6SE4011 OCTOBER 1999

SERIES 4000™ Service Manual

MTU/DDC Series 4000 12/16V Diesel and Diesel Marine Engines

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Engine Serial Number Location

See Figure 5 for engine serial number location.

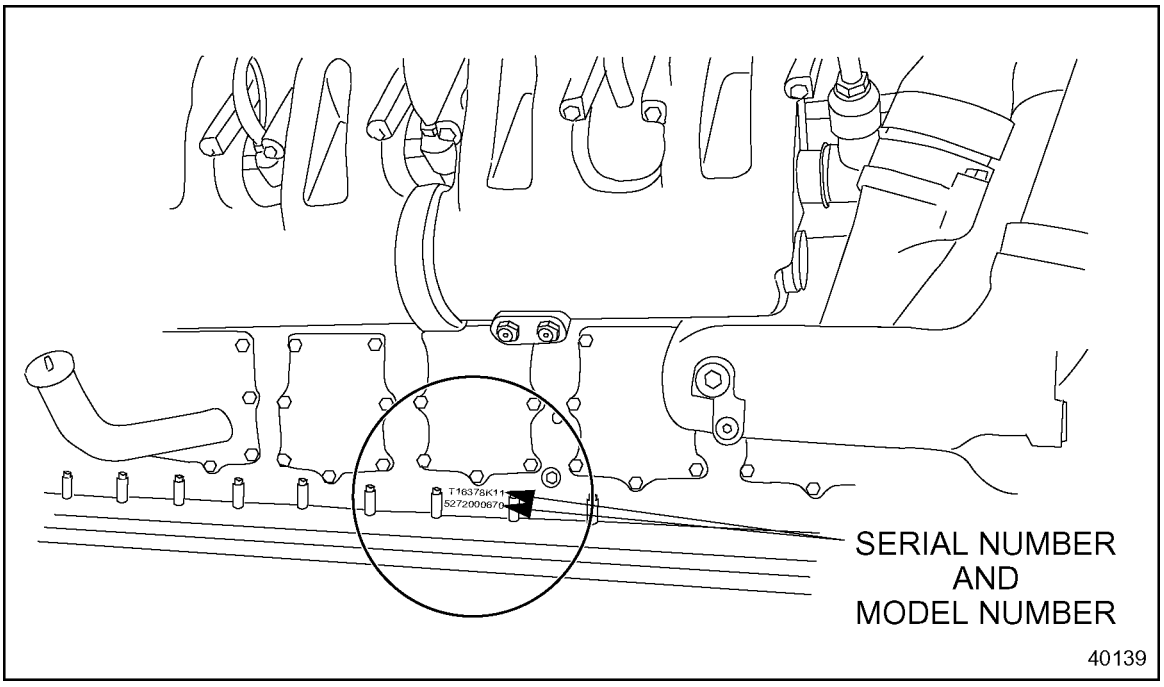


Figure 5 Engine Serial Number Location, B Bank Side, Below Side Cover and Above Oil Pan Bolt Rail

Firing Order

- 8V: A1 - B4 – A4 – A2 – B3 – A3 – B2 – B1
- 12V: A1 – B2 – A5 – B4– A3 – B1 – A6 – B5 – A2 – B3 – A4 – B6
- 16V: A1 – A7 – B4 – B6 – A4 – B8 – A2 – A8 – B3 – B5 – A3 – A5 –B2 – A6 – B1 – B7

Clearance of New Parts and Wear Limits

New part clearances apply only when all new parts are used at the point where the various specifications apply. This requirement applies to references within the text of the manual. These wear limits are, in general, for parts most frequently replaced in engine overhaul work

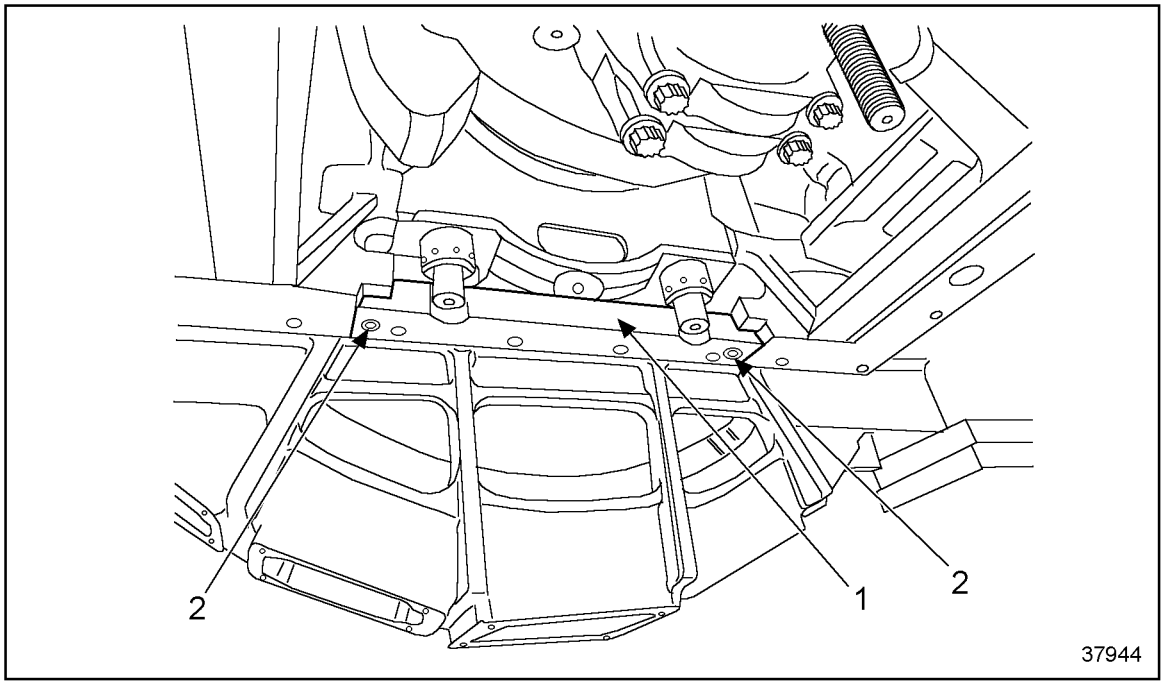
Repairing Threaded Bores

Data to repair the threaded bores with threaded inserts (heli-coil) is listed in Table 10.

Thread	Core Hole Bore Dia. Max (Min)	Twist Drill Diameter
M 6	631 (6.04)	6.1-6.2-6.25
M 8	8.35 (8.04)	8.1-8.2-8.25-8.3
M 8 x 1	8.32 (8.04)	8.1-8.2-8.25-8.3
M 10	10.40 (10.05)	10.25
M 12	12.50 (12.05)	12.25-12.5
M 12 x 1.5	12.43 (12.05)	12.25
M 14	14.53 (14.06)	14.25-14.5
M 14 x 1.5	14.43 (14.05)	14.25
M 15 x 2	15.30 (15.20)	15.25
M 16	16.53 (16.06)	16.25-16.5
M 16 x 1.5	16.43 (16.05)	16.25
M 24 x 1.5	24.43 (24.05)	24.25
M 26 x 1.5	26.43 (24.05)	26.25
M 30 x 1.5	30.43 (30.05)	30.25

Table 10 Data to Repair Threaded Bores

5. Remove the filler spacer (1) at the #1 main bearing journal (rear of engine). There are five bolts; two Allen head bolts (2) are removed. See Figure 7.



1. Filler Spacer
2. Allen Head Bolts

Figure 7 Removing Filler Spacer

CAUTION:

To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

8. After cleaning, flush bore (under pressure if possible) and blow clear with compressed air. See Figure 30.

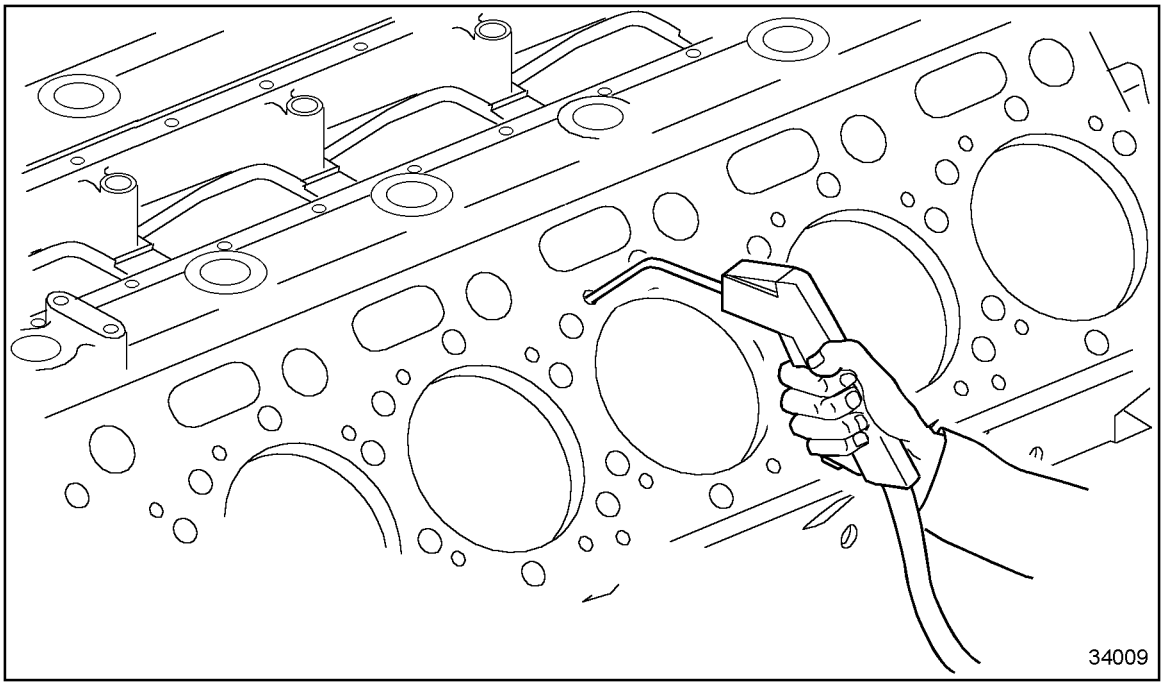
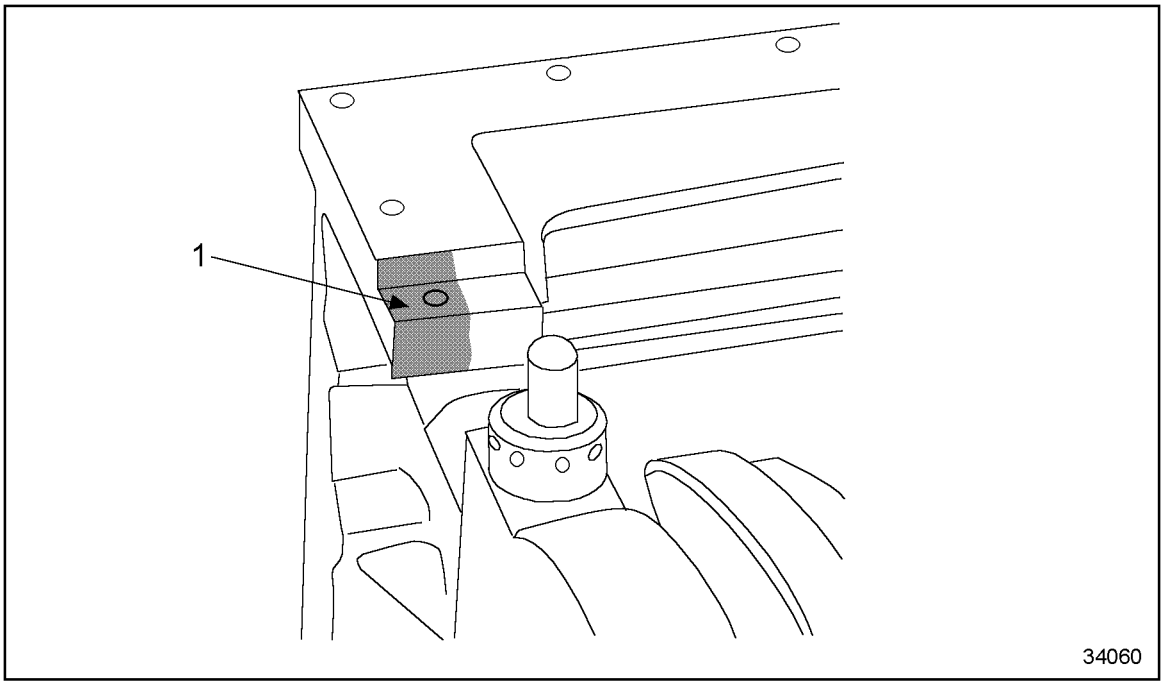


Figure 30 Flushing Bore with Compressed Air

9. Protect all bores against contamination, with plastic plugs, until assembly of the engine.

39. Tighten stabilizer bolts of main bearing cap to specification. Refer to section A 003A 003 . Start on the (A) side (left), then move to the (B) side (right) until all are properly torqued.
40. Carefully coat mating surface with sealing compound for oil pan extension, see Figure 1, at the main bearing thrust cap location. See Figure 57.

NOTE:
When coating mating surface for oil pan extension, take the front surfaces into consideration.



1. Mating Surface of Oil Pan Extension (Main Bearing Thrust Cap Location)

Figure 57 Coating Mating Surface for Oil Pan Extension

[b] If reversing point of first piston ring does not show wear, continue inspection.

NOTE:
There must be no signs of wear at reversing point of first piston ring.

NOTE:
When re-using cylinder liners, the honing must be recognizable over entire running surface. See Figure 77.

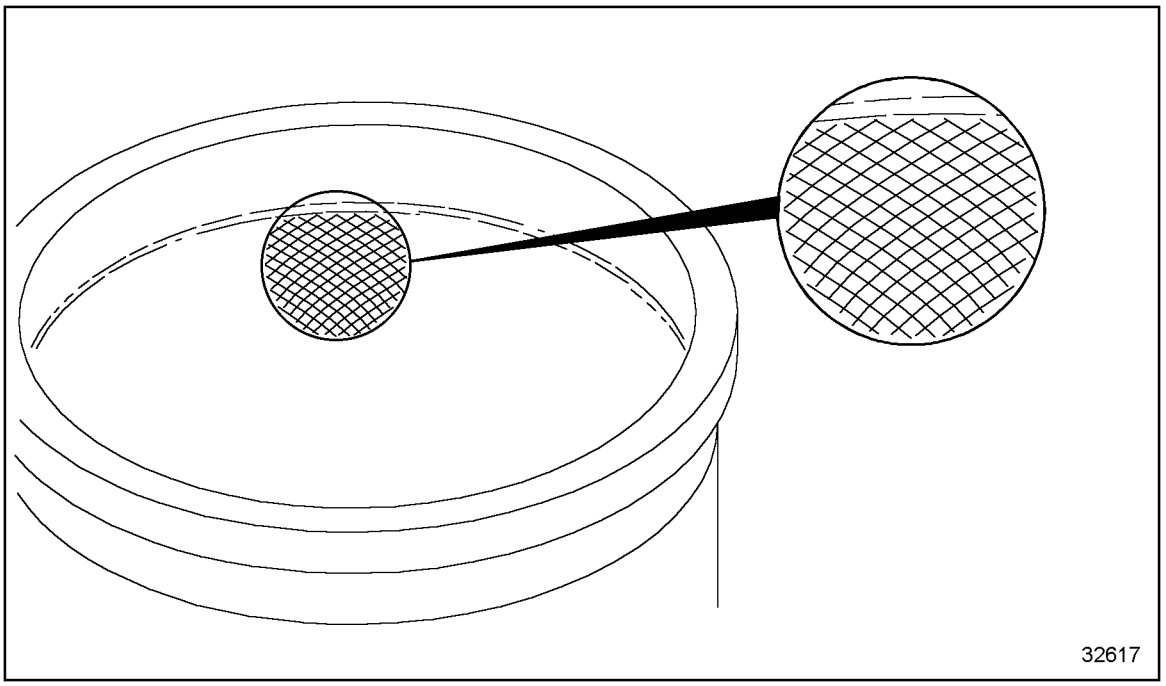
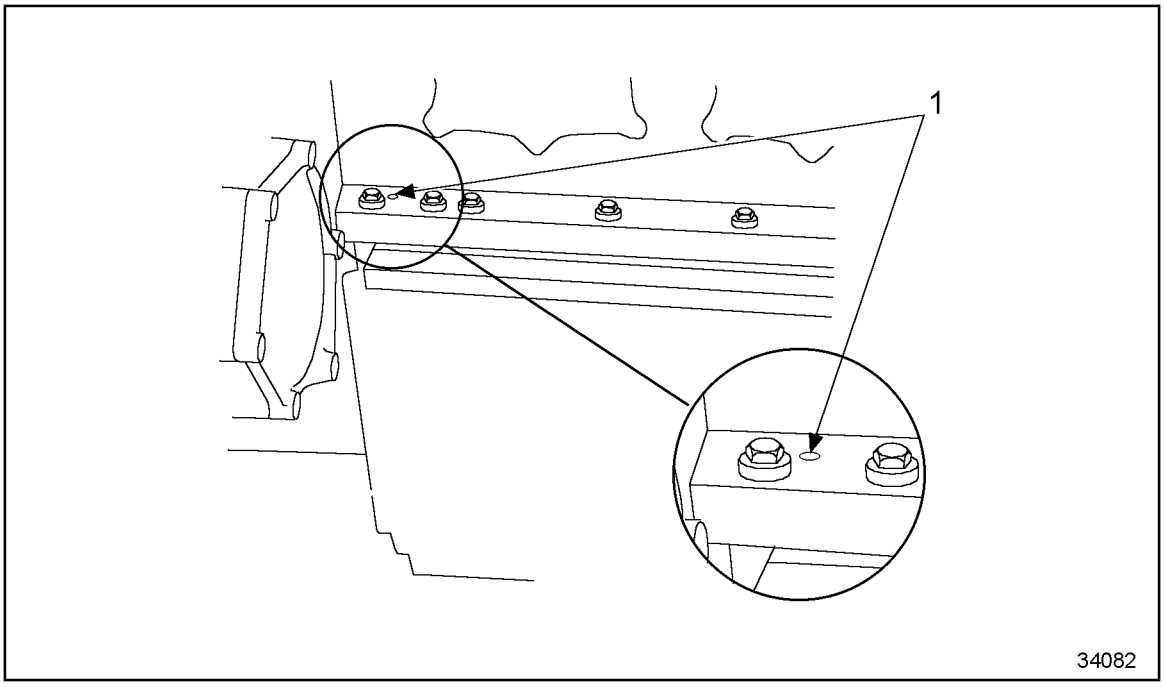


Figure 77 Inspecting Honing Marks for Consistency

Measuring Cylinder Liner I.D.

1. Adjust dial bore gage (2) and dial gage with micrometer or adjusting gage ring (1) to basic size for cylinder liner. See Figure 78.

13. Install taper pins in oil pan. See Figure 96.



1. Taper Pin Location

Figure 96 Installing Taper Pins in Oil Pan

NOTE:
During initial assembly, oil pan is secured to cylinder block on “A” and “B” bank side with one taper pin on each side. For the position of taper pins, see Figure 96. New oil pans do not yet have a bore for the taper pins.

14. Install taper pin 10 x 65 with standardized tapering C = 1:50 based on DIN 258 as follows.

C 016.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the flywheel housing.

1. Clean all components and visually inspect for damage and defects.
   [a] If components are damaged or defective, repair as necessary.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If components are not damaged or defective, continue inspection.
2. Visually inspect lifting carrier and eyebolts for cracks using magnetic crack-testing method with fluorescent powder.
   [a] If lifting carrier and eyebolts are cracked, replace component.
   [b] If lifting carrier and eyebolts are not cracked, continue inspection.
3. Visually inspect dead-center indicator for damage. (marine only)
   [a] If dead-center indicator is damaged, replace component.

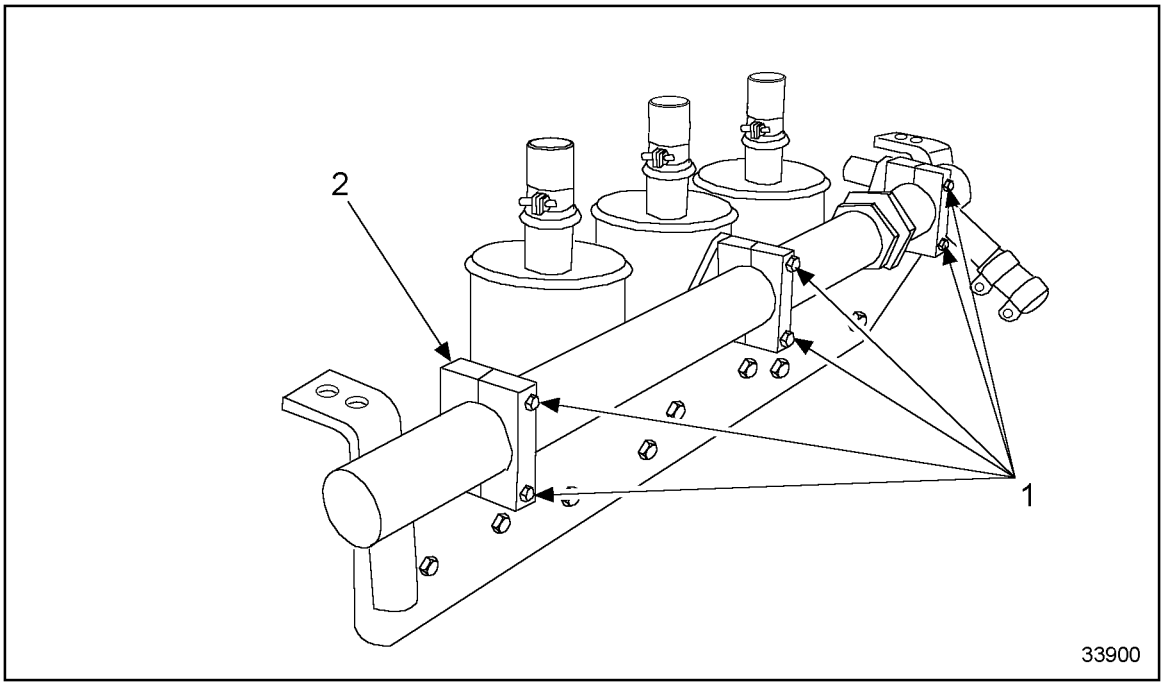
NOTE:
Do not straighten dead-center indicator if it is damaged or bent, but replace with a new part.

   [b] If dead-center indicator is not damaged, continue inspection.
4. Visually inspect condition of mating surfaces and/or bolting surfaces for damage.
   [a] If mating surface and/or bolting surface are damaged, rub down with emery cloth or an oilstone as necessary.
   [b] If mating surfaces are beyond repair, replace component as necessary.
   [c] If mating surface and/or bolting surface are not damaged, continue inspection.
5. Visually inspect condition of threads for damage or wear.
   [a] If threads are damaged or worn, rechase threads as necessary.
   [b] If damage is beyond repair, replace component.
   [c] If threads are not damaged or worn, continue inspection.

Measure Crankshaft Bore in Flywheel Housing

Perform the following steps to measure crankshaft bore in flywheel housing.

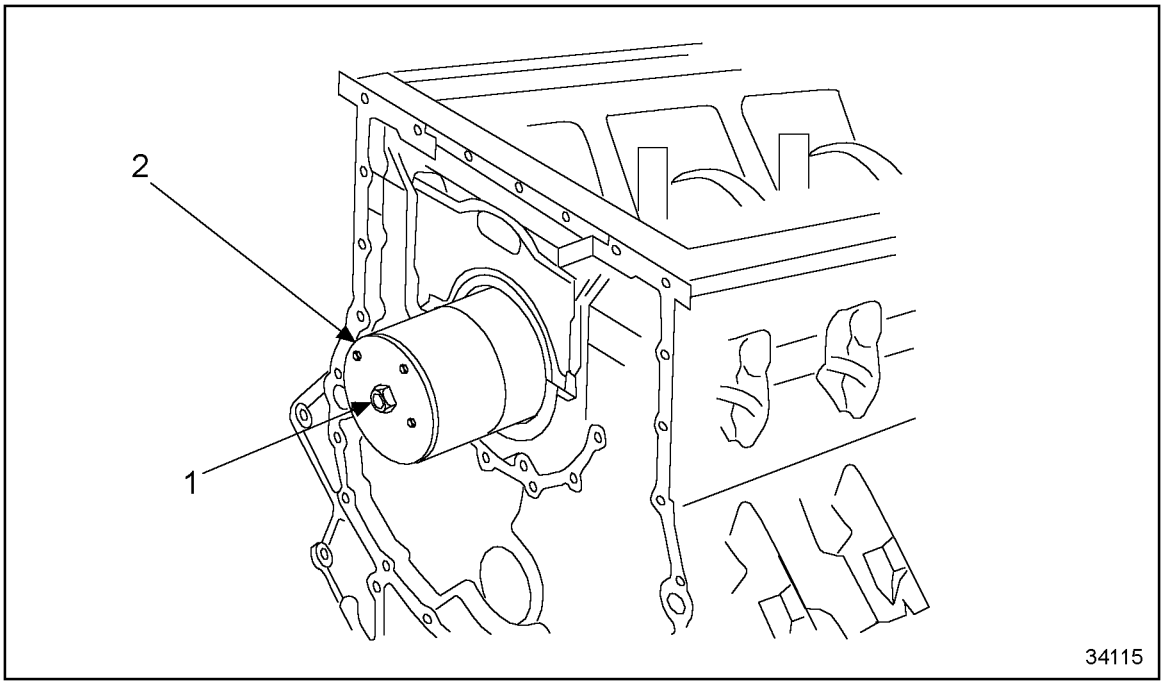
3. Replace six bolts (1) and washers securing the cylinder block tubing to the cylinder block ventilation bracket. See Figure 131.



1. Mounting Bolt
2. Pipe Clamp Half

Figure 131 Replacing Bolts and Washers Securing Cylinder Block Tubing

11. Place guide bushing (2) with hex bolt (1) on crankshaft. See Figure 149.

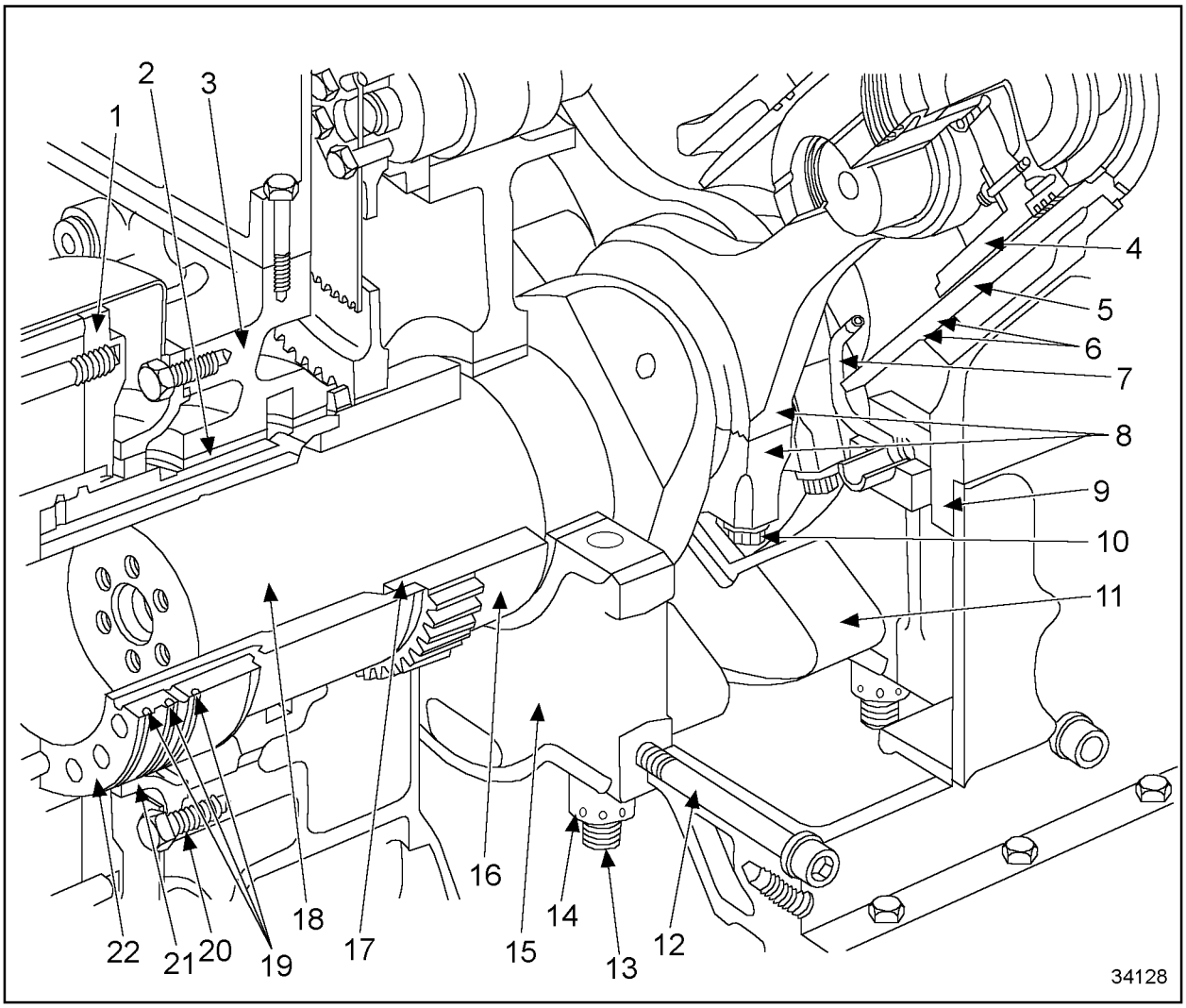


1. Hex Bolt
2. Gear Case Alignment Tool Guide Bushing

Figure 149 Placing Guide Bushing on Crankshaft

C 031.05.01 – GENERAL VIEW

See Figure 164 for a general view of the crankshaft components.



1. Vibration Damper
2. Outboard Bearing, Gear Case End
3. Gear Case
4. Piston
5. Cylinder Liner
6. O-ring
7. Oil Spray Nozzle
8. Connecting Rod
9. Cylinder Block
12. Hex Socket Bolt
13. Stud
14. Nut for Main Bearing Cap
15. Crankshaft Bearing Cap
16. Crankshaft Gear
17. O-ring
18. Crankshaft
19. O-ring
20. Hex Bolt

[b] If no scoring or damage is found, continue with inspection. See Figure 186.

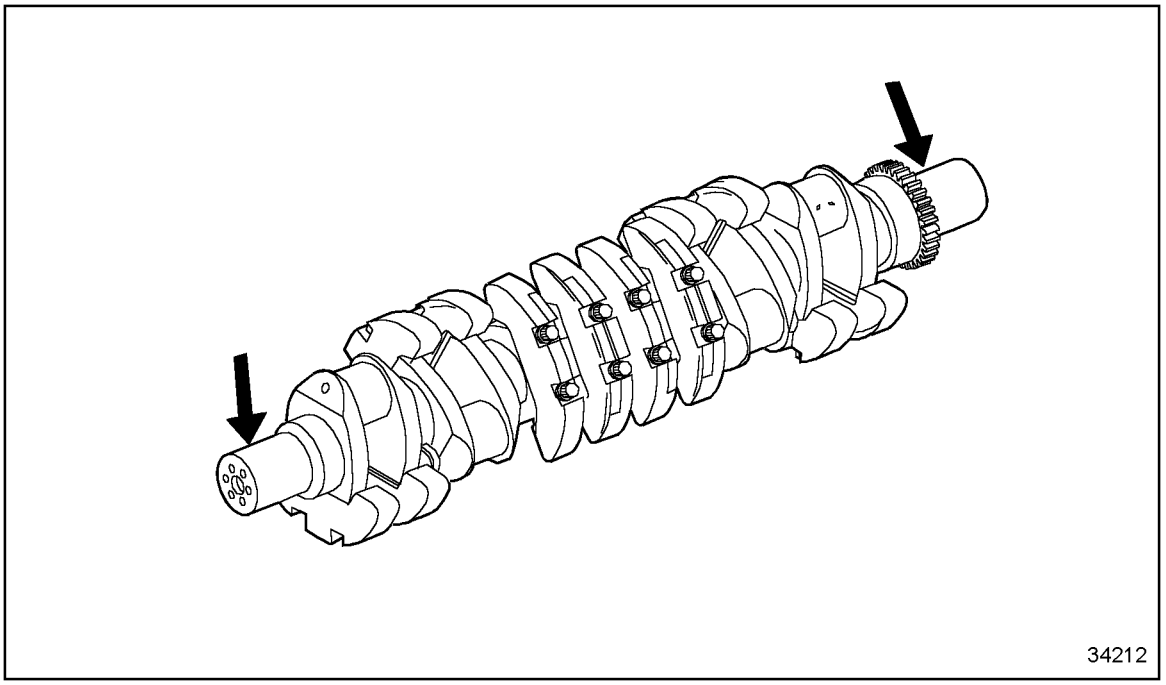


Figure 186 Checking Crankshaft Taper

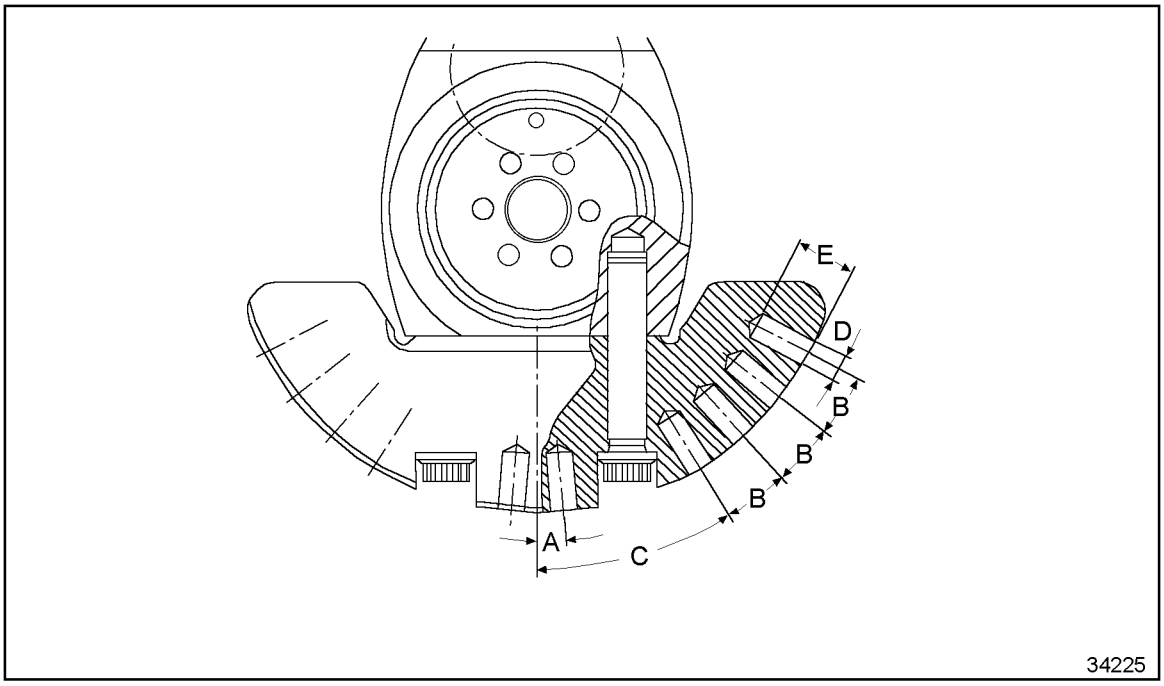
2. Check tapers 1:50 with taper gage.
   [a] If necessary, machine taper to specifications.
   [b] If taper is to specifications, continue inspection.

