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SERIES 4000™ Service Manual

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

DETROIT DIESEL CORPORATION

Detroit Diesel Corporation
13400 Outer Drive, West / Detroit, Michigan 48239-4001
Telephone: 313-592-5000
Fax: 313-592-7888
http://www.detroitdiesel.com

MTU Motoren-und Turbinen-Union
Friedrichshafen GmbH
88040 Friedrichshafen, Germany
Fax: 497547 90 3642
www.mtu-friedrichshafen.com

CALIFORNIA
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

CAUTION:

Engine exhaust may be harmful to your health if inhaled. To reduce the chance of personal injury and/or property damage, the following instructions must be carefully observed.

Proper service and repair are important to the safety of the service technician and the safe, reliable operation of the engine. If part replacement is necessary, the part must be replaced with one of the same part number or with an equivalent part number. Do not use a replacement part of lesser quality.

The service procedures recommended and described in this manual are effective methods of performing repair. Some of these procedures require the use of specially designed tools.

Accordingly, anyone who intends to use a replacement part, procedure or tool which is not recommended, must first determine that neither personal safety nor the safe operation of the engine will be jeopardized by the replacement part, procedure or tool selected.

It is important to note that this manual contains various "Cautions" and "Notices" that must be carefully observed in order to reduce the risk of personal injury during repair or the possibility that improper repair may damage the engine or render it unsafe. It is also important to understand that these "Cautions" and "Notices" are not exhaustive, because it is impossible to warn personnel of the possible hazardous consequences that might result from failure to follow these instructions.

Abstract

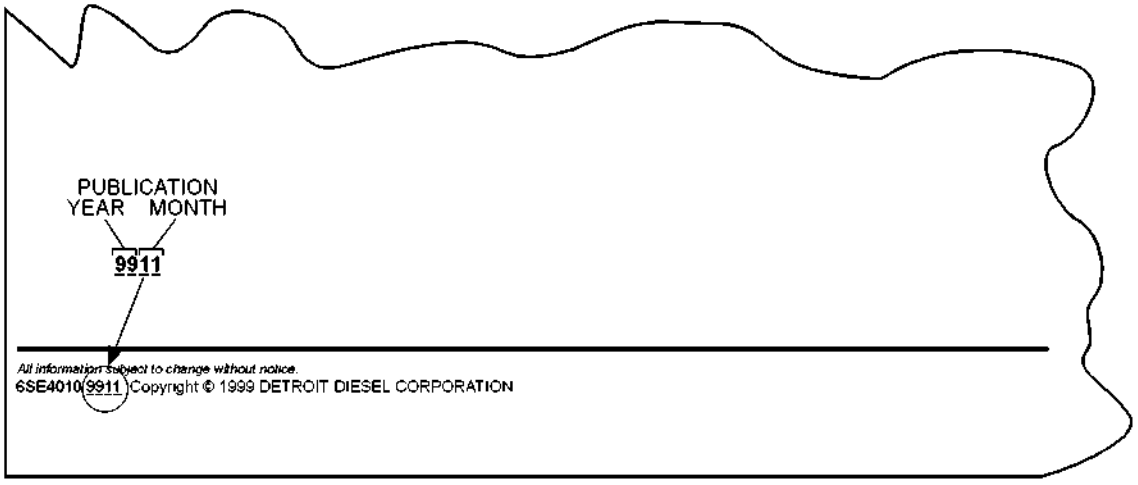
This manual provides instruction for construction and industrial and marine applications of Detroit Diesel Series 4000 Engines.

Specifically, a basic overview of each major component and system along with recommendations for removal, cleaning, inspection, criteria for replacement, repair and installation and mechanical troubleshooting are contained in this manual.

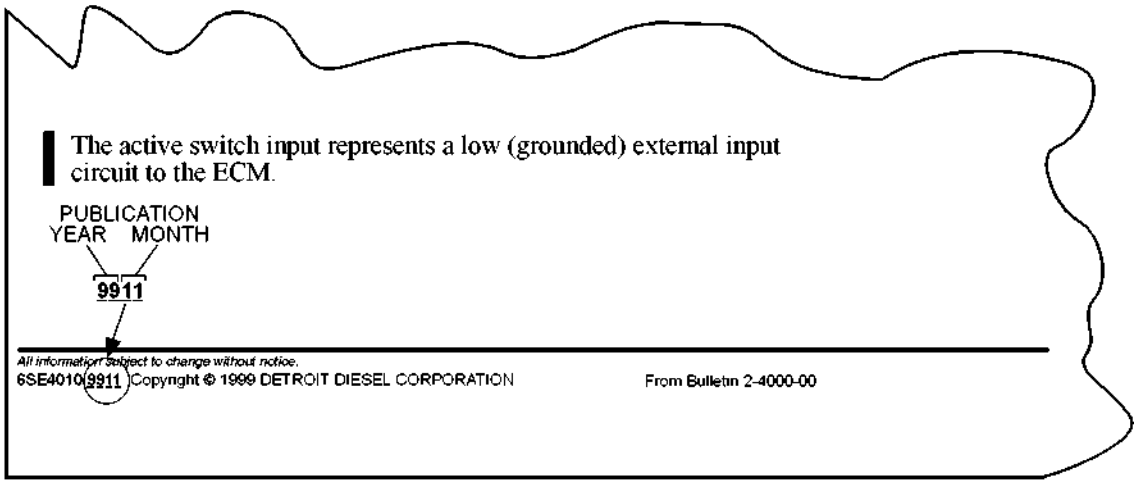
Revision Notification

Modification to this manual are announced in the form of Service Information Bulletins. The bulletins include attachment pages and are posted on the World Wide Web (www.detroitdiesel.com/svc/sibinex.htm).

Revisions to this manual will be sent marked with a revision bar (see Example 2). Sections containing revisions will have a third line in the page footer (compare Examples 1 and 2).



Example 1 - Unchanged Pages



Example 2 - Changed Pages

Engine Exhaust

Consider the following before servicing engines:

CAUTION:

To avoid injury while operating an engine, ensure the work area is properly ventilated. Engine exhaust is toxic.

Please note this caution and remember:

- ☐ Always start and operate the engine in a well-ventilated area.
- ☐ If in an enclosed area, vent the exhaust to the outside.
- ☐ Do not modify or tamper with the exhaust system.
- ☐ For accurate dynamometer readings during an engine run-in, the chassis dynamometer room*must* be properly ventilated. See Figure 1.

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A – GENERAL INFORMATION

A 001 – IMPORTANT INFORMATION

Section **Page**

Important Information

This manual is intended for use by technical personnel responsible for the maintenance and servicing of the DDC Series 4000 diesel engine.

This manual describes:

- ☐ Scheduled service operations from maintenance echelons W6 and M6. Disassembly of the engine, repair, or overhaul of the relevant components is determined based on actual condition.
- ☐ Unscheduled service operations on the individual assemblies.

Index sheets divide this handbook into three main sections:

- ☐ Section A — General
- ☐ Section B — Work schedules
- ☐ Section C — Task description
- ☐ Section D — Tolerance and Wear Limits
- ☐ Section E — Troubleshooting
- ☐ Section F — Preventive Maintenance

Section C is further subdivided into main function groups and function groups. The structure is oriented toward the logical structure of the parts list and spare parts manuals. Each function group consists of no more than nine parts, for example:

- ☐ C 011.05.01 — General View
- ☐ C 011.05.02 — Special Tool
- ☐ C 011.05.04 — Before-Removal Operations
- ☐ C 011.05.05 — Removal
- ☐ C 011.05.06 — Disassembly
- ☐ C 011.05.08 — Inspection and Repair
- ☐ C 011.05.10 — Assembly
- ☐ C 011.05.11 — Installation
- ☐ C 011.05.12 — After-Installation Operations

NOTE:
Some sections will have an “M” following the section numbers. This designates marine application only.

Systematic searches for specific information and rapid orientation in the manual are supported by:

- ☐ The tables of contents on each main index sheet. These cross - reference the tables of contents of the individual groups.
- ☐ An alphabetical subject index in Section A provides direct access to the individual groups.
- ☐ The Group Summary at the start of Section C lists the individual main function groups.

Basic Requirements for Maintenance and Service Work

Customers performing their own maintenance must ensure that the following conditions and basic requirements are satisfied:

- ☐ All safety regulations are observed
- ☐ Good general-purpose tools are provided
- ☐ Cleaning and testing equipment is provided
- ☐ Work is performed by trained personnel
- ☐ Special tools are provided
- ☐ Service area is adequately equipped

General Assembly Instructions

The following general instructions will help you care for your engine:

- ☐ Component cleanliness — Areas of all components that come into contact with oil, fuel, coolant, water and combustion air must be kept clean.
- ☐ Components requiring special cleanliness (e.g. oil and fuel-carrying components) must be cleaned with suitable cleaning procedures before assembly and then checked for cleanliness and treated accordingly.
- ☐ Component packaging must only be removed immediately before installation.
- ☐ Elastomer components (e.g. rubber parts, etc.) must not be washed with diesel fuel, solvents or cold cleaners.

Parts dirtied with oil and fuel must be cleaned immediately. The parts should be wiped with a dry cloth.

Elastomer components such as engine mounts, damping elements, couplings and Vee-belts must not be painted. They can only be installed after painting the engine or must be covered before painting work is carried out.

- ☐ Radial-lip shaft seals treated with oil by the manufacturer show definite signs of swelling when delivered. They must, therefore, be cleaned (not washed) only with an abrasion-proof paper towel before installation.
- ☐ The surfaces of parts that slide against each other must be lubricated with engine oil when installed, unless otherwise specified.
- ☐ O-rings and surfaces moving against them during installation (bores and shafts) must be coated with petroleum jelly, unless otherwise specified.

When installing O-rings with counter-rings in coolant pumps, always follow the installation instructions.

- O-rings must be installed in shaft grooves without twists. To remove twists, pass a rounded marking tool under the sealing ring along the circumference (if O-ring diameter is sufficiently large).
- Before shaft seal installation:
  - The sealing lip of the shaft seal (except teflon-type seals) must be coated with petroleum jelly and the shaft running surface with thin-film lubricant or engine oil.
  - Teflon seals used in the front and rear main seals must be installed dry.
  - The outer surface of metal outer jackets in the support bore must be coated with surface sealant, unless otherwise specified in the drawing. For elastomer outer jackets or combined metal/elastomer outer jackets, the outer surface must be coated with denatured ethanol.
- Sealing compound must be used to fix the position of flat gaskets. Sealing compound is to be thinly applied in spots on the flat gaskets or mating faces. Immediately after application of the sealing paste, the flat gaskets must be fitted to the component and then, no more than 20 minutes later, the seal components mated together. Oil, multi-purpose grease, or other materials, must not be used to fix the position.
- Before installing antifriction bearings, lightly lubricate the bearing seats. To avoid bearing contamination, only remove the bearings from their original packaging immediately before installation. Do not remove the corrosion inhibitor from the bearings in the original packaging. Use petroleum spirits or acid-free kerosene to clean the antifriction bearings. After cleaning, lubricate the bearings again with engine oil.

During assembly, do not apply axial forces to antifriction elements and do not hit the bearing rings with a hammer. Use assembly aids.

Do not use an open flame to heat bearing inner races. The temperature should be between 80°C and 100°C (176 - 212°F). It must never exceed 120°C (248°F).

Deep freezing for friction bearing installation is not permissible due to risk of cracking or rusting through condensate.

- ☐ Dry bearings must not be oiled.
- ☐ When installing gears, the splines must be lubricated with engine oil.
- ☐ All support and mating surfaces of components (e.g. mating surfaces for centering devices, flange and sealing surfaces, joint surfaces of press fits) must be clean, polished or provided with the specified surface protection and free from warping and damage. Corrosion inhibitors (e.g. oil, grease) must be removed from support and mating surfaces.
- ☐ After parts are installed by means of cooling using liquid nitrogen, all condensate must be removed and the parts coated with engine oil.
- ☐ Sensors must be coated with lubricant or anti-sieze before installation in the immersion sleeves.
- ☐ To install cable connections with cutting ring threaded connections, first coat the thread with thin-film lubricant. Cable connections with cutting ring threaded connections must be installed in a vice and tightened.
- ☐ After any part has been etched, the solution must be removed by means of a neutralization agent. The affected parts must then be preserved with engine oil.
- ☐ Components used in hot part areas (e.g. Vee-clamps, bellows, plug-in pipes, O-rings) must be coated at the support and mating surfaces with assembly paste, unless otherwise specified.
- ☐ The assembly surfaces of bolts, nuts, washers and of parts to be tensioned must be clean and polished or provided with the specified surface protection, and free from warping and damage. Corrosion inhibitors (e.g. oil, grease) must be removed. Threads and bolt heads must be coated with lubricant before assembly as per tightening specifications.

Unless otherwise specified, the following lubricants should be used:

- ☐ Engine oil for general application.
- ☐ Assembly paste in hot part areas.
- ☐ Threaded connections without tightening specifications:
  - ☐ For threaded connections without tightening specifications, the tightening procedure can be selected as required: mechanical tightening with screwdriver or normal manual tightening with an open-end wrench or box wrench.
  - ☐ For mechanical tightening, the tightening torque must be taken from the general tightening specifications according to thread size and property class.
- ☐ Threaded connections with tightening specifications:
  - ☐ Torque tightening—The bolt connections must be tightened by hand with a torque wrench or angle-of-rotation torque wrench. The specified tightening torques must be set at the torque wrench without consideration of the specified tolerance. When using an angle-of-rotation torque wrench, the torque indicated must be within the torque specification limit value. Proceed in a similar manner with torsionally protected threaded connections. These instructions apply also to testing torque.

Angle of rotation tightening—

The additional angles of rotation specified in the tightening specifications must be achieved and may be exceeded within the specified tolerance.

If no tightening tolerance is specified, the following tolerances must be observed:

+ 5 degrees for angle of further rotation less than or equal to 90 degrees.

+ 10 degrees for angle of further rotation greater than 90 degrees.

Before angle-of-rotation tightening, each bolt head must be color-marked so that after tightening it is possible to check that the angle of rotation is correct. (Exception: color-marking is not necessary in the case of a self-monitoring, numerically controlled, NC screwdriver.)

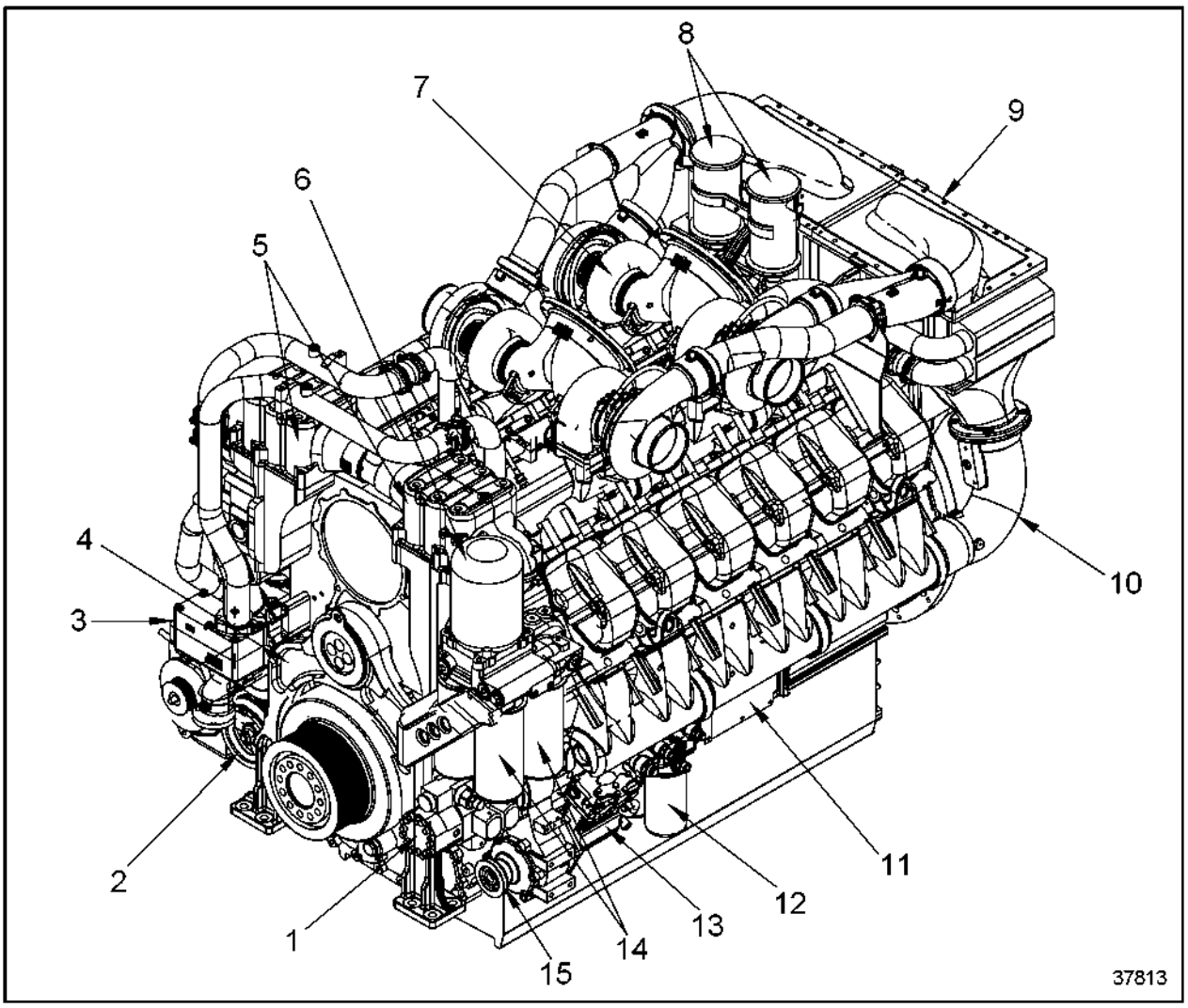
- Elongation tightening— Tightening must be carried out in accordance with tightening specifications taking the tightening tolerance into consideration.
- Always mark each fastener upon completion of the torquing process to ensure torque is applied to all and none of the fasteners were missed.

A 002 – GENERAL ENGINE INFORMATION

Section **Page**

Engine Layout

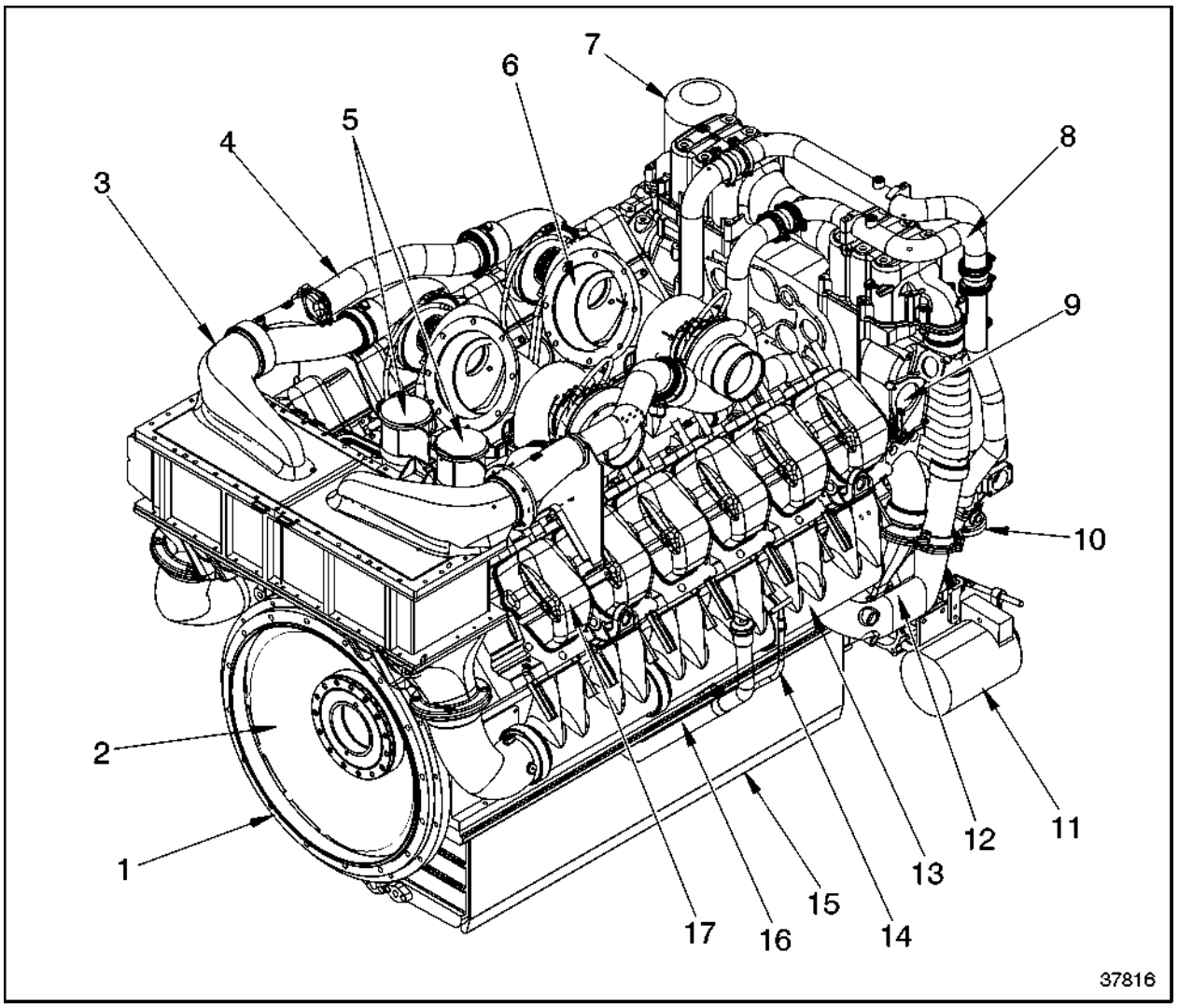
See Figure 1 for the front view of the Series 4000 12V engine.



1. High Pressure Fuel Pump
2. Alternator Drive
3. Low Temp Coolant (LTC) Thermostat
4. Trunnion Mount
5. Oil Coolers
6. Centrifugal Oil Filter
7. Turbocharger (4)
8. Crankcase Breathers
9. Charge Air Cooler
10. Intake Manifold
11. DDEC ECMs
12. Fuel Filters
13. Air Compressor
14. Oil Filter Cartridges
15. Accessory Drive

Figure 1 Front View, 12V Engine

See Figure 2 for the back view of the Series 4000 12V engine.



1. Flywheel Housing
2. Flywheel
3. Charge Air Cooler Intake
4. Air Inlet
5. Crankcase Breathers
6. Exhaust Outlet
7. Centrifugal Oil Filter
8. Charge Air Coolant Line
9. High Temp Thermostat Housing
10. Low Temp Water Pump
11. Alternator Drive
12. High Temp Water Pump Drive
13. Intake Manifold
14. Dipstick
15. Oil Pan
16. Oil Filler Tube
17. Cylinder Head Rocker Cover

Figure 2 Back View 12V Engine

Engine Model Designation

The key to engine model designation for the 8V, 12V and 16V engines is listed in Table 1. Example of a Series 4000 engine model number is T1237K16, for the DDC model numbering format:

Series	Cylinders	Application	Rotation and Type	Design Variation	Specific Model Number
Position 1	Position 2, 3	Position 4	Position 5	Position 6	Position 7, 8
T - 4000	08	0 - Incomplete	0 - LH	K - DDEC III, IV	00 - Basic
-	12	2 - Marine	1 - LA	-	-
-	16	3 - Industrial and Genset	2 - LB	-	-
-	-	4 - Power Base	3 - LC	-	-
-	-	5 - Generator	4 - LD	-	-
-	-	-	5 - RA	-	-
-	-	-	6 - RB	-	-
-	-	-	7 - RC	-	-
-	-	-	8 - RF	-	-
-	-	-	9 - RH	-	-

Table 1 DDC Model Numbering Format

Engine Side and Cylinder Designations

Engine sides are always designated as viewed from the driving end.

The left bank of cylinders is marked "A" and the right bank "B" (as per DIN ISO 1204).

Each cylinder bank is numbered consecutively from No. 1, starting at the driving end of the engine.

Other components and assemblies are also numbered consecutively starting with No. 1 at the driving end. See Figure 3.

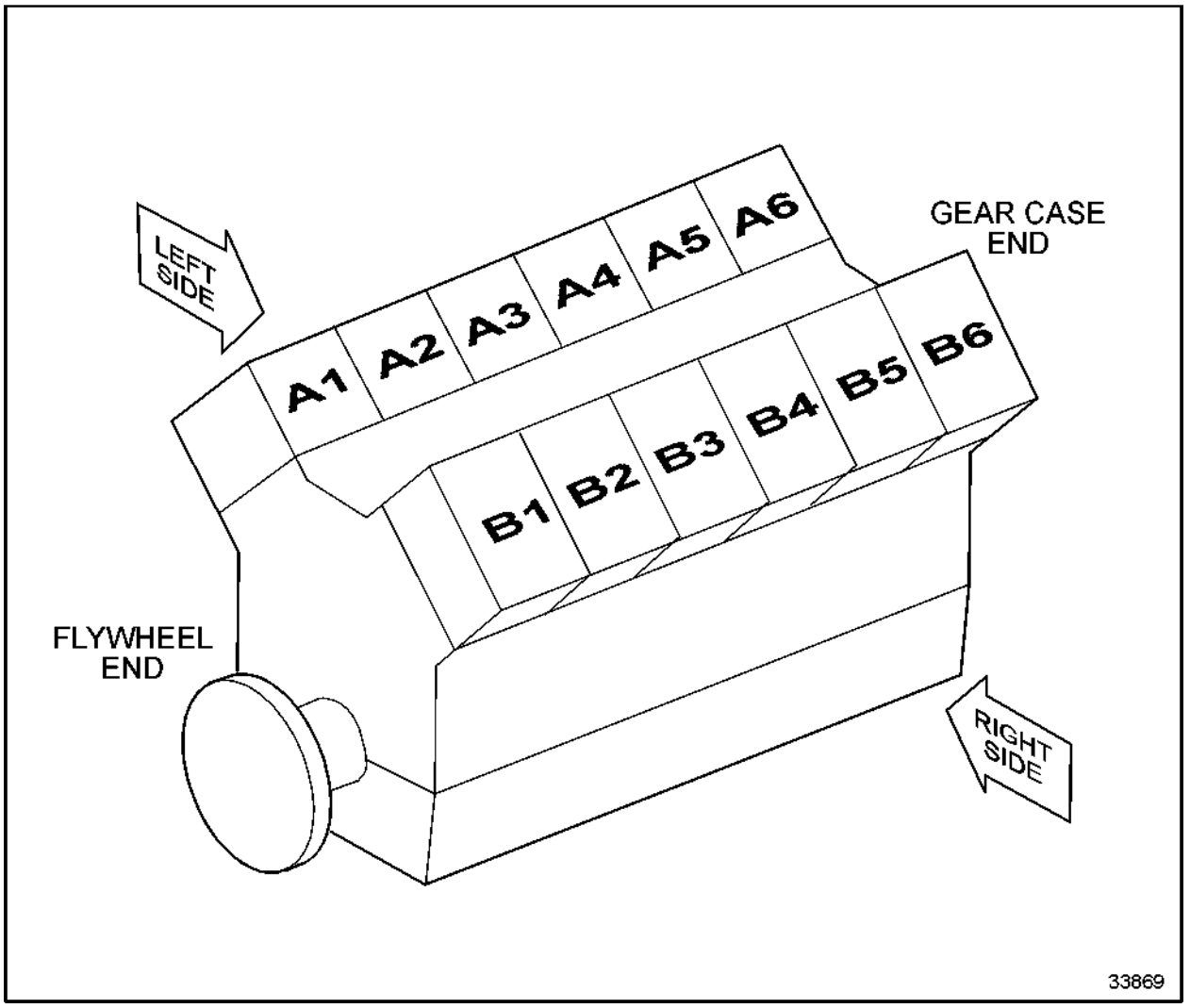


Figure 3 Cylinder Designations, 12V Engine

Option Label

A laminated paper engine option label is currently used to carry the engine serial number and model number, and list any optional equipment used on the engine. See Figure 4. This label is attached to the charge air cooler housing along with a disclaimer label and a bar code label that contains the engine serial number and customer specification number.

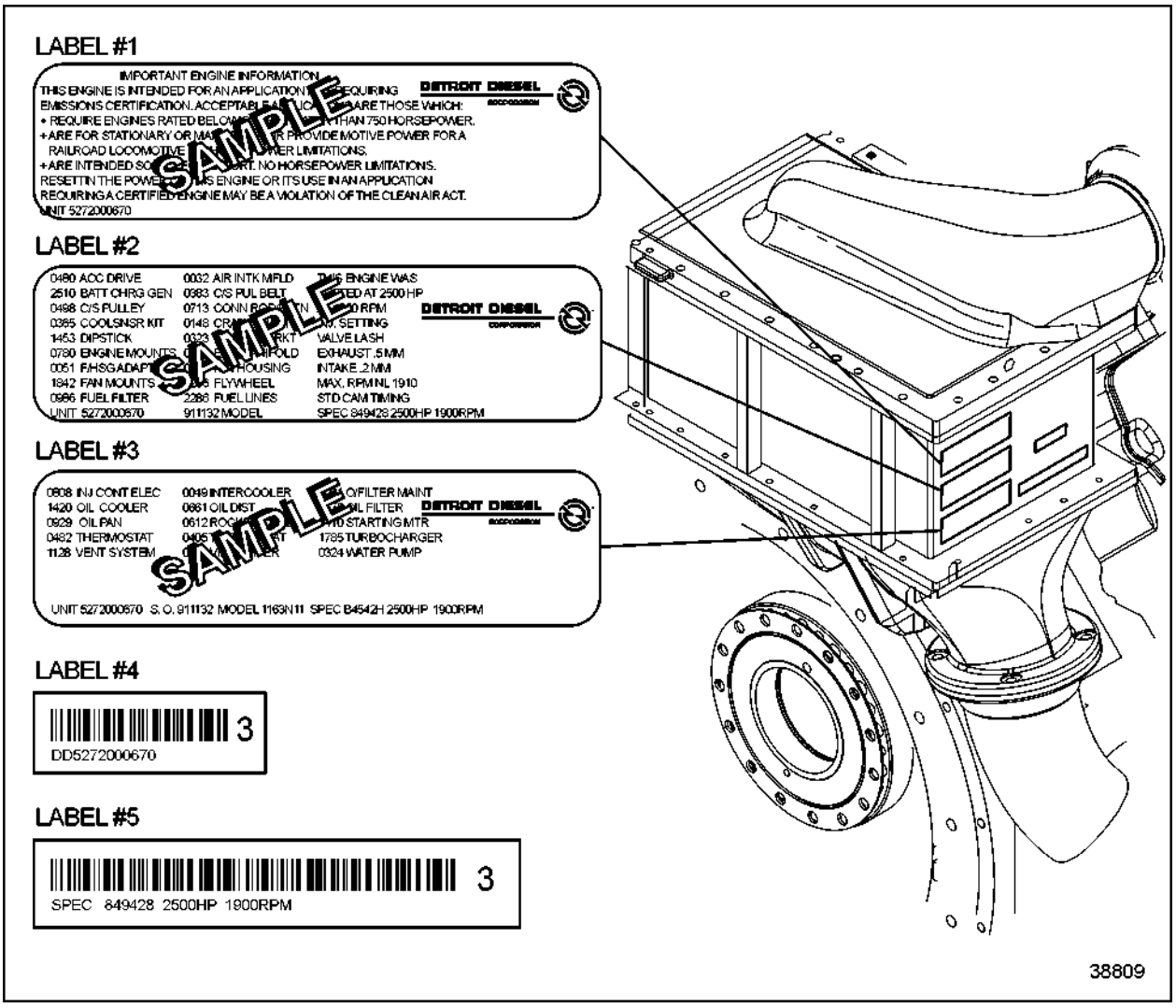


Figure 4 Option Label

Distributors will provide their own label(s) to notify the customer of any distributor-made changes to Detroit Diesel manufactured engines. Distributor-typed label(s) will indicate the distributor name, address, and the group and type revisions that reflect their changes as originally manufactured by Detroit Diesel.

NOTICE:
Extreme heat from components, such as turbocharger exhaust piping, can cause the labels to darken, discolor or deteriorate over a period of time.

Labels must be placed on the charge air cooler housing. Replacement option labels can be placed directly over existing option labels. Ensure the labels are applied to clean, dry, oil-free surfaces to ensure adhesion and retention. Laminate should completely cover the label to provide a good seal.

With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option label covering the equipment required, this number should be included on the parts order.

All groups of parts used on a unit are standard for the model, unless otherwise listed on the option label.

Power take-off assemblies, torque converters, marine gears, etc., may also carry nameplates. The information on these nameplates is also useful when ordering replacement parts for these assemblies.

Certain component parts used on a given model or in a particular engine type may be superseded or replaced at the discretion of Detroit Diesel. In most cases when this occurs, only the newer part is available for service. Parts catalogs and microfiche are revised periodically to reflect any changes.

Engine Serial Number Location

See Figure 5 for engine serial number location.

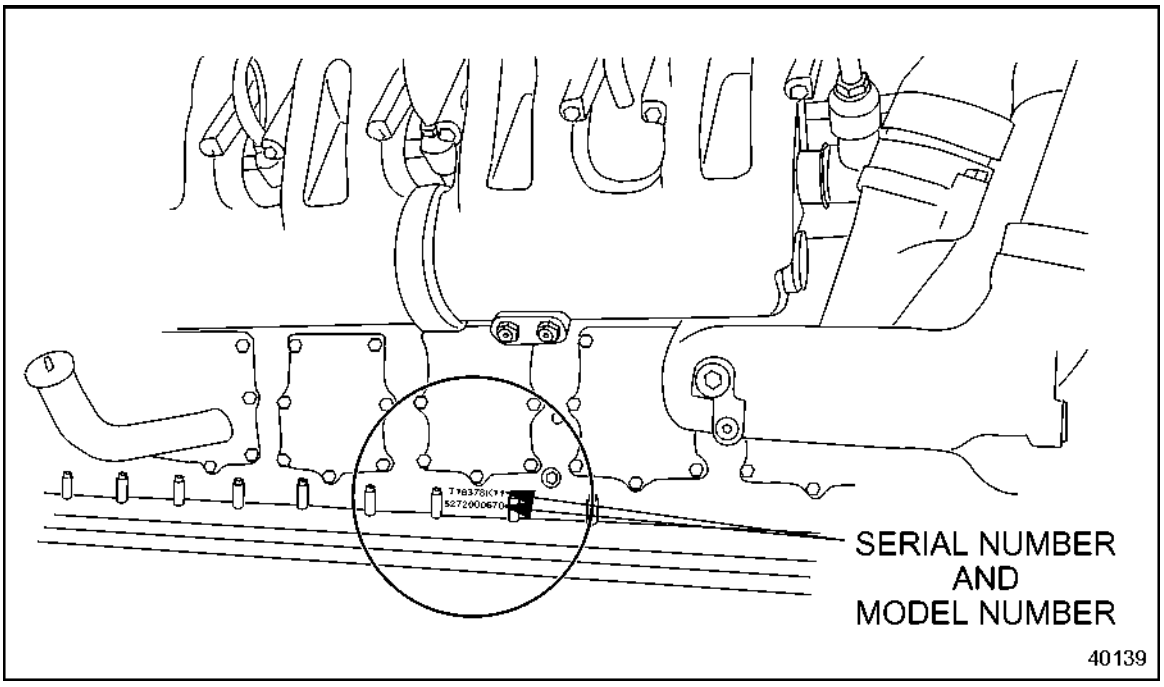


Figure 5 Engine Serial Number Location, B Bank Side, Below Side Cover and Above Oil Pan Bolt Rail

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

Direction of Rotation

Listed in Table 2 are the directions of rotation when viewed from the flywheel end.

Component Description	Direction
Crankshaft	Counterclockwise
Camshaft	Clockwise
High-Pressure Fuel Pump	Counterclockwise
Oil Pump	Counterclockwise
Engine Coolant Pump	Counterclockwise
Charge Air Coolant Pump	Counterclockwise
Air Conditioner Compressor	Counterclockwise

Table 2 Direction of Rotation

Valve Clearance with Engine Cold

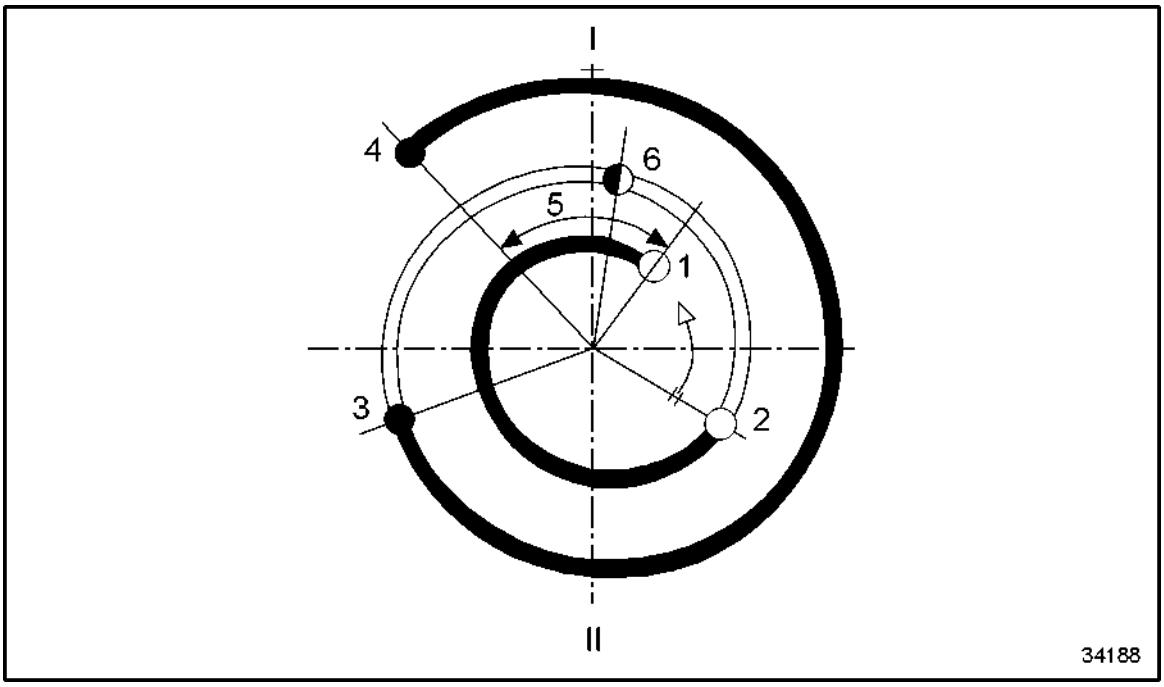
Listed in Table 3 are the valve clearances with engine cold, 20°C (68°F).

Component Description	Dimension
Inlet	0.20 mm (0.008 in.)
Exhaust	0.50 mm (0.02 in.)

Table 3 Valve Clearance

Valve Timing

See Figure 6 for valve timing with valve clearance adjusted.



1 — Inlet valve opens; crank angle 42.6 degrees before TDC

2 — Inlet valve closes; crank angle 66.6 degrees after BDC

3 — Exhaust valve opens; crank angle 57.6 degrees before BDC

4 — Exhaust valve closes; crank angle 30.4 degrees after TDC

5 — Overlap; crank angle 73 degrees

6 — Start of delivery; map based

I — TDC (top dead center)

II — BDC (bottom dead center)

Figure 6 Valve Timing Diagram

Camshaft and Valve Lift

Listed in Table 4 are the camshaft and valve lifts for camshaft adjustment.

Operation	Inlet	Exhaust
Camshaft lift at TDC	1.43 mm (0.056 in.)	1.43 mm (0.056 in.)
Valve lift at TDC (zero valve clearance)	2.00 mm (0.07874 in.)	2.00 mm (0.07874 in.)

Table 4 Camshaft and Valve Lift

A 003 – TORQUE SPECIFICATIONS

Section **Page**

Torque Specifications

Listed in Table 5 are the torque specifications.

Description	Size	Category	Usage Description	Torque (N·m)
Bolt	—	A	ECM Strain Relief Comb	0.8-1.5
Bolt	M3	A	Injector Terminal	1.4-2.0
Bolt, Class 8.8	M6	A	Standard	9-10
Bolt, Class 8.8	M8	A	Standard	21-24
Bolt, Class 8.8	M10	A	Standard	42-47
Bolt, Class 8.8	M12	A	Standard	74-82
Bolt, Class 8.8	M14	A	Standard	115-127
Bolt, Class 8.8	M16	A	Standard	180-198
Bolt, Class 8.8	M18	A	Standard	250-275
Bolt, Class 8.8	M20	A	Standard	350-385
Bolt, Class 8.8	M22	A	Standard	480-528
Bolt, Class 9.8	M8	A	Standard	31-35
Bolt, Class 9.8	M10	A	Exhaust Outlet Mounting	42-47
Bolt, Class 10.9	M6	A	Standard	12-14
Bolt, Class 10.9	M8	A	Standard	31-35
Bolt, Class 10.9	M8	A	Top cover of CAC	21-24
Bolt, Class 10.9	M10	A	Standard	60-66
Bolt, Class 10.9	M10	A	Oil Pan/Block, Front 4 Bolts (Reference Category F)	60-66*
Bolt, Class 10.9	M10	A	Oil Pan/Block (Reference Category F)	30-33*
Bolt, Class 10.9	M12	A	Standard	100-110
Bolt, Class 10.9	M12	A	Oil Pan to Gear Case (Reference Category F)	65-75*
Bolt, Class 10.9	M14	A	Standard	160-176
Bolt, Class 10.9	M16	A	Standard	250-275
Bolt, Class 10.9	M16	H	Flywheel/Flex Plate (Reference F and H)*	130 60 Degrees
Bolt, Class 10.9	M18	A	Standard	350-385

Description	Size	Category	Usage Description	Torque (N·m)
Bolt, Class 10.9	M18	A	Main Bearing Stabilizer (Reference Category F)*	80* 280*
Bolt, Class 10.9	M20	A	Standard / Damper	500-550
Bolt, Class 10.9	M20 X 1.5	H	Rod Joint (Reference Category F and H)*	240* 90 Degrees
Bolt, Class 10.9	M22	A	Standard	680-748
Bolt, Class 10.9	M22	H	Head Joint Reference Category F and H)*	180* 180 Degrees*
Bolt, Class 10.9	M24	A	Standard	850-935
Plug, Copper Washer in Steel/Cast Iron	M10 X 1.0	A	Standard	15-17
Plug, Copper Washer in Steel/Cast Iron	M12 X 1.5	A	Standard	35-39
Plug, Copper Washer in Steel/Cast Iron	M14 X 1.5	A	Standard	35-39
Plug, Copper Washer in Steel/Cast Iron	M16 X 1.5	A	Standard	40-44
Plug, Copper Washer in Steel/Cast Iron	M18 X 1.5	A	Standard	50-55
Plug, Copper Washer in Steel/Cast Iron	M20 X 1.5	A	Standard	55-61
Plug, Copper Washer in Steel/Cast Iron	M22 X 1.5	A	Standard	60-66
Plug, Copper Washer in Steel/Cast Iron	M24 X 1.5	A	Standard	70-77
Plug, Copper Washer in Steel/Cast Iron	M26 X 1.5	A	Standard	80-88
Plug, Copper Washer in Steel/Cast Iron	M27 X 2.0	A	Standard	80-88
Plug, Copper Washer in Steel/Cast Iron	M30 X 1.5	A	Standard	100-110
Plug, Copper Washer in Steel/Cast Iron	M30 X 2.0	A	Standard	95-105
Plug, Copper Washer in Steel/Cast Iron	M33 X 2.0	A	Standard	120-132
Plug, Copper Washer in Steel/Cast Iron	M36 X 1.5	A	Standard	130-143

Description	Size	Category	Usage Description	Torque (N·m)
Plug, Copper Washer in Steel/Cast Iron	M38 X 1.5	A	Standard	140-154
Plug, Copper Washer in Steel/Cast Iron	M42 X 1.5	A	Standard	150-165
Plug, Copper Washer in Steel/Cast Iron	M45 X 1.5	A	Standard	160-176
Plug, Copper Washer in Steel/Cast Iron	M48 X 1.5	A	Standard	170-187
Plug, Copper Washer in Steel/Cast Iron	M52 X 1.5	A	Standard	180-198
Plug, Copper Washer in Steel/Cast Iron	M56 X 1.5	A	Standard	190-209
Plug, Copper Washer in Steel/Cast Iron	M64 X 1.5	A	Standard	205-226
Plug, Copper Washer in Aluminum	M10 X 1.0	A	Standard	15-17
Plug, Copper Washer in Aluminum	M12 X 1.5	A	Standard	25-28
Plug, Copper Washer in Aluminum	M14 X 1.5	A	Standard	25-28
Plug, Copper Washer in Aluminum	M16 X 1.5	A	Standard	30-33
Plug, Copper Washer in Aluminum	M18 X 1.5	A	Standard	35-39
Plug, Copper Washer in Aluminum	M20 X 1.5	A	Standard	45-50
Plug, Copper Washer in Aluminum	M22 X 1.5	A	Standard	50-55
Plug, Copper Washer in Aluminum	M24 X 1.5	A	Standard	60-66
Plug, Copper Washer in Aluminum	M26 X 1.5	A	Standard	70-77
Plug, Copper Washer in Aluminum	M27 X 2.0	A	Standard	70-77
Plug, Copper Washer in Aluminum	M30 X 1.5	A	Standard	90-99
Plug, Copper Washer in Aluminum	M30 X 2.0	A	Standard	85-94
Plug, Copper Washer in Aluminum	M33 x 2.0	A	Standard	110-121

Description	Size	Category	Usage Description	Torque (N·m)
Plug, Copper Washer in Aluminum	M36 X 1.5	A	Standard	115-127
Plug, Copper Washer in Aluminum	M38 X 1.5	A	Standard	120-132
Plug, Copper Washer in Aluminum	M42 X 1.5	A	Standard	130-143
Plug, Copper Washer in Aluminum	M45 X 1.5	A	Standard	140-154
Plug, Copper Washer in Aluminum	M48 X 1.5	A	Standard	145-160
Plug, Copper Washer in Aluminum	M52 X 1.5	A	Standard	150-165
Plug, Fitting, Sensor - ISO 6149	M10 X 1.0	A	Standard	10-12
Plug, Fitting, Sensor - ISO 6149	M12 X 1.5	A	Standard	14-16
Plug, Fitting, Sensor - ISO 6149	M14 X 1.5	A	Standard	15-18
Plug, Fitting, Sensor - ISO 6149	M16 X 1.5	A	Standard	18-21
Plug, Fitting, Sensor - ISO 6149	M18 X 1.5	A	Standard	23-26
Plug, Fitting, Sensor - ISO 6149	M22 X 1.5	A	Standard	33-37
Plug, Fitting, Sensor - ISO 6149	M27 X 2.0	A	Standard	57-62
Plug, Fitting, Sensor - ISO 6149	M33 X 2.0	A	Standard	103-113
Fitting, O-ring Face Seal (ORFS)	9/16-18 (-4 Hose)	A	Standard	14-16
Fitting, O-ring Face Seal (ORFS)	11/16-16 (-6 Hose)	A	Standard	24-27
Fitting, O-ring Face Seal (ORFS)	13/16-16 (-8 Hose)	A	Standard	43-48
Fitting, O-ring Face Seal (ORFS)	1 3/16-12 (-12 Hose)	A	Standard	90-99
Fitting, Steel 37 Degree, Flared	9/16 - 18 (-6 Hose)	A	Standard	24-28
Fitting, Steel 37 Degree, Flared	3/4 - 16 (-8 Hose)	A	Standard	52-58

Description	Size	Category	Usage Description	Torque (N·m)
Fitting, Steel 37 Degree, Flared	1 5/16 - 12 (-16 Hose)	A	Standard	148-154
Fitting, Steel 37 Degree, Flared	1 7/8 - 12 (-24 Hose)	A	Standard	216-227
Fitting, Steel 37 Degree, Flared	2 1/2 - 12 (-32 Hose)	A	Standard	334-352
Fitting, Straight Metric O-ring	M14 X 1.5	A	Standard	25-28
Fitting, Straight Metric O-ring	M18 X 1.5	A	Standard	35-39
Fitting, Straight Metric O-ring	M22 X 1.5	A	Standard	50-55
Fitting, Straight Metric O-ring	M30 X 1.5	A	Standard	90-99
Plug, Fitting - NPTF	1/4-18 (3/4 Taper)	A	Standard	19-22
Plug, Fitting - NPTF	1/2 -14 (3/4 Taper)	A	Standard	31-37
Plug, Fitting - NPTF	3/4 -14 (7/8 Taper)	A	Standard	45-56
Plug, Fitting - NPTF	3/4 -14 (3/4 Taper)	A	Standard	45-56
Plug, Fitting - NPTF	1-11 X 1/2 (3/4 Taper)	A	Standard	102-107
Plug	G 1/4	A	Plug, Hydraulic Expansion Port	25-35
Plug - Special	M26 X 1.5	A	Oil Filter Drain Plug	80-88
Plug - Special	M42 X 2.0	A	Oil Filter Bypass Plug	130-140
Banjo Bolt	M12 X 1.5	A	Standard	20-22
Banjo Bolt	M14 X 1.5	A	Standard	25-28
Metal to Metal Cone Seal	M12 X 1.5	A	Low Pressure Jumper Lines (N 15001)	30-33
Metal to Metal Cone Seal	M14 X 1.5	A	High-Pressure Fuel Sensor	30-40
Metal to Metal Cone Seal	M14 X 1.5	A	Coolant Vent System (06K03)	30-33
Metal to Metal Cone Seal	M16 X 1.5	A	Low Pressure Fuel Rail End Cap	30-33
Metal to Metal Cone Seal	M18 X 1.5	A	Sequential Controls (06M03A / 06N06)	30-33
Clamp	—	C	Turbo Compressor Vee-Band Clamp* (F)	12.4-14.7
Clamp	—	C	Turbo Turbine Vee-Band Clamp* (F)	17-19
Nut - Hex Jam	1 - 14	A	Nut to Isolator Washer	603 - 617

Description	Size	Category	Usage Description	Torque (N·m)
Nut	M10	A	Turbo Mounting (Dry Exhaust)	60 - 66
Nut	M12	B	Nut, Gear Case to Block Joint	110-120*
Nut	M16 X 1.5	A	Valve Bridge and Rocker Arm Nut*	90-100
Nut	M24 X 2.0	E	Main Bearing Cap (Reference Category F and H)*	**
Stud	M10	A	Stud Installation, Turbo Oil Drain Flange	10-15
Stud	M12	A	Stud Installation, Gear Case/Block Joint	10-15
Stud	M24 X 2.0	A	Main Bearing Cap Stud	80-90
Fuel Line	M24 X 1.5	C	Nut, High-Pressure Fuel Lines (Reference Category F)*	100-110*
Fuel Line	M40 X 1.5	C	Nut, High-Pressure Fuel Lines (Reference Category F)*	100-110*
Fuel Line	M42 X 1.5	A	Fuel Rail Nut	550-605
Sensor	M18 X 1.5	A	Fuel Monitor - Marine	25-28
Sensor	1/4 - 18 NPTF	A	Coolant Temperature - Marine	10.8-16.3
Sensor	1/4 - 18 NPTF	A	Pressure Transducer - Marine	20-45
Sensor	1/4 - 18 PTF-SAE	A	Coolant Level Indicator - Marine	2.7-4.1
Sensor	1/4 - PTF-SAE	A	Coolant Level - Industrial	42-45
Sensor	3/8 - PTF-SAE	A	Coolant Level - Industrial	42-45
Regulator	M45 X 1.5	A	Oil Pressure Regulator	60-70

* Additional information in assembly drawing referenced in the respective UPC group.

** Main bearing cap stud stretching detailed in assembly referenced in 6A1 Group.

Category A — Load within design capability. Process verification controlled by correct tooling. Verification — to minimum torque value.

Category B — Load required at or near yield. Process controlled by special torque equipment or process. Verification — to minimum torque value.

Category C — Load required sensitive to both low and high values. Process controlled by special torque equipment or process. Verification — to given range of torque values.

Category D — Load at yield. Process controlled by special torque equipment or process. Fasteners require lubricant 7Y2 or equivalent. Verification — to minimum torque value.

Category E — Load, both high and low critical. Process controlled by special torque equipment. Verification — to equipment capability.

Category F — Joint sensitive to torque sequence. See engine build instructions.

Category G — Gasket eliminator used as a sealant. Joint sensitive to bolt removal.

Category H — Critical joint. Torque plus angle required.

Table 5 Fastener Torque Specifications

NOTE:
Torque specification does not apply to hot engines. Re-check of torque at room temperature to be not less than 90 percent of minimum assembly values.

A 004 – SAFETY PRECAUTIONS

Section **Page**

Safety Precautions

The following safety precautions must be observed when working on a Detroit Diesel engine:

CAUTION:

The exhaust products of an internal combustion engine are toxic. They may cause injury or death if inhaled. All engine installations, especially those within enclosed spaces, should be equipped with an exhaust discharge pipe so that exhaust gases are delivered into the outside air. An enclosed space must be adequately vented. Some means of providing fresh air into an enclosed space must be ensured.

Stands

Stands must be used in conjunction with hydraulic jacks or hoists. **Do not** rely on a jack or hoist alone. When lifting an engine, ensure the lifting device is securely fastened. Also ensure that the weight of the load being lifted does not exceed the lifting capacity of the device.

Glasses

Wear appropriate safety glasses. Safety glasses are especially important when tools, such as hammers, chisels, pullers, and punches, are used.

Welding

Wear welding goggles and gloves when welding or using an acetylene torch. Ensure that a metal shield separates the acetylene and oxygen tanks. These must be securely chained to a cart.

CAUTION:

To avoid injury when arc welding, gas welding or cutting, wear required safety equipment such as arc welder's face plate or gas welder's goggles, plus welding gloves and protective apron, long sleeve shirt, head protection, and safety shoes. Always perform welding or cutting operations in a well-ventilated area. The gas in oxygen/acetylene cylinders used in gas welding and cutting is under high pressure. If a cylinder should fall due to careless handling, the gage end could strike an obstruction and fracture, resulting in a gas leak which could lead to fire or an explosion, both of which could cause personal injury or property damage or both. If a fall should result in the gage end breaking off, the sudden release of high pressure gas could turn the cylinder into a dangerous projectile, which could cause severe personal injury or property damage or both. Observe the following precautions when using oxygen/acetylene gas cylinders:

1. To avoid possible foot injury, always wear required safety toed shoes.

2. Do not handle tanks in a careless manner or with greasy gloves or slippery hands.

3. Use a chain, bracket, or other restraining device at all times to prevent gas cylinders from falling.

4. Do not place gas cylinders on their sides, but stand them right side up when in use.

5. Do not drop, drag, roll, or strike a cylinder forcefully.

6. Always close valves completely when finished welding or cutting.

Work Place

Organize your work area and keep it clean. Eliminate the possibility of a fall by:

- ☐ Wiping up oil spills
- ☐ Keeping tools and parts off the floor

After servicing or adjusting the engine:

- ☐ Reinstall all safety devices, guards, or shields
- ☐ Ensure all tools and service equipment are removed from the engine

Clothing

Work clothing should fit well and be in good repair. Work shoes should be sturdy and rough-soled. Bare feet, sandals, or sneakers are **not** acceptable footwear when adjusting or servicing an engine.

CAUTION:

To avoid injury when working near the engine, do not wear jewelry or loose fitting clothing. Any of these items could catch on moving parts and cause serious injury. Safety glasses and hearing protection must be worn.

Power Tools

NEVER use defective portable power tools.

CAUTION:

To avoid injury, do not use defective portable power tools. Check for frayed cords prior to use. Ensure all electric tools are grounded. Using defective electrical equipment can cause severe injury. Improper use of electrical equipment can result in electrical shock, fire, or explosion under certain conditions which may cause severe injury.

Air

Recommendations regarding the use of compressed air are indicated throughout the manual.

CAUTION:

To avoid injury do not exceed air pressure recommendations. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury. Use only approved air blow guns that do not exceed 276 kPa (40 lb/in.^{2}). Be sure to wear safety glasses or goggles. Use proper shielding to protect everyone in the work area.

CAUTION:

To avoid injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

Transport

- ☐ Lift the engine only with the lifting eyes provided.
- ☐ Use only the transport and lifting equipment approved by Detroit Diesel Technical Service.
- ☐ The engine must be transported only in an installation position.

Fuel Lines

Remove fuel lines as an assembly. Do not remove fuel lines individually. Avoid mixing fuel injection lines. Do not attempt repairs of high-pressure lines while engine is running.

Fluids and Pressure

The following cautions should be followed when using fluids under pressure:

CAUTION:

To avoid injury, use care when dealing with fluids under pressure. Fluids under pressure have enough force to penetrate the skin. These fluids can cause a minor cut or opening in the skin. If injured by escaping fluid, see a doctor immediately. Serious infection or adverse reaction to the fluid can result if not treated immediately.

CAUTION:

To avoid injury, do not put your hands in front of fluid under pressure. Fluids under pressure can penetrate skin and clothing and cause injury.

Fuel

The following cautions should be followed when filling or refueling a fuel tank:

CAUTION:

To avoid injury or equipment damage when refueling, keep the hose, nozzle, funnel, or container in contact with the metal of the fuel tank. This will reduce the likelihood of a dangerous spark.

CAUTION:

To avoid injury, do not overfill the fuel tank. Overfilling will release flammable liquid and create a fire hazard.

CAUTION:

To avoid injury do not smoke when refueling. Do not refuel when the engine is hot or running. Failure to follow this caution may result in a fire or explosion caused by fuel ignition.

Batteries

The following cautions should be followed when charging a battery:

CAUTION:

Electrical storage batteries emit highly flammable hydrogen gas when charging. They continue to do so for some time after receiving a steady charge. To avoid injury, do not under any circumstances allow an electric spark or open flame near the battery. An explosion may occur.

Always disconnect the battery cable before working on the electrical system.

CAUTION:

To prevent accidental starting which could result in personal injury, disconnect the batteries or disable the air starter (if so equipped).

Fire

Keep a charged fire extinguisher within reach. Ensure the proper type of extinguisher is on hand.

Cleaning Agent

The following cautions should be followed when using cleaning agents:

CAUTION:

To avoid injury, avoid the use of carbon tetrachloride as a cleaning agent. It releases harmful vapors. Ensure the work area is adequately ventilated. Use protective gloves, goggles or face shield, and apron whenever using caustic chemicals.

Exercise care when using oxalic acid to clean engine cooling passages.

Working on a Running Engine

The following cautions should be followed when working on an engine that is running:

CAUTION:

Avoid personal contact with the engine and associated components when working on a running engine. Accidental contact with the exhaust manifold can cause severe burns. To avoid injury, remain alert to the location of the fan, pulleys, and belts. Avoid making contact across the two terminals of a battery. This can cause arcing or battery explosion.

Start Attempts

Observe the following notice during start attempts:

NOTICE:

Avoid excessive injection of ether into the engine during start attempts. Injection of excessive ether may result in an uncontrolled internal engine explosion that could cause engine damage. Follow the manufacturer's instructions on proper product use.

Turbocharger Compressor Inlet Shield

The following cautions should be followed when the engine is operated with the air inlet piping removed:

CAUTION:

To avoid injury or engine damage if the engine is operated with the air inlet piping removed, turbocharger compressor inlet screen must be installed over the turbocharger air intake. The shield prevents the service technician from accidentally touching the turbocharger impeller. It also helps prevent foreign objects from entering and damaging the turbocharger. Use of this shield does not preclude other safety practices contained in this manual.

Fluoroelastomer (Viton)

Under normal design conditions, fluoroelastomer (*VITON*) parts, such as O-rings and seals, are perfectly safe to handle.

CAUTION:

To avoid injury, wear goggles or a faceplate and neoprene or PVC gloves when handling fluoroelastomer O-rings or seals that have been degraded by excess heat. Make sure engine parts have cooled before handling them. If hydrogen fluoride condensate is suspected, wash equipment and parts well with lime water (calcium hydroxide solution) before reusing. Discard gloves after handling degraded fluoroelastomer.

However, a potential hazard may occur if these components are raised to a temperature above 316°C (600°F), such as during a cylinder failure or engine fire. At temperatures above 316°C (600°F) fluoroelastomer will decompose (indicated by charring or the appearance of a black, sticky mass) and produce hydrofluoric acid. This is extremely corrosive and, if touched by bare skin, may cause severe burns, sometimes with symptoms delayed for several hours.

Cleaning

Use only fluids and lubricants that have been tested and approved by Detroit Diesel Technical Service.

Before removing any engine subassemblies (but after removing electrical equipment), thoroughly clean the engine exterior.

NOTICE:
Engine sensors, and other electronic components, may be damaged if subjected to the high temperatures of a solvent tank. Therefore, ensure that all electronic components are removed from engine assemblies before subassemblies are submerged in a solvent tank.

After each subassembly is removed and disassembled, individual parts should be cleaned. Only clean parts can be satisfactorily inspected.

The same basic procedure is used to clean all ordinary cast iron parts, including the cylinder block.

Steam Cleaning

A steam cleaner is indispensable for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

Solvent cleaning requires a tank large enough to accommodate the largest part to be cleaned (usually the cylinder block).

 CAUTION:
To avoid injury (burning), wear adequate protective clothing (eye protection, rubber apron, rubber boots, rubber gloves). To prevent splashing, carefully lower the block into the phosphoric acid solution.

Fill the tank with a commercial heavy-duty solvent. Heat the cleaning solution to 82-93°C (180-200°F). Using a hoist, lower large parts directly into the tank. Use a wire mesh basket for smaller parts. Immerse parts until grease and dirt are loosened.

NOTE:
Aluminum parts, such as flywheel housing, pistons, air intake manifold, oil filter adaptor and the camshaft gear access cover should NOT be cleaned in this manner. Mention will be made of special procedures when necessary.

Rinsing Bath

Provide a tank of similar size, filled with hot water, to rinse parts.

Liquid Nitrogen

CAUTION:

To avoid injury (freezing of body parts & suffocation), when using liquid nitrogen, wear eye protection and protective clothing, gloves and closed shoes.

- ☐ Store liquid nitrogen only in small quantities and always in regulation containers (without fixed seal).
- ☐ Do not allow liquid nitrogen to come into contact with parts of body (eyes, hands). Liquid nitrogen causes cold burns and severe frostbite.
- ☐ Wear protective clothing (including gloves and closed shoes) and protective goggles.
- ☐ Ensure good ventilation (suffocation if nitrogen enrichment in inhaled air reaches 88%).
- ☐ Do not subject containers, fittings and tools to impact or shock.

Drying

CAUTION:

To avoid injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

Parts may be dried with compressed air. Heat from the hot tanks will frequently dry the parts, making blow drying unnecessary.

Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. Remove the rust preventive coating before installing the parts.

Service Parts Availability

Service parts are available throughout the world. A complete list of distributors and dealers is provided in the **Detroit Diesel Corporation Worldwide Distributor/Dealer Directory**, 6SE280. This publication is available from all authorized Detroit Diesel distributors. When parts are ordered, the distributor or dealer must be provided with the engine identification and model number. The engine serial number and model number are stamped on the right side of the cylinder block (as viewed from the flywheel end), above the pan rail.

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

A 005 – GENERAL DESCRIPTION OF SERIES 4000 OPERATION

Section **Page**

General Description of Series 4000 Operation

The Series 4000 Diesel Engine is a four stroke, direct injected engine. The engine is available in 8V, 12V, or 16V configurations, ranging from 850 to 2700 hp (634–2013 kW). The Series 4000 is the result of a strategic partnership between MTU Motoren-und Turbinen-Union (MTU) and Detroit Diesel Corporation (DDC) to design, produce and distribute an engine for applications requiring 850–2700 hp (634–2013 kW).

Vital features of the Series 4000 include:

- ☐ Electronic engine control through the Detroit Diesel Electronic Control (DDEC®) IV System
- ☐ A common rail fuel injection system
- ☐ A single casting cylinder block
- ☐ Individual cylinder liners
- ☐ Individual cylinder heads

The *Series 4000 Application and Installation* manual, is a compilation of the installation drawings, component sketches and technical information required for proper application and installation of the engine.

General Specifications

Listed in Table 6 are the general specifications for the Series 4000 engine.

Description	8V	12V	16V
Type	4 Cycle	4 Cycle	4 Cycle
Number of Cylinders	8	12	16
Bore (mm)	6.5	6.5	6.5
Stroke (mm)	7.48	7.48	7.48
Total Displacement - (cubic inches)	1984	2975	3967
Total Displacement - (liters)	32L	48L	65L
Compression Ratio	14:1	14:1	14:1

Table 6 General Specifications for the Series 4000 Engine

Publication Summary

Listed in Table 7 are the applicable customer service documents:

Publications	Publication Number
MTU/DDC Series 4000 Service Manual (12 and 16V)	6SE4011
MTU/DDC Series 4000 Operator's Guide, C & I (8, 12 and 16V)	6SE4009
MTU/DDC Series 4000 Operator's Guide, Marine (8, 12 and 16V)	6SE4008
Engine Service Fluid and Filter Requirements	7SE273
Coolant Selections	7SE298
Series 4000 Parts Catalog	6SP4011
Series 4000 Generator Set, Application and Installation	7SA810
Series 4000 C & I, Application and Installation	7SA4000
Labor Time Manual	12SE4000
DDEC Multi-ECM Troubleshooting Guide	6SE496
Product Support Plan - C & I	7SE4006

Table 7 Publications

A 006 – DATA SHEETS

Section **Page**

Data Sheets

To ensure that unusable components are not installed or components that can still be used are not discarded, all inspection work should be carried out only by qualified personnel using the necessary measuring instruments.

All measuring and testing equipment is naturally subjected to wear.

To determine resulting tolerance deviations in good time, the measuring and test equipment must be inspected annually at a location equipped with appropriate technical facilities.

Alternatively, an inspection can also be carried out by our product support service and DDC, or by an external product support service.

Measurements cannot be below or above the limit values as specified in the Tolerances and Wear Limits List.

Test data sheets are to be used during engine run-in and are as follows: see Figure 7 for cylinder block bores. See Figure 8 for cylinder block bores. See Figure 9 for crankshaft bearing. See Figure 10 for cylinder liner (installed). See Figure 11 for crankshaft main bearing. See Figure 12 for connecting rod bearing (shells installed). See Figure 13 for control times and injection timing. See Figure 14 for crankshaft data sheet. See Figure 15 and see Figure 16 for the W6 component list and dyno test data.

DDC	Test sheet for crankcase	for sheet No. 1 appendix A Housing No. _____ Casting date: _____
Material:	___ V _____ Part No. _____	Order

Cylinder No. A (L) - Side		1	2	3	4	5
Fit diameter	A					
Top	B					
Fit diameter	A					
Bottom	B					
Recess depth						
Balcony						

Cylinder No. A (L) - Side		6	7	8	9	10
Fit diameter	A					
Top	B					
Fit diameter	A					
Bottom	B					
Recess depth						
Balcony						

Cylinder No. A (L) - Side		1	2	3	4	5
Fit diameter	A					
Top	B					
Fit diameter	A					
Bottom	B					
Recess depth						
Balcony						

Cylinder No. A (R) - Side		6	7	8	9	10
Fit diameter	A					
Top	B					
Fit diameter	A					
Bottom	B					
Recess depth						
Balcony						

Remarks:

32365

Figure 7 Test Sheet for Cylinder Block Bores

DDC	Test sheet for crankcase	for sheet No. 1 appendix B Housing No. _____ Casting date: _____
Material:	____ V _____ Part No. _____	Order

Main bearing bore diameter							Camshaft bearing diameter			
Bearing No.	front direction			rear direction			le. side direction		ri. side direction	
	a	c1	c2	a	c1	c2	a	b	a	b
1										
2										
3										
4										
5										
6										
8										
9										
10										
11										
12										

Remarks:

32309

Figure 8 Test Sheet for Cylinder Block Bores

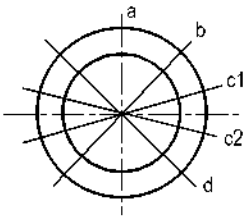
Installation Data Sheet
Single-component crankshaft bearing

DDC

Engine model: .....
Engine No.: .....
Cylinder Block No.: .....
Service hours: .....
Part No.: .....
Specified ∅ .....

Note:

Measuring plane "a" for bearing clearance



Measuring points

Component	Crankshaft bearing	a	b	c1	c2	d	Mean value
	Rear						
	Front						

Remarks:

Specified dimensions in Tolerances and Wear Limits.

Date: **Checked by:**

32305

Figure 9 Test Sheet for Crankshaft Bearing

DDC

Assembly Data Sheet
Cylinder Liners (installed)

Engine Model

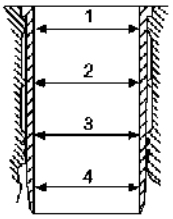
Engine No.

Cylinder Block No.: _____

Cyl. bush part No.: _____

Specified dimension, bore: _____

To measure: In measuring direction a (direction of travel) and b (transverse)
Measuring levels 1 • 2 • 3 • 4



Cylinder No.	Measuring direction	Basic dimension	Actual dimensions Measuring levels 1	2	3	4	Cylinder No.	Measuring direction	Basic dimension	Actual dimensions Measuring levels 1	2	3	4
1A	a						B1	a					
	b							b					
2A	a						B2	a					
	b							b					
3A	a						B3	a					
	b							b					
4A	a						B4	a					
	b							b					
5A	a						B5	a					
	b							b					
6A	a						B6	a					
	b							b					
7A	a						B7	a					
	b							b					
8A	a						B8	a					
	b							b					
9A	a						B9	a					
	b							b					
10A	a						B10	a					
	b							b					

Remarks:
Specified dimensions from Tolerances and Wear Limits List:

Date: **Inspected by:**

32478

Figure 10 Test Sheet for Cylinder Liner Installed

DDC	Assembly Data Sheet Crankshaft Main Bearing	Engine Model Engine No.

Cylinder Block No.: _____

Cylinder Block No.: _____

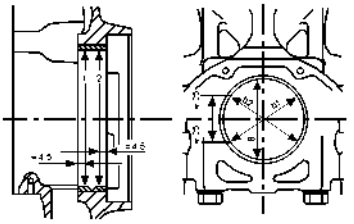
Specified dimensions:

Main bearings dia.: _____

Crankshaft dia.: _____

Radial clearance: _____

Crankshaft axial clearance: _____ Actual dimension: _____



Measuring and entry: Smallest dimension, diameter a, b1 and b2, measuring level 1 and 2
Determining bearing clearance: Smallest dimension a

Bearing No.	Actual dimensions						
	Basic dimension	1	2	3	4	5	6
Bearing dia. b1							
Bearing dia. b2							
Bearing dia. a							
Crankshaft- (actual dimension)							
Bearing clearance, rad.							

Bearing No.	Actual dimensions						
	Basic dimension	7	8	9	10	11	12
Bearing dia. b1							
Bearing dia. b2							
Bearing dia. a							
Crankshaft dia. (actual dimension)							
Bearing clearance, rad.							

Remarks

Specified Dimensions from Tolerances and Wear Limits List

Date: **Inspected by:**

32479

Figure 11 Test Sheet for Crankshaft Main Bearing

DDC

Assembly Data Sheet
Connecting Rod Bearing Spot Check
(Shells Installed)

Engine Model

Engine No.

Cylinder Block No.: _____ Specified dimensions:

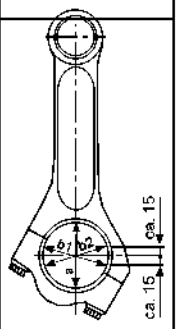
Crankshaft No.: _____ Connecting Rod bearing bore _____

Radial play _____

To measure: Diameter a, b1, b2
For calculating play, smallest dimension a, b1 or b2

Connecting rod A row

Cyl. No.	Rod No.	Actual dimensions: Basic dimension	a dimension	b1 dimension	b2 dimension	Crankshaft	Radial play
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							



Connecting rod B row

Cyl. No.	Rod No.	Actual dimensions: Basic dimension	a dimension	b1 dimension	b2 dimension	Crankshaft	Radial play
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Remarks:

Date: **Inspected by:**

32480

Figure 12 Test Sheet Connecting Rod Bearing (Shells Installed)

DDC

Assembly Data Sheet

Control Times and Injection Timing

Engine Model

Engine No.

1. Control diagram

	Specified	Actual Cylinder No.					
Exhaust valve opens before BDC							
Inlet valve opens before TDC							
Exhaust valve closes after TDC							
Inlet valve closes after BDC							

Settings for control times correspond to "setting diagrams"

2. Cam lift

	Specified	Actual Cylinder No.					
Inlet							
Exhaust							

3. Injection timing

For start of delivery, see engine master card

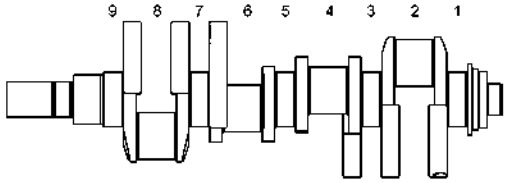
Remarks:

Date: **Inspected by:**

32481

Figure 13 Test Sheet for Control Times and Injection Timing

Figure 14 Crankshaft Data Sheet

DDC	CRANKSHAFT DATA SHEET	Model _____
Item No. _____		Shaft No. _____
Drawing No. _____		Classification _____

Measuring Point	15	14	13	12	1	10	9	8	7	6	5	4	3	2	1
Crankpin Dia. _____															
Main Journal Dia. _____															

Thrust collar _____	Oil ducts thoroughly cleaned and edges smoothed
Conecntricity _____	All fillets and countersinks as per drawing.
Crankpin hardness _____	Roughness height and flatness of counterweight seating surface as per drawing.
Journal hardness _____	Angularity of counterweight securing thread as per drawing.
Crack test _____	Test torque of counterweight bolt as per drawing.

Remarks:

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Checked by: - - - - - - - - - - Approved by: - - - - - - - - - -

S 4000 W6 - Component List

(Blanks must be filled with corresponding engine hours or date installed)

Engine S/N - Engine Hours - Date -

Distributor Name -

Cylinder Block _____

Injectors

B1 _____
B2 _____
B3 _____
B4 _____
B5 _____
B6 _____
B7 _____
B8 _____

Injectors

A1 _____
A2 _____
A3 _____
A4 _____
A5 _____
A6 _____
A7 _____
A8 _____

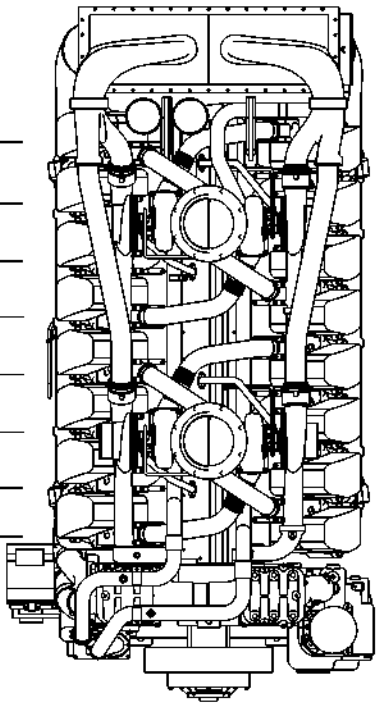
Turbos "B" Rear _____

Turbos "A" Rear _____

"B" Front _____

"A" Front _____

Camshaft _____



Maintenance Alert Kit Installed _____

Replace Bypass Valve & Spring _____

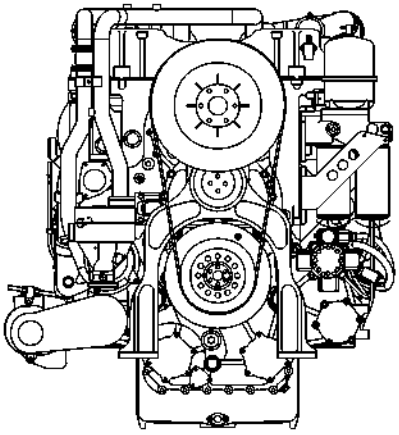
Oil Cooler Cores _____

Thermostats (LTC & HTC) _____

HTC Water Pump _____

LTC Water Pump _____

Vibration Damper & Dust Shields _____



Crankshaft _____

Centrifugal Filter Bushings _____

LP Fuel Pump _____

HP Fuel Pump _____

H.P. Fuel Pump Sensor _____

SRS Wheel Updated _____

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Figure 15 W6 Component List, Sheet 1

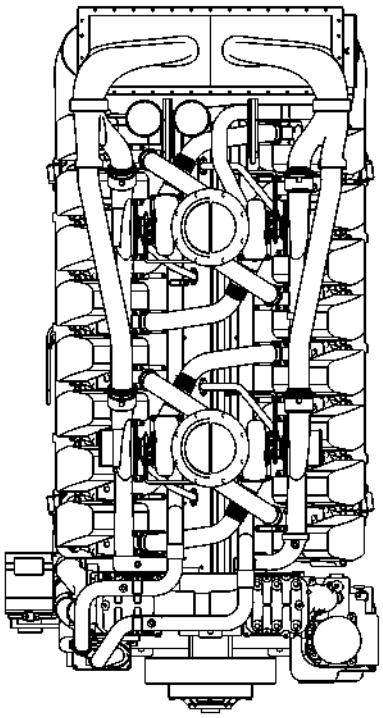
S 4000 W6 - Component List

(Blanks must be filled with corresponding engine hours or date installed)

Engine S/N - Engine Hours - Date -

Distributor Name -

Cylinder Head	Cylinder Kit	Cylinder Head	Cylinder Kit
B1		A1	
B2		A2	
B3		A3	
B4		A4	
B5		A5	
B6		A6	
B7		A7	
B8		A8	



DYNO TEST DATA

HP Rating _____ 6N4 Group _____ Idle RPM _____ Max No-Load RPM _____

(At 100% Engine Load and normal operation temperature)

LP Fuel Pressure _____ HP Fuel Pressure _____ Turbo Boost _____ R1 Turbo Boost _____

Measured HP Output _____ Measured Torque Output _____

Note: Attach a copy of DDR printout.

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Figure 16 W6 Component List and Dyno Test Data, Sheet 2

A 007 – CONVERSION TABLES

Section **Page**

This section includes the English-to-metric conversion table and the decimal-to-metric equivalents.

English-to-metric Conversion

Listed in Table 8 are the English-to-metric conversions.

Multiply Length	**By**	**To get equivalent number of:**
Inch (in.)	25.4	Millimeters (mm)
Foot (ft)	0.3048	Meters (m)
Yard (yd)	0.9144	Meters (m)
Mile (mile)	1.609	Kilometers (km)
Multiply Area	**By**	**To get equivalent number of:**
Inch^2 (in.^{2})	645.2	Millimeters^2 (mm^2)
Inch^2 (in. ^{2})	6.45	Centimeters^2 (cm^2)
Foot^2 (ft^2)	0.0929	Meters^2 (m^2)
Yard^2 (yd^2)	0.8361	Meters^2 (m^2)
Multiply Volume	**By**	**To get equivalent number of:**
Inch^3 (in.^{3})	16387	Millimeters ^{3} (mm ^{3})
Inch^3 (in.^{3})	16.387	Centimeters^3 (cm^3)
Inch^3 (in.^{3})	0.0164	Liters (L)
Quart (qt)	0.9464	Liters (L)
Gallon (gal)	3.785	Liters (L)
Yard^3 (yd^3)	0.7646	Meters^3 (m^3)
Multiply Mass	**By**	**To get equivalent number of:**
Pound (lb)	0.4536	Kilograms (kg)
Ton (ton)	907.18	Kilograms (kg)
Ton (ton)	0.907	Tonne (t)
Multiply Force	**By**	**To get equivalent number of:**
Kilogram (kg)	9.807	Newtons (N)
Ounce (oz)	0.2780	Newtons (N)
Pound (lb)	4.448	Newtons (N)
Multiply Temperature	**By**	**To get equivalent number of:**
Degree Fahrenheit (°F)	(°F-32) ÷ 1.8	Degree Celsius (°C)
Multiply Acceleration	**By**	**To get equivalent number of:**
Foot/second^2 (ft/sec^2)	0.3048	Meter/second^2 (m/s^2)
Inch/second ^{2} (in./sec^2)	0.0254	Meter/second^2 (m/s^2)
Multiply Torque	**By**	**To get equivalent number of:**
Pound-inch (lb·in.)	0.11298	Newton-meters (N·m)

Pound-foot (lb·ft)	1.3558	Newton-meters (N·m)
Multiply Power	**By**	**To get equivalent number of:**
Horsepower (hp)	0.746	Kilowatts (kW)
Multiply Power	**By**	**To get equivalent number of:**
Inches of water (in. H_2O)	0.2491	Kilopascals (kPa)
Pounds/square in. ($lb/in.^2$)	6.895	Kilopascals (kPa)
Multiply Energy or Work	**By**	**To get equivalent number of:**
British Thermal Unit (Btu)	1055	Joules (J)
Foot-pound (ft·lb)	1.3558	Joules (J)
Kilowatt-hour (kW·hr)	3,600,000. or 3.6×10^6	Joules (J = one W/s)
Multiply Light	**By**	**To get equivalent number of:**
Foot candle (fc)	10.764	Lumens/$meter^2$ (lm/m^2)
Multiply Fuel Performance	**By**	**To get equivalent number of:**
Miles/gal (mile/gal)	0.4251	Kilometers/liter (km/L)
Gallons/mile (gal/mile)	2.3527	Liter/kilometer (L/km)
Multiply Velocity	**By**	**To get equivalent number of:**
Miles/hour (mile/hr)	1.6093	Kilometers/hour (km/hr)

Table 8 English-to-metric Conversion Table

Decimal and Fraction Equivalents

Listed in Table 9 are the decimal and fraction equivalents:

Fractions of an inch	Decimal (in.)	Metric (mm)	Fractions of an inch	Decimal (in.)	Metric (mm)
1/64	0.015625	0.39688	33/64	0.515625	13.09687
1/32	0.03125	0.79375	17/32	0.53125	13.49375
3/64	0.046875	1.19062	35/64	0.546875	13.89062
1/16	0.0625	1.58750	9/16	0.5625	14.28750
5/64	0.078125	1.98437	37/64	0.578125	14.68437
3/32	0.09375	2.38125	19/32	0.59375	15.08125
7/64	0.109375	2.77812	39/64	0.609375	15.47812
1/8	0.125	3.175	5/8	0.625	15.87500
9/64	0.140625	3.57187	41/64	0.640625	16.27187
5/32	0.15625	3.96875	21/32	0.65625	16.66875
11/64	0.171875	4.36562	43/64	0.671875	17.06562
3/16	0.1875	4.76250	11/16	0.6875	17.46250
13/64	0.203125	5.15937	45/64	0.703125	17.85937
7/32	0.21875	5.55625	23/32	0.71875	18.25625
15/64	0.234375	5.95312	47/64	0.734375	18.65312
1/4	0.250	6.35000	3/4	0.750	19.05000
17/64	0.265625	6.74687	49/64	0.765625	19.44687
9/32	0.28125	7.14375	25/32	0.78125	19.84375
19/64	0.296875	7.54062	51/64	0.796875	20.24062
5/16	0.3125	7.93750	13/16	0.8125	20.63750
21/64	0.328125	8.33437	53/64	0.828125	21.03437
11/32	0.34375	8.73125	27/32	0.84375	21.43125
23/64	0.359375	9.12812	55/64	0.859375	21.82812
3/8	0.375	9.52500	7/8	0.875	22.22500
25/64	0.390625	9.92187	57/64	0.890625	22.62187
13/32	0.40625	10.31875	29/32	0.90625	23.01875
27/64	0.421875	10.71562	59/64	0.921875	23.41562
7/16	0.4375	11.11250	15/16	0.9375	23.81250
29/64	0.453125	11.50937	61/64	0.953125	24.20937
15/32	0.46875	11.90625	31/32	0.96875	24.60625
31/64	0.484375	12.30312	63/64	0.984375	25.00312
1/2	0.500	12.70000	1	1.00	25.40000

Table 9 Conversion Chart

A 008 – REPAIRING THREADED BORES

Section **Page**

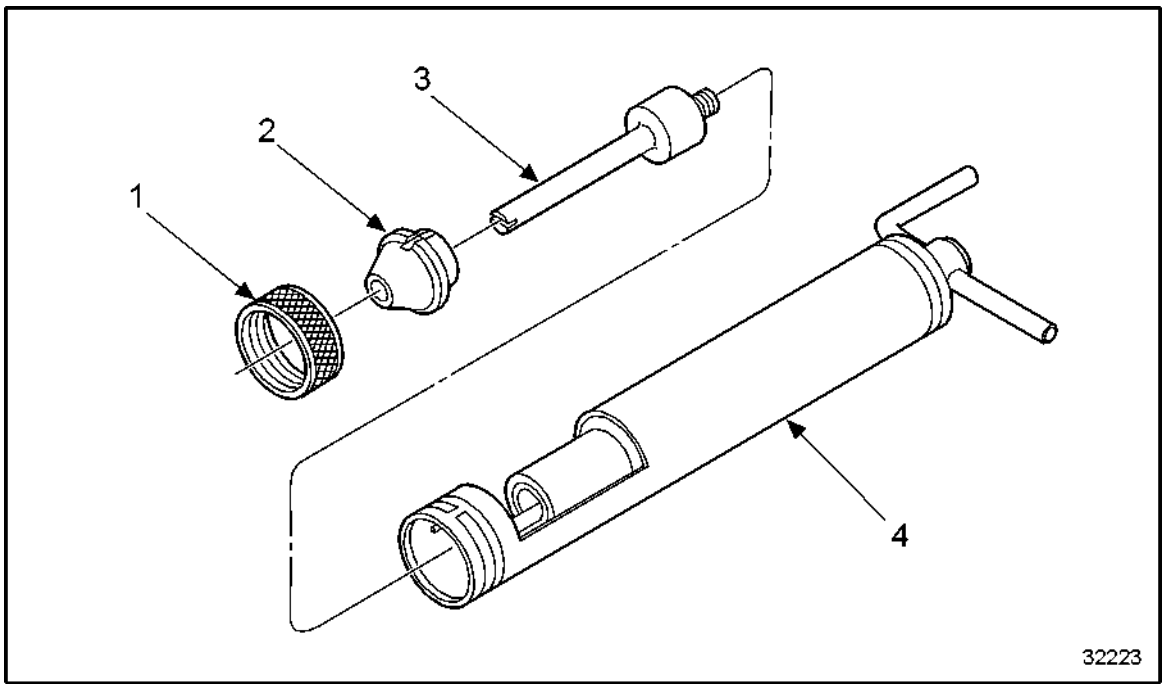
Repairing Threaded Bores

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

See Figure 17 to repair the threaded bore.



1. Helix Coil
2. Snout
3. Spindle
4. Helix Tool

Figure 17 Typical Insert Tool

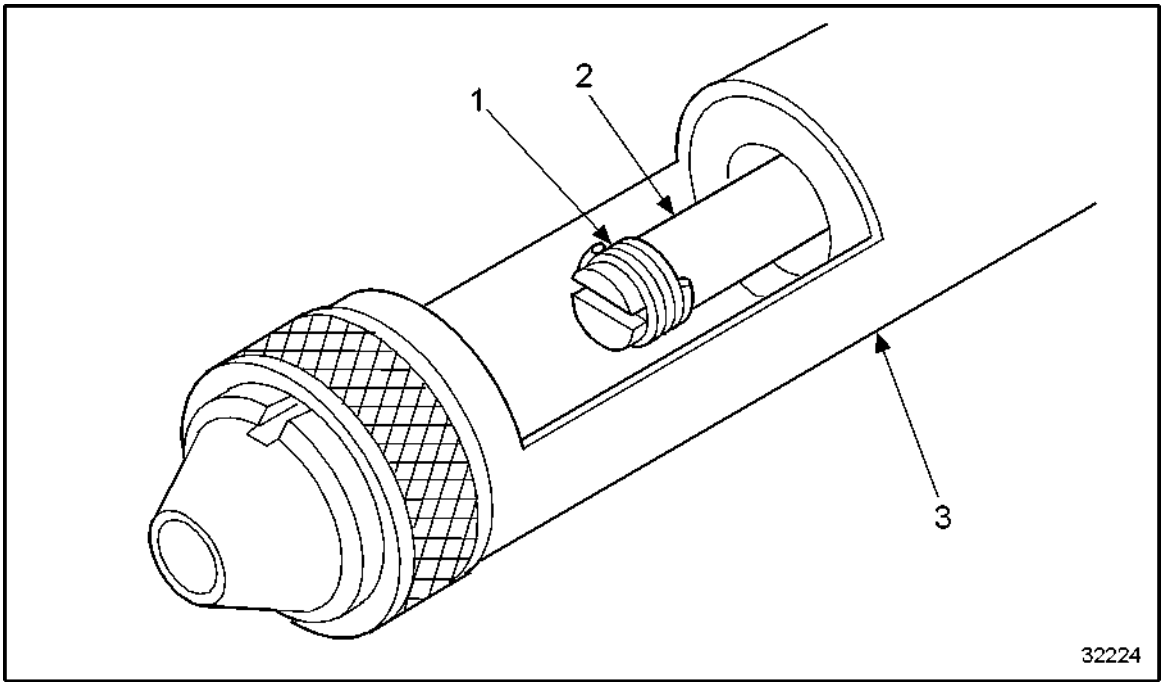
To repair a threaded bore, follow these steps:

1. If necessary, remove the thread insert from the bore with a suitable tool.
2. Bore core hole with suitable twist drill as listed in Table 10.
3. Cut thread with special tapped bore.

NOTE:
Do not countersink bore.

4. Mount spindle (3) and snout (2), corresponding with thread.
5. Groove on snout must be aligned with markings on the helix installation tool (4).

6. Insert thread insert (1) into spindle (2) in helix tool (3). See Figure 18.



1. Thread insert
2. Spindle
3. Helix Installation Tool

Figure 18 Inserting Thread Insert

7. Use spindle to turn thread insert through the snout until it is flush at the front. See Figure 19.

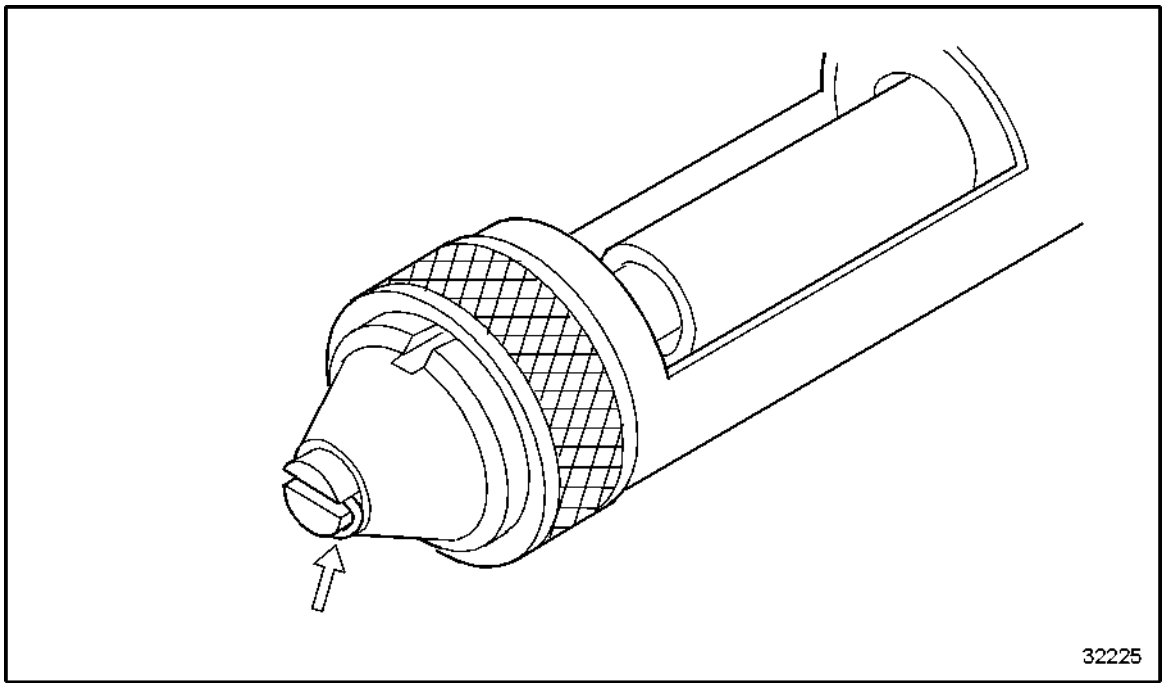


Figure 19 Turning Thread Insert

8. Mount installation tool on threaded hole and install thread insert without applying pressure to spindle. See Figure 20.

NOTE:
Insert thread insert 1/2 to 1–1/2 turns deeper than threaded bore surface.

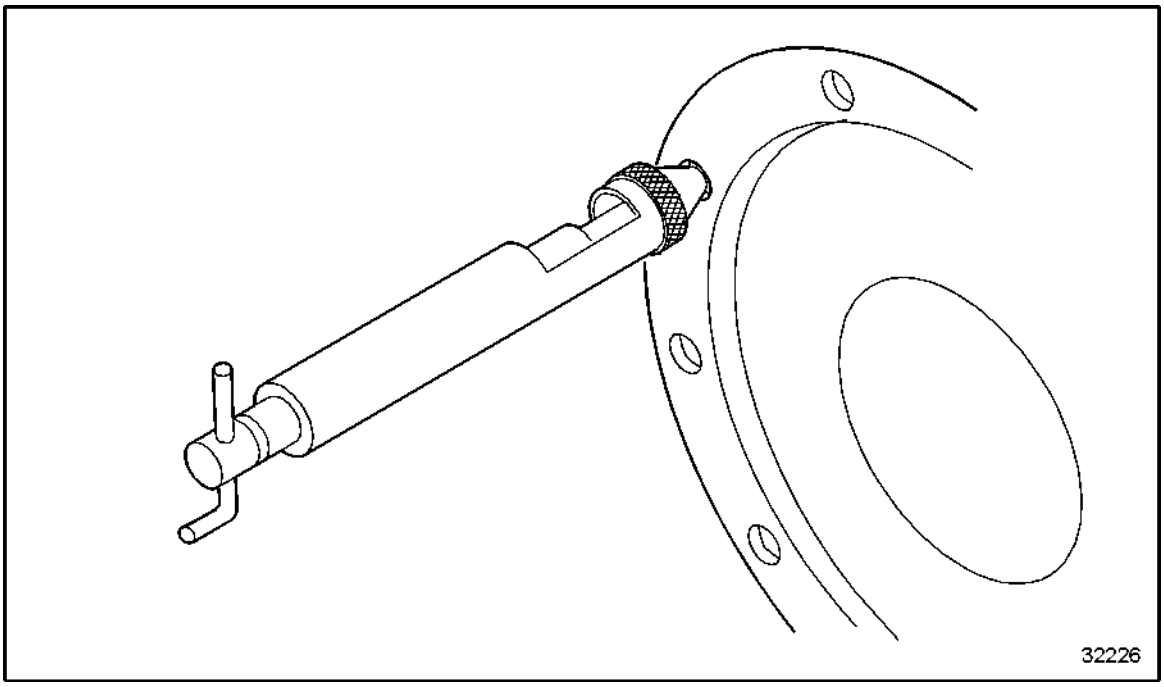


Figure 20 Thread Insert Tool

9. Use bolt shearer to remove driver journal to M 14.
10. If threaded inserts are over M 14, move the driver journal up and down with pointed pliers and remove.

B – OPERATION SCHEDULES

B 001 – CHECKING ENGINE CONDITION BEFORE A MAJOR OVERHAUL

Section **Page**

Checking Engine Condition Before a Major Overhaul

Listed in Table 1 are the operations to be performed to check the engine condition before a major overhaul.

Before the engine is removed, a brief test should be conducted to assist in evaluating its condition and running behavior. Deviations from the Engine Acceptance Test Record found during the test run provide valuable information for subsequent overhaul services.

Operations to be Performed	Refer to Section
Perform operations preparatory to starting the engine	Operators Guide
Start engine	Operators Guide
Carry out engine warm-up procedure	Operators Guide
Test engine at highest possible power	-
Check engine speed, temperatures, and pressures where gauges are installed	-
Check operating states with fault recorder; assess discrepancies	Operators Guide
Check running noises; these should be restricted to normal operating sounds	-
During test run, visually inspect engine and external lines for leaks	Operators Guide
Check for water emerging from charge air cooler drain lines and check for obstructions	Operators Guide
Check exhaust gas color	Operators Guide
Operate engine with adjustable zero-power speed	-
Connect fuel line connections for leaks	-
Remove cylinder head cover	Refer to section Removing Rocker CoverRemoving Rocker Cover
Check valve gear lubrication (visual inspection)	-
Extract engine oil sample	Operators Guide
Analyze engine oil sample (spot test, water content, dilution with fuel)	Test Kit
Extract coolant sample	Operators Guide
Analyze coolant sample	Test Kit
Check function of monitoring system and ECU	Operators Guide
Shut down engine	Operators Guide
Reduce the coolant level in the expansion tank and check the level switch response (coolant level monitoring)	Operators Guide
Drain coolant	Operators Guide
Drain charge air coolant	Operators Guide
Fill system with cleaning solution	-
Start engine	Operators Guide
Flush cooling system	-
Flush charge air cooling system	-
Shut down engine	Operators Guide
Check compression pressure	Operators Guide

Table 1 Checking Engine Condition before a Major Overhaul

B 002 – W5 MAINTENANCE OPERATIONS

Section **Page**

W5 Maintenance Operations

Listed in Table 2 are the W5 Maintenance Operations.

NOTE:
The following table is based on maintenance work. Always use the valid maintenance schedule corresponding to the affected engine.

Operations to be Performed	Refer to Section
Shut off fuel supply line	Operators Guide
Switch off monitoring system	Operators Guide
Switch off battery main switch	Operators Guide
Wash engine, without using chemical cleaning agents	Operators Guide
Drain engine coolant; take sample and analyze (MTU test kit); change coolant if necessary	Operators Guide
Whenever possible, drain engine oil while the engine is warm; take sample and analyze	Operators Guide
Fuel prefilter: drain water and contaminants; replace filter elements	Operators Guide
Replace fuel filter	Operators Guide
Clean air filter; replace if necessary. Empty dust collection box	Operators Guide
Replace exhaust turbocharger	Refer to section C 101.05.05C 101.05.05
Intake air system: remove lines, clean and replace gaskets	-
Drain exhaust system: check security of securing bolts	Operators Guide
Remove charge air cooler; clean and check for leaks	Refer to section C 111.05.05C 111.05.05
Check coolant thermostat (high-temperature circuit); replace if necessary	Refer to section C 208.05.08C 208.05.08
Check coolant thermostat (low-temperature circuit); replace if necessary	Refer to section C 208.05.08C 208.05.08
Replace engine coolant pump (high-temp)	Refer to section C 202.05.05C 202.05.05
Replace charge air coolant pump (low-temp)	Refer to section C 206.05.05C 206.05.05
Check condition of engine control system and wiring and check for security	-
Check starter wiring and connections for corrosion and loose connections	-
Check generator and contacts for corrosion and loose connections; check wiring	-
Generator drive: check tension and condition of drive belt	Operators Guide
Fan: check tension and condition of drive belt	Operators Guide
Air conditioner compressor: check tension and condition of drive belt	Operators Guide
Replace high-pressure sensor	Refer to section C 073.05.05C 073.05.05

Operations to be Performed	Refer to Section
Replace low-pressure fuel pump	Refer to section C 081.05.05C 081.05.05
Remove and check valve gear, swing arms, and valve bridges	Refer to section C 055.05C 055.05
Check swing arms, rollers, pushrod seat, and rocker arm bearings for wear	Refer to section C 055.05.05C 055.05.05
Valve gear: check valve clearances; adjust if necessary	Operators Guide
Valve gear: prelubricate	-
Remove fuel injectors	Operators Guide
Carry out endoscopic inspection on cylinder chambers	Operators Guide
Install new / overhauled fuel injectors and encode (every 7,500 hours only)	Operators Guide
Remove and examine vibration damper; repair if necessary	Refer to section C 035.05.05C 035.05.05
Clean centrifugal oil filter; check layer thickness of oil residue	Operators Guide
Check bearing; replace if necessary	Refer to section C 183.05.08C 183.05.08
Insert new sealing sleeve	Operators Guide
Engine mount: check security	Operators Guide
ECU: check wiring; check security and condition	Operators Guide
Reinstall/mount parts that were removed after they have been assembled according to the engine assembly sequence	OEM Guidelines
Fill engine coolant; vent coolant system	Operators Guide
Fill oil system with engine oil	Operators Guide
Switch on battery main switch	Operators Guide
Switch on monitoring system	Operators Guide
Carry out lamp test	-
Open fuel supply	Operators Guide
Preheat engine	Operators Guide
Start engine and let it warm up	Operators Guide
Engine test run: check speed, pressures, and temperatures Check running noises	Operators Guide
Check engine and external pipework for leaks	Operators Guide
Check turbocharger and exhaust connections for leaks; check oil supply and return lines for leaks	Operators Guide
Check exhaust gas color	Operators Guide
Check intake air system for leaks	Operators Guide
Compressor unit: check operating pressure; check hoses, lines, and connections	Operators Guide
Shut down engine	Operators Guide

Operations to be Performed	Refer to Section
Check engine oil level	Operators Guide
Check engine coolant level	Operators Guide

Table 2 W5 Maintenance Operations

B 003 – W6 MAINTENANCE OPERATIONS

Section **Page**

W6 Maintenance Operations

For Series 4000 W6 engine overhaul, the following components must be replaced or qualified as follows:

- ☐ A Series 4000 component list form must be completed and attached. Refer to section A 006 .

NOTE:
The W6 Engine Overhaul requirements do not include recommended product improvement updates, that should be considered at time of overhaul. For more information on recommended product improvements updates, contact your regional representative or Detroit Diesel Technical Service Department.

Refer to Section D for tolerances and wear limits.

NOTE:
Air compressors, alternators, and starters are not part of the engine rebuild.

- ☐ Replace all gaskets and seals
  - ☐ Series 4000 overhaul gasket kit
- ☐ Short block assembly
  - ☐ Inspect cylinder block per mandatory inspection instructions
  - ☐ Inspect crankshaft assembly 12V engine only
  - ☐ Replace crankshaft assembly 16V engine only
  - ☐ Inspect camshaft per mandatory inspection instructions
  - ☐ Replace cylinder kits
  - ☐ Replace connecting rods
  - ☐ Replace rod and main bearings
- ☐ Cylinder Heads
  - ☐ Replace all
- ☐ Valve operating mechanism
  - ☐ Replace all rocker arm assemblies
  - ☐ Replace all swing arm assemblies
  - ☐ Replace push tubes
- ☐ Gear case assembly
  - ☐ Inspect per mandatory inspection instructions
  - ☐ Modify to provide oil drain to sump capabilities
- ☐ Lubricating system
  - ☐ Insure that the oil filter bypass valve and spring have been updated per SIB 7–4000–00 (one time only)
  - ☐ Insure that the oil filter maintenance alert kit has been installed per SIB 8–4000–00 (one time only)
  - ☐ Replace oil pump assembly
  - ☐ Replace oil pressure regulator assembly
  - ☐ Replace oil cooler cores if metal contamination is present in engine
  - ☐ Replace centrifugal oil filter assembly
- ☐ Turbochargers and Air inlet system

- ☐ Replace all turbochargers with reliabilt®
- ☐ Replace turbocharger oil supply and drain lines

☐ Exhaust system
- ☐ Inspect and replace exhaust system components as needed
- ☐ For high altitude applications, install Helioflex turbocharger to exhaust manifold seals

☐ Fuel system
- ☐ If the current injectors have been updated to the low-flow design (P/N E23526589) within the past 2500 hours of operation, clean, inspect and reuse. Otherwise, replace all injectors with low-flow design (P/N E23526589)
- ☐ Recalibrate ECM to certified calibration for low-flow injectors
- ☐ Replace both A and B bank injector harnesses
- ☐ Replace injector hold-down bolts and add washers (P/N 23509483)
- ☐ Replace low pressure fuel pump with reliabilt®
- ☐ If current high pressure fuel pump exceeds 3500 hours of operation, replace with reliabilt®
- ☐ Replace high pressure rail sensor
- ☐ Inspect and clean high pressure rail relief valve
- ☐ Replace check valves in junction block
- ☐ Replace flow limiting valves

☐ Cooling system
- ☐ Replace all LTC and HTC thermostats
- ☐ Replace both LTC and HTC water pump assemblies with reliabilt®
- ☐ For 2700 HP and higher applications only, replace the charge air cooler core. For all others, inspect and pressure-test the charge air cooler core per mandatory inspection instructions
- ☐ Inspect distribution housing per mandatory inspection instructions

☐ Sensors and Harnesses
- ☐ Replace all sensors and harnesses

☐ Damper
- ☐ Replace with reliabilt® damper

☐ Accessory drives
- ☐ Replace

☐ Flywheel housing and flywheel
- ☐ Inspect per mandatory inspection items instructions

☐ Rockford fan hub assembly
- ☐ Replace with reliabilt® assembly

☐ Dyno test
- ☐ See Dyno test data on the Series 4000 component list; refer to section A 006

B 004 – ENGINE REMOVAL

Section **Page**

Engine Removal

Listed in Table 3 are the operations for engine removal.

Operations	Refer to Section
Shut off fuel supply	Refer to Operators Guide
Drain engine oil while engine is warm, if possible	Refer to Operators Guide
Examine oil sludge for metallic residues	Refer to Operators Guide
Drain engine coolant when temperature of coolant is below 60 °C	Refer to Operators Guide
Drain charge air coolant	Refer to Operators Guide
Wash engine without using chemical cleaning agents	-
Disconnect all connections	-
Seal open connections with non-linting plugs and covers	-
Release engine securing bolts	-
Remove engine and place on engine stand	-
Using a lifting device, attach engine only on suspension brackets provided as shown in installation drawing, taking center of gravity and transportation specifications into consideration.	Refer to Operators Guide

Table 3 Operations for Engine Removal

Engine Weight

(Dry weight)

12V is approximately 6070 kg (13, 920 lbs).

16V is approximately 7173 kg (15,814 lbs).

B 005 – ENGINE RUN-IN

Section **Page**

Engine Run-in

If pistons, piston rings or cylinder liners have been replaced, the engine must be run in as per the appropriate run-in schedule.

Conscientious run-in is of critical importance as this regards the durability and operational reliability of the engine.

Use a brake or alternator to absorb the power generated in the braking run.

Power must be transmitted from the engine to the brake by means of a resilient coupling.

Settings

Set fuel and intake air temperatures before engine operation in accordance with the temperatures stated for the engine in the DDC Engine Acceptance Test Record.

The engine coolant temperature depends on the operating range of the coolant thermostat.

Fuel temperature depends on the volume of the service tank insofar as there is no fuel-cooling device on the test stand.

Record readings for power fuel, lube oil, coolant, charge air and exhaust gas at each test point (time, speed and effective power) of the run-in schedule and enter readings under “Engine Run-In” in “DDC Diesel Engine Factory Test” record.

Listed in Table 4 for the operations to be performed for the engine run-in.

Operations to be Performed	Refer to Section
Install engine on test stand	-
Connect engine to brake or alternator	-
Connect air intake, exhaust, engine coolant and fuel lines	-
Connect measuring sensor and measuring lines to the corresponding measuring points to record the measured values for fuel, lube oil, engine coolant, supercharging and exhaust which were noted in the DDC Engine Acceptance Test Record.	DDC Engine Acceptance Test Record
Connect control unit to ECM	-
Fill expansion tank with coolant and 2 % corrosion inhibitor oil up to max. mark	Operators Guide
Vent coolant lines until bubble-free coolant emerges	Operators Guide
Check that fuel in service or supply tank is to specification	DDC Fluid and Lubricants Specification
Fill oil system up to max mark with fresh oil	Operators Guide
Prelubricate valve gear with oil	Operators Guide
Check operation of emergency shutdown system	-
Preheat engine coolant	Operators Guide
Start engine	Operators Guide
Shut down engine after approximately one minute no-load operation and carry out following operations:	-

Operations to be Performed	Refer to Section
- Check oil level; top up with oil if necessary	Operators Guide
- Remove valve gear cover; check valve gear lubrication	Operators Guide
Start engine; check idling speed	-
Check engine running noises	Operators Guide
Carry out engine warm-up procedure	Operators Guide
Check for leaks at coolant, oil and fuel lines, cylinder block seals, air system, and exhaust lines	Operators Guide
Run–in engine and record measurements in accordance with run-in schedule	Refer to section B 005
Compare test data with those recorded in DDC Acceptance Test Record	DDC Engine Acceptance Test Record
Check color of exhaust gas	-
Enter barometric reading and relative humidity in record	DDC Engine Acceptance Test Record
Check engine for abnormal noises and for leaks	-
Check function of monitoring units	-
After run-in, run down engine and switch off	Operators Guide
Check oil filter	Operators Guide
Check oil level and prepare engine for oil-consumption measurement	-
Carry out acceptance test in accordance with DDC Engine Acceptance Test Record	Refer to section B 005
Enter operational data in engine acceptance test record provided	DDC Engine Acceptance Test Record
Compare test data with those recorded in DDC Engine Acceptance Test Record	DDC Engine Acceptance Test Record
Carry out governor test	-
After completing acceptance test, run down engine and switch off	Operators Guide
Carry out oil-consumption test	Operators Guide
Start engine	-
Go through the governor curve (DBR) in accordance with the DDC Engine Acceptance Test Record	DDC Engine Acceptance Test Record
Set the specified service power rating as per DDC Engine Acceptance Test Record	DDC Engine Acceptance Test Record
Shut down engine and carry out six start attempts	-
Carry out engine preservation run	Operators Guide
Shut down engine and disable engine start	-
Drain engine oil and coolant	Operators Guide
Adopt suitable protective measures if engine is scheduled for marine transport	-
Remove air intake, exhaust, engine coolant and fuel lines	-

Operations to be Performed	Refer to Section
Remove measuring sensors and measuring lines from engine and seal measuring points	-
Remove engine from test stand	-
Prepare engine for paint spraying and spray with protective paint	-

Table 4 Engine Run-in

Acceptance Test (Marine Applications)

Listed in Table 5 are the power and propeller curves for the acceptance test.

Running Period	Power / Propeller Curve
15 min	275 kW at 1500 rpm
15 min	520 kW at 1675 rpm
15 min	1250 kW at 1800 rpm
2 hour	1493 kW at 1890 rpm

Table 5 Acceptance Test

Construction and Industrial Applications

Listed in Table 6 are the power and propeller curves for the acceptance test construction and industrial applications.

Running Period	Power / Propeller Curve
Warm up engine	700–1000 rpm
5 min steps	@ 100 rpm; from 1000 rpm to 1900 rpm — no load
10 min	@ 50% load at 1200 rpm
10 min	@ 50% load at 1500 rpm
10 min	@ 50% load at 1900 rpm
20 min	@ 100% load at 1900 rpm

Table 6 Dyno Test Specifications

Haul Truck Load Bank Test

Load bank on the load reference curve at 1200, 1500, 1800 and 1900 rpm @15 minutes each.

Inspection Report

Record the following information prior to completing the Inspection Report:

- ☐ Page:
- ☐ Date:
- ☐ Test Bed:
- ☐ Recorded by:
- ☐ Model number:
- ☐ Engine serial number:
- ☐ Order number:
- ☐ Fuel
  - □ Specific gravity 15°C (g/cm^3):
  - □ Heating value (kJ/kg):
- ☐ Lube oil:
- ☐ Service power
  - □ Max. effective power (kW) at (rpm):
  - □ Altitude above sea level (m):
  - □ Intake air temperature (°C):
  - □ Relative humidity (%):
  - □ Barometric pressure (mbar):
  - □ Direction of rotation per ISO 1204:
  - □ Start of fuel delivery (BTDC):

Record the following values when completing the Inspection Report:

- ☐ Time (hour, min):
- ☐ Speed (n) (rpm):
- ☐ Brake load (F) (N):
- ☐ Brake power
  - □ Test stand (Py) (kW):
  - □ Standard Conditions (Pr) (kW):
- ☐ Fuel
  - □ Quantity (V) (dm^3):
  - □ Temperature (°C):
  - □ Flow measurement (t) (s):
  - □ Specific gravity (g/cm^3):
  - □ Consumption: Hourly (B) (kg/h) and Specific (b) g/(kWh)
  - □ Rack setting (R-deg.) (mm):
- ☐ Lube oil pressure
  - □ Before filter (bar):
  - □ Before engine (bar):
  - □ In supercharger or before turbocharger (bar):
  - □ Measuring block/last bearing (bar):

- ☐ Lube oil temperature
  - ☐ Before engine (°C):
  - ☐ After engine (°C):
- ☐ Coolant temperature
  - ☐ Before engine (°C):
  - ☐ After engine (°C):
- ☐ Coolant pressure
  - ☐ Before pump (bar):
  - ☐ After pump (bar):
  - ☐ After engine (bar):
- ☐ Charge air temperature before:
  - ☐ Engine (°C):
  - ☐ Cylinder (°C):
- ☐ Charge air pressure before:
  - ☐ Engine (mm H_2O):
  - ☐ Cylinder (°C):
- ☐ Exhaust
  - ☐ Temperature, after engine (°C):
  - ☐ Pressure, after engine (°C):
  - ☐ Smoke index (SI):
- ☐ Fuel temperature, before engine (°C):
- ☐ Lube oil consumption (kg/h):
  - ☐ at Py (kW, n):
  - ☐ n = (rpm):
- ☐ Electric starter motor:
- ☐ Remarks:
- ☐ No evident faults or deficiencies occurred during the acceptance test.
- ☐ Signed for DDC:
- ☐ Signed for the purchaser:

B 006 – ENGINE INSTALLATION AND OPERATION

Section **Page**

Engine Installation and Operation

Listed in Table 7 are the operations to be performed for the engine installation and operation.

Operations to be Performed	Refer to Section
Open all connections, remove cover and rubber plugs	-
Attach engine only on suspension brackets provided as shown in installation drawing, taking center of gravity and transportation specifications into consideration, and install in plant.	-
Align engine	-
Join connections for engine coolant, fuel, compressed air, and engine monitoring as appropriate	-
Fill engine coolant system	Operators Guide
Fill charge air coolant system	Operators Guide
Fill oil system with engine oil	Operators Guide
Prepare engine for operation	Operators Guide
Preheat engine	Operators Guide
Start engine	Operators Guide
Perform checks while engine is running	Operators Guide
Carry out test run	-
Measure intake air depression	Operators Guide
Measure exhaust back pressure	Operators Guide
Shut down engine	Operators Guide
Perform after-shutdown services	Operators Guide
If an extended out-of-service period is intended, carry out external preservation, disable engine start, seal air intake and exhaust outlet. (Note: An engine preservation run was carried out after the test-stand run.)	Operators Guide

Table 7 Engine Installation and Operation

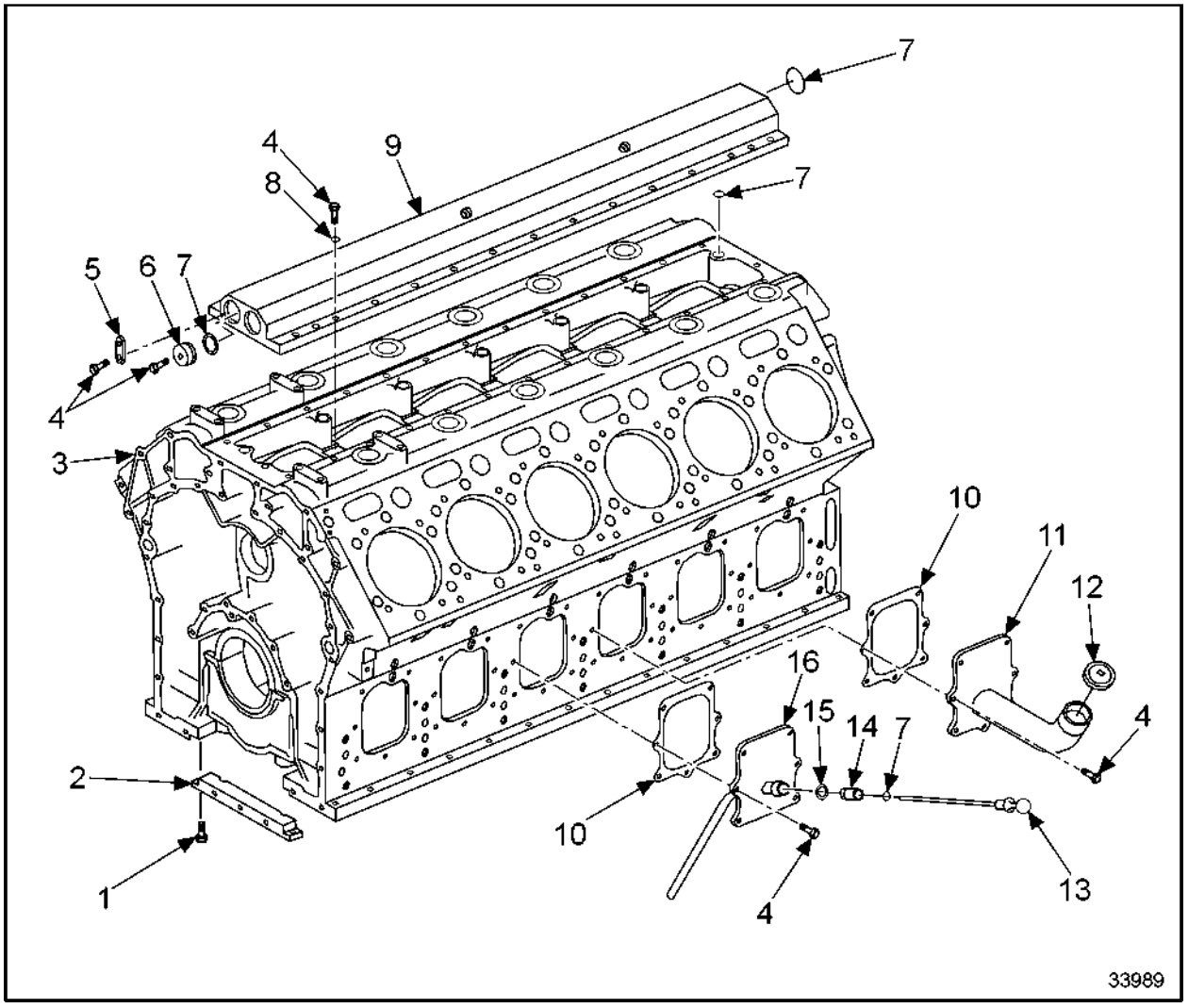
C – MAINTENANCE

C 010 – CYLINDER BLOCK

C 011.05 – CYLINDER BLOCK

C 011.05.01 – GENERAL VIEW

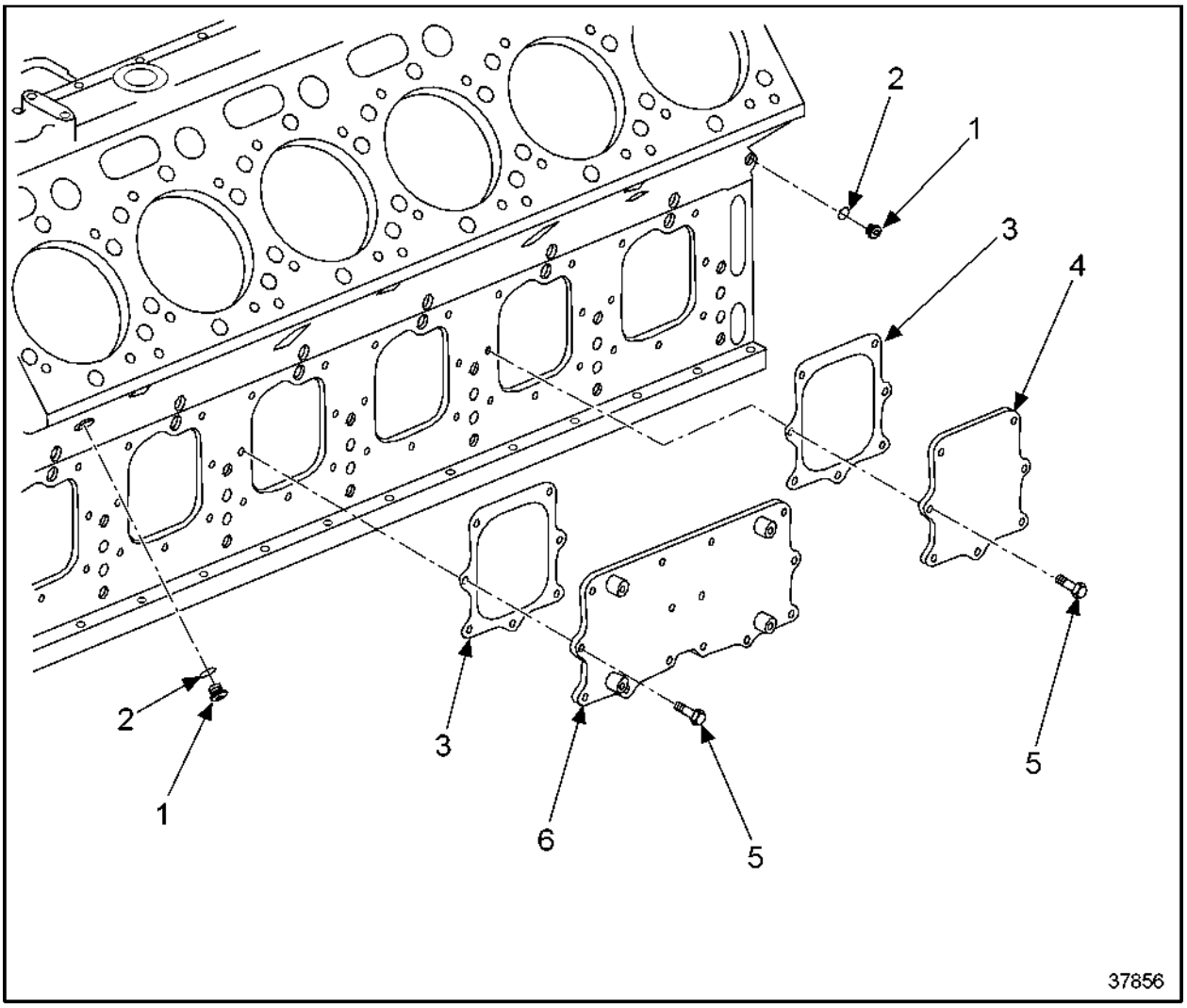
See Figure 1 for a general view of the oil gallery, access cover with dipstick tube and oil-filling feed pipe.



1. Cylinder Block Filler Strip Bolt
2. Cylinder Block Filler Strip
3. Cylinder Block
4. Hex Head Bolt
5. Link
6. Blanking Plug
7. O-ring
8. Washer
9. Oil Gallery
10. Gasket
11. Oil Filler Tube
12. Access Port Cover
13. Oil-level Dipstick
14. Dipstick Tube
15. O-ring
16. Access Cover with Dipstick Tube

Figure 1 General View of Oil Gallery, Access Cover with Dipstick Tube and Oil-filler Tube

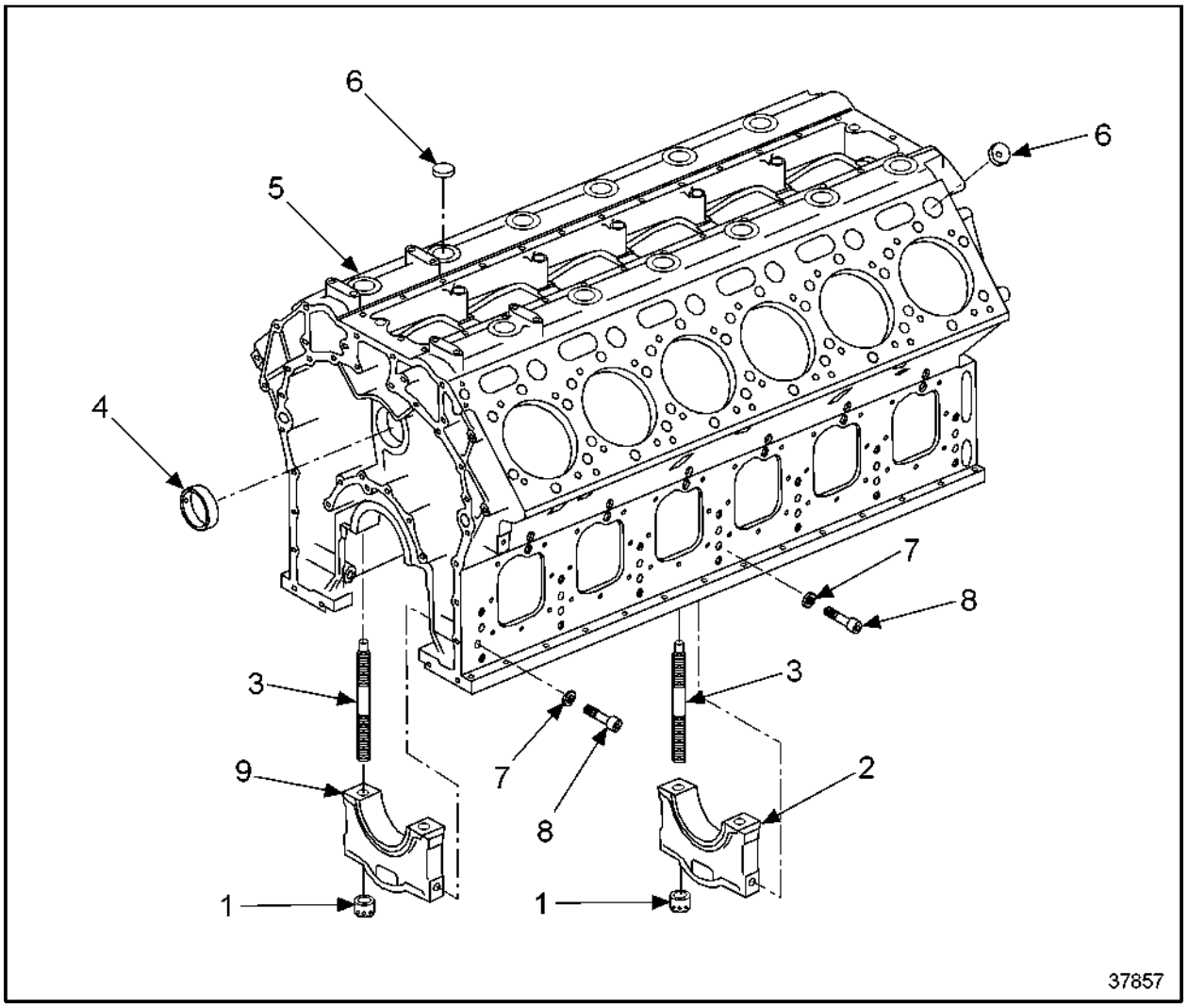
See Figure 2 for a general view of the access port covers.



1. Plug
2. O-ring
3. Gasket
4. Inspection Hole Cover
5. Hex Head Bolt
6. ECM Mount Inspection Hole Cover

Figure 2 General View of Access Port Covers

See Figure 3 for a general view of the cylinder block.



1. Main Bearing Cap Nut
2. Main Bearing Cap
3. Main Bearing Cap Stud
4. Camshaft Bushing
5. Cylinder Block
6. Core Plug
7. Washer
8. Main Bearing Cap Cross Bolt
9. Rear Main Thrust Bearing Cap

Figure 3 General View of Cylinder Block

C 011.05.02 – SPECIAL TOOLS

Listed in Table 1 are the special tools required for maintenance on the cylinder block.

Designation	Tool Number
Cylinder block barring tool	—
Stop device for assembly of camshaft bearing	—
Stop device for assembly of camshaft bearing, gear case end	—
Installation tool for camshaft bearing	—
Brass drift for cap plug	—
Hydraulic clamping device for main bearing pin	—

Table 1 Special Tools

C 011.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 2 are the Before - Removal Operations for the cylinder block.

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 2 Before-Removal Operations

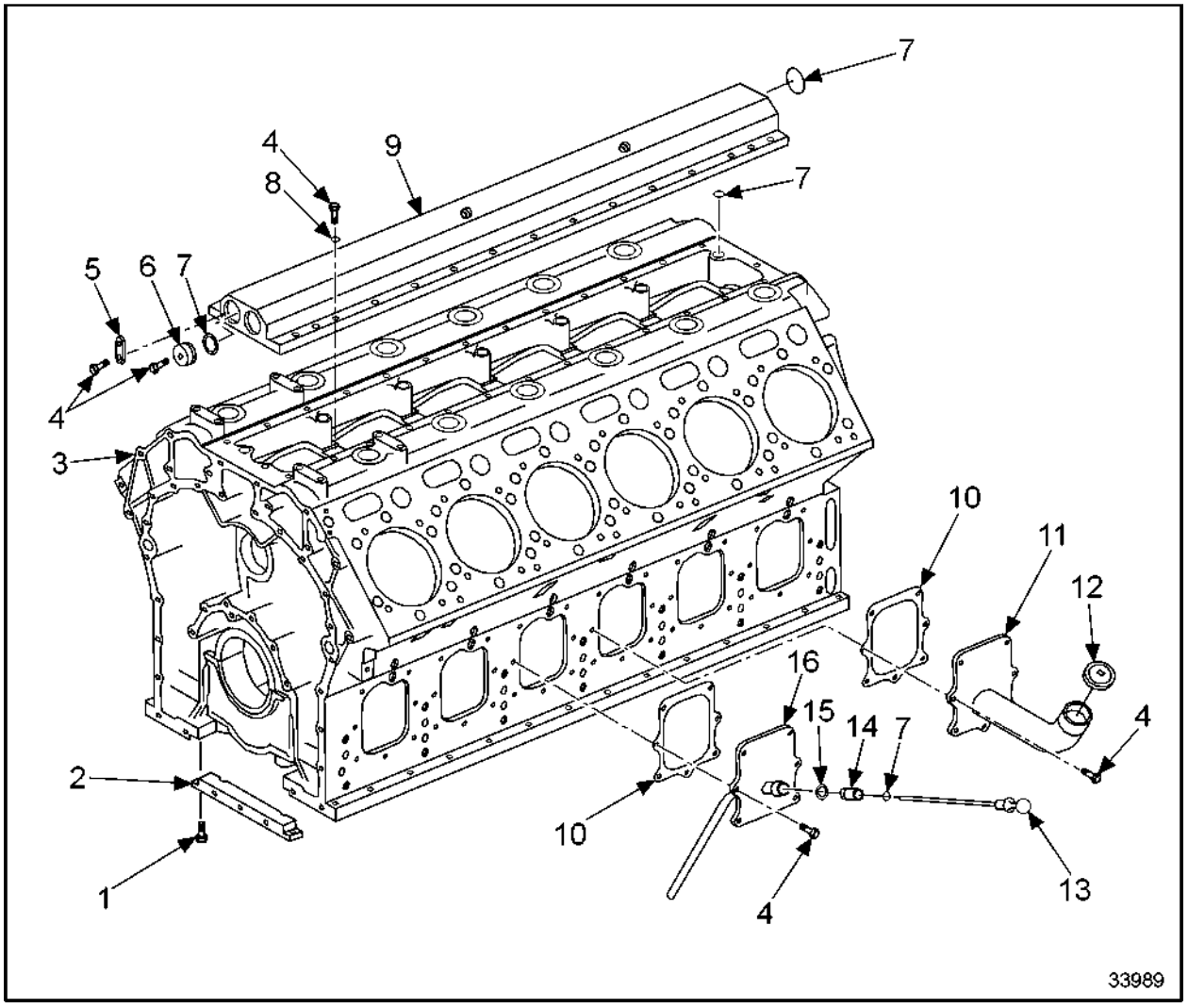
C 011.05.05 – REMOVAL OF CYLINDER BLOCK AND MAIN BEARINGS

Perform the following subsections to remove the cylinder block and main bearings:

Cylinder Block Removal

Perform the following steps to remove the cylinder block and externally mounted components:

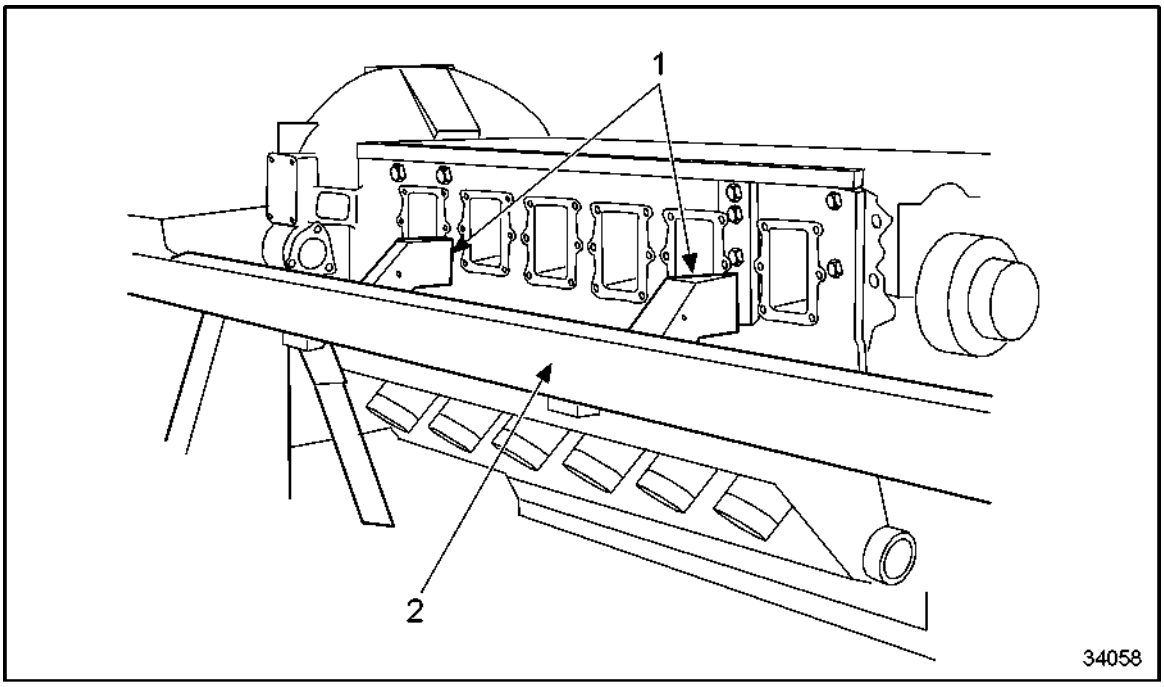
1. Remove cover (12), access cover with dipstick tube (16), oil-filling feed pipe (11) and access port cover (12). See Figure 4.



1. Cylinder Block Filler Strip Bolt
2. Cylinder Block Filler Strip
3. Cylinder Block
4. Hex Head Bolt
5. Link
6. Blanking Plug
7. O-ring
8. Washer
9. Oil Gallery
10. Gasket
11. Oil Filler Tube
12. Access Port Cover
13. Oil-level Dipstick
14. Dipstick Tube
15. O-ring
16. Access Cover with Dipstick Tube

Figure 4 Removing of Cylinder Block Components

2. Remove inspection covers and gaskets. See Figure 4.
3. To install cylinder block in turnover stand, install supports (1) for turnover stand at left and right side of the cylinder block. See Figure 5.



1. Supports
2. Turnover Stand

Figure 5 Installing Cylinder Block in Turnover Stand

CAUTION:

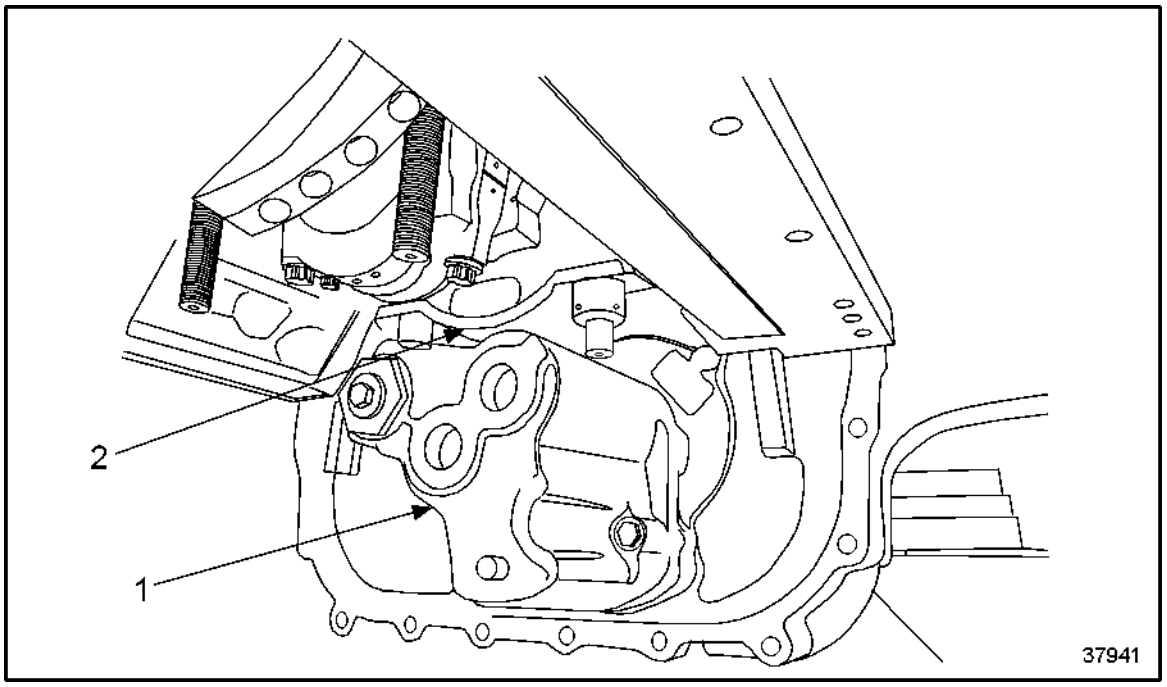
To avoid personal injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

4. Raise cylinder block with a suitable lifting device and place in turnover stand (2) and secure. See Figure 5.

Main Bearing Removal

Perform the following steps to remove the main bearings:

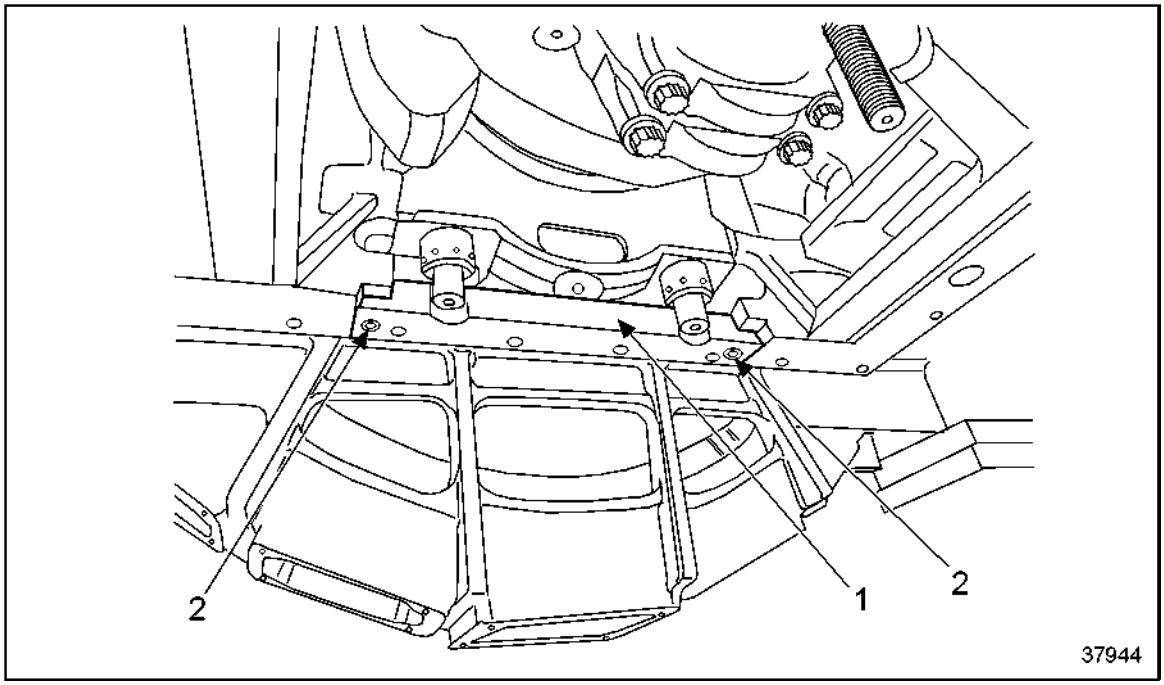
1. Measure fan belt tension with poly-vee belt tension gage. Record reading on the main bearing installation report form. Loosen fan belt to relieve tension from the crankshaft. Using a dial indicator, measure and record crankshaft thrust.
2. Remove engine lube oil filters. Take two samples, one from the lube oil filters and the other from the engine oil in the pan. Drain engine oil from both the oil pan and the gear case.
3. Remove oil pan. Refer to section C 014.05.05C 014.05.05 .
4. Wipe down the underside of the engine to remove dripping oil. Remove the oil pump to allow clearance to the #9 (16V) or #7 (12V) main bearing journal (front of engine). See Figure 6.



1. Oil Pump
2. #9 Main Bearing Journal

Figure 6 Removing Oil Pump (16V Shown)

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

6. The other three bolts are accessed from behind the flywheel through the flywheel housing into the filler spacer. See Figure 8.

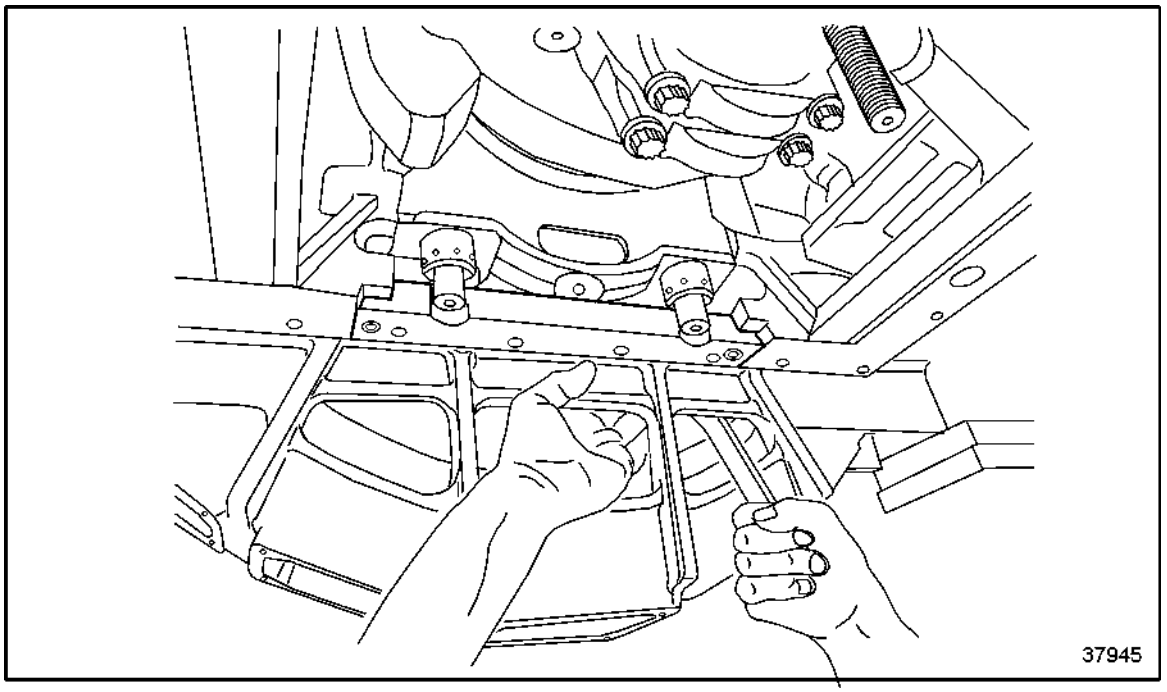


Figure 8 Removing Bolts from Filler Spacer

7. Before removing main bearing caps, ensure that the cap location number is marked clearly on the center of each main bearing cap and on the adjacent “A” bank pan rail. Mark each location starting with #1 from the rear working forward.
8. Remove all external main bearing stabilizer bolts on both sides of the engine. See Figure 9.

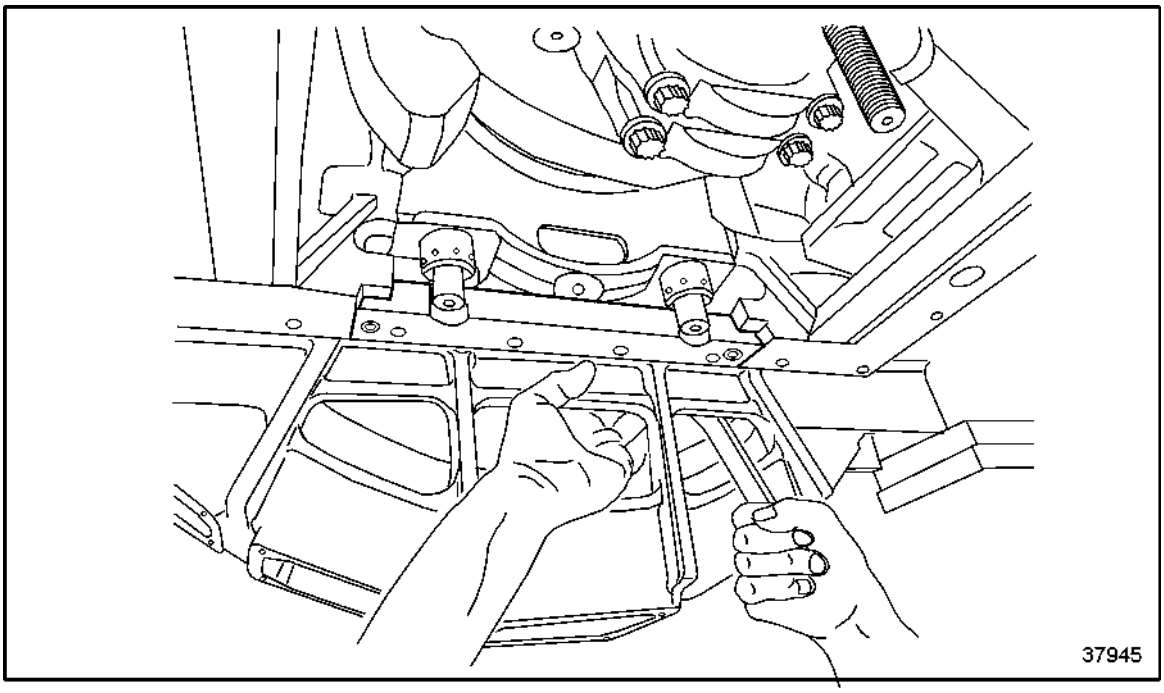


Figure 9 Removing Main Bearing Stabilizer Bolt

C 011.05.06 – DISASSEMBLY OF CYLINDER BLOCK AND MAIN BEARINGS

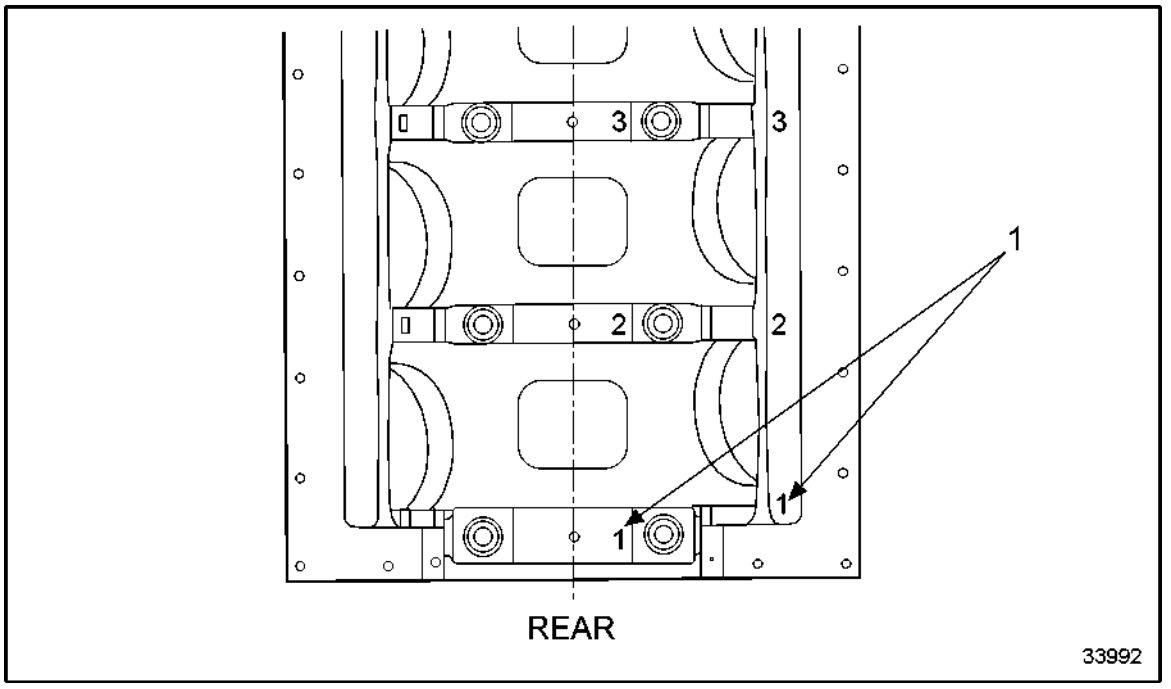
Perform the following steps to disassemble the cylinder block and main bearings:

Cylinder Block Disassembly

Perform the following steps to disassemble the cylinder block with externally mounted components:

1. Inspect marking on main bearing cap to crankshaft, and if necessary, mark according to sequence.
   [a] Punch the main bearing serial number on cylinder block and main bearing cap on left side of engine (A side).
   [b] Punch a 6 mm high number on each main bearing cap.
   [c] To numerically sequence, begin at rear (flywheel end) of engine with main bearing number 1.

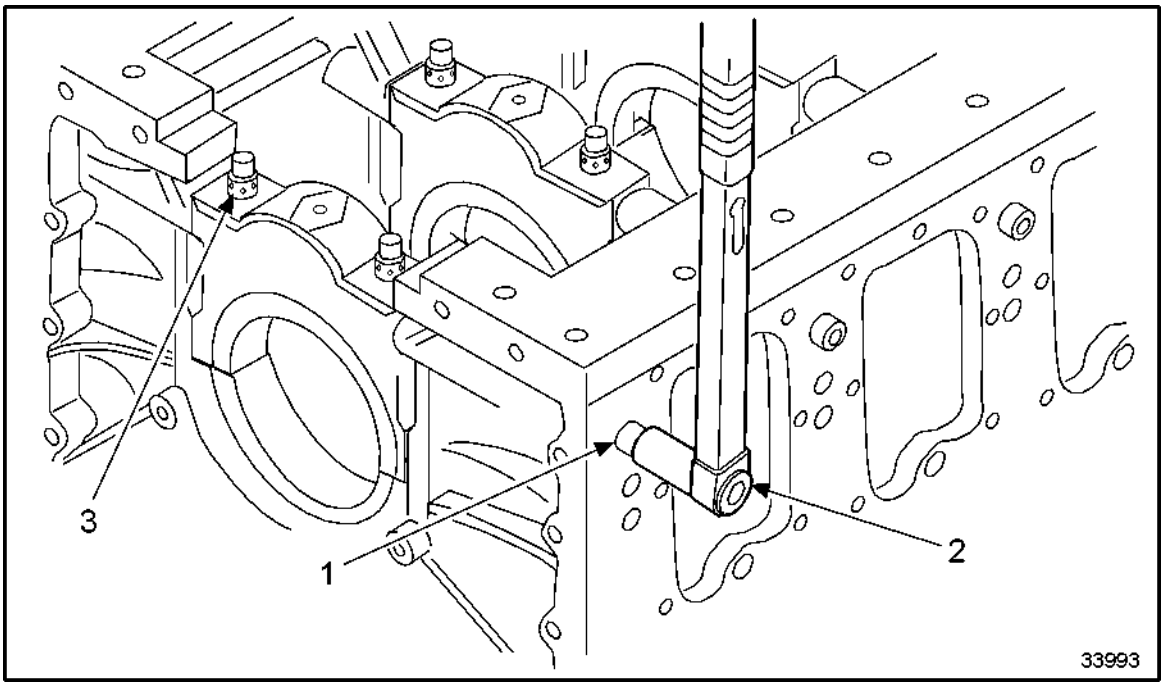
NOTE:
The A side is on the right when the cylinder block is viewed from the bottom. See Figure 10.



1. Identification Number

Figure 10 Identifying Marking on Cylinder Block Bearing Cap

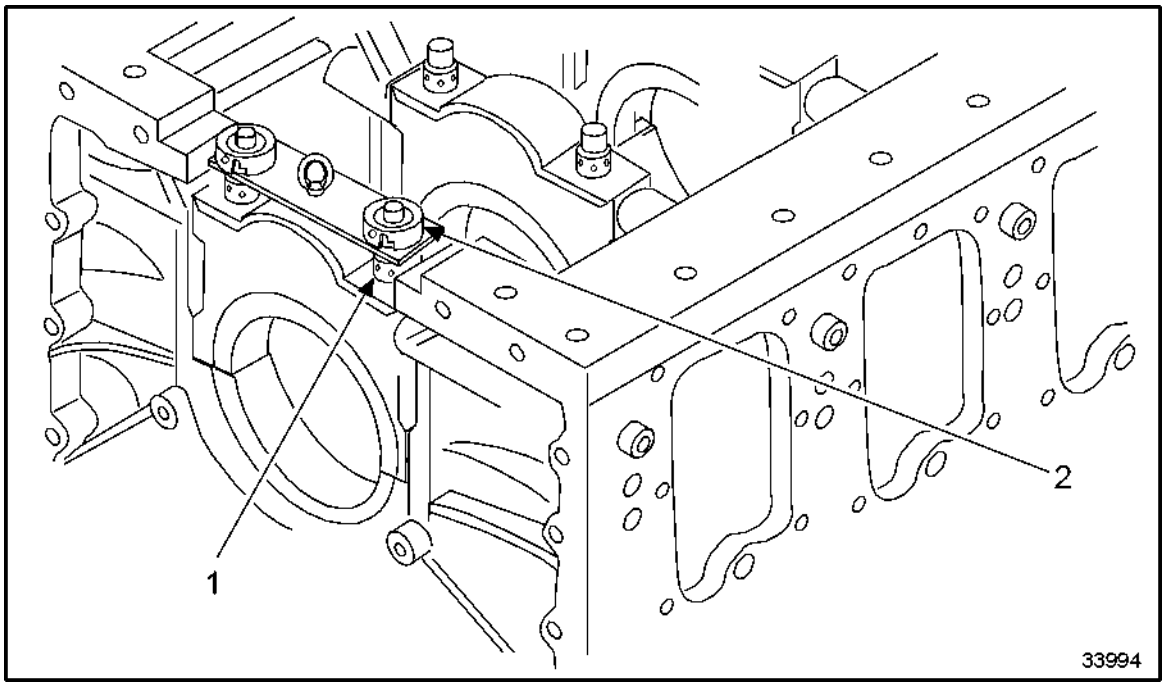
2. To remove rear main thrust bearing cap, remove cylinder block filler strip.
3. Using a ratchet and socket wrench (2), remove all side socket-head bolts (1) securing main bearing caps to the cylinder block. See Figure 11.



