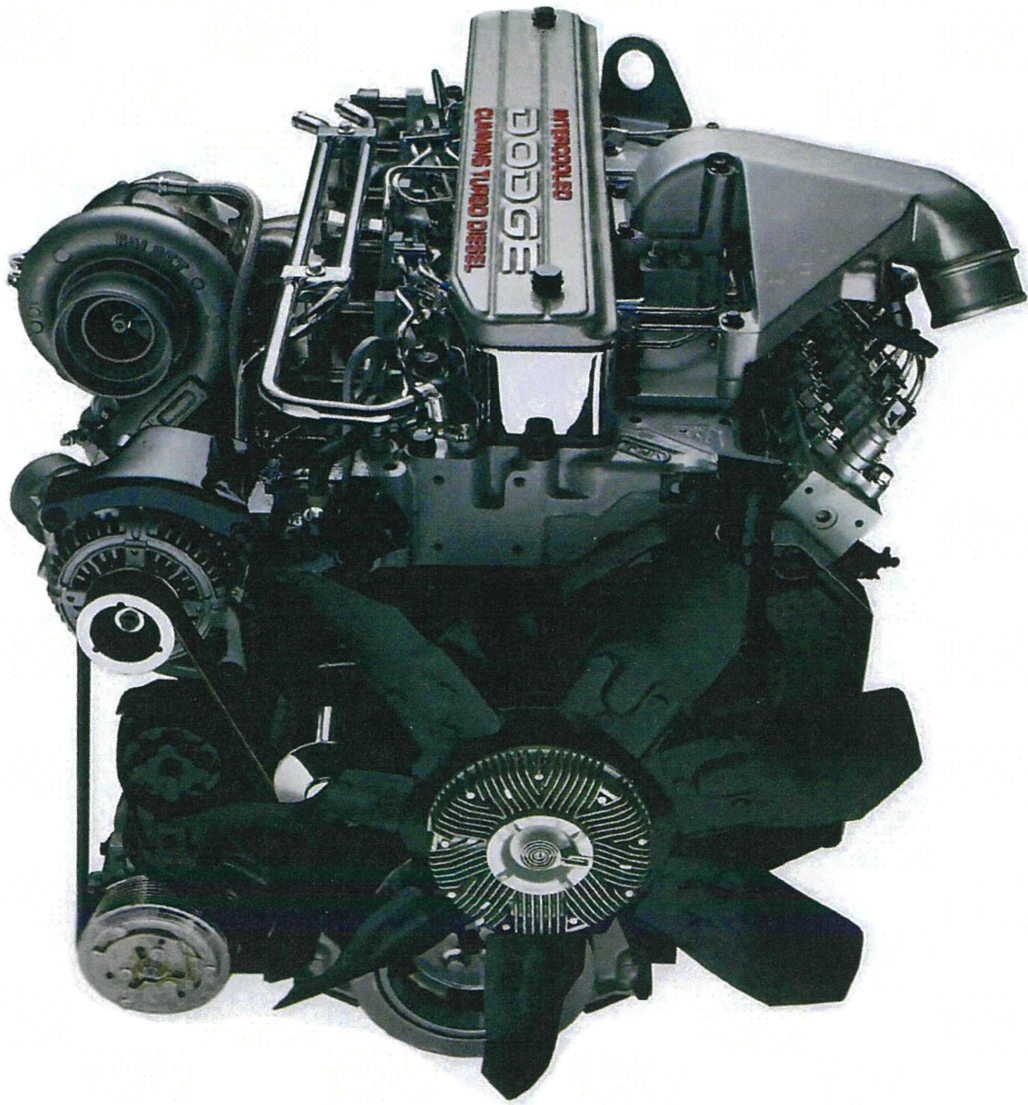


DOUBLE DUTY DIESEL



6BT ENGINE DATA

5.9L (DIESEL) ENGINE

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GENERAL INFORMATION

PISTON GRADING

When rebuilding an engine with the original cylinder block, crankshaft and pistons, make sure the pistons are installed in the original cylinder.

If replacing the piston(s), make sure the replacement piston(s) are the same grade as the original piston.

If a new cylinder block or crankshaft is used, the piston grading procedure **MUST** be performed to determine the proper piston grade for each cylinder.

OIL FILTER

When replacing the oil filter, use replacement filter specified in your Operator's Manual.

CAUTION: The internal filtering medium of some filters has been known to disintegrate. Debris from failed filters may plug the piston oil cooling nozzles, resulting in scuffed pistons and eventual engine failure.

DESCRIPTION AND OPERATION

ENGINE DESCRIPTION

The 5.9 Liter (359 CID) six-cylinder diesel engine is an In-line valve in head type (Fig. 1).

Engine Type.....	In-line 6 (Diesel-Turbo)
Bore and Stroke.....	102.0 x 120.0 mm (4.02 x 4.72 in.)
Displacement.....	5.9L (359 cu. in.)
Compression Ratio.....	17.5:1
Torque (Automatic).....	542 N•m (400 ft. lbs.) @ 1600 rpm
(Manual).....	569 N•m (420 ft. lbs.) @ 1600 rpm
Firing Order.....	1-5-3-6-2-4
Lubrication.....	Pressure Feed - Full Flow Filtration w/Bypass Valve
Engine Oil Capacity.....	9.5L (10.0 Qts) w/Filter
Cooling System.....	Liquid Cooled - Forced Circulation
Cooling Capacity.....	23L (24 Qts)
Cylinder Block.....	Cast Iron
Crankshaft.....	Induction Hardened Forged Steel
Cylinder Head.....	Cast Iron
Combustion Chambers.....	High Swirl Bowl
Camshaft.....	Chilled Ductile Iron
Pistons.....	Cast Aluminum
Connecting Rods.....	Forged Steel

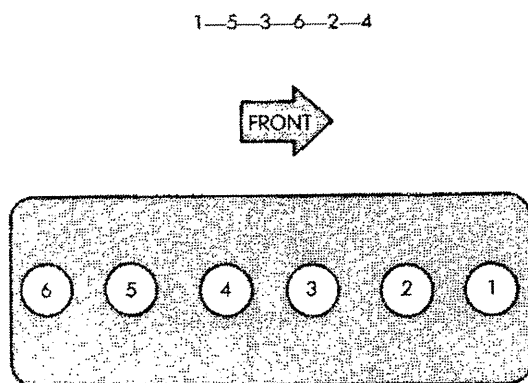
J9409-12

Fig. 1 Diesel Engine Description

This engine is designed for No.2 Diesel Fuel. Only use No.1 Diesel Fuel where extended arctic conditions exist (below -23°C or -10°F).

Engine lubrication system consists of a gerotor type oil pump and a full flow oil filter with a bypass valve.

The cylinders are numbered from front to rear; 1 to 6. The firing order is 1-5-3-6-2-4 (Fig. 2).



J9409-107

Fig. 2 Firing Order

The engine data plate is located on the driver side of the engine forward of the fuel injection pump.

LUBRICATION SYSTEM

The engine uses a gerotor type lubricating pump. The machined cavity in the block is the same for all engines. The pressure regulating valve is designed to keep the lubricating oil pressure from exceeding 449kPa (65 PSI). When the lubricating oil pressure from the pump is greater the 499kPa (65 PSI), The valve opens uncovering the dump port so part of the lubricating oil is routed to the oil pan. Because of manufacturing tolerances of the components and the oil passages, the lubricating oil pressure can differ as much as 69 kPa (10 PSI) between engines.

The engines use full flow, plate type oil coolers. The oil flows through a cast passage in the cooler cover and through the element where it is cooled by the engine coolant flowing past the plates of the elements. After the oil is cooled, it flows through the full flow oil filter.

The lubricating oil cooler cover contains a bypass valve the will let the lubricating oil flow bypass a plugged filter. The valve is designed to open when the pressure drop across the filter is more than 138 kPa (20 PSI), as with a plugged filter and lets the lubricating oil continue on through the engine. When a filter becomes plugged, an oil pressure decrease of 60 kPa (10 PSI) or less from normal operating pressure can be observed on the vehicle lubricating oil pressure gauge. This allows unfiltered oil into the engine. This condition should be avoided by changing the filter at each oil change.

The turbocharger receives filtered, cooled and pressurized lubricating oil through a supply line from the filter head. A drain line connected to the bottom of the turbocharger housing returns the lubricating oil to the lubricating oil pan through a fitting in the cylinder block.

The main bearings and the valve train are lubricated by pressurized oil directly from the main oil gallery. the other power components, connecting rods, pistons, and camshaft receive pressurized oil directly from the main oil gallery. Passages in the crankshaft supply oil to the connecting rods bearings. The oil is supplied to the camshaft journals through passages in the main bearings saddles. Smaller passages in the main bearings saddles supply oil to the pistons cooling nozzles. The spray from the nozzles also provides lubrication for the piston pins.

Lubrication for the valve train is supplied through separate passages in the cylinder block. Oil flows through the passages and across the oil transfer slot in the cylinder head gasket. From the transfer slot, the oil flows around the outside diameter at the cylinder capscrew, across a slot in the bottom of the rocker lever support, and up the vertical passage in the support. From these passages, oil flows through passages in the rocker lever shaft to lubricate the rocker levers. The oil from the channel lubricates the valves stems, push rods, and tappets.

DESCRIPTION AND OPERATION (Continued)

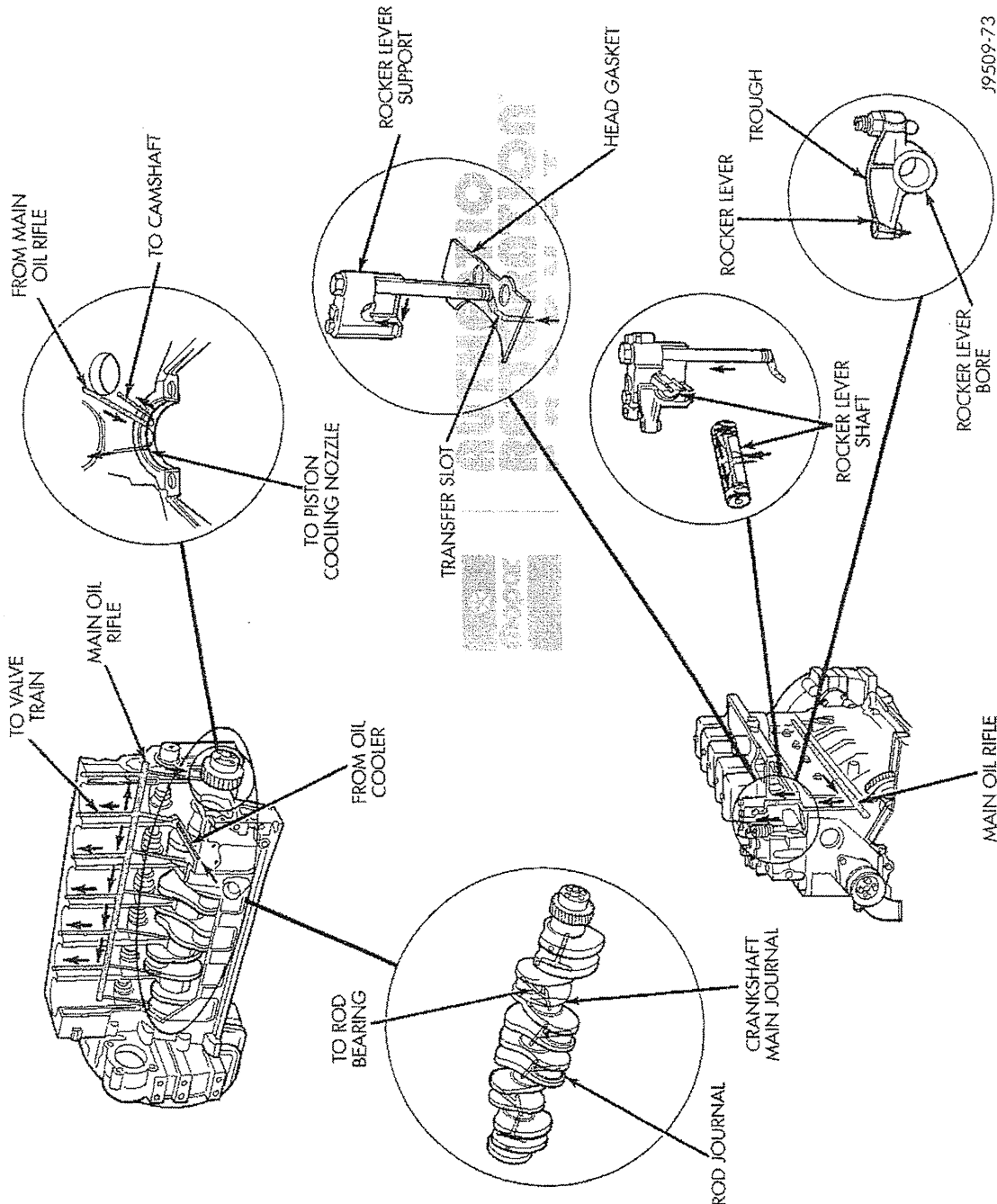


Fig. 3 Lubricating System Components

DESCRIPTION AND OPERATION (Continued)

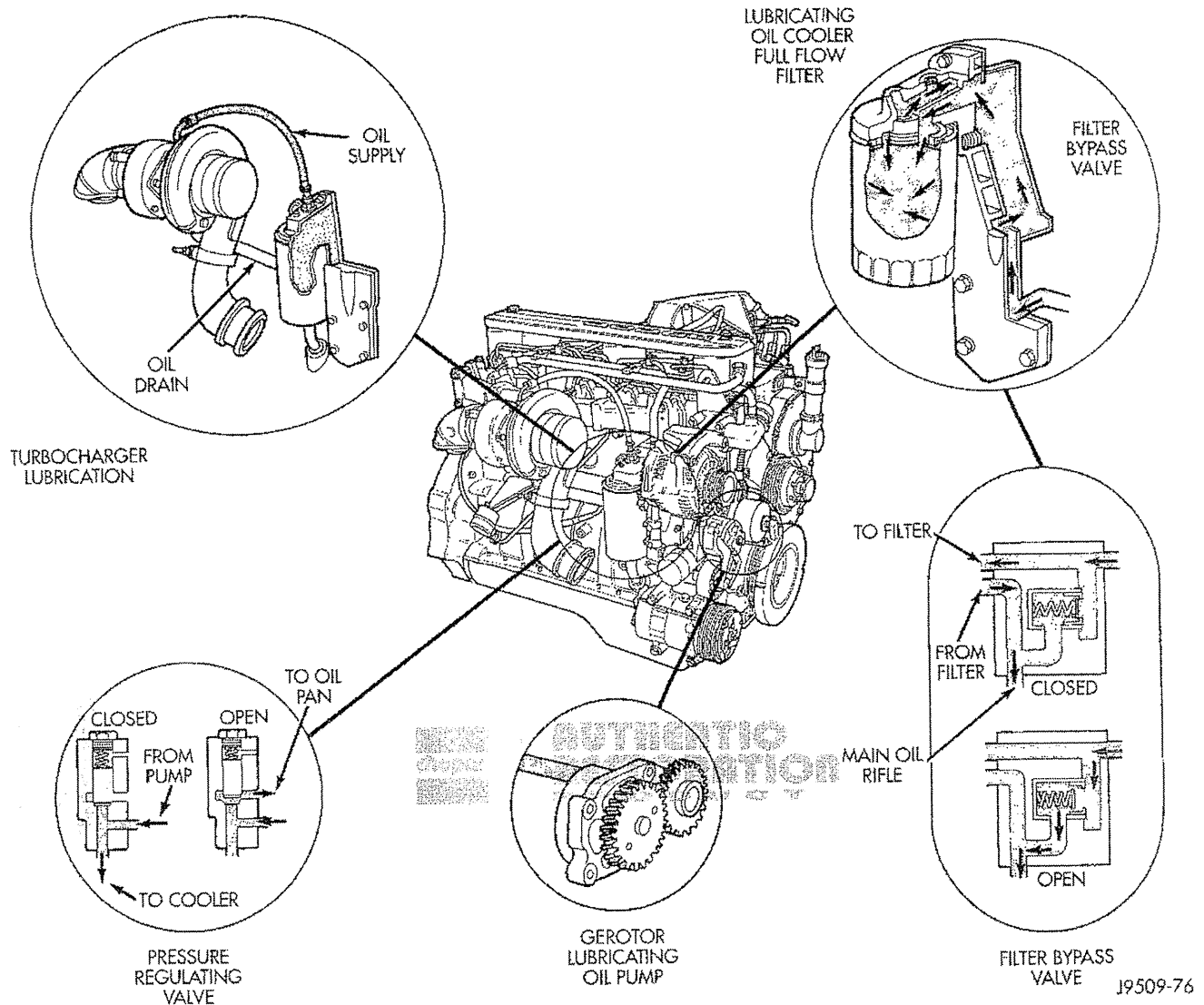


Fig. 4 Lubricating System Passages

OIL PRESSURE REGULATOR VALVE

When oil pressure from the oil pump exceeds 448 kPa (65 psi), the regulator valve opens to allow oil to drain back into the pan.

TIMING PIN

The timing pin is used for three different procedures:

- Valve adjustment
- Top Dead Center (TDC) location
- Fuel injector pump timing procedure

SERVICE PROCEDURES**OIL FILTER**

When replacing the oil filter, use replacement filter specified in your Operator's Manual.

CAUTION: The internal filtering medium of some filters has been known to disintegrate. Debris from failed filters may plug the piston oil cooling nozzles, resulting in scuffed pistons and eventual engine failure.

SERVICE PROCEDURES (Continued)**REMOVAL**

WARNING: HOT OIL CAN CAUSE PERSONAL INJURY.

(1) Operate the engine until the water temperature reaches 60°C (140°F). Shut the engine off.

(2) Use a container that can hold at least 14 liters (15 quarts) to hold the used oil. Remove the oil drain plug and drain the used engine oil into the container.

(3) Always check the condition of the used oil. This can give you an indication of some engine problems that might exist.

- Thin, black oil indicates fuel dilution.
- Milky discoloration indicates coolant dilution.

(4) Clean the area around the lubricating oil filter head. Remove the filter using a 90-95 mm filter wrench.

(5) Clean the gasket surface of the filter head. The filter canister O- Ring seal can stick on the filter head. Make sure it is removed.

INSTALLATION

(1) Fill the oil filter element with clean oil before installation. Use the same type oil that will be used in the engine.

(2) Apply a light film of lubricating oil to the sealing surface before installing the filter.

CAUTION: Mechanical over-tightening may distort the threads or damage the filter element seal.

(3) Install the filter as specified by the filter manufacturer.

(4) Clean the drain plug and the sealing surface of the pan. Check the condition of the threads and sealing surface on the oil pan and drain plug.

(5) Install the drain plug using a new sealing washer. Tighten the plug to 80 N·m (60 ft. lbs.) torque.

(6) Use only High-Quality Multi-Viscosity lubricating oil in the Cummins Turbo Diesel engine. Choose the correct oil for the operating conditions outlined in Group 0, Lubrication and Maintenance.

(7) Fill the engine with the correct grade of new oil. The engine capacity is 9.46 liters (10 quarts) in the crankcase and 0.95 liters (1 quart) in the lubricating oil filter.

(8) Start the engine and operate it at idle for several minutes. Check for leaks at the filter and drain plug.

(9) Stop the engine. Wait approximately 15 minutes to let the oil in the upper parts of the engine to drain back to the oil pan. Check the oil level again. Add oil as necessary to bring the level to the H (High) mark on the dipstick.

VALVE SERVICE**VALVE GUIDE INSTALLATION****THIN WALL—SERVICE GUIDES**

Machine the cylinder head valve guide bores to 11.125 ± 0.013 mm (0.4380 ± 0.0005 inch) in diameter (Fig. 5).

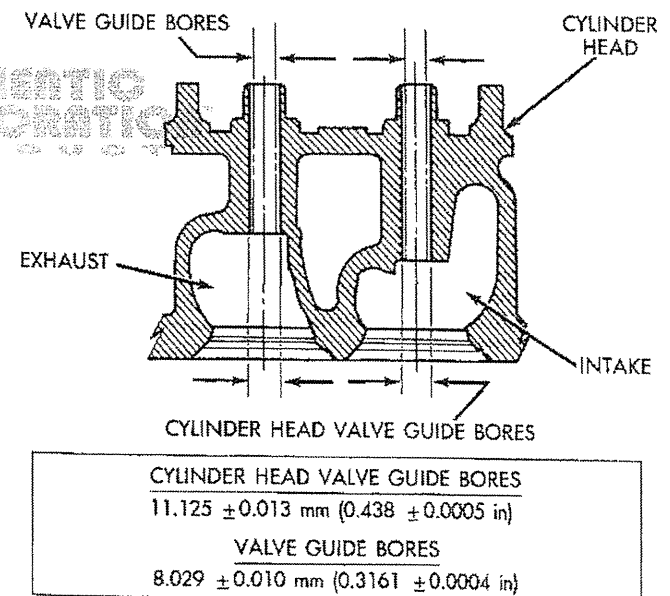
Service valve guides must be centered with valve seats within 0.35 mm (0.01378 inch) diameter. They must also be square with the combustion face within 0.10 mm (0.004 inch) at 50.0 mm (1.9685 inch) radius.

Lubricate the valve guides with oil and press the guides flush to the bottom of the bosses.

Trim off the top of the valve guides flush to top of guide bosses, if necessary.

Machine the valve guide bores to 8.029 ± 0.010 mm (0.3161 ± 0.0004 inch) - (Fig. 5).

The valve guide bore must be centered with the valve seat within 0.35 mm (0.0138 inch) diameter. It also must be square with the combustion face within 0.010 mm (0.0004 inch) at 50.0 mm (2.0 inch) radius.



J9109-136

Fig. 5 Service Valve Guides—Thin Wall

THICK WALL—SERVICE GUIDES

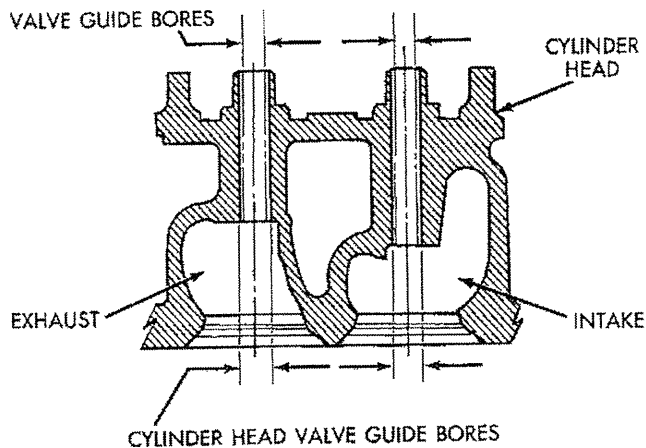
Machine the cylinder head valve guide bores to 14.000 ± 0.013 mm (0.5512 ± 0.0005 inch) diameter (Fig. 6).

Valve guides must be centered with valve seats within 0.35 mm (0.01378 inch) diameter. Valve guides must also be square with the combustion face within 0.10 mm (0.004 inch) at 50.0 mm (2.0 inch) radius.

SERVICE PROCEDURES (Continued)

Lubricate the valve guides with oil and press in the guides to 12.25 ± 0.50 mm (0.4823 ± 0.020 inch) protrusion above the cylinder head.

Ream the bores to 8.029 ± 0.010 mm (0.3161 ± 0.0004 inch) - (Fig. 6).



CYLINDER HEAD VALVE GUIDE BORES 14.000 ± 0.013 mm (0.5512 ± 0.0005 in) VALVE GUIDE BORES 8.029 ± 0.010 mm (0.3161 ± 0.0004 in)

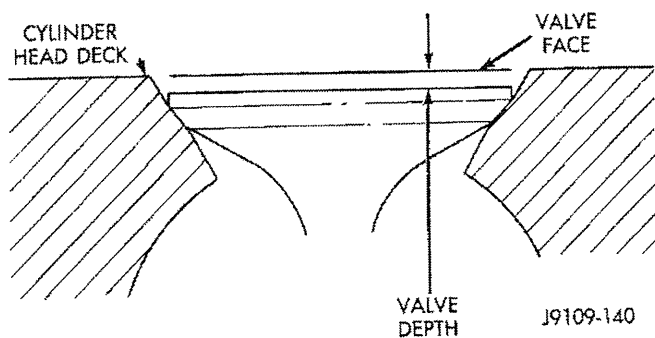
J9109-137

Fig. 6 Service Valve Guides—Thick Wall

VALVE SEATS

INTEGRAL VALVE SEAT GRINDING

After resurfacing the valves and determining that all valves meet specifications, install the valves in their designated locations and measure valve depth (Fig. 7). The valve depth is the distance from the valve face to the head deck. Record the depth of each valve.



J9109-140

Fig. 7 Valve Depth

Grind the valve seats to remove scores, scratches and burns. The seat angle should be—Intake 30° and Exhaust 45° .

Install the valves in their respective bores and measure the depth again (Fig. 7). Record the depth of each valve.

The grinding depth is the difference between the measurement before grinding and the measurement after grinding. The grinding depth maximum limit (integral seats only) is 0.254 mm (0.010 inch). Service valve seats are available for over limit integral valve seats.

Identify ground valve seats by stamping the cylinder head.

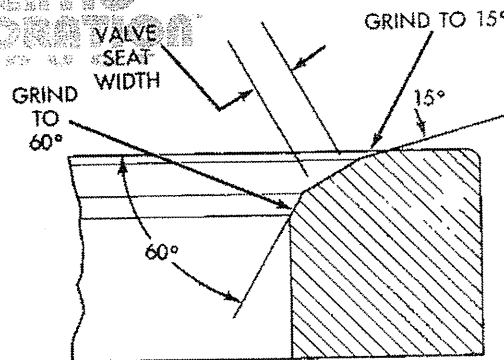
Install the valves in their designated locations and measure the depth of each. The valve depth limit (Integral and Inserted Seats) is 0.99 mm to 1.52 mm (0.039 inch to 0.060 inch). Replace the valve if the depth is over this limit.

Apply a light coat of valve lapping compound to each valve and lap each valve to its mating seat.

Remove the valves and clean lapping compound from the valves and seats.

Measure the valve seat width indicated by the lapping surface. The valve seat width limit is 1.50-2.00 mm (0.060-0.080 inch).

If required, grind the areas with a 60° stone and a 15° stone to center the seat on the valve face. Maintain the valve seat width limits (Fig. 8).



J9109-141

Fig. 8 Grind Valve Seat

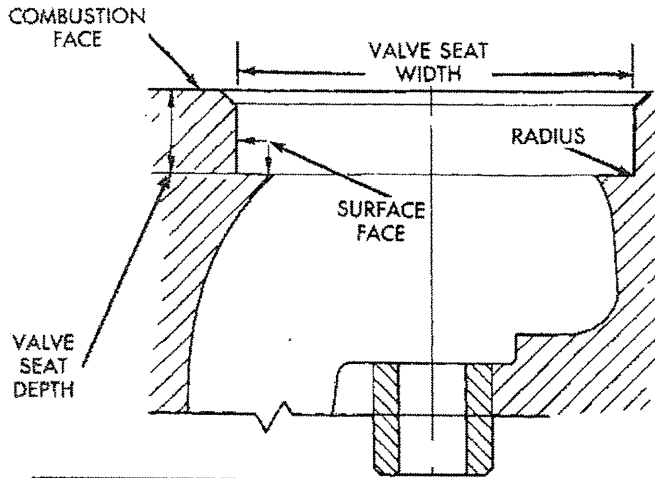
SERVICE VALVE SEAT INSTALLATION

Inspect the valve guide bores as described in the Cleaning and Inspection section of this group. If it is necessary to install valve guides, install the guides before installing the service seats.

Replacement valve seat inserts must be installed if the valve seats have been ground previously. The illustrated marks indicate valve seats have been ground previously.

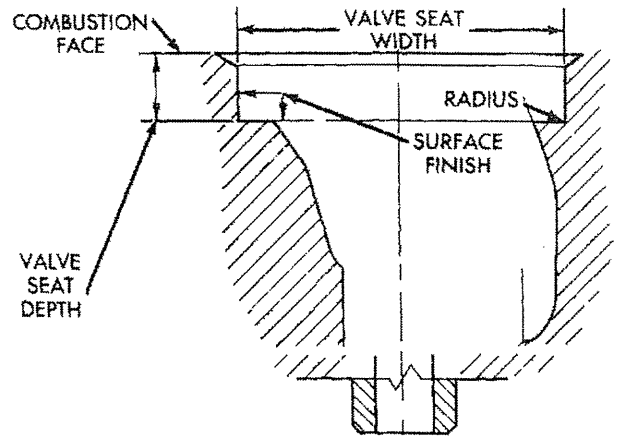
Machine the cylinder head to install the service valve seats (Fig. 9) (Fig. 10).

Press service seats into the machined pockets. Stake the valve seats into the pockets.

SERVICE PROCEDURES (Continued)

VALVE SEAT DEPTH
10.40 ± 0.10 mm (0.4094 ± 0.004 inch)
VALVE SEAT WIDTH
47.0 ± 0.013 mm (1.8504 ± 0.0005 in)
MAXIMUM RADIUS
0.40 mm (0.0157 inch) MAX.
SURFACE FINISH
3.2 micrometers (128.0 microinch)

J9409-115

Fig. 9 Machining for Service Valve Seats—Intake Valve

VALVE SEAT DEPTH
10.20 ± 0.10 mm (0.4015 ± 0.004 inch)
VALVE SEAT WIDTH
43.65 ± 0.013 mm (1.7185 ± 0.0005 in)
MAXIMUM RADIUS
0.40 mm (0.0157 inch) MAX.
SURFACE FINISH
3.2 micrometers (128.0 microinch)

J9409-116

Fig. 10 Machining for Service Valve Seats—Exhaust Valve**SERVICE VALVE SEAT GRINDING**

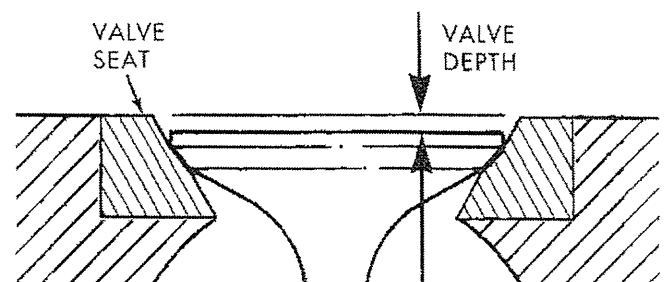
Install the valves in their designated location and measure the valve depth. The valve depth is the distance from the valve face to the head deck.

