PHASE 21
TABLE OF CONTENTS

PAGE

LAB PROJECTS 1
AUTOMOBILE DIESEL UPDATES 2
DIESEL INJECTION PUMP IDENTIFICATION

- Helix-Metered 7
- Pre-Metered 7
- Sleeve-Metered 7
- Nippondenso 8
- Bosch VE Distributor Pump 9

SD22 INJECTION PUMP CONTROL MECHANISM 11
ROOSA MASTER DISTRIBUTOR PUMP

- Checking And/Or Adjusting Timing 12
- Vacuum Regulator Valve 13
- Idle Speed Adjustments 14
- Injection Pump Fuel Lines 15
- Pump On Car Service 18
- Pump Off Car Service 20
- Pump Drive And Driven Gears 23

INJECTOR SPRAY PATTERNS 24
C.A.V. MICRO-JECTOR 25
TYPICAL INJECTOR TESTS 26
TYPICAL STARTING SYSTEM CIRCUIT 28
TYPICAL QUICK PRE-HEAT SYSTEMS 29
TYPICAL ENGINE TUNE-UP ITEMS 35
DIESEL ENGINE DIAGNOSIS 36
DIESEL ENGINE COMPRESSION TEST 45
DIESEL ENGINE CRANKCASE VENTILATION 46
DIESEL ENGINE SPECIFICATIONS

- GM 350 And 260D 47
- Isuzu 52
- Mercedes 54
- Mitsubishi 57
- Nissan 61
- Volkswagen 62
- Volvo 65
- Ford (Mazda) 2.2 69
- GM 6.2 Liter 77

UNIVERSAL TECHNICAL INSTITUTE

PHASE 21: AUTO/DIESEL ENGINES LIST OF LAB PROJECTS

INSTRUCTOR_____ STUDENT'S NAME_____

	I.D.	NOZZLE TEST	COMPRESSION TEST	PUMP TIMING	VALVE ADJUSTMENT	ENGINE RUN-UP
AD-2101						
AD-2102						
AD-2103						
AD-2104						
AD-2105						
AD-2106						
AD-2107						
AD-2108						
AD-2109						
AD-2110						
AD-2111						
AD-2112						
AD-2113						
AD-2114						
AD-2115						
AD-2116						

AUTOMOBILE DIESEL UPDATES

1929: America's first diesel automobile produced. On its inaugural 792-mile, Indianapolis to New York City run in January 1930, the 1925 Packard sedan, fitted with a 4-cylinder, 50 hp Model U Cummins diesel, makes the trip on $1.38 worth of diesel fuel and averages 26.4 miles per gallon.

1931: One of dieseldom's most significant early endurance tests, when a truck, powered by a Cummins diesel, is driven non-stop for fourteen days and 14,600 miles, averaging 43 mph, at the Indianapolis Speedway. Same year, the first diesel race car - likewise Cummins diesel powered - enters the Indy 500. It finishes the entire race in twelfth place, without a pit stop, uses only 31 gallons of fuel, and averages 86.17 mph.

Dave Evans qualifies an 85 hp Cummins diesel powered Duesenberg race car seventeenth in the annual Indianapolis 500 mile race. Evans finishes thirteenth at an average speed of 86.107 mph and drives the first car ever to finish the "500" without a pit stop, total costs of 31 gallons of fuel and 1 quart of oil consumed is $1.78

1934: One of the first newsmaking diesel conversions, a Hillman sedan powered by an English Perkins 4 cylinder diesel, makes the trip from England to Moscow.

1936: Unveiled at the Berlin Automotive Trade Show, the world's first production diesel cars: the Mercedes-Benz 260D and the Hanomag Rekord Diesel, both powered by 4 cylinder diesels.

1952: Fred Agabashian sets new one lap and four lap records of 139.104 and 138.010 mph, respectively, driving the Cummins Diesel Special to the pole position in the annual Indy 500. After starting No. 1, the car finishes seventeenth, completing 71 laps before being eliminated by turbocharger failure.

1953: Dana Fuller, of San Mateo, California, sets World Land Speed Record for diesel automobiles with a top speed of 169.32 miles per hour, in his diesel streamliner, powered by a 6 cylinder Detroit diesel engine. The record is to stand for eighteen years.

1965: In the first of numerous speed and endurance record runs, a diesel engine Peugeot 404 coupe average more than 100 mph (161 km/hr) over a 6,200 mile (10,000-km) course.

1972: A turbocharged diesel Opel sets twenty speed records during a tour around a West German test track.

1974: A 5 cylinder diesel, the first in any production passenger car, is installed in the Mercedes-Benz 300D.

1975: Fritz Busch, an automotive performance analyst, carries the sporty look in diesel cars to new heights with his Dieselstar. This custom built creation covers one mile from a standing start in a record 26.4 seconds.

1976: New world's heavy truck speed record (D tractor class), of 144 plus mph set in a 16,000-pound Kenworth two axle tractor powered by a turbocharged Detroit 12 cylinder diesel - by V.M. (Bill) Snyder, on the Bonneville, Utah, course.

1976: Nineteen major speed records are smashed in a three-day marathon at Nardo, Italy, by Daimler-Benz's futuristic, turbocharged, 5 cylinder diesel experimental C 111 (forerunner of Mercedes-Benz's turbocharged 300SD). Included in the record smash are three longstanding gas engine speed marks. Averaging better than 156 mph, the C 111 captures three world enduro marks: for 5,000 and 10,000 miles, and for 10,000 kilometers.

1977: For the first time, diesel cars are rated "most fuel economical" in three of the EPA's five fuel mileage classifications.

1977: A VW Rabbit finishes a 50,000-kilometer endurance run, setting 31 records during nonstop running on the Kleber Tire Corporation's test track in Miramas, France.

1978: New world's truck speed record (open class) - 159.01 mph top speed, an average 156.796 mph over the five mile course - set at the Bonneville, Utah, speed course by V. W. Snyder, driving a Thermo King Corp. sponsored, 11,000 pound International truck powered by a dual turbo-charged V-8 Detroit diesel engine.

1978: First American manufacturer to offer production diesel automobile as General Motors' Oldsmobile Division unveils its 350 CID V-8, first of big, economy diesel engines. Engine is initially avaiable as diesel option in the Olds 88, 98 and Custom Cruiser (later, also in the Toronado), as well as in many other GM cars and light trucks, including the Cadillac Seville and GMC/Chevro-let pickup trucks.

1978: First turbocharged diesel production car, introduced by Mercedes-Benz the Mercedes-Benz 300SD, with a top speed of 103 mph.

1978: New Class C diesel truck land speed record is set by Pete Schmidt driving a twin turbocharged Detroit 6V-53T diesel powering his 1978 GMC pickup to 132.502 mph on the Bonneville salt flats.

1979: EPA fuel economy tests confirm Volkswagen's own tests for its turbo diesel Integrated Research VW (IRVW), prototype for VW's turbocharged diesel Rabbit: 63.8 mpg Highway, 51.9 mpg city, best average fuel economy for any vehicle yet EPA tested. IRVW is a joint VW/U.S. Dept. of Transportation experimental diesel vehicle.

1979: First four wheel drive utility sports turbo diesel vehicles, unveiled by International Harvester. Optional 6-cylinder turbo diesel (also first for production utility vehicles) powers maker's on-road/off-road Scout sports wagons and pickup trucks.

1980: First production 6 cylinder turbocharged diesel automobile introduced by Germany's BMW - accelerates 0 to 100 mph in just 35 seconds.

1982: Universal Technical Institute, Phoenix, Arizona, establishes a course designed to train automobile mechanics in service and repair of automobile diesels.

DIESEL PUMP IDENTIFICATION

HELIX-METERED

In-Line Pumps:

American Bosch (USA) -- APF-APE pumps

Caterpillar (USA) -- Forged body - Compact housing

CAV (Simms) (England) -- SPE-SPGE-SPGXE pumps

Diesel Kiki (Japan) -- Same as R. B. with N. P. in front

Nippondenso (Japan) -- Same as R. B. with N. P. in front

Robert Bosch (Germany) -- PF-PFR-PE-PES pumps

Injectors:

Detroit -- High valve - Low valve - Needle valve

PRE-METERED

Distributor-Type Pumps:

CAV (England) -- DPA-DP15

Roosa Master (USA) -- DB-DC-DB2-DG-DM

Injectors:

Cummins (USA) -- PTR-PTG-AFC

SLEEVE-METERED

Distributor-Type Pumps:

American Bosch (USA) -- PSB-PSJ-PSM-PSU-Model 100

Diesel Kiki (Japan) -- VE

Nippondenso (Japan) -- VE

Robert Bosch (Germany) -- VE

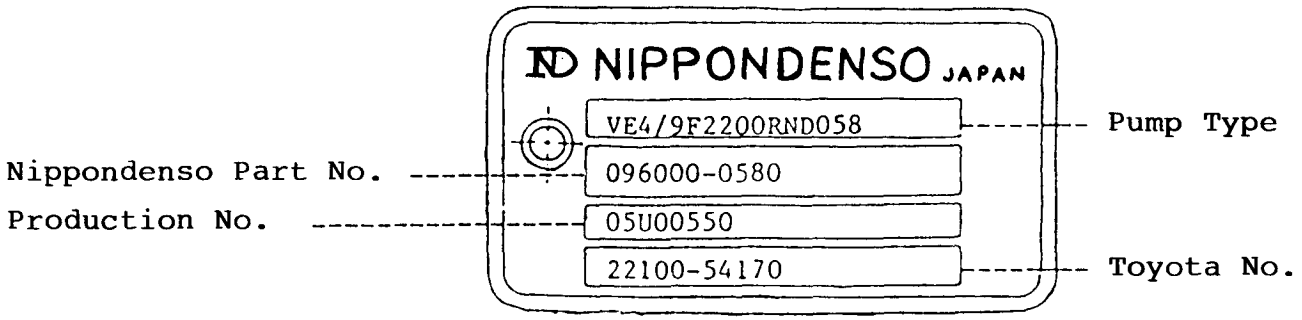
Inline pumps:

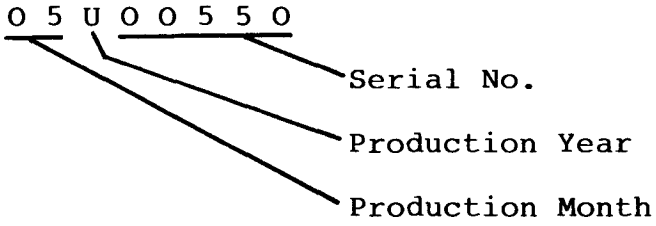
Caterpillar (USA) -- Sleeve metered

PUMP IDENTIFICATION

MARK	MEANING
A	The spare parts - old and new - are completely interchangeable with each other.
B	The new part can be used in previous models as well, but the old part cannot serve in newer models.
C	The old part is still usable for new models, but the new part cannot be used in older models.
D	Spare parts are not at all interchangeable.

Pump Identification Plate





Production Code

K	1972 Year	Q	1977 Year
L	1973 Year	R	1978 Year
M	1974 Year	S	1979 Year
N	1975 Year	T	1980 year
P	1976 Year	U	1981 Year

CONSTRUCTION OF DISTRIBUTOR TYPE FUEL INJECTION PUMP

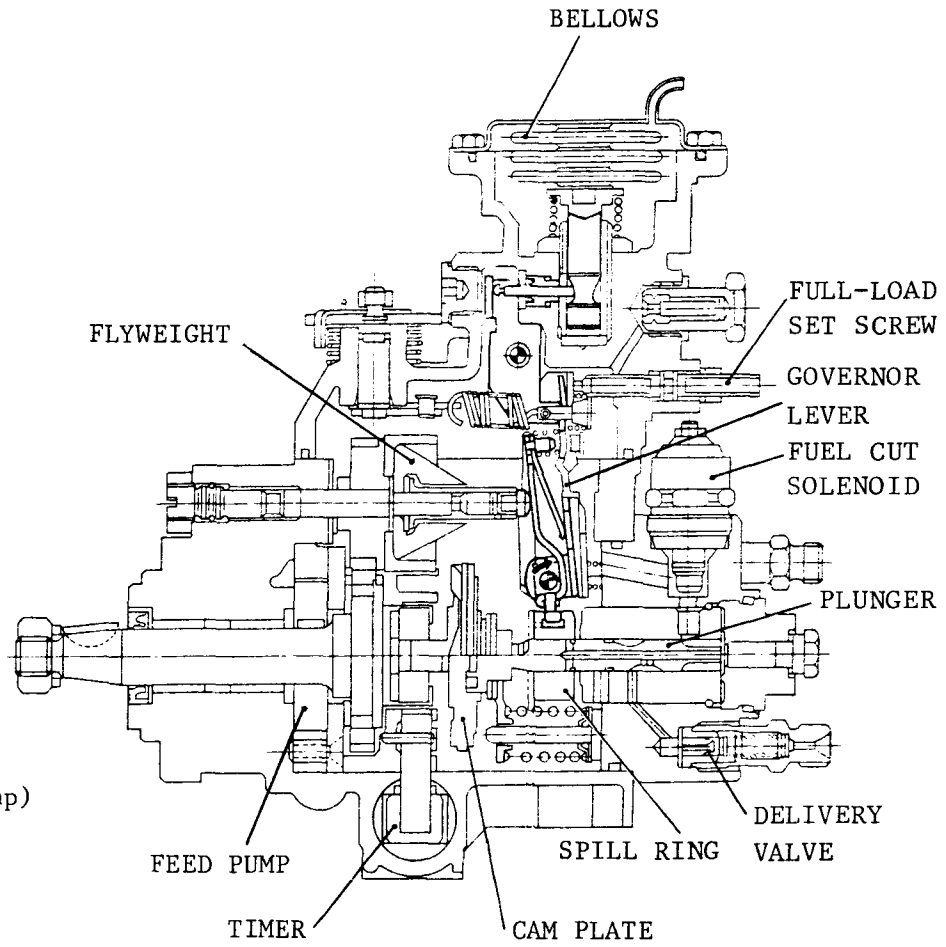
PUMP TYPE NUMBER

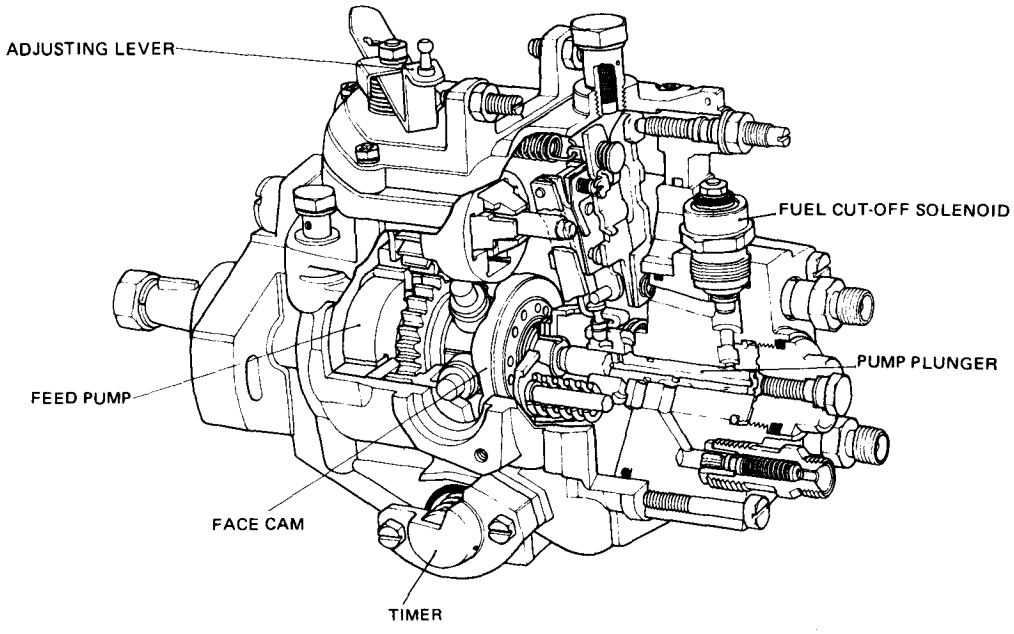
VE 4 / 9 F 2200 R ND058

- ND058 — Design Number
- R — Direction of Rotation (R:Clockwise)
- 2200 — Governed Pump Speed
- F — Mechanical Type Governor
- 9 — Plunger Diameter
- 4 — Number of Cylinders
- VE — VE Type (Distributor Type)

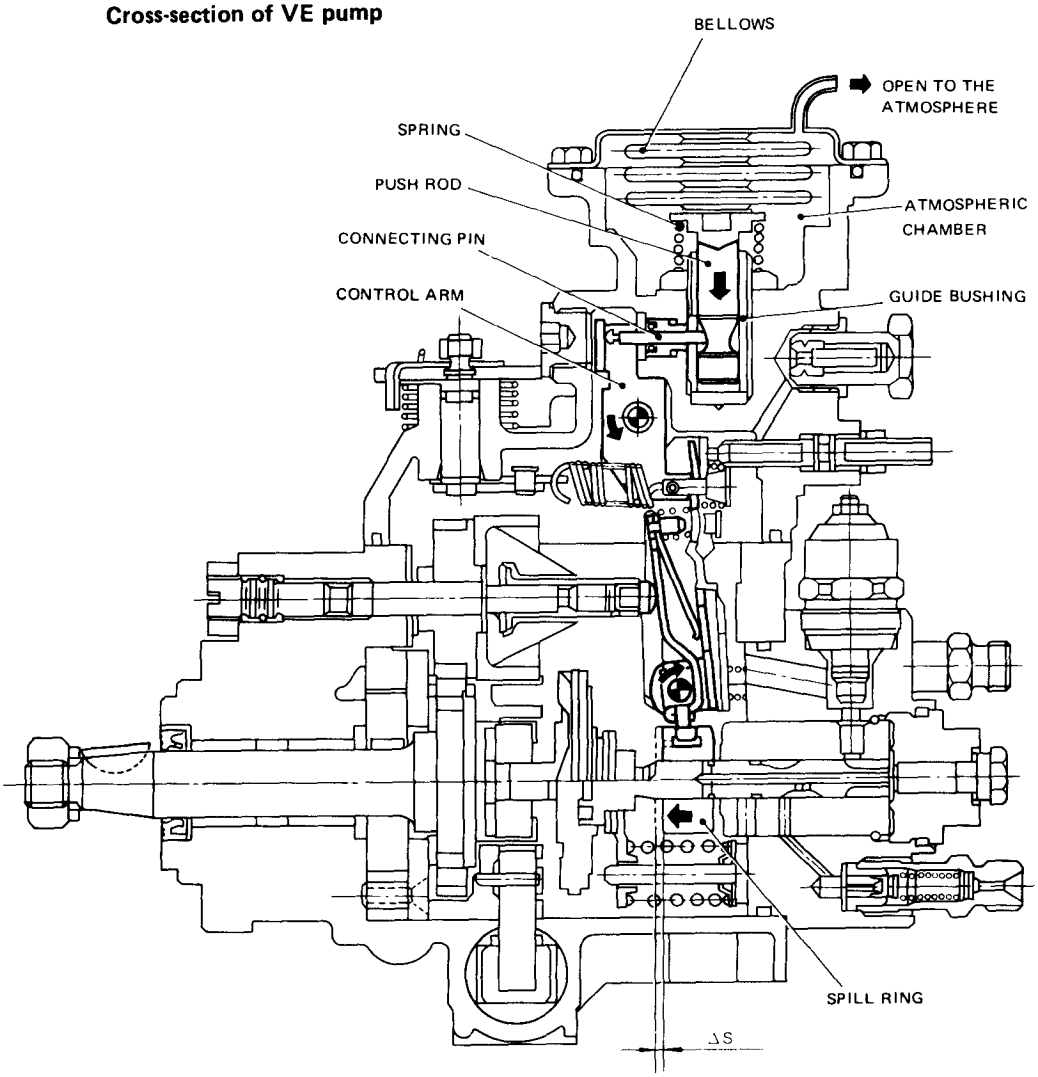
MAJOR SPECIFICATION

Weight	about 6.0 kg
Plunger Diameter	9 mm
Cam Lift	2.2 mm
Applicable Governor	All-speed control (integrated in pump)
Timer	Hydraulic type(integrated in pump)
Feed Pump	Vane type, Fuel delivery:4cc/ revolution (integrated in pump)
Lubrication System	Self-lubrication by Fuel



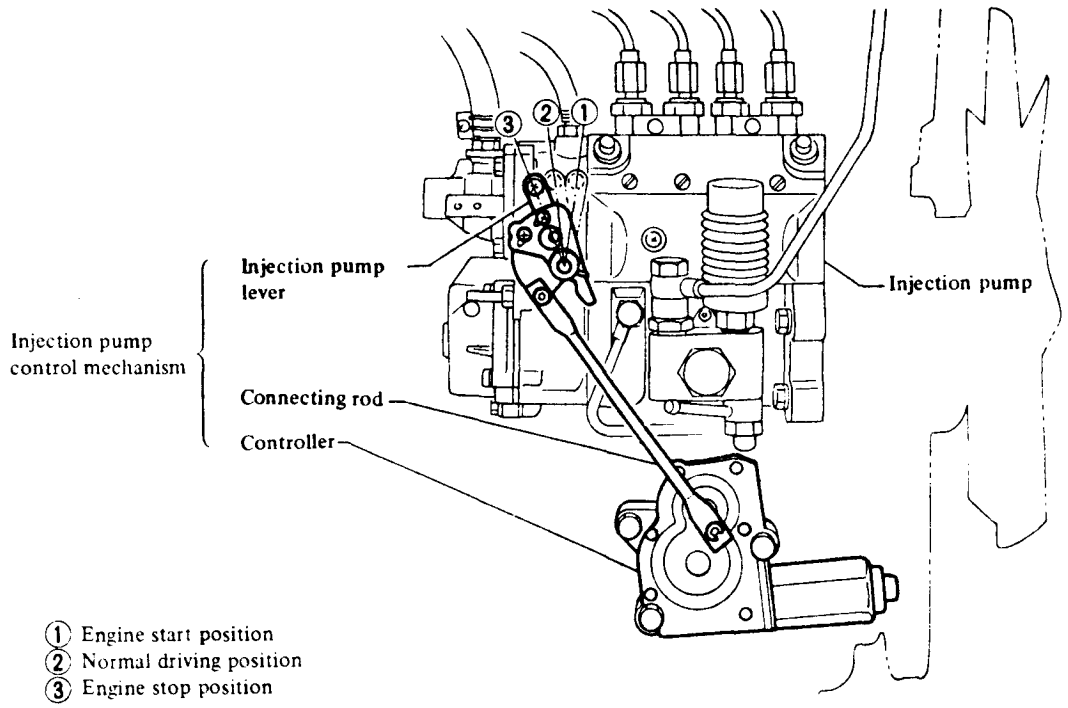


Cross-section of VE pump



D.A.C. Construction

INJECTION PUMP CONTROL MECHANISM (SD22 engine)



DESCRIPTION

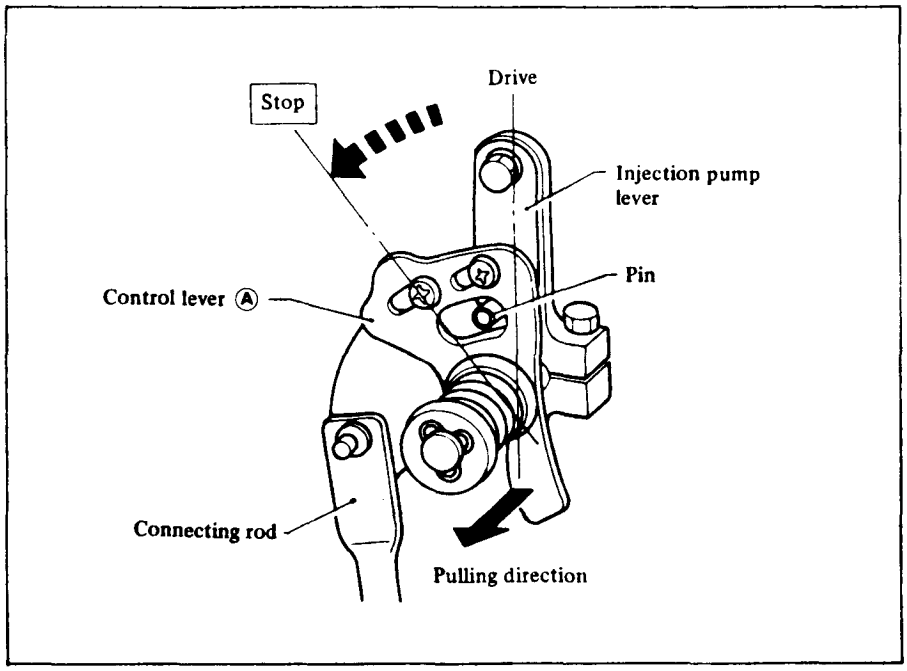
The injection pump control system is controlled by the ignition key in order to start, operate or stop the fuel injection pump.

The injection pump control mechanism is controlled by the injection pump control unit (D.P.C. module), thereby controlling the amount of fuel injection by operating the injection pump lever.

When the ignition key is in the "START" position, the injection pump lever is set at position ①, thereby increasing the fuel causing the engine to start. After starting the engine (with the ignition key in the "ON" position), the injection pump lever moves to position ②. When the ignition key is in the "OFF" position, the injection pump lever moves to position ③, thereby cutting off the fuel injection causing the engine to stop.

Even though the engine cannot be stopped by operating the ignition key, it can be manually stopped in the following manner.

1. Turn the ignition key to "OFF".
2. Pull control lever Ⓐ in the direction that is away from the fuel injection pump. This slips the pin which connects the control lever with the fuel injection pump lever.
3. Move the fuel injection pump lever to the stop position by hand.



Checking and/or Adjusting Timing (Using J-33075 Timing Meter

The timing meter picks up the engine speed and crankshaft position from the crankshaft balancer. It uses a luminosity signal through a glow plug probe to determine combustion timing. Certain engine malfunctions may cause incorrect timing readings. Engine malfunctions should be corrected before a timing adjustment is made. The marks on the pump and adapter flange will normally be aligned within .762 mm (.030") on a V8 and 1.27 mm (.050") on a V6.

NOTICE: Alignment of timing marks may be used in emergency situations (i.e. timing meter not available). However for optimum engine operation, the timing should be adjusted with the timing meter as soon as possible.

1. Place the transmission selector lever in park, apply the parking brake and block the drive wheels.
2. Start the engine and let it run at idle until fully warmed up. Then shut off the engine.

NOTICE: Failure to have the engine fully warmed up will result in incorrect timing reading and adjustments.

3. Remove the air cleaner assembly and install cover J-26996-1. The EGR valve hose must be disconnected.
4. Clean any dirt from the engine probe holder (RPM counter) and crankshaft balancer rim.
5. Clean the lens on both ends of the glow plug probe and clean the lens in the photo-electric pick-up. Use a dulled tooth pick to scrape the carbon from the combustion chamber side of the glow plug probe. Look through the probe to be sure its clean. Retarted readings will result if the probe is not clean.
6. Install the RPM probe into the crankshaft RPM counter (probe holder).
7. Remove the glow plug from No. 3 cylinder on a V8 and No. 1 on a V6. Install the glow plug probe in the glow plug opening.
8. On the V8 set the timing meter offset selector to B (99.5), on the V6 set the selector to A (20).
9. Connect the battery leads; red to positive, black to negative.
10. Start the engine and adjust the RPM (speed) to the speed specified on the "Vehicle Emission Control Information Label".
11. Observe the timing reading then at 2 minute intervals, again observe the reading. When the readings stabilize over the 2 minute interval readings, compare that reading to one specified on the "Vehicle Emission Control Information Label". The timing reading, when set to specification will be "Negative" (after top dead center).
12. Disconnect the timing meter and install the removed glow plug. Torque the glow plug to 16 N·m (12 ft. lbs.) on the V8 and 21 N·m (15 ft. lbs. on the V6.
13. Install the air cleaner being certain to reconnect the EGR valve hose.

Adjusting

1. Shut off the engine.
2. Note the relative position of the marks on the pump flange and pump intermediate adapter (V6) or pump adapger (V8).
3. Loosen the nuts or bolts holding the pump to the adapter to a point where the pump can be rotated. Use a 3/4" open end wrench on the boss at the front of the injection pump on a V8 and a 1" open end wrench on the V6. (Tool J-25304 has the proper offset on the handle to clear the fuel return line on the V6).
4. Rotate the pump to the left to advance the timing and to the right to retard the timing. On the V8 engine the width of the mark on the adapter is equal to about one degree. On the V6 the width of the mark on the intermediate adapter is about 2/3 degree. Move the pump the amount that is needed and tighten the pump retaining nuts to 24 N·m (18 ft. lbs.) on the V8 and 47 N·m (35 ft. lbs.) on the V6.
5. Start the engine and recheck the timing reading as outlined previously. Reset and recheck the timing if needed.
6. Adjust the pump rod on the V8. On V8 and V6, reset the fast and curb idle speeds. Both procedures are in this section. Please note the following:
   1. Sooty or dirty probes will result in retarded readings.
   2. The luminosity probe will soot up very fast when used in a cold engine.
   3. Wild needle fluctuations on the timing meter indicate a cylinder not firing properly. Correction of this condition must be made prior to adjusting the timing.

THROTTLE LINKAGE ADJUSTMENTS - V8 (FIGURE 6C5-5)

1. If equipped with cruise control, remove clip from cruise control throttle rod and disconnect the rod from the throttle lever assembly.
2. Disconnect the transmission T.V. (or detent) cable from the throttle assembly.
3. Loosen the lock nut on the pump rod and shorten several turns.
4. Rotate the bellcrank lever assembly to the full throttle position and hold in that position.
5. Lengthen the pump rod until the injection pump lever just contacts the full throttle stop.
6. Release the bellcrank assembly and tighten the pump rod lock nut.
7. Remove the pump rod from the lever assembly.
8. Reconnect the transmission T.V. or detent cable.
9. Depress and hold the medal lock tab on the cable upper end. Move the slider through the fitting in the direction away from the lever assembly until the slider stops against the metal fitting.
10. Release the metal tab, rotate the lever assembly to the full throttle stop and release the lever assembly.
11. Reconnect the pump rod (and cruise control throttle rod, if so equipped).
12. Adjust the vacuum regulator valve, see "Vacuum Regulator Adjustment".
13. Reset the idle speeds and adjust the cruise control servo rod, see "Idle Speed Adjustment."

VACUUM REGULATOR VALVE ADJUSTMENT

1. Remove the air crossover (Figures 6C5-6 or 6C5-7).. Install the screened covers in the intake manifold openings; J-26996-10 on V8 and J-29657 on the V6.
2. Disconnect the throttle rod from the pump on the V8 and disconnect the throttle cable and detent/T.V. cable from the pump throttle lever on the V6.
3. Loosen the vacuum regulator valve to injection pump bolts.
4. Install BT-7944 or J-26701-15 carburetor angle gage adapter to the injection pump throttle lever. Place angle gage BT-7704 or J-26701 on adapter.

NOTICE: On the V6 pumps it may be necessary to rework tool BT-7944 or J-26701-15 by filing the tool so that it can fit onto the V6 pump's thicker throttle lever.

5. Rotate throttle lever to the wide open throttle position and set angle gage to zero degrees. (Figure 6C5-8)

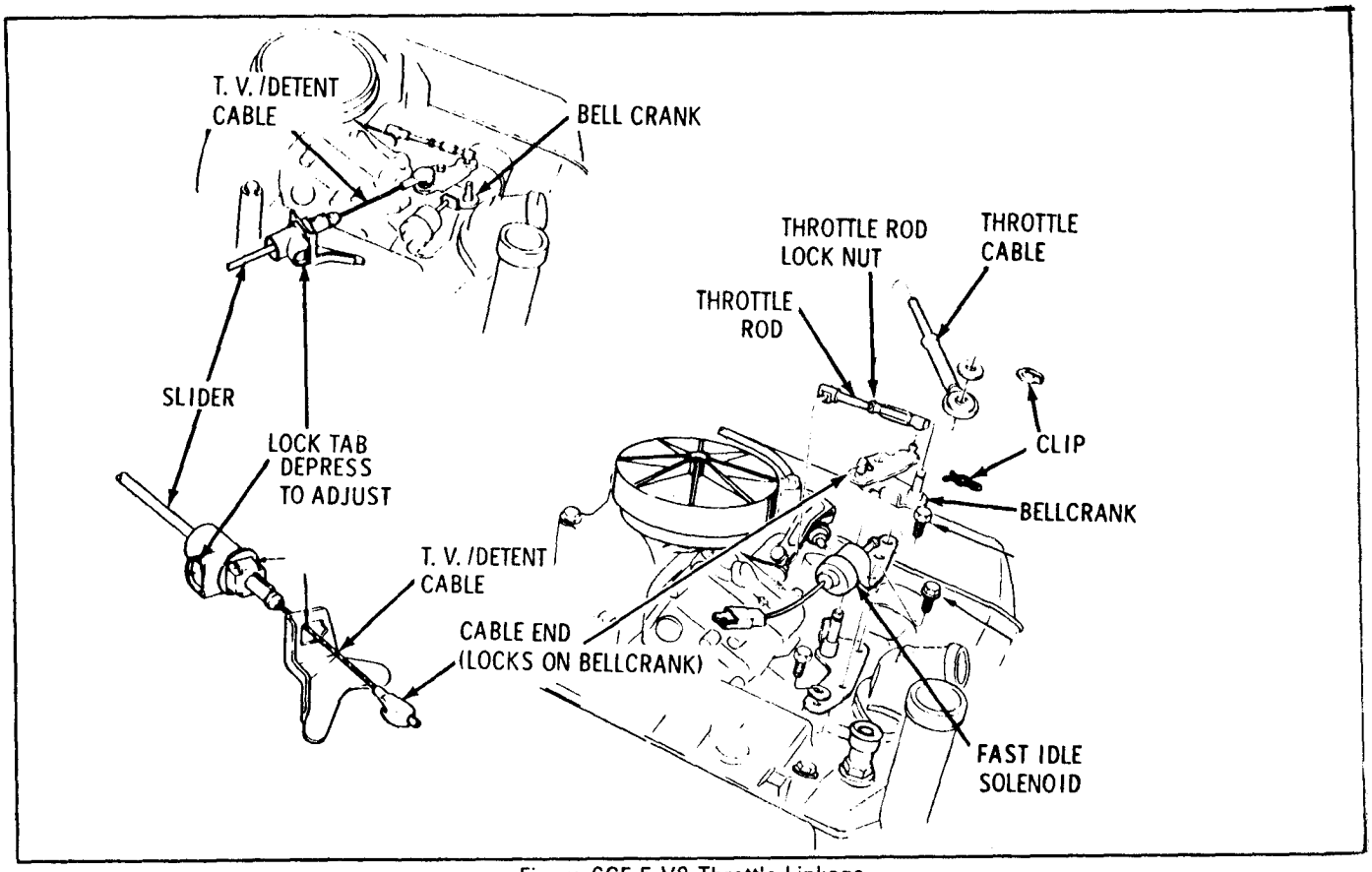


Figure 6C5-5 V8 Throttle Linkage

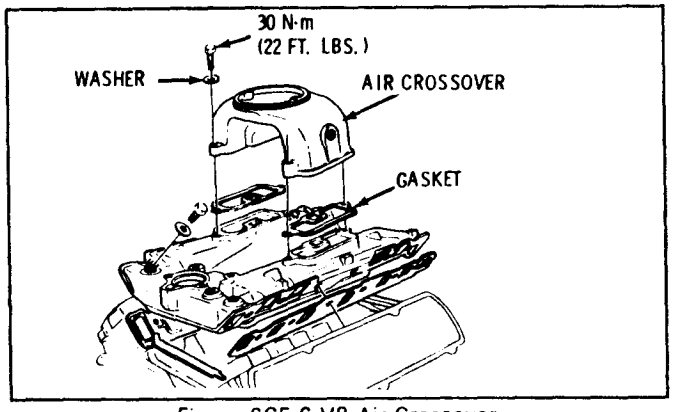


Figure 6C5-6 V8 Air Crossover

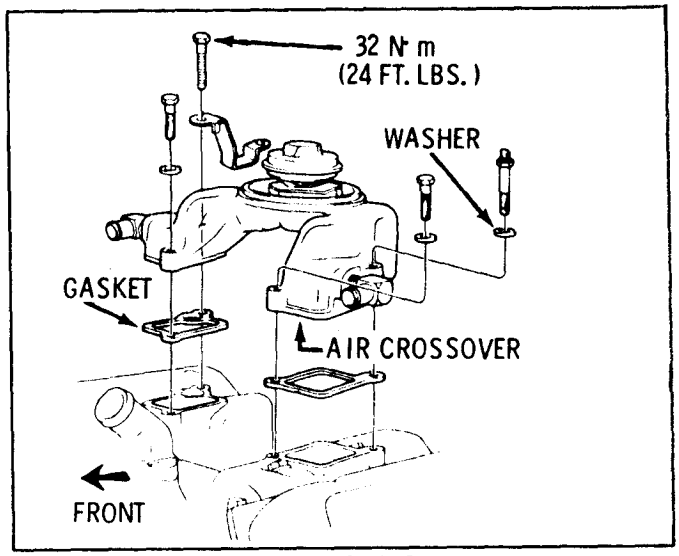


Figure 6C5-7 V6 Air Crossover

6. Center bubble in level.
7. Set angle gage to 58 degrees on the V8, and 49 degrees on the V6.
8. Rotate throttle lever so lever bubble is centered. (Figure 6C5-9)
9. Attach vacuum source such as BT-7517 or J-2378 vacuum pump to port A. Install vacuum gage to port B. Apply 61-74 kPa (18-24 inches) of vacuum to port A, Figures 6C5-10A.
10. Rotate vacuum valve clockwise to obtain 35 kPa (10.6 inches) of vacuum.
11. Tighten vacuum valve bolts. Remove vacuum source and vacuum gage.
12. Connect the throttle rod to the pump throttle lever on the V8 and connect the throttle cable and detent/T.V. cables to the pump throttle lever on the V6.
13. Remove the intake manifold screened covers.
14. Install the air crossover, Figure 6C5-6 or 6C5-7.