Checking Hardness of Journals

Perform the following steps to check the hardness of journals:

Bore Values at 12V Counterweights

To determine 12V counterweight bore values, see Figure 213.



A = 5 degrees (minimum)

B = 10 degrees

C = 32 degrees (minimum)

D = 18 mm (.7086 in.) (maximum bore diameter)

E = 40 mm (.5748 in.) (maximum bore depth)

Minimum wall strength around balancing bores is 5 mm (.1967 in.).

Figure 213 Bore Values at 12V Counterweights

Checking Oil Bores

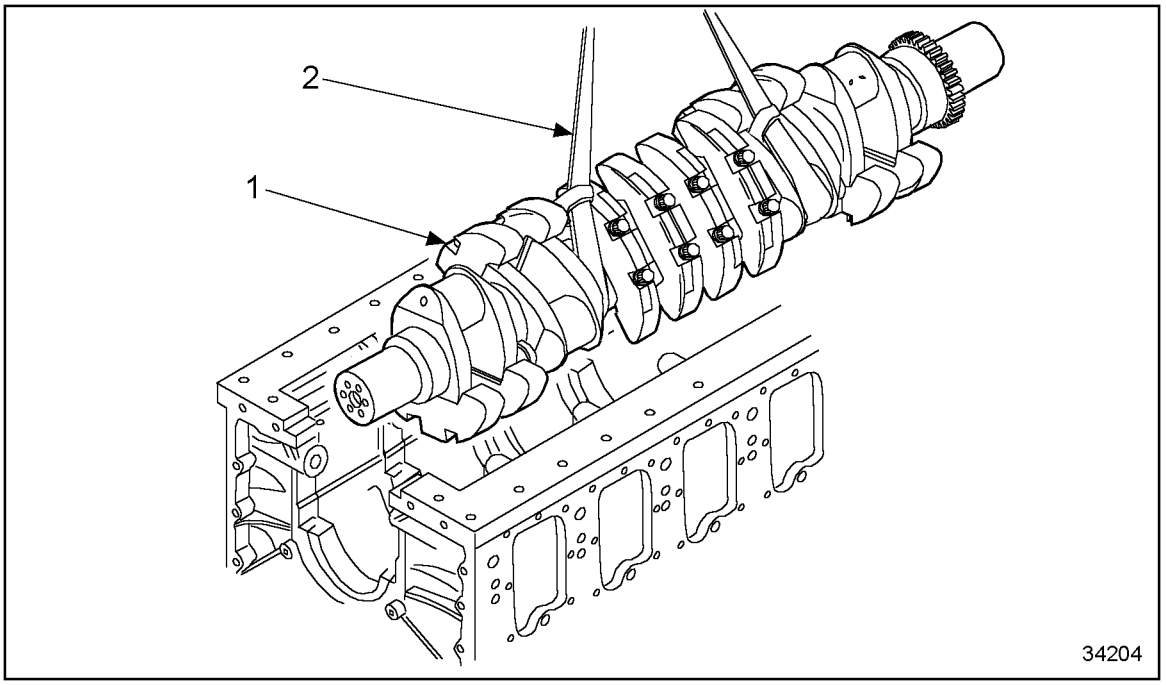
To check oil bores, perform the following steps:

1. Using an borescope, inspect all bores with cold light source.
   [a] Clean bores if they are not perfectly clean.

CAUTION:

To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

5. Lift crankshaft (1) using lifting device (2) and crane. See Figure 240.



1. Crankshaft
2. Lifting Device

Figure 240 Lowering Crankshaft

6. Align crankshaft horizontally and vertically with line of bores in cylinder block, and gradually lower crankshaft.

CAUTION:

To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

32. Attach flex coupling with crane and lifting device. See Figure 255.

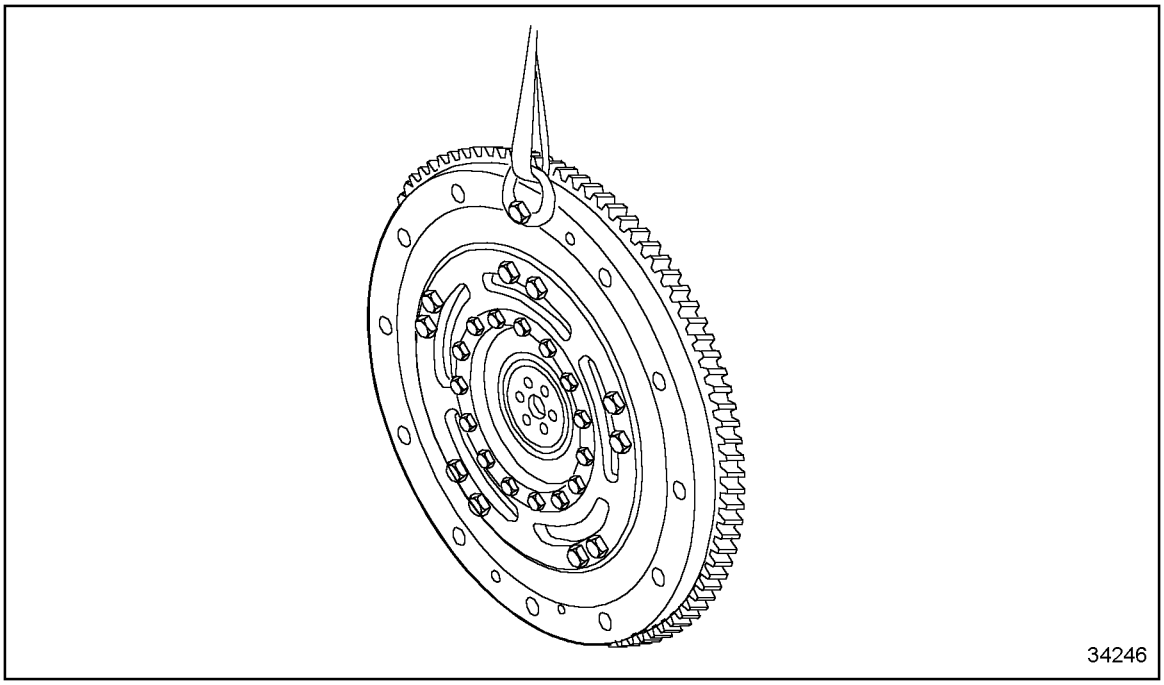


Figure 255 Lifting Flex Coupling by Eyebolt

CAUTION:

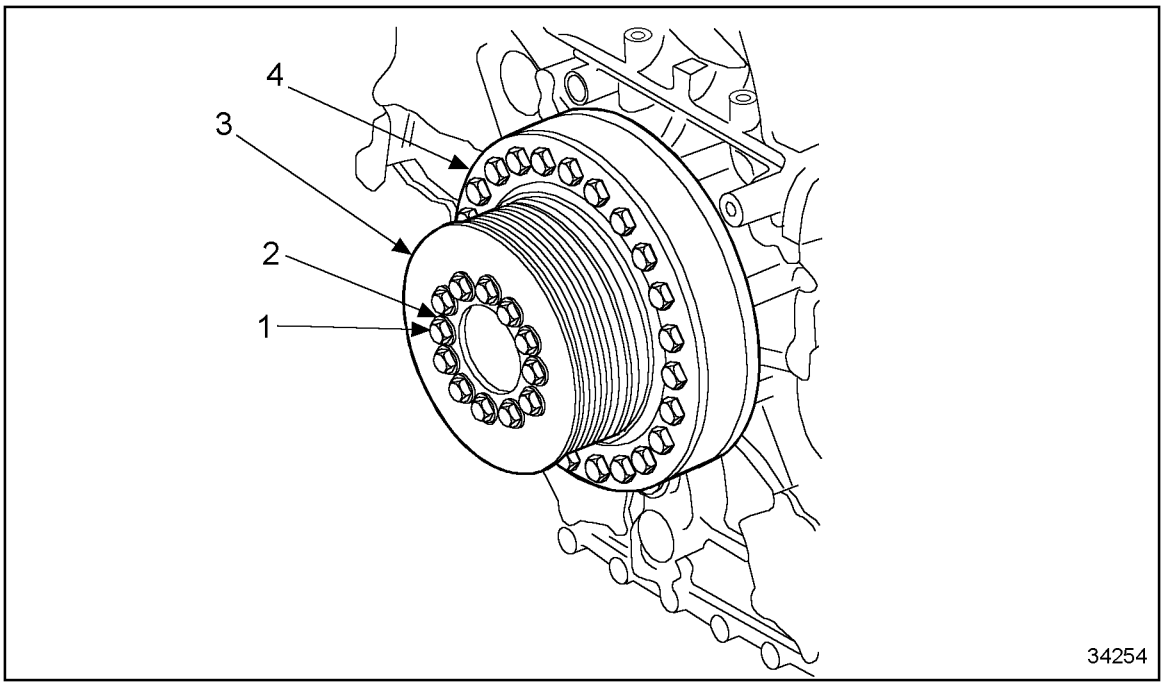
To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

33. Using crane and lifting device, position flex coupling on drive via guide pin.

19. Remove the nut, pressure sleeve and adapter.

NOTICE
The drive flange cannot be subjected to an operational load for at least eight hours.

20. Insert guide pin for installing hex bolt (1) and vibration damper (4) into threaded bore of crankshaft. See Figure 271.



1. Hex Bolt
2. Washer
3. Belt Pulley
4. Vibration Damper

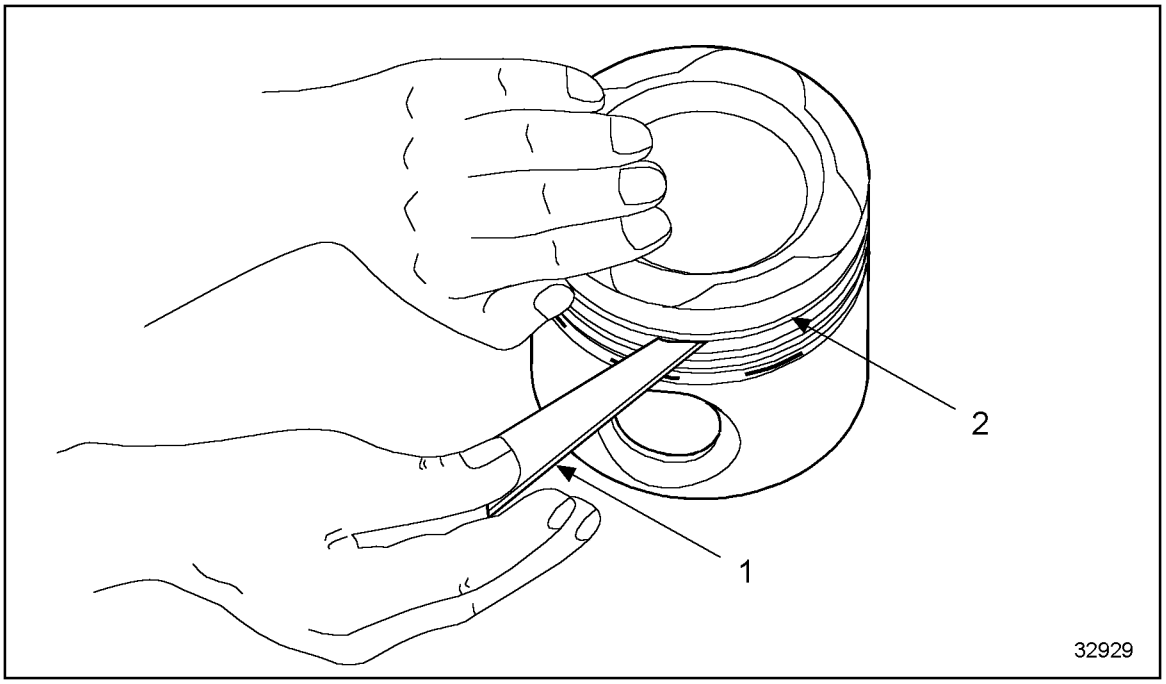
Figure 271 Installing Belt Pulley and Vibration Damper

21. Coat O-rings with petroleum jelly and install onto damper hub.

NOTE:
Make sure parts are perfectly clean.

1. Check groove width with final measurements.

NOTE:
If a set of final measurements is not available, a new piston ring (2) can be inserted into the groove and axial clearance can be measured with a feeler gage (1). See Figure 289.



1. Feeler Gage
2. Piston Ring

Figure 289 Inspecting Piston Ring Grooves

2. If the limit values are exceeded, or measurements are below limit values for oil control ring groove, replace piston.

Inspecting Piston Pin Boss

Perform the following steps to inspect and repair piston pin boss.

1. Adjust bore gage and measure piston pin bore.
   [a] If limit values are exceeded, replace pistons.

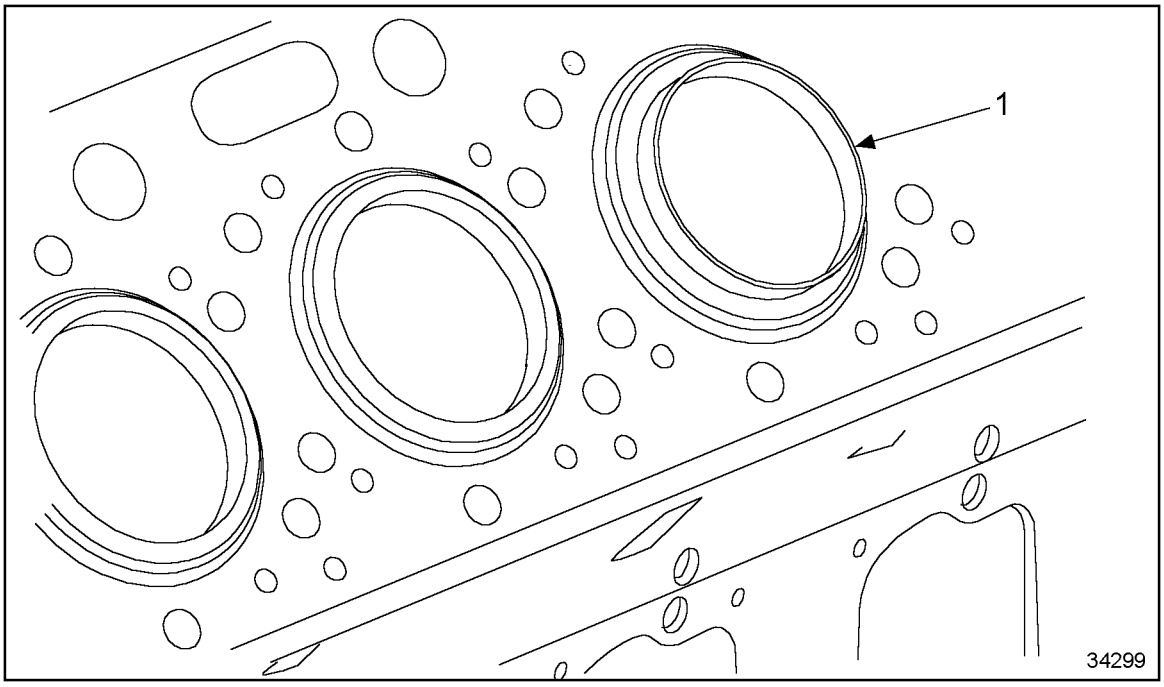
C 037.05.10 – ASSEMBLY OF PISTON WITH CONNECTING ROD

Perform the following steps to assemble piston with connecting rod.

Installing Connecting Rod Bushing

NOTE:
Always make sure that all components are perfectly clean.

3. Insert carbon scraper ring (marine only). See Figure 339.



1. Carbon Scraper Ring

Figure 339 Carbon Scraper Ring (Marine Only)

[b] Reuse cylinder heads if bores are within specifications.

19. To remove bridge pin with engine installed, remove all overhead components prior as necessary.

NOTE:
Identify any valve bridges that have turned, indicate turn or show unusual wear. Replace all bridges that meet these criteria.

20. Install slide-hammer puller to bridge pin. Remove pin.

NOTE:
Count the number of pulls required to remove pin. If pin was removed with few pulls or removed with little resistance, see step 20.

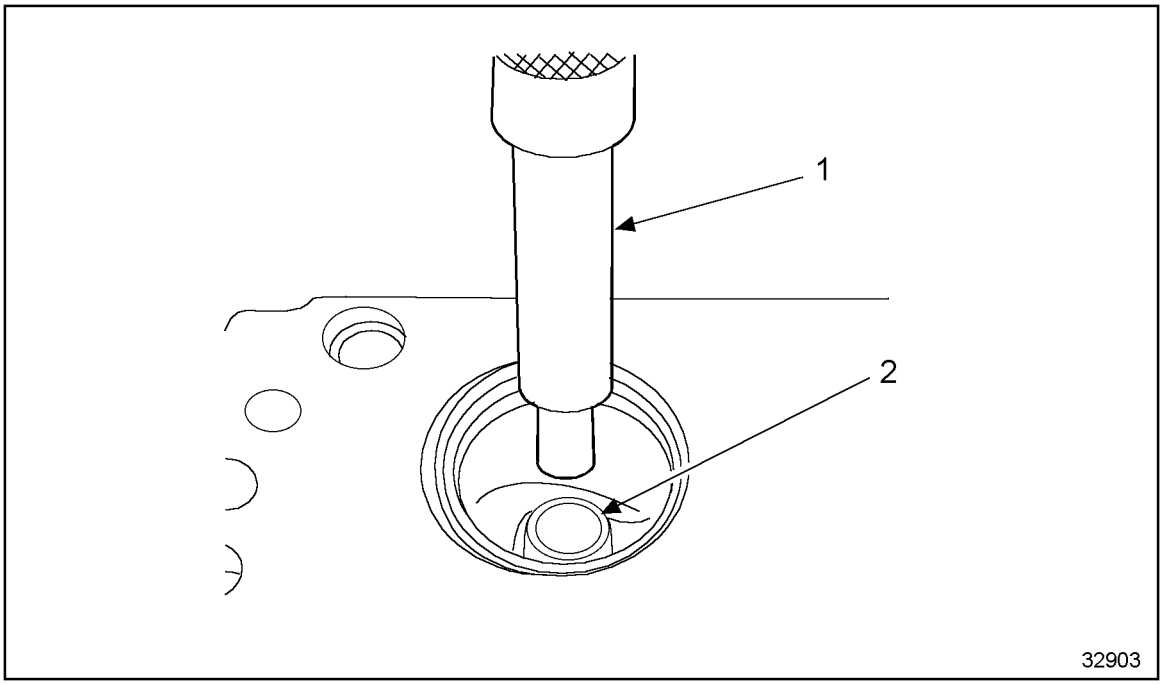
Measure bridge pin bore using pin bore digital measuring tool. Measure bore at three locations; bottom, middle and top. Record values to a data sheet.

21. Preset tool to 12.7 mm (0.50 in.) prior to measuring.

[a] Replace cylinder heads if any bore is out of tolerance (13.984 – 14.00 mm (0.550 – 0.551 in.))

[b] Reuse cylinder heads if bores are within specifications.

22. Place cylinder head on hydraulic press. See Figure 357.



1. Removal Brass Drift
2. Valve Guide

Figure 357 Removing Valve Guides

15. Install new valve locks in groove on valve stem end. See Figure 379.

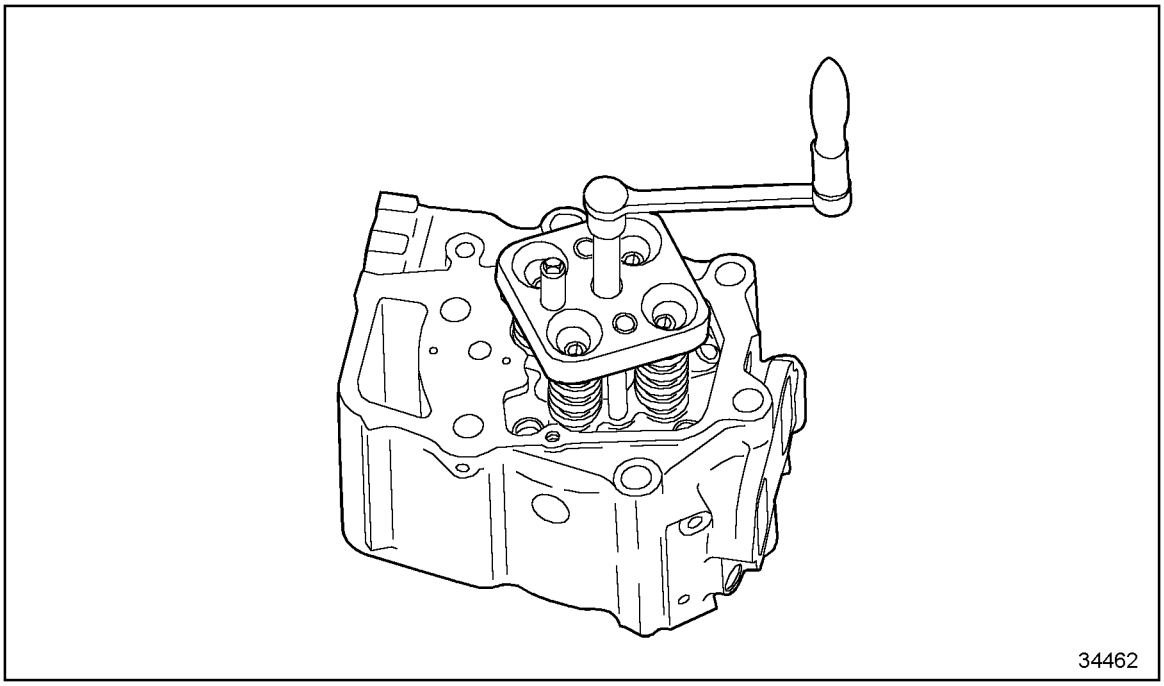


Figure 379 Installing Valve Locks

16. Release valve springs so that spring retainers are pushed over valve locks.
17. Ensure that lip of valve lock is securely seated in groove at valve stem end.
18. Remove pressure plate with manual spindle.
19. Lift cylinder head out of base plate.

C 051.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the camshaft:

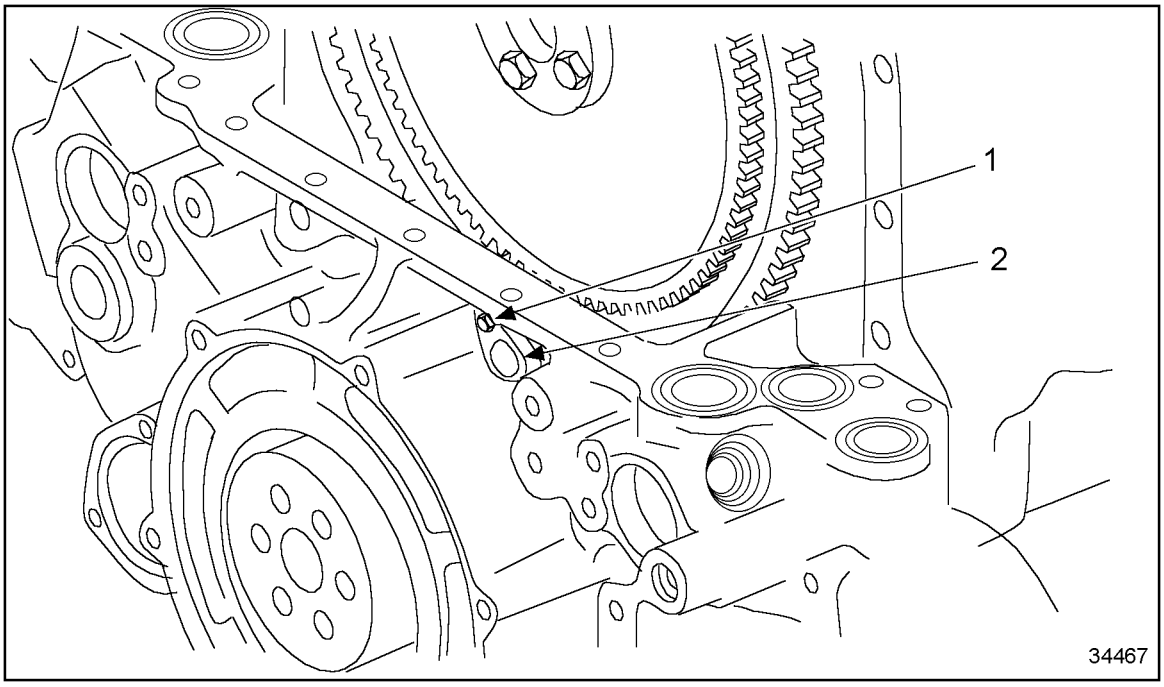
1. Clean camshaft.
2. Pre-polish bearing journals and cams with emery cloth.
3. Using the magnetic crack-testing method with fluorescent magnetic powder, check camshaft for cracks.
   [a] If cracked, replace camshaft.
   [b] If camshaft is not cracked, continue inspection.
4. Check cam bearing surface, journal surfaces and roller tracks for scoring, wear and indentations.
   [a] If cam bearing surface, journal surfaces and roller tracks show signs of scoring, wear or indentations, replace cam.
   [b] If cam bearing surface, journal surfaces and roller tracks do not show signs of scoring, wear or indentations, continue inspection.
5. Check gear mating surface for wear or damage.
   [a] If gear mating surface is worn or damaged, rub down with oilstone
   [b] If gear mating surface is beyond repair, replace component.
   [c] If gear mating surface is not worn or damaged, continue inspection.
6. Check surface condition of gear teeth with magnifying glass.
   [a] If gear teeth are worn, replace gear.
   [b] If gear teeth are not worn, continue inspection.
7. Remove minor scoring, wear and indentations by polishing with emery cloth; if necessary, machine to DDC specifications or replace camshaft.

NOTE:
Ensure parts are perfectly clean.

Checking Hardness of Cam and Journal

Perform the following steps to check hardness of cam and journal:

7. Remove hex bolt (1).
8. Turn SRS sensor (2) slightly to remove from housing bore. See Figure 417.



1. Hex Bolt
2. SRS Sensor

Figure 417 Turning SRS Sensor

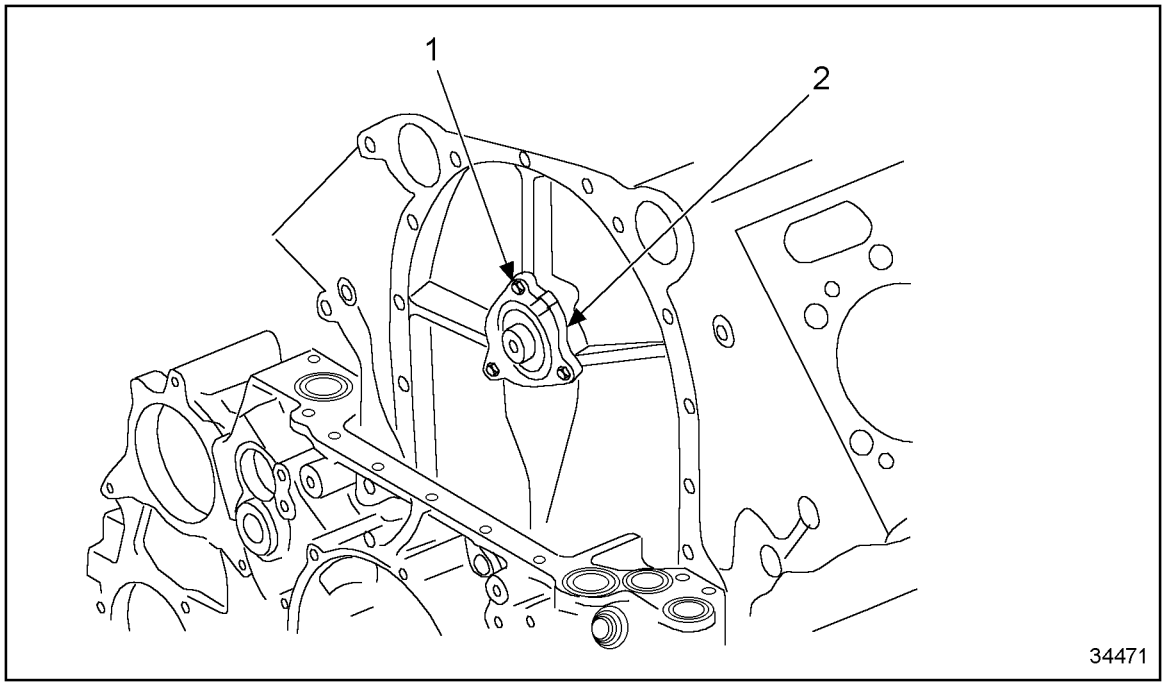
9. If shims are installed on the sensor, save all shims for re-installation.

Removing SRS Wheel (Camshaft Gear)

Perform the following steps to remove SRS wheel (camshaft gear):

1. Position locating tool (2) on bolting surface of rocker shaft flywheel end. See Figure 418.

5. Remove locating tool.
6. Install ring (1) with hex bolt (2) on camshaft. See Figure 439.



1. Spacer
2. Hex Bolt

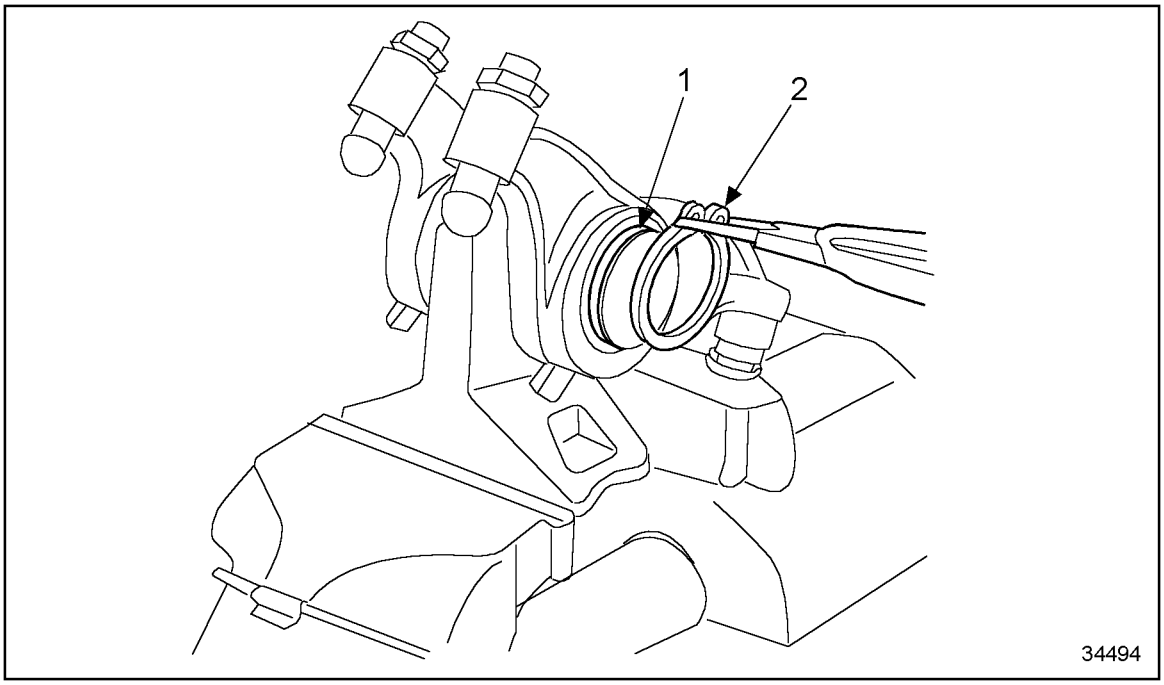
Figure 439 Installing Spacer with Hex Bolt on Camshaft

NOTE:
The spacer serves only to secure the camshaft axially and prevent it from falling out during cylinder block transportation.

C 055.05.06 – DISASSEMBLY OF ROCKER ARM ASSEMBLY

Perform the following steps to disassemble rocker arm assembly:

1. Clamp rocker shaft bracket in vice with aluminum jaws. See Figure 459.



1. Washer
2. Snap Ring

Figure 459 Clamping Rocker Shaft Bracket Support in Vice and Removing Snap Ring and Washer from Rocker Shaft

2. Using snap ring pliers, remove snap ring (2) from rocker shaft.
3. Remove washer (1).

Adjusting Valve Clearance

Perform the following steps to adjust valve clearance for entire engine:

NOTE:
Before valve clearance is adjusted, valve bridge must be adjusted. See Figure 483.