1. Main Bearing Cap Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing Cap Nut

Figure 11 Removing Main Bearing Cap Stabilizer Bolts

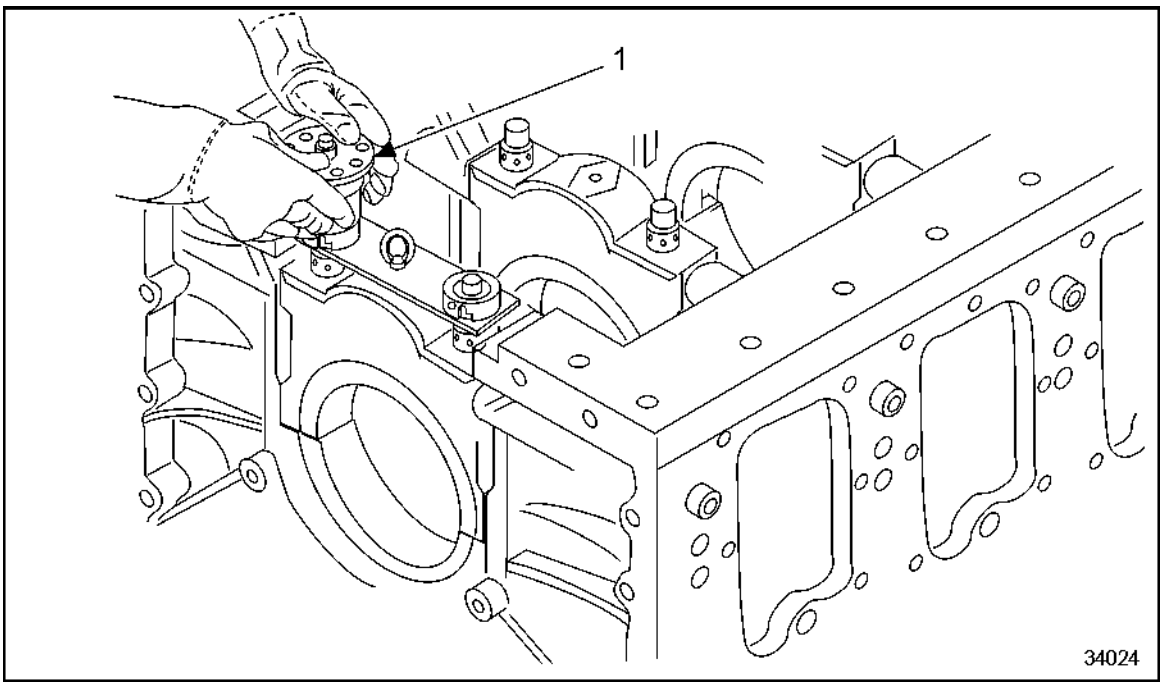
4. Beginning with rear main thrust bearing cap, place main bearing cap nut (1) of hydraulic pretensioner on stud (2) of relevant main bearing cap. See Figure 12.



1. Main Bearing Cap Nut
2. Main Bearing Pretensioner Nut Stud

Figure 12 Attaching Main Bearing Cap Stud of Hydraulic Pretensioner

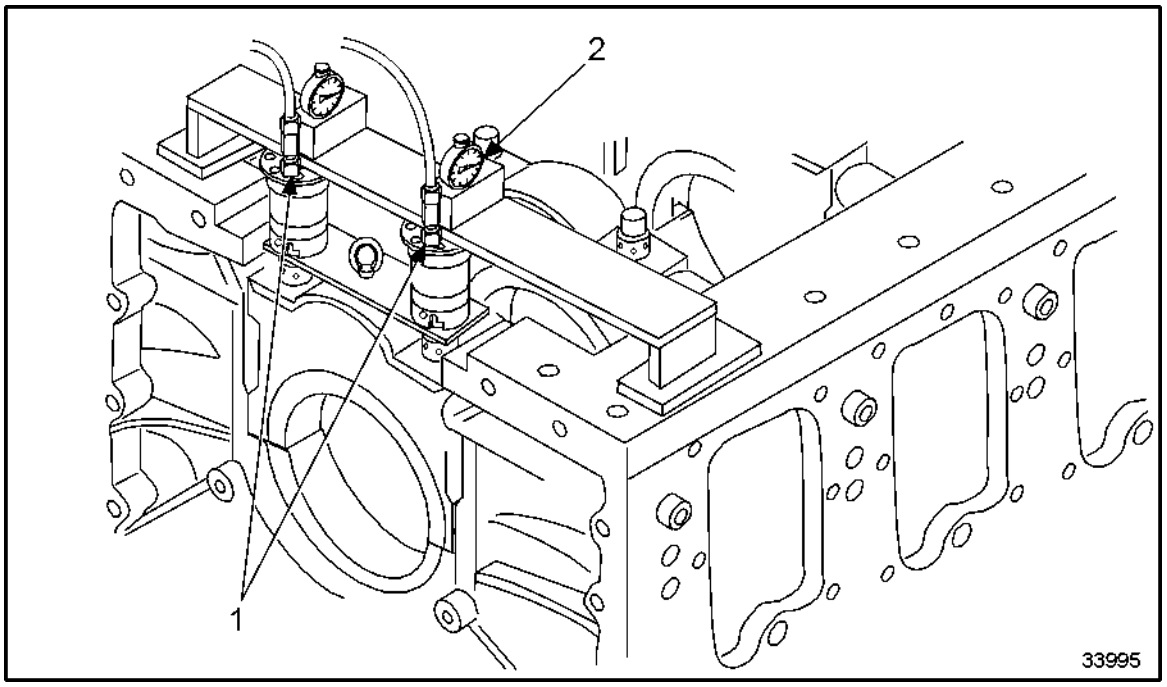
5. Turn hydraulic pretensioner by hand until it is in position. See Figure 13.



1. Hydraulic Stud Pretensioner

Figure 13 Hand-Tightening Hydraulic Pretensioner

6. Connect high-pressure hose of the hydraulic hand pump to hydraulic pretensioner. See Figure 14.



1. High-Pressure Hose of Hydraulic Hand Pump
2. Magnetic Dial Indicator

Figure 14 Connecting High-Pressure Hose of Hydraulic Hand Pump

7. Position magnetic-base indicator holder with dial gages on cylinder block support surface for extension measurement of studs.

8. Position both dial gage styluses in the center on the respective measuring core (arrow) on the surface of the sleeve measuring pin. See Figure 15.

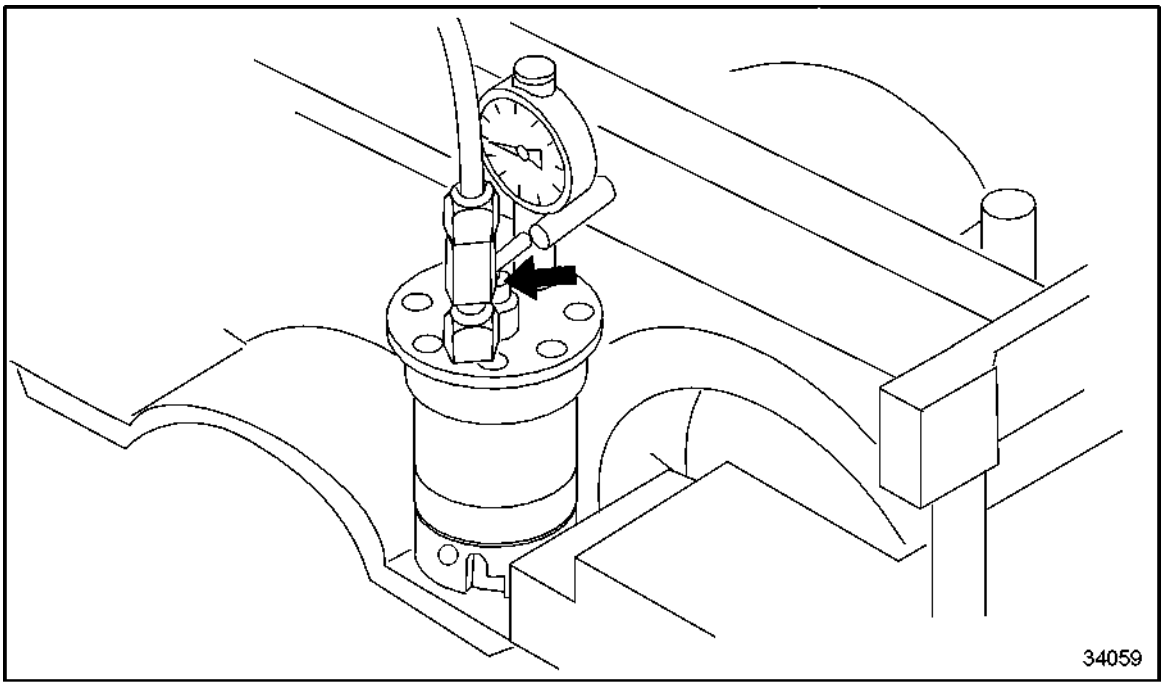


Figure 15 Positioning Dial Gage Styluses in Surface of Sleeve of Measuring Pin

9. Set dial gages with preload to zero.
10. Operate hydraulic hand pump and, at the same time, elongate studs (each by a maximum 0.25 mm). See Figure 16.

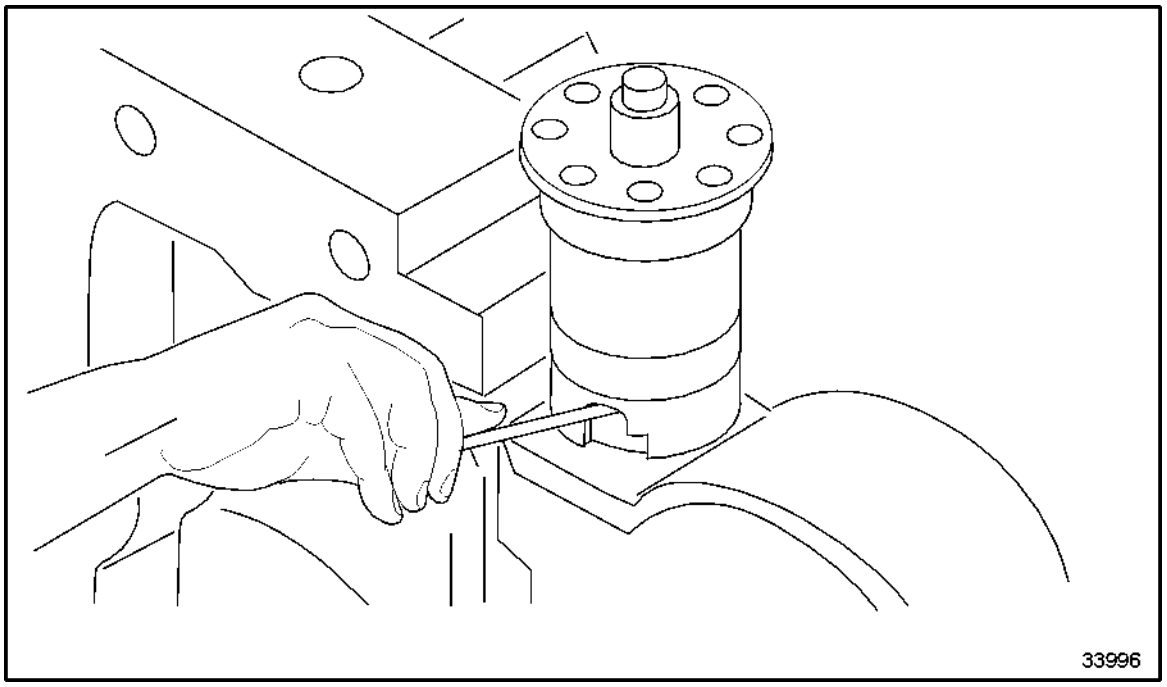


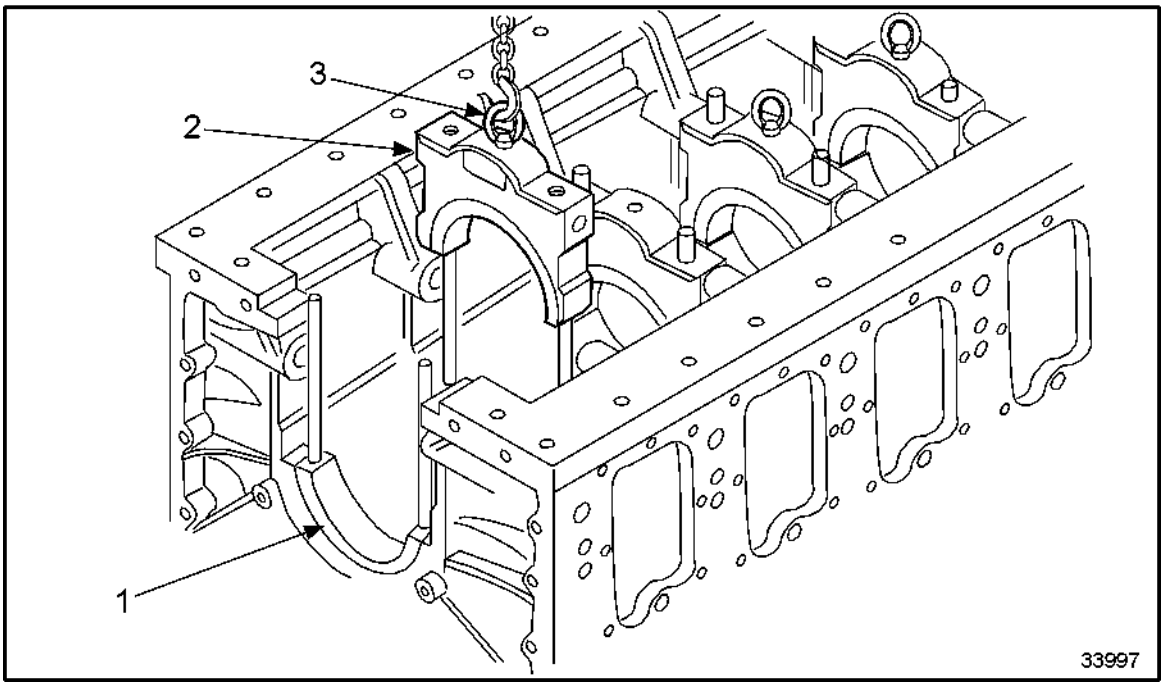
Figure 16 Removing Main Bearing Cap

11. Using a pin, remove the nuts at the main bearing cap.
12. Relieve the tension on the main bearing cap stud.
13. Remove studs, mount magnetic-base indicator holder with dial gages and hydraulic pretensioner.
14. Mount magnetic base indicator holder and hydraulic pretensioner on each adjacent bearing cap in turn and remove all nuts in the same sequence.
15. Remove loose nuts from the studs.

CAUTION:

To avoid a hand injury while handling 'sharp edged' components, wear protective gloves. Handle components only when wearing protective gloves.

16. Screw lifting eye into bearing cap. See Figure 17.



1. Upper Main Bearing Shell
2. Main Cylinder Block Bearing Cap
3. Lifting Eye

Figure 17 Pulling Bearing Cap out of Cylinder Block

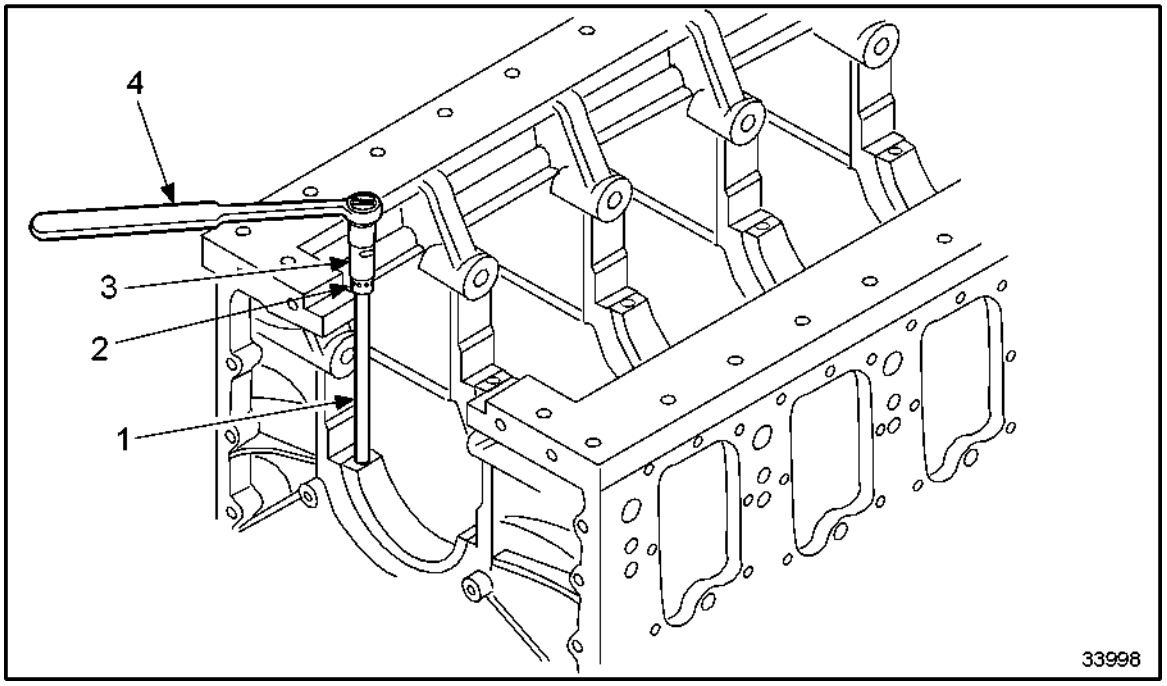
CAUTION:

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.

17. Move suitable lifting device into position.
18. Pull bearing cap (2) carefully out of cylinder block, taking care not to tilt it.

NOTE:
Remove studs only if damaged.

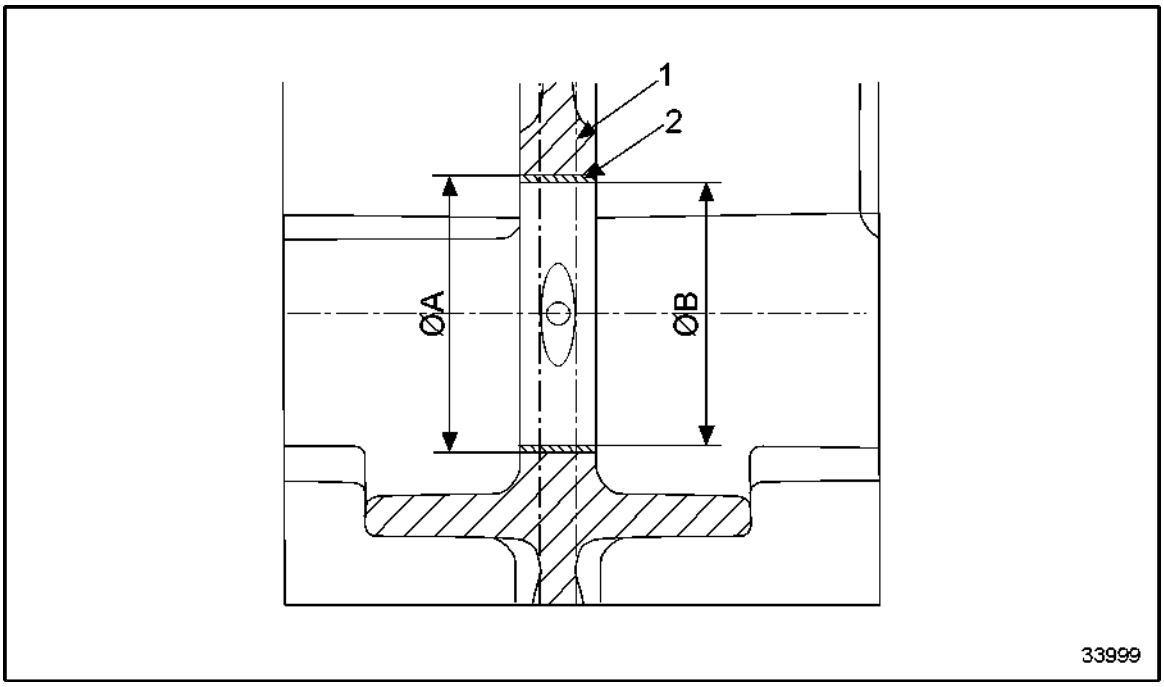
19. To remove the studs for main bearing cap, use a bearing cap nut (2), which is no longer needed, as a locknut. See Figure 18.



1. Main Bearing Cap Stud
2. Main Bearing Cap Nut
3. Socket Wrench Extension
4. Socket Wrench

Figure 18 Removing Studs for Main Bearing Cap

20. Screw main bearing cap nut (2) onto the stud which is to be removed. See Figure 18.
21. Place socket wrench (4) onto stud (1) which is to be removed and lock with main bearing cap nut (2). See Figure 18.
22. Unscrew stud (1) with socket wrench (4). See Figure 18.
23. Measure the camshaft bushing bore. Refer to section C 011.05.08 .
    [a] If limits values are exceeded, replace camshaft bushing bore.
    [b] If limit values are not exceeded, continue disassembly.
24. To remove camshaft bushing (2), use a suitable extraction tool and remove bushing carefully from bore in cylinder block. See Figure 19.



1. Camshaft
2. Camshaft Bushing

Figure 19 Removing Camshaft Bushing

NOTE:
Remove core plug only if necessary (for example in event of leakages).

25. Using a brass drift and hammer, carefully knock the edge of one side of the core plug inward until it tilts down into the bore. See Figure 20.

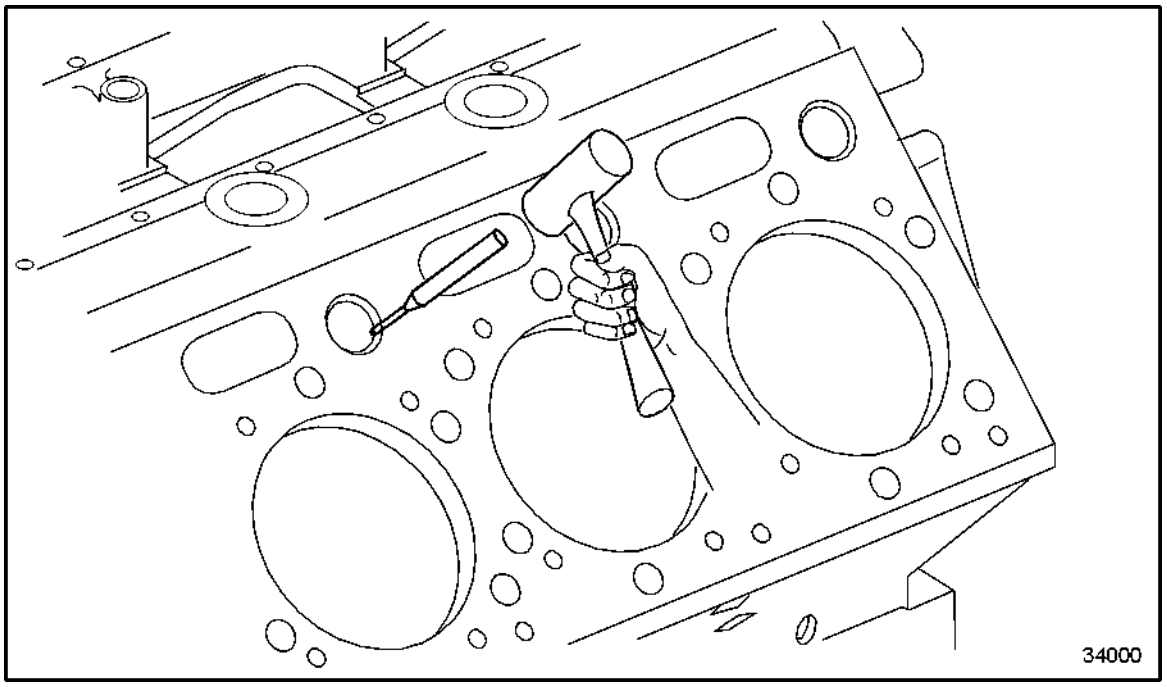
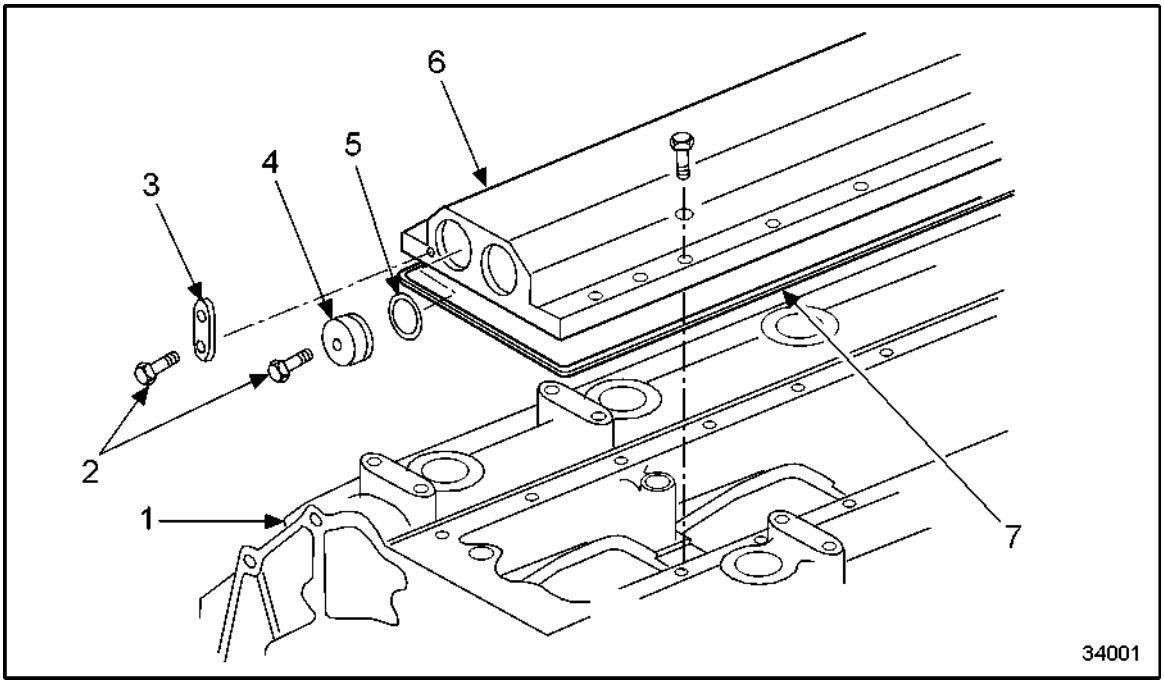


Figure 20 Removing Core Plug

26. Pull plug out with pliers.

NOTICE
Never attempt to drill a hole in the core plug, as metal chips can cause localized overheating in engine cooling jacket.

27. When removing plugs, take care that it does not fall into the bore and that the sealing surface of the bore is not damaged.
28. To remove blanking plug from oil gallery, release hex bolts (2) and link. See Figure 21.



1. Cylinder Block
2. Hex Bolts
3. Link
4. Blanking Plug
5. O-ring
6. Oil Gallery
7. Pan Seal

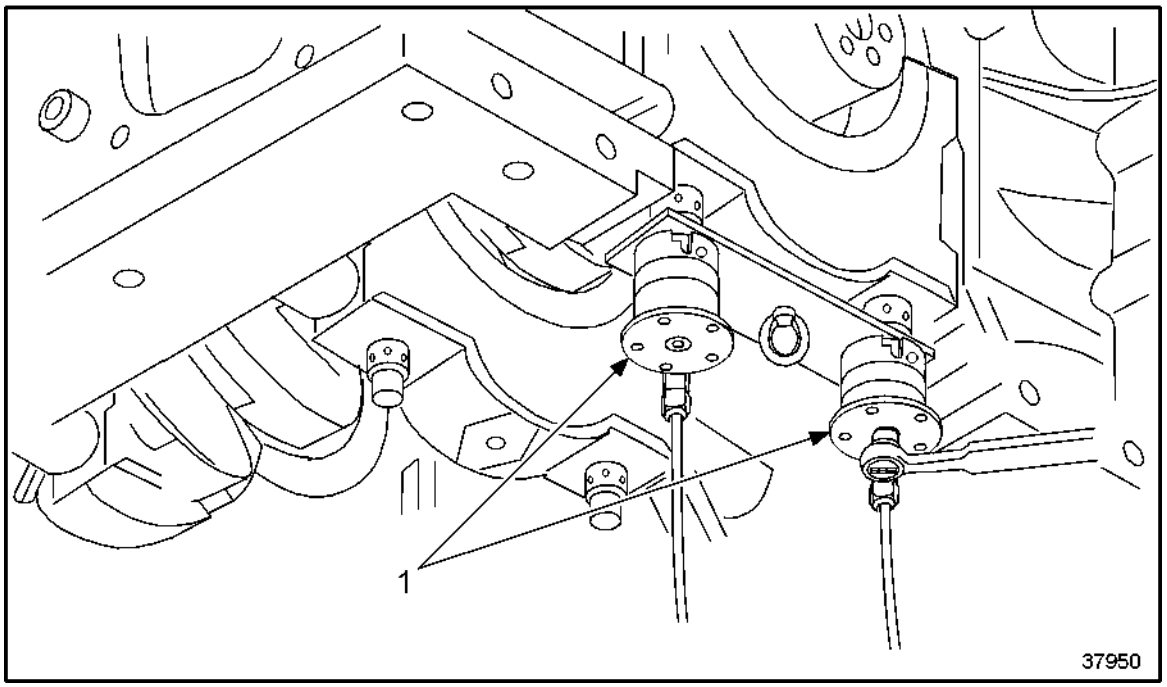
Figure 21 Removing Blanking Plug

29. Using a hex bolt (2), carefully withdraw blanking plug from oil bore. See Figure 21.
30. Remove O-ring (5) from blanking plug (4). See Figure 21.

Main Bearing Disassembly

Perform the following steps to disassemble the main bearings:

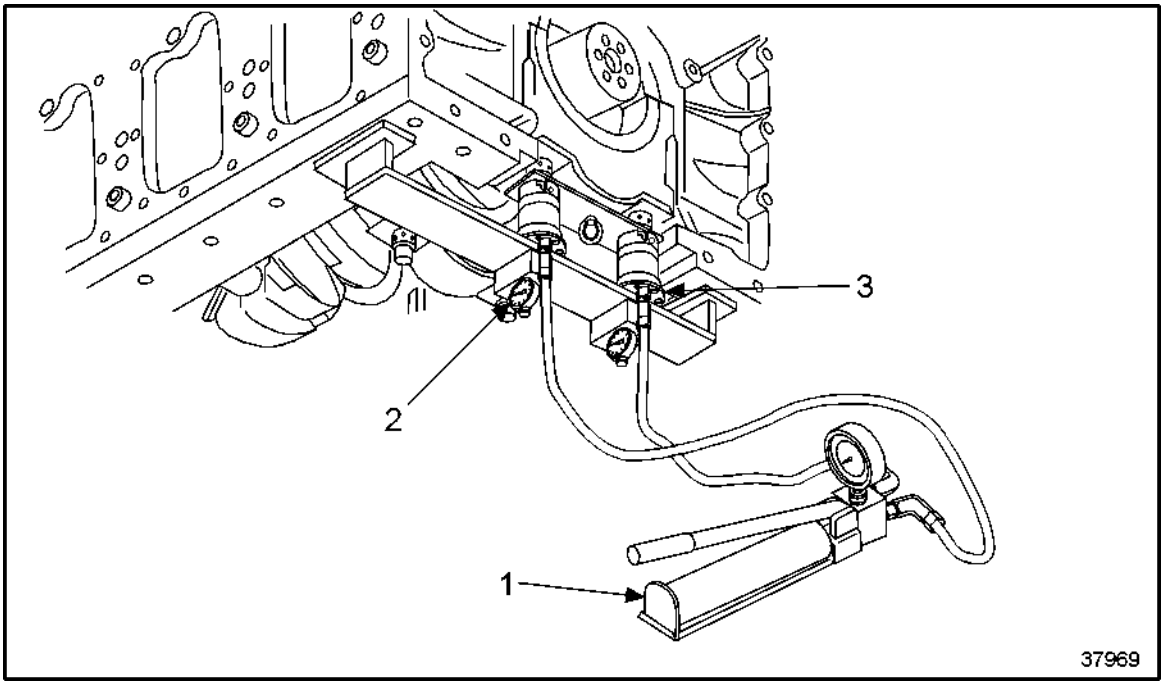
1. Beginning with the #1 main bearing cap (rear of engine), lubricate the studs to be stretched with clean engine oil. Place the main bearing stud tensioner (1) on the studs of the main bearing cap. Turn the hydraulic pretensioner by hand until it is snug, then back off one turn. See Figure 22.



1. Main Bearing Stud Tensioner

Figure 22 Stud Tensioner

2. Connect the high-pressure hose of the hydraulic hand pump to hydraulic pretensioner (3). Close the pressure bleed screw hand-tight. Position magnetic-based dial indicator bridge (J 43196) (2) with both indicator pins centered on each main bearing stud. See Figure 23.



1. Main Bearing Stud Tensioner
2. J 43196 Dial Indicator Bridge
3. Hydraulic Pretensioner

Figure 23 Connecting High-pressure Hose

3. Operate the hydraulic hand pump to elongate the studs and measure breakaway pressure. Record breakaway pressure on the main bearing installation report. Elongate the stud only enough to rotate nut loose. Using a pin, rotate the nuts on the main bearing cap studs until loose (three full turns). Open the pressure bleed valve on the hydraulic pump and release all pressure. Remove the magnetic-base dial indicator bridge.
4. Remove hydraulic pretensioners and attach a slide hammer to the 12 mm bolt hole in the center of the main bearing cap. Using the slide hammer, loosen the main bearing cap. Remove the slide hammer, main bearing stud nuts, main bearing cap, and lower main bearing shell.

NOTE:
Care should be taken not to allow the main bearing cap to drop and become damaged.

C 011.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the cylinder block:

1. Visually inspect cylinder block for cracks using the surface crack-testing method with red penetrant dye.
   [a] If cylinder block is cracked, replace component.
   [b] If cylinder block is not cracked, continue inspection.
2. Visually inspect main bearing caps for cracks using the magnetic crack-testing method with fluorescent powder.
   [a] If crankshaft main bearing caps or bolts of main bearing cap are cracked, replace component.
   [b] If crankshaft main bearing caps or bolts of main bearing cap are not cracked, continue inspection.
3. Visually inspect mating surfaces, upper and lower bores of the cylinder liners in the cylinder block for wear, damage or pitting.
   [a] If mating surfaces, upper and lower bores of the cylinder liners in the cylinder block are worn, damaged or pitted, machine as necessary.
   [b] If mating surfaces are beyond repair, replace component as necessary.
   [c] If mating surfaces, upper and lower bores of the cylinder liners in the cylinder block are not worn, damaged or pitted, continue inspection.
4. Visually inspect thread and shaft of main bearing cap studs for damage.
   [a] If thread or shaft of main bearing cap studs are damaged, replace component as necessary.
   [b] If thread and shaft of main bearing cap studs are not damaged, continue inspection.
5. Visually inspect thread, shaft and bolt head surface of the cross bolts to secure crankshaft main bearing cap at the side, to ensure that they are in perfect condition.
   [a] If cross bolts are not in perfect condition, replace as necessary.
   [b] If cross bolts are in perfect condition, continue inspection.
6. Visually inspect camshaft bushings for wear and damage.
   [a] If camshaft bushings are worn or damaged, replace component.
   [b] If camshaft bushings are not worn or damaged, continue inspection.
7. Visually inspect all mating surfaces, sealing surfaces and bores for damage, wear or pitting.
   [a] If mating surfaces are beyond repair, replace component as necessary.
   [b] If mating surfaces, sealing surfaces or bores are not damaged, worn or pitted, continue inspection.

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. Thoroughly blow clear all threads and inspect for ease of movement.
   [a] If threads do not show ease of movement, machine component as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If threads do show ease of movement, continue inspection.

Access Cover with Oil Filler Neck Inspection and Repair

Perform the following steps to inspect and repair the access cover with oil filler neck:

1. Clean all components.

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.

2. Clean access cover with oil filler neck with suitable solvent and blow clear with compressed air.
3. Visually inspect access cover with oil filler neck for damage and defects.
   [a] If access cover with oil filler neck is damaged or defected, replace component.
   [b] If access cover with oil filler neck is not damaged or defected, continue inspection.
4. Visually inspect threads for damage or wear.
   [a] If damage is beyond repair, replace as necessary.
   [b] If threads are not damaged, continue inspection.
5. Replace gasket.

NOTE:
Ensure access cover with oil filler neck is perfectly clean.

Oil Dipstick Cleaning, Inspection and Repair

To clean, inspect and repair the oil level dipstick, perform the following steps:

1. Visually inspect oil dipstick for damage, defects or previous repairs.
   [a] If dipstick shows damage, defects or previous repairs, replace component.
   [b] If dipstick does not show damage, defects or previous repairs, continue inspection.

NOTE:
When replacing dipstick, ensure correct version is used. Part number is stamped on grip.

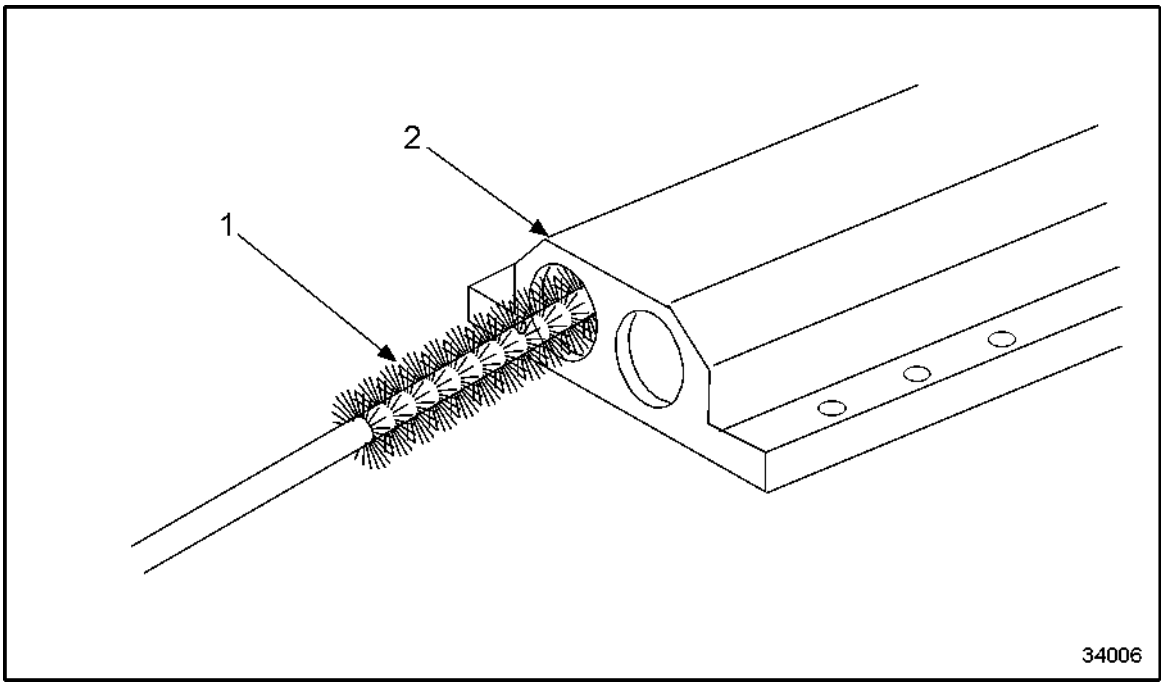
2. Ensure that the oil level dipstick is secure in the access cover with dipstick tube.
3. Replace O-ring.

NOTE:
Ensure that parts are perfectly clean.

Oil Gallery Cleaning, Inspection and Repair

Perform the following steps to clean, inspect and repair the oil gallery:

1. Remove old sealant from mating surfaces and visually inspect for wear and damage. See Figure 24.



1. Hole Brush
2. Oil Gallery

Figure 24 Cleaning Oil Bores in Cap with Hole Brush

   [a] If mating surface is worn or damaged, machine as necessary.

   [b] If damage is beyond repair, replace component as necessary.

   [c] If mating surface is not worn or damaged, continue inspection.

2. Thoroughly clean oil bore, using a bristle brush if necessary.

NOTE:
Never use a wire brush.

CAUTION:

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

3. After cleaning, flush oilway (under pressure if possible) and blow clear with compressed air.
4. Protect bore with plastic plugs or suitable adhesive tape against contamination, until assembly of engine.

Oil Bore in Cylinder Block Inspection and Repair

NOTE:
During a major engine overhaul or when there are metal chips in the engine oil system, all oil bores must be thoroughly inspected to ensure they are clean.

Perform the following steps to inspect and repair the oil bores in cylinder block:

1. Light oil bores with a borescope and cold light sources to ensure they are clean. See Figure 25.

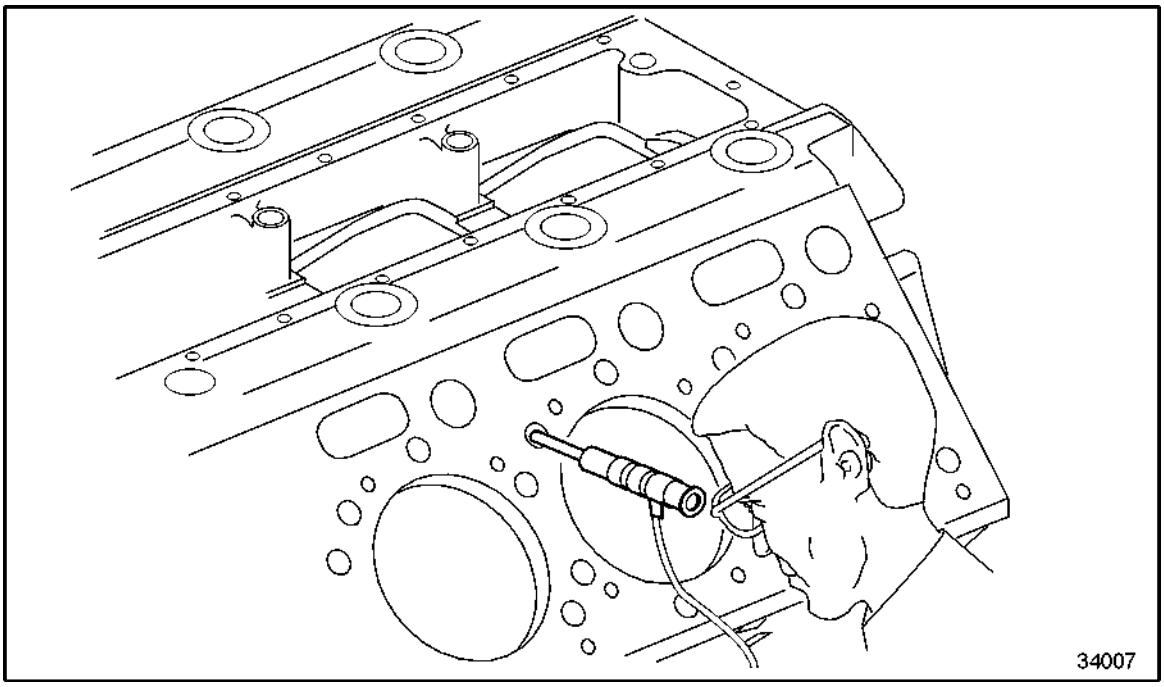


Figure 25 Viewing Oil Bores to Valve Operating Mechanism with Borescope

2. Visually inspect oil supply bores to valve operating mechanism at cylinder block, sides A and B.
   [a] If oil supply bores are not clean, use bristle brush to clean.
   [b] If oil supply bores are clean, continue inspection.

3. Visually inspect main oil supply bores to camshaft and main bearings in block valley. See Figure 26.

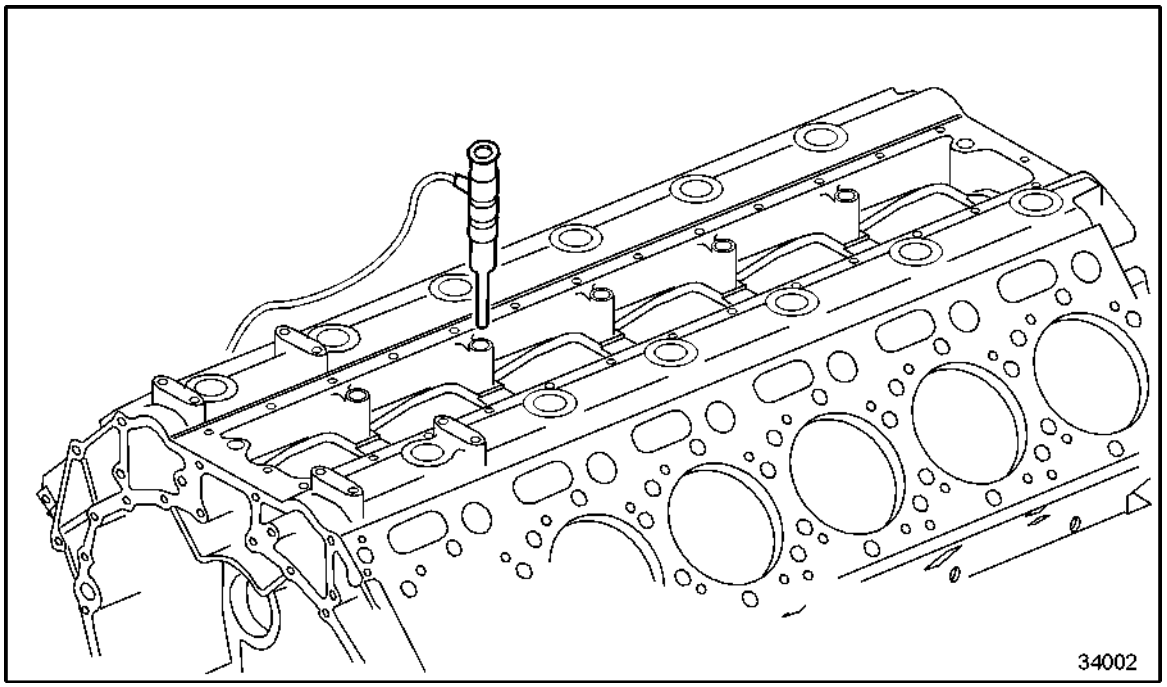
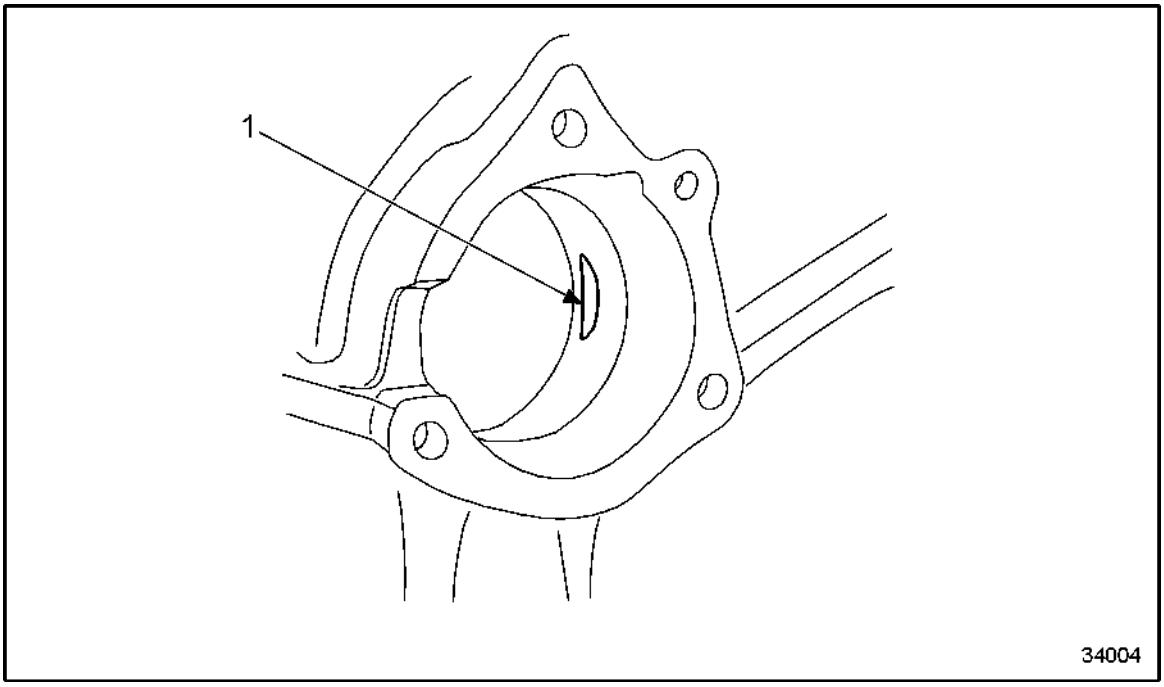


Figure 26 Viewing Main Oil Supply Bores to Camshaft and Main Bearing with Borescope

[a] If main oil bores to camshaft and main bearings in block valley are not clean, use bristle brush to clean.

[b] If main oil bores to camshaft and main bearing in block valley are clean, continue inspection.

4. Visually inspect oil bores (1) in the camshaft bushing bores. See Figure 27.



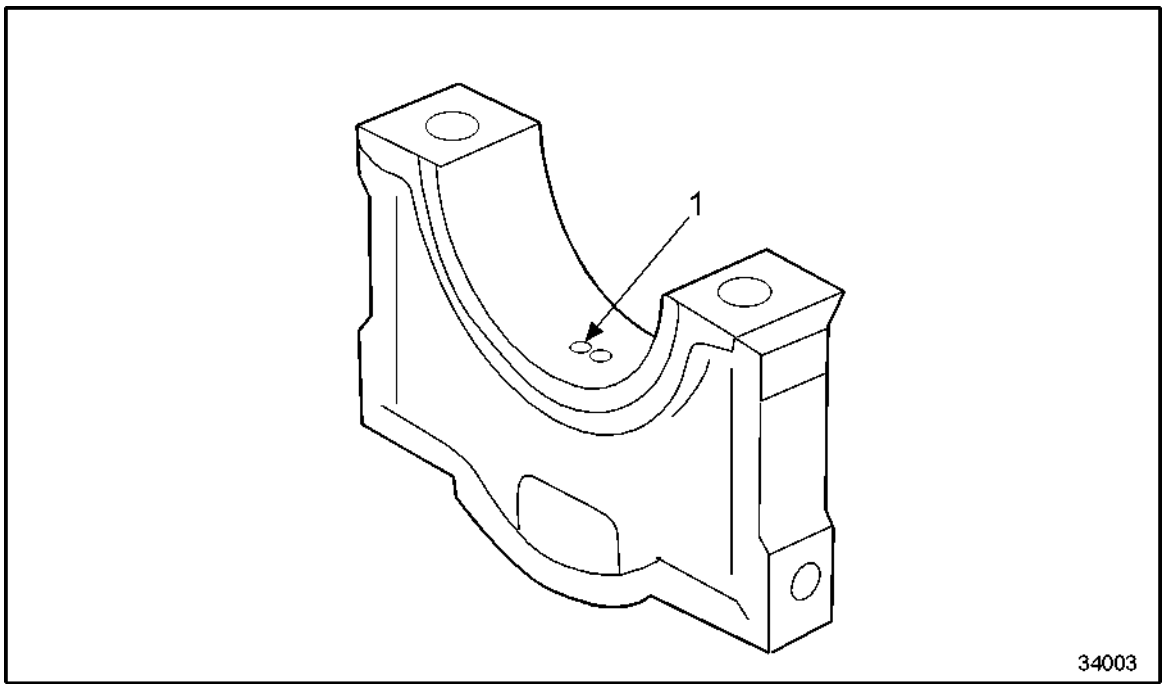
1. Oil Bore

Figure 27 Inspecting Oil Bores in Camshaft Bushing Bore

[a] If oil bores in camshaft bushing bores are not clean, use bristle brush to clean.

[b] If oil bores in camshaft bushing bores are clean, continue inspection.

5. Visually inspect oil bores (1) to the main bearings. See Figure 28.



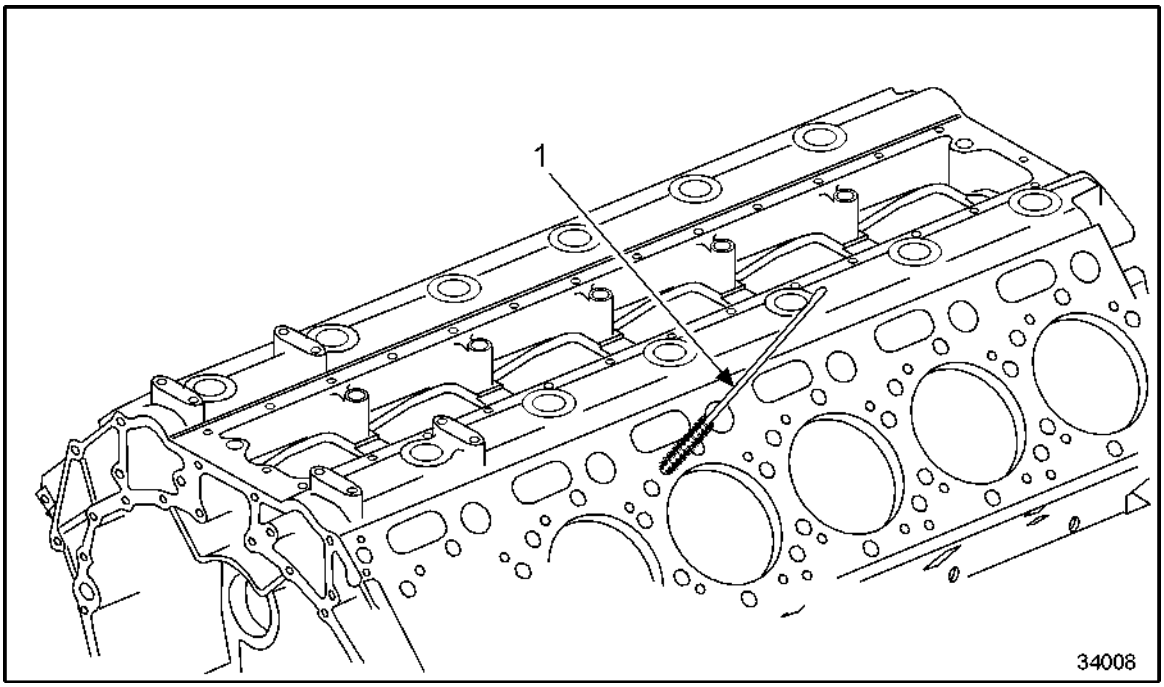
1. Oil Bores

Figure 28 Inspecting Oil Bores To Main Bearing

[a] If oil bores to the main bearings are not clean, use bristle brush to clean.

[b] If oil bores to the main bearings are clean, continue inspection.

6. Visually inspect all other coolant and oil carrying bores for contamination in the same manner. See Figure 29.



1. Bristle Brush

Figure 29 Cleaning Bores with Bristle Brush

[a] If any other coolant or oil-carrying bores are contaminated, use a bristle brush to clean.

[b] If all other coolant or oil-carrying bores are not contaminated, continue inspection.

7. If necessary, clean bores with bristle brush (1).

NOTE:
To avoid scratching cylinder block, never use a wire brush.

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.

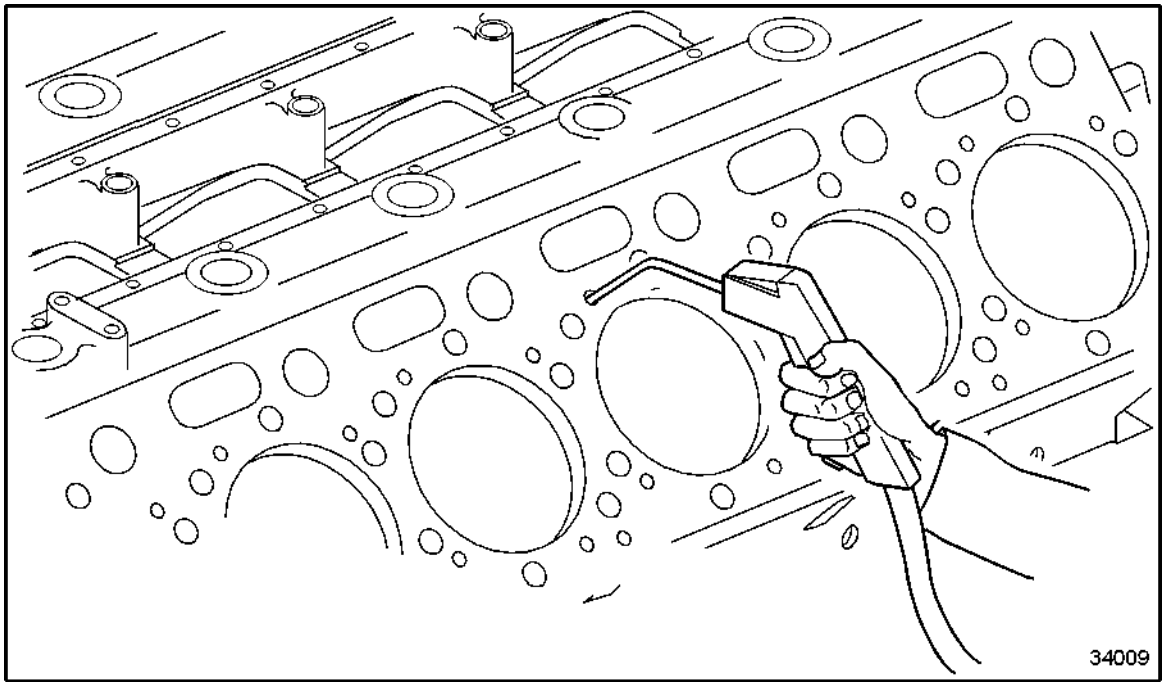


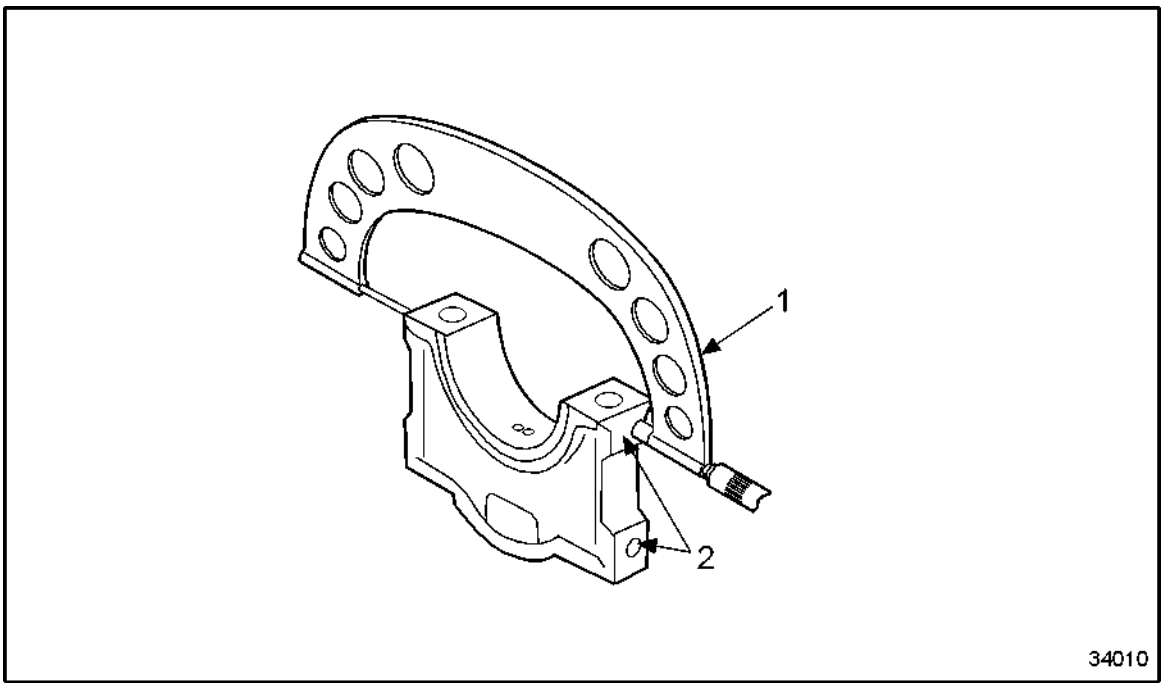
Figure 30 Flushing Bore with Compressed Air

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

Measure Main Bearing Cap Width

Perform the following steps to measure main bearing cap width:

1. Using an outside micrometer (1), measure the main bearing cap width at the bottom and top fits of the bearing cap (2). See Figure 31.



1. Outside Micrometer
2. Measurement Area (Upper and Lower)

Figure 31 Measuring Main Bearing Cap Width

Install Main Bearing Cap

Perform the following steps to install the main bearing cap:

1. Wipe bearing shell mating surfaces on main bearing cap using chamois cloth. See Figure 32.

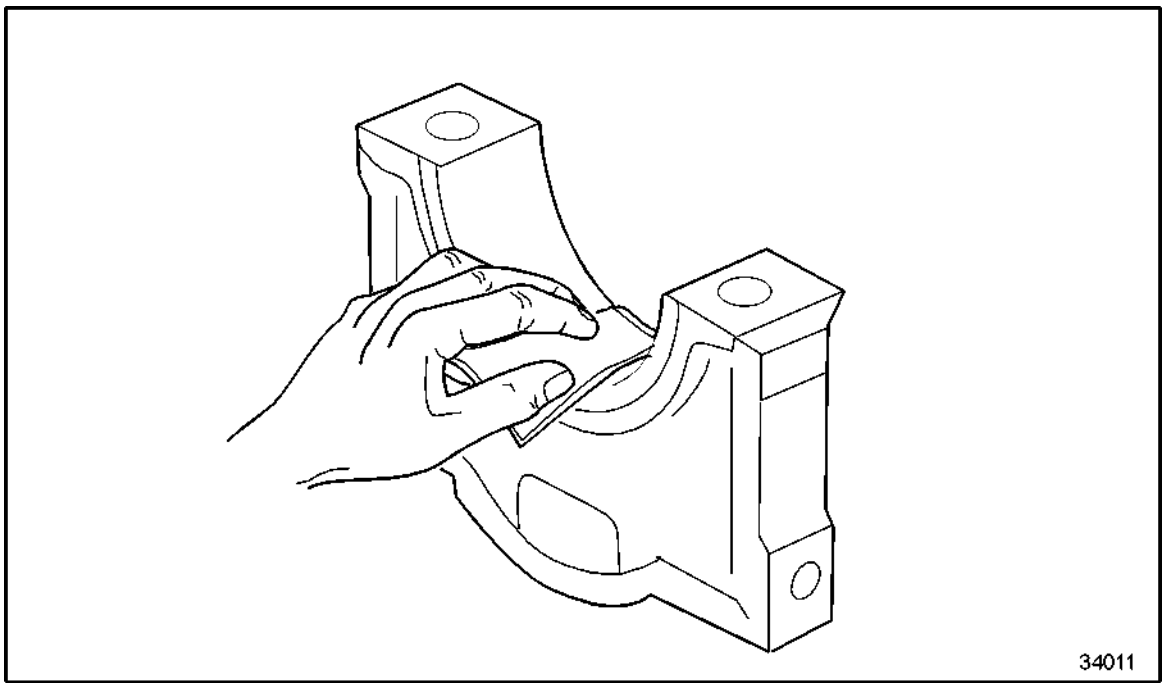


Figure 32 Cleaning Main Bearing Cap

CAUTION:

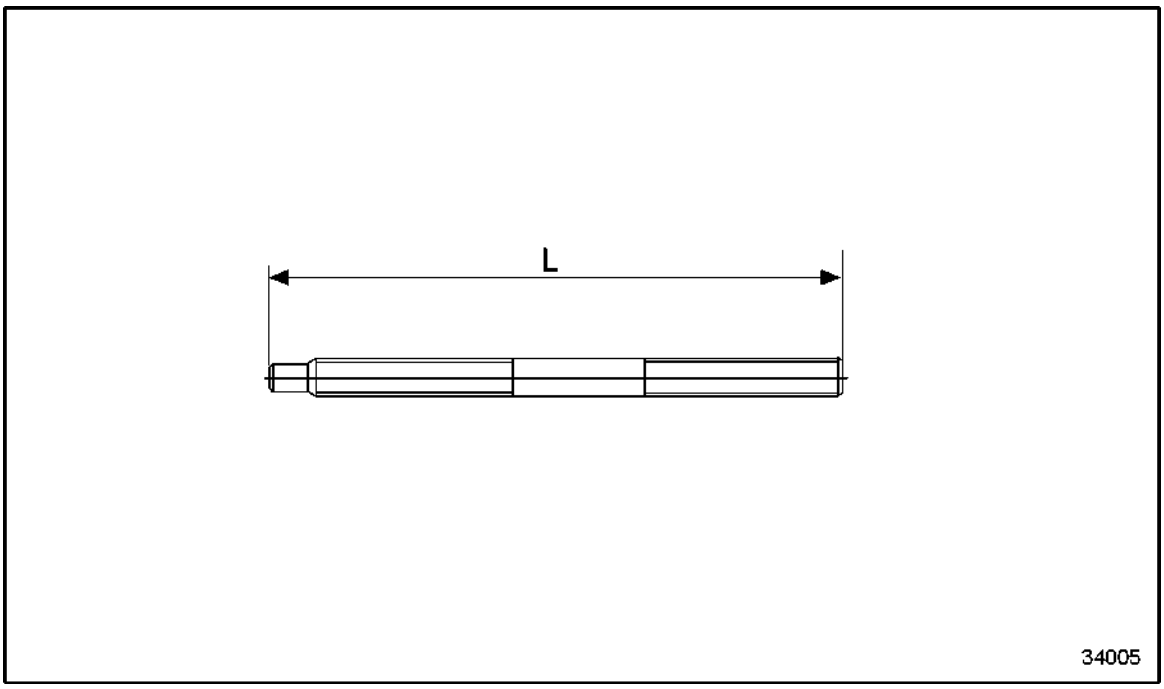
To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

2. Visually inspect mating surfaces on main bearing cap and cylinder block to ensure they are clean.
   [a] If mating surfaces on main bearing cap and cylinder block are not clean, blow out with compressed air as necessary.
   [b] If mating surfaces on main bearing cap and cylinder block are clean, continue inspection.

Inspect Stud for Main Bearing Cap

Perform the following steps to inspect the stud for the main bearing cap.

1. Measure length L of the stud. See Figure 33.



L_{max} = 348.5 mm (13.7 in)
If L > L_{max}, replace stud.

Figure 33 Inspecting Stud for Main Bearing Cap

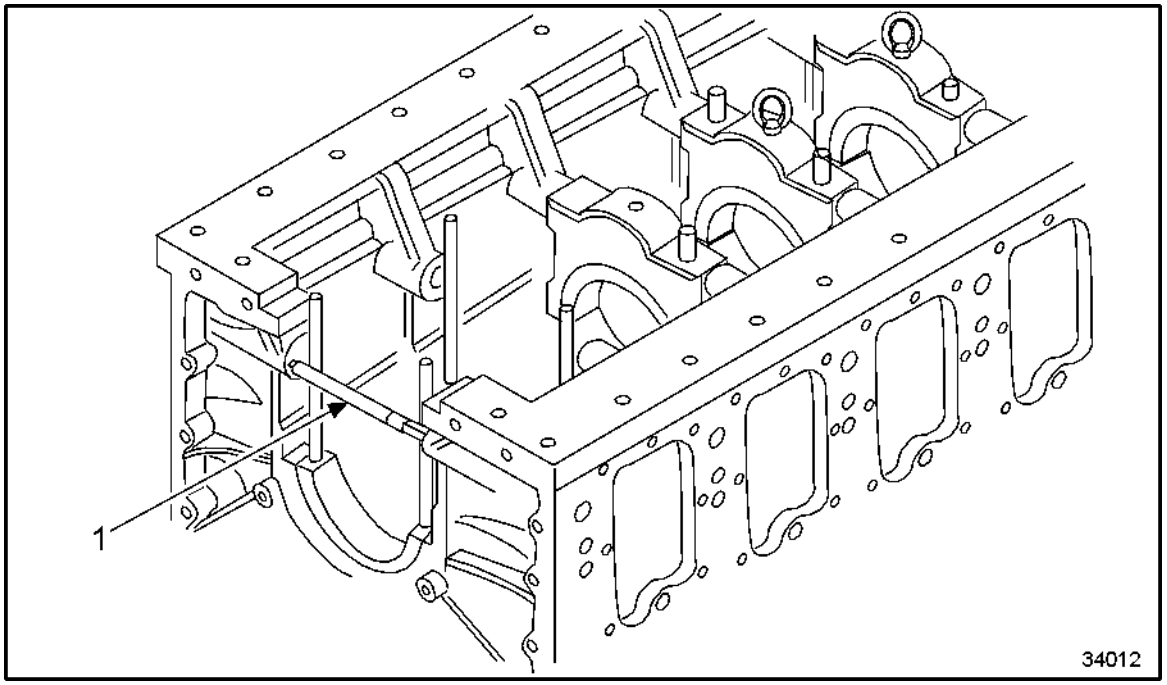
2. Visually inspect thread and shaft to ensure they are in perfect condition.
   [a] If thread and shaft are not in perfect condition, replace stud.
   [b] If thread and shaft are in perfect condition, continue inspection.

Measure Bearing Cap Guides

Perform the following steps to measure main bearing cap guides:

1. Using bore gage (1), measure main bearing cap guides at upper and lower fits. See Figure 34.

NOTE:
Do not measure main bearing cap guides with cylinder block installed in turnover stand (measured values will be incorrect).



1. Bore Gage

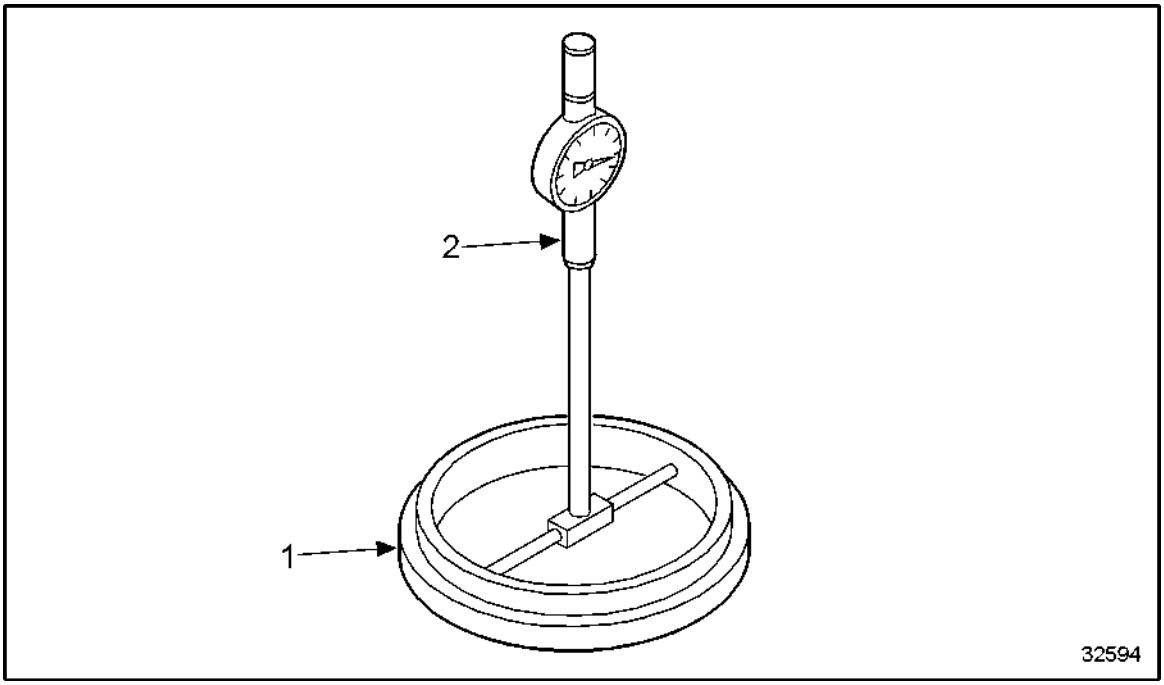
Figure 34 Measuring Main Bearing Cap Guides

For an example of data sheet, refer to section A 006A 006 .

Set Bore Gage

Perform the following steps to set the bore gage:

1. Adjust bore gage and dial gage (2) with adjusting ring (1) or micrometer to basic size of respective bore to be measured. See Figure 35.



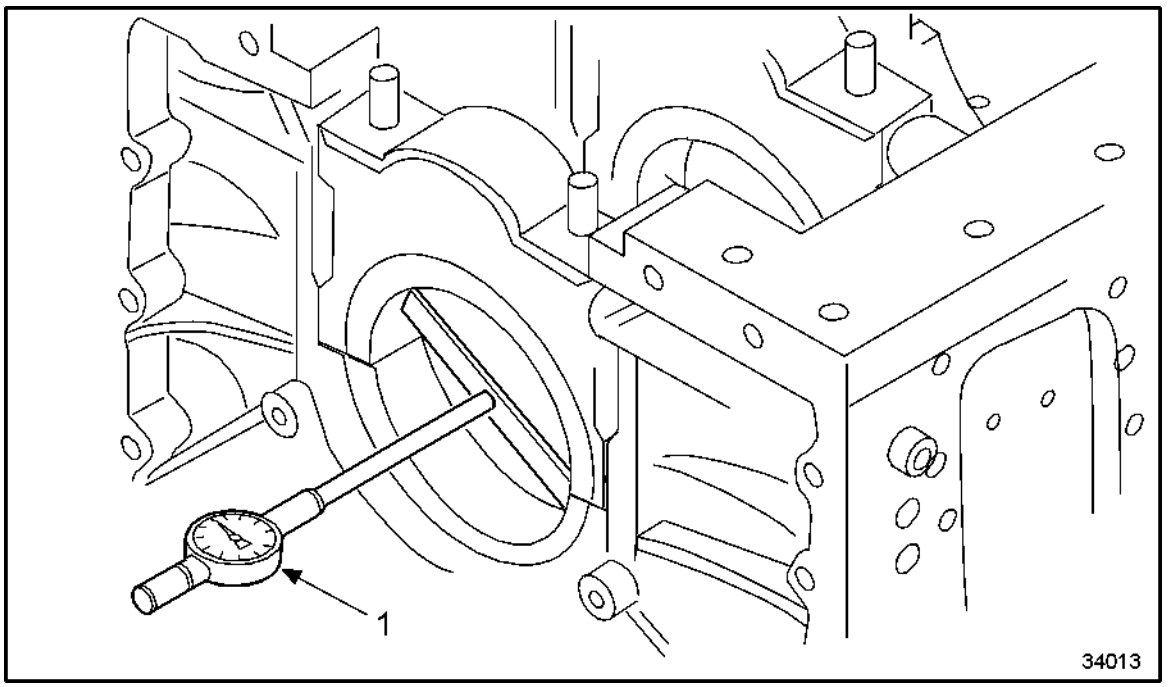
1. Adjusting Ring
2. Dial Gage

Figure 35 Setting Bore Gage

Measure Main Bearing Bore

Perform the following steps to measure the main crankshaft bearing bore.

1. Install main bearing cap. Refer to section C 011.05.11 .
2. Using a bore gage (1), measure the main bearing bore. See Figure 36.



1. Bore Gage

Figure 36 Measuring Main Bearing Bore

3. If reconditioning is necessary, recondition only the respective bearing in the cylinder block to the next repair stage.
   [a] Mark repair stage work on a main bearing bore with numeral punches, at least 6 mm (0.23622 in.) high;

   — at stage 1: + 0.5 mm

   — at stage 2: +1.0 mm

   [b] Marking location is on the underside of the cylinder block, on the B side web of the main bearing affected, also refer to section C 011.05.06 .

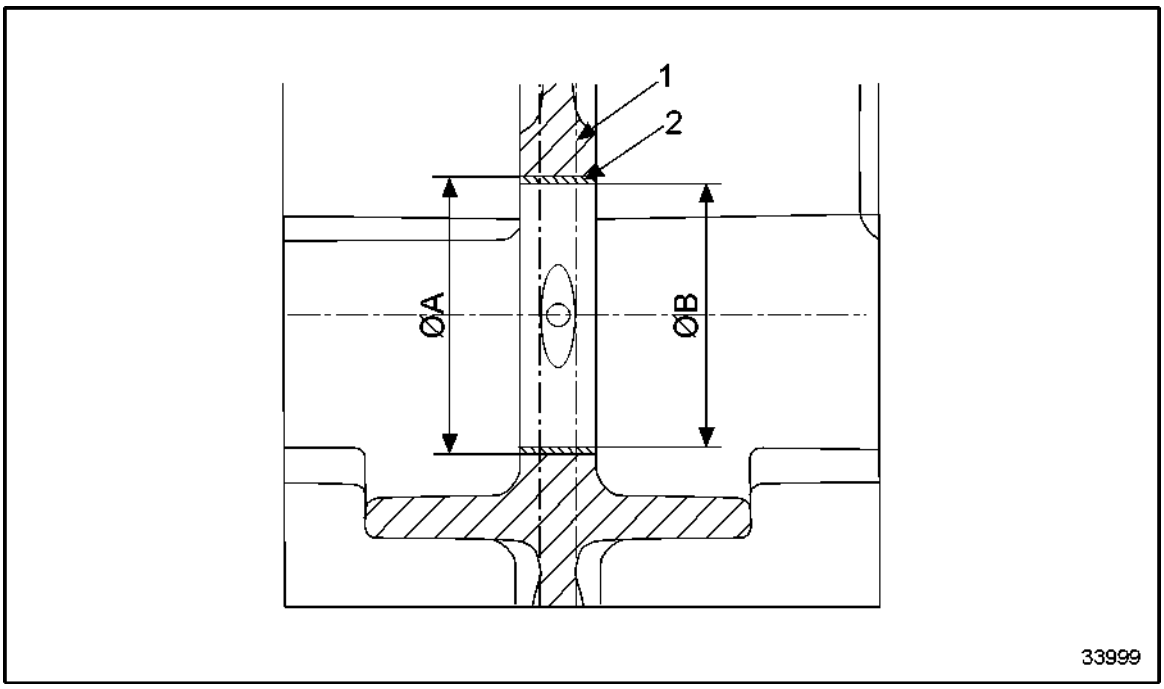
NOTE:
If a new main bearing cap is being installed, its position must be marked accordingly. See information on installing bearing cap and refer to section C 011.05.06 .

For an example of data sheet, refer to section A 006A 006 .

Measure Camshaft Bushing Bore

Perform the following steps to measure camshaft bushing bore:

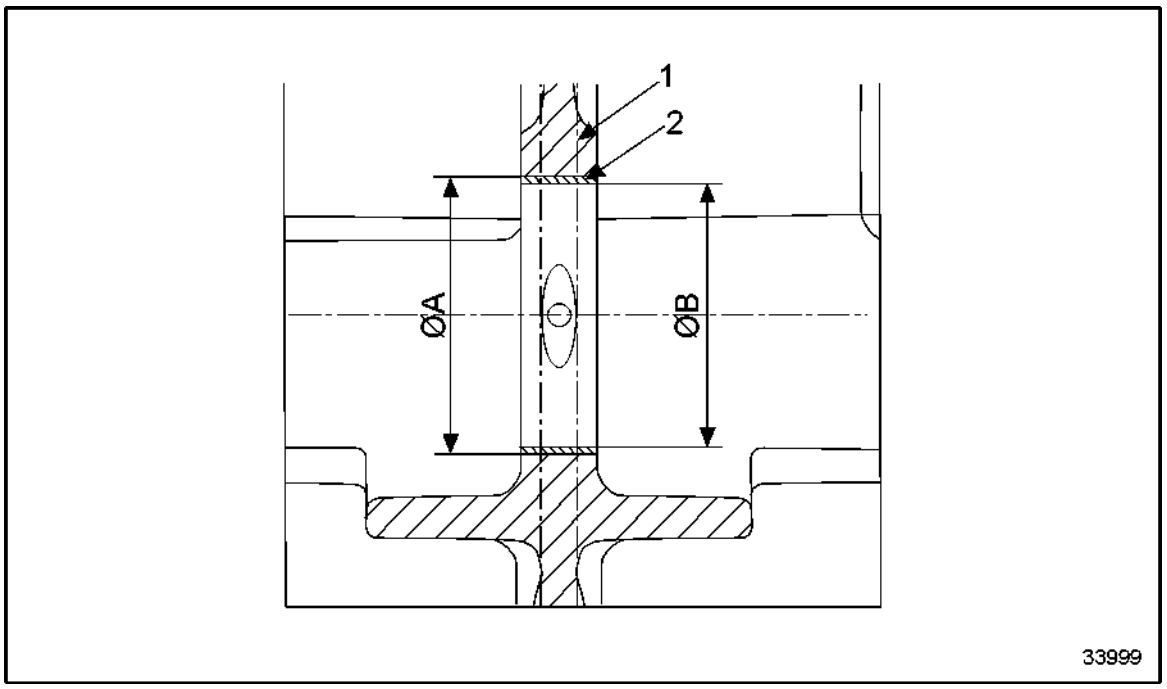
1. Using a bore gage, measure camshaft bushing bore (diameter B). See Figure 37.



1. Cylinder Block
2. Bushing

Figure 37 Measuring Camshaft Bushing Bore

2. Replace camshaft bushing (2) if limit values are exceeded. See Figure 38.



1. Cylinder Block
2. Bushing

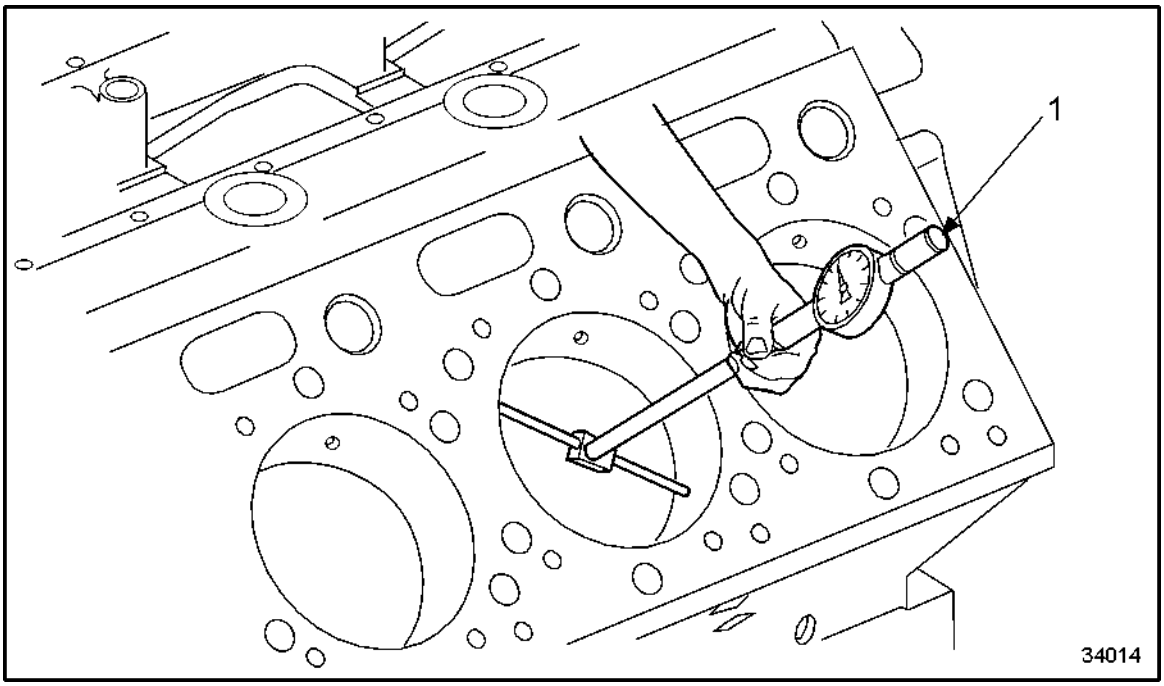
Figure 38 Measuring Camshaft Bushing Bore

3. After removing camshaft bushing, measure bushing bore (diameter A) in cylinder block (1). See Figure 38.
   [a] If limit values are exceeded, recondition bushing bore to next repair size.
   [b] If limit values are not exceeded, continue to next step.

Measure Cylinder Block Bore

Perform the following steps to measure cylinder block bores for cylinder liners:

1. Using bore gage (1), measure cylinder block bores for cylinder liners by measuring upper and lower circumference of cylinder liner bores. See Figure 39.



1. Bore Gage

Figure 39 Measuring Cylinder Block Bores for Cylinder Liners

[a] If wear limit values are exceeded, recondition bores to next repair size.

[b] If wear limits are not exceeded, continue to next step.

2. If reconditioning is necessary, only recondition the respective cylinder liner bore in cylinder block - top and bottom of bores - to next repair stage.

[a] Mark repair stage work with numeral punches at least 6 mm high;

— at stage 1: + 0.5 mm

— at stage 2: +1.0 mm

[b] Marking location is at the top edge of the cylinder block side surface below the roof surface, beside the affected cylinder.

For an example of data sheet, refer to section A 006A006 .

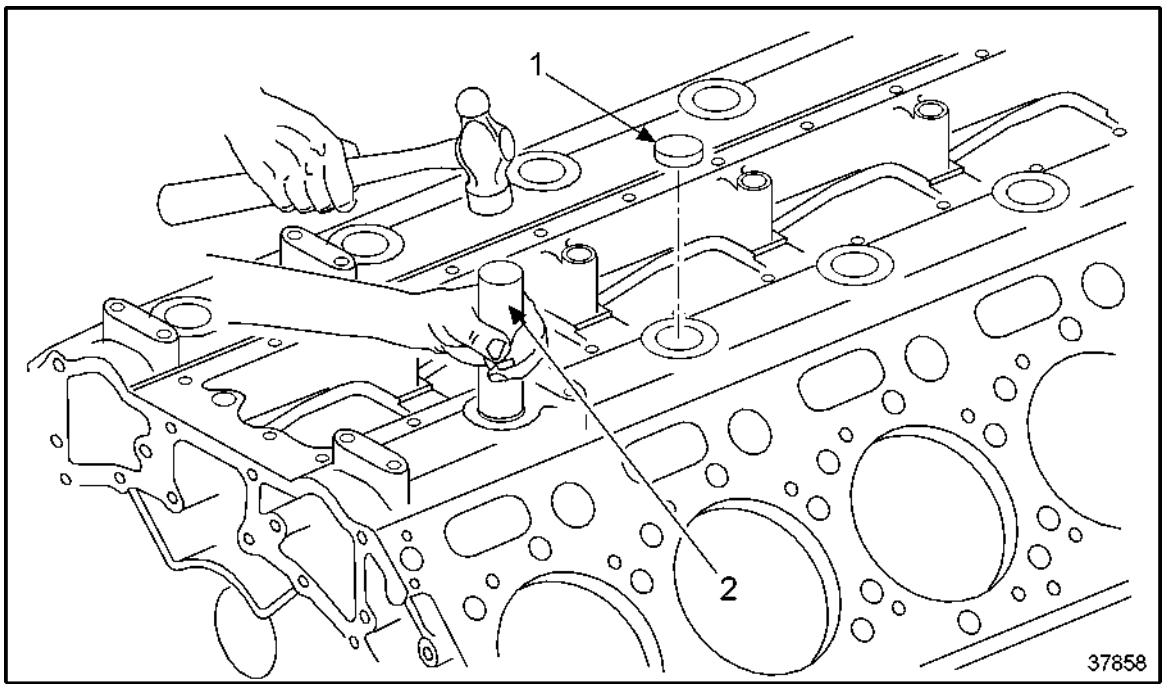
C 011.05.10 – ASSEMBLY OF CRANKSHAFT AND MAIN BEARINGS

Perform the following subsections to assemble the crankshaft and main bearings:

Crankshaft Assembly

Perform the following steps for the assembly of the crankshaft:

1. To install core plugs (1), clean and degrease seating surface on core plugs and bore in cylinder block. See Figure 40.



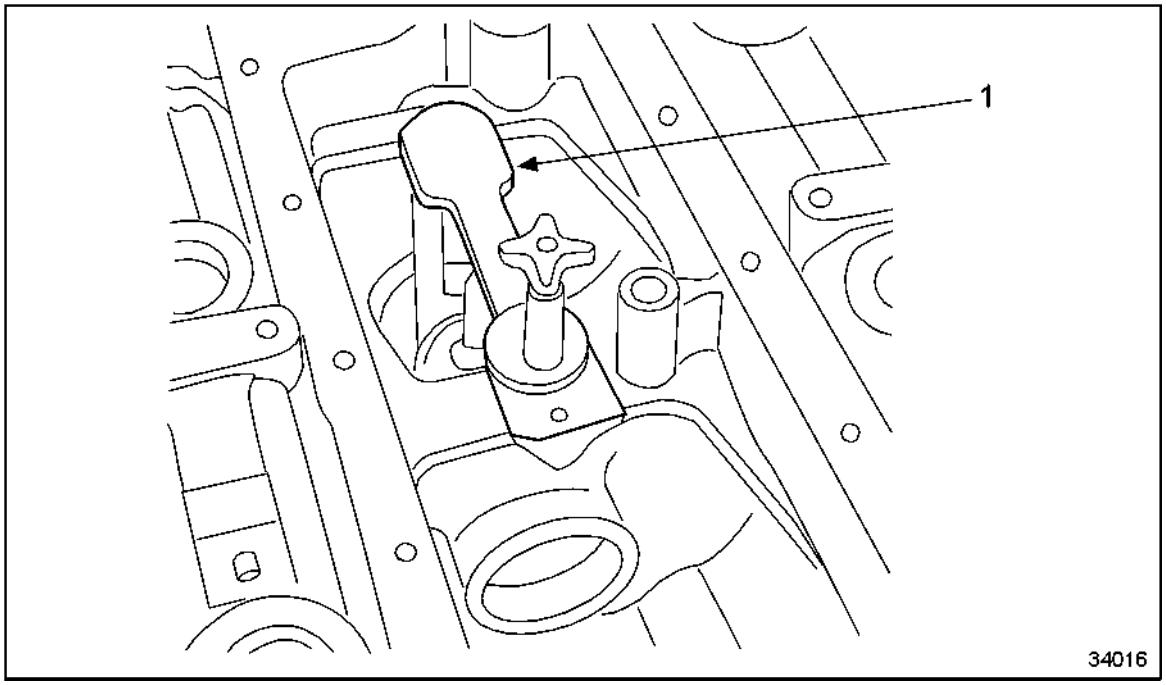
1. Core Plug
2. Plug Installer

Figure 40 Installing Core Plugs

2. Coat sealing surface of plugs with thread locking compound.
3. Using a plug installer, knock cap plug into the cylinder block plug bore.

NOTE:
If necessary (because of leaks, sealing surface damage), the plug can be replaced after it has been knocked out with a brass drift.

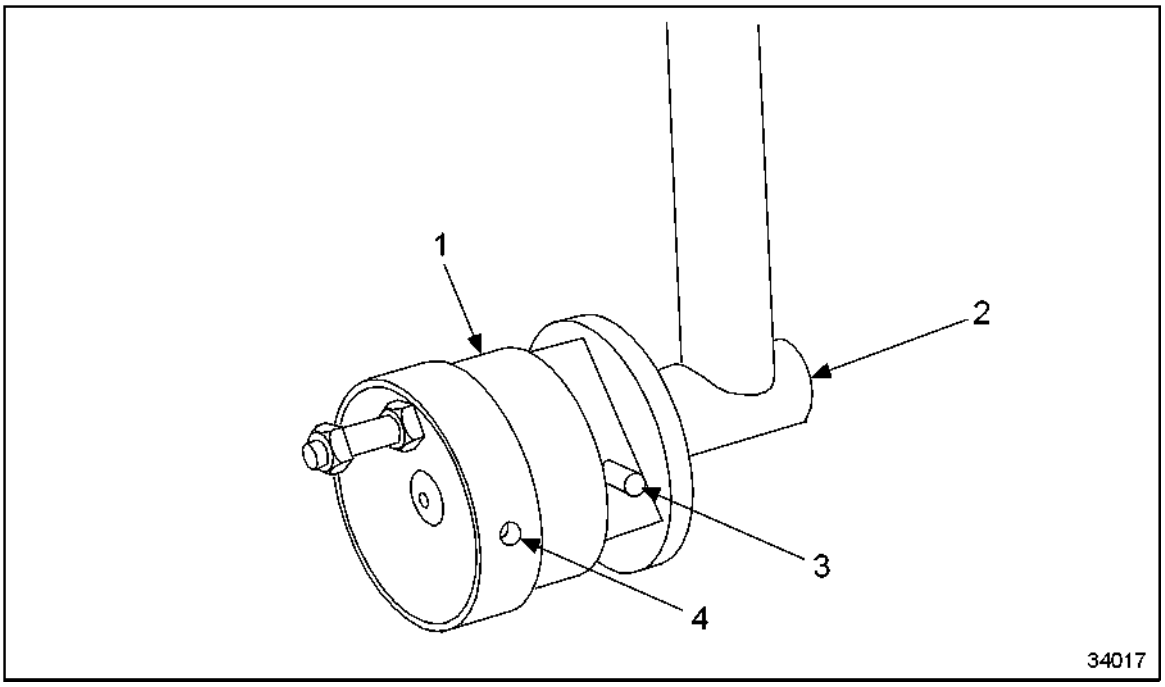
4. Beginning with the first camshaft bushing, screw the stop and camshaft bushing alignment device (1) onto the locating bore of the rocker shafts. See Figure 41.



1. Fixture for Stop and Alignment of Camshaft Bushing

Figure 41 Installing Camshaft Bearings 1 to 6

5. Numerical sequence begins at flywheel end with camshaft bushing number 1.
6. Fit plastic insertion pin (2) onto assembly tool (1). See Figure 42.



1. Assembly Tool
2. Plastic Insertion Brass Drift
3. Spring-Loaded Locating Brass Drift
4. Oil Bore of Camshaft Bushing

Figure 42 Fitting Plastic Insertion Brass Drift onto Assembly Tool

CAUTION:

To avoid personal injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

7. Cool camshaft bushings in liquid nitrogen.
8. Fit the cooled camshaft bushing onto the assembly tool so that the spring-loaded fixing brass drift (3) of the assembly tool engages in the oil bore (4) of the camshaft bushing. See Figure 42.
9. Remove insertion brass drift from assembly tool. See Figure 43.

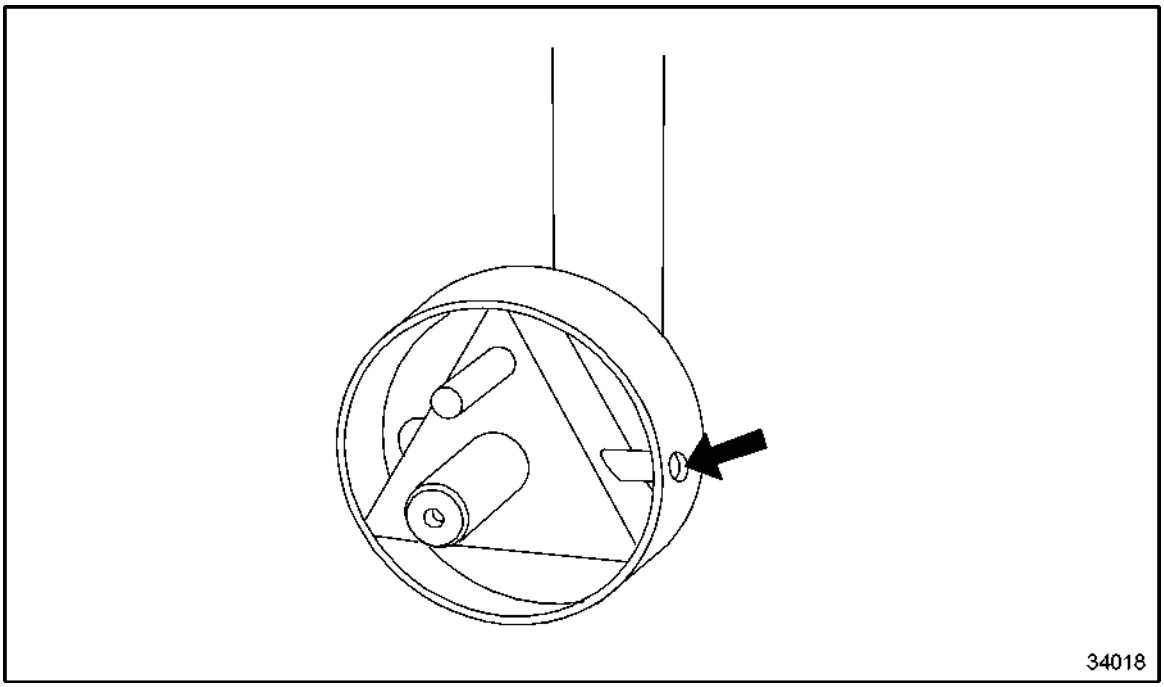
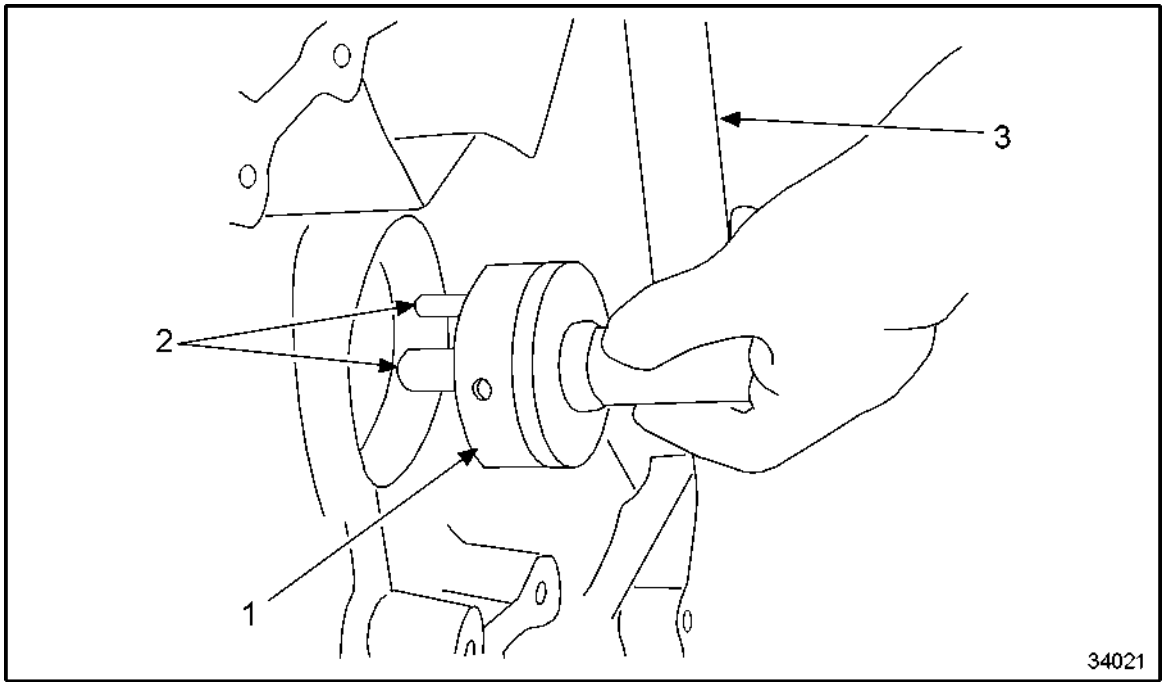


Figure 43 Removing Insertion Brass Drift from Assembly Tool

10. Verify position of camshaft bushing oil bore in assembly tool (arrow).
11. Prepare assembly tool (3) as described above. See Figure 44.

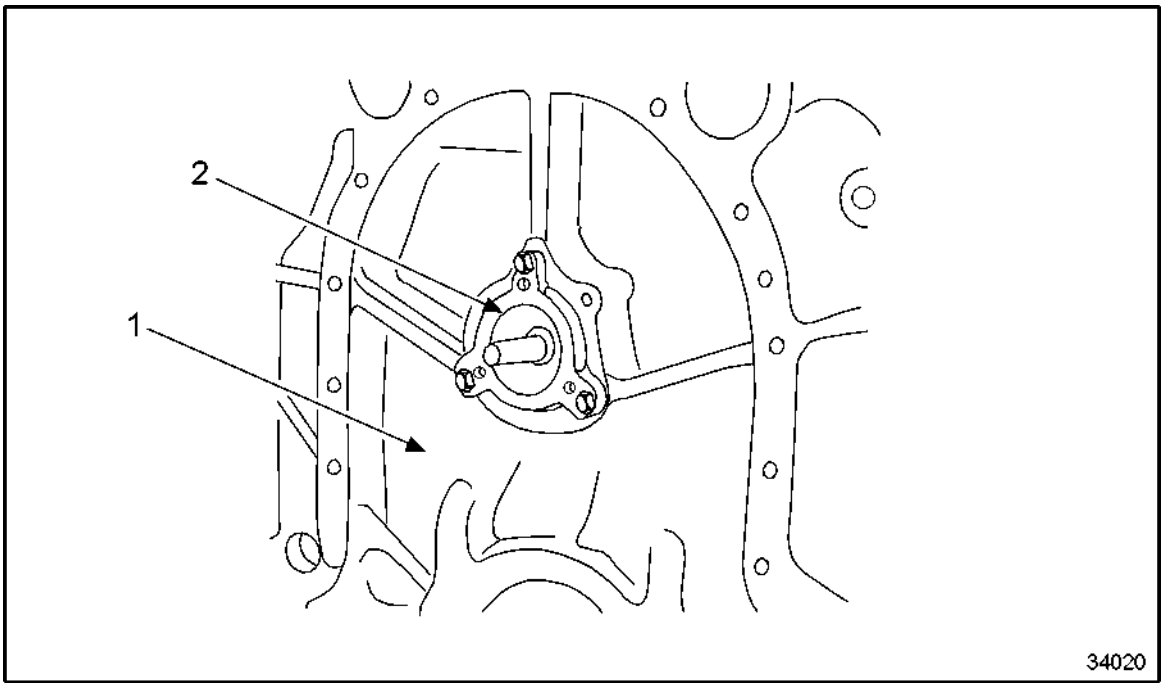


1. Camshaft Bushing
2. Brass Drifts
3. Assembly Tool

Figure 44 Removing Brass Drift

12. Using the assembly tool, insert camshaft bushing (1) from the outside into the camshaft locating bore as far as it will go. See Figure 44.
13. At the same time, position the assembly tool by the centering and positioning brass drifts which are inserted as the camshaft bushing is fitted in the stop. See Figure 44.

14. Verify that lube-oil bores in bushing and cylinder block are aligned.
15. Install stop and alignment device (2) for camshaft bushing number 7 from the outside on the front of the cylinder block (1). See Figure 45.

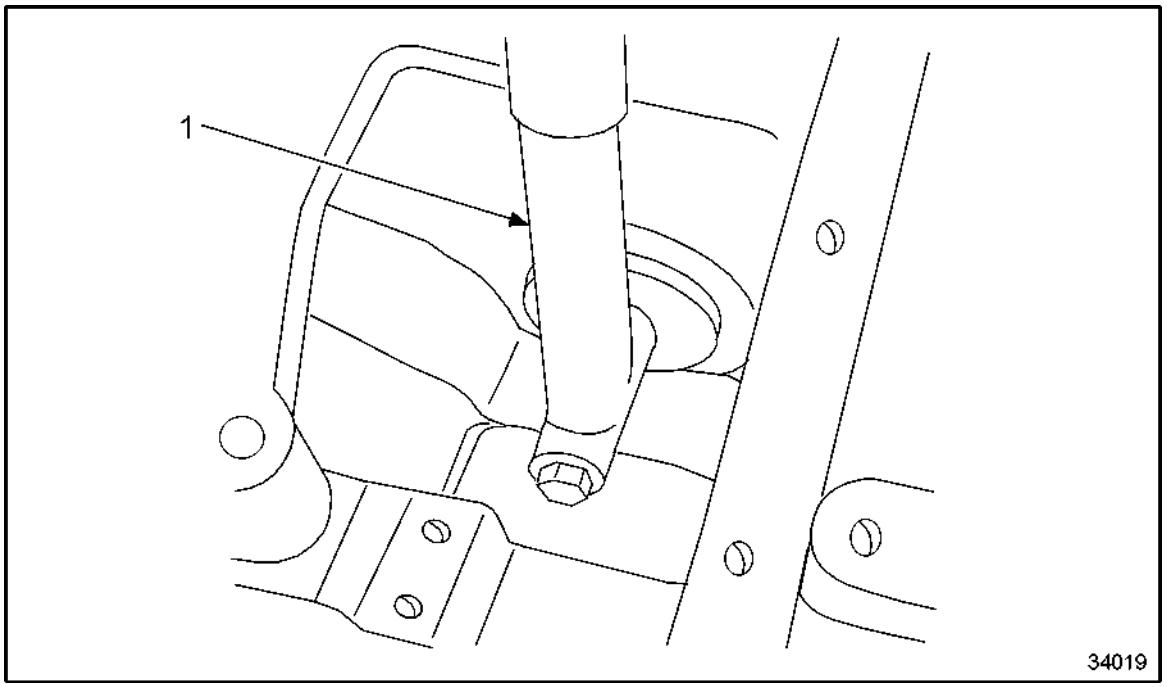


1. Front View of Block
2. Stop and Alignment Device

Figure 45 Installing Camshaft Bushing Number 7

NOTICE
Ensure that the assembly tool and brass drifts are correctly positioned prior to inserting the camshaft bushing. Improperly seated camshaft bushings will result in engine damage.

16. Insert camshaft bushing in the camshaft bore as far as it will go using the assembly tool. See Figure 46.



1. Assembly Tool

Figure 46 Inserting Camshaft Bushing in Camshaft with Assembly Tool

17. Verify that lube-oil bores in bushing and cylinder block are aligned.

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.

18. To install studs for main bearing caps, clean threaded bore in cylinder block and blow clear with compressed air. See Figure 47.

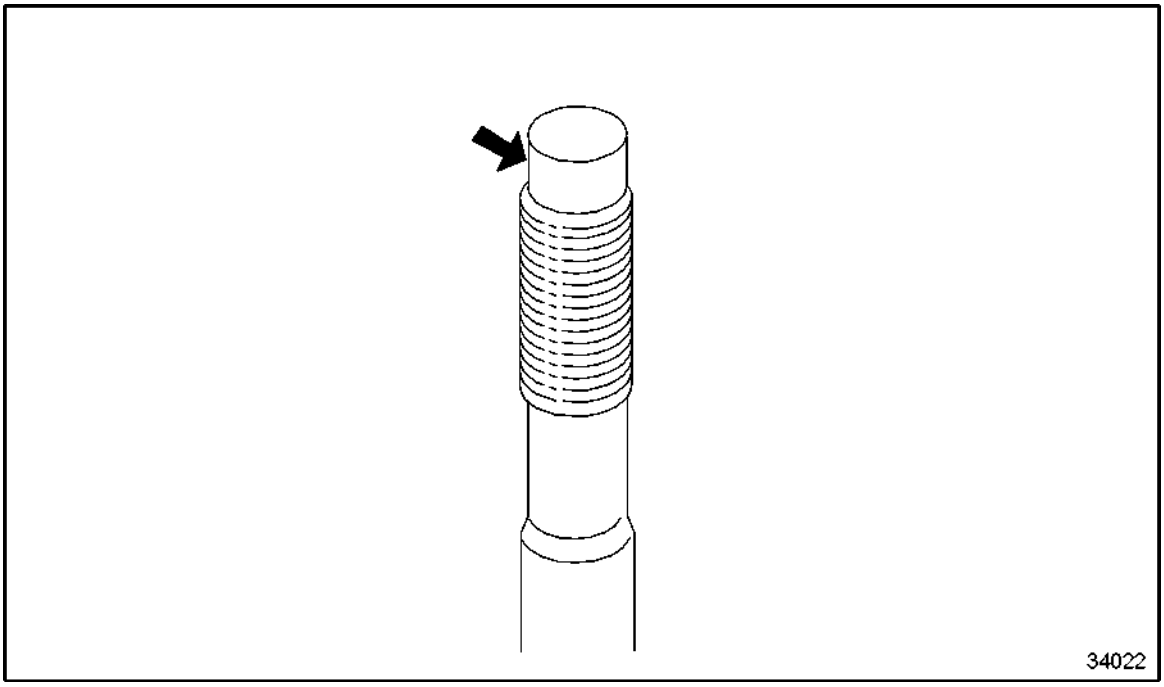
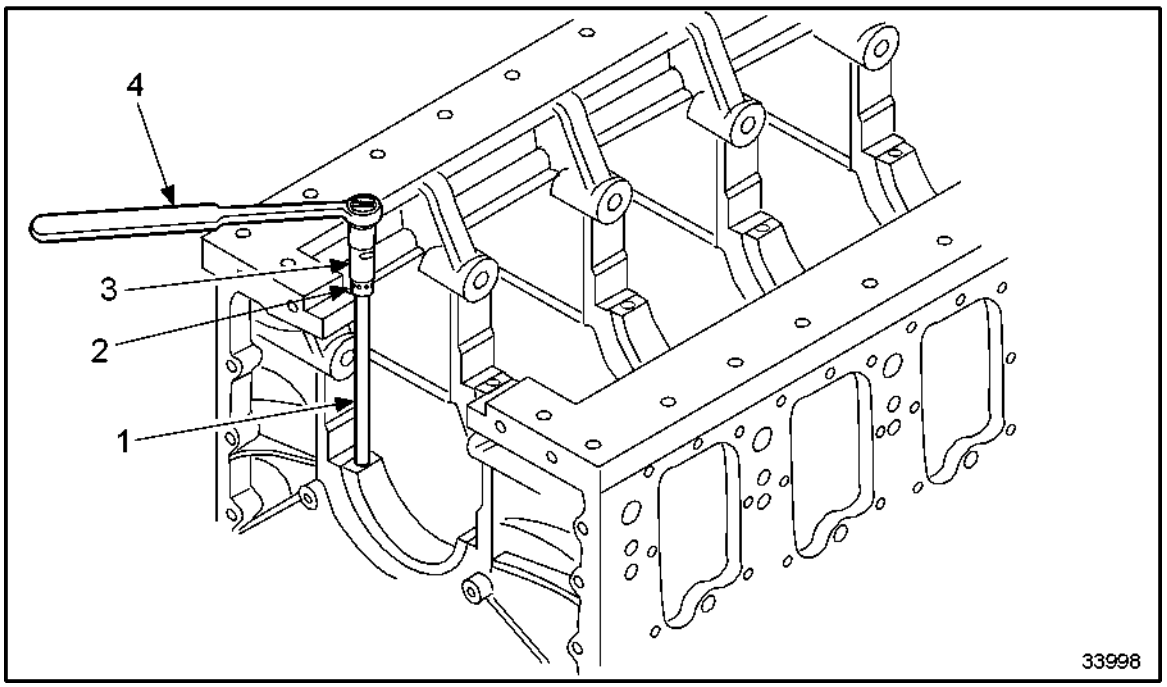


Figure 47 Installing Crankshaft Main Bearing Cap Studs

19. Test threaded bore with a new stud for ease of movement up to the threaded end in the cylinder block. See Figure 47.
    [a] If stud does not show ease of movement, replace component.
    [b] If stud does show ease of movement, continue inspection.
20. Coat stud thread on the journal side (arrow) with engine oil. See Figure 47.

21. Insert stud (1) with the journal side in the threaded bore. See Figure 48.



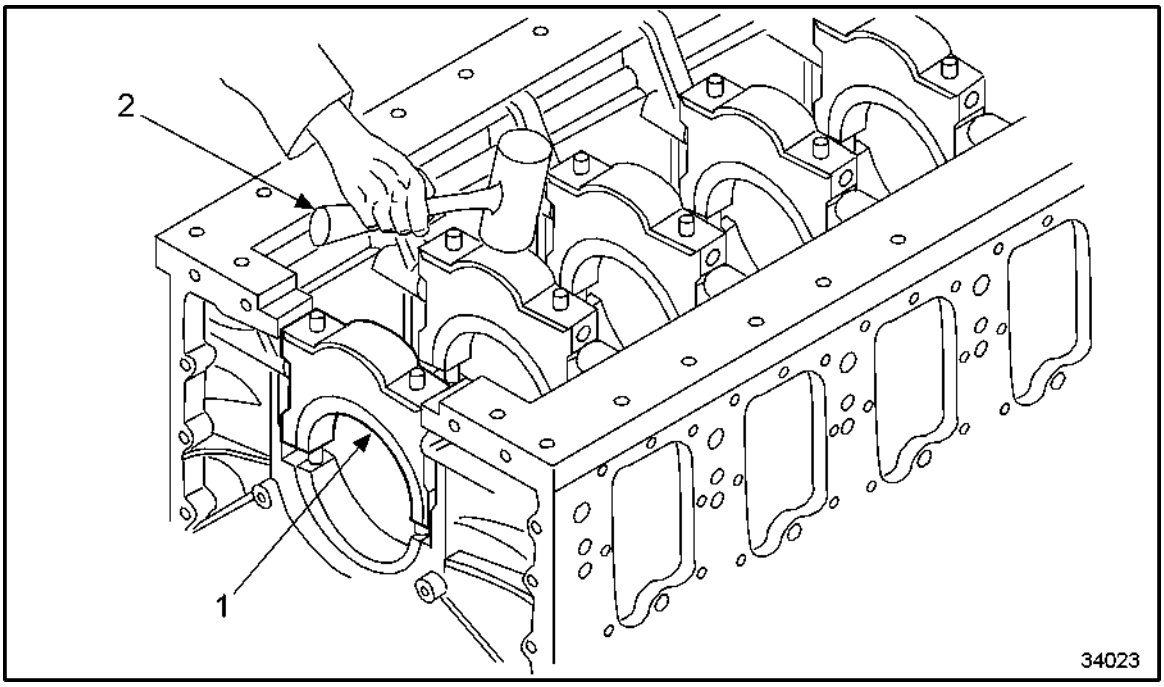
1. Main Bearing Cap Stud
2. Main Bearing Cap Nut
3. Socket Wrench Extension
4. Socket Wrench

Figure 48 Cylinder Block Stud Insertion

22. Using the installation tool and torque wrench, screw stud in until it reaches the limit of travel. Torque studs to specification. Refer to section A 003A 003 .

NOTE:
Cylinder block is upside down, with oil pan mating face horizontal.

23. To install main bearing caps, allocate bearing caps according to cylinder block numbering to respective location. See Figure 49.



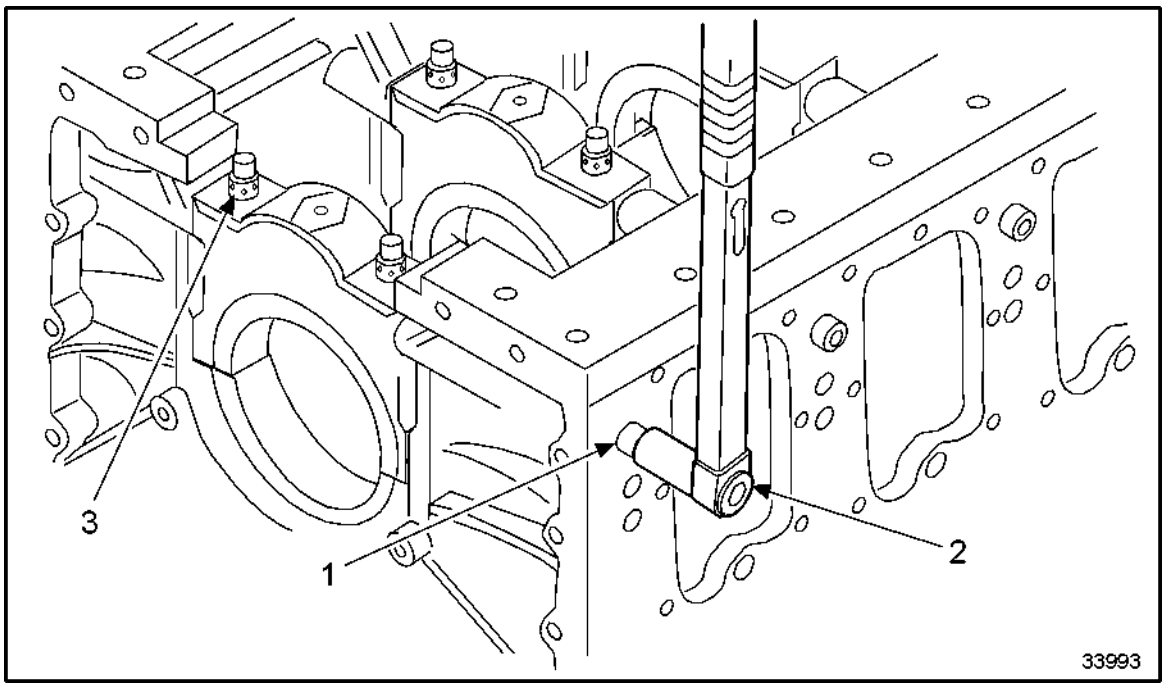
1. Main Bearing Cap
2. Copper Hammer

Figure 49 Installing Main Bearing Cap

NOTE:
Main bearing caps must not be interchanged!

24. Insert bearing cap into cylinder block so that the markings on bearing cap and cylinder block are on the same side.
25. If the main bearing cap binds, tap it on with a soft mallet as necessary.

26. Screw in all main bearing stabilizer bolts (1) but do not tighten fully. See Figure 50.

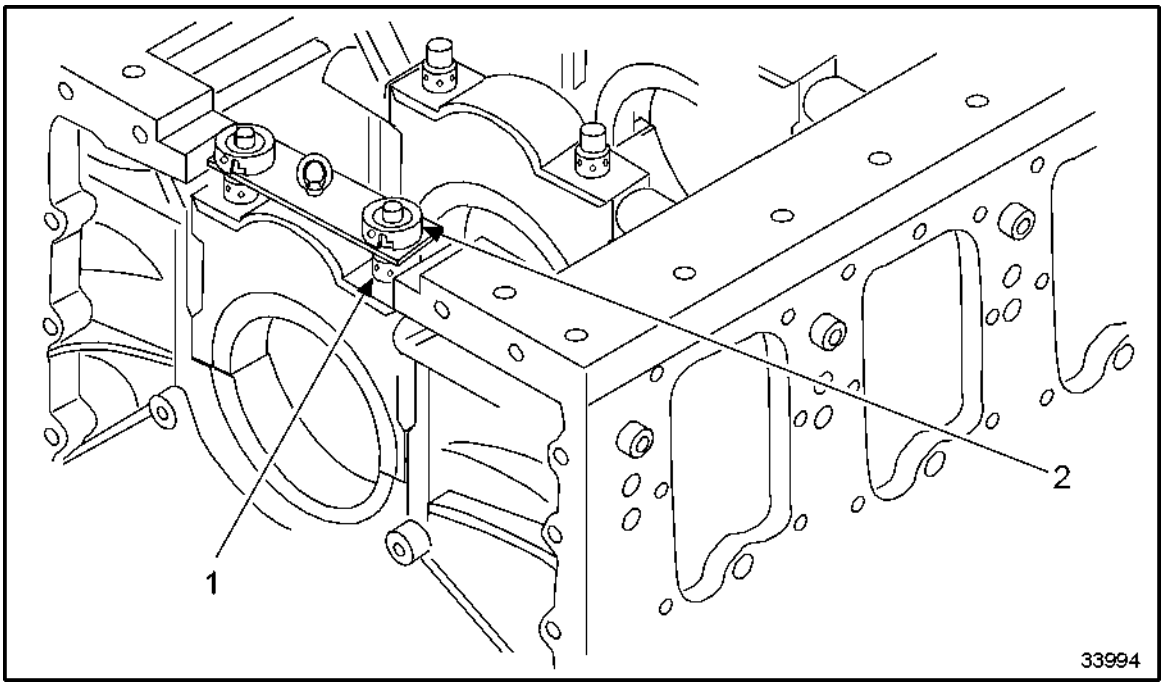


1. Main Bearing Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing Cap Nut

Figure 50 Positioning Main Bearing Stabilizer Bolts

27. Screw in all stabilizer bolts for crankshaft main bearing cap and tighten by hand. See Figure 50.

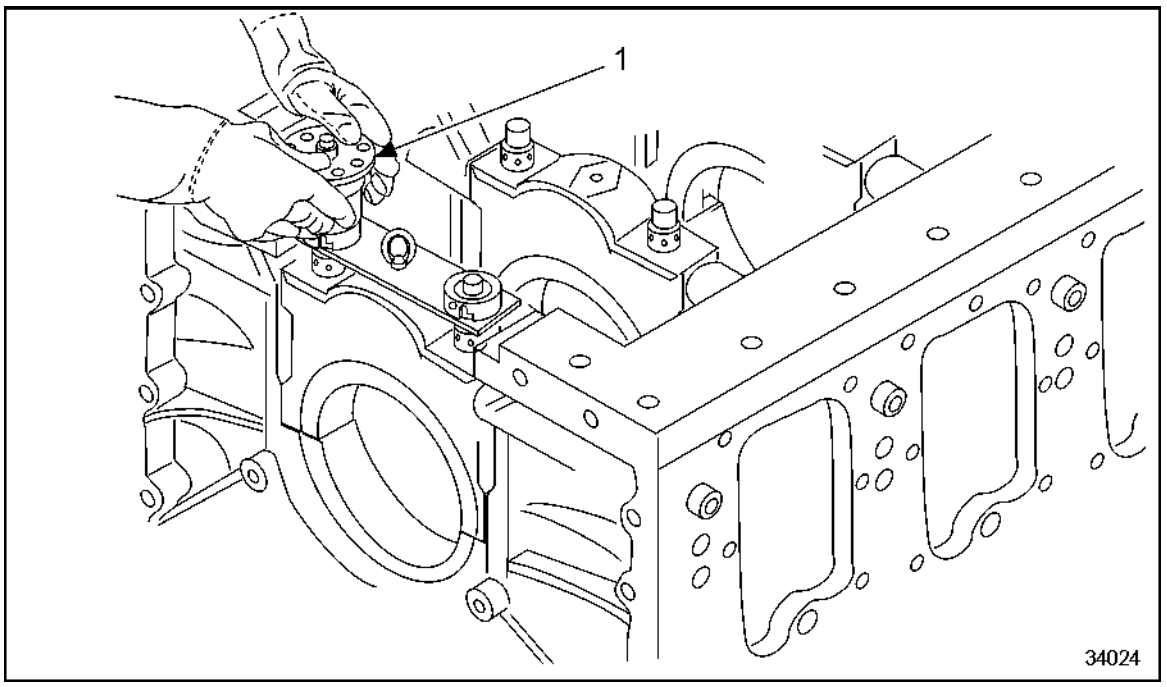
28. Beginning with the main bearing thrust cap (flywheel end of engine), place the main bearing cap nut (1) on the studs of main bearing cap. See Figure 51.



1. Main Bearing Cap Nut
2. Main Bearing Pretensioner Nut Stud

Figure 51 Placing Hydraulic Pretensioner on Studs of Main Bearing Cap

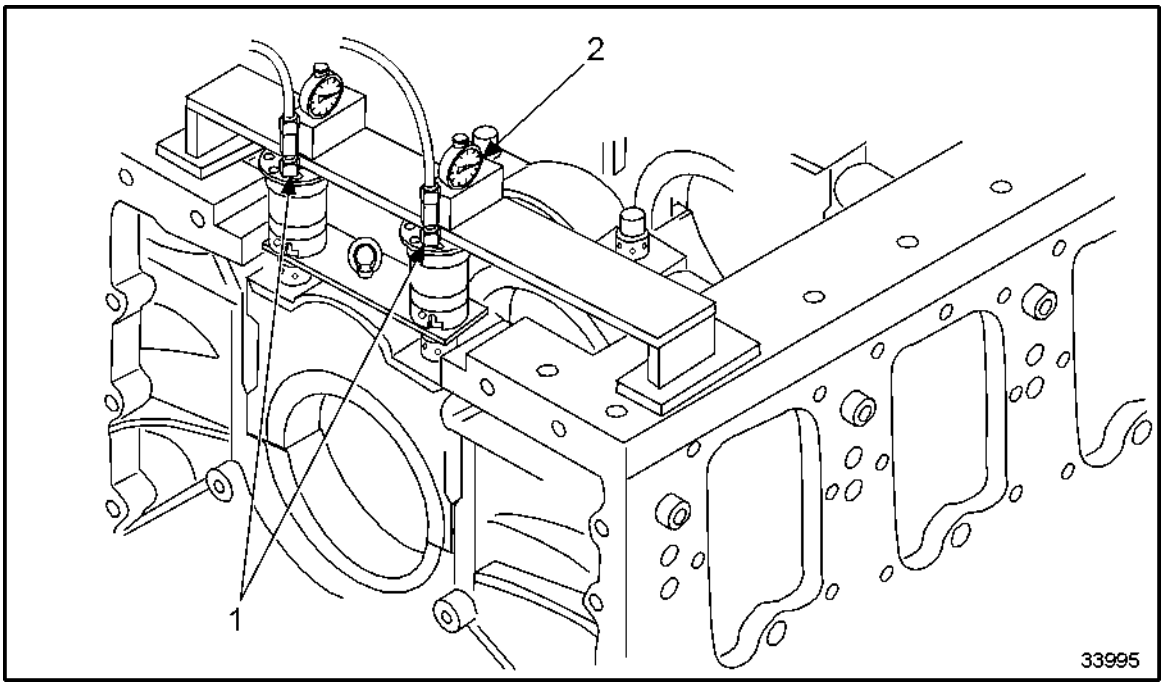
29. Install hydraulic pretensioner (1) by hand until it is in position. See Figure 52.



1. Hydraulic Stud Pretensioner

Figure 52 Installing Hydraulic Pretensioner

30. Connect high-pressure hose of the hydraulic hand pump to hydraulic pretensioner. See Figure 53.



1. High-Pressure Hose of Hydraulic Hand Pump
2. Magnetic Dial Indicator

Figure 53 Connecting High-Pressure Hose

31. Position magnetic-base indicator holder with dial gages on the cylinder block pan rail for extension measurement of the studs.
32. Position both dial gage styluses in the center on the respective measuring core (arrow) on the face of the sleeve measuring pin. See Figure 54.

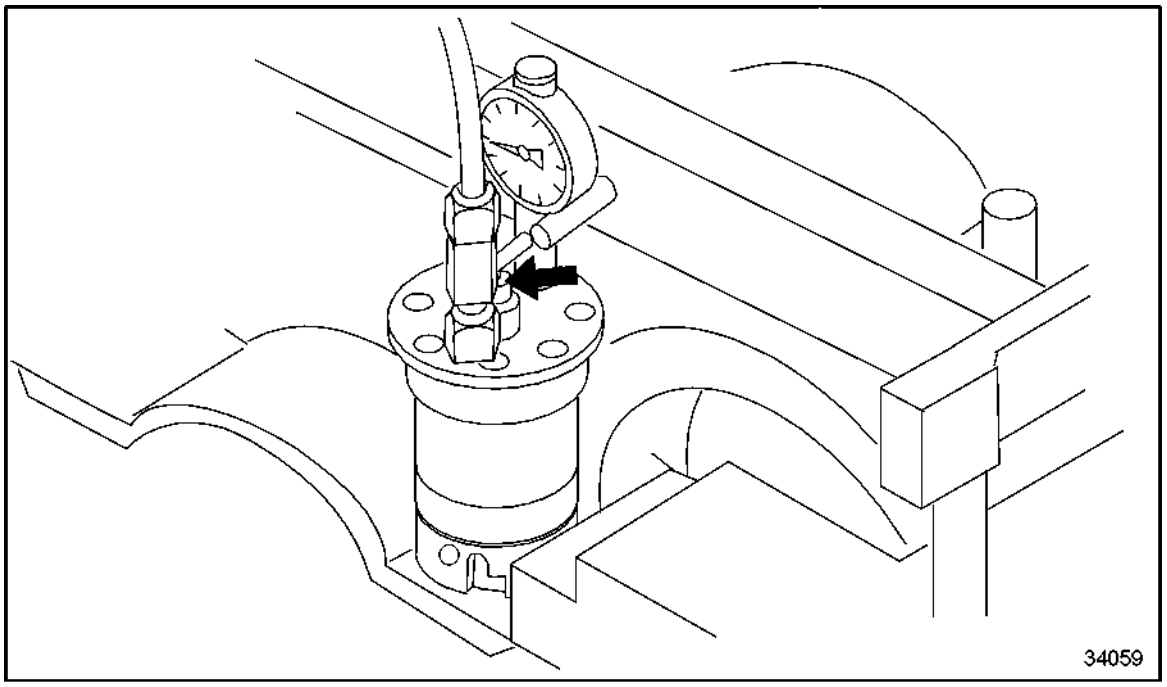


Figure 54 Positioning Dial Gage Styluses in Center on Respective Measuring Core

33. Set dial gages with preload to zero.
34. Operate hydraulic hand pump and elongate studs at same time (maximum 1.15 + 0.05 mm), use pin (arrow) to tighten nuts on main bearing cap (arrow). See Figure 55.

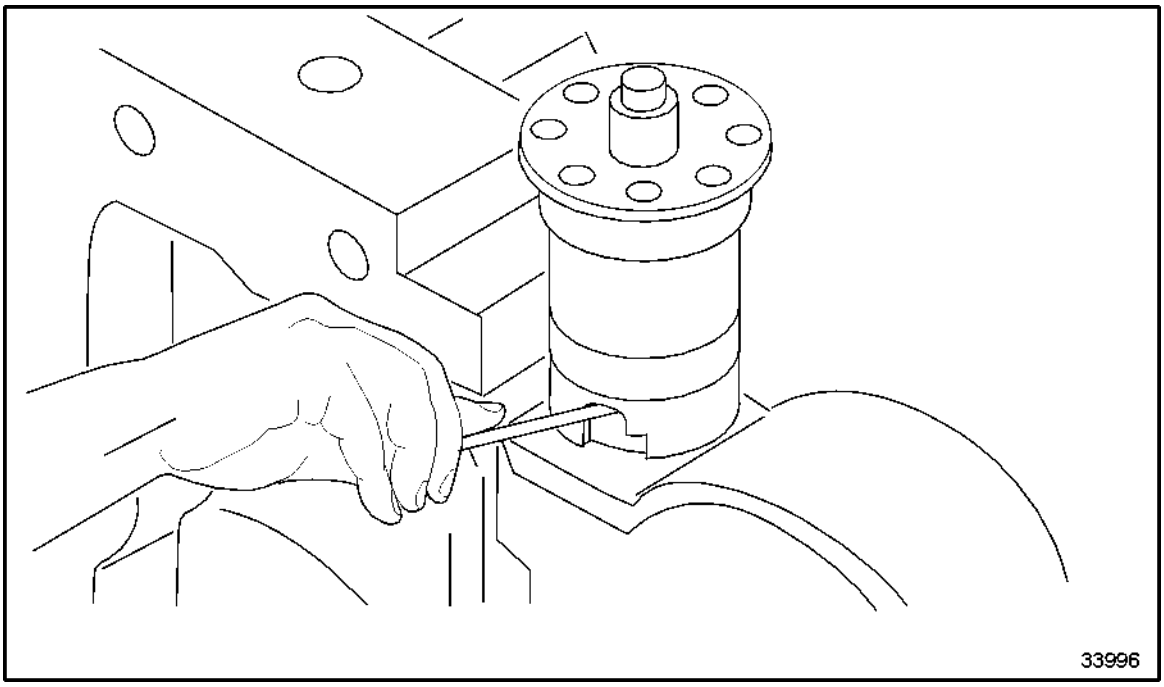
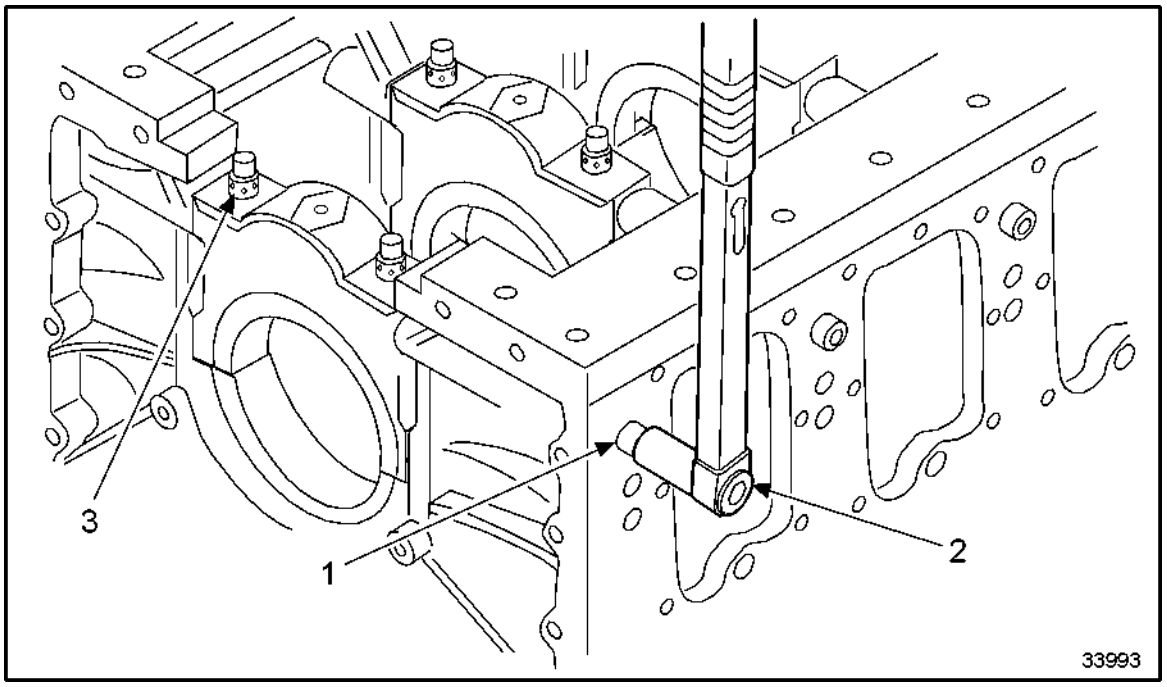


Figure 55 Operating Hydraulic Hand Pump and Elongating Studs

35. Relieve tension on studs, mount dial gages with magnetic holders and hydraulic pretensioner on studs.
36. Move the hydraulic pretension mount for the dial gages to the next main bearing cap.
37. Repeat torquing procedure until all main bearing caps are completed.

NOTE:
Remaining elongation of studs after loosening is 0.9 + 0.05 mm.

38. If remaining elongation of studs is outside tolerance, loosen nuts, refer to section C 031.05.05C 031.05.05 and repeat nut tightening procedure; if necessary, replace studs. See Figure 56.

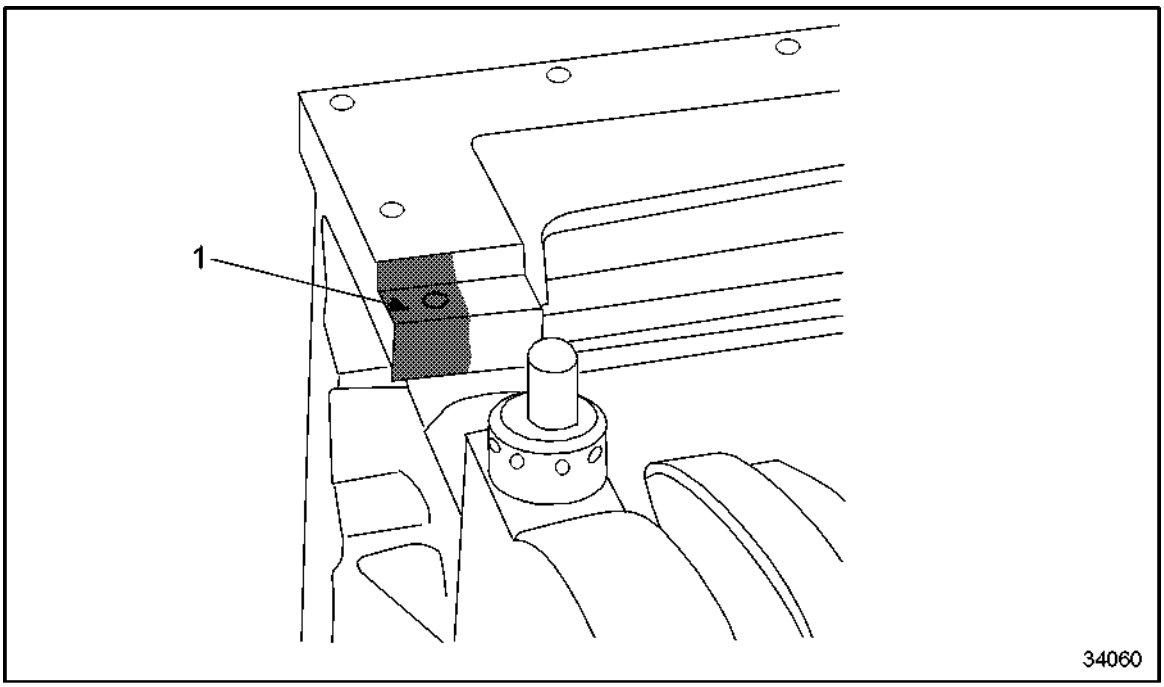


1. Main Bearing Cap Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing Cap Nut

Figure 56 Installing Main Bearing Cap

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.

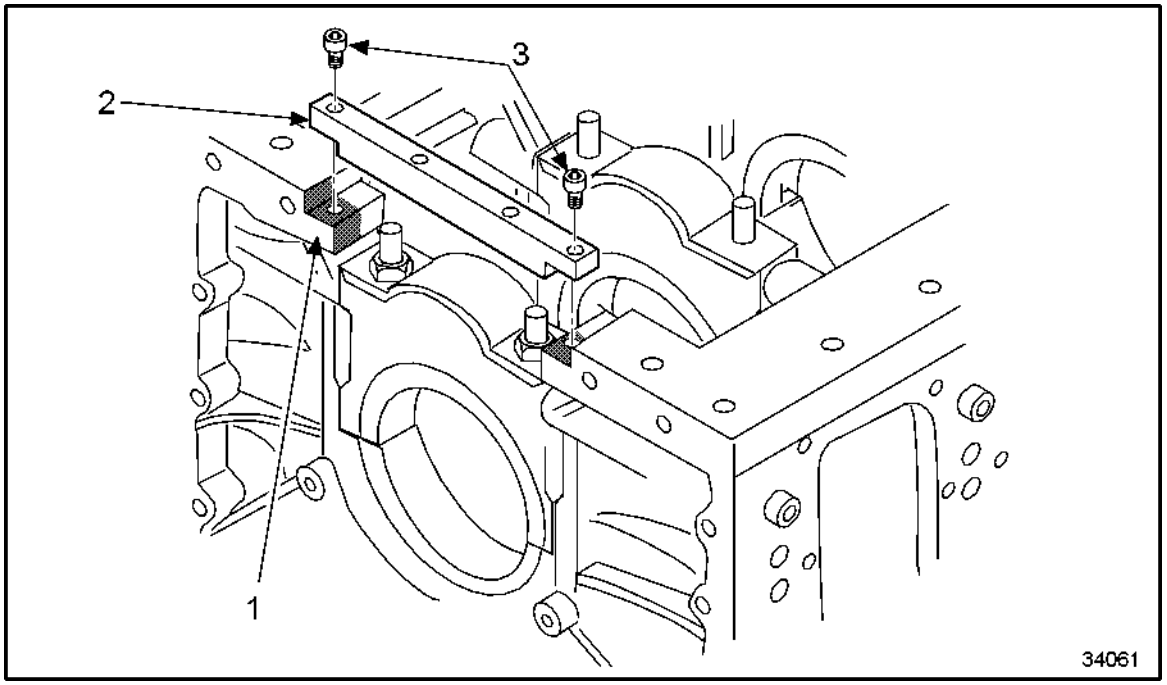
NOTE:
When coating mating surface for oil pan extension, take the front surfaces into consideration.



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

Figure 57 Coating Mating Surface for Oil Pan Extension

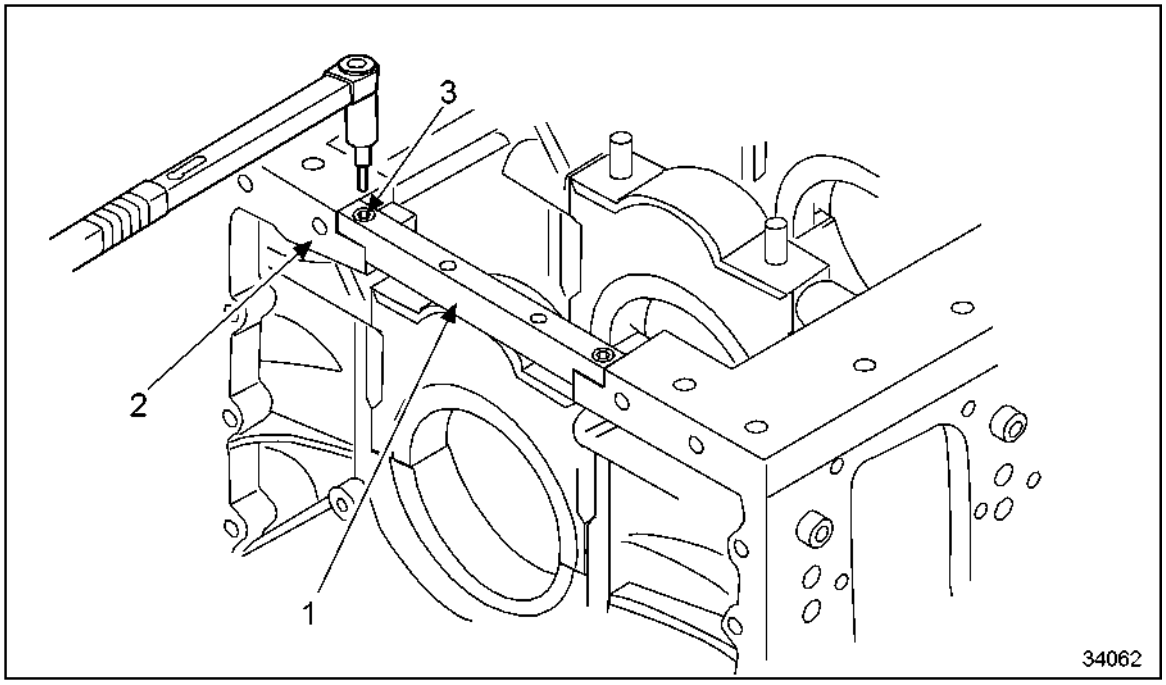
41. Align oil pan extension (2) to the bores of the securing bolts (3) in the cylinder block (1) and place on the surface of the cylinder block that was coated with sealing compound. See Figure 58.



1. Cylinder Block
2. Cylinder Block Filler Strip
3. Securing Bolt

Figure 58 Aligning Cylinder Block Filler Strip

42. Using securing bolts (3), secure the cylinder block filler strip (1) to the cylinder block (2). See Figure 59.



1. Cylinder Block Filler Strip
2. Cylinder Block
3. Securing Bolt

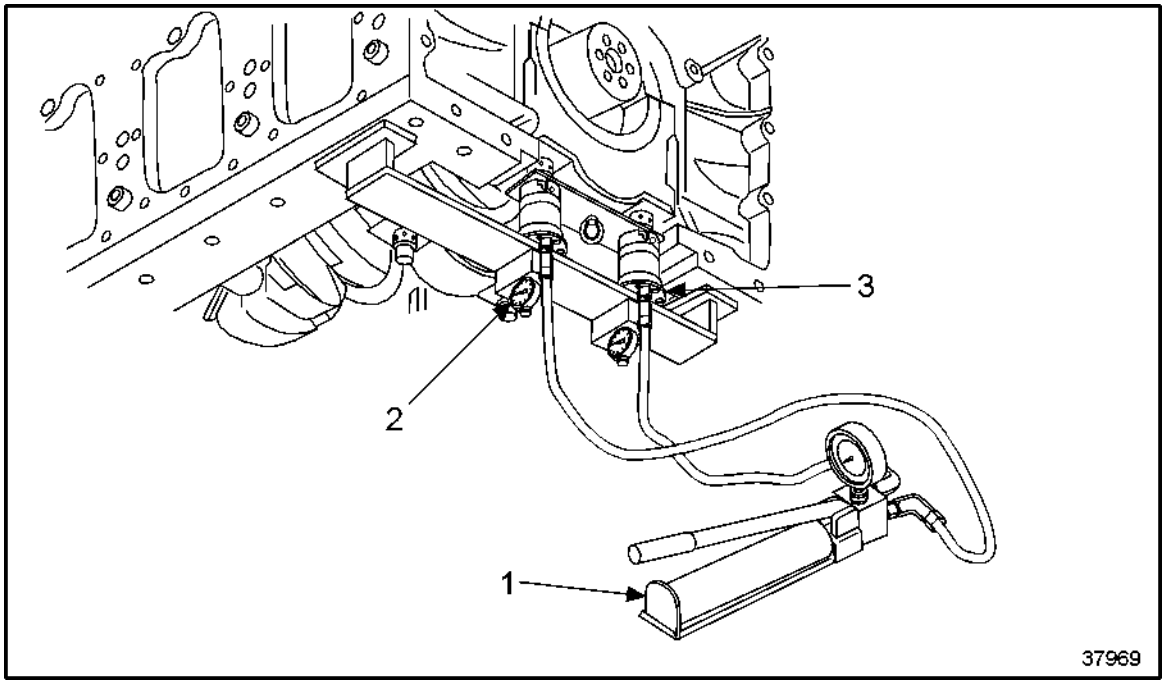
Figure 59 Securing Cylinder Block Filler Strip

NOTE:
Using a straightedge, verify the alignment of the cylinder block filler strip to the cylinder block. The cylinder block filler strip surface must form a single plane with the cylinder block parting line so that the oil pan seals perfectly.

Main Bearing Assembly

Perform the following steps to assemble the main bearing:

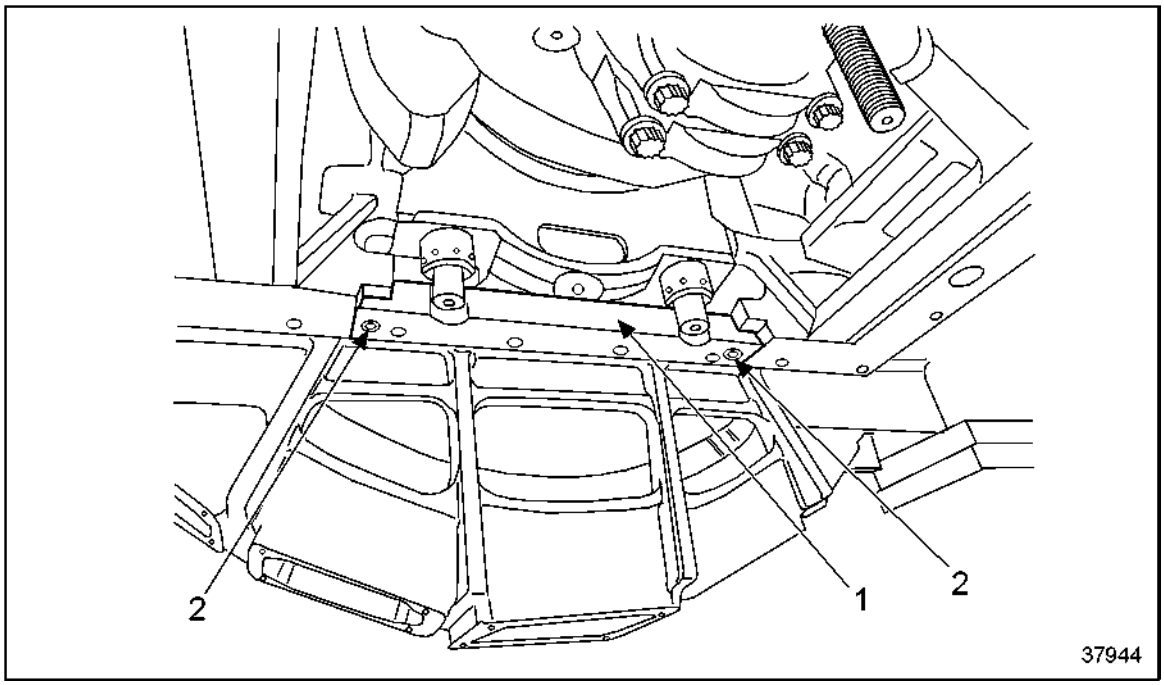
1. Ensure that the main bearing cap number corresponds with the location number stamped on the “A” bank pan rail. With the main bearing cap turned so that the 16V or 12V marking faces towards the “A” bank, replace the main bearing cap on the main on the main bearing studs flush to block. Lubricate and install the retaining nuts. Install the side stabilizer bolts and hand–tighten at this time. Install the main bearing stud tensioner on the studs of the main bearing cap, then turn the hydraulic pretensioner by hand until it is snug, then back off one turn.
2. Connect the high-pressure hose of the hydraulic hand pump to hydraulic pretensioner. Position magnetic-based dial indicator bridge with both indicator pins centered on each main bearing stud.
3. Operate the hydraulic hand pump (1) and at the same time elongate each stud (1.15 – 1.20 mm). Using a pin, rotate the nuts on the main bearing cap studs until the nuts are snug. Remove the magnetic-base dial indicator bridge. (2) The final elongation of the studs should be 0.9 – .95 mm. If the final elongation of studs is outside this tolerance, repeat nut tightening procedure. If the final elongation of studs is again outside tolerance, replace the studs and tighten to 80–90 N·m. Repeat stud elongation. Torque the side stabilizer bolts to 280 N·m. See Figure 60.



1. Hydraulic Hand Pump
2. J 43196 Dial Indicator Bridge
3. Hydraulic Pretensioner

Figure 60 Stretching Main Bearing Studs

4. Reinstall the hydraulic pretensioner and the magnetic base dial indicator bridge on the next adjacent main bearing cap and repeat until all main bearings have been replaced.
5. Using a dial indicator, check and record the crankshaft endplay on the main bearing installation report form. The reading should be 0.250 – 0.570 mm (0.0098 – 0.022).
6. Clean and apply a light film of RTV, reinstall the rear pan rail filler spacer (1). Clean and reinstall the oil pump assembly. Torque attaching bolts for each to proper torque specifications. Refer to section A 003A003 . See Figure 61.



1. Filler Spacer
2. Allen Head Bolts

Figure 61 Stretching Main Bearing Studs

7. Using a dial indicator, measure the oil pump gear backlash. Oil pump gear lash should be 0.127 – 0.346 mm (0.005 – 0.0136 in.)

C 011.05.11 – INSTALLATION OF CYLINDER BLOCK AND MAIN BEARINGS

Perform the steps in the following subsections to install the cylinder block and main bearings:

Cylinder Block Installation

Perform the following steps to install the cylinder block:

1. Install access cover with oil filler tube, dipstick and access cover with dipstick tube and tighten. See Figure 1.

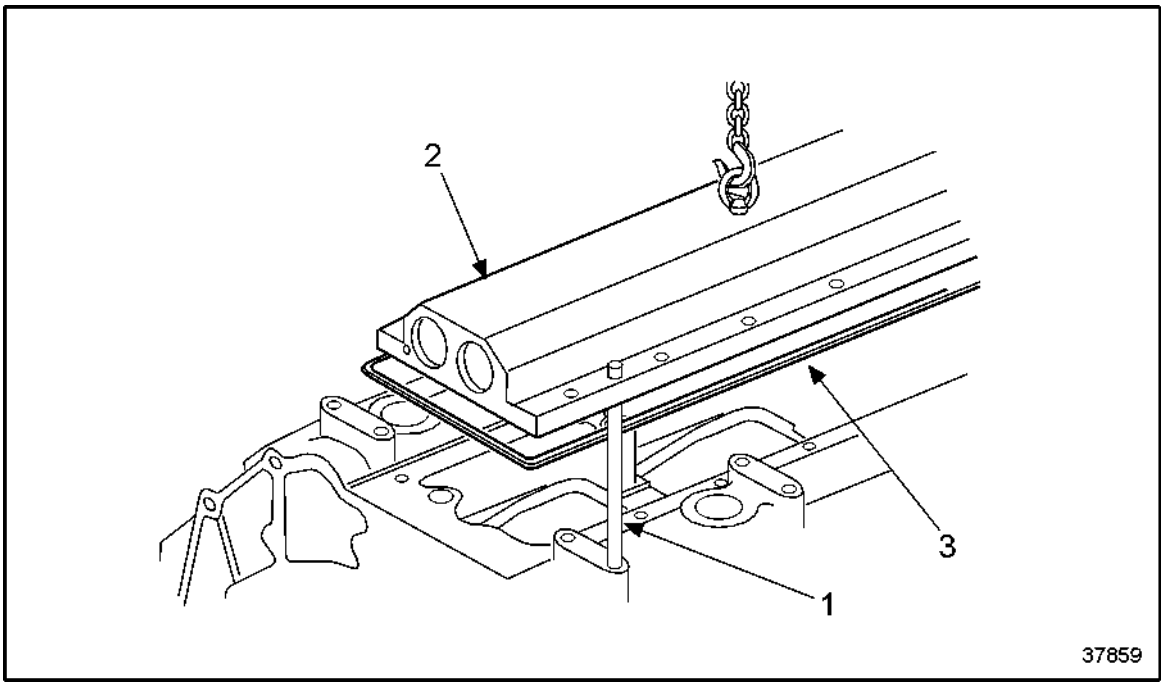
NOTE:
Before installation, remove the plugs and adhesive tape strips that were used to prevent contamination. Ensure parts are perfectly clean.

