DIESEL ENGINES

GROUP 22

6.9L — V-8 Diesel Engine

SECTION 22-08

APPLIES TO F-250 — F-350, E-250 — E-350

6.9L — V-8 Diesel Engine (Cont'd.)

SECTION 22-08

APPLIES TO F-250 — F-350, E-250 — E-350

DESCRIPTION AND OPERATION

Engine Description

Refer to Figs. 1 through 5.

The 6.9L diesel engine is a four cycle naturally aspirated V-8 with overhead valves. The right bank of cylinders are numbered 1, 3, 5, 7, with number 1 being at the front. The firing order is 1-2-7-3-4-5-6-8.

The crankcase has been especially designed to withstand the loads of diesel operation and utilizes a four bolt main bearing to assure a strong support for the rotating parts. The crankcase also has internal piston oil cooling jets which direct oil to the underside of the piston.

The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (NO. 3) bearing. Heavy-duty forged steel connecting rods are attached to the crankshaft, two to each bearing throw. The piston pin is a free floating type permitting the pin to move or float freely in piston and rod. The pin is held in place with pin retaining snap-rings.

The camshaft is supported by five insert-type bearings pressed into the block and is driven by a drive gear keyed to the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the camshaft drive gear.

The aluminum-alloy pistons are fitted with two compression rings and one oil ring.

The hydraulic valve tappets minimize engine noise and maintain zero valve lash or tappet clearance. This eliminates the need for periodic adjustment. The hydraulic valve tappets also incorporate camshaft roller followers for improved camshaft wear characteristics.

The cylinder head assemblies feature pre-combustion chambers which provide superior combustion characteristics. The cylinder heads used on the engine are equipped with positive valve-rotating mechanisms

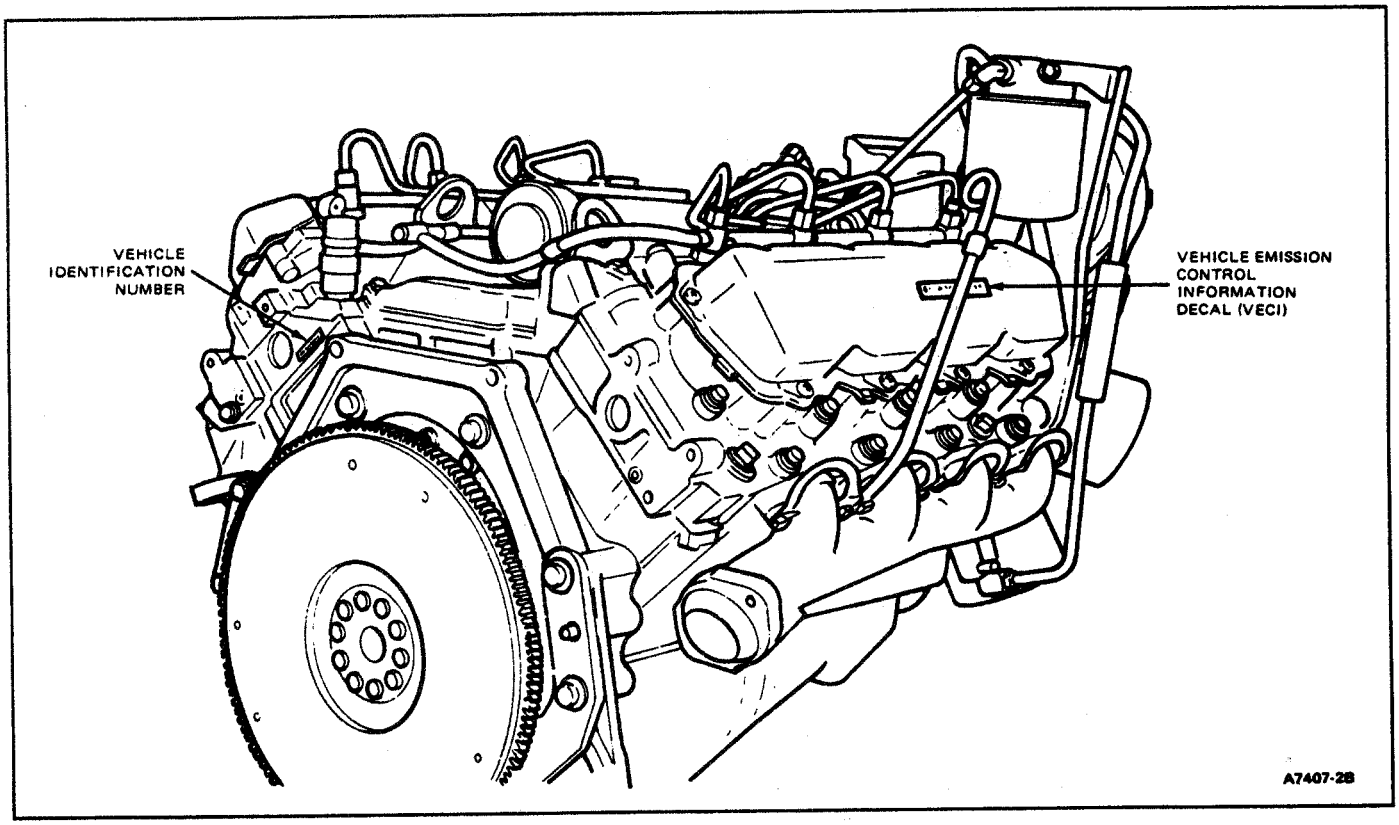

FIG. 1 6.9L Diesel—Right Side—F-150—F-250 Shown, E-150—E-350 Similar

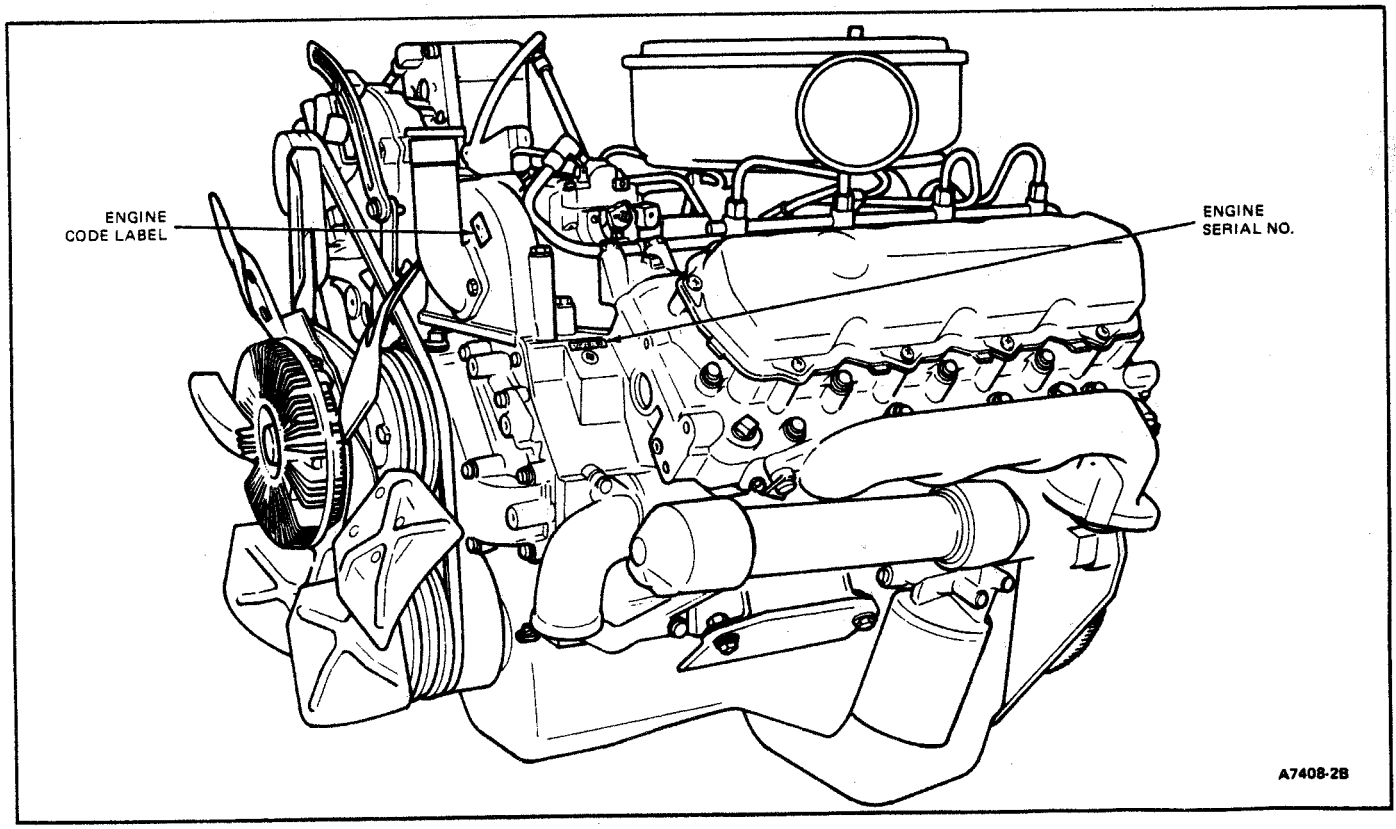

FIG. 2 6.9L Diesel—Left Side—F-150—F-350 Shown, E-150—E-350 Similar

located at the bottom of the intake and exhaust valve springs.

The engine is equipped with a fully closed crankcase ventilation system. The crankcase depression regulator (CDR) valve is mounted on the intake manifold and provides a connection between the valley pan and the intake manifold, to regulate crankcase pressure.

The rotary-type injection pump is located between the cylinder heads in a recess in the front of the engine. The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are also provided in this Section.

Coolant Flow

Coolant flows from the water pump to the engine right and left banks (Fig. 6).

Circulation of the coolant is from the front to the rear of the crank-case. Coolant flows from crankcase to the cylinder head via positive cooling passages and through one passage at the rear bulkhead of the cylinder head, and one at the front. Coolant flows between the pre-combustion chambers and valve seats and towards the front. Coolant exits the cylinder head into a common cavity which runs across the front of the crankcase then to the thermostat housing. When the thermostat is closed, coolant bathes the thermostat and runs through the bypass orifice which is located below the thermostat. No coolant is allowed to leave the crankcase.

Also when the thermostat is closed, the heater coolant flow assembly (Fig. 6, View A) reduces coolant flow and pressure to the heater core. This provides for quick engine warmups. When the coolant reaches 105°C (190°F) the thermostat begins to open, and at the same time the bottom of the thermostat moves closer to the bypass orifice, the volume of coolant allowed to bypass is decreased, and coolant is allowed to return to the radiator.

Lubrication System

Lubrication oil is drawn out of the sump through the pick up screen and oil pick up tube to the oil pump (Fig. 7). Oil pump flow is 45.4 liters (12 gallons) per minute at rated speed and a pressure of 414 kPa. From the oil pump oil is passed via drilled passageways in the crankcase to the oil cooler adapter then through the oil cooler. Oil flows around the outside of the heat exchanger tubes. (Coolant flows through the tubes). The oil passes around the tubes rearward to the oil filter header. At the oil filter header the oil meets the pressure regulating valve. This regulates the oil pressure to the oil filter and the engine oil galleries. The rear oil filter header also has a bypass valve which will open if the oil filter should become clogged. Five cross passages distribute oil to verticle passages which feed crankshaft main bearings, camshaft bearings and two tappet galleries. The piston cooling jets are fed from the same passage as the valve tappets. The connecting rod bearings are fed from the main bearings via drilled passages in the crankshaft. The timing gears are lubricated by oil splash. Oil passes through the hydraulic tappet rollers and up the hollow pushrods to lubricate the rocker arm assemblies and valve stems.

Fuel Flow

Fuel from the tank (under suction) is routed through the fuel water separator to the fuel pump (Fig. 8). It then passes through a fuel heater which reduces the formation of wax while the engine is running. This allows the use of more economical winter blend number 2 diesel fuel in cool weather.

Fuel then passes through the engine fuel filter. Properly filtered diesel fuel cannot be overemphasized. It is essential for long component life and reliability.

The Fuel Shut-Off solenoid controls the flow of fuel into the injection pump. With the ignition switch in Start or Run, the solenoid is energized and fuel is allowed to flow to the injection pump. With the ignition switch Off, fuel flow to the injection pump stops.

Fuel entering the injection pump is metered and delivered under high pressure through injection lines to injection nozzles (Fig. 3). The nozzles atomize this fuel into the cylinders for combustion. On each nozzle is a fuel return fitting that returns excess fuel to the fuel tank.

Injection Pump

The function of the diesel fuel injection pump is to accurately meter and deliver fuel to a nozzle in each cylinder at high pressure and at precisely timed intervals.

The injection pump is an opposed plunger, inlet metered, positive displacement, distributor type pump. The pump incorporates a single pumping chamber, an integral fuel transfer pump and governor, and an automatic injection advance mechanism. On-off control is provided by means of an electric solenoid located in the housing cover.

Operating principles of the pump can be understood by following the fuel circuit through a complete pump cycle (Fig. 9). Fuel flows into the injection pump inlet through the inlet filter screen (1). Fuel then flows to the vane type fuel transfer pump (2). Excess fuel from the transfer pump is bypassed through the pressure regulator assembly (3) to the suction side.

Fuel under transfer pump pressure flows through the center of the transfer pump rotor, past the rotor retainers (4) into the hydraulic head. It then flows through a connecting passage (5) in the head to the automatic advance (6) and up through a radial passage (8) to the metering valve. The position of the metering valve, controlled by the governor, regulates flow of the fuel into the radial charging passage (9) which incorporates the head charging ports. As the rotor revolves, the two rotor inlet passages (10) align with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber. With further rotation, the inlet passages move out of alignment and the discharge port of the rotor aligns with one of the head outlets. While the discharge port is opened, the rollers (11) contact the cam lobes forcing the plungers together. Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

In addition, an air vent passage (12) in the hydraulic head connects the outlet side of the transfer pump with the pump housing. This allows air and some fuel to be bled back to the fuel tank via the return line. The fuel thus bypassed fills the housing, lubricates the internal components, cools and carries off any small air bubbles.

Injection Nozzle Assemblies

Description

The injection nozzles are of the inwardly opening, differential, hydraulically operated, pintle type. Their function is to direct a metered amount of fuel, under high pressure from the fuel injection pump, into the engine combustion chamber.

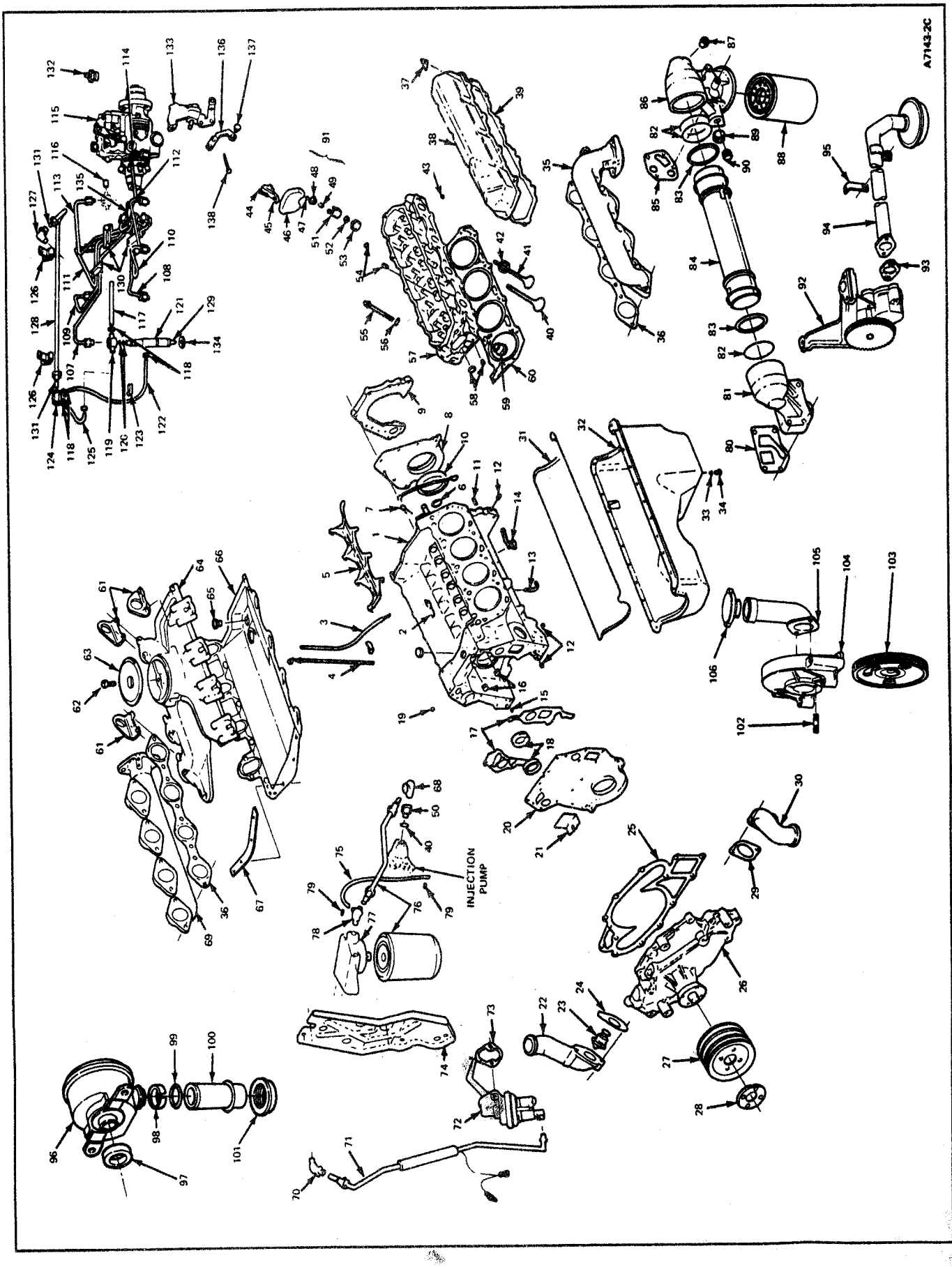

FIG. 3 Exploded External View

REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION
1	6009H	Cylinder Block Assy.	47	6518A	Key Valve Spring Retainer	93	6626	Gasket, Oil Pick-Up
2	6C329A	Guide, Tappet	48	6514A	Retainer, Valve Spring	94	6622	Pick-Up Tube
3	6754D	Tube Assembly, Oil Level Indicator	49	9N693A	Ring Sealing	95	6A661	Bracket, Oil Pick-Up
4	6750D	Indicator Assembly, Oil Lever	50	9B254A	Filling, Tube Adapter	96	6A665	CDR Valve
5	6C330A	Retainer, Tappet Guide	51	6513B	Spring, Valve, with Damper	97	6A892	Seal Ring, CDR Valve
6	6026A	Plug, Engine	52	6571A	Seal, Valve Stem	98	6C609	Back-Up Ring, CDR Valve
7	6D083A	Gasket, Rear Cover	53	6K533A	Rotator, Assembly Valve	99	6C608	O-Ring
8	6L080A	Cover Assembly, Engine, Rear	54		Plug, 1/2 Inch	100	6758	Crankcase Vent Tube
9	6A369A	Adapter, Flywheel to Transmission	55	6065A	Bolt Cylinder Head	101	6769	Grommet, Valley Cover
10	6701A	Rear Oil Seal, Crankshaft	56	6L015A	Washer, Cylinder Head Bolt	102	9F733	Mounting Stud, Injection Pump
11	6B041B	Dowel Pin, Rear Cover Plate	57	6049A	Cylinder Head Assembly	103	9A546	Drive Gear, Injection Pump
12	87614S	Pipe Plug, 1/8 NPTF	58	6026B	Plug, 1/4 Inch	104	9C516	Adapter Housing, Injection Pump
13	6C327A	Piston Cooling Jet	59	6057A	Insert, Combustion Chamber	105	6763	Elbow, Oil Filler
14	6A051A	Heater Assembly, Block	60	6051B	Gasket, Cylinder Head	106	6766	Cap, Oil Filler
15	6B041A	Dowel Pin, Front Cover Plate	61		Eye, Lifting	107	9A555H	Pipe w/Nuts Pump to Cyl. 8
16	6026E	Cup Plug	62	9C629A	Insert, Bolt Thread	108	9A555G	Pipe w/Nuts Pump to Cyl. 7
17	6020A	Gasket, Front Cover Plate	63	9F460A	Shield, Intake Manifold	109	9A555F	Pipe w/Nuts Pump to Cyl. 6
18	6A251A	Bearing Kit, Camshaft	64	9424B	Manifold, Intake	110	9A555E	Pipe w/Nuts Pump to Cyl. 5
19	6A628A	Ball, Oil Indicator Hole	65	9A450A	Drain Plug, Valley Pan	111	9A555D	Pipe w/Nuts Pump to Cyl. 4
20	6B070A	Plate, Front Cover	66	9439B	Gasket and Valley Pan	112	9A555C	Pipe w/Nuts Pump to Cyl. 3
21		Indicator, Timing (Part of Front Cover)	67	9B470A	Strap, Valley Pan	113	9A555B	Pipe w/Nuts Pump to Cyl. 2
22	8592G	Connection, Water Outlet	68	9B253A	Elbow	114	9A555A	Pipe w/Nuts Pump to Cyl. 1
23	8575A	Thermostat	69	9430A	Manifold, Exhaust, Right	115	9A543	Injection Pump
24	8255A	Gasket, Water Outlet	70	9B253B	Elbow, 3/8 Inch Tube	116	9F737	Fuel Return Cap
25	8507A	Gasket, Water Pump	71	9C330A	Tube Assembly, Fuel Pump to Filter	117		Hose
26	8501D	Water Pump	72	9350B	Pump, Fuel Supply	118	9B255	Clip
27	8509D	Pulley, Water Pump	73	9417A	Gasket, Fuel Supply Pump	119	9A564	Fuel Return Tee
28	8546A	Spacer, Fan	74	9180C	Bracket, Fuel Filter	120	87032-S92	O-Rings
29	8255A	Gasket, Water Inlet	75	9324A	Hose Fuel Return (3/16" ID x 13" Long)	121	9E527	Injection Nozzle Holder
30	8592D	Connection, Water Inlet	76	9155A	Fuel Filter	122		Fuel Return Hose
31	D6AZ-19562-A	RTV Sealant	77	9B249A	Header, Fuel Filter	123	9N659	Clamp
32	6675C	Oil Pan	78	9C402B	Elbow, Fuel Return	124	9F734	Fuel Return Junction Fitting
33	6734A	Gasket, Oil Pan Drain	79	9B255A	Clip, Hose	125		Hose
34	6730A	Plug, Oil Pan Drain	80	6A636A	Gasket, Oil Cooler, Front Header	126	9N659	Clamp
35	9431B	Manifold, Exhaust, Left	81		Header, Oil Cooler, Front	127	9F736	Elbow
36	9448A	Gasket Exhaust Manifold	82	6K649A	O-Ring, Oil Cooler	128	9D308	Tube
37	6A532A	Washer, Valve Cover	83	6C610A	O-Ring, Oil Cooler	129		Nozzle Tip
38	6582C	Valve Cover	84	6A642A	Cooler, Oil	130	9N653	Clamp
39	6584A	Gasket, Valve Cover	85	6A636B	Gasket, Oil Cooler, Rear Header	131	9C387	Ring
40	6507D	Valve, Intake	86	6881B	Header, Oil Cooler, Rear	132	9E939	Temperature Switch
41	6505D	Valve, Exhaust	87	6K862A	Plug, 1/4 Inch	133	12B526	Bracket and Solenoid
42	6057B	Insert, Exhaust Valve Seat	88	6731A	Oil Filter	134		O-Ring
43	6026F	Plug, Ball Type	89		Plug, 1/2 Inch	135	9N653	Clamp
44	6A527A	Bolt, Valve Rocker Arm Support	90		Plug, 1/2 Inch	136	9F541	Kickdown Lever (Auto. Trans.)
45	6F040A	Post, Rocker Arm	91	6514	Retainer Assy.	137	9D927	Screw, Kickdown Lever
46	6564A	Rocker Arm	92	6600	Oil Pump Assy.	138	9F539	Adjusting Screw (Kickdown Lever)

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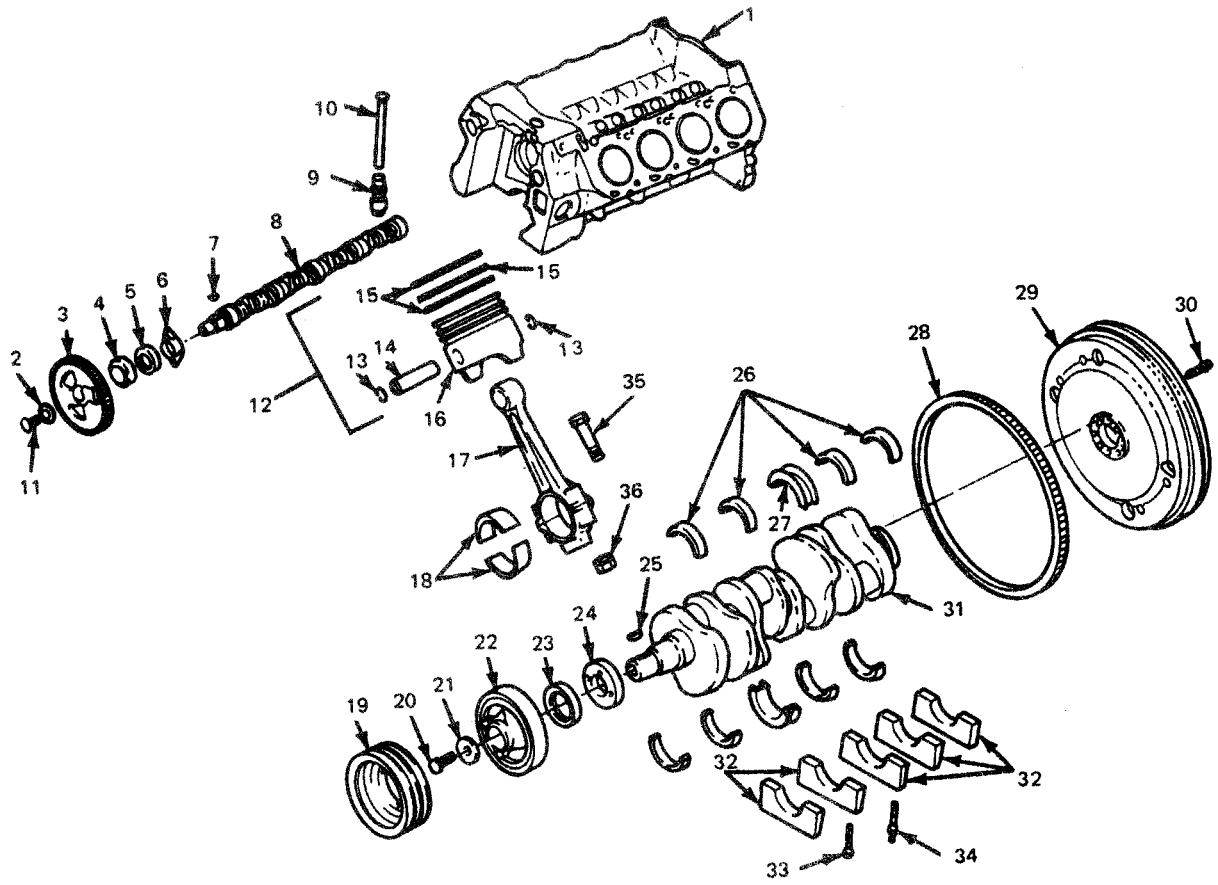
FIG. 3A Exploded External View—Key



REF. NO.	BASIC PART NO.	DESCRIPTION	REF. NO.	BASIC PART NO.	DESCRIPTION
1	6009H	Cylinder Block Assembly	19	6A312A	Pulley, Crankshaft
2	6278A	Washer, Camshaft	20		Bolt, Hex Head
3	6256A	Gear, Camshaft	21	6278B	Washer, Crankshaft
4	6287A	Eccentric, Fuel Pump	22	6379A	Damper, Crankshaft
5	6265A	Spacer, Camshaft Gear	23	6700A	Seal, Crankshaft Front Oil
6	6269A	Camshaft Thrust Plate	24	6306A	Gear, Crankshaft Drive
7	6L269A	Key, Camshaft Alignment	25	6B316A	Key, Crankshaft Alignment
8	6250B	Camshaft	26	6333A	Bearing, Crankshaft
9	6500A	Tappet Valve	27	6337A	Bearing, Crankshaft Thrust
10	6565A	Push Rod	28	6384A	Ring Gear, Flywheel
11	6K252A	Bolt, Camshaft Drive Gear	29	6375C	Flywheel
12	6108AA	Set, Piston, Pin, Rings	30	6379A	Bolt, Flywheel to Crankshaft
13	6140A	Retainer, Piston Pin	31	6303A	Crankshaft (with Bearings)
14	6135B	Piston Pin	32		Bearing Cup (Part of Cyl. Block Assy.)
15	6148D	Rings	33	6345A	Bolt, Bearing Cap
16		Piston (Not Available Separately)	34	6345B	Stud, Bearing Cap
17	6200A	Connecting Rod	35	6214A	Bolt, Connecting Rod
18	6211A	Bearing Kit, Connecting Rod	36	6212A	Nut, Connecting Rod

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FIG. 4 Exploded Internal View

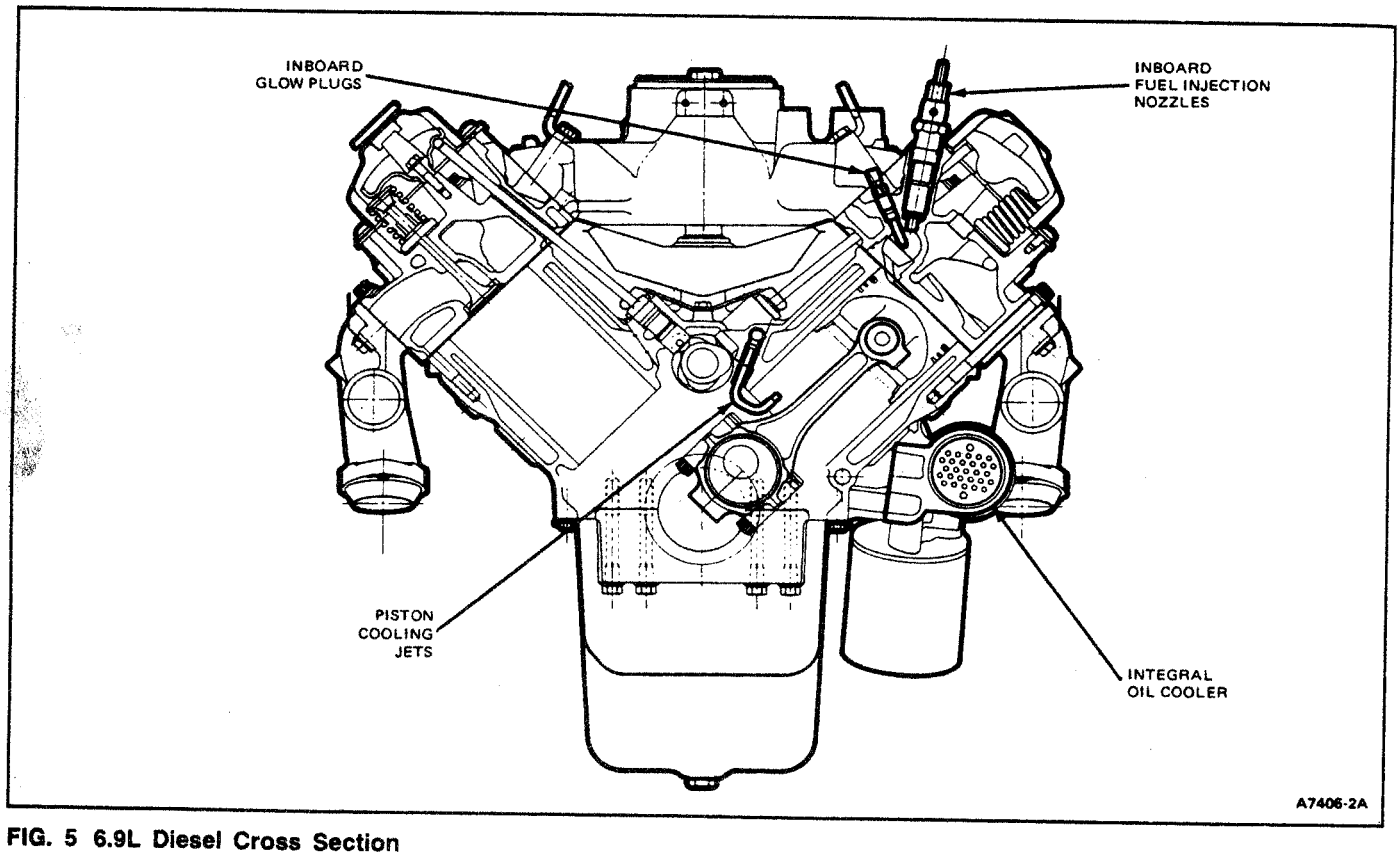


FIG. 5 6.9L Diesel Cross Section

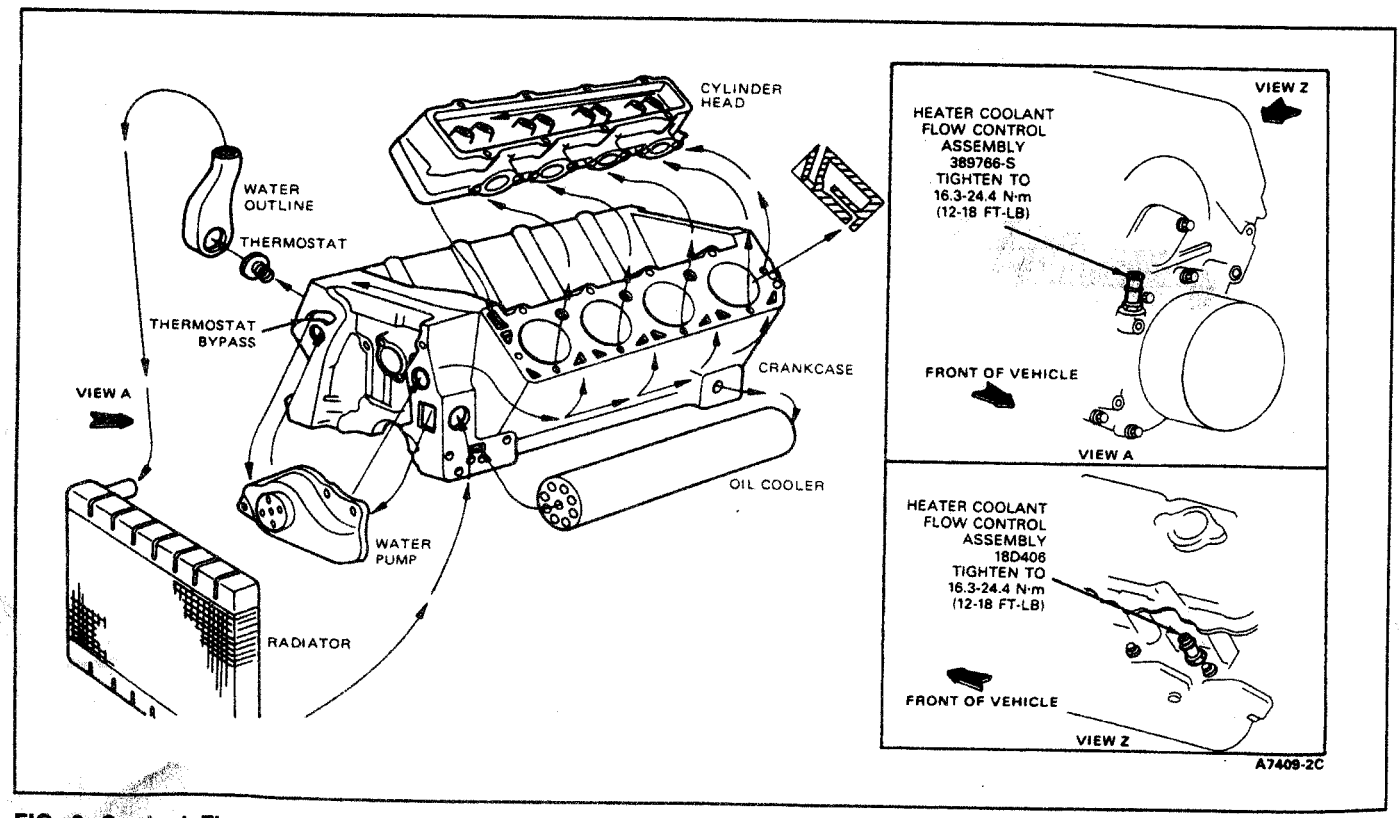


FIG. 6 Coolant Flow

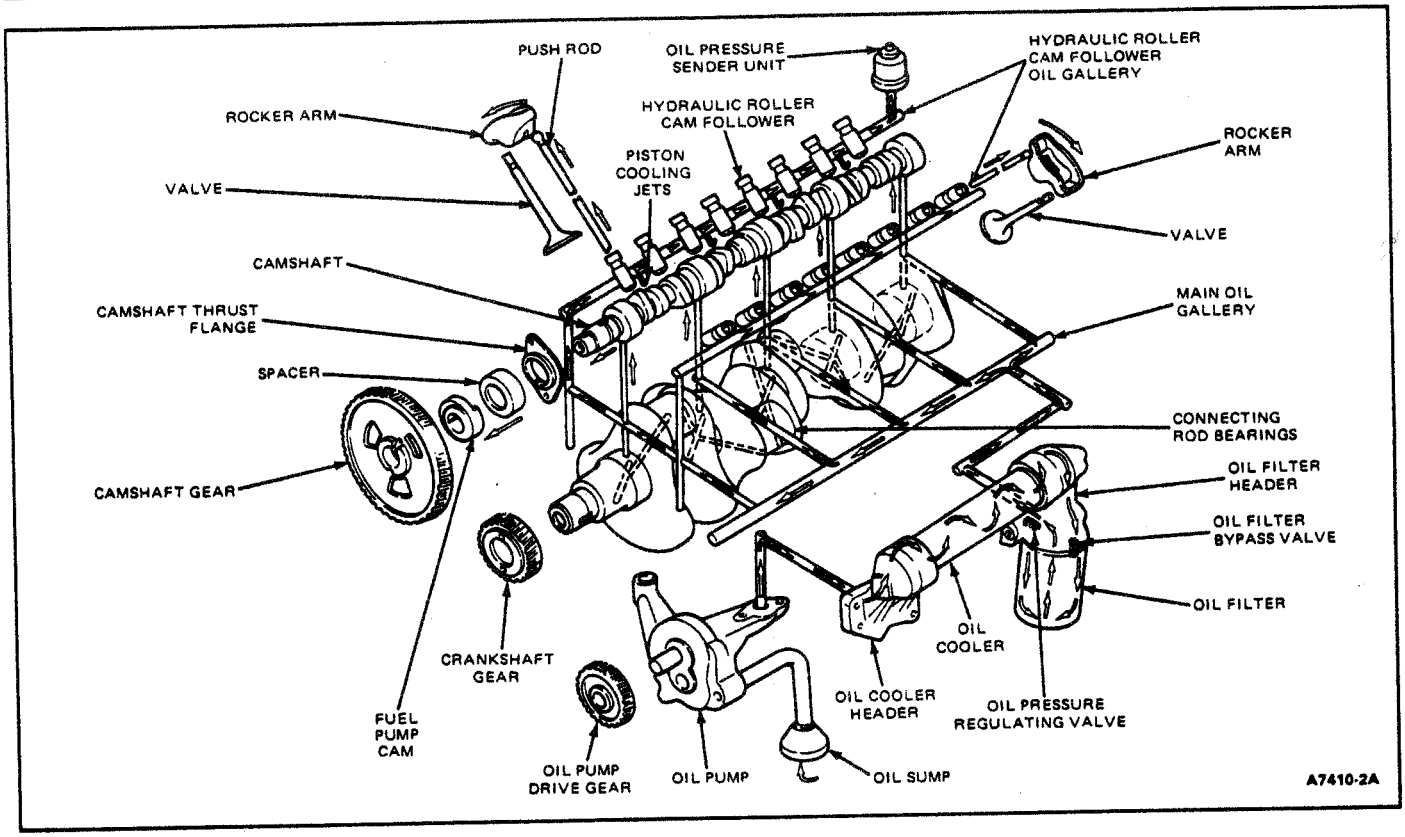


FIG. 7 Oil Flow

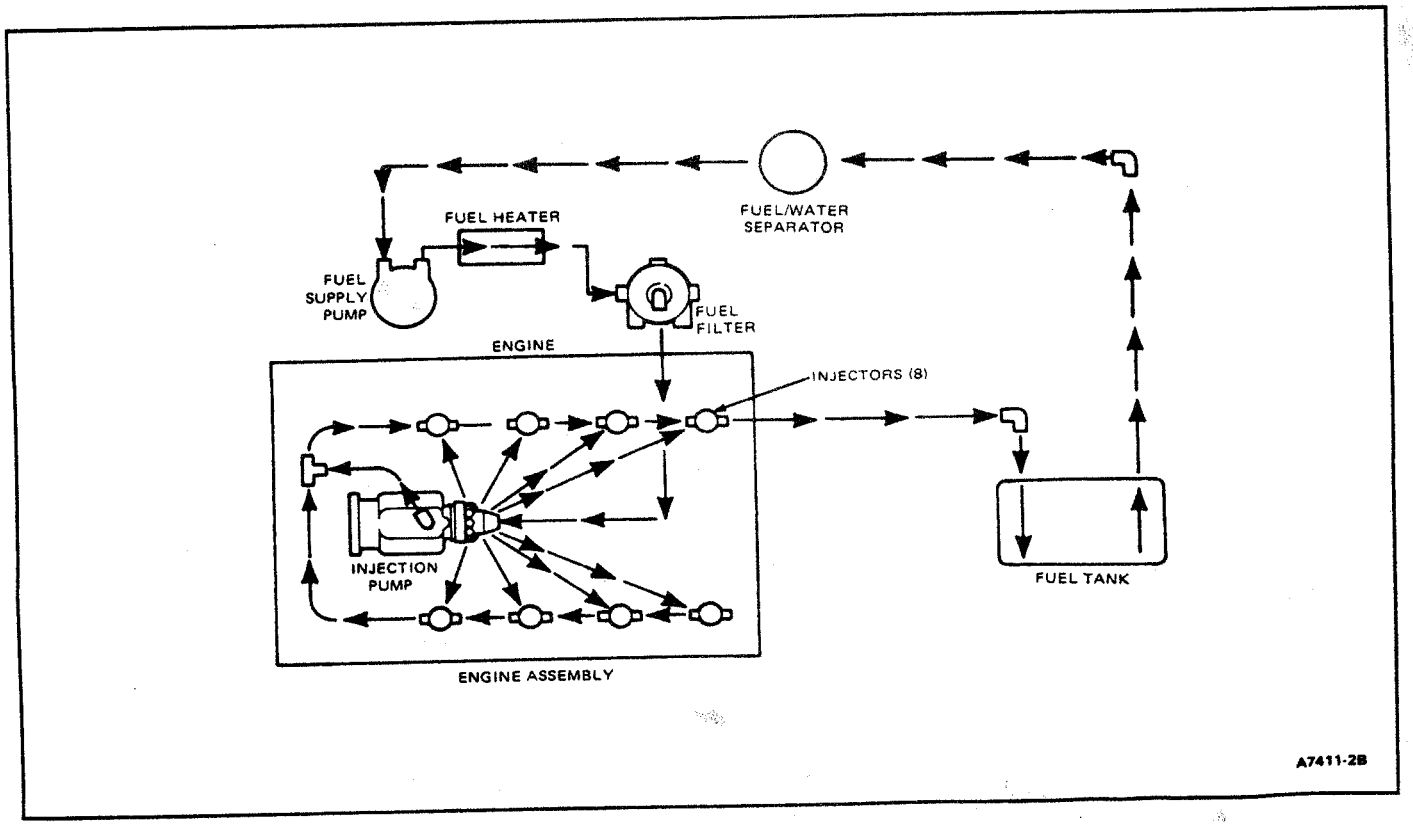


FIG. 8 Fuel Flow

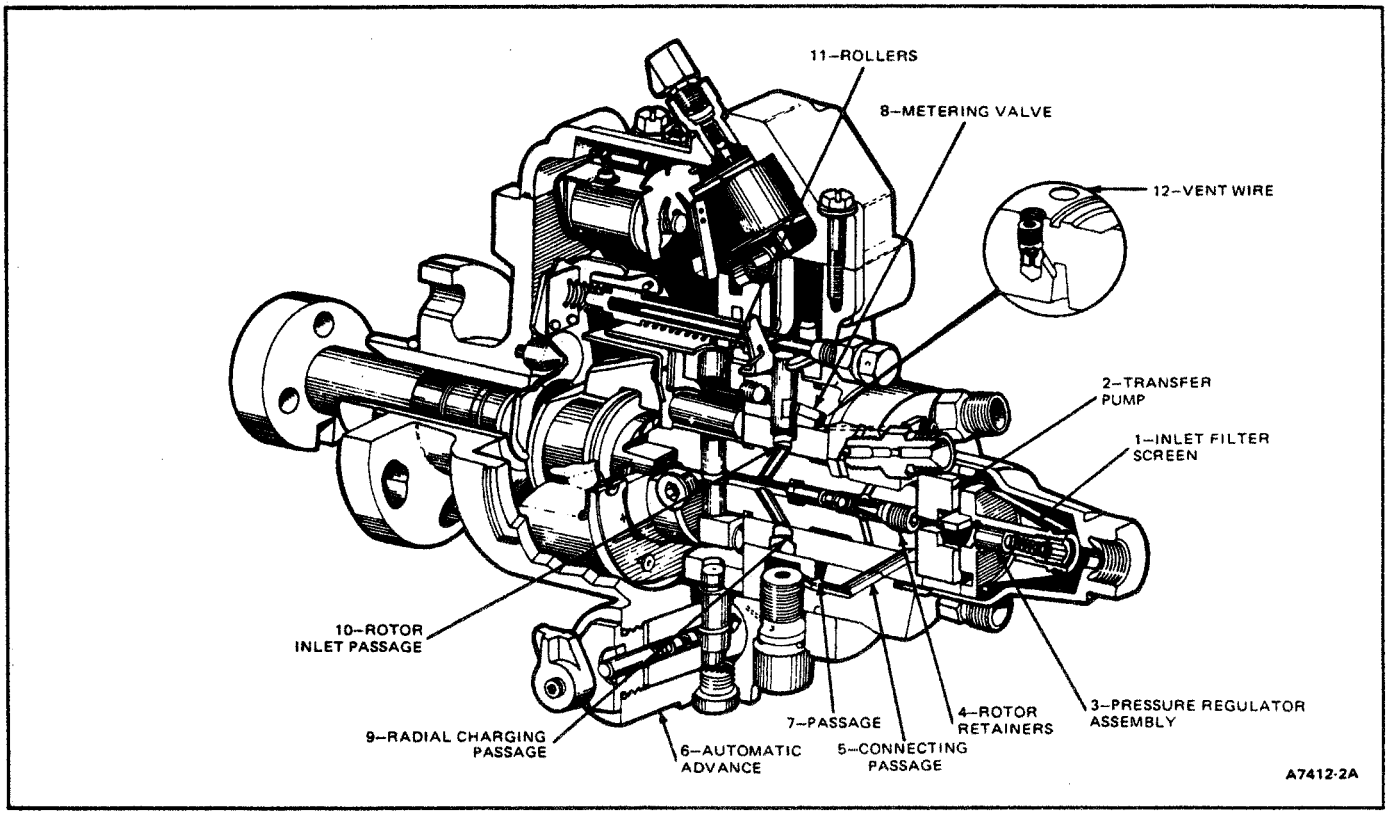


FIG. 9 Injection Pump Internal View

The injection nozzle assembly consists of two sub-assemblies; the nozzle and the nozzle holder. Fig. 10 illustrates a section view of the injection nozzle assembly.