VACUUM REGULATOR VALVE (FIGURES 6C5-10 AND 6C5-10A)

Removal

1. Remove the two vacuum hoses from the valve noting the location of the vacuum hoses.
2. Remove the 2 attaching bolts.

Installation

1. Install the valve following the "Vacuum Regulator Valve Adjustment Procedure."
2. Attach the two vacuum hoses to the valve.

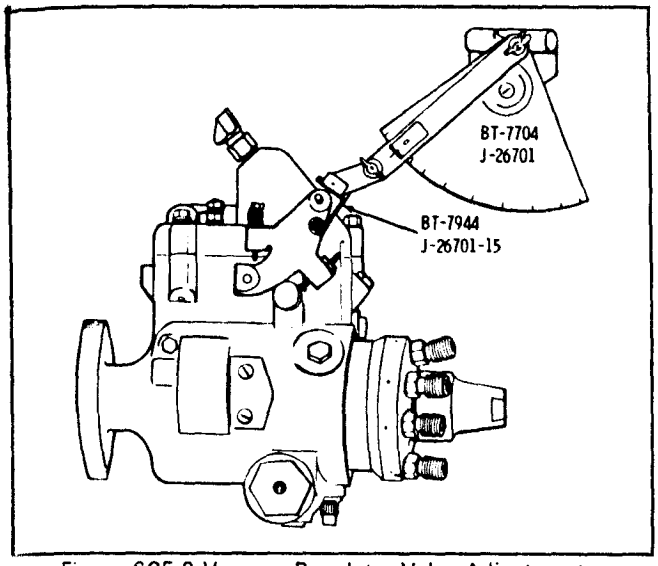


Figure 6C5-8 Vacuum Regulator Valve Adjustment

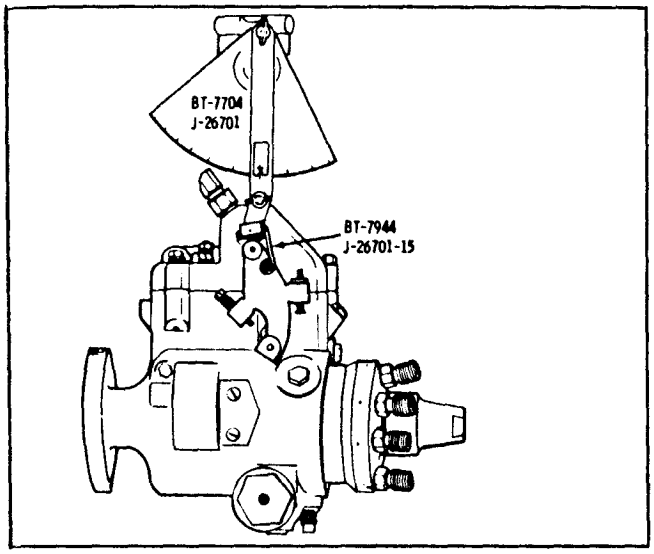


Figure 6C5-9 Vacuum Regulator Valve Adjustment

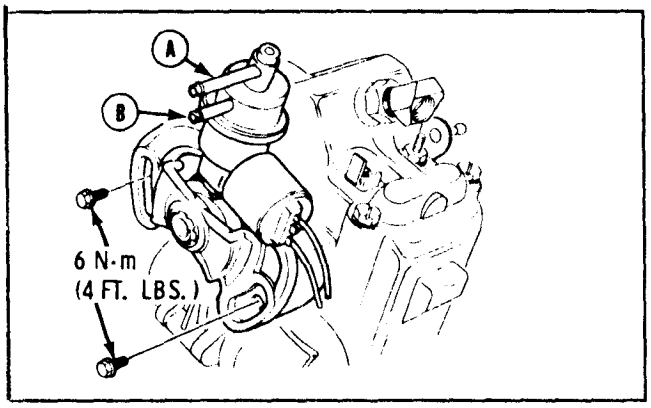


Figure 6C5-10 Vacuum Regulator Valve

IDLE SPEED ADJUSTMENTS

1. Apply the parking brake, place the transmission selector lever in " **park**" and block the drive wheels.
2. On the V8, perform the throttle linkage adjustment first, if required. See "Throttle Linkage Adjustment."
3. Start engine and allow it to run until warm, usually 10-15 minutes.
4. Shut off the engine, remove the air cleaner assembly.

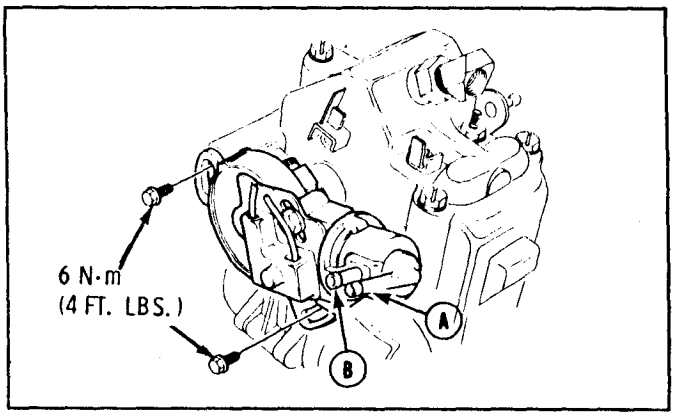


Figure 6C5-10A Vacuum Regulator Valve

5. Clean the front cover RPM counter (probe holder) and the crankshaft balancer rim.
6. Install the magnetic pick-up probe of tool J-26925 fully into the RPM counter. Connect the battery leads; red to positive and black to negative.
7. Disconnect the two lead connector at the generator.
8. On the V6 disconnect the AC compressor clutch lead at the compressor. (If so equipped.)
9. Turn off all electrical accessories.
10. Allow no one to touch either the steering wheel or service brake pedal.
11. Start the engine and place the transmission selector lever in "Drive".
12. Check the slow idle speed reading against the one given on the "Vehicle Emission Information Label". Reset if required (Figures 6C5-11 or 6C5-12).

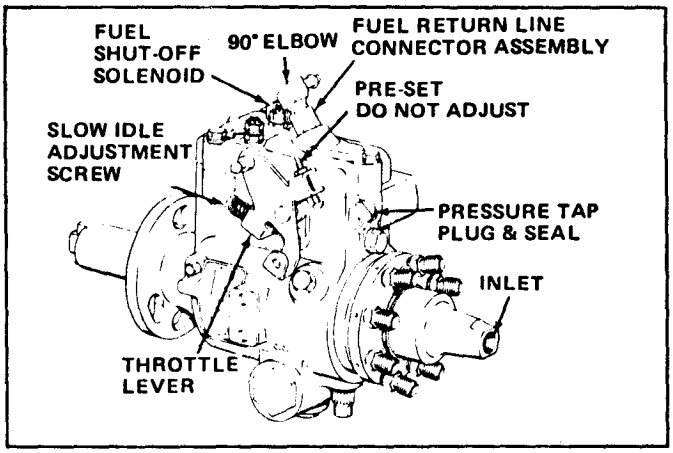


Figure 6C5-11 Injection Pump Slow Idle Screw, Roosa-Master Pump

13. Unplug the connector from the fast idle cold advance (engine temp.) switch and install a jumper between the connector terminals - Do not allow the jumper to touch ground. (Figure 6C5-13).
14. Check the fast idle solenoid speed against the one given on the "Vehicle Emission Information Label." Reset if required, see Figure 6C5-5, V8 and Figure 6C5-14, V6.
15. Remove the jumper and reconnect it to the temperature switch.
16. Recheck and reset the slow idle speed if necessary.
17. Shut off the engine.
18. Reconnect the lead at the geneator (and AC compressor, if so equipped).
19. Disconnect and remove the tachometer.
20. If equipped with cruise control adjust the servo throttle rod to minimum slack then put clip in first free hole closest to the bellcrank or throttle lever, but within the servo bail.

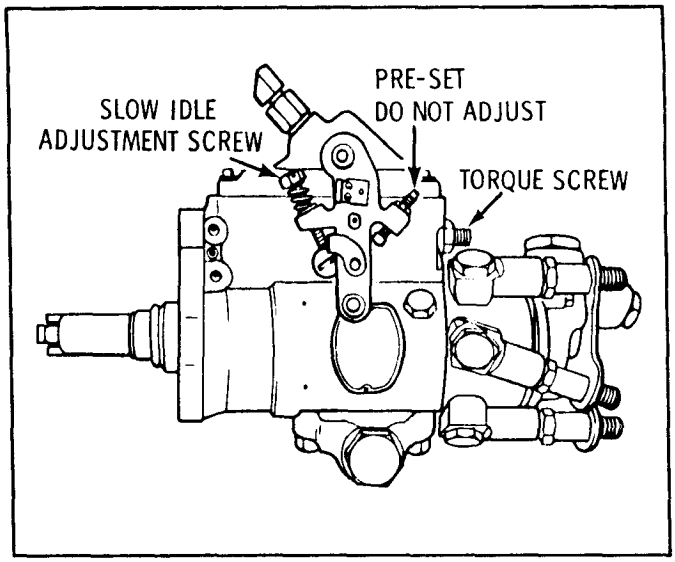


Figure 6C5-12 Injection Pump Slow Idle Screw, CAV Pump

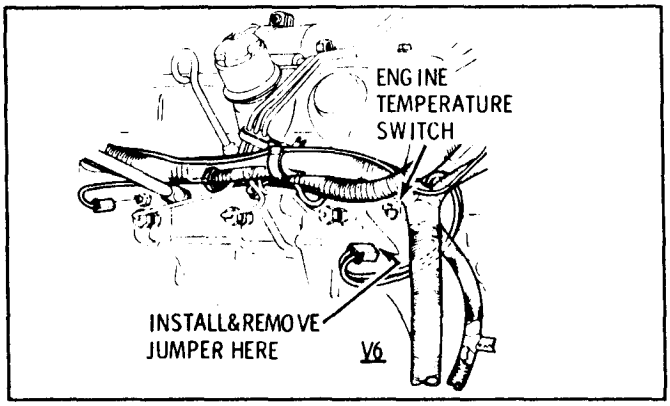


Figure 6C5-13 Fast Idle Temperature Switch (V6)

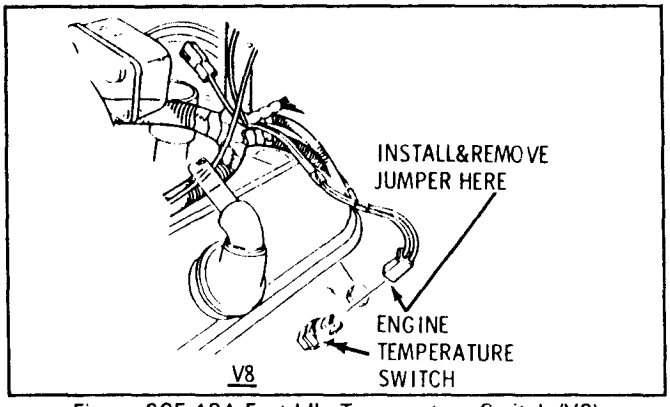


Figure 6C5-13A Fast Idle Temperature Switch (V8)

21. Install the air cleaner assembly and connect the EGR valve hose.

HOUSING PRESSURE COLD ADVANCE (HPCA) ALL ENGINES (FIGURES 6C5-15 AND 6C5-16)

The HPCA Feature is designed to advance the injection timing about 3° during cold operation. This circuit is actuated by a temperature switch on the left rear head bolt, on all series. The switch is calibrated to open the circuit at 125° F. Below the switching point, housing pressure is decreased from 8-12 psi to zero which advances the timing 3°. Above 125° F. the switch opens de-energizing the solenoid and the housing pressure is returned to

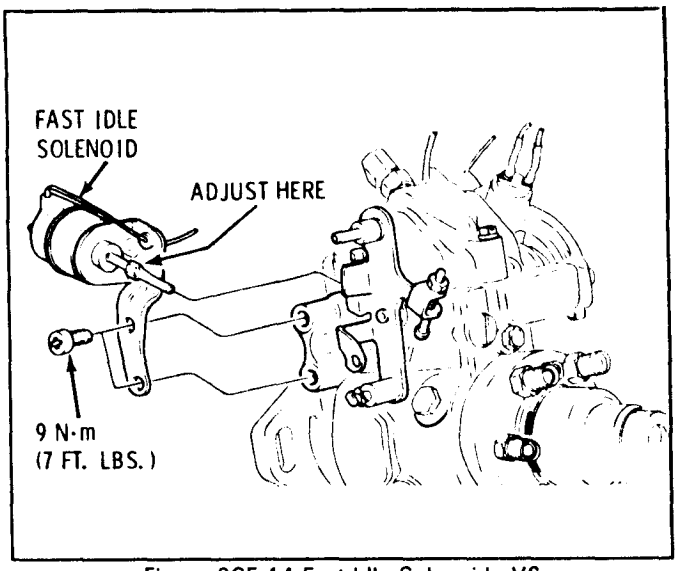


Figure 6C5-14 Fast Idle Solenoid - V6

8-12 psi. The fast idle solenoid is energized by the same switch. The switch again closes when the temperature falls below 95 °F.

PURPOSE:

1. Emission Control device.
2. Better cold starts.
3. Improbes idle, reduces white smoke and noise when cold.

When changing the fuel filter or when the car has run out of fuel, disconnect the connector from the temperature switch and jumper connector terminals. This will aid in purging air from the pump. (This procedure is necessary only on a hot engine, as the circuit will always be closed when the engine is cold.)

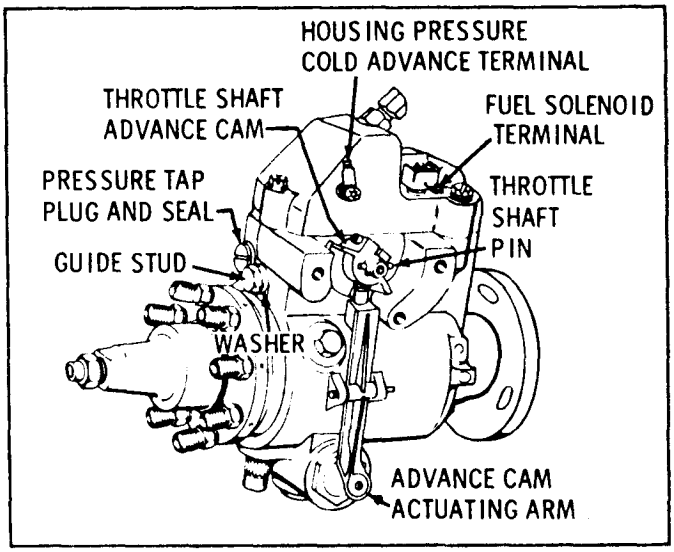


Figure 6C5-15 Housing Pressure Cold Advance Solenoid, Roosa-Master Pump

INJECTION PUMP FUEL LINES (FIGURES 6C5-17 AND 6C5-18)

When lines are to be removed, clean all line fittings thoroughly before loosening. Immediately cap the lines, nozzles and pump fittings to maintain cleanliness.

Removal

All lines may be removed without removing injection pump. It is not necessary to use a back-up wrench when removing the lines from pump.

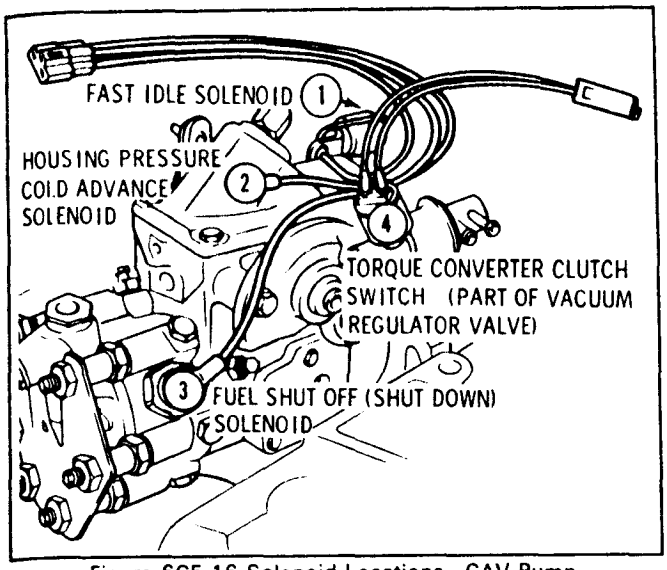


Figure 6C5-16 Solenoid Locations - CAV Pump

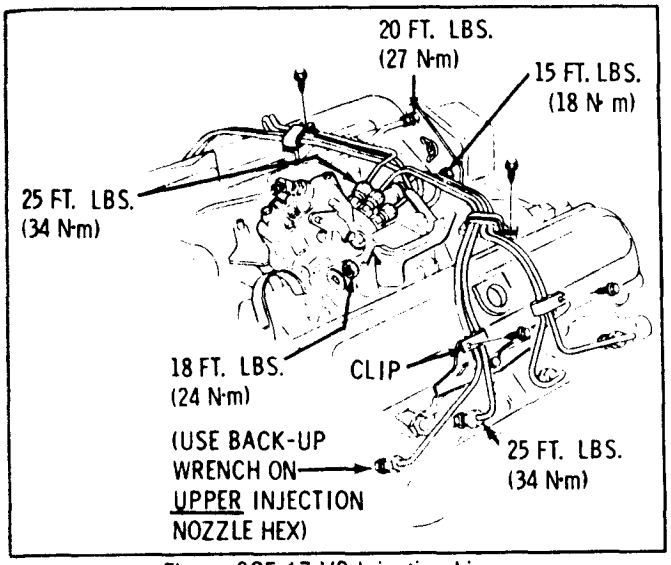


Figure 6C5-17 V8 Injection Lines

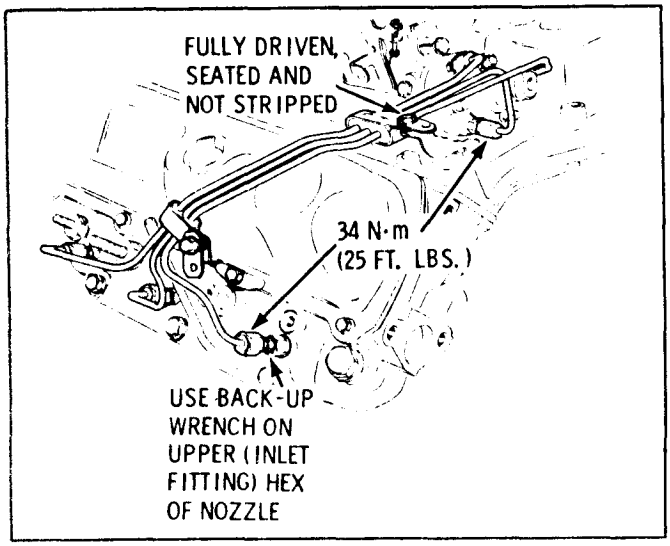


Figure 6C5-18 V6 Injection Lines

1. Remove air cleaner.
2. Remove filters and pipes from valve covers and air crossover.
3. Remove air crossover (Figures 6C5-6 and 6C5-7 and cap intake manifold with screened covers J-26996-10, V8 and J-29657, V6.
4. Remove injection pump line clamps, then remove the injection pump lines and cap open lines, nozzles, and pump fittings. Use a back-up wrench on the nozzle upper hex to prevent a fuel leak.

Installation

1. Install new injection pump line, install loose then torque both ends. See Figure 6C5-17 and 6C5-18 for the Torque Specifications. Use a back-up wrench on the nozzle upper hex to prevent nozzle damage. Then install clamps.

   If several lines are to be replaced, start with the bottom lines.
2. Start engine and check for fuel leaks.
3. Remove screened covers from intake manifold and install air crossover. (Figures 6C5-6 or 6C5-7)
4. Connect the crankcase ventilation pipes and filter(s) to the valve cover(s) and air crossover.
5. Install the air cleaner.

INJECTION PUMP AND LINES

Removal

1. Remove the air cleaner assembly.
2. Remove the crankcase ventilation filter(s) and pipes from the valve covers and air crossover.
3. Remove the air crossover (Figures 6C5-6 or 6C5-7) and install intake manifold screened covers J-26996-10 on the V8 or J-29657 on the V6. On the V6 disconnect or remove fuel lines and fuel pump. (Figure 6C5-4).
   A. On the V8, disconnect the throttle rod (Figure 6C5-5) and throttle return spring (Figure 6C5-19). Remove the throttle bellcrank.

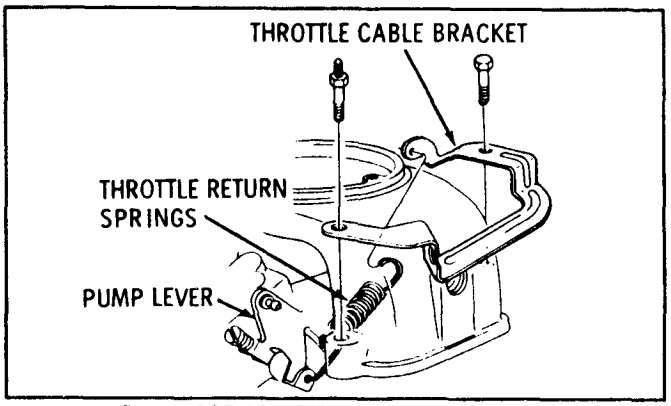


Figure 6C5-19 V8 Throttle Return Spring

   B. On the V6, disconnect the throttle cable (Figure 6C5-20 and T.V./detent cable from the pump throttle lever. Disconnect the throttle return spring (Figure 6C5-21).
4. Remove the throttle and T.V./Detent cables from the intake manifold brackets. Position the cables away from the engine.
5. Remove the fuel filter and fuel filter to injection pump line. (Figures 6C5-3 V8, or 6C5-4, V6)
6. On the V8, disconnect fuel line at fuel pump. If A/C equipped, remove rear compressor brace. Remove fuel line.
7. Disconnect the fuel return line from the injection pump. (Figure 6C5-22, V8 or Figure 6C5-4 V6)
8. Using two wrenches, disconnect injection pump lines at the nozzles.

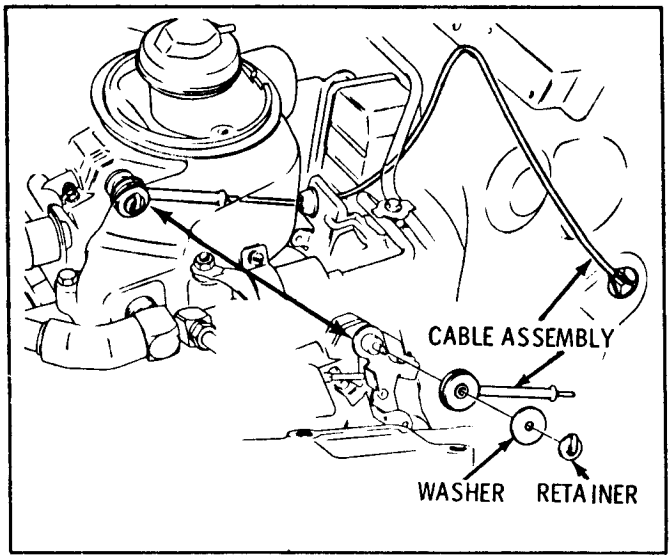


Figure 6C5-20 V6 Throttle Cable

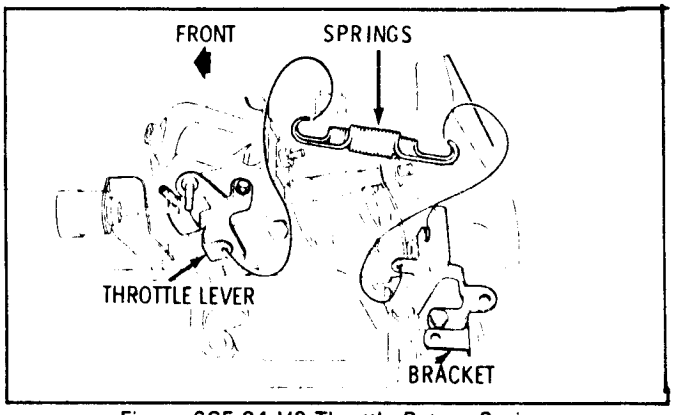


Figure 6C5-21 V6 Throttle Return Spring

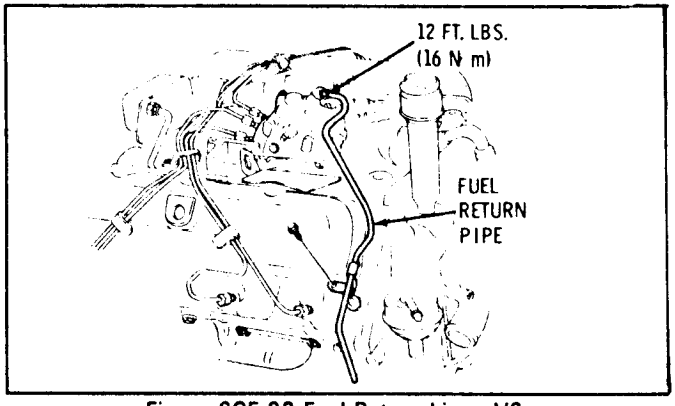


Figure 6C5-22 Fuel Return Line - V8

9. On the V8, remove 3 nuts retaining injection pump, using tool J-26987. On the V6, remove the 2 bolts retaining the injection pump.
10. Remove pump and cap all open lines and nozzles Discard the pump to adapter "O" ring.

Installation

1. Position engine No. 1 cylinder to firing position by aligning the mark on the balancer with zero mark on the indicator located on the front of the engine. Refer to Figure 6C5-23 for position of injection pump driven gear. (The index is offset to the right when number one is at T.D.C.).

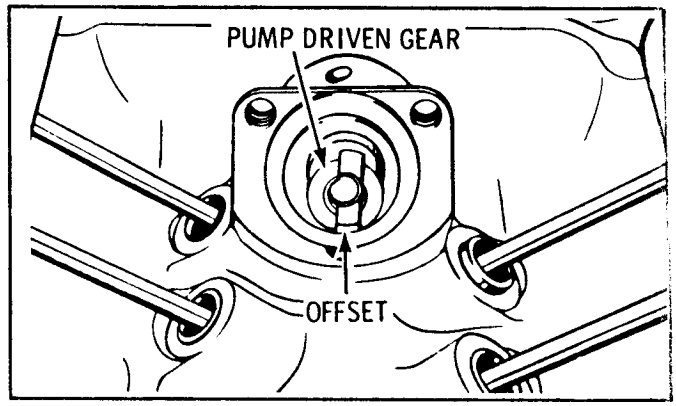


Figure 6C5-23 Pump Offset

2. Remove protective caps, then line up offset tang on pump driveshaft with the pump driven gear. Install a new pump to adapter "O" ring, then install the pump fully seating pump by hand.
3. If a new adapter (V8) or intermediate adapter (V6) is installed, set the injection pump at the center of slots in the pump mounting flange.

   If the original adapter (V8) or intermediate adapter (V6) is being retained, align the pump timing mark with the mark on the adapter or intermediate adapter. Install the 3 nuts and washers (V8) or 2 bolts and washers (V6) retaining the pump and torque to 24 N·m (18 ft. lbs.) V8, and 47 N·m (35 ft. lbs.) on the V6.
4. Connect the injection lines to the nozzles using two wrenches (Figure 6C5-17 or 6C5-18).
5. Connect the fuel return line.
6. On the V8, reconnect the fuel line at the fuel pump. If AC equipped, install the rear compressor brace.
7. Install the fuel filter and fuel filter to injection pump line (Figures 6C5-3 or 6C5-4).
8. Install the throttle and T.V. detent cables into the intake manifold brackets.
   A. On the V8, connect the throttle rod (Figure 6C5-5) and throttle return spring (Figure 6C5-19). Adjust the throttle linkage, see throttle "Linkage Adjustment V8".
   B. On the V6, connect the throttle cable (Figure 6C5-20) and T.V./detent cable to the pump throttle lever. Connect the throttle return spring (Figure 6C5-21). Adjust the T.V./detent cable, see Section 7A.
9. Install all remaining fuel lines and fuel filter.
10. Start the engine and check for leaks.
11. Check and if necessary reset the pump timing, see "Checking and/or Adjusting Pump Timing."
12. Adjust the vacuum regulator valve. see "Vacuum Regulator Valve Adjustment"
13. Adjust the idle speeds, see "Idle Speed Adjustment."
14. Remove screened covers from intake manifold, then install air crossover.
15. Install tubes and hoses in the air crossover and ventilation filters in the valve covers.
16. Install the air cleaner being certain to reconnect the EGR valve hose.

INJECTION PUMP ON CAR SERVICE (ROOSA-MASTER)

There are areas on the injection pump where leaks can be corrected without removing the pump from the engine.

Pump Cover Seal and/or Guide Stud Seal Replacement

1. Disconnect the negative cables from both batteries.
2. Remove the air cleaner and air crossover. Install screens J-29657 (V6) or J-26996-10 (V8) in the intake manifold.
3. Disconnect the injection pump fuel solenoid and housing pressure cold advance wires and the fuel return pipe.
4. Clean the injection pump cover, upper portion of the pump and the guide stud area. (Figure 6C5-26) Place several rags in engine valley to catch fuel.
5. Remove injection pump cover and remove screws from the cover.

NOTICE: Extreme care must be exercised to keep foreign material out of the pump when the cover is off. If any objects are dropped into the pump, they must be removed before the engine is started or injection pump damage or engine damage could occur.

STEPS 6, 7 and 8 ARE FOR GUIDE STUD SEAL REPLACEMENT ONLY.

6. Observe position of metering valve spring over the top of the guide stud. This position must be exactly duplicated during reassembly.
7. Remove the guide stud and washer. Note location of parts prior to removal.
8. Reinstall the guide stud with a new washer making certain that the upper extension of the metering valve spring rides on top of the guide stud. Torque the guide stud to 9.5 N·m (85 in. lbs.) Overtorquing the guide stud may strip the aluminum threads in the housing.
9. Hold the throttle in the idle position.
10. Install new pump cover seal. Make sure the screws are not in the cover and position the cover about 6.35 mm (1/4 inch) forward (toward shaft end) and about 3.17 mm (1/8 inch) above the pump. (Figure 6C5-27)
11. Move the cover rearward and downward into position, being careful not to cut the seal and reinstall the cover screws. Be careful not to drop or lose flat washer and internal lock washer with each screw. Flat washer must be against pump cover. Torque to 3.7 N·m (33 in. lbs.)
12. Reconnect the negative cables to both batteries.
13. Turn the ignition switch to the run position and touch the pink solenoid wire to the solenoids. A clicking noise should be heard as the wire is connected and disconnected. If this clicking is not observed, the linkage may be jammed in a wide open throttle position and the engine MUST NOT be started. If clicking is observed, connect the pump solenoid and housing pressure cold advance wires (Figure 6C5-26) then proceed to step 16.
14. Remove the cover. Ground the solenoid lead (opposite the hot lead) and connect the pink wires. With the ignition switch in the run position, the solenoid in the cover should move the linkage. If not the solenoid must be replaced. Minimum voltage across solenoid terminals must be 12.0.
15. Reinstall the cover and repeat Step 10, 11, 12, 13.
16. Reinstall the fuel return pipe.

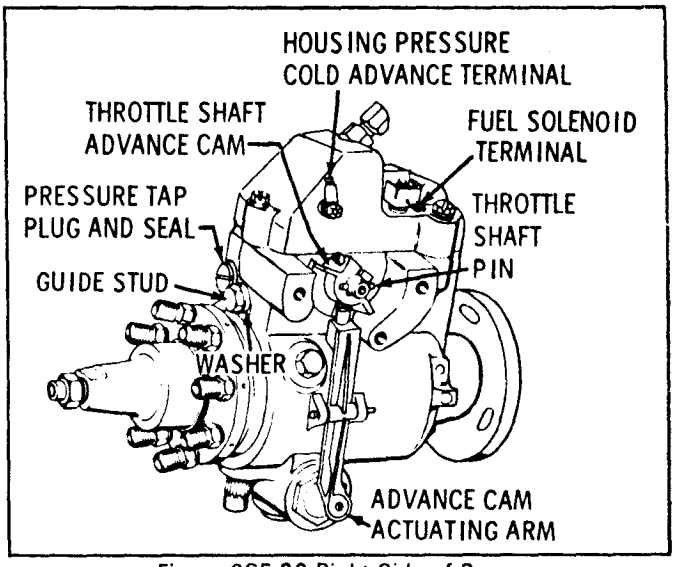


Figure 6C5-26 Right Side of Pump

17. Start the engine and check for leaks.
18. Idle roughness may be observed due to the air in the pump, give it plenty of time to purge which it will do by allowing the engine to idle. It may be necessary to shut the engine down for several minutes to allow air bubbles to rise to the top of the pump where they will be purged.
19. Remove the intake manifold screens then reinstall the air crossover and air cleaner.