Record the depth of each valve (Fig. 11). The depth is 0.99-1.52 mm (0.039-0.060 inch).

Grind the valve seats to remove scores, scratches and burns. The valve seat angle is 30° (Intake) and 45° (Exhaust).

Install the valves in their respective bores and measure the depth again (Fig. 11). The valve depth limit is 0.99-1.52 mm (0.039-0.060 inch). Replace the valve if the depth is over the limit.

Apply a light coat of valve lapping compound to each valve and lap each valve to its companion seat. Remove the valves and clean the lapping compound from the valve and seats.



MIN. - 0.990 mm (0.039 inch)
MAX. - 1.520 mm (0.060 inch)

J9109-44

Fig. 11 Valve Depth with Seat Insert

SERVICE PROCEDURES (Continued)

Measure the valve seat width indicated by the lapped surface (Fig. 12). The width limits are 1.5-2.0 mm (0.060-0.080 inch). If required, grind lower area with 60° stone and upper area with 15° stone (Fig. 12). Be sure to center the seat on the valve face. Maintain the valve seat within limits.

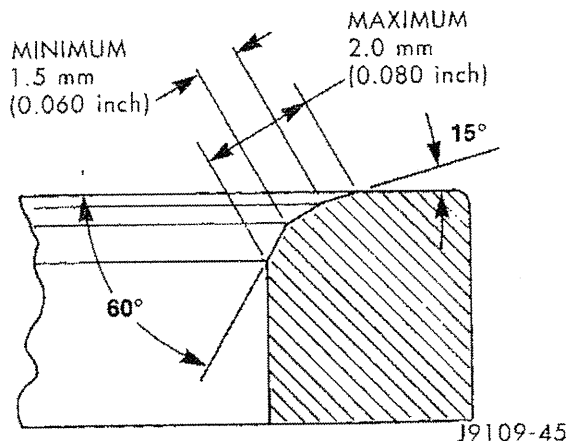


Fig. 12 Valve Seat Width

SERVICE VALVE SEAT REPLACEMENT

To replace service seat inserts, machine the insert in the same manner as if machining out the internal seat. Hold the same tolerances and follow the same installation procedures.

CYLINDER BORES—DE-GLAZE

(1) New piston rings may not seat in glazed cylinder bores.

(2) De-glazing gives the bore the correct surface finish required to seat the rings. The size of the bore is not changed by proper de-glazing.

(3) Cover the lube holes in the top of the block with waterproof tape.

(4) A correctly honed surface will have a cross-hatch appearance with the lines at 15° to 25° angles (Fig. 13). For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.

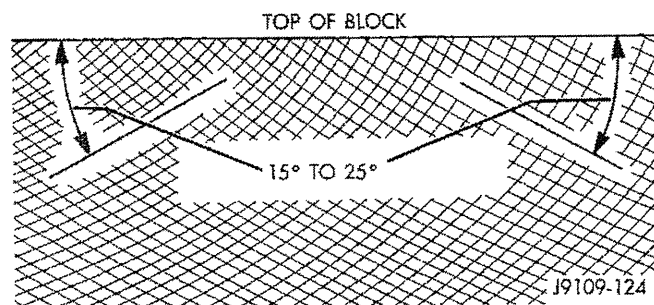


Fig. 13 Cylinder Bore Crosshatch Pattern

(5) Use a drill, a fine grit Flex-hone and a mixture of equal parts of mineral spirits and SAE 30W engine oil to de-glaze the bores.

(6) The crosshatch angle is a function of drill speed and how fast the hone is moved vertically (Fig. 14).

(7) Vertical strokes **MUST** be smooth continuous passes along the full length of the bore (Fig. 14).

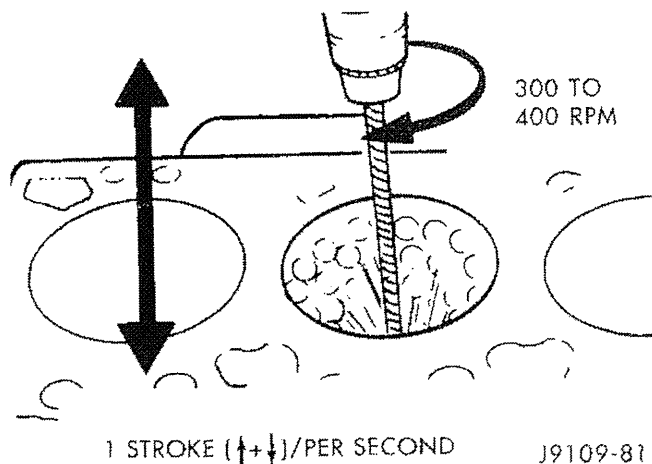


Fig. 14 De-Glazing Drill Speed and Vertical Speed

(8) Inspect the bore after 10 strokes.

(9) Use a strong solution of hot water and laundry detergent to clean the bores. Clean the cylinder bores immediately after de-glazing.

(10) Rinse the bores until the detergent is removed and blow the block dry with compressed air.

(11) Check the bore cleanliness by wiping with a white, lint free, lightly oiled cloth. If grit residue is still present, repeat the cleaning process until all residue is removed. Wash the bores and the complete block assembly with solvent and dry with compressed air.

(12) Be sure to remove the tape covering the lube holes after the cleaning process is complete.

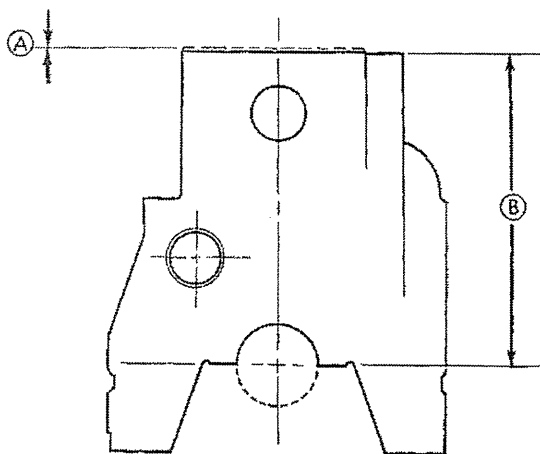
CYLINDER BLOCK REFACING

(1) The combustion deck can be refaced twice. The first reface should be 0.25 mm (0.0098 inch). If additional refacing is required, an additional 0.25 mm (0.0098 inch) can be removed. Total allowed refacing is 0.50 mm (0.0197 inch) - (Fig. 15).

(2) The upper right corner of the rear face of the block must be stamped with a X when the block is refaced to 0.25 mm (0.0098 inch). A second X must be stamped beside the first when the block is refaced to 0.50 mm (0.0197 inch) - (Fig. 16).

(3) Consult the parts catalog for the proper head gaskets which must be used with refaced blocks to ensure proper piston-to-valve clearance.

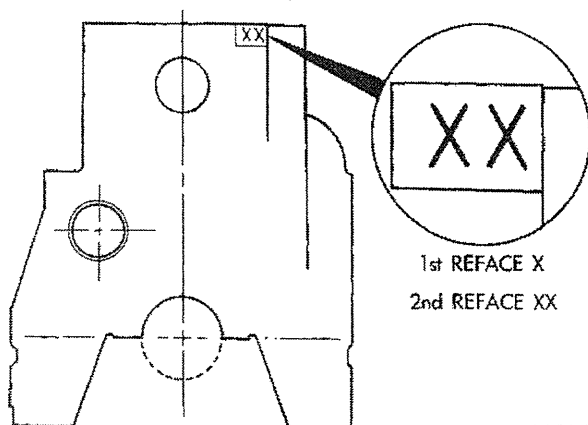
SERVICE PROCEDURES (Continued)



1st	REFACE	0.15 mm	(0.0058 inch)
2nd	REFACE	0.35 mm	(0.0138 inch)
(A)	Total	0.50 mm	(0.0197 inch)
<hr/>			
(B)	Standard	323.00 mm ±0.10 mm	(12.7165 inch ±0.0039 inch)
	1st REFACE	322.85 mm ±0.10 mm	(12.7106 inch ±0.0039 inch)
	2nd REFACE	322.50 mm ±0.10 mm	(12.6968 inch ±0.0039 inch)

J9109-118

Fig. 15 Refacing Dimensions of the Cylinder Block



J9109-116

Fig. 16 Stamp Block after Reface

CYLINDER BORE REPAIR

Cylinder bore(s) can be repaired by one of two methods:

- Method 1:—Over boring and using oversize pistons and rings.
- Method 2:—Boring and installing a repair sleeve to return the bore to standard dimensions.

METHOD 1—OVERSIZE BORE

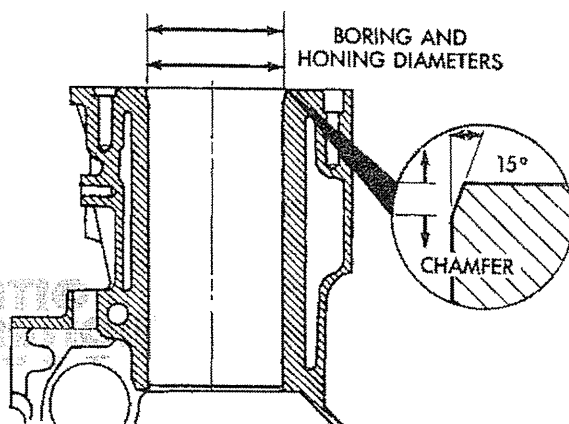
Oversize pistons and rings are available in two sizes - 0.50 mm (0.0197 inch) and 1.00 mm (0.0393 inch).

Any combination of standard, 0.50 mm (0.0197 inch) or 1.00 mm (0.0393 inch) overbore may be used in the same engine.

If more than 1.00 mm (0.0393 inch) overbore is needed, a repair sleeve can be installed (refer to Method 2—Repair Sleeve).

Cylinder block bores may be bored twice before use of a repair sleeve is required (Fig. 17). The first bore is 0.50 mm (0.0197 inch) oversize. The second bore is 1.00 mm (0.0393 inch) oversize.

After boring to size, use a honing stone to chamfer the edge of the bore (Fig. 17).



BORING DIAMETER DIMENSION	
1st REBORE	102.469 mm (4.0342 inch)
2nd REBORE	102.969 mm (4.0539 inch)
<hr/>	
HONING DIAMETER DIMENSIONS	
STANDARD	102.020 ±0.020 mm (4.0165 ±0.0008 inch)
1st REBORE	102.520 ±0.020 mm (4.0362 ±0.0008 inch)
2nd REBORE	103.020 ±0.020 mm (4.0559 ±0.0008 inch)
<hr/>	
CHAMFER DIMENSIONS	
Approx. 1.25 mm (0.049 inch) by 15°	

J9109-119

Fig. 17 Cylinder Bore Dimensions

SERVICE PROCEDURES (Continued)

A correctly honed surface will have a crosshatch appearance with the lines at 15° to 25° angles with the top of the cylinder block (Fig. 18). For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.

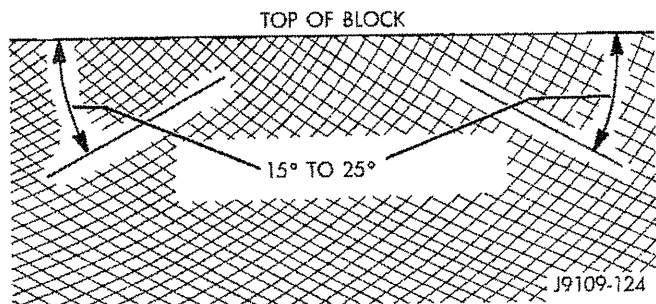


Fig. 18 Crosshatch Pattern of Repaired Sleeve(s)

A maximum of 1.2 micrometer (48 microinch) surface finish must be obtained.

After finish honing is complete, immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, blow the block dry.

Check the bore cleanliness by wiping with a white, lint-free, lightly-oiled cloth. There should be no grit residue present.

If the block is not to be used right away, coat it with a rust-preventing compound.

METHOD 2—REPAIR SLEEVE

If more than a 1.00 mm (0.03937 inch) diameter oversize bore is required, the block must be bored and a repair sleeve installed.

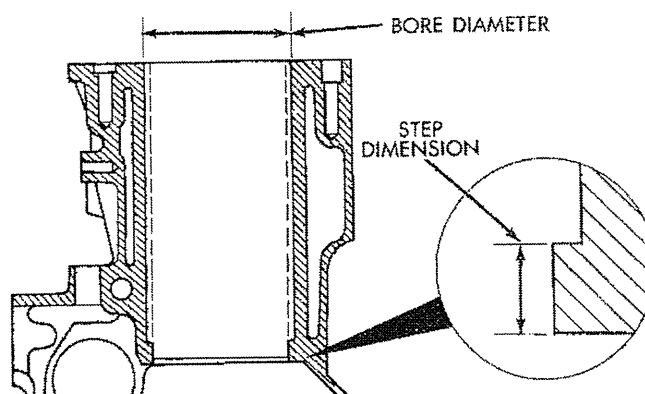
Bore the block cylinder bore to 104.500-104.515 mm (4.1142-4.1148 inch) - (Fig. 19).

Repair sleeves can be replaced by using a boring bar to bore out the old sleeve. DO NOT cut the cylinder bore beyond the oversize limit.

After machining the block for the new repair sleeve, thoroughly clean the bore of all metal chips, debris and oil residue before installing the sleeve.

Cool the repair sleeve(s) to a temperature of -12°C (10°F) or below for a minimum of one hour. Be ready to install the sleeve immediately after removing it from the freezer.

Apply a coat of Loctite 620, or equivalent to the bore that is to be sleeved.

**BLOCK REBORE FOR REPAIR SLEEVE**

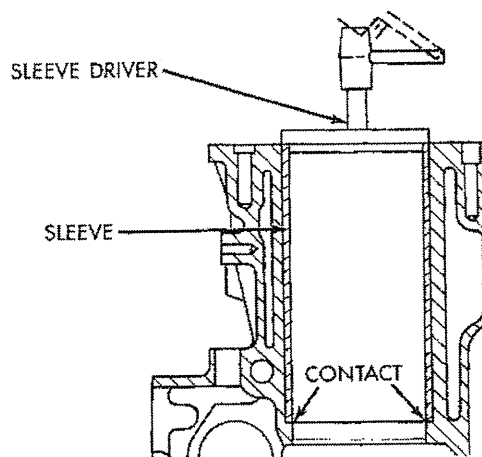
BORE DIA. - 104.500 +0.015 mm
(4.1142 +0.0006 inch)
STEP DIM. - 6.35 mm (0.25 inch)

J9109-120

Fig. 19 Block Bore for Repair Sleeve Dimensions

Wear protective gloves to push the cold sleeve into the bore as far as possible.

Using a sleeve driver, drive the sleeve downward until it contacts the step at the bottom of the bore (Fig. 20).

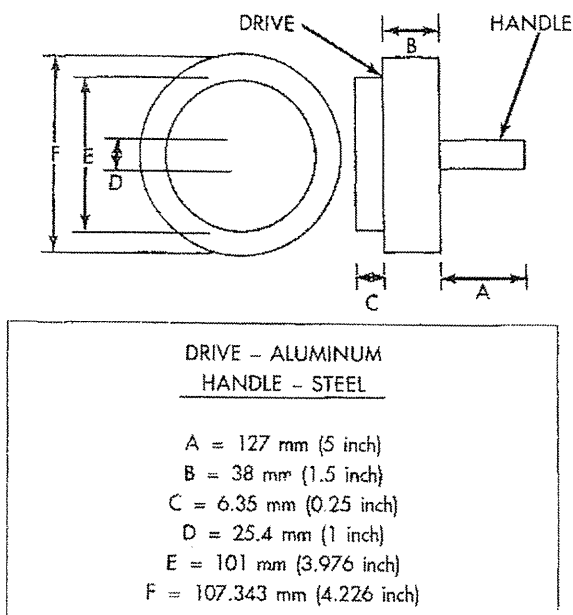


J9109-121

Fig. 20 Sleeve Installation

SERVICE PROCEDURES (Continued)

A sleeve driver can be constructed as follows (Fig. 21).

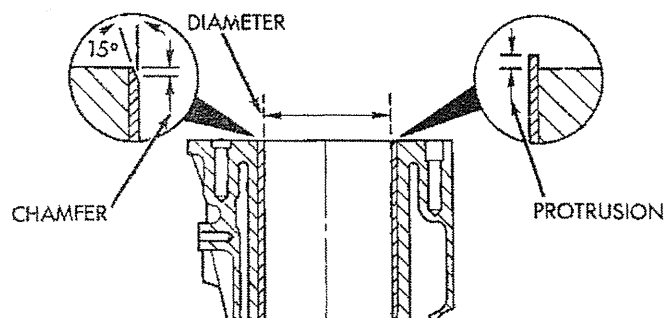


J9109-122

Fig. 21 Sleeve Driver Construction

Set up a boring bar and machine the sleeve to 101.956 mm (4.014 inch) - (Fig. 22).

After removing the boring bar, use a honing stone to chamfer the corner of the repair sleeve(s) - (Fig. 22).



SLEEVE DIAMETER - 101.956 mm (4.014 inch)
SLEEVE PROTRUSION MIN. - FLUSH WITH BLOCK MAX. - 0.050 mm (0.0019 inch)
SLEEVE CHAMFER APPROX. 1.25 mm (0.049 inch) BY 15°.

J9109-123

Fig. 22 Sleeve Machining Dimensions

A correctly honed surface will have a crosshatch appearance with the lines at 15° to 25° angles with the top of the cylinder block. For the rough hone, use 80 grit honing stones. To finish hone, use 280 grit honing stones.

Finished bore inside dimension is 102.020 ±0.020 mm (4.0165 ±0.0008 inch).

A maximum of 1.2 micrometer (48 microinch) surface finish must be obtained.

After finish honing is complete, immediately clean the cylinder bores with a strong solution of laundry detergent and hot water.

After rinsing, blow the block dry with compressed air.

Wipe the bore with a white, lint-free, lightly oiled cloth. Make sure there is no grit residue present.

Apply a rust-preventing compound if the block will not be used immediately.

A standard diameter piston and a piston ring set must be used with a sleeved cylinder bore.

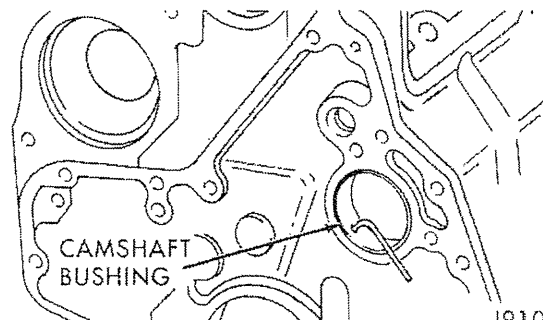
CAM BORE REPAIR

The front cam bushing bore can be bored to 57.740 Mm ±0.018 mm (2.273 inch ±0.0007 inch) oversize. DO NOT bore the intermediate or rear cam bore to the front cam bore oversize dimensions. Intermediate and rear cam bores may be bored to 57.240 mm ±0.018 mm (2.253 inch ±0.0007 inch) oversize.

A surface finish of 2.3 micrometers (92 microinch) must be maintained. Not more than 20% of an area of any one bore may be 3.2 micrometers (126 microinch).

Camshaft bores can be repaired individually. It is not necessary to repair undamaged cam bores in order to repair individually damaged cam bores. The standard front bushing cannot be used to repair intermediate or rear bores.

Install all cam bushings flush or below the front cam bore surface. The oil hole must align to allow a 3.2 mm (0.125 inch) rod to pass through freely (Fig. 23).



J9109-54

Fig. 23 Oil Hole Alignment

SERVICE PROCEDURES (Continued)**CYLINDER BLOCK CUP PLUG REPLACEMENT**

(1) Remove the cup plugs from the oil passages (Fig. 24).

(2) Apply a bead of Loctite 277 around the outside diameter of the oil passage cup plugs.

(3) Drive the cup plugs in until they bottom in the bore (Fig. 24).

(4) Fill the engine with oil. Run the engine and check for leaks.

(5) Stop the engine and check the oil level with the dipstick.

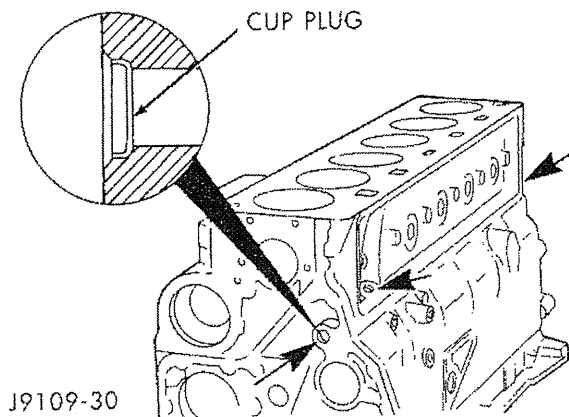


Fig. 24 Cup Plug Locations in Cylinder Block

CONNECTING ROD BEARING AND CRANKSHAFT JOURNAL CLEARANCE

Measure the connecting rod bore with the bearings installed and the bolts tightened to 100 N·m (73 ft. lbs.) torque.

Record the smaller diameter.

Measure the diameter of the rod journal at the location shown (Fig. 25). Calculate the average diameter for each side of the journal.

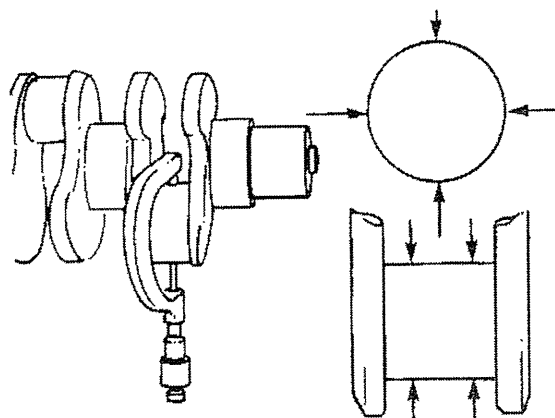
The clearance is the difference between the connecting rod bore (smallest diameter) and the average diameter for each side of the crankshaft journal.

If the crankshaft is within limits, replace the bearing. If the crankshaft is out of limits, grind the crankshaft to the next smaller size and use oversize rod bearings.

PISTON GRADING PROCEDURE

(1) Install any of the original connecting rod and piston assemblies into the No.1 cylinder. DO NOT install the piston rings.

(2) Install the upper bearing shell in the connecting rod with the tang of the bearing in the slot of the connecting rod. The connecting rod bearing shell must be installed in the original connecting rod and



MIN.	68.962 mm	(2.715 inch)
MAX.	69.013 mm	(2.717 inch)

Out-of-Round - Max.
0.050 mm (0.002 inch)

Taper - Max.
0.013 mm (0.0005 inch)

Bearing Clearance - Max.
0.089 mm (0.0035 inch)

J9109-91

Fig. 25 Connecting Rod Journal Diameter Limits

cap. Use clean lubricating oil to coat the inside diameter of the connecting rod bearing shell.

(3) Install the bearing shell in the connecting rod cap with the tang of the bearing in the slot to the cap. Use clean lubricating oil to coat the inside diameter of the bearing shell.

(4) The four digit number stamped on the connecting rod and cap at the parting line must match and be installed on the oil cooler side of the engine. Install the connecting rod cap and capscrews. Tighten the capscrews to 35 N·m (26 ft. lbs.) torque.

(5) Use a fine grit stone to remove any burrs from the cylinder block head deck. Zero the dial indicator to the cylinder block head deck.

(6) Move the dial indicator directly over the piston pin to eliminate any side-to-side movement.

(7) Rotate the crankshaft to top dead center (TDC). Rotate the crankshaft clockwise and counter-clockwise to find the highest dial indicator reading. Record the reading.

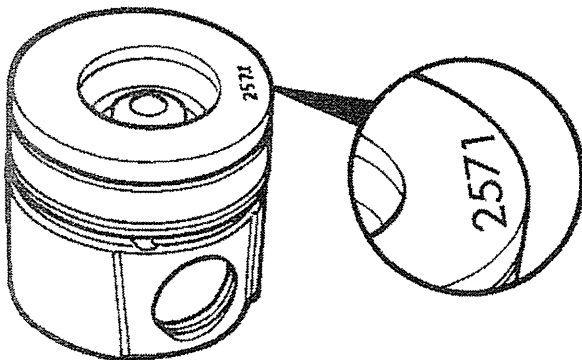
(8) Remove the piston and connecting rod assembly from the No.1 cylinder and install the assembly into the No.2 cylinder. Repeat the procedure for every cylinder using the same piston and connecting rod assembly.

SERVICE PROCEDURES (Continued)

(9) Determine the grade of the piston being used by referring to the Piston Protrusion Chart (Fig. 26). Four digits on top of the piston can be cross referenced to a Chrysler part number for replacement (Fig. 27). If the number on the piston cannot be seen, measure from the top of the piston to the top of the piston pin to see what grade piston is used (Fig. 28).

MEASURING PISTON	PROTRUSION	USE GRADE
2571	0.609-0.711 mm (0.024-0.028 in.)	A
2571	0.508-0.609 mm (0.020-0.024 in.)	B
2571	0.406-0.508 mm (0.016-0.020 in.)	C
2572	0.711-0.813 mm (0.028-0.032 in.)	A
2572	0.609-0.711 mm (0.024-0.028 in.)	B
2572	0.508-0.609 mm (0.020-0.024 in.)	C
2573	0.813-0.914 mm (0.032-0.036 in.)	A
2573	0.711-0.813 mm (0.028-0.032 in.)	B
2573	0.609-0.711 mm (0.024-0.028 in.)	C

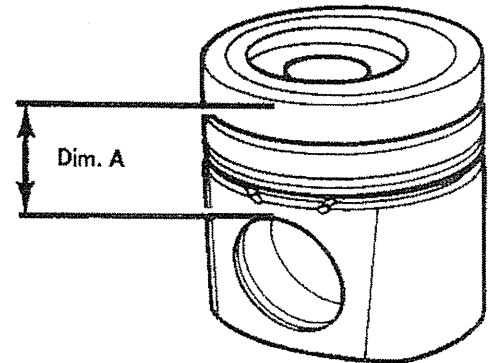
Fig. 26 Piston Protrusion Chart



J9509-2

Fig. 27 Piston Grading Number Location

Dimension A	Ref. Number	Grade
51.554 to 51.607mm (2.029 to 2.031 in)	2571	A
51.654 to 51.707mm (2.033 to 2.035 in)	2572	B
51.754 to 51.807mm (2.037 to 2.039 in)	2573	C



J9509-1

Fig. 28 Piston Grading Measurement

CRANKSHAFT REWORK

Crankshaft main and rod journals may be ground in increments of 0.25 mm (0.0098 inch) up to a total of 1.00 mm (0.0394 inch).

The only exception is the main journal thrust width surface. This journal must be ground in increments of 0.50 mm (0.0197 inch) up to a total of 1.00 mm (0.0394 inch). The thrust surface is located on the No.6 main bearing. When the thrust surface requires grinding, the main journal must be ground to the same undersize dimension.

CAUTION: Welding of the crankshaft is not allowed. Failure of the crankshaft will result.

MAIN JOURNAL

All main journals are to be ground in the opposite direction of engine rotation (clockwise as viewed from the front of crankshaft). Polish the journals in the same direction as engine rotation.

The main bearing grinding specifications are shown in (Fig. 29).

SERVICE PROCEDURES (Continued)

STANDARD MAIN JOURNAL DIAMETER	
83.000 ± 0.013 mm (3.2677 ± 0.0005 inch)	
WORN MAIN JOURNAL DIAMETER LIMIT	
82.962 (3.2662 inch)	
UNDERSIZES	REGRIND TO
0.25 mm (0.0098 inch)	82.750 ± 0.013 mm (3.2579 ± 0.0005 inch)
0.50 mm (0.0197 inch)	82.500 ± 0.013 mm (3.2480 ± 0.0005 inch)
0.75 mm (0.0295 inch)	82.250 ± 0.013 mm (3.2381 ± 0.0005 inch)
1.00 mm (0.0394 inch)	82.000 ± 0.013 mm (3.2283 ± 0.0005 inch)
OUT-OF ROUND & TAPER (MAX.)	
0.005 mm (0.0002 inch)	
ALL MAIN JOURNALS ARE TO BE PARALLEL TO THE FRONT AND REAR MAINS WITHIN: 0.030 mm (0.001 inch)	

J9109-125

Fig. 29 Crankshaft Main Journal Dimensions

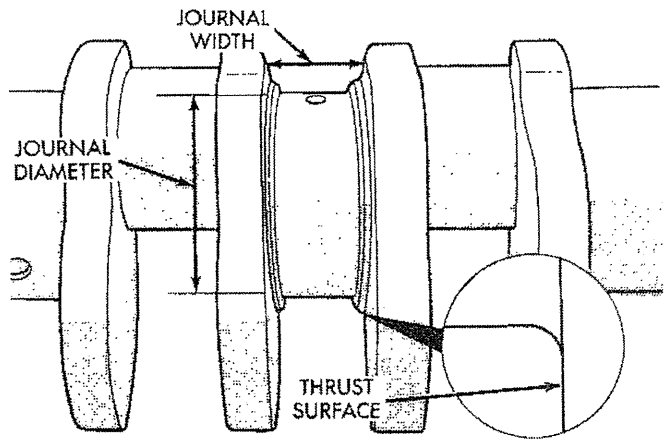
Thrust journals can be ground in the same increments and using the same specifications as all other main journals. The main journal radius may be ground using either the preferred or the alternative procedure providing the thrust surface width is not being ground. The preferred procedure must be used when the main bearing thrust width surface is ground. When the thrust surface width requires grinding, the main journal must be ground to the same undersize dimension (Fig. 30).