NOTE:
Use new gaskets.

2. Install access covers.

NOTE:
Ensure a double plate is installed in the proper location for ECM installation

3. To install cylinder block oil gallery, coat mating surface at cylinder block with sealing compound. See Figure 62.



1. Guide Pin
2. Oil Gallery Cap
3. Pan Seal

Figure 62 Installing Oil Gallery Cap

NOTE:
On new style cylinder block, an O-ring seal is used instead of the sealing compound.

4. Coat new O-rings with petroleum jelly and insert into oil transfer bores in cylinder block. See Figure 62.
5. Insert guide pins (1) in the cylinder block at two diagonally opposite corner points. See Figure 62.
6. Screw a suitable lifting eye as centrally as possible to the upper edge of the oil gallery.

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.

7. Using the lifting device, fit the oil gallery onto the assembly pins and slowly lower onto the cylinder block support surface.
8. Tighten the two hex bolts, opposite each other in the middle of the oil gallery, to specification. Refer to section yA 003A 003 . See Figure 63.

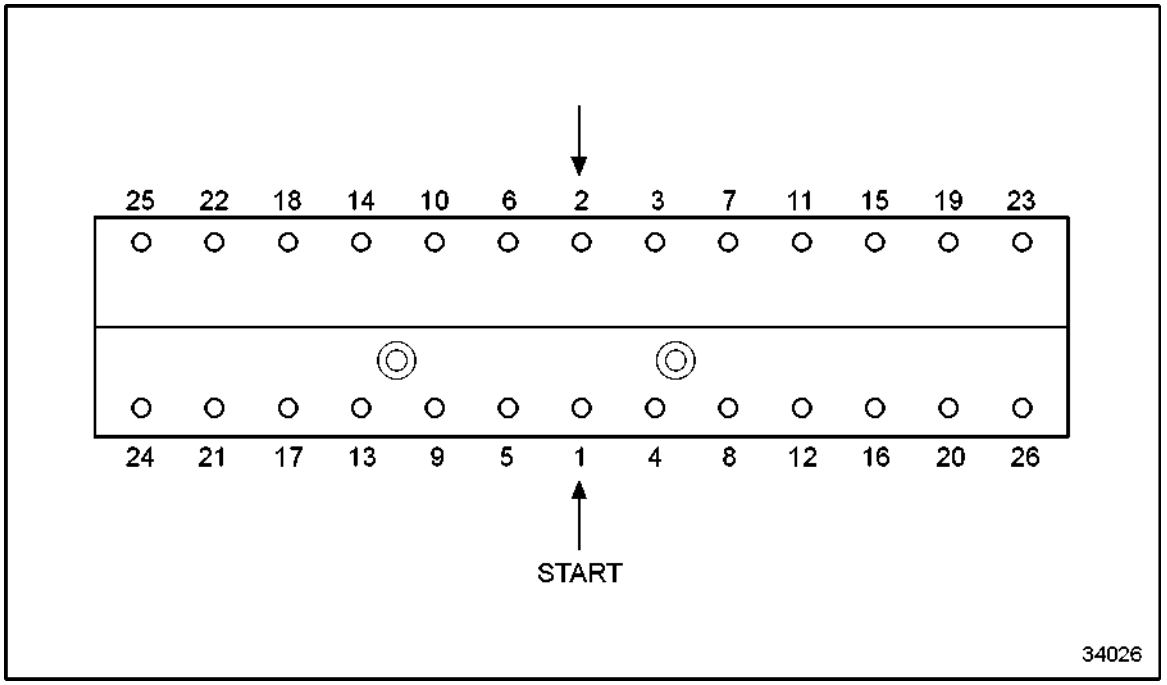
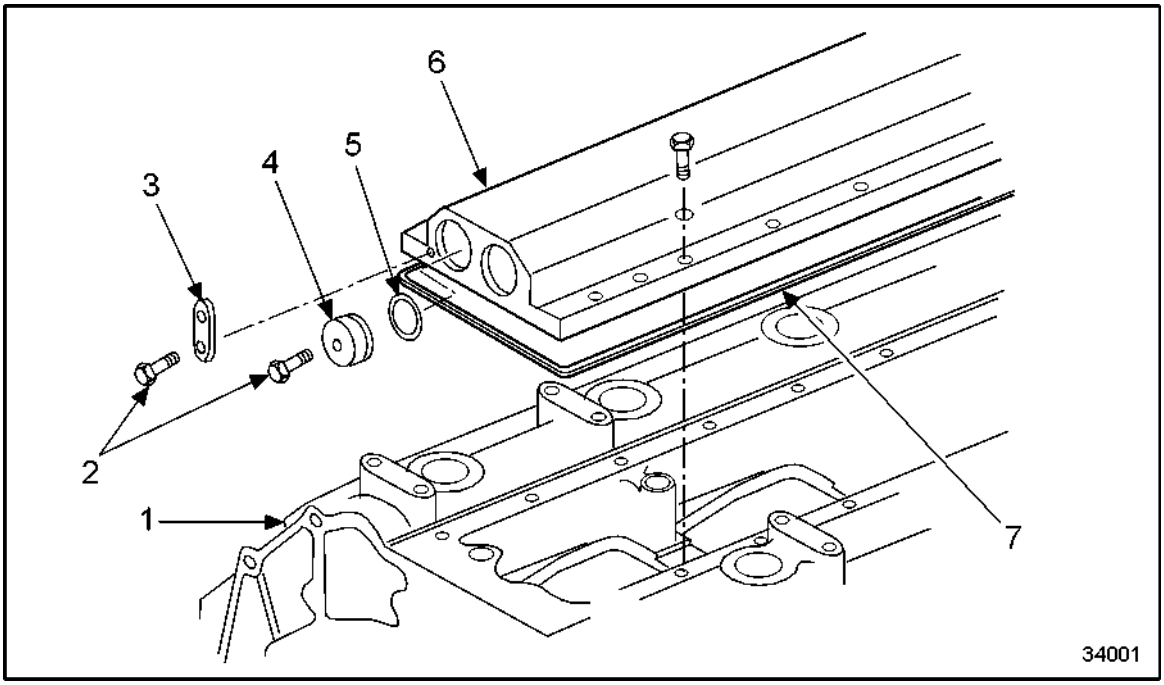


Figure 63 Tightening Hex Bolts

9. Tighten all other hex bolts to specification. Refer to section A 003A 003 . Torque the bolts by starting in the middle of the oil gallery and working in a continuous spiral or chrisscross pattern, proceeding from the center in a clockwise direction.

10. Coat O-ring (5) with petroleum jelly and fit on cap plug (6). See Figure 64.



1. Cylinder Block
2. Hex Bolt
3. Link
4. Blanking Plug
5. O-ring
6. Oil Gallery
7. Pan Seal

Figure 64 Installing Blanking Plug

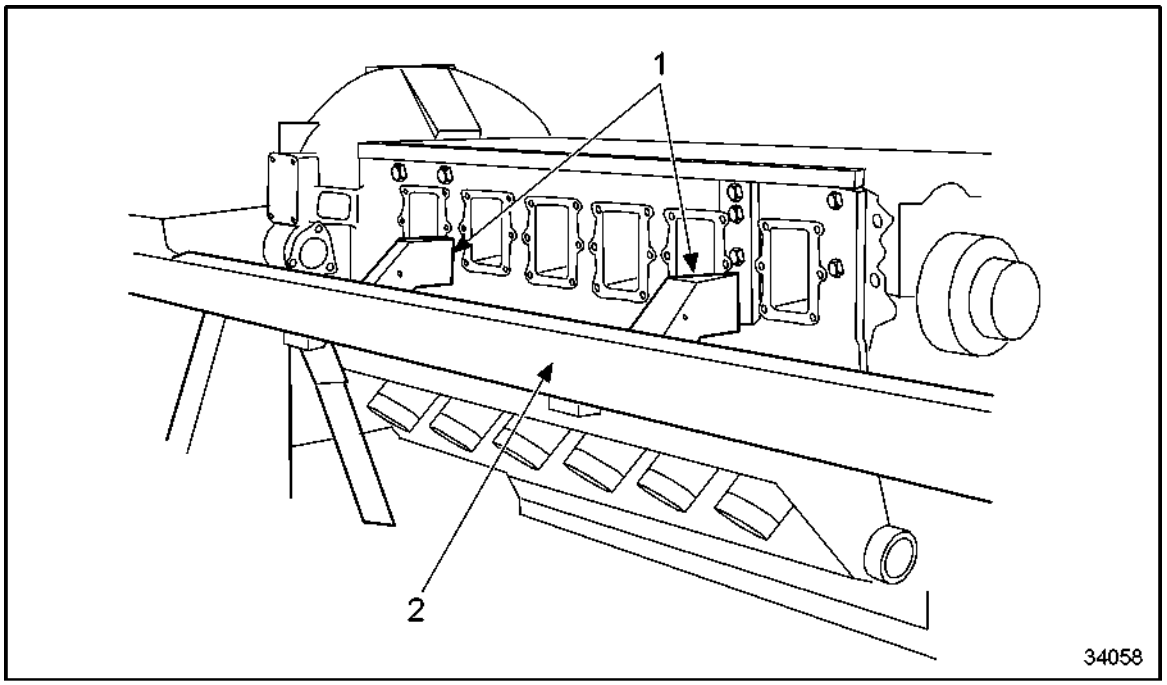
NOTE:
Ensure parts are perfectly clean.

11. Install blanking plug in oil gallery and secure with link (2).

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.

12. Move suitable lifting device and lifting ropes into position over cylinder block.
13. Ensure lifting devices are equally tensioned. See Figure 65.



1. Supports
2. Turnover Stand

Figure 65 Removing Cylinder Block from Turnover Stand

14. Separate cylinder block from turnover stand and lift it out.

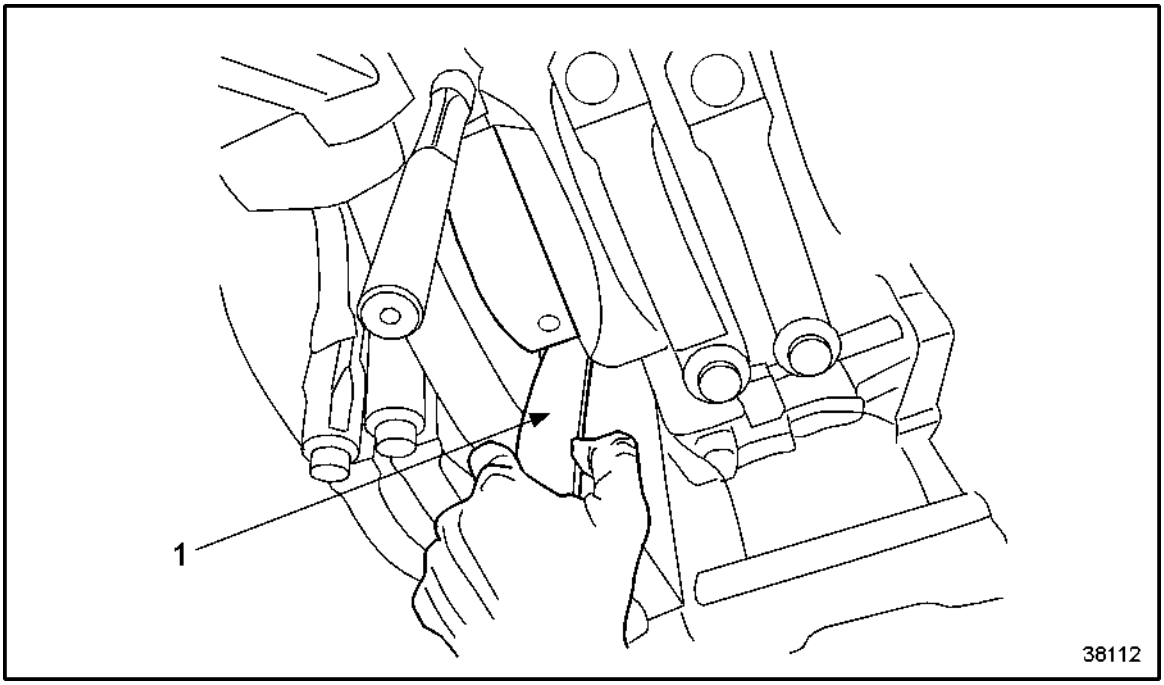
Main Bearing Installation

Perform the following steps to install the main bearings:

NOTE:
Tool kit J 44199 will have two bearing alignment tools; J 44199–25 (black in color), for use in all construction and industrial applications and J 44199–4 (white in color) for use with wider main bearings for marine applications only.

NOTICE
Ensure the correct tool is used to prevent main bearing misalignment during installation.

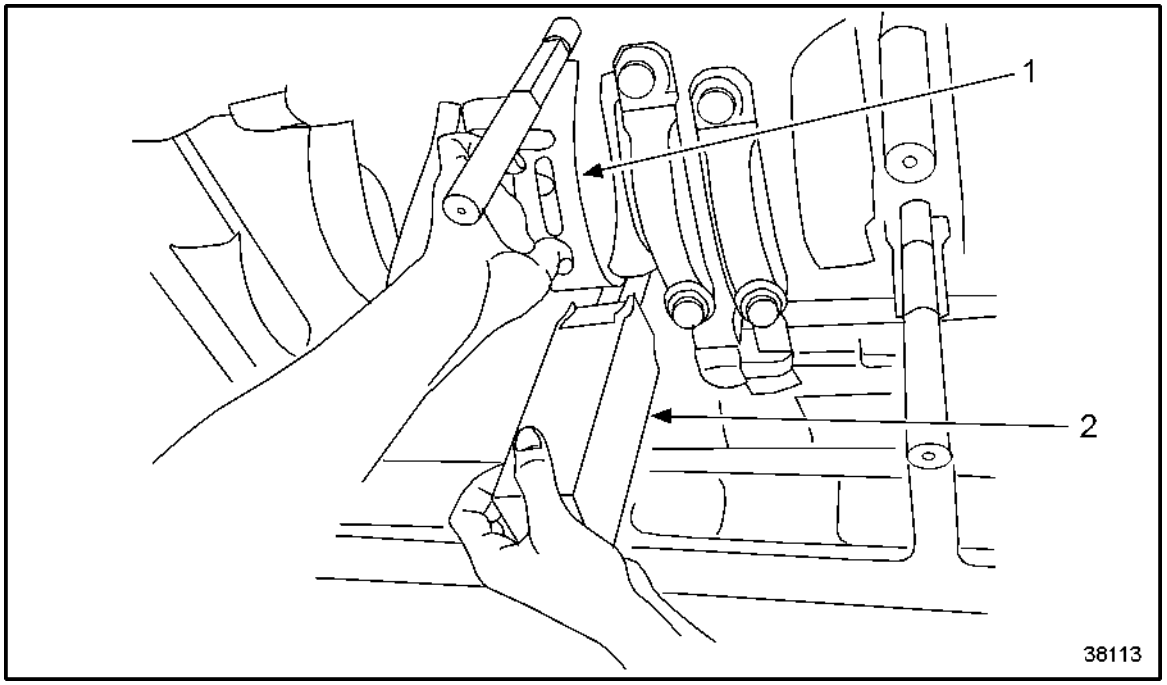
1. Center the crankshaft with reference to its thrust distance. Rotate crankshaft until the #1 rod journal is in the down position. This will allow for clearance from the crankshaft counterweights for the bearing alignment tool. With the flexible bearing pushing tool (1), push out the old upper main bearing shell. With a liquid marking pen, mark each bearing as to its location and properly protect for storage. See Figure 66.



1. Flexible Bearing Pushing Tool

Figure 66 Removing Upper Main Bearing Shell

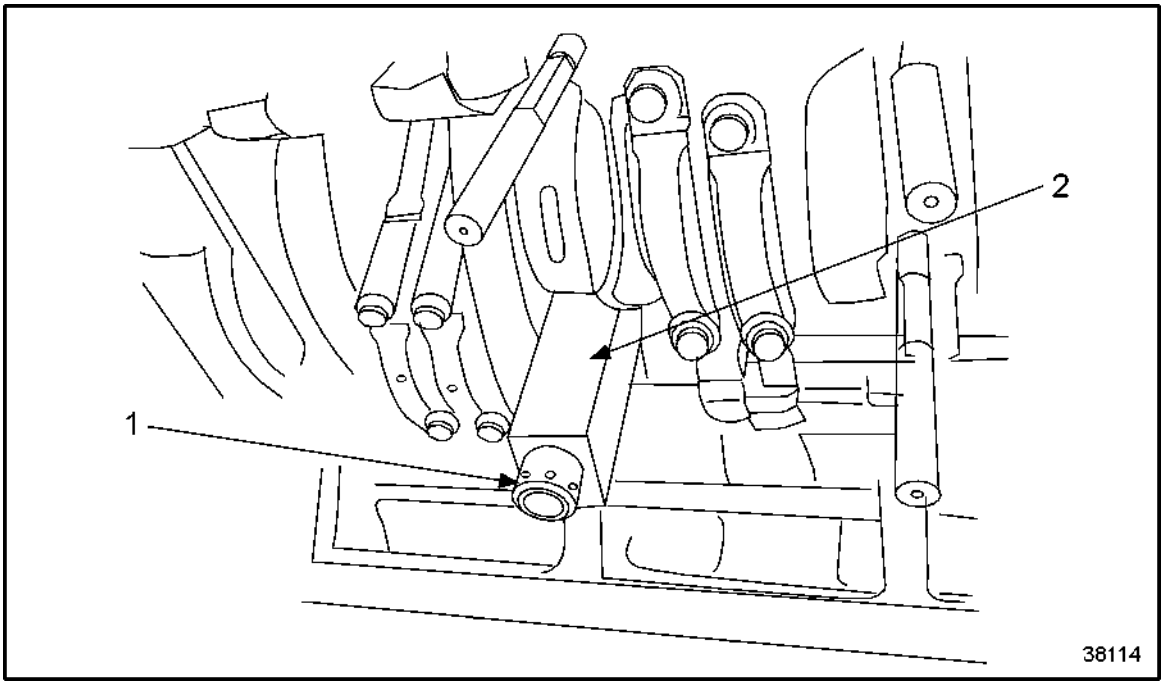
2. While rotating the crankshaft 360 degrees, clean any bearing material that may have transferred to the main bearing journals with extra fine Scotch-Brite™. Clean the block main bearing cap bore and bearing cap surfaces with extra fine Scotch-Brite. Ensure there is no damage to the crankshaft, main bearing cap and block. Record findings on the main bearing installation report form. (Scotch-Brite™ is a trademark of 3M Company.)
3. Clean the new main bearing shells before use. Lubricate the main bearings and bearing journals with clean engine oil prior to installation. Insert the upper main bearing shell (1) (one with a hole in the center) onto the crankshaft main bearing journal. With part numbers facing towards the “A” bank, install bearing alignment tool (2) onto main bearing cap stud and secure with the main bearing cap nut. See Figure 67.



1. Upper Main Bearing
2. Bearing Alignment Tool

Figure 67 Installing Lower Main Shell

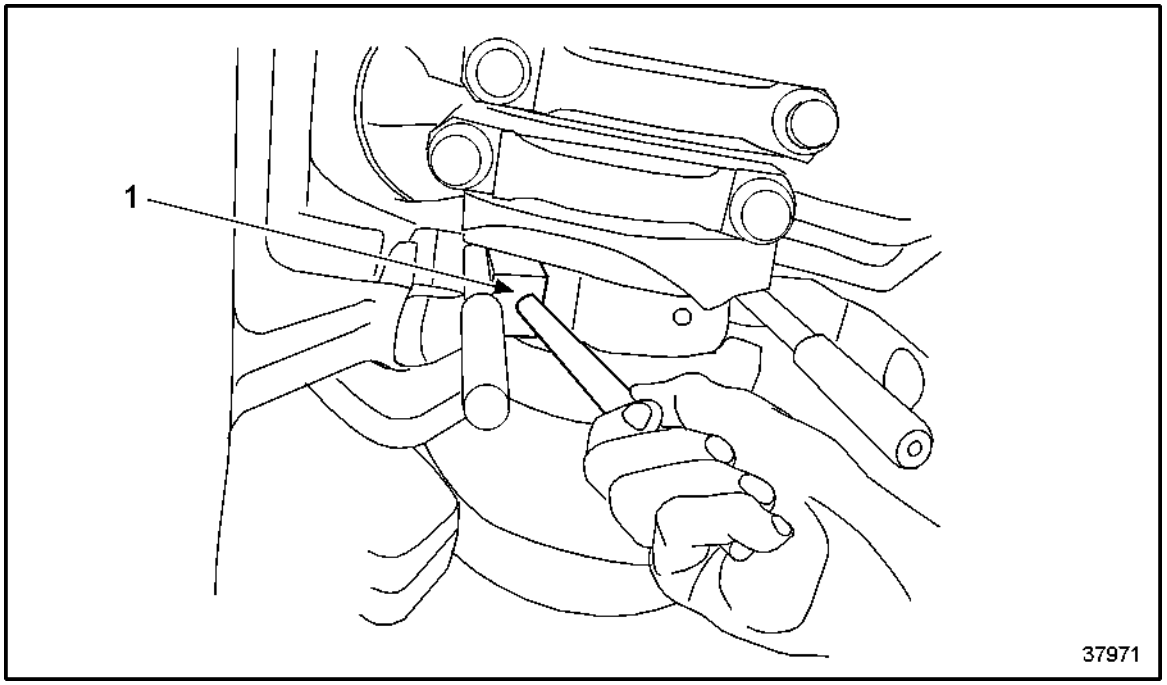
4. Rotate upper bearing shell by hand through the guide of the bearing alignment tool until bearing can no longer be moved by hand. Using the flexible bearing pusher tool, complete the rotation of the upper bearing past the alignment tool (2). See Figure 68.



1. Main Bearing Cap Nut
2. Bearing Alignment Tool

Figure 68 Installing Bearing Alignment Tool

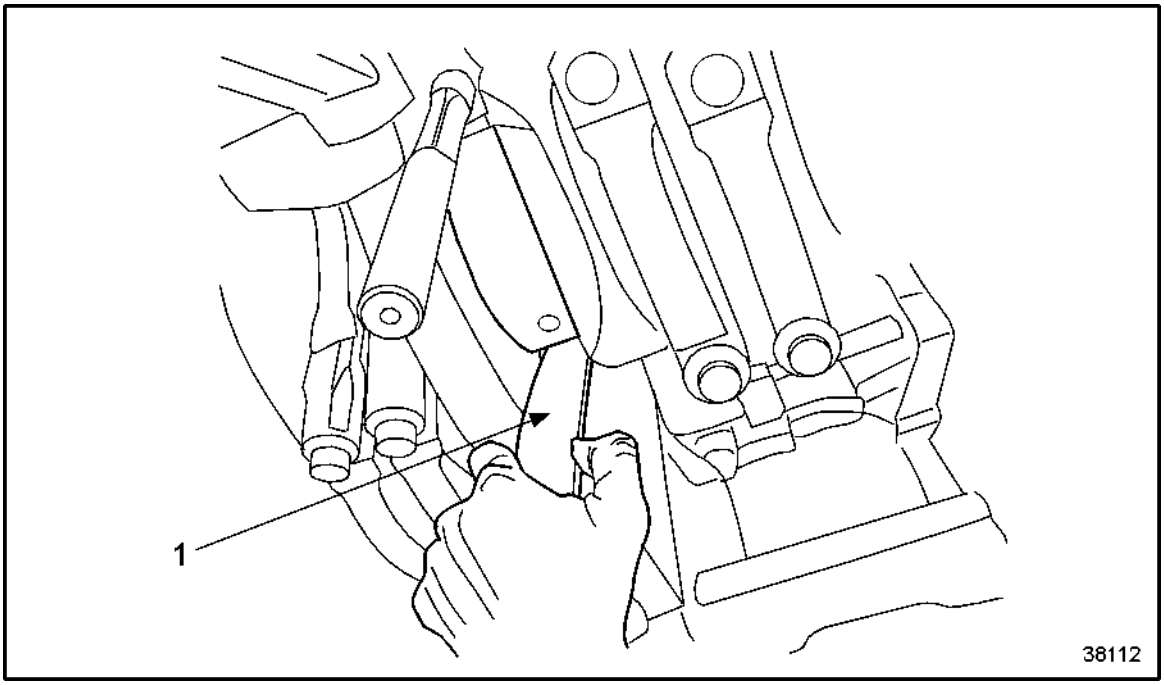
5. Remove the bearing alignment tool from the main bearing cap stud. Use the main bearing seating tool (1) to seat the upper main bearing to its proper recessed position. See Figure 69.



1. Main Bearing Seating Tool

Figure 69 Seating Upper Main Bearing to Proper Dimension

6. Preclean and lubricate the lower main bearing shell with clean engine oil. Place one end of the lower main bearing shell (part numbers towards the “A” bank) against the end of the upper main bearing shell. Place the main bearing alignment tool on the lower main bearing shell, with the shell located on the guide slot. On the other main bearing cap stud, press the bearing shell into place. This will require a little pressure to seat the bearing. See Figure 70.



1. Flexible Bearing Pushing Tool

Figure 70 Rotating Upper Main Bearing Shell into Position

C 011.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 3 are the After-Installation Operations for the cylinder block.

Level of Maintenance	Operation	Reference
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.

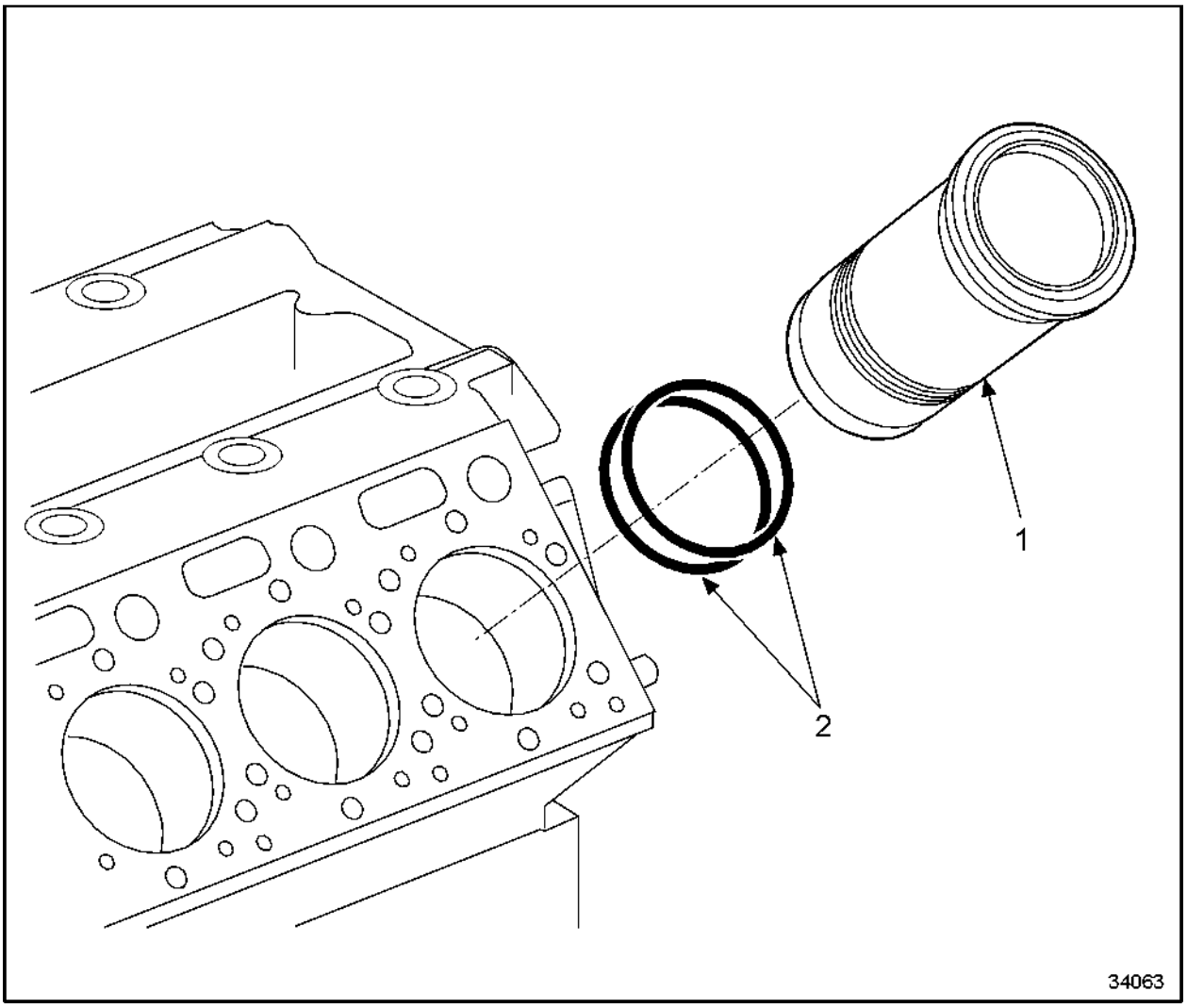
3 = The engine is to remain installed.

Table 3 After-Installation Operations

C 013.05 – CYLINDER LINER

C 013.05.01 – GENERAL VIEW

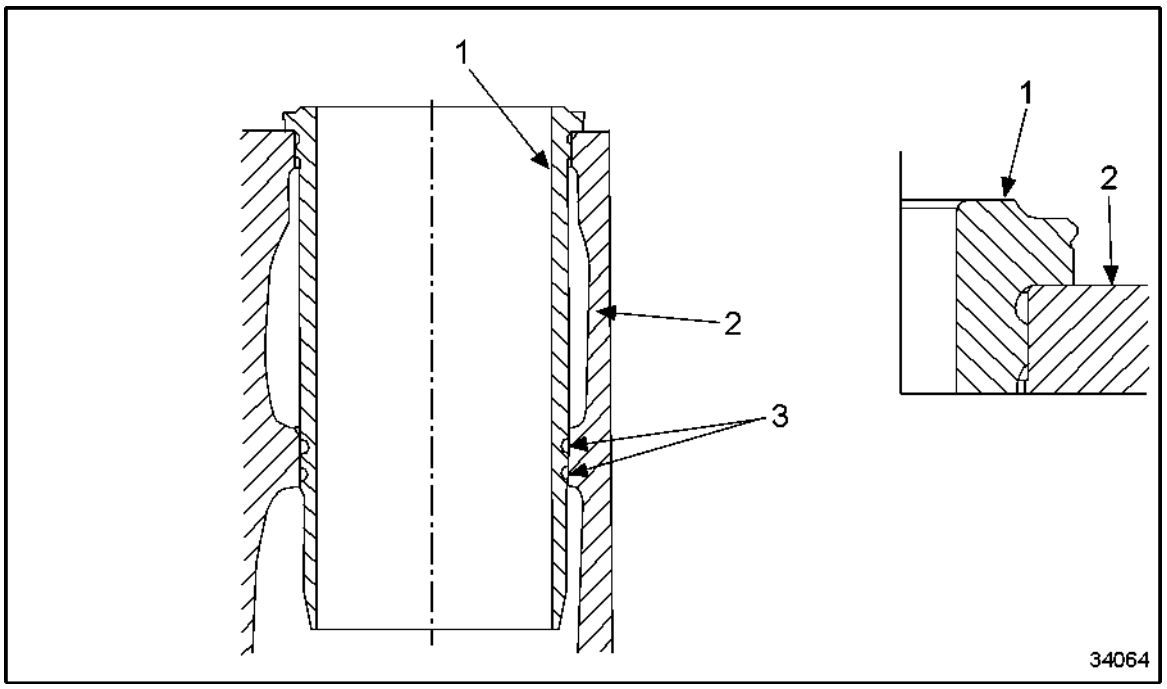
See Figure 71 for a general view of the cylinder liner.



1. Cylinder Liner
2. O-rings

Figure 71 General View of Cylinder Liner

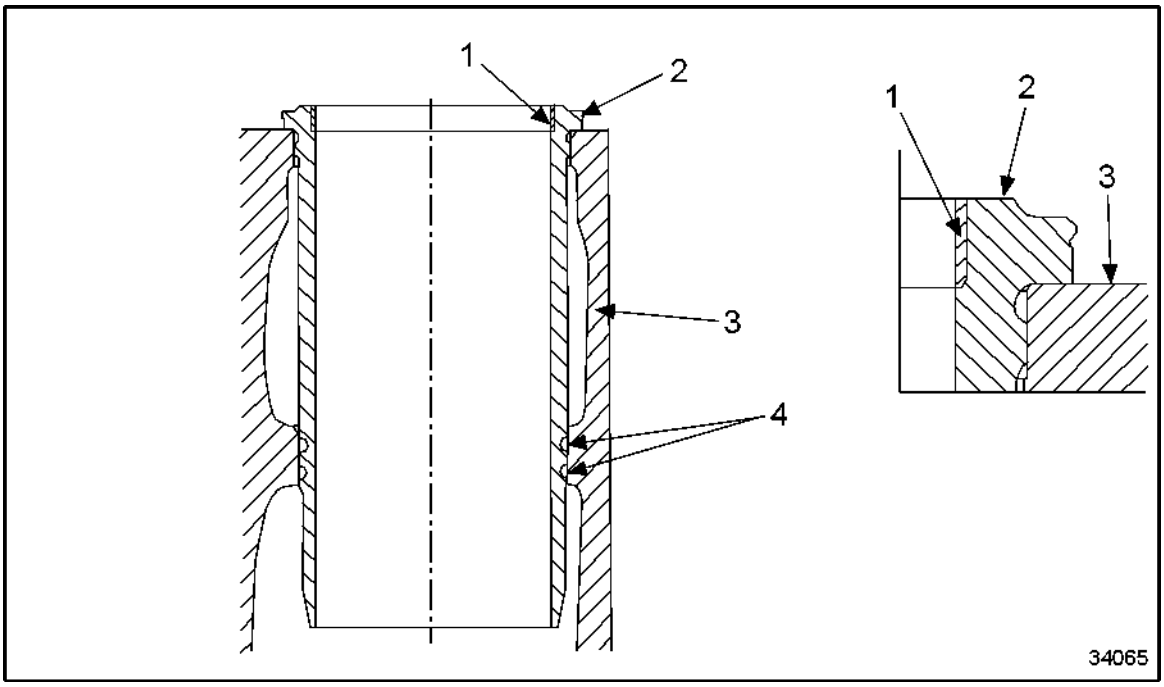
See Figure 72 for a cutaway view of the cylinder liner **without** scraper ring in cylinder block.



1. Cylinder Liner
2. Cylinder Block
3. O-rings

Figure 72 Cylinder Liner Without Scraper Ring

See Figure 73 for a cutaway view of the cylinder liner **with** scraper ring (marine only) in cylinder block.



1. Scraper Ring
2. Cylinder Liner
3. Cylinder Block
4. O-rings

Figure 73 Cylinder Liner With Scraper Ring

C 013.05.02 – SPECIAL TOOLS

Listed in Table 4 are the special tools required for maintenance on the cylinder liner.

Designation	Tool Number
Removal tool for liner	PT 6400-C
Installation tool for liner	J 42729
Bore Gage	J 5347-B

Table 4 Special Tools

C 013.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 5 are the Before-Removal Operations for the cylinder liner.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Remove air filter (If necessary)	Refer to OEM Guidelines
1, 2, 3	Remove exhaust crossover	Refer to OEM Guidelines
1, 2, 3	Remove exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove charge air manifold	Refer to section C 124.05.05
1, 2, 3	Remove rocker cover	Refer to section C 056.05.05
1, 2, 3	Remove high-pressure line	Refer to section C 073.05.05
1, 2, 3	Disconnect fuel return lines	Refer to section C 086.05.05
1, 2, 3	Remove valve drive	Refer to section C 055.05.05
1, 2, 3	Remove pushrods	Refer to section C 055.05.05
1, 2, 3	Disconnect electric wiring harness	Refer to section C 501.05 M
1, 2, 3	Remove fuel injector	Refer to section C 075.05.05
1, 2, 3	Remove cylinder head	Refer to section C 041.05.05
1, 2, 3	Remove cylinder head gasket	Refer to section C 041.05.05
1, 2, 3	Open access port cover, lower or remove oil pan as required	Refer to section C 014.05.05
1, 2, 3	Remove piston and connecting rod	Refer to section C 037.05.05

1 = The engine is to be completely disassembled.

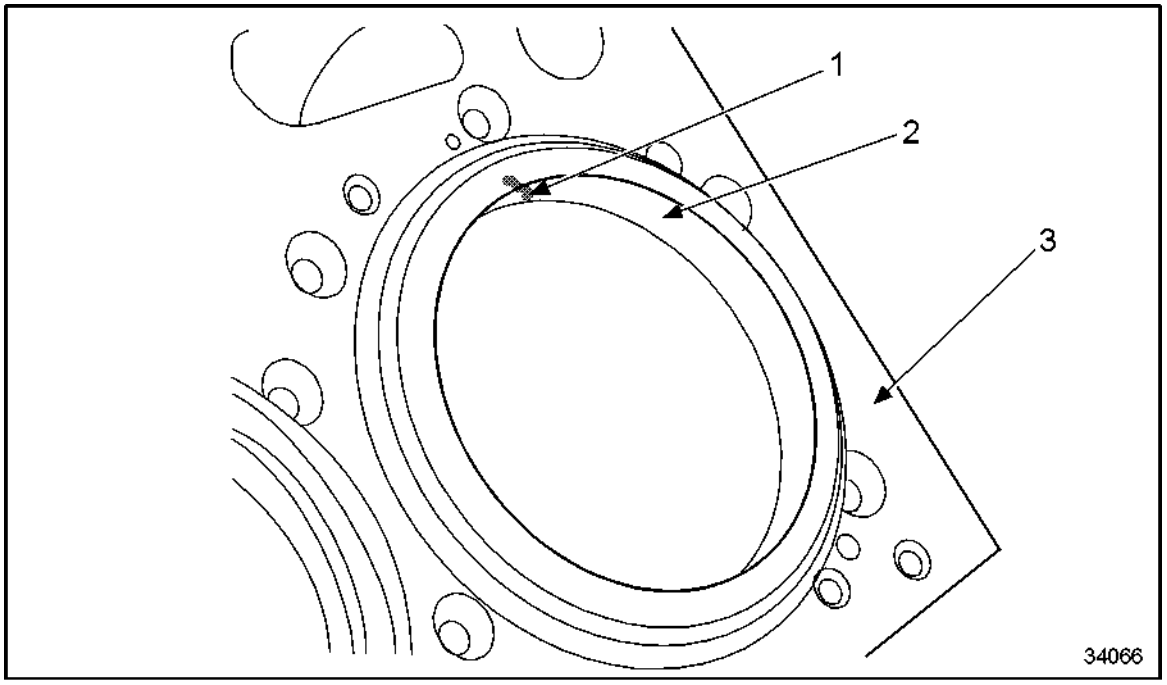
2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 5 Before-Removal Operations

C 013.05.05 – REMOVAL OF CYLINDER LINER

1. Mark installation position of cylinder liner (2) in cylinder block (3). See Figure 74.

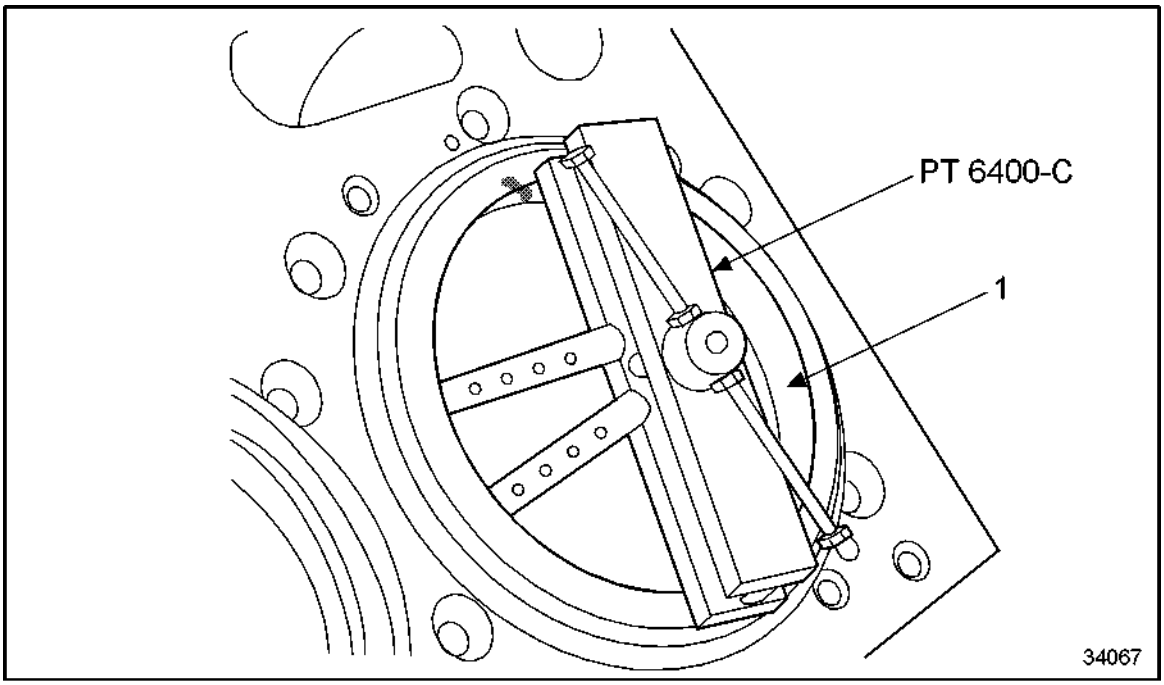


1. Installation Mark
2. Cylinder Liner
3. Cylinder Block

Figure 74 Removing Cylinder Liner

NOTE:
When examining the engine, it is advisable to mark the location of the cylinder liner in reference to the cylinder block at the inboard 12:00 position with a marker pen.

2. Mount removal tool (PT 6400–C) on cylinder liner (1). See Figure 75.



1. Cylinder Liner

Figure 75 Mounting Removal Tool on Cylinder Liner

3. Take care that oil spray nozzle is not damaged.
4. Rotate the removal tool spindle until the cylinder liner is released from the cylinder block bore.
5. Remove removal tool.
6. Remove cylinder liner from cylinder block.
7. Remove O-rings from cylinder liners.

C 013.05.08 – INSPECTION AND REPAIR

1. Clean cylinder liner.
2. Visually inspect cylinder liner for cracks using the magnetic crack-testing method with fluorescent magnetic powder.
   [a] If cylinder liner shows cracks, replace liner as necessary.
   [b] If cylinder liner does not show cracks, continue inspection.
3. Visually inspect outer wall of cylinder liner for pitting.
   [a] If outer wall of cylinder liner shows severe pitting, replace liner as necessary.
   [b] If outer wall of cylinder liner does not show pitting, continue inspection.
4. Visually inspect sealing and mating faces for wear and damage.
   [a] If sealing and mating surfaces show wear or damage, rub down with emery cloth or oilstone as necessary.
   [b] If damage is beyond repair, replace cylinder as necessary.
   [c] If sealing and mating surfaces are not damaged or worn, continue inspection.
5. Replace O-rings.
6. For cylinder liners with carbon scraper ring (marine only): visually inspect carbon scraper ring for scores and pitting.
   [a] If carbon scraper ring shows scores or pitting, replace ring as necessary.
   [b] If carbon scraper ring does not show scores or pitting, continue inspection.
7. Inspect floating mount of carbon scraper ring in the cylinder liner.
   [a] If carbon scraper ring appears to jam, measure the bore in the cylinder liner. Replace carbon scraper ring if necessary.
   [b] If carbon scraper ring does not jam, continue inspection.

Inspecting Wear Pattern of Cylinder Liners

1. Visually inspect wear pattern on wear surface of cylinder liners for flats, scores, cracks and pitting. See Figure 76.

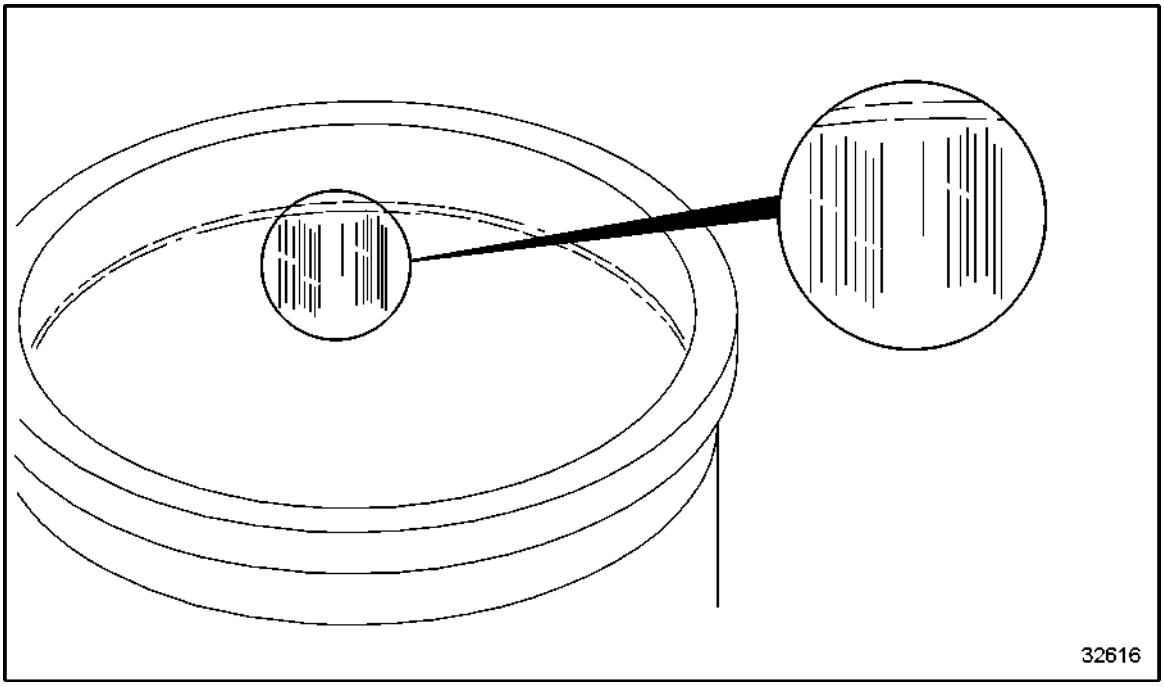


Figure 76 Visually Inspecting Wear Pattern of Cylinder Liner

   [a] If damage is beyond repair, replace cylinder liner as necessary.

NOTE:
When cylinder liners have scraper rings (marine only), honing is carried out with the scraper ring removed. After honing, carefully clean the transition from the honing pattern to the mating surface of the scraper ring.

2. Visually inspect reversing point of first piston ring for wear.
   [a] If reversing point of first piston ring shows wear, replace ring as necessary.

[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.

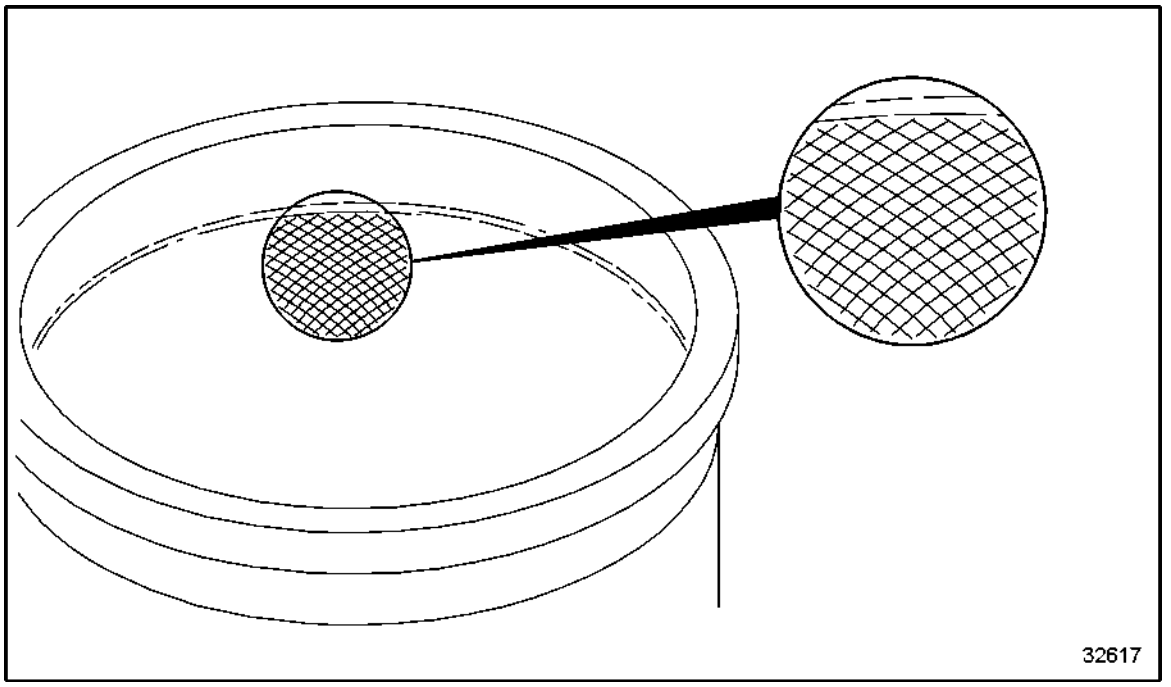
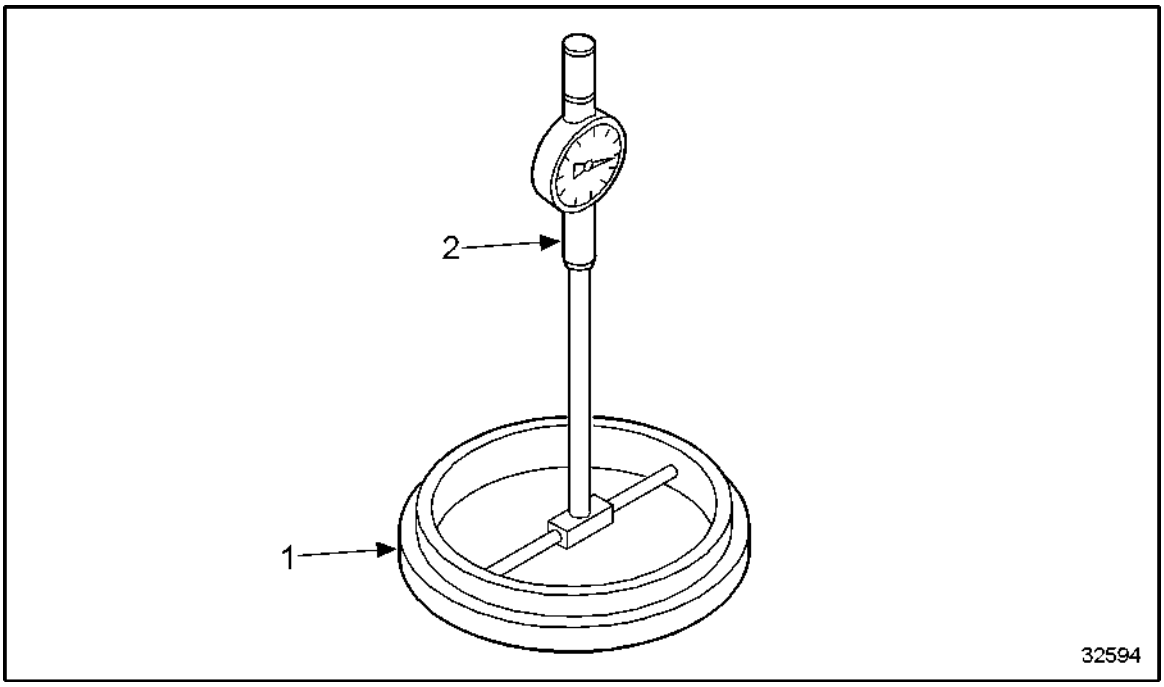


Figure 77 Inspecting Honing Marks for Consistency

Measuring Cylinder Liner I.D.

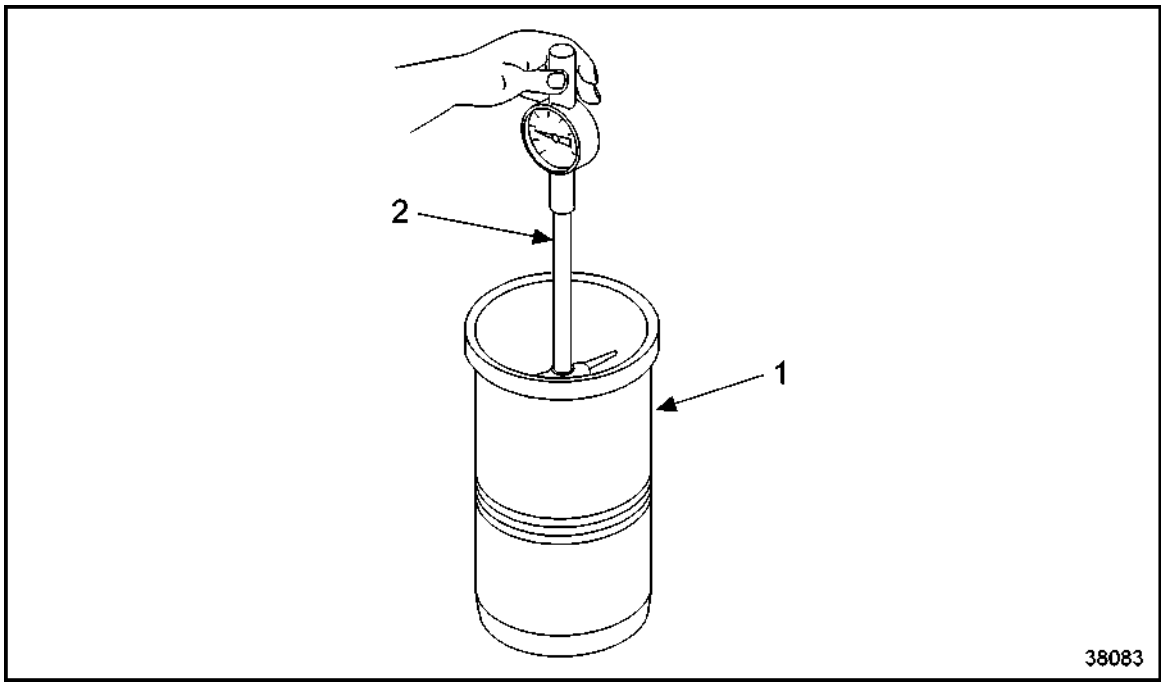
1. Adjust dial bore gage (2) and dial gage with micrometer or adjusting gage ring (1) to basic size for cylinder liner. See Figure 78.



1. Adjusting Gage Ring
2. Dial Bore Gage

Figure 78 Adjusting Bore Gage

2. Measure cylinder liner I.D. with bore gage. See Figure79.



1. Cylinder Liner
2. Bore Gage

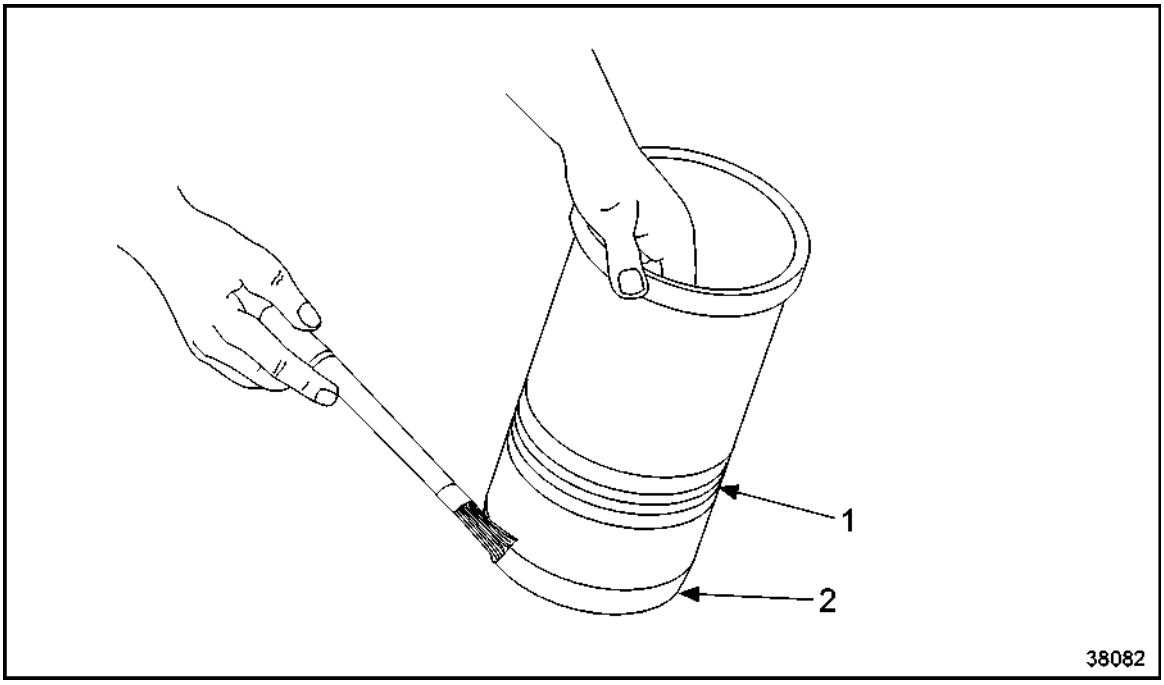
Figure 79 Measuring Cylinder Liner I.D.

[a] If limit values are exceeded, replace cylinder liner.

[b] If limit values are not exceeded, continue to installation.

C 013.05.11 – INSTALLATION OF CYLINDER LINER

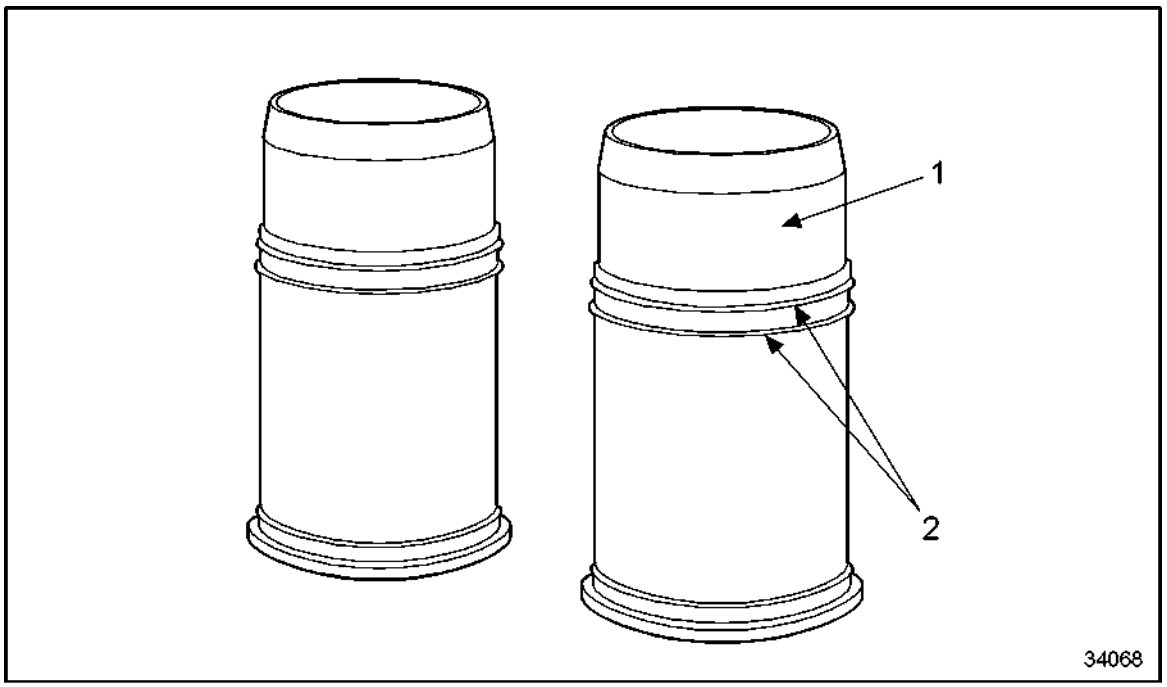
1. Verify cylinder liner repair stage in accordance with tolerance and wear limits list. Record tolerance and wear limits in cylinder block data sheet.
2. Wipe cylinder liner at O–ring lands and at chamfer inclination; then lightly coat with petroleum jelly. See Figure 80.



1. O-ring Lands
2. Chamfer Inclination Area

Figure 80 Coating Cylinder Liner with Petroleum Jelly

3. Install bottom O-rings (2) on grooves in cylinder liner (1). See Figure 81.

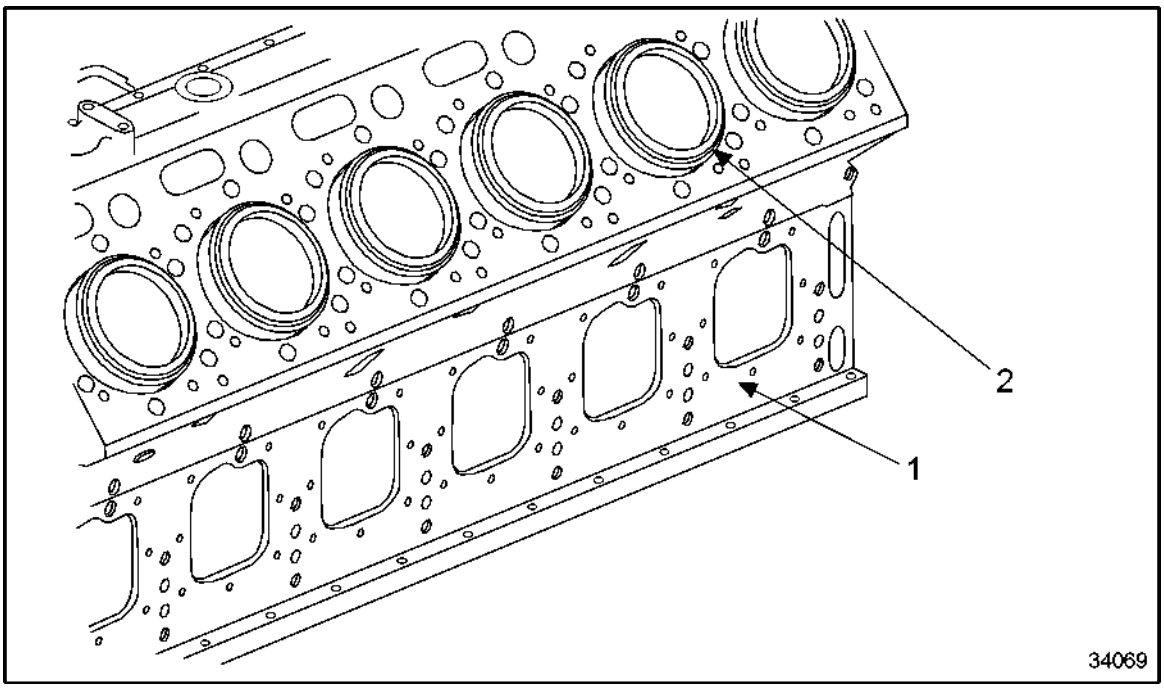


1. Cylinder Liner
2. O-ring

Figure 81 Installing O-rings

NOTE:
Install O-rings with the flat side against the cylinder liner and the rounded side against the cylinder block. Ensure that O-rings have not twisted during installation. After installation of O-rings, lightly coat O-rings with petroleum jelly before installing into cylinder block

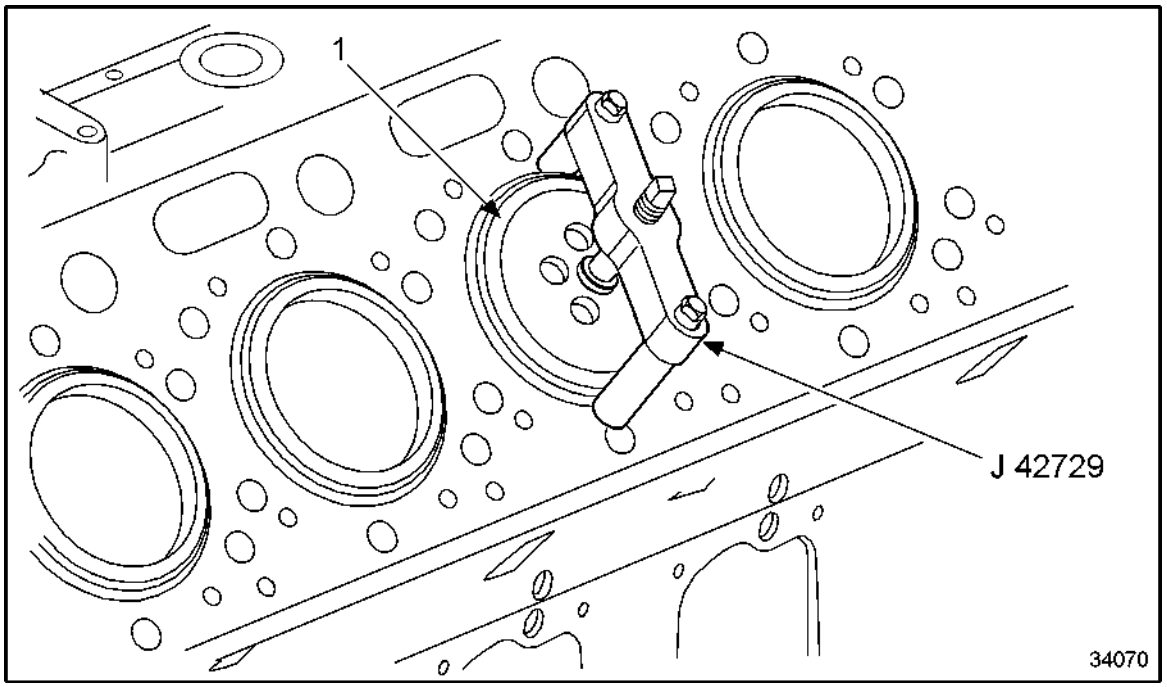
4. Insert cylinder liner in cylinder block. See Figure 82.



1. Cylinder Block
2. Cylinder Liner

Figure 82 Inserting Cylinder Liners into Cylinder Block

5. Press cylinder liner (1) with installation device, J 42729, into cylinder block bore. See Figure 83.



1. Cylinder Liner

Figure 83 Pressing Cylinder Liner with Installation Device into Cylinder Block Bore

6. Adjust bore gage and dial gage with micrometer or gage ring to basic size for cylinder liner. See Figure 84.

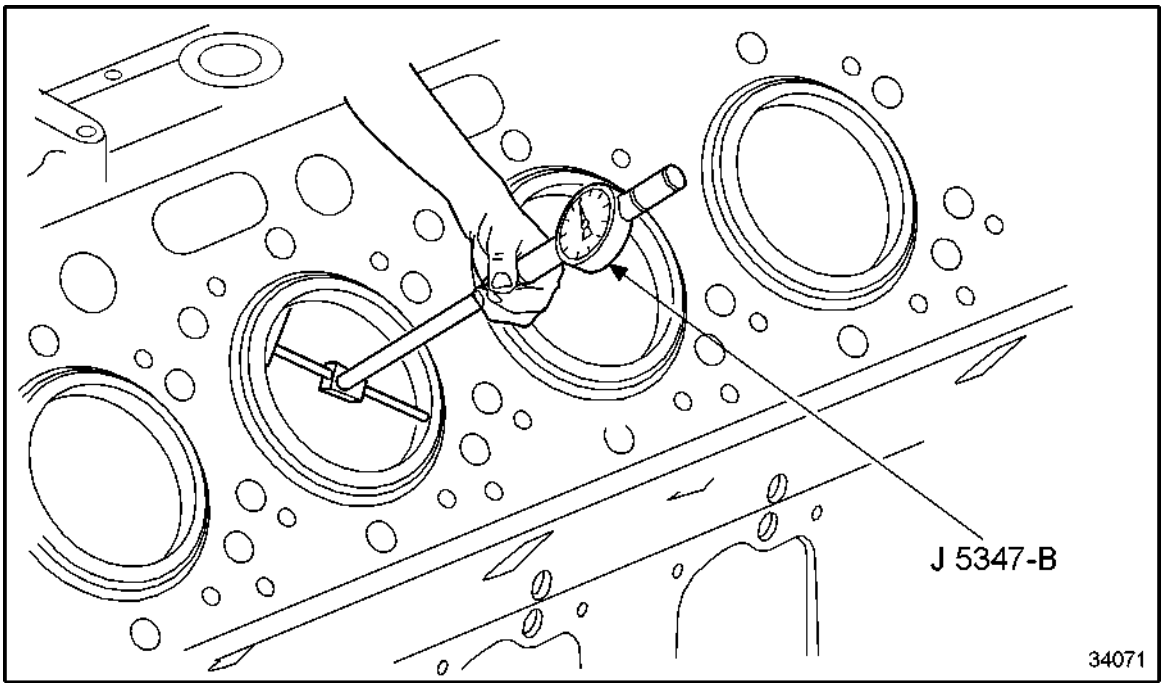


Figure 84 Measuring Cylinder Liner I.D.

7. Using a bore gage, (J 5347–B) measure cylinder liner I.D. at four points, offset at 90 degrees with respect to each other. See Figure 84.

NOTE:
When cylinder liners have carbon scraper rings (marine only), ensure that the measurement planes are below the fit for the carbon scraper ring. Do not insert the carbon scraper ring in the cylinder liner until the pistons have been installed. Refer to section C 037.05.01.

8. Enter measurement values in data sheet.
9. If cylinder liner measures out-of-round, remove liner and measure I.D. and O.D.
10. If cylinder liner is confirmed to be out-of-round, replace liner as necessary.

C 013.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 6 are the After-Installation Operations for the cylinder liner.

Level of Maintenance	Operation	Reference
1, 2, 3	Install piston and connecting rod	Refer to section C 037.05.11
1, 2, 3	Install oil pan and/or close access port cover	Refer to section C 014.05.11
1, 2, 3	Install cylinder head	Refer to section C 041.05.11
1, 2, 3	Install pushrods	Refer to section C 055.05.11
1, 2, 3	Install valve drive	Refer to section C 055.05.11
1, 2, 3	Adjust valve clearance	Refer to section C 055.05.11
1, 2, 3	Install fuel return lines	Refer to section C 086.05.11
1, 2, 3	Install fuel injector	Refer to section C 075.05.11
1, 2, 3	Install high-pressure line	Refer to section C 075.05.11
1, 2, 3	Connect electric wiring harness	Refer to section C 075.05.11
1, 2, 3	Install rocker cover	Refer to section C 056.05.11
1, 2, 3	Install charge air manifolds	Refer to section C 124.05.11
1, 2, 3	Install exhaust manifold	Refer to section C 141.05.11
1, 2, 3	Install turbocharger	Refer to section C 101.05.11
1, 2, 3	Install exhaust crossover	Refer to OEM Guidelines
1, 2, 3	Connect electric cables	Refer to section C 501.05 M
1, 2, 3	Install air filter	Refer to OEM Guidelines
1, 2, 3	Fill oil system with engine oil	Refer to Operators Guide
1, 2, 3	Fill engine coolant system	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.

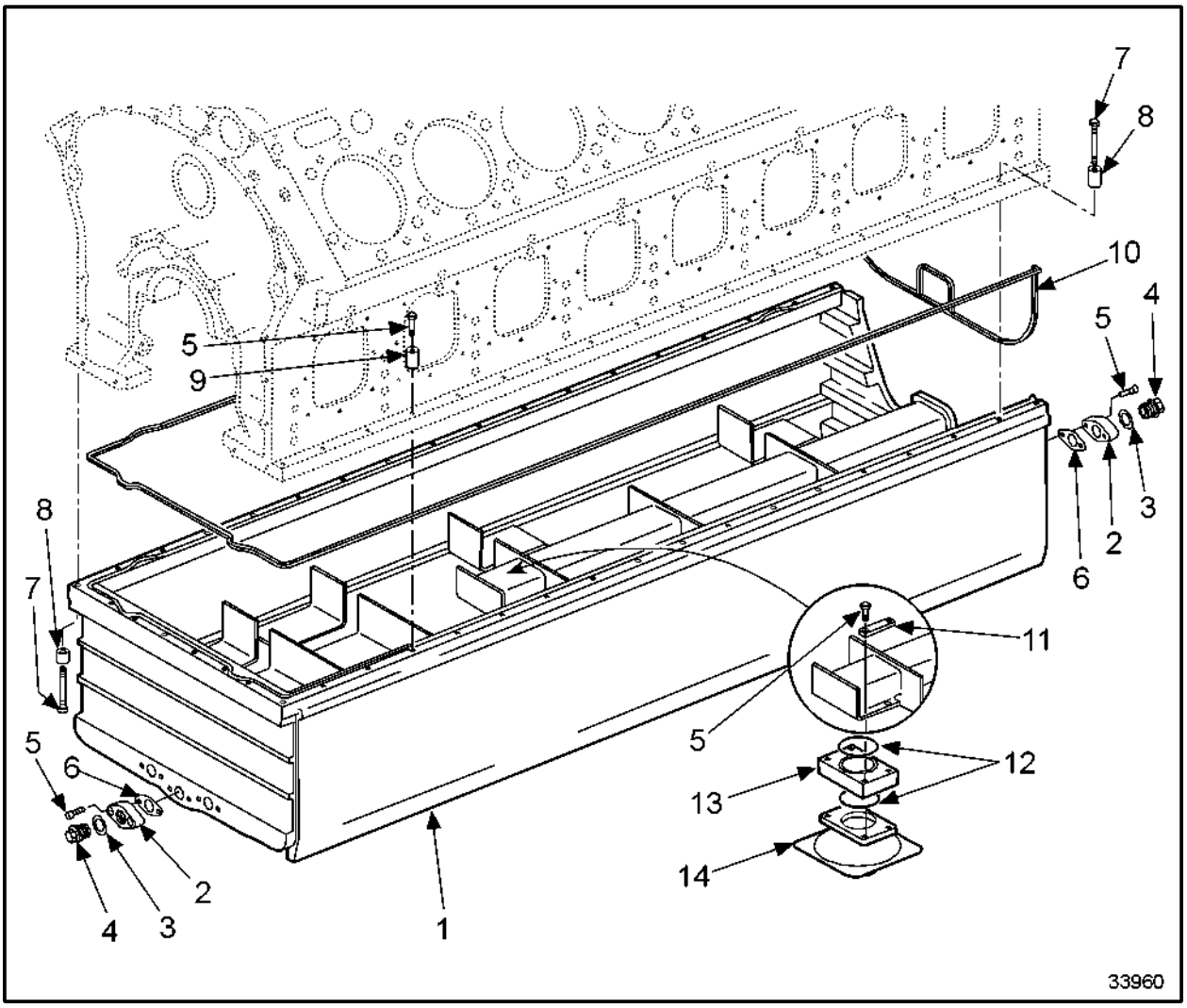
3 = The engine is to remain installed.

Table 6 After-Installation Operations

C 014.05 – OIL PAN

C 014.05.01 – GENERAL VIEW

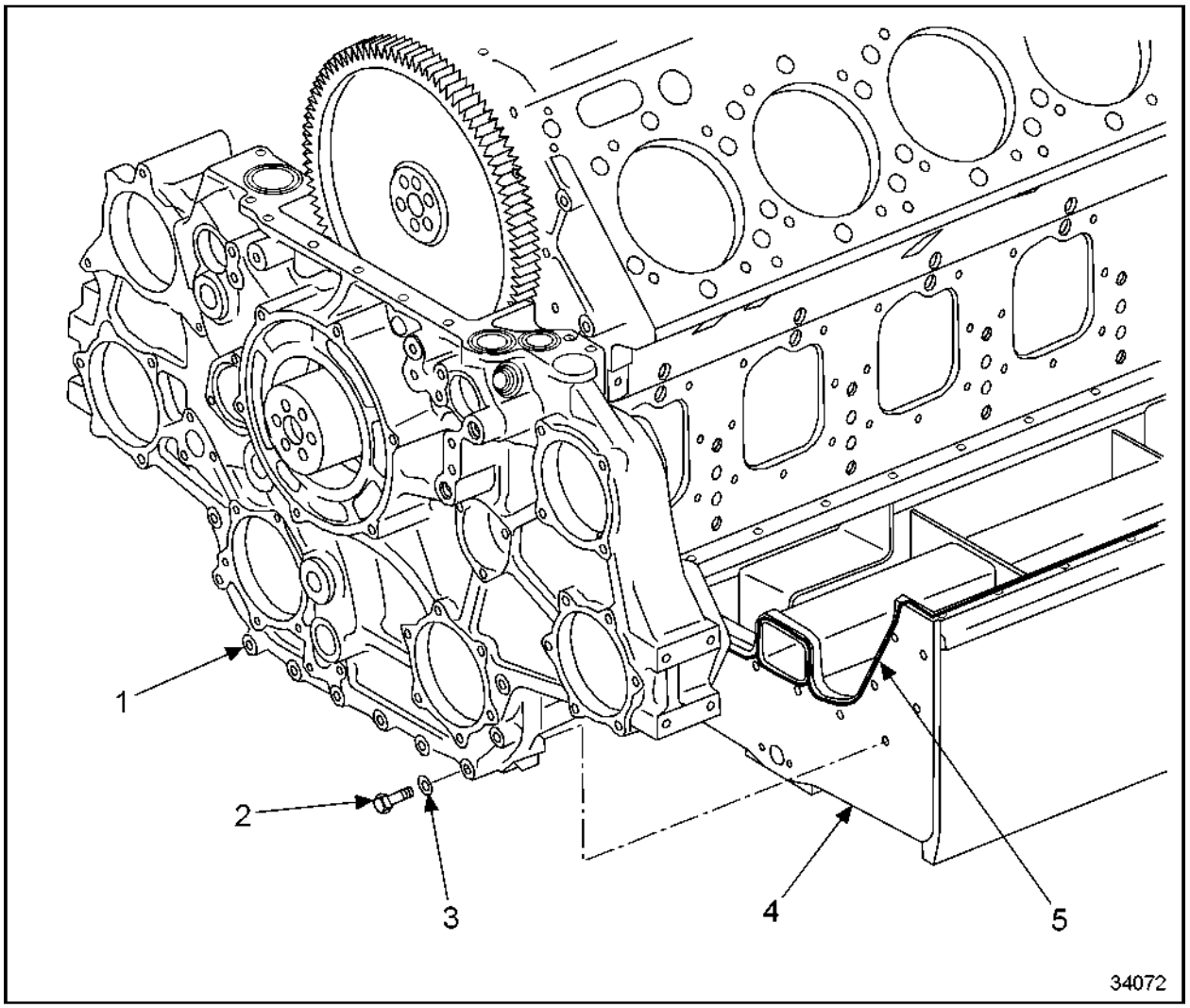
See Figure 85 for a general view of the oil pan.



1. Oil Pan
2. Flange
3. O-ring
4. Plug
5. Bolt
6. Gasket
7. Bolt
8. Spacer
9. Spacer
10. Pan Seal
11. Retainer
12. O-ring
13. Spacer Block
14. Suction Basket

Figure 85 General View of Oil Pan

See Figure 86 for an overview of the oil pan, gear case end.



1. Gear Train Cover
2. Hex Bolt
3. Washer
4. Oil Pan
5. Oil Pan Seal

Figure 86 Overview of Oil Pan, Gear Case End

See Figure 87 for the oil pan torque diagram.

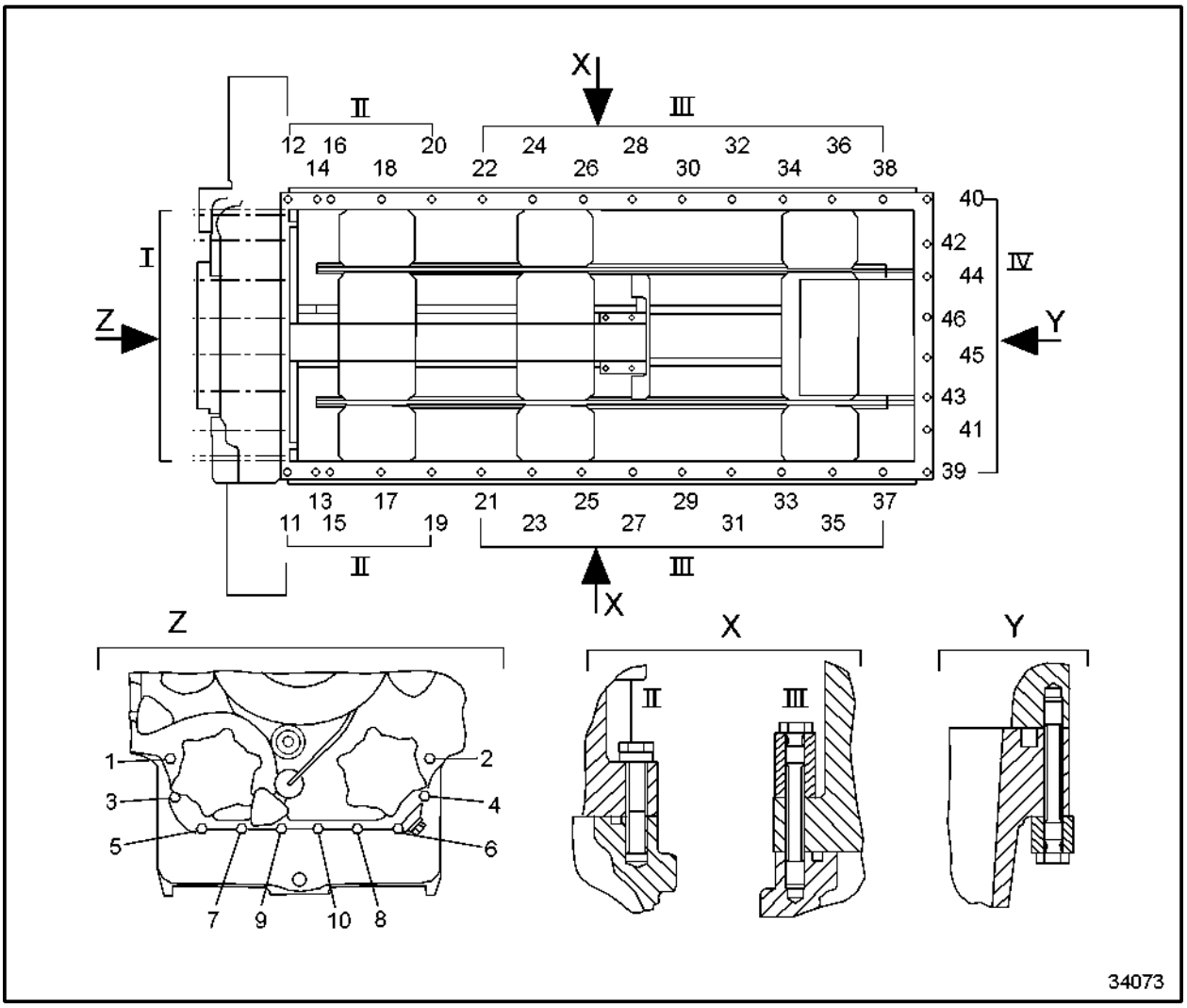


Figure 87 Oil Pan Torque Diagram

Perform the following steps to torque the oil pan hex bolts:

NOTE:
Tighten all bolts to specification. Refer to section A 003.

1. Torque four hex bolts by hand at the corner points of the oil pan (11, 24) diagonally and evenly so that seal seats properly.
2. Insert two securing bolts (1, 10) in the gear case and pretorque to 60 N·m.
3. Loosen two securing bolts (1, 10) and tighten to a final torque of 30 N·m.
4. Torque four hex bolts at the corner points (11, 24) of oil pan to respective specified final torques diagonally and evenly, hex bolts (24) to 60 + 6 N·m, hex bolts (11) to 27 + 3 N·m.

5. Torque eight hex bolts at front surface of oil pan, flywheel end, (24 to 31) to 27 N·m + 3 N·m.
6. Tighten hex bolts (11 to 24) to respective final torque.
7. Insert securing bolts (2 to 9) in the gear case and tighten to specified torque.
8. Ensure that all hex bolts used to secure the oil pan have been tightened to their correct torques. Repeat assembly procedure if necessary.

C 014.05.02 – SPECIAL TOOLS

Listed in Table 7 is the special tool required for maintenance on the oil pan.

Designation	Tool Number
Taper reamer for taper pin 10 x 65 in accordance with DIN 258.	—

Table 7 Special Tools

C 014.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 8 are the Before-Removal Operations for the oil pan.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Remove oil pan gear case (gear case end) elbow	Refer to OEM Guidelines
1, 2, 3	Remove flange from oil pan (gear case end)	Refer to section C 014.05.05
1, 2, 3	Remove fuel delivery pump	Refer to section C 081.05.05
1, 2, 3	Release pipe clamp halves of coolant line (right engine side)	Refer to section C 203.05.05
1, 2, 3	Release or remove access cover with oil filler neck	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.

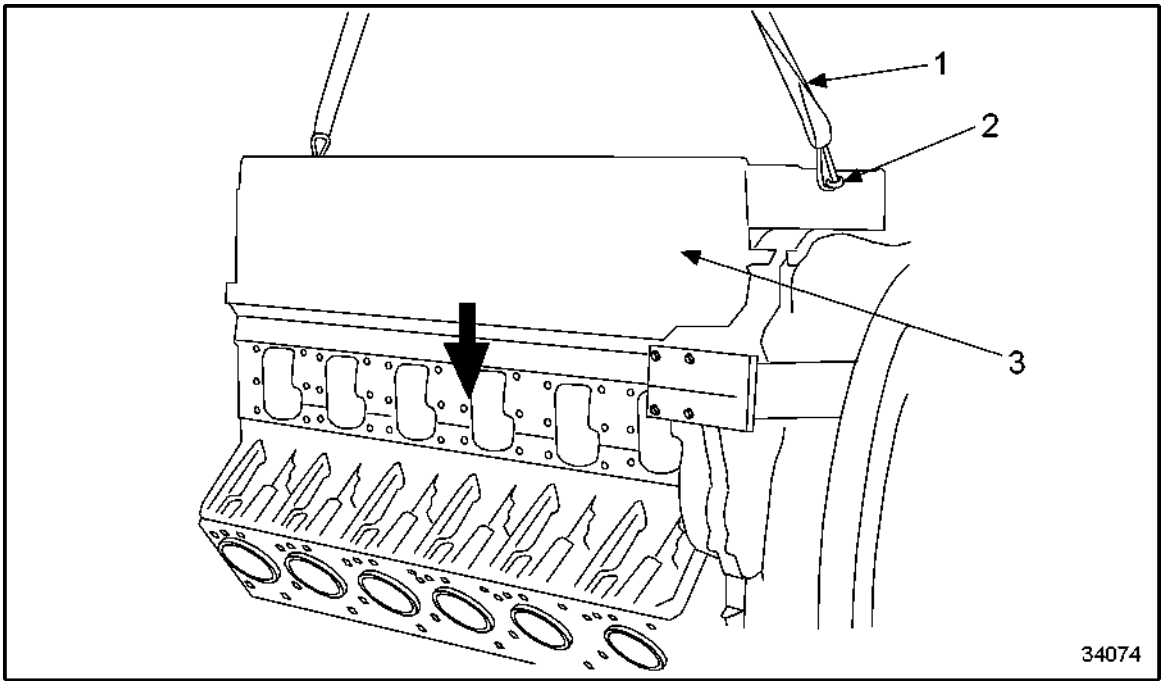
Table 8 Before-Removal Operations

C 014.05.05 – REMOVAL OF OIL PAN

Removal of Oil Pan (Out of Chassis)

Perform the following steps for the removal of the oil pan (out of chassis):

1. Install engine in turnover stand and turn by 180 degrees. See Figure 88.



1. Lifting Device
2. Eyebolt
3. Oil Pan

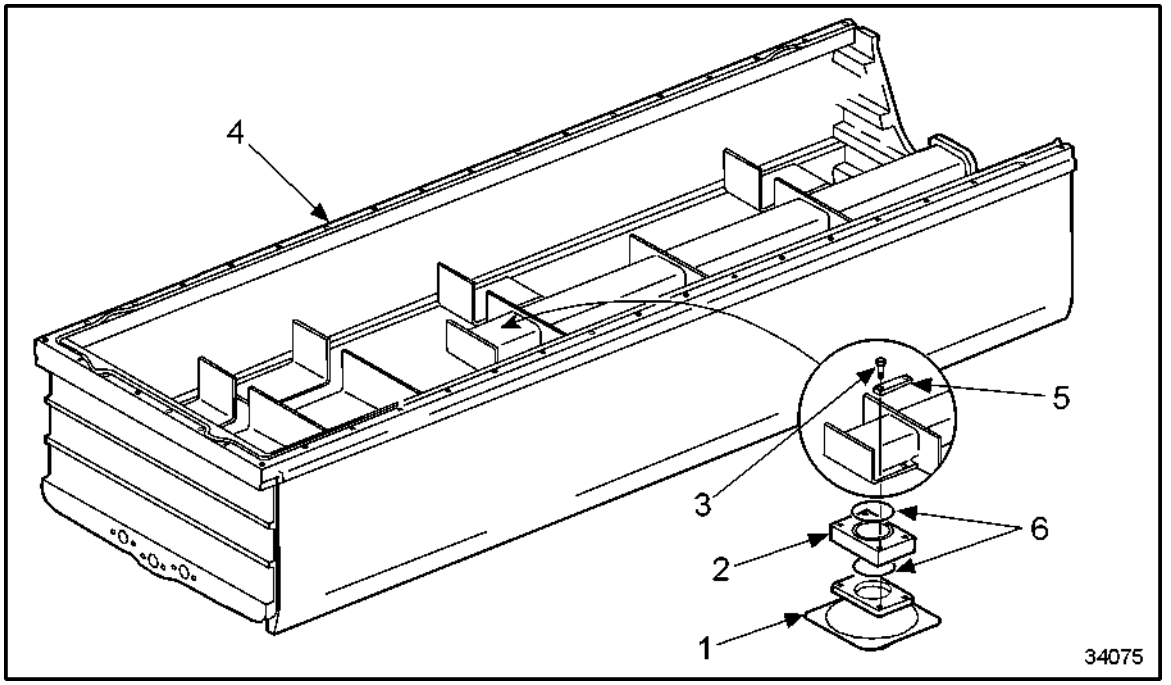
Figure 88 Removing Oil Pan

2. Remove all hex bolts for oil pan (3). See Figure 88.
3. Unscrew plugs at the front and rear surfaces of oil pan and insert two suitable eyebolts (2) in the oil pan.

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.

4. Carefully raise oil pan with lifting device (1) and crane and lower onto suitable support.
5. Remove eyebolts and flange from front and rear surfaces.
6. If necessary, remove rubber sealing ring.
7. Loosen hex bolts (3) and retainer (5) and, at the same time, hold suction basket (1) in place. See Figure 89.



1. Suction Basket
2. Spacer
3. Hex Bolt
4. Oil Pan
5. Retainer
6. O-ring

Figure 89 Removing Suction Basket

8. Withdraw spacer (2) and suction basket (1). See Figure 89.
9. Remove top and bottom O-ring from spacer.

Removal of Oil Pan (In Chassis)

Perform the following steps for the removal of the oil pan (in chassis):

1. Drain engine oil from both the oil pan and gear case.
2. Inspect installation and using OEM recommendations remove any necessary truck components that may interfere with the removal of the oil pan.
3. Remove the lube oil filler dipstick assembly from the side of the cylinder block and inspect for damage. Care should be taken to protect the dipstick and tube assembly from damage during storage.
4. Remove ECM mounting bolts and store the ECM out of the way of the main bearing stabilizer bolts. Care should be taken to protect the ECMs and harnesses
5. Install a floor jack that has been modified to cradle the oil pan at the center of the oil pan. See Figure 90.

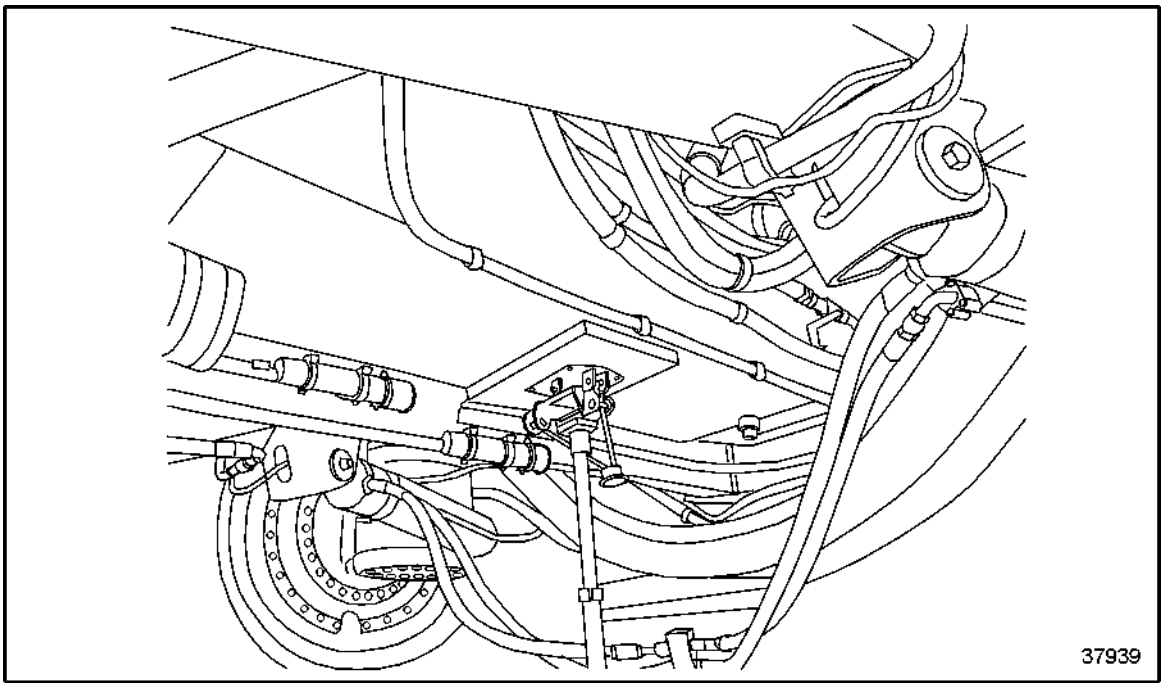


Figure 90 Installing Floor Jack

6. Remove all oil-pan-to-gear case attaching bolts. Remove all remaining oil pan bolts and spacers. Slowly lower front end of oil pan allowing remaining oil in the pan to drain.

NOTE:
Capture any foreign material that may flush out at this time.

7. Rest the rear end of the oil pan on the truck front cross member. Relocate jack to front end of the oil pan. Lower front end of oil pan to lowest position of jack. Slide pan forward and lower rear end of pan to the floor. Remove front end of the oil pan to the floor. rRemove the oil pan from under the engine.

C 014.05.08 – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the oil pan:

1. Clean oil pan and carefully remove any remaining solvents.

NOTE:
Ensure parts are perfectly clean.

2. Visually inspect oil pan using surface crack-testing method with red penetrant dye.
   [a] If oil pan shows cracks, replace oil pan.
   [b] If oil pan does not show cracks, continue inspection.
3. Visually inspect mating surface of oil pan and cylinder block for surface irregularities.
   [a] If mating surface shows surface irregularities over 0.2 mm (0.0079 in.), recondition mating surface.
   [b] If mating surface does not show surface irregularities, continue inspection.
4. Visually inspect all mating and sealing surfaces and pan seal support groove for irregularities.
   [a] If surfaces show irregularities, rub down with emery cloth or oilstone as necessary.
   [b] If irregularities are beyond repair, replace components as necessary.
   [c] If mating surfaces do not show irregularities, continue inspection.
5. Visually inspect all parts for wear and damage.
   [a] If wear or damage is found, replace components as necessary.
   [b] If wear or damage is not found, continue inspection.
6. Visually inspect condition of threads in tapped bores.
   [a] If threads are worn or damaged, replace threaded inserts as necessary.
   [b] If threads are not worn or damaged, continue inspection.
7. Visually inspect suction basket, spacer block and mating mount flange in oil pan for contamination and damage.
   [a] If the mesh grill is contaminated or damaged, replace suction basket.
   [b] If the mesh grill is not contaminated or damaged, continue inspection.
8. Visually inspect suction basket, spacer block and mating mount flange in oil pan for surface irregularities.
   [a] If suction basket, spacer block and mating mount flange in oil pan show surface irregularities, repair to ensure proper sealing.
   [b] If damage is beyond repair, replace component.

[c] If suction basket, spacer block and mating mount flange in oil pan do not show surface irregularities, continue inspection.

9. Replace gaskets, sealing rings and rubber profile.

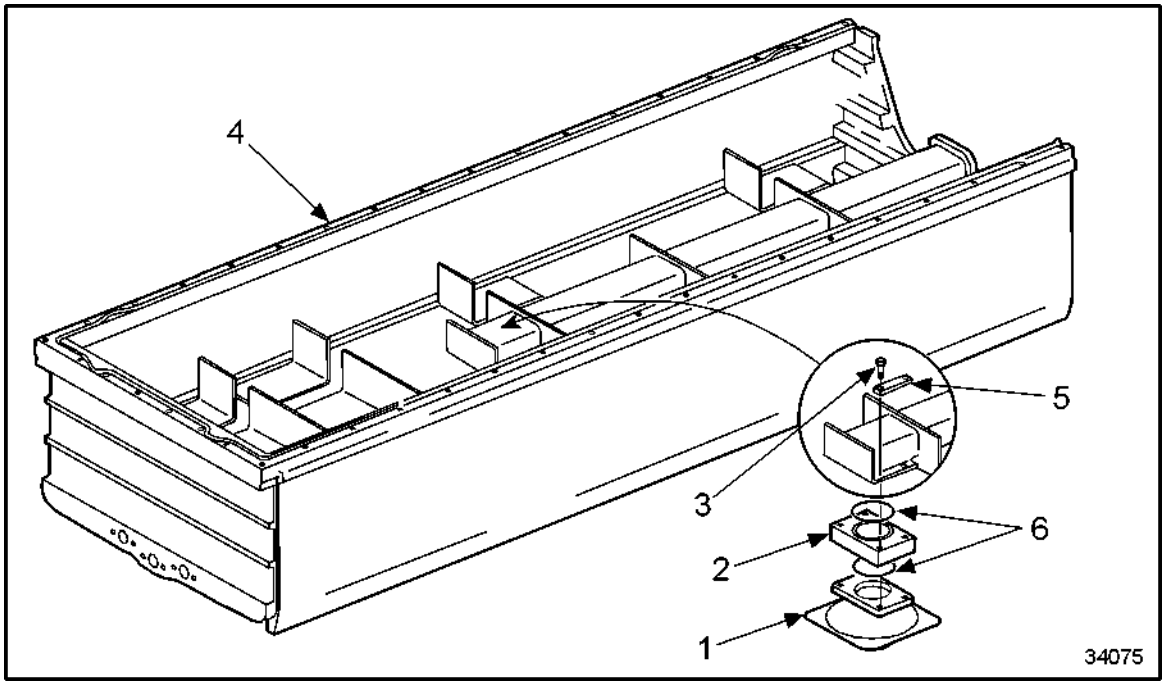
C 014.05.11 – INSTALLATION OF OIL PAN

Installation of Oil Pan (Out of Chassis)

Perform the following steps for the installation of the oil pan (out of chassis):

NOTE:
Ensure that all components are perfectly clean.

1. To install suction basket, coat top and bottom O-rings (6) with petroleum jelly and insert in the top and bottom grooves of the spacer (2). See Figure 91.

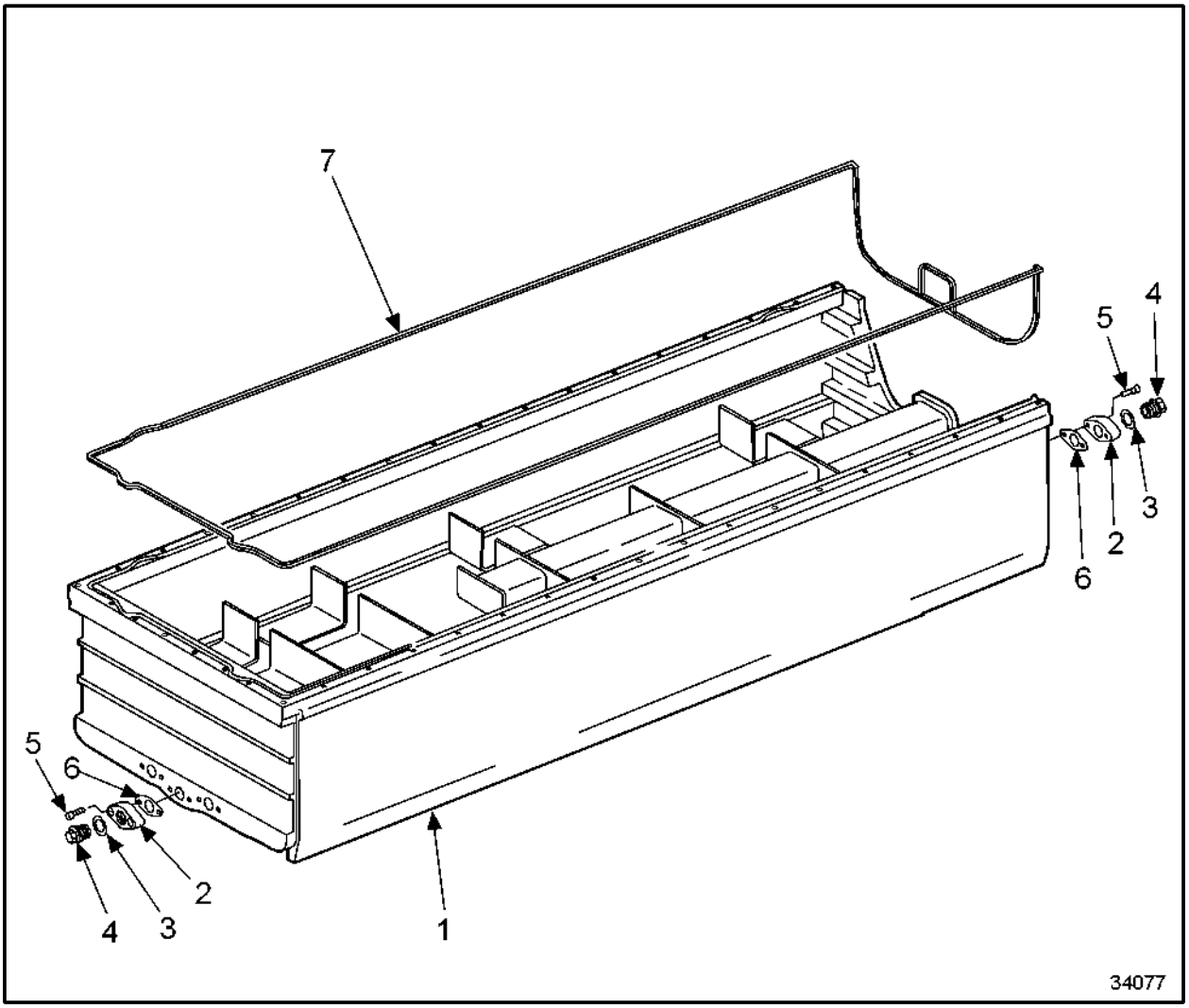


1. Suction Basket
2. Spacer
3. Hex Bolt
4. Oil Pan
5. Retainer
6. O-ring

Figure 91 Installing Suction Basket

2. Place suction basket with spacer in position at the flange surface.
3. Hold suction basket and spacer in place and screw together with hex bolts (3) and retainer (5).

4. To install oil pan, install pan strip seal (7) carefully in the designated groove on the oil pan. See Figure 92.

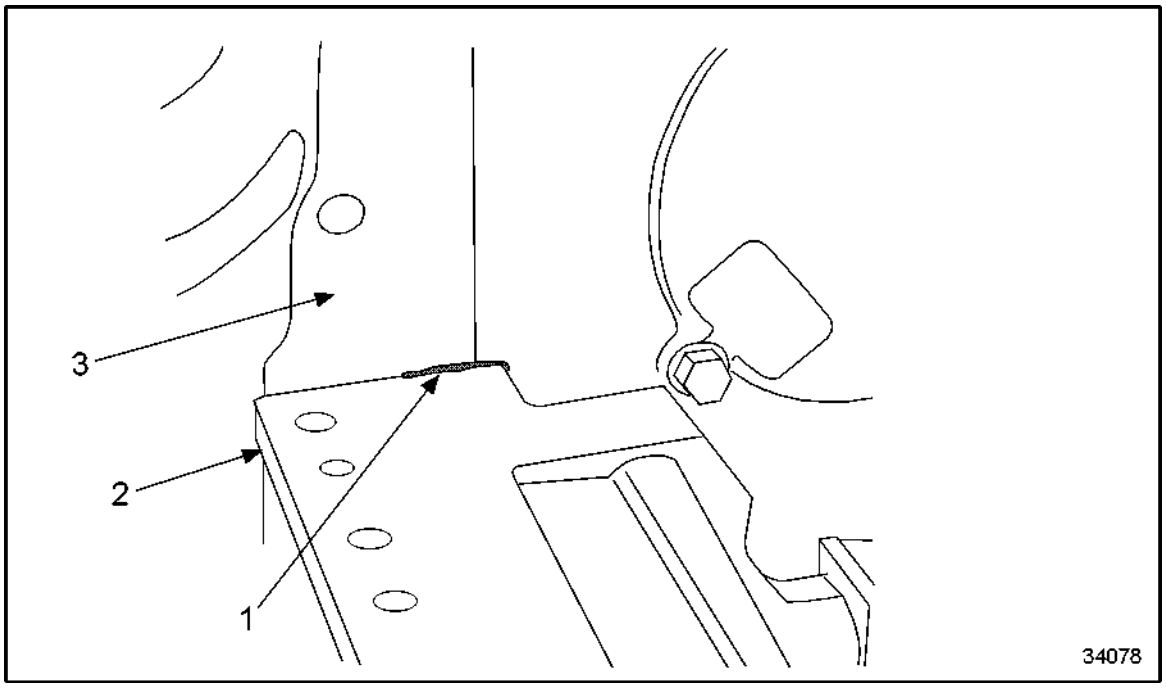


1. Oil Pan
2. Flange
3. Sealing Ring
4. Plug
5. Socket-Head Bolt
6. Gasket
7. Pan Strip Seal

Figure 92 Installing Oil Pan

5. Apply a bead of RTV (Loctite 5900 is preferred) at the “A” and “B” bank locations were the gear case and block intersect (bend of gasket).
6. Move flange for plugs into position at both front surfaces of the oil pan.

7. Move cotton seal, which protrudes on both sides of the gear case, to along the parting line of cylinder block/gear case. See Figure 93.



1. Cotton Seal
2. Cylinder Block
3. Gear Case

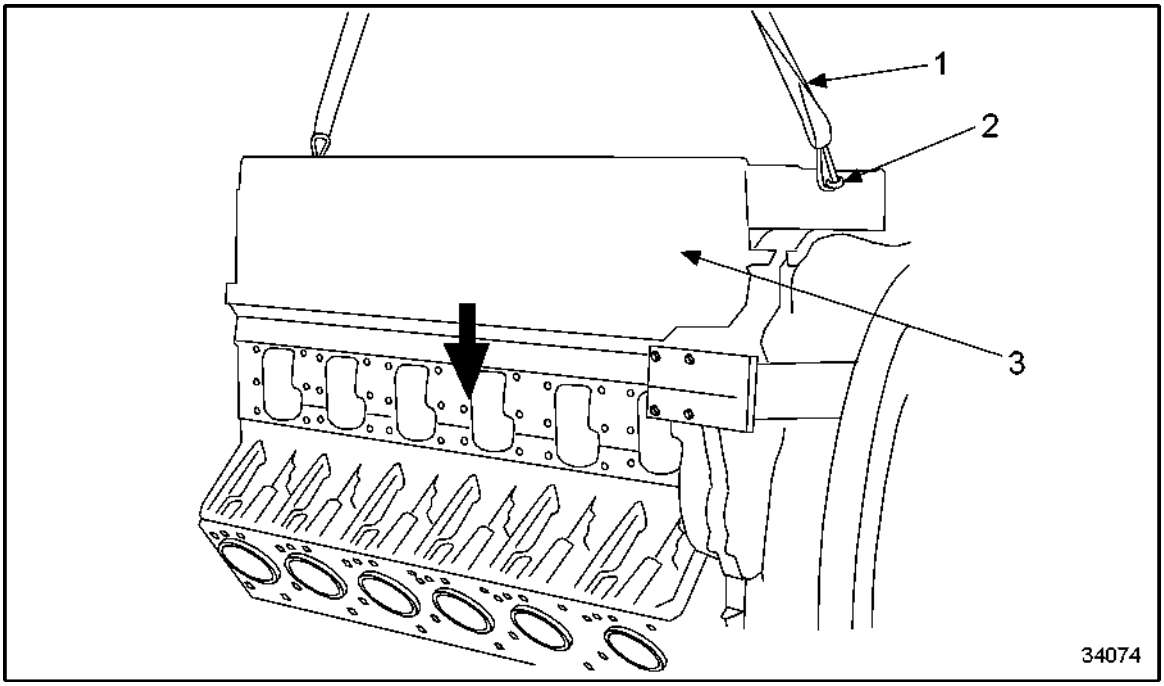
Figure 93 Moving Woolen Thread

8. Insert two suitable eyebolts (2) in the plug bores for the oil pan (3). See Figure 94.

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.

9. Using lifting device (1) and crane, lift oil pan and carefully place on mating surface of cylinder block. See Figure 94.



1. Lifting Device
2. Eyebolt
3. Oil Pan

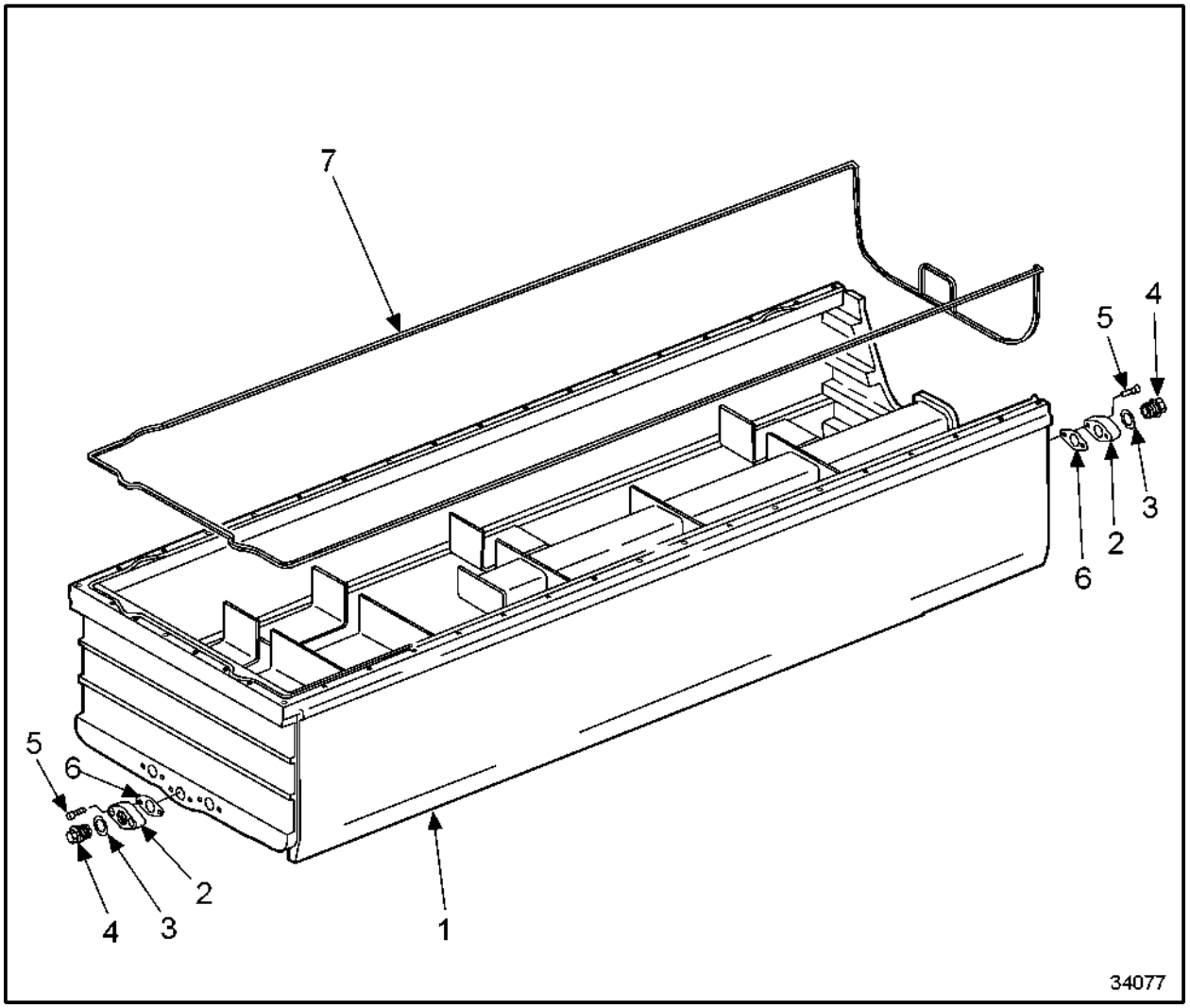
Figure 94 Placing Oil Pan on Mating Surface

10. At the same time, align oil pan to bores in mating surface of cylinder block.
11. Tighten oil pan in accordance with tightening diagram. Refer to section C 011.05.01.

NOTICE:

Oil pan may break if cylinder block is lowered onto it.

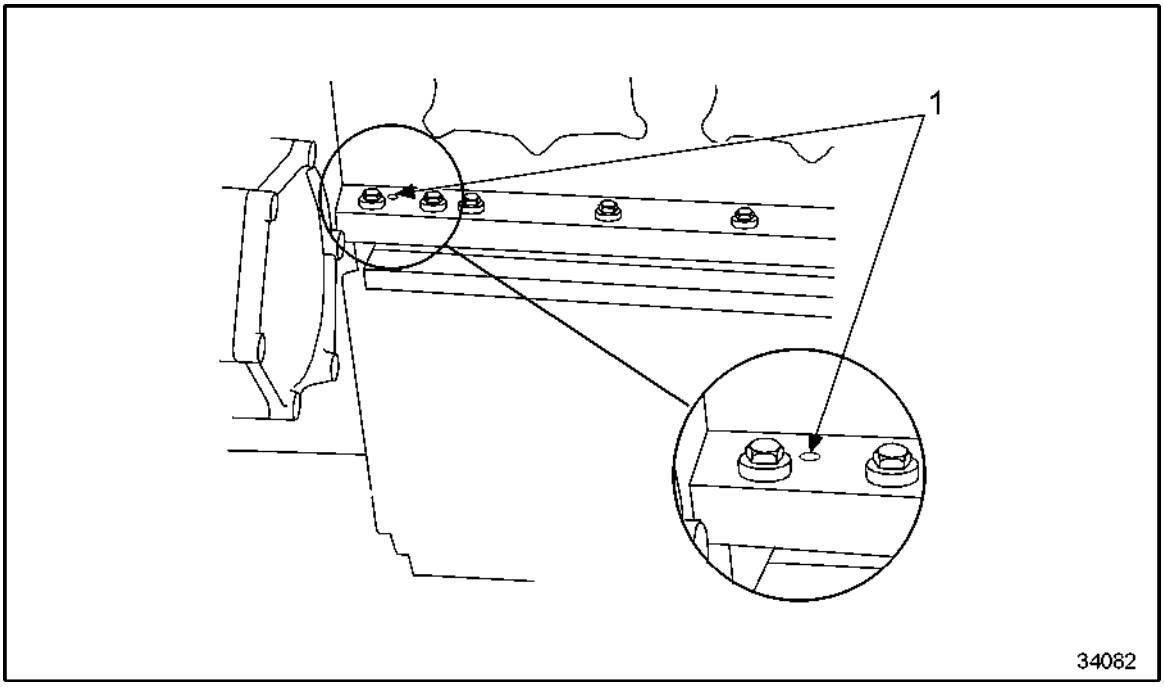
12. Install flange (2) with O–ring (3) and plug (3) on the respective surface ends of the oil pan. See Figure 95.



1. Oil Pan
2. Flange
3. O-ring
4. Plug
5. Socket-Head Bolt
6. Gasket
7. Pan Strip Seal

Figure 95 Installing Flange with Gasket and Plug on Oil Pan

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



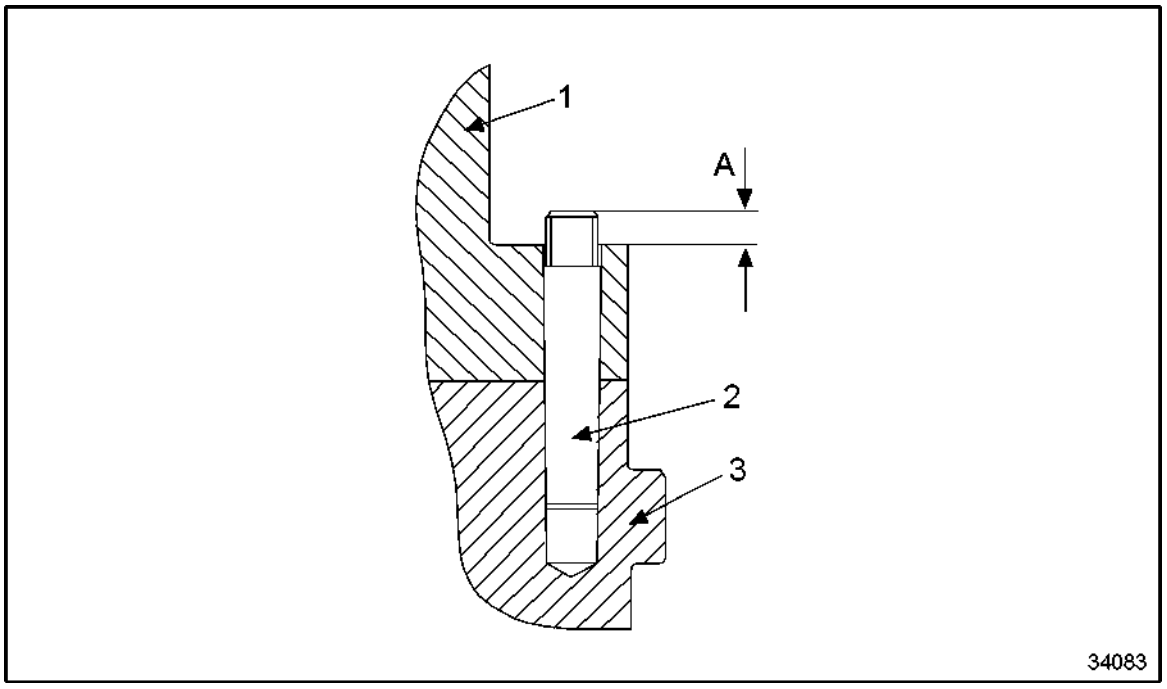
1. Taper Pin Location

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.

[a] Predrill taper pin locating bore in oil pan to a diameter of 10 mm (corresponds to the smallest taper pin diameter). See Figure 97.



1. Cylinder Block
2. Taper Pin
3. Oil Pan

Figure 97 Installing Taper Pin

[b] At the same time, position the drill in the locating bore for the taper pin in the cylinder block.

[c] See Figure 97for drilling depth.

NOTE:
Ensure parts are perfectly clean. All inlets and oil-carrying components must be sealed.

15. Clean locating bore and ream with a suitable taper reamer.

CAUTION:

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

16. Blow out parts with compressed air.
17. Drive taper pin in with gentle taps of a hammer until the specified alignment between taper pin thread and locating bore has been reached.
18. Shorten the fitted taper pin at thread end so that the thread projection is:

    A = 8 mm (0.31496 in.) +1 mm (0.03937 in.).

Installing Oil Pan (In Chassis)

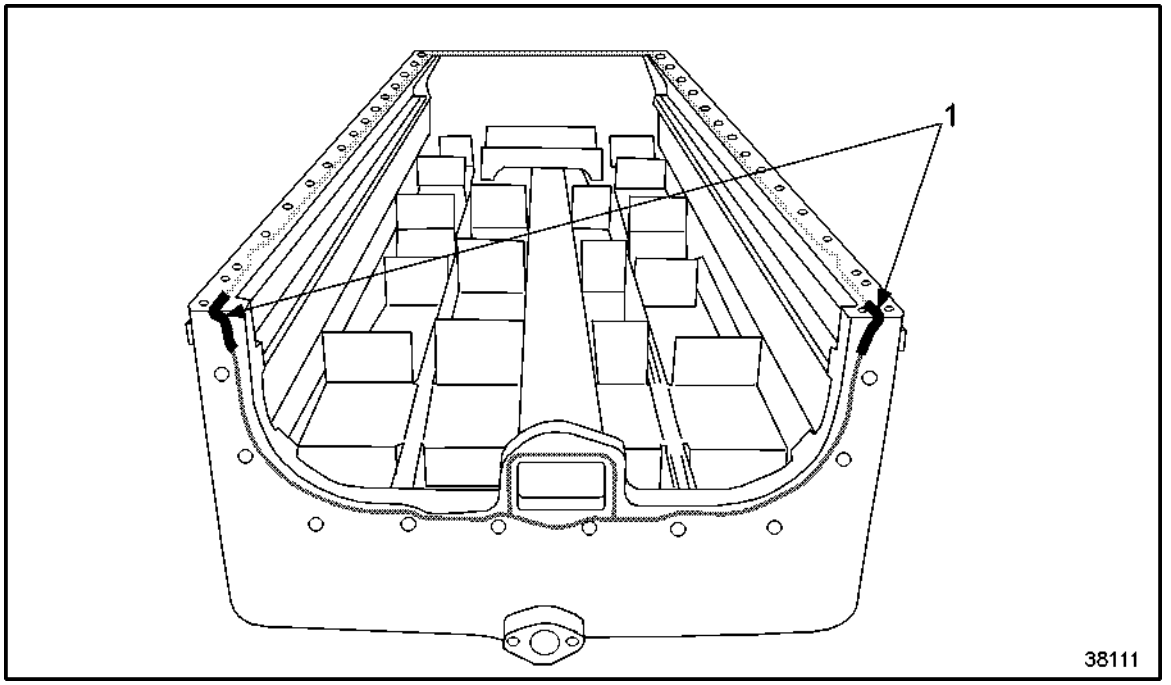
Perform the following steps to install oil pan (in chassis):

1. Clean oil pan, block rail and gear case mating surfaces thoroughly.
2. Apply a bead of RTV (Loctite 5900 is preferred) at the “A” and “B” bank locations where the gear case and block intersect.

NOTE:
This step should be done just before installing the pan; the RTV should not be allowed to dry.

NOTE:
Do not allow the “A” and “B” bank strip seal corners to be pinched between the gear case and oil pan during assembly.

3. Use a brush and apply oil liberally on the oil pan rail. Repeat this for the block rail and the gear case/oil pan mating face. Ensure the brush is not caught in the RTV at the 90 degree joint (1). See Figure 98.



1. 90 degree joint with RTV

Figure 98 Installing Oil Pan (In-Chassis)

4. Ensure block rail and oil pan rail are in a parallel plane. This can be achieved by using two telescope jacks, one forward and one aft of the pan.
5. Using the jacks, slowly raise the pan to the block while keeping the rear of the oil pan against the flywheel housing (at least two people are recommended for this job).
6. Keep checking to ensure the strip seal corners do not rub against the gear case.
7. When the pan rail is in position, start all oil pan rail bolts.
8. Pull up as necessary on the five oil pan bolts closest to the gear case on the left and right bank until the bolts through the gear case and oil pan can be started.
9. Torque the gear case oil pan bolts to 65 N·m using an alternating torque sequence (torque upper most “A” bank and then upper most “B” bank, then torque the remaining gearcase/oil pan bolts in the same sequence.
10. Torque the first oil pan rail bolt closest to the gear case on the left and right bank to 60 N·m.
11. Torque the remaining four M10 X 60 bolts on each side to 60 N·m.
12. Torque all the remaining bolts (M10 X 90 bolt with long spacers) to 30 N·m in any sequence.

13. Torque audit all the pan rail bolts and gear case bolts to ensure that they did not loosen during the initial torque process.
14. Reinstall the ECMs using proper torque specifications.
15. Reinstall the oil filler/dipstick assembly using a new gasket. Torque attaching bolts to proper specifications.
16. Torque oil pan drain plug to 45 N·m — 50 N·m. Install new oil filters and refill engine with new engine oil. Check oil level with dipstick. Clean up tools and area. Pressure pre-lube with pre-filtered oil before start-up. Remove a rocker cover and ensure oil is getting to the overhead.
17. Remove lockout from truck and start engine; let run at idle for five minutes while checking for oil leaks. Recheck oil level and top off to correct level.
18. Release truck.

C 014.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 9are the After-Installation Operations for the oil pan.

Level of Maintenance	Operation	Reference
1, 2, 3	Install engine	Refer to OEM Guidelines
1, 2, 3	Install flange in oil pan, gear case end	Refer to section C 014.05.11
1, 2, 3	Install oil pan gear case elbow, gear case end	Refer to OEM Guidelines
1, 2, 3	Install fuel delivery pump	Refer to section C 081.05.11
1, 2, 3	Install access cover with oil filler neck	Refer to OEM Guidelines
1, 2, 3	Install pipe clamp halves of coolant line	Refer to section C 203.05.11
1, 2, 3	Fill oil system with engine oil	Refer to Operator Guide
1, 2, 3	Fill engine coolant system	Refer to Operator Guide
1, 2, 3	Enable engine power	Refer to Operator Guide
1, 2, 3	Vent fuel system	Refer to Operator Guide

1 = The engine is to be completely disassembled.

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

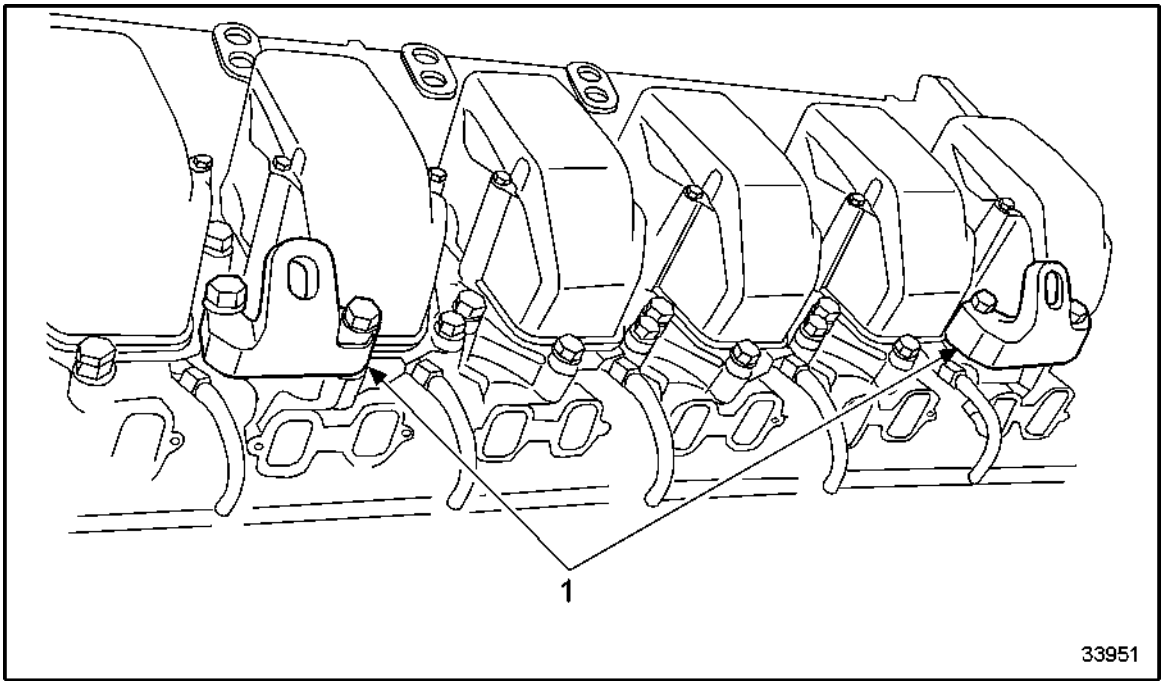
3 = The engine is to remain installed.

Table 9 After-Installation Operations

C 015.05 – LIFTING ATTACHMENTS FOR ENGINE AND RUNNING GEAR

C 015.05.01 – GENERAL VIEW

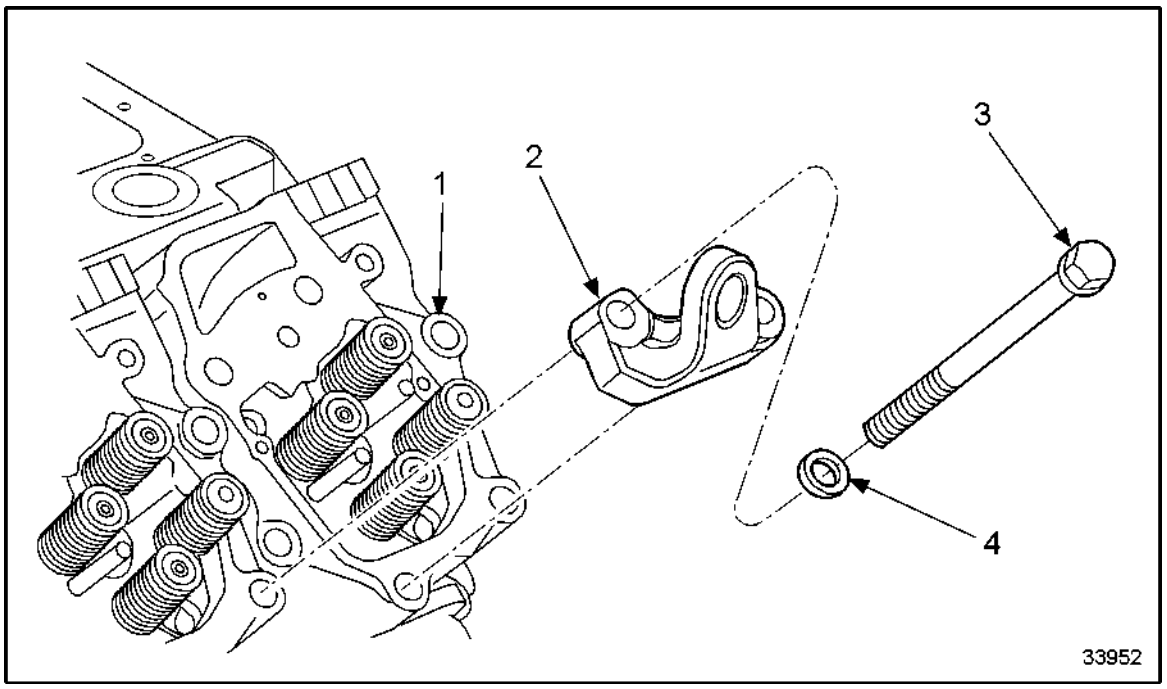
See Figure 99 for a general view of the engine lifting attachments.



1. Engine Lifting Attachments

Figure 99 General View of Engine Lifting Attachments

See Figure 100 for engine lifting attachments.



1. Cylinder Head
2. Lifting Eye
3. Mounting Bolt
4. Washer

Figure 100 Engine Lifting Attachment

C 015.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 10are the Before-Removal Operations for engine lifting attachments.

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

1 = The engine is to be completely disassembled.

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

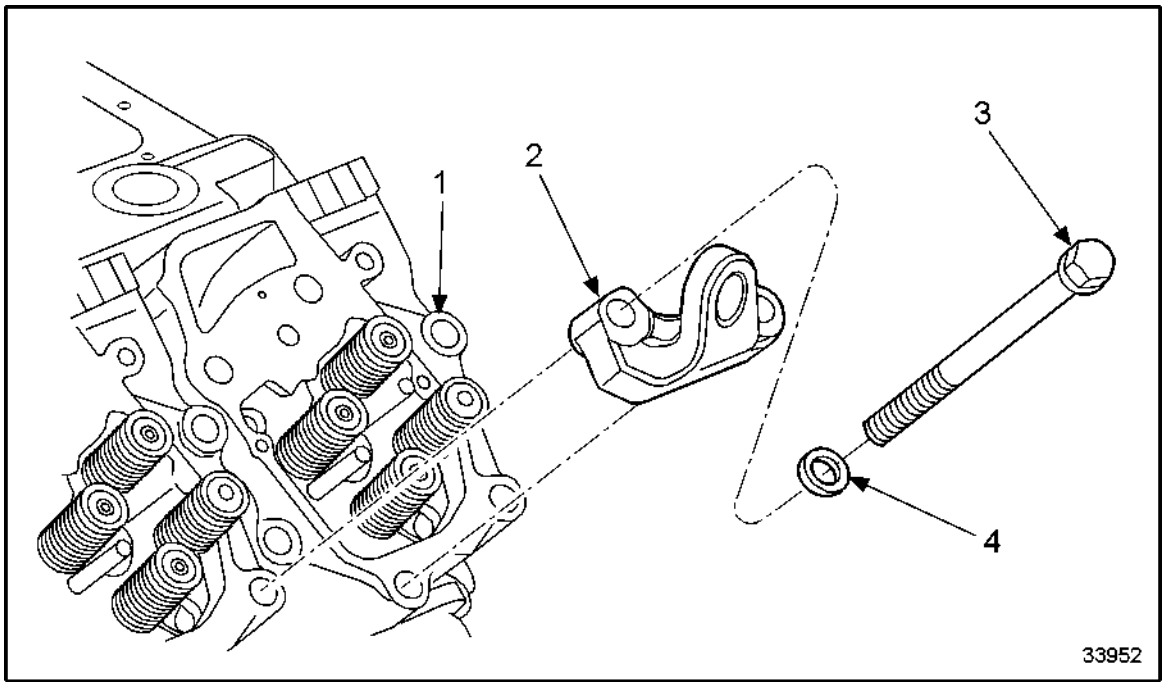
3 = The engine is to remain installed.

Table 10 Before-Removal Operations

C 015.05.05 – REMOVAL OF ENGINE LIFTING ATTACHMENTS

Perform the following steps to remove the engine lifting attachments:

1. Remove cylinder head bolts that connect the lifting eye (2) to the cylinder head. See Figure 101.



1. Cylinder Head
2. Lifting Eye
3. Mounting Bolt
4. Washer

Figure 101 Removing Cylinder Head Bolts that Connect Lifting Eye

2. Remove cylinder head bolts (3) and washers (4). See Figure 101.
3. Remove lifting eye (2). See Figure 101.

C 015.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the engine lifting attachments:

1. Clean all components and visually inspect for damage and defects.
   [a] If components are damaged or defective, replace as necessary.
   [b] If components are not damaged or defective, continue inspection.
2. Visually inspect lifting eye for cracks using the magnetic crack-testing method with fluorescent powder.
   [a] If lifting eye is cracked, replace component.
   [b] If lifting eye is not cracked, continue inspection.

NOTE:
Alignment work or repair welding is not permitted at the lifting eye.

3. Visually inspect condition of mating surfaces and/or screw–down surfaces for damage or wear.
   [a] If mating surfaces are damaged or worn, rub down with an oilstone as necessary.
   [b] If mating surfaces are not damaged or worn, continue inspection.
4. Inspect thread in cylinder head for ease of movement.
   [a] If thread in cylinder head does not show ease of movement, rechase threads as necessary.
   [b] If thread in cylinder head does show ease of movement, continue inspection.

Inspect Cylinder Head Bolts

Perform the following steps to inspect the cylinder head bolts.

1. Visually inspect thread and bolt head mating surface to ensure that they are in perfect condition.
   [a] If thread or bolt head mating surface is not in perfect condition, replace component as necessary.

[b] If thread and bolt head mating surface are in perfect condition, continue inspection of cylinder head bolts.

2. Measure shaft length of the cylinder head bolts with depth gage. See Figure 102.

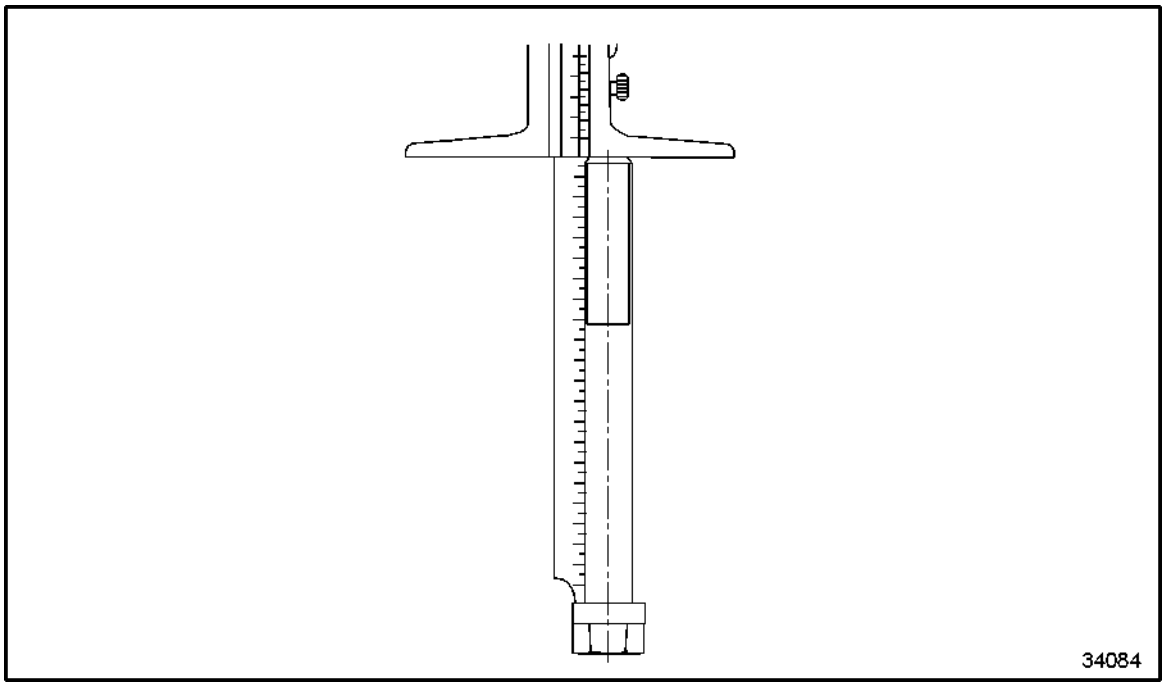


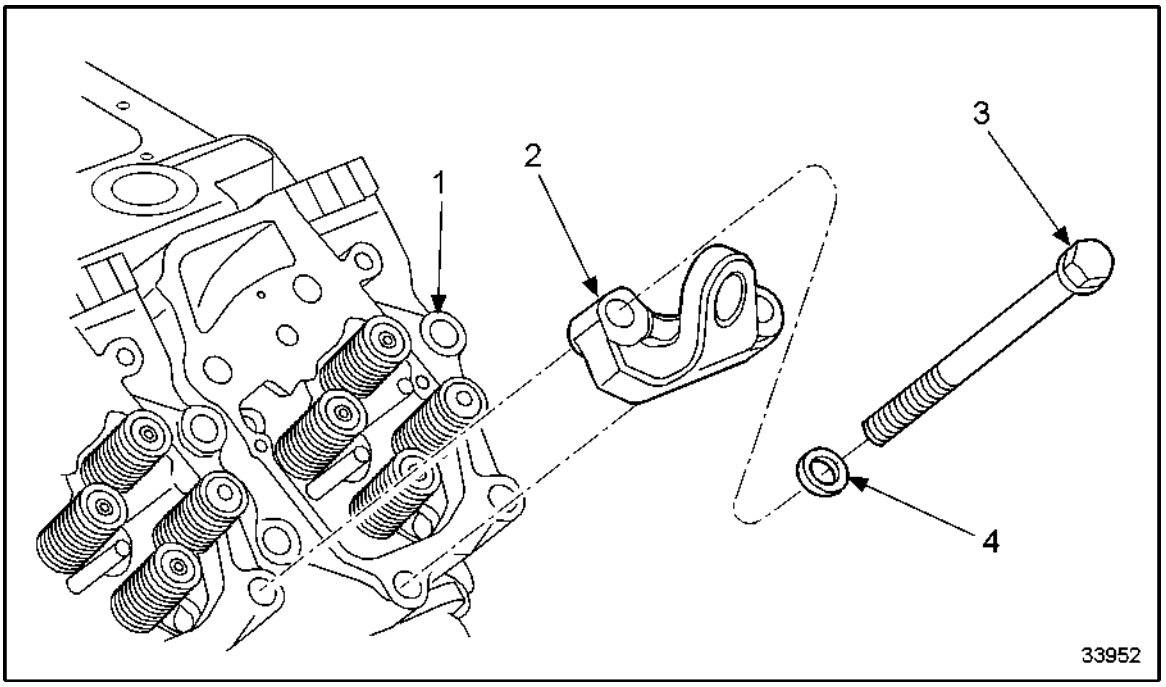
Figure 102 Inspecting Cylinder Head Bolts

3. For maximum permissible shaft length, refer to sectionC 041.05.01.

C 015.05.11 – INSTALLATION OF ENGINE LIFTING ATTACHMENTS

Perform the following steps to install engine lifting attachment.

1. Place lifting attachments (2) on cylinder head edges and align to the bores for the cylinder head bolts. See Figure 103.



1. Cylinder Head
2. Lifting Attachments
3. Mounting Bolt
4. Washer

Figure 103 Placing Lifting Attachments on Cylinder Head Edges

2. Screw in cylinder head bolt with thrust washer and tighten studs to specification. Refer to sectionA 003.

NOTE:
If, at both of the cylinder heads that carry the lifting attachments, only the cylinder head bolts at the lifting attachments itself were released, then it is sufficient to tighten both of these cylinder head bolts to torque/additional angle of rotation to specification. Refer to section A 003. Refer to section C 041.05.01. If, at both of the cylinder heads that carry the lifting attachments further cylinder head bolts were released, then the “cylinder head tightening diagram” applies entirely; refer to section A 003. For installation of cylinder head, refer to section C 041.05.11.

C 015.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 11 are the After-Installation Operations for the engine and running gear lifting attachments.

Level of Maintenance	Operation	Reference
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.

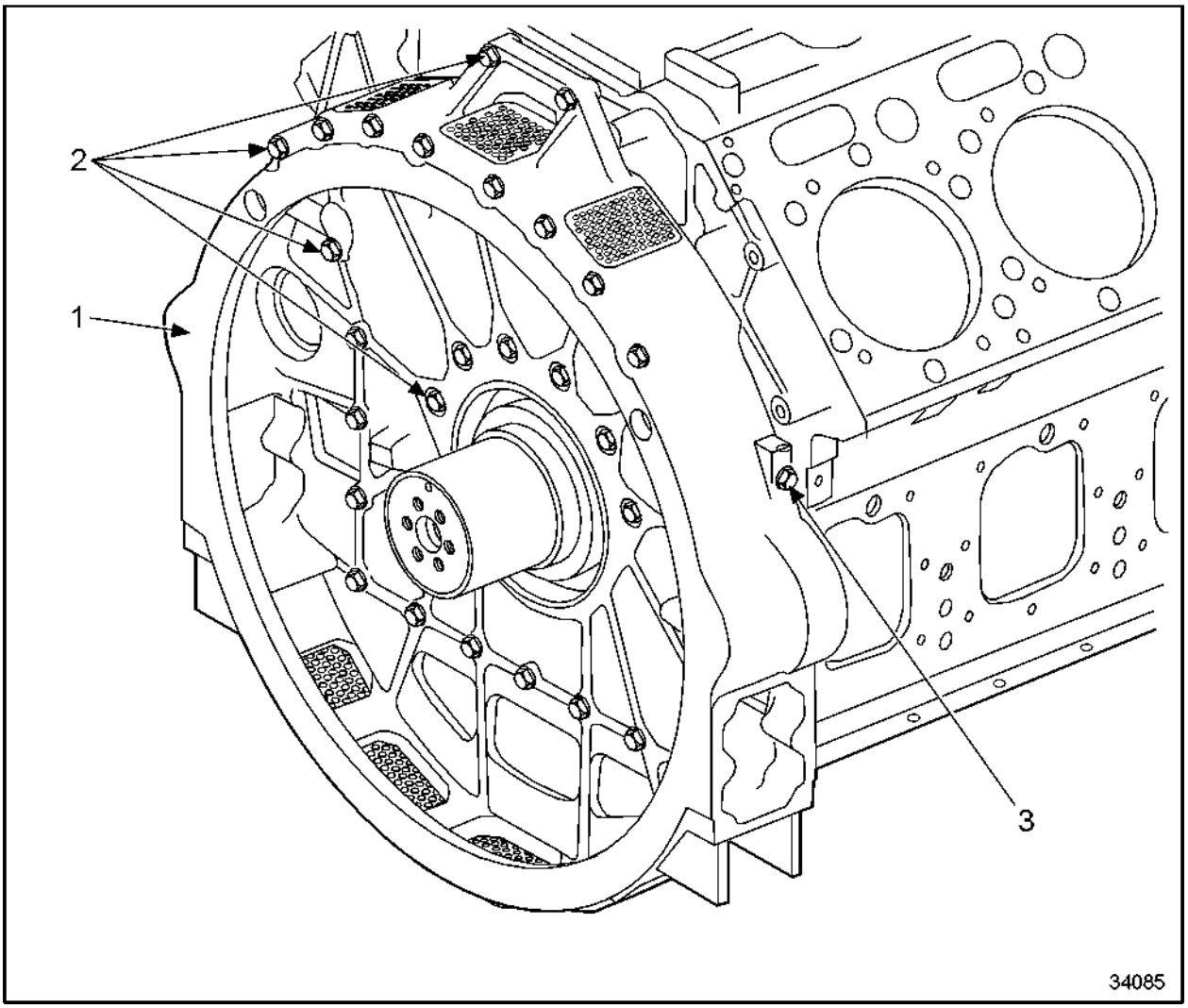
3 = The engine is to remain installed.

Table 11 After-Installation Operations

C 016.05 – FLYWHEEL HOUSING

C 016.05.01 – GENERAL VIEW

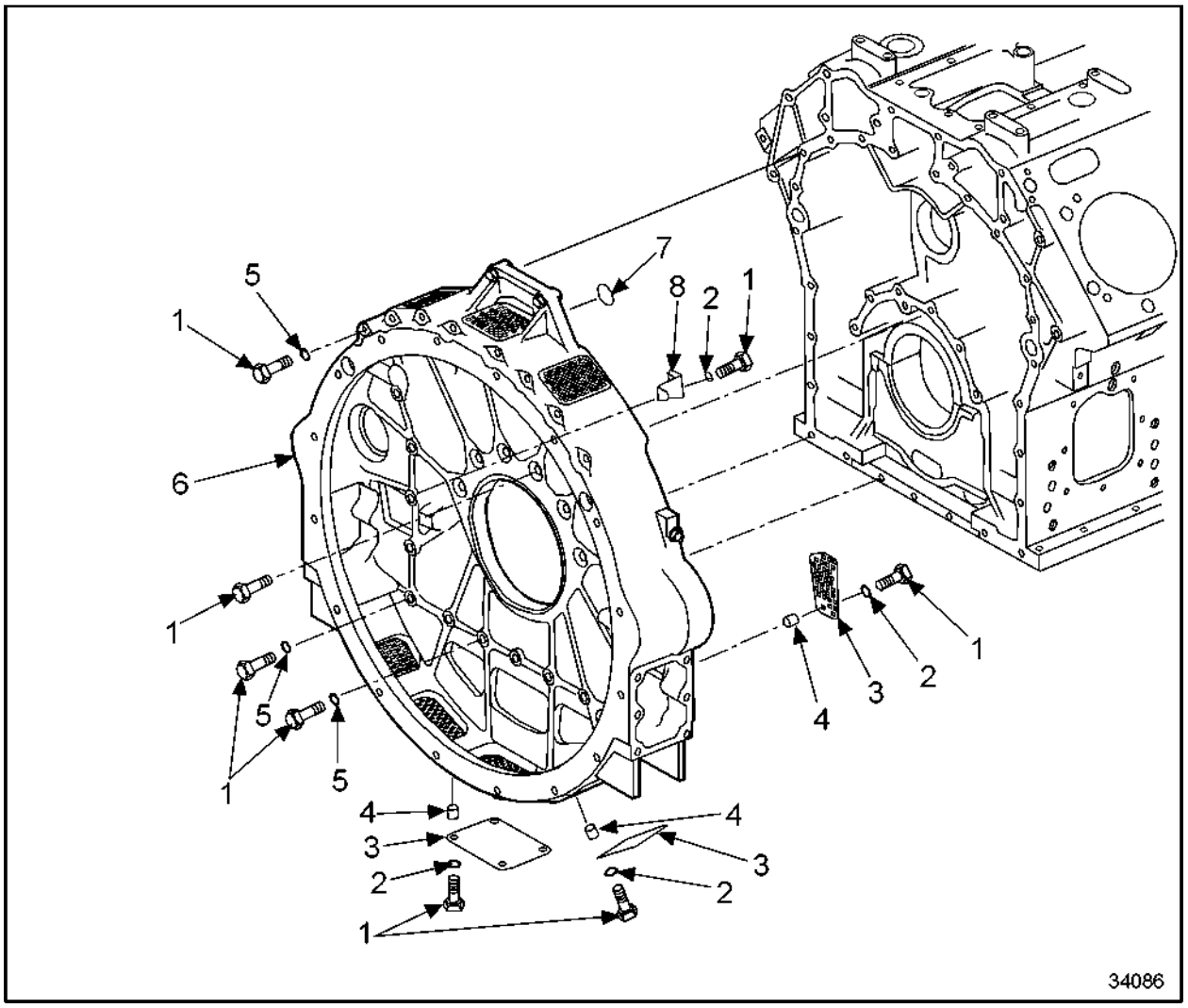
See Figure 104 for a general view of the flywheel housing.



1. Flywheel Housing
2. Hex Bolt
3. Plug

Figure 104 General View of Flywheel Housing

See Figure 105 for a general view of the flywheel housing with attachments.



1. Hex Bolt
2. Washer
3. Cap Plug
4. Spacer Bushing
5. Spring Washer
6. Flywheel Housing
7. O-ring
8. Dead-center Indicator

Figure 105 General View of Flywheel Housing with Attachments

C 016.05.02 – SPECIAL TOOLS

Listed in Table 12 are the special tools required for maintenance on the flywheel housing, flywheel end.

Designation	Tool Number
Flywheel housing alignment tool	J 42734
Guide bushing, flywheel housing	—
Support	—
Cylinder head bolt	—
Installation tool for radial-lip shaft seal	—
Flange	—
Flange	—

Table 12 Special Tools

C 016.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 13 are the Before-Removal Operations for the flywheel housing.

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

1 = The engine is to be completely disassembled.

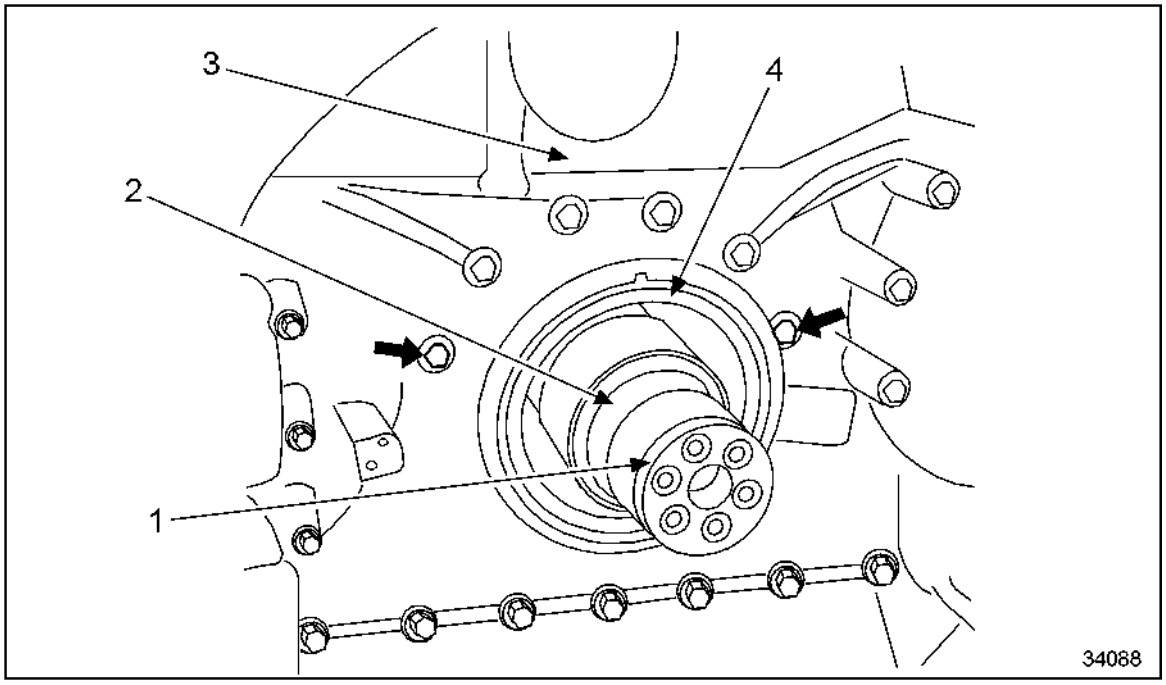
2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 13 Before-Removal Operations

C 016.05.05 – REMOVAL OF FLYWHEEL HOUSING

1. Using a suitable brass drift and hammer, knock shaft seal (4) out of flywheel housing (3). See Figure 106.



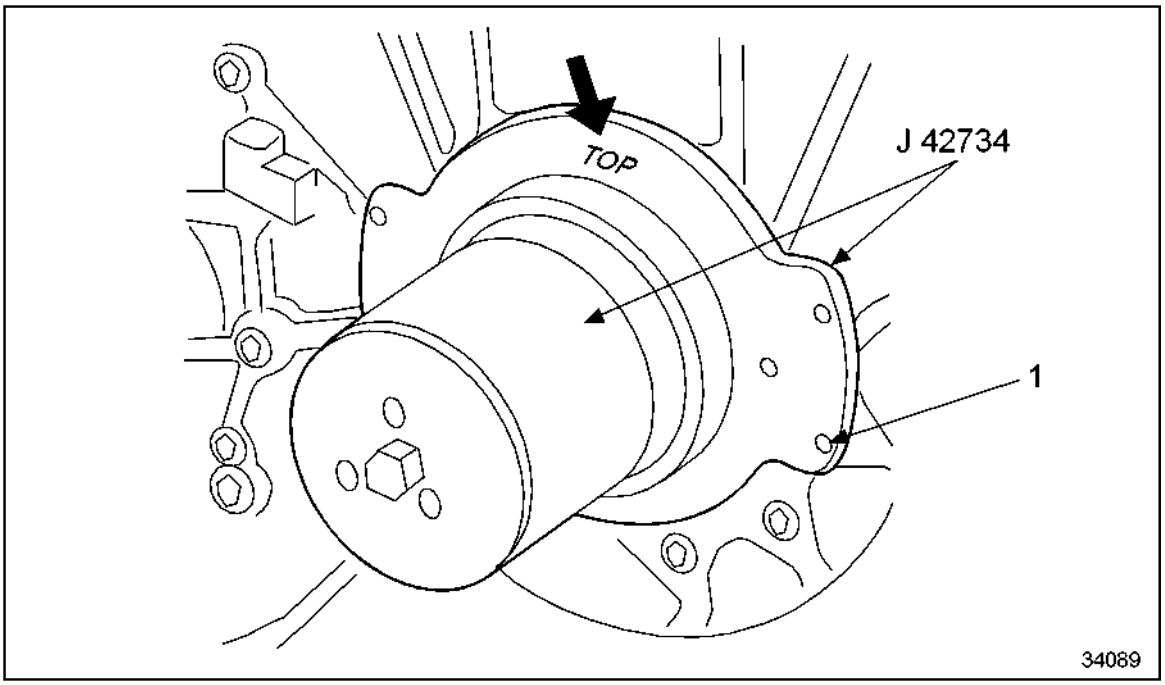
1. Crankshaft End
2. Flange
3. Flywheel Housing
4. Shaft Seal

Figure 106 Removing Radial-lip Shaft Seal

NOTE:
Engine is turned 180°, i.e. oil pan side is at top.