Throttle Shaft Seal Replacement

1. Disconnect the negative cables from both batteries.
2. Remove the air cleaner and air crossover. Install screens J-29657 (V6) or J-26996-10 (V8) in the intake manifold.

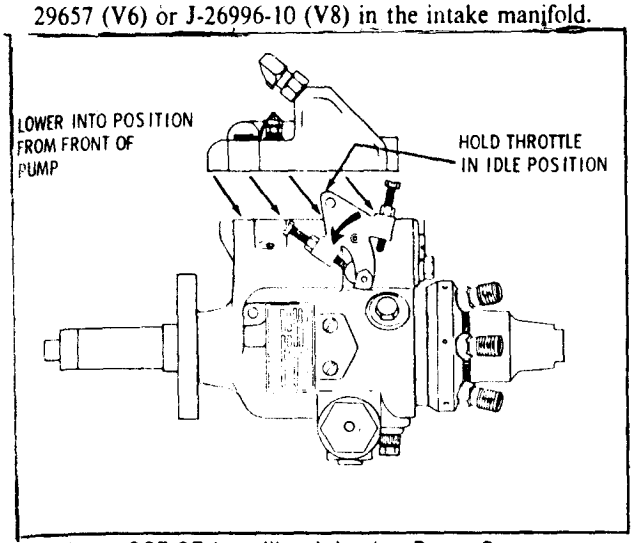


Figure 6C5-27 Installing Injection Pump Cover

3. Disconnect the injection pump fuel solenoid and housing pressure cold advance wires and the fuel return pipe. (Figure 6C5-26)
4. Remove the vacuum regulator valve, the throttle rod, V8 or throttle and T.V./detent cable, V6 and return springs.
5. Remove the throttle cable bracket, V8 only.
6. Install tool J-29601 over the throttle shaft with slots of tool engaging pin. Put the spring clip of the tool over the throttle shaft advance cam and tighten the wing nut. Without loosening the wing nut, pull the tool off the shaft. (This provides the proper alignment on reassembly.) Figure 6C5-28.

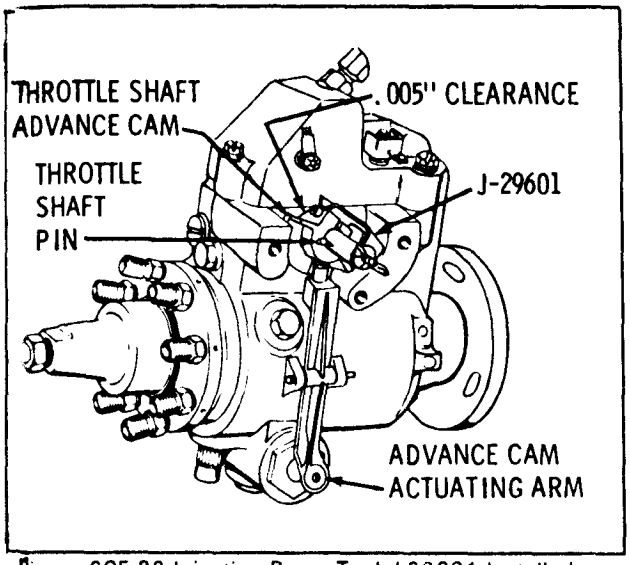


Figure 6C5-28 Injection Pump Tool J-29601 Installed

7. Drive the pin from the throttle shaft and remove the throttle shaft advance cam and fiber washer. Remove any burrs from the shaft that may have resulted from pin removal.
8. Clean the injection pump cover, upper portion of the pump, the throttle shaft and the guide stud area. (Figure 6C5-26) Place several rags in the engine valley to catch fuel.
9. Remove injection pump cover and remove screws from the cover.

NOTICE: Extreme care must be exercised to keep foreign material out of the pump when the cover is off. If any objects are dropped into the pump, they must be removed before the engine is started or injection pump damage or engine damage could occur.

10. Observe position at metering valve spring over the top of the guide stud. This position must be exactly duplicated during reassembly.
11. Remove the guide stud and washer. Note location of parts prior to removal.
12. Rotate the min-max governor assembly up to provide clearance and remove from the throttle shaft. (Figure 6C5-29).

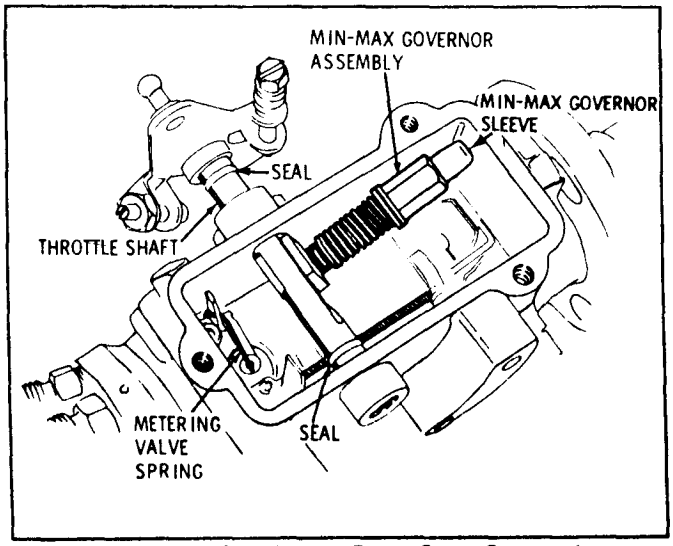


Figure 6C5-29 Injection Pump Cover Removed

13. Remove the throttle shaft assembly and examine the shaft for unusual wear or damage, replace if required. It may be necessary to loosen the nuts at the injection pump mounting flange and rotate the pump slightly to allow the throttle shaft assembly to clear the intake manifold.
14. Examine the throttle shaft bushings in the pump housing for any evidence of damage or unusual wear. Remove the pump and send to the local Roosa Master dealer if bushing replacement is necessary.
15. Remove the throttle shaft seals. Do not attempt to cut the seals to remove, as nicks in the seal seat will cause leakage.
16. Install new shaft seals using care not to cut the seals on the sharp edges of the shaft. Apply a light coating of clean chassis grease on the seals.
17. Carefully slide the throttle shaft back into the pump to the point where the min-max governor assembly will slide back onto the throttle shaft. (Figure 6C5-29)
18. Rotate the min-max governor assembly downward, hold in position and slide the throttle shaft and governor into position.
19. Install a new mylar washer, the throttle shaft advance cam, (Do not tighten cam screw at this time), and a new throttle shaft drive pin (Figure 6C5-26)
20. Align the throttle shaft advance cam so tool J-29601 can be reinstalled over the throttle shaft, pin in the slots and the spring clip over the advance cam.
21. Put a .005" feeler gage between the cam and the mylar washer. Tighten the cam screw and remove tool J-29601.
22. Reinstall the guide stud with a new washer, making certain that the upper extension of the metering valve spring rides on top of the guide stud. Torque the guide stud to 9.5 N·m (85 in. lbs.) Overtorquing the guide stud may strip the aluminum threads in the housing (Figure 6C5-26)
23. Hold the throttle in the idle position.
24. Install new pump cover seal. Make sure the screws are not in the cover and position the cover about 1/4 inch forward (toward shaft end) and about 1/8 inch above the pump. (Figure 6C5-27)
25. Move the cover rearward and downward into position, being careful not to cut the seal and reinstall the cover screws. Be careful not to drop and lose flat washer and internal lock washer with each screw. Flat washer must be against pump cover. Torque to 3.7 N·m (33 in. lbs.) Install vacuum regulator valve.
26. Reconnect the negative cables to both batteries.
27. Turn the ignition switch to the run position and touch the pink solenoid wire to the solenoid. A clicking noise should be heard as the wire is connected and disconnected. If this clicking is not observed, the linkage may be jammed in a wide open throttle position and the engine MUST NOT be started. If clicking is observed, connect the pump solenoid and housing pressure cold advance wires (Figure 6C5-26) then proceed to step 30.
28. Remove the cover. Ground the solenoid lead opposite the hot lead) and connect the pink wire. With the ignition switch in the run position, the solenoid in the cover should move the linkage. If not the solenoid must be replaced. Minimum voltage across solenoid terminals must be 12.0.
29. Reinstall the cover and repeat Step 27.
30. Reinstall throttle cable bracket and throttle rod. V8 only.

31. Reconnect the throttle cable (both) and T.V./detent cable (V6). Install the throttle return springs.
32. Install the fuel return pipe.
33. Start the engine and check for leaks.
34. Idle roughness may be observed due to the air in the pump, give it plenty of time to purge which it will do by allowing the engine to idle. It may be necessary to shut the engine down for several minutes to allow air bubbles to rise to the top of the pump where they will be purged.
35. Adjust vacuum regulator valve. See "VACUUM REGULATOR VALVE ADJUSTMENT".
36. Remove the intake manifold screens then reinstall the air crossover and air cleaner.

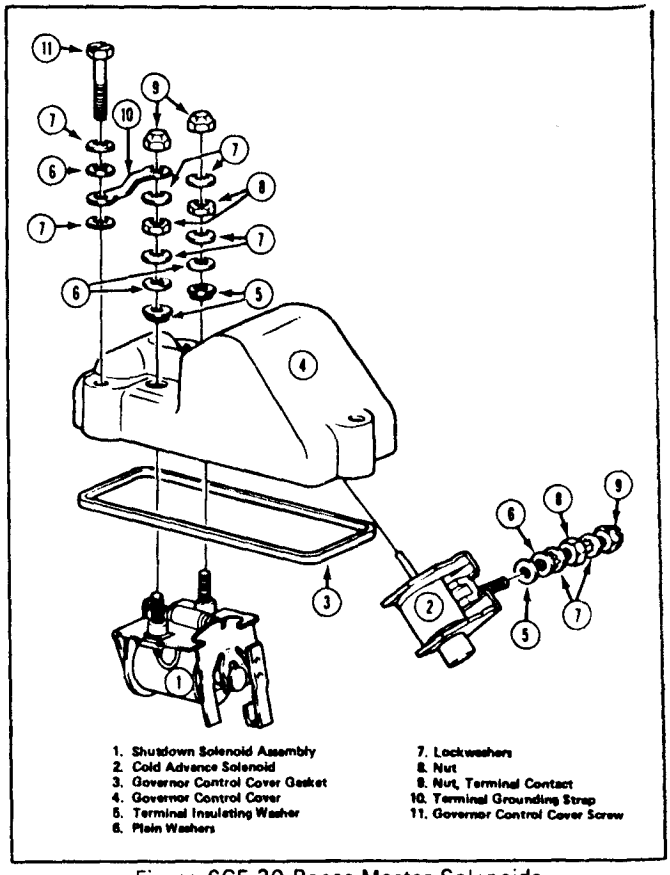


Figure 6C5-30 Roosa-Master Solenoids

SOLENOIDS (FIGURE 6C5-30)

1. Remove the pump cover, see "Pump Cover Seal."
2. Remove the terminal contact nut(s) and remove the solenoid from the cover noting the position of any insulating washers.

Installation

1. Place the solenoid in the cover making certain on the shut-off solenoid that the linkage is free, and on the Housing Pressure Cold Advance solenoid that the plunger is centered so that it will contact the fitting check ball.
2. Place the insulating washers on the terminal studs (where used) and install the terminal nuts. Torque the nuts to 1.13-1.69 N·m (10-15 in. lbs.)
3. Check the operation of the solenoid prior to installing the pump cover with the use of a 12V (min) DC power source. Make certain that the shut-off linkage is free if that solenoid was replaced.
4. Install the pump cover, see "Pump Cover Seal", steps 9 through 19.

INJECTION PUMP OFF CAR SERVICE

For pump removal and installation, see "Injection Pump and Lines," except installation steps 12 and 13.

Off car pump service operations require a leak test after repair. See "Pressure Testing."

TIMING LINE COVER GASKET (FIGURE 6C5-31)

Removal

1. Remove the 2 screws, cover and gasket.

Installation

1. Install the gasket, cover and two screws, torque the screws to 1.5-2.5 N·m (15-20 in. lbs.).

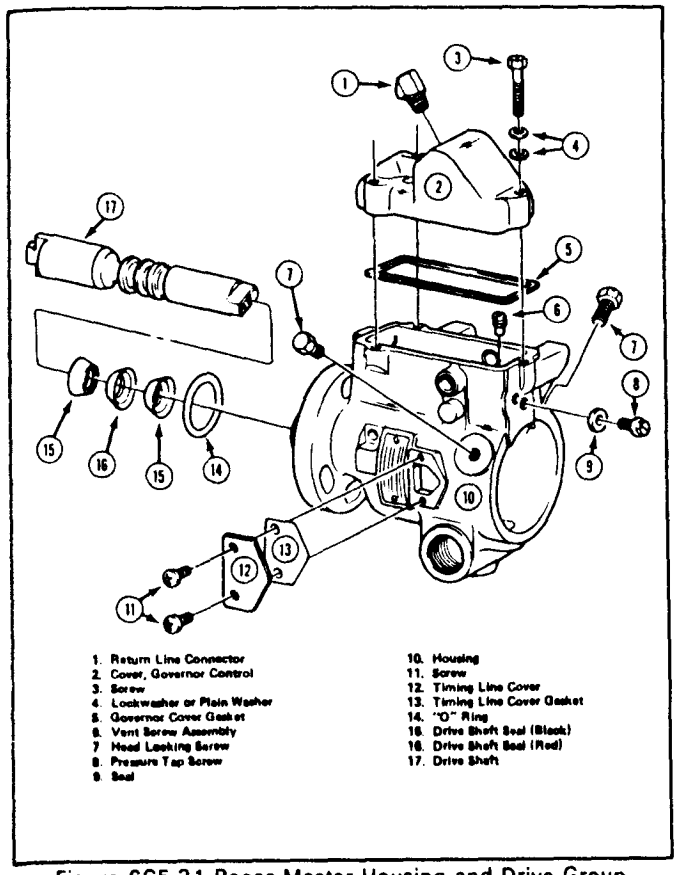


Figure 6C5-31 Roosa-Master Housing and Drive Group

ADVANCE PIN HOLE PLUG SEAL (FIGURE 6C5-32)

Removal

1. Tap the advance pin hole plug lightly with a hammer to loosen.
2. Loosen and remove the plug, remove the seal and do not reuse it.

Installation

1. Lube a new seal and install it on the plug.
2. Install the plug and torque it to 8.5-11.0 N·m (75-100 in. lbs.)

AUTO ADVANCE SEALS (FIGURE 6C5-32)

Removal

1. Remove the advance pin hole plug as stated in "Advance Pin Hole Plug."
2. Remove the spring side advance piston hole plug.
3. Remove the plug, piston, spring and slide washer.
4. Remove the power side advance piston hole plug.
5. Remove the plug, piston and slide washer.

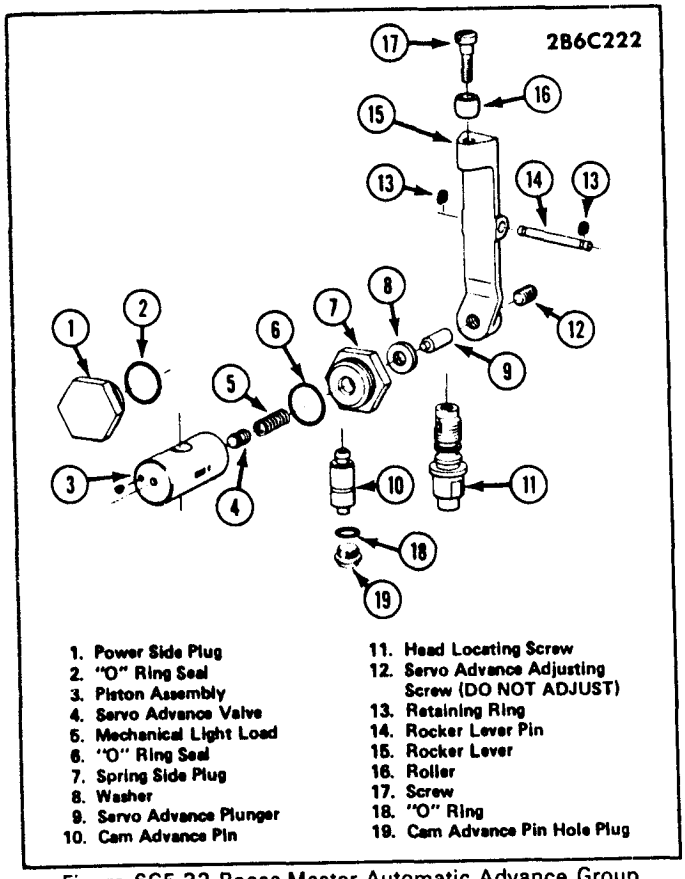


Figure 6C5-32 Roosa-Master Automatic Advance Group

6. Disassemble both plugs and pistons.

Installation

1. Lube the new seals and reassemble as shown in Figure 6C5-32.
2. Torque the plugs to 27 N·m (20 ft. lbs.)
3. Install the advance screw hole plug using a new seal. Torque to 8.5-11.0 N·m (75-100 in. lbs.)

HYDRAULIC HEAD SEAL

1. Remove the throttle shaft and seals, see "Throttle Shaft Seal Replacement"
2. Remove the metering valve (Figure 6C5-29).
3. Remove the housing vent screw assembly. (Figure 6C5-31)
4. Remove the advance pin hole plug see "Advance Pin Hole Plug."
5. Remove the advance pin (Figure 6C5-32).
6. Locate the pump assembly and holding fixture so that the rear of the pump is sloping down and remove the head locating screws and seal. (Figures 6C5-31 and 6C5-32)
7. Using a twisting motion, remove the hydraulic head assembly. Remove the "O" ring seal.

Installation

1. Install a new hydraulic head seal and lube it.
2. Install the head assembly into the pump housing, lube and install the two head locking screws finger tight. Turn the pump upside down.
3. Lube and install a new seal on the head locating screw and install the screw torquing it to 20-25 N·m (15-18 ft. lbs.). (Figure 6C5-32)
4. Torque the head locking screws to 20-25 N·m (15-18 ft. lbs.). (Figure 6C5-31)
5. Install the advance pin. (Figure 6C5-32)
6. Install the advance pin hole plug and seal, see "Advance Pin Hole Plug."
7. Move the pump so the cover opening is up, and install the metering valve.
8. Install the throttle shaft, seals and pump cover, see "Throttle Shaft and Seals."

DRIVE SHAFT SEAL REPLACEMENT (FIGURE 6C5-31)

Removal

1. Remove the shaft from the pump with a rotating motion while pulling on the shaft.
2. Remove the shaft and seals.

Installation

1. Clean the shaft.
2. Lubricate the seal installer tool.
3. Install one black seal.
4. Relubricate the seal installation tool, and install the red seal.
5. Relubricate and install the last black seal.
6. Reinstall the shaft, making sure that the drill points on the shaft end and the rotor are matched.
7. Use a rotating motion when installing the shaft to prevent rolling the lip of the seals.
8. Pressure test the pump assembly.

PRESSURE TESTING

1. Drain all fuel from the pump.
2. Connect an air line to the pump inlet connection. Be certain that the air supply is clean and dry.
3. Seal off the return line fitting and completly immerse the pump in a bath of clean test oil.
4. Raise the air pressure in the pump to 137.9 kPa (20 psi). Leave the pump immersed in the oil for 10 minutes to allow any trapped air to escape.
5. Watch for leaks after the 10 minute period. If the pump is not leaking, reduce the air pressure to 13.8 kPa (2 psi) for 30 seconds. If there is still no leak increase the pressure to 137.9 kPa (20 psi). If still no leaks are seen, the pump is ready for use.

INJECTION PUMP ADAPTER AND ADAPTER SEAL

Replacement of Adapter Seal (Fig. 6A5-11 & 6A5-12)

1. Refer to "Injection Pump and Lines" removal for pump assembly removal.
2. Using probe, pry out the adapter seal without nicking the adapter.
3. Loosen the adapter to block bolts.
4. Lube the new seal with chassis lube on both the I.D. and O.D. of the seal.
5. Install the seal using tool J-28425. First install the seal on the tool, then install the seal into the adapter. (See Fig. 6A5-11)
6. Remove the tool and inspect to see if the seal is properly installed.
7. Make sure the lower adapter to block bolt has a washer, then torque the adapter bolts to 37 N·m (25 ft. lbs.).

Replacement of Adapter (Fig. 6A5-11 & 6A5-12)

1. Refer to "Injection Pump and Lines" removal for pump assembly removal.
2. Remove the adapter to block bolts and remove the adapter.
3. Loosely install the adapter in the block.
4. Refer to "Replacement of Adapter Seal, steps 4 through 7.

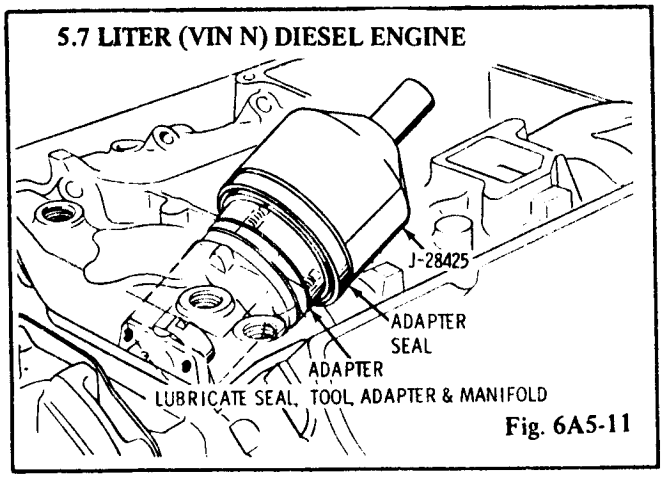
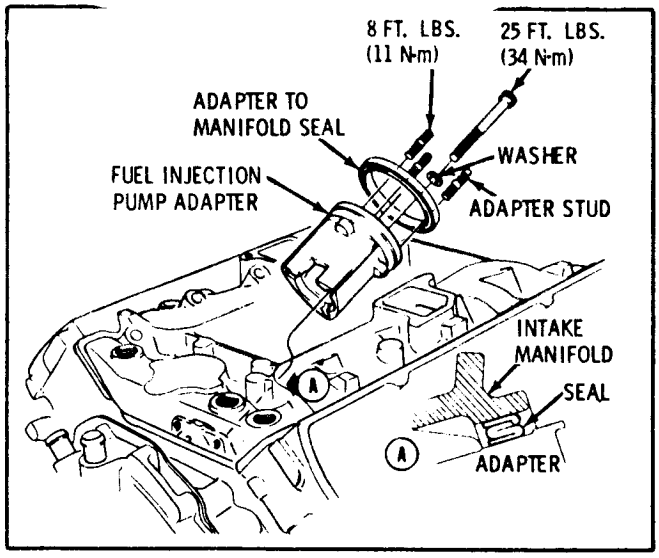


Fig. 6A5-11



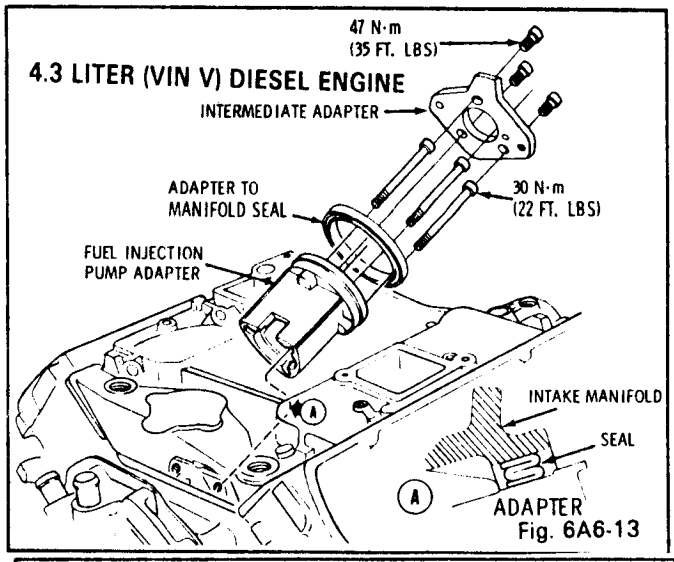
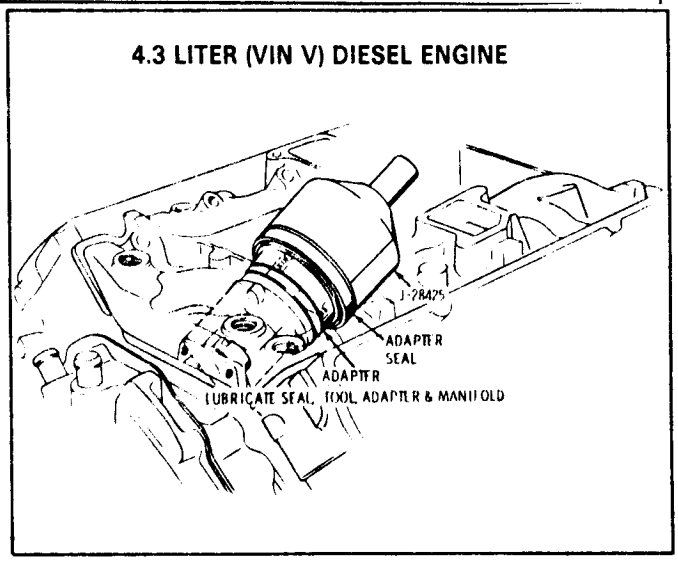


Fig. 6A6-13



INJECTION PUMP ADAPTER AND ADAPTER SEAL

Replacement of Adapter Seal (Fig. 6A6-13 and 6A6-14)

1. Refer to **"Injection Pump and Lines"** removal, Section 6C5 for pump assembly removal.
2. Remove the intermediate pump adapter.
3. Using a probe, pry out the adapter seal without nicking the adapter.
4. Lube the new seal with chassis lube on both the inside and outside diameters of the seal. Also lube the tool, adapter and intake manifold.
5. Install the seal using Tool J-28425.
   First install the seal on the tool, then install the seal into the adapter and intake manifold. (See Fig. 6A6-14.)
6. Remove the tool and inspect to see if the seal is properly installed.

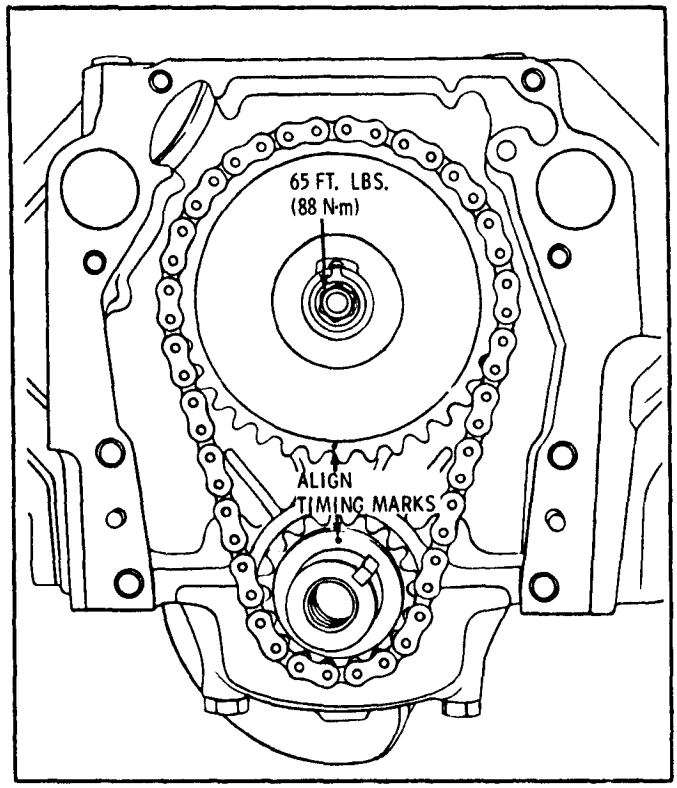


Fig. 6A5-65—Installing Timing Chain

INJECTION PUMP DRIVE AND DRIVEN GEARS

Installation

If either the pump drive or driven gears are to be replaced, replace both gears.

Coat camshaft and bearings liberally with No. 1052365 lubricant or equivalent before installing. Camshaft and crankshaft sprockets must be aligned as shown in Fig. 6A5-65.

Check the injection pump driven gear bushing.

Install the injection pump driven gear, spring, shim and snap ring. Check the gear end play. If not within .002" to .006", replace the shim to obtain the clearance. (Fig. 6A5-67)

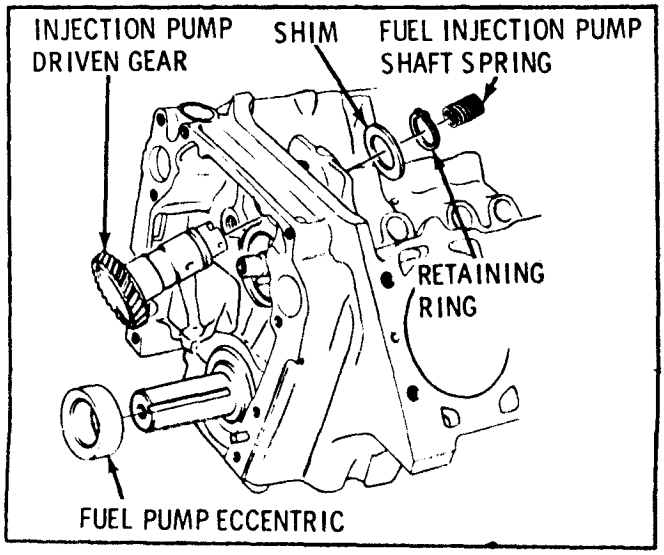
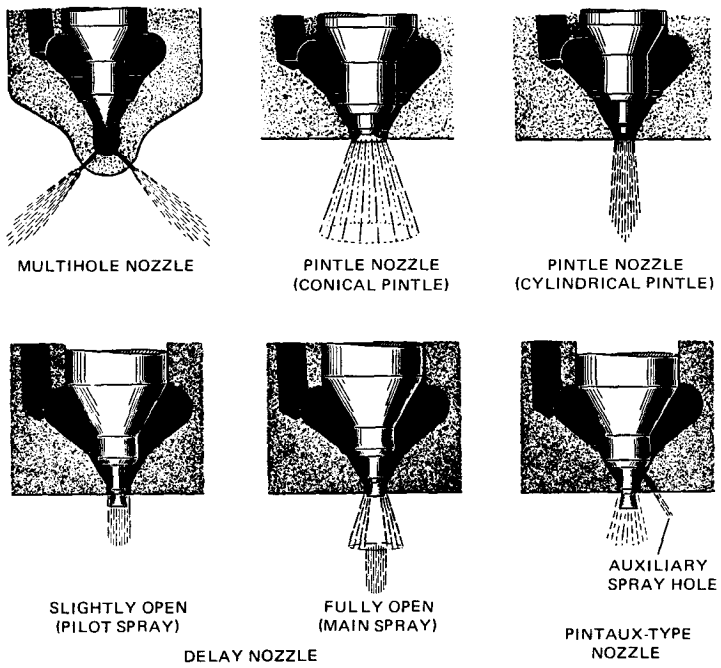
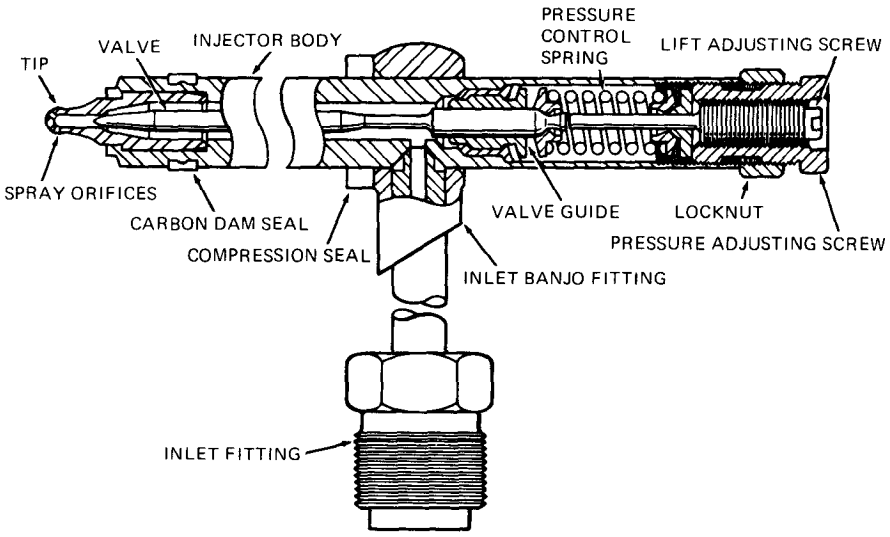


Fig. 6A5-67—Injection Pump Driven Gear End Play Shim



Spray patterns of various nozzle types



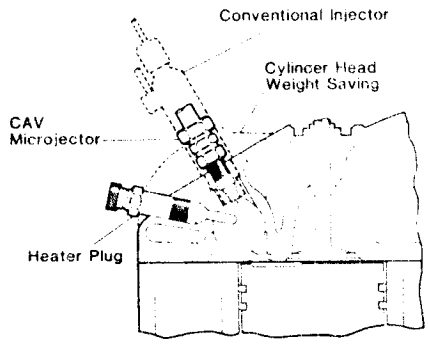
ROOSA MASTER FUEL INJECTOR

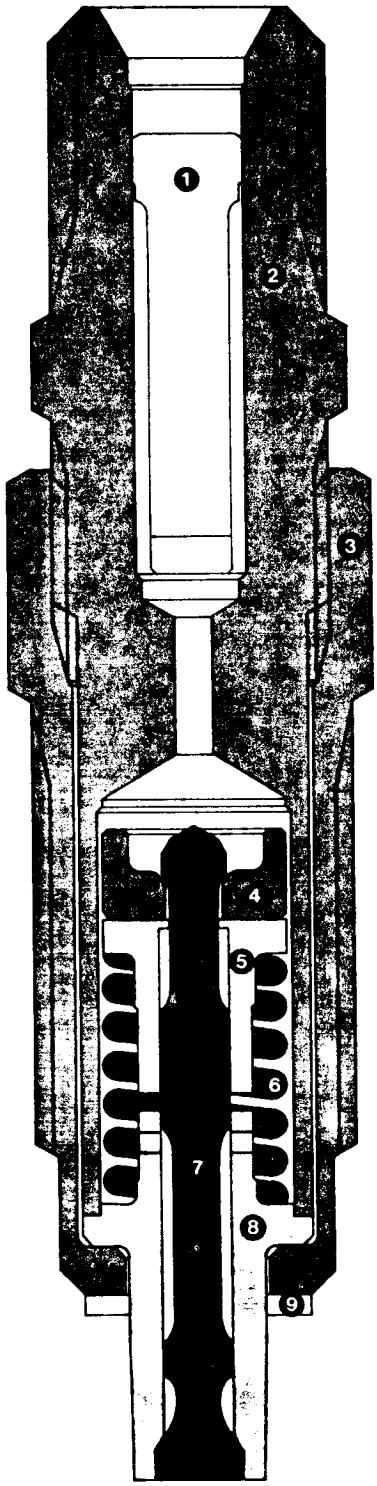
CAV MICRO-JECTOR

A miniaturized fuel injector announced by Lucas CAV has scored a major commercial success with a $65-million deal with GM to supply units for the latest Oldsmobile-built V-8 car diesels. Called Microjector, it is less than half the size of the smallest pintle-type injector in use, with an overall length of 65 mm and weighing only 52 g. It has a standard 14-mm spark plug thread, so it can be screwed directly into the cylinder head, and the small dimensions permit a reduction in head thickness since less supporting metal is required. Engine weight can thus be lowered.

