76. Upper Compression Ring
77. Lower Compression Ring
78. Oil Control Ring
79. Snap Ring
80. Piston
81. Connecting Rod
82. Connecting Rod Cap
83. Bolt
84. Piston Pin
85. Piston Pin Bushing
86. Upper Connecting Bearing Insert
87. Lower Connecting Rod Bearing Insert
88. Connecting Rod Bearing

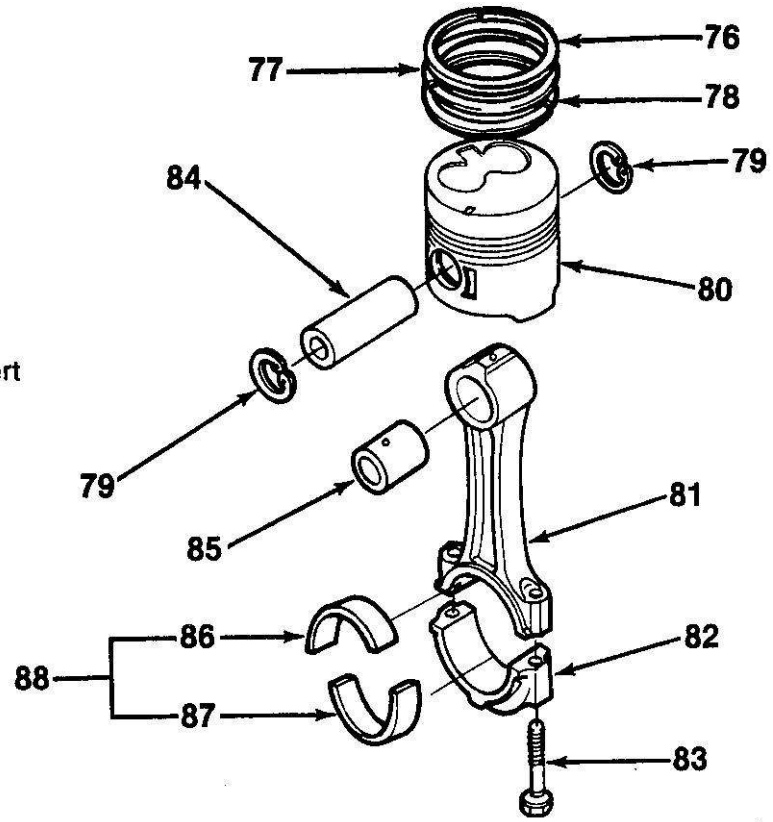
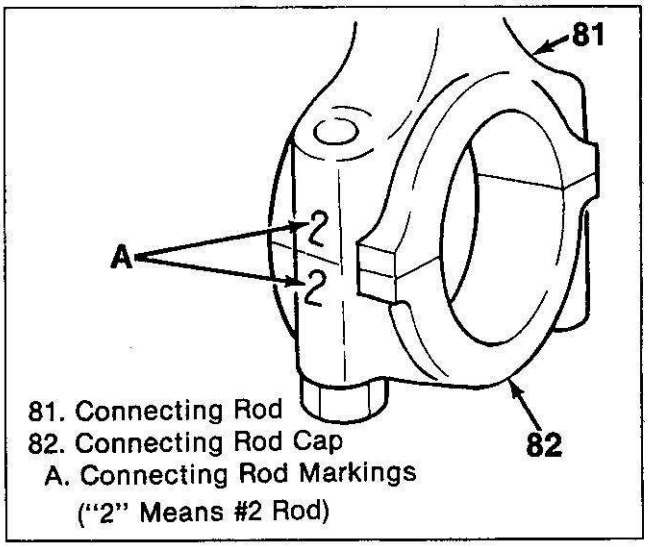


Figure 46. Piston, Connecting Rod and Components

Inspect (Figure 46)

- Piston (80) for cracks and scoring.
- Liner (89) for scratches, cracks and scoring (figure 59).
- Connecting rod (81) and connecting rod cap (82) for cracks, damage etc.
- Piston pin bushing (85) for scoring.
- Connecting rod bearing inserts (86 and 87) for scoring.
- Connecting rod bearing insert (86 and 87) tension (figure 53). Moderate finger pressure should be needed to push the bearing inserts into place. If the inserts fit loosely, they should be replaced.
- Connecting rod journal on the crankshaft for scoring or other damage.



81. Connecting Rod
82. Connecting Rod Cap
A. Connecting Rod Markings ("2" Means #2 Rod)

Figure 47. Connecting Rod Markings

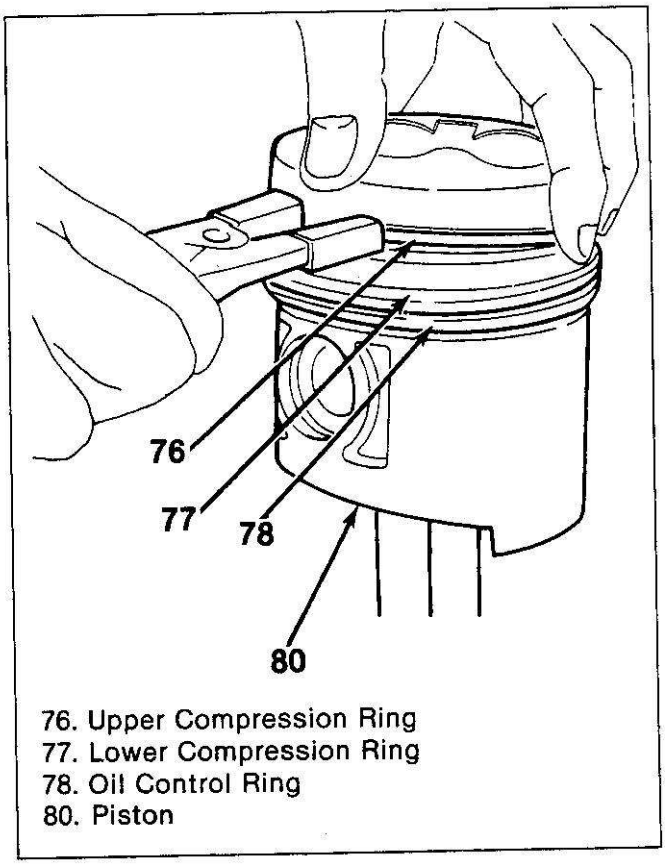


Figure 48. Removing or Installing Piston Rings

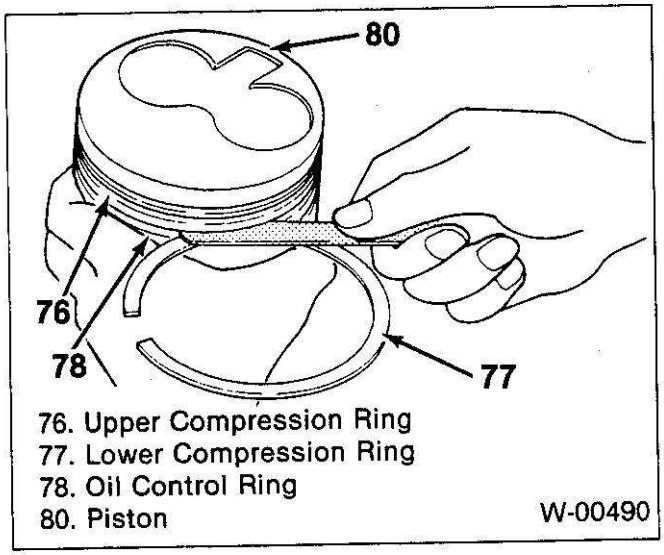


Figure 49. Measuring Piston Ring to Groove Clearance

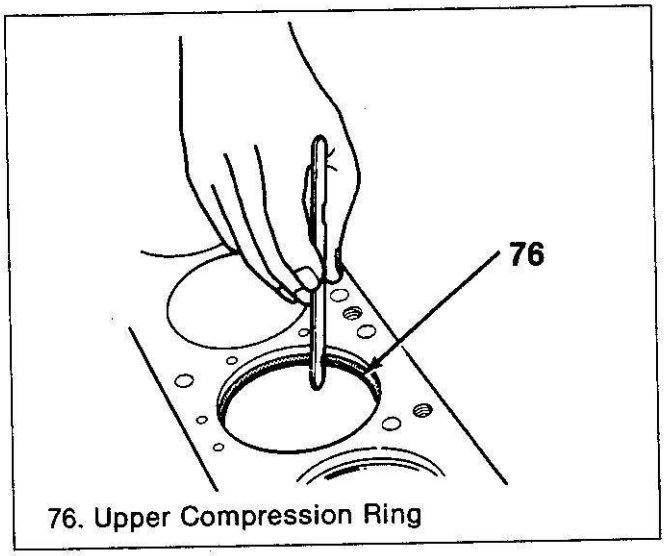


Figure 50. Measuring Piston Ring End Gap

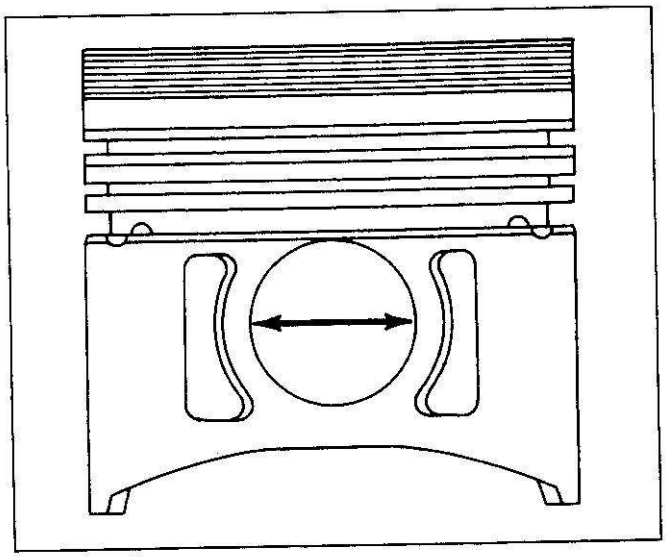


Figure 51. Measuring Piston Pin Hole Diameter

Measure

Piston Ring to Piston Ring Groove Clearance (Figure 49)

- The clearance should be as specified in "Specifications" at the end of this section.

Piston Ring End Gap (Figure 50)

- The gap should be as specified in "specifications" at the end of this section.

Piston Pin Hole Inside Diameter (Figure 51)

- The hole should measure 35.010–35.018 mm (1.3783–1.3787 in).

Piston Pin Diameter (Figure 52)

- Measure in three places as shown. The production diameter is 35.000–35.005 mm (1.3780–1.3782 in). Replace the pin if worn amaller than 34.95 mm (1.3760 in).

Piston Pin to Piston Pin Hole Clearance (Figures 51 and 52)

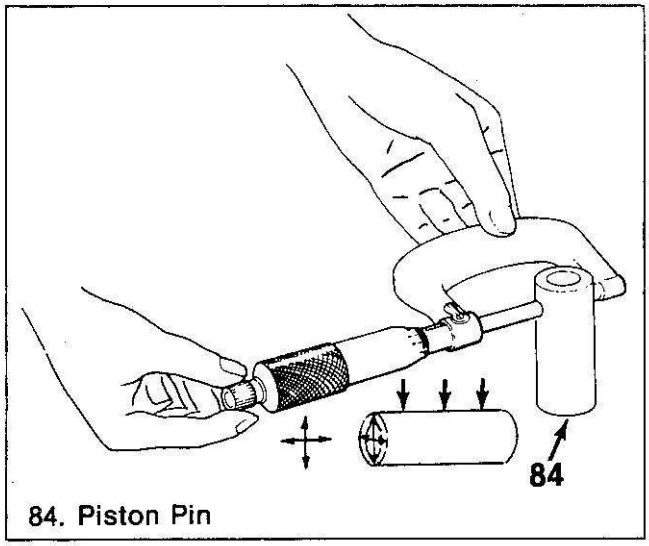
- Subtract the piston pin diameter from the piston pin hole diameter to obtain the clearance.The proper clearance is 0.005–0.018 mm (0.0002–0.0007 in).

Connecting Rod Small End Bushing Inside Diameter (Figure 54)

- The correct diameter is 35.017–35.025 mm (1.3786–1.3789 in).

Piston Pin to Connecting Small End Bushing Clearance

- Subtract the piston pin diameter from bushing inside diameter to obtain the clearance.The standard clearance is 0.012–0.025 mm (0.00047–0.00098 in).The service limit is 0.05 mm (0.002 in).



84. Piston Pin

Figure 52. Measuring Piston Pin Diameter

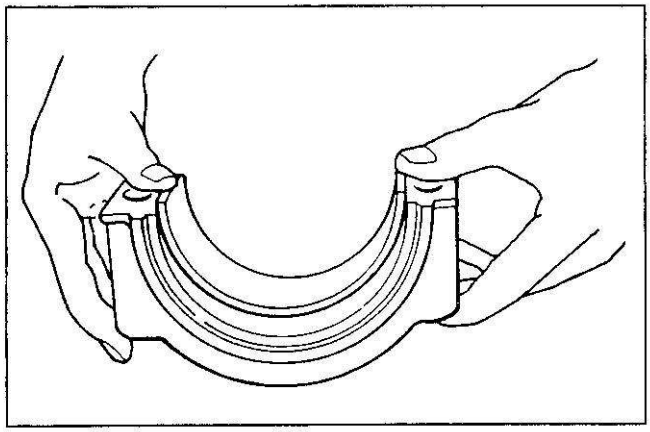


Figure 53. Checking Connecting Rod Bearing Tension

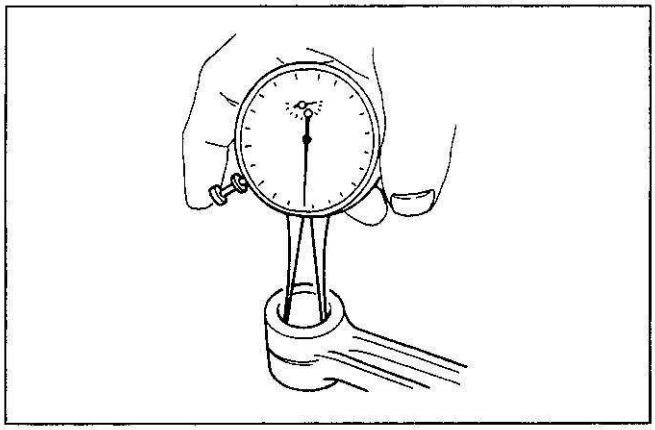


Figure 54. Measuring Piston Pin Bushing Inside Diameter

Crankpin Diameter (Figure 55)

- Measure in two places and in the horizontal and vertical, as shown. The crankpin should measure 63.924–63.944mm (2.5167–2.5175 in).

Important

- If the crankshaft is worn, it should be replaced. It cannot be reground. Undersize bearings are not available. This is becaus of the special "tufftriding" hardening process that has been applied to it.

Crankpin to Connecting Rod Bearing Clearance (Figure 46)

- Connecting rod bearing clearance can also be measured using gaging plastic as outlined later.
- Apply molybdenum disulfide grease to the threads of the bolts(83).
- Install the connecting rod cap (82), connecting rod bearing insert (86 and 87) and bolts (83).

Tighten

- Bolts (83) to "Specifications" at the end of this section.

- Measure the connecting rod bearing (88) inside diameter, using an inside micrometer (figure 56).
- The nominal inside diameter is 64 mm (2.5197 in).
- Subtract the crankpin diameter from the connecting rod bearing inside diameter to obtain the clearance. The production clearance is 0.030 – 0.081 mm (0.0012 –0.0032 in).The service limit is 0.10 mm (0.004 in).
- Remove the bolts (83).
- Remove the connecting rod cap (82) and bearings (86 and 87).

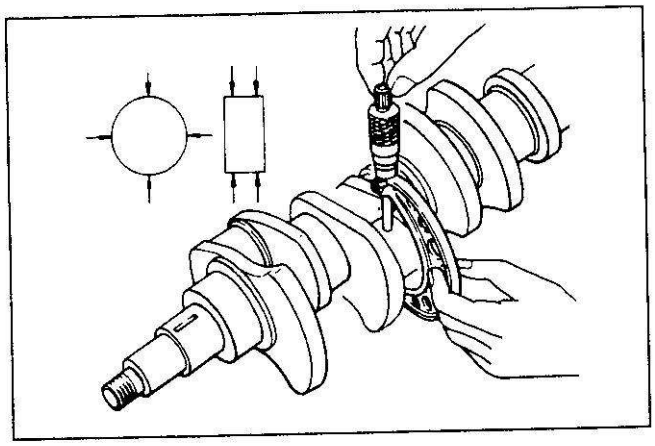


Figure 55. Measuring the Crankpin

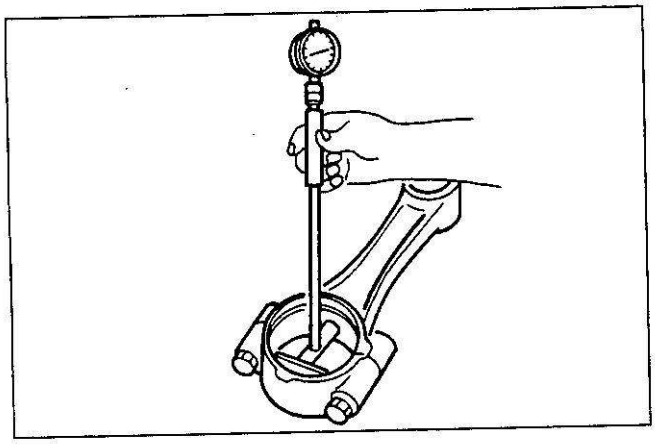


Figure 56. Measuring the Connecting Rod Bearing Inside Diameter

Piston and Liner Selection

Standard fitting interference	mm(in)	0.001–0.019 (0.00004–0.00075)

Cylinder liners are supplied as a SET with a prefitted piston having a letter grade of circle Ⓐ or Ⓒ. There are four grade numbers of liner sets. Each grade liner set has an individual part number listing, thereby providing the best fit with the cylinder bore when inserted.

There are two methods by which liners can be selected.

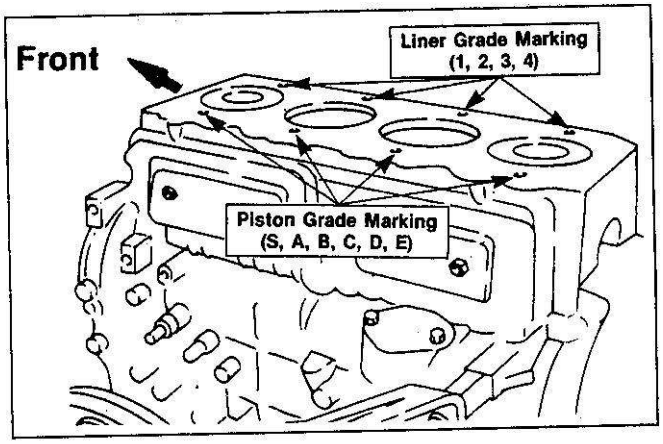


Figure 57. Liner and Piston Grade Marking

Method I

The cylinder block deck has been marked during production to indicate both the correct liner and piston sizes. The liner grade (i.e. 1, 2, 3, 4) is indicated in permanent ink (figure 57) .

The piston grade is indicated (i.e. S, A, B, C, D, E) by a metal stamping. This information is for reference only since individual piston grades are not available.

In the case of a questionable liner marking use the next method for correct liner selection.

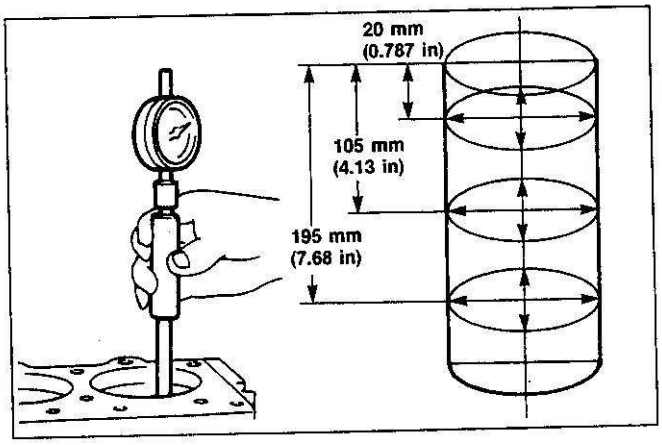


Figure 58. Measuring the Cylinder Bore

Method II

In order to select the correct liner for each cylinder bore, six measurements must be taken(figure 58).

These measurements are then averaged as follows:

$$\text{Diameter Average} = \frac{1+2+3+4+5+6}{6}$$

Consult the following table with the resultant diameter for the correct liner application.		
(CYL. BORE) DIAMETER AVERAGE mm (in)	GRADE NUMBER	LINER OUTSIDE DIAMETER mm (in)
105.001–105.010 (4.1339–4.1342)	1	105.011–105.020 (4.1343–4.1346)
105.011–105.020 (4.1343–4.1346)	2	105.021–105.030 (4.1347–4.1350)
105.021–105.030 (4.1347–4.1350)	3	105.031–105.040 (4.1351–4.1354)
105.031–105.040 (4.1351–4.1354)	4	105.041–105.050 (4.1355–4.1358)
Consult the NPR/W4 Parts Catalog with the correct liner outside diameter or grade number for ordering of liner.		

Liner Replacement

(Figure 59)

Tool Required:

J-36520, J-37365, or equivalent, Liner Remover and Installer

1. With the piston (80) and connecting rod (81) removed, turn the crankshaft until the connecting rod journal for the cylinder to be serviced is about halfway down from Top Dead Center (at 3 or 9 o'clock).
2. Assemble the ankle (H) and swivel (I) to the stud (E).
3. Insert the stud (E) with ankle (H) down through the liner (89). "Hook" the ankle into the liner. Pull up on the stud to keep the ankle fully seated in the liner.
4. Install the three-way head (F) with the risers (G) over the stud (E).
5. Set the three risers (G) on the cylinder block. Tighten the nut (D) finger tight.
6. Install the bearing (C) washer(B) nut (A), on the stud (E).
7. Tighten the nut (A) to pull the liner (89) from the block.