2. Mount flange (2) on crankshaft end. See Figure 106.
3. Unscrew the two hex bolts (arrows) in the flywheel housing inner circle.

4. Push support (3) onto guide bushing (1). See Figure 107.



1. Guide Pin

Figure 107 Pushing Flywheel Housing Alignment Tool J 42734 onto Guide Pin

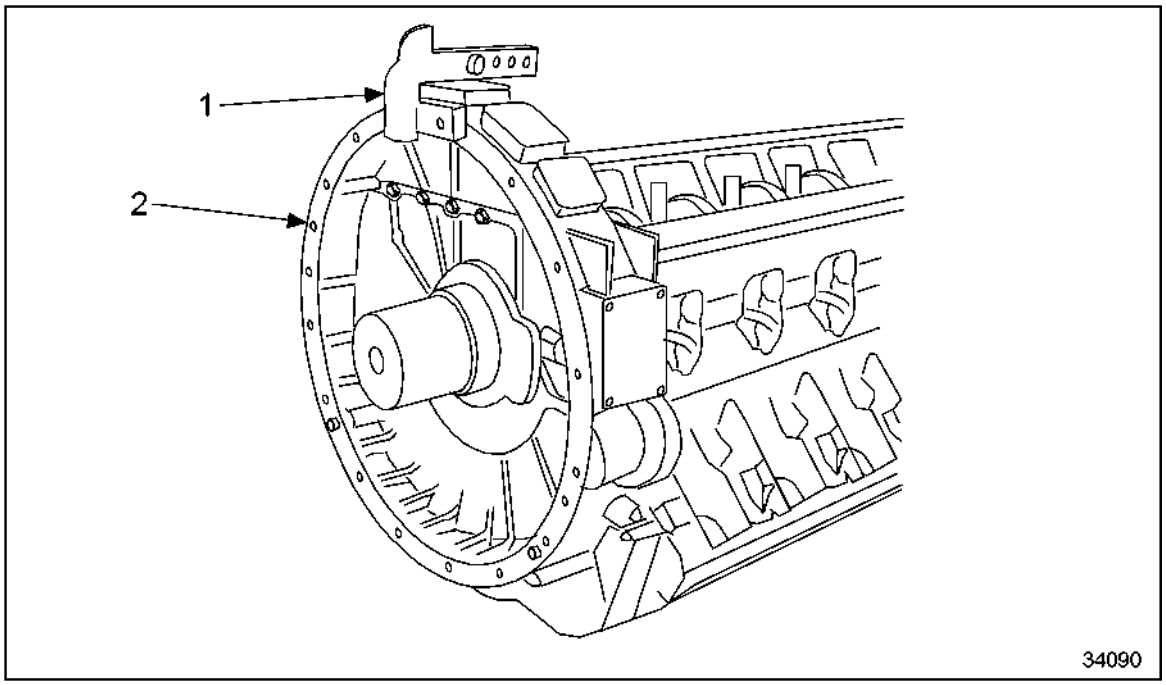
5. Insert the positioning brass drifts (2) of the flywheel housing alignment tool J 42734 in the bores of the hex bolts that were previously released and press the support against the flywheel housing as far as it will go. See Figure 107.

NOTE:
The TOP mark on the front side of the flywheel housing alignment tool J 42734 must face upwards, i.e. in the direction of the oil pan (arrow). If the guide bushing jams and does not align in the flywheel housing bore, two long guide pins can also be inserted in the bolt bores in order to remove the flywheel housing.

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.

6. Screw suitable lifting device (1) to flywheel housing and suspend load to loosen hex bolts.. See Figure 108.



1. Lifting Device
2. Flywheel Housing

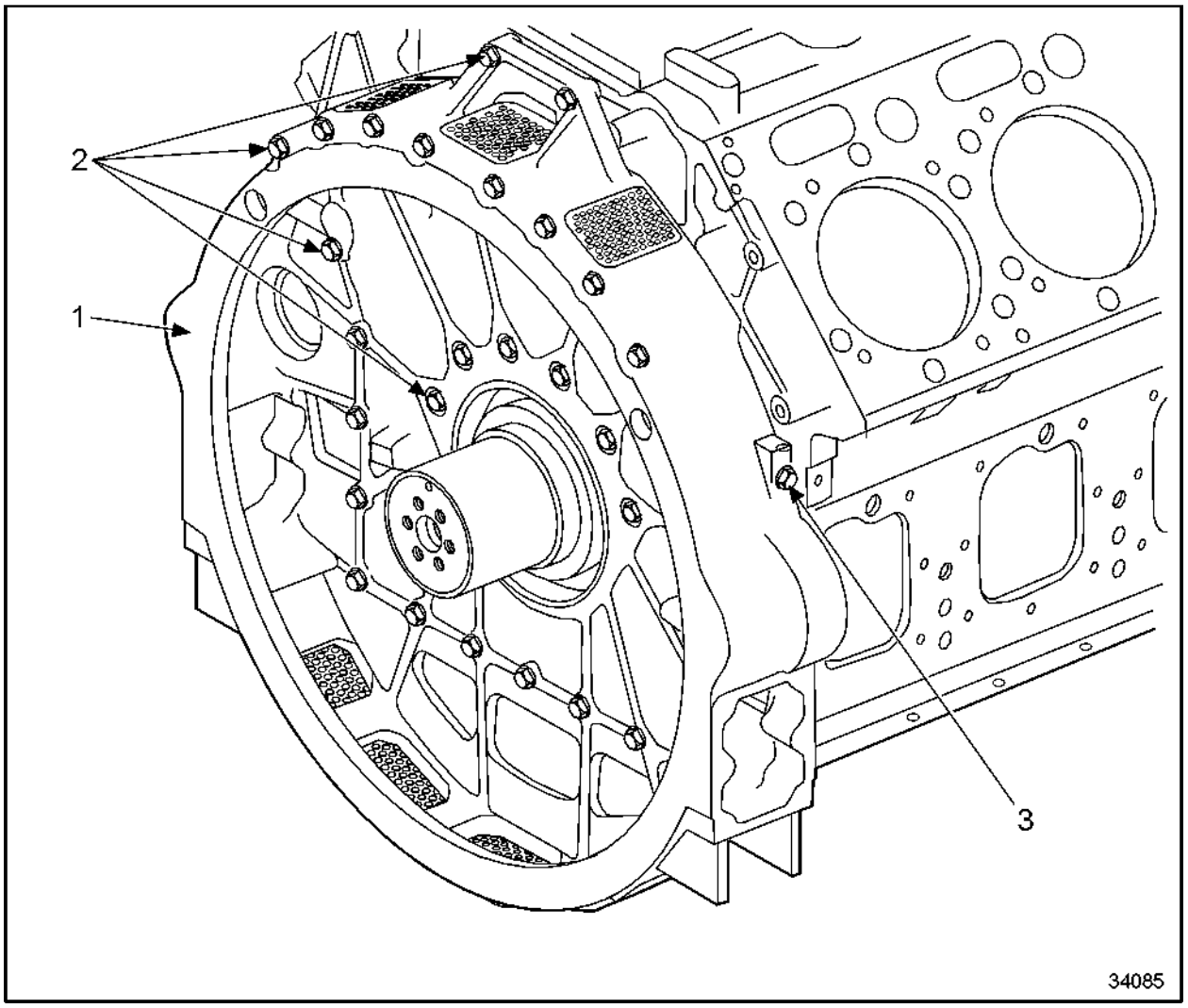
Figure 108 Attaching Lifting Device

7. Unscrew all of the hex bolts that secure the flywheel housing to the cylinder block. Refer to section C 016.05.01.
8. Remove flywheel housing from cylinder block.

C 016.05.06 – DISASSEMBLY OF FLYWHEEL HOUSING

Perform the following steps to disassemble the flywheel housing:

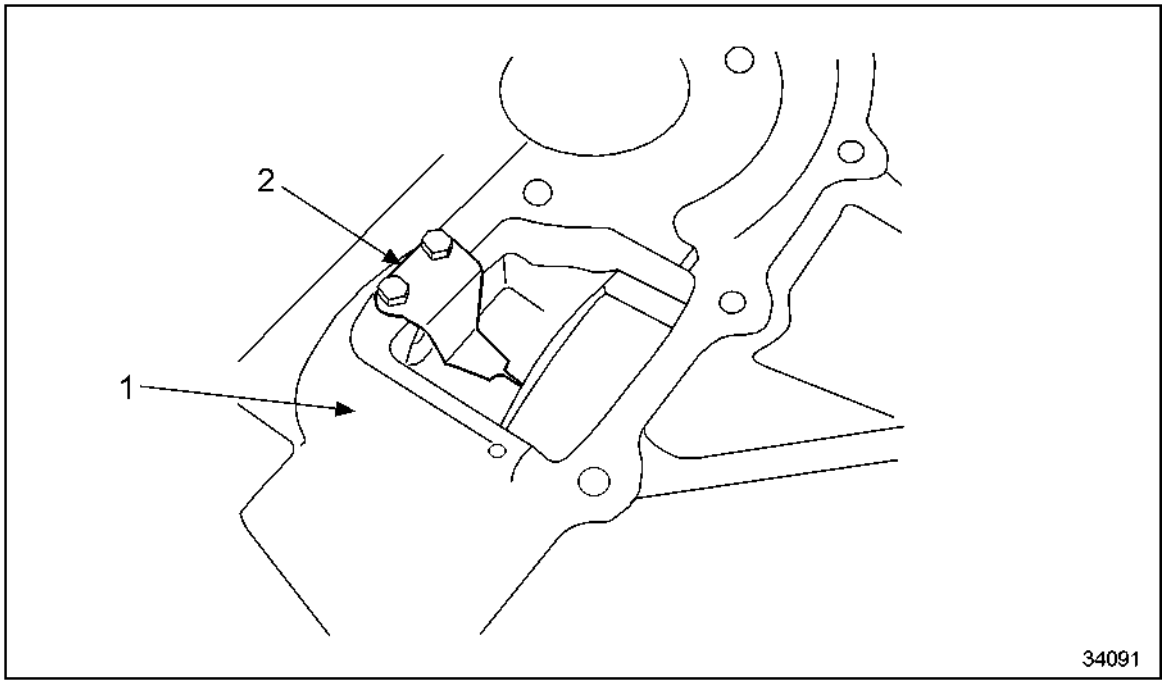
1. Remove cap plug and plugs. See Figure 104.



1. Flywheel Housing
2. Hex Bolt
3. Plug

Figure 109 Removing Cap Plug and Plugs

2. Remove dead-center indicator (2) from flywheel housing (1). See Figure 110.



1. Flywheel Housing
2. Dead-center Indicator

Figure 110 Removing Dead-center Indicator (Marine only)

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.

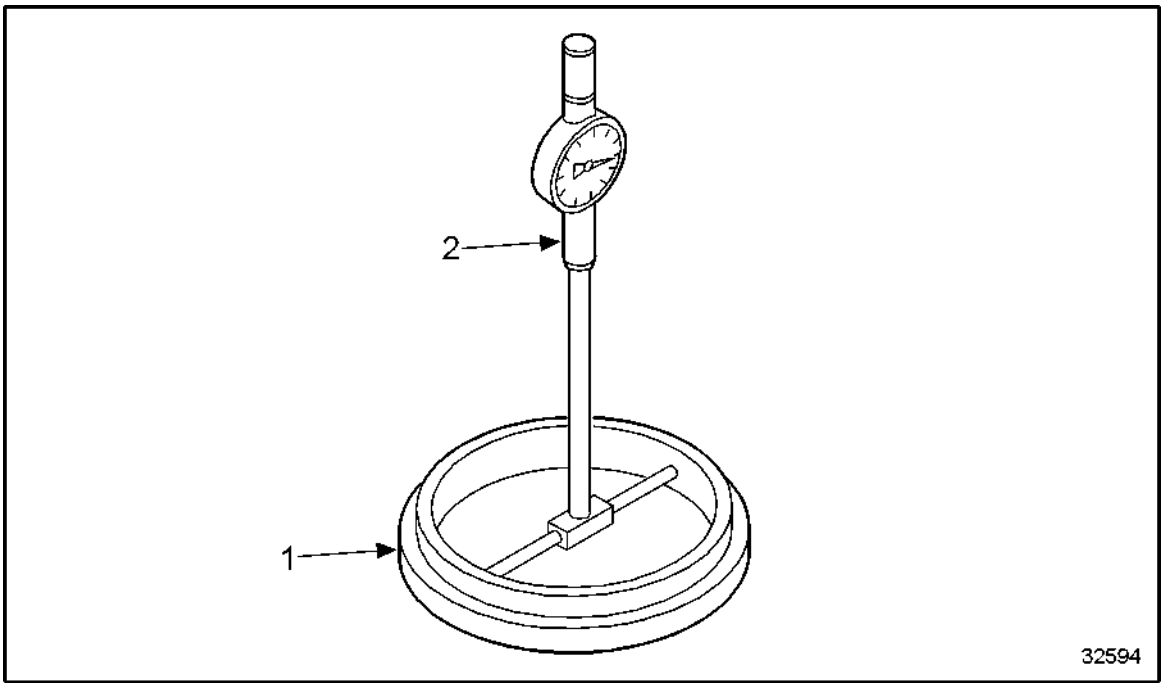
NOTE:
Do not straighten dead-center indicator if it is damaged or bent, but replace with a new part.

   [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.

1. Adjust dial bore gage (2) with micrometer or adjusting gage ring (1) to basic size for crankshaft bearing bore. See Figure 111.



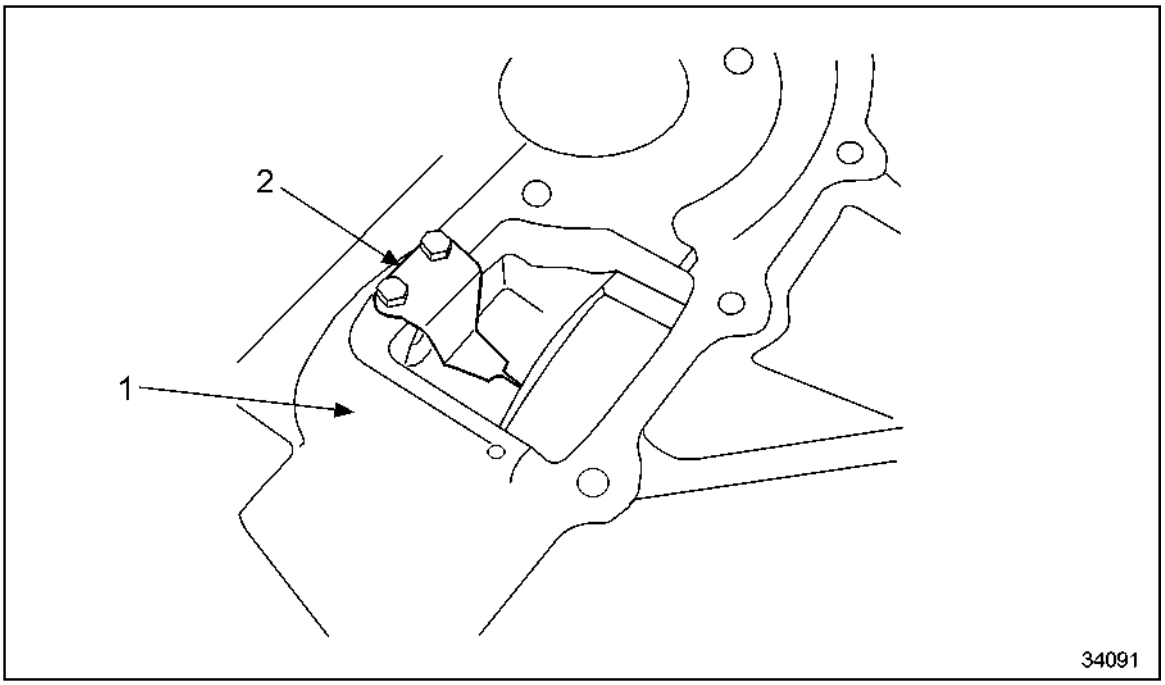
1. Adjusting Gage Ring
2. Dial Gage

Figure 111 Measuring Crankshaft Bore in Flywheel Housing

2. Using a bore gage, measure diameter of crankshaft bore at flywheel housing. See Figure 111.
3. Enter measurement values in data sheet.
4. Replace gear case if necessary.

C 016.05.10 – ASSEMBLY OF FLYWHEEL HOUSING

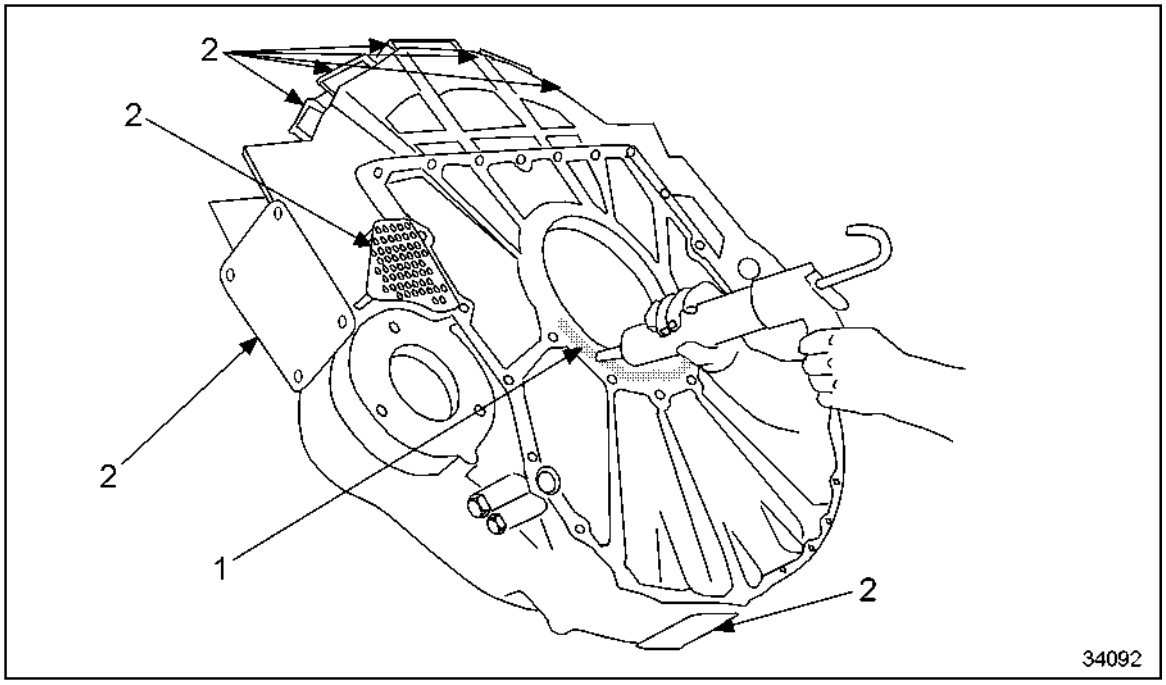
1. Mount dead-center indicator (2) to flywheel housing (1). See Figure 112.



1. Flywheel Housing
2. Dead-center Indicator

Figure 112 Mounting Dead-center Indicator (Marine only)

2. Bolt on covers (2). See Figure 113.

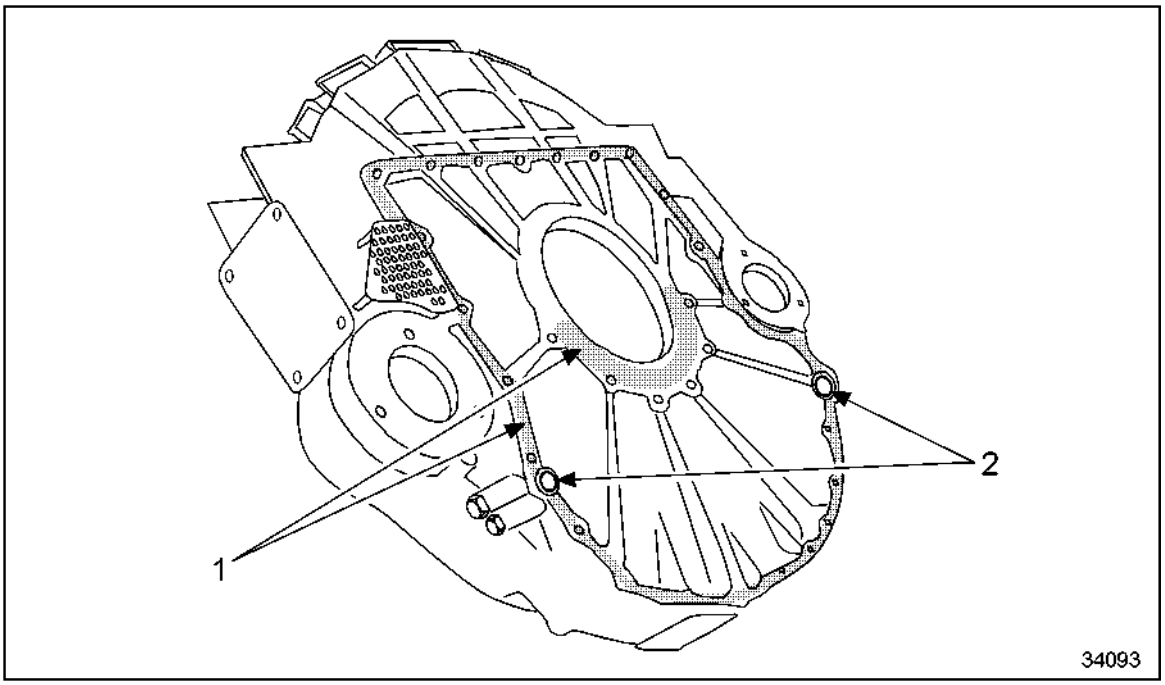


1. Gasket Eliminator 518
2. Covers

Figure 113 Applying Gasket Eliminator to Sealing Surface

3. Pre-clean sealing surface between flywheel housing and cylinder block with Loctite cleaner.
4. Apply Gasket Eliminator 518 to sealing surface evenly.

5. Smooth gasket eliminator (1) on the sealing surface. See Figure 114.



1. O-ring
2. Gasket Eliminator

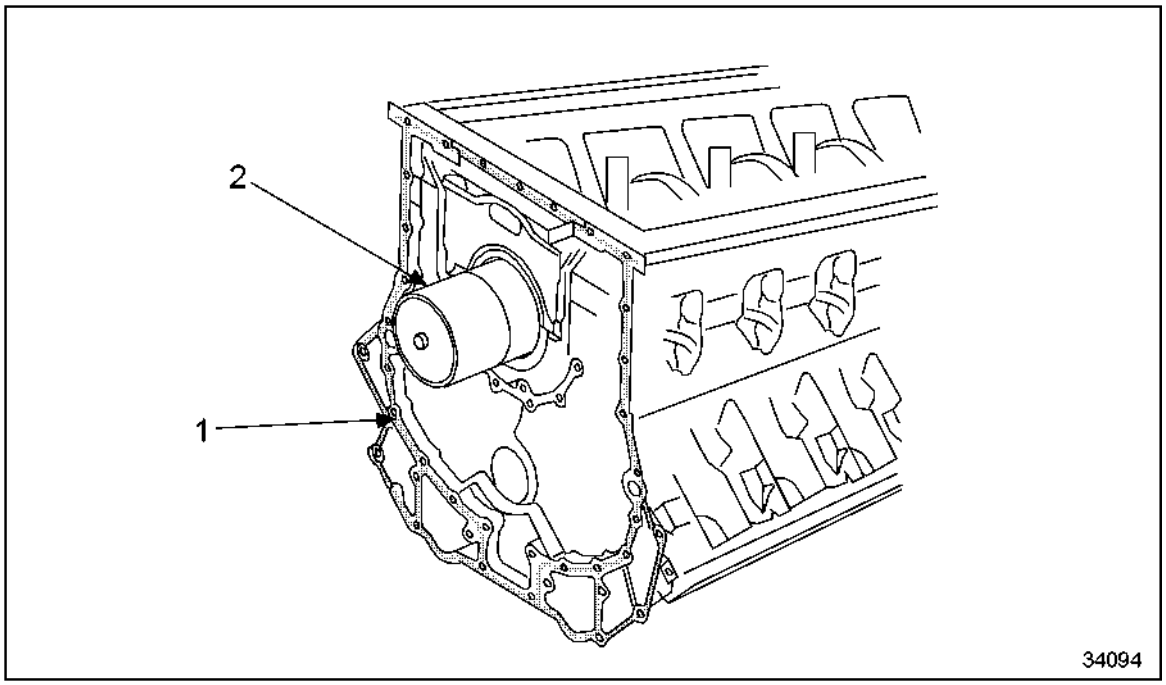
Figure 114 Smoothing Gasket Eliminator on Sealing Surface

6. Coat O-rings with petroleum jelly and insert into bores.

C 016.05.11 – INSTALLATION OF FLYWHEEL HOUSING

Perform the following steps to install the flywheel housing:

1. Clean the sealing surface (1) at cylinder block with cleaner. See Figure 115.

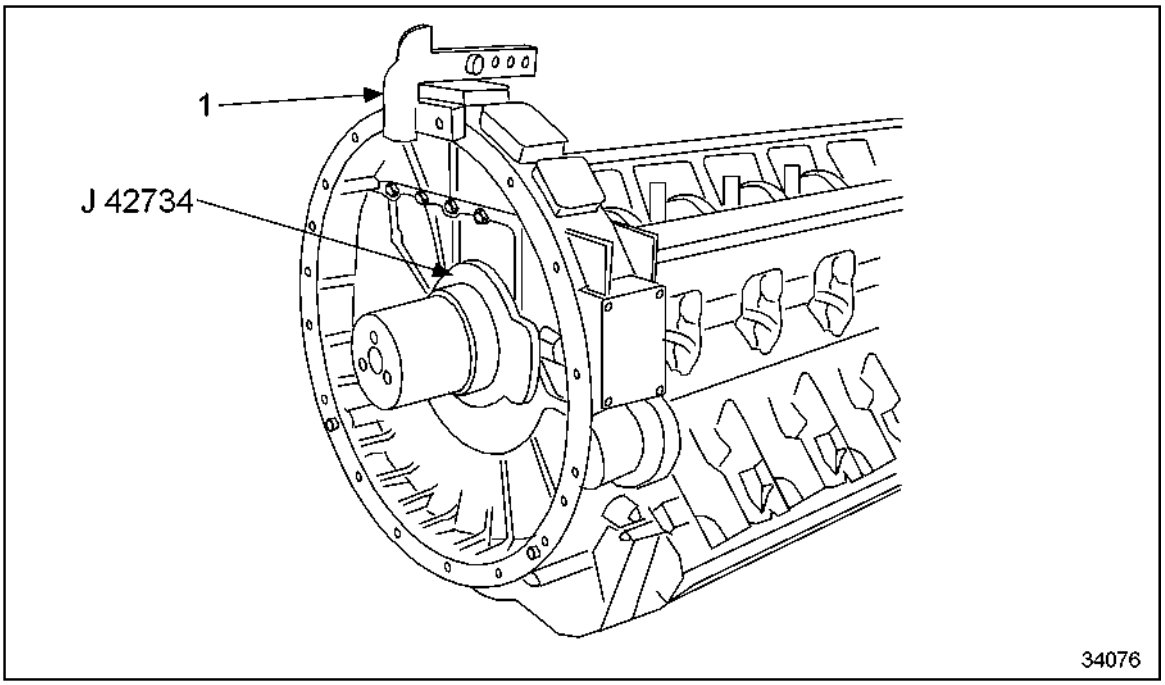


1. Sealing Surface
2. Flywheel Housing Alignment Tool J 42734

Figure 115 Cleaning Sealing Surface at Cylinder Block

2. Bolt guide bushing onto flange at crankshaft end.

3. Place flywheel housing alignment tool J 42734 on the flywheel housing. See Figure 116.



1. Lifting Tool

Figure 116 Placing Support on Flywheel Housing

CAUTION:

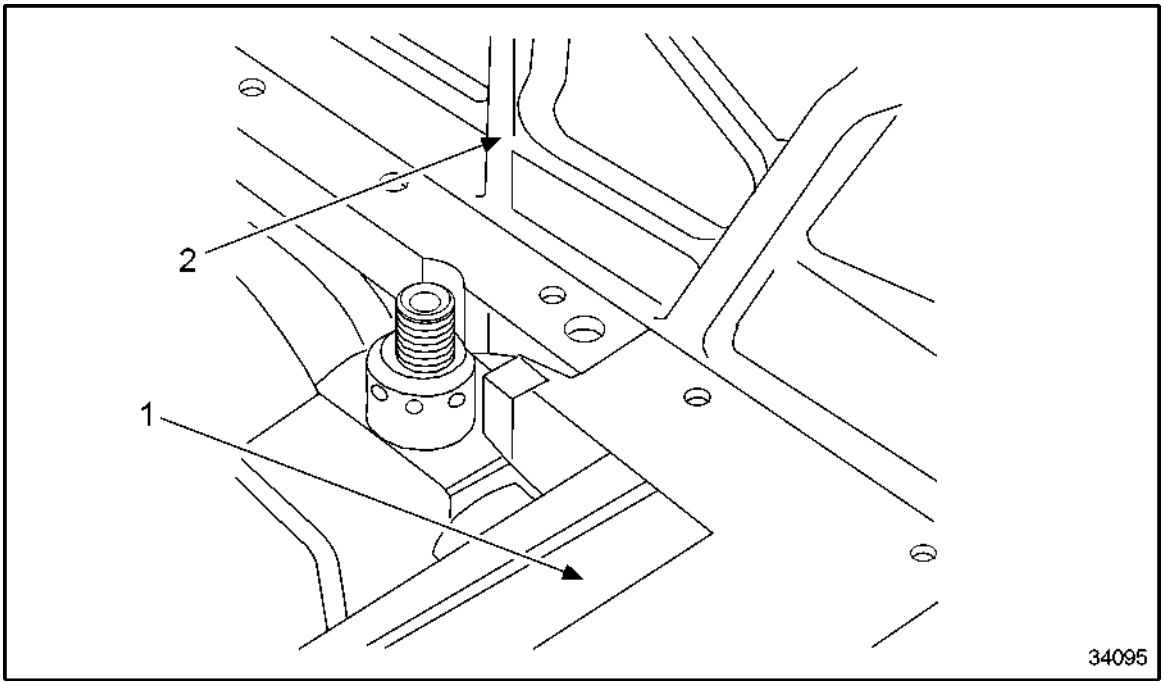
To avoid personal injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

4. Attach flywheel housing to crane with lifting device (1) and install over the flywheel housing alignment tool J 42734, pushing in direction of cylinder block as far as it will go. See Figure 116.
5. Screw hex bolts into designated bores hand-tight, refer section C 016.05.01.
6. Tighten two opposing hex bolts in the inner circle of the flywheel housing to specification. Refer to section A 003.
7. Remove flywheel housing alignment tool J 42734 from flywheel housing and screw the hex bolts in the bores as they become visible.

8. Tighten all hex bolts for securing flywheel housing and cylinder block to specification. Refer to section A 003. See Figure 105.

NOTE:
First tighten hex bolts in the inner circle of flywheel, then tighten all hex bolts in interior of flywheel housing; finally, tighten the bolts at the outer rim of the flywheel housing. Torque all hex bolts clockwise. See Figure 105.

9. Carefully remove excess gasket eliminator from the parting line between flywheel housing (2) and oil pan mating surface at the cylinder block (1). See Figure 117.



1. Cylinder Block
2. Flywheel Housing

Figure 117 Removing Excess Gasket Eliminator from Parting Line

C 016.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 14 are the After-Installation Operations for flywheel housing.

Level of Maintenance	Operation	Reference
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.

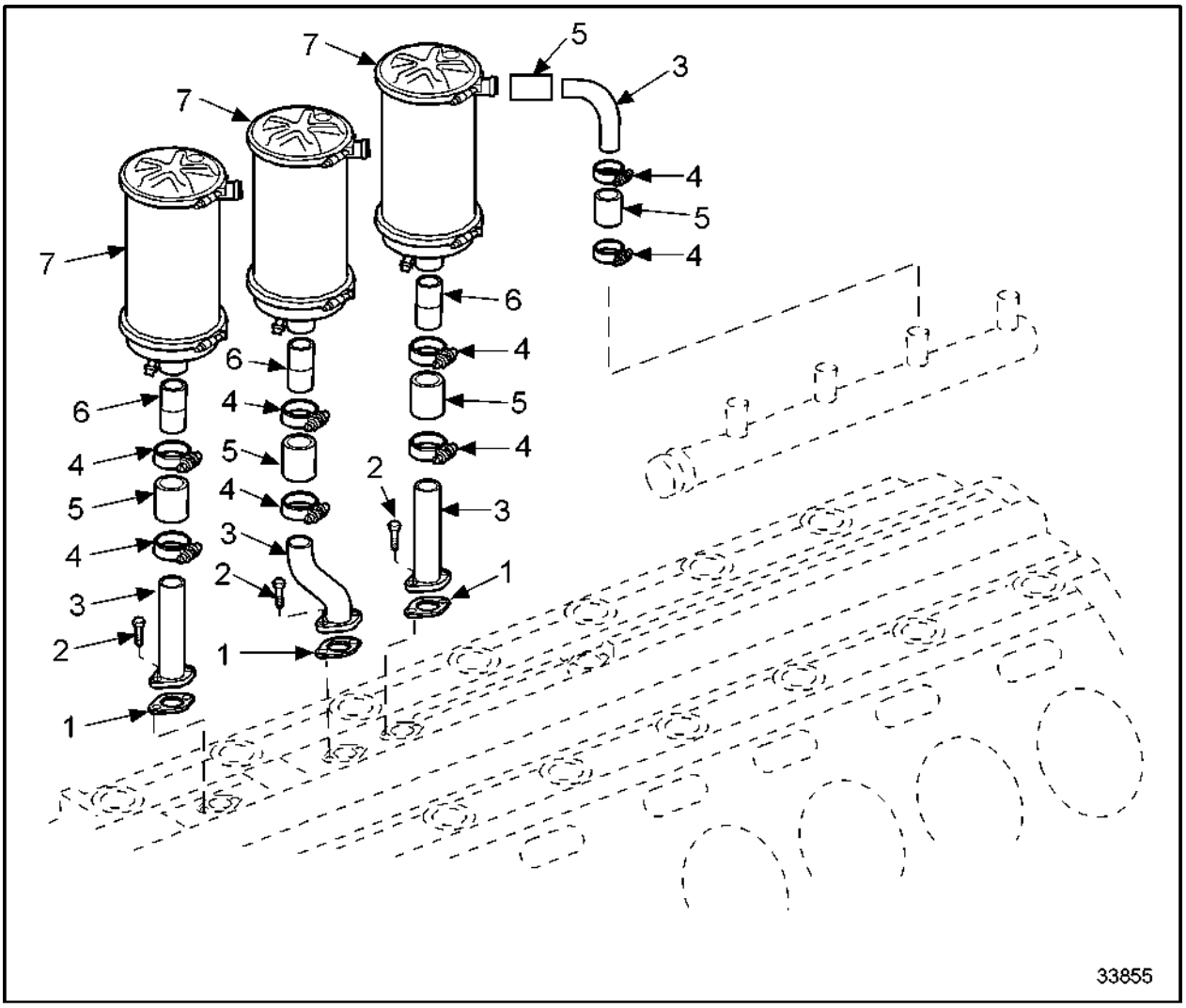
3= The engine is to remain installed.

Table 14 After-Installation Operations

C 018.11 M – CYLINDER BLOCK VENTILATION

C 018.05.01 M – GENERAL VIEW

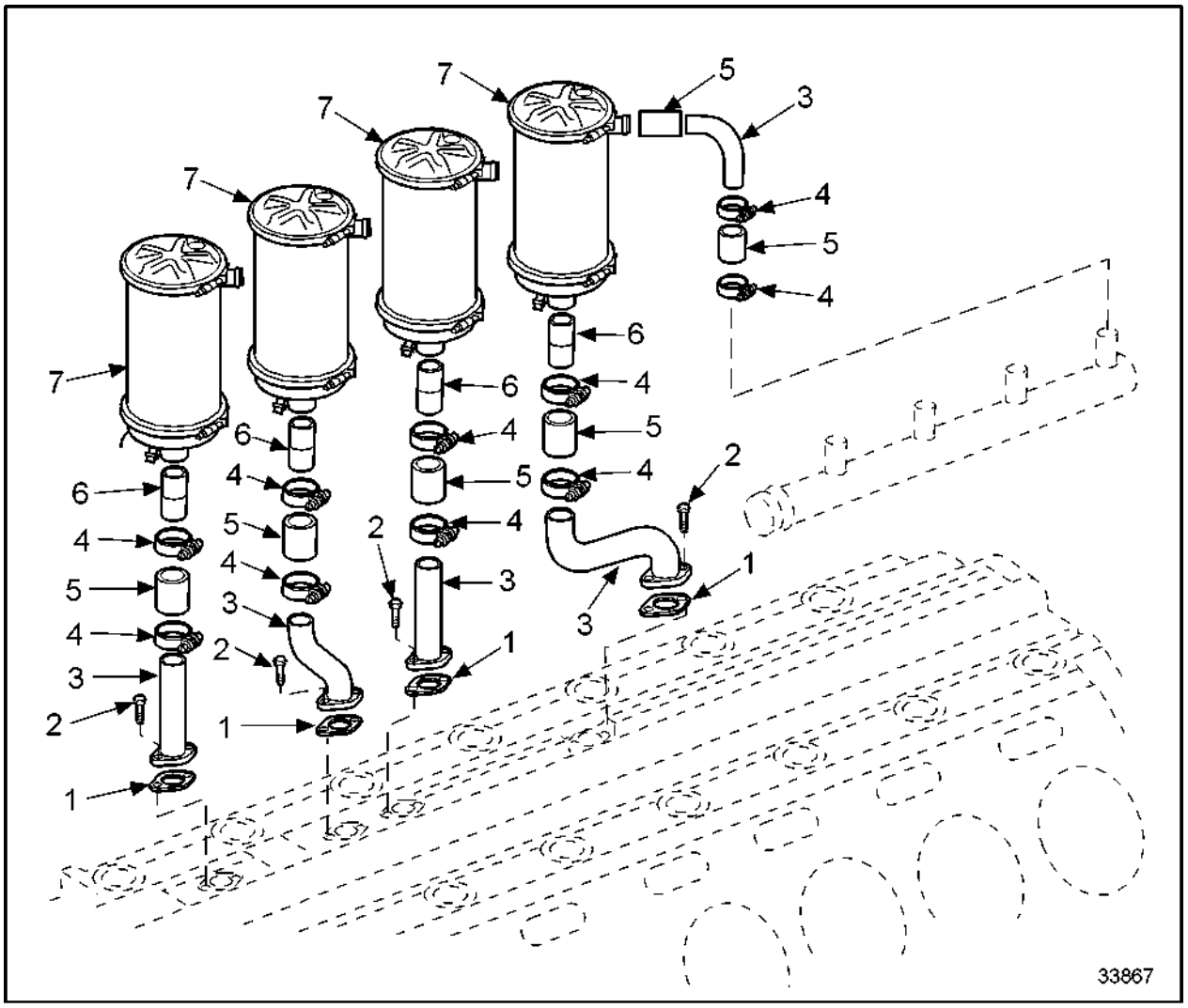
For an overview of the cylinder block ventilation assembly for the 12V marine engine, see Figure 118.



1. Gasket
2. Bolt
3. Vent Pipe
4. Clamp
5. Rubber Sleeve
6. Guide Sleeve
7. Oil Separator

Figure 118 General View of Cylinder Block Ventilation Assembly, 12V

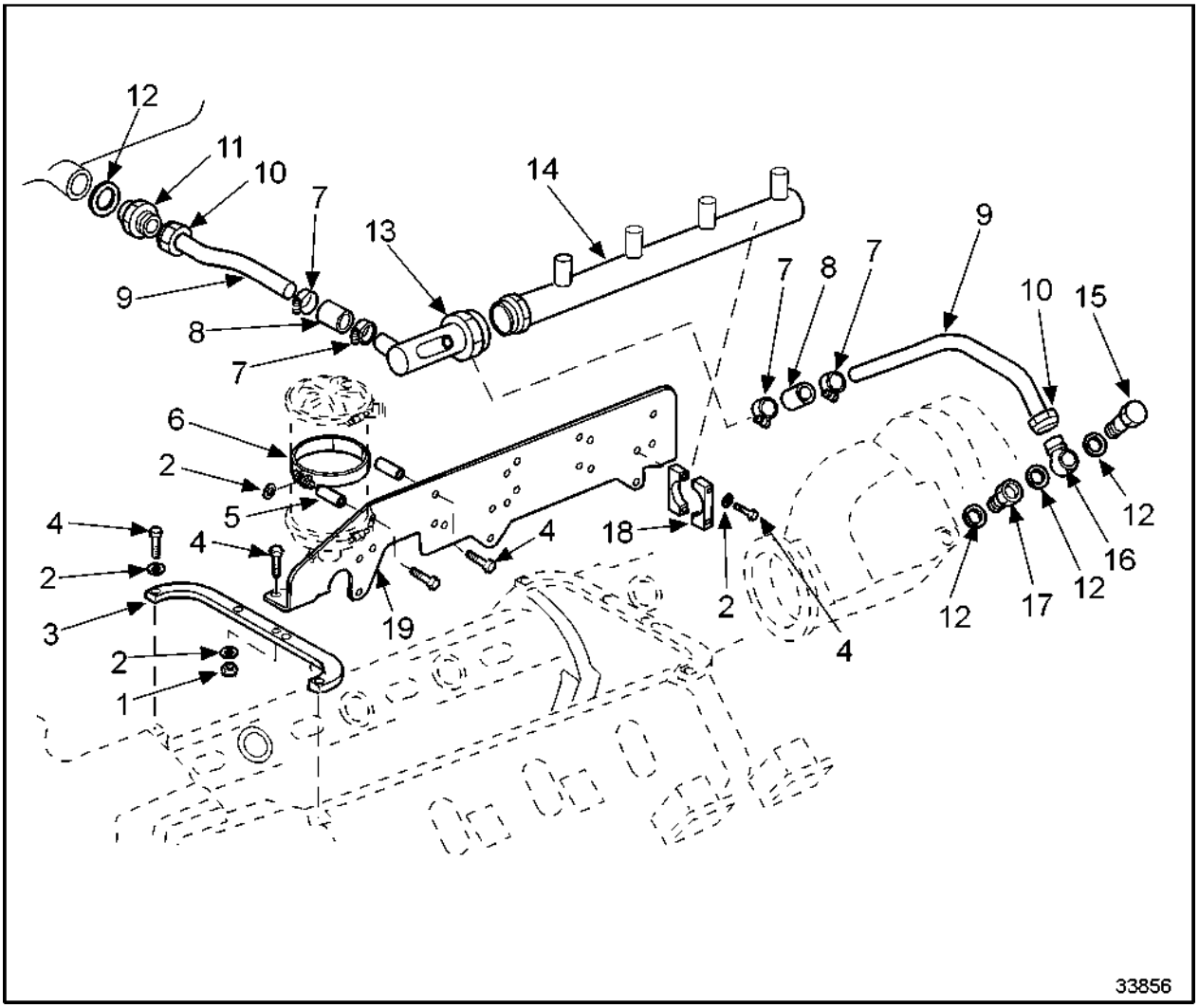
For an overview of the cylinder block ventilation assembly for the 16V marine engine, see Figure 119.



1. Gasket
2. Bolt
3. Vent Pipe
4. Clamp
5. Rubber Sleeve
6. Guide Sleeve
7. Oil Separator

Figure 119 Overview of Cylinder Block Ventilation Assembly, 16V Marine Engine

For an overview of the cylinder block ventilation piping, see Figure 120.



1. Hex Nut
2. Washer
3. Support Bracket
4. Bolt
5. Spacer Bushing
6. Clamp
7. Clamp
8. Rubber Sleeve
9. Vent Line
10. Domed Nut
11. Adaptor
12. Sealing Ring
13. Distributor
14. Manifold
15. Banjo Bolt
16. Union
17. Threaded Bushing
18. Pipe Clamp Half
19. Mounting Bracket

Figure 120 Overview of Cylinder Block Ventilation Piping, Marine Engine

C 018.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 15are the Before-Removal Operations for the cylinder block ventilation system.

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.

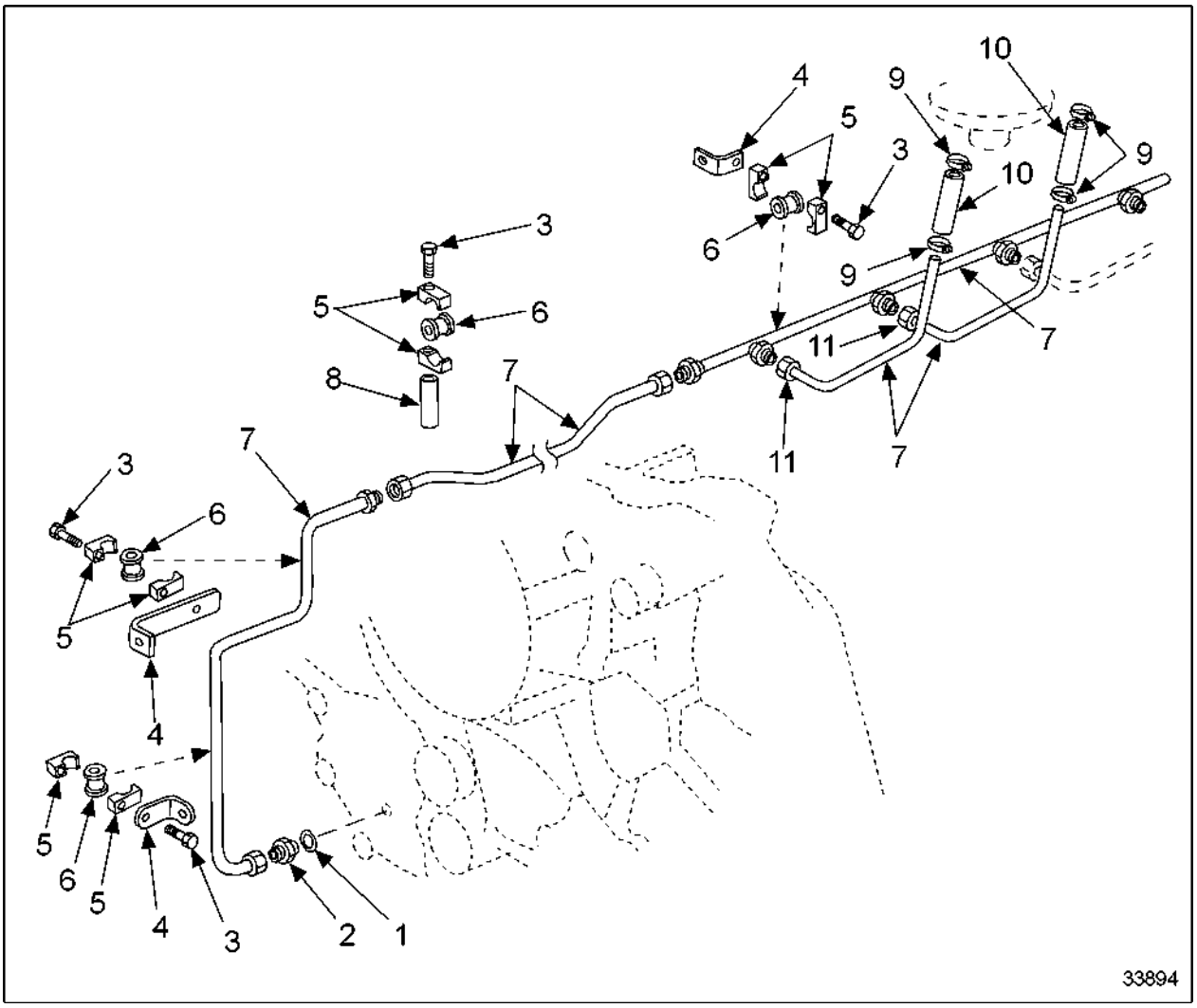
3 = The engine is to remain installed.

Table 15 Before-Removal Operations for the Marine Cylinder Block Ventilation System

C 018.05.05 M – REMOVAL OF THE MARINE CYLINDER BLOCK VENTILATION SYSTEM

Perform the following steps to remove the cylinder block ventilation system:

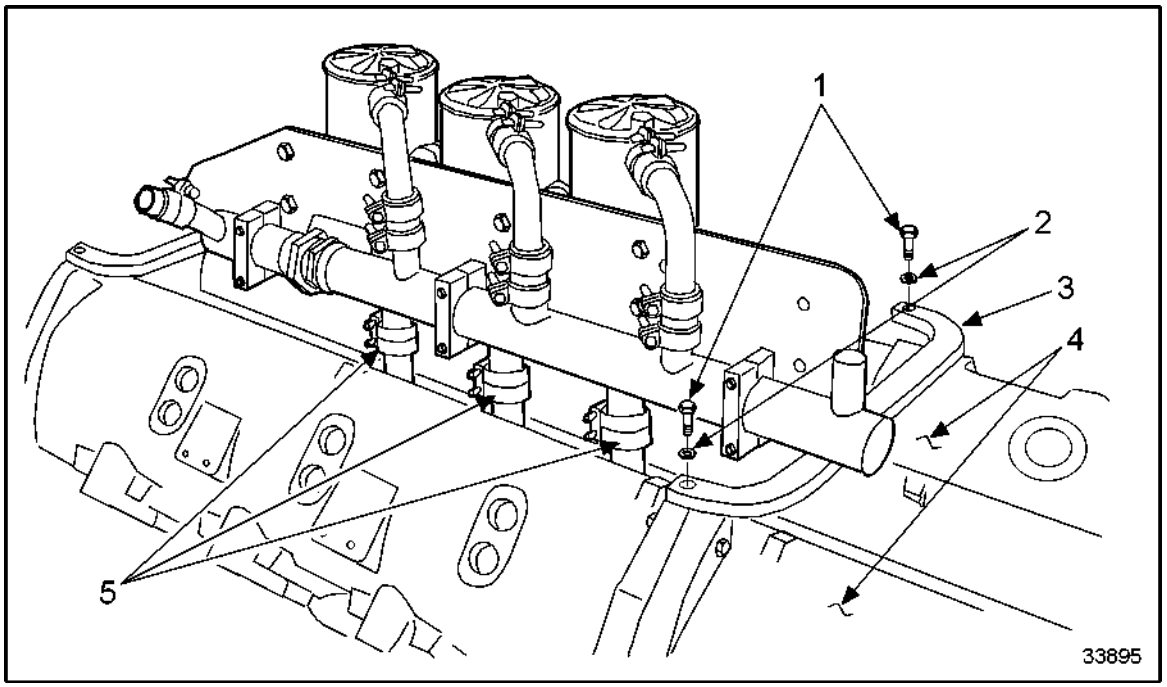
1. Disconnect the ventilation lines (7) secured to the cylinder block ventilation supports, see Figure 121.



1. Sealing Ring
2. Adaptor
3. Bolt
4. Bracket
5. Pipe Clamp Half
6. Grommet
7. Ventilation Lines
8. Spacer Bushing
9. Clamp
10. Rubber Sleeve
11. Nut

Figure 121 Disconnecting Marine Cylinder Block Ventilation Lines

2. Remove four 35 mm bolts (1) and washers (2) securing cylinder block ventilation bracket (3) to the exhaust manifold; see Figure 122.



1. Bolts
2. Washers
3. Cylinder Block Breather Bracket
4. Exhaust Manifold
5. Clamps

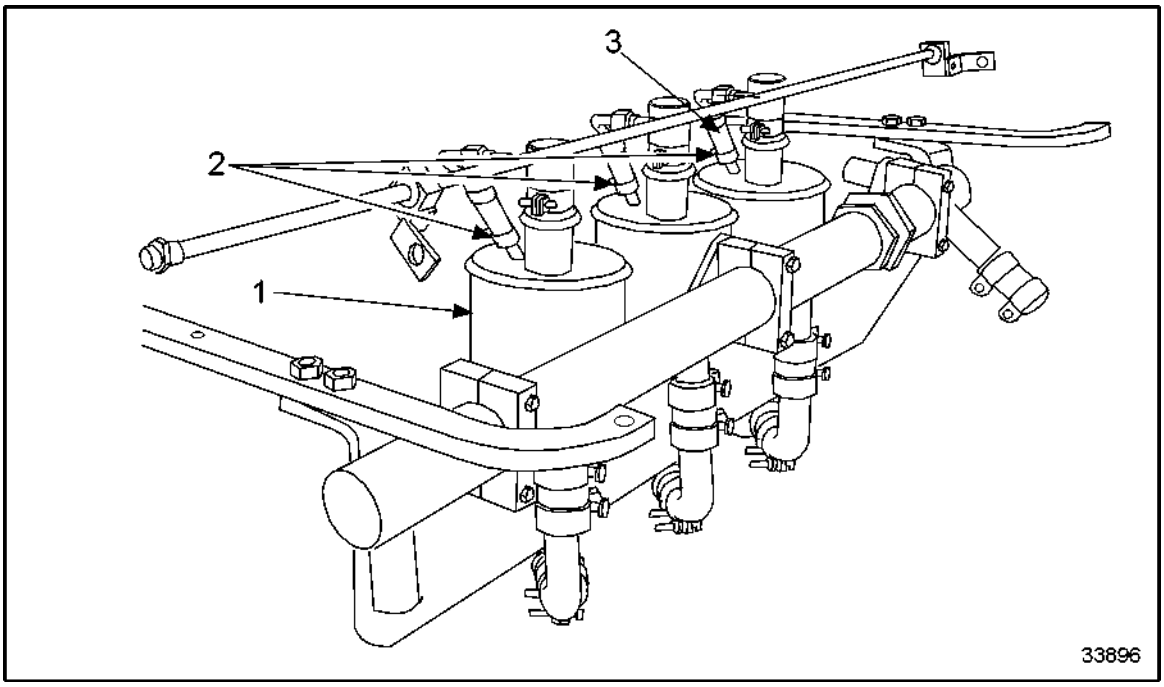
Figure 122 Removing Marine Cylinder Block Ventilation Assembly Bracket

3. Loosen three clamps (5) securing the cylinder block ventilation assembly to the cylinder block vent. See Figure 122.
4. Remove the cylinder block ventilation system from the cylinder block vent.

C 018.05.06 M – DISASSEMBLY OF THE MARINE CYLINDER BLOCK VENTILATION SYSTEM

Perform the following steps to disassemble the cylinder block ventilation system:

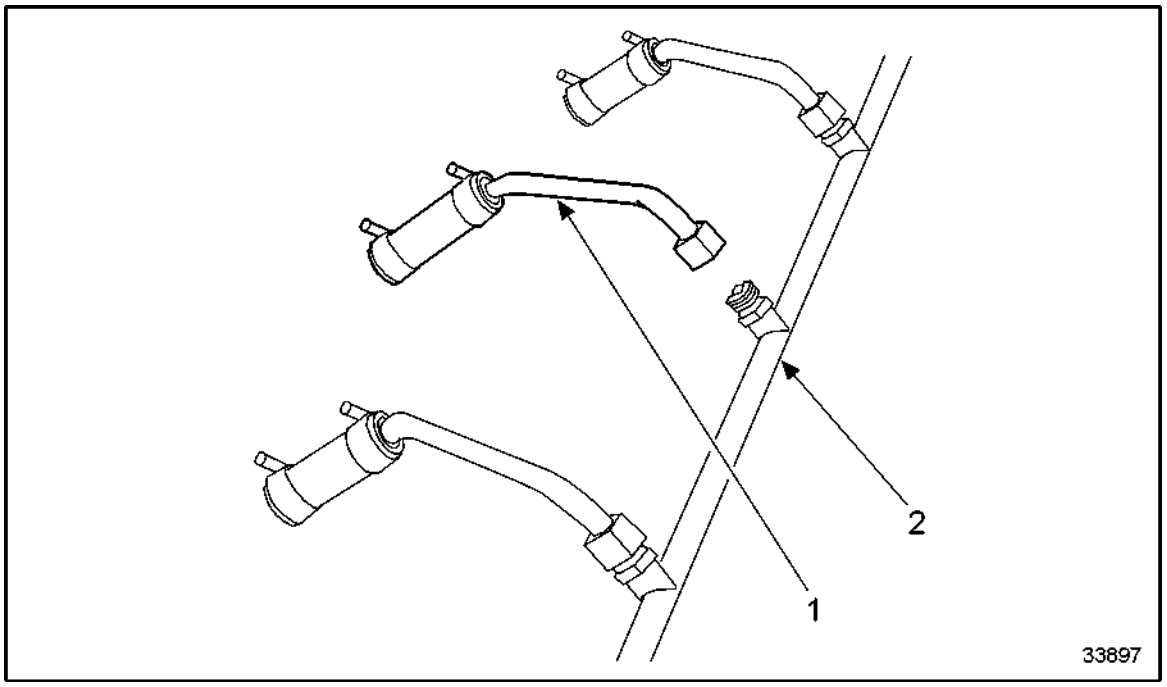
1. Loosen clamps (2) securing the vent hose to the base of the cylinder block ventilation separator canister. See Figure 123.



1. Cylinder Block Separator Canister
2. Clamp
3. Clamp Hose

Figure 123 Loosening Marine Vent Clamps

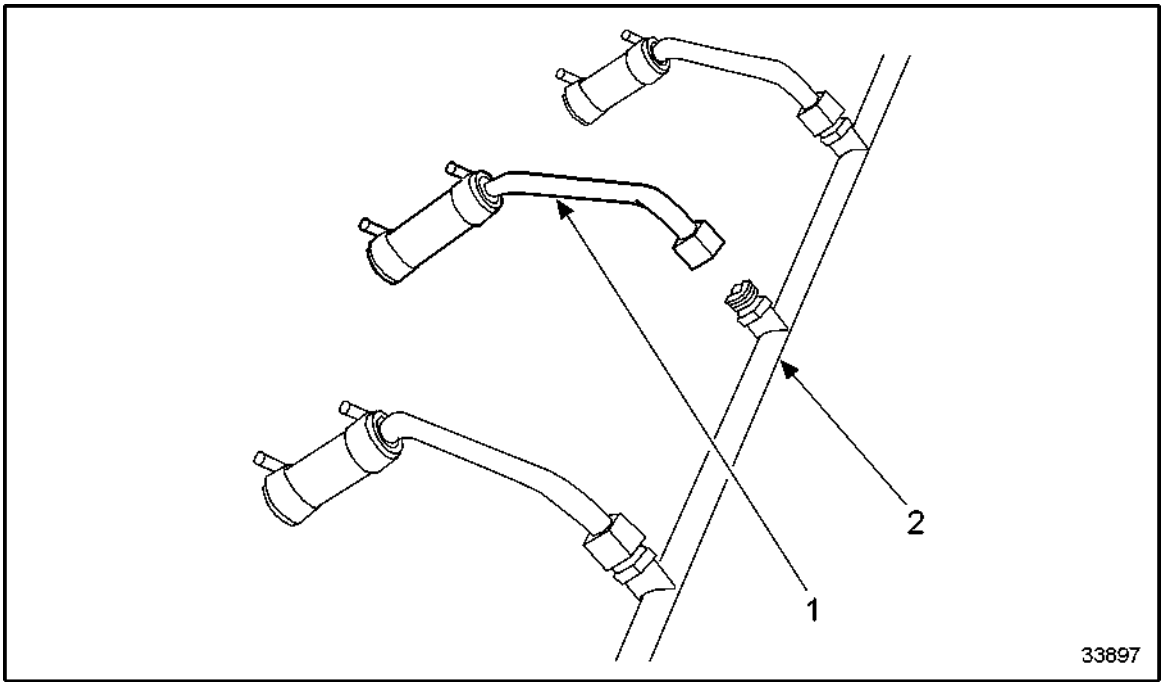
2. Remove vent tubing assembly (2). See Figure 124.



1. Vent Tubing
2. Vent Line Assembly

Figure 124 Removing Marine Vent Tubing

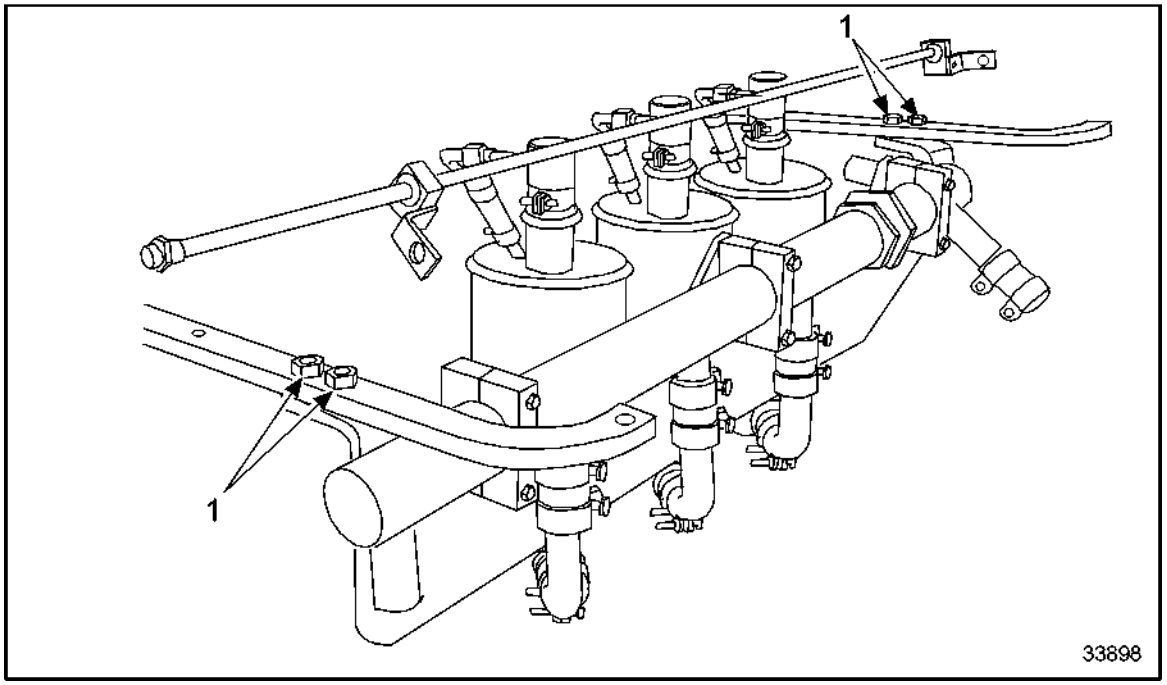
3. Remove vent tubing (1) attached to the vent line assembly (2). See Figure 125.



1. Vent Tubing
2. Vent Line Assembly

Figure 125 Removing Vent Line Assembly

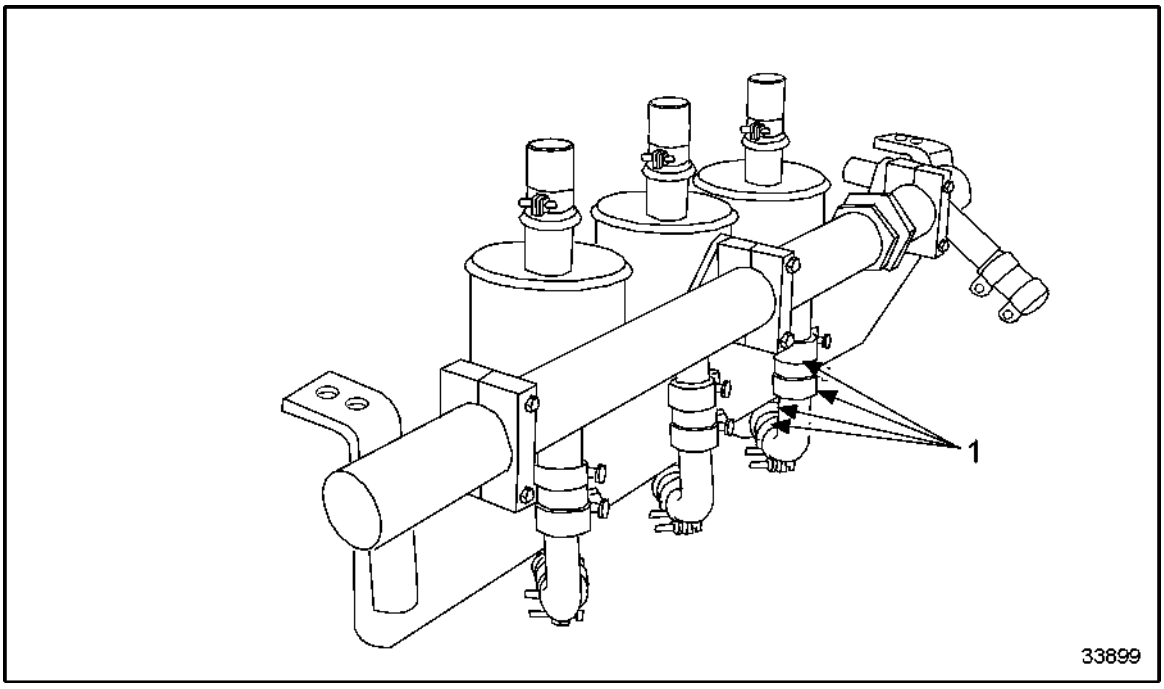
4. Remove four bolts (1), washers and nuts securing the mounting bracket to the cylinder block ventilation bracket. See Figure 126.



1. Mounting Bolt

Figure 126 Removing Mounting Bracket to Marine Cylinder Block Ventilation Bracket

5. Loosen four clamps (1) securing the tube connecting the cylinder block ventilation canister with the cylinder block tubing. See Figure 127.

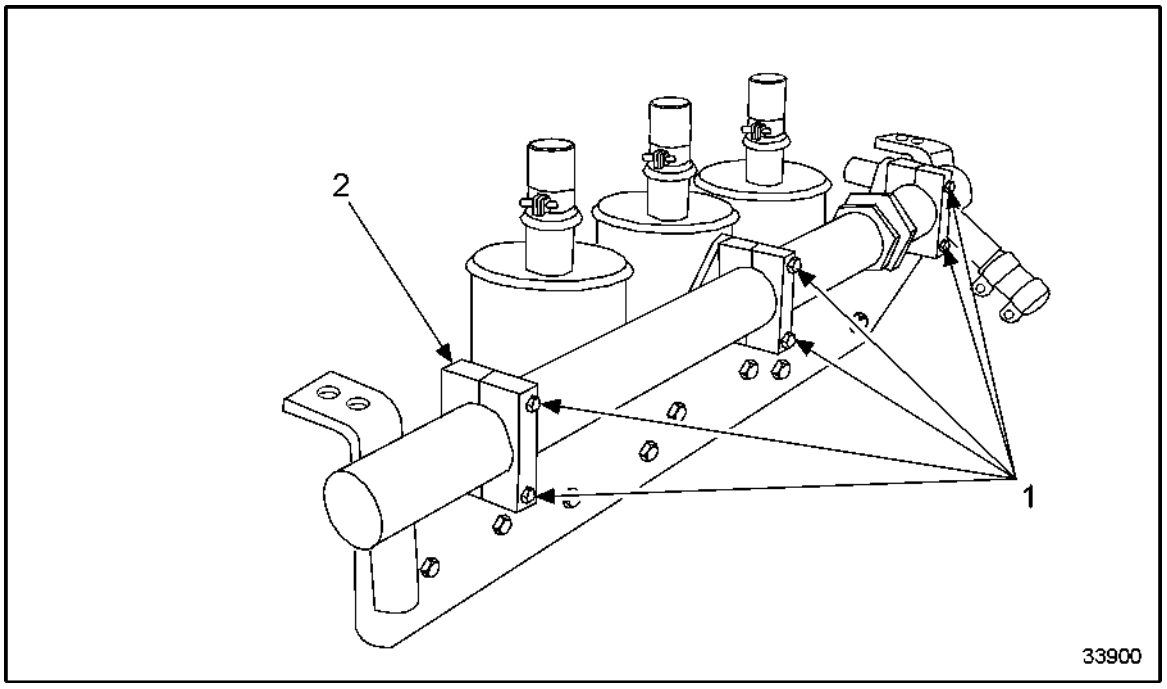


1. Clamp

Figure 127 Removing Clamps Securing Marine Cylinder Block Ventilation Canister

NOTE:
Repeat step 5 for the remaining cylinder block ventilation canisters.

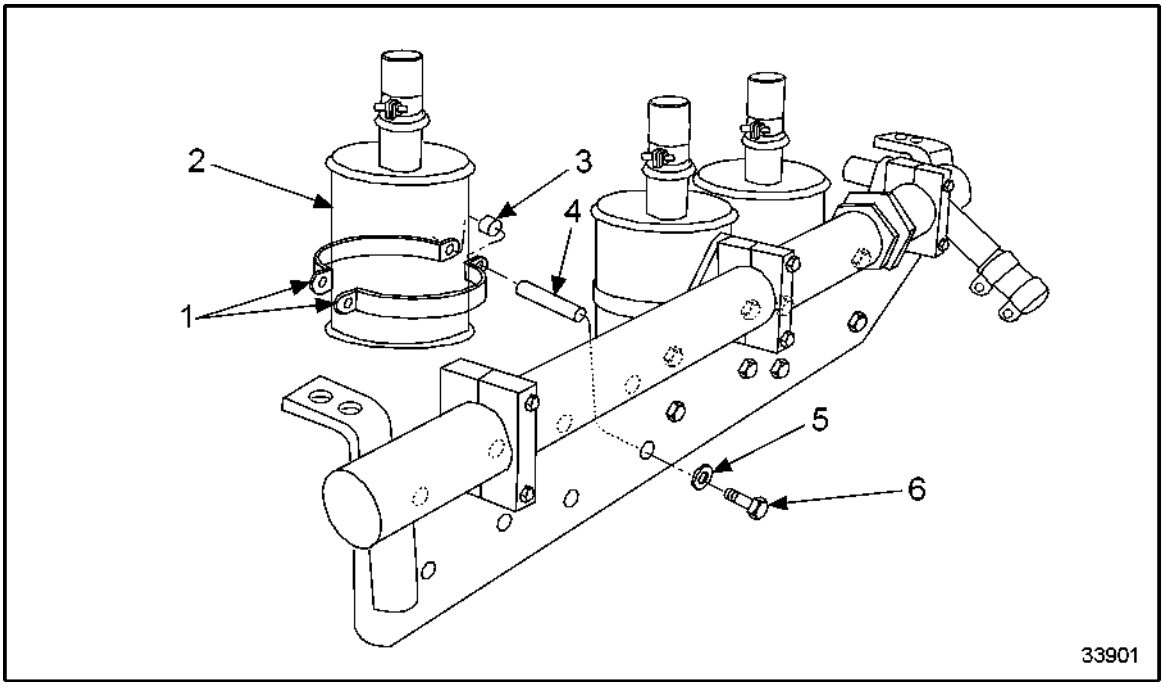
6. Remove six bolts (1) and washers securing the cylinder block tubing to the cylinder block ventilation bracket. See Figure 128.



1. Mounting Bolt
2. Pipe Clamp Half

Figure 128 Removing Clamps Securing Marine Cylinder Block Ventilation Canister

7. Remove four bolts (6), washers (5), long spacers (4), and short spacers (3) securing the cylinder block ventilation canister (2) to the cylinder block ventilation bracket. See Figure 129.



1. Clamp
2. Cylinder Block Canister Oil Separator
3. Short Spacer
4. Long Spacer
5. Washer
6. Bolt

Figure 129 Removing Marine Cylinder Block Ventilation Canister

8. Remove the cylinder block ventilation canister (2).

NOTE:
Repeat step 6 and step 8 for each cylinder block ventilation canister.

C 018.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the cylinder block ventilation system:

1. Clean all components.

> **CAUTION:**
>
> **Diesel fuel is a combustible fluid. Risk of a fire from sparks, smoking, or open flame is probable. To avoid personal injury, perform cleaning of engine components in a well ventilated work area with access to a fire extinguisher.**

2. If oil separator is clogged with stubborn, sticky oil, clean the separator with diesel fuel.
   [a] If oil separator cannot be completely cleaned, replace separator as necessary.
   [b] If oil separator has been cleaned, continue inspection.
3. Visually inspect components for wear and damage.
   [a] If components are worn or damaged, replace as necessary.
   [b] If components are not worn or damaged, continue inspection.
4. Visually inspect sealing and mating faces for damage and defects.
   [a] If sealing and mating surfaces are damaged or defective, rub down with oilstone.
   [b] If damage or defects are beyond repair, replace component as necessary.
   [c] If sealing and mating surfaces are not damaged or defective, or can be repaired, continue inspection.

> **CAUTION:**
>
> **To avoid an eye injury when blow drying parts, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.**

5. Visually inspect pipes and housing for damage.
   [a] If pipes or housing are damaged, replace components as necessary.
   [b] If pipes and housing are not damaged, continue inspection.
6. Visually inspect pipes and housing for leaks in water bath, using compressed air.
   [a] If bubbles are detected, indicating leaks, replace components as necessary.
   [b] If no leaks are detected, continue inspection.

CAUTION:

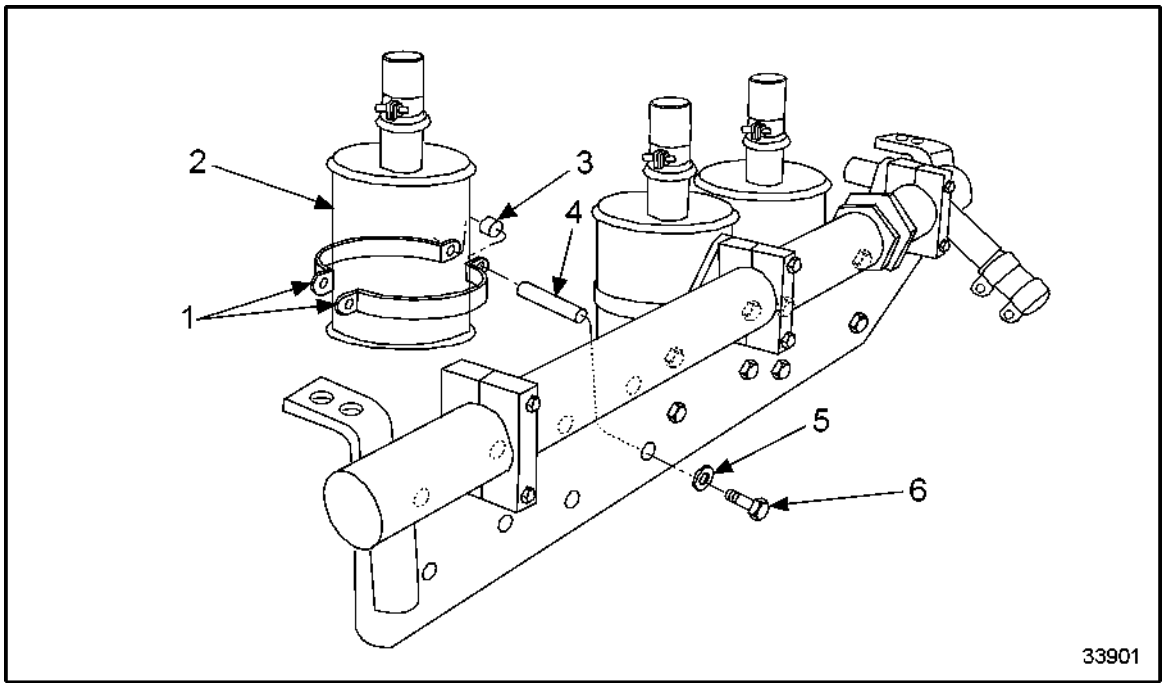
To avoid an eye or skin injury and suffocation when using hydrochloric acid, always wear protective clothing, protective gloves, goggles, and safety mask. Work in a well-ventilated area.

7. Visually inspect condition of threads.
   [a] If threads are not in perfect condition, rechase threads.
   [b] If threads are beyond repair, replace threaded inserts as necessary.
   [c] If threads are in perfect condition, continue inspection.

C 018.05.10 M – ASSEMBLY OF THE MARINE CYLINDER BLOCK VENTILATION SYSTEM

Perform the following steps to assemble the cylinder block ventilation system:

1. Replace the cylinder block ventilation canisters (2). See Figure 130.

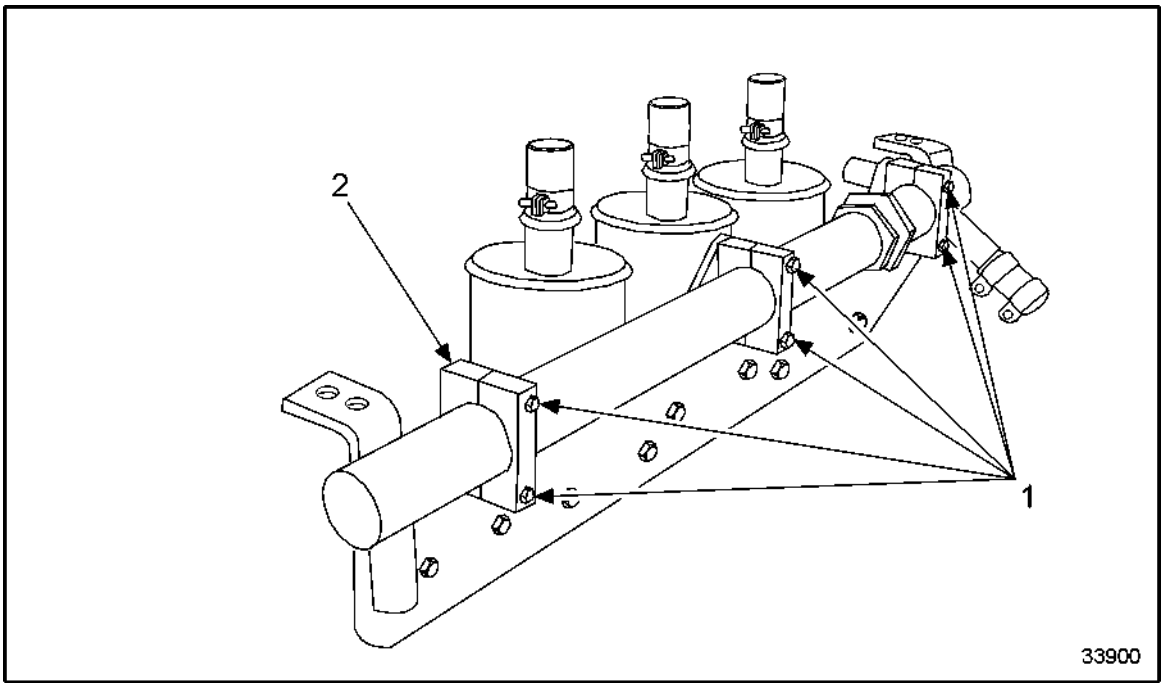


1. Clamp
2. Cylinder Block Breather Canisters
3. Short Spacer
4. Long Spacer
5. Washer
6. Bolt

Figure 130 Replacing Marine Cylinder Block Ventilation Canister

2. Replace four bolts (6), washers (5), long spacers (4), and short spacers (3) securing the cylinder block ventilation canister (2) to the cylinder block ventilation bracket. See Figure 130.

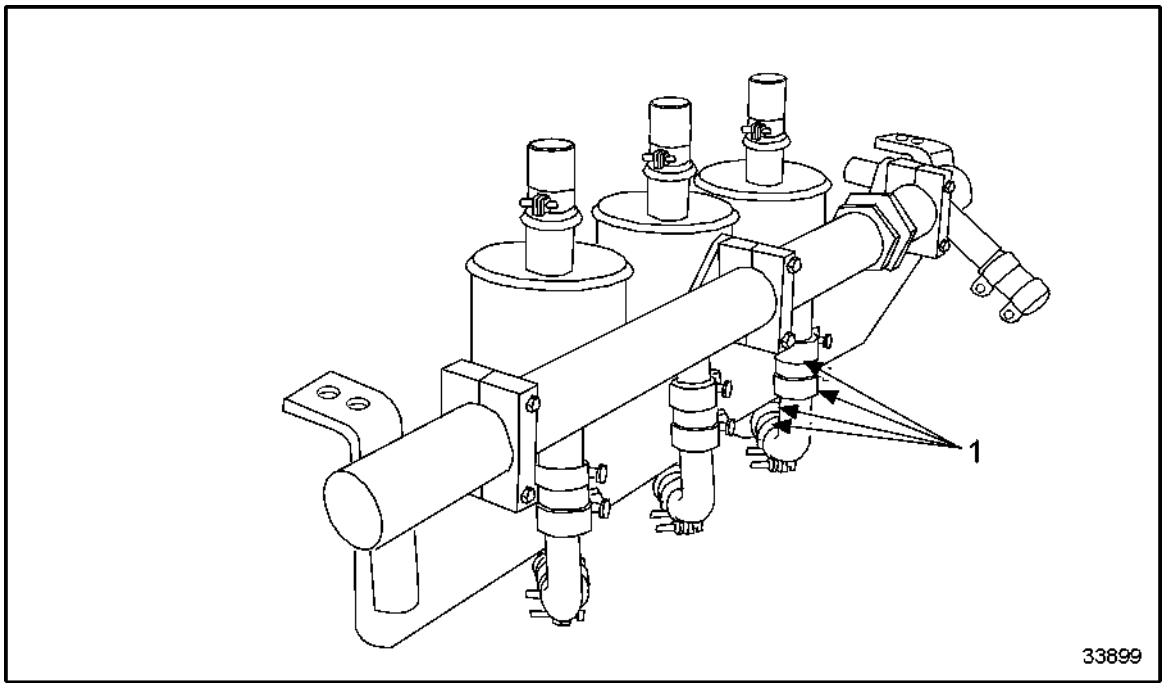
3. Replace six bolts (1) and washers securing the cylinder block tubing to the cylinder block ventilation bracket. See Figure 131.



1. Mounting Bolt
2. Pipe Clamp Half

Figure 131 Replacing Bolts and Washers Securing Cylinder Block Tubing

4. Tighten four clamps (1) securing the tube connecting the cylinder block ventilation canister with the cylinder block tubing. See Figure 132.

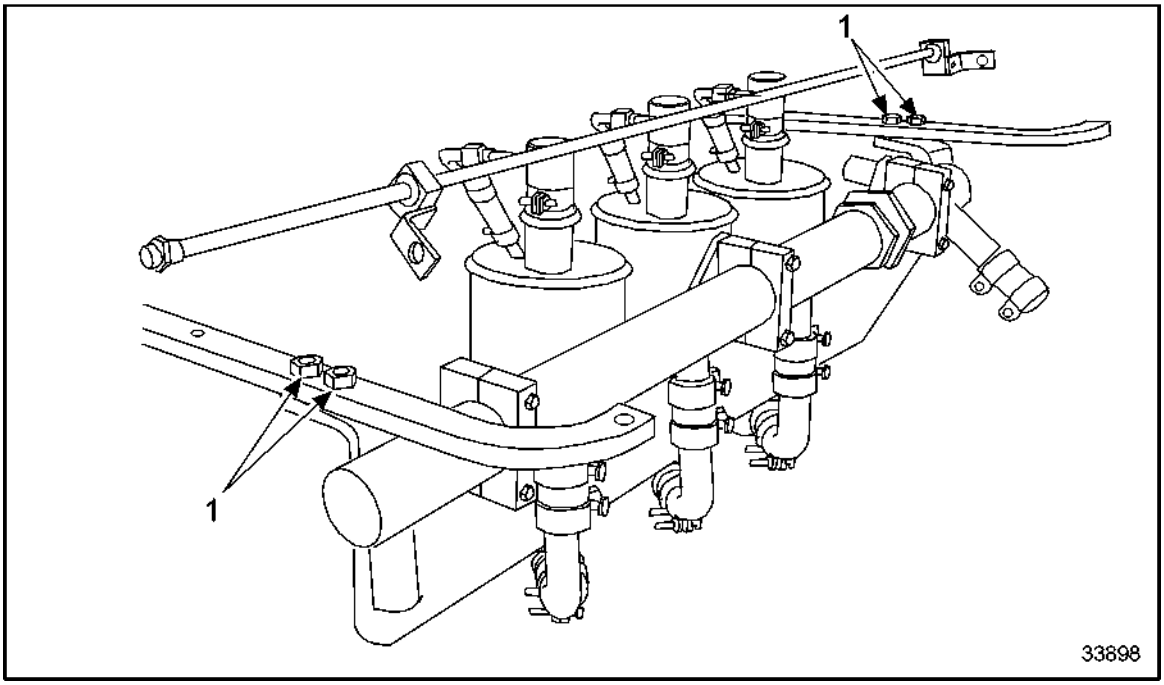


1. Clamp

Figure 132 Tightening Clamps Securing Marine Cylinder Block Ventilation Canister

NOTE:
Repeat step 4 for the remaining cylinder block ventilation canisters.

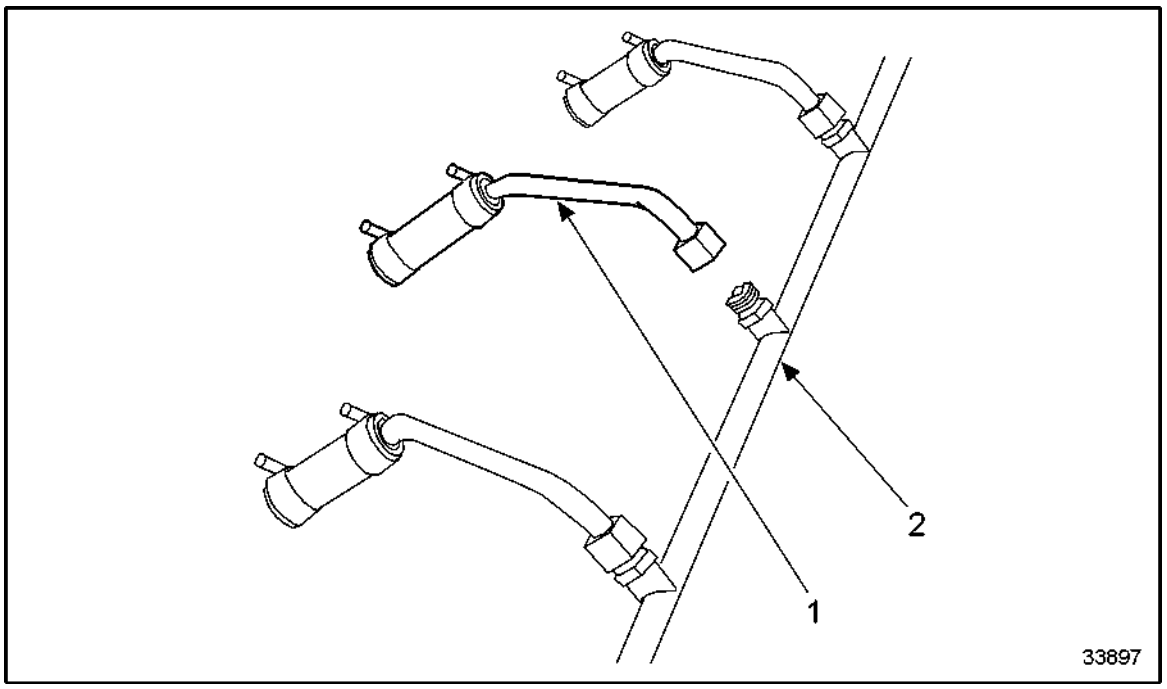
5. Replace four bolts (1), washers and nuts securing the mounting bracket to the cylinder block ventilation bracket. See Figure 133.



1. Mounting Bolt

Figure 133 Installing Mounting Bracket to Marine Cylinder Block Ventilation Bracket

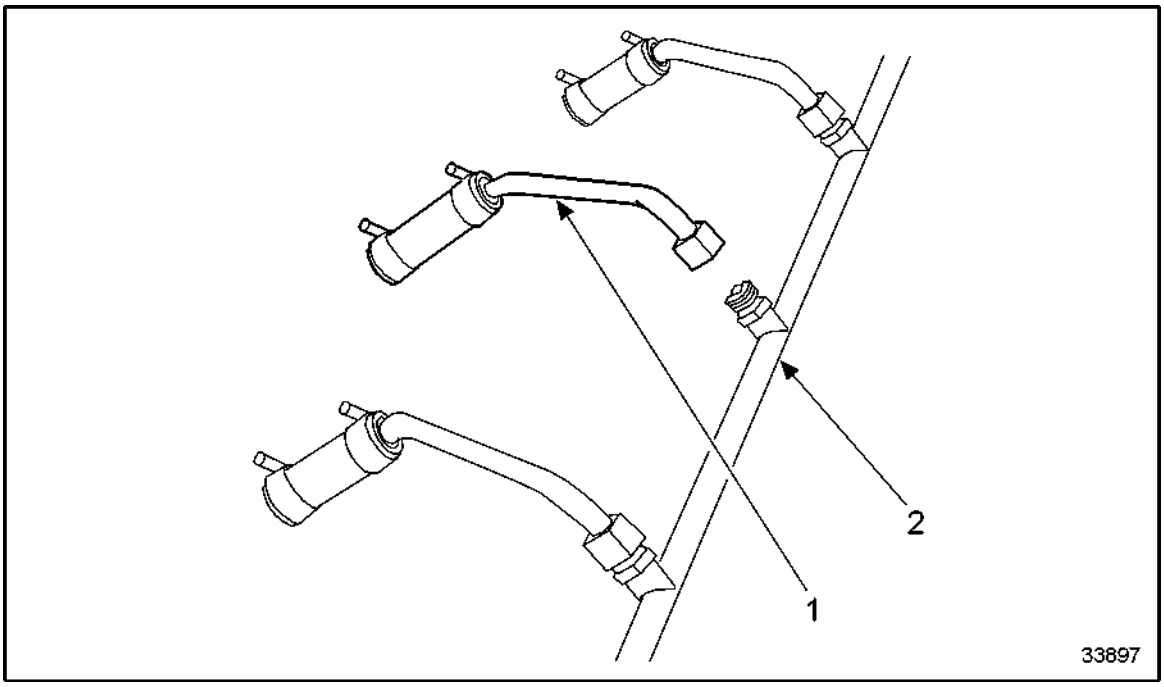
6. Replace vent tubing (1) that attaches to the vent line assembly (2). See Figure 134.



1. Vent Tubing
2. Vent Line Assembly

Figure 134 Replacing Vent Tubing

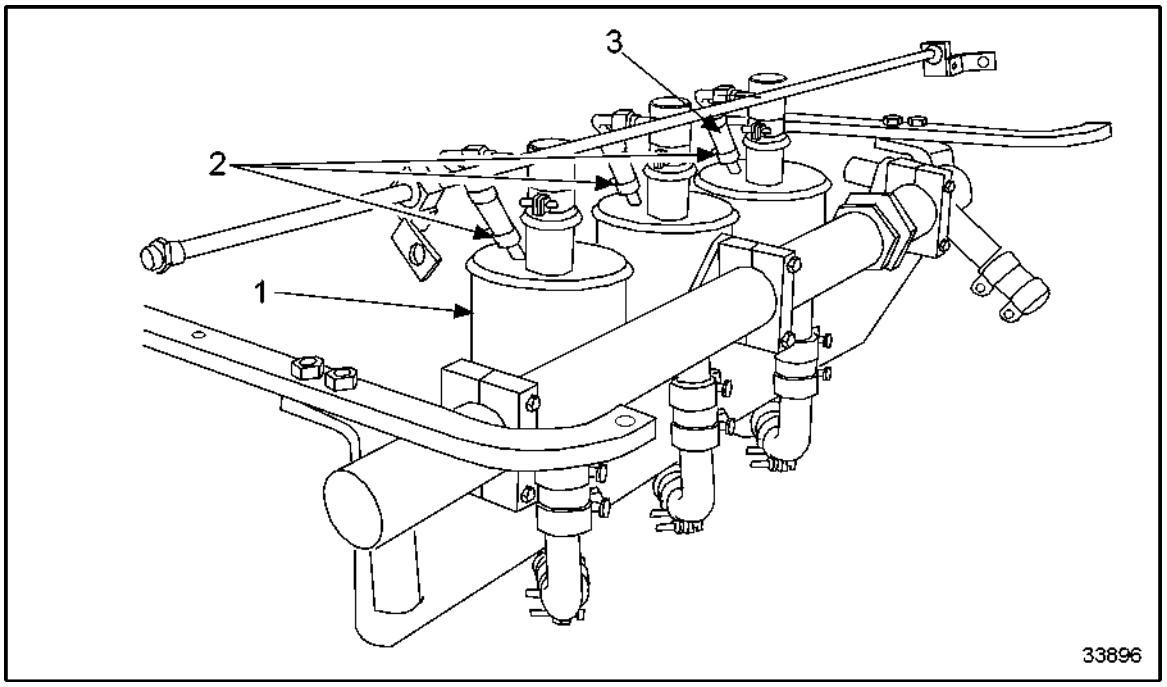
7. Replace vent line assembly (2). See Figure 135.



1. Vent Tubing
2. Vent Line Assembly

Figure 135 Replacing Vent Line Assembly

8. Tighten clamps (2) securing the vent hose to the base of the cylinder block ventilation canisters. See Figure 136.



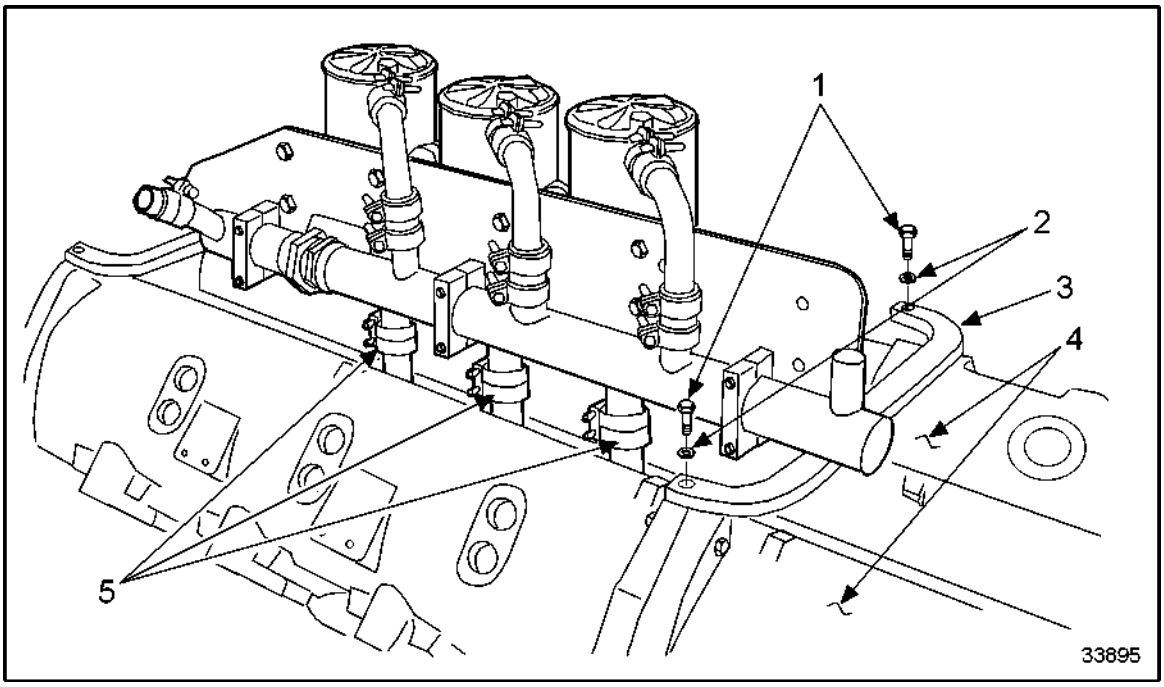
1. Cylinder Block Breather Canister
2. Clamp
3. Clamp Hose

Figure 136 Tightening Vent Clamps

C 018.05.11 M – INSTALLATION OF THE MARINE CYLINDER BLOCK VENTILATION

Perform the following steps to install the cylinder block ventilation system:

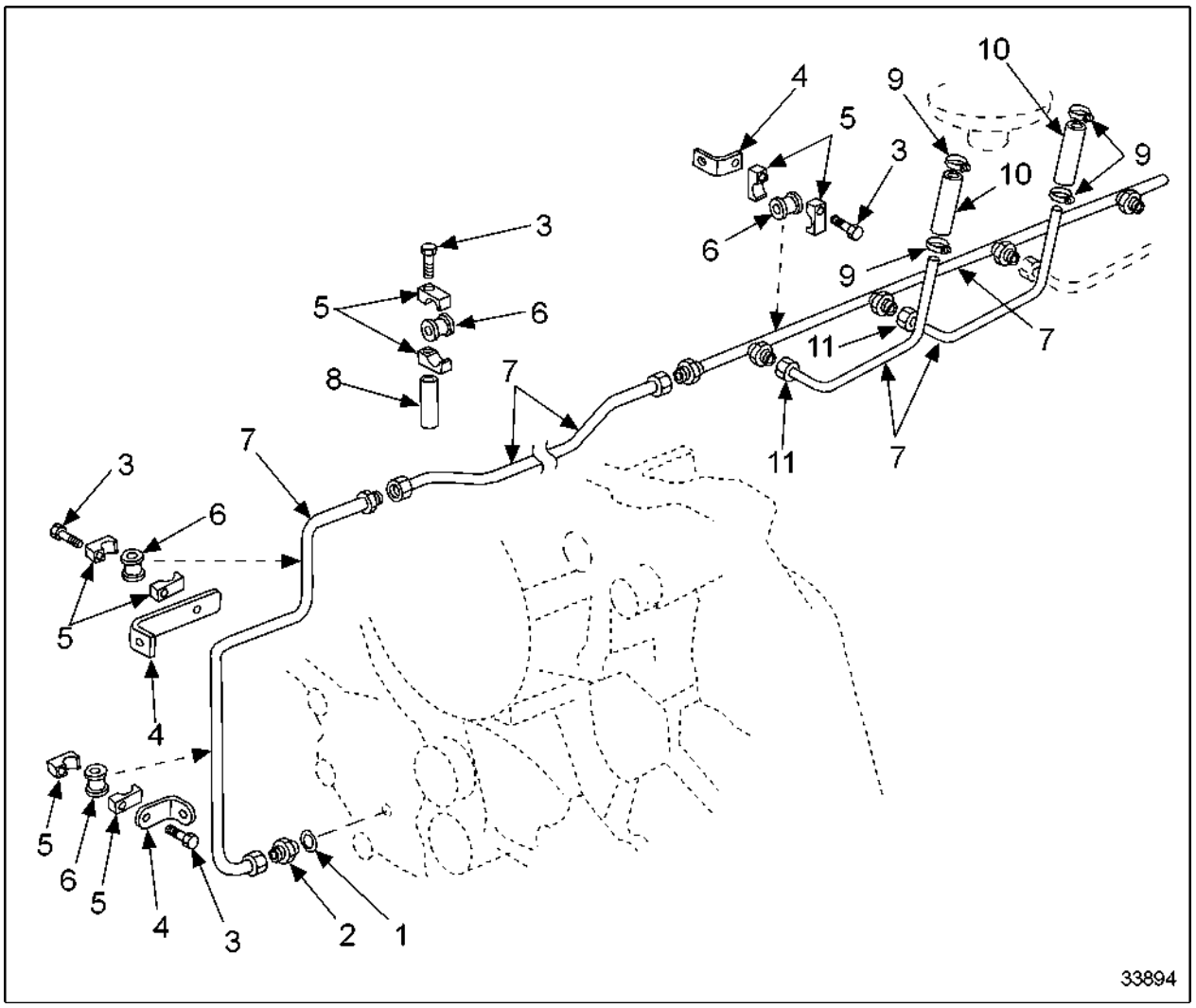
1. Install the cylinder block ventilation system to the cylinder block vent.
2. Tighten the cylinder block ventilation hose clamps.
3. Install four 35 mm bolts (1) and washers (2) to secure the cylinder block ventilation system to the exhaust manifold. Torque bolts to 74–82 N·m (55–60 lb·ft.). See Figure 137.



1. Bolts
2. Washers
3. Cylinder Block Breather Bracket
4. Exhaust Manifold
5. Clamps

Figure 137 Installing Marine Cylinder Block Ventilation Assembly Bracket

4. Connect ventilation cylinder block ventilation support. See Figure 138.



1. Sealing Ring
2. Adaptor
3. Bolt
4. Bracket
5. Pipe Clamp Half
6. Grommet
7. Ventilation Lines
8. Spacer Bushing
9. Clamp
10. Rubber Sleeve
11. Nut

Figure 138 Connecting Marine Cylinder Block Ventilation Lines

5. Verify repair of the cylinder block ventilation system.

C 018.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 16are the After-Installation Operations for Cylinder Block Ventilation.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators Guide
1, 2, 3	Connect vent lines	Refer to section 202.65.

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.

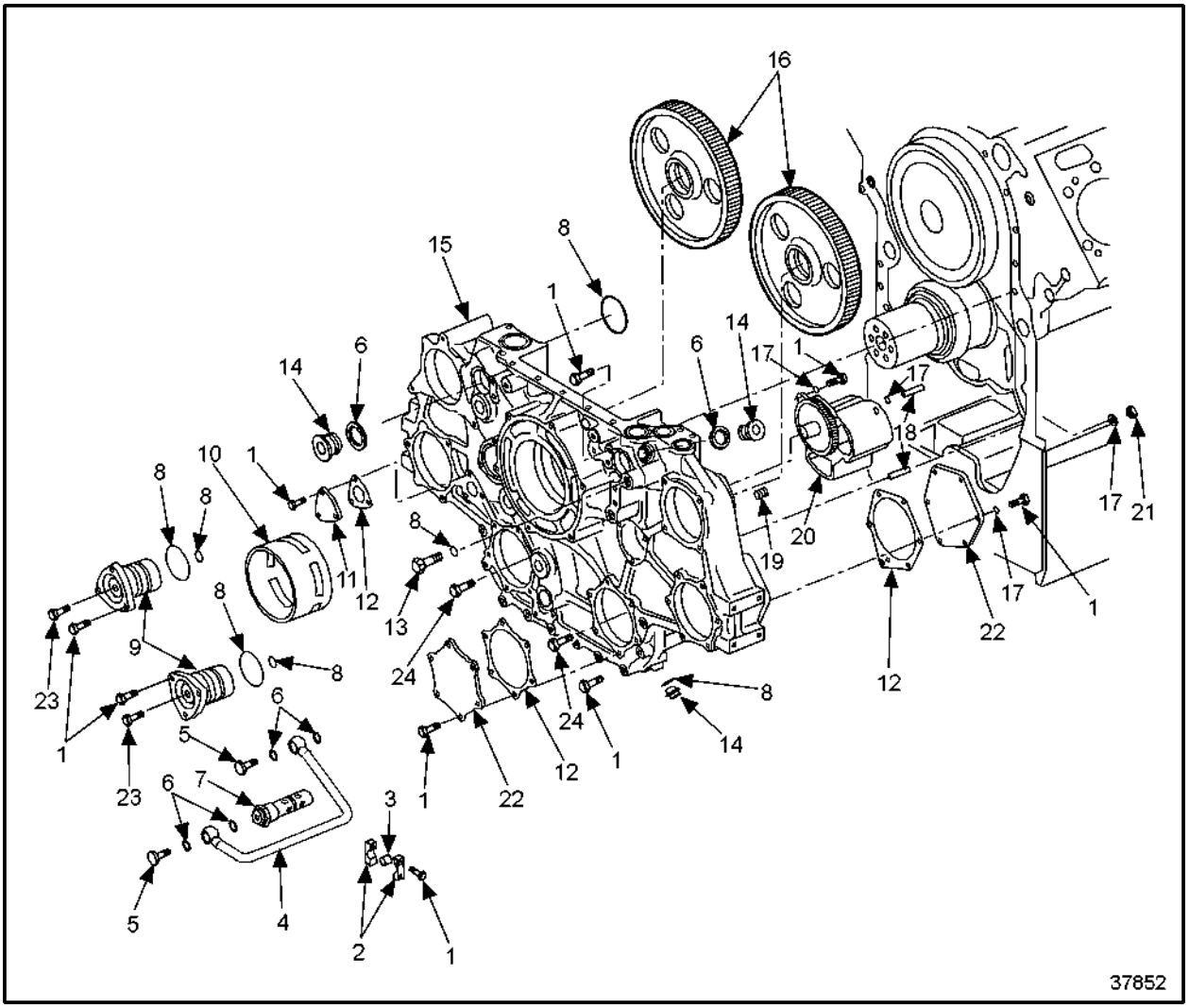
Table 16 After-Installation Operations for Marine Cylinder Block Ventilation

C 020 – GEAR CASE

C 024.05 – GEAR CASE

C 024.05.01 – GENERAL VIEW

See Figure 139 for a general view of gear case.

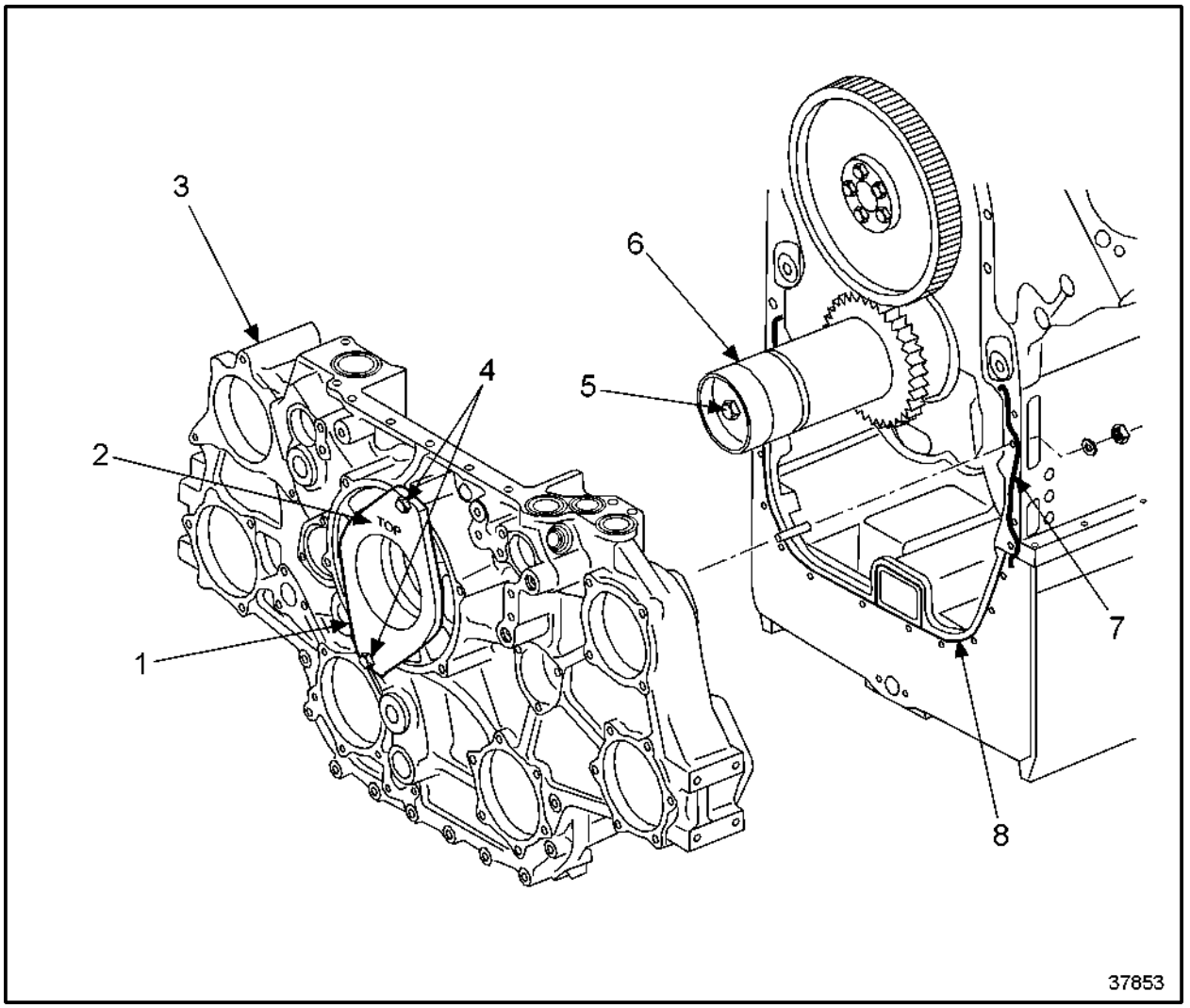


1. Hex Bolt
2. Pipe Half Clamp
3. Grommet
4. Oil Line
5. Banjo Bolt
6. Sealing Ring
7. Pressure Regulator
8. O-ring
9. Intermediate Gear Axle
10. Crankshaft Outboard Bearing
13. Plug
14. Plug
15. Gear Case
16. Idler Gear
17. Washer
18. Stud
19. Threaded Bushing
20. Oil Pump
21. Hex Nut
22. Cover

11. Cover
12. Gasket
23. Axle Bolt
24. Waist Bolt

Figure 139 General View of Gear Case

See Figure 140 for alignment tool arrangement for gear case installation.



1. Gear Case Alignment Tool J 43634
2. Top Marking
3. Gear Case
4. Hex Bolt
5. Hex Bolt
6. Guide Bushing
7. Cotton Seal (2)
8. Oil Pan Seal

Figure 140 Alignment Tool Arrangement for Gear Case Installation

C 024.05.02 – SPECIAL TOOLS

Listed in Table 17 are the special tools required for maintenance on the gear case (gear case end).

Designation	Tool Number
Alignment tool (gear case end), gear case	J 43634
Guide bushing (gear case end), crankshaft	—
Drift for removing idler gear bushing, idler gear axle	—
Installation tool for shaft/bushing in gear case	—
Puller for shaft/bushing in gear case	—
Guide pin for vibration damper	—
Support bracket for vibration damper	—

Table 17 Special Tools

C 024.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 18 are the Before-Removal Operations for the gear case.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Remove fan drive	Refer to section C 221.05.05
1, 2, 3	Remove gear case (gear case end)	Refer to section C 024.05.05
1, 2, 3	Remove vibration damper	Refer to section C 035.05.05
1, 2, 3	Disconnect and remove electric wiring	Refer to OEM Guidelines
1, 2, 3	Remove charge air coolant pump	Refer to section C 206.05.05
1, 2, 3	Remove coolant pump	Refer to section C 202.05.05
1, 2, 3	Remove charge air coolant lines	Refer to section C 207.05.05
1, 2, 3	Remove coolant vent lines	Refer to section C 205.05.05
1, 2, 3	Remove charge air coolant vent lines	Refer to OEM Guidelines
1, 2, 3	Remove coolant housing with thermostat	Refer to section C 208.05.05
1, 2, 3	Remove generator	Refer to section C 213.05.05
1, 2, 3	Remove generator drive	Refer to section C 213.05.05
1, 2, 3	Remove high pressure pump	Refer to section C 073.05.05
1, 2, 3	Remove centrifugal filter	Refer to section C 184.05.05
1, 2, 3	Remove oil filter	Refer to section C 183.05.05
1, 2, 3	Remove drive hub	Refer to section C 035.05.05

1 = The engine is to be completely disassembled.

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

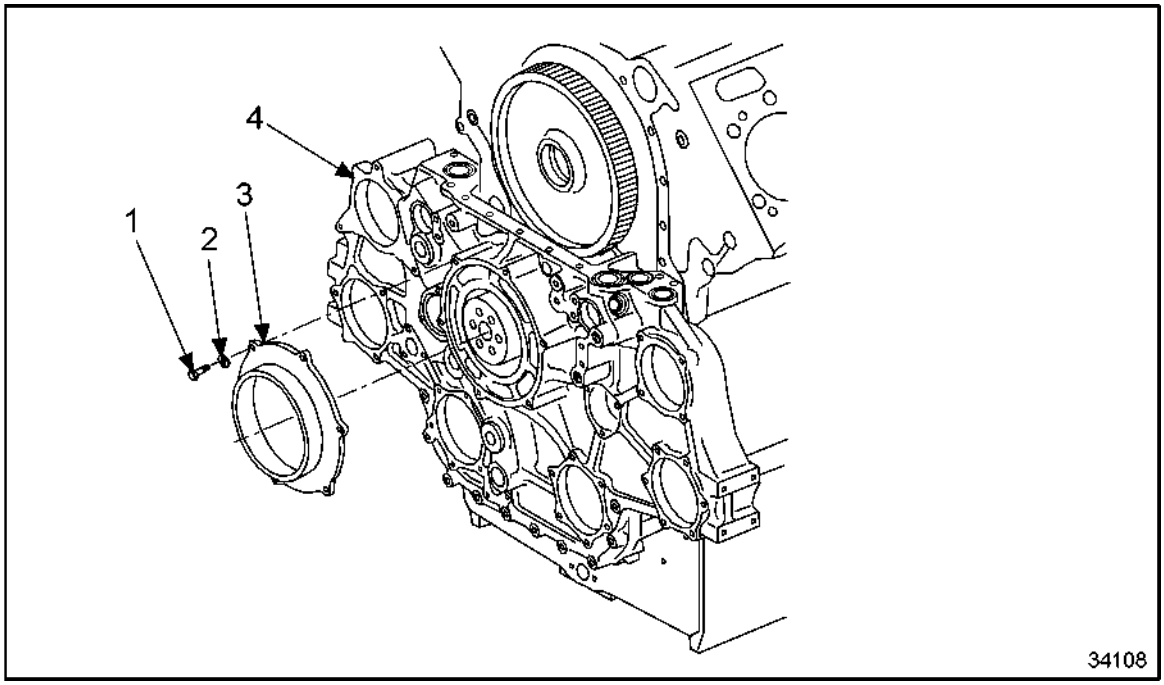
3 = The engine is to remain installed.

Table 18 Before-Removal Operations

C 024.05.05 – REMOVAL OPERATIONS FOR GEAR CASE

Perform the following operations to remove gear case.

1. Remove hex bolts (1) and washers (2) for seal carrier. See Figure 141.

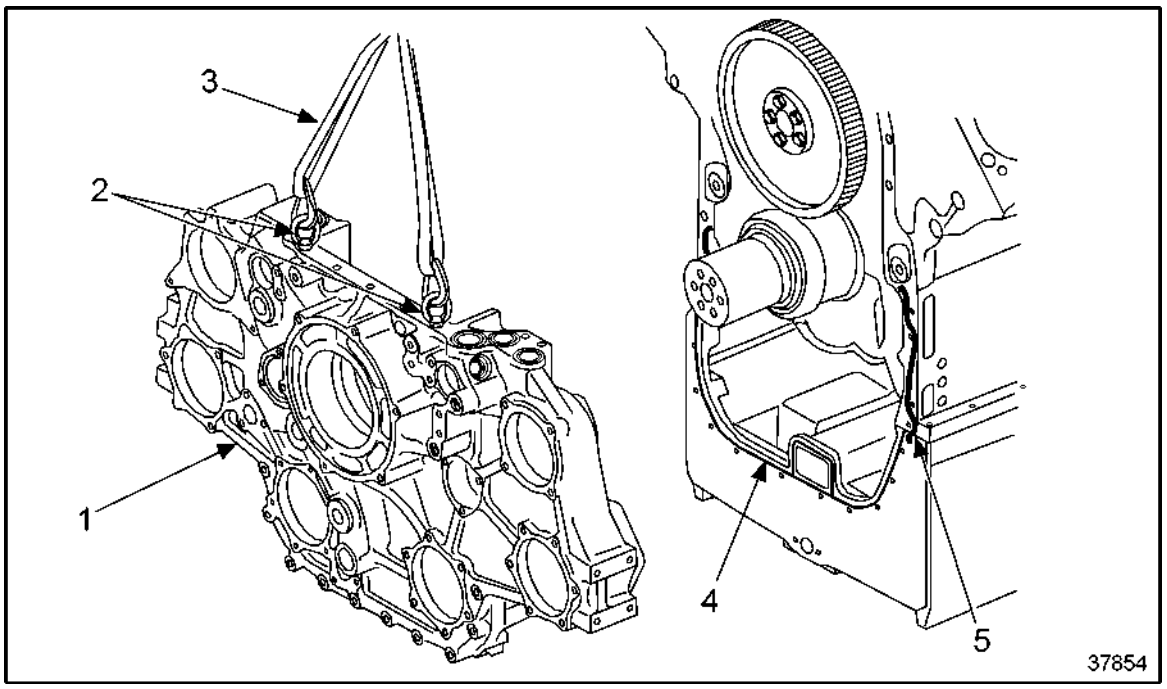


1. Hex Bolt
2. Washer
3. Seal Carrier
4. Gear Case

Figure 141 Removing Gear Case

2. Remove seal carrier (3). See Figure 141.
3. Mark all bolts (1) (differing lengths) for gear case and remove. See Figure 141.

4. Install two eyebolts in gear case. See Figure 142.



1. Gear Case
2. Eyebolt
3. Lifting Device
4. Oil Pan Seal
5. Cotton Seal (2)

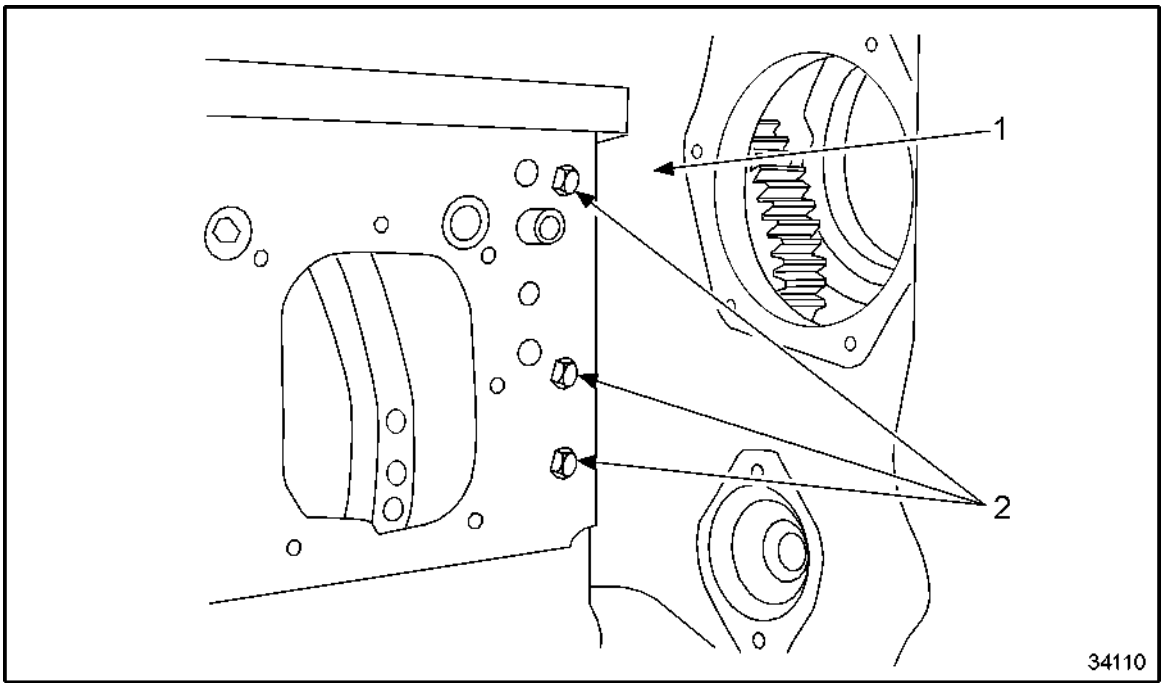
Figure 142 Installing Eye Bolts and Lifting Device

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. Attach gear case to crane with lifting device and adjust tension equally. See Figure 142.
6. Remove oil line. Refer to section C 181.05.01.
7. Remove pressure regulator valve. Refer to section C 181.05.01.

8. Release nuts (2), left and right sides of cylinder block, and remove with washers. See Figure 143.



1. Gear Case
2. Hex Nut

Figure 143 Releasing Nuts on Cylinder Block

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.

9. Carefully push gear case (2), with the lifting device pretensioned, in direction of gear case end until it is freed from cylinder block.
10. Remove O-rings.

C 024.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair gear case.

1. Clean gear case. See Figure 144.

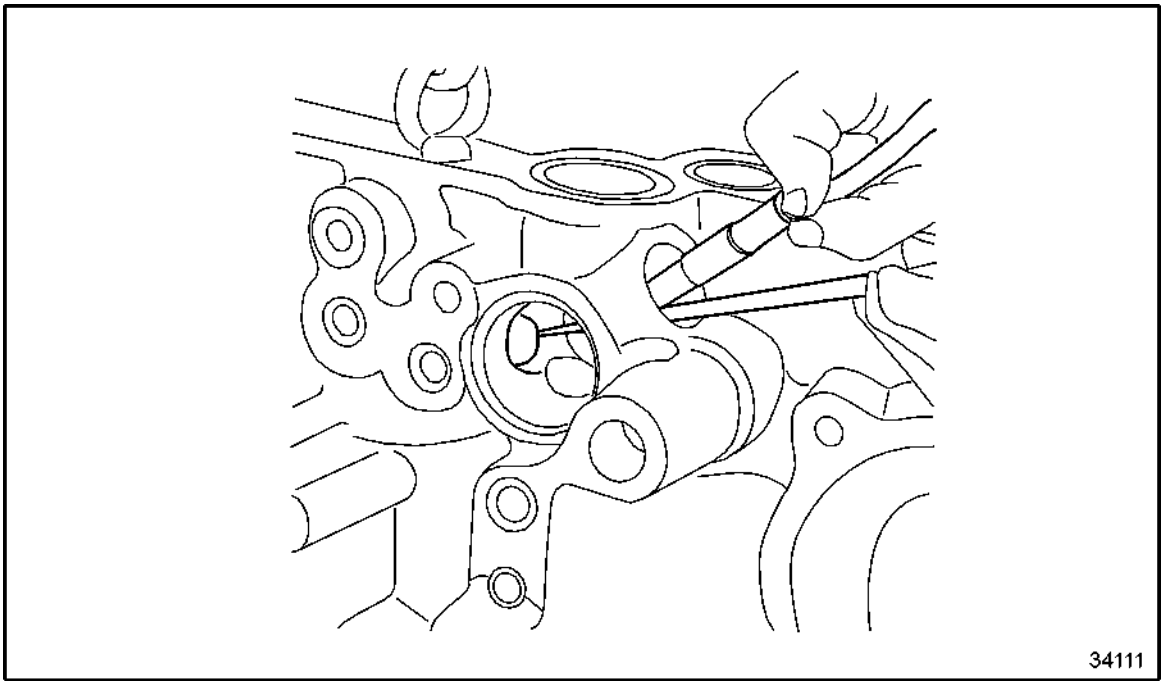
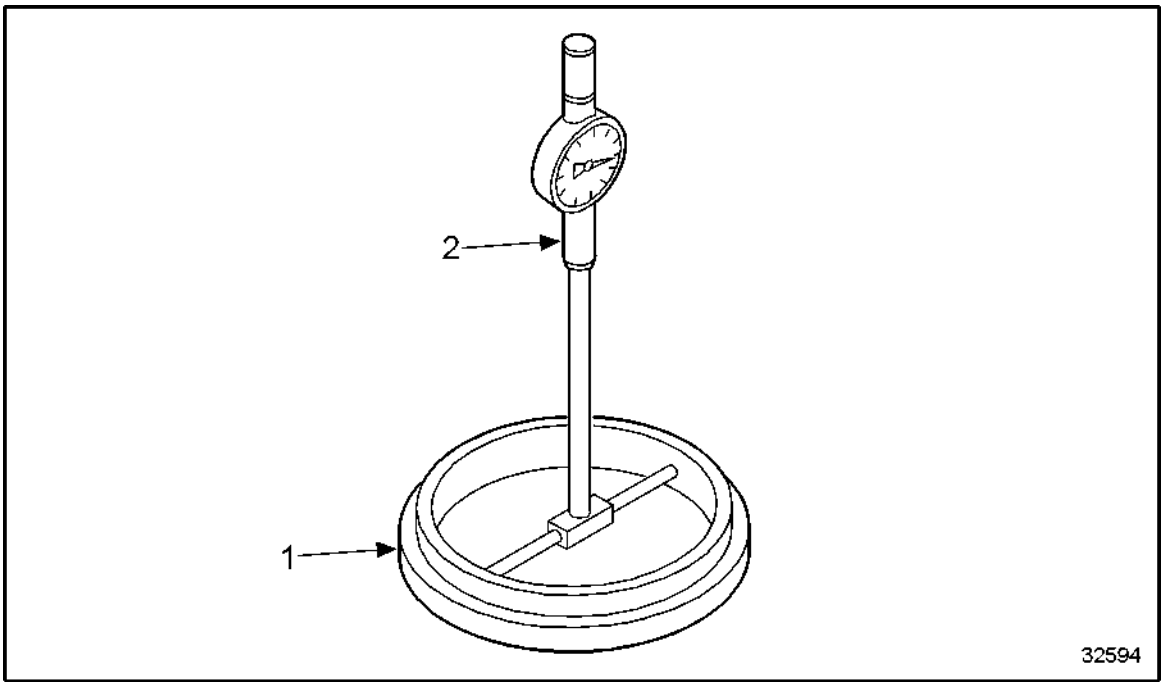


Figure 144 Cleaning Gear Case

2. Thoroughly clean oil passages and chambers in gear case.
3. Using magnetic crack testing method and fluorescent magnetic powder, check gear case for cracks.
   [a] If cracked, replace gear case. Refer to section C 024.05.11.
   [b] If gear case is not cracked, continue inspection.
4. Check crankshaft outboard bearing for wear, scoring and marks.
   [a] If worn, scored or marked, replace outboard bearing. Refer to section C 024.05.11.
   [b] If not worn, scored or marked, continue inspection.
5. Check condition of threads in gear case.
   [a] If thread condition is not acceptable, rechase threads.
   [b] If threads are in good condition, continue inspection.
6. Check threads and shaft of hex bolts and studs for damage.
   [a] If threads or shaft of hex bolts are damaged, replace bolts.
   [b] If threads or shaft of hex bolts are not damaged, continue inspection.

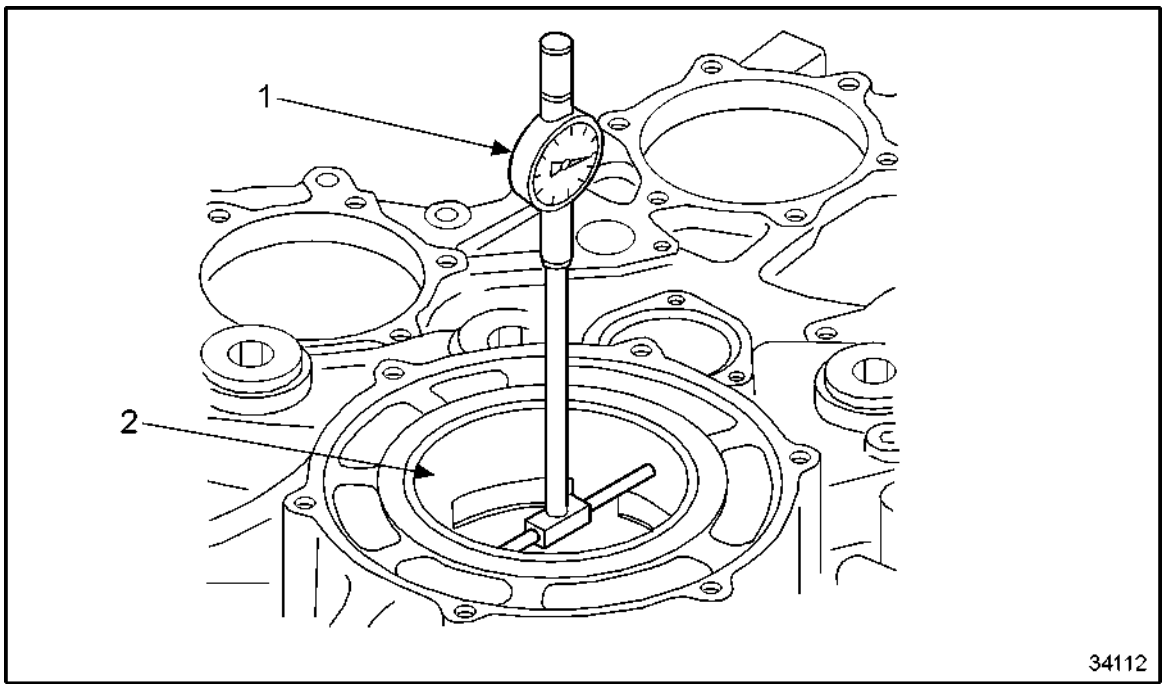
7. Check contact, sealing and mating surfaces.
   [a] If contact, sealing and mating surfaces are damaged, polish with an oilstone or emery cloth.
   [b] If contact, sealing and mating surfaces are not damaged, continue inspection.
8. Replace O-rings.
9. Adjust bore gage and dial gage (2) with micrometer or gage ring (1) to basic size for crankshaft outboard bearing bore. See Figure 145.



1. Adjusting Gage Ring
2. Dial Bore Gage

Figure 145 Adjusting Bore Gage and Dial Gage with Micrometer or Gage Ring

10. Measure diameter of crankshaft outboard bearing bore with bore gage. See Figure 146.



1. Dial Bore Gage
2. Outboard Bearing Bore

Figure 146 Measuring Outboard Bearing Bore

[a] If limit values are exceeded, replace gear case. Refer to section C 024.05.11.

[b] If limit values are not exceeded, continue inspection.

11. Enter measurement values in data sheet.

12. Check condition of outboard bearing.

[a] If the outboard bearing is damaged or out of specification, remove with a suitable removal brass drift. Refer to section C 024.05.05.

[b] Measure the gear case bore, and install a new outboard bearing in the gear case. Refer to sectionC 024.05.11.

[c] If the outboard bearing is not damaged, continue inspection.

C 024.05.11 – INSTALLATION OF GEAR CASE

Perform the following steps to install gear case.

CAUTION:

To avoid injury when handling and lifting a heavy object, use a suitable lifting device to lift heavy objects and follow the manufacturer's operator procedures.

1. Place gear case on suitable bench or rest to ensure that outboard bearing can be installed flush with the gear case.
2. Mark position of oil bores in the outboard bearing on front face (arrow). See Figure 147.

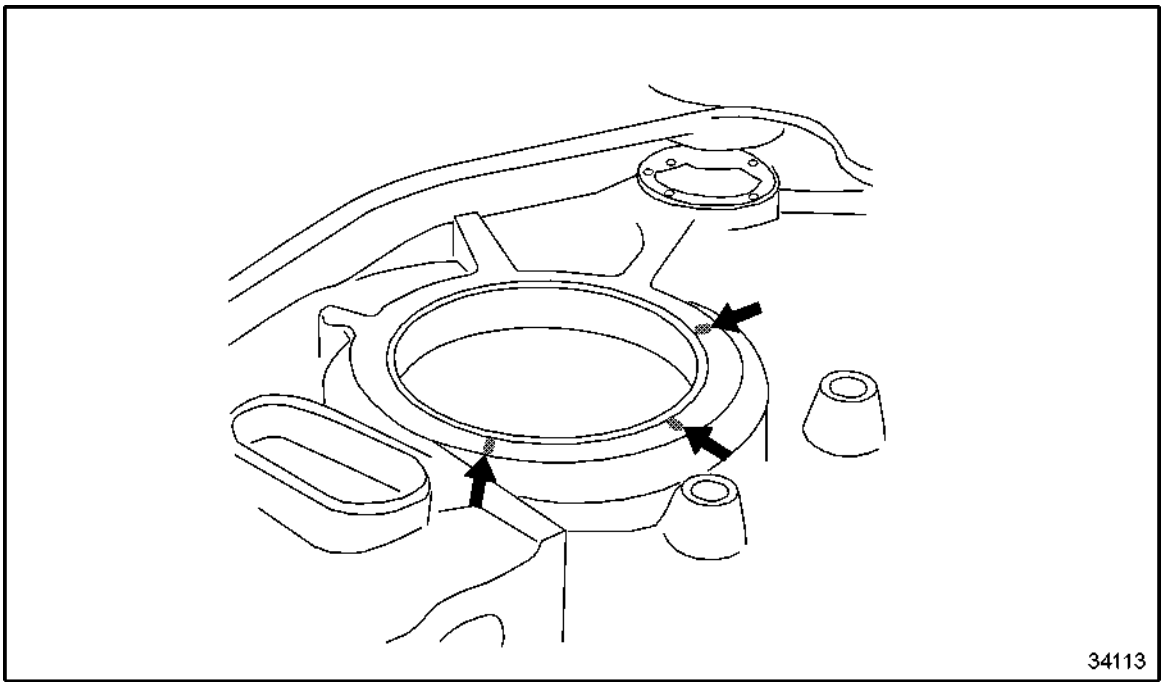


Figure 147 Marking Outboard Bearing in Gear Case for Oil Bores

NOTE:
Position bearing shell markings to face oil bores.

CAUTION:

To avoid injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

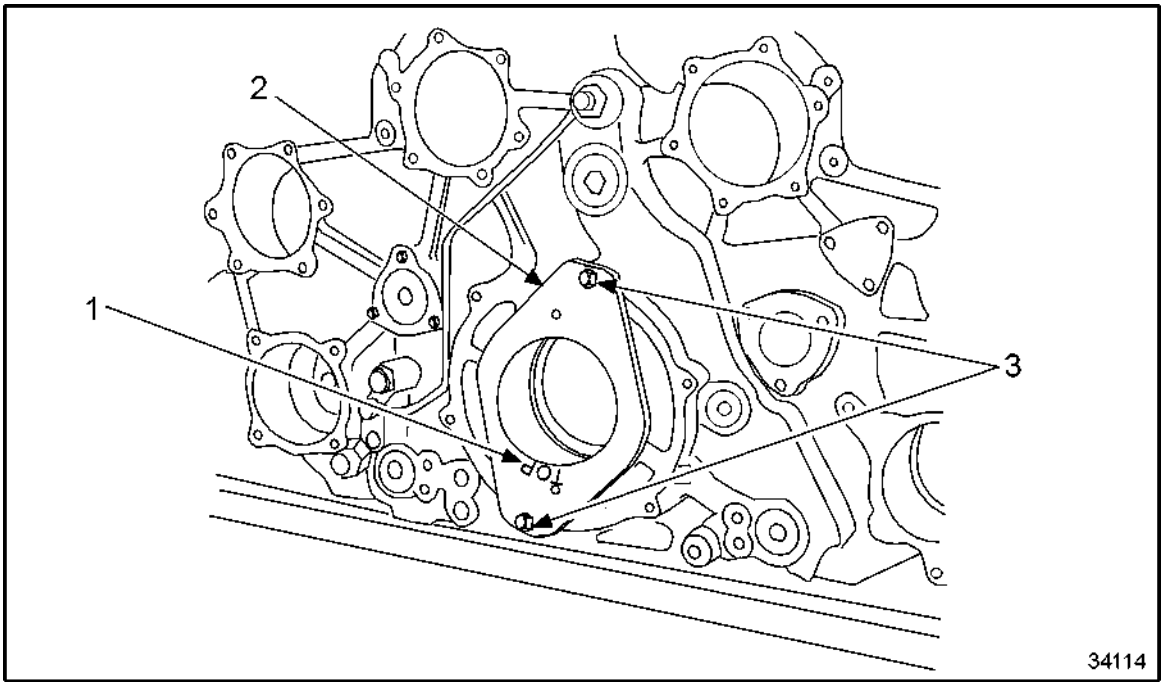
3. Chill outboard bearing in liquid nitrogen.

CAUTION:

To avoid injury while handling 'HOT' components, wear protective gloves and clothing.

4. Heat gear case to 80°C (176°F).
5. Insert chilled outboard bearing flush into gear case, ensuring that oil bores (arrows) are aligned. See Figure 147.
6. Ensure that oil passages are free of obstruction.

7. Install intermediate gears and axles. Refer to section C 025.05.11. See Figure 148.



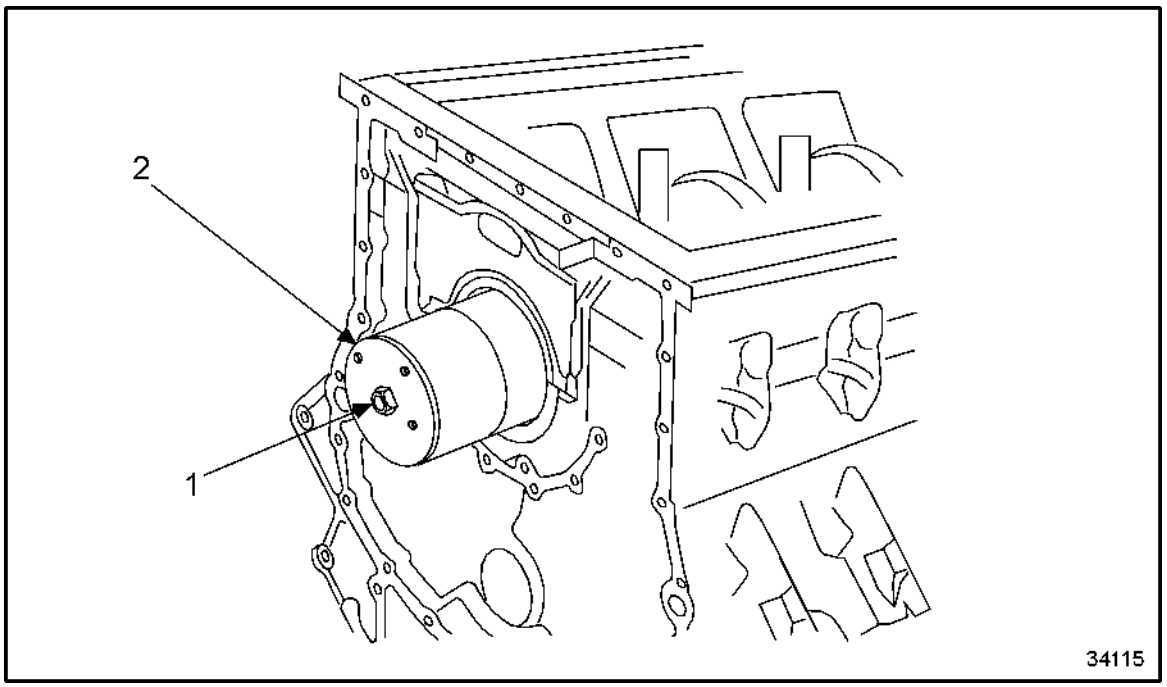
1. Installation Mark
2. Gear Case Alignment Tool J 43634
3. Hex Bolt

Figure 148 Installing Intermediate Gears and Axles

8. Install delivery valve. Refer to section Installation of Delivery Valve.
9. Install pressure regulator. Refer to section C 181.05.01.
10. Install gear case alignment tool J 43634 (2) with hex bolt (3) on gear case. See Figure 148.

NOTE:
Pay attention to TOP mark. Even when cylinder block is rotated, the alignment tool marking must be at the top.

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



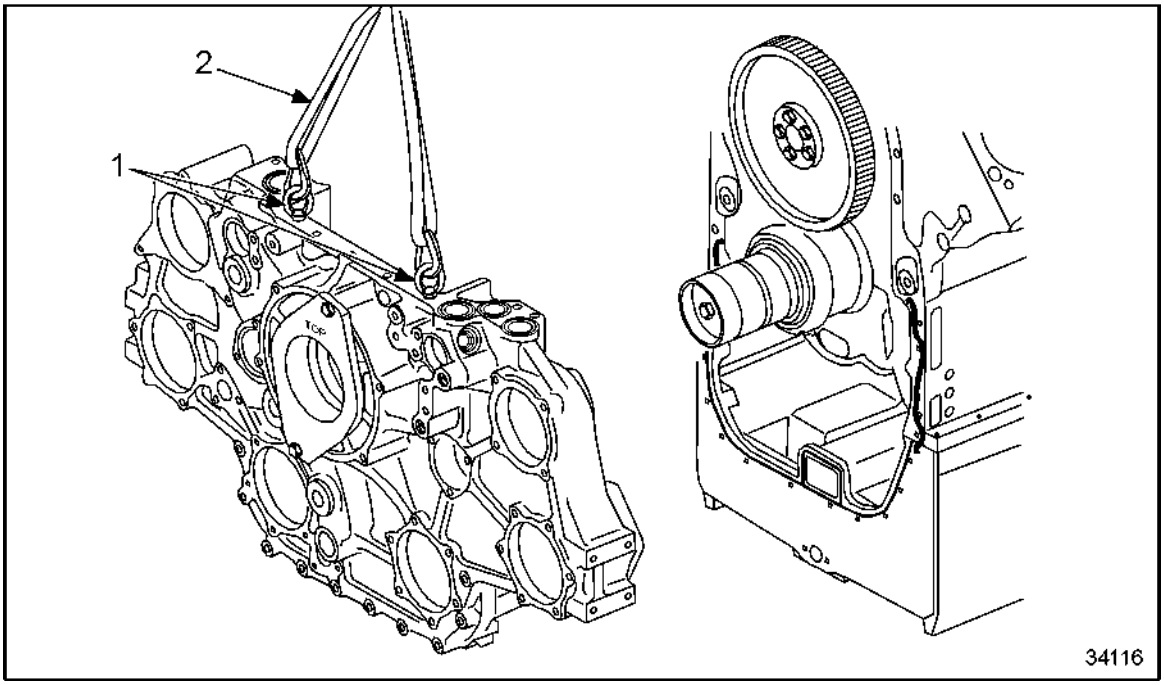
1. Hex Bolt
2. Gear Case Alignment Tool Guide Bushing

Figure 149 Placing Guide Bushing on Crankshaft

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.

12. Install eyebolts (1) in gear case and secure to crane with appropriate lifting device. See Figure 150.

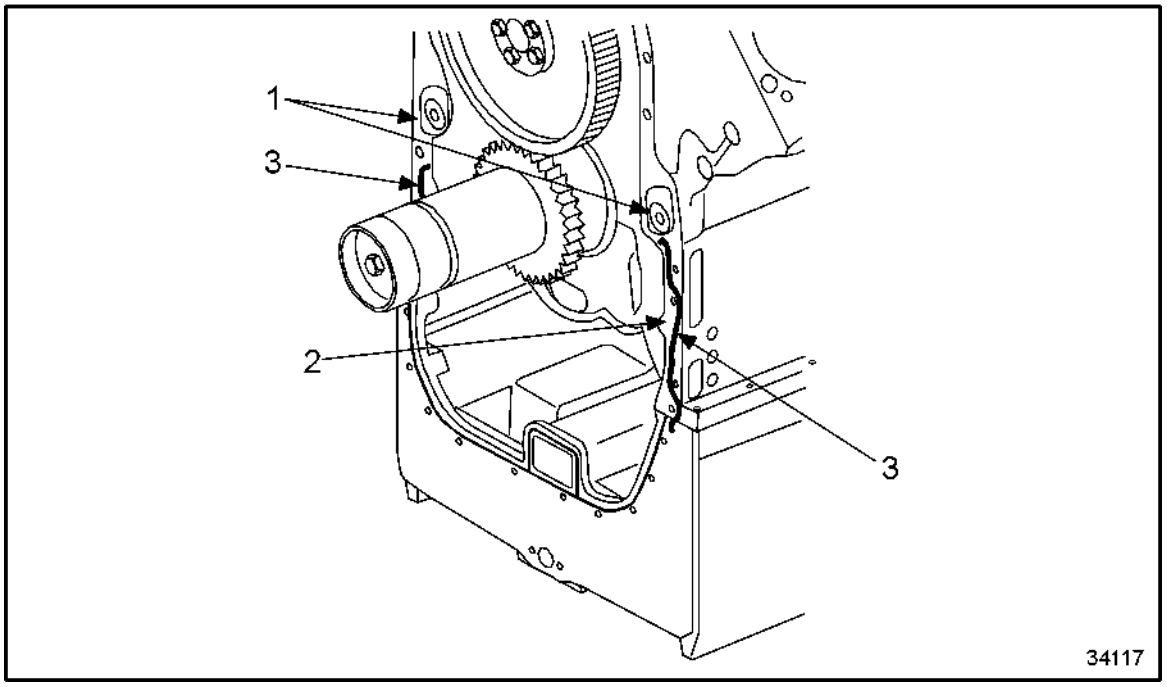


1. Eyebolt
2. Lifting Device

Figure 150 Securing Gear Case to Lifting Device

13. Install the alignment tool with TOP toward the top of the engine in the holes for the seal carrier.

14. Degrease and dry mating surface (2). See Figure 151.



1. O-ring Bore
2. Mating Surface
3. Cotton Seal

Figure 151 Coating Mating Surfaces on Block for Gear Case

15. Coat mating block surface with Gasket Eliminator 518 and attach cotton seal (3). Fit closely to O-ring bore (1).
16. Coat O-rings (1) with petroleum jelly, and insert in groove on gear case. See Figure 151.
17. Using crane, carefully move gear case over crankshaft guide bushing. Refer to section C 024.05.01.
18. Ensure that studs are properly aligned.

NOTE:
Ensure components are reinstalled in accordance with markings, and note that bolts differ in length.

19. Install all securing bolts and tighten uniformly.
20. Install nuts and washers and tighten.
21. Torque securing bolts and nuts to specification. Refer to section A 003.

NOTE:
Ensure that final strength of surface sealant is correct.

CAUTION:

To avoid injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

22. Remove lifting device and eyebolts.

NOTE:
Do not cut off cotton thread projecting over oil pan sealing surface. For further procedure, refer to section C 014.05.11.

23. Remove securing bolts of alignment tool from gear case and guide bushing from crankshaft.

C 024.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 19 are the After-Installation Operations for the gear case (gear case end).

Level of Maintenance	Operation	Reference
1, 2, 3	Install drive hub	Refer to section C 035.05.11
1, 2, 3	Install high pressure fuel pump	Refer to section C 073.05.11
1, 2, 3	Install generator drive	Refer to section C 213.05.11
1, 2, 3	Install generator	Refer to section C 213.05.11
1, 2, 3	Install oil filter	Refer to section C 183.05.11
1, 2, 3	Install centrifugal filter	Refer to section C 184.05.11
1, 2, 3	Install and connect electric wiring	Refer to section C 501.05 M
1, 2, 3	Install coolant housing with thermostat	Refer to section C 208.05.11
1, 2, 3	Install charge air coolant pump	Refer to section C 206.05.11
1, 2, 3	Install coolant pump	Refer to section C 202.05.11
1, 2, 3	Install charge air coolant lines	Refer to section C 206.05.11
1, 2, 3	Install coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install charge air coolant vent lines	Refer to OEM Guidelines
1, 2, 3	Install gear case (gear case end)	Refer to section C 024.05.11
1, 2, 3	Install vibration damper	Refer to section C 035.05.11
1, 2, 3	Install fan drive	Refer to section C 221.05.11
1, 2, 3	Fill oil system with engine oil	Operator 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.

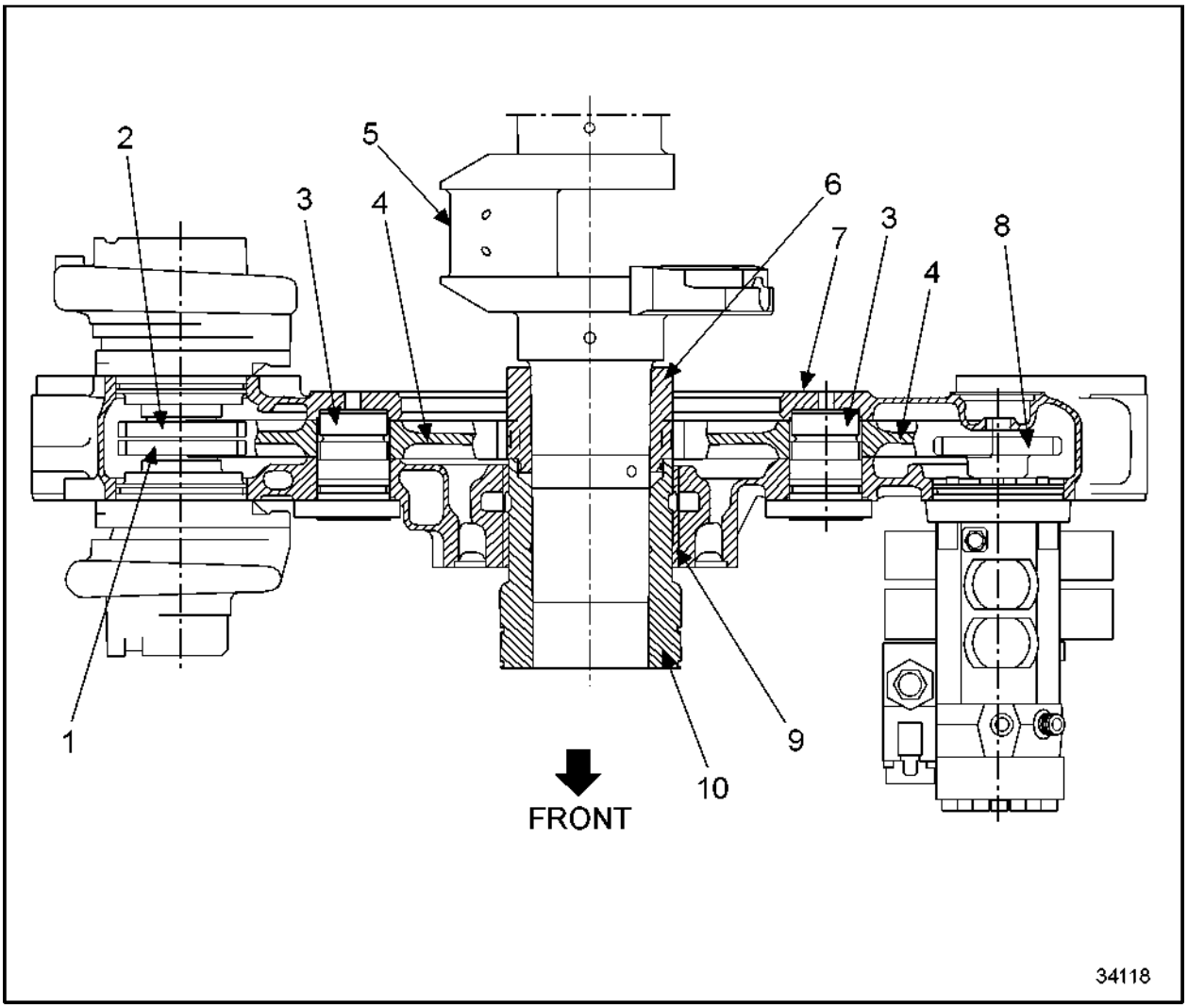
3 = The engine is to remain installed.

Table 19 After-Installation Operations

C 025.05 – GEAR TRAIN, GEAR CASE END

C 025.05.01 – GENERAL VIEW

See Figure 152 for parts location of gear train (gear case end).



1. Charge Air Coolant Pump Drive Gear
2. Engine Coolant Pump Drive Gear
3. Hub
4. Idler Gear
5. Crankshaft
6. Crankshaft Gear
7. Gear Case (Gear Case End)
8. High Pressure Fuel Pump Drive Gear
9. Outboard Bearing (Gear Case End)
10. Drive Hub (Gear Case End)

Figure 152 General View of Gear Train (Gear Case End)

C 025.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 20 are the Before-Removal Operations for the gear train, gear case end.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Remove fan drive	Refer to section C 221.05.05
1, 2, 3	Remove gear case (Gear Case)	Refer to section C 231.05.05
1, 2, 3	Remove vibration damper	Refer to section C 035.05.05
1, 2, 3	Disconnect and remove electric wiring	Refer to OEM Guidelines
1, 2, 3	Remove charge air coolant pump	Refer to section C 206.05.05
1, 2, 3	Remove coolant pump	Refer to section C 202.05.05
1, 2, 3	Remove charge air coolant lines	Refer to section C 207.05.05
1, 2, 3	Remove coolant vent lines	Refer to section C 205.05.05
1, 2, 3	Remove charge air coolant vent lines	Refer to OEM Guidelines
1, 2, 3	Remove coolant housing with thermostat	Refer to section C 208.05.05
1, 2, 3	Remove generator	Refer to section C 213.05.05
1, 2, 3	Remove generator drive	Refer to section C 213.05.05
1, 2, 3	Remove high pressure pump	Refer to section C 073.05.05
1, 2, 3	Remove centrifugal filter	Refer to section C 184.05.05
1, 2, 3	Remove oil filter	Refer to section C 183.05.05
1, 2, 3	Remove drive hub	Refer to section C 035.05.05
1, 2, 3	Remove gear case (gear case end)	Refer to section C 024.05.05

1 = The engine is to be completely disassembled.