Installation is simplified since no fuel backleak pipe is needed, as the nozzle valve guide is not required to seal against injection pressure. An outward-opening valve creates a narrow spray evenly distributed into the precombustion chamber, with engine compression assisting a sharp cutoff. NOx and smoke emissions as well as noise levels are said to be reduced.

The Microjector is suitable for high-speed indirect-injection engines of up to 0.75 L per cylinder. Lucas CAV has already tooled up for high-volume manufacture at a new 10,000 sq m facility at its Ipswich, England, plant. Deliveries to the Oldsmobile Division will extend over the next few years, when its production of passenger car diesels builds up to an annual 500,000 during this period.



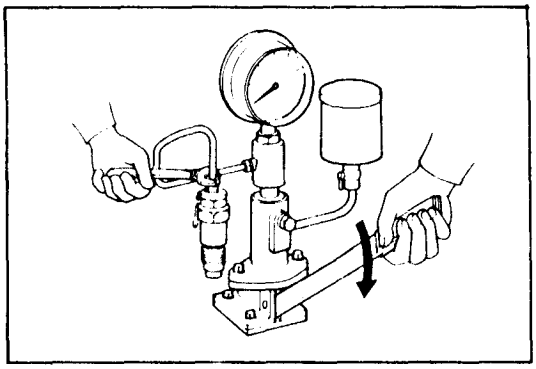


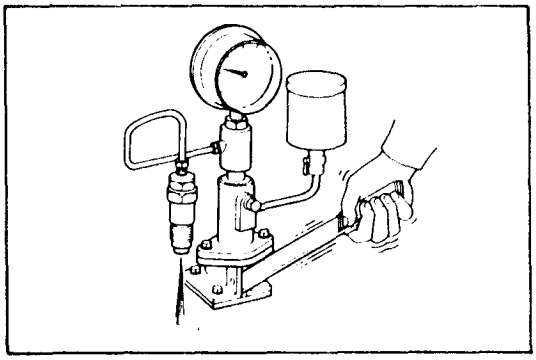
Holder body assembly

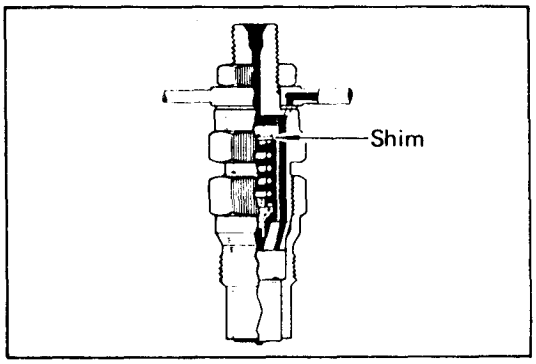
1. Edge filter
2. Nozzle holder body
3. Nozzle holder capnut

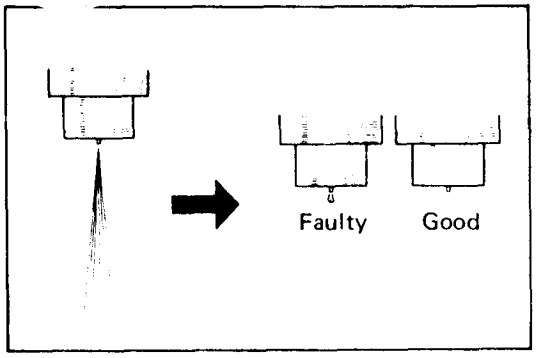
Nozzle valve assembly

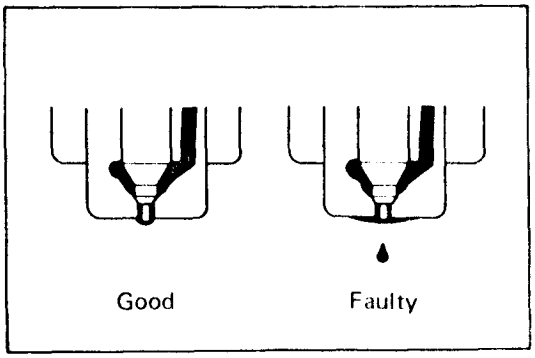
4. Collar
5. Lift stop
6. Spring
7. Nozzle valve
8. Nozzle body
9. Cylinder head sealing washer











INJECTION NOZZLE TYPICAL

INJECTION PRESSURE TEST

1. Install nozzle to injection nozzle hand tester and bleed air from union nut.

NOTE: **Do not place your finger over the nozzle injection hole.**

2. Pump the tester handle a few times as fast as possible by hand to discharge the carbon from the injection hole.
3. Pump the tester handle slowly and observe the pressure gauge.
4. Read the pressure gauge when the injection pressure just starts dropping.

   Opening pressure:
   Reused nozzle

NOTE: **Proper nozzle operation can be determined by a swishing sound.**

5. If the opening pressure is not within limits, disassemble the nozzle and change the shim on the top of the pressure spring.

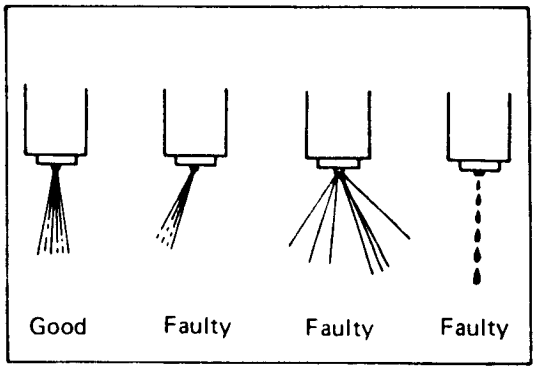
   Adjust opening pressure:

NOTE:
1. **Shims are available in 20 sizes: in increments of 0.05 mm (0.0020 in.), from 1.00 – 1.95 mm**
2. **Varying the adjusting shim thickness by 0.05 mm (0.0020 in.) changes the injection pressure by about 5 kg/cm² (71 psi).**

6. There should be no dripping after injection.

LEAKAGE TEST TYPICAL

1. While maintaining pressure at about 10 20 kg/cm² (142 – 284 psi) below opening pressure (adjust by tester handle), check that there is no dripping for 10 seconds from the injection hole or around the retaining nut.
2. If the nozzle drips within 10 seconds, replace it or clean and overhaul the nozzle assembly.



SPRAY PATTERN TEST TYPICAL

1. The injection nozzle should shudder at a certain pumping speed between 15 and 60 times/minute.
2. Check the spray pattern during shuddering.
3. If the spray pattern is not correct during shuddering, the nozzle must be replaced or cleaned.

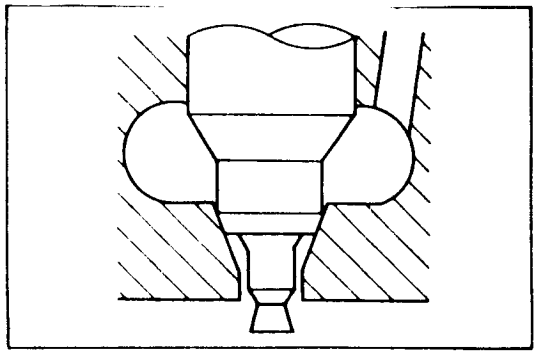
NOZZLE CLEANING

1. Refer to FUEL SYSTEM section and disassemble the nozzle holder.
2. To wash the nozzles, use a wooden stick and brass brush. Wash in clean diesel fuel.

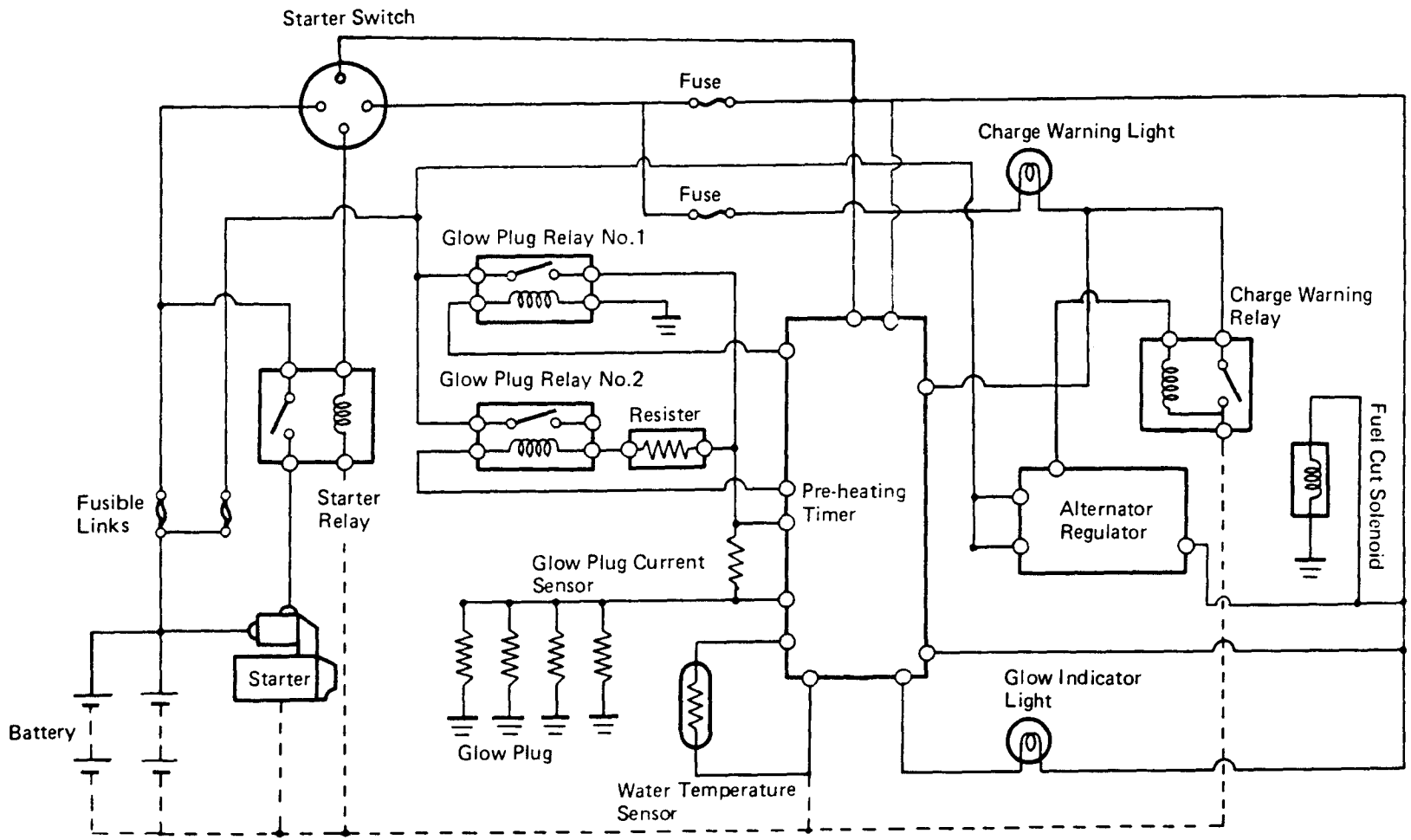
NOTE: **Do not touch the nozzle mating surfaces with your fingers.**

3. Remove the carbon adhering to the nozzle needle tip with a wooden stick.

4. Remove the carbon from the exterior of the nozzle body (except wrapping angle) with a brass brush.

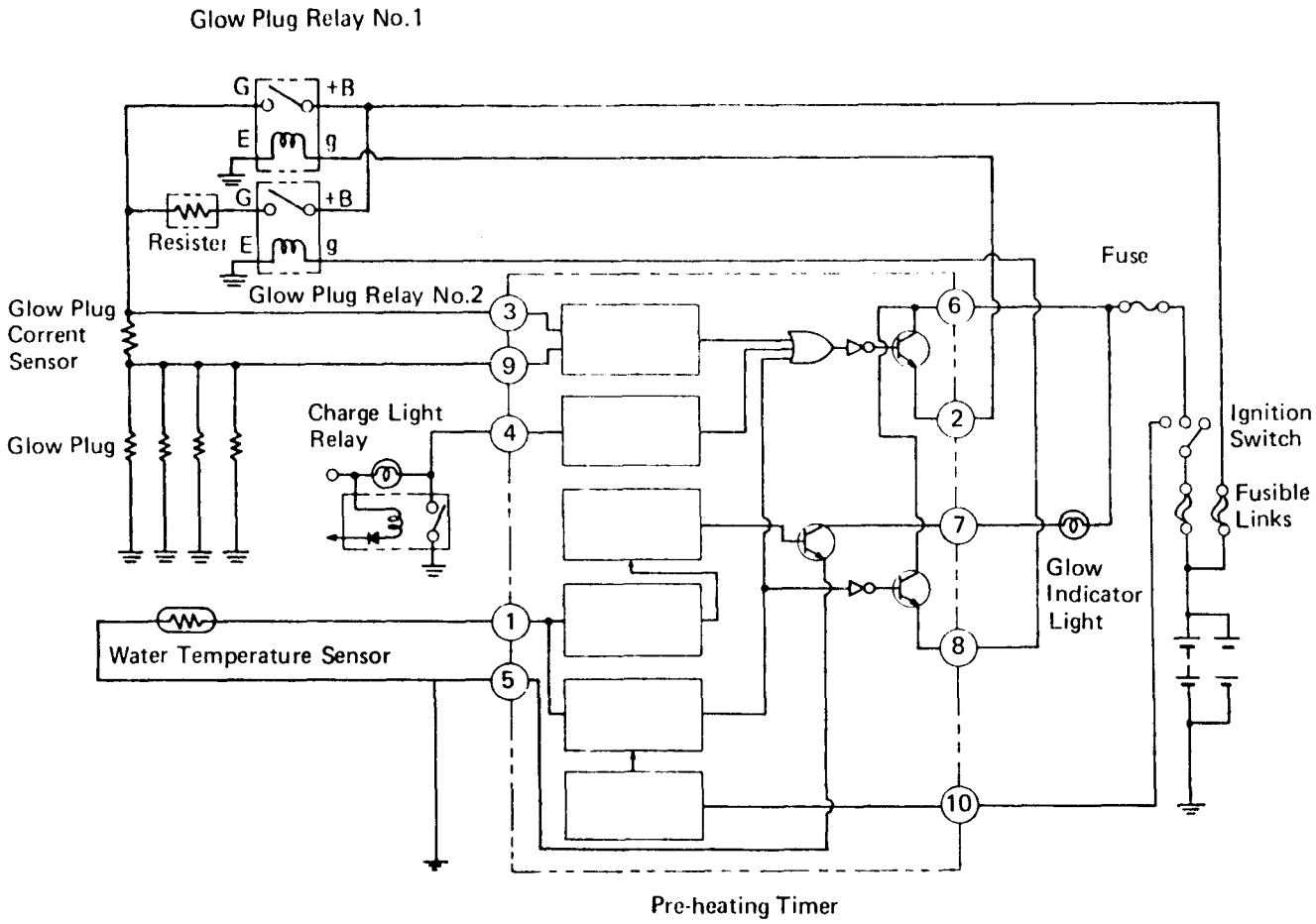


5. Inspect the seat of the nozzle body for burns or corrosion. Inspect the nozzle needle tip for damage or corrosion. If any of these conditions are presents, replace the nozzle assembly.

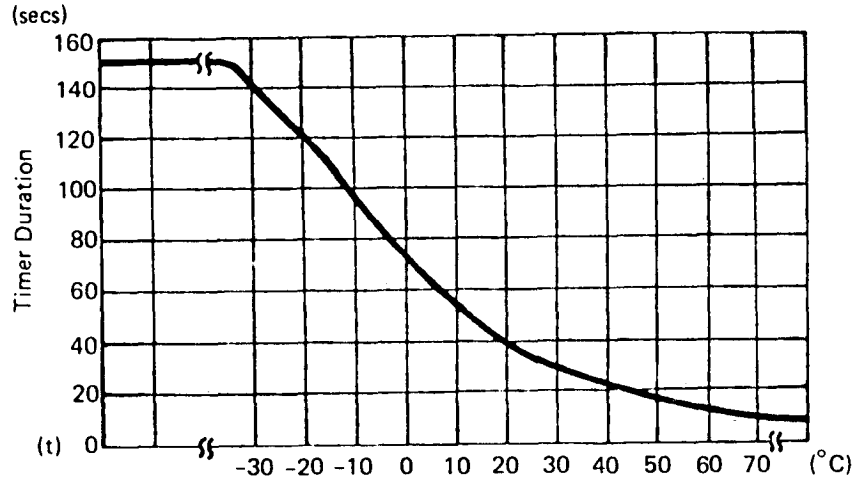


TYPICAL **STARTING SYSTEM CIRCUIT**

TYPICAL QUICK PRE-HEATING SYSTEM



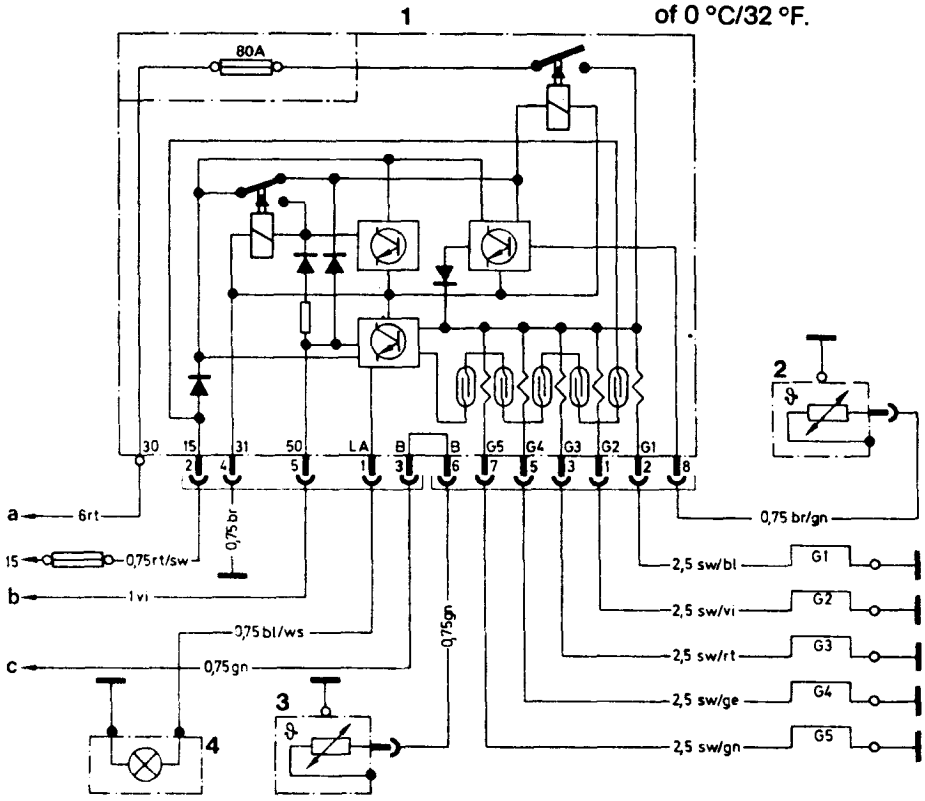
Relationship Between Water Temperature and Timer Duration



Quick Preglow System (1980 300SD)

Engine 617.950 has been equipped with a quick preglow system. The main components are the new pin-type glow plugs, which heat up very quickly, and the preglow-time relay. The temperature sensor corresponds to the already known version.

The preglow-time relay automatically indicates, as previously, certain failures of the system via the preglow indicator lamp.
The already known pin-type glow plug has been further developed, so that a preglow time of 5 to 7 seconds could be obtained at a coolant temperature of 0 °C/32 °F.



1 Control coil
2 Heating coil

Fig. 340
Electrical Wiring Diagram of Preglow System

1 Preglow-time relay
2 Temperature sensor, preglow system
3 Coolant temperature sensor
4 Preglow indicator lamp
G1 to G5 Pin-type glow plugs
a to terminal block
b to relay, air conditioner, terminal 86
c to connector, combination instrument, terminal 3

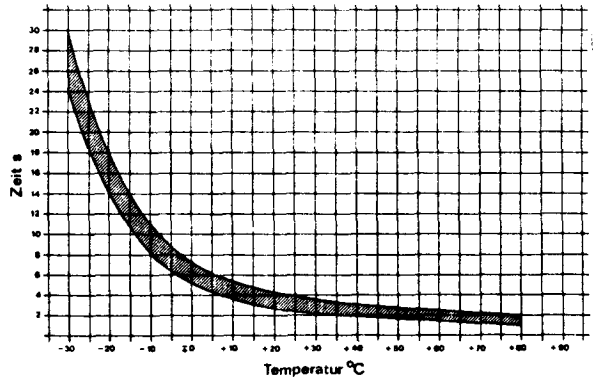
The shortened preglow process was obtained by using a pin-type glow plug with a dual material element which consists of a heating coil and a control coil.

The heating coil and the control coil receive 11 Volts when the system is turned on. Since the control coil is connected with the heating coil in series, the control coil also receives preglow current.

The material of the control coil has a positive temperature coefficient, i.e. with increasing temperature, the resistance also increases and automatically reduces the preglow current, thereby preventing a thermal overloading of the heating element.

This quick-preglow plug is identified by a brass hexagon and must not be interchanged with the previous glow plug of Model Year 1979.

The 80 A fusible link and the electrical connections in the preglow-time relay are accessible after removing the snap-on cover.

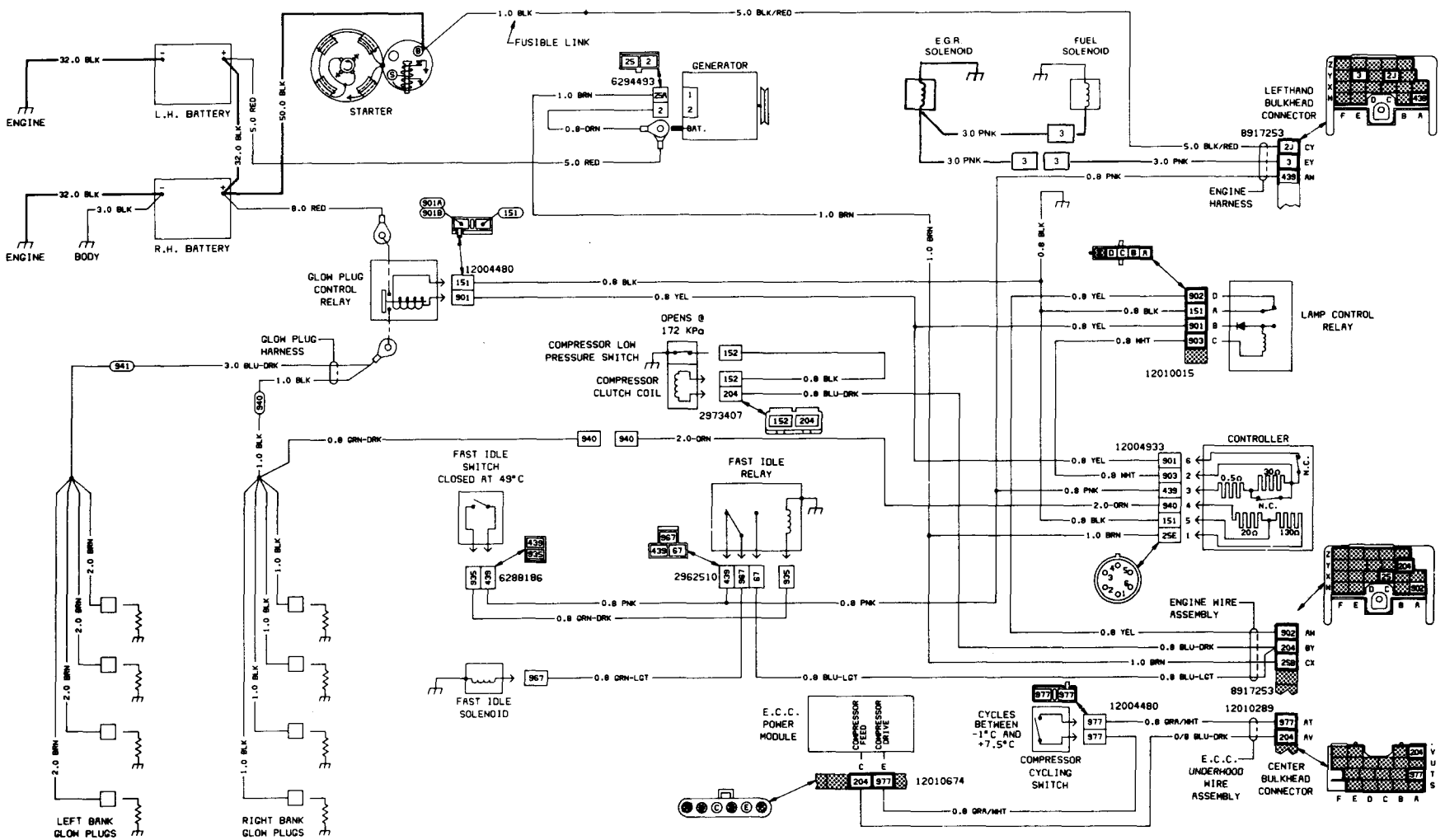


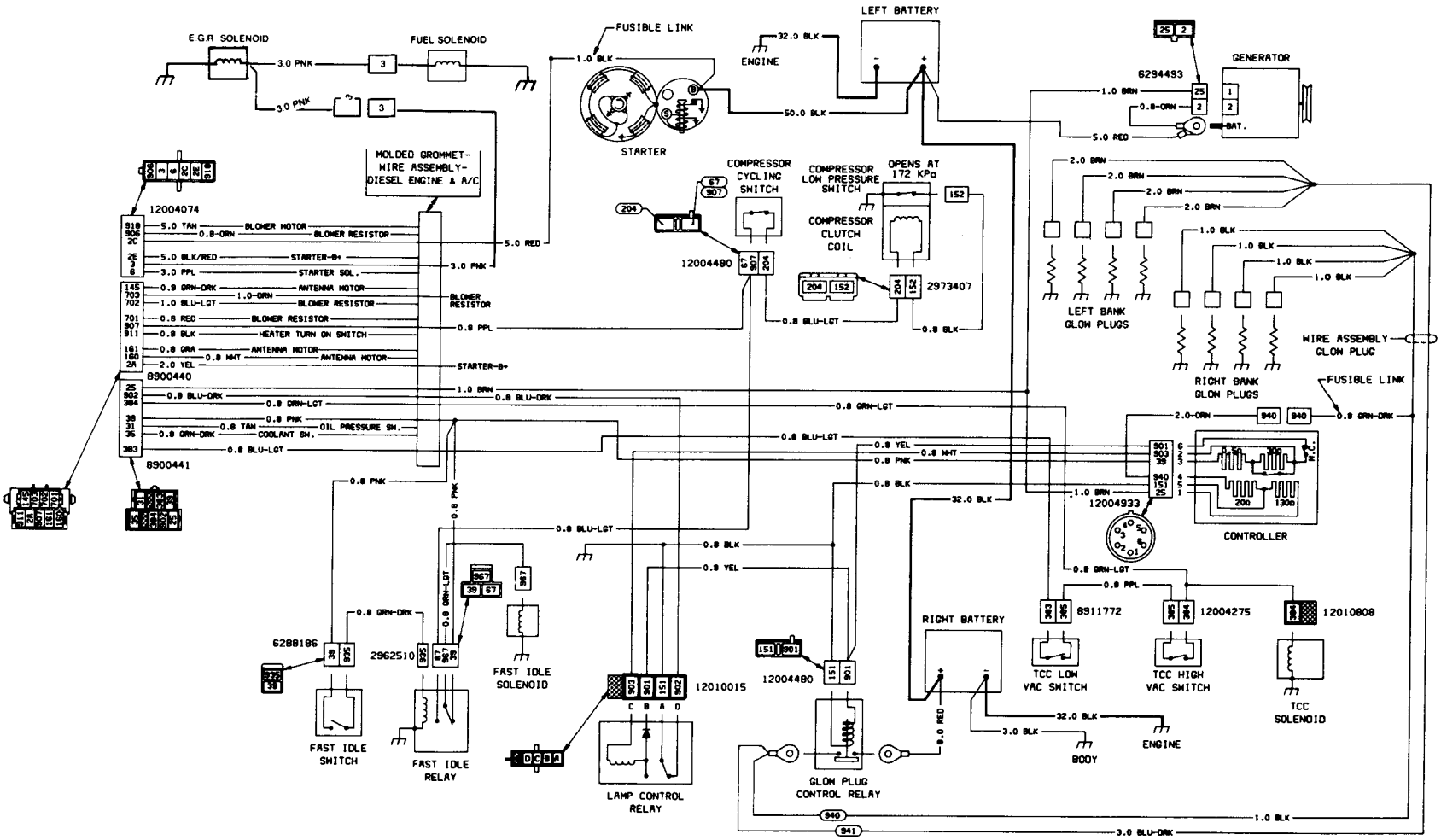
Relation of preglow time to coolant temperature

The preglow-time relay has been matched to the quick preglow plugs and is constructed so that it can be used for 4- and 5-cylinder engines. The necessary differences for 4- and 5-cylinder engines are contained in the main wiring harness.

The preglow-time relay is located in the engine compartment on the left wheel housing.

CYCLING GLOW PLUG CIRCUITS




E.G.R. SOLENOID
FUEL SOLENOID
FUSIBLE LINK
LEFT BATTERY
ENGINE
GENERATOR
6294493
STARTER
MOLDED GROMMET-WIRE ASSEMBLY-DIESEL ENGINE & A/C
COMPRESSOR CYCLING SWITCH
COMPRESSOR LOW PRESSURE SWITCH
OPENS AT 172 KPa
COMPRESSOR CLUTCH COIL
12004074
12004480
2973407
8900440
8900441
LEFT BANK GLOW PLUGS
RIGHT BANK GLOW PLUGS
WIRE ASSEMBLY GLOW PLUG
FUSIBLE LINK
CONTROLLER
12004933
RIGHT BATTERY
8911772
12004275
12010808
TCC LOW VAC SWITCH
TCC HIGH VAC SWITCH
TCC SOLENOID
6288186
2962510
FAST IDLE SOLENOID
FAST IDLE SWITCH
FAST IDLE RELAY
12010015
LAMP CONTROL RELAY
GLOW PLUG CONTROL RELAY
BODY
ENGINE
BLOWER MOTOR
BLOWER RESISTOR
STARTER-B+
STARTER SOL.
ANTENNA MOTOR
HEATER TURN ON SWITCH
OIL PRESSURE SW.
COOLANT SW.

CUTLASS ELECTRONIC GLOW PLUG CONTROL SYSTEM

DESCRIPTION

The Electronic Glow Plug Control System uses an electronic module and a control sensor to control glow plug temperature, the glow plug relay and the wait light. An engine temperature switch controls the fast idle solenoid and housing pressure cold advance solenoid.

ELECTRONIC MODULE

The module is located to the right of the steering column below the instrument cluster. It monitors the glow plug voltage and engine temperature to control the glow plugs and wait light. The module also contains circuits to monitor the system for failures and hold the wait light on to indicate a problem in the system.

CONTROL SENSOR

The control sensor is located in the right front intake manifold coolant passage. It senses engine coolant temperature to control glow plug feedback voltage to the module.

GLOW PLUG RELAY

The Glow Plug Relay is located on the right inner fender filler panel and is pulsed on and off by the electronic module to control current to the glow plugs. This pulsing maintains glow plug temperatures without overheating.

NOTICE: Do not manually energize or by-pass the glow plug relay as glow plugs will be damaged instantly.

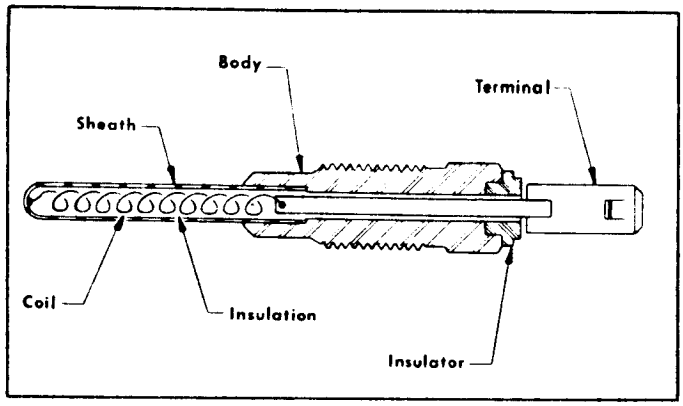
ENGINE TEMPERATURE SWITCH

The engine temperature switch is located on the left rear head bolt. At engine temperatures below 95° F (39° C) this switch closes to energize the fast idle solenoid and the housing pressure cold advance solenoid. When the engine temperature reaches about 125° F (52° C) the switch opens de-energizing both solenoids.

NORMAL OPERATION

Turn ignition to RUN. The WAIT light and glow plugs will come on. The WAIT light will remain on until glow plugs reach temperature the first time (about 7 seconds at 0° F, -18° C) and then the light will go out indicating the engine is ready to start. There is no start light used with this system. The glow plugs will continue to pulse on and off after the engine is started for about 25 seconds to provide after glow. If the ignition is turned to run and the engine is not started (in freezing temperatures), the glow plugs will continue to pulse on and off until the batteries run down (about 4 hours). The WAIT light will stay on, if the system has a problem, to warn the driver to have the system checked. In most cases the engine can still be started but the glow plug control system should be repaired.

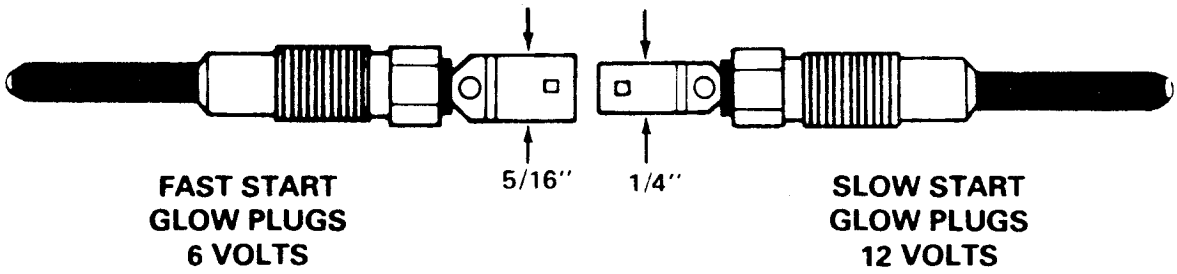
TYPICAL



Glow Plug Section

DIESEL ENGINE GLOW PLUG
IDENTIFICATION

The fast start diesel glow plug control system uses 6 volt glow plugs with controlled pulsing current applied to them for starting. The slow start system used steady current applied to 12 volt glow plugs. In either case the correct glow plug should be used for proper starting. The illustration shows the glow plug identification.