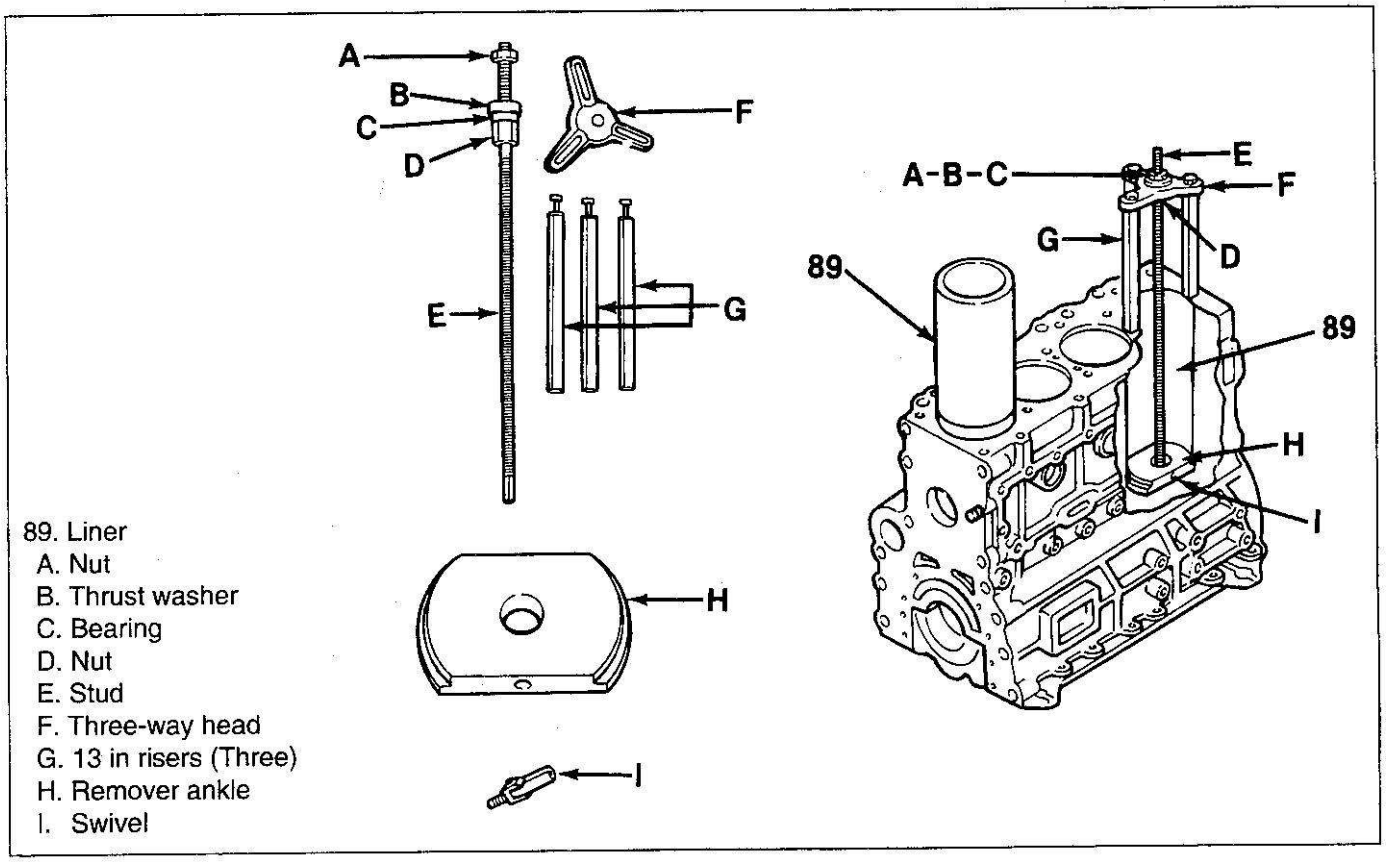
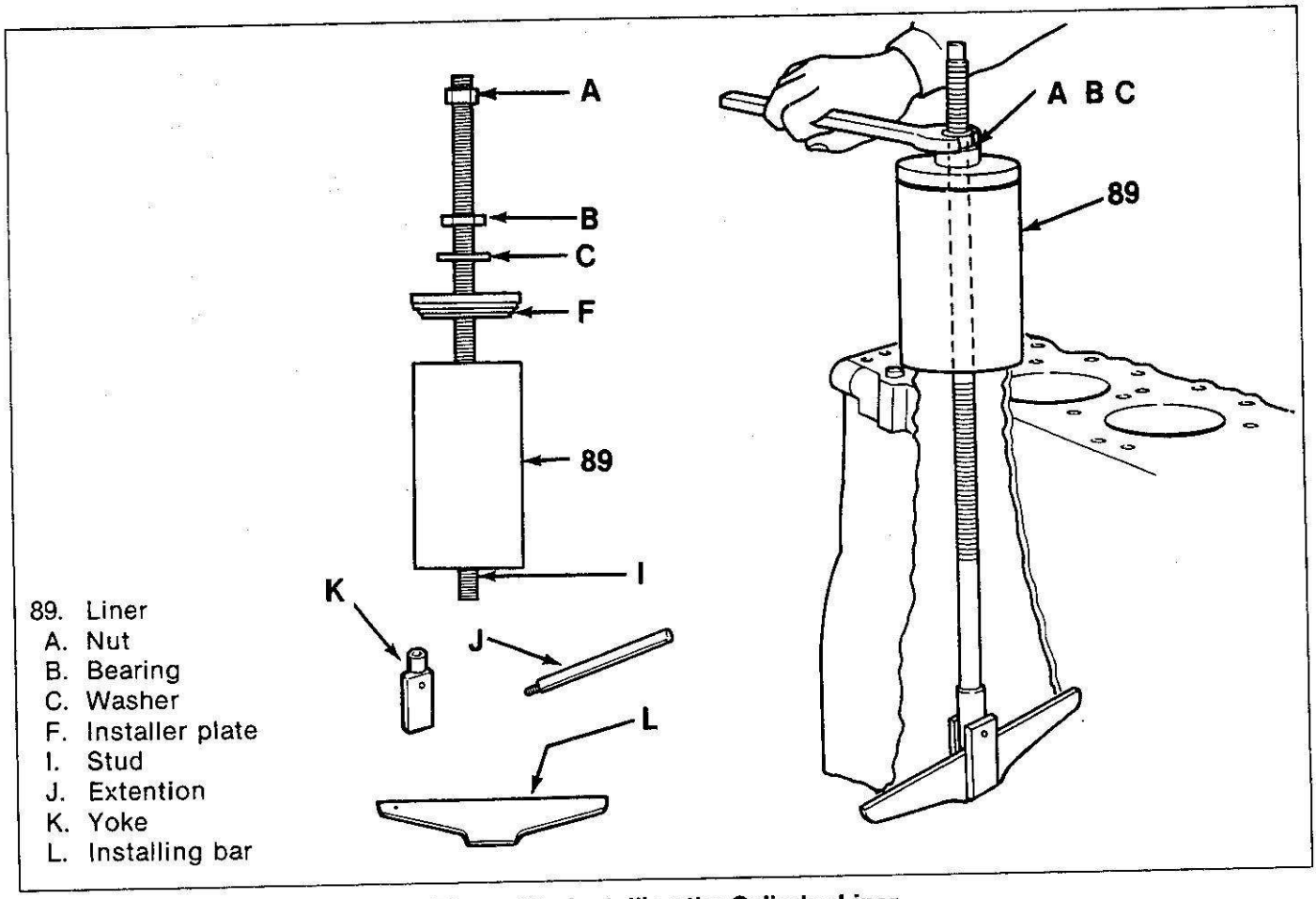


Figure 59. Cylinder Liner Removal

CAUTION: To help avoid serious injury when handling dry ice or parts that have been chilled:
- **Always wear heavy gloves and safety goggles.**
- **Do not seal dry ice in an airtight container. It may cause the container to burst.**

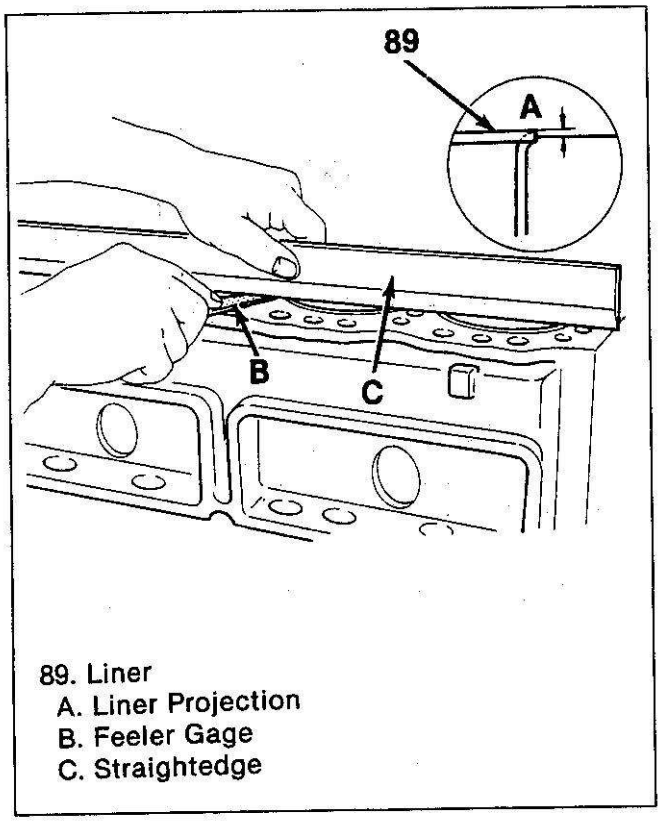
Dry ice can cause burns and/or eye injury if not properly handled.

8. Pack the selected liner in a suitable quantity of dry ice. Allow the liner to cool for 35-45 minutes.
9. Be sure the liner bore and counterbore at the top of the block are clean.
10. Remove the liner from the dry ice. WEAR HEAVY GLOVES AND SAFETY GOGGLES WHEN HANDLING THE CHILLED LINER. DO NOT wrap a shop towel around the liner, as the cloth may "stick" to the liner. This may cause the liner and cloth to jam in the block when it is inserted.
11. Quickly insert the liner into the block. Be sure it starts square (90°) straight.
12. Assemble tool J-36520,J-37365 in the liner (89) and cylinder block as shown in figure 60.
13. Turn nut (366) until the liner (89) is fully seated into the cylinder block.
14. Measure the amount of liner projection (figure 61). Use a straightedge and feeler gage, as shown. If properly installed, the liner should project 0.03–0.10 mm (0.00120–0.039 in) above the block gasket surface.
15. Measure the liner bore diameter (figure 53).
    - Place the bore gage 20 mm (0.787 in) below the head gasket surface, as shown.
    - The correct liner dimensions are as follows:
      Size Grade Ⓐ:
      102.021–102.040 mm (4.0166–4.0173 in).
      Size Grade Ⓒ:
      102.041–102.060 mm (4.0174–4.0181 in).
16. Select a piston to fit the new liner as outlined previously in this section.



89. Liner
A. Nut
B. Bearing
C. Washer
F. Installer plate
I. Stud
J. Extention
K. Yoke
L. Installing bar

Figure 60. Installing the Cylinder Liner



89. Liner
A. Liner Projection
B. Feeler Gage
C. Straightedge

Figure 61. Measuring Liner Projection

Piston Pin Bushing Replacement

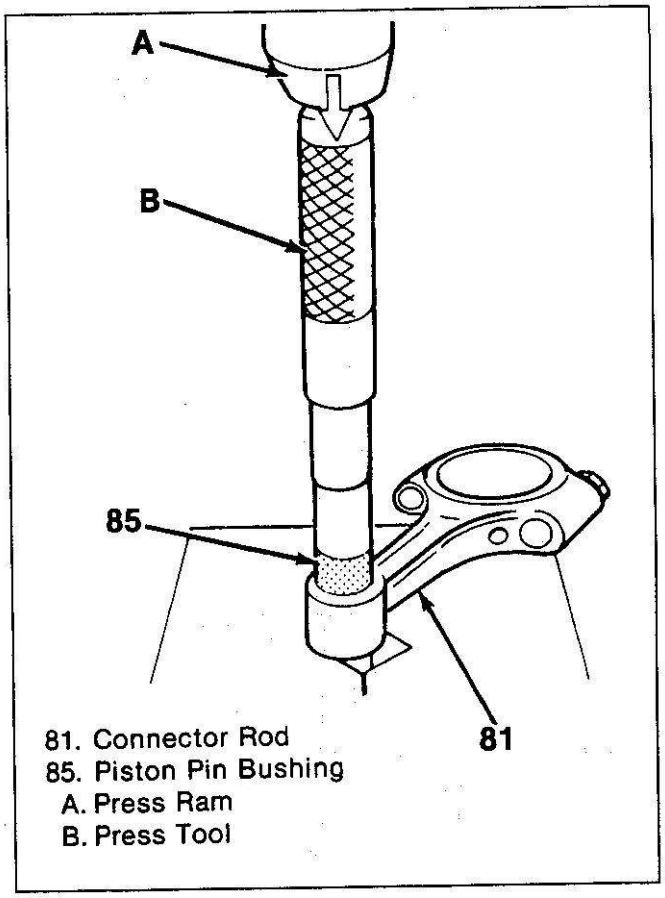
(Figures 62 and 63)

1. Fully support the connecting rod upper end in a press.
2. Press out the old bushing, using a suitable press tool (figure 62).
3. Press the new bushing into place, using the press and press tool (figure 62). Be sure the oil holes in the bushing and connecting rod align.
4. Finish the new bushing to the proper size, using a pin hole grinder (figure 63).

Assemble
(Figures 46, 48, 49, 50, 59 and 64-70)

- Heat the piston (80) in an oven, if necessary, to ease insertion of the piston pin (84).

1. Piston (80) to the connecting rod (81). Align the piston and connecting rod as shown in figure 64.
   - Lubricate the piston pin (84) with engine oil.
2. Piston pin (84).
3. Snap rings (79). Rotate the snap rings in their grooves to be sure they are fully seated.



81. Connector Rod
85. Piston Pin Bushing
A. Press Ram
B. Press Tool

Figure 62. Removing or Installing the Piston Pin Bushing

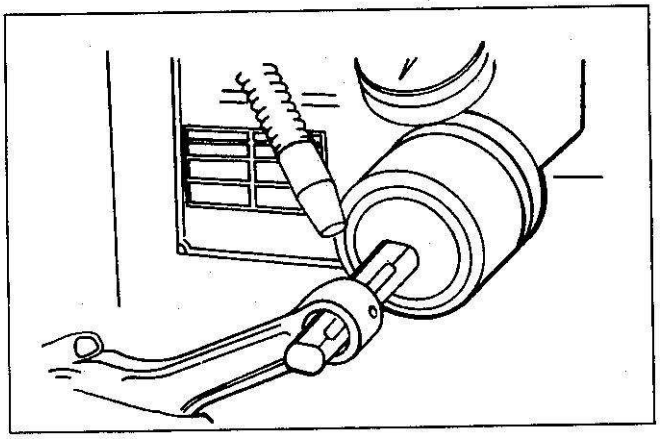
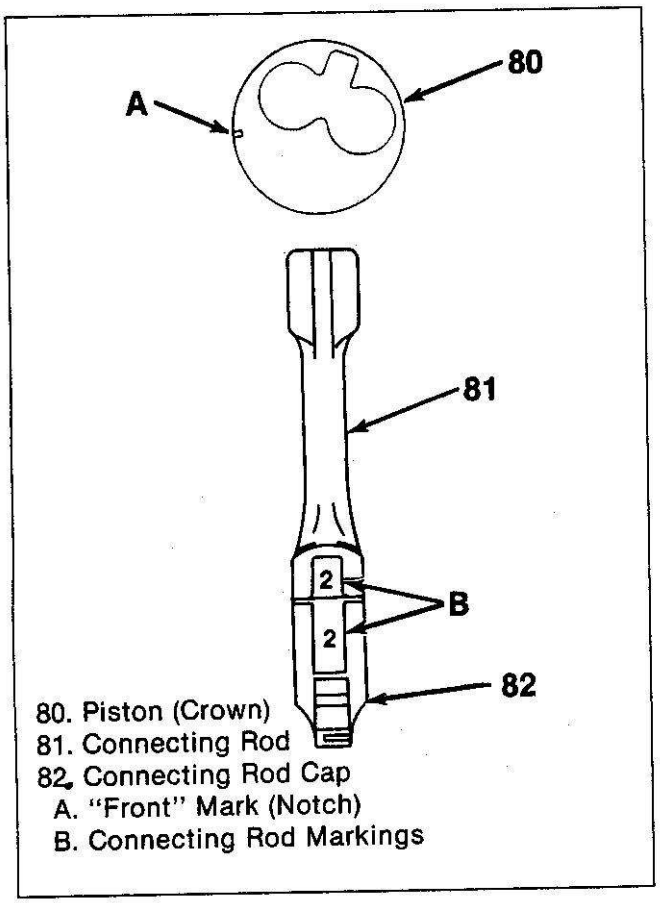


Figure 63. Honing the Connecting Rod Piston Pin Bushing

— Piston ring (76, 77 and 78) to groove clearance (if necessary) (figure 49). The clearance should be as listed in "Specifications" at the end of this section.

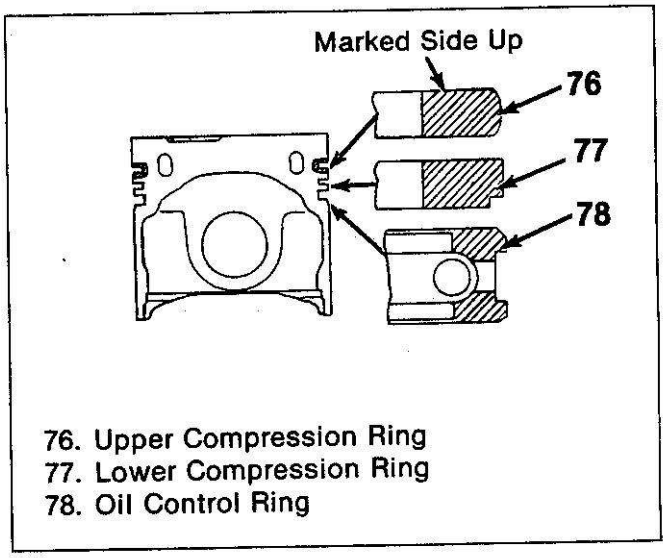
— Piston ring (76, 77 and 78) end gap (if necessary) (figure 50). The clearance should be as listed in "Specifications" at the end of this section.



80. Piston (Crown)
81. Connecting Rod
82. Connecting Rod Cap
A. "Front" Mark (Notch)
B. Connecting Rod Markings

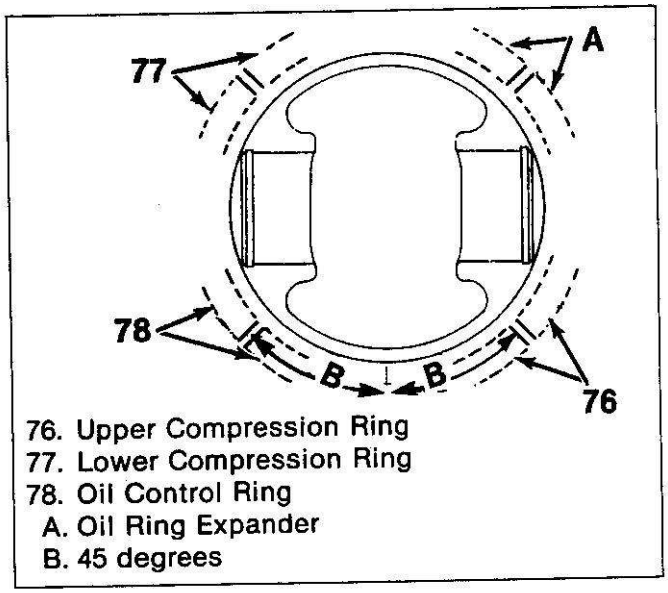
Figure 64. Aligning the Piston and Connecting Rod

4. Oil control ring expander to the piston (80).
5. Oil control ring (78). Use a ring installing tool (figure 48).
6. Lower compression ring (77). Use a ring installing tool (figure 48).
7. Upper compression ring (76). Use a ring installing tool (figure 48). The marked face of the ring must face up (figure 65).
   - Locate the ring end gaps as shown in figure 66.
8. Upper connecting rod bearing insert (86) to the connecting rod (81).
9. Lower connecting rod bearing insert (87) to the connecting rod cap (82).
10. Piston (80) and connecting rod (81) assembly to the proper liner (89) (figure 59).
    - Lubricate the piston (80) and connecting rod bearing with engine oil.
    - Without disturbing the ring end gap locations, install the piston ring compressor tool over the piston.
    - Push the piston into place (figure 67). Make the "front" marks face the front of the engine, as shown.



76. Upper Compression Ring
77. Lower Compression Ring
78. Oil Control Ring

Figure 65. Installing the Piston Rings



76. Upper Compression Ring
77. Lower Compression Ring
78. Oil Control Ring
A. Oil Ring Expander
B. 45 degrees

Figure 66. Piston Ring End Gap Locations

Connecting Rod Bearing Selection (Figures 46 and 68~70)

The simplest, most accurate way to measure connecting rod bearing clearance is with the use of plastigage. This wax-like material compresses evenly between the bearing and journal surfaces without damaging them. Proceed as follows. It is assumed that the parts have been inspected as previously outlined.

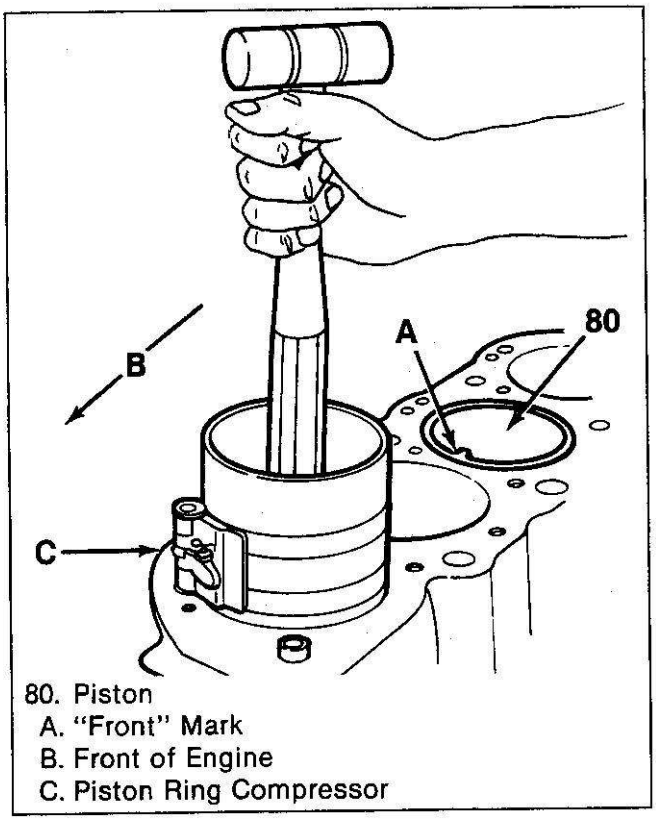
Clean

- All oil from the crankshaft journal and the bearing inserts (86 and 87).