Nozzle Holder

The nozzle holder is used to hold the nozzle in its correct position in the cylinder head and to provide channels for conducting diesel fuel to the nozzle.

Nozzle

The nozzle consists of two parts; nozzle body and nozzle valve. These parts are lapped to form an extremely close-fitting matched set.

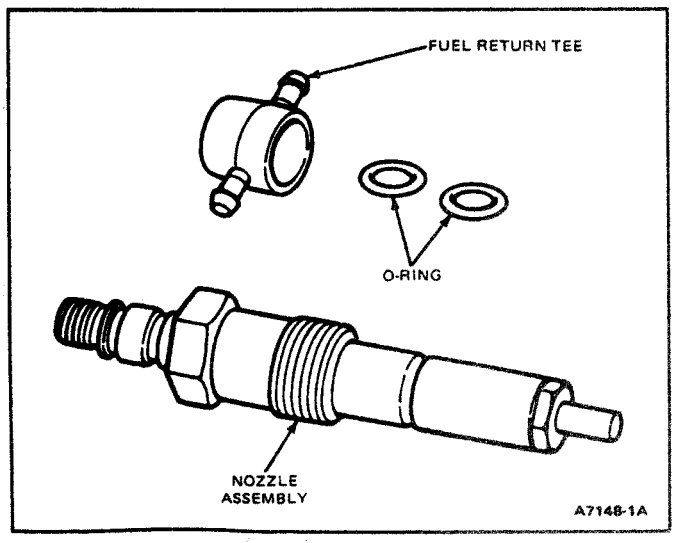


FIG. 10 Injection Nozzle Assembly

The nozzle valve carries an extension at its lower end, called the pintle, which protrudes through the closely fitting hole in the bottom nozzle face. This construction requires the fuel to pass through an annular orifice, thus producing a hollow, cone-shaped spray.

Operation

Operation of the injection nozzle assembly is simple and positive. The metered quantity of fuel from the injection pump enters the nozzle holder through the inlet fitting and passes through ducts to the pressure chamber just above the nozzle valve seat. At the instant the pressure of fuel acting on the differential area of the valve exceeds a predetermined spring load, it lifts the valve from its seat and fuel flows from the nozzle until delivery from the injection pump ceases. Positive cut-off of fuel occurs as the valve is seated by the nozzle spring. A small amount of fuel leakage to the spring cavity is necessary for lubrication. This fuel leakage accumulates in the spring cavity and drains through to the leak-off outlet provided for this purpose.

Nozzles opening pressure and spray pattern should be inspected every 96,500 km (60,000 mi.). Refer to Nozzle Testing in the Engine/Emissions Diagnosis Manual.

Glow Plug Fast Start System

Refer to Figs. 11 and 12.

The 6.9L diesel engine utilizes an electric glow plug system to aid in the start of the engine. The function of this system is to pre-heat the air in the combustion chamber to aid ignition of the fuel.

The system consists of eight glow plugs (one for each cylinder), Controller Cycling switch, After-Glow Timer, Power relay, circuit breaker, two fusible links located between the Power relay and the glow plug harness (one

for each bank of four glow plugs), Glow Plug Indicator Lamp and a wiring harness which incorporates eight fusible wires (one for each glow plug) located between the wiring harness and the glow plug terminal.

On initial start with cold engine, the glow plug system operates as follows:

When the ignition switch is turned to Run, voltage is applied through the Glow Plug Controller to the Glow Plug Power relay. The contacts in the relay close, and voltage is applied to the Glow Plug Indicator Lamp, the glow plugs and the Controller Cycling switch. The glow plugs are heated from zero to nine seconds, depending on engine temperature, then the Controller Cycling switch opens, and voltage to the Glow Plug Power relay is cut off. This opens the relay contacts, turning Off the Glow Plug Indicator Lamp and the glow plugs. The glow plugs are now warm enough for the engine to be started.

CAUTION: Hard starting will result if the ignition switch is left on for over two minutes without starting the engine. The afterglow switch will have opened, stopping the glow plugs and glow plug indicator from cycling. The glow plugs can be reset to continue cycling if the ignition switch is turned Off for approximately one minute to allow the glow plug timer to cool down and close.

At the same time the ignition switch is turned to Run, voltage is applied to the After-Glow Timer. The After-Glow Timer is heated for up to two minutes, depending on engine temperature. The After-Glow switch then opens.

During the time the After-Glow Timer is heating up, the Controller Cycling switch cycles On and Off, turning the Glow Plug relay On and Off. This keeps the glow plugs hot, helping the engine run smoother and cutting down on smoke during warm up. This also cycles the Glow Plug Indicator Lamp On and Off. The cycling stops when the After-Glow Timer switch opens or sooner if the engine reaches approximately 165°F.

The Glow Plug Controller includes a circuit breaker to protect the glow plugs from overheating if the Controller Cycling switch stays closed. In the event the Controller Cycling switch stays closed approximately two seconds longer than it was supposed to, the circuit breaker opens, cutting of voltage to the Glow Plug relay and glow plugs. The Glow Plug Controller (the brain of the operation) is threaded into the left cylinder head coolant jacket. The control unit senses engine coolant temperature. Since the control unit senses temperature and glow plug operation the glow plug system will not be activated unless needed. On a restart (warm engine) the glow plug system will not be activated unless the coolant temperature drops below 91°C (165°F).

The fast start system utilizes 6 volt glow plugs in a 12 volt system to achieve rapid heating of the glow plugs. To prevent overheating of the glow plug, a cycling device is required in the circuit.

CAUTION: Never bypass the power relay of the glow plug system. Constant battery current (12 volts) to glow plugs will cause them to overheat and fail, possibly resulting in severe engine damage.

Vehicle and Engine Identification

Vehicle identification, the location of the vehicle rating and data plates and engine code information is fully covered in Section 20-00, Identification Codes. For specific and exact engine identification a decal label (Fig. 13) is located on the front of the injection pump gear housing (Fig. 2).

Always refer to this label when replacement parts are required or when checking engine calibrations. Some engine parts vary with engine application and vehicle type. The identification codes will insure that the proper parts are obtained. The codes contain all pertinent information relating to dates, optional equipment and revisions. The Ford Master Parts Catalog contains a complete listing of the codes and their application. In addition, an engine serial number tag is located on the front of the engine block (Fig. 2).

DIAGNOSIS AND TESTING

Diagnostic Procedures—Engine Components

Engine Oil Leaks

When diagnosing engine oil leaks, it is important that the source and location of the leak be positively identified before any repairs are made. The following procedure has been found to be very effective and requires only a minimum of equipment available in most dealerships. Prior to using this procedure, it is important to clean the cylinder block, cylinder head(s), rocker cover(s), oil pan and flywheel housing areas with a suitable solvent to remove all traces of oil.

CAUTION: Do not wash or steam clean the engine with engine running. Serious damage to the injection pump could result.

To perform oil leak diagnosis use Rotunda Model 072-00007 (Fig. 14) or equivalent.

CAUTION: Do not use an air pressure leak test kit for diagnosing engine oil leaks. Loss of sealing may result at the valley pan seal.

To perform oil leak diagnosis use Rotunda Model 072-00007 Oil Leak Detector Kit (Fig. 14), or equivalent, and Rotunda 072-00008 fluorescent dye.

1. Open two containers of dye by cutting off end of spout and empty entire contents of containers into crankcase.

CAUTION: Dye may cause irritation. Avoid contact with skin or eyes. Wash thoroughly after handling.

2. Drive vehicle for five to ten miles at various road speeds.
3. Turn on spot lamp. (Lamp requires 3-5 minutes to warm up).
4. Open hood. Remove air cleaner and install intake manifold cover, Tool T83T-9424-A, over intake manifold opening.
5. Inspect sealed and/or gasketed areas for leaks with the spot lamp. A leak will appear as a bright contrasting yellow-green fluorescence. Examine the following areas, as required:

Under Hood

a. Valve cover gaskets and around bolts.
b. Crankcase front cover gaskets.
c. Front and rear valley pan end seals.
d. Cylinder head gaskets.
e. Injection pump mounting adapter to crankcase.
f. Injection pump to adapter.
g. Front oil fill tube and oil fill cap.

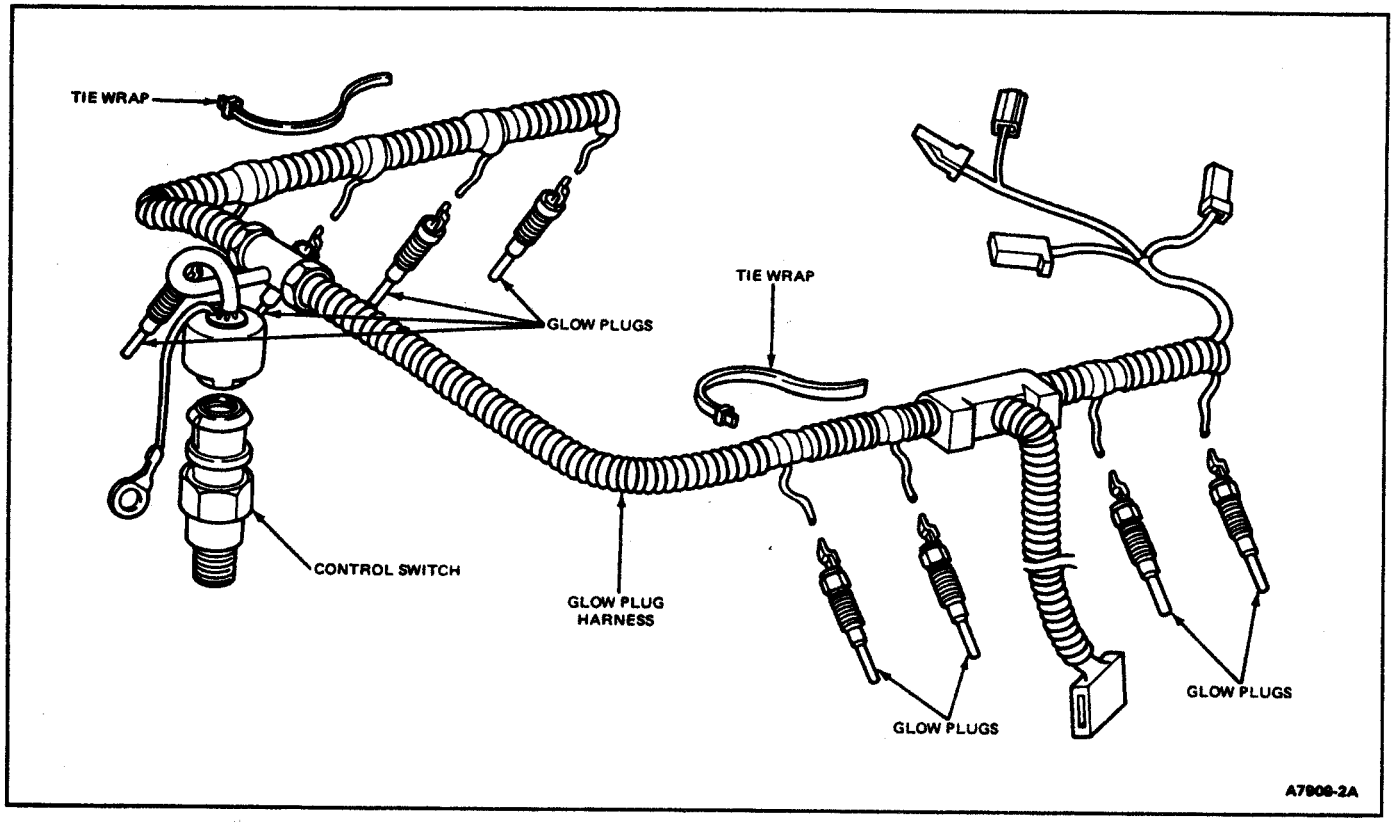


FIG. 11 Glow Plug Engine Harness

h. Fuel supply pump and/or mounting gasket.
i. Oil pressure sending unit.
j. Cup plugs and/or pipe plugs at the end of oil passages.

Under Engine—With Vehicle on Hoist

a. The complete oil pan perimeter.
b. Crankcase front cover gaskets.
c. Front crankshaft seal.
d. Oil filter seal.
e. Oil cooler mounting gaskets and header O-rings.
f. Fuel supply pump and/or mounting gasket.
g. Oil level indicator (dipstick) tube connections.

With Transmission Removed

a. Flywheel mounting bolts.

With Transmission and Flywheel Removed and Flywheel Mounting Bolt Holes Plugged

a. Rear crankshaft seal.
b. Rear cup plugs and/or pipe plugs.
c. Rear cover gasket.
d. Rear cover oil pan seal.

NOTE: Install specified sealant on flywheel bolts and install flywheel as specified in this Section.

Oil Cooler Internal Leakage Test

When oil is found in the cooling system or coolant in the oil, the oil cooler assembly should be inspected for leakage, as described below.

Areas of possible leakage are:

- "O" rings
- Oil Cooler Bundle (Tubes)
- Front Header
- Rear Header

The service technician must clean cooling system if oil is found in the coolant (refer to Section 27-02, Cooling System Service). If coolant is found in the oil, change engine oil and filter.

1. Remove oil cooler assembly from engine with filter installed, as identified in this Section.
2. Inspect the gaskets at the header flanges for leakage of coolant into the oil or oil into the coolant.
3. Using new header gaskets. Assemble Rotunda oil cooler leak test kit 019-00026 or equivalent, to the engine oil cooler by bolting the cover plate to the rear header, bolting the cover plate and tie bar assembly to the front header and bolting the tie bar to the rear header cover plate (Fig. 16).

   NOTE: Use original oil cooler tube and NOT test cooler tube included with Rotunda model 019-00026 Oil Cooler Test Kit.

   NOTE: The inner O-ring (rust colored) must be installed in the header (not on the bundle) to avoid cutting the inner O-ring during assembly, (Fig. 17).
4. Pressurize coolant side of front header test plate (adapter A) at air supply fitting with 276.8 kPa (40 psi) air pressure.
5. Check for air leakage at the plastic tube or each header cover plate. If air leakage is not felt, put a cup of water up to the plastic tubes and look for bubbles. There should be no bubbles for a one minute time period.

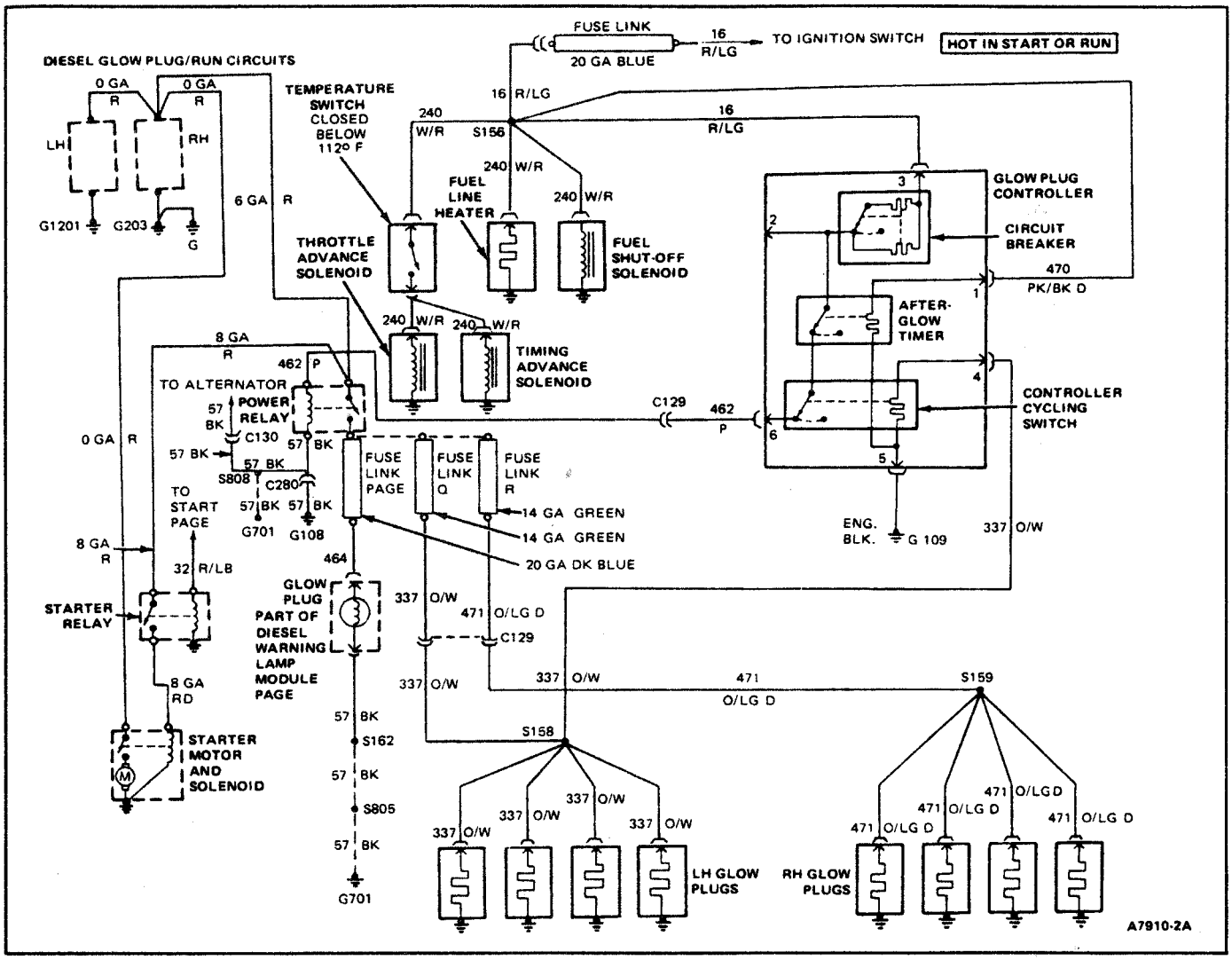


FIG. 12 Glow Plug Schematic

NOTE: If no leakage is observed, the complete oil cooler assembly (headers, O rings and cooler bundle (tube)) **DOES NOT** have an internal leak. Reinstall the oil cooler assembly to the engine as described in this Section. Continue with other engine diagnostic procedures to identify the source of the leak.

NOTE: Steps 3 through 5 should also be used as a functional test of a newly overhauled oil cooler assembly.

6. If air leakage is observed, unbolt the test kit tie bar and remove the front and rear headers from the cooler bundle (with cover plates attached to headers). Replace the four cooler bundle O-rings. NOTE: A rust colored O-ring must be installed in each header, not on the bundle tube, to avoid cutting the O-rings during assembly. Reassemble the headers on the cooler bundle tube.

7. Bolt the test kit tie bar to the rear header cover plate and repeat Steps 4 and 5, with the cooler assembly submerged in water. If leakage persists, the defective component in the oil cooler assembly, can be isolated by continuing the following procedure:

   A) For a leaking oil cooler still covered by warranty (3 yrs. or 50,000 miles) go to Step 8.

   B) For a leaking oil cooler not covered by warranty go to Step 10.

8. For a leaking oil cooler covered by warranty, replace and retest the following oil cooler components in the following sequence until no leakage is observed:

   1. Front header
   2. Rear header
   3. Cooler bundle (tube)

   NOTE: Prior to each retest, inspect the condition of the affected header gasket(s) and O-rings and replace if damaged.

9. Reassemble the affected test kit cover plate(s) and tie bar and repeat Steps 4 and 5 with cooler assembly submerged in water. If leak persists, replace the next component listed in Step 8. If no leakage was observed, go to Step 12.

10. For a leaking oil cooler not covered by warranty, replace and retest the following oil cooler components in the following sequence until no leakage is observed:

    1. Cooler bundle (tube)
    2. Front header

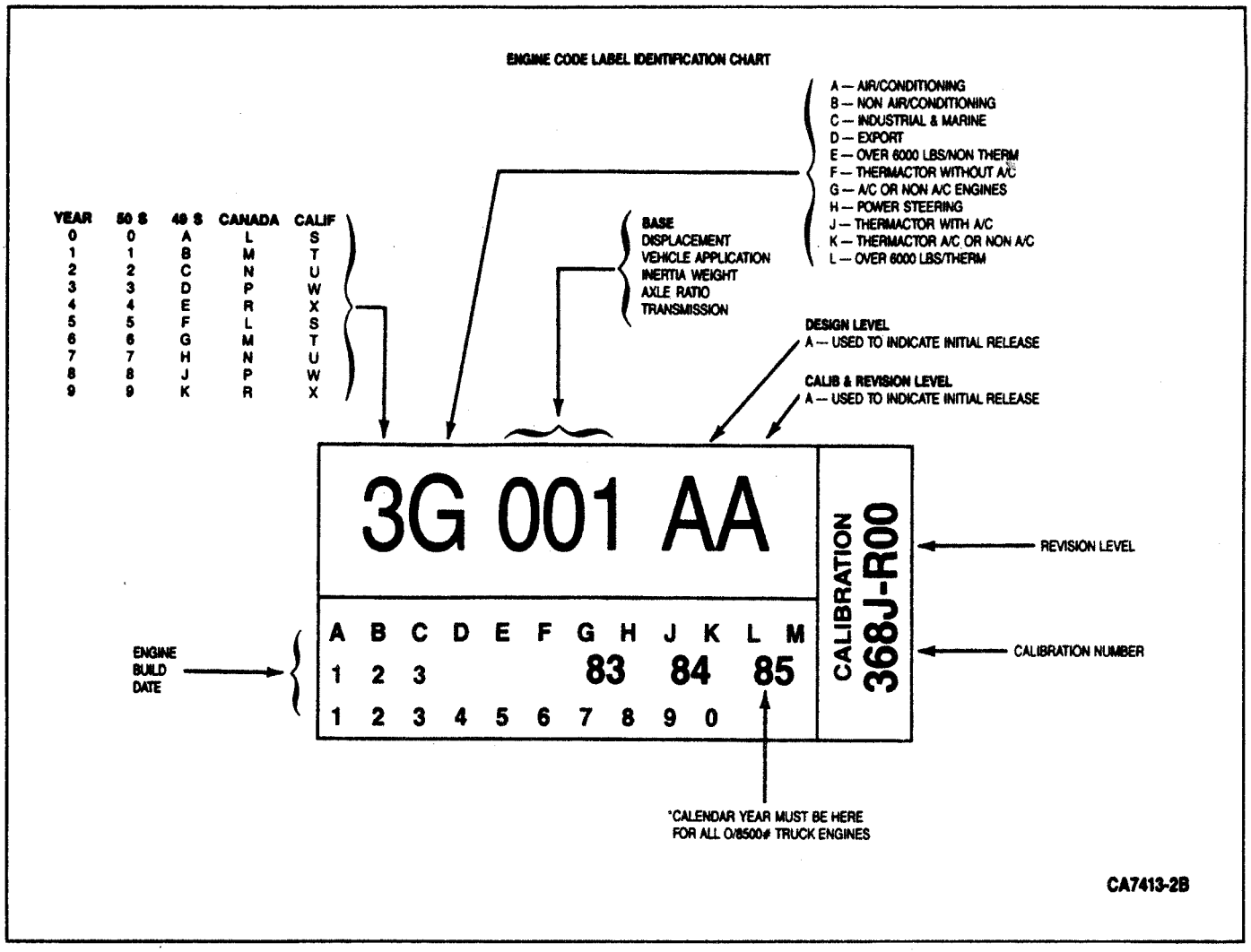


FIG. 13 Engine Identification

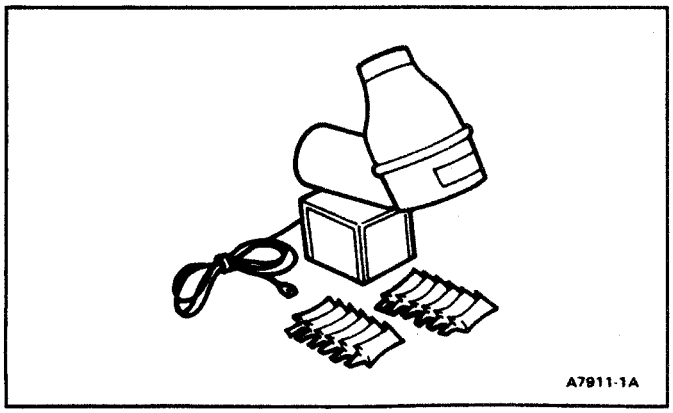


FIG. 14 Leak Test Kit

3. Rear header

NOTE: Prior to each retest, inspect the condition of the affected header gasket(s) and O-rings and replace if damaged.

11. Re-assemble the affected test kit cover plate(s) and tie bar and repeat Steps 4 and 5 with cooler assembly submerged in water. If leak persists, replace the next component listed in Step 8. If no leakage was observed, go to Step 12.

12. Reinstall oil cooler assembly on engine with new gaskets as described in this Section.

NOTE: If oil is found in the coolant, the cooling system must be cleaned. Refer to Section 27-02. If coolant is found in the oil, change the oil and filter.

HIGHEST CYLINDER	LOWEST CYLINDER
Maximum kPa (PSI)	Minimum kPa (PSI)
1792 (260)	1344 (195)
1929 (280)	1447 (210)
2067 (300)	1551 (225)
2205 (320)	1654 (240)
2343 (340)	1757 (255)
2481 (360)	1860 (270)
2619 (380)	1964 (285)
2756 (400)	2067 (300)
2894 (420)	2171 (315)
3032 (440)	2274 (330)

CA7414-1B

FIG. 15 Compression Test Pressures

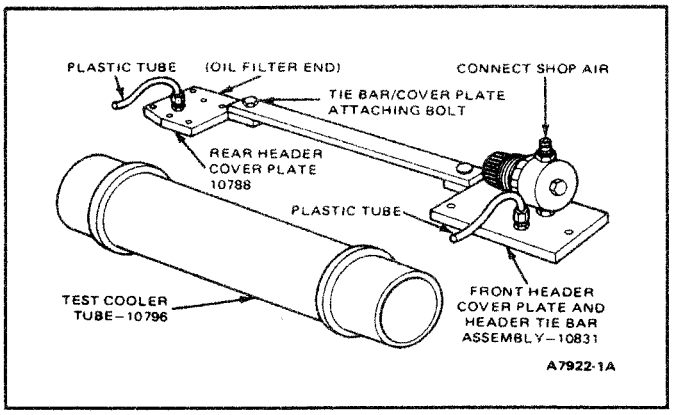


FIG. 16 Oil Cooler Internal Leakage Test Equipment

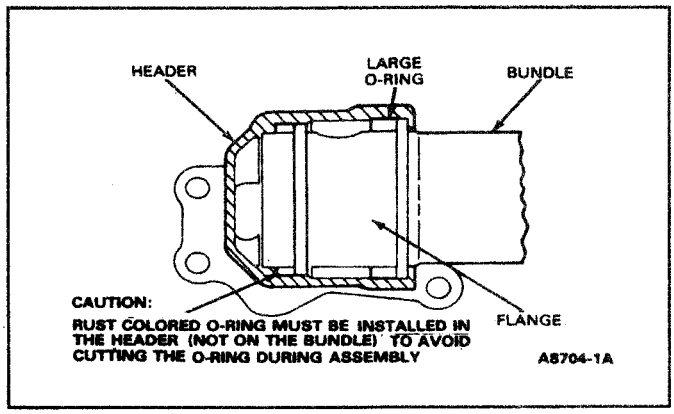


FIG. 17 Oil Cooler Tube Installed in Header

Compression Test

The following procedure is to be used when checking compression:

1. Be sure that the battery is properly charged. Operate the engine until the engine is at normal operating temperature. Turn the ignition switch Off. Remove air cleaner and/or intake opening cover Tool T83T-9424-A. Disconnect injection pump solenoid leads from injection pump to prevent accidental engine starting. Then remove all the glow plugs.
2. Install a compression gauge, Rotunda Model 019-00001 or equivalent in No. 1 cylinder glow plug hole.
3. Crank the engine (with the ignition switch Off) at least five pumping strokes and record the highest reading indicated. Note the approximate number of compression strokes required to obtain the highest reading.
4. Repeat the check on each cylinder, cranking the engine approximately the same number of compression strokes.

Test Conclusion

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75 percent of the highest. Variations exceeding 75 percent implies an improperly seated valve or worn or broken piston rings (Refer to Fig. 16).

CAUTION: Do not add oil to cylinder. This could cause hydrostatic lock.

Hydraulic Valve Tappet

Hydraulic tappet noise may be caused by any of the following:

1. Excessive collapsed tappet gap.
2. Sticking tappet plunger.
3. Tappet check valve not functioning properly.
4. Air in lubrication system.
5. Leakdown rate too rapid.
6. Excessive valve guide wear.

Excessive collapsed tappet gap may be caused by loose rocker arm fulcrum bolts, or wear of tappet roller, pushrod, rocker arm, rocker arm fulcrum or valve tip. With tappet collapsed, using Tool T83T-6500-A, check gap between valve tip and rocker arm to determine if any other valve train parts are damaged, worn, or out of adjustment.

A sticking tappet plunger may be caused by dirt, chips, or varnish inside the tappet. The sticking can sometimes be corrected by disassembling the tappet and removing the dirt, chips or varnish that is causing the condition.

A tappet check valve that is not functional may be caused by an obstruction such as dirt or chips preventing it from closing when the cam lobe is lifting the tappet, or it may be caused by a broken check valve spring.

Air bubbles in the lubrication system will prevent the tappet from supporting the valve spring load and may be caused by too high or too low an oil level in the oil pan, or by air being drawn into the system through a hole, crack, or leaking gasket on the oil pump pickup tube.

If the leakdown time is below the specified time for used tappets, noisy operation may result. If no other cause for noisy tappets can be found, the leakdown rate should be checked and any outside the specification should be replaced.

Assembled tappets can be tested with Tool 6500-E to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance of its travel while under a 22.68 kg (50 lb) load. Test the tappets as follows:

1. Disassemble and clean the tappet to remove all traces of engine oil.

   NOTE: Do not mix parts from different tappets.

   Parts are select-fitted and are not interchangeable.

   Tappets cannot be checked with engine oil in them. Only the testing fluid can be used.
2. Place the tapped in the tester, with the plunger facing upward. Pour hydraulic tappet tester fluid into the cup to a level that will cover the tappet assembly. The fluid can be purchased from the manufacturer of the tester.

   NOTE: Using kerosene or any other fluid will not provide an accurate test.
3. Place the 5/16 inch steel ball provided with the tester in the plunger cap (Fig. 18).
4. Adjust the length of the ram (Fig. 19) so that the pointer is 1.59mm (1/16 inch) below the starting mark when the ram contacts the tappet plunger, to facilitate timing as the pointer passes the Start Timing mark. Use the center mark on the pointer scale as the Stop Timing point instead of the original Stop timing mark at the top of the scale.

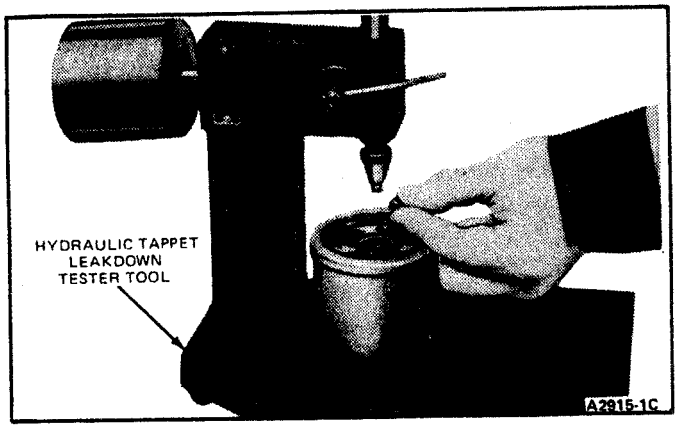


FIG. 18 Placing Steel Ball in Valve Tappet Plunger Cap

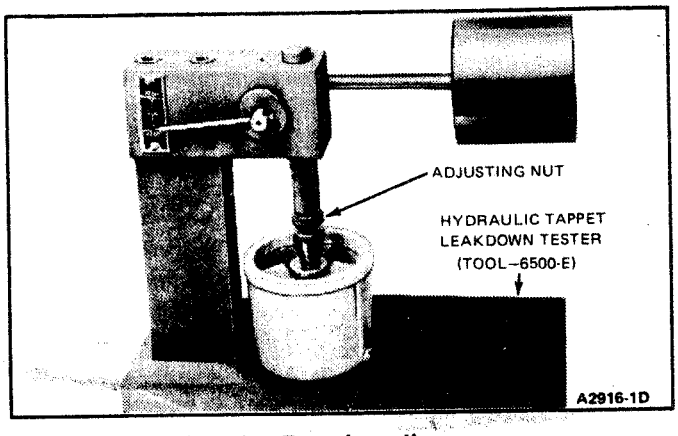


FIG. 19 Adjusting the Ram Length

5. Work the tappet plunger up and down until the tappet fills with fluid and all traces of air bubbles have disappeared.
6. Allow the ram and weight to force the tappet plunger downward. Measure the exact time it takes for the pointer to travel from the Start Timing to the Stop Timing marks of the tester.
7. A tappet that is satisfactory must have a leakdown rate (time in seconds) within the minimum and maximum limits specifications.
8. If tappet is not within specifications, replace it with a new tappet. It is not necessary to disassemble and clean new tappets before testing, because the oil contained in new tappets is test fluid.
9. Remove fluid from cup and bleed fluid from tappet by working plunger up and down. This step will aid in depressing the tappet plungers when checking the valve clearance.

Static (Engine Off) Valve Train Analysis

Rocker Arm Cover Removal

1. Remove air cleaner and install intake opening cap Tool T83T-9424-A.
2. On Econoline, remove engine oil dipstick tube fasteners and remove dipstick, tube assembly and rocker arm cover bracket.
3. Remove rocker arm cover bolts.
4. Remove rocker arm cover.

Valve Train Analysis

Check for damaged and/or severely worn parts, for correct assembly and assure use of correct parts by proceeding, as follows, with the static engine analysis (Fig. 19).

1. Rocker Arm Assemblies
   a. Check for loose mounting bolts.
   b. Check for plugged oil hole in the rocker arm.
2. Push Rods: Check for bent push rods. Check for clogged passages.
3. Valve Spring Assembly—With Damper Spring: Check for broken or damaged parts.
4. Retainer and Keys: Check for proper seating of keys on valve stem in retainer.
5. Positive Valve Rotator: Check for proper seating of the positive valve rotator.
6. Valves and Cylinder Head
   a. Check cylinder head gasket for proper installation.
   b. Check for plugged oil drain back holes.
   c. Check for worn or damaged valve tips.
   d. Check for missing or damaged valve stem oil seals.
   e. Check collapsed tappet gap.

Rocker Arm Cover Installation

1. Remove old gasket from cover. Scrape both valve cover rail on cylinder head and gasket flange on cover to remove all traces of old gasket, if necessary.
2. Install new gasket and install rocker arm cover on engine. Tighten bolts to specification.
3. Install engine oil dipstick tube and valve cover bracket and cover tighten to specification. Install engine oil dipstick.
4. Remove intake manifold cover. Install air cleaner and tighten to specification.

Camshaft Lobe Lift

Check lift of each lobe (in consecutive order) and make a note of readings.

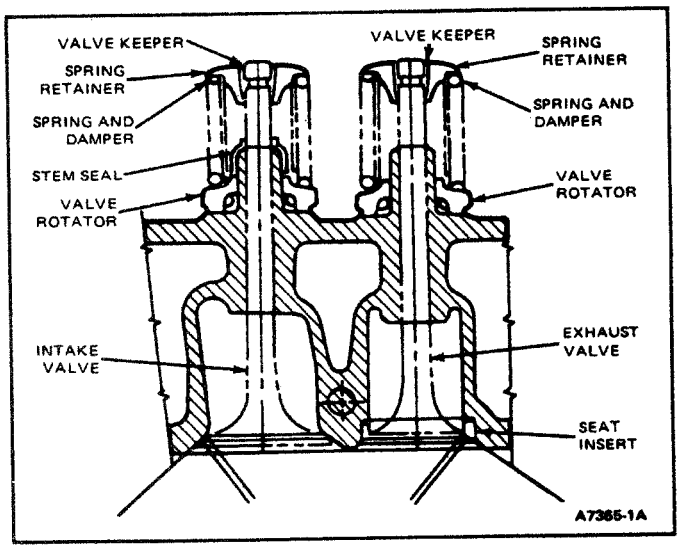


FIG. 20 Valve Spring Assembly

1. Remove fresh air inlet tube and air cleaner and install Intake Opening Cap Tool T83T-9424-A.
2. Remove rocker arm cover(s) as described in this Section.
3. Remove fulcrum bolts, fulcrum seats and rocker arms as described in this Section.
4. Make sure the push rod is in the valve tappet socket. Install a dial indicator D78P-4201-G (or equivalent) so that the indicator ball socket adapter Tool 6565-AB is on the end of the push rod and in the same plane as the push rod movement (Fig. 21).
5. Turn the crankshaft over by hand rotation until the tappet is on the base circle of the crankshaft lobe. At this point, the push rod will be in its lowest position.

   NOTE: Remove glow plugs with Tool D83T-6002-A or equivalent to facilitate turning engine over by hand.
6. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position.
7. Compare the total lift recorded on the indicator with specification.
8. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the indicator reads zero. If the lift on any lobe is below specified wear limits, the camshaft and the valve tappet operating on the worn lobe(s) must be replaced.
9. Remove the dial indicator.
10. Install rocker arms, fulcrum seats and fulcrum bolts as described in this Section. Tighten bolts to specification.
11. Install the valve cover(s) as described in this Section. Tighten bolts to specification.
12. Remove intake manifold cover, install air cleaner and tighten to specification.

Camshaft End Play

Push the camshaft toward the rear of the engine. Install a dial indicator (Tools D78P-4201-F, -G or equivalent) so that the indicator point is on the camshaft gear attaching screw (Fig. 22). Zero the dial indicator. Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with the specifications.

Remove the dial indicator. If the end play is excessive replace the camshaft thrust plate.

Drive Gear Backlash (All Gears)

Install a dial indicator (Tools D78P-4201-F, -G or equivalent) on the cylinder block (Fig. 23). Check the backlash between the drive gear and the driven gear with a dial indicator at six equally spaced teeth. Hold the gear firmly against the block while making the check. Refer to specifications for the backlash limits.

Crankshaft End Play

1. Force the crankshaft toward the rear of the engine.
2. Install a dial indicator (Tools D78P-4201-F, -G or equivalent) so that the contact point rests against the crankshaft flywheel flange and the indicator axis is parallel to the crankshaft axis (Fig. 24).