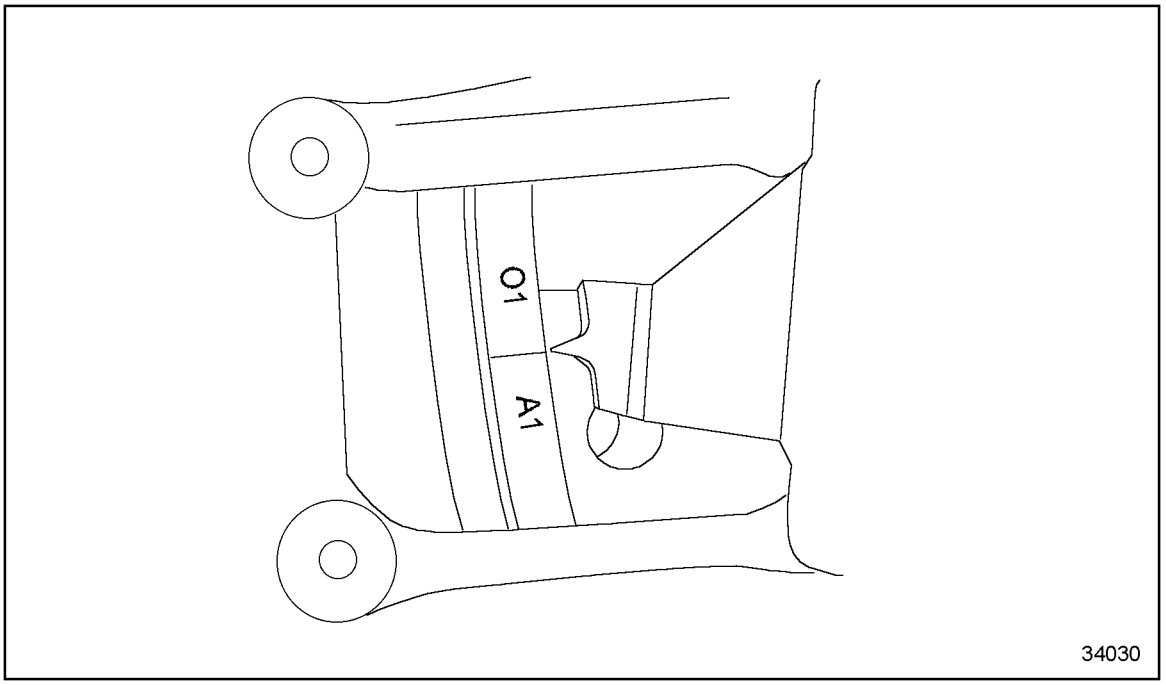


Figure 483 Adjusting Valve Clearance (Marine only)

CAUTION:

To avoid personal injury when barring the engine over, stand clear so that the crankshaft will not unexpectedly rotate and cause loss of control of barring tool.

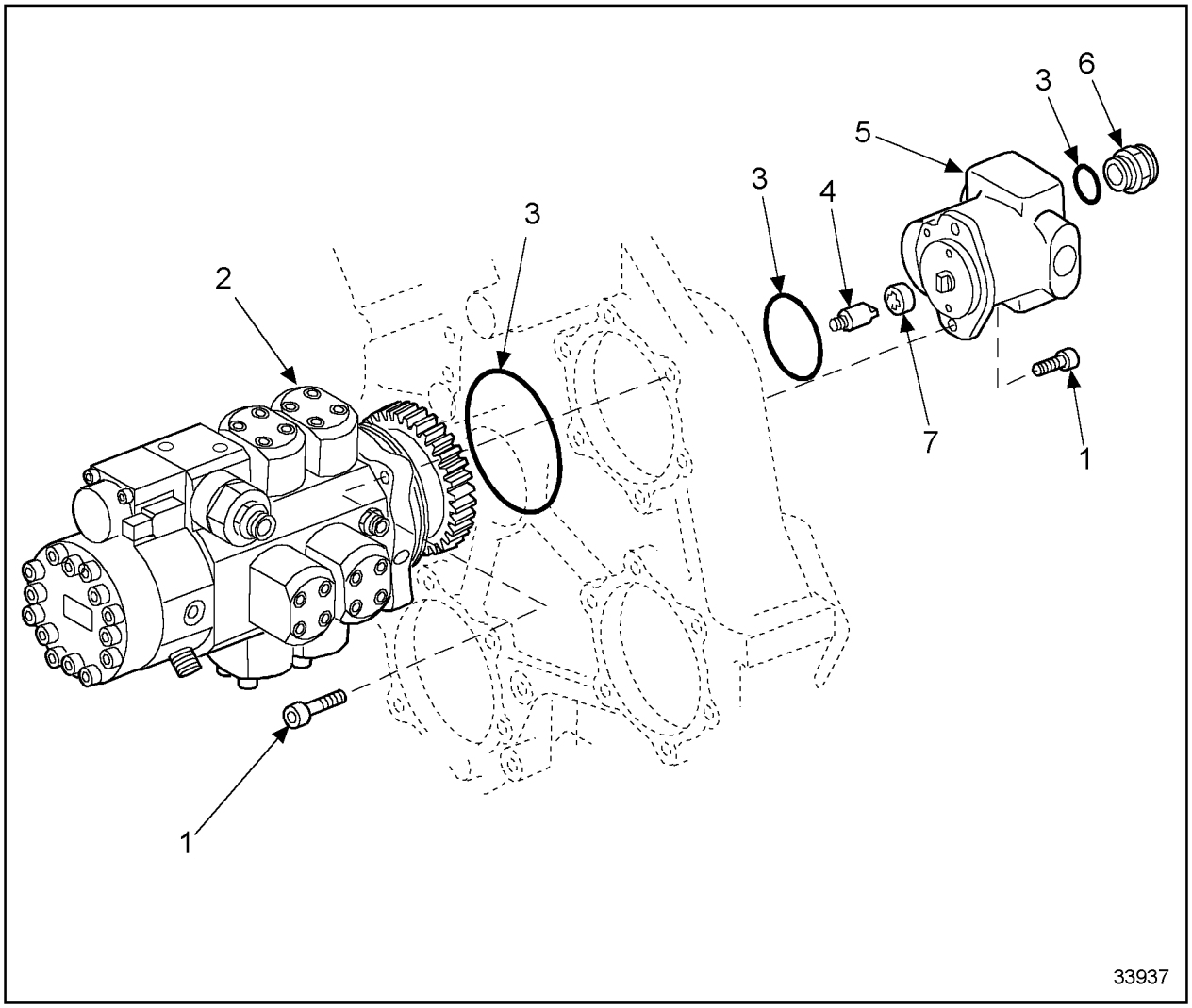
1. With barring tool, turn engine in normal direction of rotation until TDC A1 mark and arrow on flywheel housing are aligned.

Adjusting Valve Clearance in Two Crankshaft Positions

Perform the following steps to adjust valve clearance in two crankshaft positions:

C 073.05.01 – GENERAL VIEW

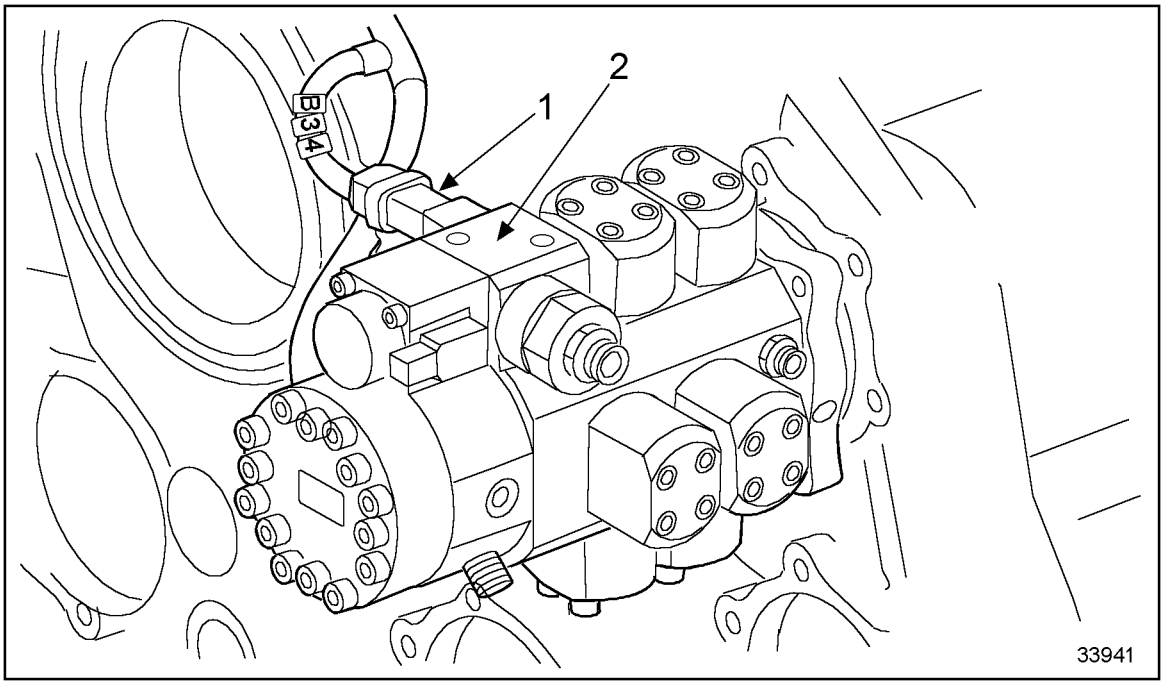
See Figure 495 for a general view of the high-pressure fuel pump.



1. Bolt
2. High-Pressure Fuel Pump
3. O-ring
4. Drive Adaptor
5. Low-Pressure Fuel Transfer
6. Fitting
7. Drive Coupling

Figure 495 General View of the High-Pressure Fuel Pump

3. Disconnect B34 (1) (low fuel pressure sensor) wiring harness from the high pressure fuel pump controller solenoid (2). See Figure 512.



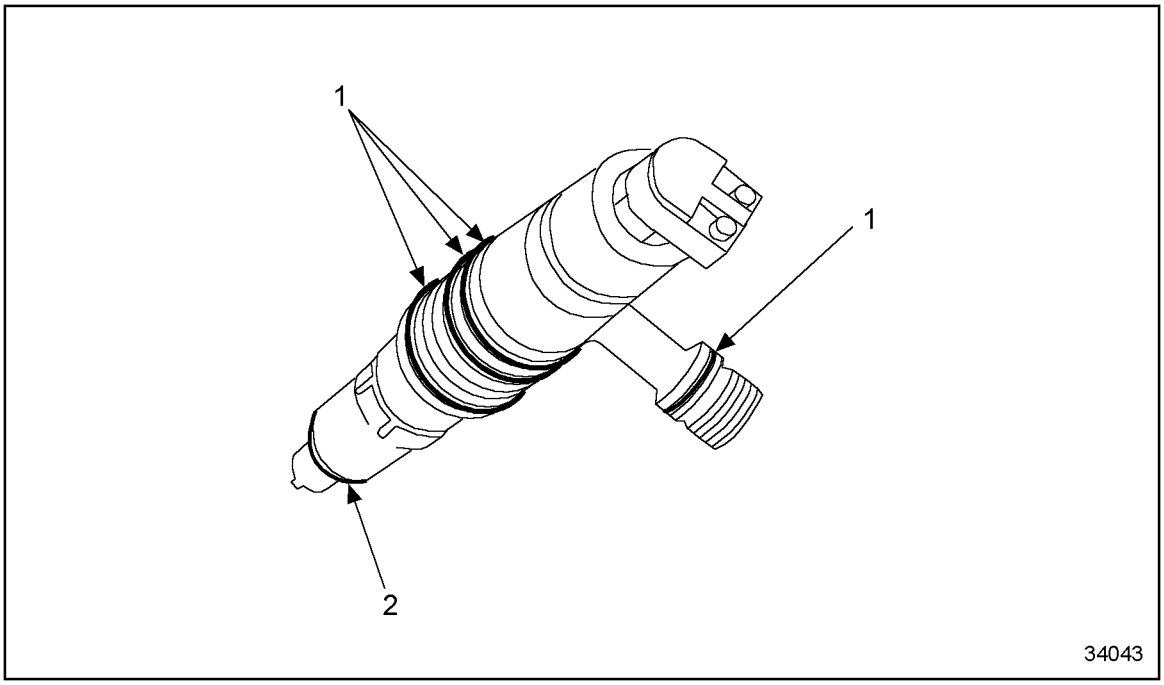
1. B34 (Low Fuel Pressure Sensor) Connector
2. High-Pressure Pump Controller Solenoid

Figure 512 Disconnecting Low Fuel Pressure Sensor

C 075.05.11 – INSTALLATION OF THE INJECTOR

Perform the following steps for installation of the injector:

1. Coat new O-rings (1) with petroleum jelly and install on injector. See Figure 530



1. O-ring 2. C-E Ring

Figure 530 Installing O-rings and CE Support Rings on Injector

2. Affix new C–E ring with grease on mating surface of injector tip.

NOTE:
Ensure that C-E support ring is correctly fitted and seated on injector. See Figure 531.

C 077.05.06 – DISASSEMBLY OF HIGH-PRESSURE RAIL

1. To disassemble high-pressure rail, use special tool J 42731 to clamp high-pressure rail in vise. See Figure 550.

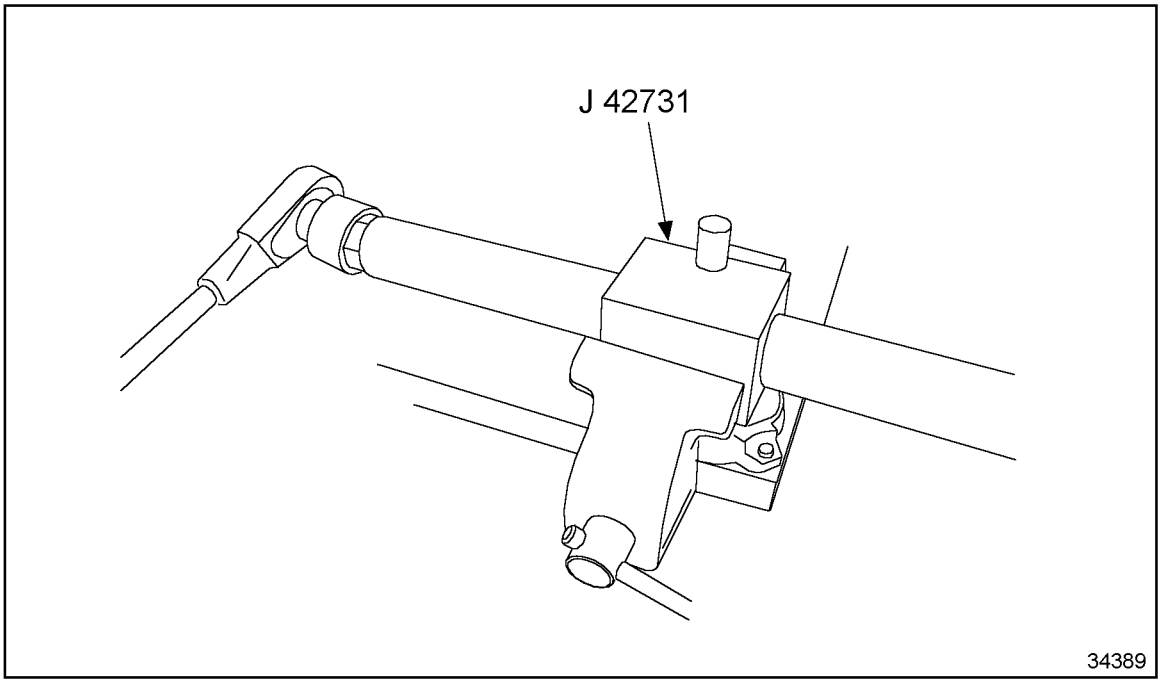
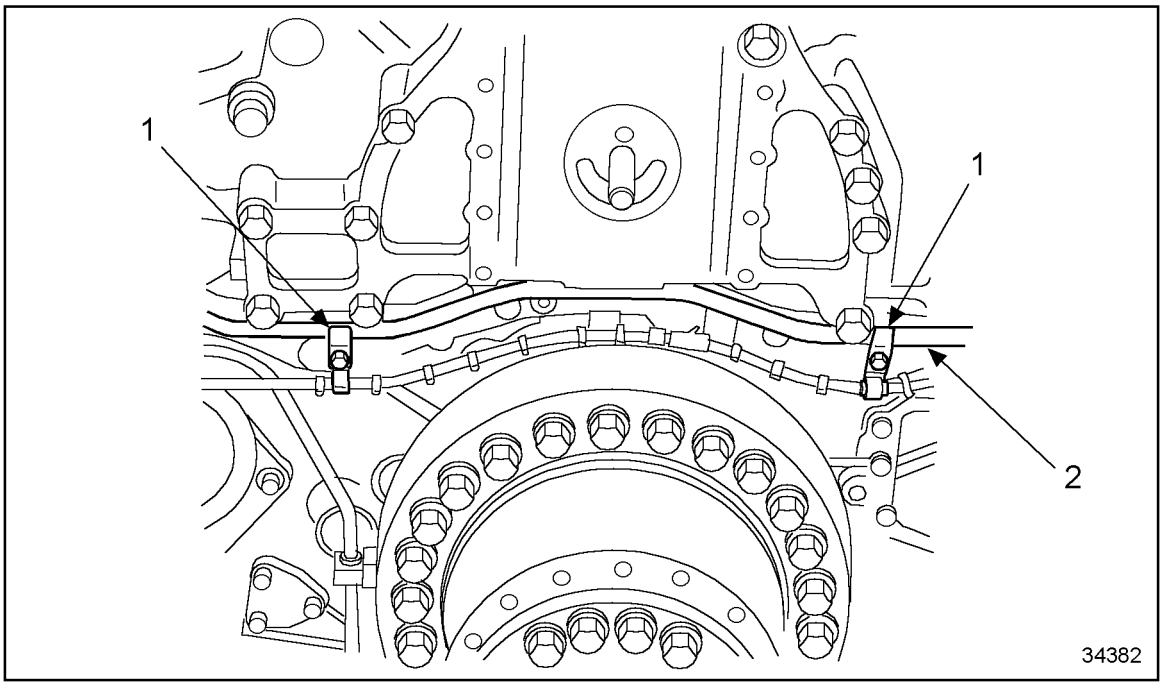


Figure 550 Clamping High-Pressure Rail in Vise

2. Remove thrust bolts. See Figure 551.

35. Install pipe clamp halves (1) of high-pressure line (2), “B” bank. See Figure 578.



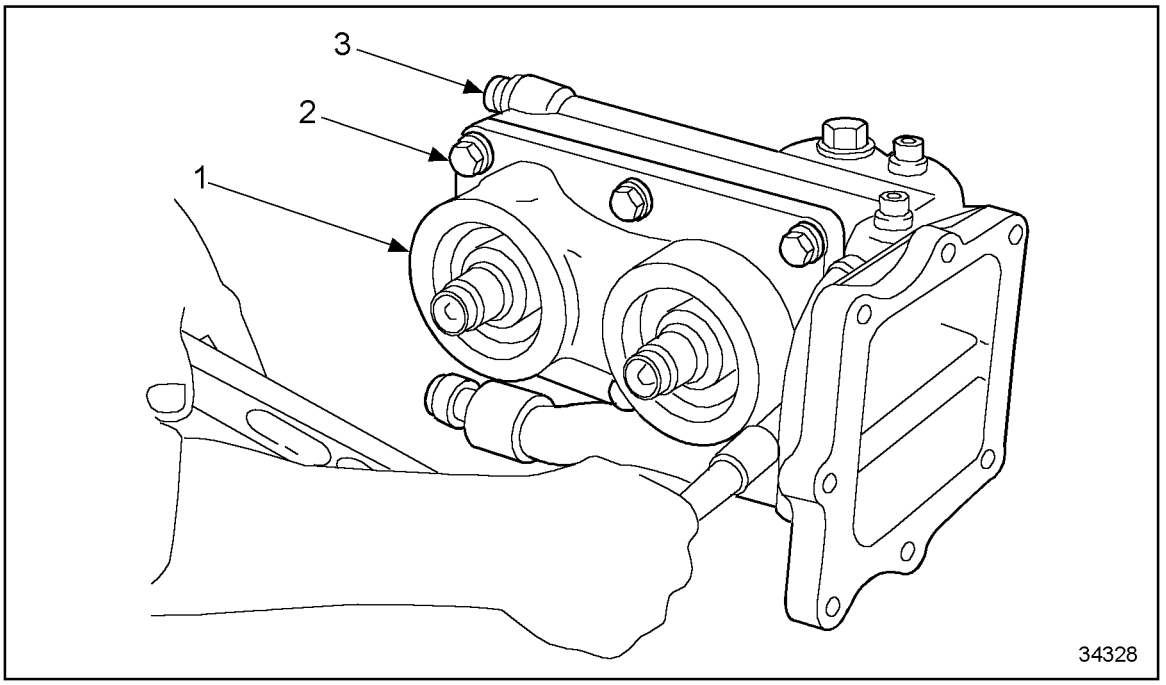
1. Pipe Clamp Half
2. High-Pressure Line

Figure 578 Installing Pipe Clamp Halves of High-Pressure Line, “B” Bank

C 083.05.06 – DISASSEMBLY OF FUEL FILTER

Perform the following steps to disassemble the fuel filter:

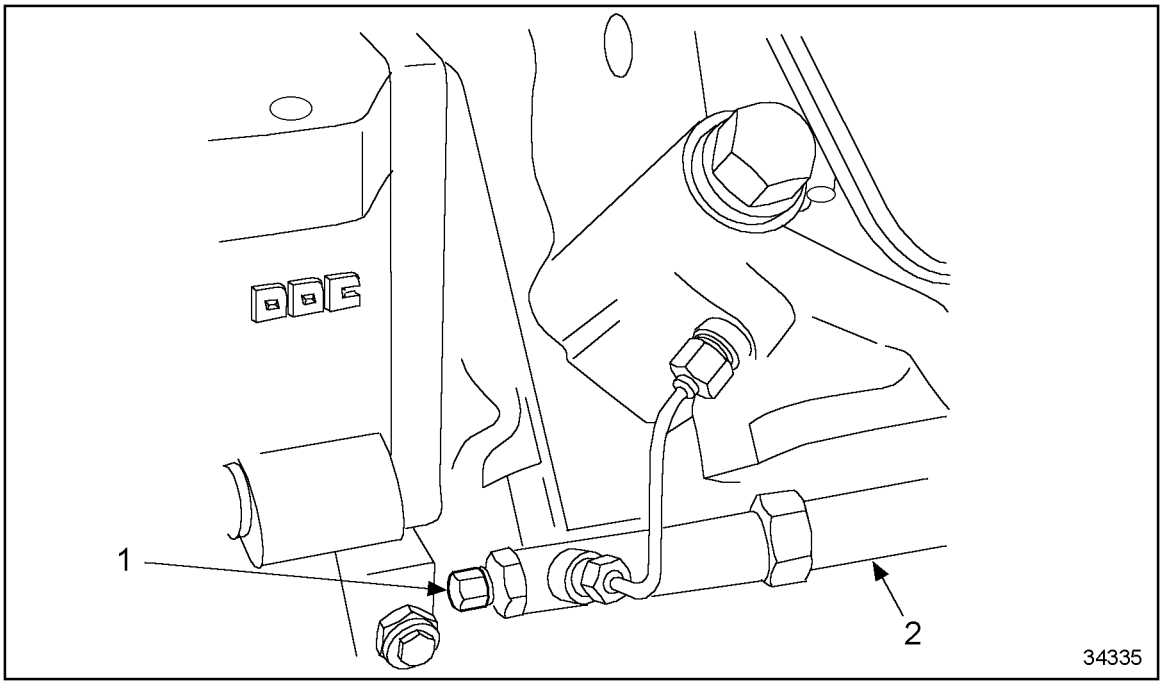
1. Remove hex bolts (2) and separate filter head (1) from junction block (3). See Figure 592.



1. Filter Head
2. Hex Bolt
3. Junction Block

Figure 592 Removing Hex Bolts and Separating Filter Head from Junction Block

2. Remove the blanking plug (4) and threaded connection (3) from filter head (1) and junction block (2). See Figure 593.

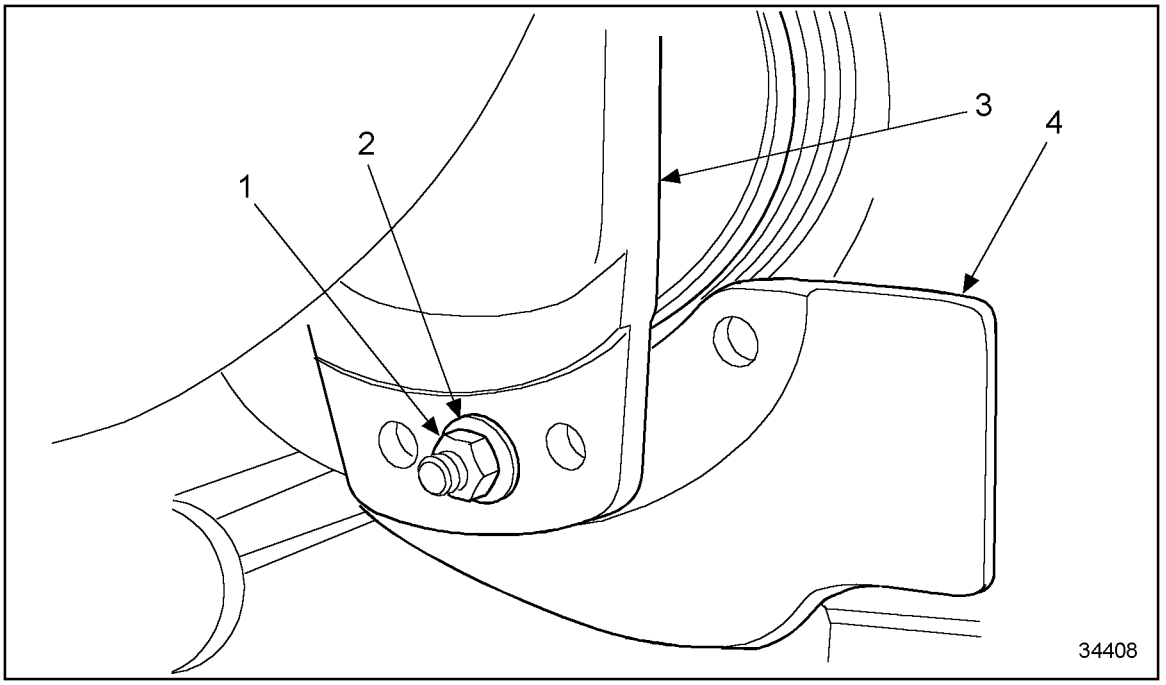


1. Adaptor Nut
2. Fuel Return Rail

Figure 607 Removing Adaptor Nut and Blanking Plug (Fuel Return Rail)

3. Remove blanking plug from fuel return rail.

3. Install exhaust outlet (Y-pipe) (3) into turbocharger exhaust outlet. See Figure 620.



1. Hex Bolt
2. Washer
3. Y-pipe
4. Bracket

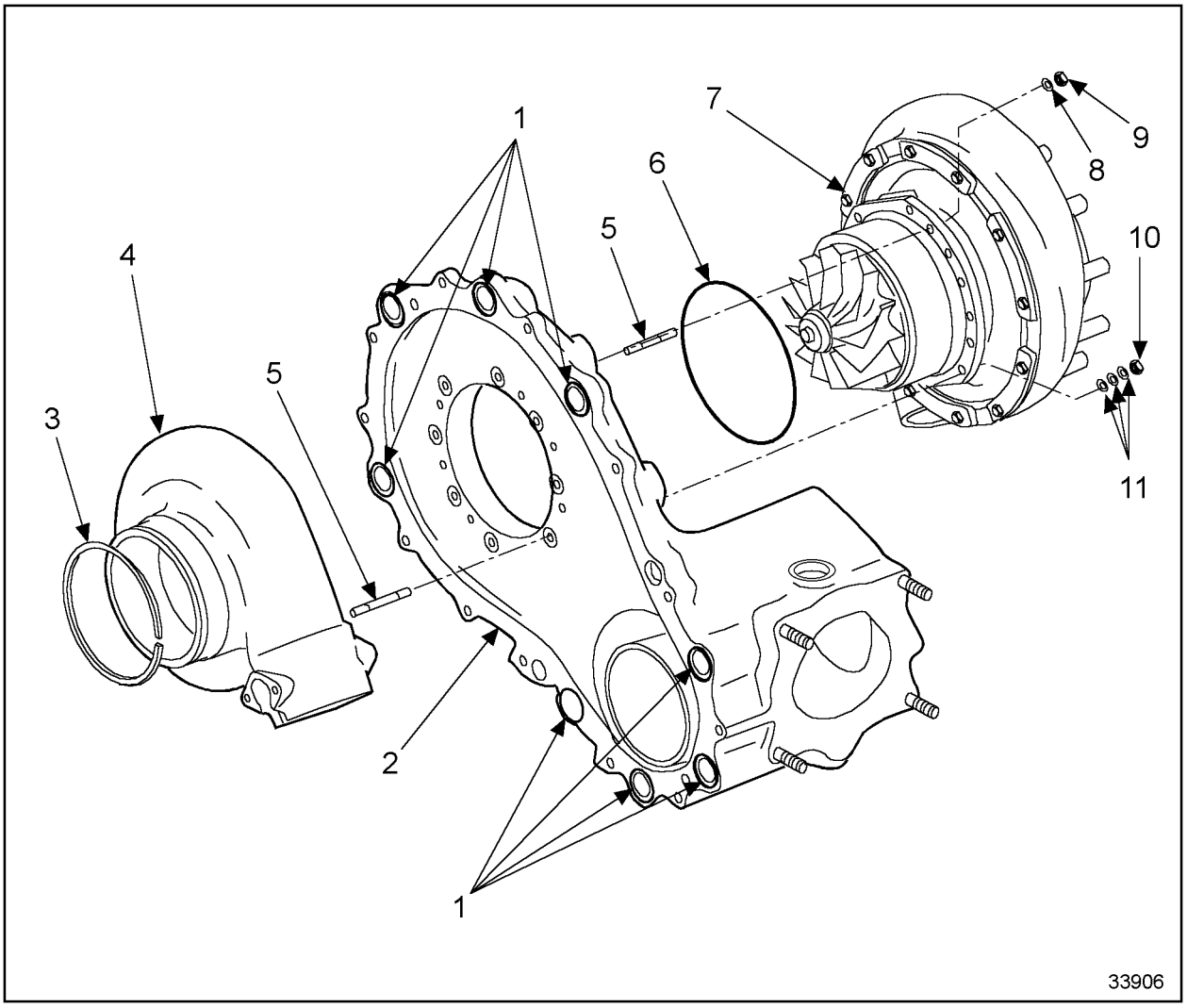
Figure 620 Installing Exhaust Outlet (Y-pipe) into Turbocharger Exhaust Outlet

4. Bolt bracket (4) and (Y-pipe) (3) together with hex bolt (1) and washer (2). Refer to section A 003 .

NOTE:
Join retainers on exhaust outlet (Y-pipe) and bracket at central bores. Final alignment on exhaust outlet (Y-pipe) with vehicle exhaust system can be carried out after installation.

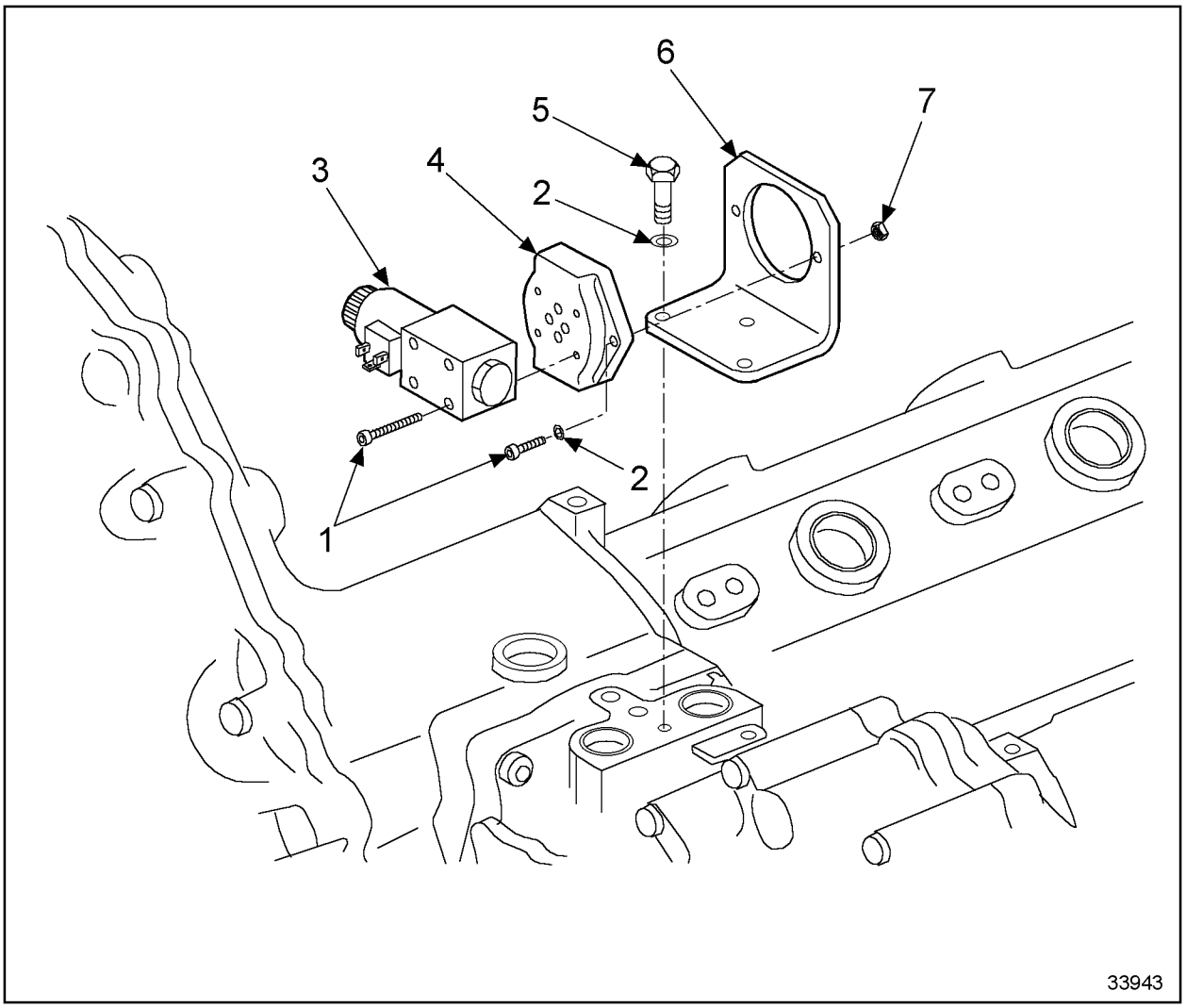
NOTE:
Secure exhaust outlet (Y-pipe) to prevent from falling.