1. Install the connecting rod (81) with the upper bearing insert (86) to the crankshaft journal.

Important

- If a bearing is being fitted to an out-of-round crankpin, be sure to fit to the maximum diameter of the crankpin. If the bearing is fitted to the minimum diameter and the crankpin is excessively out-of-round, interference between the bearing and the crankpin will result in rapid bearing failure.



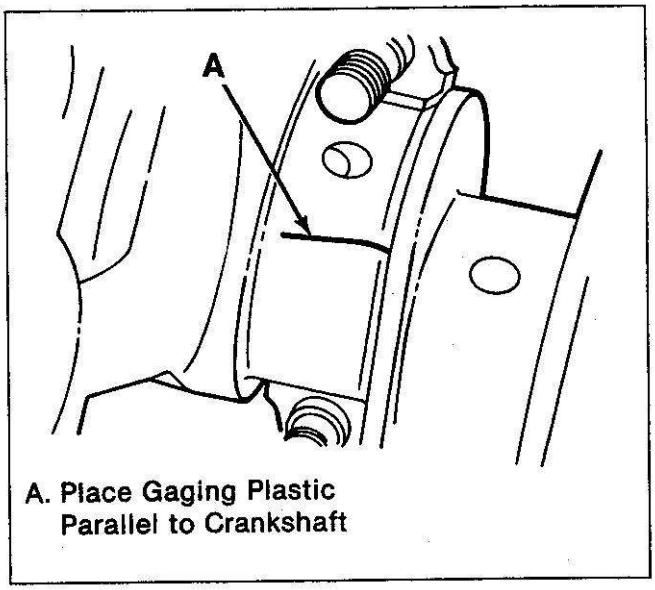
80. Piston
A. "Front" Mark
B. Front of Engine
C. Piston Ring Compressor

Figure 67. Installing the Piston

2. A piece of plastigage the length of the bearing (parallel to the crankshaft) on the journal (figure 68). Do not turn the crankshaft with the gaging plastic installed.
3. Install the connecting rod cap (82) with the lower bearing insert (87). Be sure the numbers on the connecting rod (81) and connecting rod cap align (figure 47).
   - Apply molybdenum disulfide grease to the threads of the bolts (83).
4. Install the Bolts (83).

Tighten

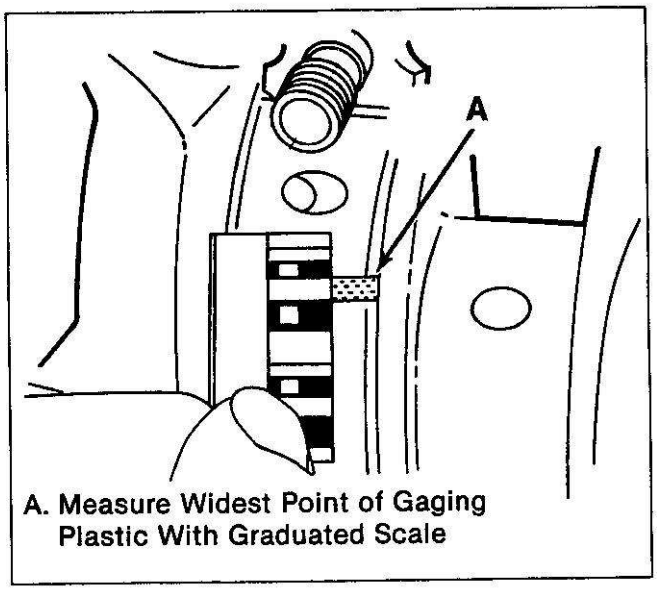
- Bolts (83) to "Specifications" at the end of this section.



A. Place Gaging Plastic Parallel to Crankshaft

Figure 68. Placing the Gaging Plastic on the Journal

5. Remove the bolts (83).
6. Remove the connecting rod cap (82).
   - The gaging plastic will be found sticking either to the journal or lower bearing insert (87). Do not remove it at this time.



A. Measure Widest Point of Gaging Plastic With Graduated Scale

Figure 69. Measuring the Gaging Plastic

- Gaging plastic at its widest point, using the scale at the gaging plastic envelope (figure 69).
- If the clearance exceeds specifications, select a new, correct size connecting rod bearing (88) and remeasure the clearance.
- Do not attempt to use shims or file the bearing to obtain the needed clearance.
- If clearance cannot be brought to within specifications, replace the crankshaft. The

crankshaft cannot be reground. Undersize bearings are not available.
- Remove the gaging plastic.

Install or Connect (Figures 46, 47, 70 and 73)

1. Connecting rod cap (82) with the lower bearing insert (86) to the connecting rod (81). The numbers on the connecting rod and connecting rod cap must align (figure 47).
   - Apply molybdenum disulfide grease to the threads of the bolts (83).
2. Bolts (83).

Tighten

- Bolts (83) in two stages, as follows:
- Stage 1: Tighten both bolts to 39 N·m (29 lb·ft).
- Stage 2: Refer to figure 70. Make a punch mark on the bolt heads, as shown. Then make a second punch mark on the connecting rod cap, 60–90 degrees clockwise from the first mark. Tighten both bolts 60–90 degrees (until the punch marks align).

3. Oil pan (134) as outlined in "Oil Pan Replacement" later in this section.
4. Cylinder head (14) as outlined in "Cylinder Head" previously in this section.
5. Battery cables.

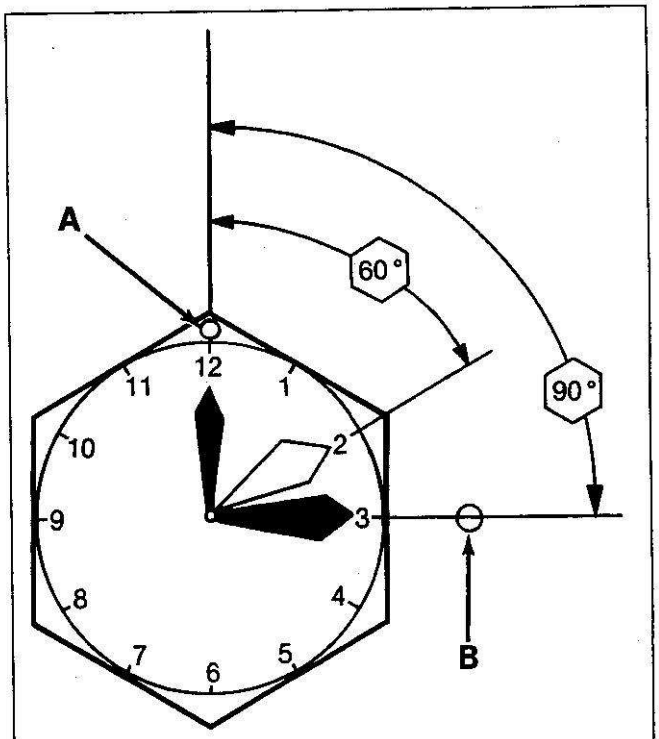
VIBRATION DAMPER REPLACEMENT

Remove or Disconnect (Figure 71)

1. Battery cables.
2. Radiator. Refer to RADIATOR (SEC. 6B2).
3. Loosen the A/C compressor adjusting bolt and remove the drive belt. Refer to AIR CONDITIONING (SEC. 1B).
4. Loosen the generator adjusting arm bolt and remove the water pump and generator belts. Refer to ENGINE ELECTRICAL (SEC. 6D).
5. Damper nut (93). The nut is 41 mm (1-5/8 in).
6. Washer (92).
7. Vibration damper (90).

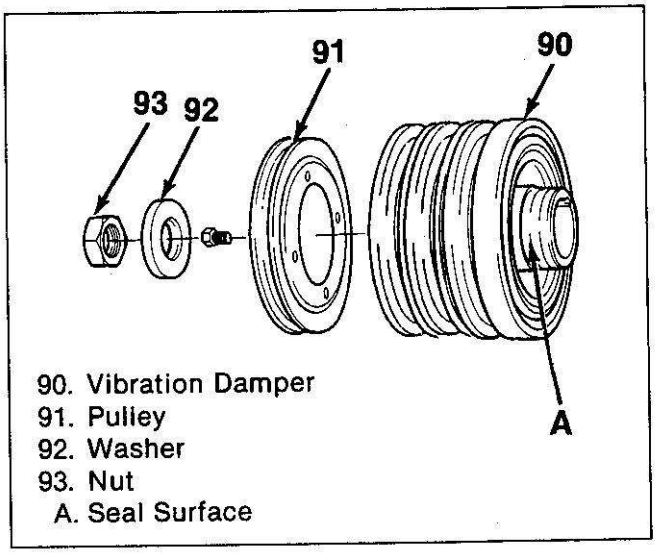
Inspect (Figures 71 and 72)

- Oil seal mating surface (A) on the vibration damper shaft for roughness or grooving (figure 71). Replace the vibration damper (90) and timing cover oil seal (100) if this condition exists (figure 72).



A. Reference Punch Mark on Bolt
B. Reference Punch Mark on Connecting Rod Cap

Figure 70. Angle Torquing Method for Connecting Rod Bolts



90. Vibration Damper
91. Pulley
92. Washer
93. Nut
A. Seal Surface

Figure 71. Crankshaft Damper and Pulley

Install or Connect (Figure 71)

1. Timing cover oil seal (100). Tap into place, using a block of wood to protect the seal. Lubricate the seal lips with grease. Refer to "Timing Cover Replacement" in this section.
2. Vibration damper (90).

3. Lubricate the nut (93) threads with grease containing molybdenum disulfide.
4. Nut (93) and washer (92).

Tighten

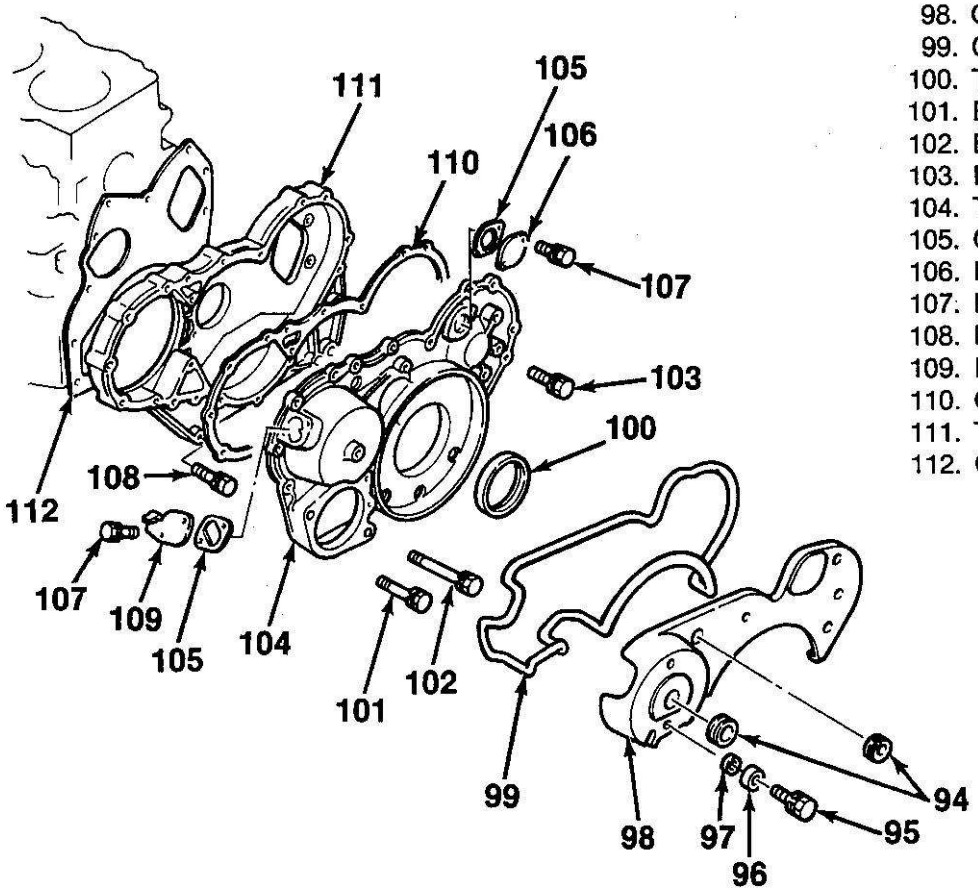
- Nut (93) to 413 N·m (305 lb·ft).

5. Water pump and generator belts. Refer to ENGINE ELECTRICAL (SEC. 6D).
6. Air conditioning compressor belt. Refer to AIR CONDITIONING (SEC. 1B).
7. Radiator. Refer to RADIATOR (SEC. 6B2).
8. Battery cables.

TIMING COVER REPLACEMENT

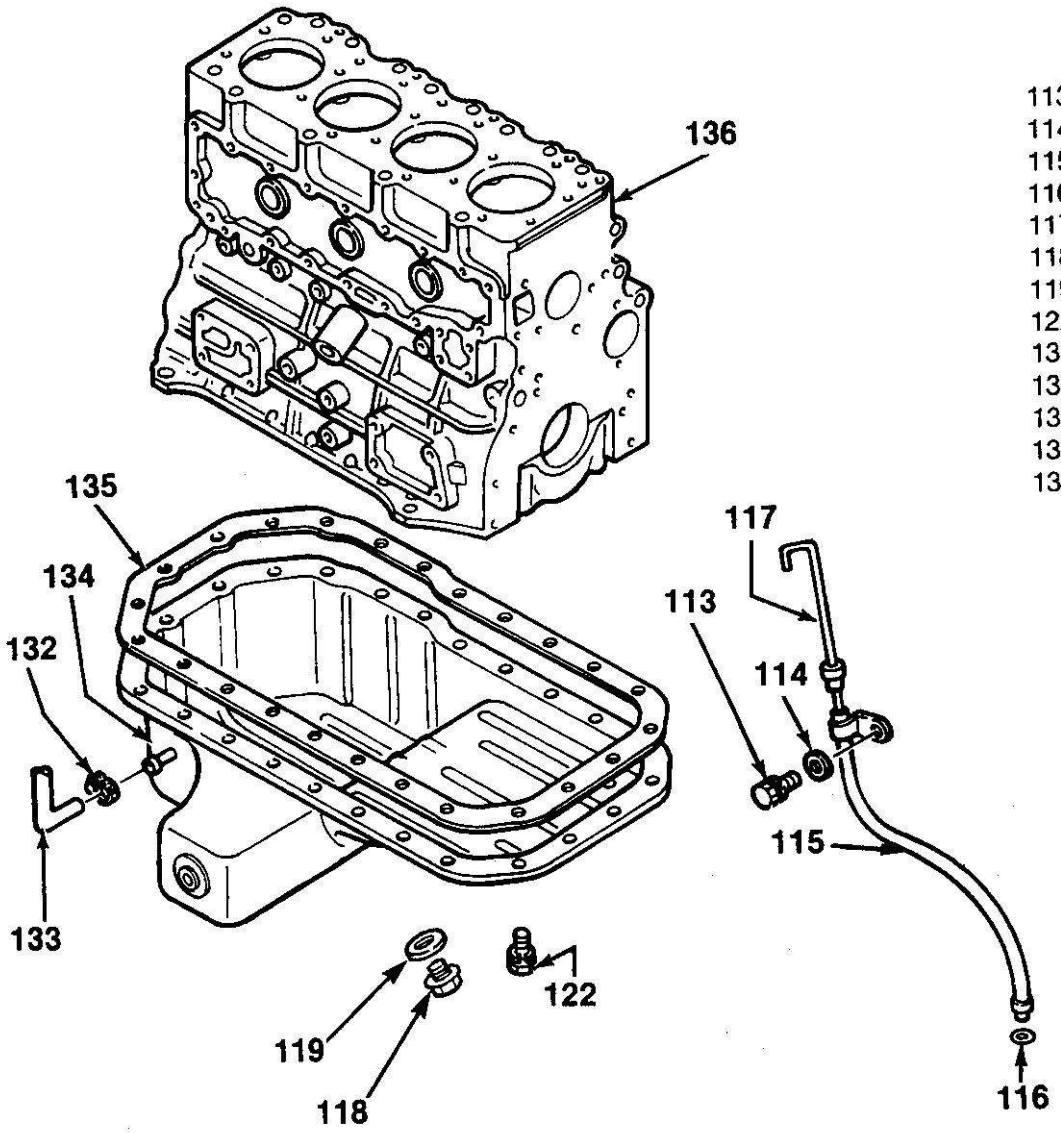
Remove or Disconnect (Figure 72)

1. Battery cables.
2. Vibration damper (90) as outlined in "Vibration Damper Replacement" previously in this section.
3. Outer cover bolts (95) and cover (98).
4. Bolts (103).
5. Timing cover (104) and gasket (110).
6. Timing cover oil seal (100) from the timing cover (104). Pry the seal out with a screwdriver.



94. Plug
95. Bolt
96. Washer
97. Insulator
98. Outer Cover
99. Cover Seal
100. Timing Cover Oil Seal
101. Bolt
102. Bolt
103. Bolt
104. Timing Cover
105. Gasket
106. Inspection Cover
107. Bolt
108. Bolt
109. Inspection Cover
110. Gasket
111. Timing Case
112. Gasket

Figure 72. Timing Gear Housing, Case and Cover



113. Bolt
114. Washer
115. Dipstick Tube
116. O-Ring
117. Dipstick
118. Plug
119. Gasket
122. Bolt
132. Clamp
133. Tube
134. Oil Pan
135. Gasket
136. Cylinder Block

Figure 73. Oil Pan Attachment

Clean (Figure 72)

- Old gasket (110) from the timing cover (104) and block.

Inspect (Figure 72)

- Timing cover and outer cover (98, 104) for damage.

Install or Connect (Figure 72)

1. Seal (100) to the timing cover (104).
   - Use a block of wood or Seal Driver 3-35004 to protect the seal.
   - Lubricate the seal lips with grease.
2. Timing cover (104) and gasket (110).
3. Bolts (103).

Tighten

- Bolts (103) to 20 N·m (14 lb·ft)

4. Outer cover (98) and bolts (95).
5. Vibration damper (90) as outlined previously in "Vibration Damper Replacement" in this section.
6. Battery cables.

OIL PAN REPLACEMENT

Remove or Disconnect (Figure 73)

1. Dipstick tube bolt (113) and washer (114).
2. Dipstick (117), dipstick tube (115), and seal (O-ring) (116).
3. Oil pan plug (118) and gasket (119). Drain oil.
4. Crankcase breather tube clamp (132) and tube (133).
5. Bolts (122).
6. Oil pan (134) and gasket (135).

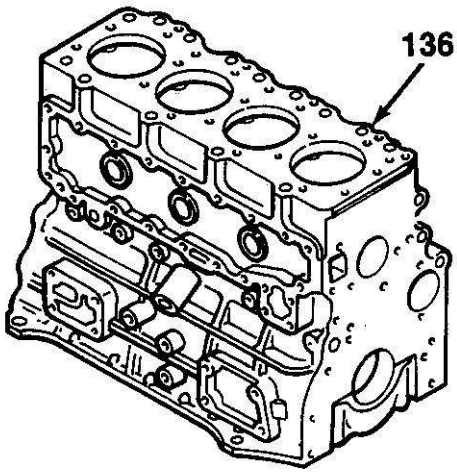
Clean (Figure 73)

- Old gasket(135) from the oil pan (134) and block (136).
- Sludge and dirt from the inside of the oil pan (134).

Install or Connect (Figure 73)

- Apply gasket sealer to the cylinder block at the points where the front and rear main bearing caps and oil seal retainers meet the oil pan gasket flange of the cylinder block.

1. Oil pan gasket (135) to cylinder block (136).



136. Cylinder Block
137. Bolt
138. Bolt
139. Bolt
140. Pipe
141. Oil Pump

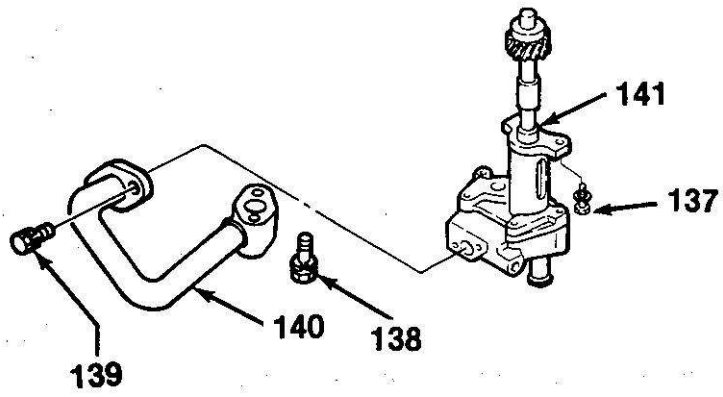


Figure 74. Oil Pump Attachment

2. Oil pan (134).
3. Bolts (122).

Tighten

- Bolts (122) to 20 N·m (14 lb·ft).

4. Crankcase breather tube (133) and clamp (132).
5. Oil pan plug (118) and gasket (119).
6. O-ring (116) to dipstick tube (115).
7. Dipstick tube (115) to oil pan (134).
8. Dipstick tube bolt (113) and washer (114).
9. Dipstick (117).
   - Fill the crankcase with the proper quantity and grade of oil. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

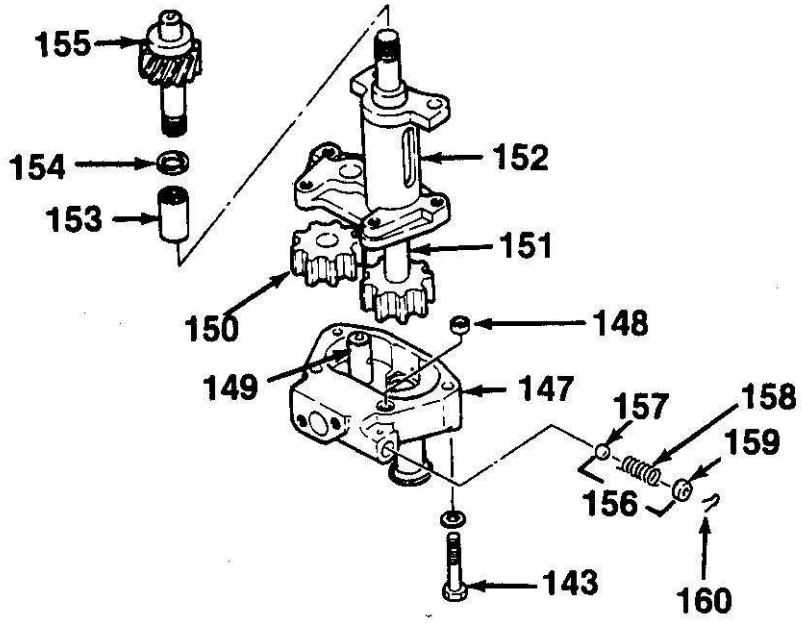
OIL PUMP

Remove or Disconnect (Figure 74)

1. Oil pan (134) as outlined previously in this section.
2. Oil pump pressure pipe (140).
3. Bolts (137).
4. Oil pump (141).