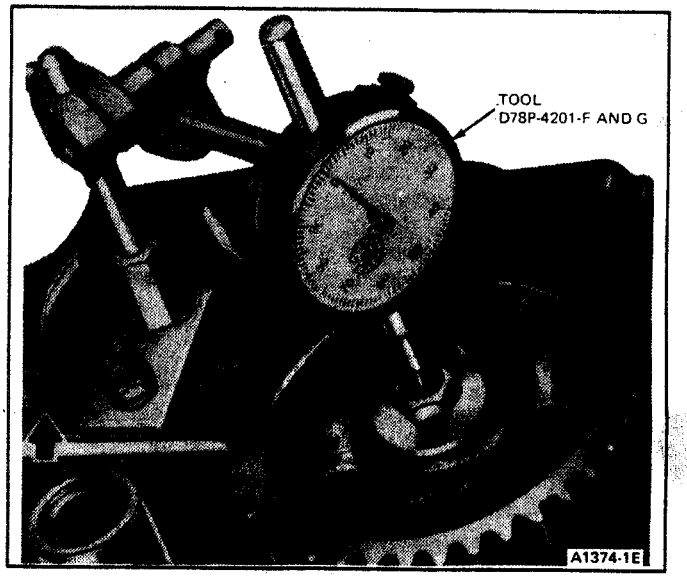


FIG. 22 Check Camshaft End Play

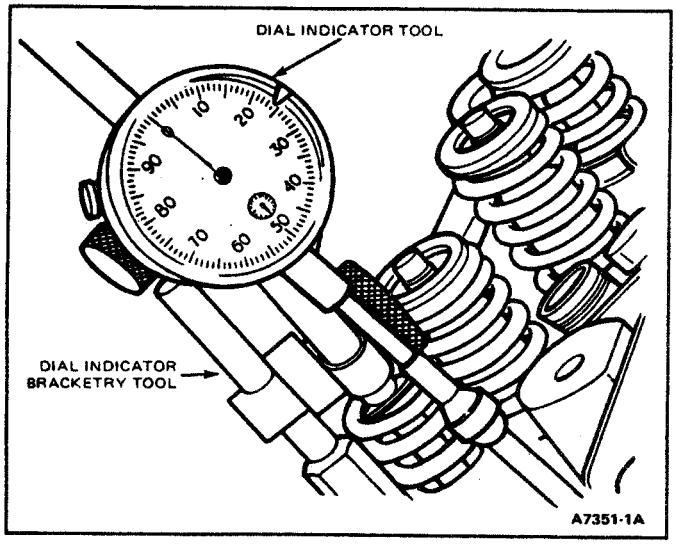


FIG. 21 Camshaft Lobe Lift Test

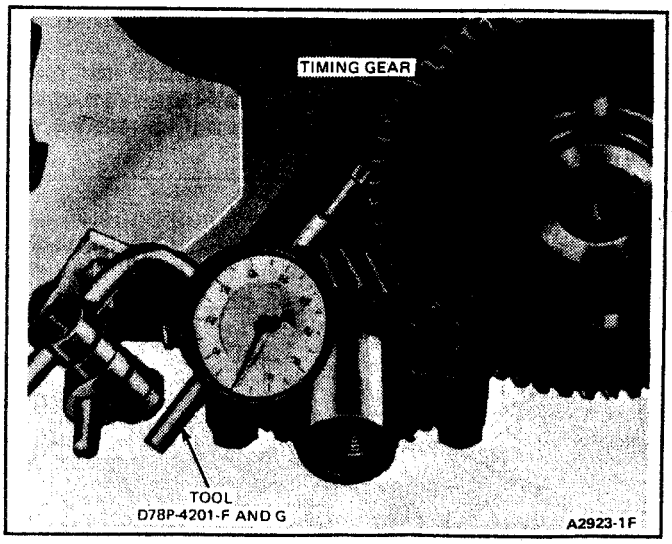


FIG. 23 Checking Drive Gear Backlash

3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds specification, replace the thrust bearing. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks, or dirt. If the thrust faces are not damaged or dirty, they probably were not aligned properly. Lubricate and install the thrust bearing and align the faces following the procedure recommended under Main Bearing Replacement in this Section. Check the crankshaft end play.

Flywheel Runout—Manual-Shift Transmission

NOTE: Remove glow plugs with Tool D83T-6002-A or equivalent to facilitate turning engine over by hand.

Install a dial indicator (Tools D78P-4201-F, -G or equivalent) so that the indicator point bears against the flywheel face, one inch in from the edge of the flywheel (Fig. 25). Turn the flywheel making sure that it is full forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the flywheel clutch face runout exceeds specifications, remove the flywheel and check for burrs between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. If crankshaft mounting flange face runout is excessive, machine mounting flange or replace crankshaft. If crankshaft mounting flange runout is not excessive, reface or replace flywheel. If the ring gear runout exceeds specifications, check installation of the gear to the flywheel flange. If it is not properly seated, re-install it to the flywheel. If it is properly seated, replace it. Refer to Ring Gear Replacement in this Section for the proper procedure.

Flywheel Runout—Automatic Transmission

Remove the glow plugs to facilitate turning the engine over by hand.

Install a dial indicator so that the indicator point rests on the face of the ring gear adjacent to the gear teeth.

Push the flywheel and crankshaft forward or backwards as far as possible to prevent crankshaft end play from being indicated as flywheel runout.

Set the indicator dial on the zero mark. Turn the flywheel one complete revolution while observing the total indicator reading (TIR). If the TIR exceeds specifications, remove flywheel and check for burrs between flywheel and face of crankshaft mounting flange. If no burrs exist, check runout of crankshaft mounting flange. If crankshaft flange face exceeds specifications, machine mounting flange or replace crankshaft. If crankshaft flange face runout is not excessive, check installation of ring gear to flywheel. If not properly seated, remove and reinstall ring gear to flywheel. If ring gear is properly seated, replace flywheel.

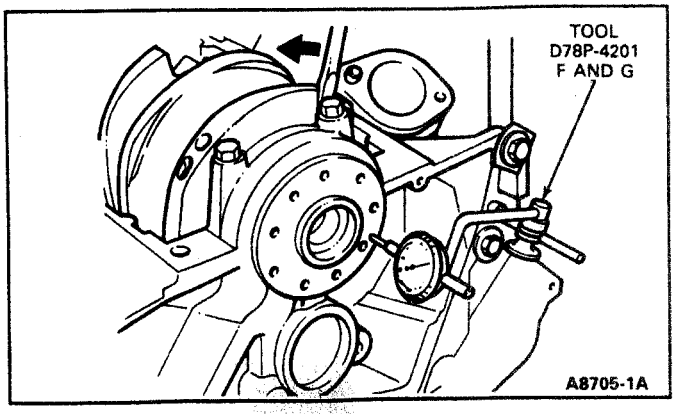


FIG. 24 Checking Crankshaft End Play

Diagnostic Procedures—Engine Performance and Glow Plug System

The diagnostic procedures for the performance, fuel injection and glow plug fast start system are covered in the Engine/Emissions Diagnosis Manual. Injection pump timing and nozzle performance are also covered in the Engine/Emissions Diagnosis Manual*.

ADJUSTMENTS

Refer to Engine/Emissions Diagnosis Manual* for adjustment procedures.

REMOVAL AND INSTALLATION

When installing nuts or bolts that must be tightened (refer to torque specifications at the end of this Section), oil threads with light weight engine oil. **Do not oil threads that require oil-resistant or water resistant sealer.**

Engine Assembly

F-250-F-350

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Scribe alignment marks at hood hinges and remove hood.
4. Drain cooling system (refer to Section 27-02, Cooling System Service).
5. Remove air cleaner and intake duct assembly.
6. Install intake manifold cover T83T-9424-A, or equivalent, over air intake opening.
7. Remove radiator fan shroud halves (refer to Section 27-04, Radiators in this Manual).

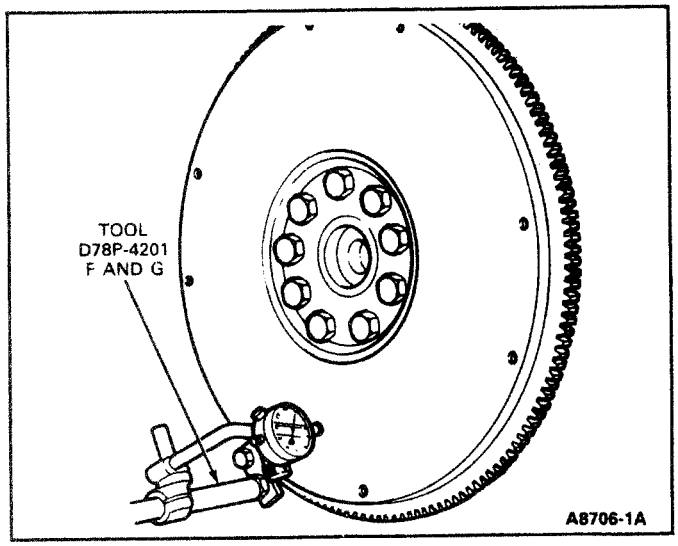


FIG. 25 Checking Flywheel Face Runout—Manual Transmission

*This manual can be purchased as a separate item.

8. Remove fan and clutch assembly as described in this Section, using Tools T83T-6312-A and B, or equivalent.

   CAUTION: Left-hand thread. Remove by turning nut clockwise.
9. Disconnect radiator upper and lower hoses from radiator.
10. Disconnect automatic transmission oil cooler lines at radiator, if so equipped.
11. Remove radiator (refer to Section 27-04, Radiators in this manual).
12. Loosen A/C compressor, if so equipped, and remove drive belt.
13. Remove A/C compressor, if so equipped, and position it on radiator upper support (refer to Section 36-61, F-150 Through F-350 and Bronco Manual A/C Heater System).
14. Loosen power steering pump and remove drive belt.
15. Remove power steering pump and position out of the way on left side of engine compartment.
16. Disconnect fuel supply line heater and alternator wires at alternator.
17. Disconnect oil pressure sending unit wire at sending unit located at back of engine.
18. Disconnect accelerator cable from injection pump.
19. Disconnect speed control cable from injection pump, if so equipped.
20. Remove accelerator cable bracket with cables attached, from intake manifold and position out of the way.
21. Disconnect transmission kick down rod from injection pump, if so equipped.
22. Disconnect main wiring harness connector from right side of engine.
23. Disconnect engine ground strap from rear of engine (Fig. 55).
24. Disconnect fuel return hose from left rear of engine (Fig. 55).
25. Remove vacuum supply hose from vacuum pump.
26. Remove two upper transmission-to-engine attaching bolts.
27. Disconnect heater hoses from water pump and right cylinder head.
28. Disconnect water temperature sender wire from sender on left front of engine block.
29. Disconnect water temperature overheat lamp switch wire from switch on top front of left cylinder head.
30. Position wires out of the way.
31. Raise vehicle.
32. Disconnect both battery ground cables from lower front of engine.
33. Disconnect and cap fuel inlet line at fuel supply pump.
34. Disconnect starter cables at starter motor.
35. Disconnect muffler inlet pipe at exhaust manifolds.
36. Disconnect engine insulators from No. 1 crossmember.
37. Remove flywheel inspection plate.
38. Remove four convertor-to-flywheel attaching nuts, if so equipped.
39. Lower vehicle.
40. Support transmission.
41. Remove four lower transmission to engine attaching bolts.
42. Attach engine lifting sling, Rotunda Model 014-00036 or equivalent.
43. Raise engine high enough to clear number one crossmember and pull forward.
44. Rotate the front of the engine approximately 45 degrees to the left and lift it out of the engine compartment.

    CAUTION: Use care not to damage windshield wiper motor when lifting engine out of vehicle.

Installation

NOTE: If the engine to be installed has been overhauled or has been in storage, take the following precaution to prevent piston and bearing scuffing. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

1. Lower engine into engine compartment.

   CAUTION: Use care not to damage windshield wiper motor when installing engine in vehicle.
2. Start transmission main shaft into clutch disc. It may be necessary to adjust position of transmission in relation to engine if main shaft binds or will not enter clutch disc. If engine hangs up after main shaft enters clutch disc, rotate crankshaft slowly (transmission in gear) until mainshaft splines mesh with clutch disc splines.
3. Align converter to flywheel studs, if so equipped.
4. Lower engine on to engine insulator brackets on number one crossmember.
5. Install four lower transmission to engine attaching bolts and tighten to specifications.
6. Remove engine lifting sling.
7. Raise vehicle.
8. Install four converter to flywheel attaching nuts, if so equipped, and tighten to specifications.
9. Install flywheel inspection plate and tighten bolts to specifications.
10. Install engine insulator support to crossmember bracket attaching nuts and washers and tighten to specifications.
11. Connect muffler inlet pipes to exhaust manifolds and tighten nuts to specifications.
12. Connect both battery ground cables to the lower front of the engine and tighten bolts to specifications.
13. Connect starter cables to starter and tighten to specifications.
14. Install fuel pump inlet line on fuel pump and tighten to specifications.
15. Lower vehicle.
16. Connect water temperature sender wire to sender on left front of engine block.

17. Connect wire to water temperature overheat lamp switch on top of left cylinder head.
18. Install heater hoses on right cylinder head and water pump and tighten clamps to specifications.
19. Connect engine ground strap at rear of engine.
20. Connect fuel return hose at left rear of engine.
21. Connect vacuum supply hose to vacuum pump.
22. Connect transmission kickdown rod, if so equipped.
23. Install accelerator cable bracket on intake manifold and tighten to specifications.
24. Connect accelerator cable to injection pump.
25. Connect speed control cable, if so equipped, to injection pump.
26. Connect oil pressure gauge sender wire to oil pressure sender.
27. Connect fuel supply line heater and alternator wires to alternator.
28. Install power steering pump and drive belt. Do not adjust belt at this time.
29. Install A/C compressor and drive belt (refer to Section 36-61, F-150 Through F-350 and Bronco Manual A/C Heater System, in Body/Chassis/ Electrical Manual).
30. Adjust A/C compressor and power steering pump drive belts to specifications (refer to Section 27-06, Accessory Drive Belt Service in this Manual).
31. Install radiator (refer to Section 27-04, Radiators, in this Manual).
32. Connect automatic transmission oil cooler lines at radiator, if so equipped. Tighten line nuts to specifications.
33. Connect upper and lower radiator hoses to radiator and tighten hose clamps to specifications.
34. Fill and bleed the cooling system (refer to Section 27-02, Cooling System Service, in this Manual).
35. Install fan and clutch assembly using Tools T83T-6312-A and B, or equivalent.

    CAUTION: Left hand thread. Turn nut counterclockwise to tighten.

    Tighten nut to specifications.
36. Install radiator fan shroud halves (refer to 27-04, Radiators, in this Manual).
37. Remove intake manifold cover, and install air cleaner and tighten to specifications.
38. Install intake duct assembly.
39. Install hood using scribe marks drawn on hood at removal.
40. Connect battery ground cables at both batteries.
41. Check the engine oil level and fill as needed with the specified type and grade of oil.
42. Run engine and check for fuel, oil and coolant leaks.
43. Close hood.

E-250—E-350

Removal

The engine removal and installation procedures are for the engine only without the transmission attached.

1. Remove engine cover.
2. Open hood and disconnect battery ground cables from both batteries.
3. Drain cooling system (Refer to Section 27-02, Cooling System Service).
4. Remove front bumper, grille assembly and gravel deflector.
5. Remove speed control servo bracket and position out of the way (if so equipped).
6. Mark location and remove hood latch and cable assembly from grille upper support bracket.
7. Remove upper grille support.
8. Discharge the A/C system, if so equipped (refer to Section 36-65, E-150 — E-350 Air Conditioning System in Body/Chassis/Electrical Shop Manual).
9. Disconnect A/C lines from A/C condenser, if so equipped.
10. Remove A/C condenser, if so equipped.
11. Disconnect transmission oil cooler lines at transmission oil cooler and radiator.
12. Remove transmission oil cooler and brackets.
13. Disconnect radiator hoses at engine.
14. Remove radiator shroud (refer to Section 27-04, Radiators, in this manual).
15. Remove radiator cooling fan using tool T83T-6312-A, or equivalent.

    CAUTION: Left hand thread. Remove by turning nut clockwise.
16. Support radiator. Install lifting hooks in lifting eyes on radiator.
17. Remove radiator attaching bolts from bottom of radiator and lift radiator out of vehicle.
18. Loosen and remove vacuum pump and drive belt. Disconnect vacuum hose from pipe for transmission modulation.
19. Loosen and remove alternator adjusting arm, adjusting arm bracket and drive belt. Pivot alternator, inward toward engine.
20. Disconnect alternator wiring harness from alternator and fuel line heater.
21. Disconnect water temperature sender wire from sender on left front of engine block.
22. Disconnect water temperature overheat lamp switch wire from switch on top front of left cylinder head.
23. Position wires out of the way.
24. Remove two engine ground cables from bottom front of engine.
25. Remove power steering pump and bracket from engine.
26. Disconnect and plug power steering pump return line.
27. Position power steering pump out of the way.
28. Remove A/C lines at A/C compressor using tool for 1/2 inch line and tool for 5/8 inch line.
29. Remove vacuum hose between vacuum regulator valve (VRV) and injection pump and position out of the way.

30. Disconnect and cap fuel heater inlet line at fuel filter and fuel pump.
31. Remove air cleaner assembly and inlet duct.
32. Cover air intake opening with Intake Manifold Cover T83T-9424-A or equivalent.
33. Disconnect and cap fuel filter outlet line at fuel filter and injection pump. Cap injection pump and fuel filter fittings.
34. Remove fuel filter return hose.
35. Remove fuel filter and bracket from engine as an assembly.
36. Loosen A/C compressor and rotate toward engine.
37. Remove and plug fuel inlet hose at fuel pump.
38. Remove accelerator and speed control cables from injection pump and bracket on intake and position out of the way. Remove cable bracket.
39. Disconnect engine wiring harnesses from inside vehicle and position out of the way.
40. Remove transmission kickdown rod.
41. Disconnect heater hose from water pump and right cylinder head.
42. Remove auxillary heater and A/C hoses from bracket at left rear of engine, if so equipped.
43. Disconnect oil pressure sender wire from sender on rear of engine.
44. Disconnect fuel return line from left rear of engine.
45. Remove transmission oil dipstick tube attaching bolt from rear of right cylinder head.
46. Remove engine oil dipstick attaching nut from right exhaust manifold. Remove screw from valve cover bracket and remove dipstick and dipstick tube.
47. Remove the bolt attaching the ground cable to the cylinder block.
48. Remove top four transmission to engine attaching bolts.
49. Raise vehicle.
50. Remove the engine mount attaching nuts.
51. Disconnect the muffler inlet pipe at the exhaust manifolds.
52. Remove the converter inspection plate.
53. Remove the four converter to flywheel attaching nuts.
54. Remove the starter cable.
55. Position fuel line on No. 1 crossmember down and out of the way.
56. Lower the vehicle.
57. Install engine lifting bracket, Rotunda Model 014-00312 or equivalent.
58. Support transmission and remove the remaining transmission to engine attaching bolts.
59. Separate engine from transmission, raise engine high enough to clear number one crossmember, then pull engine forward and out of vehicle.

Installation

NOTE: If the engine to be installed has been overhauled or has been in storage, take the following precaution to prevent piston and bearing scuffing. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

1. Lower engine into engine compartment.
2. Align converter to flywheel studs.
3. Position transmission and install two lower transmission to engine attaching bolts.
4. Remove engine lifting bracket and tighten to specification.
5. Raise the vehicle.
6. Install the starter cable and tighten to specification.
7. Install the four converter to flywheel attaching nuts and tighten to specification.
8. Install the converter inspection plate and tighten to specification.
9. Connect the muffler inlet pipe to the exhaust manifolds and tighten to specification.
10. Install the engine mount attaching nuts and tighten to specification.
11. Reposition fuel line on No. 1 crossmember.
12. Lower vehicle.
13. Install the top four transmission to engine attaching bolts and tighten to specification.
14. Position engine oil dipstick to right exhaust manifold and valve cover bracket. Install dipstick attaching fasteners and tighten to specification. Install dipstick into dipstick tube.
15. Position transmission oil dipstick tube to rear of right cylinder head and install attaching bolt and tighten to specification. Install dipstick into dipstick tube.
16. Connect fuel return line at left rear of engine and tighten to specification.
17. Connect battery ground cable to engine block.
18. Connect auxiliary heater and A/C hoses to bracket at left rear of engine, if so equipped.
19. Install heater hoses on right cylinder head and water pump and tighten clamps to specifications.
20. Install transmission kickdown rod.
21. Connect engine wiring harness to inside of passenger compartment.
22. Connect oil pressure sender wire to sender at rear of engine.
23. Install accelerator cable bracket to intake manifold. Install accelerator and speed control cables to bracket and the injection pump.
24. Remove plug from fuel inlet hose at fuel pump and install hose to fuel pump. Tighten clamp to specification.
25. Install fuel filter and bracket to engine.
26. Remove caps from fuel filter, outlet line and injection pump. Install line between fuel filter outlet and injection pump.
27. Connect fuel filter return hose.
28. Remove intake manifold cover and install air cleaner and inlet duct assembly.
29. Connect fuel heater line between fuel filter inlet and fuel pump.
30. Install vacuum hose between vacuum regulator valve (VRV) and injection pump.

31. Connect water temperature sender wire to sender on left front of engine block.
32. Connect wire to water temperature overheat lamp switch on top of left cylinder head.
33. Install A/C lines and A/C drive belt to the A/C compressor (refer to Section 36-65, E-150—E-350 Air Conditioning System, in the Body/Chassis/ Electrical Shop Manual.
34. Remove plug from power steering pump return line and install return line hose.
35. Install power steering pump drive belt and bracket.
36. Install two engine ground cables to bottom front of engine.
37. Connect alternator wiring harness to alternator and fuel line heater.
38. Loosely attach alternator adjusting arm and adjusting bracket to alternator and engine. Install drive belt.
39. Loosely install vacuum pump to engine, install drive belt and connect vacuum hose to pipe for transmission modulator.
40. Adjust all accessory drive belt to specifications (refer to Section 27-06, Accessory Drive Belt Service).
41. Position radiator into engine compartment and install radiator attaching bolts.
42. Install radiator cooling fan.

    CAUTION: Left hand thread. Tighten nut by turning counterclockwise.
43. Install radiator shroud (refer to Section 27-04, Radiators, in this manual).
44. Connect radiator hoses to engine.
45. Install transmission oil cooler and brackets and tighten to specifications.
46. Connect transmission oil cooler lines to transmission oil cooler and radiator.
47. Install A/C condenser, if so equipped (refer to Section 36-65, E-150—E-350 Air Conditioning System, in the Body/Chassis/Electrical Shop Manual).
48. Connect A/C lines to A/C condenser, if so equipped.
49. Charge the A/C system (refer to Section 36-65, E-150—E-350 Air Conditioning System, in the Body/Chassis/Electrical Shop Manual).
50. Install upper grill support.
51. Install hood latch and cable assembly to grille upper support bracket.
52. Install speed control servo bracket, if so equipped.
53. Install front bumper, grille assembly and gravel deflector.
54. Fill and bleed cooling system (refer to Section 27-02, Cooling System Service).
55. Connect battery ground cables to both batteries.
56. Check the engine oil level and fill as needed with the specified type and grade of oil.
57. Run engine and check for fuel, oil and coolant leaks.
58. Close hood.
59. Install engine cover.

Engine Front Insulators

F-250—F-350

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove fan shroud halves (refer to Section 27-04, Radiators in this Section).
4. Raise vehicle.
5. Remove nuts attaching insulators to No. 1 crossmember (Fig. 26).
6. Disconnect muffler inlet pipes at exhaust manifolds.
7. Remove bolts attaching insulators to engine block.
8. Lower vehicle.
9. Install lifting sling, Rotunda Model 014-00036 or equivalent, to lifting eyes on engine and raise engine high enough for insulators to clear No. 1 crossmembers.
10. Remove insulator and bracket assemblies.
11. Remove insulator from bracket.

Installation

1. Install insulator on insulator bracket and tighten to specifications (Fig. 26).
2. Install insulator and bracket assembly on engine block and tighten to specifications.
3. Lower engine onto No. 1 crossmember.
4. Remove lifting sling.
5. Raise vehicle.
6. Install insulator-to-crossmember attaching nuts and washers and tighten to specifications.
7. Lower vehicle.
8. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual).
9. Connect battery ground cables to both batteries.
10. Close hood.

Removal

E-250—E-350

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove radiator fan shroud (refer to Section 27-04, Radiators).
4. Loosen and remove vacuum pump drive belt.
5. Loosen and remove alternator drive belt.
6. Disconnect alternator wiring harness from alternator and fuel line heater.
7. Remove alternator adjusting bracket.
8. Remove alternator through bolt and remove alternator from engine.
9. Remove fuel heater inlet line from fuel pump and fuel filter.
10. Discharge the A/C system, if so equipped (refer to Section 36-65, E-150—E-350, Air Conditioning

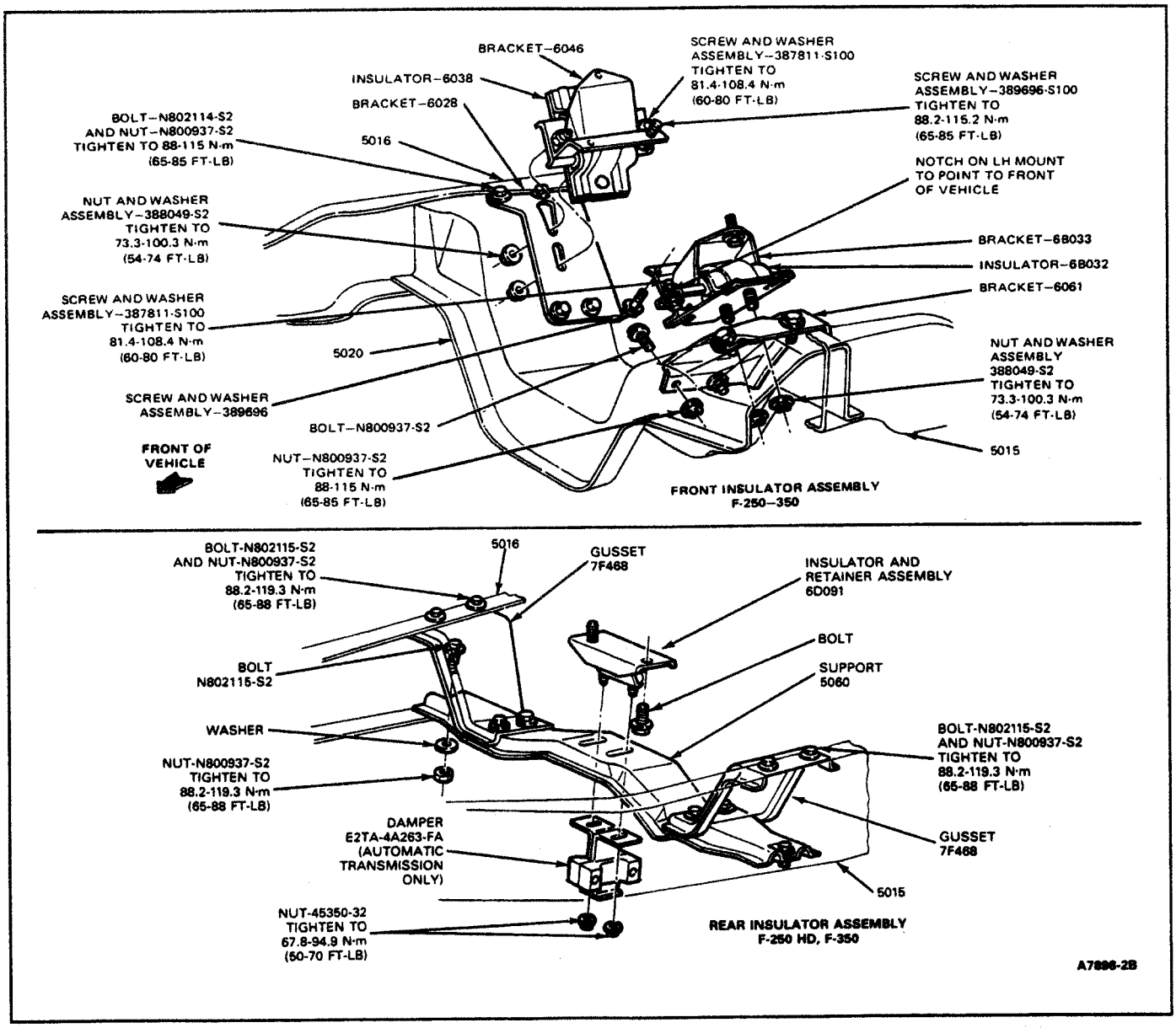


FIG. 26 Engine Insulators—F-250—F-350

System in the Body/Chassis/Electrical Shop Manual).

11. Remove A/C hoses, if so equipped (refer to Section 36-65, E-150—E-350 Air Conditioning System).
12. Remove A/C compressor and bracket, if so equipped (refer to Section 36-65, E-150—E-350 Air Conditioning System).
13. Remove engine cover.
14. Remove air cleaner and install intake manifold cover T83T-9424-A, or equivalent, over air intake opening.
15. Remove and cap fuel filter to injection pump fuel line. Cap injection pump and fuel filter fittings.
16. Remove fuel filter return line hose.
17. Remove fuel filter bracket attaching bolts and remove filter and bracket as an assembly.
18. Remove kickdown rod from injection pump.
19. Raise vehicle.
20. Disconnect engine ground cables from lower front of engine (Fig. 55).
21. Remove nuts attaching insulators to No. 1 crossmember (Fig. 27).
22. Disconnect and remove transmission kickdown rod from transmission.
23. Lower vehicle.
24. Install engine lifting brackets, Tool T70P-6000 or equivalent, to front of engine.
25. Install lifting sling, Rotunda Model 014-03012 or equivalent, to lifting eyes.
26. Raise engine until it contacts body.
27. Remove insulator and bracket assemblies.

Installation

1. Install insulator to bracket and tighten to specifications (Fig. 27).
2. Install insulator and bracket assembly on engine and tighten to specifications.

3. Lower engine.
4. Remove lifting sling from lifting eyes.
5. Remove lifting eyes from lifting brackets.
6. Remove lifting brackets.
7. Raise vehicle.
8. Install insulator to crossmember No. 1 with attaching nuts and tighten to specifications.
9. Install transmission kickdown rod and connect to transmission.
10. Install engine ground cables and tighten to specification as listed at the end of this Section.
11. Lower vehicle.
12. Install fuel filter and bracket assembly and tighten to specification.
13. Uncap and install fuel filter to injection pump fuel line.
14. Install fuel filter return hose and clamp.
15. Remove intake opening cover and install air cleaner and tighten to specifications.
16. Install A/C compressor and bracket, if so equipped, and tighten to specifications (refer to Section 36-65, E-150—E-350 Air Conditioning System in the Body/Chassis/Electrical Shop Manual).
17. Install A/C hoses (refer to Section 36-65, E-150—E-350 Air Conditioning System) if so equipped.
18. Install A/C compressor drive belt, if so equipped.
19. Install fuel pump to fuel filter fuel heater line and tighten to specification.
20. Install alternator and alternator adjusting bracket.
21. Install alternator drive belt.
22. Install alternator wiring on alternator and fuel line heater.
23. Install vacuum pump drive belt on alternator pulley.
24. Adjust A/C compressor, alternator, and vacuum pump drive belts to specification (refer to Section 27-06 Accessory Drive Belt Service in this manual).
25. Install fan and clutch assembly and tighten to specifications (refer to Section 27-04, Radiators, in this manual).
26. Install fan shroud (refer to Section 27-04, Radiators).
27. Evacuate and charge A/C system, if so equipped (refer to Section 36-65, E-150—E-350 Air Conditioning System in the Body/Chassis/Electrical Manual).
28. Connect battery ground cables to both batteries.
29. Install engine cover and close hood.

Engine Rear Insulator

Removal

1. Remove the insulator to support assembly bolt and locknut (Figs. 26 and 27).
2. Remove the insulator to transmission housing bolts and lockwashers.
3. Raise the transmission with a floor jack and remove the insulator and retainer.

Installation

1. Position the insulator and retainer to the transmission housing and install the attaching bolts and lockwashers, using the holes noted on removal (Figs. 26 and 27). Tighten to specifications.
2. Lower the transmission and remove the jack.
3. Install the insulator to support assembly bolt and locknut and tighten to specification.
4. Lower the vehicle.

Water Pump

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Drain cooling system (Refer to Section 27-02, Cooling System Service, in this Manual).
4. Remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual).
5. Remove fan and clutch assembly using Tool T83T-6312-A and B.

   CAUTION: Left hand thread: Remove by turning nut clockwise (Fig. 28).
6. Loosen power steering pump and A/C compressor and remove drive belts.
7. Loosen vacuum pump and remove drive belt.
8. Loosen alternator and remove drive belt.
9. Remove water pump pulley.
10. Disconnect heater hose from water pump.
11. Remove heater hose fitting from water pump.
12. Remove alternator adjusting arm and adjusting arm bracket.
13. Remove A/C compressor and position out of the way.
14. Remove A/C compressor brackets.
15. Remove power steering pump and bracket and position out of the way.
16. Remove bolts attaching water pump to front cover and remove pump.

Installation

1. Clean water pump and engine front cover mating surfaces with solvent.
2. Install fabricated dowel pins for water pump alignment (Fig. 29).
3. Install water pump with new gasket and tighten to specifications.

   NOTE: Coat two top bolts and two bottom bolts with RTV Sealer D6AZ-19562-A or equivalent before installation (Fig. 30).
4. Install alternator adjusting arm bracket and tighten to specifications.
5. Install water pump pulley and tighten to specification.
6. Coat heater hose fitting with pipe sealant D8AZ-19554-A or equivalent and install in water pump. Tighten to specifications.
7. Connect heater hose to water pump and tighten clamp to specifications.

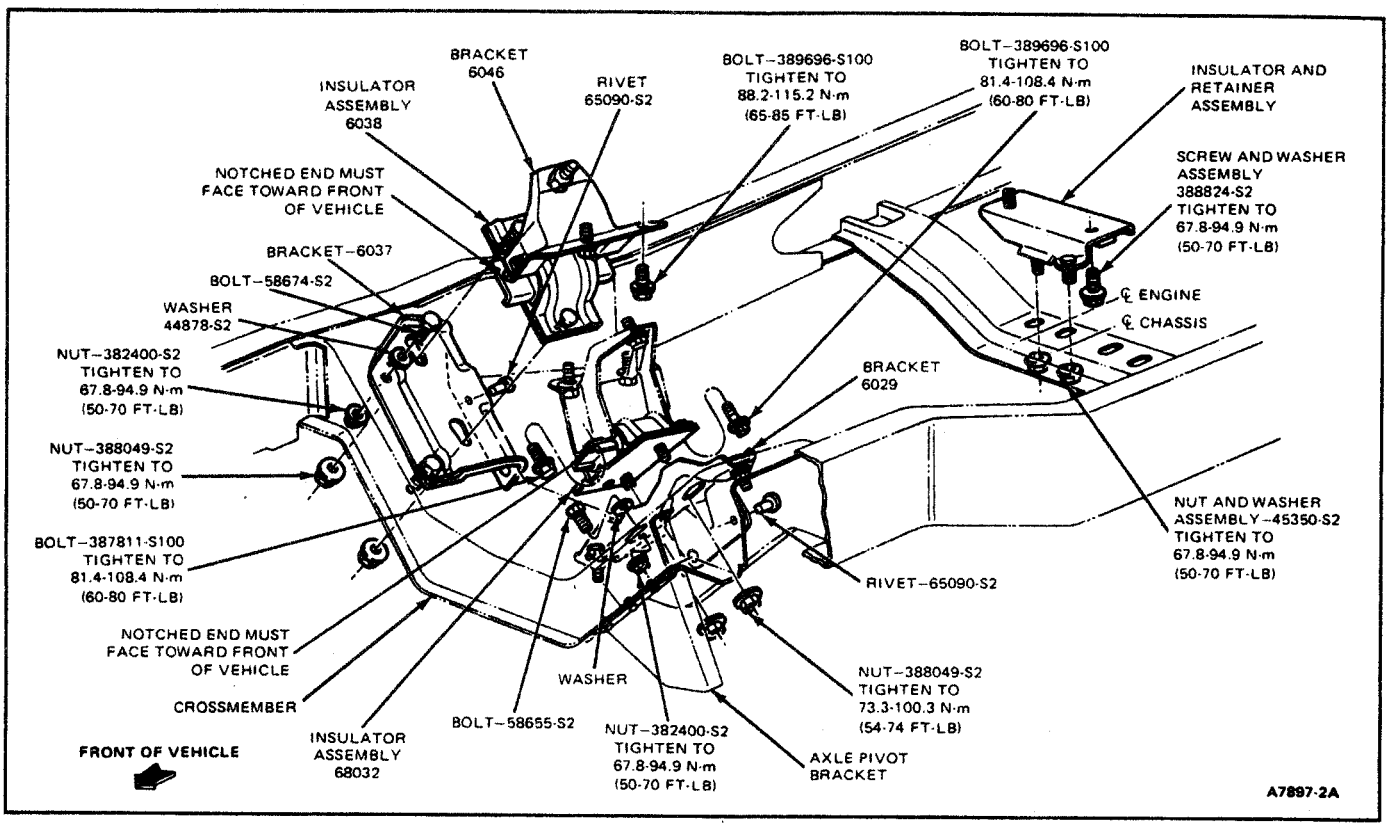


FIG. 27 Engine Insulators—E-250—E-350

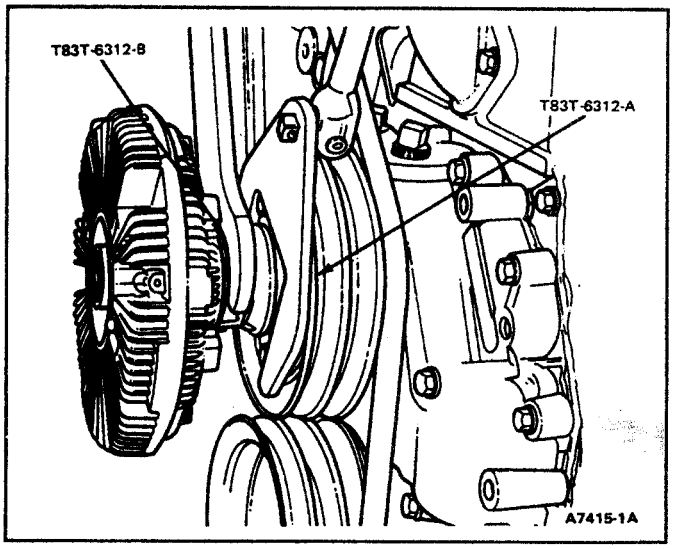


FIG. 28 Removing Fan and Clutch Assembly

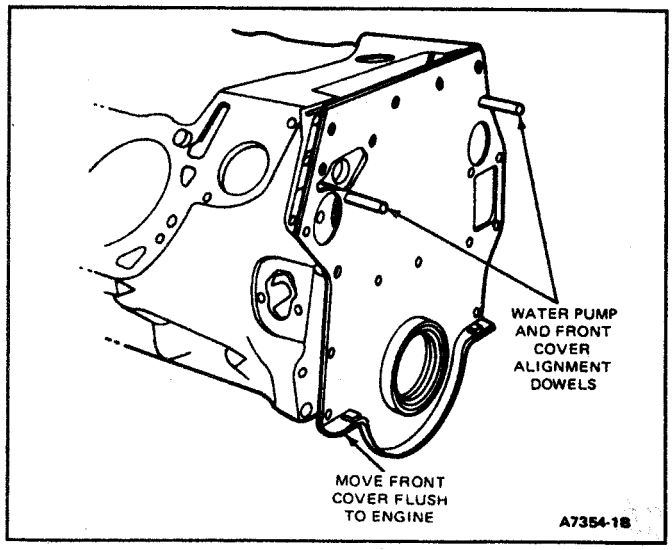


FIG. 29 Water Pump and Front Cover Installation Dowels

8. Install power steering pump bracket and tighten to specification.
9. Install power steering pump and drive belt.
10. Install A/C compressor bracket and tighten to specification.
11. Install A/C compressor and drive belt.
12. Install alternator adjusting arm and alternator drive belt.
13. Install vacuum pump drive belt.
14. Adjust accessory drive belts to specification (refer to Section 27-06, Accessory Drive Belt Service, in this manual).
15. Install fan and clutch assembly using Tools T83T-6312-A and B or equivalent, and tighten to specification.

    CAUTION: Left hand thread. Turn nut counter-clockwise to tighten.
16. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual).
17. Fill and bleed cooling system (refer to Section 27-02, Cooling System Service, in this manual).
18. Connect battery ground cables to both batteries.
19. Run engine and check for coolant leaks.

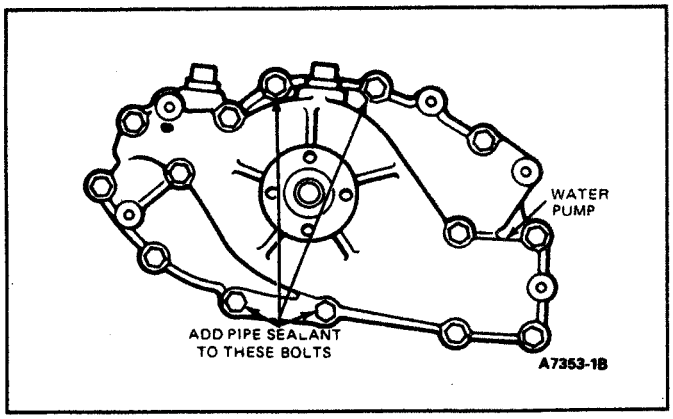


FIG. 30 Water Pump

20. Close hood.

Crankshaft Vibration Damper

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove radiator fan shroud halves (refer to Section 27-04, Radiators in this Manual).
4. Remove fan and clutch assembly as described in this Section, using Tools T83T-6312-A and B, or equivalent.

   CAUTION: Left-hand thread. Remove by turning nut clockwise.
5. Loosen and remove A/C compressor drive belt.
6. Loosen and remove power steering pump drive belt.
7. Loosen and remove alternator and vacuum pump drive belts.
8. Raise vehicle.
9. Remove crankshaft pulley.
10. Remove bolt attaching damper to crankshaft.
11. Install Crankshaft Damper remover T83T-6316-A and remove crankshaft damper (Fig. 31).

    NOTE: To prevent crankshaft, rotation use breaker bar for in vehicle removal or crankshaft holding Tool, T74P-6375-A for overhaul.

Installation

NOTE: A new front crankshaft seal should be installed whenever the crankshaft damper is removed.

1. Lubricate the damper seal nose with clean engine oil and install crankshaft damper using Tool T83T-6316-B (Fig. 32).

   NOTE: Add RTV Sealant D6AZ-19562-A to engine side of washer to prevent oil leakage past keyway.
2. Install bolt attaching damper to crankshaft and tighten to specification.
3. Install crankshaft pulley and tighten to specification.
4. Lower vehicle.
5. Install alternator, vacuum pump, power steering pump, and A/C compressor drive belts and adjust to specification (refer to Section 27-06, Accessory Drive Belts, in this manual).