THRUST JOURNAL WIDTH	
37.500 ± 0.025 mm (1.4764 ± 0.001 inch)	
UNDERSIZES	REGRIND WIDTH TO
0.50 mm (0.0197 inch)	38.000 ± 0.025 mm (1.4961 ± 0.001 inch)
1.00 mm (0.0394 inch)	38.500 ± 0.025 mm (1.5158 ± 0.001 inch)

J9109-127

Fig. 30 Crankshaft Thrust Journal Width Dimensions

The thrust surface is to be ground on center within 0.10 mm (0.004 inch). It also must be perpendicular to the front and rear mains within 0.0015 mm (0.00006 inch) per radial inch on the thrust area (Fig. 31). The surface finish requirement is 0.04 micrometer (16.0 microinch).

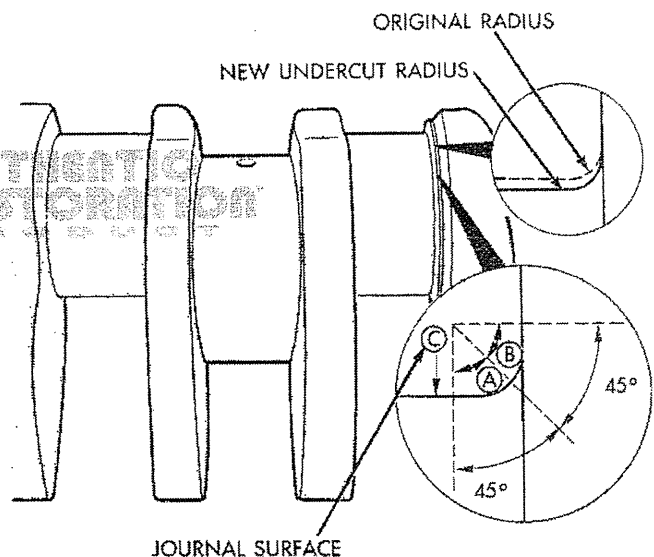


J9109-128

Fig. 31 Crankshaft Thrust Surface

PREFERRED PROCEDURE:

Smoothly blend a 4.20 ± 0.020 mm (0.1654 ± 0.0008 inch) radius to the ground diameters (Fig. 32).



SURFACE FINISH	
(A)	0.8 micrometer (32.0 microinch) for a minimum of 45° into the fillet beyond journal surface
(B)	1.6 micrometer (64.0 microinch) for remainder of fillet
(C)	0.4 micrometer (16.0 microinch)

J9109-129

Fig. 32 Grind Crankshaft Main Journal—Preferred Method

SERVICE PROCEDURES (Continued)

CAUTION: DO NOT use the Alternative Procedure when the thrust surface width is ground.

ALTERNATIVE PROCEDURE:

Smoothly blend a 1.25 ± 0.020 mm (0.0492 ± 0.0008 inch) radius to the ground diameters (Fig. 33).

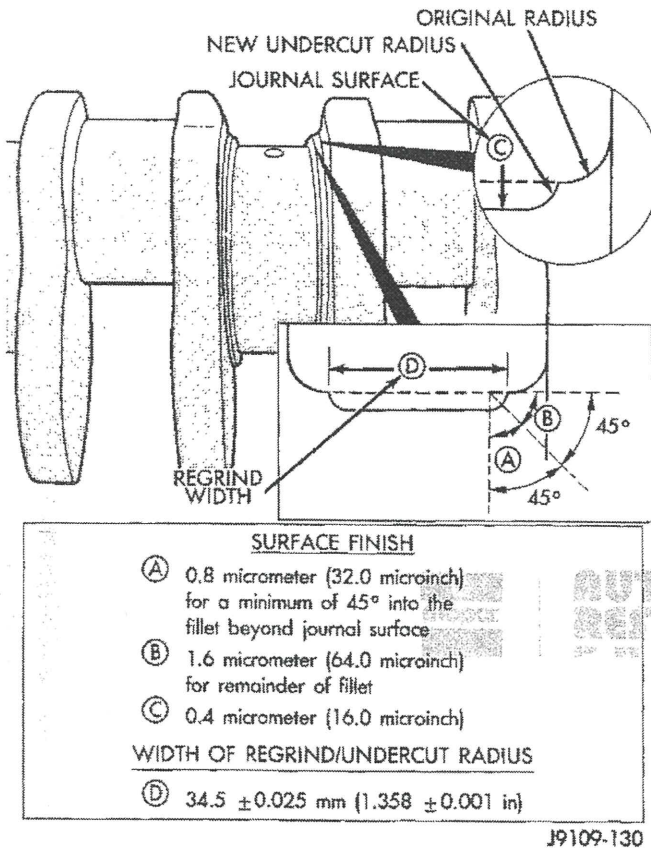


Fig. 33 Grind Crankshaft Main Journal—Alternative Method

ROD JOURNAL

All rod journals are to be ground in the opposite direction of engine rotation (clockwise as viewed from the front of crankshaft). Polish the journals in the same direction as engine rotation.

The rod bearing grinding specifications are shown in (Fig. 34).

PREFERRED PROCEDURE:

Smoothly blend a 4.00 ± 0.020 (0.1575 ± 0.0008 inch) radius to the ground diameters and side faces (Fig. 35).

STANDARD ROD JOURNAL DIAMETER	
69.000 ± 0.013 mm (2.7165 ± 0.0005 inch)	
WORN ROD JOURNAL DIAMETER LIMIT	
68.962 (2.7150 inch)	
UNDERSIZES	REGRIND TO
0.25 mm (0.0098 inch)	68.750 ± 0.013 mm (2.7067 ± 0.0005 inch)
0.50 mm (0.0197 inch)	68.500 ± 0.013 mm (2.6969 ± 0.0005 inch)
0.75 mm (0.0295 inch)	68.250 ± 0.013 mm (2.6870 ± 0.0005 inch)
1.00 mm (0.0394 inch)	68.000 ± 0.013 mm (2.6772 ± 0.0005 inch)
OUT-OF ROUND & TAPER (MAX.)	
0.005 mm (0.0002 inch)	
ALL MAIN JOURNALS ARE TO BE PARALLEL TO THE FRONT AND REAR MAINS WITHIN: 0.030 mm (0.001 inch)	

J9109-126

Fig. 34 Crankshaft Rod Journal Dimensions

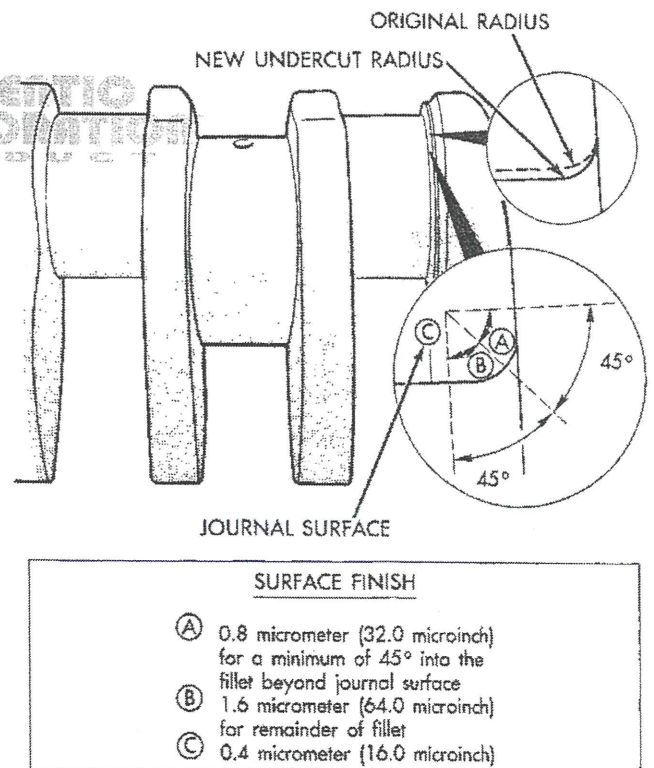
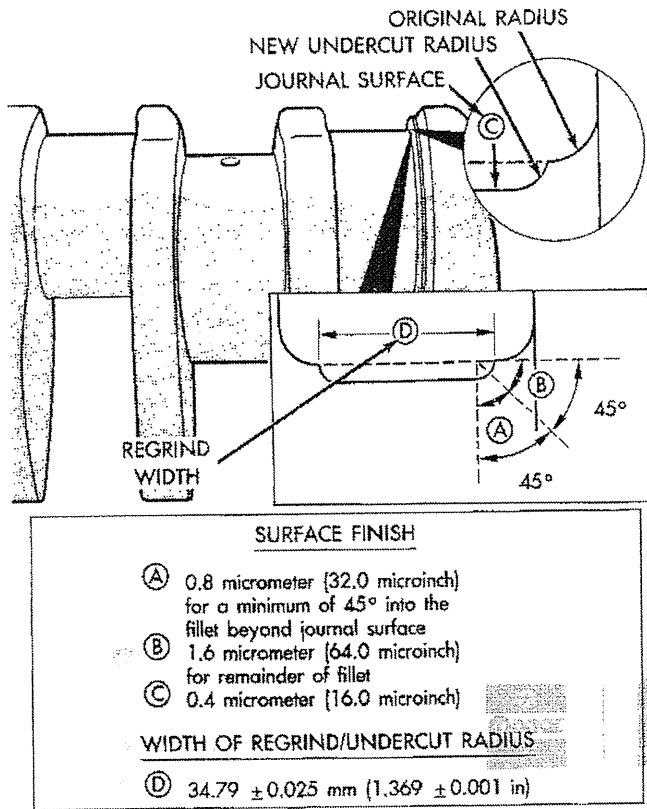


Fig. 35 Crankshaft Rod Journal Grind—Preferred Method

SERVICE PROCEDURES (Continued)

ALTERNATIVE PROCEDURE:

Smoothly blend a 1.25 ± 0.020 mm (0.0492 ± 0.0008 inch) radius to the ground journals (Fig. 36).



J9109-132

Fig. 36 Grind Crankshaft Rod Journal—Alternative Method

MAIN BEARING CLEARANCE

Inspect the main bearing bores for damage or abnormal wear.

Install the crankshaft main bearings and measure main bearing bore diameter with the main bolts tightened to 176 N·m (130 ft. lbs.) torque (Fig. 37).

Measure the diameter of the main journal at the locations shown (Fig. 38). Calculate the average diameter for each side of the journal.

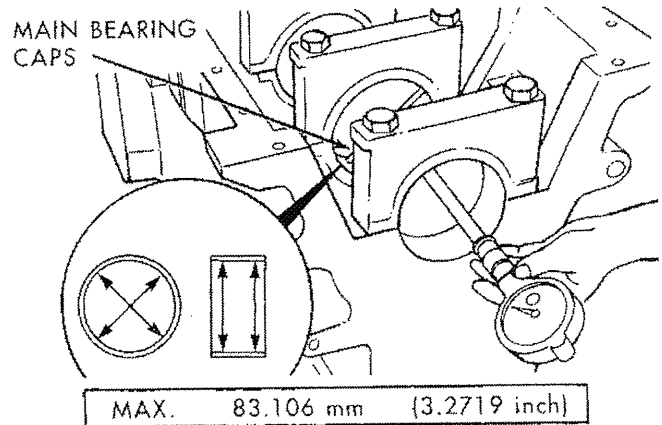
Calculate the main bearing journal to bearing clearance. The clearance specifications are 0.119 mm (0.00475 inch). If the crankshaft journal is within limits, replace the main bearings. If not within specifications, grind the crankshaft to next size and use oversize bearings.

REMOVAL AND INSTALLATION

ENGINE FRONT MOUNTS

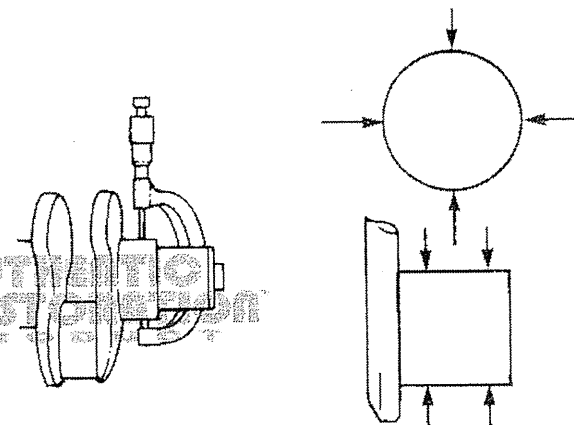
REMOVAL

- (1) Disconnect the negative cable from the battery.



J9109-92

Fig. 37 Crankshaft Main Bearing Bore Diameter



MIN.	82.962 mm	(3.2662 inch)
MAX.	83.103 mm	(3.2682 inch)

J9109-93

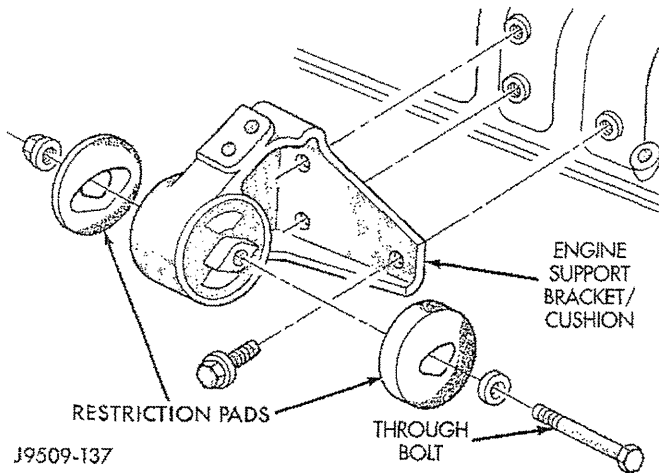
Fig. 38 Crankshaft Main Journal Diameter

- (2) Position fan to assure clearance for radiator top tank and hose.
- (3) Install engine support/lifting fixture.
- (4) Raise vehicle on hoist.
- (5) Lift the engine SLIGHTLY and remove the thru-bolt and nut (Fig. 39).
- (6) Remove engine support bracket/cushion bolts (Fig. 39). Remove the support bracket/cushion.

INSTALLATION

- (1) With engine raised SLIGHTLY, position the engine support bracket/cushion to the block. Install new bolts and tighten to 189 N·m (140 ft. lbs.) torque.
- (2) Install the thru-bolt into the engine support bracket/cushion.

REMOVAL AND INSTALLATION (Continued)



J9509-137

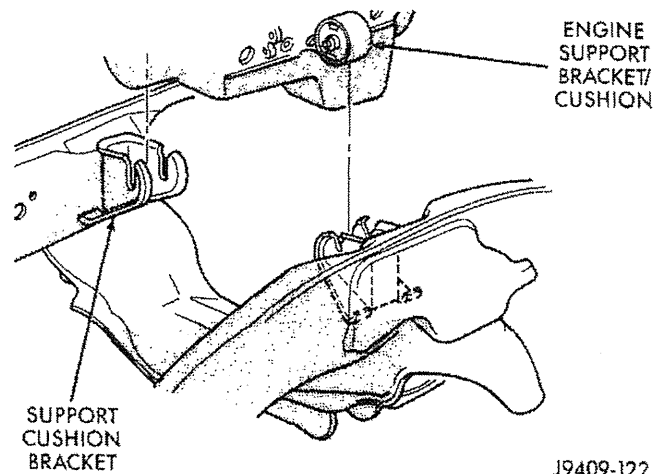
Fig. 39 Front Engine Mounts

(3) Lower engine with support/lifting fixture while guiding the engine bracket/cushion and thru-bolt into support cushion brackets (Fig. 40).

(4) Install thru-bolt nuts and tighten the nuts to 68 N·m (50 ft. lbs.) torque.

(5) Lower the vehicle.

(6) Remove lifting fixture.



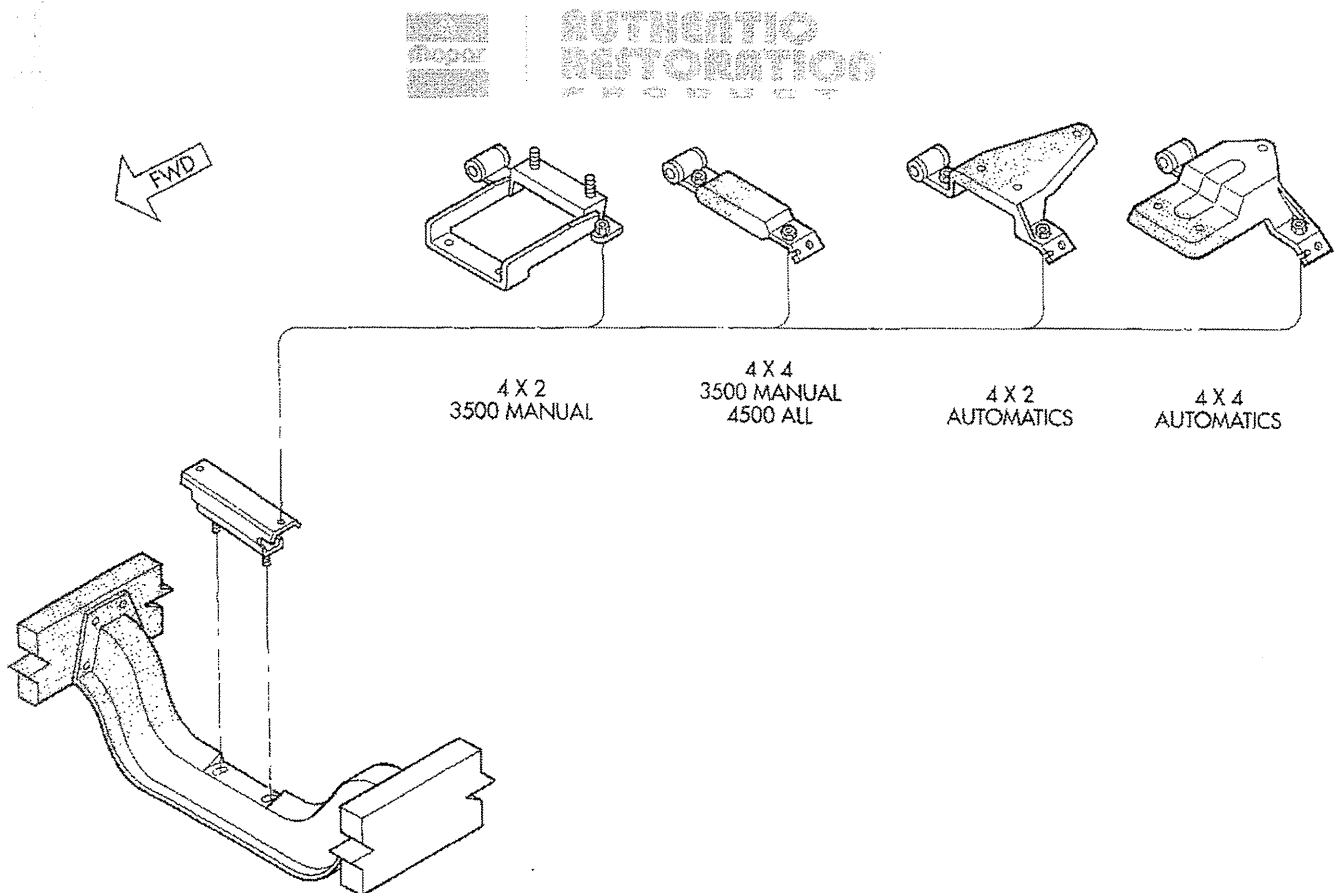
J9409-122

Fig. 40 Positioning Engine Front Mounts

ENGINE REAR MOUNT

REMOVAL

- (1) Raise the vehicle on a hoist.
- (2) Position a transmission jack in place.
- (3) Remove support cushion stud nuts (Fig. 41).
- (4) Raise rear of transmission and engine SLIGHTLY.



J9509-126

Fig. 41 Engine Rear Support Cushion Assemblies

REMOVAL AND INSTALLATION (Continued)

(5) Remove the bolts holding the support cushion to the transmission support bracket. Remove the support cushion.

(6) If necessary, remove the bolts holding the transmission support bracket to the transmission.

INSTALLATION

(1) If removed, position the transmission support bracket to the transmission. Install new attaching bolts and tighten to 102 N·m (75 ft. lbs.) torque.

(2) Position support cushion to transmission support bracket. Install stud nuts and tighten to 47 N·m (35 ft. lbs.) torque.

(3) Using the transmission jack, lower the transmission and support cushion onto the crossmember (Fig. 41).

(4) Install the support cushion bolts and tighten to 47 N·m (35 ft. lbs.) torque.

(5) Remove the transmission jack.

(6) Lower the vehicle.

ENGINE ASSEMBLY**REMOVAL**

(1) Remove the battery.

(2) Drain cooling system (refer to Group 7, Cooling System for the proper procedure).

(3) Remove the upper crossmember and top core support.

(4) Remove the transmission oil cooler.

(5) Discharge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).

(6) Remove the serpentine belt (refer to Group 7, Cooling System).

(7) Remove the A/C compressor with the lines attached. Set aside.

(8) If equipped, remove the condenser.

(9) Remove the washer bottle.

(10) Remove the radiator overflow bottle.

(11) Disconnect the top radiator hose.

(12) Remove the fan.

(13) Remove the fan shroud.

(14) Disconnect the lower radiator hose.

(15) Remove radiator (refer to Group 7, Cooling System).

(16) Remove the generator (Fig. 42) with the wire connections (refer to Group 8B, Battery/Starter/Generator Service).

(17) Disconnect the heater hoses at the dash panel and at the water valve (Fig. 43).

(18) Disconnect the air inlet tube from the turbocharger (Fig. 44) and the air intake housing. Remove the tube.

(19) Remove the exhaust pipe from the turbocharger outlet flange (Fig. 44).

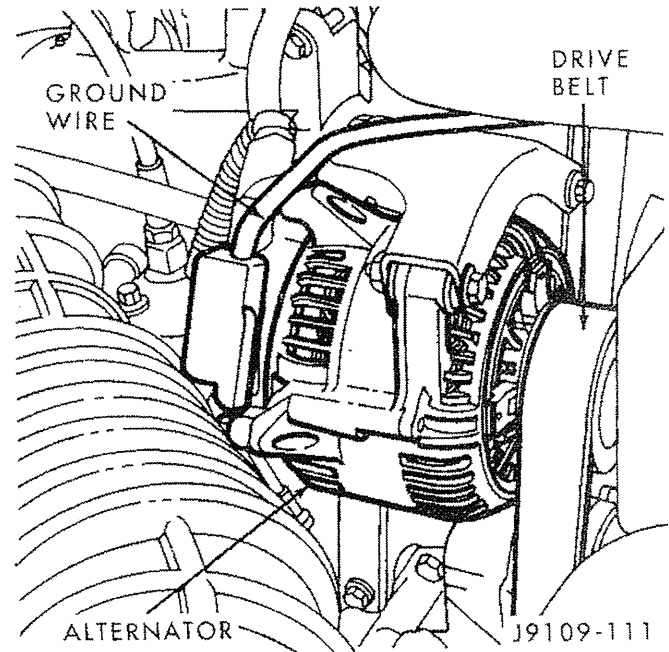


Fig. 42 Generator Removal

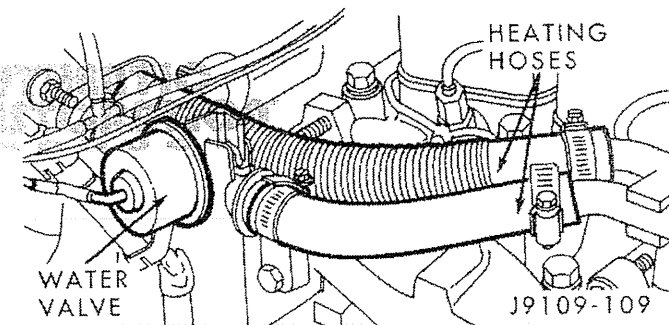


Fig. 43 Heater Hoses

(20) Disconnect the intercooler inlet duct from the turbocharger and the intercooler. Remove the inlet duct.

(21) Disconnect the intercooler outlet duct from the air inlet housing and the intercooler. Remove the outlet duct.

(22) Disconnect the accelerator linkage, the speed control linkage and the throttle valve linkage.

(23) Disconnect the power steering hoses, if equipped.

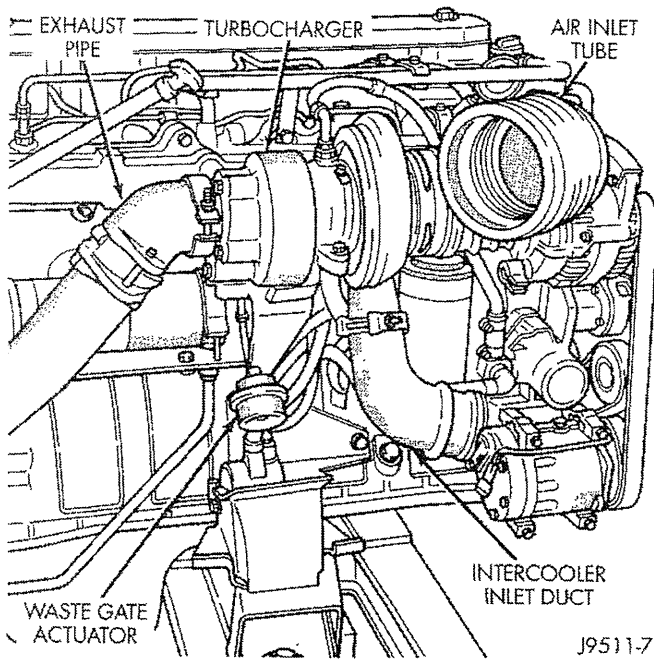
(24) Disconnect the transmission cooler lines.

(25) Disconnect all electrical connections from the engine. Put tags on the connections to identify their locations.

(26) Disconnect the fuel lines to the lift pump and fuel return. Use tags to identify the lines.

(27) On Manual Transmission vehicles, remove the shift lever (refer to Group 21, Transmissions).

(28) Raise and support the vehicle on a hoist.

REMOVAL AND INSTALLATION (Continued)

J9511-7

Fig. 44 Air Inlet Tube and Exhaust Pipe Connection

(29) Drain the engine lubricating oil. Dispose of the oil according to all applicable regulations.

(30) Remove the oil pan.

(31) Remove engine front mount thru-bolt nuts.

(32) Remove the transmission cooler-line brackets from oil pan.

(33) Disconnect exhaust pipe at manifold.

(34) Disconnect the starter wires. Remove starter motor (refer to Group 8B, Battery/Starter/Generator Service).

(35) Remove the dust shield and transmission cover.

(36) Refer to Group 21, Transmissions for transmission removal.

(37) Lower the vehicle.

(38) Put a cover or tape over all engine openings.

(39) Lift the engine out of the vehicle.

(40) Install the engine on a suitable stand.

(41) Remove all accessories and brackets not previously removed for use with the replacement engine.

INSTALLATION

(1) Check the data plate to verify that the replacement engine is the same model and rating as the engine that was removed.

(2) Install all accessories and brackets that had been removed from the previous engine.

(3) Use the lifting brackets to lift the engine off of the stand.

(4) Position the engine in the chassis with the thru-bolt installed.

(5) Remove the covers or tape covering the engine openings.

(6) Raise and support the vehicle.

(7) Refer to Group 21, Transmissions for transmission installation.

(8) Install the dust shield and transmission cover.

(9) Install the prop shaft (refer to Group 16, Propeller Shaft).

(10) Install the starter motor (refer to Group 8B, Battery/Starter/Generator Service). Connect the starter wires.

(11) Install the transmission cooler line brackets to oil pan.

(12) Install and tighten engine front mount thru-bolt nuts.

(13) Install the oil pan. Install the drain plug.

(14) Lower the vehicle.

(15) On Manual Transmission vehicles, install the shift lever (refer to Group 21, Transmissions).

(16) Connect the fuel lines to the lift pump and fuel return. Use tags to identify the lines.

(17) Connect all electrical connections to the engine. Use tags to identify their locations.

(18) Connect the transmission cooler lines.

(19) Connect the power steering hoses, if equipped.

(20) Connect the accelerator linkage, the speed control linkage and the throttle valve linkage.

(21) Install the outlet duct. Connect the intercooler outlet duct to the air inlet housing and the intercooler.

(22) Install the inlet duct. Connect the intercooler inlet duct to the turbocharger and the intercooler.

(23) Install the exhaust pipe to the turbocharger outlet flange.

(24) Install the air inlet tube. Connect the air inlet tube to the turbocharger and the air intake housing.

(25) Connect the heater hoses at the dash panel and at the water valve.

(26) Install the generator and wire connections (refer to Group 8B, Battery/Starter/Generator Service).

(27) Install the radiator (refer to Group 7, Cooling System).

(28) Connect the lower radiator hose.

(29) Install the fan shroud.

(30) Install the fan.

(31) Connect the top radiator hose.

(32) Install the radiator overflow bottle.

(33) Install the washer bottle.

(34) If equipped, install the condenser.

(35) Install the A/C compressor with the lines attached.

(36) Evacuate and charge the air conditioning system, if equipped (refer to Group 24, Heating and Air Conditioning for service procedures).

(37) Install the transmission oil cooler.

(38) Install the upper crossmember and top core support.

(39) Install the serpentine belt (refer to Group 7, Cooling System).

REMOVAL AND INSTALLATION (Continued)

(40) Fill the cooling system with a mixture of 50% water and 50% ethylene-glycol base antifreeze (refer Group 7, Cooling System for the proper procedure).

(41) Fill the engine with the required amount of clean engine lubricating oil (refer to Group 0, Lubrication and Maintenance).

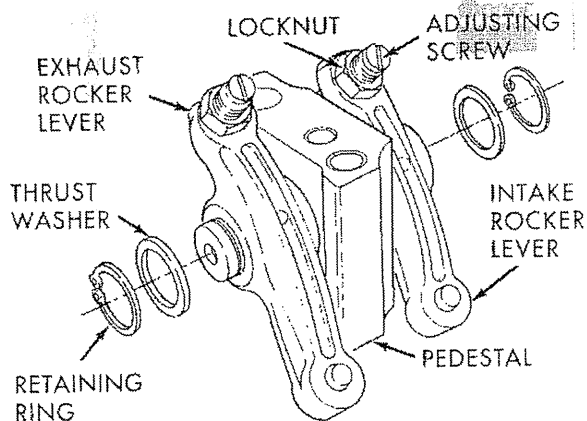
(42) Install the battery and connect the battery cables.