12. Install new O-rings (1) to the rear carrier housing (2). See Figure 637.



1. O-rings
2. Rear Carrier Housing
3. Snap Ring
4. Turbine Housing
5. Stud
6. O-ring
7. Turbocharger Compressor Housing
8. Washer
9. Hex Nut (10 mm - 6)
10. Hex Nut (8 mm - 8)
11. Tapered Washers

Figure 637 Installing O-rings (Marine)



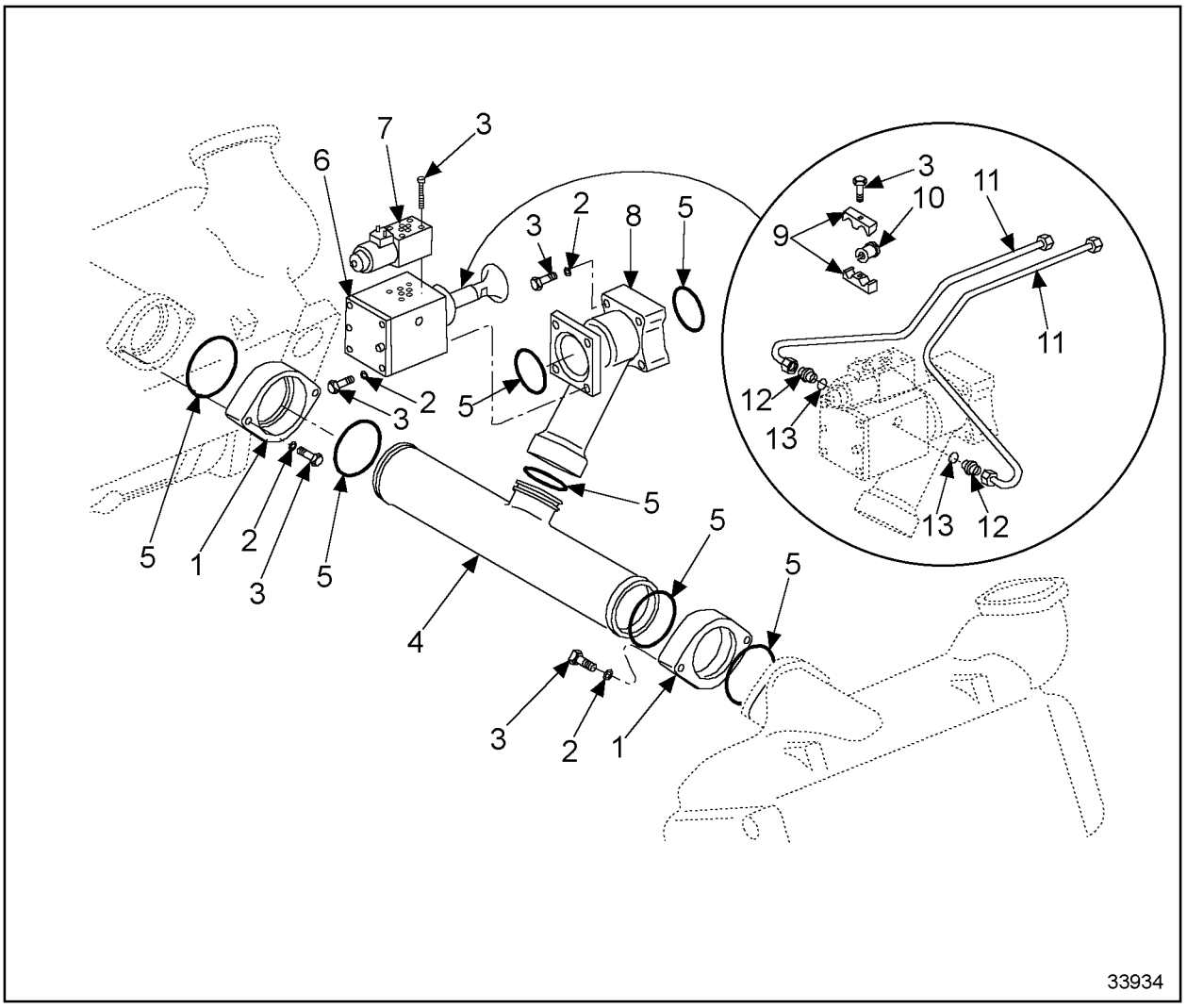
1. Bolt
2. Washer
3. Turbocharger Actuator Control Solenoid Valve
4. Mounting Plate
5. Bolt
6. Mounting Bracket
7. Nut

Figure 650 Removing Bolt and Washer from Turbocharger Actuator Control Solenoid Valve (Marine)

3. Remove bolts (5) and washers (2) securing the mounting bracket (6) to the exhaust crossover housing and remove the mounting bracket. See Figure 650.

C 111.05 M – CHARGE AIR COOLER

4. Remove the two O-rings (5) from intercooler. See Figure 682 for the boost bypass valve location.

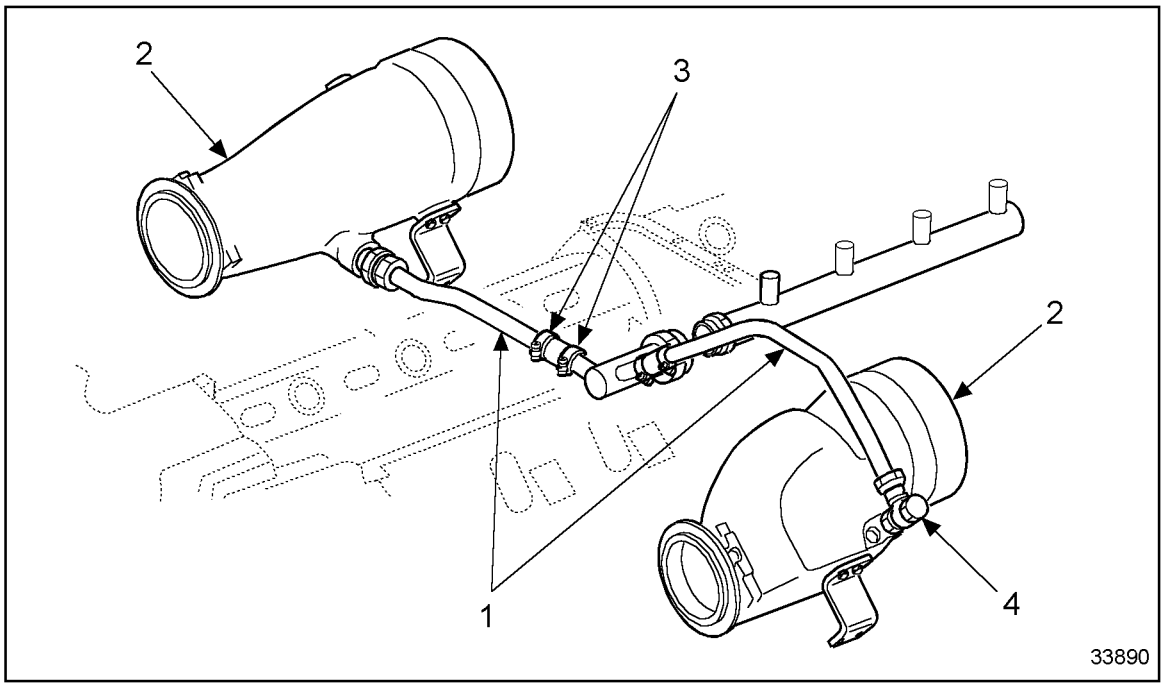


1. Flange
2. Washer
3. Bolt
4. Crossover Tube
5. O-ring
6. Actuating Cylinder
7. Boost Bypass Valve
8. Elbow
9. Pipe Half Clamp
10. Grommet
11. Oil Feed Line
12. Adaptor
13. Sealing Ring

Figure 682 Removing Boost Bypass Valve and Crossover Tube

5. Disconnect oil feed lines from boost bypass valve (7).

4. Release clamps (3) securing the air intake vent tube to the cylinder block breather system. See Figure 693.



1. Air Intake Vent Tube
2. Intake Housing
3. Clamps
4. Vent Tube Fitting

Figure 693 Removing Air Intake Vent Tube

5. Remove the air intake vent tube (1) from the intake housing (2). See Figure 693.

C 125.05.04 – BEFORE-REMOVAL OPERATION

Listed in Table 92 are the Before-Removal Operations for the air supply system from exhaust turbocharger to charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide

1 = The engine is to be completely disassembled.

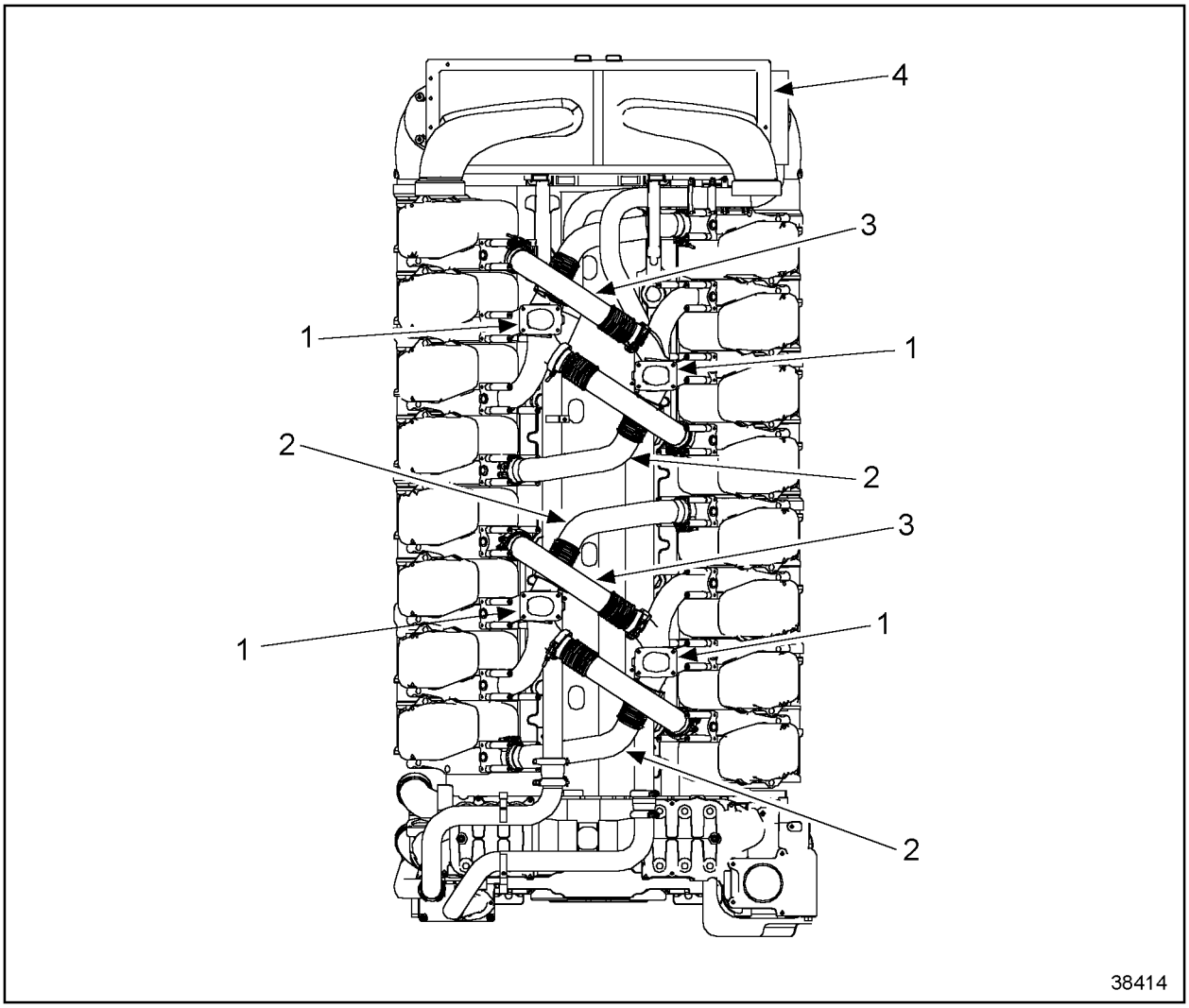
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 92 Before-Removal Operations

C 141.05.01 M – GENERAL VIEW

See Figure 720and see Figure 721 for a general view of the exhaust manifold.



1. Turbocharger
2. Cross-over Tube
3. Tube
4. Charge Air Cooler

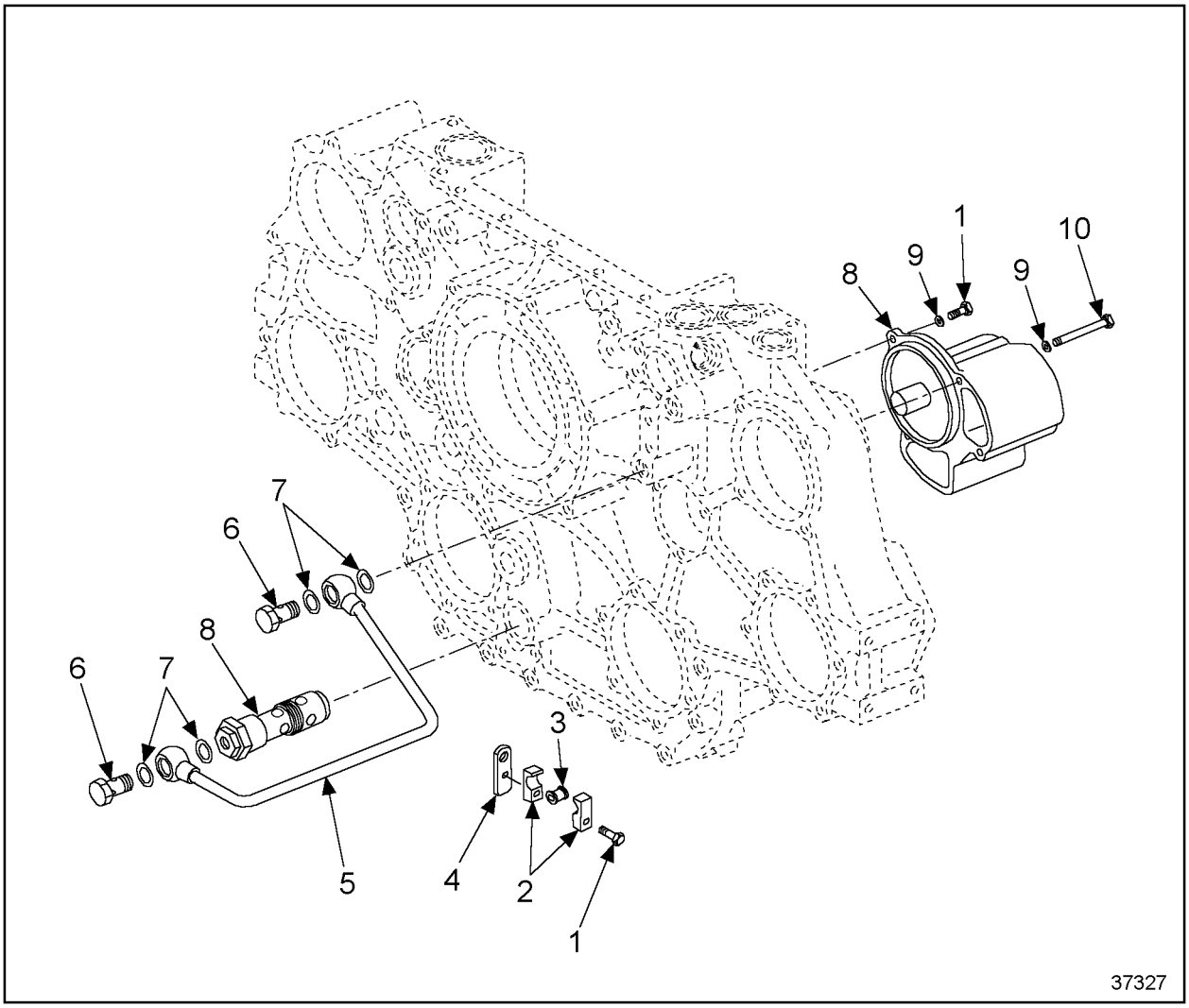
Figure 720 Top View of Marine Exhaust Manifold

C 172.05.06 – DISASSEMBLY OF STARTER

See OEM Guidelines.

C 181.05.01 – GENERAL VIEW

See Figure 743 for a general view of lube oil pump with drive.



1. Hex Bolt
2. Pipe Clamp Half
3. Grommet
4. Bracket
5. Oil Line
6. Banjo Bolt
7. Sealing Ring
8. Pressure Regulator
9. Washer
10. Hex Bolt

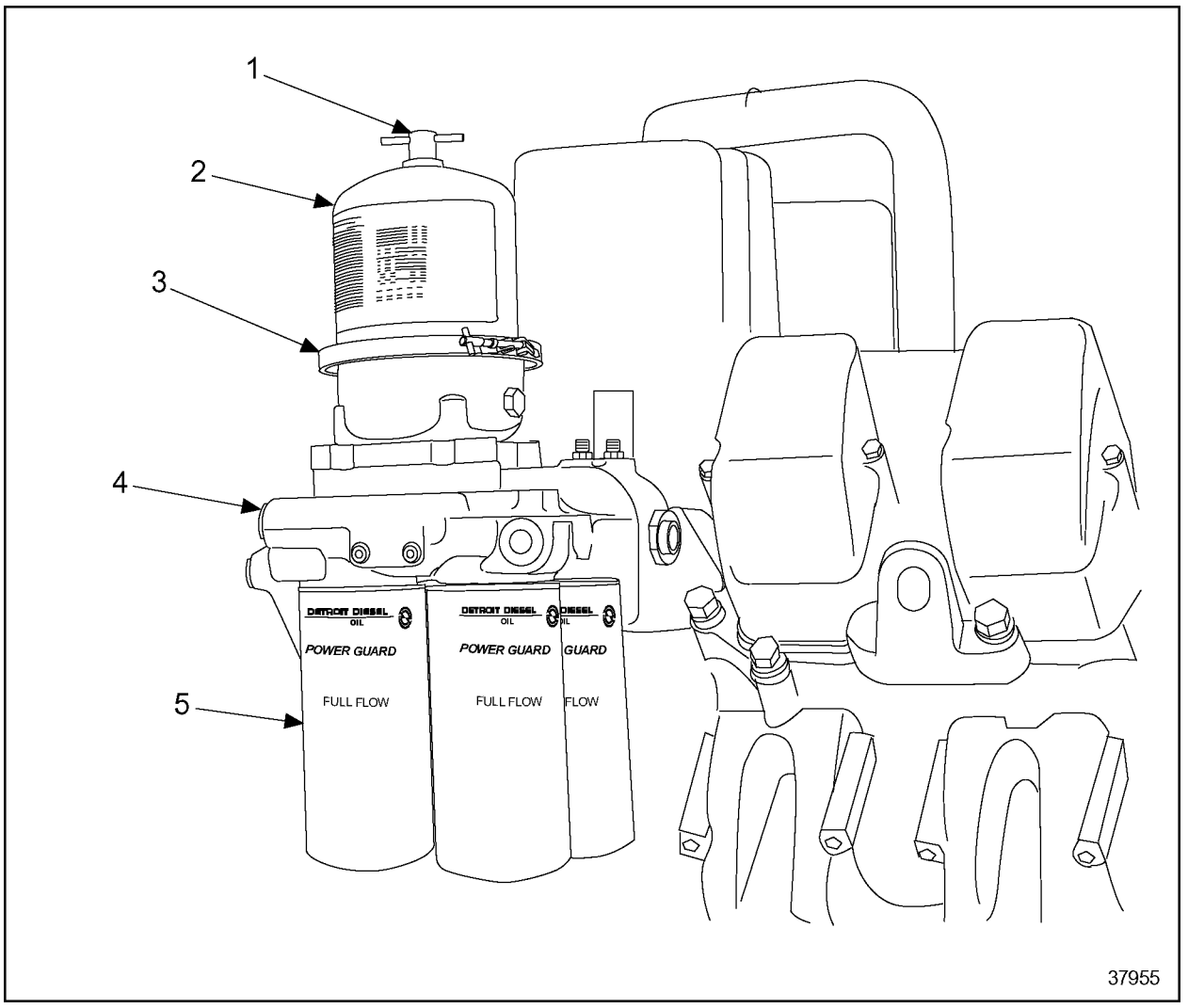
Figure 743 General View of Lube Oil Pump with Drive

C 183.05.06 – DISASSEMBLY OF CENTRIFUGAL OIL FILTER ASSEMBLY

Perform the following steps for the removal and disassembly remove the centrifugal oil filter assembly:

1. Stop engine and enable engine lockout.

NOTE:
Clean around centrifugal oil filter area before disassembly. See Figure 761.

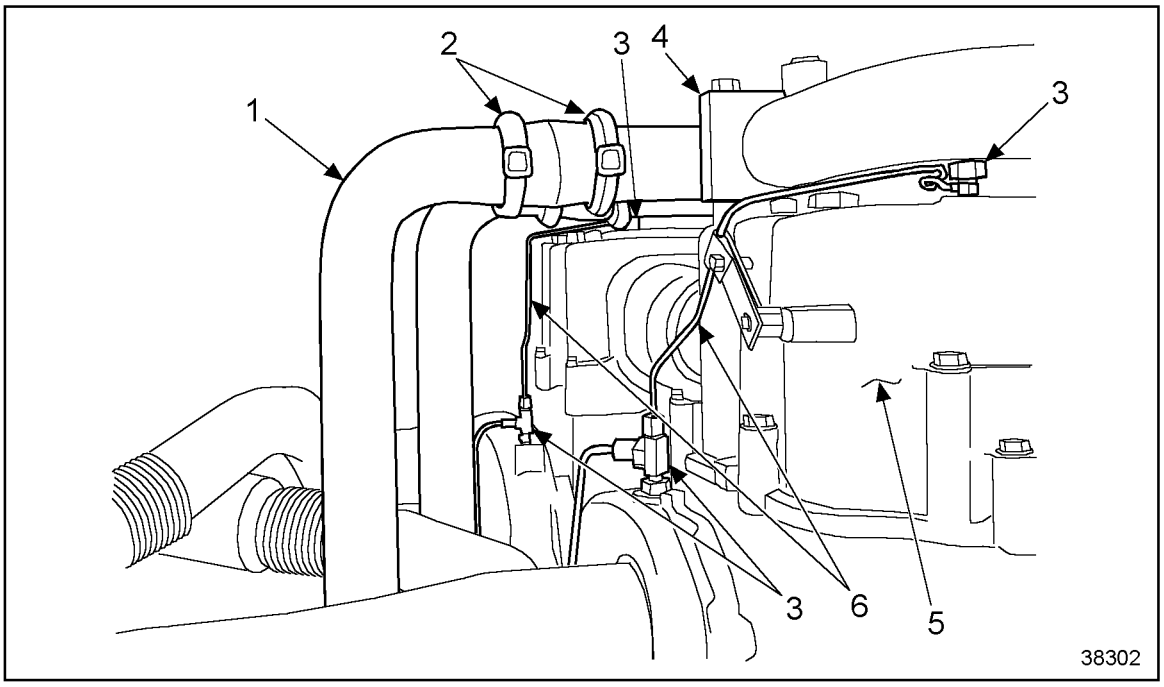


1. Cover Nut
2. Centrifugal Oil Filter
3. T-bolt Clamp
4. Oil Filter Housing Assembly
5. Oil Filter Cartridge

Figure 761 Centrifugal Oil Filter Location

2. Install by-pass valve into oil filter housing bore with valve seat towards bore.
3. Install by-pass valve spring (14) into by-pass valve opening.
4. Coat O-ring on thread plug (11) and coat O-ring (12) with petroleum jelly.
5. Install threaded plug from oil filter housing.
6. Torque threaded plug to 130–140 N·m (95.88–103.26 lb·ft).

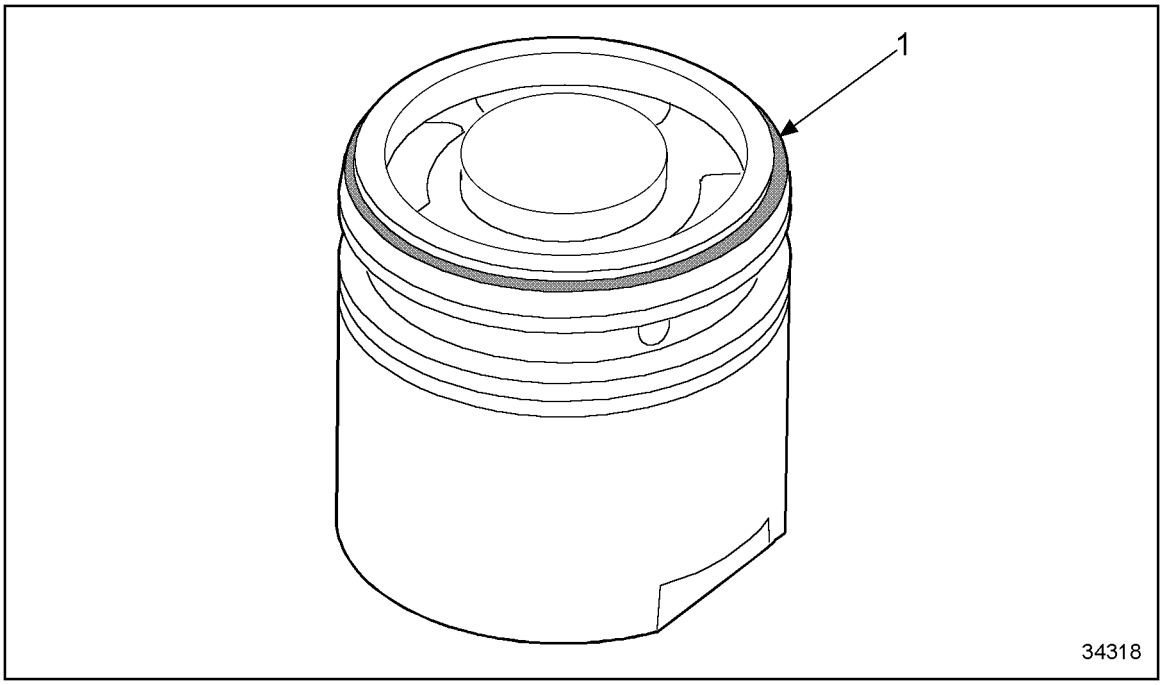
22. Coat seals (arrow) with petroleum jelly. See Figure 815.



1. Charge Air Cooler Pipe
2. Coupling
3. Vent Lines Connection
4. Charge Air Cooler Pipe Support Bracket
5. Oil Cooler Housing
6. Vent Lines

Figure 815 Installing Vent Line

23. Install and center V-clamps (1) and pipe connection (5) on pipe (3).
24. Install hex nuts (4) for V-clamps, but do not tighten.
25. Install vent line (2).

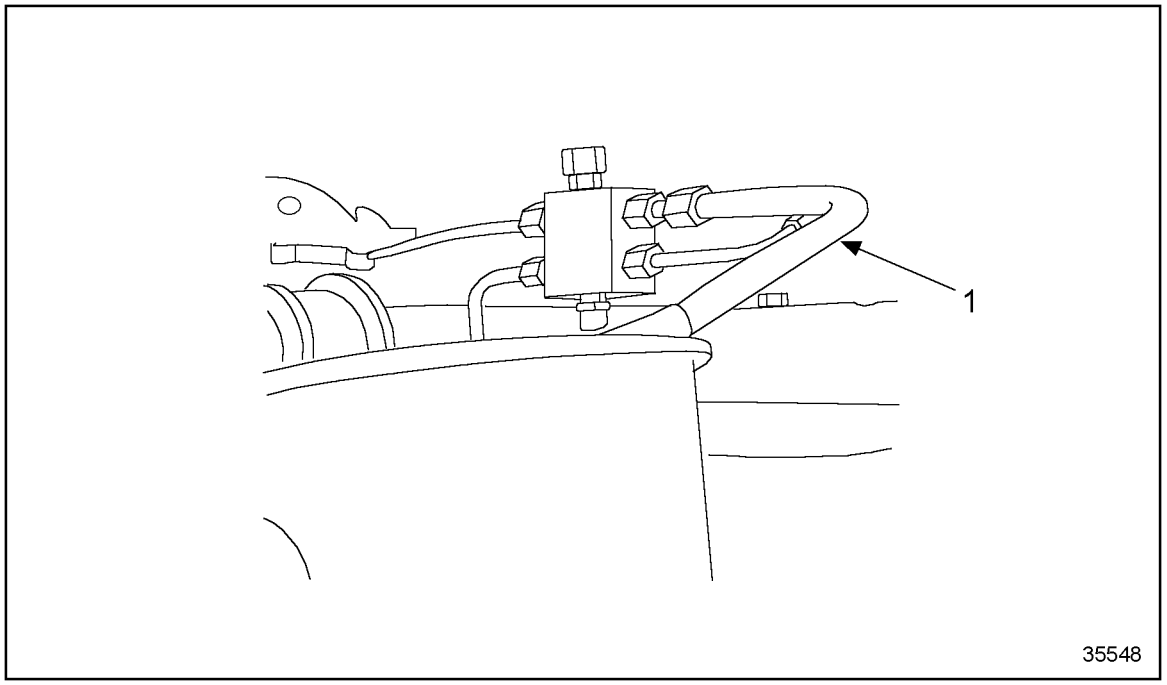


1. O-ring

Figure 833 Installing O-rings on Delivery Valve

4. Repeat step for the “B” bank turbocharger. See Figure 842.
5. Remove gasket (1) from the “A” bank turbocharger.
6. Repeat step for the “B” bank turbocharger. See Figure 842.
7. Remove mounting brackets (6) and pipe half clamps (7) as necessary. See Figure 842.

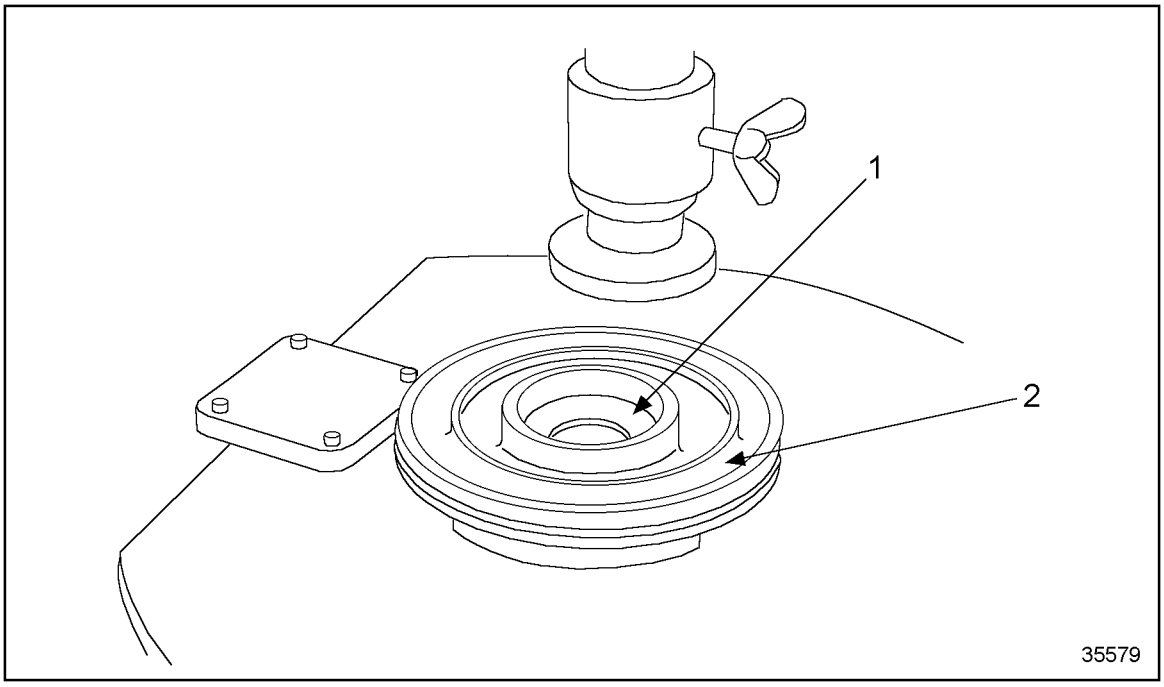
6. Connect vent line (1) of coolant pressure-testing device to engine vent. See Figure 850.



1. Vent Line

Figure 850 Connecting Vent Line to Coolant Pressure Testing Device

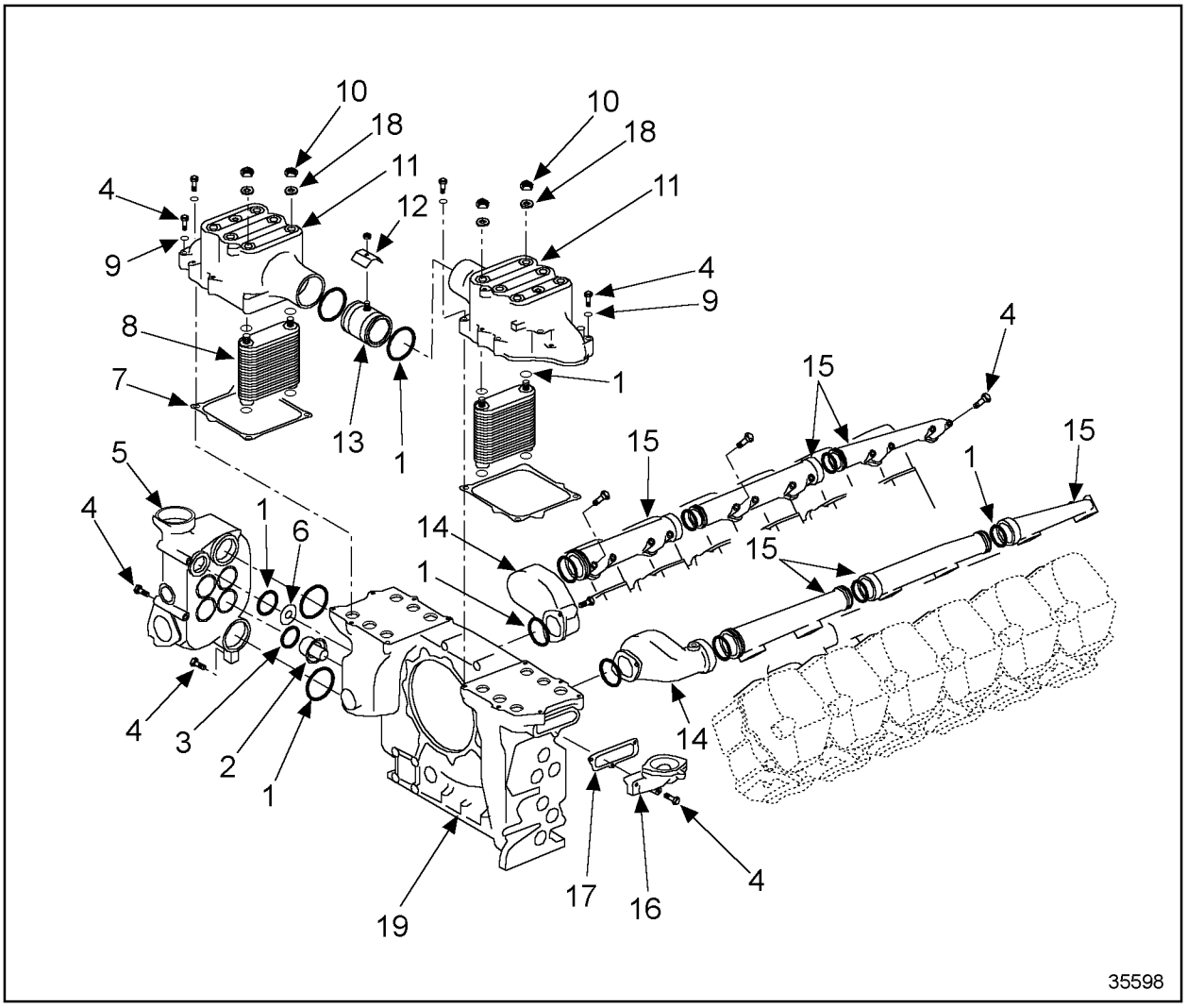
10. Insert shaft seal (1) evenly in seal carrier (2). See Figure 868.