DO NOT INTERCHANGE

Glow Plug Identification

ENGINE TUNE-UP

TYPICAL ENGINE TUNE-UP ITEMS		
1	COOLING SYSTEM	Coolant level
		Coolant quality
		Leakage
		Radiator cap valve opening pressure STD
		Limit
		Coolant capacity (w/Heater)
2	DRIVE BELT (Borroughs Drive Belt Tension Gauge No. BT-33-73F)	
		New belt
		Used belt
3	AIR CLEANER	
4	BATTERY	Specific gravity
5	ENGINE OIL	Oil level
		Oil quality
		Replenishment
		Oil capacity
		Dry refill w/ Oil filter
		Drain & refill w/ Oil filter
		w/o Oil filter
6	COMPRESSION PRESSURE	STD
		Limit
		Variation limit between cylinder
7	VALVE CLEARANCE (HOT)	IN
		EX
8	INJECTION NOZZLE	Injection starting pressure
		New nozzle
		Reused nozzle
		Spray condition
		Leakage test
		Cleaning
9	INJECTION TIMING	
		Except High altitude area
		For High altitude area
	AIR BLEEDING	Fuel filter
		High pressure pipe
10	IDLE SPEED	
11	MAXIMUM SPEED (NO LOAD)	
12	PRE-HEATING SYSTEM	Glow time at 0°C (32°F)

DIESEL ENGINE DIAGNOSIS

	CONDITION	WILL NOT START	HARD STARTING	STARTS — THEN STOPS	ROUGH IDLE	MISSES	DILUTION OF OIL	KNOCKS	LOW POWER	BLACK SMOKE AT IDLE	BLACK SMOKE AT LOAD	WHITE SMOKE	EXCESSIVE FUEL CONSUMPTION	NO HEAT FROM HEATER
AIR SYSTEM	RESTRICTED AIR INTAKE		•	•					•	•	•		•	
	HIGH EXHAUST BACK PRESSURE			•					•		•		•	
FUEL SYSTEM	OUT OF FUEL	•		•										
	RESTRICTED FUEL RETURN LINE			•	•	•			•			•	•	
	AIR LEAKS IN SUCTION LINES	•	•	•	•	•			•			•		
	RESTRICTED FUEL LINE OR FILTER	•	•	•		•			•	•	•	•	•	
	EXTERNAL FUEL LEAKS		•	•	•	•			•				•	
	DEFECTIVE NOZZLES		•		•	•		•	•	•	•		•	
	FAST IDLE INOPERATIVE			•	•									
	FAULTY FUEL SUPPLY PUMP	•	•	•	•	•	•						•	
	INCORRECT FUEL (GASOLINE)	•	•			•		•	•		•		•	
	PARAFFIN DEPOSIT IN FILTER	•	•	•					•					
	IDLE SPEED TOO LOW			•	•									
	INJECTION PUMP DEFECTIVE	•	•	•	•	•	•	•	•		•	•	•	
OIL	WRONG GRADE FOR AMBIENT	•	•											
MECHANICAL	HEAD GASKET LEAKS								•				•	•
	BROKEN OR WORN PISTON RINGS				•		•	•	•	•			•	
	VALVE LEAKAGE				•	•			•				•	
	INCORRECT BEARING CLEARANCE							•						
	DAMAGED BEARINGS							•						
	LOW COMPRESSION	•	•		•	•					•		•	
	LOOSE TIMING CHAIN				•	•			•			•	•	
	TIMING ADVANCED		•		•			•	•	•	•		•	
	TIMING RETARDED		•		•				•			•	•	
	CAMSHAFT WORN		•		•	•			•		•		•	
ELECTRICAL	BATTERIES NOT CHARGED	•												
	GLOW PLUGS INOPERATIVE	•	•									•		

DIESEL ENGINE DIAGNOSIS

Diesel Engine Mechanical Diagnosis such as noisy lifters, rod bearings, main bearings, valves, rings and pistons is the same as for a gasoline engine. This diagnosis covers only those conditions that are different for the diesel engine.

CONDITION	POSSIBLE CAUSE	CORRECTION
Engine Will Not Crank	1. Loose or Corroded Battery Cables	Check connections at batteries, engine block and starter solenoid.
	2. Discharged Batteries	Check generator output and generator belt adjustment.
	3. Starter Inoperative	Check voltage to starter and starter solenoid. If OK, remove starter for repair. (Use diagnostic connector terminals shown on circuit drawing in ELECTRICAL DIAGNOSIS.)
Engine Cranks Slowly-Will Not Start (Minimum Engine Cranking Speed-100 RMP COLD, 240 RPM HOT)	1. Battery Cable Connections Loose or Corroded	Check connections at batteries, engine block and starter.
	2. Batteries Undercharged	Check charging system.
	3. Wrong Engine oil	Drain and refill with oil of recommended viscosity.
Engine Cranks Normally-Will Not Start	1. Incorrect Starting procedure	Use recommended starting procedure.
	2. Glow Plugs Inoperative	Refer to ELECTRICAL DIAGNOSIS.
	3. Glow Plug Control System Inoperative.	Refer to ELECTRICAL DIAGNOSIS.
	4. No Fuel Into Cylinders	Remove any one glow plug. Depress the throttle part way and crank the engine for 5 seconds. If no fuel vapors come out to the glow plug hole, go to step 5. If fuel vapors are noticed remove the remainder of the glow plugs and see if fuel vapors come out of each hole when the engine is cranked. If fuel comes out of one glow plug hole only replace the injection nozzle in that cylinder. Crank the engine and check to see that fuel vapors are coming out of all glow plug holes. If fuel is coming from each cylinder, go to step 1.

5. Plugged Fuel Return System	Disconnect fuel return line at injection pump and route hose to a metal container. Connect a hose to the injection pump connection, route it to the metal container. Crank the engine. If it starts and runs, correct restriction in fuel return lines. If it does not start, remove the ball check connector from the top of the injection pump and make sure that it is not plugged.
6. No Fuel To Injection Pump	Loosen the line coming out of the filter. Crank the engine, the fuel should spray out of the fitting, use care to direct fuel away from sources of ignition. If fuel sprays from the fitting go to step 10.
7. Restricted Fuel Filter	Loosen the line going to the filter. If fuel sprays from the fitting, the filter is plugged and should be replaced. Use care to direct the fuel away from sources of ignition.
8. Fuel Pump Inoperative	Remove inlet hose to fuel pump. Connect a hose to the pump from a separate container that contains fuel. Loosen the line going to the filter. If fuel does not spray from the fitting, replace the pump. Use care to direct the fuel away from source of ignition.
9. Restricted Fuel Tank Filter	Remove fuel tank and check filter. (Filter for diesel fuel is blue.)
10. No Voltage To Fuel Solenoid	Connect a voltmeter to the wire at the injection pump solenoid and ground. The voltage should be a minimum of 9 volts. If there is inadequate voltage, refer to the ELECTRICAL DIAGNOSIS for more information.
11. Incorrect or Contaminated Fuel	Flush fuel system and install correct fuel.
12. Pump Timing Incorrect	Check timing with timing meter J-33075 and reset if needed.
13. Low Compression	Check compression to determine cause.
14. Injection Pump Malfunction	Remove injection pump for repair.

Engine Starts But Will Not Continue To Run At Idle	1. Slow Idle Incorrectly Adjusted	Adjust idle screw to specification.
	2. Fast Idls Solenoid Inoperative	With engine cold, start engine; solenoid should move to hold injection pump pump lever in "fast idle position." If solenoid does not move, refer to ELECTRICAL DIAGNOSIS.
	3. Restricted Fuel Return System	Disconnect fuel return line at injection pump and route hose to a metal container. Connect a hose to the injection pump connection; route it to the metal container. Crank the engine and allow it to idle. If engine idles normally, correct restriction in fuel return lines. If engine does not idle normally, remove the return line check valve fitting from the top of the pump and make sure it is not plugged.
	4. Glow Plugs Turn Off Too Soon	Refer to ELECTRICAL DIAGNOSIS.
	5. Pump Timing Incorrect	Check timing with J-33075 timing meter and reset if needed.
	6. Limited Fuel To Injection Pump	Test the engine fuel pump; check fuel lines. Replace or repair as necessary.
	7. Incorrect or Contaminated Fuel	Flush fuel system and install correct fuel.
	8. Low Compession	Check compression to determine cause.
	9. Fuel Solenold Closes In Run Position	Ignition switch out of adjustment. If OK, refer to ELECTRICAL DIAGNOSIS.
	10. Injection Pump Malfunction.	Remove injection pump for repair.
Excessive Surge at Light Throttle, Under Load. NOTE: If Engine has a rough idle, use rough idle diagnosis and correct prior to reevaluating for this condition.	1. Torque converter clutch engages too soon.	See Section 7A, "Torque Converter Clutch Diagnosis."
	2. Timing Retarded	Reset timing using J-33075 timing meter.
	3. Clogged Fuel Filter	Check fuel pump pressure on inlet and outlet sides of filter, see Section 6C1.
	4. Injection Pump Housing Pressure Too High	Correct pressure, see Section 6C5.
	5. Injection Line Volume Too Low	Replace Affected Line(s).

Engine Starts and Idles Rough WITH Excessive Noise and/or Smoke, But Clears Up After Warm-Up	1. Injection Pump Timing Incorrect	Check timing with J-33075 timing meter and reset if needed.
	2. Insufficient Engine Break-in Time	Break-in engine 2000 or more miles.
	3. Air in System	Install a section of clear plastic tubing on the fuel return fitting from the engine. Evidence of bubbles in fuel when cranking or running indicates the presence of an air leak in the suction fuel line. Locate and correct.
	4. Nozzle(s) Malfunction	Remove and clean or replace.
	5. Housing Pressure Cold Advance In-Op.	Check operation - See Section 6C5.
Engine Misfires Above Idle But Idles Correctly	1. Plugged Fuel Filter	Replace filter.
	2. Incorrect Injection Pump Timing	Check timing with J-33075 timing meter and reset if needed.
	3. Incorrect or Contaminated Fuel	Flush fuel system and install correct fuel.
Engine Will Not Return To Idle	1. External Linkage Binding Or Misadjusted	Free up linkage. Adjust or replace as required.
	2. Fast Idle Malfunction	Check fast idle adjustment.
	3. Internal Injection Pump Malfunction	Remove injection pump for repair.
Fuel Leaks On Ground- No Engine Malfunction	1. Loose or Broken Fuel Line or Connection	Examine complete fuel system, including tank, lines, and injection lines. Determine source and cause of leak and repair.
	2. Injection Pump Internal Seal Leak	Remove injection pump for repair.
Noticeable Loss Of Power	1. Restricted Air Intake	Check air cleaner element.
	2. Timing not set to Specifications	Check timing with J-33075 timing meter and reset if needed.
	3. EGR Malfunction	Refer to Section 6E.
	4. Restricted or Damaged Exhaust System	Check system and replace as necessary.
	5. Plugged Fuel Filter	Replace filter.
	6. Plugged Fuel Tank Vacuum Vent In Fuel Cap	Remove fuel cap. If loud hissing noise is heard, Vacuum vent in fuel cap is plugged. Replace cap. (Slight hissing sound is normal.)
	7. Restricted Fuel Supply From Fuel Tank To Injection Pump	Examine fuel supply system to determine cause of restriction. Repair as required.
	8. Restricted Fuel Tank Filter	Remove fuel tank and check filter. (Filter for diesel fuel is blue.)
	9. Pinched or Otherwise Restricted Return System	Examine system for restriction and correct as required.

	10. Incorrect or Contaminated Fuel	Flush fuel system and install correct fuel.
	11. External Compression Leaks	Check for compression leaks at all nozzles and glow plugs, using "Leak-Tec" or equivalent. If leak is found, tighten nozzle or glow plug.
	12. Plugged Nozzle(s)	Remove nozzles. Check nozzles, clean or replace.
	13. Low Compression	Check compression to determine cause.
Noise - "Rap" From One or More Cylinders (Sounds Like Rod Bearing Knock)	1. Nozzle(s) Sticking Open or with very low Nozzle Opening Pressure	Remove nozzle for test, clean or replace as necessary.
	2. Mechanical Problem	Refer to Mechanical Diagnosis.
	3. Piston Hitting Cylinder Head	Replace malfunctioning parts. Check timing with timing meter J-33075 and reset if necessary.
Noise - Objectionable Overall Combustion Noise Over Normal Noise Level With Excessive Black Smoke	1. Timing Not Set To Specification	Check timing with J-33075 timing meter and reset if needed.
	2. EGR Malfunction	Refer to Emission Diagnosis (Section 6E).
	3. Injection Pump Housing Pressure Out Of Specifications	Check housing pressure as described in this section.
	4. Injection Pump Internal Problem	Remove injection pump for repair.
Engine Noise - Internal Or External	1. Engine Fuel Pump, Generator, Water Pump, Valve Train, Vacuum Pump, Bearings, Etc.	Repair or replace as necessary. If noise is internal, see Diagnosis For Noise - Rap From One or More Cylinders and Engine Starts and Idles Rough With Excessive Noise and/or Smoke.
Engine Overheats	1. Coolant System Leak, Oil Cooler System Leak or Coolant Recovery System Not Operating.	Check for leaks and correct as required. Check coolant recovery jar, hose and radiator cap.
	2. Belt Slipping or Damaged	Replace or adjust as required.
	3. Thermostat Stuck Closed	Check and replace if required.
	4. Head Gasket Leaking	Check and repair as required.
Instrument Panel Oil Warning Lamp "ON" at Idle	1. Oil Cooler or Oil or Cooler Line Restricted	Remove restrictions in cooler or cooler line.
	2. Oil Pump Pressure Low	See oil pump repair procedures in this section.
Engine Will Not Shut Off With Key NOTE: With engine at idle, pinch the fuel return line at the flexible hose to shut off engine.	1. Injection Pump Fuel Solenoid Does Not Return Fuel Valve To OFF Position	Refer to ELECTRICAL DIAGNOSIS.

DIESEL ENGINE IDLE ROUGHNESS DIAGNOSIS PROCEDURE

CONDITION

IDLE ROUGHNESS

Idle roughness is defined as an uneven shaking of the engine in comparison to others with the same number of cylinders and in the same body style.

A rough idle condition may be caused by a difference in the output between cylinders on diesel engines. By selection of parts it is possible to alter the output between cylinders, and smooth out the idle quality.

CORRECTION

Follow the diesel engine idle roughness diagnosis procedure. Make all necessary adjustments and corrections. The idle roughness procedure must be followed step by step prior to performing the glow plug resistance check. The glow plug resistance check will only be successful after the idle roughness procedure is performed and corrections made.

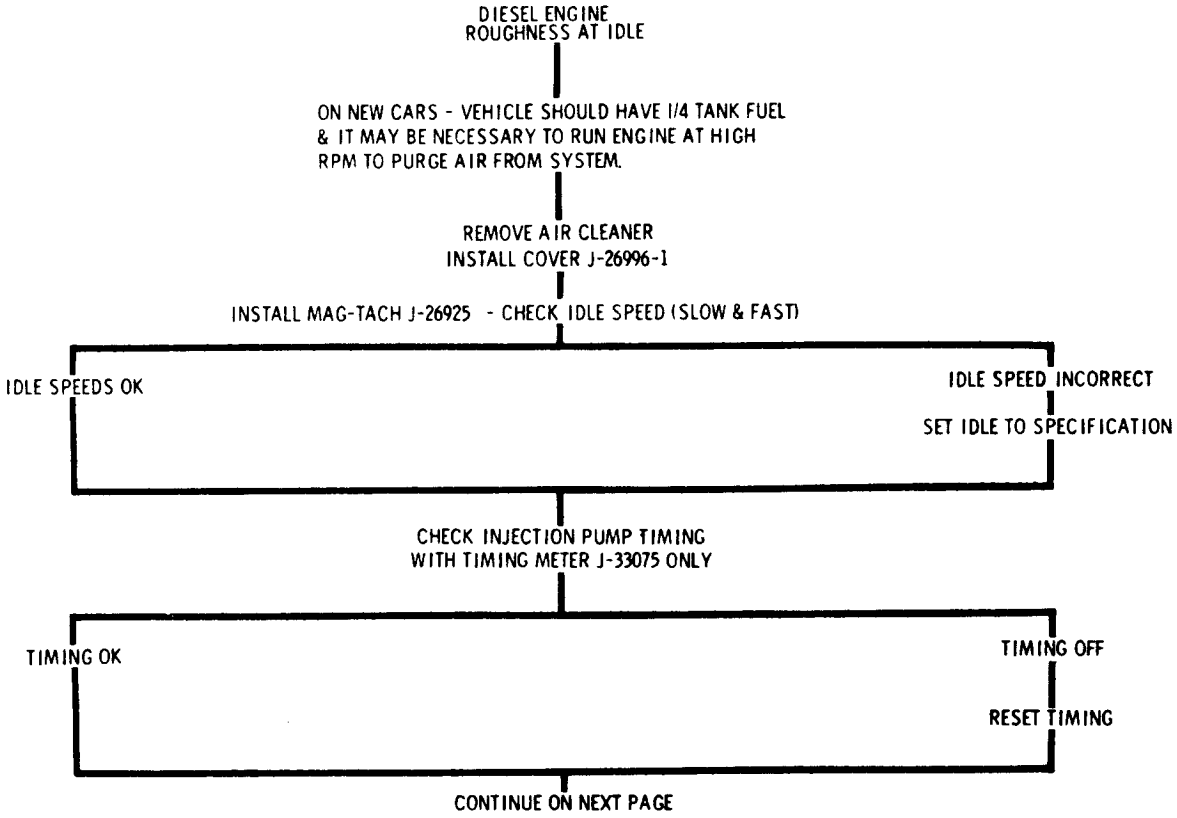
CONDITION

COAST DOWN ROUGHNESS

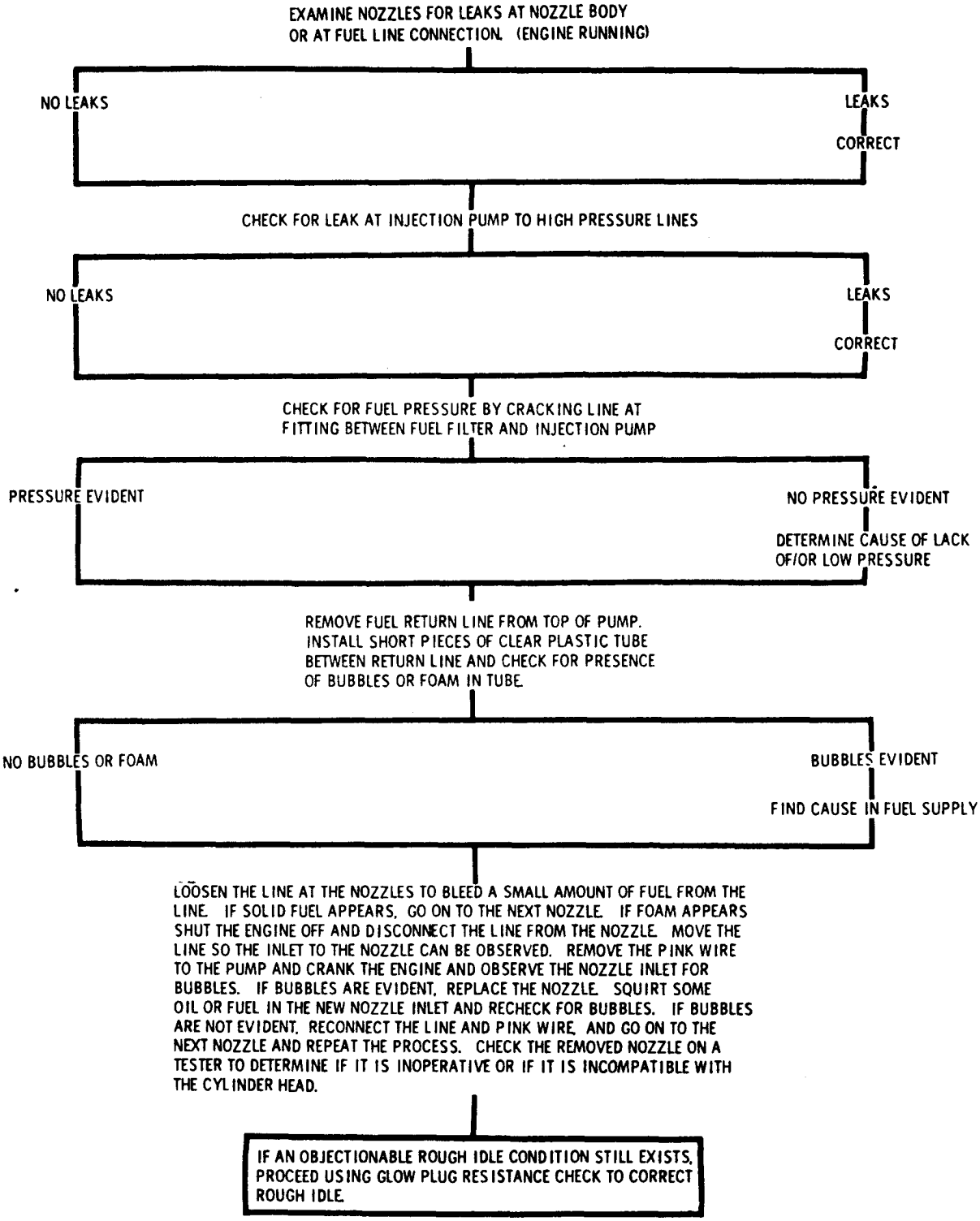
A condition may exist where a roughness is observed on coast down at 50 mph or less with a closed throttle.

CORRECTION

Confirm that this condition is engine roughness rather than a tire waddle or a bent wheel by coasting down through the roughness period in neutral with the engine at 1500 to 2000 RPM. If roughness still exists, during the coast down, the condition is not caused by engine roughness. If the roughness condition is gone, follow the idle roughness diagnosis procedure. If not corrected prior to the glow plug resistance procedure, correct the roughness using the glow plug resistance procedures.



DIESEL ENGINE IDLE ROUGHNESS DIAGNOSIS PROCEDURE (CONT'D)



GLOW PLUG RESISTANCE PROCEDURE

1. Use the Kent-Moore High Impedence Digital Multimeter (Essential Tool J-29125) for resistance measurements.

2. Select scales as follows: LH Switch to "OHMS", RH Switch to full counterclockwise, "200Ω," Slide Center Switch to the left "DC.LO."

3. Start engine, turn on heater and allow engine to warm up. REMOVE all the feed wires from the glow plugs.

4. Using Mag-Tach J-26925, adjust engine speed by turning the idle speed screw on the side of the injection pump to the worst engine idle roughness, but do not exceed 900 RPM.

5. Allow engine to run at worst idle speed for at least one minute. The thermostat must be open and the upper radiator hose hot.

6. Attach an alligator clip to the black test lead of the multimeter. This clip must be grounded to the engine lift strap on the left-hand side of the intake manifold. It must remain grounded to this point until all tests are completed.

7. On a separate sheet of plain writing paper write down the engine firing order.

8. With engine still idling, probe each glow plug terminal and record the resistance values on each cylinder in firing sequence. Most readings will be between 1.8 and 3.4 OHMS. If these readings are not obtained, turn engine "OFF" for several minutes and recheck the glow plugs. The resistance should be .7 or .8 OHMS. If this reading is not obtained check meter for correct settings, check for low or incorrect battery in meter and check the meter ground wire to the engine.

9. The resistance values are dependent on the temperature in each cylinder, and therefore indicate the output of each cylinder.

10. If ohm reading on any cylinder is about 1.2 or 1.3 ohms, check to see if there is an engine mechanical problem. Make a compression check of the low reading cylinder and the cylinders whcih fire before and after the low cylinder reading. Correct the cause of the low compression before proceeding to the fuel system.

11. Examine the results of all cylinder glow plug resistance readings, looking for differences between cylinders. Normally, rough engines will have a difference of .3 ohms or more between cylinders in firing order. It will be necessary to raise or lower the reading on one or more of these cylinders by selection of nozzles.

12. Remove the nozzles from the cylinders in which you wish to raise or lower the ohm reading. Determine the pop off pressure of the nozzles as well as checking the nozzle for leakage and spray pattern. (Refer to Testing of Nozzles.)

    A. Install nozzles with a higher pop off pressure to lower the ohm reading, and nozzles with lower pop off pressure to raise an ohm reading. Normally, a change of about 30 psi in pressure will change the reading by .1 ohm. Nozzles normally will drop off in pop off pressure with miles. Use nozzles from parts stock or a new car. Use broken-in nozzles on a car with 1500 or more miles, if possible.

    B. Whenever a nozzle is cleaned or replaced, before installing the injection pipe, crank the engine and watch for air bubbles at the nozzle inlet. If bubbles are present, clean or replace the nozzle.

    C. Install the injection pipe, restart engine and check idle quality. If idle is still not acceptable, recheck glow plug resistance of each cylinder in firing order sequence. Record readings.

    D. Examine all glow plug resistance readings looking for differences of .3 ohms or more between cylinders.

    It will be necessary to raise or lower the reading on one or more of these cylinders as previously done.

    E. After making additional nozzle changes again check idle quality. Normally, after completing two series of resistance checks and nozzle changes, idle quality can be restored to an acceptable level.

13. An injection pump change may be necessary if the following occurs:

    A. If the problem cylinder moves from cylinder to cylinder as changes in nozzles are made.

    B. If cylinder ohm readings do not change when nozzles are changed.

    NOTE: It is important to always recheck the cylinders at the same RPM. Sometimes the cylinder readings do not indicate that an improvement has been made although the engine may in fact idle better.

    A nozzle with a tip leak can allow more fuel than normal into the cylinder, which will raise the glow plug ohm reading. This will rob fuel from the next nozzle in the firing sequence and will result in that glow plug having a low ohm reading. If this is encountered, it is advisable to remove and check the nozzle with a high reading. If it is leaking, it could be causing the rough idle.

    Some glow plugs have been found which do not increase in resistance with heat. If you experience low readings on a glow plug and it does not change with nozzle change, then switch glow plugs between a good and bad cylinder. If the reading of each cylinder is not the same as before the switch, then the glow plug can not be used for rough idle diagnosis, although it will function for starting the car.

VACUUM PUMP DIAGNOSIS

Excessive noise or	1. Loose screws between	1. A Tighten screws to spec.
clattering noise.	pump assy. and drive assy.	B Replace pump assy.
	2. Loose tube on pump assy.	2. Replace pump assy.
Hooting noise.	Valves not functioning properly.	Replace pump assy.
Pump assy. loose on drive assy.	Stripped threads.	Replace pump assy.
Oil around end plug.	Loose plug.	1. Seat Plug. 2. Replace drive assy.
Oil leaking out crimp.	Bad crimp.	Replace pump assy.
Install hose and vacuum gage to pump, engine running, gage should have reading of 20 inches vacuum minimum. With engine off, vacuum level loss should not drop from 20 inches to 19 inches in less than 1-1/2 seconds.	1. Defective valves. 2. Defective diaphragm. 3. Worn push rod seal. 4. Loose tube.	Replace pump assy.

ENGINE COMPRESSION TEST

COMPRESSION TEST - DIESEL ENGINES

To determine if the valves or rings are the cause of low compression, a test should be made to determine the cylinder compression pressure.

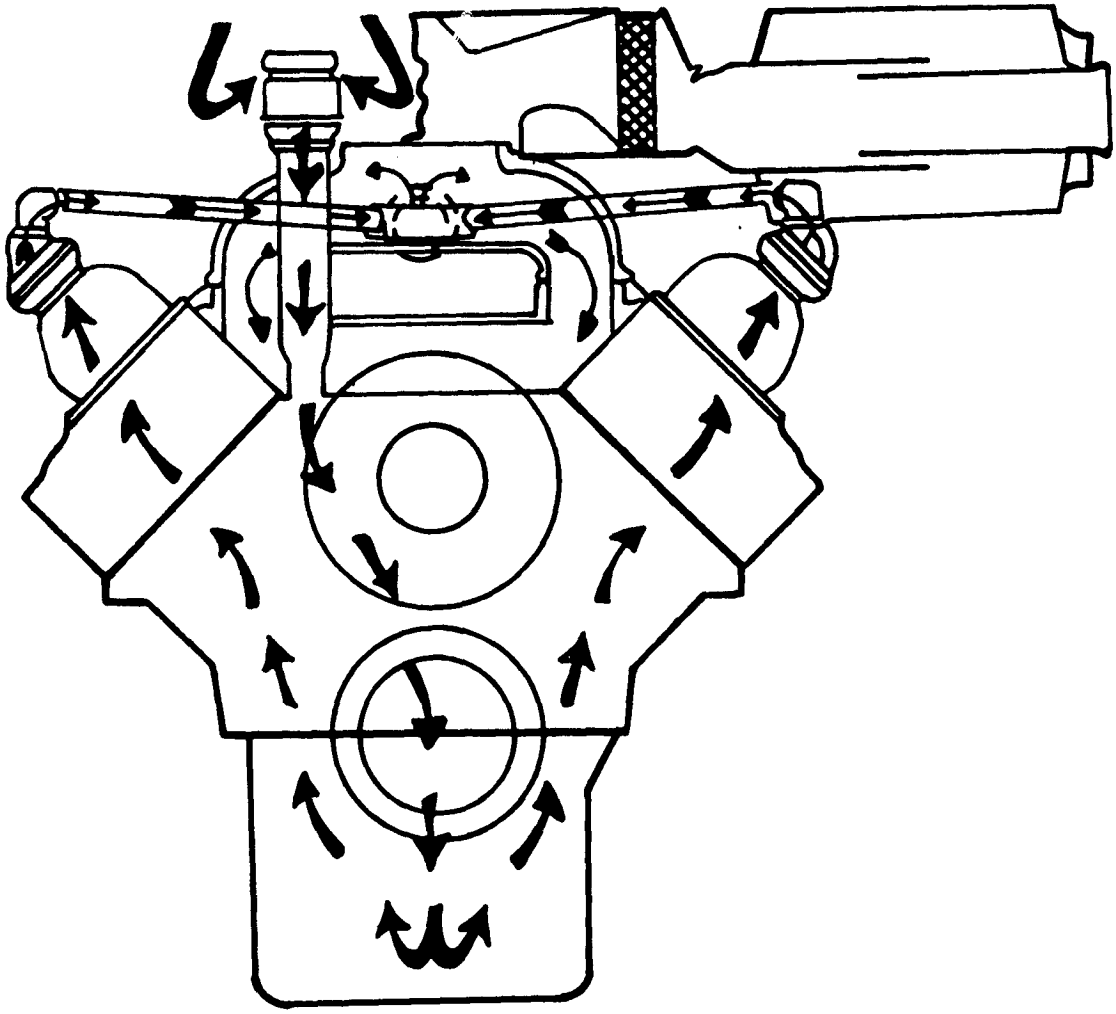
When checking compression, the batteries should be at or near full charge. The lowest reading cylinder should not be less than 70% of the highest and no cylinder reading should be less than 275 pounds.

1. Remove air cleaner then install air crossover cover J-26996-1.
2. Disconnect the wire from the fuel solenoid terminal of the injection pump.
3. Disconnect wires from glow plugs then remove all glow plugs.
4. Screw the compression gage J-26999 into the glow plug hole of the cylinder that is being checked.
5. Crank engine.
   Allow six **"puffs"** per cylinder.

Normal - Compression builds up quickly and evenly to specified compression on each cylinder. **Piston Rings Leaking** - Compression low on first stroke tends to build up on following strokes but does not reach normal.

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

DIESEL CRANKCASE VENTILATION



Fresh air enters via a combination filter and check valve mounted in the oil fill tube cap at the front of the engine. Ventilation vapor is drawn from both valve cover assemblies into the rear of the air intake crossover. A ventilation control valve in the air crossover guards against excessive crankcase purge and oil pullover should the air cleaner become extremely plugged and the normally low purge increase.

G.M. 350 AND 260D
NOZZLE SPECIFICATIONS

Oldsmobile:

Pre 1980 - Return Lines

1. Opening - 1,800 P.S.I. ± 100/50.
2. Pattern - Spray, double cone or swirl.
3. Tightness - At 1,300-1,400 P.S.I. no drop in 10 seconds.
4. Chatter Test - Operate tester rapidly - Nozzle should chatter.
5. Return Line - Nozzle above horizontal - 1,500 P.S.I. - After first drop appears, should be 3-10 more drops in 30 seconds.

Post 1980 - No Return Lines

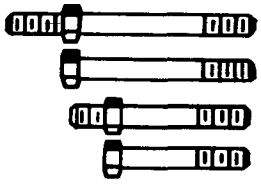
1. Opening - 870 P.S.I. minimum.
2. Pattern - Mist or cloud.
3. Tightness - a. 290 P.S.I. below recorded opening pressure.
   b. Increase pressure 220 P.S.I., hold 5 seconds, no drips.

BORE DIA.	CYL. BORE SELECTION	BORE SIZES	PISTON SELECTION	PISTON SIZE	PISTON DIA.	PISTON TO CYL. BORE CLEARANCE
4.056-4.058 STD.	A	4.0560-4.0565	A	4.0505 - 4.0510	4.0505 - 4.0525 STD.	.0050 to .0060
	B	4.0565-4.0570	B	4.0510 - 4.0515		
	C	4.0570-4.0575	C	4.0515 - 4.0520		
	D	4.0575-4.0580	D	4.0520 - 4.0525		
4.066-4.068 .010 O.S.	J	4.0660-4.0665	J	4.0605 - 4.0610	4.0605 - 4.0625 .010 O.S.	
	K	4.0665-4.0670	K	4.0610 - 4.0615		
	L	4.0670-4.0675	L	4.0615 - 4.0620		
	M	4.0675-4.0680	M	4.0620 - 4.0625		

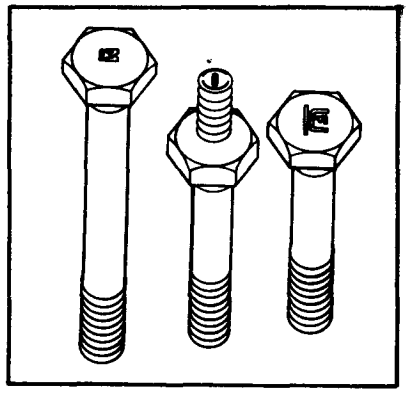
HEAD BOLTS FOR GM DIESEL ENGINE 1978-80

A new type head bolt is available for the 5.7 liter engines. When a cylinder head has been removed for service, be sure to use the new type head bolts if they have not already been installed. General Motors placed the new bolts into production in March of 1980, and they are available from authorized GM dealerships.

The new bolts are torqued to 130 ft. lbs.



PART NUMBER	SIZE
22510585	1/2 - 13 x 4.30 stud end
22510579	1/2 - 13 x 4.30
22510582	1/2-13 x 3.10 stud end
22510580	1/2-13 x 3.10



Cylinder Head Gasket Dowel Pins

On some engines, it is possible to install the cylinder head gasket upside down because of the dowel pin location. A dowel pin has been added to the cylinder block on later engines to prevent incorrect installation.

When installing any diesel engine head gasket, the prechamber shield on the gasket must face toward the cylinder head.