Disassemble (Figure 75)

1. Bolts (143).
2. Cover (147) and dowel (148).
3. Driven shaft (149), driven gear (150), and drive shaft and gear (151).
4. Body (152) and coupling (153).
5. O-ring (154) and pinion (155).
6. Relief valve (156).



143. Bolt
147. Cover
148. Dowel
149. Driven Shaft
150. Driven Gear
151. Drive Shaft and Gear
152. Body
153. Coupling
154. O-Ring
155. Pinion
156. Relief valve
157. Ball
158. Spring
159. Seat
160. Cotter pin

Figure 75. Oil Pump

Clean

- All parts is solvent. Blow dry with compressed air.

Inspect (Figure 75)

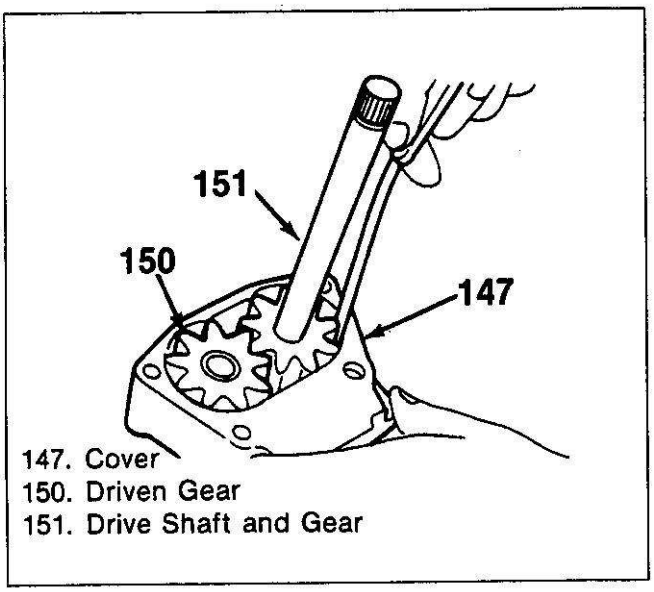
— Body (152) for cracks or damage.
— Gears (150, 151), and cover (147) for pitting or wear.

Measure (Figures 76, 77 and 78)

— Gear teeth to cover inner wall clearance as shown in figure 76. Use a feeler gage, as shown.
The clearance must not exceed 0.18 mm (0.007 in). If excessive, replace the pump assembly.
— Cover and gear end clearance, as shown in

figure 77. Use a straightedge and feeler gage, as shown. The clearance must not exceed 0.12 mm (0.0047 in). If excessive, replace the cover and gear set.

— Drive and driven shaft diameters as shown in figure 78. If the diameter is less than 15.9 mm (0.63 in), replace the shaft and gear set.



147. Cover
150. Driven Gear
151. Drive Shaft and Gear

Figure 76. Checking Oil Pump Gear-to-Cover Clearance

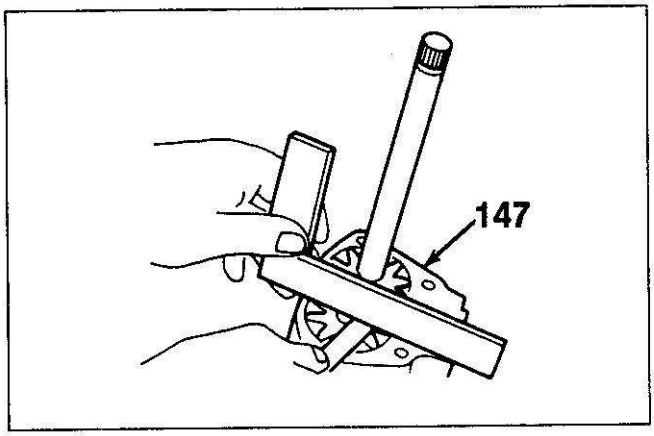
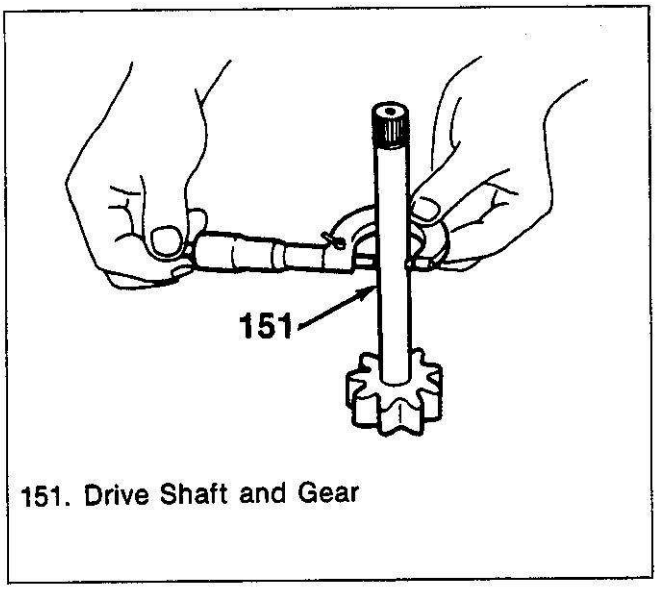


Figure 77. Checking Oil Pump Cover and Gear End Clearance



151. Drive Shaft and Gear

Figure 78. Check Oil Pump Drive and Driven Shaft Diameter

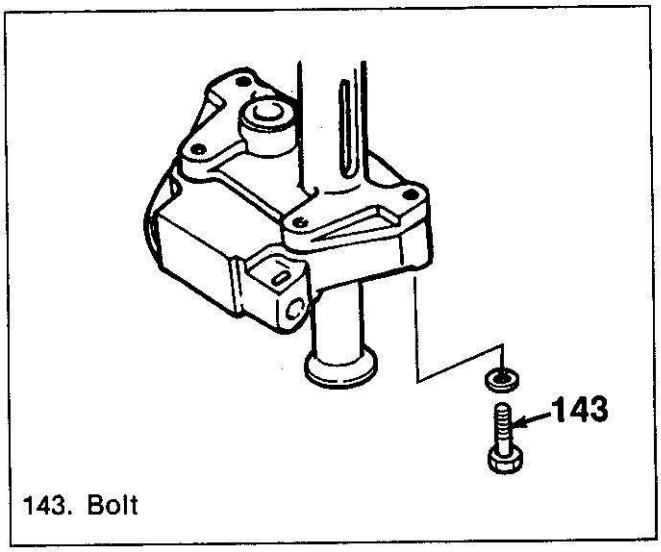
Assemble (Figures 75 and 78a)

1. Ball (157), spring (158), seat (159) and cotter pin (160) to cover (147).
2. Drive shaft and gear (151) to body (152).
3. Driven shaft (149), gear (150) and cover (147) to body (152).
4. Bolts (143).

Tighten

- Oil pump cover bolt to 16 N·m (12 lb·ft).

5. Coupling (153), O-ring (154), and pinion (155).
6. When assembling the pinion gear, apply engine oil mixed with approximately 20% of MoSz (Molybdenum disulfide) to the entire surface of gear teeth.



143. Bolt

Figure 78a. Assembling Oil Pump

Install or Connect (Figure 74)

- Fill oil pump with oil.

1. Oil pump (141) to the engine.
2. Bolts (137).

Tighten

- Bolts (137) to 52 N·m (38 lb·ft).

3. Oil pump pressure pipe (140) bolts (138 and 139).

Tighten

- Oil pump pressure pipe bolts to 26 N·m (20 lb·ft).

4. Oil pan (134) as outlined in "Oil Pan Replacement" previously in this section.

TIMING GEAR REPLACEMENT

Idler Gear Replacement

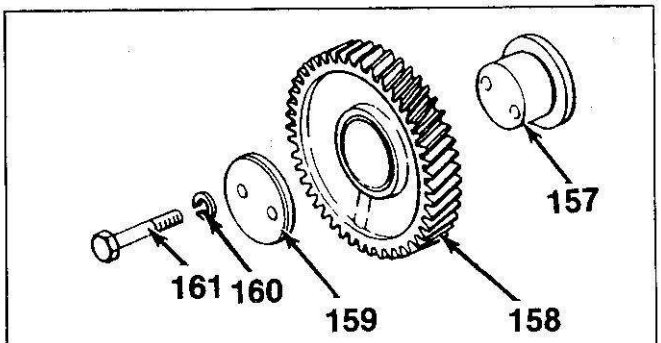
Remove or Disconnect (Figures 79-82)

1. Timing cover (104) as outlined in "Timing Cover Replacement" previously in this section.

Measure

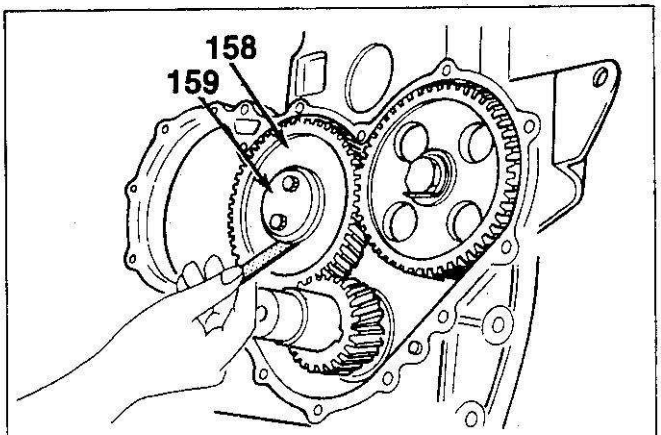
- Idler gear (158) end play, as shown in figure 80. Production end play is 0.058–0.115 mm (0.002–0.005 in). If greater than 0.2 mm (0.008 in), the idler gear (158) and/or hub (157) should be replaced.
- Gear backlash. Use a dial indicator with a magnetic base as shown in figure 81. The plunger should rest against the teeth of the idler gear (158). Turn the idler gear back and forth and read the backlash (figure 81). Production backlash is 0.10–0.17 mm (0.004–0.007 in). Service limit is 0.3 mm (0.012 in).
  If excessive, replace the worn gear or gears.
  — Turn the crankshaft until the timing marks align, as shown in figure 82.

2. Bolts (161), and washer (160).
3. Plate (159).
4. Idler gear (158).
5. Idler gear hub (157) (if required). Pry the hub from the block to remove. The locating pin on the rear of the hub is easily broken during removal. Removal is not recommended unless the hub is to be replaced.



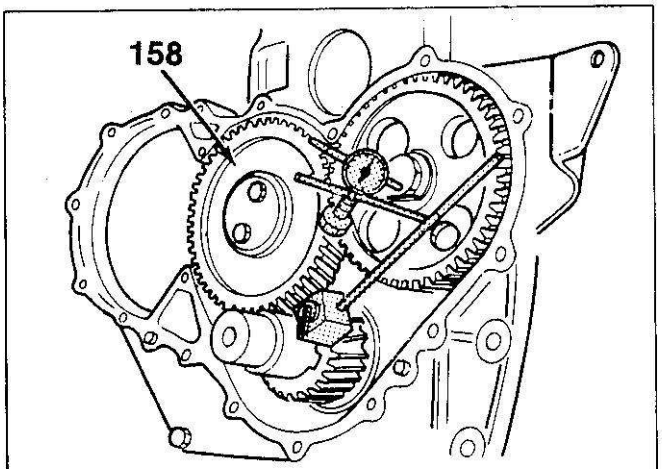
157. Hub
158. Idler Gear
159. Plate
160. Washer
161. Bolt

Figure 79. Timing Idler Gear and Hub



158. Idler Gear
159. Plate

Figure 80. Measuring Idler Gear End Play



158. Idler Gear

Figure 81. Measuring Gear Backlash

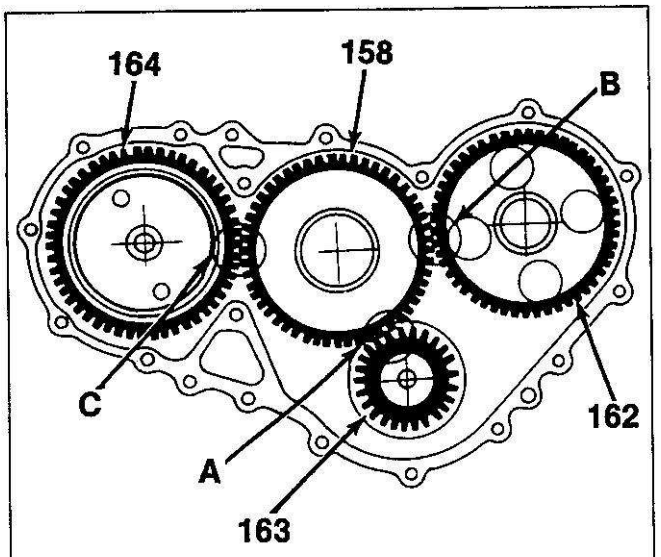
Inspect (Figure 79)

— Gear teeth for chips or excessive wear.
— Gear bushing for scoring or damage.
— Hub (157) for scoring or damage.

Measure (Figures 79, 83 and 84)

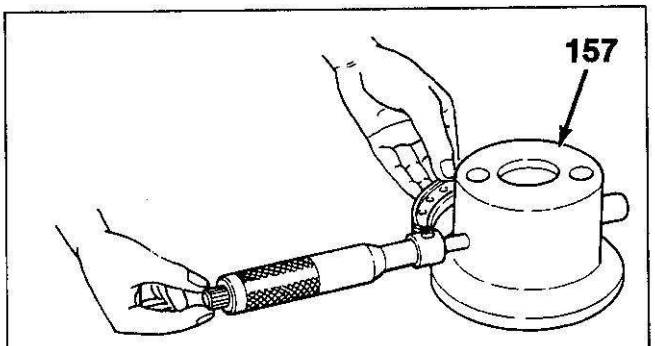
Hub (157) to gear bushing clearance, as follows:

- Hub outside diameter, using a micrometer (figure 83).
- Idler gear bushing inside diameter, using an inside micrometer (figure 84).
- Subtract the hub outside diameter from the idler gear bushing inside diameter to obtain the hub to idler gear bushing clearance.
  Production clearance is 0.009–0.060 mm (0.00035–0.0024 in). Service limit is 0.2 mm (0.0079 in). If excessive, replace the hub or gear as required. The bushing is not available separately.



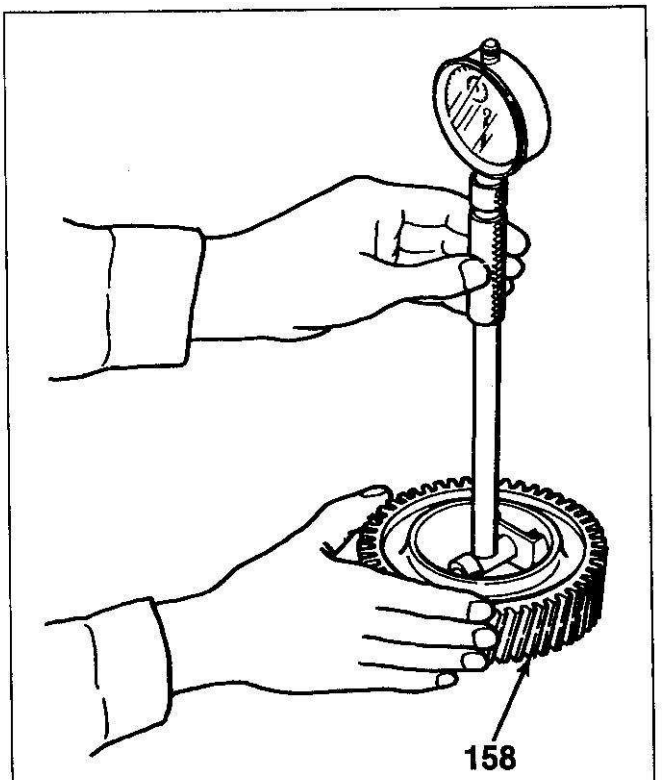
158. Idler Gear
162. Camshaft Gear
163. Crankshaft Gear
164. Injection Pump Drive Gear
A. "A" Marks
B. "B" Marks
C. "C" Marks

Figure 82. Gear Train Timing Marks



157. Idler Gear Hub

Figure 83. Measuring Idler Gear Hub Diameter



158. Idler Gear

Figure 84. Measuring the Idler Gear Inside Diameter

Install or Connect (Figures 79 and 82)

1. Hub (157) to the block (if removed). The oil hole must face toward the camshaft side of the block. Use the bolts (161) as a guide when driving the hub into place.
   - Lubricate the hub (157) with engine oil.
2. Idler gear (158).

Important

- The timing marks must align as shown in figure 82.

3. Plate (159). The chamfer faces away from the idler gear (158).
4. Bolts (161) and washer (160).

Tighten

- Bolts (161) to 52 N·m (38 lb-ft).

5. Timing cover (104) as outlined in "Timing Cover Replacement" previously in this section.

Camshaft Gear Replacement

The camshaft must be removed, and the gear removed with a press. Refer to "Camshaft and Bearings" later in this section.

Crankshaft Gear Replacement

Refer to "Crankshaft and Main Bearings" later in this section.

CAMSHAFT AND BEARINGS

Refer to "Statement on Cleanliness and Care," previously mentioned in this section.

Remove or Disconnect (Figures 85, 86 and 87)

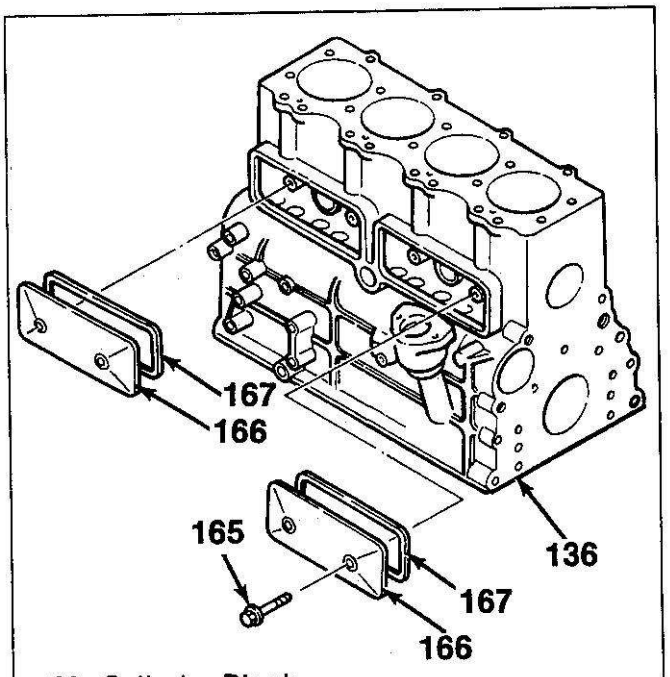
1. Radiator and hoses. Refer to RADIATOR (SEC. 6B2) in this manual.
2. Timing cover (104) as outlined in "Timing Cover Replacement" previously in this section.
3. Tappet covers (166) (figure 85).
4. Valve train components, as outlined in "Valve Train Component Replacement" previously in this section.
   - Pull the tappets (168) up as far as they will go (figure 86).
   - Secure the tappets (168) with wire (169) (figure 86).
5. Bolts (171) and cover (172) (figure 86).
6. Oil pump drive gear (170) (figure 86).
   - Turn the crankshaft until the timing marks align as shown in figure 82.
7. Idler gear (158) as outlined in "Timing Gear Replacement" previously in this section.
8. Bolts (173) (figure 87).
9. Camshaft (174) with camshaft gear (176) from the block. Support the camshaft carefully to prevent damage to the camshaft and bearings.
10. Tappets (168) as follows:
    - Remove the oil pan (134) as outlined in "Oil Pan Replacement" previously in this section.
    - Remove the tappets from the underside of the engine.

Inspect (Figures 85, 86, 87 and 88)

— Tappets (168) for wear or damage (figure 88).
— Camshaft (174) lobes and bearing journals for pitting, galling, or scratches.
— Camshaft gear (176) for chipped or broken teeth.
— Oil pump drive gear (170) for chipped or broken teeth.

Measure (Figures 89-94)

— Refer to "Specifications" at the end of this section for proper tolerances.



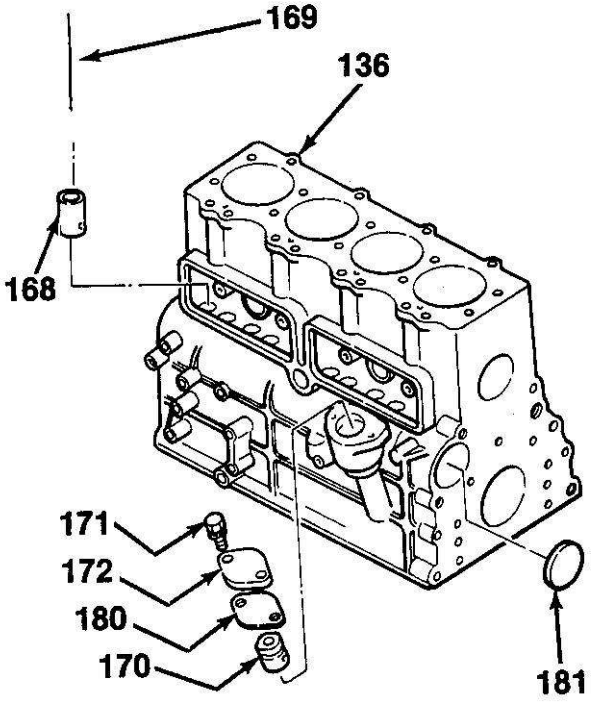
136. Cylinder Block
165. Tappet Cover Bolt
166. Tappet Cover
167. Gasket

Figure 85. Tappet Chamber Covers

1. Tappet (168) body diameter, using a micrometer as shown in figure 89. The production diameter is 27.97–27.98 mm (1.1020–1.1024 in). The service limit is 27.92 mm (1.1000 in).
2. Tappet (168) to tappet bore clearance.
   - Measure the tappet bore diameter in the block, using an inside micrometer.
   - Subtract the tappet body diameter, as measured previously, from the tappet bore diameter to obtain the clearance.
   - The production clearance is 0.02–0.054 mm (0.0007–0.0021 in). The service limit is

0.1 mm (0.004 in).

3. Camshaft (174) to thrust plate (178) clearance (camshaft end play) (figure 90). Use a feeler gage as shown. The production clearance is 0.050–0.114 mm (0.0002–0.0045 in). If more than 0.2 mm (0.008 in), replace the thrust plate as outlined later in this section.
4. Camshaft (174) journal diameter using a micrometer (figure 91). Measure in two places, as shown.
   The production diameter is 55.94–55.97 mm (2.2040–2.2052 in). The service limit is 55.60 mm (2.1906 in).
5. Camshaft bearing inside diameter (figure 92). The correct measurement is 56.00–56.03 mm (2.2064–2.2076 in).



