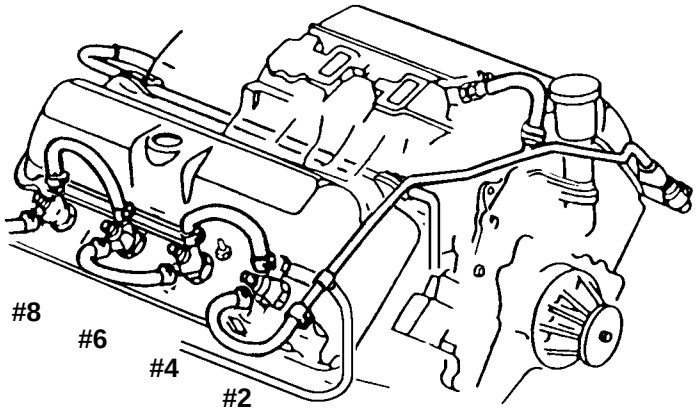
The return hoses for cylinders #1 and #2 connect to a center pipe (view A). The injection pump fuel return hose also connects to the center pipe with a black rubber hose, (view B).

On the left side of the engine, the return system pipe connects to a series of hoses and pipes that send fuel back to the fuel tank (view C).

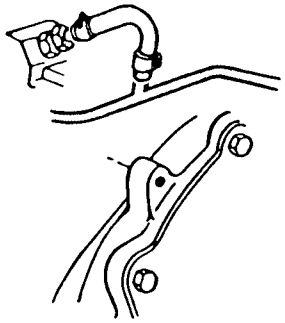
The rear injectors, (#7 and #8), are capped with rubber caps and clamps.

During diagnosis of the injection pump, the return system is checked for restrictions. Any blockage in the path of fuel leaving the injection pump will greatly affect the performance of the engine.

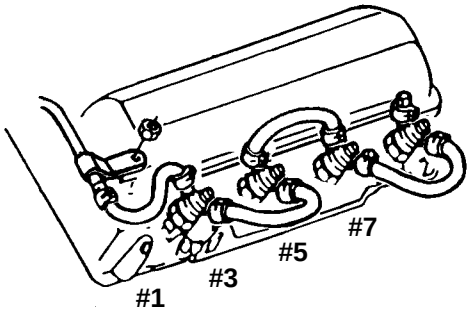
**VIEW A**




**VIEW B**



**VIEW C**




Fuel Return System