(43) Check the oil level after the engine has run for 2 or 3 minutes. Oil held in the oil filter and oil passages will cause the oil level in the pan to be lower than normal for a short period of time.

(44) Operate the engine at idle for 5 to 10 minutes and check for leaks and loose parts.

ROCKER LEVERS AND PUSH RODS**REMOVAL**

- (1) Remove the valve covers.
- (2) Loosen the adjusting screw locknuts. Loosen the adjusting screws until they stop (Fig. 45).
- (3) Remove the bolts from the rocker lever pedestals. Remove the pedestals and rocker lever assemblies (Fig. 45).
- (4) Remove the push rods. The rear two push rods must be raised through holes in cab overhang.



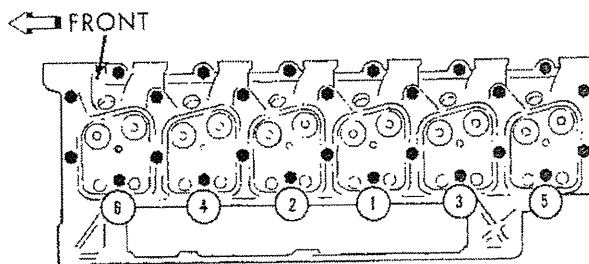
J9109-31

Fig. 45 Location of Rocker Lever Components**INSTALLATION**

- (1) Make sure the dowel rings in the pedestals are installed into the dowel bores in the cylinder head.
- (2) If the push rod is holding pedestal off head, bar the engine until the pedestal will set on the head surface without interference.
- (3) Use clean engine oil to lubricate the cylinder head bolt threads and under the bolt heads.
- (4) Install the long bolts (12 mm) into the rocker lever pedestals. Tighten the bolts as follows:
 - Step 1—Tighten the bolts, in sequence (Fig. 46), to 90 N·m (66 ft. lbs.) torque. Check the torque. If lower than 90 N·m (66 ft. lbs.), tighten to this torque.

- Step 2—Tighten the bolts, in sequence (Fig. 46), to 120 N·m (89 ft. lbs.) torque. Check the torque. If lower than 120 N·m (89 ft. lbs.), tighten to this torque.

- Step 3—Tighten the bolts, in sequence (Fig. 46), an additional 90°.



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Fig. 46 Rocker Lever (Head Bolts) Tightening Sequence

- (5) Tighten the 8 mm bolts to 24 N·m (18 ft. lbs.) torque.

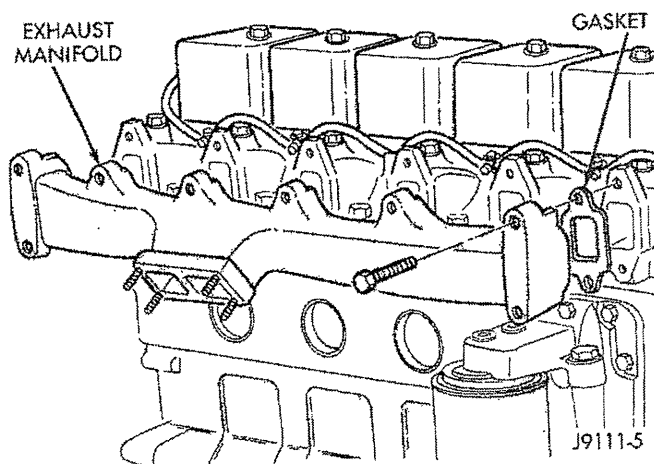
- (6) Install the valve cover. Tighten the valve cover bolt to 24 N·m (18 ft. lbs.) torque.

CYLINDER HEAD

These cylinder heads can only be used on engines with an intercooler. DO NOT interchange with earlier models.

REMOVAL

- (1) Drain the coolant. DO NOT waste reusable coolant. If the solution is clean, drain the coolant into a clean container for reuse.
- (2) Drain the engine oil. Dispose of the used oil properly.
- (3) Disconnect the radiator and heater hoses (refer to Group 7, Cooling System).
- (4) Remove the turbocharger.
- (5) Remove the exhaust manifold (Fig. 47).



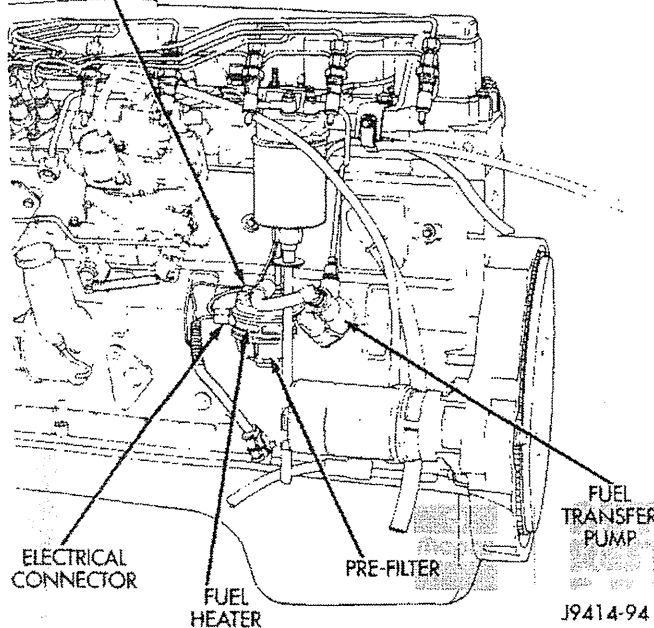
J9111-5

Fig. 47 Exhaust Manifold

REMOVAL AND INSTALLATION (Continued)

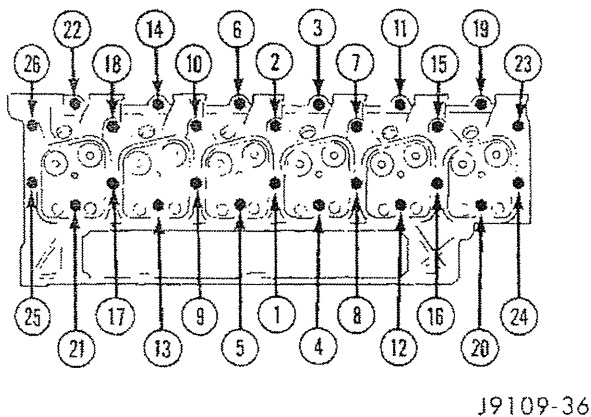
- (6) Remove the fuel lines and injector nozzles (refer to Group 14, Fuel System).
- (7) Remove the valve covers.
- (8) Remove the rocker levers and push rods.
- (9) Remove the fuel filter/water separator (Fig. 48). Refer to Group 14, Fuel System, for the proper procedures. Remove the remote fuel filter/water separator head.

FUEL TEMPERATURE SENSOR

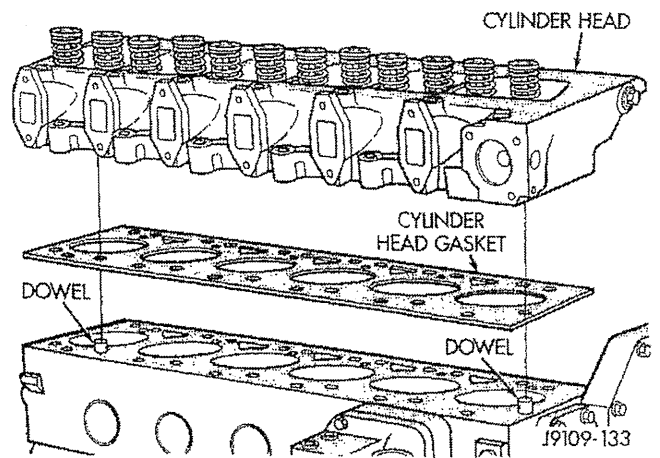
**Fig. 48 Fuel/Water Separator Filter**

(10) If the engine is hot, remove the cylinder head bolts in the sequence shown in (Fig. 49). The removal sequence is not important if the engine is cold. There are 3 sizes of head bolts. Note the position of each bolt for future installation.

(11) Remove the cylinder head and gasket from the cylinder block.

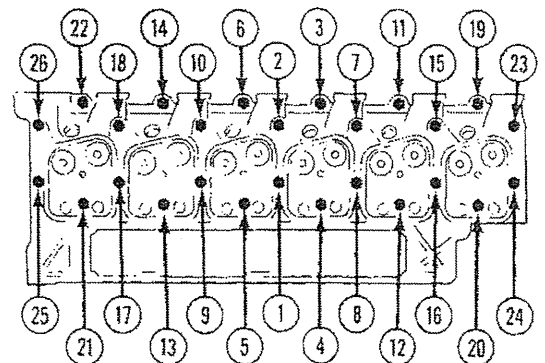
**Fig. 49 Cylinder Head Bolt Removal Sequence—Cylinder Head Hot****INSTALLATION**

- (1) The cylinder block and head must be clean and dry.
- (2) Position the gasket onto the dowels (Fig. 50). Make sure the gasket is correctly aligned with the holes in the cylinder block.
- (3) Carefully put the cylinder head onto the gasket and cylinder block. Make sure the cylinder head is installed onto the dowels in the cylinder block (Fig. 50).

**Fig. 50 Cylinder Head/Gasket Alignment**

- (4) Install the push rods and rocker levers.
- (5) Use clean engine oil to lubricate the cylinder head bolt threads and under the bolt heads.
- (6) The cylinder head bolts are 3 different sizes. Install the bolts in the proper hole. Tighten the bolts as follows:

- Step 1—Tighten all bolts, in sequence (Fig. 10), to 90 N·m (66 ft. lbs.) torque. Check the torque. If lower than 90 N·m (66 ft. lbs.), tighten to this torque.
- Step 2—Tighten all long 12 mm bolts (Nos. 4, 5, 12, 13, 20 and 21), in sequence (Fig. 51), to 120 N·m (89 ft. lbs.) torque. Check the torque. If lower than 120 N·m (89 ft. lbs.), tighten to this torque.
- Step 3—Tighten all bolts, in sequence (Fig. 51), an additional 90°.

**Fig. 51 Cylinder Head Tightening Sequence**

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REMOVAL AND INSTALLATION (Continued)

(7) Be sure to lubricate the push rod sockets with clean engine oil. Be sure push rod is seated properly in the tappet.

(8) Install the rocker lever pedestal bolts and tighten to 24 N·m (18 ft. lbs.) torque.

(9) Adjust the valve clearance.

(10) Install the valve covers. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(11) Install the injector nozzles and fuel lines (refer to Group 14, Fuel System).

(12) Install the remote fuel filter/water separator head. Install the fuel filter/water separator (refer to Group 14, Fuel System for the proper procedures).

(13) Install the exhaust manifold (refer to Group 11, Exhaust System and Intake Manifold).

(14) Install the turbocharger.

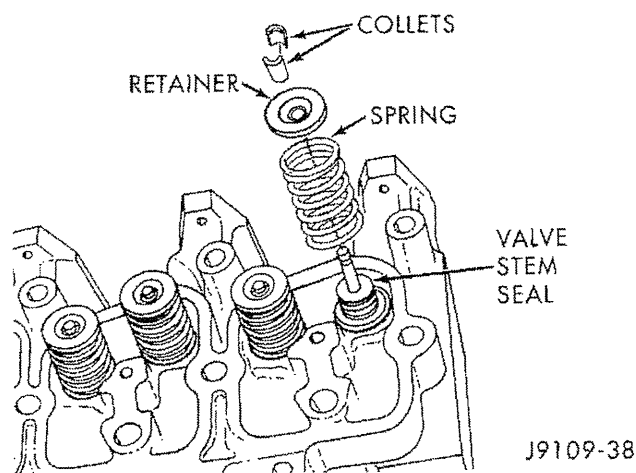
(15) Connect the radiator and heater hoses.

(16) Fill the engine with new coolant or the clean drained coolant (refer to Group 7, Cooling System for the proper procedure).

(17) Fill the engine with clean lubricating oil (refer to Group 0, Lubrication and Maintenance).

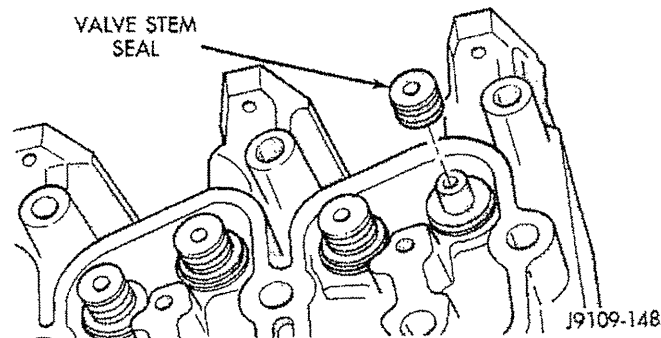
VALVES AND VALVE SPRINGS**REMOVAL**

- (1) Remove the cylinder head.
- (2) Mark the valves to identify their position.
- (3) Compress the valve spring and remove the valve stem collets (Fig. 52).
- (4) Release valve spring and remove the retainer and spring (Fig. 52).
- (5) Remove the remaining collets, retainers, springs and valves. Keep the valves in a labeled rack.
- (6) Remove the valve stem seals (Fig. 52).

**Fig. 52 Valve Removal****INSTALLATION**

(1) Clean all cylinder head components before assembling.

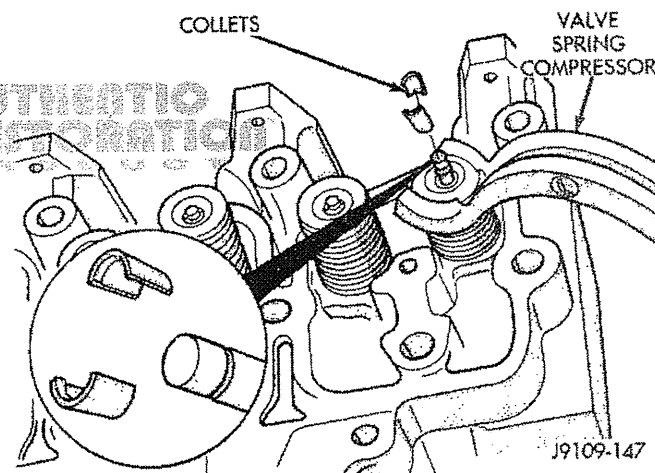
(2) Install the valve stem seals (Fig. 53). The intake and exhaust valve seals are the same.

**Fig. 53 Valve Stem Seal Installation**

(3) Lubricate the stems with SAE 90W oil before installing the valves. Install the valves in the same positions as removed.

(4) Compress the valve spring after installing the spring and retainer (Fig. 54).

(5) Install new valve collets and release the spring tension (Fig. 54).

**Fig. 54 Valve, Valve Spring and Collet Installation**

WARNING: WEAR PROTECTIVE EQUIPMENT AND DO NOT STAND IN LINE WITH THE VALVE STEM WHEN TAPPING THE VALVES.

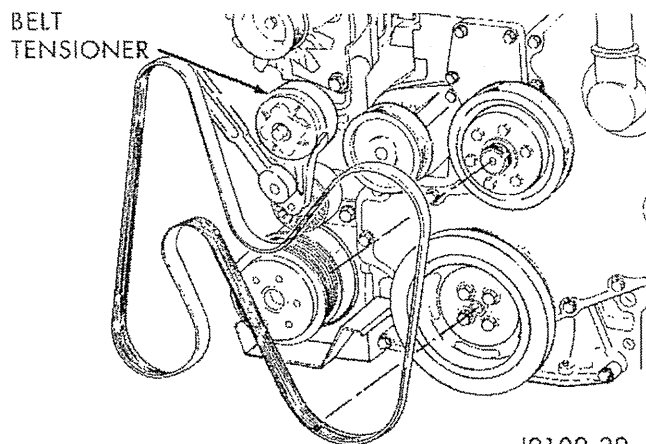
(6) Tap the ends of the valve stems with a mallet to verify the collets are seated.

(7) Install the cylinder head.

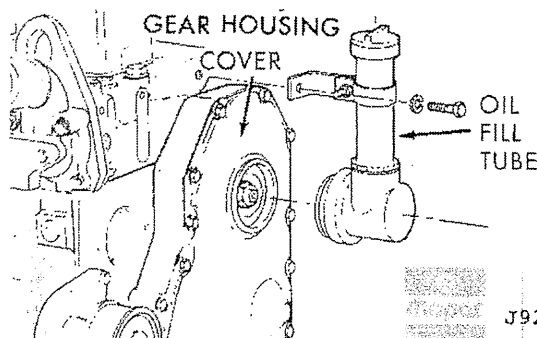
(8) Check the valve clearance adjustment.

GEAR HOUSING COVER**REMOVAL**

- (1) Remove fan drive assembly.
- (2) Remove the fan belt (Fig. 55).
- (3) Remove belt tensioner (Fig. 55).
- (4) Remove oil fill tube and adaptor (Fig. 56).

REMOVAL AND INSTALLATION (Continued)

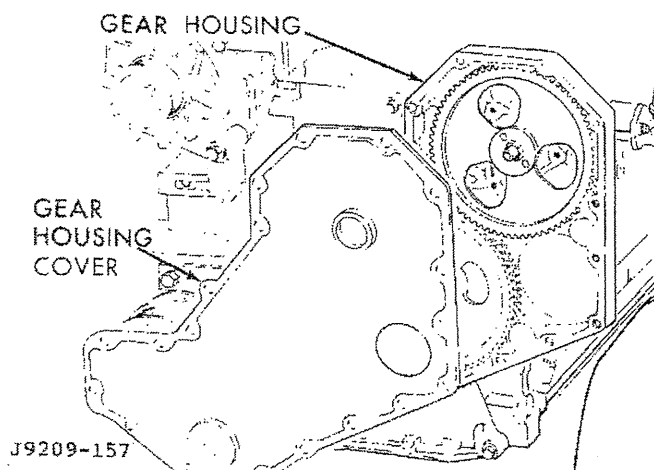
J9109-29

Fig. 55 Drive Belt Installation

J9209-158

Fig. 56 Oil Fill Tube

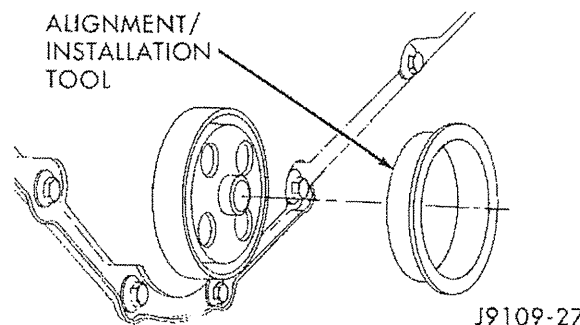
- (5) Remove vibration damper.
- (6) Remove the bolts that hold the gear cover to the gear housing.
- (7) Gently pry the cover away from the housing, taking care not to mar the gasket surfaces (Fig. 57).
- (8) Clean the old gasket residue from the back of the gear cover and front of the gear housing.



J9209-157

Fig. 57 Gear Housing and Cover**INSTALLATION**

- (1) Lubricate the front gear train with clean engine oil.
- (2) Thoroughly clean the front seal area of the crankshaft. The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.
- (3) Install the gear housing cover and a new gasket.
- (4) Install the bolts but **DO NOT** tighten them at this time.
- (5) Use the alignment/installation tool from the seal kit to align the cover to the crankshaft (Fig. 58).



J9109-27

Fig. 58 Alignment/Installation Tool

- (6) Tighten the gear housing cover bolts to 24 N·m (18 ft. lbs.) torque.
- (7) Remove the alignment/installation tool. Always use a seal pilot when you install a seal.
- (8) Apply a bead of Loctite 277 to the outside diameter of the seal. Install the pilot from the seal kit onto the crankshaft. Install the seal onto the pilot and start into the gear housing cover. Remove the pilot.
- (9) Use the alignment/installation tool and a plastic hammer to install the seal to the correct depth. To prevent damage to the seal carrier, hit the alignment/installation tool alternately at the 12, 3, 6 and 9 o'clock positions.
- (10) Install the oil fill tube and mounting bolts. Tighten the bolts to 43 N·m (32 ft. lbs.) torque.
- (11) Install the vibration damper. **DO NOT** tighten the bolts to the correct torque value at this time.
- (12) Install the belt tensioner. Tighten the mounting bolts to 43 N·m (32 ft. lbs.) torque.
- (13) Raise the belt tensioner to install the belt.
- (14) Tighten the vibration damper bolts to 125 N·m (92 ft. lbs.) torque. Use an engine barring tool to keep the engine from rotating during tightening operation.

GEAR HOUSING**REMOVAL**

- (1) Remove the engine assembly from the vehicle.

REMOVAL AND INSTALLATION (Continued)

(2) Remove the front end components and the gear housing cover (refer to Gear Housing Cover Removal for the proper procedures).

(3) Remove the following:

- Camshaft
- Gear driven accessories
- Fuel injection pump (refer to Group 14, Fuel System)
- Fan hub assembly (refer to Group 7, Cooling System)

(4) Remove the gear housing and gasket (Fig. 59).

(5) Clean the gasket material from the cylinder block.

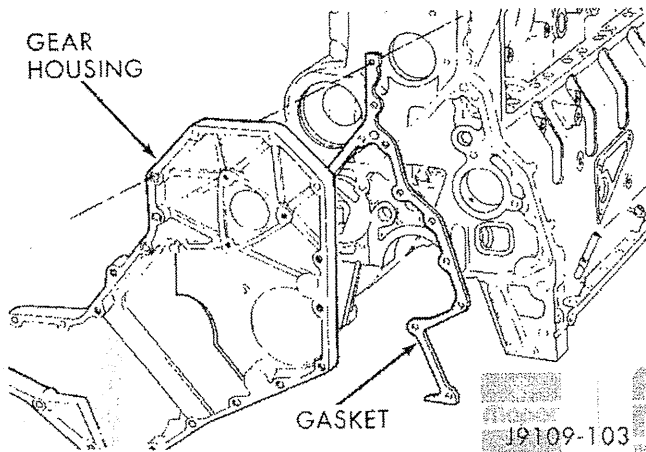


Fig. 59 Gear Housing/Gasket

INSTALLATION

(1) Install a new gasket and the gear housing. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(2) Install the camshaft. Make sure the alignment marks on the camshaft and crankshaft gears are aligned (Fig. 60).

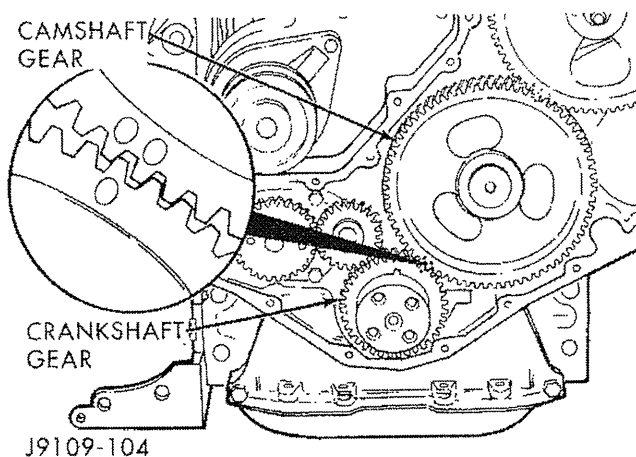


Fig. 60 Camshaft/Crankshaft Gear Alignment

(3) If a new housing is installed, the timing pin assembly must be accurately located.

(4) Install the following:

- Fan hub assembly (refer to Group 7, Cooling System)
- Fuel injection pump (refer to Group 14, Fuel System)
- Gear driven accessories

(5) Install the gear housing cover (refer to Gear Housing Cover Installation for the proper procedures).

(6) Install the front end components.

(7) Install the engine assembly into the vehicle.

TIMING PIN

The timing pin can be replaced without removing the assembly from the gear housing.

REMOVAL

(1) Remove the timing pin by prying the retaining ring out with a small screwdriver. Replace the retaining ring if it is damaged during removal.

INSTALLATION

(1) If timing pin assembly is removed from gear housing, it must be precisely reset to obtain exact TDC.

(2) Install a new O-Ring, lubricate the pin and position in the housing (Fig. 61). Install the new retaining ring to 1.5 mm (0.059 inch).

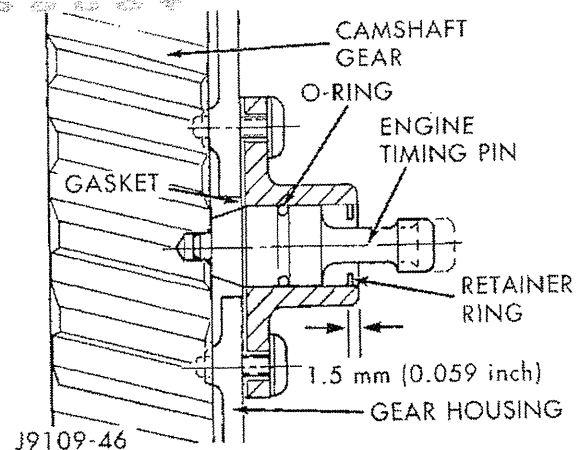


Fig. 61 Engine Timing Pin Location

TIMING PIN HOUSING ASSEMBLY**REMOVAL**

(1) Locate TDC for cylinder No.1.

(2) Remove the timing pin housing assembly and gasket.

(3) Clean any gasket material from the gear housing and from the timing pin housing assembly.

INSTALLATION—CYLINDER HEAD ON

The location of the timing pin assembly on the gear housing is critical for correct engine adjustment.

REMOVAL AND INSTALLATION (Continued)

Follow this procedure to install the assembly so that it corresponds to TDC for cylinder No.1.

(1) Look through the hole in the gear housing and rotate the engine until the hole in the cam gear can be seen.

(2) Remove the injector nozzles from all of the cylinders. This step is important to vent the cylinders so the crankshaft can be rotated smoothly to locate TDC for cylinder No.1.

(3) Temporarily install the vibration damper.

(4) Fabricate and install a wire pointer (Fig. 62). This can be done by forming a piece of wire that can be tightened under one of the gear housing capscrews. The wire should extend from the gear cover to a place on the crankshaft vibration damper that is easily seen.

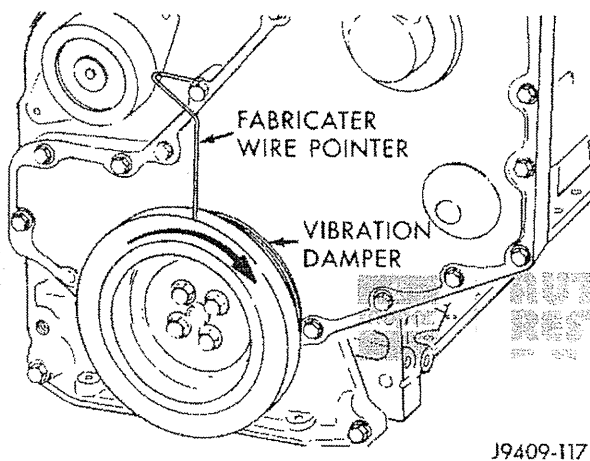


Fig. 62 Fabricated Wire Pointer

(5) Rotate the crankshaft one-quarter rotation in the direction of engine rotation.

(6) Tighten the adjusting screw for the No.1 intake valve to zero lash plus 5 turns.

CAUTION: Use extreme care when rotating the crankshaft. Use of too much force could damage the valve or push rod (Fig. 63).

(7) Rotate the crankshaft slowly in the opposite direction of normal engine rotation until the piston touches the intake valve (Fig. 63).

(8) Mark the vibration damper at the wire pointer (Fig. 63).

(9) Rotate the crankshaft in the direction of normal engine rotation until the piston touches the intake valve (Fig. 64). **Make sure that the piston touches the intake valve with approximately the same amount of force as in the previous step (Fig. 64).**

(10) Mark the vibration damper at the wire pointer (Fig. 64).

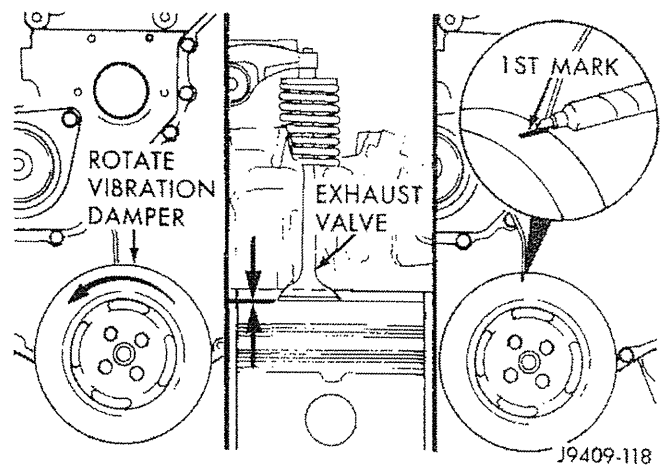


Fig. 63 Locate and Mark Vibration Damper—First Mark

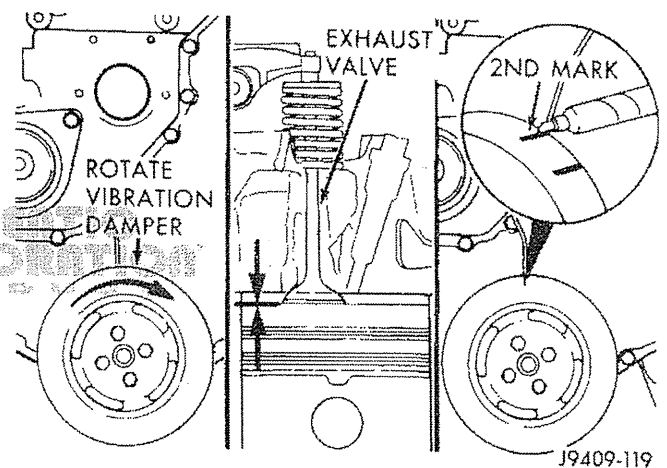


Fig. 64 Mark Vibration Damper—Second Mark

(11) Measure the distance and mark the vibration damper at one-half that distance between the two marks. This mark is the TDC mark (Fig. 65).