136. Cylinder Block
168. Tappet
169. Wire for Securing Tappet
170. Oil Pump Drive Gear
171. Bolt
172. Cover
180. Gasket
181. Plug

Figure 86. Removing or Installing the Oil Pump Drive Gear

6. Camshaft (174) journal to camshaft bearing clearance.
   - Subtract the camshaft journal diameter from the camshaft bearing inside diameter to obtain the clearance.
   - The production clearance is 0.03–0.09 mm (0.0012–0.0035 in). The service limit is 0.15 mm (0.006 in).
7. Camshaft (174) lobe height (figure 93). Measure in two places, as shown. Replace the camshaft if the lobe height is less than 46.55 mm (1.832 in).
8. Camshaft (174) runout (figure 93). Replace the camshaft if the runout is more than 0.10 mm (0.0039 in).

Camshaft Gear and Thrust Plate Replacement

Tool Required:
J-22912-01 Bearing Separator, or equivalent

1. Remove the bolt (177) and washer (175).
2. Remove the camshaft gear (176).
   - Support the camshaft gear (176) in a press (figure 95).
   - Press the camshaft (174) out of the camshaft gear (176).
3. Remove the thrust plate (178).
4. Remove the key (179).

Clean (Figure 87)

- Camshaft gear (176) bore and keyway.
- Camshaft (174) end where the camshaft gear (176) fits.

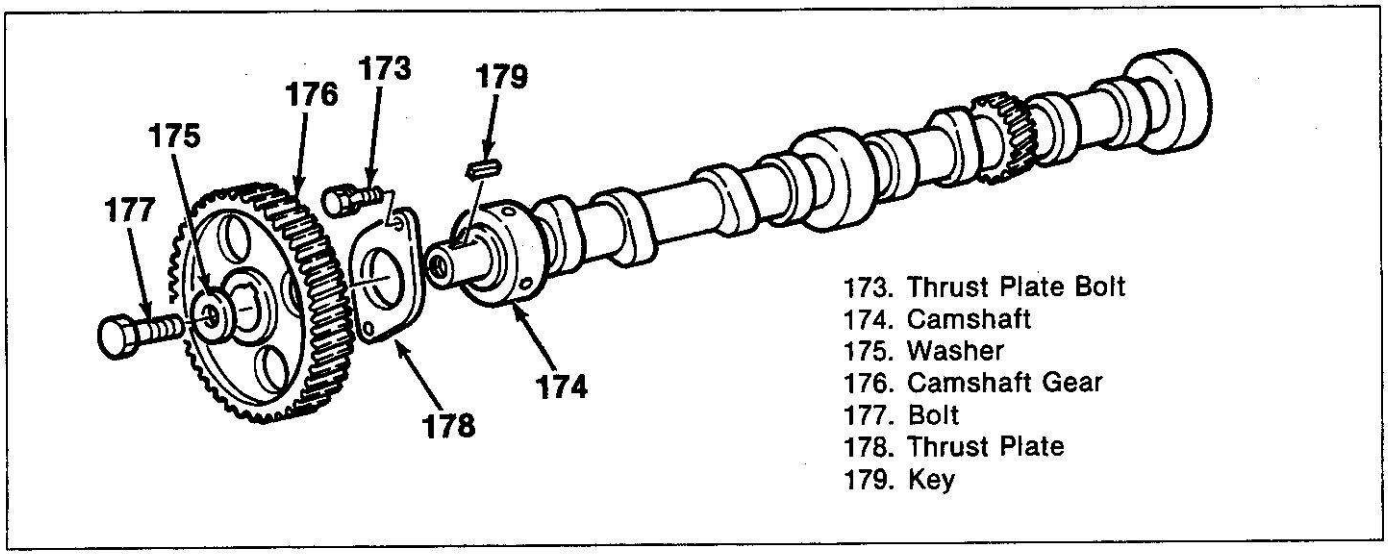


Figure 87. Camshaft and Components

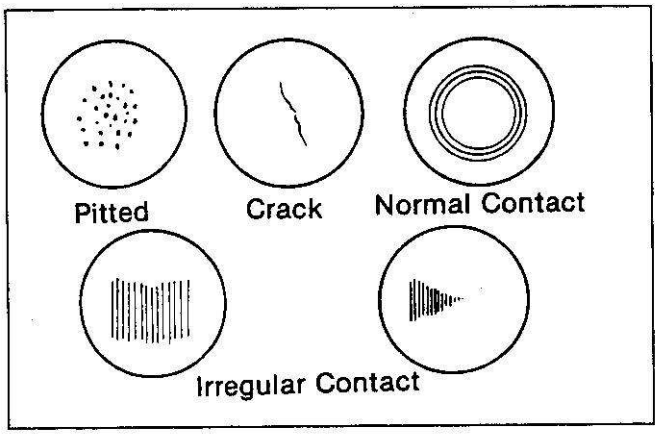


Figure 88. Tappet Inspection

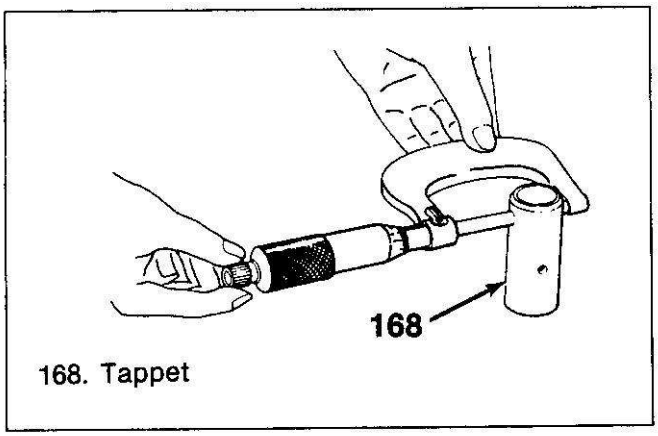


Figure 89. Tappet Measurement

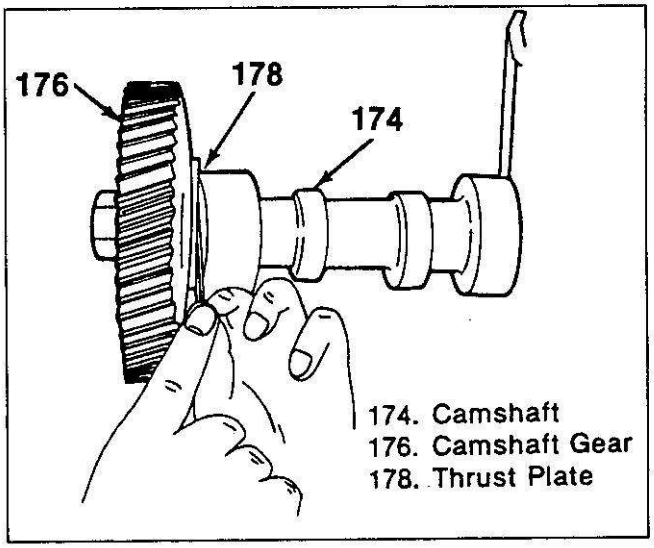


Figure 90. Measuring Camshaft End Play

5. Lubricate the thrust plate (178) with engine oil.
6. Install the thrust plate (178) to the camshaft (174).
7. Install the key (179).
8. Install the camshaft gear (176).
   - Support the camshaft (174) in a press behind the front cam bearing journal. Use tool J-22912-01, or equivalent, as shown in figure 96.
   - Press the camshaft gear (176) into place. Be sure the timing mark faces outside.
9. Install the bolt (177) and washer (175).

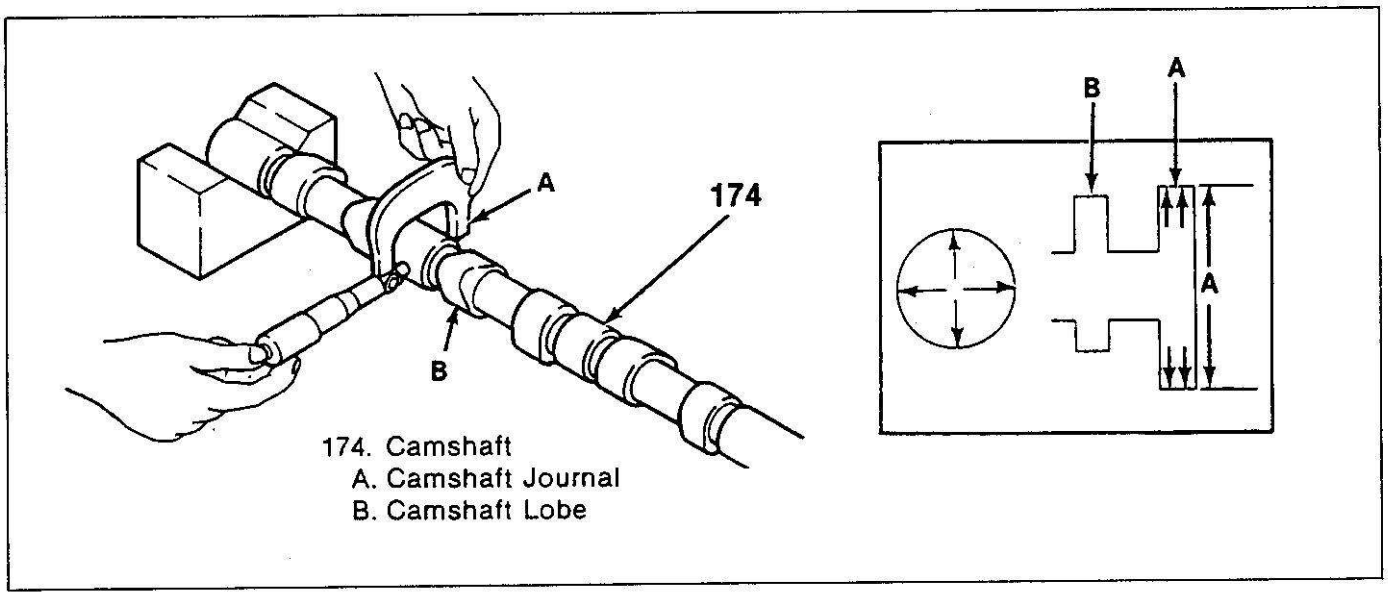


Figure 91. Measuring the Camshaft Journal

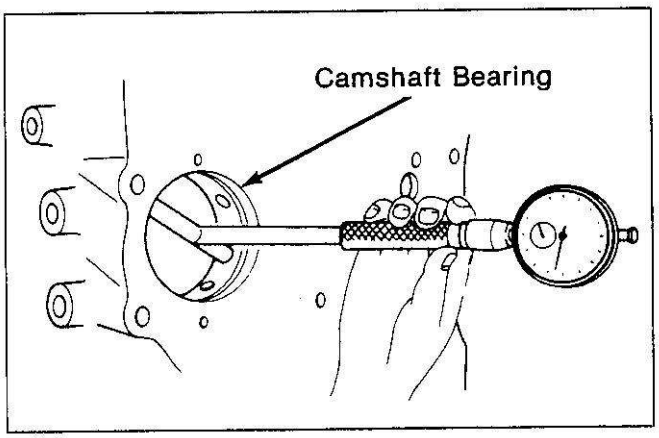


Figure 92. Measuring the Camshaft Bearing Inside Diameter

Tighten

- Bolts (177) to 132 N·m (98 lb·ft)

Camshaft Bearing Replacement

The camshaft bearings are a press fit in the block. Three camshaft bearings are used. The camshaft bearings can be replaced with the engine in the vehicle if desired. However, it may be difficult to see the alignment of the oil holes in the bearings and block at assembly.

Tools Required:

J-7593-20 Camshaft Bearing Tool, or equivalent

J-7593-19 Handle, or equivalent

1. Remove the engine assembly, if desired. Refer to ENGINE (SEC. 6A) in this manual.
2. Remove the flywheel and flywheel housing, as outlined later in this section.
3. Remove the camshaft hole plug (181).
4. Remove the camshaft bearings (182), using tool J-7593-20 and tool J-7593-19 (figure 97).

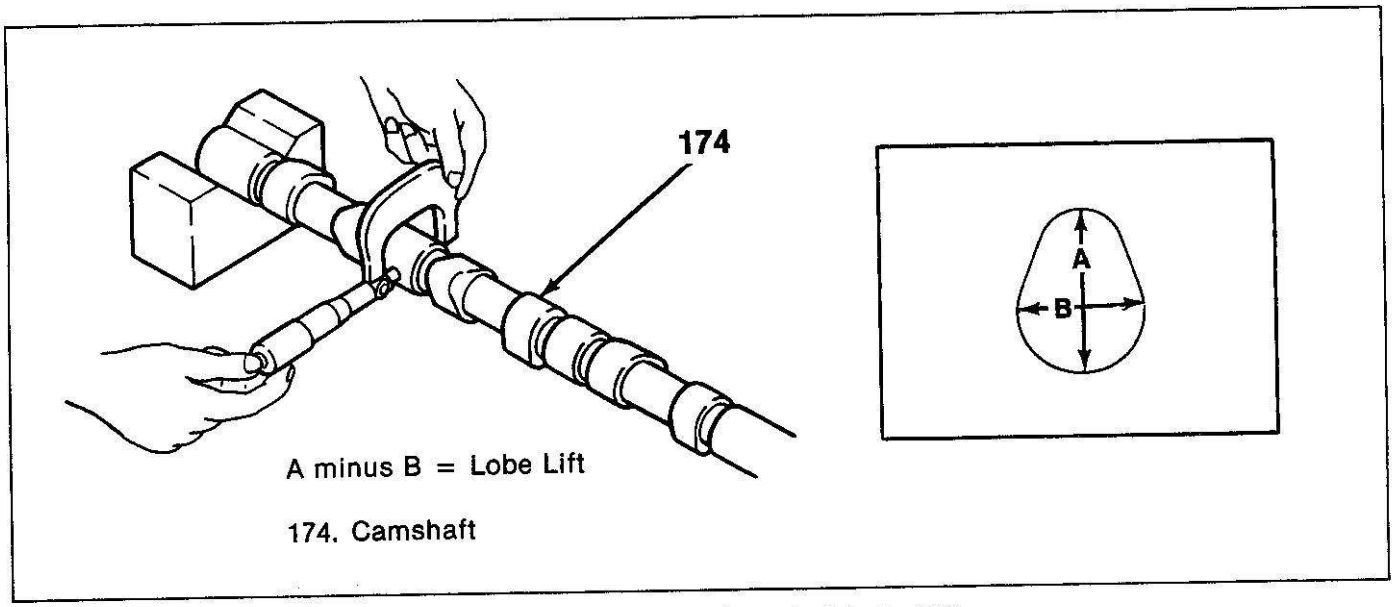


Figure 93. Measuring Camshaft Lobe Lift

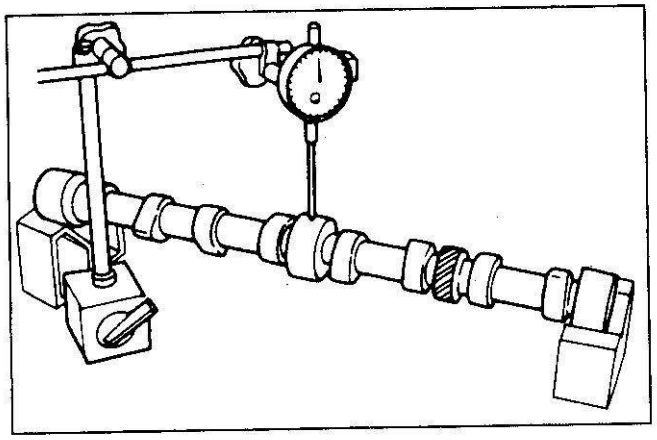


Figure 94. Measuring Camshaft Runout

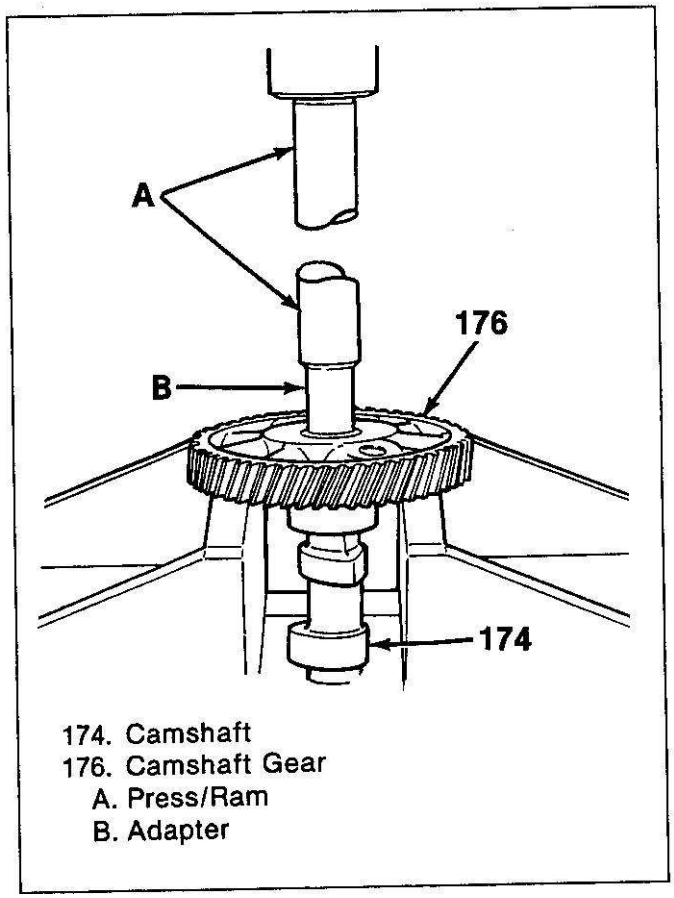


Figure 95. Removing the Camshaft Gear

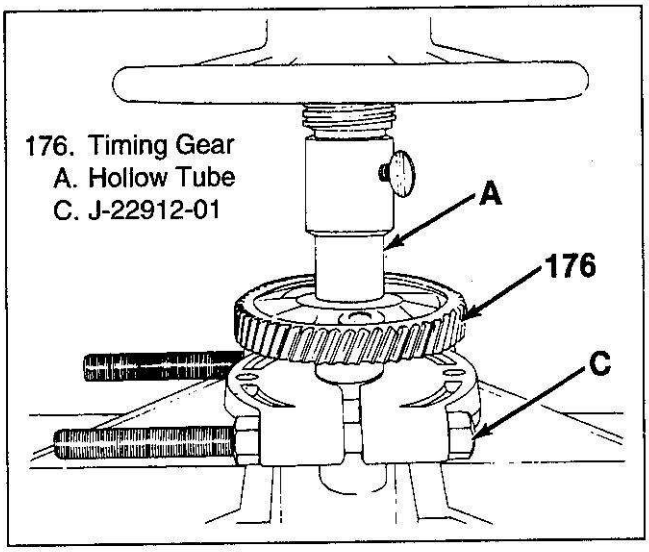


Figure 96. Installing the Camshaft Gear

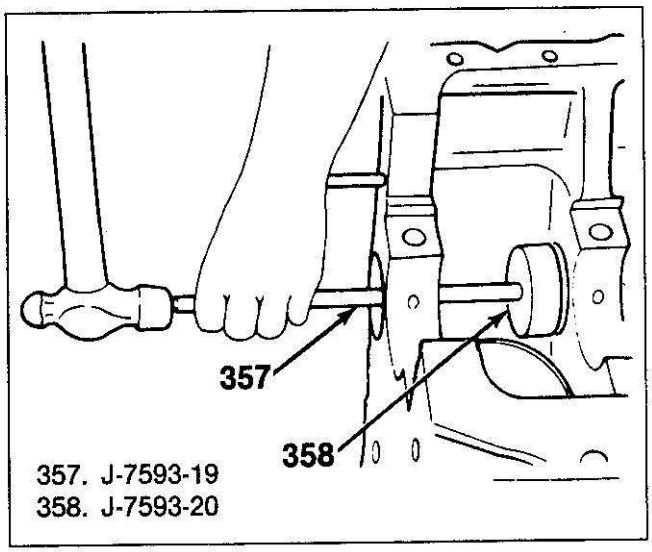


Figure 97. Removing or Installing the Camshaft Bearings

5. Install the camshaft bearings to the block, using tool J-7593-20 and J-7593-19 (figure 97).

Important

- The front camshaft bearing (182) is different from the other camshaft bearings and they should never be interchanged. The front camshaft bearing has two oil holes. The other camshaft bearings have one oil hole.

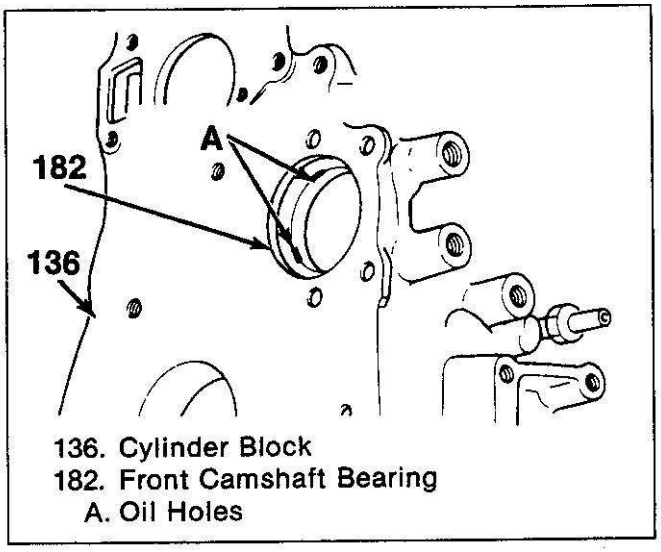
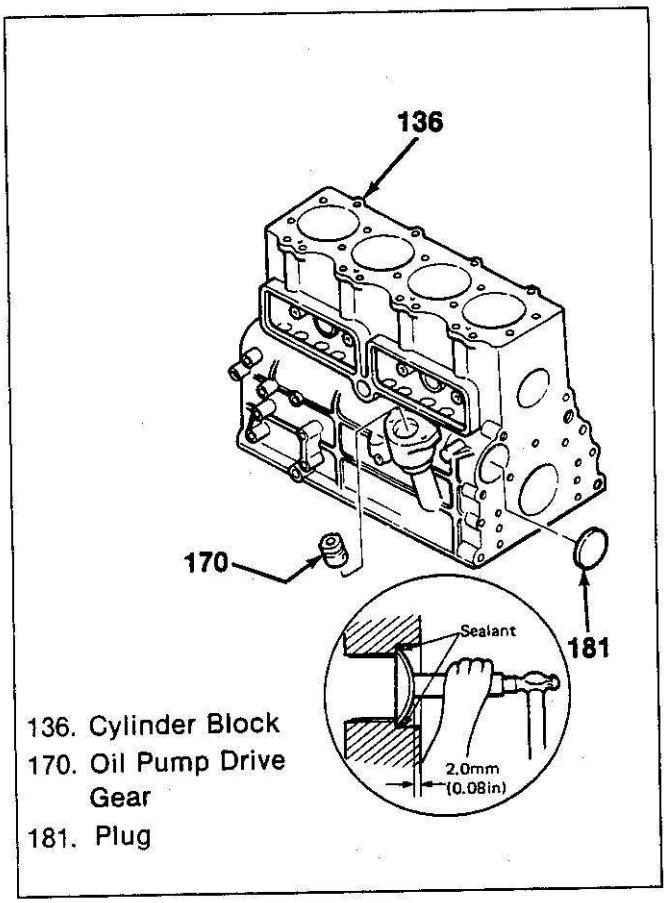


Figure 98. Aligning Camshaft Bearing Oil Holes

- The oil holes in the camshaft bearings (182) MUST align with the oil drillings in the block (figure 98). When installing the front camshaft bearing (182) BOTH holes must align, as shown.
- Apply engine oil to the camshaft bearings after installation.