1. Shaft Seal
2. Seal Carrier

Figure 868 Inserting Shaft Seal in Seal Carrier

11. Clean bore bearing surfaces with ethanol.

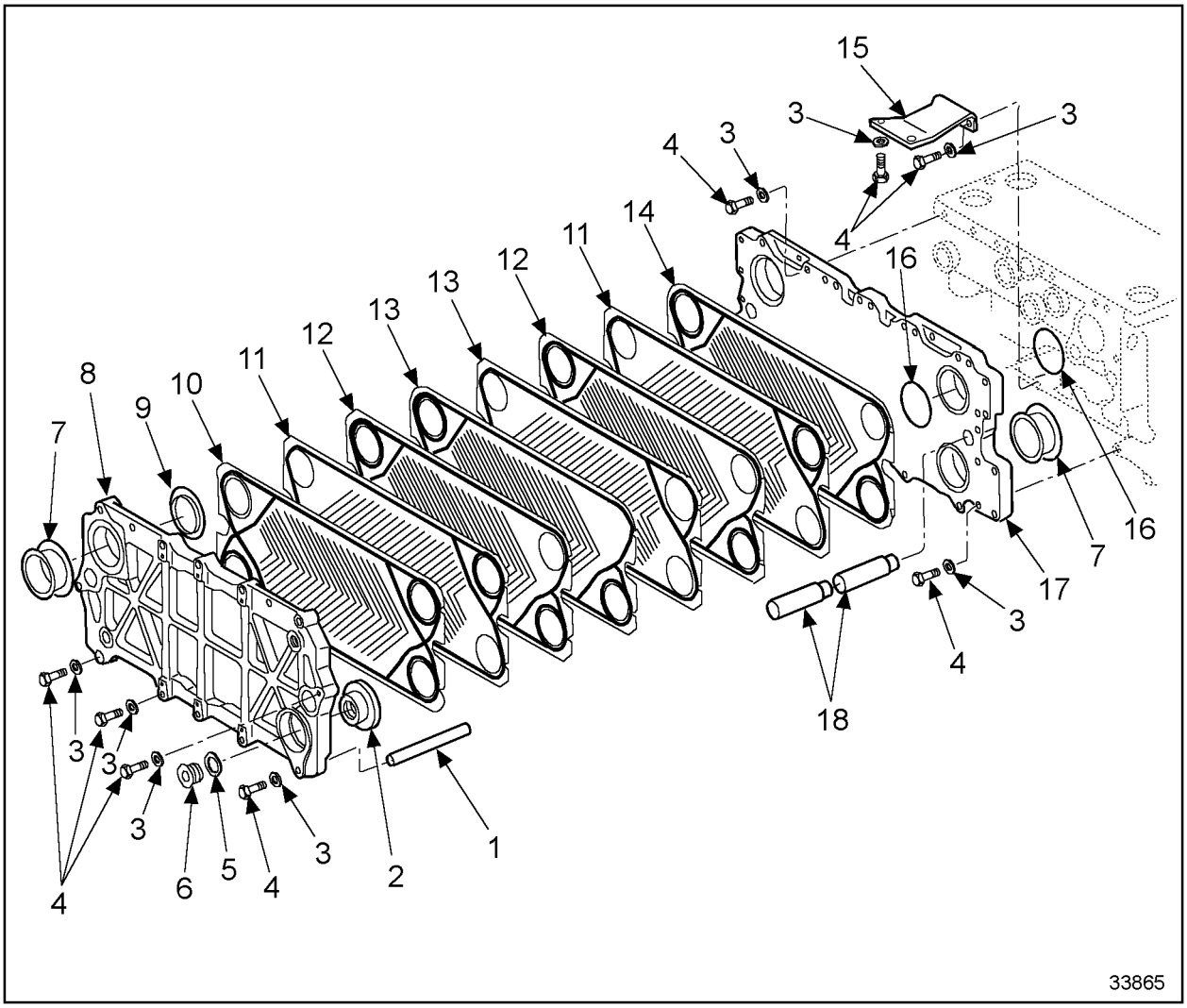


1. O-ring
2. Thermostat Element
3. Sealing Ring
4. Hex Bolt
5. Thermostat Housing
6. Restrictor
7. Gasket
8. Oil Cooler Core
9. Washer
10. Nut
11. Oil Cooler Housing
12. Bracket
13. Plug-in Pipe
14. Connector
15. Manifolds
16. Elbow
17. Gasket
18. Washer
19. Distribution Housing

Figure 892 General View of Engine Cooling System Pipework

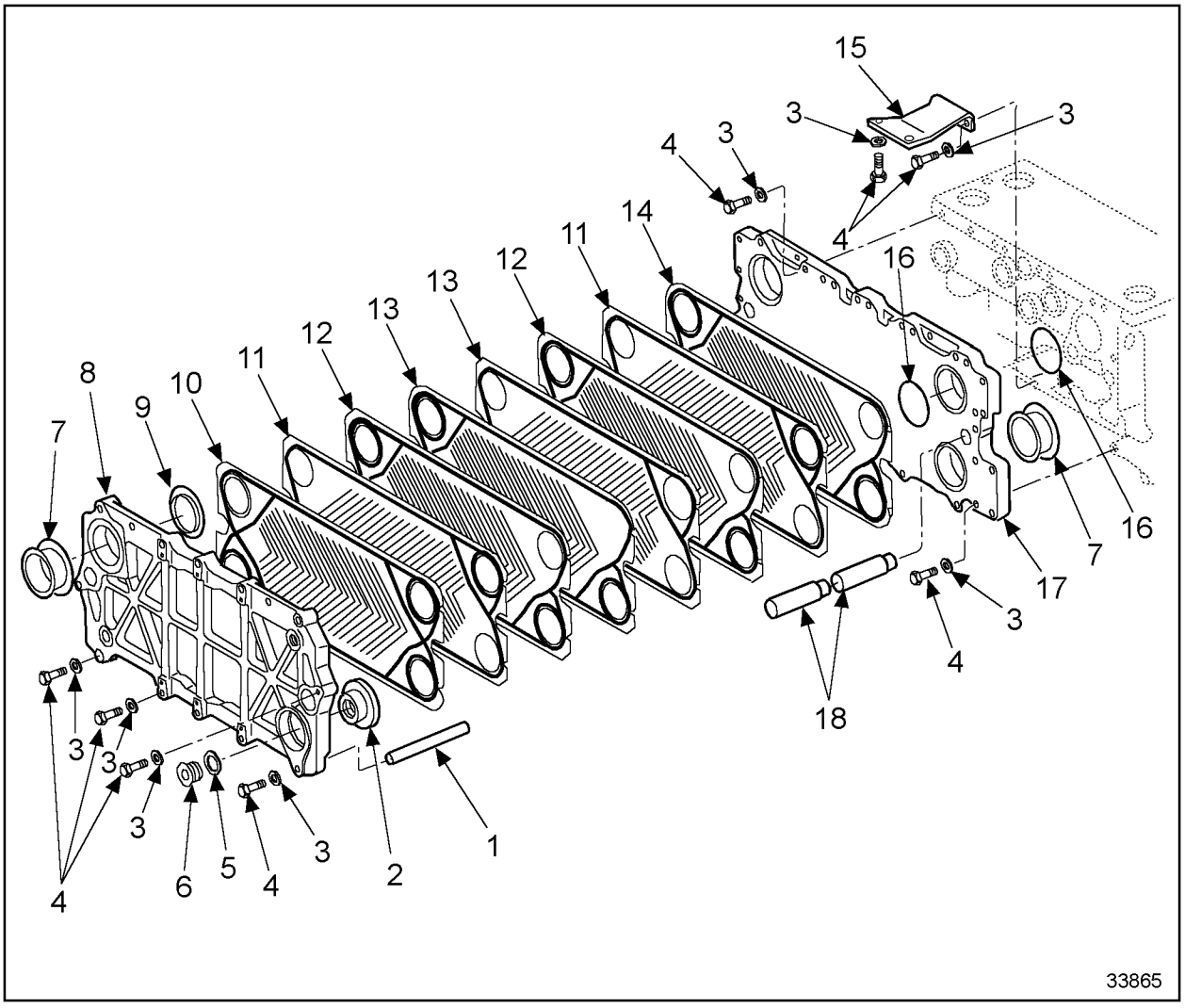
C 205.05.01 M – GENERAL VIEW

See Figure 896for the coolant heat exchanger parts location.



1. Spacer Sleeve
2. Cover
3. Washer
4. Bolt
5. Sealing Ring
6. Plug
7. Rubber Ring
8. Cover Plate
9. Guide Ring
10. Coolant Plate
11. Plate B
12. Plate A
13. Intermediate Plate
14. End Plate
15. Mounting Bracket
16. Plug
17. Base Plate
18. Guide Sleeve

Figure 896 General View of Coolant Heat Exchanger



1. Spacer Sleeve
2. Cover
3. Washer
4. Bolt
5. Sealing Ring
6. Plug
7. Rubber Ring
8. Cover Plate
9. Guide Ring
10. Coolant Plate
11. Plate B
12. Plate A
13. Intermediate Plate
14. End Plate
15. Mounting Bracket
16. Plug
17. Base Plate
18. Guide Sleeve

Figure 920 Installing Coolant Heat Exchanger Bracket

12. Coat outer surface of rotary seal with sealant. See Figure 939.

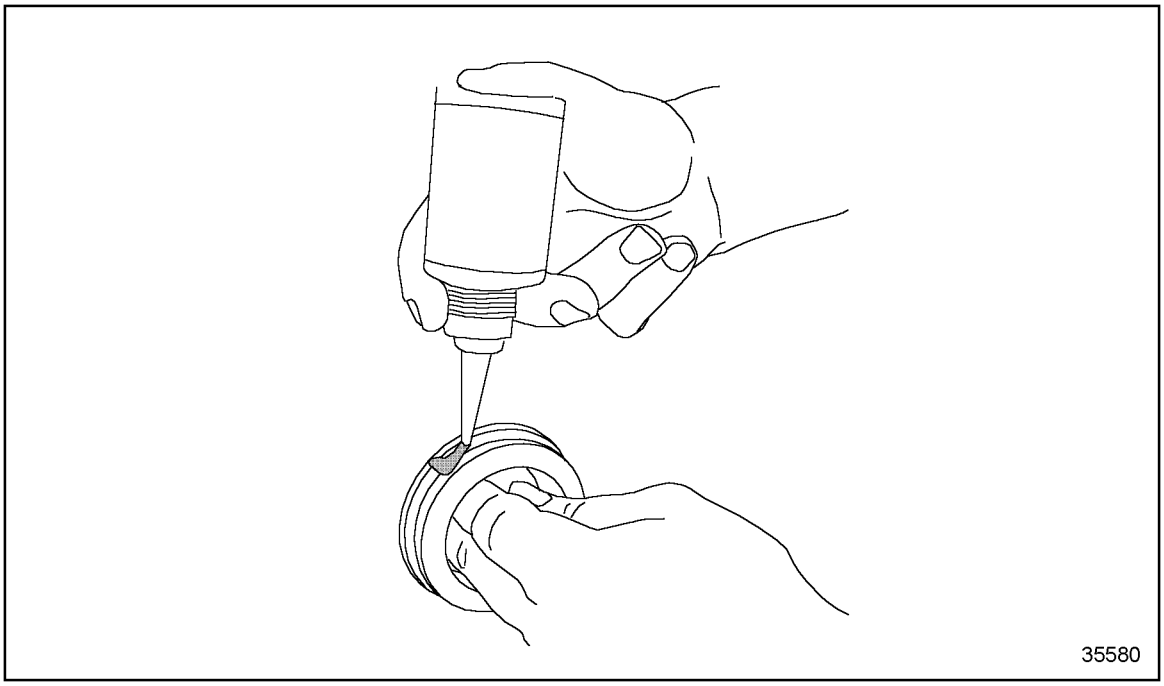


Figure 939 Coating Outer Surface of Rotary Seal with Sealant

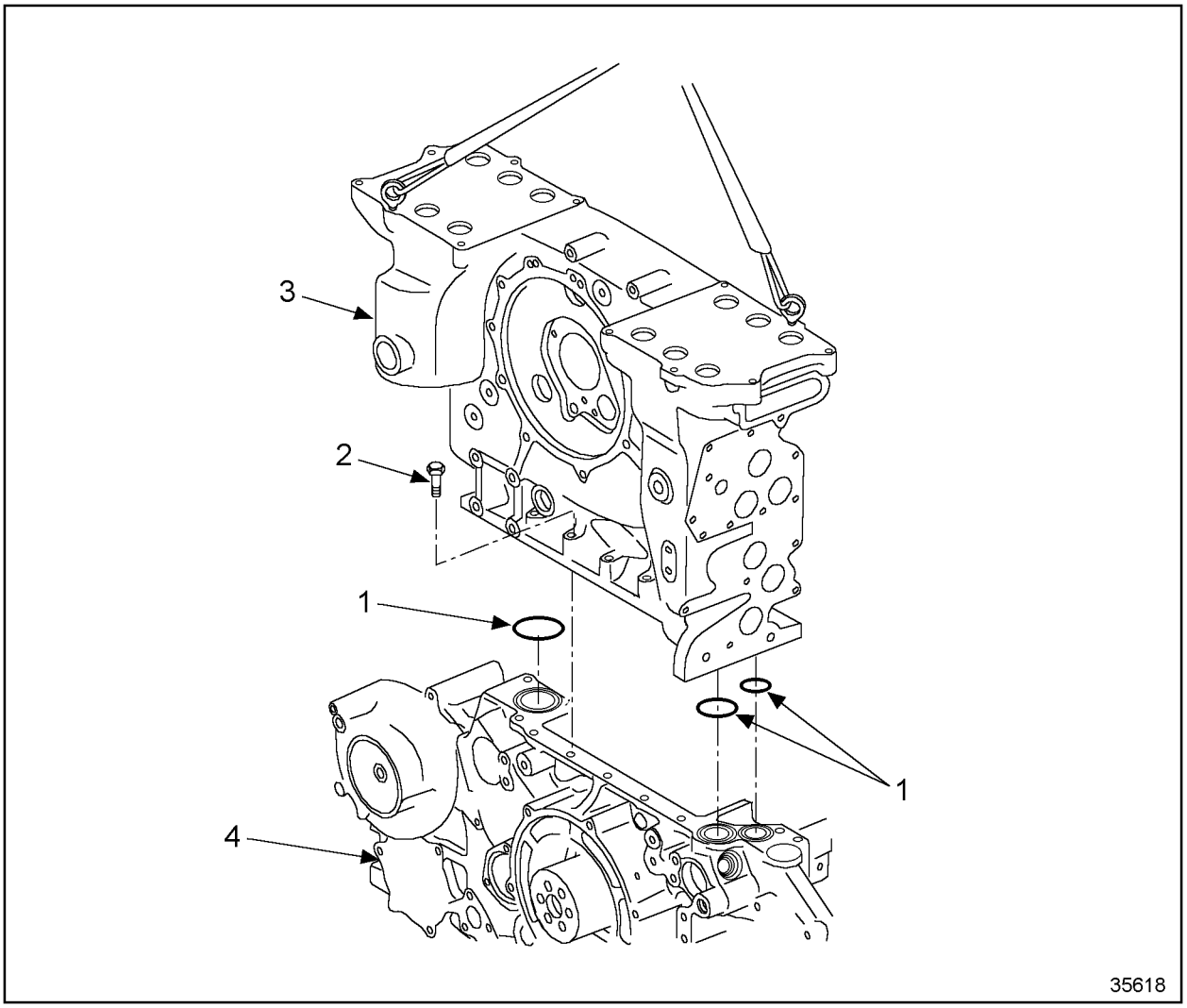
C 207.05.01 M – GENERAL VIEW

NOTE:
Refer to section before beginning any work in the cooling system.

CAUTION:

To avoid personal injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

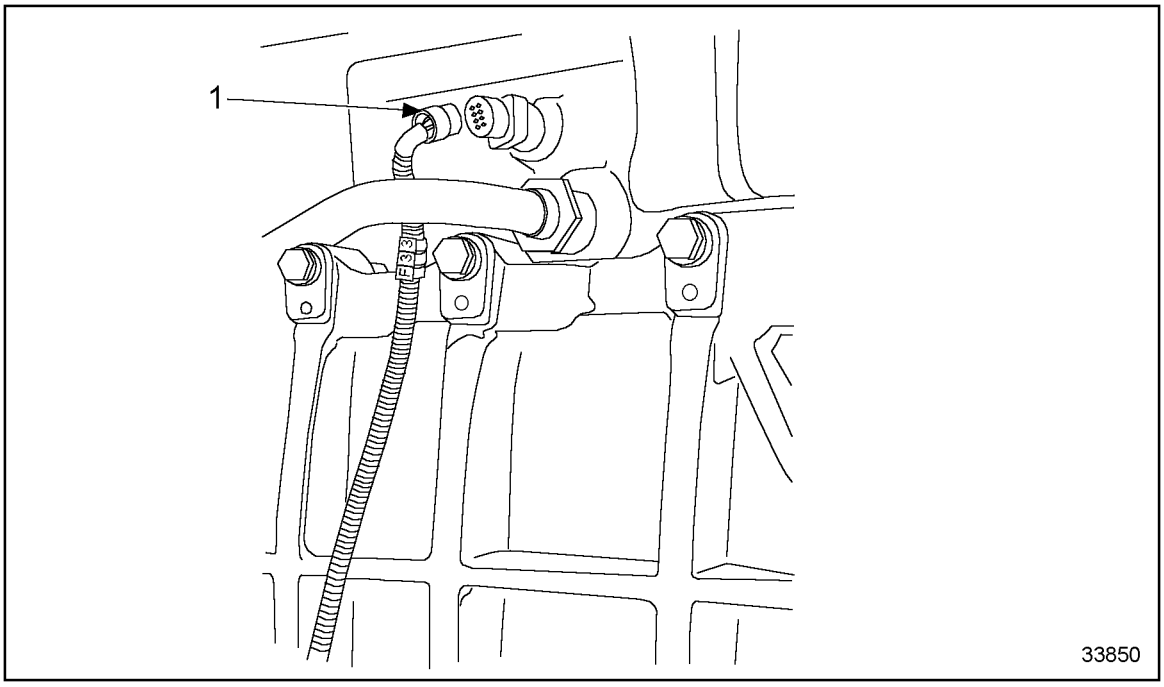
10. Lift distribution housing from gear case. See Figure 987.



1. O-ring
2. Hex Bolt
3. Coolant Distribution Housing
4. Gear Case

Figure 987 Lifting Distribution Housing from Gear Case

3. Install the coolant level sensor (1) and connect the wiring harness. See Figure 1003.



1. Coolant Level Sensor

Figure 1003 Installing the Coolant Level Sensor

C 213.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 145 are the After-Installation Operations for the battery charging alternator.

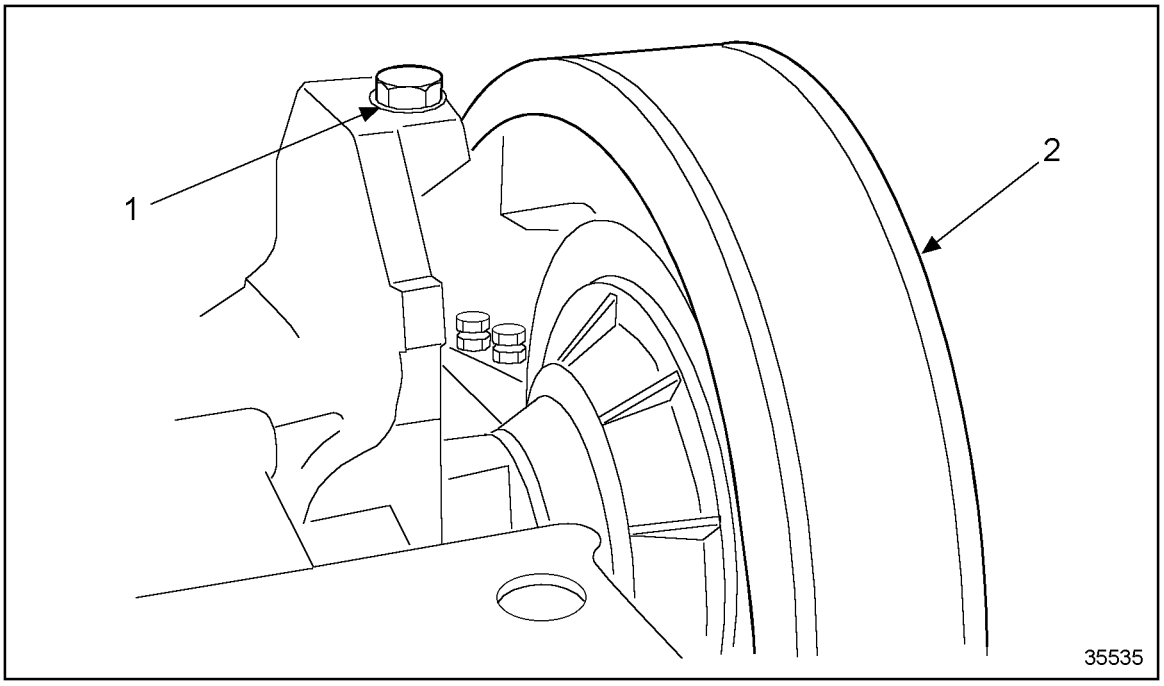
Level of Maintenance	Operation	Reference
1, 2, 3	Connect electric cables in accordance with markings	Refer to section C 501.05 M
1, 2, 3	Mount protective guard	Refer to Operators Guide
1, 2, 3	Enable engine power	Refer to Operators Guide

1 = The engine is to be completely disassembled.

2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 145 After-Installation Operations



1. Adjusting Bolt
2. Vee-belt

Figure 1031 Loosening Adjusting Bolt

3. Remove Vee-belt (2).

Oil then travels through the orifice, through the bracket, and into the fan clutch shaft. Oil passages in the shaft distribute lubricating oil to the bearings and other internal parts, and into the clutch hub cavity. Centrifugal force drives oil through slots in the clutch hub to cool the clutch plates. The grooved configuration of the facing plates allows oil to pass over the clutch plates at all times. It is this flow of cooling oil over the clutch plates which permits clutch slip and variable fan speeds.

NOTICE:
The pitot tubes pump oil from the pulley and maintain low internal pressure in the fan clutch. **Never** run the engine without belts driving the fan clutch pulley.

Centrifugal force carries the oil outward to the inside diameter of the pulley (or pulley adapter). The rotational movement of the pulley carries the oil in the direction of input rotation. Pitot tubes face into the direction of input rotation. The rotational movement of the oil rams the oil into the pitot tubes, which direct the oil through a passage into and through the fan clutch shaft and bracket, to an external "OIL OUT" port. A line from the "OIL OUT" port carries the oil to an unrestricted, non-pressurized port on the engine where the engine oil is returned to the engine oil sump.

Control Pressure Oil

The Rockford fan clutch is controlled by oil pressure supplied through the solenoid valve. Engine oil flowing from the "COM" or "CLUTCH" port of the solenoid valve enters the fan clutch through the "CONTROL PRESSURE" port of the shaft and bracket assembly and travels through shaft to the control pressure cavity of the fan clutch, which is formed by the piston and the pulley (or pulley adapter). Pressure reacting within the pressure cavity, forces the piston against the clutch plates to create a drive through the fan clutch. As the engine cools, oil in the pressure cavity exhausts back through the same oil line attached to the "COM" or "CLUTCH" port of the solenoid valve and is dumped by the solenoid back to the engine oil sump through the "NC" or "SUMP" port in the solenoid valve.

Rockford Part Numbering System

Rockford Fan Clutch part numbers have changed in the way they were displayed in print over the years, primarily due to advances in technology.

The part number format for a Rockford Fan Clutch Assembly is 040XXXX, where XXXXX is a five digit alpha number unique to that particular assembly.

Pervious numbers may have been displayed as: 4-XXXXX, 40XXXXX, 04-XXXXX, or 4-0XXXXX. The unique five-digit number remains unchanged, regardless of how the prefix may have been written at one time or another.

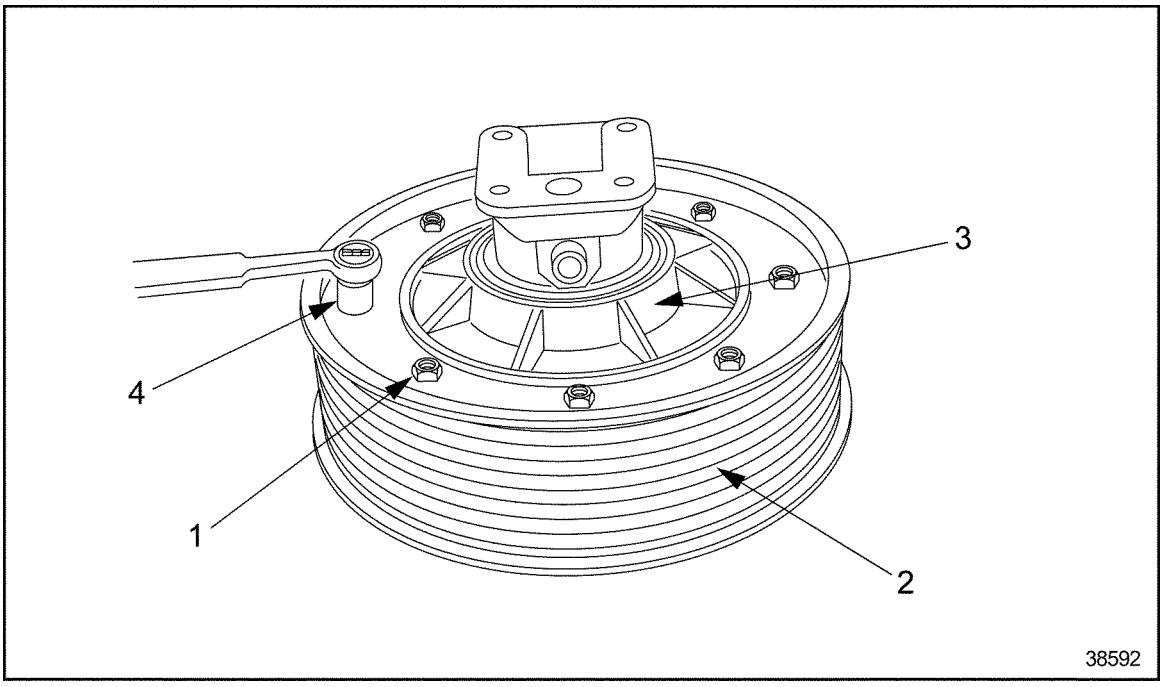
A serial number is assigned to each fan clutch produced by Rockford Powertrain, Inc.

Fan Clutch Part Number and Serial Number

Refer to the nameplate for part number and serial number information.

19. Remove bolts (1) and lock washers securing rear bearing retainer (3) to pulley (2). See Figure 1075.

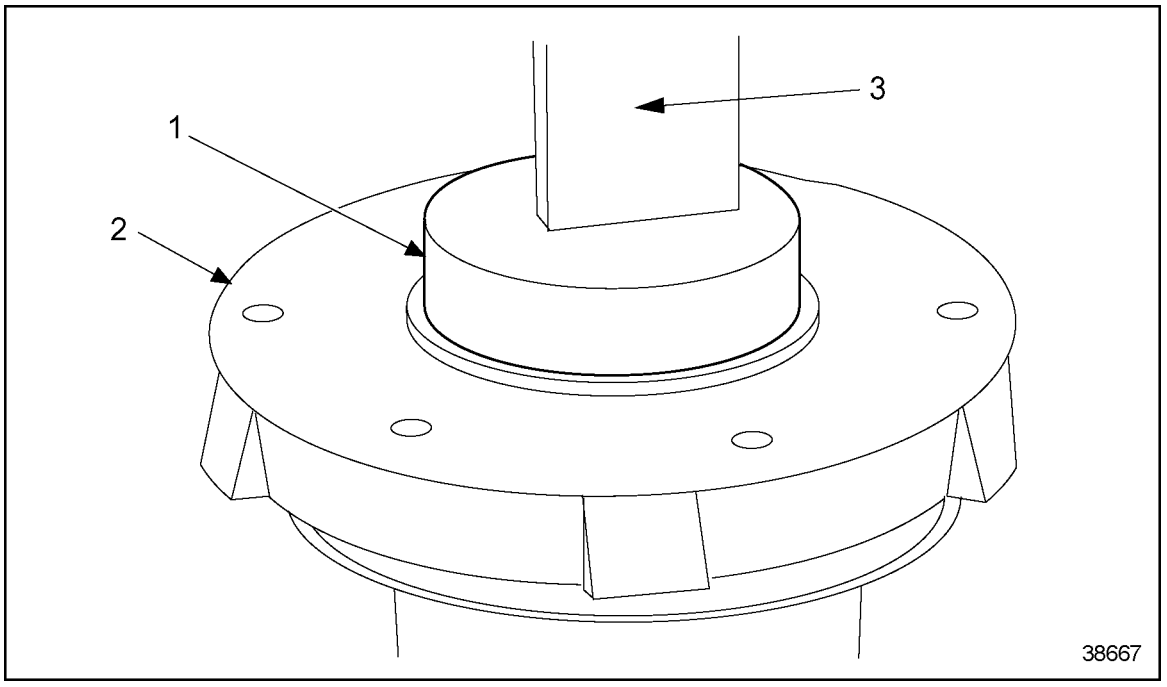
NOTE:
Pulley (2) should not be allowed to drop to the bench when the supports are removed. However, if bearing retainer (3) is not able to be removed from pulley (2), stand the unit on the bench resting on the nose of the shaft. Rap pulley (2) with a soft, but heavy mallet to break it loose from rear bearing retainer (3).



1. Bolts
2. Pulley
3. Rear Bearing Retainer
4. Socket

Figure 1075 Removal of Rear Bearing Retainer

5. Coat end cap bore of fan mounting hub (2) with a thin coating of Loctite #242 (or equivalent). See Figure 1093.



1. End Cap
2. Fan Mounting Hub
3. Hydraulic Press

Figure 1093 Installation of End Cap

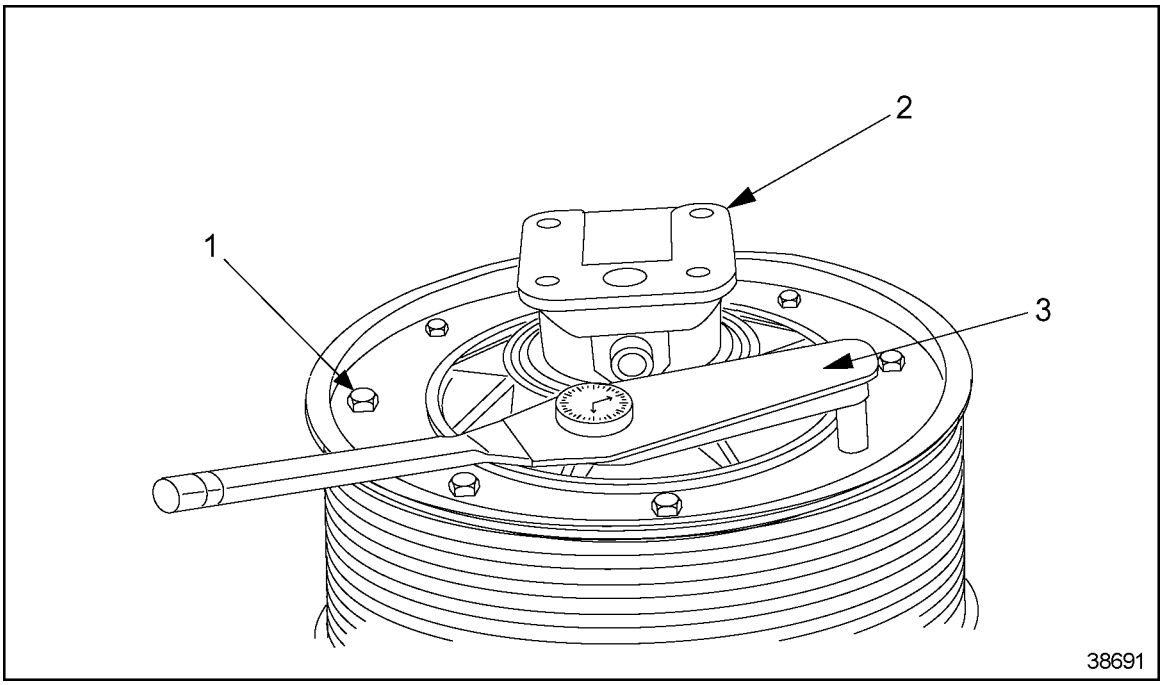
CAUTION:

To avoid injury from freezing or suffocation when using liquid nitrogen, wear a face shield and protective clothing and work in a well-ventilated area.

6. Freeze end cap (1) in a freezer or dry ice for 15–30 minutes. See Figure 1093.

NOTE:
Liquid nitrogen may be used to freeze the end cap.

49. Install bolts and lock washers (1) to secure shaft subassembly (2) to the pulley. Torque bolts to 26–32 lb·ft (115–142 N·m). See Figure 1120.



1. Bolts and Lock Washers
2. Shaft Subassembly
3. Torque Wrench

Figure 1120 Installation of Bolts and Lock Washers

C 231.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 181are the Before-Removal Operations for the marine engine mounts.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove protective guard	-
1, 2, 3	Remove fan wheel	-

1 = The engine is to be completely disassembled.

2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 181 Before-Removal Operations for the Marine Engine Mounts

C 259.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 186 are the Before-Removal Operations for the auxiliary PTO assembly.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove protective guard	—
1, 2, 3	Remove V-belt	Refer to OEM Guidelines

1 = The engine is to be completely disassembled.