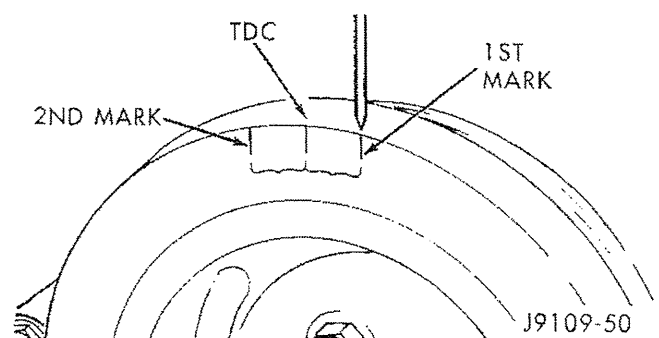


Fig. 65 Location of Top Dead Center (TDC)

(12) Completely loosen the intake valve adjusting screw. If not done, damage to the intake valve or push rod could occur when the crankshaft is rotated.

REMOVAL AND INSTALLATION (Continued)

(13) Rotate the crankshaft in the direction of normal engine rotation until the pointer is aligned with the TDC mark. Rotate crankshaft one additional turn.

(14) The timing pin hole in the cam gear should be visible or felt through the back side of the gear housing. If not, the crankshaft must be rotated one revolution in the direction of engine rotation.

(15) Apply a coat of Loctite[®] 59241 (Liquid Teflon), or equivalent to the threads of the Torx head bolts. Install the timing pin assembly and new O-ring.

(16) Hold the timing pin in the hole to align the housing and install the Torx head bolts. Tighten the Torx bolts to 5 N·m (44 in. lbs.) torque.

(17) Install the remaining rocker lever pedestal assemblies. Tighten the rocker lever pedestal mounting capscrews.

(18) Adjust the valves.

(19) Install the injectors and bleed the fuel system (refer to Group 14, Fuel System).

(20) Install the fuel pump (refer to Group 14, Fuel System).

(21) Install the gear cover.

(22) Remove the pointer. Install the crankshaft vibration damper.

INSTALLATION—CYLINDER HEAD REMOVED

The timing pin assembly is precisely located on the gear housing to correspond to TDC for Cylinder No.1. The timing pin assembly must be relocated if the gear housing is interchanged.

(1) Temporarily install the vibration damper and a fabricated wire pointer (Fig. 66). Put a flat washer between the pointer and gear housing to prevent damage to the gear housing.

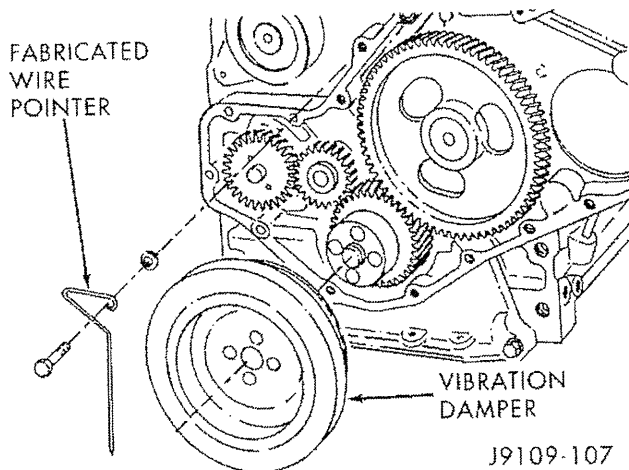


Fig. 66 Fabricated Wire Pointer

(2) Fabricate a steel plate (Fig. 67).

(3) Use two flywheel housing bolts to assemble the plate over No.1 cylinder (Fig. 68).

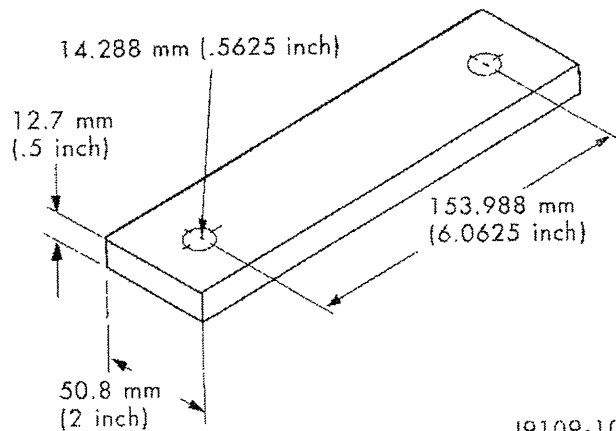


Fig. 67 Fabricated Steel Plate

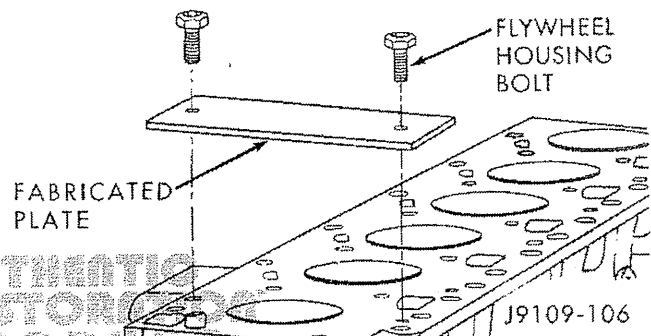


Fig. 68 Fabricated Plate Location on No.1 Cylinder

(4) Rotate the crankshaft in the direction of rotation until the piston contacts the plate.

(5) Mark the vibration damper (Fig. 65).

(6) Rotate the engine in the opposite direction until the piston contacts the plate.

(7) Mark the vibration damper (Fig. 65).

(8) Mark the vibration damper for TDC. TDC will be one-half the distance between the first two marks (Fig. 65).

(9) Remove the plate and rotate the engine in the direction of rotation until the pointer aligns with the TDC mark.

(10) Look for the timing pin hole in the camshaft gear. If it is not visible, rotate the crankshaft one complete rotation. Align the pointer with the TDC mark.

(11) Install the timing pin housing assembly with a new gasket.

(12) Apply a coat of Loctite 59241 liquid teflon, or equivalent to the threads of the torx head bolts.

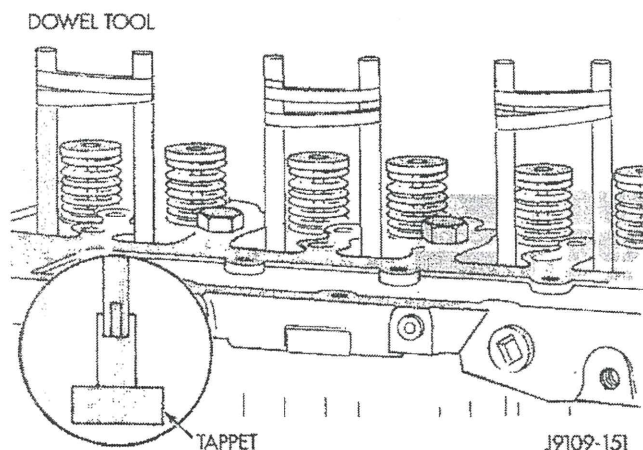
(13) Push the pin into the hole in the cam gear to align the timing pin housing.

(14) Hold the pin in while tightening the torx head bolts to 5 N·m (44 in. lbs.) torque. Be sure timing pin is disengaged before rotating the engine.

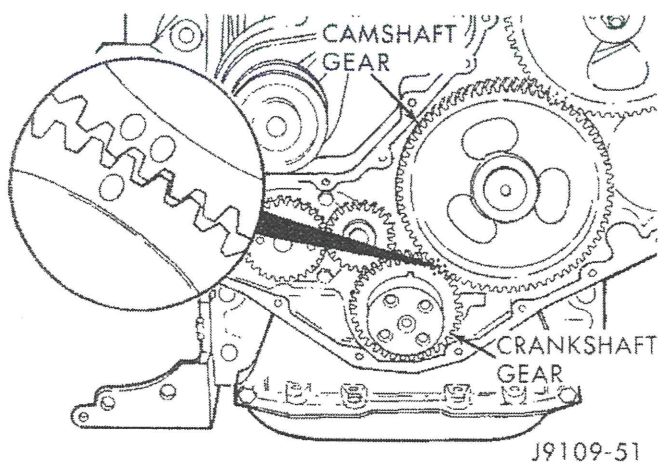
(15) Remove the vibration damper and wire pointer.

REMOVAL AND INSTALLATION (Continued)**CAMSHAFT****REMOVAL**

- (1) Remove the following parts:
 - Valve covers
 - Rocker lever assemblies
 - Push rods
 - Drive belt
 - Fan hub assembly
 - Vibration damper
 - Gear housing cover
 - Lift pump
- (2) Insert the dowels through the push tube holes and into the top of each tappet. When properly installed, the dowels can be used to pull the tappets up (Fig. 69).
- (3) Pull the tappets up and wrap a rubber band around the top of the dowel rods (Fig. 69). This will prevent the tappets from dropping down.

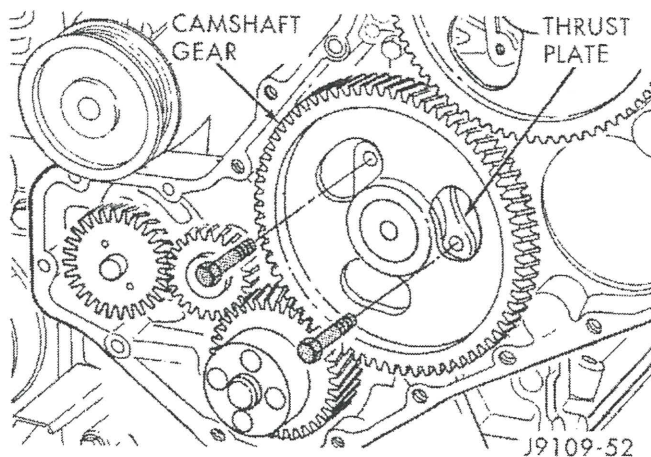
**Fig. 69 Holding Tappets in Place**

- (4) Rotate the crankshaft to align the crankshaft to camshaft timing marks. (Fig. 70)

**Fig. 70 Align Crankshaft to Camshaft**

- (5) Remove the bolts from the thrust plate (Fig. 71).

- (6) Remove the camshaft, gear and thrust plate.

**Fig. 71 Thrust Plate Bolt Location****BUSHING REPLACEMENT**

(1) Measure the diameter of each bore. (The limit for the bushing in the No.1 bore is the same as for the other bores without bushings). The limit of the inside diameter is 54.133 mm (2.1312 inch). If the camshaft bore for the first cam bushing is worn beyond the limit, install a new service bushing. Inspect the rest of the camshaft bores for damage or excessive wear.

(2) If the bores without a bushing are worn beyond the limit, the engine must be removed for machining and installation of service bushings. If badly worn, replace the cylinder block.

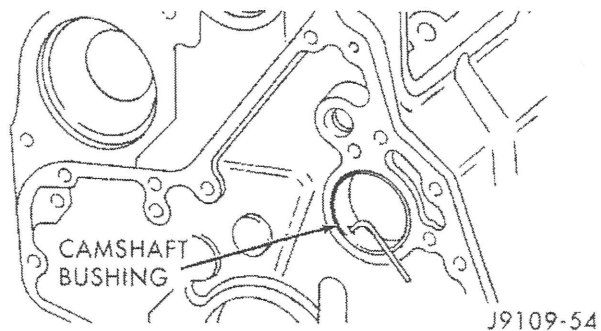
(3) Remove the bushing from the No.1 bore, using a universal cam bushing tool.

(4) Mark the cylinder block so you can align the oil hole in the cylinder block with the oil hole in the bushing.

Apply a coating of loctite® 609 to the backside of the new bushing. Avoid getting loctite® in the oil hole.

(5) Use a universal cam bushing installation tool and install the bushing so that it is even with the front face of the cylinder block. The oil hole must be aligned. A 3.2 mm (0.128 inch) diameter rod must be able to pass through the hole (Fig. 72).

(6) Measure the installed bushing. The limit of the inside diameter is 54.133 mm (2.1312 inch).

**Fig. 72 Oil Hole Alignment**

REMOVAL AND INSTALLATION (Continued)**GEAR REPLACEMENT**

- (1) Press the camshaft out of the gear.
- (2) Remove all burrs and smooth any rough surfaces caused by removing the gear.
- (3) Install the camshaft key.
- (4) Lubricate the camshaft surface with Lubriplate 105, or equivalent.

CAUTION: The camshaft gear will be permanently distorted if overheated. The oven temperature should never exceed 177°C (350°F).

- (5) Heat the gear in an oven at 177°C (350°F) for 45 minutes.

WARNING: WEAR PROTECTIVE GLOVES TO HANDLE THE HOT GEAR.

- (6) Install the gear with the timing marks visible. Be sure the gear is seated against the camshaft shoulder.

- (7) If the camshaft is not to be used immediately, lubricate the lobes and journals to prevent rust.

INSTALLATION

- (1) Apply a coat of Lubriplate 105 to the camshaft bores.
- (2) Lubricate the camshaft lobes, journals and thrust washer with Lubriplate 105, or equivalent.

CAUTION: When installing the camshaft, **DO NOT** push it in farther than it will go with the thrust washer in place. Pushing it too far can dislodge the plug in the rear of the camshaft bore and cause an oil leak.

- (3) Install the camshaft/thrust washer. Align the timing marks as illustrated (Fig. 70).
- (4) Install the thrust washer bolts and tighten to 24 N·m (18 ft. lbs.) torque.
- (5) Verify the camshaft has the correct amount of backlash and end clearance (Fig. 73).
- (6) Install the following parts:
 - Lift pump
 - Gear housing cover
 - Vibration damper
 - Fan hub assembly
 - Drive belt
 - Push rods
 - Rocker lever assemblies
 - Valve covers
- (7) Install the engine in the vehicle.
- (8) Operate the engine at idle for five to ten minutes and check for leaks and loose parts.

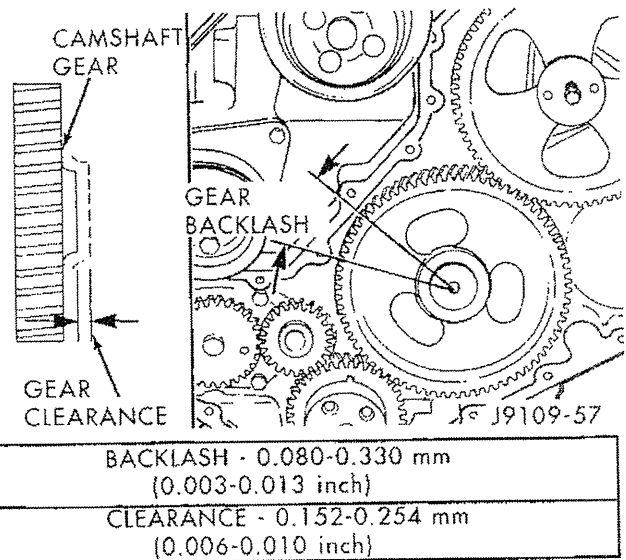


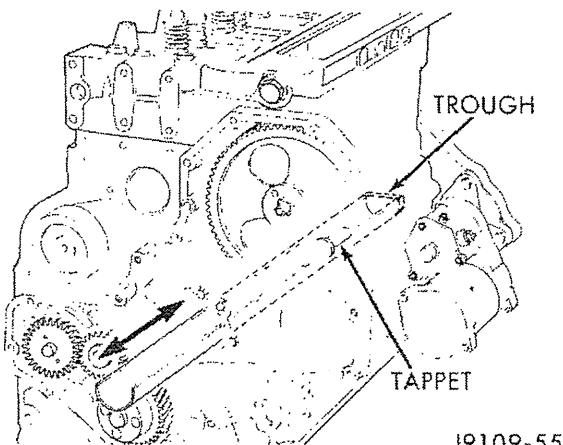
Fig. 73 Camshaft Backlash and End Clearance

TAPPET**REMOVAL**

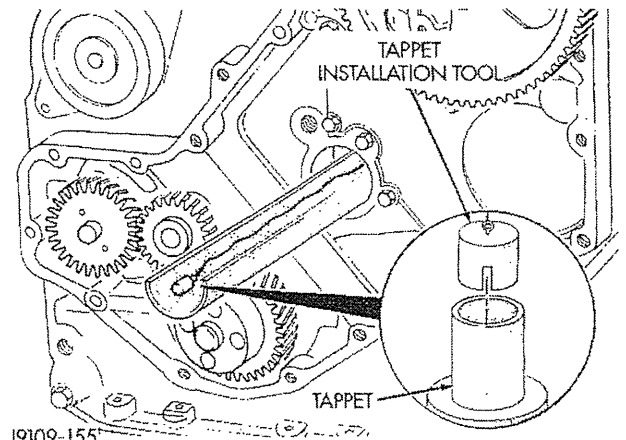
- (1) Remove the camshaft.
- (2) Insert a trough the full length of the cam bore (Fig. 74). Cummins Tappet Changing Tool 3822513 is available for this job.
- (3) Make sure the trough is positioned so it will catch the tappet when the wooden dowel is removed.
- (4) Identify the location of each tappet as it is removed. The tappets must be installed in their original locations.
- (5) Only remove one tappet at a time. Remove the rubber band from the two companion tappets, securing the tappet not to be removed with the rubber band.
- (6) Pull the wooden dowel from the tappet bore allowing the tappet to fall into the trough (Fig. 74).
- (7) Normally the tappet will fall over when it drops into the trough. Use a flashlight to determine this. If the tappet does not fall over, shake the trough gently to get it to do so.
- (8) Special care should be taken, when removing the No.6 cylinder tappets. **DO NOT** knock or shake the tappet over the end barrier of the trough.
- (9) Carefully pull the trough and tappet from the cam bore and remove the tappet. Repeat the process until all tappets are removed.

INSTALLATION

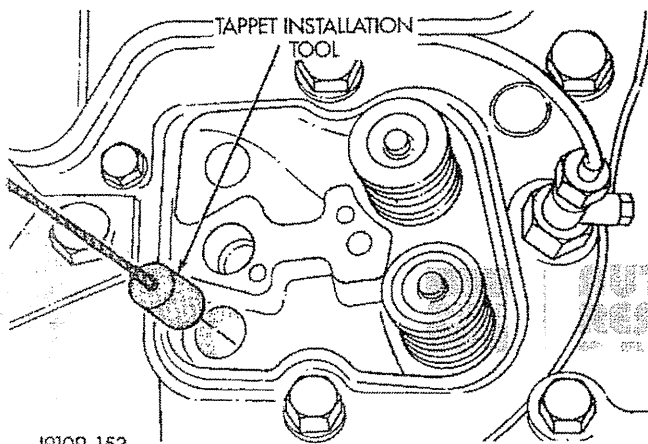
- (1) Insert the trough the full length of the cam bore.
- (2) Feed the installation tool down the tappet bore and into the trough (Fig. 75).
- (3) Feed the installation tool cord through the cam bores. Carefully pull the trough and installation tool

REMOVAL AND INSTALLATION (Continued)

J9109-55

Fig. 74 Tappet Removal using a Trough

J9109-155

Fig. 76 Insert Installation Tool into Tappet

J9109-153

Fig. 75 Tappet Installation Tool

out the front. The barrier at the rear of the trough will assure the tool will be pulled out with it.

(4) Lubricate the tappets with Lubriplate 105, or equivalent.

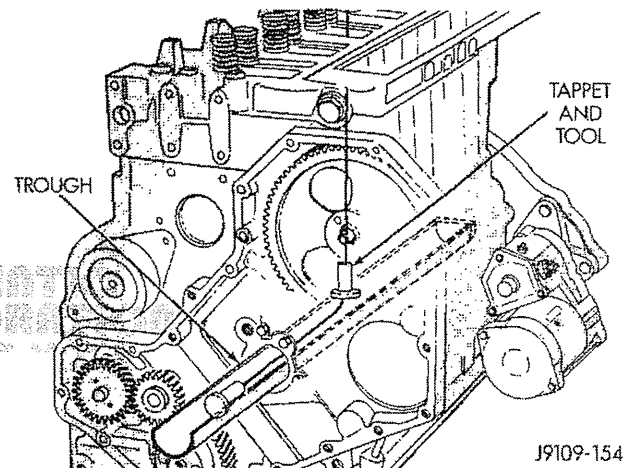
(5) Insert the installation tool into the tappet (Fig. 76). To aid in removing the installation tool after the tappets is installed, work the tool in and out of the tappet several times before installing the tappets.

(6) Place the tappet and tool in the trough and slide the trough back into the cam bore (Fig. 76).

(7) Pull the tool/tappet through the cam bore and up into the tappet bore (Fig. 77).

(8) Difficulty could be experienced in getting the tappet to make the bend from the trough up to the tappet bore (due to the webbing of the block). If this occurs, pull the trough out enough to allow the tappet to drop down and align itself. Now pull the tappet up into the bore carefully.

(9) After the tappet has been pulled up into position, slide the trough back into the cam bore and rotate it 1/2 turn. This will position the round side of the trough up, which will hold the tappet in place.



J9109-154

Fig. 77 Pull Tappet/Tool into Position

(10) Remove the installation tool from the tappet.

(11) Install a wooden dowel into the top of the tappet and secure it with a rubber band.

(12) Repeat this process until all tappets have been installed.

(13) Install the camshaft.

OIL PAN AND SUCTION TUBE**REMOVAL**

(1) Disconnect the negative cable from the battery.

(2) Remove transmission from vehicle, refer to Group 21 Transmission and Transfer Case.

(3) Remove flywheel ring gear assembly.

(4) Disconnect starter cables from starter motor.

(5) Remove transmission oil cooler bolts.

(6) Remove starter motor and spacer plate assembly.

WARNING: HOT OIL CAN CAUSE PERSONAL INJURY.

REMOVAL AND INSTALLATION (Continued)

(7) Drain the used engine oil. Dispose of the used oil properly.

(8) Remove oil pan bolts, lower pan slightly and remove oil suction tube.

(9) Remove oil pan.

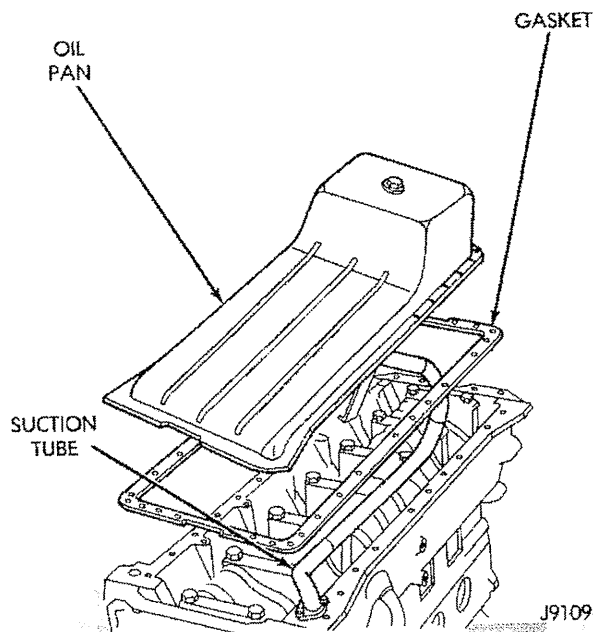


Fig. 78 Oil Pan, Suction Tube and Gasket

INSTALLATION

(1) Clean the sealing surface.

(2) Install the suction tube and gasket. Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(3) Fill the joint between the pan rail/gear housing and pan rail/rear cover with sealant. Use Three Bond 1207-C, or equivalent.

(4) Install the pan and gasket (Fig. 78). Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

(5) Install the drain plug with a new sealing washer and tighten to 80 N·m (60 ft. lbs.) torque.

(6) Fill the engine with clean lubrication oil. Run the engine and check for leaks.

(7) Stop the engine and let it set for five minutes. Check the oil level, and add oil if needed.

PISTON AND CONNECTING ROD ASSEMBLY

The turbocharged intercooler piston has a Ni-Resist insert with a keystone profile for the top compression ring. The new piston has a new design bowl and a 7 mm longer piston pin. These pistons can not be interchanged with earlier models.

REMOVAL

- (1) Remove the engine assembly from the vehicle.
- (2) Remove the cylinder head from the block.
- (3) Remove the oil pan and suction pump.

(4) If the cylinder bores have ridges, use a ridge reamer to cut the ridge from the top of the cylinder bore before removing the piston. Make sure the ridge reamer does not make a deep cut into the bore. DO NOT remove more metal than is necessary to remove the ridge.

(5) If cylinders have ridges, the cylinders are over-size and will need boring.

(6) Use a hammer and a steel stamp to mark the cylinder number onto each connecting rod cap. Mark the cylinder number onto the top of each piston.

(7) Remove the connecting rod bolts and rod caps. Use care so the cylinder bores and connecting rods are not damaged.

(8) Use a hammer handle or similar object to push the piston and connecting rod through the cylinder bore.

(9) Store the piston/rod assemblies in a rack.

(10) If a piston must be replaced, replace with the same part number (grading) that was removed.

INSTALLATION

(1) Lubricate the cylinder bore with clean engine oil.

(2) Generously lubricate the rings and piston skirts with clean engine oil.

(3) Compress the rings using a piston ring compressor tool (Fig. 79). If using a strap-type ring compressor, make sure the inside end of the strap does not hook on a ring gap and break the ring.

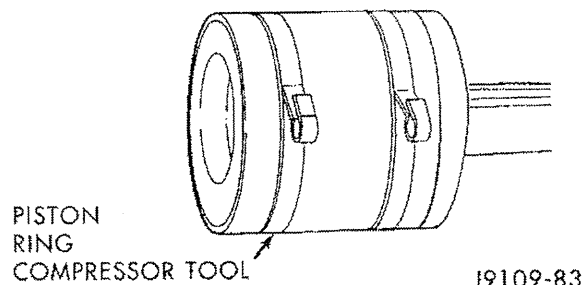


Fig. 79 Piston Ring Compressor Tool

(4) Bar the crankshaft so the rod journal for the piston to be installed is at BDC (Bottom Dead Center) - (Fig. 80).

(5) Be sure the FRONT marking on the piston and the numbers on the rod and cap are oriented as illustrated.

(6) Position the piston and rod assembly into the cylinder bore with the word FRONT on the piston towards the front of the cylinder block. Use care when you install the piston and connecting rod so the cylinder bore is not damaged.

(7) Push the piston into the bore until the top of the piston is approximately 50 mm (2 inch) below the

REMOVAL AND INSTALLATION (Continued)

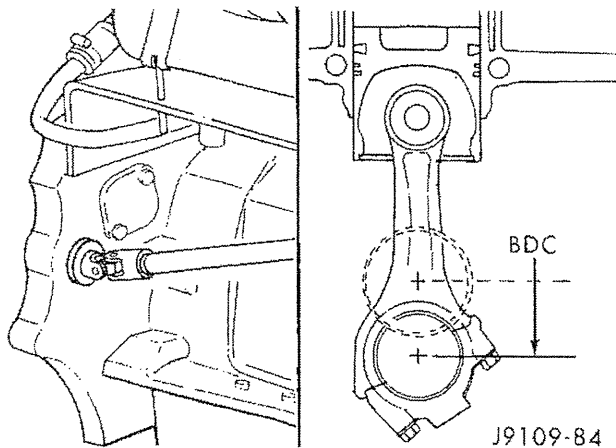


Fig. 80 Piston/Rod Assembly at BDC

top of the block. Carefully pull the connecting rod onto the crankshaft journal.

(8) Use clean engine oil to lubricate the threads and under the heads of the connecting rod bolts.

(9) The 4 digit number stamped on the rod cap at the parting line must match and be installed towards the oil cooler side of the engine (Fig. 81).

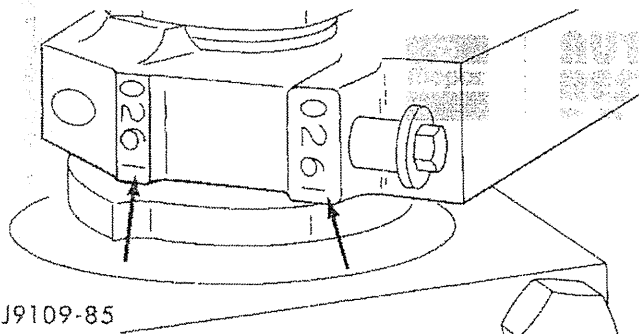


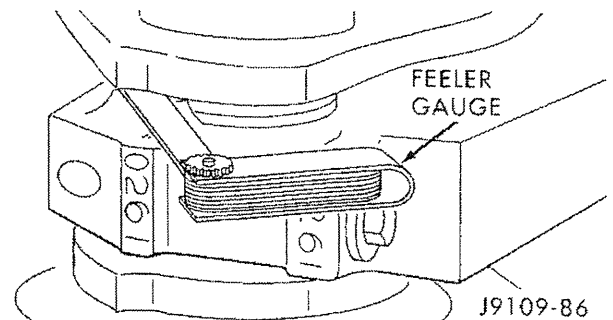
Fig. 81 Correct Rod Cap Installation

(10) Install the rod cap and bolts to the connecting rod. Tighten the connecting rod and bolt evenly in 3 steps.

- Tighten the bolts to 35 N·m (26 ft. lbs.) torque.
- Tighten the bolts to 70 N·m (51 ft. lbs.) torque.
- Tighten the bolts to 100 N·m (73 ft. lbs.) torque.

(11) The crankshaft must rotate freely. Check for freedom of rotation as the caps are installed. If the crankshaft does not rotate freely, check the installation of the rod bearing and the bearing size.

(12) Measure the side clearance between the connecting rod and the crankshaft (Fig. 82). DO NOT measure the clearance between the cap and crankshaft.



SIDE CLEARANCE LIMITS

MIN.	0.100 mm	(0.004 inch)
MAX.	0.300 mm	(0.012 inch)

Fig. 82 Side Clearance between Connecting Rod/Crankshaft

- (13) Install the suction tube and oil pan.
- (14) Install the cylinder head onto the block.
- (15) Install the engine assembly into the vehicle.