6. Install the camshaft hole plug (181).
   - Apply PERMATEX ® No. QM-50A, 80A, or equivalent to the plug (181).
   - Strike the convex portion of the plug correctly so that the plug may come to the bottom evenly (figure 98a).



136. Cylinder Block
170. Oil Pump Drive Gear
181. Plug

Figure 98a. Installing the Oil Pump Drive Gear and Plug

7. Install the flywheel and flywheel housing as outlined later in this section.
8. Install the engine assembly (if removed). Refer to ENGINE (SEC. 6A) in this manual.

Install or Connect (Figures 82, 85, 86 and 87)

- Apply engine oil to the tappets (168) (if removed).

1. Tappets (168) (if removed).
   - Push the tappets into place from underneath the engine.
   - Have an assistant secure the tappets with wire (figure 86).
2. Oil pan (134) (if removed), as outlined previously in this section.
   - Apply engine oil to the camshaft (174) lobes and journals.
3. Camshaft (174) with the camshaft gear (176) to the block. Support the camshaft to prevent damage to the camshaft or bearings.
4. Bolts (173).

Tighten

- Bolts (173) to 26 N·m (20 lb·ft).

5. Idler gear (158) as outlined previously in "Timing Gear Replacement" in this section.

Important

- Align the timing marks as shown in figure 82.

6. Oil pump drive gear (170) (figure 86).

Important

- Be sure the oil pump drive gear (170) fully engages the camshaft gear and oil pump shaft.

7. Cover (172), gasket (180), and bolts (171) (figure 86).

Tighten

- Bolts (171) to 26 N·m (20 lb·ft)

8. Remove the wire from the tappets (168) (figure 86).
9. Tappet covers (166), gaskets (167), and bolts (165) (figure 85).

Tighten

- Tappet cover bolts to 26N·m (20 lb·ft)

10. Timing cover (104) as outlined previously in this section.
11. Valve train components, as outlined previously in "Valve Train Component Replacement" in this section.

Adjust

- Valve clearance, as outlined previously in this section.

12. Radiator and hoses. Refer to RADIATOR (SEC.6B2) in this manual.

— Fill the radiator with the proper engine coolant. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

— Fill the crankcase with the proper quantity and grade of engine oil (if the oil pan [134] was removed). Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

FLYWHEEL REPLACEMENT

Remove or Disconnect (Figures 99 and 100)

1. Manual transmission and clutch or Automatic transmission and torque converter. Refer "MANUAL TRANSMISSION" (SEC 7B) or "AUTOMATIC TRANSMISSION" (SEC 7A) in this manual.

2. Bolts (184).
   - Loosen the bolts (184) in the sequence shown in figure 99.
   - Remove the bolts (184).
3. Plate (185) (figure 100).
4. Flywheel (183).

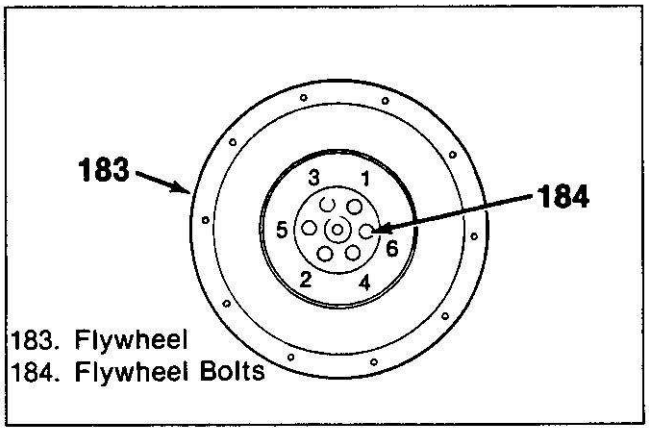
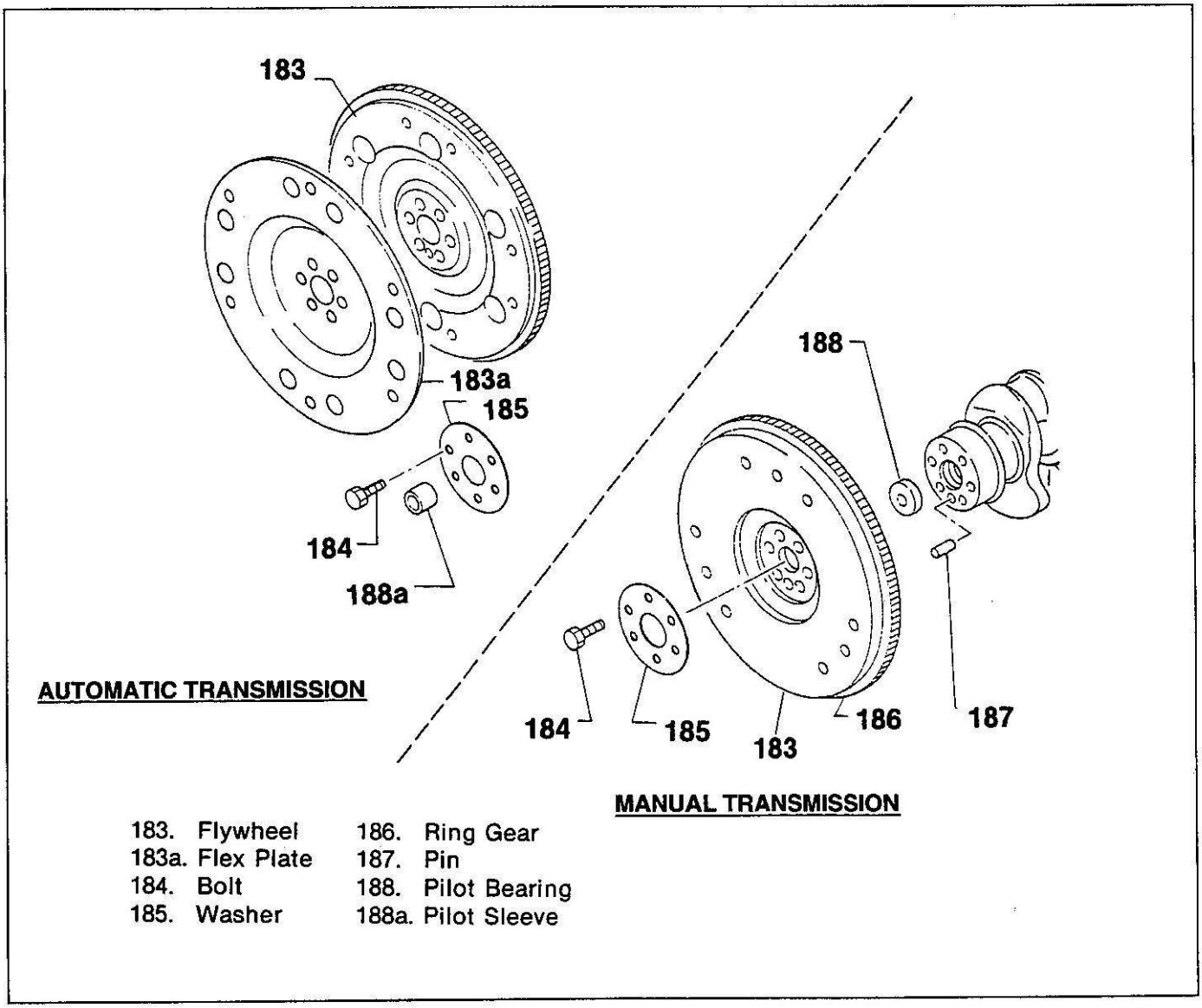


Figure 99. Flywheel Removal–Bolt Loosening Sequence



183. Flywheel
183a. Flex Plate
184. Bolt
185. Washer
186. Ring Gear
187. Pin
188. Pilot Bearing
188a. Pilot Sleeve

Figure 100. Flywheel and Attaching Parts

Inspect (Figures 100 and 100a)

- Friction surface for burning, scoring, warpage, and wear. Resurfacing or replace the flywheel (183), if necessary.

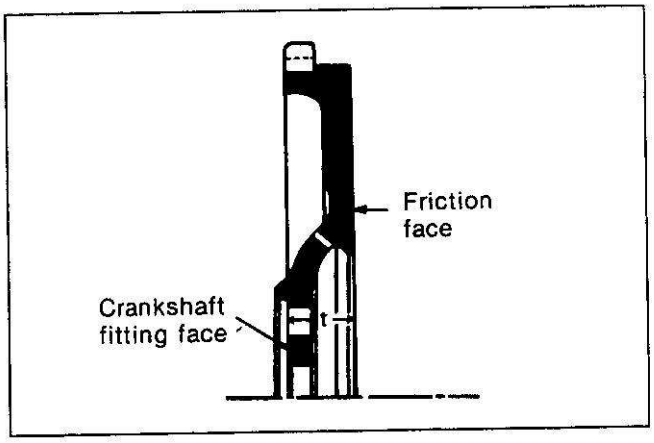


Figure 100a. Flywheel Thickness

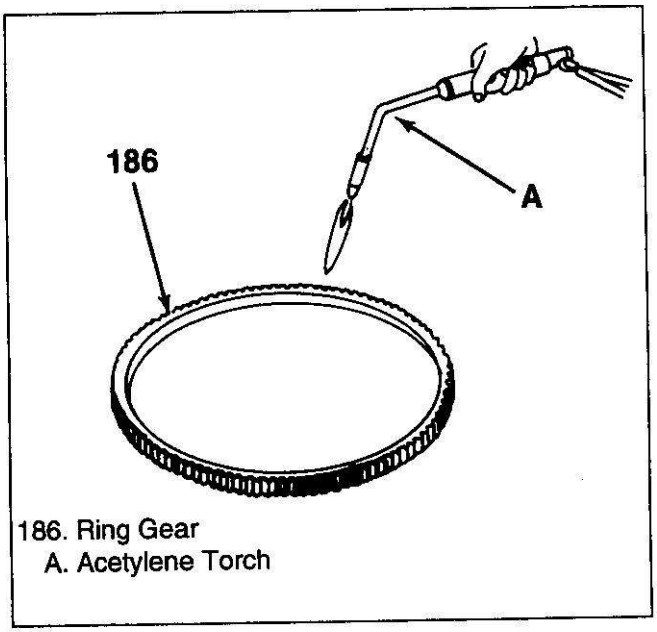
mm(in)

Standard Thickness; t	31.4–31.6 (1.236–1.244)
Limit; t	30.5(1.201)
Surface Finish	16–32 μ in

- Ring gear (186) for worn or damaged teeth.

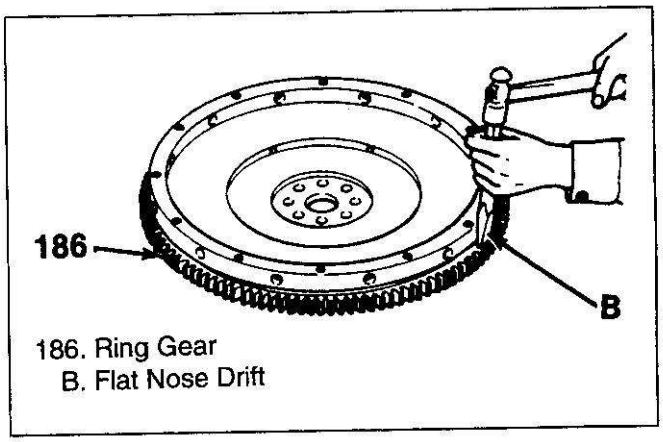
Ring Gear Replacement (Figures 101 and 101a)

1. Using a torch, heat the ring gear (186) evenly.
2. Drive the ring gear (186) off the flywheel (183), using a drift (B) and hammer. Take care not to damage the wheel.



186. Ring Gear
A. Acetylene Torch

Figure 101. Heating the Flywheel Ring Gear

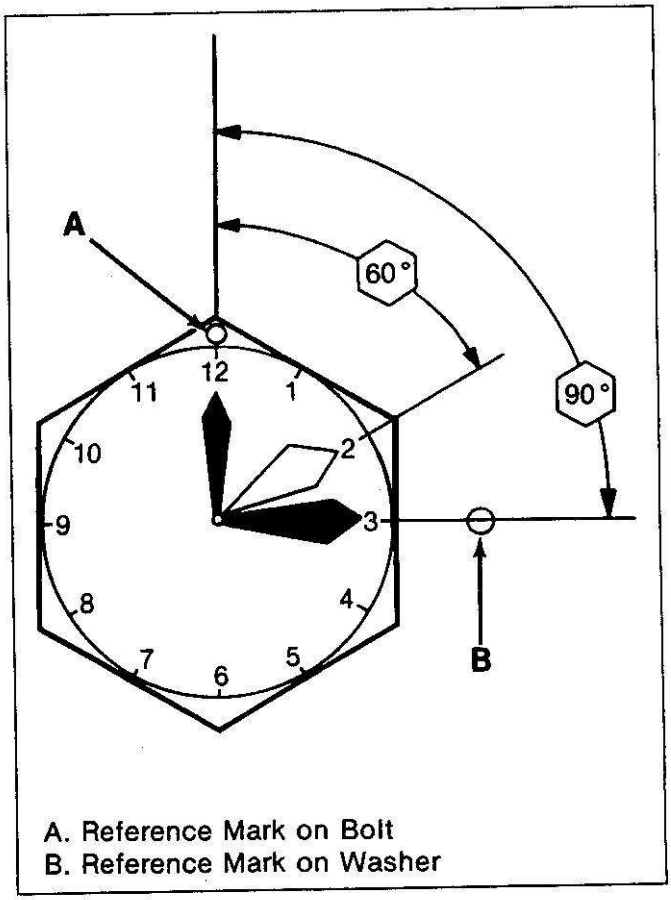


186. Ring Gear
B. Flat Nose Drift

Figure 101a. Removing or Installing the Flywheel Ring Gear

NOTICE: Never heat the ring gear to red heat, as this will change its metal structure.

3. Uniformly heat the ring gear (186) to a temperature that will permit installation. Do not exceed 120 °C (250 °F).
4. Drive the ring gear (186) onto the flywheel (183).



A. Reference Mark on Bolt
B. Reference Mark on Washer

Figure 102. Angle Torquing Method for Flywheel Bolts

Install or Connect (Figures 99, 100 and 102)

1. Flywheel (183) or flexible plate (183a-Automatic transmission only) to the crankshaft.
   - Apply molybdenum disulfide grease to the bolts (184) threads and bolt head seat, except new bolts.
2. Washer (185) and bolts (184).

Tighten

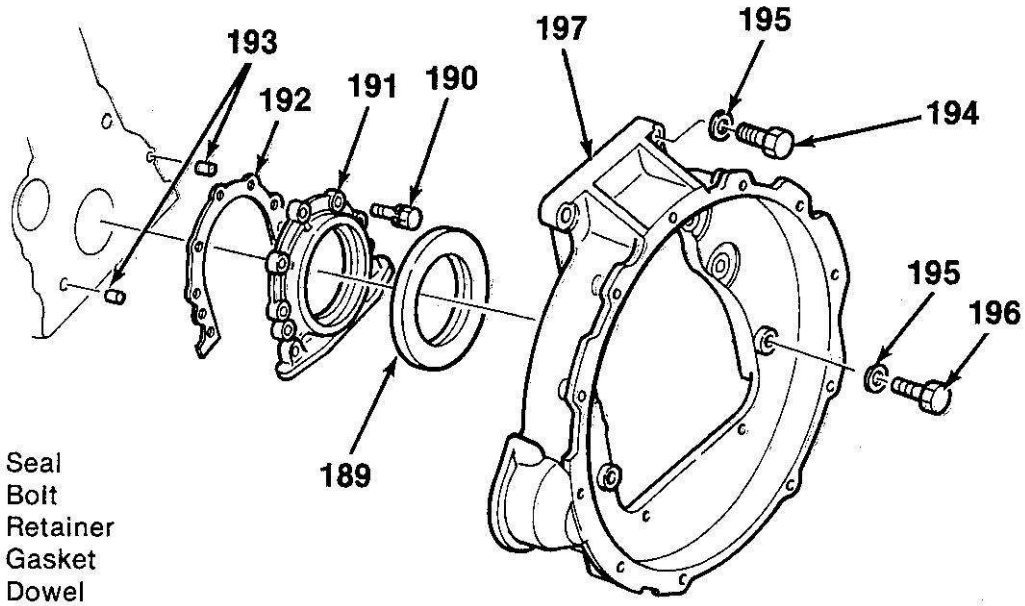
Bolts (184) in two stages, as follows:
- Stage 1: Tighten bolts to 39 N·m (29 lb·ft).
- Stage 2: Refer to figure 102. Make a mark on the bolt heads, as shown. Then make a second mark on the washer. 60–90 degrees clockwise from the first mark. Tighten bolts 60–90 degrees (until the marks align). Using the sequence shown in figure 99.

3. Manual transmission and clutch or automatic transmission and torque converter. Refer to MANUAL TRANSMISSION (SEC 7B) or AUTOMATIC TRANSMISSION (SEC. 7A).

REAR CRANKSHAFT SEAL REPLACEMENT

Remove or Disconnect (Figure 103)

1. Flywheel (183) as outlined previously in "Flywheel Replacement" in this section.
2. Bolts (190) and seal retainer (191).
3. Seal (189). Use a slide hammer-type seal puller or pry seal from retainer (191).



189. Seal
190. Bolt
191. Retainer
192. Gasket
193. Dowel
194. Bolt
195. Washer
196. Bolt
197. Flywheel Housing

Figure 103. Rear Crankshaft Seal and Retainer

Install or Connect (Figures 99, 100, 103 and 104)

Tool Required:
J-34543 Seal Installer

1. Apply grease to the seal (189) lips.
2. Seal (189).
   - The open (spring) side of the seal must face the engine, block (figure 103).
   - Drive the seal (189) into the retainer(191), using tool J-34543 (figure 104).
3. Gasket (192) and retainer (191) to cylinder block (figure 103) in "Flywheel Replacement".

Tighten

- Bolts (190) to 26 N·m (20 lb·ft).

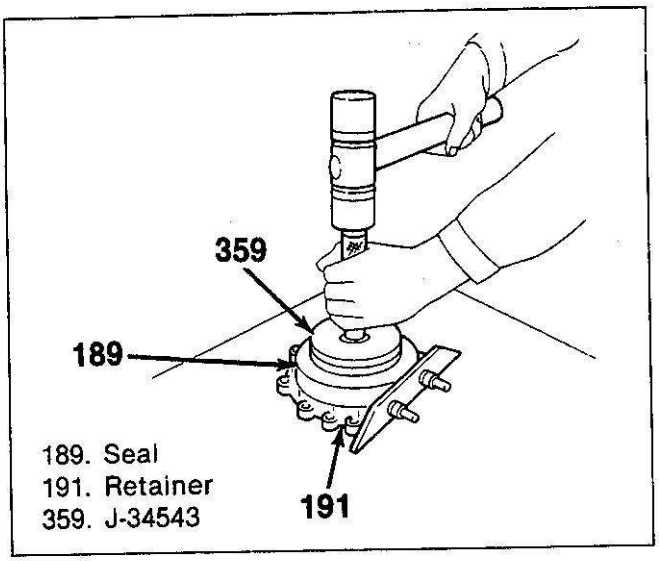
4. Flywheel (183) as outlined previously in "Flywheel Replacement" in this section.

FLYWHEEL HOUSING REPLACEMENT

Remove or Disconnect (Figure 103)

1. Flywheel (183) as outlined previously in "Flywheel Replacement" in this section.
2. Starter motor. Refer to ENGINE ELECTRICAL (SEC. 6D) in this manual.
3. Linkages from the flywheel housing (197).

NOTICE: When raising or supporting the engine for any reason, do not use a jack under the oil pan or any sheet metal. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to bend against the pump screen, resulting in a damaged oil pump or screen.



189. Seal
191. Retainer
359. J-34543

Figure 104. Installing Rear Oil Seal into Retainer

4. Bolts (194 and 196) and washers (195).
5. Flywheel housing (197).

Clean (Figure 103)

Mounting surfaces on the flywheel housing (197) and block.

Inspect (Figure 103)

- Mounting surfaces for heavy scratches or damage.
- Flywheel housing (197) for cracks or damage.

Install or Connect (Figures 100 and 103)

1. Flywheel housing (197) to the block.
2. Bolts (194 and 196) and washers (195).

Tighten

- Bolts (194 and 196) to 127 N·m (94 lb·ft).

NOTICE: See "NOTICE" on page 6A6-1 of this section.

3. Linkages to the flywheel housing (197).
4. Starter motor. Refer to ENGINE ELECTRICAL (SEC. 6D) in this manual.
5. Flywheel (183) as outlined previously in this section.

CRANKSHAFT AND MAIN BEARINGS

- Refer to "Statement on Cleanliness and Care", previously mentioned in this section.
- When references are made to previous procedures, disregard the steps pertaining to on-vehicle servicing.

Remove or Disconnect (Figures 105-107)

1. Engine. Refer to ENGINE (SEC. 6A) in this manual.
   - Mount the engine in a suitable engine stand.
2. Flywheel housing (197), as outlined previously in this section.
3. Oil pump (141) as outlined previously in this section.
4. Idler gear (158) as outlined under "Timing Gear Replacement" in this section.
5. Injection pump. Refer to DIESEL FUEL INJECTION (SEC. 6C3).
6. Camshaft. Refer to "Camshaft and Bearings" previously in this section.
7. Connecting rod bolts, (83) as outlined previously in "Piston, Connecting Rod and Liner" in this section.
8. Connecting rod caps (82) with the connecting rod bearing lower insert (87) as outlined previously in "Piston, Connecting Rod and Liner" in this section.
   - Note the connecting rod (81) and connecting rod cap (82) markings (figure 46). The markings are provided so the caps can be returned to their original positions at assembly.
   - Tap the pistons (80) up in their bores until the connecting rods (81) clear the crankshaft (198).

Measure

Crankshaft (198) end, play, using a feeler gage (figure 105).