2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 186 Before-Removal Operations

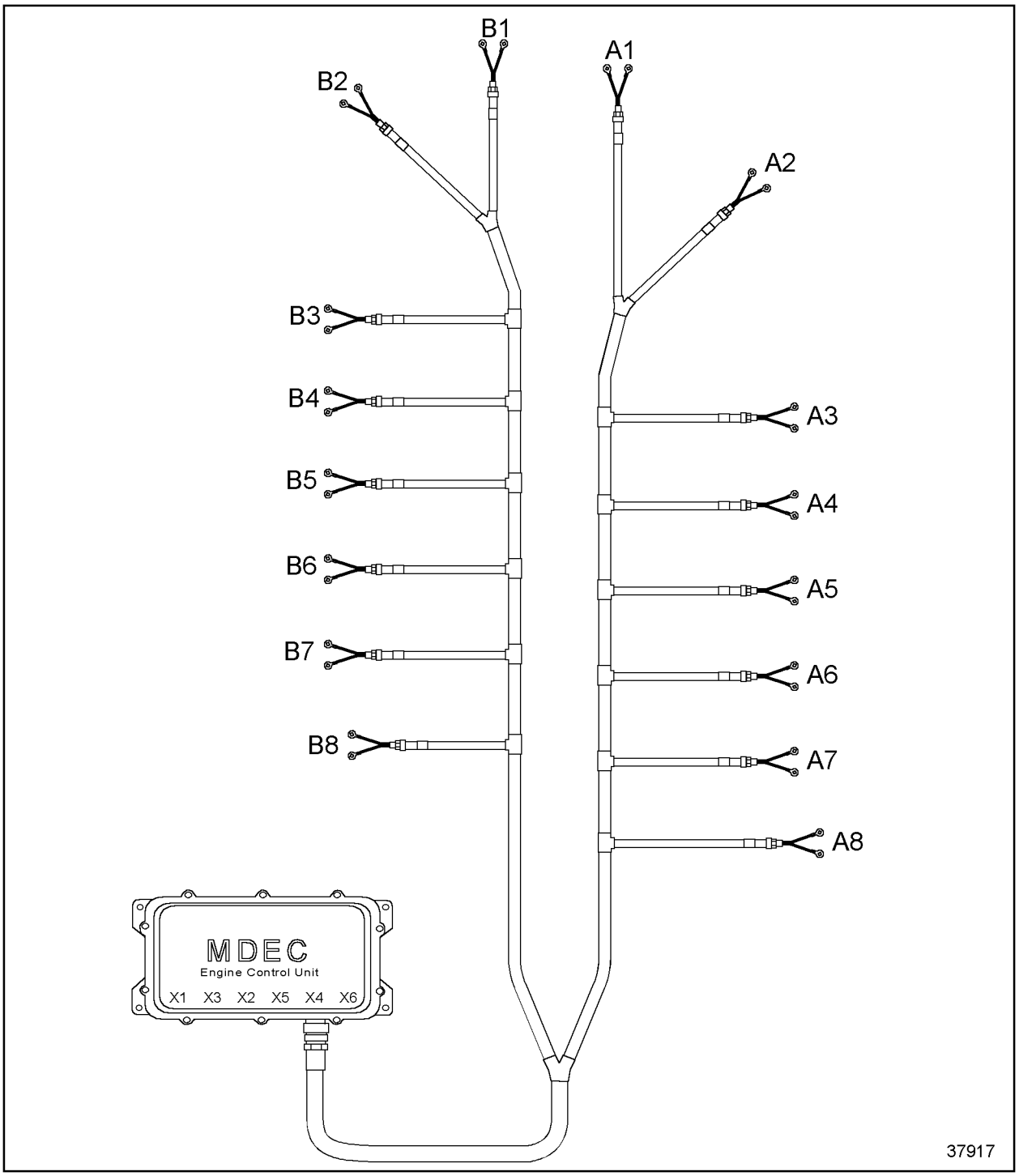


Figure 1151 16V Marine Engine Injector Harness (SB3)

J 39263	Nozzle Holding Fixture	40
J 41165	Nozzle Puller	40
J 39261	Nozzle Sleeve Installer	40
J 39262	Nozzle Sleeve Remover	40
J 35636-A	Overhaul Stand Adaptor-Cyl Head	50,60
J 34650	Pipe Plug Remover (SQ Drive Plug)	50,71,V71,92,149,8.2L
J 3092-01	Push Rod Remover Set	53,V53,71,V71,92
J 35996	Rocker Arm Shaft Lifter	60
J 39647-A	Rocker Arm Shaft Lifter	50
J 36003-A	Rocker Arm Shaft Stud Socket	50,60
J 22273-01	Sled Gage	53,V53,71,V71,92,149,8.2L
J 41488-A	Spark Plug Adaptor Remover	50G
J 36347	Valve Button Retainer Expander	50,60
J 39196	Valve Guide Installer (Narrow Stem)	149
J 39260	Valve Guide Reamer	40
J 269	Valve Guide Remover	40
J 41164	Valve Guide Remover	40
J 39880-A	Valve Seal Installer Set	149
J 8165-2	Valve Seat Concentricity Gage	53,V53,71,V71,92,149
J 26541-213	Valve Seat Cutter 1.50 X 15/60 Deg	55,71,V71
J 26541-628	Valve Seat Cutter 1.50 X 31 Deg	71,V71
J 26541-292	Valve Seat Cutter 1.50 X 15/60 Deg	55,149
J 26541-649	Valve Seat Cutter 1.75 X 31 Degree	149
J 26541-343	Valve Seat Cutter Pilot (0.344)	71,V71
J 26541-344	Valve Seat Cutter Pilot (0.345)	71,V71
J 26541-345	Valve Seat Cutter Pilot (0.346)	71,V71
J 26541-346	Valve Seat Cutter Pilot (0.347)	71,V71
J 26541-375	Valve Seat Cutter Pilot (0.375)	149
J 26541-376	Valve Seat Cutter Pilot (0.376)	149
J 26541-377	Valve Seat Cutter Pilot (0.377)	149
J 26541-378	Valve Seat Cutter Pilot (0.378)	149
J 26541-354	Valve Seat Cutter Pilot (9 mm)	55
J 26541	Valve Seat Cutting Set	53,V53,71,V71,92
J 26541-3	Valve Seat Cutting Set Power Unit	53,V53,71,V71,92
J 7924-02	Valve Seat Grind Adapt Kit (2 Valve-53)	53
J 6390-02	Valve Seat Grind Adapt Kit (4 Valve-71)	71,V71

J 26927	Injector Rack Gage (.586 & .686)	71,V71
J 29063	Injector Rack Gage (.594)	71,92
J 34079	Injector Rack Gage (.610)	92
J 25560	Injector Rack Gage (.636)	92
J 29064	Injector Rack Gage (.660)	92
J 29014-C	Injector Timing Dial Indicator	8.2L
J 34610	Injector Timing Gage (1.458)	71
J 1853	Injector Timing Gage (1.460)	53,V53,71,V71,92
J 34081	Injector Timing Gage (1.464)	92
J 26888	Injector Timing Gage (1.466)	71,V71,92
J 24236	Injector Timing Gage (1.470)	53,V53,71,V71,92
J 34921	Injector Timing Gage (1.475)	V71
J 29065	Injector Timing Gage (1.480)	71,V71,92
J 1242	Injector Timing Gage (1.484)	53,V53,71,V71,92
J 29066	Injector Timing Gage (1.490)	V53,71,V71,92
J 9595	Injector Timing Gage (1.496)	V53,71,V71,92
J 25454	Injector Timing Gage (1.500)	V53,71,V71,92
J 8909	Injector Timing Gage (1.508)	V53,71,V71
J 34192	Injector Timing Gage (1.515)	92
J 25502	Injector Timing Gage (1.520)	V71,92
J 36869	Injector Timing Gage (2.170)	149
J 22412-A	Injector Timing Gage (2.175)	149
J 29116-A	Injector Timing Gage (2.185)	149
J 24283-A	Injector Timing Gage (2.205)	149
J 39762	Injector Timing Gage (2.590)	149
J 38349	Injector Timing Gage (64.1MM)	149
J 35637-A	Injector Timing Gage (78.2 MM)	60
J 39697	Injector Timing Gage (78.8 MM)	50,60
J 9509-C	Throttle Delay Gage (.404)	53,V53,92
J 28479	Injector Rack Gage (.395)	53
J 38768	Cylinder Compression Test Adpt Set	50,60