G.M. 350 & 260D
DIESEL ENGINE SPECIFICATIONS

FLYWHEEL	
No. of Teeth on Starter Gear	166
No. of Teeth on Starter Pinion	9
LUBRICATION SYSTEM	
Crankcase Capacity Drain and Refill (Including Filter)	7 Qts.
Oil Pump	
Clearance Pressure Relief Valve in Bore	.0025"-.0050"
End Clearance-Gear	.0005"-.0075"
CYLINDER BLOCK	
Engine Type	90° V-Type
No. of Cylinders	8
Bore and Stroke	4.057" x 3.385"
Piston Displacement	5.7 Litre (350 C.I.D.)
Compression Ratio	22.5:1
Firing Order	1-8-4-3-6-5-7-2
Main Bearing Bore In Iron (I.D.)	3.188"-3.189"
CRANKSHAFT	
Diameter - Main Bearing Journal	3.0003"-2.9993"
Width - Main Thrust Bearing Journal (No. 3) (with fillets)	1.1985"-1.2015"
Diameter - Connecting Rod Bearing Journal	2.1248"-2.1238"
Width - Connecting Rod Bearing (with fillets)	1.877"-1.887"
Length - Overall Crankshaft	26.470"
Diameter - Oil Holes in Crankshaft	.220"-.250"
Clearance - Crankshaft End	.0035"-.0135"
MAIN BEARINGS	
Bearing Clearance - Crankshaft 1,2,3,&4	.0005"-.0021"
Bearing Clearance - (Vertical) 5	.0015"-.0031"
Width - Bearing Shell	
No. 1, 2 and 4	.970"-.980"
No. 3	1.193"-1.195"
No. 5	1.624"
CONNECTING RODS	
Length - Center to Center	5.8835"-5.8875"
Diameter - Connecting Rod Bore	2.2495"-2.2500"
Diameter - Pin Bore (Finish Bore in Bushing	1.0956"-1.0962"
Bearing Clearance - (Vertical)	.0005"-.0026"
Side Clearance - Big End	.060"-.020"
PISTON	
Diameter Nominal Outside	4.051"
Top of Piston to Center of Pin	1.770"
Clearance to Bore (selective)	.005"-.006"
Weight Less Pin & Rings (all)	796±2g
Skirt Taper (Piston Pin Centerline to Bottom of Skirt)	.000"-.002" Larger at Bottom

PISTON (Cont.)	
Ring Groove Width (top compression)	.0818"-.0828"
Ring Groove Width (lower compression)	.0798"-.0808"
Ring Groove Width (1 oil)	.1881"-.1891"
PISTON PINS	
Diameter	1.0949"-1.0953"
Pin to Piston Clearance	.0003"-.0005"
Pin to Rod Clearance	.0003"-.0013"
PISTON RINGS	
No. of Compression Rings (per piston)	2
Width of Compression Rings (top & bottom)	.0780"-.0770"
Gap Clearance Compression Rings	.015"-.025"
Clearance in Groove Compression Rings-Upper	.005"-.007"
Clearance in Groove Compression Rings-Lower	.0018"-.0038"
No. of Oil Rings (per piston)	1
Gap Clearance, Oil Ring	.015"-.055"
Clearance in Groove, Oil Rings	.001"-.005"
CAMSHAFT	
Bearing Journal Diameters	
No. 1	2.0365"-2.0357"
No. 2	2.0165"-2.0157"
No. 3	1.9965"-1.9957"
No. 4	1.9765"-1.9757"
No. 5	1.9565"-1.9557"
Width (including chamfers)	
No. 1	.810"
No. 2, 3 and 4	.741"
No. 5	.788"
Journal Clearance in Bearing (all)	.0020"-.0058"
End Clearance	.011"-.077"
Push Rod - Length	8.265"
VALVE-INTAKE	
Diameter - Head	1.875"
Diameter - Stem	.3425"-.3432"
Angle - Valve	44°
Angle - Valve Seat	45°
Width - Valve Seat (Cylinder Head)	.075"-.098"
Overall Length	5.120"
Clearance in Guide	.0010"-.0027"
Lash	Hydraulic
VALVE-EXHAUST	
Diameter - Head	1.625"
Diameter - Stem	.3420"-.3427"
Angle - Valve	30°
Angle - Valve Seat	31°
Width - Valve Seat (Cylinder Head)	.037"-.075"
Overall Length	5.029"
Clearance in Guide	.0015"-.0032"
Lash	Hydraulic

VALVE SPRINGS	
Length	2.09"
Diameter - Wire	.177"
Inside Diameter	1.065"-1.041"
Load	77-83 Lbs.@1.670"
Load	144-158 Lbs.@1.300"
VALVE LIFTERS	
Diameter - Body	.8422"-.8427"
Length - Overall	2.000"
Clearance in Boss	.0005"-.0022"
Also available in .010" Over Size	
CAMSHAFT SPROCKET	
Pitch	1/2"
No. of Teeth	36
CRANKSHAFT SPROCKET	
Pitch	1/2"
No. of Teeth	18
TIMING CHAIN	
Width	.570"
No. of Links	48
Pitch	1/2"
Type	Roller

TORQUE SPECIFICATIONS

Note: Specified torque is for installation of parts only. Checking of torque during inspection may be 10% below specification.

APPLICATION	Ft.Lbs.
FUEL PUMP	
Fuel Pump to Block Bolt and Nut	25
EXHAUST SYSTEM	20
ENGINE	
Injection Pump Attaching Nuts	18
Injection Line Nut to Pump	35
Injection Pump Adapter Bolts	25
Injection Line Nut to Nozzle	25
Injection Pump Fuel Filter Inlet Line	20
Injection Pump Fuel Filter Outlet Line	10
Injection Pump Fuel Inlet Line	20
Injection Nozzle Hold-Down Clamp	25
Glow Plug	12
Crankshaft Bearing Cap Bolts	120
Flywheel to Converter	40
Flywheel to Crankshaft	60

ENGINE (Cont.)	
Oil Pump to Bearing Cap Bolts	35
Oil Pump Cover to Pump Bolts	8
Rocker Arm Pivot Bolt to Head	25
Valve Cover Bolts	Fully Driven, Seated, Not Stripped
Oil Pan Bolts	10
Oil Pan Drain Plug	30
Crankshaft Balancer to Crankshaft Bolt	200-310
Oil Filter Element to Base	20
Oil Filter Assembly to Cylinder Block Bolts	35
Oil Cooler Lines to Oil Filter Base	12
Oil Cooler Lines to Radiator	25
Support/Front Cover to Cylinder Block Bolts 3/8"	35
Fan Driven Pulley to Hub Bolts	20
Fan Driving Pulley to Balancer Bolts	20
Water Pump to Front Cover Bolts	13
Water Outlet to Manifold Bolts	20
*Intake Manifold to Cylinder Head Bolts	40
Exhaust Manifold to Cylinder Head Bolts	25
Engine Mount to Cylinder Block Bolts	75
Engine Mount to Frame Mount	50
Starter to Cylinder Block Bolts	35
Starter Brace to Cylinder Block Bolts	25
Starter Brace to Starter Bolt	15
Vacuum Pump Clamp to Cylinder Block Bolt	17
*Cylinder Head Bolts	130
Connecting Rod Nuts	42
Camshaft Sprocket Bolt	65

*Clean and dip entire bolt in engine oil before tightening to obtain a correct torque reading.

BLOCK IDENTIFICATION

350D - On block - Part #558306-D3 - Early
Weak Main Bolts

350DX - On block - Part #7582-D3
Lifter bores machined at top - Two extra bosses between #2 and #4 lifter bores - main webs .100" thicker

350DX - Part # 7582-D3 - Late
Lifter bore increased to .920" from .840"

Always check #2 and #4 main area and use late main cap bolts - green dot.

ISUZU
C190GB, C190KE, C190, C240 MODELS
DIESEL ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine type (all)	Water-cooled, 4-cycle in-line, overhead valve type
Combustion Chamber Type (all)	Swirl chamber type
Cylinder Liner Type (all)	Dry type, Cromard liner
Timing Gear System	
C190GB, C190KE	Belt drive
C190, C240	Gear drive
No. of Piston Ring (all)	Compression ring 2, oil ring 1
No. of Cylinder - Bore x Stroke (mm)	
C190GB, C190KE, C190	4 - 86 x 84
C240	4 - 86 x 102
Total Piston Displacement (cc)	
C190GB, C190KE, C190	1,951
C240	2,369
Compression Ratio (all)	20:1
Engine Dimensions: (mm) length x width x height	
C190GB	730 x 570 x 625
C190KE	696 x 666 x 715
C190	682 x 600 x 633
C240	685 x 606 x 685
Engine Weight (Dry)(kg)	
C190GB, C190KE	Approx. 220
C190	Approx. 221
C240	Approx. 223
Fuel Injection Order (all)	1-3-4-2
Fuel Injection Timing (BTDC static)	
C190GB, C190KE	15^{o}
C190	18^{o}
C240	14^{o}
Type of Fuel used (all)	High-speed diesel fuel (SAE No.2)
Fuel Filter Type (all)	Cartridge type
Injection Pump Type	
C190GB, C190KE	Bosch distributor VE type
C190, C240	Bosch in-line A type with automatic timer
Governor Type	
C190GB, C190KE	Mechanical variable speed (half all speed)
C190, C240	Pneumatic and mechanical variable speed
Injection Nozzle (all)	Throttle type
Fuel Injection Pressure (kg/cm^2)	
C190GB, C190KE	105
C190, C240	120
Compression Pressure (kg/cm^2)(all)	31 (at 200 rpm)
Idle Speed (rpm)	
C190GB	600-650
C190KE	675-725
C190, C240	675-725
Intake and Exhaust Valve Clearance (cold) (mm)(all)	0.45
Intake Valve	
Open at (all)	11^{o} (BTDC)
Close at (all)	49^{o} (ABDC

Exhaust Valve	
Open at (all)	51° (BBDC)
Close at (all)	9° (ATDC)
Lubrication Method (all)	Pressurized circulation
Oil Pump Type	
C190GB, C190KE, C190	Gear type (4x4), Rotor type (4x2)
C240	Rotor type
Oil Filter Type (all)	Paper element, full-flow type
C190GB, C190KE, C190	Cartridge type
C240	Cartridge type or paper element type
Piston Cooling	With oiling jets
Lubricating Oil Capacity (liters)	
C190GB	6.0
C190KB, C190, C240	6.5
Oil Cooler Type (all)	Water-cooled
Cooling Method	Pressurized circulation
Cooling Water Capacity (liters)(all)	9.0
Water Pump Type	Impeller type
Thermostat type	Wax pellet type (with jiggle valve)
Air Cleaner Type	Cyclone type combined with paper element type
Battery Type - Voltage (V) x No. of unit	
C190GB, C190KE, C190	NS70/NX120-7 - 12 x 1
C240	N100 - 12 x 1
Generator - Voltage-capacity (V-A)	
C190GB, C190KE	12 - 50/65/80
C190, C240	12 - 40
Starter - Voltage-output (V-KW)	
C190GB, C190KE	12 - 1.8/2.2
C190	12 - 1.8
C240	12 - 2.2

MERCEDES-BENZ
DIESEL ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

Chassis Type	
220D	115.110
240D	115.117
240D	123.123
300D	115.114/123.1
Engine	
220D	615.912
240D	616.916
240D	616.912
300D	617.901/617.912
Operation	Four-stroke diesel engine
Number of Cylinders	
220D, 240D	4
300D	5
Arrangement of cylinders	Upright in line
Bore (mm/in.)	
220D	87/3.43
240D, 300D	91/3.58
Stroke (mm/in.)	
220D	92.4/3.64
240D, 300D	92.4/3.64
Total Eff. Piston Displacement (cm^3/cu.in.)	
220D	2197/134.1
240D	2404/146.7
300D	3005/183.4
Compression Ratio	21:1
Firing order	
220D, 240D	1-3-4-2
300D	1-2-4-5-3
Max. Engine rpm (no load)	
220D	4350
240D	5400
240D	5200
300D	5100
Engine Output (SAE net bhp/rpm)	
220D	57/4200
240D	62/4000
240D	65/4200
300D	77/4000
Max. Torque (SAE net lb.ft./rpm)	
220D	88/2400
240D	97/2400
300D	115/2400
Crankshaft Bearings	
220D, 240D	5
300D	6
Valve Arrangement	Overhead
Camshaft Arrangement	OHC
Oil Cooling	Air-oil cooler

GENERAL SPECIFICATIONS (Cont.)

Cooling	Water circulation pump, thermostat with by-pass line, fan with viscous coupling, finned tube radiator
Oil Filter	Forced oil circulation via gear-type oil pump
Air Filter	
220D, 240D	Oil bath
240D, 300D	Paper cartridge
Injection pump abbreviations	
M	pump with pneumatic governor
MW, MRSF	pump with mechanical governor

INJECTION NOZZLES

Standard Version
National Version (AUS, E, J, S up to 1978, USA up to 1977, ZA)
Engines 615.912/941, 616, 617
DNO SD 220, DNO SD 240[3] Bosch injection nozzles
Opening pressure in bar gauge pressure[1]

New injection nozzles	1690-1783 psi
Used injection nozzles (min.)	1470 psi

Engines 615.913/940
DNO SD 1510 Bosch injection nozzles
Opening pressure in bar gauge pressure[1]

New injection nozzles	1690-1783 psi
Used injection nozzles (min.)	1470 psi

National Version S starting 1979, USA starting 1978
Engines 616, 617
DNO SD 240[2] Bosch injection nozzles
Opening pressure in bar gauge pressure[1]

New injection nozzles	1690-1783 psi
Used injection nozzles (min.)	1470 psi

[1]The difference in opening pressure of injection nozzles
[2]within one engine should not exceed 5 bar gauge pressure
[3]Starting 1979 with rod-type filter.
[3]Engine 616, 617 starting from power increase.

INJECTION PUMP

Test Valves
Beginning of delivery before TDC in compression stroke

Engine 615.912/941	24°
Engine 615.913/940	26°
Engine 616, 617	24°

Attention: On MW and MRSF injection pumps with mechanical governor, push regulating lever of injection pump to full load while measuring and pull vacuum hose from vacuum box.

FUEL PUMP

Injection pump abbreviation

M	Engine 615, 616
MW	Engine 616, 617
MRSF	Engine 615, 616, 617

FUEL PUMP (Cont.)

Model	
M (615/616)	115.1/123.1
MW (617/616,617)	115.1/123.1
MRSF (615, 616, 617)	123.1
Fuel Pump/Bosch Designation	
M	FP/K 22/M 13 FP/K 22/M 14
MW	FP/K 22/MW 3 FP/K 22/MW 7
MRSF	FP/K 22/M 101
Vacuum	
Measuring point	prior to pump input
At idle speed, bar gauge pressure (atu)	0.1
Delivery pressure	
Measuring point	Between fuel main filter and injection pump
At idle speed, bar gauge pressure (atu)	0.6-0.8
At 3000/min, bar gauge pressure (atu)	min. 0.8
Delivery End Pressure	
At idle speed, bar gauge pressure (atu)	min. 1.1
At 3000/min, bar gauge pressure (atu)	min. 1.3
Fuel Overflow Valve, opening pressure in bar gauge presure (atu)	
Engine 615, 616, 617	
At idle speed	0.6-0.8
At 3000/min.	min. 1.3

TORQUE SPECIFICATIONS

	NM	kpm
Bolts for cylinder head cover (engine 615)	5	0.5
Nuts for cylinder head cover (engines 615, 616, 617)	15	1.5
Waisted bolt for camshaft sprocket	80	8
Fastening bolt, injection timing device	40	4
Nut for injection timing device	70	7
Cap nuts of injection lines	25	2.5
Bolts and nuts for oil filter cover (type 123.1)	20-25	2.0-2.5
Injection nozzles top and bottom (51-58 lbs.)	70-80	7-8
Glow Plugs	50	5
Injection lines (M, MW, MRSF)(Engines 615, 616, 617)	25	2.5
Pipe connection for pressure valve -		
MW (Engines 616, 617)	40-50	4-5
M, MRSF (Engines 615, 616, 617)	35	3.5

MITSUBISHI DIESEL ENGINE
MODEL 6DR5
SPECIFICATIONS

GENERAL SPECIFICATIONS

Model	6DR50A
Type	Diesel engine
Cooling Method	Water-cooled
Operation Cycles	4
Combustion Chamber Type	Swirl chamber
No. and Arrangement of Cylinders	6, in-line
Bore and Stroke	92 x 100 mm
Total Displacement	3,988 c.c.
Compression Ratio	20:1
Firing Order	1-5-3-6-2-4
Direction of Rotation	Clockwise (as viewed from timing gear case)
Fuel	Gas oil
Engine Oil	Mobile oil (API Class CA, CB)
Dimension	
Overall length	974 mm
Overall width	594 mm
Overall height	701 mm
Weight	
Dry	360 kg
Rated output PS/rpm	105/3,500
Maximum torque kg-m/rpm	25.0/2,200
Compression pressure	30 kg/cm^2 (170 rpm)
Idling Speed	450 to 500 rpm
Maximum Speed	3,500 rpm
Cylinder Liner Type	Dry, special cast iron sleeves
No. of Piston Ring	
Compression Ring	3
Oil Ring	1 (w/expander)
Valve Arrangement	Overhead valve type
Valve Timing	
Intake Valve Opens	32° BTDC
Intake Valve Closes	64° ABDC
Exhaust Valve Opens	68° BBDC
Exhaust Valve Closes	28° ATDC
Valve Clearance	
Intake Valve	0.3 mm (cold)
Exhaust Valve	0.3 mm (cold)
Starting Method	Starter

FUEL SYSTEM

Feed Pump	
Type	ND-FP/KS22
Manufacturer	Nippon Denso
Cam Lift	6 mm
Injection Pump	
Type	Bosch type PES6A
Manufacturer	Nippon Denso
Plunger Diameter	6.5 mm

FUEL SYSTEMS (Cont.)

Injection Pump	
Plunger Lead	Right-hand 15 mm lead or equivalent
Cam Lift	8 mm
Fuel Injection Timing	$22+1^{\circ}$ BTDC 16°BTDC (After E. No. 6DR5-14279)
Governor	
Governor System	Mechanical centrifugal type
Model	ND-EP/RU250-1780ARND173
Manufacturer	Nippon Denso
Auto Timer	
Model	ND-EP/SCZ600
Manufacturer	Nippon Denso
Type	Mechanical Type
Advance Characteristics	Advance angle 8.5° at 600 to 1,900 rpm -Advance angle 5.0° at 600 to 900 rpm and 5.5° at 900 to 1,750 rpm (After E. No 6DR5-14279)
Nozzle	
Manufacturer	Nippon Denso
Nozzle Holder Type	Bosch KCA17SD
Nozzle Tip Type	Bosch ND-DN4SD24
Type	Throttle type
Nozzle Diameter	1 mm
Spray Angle	4°
Nozzle Holder	
Injection Pressure	120 to 130 kg/cm^2
Fuel Filter	
Filter	Filter-paper type
Manufacturer	Nihon Rokaki

LUBRICATION SYSTEM

Oil Capacity	
Oil Pan	10.5 lit. (including quantity of oil in oil filter, oil cooler)
Oil Filter	2 lit.
Engine Oil Pressure	
During Operation	3 to 4 kg/cm^2
At Idling	1.5 kg/cm^2
Oil Pump	
Type	Trochoid gear type
Rate of Pump Speed to Crankshaft Speed	1/2

COOLING SYSTEM

Quantity of Coolant	
Engine Water Jacket	5 lit.
	14 lit. (including quantity of coolant in radiator)
Water Pump	
Type	Centrifugal type
Thermostat	
Type	Wax type
Manufacturer	Juji Seiko

COOLING SYSTEM (Cont.)

Thermostat	
Valve Opening Temperature	74.5 to 78.5°C (90°C wide-open)
Fan	
Type	Pusher type
No. of Plates	6

AUTOMATIC TIMER ADVANCE CHARACTERISTICS

Before E. No. 6DR5-14278	
Timing	BTDC 22°
Model	ND-EP/SCZ600-1900A85RND24
Pump Speed/Advance Angle	
600 rpm	0°
1,200 rpm	4°
1,800 rpm	8°
1,900 rpm	8.5°
After E. No. 6DR5-14279	
Timing	BTDC 16°
Model	ND-EP/SCZ600-1750A10.5RND75
Pump Speed/Advance Angle	
600 rpm	0°
900 rpm	4 to 6°
1,750 rpm	10 to 11°

GLOW PLUG

Type	Sheath parallel type
Rated Voltage	22.5V
	18V (After E. No. 6DR5-14279)
Rated Current	4.8A±10%
	6A±10% (After E. No. 6DR5-14279)

TORQUE SPECIFICATIONS

	kg-m
Engine	
Cylinder Head Bolts (Apply Oil)	12.5
Main Bearing Cap (Apply Oil)	9 to 10
	10.6 to 11.8 (Bolt with H mark)
Connecting Rod Cap (Apply Oil)	8.5 to 9.5
Flywheel	8.5 to 9.5
Flywheel Housing Bolt	2.5 to 4.1
Camshaft Thrust Plate	1.5 to 2.1
Front Plate	0.7 to 1.3
Timing Gear Case	0.7 to 1.3
Crankshaft Pulley	3 to 5
Camshaft Gear Bolt	3 to 4
Idler Gear Bolt	3 to 4
Rear Oil Seal	0.3 to 0.5
Oil Pan Bolt	0.5 to 0.9
Oil Pan Drain Plug	6 to 7
Engine Lubrication	
Oil Pump Connector	5 to 6
Oil Filter Center Bolt	2 to 2.6

Fuel System	
Nozzle Holder Retaining Nut	6 to 8
Automatic Timer Round Nut	6 to 7
Injection Pump Delivery Valve Holder	2.5 to 3.5
Governor Gear Slip Torque	0.4 to 0.6
Governor Gear Round Nut	2 to 3
Fuel Hose	3 to 4
Cooling System	
Water Pump Flange Tightening Nut	5 9 (After E. No. 14900)
Water Pump Impellar	5 3.5 (After E. No. 14900)

NISSAN
DIESEL ENGINE SPECIFICATIONS

ENGINE SPECIFICATIONS	
Valve Clearance (Hot)	
Intake Valve	0.35 mm (0.014")
Exhaust Valve	0.35 mm (0.014")
Compression Pressure - kPa (kg/cm^2, psi)/rpm	
Standard	2,942 (30,427)/200
Minimum	2,452 (25,356)/200
Compression Differential Limit between Cylinders	294 (3,43)/200
INJECTION SYSTEM	
Idle Speed (rpm)	600^{+100}_{-50}
Injection Timing (degree BTDC at idle speed)	20°
Dash Pot	
Touch Speed (rpm)	1,280-1,350
Injection Nozzle Assembly	
Type	Closed, throttle type
Injection Angle	0°
Initial Injection Pressure - kPa(kg/cm^2, psi)	
New	10,297-11,082 (105-113, 1,493-1,607)
Used	9,807-10,297 (100-105, 1,422-1,493)

TORQUE SPECIFICATIONS

	N·m	kg-m	ft-lb
Delivery Valve Holder	29-34	3.0-3.5	22-25
Injection Tube Flare Nut	29-34	3.0-3.5	22-25
Injection Pump Securing Nut	20-25	2.0-2.5	14-18
Injection Nozzle Assembly (to cylinder head)	59-69	6.0-7.0	43-51
Oil Pan Drain Plug	49-59	5-6	36-43
Rocker Arm Lock Nut	20-25	2.0-2.5	14-18
Spill Tube Nut	39-49	4-5	29-36
Timer	59-69	6-7	43-51
Rocker Cover Fixing Bolt	10-13	1.0-1.3	7-9

VOLKSWAGON
DIESEL ENGINE SPECIFICATIONS

GENERAL ENGINE DATA

Engine Code Letter	1977-1980: CK 1981: CR
Number of Cylinders	4
Cylinder Layout	Inline, transverse engine
Valve Operation	Belt-driven, single overhead camshaft
Cylinder Bore	76.50 mm (3.012 in.)
Piston Stroke	1977-1980: 80.00 mm (3.150 in.) 1981: 86.40 mm (3.400 in.)
Compression Ratio	1977-1980: 23.5:1 1981: 23:1
Piston Displacement	1977-1980: 1471 cm^3 (89.7 $in.^3$) 1981: 1588 cm^3 (96.9 $in.^3$)
Fuel Requirement	Diesel Fuel No. 2
Power	1977-1980: 37 kW (48 SAE net bhp) @ 5000 rpm 1981: 40 kW (52 SAE net bhp) @ 4800 rpm
Torque	1977-1980: 78.5 Nm (58 ft.lb.) @ 2500 rpm 1981: 96 Nm (71 ft.lb.) @ 3000 rpm

BASIC TUNE-UP SPECIFICATIONS

Coolant Capacity	6.9 liters (7.3 US qts, 6.1 Imp qts)
Oil Capacity	1977-1980: With filter change: 3.5 liters (3.7 US qts, 3.1 Imp qts) Without filter change: 3.0 liters (3.2 US qts, 2.6 Imp qts) 1981: With filter change: 4.5 liters (4.7 US qts, 3.9 Imp qts) Without filter change: 4.0 liters (4.2 US qts, 3.5 Imp qts)
Firing Order	1-3-4-2
Cylinder Location	No. 1 at camshaft drive end of engine cylinders numbered consecutively from curb side of vehicle to driver's side
Valve Clearance	
Intake Valve (Cold)	0.15-0.25 mm (.006-.010 in.)
Intake Valve (Hot)	0.20-0.30 mm (.008-.012 in.)
Exhaust Valve (Cold)	0.35-0.45 mm (.014-.018 in.)
Exhaust Valve (Hot)	0.40-0.50 mm (.016-.020 in.)
Compression Pressure	34 bar (483 psi)
Wear Limit	28 bar (398 psi)-or a cylinder-to-cylinder difference over 5 bar (71 psi)
Electrical System	12-volt, negative ground
Injection Pump Timing	1977-1980: Pump with yellow dot: 0.86 mm $\pm$ 0.02 mm (.034 in. $\pm$ .0008 in.) Pump without yellow dot: 1.15 mm $\pm$ 0.02 mm (.045 in. $\pm$ .0008 in.) 1981: 0.86 mm $\mp$ 0.02 mm (.034 in. $\mp$ .0008 in.)

BASIC TUNE-UP SPECIFICATIONS (Cont.)

Idle Speed	800-850 rpm
Maximum rpm (no load)	1977-1980: 5500-5600 rpm 1981: 5300-5400 rpm

DIESEL FUEL SYSTEM GENERAL TECHNICAL DATA

Fuel Requirement	Diesel Fuel No. 2
Car Fuel Tank Capacity (Nominal)	Through 1979: 45 liters (11.9 US gallons or 9.9 Imp gallons) From 1980: 38 liters (10 US gallons or 8.3 Imp. gallons)
Pickup Truck Tank Capacity (nominal)	56 liters (15 US gallons or 12.3 Imp gallons)
Quantity of Fluid to be drained from Fuel Filter at Service Intervals between Filter changes	About 100 ml (about 3½ oz. or a scant ½ cup)
Engine Idle Speed	800 to 850 rpm
Engine Maximum Speed	Through 1980: 5500 to 5600 rpm 1981: 5300 to 5400 rpm
Injection Pump Lift at TDC (top dead center)(with injection timing and valve timing correct)	Through 1980: (yellow dot on pump): 0.83 mm (.033 in.) (no yellow dot on pump): 1.15 mm (.045 in.) 1981: 0.83 mm (.033 in.)
Injection Pump Timing Advance with Cold Start Knob pulled out	2.5° at pump
Injector Pipe connecting locations at pump	Pump connection A to injector for cylinder No. 1 Pump connection B to injcetor for cylinder No. 3 Pump connection C to injector for cylinder No. 4 Pump connection D to injector for cylinder No. 2
Injector Leakage Test specification	No leakage for 10 seconds at 110 bar (1564 psi)
Injector Breaking Pressure	120 to 130 bar (1706 to 1849 psi)

AVAILABLE SHIMS FOR ADJUSTING INJECTOR BREAKING PRESSURE

Shim Thickness	Part Number	Shim Thickness	Part Number
1.00 mm	068 130 251	1.50 mm	068 130 261
1.05 mm	068 130 252	1.55 mm	068 130 262
1.10 mm	068 130 253	1.60 mm	068 130 263
1.15 mm	068 130 254	1.65 mm	068 130 264
1.20 mm	068 130 255	1.70 mm	068 130 265
1.25 mm	068 130 256	1.75 mm	068 130 266
1.30 mm	068 130 257	1.80 mm	068 130 267
1.35 mm	068 130 258	1.85 mm	068 130 268
1.40 mm	068 130 259	1.90 mm	068 130 269
1.45 mm	068 130 260	1.95 mm	068 130 270

TORQUE SPECIFICATIONS

	Nm	Ft.lb.
Fuel Tank Mounting Strap to Vehicle Body (Nut)	25	18
Rear Axle Mount to Car Body (Nut)	45	33
Brake Line Union at Rear Axle (Union Nut)	15 to 20	11 to 15
Exhaust System Clamps (Nut or Bolt)	25	18
Exhaust Pipe to Engine's Exhaust Manifold (Nut)	25	18
Header Pipe's Transmission Bracket to Transaxle (Nut)	30	22
Car Muffler Front Bracket to Pipe (U-Bolt)	15	11
Camshaft Drive Belt Tensioner (Locknut)	45	33
Camshaft Drive Belt Cover to Engine (Bolt or Nut)	10	7.5
Camshaft Drive Belt Sprocket to Camshaft (Bolt)	45	33
Intermediate Shaft Pulley to Intermediate Shaft (Bolt)	45	33
Camshaft Drive Belt Sprocket to Crankshaft (Bolt)	80	59
Camshaft Bearing Caps to Cylinder Head (Nut)	20	15
Cylinder Head to Engine Block (Socket-Head Bolt)	85	63
Manifolds to Cylinder Head (Nut or Bolt)	25	18
Cylinder Head Cover to Cylinder Head (Bolt)	10	7.5
V-belt Pulleys to Water Pump Hub or Crankshaft Sprocket (Bolt)	20	26
Oil Filter Mounting Flange to Engine Block (Socket-Head Bolt)	20	15
Connecting Rod Cap to Connecting Rod (Nut)	45	33
Crankshaft Sprocket to Crankshaft (Engine Code CK)(use Locktite 270 or 271) (Bolt)	80	59
Crankshaft Sprocket to Crankshaft (Engine Code CR) (Bolt)	110	81
Crankshaft and Intermediate Shaft Oil Seal Carriers to Engine Block (Bolt)	20	15
Main Bearing Cap to Engine Block (Bolt)	65	48
Fuel Injection Pump to Mounting Plate and Support (Bolt)	25	18
Fuel Pipe Connections to Injection Pump Unions (Union Nut)	25	18
Unions in Injection Pump Head	45	33
Camshaft Drive Belt Sprocket to Injection Pump (Nut)	45	33
Fuel Pipe Connections to Injectors (Union)	25	18
Injector in Cylinder Head (always install with a new heatshield) (Injector)	70	52
Injector upper part to Injector lower part.	70	52

VOLVO - TYPE D-24
DIESEL ENGINE SPECIFICATIONS

ENGINE IDENTIFICATION NUMBER - SERIAL

Stamped under the vacuum pump on engine left side.

GENERAL SPECIFICATIONS

Engine designation	D24
Engine Identification Number	
D24 with manual transmission	498704
D24 with automatic transmission	498705
Compression Ratio	23.5:1
Diesel Fuel Minimum Cetan Rating	45
Output, DIN	60 kW at 80 rps 82 hp at 4800 rpm
Torque, DIN	140 NM at 47 rps 14.3 kpm at 2800 rpm
Cylinders	6
Firing Order	1-5-3-6-2-4
Displacement	2.383 liters = 145 cu.in.
Weight, including Engine Mounts, Starter, Motors and Alternator	198 kgs = 436 lbs.
Compression Pressures	
New Engine	3.4 MPa = 485 psi
Minimum	2.8 MPa = 400 psi
Max. difference between Cylinders	0.5 MPa = 70 psi
Cylinder Bore	76.5 mm = 3.0188"
Stroke	86.4 mm = 3.4016"

CYLINDER HEAD GASKET

(Three cylinder head gaskets are available. Selecting the proper gasket depends on piston projection above cylinder block face.)

Piston Projection

Gasket Notches = 1, Gasket Thickness = 1.4 mm (0.055")	0.67-0.80 mm (0.026-0.031")
Gasket Notches = 2, Gasket Thickness = 1.5 mm (0.059")	0.81-0.90 mm (0.032-0.035")
Gasket Notches = 3, Gasket Thickness = 1.6 mm (0.063")	0.91-1.02 mm (0.036-0.040")

GEAR BELTS

Belt Tension (check with Tool 5197)

Valve when checking	12-13 mm
Valve when setting	12.5 mm

VALVE SYSTEM

Valve clearances, cold engine

Intake Valve, checking	0.15-0.25 mm (0.006-0.010")
Intake Valve, setting	0.20 mm (0.008")
Exhaust Valve, checking	0.35-0.45 mm (0.014-0.018")
Exhaust Valve, setting	0.40 mm (0.016")

VALVE SYSTEM (Cont.)
- Valve clearances, warm engine
  - Intake Valve, checking. . . . . 0.20-0.30 mm (0.008-0.012")
  - Intake Valve, setting . . . . . 0.25 mm (0.010")
  - Exhaust Valve, checking . . . . 0.40-0.50 mm (0.016-0.020")
  - Exhaust Valve, setting. . . . . 0.45 mm (0.018")
  - Adjusting Disc Thicknesses. . . . . 3.30 to 4.25 mm in increments of 0.05 mm (0.1299" to 0.1673" in increments of 0.0020")

ENGINE OIL SYSTEM
- Oil Capacities
  - Excl. Oil Filter. . . 6.2 liters = 6.6 US qts = 5.45 Imp qts
  - Incl. Oil Filter. . . 7.0 liters = 7.4 US qts = 6.2 Imp qts
  - Difference between Minimum and Maximum. . . 1.0 liters = 1 US qt. = 0.9 Imp qt.
- Lubricant
  - Quality . . . . . .API Service SE/CC
  - Viscosities
    - Normal and high temperature range, from -10°C=14°F and up. . . . . SAE 15W/50 or 20W/50
    - Normal and low temperature range, from +30°C=86°F and down. . . . . SAE 10W/40 or 10W/30

    These oils can be used within the "normal" temperature range of from -10°C to +30°C (from 14°F to 86°F).

    Oil pressure at an oil temperature of +80°C=175°F and 2000 rpm, minimum . . . . 200 kPa (28 psi)
- Oil Pressure Sender
  - Oil pressure warning light goes out at. .15-45 kPa (2-6 psi)
- Oil Pump
  - Relief valve opens at . . . . . 600-700 kPa (85-100 psi)

FUEL SYSTEM
- General
  - Injection Sequence. 1-5-3-6-2-4
  - Low Idle. . . . . 13.3 rps = 800 rpm
  - High Idle . . . . . 87 rps = 5200 rpm
- Fuel
  - Standards . . . . . ASTM-D 975-No 2D
DIN 51601
CEC-ERF-DI
  - Cetan Rating, Minimum 45
  - Sulphur content, max. weight proportion 0.5%
- Fuel Tank
  - Capacity. . . . . 60 liters = 15.8 US gal = 13.2 Imp gal
- Injection Pump
  - Distributor Type Pump
  - Designation
    - Vehicles with Manual Transmissions. Bosch VE6/10 F2400 L32
    - Vehicles with Automatic Transmissions . . . . . Bosch VE6/10 F2400 L32-1

FUEL SYSTEM (Cont.)

Injection Pump

Injection Timing (Distributor plunger stroke at top dead center)

When checking	0.65-0.73 mm (0.0256-0.0287)
When setting	0.70 mm (0.02)

Injectors

Nozzles

Designation	Bosch DNO SD 193
Volvo P/N	1257146-9

Injector Assembly

Designation	Bosch KCA 30SD 27/4
Volvo P/N	1257144-4

Injector Opening Pressure

When checking	12-13 MPa (1700-1845 psi)
When setting	12.5-13.5 MPa (1775-1920 psi)

TORQUE SPECIFICATIONS

Cylinder Head Bolts

After installation, with cold engine, cylinder head bolts should be torqued in two steps:

-First: follow tightening sequence shown and torque to: 40 Nm = 30 ft.lbs.

fan

12	10	4	2	6	8	14
13	7	5	1	3	9	11

(When removing cylinder head; loosen bolts in reverse order.)

-Secondly: follow tightening sequence shown and torque to: 90 Nm - 65 ft. lbs.

After driving 1000-2000 km = 600-1,200 miles, bolt torque should be checked with warm engine. Apply torque wrench and torque to: 85 Nm = 62 ft.lbs.