CRANKSHAFT

REMOVAL

- (1) Remove the rear crankshaft seal housing.
- (2) Remove the gear housing.
- (3) Rotate the engine to a horizontal position and remove the main bearing bolts.
- (4) The main bearing caps should be numbered. If they are not, be sure to mark them, beginning with number one at the front and ending with number seven at the rear (Fig. 83).

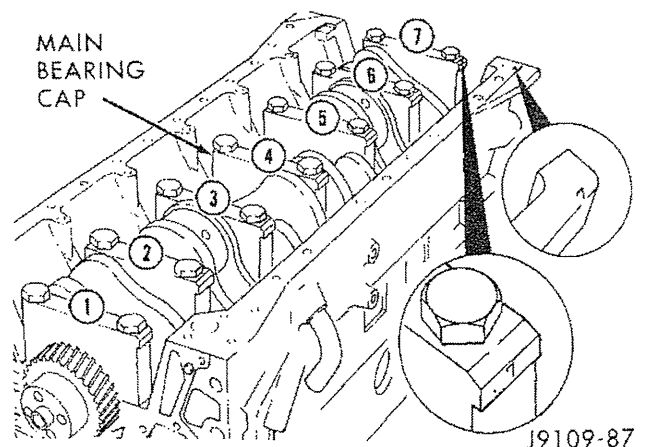


Fig. 83 Numbering Main Bearing Caps

CAUTION: DO NOT pry on the main caps to free them from the cylinder block.

REMOVAL AND INSTALLATION (Continued)

(5) Use two of the main bearing cap bolts to wiggle the main cap loose, being careful not to damage the bolt threads (Fig. 84). Remove the caps.

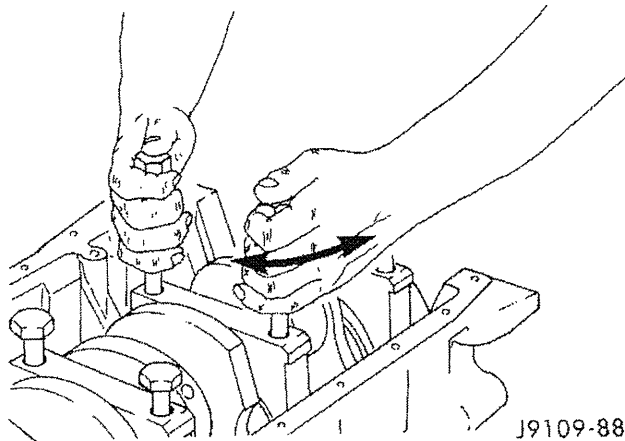


Fig. 84 Main Bearing Cap Removal

WARNING: USE A HOIST TO AVOID INJURY.

(6) Lift the crankshaft and gear from the cylinder block (Fig. 85).

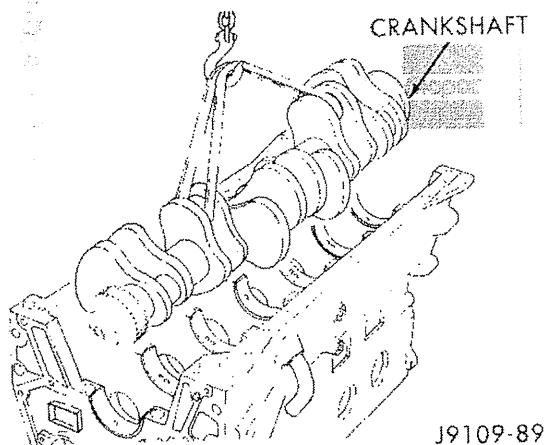


Fig. 85 Lifting Crankshaft out of Cylinder Block

(7) Remove the main bearings from the block and the main caps.

(8) Remove the piston cooling nozzles by using a 3/16 inch pin punch to push them out (Fig. 86).

INSTALLATION

CAUTION: Use only hand force to push the nozzle in place. If driven with a hammer, the nozzle will be damaged.

(1) Use a center punch to push the piston cooling nozzle into place. Install nozzles so they are even with or slightly below the saddle surface.

(2) Make sure the saddle surface is clean and dry. Install the upper main bearings.

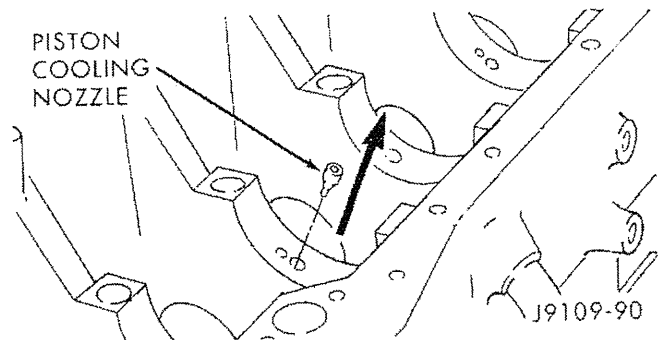


Fig. 86 Piston Cooling Nozzles

(3) Install the combination thrust/main bearing in the number six main bearing location.

(4) Lubricate the bearings with Lubriplate 105, or equivalent.

WARNING: TO AVOID INJURY, USE A HOIST TO INSTALL THE CRANKSHAFT.

(5) Install the crankshaft.

CAUTION: Crankshaft must be lowered onto the bearings straight to prevent damage to thrust bearings.

(6) Install the ring dowels in the main bearing caps (Fig. 87).

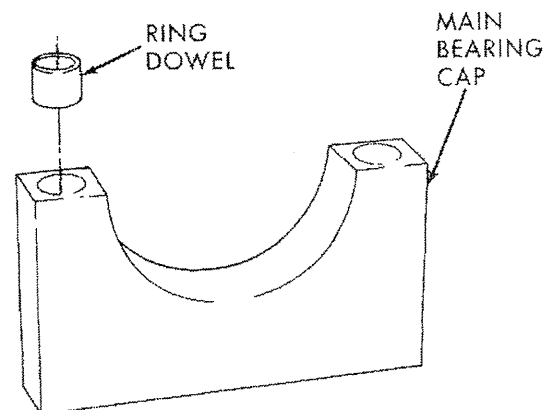


Fig. 87 Install Ring Dowels

(7) Install the lower main bearings in the caps.

(8) Lubricate the bearings with Lubriplate, or equivalent.

(9) Numbers on the main bearings caps face the oil cooler side of the engine with number one at the front of the engine.

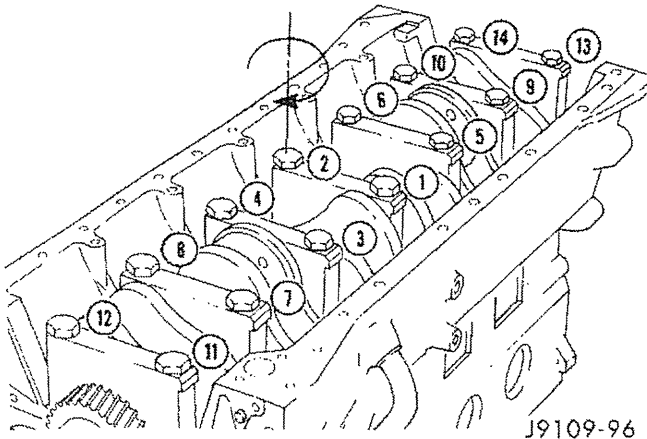
(10) Place the caps in their respective positions.

(11) Lubricate the main bearing bolt threads and underside of the bolt head with clean engine oil.

(12) Tighten the bolts evenly in the sequence shown using the following torque steps (Fig. 88).

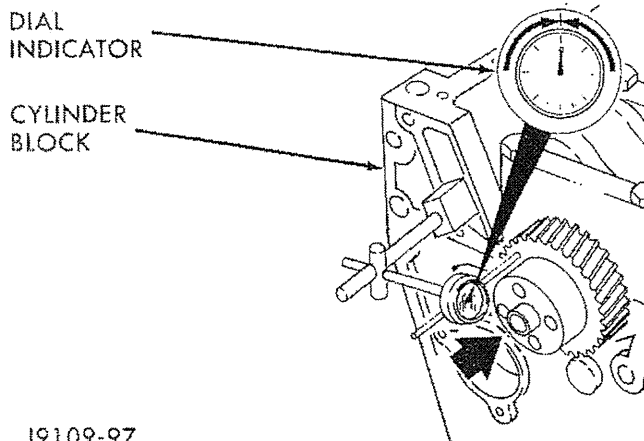
REMOVAL AND INSTALLATION (Continued)

- STEP 1—Tighten all bolts in sequence to 60 N·m (44 ft. lbs.) torque.
- STEP 2—Tighten all bolts in sequence to 119 N·m (88 ft. lbs.) torque.
- STEP 3—Tighten all bolts in sequence to 176 N·m (129 ft. lbs.) torque.

**Fig. 88 Main Bearing Bolt Tightening Sequence**

(13) Turn the crankshaft to determine that it will rotate freely all 360°. Check the main bearing cap installations and/or the bearing sizes if the shaft does not turn easily.

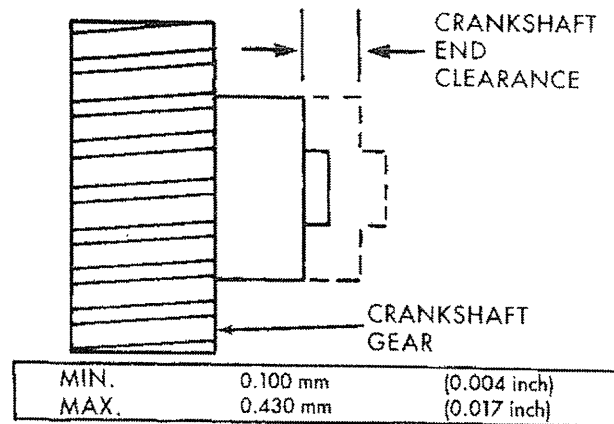
(14) Push the crankshaft towards one end of its thrust and place a dial indicator as shown (Fig. 89).

**Fig. 89 Position of Dial Indicator**

(15) Zero the indicator needle and push the crankshaft towards the other end of its thrust and record the crankshaft end clearance (Fig. 90).

CRANKSHAFT FRONT SEAL**REMOVAL**

- (1) Remove the drive belt.
- (2) Remove the vibration damper.



J9409-120

Fig. 90 Crankshaft End Clearance

(3) Drill two 1/8th inch holes into the seal face, 180° apart.

(4) Use a slide hammer tool with a #10 metal screw. Pull alternating from side-to-side until the seal is free.

INSTALLATION

(1) The sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

(2) If the gear cover was replaced, use the alignment tool from the seal kit to make sure the cover is aligned with the crankshaft.

(3) Apply a bead of Loctite 277 to the outside diameter of the seal.

(4) Install the pilot from the seal kit onto the crankshaft.

(5) Install the seal onto the pilot and start it into the gear housing cover seal bore.

(6) Remove the pilot.

(7) Use the alignment/installation tool and a plastic hammer to install the seal to the correct depth.

(8) Install the vibration damper, but DO NOT tighten the damper bolt until the belt is installed.

(9) Install the drive belt.

(10) Tighten the vibration damper bolts to 125 N·m (92 ft. lbs.) torque. Use the engine barring tool to keep the engine from rotating during torquing operation.

CRANKSHAFT REAR SEAL**REMOVAL**

(1) Remove the transmission (refer to Group 21, Transmission for the proper procedure).

(2) Remove the clutch cover.

(3) Remove the clutch plate.

(4) Remove the flywheel.

(5) Drill holes 180° apart into the seal. Be careful not to get the drill against the crankshaft.

REMOVAL AND INSTALLATION (Continued)

(6) Install #10 sheet metal screws in the drilled holes and remove the rear seal with a slide hammer (Fig. 91).

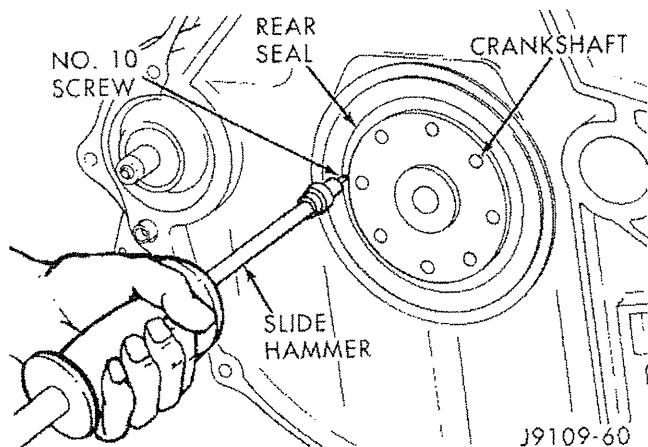


Fig. 91 Crankshaft Rear Seal Removal

INSTALLATION

CAUTION: The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

The crankshaft and seal must be dry when the seal is installed.

(1) Install the seal pilot, provided in the replacement kit, on the crankshaft. Push the seal on the pilot and crankshaft.

(2) Remove the seal pilot.

(3) Seal O.D. lubricant/sealant:

- Rubber O.D. rear crankshaft seals are lubricated with soapy water.

- Seals without rubber O.D. use Loctite 277 or equivalent sealant.

(4) Use the alignment tool to install the seal to the correct depth in the housing. Use a hammer to drive the seal into the housing until the alignment tool stops against the housing (Fig. 92).

(5) Hit the tool at the 12, 3, 6 and 9 o'clock positions to drive the seal evenly and prevent bending the seal housing.

CRANKSHAFT REAR SEAL HOUSING**REMOVAL**

(1) Remove the rear seal housing and gasket (Fig. 93).

(2) Support the seal area of the rear seal housing and press/drive out the seal using a hammer and a pin pinch.

(3) Clean the rear seal housing.

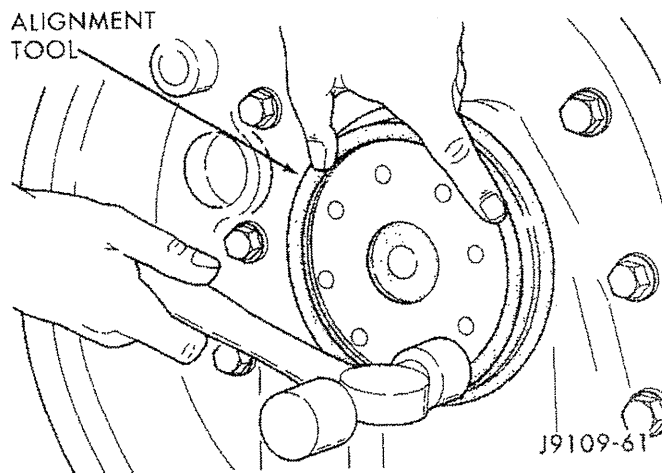


Fig. 92 Seal Installation using Alignment Tool

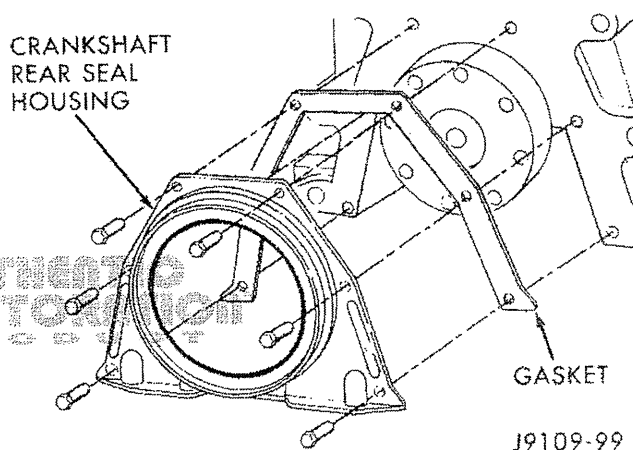


Fig. 93 Crankshaft Rear Seal Housing/Gasket

INSTALLATION

(1) Clean and dry the rear crankshaft sealing surface. The seal lip and the sealing surface on the crankshaft must be free from all oil residue to prevent seal leaks.

(2) Assemble the rear seal housing and gasket to the cylinder block with the bolts.

(3) Align the seal housing to the crankshaft with the alignment tool provided in the seal kit (Fig. 14). Make sure the seal housing is level with both sides of the block oil pan rail. Tighten the bolts to 9 N·m (7 ft. lbs.) torque.

(4) Remove the alignment tool and trim the gasket even with the oil pan mounting surface (Fig. 94).

(5) The rubber O.D. rear crankshaft seals are lubricated with soapy water. Seals without rubber O.D. use Loctite 277, or equivalent.

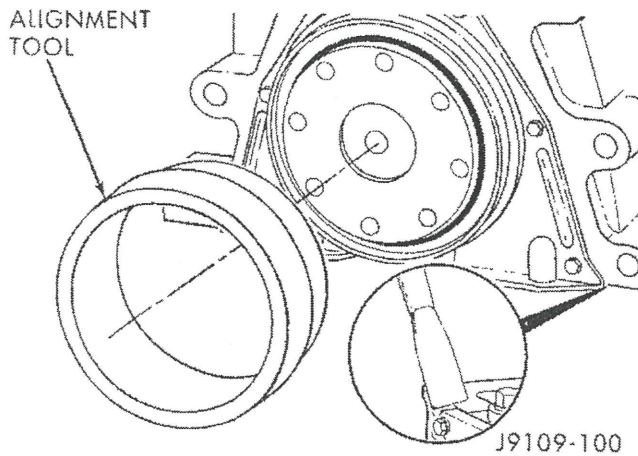
REMOVAL AND INSTALLATION (Continued)

Fig. 94 Crankshaft Rear Seal Housing Alignment Tool

(6) Install the seal pilot (provided with the replacement kit) onto the crankshaft. Push the seal onto the crankshaft (Fig. 95).

(7) Remove the seal pilot.

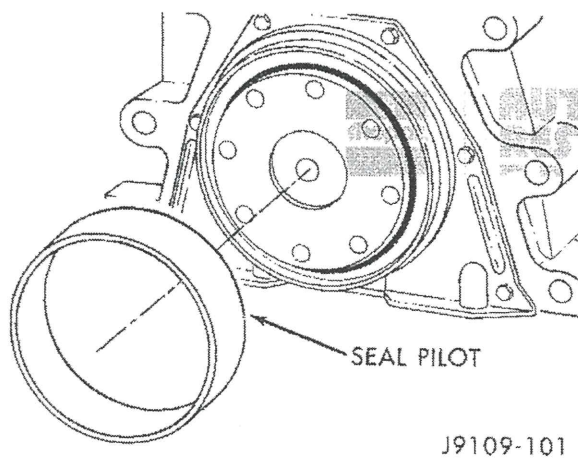


Fig. 95 Crankshaft Rear Seal Pilot

(8) Use alignment and installation tool packaged in the seal kit (Fig. 96). Alternately, drive the seal at the 12, 3, 6 and 9 o'clock positions to prevent bending the seal carrier during installation.

FLYWHEEL RING GEAR**REMOVAL**

- (1) Remove the transmission.
- (2) Remove the clutch cover.
- (3) Remove the clutch plate.
- (4) Remove the flywheel.
- (5) Use a drift pin to drive the ring gear from the flywheel (Fig. 19). Strike the gear at several points around the wheel until it is off.

(6) Heat the new ring for 20 minutes in an oven preheated to 127°C (250°F).

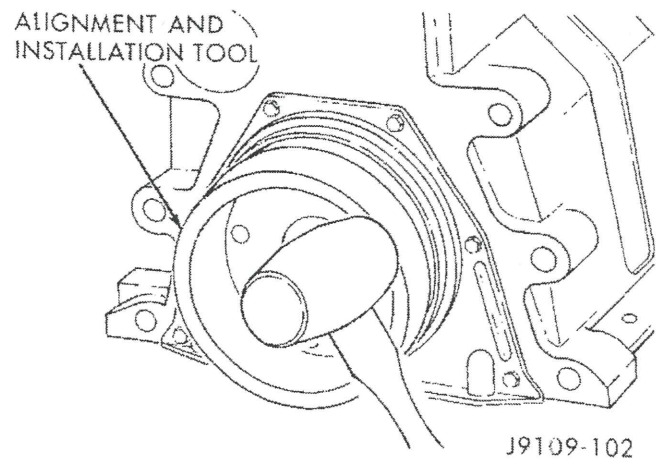


Fig. 96 Crankshaft Rear Seal Alignment/Installation Tool

(7) Install the gear. The gear must be installed so the bevel on the teeth is towards the crankshaft side of the flywheel (Fig. 97).

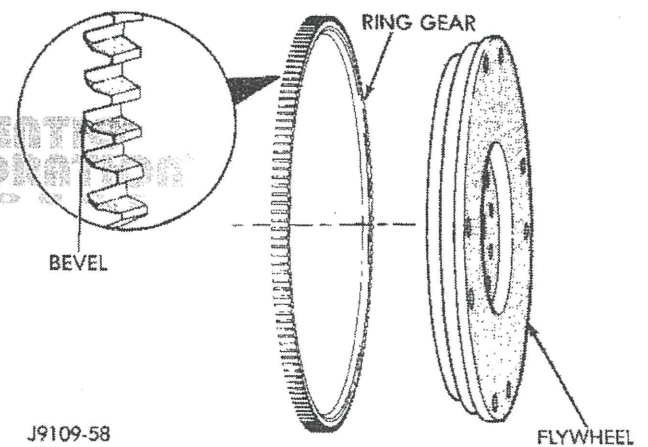


Fig. 97 Flywheel/Ring Gear Position

INSTALLATION

CAUTION: Never use the timing pin to hold the crankshaft in position.

- (1) Use the engine barring tool to hold the crankshaft when the flywheel bolts are being tightened.
- (2) Tighten the bolts in a criss-cross pattern to 137 N·m (101 ft. lbs.) torque.

CRANKSHAFT GEAR**REMOVAL**

Remove the crankshaft gear using a heavy duty puller.

INSTALLATION

Remove all burrs and make sure the gear surface on the end of the crankshaft is smooth.

REMOVAL AND INSTALLATION (Continued)

If removed, install a new alignment pin. Drive the pin in using a ball-peen hammer, leaving it protruding 1.60 mm (0.063 inch) to 2.39 mm (0.094 inch) above the crankshaft (Fig. 98).

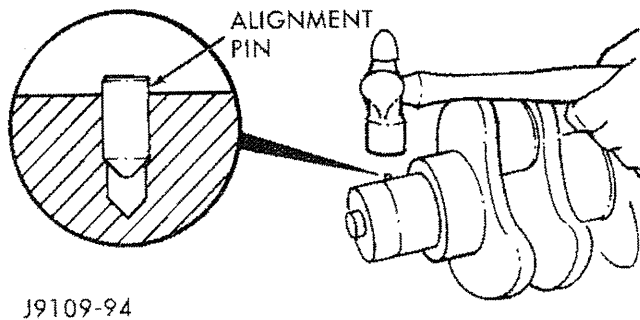


Fig. 98 Installing Alignment Pin

Heat the crankshaft gear for 45 minutes at a temperature of 121°C (250°F).

CAUTION: DO NOT heat the gear longer than 45 minutes.

WARNING: WEAR PROTECTIVE GLOVES TO PREVENT INJURY.

Position the gear with the timing mark out and install it on the crankshaft using the alignment pin. Make sure the gear contacts the shoulder.

OIL PUMP

The non-intercooled turbocharged engine oil pumps can not be used on intercooled engines.

REMOVAL

- (1) Remove the radiator (refer to Group 7, Cooling System for the proper procedure).
- (2) Loosen the crankshaft vibration damper and remove the drive belt.
- (3) Remove the fan clutch assembly.
- (4) Remove the fan hub.
- (5) Remove the oil fill tube.
- (6) Remove the crankshaft vibration damper.
- (7) Remove the gear housing cover.
- (8) Remove the four mounting bolts and pull the pump from the bore in the cylinder block (Fig. 99).

INSTALLATION

(1) Lubricate the pump with clean engine oil. Filling the pump with clean engine oil during installation will help to prime the pump at engine start up. Make sure the idler gear pin is installed in the locating bore in the cylinder block.

(2) Install the pump. Tighten the oil pump mounting bolts in two steps and in the sequence shown (Fig. 99).

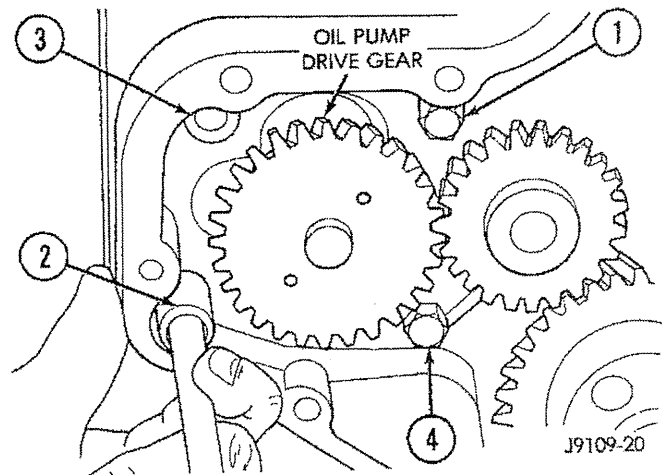


Fig. 99 Oil Pump Removal

- Step 1—Tighten to 5 N·m (44 in. lbs.) torque.
- Step 2—Tighten to 24 N·m (18 ft. lbs.) torque.

(3) The back plate on the pump seats against the bottom of the bore in the cylinder block. When the pump is correctly installed, the flange on the pump will not touch the cylinder block.

(4) Measure the idler gear to pump drive gear backlash and the idler gear to crankshaft gear backlash (Fig. 100). The backlash should be 0.080- 0.330 mm (0.003-0.013 inch). If the backlash is out of limits, replace the oil pump drive gear and the idler gear.

(5) If the adjoining gear moves when you measure the backlash, the reading will be incorrect.

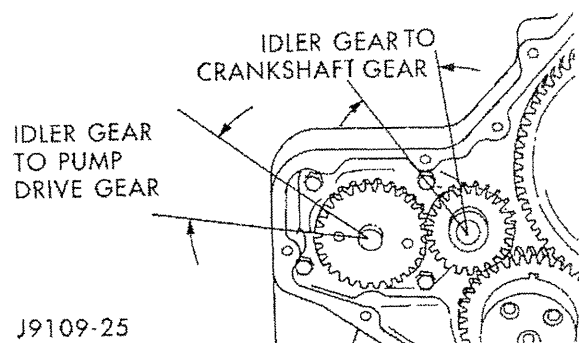


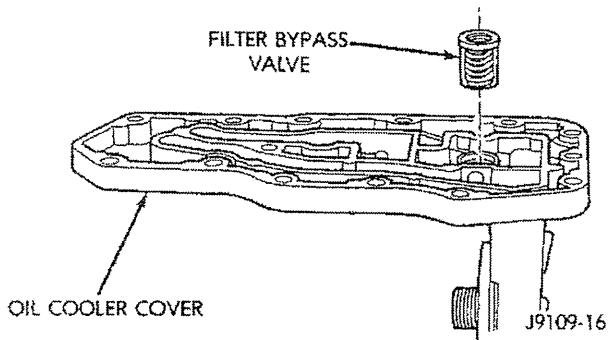
Fig. 100 Idler Gear to Pump Drive Gear and Crankshaft Gear Backlash

OIL FILTER BYPASS VALVE**REMOVAL**

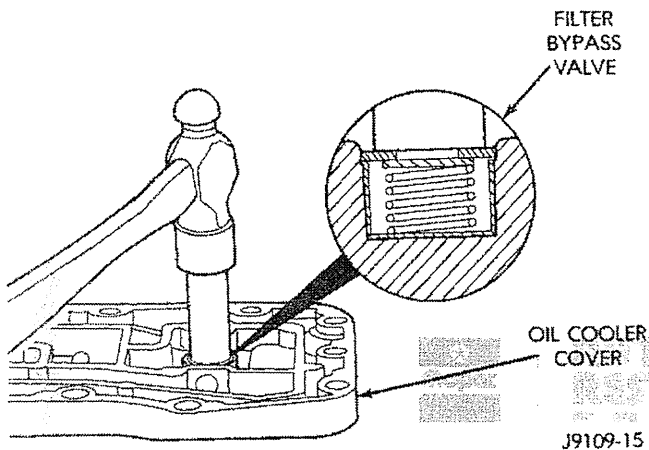
- (1) Remove the oil cooler cover (Fig. 101).
- (2) Remove the valve from the cooler cover (Fig. 101).

INSTALLATION

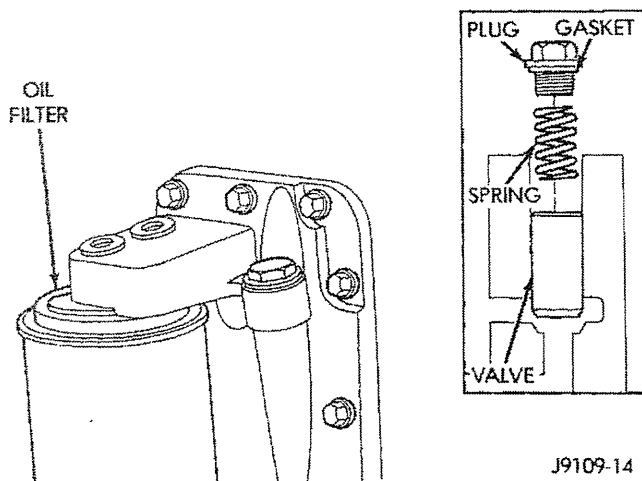
- (1) Drive the new valve in until it bottoms against the step in the bypass valve bore (Fig. 102).

REMOVAL AND INSTALLATION (Continued)**Fig. 101 Removing Filter Bypass Valve**

(2) Install the oil cooler cover.

**Fig. 102 Installing New Filter Bypass Valve****OIL PRESSURE REGULATOR VALVE AND SPRING****REMOVAL**

(1) Remove the threaded plug, gasket, spring and valve (Fig. 103).

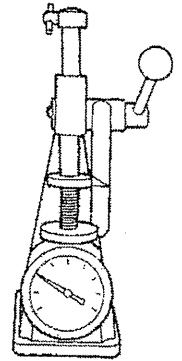
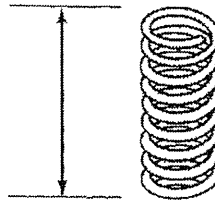
**Fig. 103 Oil Pressure Regulator**

(2) Check the spring for height and load limitations (Fig. 104). Replace the spring if out of limits.