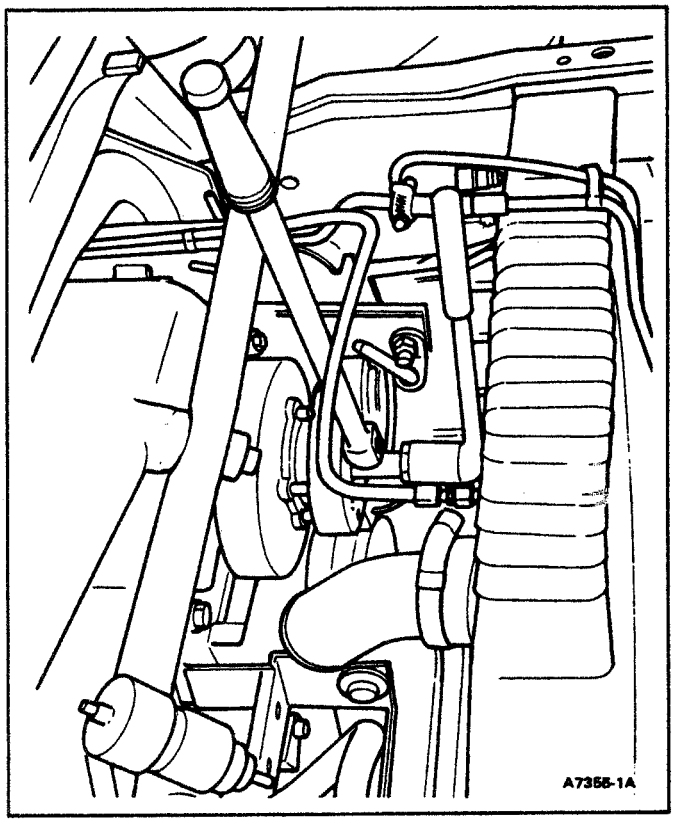


FIG. 31 Crankshaft Damper Removal (Bottom View)

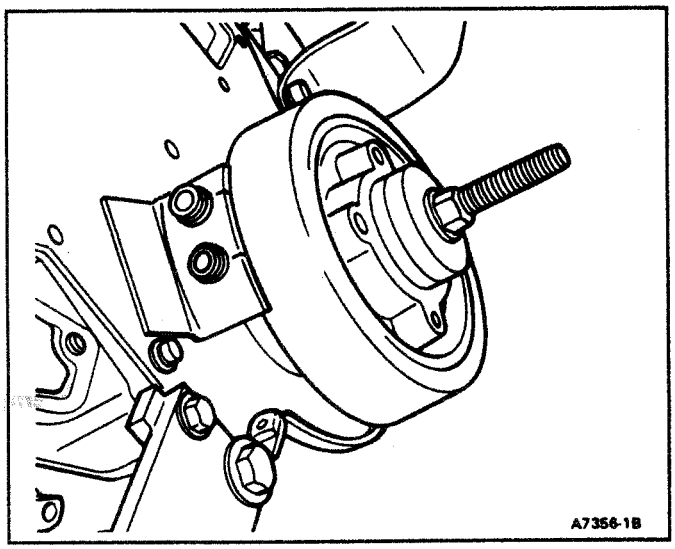


FIG. 32 Crankshaft Damper Installation

6. Install fan and clutch assembly using Tools T83T-6312-A and B or equivalent.

   CAUTION: Left hand thread. Turn nut counterclockwise to tighten.

   Tighten nut to specifications.
7. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
8. Connect battery ground cables to both batteries.
9. Close hood.

Front Crankshaft Oil Seal

In Vehicle Replacement—Use The Following Procedure

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
4. Remove fan and clutch assembly as described in this Section, using Tools T83T-6312-A and B, or equivalent.

   CAUTION: Left-hand thread. Remove by turning nut clockwise.
5. Loosen and remove A/C compressor drive belt.
6. Loosen and remove power steering pump drive belt.
7. Loosen and remove alternator and vacuum pump drive belts.
8. Raise vehicle.
9. Remove crankshaft pulley.
10. Remove bolt attaching damper to crankshaft.
11. Install Crankshaft Vibration Damper remover T83T-6316-A and remove crankshaft vibration damper. To prevent crankshaft rotation install breaker bar into removal tool.
12. Pry out front oil seal from the front cover using a screwdriver.

    CAUTION: Use care to prevent damage to the front cover, crankshaft or breaking oil pan seal by bending front cover.

Installation

1. Coat new oil seal with D0AZ-19584-A Polyethylene grease.

   NOTE: It may be necessary to rotate crankshaft to align the damper key with seal installing tool (Fig. 33).
2. For engines without 3 weldnuts on front cover, place seal into Tool T83T-6700-A, and install over end of crankshaft. Install Tool T83T-6316-B and tighten nut against washer and installation tool to force seal into front cover plate (Fig. 34).

   CAUTION: Use care to prevent bending front cover during oil seal installation and breaking oil pan seal.
3. For engines with 3 weldnuts on front cover, place seal into Tool T83T-6700-A, install over end of crankshaft and attach bridge to weldnuts. Draw seal into front cover by rotating center screw clockwise (Fig. 34).

   NOTE: Seal is automatically installed at the proper depth when the tool bottoms on the front cover.
4. Clean outside surfaces from grease and apply a 3.2mm (1/8 inch bead of RTV sealant D6AZ-19562-A around the outside diameter of the front seal and the edge of the front cover.

   NOTE: When applying RTV rubber silicon sealant, always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
5. Lubricate the damper seal nose with clean engine oil and install crankshaft vibration damper using Tool T83T-6316-B.
6. Add RTV D6AZ-19562-A Sealant to engine side of washer to prevent oil leakage past keyway. Install bolt attaching vibration damper to crankshaft and tighten to specification.
7. Install crankshaft pulley and tighten to specification.
8. Lower vehicle.
9. Install alternator, vacuum pump, power steering pump, and A/C compressor drive belts and adjust to specification (refer to Section 27-06, Accessory Drive Belt Service, in this manual).
10. Install fan and clutch assembly using Tools T83T-6312-A and B, or equivalent.

    CAUTION: Left hand thread. Turn nut counterclockwise to tighten. Tighten nut to specifications.
11. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
12. Connect battery ground cables to both batteries.
13. Close hood.

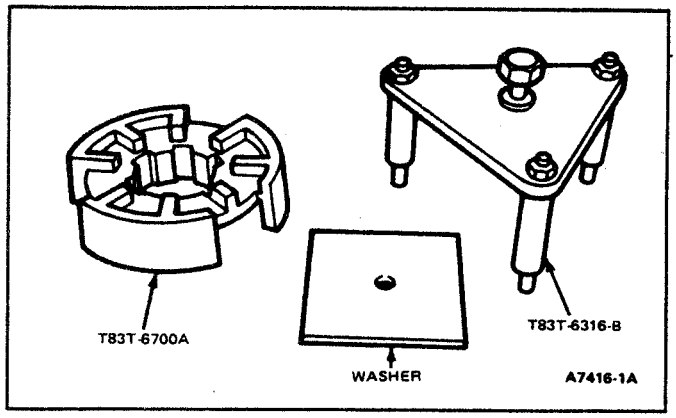


FIG. 33 Front Crank Seal Installation Tools—In Vehicle

Engine Front Cover and Crankshaft Oil Seal

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Drain cooling system.

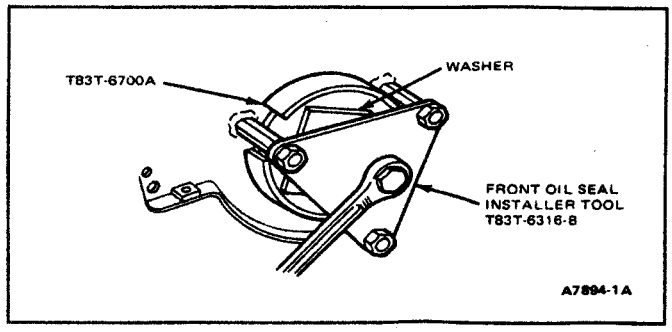


FIG. 34 Front Crankshaft Seal Installation—In Vehicle

4. Remove air cleaner and install intake air opening cap Tool T83T-9424-A.
5. Remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual).
6. Remove fan and clutch assembly using Tool T83T-6312-A and B.

   CAUTION: Left hand thread. Remove by turning nut clockwise.
7. Remove injection pump as described in this Section.
8. Remove injection pump adapter as described in this Section.
9. Remove water pump as described in this Section.
10. Raise vehicle.
11. Remove crankshaft pulley and vibration damper as described in this Section.
12. Remove ground cables at front of engine.
13. Remove five bolts attaching front cover to engine block and oil pan.
14. Lower vehicle.
15. Remove bolts attaching engine front cover to engine block, and remove front cover.
16. Support engine front cover, and using an arbor press, Drive Handle Tool T80T-4000-W, and an 82.55mm (3 1/4 inch) diameter spacer, drive crankshaft seal out of front cover (Fig. 35).

Installation

1. Remove old gasket material and clean engine block, engine front cover, and oil pan sealing surfaces with a suitable solvent and dry throughly.
2. Clean water pump sealing surface.
3. Coat new front crankshaft oil seal with Polyethylene grease D0AZ-19584-A or equivalent.
4. Install new oil seal using front crankshaft seal replacer. Tool T83T-6700-A, a suitable spacer, and an arbor press.

   CAUTION: Support engine front cover (Fig. 35).

   Bottom out tool on front cover surface. Seal is automatically installed at proper depth.
5. Clean outside surfaces of the front cover to remove any grease and apply a 3.2mm (1/8 inch) bead of RTV sealant, D6AZ-19562-A or equivalent, around the outside diameter of the front seal and the edge of the front cover.
6. For in-vehicle repair, install fabricated alignment dowels, (Fig. 36) on engine block and oil pan to align front cover and gaskets. For overhaul repair, install fabricated alignment dowels as shown in Fig. 29.
7. Apply gasket sealer, B5A-19554-A or equivalent on engine block and front cover sealing surfaces.
8. Install gaskets on engine block.

   NOTE: RTV Sealant should be applied immediately prior to front cover installation. When applying RTV Sealant always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
9. For in vehicle repair, apply a 3.2mm (1/8 inch) bead of RTV sealant D6AZ-19562-A, or equivalent, to rear corners of oil pan and apply a 6.4mm (1/4 inch) bead of RTV sealant D6AZ-19562-A, or equivalent on oil pan as shown in Fig. 37.
10. Install engine front cover in position, on oil pan dowels first, and install three attaching bolts as shown in Fig. 36.
11. For in vehicle repair, remove engine front cover alignment dowels from engine and oil pan and install and hand tighten remaining front cover bolts.
12. Install fabricated alignment dowels in engine block, (Fig. 29), if necessary.
13. Install water pump gasket on engine front cover alignment dowels.
14. Install water pump and hand tighten bolts.

    NOTE: Apply RTV sealant D6AZ-19562-A, or equivalent to four bolts as shown in Fig. 30.
15. Remove alignment dowels and install two remaining attaching bolts.

    Tighten all water pump bolts to specification.

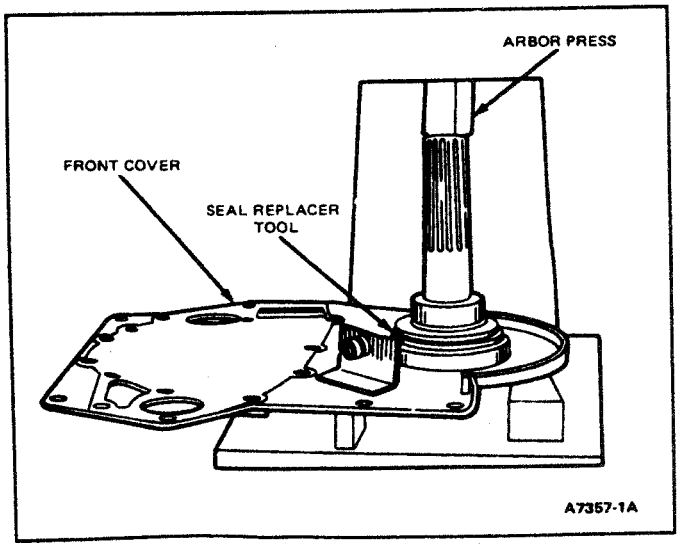


FIG. 35 Engine Front Cover Oil Seal Removal and Installation

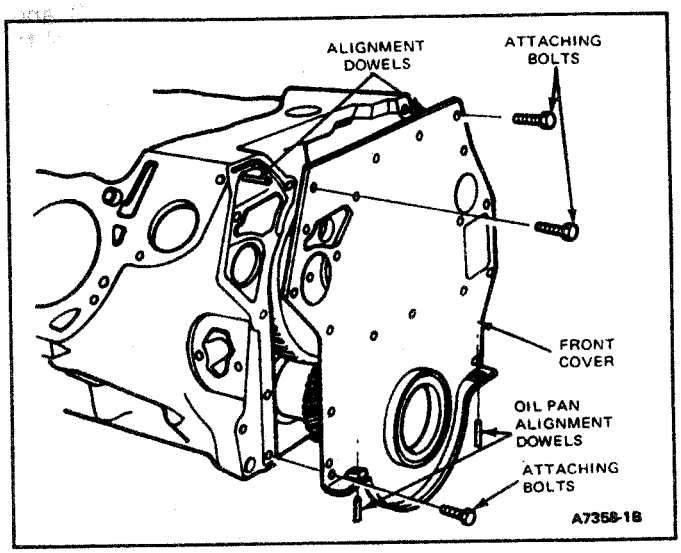


FIG. 36 Front Cover Alignment Dowels

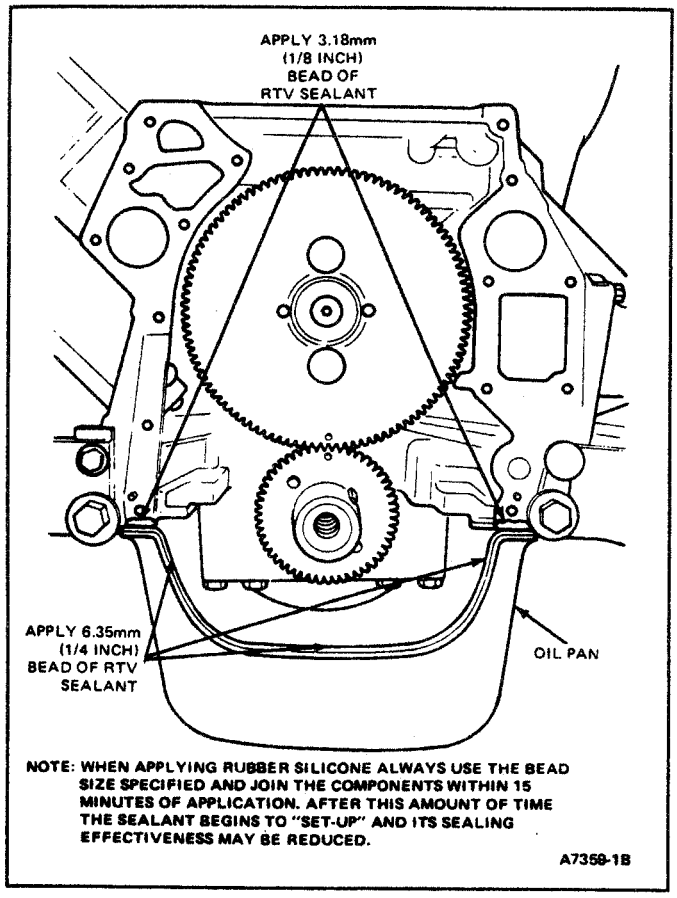


FIG. 37 Front Cover RTV Sealant Installation

16. Tighten engine front cover bolts to specification.
17. Install injection pump adaptor as described in this Section.
18. Install injection pump as described in this Section.
19. Install heater hose fitting in pump using pipe sealant D8AZ-19554-A, or equivalent.
20. Connect heater hose to water pump and tighten clamp to specification.
21. Raise vehicle.
22. Lubricate damper seal nose with clean engine oil and install crankshaft vibration damper, using Tools T83T-6316-B (Fig. 32).

    NOTE: Add RTV sealant, D6AZ-19562-A, to engine side of retaining bolt washer to prevent oil leakage past keyway.
23. Install vibration damper-to-crankshaft attaching bolt and tighten to specification.
24. Install crankshaft pulley and tighten to specification.
25. Install both battery ground cables on front of engine.
26. Lower vehicle.
27. Install alternator adjusting arm bracket and tighten to specification.
28. Install water pump pulley and tighten to specification.
29. Install power steering pump bracket and tighten to specification.
30. Install power steering pump and drive belt.
31. Install A/C compressor bracket and tighten to specification.
32. Install A/C compressor and drive belt.
33. Install alternator adjusting arm and install alternator and vacuum pump drive belts.
34. Adjust alternator, vacuum pump, power steering pump and A/C compressor drive belts to specification (refer to Section 27-06, Accessory Drive Belts, in this Manual).
35. Refill and bleed cooling system (refer to Section 27-02, Cooling System Service, in this Manual)
36. Connect battery ground cables to both batteries.
37. Remove intake manifold cover, install air cleaner and tighten to specification.
38. Run engine and check for coolant and oil leaks.
39. Install fan and clutch assembly using Tool T83T-6312-A and B, and tighten to specification.
40. Install radiator fan shroud halves (refer to Section 27-04, Radiator, in this Manual).
41. Close hood.

Flywheel, Engine Rear Cover and Oil Seal.

Removal

1. Remove transmission. Refer to Group 16 or Group 17, in Body/Chassis/Electrical Manual.
2. Remove clutch and clutch housing, if so equipped. Refer to Group 16, in Body/Chassis/Electrical Manual.
3. Remove ten flywheel mounting bolts and remove flywheel.
4. Remove bolts attaching rear engine cover to engine block and remove rear cover (Fig. 38).
5. Using an arbor press and a suitable spacer 104.78mm (4 1/8 inch) diameter, remove rear oil seal.

   NOTE: Support rear cover (Fig. 39).

Installation

1. Clean rear cover and engine block gasket surfaces.

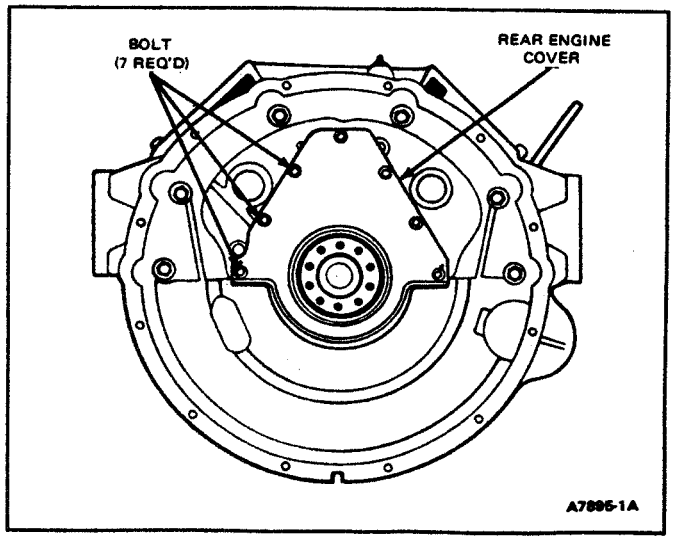


FIG. 38 Rear Engine Cover Removal

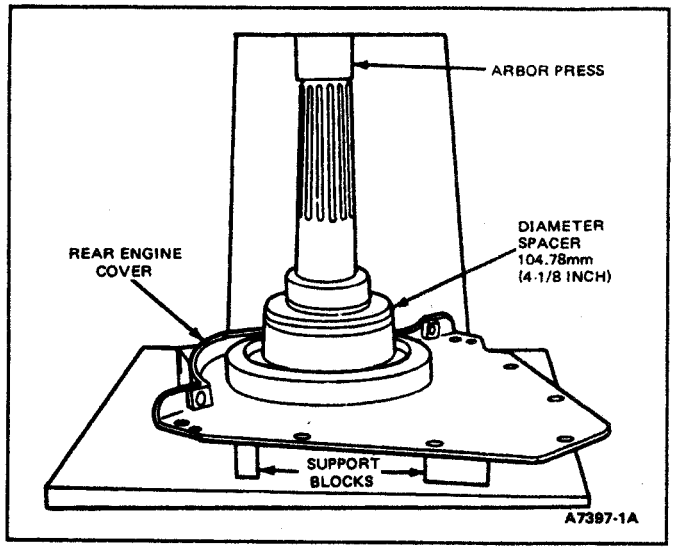


FIG. 39 Rear Oil Seal Removal

2. Remove old RTV sealant from oil pan to rear cover sealing surface on oil pan and clean with a suitable solvent, and dry thoroughly.
3. Coat new rear crankshaft oil seal with Polyethylene grease, D0AZ-19584-A, or equivalent, and using an arbor press and Tool T83T-6701-A, install new rear main oil seal.

   NOTE: Seal must be installed from the engine block side of rear cover flush with seal bore inner surface.
4. Clean outside surface of seal and cover from grease and apply a 3.2mm (1/8 inch) bead of RTV sealant D6AZ-19562-A around the outside diameter of the rear seal and the edge of the rear cover.
5. Install seal pilot, Tool T83T-6701B on crankshaft.
6. Apply gasket sealant, D7AZ-19B508-A, or equivalent, to engine block and rear cover gasket surfaces.
7. Install rear cover gasket to engine block.
8. For in-vehicle repair, apply a 3.2mm (1/8 inch) bead of RTV Sealant D6AZ-19562-A or equivalent at the corners of the oil pan and apply a 6.35mm (1/4 inch) bead of RTV Sealant D6AZ-19562-A or equivalent, on oil pan sealing surface.

   NOTE: When applying RTV sealant, D6AZ-19562-A always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
9. Push rear cover into position on engine block, install attaching bolts and tighten to specification.
10. Position flywheel on crankshaft flange. Coat threads of flywheel attaching bolts with sealant, B5A-19554-A, or equivalent, and install bolts and washers (with flexplate, if so equipped). Tighten bolts to specification, alternating across from each other.
11. Install clutch, if so equipped. Refer to Group 16, in Body/Chassis/Electrical Manual.
12. Install transmission. Refer to Group 16 or Group 17 in Body/Chassis/Electrical Manual.
13. Run engine and check for oil leaks.

Flywheel Ring Gear

Removal

To replace a damaged or worn ring gear, heat the ring gear with a blow torch on the engine side of the gear, and knock it off the flywheel. **Do not hit the flywheel when removing the ring gear.**

Installation

Heat the new ring gear evenly until the gear expands enough to slip onto the flywheel. Make sure the gear is seated properly against the shoulder. **Do not heat any portion of the gear to a temperature higher than 278°C (500°F). If this limit is exceeded, the hardness will be removed from the ring gear teeth.**

Crankshaft Drive Gear

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove air filter and install intake manifold cover, Tool T83T-9424-A on intake manifold opening.
4. Drain cooling system.
5. Remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual.
6. Remove fan and clutch assembly using Tool T83T-6312-A and B.

   NOTE: Left hand thread. Turn nut clockwise to remove.
7. Loosen and remove alternator and vacuum pump belts.
8. Remove A/C compressor and position out of the way.
9. Remove A/C mounting bracket.
10. Remove power steering pump and position out of the way.
11. Remove power steering pump bracket.
12. Remove water pump pulley.
13. Remove water pump as described in this Section.
14. Remove engine front cover as described in this Section.
15. Install crankshaft drive gear remover Tool T83T-6316-A, and using a breaker bar to prevent crankshaft rotation, or flywheel holding Tool T74P-6375-A, remove crankshaft gear (Fig. 40).

Installation

1. Install crankshaft gear using Tool T83T-6316-B (Fig. 41) aligning crankshaft drive gear timing mark with crankshaft drive gear timing mark (Fig. 42).

   NOTE: Gear may be heated to 167-194°C (300-350°F) for ease of installation. Heat in oven. Do not use torch.
2. Clean engine front cover, water pump and engine block sealing surface with a suitable solvent and dry thoroughly.
3. Install new crankshaft oil seal in engine front cover as described in this Section.
4. Install engine front cover as described in this Section.

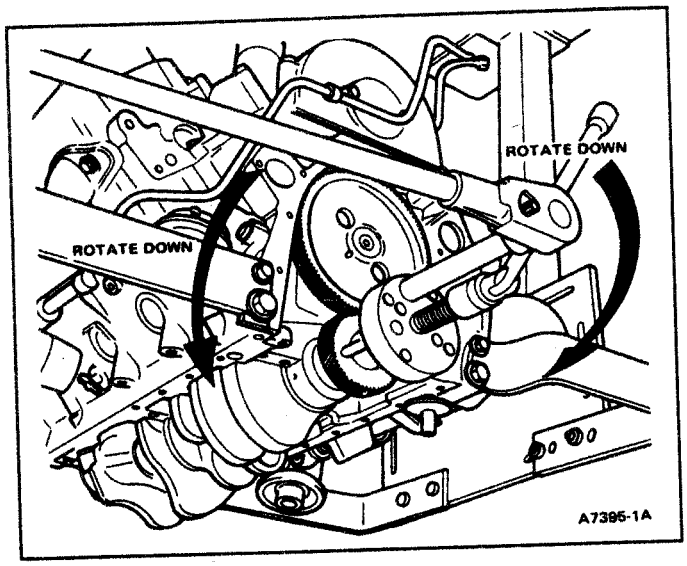


FIG. 40 Crankshaft Drive Gear Removal

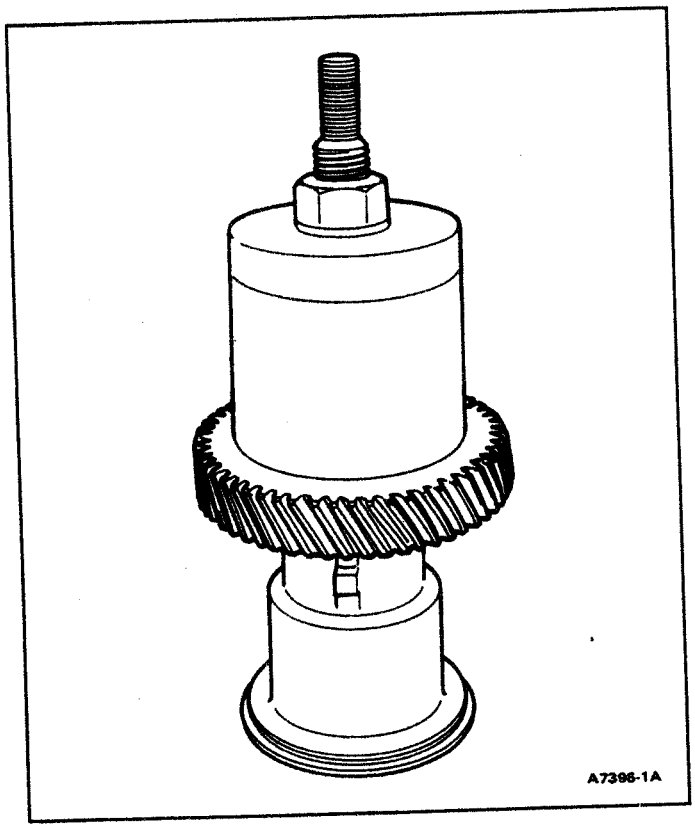


FIG. 41 Crankshaft Drive Gear Installation

5. Install crankshaft vibration damper using Tool T83T-6316-B (Fig. 32).

   NOTE: Apply RTV sealant D6AZ-19562-A, to engine side of washer to prevent oil leakage past Keyway.

6. Install crankshaft vibration damper attaching bolt and tighten to specification.
7. Install crankshaft pulley and tighten to specification.
8. Install water pump as described in this Section, and tighten to specification (Fig. 30).
9. Install injection pump adaptor as described in this Section.

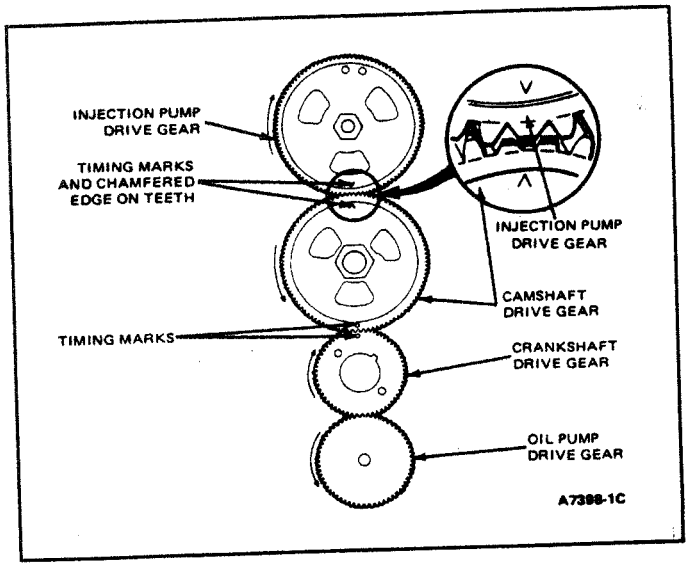


FIG. 42 Aligning Timing Marks

10. Install injection pump as described in this Section.
11. Install heater hose fitting in water pump using pipe sealant D8AZ-19554-A, or equivalent.
12. Connect heater hose to water pump and tighten clamp to specification.
13. Install power steering pump bracket and tighten to specification.
14. Install power steering pump and drive belt
15. Install A/C compressor bracket and tighten to specification.
16. Install A/C compressor and drive belt.
17. Install alternator adjusting arm and install alternator and vacuum pump and drive belts.
18. Adjust alternator, vacuum pump, power steering pump and A/C compressor drive belts to specification (refer to Section 27-04, Radiators, in this Manual).
19. Refill and bleed cooling system (refer to Section 27-02, Cooling System Service, in this Manual).
20. Connect battery ground cables to both batteries.
21. Remove intake manifold cover, install air cleaner and tighten to specification.
22. Run engine and check for coolant and oil leaks.
23. Refer to Engine/Emissions Diagnosis Manual for injection pump timing procedures.
24. Install radiator fan and clutch assembly using Tool T83T-6312-A and B, and tighten to specification.
25. Install radiator fan shroud halves (refer to Section 27-04, Radiator, in this Manual).
26. Close hood.

Injection Pump Drive Gear and Adapter

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove engine cover (E-250—E-350 only).
4. Remove air cleaner and install intake opening cover, Tool T83T-9424-A.

5. Remove injection pump as described in this Section.
6. Remove bolts attaching injection pump adapter to engine block, and remove adapter (Fig. 43).

   NOTE: Do not remove drive gear yet.
7. Turn engine over by hand to TDC of compression stroke of No. 1 piston.

   NOTE: Remove glow plugs with Tool D83T-6002-A or equivalent to facilitate turning engine over by hand.

   NOTE: To determine that No. 1 piston is at TDC of compression stroke, position injection pump drive gear dowel at four o'clock position. The scribe line in vibration damper should be at TDC.
8. Draw a line on the front of the injection pump drive gear at the six o'clock position where the one locating chamfer (Fig. 42) meshes between the two chamfers on the camshaft gear.
9. Remove injection pump drive gear.

Installation

1. Clean all gasket and sealent surfaces of components removed with a suitable solvent and dry thoroughly.

   NOTE: To allow easy visual inspection of drive gear alignment with the engine front cover installed, the injection pump gear has one chamfered tooth which fits between the two chamfered teeth on the camshaft gear.

   NOTE: To determine that No. 1 piston is at TDC of compression stroke, position injection pump drive gear dowel at four o'clock position. The scribe line in vibration damper should be at TDC.
2. With drawn line on drive gear at six o'clock position, install gear and align all drive gear timing marks (Fig. 42).

   CAUTION: Use extreme care to avoid disturbing injection pump drive gear, once it is in position.
3. Apply a 3.16mm (1/8 inch) bead of RTV Sealant D6AZ-19562-A or equivalent along bottom surface or injection pump adapter.

   NOTE: When applying RTV Sealant, D6AZ-19562-A, always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
4. Install injection pump adaptor and tighten to specification. Apply sealer, B5A-19554-A, to bolt threads before assembly.

   NOTE: With injection pump adapter installed, the injection pump drive gear cannot "jump" timing.
5. Remove intake manifold cover and install air cleaner.
6. Install battery ground cables to both batteries.
7. Run engine and check for oil, fuel and coolant leaks.
8. If necessary, purge high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles, flows from connection.

   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.
9. Close hood. (Install engine cover, E-250—E-350).

Camshaft Drive Gear, Fuel Pump Cam, Spacer and Thrust Plate

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove air cleaner and install Tool T83T-9424-A on intake manifold opening.
4. Drain cooling system (refer to Section 27-02, Cooling System Service, in this manual).
5. Loosen and remove alternator and vacuum pump drive belts.
6. Remove A/C compressor mounting bolts and position compressor out of the way.
7. Remove A/C compressor mounting bracket.
8. Remove power steering pump and position out of the way.
9. Remove power steering pump bracket.
10. Remove water pump pulley.
11. Remove water pump as described in this Section.
12. Remove engine front cover as described in this Section.
13. Remove camshaft allen screw (Fig. 43).
14. Install gear puller, Tool T83T-6316-A and remove gear (Fig. 44).
15. Remove fuel supply pump, if necessary as described in this Section.
16. Install gear puller, Tool T77F-4220-B1 and shaft protector T83T-6316-A and remove fuel pump cam and spacer, if necessary.
17. Remove bolts attaching thrust plate, and remove thrust plate, if necessary.

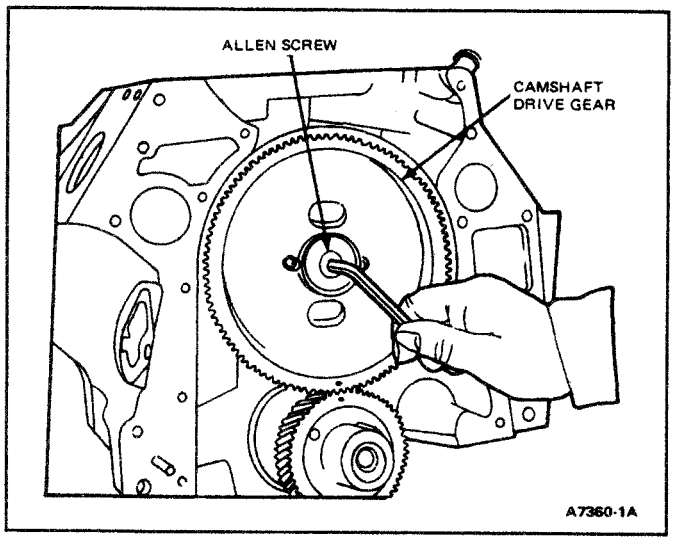


FIG. 43 Camshaft Drive Gear Allen Screw

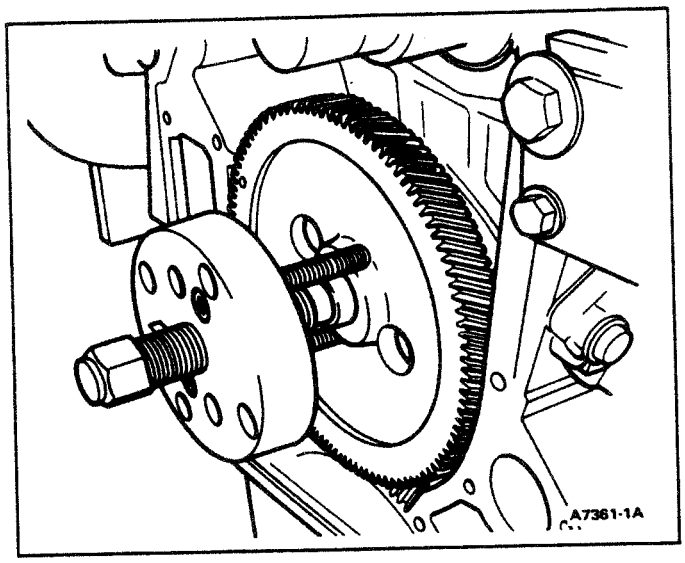


FIG. 44 Camshaft Drive Gear Removal

Installation

1. Install new thrust plate, if removed, and tighten to specification.
2. Install spacer and fuel pump cam against camshaft thrust flange, using installation sleeve and replacer Tool T83T-6316-B, if removed.
3. Install camshaft drive gear against fuel pump cam, aligning timing mark with timing mark on crankshaft drive gear, using installation sleeve and replacer Tool T83T-6316-B.
4. Install camshaft allen screw and tighten to specification.
5. Install fuel pump as described in this Section, if removed.
6. Install new crankshaft oil seal in engine front cover as described in this Section.
7. Install engine front cover as described in this Section.
8. Install water pump as described in this Section.
9. Install injection pump gear and adaptor as described in this Section.
10. Install injection pump as described in this Section.
11. Install water pump pulley.
12. Install power steering pump bracket and tighten to specifications.
13. Install power steering pump and drive belt.
14. Install A/C compressor mounting bracket and tighten mounting bracket bolts to specification.
15. Install A/C compressor and drive belt.
16. Install alternator and vacuum pump drive belts.
17. Adjust alternator, vacuum pump, A/C compressor and power steering pump drive belts to specifications. (Refer to Section 27-06, Accessory Drive Belt Service, in this manual).
18. Connect battery ground cables to both batteries.
19. Remove intake manifold cover and install air cleaner and tighten to specification.
20. Run engine and check for fuel, oil, and coolant leaks.
21. If necessary, purge high pressure fuel pipes of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles, flows from connection.

    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.
22. Close hood.

Crankcase Depression Regulator (CDR)

Removal

1. Open hood on F-250—F-350. Remove engine cover on E-250—E-350.
2. Remove air cleaner and install Tool T83T-9424-A on intake manifold opening.
3. Remove two bolts attaching CDR valve to intake manifold and remove valve.

Installation

1. Install new seal ring, backup ring and O-rings on CDR valve and install valve in crankcase vent tube (Fig. 45).
2. Install two attaching bolts in intake manifold and tighten to specification.
3. Install air cleaner and tighten to specification.
4. Close hood or install engine cover as required.

Valve Cover, Rocker Arm, and Pushrod

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. On E-250—E-350, remove fan shroud halves (refer to Section 27-04, Radiators in this Manual).
4. Remove engine cover (E-250—E-350 only).
5. Perform steps 5 through 10 on E-250—E-350, right-hand side only: Remove engine oil dipstick tube fasteners and remove dipstick, tube assembly and valve cover bracket.

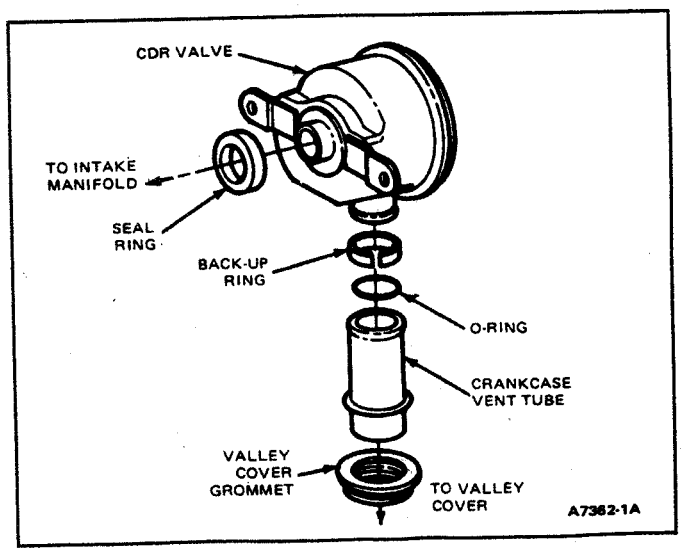


FIG. 45 CDR Installation

6. Remove transmission filler tube fasteners and remove filler tube and dipstick.
7. Raise vehicle.
8. Remove nuts attaching RH engine mount insulator to frame.
9. Slightly raise right side of the engine until fuel filter header touches vehicle sheet metal. Install suitable wood block between insulator and frame. Lower engine on block.
10. Lower vehicle.
11. Remove valve cover attaching screws and remove covers.
12. Remove valve rocker arm post mounting bolts (Fig. 46).
13. Remove valve rocker arms and posts in order and identify so they are returned to their original positions.
14. Remove pushrods in order and identify so they are returned to their original positions.

Installation

1. Install pushrods in their original positions, making sure they are fully seated in tappet pushrod seats.

   NOTE: Copper colored end of pushrod goes toward rocker arm.
2. Install valve rocker arms and posts in their original positions. (Fig. 47). Apply Polyethylene grease D0AZ-19584-A, or equivalent to valve stem tips.
3. Install valve rocker arm post attaching bolts as follows:
   a. Turn engine over by hand until timing mark is at 11:00 o'clock position as viewed from front of engine.
   b. Install all rocker arm post attaching bolts, and tighten to specification.
4. Clean valve covers with clean solvent and install new gaskets.
5. Install valve covers on cylinder heads and tighten attaching screws to specification.
6. Raise vehicle.
7. Raise engine, remove wood block and lower engine on to No. 1 crossmember, if required.
8. Install insulator attaching washers and nuts and tighten to specification, if required.
9. Lower vehicle.
10. Install transmission filler tube and tighten to specification. Install transmission oil dipstick (if required).

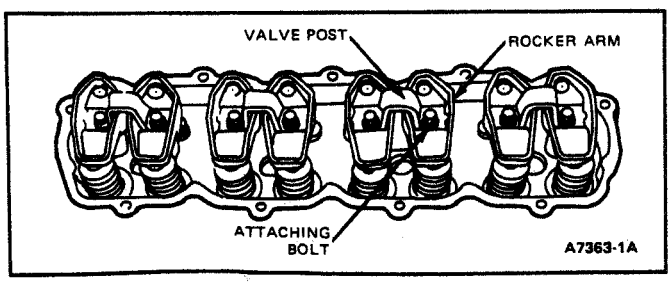


FIG. 46 Valve Rocker Arm Assembly

11. Install engine oil dipstick tube and valve cover bracket and tighten fasteners to specification. Install engine oil dipstick.
12. Install radiator fan shroud halves if required (refer to Section 27-04, Radiators, in this Manual).
13. Install battery ground cables to both batteries.
14. Run engine and inspect for oil leaks.
15. Close hood and install engine cover, if required.

Valve Spring, Retainer and Stem Seal

Broken valve springs or damaged valve stem seals and retainers may be replaced without removing the cylinder head, provided damage to the valve or valve seat has not occured.

Removal

1. Remove the required rocker arm(s).
2. Remove glow plug(s) with Tool D83T-6002-A or equivalent.
3. Install an air line with the adapter from Compression Tester, Rotunda Model 019-00001, in the glow plug hole and turn on the air supply.
4. Install spring compressor Tool T83T-6513-A or equivalent as shown in Fig. 47. Compress valve spring and remove retainer locks, spring retainer, valve spring and damper spring (Fig. 48).

   NOTE: It may be necessary to strike valve stem end with a plastic tipped hammer to loosen valve retainer locks.
5. Remove valve stem seal and valve rotators.
6. If air pressure has forced the piston to bottom of the cylinder, any removal of air pressure will allow valve(s) to fall into cylinder. A rubber band, tape or string wrapped around end of valve stem will prevent this condition and will still allow enough travel to check to valve for binding.