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

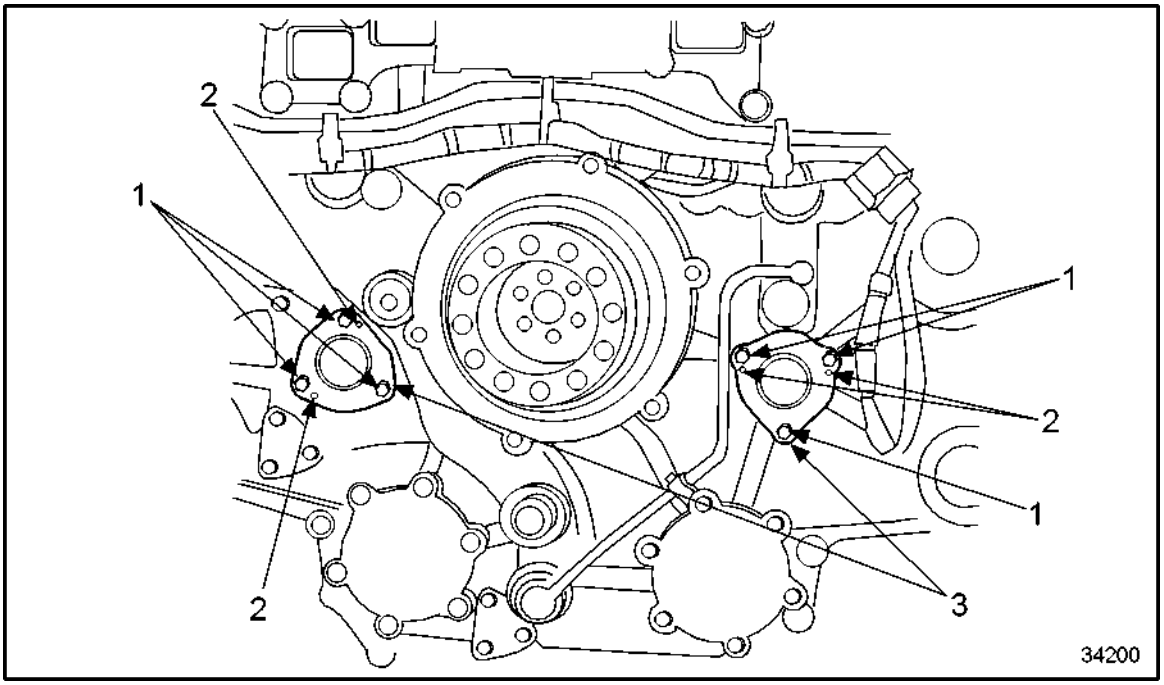
3 = The engine is to remain installed.

Table 20 Before-Removal Operations

C 025.05.05 – REMOVAL OF GEAR TRAIN (GEAR CASE END)

Perform the following steps for removal of gear train.

1. Unscrew and remove hex bolts (1). See Figure 153.



1. Hex Bolt
2. M 8 Jackscrews
3. Hub

Figure 153 Removing Idler Gear Hubs

2. Screw in M 8 jackscrews (2) with continuous thread in thread of hub (3). See Figure 153.
3. Using M 8 jackscrews (2), push off hubs evenly. See Figure 153.

4. Mark respective hub according to installation position and remove from gear case. See Figure 154.

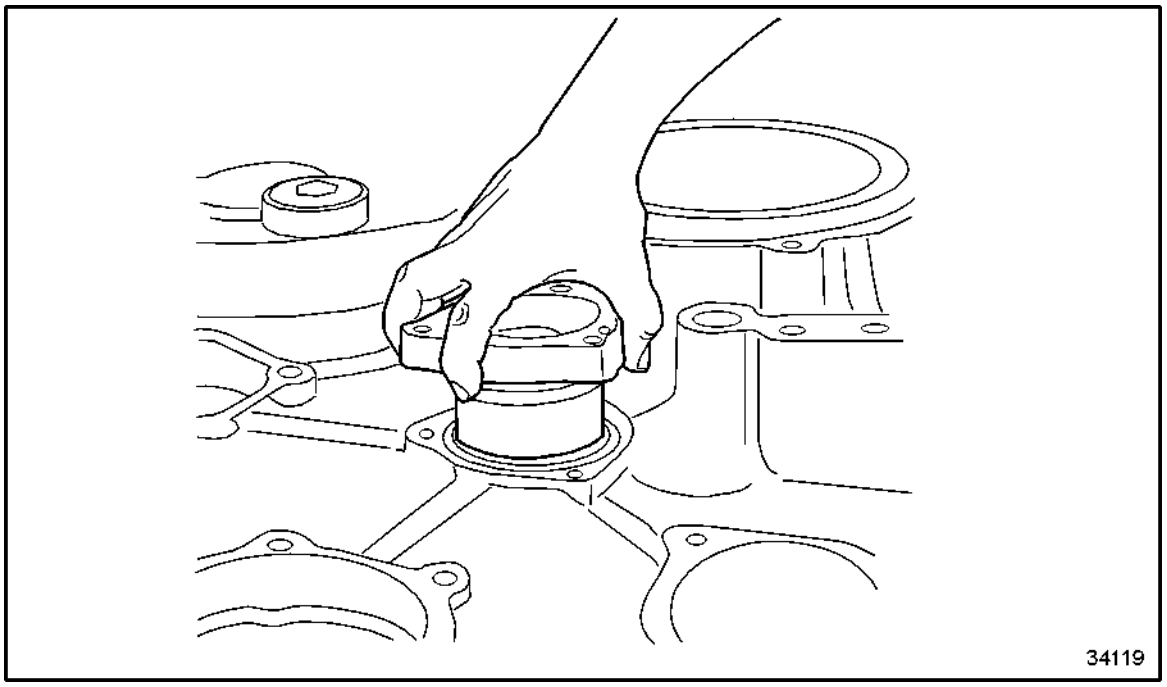
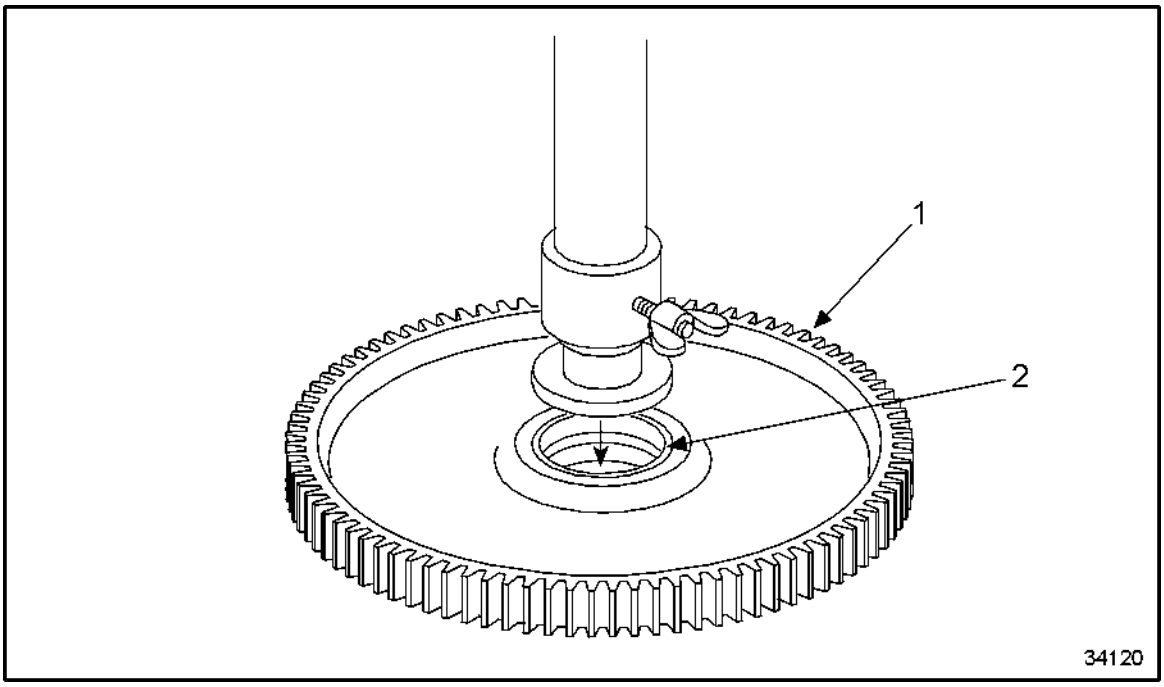


Figure 154 Removing Idler Gear Hubs from Gear Case

5. Remove idler gears from bore. See Figure 154.
6. Using a suitable sleeve and manual press, remove bushing (2) from idler gear (1). See Figure 155.



1. Idler Gear
2. Bushing

Figure 155 Removing Bushing from Idler Gear

C 025.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of gear train (gear case end).

1. Clean all components.
2. Using magnetic crack testing method and fluorescent magnetic powder, check idler gears for cracks.
   [a] If cracks are detected, replace idler gear. Refer to section C 025.05.10.
   [b] If cracks are not detected, continue inspection.
3. Visually inspect surface condition of idler gear for wear with magnifying glass.
   [a] If wear is detected on surface, replace idler gear. Refer to section C 025.05.10.
   [b] If no wear is detected on surface of idler gear, continue inspection.
4. Visually inspect running surface of idler gear hub, bushing in idler gears and bearing surfaces of gears for wear and scores.
   [a] If wearing or scoring is detected, replace component if necessary. Refer to section C 025.05.10.
   [b] If scoring or wear is not detected, continue inspection
5. Check taper seat and bolt-on surface of idler gear hubs for scoring and wear.
   [a] If scored or worn, replace taper seat and idler gear hubs. Refer to section C 025.05.10.
   [b] If the taper seat and bolt-on surface of idler gear hubs show no scoring or wear, continue with inspection.
6. Check bolts for damage and check condition of threads.
   [a] Replace bolts if damaged.
   [b] If bolts are not damaged, continue with inspection.

7. Thoroughly clean all axle oil passages (arrow). See Figure 156.

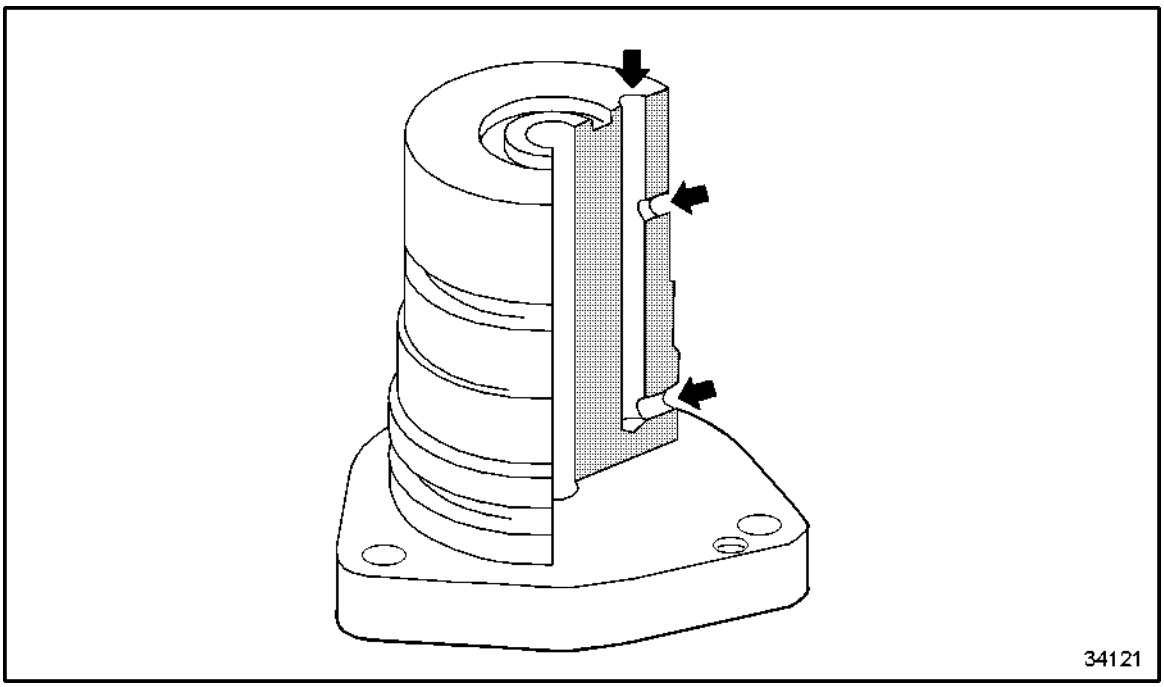
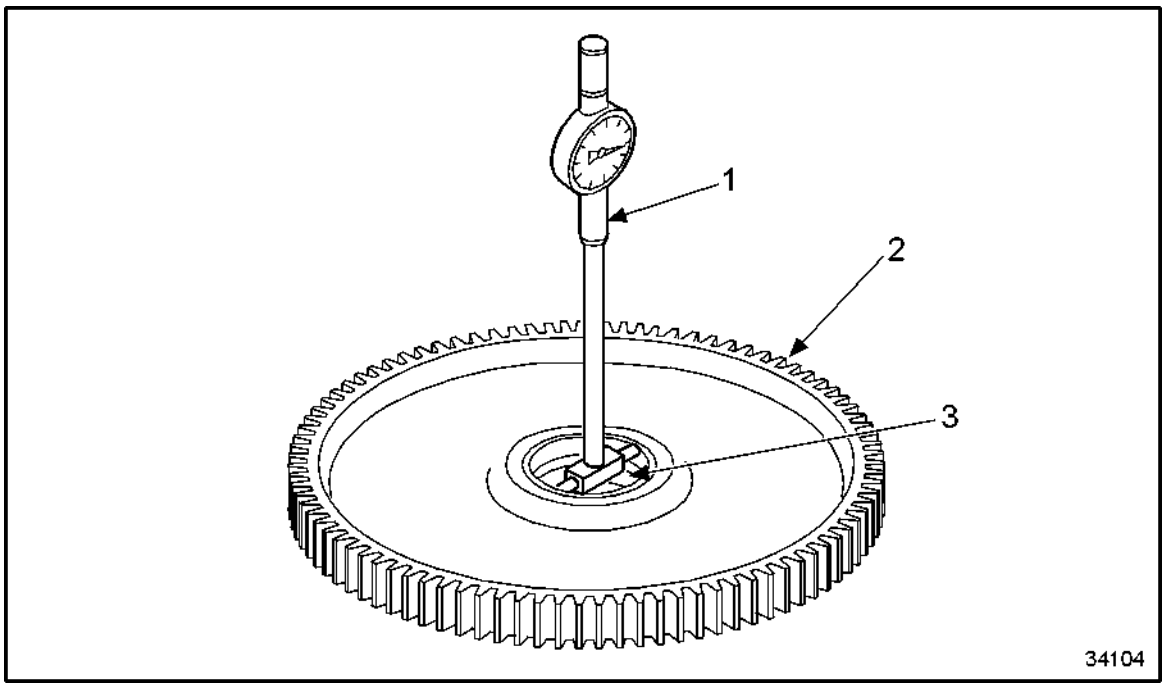


Figure 156 Cleaning Axle Oil Passages

8. Measure axle oil passages.
   [a] If wear limit values are exceeded, replace components as necessary.
   [b] If wear limit values are not exceeded, continue inspection.

9. Set bore gage to basic size of bushing bore in idler gear. See Figure 157.



1. Dial Bore Gage
2. Idler Gear
3. Bushing Bore

Figure 157 Measuring Bushing Bore in Idler Gear

10. Measure diameter of bore.
    [a] If limit values are exceeded, replace idler gear. Refer to section C 025.05.10.

[b] If limit values are not exceeded, continue inspection.

11. Using micrometer, measure outside diameter of idler gear hubs at running surface. See Figure 158.

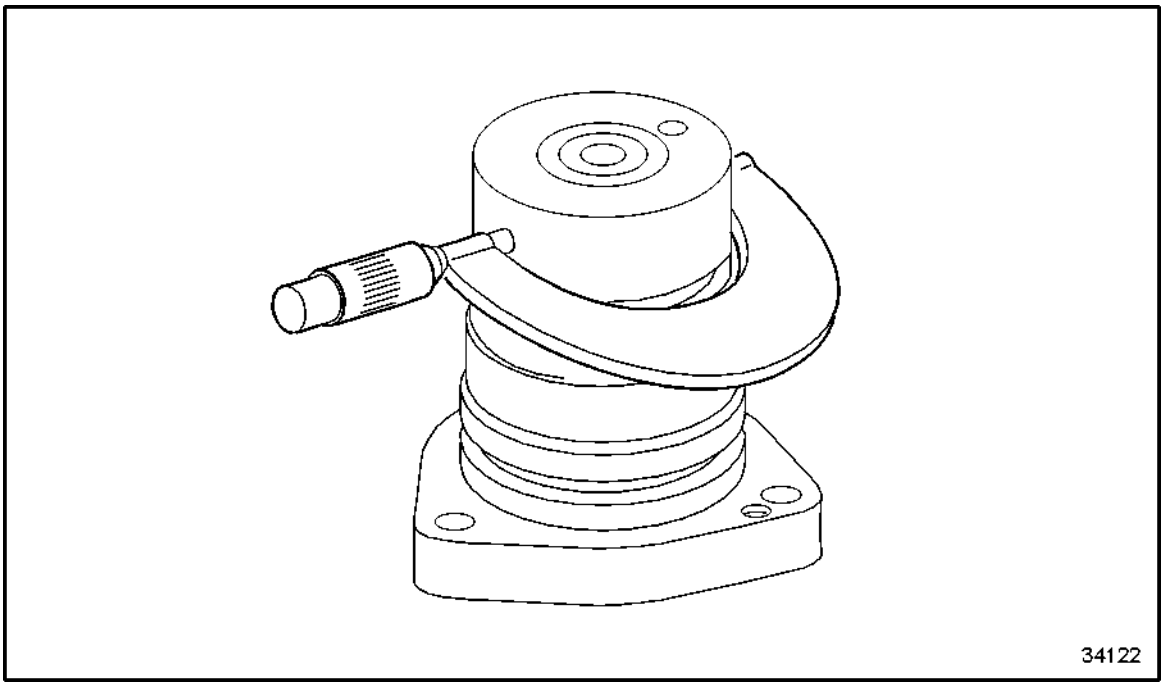


Figure 158 Measuring Bearing Diameter on Idler Gear Hubs

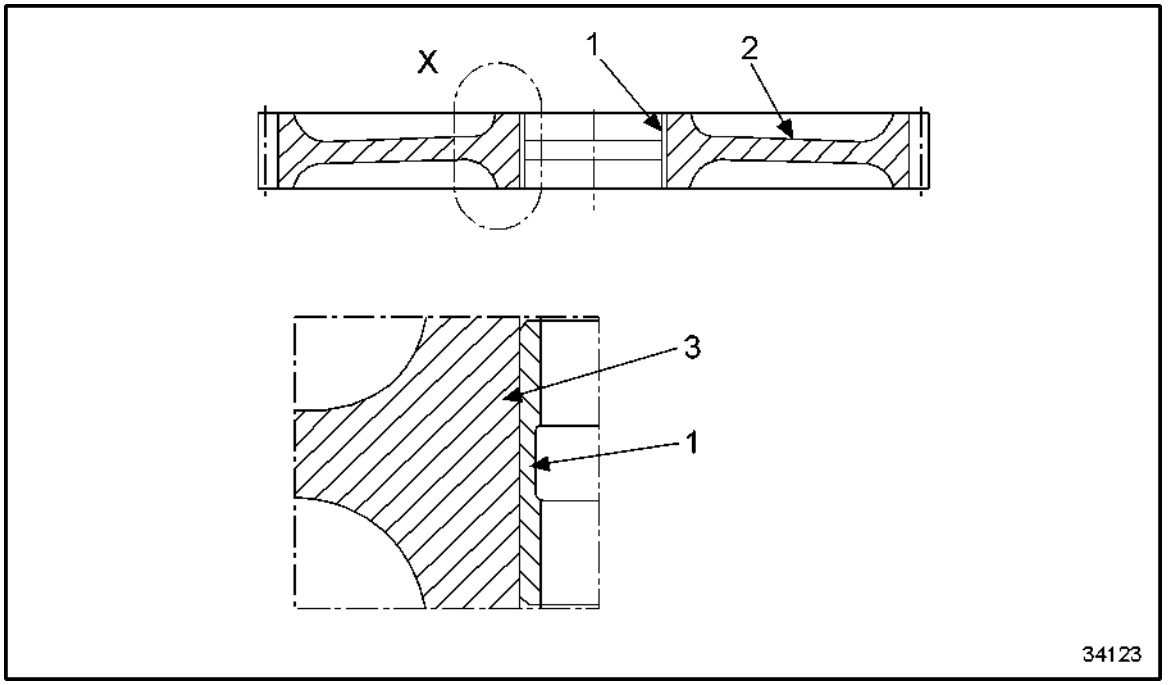
[a] If limit values are exceeded, replace idler gear hub. Refer to section C 025.05.10.

[b] If limit values are not exceeded, proceed to assembly. Refer to section C 025.05.10.

C 025.05.10 – ASSEMBLY OF GEAR TRAIN (GEAR CASE END)

Perform the following steps to assemble gear train (gear case end). Refer to section C 025.05.08.

1. Measure basic bore (3) in idler gear (2). See Figure 159.



1. Bushing
2. Idler Gear
3. Bushing Bore

Figure 159 Installing Bushing Idler Gear

2. Place idler gear on suitable bench or rest to ensure that when bushing (1) is installed there is no interference. See Figure 159.

CAUTION:

To avoid injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

3. Cool bushing in liquid nitrogen.

CAUTION:

To avoid injury while handling 'HOT' components, wear protective gloves and clothing.

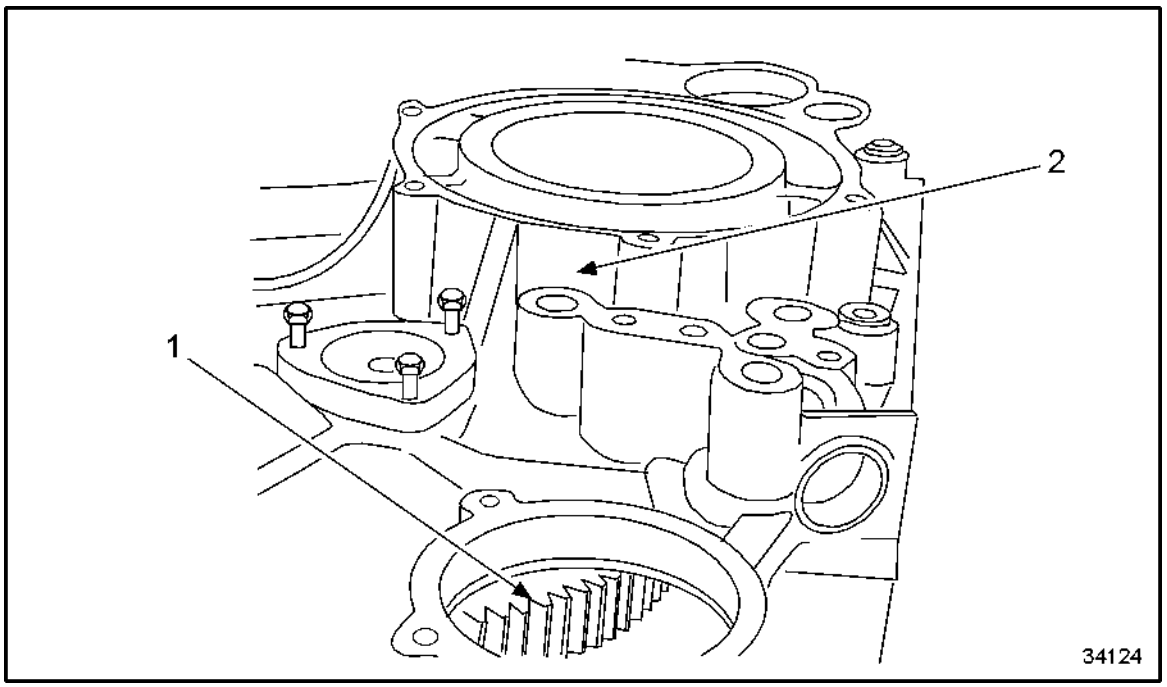
4. Heat idler gear to 80°C (176°F).
5. Insert cooled bushing flush into idler gear.

C 025.05.11 – INSTALLATION OF GEAR TRAIN (GEAR CASE END)

Perform the following steps to install gear train (gear case end):

NOTE:
Ensure all components are clean.

1. Coat bushings in idler gear with engine oil. See Figure 160.



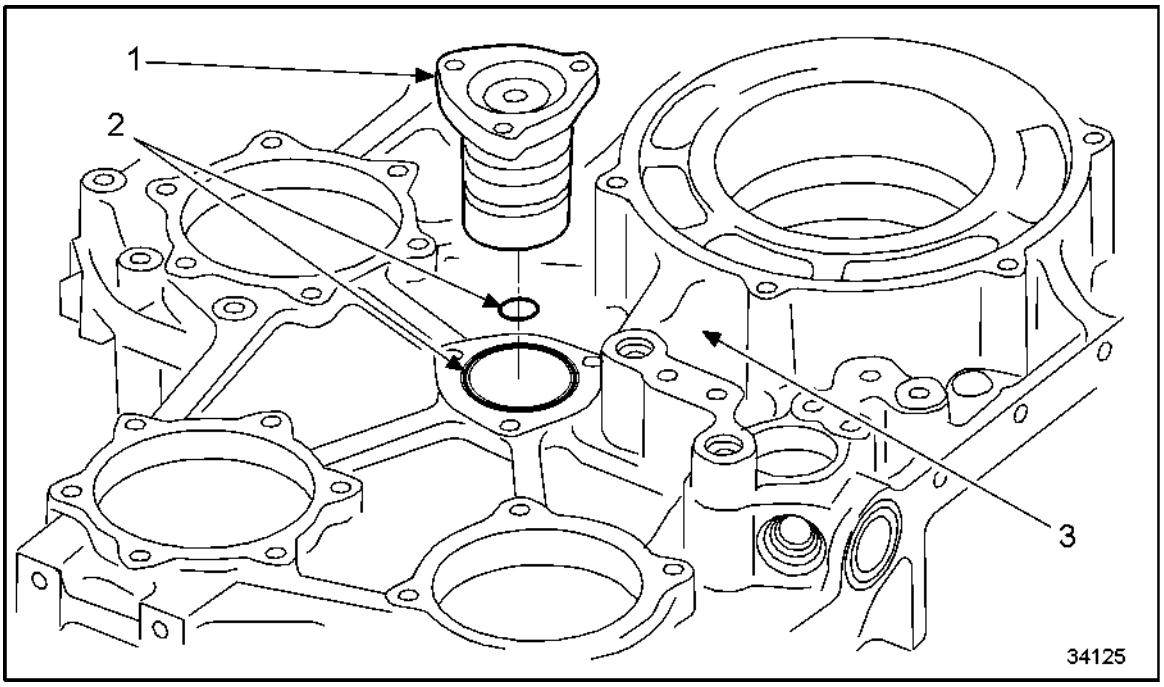
1. Idler Gear
2. Gear Case

Figure 160 Installing Idler Gear in Gear Case

2. Insert idler gear (1) via opening in gear case (2). See Figure 160.
3. Ensure that idler gear is positioned correctly. Refer to section C 025.05.01.

4. Coat O-rings (2) with petroleum jelly. See Figure 161.

NOTE:
Ensure that oil bores of the idler gear hubs (1) are clean.

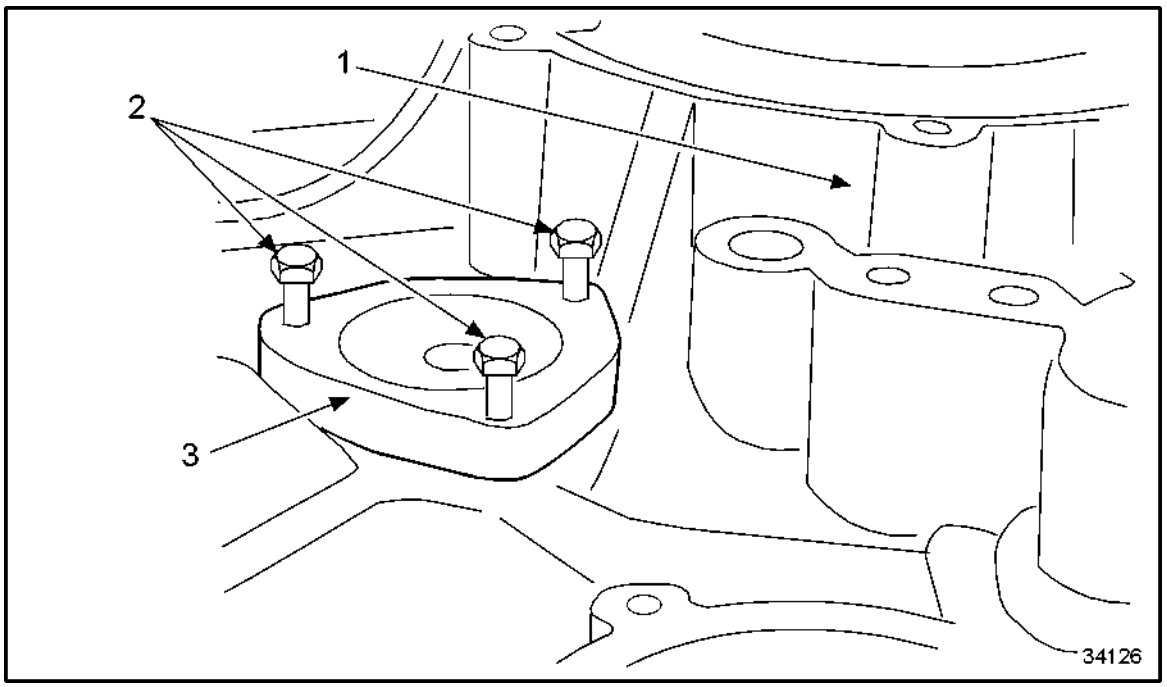


1. Hub
2. O-ring
3. Gear Case

Figure 161 Installing Idler Gear Hubs

5. Insert O-ring (2) into groove of gear case (3). See Figure 161.
6. Secure O-ring (2) in groove in hub base with petroleum jelly. See Figure 161.
7. Insert hubs in gear case, paying attention to fit of idler gear. See Figure 161.

8. Push idler gear hub (3) into gear case (1). See Figure 162.



1. Gear Case
2. Hex Bolts
3. Hub

Figure 162 Pushing Idler Gear Hub Into Gear Case

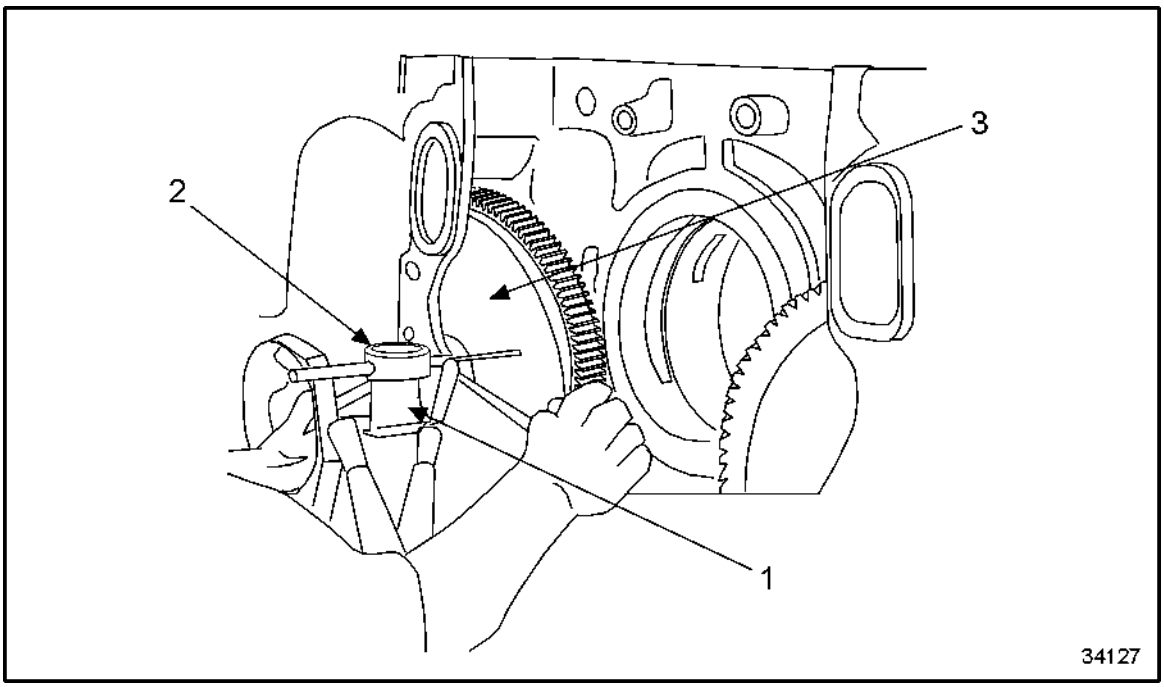
9. Install hex bolts (2) and tighten evenly. See Figure 162.
10. Install two eyebolts in gear case.

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.

11. Attach gear case to crane with lifting device and adjust tension equally.
12. Bring gear case into vertical position.

13. Mount magnetic dial-gage holder (1) with dial gage (2) in gear case. See Figure 163.



1. Magnetic Dial Gage Holder
2. Magnetic Dial Gage
3. Lateral Collar of Idler Gear

Figure 163 Checking Axial Clearance and Backlash

14. Place dial gage stylus (2) with preload on lateral collar of idler gear (3). See Figure 163.
15. Set dial gage (2) to zero. See Figure 163.
16. Check axial play by moving idler gear back and forth horizontally.
17. To measure backlash, place dial gage stylus with preload on tooth surface of idler gear.
18. Set dial gage with preload to zero.
19. Move idler gear back and forth in radial direction to check backlash.
    [a] If values are exceeded, replace idler gears. Refer to section C 025.05.05.
    [b] If values are not exceeded, proceed with after-installation operations. Refer to sectionC 025.05.12.

C 025.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 21 are the After-Installation Operations for the gear train, gear case end.

Level of Maintenance	Operation	Reference
2, 3	Install engine	Refer to OEM Guidelines
1, 2, 3	Install gear case, gear case end	Refer to section C 024.05.11
1, 2, 3	Install drive hub	Refer to section C 035.05.11
1, 2, 3	Install generator drive	Refer to section C 213.05.11
1, 2, 3	Install oil filter	Refer to section C 183.05.11
1, 2, 3	Install centrifugal filter	Refer to section C 184.05.11
1, 2, 3	Install generator	Refer to section C 213.05.11
1, 2, 3	Install coolant housing with thermostat	Refer to section C 208.05.11
1, 2, 3	Install charge air coolant pump	Refer to section C 206.05.11
1, 2, 3	Install coolant pump	Refer to section C 202.05.11
1, 2, 3	Install charge air coolant lines	Refer to section C 207.05.11
1, 2, 3	Install coolant vent lines	Refer to OEM Guidelines
1, 2, 3	Install charge air coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install vibration damper	Refer to section C 035.05.11
1, 2, 3	Install and connect electric wiring	Refer to section C 501.05 M
1, 2, 3	Install engine carrier (gear case end)	Refer to section C 231.05.11
1, 2, 3	Install fan drive	Refer to section C 221.05.11
1, 2, 3	Fill oil system with engine oil	Refer to Operators Guide
1, 2, 3	Fill engine coolant system	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.

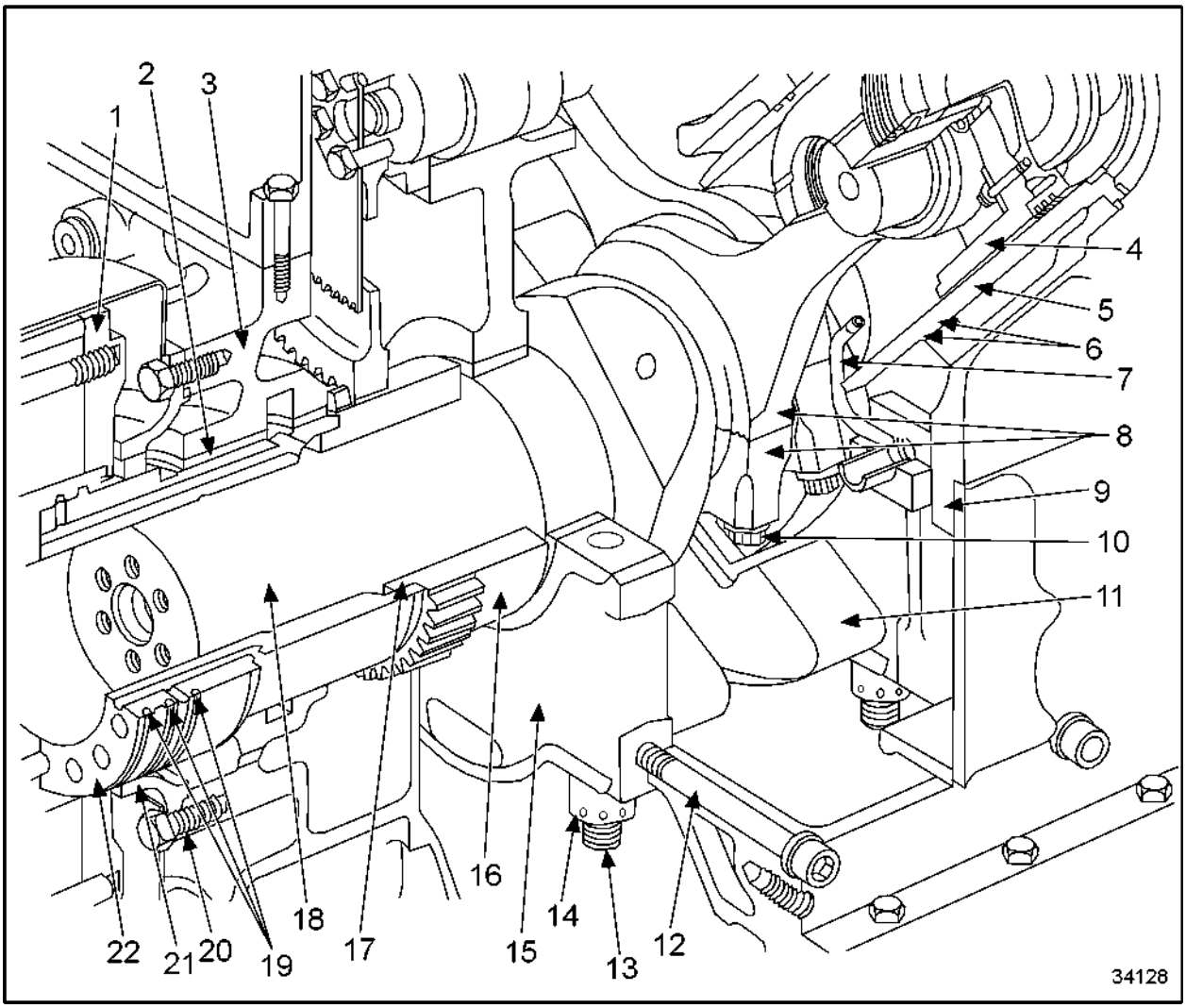
Table 21 After-Installation Operations

C 030 – RUNNING GEAR

C 031.05 – CRANKSHAFT

C 031.05.01 – GENERAL VIEW

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

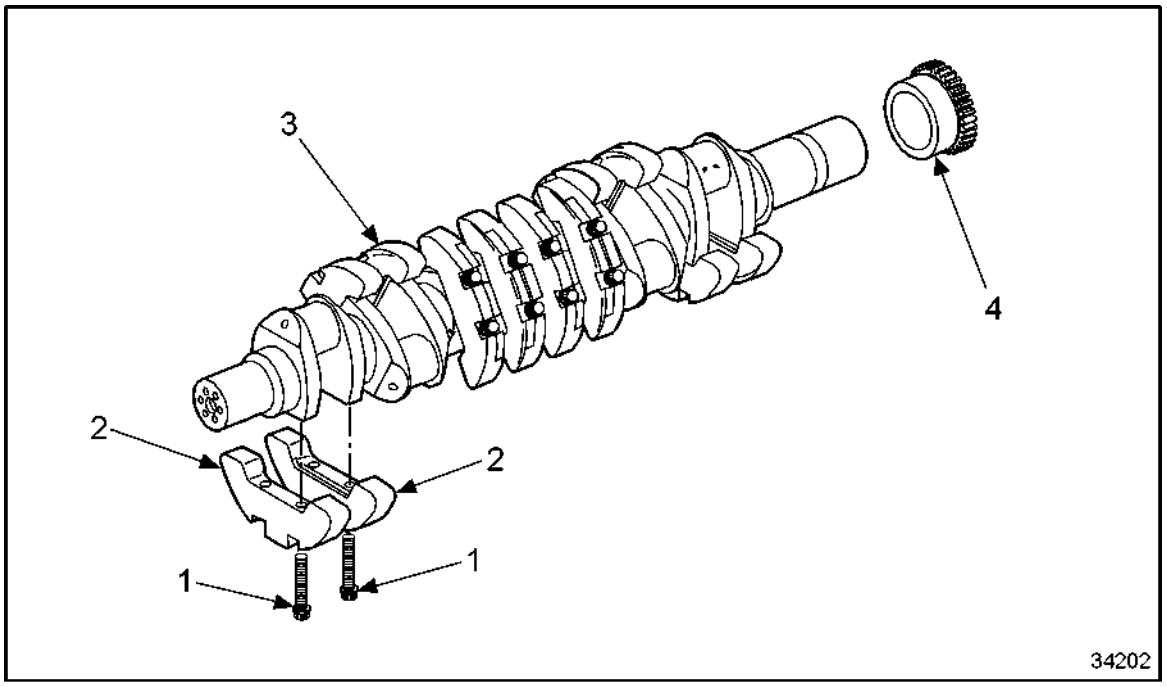


1. Vibration Damper
2. Outboard Bearing, Gear Case End
3. Gear Case
4. Piston
5. Cylinder Liner
6. O-ring
7. Oil Spray Nozzle
8. Connecting Rod
9. Cylinder Block
12. Hex Socket Bolt
13. Stud
14. Nut for Main Bearing Cap
15. Crankshaft Bearing Cap
16. Crankshaft Gear
17. O-ring
18. Crankshaft
19. O-ring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

10. Connecting Rod Bolt
11. Crankshaft Counterweight
21. Seal Carrier
22. Drive Hub

Figure 164 General View of Crankshaft Installation

See Figure 165 for components of the crankshaft.



1. Bolt
2. Counterweight
3. Crankshaft
4. Crankshaft Gear, Gear Case End

Figure 165 Series 4000 Crankshaft (16V)

C 031.05.02 – SPECIAL TOOL

Listed in Table 22 is the special tool required for maintenance on the crankshaft.

Designation	Tool Number
Bearing Alignment Tool	J 34199

Table 22 Special Tool

C 031.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 23 are the Before-Removal Operations for the crankshaft.

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

1 = The engine is to be completely disassembled.

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

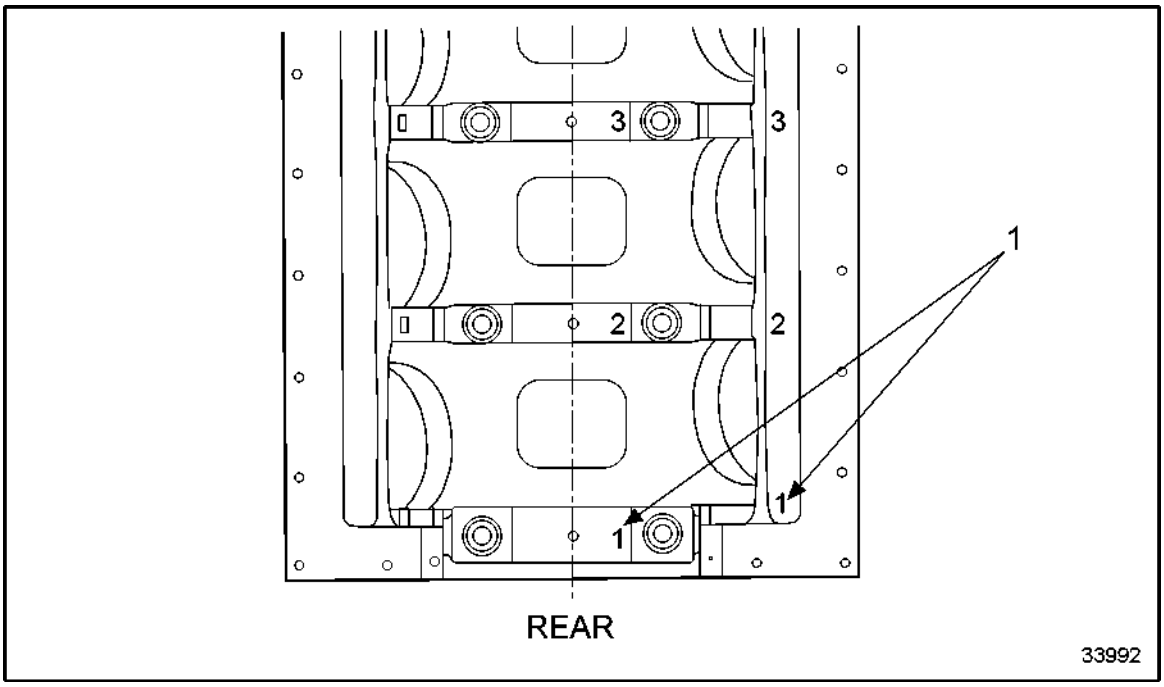
3 = The engine is to remain installed.

Table 23 Before-Removal Operations

C 031.05.05 – REMOVAL OF CRANKSHAFT

Perform the following steps to remove the crankshaft:

1. Verify that marking on crankshaft main bearing cap matches marking on cylinder block; if necessary, mark according to sequence. See Figure 166.

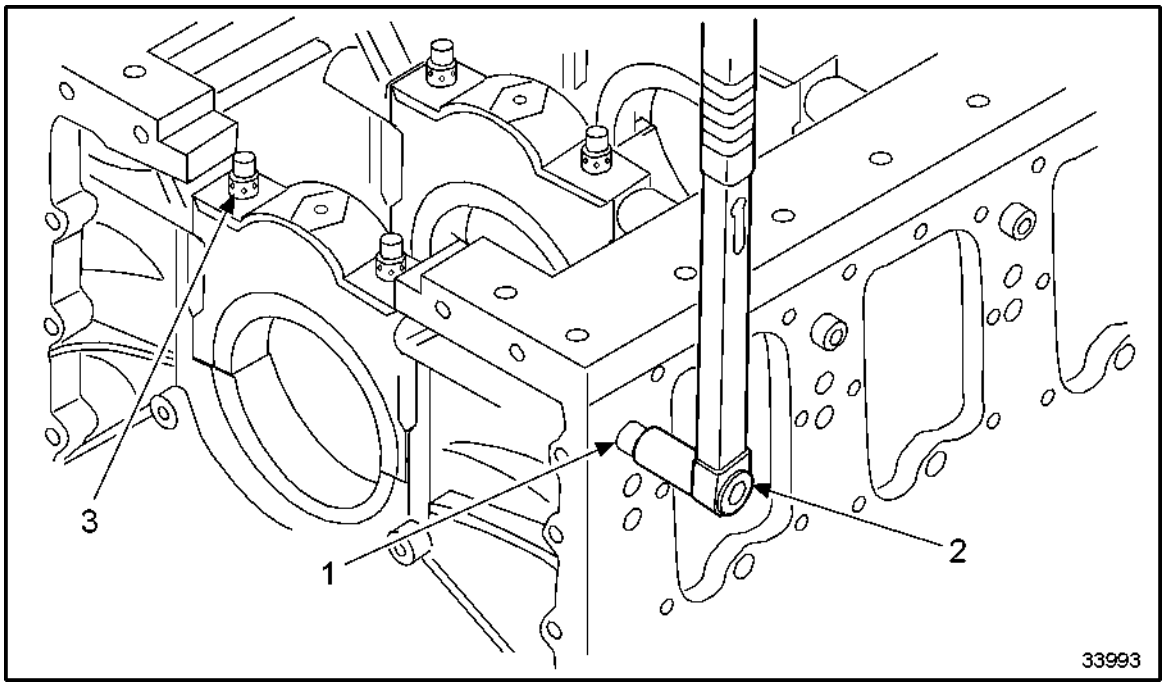


1. Identification Number

Figure 166 Marking of Cylinder Block Bearing Cap Location

2. Starting at flywheel end of the cylinder block, stamp number of the main bearing cap with 6 mm (0.2362 in.) numbers so they can be read from the same direction.

3. Turn cylinder block upside down on engine stand, with oil pan mating surface horizontal. See Figure 167.

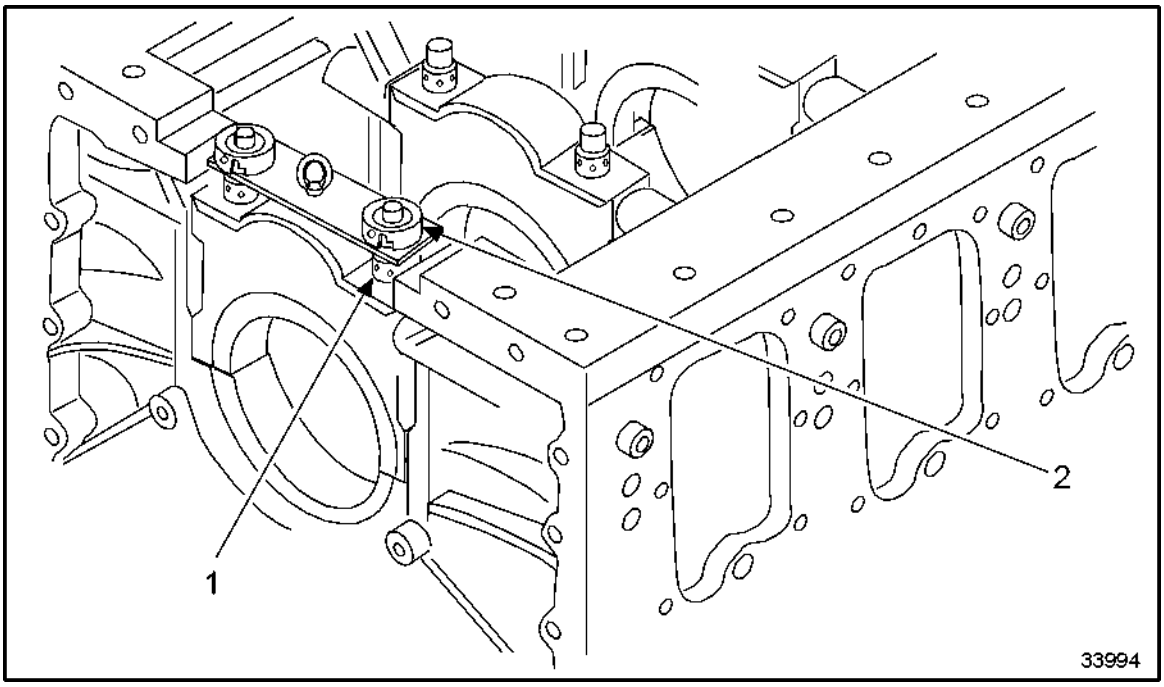


1. Main Bearing Cap Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing Cap Nut

Figure 167 Removing Main Bearing Stabilizer Bolts for Main Bearing Cap

4. Remove all main bearing cap stabilizer bolts (1) of main bearing caps from cylinder block with ratchet and socket wrench (2).

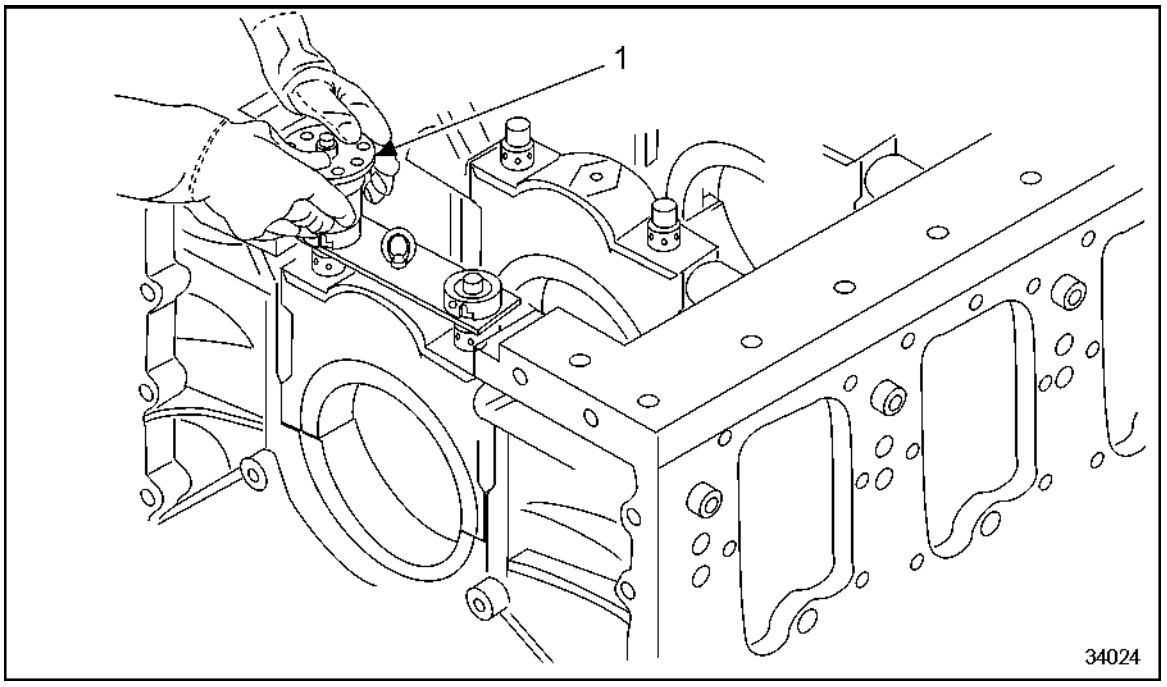
5. Beginning with the first bearing cap (flywheel end), place main bearing cap nut (1) of hydraulic bolt pretensioner on studs (2) of respective main bearing cap. See Figure 168.



1. Main Bearing Cap Nut
2. Main Bearing Pretensioner Nut Stud Hydraulic Pretensioner

Figure 168 Attaching Main Bearing Cap Nut of Hydraulic Bolt Pretensioner

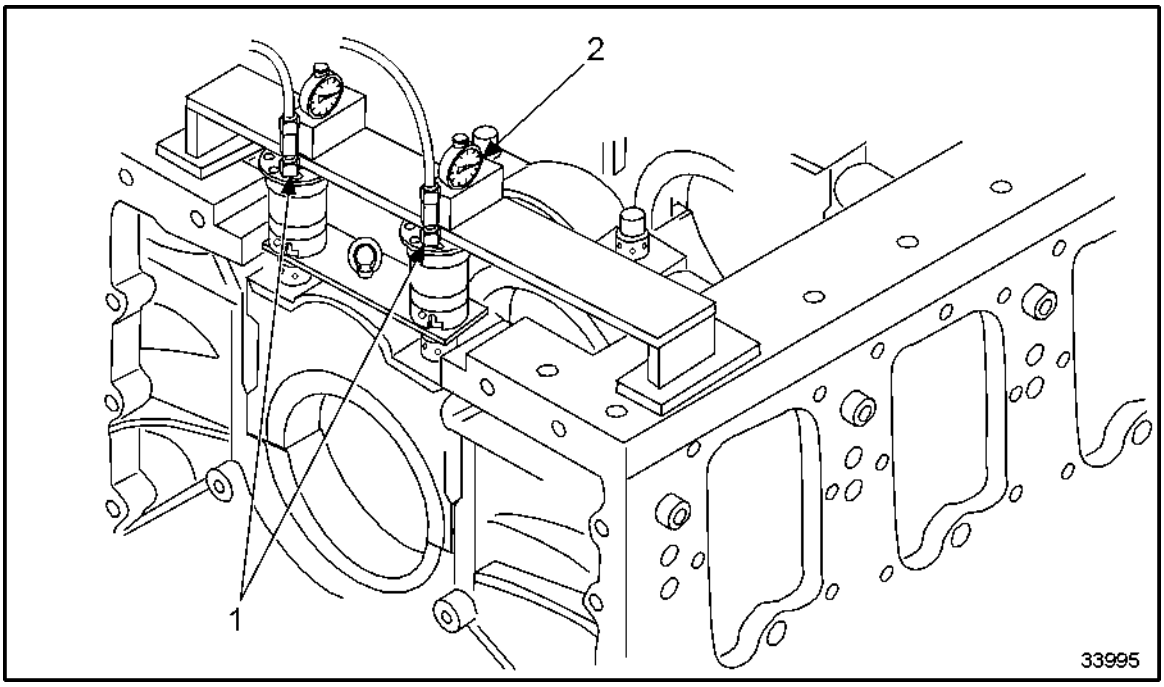
6. Install hydraulic bolt pretensioner by hand until contact is made, then back off one turn. See Figure 169.



1. Hydraulic Stud Pretensioner

Figure 169 Installing Hydraulic Bolt Pretensioner

7. Connect high-pressure hose (1) of hydraulic hand pump to hydraulic bolt pretensioner. See Figure 170.



1. High-pressure Hose
2. Magnetic Dial Indicator

Figure 170 Connecting High-Pressure Hose of Hydraulic Hand Pump to Hydraulic Bolt Pretensioner

8. Mount magnetic dial gage holders with magnetic dial indicator (2) on cylinder block oil jam sealing surface.
9. The dial gages are for measuring the elongation of the studs.

10. Position the two dial gage styluses (arrow) centrally, to respectively measure core on surface of sleeve measuring pin. See Figure 171.

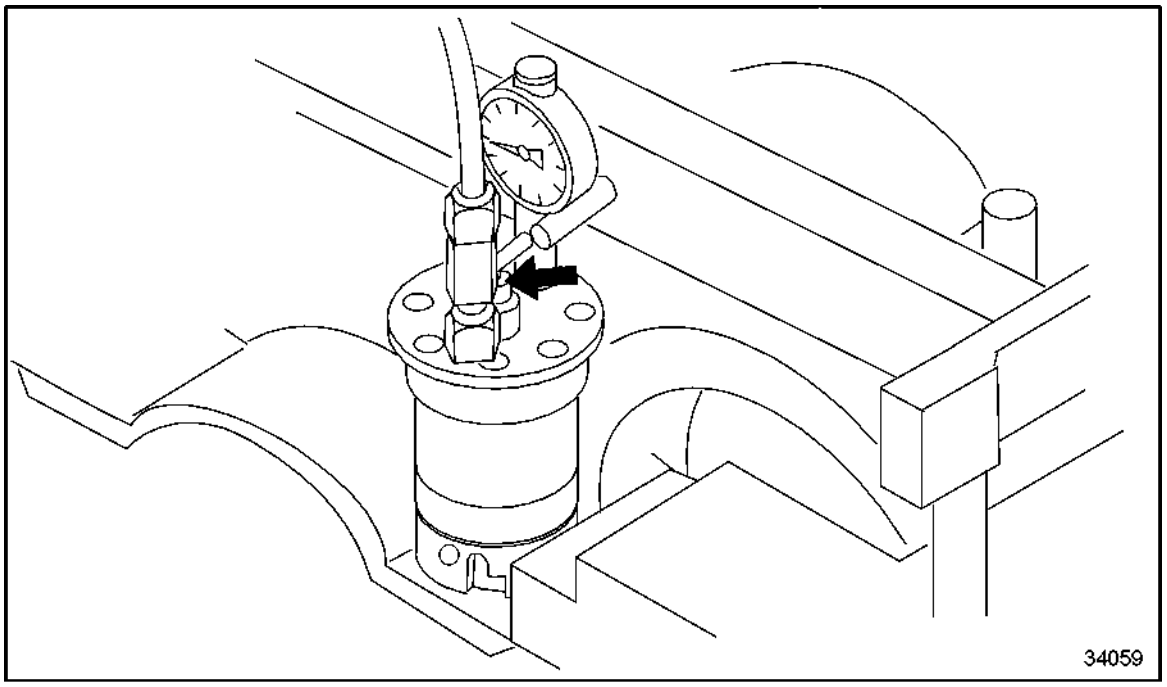


Figure 171 Positioning Dial Gage Styluses

11. Set dial gages to zero with preload.

12. Operate hydraulic hand pumps and elongate both studs at same time, until nuts of main bearing caps can be released with the aid of a pin. See Figure 172.

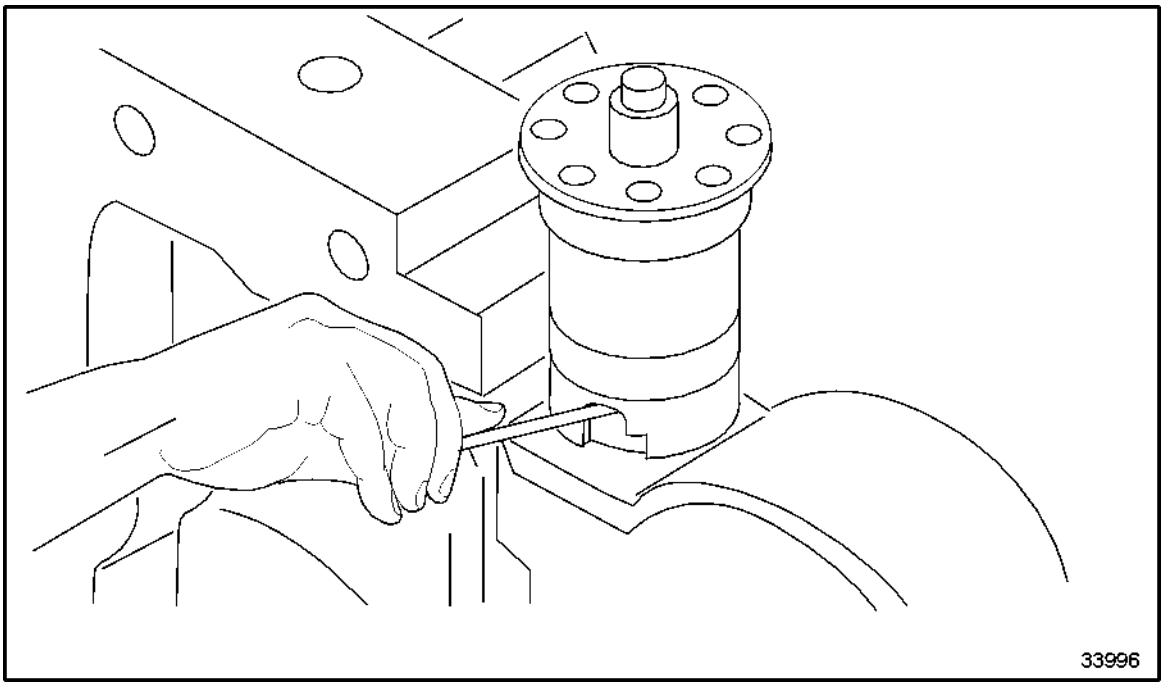


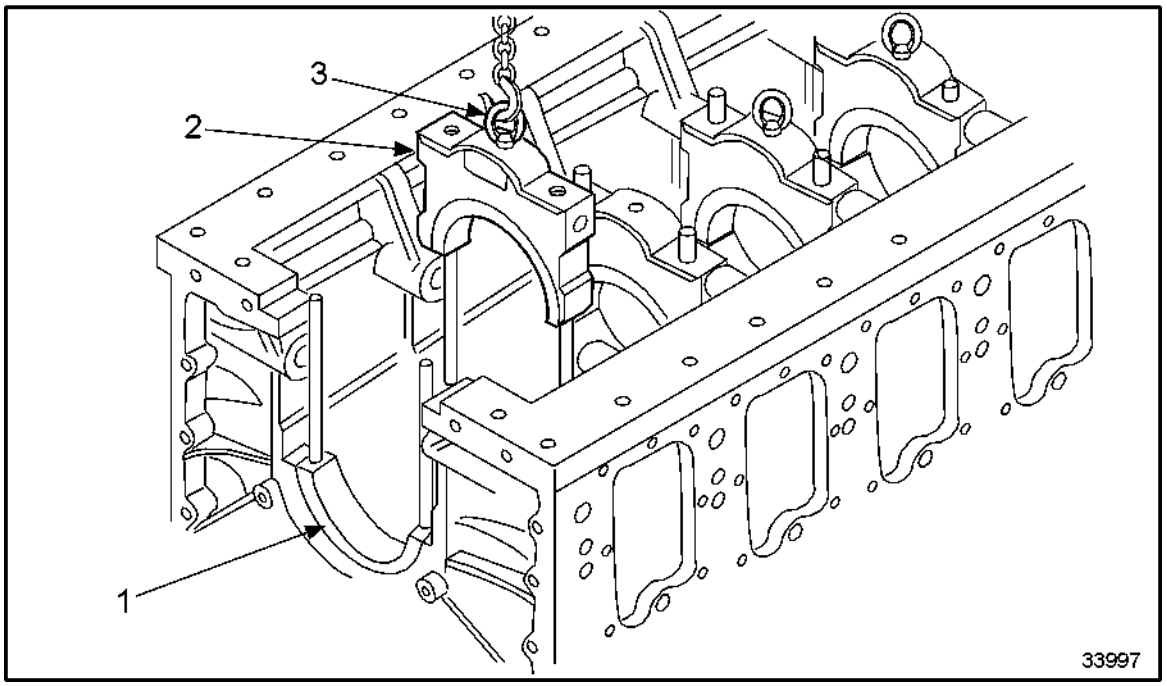
Figure 172 Loosening Nuts at Main Bearing Cap with a Pin

13. Loosen nuts on main bearing cap with a pin (arrow).
14. Relieve tension on studs, and move the dial gages with magnetic holders and hydraulic preloading devices to the next adjacent main bearing cap.
15. Follow the same procedure to loosen all remaining nuts.
16. Remove loose nuts from studs.
17. Screw eyebolt into bearing cap.

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.

18. Attach main bearing cap (2) to crane and lifting device; apply slight tension to lifting device. See Figure 173.



1. Upper Main Bearing Bore
2. Main Bearing Cap
3. Lifting Eye

Figure 173 Pulling Main Bearing Cap

CAUTION:

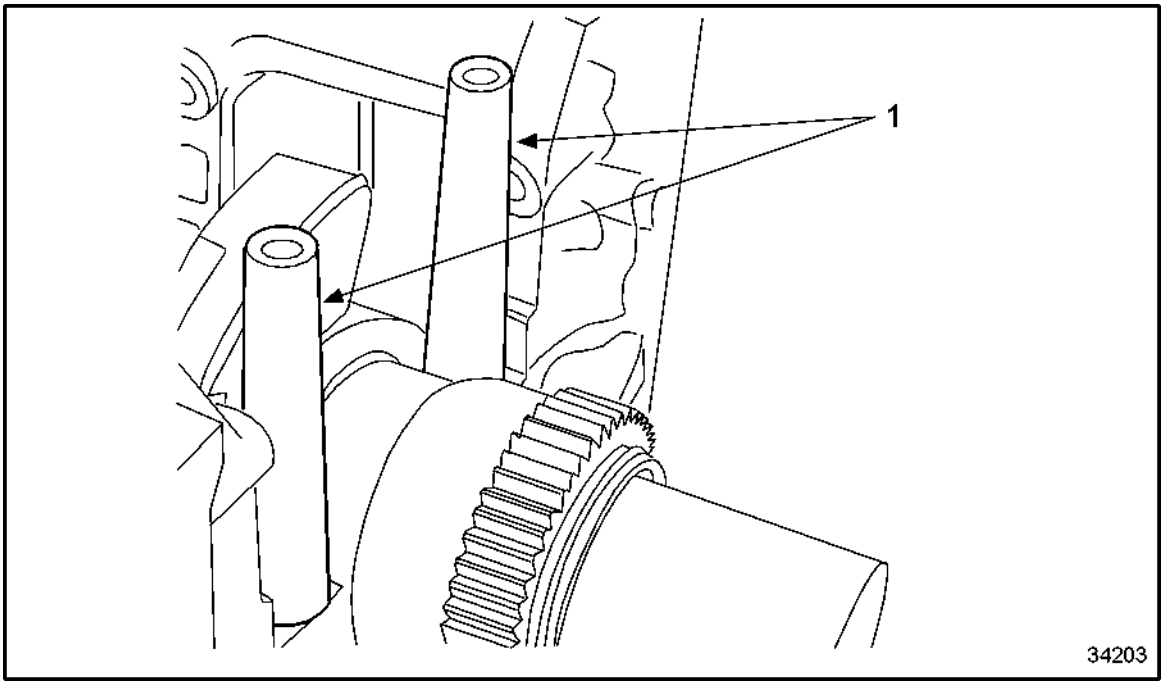
To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

19. Using lifting device and crane, carefully raise bearing cap (2) vertically until clear of cylinder block. See Figure 173.
20. Mark upper main bearing shell of respective bearing cap with location and remove. See Figure 173.

NOTICE:

To avoid damage, protect main block bearing shells.

21. To protect crankshaft, slip four protective sleeves (1) over main bearing cap studs of first and last bearings. See Figure 174.



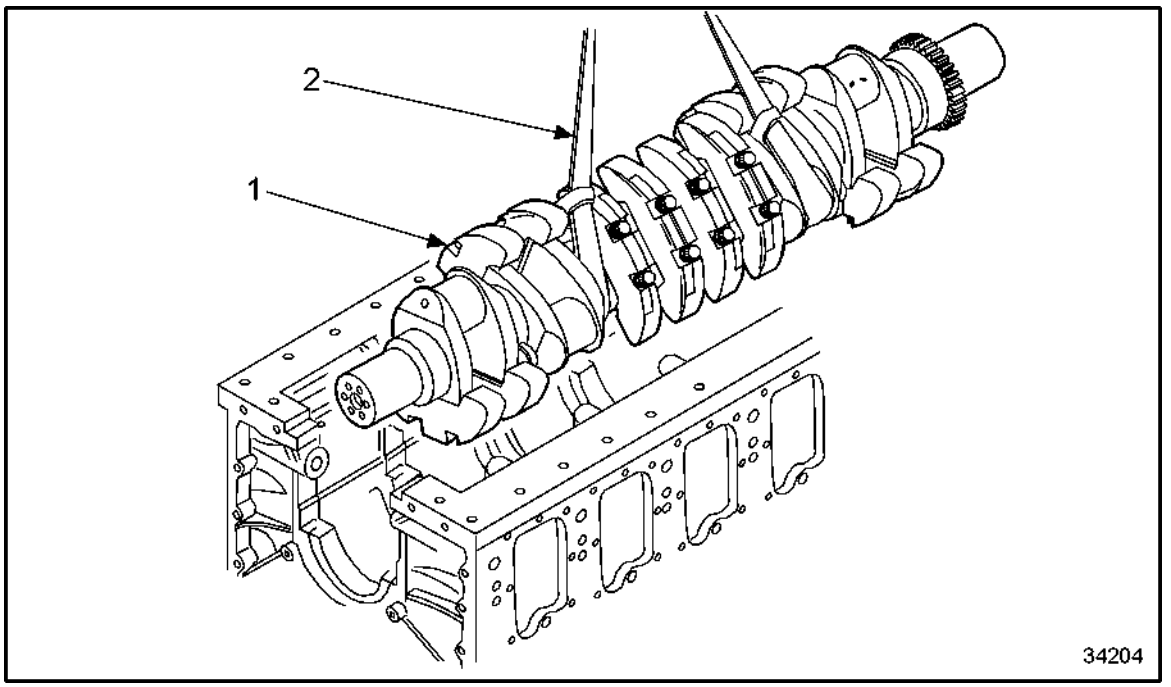
1. Protective Sleeves

Figure 174 Placing Protective Sleeves over Main Bearing Cap Studs

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.

22. Using lifting device (2) and crane, raise crankshaft (1) clear of cylinder block. See Figure 175.



1. Crankshaft
2. Lifting Device

Figure 175 Lifting Crankshaft from Cylinder Block

23. Take care to keep crankshaft horizontal.

24. Lower crankshaft onto a sturdy stand. See Figure 176.

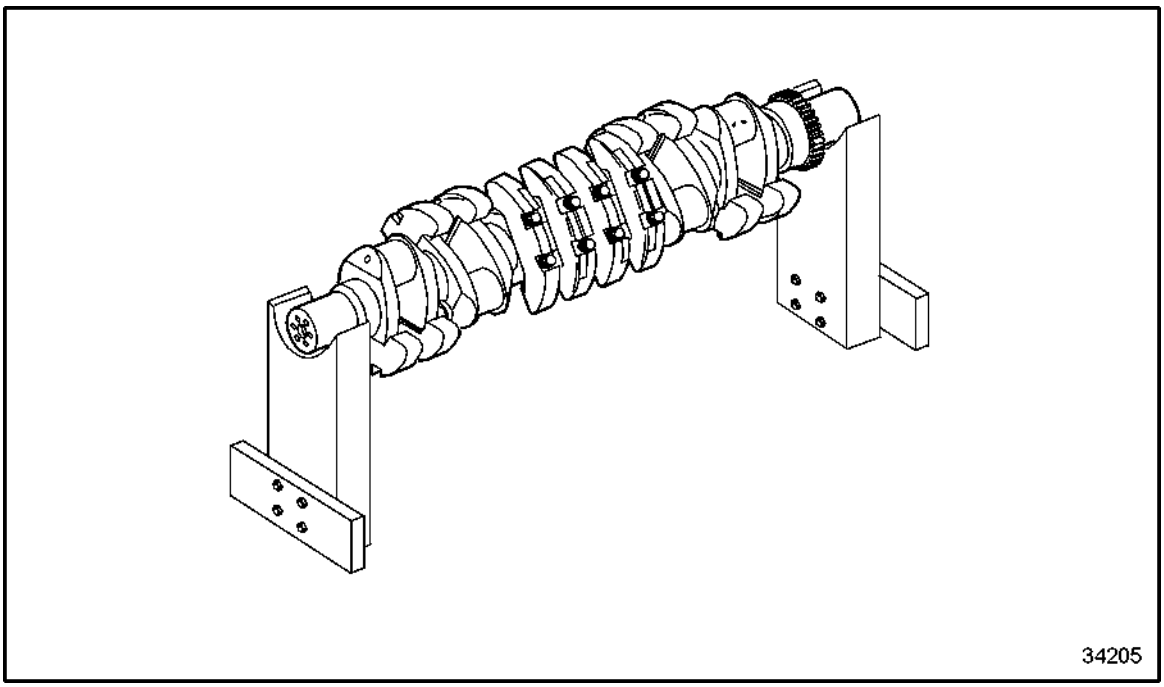


Figure 176 Lowering Crankshaft onto Sturdy Stand

25. Remove bearing shells from bearing webs.

26. Mark bearing shells toward the drive end (arrows) with number of respective main bearing. See Figure 177.

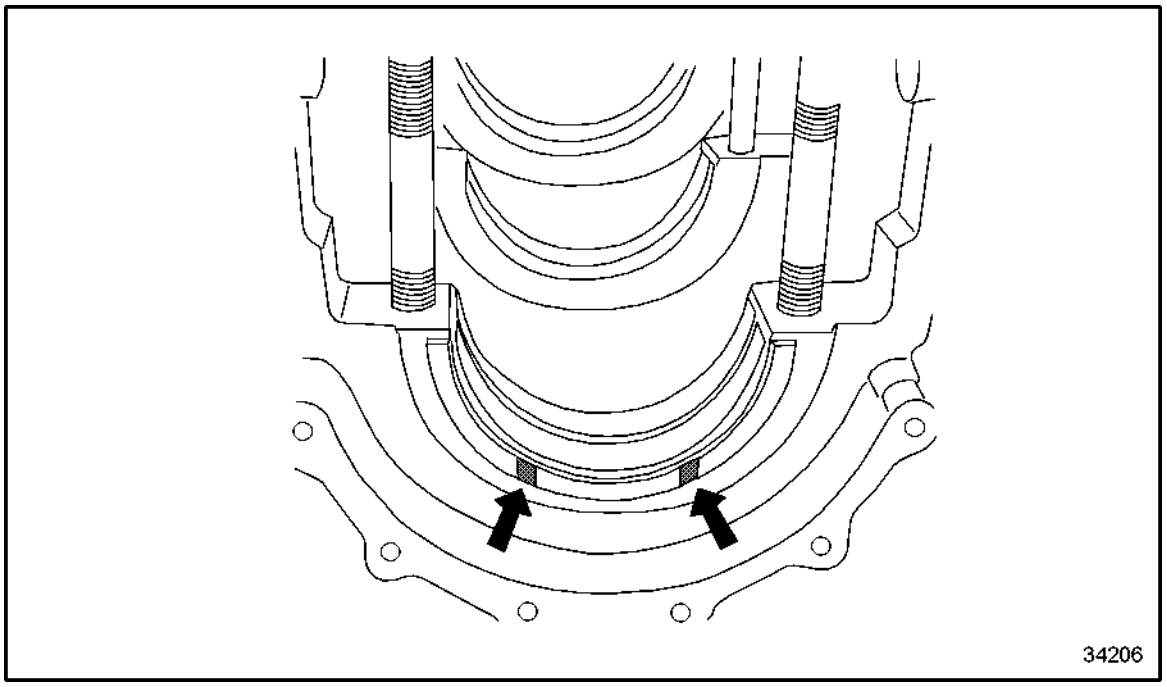


Figure 177 Marking Bearing Shells toward Drive End

NOTE:
Do not etch bearing surface of the number one bearing, which is the thrust washer for the crankshaft.

27. Etch the markings or use a non-wipe felt marker pen.

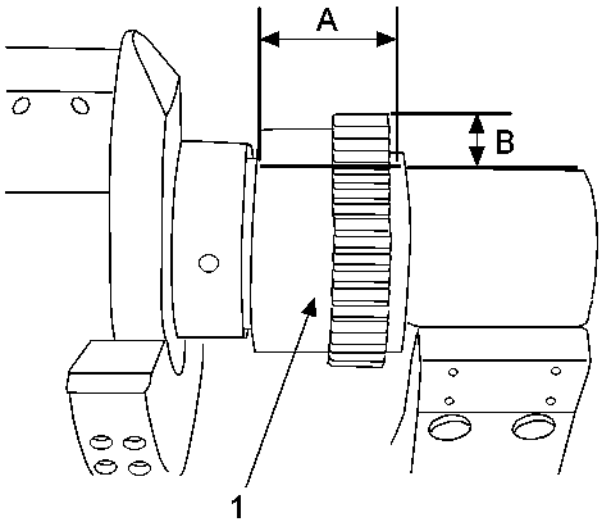
C 031.05.06 – DISASSEMBLY OF CRANKSHAFT

Perform the following steps to disassemble the crankshaft:

CAUTION:

To avoid injury while handling 'HOT' components, wear protective gloves and clothing.

1. Cut a groove (A) in crankshaft gear (1), leaving wall thickness of approximately 1 mm (0.0393 in.) to relieve gear tension. See Figure 178.



1. Crankshaft Gear

Figure 178 Relieving Tension in Crankshaft Gear

NOTE:
Do not remove gear unless damaged.

2. Observe proper cutting procedure and take into consideration appropriate cooling periods.

NOTE:
To prevent sparks, cover crankshaft with heat-resistant cloth.

3. Determine separation depth (B) before starting work and check frequently.
4. Expand crankshaft gear with suitable wedge and remove.
5. Smooth seating surface with emery cloth and remove minor scoring.
6. Clean crankshaft, refer to section C 031.05.08.

7. Determine and record distance A (web to counterweight). See Figure 179.

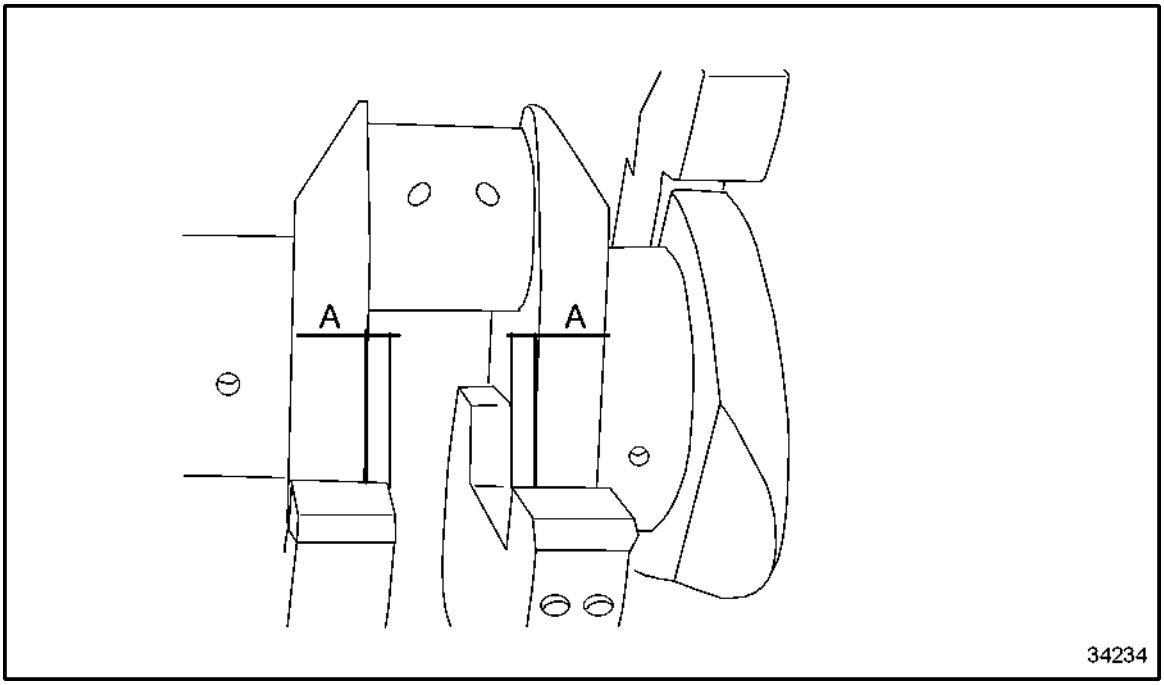
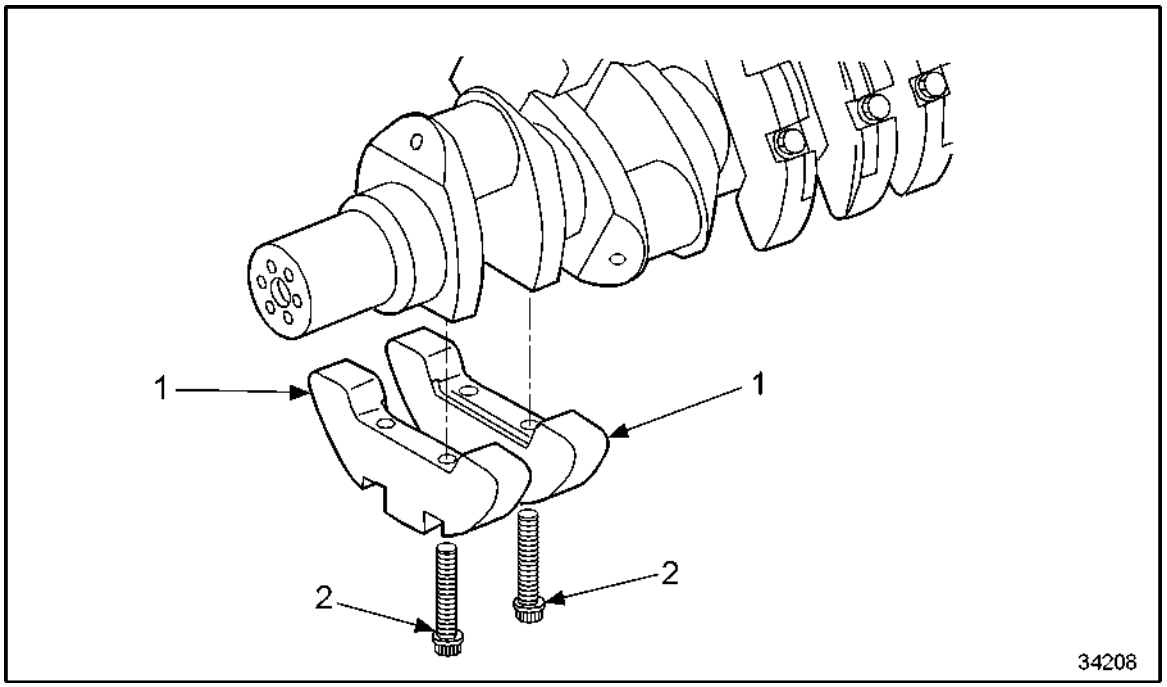


Figure 179 Determining and Recording Distance (Web to Counterweight)

NOTE:
Before counterweights are removed after balancing, mark relevant counterweight in its installation position with regard to crankshaft.

8. Check that counterweights are numbered in consecutive order; stamp new numbers if necessary.
9. Remove mounting bolts (2) and counterweight (1). See Figure 180.



1. Counterweights
2. Mounting Bolts

Figure 180 Removing Bolts and Counterweight

NOTE:
Remove counterweights with crankshaft in a sturdy stand.

C 031.05.08 – INSPECTION AND REPAIR

Perform the following subsections to inspect and repair the crankshaft:

Cleaning and Checking Crankshaft

Perform the following steps to clean and inspect crankshaft:

1. Clean crankshaft with cold cleaner.

CAUTION:

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

2. Using suitable bottle brush and cold cleaner, thoroughly clean all crankshaft bores and blow through with compressed air.
3. Visually inspect crankshaft for rust spots, scores and individual foreign body impressions.
   [a] If rust spots, scores or foreign body impressions are found, remove by localized polishing.
   [b] If no rust spots, scores or foreign body impressions are found, continue inspection.
4. Crack-test crankshaft using magnetic test method.
5. Visually inspect crankshaft for foreign body indentations.
   [a] If foreign body indentations are found, remove from crankshaft by regrinding to next stage.
   [b] If no indentations are found, continue inspection.
6. After grinding, perform hardness test.
7. Visually inspect bearing journals for scores or thermal fissures.
   [a] If scores or thermal fissures are found, remove from bearing journals by regrinding to the next repair stage.
   [b] If no scores or thermal fissures are found, continue inspection.
8. Using a micrometer, measure crankshaft main bearing and crankpin journals in each of four positions.
   [a] If measurements are beyond limits, replace component.
   [b] If measurements are not beyond limits, continue inspection.
9. Visually inspect oil passage to running surface transitions for burrs.
   [a] If burrs are found, polish oil passage.
   [b] If no burrs are found, continue inspection.

10. Visually inspect crankshaft webs and connecting rod guide surfaces for irregularities.
    [a] If irregularities are found, polish crankshaft webs and connecting rod guide surfaces.
    [b] If no irregularities are found, continue inspection.
11. Inspect crankshaft taper for any traces of corrosion or minor scoring.
    [a] If corrosion or minor scoring is found, polish crankshaft taper.
    [b] If no corrosion or minor scoring is found, continue inspection.
12. Test the threaded bores at driving and gear case ends of crankshaft with new bolts to ensure that bolts move easily in bores.
13. Remove cold welds by polishing.
14. Crack-test crankshaft gear, particularly gear tooth surfaces.
15. Visually inspect gear tooth surfaces for minor surface cracks (hairline cracks).
    [a] If minor surface cracks are found, polish tooth surfaces.
    [b] If no cracks are found, continue inspection.
16. Visually inspect crankshaft gear for surface or deeper fissures.
    [a] If several surface or deeper fissures are found, replace crankshaft gear.
    [b] If no fissures are found, continue inspection.
17. Visually inspect crankshaft gear for individual scores.
    [a] If individual scores are found, remove by polishing the gear.
    [b] If several scores are found, replace the gear.
    [c] If no scores are found, continue inspection.

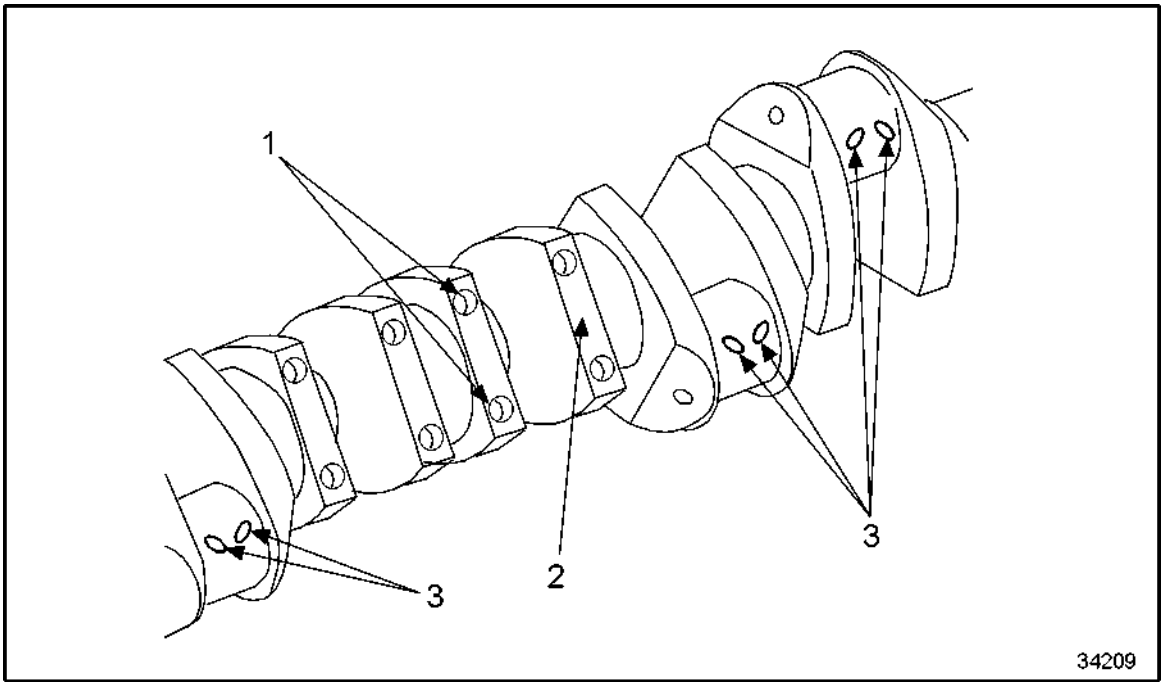
NOTE:
Never use a wire brush.

Checking Crankshaft for Cracks

Perform the following steps to check crankshaft for cracks:

1. Visually inspect counterweight mating surfaces (2) for wear.
    [a] If counterweight mating surfaces are worn, machine-grind.

[b] If counterweight mating surfaces are not worn, continue inspection. See Figure 181.



1. Tapped Bores
2. Mating Surfaces
3. Oil Bores and Journal Bores

Figure 181 Checking Crankshaft for Cracks

2. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect crankshaft for longitudinal and transverse cracks.
   [a] If longitudinal or transverse cracks are found, replace crankshaft.
   [b] If crankshaft is not cracked, continue inspection.
3. Inspect oil bores and journal bores (3), counterweight mating surfaces and tapped bores (1). See Figure 181.
4. Install crankshaft in longitudinal direction between jaws of test device.
5. The specified magnetic field strength of 20 A/cm to 60 A/cm must be applied at every part of the component.
6. Demagnetize crankshaft after crack-testing. The maximum permissible residual field strength after demagnetization is 2.5 A/cm to 4 A/cm.

NOTE:
A component is considered sufficiently demagnetized when a paper clip suspended on a thread is no longer attracted by the component.

Thermal Cracks

Review the following comments on thermal cracks:

1. A characteristic of thermal cracks (arrows) is that they are almost always parallel to the axis of the component. See Figure 182.

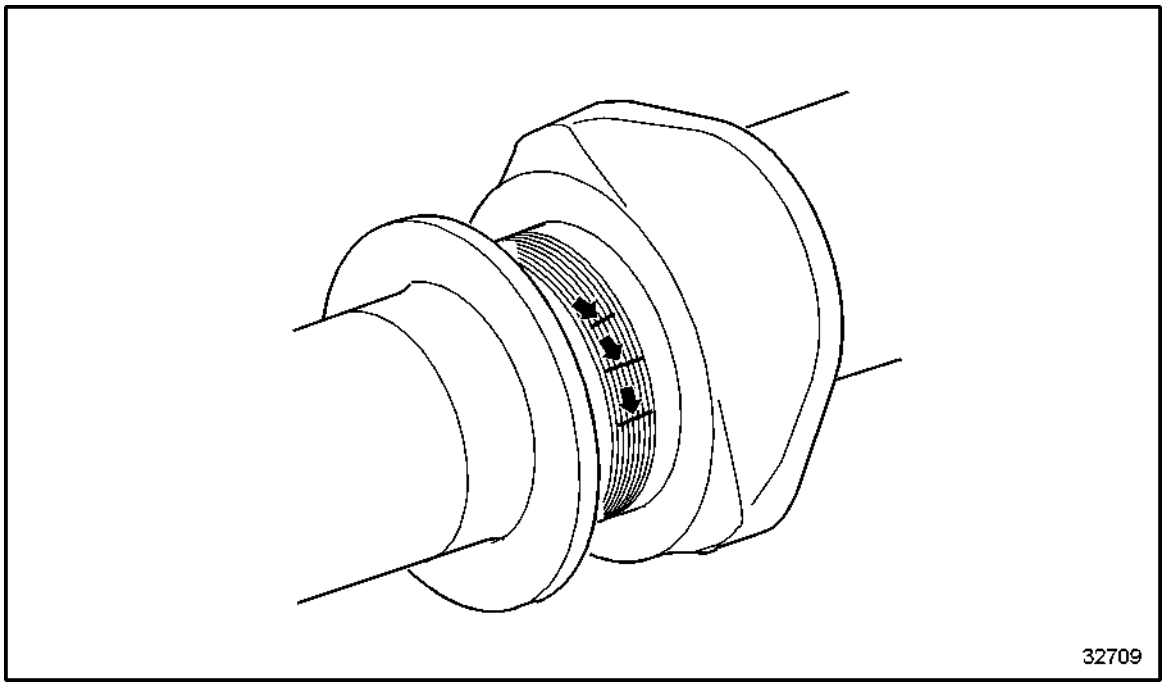


Figure 182 Thermal Cracks on Crankshaft

2. Transverse cracks sometimes come out from these cracks.
3. Heavy thermal cracks are approximately as deep as the thickness of the hardness layer.
4. Replace crankshaft with such cracks.
5. Crankshafts exhibiting minor thermal cracks can be repaired, providing that regrinding to a repair stage or local grinding will remove the damage.
6. Carefully regrind the affected bearing journals, according to crack depth, to a permissible repair size.
7. Minor cracks can also be repaired by local grinding.
8. Carry out preliminary grinding before the after-curing, otherwise the thermal cracks could increase in length and depth.
9. Grind to specified repair stage only after bearing journals have been hardened.

Cracks Caused by Grinding

Review the following comments on cracks caused by grinding:

1. Fine branching is characteristic of thermal cracking (arrows). See Figure 183.

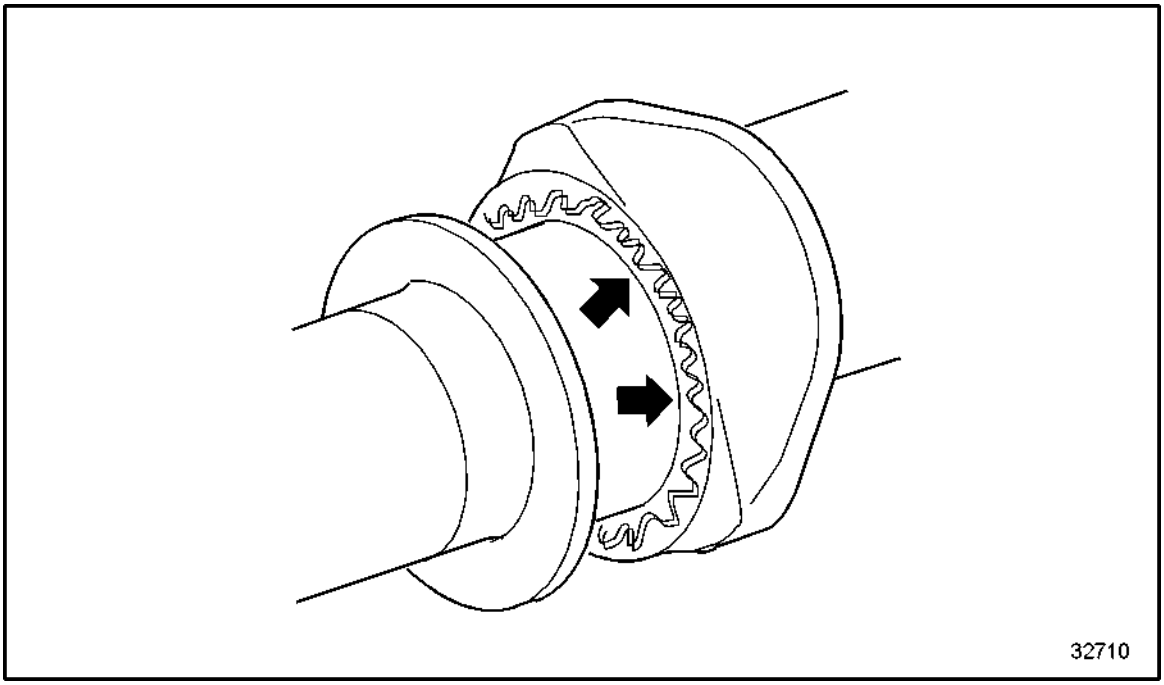


Figure 183 Bearing Journal with Grinding Cracks

2. Replace crankshaft with such thermal cracks.
3. Grinding cracks occur due to insufficient cooling during grinding or through excessive feed.

Checking Crankshaft Journal

Perform the following steps to inspect the crankshaft journal:

1. Rub down all journals with emery cloth. See Figure 184.

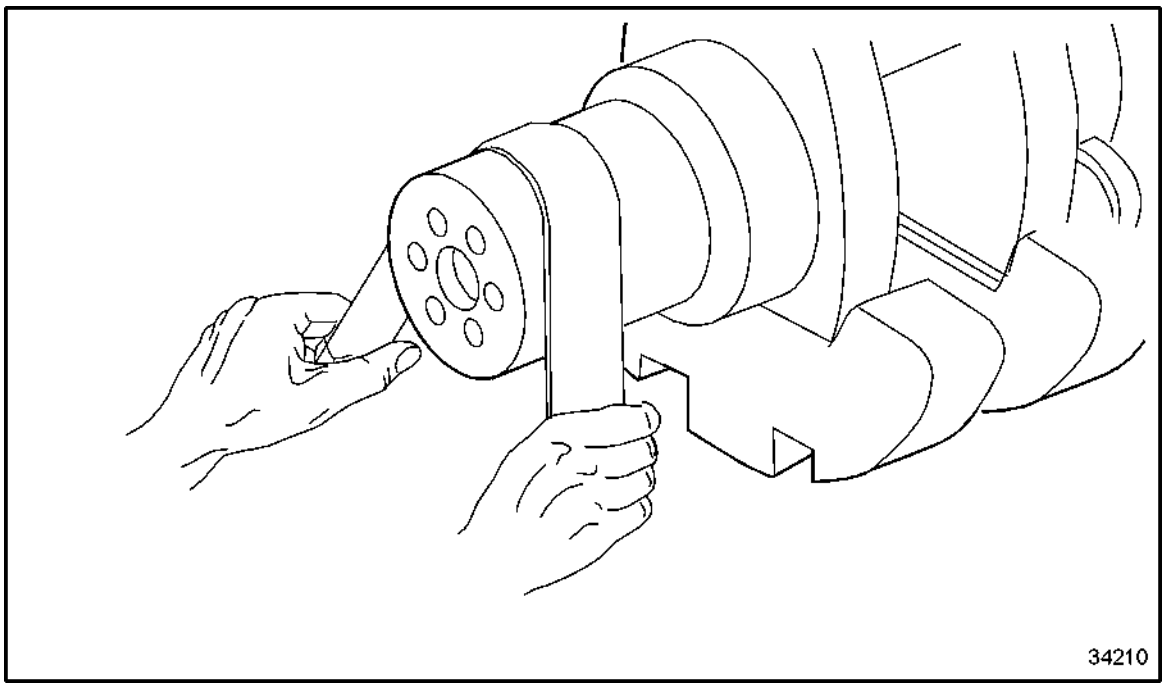


Figure 184 Polishing with Emery Cloth

2. Standardized roughness height (R_z) of journal sliding surface = 2.5 µm to 6.3, µm. Refer to section Regrinding Crankshaft.
3. Polish all fillets and transitions.
4. Check main bearing and crankpin surfaces for scoring and damage.
   [a] If scoring or damage is found, regrind relevant journal to next repair stage.
   [b] If no scoring or damage is found, continue inspection.
5. Check thrust washer surface of first main bearing for wear.
   [a] If thrust washer surface is worn, regrind to next repair stage.
   [b] If thrust washer is not worn, continue inspection.
6. Inspect crankshaft journal for minor scoring or damage.
   [a] If minor scoring or damage is found, polish with emery cloth.
   [b] If no scoring or damage is found, continue inspection.

Measuring Crankshaft Journal

Perform the following steps to measure the crankshaft journal:

1. Using micrometer, measure main bearings and crankpins of crankshaft in four locations for out-of-round and surface irregularities; record measured values in Data Sheet. See Figure 185.

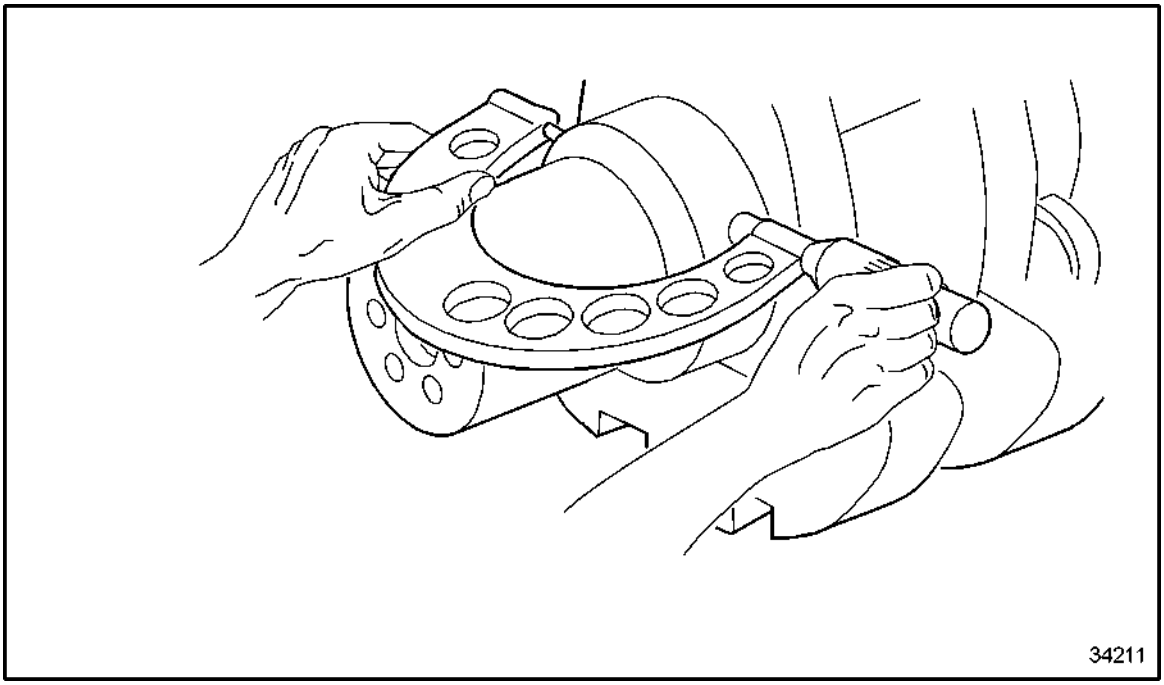


Figure 185 Measuring Crankshaft Journal

[a] If limit values are exceeded, grind crankshaft to next repair size.

[b] If limit values are not exceeded, continue inspection.

Checking Crankshaft Taper

Perform the following steps to check the crankshaft taper:

1. Check crankshaft taper surfaces (arrows) for minor scoring and damage.
   [a] If minor scoring or damage is found, polish taper surfaces with emery cloth.

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

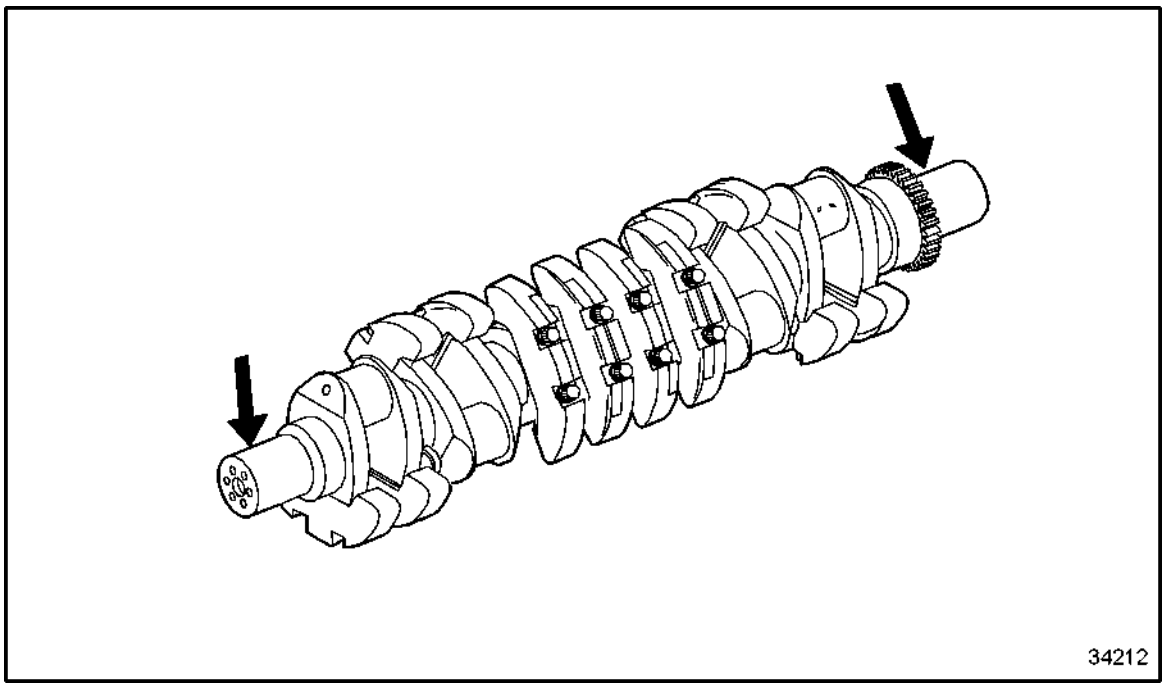


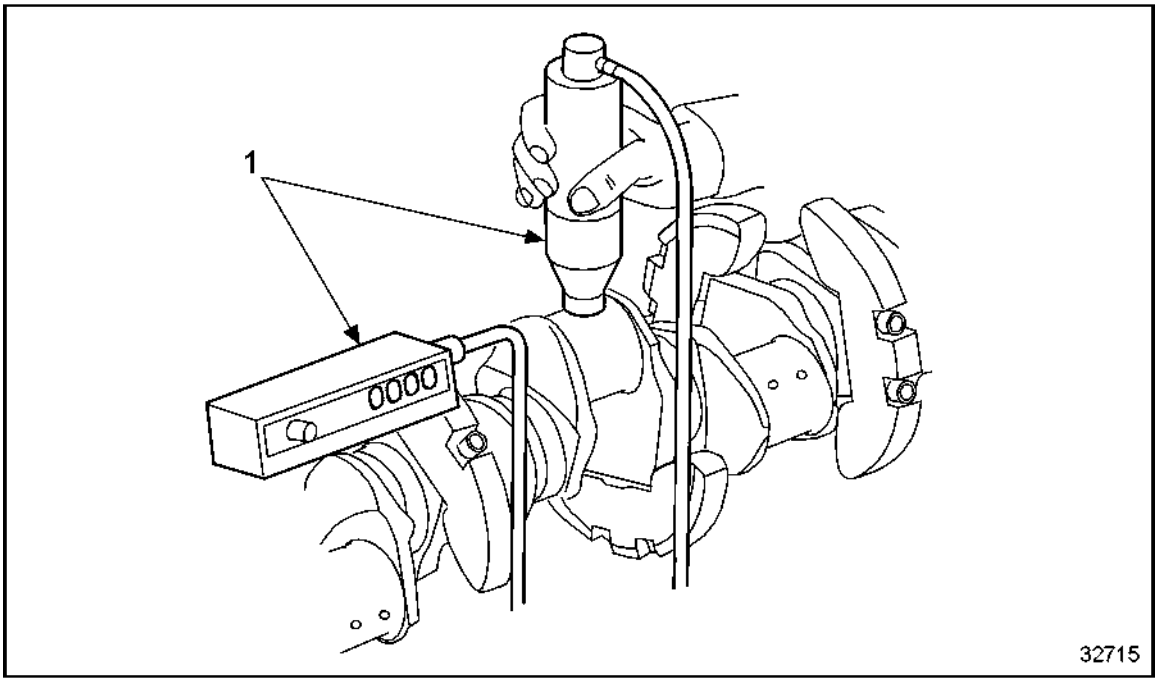
Figure 186 Checking Crankshaft Taper

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:

1. Check hardness of all journals using the Microdur tester (1) or other suitable hardness tester. See Figure 187.



1. Microdur Tester

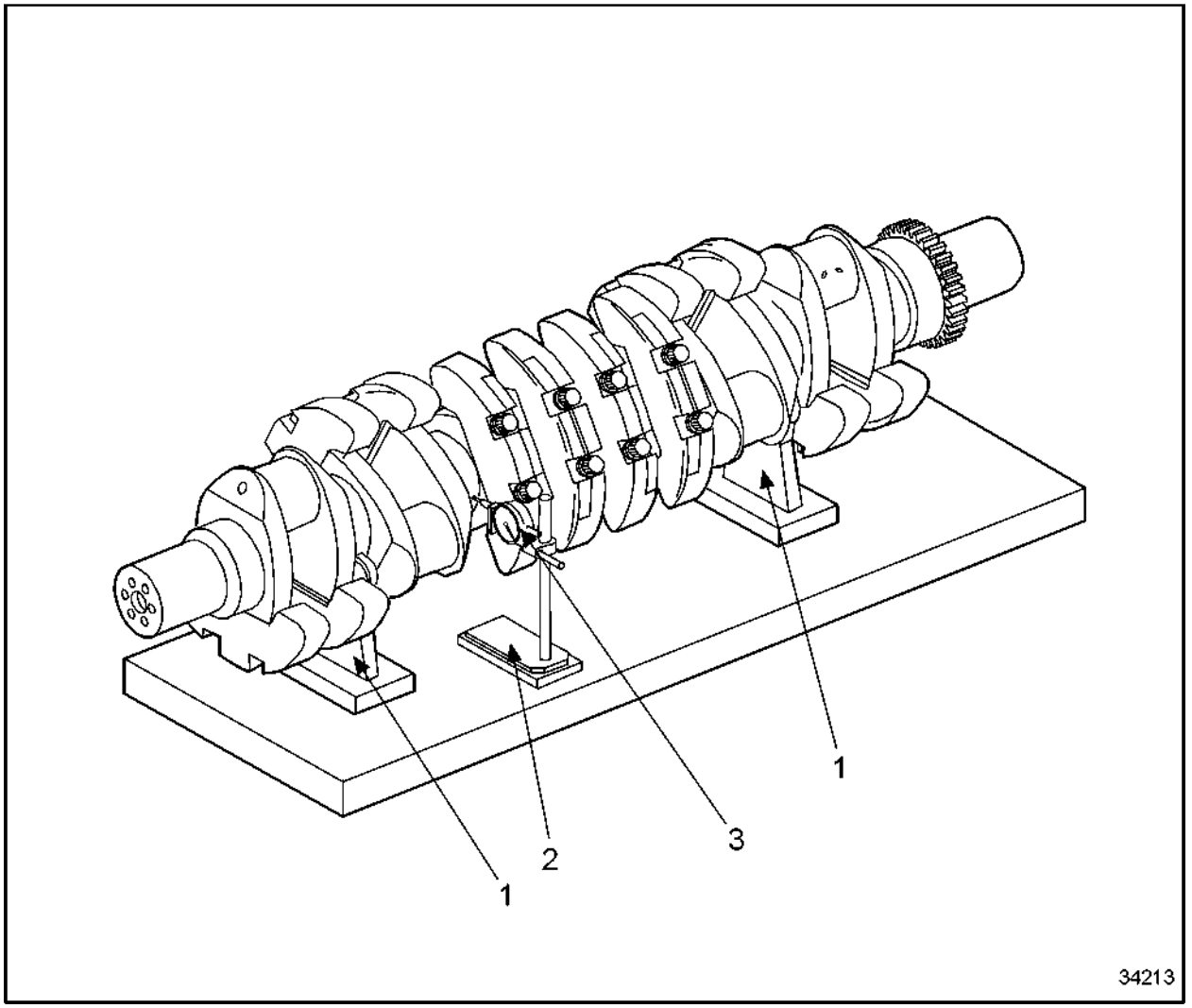
Figure 187 Checking Hardness of Journals

2. Test hardness of each journal at four 90–degree intervals around circumference.
3. Specified hardness is from 49 HRC to 53 HRC.
4. If a bearing journal has lost its hardness due to bearing scuffing or machining, reharden journal.

Checking Crankshaft Concentricity

To check crankshaft concentricity perform the following steps:

1. Place roller stands under the following bearing journals; 12V crankshaft journal 2 and 6 = fixed mount. See Figure 188.



1. Fixed Mount (Roller Stand, Rigid)
2. Magnetic-base Indicator Holder
3. Dial Gage

Figure 188 Checking Crankshaft Concentricity (12V shown)

2. Using adjustable dial gage holder and dial gage, check concentricity of main bearing journal.
3. If wear across circumference of journal is irregular, check at transition from cylindrical section of journal to radius.
4. Measure journals.
   [a] If journals are outside specifications, grind to next repair stage.

[b] If journals are not outside specifications, continue inspection.

NOTE:
Do not straighten crankshaft after hardening.

Regrinding Crankshaft

To regrind crankshaft, review and perform the following steps:

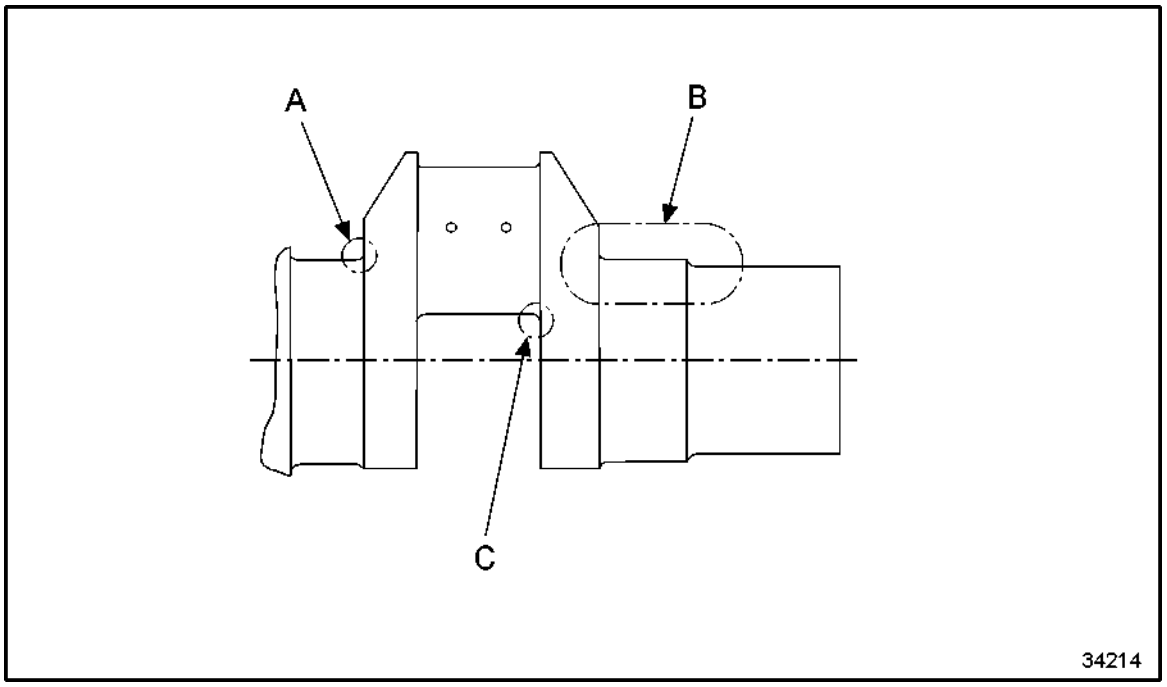
1. Only journals which are not dimensionally stable must be reconditioned to next repair stage.
2. When regrinding, make every effort to remove only as much material as is required to achieve next repair size.
3. Adhere strictly to all specifications for crankshaft sizes and tolerances; this also applies to transition radii and surface finish.
4. Record crankshaft serial number, main bearing journal and crankpin diameters, guide bearing width, concentricity values and journal hardness values in the Crankshaft Data Sheet. Refer to section .
5. Thoroughly clean oil bores after grinding.
6. Necessary checks after grinding:
   - ☐ Check dimensions and surface finish of all bearing journals.
   - ☐ Check radii at bearing journals.
   - ☐ Check that oil bores are correctly radiused and polished.

NOTICE:
To prevent damage to bearing shells and ensure adequate lubrication, perform oil bores check with great care.

   - ☐ Check concentricity and axial runout.
   - ☐ Check hardness.
   - ☐ Check for cracks.

Hardness Transient Across Journal

To determine hardness transient across journal, see Figure 189.



A = Main bearing Journals 2 to 7

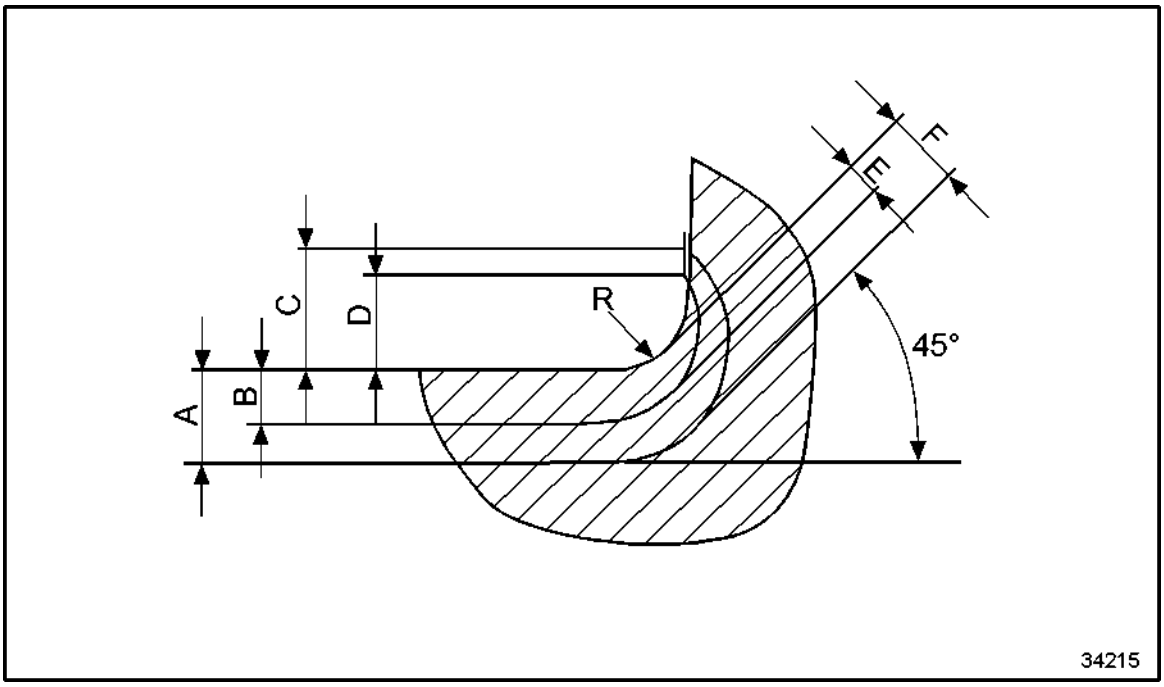
B = Main bearing 1

C = Connecting Rod Journals 1 to 6

Figure 189 Hardness Transient Across Journal

Hardness Characteristic at Main Bearing Journals 2 to 7

To determine hardness characteristic at main bearings 2 to 7, see Figure 190.



A = 7 mm (0.2755 in.) (Maximum hardened zone depth; only alignment bearings)

B = 4 mm (0.1574 in.) (Minimum hardened zone depth; only alignment bearings)

C = 9 mm (0.3545 in.) (Maximum hardened zone depth in radius area)

D = 7 mm (0.2755 in.) (Minimum hardened zone depth in radius area)

E = 2.5 mm (0.0984 in.) (Minimum hardened zone depth in radius area)

F = 5.5 mm (0.2165 in.) (Maximum hardened zone depth in radius area)

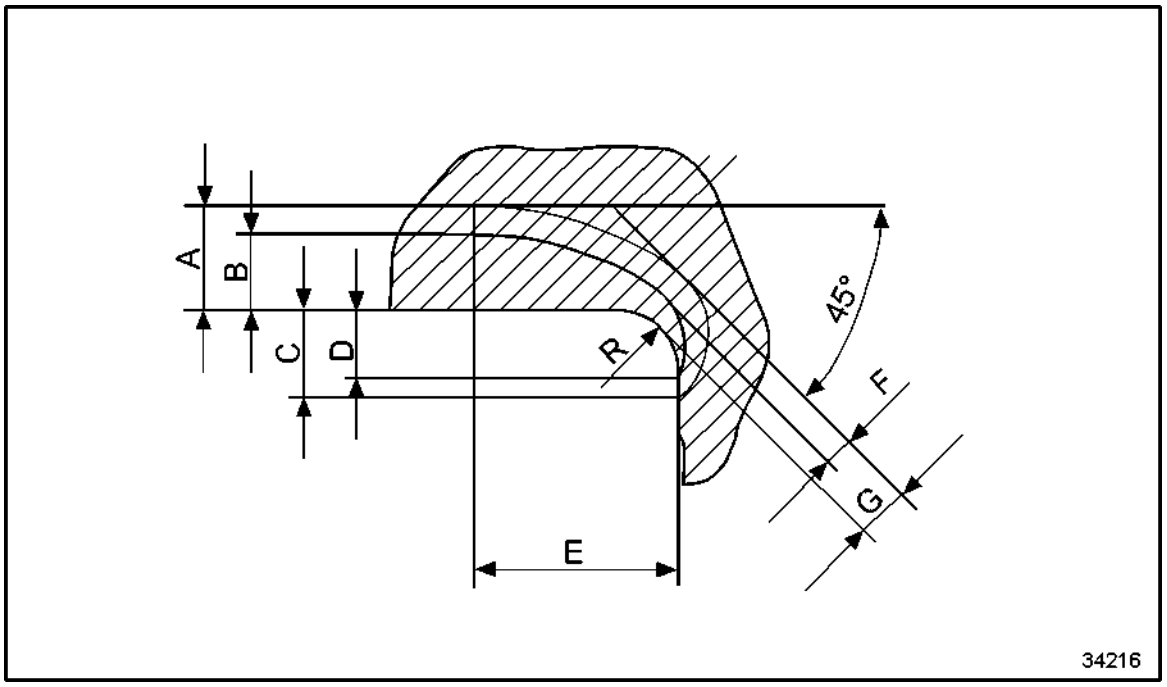
R = from 4.9-5.1 mm (0.1929 —0.2007 in.)

Maximum peak-to-valley height at radii = 4 µm

Figure 190 Hardness Characteristic at Main Bearing Journals 2 to 7

Hardness Characteristic at Connecting Rod Journals 1 to 6

To determine hardness characteristic at connecting rod journals 1 to 6, see Figure 191.



A = 11 mm (0.4330 in.) (Maximum hardened zone depth)

B = 8 mm (0.3149 in.) (Minimum hardened zone depth)

C = 9 mm (0.3543 in.) (Maximum hardened zone depth in radius area)

D = 7 mm (0.2755 in.) (Minimum hardened zone depth in radius area)

E = 21 mm (0.8267 in.)

F = 2.5 mm (0.0984 in.) (Minimum hardened zone depth in radius area)

G = 5.5 mm (0.2165 in.) (Maximum hardened zone depth in radius area)

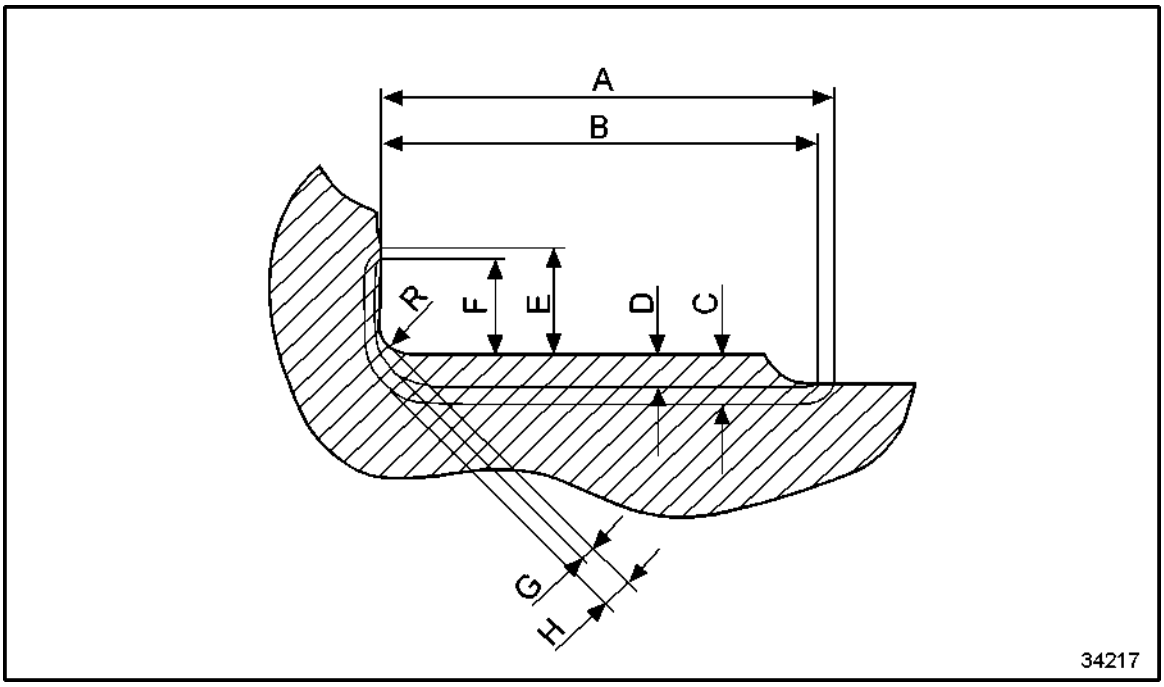
R = from 4.9-5.1 mm (0.1929 —0.2007 in.)

Maximum peak-to-valley height at radii = 4 µm

Figure 191 Hardness Characteristic at Connecting Rod Journals 1 to 6

Hardness Characteristic at Main Bearing 1

To determine hardness characteristic at main bearing 1, see Figure 192.



A = 80.5 mm (3.1693 in.)

B = 77.5 mm (3.0512 in.); A to B hardness width 3 mm (.1181 in.)

C = 9 mm (0.3543 in.) (Maximum hardened zone depth)

D = 6 mm (0.2362 in.) (Maximum hardened zone depth)

E = 19 mm (0.7480 in.) (Maximum hardened zone depth in radius area)

F = 17 mm (0.6693 in.) (Minimum hardened zone depth)

G = 2.5 mm (0.0984 in.) (Minimum hardened zone depth in radius area)

H = 5.5 mm (0.2165 in.) (Maximum hardened zone depth in radius area)

R = from 4.9 — 5.1 mm (0.1929 —0.2007 in.)

Maximum peak-to-valley height at radii = 4 µm

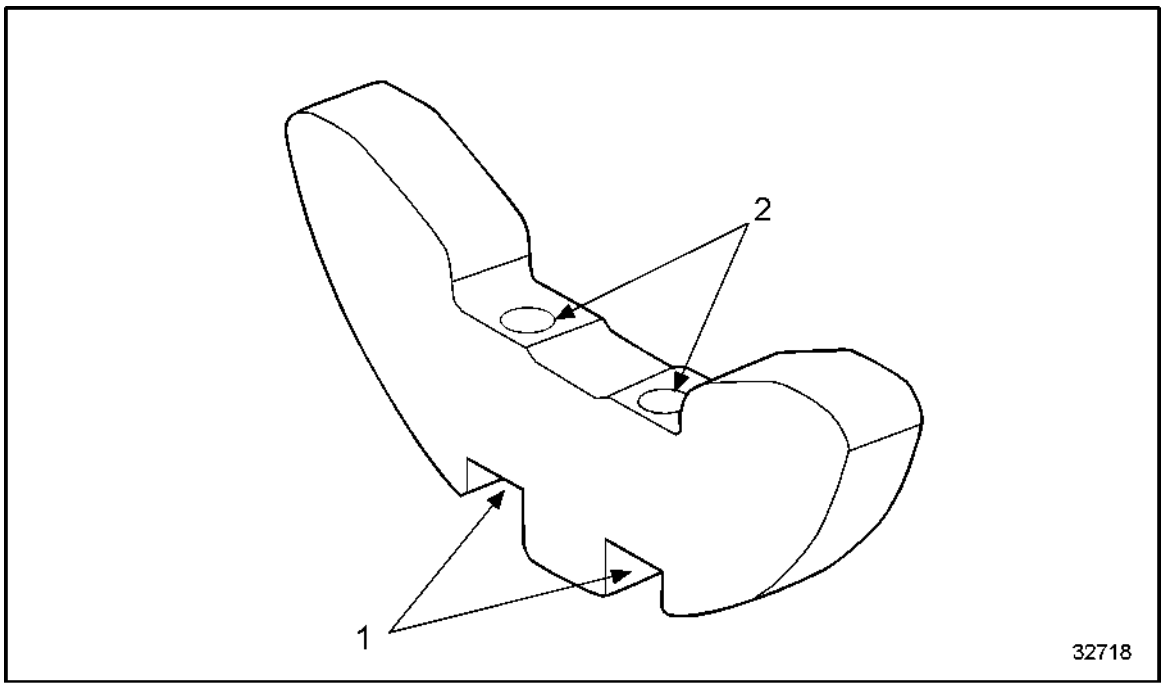
Figure 192 Hardness Characteristic at Main Bearing 1

Checking Counterweights

To check counterweights of crankshaft, perform the following steps:

1. Using the magnetic crack-testing method with fluorescent magnetic powder, check counterweight for cracks.
   [a] If cracks are detected on counterweight, replace counterweight.
   [b] If cracks are not detected, continue inspection.
2. Check crankshaft mating surface (2) for wear.
   [a] If crankshaft mating surface is worn, machine-grind.

[b] If crankshaft mating surface is not worn, continue inspection. See Figure 193.



1. Contact Pattern of Mating Surface
2. Crankshaft Mating Surface

Figure 193 Checking Counterweight for Wear

3. Using engineer's blue, check contact pattern of mating surface (1) for stress bolt heads. See Figure 193.
   [a] Remove surface irregularities if found.
   [b] If no surface irregularities are found, continue inspection.

Checking Bolts for Counterweights

To check bolts for counterweights, perform the following steps:

1. Measure shaft length of bolts with depth gage; for maximum permissible shaft length, refer to sectionC 031.05.01, see Figure 194.

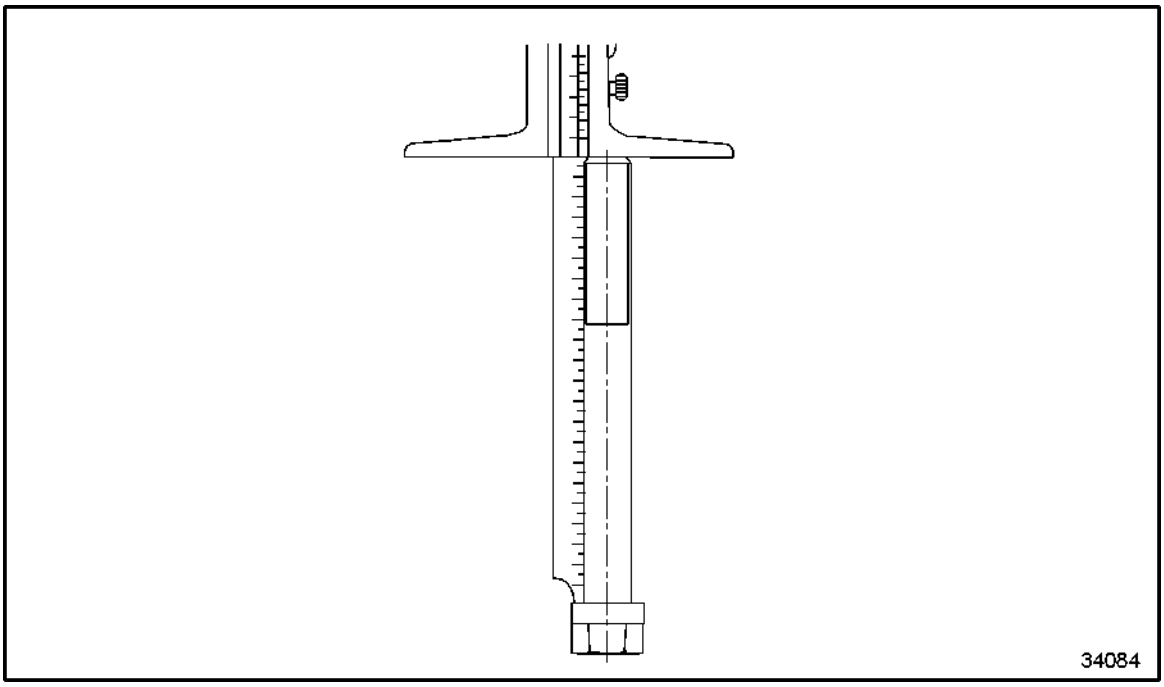


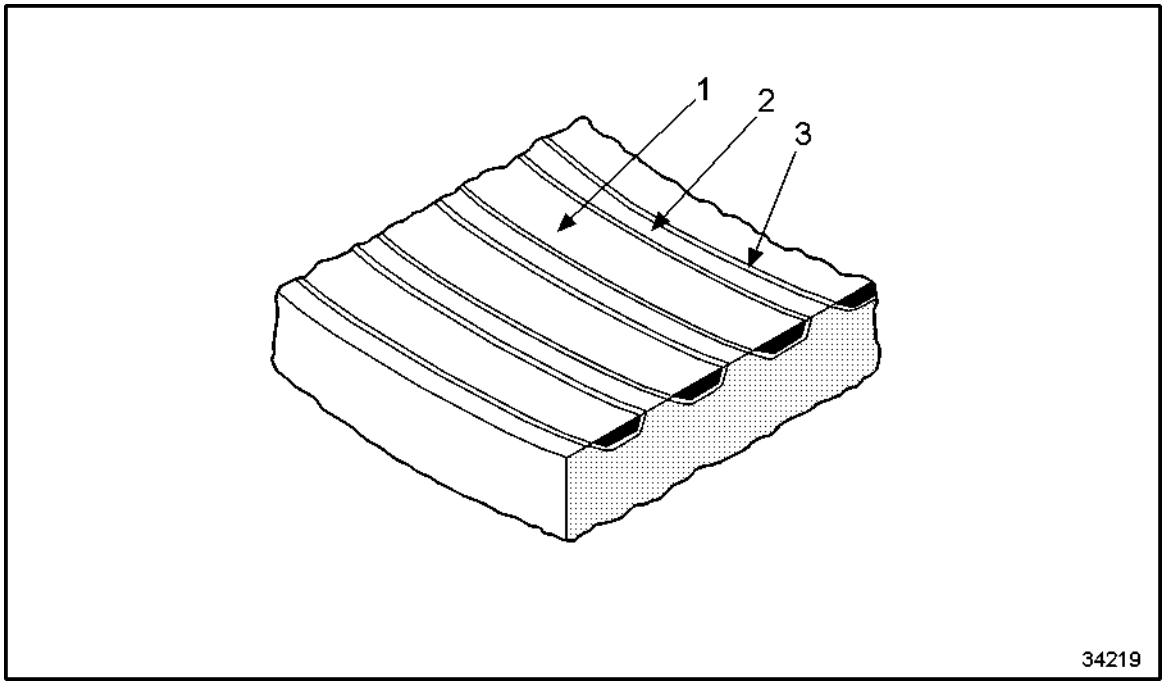
Figure 194 Checking Counterweight Bolts

2. Replace bolts if necessary.
3. Using the magnetic crack-testing method with fluorescent magnetic powder, check bolts for cracks.
   [a] If cracks are found, replace bolts.
   [b] If no cracks are found, continue inspection.
4. Ensure that threads are in perfect condition.

Checking and Assessing Main Bearing Shells (Sputtered Bearing)

To check and assess the main bearing shells (sputtered bearing) perform the following steps:

1. In new condition, the running surface is approximately 75% wear layer (1), approximately 25% intermediate layer (2) and approximately 5% run-in layer (3), corresponding to 1 — 3 mm (0.0393 —0.1181 in.) sputtered. See Figure 195.



1. Wear Layer
2. Intermediate Layer
3. Run-In Layer

Figure 195 Checking and Assessing Main Bearing Shells

2. Wear of the bearing running surfaces starts at the galvanized wear layer (1). See Figure 195.
3. The wear layer in the groove is removed by some 0.0001 mm (0.000039 in.).
4. The difference between intermediate layer (2) and wear layer (1) for further wear remains approximately constant at roughly 0.005 mm (0.00275 in.). See Figure 195.

NOTE:
A magnifying glass is required for a more accurate assessment of the wear condition of the running surface (magnification minimum 5x).

5. The wear layer is seen as a dark zone and the intermediate layer as a light zone. The decisive factor for the wear condition of the grooved bearing is the ratio "width of intermediate layer: width of groove" and the extent of the worn surface.
6. The sputtered bearing is still functional if the wear layer is partially missing in the grooves. Practice has shown that the sputtered bearing with partially empty grooves can continue in use without negatively affecting bearing function.

7. During each assessment of groove condition, the running surface in the area subject to least load (with groove mostly new) should be used for comparison.
8. The condition of the sputtered bearings is assessed in five groups:
   - □ Continued use.
   - □ Wear.
   - □ Borderline wear and levelling.
   - □ Wear layer fatigue fractures.
   - □ Borderline fatigue fractures and empty grooves.

Damage to Bearings

Damage to bearings occurs mainly through foreign body scoring, impressions and bedding, cavitation and corrosion, pitting, fatigue and installation faults. Bearings showing such damage must be replaced.

Listed in Table 24 are types of main bearing damage.

Type of Damage	Inspection Procedure
1. Continued Use	Refer to section Continued Use
2. Wear	Refer to section Wear
3. Borderline Wear and Leveling	Refer to section Borderline Wear and Leveling
4. Wear Layer Fatigue Fractures	Refer to section Wear Layer Fatigue Fractures
5. Borderline Case: Wear Layer Fatigue Fracture and Empty Grooves	Refer to section Borderline Case: Wear Layer Fatigue Fracture and Empty Grooves

Table 24 Crankshaft Bearing Damage

Continued Use

Condition

The groove geometry corresponds to new condition. The wear layer is fully retained within the grooves. Dark spots are primarily embedded particles of oil carbon. See Figure 196 and see Figure 197.

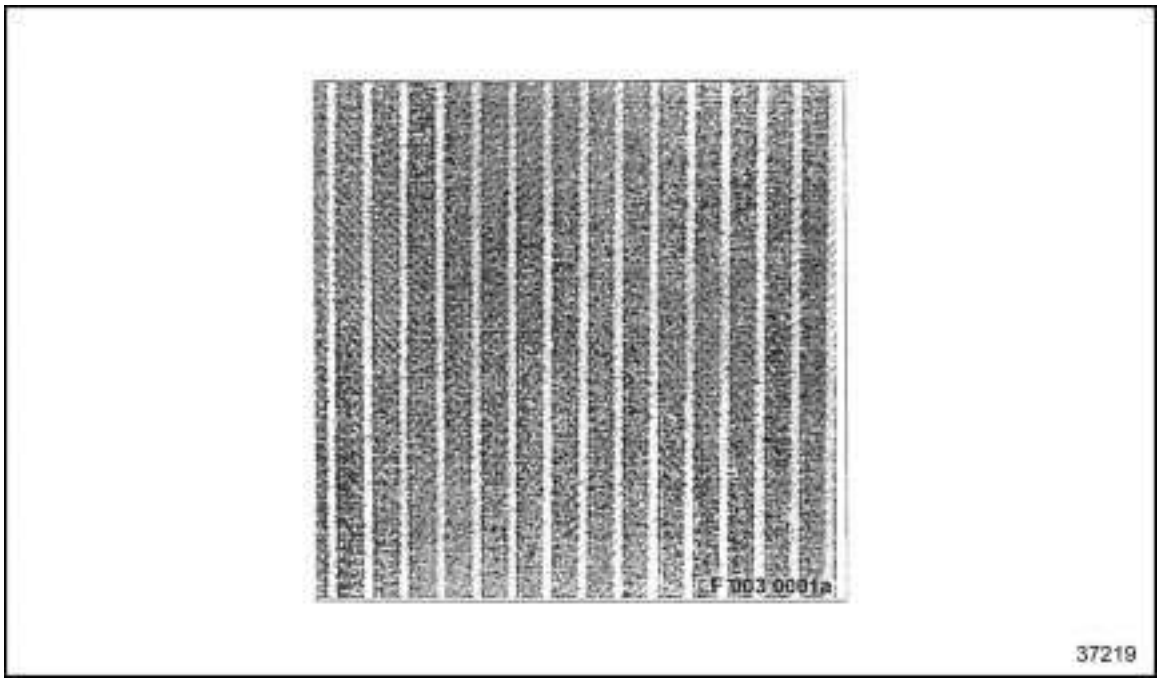


Figure 196 Wear Layer (View 1 of 2)

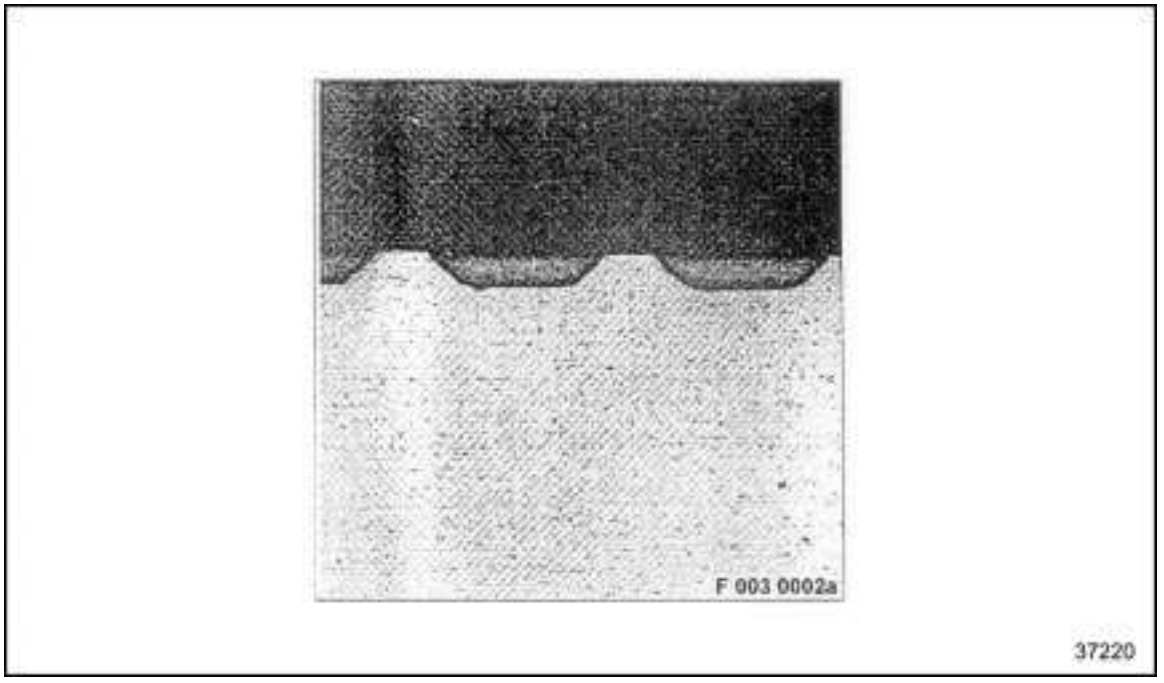


Figure 197 Wear Layer (View 2 of 2)

Assessment

The ratio wear layer/intermediate layer is approximately 25% to 75%.

Condition

The wear layer is uniformly removed by approximately **0.005 mm** from the grooves. The intermediate layer links show no wear. Dark spots are primarily embedded particles of oil carbon. See Figure 198 and see Figure 199.

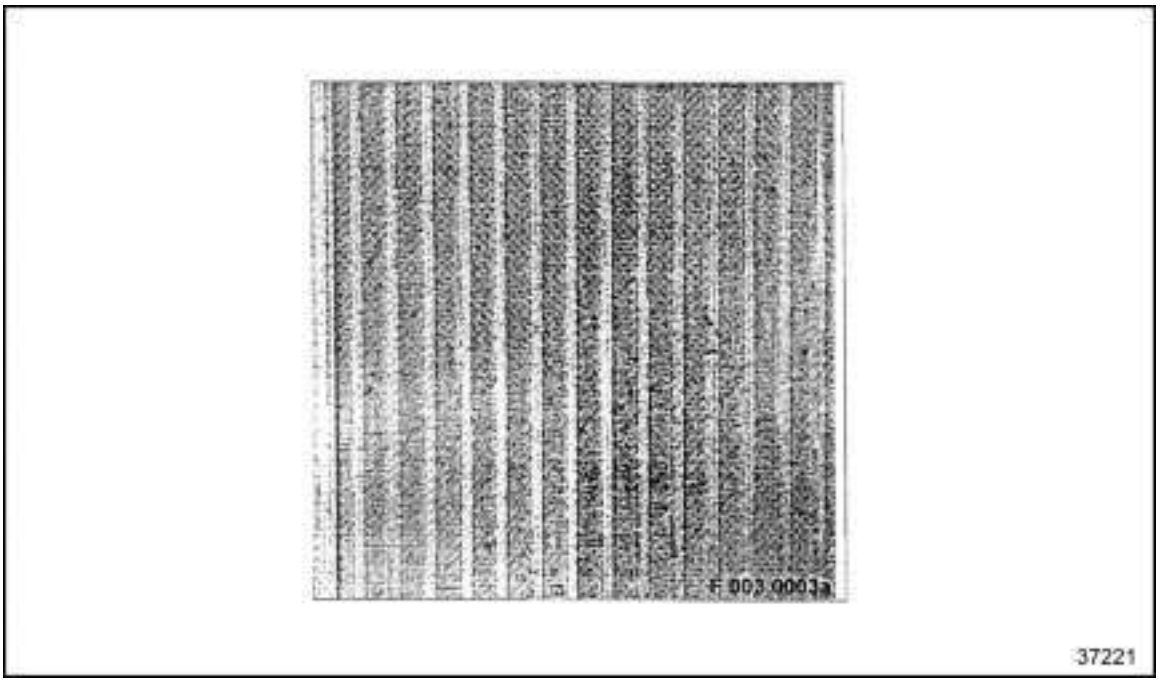


Figure 198 Intermediate Layer (View 1 of 2)

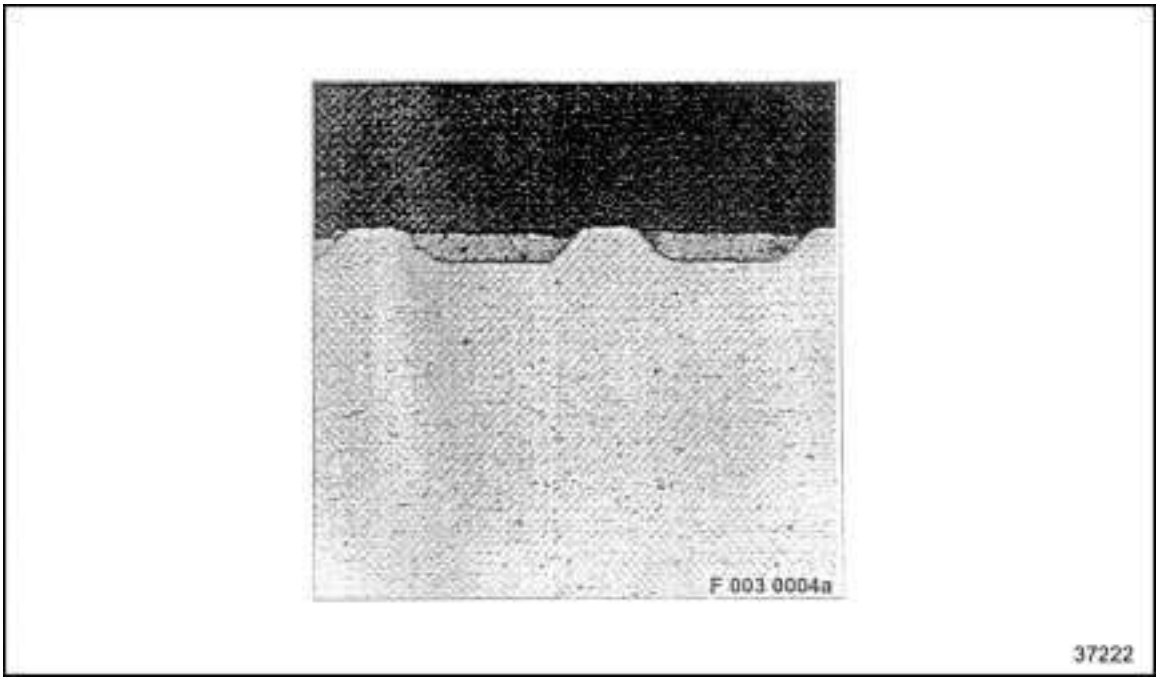


Figure 199 Intermediate Layer (View 2 of 2)

Assessment

As a result of wear layer removal, the intermediate layer links appear slightly wider.

Condition

Small foreign bodies are spread over entire running surface. There is no notable alteration of intermediate layer. See Figure 200 and see Figure 201.

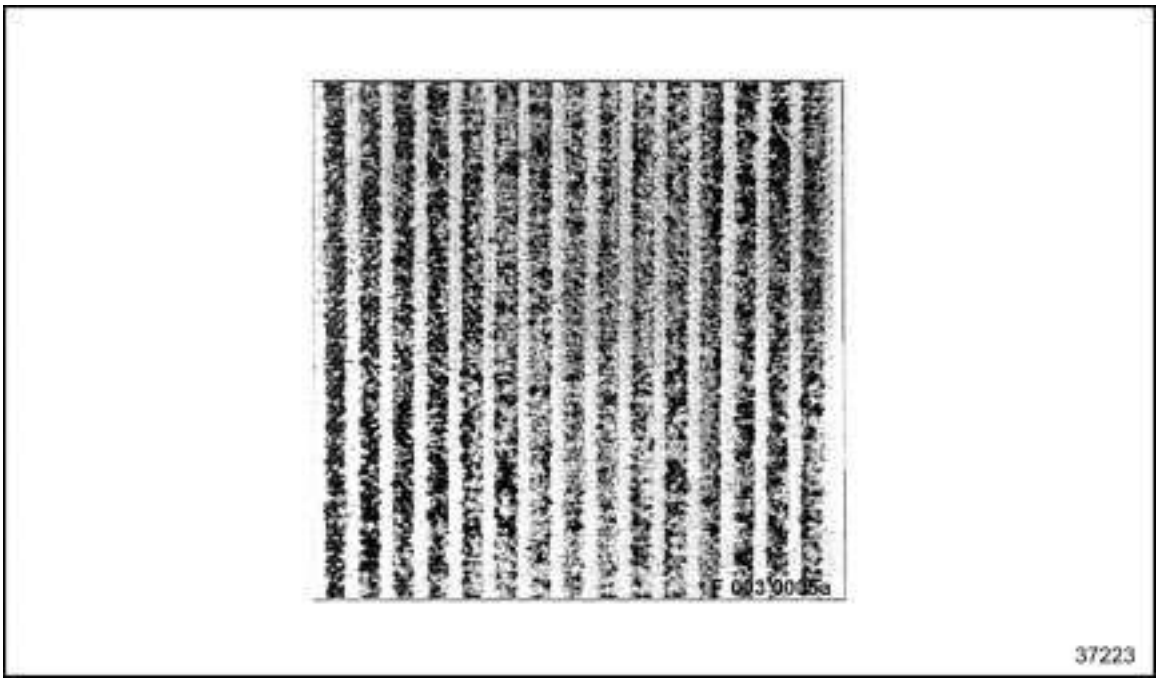


Figure 200 Small Foreign Bodies on Running Surface (View 1 of 2)

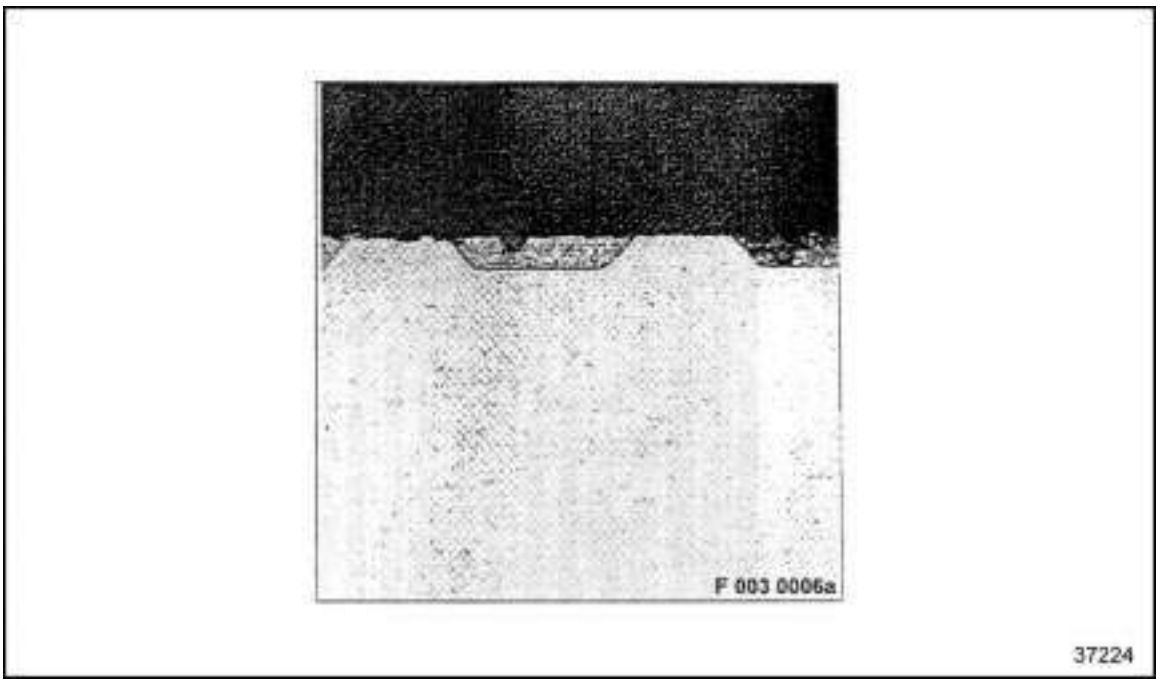


Figure 201 Small Foreign Bodies on Running Surface (View 2 of 2)

Assessment

Continued use of bearing shell.