Cylinder head bolts should NOT be loosened before re-torquing.

	Nm	ft.lbs.
Crankshaft Pulley (vibration damper)		
Center Bolt, with wrench 5188	350	255
Center bolt, torque wrench	450	330

Note: Sealing fluid, Volvo P/N 277961-9, should be applied to bolt threads and bolt head contact surface. Not difference in torque when using special tool 5188 and an ordinary torque wrench.

Inhex screws	20	15
Flywheel Bolts (use new bolts and sealing fluid, Volvo P/N 277961-9)	75	55

	Nm	ft.lbs.
Camshaft Gears		
Front	45	33
Rear	100	73
Camshaft Bearing Cap Nuts	20	15
Fuel System		
Injector to Cylinder Head	70	50
Injector Top to Bottom	70	50
Gear on Injection Pump	45	33
Delivery Pipes	25	18

QUICK START AND AFTERGLOW SYSTEM

This system is used to enable the engine to start more quickly when the engine is cold. It consists of the four glow plugs, the control module, two relays, a glow plug resistor assembly, coolant temperature switch, clutch and neutral switches and connecting wiring. Relay power and feedback circuits are protected by fuse links in the wiring harness. The control module is protected by a separate 10A fuse in the fuse panel.

When the ignition switch is turned to the ON position, a Wait-to-Start signal appears near the cold-start knob on the panel. When the signal appears, relay No. 1 also closes and full system voltage is applied to the glow plugs. If engine coolant temperature is below 30°C (86°F), relay No. 2 also closes at this time. After three seconds, the control module turns off the Wait-to-Start light indicating that the engine is ready for starting. If the ignition switch is left in the ON position about three seconds more without cranking, the control module opens relay No. 1 and current to the plugs stops to prevent overheating. However, if coolant temperature is below 30°C (86°F) when relay No. 1 opens, relay No. 2 remains closed to apply reduced voltage to the plugs through the glow plug resistor until the ignition switch is turned off

CAUTION: LEAVING THE IGNITION SWITCH ON WITHOUT STARTING THE ENGINE WILL RUN THE BATTERIES DOWN.

When the engine is cranked, the control module cycles relay No. 1 intermittently. Thus, glow plug voltage will alternate between 12 and four volts, during cranking, with relay No. 2 closed, or between 12 and zero volts with relay No. 2 open. After the engine starts, alternator output signals the control module to stop the No. 1 relay cycling and the afterglow function takes over.

If the engine coolant temperature is below 30°C (86°F), the No. 2 relay remains closed. This applies reduced (4.2 to 5.3) voltage to the glow plugs through the glow plug resistor. When the vehicle is under way (clutch and neutral switches closed), or coolant temperature is above 30°C (86°F), the control module opens relay No. 2, cutting off all current to the glow plugs.

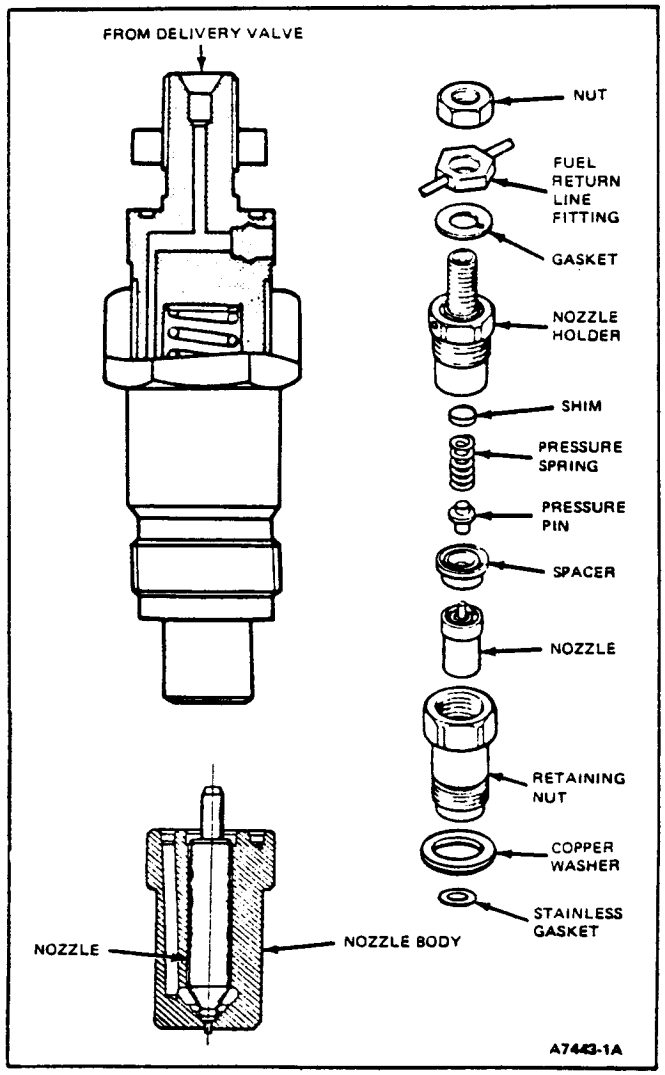
AIR BLEEDING FUEL SYSTEM

If fuel system was opened by replacement of fuel filter, air bleed system as follows:

1. Loosen fuel filter air vent plug.
2. Operate priming pump on top of fuel filter adapter.
3. Continue pumping until clear fuel, free from air bubbles, flows from air vent plug.
4. Depress priming pump and hold down while closing air vent plug.

If fuel system was run out of fuel, or fuel supply lines were removed, air bleed system as follows:

1. Air bleed fuel filter as described previously.
2. Disconnect fuel return hose from injection pump.
3. Pump priming pump until fuel flows from return port on injection pump.
4. Connect fuel return hose to injection pump.
5. Run engine and check for fuel leaks.



FUEL SYSTEM

Fuel injection pump	
Type	Distributor type
Plunger diameter	10.0mm (0.394 in.)
Cam lift	2.2mm (0.09 in.)
Governor	Hydraulic, Mechanical type
Injection timing	2° ATDC
Injection nozzle	
Type	Throttle type
Nozzle diameter	0.8mm (0.031 in.)
Injection pressure	13,500 +500 −0 kPa (1957 +73 −0 psi)

CA7537-1A

INJECTION NOZZLE TESTING

Where ideal conditions of good combustion, specified engine temperature control and absolutely clean fuel prevail, nozzles require little attention.

Nozzle trouble is usually indicated by one or more of the following symptoms:

1. Smoky exhaust (black)
2. Loss of power
3. Misfiring
4. Increased fuel consumption
5. Combustion knock
6. Engine overheating

Where faulty nozzle operation is suspected on an engine that is misfiring or puffing black smoke, a simple test can be made to determine which cylinder is causing the difficulty.

With the engine running at a speed that makes the problem most pronounced, momentarily loosen the high pressure fuel inlet line connection on one nozzle assembly sufficiently to "cut-out" the cylinder (one half to one turn) to leak off the fuel charge to the cylinder. Then tighten to specifications.

Check each cylinder in the same manner. If one is found where loosening makes no difference in the irregular operature or causes puffing black smoke to stop, the injection nozzle for the cylinder should be tested.

CAUTION: KEEP EYES AND HANDS AWAY FROM NOZZLE SPRAY. FUEL SPRAYING FROM THE NOZZLE UNDER HIGH PRESSURE CAN PENETRATE THE SKIN AND CAUSE INFECTION. MEDICAL ATTENTION SHOULD BE PROVIDED IMMEDIATELY IN THE EVENT OF SKIN PENETRATION.

When servicing injection nozzle assemblies, the necessity of cleanliness cannot be over-emphasized. A clean workbench, clean washing fluid containers, clean tools and clean hands are all essential to produce satisfactory results. The use of suitable tools for this type of work is equally important.

The nozzle assembly should be tested using a Rotunda Injector Nozzle Tester, 014-00300, or equivalent (Fig. 29) and the nozzle opening pressure noted, the condition of the spray pattern observed, and the general operating condition of the assembly noted. This information will indicate whether or not the nozzle assembly needs to be replaced.

For testing, the nozzles must be removed as described in this Section.

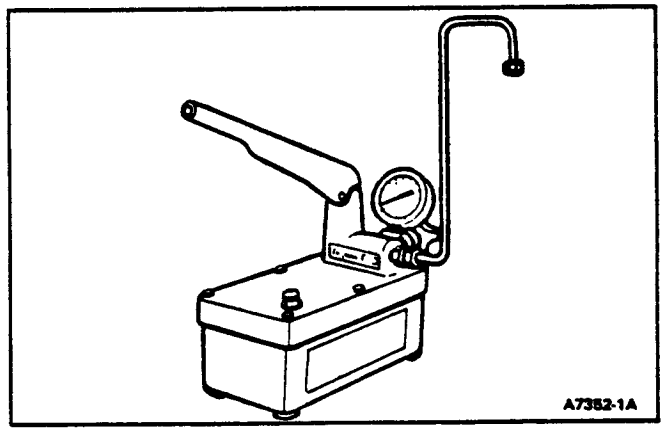


FIG. 29 Injection Nozzle Tester

IMPORTANT: It is advisable to test nozzles before cleaning them.

The nozzle pop test procedure is as follows:

1. **Prepare hand pump for making tests.** Fill pump reservoir with clean calibration fluid. Open pump valve slightly and operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fuel (without air bubbles) flows from end of outlet pipe. Close pump valve.

2. **Connect injection nozzle to test pump.** Care should be taken to avoid "cross-threading." Tighten connector nut securely with end wrench. Adapter has right hand threads to nozzle assembly and left hand threads to tester piping.

3. **Bleed air from nozzle.** Open pump valve and operate pump for several quick strokes to expel (bleed) air from injection nozzle. Fuel should spray from the spray hole in nozzle tip.

4. **Check spray pattern.** Operate test pump in smooth, even strokes and observe pattern of fuel spraying from nozzle tip spray hole. The spray should be finely atomized in an even, straight pattern (Fig. 30). If spray pattern is faulty, disassemble and clean nozzle as described in this Section. Retest nozzle. If still faulty, replace nozzle.

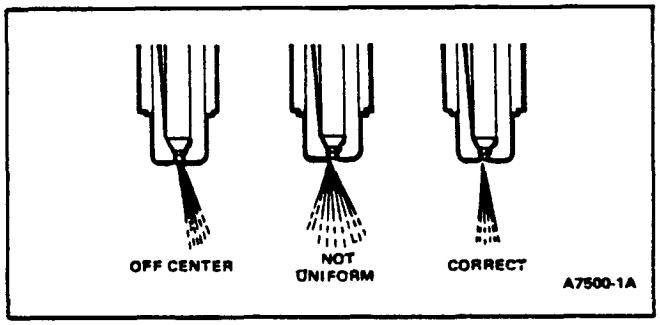


FIG. 30 Nozzle Spray Pattern

5. **Check nozzle opening pressure.** Open gauge valve, build up line pressure by slowly depressing handle until nozzle opens (sprays fuel). Observe gauge to determine pressure at which nozzle opens, then repeat operation to establish an average opening pressure. Refer to specification at end of this Section. If opening pressure is not within specification, adjust by replacing shim with one of the correct thickness (Fig. 31). Each 0.04mm (0.016 inch) change in shim thickness changes opening pressure by 480 kPa (68 psi) (Fig. 32). Refer to Nozzle Disassembly in this Section.

NOTE: Upon operating the test pump you will note a distinct and relatively regular nozzle chatter. A sharp pitched sound is not mandatory and an occasional skip or variation in sound may occur. In addition, chatter may vary from nozzle to nozzle.

6. **Check for tip leakage.** Wipe nozzle tip dry. Operate test pump to maintain pressure at about 2,000 kPa (284 psi) below opening pressure. Nozzle tip should remain dry without an accumulation of fuel drops at spray hole. A slight wetting after about 10 seconds is permissible if no droplets are formed.

If nozzle leaks, disassemble and clean nozzle as described in this Section. Retest nozzle. If nozzle still leaks, replace it.

NOTE: Do not wipe tip with fingers as this will tend to draw the fuel present in the sac hole through the orifice and falsely indicate a leak and rejection of a good nozzle.

If nozzle passes above tests, it is suitable for further service in the engine following external cleaning with Rotunda Decarbonizing Solution.

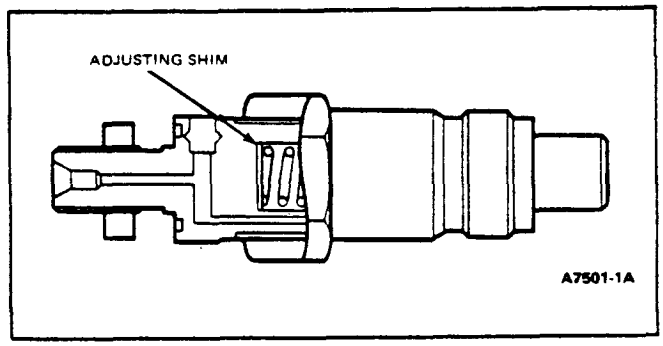


FIG. 31 Adjusting Shim Location

QUICK REFERENCE NOZZLE SHIM ADJUSTMENT CHART

Part No.	Thickness (mm)	Resulting Pressure Change (kPa)
E3TZ-9M577-A	0.50	Base
E3TZ-9M557-B	0.54	480
E3TZ-9M557-C	0.58	960
E3TZ-9M557-D	0.62	1440
E3TZ-9M557-E	0.66	1920
E3TZ-9M557-F	0.70	2400
E3TZ-9M557-G	0.74	2880
E3TZ-9M557-H	0.78	3360
E3TZ-9M557-J	0.82	3840
E3TZ-9M557-K	0.86	4320
E3TZ-9M557-L	0.90	4800
E3TZ-9M557-M	0.94	5280
E3TZ-9M557-N	0.98	5760
E3TZ-9M557-P	1.02	6240
E3TZ-9M557-Q	1.06	6720
E3TZ-9M557-R	1.10	7200
E3TZ-9M557-S	1.14	7680
E3TZ-9M557-T	1.18	8160
E3TZ-9M557-U	1.22	8640
E3TZ-9M557-V	1.26	9120
E3TZ-9M557-W	1.30	9600
E3TZ-9M557-X	1.34	10,080
E3TZ-9M557-Y	1.38	10,560
E3TZ-9M557-Z	1.42	11,040
E3TZ-9M557-AA	1.46	11,520
E3TZ-9M557-BB	1.50	12,000
E3TZ-9M557-CC	1.54	12,480

CA7502-1A

FIG. 32 Adjusting Shim Chart

STATIC TIMING GAUGE ADAPTER

OPERATING INSTRUCTIONS

To use the Static Timing Gauge Adapter on the 2.2 L diesel engine use the following procedure:

INJECTION TIMING TEST

Note: Injection pump timing is correct when the injection pump cam lifts 1 mm (.039 In.) when the No. 1 piston is at top dead center of the compression stroke.

1. Remove the injection pump distributor head plug bolt.
2. Install the Static Timing Gauge Adapter, see Figure 1, tight against the end of the fuel injection pump.
3. Rotate the crankshaft until the indicator pin is at 30° BTDC.
4. Turn the outside ring on the dial indicator until it reads "O".

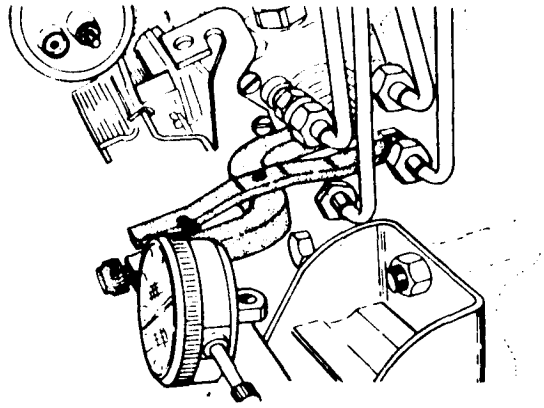


FIGURE 1

Note: Slightly rotate the crankshaft to the right and to the left to insure that the dial indicator reading remains at "O".

5. Turn the crankshaft the same direction as the engine rotates until the indicator pin points at 0° TDC. See Figure 2.
6. Read the dial indicator on the Static Timing Gauge Adapter. If the dial indicator reads 1 mm (.039 In.), the injection pump is timed correctly. Proceed to step 3 of REASSEMBLY. If the dial indicator does not read 1 mm (.039 In.) continue to INJECTION TIMING.

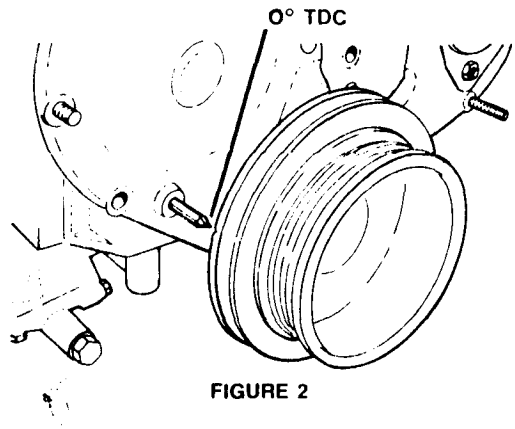


FIGURE 2

INJECTION TIMING ADJUSTMENT

IMPORTANT: These adjusting procedures must be followed to minimize gear backlash.

1. Loosen the nuts and bolts that attach the injection pump to the block.
   - A. If the dial indicator reads **more** than 1 mm (.039 In.) in step 6:
     1. Rotate the injection pump in the opposite direction as engine rotation until the dial indicator reads less than 1 mm (.039 In.).
     2. Rotate the injection pump in the same direction as engine rotation until the dial indicator reads 1 mm (.039 In.).
   - B. If the dial indicator reads **less** than 1 mm (.039 In.) in step 6:
     1. Rotate the injecton pump in the same direction as engine rotation until the dial indicator reads 1 mm (.039 In.).

REASSEMBLY

1. Tighten the nuts and bolts that attach the injection pump to the block.
2. Check the reading on the dial indicator to insure that the injection pump is still correctly timed.
3. Remove the Static Timing Gauge Adapter and reinstall the injection pump distributor head plug bolt.

TORQUE SPECIFICATION

Unless otherwise specified	N·m	Ft-Lb
6T		
6mm bolt/nut	7-10	5-7
8mm bolt/nut	16-23	12-17
10mm bolt/nut	31-46	23-34
12mm bolt/nut	55-80	41-59
14mm bolt/nut	76-103	56-76
8T		
6mm bolt/nut	8-12	6-9
8mm bolt/nut	18-27	13-20
10mm bolt/nut	36-54	27-40
12mm bolt/nut	63-93	46-69
14mm bolt/nut	102-137	75-101
Engine		
Cylinder head	108-115	80-85
Cylinder head cover	2.9-4.4	2.2-3.3
Connecting rod cap	68-74	50-54
Main bearing cap	108-115	80-85
Camshaft thrust plate	16-24	12-18
Camshaft gear	61-69	45-51
Idle gear	16-24	12-17
Injection pump drive gear	39-69	29-51
Rocker arm assembly		
Cylinder head	108-115	80-85
Rocker arm support	16-24	12-17
Adjust screw	12-17	9-12
Timing gear case	16-24	12-17
Timing gear cover	16-24	12-17
Rear oil seal cap	15-20	11-15
Oil pan	10-17	7-12
Oil pan drain plug	29-41	22-30
Oil pipe (Oil pump)	8-12	6-9
Water pump	16-24	12-17
Crankshaft pulley	343-392	253-289
Glow Plug	15-20	11-15
Injection nozzle	59-69	43-51
Injection pipe flare nut	25-29	18-22
Cooling fan	16-24	12-17
Intake manifold	16-24	12-17
Exhaust manifold	23-26	17-20①
End plate	32-47	24-35
Flywheel	129-186	95-137
Oil filter (primary)	12-16	9-12
By-pass oil filter	19-25	14-18
Fuel filter	13-16	10-12

①After warming up, retighten by the same torque.

SPECIFICATIONS

ENGINE

Type	Four cylinder four stroke engine in line, water cooled, overhead valve
Bore	88.9mm (3.50 in.)
Stroke	89.0mm (3.50 in.)
Piston displacement	2,209 cc (134.8 cu. in.)
Compression pressure (at 200 rpm)	
Standard	3,000 kPa (427 lb./in.²)
Limit	2,700 kPa (384 lb./in.²)
Valve clearance (warm engine)	
Intake	0.30mm (0.012 in.)
Exhaust	0.30mm (0.012 in.)
Cylinder head	
Permissible distortion of cylinder head surface	Laterally 0.10mm (0.004 in.) Longitudinally and Diagonally 0.25mm (0.010 in.)
Valve seat	
Valve seat angle	45°
Intake	
Exhaust	30°
Valve seat width	
Intake	2.0mm (0.079 in.)
Exhaust	2.0mm (0.079 in.)
Dimension "L" (valve sinking)	
Standard	48.0mm (1.890 in.)
Limit	49.5mm (1.949 in.)
Valve guide	
Protrusion from cylinder head	16.5mm (0.650 in.)
Valve — Intake	
Overall length	114.5mm (4.508 in.)
Head diameter	40.5 ± 0.1mm (1.595 ± 0.004 in.)
Face angle	45°
Stem diameter	
Standard	$8\ ^{-0.050}_{-0.075}$ mm $(0.3150\ ^{-0.0020}_{-0.0030}$ in.)
Limit	7.880mm (0.3102 in.)
Stem to guide clearance	
Standard	0.038 ~ 0.116mm (0.0015 ~ 0.0046 in.)
Limit	0.14mm (0.0055 in.)
Valve — Exhaust	
Overall length	114.6mm (4.512 in.)
Head diameter	36 ± 0.13mm (1.417 ± 0.005 in.)
Face angle	30°
Stem diameter	
Standard	$8\ ^{-0.063}_{-0.088}$ mm $(0.3150\ ^{-0.0025}_{-0.0035}$ in.)
Limit	7.867mm (0.3097 in.)
Stem to guide clearance	
Standard	0.051 ~ 0.129mm (0.002 ~ 0.0051 in.)
Limit	0.14mm (0.0055 in.)
Valve spring — Outer	
Wire diameter	4.5mm (0.177 in.)
Outer coil diameter	38.0mm (1.496 in.)
Free length	
Standard	45.9mm (1.807 in.)
Limit	43.6mm (1.717 in.)
Valve spring — Outer (Cont'd.)	
Fitting length	40.3mm (1.587 in.)
Fitting load	
Standard	180 ± 9N (39.7 ± 2.0 lb.)
Limit	145 N (32.0 lb.)
Squareness limit	1.60mm (0.063 in.)
Valve spring — Inner	
Wire diameter	3.5mm (0.138 in.)
Outer coil diameter	27.5mm (1.083 in.)
Free length	
Standard	44.1mm (1.736 in.)
Limit	42.0mm (1.654 in.)
Fitting length	37.8mm (1.488 in.)
Fitting load	
Standard	127 ± 6N (28.0 ± 1.3 lb.)
Limit	103 N (22.7 lb.)
Squareness limit	1.54mm (0.061 in.)
Rocker arm	
Bore in rocker arm	18.258 ~ 18.278mm (0.7188 ~ 0.7196 in.)
Rocker arm bushing	
Inner diameter	$15.8\ ^{+0.096}_{+0.076}$ mm $(0.6221\ ^{+0.0038}_{+0.0030}$ in.)
Outer diameter	$18.1\ ^{+0.22}_{+0.19}$ mm $(0.7126\ ^{+0.0087}_{+0.0075}$ in.)
Rocker arm shaft	
Outer diameter	15.835 ~ 15.860mm (0.6234 ~ 0.6244 in.)
Clearance in rocker arm	
Standard	0.016 ~ 0.061mm (0.0006 ~ 0.0024 in.)
Limit	0.07mm (0.0028 in.)
Tappet	
Outer diameter	14.224 ~ 14.249mm (0.5600 ~ 0.5610 in.)
Bore in cylinder block	14.288 ~ 14.319mm (0.5625 ~ 0.5637 in.)
Clearance in cylinder block bore	
Standard	0.039 ~ 0.095mm (0.0015 ~ 0.0037 in.)
Limit	0.10mm (0.0039 in.)
Camshaft	
Journal diameter	
No. 1 (Front)	$52\ ^{-0.06}_{-0.09}$ mm $(2.0473\ ^{-0.0024}_{-0.0035}$ in.)
No. 2 (Center)	$51.75\ ^{-0.06}_{-0.09}$ mm $(2.0374\ ^{-0.0024}_{-0.0035}$ in.)
No. 3 (Rear)	$51.25\ ^{-0.06}_{-0.09}$ mm $(2.0177\ ^{-0.0024}_{-0.0035}$ in.)

ENGINE (Cont'd.)

Wear limit of journal	0.008mm (0.0003 in.)
Cam lobe height	
Intake	
Standard	42.587mm (1.6767 in.)
Limit	42.485mm (1.6727 in.)
Exhaust	
Standard	42.587mm (1.6767 in.)
Limit	42.485mm (1.6727 in.)
Cam lobe lift	
Intake	6.535mm (0.257 in.)
Exhaust	6.535mm (0.257 in.)
Camshaft end play	
Standard	0.020 ~ 0.180mm (0.0008 ~ 0.0071 in.)
Limit	0.30mm (0.012 in.)
Camshaft run-out	
Limit	0.08mm (0.0031 in.)
Camshaft support bore in cylinder block	
No. 1 (Front)	$52\ ^{+0.03}_{+0}$ mm $(2.0473\ ^{+0.0012}_{+0}$ in.)
No. 2 (Center)	$51.75\ ^{+0.03}_{+0}$ mm $(2.0374\ ^{+0.0012}_{+0}$ in.)
No. 3 (Rear)	$51.25\ ^{+0.03}_{+0}$ mm $(2.0177\ ^{+0.0012}_{+0}$ in.)
Oil clearance	
No. 1 (Front)	0.060 ~ 0.120mm (0.0024 ~ 0.0047 in.)
No. 2 (Center)	0.060 ~ 0.120mm (0.0024 ~ 0.0047 in.)
No. 3 (Rear)	0.060 ~ 0.120mm (0.0024 ~ 0.0047 in.)
Oil clearance limit	0.145mm (0.0057 in.)
Camshaft gear backlash	
Standard	0.10 ~ 0.17mm (0.0039 ~ 0.0067 in.)
Limit	0.30mm (0.0118 in.)
Idle gear	
Bore in idle gear boss	$48\ ^{+0.025}_{+0}$ mm $(1.8898\ ^{+0.0010}_{+0}$ in.)
End play	0.20 ~ 0.30mm (0.0079 ~ 0.0118 in.)
Idle gear bushing	
Inner diameter	$44\ ^{+0.034}_{+0.009}$ mm $(1.7323\ ^{+0.0013}_{+0.0004}$ in.)
Outer diameter	$48\ ^{+0.115}_{+0.075}$ mm $(1.8898\ ^{+0.0045}_{+0.0030}$ in.)
Idle gear spindle	
Length	29 ± 0.05mm (1.1418 ± 0.0020 in.)

Idle gear spindle (Cont'd.)	
Outer diameter	$44\ ^{-0.025}_{-0.050}$ mm $(1.7323\ ^{-0.0010}_{-0.0020}$ in.)
Spindle and bushing clearance	
Standard	0.034 ~ 0.084mm (0.0013 ~ 0.0033 in.)
Limit	0.15mm (0.0059 in.)
Connecting rod	
Permissible bend or twist	0.05mm per 100mm (0.0020 in. per 4 in.)
Side play	
Standard	0.239 ~ 0.340mm (0.0094 ~ 0.0134 in.)
Limit	0.40mm (0.0157 in.)
Small end bore	$31\ ^{+0.039}_{+0}$ mm $(1.2205\ ^{+0.0015}_{+0}$ in.)
Small end bushing	
Inner diameter	$28\ ^{+0.035}_{+0.014}$ mm $(1.1024\ ^{+0.0014}_{+0.0005}$ in.)
Outer diameter	$31\ ^{+0.138}_{+0.099}$ mm $(1.2205\ ^{+0.0054}_{+0.0039}$ in.)
Piston pin and small end bushing clearance	
Standard	0.014 ~ 0.041mm (0.0006 ~ 0.0016 in.)
Limit	0.05mm (0.0020 in.)
Connecting rod bearing	
Bearing clearance	
Standard	0.036 ~ 0.076mm (0.0014 ~ 0.0030 in.)
Limit	0.10mm (0.0039 in.)
Available undersize bearing	0.254mm (0.010 in.) 0.508mm (0.020 in.) 0.762mm (0.030 in.)
Piston	
Diameter	88.88 ± 0.013mm (3.4993 ± 0.0005 in.)
Piston pin hole bore	$28\ ^{+0.01}_{+0}$ mm $(1.1024\ ^{+0.0004}_{+0}$ in.)
Ring groove width	
Top	$2.433\ ^{+0.02}_{+0}$ mm $(0.0958\ ^{+0.0008}_{+0}$ in.)
Second	$2.423\ ^{+0.02}_{+0}$ mm $(0.0954\ ^{+0.0008}_{+0}$ in.)
Oil	$4.793\ ^{+0.02}_{+0}$ mm $(0.1887\ ^{+0.0008}_{+0}$ in.)
Piston and liner clearance	0.054 ~ 0.080mm (0.0021 ~ 0.0031 in.)

CA7532-2A

Piston ring	
Thickness	
Top	3.5 $^{+0.10}_{-0.25}$ mm
	(0.1378 $^{+0.0039}_{-0.0098}$ in.)
Second	3.5 $^{+0.10}_{-0.25}$ mm
	(0.1378 $^{+0.0039}_{-0.0098}$ in.)
Oil	2.9 $^{+0.25}_{-0.15}$ mm
	(0.1142 $^{+0.0098}_{-0.0059}$ in.)
Width	
Top	2.393 $^{-0.01}_{-0.03}$ mm
	(0.0942 $^{-0.0004}_{-0.0012}$ in.)
Second	2.383 $^{-0.02}_{+0}$ mm
	(0.0938 $^{-0.0079}_{+0}$ in.)
Oil	4.763 $^{-0.02}_{+0}$ mm
	(0.1875 $^{-0.0079}_{+0}$ in.)
Side clearance	
Top	0.050 ~ 0.090mm (0.0020 ~ 0.0035 in.)
Second	0.040 ~ 0.080mm (0.0016 ~ 0.0031 in.)
Oil	0.030 ~ 0.070mm (0.0012 ~ 0.0028 in.)
Side clearance limit	0.30mm (0.012 in.)
End gap	
Top	0.40 ~ 0.55mm (0.0157 ~ 0.0217 in.)
Second	0.30 ~ 0.40mm (0.0118 ~ 0.0157 in.)
Oil	0.35 ~ 0.55mm (0.0138 ~ 0.0217 in.)
End gap limit	1.5mm (0.059 in.)
Piston pin	
Diameter	28 $^{+0}_{-0.006}$ mm
	(1.1024 $^{+0}_{-0.0002}$ in.)
Clearance between piston and pin	0 ~ 0.016mm (0 ~ 0.0006 in.)
Crankshaft	
Main journal diameter	
Standard	65 $^{+0}_{-0.013}$ mm
	(2.5591 $^{+0}_{-0.0005}$ in.)
Wear limit	0.05mm (0.0020 in.)
Crankshaft (Cont'd.)	
Crankpin diameter	
Standard	53 $^{+0}_{-0.013}$ mm
	(2.0866 $^{+0}_{-0.0005}$ in.)
Wear limit	0.05mm (0.0020 in.)
Crankshaft processing diameter	0.762mm (0.030 in.)
Crankshaft end play	
Standard	0.140 ~ 0.390mm (0.0055 ~ 0.0154 in.)
Limit	0.40mm (0.0157 in.)
Crankshaft run out	
Limit	0.05mm (0.0020 in.)
Main bearing	
Bearing clearance	
Standard	0.040 ~ 0.091mm (0.0016 ~ 0.0036 in.)
Limit	0.12mm (0.0047 in.)
Available undersize bearing	0.254mm (0.010 in.) 0.508mm (0.020 in.) 0.762mm (0.030 in.)
Cylinder block	
Bore	96.838 $^{+0.025}_{-0}$ mm
	(3.8126 $^{+0.0010}_{-0}$ in.)
Warpage limit	Laterally 0.10mm (0.004 in.) Longitudinally 0.25mm (0.010 in.)
Cylinder liner	
Length	162.5 $^{+0.25}_{-0}$ mm
	(6.3977 $^{+0.0098}_{-0}$ in.)
Inner diameter	
Standard	88.9 $^{+0.050}_{+0.025}$ mm
	(3.5001 $^{+0.0020}_{+0.0010}$ in.)
Wear limit	0.20mm (0.0079 in.)
Outer diameter	96.838 $^{+0.076}_{+0.050}$ mm
	(3.8126 $^{+0.0030}_{+0.0020}$ in.)
Liner protrusion above cylinder block	0.659 ~ 0.790mm (0.0259 ~ 0.0311 in.)
Flywheel	
Run-out limit	0.20mm (0.0079 in.)