Table 202 Engine Tune UP

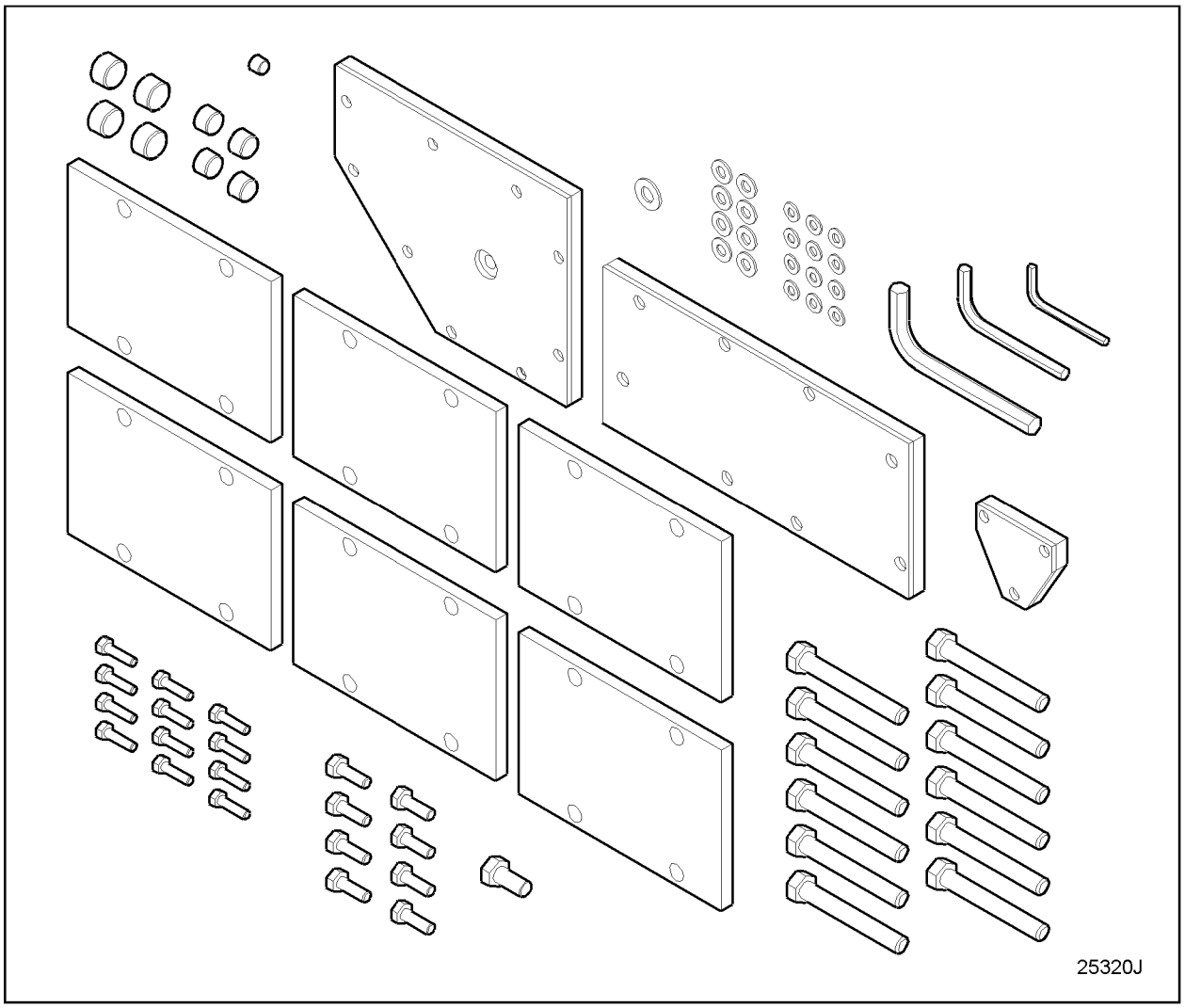


Figure 1095 Cylinder Block Pressure Kit,J 41566

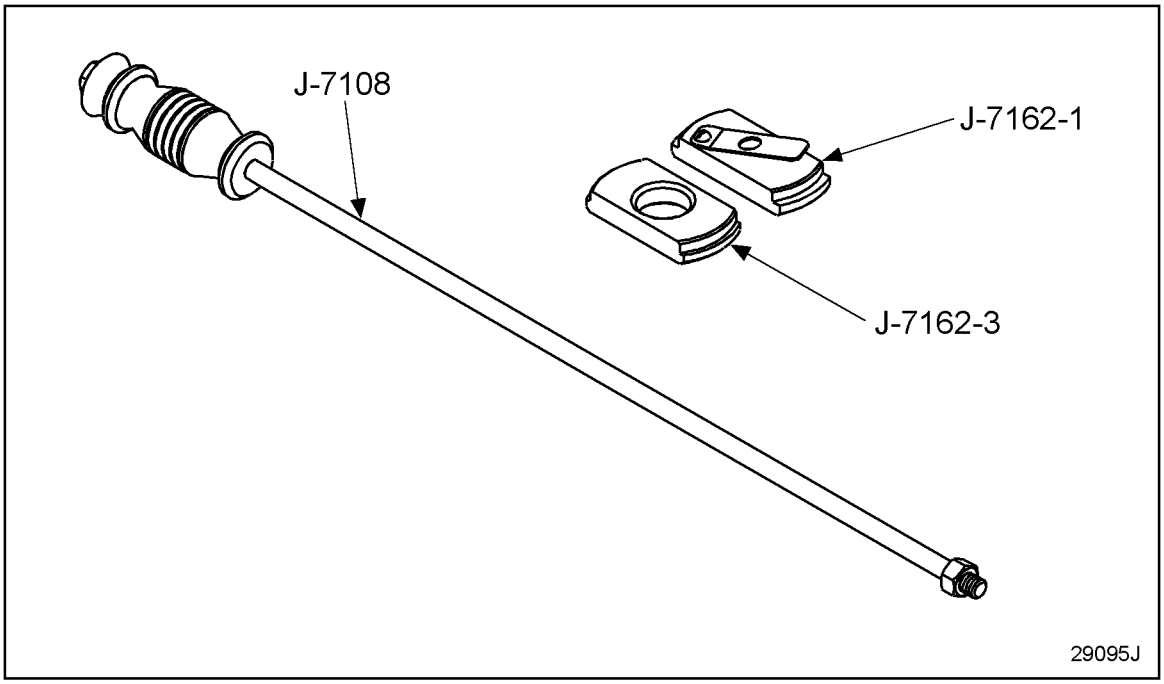


Figure 1133 Liner Remover (Screw Type), J 22490

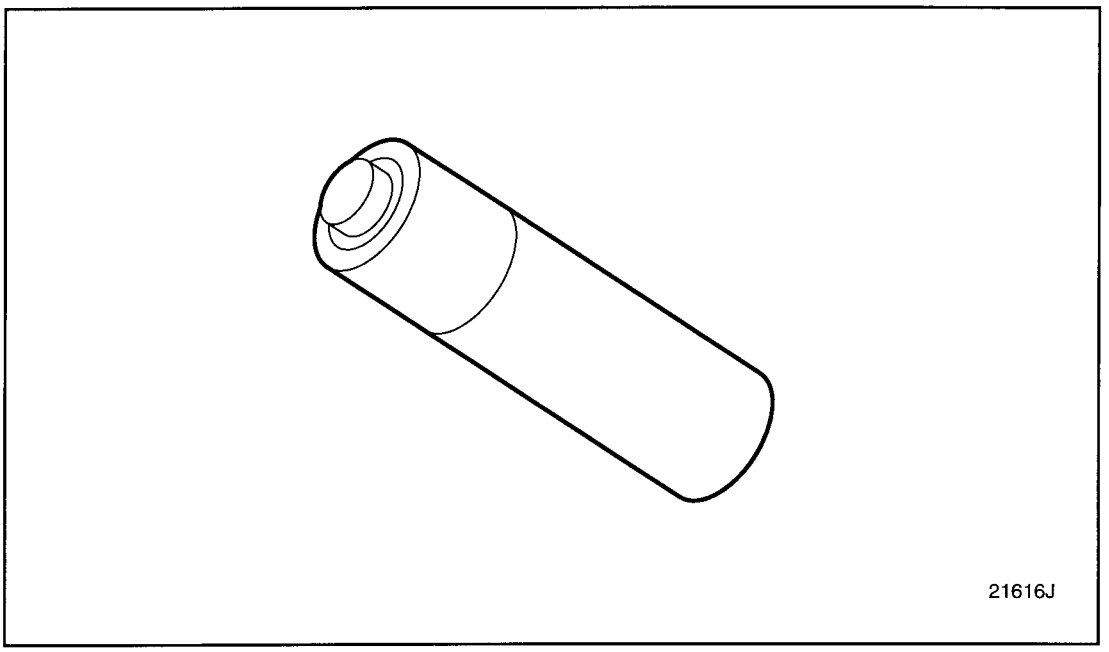


Figure 1172 Car Plug Install-Rocker Arm Shaft,J36326

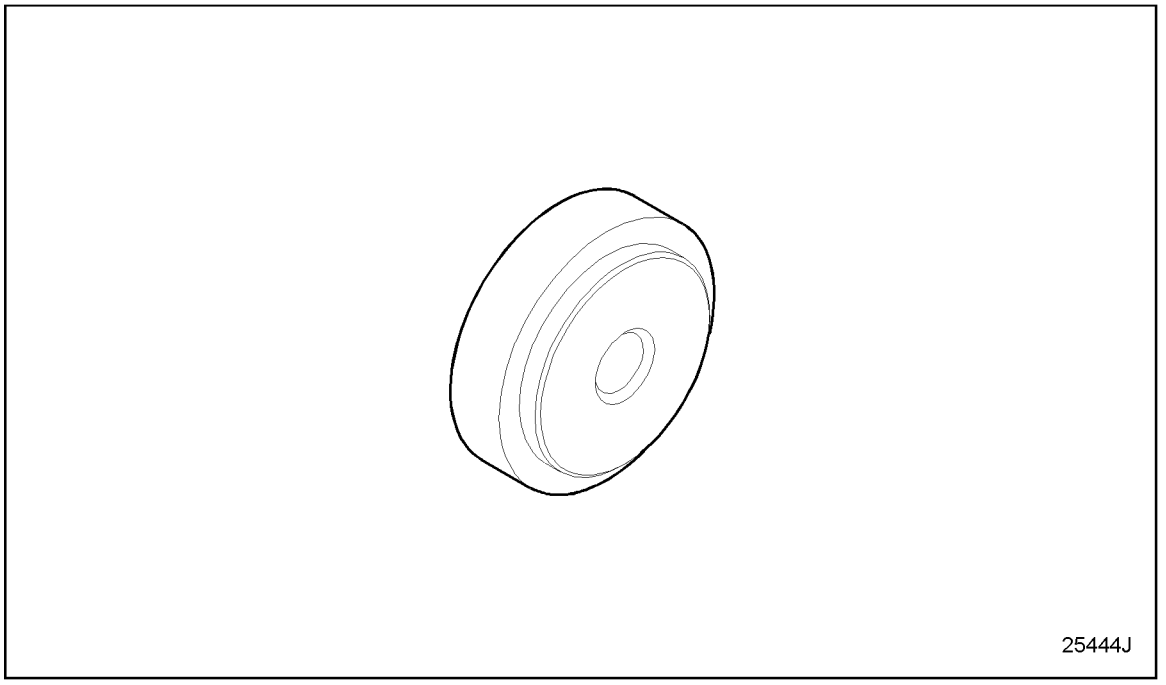


Figure 1173 Cup Plug Installer,J 41746

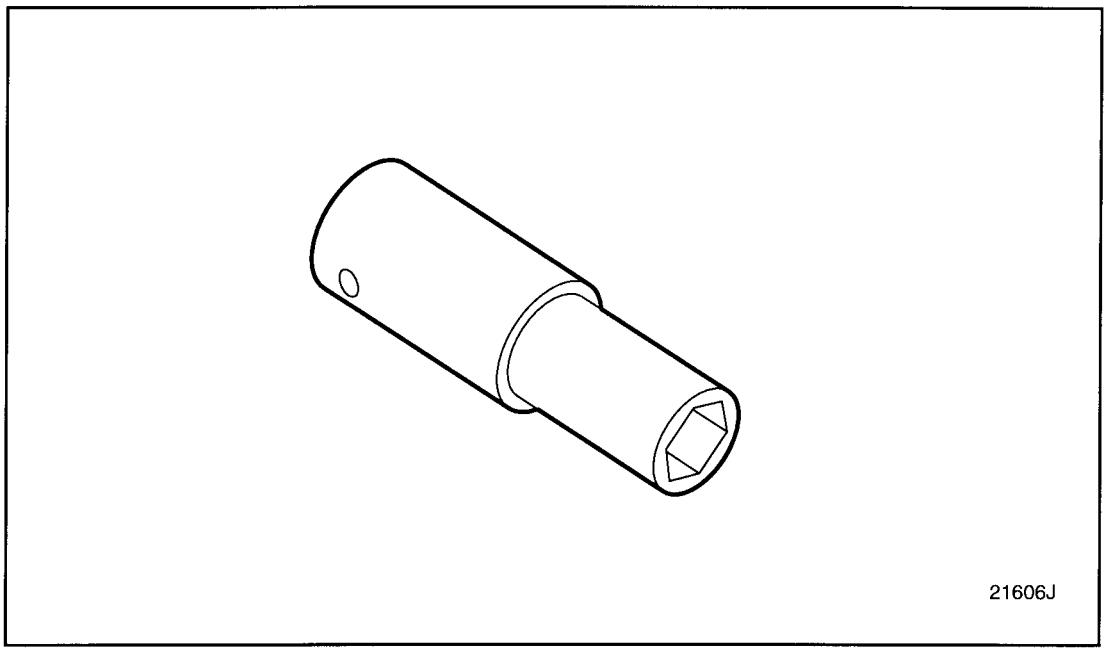


Figure 1210 Rocker Arm Shaft Stud Socket, J 36003–A

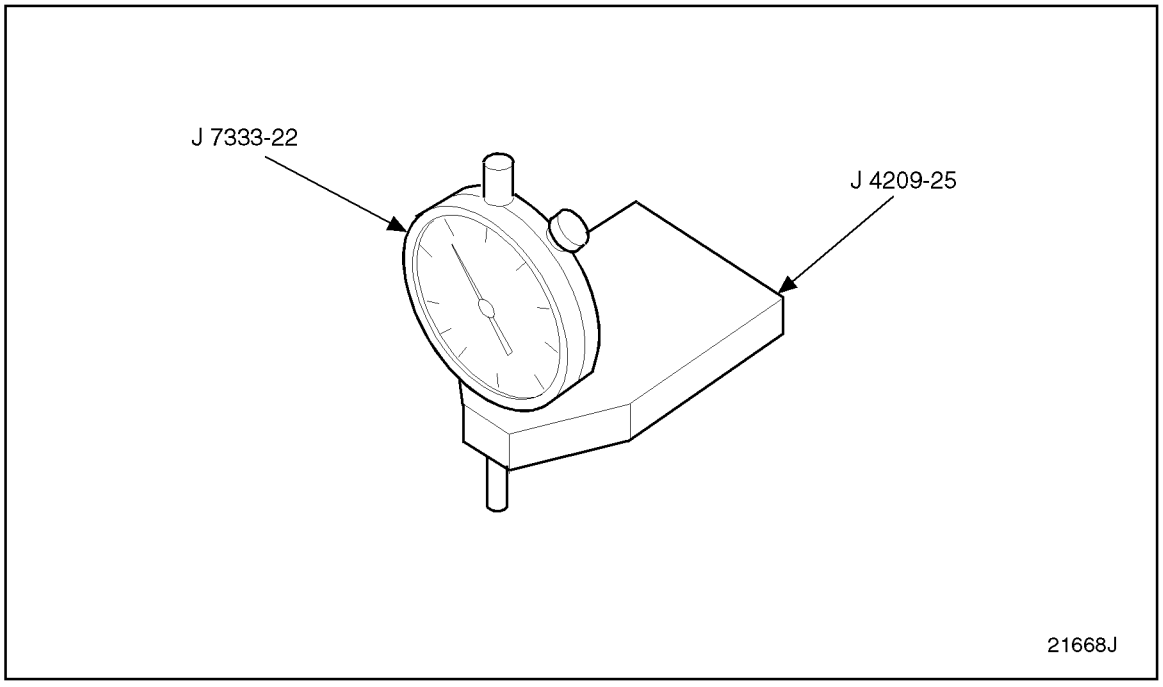


Figure 1211 Sled Gage, J 22273–01

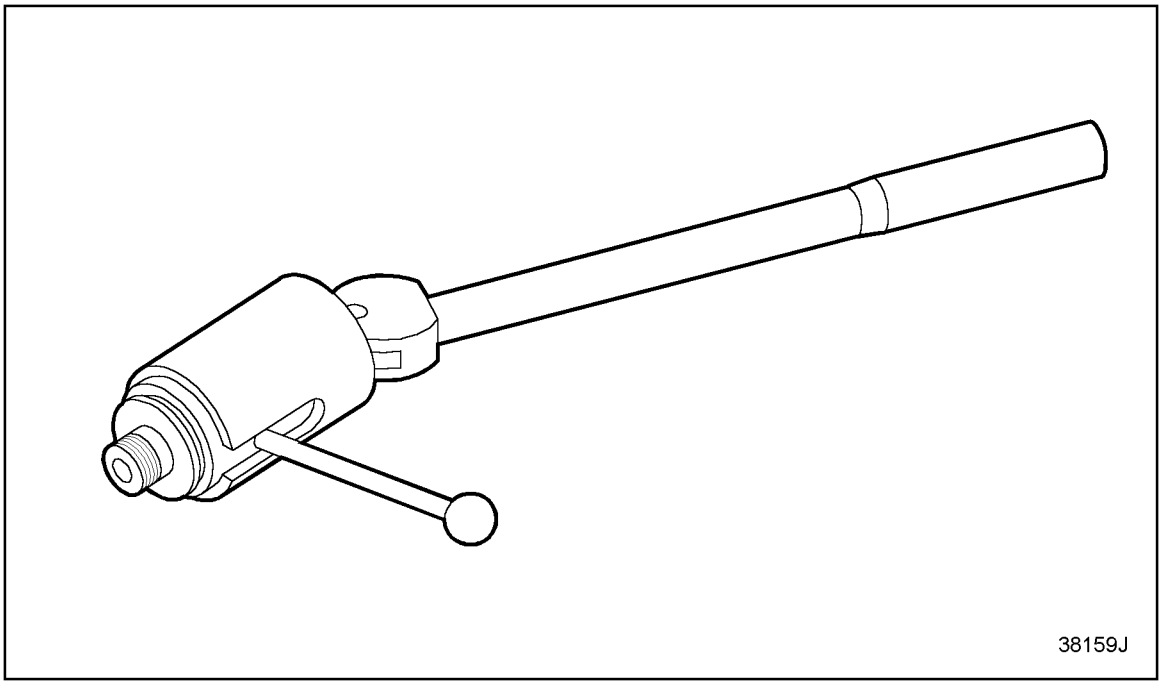


Figure 1257 Valve Seat Insert Puller Assembly,J 23479–35

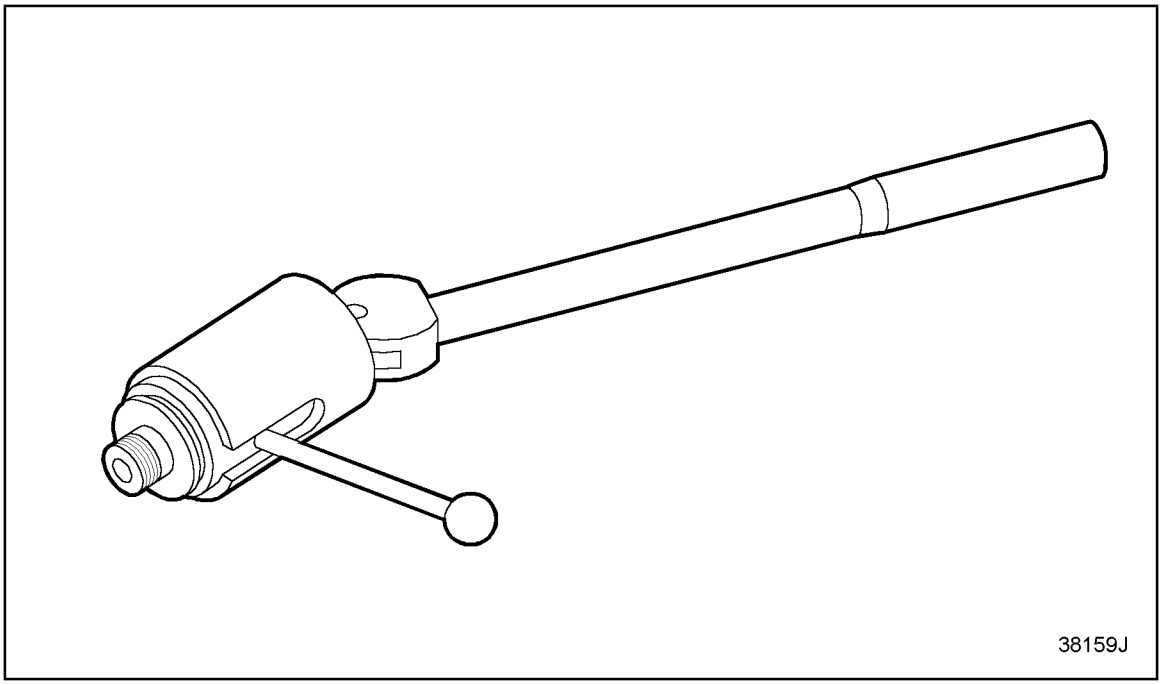


Figure 1258 Valve Seat Insert Puller Body,J 23479–37

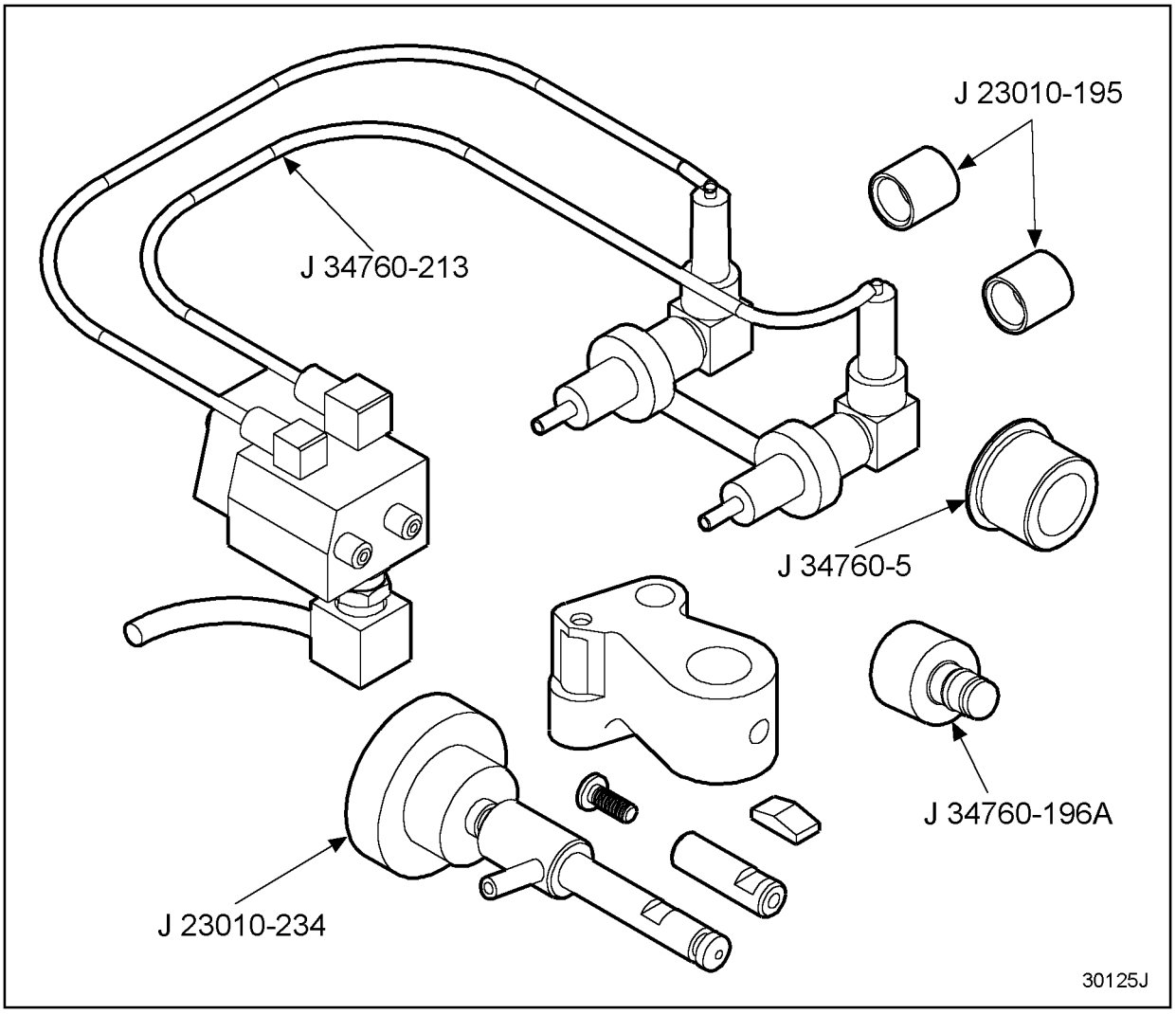


Figure 1305 Injector Pop Fixture Adapter, 149,J 34760–144

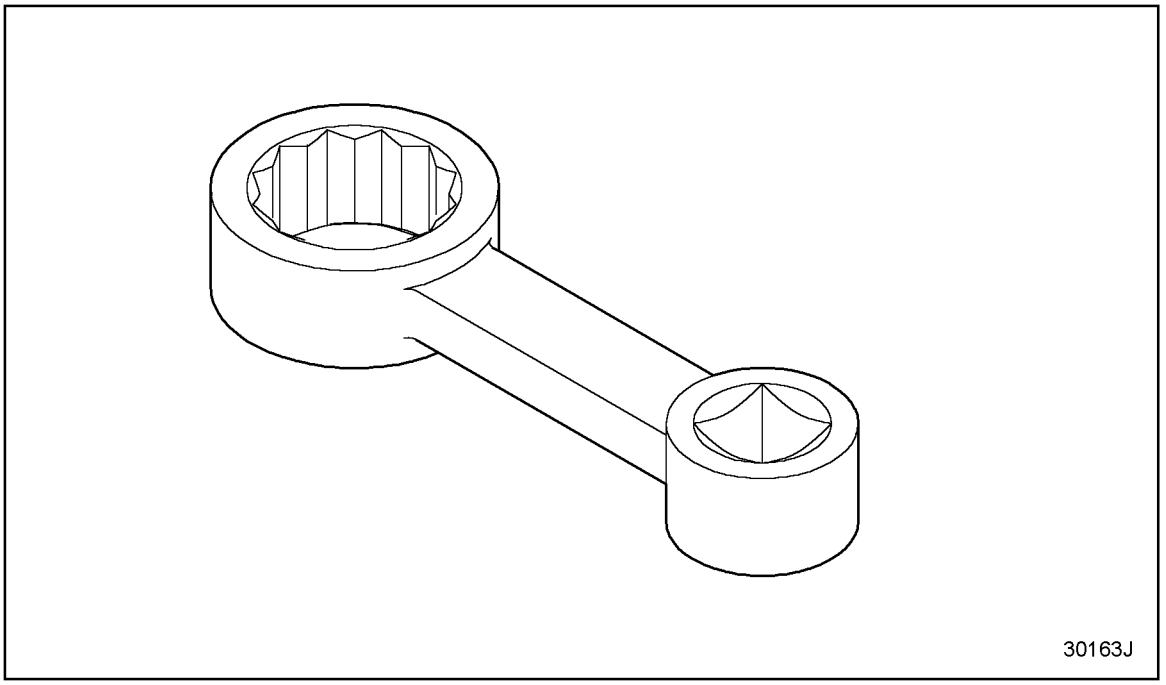


Figure 1349 Crankshaft Torque Wrench Adapter,J 22898–A

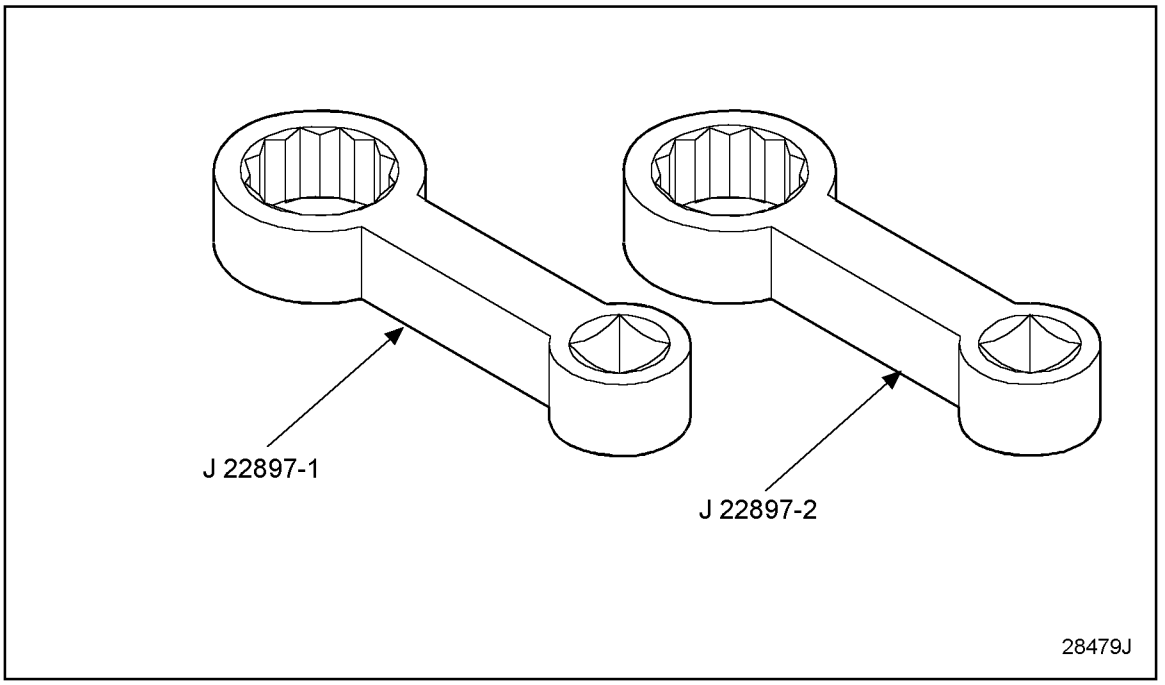


Figure 1350 Crankshaft Torque Wrench Adapter Set,J 22897

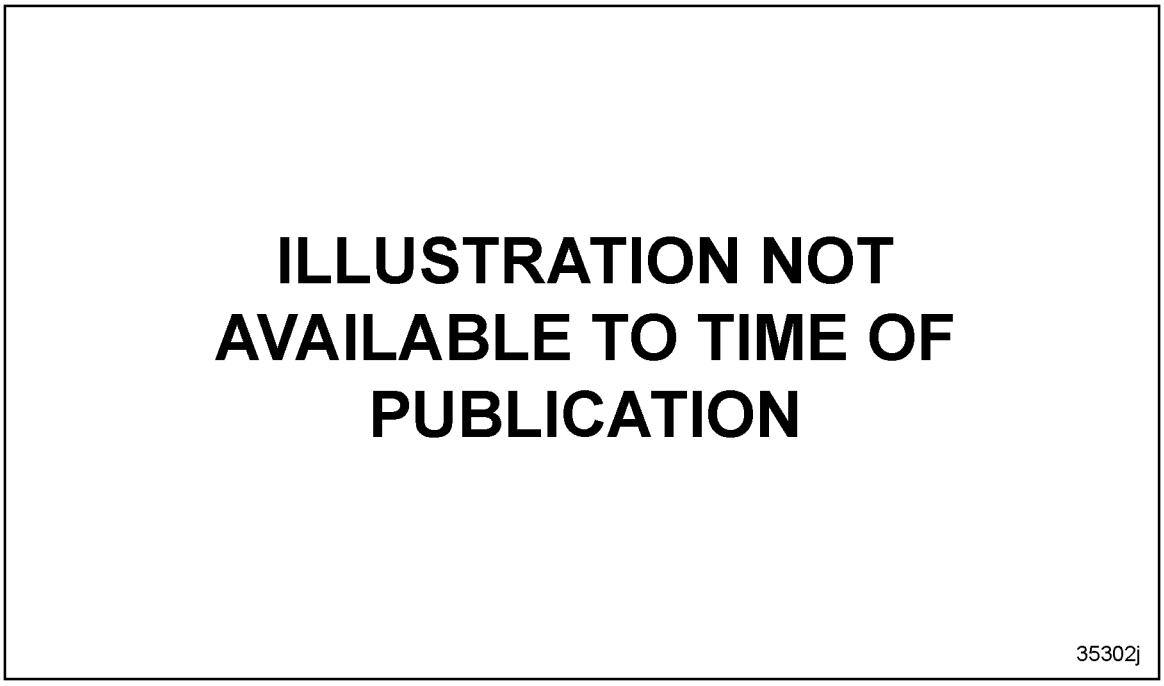
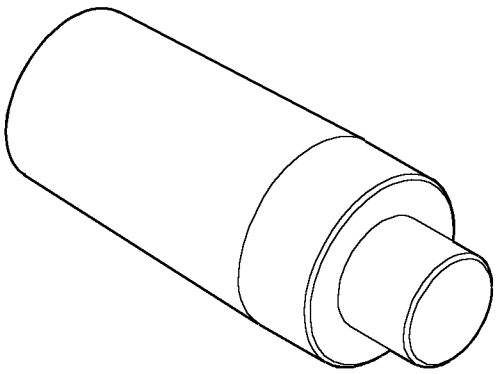