Installation

1. Inspect cylinder head and valve assemblies as described in this Section. Inspect the valve stem for damage. Rotate the valve and check valve stem tip for eccentric movement during rotation. Move valve up and down through normal travel in valve guide

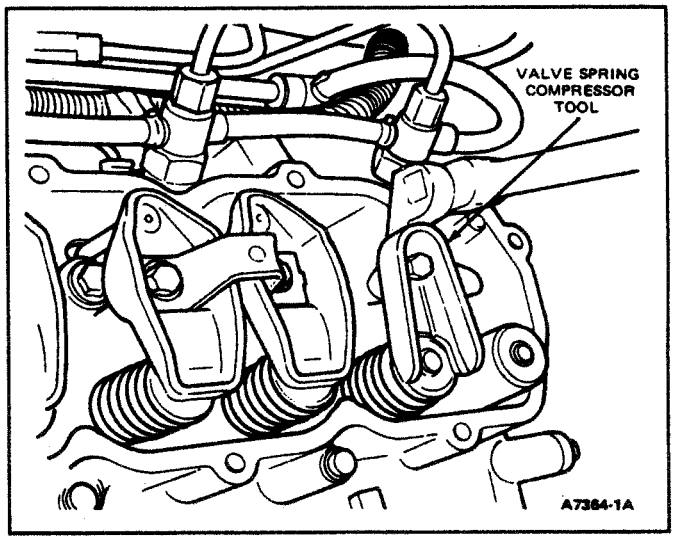


FIG. 47 Valve Spring Removal

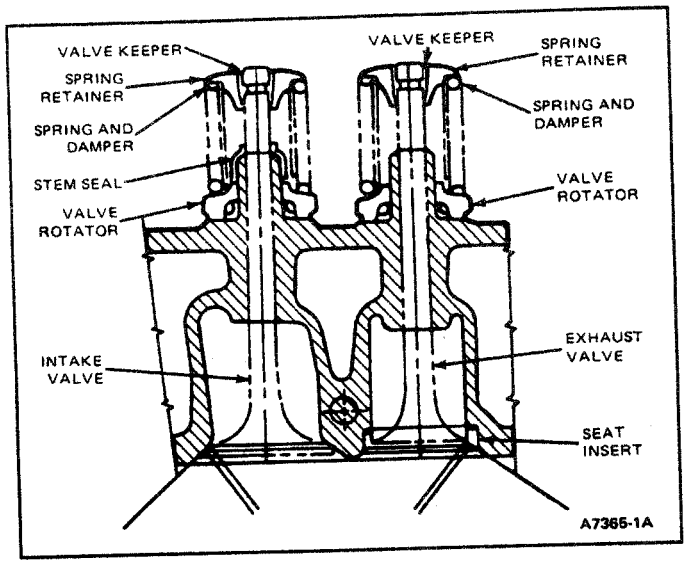


FIG. 48 Valve Spring Assembly

and check stem for binds. If valve has been damaged, it will be necessary to remove cylinder head for repairs as described in this Section. Inspect valve retainer locks for excessive wear, and replace in pairs, as necessary. When installing a new valve, always use new retainer locks.

2. If condition of valve proved satisfactory, hold valve in closed position and apply air pressure within cylinder.
3. Lubricate valve stem with recommended quality engine oil.
4. Install a seal guide on valve tip and install a new intake valve stem seal (Fig. 48) using Tool T83T-6571-A and a light hammer or mallet to seat seal on intake valve stem and damper. Place spring in position over valve and install valve spring retainer assembly. Compress valve spring and install valve spring retainer locks. Remove compressor tool. Turn off air and remove air line adapter.
5. Apply Ford Polyethylene Grease D0AZ-19584-A or equivalent to tips of valve stem and pushrods.
6. Install required rocker arm(s) and pushrod(s) following instructions given in Rocker Arm Installation.
7. Install glow plugs using Tool D83T-6002-A and tighten to specification.

Fuel Supply Pump

Removal

1. Loosen threaded connections with proper size wrench (flare nut wrench preferred) and retighten snugly. Do not remove lines at this time.
2. Loosen mounting bolts one to two turns. Apply force with hand to loosen fuel pump if gasket is stuck. Rotate engine, by nudging starter, until fuel pump cam lobe is at low position. At this position, spring tension against fuel pump bolts will be greatly reduced.
3. Disconnect fuel supply pump inlet, outlet, and fuel return line.

WARNING: USE CARE TO PREVENT COMBUSTION OF SPILLED FUEL.

4. Remove fuel pump attaching bolts and remove pump and gasket. Discard old gasket.

Installation

1. Remove all fuel pump gasket material from engine and from fuel supply pump if, reinstalling used pump.
2. Install attaching bolts into fuel supply pump and install a new gasket on bolts. Position fuel supply pump to mounting pad. Turn attaching bolts alternately and evenly and tighten to specification.

   NOTE: Cam must be at it's low position before attempting to install fuel supply pump. If it is difficult to start the mounting bolts, due to spring action of the fuel pump, turn crankshaft by hand 360° to relocate camshaft lobe. Then, proceed with fuel supply pump installation. Reinstall with lever on bottom side of cam.
3. Install fuel outlet line. Start fitting by hand to avoid crossthreading. Tighten to specification.
4. Install inlet line and tighten hose clamp to specification.
5. Start engine and observe all connections for fuel leaks for two minutes.
6. Stop engine and check all fuel supply pump fuel line connections. Check for oil leaks at pump mounting pad.

Injection Pump

NOTE: Before removing any fuel lines, clean exterior with clean fuel oil or solvent to prevent entry of dirt into engine when fuel lines are removed.

CAUTION: Do not wash or steam clean engine while engine is running or still hot from running. Serious damage to injection pump could occur.

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Remove engine cover on E-250—E-350.
4. Remove engine oil filler neck (Fig. 49).
5. Remove bolts attaching injection pump to drive gear. (Fig. 50).
6. Disconnect electrical connectors to injection pump.
7. Disconnect accelerator cable and speed control cable from throttle lever, if so equipped.

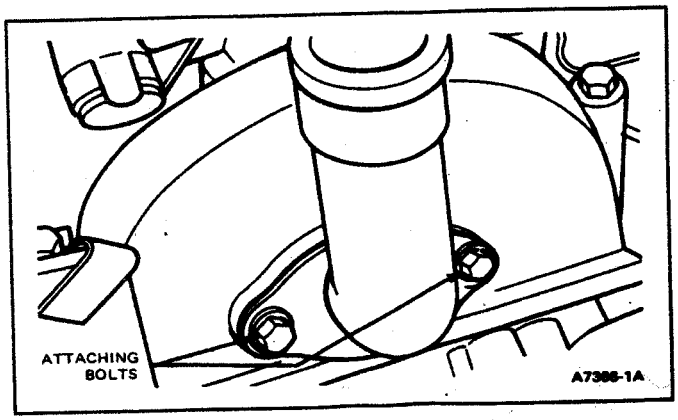


FIG. 49 Oil Filler Neck Removal

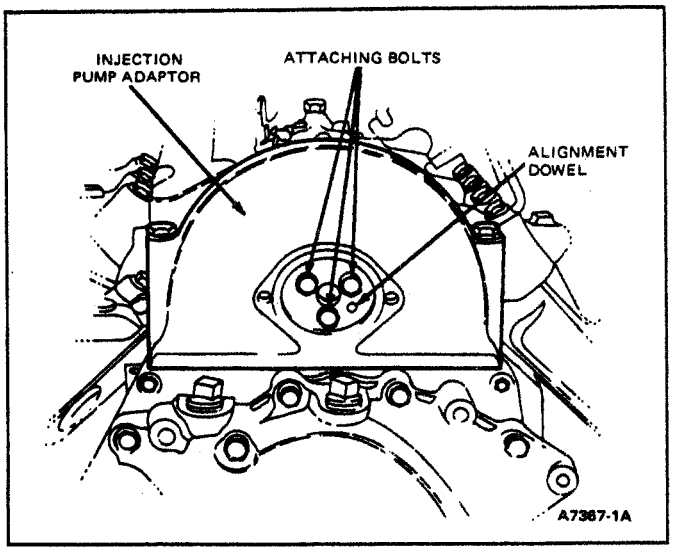


FIG. 50 Injection Pump Drive Gear Attaching Bolts

8. Remove air cleaner and install intake opening cover, Tool T83T-9424-A.
9. Remove accelerator cable bracket, with cables attached, from intake manifold and position out of the way.

   NOTE: All fuel lines and fittings must be capped using Fuel System Protective Cap Set T83T-9395-A, to prevent fuel contamination.
10. On E-250—E-350, disconnect fuel inlet line from the fuel filter.
11. On E-250—E-350, disconnect fuel return line from fuel filter.
12. On E-250—E-350, remove fuel filter bracket attaching bolts and remove fuel filter and bracket as an assembly.
13. Remove fuel filter-to-injection pump fuel line and cap fittings.
14. Remove and cap injection pump inlet elbow.
15. Remove and cap injection pump fitting adapter.
16. Disconnect fuel return line on injection pump, rotate out of the way, and cap all fittings.

    NOTE: It is not necessary to remove injection lines from injection pump to remove injection pump. If lines are to be removed, loosen injection line fittings at injection pump before removing it from engine.
17. Remove fuel injection lines from nozzles and cap lines and nozzles.
18. Remove three nuts attaching injection pump to injection pump adapter using Tool T83T-9000-B.
19. If injection pump is to be replaced, loosen injection line retaining clips and injection nozzle fuel lines with Tool T83T-9396-A and cap all fittings at this time with protective cap set T83T-9395-A. Do not install injection nozzle fuel lines until new pump is installed in engine.
20. On F-250—F-350, lift injection pump, with nozzle lines attached, up and out of engine compartment. (Fig. 51).

    CAUTION: Do not carry injection pump by injection nozzle fuel lines as this could cause lines to bend or crimp.
21. On E-250—E-350, remove injection pump through passenger compartment.

    NOTE: Use care to avoid spilling diesel fuel in passenger compartment.

    CAUTION: Do not carry injection pump by injection nozzle fuel lines as this could cause lines to bend or crimp.

Installation

1. Install new O-ring on drive gear end of injection pump.
2. On F-250—F-350, move injection pump down and into position.
3. On E-250—E-350, install injection pump from passenger compartment.

   NOTE: Use care to avoid spilling diesel fuel in passenger compartment.
4. Position alignment dowel on injection pump into alignment hole on drive gear (Fig. 50).
5. Install bolts attaching injection pump to drive gear and tighten to specification.
6. Install nuts attaching injection pump to adapter. Align scribe lines on injection pump flange and injection pump adapter and tighten to specification.
7. If injection nozzle fuel lines were removed from injection pump, install at this time (refer to Injection Nozzle Fuel Lines - Installation, in this Section).
8. Remove caps from nozzles and fuel lines and install fuel line nuts on nozzles and tighten to specification using T83T-9396-A.
9. Connect fuel return line to injection pump and tighten nuts to specifications.
10. Install injection pump fitting adapter with a new O-ring.
11. Clean old sealant from injection pump elbow threads, using clean solvent, and dry thoroughly. Start elbow into injection pump adapter, and then apply a light coating of pipe sealant D8AZ-19554-A, or equivalent, on elbow threads.
12. Tighten elbow in injection pump adapter to a minimum of 8 N·m (6 ft-lbs). Then tighten further, if necessary, to align elbow with injection pump fuel

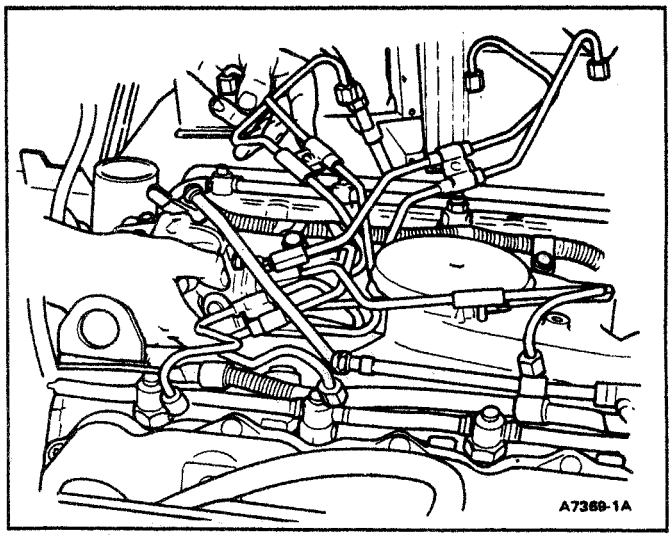


FIG. 51 Injection Pump Removal

inlet line, but do not exceed 360° of rotation or 13 N·m (10 ft-lbs).

13. Remove caps and connect fuel filter-to-injection pump fuel line and tighten to specification.
14. On E-250—E-350, install fuel filter and bracket as an assembly and tighten bolts to specifications.
15. On E-250—E-350, install fuel filter return line and tighten clamp to specifications.
16. On E-250—E-350, install fuel filter inlet fuel line and tighten to specifications.
17. Install accelerator cable bracket to intake manifold and tighten to specifications.
18. Remove intake manifold cover and install air cleaner and tighten to specifications.
19. Connect accelerator and speed control cable, if so equipped, to throttle lever.
20. Install electrical connectors on injection pump.
21. Clean injection pump adapter and oil filler neck sealing surfaces.
22. Apply a 3.2mm (1/8 inch) bead of RTV Sealant, D6AZ-19562-A, or equivalent in adapter housing grooves.

    NOTE: When applying RTV Sealant, D6AZ-19562-A always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
23. Install oil filler neck and tighten to specifications (Fig. 49).
24. Connect battery ground cables to both batteries.
25. Run engine and check for fuel leaks.
26. If necessary, purge high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles flows from connection.

    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.
27. Check and adjust injection pump timing as described in the Engine/Emission Diagnosis Manual.
28. Close hood.

Injection Nozzle Fuel Lines

Removal

NOTE: Before removing any fuel lines, clean exterior with clean fuel oil, or solvent to prevent entry of dirt into fuel system when fuel lines are removed. Blow dry with compressed air.

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. On E-250—E-350, remove engine cover.
4. Remove air cleaner and cap intake manifold opening with Tool T83T-9424-A.
5. Disconnect accelerator cable and speed control cable, if so equipped, from injection pump.
6. Remove accelerator cable bracket from intake manifold and position out of the way with cable(s) attached.

   NOTE: To prevent fuel system contamination, cap all fuel lines and fittings with protective cap set. T83T-9395-A.
7. Disconnect fuel line from fuel filter to injection pump and cap all fittings.
8. Disconnect and cap nozzle fuel lines at nozzles.
9. Remove fuel line clamps from fuel lines to be removed (Fig. 53).
10. Remove and cap injection pump inlet elbow.
11. Remove and cap inlet fitting adapter.
12. Remove injection nozzle lines, one at a time, from injection pump using Tool T83T-9396-A.

    NOTE: Fuel lines must be removed following this sequence; 5-6-4-8-3-1-7-2. Install caps on each end of each fuel line and pump fitting as it is removed and identify each fuel line accordingly (Fig. 52).

Installation

1. Install fuel lines on injection pump, using Tool T83T-9396-A, one at a time, and tighten to specification (Fig. 52).

   NOTE: Fuel lines must be installed in the sequence: 2-7-1-3-8-4-6-5 (Fig. 52).
2. Clean old sealant from injection pump elbow, using clean solvent, and dry thoroughly.
3. Apply a light coating of pipe sealant D8AZ-19554-A, or equivalent, on elbow threads.
4. Install elbow in injection pump adapter and tighten to a minimum of 8 N·m (6 ft-lbs) then tighten further, if necessary, to align elbow with injection pump fuel inlet line, but do not exceed 360° of rotation or 13 N·m (10 ft-lbs).
5. Remove caps from fuel lines and connect lines to nozzles and tighten to specification using Tool T83T-9396-A.
6. Uncap and connect fuel line from fuel filter to injection pump and tighten to specification.
7. Install fuel line retaining clamps and tighten to specification (Fig. 53).

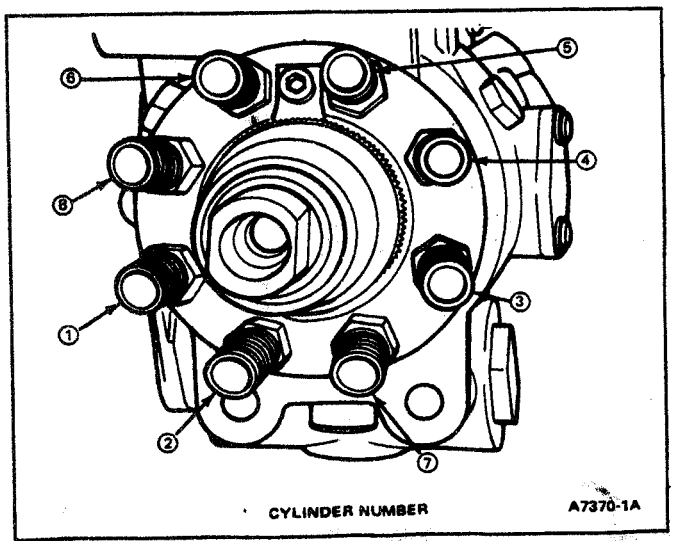


FIG. 52 Injection Pump Cylinder Numbering Sequence

8. Install accelerator cable bracket on intake manifold and tighten to specification.
9. Connect accelerator and speed control cable, if so equipped, to injection pump throttle lever.
10. Remove intake manifold cover, and install air cleaner and tighten to specification.
11. On E-250—E-350, install engine cover.
12. Connect battery ground cables to both batteries.
13. Run engine and check for fuel leaks.
14. If necessary, purge high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles, flows from connection.

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.

15. Close hood.

Injection Nozzles

Removal

NOTE: Before removing nozzle assemblies, clean exterior of each nozzle assembly and the surrounding area with clean fuel oil or solvent to prevent entry of dirt into engine when nozzle assemblies are removed. Also, clean fuel inlet and fuel leak-off piping connections. Blow dry with compressed air.

1. Remove fuel line retaining clamp(s) from effected nozzle line(s).

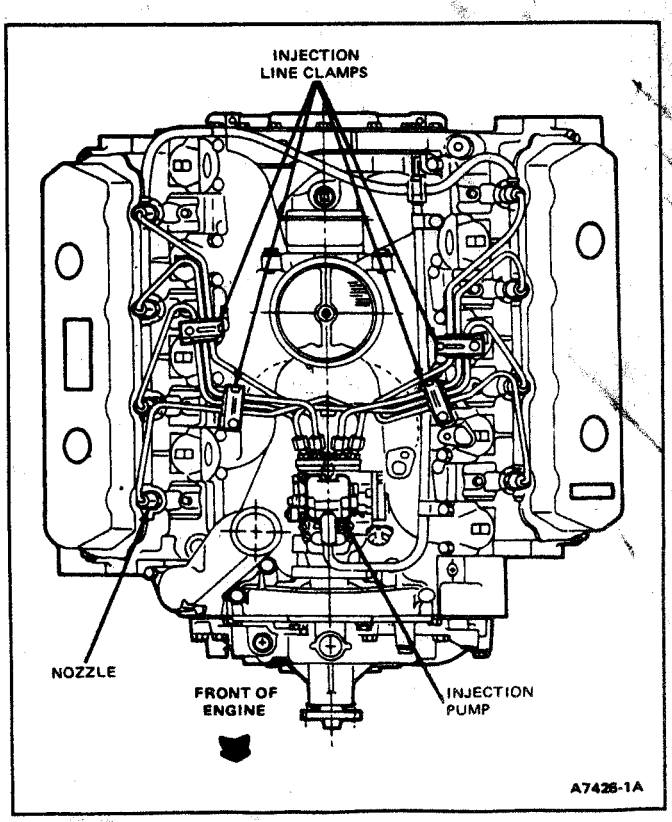


FIG. 53 Injection Line and Clamp Installation

2. Disconnect nozzle fuel inlet (high pressure) and fuel leak-off tees from each nozzle assembly and position out of the way. **Cover open ends of fuel inlet lines and nozzles to prevent entry of dirt with protective cap set T83T-9395-A.**
3. Remove injection nozzles by turning counterclockwise. Pull nozzle assembly with copper washer from engine. **Be careful not to strike nozzle tip against any hard surface during removal. Cover nozzle assembly fuel inlet opening and nozzle tip with plastic cap to prevent entry of dirt, Tool T83T-9395-A.**

   NOTE: Remove copper injector nozzle gasket from nozzle bore with Tool T71P-19703-C, or equivalent, if not attached to nozzle tip.
4. Place nozzle assemblies in a fabricated holder as they are removed from the heads, (Fig. 54). The holder should be marked with numbers corresponding to the cylinder numbering of the engine. Use of this holder permits replacing nozzles in their respective bores in the cylinder heads.

Installation

1. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle assembly with nozzle seat cleaner, Tool T83T-9527-A. Pay particular attention to seating surface, in order that no small particles of metal or carbon will cause assembly to be cocked or permit blow-by of combustion gases. Blow out particles with compressed air.
2. Remove protective cap and install a new copper gasket on nozzle assembly, with a small dab of grease D0AZ-19584-A.

   NOTE: Anti-Seize Compound or equivalent should be used on nozzle threads to aid installation and future removal.
3. Install nozzle assembly into cylinder head nozzle bore.

   CAUTION: Be careful that nozzle tip does not strike against recess wall.
4. Tighten nozzle assembly to specification.
5. Remove protective caps from nozzle assemblies and fuel lines.
6. Install leak-off tees to nozzle assembly.

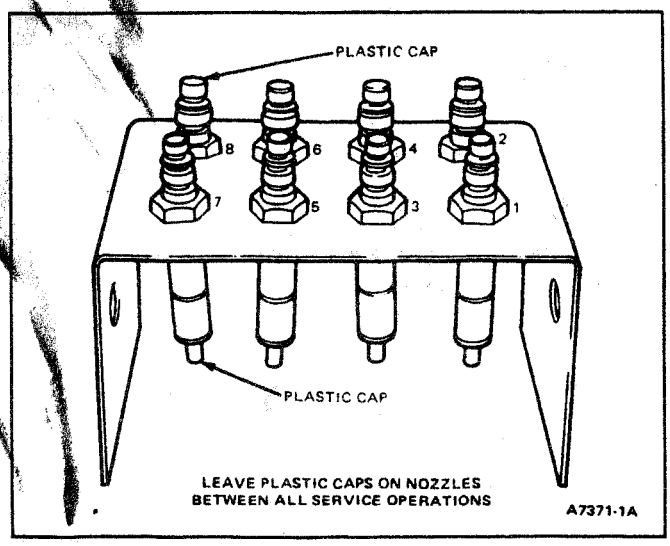


FIG. 54 Nozzle Holding Fixture

NOTE: Install two new O-ring seals for each fuel return tee.

7. Connect high pressure fuel line and tighten to specification using Fuel Line Nut Wrench T83T-9396-A.
8. Install fuel line retainer clamp(s), and tighten to specification.
9. Start engine.
10. If necessary, purge high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles flows from connection.

    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.
11. Check for fuel leakage at high pressure connections.
12. Close hood.

Intake Manifold, Valley Pan and Tappets

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. On E-250—E-350, remove engine cover.
4. Remove air cleaner and install intake manifold cover, Tool T83T-9424-A.
5. On E-250—E-350, disconnect fuel inlet line from the fuel filter.
6. On E-250—E-350, disconnect fuel return line from fuel filter.
7. On E-250—E-350, remove fuel filter bracket attaching bolts and remove fuel filter and bracket as an assembly.
8. Remove injection pump as described in this Section.
9. On F-250—F-350, remove fuel return hoses from No. 7 and No. 8 (rear) nozzles and remove return hose to fuel tank (Fig. 55).
10. Remove engine wiring harness from engine.

    NOTE: Remove engine harness ground cable from back of left cylinder head (Fig. 55).
11. Remove bolts attaching intake manifold to cylinder heads and remove manifold (Fig. 56).
12. Remove CDR tube and grommet from valley pan.
13. Remove bolts attaching valley pan strap to front of engine block, and remove strap.
14. Remove valley pan drain plug and remove valley pan.
15. If tappets are being serviced, remove valve covers, rocker arms and pushrods as described in this Section.
16. Remove tappet guide retainer (Fig. 57).

    NOTE: Tappets should be kept in order so they can be reinstalled in their original position. Inspect and test each tappet separately so as not to intermix the internal parts.

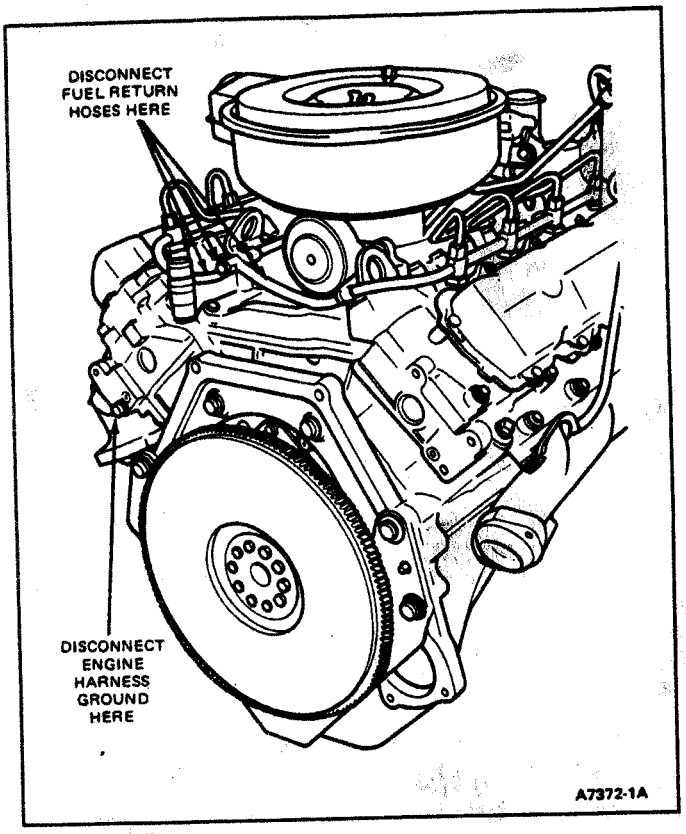


FIG. 55 Engine Wiring Harness Ground

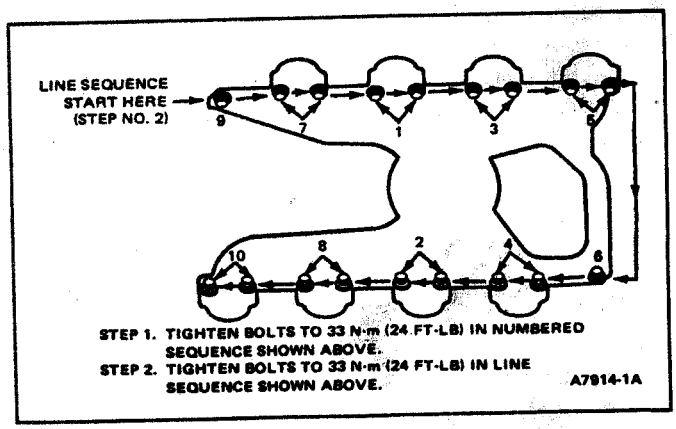


FIG. 56 Intake Manifold Attaching Bolts Tightening Sequence

Installation

1. Lubricate tappets and bores with recommended quality engine oil and install tappets in their original positions.
2. Install tappet guides.
3. Install tappet guide retainer and tighten to specifications.
4. Position pushrods, copper colored ends toward rocker arms, into their respective tappets making sure they are seated fully in pushrod seats.
5. Install rocker arms and valve covers with new gaskets as described in this Section.
6. Clean cylinder block gasket surfaces of any old RTV Sealant or oil. Apply a 3.18mm (1/8 inch) bead of RTV Sealant D6AZ-19562-A, or equivalent, to each end of the cylinder block (Fig. 58).

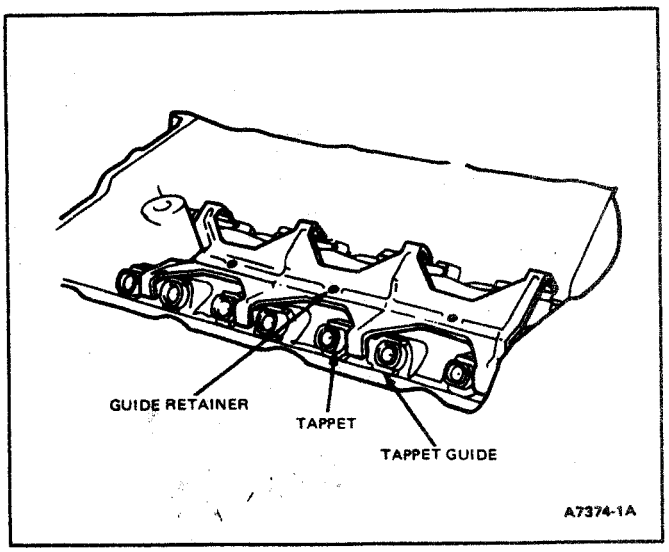


FIG. 57 Tappet Removal

NOTE: When applying RTV Sealant always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.

7. Install new valley pan.
8. Install valley pan drain plug.
9. Install CDR tube and new grommet into valley pan.
10. Install new O-ring and new back-up ring on CDR valve.
11. Install valley pan strap on front of valley pan and tighten to specification.
12. Install intake manifold and tighten to specifications using the two-step method shown in Fig. 56.
13. Install engine wiring harness on engine.

    NOTE: Connect engine wiring harness ground wire to rear of left cylinder head and tighten to specification (Fig. 55).
14. On E-250—E-350, install fuel filter and bracket as an assembly and tighten bolts to specifications.
15. On E-250—E-350, install fuel filter return line and tighten clamp to specifications.
16. On E-250—E-350, install fuel filter inlet fuel line and tighten to specifications.

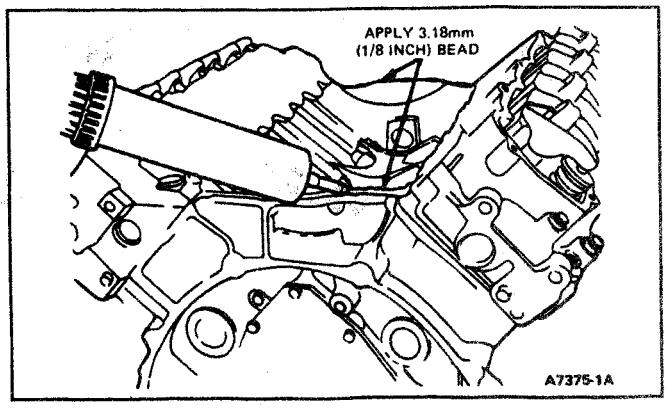


FIG. 58 Applying RTV Sealant

17. Install injection pump as described in this Section.
18. Connect fuel tank return hose and No. 7 and No. 8 nozzle fuel return hoses (Fig. 55).
19. Remove intake manifold cover and install air cleaner and tighten to specification.
20. Install engine cover, E-250—E-350.
21. Connect battery ground cables to both batteries.
22. Run engine and check for oil and fuel leaks.
23. If necessary, purge nozzle high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles, flows from the connection.

    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.
24. Close hood.

Exhaust Manifolds

F-250—F-350

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Raise vehicle.
4. Disconnect muffler inlet pipe from exhaust manifolds.
5. If right exhaust manifold is to be removed, lower vehicle at this time. If left exhaust manifold is to be removed, leave hoist up.
6. Bend tabs for exhaust manifold attaching bolts and remove bolts and manifold.

Installation

1. Clean mounting surfaces.
2. Apply anti-seize compound on exhaust manifold bolt threads and install left manifold with new gasket and new locking tabs.

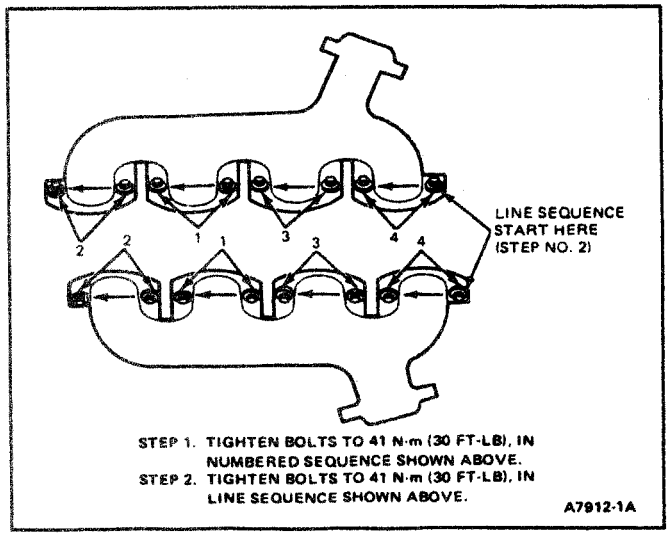


FIG. 59 Exhaust Manifold Tightening Sequence

3. Tighten bolts to specifications, using the two-step method shown in Fig. 59 and bend tabs over flats of bolt heads to prevent them from loosening and raise vehicle.
4. If right exhaust manifold is being installed, raise vehicle at this time, and repeat installation Steps 2 and 3.
5. Connect muffler inlet pipe to manifolds and tighten to specification.
6. Lower vehicle.
7. Connect battery ground cables to both batteries.
8. Run engine and check for exhaust leaks.
9. Close hood.

E-250—E-350

Removal

1. Open hood. Remove engine cover.
2. Disconnect battery ground cables from both batteries.
3. For right-hand manifold only, remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
4. For right-hand manifold only, remove engine oil dipstick tube fasteners and remove dipstick and tube.
5. For right-hand manifold only, remove transmission filler tube fasteners and remove filler tube and dipstick.
6. Raise vehicle.
7. For right-hand manifold only, remove nuts attaching right-hand engine mount insulator to frame.
8. For right-hand manifold only, slightly raise right hand side of the engine until fuel filter header touches vehicle sheet metal. Install suitable wood block between insulator and frame. Lower engine on block.
9. Remove muffler inlet pipe from exhaust manifolds.
10. Lower verhicle.
11. Bend locking tabs away from bolt heads, remove bolts and manifold.

Installation

1. Install manifold with new gasket and locking tabs.
2. Tighten bolts to specifications using the two-step method shown in Fig. 59 and bend locking tabs over flats of bolts heads to prevent them from loosening.
3. Raise vehicle.
4. For right-hand manifold only, raise engine, remove wood block and lower engine on to No. 1 crossmember.
5. For right-hand manifold only, install insulator attaching washers and nuts and tighten to specification.
6. Install muffler inlet pipe to exhaust manifolds and tighten to specification.
7. Lower vehicle.
8. For right-hand manifold, install transmission filler tube and tighten to specification. Install transmission oil dipstick.
9. Install engine oil dipstick tube and tighten fasteners to specification. Install engine oil dipstick.
10. For right-hand manifold, install radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
11. Connect battery ground cables at both batteries.
12. Run engine and check for exhaust leaks.
13. Install engine cover and close hood.

Thermostat

A poppet-type thermostat is used with the engine. When the thermostat is closed, coolant flows to the water pump through a bypass passage at the front of the engine. When the thermostat is open, coolant flows through the coolant outlet elbow (thermostat housing) to the radiator.

CAUTION: Replacement thermostats other than the specified Motorcraft, or International Harvester thermostats may result in engine overheat damage. The specified thermostat does not contain an internal by-pass, since the by-pass is located in the cylinder block. Therefore, whenever the thermostat is replaced, it is mandatory that only the specified Motorcraft E3TZ-8575-A, or International Harvester 1803357 C91 thermostat be installed.

The thermostat is a high temperature thermostat for use with a mixture of water and permanent-type anti-freeze.

CAUTION: Do not attempt to repair the thermostat. It should be replaced if it is not operating properly.

Check the thermostat before installing it, following the procedure described in this Section.

Removal

1. Open hood and disconnect battery ground cables from both batteries.
2. Drain the radiator so that the coolant level is below the thermostat (refer to Section 27-02 Cooling System Service, in this manual).
3. Loosen and remove alternator and vacuum pump drive belts.
4. Remove alternator and position it out of the way.
5. Remove vacuum pump and bracket and position out of the way.
6. Remove all but the lowest alternator/vacuum pump mounting casting bolt. Loosen the lowest bolt and pivot the alternator/vacuum pump casting outboard.
7. Remove the water outlet housing attaching bolts. Bend the radiator upper hose upward and remove the thermostat and gasket.

Installation

1. Clean the water outlet housing gasket surfaces. Coat a new outlet housing gasket with B5A-10554-A water-resistant sealer. Position the water outlet housing gasket on the intake manifold opening.
2. Install the thermostat in the intake manifold opening with the copper pellet or element toward the engine and the thermostat flange positioned in the recess. If the thermostat is improperly installed, it will cause a restricted flow of coolant.

3. Position the water outlet housing against the intake manifold. Install and tighten the attaching bolts to specification.
4. Reposition the alternator/vacuum pump casting.
5. Install vacuum pump with bracket and tighten to specification.
6. Install alternator and drive belt.
7. Install vacuum pump drive belt.
8. Adjust alternator and vacuum pump belts to specification. (Refer to Section 27-06, Accessory Drive Belt Service in this Manual).
9. Fill and bleed the cooling system (Section 27-02, Cooling System Service).
10. Connect battery ground cables to both batteries.
11. Operate the engine until normal operating temperature is reached, then check the coolant level and check for leaks.

    WARNING: DO NOT STAND IN LINE OR NEAR RADIATOR FAN WHEN REVVING ENGINE.
12. Close hood.

Cylinder Heads

Right Side Described, Left Side Similar

Removal

1. Open hood. (E-250—E-350, remove engine cover).
2. Disconnect battery ground cables from both batteries.
3. Drain cooling system.
4. Remove radiator fan shroud halves. (Refer to Section 27-04, Radiators, in this Manual).
5. Remove radiator fan and clutch assembly using Tool T83T-6312-A and B.

   CAUTION: Left hand thread. Remove by turning nut clockwise.
6. Disconnect alternator and fuel supply line heater wiring from alternator.
7. Remove alternator adjusting bolt and pivot bolt and remove alternator.
8. Remove vacuum pump adjusting bolt and pivot bolt and remove vacuum pump.
9. Remove fuel filter inlet, outlet and return lines and cap lines and fittings with protective cap set T83T-9395-A (F-250—F-350, right side only).
10. Remove alternator and vacuum pump mounting bracket. On F-250—F-350, remove fuel filter bracket with filter attached (right side only).
11. Remove heater hose from cylinder head.
12. Remove injection pump as described in this Section.
13. Remove intake manifold and valley cover as described in this Section.
14. Raise vehicle.
15. Disconnect muffler inlet pipe from exhaust manifolds.
16. Remove bolt attaching transmission oil dipstick tube to cylinder head (right side only).
17. Lower vehicle.
18. Remove fasteners holding engine oil dipstick tube in position (right side only).
19. Remove right hand exhaust manifold as described in this Section.
20. Remove engine oil dipstick, dipstick tube and O-ring (right side only).
21. Remove valve cover, rocker arms and pushrods as described in this Section.
22. Remove nozzles and glow plugs as described in the Section.
23. Remove bolts attaching cylinder head to engine block.
24. Attach lifting eyes Tool T70P-6000, or equivalent, to each end of cylinder head.
25. For F-250—F-350, install lifting sling to lifting eyes and carefully lift cylinder head out of engine compartment.
26. For E-250—E-350, install suitable bar through rings on lifting eyes. With an assistant, carefully lift cylinder head and remove (Fig. 60).
27. Remove head gasket.

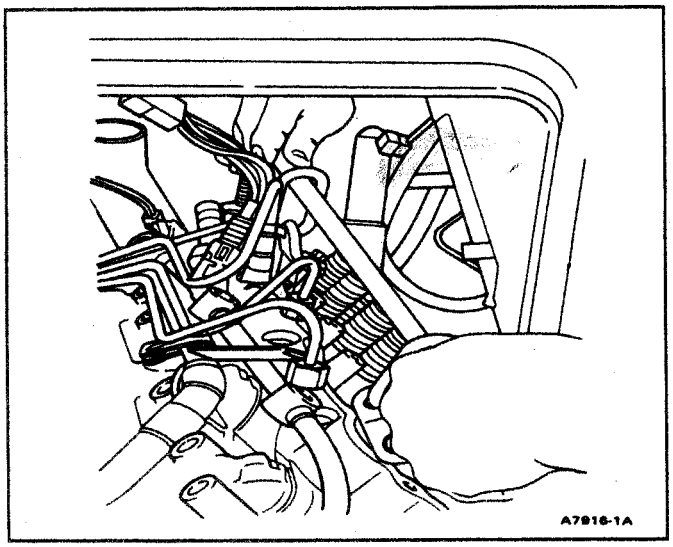


FIG. 60 Cylinder Head Removal—E-250—E-350

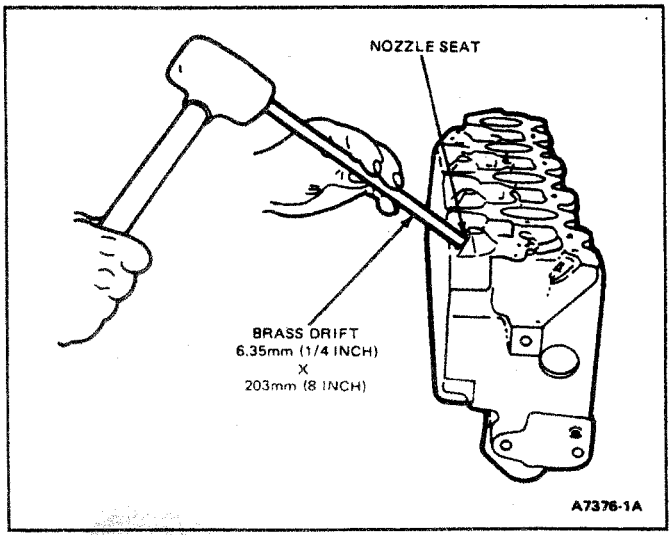


FIG. 61 Prechamber Removal

CAUTION: Prechambers may fall out of cylinder head upon removal.

28. Remove prechambers using a 6.35mm x 203mm (1/4 inch x 8 inch) brass drift and suitable hammer (Fig. 61).
29. Place cylinder head in suitable holding Fixture.

    NOTE: Be careful not to damage the cylinder head gasket surface.
30. Install valve spring compressor Tool T83T-6513-A, compress valve spring, and remove valve keeper, (Fig. 47).

    NOTE: It may be necessary to strike valve stem end with a light, soft hammer to loosen valve keepers.
31. Release spring compressor and remove spring retainer, valve spring and damper assembly, (Fig. 48).

    NOTE: Keep valves and their related parts together so they may be installed in their original positions.
32. Remove valve seal; valve rotators and valves.

    NOTE: Remove any burrs from valve stem before removing valves to prevent damage to the valve bore.

Installation

1. Clean and inspect cylinder head and valves as described in this Section.
2. Clean and inspect cylinder head gasket surface for cracks and flatness as described in this Section.
3. Install valves, springs, retainers and stem seals, as described in this Section.
4. Clean and inspect prechambers and ports for cracks. Reinstall or replace prechambers as necessary. Refer to Overhaul—Cylinder Head Assembly in this Section.
5. Apply a light coating of extra-heavy duty grease, D4AZ-19590-A or equivalent to mounting edge of prechamber and install prechamber in head. Lightly tap with plastic tipped hammer, if necessary.
6. Clean and inspect engine block head gasket surface for cracks and flatness.
7. Position new cylinder head gasket on engine block using locating dowels. Install gasket with silver stamped "This Side Up" facing installer.
8. Carefully lower cylinder head onto engine block.

   CAUTION: Use care in installing cylinder head to prevent pre-chambers from falling into cylinder bores.
9. Install cylinder head attaching bolts and tighten to specifications using the four step method given in Fig. 62.

   NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil.
10. Install pushrods, copper colored ends toward rocker arms, making sure pushrods are fully seated in tappet pushrod seats.
11. Install rocker arms and valve covers as described in this Section.
12. Install valley pan and intake manifold as described in this Section.
13. Install injection pump as described in this Section.