Condition

The wear layer was “dragged” and “smeared” over the intermediate layer links. In places, the intermediate layer links are no longer visible. See Figure 202and see Figure 203.

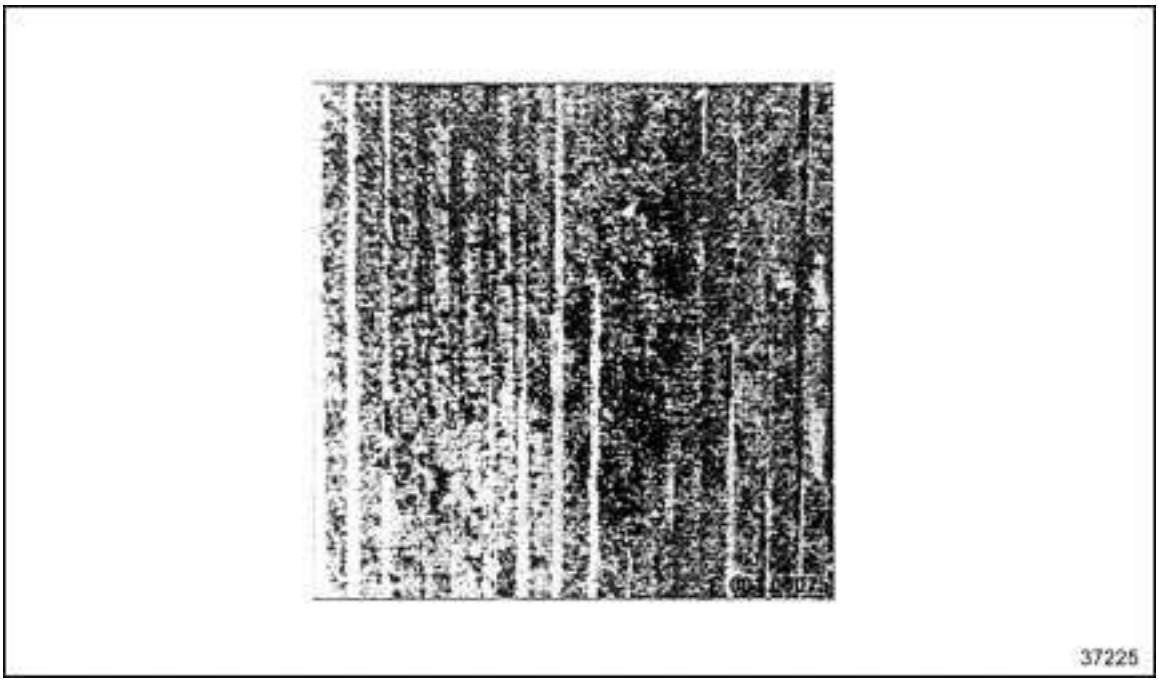


Figure 202 Wear Layer “Dragged” over Intermediate Layer Links (View 1 of 2)

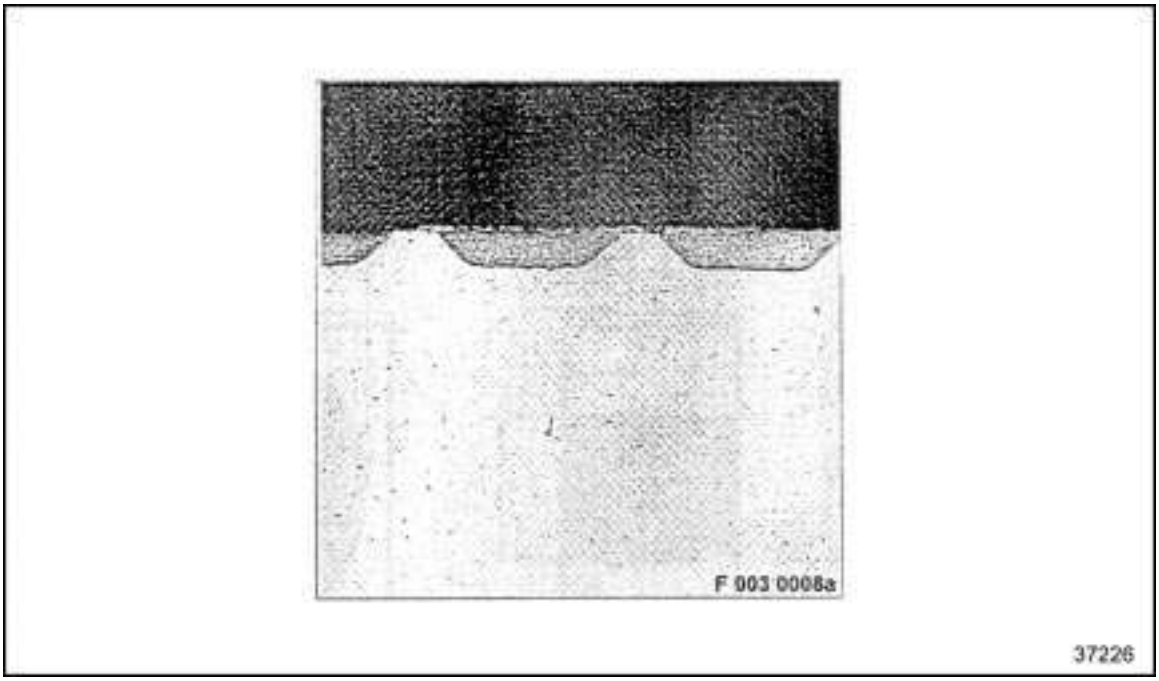


Figure 203 Wear Layer “Dragged” over Intermediate Layer Links (View 2 of 2)

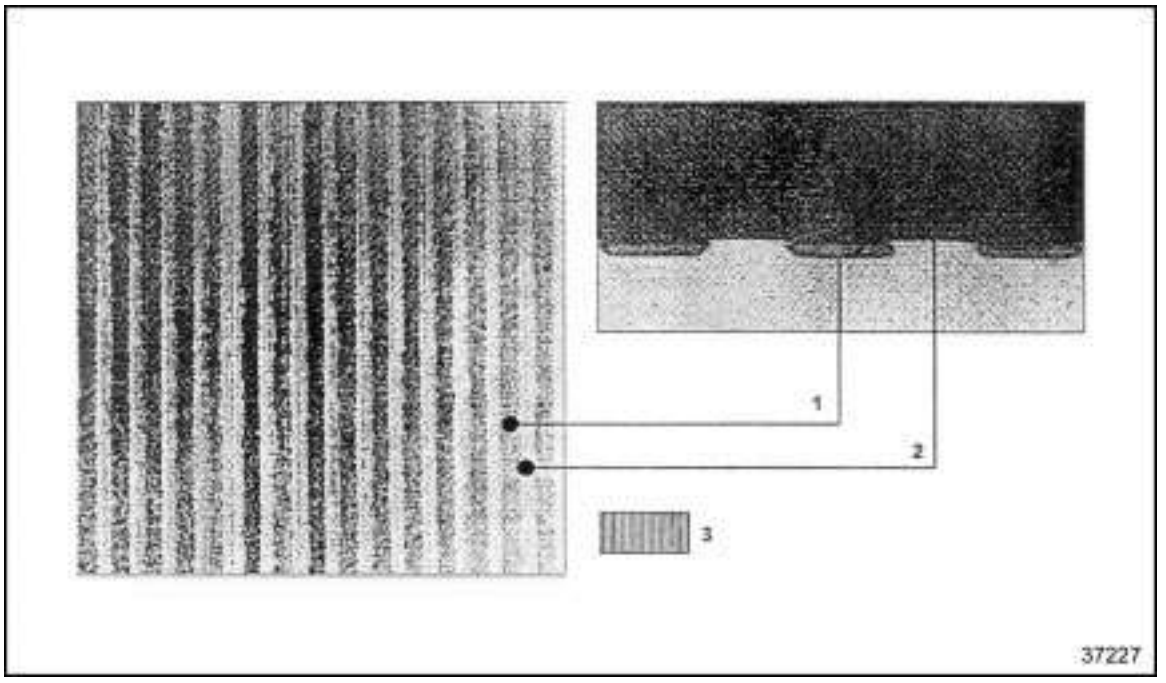
Assessment

Continued use of bearing shell.

Wear

Condition

The bearing is so worn in places that the intermediate layer links and wear layers have reached a ratio of 1:1. The width of the bearing metal links has increased from 25% (new condition) to 50%. There is still some wear layer in the grooves. See Figure 204.



1. Wear layer groove
2. Intermediate layer link
3. Wear 1:1

Figure 204 Wear Layer Groove/Intermediate Links

Wear Limits

For general wear limits, see Figure 205.

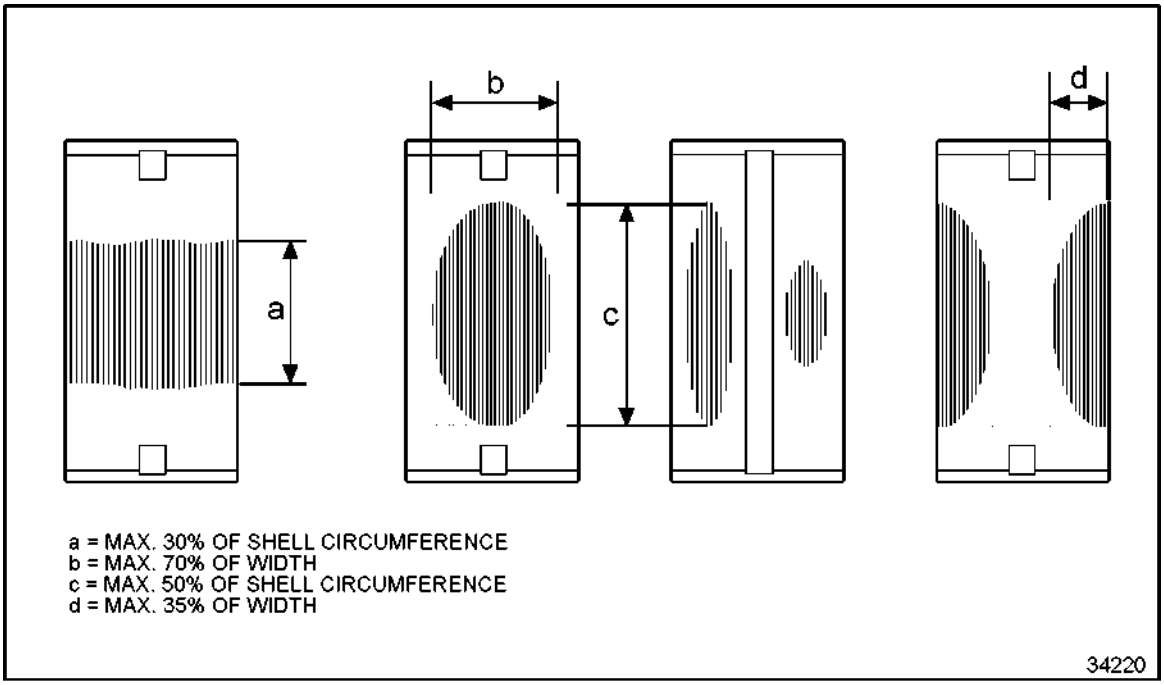


Figure 205 Wear Limits: Wear

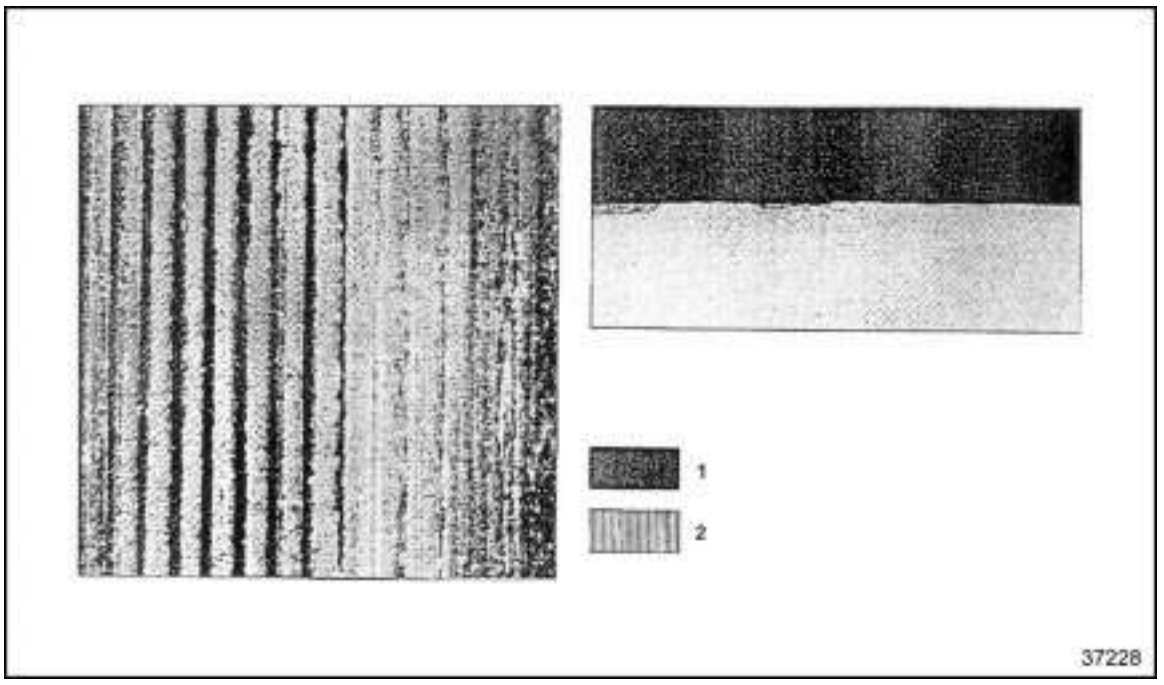
Assessment

The bearing is functional. If wear is expected before the next inspection, the bearing must be replaced as a safety measure.

Borderline Wear and Leveling

Condition

For intermediate layer links that are worn locally, see Figure 206.



1. Intermediate layer links worn
2. Wear 1:1

Figure 206 Locally Worn Intermediate Layer Links

Wear Limits

For borderline wear limits, see Figure 207.

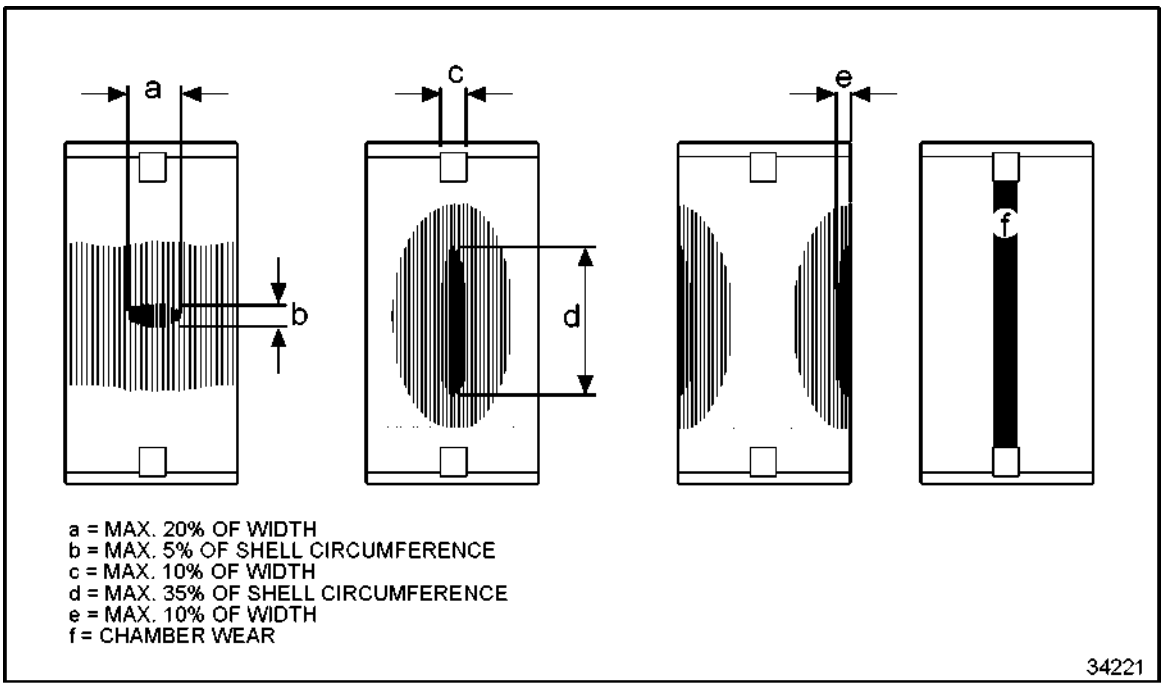


Figure 207 Wear Limits: Borderline Wear and Leveling

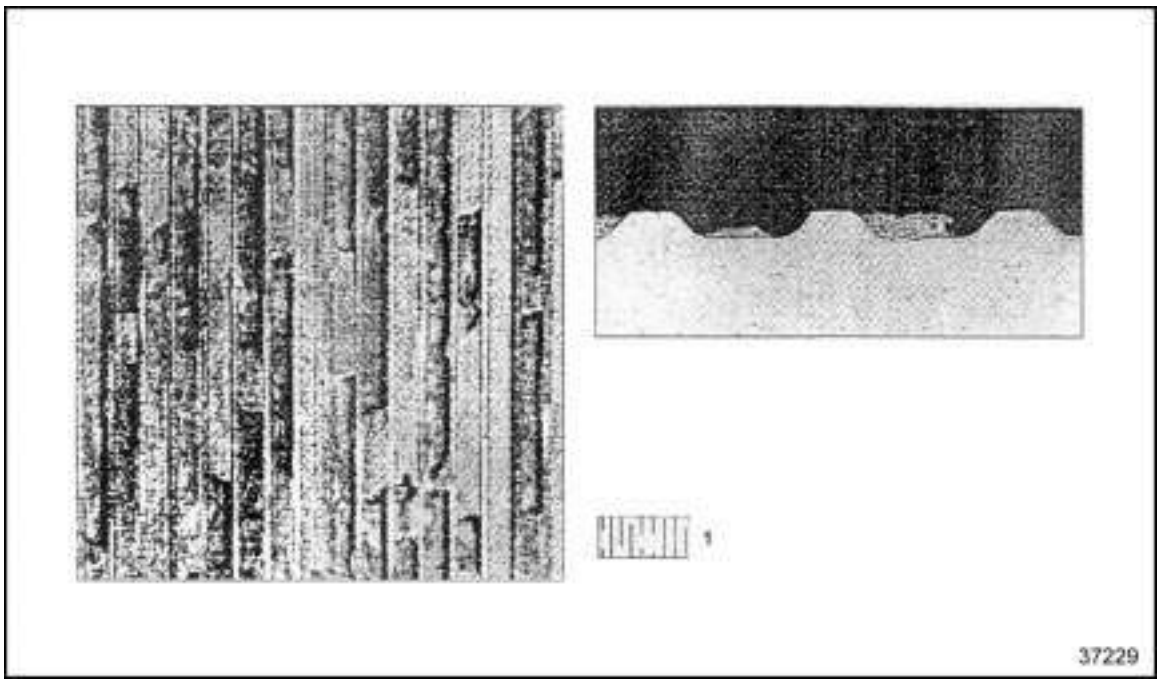
Assessment

When the above-defined wear condition is reached, the bearing must be replaced.

Wear Layer Fatigue Fractures

Condition

For wear layer fatigue fractures in grooves through local overloading, see Figure 208.



1. Wear layer fatigue fractures

Figure 208 Wear Limits: Wear Layer Fatigue Fractures

Wear Limits

For wear limits on wear layer fatigue fractures, see Figure 209.

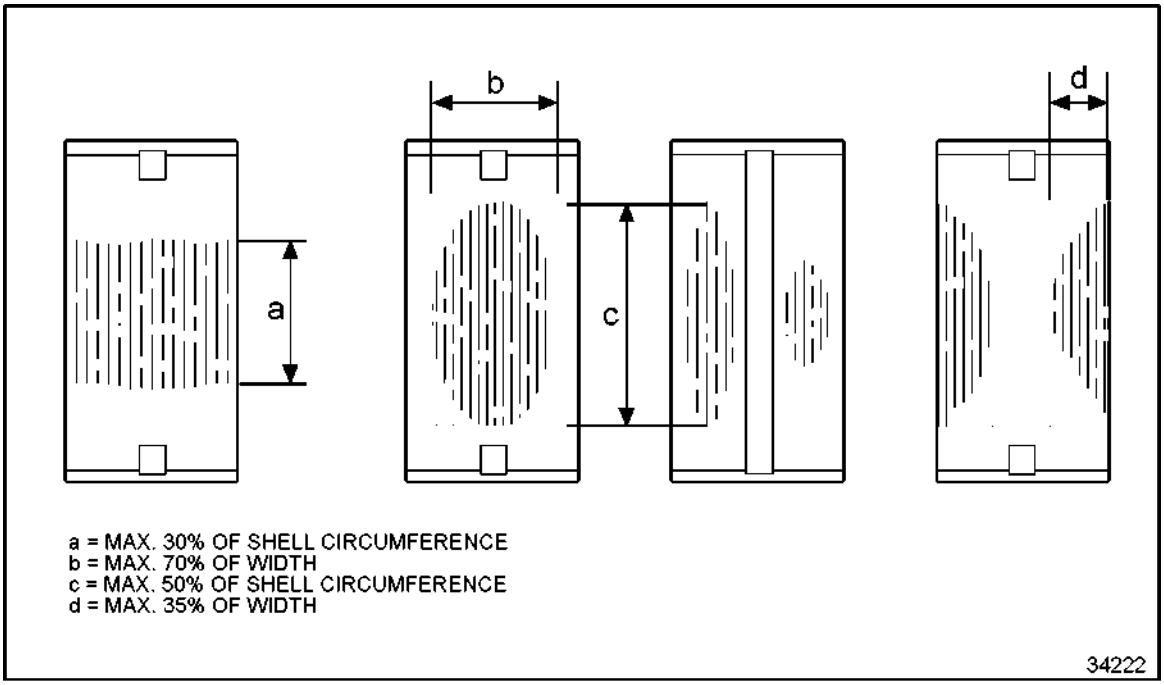


Figure 209 Wear Limits: Wear Layer Fatigue Fractures

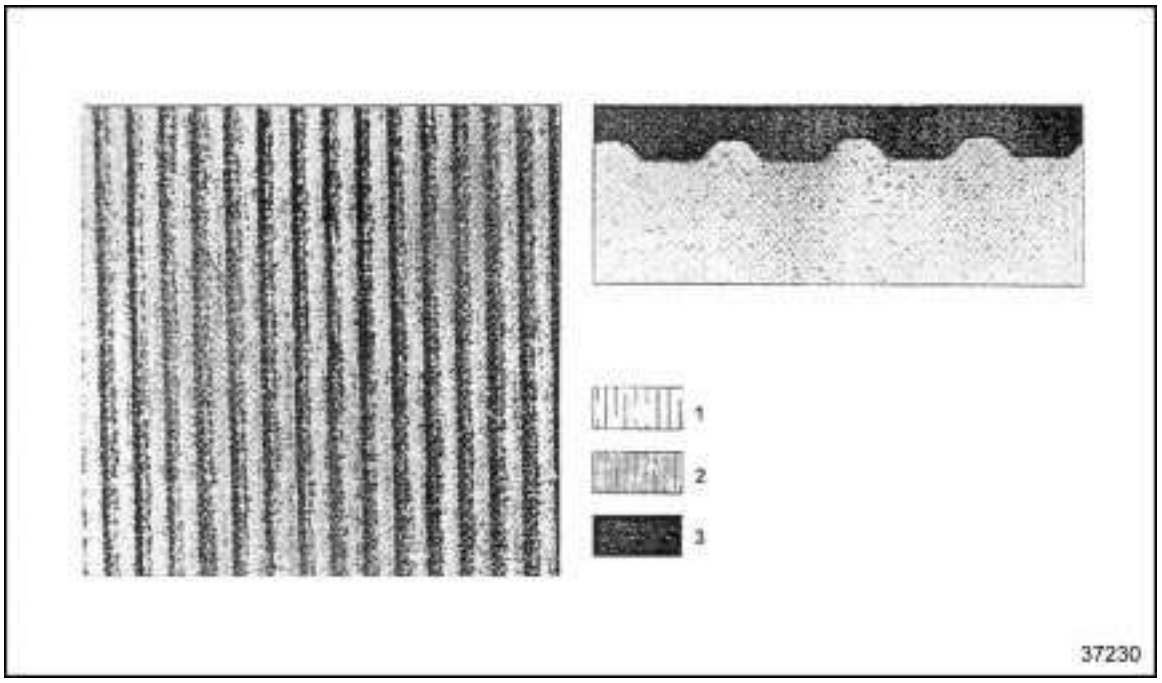
Assessment

The bearing is functional. If wear is expected before the next inspection, the bearing must be replaced as a safety measure.

Borderline Case: Wear Layer Fatigue Fracture and Empty Grooves

Condition

In some zones, after the broken wear layer is washed, empty grooves are visible. In places, the intermediate layer links may already be worn. See Figure 210.



1. Wear layer fatigue fractures
2. Empty grooves
3. Intermediate layer links worn

Figure 210 Empty Grooves

Wear Limits

For wear limits on borderline cases with fatigue fractures and empty grooves, see Figure 211.

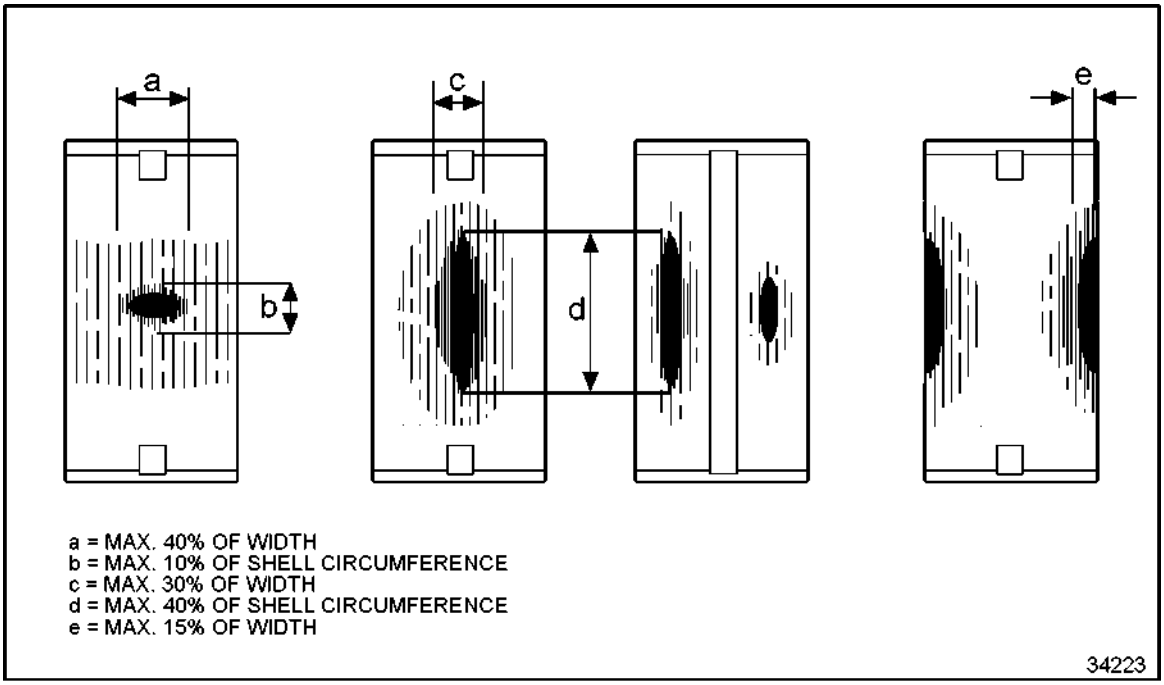


Figure 211 Wear Limits: Borderline Case: Wear Layer Fatigue Fractures and Empty Grooves

Assessment

When the above-defined condition is reached, the bearing must be replaced.

Dynamically Balancing the Crankshaft

To dynamically balance the crankshaft, perform the following steps:

NOTE:
Prior to dynamically balancing the crankshaft, seal all oil passages to prevent foreign matter from entering.

1. For 12V: Place crankshaft in main journals 2 and 6; the balancing levels are in main journals 2 and 6. See Figure 212.

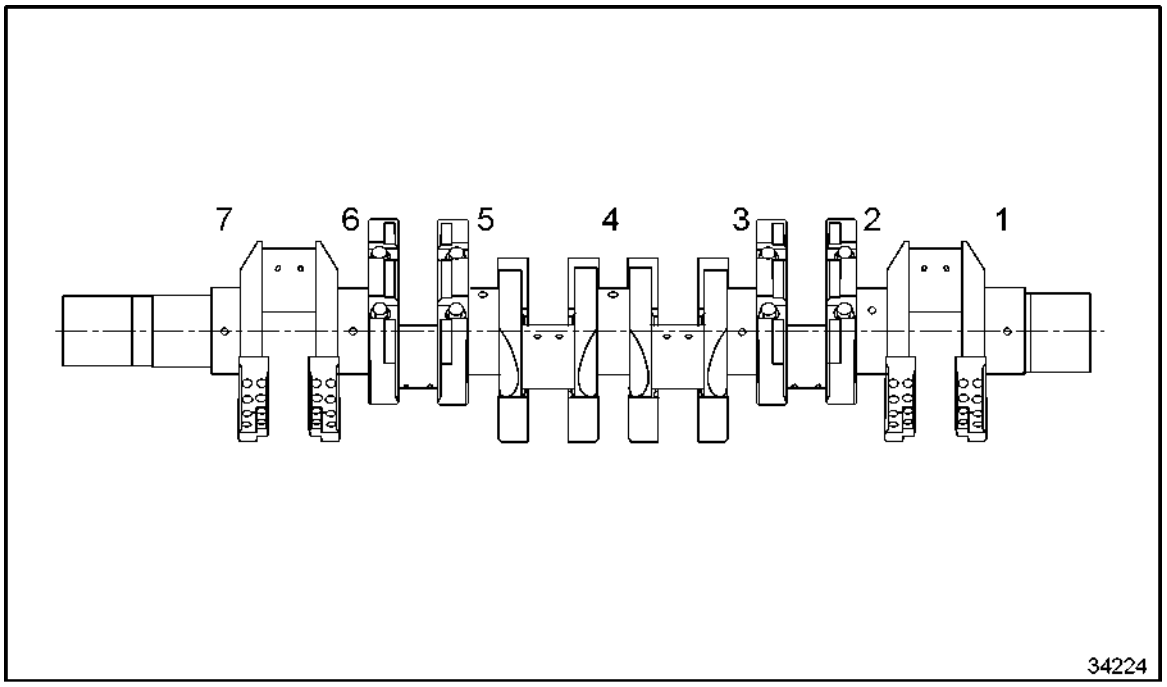


Figure 212 Dynamic Balancing of 12V Crankshaft

2. Listed in Table 25 are the specifications for dynamically balancing the 12V crankshaft.

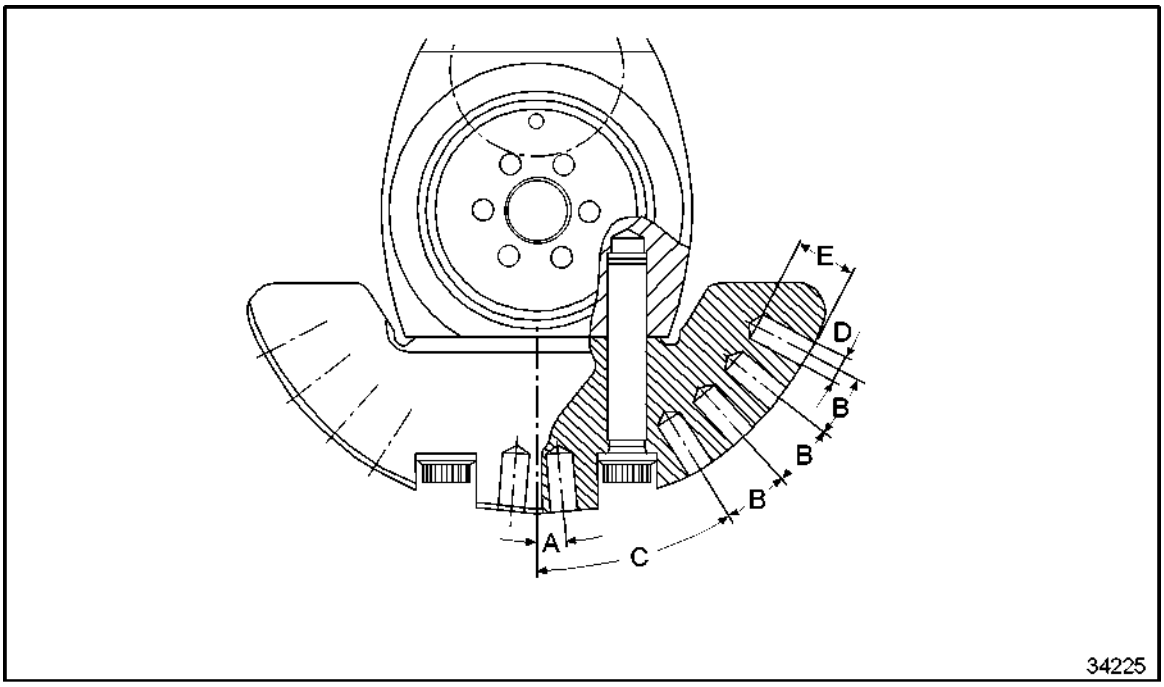
Specifications	Measurement
Mass of Balancing Group	525 kg
Maximum Operating Speed	1900 rpm
Balancing Speed	150 rpm
Permissible Residual Imbalance Per Balancing Plane for Initial Balancing	160 gcm
Permissible Residual Imbalance Per Balancing Plane for Comparative Balancing In Different Configuration or Balancing Machine	480 gcm

Table 25 Crankshaft Dynamic Balancing Specifications (12V)

3. Remove material to balance crankshaft only from counterweights by drilling radially with twist drill.
4. After balancing, recheck numbers on counterweights and renumber if necessary.

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.

[b] If bores are clean, continue inspection. See Figure 214.

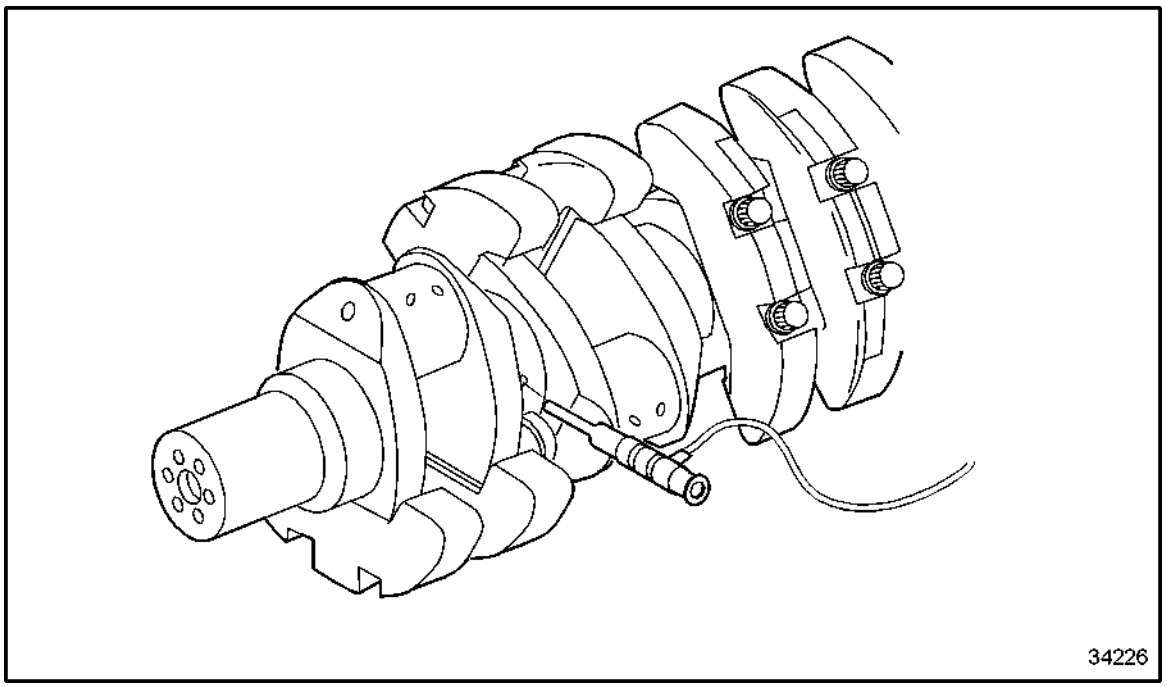


Figure 214 Inspecting Oil Bores with Borescope

Cleaning Oil Bores

To clean oil bores perform the following steps:

1. Thoroughly clean crankshaft bores with cold cleaner and suitable bristle brush.

NOTE:
Never use a wire brush.

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.

2. After cleaning, flush bores with compressed air and blow clear. See Figure 215.

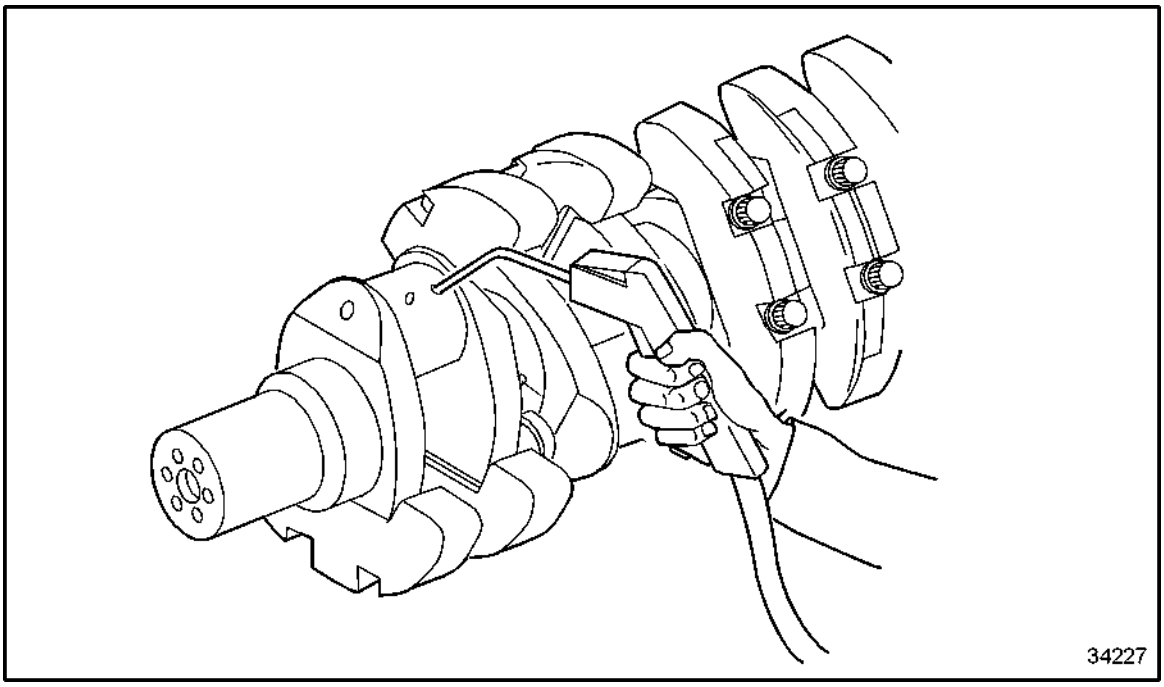


Figure 215 Cleaning Oil Bores with Compressed Air

Measuring Main Bearing Shells Fit to Main Bearing Bore

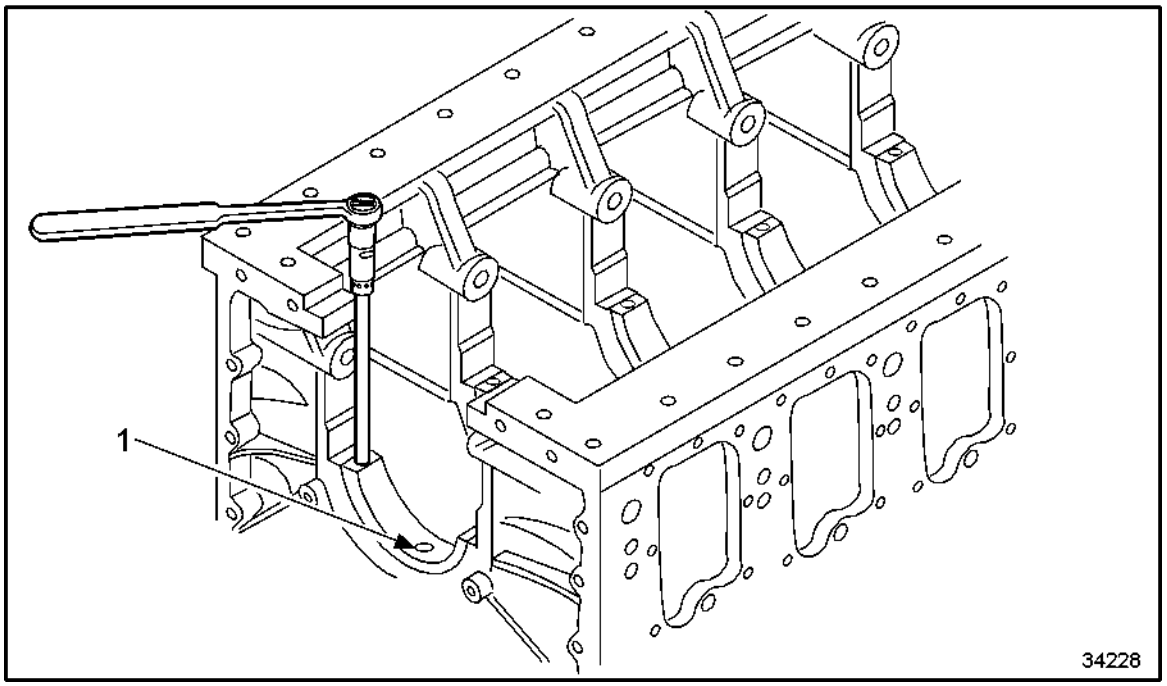
NOTE:
The main bearing bore must first be tested without installed main bearings and then with installed main bearings. The following describes the test with installed main bearings. The procedure is the same for testing the main bearing bore without installed main bearings.

Installing Main Bearing Shells

To install bearing shells perform the following steps:

NOTE:
Ensure that all components are perfectly clean.

1. Turn cylinder block upside down in engine stand with oil pan mating face horizontal.
2. Clean oil bores (1) for crankshaft main bearing in cylinder block and bearing shells on both sides. See Figure 216.

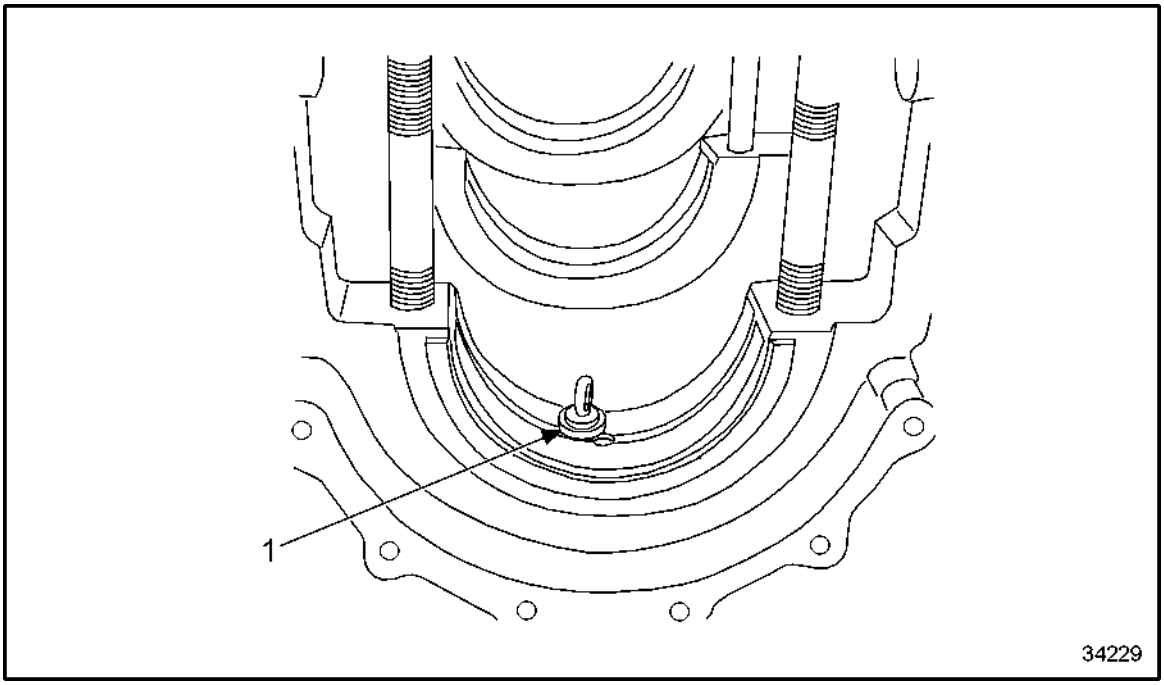


1. Oil Bore

Figure 216 Installing Main Bearing Shells

NOTE:
Check codes for repair size and journal diameter of new shells and bearing number of used shells. These markings must be on sides facing toward flywheel end. Compare cylinder block data sheet and crankshaft data sheet.

3. In accordance with bearing number, manually insert bearing shells on web side into web bore to form a positive connection, and align with bearing alignment tool (1). See Figure 217.



1. Bearing Alignment Tool

Figure 217 Aligning Bearing Shells with Housing Bore

4. Oil bores in bearing shells and cylinder block must be aligned.

Installing Main Bearing Caps

To install main bearing caps, perform the following steps:

1. Clean main bearing shell mating surfaces on main bearing cap. See Figure 218.

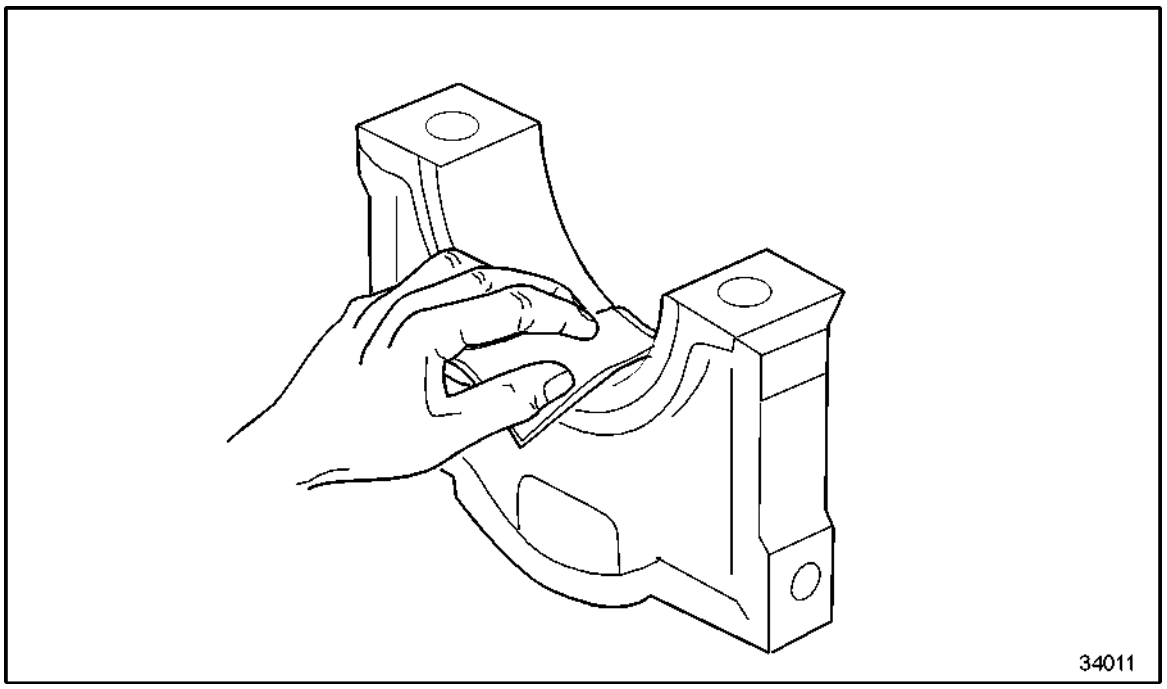


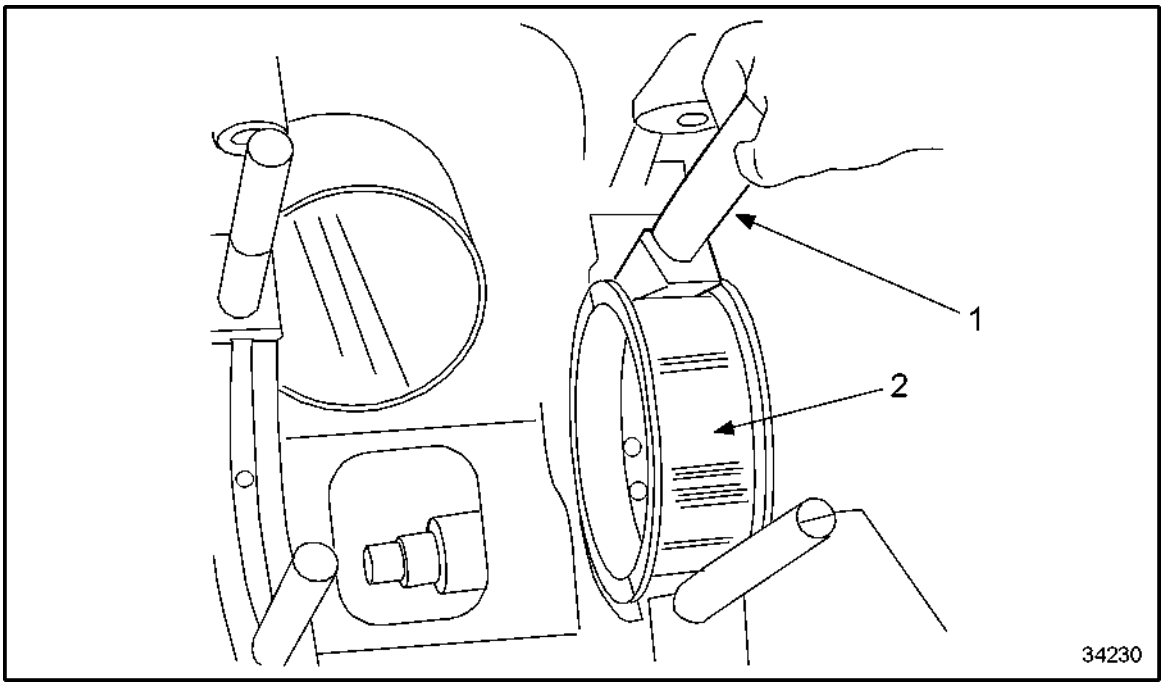
Figure 218 Cleaning Main Bearing Cap

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.

2. Check that mating surfaces on main bearing cap and on bores are clean; blow out with compressed air.
3. Clean main bearing shell on both sides and insert into main bearing cap according to markings or bearing number.
4. Bearing numbers on shells must be aligned, and all numbers must be toward flywheel end.

5. Position main bearing installation tool (1) between main bearing cap stud and end of main bearing cap shell (2) on butting joint side. See Figure 219.



1. Main Bearing Installation
2. Main Bearing Shell

Figure 219 Positioning Tool between Main Bearing Cap Stud and Rear Surface of Bearing Shell

6. Compress main bearing shell (2) until gear case end can be pressed down onto butting surface of main bearing shell. See Figure 219.
7. Butting joint must be closed.
8. Horizontally align bearing shells in center of cap and block bore.
9. Install main bearing caps.

10. Measure stud used with main bearing caps, see Figure 220 and refer to section C 031.05.01.

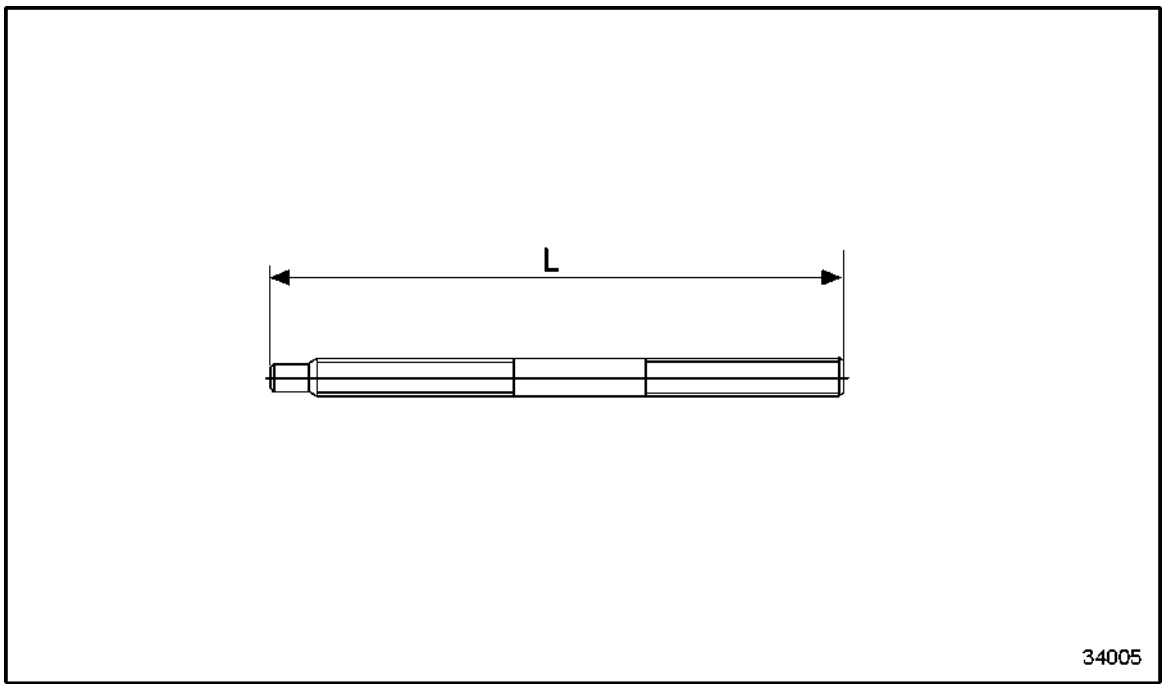


Figure 220 Measuring Stud for Cylinder Block Bearing Cap

NOTE:
Main bearing caps must not be interchanged.

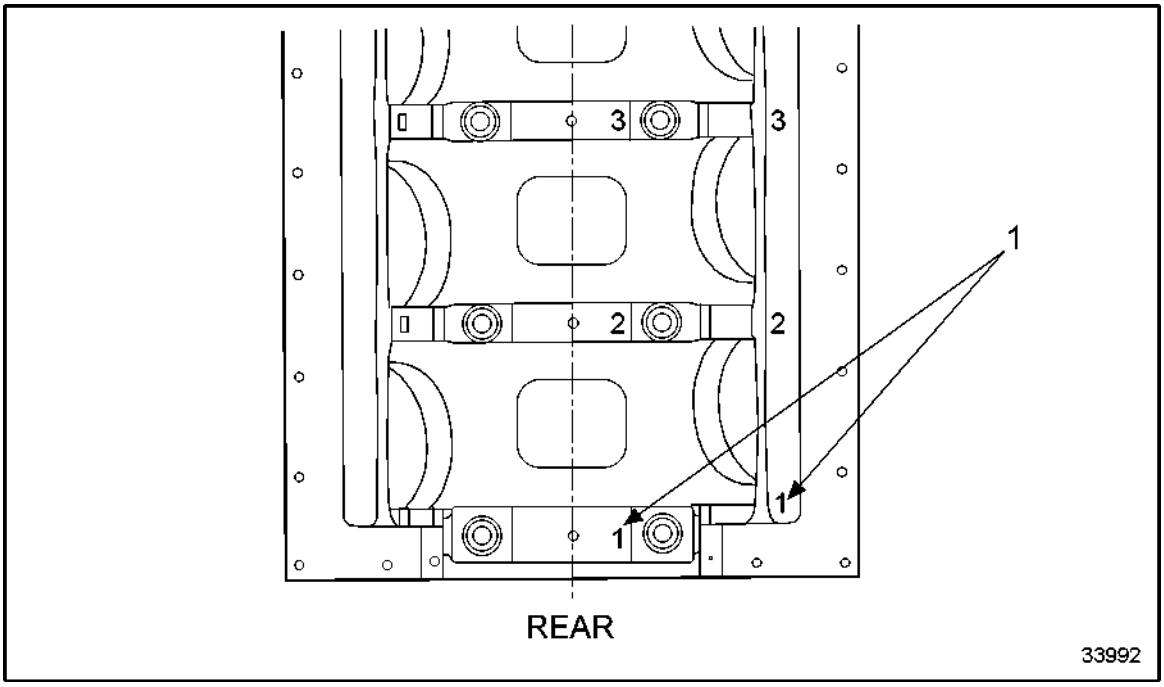
11. Check that thread and shaft are in perfect condition.
    [a] If thread or shaft are damaged, replace stud.
    [b] If thread or shaft are not damaged, continue inspection.

NOTE:
Check only those studs that had to be removed for length.

CAUTION:

To avoid a hand injury while handling sharp-edged components, wear protective gloves. Handle components only when wearing protective gloves.

12. Install main bearing cap to respective bearing bore according to cylinder block marking. See Figure 221.



1. Identification Number

Figure 221 Verification of Cylinder Block Main Bearing Cap Markings

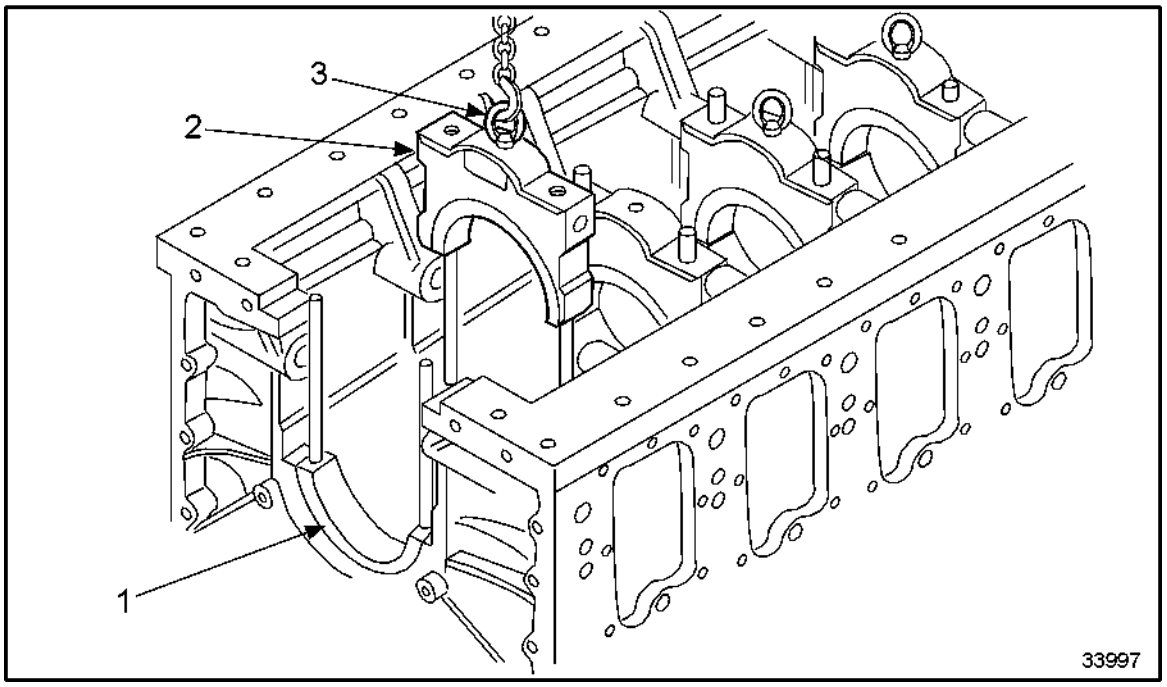
CAUTION:

To avoid injury keep fingers clear of bearing cap during installation. The narrow gap can cause risk of finger crushing.

NOTICE:

To avoid damage to main bearing, do not drop main bearing cap on main bearing.

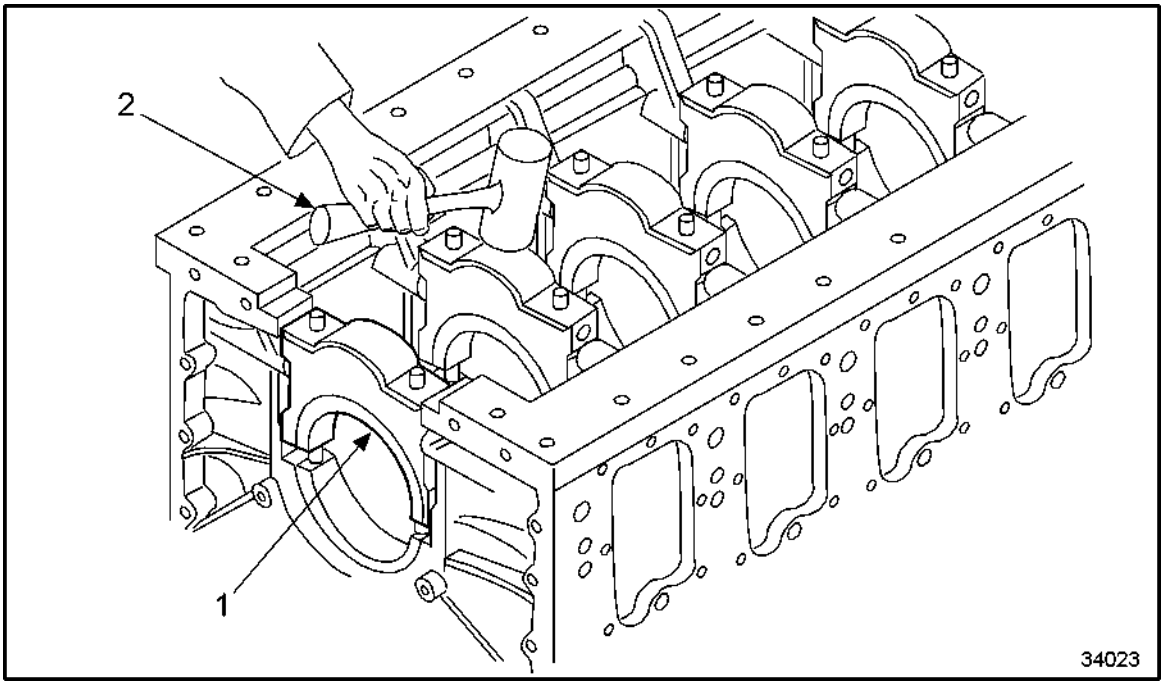
13. Position the main bearing cap on respective bearing bore in block. See Figure 222.



1. Upper Main Bearing Bore
2. Main Bearing Cap
3. Lifting Eye

Figure 222 Positioning Main Bearing Cap

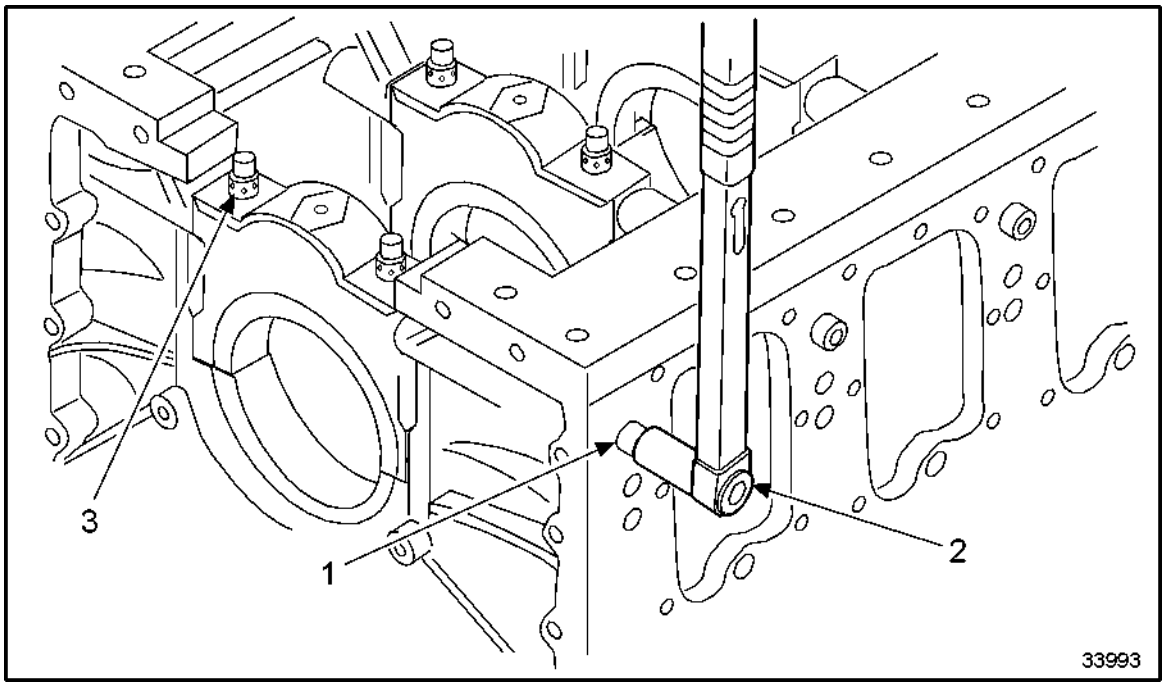
14. Using a mallet, tap main bearing cap lightly to settle it in final position. See Figure 223.



1. Main Bearing Cap
2. Mallet

Figure 223 Tapping Main Bearing Cap with Mallet

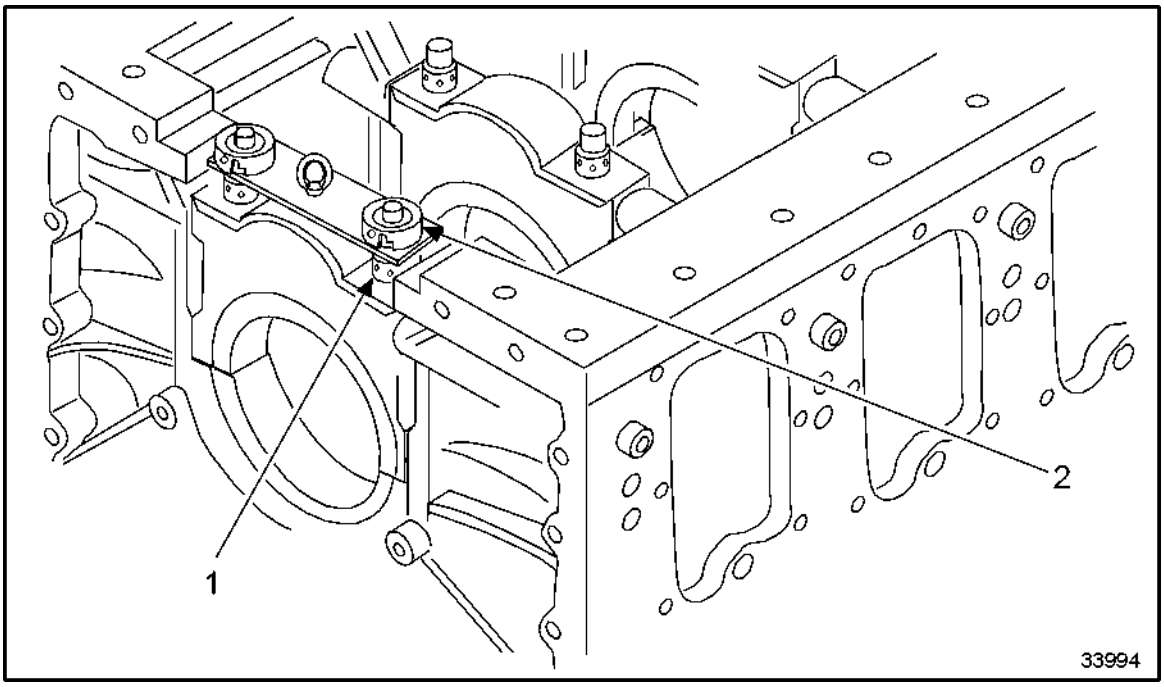
15. Coat thread and mating surface of main bearing cap stabilizer bolts (1) with engine oil and insert main bearing cap stabilizer bolts, but do not tighten yet. See Figure 224.



1. Main Bearing Cap Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing cap Nut

Figure 224 Installing Main Bearing Cap Stabilizer

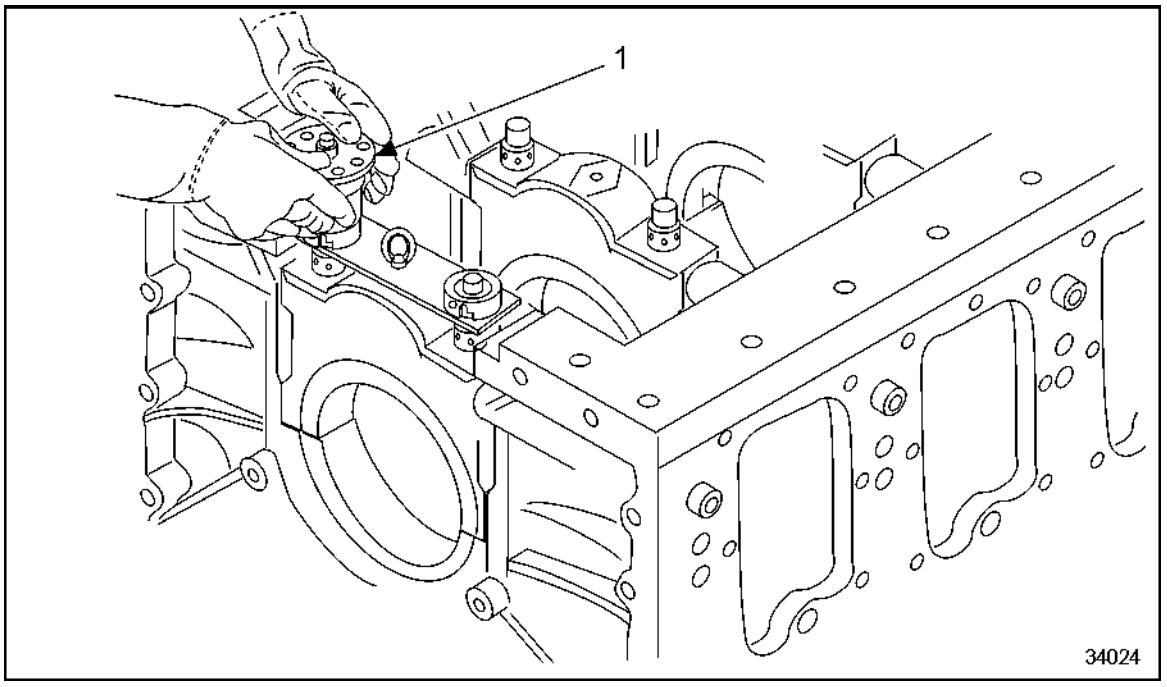
16. Beginning with the first main bearing cap (flywheel end), place main bearing cap nut (1) on studs (2) of respective main bearing cap. See Figure 225.



1. Main Bearing Cap Nut
2. Main Bearing Pretensioner Nut Stud

Figure 225 Attaching Main Bearing Cap Nut

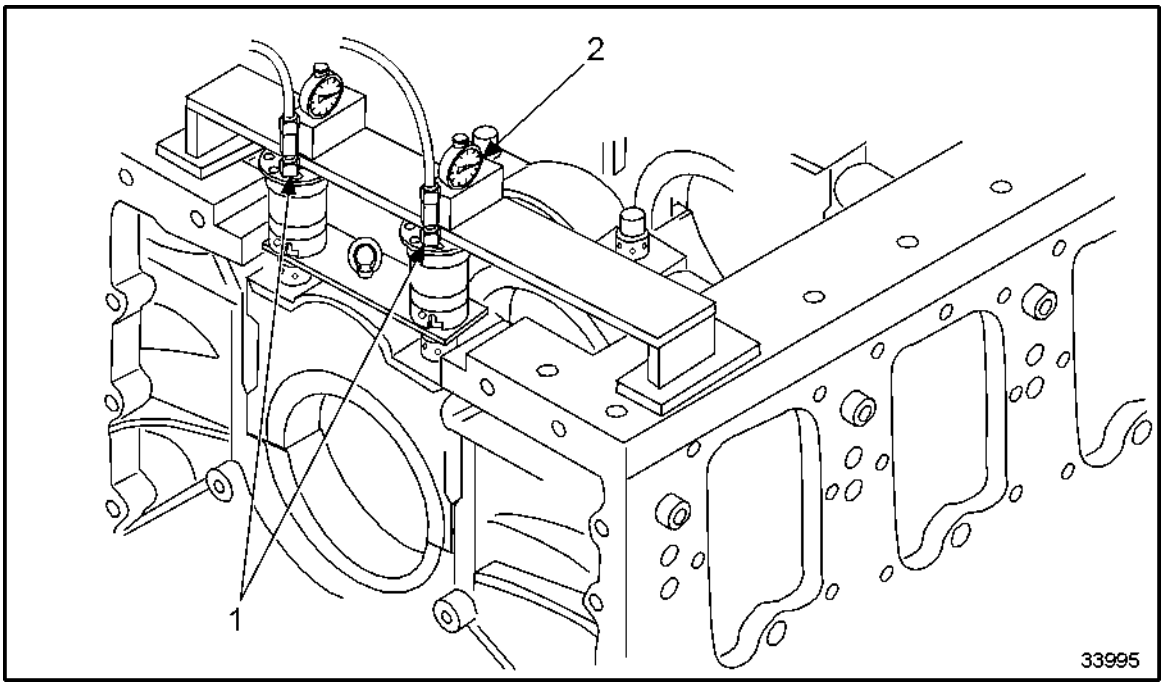
17. Install hydraulic pretensioner (1) by hand until contact is made and turn back one turn. See Figure 226.



1. Hydraulic Stud Pretensioner

Figure 226 Installing Hydraulic Bolt Pretensioner

18. Connect high-pressure hose of hydraulic hand pump (1) to hydraulic pretensioner. See Figure 227.



1. High-pressure Hose of Hydraulic Hand Pump
2. Magnetic Dial Gage

Figure 227 Connecting High-Pressure Hose of Hydraulic Hand Pump

19. Mount magnetic dial gage (2) holders with dial gages to cylinder block pan rail. See Figure 227.
20. The dial gages are for measuring the elongation of the studs.

21. Position the two dial gage styluses centrally on the respective measuring core (arrow) on the face of the sleeve measuring pin. See Figure 228.

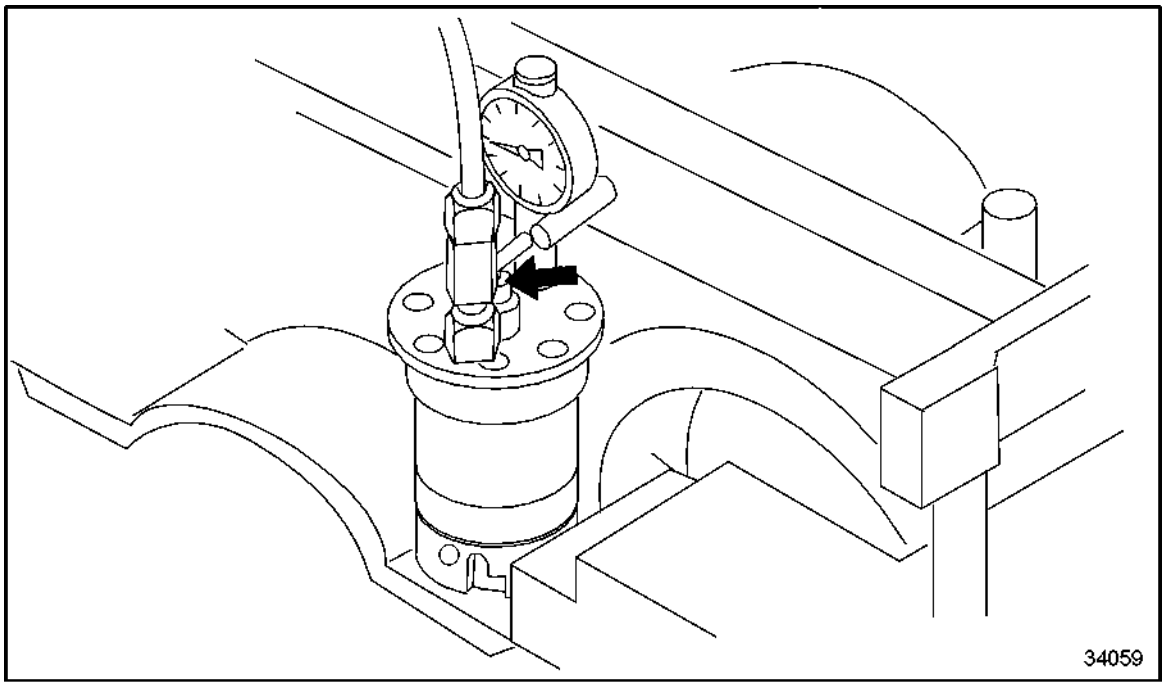


Figure 228 Positioning Dial Gage Styluses

22. Set dial gages to zero with preload.

23. Operate hydraulic hand pump and elongate studs at same time (maximum 1.20 mm [0.0472 in.]). Use pin to install nuts on main bearing cap. See Figure 229.

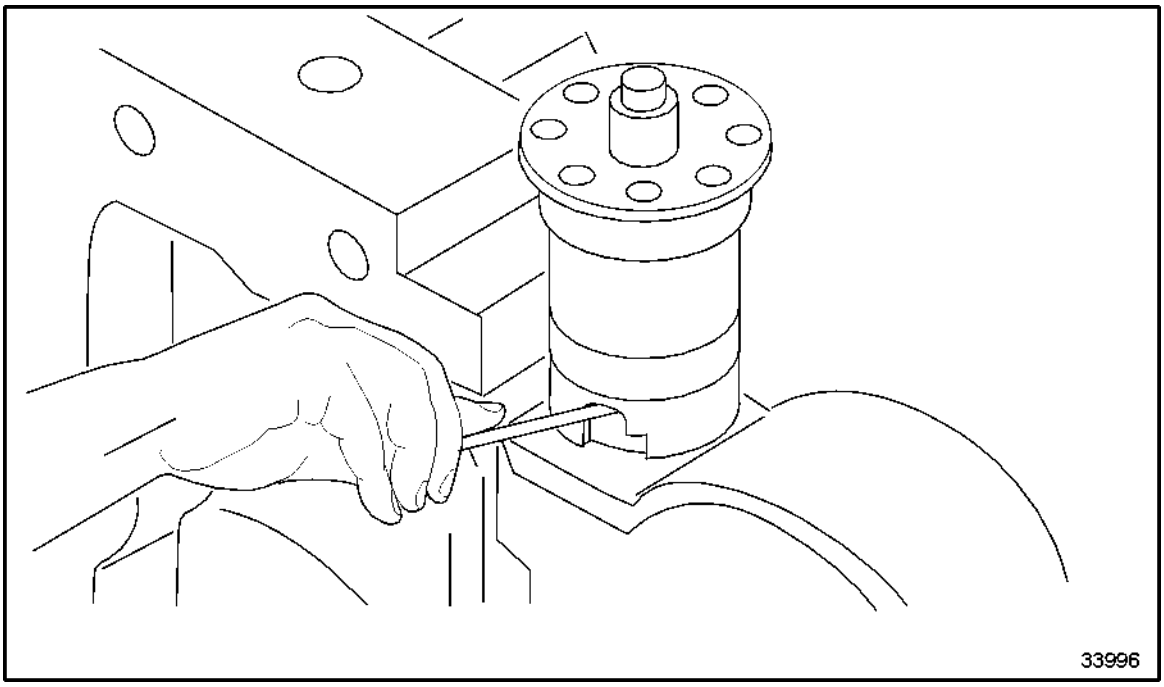
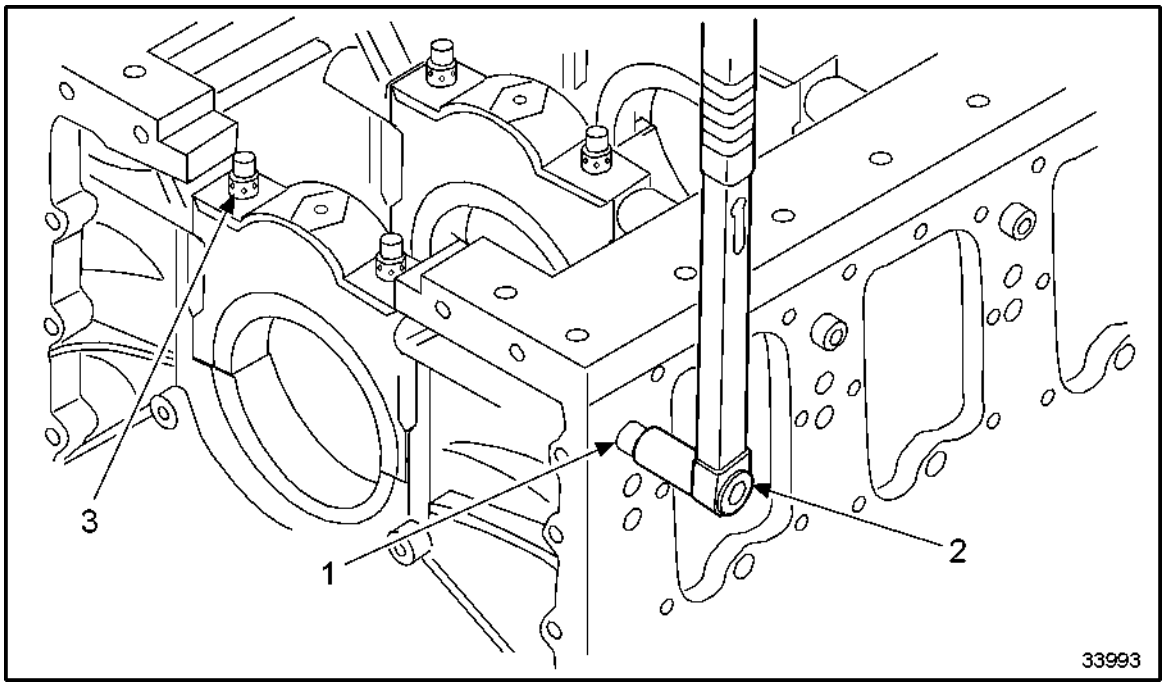


Figure 229 Installing Nuts on Main Bearing Cap with a Pin

24. Relieve tension on studs.
25. Mount dial gages with magnetic holders and hydraulic preloading devices on studs of next adjacent main bearing cap.
26. Install all nuts in same order.

NOTE:
Remaining elongation of studs after release: 0.95 mm (0.037 in.)

27. If remaining elongation of studs is outside tolerance, release nuts. Refer to section C 031.05.05 and repeat nut tightening procedure; if necessary, replace studs.
28. Tighten side hex socket bolts (1) to specifications in same sequence as when tightening bearing caps. Torque to specification. Refer to section A 003. See Figure 230.



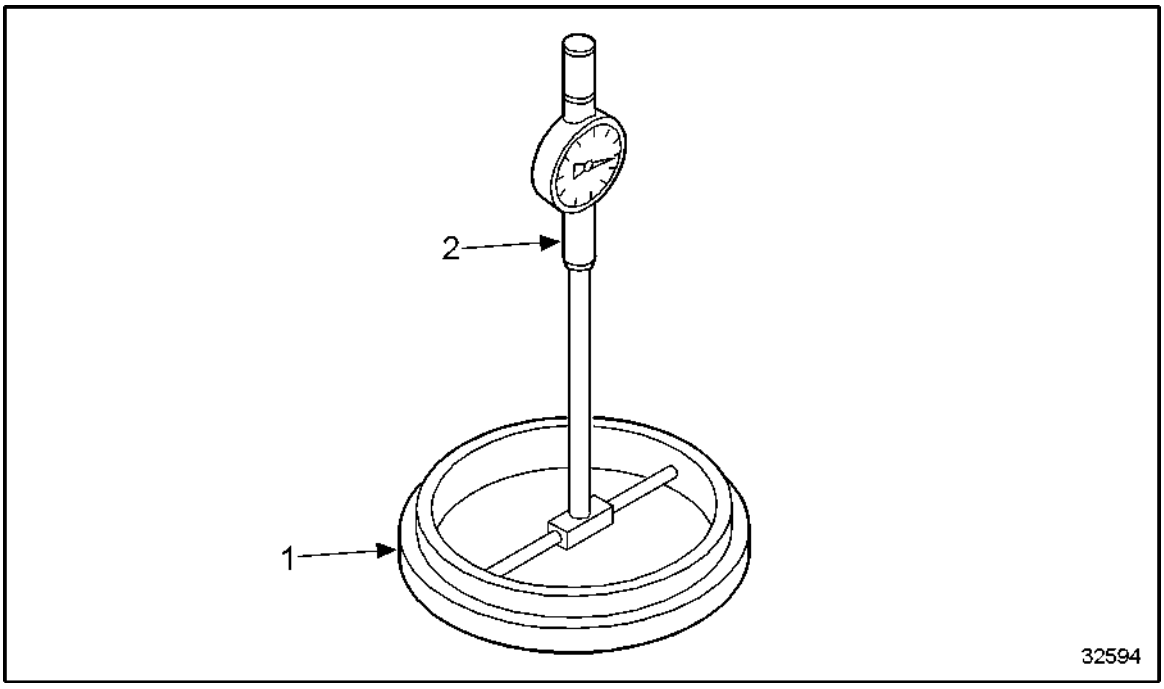
1. Main Bearing Cap Stabilizer Bolt
2. Ratchet and Socket Wrench
3. Main Bearing Cap Nut

Figure 230 Tightening Main Bearing Cap Stabilizer Bolts

Measuring Main Bearing I.D.

Perform the following steps to measure main bearing I.D.

1. Adjust bore gage and dial bore gage (1) with micrometer or gage ring (1) to basic size for main bearing bore. See Figure 231.

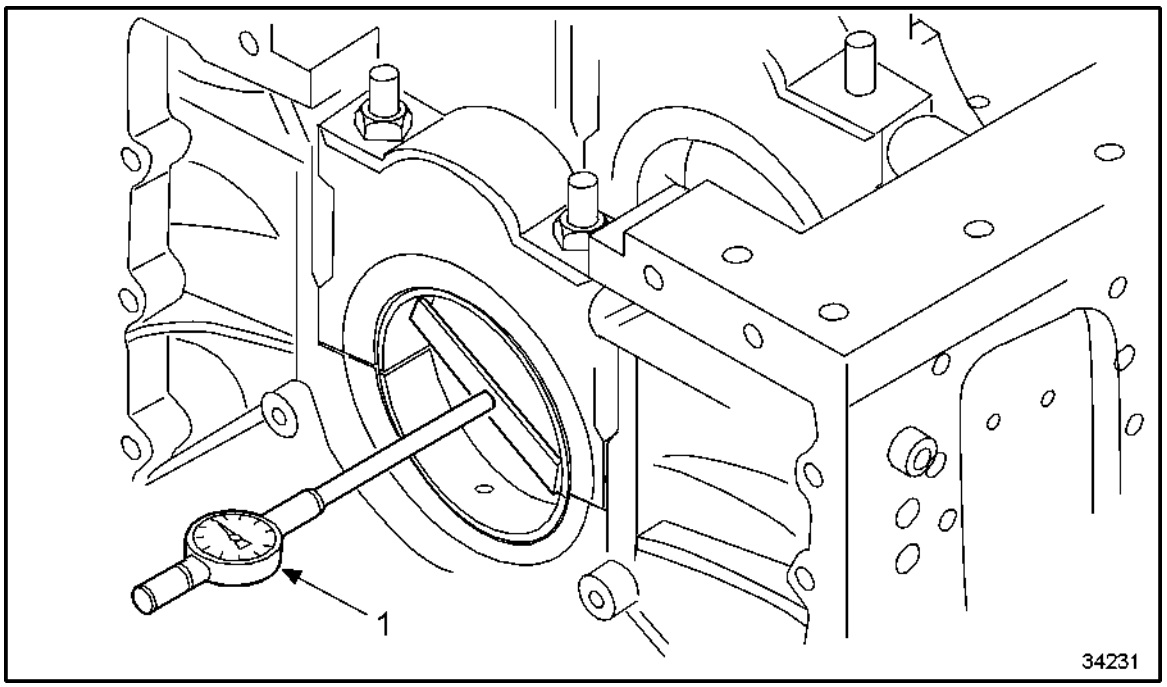


1. Adjusting Gage Ring
2. Dial Bore Gage

Figure 231 Measuring Main Bearing I.D.

2. Coat wear surfaces of main bearing shells with engine oil.

3. Measure I.D. of main bearing bore with shells installed. See Figure 232.



1. Bore Gage

Figure 232 Measuring I.D. of Main Bearing Bore

[a] If measuring points or limit values are exceeded, replace main bearing shells.

[b] If measuring points or limit values are not exceeded, continue inspection.

4. Enter measurement values in data sheet.
5. After measuring main bearing bore I.D., mark bearing shell according to bearing shell number, if necessary.

NOTE:
Loosen nuts of one bearing at a time, refer to section C 031.05.05.

6. Loosen and remove main bearing cap stabilizer.

C 031.05.10 – ASSEMBLY OF CRANKSHAFT

Perform the following steps to assemble the cylinder block.

1. Measure shaft length of bolts for counterweights; for maximum shaft length, see Figure 233and refer to section C 031.05.01.

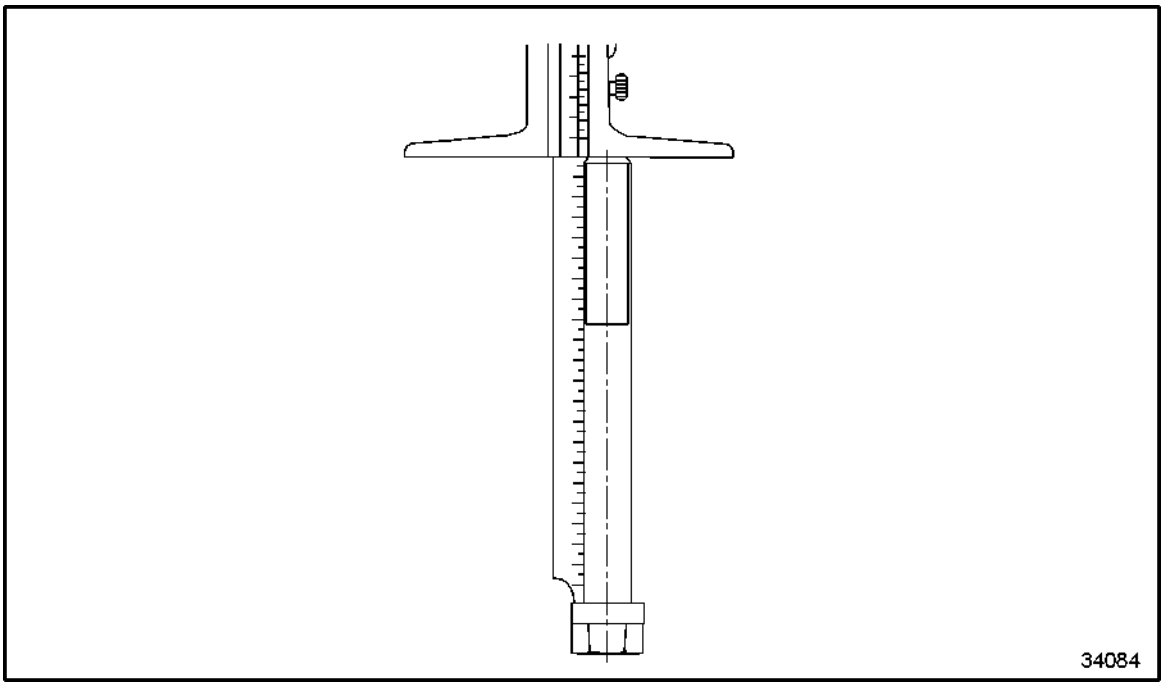
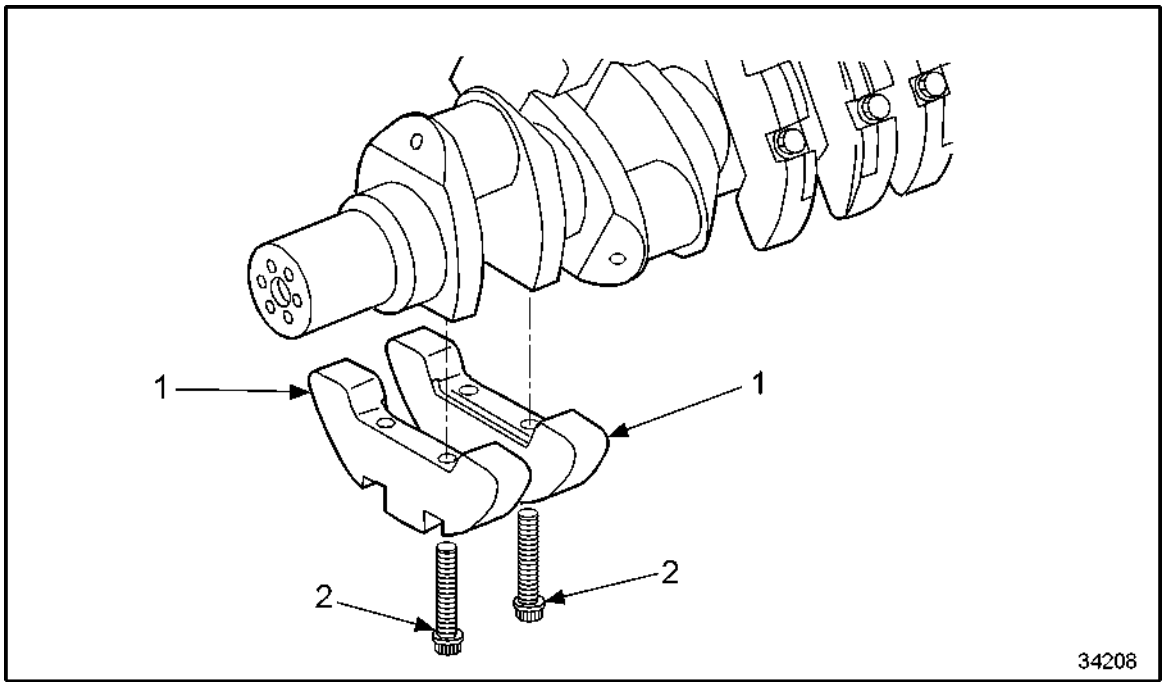


Figure 233 Measuring Shaft Length of Cylinder Head Bolts

2. Clean and degrease mating surface on crankshaft and counterweight (1). See Figure 234.



1. Counterweight
2. Mounting Bolts

Figure 234 Installing Bolts and Counterweights

3. Coat threads and head mating surface of mounting bolts (2) with engine oil. See Figure 234.

NOTE:
Install counterweights (1) in accordance with markings.

4. Fit counterweight on crankshaft and tighten slightly with bolts. See Figure 234.

5. Set counterweight to marking (A) and pretighten bolts to specified pretightening torque. See Figure 235and refer to section C 031.05.02; torque to specification. Refer to section A 003.

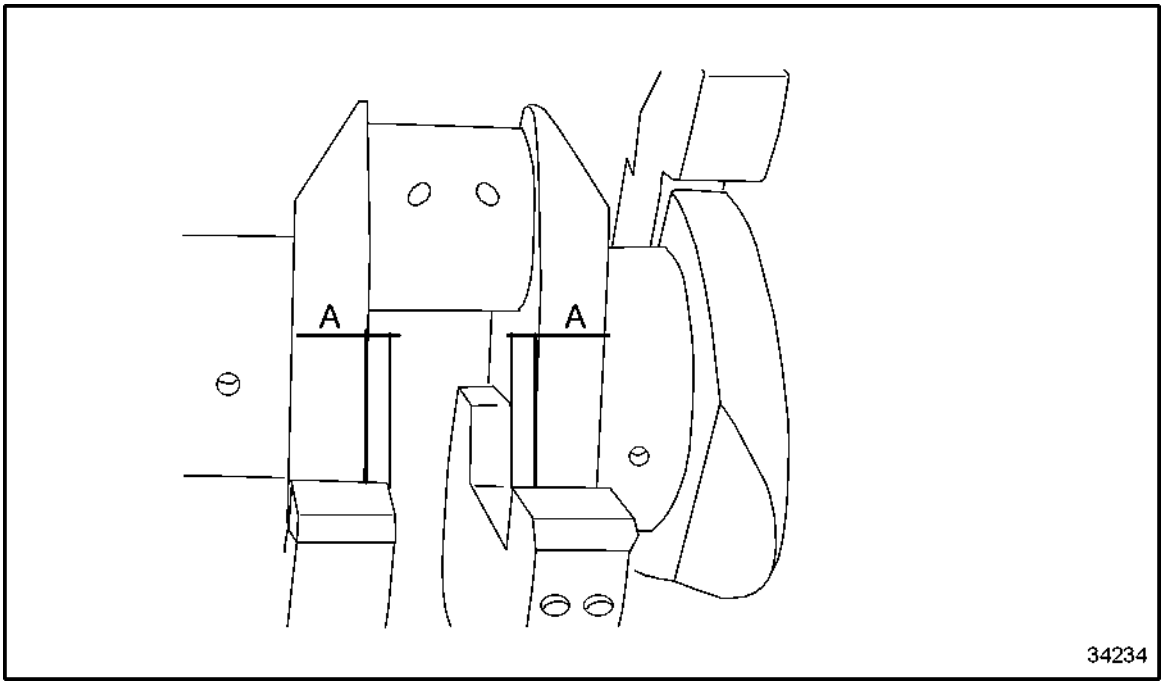


Figure 235 Setting Counterweight to Markings

6. Check that marks applied prior to disassembly and measured distances are correct.
7. Mark counterweight bolt heads.

8. Tighten bolts through specified additional angle of rotation to specification. Refer to sectionA 003. See Figure 236.

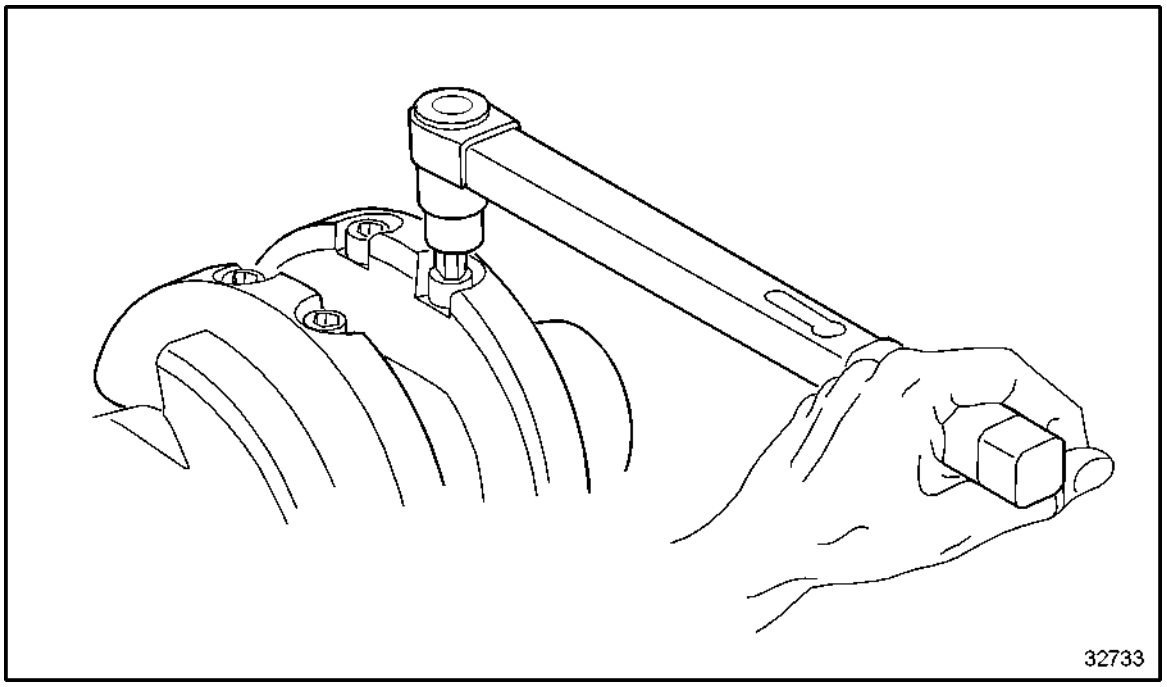


Figure 236 Tightening Counterweight Bolts

9. After installing counterweights, recheck identification marks on counterweights and webs.

NOTE:
If new counterweights have been installed, dynamically balance crankshaft. Beginning at flywheel end, apply identification numbers to counterweights using punch numerals.

10. Clean and degrease surface of main journal and gear bore.

CAUTION:

To avoid injury while handling 'HOT' components, wear protective gloves and clothing.

11. Heat crankshaft gear, fan end, with heating unit to approximately 180°C (356°F). See Figure 237.

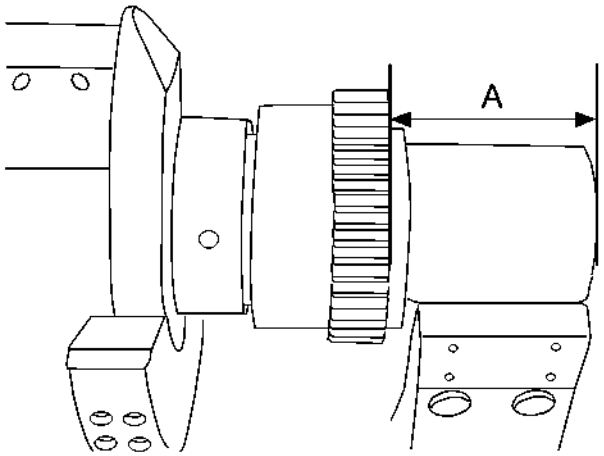


Figure 237 Calculating Force-On Distance

12. Install heated crankshaft gear on crankshaft. See Figure 237.
13. Calculate force-on distance (A) by measuring distance from end surface of crankshaft to end surface of crankshaft gear with depth gage. See Figure 237.
14. Force-on depth (A) measured from face of crankshaft to surface of crankshaft gear is 145.2 — 145.8 mm (5.7165 — 5.7402 in.). See Figure 237.
15. When the components have cooled, lubricate crankshaft gear with engine oil.
16. Coat O-ring with petroleum jelly and fit in groove on crankshaft. See Figure 237.

C 031.05.11 – INSTALLATION OF CRANKSHAFT

Perform the following steps to install crankshaft.

NOTE:
Ensure that all components are perfectly clean.

1. Spray running surfaces of cylinder block main bearing shells with engine oil.
2. Clean crankshaft bearing surfaces. See Figure 238.

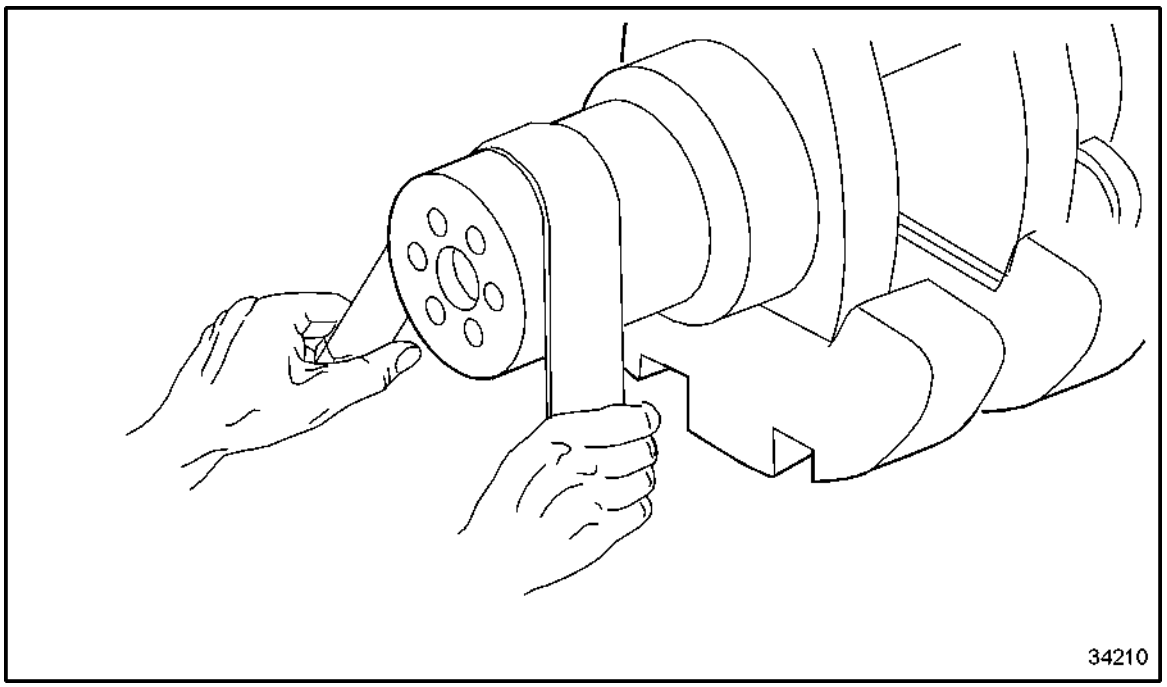
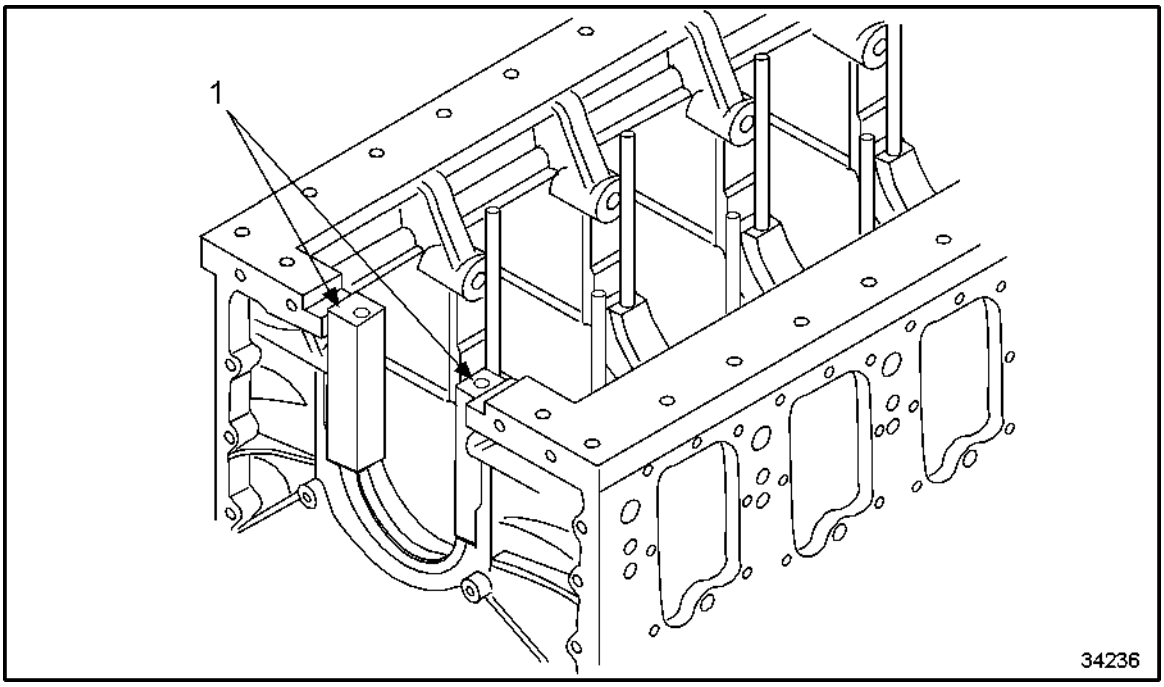


Figure 238 Polishing Crankshaft with Emery Cloth

3. Inspect oil bores with lamp, and ensure they are perfectly clean.

4. To protect crankshaft, slip four protective sleeves (1) over main bearing cap studs of first and last bearings. See Figure 239.



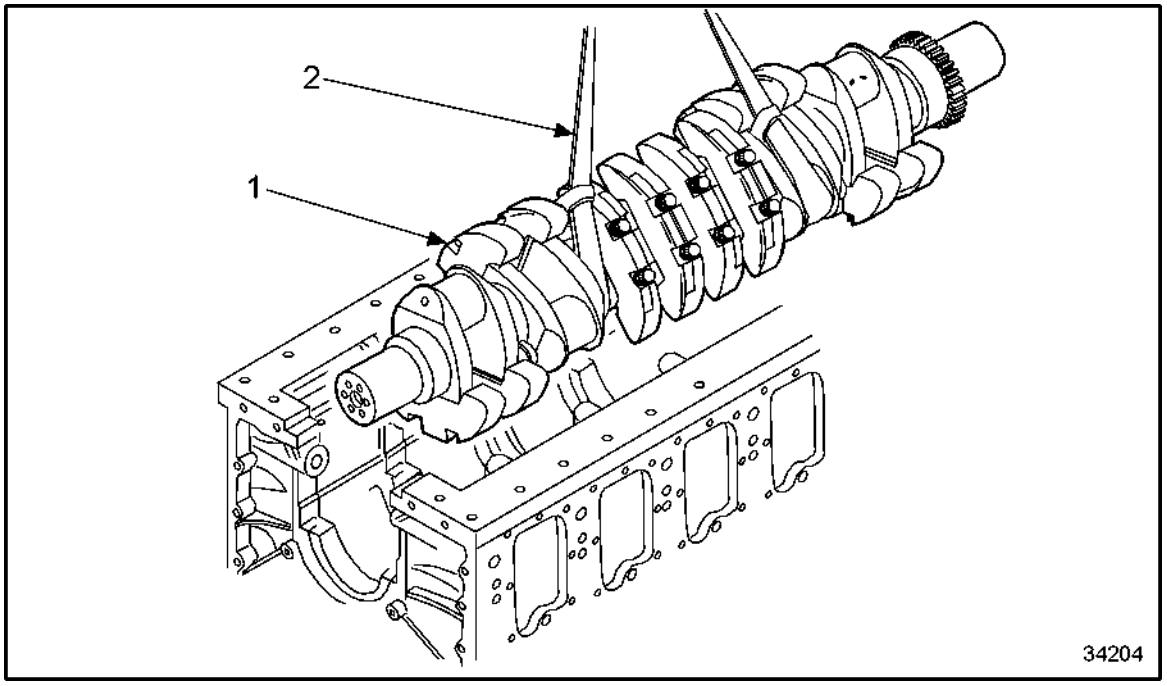
1. Protective Sleeves

Figure 239 Inserting Protective Sleeves

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.

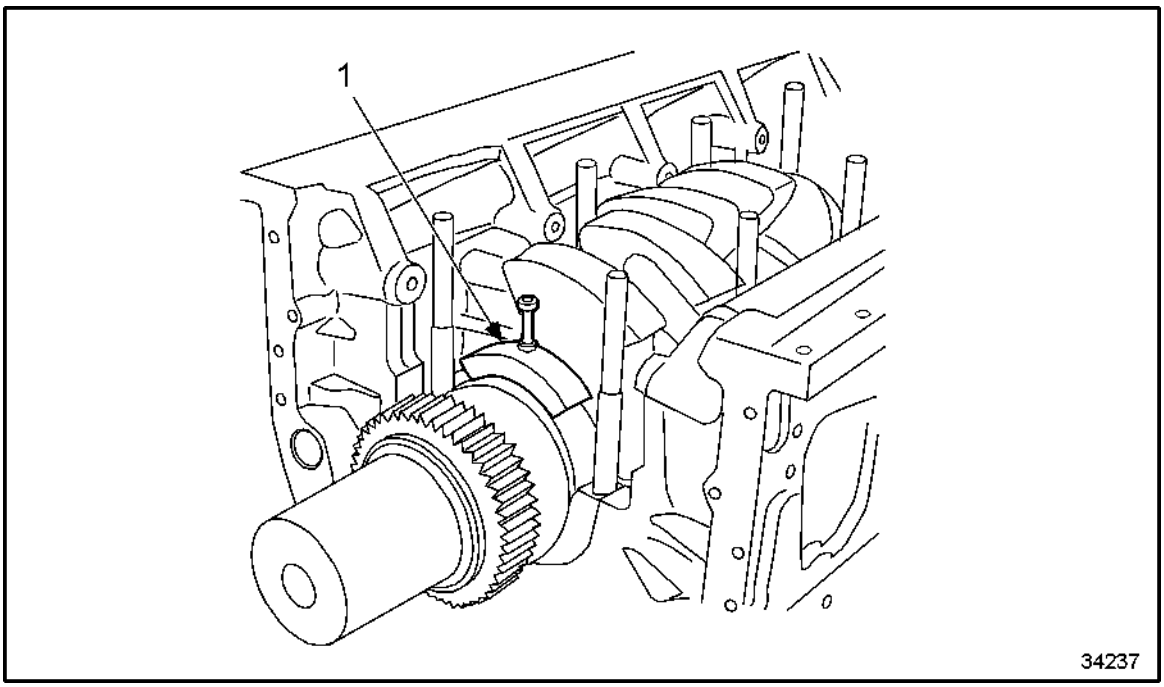


1. Crankshaft
2. Lifting Device

Figure 240 Lowering Crankshaft

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

7. Lower crankshaft slowly onto the upper main bearing shells. See Figure 241.



1. Bearing Installation

Figure 241 Lowering Crankshaft onto Upper Main Bearing Shells

8. Remove protective sleeves.

NOTE:
The crankshaft may not be turned before mounting the lower main bearings.

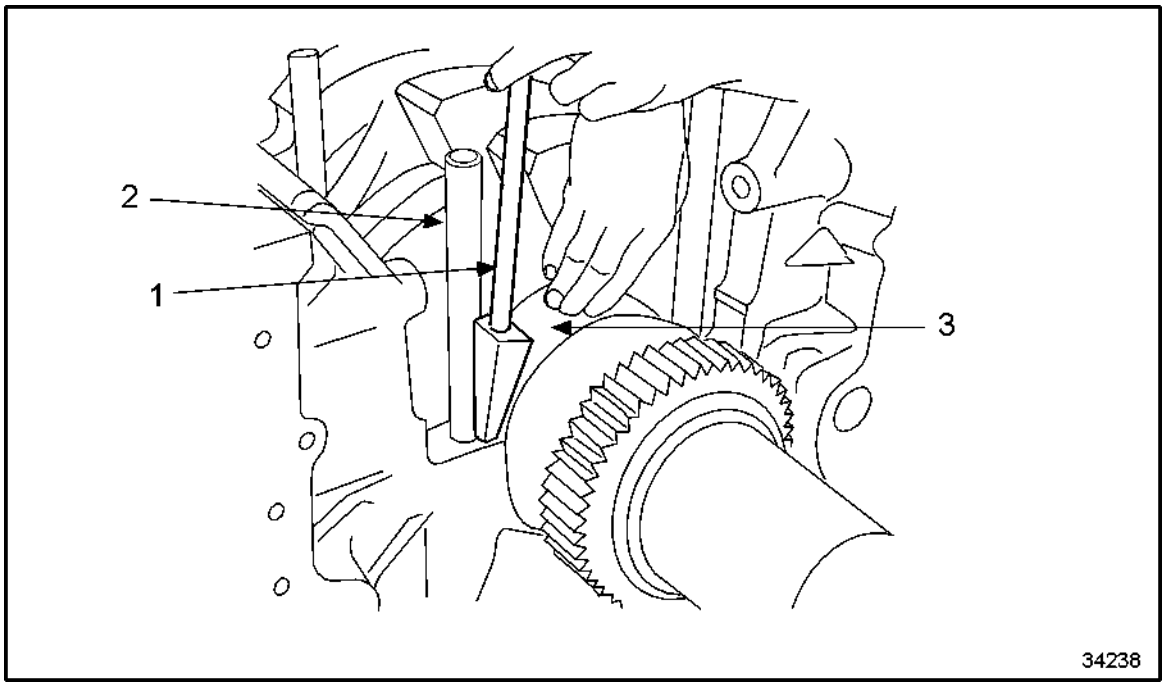
CAUTION:

Engine oil is hot and can contain combustion residues which are harmful to health. To avoid injury, wear protective gloves. Avoid extended and intensive contact with skin. Do not inhale oil vapor.

9. Clean the lower main bearing shell and main bearing cap, and coat the running surface with engine oil.
10. Insert the lower main bearing shells with bearing installation tool.

NOTE:
The numbers of the main bearing cap locations must align and face toward the flywheel end direction.

11. Position bearing alignment tool (1), J 34199, between main bearing cap stud (2) and rear face of shell on butting joint side. See Figure 242.



1. Bearing Alignment Tool
2. Main Bearing Cap Stud
3. Main Bearing Shell

Figure 242 Positioning Bearing Installation Tool Between Bearing Cap Stud and Rear Face of Shell

12. To release the tension, press the main bearing shell on the side of the cover against the bearing shell on the side of the housing.

NOTE:
Butting joint must be closed.

13. Bearing shells (upper and lower) must be centered in the main bearing bore.

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.

14. Check that mating surfaces on main bearing cap and bores are clean, and blow out with compressed air.

CAUTION:

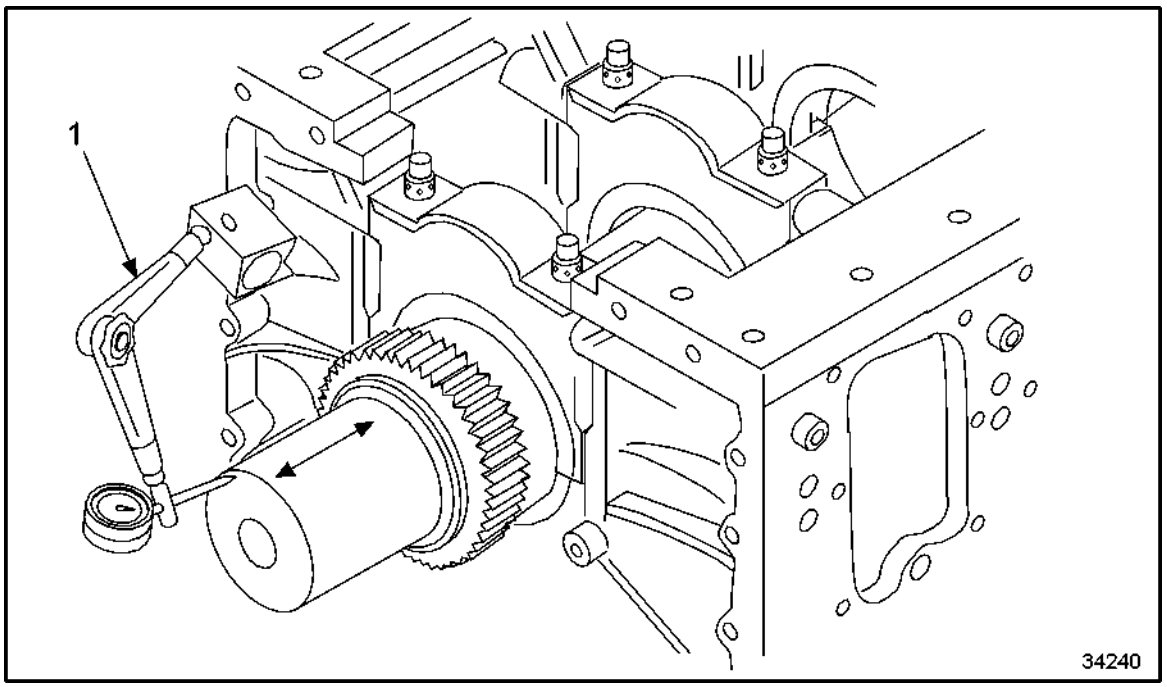
To avoid an eye injury when spraying engine lubrication oil, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

15. Spray main bearing journals with engine oil.

NOTE:
Main bearing caps must not be interchanged.

16. Repeat the main bearing cap installation procedure.

17. Mount magnetic dial gage holder with dial gage (1) on cylinder block. See Figure 243.



1. Magnetic Dial Gage

Figure 243 Measuring Crankshaft Axial Play

18. Position dial gage stylus against front surface of crankshaft.
19. Using pry bar, press crankshaft axially as far as it will go.
20. Set dial gage with preload to zero.
21. Move crankshaft from stop to stop (arrows) and enter measured value (axial clearance) in data sheet. See Figure 243.
    [a] If determined measured value is outside permissible tolerance, remove crankshaft and check cause.
    [b] If measured value is within permissible tolerance, continue installation.

C 031.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 26 are the After-Installation Operations for the crankshaft.

Level of Maintenance	Operation	Reference
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.

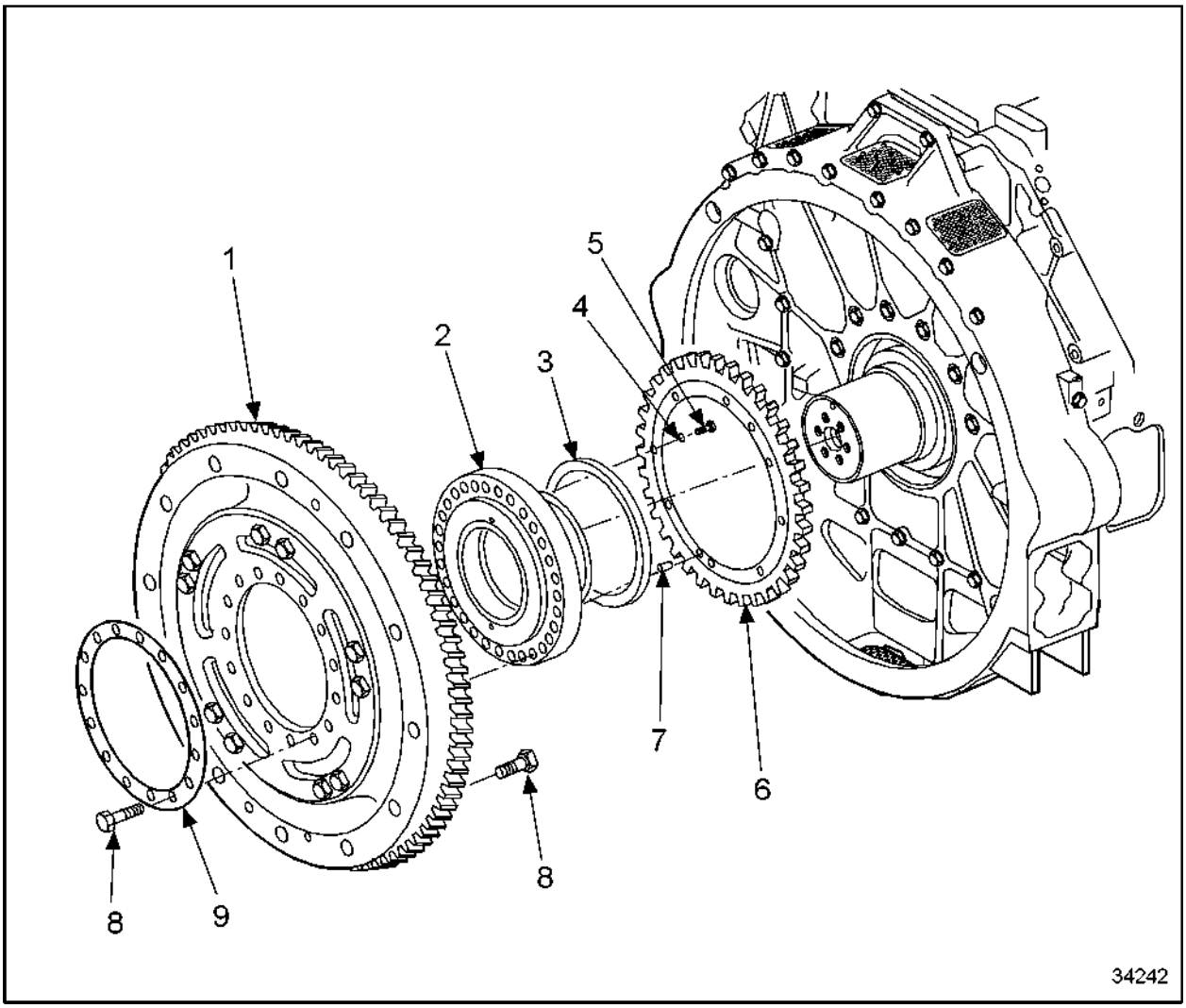
3= The engine is to remain installed.

Table 26 After-Installation Operations

C 032.05 – FLYWHEEL

C 032.05.01 – GENERAL VIEW

For a general view of the flywheel assembly, see Figure 244.



1. Flex Coupling
2. Drive Hub
3. Crankshaft Seal
4. Washer
5. Hex Bolt
6. Timing Reference Wheel
7. Spring Pin
8. Hex Bolt
9. Scuff Plate

Figure 244 General View of Flywheel

C 032.05.02 – SPECIAL TOOLS

Listed in Table 27 are the special tools required for maintenance on the flywheel.

Designation	Tool Number
Crankshaft hub installation/removal sleeve	J 42916
Crankshaft Seal Installer	J 42735
Flywheel Guide Studs	J 42999

Table 27 Special Tools

C 032.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 28 are the Before-Removal Operations for the flywheel.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operator Guidelines
1, 2, 3	Separate engine from gearbox or alternator	-

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 28 Before-Removal Operations

C 032.05.05 – REMOVAL OF THE FLYWHEEL

Perform the following steps to remove the flywheel:

1. If necessary, lock engine on flywheel ring gear of flex coupling with locking device.
2. Remove all hex bolts (arrow) from flex coupling except for one hex bolt. See Figure 245.

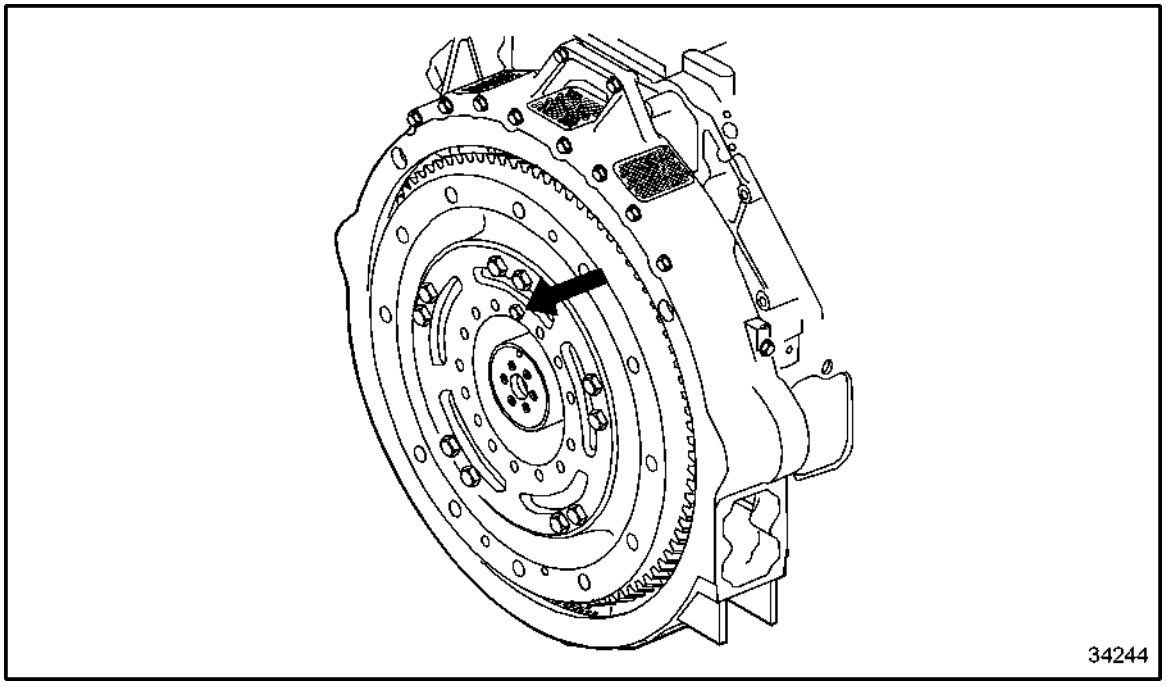
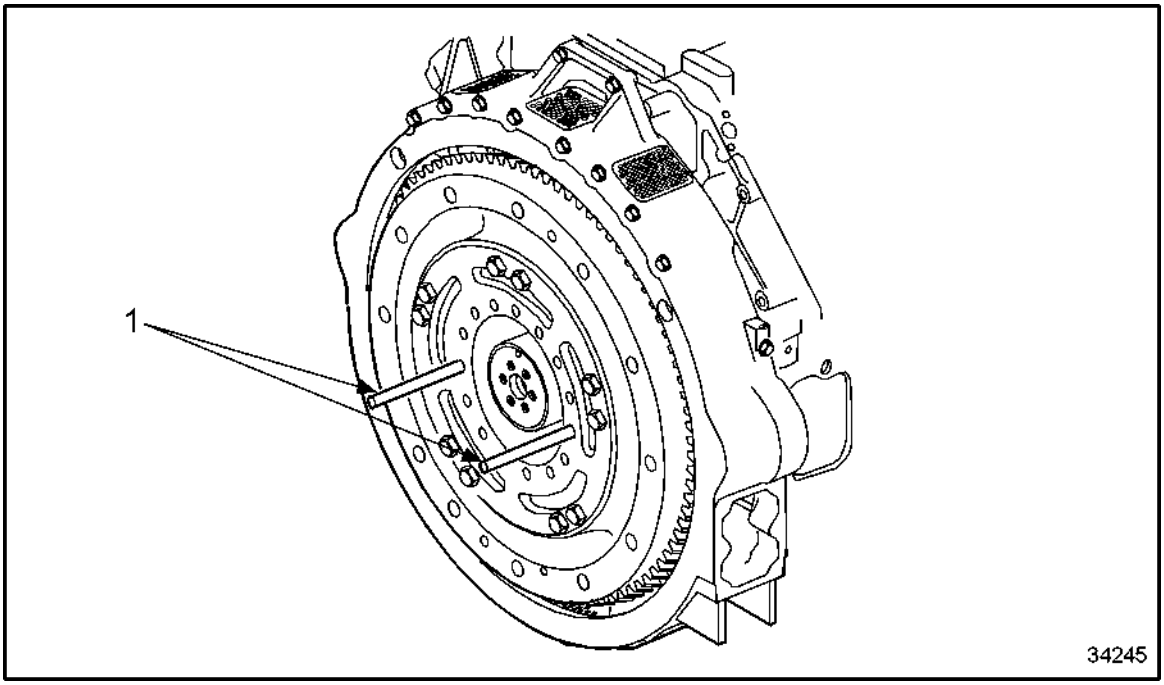


Figure 245 Removing Hex Bolts from Flex Coupling (Except One)

3. Screw in two guide pins in two opposite threaded bores of drive hub. See Figure 246.



1. Flywheel Guide Studs J 42999

Figure 246 Screwing Guide Studs into Drive Hub

4. Screw eyebolt into flex coupling.

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. Attach flex coupling to crane with a lifting device; apply slight tension. See Figure 247.

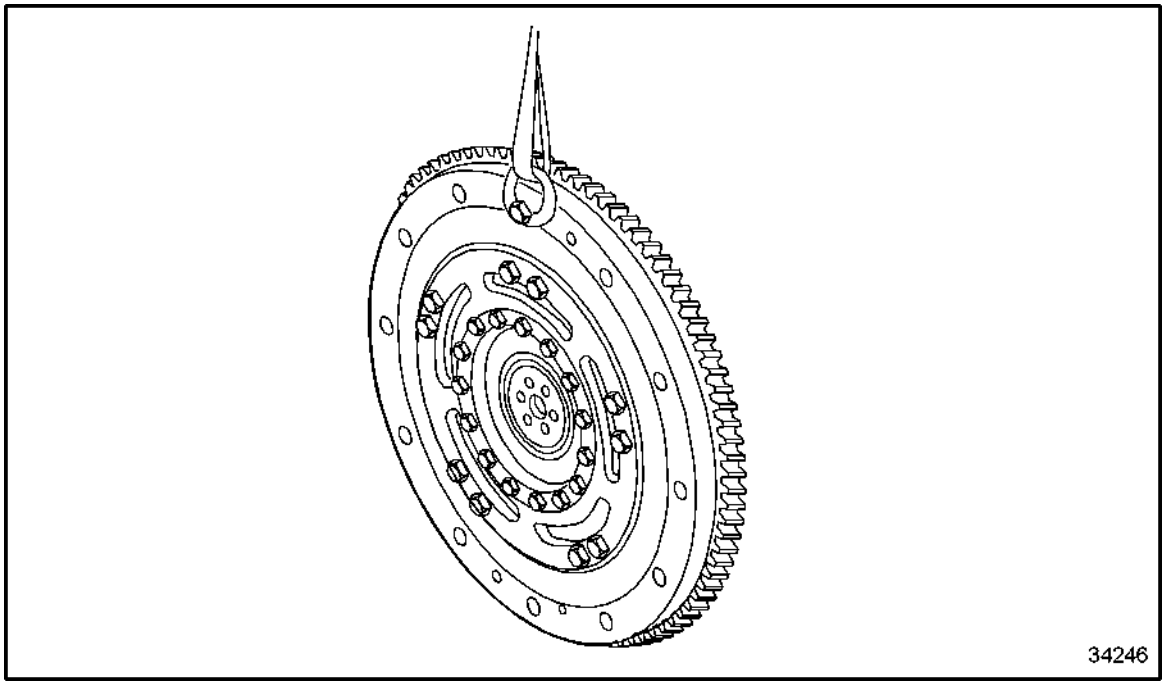


Figure 247 Lifting Flex Coupling by Eyebolt

6. Remove last hex bolt for flex coupling.

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.

7. Using crane and lifting device, remove flex coupling from flywheel housing via guide pin.
8. Remove guide pin and locking device.
9. Install the adapter hub onto the crankshaft ensuring that the arrow is aligned with the dowel hole on the crankshaft
10. Remove the plug from the drive flange expansion port.

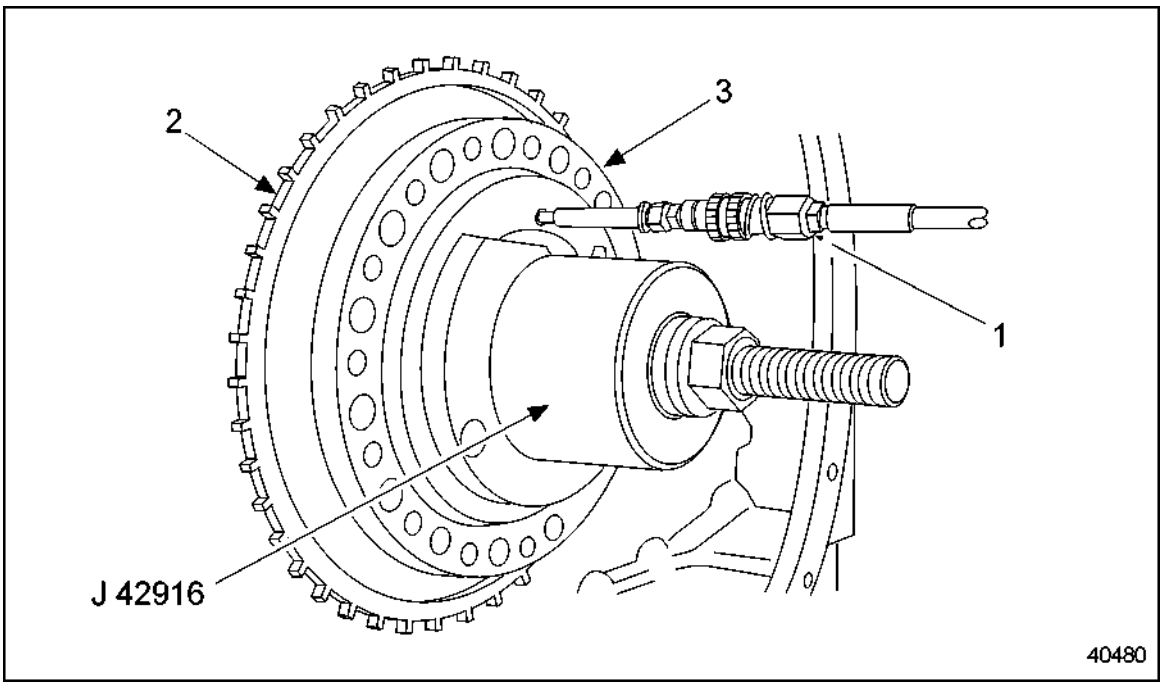
11. Install the threaded shaft into adapter hub.

CAUTION:

To avoid injury from failure of a fitting, hose, or oil cooler core, wear a face shield or goggles when conducting a pressure test.

12. Install the high-pressure line of the hand pump (1). See Figure 248.

NOTE:
Ensure that the flywheel guide studs are removed.



1. High-Pressure Line of Hand Pump
2. TRS Wheel
3. Rear Crankshaft Hub

Figure 248 Crankshaft Hub Installer Sleeve

13. Lubricate the threaded shaft, nut and washers with Anti-Seize.
14. Install the washers and nut onto the shaft. Fully tighten, then back off a distance equal to that of the push-on dimension.
15. Install the high-pressure line into the drive flange.

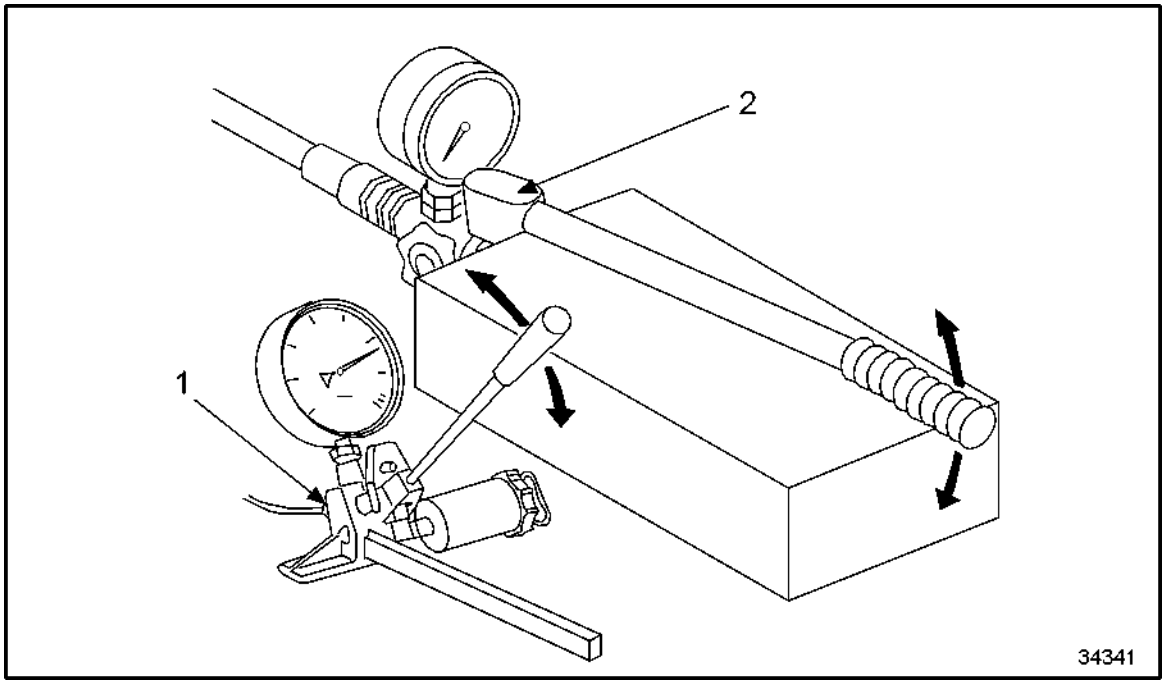
NOTE:
Do not tighten at this time.

16. Fill the pump's oil reservoir with 10W oil and install into pump
17. Open the pump to obtain half the maximum pressure. Maintain pressure for five minutes.

NOTE:
Maximum pressure rating is stamped on the drive flange.

18. Operate the pump to obtain half the maximum pressure. Maintain this pressure for five minutes. See Figure 249.

NOTE:
Maximum pressure rating is stamped on the drive flange.



1. Hydraulic Hand Pump 1
2. Hydraulic Hand Pump 2

Figure 249 Operating Hydraulic Hand Pumps

19. Increase the expansion pressure in increments of 0.1 x pmax. Wait two minutes between increases, until drive flange is free from the crankshaft.

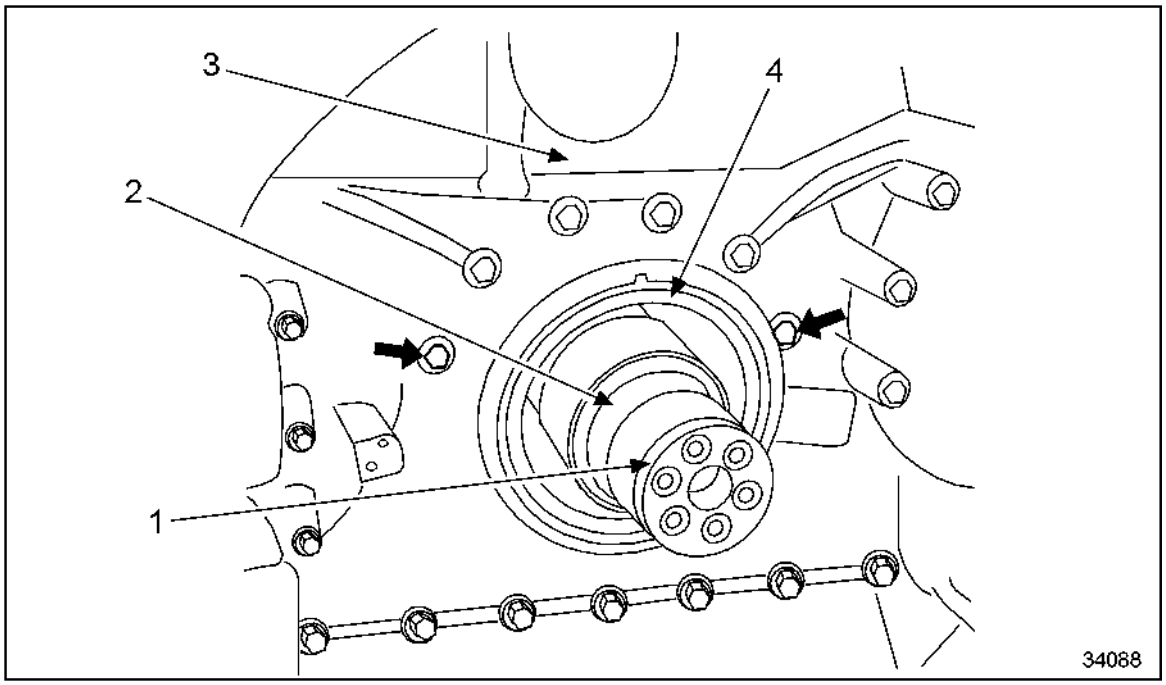
NOTICE
Do not exceed maximum pressure.

20. Remove nut, washers and pressure sleeve.
21. Remove the high-pressure line.
22. Remove the drive flange
23. Remove the adapter hub.

C 032.05.06 – DISASSEMBLY OF FLYWHEEL

Perform the following steps to disassemble the flywheel:

1. Remove crankshaft seal from flywheel housing (1). See Figure 250.



1. Crankshaft End
2. Flange
3. Flywheel Housing
4. Crankshaft Seal

Figure 250 Removing Crankshaft Seal from Flywheel Housing

2. Remove flywheel housing if necessary. Refer to section C 016.05.01.
3. Using suitable brass drift and hammer, remove drive crankshaft sealing ring (4) out of flywheel housing. See Figure 250.

C 032.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the flywheel:

1. Clean and inspect all components.
2. Using the magnetic crack-testing method with fluorescent powder, inspect drive hub, ring gear and hex bolts of flex coupling for cracks.
   [a] If cracks are found, replace cracked component.
   [b] If no cracks are found, continue inspection.
3. Visually inspect mating surfaces on flex coupling for evenness, wear, scoring and indentations.
   [a] If mating surfaces are uneven or show wear, scoring or indentations, recondition affected component as necessary.
   [b] If no unevenness, wear, scoring or indentations are found, continue inspection.
4. Visually inspect all sealing, mating and bearing surfaces on drive hub for wear, scoring and indentations.
   [a] If minor wear, scoring or indentations are found, remove by rubbing down with oilstone or emery cloth.
   [b] If damage cannot be removed with oilstone or emery cloth, replace drive hub as necessary.
   [c] If no wear, scoring or indentations are found, continue inspection.
5. Visually inspect taper surfaces of drive hub for scoring and damage.
   [a] If minor scoring or damage is found, polish with emery cloth.
   [b] If no scoring or damage is found, continue inspection.
6. Check taper 1:50 with taper gage.
   [a] If taper bore is oversized, replace drive hub.
   [b] If taper bore is not oversized, continue inspection.
7. Visually inspect threads of hex bolts for flex coupling.
   [a] If threads are not in perfect condition, replace hex bolts as necessary.
   [b] If threads are in perfect condition, continue inspection.
8. Visually inspect threads of expansion bore.
   [a] If threads of expansion bore are not in perfect condition, rechase threads as necessary.
   [b] If threads are in perfect condition and show ease of movement, continue inspection.
9. Inspect thread in drive hub for condition and ease of movement.
   [a] If threads of drive hub are not in perfect condition or do not show ease of movement, rechase threads as necessary.

[b] If threads of drive hub are in perfect condition, continue inspection.

10. Visually inspect ring gear for wear.
    [a] If ring gear is worn, replace gear.
    [b] If ring gear is not worn, continue inspection.
11. Visually inspect ring gear teeth for slight burrs and chipping.
    [a] If gear teeth have slight burrs or are chipped, remove burrs or chips by filing.
    [b] If gear teeth do not have burrs or chips, continue inspection.
12. Replace shaft seal during W6 maintenance.

C 032.05.10 – ASSEMBLY OF THE FLYWHEEL

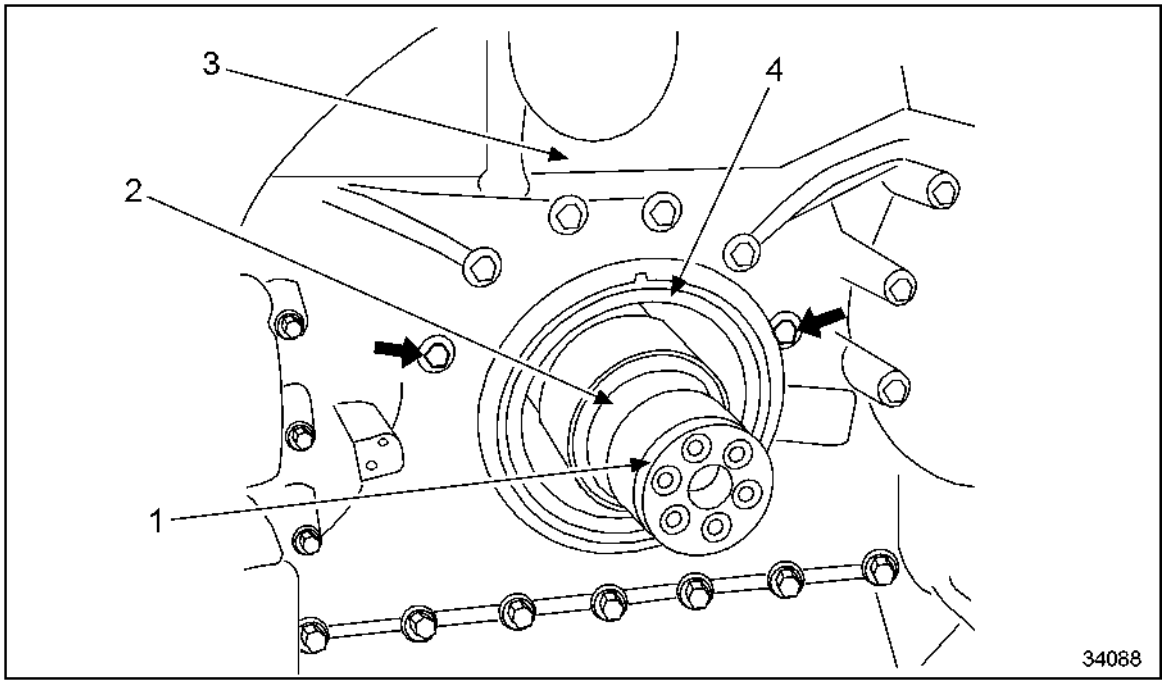
Perform the following steps to assemble the flywheel:

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.

NOTE:
The crankshaft seal can only be installed in the flywheel housing with the installer tool if it is mounted on the cylinder block. Refer to section C 016.05.01.

1. Install crankshaft adaptor (1) with hex socket bolts on front of cylinder block. See Figure 251.



1. Crankshaft End
2. Flange
3. Flywheel Housing
4. Crankshaft Seal

Figure 251 Installing Crankshaft Seal into Flywheel Housing

2. Install crankshaft seal (2), with sealing lip facing outwards on press-fitting tool. See Figure 251.

NOTE:
Denatured ethanol acts as lubricant for the seal.

3. Clean and degrease support bore for crankshaft oil seal in flywheel housing.

4. Use rear crankshaft seal installer J 42735 to install crankshaft seal flush in flywheel housing. See Figure 252.

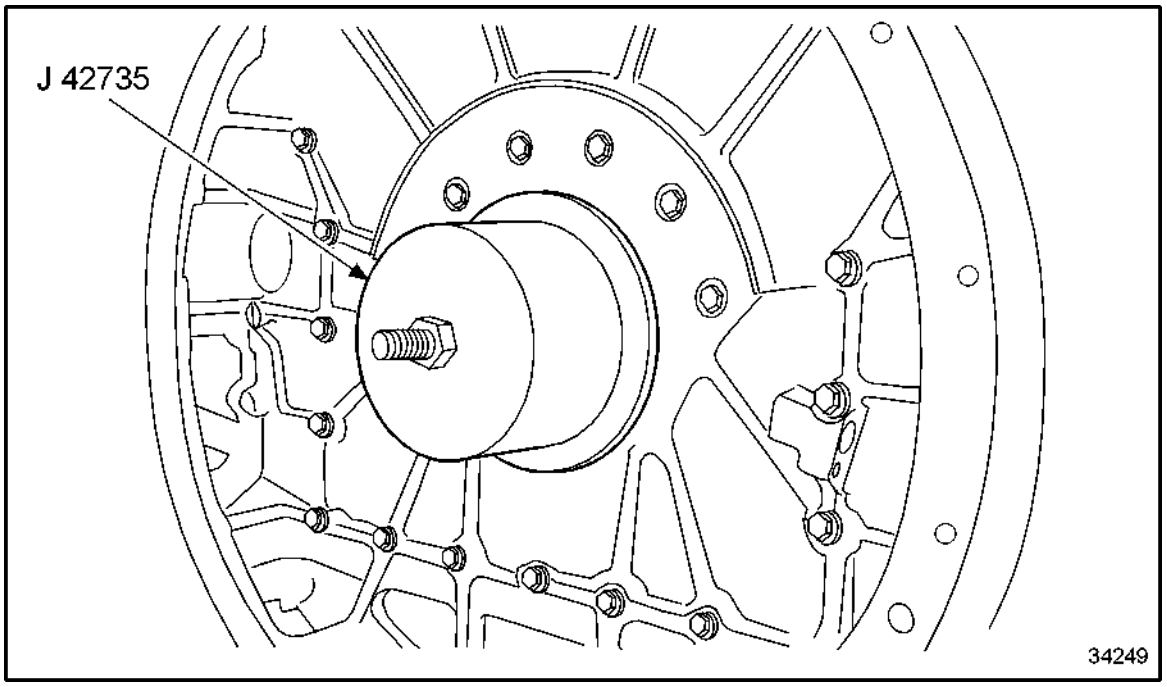


Figure 252 Installing Crankshaft Seal in Flywheel Housing

5. Remove pressure spindle with crankshaft adaptor from crankshaft.
6. Lightly coat the outside of the seal with engine oil.

NOTE:
Do not touch or get oil on the Teflon seal lip or on the drive hub when it is installed.

C 032.05.11 – INSTALLATION OF THE FLYWHEEL

Perform the following steps to assemble the flywheel drive hub:

CAUTION:

To avoid injury from the sudden release of a high-pressure hose connection, wear a face shield or goggles. Bleed the air from the air starter system before disconnecting the air supply hose.

CAUTION:

To avoid injury from tank rupture or a sudden air hose failure, do not use unregulated air pressure or an accumulator tank with an inadequate pressure rating.

CAUTION:

To avoid injury from failure of a fitting, hose, or oil cooler core, wear a face shield or goggles when conducting a pressure test.

1. Clean and degrease tapers of crankshaft and drive hub. See Figure 252.
2. Coat running surface of drive hub for crankshaft seal with thin-film lubricant (marine only).
3. Coat lip of crankshaft oil seal with petroleum jelly.