VALVE OPEN

- HEIGHT: 41.25mm (1.62 inch)
- LOAD: 126 N (28.4 lb)

FREE LENGTH: 66mm (2.6 inch)

**Fig. 104 Oil Pressure Regulator Spring Check****INSTALLATION**

(1) Clean and inspect the plunger, bore and seat before assembly. The plunger must move freely in the valve bore.

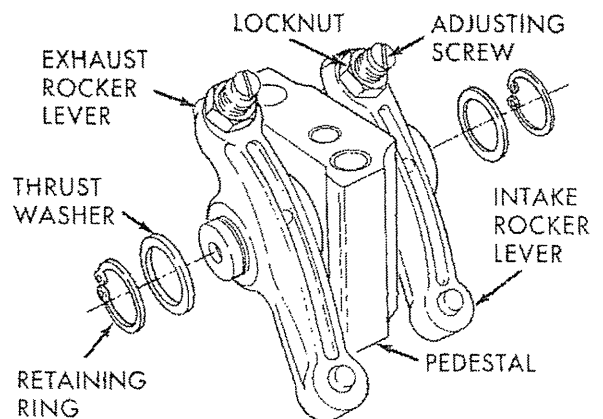
(2) Install the valve, spring, gasket and plug. Tighten the plug to 80 N·m (60 ft. lbs.) torque.

DISASSEMBLY AND ASSEMBLY**ROCKER LEVERS****DISASSEMBLE**

(1) Remove the retaining rings and thrust washers (Fig. 105).

(2) Remove the rocker levers (Fig. 105). DO NOT disassemble the rocker lever shaft and pedestal. The pedestal and shaft must be replaced as an assembly.

(3) Remove the locknut and adjusting screw (Fig. 105).

**Fig. 105 Rocker Lever Components**

DISASSEMBLY AND ASSEMBLY (Continued)

(4) Clean all parts in a strong solution of laundry detergent in hot water.

(5) Use compressed air to dry the parts after rinsing in clean hot water. The pedestals are made from powdered metal and may continue to show wetness after they have been cleaned and dried.

(6) Inspect for excessive wear in the bore and the contact surface for the valve stem.

(7) Measure the rocker lever bore diameter. The maximum diameter is 19.05 mm (0.75 inch). Replace if out of limits.

(8) Inspect the pedestal and shaft.

(9) Measure the shaft diameter. The minimum diameter is 18.94 mm (0.746 inch). Replace if out of limits.

ASSEMBLE

(1) Install the adjusting screw and locknut.

(2) Lubricate the shaft with clean engine oil. Be sure to assemble the intake and exhaust rocker levers in the correct location.

(3) Position the levers on the rocker shaft. Install the thrust washers.

(4) Clean the push rods in the hot soapy water.

(5) Inspect the push rod ball and socket for signs of scoring or cracks where the ball and the socket are pressed into the tube.

(6) Check the push rods for roundness and straightness.

(7) Install the push rods into the sockets of the valve tappets. Lubricate the push rod sockets with clean engine oil.

(8) Make sure the rocker lever adjusting screws are completely backed out.

PISTON AND CONNECTING ROD ASSEMBLY**DISASSEMBLE**

(1) Remove the retainer rings from the piston (Fig. 106).

(2) Remove the piston pin. Heating the piston is not required.

(3) Remove the piston rings (Fig. 106).

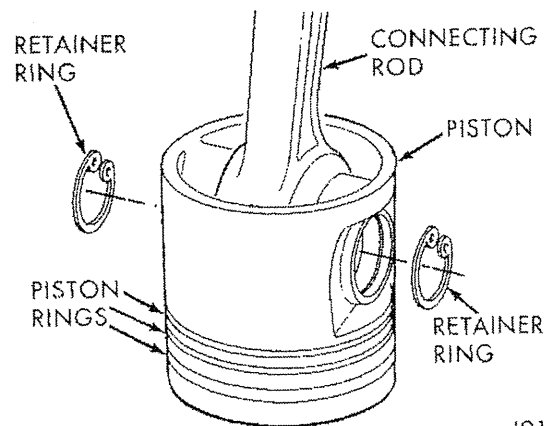
ASSEMBLE

(1) Be sure the FRONT marking on the piston and the numbers on the rod and cap are oriented (Fig. 107). Install the retaining ring into the pin groove on the FRONT side of the piston.

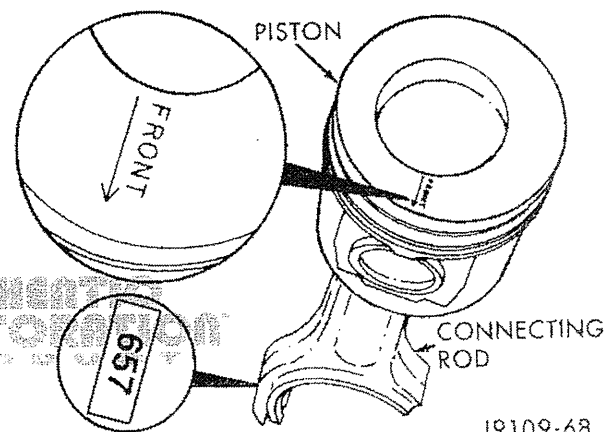
(2) Lubricate the pin and bore with engine oil.

(3) Install the piston pin in the opposite side of the installed retaining pin. Pistons do not require heating to install the pin, however, the piston does need to be at room temperature or above.

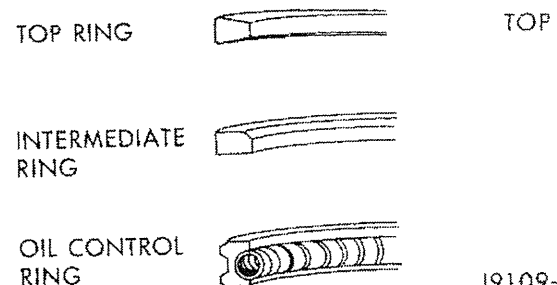
(4) Determine the piston diameter and obtain the appropriate ring set. The piston rings can be identified as shown in (Fig. 108).



J9109-62

Fig. 106 Retainer Rings

J9109-68

Fig. 107 Proper Markings on the Piston and Connecting Rod

J9109-69

Fig. 108 Piston Ring Identification

(5) Position each ring in the cylinder and use a piston to square it with the bore at a depth of 89.0 mm (3.5 inch) - (Fig. 109).

(6) Use a feeler gauge to measure the piston ring gap (Fig. 110).

(7) The top surface of all of the rings are identified with the word TOP or the supplier's MARK. Assemble the rings with the word TOP or the supplier's MARK up.

DISASSEMBLY AND ASSEMBLY (Continued)

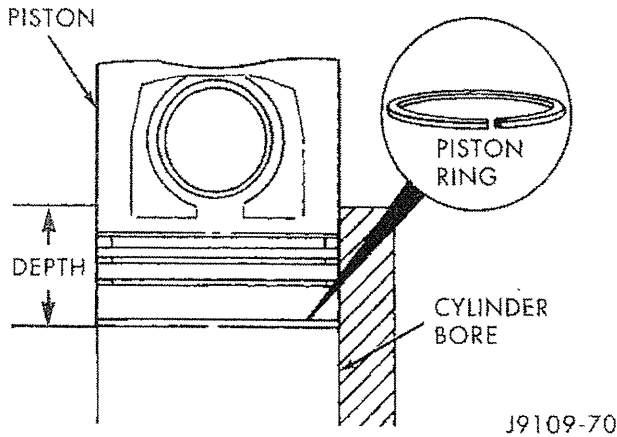


Fig. 109 Position of Ring in Cylinder Bore

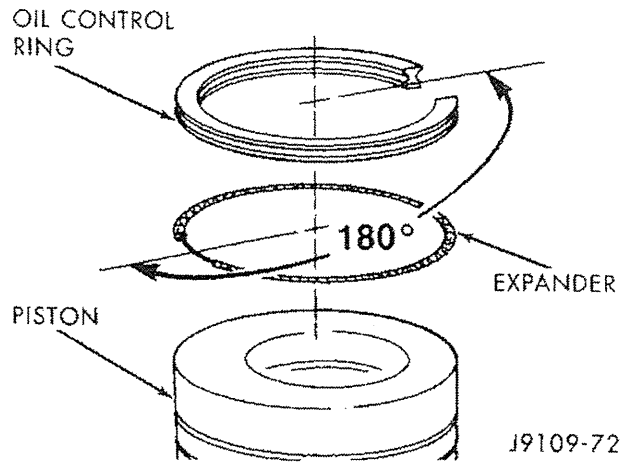
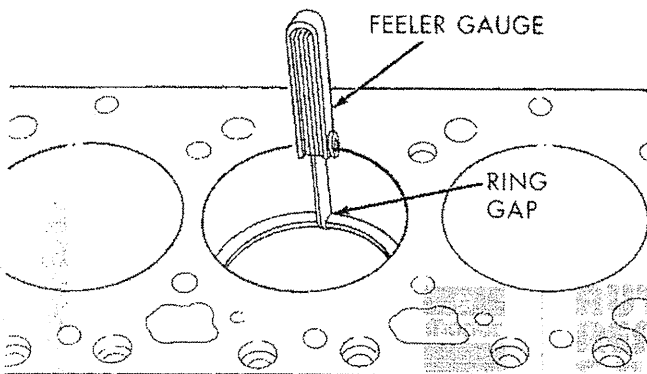


Fig. 111 Oil Control Ring/Expander Location in Groove



	MINIMUM	MAXIMUM
TOP	0.400 mm (0.0160 inch)	0.700 mm (0.0275 inch)
INTERMEDIATE	0.250 mm (0.0100 inch)	0.550 mm (0.0215 inch)
OIL CONTROL	0.250 mm (0.0100 inch)	0.550 mm (0.0215 inch)

J9109-71

Fig. 110 Piston Ring Gap

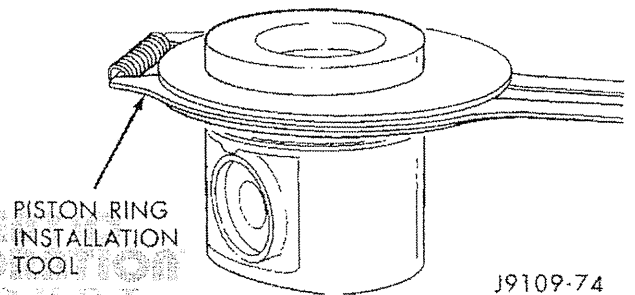
(8) Position the oil ring expander in the oil control ring groove (bottom groove).

(9) Install the oil control ring with the end gap OPPOSITE the ends on the expander (Fig. 111).

(10) Install the intermediate piston ring in the second groove (Fig. 109).

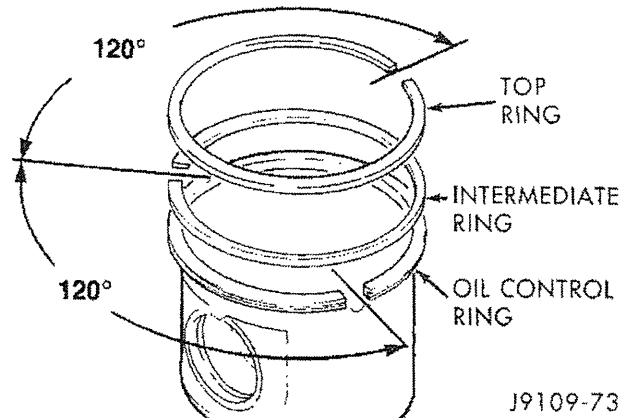
(11) Install the top piston ring in the top groove (Fig. 112).

(12) Position the rings as shown in (Fig. 113).



J9109-74

Fig. 112 Piston Ring Installation Tool



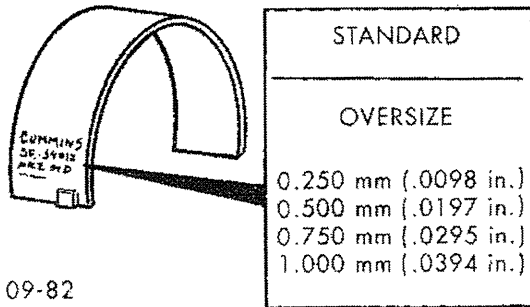
J9109-73

Fig. 113 Piston Ring Positioning

(13) Install the original bearings as removed or install new bearings. If new bearings are used, be sure to obtain the proper bearing clearance (Fig. 114).

DISASSEMBLY AND ASSEMBLY (Continued)

(14) DO NOT lubricate the side of the bearing that is against the connecting rod or cap. Apply a coat of Lubriplate 105, or equivalent to the new upper and lower connecting rod bearings.



J9109-82

Fig. 114 Connecting Rod Bearing Size Location

CLEANING AND INSPECTION

OIL COOLER ELEMENT AND GASKET

CLEANING AND INSPECTION

Clean the sealing surfaces. Apply 483 kPa (70 psi) air pressure to the element to check for leaks. If the element leaks, replace the element.

CYLINDER HEAD

INSPECTION

Remove the cup plugs and inspect the coolant passages. A large build up of rust and lime will require removal of the cylinder block for cleaning in a hot tank.

Inspect the cylinder bores for damage or excessive wear. Rotate the crankshaft so the piston is at Bottom Dead Center (BDC) to inspect the bores.

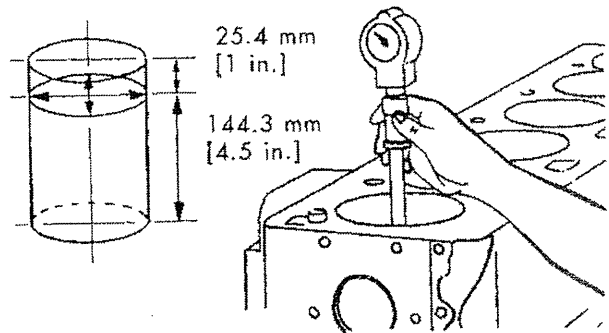
Measure the cylinder bores (Fig. 115). DO NOT proceed with in-chassis repair if the bores are damaged or worn beyond the limits (refer to Cylinder Bore Repair - Cylinder Block).

Check the top surface for damage caused by the cylinder head gasket leaking between cylinders.

Inspect the block and head surface for nicks, erosion, etc.

Check the head distortion (Fig. 116). The distortion of the combustion deck face is not to exceed 0.010 mm (0.0004 inch) in any 50.8 mm (2.00 inch) diameter. Overall variation end to end or side to side 0.30 mm (0.012 inch).

DO NOT proceed with the in-chassis overhaul if the cylinder head or block surface is damaged or not flat (within specifications).



MIN.	102.0 mm	(4.0157 inch)
MAX.	102.116 mm	(4.0203 inch)
Out-of-Round	0.038 mm	(0.0015 inch)
Taper	0.76 mm	(0.003 inch)
Oversize pistons and rings are available for bored cylinder blocks.		

J9109-75

Fig. 115 Cylinder Bore Diameter

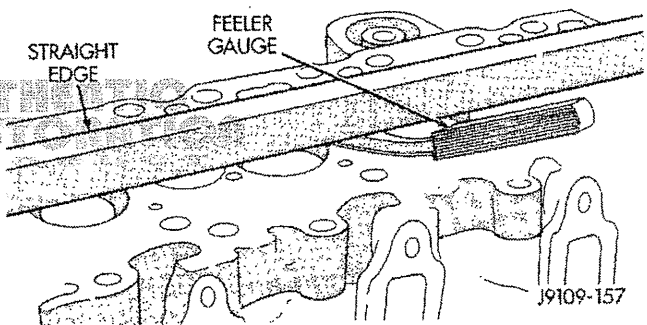
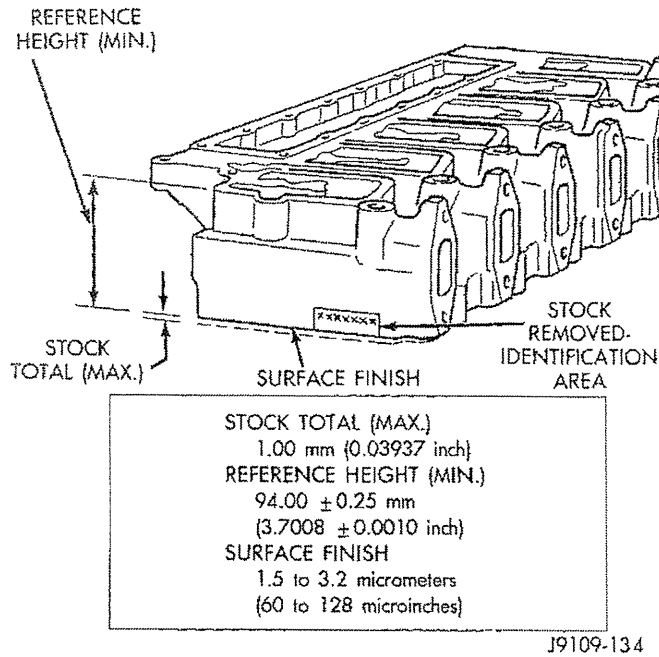


Fig. 116 Cylinder Head Combustion Deck Face Measurement

REFACING HEAD SURFACE

The cylinder head combustion deck may be refaced in whatever increments necessary to clean up the surface and maintain the surface finish and flatness tolerances. The combined total of stock removed must not exceed 1.00 mm (0.03937 inch). The amount of stock removed each time must be steel stamped above combustion deck edge, on the lower right hand corner of the rear face (Fig. 117). Check valve protrusion after head surface refacing.

Surface finish requirements are 1.5-3.2 micrometers (60-126 microinch).

CLEANING AND INSPECTION (Continued)**Fig. 117 Cylinder Head Stock Removal****CLEANING**

Clean the carbon from the injector nozzle seat with a nylon or brass brush.

Scrape the gasket residue from all gasket surfaces.

Wash the cylinder head in hot soapy water solution (88°C or 140°F).

After rinsing, use compressed air to dry the cylinder head.

Polish the gasket surface with 400 grid paper. Use an orbital sander or sanding block to maintain a flat surface.

VALVES AND VALVE SPRINGS**VALVES****CLEANING AND INSPECTION**

Before cleaning, note the valve number. Clean the valve heads with a soft wire wheel. Mark the valve with the number noted above.

Polish the valve stems with crocus cloth.

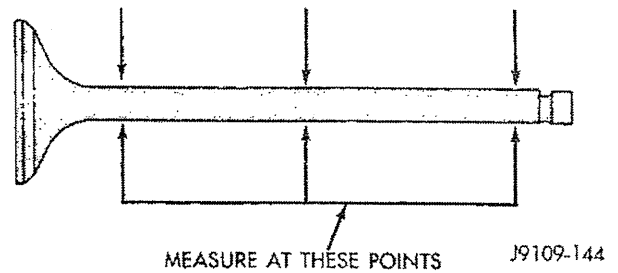
Inspect for abnormal wear on the valve heads and stems. Replace badly worn valves.

Check for bent valves. Replace bent valves.

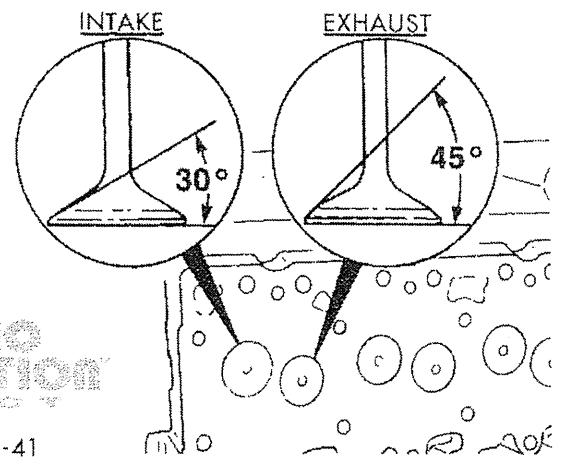
Measure the valve stem diameter (Fig. 118). The valve stem diameter should be 7.935-7.960 mm (0.3126-0.3134 inch). If out of limits, replace the valve. Mark the new valves with the replacement location.

Inspect the end of the valve stem for flatness.

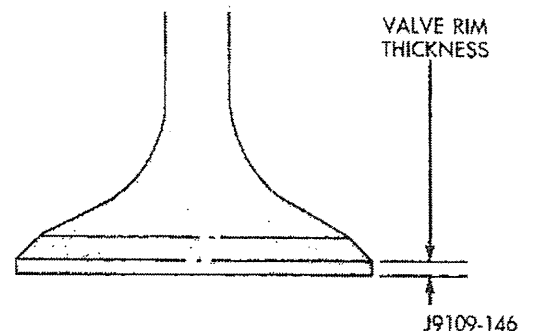
If required, resurface the valve end.

**Fig. 118 Measure Valve Stem Diameter****VALVE GRINDING**

The valve seat angle should be 30° (Intake Valve) and 45° (Exhaust Valve) - (Fig. 119).

**Fig. 119 Valve Seat Angle**

Measure the rim thickness (Fig. 120). The minimum valve rim thickness is 0.79 mm (0.031 inch).

**Fig. 120 Valve Rim Thickness**

Grind the face of valves to be reused.

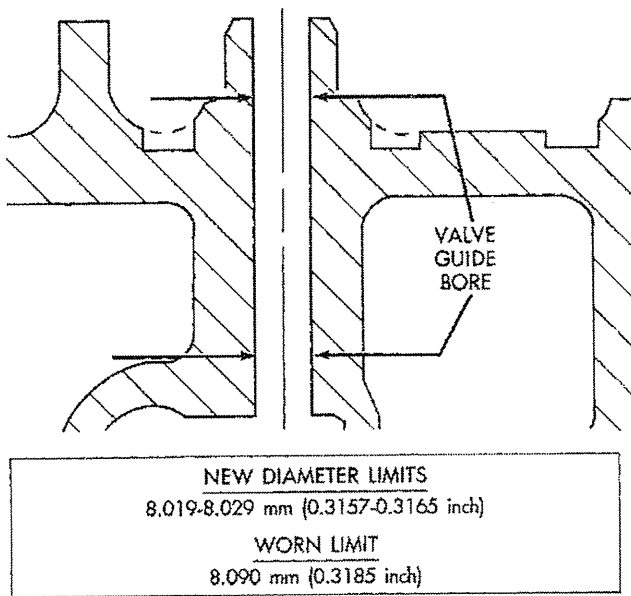
Check the valve stem tip for flatness. If required, re-surface the tip.

VALVE GUIDES**INSPECTION**

Inspect the valve guides for scuffing or scoring.

CLEANING AND INSPECTION (Continued)

Measure the valve guide bore (Fig. 121). The bore diameter should be 8.019-8.089 mm (0.3157-0.3185 inch).



J9109-135

Fig. 121 Valve Guide Bore

If the valve guide bores are larger than the worn limit, the cylinder head must be machined for service valve guides. New valve guides must be reamed to size after they are installed.

If the cylinder head needs service valve guides and valve seat inserts, the valve guides should be installed first.

VALVE SPRINGS**INSPECTION**

Measure the valve spring length. The approximate free length is 60 mm (2.36 inch) with the maximum inclination of 1.0 mm (0.039 inch).

Measure the valve spring force. 359 N (81 lbs.) is the minimum acceptable load required to compress the spring to a height of 49.25 mm (1.94 inch).

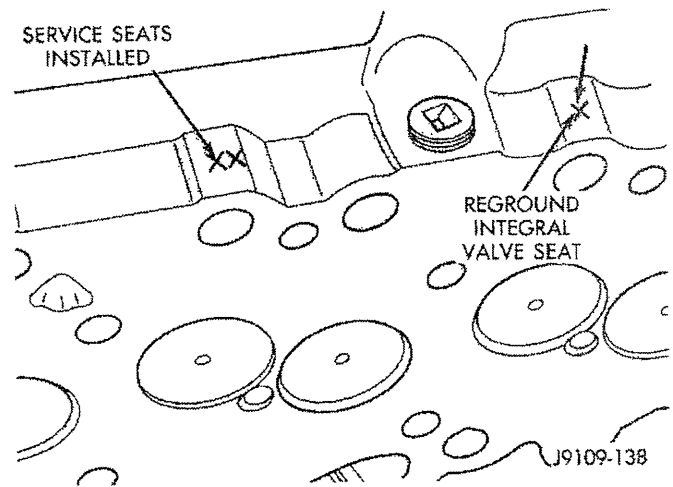
If the valve spring does not meet the limits above, replace the spring.

VALVE SEATS**INSPECTION**

Cylinder head with integral valve seats can be ground only once. Previously ground integral seats must be replaced with service seats.

One X stamped into the head casting identify seats that have been ground previously (Fig. 122).

Two X's stamped on the head indicate service seats have been installed (Fig. 122). Service seats can be ground.

**Fig. 122 Reworked Cylinder Head Seats—Stamped Identification**

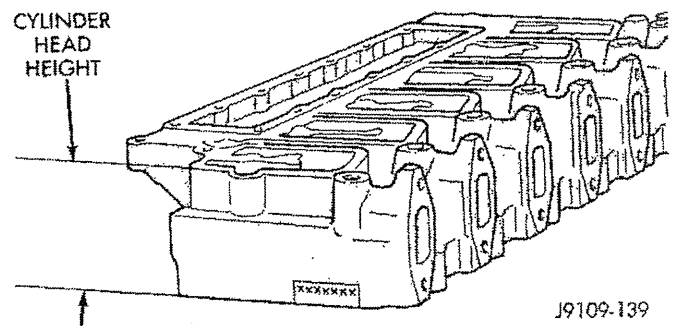
On the integral seat head, if 0.254 mm (0.010 inch) or more has been removed from the head combustion surface, service seats must be installed.

To determine if the head has been previously resurfaced, before calculating valve depth, process as follows:

(1) Check the rear lower right corner of the head for a stamping that would indicate previous resurfacing (.003).

(2) To verify the information, or if no amount is indicated, measure the head height (Fig. 123).

(3) If the head height is 94.75 mm (3.730 inch) or greater, the valve seats may be ground, if they have not been ground previously.

**Fig. 123 Cylinder Head Height****TAPPET****INSPECTION**

Inspect the tappet socket, stem and face for excessive wear, cracks and other damage (Fig. 124).

CLEANING AND INSPECTION (Continued)

The minimum tappet stem diameter is 15.925 mm (0.627 inch) - (Fig. 124). If the tappet is out of limits, replace the tappet.

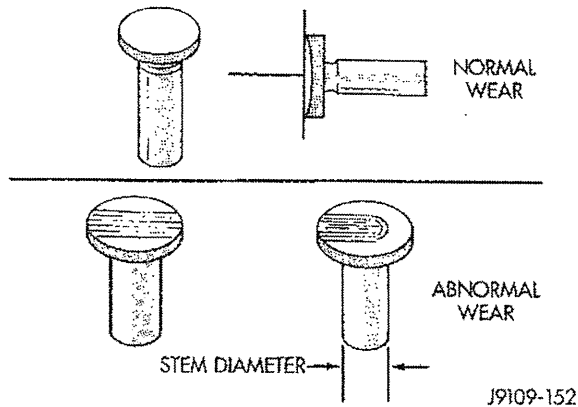


Fig. 124 Tappet Inspection

CAMSHAFT

INSPECTION

Inspect the lift pump lobe, valve lobes and bearing journals for wear, cracking, pitting and other damage.

Clean the camshaft and gear with solvent and a lint free cloth.

Inspect the gear teeth for wear and damage. Look for cracks at the root of the teeth.

Measure the bearing journals, lift pump lobe and valve lobes (Fig. 125).

OIL PUMP

CLEAN AND INSPECT

Visually inspect the lube pump gears for chips, cracks or excessive wear.

Remove the back plate (Fig. 126).

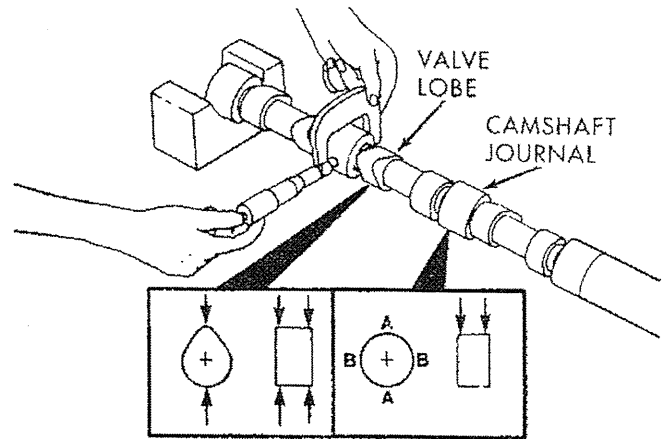
Mark TOP on the gerotor planetary using a felt tip pen (Fig. 126).

Remove the gerotor planetary (Fig. 126).

Inspect for excessive wear or damage.

Clean all parts in solvent and dry with compressed air.

Inspect the pump housing and gerotor drive for damaged and excessive wear.