- Tap the crankshaft on the flywheel end with a brass hammer to force it forward.
- Insert the feeler gage between the lower thrust washer half (199) and crankshaft (198), as shown.

- If the end play is more than 0.4 mm (0.016 in), replace the thrust washer halves (199 and 200) (figure 106).

9. Bolts (202).
10. Main bearing caps (203).
    - Note the main bearing cap (203) markings (figure 107). The markings are provided so the main bearing caps can be returned to their original positions at assembly.
11. Crankshaft (198) (figure 106).
12. Thrust washer halves (199 and 200).
13. Main bearing inserts (201). If the bearings are to be reused, mark them so they can be returned to their original place at assembly.

Clean (Figure 106)

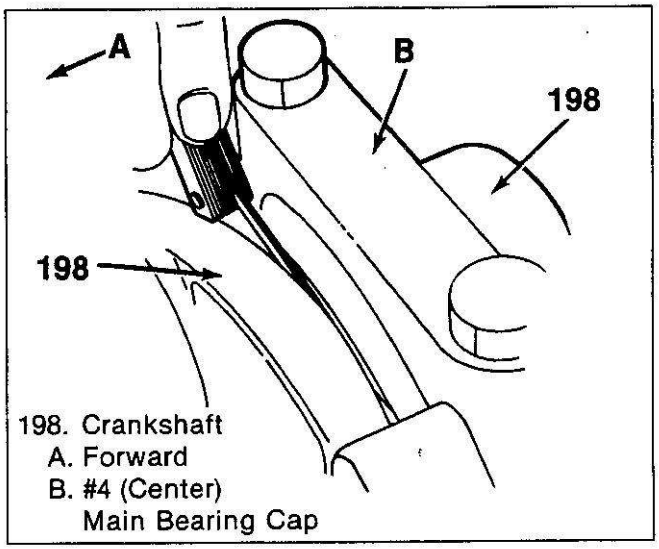
— Crankshaft (198) with solvent.
— Do not scratch the bearing journals.
— Blow all sludge from the oil passages with compressed air.
— Main bearing inserts (201) and thrust washer halves (199 and 200). Wipe free of oil with a soft cloth.

Inspect (Figure 106)

— Crankshaft (198) for cracks. Use the magnaflux method, if available.
— Crankpins, journals and thrust surfaces for scoring, nicks, or damage caused by lack of lubrication.
— Lower and upper main bearing inserts (201 and 206) and thrust washer halves (199 and 200) for scoring or other damage.

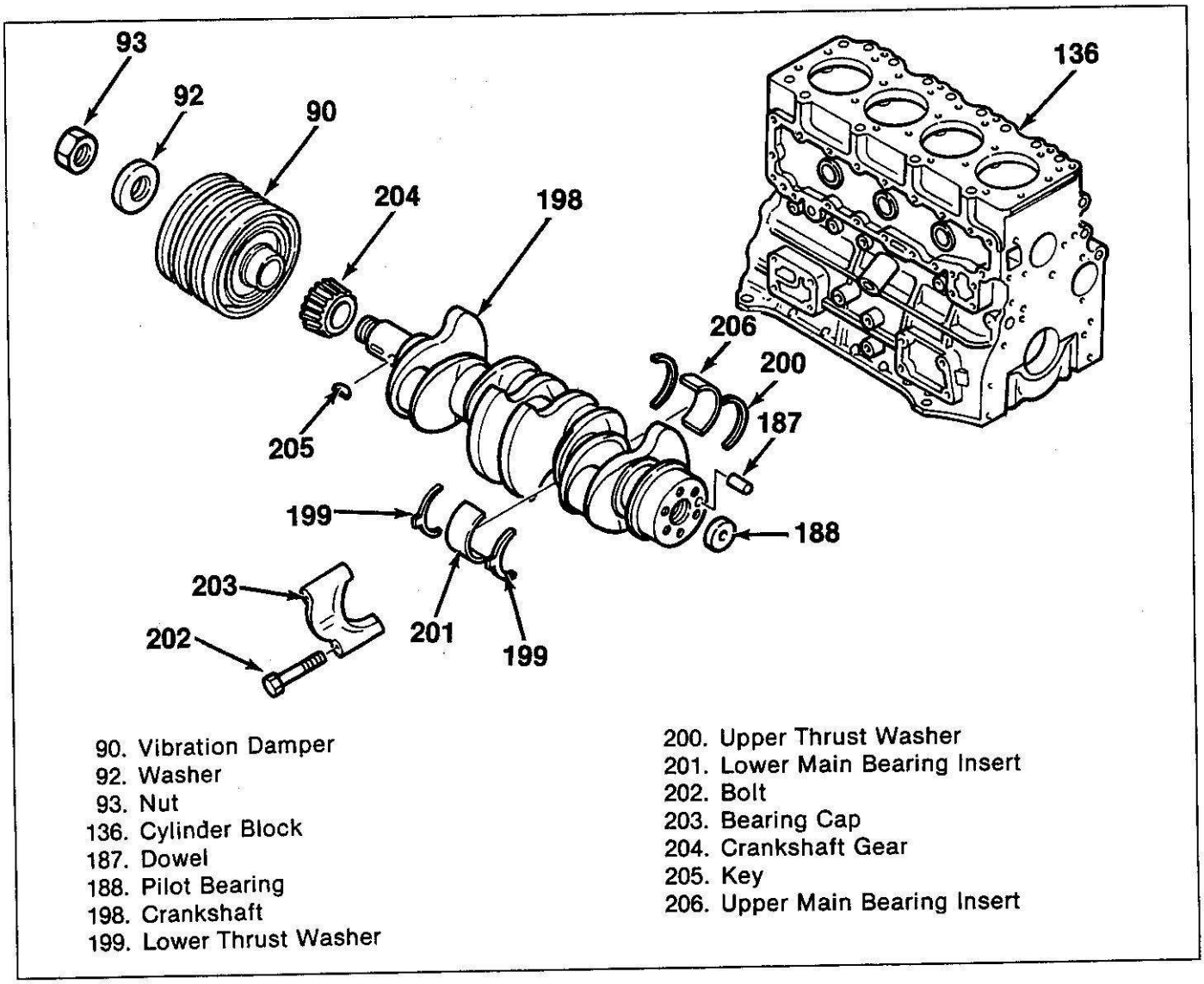
Measure (Figures 108-111)

— Crankshaft journal diameter (figure 108). Measure in two places, and in both the horizontal and vertical (figure 109). The correct measurement is 79.905–79.925 mm (3.1459–3.1467 in).
— Crankpin diameter. Refer to "Piston, Connecting Rod, and Liner" previously in this section.
— Crankshaft (198) runout (figure 110).
    - Mount the crankshaft in V-blocks, or between centers.
    - Set up a dial indicator as shown.
    - Runout should not exceed 0.30 mm (0.012 in).



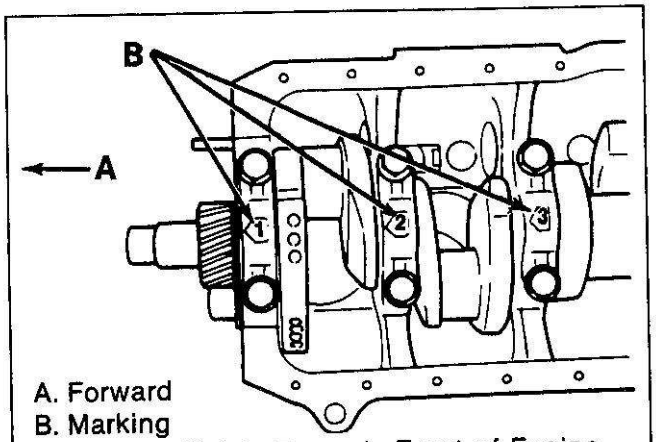
198. Crankshaft
A. Forward
B. #4 (Center) Main Bearing Cap

Figure 105. Measuring Crankshaft End Play



90. Vibration Damper
92. Washer
93. Nut
136. Cylinder Block
187. Dowel
188. Pilot Bearing
198. Crankshaft
199. Lower Thrust Washer
200. Upper Thrust Washer
201. Lower Main Bearing Insert
202. Bolt
203. Bearing Cap
204. Crankshaft Gear
205. Key
206. Upper Main Bearing Insert

Figure 106. Crankshaft and Components



A. Forward
B. Marking
- Arrow Points Towards Front of Engine
- Number Indicated Main Bearing Journal Number

Figure 107. Main Bearing Cap Markings

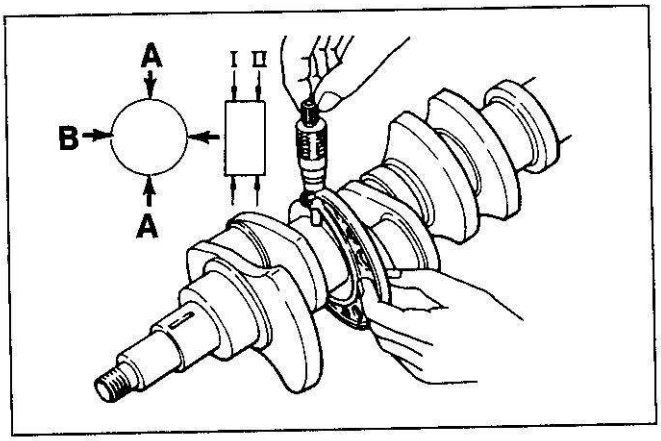
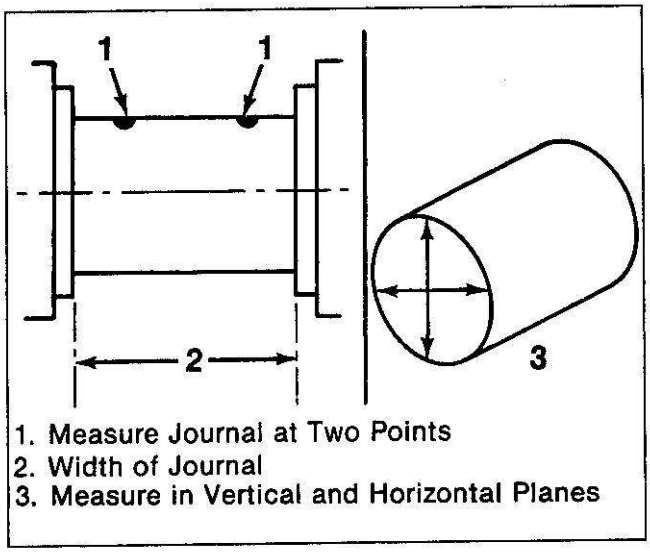
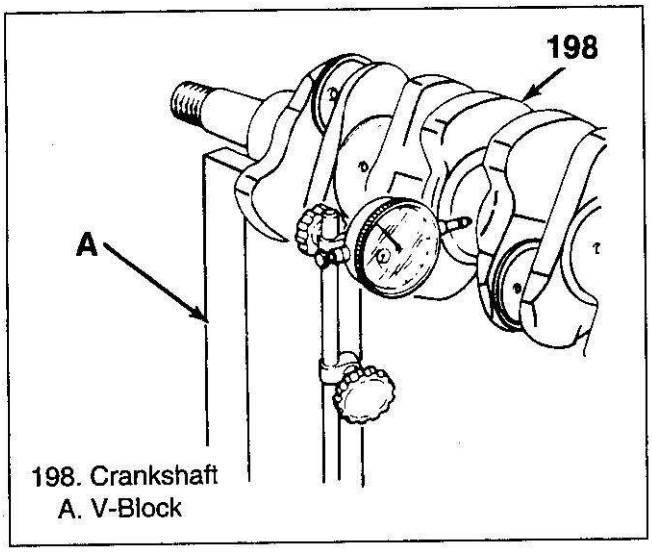


Figure 108. Measuring the Crankshaft Journal's Outside Diameter



1. Measure Journal at Two Points
2. Width of Journal
3. Measure in Vertical and Horizontal Planes

Figure 109. Main Bearing Journal Checking Points



198. Crankshaft
A. V-Block

Figure 110. Measuring Crankshaft Runout

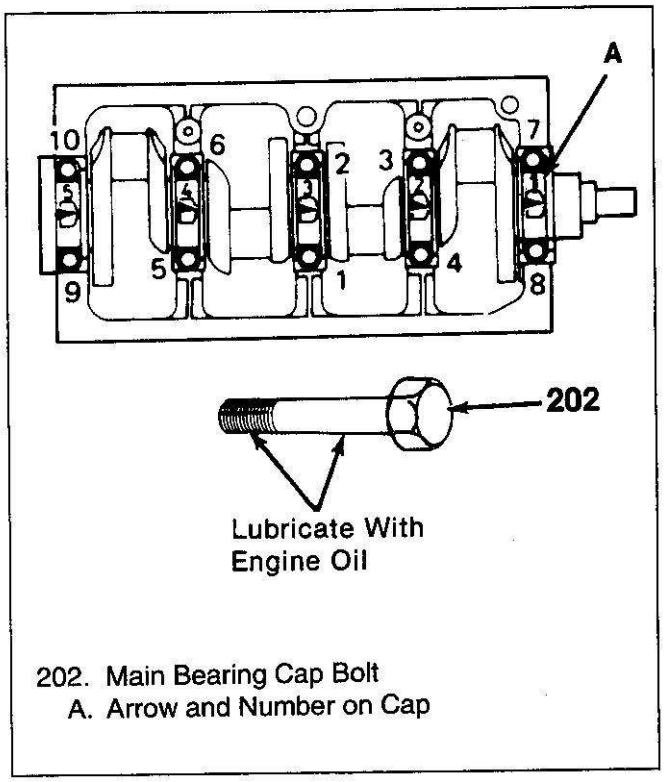
Important

- If the crankshaft (198) does not meet specifications, it should be replaced. It must not be straightened or reground. Undersize bearings are not available. This is because of the special "tufftriding" hardening process that has been applied to it.
- Main bearing clearance as follows:
  Main bearing clearance can also be measured using plastigage, as outlined later.

— Install the main bearing inserts (201 and 206) and main bearing caps (203) to the cylinder block (136). Be sure to put the main bearing caps in their original locations.
— Apply engine oil to the bolt (202) threads (figure 106).
— Install the bolts (202).

Tighten

- Bolts (202) to 235 N·m (174 lb-ft) using the tightening sequence shown in figure 111.



202. Main Bearing Cap Bolt
A. Arrow and Number on Cap

Figure 111. Main Bearing Bolt Tightening Sequence

NOTICE: If one or more than one main cap bearing is removed, this tightening sequence must be followed without fail.

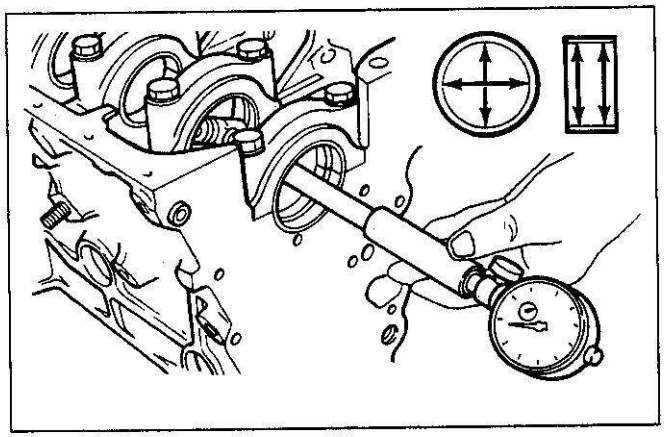


Figure 112. Measuring the Main Bearing's Inside Diameter

— Main bearing inside diameter, using an inside micrometer (figure 112). Check the bearing in two places and in the horizontal and vertical (figure 113). The nominal inside diameter is 80.0 mm (3.152 in).

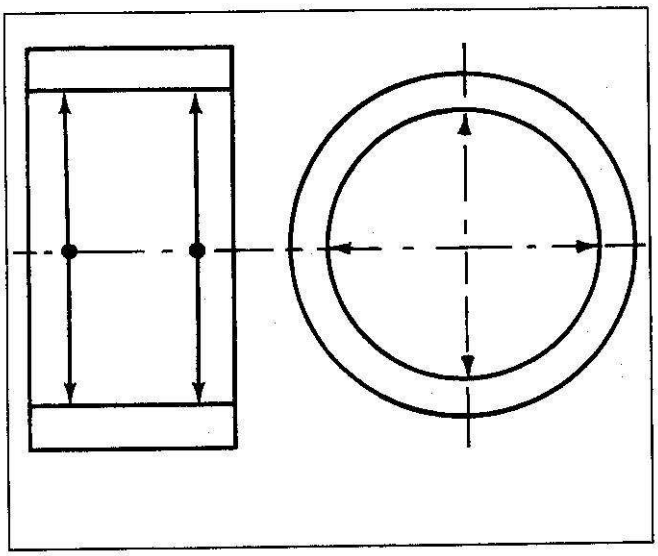


Figure 113. Main Bearing Checking Points

— Subtract the crankshaft journal diameter from the main bearing inside diameter to obtain the clearance. The proper clearances are as follows:

Production	Service Limit
0.025–0.076 mm (0.001–0.003 in)	0.11 mm (0.0043 in)

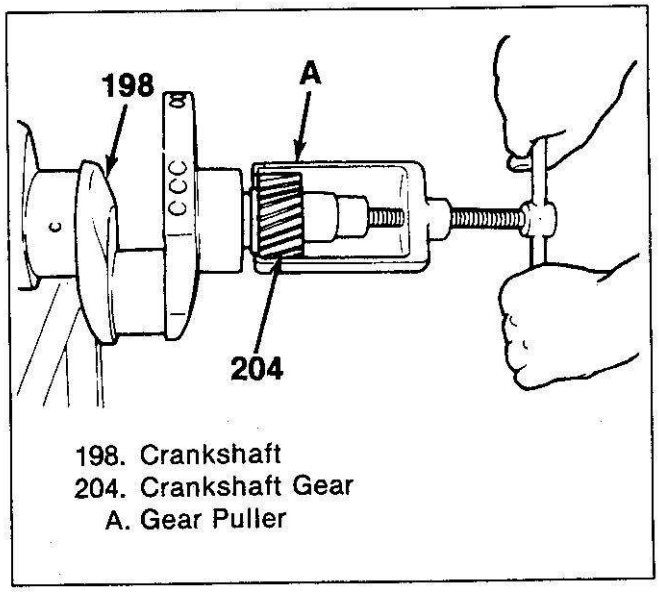
— Replace the main bearing inserts (201) or crankshaft as needed to obtain the proper clearance.
— Remove the bolts (202) and main bearing caps (203).

Crankshaft Gear Replacement

(Figures 106, 114 and 115)

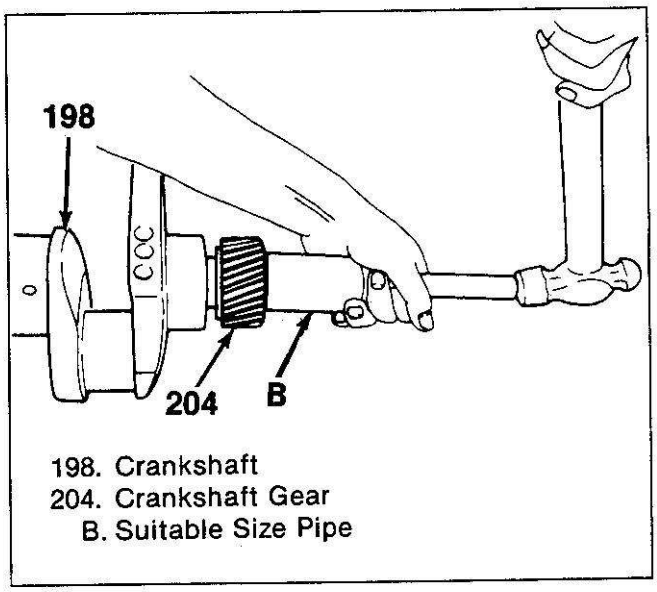
1. Remove the crankshaft gear (204), using a gear puller.
2. Remove the key (205).
3. Install the key (205).
4. Install the crankshaft gear (204). Use a suitable piece of pipe as a driver (figure 115). Be sure the timing mark faces outside.

Main bearings are of the precision insert-type and do not utilize shims for adjustment. If clearances are found to be excessive, a new bearing, both upper and lower inserts, will be required. If clearances are still excessive with the new main bearing, the crankshaft must be replaced.



198. Crankshaft
204. Crankshaft Gear
A. Gear Puller

Figure 114. Crankshaft Gear Removal



198. Crankshaft
204. Crankshaft Gear
B. Suitable Size Pipe

Figure 115. Crankshaft Gear Installation

Main Bearing Selection (Figures 106, 107 and 111)

The simplest most accurate way to measure main bearing clearance is with the use of gaging plastic. This wax-like material compresses evenly between the bearing and journal surfaces without damaging them. Proceed as follows:

1. Install the upper main bearing inserts (206) to the block (136).

Important

- The upper main bearing inserts (206) have both an oil hole and an oil groove (figure 116).
- Be sure the bearing tang fits properly in the cutout in the block (136).
- Check the bearing tension. Moderate finger

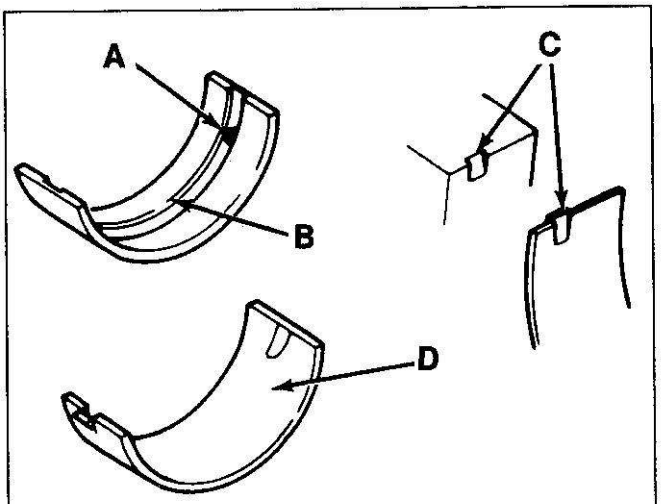
pressure should be required to push the bearing insert into position. If not, do not reuse the bearing.
- If the original bearing inserts are being reused, be sure the bearings are returned to their original locations.
- Lubricate the upper bearing inserts (206) with engine oil.

2. Install the dowels in #4 cap (if removed).
3. Install the crankshaft (198). Be careful not to damage the journals or thrust surfaces.
4. Apply engine oil to the upper thrust washer halves (200) and install.
   — The upper thrust washers do not have a locating ring.
   — New thrust washers must be used if the crankshaft end play measured at disassembly was excessive.
   — The oil groove faces toward the crankshaft (198).
   — "Roll" the thrust washer halves into place.
5. Install the lower main bearing inserts (201) to the main bearing caps (203).