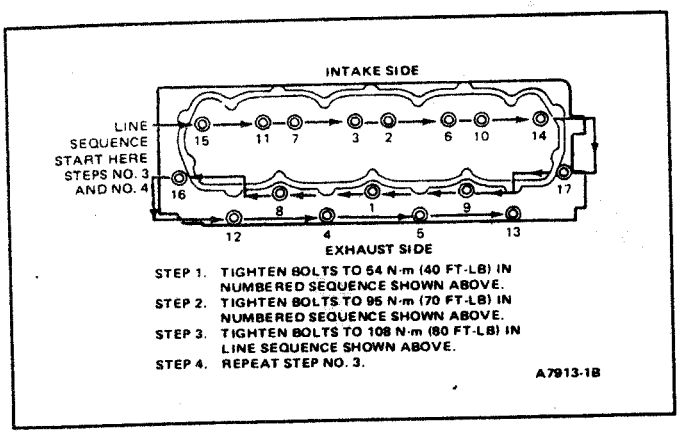


FIG. 62 Cylinder Head Bolt Tightening Sequence

14. Connect heater hose to cylinder head and tighten clamp to specification.
15. Install fuel filter with bracket (F-250—F-350, right side only), and/or alternator and vacuum pump bracket and tighten to specification.
16. Remove protective caps and install fuel filter inlet, outlet and return lines and tighten to specifications.
17. Loosely install engine oil dipstick tube and O-ring into cylinder block (right side only).
18. Raise vehicle.
19. Remove dipstick tube from block and install retaining clip. Coat end of tube with adhesive, EOAZ-19554-A, or equivalent. Reinstall tube with block, attach clip and tighten to specification (right side only).
20. Install right hand exhaust manifold as described in this Section.
21. Install bolt attaching transmission oil dipstick to cylinder block and tighten to specification (right side only).
22. Connect muffler inlet pipe to exhaust manifolds and tighten to specification.
23. Lower vehicle.
24. Install vacuum pump.
25. Install alternator and drive belt.
26. Install vacuum pump and drive belt.
27. Adjust alternator and vacuum pump drive belts to specifications (refer to Section 27-06, Accessory Drive Belt Service, in this Section).
28. Connect alternator wiring harness.
29. Remove intake manifold cover and install air cleaner and tighten to specification.
30. Connect battery ground cables to both batteries.
31. Refill and bleed cooling system (refer to Section 27-02, Cooling System Service, in this Manual).
32. Run engine and check for fuel, coolant and exhaust leaks.
33. If necessary, purge high pressure fuel lines of air by loosening connector one half to one turn and cranking engine until solid fuel, free from bubbles flows from connection.

    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.

34. Install radiator fan and clutch assemby using Tools T83T-6312-A and B.

    CAUTION: Left hand thread. Tighten by turning nut counterclockwise.

35. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this manual).
36. Close hood. (E-250—E-350, install engine cover).

Engine Oil Filter

Removal

1. Open hood.
2. Raise vehicle.
3. Remove oil filter, using a suitable oil filter wrench.

Installation

1. Clean gasket mating surface on oil filter flange.
2. Lightly coat sealing gasket with clean engine oil.
3. Install oil filter until seal contacts filter flange and tighten 1 1/4 to 2 additional turns.
4. Lower vehicle.
5. Check engine oil level, and add as required.
6. Run engine and check for oil leaks.
7. Close hood.

Engine Oil Cooler

Removal

1. Open hood.
2. Disconnect battery ground cables from both batteries.
3. Drain cooling system.
4. Remove radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
5. Remove fan and clutch assembly using Tools T83T-6312-A and B, or equivalent.

   CAUTION: Left-hand thread. Remove by turning nut clockwise.

6. Raise vehicle.
7. Drain engine oil and remove oil filter. Do not install drain plug.
8. Remove nut attaching LH engine mount insulator to frame (F-250—F-350 only).
9. Slightly raise left side of the engine and install a 25mm (one inch) wood block between insulator and frame. Lower engine on block (F-250—F-350 only).
10. Remove bolts attaching oil cooler to engine block and remove engine oil cooler.

Installation

1. Install engine oil cooler assembly with new gaskets and tighten to specification.

   NOTE: Four O-rings are used on all oil coolers from 1985 model F-Series and E-Series.

   CAUTION: The inner O-ring must be installed on the header (not on the bundle) to avoid cutting the inner O-ring during assembly (Fig. 17).

2. Raise engine, remove wood block and lower engine on to No. 1 crossmember (F-250—F-350 only).
3. Install insulator attaching washer and nut and tighten to specification (F-250—F-350 only).
4. Install new oil filter and install drain plug and tighten to specification.
5. Prime the entire engine lubricating system to fill the oil cooler, oil filter and cylinder block galleries with the specified type and grade of oil.

   NOTE: Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.

6. Lower vehicle.
7. Check the engine oil level and fill as necessary with the specified type and grade of oil.
8. Fill and bleed the cooling system (refer to Section 27-02, Cooling System Service, in this Manual).
9. Install fan and clutch assembly using Tools T83T-6312-A and B, or equivalent.

   CAUTION: Left hand thread. Turn nut counterclockwise to tighten.

   Tighten nut to specifications.

10. Install radiator fan shroud halves (refer to Section 27-04, Radiators, in this Manual).
11. Connect battery ground cables at both batteries.
12. Run engine and check for oil and coolant leaks.
13. Close hood.

Oil Pan, Oil Pump and Oil Pick-Up Tube

Removal

1. Open hood.
2. Disconnect battery ground cable from both batteries.
3. Remove engine oil level dipstick.
4. Remove transmission oil level dipstick, if so equipped.
5. Remove air cleaner and install intake opening cover Tool T83T-9424-A.
6. Remove fan and clutch assembly using Tool T83T-6312-A and B.

   CAUTION: Left hand thread. Remove by turning nut counterclockwise.

7. Drain cooling system.
8. Disconnect lower radiator hose.
9. Disconnect power steering return hose from pump. Plug hose and pump to prevent contamination of the system.
10. Disconnect alternator wiring harness and fuel line heater connector from alternator.
11. Raise vehicle.
12. Disconnect and plug transmission oil cooler lines from radiator, if so equipped.
13. Disconnect and plug fuel pump inlet fuel line.
14. Drain crankcase and remove oil filter.
15. Remove bolt attaching transmission oil filler tube to engine block and remove tube.

16. Disconnect muffler inlet pipe from exhaust manifolds.
17. Disconnect muffler inlet pipe at muffler flange and remove inlet pipe.
18. Remove upper inlet pipe mounting stud from right exhaust manifold.
19. Remove nuts and washers attaching engine insulators to No. 1 crossmember.
20. Lower vehicle.
21. E-250—E-350: Install engine lifting brackets Rotunda Tool 014-00306 or equivalent to front of engine. Connect lifting eyes, Tool T70P-6000 or equivalent to lifting sling and raise engine until transmission housing contacts body.

    F-250—F-350: Install lifting sling to lifting eyes on intake manifold and raise engine until transmission housing contacts body.
22. Install wood blocks (2 3/4 inch LH side, 2 inch RH side) between engine insulators and crossmember.
23. Lower engine so that blocks support engine.
24. Raise vehicle.
25. Remove flywheel inspection plate.
26. Position fuel pump inlet line at rear of No. 1 crossmember and transmission oil cooler lines, if so equipped, out of the way.
27. Remove oil pan attaching bolts.
28. Remove oil pump and pick-up tube from engine and lay in oil pan (F-250—F-350 only).
29. Remove oil pan by pulling down and toward rear of vehicle.

    NOTE: Crankshaft may have to be turned to reposition counterweights to aid in removal of oil pan.
30. Remove oil pump pickup tube from oil pump, if required.

    NOTE: E-250—E-350, oil pump can be removed at this time, if necessary.

Installation

1. Remove old gasket material and clean mating surfaces of oil pan, engine block and front and rear covers with a suitable solvent and dry thoroughly.
2. Clean mating surfaces of oil pickup tube. Inspect for cracks, and assemble to oil pump with new gasket, if removed. Tighten nuts to specification.

   NOTE: Prime oil pump with recommended engine oil. Rotate pump drive gear to distribute oil within pump body.
3. E-250—E-350, install oil pump and tighten bolts to specification, if removed.
4. Place oil pump and pick-up tube in oil pan.
5. Place oil pan in position on No. 1 crossmember.
6. Install oil pump and pick-up tube and tighten to specifications (F-250—F-350 only).
7. Apply a 3.16mm (1/8 inch) bead of RTV Sealant D6AZ-19562-A, or equivalent, on side rails of engine block oil pan mating surface, and a 6.35mm (1/4 inch) bead of RTV Sealant D6AZ-19562-A, or equivalent on ends of engine oil pan mating surface on front and rear covers, and in mating corners.

   NOTE: When applying RTV Sealant always use the bead size specified and join the components within 15 minutes of application. After this amount of time the sealant begins to "set-up" and its sealing effectiveness may be reduced.
8. Install locally fabricated oil pan installation dowels in position (Fig. 63).
9. Position oil pan on engine and install attaching bolts.
10. Remove oil pan locating dowels and install two remaining oil pan bolts. Tighten all oil pan bolts to specifications.
11. Install flywheel inspection plate and tighten to specifications.
12. Lower vehicle.
13. Raise engine and remove wooden engine support blocks.
14. Lower engine onto No. 1 crossmember and remove lifting sling.
15. Raise vehicle.
16. Install nuts and washers attaching engine insulators to No. 1 crossmember and tighten to specifications.
17. Install upper muffler inlet pipe mounting stud on right exhaust manifold.
18. Position muffler inlet pipe in vehicle and connect muffler inlet pipe to muffler flange, using a new gasket, and tighten to specification.
19. Connect muffler inlet pipe to exhaust manifolds and tighten to specification.
20. Install transmission oil filler tube, using a new O-ring and tighten attaching bolt to specification.
21. Install oil pan drain plug and new oil filter and tighten to specifications.
22. Connect fuel pump inlet line to fuel pump and tighten to specification.

    NOTE: Make sure fuel line clip is re-installed in No. 1 crossmember.
23. Connect transmission oil cooler lines and tighten to specification, if so equipped.
24. Lower vehicle.

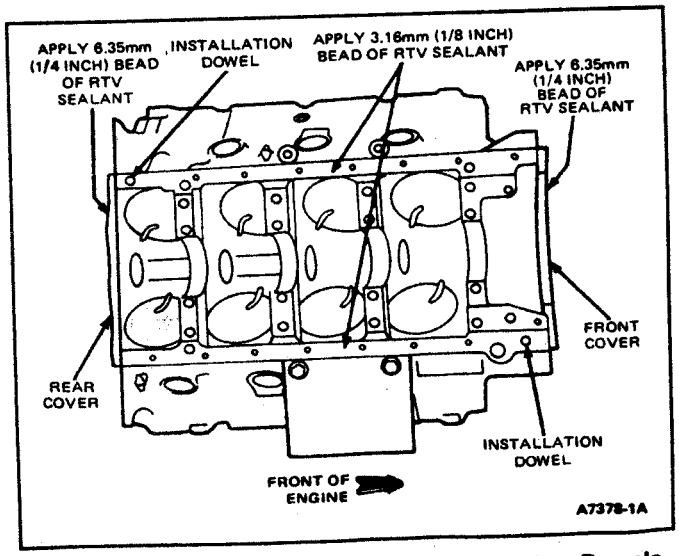


FIG. 63 Applying RTV Sealant and Installation Dowels

25. Connect alternator wiring harness and fuel line heater connector to alternator.
26. Connect power steering return hose to power steering pump.
27. Connect lower radiator hose clamp and tighten to specification.
28. Install radiator fan and clutch assembly using Tools T83T-6312-A and B, and tighten to specification.

    CAUTION: Left hand thread. Install by turning nut counterclockwise.
29. Remove intake manifold cover, and install air cleaner and tighten to specifications.
30. Install engine oil and transmission oil dipsticks.
31. Refill and bleed cooling system (refer to Section 27-02, Cooling System Service, in this Manual).
32. Fill Crankcase with specified quantity, quality, and viscosity of engine oil.
33. Connect battery ground cables to both batteries.
34. Run engine and check for oil, fuel and coolant leaks.
35. Check power steering fluid and add, if necessary.
36. Close hood.

Overhaul

NOTE: Engine must be removed from chassis for piston or crankshaft service.

NOTE: Crankshaft and piston cooling jets must be removed prior to cylinder, or piston/ring service. Piston cooling jets could be damaged by cylinder deglazing or honing operations. New piston cooling jets must be installed.

NOTE: When assembling the engine during overhaul it is important to prelubricate the running parts with clean engine oil to assure initial lubrication when the engine is started. To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.

Cylinder Assembly—6009

Disassembly

1. Mount the old engine on a work stand using mounting adapters, Rotunda Model 014-00306, and remove all parts not furnished with new cylinder assembly, following the procedures given in Removal and Installation of this Section.
2. Remove 4 cylinder head locating dowels and block drain plugs.
3. Remove old cylinder assembly from work stand.

Assembly

1. Clean gasket and seal surfaces of all serviceable parts and assemblies with a suitable solvent and dry thoroughly.
2. Position new cylinder assembly on a work stand and install cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from old cylinder assembly, following procedures described under Removal and Installation in this Section.
4. Check all assembly clearances following Specifications listed at end of this Section and correct as necessary.

Cylinder Block—6010

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs, following procedures described in this Section.

Disassembly

1. Mount old engine in a work stand using mounting adapters, Rotunda Model 014-00306, and completely disassemble it, following procedures described under Removal and Installation in this Section.
2. Remember to ridge-ream cylinder bores before removing piston assemblies.
3. Remove cylinder head locating dowels and block drain plugs.

Assembly

1. Clean gasket and seal surfaces of all serviceable parts and assemblies with a suitable solvent and dry thoroughly.
2. Position new cylinder block in a work stand and install cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from old cylinder block, following procedures described under Removal and Installation in this Section.
4. Check all assembly clearances following Specifications at end of this Section and correct as necessary.

Pistons and Connecting Rods

NOTE: Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of connecting rod bolt or nut threads.

Removal

1. With engine removed from vehicle and placed on an engine stand, using mounting adapter, Rotunda Model 014-00306, remove injection pump, intake manifold, cylinder heads, oil pan and oil pump, following procedures described in this Section.
2. Remove any ridges and/or deposits from upper end of cylinder bores as follows:
   a. Turn crankshaft until piston to be removed is at the bottom of its travel and place a cloth on piston head to collect cuttings. Remove any ridge and/or deposits from upper end of cylinder bores. Remove cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturer.

      CAUTION: Never cut into ring travel area. Maximum cylinder ridge cutter depth is 0.79mm (0.031 inch).
3. Make sure all connecting rods and caps are marked so that they can be installed in their original positions.
4. Turn crankshaft until connecting rod being removed is down (BDC).
5. Remove connecting rod nuts and cap.

6. Install protective sleeves, Rotunda Model 014-00313, on connecting rod bolts.
7. Push connecting rod and piston assembly out top of cylinder with handle end of a hammer. **Avoid damage to cooling jets, crankshaft journal or cylinder wall when removing piston and rod.**
8. Remove bearing inserts from connecting rod and cap if required.
9. Install cap on connecting rod from which it was removed.

Installation

1. If new piston rings are to be installed, remove cylinder wall glaze. Follow instructions of the tool manufacturer. Cylinder bores must be cleaned with a soap and water solution after deglazing or honing. Dry and oil cylinder walls immediately after cleaning as described in this Section. Use proper size ring installer tool.
2. Oil piston rings, pistons and cylinder walls with recommended quality engine oil. **Be sure to install pistons in same cylinders from which they were removed or to which they were fitted. Connecting rods and bearing caps are numbered 1, 3, 5, 7, in left bank, beginning at front of engine. The numbers on connecting rod and bearing cap must be on same side when installed in cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and connecting rod should be numbered to correspond with a new cylinder number.**
3. Make sure ring gaps (oil ring spacer-A, oil ring-B, compression ring-C) are properly spaced around circumference of piston (Fig. 64).
4. Turn crankshaft throw to position shown in Fig. 65.
5. Install connecting rod upper bearing, and install guide sleeves, Rotunda Model 014-00313. Before installing, verify that large chamfer on connecting rod faces crankshaft check (facing toward front on engine on right bank rods, and toward rear of engine on left bank rods). Install a piston ring compressor Tool D81L-6002-C on piston and push piston in with a hammer handle until it is slightly below top of cylinder (Fig. 65). Guide connecting rods to avoid damaging cooling jets and crankshaft journals. **Install piston with arrow and eyebrows on piston head toward camshaft. (Fig. 66).**
6. Push piston all the way down until connecting rod bearing seats on crankshaft journal. Remove protective sleeves and install lower bearing and cap.
7. Check clearance of each bearing and connecting rod side clearance following procedure described under Main and Connecting Rod Bearings in this Section.
8. After bearings have been fitted, apply a light coat of recommended quality engine oil to journals and bearings.
9. Install connecting rod cap and bearing. Tighten connecting rod nuts alternately to specification. Loosen and then retighten nuts to specification.

   NOTE: Lightly coat bolt threads with oil before installing.

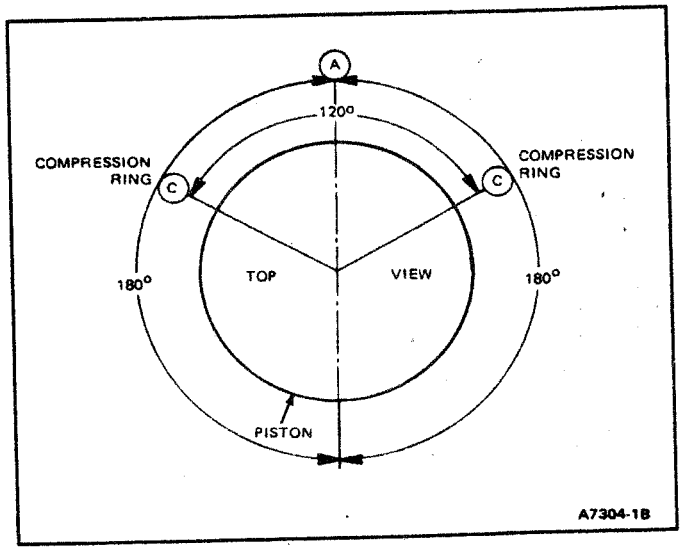


FIG. 64 Piston Ring Spacing

Crankshaft

Removal

1. With engine removed from vehicle and placed on an engine stand, using mounting adapter, Rotunda Model 014-00306, remove injection pump and adapter, engine front and rear covers, oil pan, oil pump and pick up, as described in this Section.

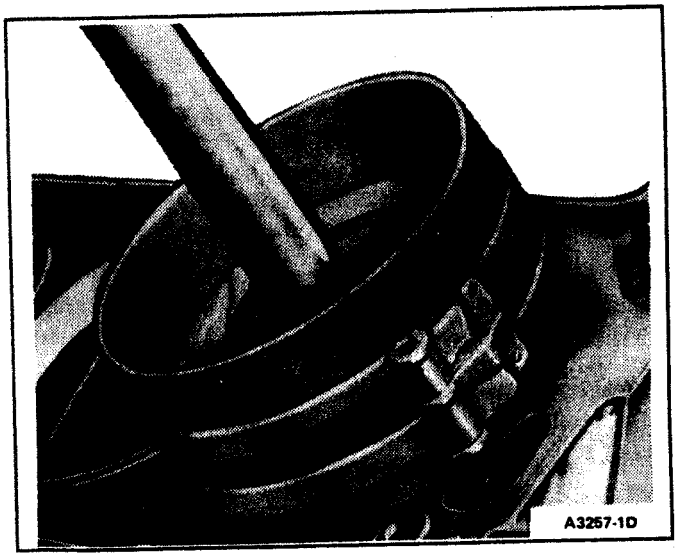


FIG. 65 Installing Piston

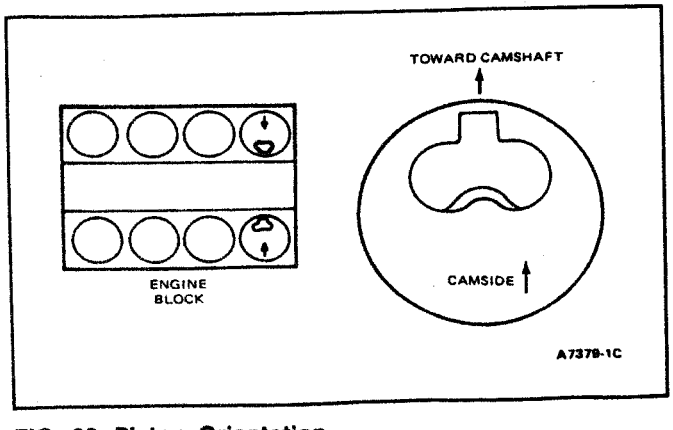


FIG. 66 Piston Orientation

2. Make sure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.
3. Turn crankshaft until connecting rod from which cap is being removed is down (BDC), and remove bearing cap. Install connecting rod guide, Rotunda Model 014-00313, and push connecting rod and piston assembly up into cylinder. Remove guides and install bearing cap. Repeat this procedure until all connecting rods are removed.

   CAUTION: Use care to avoid damage to crankshaft journal, cooling jets and cylinder wall when moving piston assembly.
4. Remove main bearing caps. Main bearing caps are numbered from front of engine.
5. Install lifting eyes, Tool T70P-6000, to crankshaft and carefully lift crankshaft out of block so that thrust bearing surfaces are not damaged. **Handle crankshaft with care to avoid possible fracture or damage to finished surfaces. (Refer to Cleaning and Inspection in this Section.**

Installation

1. Remove main bearing inserts from block and bearing caps.
2. Clean mating surfaces of block and main bearing caps.
3. Remove connecting rod bearing inserts from connecting rods and caps.
4. If crankshaft main bearing journals have been refinished to a definite undersize, install correct undersize bearings. Be sure bearing inserts and bearing bores are clean. Foreign material under inserts will distort bearings and cause a failure.
5. Place upper main bearing inserts with oil holes in position in bores, except thrust bearing (No. 3 main bearing), with tang fitting in slot provided.
6. Install lower main bearing inserts in bearing caps.
7. Carefully lower crankshaft into place. **Be careful not to damage bearing surface.**
8. Remove lifting eyes.
9. Install upper No. 3 main bearing (thrust flanges and oil hole) by rolling main bearing into saddle.
10. Check clearance of each main bearing following procedure under Fitting Main and Connecting Rod Bearings in this Section.
11. Apply recommended quality engine oil to journals and bearings.
12. Install all bearing caps, except thrust bearing cap (No. 3 bearing). **Be sure that main bearing caps are installed in their original locations.** Tighten bearing cap bolts to specification.
13. Install thrust bearing cap with bolts finger tight.
14. Pry crankshaft forward against thrust surface of upper half of bearing (Fig. 67).
15. Hold crankshaft forward and pry thrust bearing cap to rear. This will align thrust surfaces of both halves of bearing.
16. Retain forward pressure on crankshaft. Tighten cap bolts to specification.
17. Force crankshaft toward rear of engine.
18. Check crankshaft end play as described in this Section.

Camshaft

Removal

1. Remove engine from vehicle as described in this Section.
2. With engine placed on an engine stand, using mounting adapter, Rotunda Model 014-00306, remove injection pump and adapter, intake manifold and tappets, engine front cover and fuel supply pump as described in this Section.
3. Remove camshaft drive gear, fuel supply pump cam, spacer and thrust plate from the camshaft as described in this Section.
4. Carefully remove camshaft.

   CAUTION: Use care to avoid damaging camshaft bearings.

Installation

Camshaft lobes are to be coated with Ford Polyethylene Grease (D0AZ-19584-A) or equivalent and journals lubricated with recommended quality engine oil before installation.

1. Oil camshaft journal and apply Ford Polyethylene Grease (D0AZ-19584-A) to lobes. Carefully slide camshaft through bearings. If tools are available, a handle may be fabricated for easier installation of camshaft by connecting the Puller Screw Extension from the Camshaft Service Set Tool T65L-6250-A into Camshaft Installation Adapter, Tool D83T-6250-A (Rotunda Model 014-00314). This assembly is then connected onto the end of the camshaft prior to installation. Remove the handle assembly when camshaft is properly seated in the bearings. Install new camshaft thrust plate onto cylinder block and tighten to specification.
2. Install spacer and fuel pump cam against camshaft thrust flange using installation sleeve and replacer Tool T83T-6316-B.
3. Install camshaft drive gear against fuel pump cam, aligning timing mark with timing mark on crankshaft drivegear using installation sleeve and replacer Tool T83T-6316-B.
4. Install camshaft allen screw and tighten to specification.
5. Install fuel supply pump, as described in this Section.
6. Install new crankshaft oil seal in engine front cover as described in this Section.
7. Install engine front cover as described in this Section.
8. Install water pump as described in this Section.
9. Install injection pump adapter as described in this Section.
10. Lubricate tappets and bores with recommended quality engine oil and install tappets in their original positions.
11. Install tappet guides.
12. Install tappet guide retainer and tighten to specification.

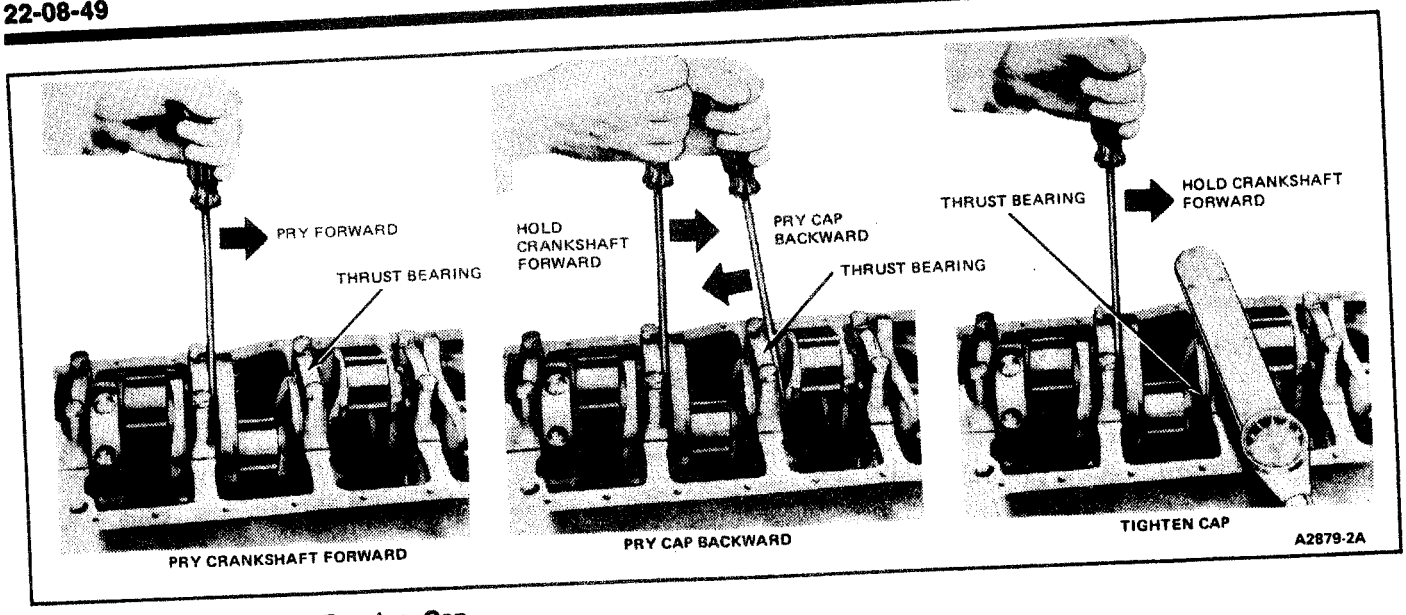


FIG. 67 Aligning Thrust Bearing Cap

13. Position pushrods, copper colored ends toward rocker arms, into their respective tappets making sure they are seated fully in pushrod seats.
14. Install rocker arms and valve covers with new gaskets as described in this Section.
15. Install intake manifold as described in this Section.
16. Install injection pump as described in this Section.
17. Install engine in vehicle as described in this Section.

Camshaft Bearings

The bearings are interchangeable from one bore to another except for the front bearing which is wider than the others.

Removal

1. Remove engine from vehicle and mount on engine stand using mounting adapter, Rotunda Model 014-00306.
2. Remove camshaft, flywheel and crankshaft, following appropriate procedures in this Section. Push pistons to top of cylinders.

   CAUTION: Use care in pushing pistons to top of cylinders to prevent damage to piston cooling jets, using connecting rod guides, Rotunda Model 014-00313.

3. Using Tool T65L-6250-A, select proper size expanding collet and backup nut and assemble on expanding mandrel. With expanding collet collapsed, install collet assembly in camshaft bearing, and tighten back-up nut on expanding mandrel until collet fits camshaft bearing (Fig. 68).
4. Assemble puller screw and extension, if necessary, as shown and install on expanding mandrel. Wrap a cloth around threads of puller screw to protect front bearing or journal. Tighten pulling nut against thrust bearing and pulling plate to remove camshaft bearing. Be sure to hold wrench on end of puller screw to prevent it from turning.
5. Repeat procedure for each bearing. To remove front bearing, install puller screw from rear of cylinder block.

Installation

1. Position new bearings at bearing bores with oil holes aligned, and press in place with Tool (T65L-6250-A or equivalent) shown in Fig. 68. Be sure to center pulling plate and puller screw to avoid damage to bearing. **Failure to use correct expanding collet can cause severe bearing damage. Be sure front bearing is installed the specified distance below front face of cylinder block.**
2. Install camshaft, crankshaft, flywheel and related parts, as described in this Section. It is not necessary to check connecting and main bearing clearances as a part of Camshaft Bearing Replacement.
3. Install engine in vehicle, as described in this Section.

Core Plugs

Removal and Installation

To remove a large core plug, drill a 12.70mm (1/2 inch) hole in the center of plug and remove with a universal impact slide hammer T59L-100-B and T50T-100-A or pry it out with a large drift punch. On a small core plug, drill a 6.35mm (1/4 inch) hole in center of plug and pry it out with a small pin punch. Clean and inspect plug bore.

Prior to installing a core plug, plug bore should be inspected for any damage that would interfere with proper sealing of plug. If the bore is damaged it will be necessary to true surface by boring for next specified oversized plug.

Oversize (OS) plugs are identified by OS stamped in flat located on cup side of plug.

Coat plug and/or bore lightly with an oil-resistant (oil galley) or water-resistant (cooling jacket) sealer B5A-195540A, or equivalent, and install it following procedure for cup type or expansion type below:

Cup-Type

Cup-type core plugs (Fig. 69) are installed with flanged edge outward. Maximum diameter of plug is located at outer edge of flange. Flange on cup-type plugs flares outward with largest diameter at outer (sealing) edge.

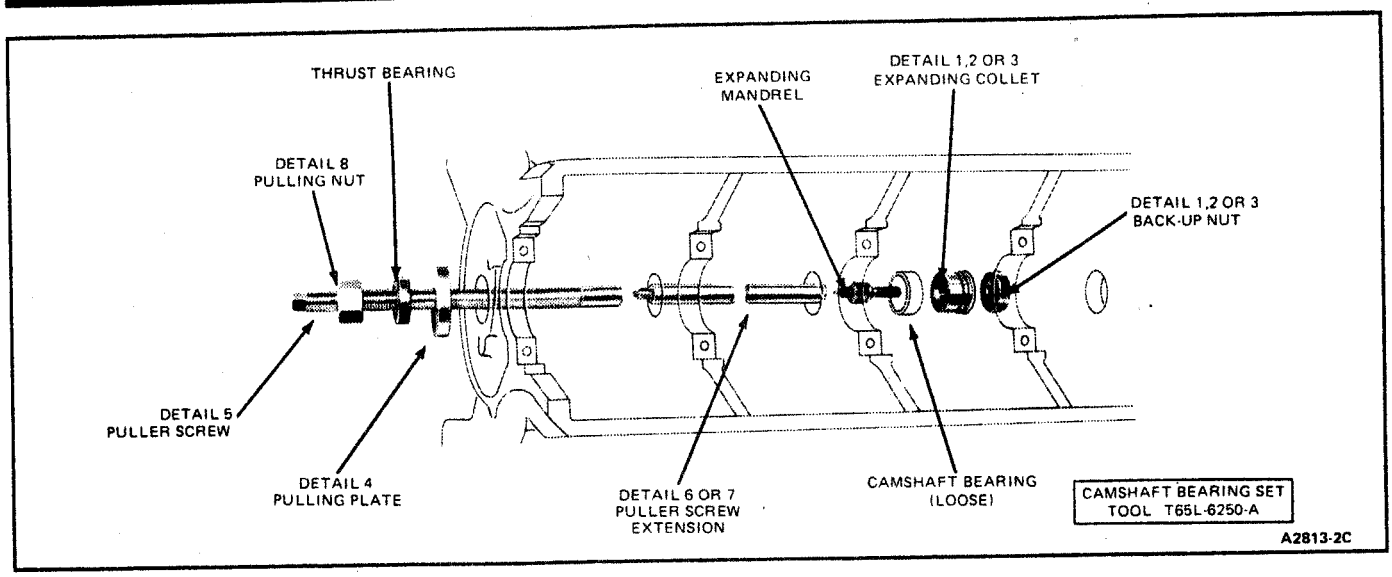


FIG. 68 Camshaft Bearing Replacement

CAUTION: It is important to pull plug sealing edge into machined bore by using a properly sized socket. Under no circumstances is plug to be driven into bore using a tool that contacts flange. This method will damage sealing edge and will result in leakage and/or plug blow out.

Flanged (trailing) edge must be below chamfered edge of bore to effectively seal plugged bore.

If core plug replacing tool has a depth seating surface, do not seat tool against a non-machined (casting) surface.

Expansion-Type

Expansion-type core plugs (Fig. 69) are installed with (dished) edge inward flush with bottom edge of chamfer.

Coat edges of plug with a suitable non-hardening sealing compound and install using Rotunda Model 014-00305 and hammer. When installed, trailing (maximum) diameter must be below edge of bore to effectively seal bore.

NOTE: For in-vehicle repair, use commercially available closure plugs until engine is removed for overhaul.

Cylinder Head

The cylinder head assemblies are interchangeable from one cylinder bank to another. Cylinder head gaskets are also interchangeable.

1. Clean gasket surface. Remove all burrs or scratches with an oil stone.

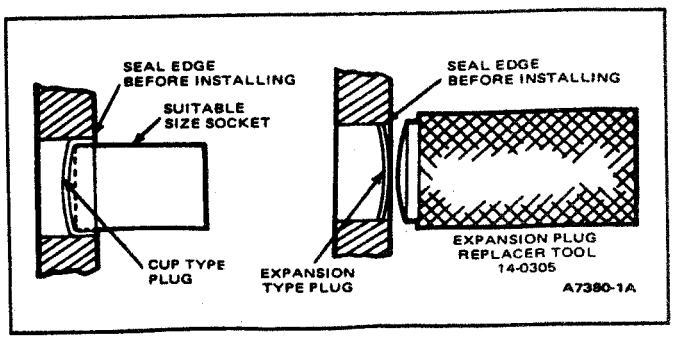


FIG. 69 Typical Core Plugs and Installation Tool

2. Check for warpage or cracks. Replace head if warped or cracked.

   NOTE: Cylinder heads are not to be resurfaced.

Replacing Valve Guides

Excessive guide clearance prevents adequate cooling of valve through guide and allows valve to tilt or tip which may cause valve breakage at high engine speed. These conditions prevent good seating and promote leakage past valve face. If valve guides are larger than specified or damaged, use Rotunda Tool Set 014-00308, or equivalent, and follow manufacturer's instructions. Install repair insert as follows:

1. Drill out valve guide.
2. Ream drilled guide bore for recommended insert sleeve.
3. Chill repair insert in dry ice. Carefully press insert in (Fig. 70).

   NOTE: When installing repair insert be careful not to burr ID of insert.
4. Finish insert with recommended size reamers to specified valve guide diameter. Always re-face valve seat after valve guide has been reamed, and

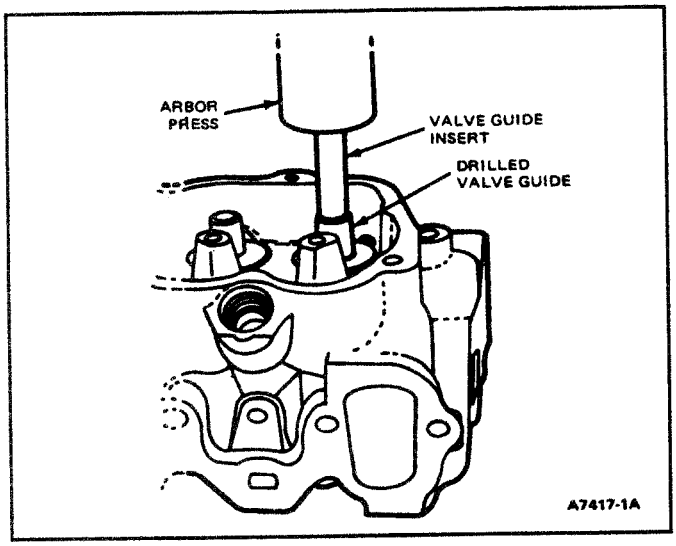


FIG. 70 Installing Valve Guide Insert

use suitable scraper to break sharp corner (ID) at top of valve guide.

NOTE: Before installing inserts they should be thoroughly chilled with dry ice or other means to facilitate their installation in the cylinder head.

Valve Seats

Prior to seat reconditioning, clean seats and inspect for cracks, burning or other damage. Inspect exhaust seat inserts for looseness.

Removal—Exhaust Seats

1. Use Rotunda Model 014-00309, to remove damaged or loose seats (Fig. 71). Position removal collet into insert and rotate collet nut clockwise to expand collet jaws under lip of seat insert.
2. Rotate top nut clockwise to remove insert.

   NOTE: If an oversize seat insert is required, the cylinder head should be sent out to a qualified machine shop for insert counterbore procedure.

Installation

1. Install using Rotunda Model 014-00309 and a hammer (Fig. 72). Valve seat, inserts supplied for service are standard size, .015" oversize and .030" oversize.

Refacing Valve Seats

Refacing of valve face so that finished seat and valve face will be concentric and specified interference fit will be maintained. This is important so that valve and seat will have a compression tight fit. Be sure that valve seat grinding wheels are properly dressed.

Grind valve seats to specification. Remove only enough stock to clean up pits and grooves or to correct valve seat runout. After seat has been refaced, use seat width scale or machinist scale to measure seat width (Fig. 73). Narrow seat, if necessary to bring it within specification. Refer to specifications.

If valve seat width exceeds maximum limit, remove enough stock from top edge and/or bottom edge of seat to reduce width to specification.

Use a 60 degree angle grinding wheel to remove stock from bottom of seats (raise seats) and use a 15 degree angle wheel to remove stock from top of seats (lower seats) (Fig. 74).

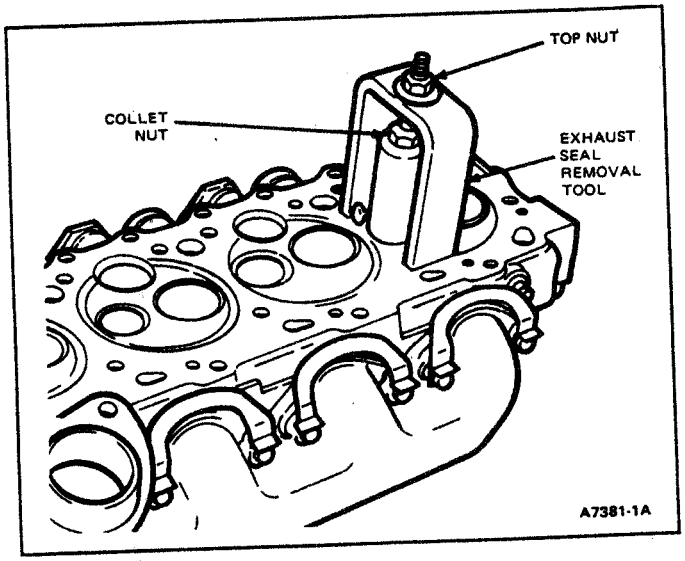


FIG. 71 Exhaust Seat Insert Removal

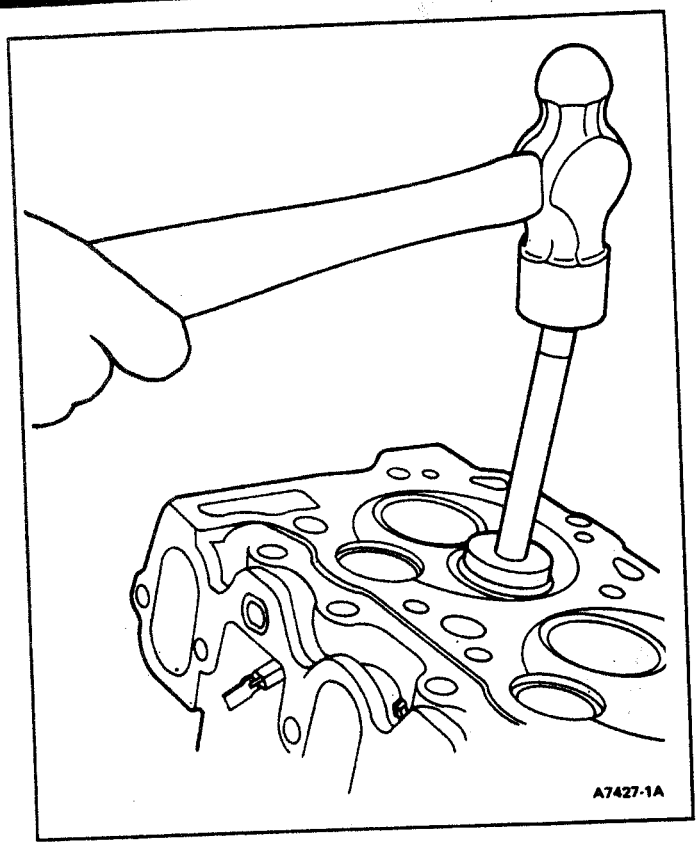


FIG. 72 Installing Exhaust Seat Insert

Finished valve seat should contact approximate center of valve face. It is good practice to determine where valve seat contacts face. To do this, coat seat with Prussian blue and set valve in place. Rotate valve with light pressure. If blue is transferred to center of valve face, contact is satisfactory. If blue is transferred to top edge of valve face, lower valve seat. If blue is transferred to bottom edge of valve face, raise valve seat. **Fit of valve and seat should never be lapped out with lapping compounds.**

Valves

Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, or if face runout cannot be corrected by refinishing or if stem clearance exceeds specifications. Refer to specification.

Discard any worn or damaged valve train parts.