Figure 1390 Seal/Wear Sleeve Installer,J 39184

ILLUSTRATION NOT AVAILABLE TO TIME OF PUBLICATION

35302j

Figure 1434 Piston & Rod Bushing REM/INST SET,J 7587



29115J

Figure 1435 Piston Pin Alignment Tool,J 24285

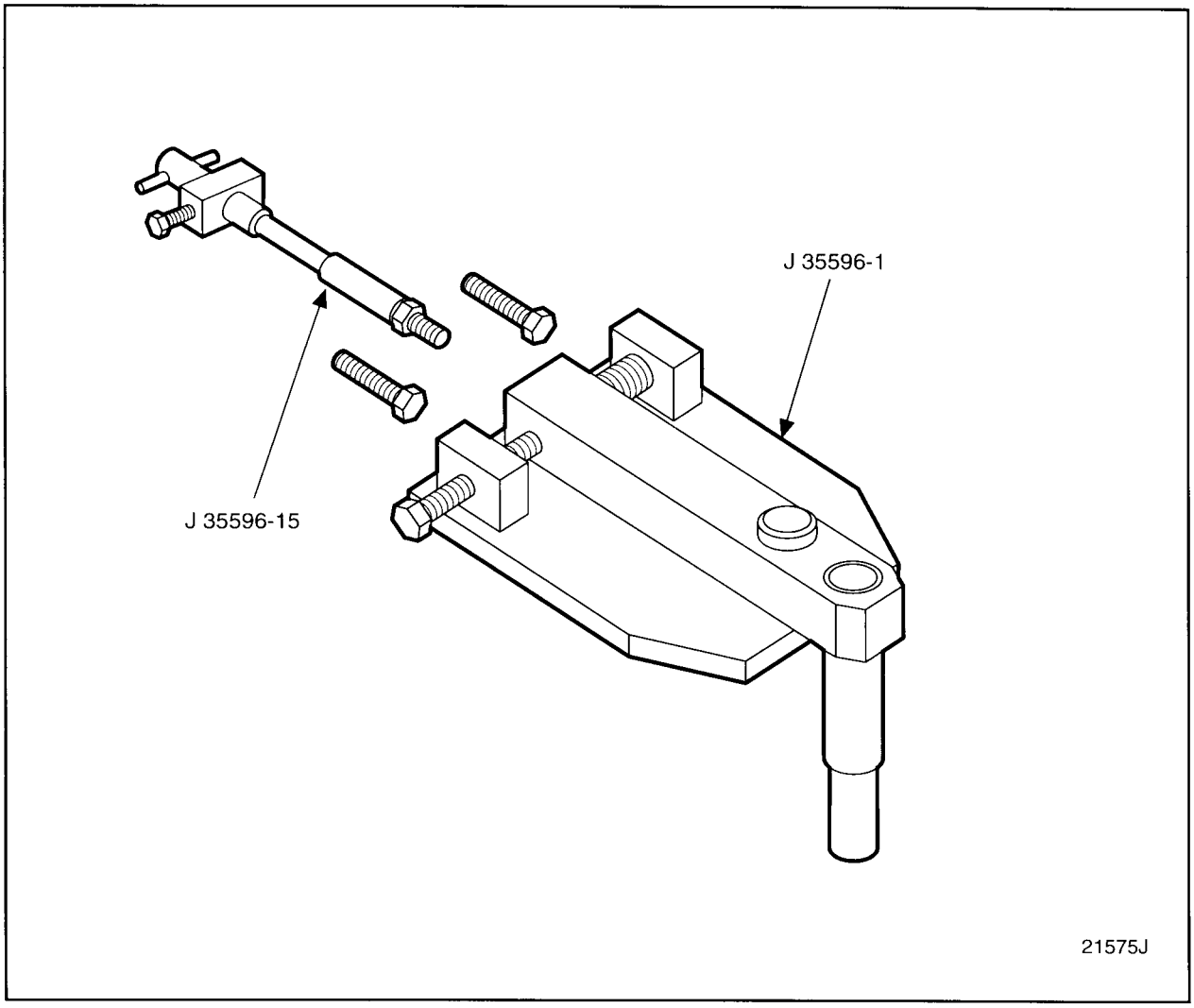


Figure 1475 Cam & Idler Gear Lash Adapter ,J 35596

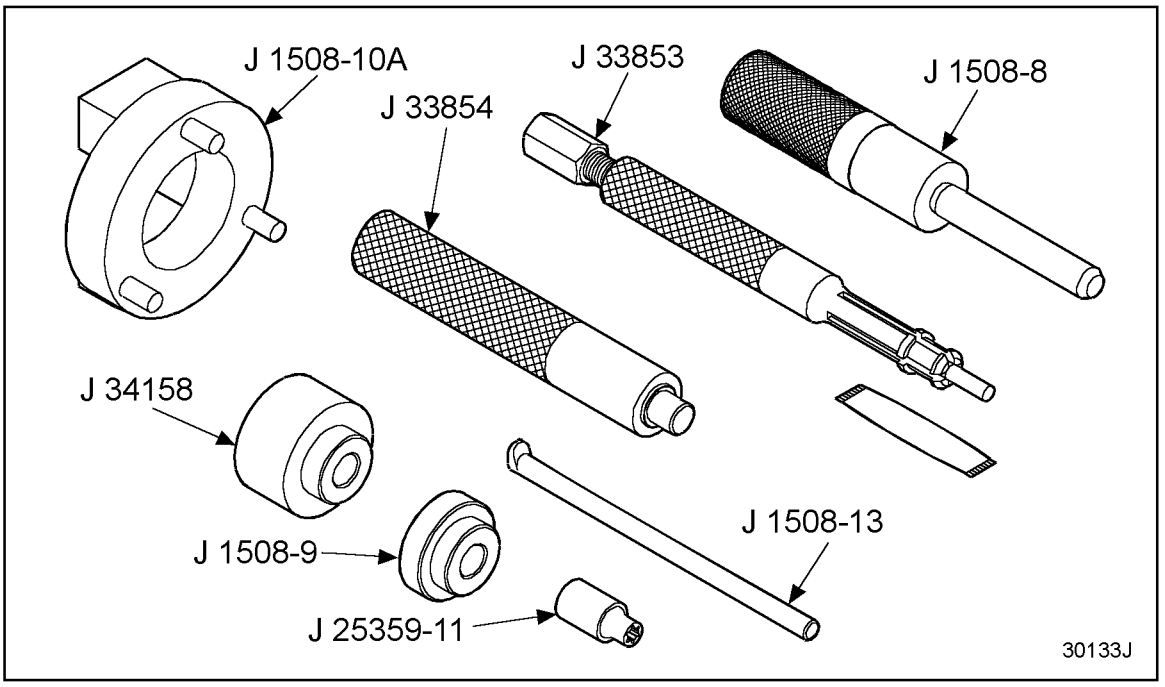


Figure 1513 Fuel Pump Repair Kit,J 34607–A

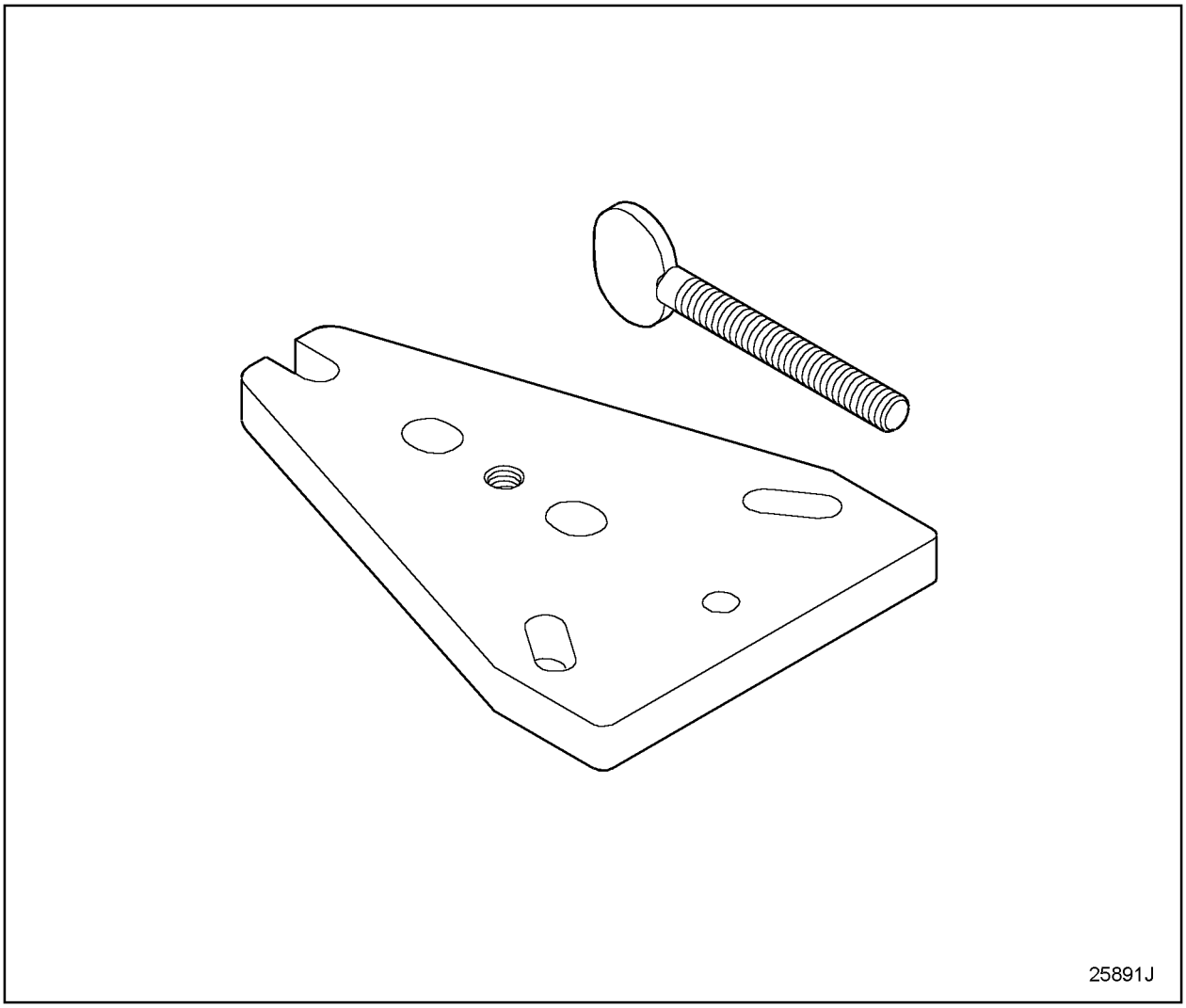


Figure 1560 Water Pump Impeller Remover, J 22143

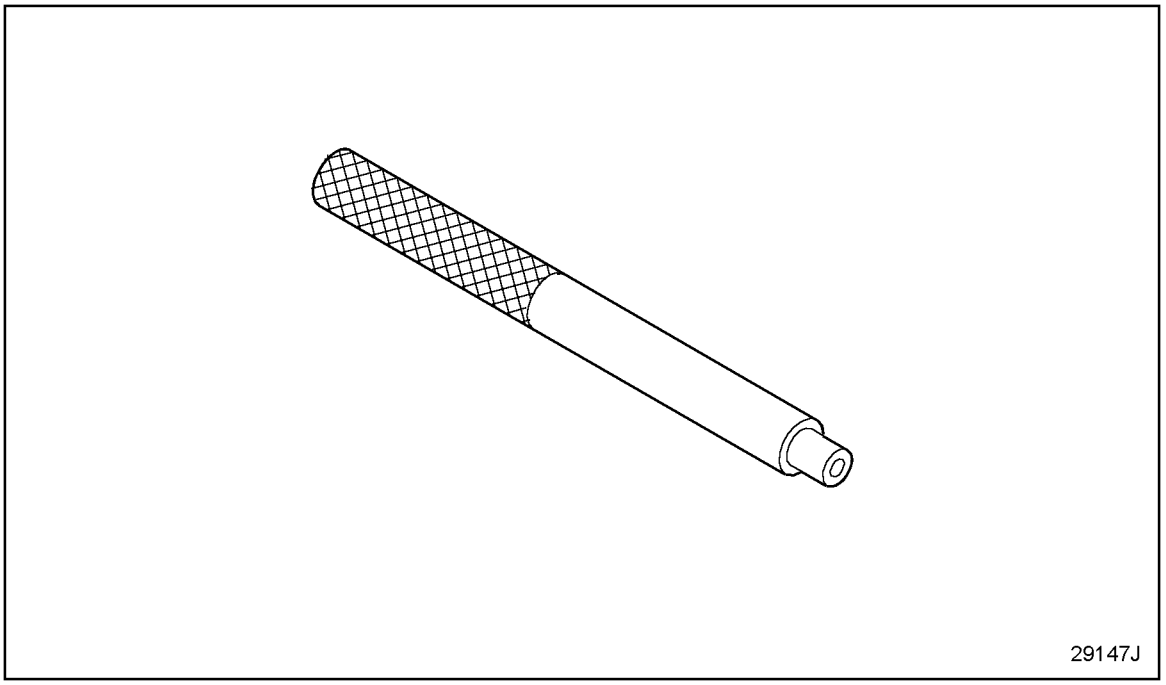


Figure 1599 Groove Pin Installer,J 29088

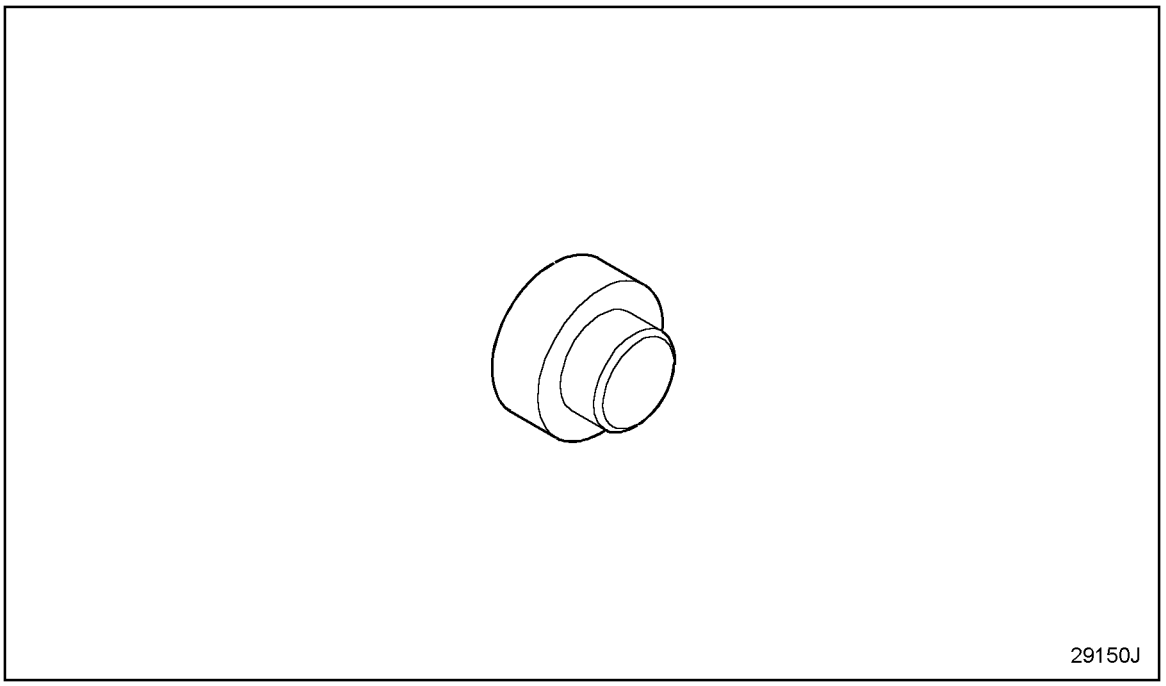


Figure 1600 Seal Ring Installer,J 29104

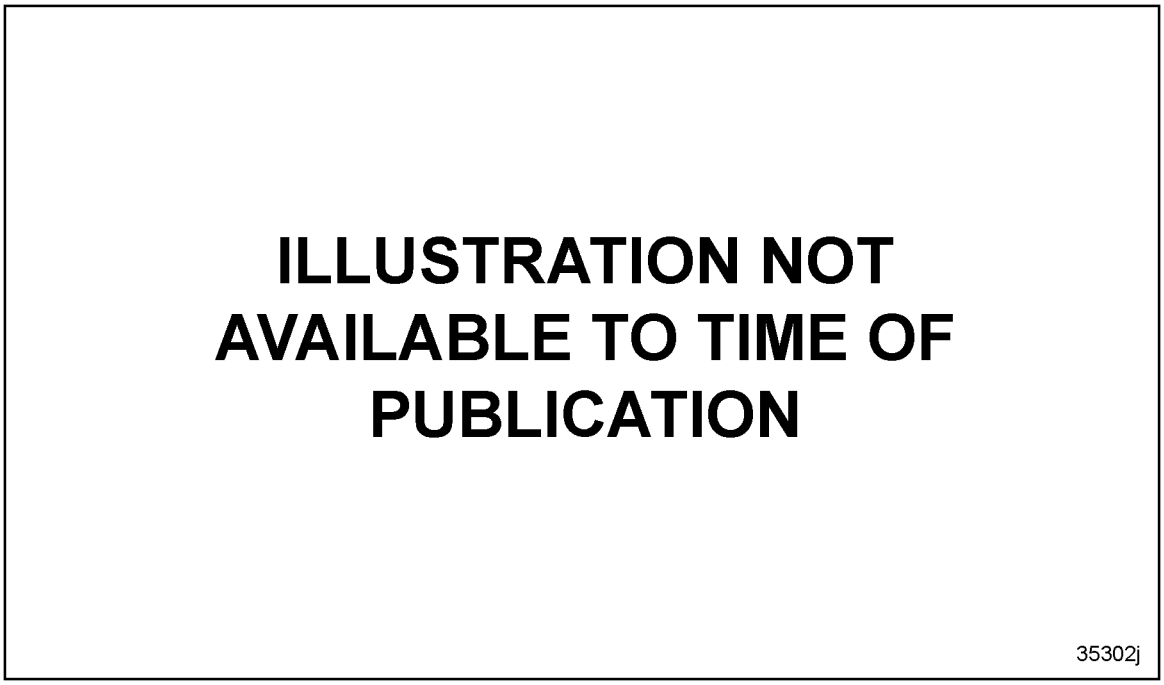


Figure 1643 Injection Pump Plunger Pin,J 41162

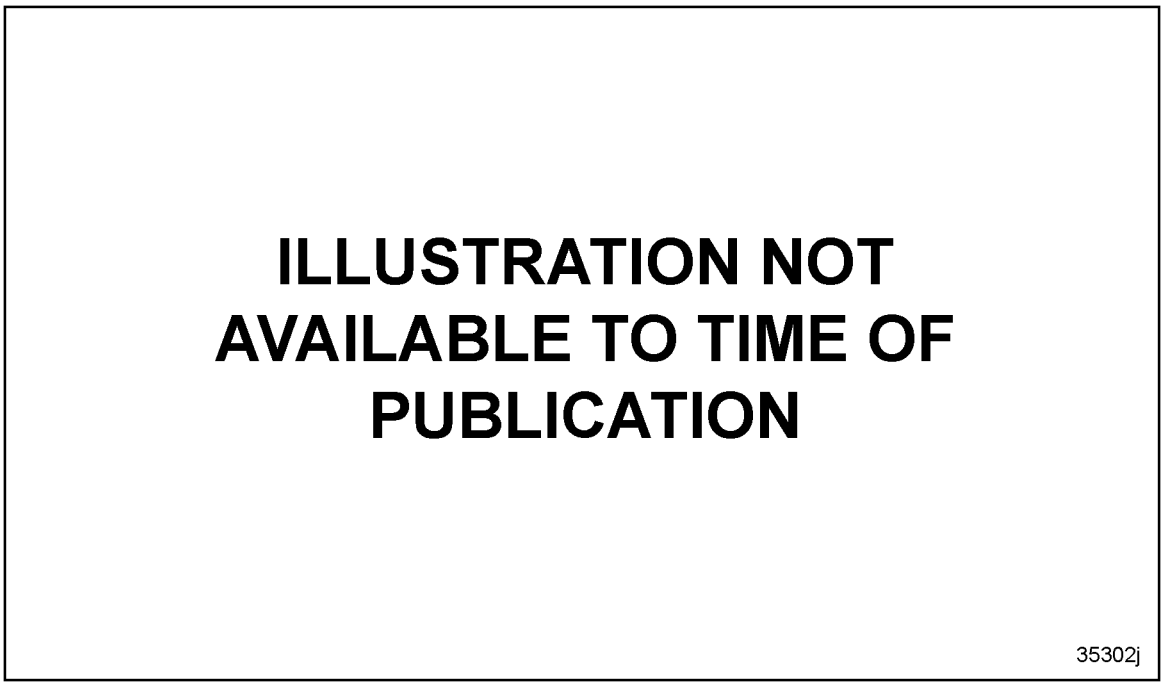


Figure 1644 Injection Pump Timing Pin,J 41161

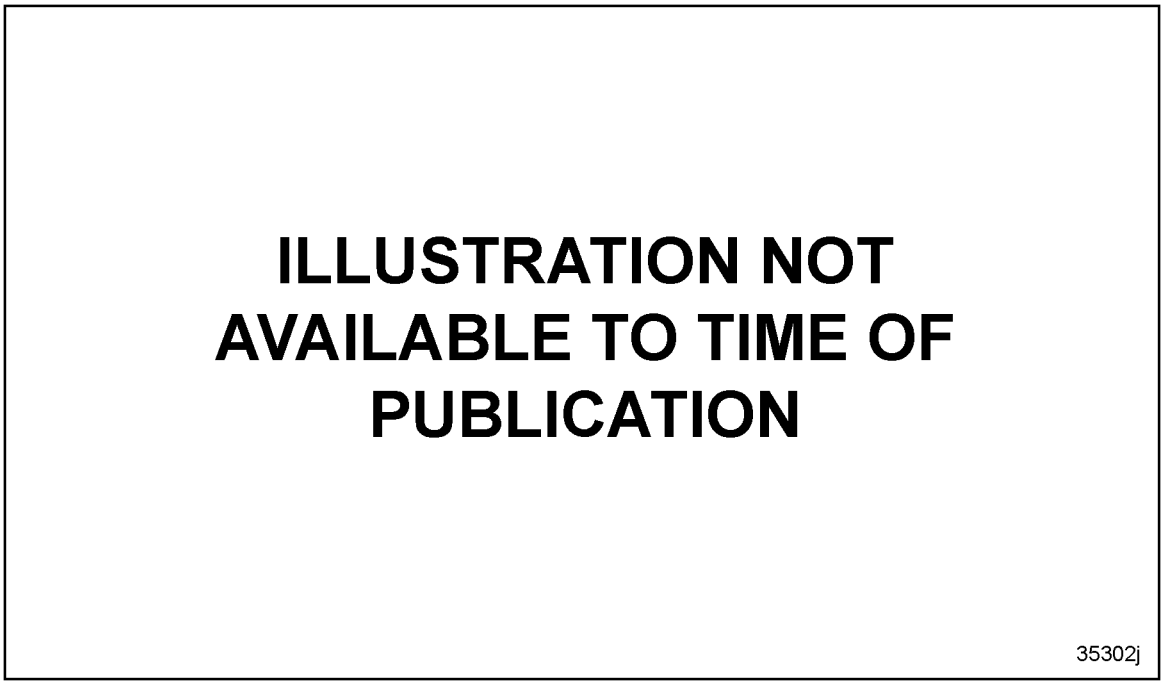


Figure 1690 Injector Timing Gage (1.464),J 34081

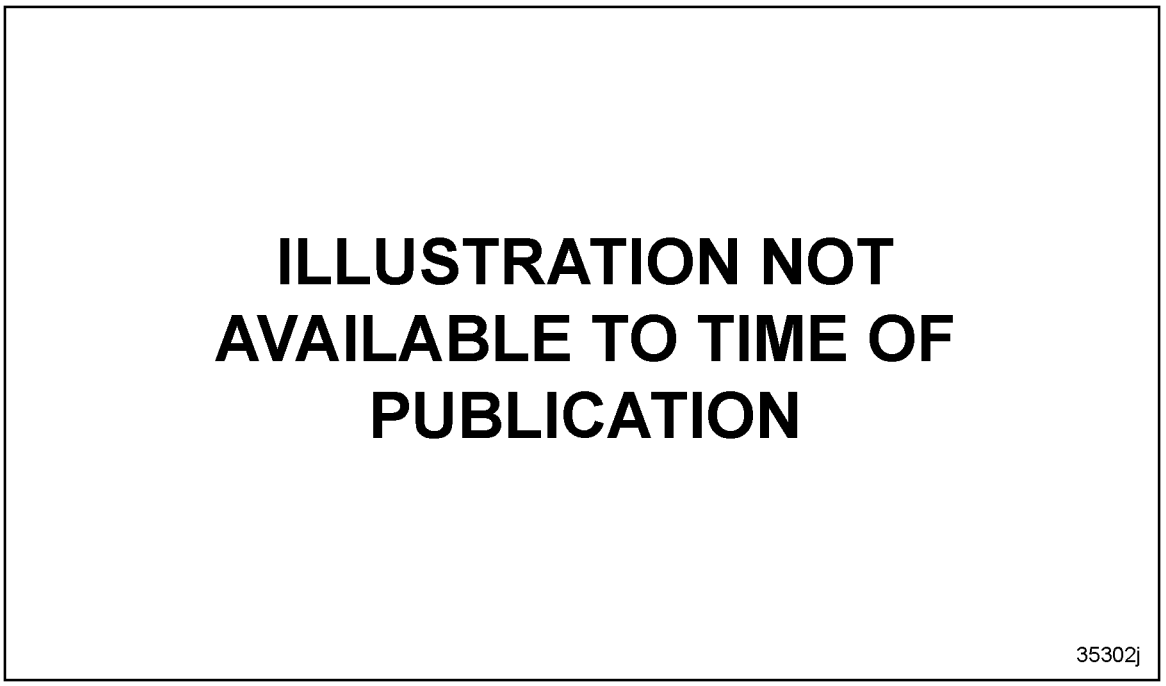


Figure 1691 Injector Timing Gage (1.466),J 26888

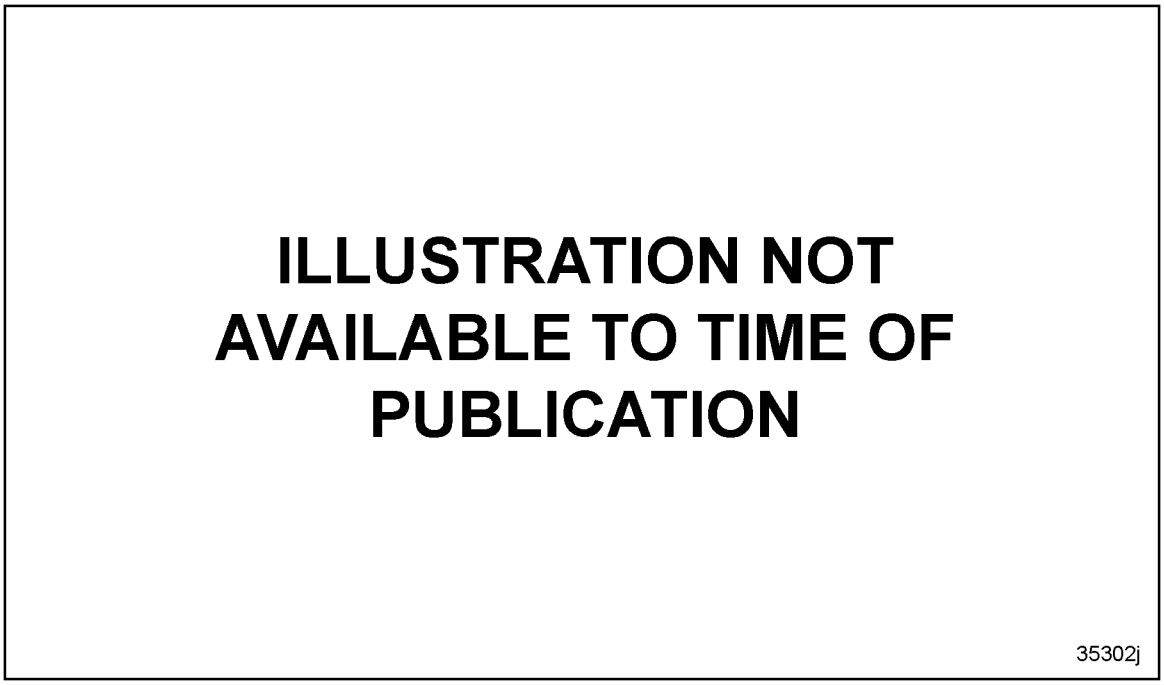


Figure 1739 Micrometer (Inch & MM) 2"-3",J 26900–3

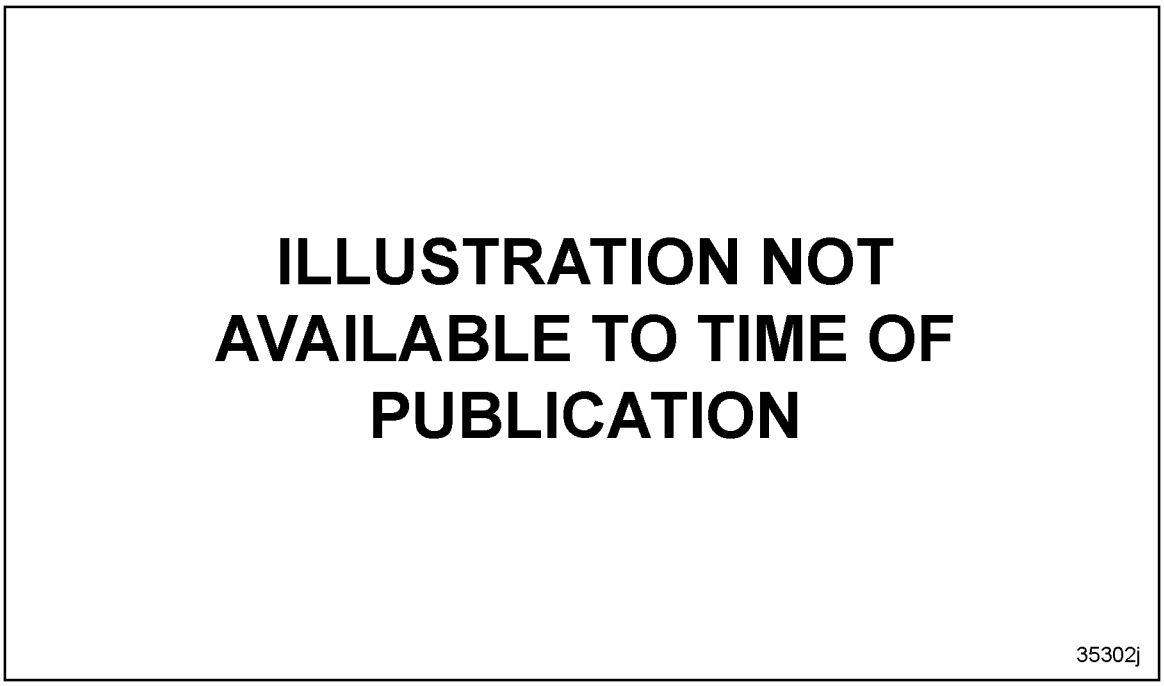


Figure 1740 Micrometer (Inch & MM) 3"-4",J 26900–4

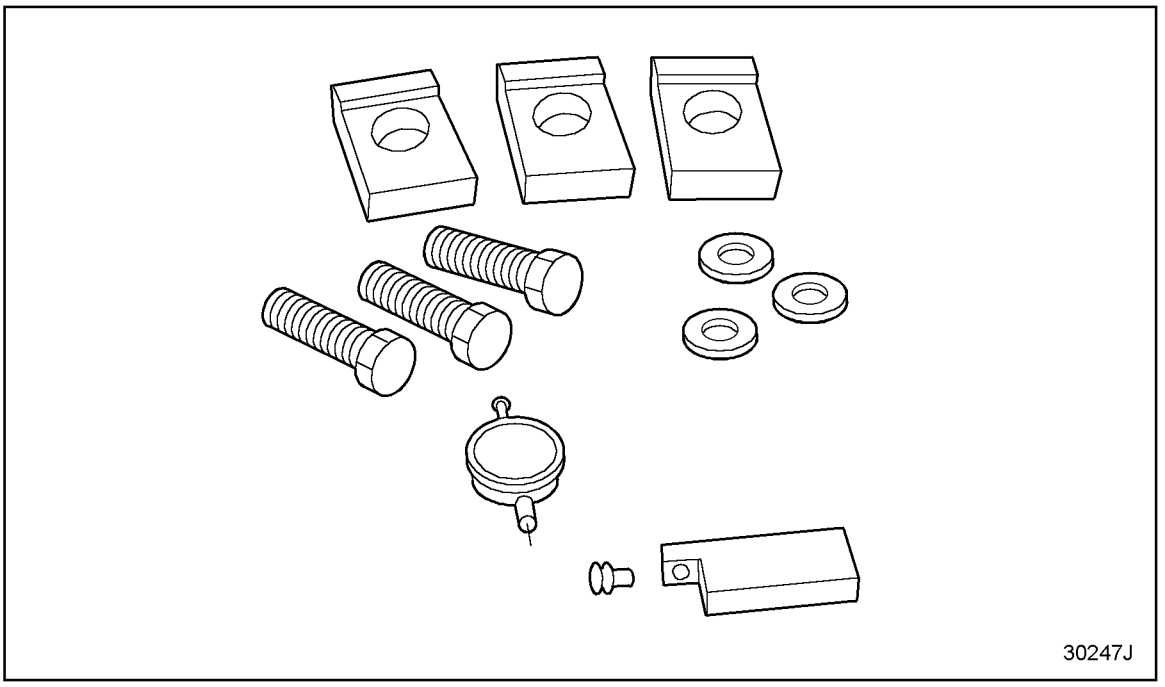


Figure 1782 Cylinder Sleeve Holding Adapters,J 43095

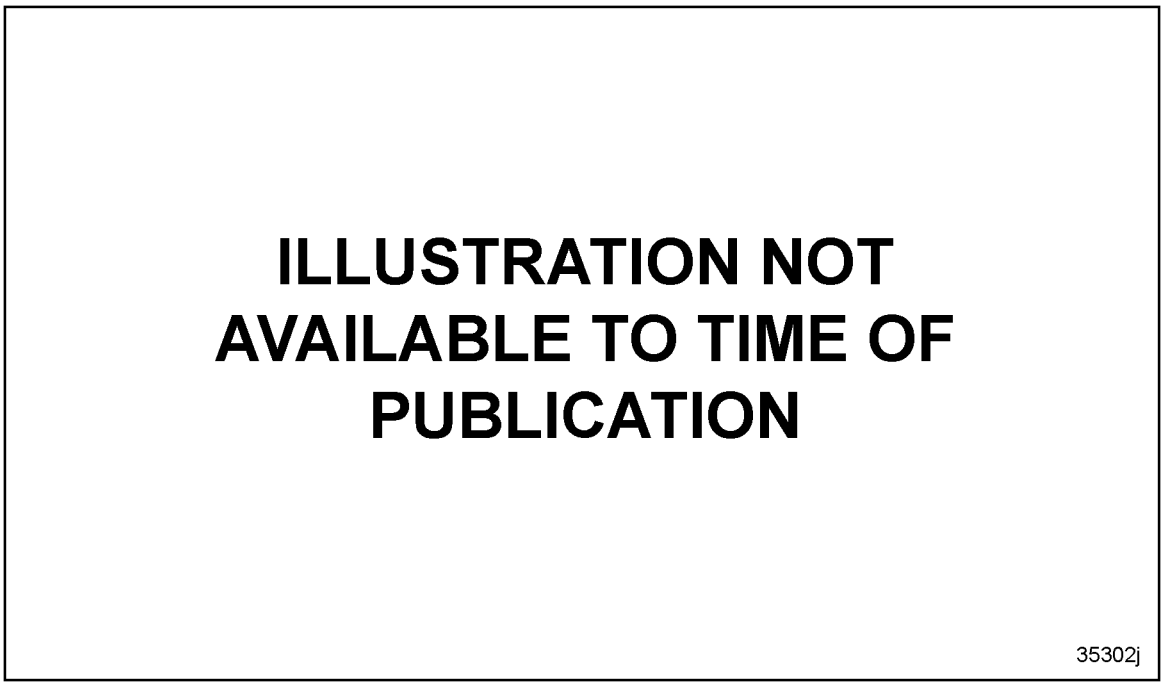


Figure 1783 Depth Collar,PT-2200–83

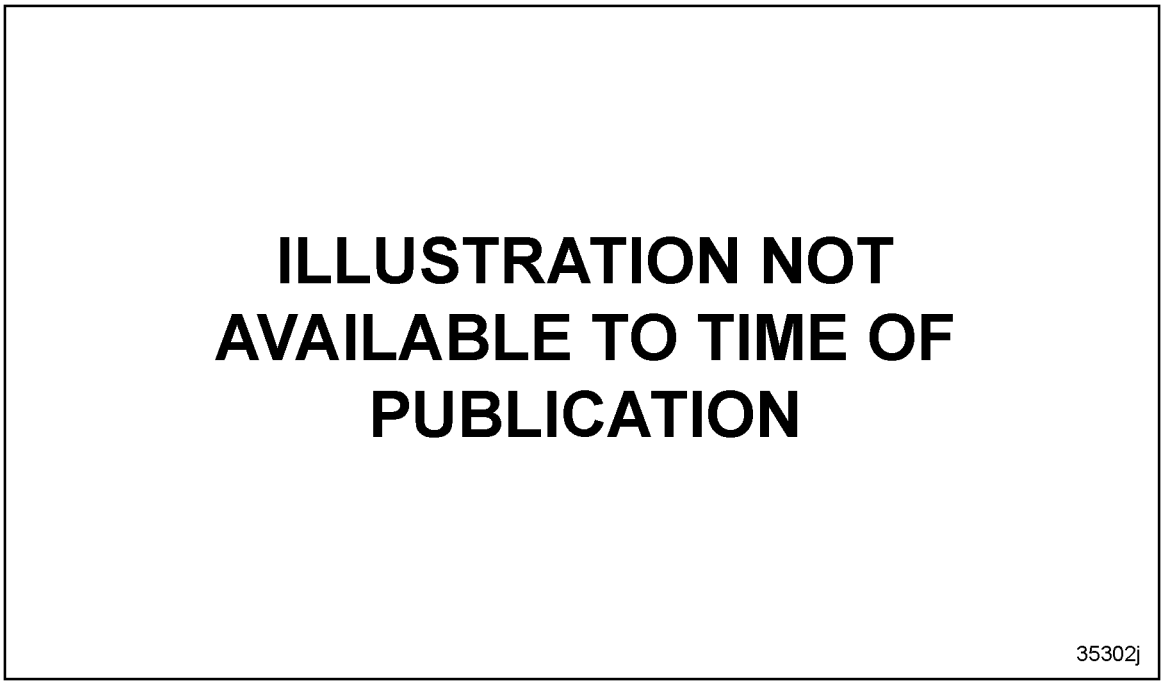


Figure 1828 Gear Case Bushing Kit (40), J 43030–40

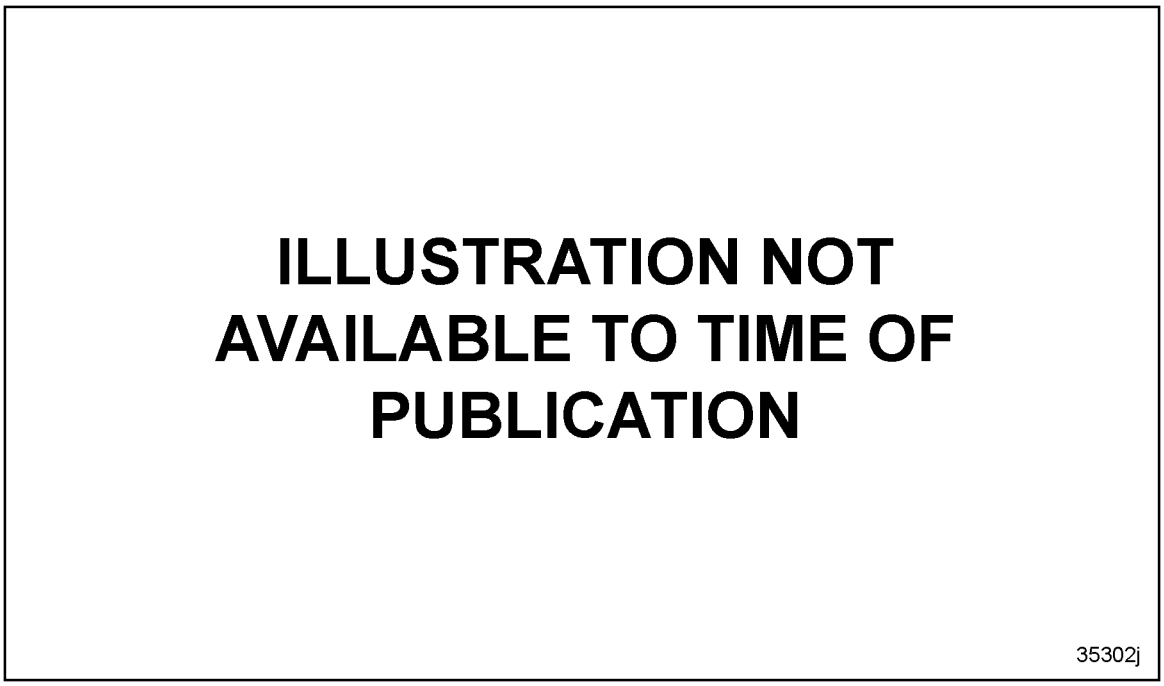


Figure 1829 Gearcase Reaming Fixture, J 43030

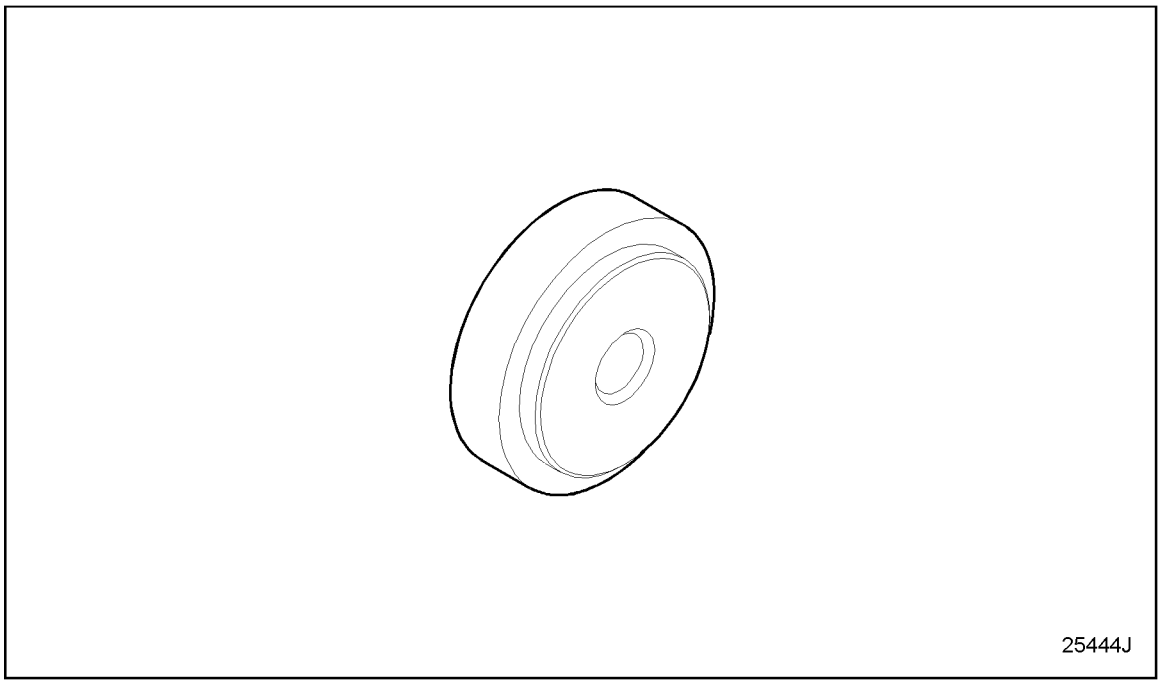


Figure 1880 Cup Plug Installer,J 41746

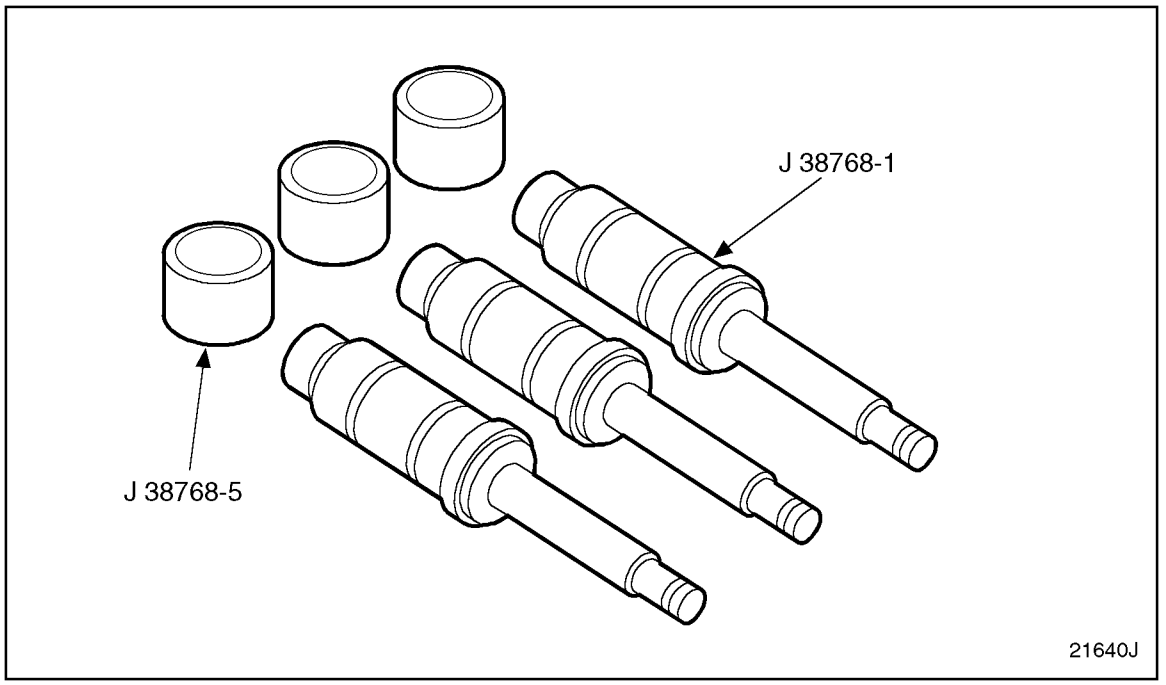


Figure 1881 Cylinder Compression Test Adaptor SetJ 38768

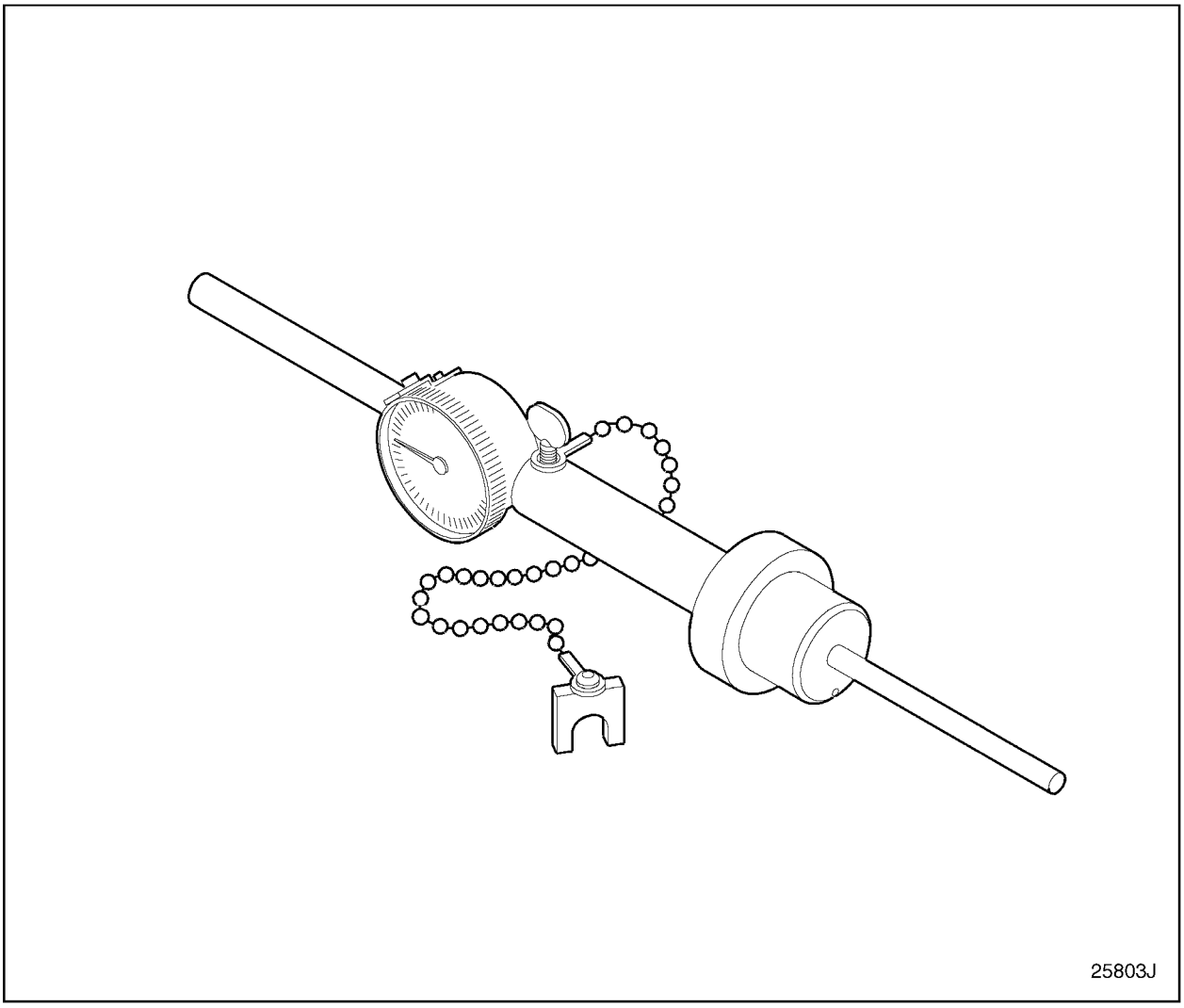


Figure 1921 Crankshaft Position Timing Tool J 34930-A

Coaxial Tolerance of Cylinder Block Bores for Camshaft Bearings

See Figure 1072 for a view of the cylinder block bores and camshaft bearings coaxial tolerance points and listed in Table 7 are the maximum permissible coaxial deviations.

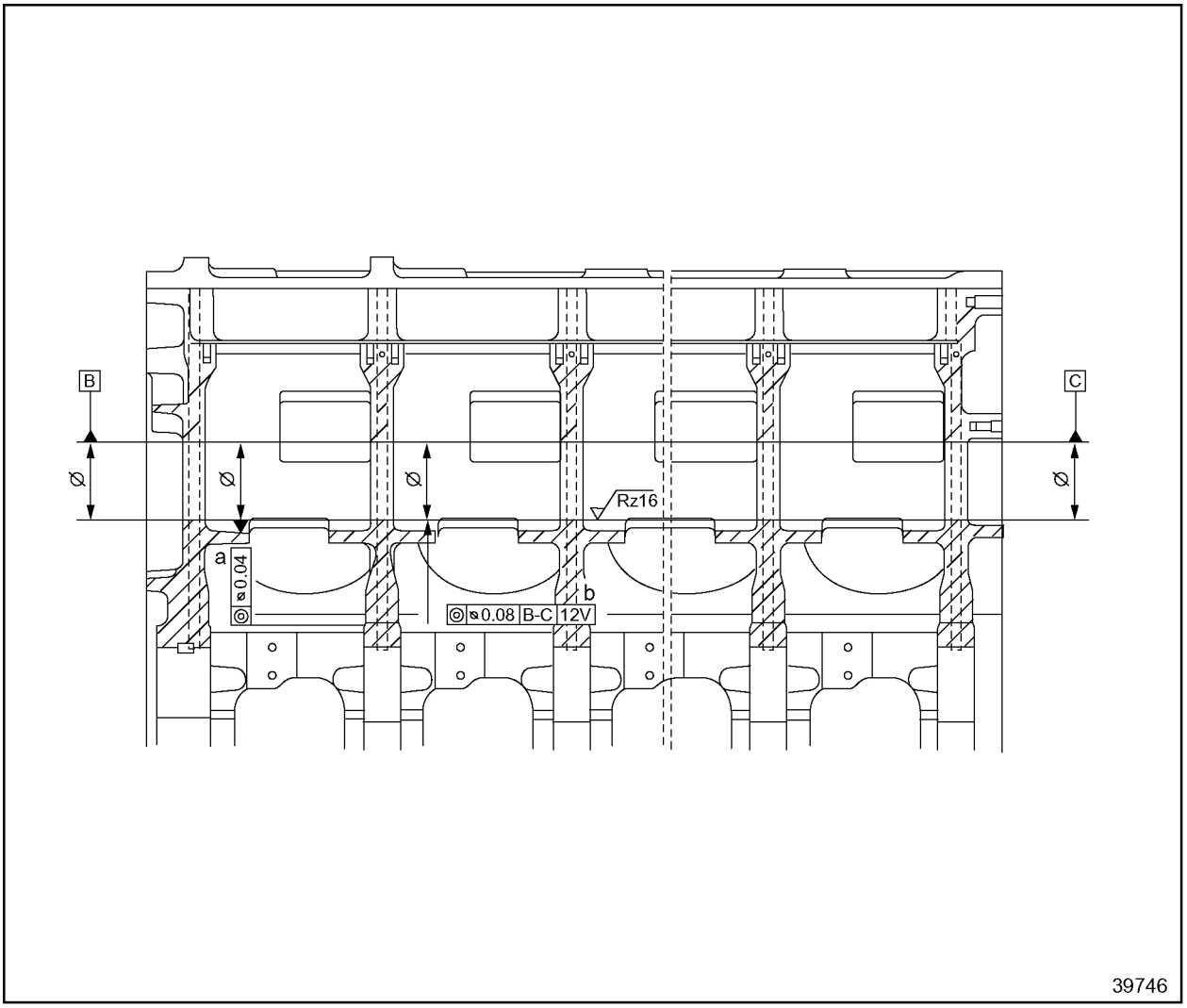


Figure 1072 Coaxial Tolerance Points of Cylinder Block Bores for Camshaft Bearings

Maximum Permissible Coaxial Deviation	New Condition
a - with adjacent left and right bearings	Diameter 0.040
b - from camshaft bearing 1 to 7	Diameter 0.080

Table 7 Maximum Permissible Coaxial Deviation

No.	Designation	Stage	Tol. Size	Deviation		Clearance		Interference		Wear Limit
				Lower	Upper	Min	Max	Min	Max	
1	Connecting rod bore	0	75.00^{H6}	0	+ 0.019	-	-	0.101	0.139	Axial test load, bushing installed min. 17000 N
		1	75.20^{H6}							
		2	75.40^{H6}							
	Bushing OD	0	75.00_{v6}	+ 0.120	+ 0.139					
		1	75.20_{v6}							
		2	75.40_{v6}							
2	Bushing ID-finish-machined	-	68.00	+ 0.008	+ 0.018	0.008	0.023	-	-	-
	Piston pin OD		68.00	– 0.005	0					
3	Bushing ID-finish-machined	-	68.00	+ 0.008	+ 0.018	0.008	0.023	-	-	-
	Piston pin OD		68.00	– 0.005	0					
4	MTU part number and stage stamped on									

Reconditioning Instructions

Re 1: Bushing loose at 17000 N test load; replace bushing, introduce next repair stage if necessary.

Table 24 Piston Bearing Tolerances

Engine Coolant Pump for H.P. Temperature System

See Figure 1108 is the engine coolant pump for high pressure temperature system.
Listed in Table 42 are the tolerances for the engine coolant pump for high pressure temperature system.

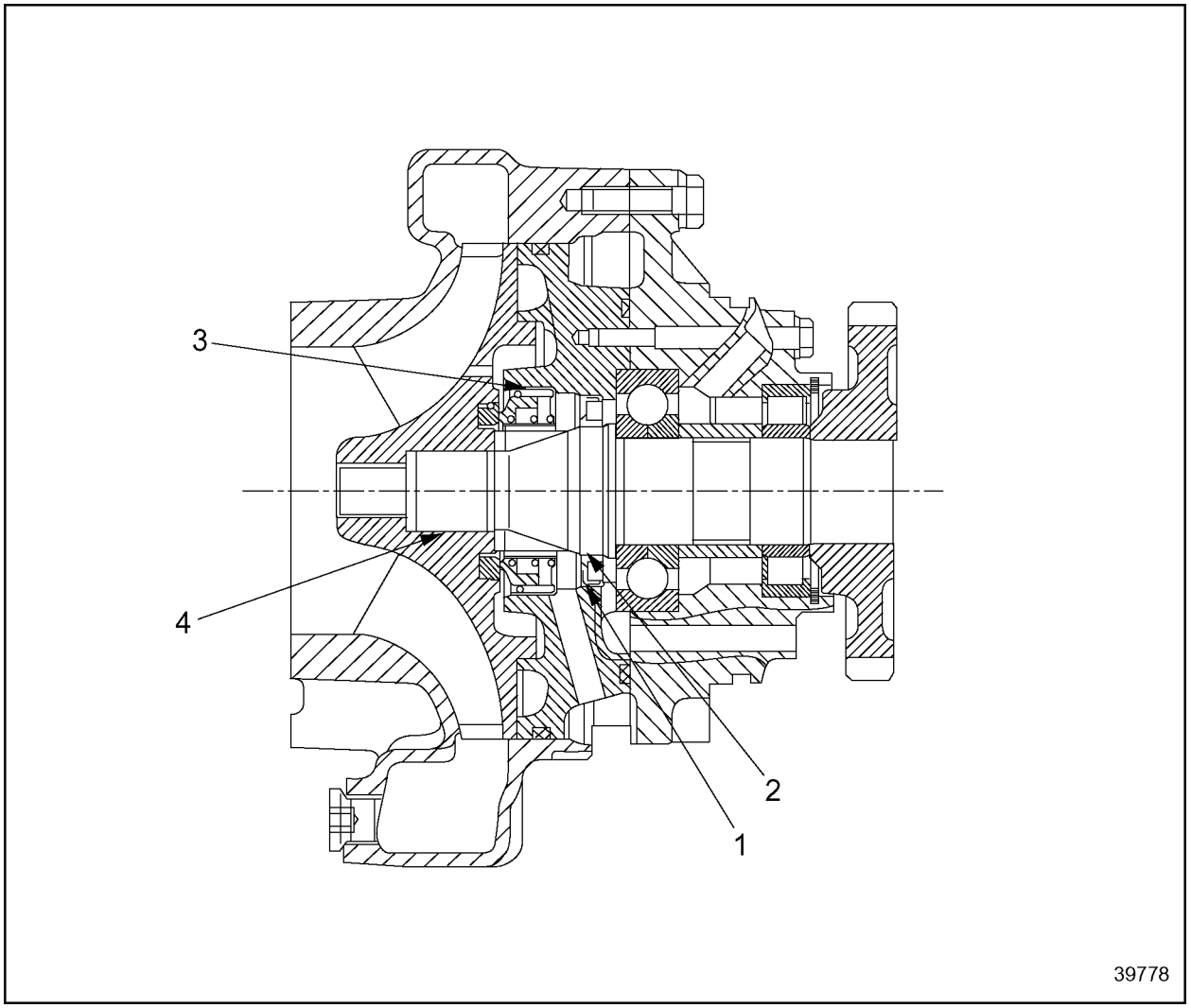


Figure 1108 Engine Coolant Pump for H.P. Temperature System

E 012.05 A – GENERAL

Internal Coolant Leakage

Subsequential cooling system damage caused by corrosion must be avoided. If the engine cannot be repaired immediately, carry out the following operations:

NOTE:
These corrosion-prevention measures are only effective for a few days. Repair of the engine and thorough cleaning of all components should, therefore, be carried out as soon as possible.

1. Drain coolant and engine oil.
2. Pour corrosion-inhibitor oil, kerosene, or diesel fuel into the cylinder block via the oil filler tube until the highest possible level of the filler neck is reached.
3. Disconnect charge air coolant manifolds.
4. Remove the fuel injectors. Refer to section C 075.05.05C 075.05.05 .
5. Bar the engine manually and spray corrosion-inhibitor oil, kerosene, or diesel fuel into the combustion chambers via the opening inlet valves.

Before restarting the repaired engine, fill with new oil and coolant in compliance with the current specification in the publication *Oil, Fuel, and Filter Requirements, DDC/MTU Series 2000, MTU/DDC Series 4000* (7SE273).

It is essential to change the engine oil after 50 operating hours as the oil may be contaminated by coolant residues left in the cylinder block.

Engine Oil Dilution by Fuel

When engine oil has been diluted by fuel, it is essential to change the engine oil before restarting the engine. Remove the old oil from the cylinder block with particular care. Replace the engine oil filter.

After Servicing Engine

If running gear components, e.g. pistons, piston rings, cylinder liners, etc. have been replaced, carry out the engine running-in procedure; refer to section B 005B 006 .