Important (Figure 116)

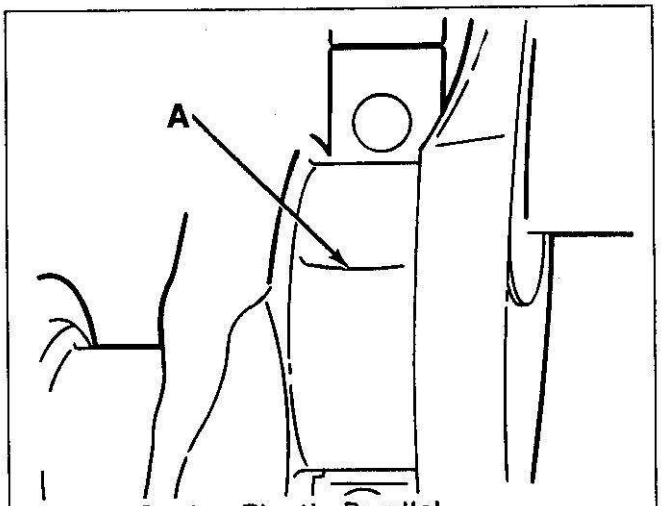
- The lower main bearing insert may not have an oil hole or groove.
- Be sure the bearing tang fits correctly in the cutout in the main bearing cap.
- Check the bearing tension. Good finger pressure should be required to push the bearing insert into position (figure 116). If not, do not reuse the bearing.
- If the original bearings are being reused, be sure the bearings are returned to their original locations.

6. Install the plastigage.
   - Wipe the oil from the crankshaft (198) journal and the lower main bearing insert (201).
   - Place a piece of gaging plastic the full width of the lower bearing insert (201) (parallel to the crankshaft) on the journal (figure 117). Do not rotate the crankshaft (198) while the gaging plastic is between the bearing and journal.
7. Install the main bearing caps (203). Return the caps to their original positions, with the arrow facing the front of the engine (figure 111).
   - Apply engine oil to the bolt (202) threads and washer (figure 106).
8. Install the bolts (202).



A. Oil Hole (Upper Main Bearing Halves Only)
B. Oil Groove
C. Be sure the bearing tang fits correctly in the cutout
D. Lower Main Bearing (no oil hole or groove)

Figure 116. Main Bearing Locations



A. Place Gaging Plastic Parallel to Crankshaft

Figure 117. Location of Gaging Plastic

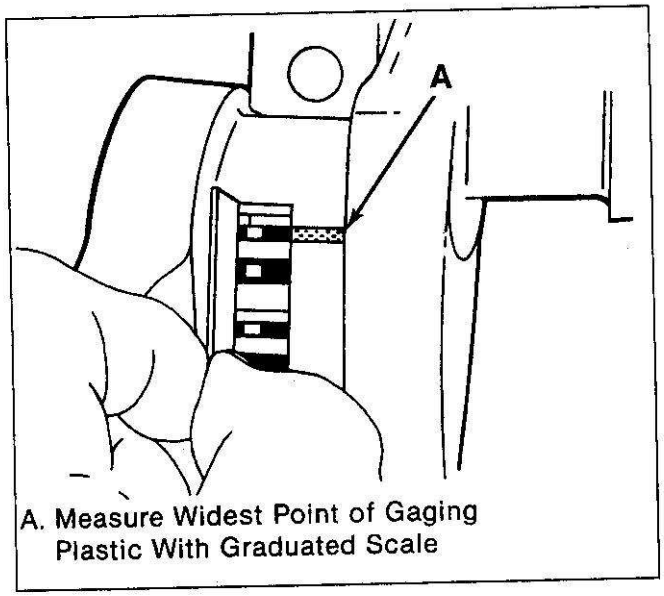
Tighten

- Bolts (202) to 235 N·m (174 lb·ft). Use the tightening sequence shown in figure 111.

9. Remove the bolts (202).
10. Remove the main bearing caps (203).
    - DO NOT REMOVE THE GAGING PLAS TIC FROM THE JOURNAL OR LOWER BEARING HALF (203).

Measure (Figures 106 and 118)

- Gaging plastic as follows:
- The flattened gaging plastic will be found adhering to either the lower bearing insert (201) or journal.
- On the edge of the gaging plastic envelope there is a graduated scale. Without removing the gaging plastic, measure its compressed width (at the widest point) with the graduations on the gaging plastic envelope (figure 118).



A. Measure Widest Point of Gaging Plastic With Graduated Scale

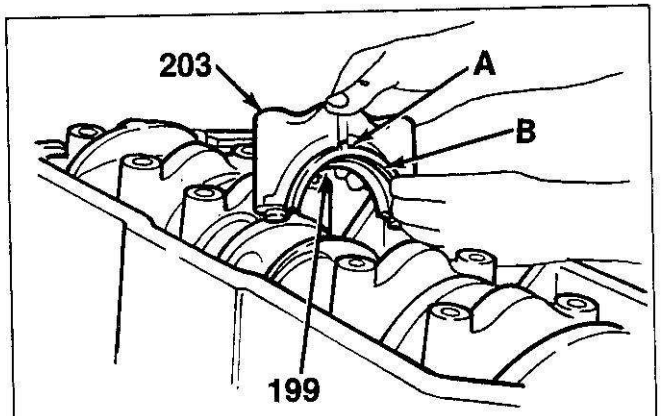
Figure 118. Measuring the Gaging Plastic

- If the flattened gaging plastic tapers toward the middle or ends, there is a difference in clearance indicating taper, low spot or other irregularity of the bearing or journal. Be sure to measure the journal with a micrometer if the flattened gaging plastic indicates more than 0.02 mm (0.0008 in) difference.
- Normally, main bearing journals wear evenly and are not out-of-round.
  However, if a bearing is being fitted to an out-of-round journal, be sure to fit to the maximum diameter of the journal. If the bearing is fitted to the minimum diameter and the journal is excessively out-of-round, interference between the bearing and the journal will result in rapid bearing failure.
- If the bearing clearance is within specifications, the bearing is satisfactory. If the clearance is not within specifications, replace the bearing. Always replace both upper and lower inserts as a unit.
- Remove the flattened gaging plastic.
  Perform the preceding steps on the remaining bearings.

Install or Connect (Figures 106, 107, 111 and 119)

- The crankshaft (198) and upper main bearing inserts (206) should already be installed, from the Main Bearing Selection procedure.
- Apply engine oil to the lower main bearing inserts (201) and lower thrust washer halves (199).

1. Main bearing caps (203) with the selected lower main bearing inserts (201).
   - Install the lower thrust washer halves (199) along with the #4 main bearing cap (figure 119).



199. Lower Thrust Washer Half
203. Main Bearing Cap
   A. Tang
   B. Oil Groove

Figure 119. Installing the Crankshaft Lower Thrust Bearings

   - Align the thrust washer tang with the slot in the main bearing cap. The oil grooves face toward the crankshaft (198).
   - Be sure to put the main bearing caps in their original locations, with the arrows facing the front of the engine (figure 107).
     — Apply engine oil to the bolt (202) threads (figure 106).

2. Bolts (202).

Tighten

- Bolts (202) to 235 N·m (174 lb·ft). Use the tightening sequence shown in figure 111.

Inspect

- Crankshaft (198) for binding. Try turning the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the bolts (202), one pair at a time, until the tight bearing is located. Burrs on the bearing cap, foreign matter between the insert and the

block or the bearing cap, or a defective insert could cause a lack of clearance at the bearing.

Measure

- Crankshaft (198) end play (figure 105).
- Tap the crankshaft on the flywheel end with a brass hammer to force it forward.
- Insert a feeler gage between the lower thrust washer half (199) and crankshaft, as shown.
- The production end play is 0.15–0.33 mm (0.006–0.013 in). The service limit is 0.45 mm (0.018 in).

3. Idler gear (158) as outlined under "Timing Gear Replacement" in this section.

Important (Figure 82)

- Align the timing marks as shown in figure 82.

4. Connecting rods (81), connecting rod bearing inserts (86 and 87), connecting rod caps (82) and bolts (83). Refer to "Piston, Connecting Rod and Liner Replacement" in this section.
5. Oil pump (141) as outlined previously in this section.
6. Flywheel housing (197) as outlined previously in this section.
7. Engine. Refer to ENGINE (SEC. 6A) in this manual.
   - Fill the engine with the proper quantity and grade of coolant and oil. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

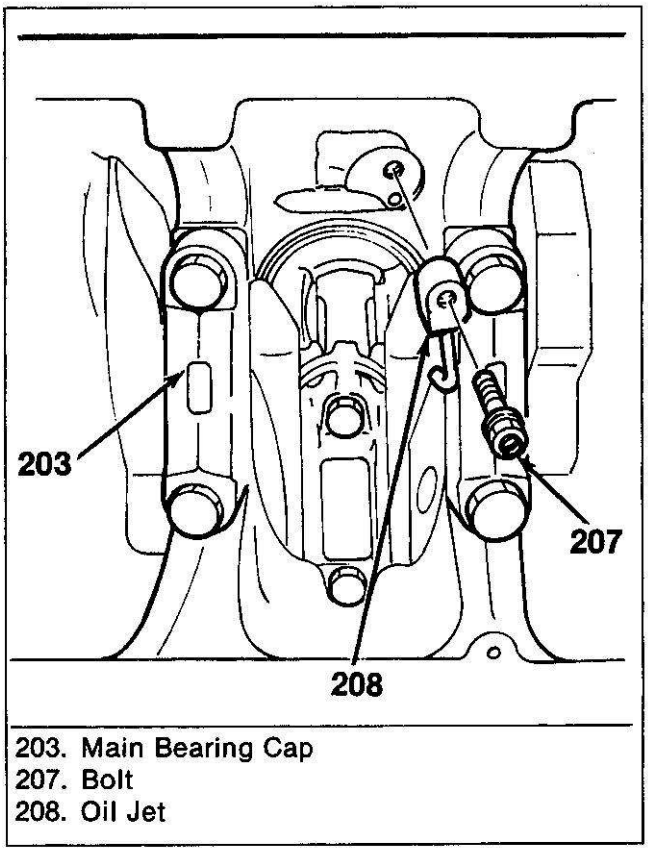
OIL JET REPLACEMENT

1. Remove the oil pan (134) as outlined previously in this section.
2. Remove the bolts (207) and oil jet (208) (figure 120).
   - Inspect the oil jet (208) passage for obstructions.
3. Install the oil jet (208) and bolt (207).

Tighten

- Bolt (207) to 20 N·m (14 lb·ft)

4. Install the oil pan (134) as outlined previously in this section.
   - Fill the oil pan with the proper quantity and grade of oil. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.



203. Main Bearing Cap
207. Bolt
208. Oil Jet

Figure 120. Oil Jet Location

SPECIFICATIONS

MODEL	4BDTC-TC
TYPE	In-line 4, 4-stroke
INDUCTION	Turbocharger with Charge Air Cooler
COMBUSTION CHAMBER-TYPE	In-Direct Fuel Injection
BORE	102 mm (4.02 in)
STROKE	118mm (4.65 in)
DISPLACEMENT	3.85 L (235 cu. in)
COMPRESSION RATIO	21:1
FIRING ORDER	1-3-4-2
VALVE CLEARANCE, COLD	0.4 mm (0.016 in)
IDLE SPEED (CURB IDLE SPEED)	Manual Transmission 650 RPM Automatic Transmission 650 RPM (in "D" position)
OIL CAPACITY	
Drain and Refill With Full-Flow Filter Bypass Filter Capacity	11.2 L (2.96 gallons)
OIL PRESSURE (MINIMUM AT IDLE)	96 kPa (14 psi)
COMPRESSION PRESSURE AT 200 RPM	
Production	3043 kPa (441 psi)
Service Limit	2160 kPa (313 psi)

FASTENER TORQUES

Special Torques*

Fastener	First Stage	Second Stage	Third Stage
Cylinder Head Bolts	68 N·m (50 lb·ft)	88 N·m (65 lb·ft)	120–150 degrees
Connecting Rod Bolts	39 N·m (29 lb·ft)	60–90 degrees	—
Flywheel Bolts	39 N·m (29 lb·ft)	60–90 degrees	—

* See Text for Tightening Procedure. Refer to figure 45, 70, 102.

SPECIFICATIONS (CONT.)

Conventional Torques

Charge Air Pipe Bolts	26 N·m (20 lb·ft)
Intake Manifold Nuts	19 N·m (14 lb·ft)
Fuel Injector Line Nuts	26 N·m (20 lb·ft)
Turbocharger to Exhaust Manifold Nuts	26 N·m (20 lb·ft)
Turbocharger Oil Drain Line Bolts	19 N·m (14 lb·ft)
Water Supply and Drain Lines	21 N·m (15 lb·ft)
Turbocharger Oil Feed Line Bolts	14 N·m (122 lb·in)
Exhaust Pipe Adapter to Exhaust Manifold Bolts	21 N·m (15 lb·ft)
Exhaust Pipe to Exhaust Adapter	37 N·m (27 lb·ft)
Exhaust Manifold Nuts	19 N·m (14 lb·ft)
Cylinder Head Cover	10 N·m (87 lb·in)
Rocker Arm Shaft Support Bolts and Nuts	23 N·m (17 lb·ft)
Glow Plug	23 N·m (17 lb·ft)
Nozzle Holder Assembly	64 N·m (47 lb·ft)
Thermostat Housing Bolts	23 N·m (17 lb·ft)
Vibration Damper Nut	413 N·m (305 lb·ft)
Timing Cover Bolts	20 N·m (14 lb·ft)
Oil Pan Bolts	20 N·m (14 lb·ft)
Oil Pump Cover Bolts	16 N·m (12 lb·ft)
Oil Pump Bolts (to engine)	52 N·m (38 lb·ft)
Oil Pump Pressure Pipe Bolts	26 N·m (20 lb·ft)
Idler Gear Plate Bolts	52 N·m (38 lb·ft)
Camshaft Gear Bolt	132 N·m (98 lb·ft)
Camshaft Thrust Plate Bolts	26 N·m (20 lb·ft)
Oil Pump Drive Gear Cover Bolts	26 N·m (20 lb·ft)
Tappet Cover Bolts	26 N·m (20 lb·ft)
Oil Seal Retainer to Cylinder Block Bolts	26 N·m (20 lb·ft)
Flywheel Housing Bolts	127 N·m (94 lb·ft)
Main Bearing Cap Bolts	235 N·m (174 lb·ft)
Oil Jet Bolts	20 N·m (14 lb·ft)

SPECIFICATIONS (CONT.)

ENGINE SPECIFICATIONS

Item	Production	Service Limit
TURBOCHARGER		
Bearing Radial Clearance	—	0.14 mm (0.0055 in)
Turbine Shaft End Play	—	0.097 mm (0.0038 in)
VALVE TRAIN		
Rocker Arm Shaft Diameter	18.98–19.00 mm (0.7478–0.7486 in)	18.85 mm (0.7427 in)
Rocker Arm Inside Diameter	19.01–19.03 mm (0.7489–0.7497 in)	19.05 mm (0.7505 in)
Rocker Arm to Shaft Clearance	0.014–0.062 mm (0.00055–0.00244 in)	0.20 mm (0.008 in)
Pushrod Runout	—	0.3 mm (0.012 in)
Tappet Body Diameter	27.97–27.98 mm (1.1020–1.1024 in)	27.92 mm (1.100 in)
Tappet to Bore Clearance	0.020–0.054 mm (0.0008–0.00213 in)	0.1 mm (0.004 in)
CYLINDER HEAD		
Head Gasket Distortion Surface	0.05 mm or less (0.020 in)	0.20 mm (0.008 in)
Minimum Thickness (See Text)	89.95–90.05 mm (3.541–3.545 in)	89.75 mm (3.533 in)
VALVES, GUIDES AND SEATS		
Valve Installed Depth (See Text)	0.65–1.10 mm (0.026–0.043 in)	2.50 mm (0.100 in)
Valve Seat Angle (All Valves)	45°	—
Valve Face Angle (All Valves)	45°	—
Valve Seat Width	1.5 mm (0.060 in)	—
Minimum Valve Margin' Thickness	1.5 mm (0.060 in)	1.0 mm (0.040 in)
Valve Stem Diameter (Intake)	8.946–8.961 mm (0.352–0.353 in)	8.880 mm (0.350 in)
(Exhaust)	8.921–8.936 mm (0.351–0.352 in)	8.880 mm (0.350 in)
Valve Guide Inside Diameter (Intake)	9.00–9.017 mm (0.3546–0.3553 in)	9.080 mm (0.3577 in)
(Exhaust)	9.00–9.017 mm (0.3546–0.3553 in)	9.100 mm (0.3585 in)
Valve Guide to Valve Stem Clearance (Intake)	0.039–0.068 mm (0.0015–0.0027 in)	0.20 mm (0.008 in)
(Exhaust)	0.064–0.093 mm (0.0025–0.0037 in)	0.25 mm (0.010 in)
VALVE SPRINGS		
Free Length (Inner)	52.4 mm (2.065 in)	50.0 mm (1.970 in)
(Outer)	53.65 mm (2.112 in)	50.65 mm (1.994 in)
Inclination (See Text)	—	1.0 mm (0.039 in)
Tension		
(Inner) (At 42.0 mm [1.65 in]Length)	10.9 kg (24.03 lb)	9.9 kg (21.83 lb)
(Outer) (At 44.0 mm [1.73 in]Length)	23.0 kg (50.72 lb)	20.0 kg (44.10 lb)
LINER		
Bore Diameter	102.021–102.060 mm (4.0166–4.0181 in)	102.200 mm (4.0236 in)
Projection Above Block Gasket Surface	0.03–0.10 mm (0.0012–0.0039 in)	
Liner Interference Fit in Block	0.001–0.019 mm (0.00004–0.00075 in)	

SPECIFICATIONS (CONT.)

ENGINE SPECIFICATIONS (CONT.)

Item	Production	Service Limit
PISTON, PIN AND RINGS		
Piston Diameter		
(Size Grades "A" and "B")	101.955–101.974 mm (4.0140–4.0147 in)	—
(Size Grades "C" and "D")	101.975–101.994 mm (4.0148–4.0155 in)	—
Piston Clearance	0.057–0.075 mm (0.0022–0.0030 in)	—
Ring to Groove Clearance		
(Upper Compression)	0.105–0.130 mm (0.0041–0.0051 in)	0.200 mm (0.008 in)
(Lower Compression)	0.040–0.075 mm (0.0016–0.0030 in)	0.150 mm (0.006 in)
(Oil Control)	0.030–0.070 mm (0.0012–0.0028 in)	0.150 mm (0.006 in)
Ring End Gap (Upper Compression)	0.25–0.45 mm (0.0098–0.0177 in)	1.50 mm (0.059 in)
(Lower Compression)	0.20–0.40 mm (0.0078–0.0157 in)	1.50 mm (0.059 in)
(Oil Control)	0.20–0.40 mm (0.0078–0.0157 in)	1.50 mm (0.059 in)
Piston Pin Diameter	35.000–35.005 mm (1.3780–1.3781 in)	34.950 mm (1.376 in)
Piston Pin Hole Diameter in Piston	35.010–35.018 mm (1.3783–1.3787 in)	—
Piston Pin to Piston Clearance	0.005–0.018 mm (0.0002–0.0007 in)	—
Piston Pin to Connecting Rod Bushing Clearance	0.012–0.025 mm (0.00047–0.00098 in)	0.05 mm (0.002 in)
CONNECTING ROD		
Piston Pin Bushing Inside Diameter	35.017–35.025 mm (1.3786–1.3789 in)	—
Piston Pin to Connecting Rod Bushing Clearance	0.012–0.025 mm (0.00047–0.00098 in)	0.05 mm (0.002 in)
Distortion on Rod Aligner	0.05 mm (0.002 in) or less	0.20 mm (0.008 in)
Connecting Rod Bearing Inside Diameter (Nominal)	64 mm (2.52 in)	—
OIL PUMP		
Gear Tooth to Body Inner Wall Clearance	—	0.18 mm (0.007 in)
Gear End Clearance	—	0.12 mm (0.005 in)
TIMING GEARS		
Timing Gear Backlash	0.10–0.17 mm (0.0039–0.0067 in)	0.3 mm (0.012 in)
Idler Gear End Play	0.058–0.115 mm (0.0023–0.0045 in)	0.2 mm (0.008 in)
Idler Gear Hub Outside Diameter	44.945–44.975 mm (1.769–1.771 in)	44.845 mm (1.766 in)
Idler Gear to Hub Clearance	0.025–0.085 mm (0.00098–0.00334 in)	0.2 mm (0.008 in)
CAMSHAFT		
Camshaft End Play	0.050–0.114 mm (0.0020–0.0045 in)	0.2 mm (0.008 in)
Journal Diameter	55.94–55.97 mm (2.2024–2.2035 in)	55.6 mm (2.189 in)
Camshaft Bearing Inside Diameter	56.00–56.03 mm (2.2047–2.2059 in)	—
Journal to Bearing Clearance	0.03–0.09 mm (0.0012–0.0035 in)	0.15 mm (0.006 in)
Camshaft Lobe Height	47.05 mm (1.852 in)	46.55 mm (1.833 in)
Camshaft Runout	—	0.12 mm (0.005 in)
CRANKSHAFT AND BEARINGS		
Crankshaft End Play	0.15–0.33 mm (0.006–0.013 in)	0.045 mm (0.018 in)
Crankshaft Runout	0.05 mm (0.002 in) or less	0.30 mm (0.012 in)
Connecting Rod Journal Diameter	63.924–63.944 mm (2.5167–2.5175 in)	—
Connecting Rod Bearing Inside Diameter (Nominal)	64 mm (2.52 in)	—

SPECIFICATIONS (CONT.)

ENGINE SPECIFICATIONS (CONT.)

Item	Production	Service Limit
CRANKSHAFT AND BEARINGS (CONT.)		
Connecting Rod Bearing Clearance	0.030–0.081 mm (0.0012–0.0032 in)	0.1 mm (0.004 in)
Available Undersize Connecting Rod Bearings	None	—
Crankshaft Journal Diameter	79.905–79.925 mm (3.1459–3.1467 in)	—
Main Bearing Inside Diameter (Nominal)	80 mm (3.1496 in)	—
Main Bearing Clearance	0.025–0.076 mm (0.00098–0.00299 in)	0.11 mm (0.0043 in)
Available Undersize Main Bearings	None	—

SPECIAL TOOLS

J-26999-12	Compression Gage
J-26999-20	Compression Gage Adapter
J-34535	Valve Guide Remover and Installer
J-34545	Valve Stem Seal Installer
J-34543	Rear Crankshaft Seal Installer
J-35691	Pressure Gage—Turbocharger
J-26513-A	Valve Spring Compressor
J-36520/J-37365	Liner Remover or Installer