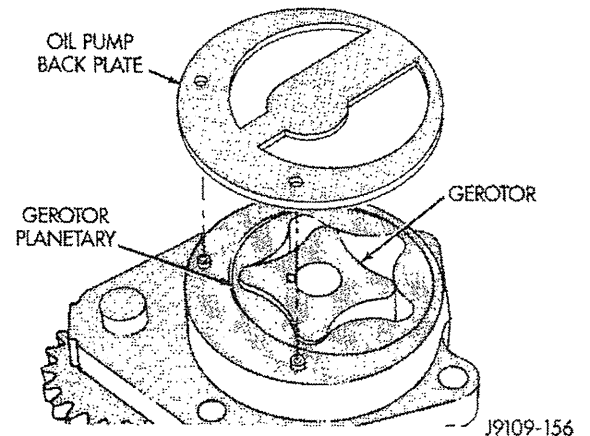
CAMSHAFT JOURNAL DIAMETER (MIN.)
53.962 mm (2.1245 inch)

VALVE LOBE HEIGHT (MIN.)
INTAKE - 47.040 mm (1.852 inch)
EXHAUST - 46.770 mm (1.841 inch)

LIFT PUMP LOBE DIAMETER (MIN.)
35.500 mm (1.398 inch)

J9109-53

Fig. 125 Bearing Journal/Valve Lobe Measurements



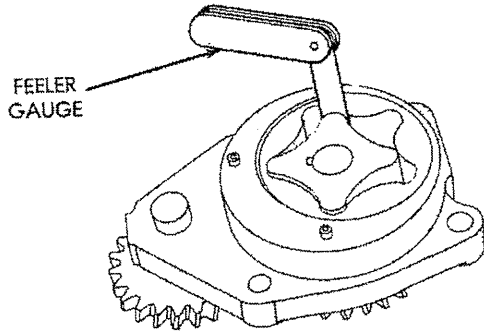
J9109-156

Fig. 126 Gerotor Planetary and Gerotor

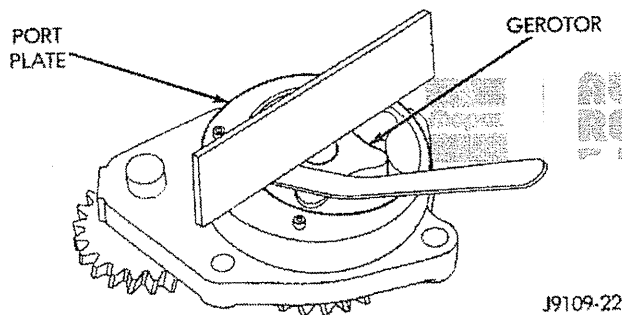
CLEANING AND INSPECTION (Continued)

Install the gerotor planetary in the original position. The chamfer must be on the O.D. and down.

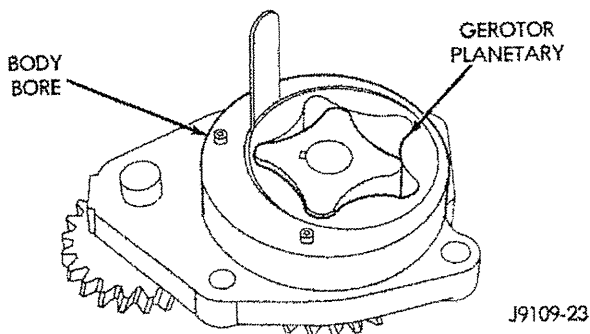
Measure the tip clearance (Fig. 127). Maximum clearance is 0.1778 mm (0.007 inch). If the oil pump is out of limits, replace the pump.

**Fig. 127 Tip Clearance**

Measure the clearance of the gerotor drive/gerotor planetary to port plate (Fig. 128). Maximum clearance is 0.127 mm (0.005 inch). If the oil pump is out of limits, replace the pump.

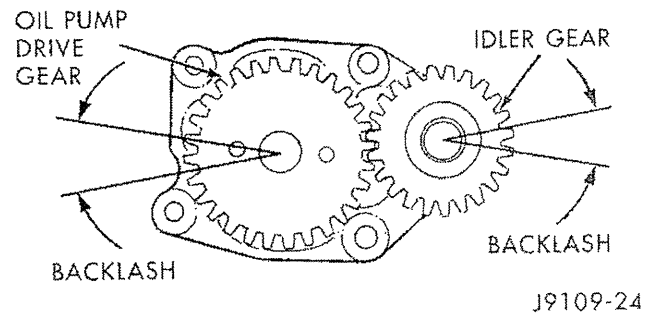
**Fig. 128 Gerotor to Port Plate Clearance**

Measure the clearance of the gerotor planetary to the body bore (Fig. 129). Maximum clearance is 0.381 mm (0.015 inch). If the oil pump is out of limits, replace the pump.

**Fig. 129 Gerotor Planetary to Body Bore Clearance**

Measure the gears backlash (Fig. 130). The limits of a used pump is 0.080- 0.380 mm (0.003-0.015

inch). If the backlash is out of limits, replace the oil pump.

**Fig. 130 Measure Gear Backlash**

Install the back plate.

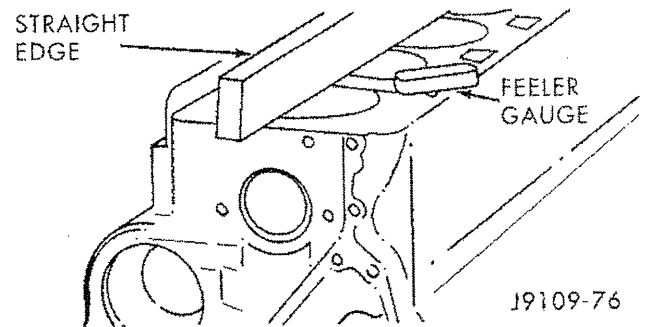
CYLINDER BLOCK

- (1) Remove the engine assembly from the vehicle.
- (2) Remove the cylinder head from the block.
- (3) Remove the camshaft.
- (4) Remove the piston/connecting rod assemblies.

INSPECTION

Measure the combustion deck face using a straight edge and a feeler gauge (Fig. 131). The distortion of the combustion deck face is not to exceed 0.010 mm (0.0004 inch) in any 50.00 mm (2.0 inch) diameter. Overall variation end to end or side to side is 0.075 mm (0.003 inch).

If the surface exceeds the limit, refer to Cylinder Block Refacing.

**Fig. 131 Combustion Deck Face Measurement**

Inspect the cylinder bores for damage or excessive wear.

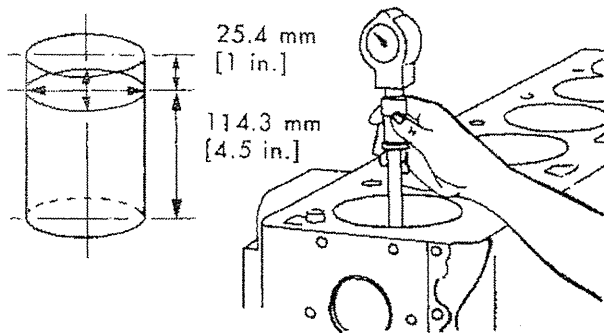
Measure the cylinder bores (Fig. 132). If the cylinder bores exceeds the limit, refer to Cylinder Bore Repair.

Inspect the camshaft bores for scoring or excessive wear.

Measure the camshaft bores (Fig. 133). Limit for the No.1 bore applies to the ID of the bushing.

If a bore exceeds the limit, refer to Camshaft Bore Repair.

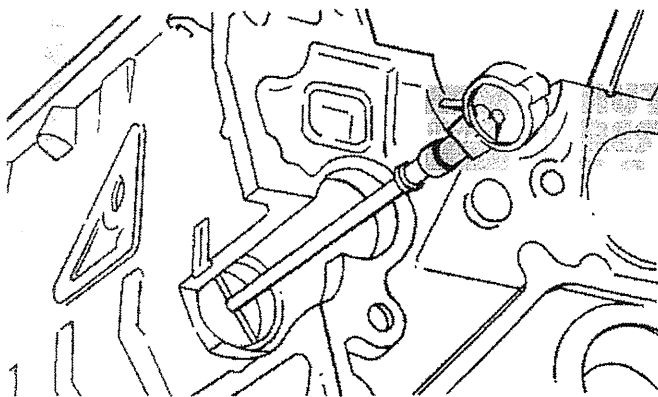
CLEANING AND INSPECTION (Continued)



MIN.	102.0 mm	(4.0157 inch)
MAX.	102.116 mm	(4.0203 inch)
Out-of-Round	0.038 mm	(0.0015 inch)
Taper	0.076 mm	(0.003 inch)
Oversize pistons and rings are available for bored cylinder blocks.		

J9209-167

Fig. 132 Cylinder Bore Diameter

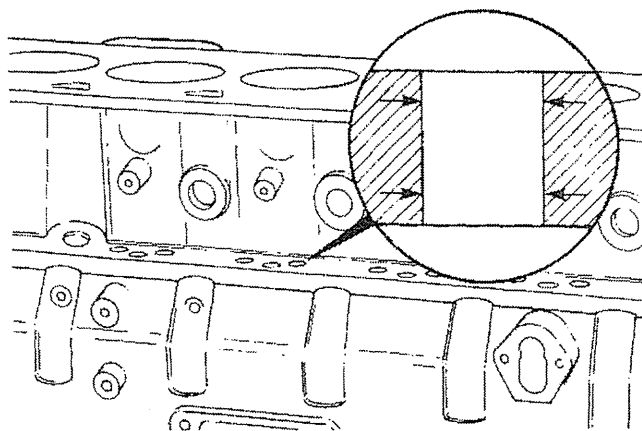


<u>CAMSHAFT BORE DIAMETER</u>		
MAX.	54.133 mm	(2.1312 inch)

J9109-78

Fig. 133 Camshaft Bores

Inspect the tappet bores for scoring or excessive wear (Fig. 134). If out of limits, replace the cylinder block.



<u>TAPPET BORE DIAMETER</u>		
MAX.	16.055 mm	(0.632 inch)

J9109-79

Fig. 134 Tappet Bore Diameter

PISTON AND CONNECTING ROD ASSEMBLY

CLEANING

CAUTION: DO NOT use bead blast to clean the pistons. DO NOT clean the pistons and rods in an acid tank.

Soak the pistons in cold parts cleaner. Soaking the pistons overnight will usually loosen the carbon deposits.

Wash the pistons and rods in a strong solution of laundry detergent and hot water.

Clean the remaining deposits from the ring grooves with the square end of a broken ring. DO NOT use a ring groove cleaner and be sure not to scratch the ring sealing surface in the piston groove.

Wash the pistons again in a detergent solution or solvent.

Rinse the pistons. Use compressed air to dry.

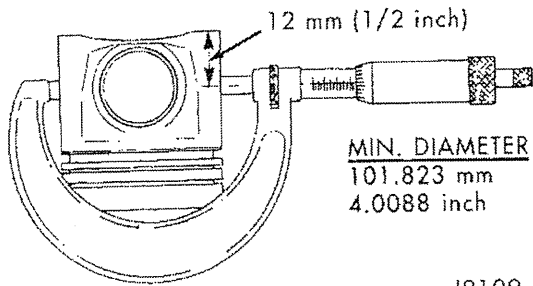
INSPECTION

Inspect the rod journals for deep scratches, indication of overheating and other damage.

Inspect the pistons for damage and excessive wear. Check top of the piston, ring grooves, skirt and pin bore.

CLEANING AND INSPECTION (Continued)

Measure the piston skirt diameter (Fig. 135). If the piston is out of limits, replace the piston.



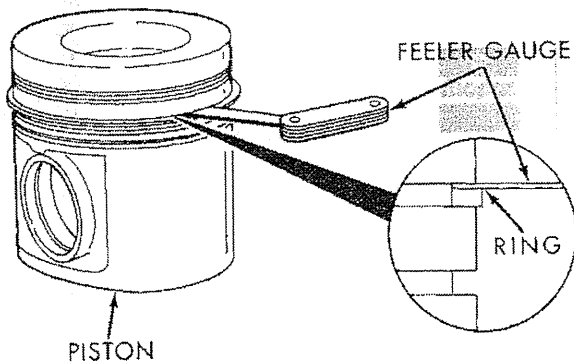
J9109-63

Fig. 135 Piston Skirt Diameter

The upper groove only needs to be inspected for damage.

Use a new piston ring to measure the clearance in the intermediate ring groove (Fig. 136). If the clearance of the intermediate ring exceeds 0.152 mm (0.006 inch), replace the piston.

Use a new oil ring to measure the clearance in the oil groove (Fig. 136). If the clearance exceeds 0.127 mm (0.005 inch), replace the piston.



J9109-64

Fig. 136 Intermediate and Oil Ring Clearances

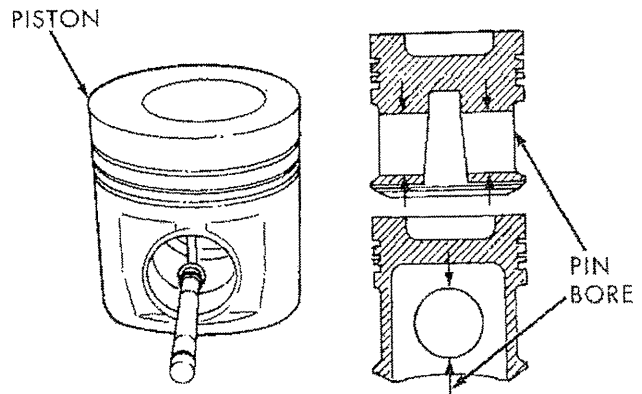
Measure the pin bore (Fig. 137). The maximum diameter is 40.025 mm (1.5758 inch). If the bore is over limits, replace the piston.

Inspect the piston pin for nicks, gouges and excessive wear.

Measure the pin diameter (Fig. 138). The minimum diameter is 39.990 mm (1.5744 inch). If the diameter is out of limits, replace the pin.

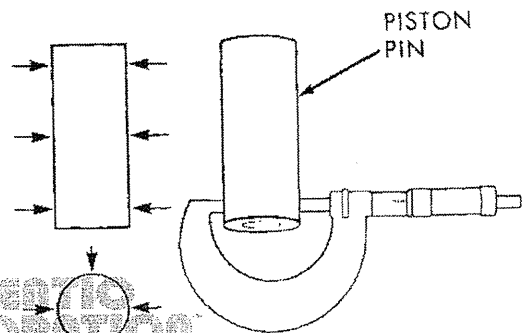
Inspect the rod for damage and wear. The I-Beam section of the connecting rod cannot have dents or other damage. Damage to this part can cause stress risers which will progress to breakage.

Measure the connecting rod pin bore (Fig. 139). The maximum diameter is 40.042 mm (1.5764 inch). If out of limits, replace the connecting rod.



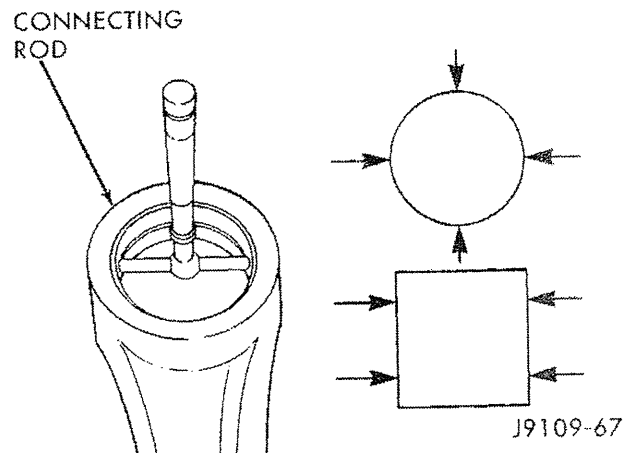
J9109-65

Fig. 137 Piston Pin Bore



J9109-66

Fig. 138 Piston Pin Diameter



J9109-67

Fig. 139 Connecting Rod Pin Bore

CRANKSHAFT

CLEANING AND INSPECTION

Clean the crankshaft oil galley holes with a nylon brush.

Rinse in clean solvent and dry with compressed air.

CLEANING AND INSPECTION (Continued)

Inspect the front and rear seal contact areas of the crankshaft for scratches or grooving.

The service seal kit will position the seal slightly deeper into the seal bore so it will contact the crankshaft at a different location. If this has already been done and the crankshaft has two worn areas, install a wear sleeve to provide a new contact surface for the seal.

Inspect the rod and main journal for deep scores, signs of overheating and other abnormal marks.

ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

Use the timing pin to locate Top Dead Center (TDC) for cylinder No.1 (Fig. 140). The timing pin is located at the back of the gear housing and below the injection pump. **Be sure to disengage the timing pin after locating top dead center. Refer to TIMING PIN for more information.**

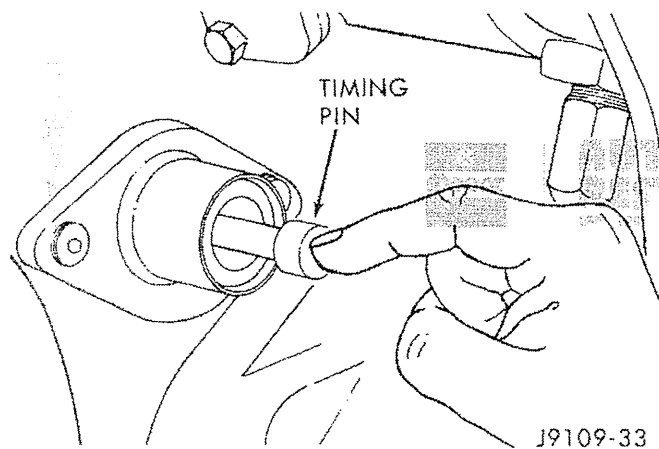


Fig. 140 Locating TDC using Timing Pin

Adjust the valves when the engine is cold, below 60°C (140°F).

STEP 1

Adjust the clearance for the valves shown in (Fig. 141). The valve lash adjustment is 0.254 mm (0.010 inch) for the intake valve. The valve lash adjustment is 0.508 mm (0.020 inch) for the exhaust valve.

Tighten the valve adjusting nuts to 24 N·m (18 ft. lbs.) torque. **Be sure timing pin is disengaged before rotating the crankshaft.** Mark the pulley and rotate the crankshaft 360°.

I = INTAKE

E = EXHAUST

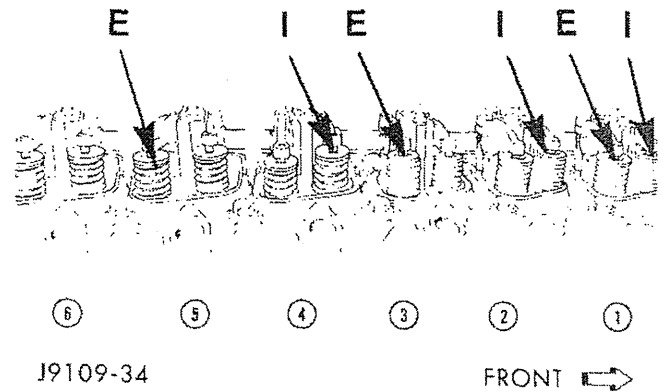


Fig. 141 Adjust Valve Clearance—Step 1

STEP 2

Adjust the clearance for the valves shown in (Fig. 142). The valve lash adjustment is 0.254 mm (0.010 inch) for the intake valve. The valve lash adjustment is 0.508 mm (0.020 inch) for the exhaust valve.

Tighten the bolts to 24 N·m (18 ft. lbs.) torque.

I = INTAKE

E = EXHAUST

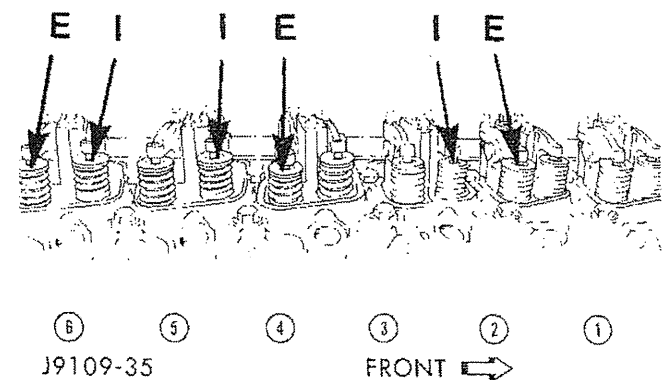


Fig. 142 Adjust Valve Clearance—Step 2

SPECIFICATIONS**5.9L (DIESEL) ENGINE****Camshaft**

Journal Diameter (Min.)	53.962 mm (2.1245 in)
Valve Lobes (Min. Diameter @ Peak of Lobe)	
Intake	47.040 mm (1.852 in)
Exhaust	46.770 mm (1.841 in)
Lift Pump Lobe (Min. Diameter @ Peak of Lobe)	35.500 mm (1.398 in)
End Clearance	0.152-0.254 mm (0.006-0.010 in)
Gear Backlash	0.080-0.330 mm (0.003-0.013 in)

Connecting Rods

Pin Bore Diameter (Max.)	40.042 mm (1.5764 in)
Side Clearance	0.100-0.300 mm (0.004-0.012 in)

Crankshaft**Main Bearing Journal Diameter**

Standard	82.962 mm (3.2662 in)
Machined 0.25 mm (0.0098 in)	82.712 mm (3.2564 in)
Machined 0.50 mm (0.0197 in)	82.462 mm (3.2465 in)
Machined 0.75 mm (0.0295 in)	82.212 mm (3.2367 in)
Machined 1.00 mm (0.0394 in)	81.962 mm (3.2269 in)
Out-of-Round (Max.)	0.050 mm (0.002 in)
Taper (Max.)	0.013 mm (0.0005 in)
Oil Clearance (Max.)	0.119 mm (0.0047 in)

Connecting Rod Journal Diameter

Standard	68.962 mm (2.7150 in)
Machined 0.25 mm (0.0098 in)	68.712 mm (2.7052 in)
Machined 0.50 mm (0.0197 in)	68.462 mm (2.6954 in)
Machined 0.75 mm (0.0295 in)	68.212 mm (2.6855 in)
Machined 1.00 mm (0.0394 in)	67.962 mm (2.6757 in)
Out-of-Round (Max.)	0.050 mm (0.002 in)
Taper (Max.)	0.013 mm (0.0005 in)
Oil Clearance	0.089 mm (0.0035 in)
End Clearance	0.100-0.430 mm (0.004-0.017 in)

Crankshaft (Cont.)

Gear Backlash	0.080-0.330 mm (0.003-0.03 in)
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Cylinder Block**Cylinder Bore**

Diameter	102.116 mm (4.0203 in)
Out-of-Round (Max.)	0.038 mm (0.0015 in)
Taper (Max.)	0.076 mm (0.003 in)
Tappet Bore Diameter	16.055 mm (0.632 in)
Top Surface Flatness (Max. Overall Variation)	0.075 mm (0.003 in)
Max. Variation any 50 mm (2 in) Diameter Area	0.010 mm (0.0004 in)

Refacing Combustion Deck

First Reface	0.250 mm (0.0098 in)
Second Reface	0.250 mm (0.0098 in)
Total Reface	0.500 mm (0.0197 in)

Surface Finish	1.50-3.20 micrometers (60-126 microinches)
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Main Bearing Bore Diameter (Max.) with Bearing Installed	83.106 mm (3.2719 in)
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Camshaft Bore Diameter (Max.)

No. 1 without Bushing	57.258 mm (2.2543 in)
Nos. 1-7 with Bushing	54.133 mm (2.1312 in)

Cylinder Head

Flatness Max. Overall	0.030 mm (0.012 in)
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Max. Variation within 0.01 mm (0.0004 in) in any
50.8 mm (2.00 in) diameter area.

Valve Seat Angle

Intake	30°
Exhaust	45°

Valve Seat Width

Minimum	1.52 mm (0.060 in)
Maximum	2.03 mm (0.080 in)

Tappets

Stem Diameter	15.925 mm (0.627 in)
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ENGINE SPECIFICATIONS

J9409-4

SPECIFICATIONS (Continued)

Oil Pump

Tip Clearance (Max.)	0.1778 mm (0.007 in)
Gerotor Drive/Planetary to Port Plate Clearance (Max)	0.127 mm (0.005 in)
Gerotor Planetary to Body Clearance (Max.)	0.381 mm (0.015 in)
Gear Backlash (Used Pump)	0.080-0.380 mm (0.003-0.015 in)

Oil Pressure (minimum)

At Idle Speed*	69 kPa (10 psi)
At 2,500 rpm	207 kPa (30 psi)
Regulating Valve Opening Pressure	448 kPa (65 psi)

*** CAUTION: If pressure is ZERO at curb idle,
DO NOT run engine at 2,500 rpm.**

Oil Filter

Differential Pressure to Open Filter Bypass	172.3 kPa (25 psi)
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Pistons

Skirt Diameter	101.880-101.823 mm (4.0110-4.0088 in)
Ring Groove Depth	
Intermediate	0.150 mm (0.006 in)
Oil Control	0.130 mm (0.005 in)

Piston Pins

Diameter (Min.)	39.990 mm (1.5744 in)
Bore Diameter (Max.)	40.025 mm (1.5758 in)

Piston Rings

Ring End Gap	
Top Ring	0.400-0.700 mm (0.016-0.0275 in)
Intermediate Ring	0.250-0.550 mm (0.010-0.0215 in)
Oil Control Ring	0.250-0.550 mm (0.010-0.0215 in)

Valves

Clearance — Intake	0.25 mm (0.010 in)
Exhaust	0.51 mm (0.020 in)
Guide Diameter	8.019-8.089 mm (0.3157-0.3185 in)
Stem Diameter	7.935-7.960 mm (0.3126-0.3134 in)
Depth (Installed)	0.99-1.52 mm (0.039-0.060 in)

Valve Springs

Free Standing Length	60 mm (2.36 in)
Inclination (Max.)	1.00 mm (0.039 in)
Minimum Load	@49.25 mm-359 N (@1.94 in-81 lbs)

J9509-159

SPECIFICATIONS (Continued)

TORQUE SPECIFICATIONS

DESCRIPTION	TORQUE	DESCRIPTION	TORQUE
Air Fuel Control Fitting (In Head).....	8 N•m (6 ft. lbs.)	Intercooler Attaching Bolts	2 N•m (17 in. lbs.)
Battery Cable (Negative) Mounting to Block.....	77 N•m (57 ft. lbs.)	Intercooler Duct Clamp Nuts	8 N•m (72 in. lbs.)
Belt Tensioner Mounting.....	43 N•m (32 ft. lbs.)	Lifting Bracket (Rear)	77 N•m (57 ft. lbs.)
Block Heater Mounting	12 N•m (9 ft. lbs.)	Oil Cooler Assembly	24 N•m (18 ft. lbs.)
Cab Heater Hose Clamp.....	4 N•m (35 in. lbs.)	Oil Fill Tube Bracket Bolt.....	43 N•m (32 ft. lbs.)
Cab Heater Tubing Clamp Mounting	9 N•m (7 ft. lbs.)	Oil Filter.....	3/4 Turn After Contact
Camshaft Thrust Plate Bolts	24 N•m (18 ft. lbs.)	Oil Pan Drain Plug.....	80 N•m (60 ft. lbs.)
Clutch Cover Mounting to Flywheel Bolts.....	23 N•m (17 ft. lbs.)	Oil Pan Bolts.....	24 N•m (18 ft. lbs.)
Connecting Rod Bolts		Oil Pressure Regulator Plug.....	80 N•m (60 ft. lbs.)
Step 1 (Alternately Tighten).....	35 N•m (26 ft. lbs.)	Oil Pressure Sender/Switch	16 N•m (12 ft. lbs.)
Step 2 (Alternately Tighten).....	70 N•m (51 ft. lbs.)	Oil Pump Mounting Bolts.....	24 N•m (18 ft. lbs.)
Step 3 (Alternately Tighten).....	100 N•m (73 ft. lbs.)	Oil Suction Tube (Flange).....	24 N•m (18 ft. lbs.)
Cooling Fan Mounting to Fan Clutch	20 N•m (15 ft. lbs.)	Oil Suction Tube Brace Bolt.....	24 N•m (18 ft. lbs.)
Crankshaft Main Bearing Bolts		Oil Supply Fitting for Vacuum Pump	10 N•m (7 1/2 ft. lbs.)
Step 1	60 N•m (45 ft. lbs.)	Rear Mount — Support	
Step 2	119 N•m (88 ft. lbs.)	Cushion-to-Crossmember Nut	47 N•m (35 ft. lbs.)
Step 3	176 N•m (129 ft. lbs.)	Rear Mount — Support Cushion-to-Trans.	
Cylinder Head Bolts		Support Bracket Nuts	47 N•m (35 ft. lbs.)
All Bolts.....	90 N•m (66 ft. lbs.)	Rear Mount — Transmission Support	
All Long Bolts.....	120 N•m (89 ft. lbs.)	Bracket Bolts.....	102 N•m (75 ft. lbs.)
Tighten All Bolts an Additional.....	90°	Rear Support Plate-to-Transfer	
Exhaust Manifold Bolts	43 N•m (32 ft. lbs.)	Case Bolts	41 N•m (30 ft. lbs.)
Fan Clutch Mounting/Fan Hub (Left Hand Threads).....	57 N•m (42 ft. lbs.)	Rocker Arm Bolts	24 N•m (18 ft. lbs.)
Fan Hub Bracket Mounting	24 N•m (18 ft. lbs.)	Starter Mounting Bolts.....	68 N•m (50 ft. lbs.)
Fan Hub Bearing Retaining Capscrew	77 N•m (57 ft. lbs.)	Torque Converter Drive Plate Bolts	31 N•m (270 in. lbs.)
Fan Pulley to Fan Hub	9 N•m (7 ft. lbs.)	Transfer Case-to-Insulator Mounting	
Fan Shroud Mounting Nuts.....	11 N•m (95 in. lbs.)	Plate Nuts.....	204 N•m (150 ft. lbs.)
Flywheel Bolts	137 N•m (101 ft. lbs.)	Transmission Support Bracket Bolts	
Flywheel Housing Adaptor.....	77 N•m (57 ft. lbs.)	(2WD)	68 N•m (50 ft. lbs.)
Front Mount — Thru-Bolt Nut.....	68 N•m (50 ft. lbs.)	Transmission Support Spacer Bolts	
Front Mount — Engine Support		(4WD)	68 N•m (50 ft. lbs.)
Bracket/Cushion Bolts	176 N•m (140 ft. lbs.)	Transmission Support Spacer-to-Insulator	
Generator Mounting Bolts.....	41 N•m (30 ft. lbs.)	Mounting Plate Nuts (4WD).....	204 N•m (150 ft. lbs.)
Generator Pulley.....	80 N•m (59 ft. lbs.)	Vacuum Pump Oil Supply Line	10 N•m (7 1/2 ft. lbs.)
Generator Support (Upper).....	24 N•m (18 ft. lbs.)	Vibration Damper Retainer Bolts	125 N•m (92 ft. lbs.)
Gear Cover	24 N•m (18 ft. lbs.)	Water Pump	24 N•m (18 ft. lbs.)
Gear Housing Bolts	24 N•m (18 ft. lbs.)		
Intake Manifold Cover Bolts	24 N•m (18 ft. lbs.)		

TORQUE SPECIFICATIONS