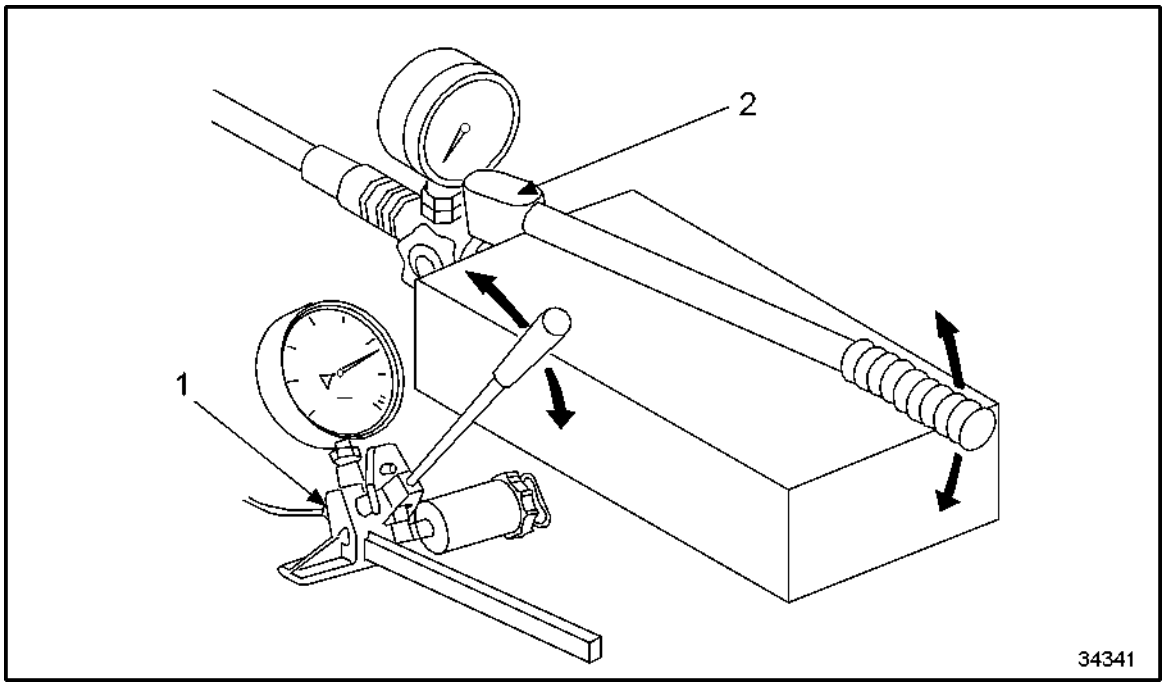
NOTE:
Do not touch or get oil on the Teflon seal lip or on the drive hub when it is installed.

4. Join crankshaft adaptor and flange together and use hex socket bolts to install on front surface of crankshaft, paying attention to centering pins.
5. Insert draw spindle with hydraulic press into crankshaft adaptor.
6. Check reference dimension A of draw spindle.
7. Install bushing and hydraulic press on draw spindle and fit nut.
8. Connect high-pressure line.
9. Connect high-pressure line of hand pump to hydraulic press.
10. Fully tighten nut, and pump hand pump until pressure starts to rise.

11. Release pressure and tighten nut again, until the hydraulic press is at the initial position (0 stroke).
12. A reference measurement should be taken to determine if the minimum push-on distance can be obtained.
13. Force-on distance B is stamped on drive hub.

NOTE:
Before tightening nut, ensure that hydraulic press is in initial position (0 stroke).

14. Pressure plate with centering pin centers drive hub in the specified installation position. Refer to section C 032.05.01.
15. Fill hydraulic hand pumps with SAE 10 engine oil.
16. Vent pumps and lines until escaping oil is free of bubbles.
17. Tighten high-pressure line.
18. Before installing, coat taper surfaces with expansion fluid by operating hydraulic hand pump (1) until expansion fluid emerges at both sides of the drive hub. See Figure 253.



1. Hydraulic Hand Pump 1
2. Hydraulic Hand Pump 2

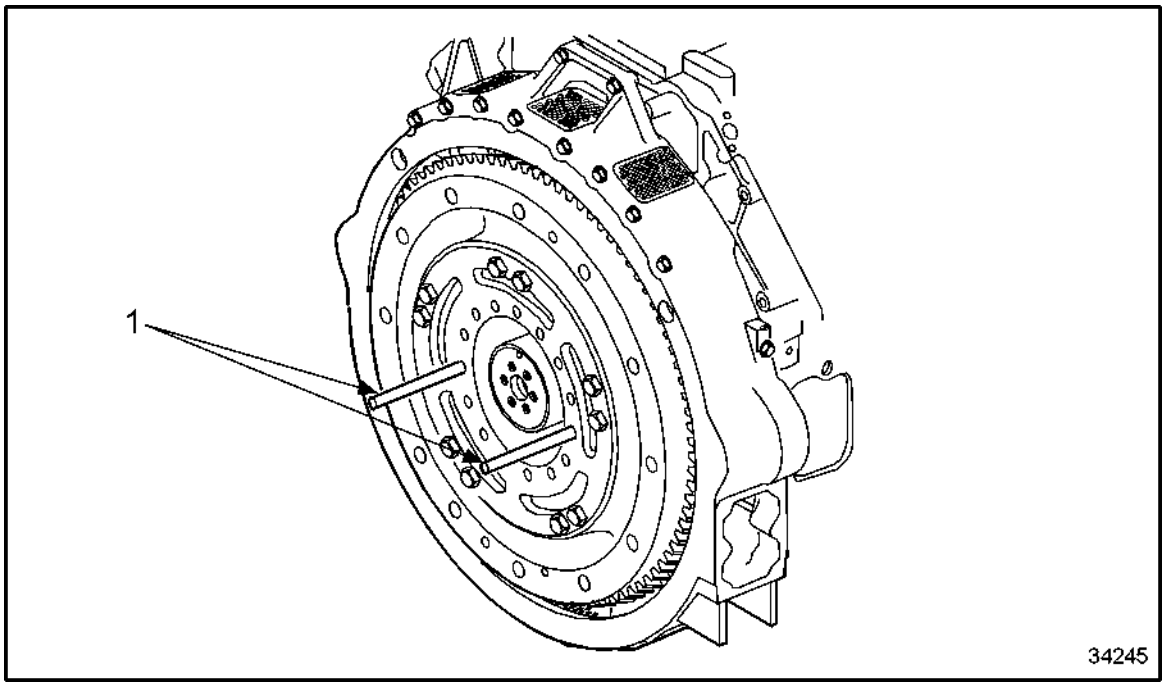
Figure 253 Operating Hydraulic Hand Pumps

19. Operate hand pump (2) for hydraulic press and, by applying minimum pressure, seat press against drive hub. See Figure 253.

20. Operate hydraulic hand pump (1) for expansion fluid until no further increase in expansion pressure is possible, then operate force-on pump to increase force-on pressure. See Figure 253.
21. Repeat this process until drive hub is correctly seated.
22. Select enough force-on pressure to seat shaft in approximately 5 steps.
23. When installing, make sure that expansion pressure does not exceed maximum permissible expansion pressure p_{max}.
24. See specifications on drive hub for p_{max}.
25. Hydraulic installation is completed when pressure plate is seated against crankshaft.
26. Open relief bolt in hydraulic oil pump to relieve expansion pressure.
27. Maintain maximum force-on pressure (p_{max}), for 60 minutes, to ensure that the expansion fluid is expelled from the joint and static friction can build up between fixed components.
28. Disconnect high-pressure lines.
29. Allow specified retention time to elapse; remove nut, hydraulic press, pressure sleeve and draw spindle.

NOTE:
The press-on connection must not be subjected to operational load for at least 8 hours.

30. To install flex coupling, screw in two guide pins in two opposite threaded bores of drive flange. See Figure 254.



1. Flywheel Guide Studs J 42999

Figure 254 Installing Guide Studs in Drive Hub

31. Screw eyebolt into flex coupling.

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.

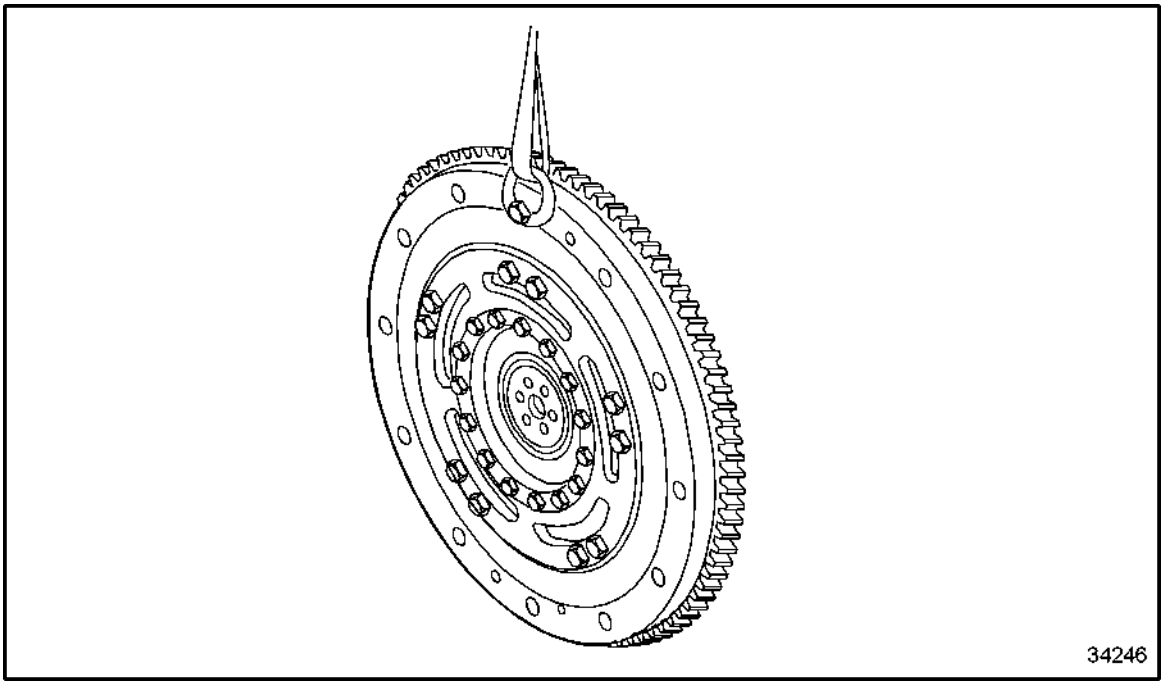


Figure 255 Lifting Flex Coupling by Eyebolt

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.

34. Insert hex bolts (arrow) for flex coupling; tighten diagonally and evenly. See Figure 256.

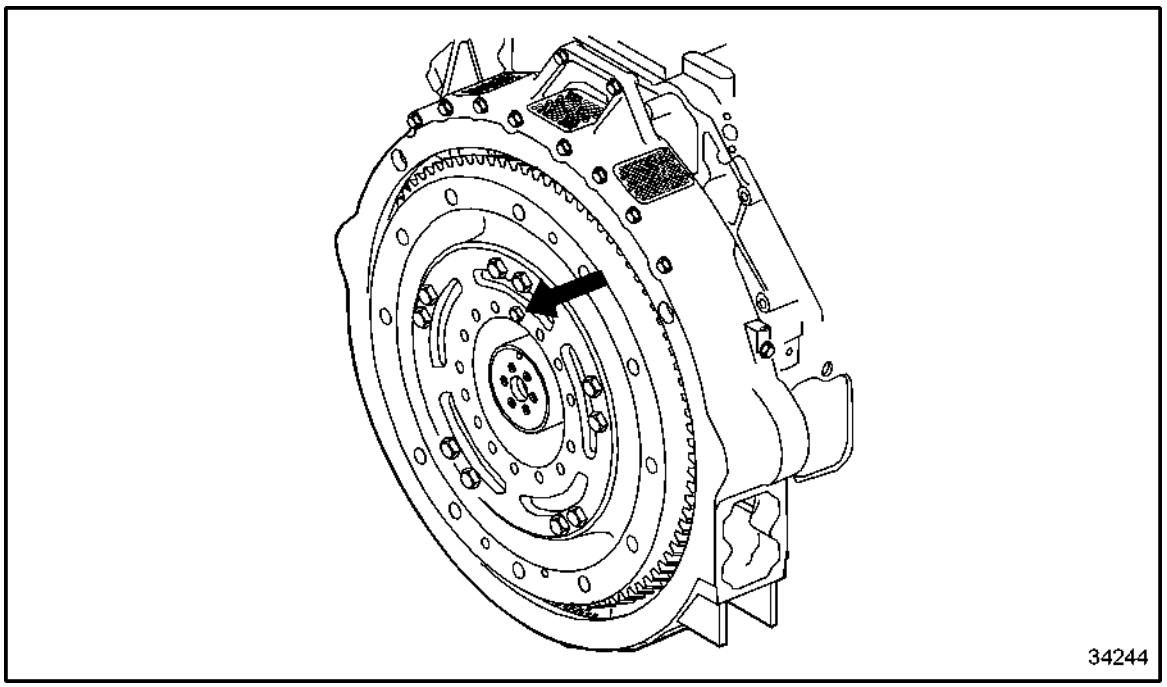


Figure 256 Installing Hex Bolts for Flex Coupling

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.

35. Remove guide pins and lifting device.
36. Lock engine, if necessary, on flywheel ring gear with locking device.
37. Tighten hex bolts in crossing pattern sequence to specification. Refer to section A 003.
38. Remove locking device, if installed.

C 032.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 29 are the After-Installation Operations for the flywheel.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators Guide
1, 2, 3	Connect engine to gearbox or alternator	-

1 = The engine is to be completely disassembled.

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

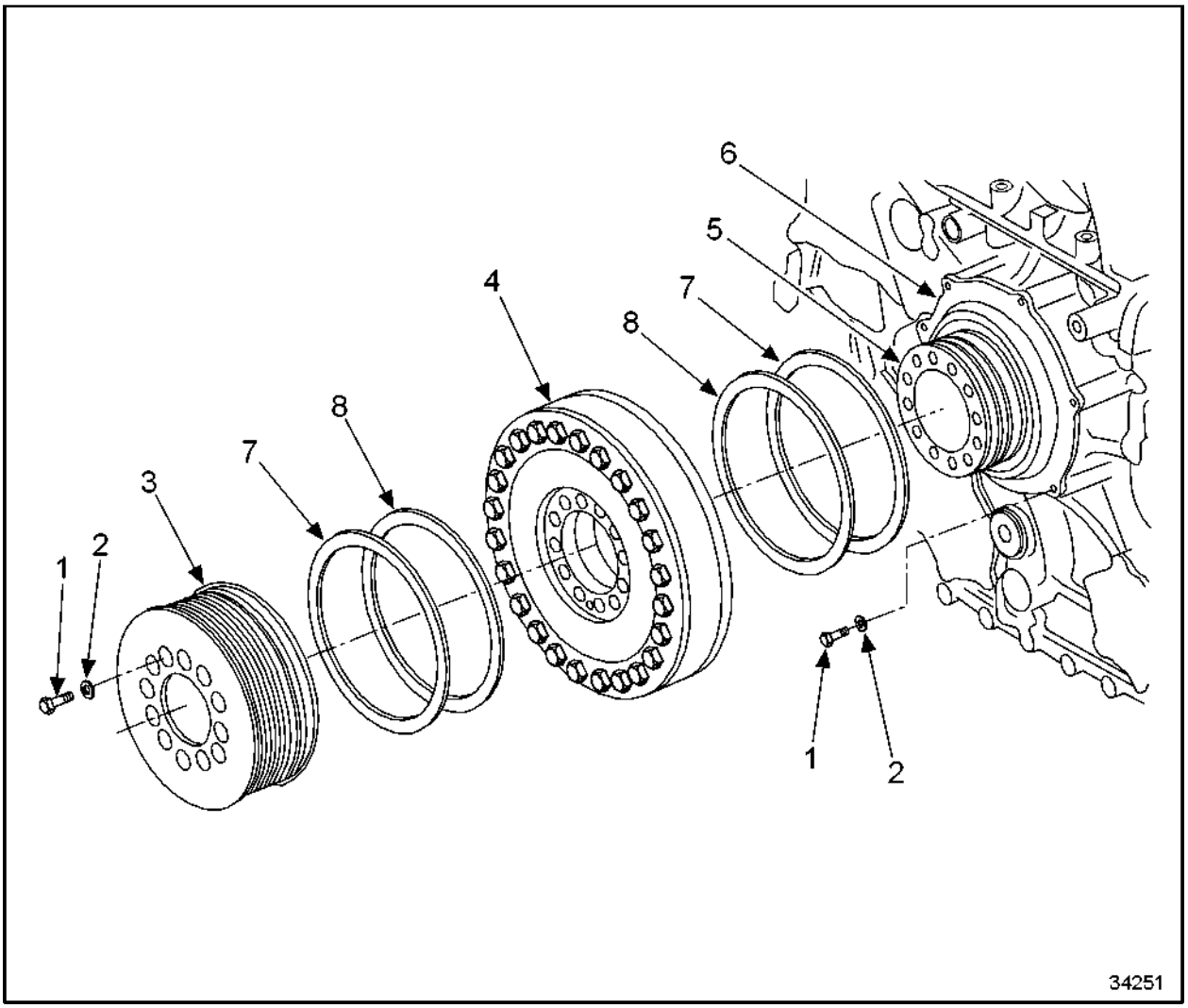
3= The engine is to remain installed.

Table 29 After-Installation Operations

C 035.05 – CRANKSHAFT VIBRATION DAMPER

C 035.05.01 – GENERAL VIEW

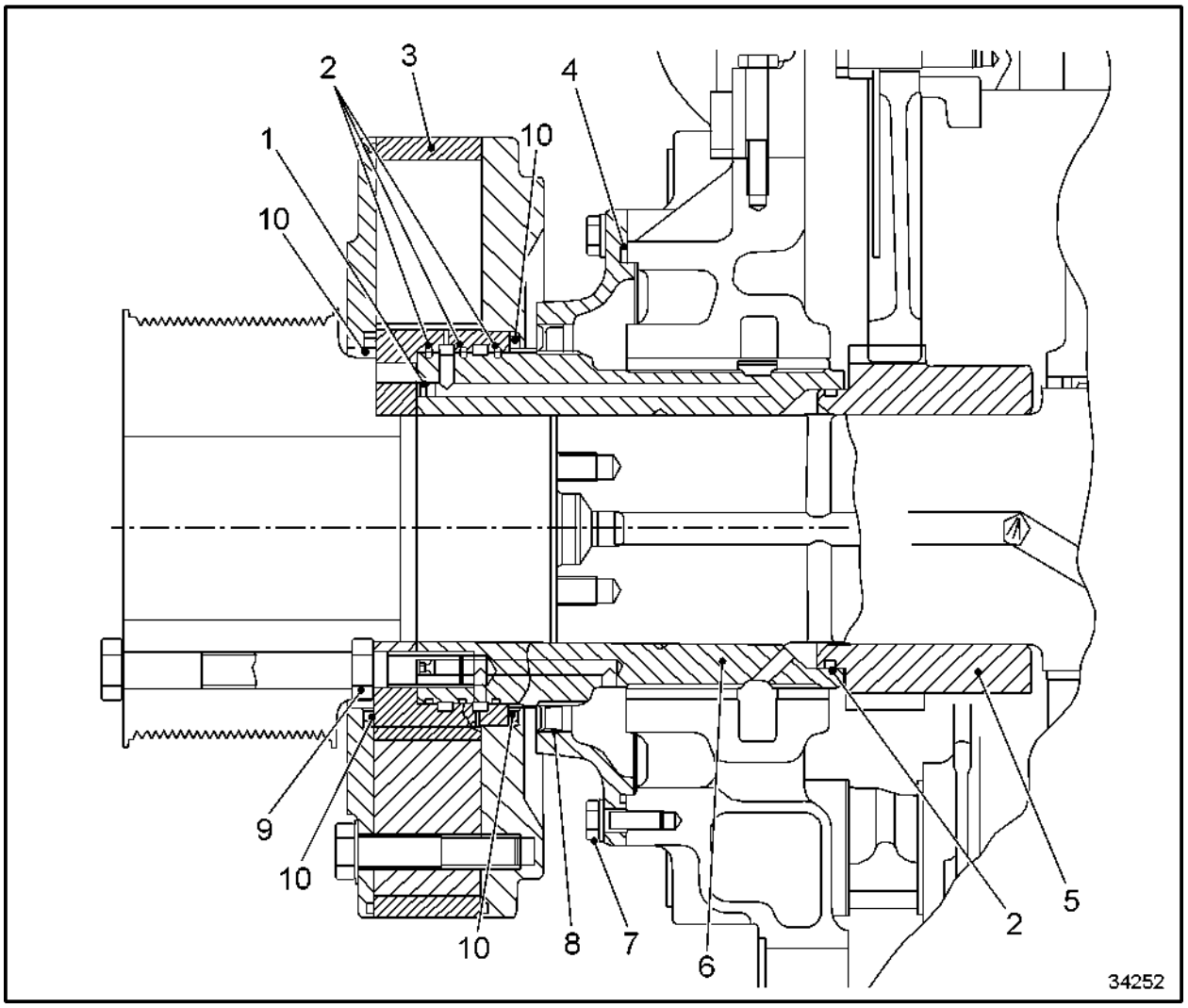
See Figure 257 for a general view of the vibration damper.



1. Hex Bolt
2. Washer
3. Belt Pulley
4. Vibration Damper
5. Damper Hub
6. Seal Carrier
7. Dust Ring
8. Dust Felt

Figure 257 General View of Crankshaft Vibration Damper

For a cutaway view of the vibration damper, see Figure 258.



1. Blanking Plug
2. O-rings
3. Vibration Damper
4. O-ring
5. Crankshaft Gear
6. Damper Hub
7. Hex Bolt
8. Crankshaft Seal
9. Hex Bolt
10. Dust Ring and Felt

Figure 258 Cutaway View of Vibration Damper

C 035.05.02 – SPECIAL TOOLS

Listed in Table 30 are the special tools required for maintenance on the vibration damper.

Designation	Tool Number
Guide pin for vibration damper	—
Hydraulic nut M 90 x 2	—
Support	—
Bushing	—
Hex nut M 36 x 3	—
Draw spindle	—
Pressure Housing	—
Flange	—
Spacer	—
Socket-head bolts M 16 x 100	—
Hydraulic hand pump 0-3500	—
SKF - hand pump 0-1000	—

Table 30 Special Tools

C 035.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 31 are the Before-Removal Operations for the vibration damper.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operator Guide
1, 2, 3	Remove V-belt	Refer to Operator Guide

1 = The engine is to be completely disassembled.

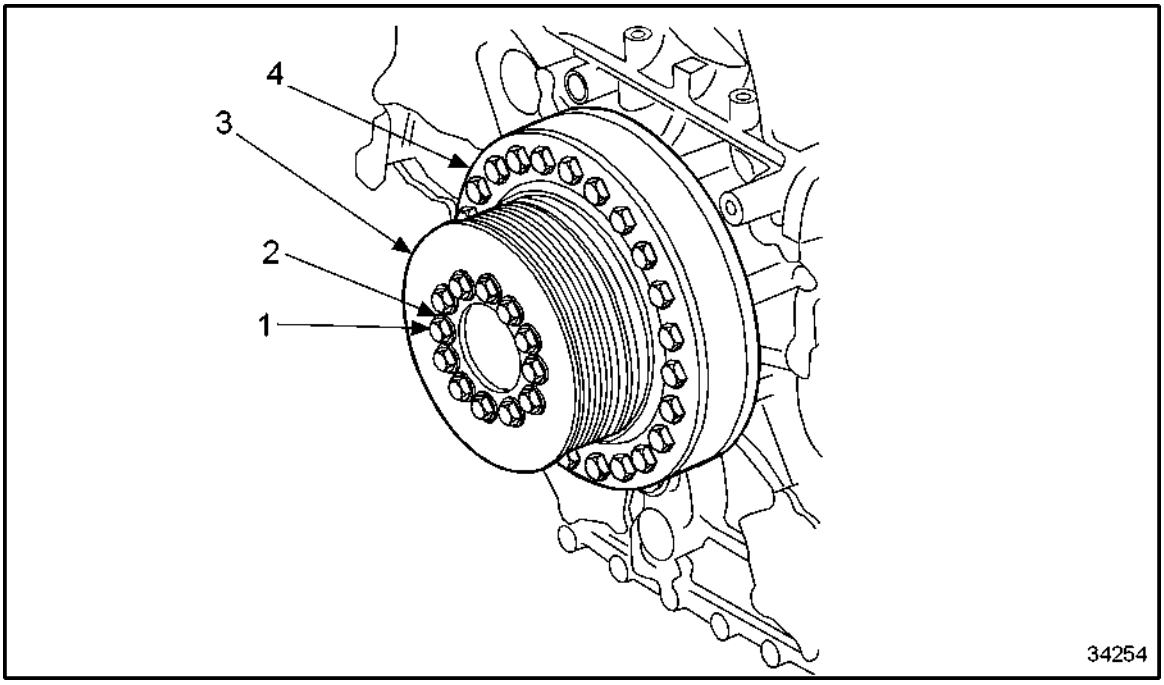
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 31 Before-Removal Operations

C 035.05.05 – REMOVAL OF THE VIBRATION DAMPER

1. Remove hex bolts (1) together with washers (2). See Figure 259.

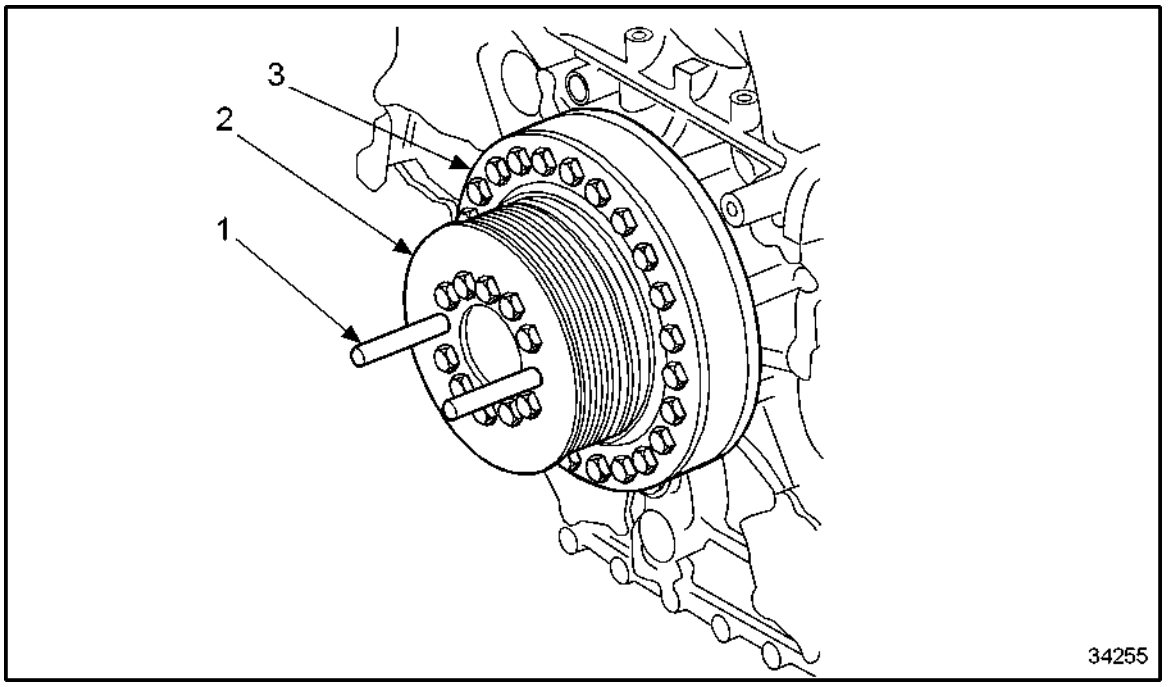


1. Hex Bolts
2. Washers
3. Belt Pulley
4. Vibration Damper

Figure 259 Removal of Vibration Damper

2. Leave one bolt remaining to secure vibration damper.

3. Insert guide pin (1) for removing belt pulley (2) and vibration damper (3) into threaded bore of crankshaft. See Figure 260.



1. Damper Guide Studs J 42999
2. Belt Pulley
3. Vibration Damper

Figure 260 Inserting Guide Studs

4. Remove bolts securing belt pulley (2) and vibration damper (3). See Figure 260.
5. Pull off and remove belt pulley (2). See Figure 260.
6. Remove vibration damper (3) with two bolts M 12 x 60 mm (2.3622 in.) and continuous thread. See Figure 260.

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.

7. Attach a suitable lifting device and crane to the vibration damper (3) and remove from guide studs. See Figure 260.
8. Remove guide studs (1). See Figure 260.

CAUTION:

To avoid injury from the sudden release of a high-pressure hose connection, wear a face shield or goggles. Bleed the air from the air starter system before disconnecting the air supply hose.

CAUTION:

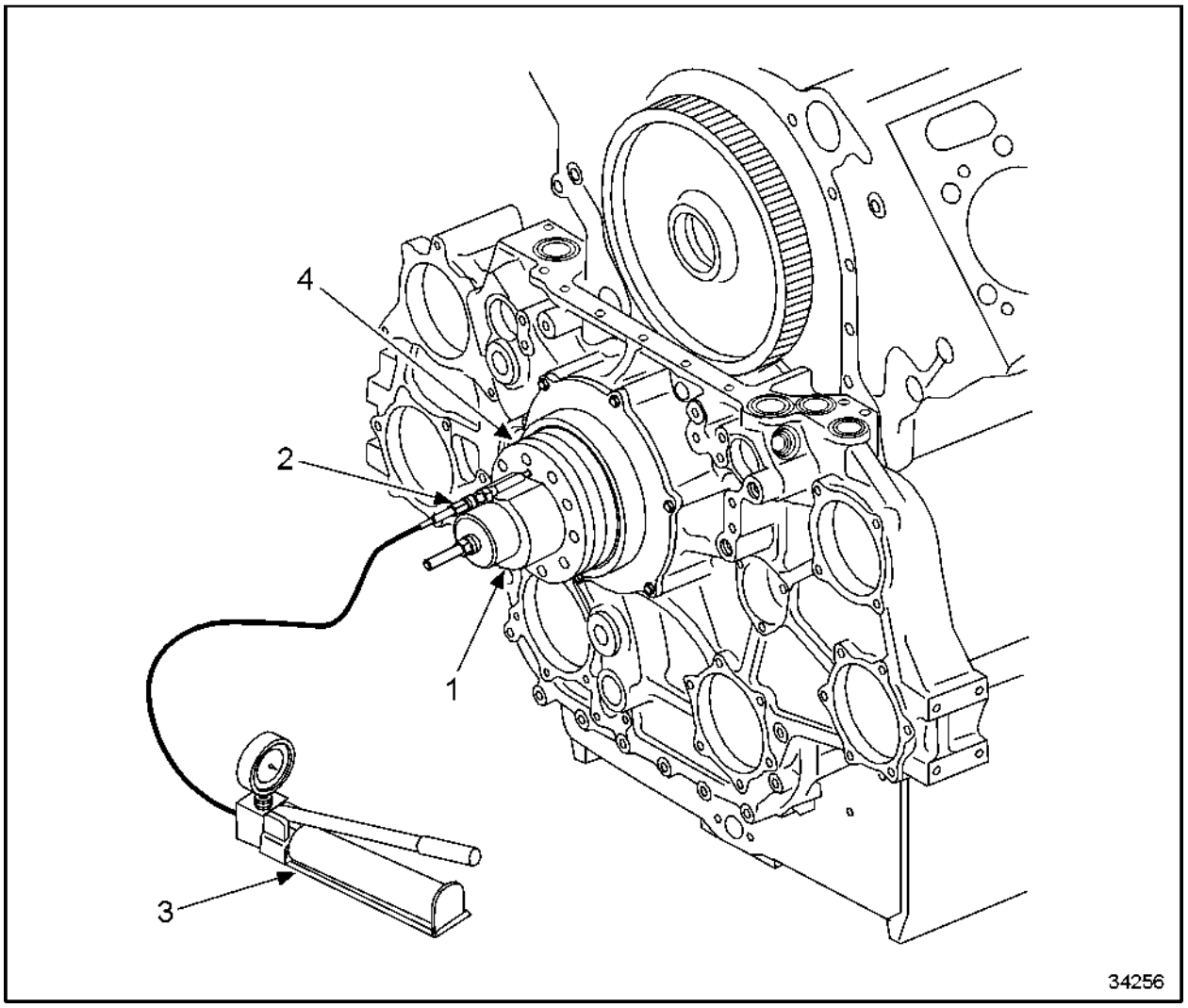
To avoid injury from tank rupture or a sudden air hose failure, do not use unregulated air pressure or an accumulator tank with an inadequate pressure rating.

CAUTION:

To avoid injury from failure of a fitting, hose, or oil cooler core, wear a face shield or goggles when conducting a pressure test.

9. To remove front drive flange removal procedure, install crankshaft adapter to the crankshaft.

10. Bolt draw spindle (3) into crankshaft adapter. See Figure 261.

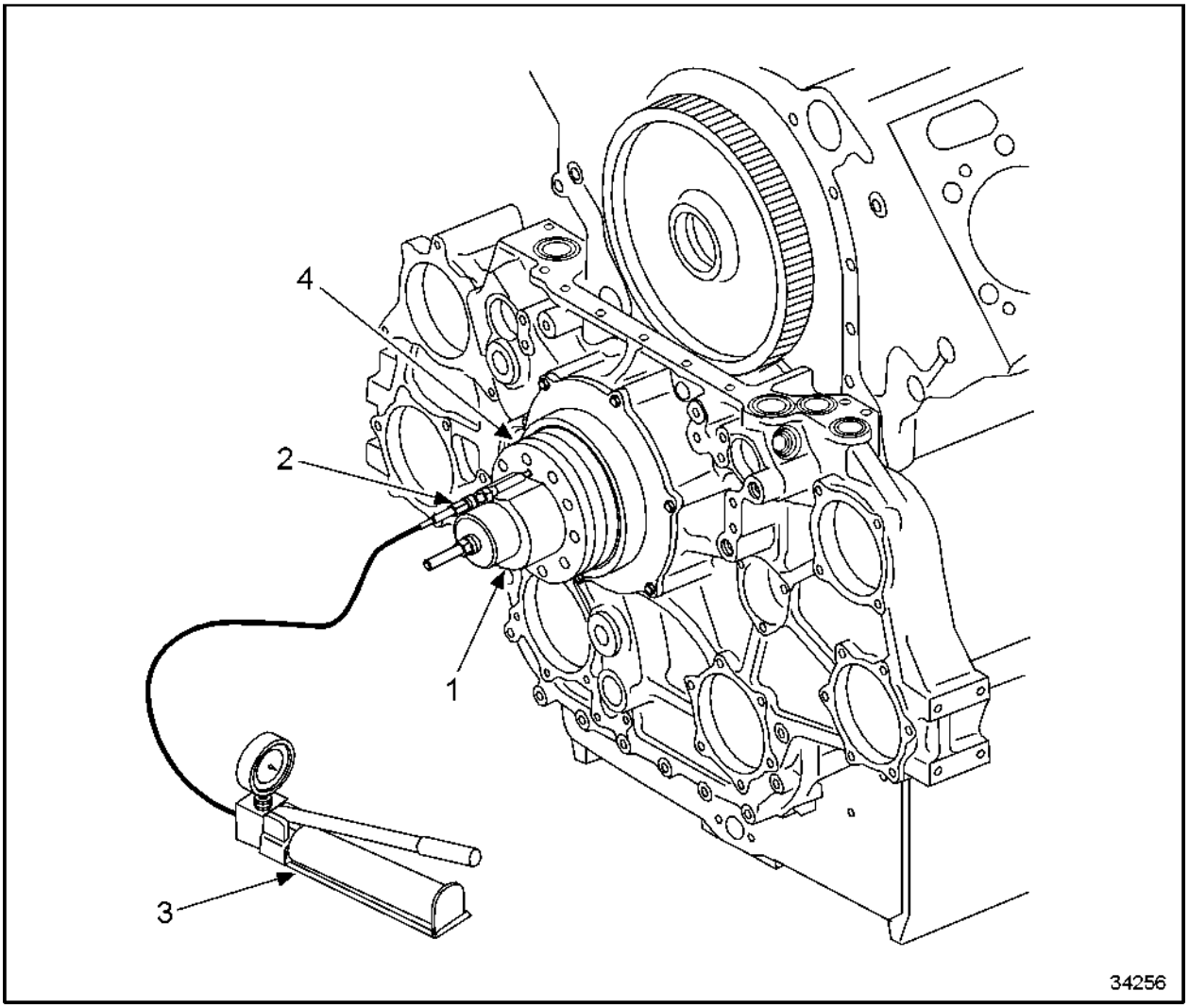


1. J 42916
2. High Pressure Fuel Line and Connector
3. High Pressure Hand Pump
4. Front Crankshaft Hub

Figure 261 Removing Drive Flange

11. Install spacer bushing (9) onto crankshaft adapter.

12. Install pressure sleeve (6) (bolt alignment dowel in on pressure sleeve until it is flush with surface) nut and washers. See Figure 262.



1. J 42916
2. High Pressure Fuel Line and Connector
3. High Pressure Hand Pump
4. Front Crankshaft Hub

Figure 262 Removing Drive Hub

13. Hand tighten and back off distance equal to that of the force-on dimension.

NOTE:
Force-on dimension is stamped on the drive flange.

14. Install SKF hydraulic pump line to oil hole on drive flange.

NOTE:
Do not tighten at this time.

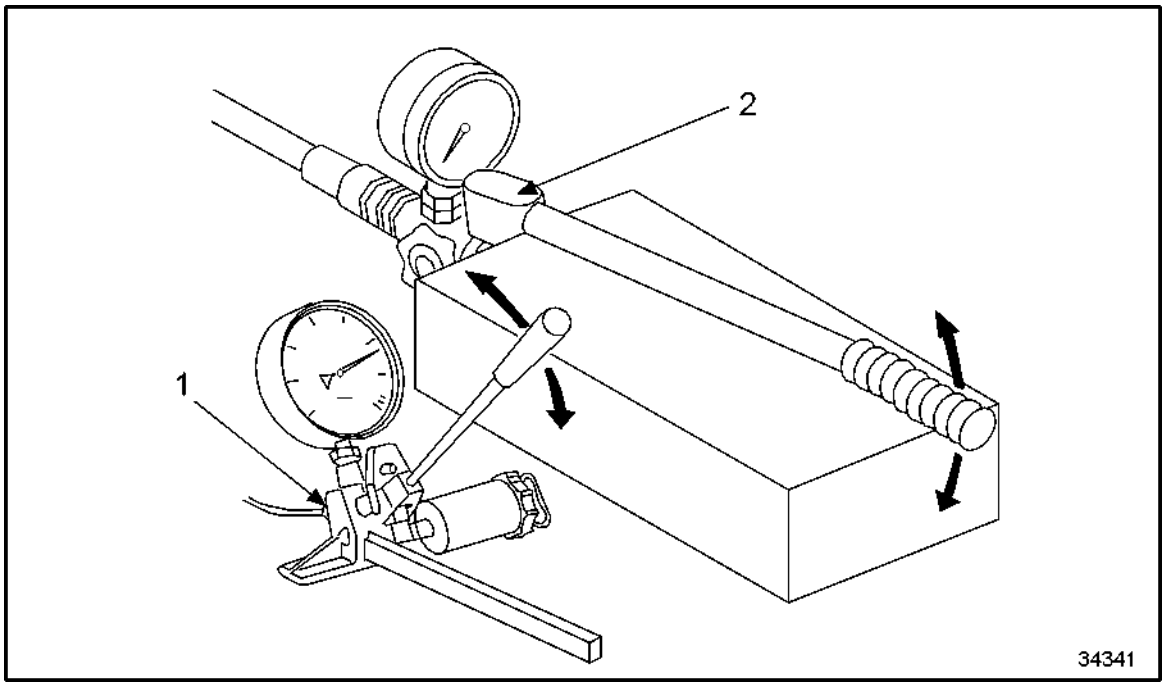
15. Fill SKF hydraulic pump oil reservoir and install onto pump. Open pump bleeder valve and bleed. Close valve and bleed and tighten pump line.
16. Operate pump to obtain half of maximum expansion pressure. See Figure 263.

NOTE:
Expansion pressure specification is stamped on hub.

17. Maintain pressure for five minutes. Increase expansion pressure in 0.1 X Maximum Pressure holding for 2 minutes in between each increase until drive flange is free from the crankshaft.
18. Operate hand pump (2) for hydraulic press, and seat press against drive flange by applying minimum pressure (start of pressure increase).

NOTE:
The hydraulic press acts as a buffer, stopping the hub as it slips off its taper seat.

19. Operate hydraulic hand pump (1) for expanding the driver flange taper until expansion pressure is half the permitted maximum. See Figure 263.



1. Hydraulic Hand Pump 1
2. Hydraulic Hand Pump 2

Figure 263 Operating Hydraulic Press and Hand Pump for Removal

20. Maintain this pressure for approximately 5 minutes.

NOTE:
Maximum expansion pressure (p_{max}) is stamped on drive hub.

21. Increase expansion pressure in stages by 0.1 p_{max}, holding for approximately 2 minutes between each stage, until drive hub is released from crankshaft.
22. With drive flange free from crankshaft, remove draw spindle nut, washers, draw spindle crankshaft adapter sleeve and adapter.
23. Remove hydraulic line

CAUTION:

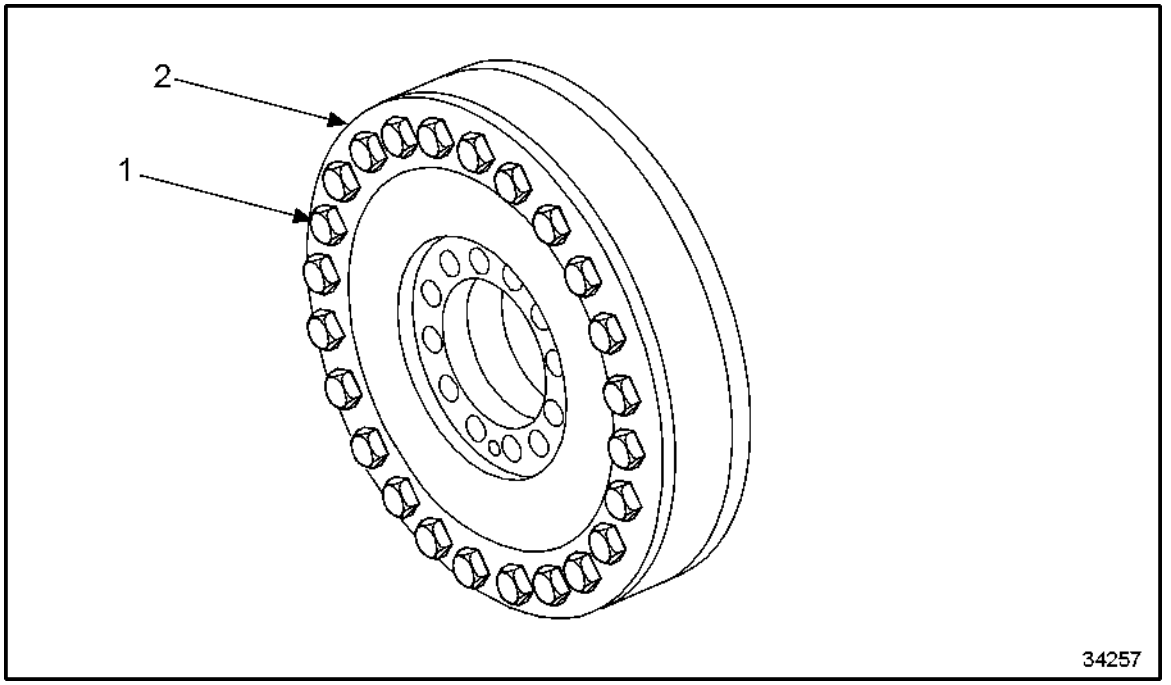
To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

24. Remove drive flange

C 035.05.06 – DISASSEMBLY OF THE VIBRATION DAMPER

Perform the following steps to disassemble the vibration damper:

1. Remove hex bolts (1) and dished washers. See Figure 264.



1. Hex Bolt
2. Side Plate

Figure 264 Disassembling Vibration Damper

2. Remove side plate (2). See Figure 264.
3. Remove O-rings.

NOTE:
A complete inspection is possible in this condition. The spring pack can only be disassembled with the aid of special tools. Refer to OEM guidelines.

C 035.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the vibration damper:

1. Clean and inspect all components.
2. Visually inspect spring pack of vibration damper, inner teeth of inner hub and side plate for damage and wear.
   [a] If excessive damage or wear is found, replace vibration damper.
   [b] If excessive damage or wear is not found, continue inspection.
3. Visually inspect O-ring sealing surfaces for wear and rust.
   [a] If O-ring sealing surfaces are worn or rusty, remove minor wear or rust by rubbing down with oilstone or emery cloth.
   [b] If O-ring sealing surfaces are not worn or rusty, continue inspection.
4. Visually inspect condition of threads in flange.
   [a] If threads in flange are damaged, rechase threads as necessary.
   [b] If threads in flange are not damaged, continue inspection.
5. Ensure that oil bores are particularly clean.
6. Visually inspect sealing surface of inner hub to drive hub for wear and scoring.
   [a] If sealing surface is worn or scored, replace inner hub.
   [b] If sealing surface is not worn or scored, continue inspection.
7. Inspect hex bolts for damage and check threads for ease of movement.
   [a] If hex bolts are damaged or their threads do not show ease of movement, replace bolts as necessary.
   [b] If hex bolts are not damaged, continue inspection.
8. Replace O-rings.

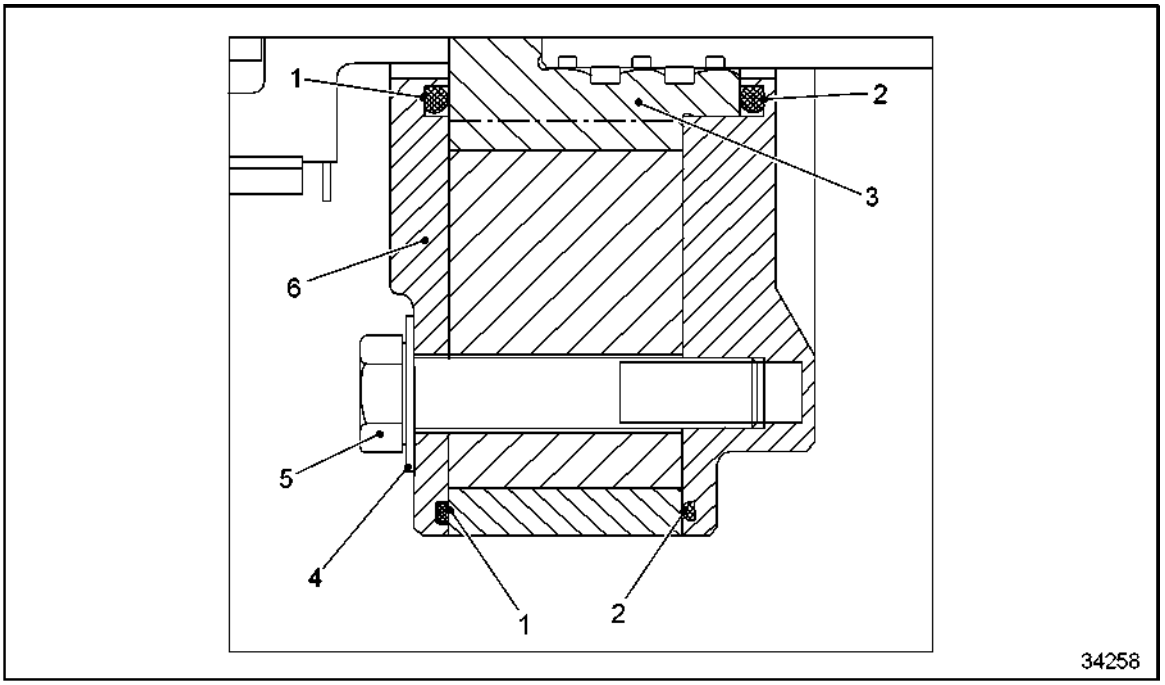
C 035.05.10 – ASSEMBLY OF VIBRATION DAMPER

Perform the following steps to assemble the vibration damper:

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.

1. Blow through oil bores in vibration damper with compressed air, and ensure that they are perfectly clean.
2. Coat O-rings (1) and (2) with petroleum jelly and insert into the side plate grooves (8). See Figure 265.



1. O-ring
2. O-ring
3. Inner Hub
4. Dished Washer
5. Hex Bolt

Figure 265 Assembling Vibration Damper

3. Coat inner circumference of side plate (8) and outer circumference of inner hub (3) and driver grooves with thin-film lubricant. See Figure 265.
4. Clean and degrease contact areas of dished washers (6). See Figure 265.

5. Coat dished washers (6) on both sides sufficiently with Loctite and fit correctly on bolts. See Figure 265.

NOTE:
Convex end of dished washer must point to bolt head. It is advisable to replace dished washers for each new installation.

6. Install side plate (8) in correct position.
7. Tighten hex bolts (7), offset by 90 degrees, uniformly in small steps to specification. Refer to section A 003. Ensure that side plate does not jam and the plate is not damaged. See Figure 265.

NOTE:
Ensure that correct final strength of surface sealant is reached after 72 hours.

8. When replacing O-rings (1) and (2), a special tool is required. See Figure 265.
9. After specified torque is reached, check measurement levels A, B and C. See Figure 266.

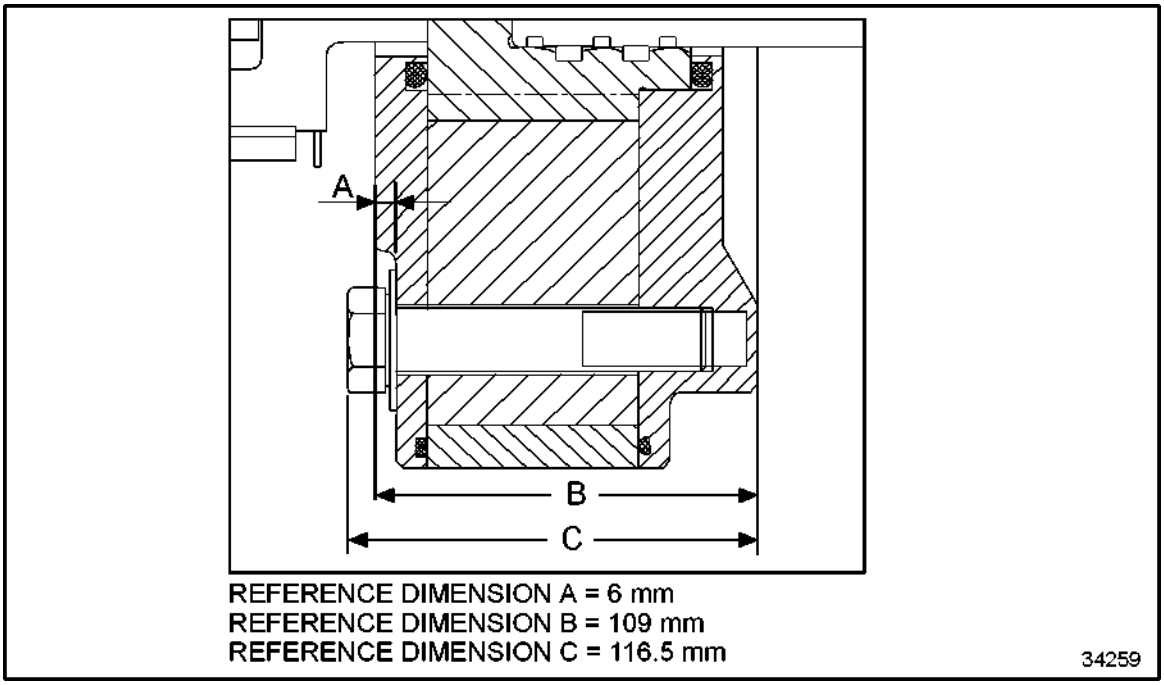
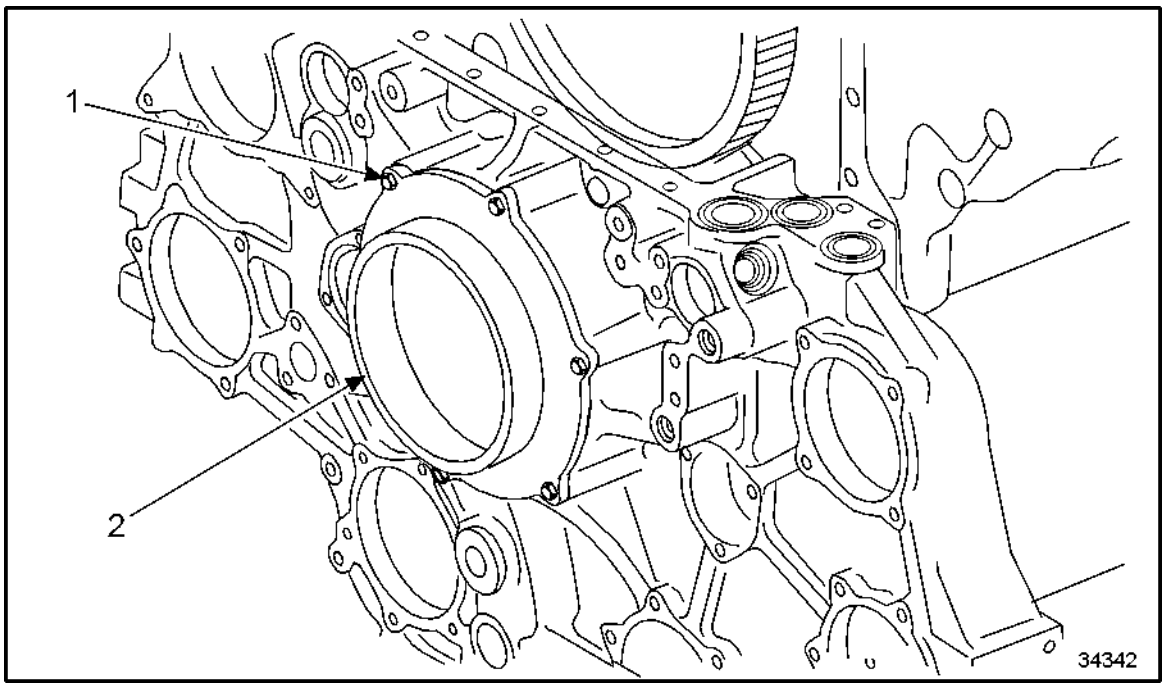


Figure 266 Checking Torque Dimensions

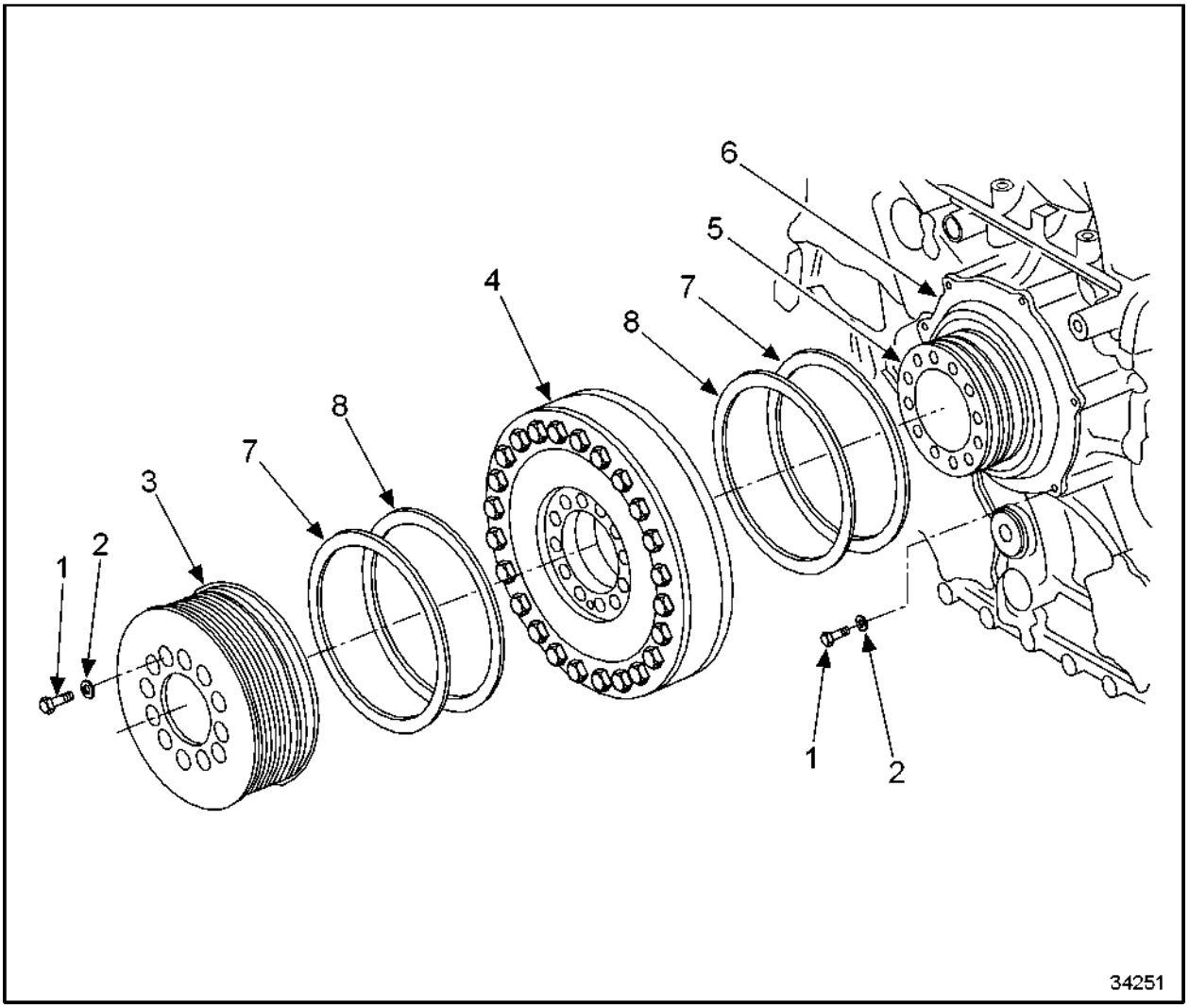
10. Install seal carrier (2) on gear case. See Figure 267.



1. Hex Bolt
2. Seal Carrier

Figure 267 Installing Seal Carrier

11. Coat O-ring with petroleum jelly and press seal carrier evenly into gear case. Ensure that it is perfectly flush to the gear case.
12. Tighten hex bolts (1) with washers diagonally and evenly to specification. Refer to sectionA 003. See Figure 268.



1. Hex Bolt
2. Washer
3. Belt Pulley
4. Vibration Damper
5. Damper Hub
6. Seal Carrier
7. Dust Ring
8. Dust Felt

Figure 268 General View of Crankshaft Vibration Damper

C 035.05.11 – INSTALLATION OF THE VIBRATION DAMPER

Perform the following steps to install the vibration damper:

CAUTION:

To avoid injury from the sudden release of a high-pressure hose connection, wear a face shield or goggles. Bleed the air from the air starter system before disconnecting the air supply hose.

CAUTION:

To avoid injury from tank rupture or a sudden air hose failure, do not use unregulated air pressure or an accumulator tank with an inadequate pressure rating.

CAUTION:

To avoid injury from failure of a fitting, hose, or oil cooler core, wear a face shield or goggles when conducting a pressure test.

1. Clean and degrease tapers of crankshaft and vibration damper hub.
2. Coat running surface of crankshaft bearing and damper hub with oil.

NOTE:
Do not touch or get lubricant on the Crankshaft Teflon seal lip or on the damper hub sealing surface when it is installed. Ensure that the lip and sealing surface are clean and dry.

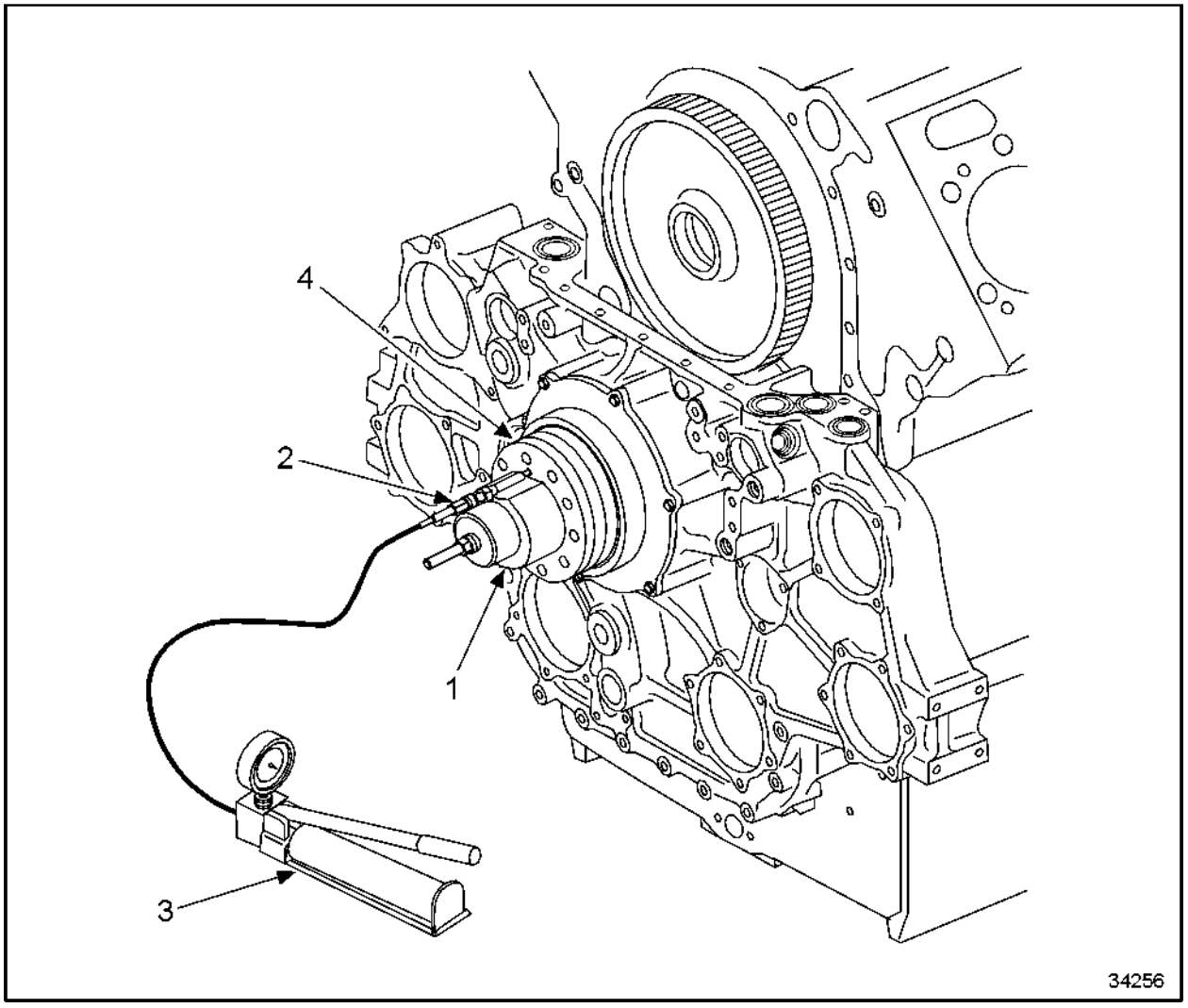
CAUTION:

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.

3. Mount damper hub on crankshaft taper.
4. To install rear drive flange, install crankshaft adapter and crankshaft adapter sleeve.
5. Clean crankshaft surface inner hub bore ensuring all dirt and lint is removed
6. Oil both the inner hub bore and the crankshaft.
7. Place the drive flange onto the crankshaft and push it as far as it will go. The hydraulic pressure created by the oil will cause the drive flange to resist being seated. Push until enough oil is released to allow drive flange to seat.

8. Install the pressure sleeve (6) and the threaded shaft. See Figure 269.

NOTE:
Lubricate the shaft with Anti-Seize®



1. J 42916
2. High Pressure Fuel Line and Connector
3. High Pressure Hand Pump
4. Front Crankshaft Hub

Figure 269 Installing Drive Hub

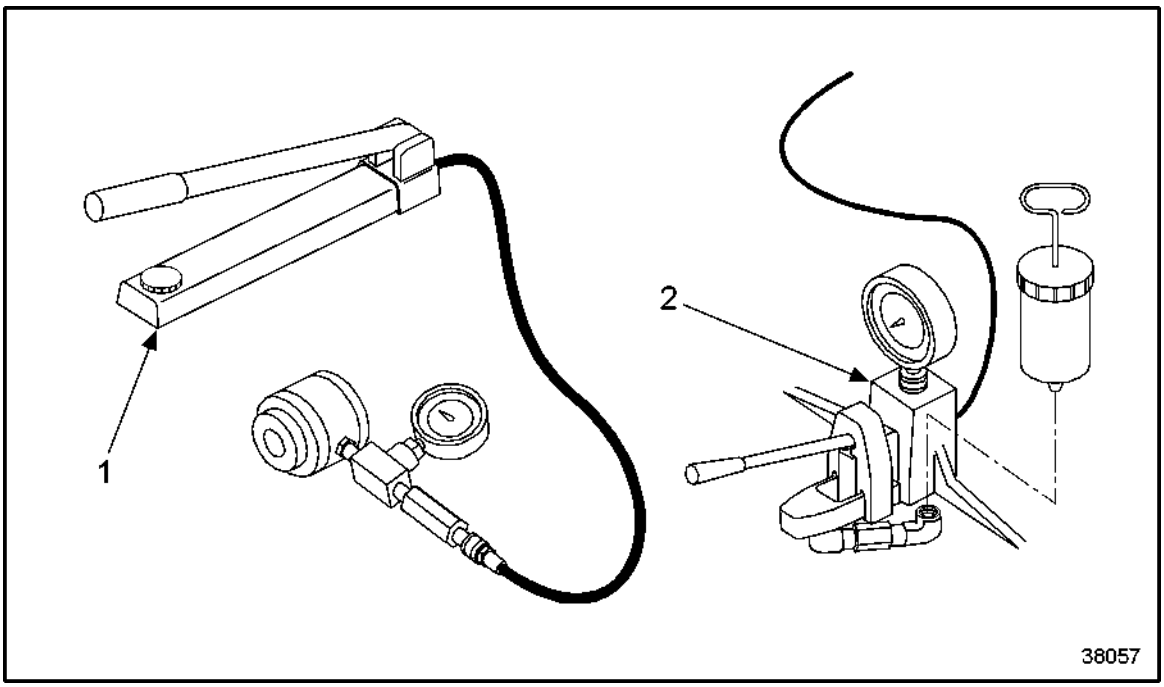
9. Install washers and nut. Hand tighten only until snug. See Figure 269.
10. Measure distance from the outer edge of the drive flange to the edge of the spacer sleeve.

NOTE:
Specifications are stamped on front of hub.

11. Install expansion pump line to drive flange.

NOTE:
Do not tighten at this time.

12. Fill SKF hydraulic pump oil reservoir and install onto pump. Open pump bleeder valve and bleed. Close bleeder valve and bleed line. Tighten line after bleeding.
13. Operate expansion pump until no further increase in pressure is possible. See Figure 270.



1. Hydraulic Hand Pump 1
2. Hydraulic Hand Pump 2

Figure 270 Hydraulic Hand Pumps

14. Tighten nut to draw-on the drive flange.
15. Repeat steps13and steps 14 until the drive flange is properly seated.

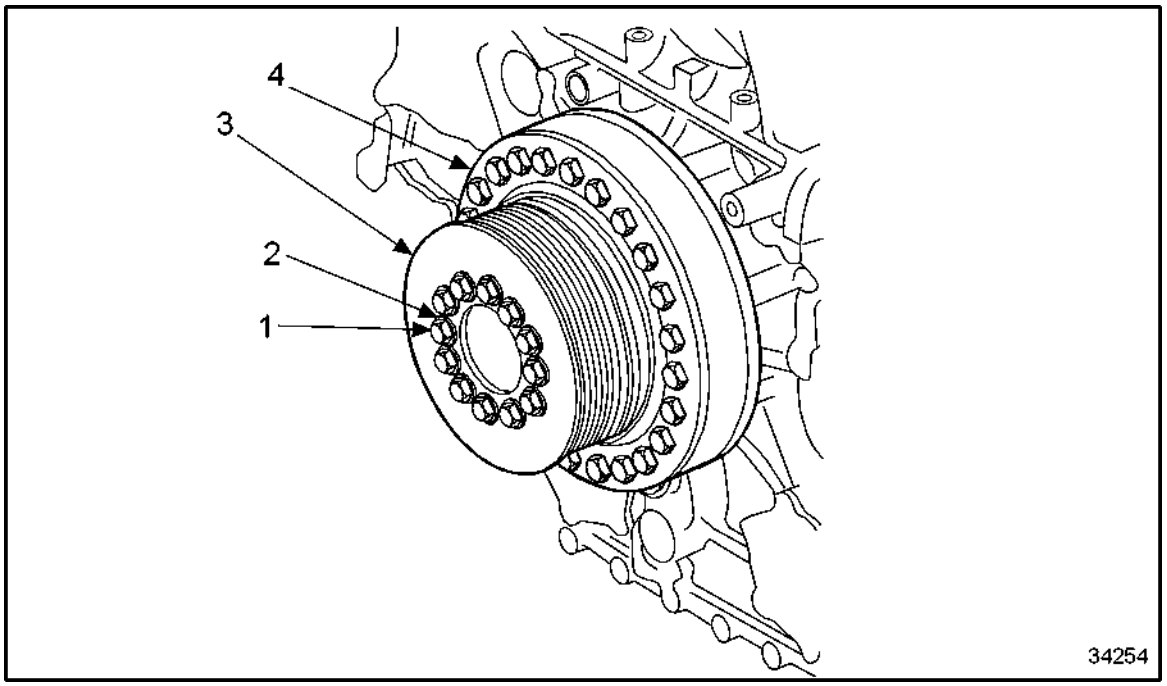
NOTICE
Do not exceed maximum expansion pressure.

16. Open bleed screw at pump to release oil pressure.
17. Disconnect the pump line at the drive flange.
18. Wait one hour before removing the drive-on nut.

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.

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.

22. Attach vibration damper with lifting device and crane and install over guide pins.
23. Install belt pulley over guide pins.
24. Coat thread and underside of hex bolt heads with engine oil and install.
25. Remove guide pins and tighten hex bolts to specification. Refer to section A 003. Refer to section C 035.05.01.

C 035.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 32 are the After-Installation Operations for the vibration damper.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators guide
1, 2, 3	Install V-belt tension	Refer to Operators guide
1, 2, 3	Release engine start	Refer to Operators guide

1 = The engine is to be completely disassembled.

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

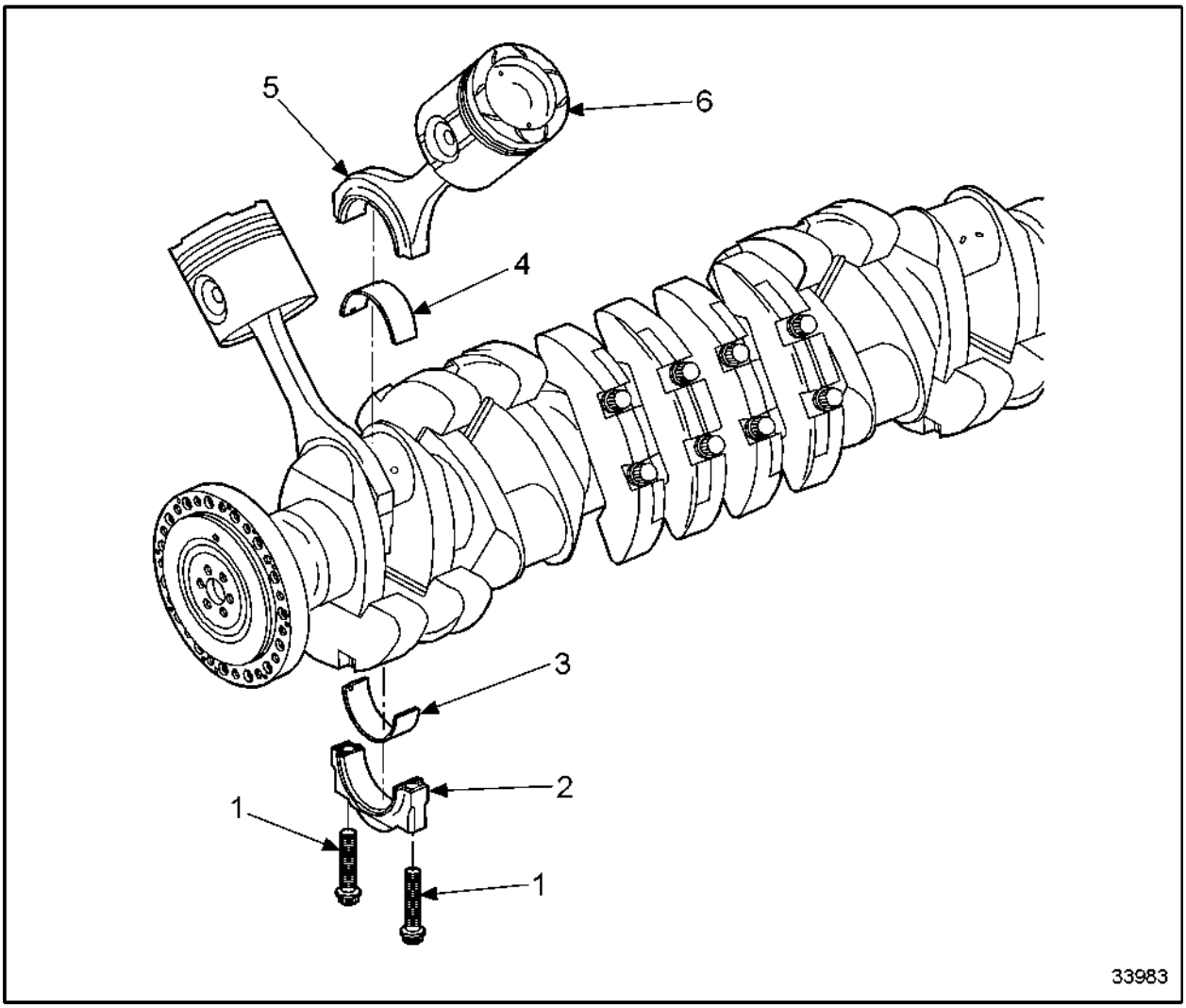
3= The engine is to remain installed.

Table 32 After-Installation Operations

C 037.05 – PISTONS AND CONNECTING RODS

C 037.05.01 – GENERAL VIEW

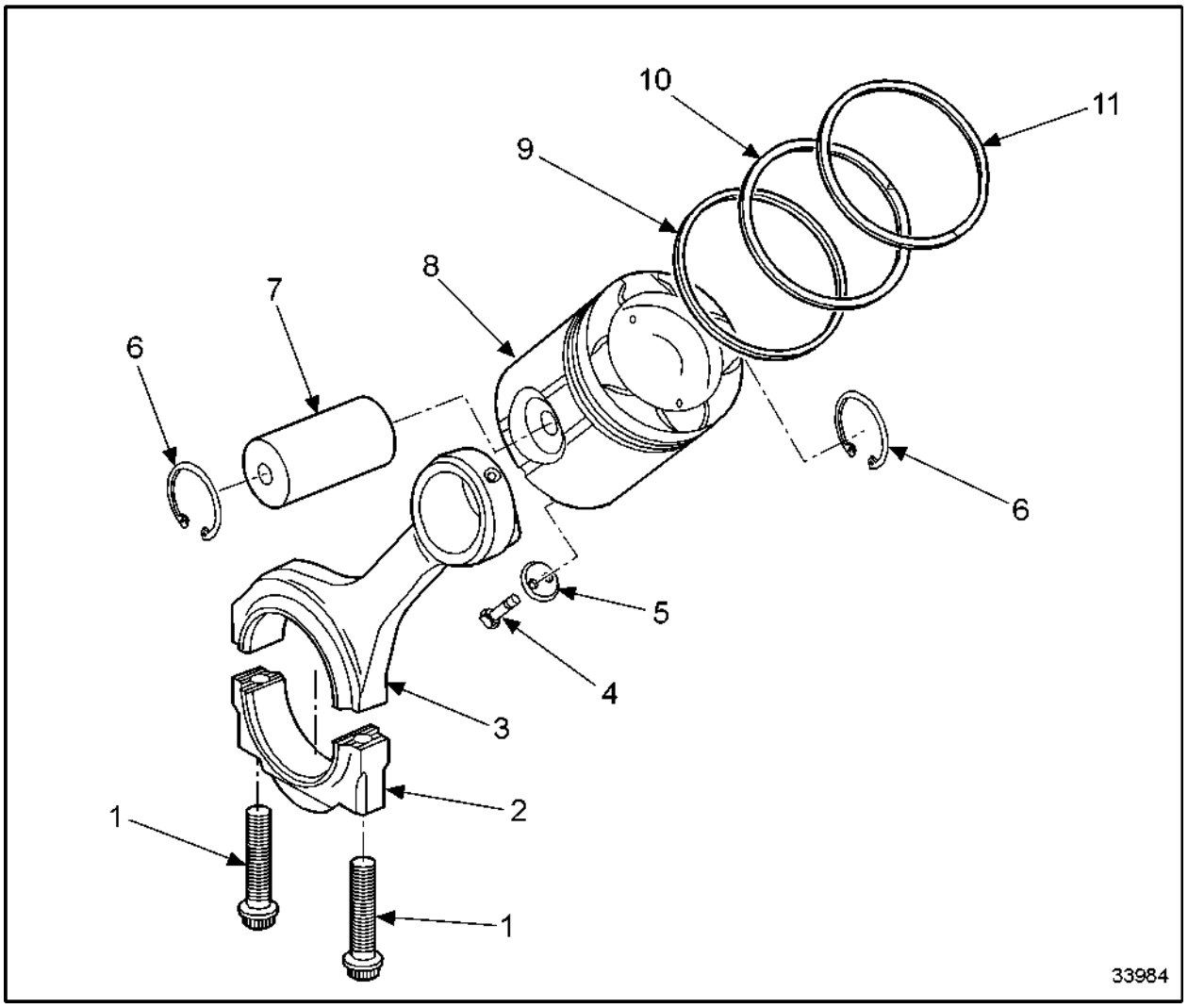
See Figure 272 for a general view of pistons and connecting rods.



1. Connecting Rod Bolt
2. Connecting Rod Cap
3. Lower Connecting Rod Bearing Shell
4. Upper Connecting Rod Bearing Shell
5. Connecting Rod
6. Piston

Figure 272 General View of Pistons and Connecting Rods

For a view of piston components, see Figure 273.



1. Connecting Rod Bolt
2. Connecting Rod Cap
3. Connecting Rod
4. Piston Bolt
5. Pressure Plate
6. Snap Ring
7. Piston Pin
8. Piston
9. Oil Control Ring
10. Compression Ring
11. Fire Ring

Figure 273 Piston Components

C 037.05.02 – SPECIAL TOOLS

Listed in Table 33 are the special tools required for maintenance on the piston with connecting rod.

Designation	Tool Number
Installation tool for connecting rod bearings	—
Adjusting brass drift for connecting rod bearings	—
Engine barring tool	—
Assembly sleeve, piston/connecting rod for carbon scraper ring	—
Assembly sleeve, piston/connecting rod without carbon scraper ring	—
Installation tool for connecting rod	—
Installation/removal of piston with connecting rod	—
Piston ring pliers	—
Ring gage for measuring piston ring and clearance	—
Torque-angle tightening device for connecting rod	—

Table 33 Special Tools

C 037.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 34are the Before-Removal Operations for the piston with connecting rod.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Drain or draw off charge air coolant	Refer to section C 206.05.05
1, 2, 3	Remove left or right exhaust line	Refer to section C 141.05.05
1, 2, 3	Remove cylinder head cover (as required)	Refer to section C 056.05.05
1, 2, 3	Remove charge air manifold (as required)	Refer to section
1, 2, 3	Remove air filter	Refer to OEM Guidelines
1, 2, 3	Disconnect or remove electric cables	Refer to section C 501.05 M
1, 2, 3	Remove coolant lines (as required)	Refer to section C 204.05.05
1, 2, 3	Remove high pressure injection line	Refer to section C 077.05.05
1, 2, 3	Remove low pressure fuel return rails and lines	Refer to section C 086.05.05
1, 2, 3	Remove fuel injector	Refer to section C 077.05.05
1, 2, 3	Remove valve drive	Refer to section C 055.05.05
1, 2, 3	Remove pushrods	Refer to section C 055.05.05
1, 2, 3	Remove cylinder head	Refer to section C 041.05.05
1, 2, 3	Remove starter (as required)	Refer to section C 172.05.05
1, 2, 3	Remove ECU housing with bracket (as required)	Refer to section C 501.05 M
1, 2, 3	Remove oil dipstick and access cover with oil filler neck	Refer to OEM Guidelines
1, 2, 3	Lower or remove oil pan	Refer to section C 014.05.05

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 34 Before-Removal Operations

C 037.05.05 – REMOVAL OF PISTON WITH CONNECTING ROD

Removing Piston with Connecting Rod (With Oil Pan Installed)

Perform the following steps to remove piston with connecting rod (with oil pan installed).

1. Clean combustion residues from cylinder liner.

NOTE:
This is not required for cylinder liners with carbon scraper ring.

2. For cylinder liner with carbon scraper ring, remove carbon scraper ring (arrows). See Figure 274.

NOTE:
Cylinder liners with carbon scraper rings are applicable to marine engines only.

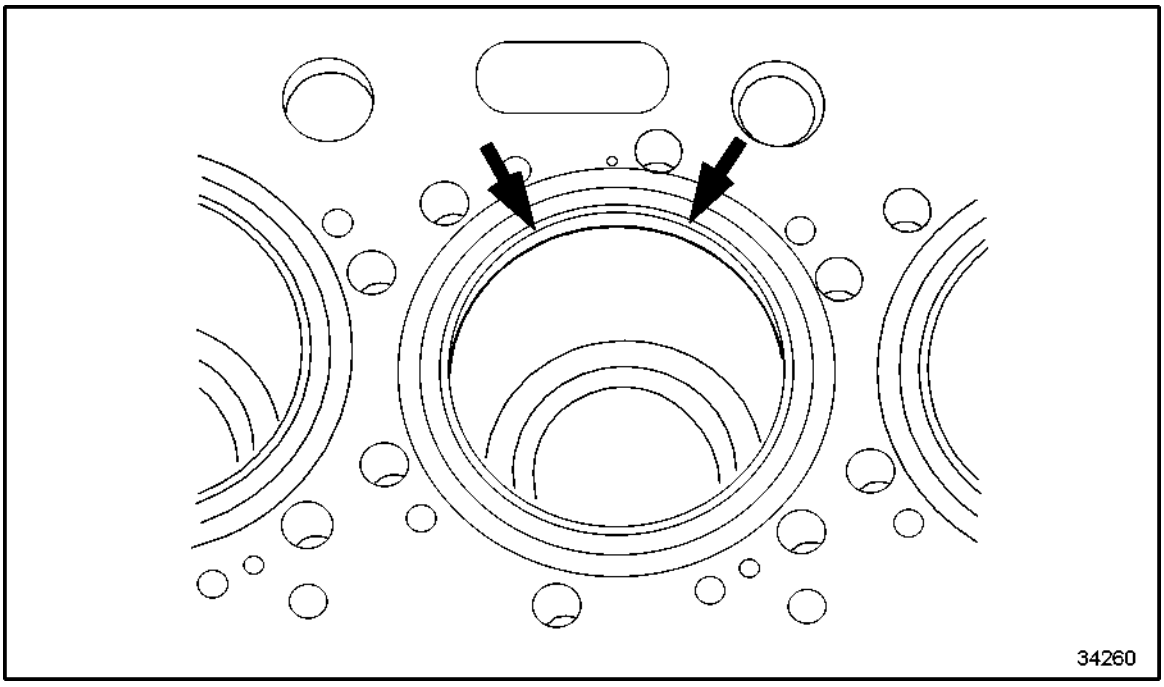


Figure 274 Removing Carbon Scraper Ring (Marine Engines Only)

CAUTION:

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

3. Install barring tool.
4. Remove access port covers, left and right sides, from respective cylinders.
5. Turn crankpin of respective cylinder on right side 40° before TDC and left side 40° after TDC.
6. Loosen connecting rod bolts (arrows) through inspection port with socket and large ratchet. See Figure 275.

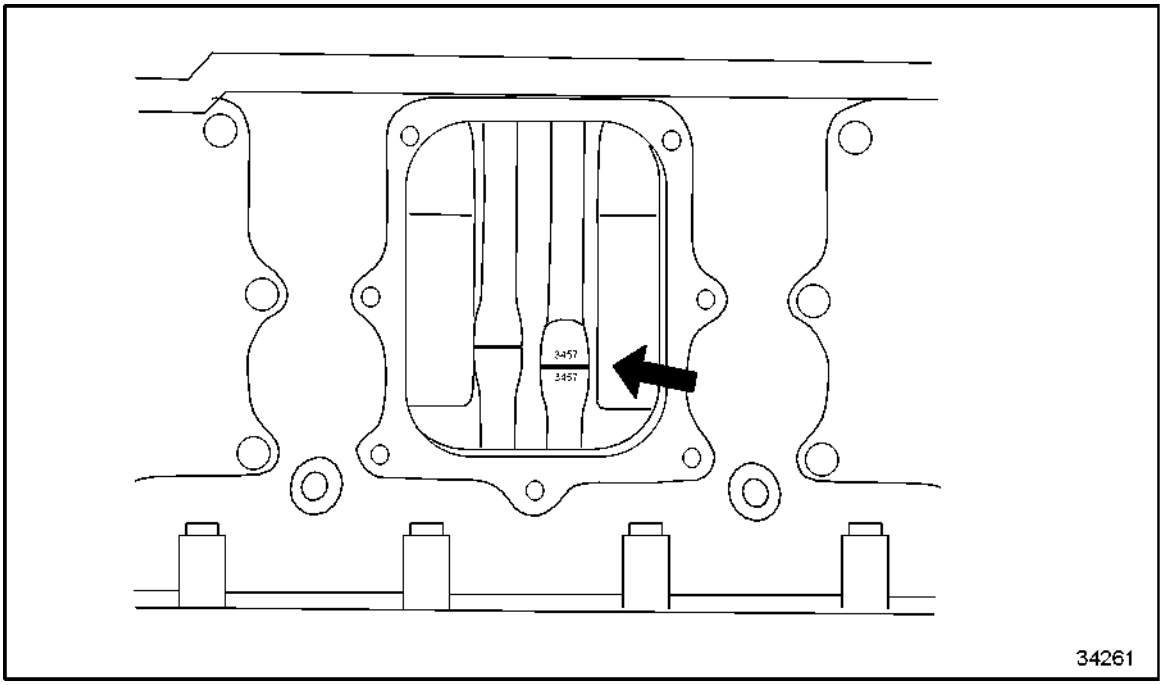


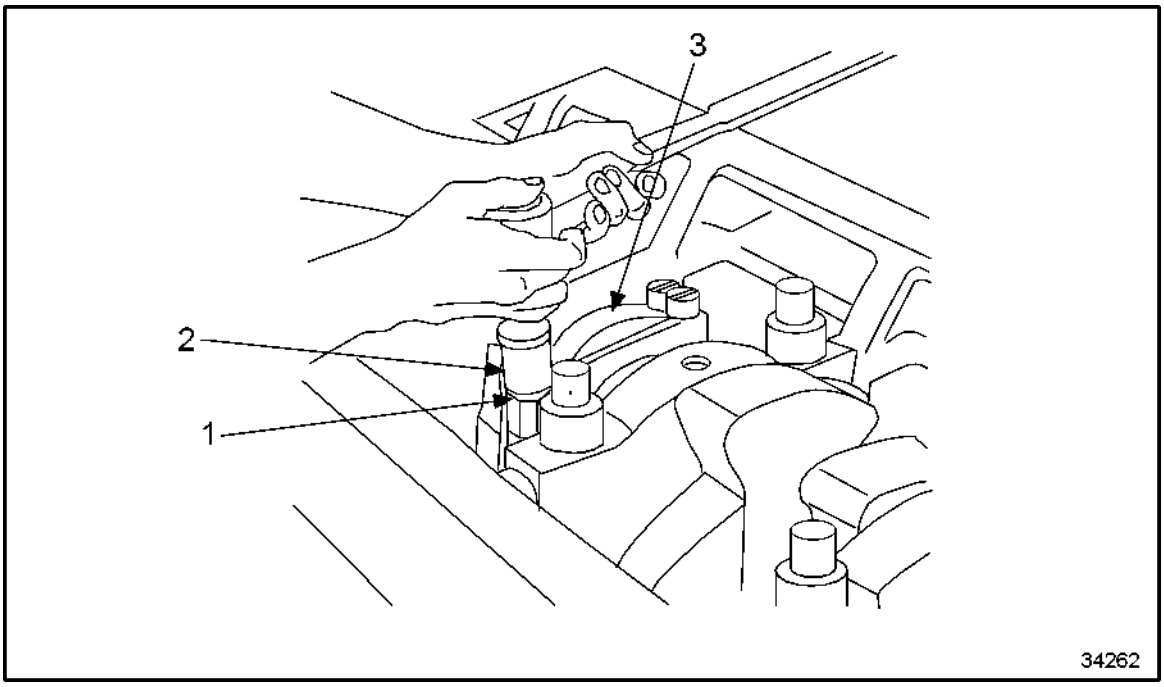
Figure 275 Release Connecting Rod Bolts Through Inspection Port

Except for the different position of the crankshaft, the remainder of the removal procedure is the same as for removing piston with connecting rod on engine stand.

Removing Piston with Connecting Rod (Mounted on Engine Stand)

Perform the following steps to remove piston with connecting rod in turnover stand.

1. Turn cylinder block so that connecting rod bearing cap (3) of piston to be removed is horizontal. See Figure 276.

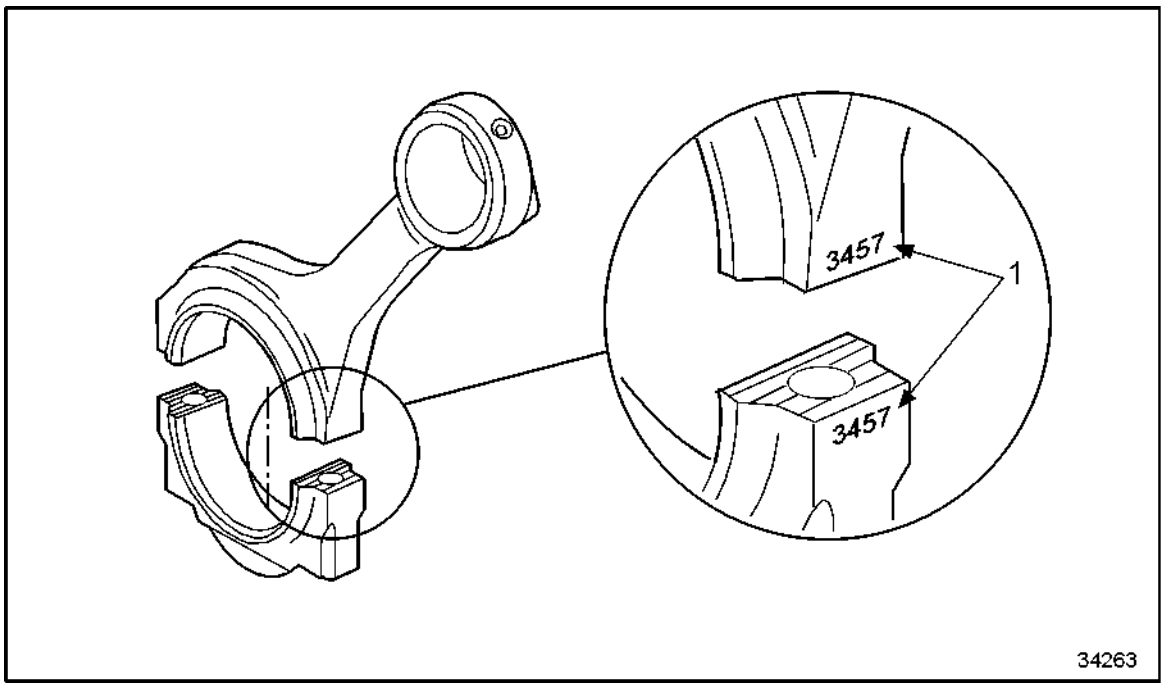


1. Connecting Rod Bolt
2. Socket Extension
3. Connecting Rod Bearing Cap

Figure 276 Removing Piston with Connecting Rod in Turnover Stand

2. Turn crankpin of respective cylinder on right side 40° before TDC and left side 40° after TDC.
3. Loosen connecting rod bolt (1) with socket extension (2) and ratchet. See Figure 276.

4. Check marking of connecting rod cap to connecting rod. See Figure 277.



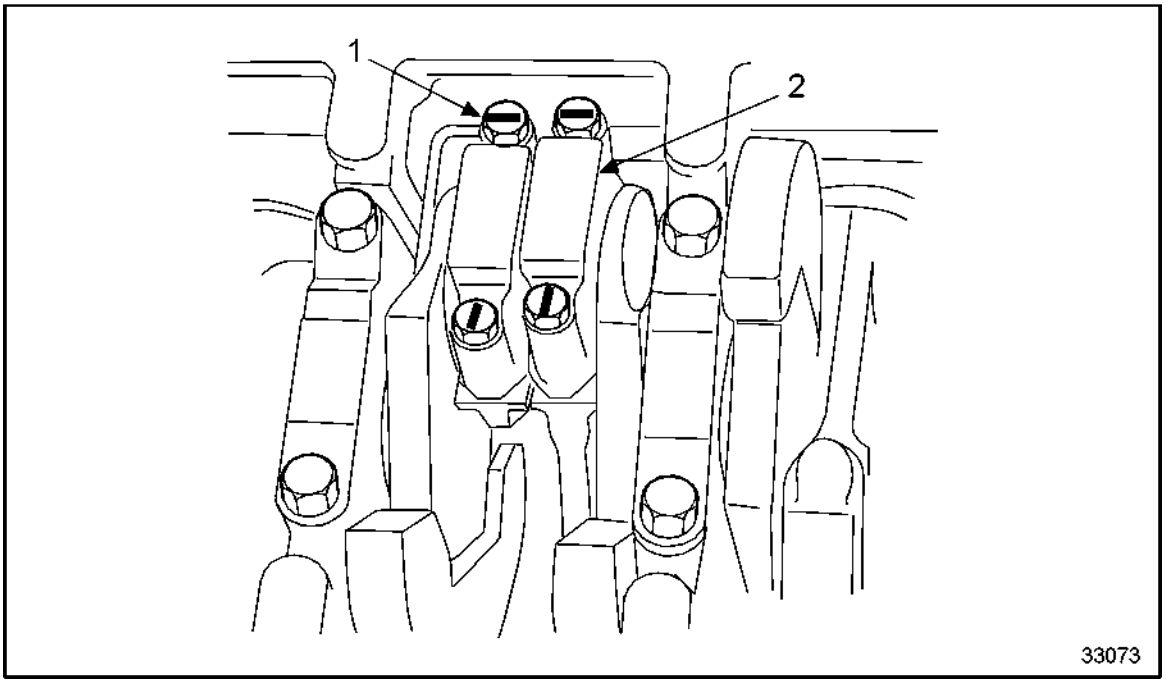
1. Connecting Rod Cap and Connecting Rod Markings

Figure 277 Check Markings of Connecting Rod Cap to Connecting Rod

NOTE:
Mark parts as necessary.

NOTE:
Bearing cap and connecting rod are a single unit and must not be interchanged.

5. Remove connecting rod bolts (1) with socket and ratchet, and remove connecting rod cap (2). See Figure 278.



1. Connecting Rod Bolt
2. Connecting Rod Cap

Figure 278 Removing Connecting Rod Bolts

6. Remove main bearing shell from connecting rod cap, and protect from damage.

NOTE:
The serrations on the connecting rod and connecting rod cap mating surfaces must not be damaged. If necessary, replace connecting rod.

7. Check markings from main bearing shell to connecting rod.

NOTE:
Mark parts as necessary.

8. Turn cylinder block so that piston to be removed with connecting rod is vertical.

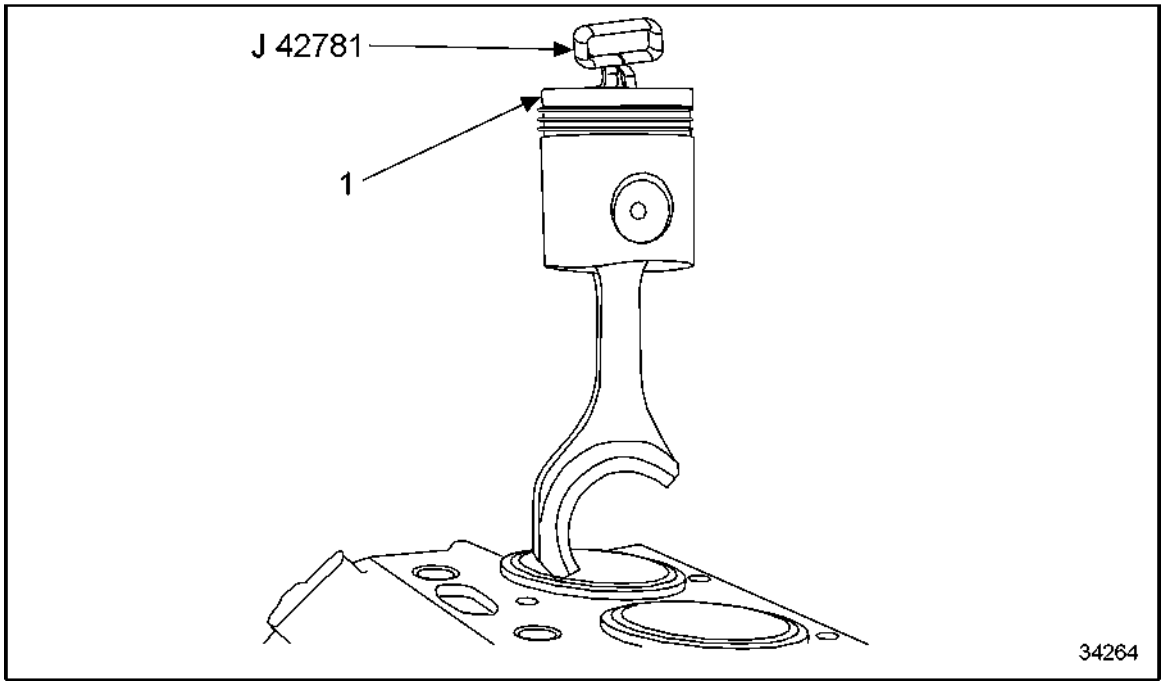
NOTE:
When removing piston, do not damage or warp oil spray nozzle. Oil spray nozzles can be removed so that no damage can occur.

9. Remove main bearing shell from connecting rod and protect from damage.

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.

10. Secure piston and connecting rod lifting tool J 42781 (2) on piston crown (1). See Figure 279.



1. Piston Crown

Figure 279 Removing Piston with Connecting Rod in Vertical Position

CAUTION:

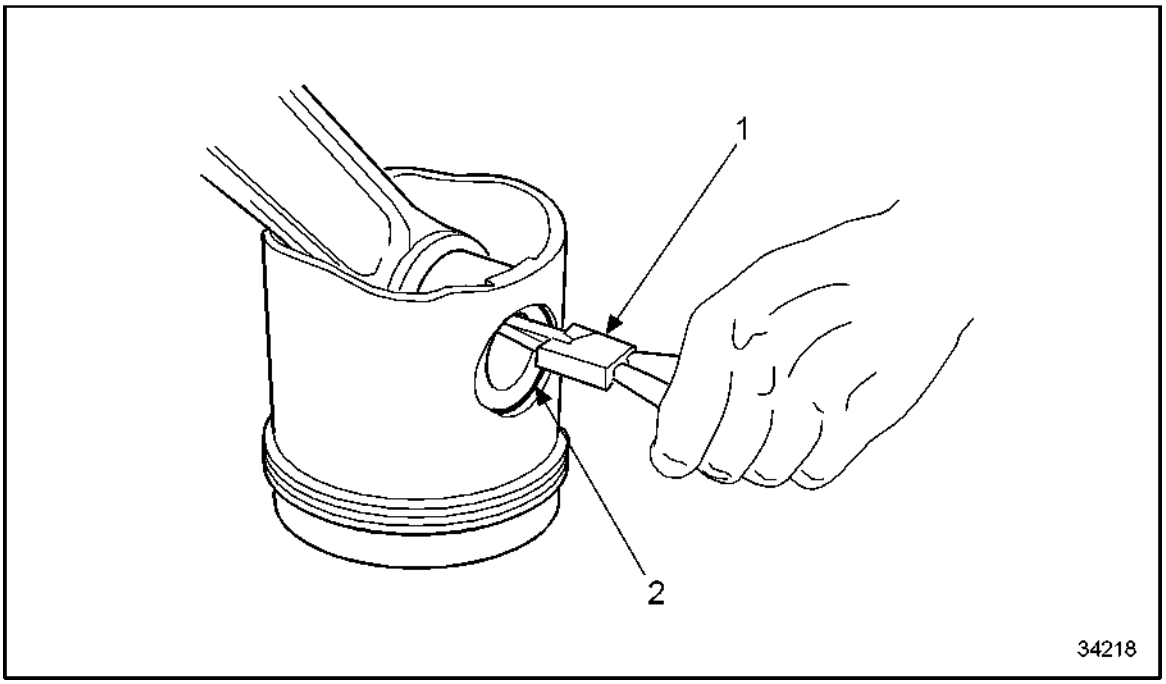
To avoid injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

11. Remove piston and connecting rod with lifting device and crane from cylinder liner bore.
12. Remove lifting device from piston crown.

C 037.05.06 – DISASSEMBLY OF PISTON WITH CONNECTING ROD

To disassemble the piston with connecting rod, perform the following steps:

1. Place piston and connecting rod on workbench.
2. Check markings on connecting rod, piston and piston pin. Correct markings if necessary.
3. Using snap ring pliers (1), remove snap ring (2). See Figure 280.

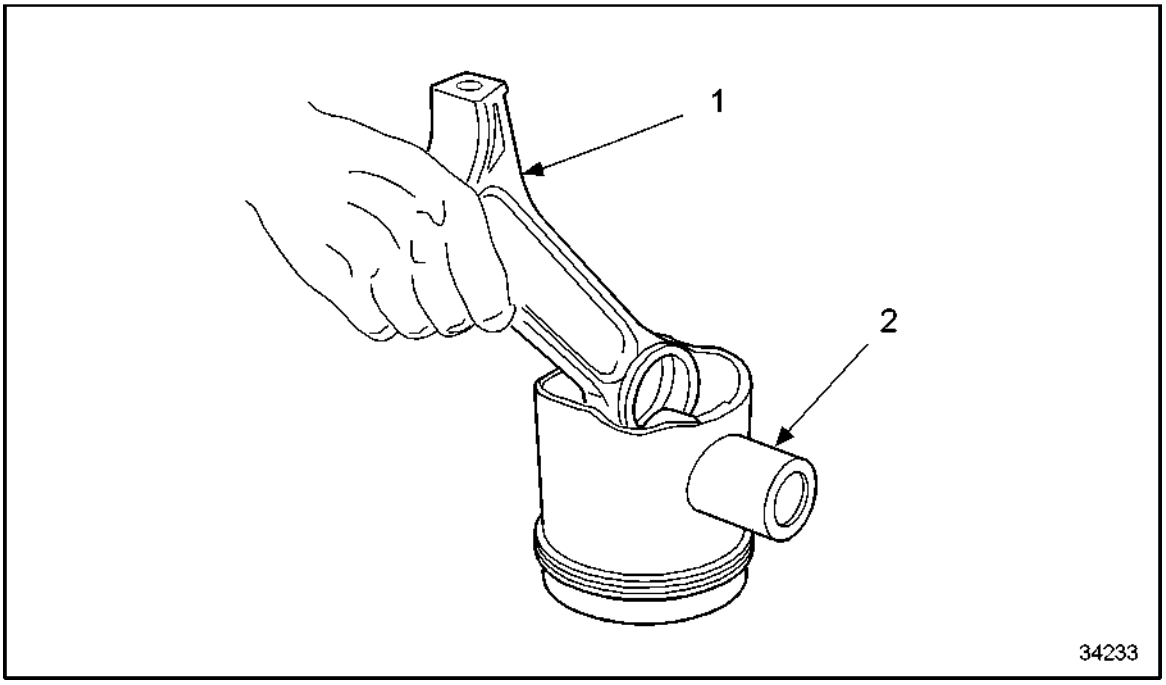


1. Snap Ring Pliers
2. Snap Ring

Figure 280 Removing Snap Ring

4. Use wooden rod to press out piston pin (2). See Figure 281.

NOTE:
Do not use sharp-edged tool to force out piston pin.



1. Connecting Rod
2. Piston Pin

Figure 281 Removing Piston Pin

5. Hold connecting rod (1) and remove piston pin (2). See Figure 281.
6. Remove connecting rod from piston.

NOTICE:
To avoid breaking piston rings, stretch them only until they can be removed from the piston.

7. Remove piston rings with ring expander pliers (arrows) in sequence from top to bottom. See Figure 282.

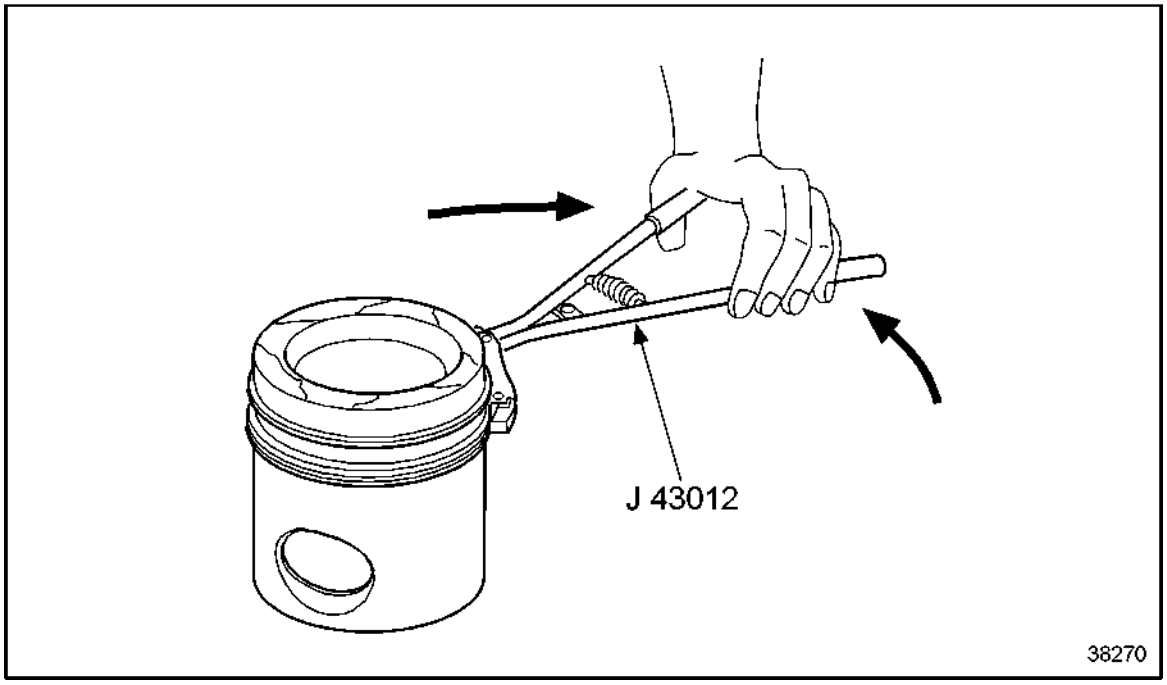
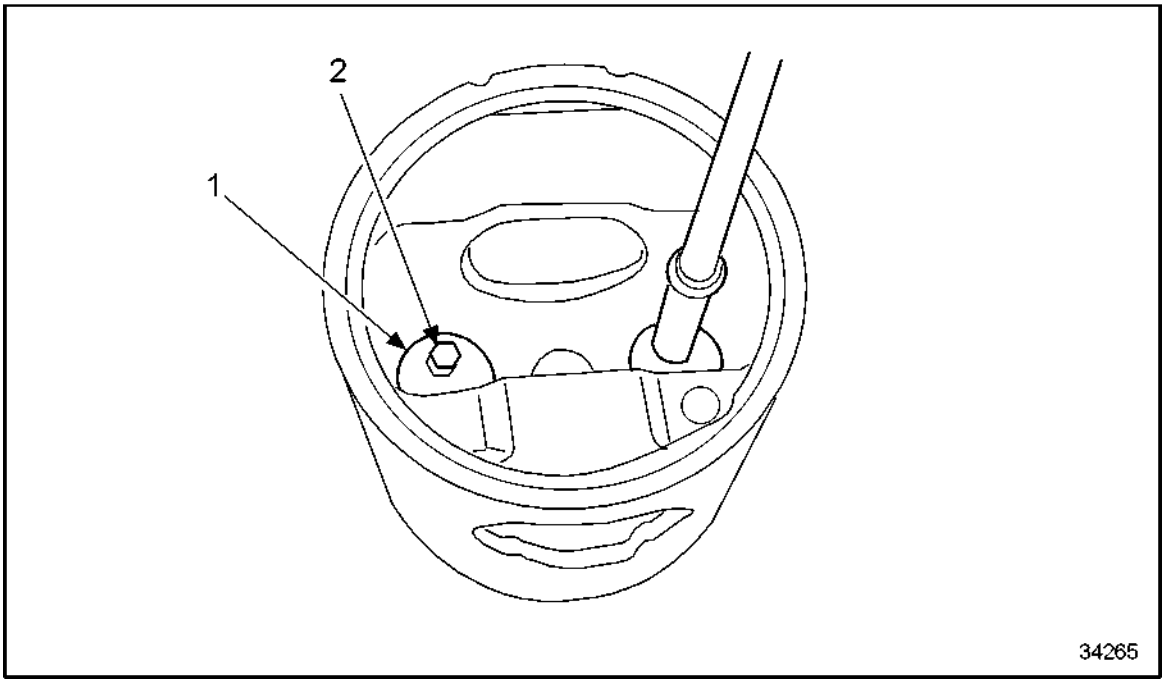


Figure 282 Removing Piston Rings

8. Install piston on suitable retaining device.

9. Use socket to unscrew piston crown bolt (2) and remove with pressure plate (1). See Figure 283.



1. Pressure Plate
2. Piston Crown Bolt

Figure 283 Removing Piston Crown Bolt

10. Remove piston crown.

C 037.05.08 – INSPECTION AND REPAIR

Perform the following subsections to inspect and repair piston with connecting rod.

Piston

Perform the following steps to inspect and repair piston.

NOTE:
The graphite layer on the piston skirt must not be mechanically removed or treated with strong cleaners.

CAUTION:

To avoid injury when using carbon-deposit remover chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

1. Treat carbon deposits on piston crown and piston ring grooves with decarbonizer.
2. Clean area of piston ring grooves with rotating brush.
3. Clean oil chamber and compression surfaces with synthetic abrasive MTH 688 (rated grain).
4. Using the surface crack testing method with fluorescent penetrant dye, check piston for cracks.
   [a] If cracked, replace the piston.
   [b] If not cracked, continue inspection.
5. Carefully inspect piston ring grooves for cracks.
   [a] If cracked, replace the piston.
   [b] If not cracked, continue inspection.

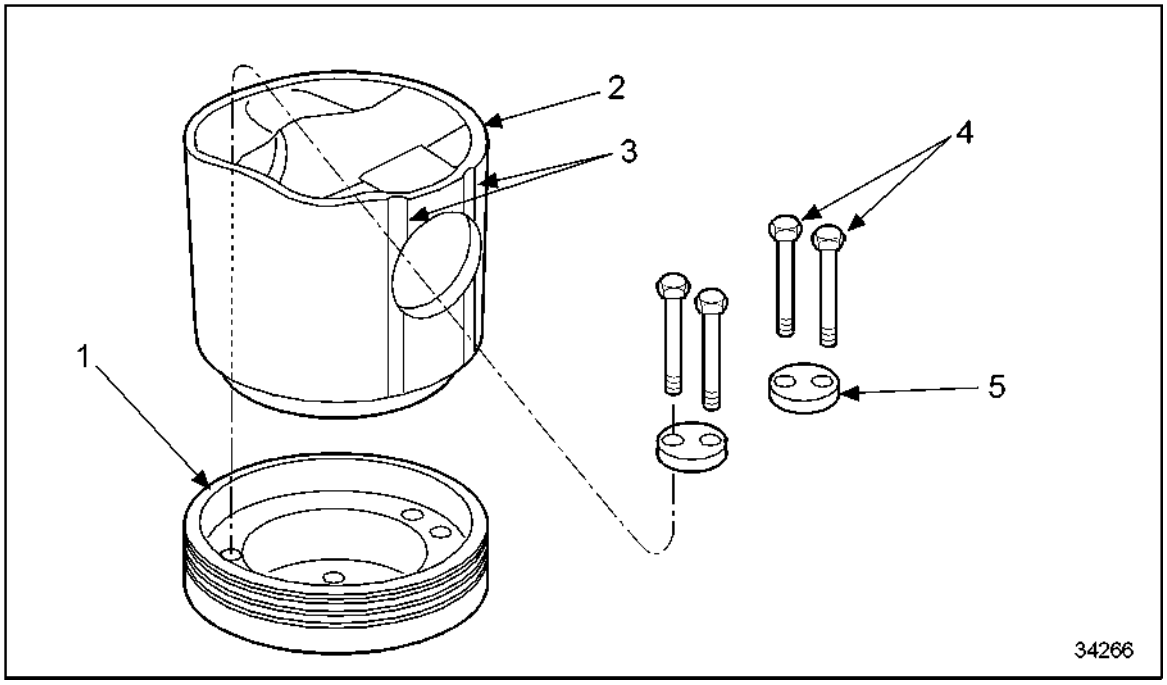
Checking Piston Skirt and Top Land

Perform the following steps to inspect and repair piston skirt and top land.

1. Check piston skirt surface condition for wear, pitting and scoring.
   [a] If worn, pitted or scored, replace the piston.

[b] If not worn, pitted or scored, continue inspection.

2. The piston skirt wear pattern must cover most of the surface. The friction scores (3) in this area must be easily identifiable. See Figure 284.



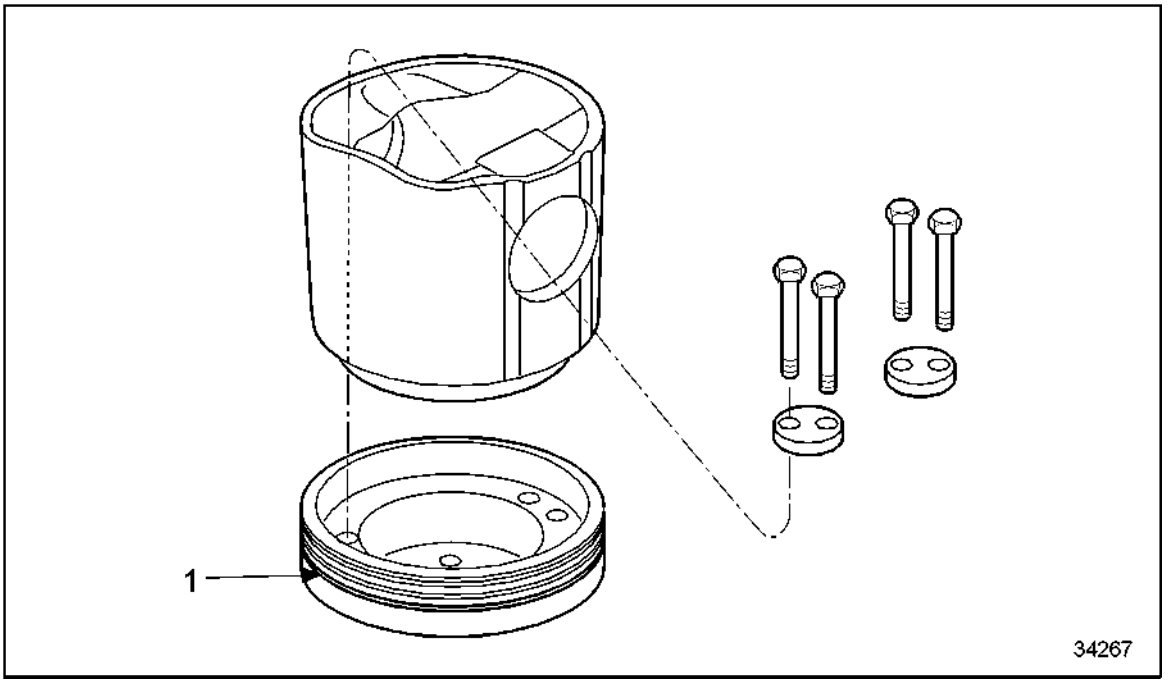
1. Piston Crown
2. Piston Skirt
3. Friction Scores
4. Piston Crown Bolt
5. Pressure Plate

Figure 284 Checking Piston Skirt Wear Pattern

NOTE:
The friction scores on the circumference are artificial depressions which are filled with oil and result in improved lubrication.

3. Inspect the piston edge for heavy contact, wear, pitting, scoring or erosion.
   [a] If piston edge shows signs of heavy contact, wear, pitting, scoring or erosion, replace the piston.
   [b] If piston edge is not worn, pitted, scored or eroded, continue inspection.
4. Inspect piston for scoring or scuffing on top land (piston crown).
   [a] Remove scoring or scuffing on top land (piston crown) of piston if localized and does not extend as far as first ring groove.

[b] Replace piston if damage is more extensive, i.e., if scoring or pitting extends as far as the first piston groove (1). See Figure 285.



1. First Piston Groove

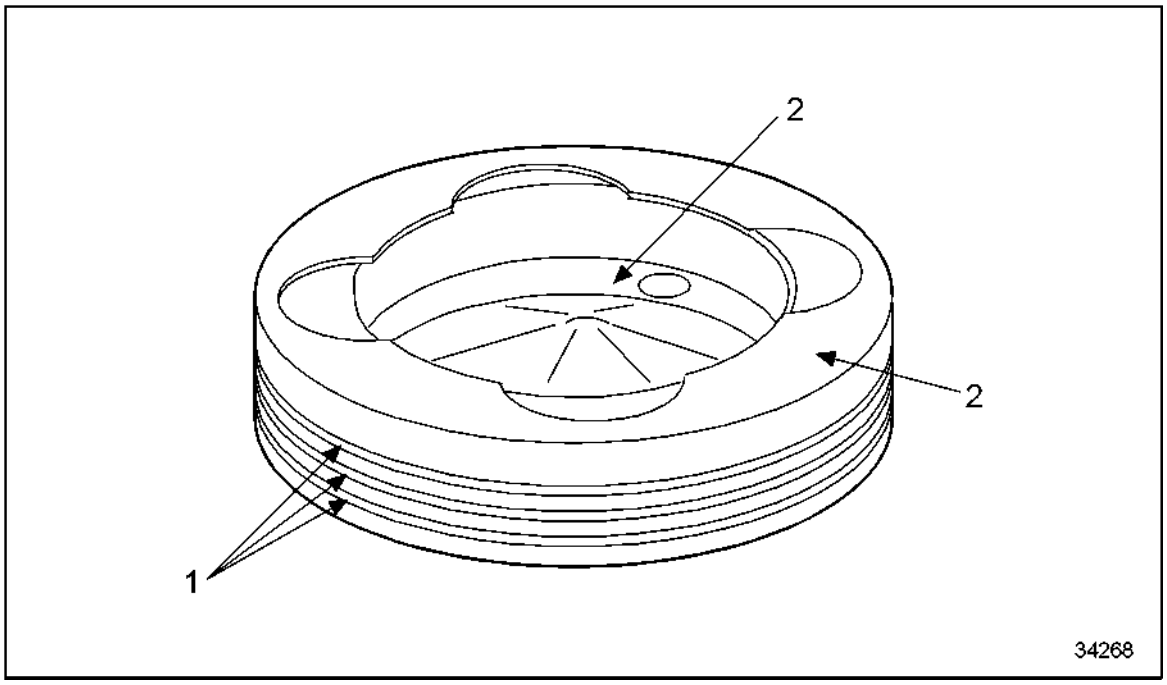
Figure 285 Checking Piston Skirt and Top Land

5. Inspect piston for extensive polishing wear on piston skirt (appears dull rather than shiny) and concentrated scoring.
   [a] If piston skirt shows extensive polishing wear or concentrated scoring, replace the piston.
   [b] If piston skirt does not show extensive polishing wear or concentrated scoring, continue inspection.
6. Inspect piston skirt for minor, localized scuffing.
   [a] If piston skirt shows localized scuffing, replace piston.
   [b] If piston skirt does not show localized scuffing, continue inspection.

Checking Piston Crown

Perform the following steps to inspect and repair the piston crown.

1. Treat carbon deposits on piston crown and piston ring grooves with decarbonizer.
2. Clean area of piston ring grooves (1) with rotating brush. See Figure 286.



1. Piston Ring Grooves
2. Compression Surface

Figure 286 Cleaning Piston Ring Grooves and Oil Chamber

3. Clean oil chamber and compression surface (2) with synthetic abrasive MTH 688 (rated grain). See Figure 286.
4. Using the magnetic crack testing method with fluorescent magnetic powder, check piston crown for cracks.
   [a] If cracked, replace the piston.
   [b] If not cracked, continue inspection.
5. Clamp piston crown axially in magnetic crack testing machine.
6. When testing, turn piston through 180°.
7. Carefully inspect piston ring grooves for cracks.
   [a] If cracks are found in piston ring grooves, replace complete piston.
   [b] If not piston ring grooves are not cracked, continue inspection.
8. Inspect sealing surface of piston crown and piston skirt for fretting.
   [a] If minor fretting is found, smooth sealing surface with oilstone.
   [b] If excessively fretted, replace piston.
   [c] If not fretted, continue inspection.

9. Inspect circlip bore.
   [a] If minor wear is found, replace piston.
   [b] If not worn, continue with inspection.
10. Inspect clearance pockets or piston edges for scorching.
   [a] If scorching is found on valve clearance pockets or piston edges, complete piston must be replaced.
   [b] If no scorching is found on valve clearance pockets or piston edges, continue with inspection.
11. Inspect top land of piston for scoring and scuffing.
   [a] Remove scoring or scuffing on top land of piston crown with an oilstone if localized and does not extend as far as first ring groove.
   [b] If not scored or scuffed, continue with inspection.
12. Inspect piston for extensive damage, i.e. if scoring or pitting extends as far as the first annular groove.
   [a] If damage is extensive, replace complete piston.
   [b] If damage is not extensive, continue inspection.

Checking Piston Crown Bolts

Perform the following steps to inspect and repair the piston crown bolts.

1. Measure shaft length of bolt with depth gage.
   [a] If bolt is not proper length, replace bolt.

[b] If bolt is proper length, continue inspection. See Figure 287.

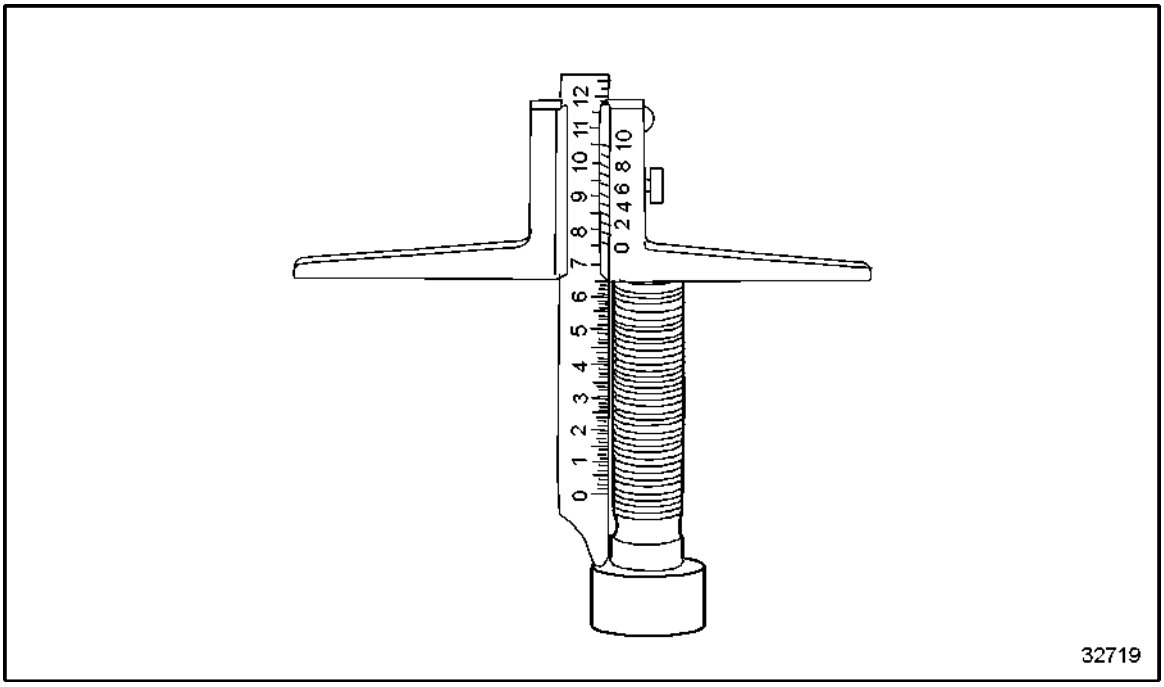


Figure 287 Measuring Shaft Length of Bolt with Depth Gage

2. Make sure bolt threads are in perfect condition.
   [a] If bolt threads are worn, replace bolt.
   [b] If bolt threads are not worn, continue with inspection.

Measuring Piston Skirt Diameter

Perform the following steps to measure the piston skirt diameter.

1. Use an outside micrometer to measure outside diameter on wear surfaces.
   [a] If limit values are not reached, replace piston.

[b] If limit values are reached, continue inspection. See Figure 288.

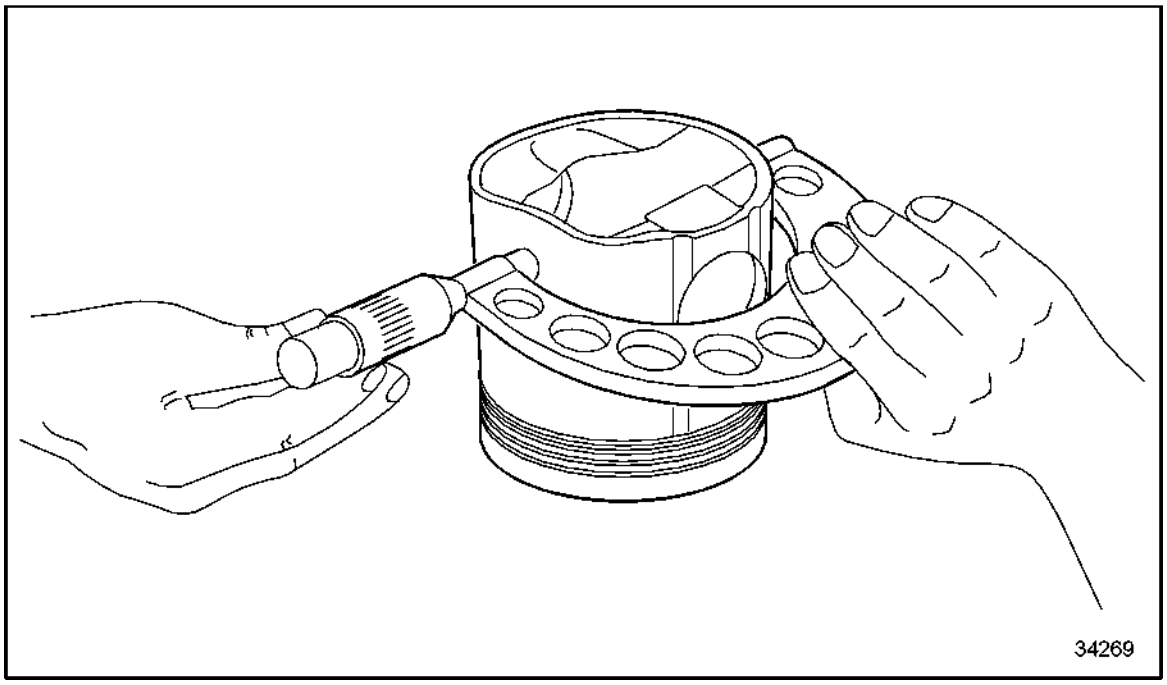


Figure 288 Measuring Piston Skirt Diameter

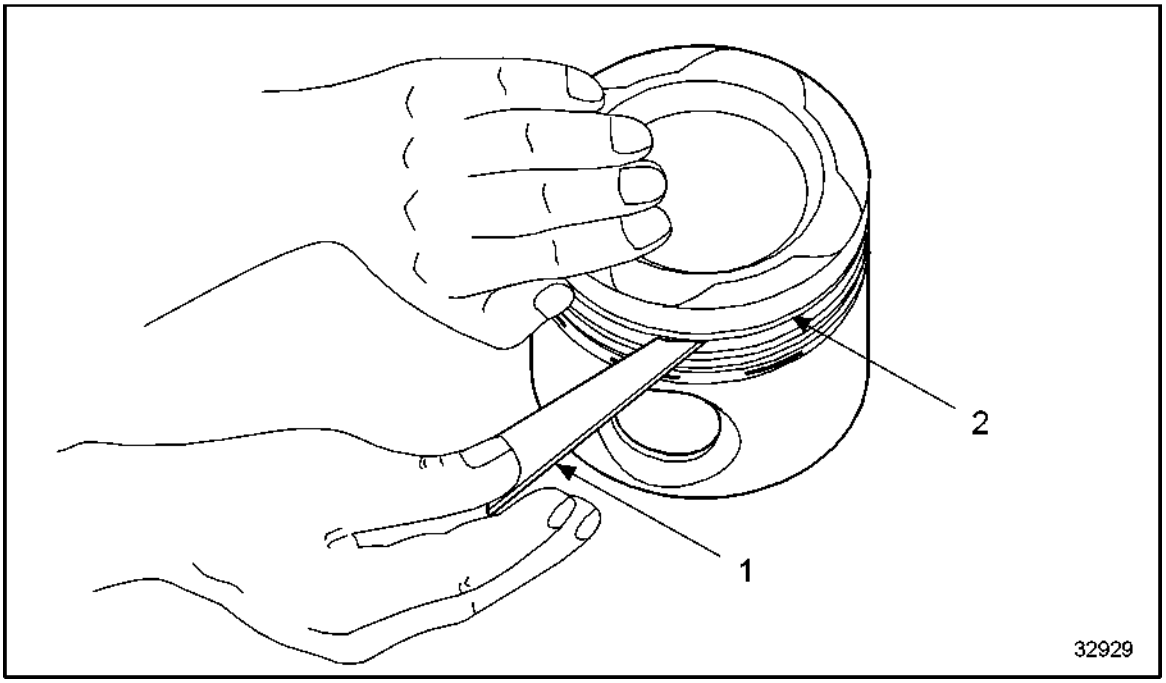
2. Check bolts in piston skirt for condition and specified torque. Refer to section A 003.
   [a] If not within specifications, replace bolts.
   [b] If within specifications, continue inspection.

Inspect Piston Ring Grooves

Perform the following steps to inspect and repair piston ring grooves.

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.

[b] If limit values are not exceeded, continue inspection. See Figure 290.

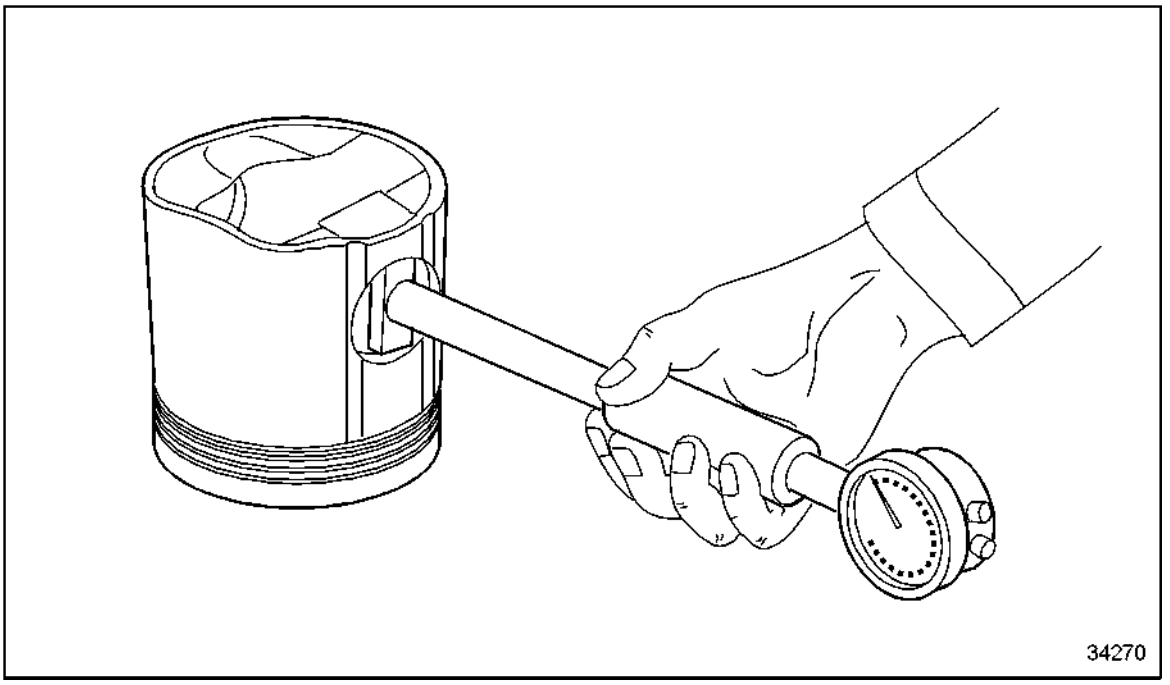


Figure 290 Inspecting Piston Pin Boss

2. Check sliding surfaces of bronze bushing for wear and scoring.
   [a] If sliding surfaces of bronze bushing are worn or scored, replace piston.
   [b] If not worn or scored, continue with inspection.

Inspecting Piston Pin

Perform the following steps to inspect and repair piston pin.

1. Measure outside diameter with outside micrometer and determine pin clearance. See Figure 291.

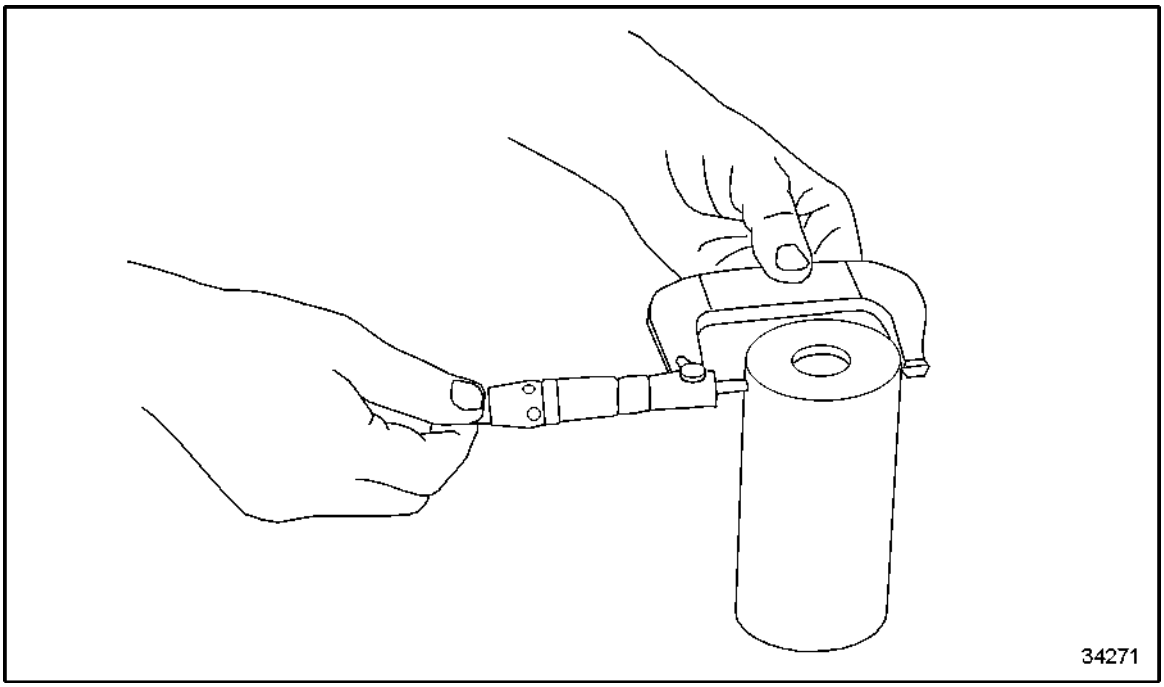


Figure 291 Inspecting Piston Pin

2. Using magnetic crack testing method and fluorescent magnetic powder, check piston pin for cracks.
   [a] If cracked, replace piston pin.
   [b] If not cracked, continue inspection.
3. Inspect piston pin for minor traces of wear and scoring.
   [a] If worn or scored, replace piston pin.
   [b] If not worn or scored, continue inspection.
4. Inspect piston pin for scuffing, indentations and severe wear.
   [a] If scuffing, indentations and severe wear are present, replace piston pin.
   [b] If not scuffed, indented or worn, continue inspection.

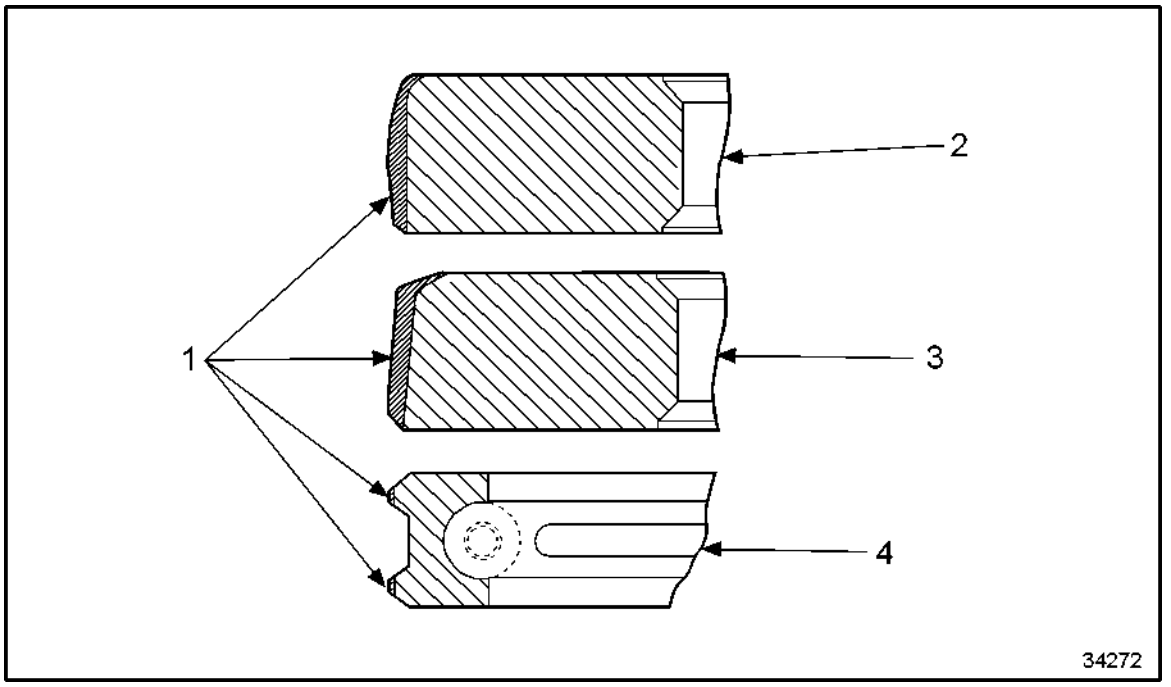
Inspecting Piston Rings

Perform the following steps to inspect and repair the piston rings.

1. Replace piston rings during W6 overhaul.
2. Clean combustion residue from piston rings and inspect for damage.
   [a] If damaged, replace piston rings.

[b] If piston rings are not damaged, continue with inspection.

Condition or wear of chrome layer (1) is a deciding factor when reusing or replacing fire ring (2), compression ring (3) and oil control ring (4). See Figure 292.

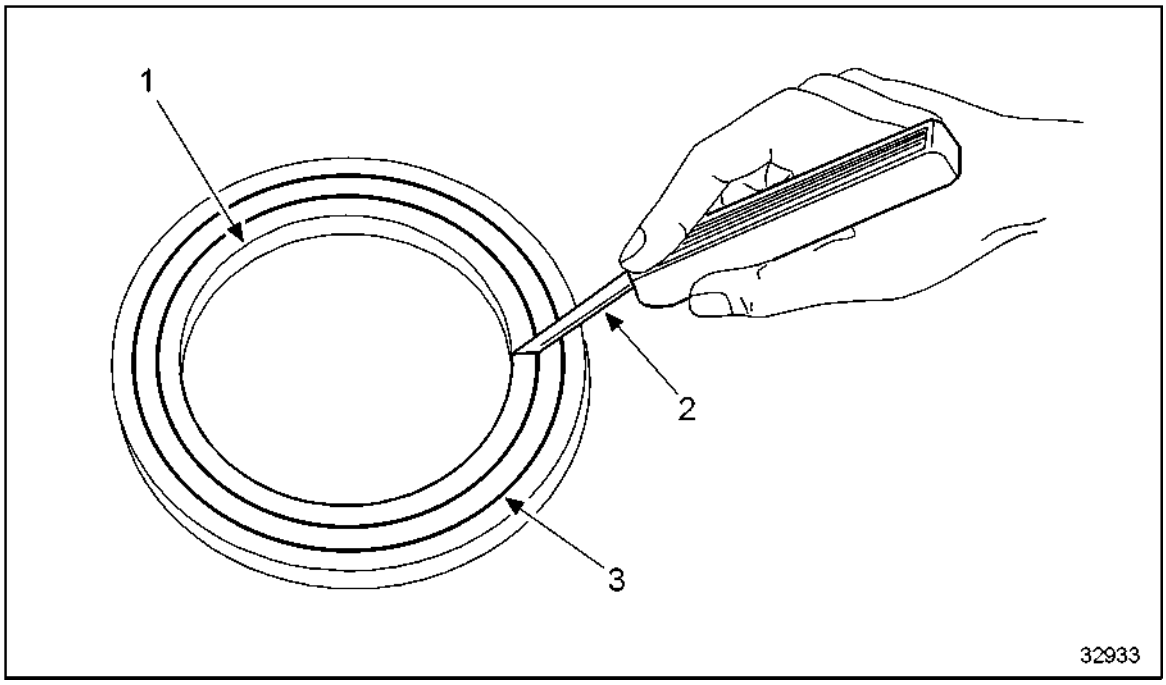


1. Chrome Layer
2. Fire Ring
3. Compression Ring
4. Oil Control Ring

Figure 292 Inspecting Piston Rings

3. Inspect chrome layer for scoring, cracks or heat discoloration.
   [a] If scoring, cracks or heat discoloration is found, replace piston rings.
   [b] If piston rings are not scored, cracked or no heat discoloration is found, continue with inspection.
4. Inspect piston rings for sharp edges.
   [a] Replace sharp-edged piston rings.
   [b] If piston rings are not sharp-edged, continue with inspection.
5. Inspect upper edge of rectangular section ring for sharp edge.
   [a] If upper edge of rectangular section ring is sharp-edged, replace ring.
   [b] If upper edge of rectangular section ring is not sharp-edged, continue with inspection.
6. Visually check oil slits of control ring for clogged or carbon deposit areas.
   [a] If oil slits of oil control ring are clogged with carbon, remove carbon deposits.
   [b] If oil slits of control ring are not clogged with carbon, continue inspection.

7. Place piston ring (1) in ring gage (3) to measure piston ring end clearance. See Figure 293.



1. Piston Ring
2. Ring Gage
3. Feeler Gage

Figure 293 Measuring Piston Ring End Clearance

NOTE:
Ensure that piston ring is installed evenly in ring gage.

8. Check piston ring gap with feeler gage (2).
   [a] If limit values are exceeded, replace piston rings.
   [b] If limits are within specification, continue inspection.

NOTE:
Piston rings must only be replaced in sets. Hone cylinder liners if new piston rings are installed. Refer to section C 013.05.08.

Inspecting Connecting Rod

Perform the following steps to inspect and repair the connecting rod.

1. Using magnetic crack testing method with fluorescent magnetic powder, check connecting rod, connecting rod cap and connecting rod bolts for cracks.
   [a] If connecting rod, connecting rod cap or connecting rod bolts are cracked, replace cracked components.

[b] If connecting rod, connecting rod cap or connecting rod bolts are not cracked, continue with inspection.

2. Check connecting rod and connecting rod bolt threads for ease of movement.

   [a] If connecting rod and connecting rod bolt threads do not move easily, polish out all traces of nicks in connecting rod, or replace if necessary.

   [b] If connecting rod and connecting rod bolts move easily, continue with inspection.

CAUTION:

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

3. Use a brass brush to clean serrations on connecting rod and connecting rod cap mating surfaces, and blow dry with compressed air.
4. Inspect serrations on connecting rod and connecting rod cap mating surfaces for wear by ink-check method.

   [a] If serrations on connecting rod and connecting rod cap mating surfaces are worn, smooth with oilstone.

   [b] If serrations on connecting rod and connecting rod cap mating surfaces are not worn, continue with inspection.

5. Check connecting rod for bearing damage.

   [a] If connecting rod is blue in color (due to bearing damage), replace connecting rod.

   [b] If connecting rod is not damaged, continue with inspection.

6. Check main bore for wear and scoring.

   [a] If main bore is worn or scored, machine bore to repair size or replace connecting rod.

   [b] If main bore is not worn or scored, continue with inspection.

7. Check connecting rod bushing for scoring, dirt and wear.

   [a] If connecting rod bushing is scored, dirty or worn, burnish minor scoring with emery cloth; replace connecting rod bushing if necessary.

   [b] If connecting rod bushing is not scored, dirty or worn, continue with inspection.

8. Check connecting rod main bore for wear or damage.

   [a] If connecting rod main bore is worn or damaged, smooth with emery cloth.

   [b] If main bore is not worn or damaged, continue inspection.

CAUTION:

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

9. Check that lube oil bore in connecting rod is perfectly clean.

   [a] If lube oil bore in connecting rod is not clean, clean with bristle brush and blow with compressed air.

NOTE:
Never use a wire brush.

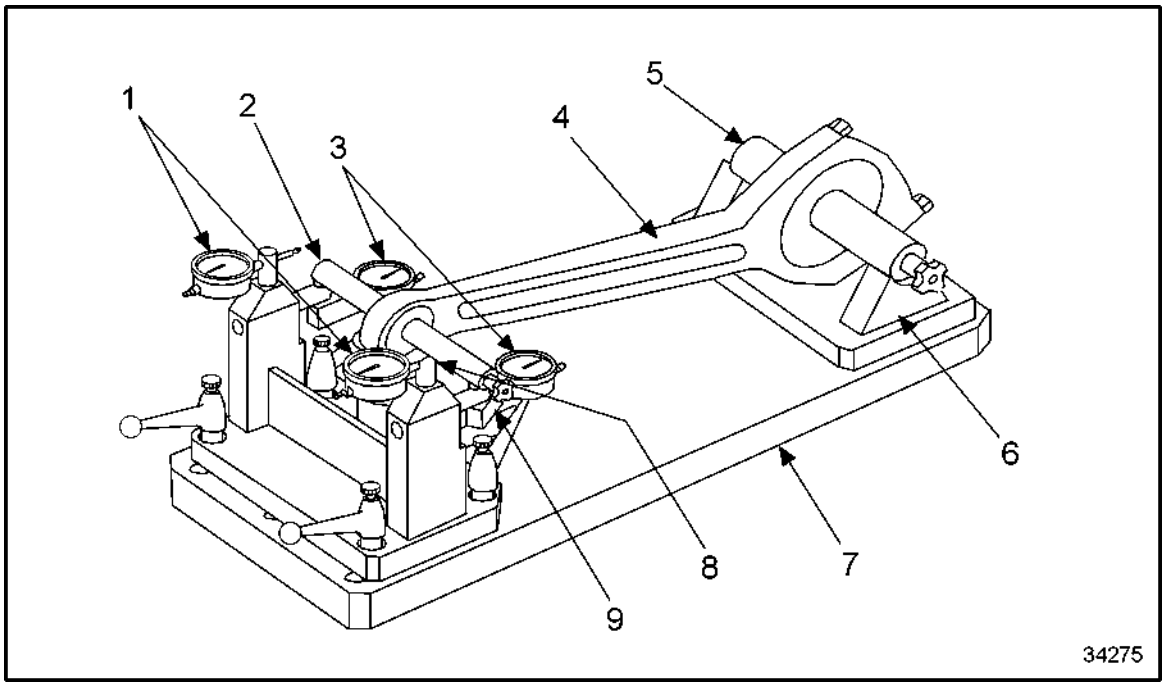
   [b] If lube oil bore in connecting rod is clean, continue with inspection.

Checking Axial Parallelism and Twist of Connecting Rod Bore

To check axial parallelism and twist of connecting rod bore, perform the following steps.

1. See Figure 294for the arrangement of the testing device.

NOTE:
To check axial parallelism and twist of connecting rod bores, install connecting rod cap and tighten connecting rod bolts as per tightening specifications.

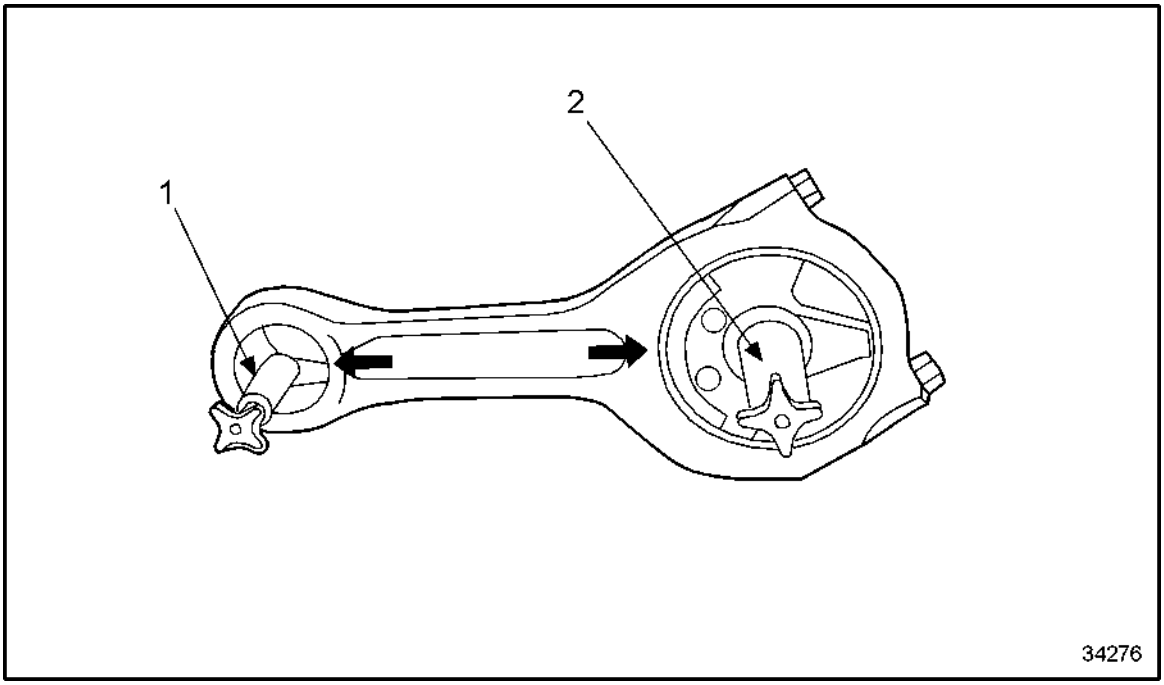


1. Dial Gage for Axial Parallelism
2. Test Brass Drift, Small Connecting Rod Eye
3. Dial Gage for Connecting Rod Twist
4. Connecting Rod
5. Test Brass Drift, Large Connecting Rod Eye
6. V-Block
7. Base Plate
8. Resilient Stop
9. Adjustable Dial Gage Holder

Figure 294 Checking Axial Parallelism and Twist of Connecting Rod Bore

2. Clean large and small connecting rod bore.

3. Insert test brass drift (2) in large connecting rod bore. See Figure 295.



1. Small Connecting Rod Bore Test Brass Drift
2. Large Connecting Rod Bore Test Brass Drift

Figure 295 Test Brass Drift in Connecting Rod

4. Make sure that installation position is correct.
5. Wide section end of test brass drift (arrow) must point to connecting rod shaft, narrow section side to connecting rod cap. See Figure 295.
6. Lightly secure test brass drift with securing screw.

NOTE:
Ensure that test brass drift is properly inserted.

7. Insert test brass drift (1) in small connecting rod bore. See Figure 295.

NOTE:
Ensure that installation position is correct.