CA7533-2A

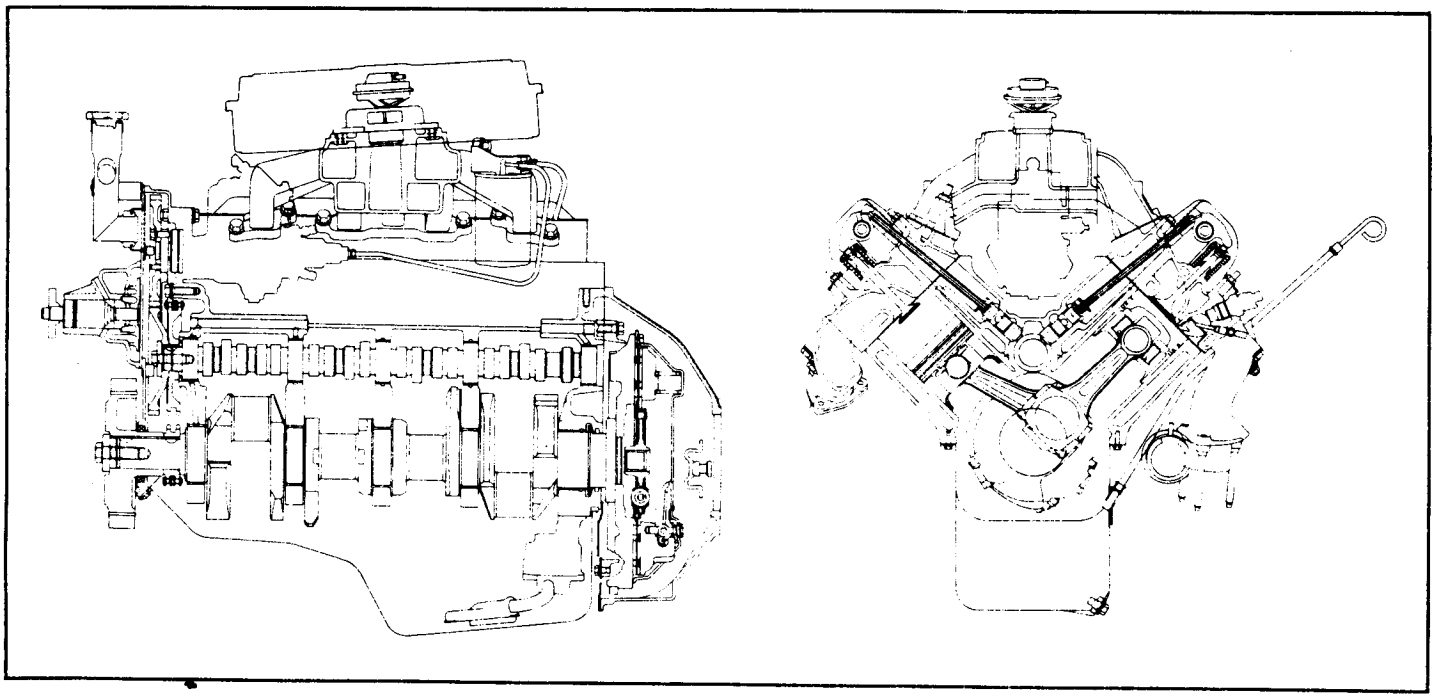
NOTES

6.2L ENGINE

GENERAL DATA AND SPECIFICATIONS

Regular Production Option Codes (RPO) - (C) LH6 - Lt. Duty < 8500 lbs. GVWR
Regular Production Option Codes (RPO) - (J) LL4 - Hv. Duty > 8500 lbs. GVWR

Engine Type	4 Stroke Cycle 90° V-8 Normally Aspirated
Combustion Chamber Type	Ricardo Comet V Swirl Ante-Chamber
Cylinder Block	Cast Iron with Combined Cylinders
Valve Timing	Chain and Sprockets (Overhead Valves)
Bore and Stroke	101mm (3.98") x 97mm (3.80")
Displacement	6217 cc (379.4 cu. in.)
Horsepower LH6	130 Net H.P. (97 Kw) @ 3600 RPM
Horsepower LL4	135 Net H.P. (101 Kw) @ 3600 RPM
Torque LH6 — LL4	240 lb. ft. @ 2000 RPM
Volume of Acyl. at BDC	815.4048 cc (49.756 cu. in.)
Volume of Acyl. at TDC	37.8148 (2.3075 cu. in.)
Compression Ratio LL4	21.3 (1982 20.3) to 1
Compression Ratio LH6	21.5 to 1
Engine Weight	700 lbs. M.T. — 655 lbs. A.T.
Firing Order	1 - 8 - 7 - 2 - 6 - 5 - 4 - 3
Static Timing	Top Dead Center
Type of Fuel Used	No. 2 Diesel Fuel Above 20°F No. 2 Diesel Blended or No. 1 Diesel Fuel Below 20°F
Injection Pump	Stanadyne DB2 (Roosa-Master)
Injection Nozzle	Robert Bosch DN
Injection Pressure	1520 - 1960 P.S.I.
Idle Speed	M.T. 650 in Neutral — A.T. 650 in Neutral
Fast Idle	800 RPM in Neutral M.T. & A.T.
Oil Capacity	Approx. 7 Qts. including Filter
Oil Filter	AC PF 35
Primary Fuel Filter	AC T-944 (Spin-On)
Secondary Fuel Filter	AC 10 Micron (Spin-On)
Oil Cooler	Water Cooled Type
MAX. GVWR	11,000 lbs.
MAX. GCWR	13,500 lbs.
Oil Pressure	40-45 PSI @ 2000 RPM



GENERAL DATA:

Type	90° V8 Diesel
Displacement	6.2 Liter
RPO	LH6, LL4
Bore	101 mm
Stroke	97 mm
Compression Ratio	21.5:1
Firing Order	1-8-7-2-6-5-4-3

CYLINDER BORE:

Diameter	100.987-101 .065
Out of Round	.02 Max.
Taper-Thrust Side	.02 Max.

PISTON:

Clearance	B*	.089-.115
	Z*	.112-.138

PISTON RING:

Compression	Groove Clearance	Top	.076-.178
		2nd	.039-.080
	Gap	Top	.3-.55
		2nd	.75-1.0
Oil	Groove Clearance		.040-.096
	Gap		0.25-0.51

PISTON PIN:

Diameter	30.9961-31.0039
Clearance	.0101-.0153
Fit in Rod	.0081-.0309

CAMSHAFT:

+ Lift −.05	In	7.133
	Ex	7.133
Journal Diameter	#1, 2, 3, 4	55.025-54.975
	#5	51.025-50.975
Journal Clearance		.026-.101

CRANKSHAFT:

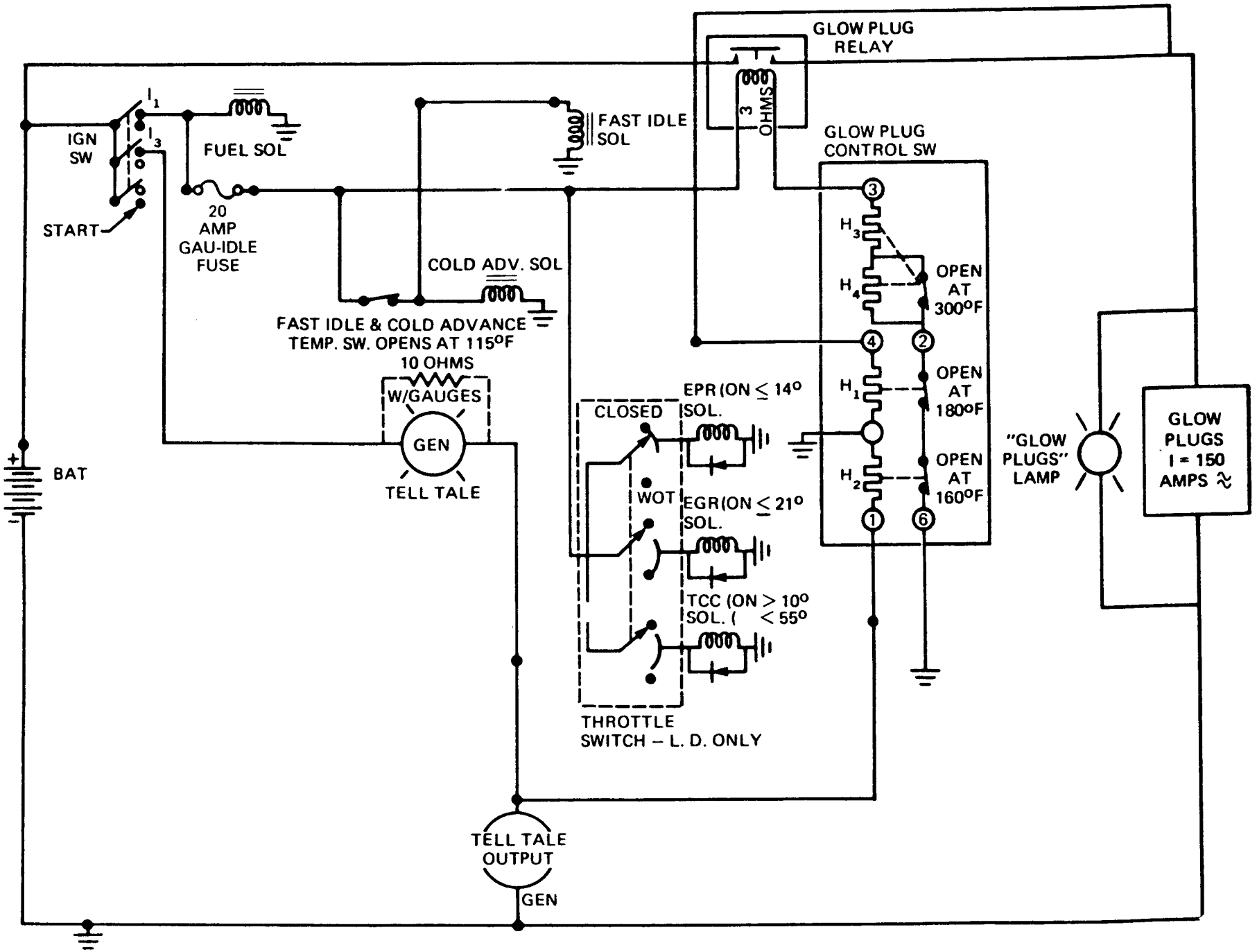
Main Journal	Diameter	#1 2 3 4	74.917-74.941
		#5	74.912-74.936
	Taper		.005 Max.
	Out Of Round		.005 Max.
Main Bearing Clearance		#1, 2, 3, 4	.045-.083
		#5	.055-.093
Crankshaft End Play			0.05-0.18
Crankpin	Diameter		60.913-60.939
	Taper		.005 Max.
	Out Of Round		.005 Max.
	Rod Bearing Clearance		
	Rod Side Clearance		.063/.17

VALVE SYSTEM:

Lifter		Hydraulic Roller
Rocker Arm Ratio		1.5 to 1
Face Angle (All)		45°
Seat Angle (All)		46°
Seat Runout		.05
Seat Width	In	.89-1.53
	Ex	1.57-2.36
Stem Clearance	In	.026/.069
	Ex	.026/.069
Valve Spring		
	Pressure Closed	356 @ 46.0
	N @ mm Open	1025 @ 35.3
	Installed Height	46

NOTICE: All dimensions are in millimetres (mm) unless otherwise specified.

*B — Bohn Pistons
*Z — Zollner Pistons


GLOW PLUG RELAY
3 OHMS
IGN SW
I1
I3
START
FUEL SOL
20 AMP GAU-IDLE FUSE
FAST IDLE SOL
COLD ADV. SOL
FAST IDLE & COLD ADVANCE TEMP. SW. OPENS AT 115°F
10 OHMS W/GAUGES
GEN
TELL TALE
BAT
GLOW PLUG CONTROL SW
H3
H4
H1
H2
OPEN AT 300°F
OPEN AT 180°F
OPEN AT 160°F
EPR (ON ≤ 14° SOL.
CLOSED
WOT
EGR (ON ≤ 21° SOL.
TCC (ON > 10° SOL. (< 55°
THROTTLE SWITCH – L. D. ONLY
"GLOW PLUGS" LAMP
GLOW PLUGS I = 150 AMPS ≈
TELL TALE OUTPUT
GEN

PUMP RELATED EXTERNAL AND INTERNAL REPAIRS

INJECTION PUMP

Removal

1. Remove intake manifold.
2. Remove fuel lines Fig. 4-13.
3. Disconnect accelerator cable at injection pump, and detent cable where applicable.
4. Disconnect necessary wires and hoses at injection pump.
5. Disconnect fuel return line.
6. Disconnect fuel line at pump.
7. Remove A/C hose retainer bracket if equipped with A/C.
8. Remove oil fill tube, includes PCV vent hose assembly.
9. Scribe or paint a mark on front cover and align, alignment mark on pump and front cover.
10. It will be necessary to rotate engine in order to gain access to injection pump retaining bolts through the oil filler neck hole.
11. Remove injection pump to front cover attaching nuts.
12. Remove pump and cap all open lines and nozzles.

Installation

1. Replace gasket.
2. Align locating pin on pump hub with slot in injection pump gear. At the same time, align timing marks.
3. Attach injection pump to front cover, torque nuts to 40 N·m (30 ft. lbs.).
4. Attach pump to drive gear, torque bolts to 25 N·m (20 ft. lbs.).
5. Install oil fill tube, includes PCV vent hose assembly.
6. Install A/C hose retainer bracket if equipped.
7. Install fuel line at pump, torque to 25 N·m (20 ft. lbs.).
8. Install fuel rrn line.
9. Connect necessary wires and hoses.
10. Connect accelerator cable.
11. Connect injection lines.
12. Install intake manifold.

CHECKING OR ADJUSTING TIMING

Checking (Fig. 4-14)

For the engine to be properly timed, the marks on the top of the engine front cover and the injection pump flange must be aligned. The engine must be off when the timing is reset.

Adjusting *

If the marks are not aligned, adjustment is necessary.

1. Loosen the three pump retaining nuts.
2. Align mark on injection pump with mark on front cover and tighten nuts to 40 N·m (30 ft. lbs.). Use tool J-29872 to aid in rotating the pump to align the marks. *see note.
3. Adjust throttle rod.

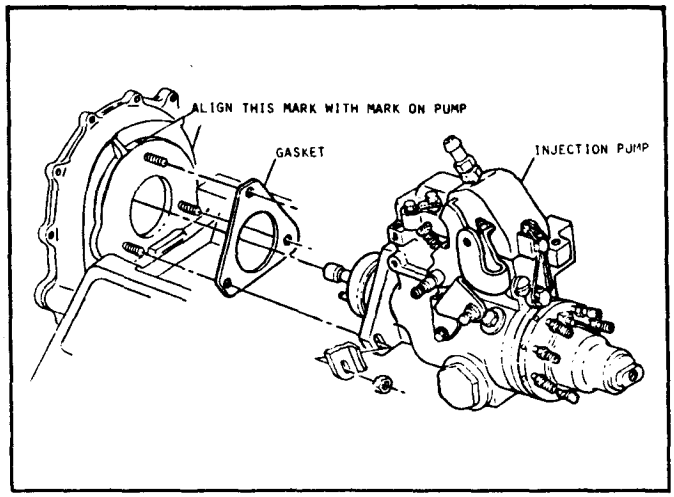


Fig. 4-14 Timing Marks

**NOTE: On marks for 1982 Pumps
Pump # DB2-4090 advance 1.5mm to the left bank 1st design L.D.
DB2-4091 advance 2.5mm to the left bank 1st design H.D.
All other Pump numbers, line up the marks.

MARKING TDC ON FRONT HOUSING

1. Set engine to TDC #1 cylinder (firing).
2. Install timing fixture J-33042 in F.I. pump location. Do not use gasket.
3. Slot of F.I. pump gear to be in vertical 6 o'clock position — (If not, remove fixture and rotate engine crankshaft 360°). The timing marks on gears will be aligned. See Fig. 4-15.
4. Fasten gear to fixture, and tighten.
5. Install on 10mm nut to housing upper stud to hold fixture flange nut to be "finger" tight.
6. Torque large bolt (18mm head) counterclockwise (toward left bank) to 50 ft. lbs. Tighten 10mm nut.
7. Insure crankshaft has not rotated (and fixture did not bind on 10mm nut).
8. Strike scriber with mallet to mark "TDC" on front housing.
9. Remove timing fixture.
10. Install fuel injection pump with gasket.
11. Install one 8mm bolt to attach gear to pump hub and tighten to specification.
12. Align timing mark on F.I. pump to front housing mark. Tighten to specification (3) 10mm attachment nuts 22 N•m (16 ft. lbs.).
13. Rotate engine and install remaining (2) pump gear attaching bolts and tighten to specification.

COMPRESSION TEST

To determine if the valves or rings are the cause of low compression, a test shoud be made to determine the cylinder compression pressure.

When checking compression, the batteries should be at or near full charge. The lowest reading cylinder should not be less that 70 percent of the highest and no cylinder reading should be less that 275 p.s.i. (1900 kPa).

1. Remove air cleaner.
2. Disconnect the wire from the fuel solenoid terminal of the injection pump.
3. Disconnect wires from glow plugs then remove all glow plugs.
4. Screw the compression gage J-26999-10 into the glow plug hole of the cylinder that is being checked.
5. Crank engine.

This should be done with six "puffs" per cylinder.

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

Piston Rings Leaking-Compression low on first stroke tends to build up on following strokes but does not reach normal.

NOTICE: Do not add oil to any cylinder to compression test as extensive damage may result.

6.2L NOZZLE AND HIGH PRESSURE FUEL LINES

The fuel from the injection pump is directed through the 8 high pressure lines to the fuel injection nozzles. To a large degree, the successful operation of the engine depends on these eight injector nozzles.

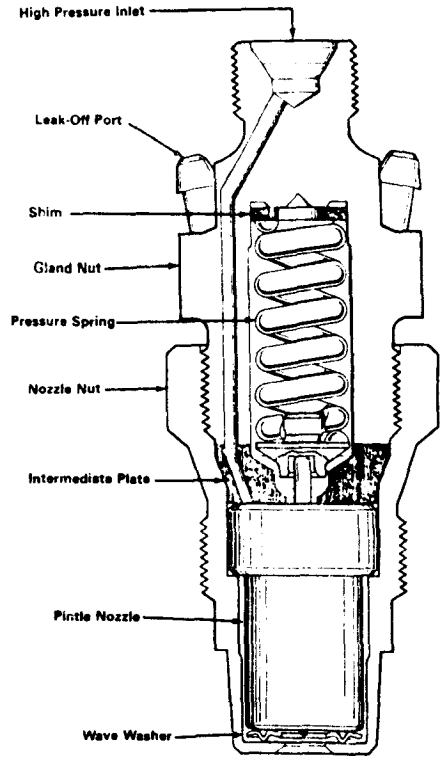
The injector nozzle for the 6.2L diesel is made by Robert Bosch. The G-Series nozzle is 10 mm shorter. The 1982 & 1983 nozzles are not interchangeable. This is due to thread pitch difference.

PINTLE INJECTOR NOZZLES — TRUCK

Metered fuel, under pressure from the injection pump, enters the nozzle and pressurizes the nozzle body. When the pressure in the nozzle body overcomes the spring force, the valve lifts off of its seat allowing fuel to spray into the prechamber.

During injection a small amount of fuel leaks through the clearance of the valve guide. This fuel flows through the fuel drain back nipple at the top of the nozzle and is returned to the fuel tank through the fuel return line.

The nozzle also has a bleed back path for bleeding excess fuel back to the gas tank. The nozzle allows only the amount of fuel to pass that is needed for engine operation.



The main purpose of the nozzle is to direct and to 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. Fuel is forced out into the precombustion chamber while the needle valve is lifted. The pressure required to open this injector needle valve is approximately 1850 p.s.i. As the fuel sprays into the precombustion chamber, the pump continues to turn and instantaneously closes off fuel to the nozzle. This action causes a rapid drop in fuel line pressure and spring pressure forces the needle valve to close and seat again, sealing off fuel from the pre-combustion chamber. The injector nozzle injects fuel once for every 2 revolutions of the crankshaft. This means that under normal driving conditions it will open and close about 1,000 times for every mile driven. In a 10-mile drive to and from work each day each injector nozzle would open and close approximately 10,000 times. In relation to time if you are driving 60 mph, each injector nozzle will open and close 1,000 times/minute. As you can readily see, the injector nozzle is a very critical component of the 6.2L diesel engine.

The Bosch nozzle at the present time will be serviced only as an assembly.

Tool J-29873 a 30 mm socket is used for R&R. There is a copper washer used to seal the outside from the combustion area. It must be replaced any time the injector is removed. Maximum pop-off is 135 bars (1960 p.s.i.) minimum pop-off 125 bars (1810 p.s.i. on new nozzles) leakage 105 bars (1520 p.s.i.).

INJECTION NOZZLE

Removal

1. Disconnect battery.
2. Disconnect fuel line clip.
3. Remove fuel return hose.
4. Remove fuel injection line.
5. Remove injection nozzle using tool J-29873.

NOTICE: When removing an injection nozzle, use tool J-29873. Be sure to remove the nozzle using the 30mm hex. Failure to do so will result in damage to the injection nozzle. Always cap the nozzle and lines to prevent damage and contamination.

Testing

Test is comprised of the following checks:
Nozzle Opening Pressure
Chatter
Leakage
Spray Pattern

If all of the above tests are satisfied, the nozzle holder assembly can be again installed in the engine without any changes. If any one of the tests is not satisfied, the complete nozzle holder assembly must be replaced. The nozzle holder will then be further checked and repaired at a centralized location.

- Test Lines — 6x2x400mm (1.5mm bore).
- Test Fluid per ISO 4113 (Example Shell V1399, Viscor 1487c or equivalent).
- Kinetic Viscosity at 40° per ISO 3104: 2.45...2.75mm^{44}/second.
- Test Oil Temperature during Test: 20-25°C (room temperature).
- Refer to the equipment manufacturers instructions for exact test procedures.

CAUTION: When testing nozzles, do not place your hands or arms near the tip of the nozzle. The high pressure atomized fuel spray from a nozzle has sufficient penetrating power to puncture flesh and destroy tissue and may result in blood poisoning. The nozzle tip should always be enclosed in a receptacle, preferably transparent, to contain the spray.

Test Sequence

Preparation

1. Connect the nozzle holder assembly to the test line.
2. Close the shutoff valve to the pressure gage.
3. Fill and flush the nozzle holder assembly with test oil by activating the lever repeatedly and briskly. This will apply test oil to all functionally important areas of the nozzle and purge it of air.

Obtaining Pressure Check

1. Open shutoff valve at pressure gage 1/4 turn.
2. Depress lever of tester slowly. Note at what pressure the needle of the pressure gage stopped, indicating an increase in pressure (nozzle does not chatter) or at which pressure the pressure dropped substantially (nozzle chatters). The maximum observed pressure is the opening pressure.
3. The opening pressure should not fall below the lower limit of 110 bar (1600 psi on used nozzles).
4. Replace nozzles which fall below the lower limit.

Leakage Test

1. Further open shutoff valve at pressure gage (1/2 to 1-1/2 turns).
2. Blow-dry nozzle tip.
3. Install two clear plastic lines (approximately 1-1 1/2") over leak-off connections.
4. Depress lever of manual test stand slowly until gage reads a pressure of 105 bar (1520 psi). Observe tip of nozzle. A drop may form but not drop off within a period of 10 seconds.
5. Replace the nozzle holder assembly if a droplet drops off the nozzle bottom within the 10 seconds.

Chatter Test

1. Close shutoff lever at pressure gage.
2. Depress lever of manual test stand slowly noting whether chatter noises can be heard.
3. If no chatter is heard, increase the speed of lever movement until it reaches a point where the nozzle chatters.
4. The chatter indicates that the nozzle needle moves freely and that the nozzle seat, guide, as well as the pintle, have no mechanical defects.

Spray Pattern

1. Close shutoff valve at pressure gage.
2. Depress lever of manual test stand downward abruptly and quickly. The spray should have a tight, evenly shaped conical pattern which is well atomized. This pattern should be concentric to the nozzle axis. Streamlike injections indicate a problem, and should be replaced.

Installation

1. Remove protective caps from nozzle.
2. Install nozzle and torque to 70 N·m (50 ft. lbs.).
3. Connect fuel injection line, torque nut to 25 N·m (20 ft. lbs.).

IDLE SPEED SETTING PROCEDURE (Fig. 4-16)

1. All idle speeds are to be set within 25 RPM of specified value.
2. Set parking brake and block drive wheels.
3. Engine must be at normal operating temperature. Air cleaner should be on and all accessories should be turned off.
4. Install, tool J-26925, diesel tachometer or equivalent per manufacturers instructions.
5. Adjust low idle speed screw on fuel injection pump to an engine speed of 650 RPM in neutral for automatic and manual transmissions. The head of the idle screw is orange.

EMISSION SYSTEMS

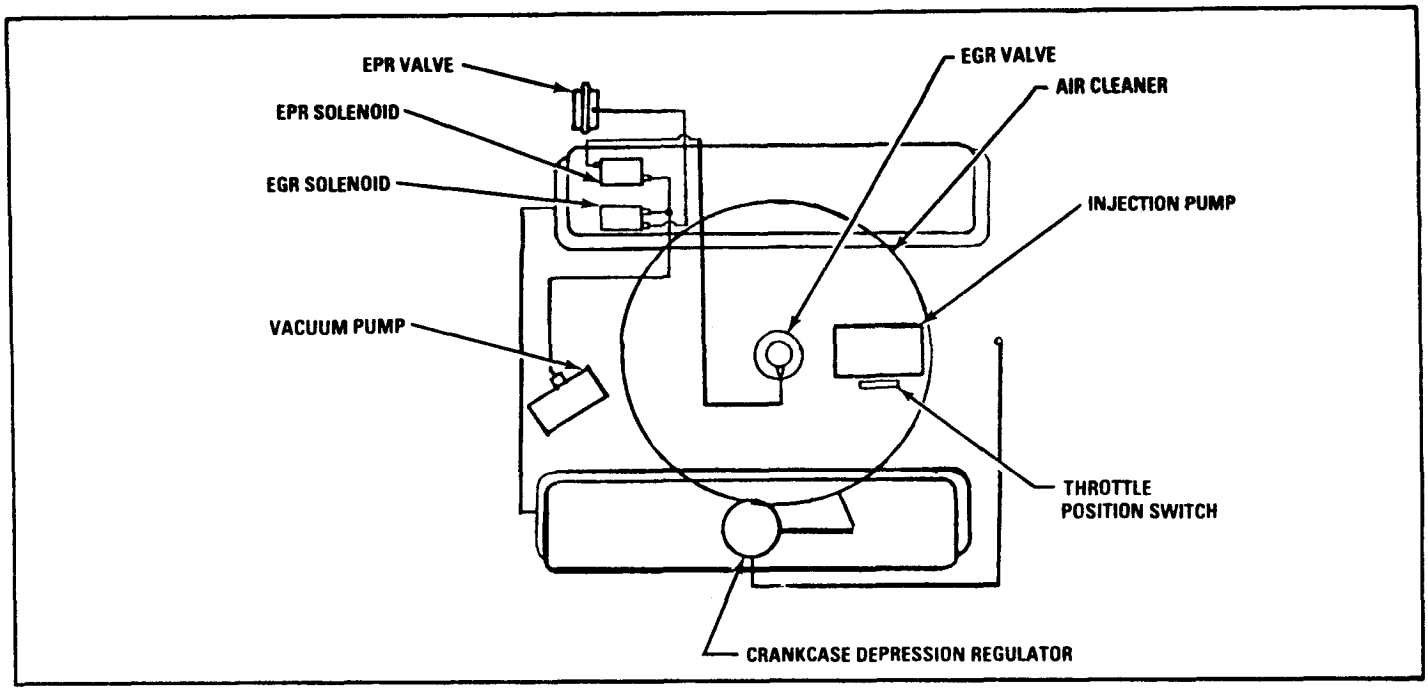


Fig. 5-1 Emission Systems

Emission Systems

1. Exhaust Pressure Regulator
2. Exhaust Gas Recirculation
3. Throttle Position Switch is used in conjunction with the EPR/EGR solenoids to activate them.
4. Crankcase Depression Regulator
5. Vacuum Pump

The EPR valve function is to increase exhaust back-pressure during idle in order to increase EGR flow to reduce NOx emissions. It is only used on the LH6 Lt. duty engine equipped with EGR. The EPR valve is normally open. See Fig. 5-2.

EGR is designed to control (Oxides of Nitrogen) NOx. This is done by blending the fuel-air with exhaust gases to reduce the peak temperatures and therefore reduce NOx. The O_2 content of this exhaust gas is quite low. This spent gas is run through an EGR valve to the manifold, and then is part of the air intake. This is introduced into the combustion chamber. It takes up some of the volume of the incoming charge of air. When ignition takes place, the spent exhaust gases cannot partake in the combustion process, since they have already been used previously, so they add nothing. As the flame travels in the cylinder, the temperature increases quite rapidly. The temperature rise cause the gases to expand. The temperature in the chamber is much higher than the

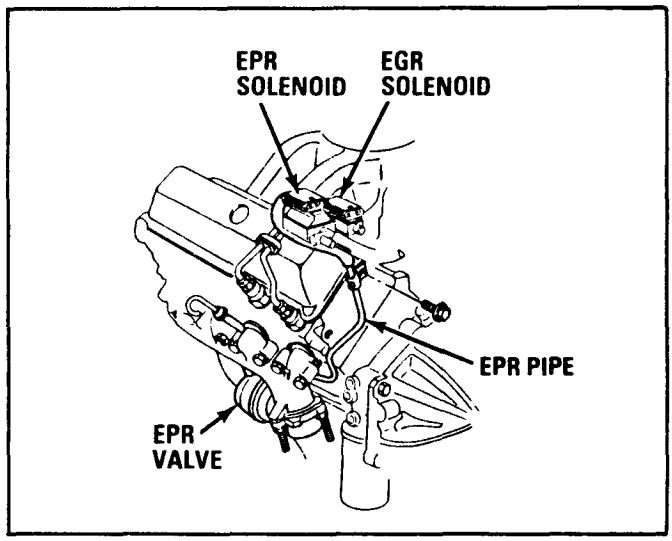


Fig. 5-2 EPR Valve

exhaust gases. The spent gases now take part in the process. They cannot add to the process because of lack of O_2. So the spent or inert gas acts as a sponge and pulls heat into itself causing it to expand. As it does it absorbs heat of combustion and drops the temperature approximately 500°F. Carbon monoxide is not a significant emission factor with diesels. Hydrocarbons are controlled by the injector nozzles, pump timing and combustion chamber design.

Vacuum Switched EPR (Fig. 5-2)

The EPR solenoid is normally closed. When energized by (B+) from the T.P.S. it is open allowing vacuum to the EPR, closing it. This occurs at idle. As the throttle is opened, at a calibrated throttle angle the TPS de-energizes the EPR solenoid, cutting off vacuum to the EPR valve and opening it.

Vacuum Switched EGR (Fig. 5-3)

With vacuum switched EGR, either full flow or no flow of exhaust gas is admitted to the intake manifold. At closed throttle the EGR valve is opened. The EGR valve remains fully open to a calibrated throttle position at which point it closes. The throttle position is sensed by a throttle position switch (TPS) mounted on the throttle shaft on the injection pump.

With TPS, as the throttle is opened the switch closes at the calibration point. It energizes a solenoid which is normally open. This cuts off the vacuum signal to the EGR valve, allowing the valve to close.

EGR is not used on the LL4 heavy duty version in the 20, 2500 & 30 & 3500 series trucks.

Fig. 5-3 Shows EGR Flow

The throttle position switch just has 2 contacts inside it: One to send (B +) at idle on a blue wire to the EPR solenoid which is N.C. and this opens the solenoid valve and closes the EPR valve. The other contact will send (B +) on a yellow wire to the EGR solenoid, at a specified throttle angle. The EGR solenoid is N.O. This current closes the EGR solenoid, closing the EGR valve. There is a delay on some switches in the time when the EPR opens and the EGR closes. There are three different cams used to change EPR/EGR switch points:

Blue Cam	0° Difference
Black Cam	5° Difference
Red Cam	10° Difference

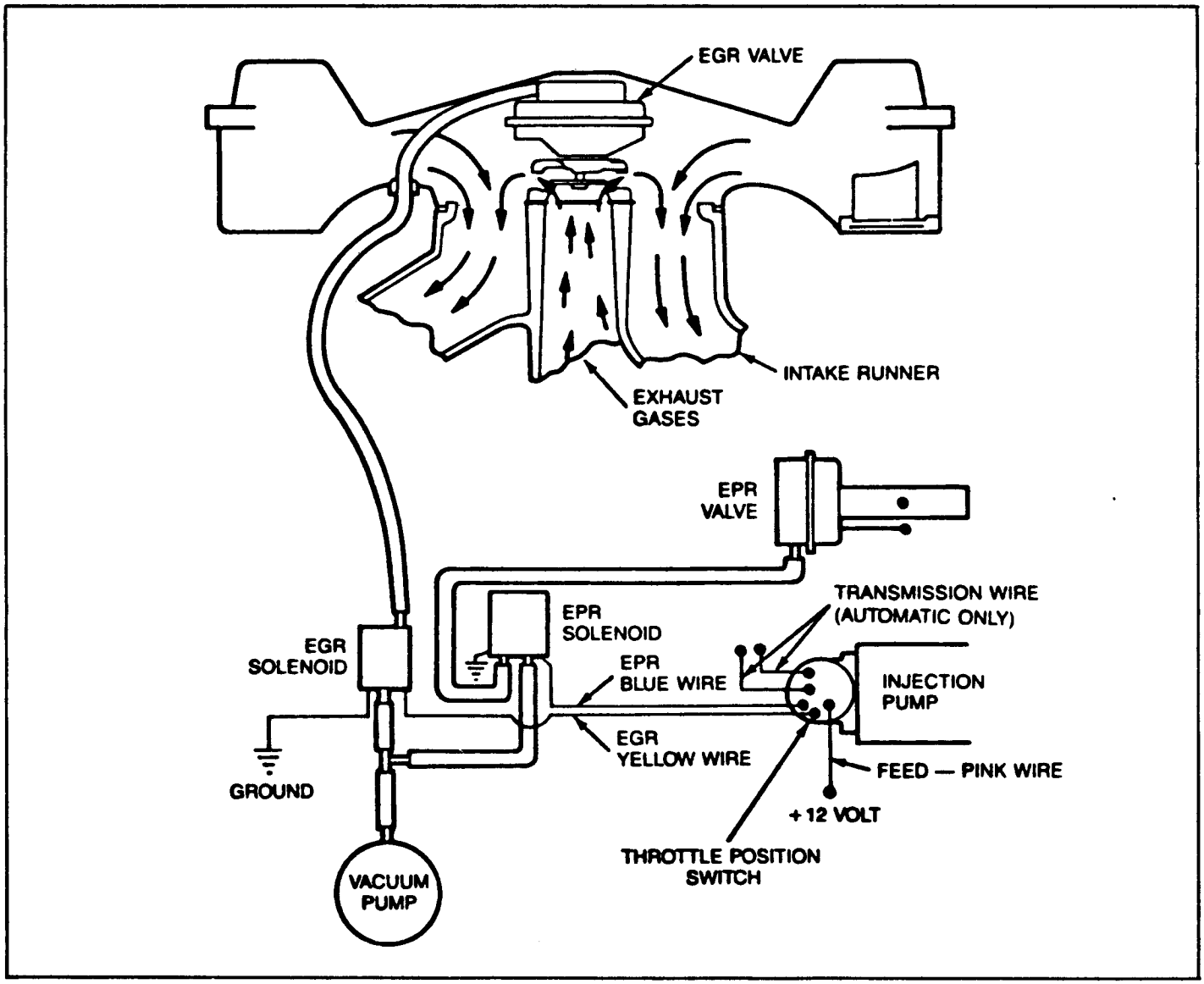


Fig. 5-3 EGR System

	Ft. Lbs.	(N•m)
ENGINE		
Injection Pump to Gear Bolts	13-20	18-27
Injection Pump Attaching Nuts	25-37	34-50
Injection Line Nut to Pump	15-24	20-32
Injection Line Nut to Nozzle	15-24	20-32
Injection Pump Fuel Filter Inlet Line	15-20	20-27
Injection Pump Fuel Filter Outlet Line	15-20	20-27
Injection Pump Fuel Inlet Line	15-20	20-27
Injection Nozzle to Cylinder Head	44-60	60-80
Glow Plug	8-12	11-16
Main Bearing Cap Bolts		
Inner	105-117	143-158
Outer	94-105	128-143
Oil Pump to Bearing Cap Bolts	59-74	80-100
Rocker Arm Shaft Bolt to Head	30-37	40-50
Valve Cover Bolts and Studs	13-20	18-27
Oil Pan Bolts	4-7	6-10
Oil Pan Rear Bolts	13-20	18-27
Crankshaft Balancer to Crankshaft Bolt	140-162	190-220
Front Cover to Cylinder Block	25-37	34-50
Fan Driven Pulley to Hub Bolts	15-20	20-27
Fan Clutch to Fan	15-20	20-27
Water Pump to Front Cover Bolts	25-37	34-50
Water Pump to Cover Bolts M8—1.25 x 35	15-20	20-27
Water Pump Plate to Front Cover	13-20	18-27
Water Pump Plate to Water Pump	13-20	18-27
Thermostat Housing Crossover to Head	25-37	34-50
Intake Manifold to Cylinder Head Bolts	25-37	34-50
Exhaust Manifold to Cylinder Head Bolts	18-25	25-35
Engine Mount to Cylinder Block Bolts	30-40	40-54
Engine Mount to Frame Mount	25-35	34-48
Vacuum Pump Clamp to Cylinder Block Bolt	25-37	34-50
Cylinder Head Bolts	92-107	125-145
Connecting Rod Nuts	44-52	60-70
Camshaft Sprocket Bolt	55-66	75-90

NOTES

NOTES

NOTES