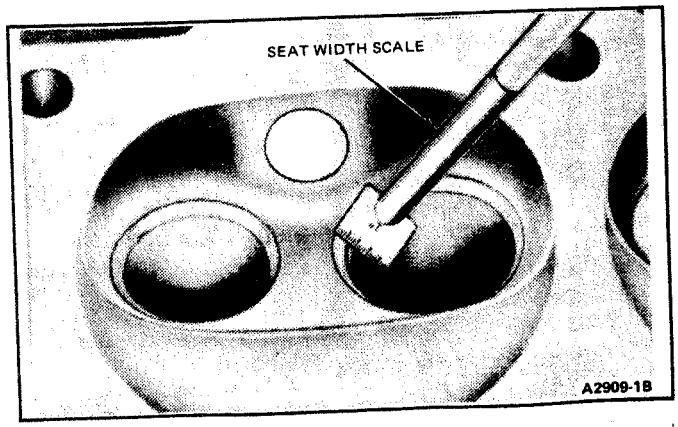


FIG. 73 Checking Valve Seat Width

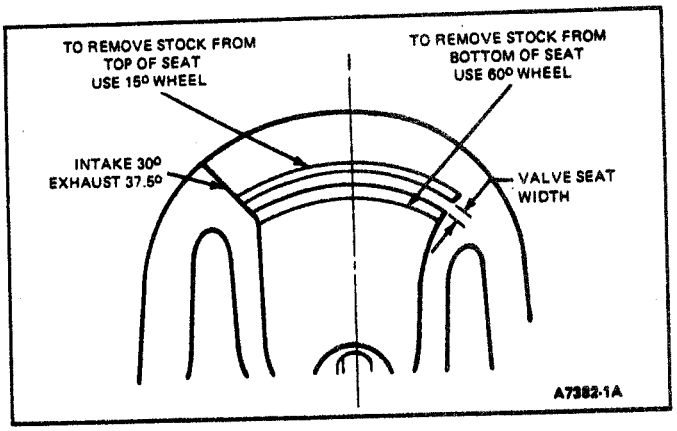


FIG. 74 Refacing Valve Seat

Refacing Valves

The valve refacing operation should be closely coordinated with valve seat refacing operations so that finished angles of valve face of valve seat will be to specifications and provide a compression tight fit. Be sure that valve grinding wheels are properly dressed.

If valve face runout is excessive and/or to remove pits and grooves, reface valves to specification. Remove only enough stock to correct runout or to clean up pits and grooves. If edge of valve head is less than 0.79mm (1/32 inch) thick after grinding (Fig. 75), replace valve as valve will run too hot in engine. **Interference fit of valve and seat should not be lapped out.**

Remove all grooves or score marks from end of valve stem, and chamfer it as necessary. **Do not remove more than 0.254mm (0.010 inch) from end of valve stem.**

If valve and/or valve seat has been refaced, it will be necessary to check clearance between rocker arm pad and valve stem tip with valve train assembly installed in engine.

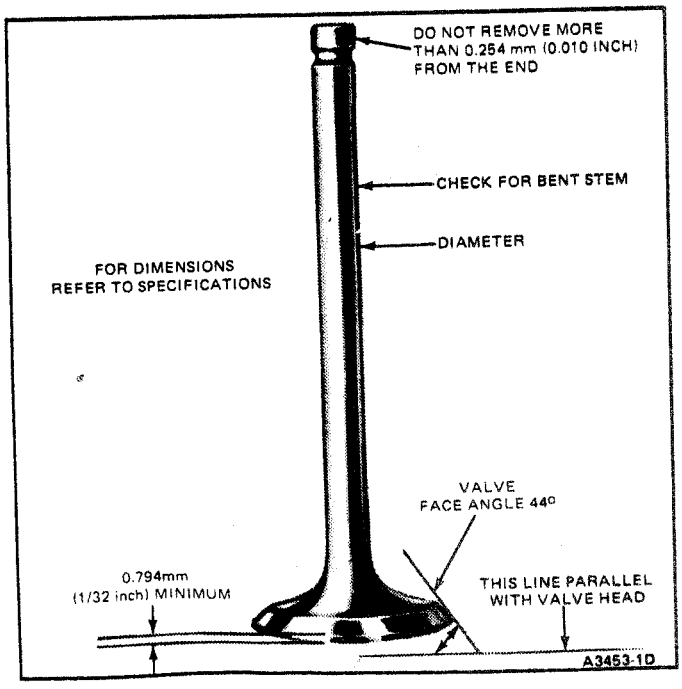


FIG. 75 Critical Valve Dimensions

Camshaft Repair

Remove light scuffs, scores or nicks from camshaft machined surfaces with smooth oil stone marks.

Crankshaft Repair

Clean all parts with cleaning solvent, dry with compressed air, and inspect bearings for wear and evidence of uneven bearing support. If such evidence is present, examine bearing caps and supporting surfaces or crankcase for high spots and burrs.

Inspect crankshaft journals for scoring and measure diameter of each journal, using a micrometer. Check dimensions obtained against Specifications. Measure each journal at two points, one at right angles to other, in order to show any evidence of out-of-round. Move micrometer over entire width of journal.

Hardness must be checked on every journal which incurred a bearing failure or shows evidence of overheating. All crankshafts must be hardness checked before regrinding. Bearing failures can cause overheating of crankshaft journals and reduction of hardness. When such occurs, crankshaft strength may be unacceptably reduced. Test crankshafts as follows:

a. Using a Rockwell Hardness Tester, check main journal in at least three locations.

b. Check rod journals at top, bottom and one other location. (Top and bottom determined with journal at TDC.) Top check should be made 12.7mm (.50") from fillet (top of pin fillet is not hardened). The bottom should be checked as close to fillet as possible.

c. Minimum hardness: 50-55 Rc. If any reading is below minimum, shaft must be scrapped.

CAUTION: The 6.9L crankshaft is induction hardened and MUST NOT be straightened. Even slight straightening with complete absence of cracks will endanger high strength built into shaft.

Crankshaft Grinding

An induction-hardened fillet and journal crankshaft can be reground similar to any precision crankshafts. However, these shafts require special treatment when grinding. Before grinding, all crankshafts must be checked for hardness.

Crankshafts should be ground at a qualified machine shop, experienced in grinding induction hardened crankshafts. Crankshafts should be magnifluxed after grinding to insure that there are no surface cracks.

Crankshaft Undersize Grinding Limits

Grinding Limits:

Maximum allowable taper on crankpins (rod journals) and main journals .013mm (.0005 inches) per 25.4mm (1 inch) of length. Crankpins and journals must be polished to 508 Micro-mm (20 Micro-inch) maximum - to 127 Micro-mm (5 Micro-inch) minimum, and must not be over 0.003mm (0.0001 inch) out of round.

The main journal fillet radii should be 3.07 - 3.226mm (.121 - .127 inch) with the crankpins (rod journals) fillet radii held at 3.05mm (.120 inch).

The third main journal controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. For this reason the width of the third journal must be 28.765 - 28.842mm (1.1325 - 1.1355 inch).

Fitting Main or Connecting Rod Bearings With Plastigage

Fitting Main Bearings.

NOTE: Be sure bearing inserts, bearing bore and mating surfaces are clean. Foreign material under inserts will distort bearing and cause incorrect readings and subsequent bearing failure.

To obtain an accurate reading using Plastigage method of checking, all bearing caps must be in place and tightened to specification.

1. Remove one bearing cap and insert. Remaining caps are left tight while checking fit of bearing.
2. Wipe oil from all contact surfaces such as crankshaft journal, bearing insert, bearing caps, etc.
3. Place piece of Plastigage D81L-6002-B across full width of bearing surface on crankshaft journal (or bearing cap insert) approximately 6.35mm (1/4 inch) off center. Install bearing cap and tighten cap bolt to specification.

   NOTE: Lightly coat bolt threads with oil before installing.

   NOTE: Do not turn crankshaft while making check with plastigage.
4. Remove bearing cap and insert.
5. Do not disturb Plastigage. Using Plastigage envelope, measure widest point of Plastigage (Fig. 76). Reading indicates bearing clearance in thousandths of an inch.
6. If the bearing clearance is not within specifications, crankshaft must be reground and undersize bearings installed.
7. No. 3 crankshaft bearing controls crankshaft and provides initial location of crankshaft in relation to crankcase. Use dial indicator Tool 4201-C to check end play as described in this Section.

Fitting Connecting Rod Bearings

NOTE: Be sure bearing inserts, bearing bore and mating surfaces on connecting rod and cap are clean. Foreign material under inserts will distort bearing and cause incorrect readings and subsequent bearing failure.

1. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.
2. Place a piece of Plastigage Tool D81L-6002-B on bearing surface across full width of bearing about 6.35mm (1/4 inch) off center.

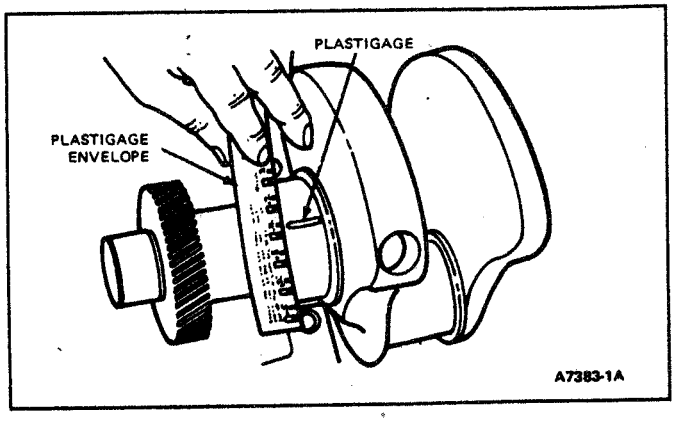


FIG. 76 Checking Main Bearing Clearance

3. Install cap and tighten to specification.

   NOTE: Lightly coat bolt threads with oil before installing.

   NOTE: Do not turn crankshaft while plastigage is in place.
4. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage (Fig. 77). Reading indicates bearing clearance in thousandths of an inch.
5. If bearing clearance is not within specifications, crankshaft must be reground and undersize bearings installed.
6. Check connecting rod end clearance using feeler gauge Tool D81L-4201-A as shown in Fig. 78. Excessive clearance may require replacement of rods or shaft. Check should be made to make certain specified running clearance exists. Lack of clearance could indicate damaged rod or rod bearing out of position.

Pistons, Pins and Rings

Fitting Pistons

Pistons are available in standard size or oversize for service. Refer to Ford Parts Master Catalog for available oversize pistons.

Refer to Specifications for standard size piston dimensions.

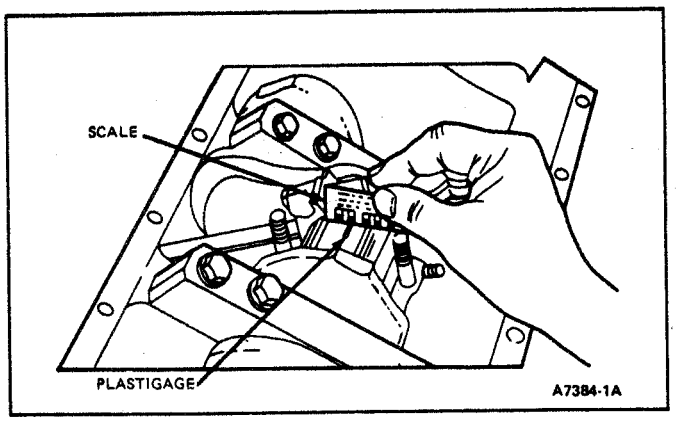


FIG. 77 Checking Connecting Rod Bearing Clearance

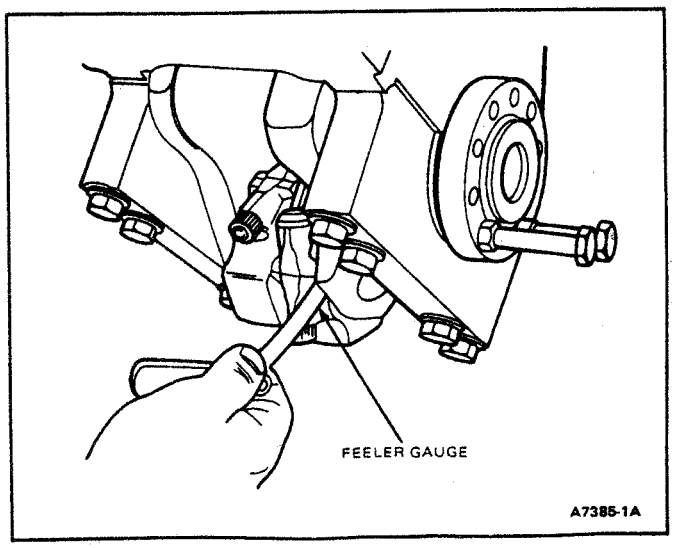


FIG. 78 Checking Connecting Rod End Clearance

Measure cylinder bore, (Fig. 79) and select piston to assure proper clearance.

After cylinder bores have been measured and recorded, measure piston diameter to ensure that specified clearance is obtained. Measure piston diameter 31.75mm (1 1/4 inches) below bottom ring land perpendicular to pin center line (Fig. 80). It may be necessary periodically to use another piston (within same grade size) that is either slightly larger, or smaller to achieve specified clearance.

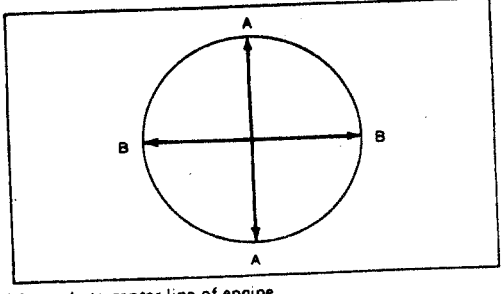
If none can be fitted, refinish cylinder to provide proper clearance for piston.

NOTE: Piston cooling jets must be removed before glaze breaking cylinders. Cooling jets are not reusable. Install new cooling jets.

When piston has been fitted, mark it for assembly in cylinder to which it was fitted.

If taper, out-of-round and piston to cylinder bore clearance conditions of cylinder bore are within specified limits, new piston rings will give satisfactory service. **If new rings are to be installed in a used cylinder that has not been refinished, remove cylinder wall glaze (refer to Cylinder Block, Refinishing Cylinder Walls). Be sure to clean cylinder bore thoroughly.**

1. Calculate size of piston to be used by taking a cylinder bore check. Follow procedures described under Cleaning and Inspection.
2. Select proper size piston to provide desired clearance (refer to Specifications).
3. Make sure piston and cylinder block are at room temperature 39°C (70°F). After any refinishing and washing operation allow cylinder bore to cool, and make sure piston and bore are clean and dry before piston fit is checked.



A – At right angle to center line of engine
B – Parallel to center line of engine
Top Measurement: Make 12.70mm (1/2 inch) below top of block deck
Bottom Measurement: Make within 12.70mm (1/2 inch) above top of piston—when piston is at its lowest travel (B.D.C.)
Bore Service Limit: Equals the average of "A" and "B" when measured at the center of the piston travel.
Taper: Equals difference between "A" top and "A" bottom.
Out-of-Round: Equals difference between "A" and "B" when measured at the center of piston travel.
Refer to Specification tables at end of each engine section. A4165-1F

FIG. 79 Cylinder Bore Measurement

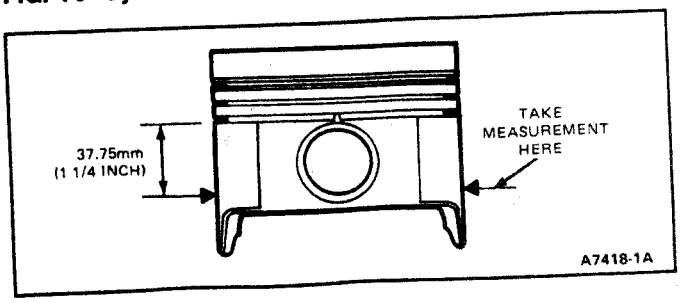


FIG. 80 Piston Diameter

Fitting Piston Pins

Inspect and measure piston pins for wear. If piston pins show signs of wear, corrosion or etching replace with new pins.

Check ID of connecting rod and piston pin bores. Replace any connecting rod or piston that is not within specifications. Piston assemblies furnished for service replacement are complete with new piston pins.

Fitting Rings

1. Select proper ring set for size of cylinder bore.
2. Position ring in cylinder bore in which it is going to be used.
3. Push ring down into bore area where normal ring wear is not encountered.
4. Use head of a piston to position ring in bore so that ring is square with cylinder wall. Use caution to avoid damage to ring or cylinder bore.
5. Measure gap between ends of ring with a feeler gauge Tool D81L-4201-A, or equivalent (Fig. 81). If ring gap is less or greater than specifications, try another ring set listed under Specifications.
6. Check ring side clearance of compression rings feeler gauge, Tool D81L-4201-A, inserted between ring and its lower land (Fig. 82). Gauge should slide freely around entire ring circumference without binding. Any wear that occurs will form a step at inner portion of lower land. If lower lands have high steps, piston should be replaced.

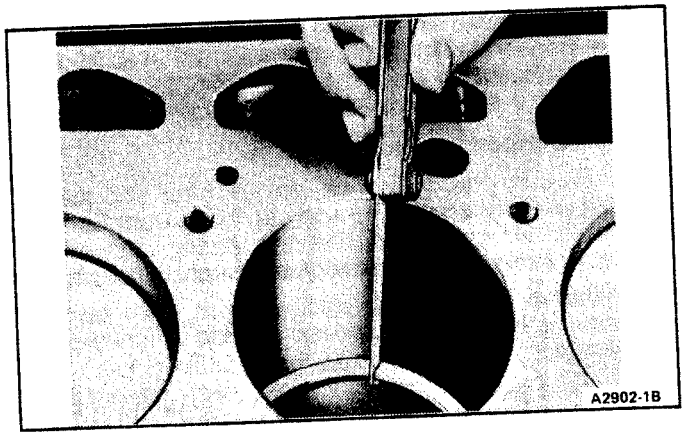


FIG. 81 Checking Piston Ring Gap

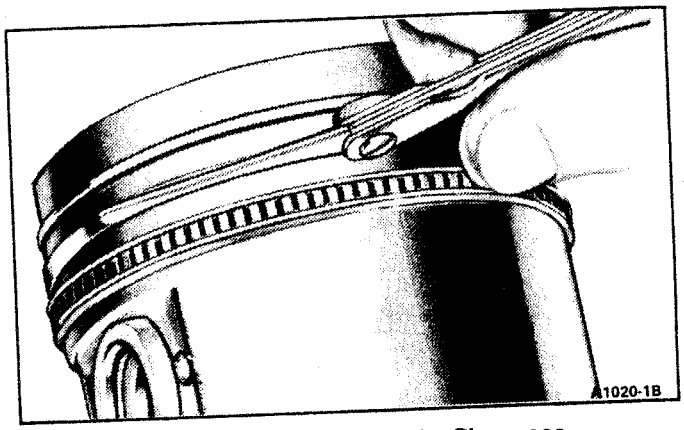


FIG. 82 Checking Piston Ring Side Clearance

Piston and Connection Rod Assembly

Disassembly

1. Remove bearing inserts from connecting rod and cap.
2. Mark pistons to assure assembly with same rod and installation in same cylinders from which they were removed.
3. To disassemble connecting rod from piston and piston pin assembly, remove piston pin retainers from each end of pin using snap ring pliers.
4. Heat piston in boiling water or piston heater and after placing piston in vise, drive pin from assembly with T68P-6135-A (Fig. 83) or brass drift and plastic tipped hammer.
5. After pin is removed, separate piston from connecting rod. Remove all old rings from piston. Clean and inspect components as described in this Section.

Assembly

1. To assemble piston to connecting rod, position rod into piston so that connecting rod weight pad and large chamfered side is located against crankshaft face and top of piston's arrow faces camside (Fig. 84).
2. Lubricate piston pin with recommended quality engine oil. Align rod bore and piston bore and insert piston pin. Push piston pin with thumb and install retainer snap rings. Ensure that retainer rings seat fully in their grooves.
3. After checking piston ring end gap as described in this Section, assemble rings on pistons to which they were fitted by using a suitable ring expander tool. This type of tool is recommended to avoid over expansion of rings and also to expand rings to a true circle to avoid distortion (Fig. 85).
4. Check ring side clearance as described in this Section.

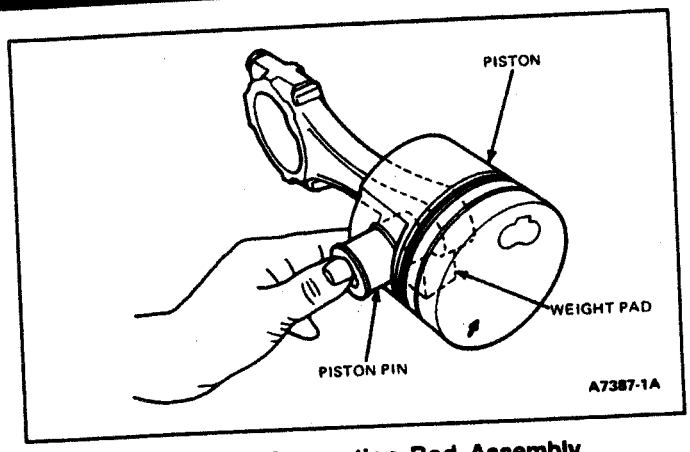


FIG. 84 Piston and Connection Rod Assembly

Cylinder Block

Refinishing Cylinder Walls

CAUTION: If cylinder walls are to be deglazed or honed, piston oil cooling jets must be removed.

Piston oil jets can be removed by clamping locking pliers on jet and placing a pry bar under pliers and prying up. (Fig. 86).

Cylinder walls may now be deglazed or honed. Cylinder bores can be deglazed by use of a commercially available glaze breaker brush. This silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on cylinder wall surface in a single operation. The brush contours itself to

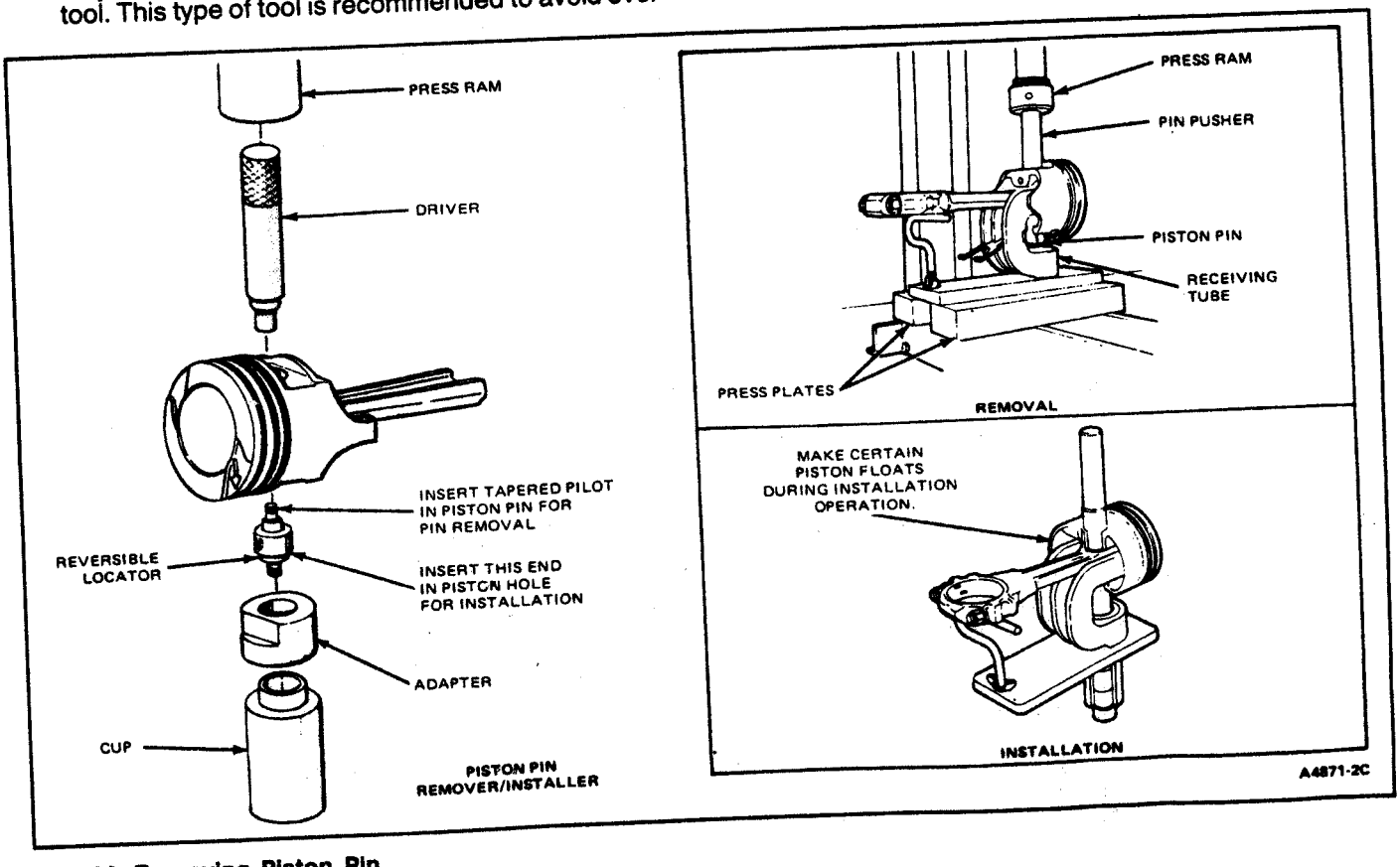


FIG. 83 Removing Piston Pin

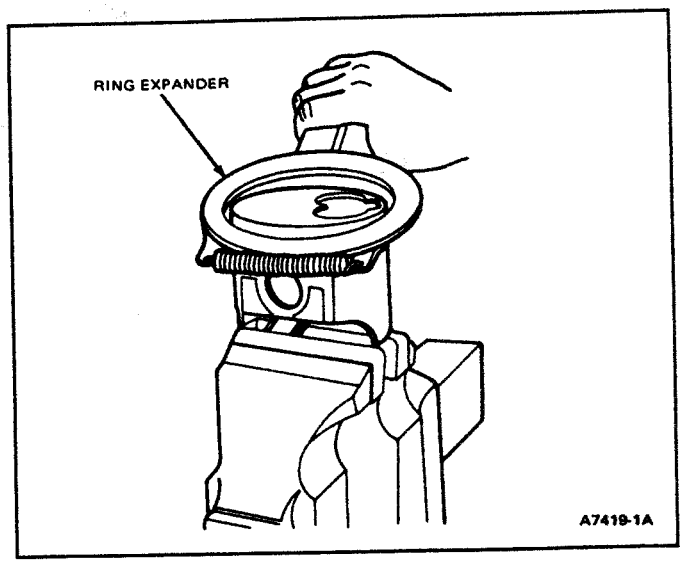


FIG. 85 Installing Piston Ring Using Suitable Piston Ring Expander Tool

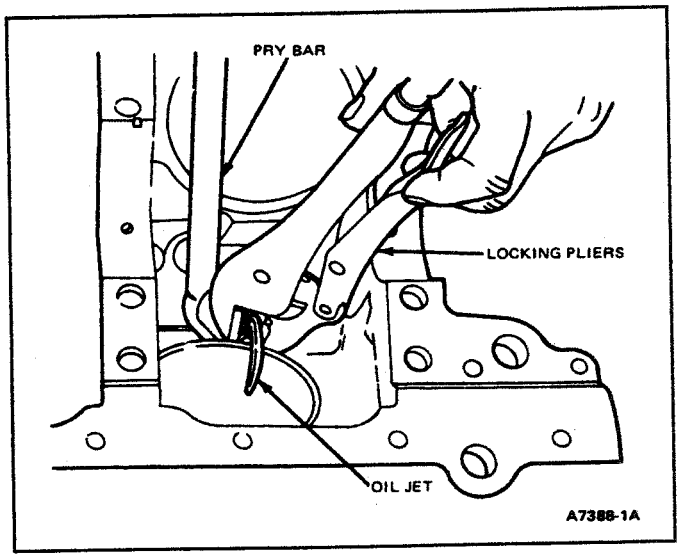


FIG. 86 Piston Oil Cooling Jet Removal

cylinder wall and conditions wall surface without altering cylinder bore.

The brush is used in conjunction with an electric drill. A slow RPM drill is recommended. Most 3/8 inch capacity electric drills are satisfactory for driving brush. A drill speed of 350-500 RPM has been found to be a practical speed for deglazing cylinder block bores.

An SAE 20 or 30 weight engine oil should be used with brush to produce a desirable finish on wall surface.

When conditioning cylinder block bores, stroke brush up and down in bore at a rate of 30-40 strokes per minute for a duration of 15-20 seconds per cylinder bore or until a crosshatch pattern is produced on cylinder wall surface. Cross-hatch pattern should be at an angle of approximately 30 degrees to cylinder bore.

After final deglazing operation and prior to checking piston fit, thoroughly clean bore(s) with soap or detergent and water. **Then, thoroughly rinse bore(s) with clean water to remove soap or detergent, and wipe bore(s) dry thoroughly with a clean, lint-free cloth. Finally, wipe bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of cylinder bore(s) may occur.**

Mark pistons to correspond to cylinders in which they are to be installed. When refinishing of all cylinders that require it has been completed and all pistons are fitted, thoroughly clean entire block and oil cylinder walls as described above.

Cylinder walls that are severely marred and/or worn beyond specifications should be refinished.

Refinish only cylinder or cylinders that require it. All pistons are same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance.

Refinish cylinder with most wear first to determine maximum oversize. If cylinder will not clean up when refinished for maximum oversize piston recommended, replace block.

Refinish cylinder to within approximately 0.035mm (0.0015 inch) of required oversized diameter. This will allow enough stock for final step of honing so that correct surface finish and pattern are obtained.

For proper use of refinishing equipment, follow instructions of manufacturer. Only experienced personnel should be allowed to perform this work.

Use a motor-driven, spring pressure-type hone at a speed of 300-500 rpm. Hones of grit sizes 180-220 will normally provide desired bore surface finish. When honing cylinder bores, use a lubricant mixture of equal parts of kerosene and SAE No. 20 Motor Oil. Operate hone in such a way as to produce a cross-hatch finish on cylinder bore. Cross-hatch pattern should be at an angle of approximately 30 degrees to cylinder bore.

NOTE: After honing operation is completed, sharp burred edge that develops at bottom of newly honed cylinder should be removed manually with emery cloth. Then thoroughly clean block cylinder bores.

After final honing and prior to checking the piston fit, thoroughly clean cylinder bore(s) with soap or detergent or water. Then thoroughly rinse bore(s) with clean water to remove soap or detergent, and wipe bore(s) dry thoroughly, with a clean, lint-free cloth. Finally wipe bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of cylinder bore(s) may occur. Mark pistons to correspond to cylinders in which they are to be installed. When refinishing of all cylinders that require it has been completed and all

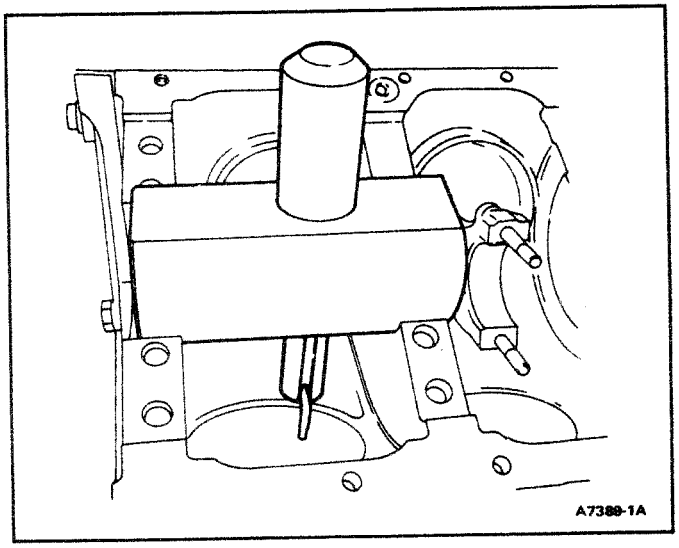


FIG. 87 Piston Cooling Jet Tool—Installation

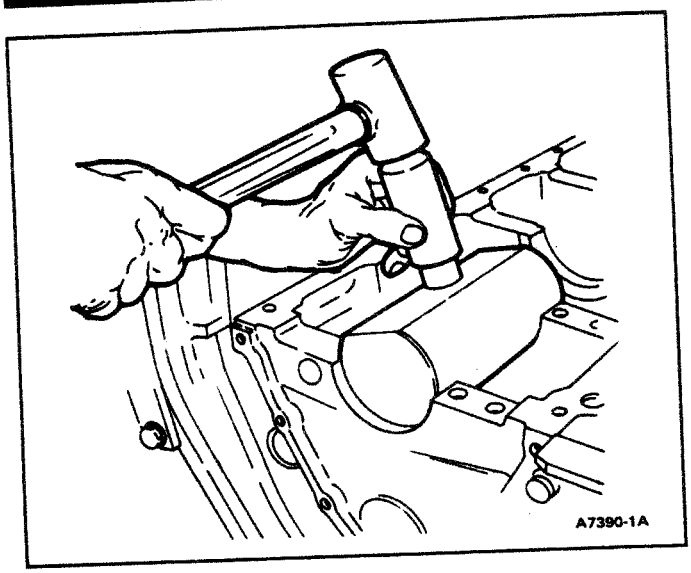


FIG. 88 Installing Piston Cooling Jet

pistons are fitted, thoroughly clean entire block and oil cylinder walls as described above.

After deglazing or honing, replace oil cooling jets as follows:

1. Place Rotunda Model 014-00307 over saddles of main bearing. Place new oil cooling jet in tool and install in hole, align tool over hole (Fig. 87).
2. Start jet by lightly hitting tool with hammer. Then hit tool with hammer until drive bottoms on body of tool (Fig. 88).
3. Verify cooling jet alignment using Rotunda Model 014-00311 (Fig. 89). Pointer must locate in target hole. If not, slightly bend cooling jet tube until pointer is properly aligned.

Repairing Engine Castings Having Sand Holes or Being Porous

Porosity or sand hole(s) which will cause oil seepage or leakage can occur with modern casting processes. A complete inspection of engine and transmission should be made. If leak is attributed to porous condition of cylinder block or sand hole(s), repairs can be made with metallic plastic (Epoxy Resin) C6AZ-19554-A or an equivalent metallic plastic). **Do not repair cracks with this material. Repairs with this metallic plastic (Epoxy Resin) must be confined to those cast iron engine component surfaces (Fig. 90) where inner wall surface is not exposed to engine coolant pressure or oil pressure.** For example:

a. Cylinder block surfaces extending along length of the block, upward from the oil pan rail to cylinder water jacket but not including machined areas.
b. Lower rear face of cylinder block.
c. Cylinder head, along rocker arm cover gasket surface.

The following procedures should be used to repair porous areas or sand holes in cast iron:

1. Clean surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut hole or porosity to a depth greater than rest of the cleaned surface. Solid metal must surround hole. Openings larger than 6.35mm (1/4 inch) should not be repaired using metallic plastic (Epoxy Resin). Openings in excess of 6.35mm (1/4 inch) can be drilled, tapped and plugged using common tools. Clean repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.
2. Mix Epoxy Resin base and hardener as directed on container. Stir thoroughly until uniformly mixed.
3. Apply repair mixture with a suitable clean tool (putty knife, wood spoon, etc.) forcing metallic plastic into hole or porosity.
4. Allow mixture to harden. This can be accomplished by two methods; heat cure with a 250 watt lamp placed 0.254mm (10 inches) from repaired surface, or air dry from 10-12 hours at temperatures above 10°C (50°F). Repair with Metallic Plastic (Indicated by Shaded Areas)
5. Sand or grind the repaired area to blend with general contour of surrounding surface.
6. Paint surface to match rest of block.

CLEANING AND INSPECTION

Cleaning and inspection procedures are for a complete engine overhaul; therefore, for partial engine

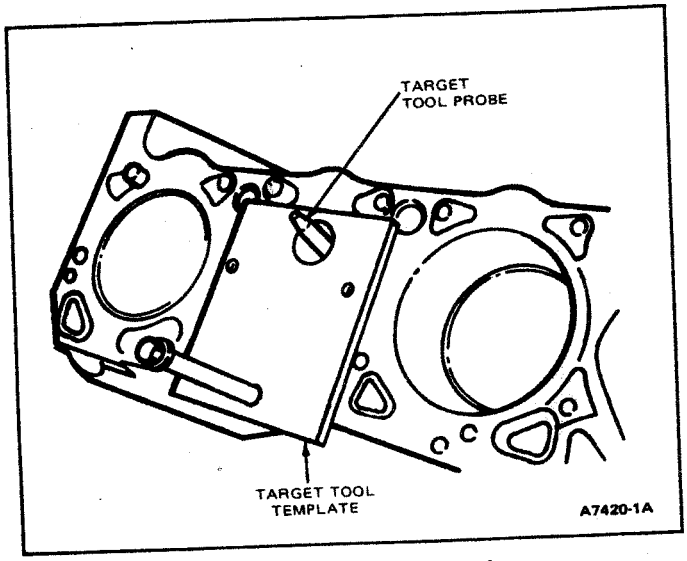


FIG. 89 Piston Cooling Jet Target Tool

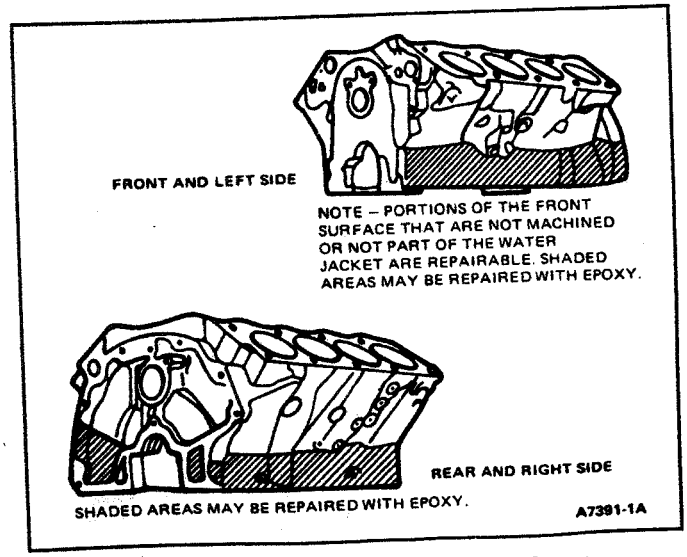


FIG. 90 Typical Cast Iron Cylinder Block Areas

overhaul or parts replacement, follow the pertinent component cleaning or inspection procedure.

Crankcase Depression Regulator

Refer to Truck Pre-Delivery, Maintenance and Lubrication Manual for the correct mileage interval for maintenance. Service following procedures described in this Section.

Valve Rocker Arm Assembly

Cleaning

Clean all parts thoroughly

Inspection

Inspect pad at valve end of rocker arms for indications of scuffing or abnormal wear. If pad if grooved, replace rocker arm. **Do not attempt to true this surface by grinding.** Check fulcrum and spherical pushrod seats for excessive wear, cracks, nicks or burrs. Inspect fulcrum seat of rocker arm post for excessive wear.

Push Rods

Cleaning

Clean all push rods in a suitable solvent. Blow out oil passage with compressed air.

Inspection

Check ends of push rods for nicks, grooves, roughness or excessive wear.

Push rods can be visually checked for straightness while are installed in engine by rotating them with the valve closed. They also can be checked with a dial indicator Tool D78P-4201-G, or equivalent (Fig. 91).

Cylinder Heads

Cleaning

With valves installed to protect the seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. **Be careful not to damage cylinder head gasket surface.** After valves are removed, clean valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits; clean all bolt holes; be sure valve seats, gasket surfaces and oil return passages are clean. Clean all valve assembly components using a suitable solvent and dry thoroughly.

Inspection

Examine cylinder head for cracks in combustion chambers, intake and exhaust valve ports, and around intake valve seats. Inspect exhaust valve seat inserts for looseness burned or cracked condition. Inspect gasket and sealing surfaces for scratches or mars which may cause leakage after assembly.

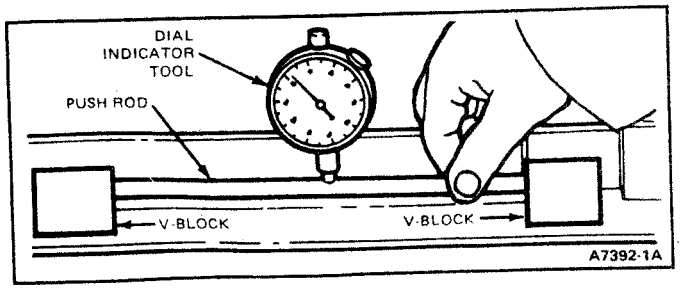


FIG. 91 Checking Push Rod Runout

Pre-cup insert cracking is acceptable from the throat of the pre-combustion chamber. The cracking becomes unacceptable if the cracks are beyond the fire ring. Acceptable and unacceptable pre-cup cracks are shown in Fig. 92. Replace unacceptable pre-combustion chambers.

Using a straight edge and a 0.15mm (0.006 inch) feeler gauge, check cylinder head gasket surface for warpage (Fig. 93).

Replace cylinder head if is cracked or warped.

NOTE: Cylinder heads cannot be resurfaced.

Valve Seat Runout

Check valve seat runout with an accurate gauge Tool D81P-6002-E (Fig. 94). Follow instructions of gauge manufacturer. If runout exceeds service limit, reface valve and valve seat.

Valve Seat Width

Measure valve seat width (Fig. 73). Reface valve seat(s), as described in this Section, if width is not within specifications.

Valves

Critical inspection points and tolerances of valve are illustrated in Fig. 75. Refer to specifications for service limits. Remove all carbon from valve stems and valve heads using a fine wire brush or buffing wheel.

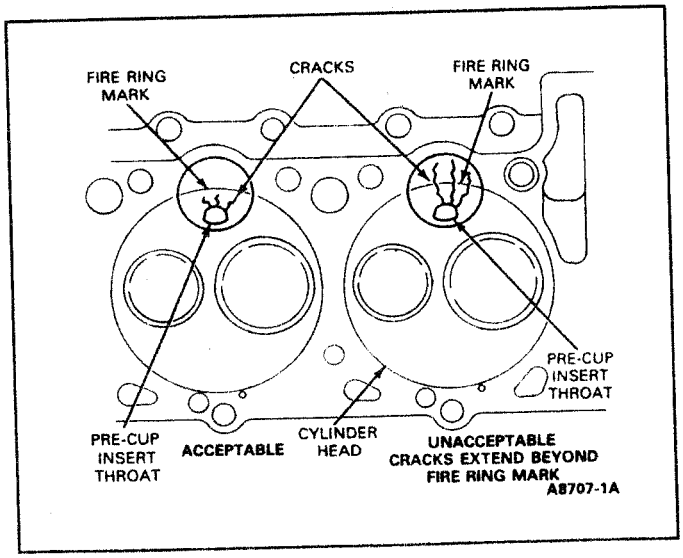


FIG. 92 Pre-Combustion Chamber Cracking

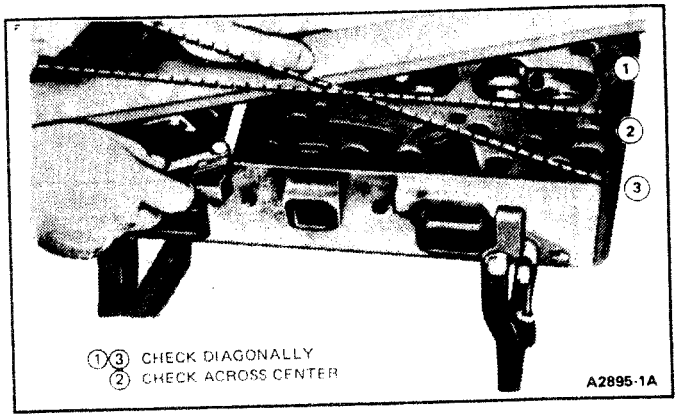


FIG. 93 Checking Cylinder Head Flatness

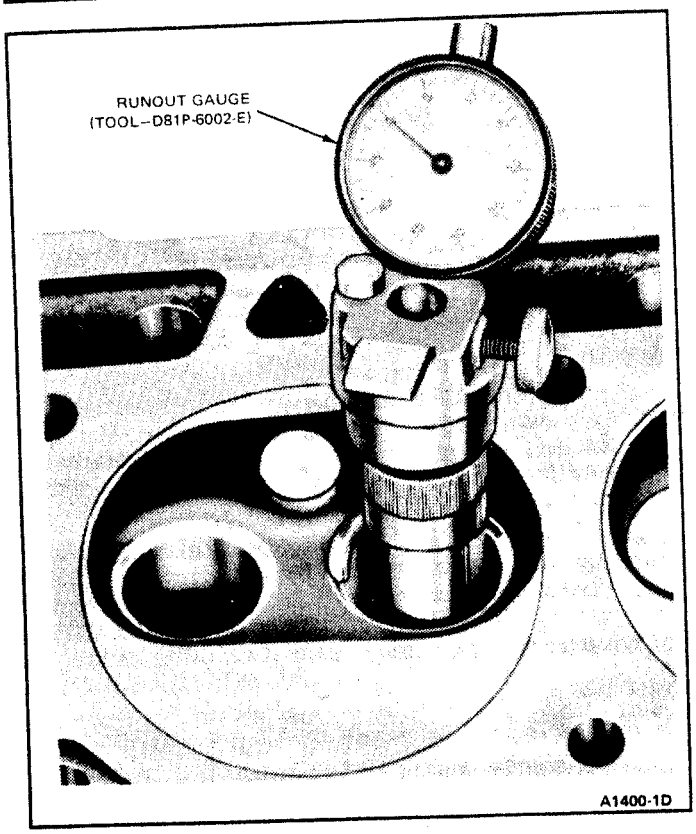


FIG. 94 Checking Valve Seat Runout

Inspect valve face and edge of valve head for pits, grooves or scores. Inspect stem for a bent condition and end of stem for grooves or scores. Check valve head for signs of burning or erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard severly damaged valves.

Inspect valve springs, valve spring retainers, locks and sleeves and discard any visually damaged parts.

Inspect valve keepers for excessive wear and replace in pairs as required. When installing a new valve, always use new valve keepers.

Valve Face Runout

Check valve face runout. It should not exceed specifications. If runout exceeds service limit, valve should be replaced or refaced as described under Refacing Valves in this Section.

Valve Stem Clearance

Check valve stem to valve guide clearance of each valve in its respective valve guide with Tool -6505-F (3/8 valves) or the equivalent shown in Fig. 95. Use a flat end indicator point.

Install tool on valve stem until fully seated, and tighten knurled set screw firmly. Permit valve to drop away from its seat until tool contacts upper surface of valve guide.

Position dial indicator with its flat tip against center portion of tool's spherical section at approximately 90 degrees to valve stem axis. Move tool back and forth in line with indicator stem. Take a reading on dial indicator without removing tool from valve guide upper surface. Divide reading by two, the division factor for tool. If valve stem to valve guide clearance exceeds specifications install new valve guide as described in this Section.

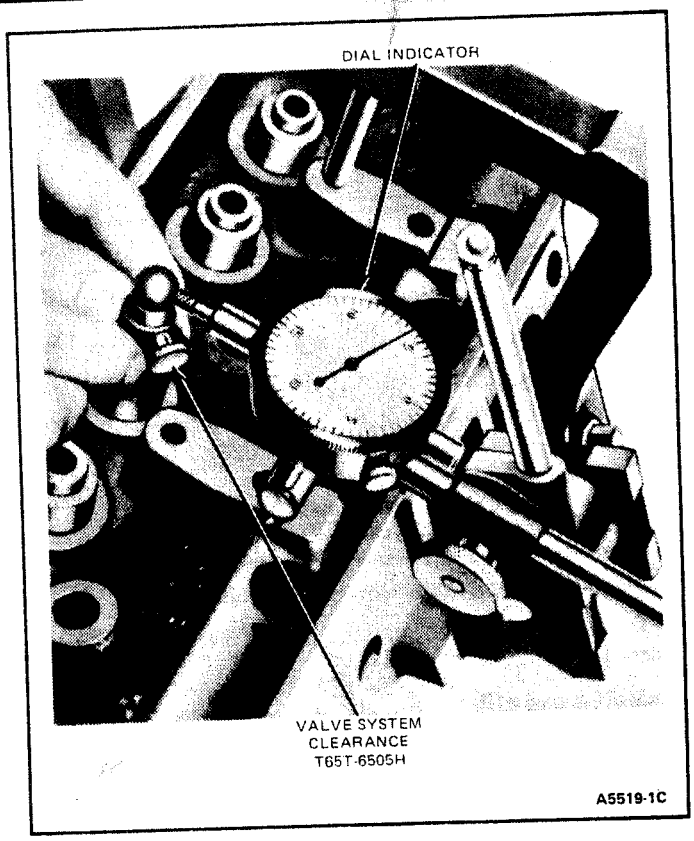


FIG. 95 Check Valve Stem Clearance

Valve Spring Pressure

Check the valve spring for proper pressure (Fig. 96) at specified spring lengths using Tool 6513-DD or equivalent. Weak valve springs cause poor performance; if pressure of any spring is lower than service limit, replace spring.

Valve Spring Squareness

Check each spring for squareness using a steel square and a surface plate (Fig. 97). Stand spring and square on end on surface plate. Slide spring up to square. Rotate spring slowly and observe space between top coil of spring and square. If spring is out of square more than 1.984mm (5/64 inch), replace it.

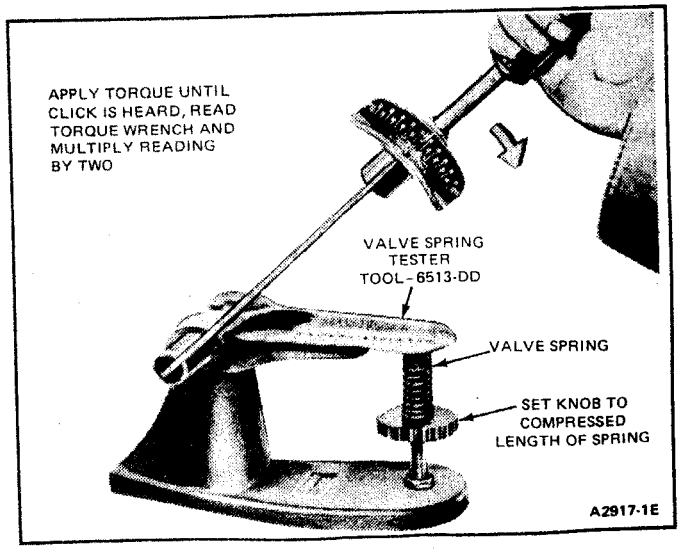


FIG. 96 Checking Valve Sping Pressure

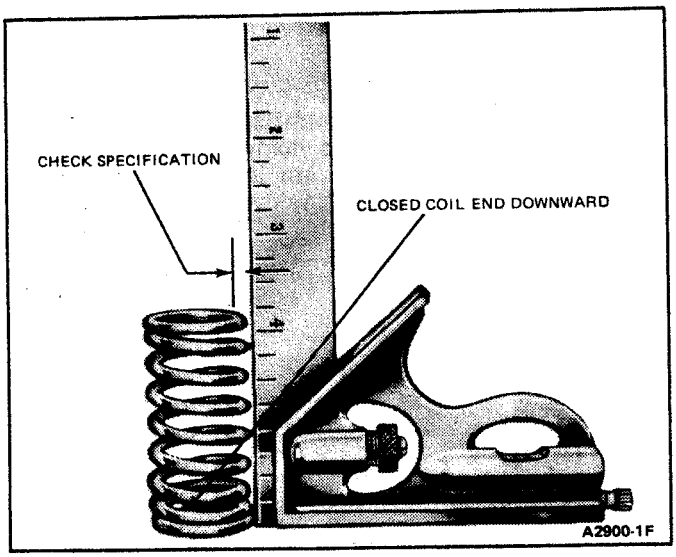


FIG. 97 Checking Valve Spring Squareness

Follow same procedure to check new valve springs before installation.

Intake Manifold

Cleaning

Remove all gasket material from machined surfaces of manifold. Clean manifold in a suitable solvent and dry with compressed air.

Inspection

Inspect manifold for cracks, nicked gasket surfaces, or other damage that would make it unfit for further service. Place cylinder head mounting faces of manifold on a smooth, clean surface and check for warpage. Replace manifold if warped or cracked.

Exhaust Manifolds

Cleaning

Remove all gasket material from manifold(s).

Inspection

Inspect manifold(s) for cracks, damaged gasket surfaces, or other wear or damage that would make them unfit for further service. Inspect cylinder head joining flanges of exhaust manifold(s) for evidence or warpage by placing on a flat surface. Minor warpage can be corrected by surface grinding. If warpage is extreme, replace manifold.

Hydraulic Valve Tappets

Valve tappet assemblies should be kept in proper sequence so that they can be installed in their original position. Inspect and test each tappet separately so as not to intermix internal parts. **If any part of tappet assembly needs replacing, replace the entire assembly (Fig. 98).**

Disassembly

1. Remove plunger retainer with small screwdriver.
2. Remove pushrod seat and metering valve.
3. Remove plunger and plunger spring.

Cleaning

Thoroughly clean all parts in clean solvent and wipe with a clean, lint-free cloth.

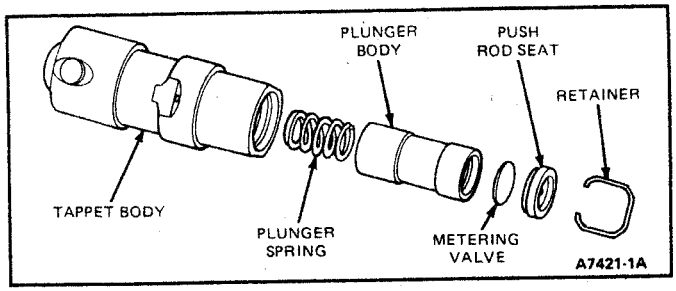


FIG. 98 Tappet Assembly

Inspection

Inspect parts and discard the entire tappet assembly if any part shows pitting, scoring, galling or evidence of non-rotation. Replace entire assembly if the plunger is not free in body. Plunger should drop to bottom of body by its own weight when assembled dry (Fig. 98).

Roller should rotate freely, without excessive play. Check for missing or broken needle bearings. Roller should be free of pits or roughness. If present, inspect camshaft lobes for similar condition. If pits or roughness are evident, replace cam follower and camshaft.

Assembly

1. Coat all parts with recommended quality engine oil.
2. Install plunger spring and plunger into tappet body.
3. Install metering valve and pushrod seat into tappet body and install retaining ring.

   Check for freeness of operation by pressing down on the push rod cup. Tappets can also be checked with a hydraulic tester to test leak-down rate. Follow instructions of test unit manufacturer or procedure in this Section.

Camshaft

Clean camshaft in solvent and wipe dry. Inspect camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in general area of lobe toe. This pitting is not detrimental to the operation of camshaft; therefore, camshaft should not be replaced unless camshaft lobe lift loss has exceeded specifications.

Lift of camshaft lobes can be check with camshaft installed in engine or on centers. Refer to Camshaft Lobe Lift under Diagnosis and Testing in this Section.

Check fuel pump eccentric for excessive wear.

Drive Gears

Cleaning

Clean gears in solvent and dry with compressed air.

Inspection

Inspect gear teeth for scores, nicks, etc. Note condition of tooth contact pattern. If teeth are scored, replace gears.

It is not necessary to replace gears in sets. Replace damaged gears and check backlash, runout, etc, as described in this Section, to determine if any other gear should be replaced.

Crankshaft Vibration Damper

Cleaning

Clean oil seal contact surface on crankshaft damper sleeve with solvent to remove any corrosion, sludge or

varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect crankshaft vibration damper sleeve oil seal surface for nicks, sharp edges or burrs that might damage oil seal during installation.

Crankshaft

Cleaning

Handle crankshaft with care to avoid possible fractures or damage to finish surfaces. Clean crankshaft with solvent, and blow out all oil passages with compressed air.

Clean oil seal contact surface at rear of crankshaft with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that seal surfaces become polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect main and connecting rod journals for cracks, scratches, grooves or scores.

Measure diameter of each journal at least four places to determine out-of-round, taper or undersize condition (Fig. 99).

Flywheel

Automatic Transmission

Inspection

Inspect flywheel for cracks or other damage that would make it unfit for further service. Inspect starter ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace ring gear.

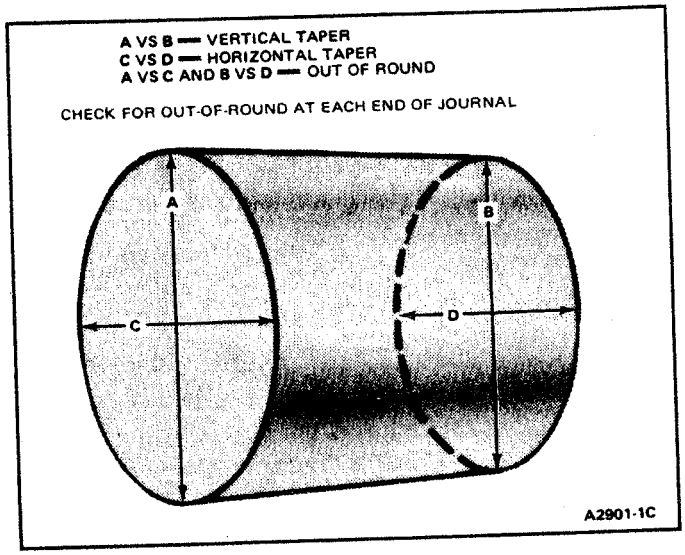


FIG. 99 Crankshaft Journal Measurement

With flywheel install on crankshaft, check gear face runout of flywheel (refer to Diagnosis and Testing in this Section, for the proper procedure).

Flywheel

Manual-Shift Transmission

Inspection

Inspect flywheel for cracks, heat checks, or other damage that would make it unfit for further service. Machine friction surface of flywheel if it is scored or worn. If it is necessary to remove more than 1.143mm (0.045 inch) of stock from original thickness, replace flywheel.

Inspect ring gear for worn, chipped, or cracked teeth. If teeth are damaged, replace ring gear.

With flywheel installed on crankshaft, check flywheel face runout, following procedure described under Diagnosis and Testing in this Section.

Main and Connecting Rod Bearing

CAUTION: In event of bearing failure the oil cooler must be disassembled and the tube bundle must be thoroughly flushed and drained to remove all contaminated oil.

Cleaning

Clean bearing inserts and caps thoroughly in solvent, and dry with compressed air. **Do not scrape gum or varnish deposits from bearing shells.**

Inspection

Inspect each bearing carefully. Bearings that have a scored, chipped, or worn surface should be replaced. Typical examples of bearings that should be replaced and causes are shown in Fig. 100. Cooper-lead bearing base may be visible through bearing overlay in small localized areas. This may not mean that bearing is excessively worn **It is not necessary to replace the bearing if bearing clearance is within recommended limits.** Check clearance of bearings that appear to be satisfactory with Plastigage or it's equivalent. Fit new bearings following procedure described in this Section.

Connecting Rods

Cleaning

Remove bearings from rod and cap. Identify bearing if they are to be used again. Clean connecting rod in solvent, including rod bore and back of inserts. **Do not use a caustic cleaning solution.**

Inspection

Connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified.

A shiny surface on edge of piston pin bushing usually indicates that a connecting rod is bent or piston pin hole is not in proper relation to piston skirt and ring grooves.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, an improperly machined journal, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb action of entire piston, rings, and connecting rod assembly and may be cause of excessive oil consumption.

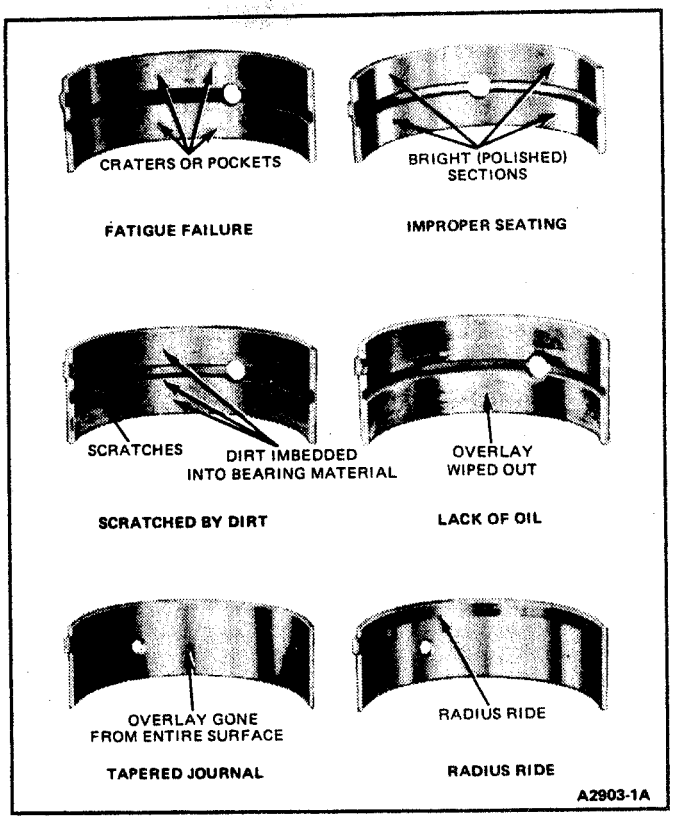


FIG. 100 Typical Bearing Failures

Inspect connecting rods for signs of fractures and bearing bores for out-of-round and taper. If bore exceeds maximum limit and/or if rod is fractured, replace rod.

Check ID of connecting rod piston pin bushing. If pin bore is not within specification, replace rod. Replace worn or damaged connecting rod nuts and bolts.

After connecting rods are assembled to piston, check rods for bends or twists on a suitable alignment fixture. Follow instructions of fixture manufacturer. If bend and/or twist exceeds specifications, replace rod.

Pistons, Pins and Rings

Remove deposits from piston surfaces. Clean gum or varnish from piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.** Clean ring groove with a ring groove cleaner Tool D81L-6002-D (Fig. 101).

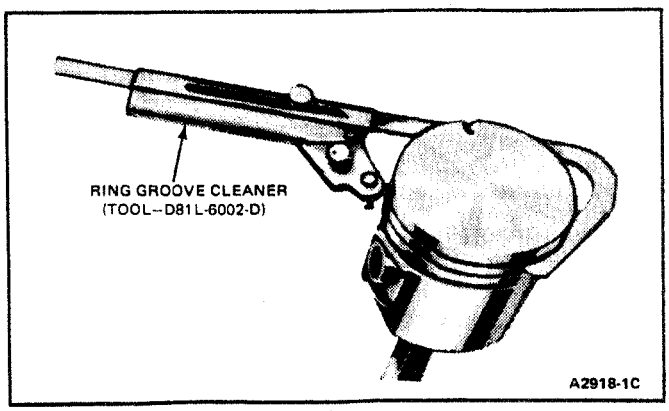


FIG. 101 Cleaning Ring Grooves—Typical

Inspection

Carefully inspect pistons for fractures at ring lands, skirts, and pin bosses, and for scuffed, rough, or scored skirts. If lower inner portion of ring grooves have high steps, replace piston. The step will interfere with ring operation and cause excessive ring side clearance. Replace pistons that show signs of excessive wear, wavy ring lands or fractures.

Check piston to cylinder bore clearance by measuring piston and bore diameter. Refer to Cylinder Block Inspection in this Section for the bore measurement procedure. Measure OD of piston with a micrometer at top of piston skirt and at 90 degrees to pin bore axis, (Fig. 80). Check ring side clearance following procedure described under Fitting Piston Rings in this Section.

Replace piston pins showing signs of fracture, etching or wear. Check piston pin fit in piston and rod. Refer to Piston, Pins and Rings in this Section.

Replace all rings that are scored, chipped or cracked. Check end gap and side clearance. It is good practice to always install new rings when overhauling an engine. Rings should not be transferred from one piston to another regardless of mileage.

Cylinder Block

Cleaning

After any cylinder bore repair operation, such as honing or deglazing, clean bore(s) with soap or detergent and water. **Then thoroughly rinse bore(s) with clean water to remove soap or detergent, and wipe bore(s) dry with a clean, lint-free cloth. Finally, wipe bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of cylinder bore(s) may occur.**

If engine is disassembled, thoroughly clean block in solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs that seal oil passages; then clean out all passages. Blow out all passages, bolt holes, etc., with compressed air.

Remove main oil gallery plug and use a 9.5mm (3/8 inch) diameter brush to clean main oil gallery (Fig. 102). Replace oil plug after coating with B5A-19554-A non-hardening sealing compound.

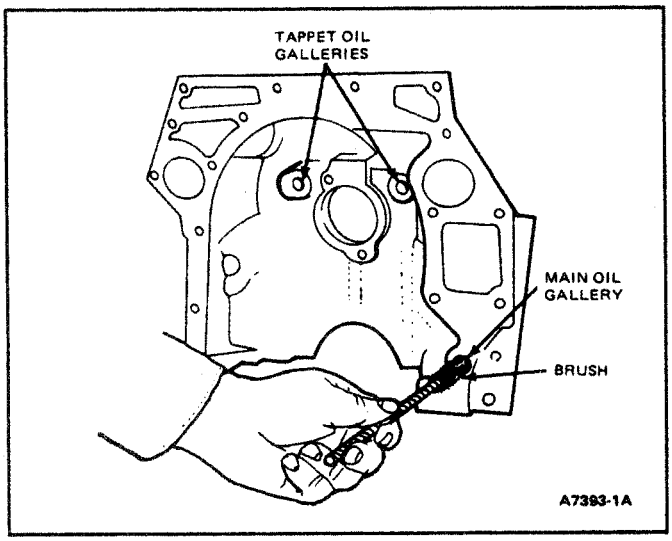


FIG. 102 Cleaning Main and Tappet Oil Galleries with Brush

Remove tappet oil gallery plugs by drilling small hole in plug and prying with a screwdriver or suitable tool. Clean tappet oil galleries with a 8mm (5/16 inch) brush. Replace tappet gallery plugs flush to 1.52mm (.060") below crankcase surface as described in this Section.

Make sure threads in cylinder head bolt holes are clean. Dirt in threads may cause binding and result in a false torque reading. Use tap to true-up threads and to remove any deposits.

Inspection

After block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating suspected area with a mixture of 25 percent kerosene and 75 percent light engine oil. Wipe part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. Avoid use of methanol substitute rubbing alcohol. If cracks are present, coating will become discolored at cracked area. Replace block if cracked.

Check all machined gasket surfaces for burrs, nicks, scratched and scores. Remove minor imperfections with an oil stone. Check cylinder block for flatness of cylinder head gasket surface following procedure and specifications recommended for cylinder head.

NOTE: If flatness is out of specification, do not resurface top deck of crankcase. Replace cylinder block.

Replace all expansion-type plugs that show evidence of leakage.

Inspect cylinder walls for scoring, roughness, or other signs of wear. Check cylinder bore for out-of-round and taper. Measure bore with an accurate bore gauge following instructions of manufacturer. Measure diameter of each cylinder bore at top, middle and bottom with gauge placed at right angles and parallel to centerline of engine. Use only measurements obtained at 90 degrees to engine centerline when calculating piston to cylinder bore clearance.

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed specifications.

If cylinder walls have minor surface damage, but out-of-round and taper are within limits, it may be possible to remove such damage by honing cylinder walls and installing new service piston rings providing piston clearance is within specified limits.

To remove cylinder wall glaze or to refinish a cylinder bore, follow deglazing and honing procedures described under Cylinder Block-Refinishing Cylinder Walls in this Section.

Oil Pan

Cleaning

Scrape any dirt or metal particles from inside of pan. Scrape or wire brush all old gasket material the gasket surface. Wash pan in a degreasing solvent and dry it thoroughly. Be sure all foreign particles are removed from below baffle plate.

Inspection

Check pan for cracks, holes and damaged drain plug threads. Check gasket surface for damage caused by over-tightened bolts. Straighten surface as required to restore original flatness.

Replace pan if repairs cannot be made.

Oil Pump

Check oil pump drive gear backlash as described in this Section. If backlash is out of specification replace pump. Oil pump is serviced as a complete assembly only.

Oil Cooler

If oil is found in the cooling system or coolant found in the oil, the oil cooler should be checked for leakage as described in this Section.

If oil cooler O-rings are leaking, remove oil cooler as described in this Section. Disassemble and repair as follows;

Disassembly

1. Gently rap front and oil filter headers to loosen O-rings. Twist oil cooler apart (Fig. 103).
2. Thoroughly clean oil cooler, front and filter headers in suitable solvent. The oil cooler should be thoroughly flushed and drained to remove all residue within it.
3. Use new O-rings when reassembling oil cooler. Lubricate all O-rings mating surfaces and O-rings prior to assembly with clean engine oil.

Assembly

1. Install one rust colored O-ring into each header.

   NOTE: The inner O-ring must be installed in the header (not on the bundle) to avoid cutting the inner O-ring during assembly.
2. Place large O-ring over oil cooler shell.
3. Press assembly together assuring locating clips align in slots.
4. Test oil cooler assembly, as described in this Section, before installing on engine.

Mechanical Fuel Supply Pump

Inspect fuel supply pump for cracks or damage. Inspect mounting flange for distortion. Inspect rocker arm spring, pin and rocker arm for wear, cracks or damage. **If any fuel supply pump components are damaged, replace fuel supply pump.**

Thermostat

To check operation, place thermostat in a pan of water, heat water, and using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 100-107°C (180-192°F) and be fully open at approximately 111-118°C (200-212°F). The thermostat

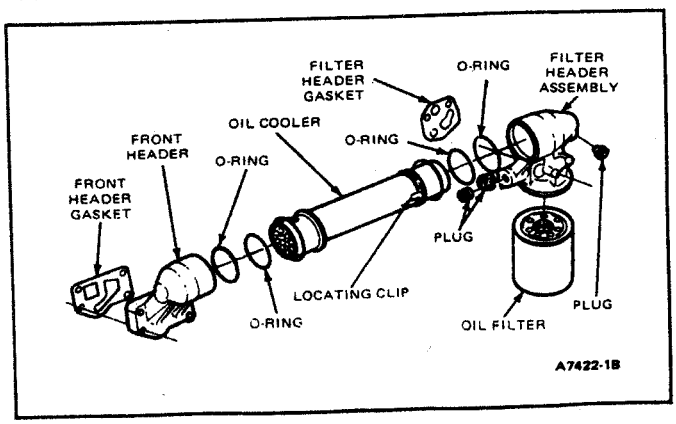


FIG. 103 Oil Cooler

is not adjustable. If it does not operate within above limits, replace it.

If problem being investigated is insufficient heat, thermostat should be checked for leakage. This may be done by holding thermostat up to a lighted background. Light leakage around thermostat valve (thermostat at room temperature) is unacceptable and thermostat should be replaced.

SPECIFICATIONS

GENERAL SPECIFICATIONS

Engine	Bore and Stroke	Firing Order	Oil Pressure Hot @ 2000 RPM kPa (PSI)	Engine Type and Number of Cylinders	Compression Ratio
6.9L Diesel (420 CID)	4.00" x 4.18"	1-2-7-3-4-5-6-8	276-414 (40-60)	O.H.V. V-8	20.7 to 1

Belt Size	Newly Installed ①		Used Over 10 Min.	
	Kg	(lbs)	Kg	(lbs)
All	55-72	120-160	34-54	75-120②

①Tension measured immediately after belt is installed and before it is stretched or seats in pulley grooves (all belts).
②If less than 34 Kg (75 lbs), readjust to 41-54 Kg (90-120 lbs).

CYLINDER HEAD

Engine	Pre-Chamber Insert Protrusion	Valve Guide Bore Diameter		Valve Seat Width①		Valve Seat Runout TIR Maximum	Valve Arrangement Front to Rear	Gasket Surface Flatness ②
		Intake	Exhaust	Intake	Exhaust			
6.9L Diesel V-8	(−.002)-(+.002)	.3736 .3746	.3736 .3746	.080 ± .015	.080 ± .015	.002	LT I-E-I-E-I-E-I-E RT E-I-E-I-E-I-E-I	.003 in any 6 in. .006 overall

①Valve seat angle — Intake 30° and Exhaust 37.5°.
②Gasket surface finish — RMS 60-150.

VALVE ROCKER ARM SHAFT, PUSH RODS AND TAPPETS

Engine	Type	Push Rod Runout TIR Maximum	Valve Tappet or Lifter			Collapsed Tappet Gap (Clearance)
			Standard Diameter	Clearance to Bore①	Hydraulic Lifter Leakdown Rate②	
6.9L Diesel V-8	Hydraulic Roller Follower	0.015	.9209 .9217	.0011 .0034	12 to 90 Sec. For .125 Travel	

①Service limit — .005.
②Time required for plunger to leakdown .125 in. under load of 50 lbs. using leakdown fluid in tappet.

VALVE SPRINGS

Engine	Valve Spring Compression Pressure Lbs. @ Specified Height		Valve Spring Free Length (Approximate)		Valve Spring Assembled Height		Valve Spring Out of Square Maximum
	Intake①	Exhaust	Intake	Exhaust	Intake	Exhaust	
6.9L Diesel V-8	60 @ 1.798	60 @ 1.798	2.040	2.040			5/64 (.078)

①Service Limit — 10% loss of pressure.

VALVES

Engine	Valve Stem to Guide Clearance①		Valve Face Angle		Valve Face Runout TIR Maximum
	Intake	Exhaust	Intake	Exhaust	
6.9L Diesel V-8	.0012-.0029	.0012-.0029	30°	37.5°	.002

①Service clearance — .0055.

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VALVES (Continued)

Engine	Valve Stem Diameter		Valve Head Recession Relative To Deck Surface	
	Intake	Exhaust	Intake	Exhaust
6.9L Diesel	.37165-.37235	.37165-.37235	.042-.054	.043-.055

CAMSHAFT

Engine	Camshaft End Play		Camshaft Journal to Bearing Clearance
	End Play	Service Limit	
6.9L Diesel	.001-.009	—	.025-.140 mm (.001-.0055")

CAMSHAFT DRIVE

Engine	Camshaft Bearing Inside Diameter②					Camshaft Front Bearing Location①	Gear Backlash
	No. 1	No. 2	No. 3	No. 4	No. 5		
6.9L Diesel V-8	2.1020-2.1055	2.1020-2.1055	2.1020-2.1055	2.1020-2.1055	2.1020-2.1055	.040-.060	.0015-.013

①Distance in inches that front edge of the bearing is installed below the front face of the cylinder block.
②All camshaft journals are 2.0990-2.1000.

INJECTION PUMP DRIVE GEAR BACKLASH — .0055-.0010

CYLINDER BLOCK

Engine	Cylinder Bore Diameter①	Main Bearing Bore Diameter②	Head Gasket Surface Flatness	Head Gasket Surface Finish
6.9L Diesel	3.9995-4.0015	3.1254-3.1274	.003 in any 6 in. .006 overall	RMS 90-150

①Maximum out-of-round — .002; Maximum taper service limit — .005; Cylinder bore surface finish RMS 18-38.
②With bearing caps tightened in place.

CRANKSHAFT AND FLYWHEEL

Engine		Main Bearing Journal Diameter①	Main Bearing Journal Runout TIR Maximum②	Main Bearing Thrust Face Runout TIR Maximum	Main Bearing Journal Taper Maximum Per Inch	Thrust Bearing Journal Length	Main and Rod Bearing Journal Finish RMS Maximum	Main Bearing Thrust Face Finish RMS Maximum
6.9L Diesel		3.1228-3.1236	.002	.001	.0005	1.1325-1.1355	5-20	25 Front — 23 Rear
Undersize	0.010	3.1128-3.1136						
	0.020	3.1028-3.1036						
	0.030	3.0928-3.0936						

①Maximum out-of-round — 0.0002.
②Service limit — 0.005.

CRANKSHAFT AND FLYWHEEL (Continued)

Engine		Connecting Rod Journal Diameter ①	Connecting Rod Journal Taper Per Inch Maximum	Crankshaft End Play ②	Flywheel and Ring Gear Runout
6.9L Diesel		2.4980-2.4990	.0005	.002-.009	.008
Undersize	0.010	2.488-2.489			Flywheel and Ring Gear Concentricity
	0.020	2.478-2.479			
	0.030	2.468-2.469			.008

①Maximum out-of-round — .0003.
②Service limit — .012.

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CRANKSHAFT BEARINGS

Engine	Connecting Rod Bearing to Crankshaft Clearance Selective Fit			Main Bearing to Crankshaft Clearance Selective Fit		
	Desired	Allowable	Bearing Wall Thickness Std.	Desired	Allowable	Bearing Wall Thickness Std.
6.9L Diesel	.0011-.0026	.0011-.0036	—	.0018-.0036	.0018-.0046	—

CONNECTING ROD

Engine	Piston Pin Bushing I.D.	Rod Bearing I.D. ① ③	Rod Length Center to Center	Connecting Rod Alignment Maximum Total Difference		Rod to Crankshaft Assembled Side Clearance
				Twist②	Bend②	
6.9L Diesel	1.1105-1.1107	2.5001-2.5016		.016	.008	.008-.020

①Connecting rod bearing bore maximum out-of-round — .005 and maximum bore taper — .0005.
②Pin bushing and crankshaft bore must be parallel and in same vertical plane within specified total difference when measured at the ends of an 8-inch long bar, 4 inches on each side of rod centerline.
③With bearing caps tightened in place.

PISTON

Engine	Skirt Diameter① ②	Piston to Bore Clearance Selective Fit	Piston Pin Bore Diameter	Piston Height Above Crankcase
	Standard			
6.9L Diesel	3.9935-3.9955	.0055-.0065	1.1104-1.1106	.010-.031

①Measured at 90° to the pin, at 1.25 inch below oil ring groove.
②Service piston is 3.9945-3.9955.

PISTON PIN

Engine	Length	Diameter	Ring End Clearance	To Piston Pin Bore Clearance ①	To Connecting Rod Bushing Clearance
6.9L Diesel	2.705-2.715	1.1099-1.1101	.001-.029	.0003-.0007	.0004-.0008

①Selective fit.

PISTON RINGS

Engine	Ring Diameters	Side Clearance①			Ring Gap		
		Compression		Oil	Compression		Oil
		Top	Bottom		Top	Bottom	
6.9L Diesel	101.6mm (4.00 in.)	.002-.004	.002-.004	.001-.003	.014-.024	.060-.070	.010-.024

①Service limit — .002 maximum increase in clearance.

OIL PUMP, OIL COOLER AND OIL CAPACITY

Engine	Oil Pump Pressures		Engine Oil Capacity①			Oil Pump Drive Gear Backlash
	Curb Idle	2200 RPM	U.S. Qts.	Imperial Qts.	Liters	
6.9L Diesel	69 kPa (10 psi)	276-414 kPa (40-60 psi)	9	9.7	8.5	.0015-.013

①Add 1 U.S. quart (or equivalent in Imperial quarts or liters) when replacing filter.

OIL SEALS

Crankcase Oil Seal Journal Finish	10-20 RMS
Front Oil Seal Journal Finish (On Damper)	10-20 RMS

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SPECIAL TORQUE WRENCH INFORMATION

Use of special tool torquing adapters requires use of calculations from the formula below.

WHERE
T = Desire torque from specifications tables
L = Length of torque wrench in inches/MM
E = Length of adapter in inches/MM
Y = Indicated torque wrench setting/reading

$$Y = \frac{T \times L}{L + E}$$

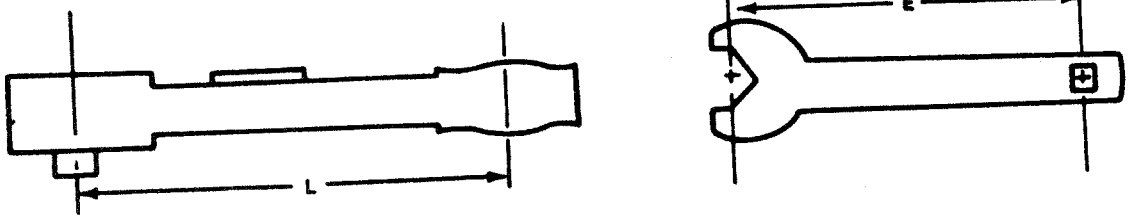
Example: Desired torque from specifications (T) is 100 lb. ft.

Adapter is 8" Long (E)
Torque wrench is 15" Long (L)

$$Y = \frac{100 \times 15}{.15 + 8}$$

$$Y = \frac{1500}{23}$$

Y = 65 (Approx.)



Note: Units for L or E may be either metric or inches — but same units must be used for both.

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TORQUE LIMITS — 6.9L V-8 DIESEL ENGINE

NOTE: Unless otherwise specified, use standard torque chart. Torque values are with threads and washer faces coated with engine oil. Torque values are listed without tolerance. Variations to torque will occur due to torque wrench calibration. Variation should be within 10% of nominal values.

STANDARD TORQUE

1/4x20 UNC	5/16-18 UNC	3/8-16 UNC	7/16-14 UNC	1/2x13 UNC
9.5 N•m (7 ft-lb)	19 N•m (14 ft-lb)	32 N•m (24 ft-lb)	51 N•m (38 ft-lb)	81 N•m (60 ft-lb)

PIPE THREADS

1/8x27	1/4x18	3/8x18	1/2x14
7-11 N•m (5-8 ft-lb)	17-24 N•m (12-18 ft-lb)	30-44 N•m (22-33 ft-lb)	34-47 N•m (25-35 ft-lb)

Item	N•m		Ft-Lb
Camshaft Gear Screw	17-24		12-18
Connecting Rod Nut		②	
Crankcase Front Cover		①	
Cylinder Head Bolts		③	
Damper to Crankshaft	122		90
CDR Valve		①	
Fuel Supply Pump		①	
Fuel Filter Adapter to Brake	33-52		24-39
Fuel Filter Bracket to Cylinder Block	33-52		24-39
Fuel Filter to Adapter	1/2 turn after gasket contacts sealing surface		
Flywheel to Crankshaft	64		47
Main Bearing Cap Bolts		④	
Manifold — Exhaust	41	⑧	30
Manifold — Intake		⑥	
Oil Filter to Header Adapter	1-1/4 to 2 turns after gasket contacts sealing suface — oiled gasket		
Oil Cooler to Cylinder Block		①	
Oil Cooler Plug	21		15
Oil Pan Drain Plug	38		28
Oil Pan to Cylinder Block		①	
Pulley to Vibration Damper		①	
Valve Cover Screw	8	⑦	6
Valve Lever Post Bolt	27		20
Glow Plug	16		12
Nozzle Assembly	47		35
Nozzle Connector Nut	30		22
Injection Pump Outlet Fitting Nut	30		22
Injection Pump Adapter	19		14
Injection Pump Gear Mounting Bolts	34		25
Water Pump to Front Cover	19	⑤	14
Heater Hose Connector (Water Pump, Cylinder Head)	17-24		12-18
Oil Pressure Hose Assembly	20-27		15-20
Alternator Bracket to Cylinder Block	33-52		24-39
Alternator Pivot Bolt	38-71		28-53
Alternator Support Bracket to Water Pump	33-52		24-39
Alternator Adjusting Arm to Support	33-52		24-39
Alternator Adjusting Bolt	33-52		24-39
Water Outlet (Thermostat)	27		20

① Use Standard Torque Chart Above
② Tighten to 52 N•m (38 ft-lb), then to 66-72 N•m (48.5-53.5 ft-lb)
③ Tighten to 54 N•m (40 ft-lb), then to 95 N•m (70 ft-lb), then to 108 N•m (80 ft-lb), and again to 108 N•m (80 ft-lb) in sequence.
④ Tighten to 101 N•m (75 ft-lb), then to 129 N•m (95 ft-lb)
⑤ RTV Sealer required, refer to Light Truck Engine Shop manual.
⑥ Tighten using Standard Torque Chart above, then tighten again in sequence.
⑦ Tighten to 8 N•m (6 ft-lb), then tighten again to 8 N•m (6 ft-lb) in sequence.
⑧ Tighten to 41 N•m (30 ft-lb), then tighten again to 41 N•m (30 ft-lb) in sequence.

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SPECIAL SERVICE TOOLS

Tool Number	Description	Tool Number	Description
T50T-100-A	Impact Slide Hammer	T83T-6316-A	Crank/Cam Gear and Damper Remover
T59L-100-B	Impact Slide Hammer	T83T-6316-B	Crank/Cam Gear and Damper Replacer
D82L-800-B	Hammer	T74P-6375-A	Flywheel Holding Tool
T80T-4000-W	Driver Handle	T83T-6500-A	Tappet Bleed-Down Wrench
D78P-4201-F	Dial Indicator Bracketry	Tool-6500-E	Hydraulic Tappet Leakdown Tester
D78P-4201-G	Dial Indicator — 1 Inch Travel	Tool-6505-F	Valve Stem Clearance Tool
D81L-4201-A	Feeler Gauge	T83T-6513-A	Valve Spring Compressor
Tool-4201-C	Dial Indicator w/Bracketry	Tool-6513-DD	Valve/Clutch Spring Tester
T77F-4220-B1	Gear Puller	Tool-6565-AB	Cup Shaped Adapter
T837-6000-D6.9	6.9L Essential Service Tool Kit	T83T-6571-A	Valve Stem Seal Replacer
T70P-6000-	Engine Lifting Brackets	T83T-6700-A	Front Crank Seal Replacer
D81L-6002-B	Plastigauge	T83T-6701-A	Rear Crankshaft Seal Replacer
D81L-6002-C	Piston Ring Compressor	T83T-6701-B	Rear Crankshaft Seal Pilot
D81L-6002-D	Piston Ring Groove Cleaner	T83T-9000-A	Fuel Transfer Pump Pressure Adapter
D81P-6002-E	Valve Seat Runout Gauge	T83T-9000-B	Injection Pump Mounting Wrench
D83T-6002-A	Glow Plug Socket	T83T-9000-C	Injection Pump Rotating Tool
D83T-6250-A	Camshaft Installation Adapter	T83T-9395-A	Fuel System Protection Cap Set
T65L-6250-A	Camshaft Bearing Set	T83T-9396-A	Fuel Line Nut Wrench
T68P-6135-A	Piston Pin Remover/Replacer	T83T-9424-A	Intake Manifold Cover
T70P-6011-A	Expansion Plug Installer	T83T-9527-A	Nozzle Seat Cleaner
T83T-6312-A	Fan Clutch Pulley Holder	T71P-19703-C	O-Ring Tool
T83T-6312-B	Fan Clutch Nut Wrench		

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ROTUNDA EQUIPMENT

Model Number	Description
014-00036	Universal Load Positioning Sling
014-00300	Injection Nozzle Tester
014-00301	Injection Nozzle Cleaning Kit
014-00302	Throttle Control
014-00305	Expansion Plug Replacer
014-00306	Engine Stand Mounting Adapter
014-00307	Piston Cooling Jet Installer
014-00308	Valve Guide Tools
014-00309	Exhaust Valve Seat Remover/Replacer
014-00311	Cooling Jet Tube Target
014-00312	Engine Lifting Bracket
014-00313	Piston Rod Guide Shaft
014-00314	Cam Remover/Replacer Adapter
019-00001	Compression Tester
019-00002	Pressure Test Kit
019-00026	Oil Cooler Internal Leakage Tester
072-00003	Pressure Leak Tester
072-00007	Oil Leak Detector
072-00008	Oil Additive
078-00100	Dynamic Timing Meter
099-00001	Photo Tachometer

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