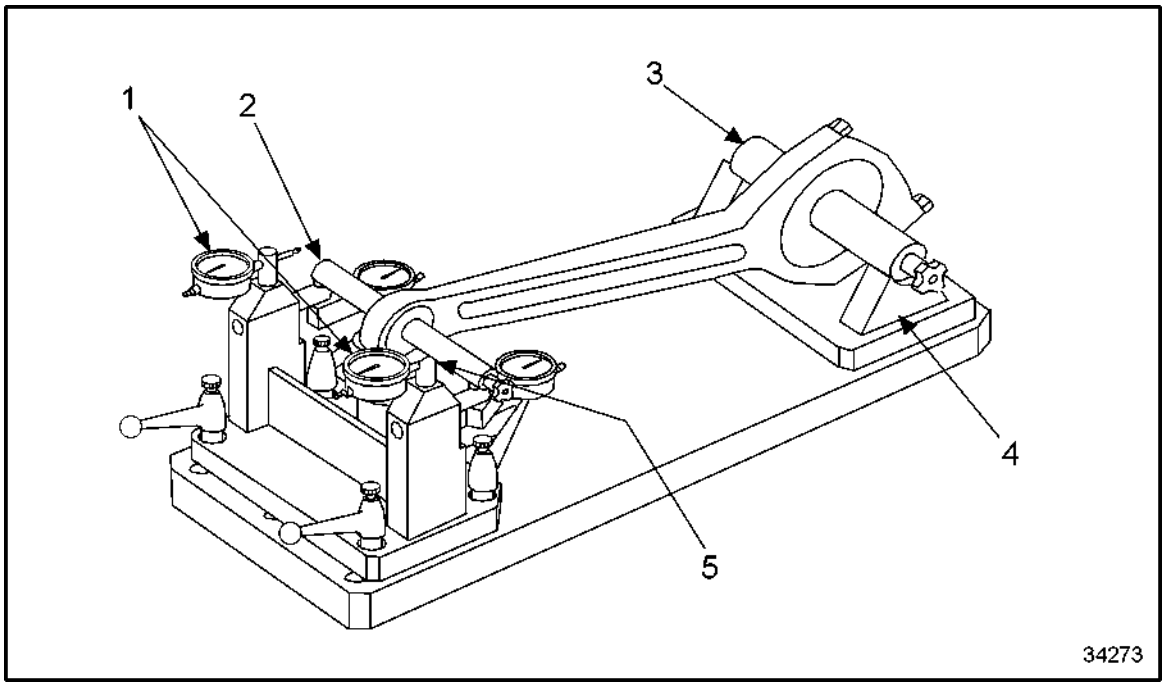
8. The wide section of test brass drift (arrow) must point toward connecting rod shaft, narrow section to oil bores of small connecting rod bore. See Figure 295.
9. Lightly secure test brass drift with securing screw.

NOTE:
Insert test brass drifts so that tension pins of narrow section of test brass drifts are aligned in the same direction.

Checking Axial Parallelism

To check axial parallelism, perform the following steps:

1. Insert connecting rod with test brass drift in large connecting rod bore (3) into block (4) of testing device. See Figure 296.



1. Dial Gage for Axial Parallelism
2. Test Brass Drift, Small Connecting Rod Eye
3. Test Brass Drift, Large Connecting Rod Eye
4. V-Block
5. Resilient (Adjustable) Stop

Figure 296 Checking Axial Parallelism

2. Place small connecting rod eye (2) on adjustable stop (5). See Figure 296.
3. Adjust the rigid stop of adjustable stop (5) so that axle of test brass drift (2) is approximately 2.0 mm (0.0787 in.) below dial gage stylus (1). See Figure 296.
4. Adjust both dial gages at highest point on test brass drift, with approximately 2.0 preload, set to zero.
5. Rotate connecting rod through 180 degrees and carefully place in testing device.
6. Move test brass drift in small connecting rod eye (2) through dial gage styluses (1) at highest point of test brass drift axle.
7. Determine and record deviations on dial gages.

Calculating Axial Parallelism

Perform the following steps to calculate axial parallelism.

1. Set the testing device for measuring axial parallelism at 200 mm (7.8740 in.) intervals.
2. In order to achieve correct value at 100 mm (3.9370 in.) intervals, calculate values read off at dial gages.
   [a] If limit value is exceeded, replace connecting rod.
   [b] If limit value is not exceeded, continue inspection. See Figure 297.

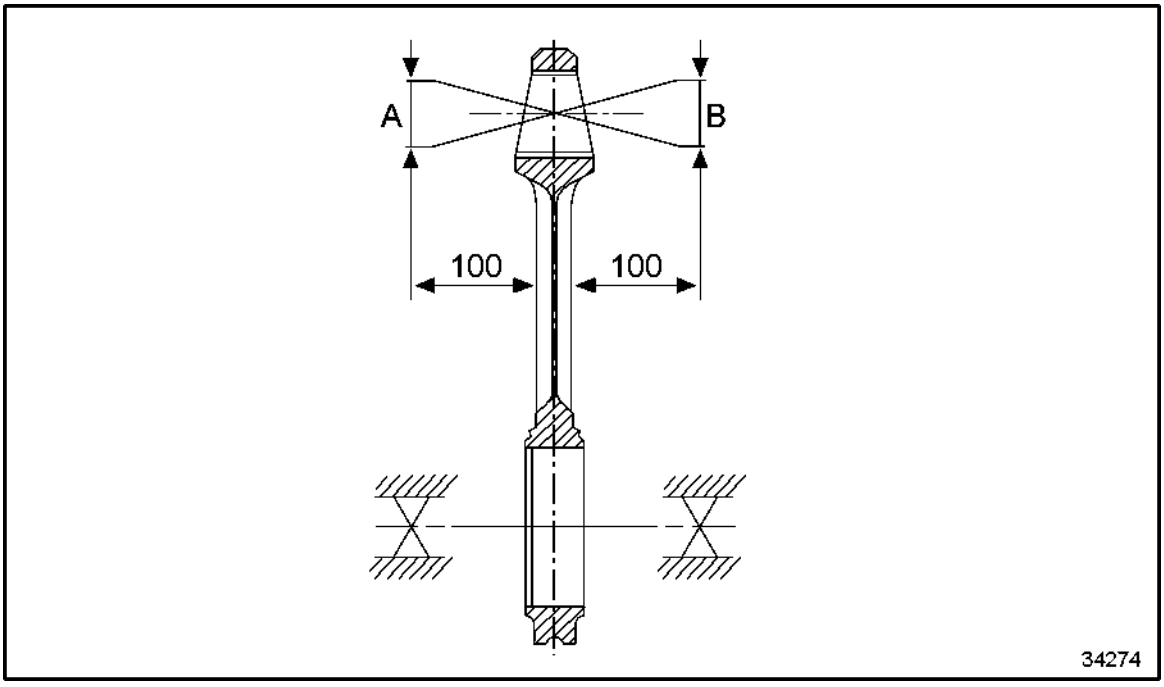


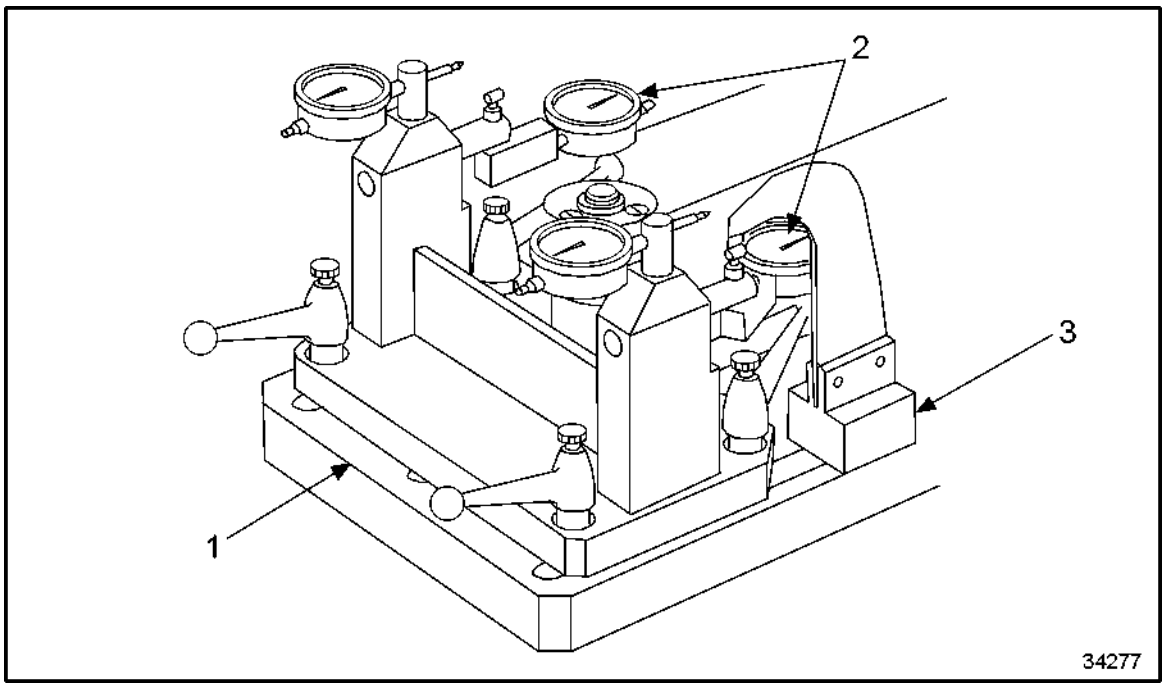
Figure 297 Calculating Axial Parallelism

For example: If left dial gage (A) reads –0.05 mm and right dial gage (B) reads +0.03 mm, calculated value is 0.08 mm. Axial parallelism as per example 0.08 mm (0.00315 in.) : 4 = 0.02 mm (0.007 in.).

Checking Axial Twist

Perform the following steps to check axial twist.

1. Set both dial gages (2) to zero with setting gage (3) via dial gage stylus. See Figure 298.

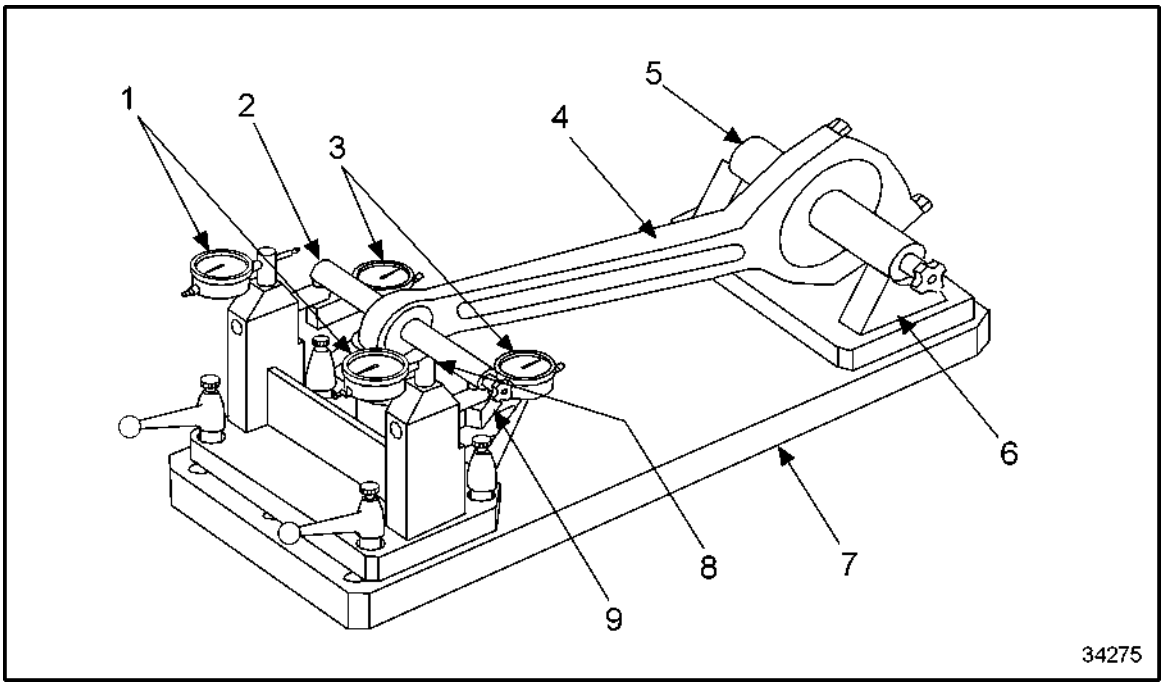


1. Testing Device
2. Dial Gages
3. Setting Gage

Figure 298 Checking Axial Twist

2. Remove setting gage (3) from testing device (1). See Figure 298.

3. Insert connecting rod with test brass drift (2) into block of testing device (3). See Figure 299.



1. Dial Gage for Axial Parallelism
2. Test Brass Drift, Small Connecting Rod Eye
3. Dial Gage for Connecting Rod Twist
4. Connecting Rod
5. Test Brass Drift, Large Connecting Rod Eye
6. V-Block
7. Base Plate
8. Resilient Stop
9. Adjustable Dial Gage Holder

Figure 299 Insert Connecting Rod with Test Brass Drift

4. Set fixed support of adjustable stop so that dial gage stylus travel is approximately 2 mm (0.07874 in.).
5. Press connecting rod at small connecting rod eye on fixed support.
6. Read and record values on dial gages (1).

Calculating Axial Twist

Perform the following steps to calculate axial twist.

1. To determine connecting rod bore axial twist, calculate value measured at 100 mm (3.9370 in.) intervals.
   [a] If limit value is exceeded, replace connecting rod.

[b] If limit value is not exceeded, continue inspection. See Figure 300.

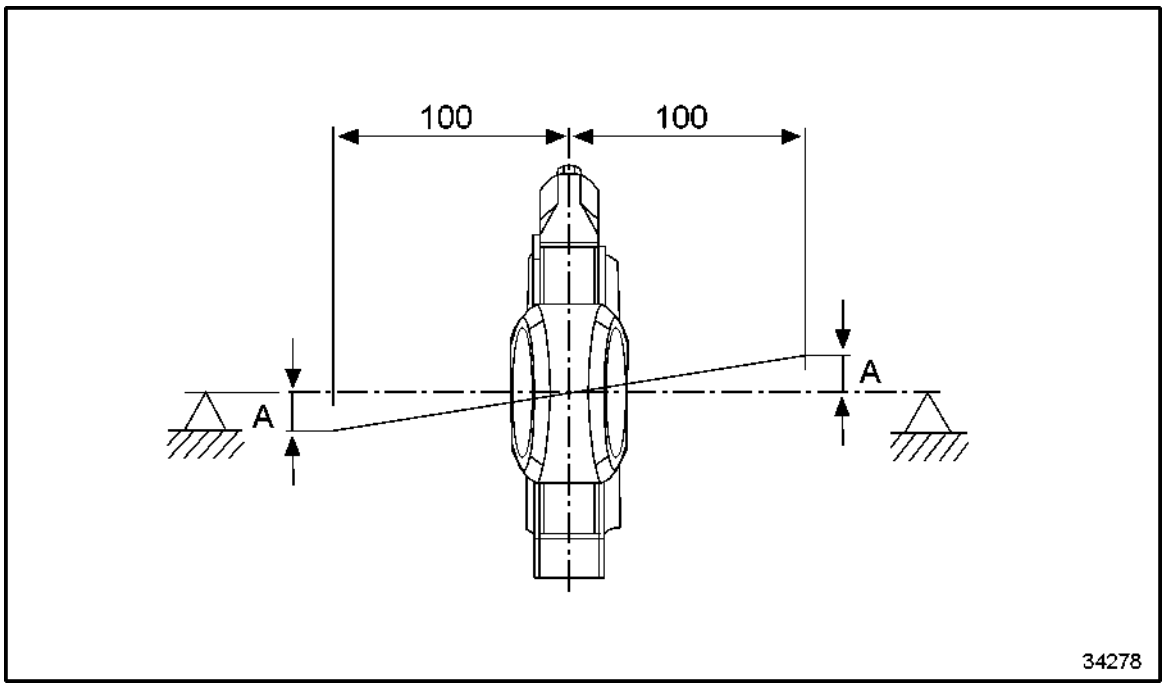


Figure 300 Calculating Axial Twist

For example: If left dial gage (A) reads –0.06 mm (0.0023 in.) and right dial gage (A) reads +0.04 mm (0.0015 in.), the difference equals 0.10 mm (0.0039 in.). Axial twist A = 0.10 mm (0.0039 in.): 2 = 0.05 mm (0.0019 in.).

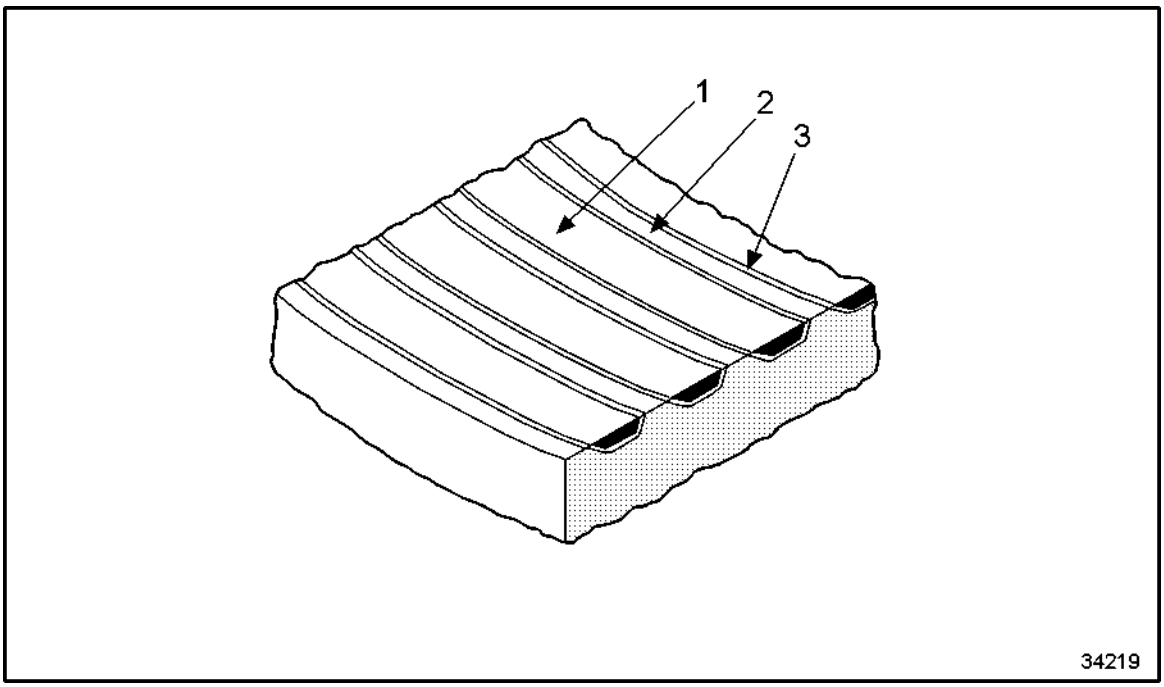
2. Axial twist A = 0.10 mm (0039 in.) : 2 = 0.05 mm (0.0019 in.). See Figure 300.
   [a] If limit value is exceeded, replace connecting rod.
   [b] If limit value is not exceeded, continue inspection.

Checking and Assessing Connecting Rod Bearing Shells (Sputtered Bearing-Lower Half)

Perform the following steps to check and assess connecting rod bearing shells (sputtered bearing-lower half).

1. Check rod bearing shells for wear.
   [a] If worn, replace rod bearing shells.

[b] If rod bearing shells are not worn, continue inspection. See Figure 301.



1. Wear Layer
2. Intermediate Layer
3. Running-in Layer

Figure 301 Checking and Assessing Connecting Rod Bearing Shells

2. Replace rod bearing shells as part of every W6 overhaul.
3. Wear of the bearing running surfaces starts at the galvanized wear layer (1). See Figure 301.

NOTE:
A magnifying glass is required for a more accurate assessment of the wear condition of the running surface (magnification minimum 5x).

4. The wear layer (1) appears as a dark zone and the intermediate layer (2) as a light zone. The decisive factor for the wear condition of the sputtered bearing is the ratio between the "width of intermediate layer: width of groove" and the extent of the worn surface. See Figure 301.
5. The grooved bearing is still functional if the wear layer is partially missing in the grooves. Practice has shown that the sputtered bearing with partially empty grooves can continue in use without negatively affecting the function of the bearing.
6. During each assessment of the condition of the grooves, the running surface in the area that is subject to least load (groove mostly new) should be used for comparison.
7. The condition of the sputtered bearings is assessed in five groups:
   □ Continued use

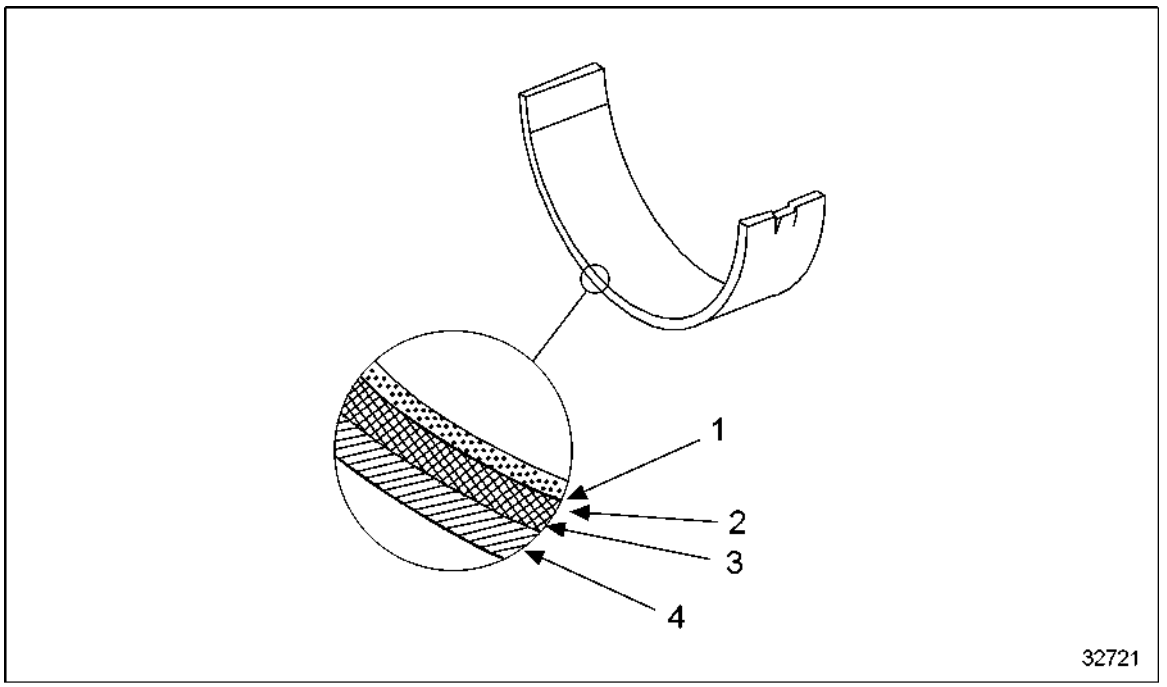
- □ Wear
- □ Borderline wear and levelling
- □ Wear layer fatigue fractures
- □ Borderline wear layer, continuous fractures and empty grooves

8. Damage to bearings occurs mainly through foreign body scoring, impressions and bedding, cavitation and corrosion, pitting, fatigue and installation faults.
9. Bearings showing such damage must be replaced.

Checking and Assessing Connecting Rod Main Bearing Shells

Perform the following steps to check and assess the connecting rod main bearing shells.

1. Check rod bearing shells for wear.
   [a] If worn, replace rod bearing shells.
   [b] If rod bearing shells are not worn, continue inspection.
2. Replace main bearing shells as part of every W6 overhaul.
3. Wear on bearing running surfaces starts at the galvanized wear layer (1). See Figure 302.



1. Wear Layer (from 12µm – 18µm)
2. Running-in Layer (from 1µm — 3µm)
3. Intermediate Layer Corresponds to Approximately 10% of Bearing Thickness
4. Protective Steel Shell Corresponds to Approximately 88% of Bearing Thickness

Figure 302 Checking and Assessing Connecting Rod Bearing Shells

4. An important indicator for assessing extent of wear on bearing shell is the shape and extent of the nickel barrier (running-in layer) areas exposed.
5. Use of rod bearing shell is already restricted in friction area once the sliding layer is reduced to 70%.

NOTE:
It is often difficult to differentiate between the hard nickel barrier and softer sliding layer.

Connecting Rod Cap Bolt

Perform the following steps to check connecting rod cap bolt.

1. Check bolt head support and thread for scoring or damage.
   [a] If scored or damaged, replace bolt.
   [b] If bolt is not scored or damaged, continue inspection.
2. Measure shaft length of connecting rod bolt with depth gage. See Figure 303.

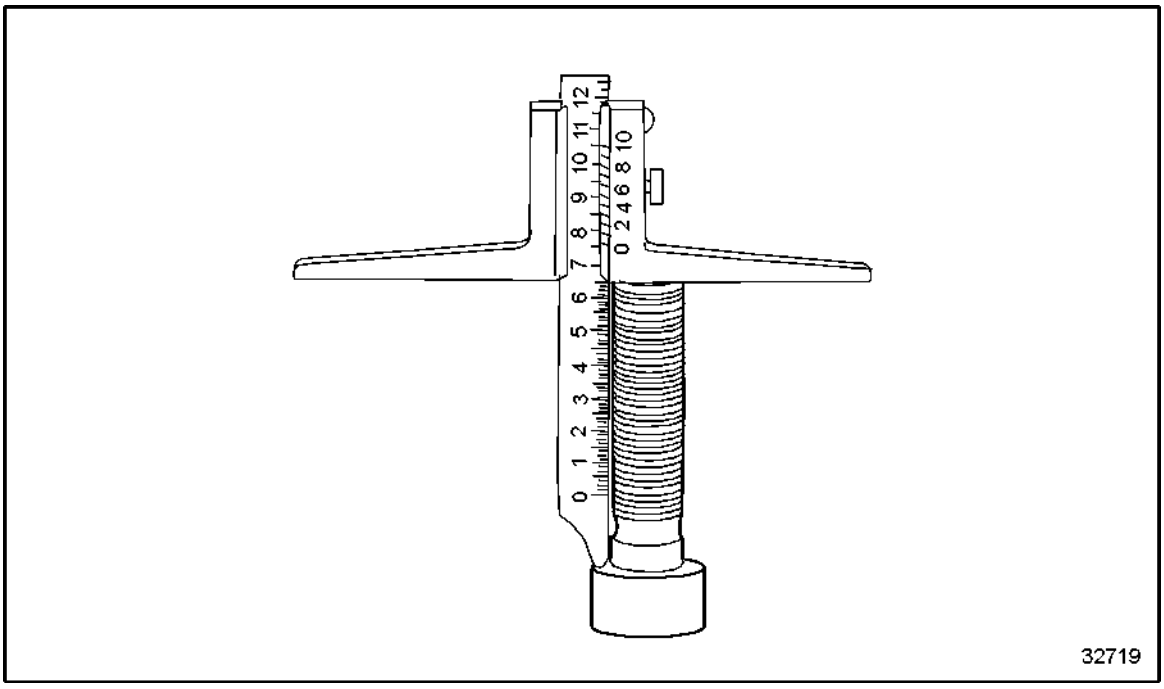


Figure 303 Measuring Connecting Rod Cap Bolt

3. For maximum permissible shaft length, refer to section C 037.05.01.

Storing Connecting Rod

Perform the following steps to store connecting rod.

CAUTION:

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

1. Blow out interfaces on connecting rod and connecting rod cap with compressed air, and check that they are clean.
2. Inspect the serrations on the connecting rod and connecting rod cap mating surfaces for damage.
   [a] If damaged, replace the connecting rod and connecting rod cap.
   [b] If connecting rod and connecting rod cap are not damaged, continue inspection.
3. Clean bearing shell mating surfaces on connecting rod and connecting rod cap. See Figure 304.

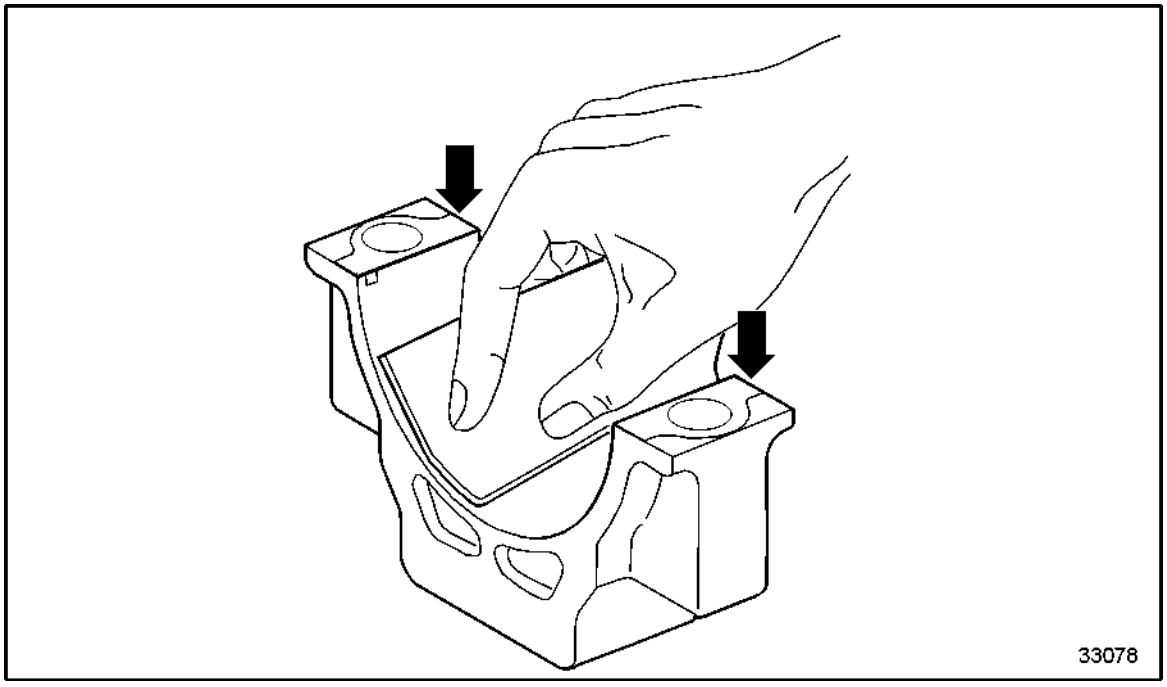
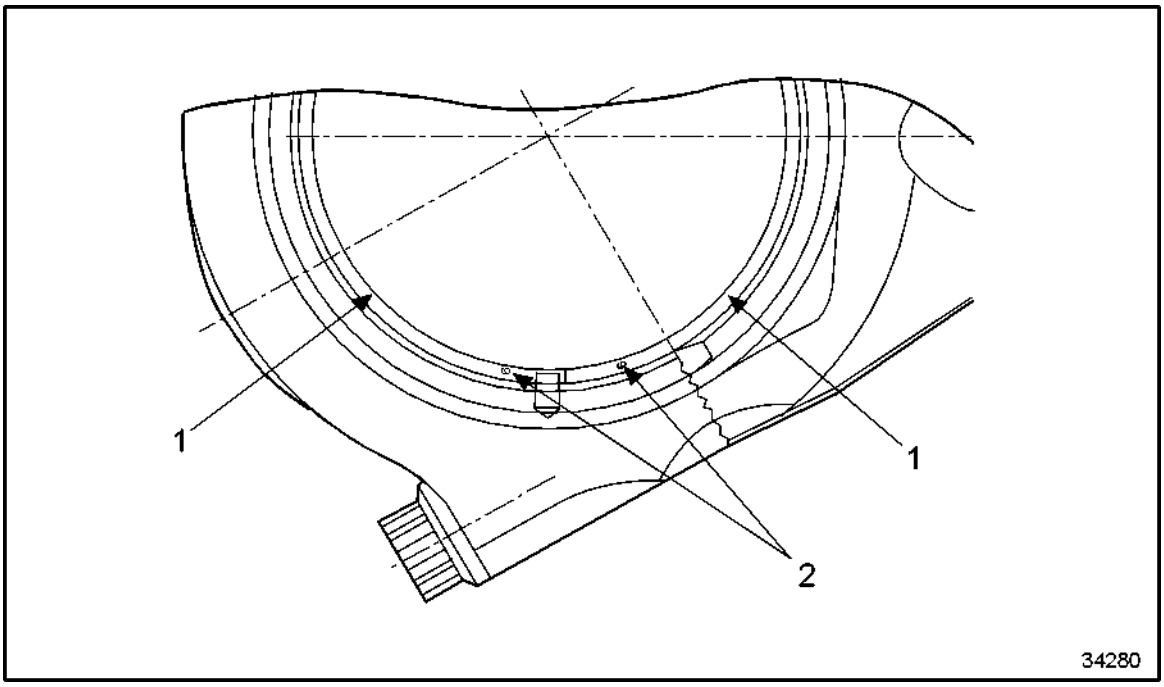


Figure 304 Cleaning Bearing Shell Mating Surfaces

NOTE:
New connecting rod bearing shells (1) must be installed as part of every W6 overhaul.

4. Mark connecting rod bearing shells according to cylinder number on front surface (2). See Figure 305.



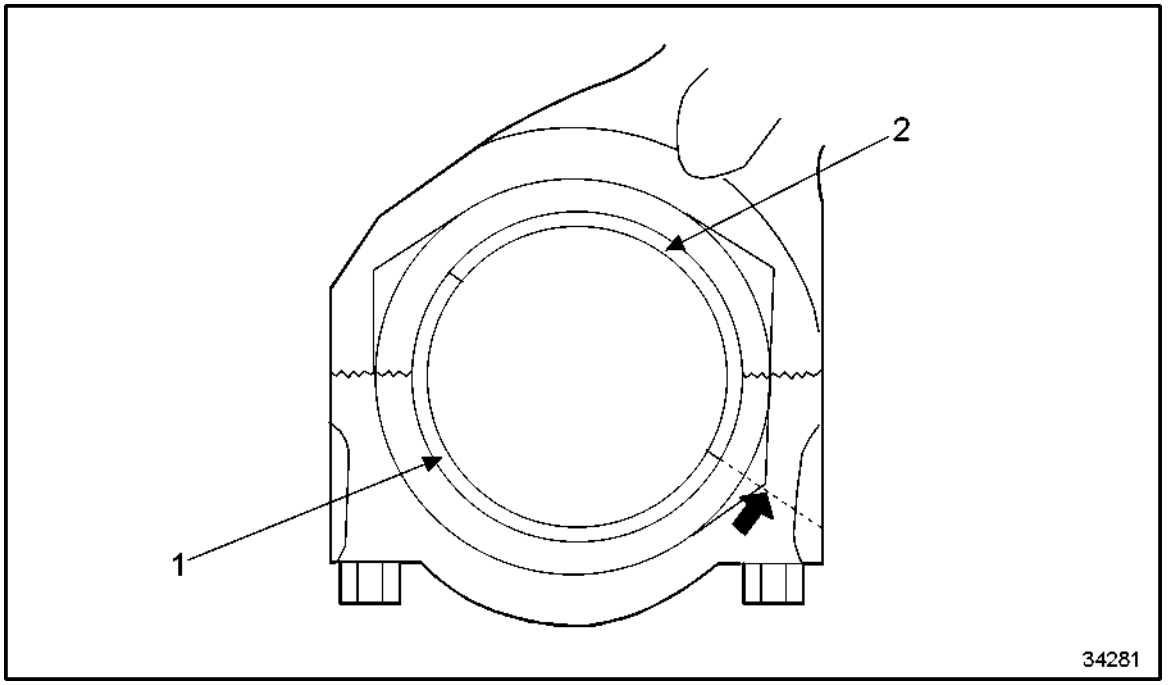
1. Bearing Shells
2. Cylinder Number on Front Surface of Cylinder

Figure 305 Marking Connecting Rod Bearing Shells According to Cylinder Number on Front Surface

NOTE:
Prior to installing connecting rod bearing shells, compare repair stage marking on connecting rod and in crankshaft data sheet.

5. Secure connecting rod in assembly fixture or in vice with aluminum jaws with mating surface horizontal.

6. Place connecting rod bearing "groove" (2) (bottom), (identifying feature: shiny running surface), in connecting rod cap so that bearing shell recess engages locating pin. See Figure 306.



1. Connecting Rod Bearing "Groove" (Bottom) 2. Connecting Rod Bearing (Top)

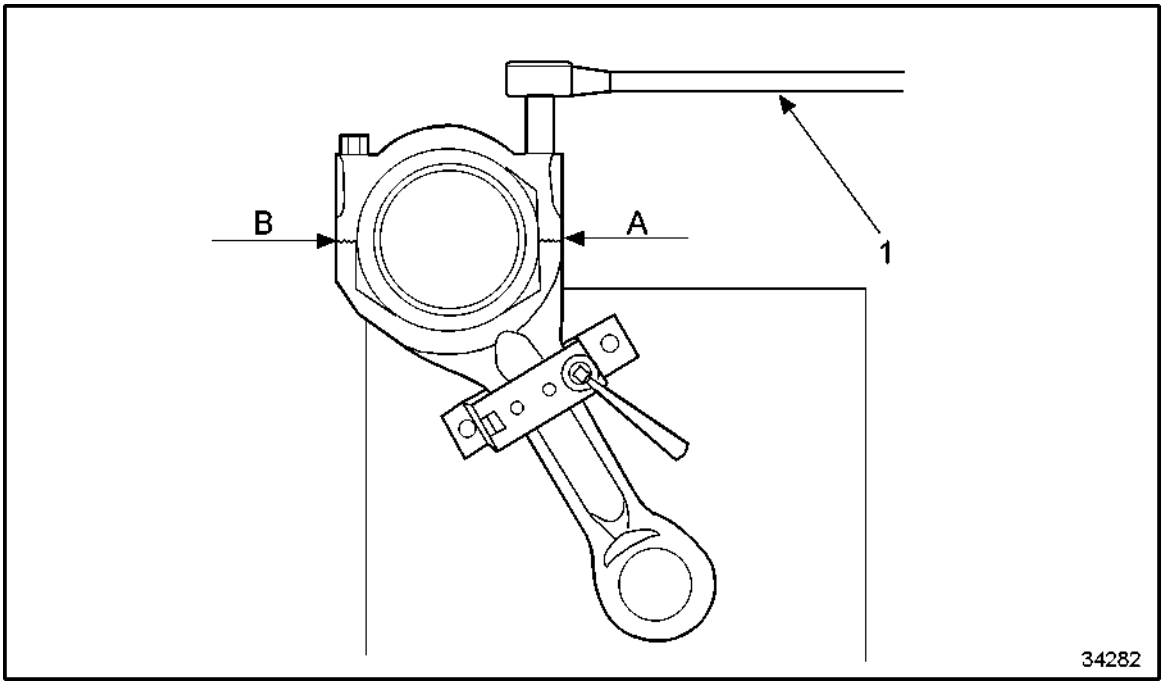
Figure 306 Placing Connecting Rod Bearing Shells in Connecting Rod

7. Place connecting rod bearing (2) (top), (identifying feature: matte finish running surface) in connecting rod so that connecting rod bearing projects approximately 40 degrees (arrows) over short connecting rod arm. See Figure 306.
8. Carefully press connecting rod cap by hand onto connecting rod.
9. Pay attention to locating pin and correct location of bearing shell.
10. Coat threads of bolt head mating surfaces and bolt head seating surfaces with engine oil.
11. Carefully insert connecting rod bolt into bearing cap bore by hand up to first contact with thread flanks, then turn first three rotations without a tool.

NOTE:
Do not drop bolts into connecting rod cap bore. Thread must not be recut.

12. Install connecting rod cap bolts until bolt heads make contact, and use socket wrench to tighten firmly.
13. Connecting rod and connecting rod cap serrations on short and long connecting rod arms must be closed.

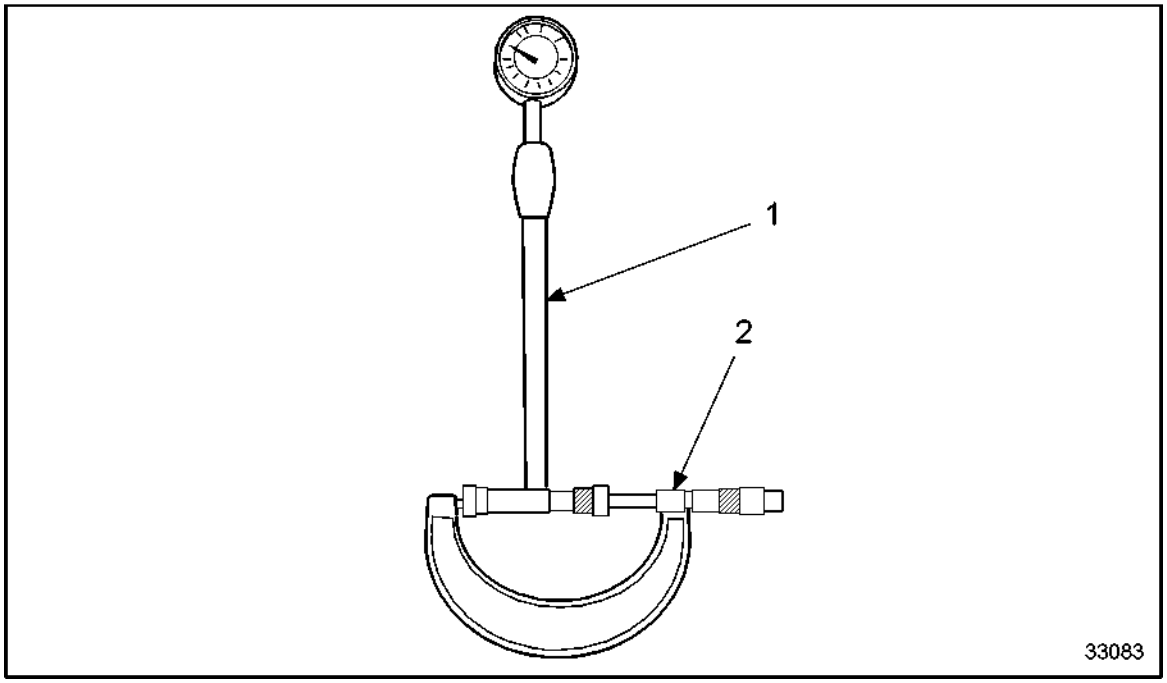
14. Using torque wrench (1), first tighten connecting rod cap bolt on short connecting rod arm (A) and then on long connecting rod arm (B) to specification. Refer to sectionA 003.See Figure 307.



1. Torque Wrench

Figure 307 Inserting Connecting Rod Bolt into Connecting Rod Bearing Cap

15. Adjust bore gage (1) and dial gage with micrometer (2) to basic size for connecting rod bearing bore. See Figure 308.



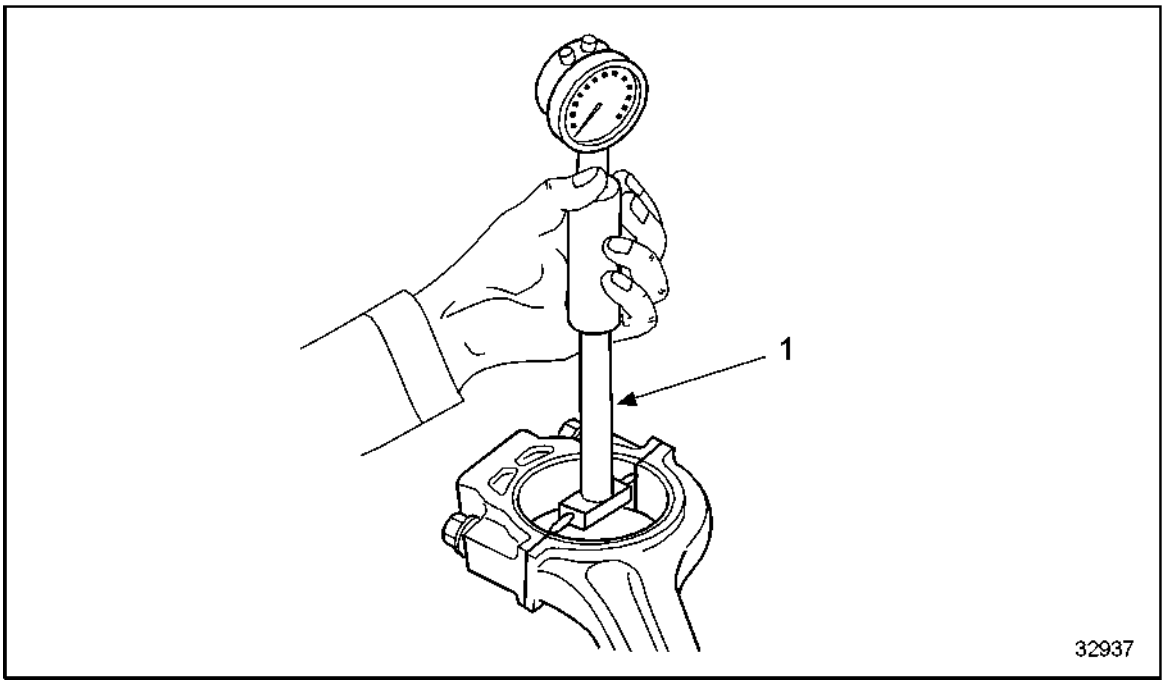
1. Bore Gage
2. Micrometer

Figure 308 Adjust Gages with Micrometer

Measuring Connecting Rod Bore

Perform the following steps to measure the connecting rod bore.

1. Coat sliding surfaces of main bearing shells with engine oil.
2. Measure bearing bore of connecting rod with bore gage (1). See Figure 309.



1. Bore Gage

Figure 309 Measuring Connecting Rod Bore

   [a] If limit values are exceeded or not achieved, replace rod bearing shells or machine connecting rod basic bore to repair size.

   [b] If limit values are not exceeded or are achieved, continue inspection.

3. Enter measurement values in data sheet.
4. Remove connecting rod bolts, connecting rod cap and bearing shells.

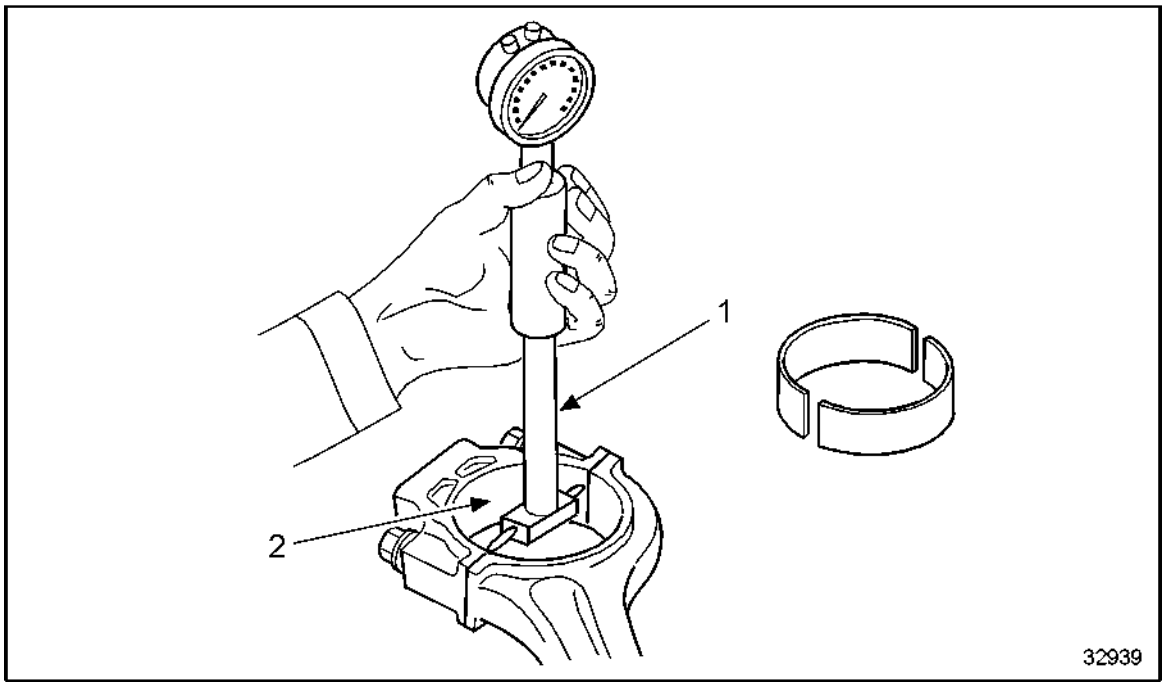
NOTE:
Protect rod bearing shells from damage.

Measuring Connecting Rod Bearing Bore

Perform the following steps to measure connecting rod bearing bore.

1. Check connecting rod bore for wear and scoring.
   [a] If worn or scored, machine bore to repair size or replace connecting rod.
   [b] If not worn or scored, continue procedure.
2. Before measuring, smooth big end bore (2) with emery cloth.

3. Adjust bore gage (1) and measure big end bore of connecting rod. See Figure 310.



1. Bore Gage
2. Big End Bore

Figure 310 Adjusting Bore Gage

[a] If limits are exceeded, recondition bore to next repair stage or replace connecting rod.

[b] If limits are not exceeded, continue inspection.

4. When reconditioning bore, recondition locating pin bore as required and replace locating stud.

Measuring Connecting Rod Bushing Bore

Perform the following steps to measure connecting rod bushing bore.

1. Set bore gage to zero dimension of connecting rod bushing bore, and measure connecting rod bushing bore. See Figure 311.

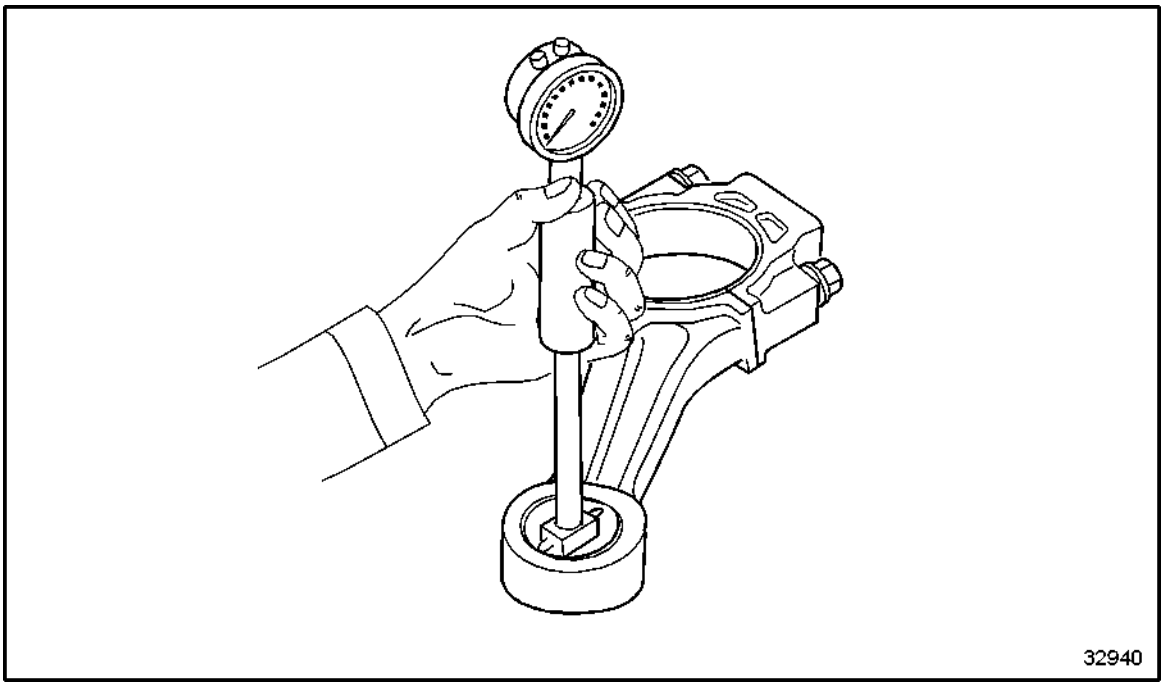
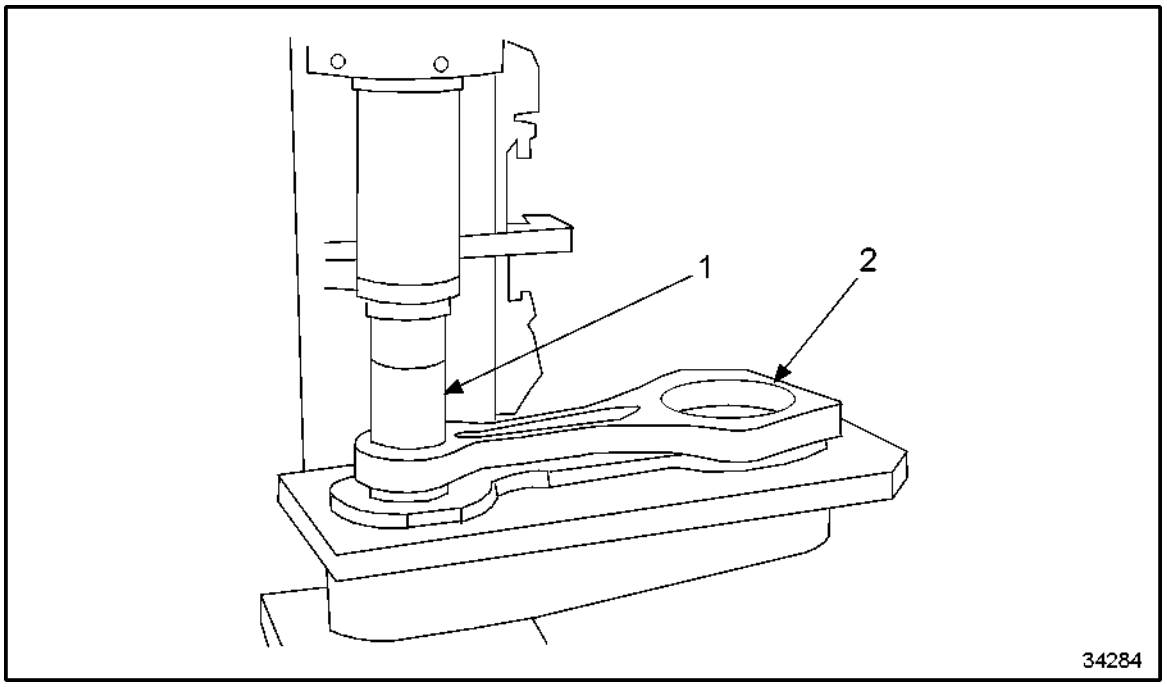


Figure 311 Measuring Connecting Rod Bushing Bore

NOTE:
Do not remove connecting rod bushing unless necessary.

2. Remove connecting rod bearing.See Figure 312.



1. Brass Drift
2. Connecting Rod

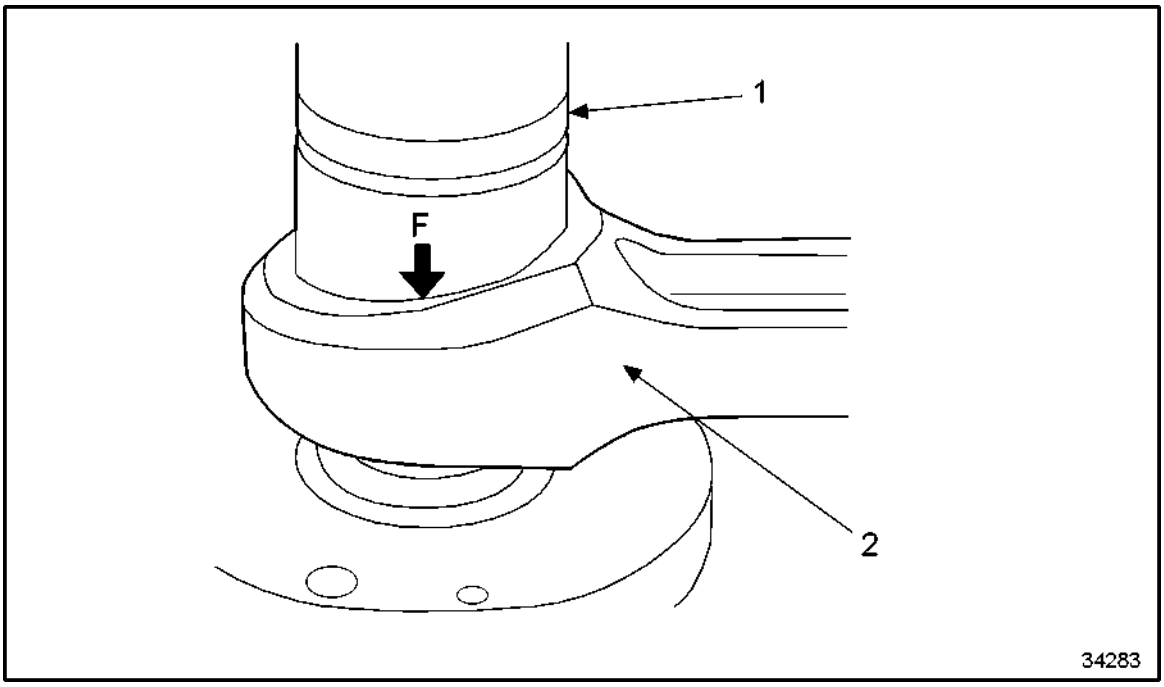
Figure 312 Removing Connecting Rod Bushing

3. Measure connecting rod bushing.
   [a] If limit values are exceeded, remove connecting rod bushing and replace connecting rod.
   [b] If limit values are not exceeded, continue inspection.

Checking Connecting Rod Bushing Axial Seating

Perform the following steps to check connecting rod bushing axial seating.

1. Use test brass drift (1) and hydraulic press to check connecting rod bushing axial seating. See Figure 313.



1. Test Brass Drift
2. Connecting Rod

Figure 313 Connecting Rod Bushing Axial Seat

2. If test force is not reached, use brass drift and hydraulic press to remove connecting rod bushing from connecting rod (2). See Figure 313.

C 037.05.10 – ASSEMBLY OF PISTON WITH CONNECTING ROD

Perform the following steps to assemble piston with connecting rod.

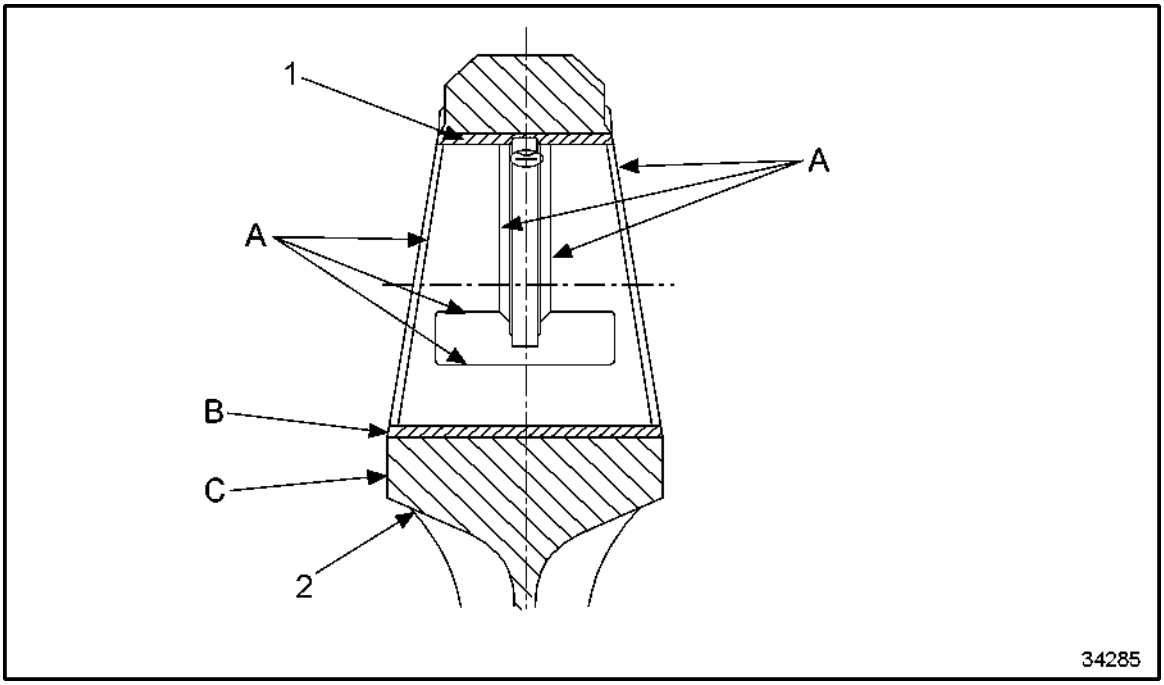
Installing Connecting Rod Bushing

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

CAUTION:

To avoid injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

1. Cool new connecting rod bushing (1) in liquid nitrogen. Insert plastic or wooden brass drift, without pressure, in control bore (2). See Figure 314.



1. Connecting Rod Bushing
2. Connecting Rod Bore

Figure 314 Installing Connecting Rod Bushing

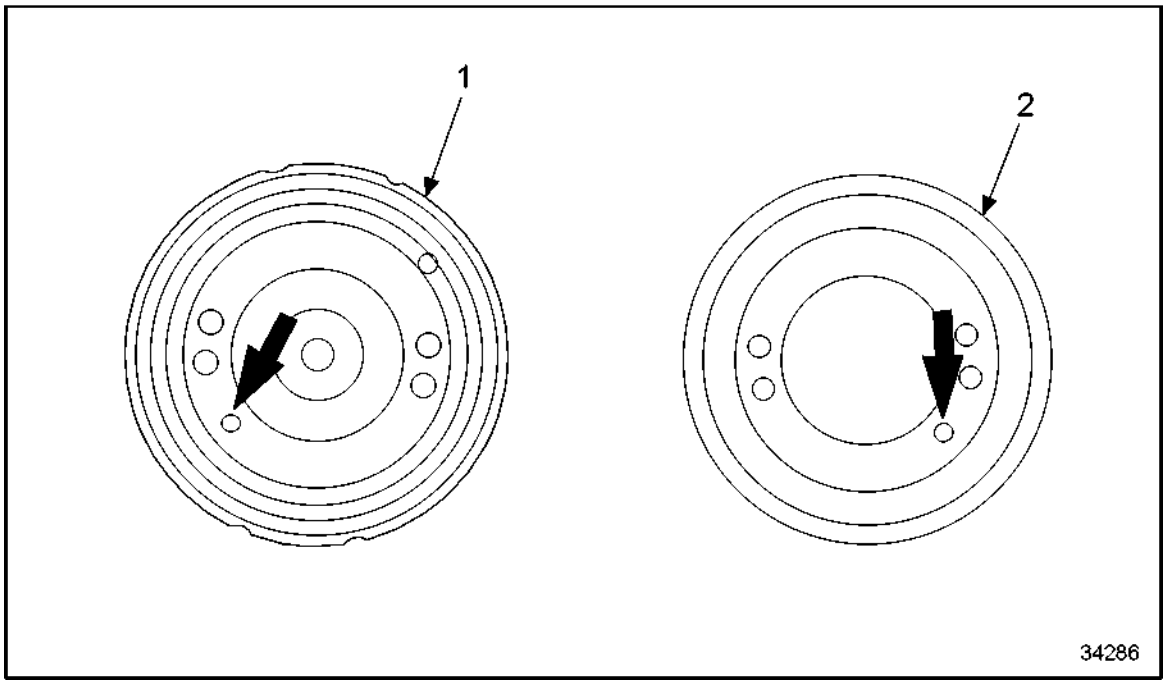
NOTE:
Ensure that lube oil bores are aligned.

2. Check that connecting rod bushing is firmly seated, and use a fine drilling tool to machine to specified final dimension.
3. After machining, cover edges (A) of connecting rod bushing with felt washer ø 30 — 40. See Figure 314.
4. Stamp connecting rod bushing repair stage diameter on surface (B) of connecting rod bushing with 2 mm (.7874 in.) numeral punch and on surface (C) of connecting rod with 4 mm (.1574 in.) numeral punch. See Figure 314.

Installing Piston Crown

1. To install the piston crown, check length of piston crown bolts.
2. Place piston crown on piston skirt.

NOTE:
Piston crown (2) and piston skirt (1) form a matched pair and must not be separated. See Figure 315.

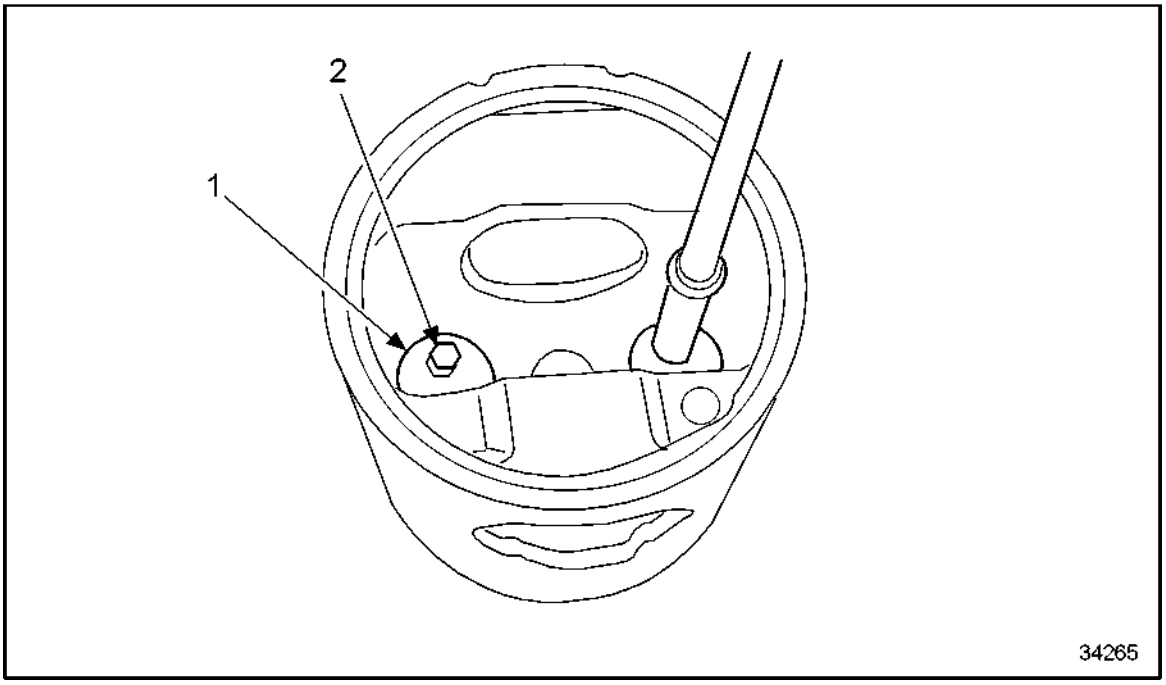


1. Piston Skirt
2. Piston Crown

Figure 315 Installing Piston Crown

3. Check that spring pin (arrow) is correctly seated. See Figure 315.

4. Coat thread of piston crown bolts with Molykote G - n Plus.
5. Install piston crown bolts in socket (2) to specification. Refer to section A 003. See Figure 316.

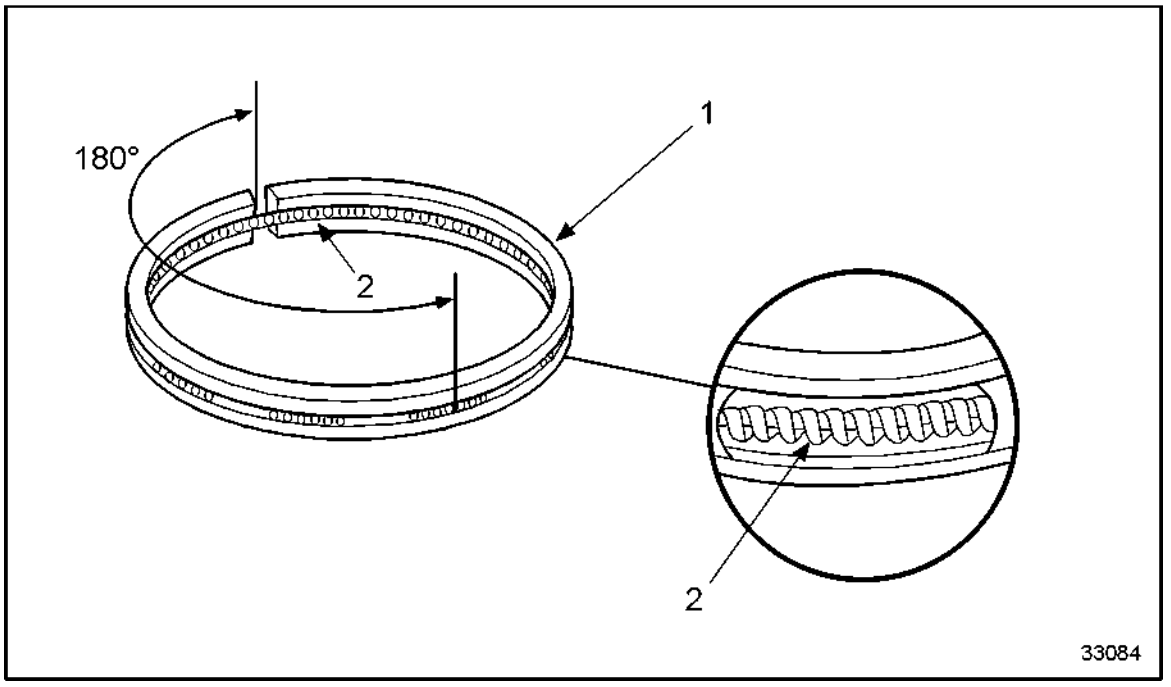


1. Pressure Plate
2. Piston Crown Bolt

Figure 316 Installing Piston Crown Bolts

Installing Piston Rings

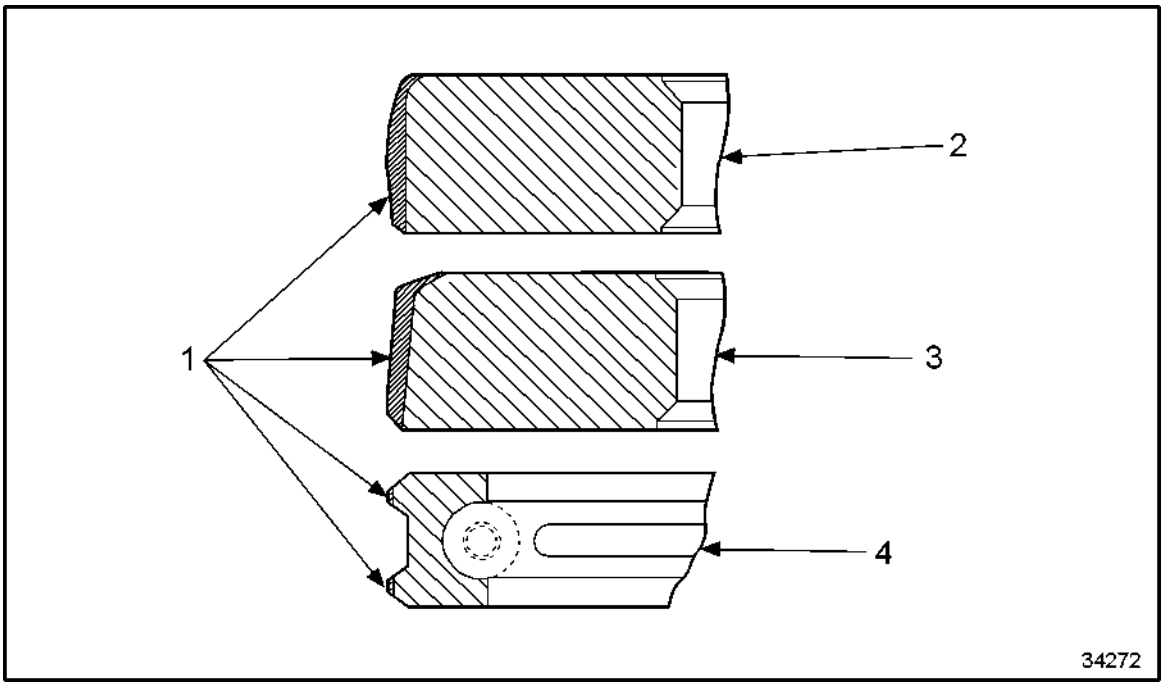
1. Turn mating surface of coiled spring expander (2) 180 degrees from gap in oil ring (1). See Figure 317.



1. Oil Ring
2. Coiled Spring Expander

Figure 317 Installing Piston Rings

2. In sequence from bottom to top (oil control ring first), insert piston rings with piston ring pliers into annular grooves on piston.
   [a] Stretch piston rings only until they can be fitted over the piston. Do not overstretch, or they may break.
   [b] Ensure that piston rings are installed in correct sequence.
   [c] Top marking on piston rings must point in direction of piston crown. See Figure 318 and see Figure 319.



1. Chrome Layer
2. Free Ring
3. Compression Ring
4. Oil Control Ring

Figure 318 Sequence of Piston Rings

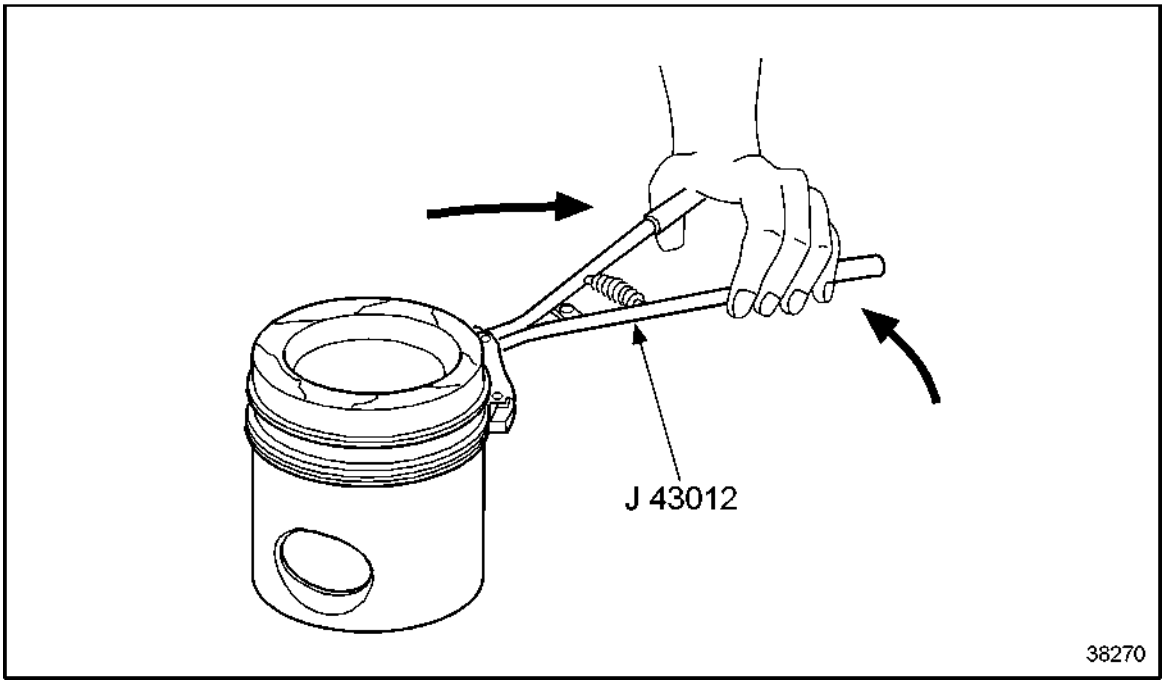
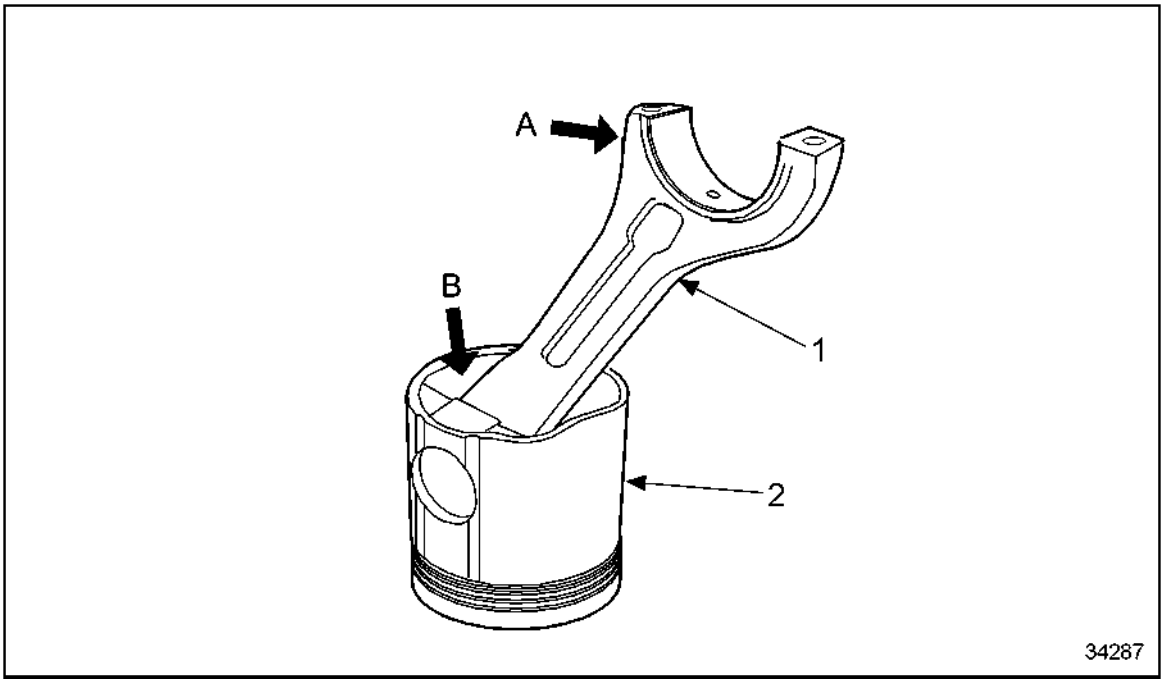


Figure 319 Installing Piston Rings with Piston Ring Pliers

3. Check that piston rings move freely in their grooves.

NOTE:
Piston rings must only be replaced in sets. Hone cylinder liners if new piston rings are installed.

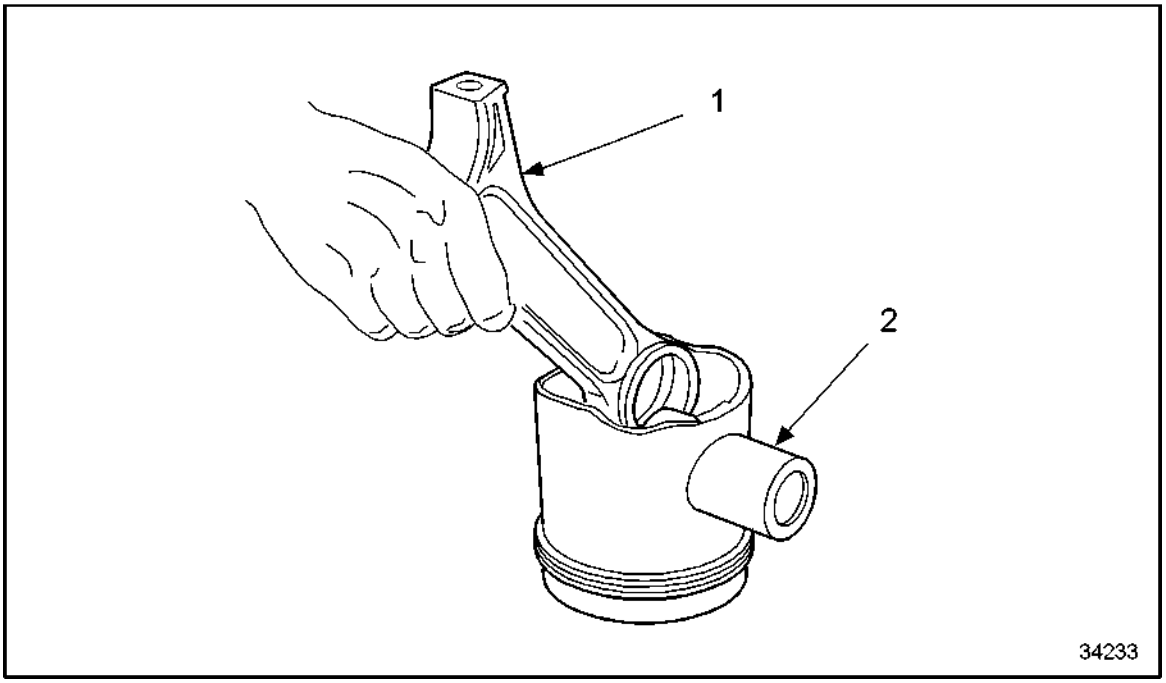
4. Clean piston pin, connecting rod bushing and piston pin bore, then coat with engine oil.
5. Insert connecting rod (1) into piston (2) according to markings, in such a way that the shorter end (A) of the angle-split connecting rod faces piston cooling oil bore hole (B). See Figure 320.



1. Connecting Rod
2. Piston

Figure 320 Connecting Rod with Piston

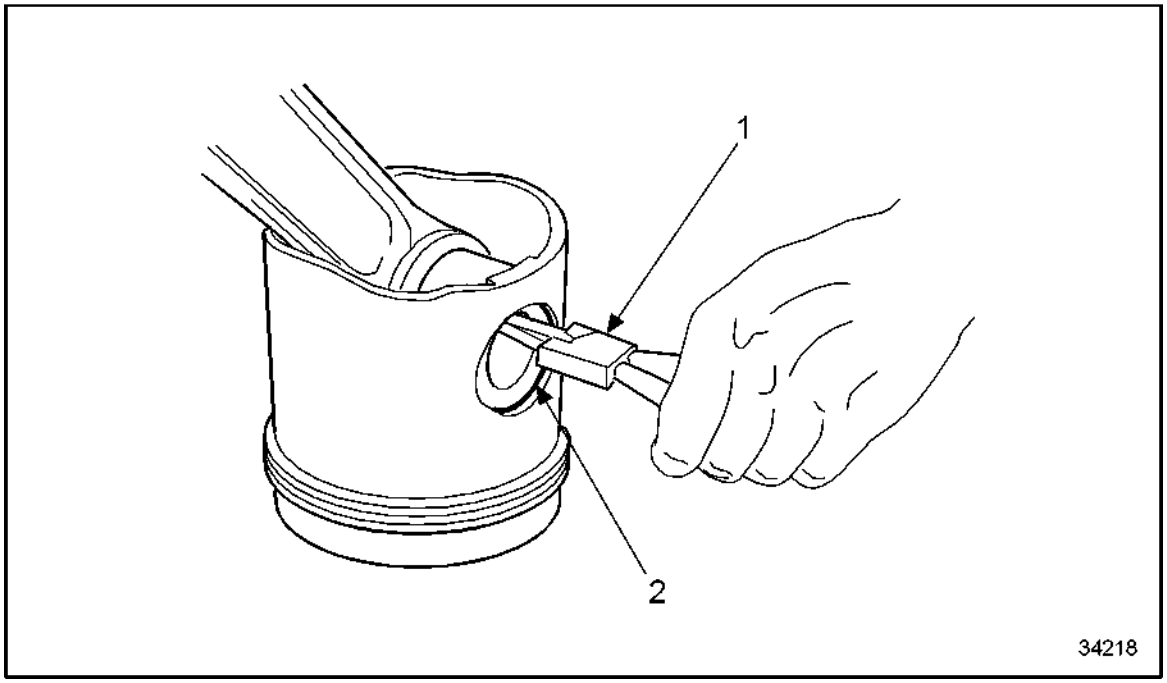
6. Push associated piston pin (2) into piston and connecting rod (1) until seated against snap ring (installed beforehand). See Figure 321.



1. Connecting Rod
2. Piston Pin

Figure 321 Pushing Piston Pin into Piston and Connecting Rod

7. Insert second snap ring (2) with snap ring pliers (1). See Figure 322.



1. Snap Ring Pliers
2. Snap Ring

Figure 322 Inserting Snap Ring

NOTE:
Make sure snap ring is perfectly seated in groove.

C 037.05.11 – INSTALLATION OF PISTON WITH CONNECTING ROD

Perform the following subsections to install the piston with connecting rod.

Installing Piston with Connecting Rod in Turnover Stand

Perform the following steps to install the piston with connecting rod in turnover stand.

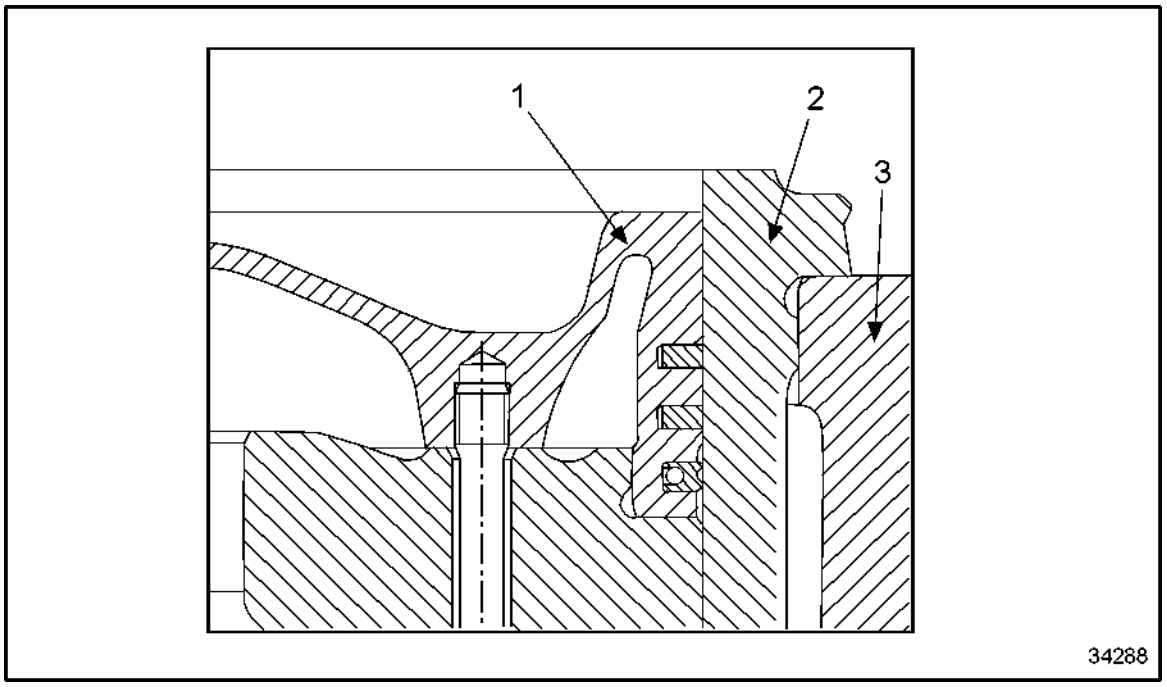
NOTE:
Always make sure that all components are perfectly clean.

1. Rotate cylinder block in turnover stand until cylinder liner is vertical.
2. Turn crankshaft crankpin of piston to be installed and connecting rod to assembly position (40° before TDC on the right side; 40° after TDC on the left side).
3. Clean crankpin and running surface of cylinder liner and spray with engine oil.

Cylinder Liner without Carbon Scraper Ring

Perform the following steps to install cylinder liner **without** carbon scraper ring.

1. When installing piston in cylinder liner, check that piston is correctly positioned with regard to cylinder liner.
2. Ensure that piston crown running surface is smooth. See Figure 323.



1. Piston
2. Cylinder Liner
3. Cylinder Block

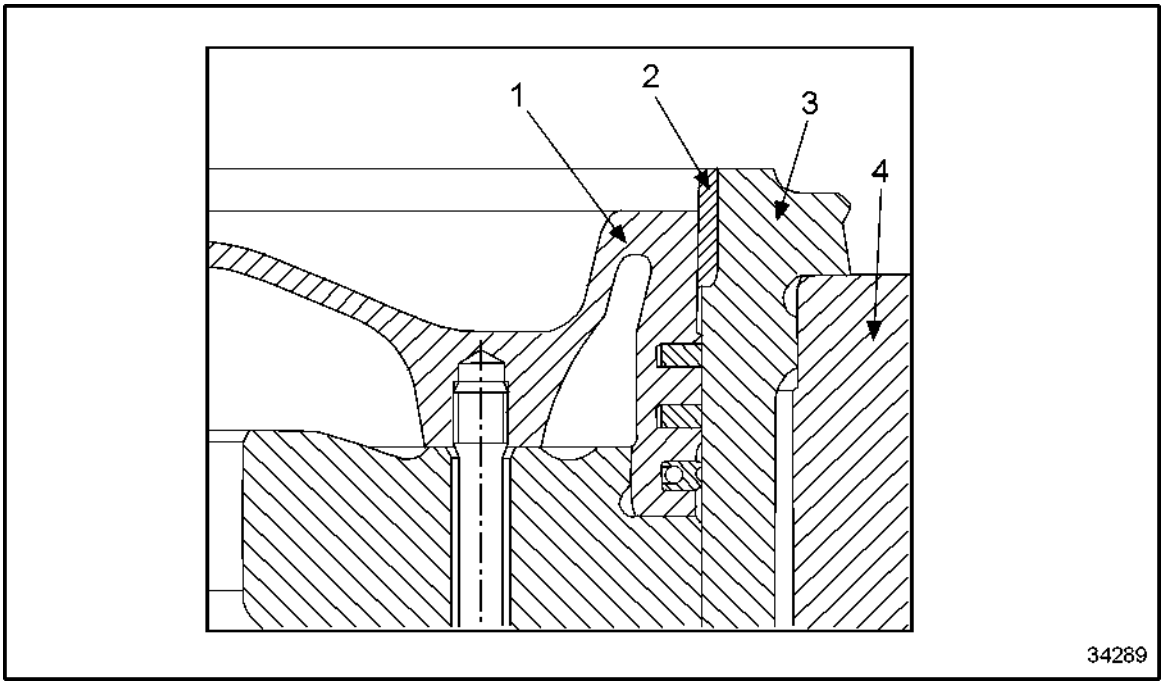
Figure 323 Cylinder Liner without Carbon Scraper Ring

NOTE:
Piston crown and piston skirt form a matched pair and must not be interchanged.

Cylinder Liner with Carbon Scraper Ring (Marine Only)

Perform the following steps to install cylinder liner **with** carbon scraper ring.

1. Machine running surface of piston crown according to carbon scraper ring. See Figure 324.



1. Piston
2. Carbon Scraper Ring
3. Cylinder Liner
4. Cylinder Block

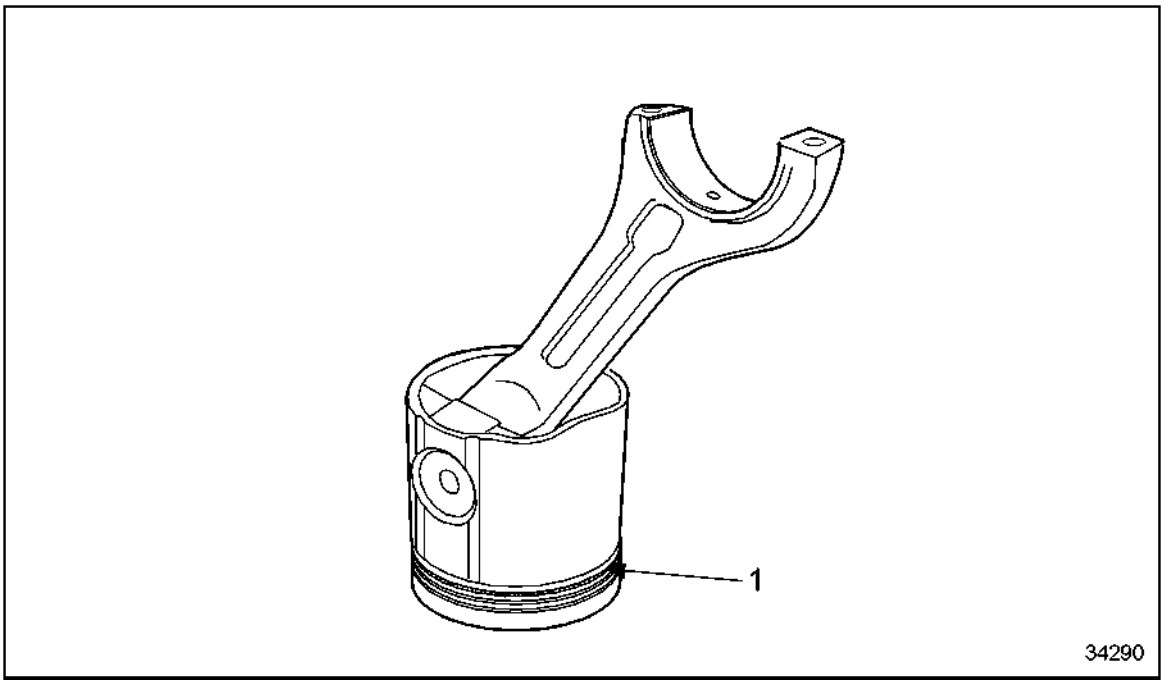
Figure 324 Cylinder Liner With Carbon Scraper Ring (Marine Only)

2. Install piston before the carbon scraper ring is installed in the liner.

NOTE:
Piston crown and piston skirt form a matched pair and must not be interchanged.

3. Spray the piston and piston rings with engine oil.
4. Ensure that piston rings are evenly fitted around piston circumference.

5. Center the rings in the grooves. See Figure 325.



1. Oil Control Ring with Coiled Spring Expander

Figure 325 Checking Piston Rings in Grooves

6. The oil control ring with coiled spring expander must be carefully centered to avoid damage.

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

7. Blow out mating surfaces (arrows) on connecting rod and connecting rod cap with compressed air, and check that they are clean. See Figure 326.

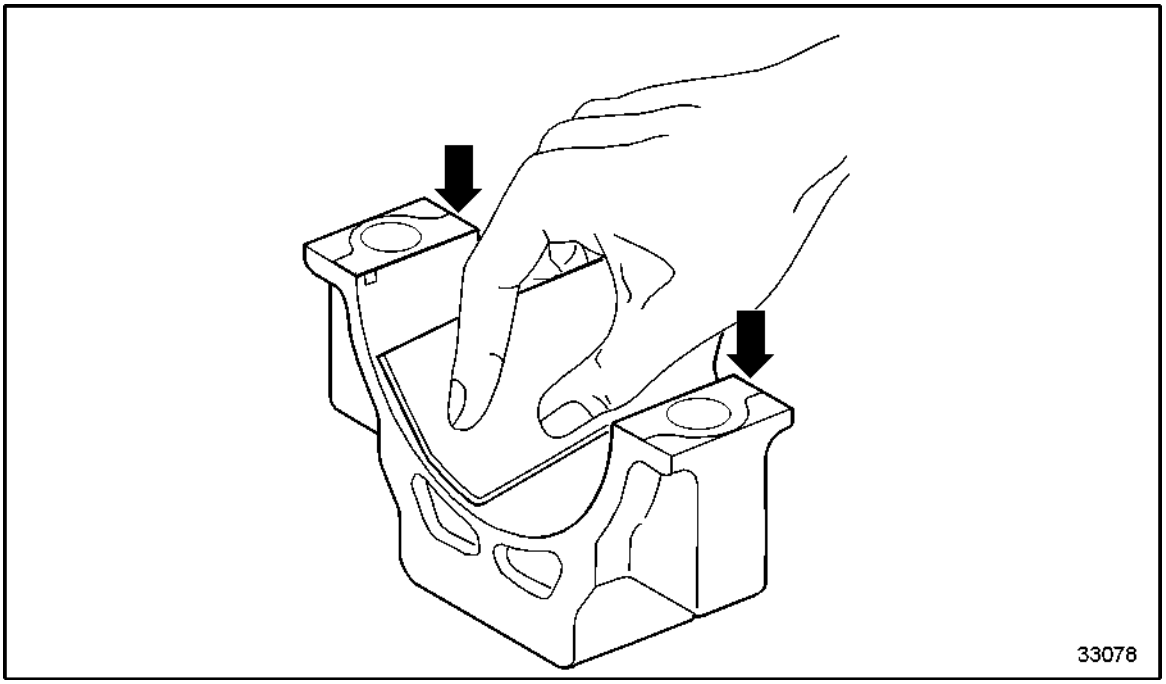
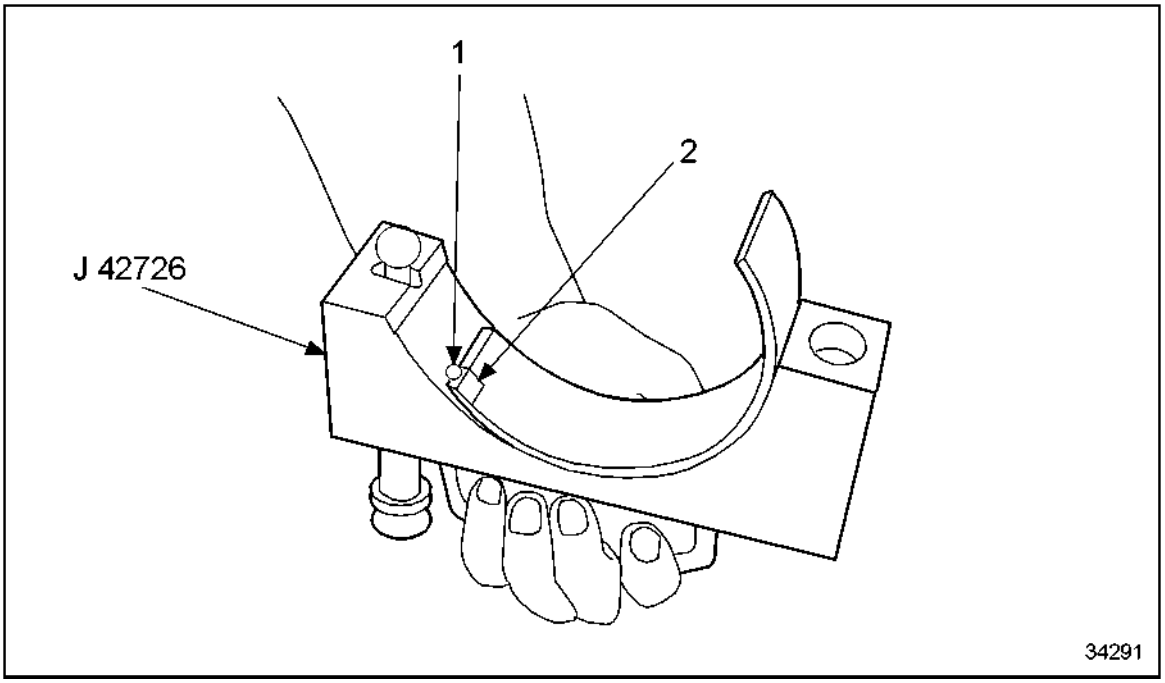


Figure 326 Cleaning Surfaces on Connecting Rod

NOTICE:
Do not damage serrations on mating surfaces.

8. If damaged, replace connecting rod.
9. Clean bearing shell mating surfaces on connecting rod and connecting rod cap.

10. Place connecting rod bearing "groove" (bottom) in bearing installation device (1) so that connecting rod bearing recess (3) engages locating pin (2). See Figure 327.



1. Locating Pin
2. Bearing Shell Recess

Figure 327 Connecting Rod Bearing Shell

11. Coat running surface of bearing shell with engine oil.

12. By hand, push bearing installation device (with bearing shell half) on crankshaft crankpin. See Figure 328.

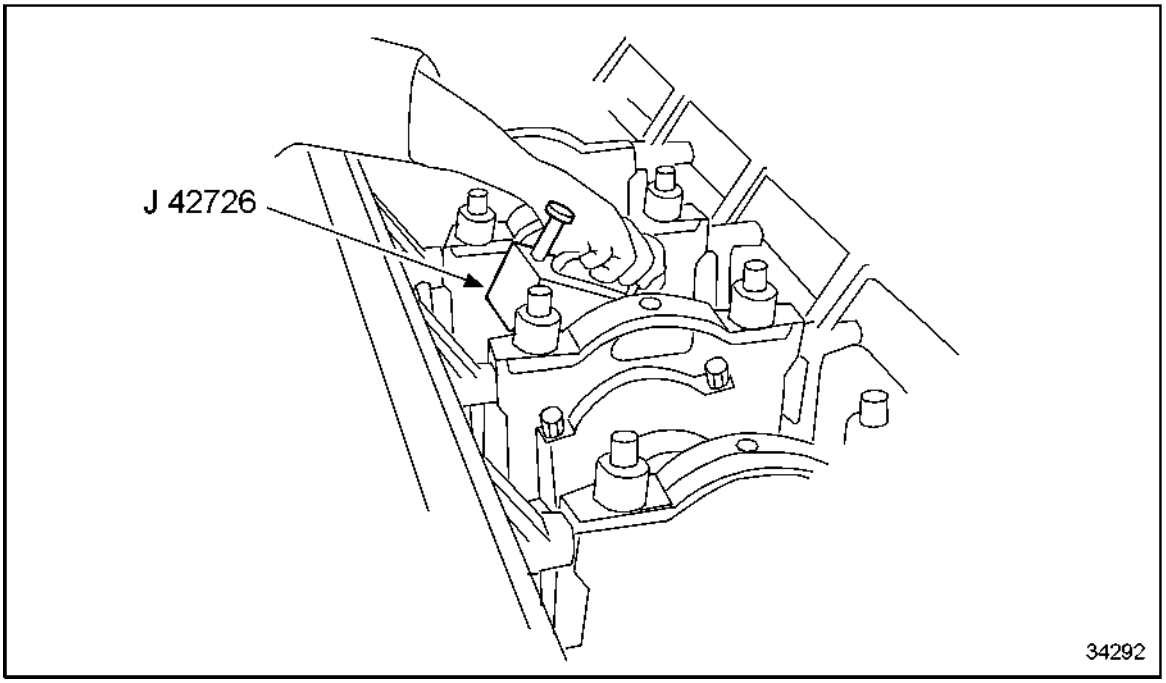
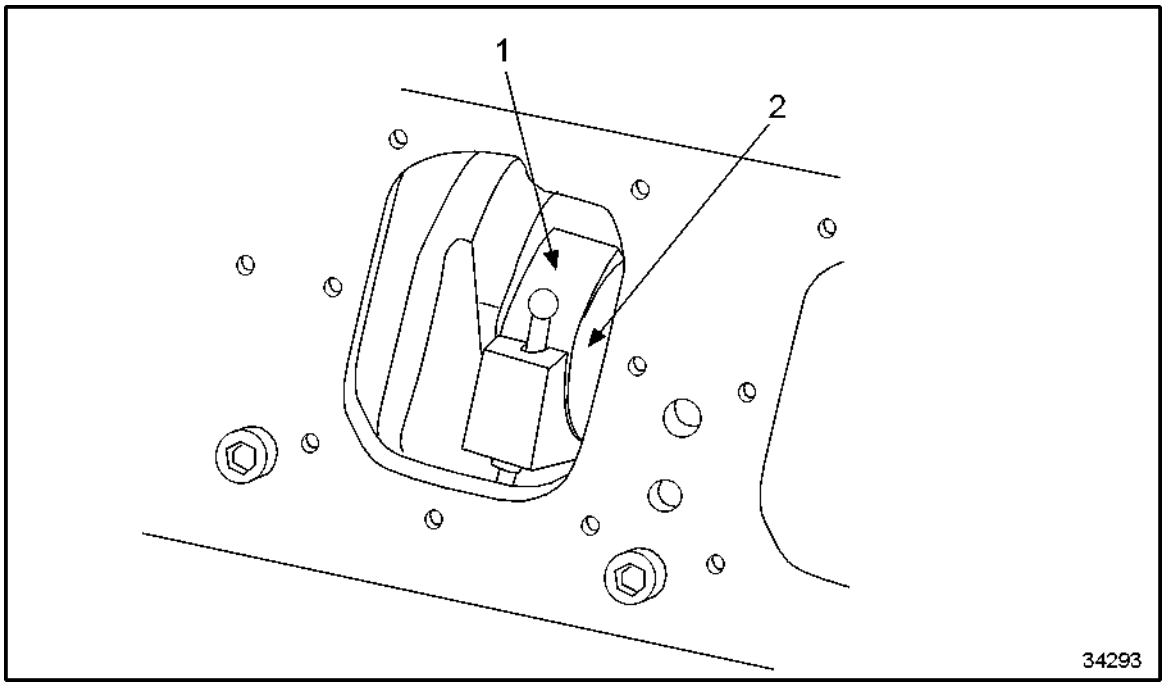


Figure 328 Installing Bearing Shell

13. Coat connecting rod bearing, "sputter" (top) running surface of bearing shell with engine oil.

14. Position bearing shell half (1) according to recess for locating pin on crankpin (2) so that the two recesses are aligned. See Figure 329.



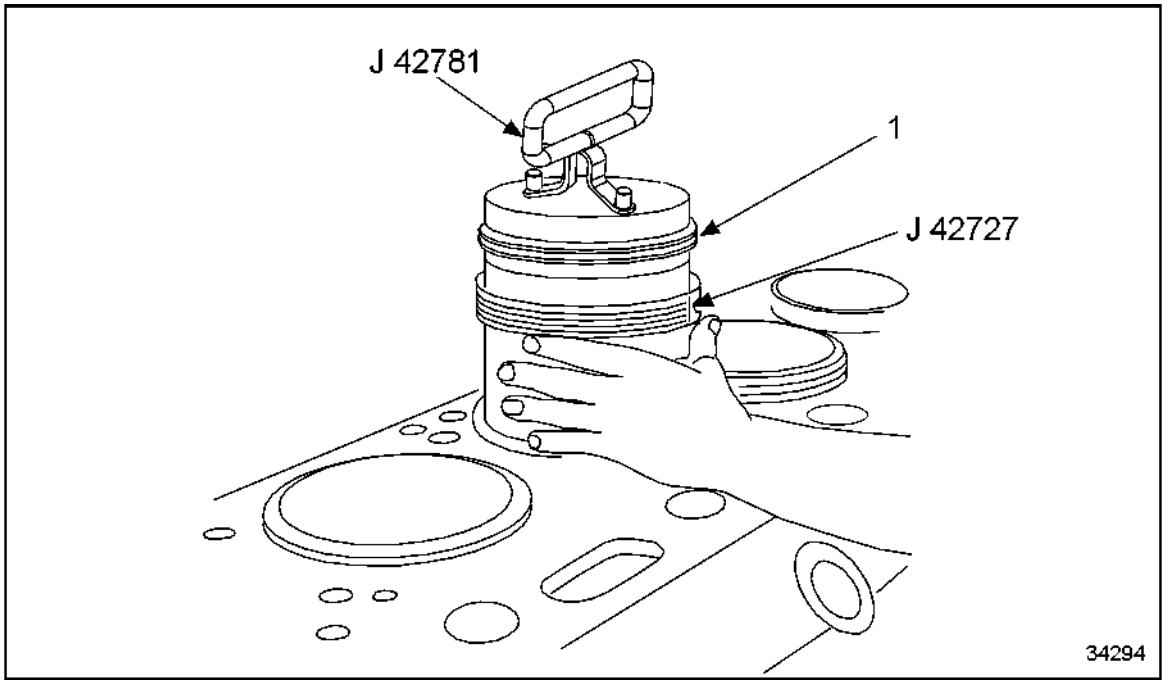
1. Bearing Shell Half
2. Crankpin

Figure 329 Positioning Bearing Shell Half

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.

15. Attach lifting device (1) for piston (2). See Figure 330.



1. Piston

Figure 330 Attaching Lifting Tool

16. Place piston ring compressor (2) for piston on appropriate cylinder liner. See Figure 330.

17. Use correct assembly sleeve with carbon scraper ring (marine only). See Figure 331.

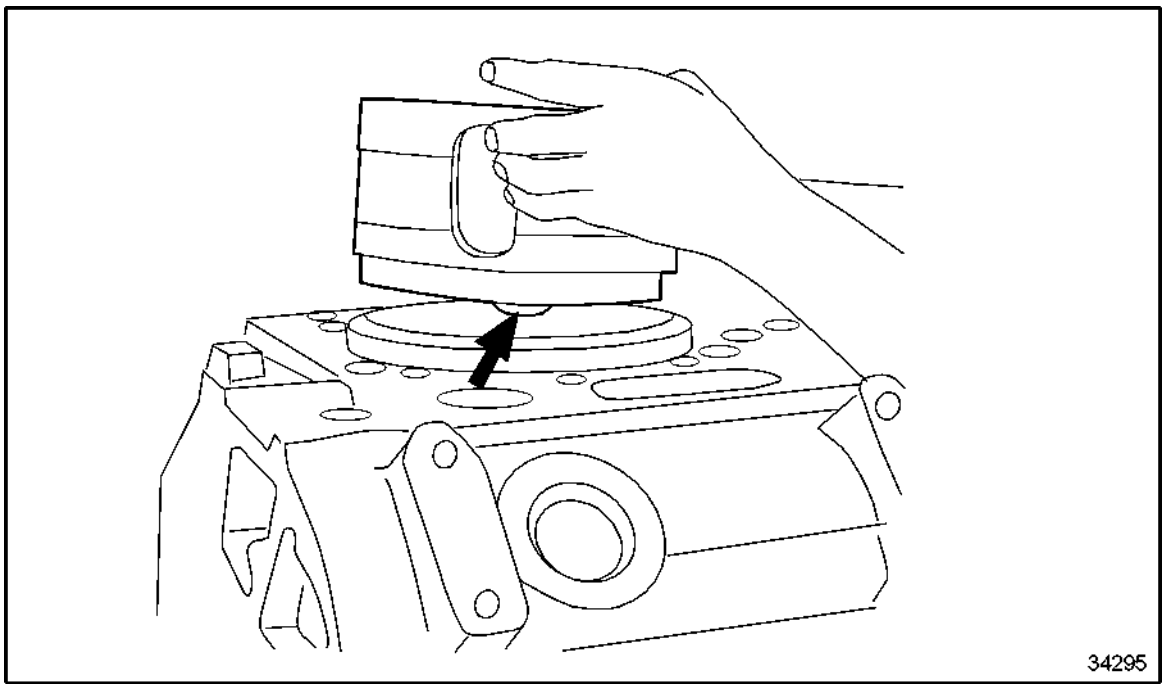


Figure 331 Cylinder Liner With Carbon Scraper Ring (Marine Only)

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.

18. Using lifting device and crane, install piston in accordance with markings from above into oiled assembly sleeve with chamfered side facing piston into cylinder liner.
19. Install piston into oiled cylinder liner so that short arm of connecting rod points outwards to air intake side.
20. Gently turn piston when inserting so that the oil spray nozzle is not damaged when the connecting rod is installed, or have the oil spray nozzle removed.
21. If the oil spray nozzle is damaged, remove spray nozzle and replace.

NOTE:
In order to guide the connecting rod and avoid damage to the oil spray nozzle, piston installation must be carried out by two people.

22. Insert assembly sleeve with collar into carbon scraper ring support.

NOTE:
In order to avoid damaging piston rings, use appropriate assembly sleeve.

23. Ensure that assembly sleeve is properly seated. See Figure 332.

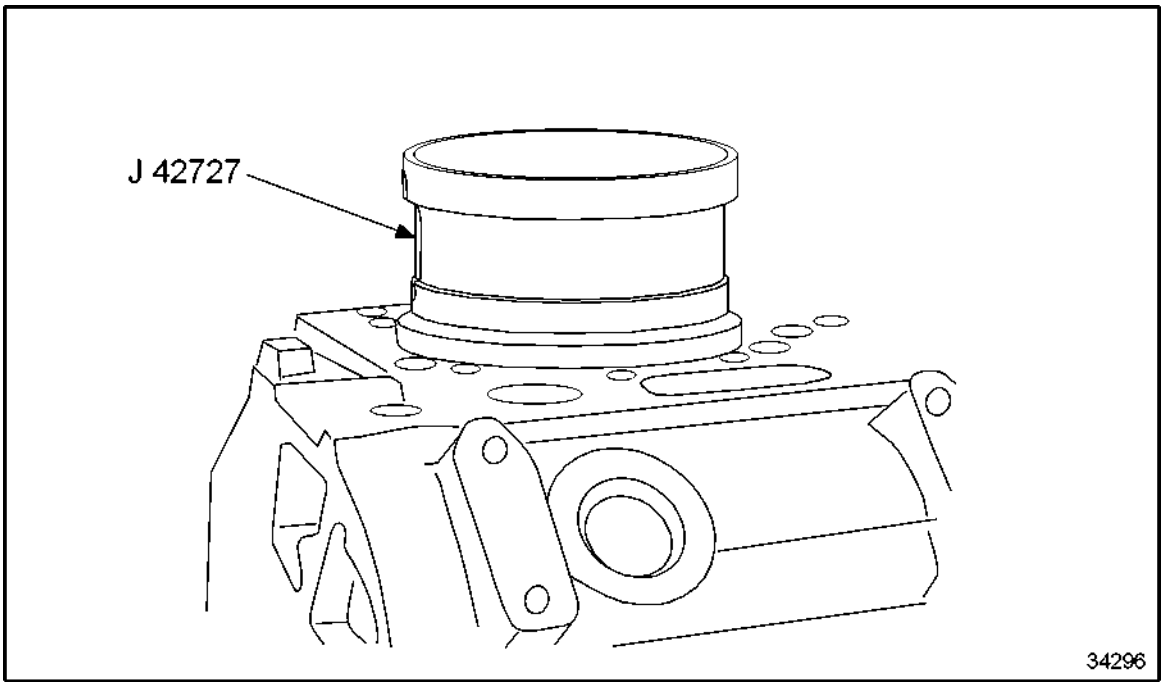
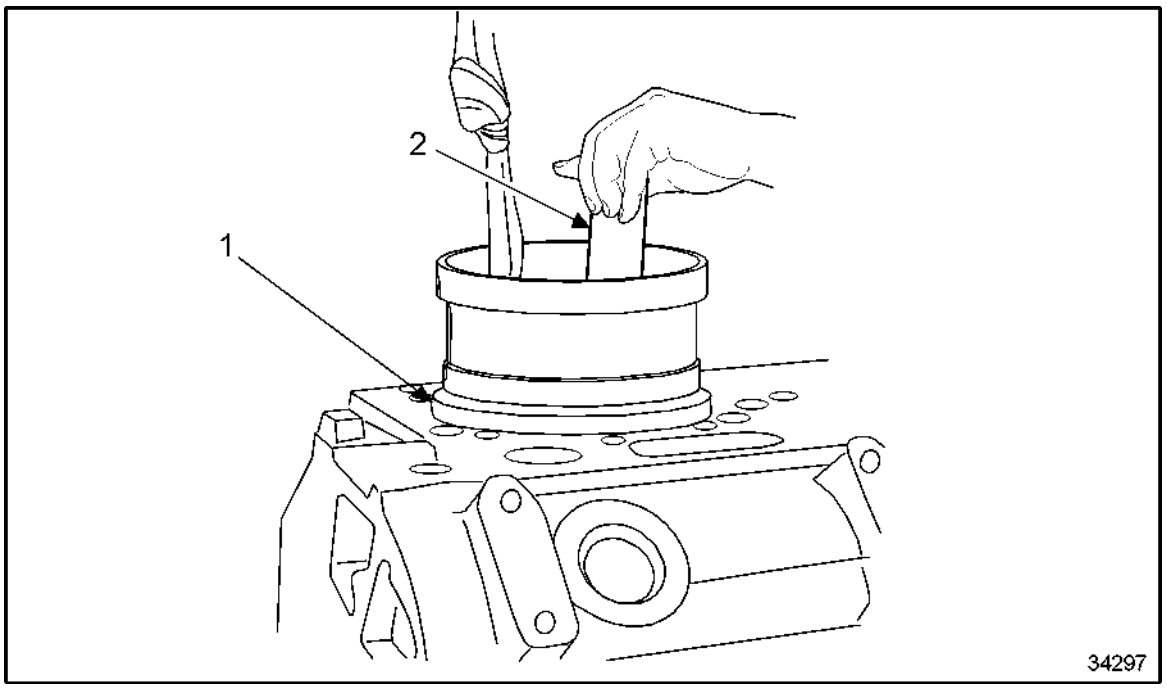


Figure 332 Piston Ring Compressor

24. Use brass drift (2) to push piston into cylinder liner (1). See Figure 333.



1. Cylinder Liner
2. Brass Drift

Figure 333 Pushing Piston into Cylinder Liner

25. Place connecting rod on bearing installation device for connecting rod bearing. See Figure 334.

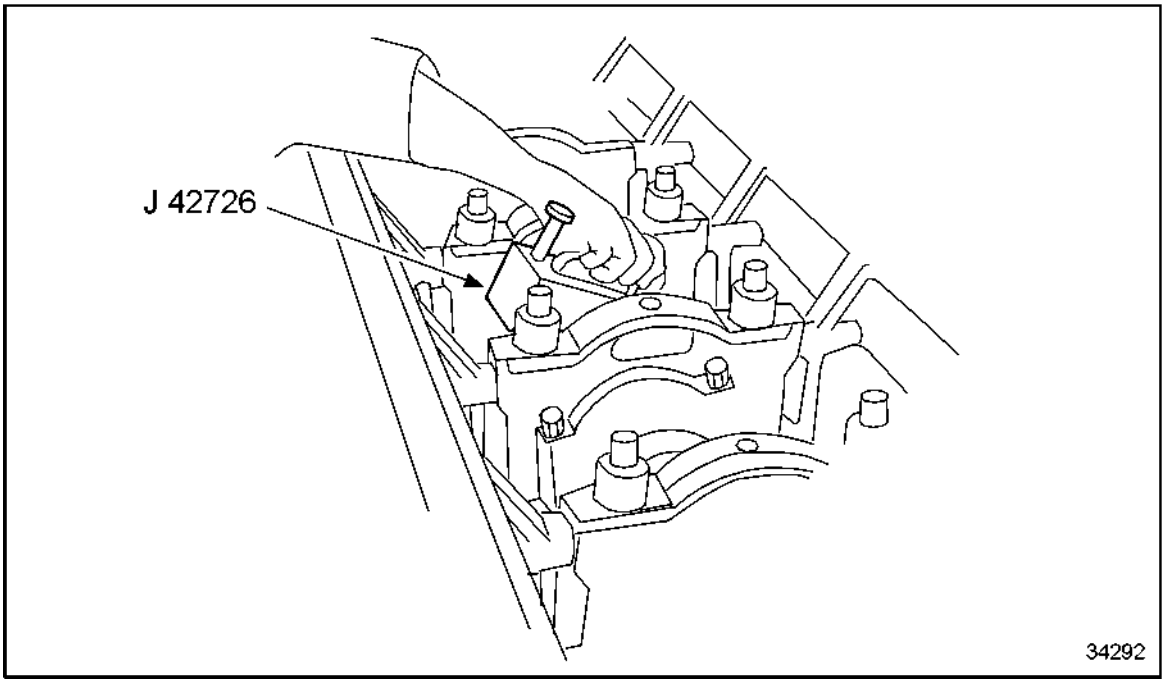


Figure 334 Connecting Rod With Connecting Rod Bearing

26. Remove assembly sleeve for piston.
27. At same time, position assembly device with guide pin. See Figure 334.
28. Remove bearing installation device and push connecting rod cap by hand onto connecting rod.
29. Pay attention to fit of locating pin in recess in connecting rod cap.
30. Measure shaft length of connecting rod bolts. For maximum shaft length, refer to section C 037.05.01.

31. Coat threads and bolt head seating surfaces with engine oil. See Figure 335.

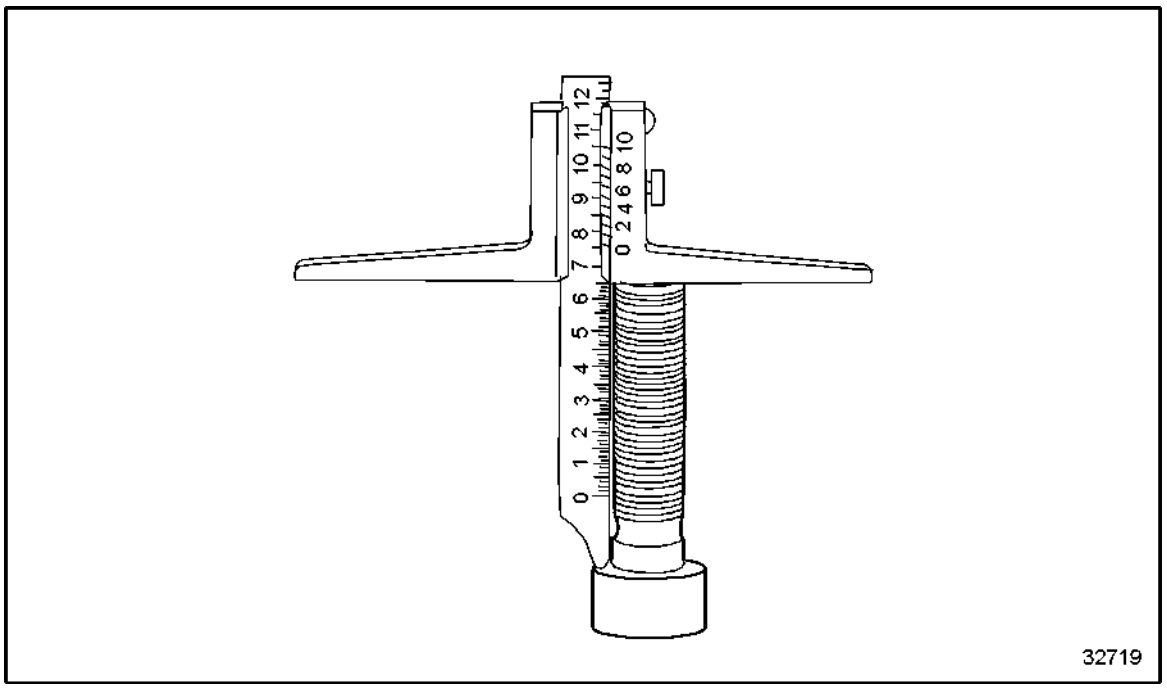
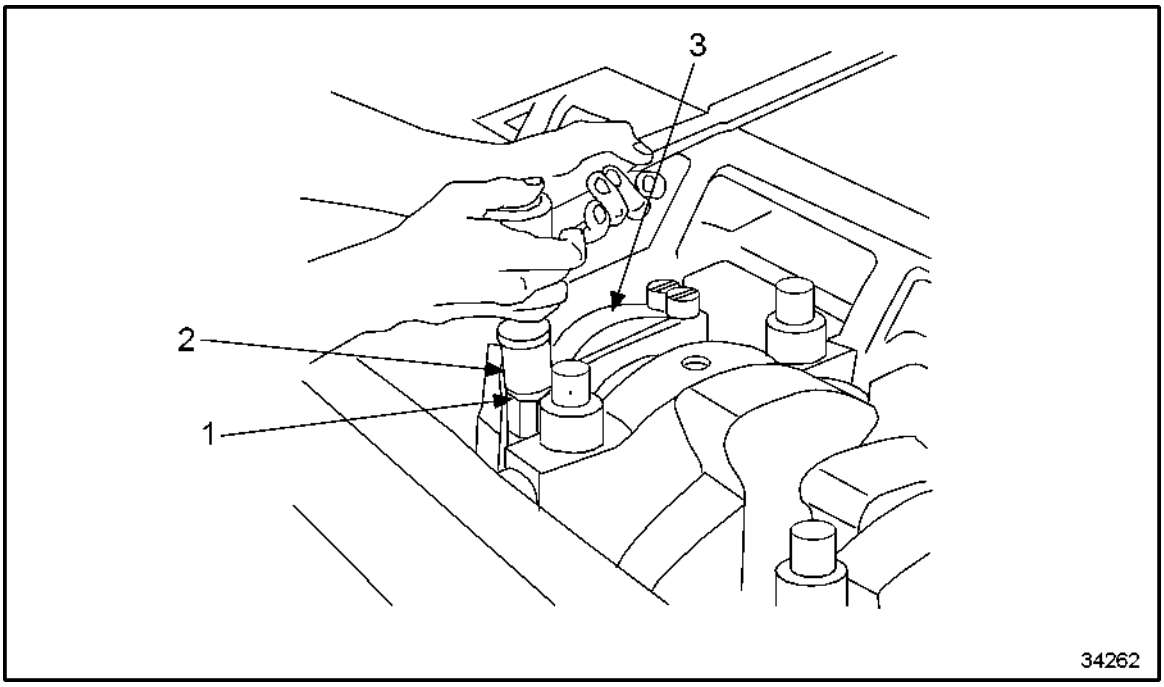


Figure 335 Measuring Shaft Length

32. Carefully insert connecting rod bolt into bearing cap bore by hand to first contact with thread flanks, then turn first three rotations without a tool.

33. Install connecting rod cap bolts until bolt heads make contact, and use socket wrench to tighten firmly by hand. See Figure 336.



1. Connecting Rod Bolt
2. Socket Extension
3. Connecting Rod Bearing Cap

Figure 336 Inserting Connecting Rod Bolt Into Connecting Rod Cap

34. Connecting rod and connecting rod cap serrations must be closed.
35. Using torque wrench, first tighten connecting rod cap bolt at short connecting rod arm and then on long connecting rod arm to specification. Refer to section A 003. For a general view of pistons and connecting rods, refer to section C 037.05.01.

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.

36. Check that connecting rod has axial play.

NOTE:
Remove lifting device and assembly sleeve for piston with connecting rod.

CAUTION:

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

37. Bar crankshaft and ensure that there is ease of movement between oil spray nozzle, piston and connecting rod; or, reinstall oil spray nozzle making sure the nozzle is located in the exact center of piston cooling hole.

Installing Piston With Connecting Rod With Oil Pan Installed

Perform the following steps to install the piston with connecting rod with oil pan installed.

1. During installation, the installation position of the cylinder block is changed, and the connecting rod bearing, connecting rod cap and connecting rod bolts are installed through access port cover. See Figure 337.

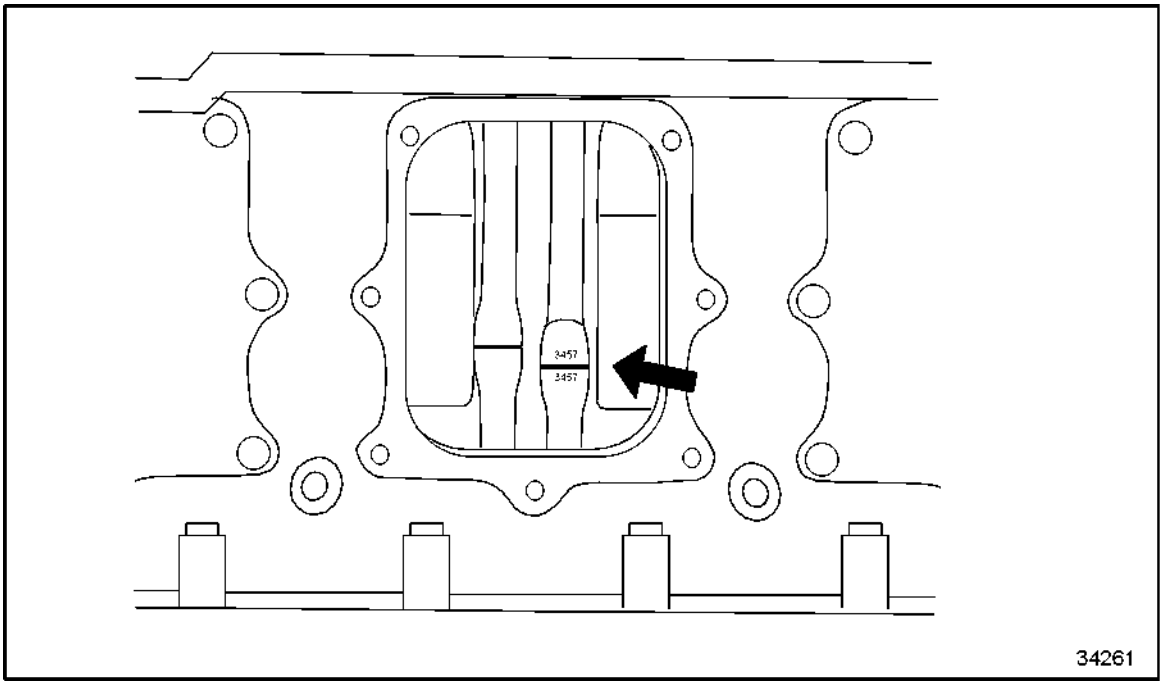


Figure 337 Inserting Connecting Rod Bolt Into Connecting Rod Cap

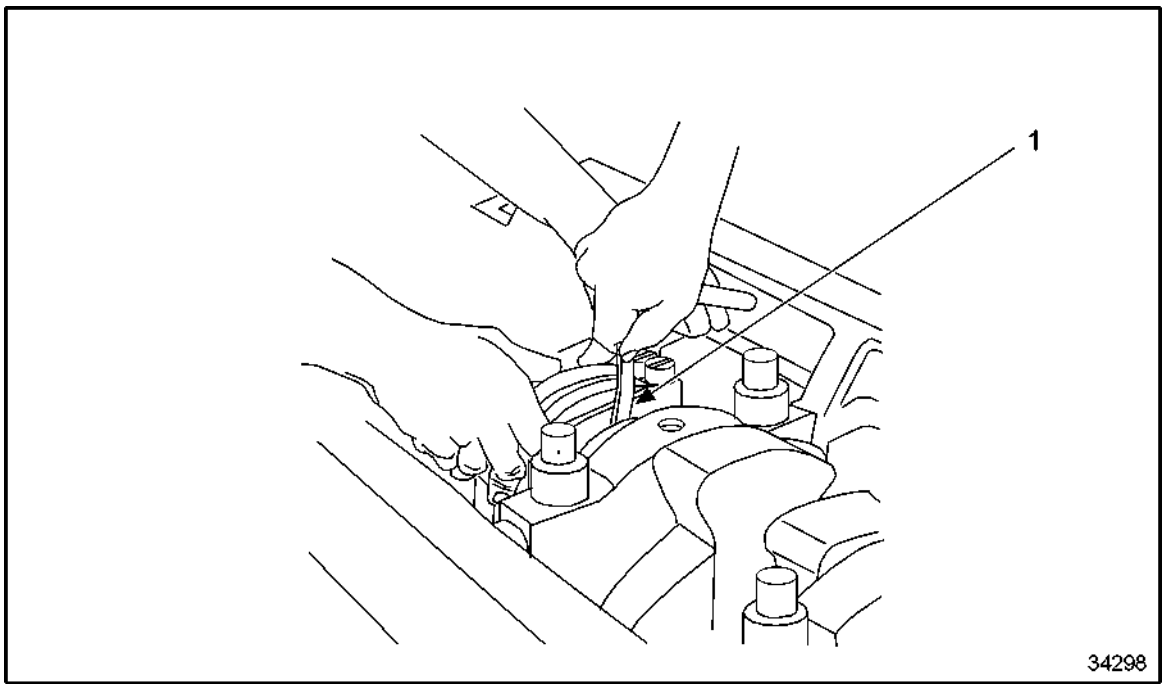
2. Refer to sectionInstalling Piston with Connecting Rod in Turnover Stand as the installation procedure is principally identical.
3. Turn crankpin of respective cylinder on right side 40° before TDC and left side 40° after TDC.
4. Remove barring tool.
5. Install access port covers, left and right sides, from respective cylinders.

Connecting Rod Axial Clearance in Turnover Stand

Perform the following steps to check connecting rod axial clearance in turnover stand.

1. Rotate cylinder block in turnover stand until oil pan mating surface is horizontal.
2. Check distance between crankshaft web and connecting rod or between connecting rod and connecting rod, pressed towards each other.
3. The above-stated components must touch each other.

4. Check rod end clearance with feeler gage (1). See Figure 338.



1. Feeler Gage

Figure 338 Checking Connecting Rod Axial Clearance in Turnover Stand

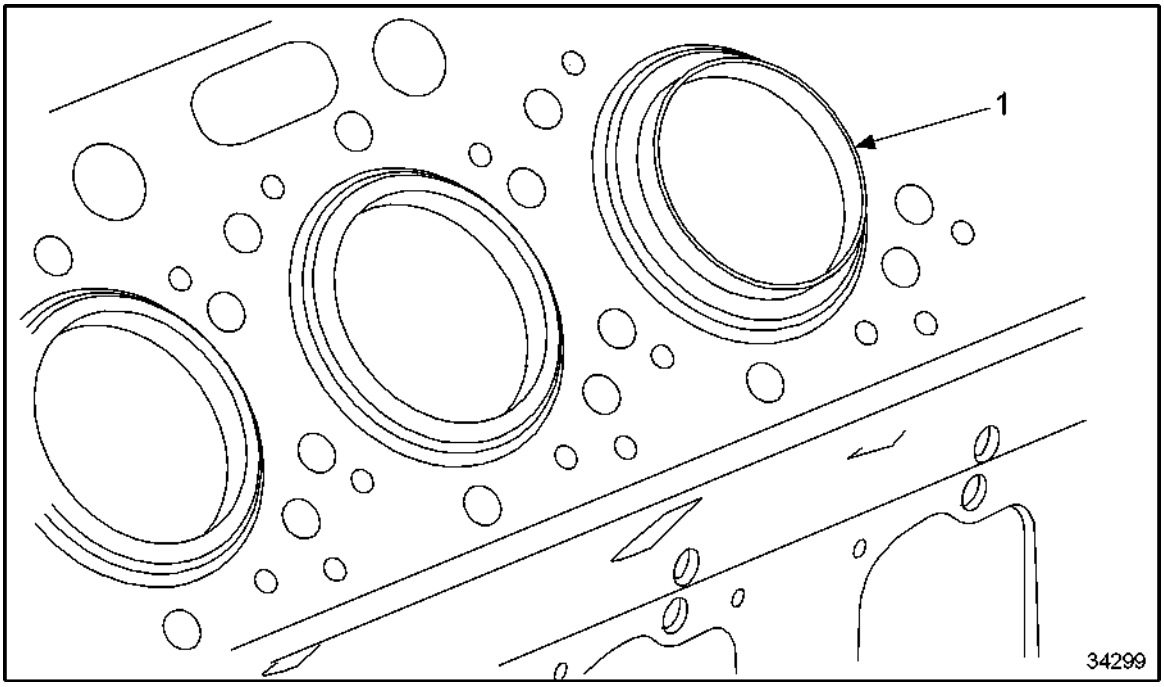
5. It is necessary to adjust clearance if following tolerance of a minimum 0.20 mm (0.00065 in.) and/or maximum of 0.60 mm (0.0019 in.) is exceeded or not reached, measured on three levels.
6. Release connecting rod bolts and compensate axial clearance.
7. Using torque wrench, first tighten connecting rod bolt at short connecting rod arm and then on long connecting rod arm to specification. Refer to section A 003. For a general view of pistons and connecting rods, refer to section C 037.05.01.
8. Check axial clearance.

Checking Axial Clearance of Connecting Rods With Oil Pan Installed

Perform the following steps to check axial clearance of connecting rods with oil pan installed.

1. Apart from altered installation position of cylinder block, checking axial clearance through access port cover is basically the same. Refer to section Connecting Rod Axial Clearance in Turnover Stand.
2. Before installing, spray cylinder liner and carbon scraper ring (marine only) with engine oil.

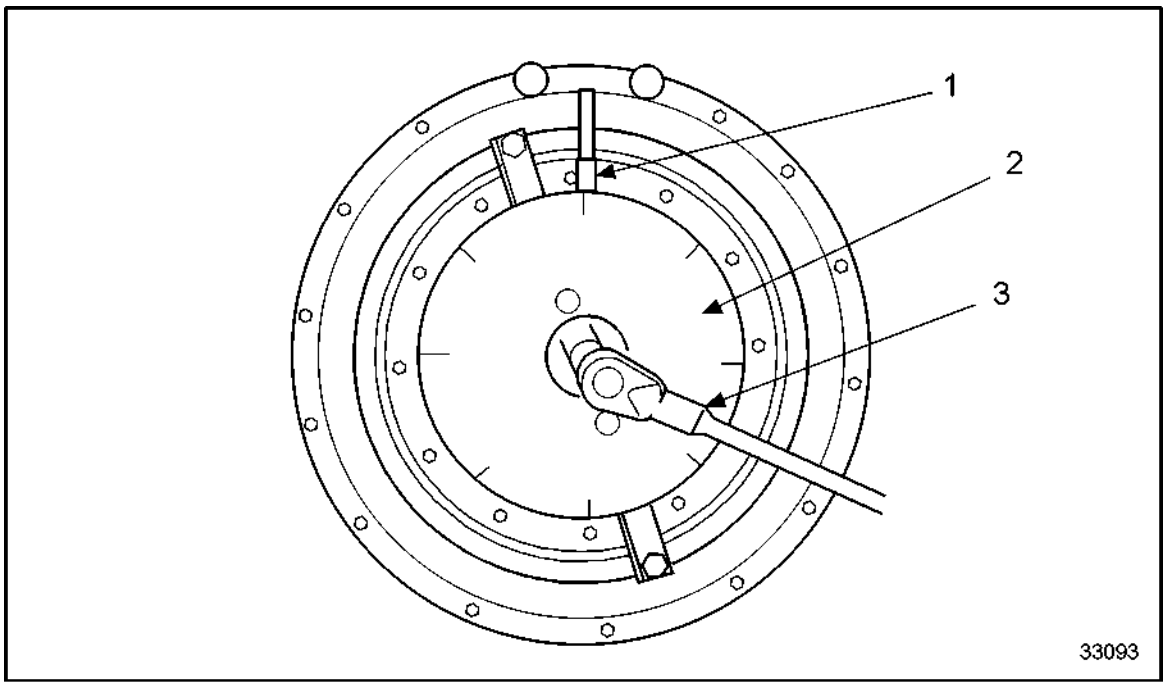
3. Insert carbon scraper ring (marine only). See Figure 339.



1. Carbon Scraper Ring

Figure 339 Carbon Scraper Ring (Marine Only)

4. Install pointer (1) on damper hub or flywheel housing. See Figure 340.



1. Pointer
2. Index Plate
3. Barring Tool

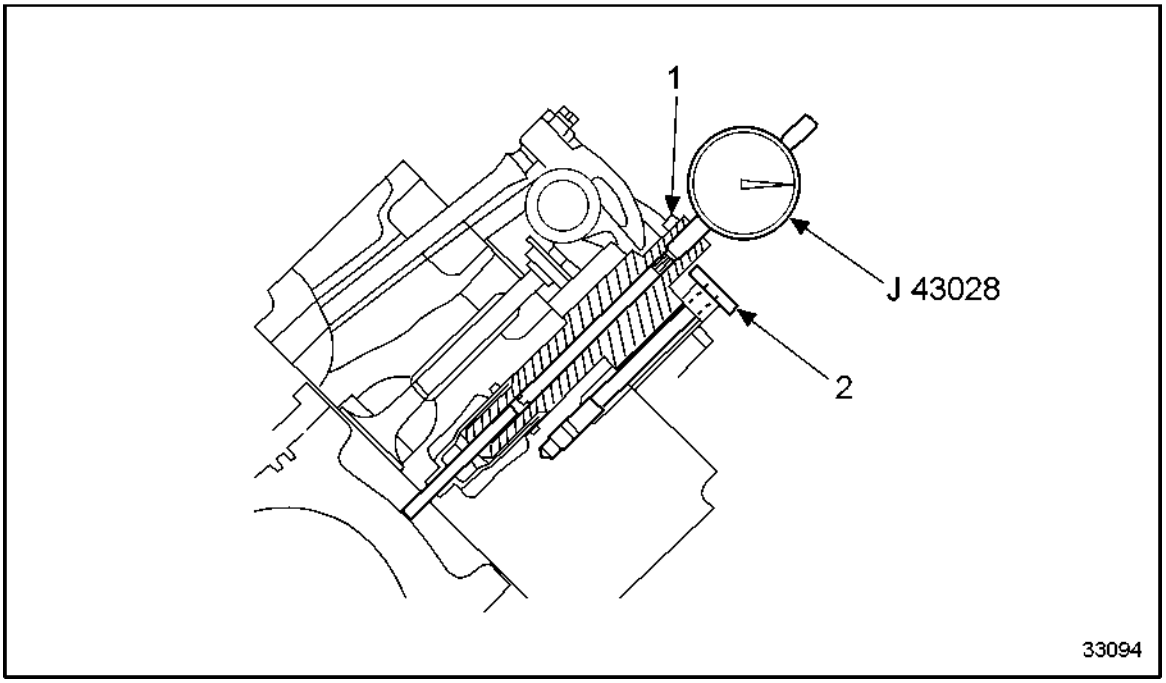
Figure 340 Install Pointer

CAUTION:

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

5. Install index plate (2) with barring tool on crankshaft, gear case end, or flex plate coupling and adjust to TDC mark A1. See Figure 340.
6. Set piston A1 to firing TDC. Refer to section C 037.05.

7. Install dial gage (2) under preload in measuring unit (4) and clamp with bolt (1). See Figure 341.



1. Clamp with Bolt
2. Knurled-head Bolt

Figure 341 Install Dial Gage

8. Install measuring unit into cylinder head and secure with knurled-head bolt (3). See Figure 341.
9. Set dial gage to zero.
10. Move piston several times up and down through TDC until needle of dial gage registers its highest reading.
11. Set dial gage to zero and readjust index plate accordingly.

CAUTION:

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

12. Bar crankshaft in normal direction of rotation to 5 degrees before TDC, read dial gage and make a note of measured value.
13. Bar crankshaft past TDC to approximately 10 degrees (to take up bearing play).
14. Bar crankshaft in direction opposite to normal direction of rotation to 5 degrees after TDC, read dial gage and make a note of measured value.
15. For example, if piston went to 5 degrees before TDC - 0.36 mm (1.4173 in.) and the piston went to 5 degrees after TDC - 0.32 mm (1.2598 in.), the total values = 0.68 mm (2.6771 in.) Thus the mean value = 0.34 mm (1.3385 in.).
16. Bar crankshaft to approximately 10 degrees after TDC, then bar in direction opposite to normal direction of rotation until dial gage reads mean value, i.e. = 0.34 mm (0.0133 in.).
17. Set pointer of index plate to 5 degrees after TDC and tighten.
18. Perform the following steps for a bar crankshaft inspection:
    [a] Absolute TDC is reached when the dial gage shows the same values before and after TDC at the same angle.
    [b] To eliminate bearing clearance, the piston must always move in direction of TDC.

C 037.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 35 are the After-Installation Operations for the piston with connecting rod.

Level of Maintenance	Operation	Reference
1, 2, 3	Install oil pan	Refer to section C 014.05.11
1, 2, 3	Install oil dipstick and access cover with oil filler neck	Refer to OEM Guidelines
1, 2, 3	Install ECU housing with bracket (If removed)	Refer to OEM Guidelines
1, 2, 3	Install starter (If removed)	Refer to section C 172.05.11
1, 2, 3	Install cylinder head	Refer to section C 041.05.11
1, 2, 3	Install pushrods	Refer to section C 056.05.11
1, 2, 3	Install rocker arm assembly	Refer to section C 056.05.11
1, 2, 3	Install valve drive	Refer to section C 056.05.11
1, 2, 3	Adjust valve clearance	Refer to section C 056.05.11
1, 2, 3	Install fuel injector	Refer to section C 075.05.11
1, 2, 3	Install low pressure fuel return rails and lines	Refer to section C 086.05.11
1, 2, 3	Install high pressure injection lines	Refer to section C 077.05.11
1, 2, 3	Connect electric cables (as required)	Refer to OEM Guidelines
1, 2, 3	Install appropriate exhaust line	Refer to section C 141.05.11
1, 2, 3	Install appropriate charge air manifold	Refer to section C 124.05.11
1, 2, 3	Install cylinder head cover	Refer to section C 056.05.11
1, 2, 3	Install appropriate coolant lines	Refer to section C 204.05.11
1, 2, 3	Connect coolant lines	Refer to section C 204.05.11
1, 2, 3	Install air filter	Refer to OEM Guidelines
1, 2, 3	Fill charge air coolant system	Refer to section C 206.05.11
1, 2, 3	Fill oil system with engine oil	Refer to Operators Guide
1, 2, 3	Fill engine coolant system	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 35 After — Installation Operations

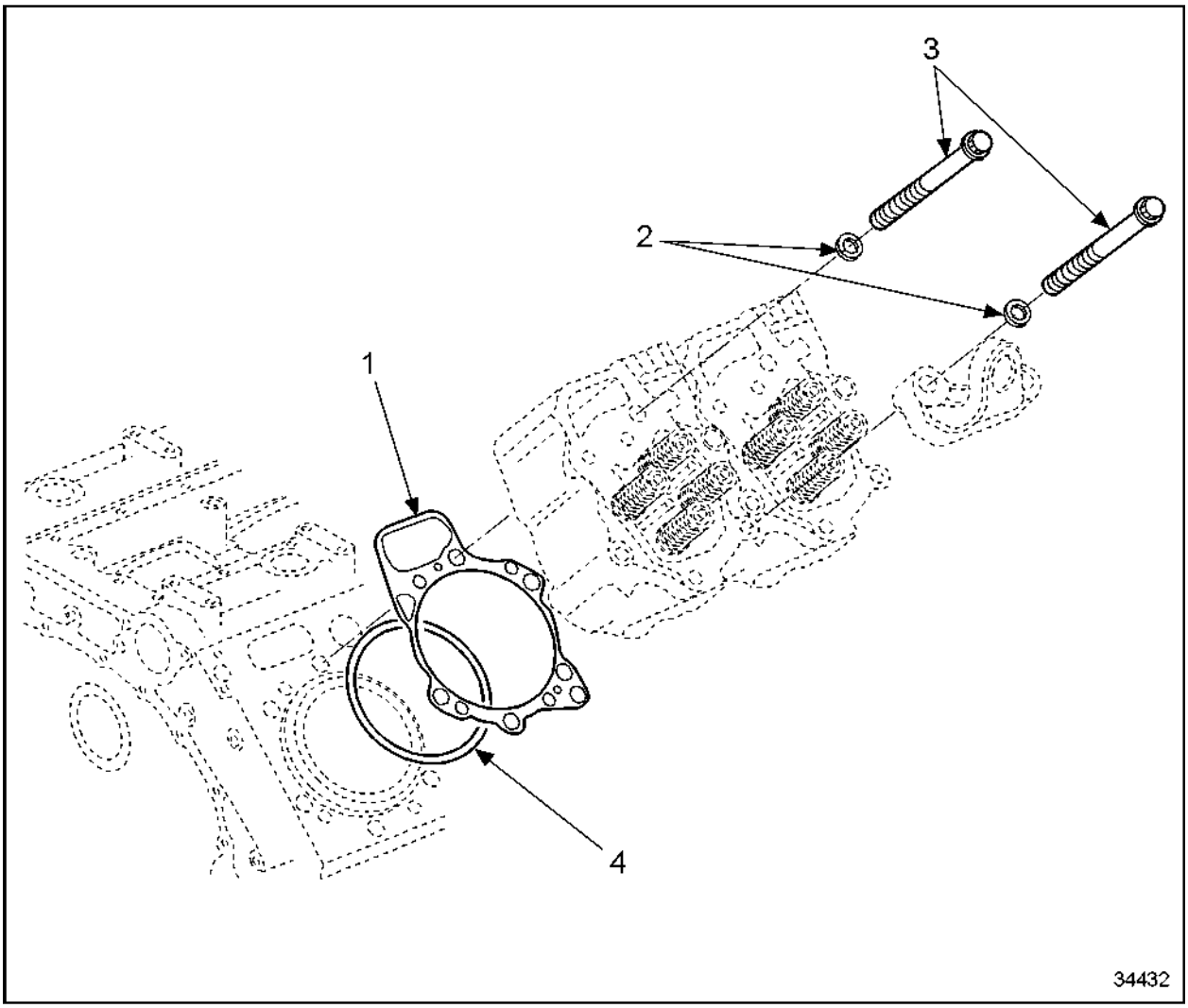
C 040 – CYLINDER HEAD WITH FIXTURES

Section **Page**

C 041.05 – CYLINDER HEAD

C 041.05.01 – GENERAL VIEW

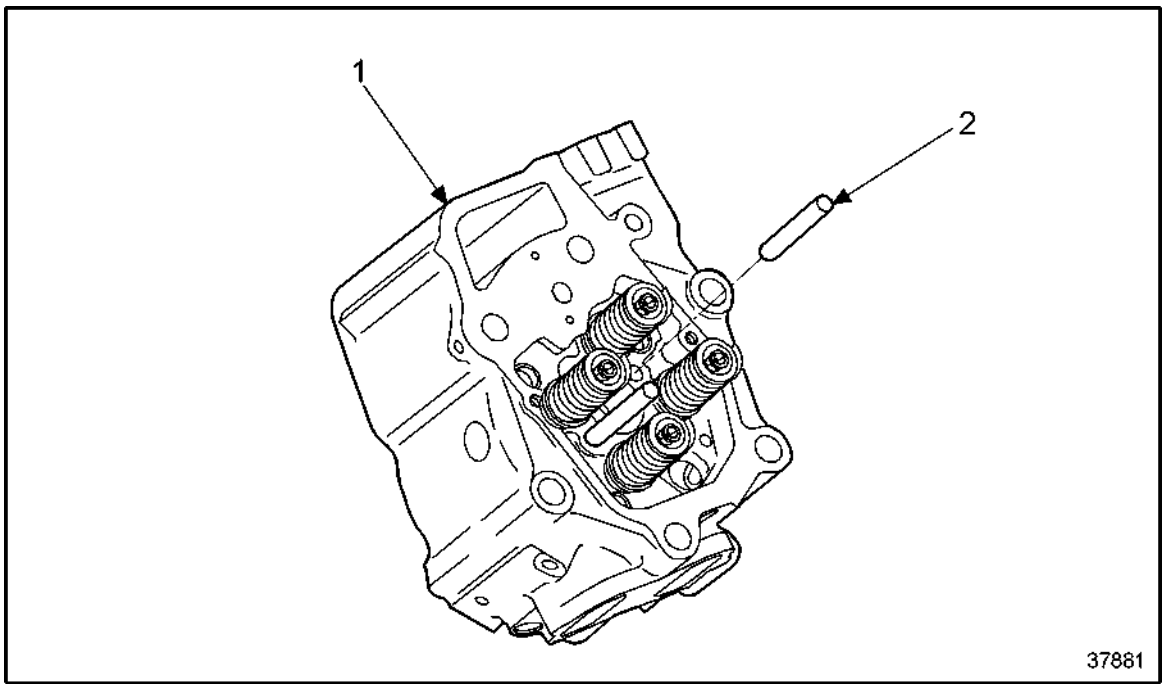
See Figure 342 for a general view of the cylinder head components.



1. Gasket
2. Washer
3. Cylinder Head Bolt
4. Sealing Ring

Figure 342 General View of Cylinder Head with Attachments

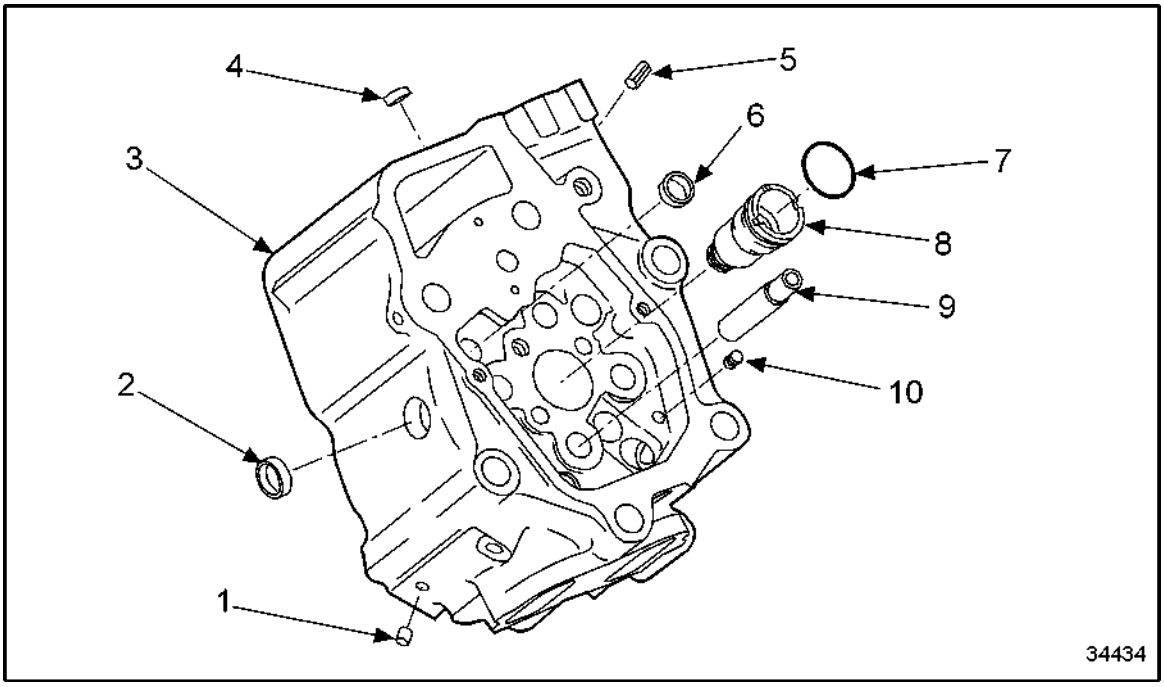
See Figure 343 for a view of the cylinder head **with** valves.



1. Cylinder Head
2. Bridge Guide

Figure 343 Cylinder Head With Valves

See Figure 344 for a view of the cylinder head **without** valves.



1. Plug
2. Sealing Cap
3. Cylinder Head
4. Cap Plug
5. Spring Pin
6. Cap Plug, DM 24
7. O-ring
8. Sleeve Injector
9. Valve Guide
10. Plug

Figure 344 Overview of Cylinder Head Without Valves

C 041.05.02 – SPECIAL TOOLS

Listed in Table 36 are the special tools required for maintenance on the cylinder head.

Designation	Tool Number
Socket for cylinder head bolts	—
Socket for protective sleeve	—
Valve installation and removal tool	—
Valve seat rotating unit VDS 2	—
Brass drift for cap plug	—
Removal brass drift for valve guides	—
Spacer tool, valve guide installation	—
Spreader for valve stem seal	—
Plug gage for valve guides	—
Plug gage for valve seats	—
Alignment tool for cylinder head installation	—

Table 36 Special Tools

C 041.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 37 are the Before-Removal Operations for the cylinder head.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine start	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Remove air filter (If necessary)	Refer to OEM Guidelines
1, 2, 3	Remove exhaust manifold bolts	Refer to section C 141.05.05
1, 2, 3	Remove swing arm brackets	Refer to section C 055.05.05
1, 2, 3	Remove pushrods	Refer to section C 055.05.05
1, 2, 3	Remove valve bridges	Refer to section C 055.05.05
1, 2, 3	Disconnect and remove electric cable at injector	Refer to OEM Guidelines
1, 2, 3	Remove fuel injector	Refer to section C 075.05.05
1, 2, 3	Remove charge air manifold bolts	Refer to section C 124.05.05
1, 2, 3	Remove high-pressure line between cylinder head and high-pressure rail	Refer to section C 077.05.05
1, 2, 3	Disconnect fuel return lines	Refer to section C 086.05.05

1 = The engine is to be completely disassembled.

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

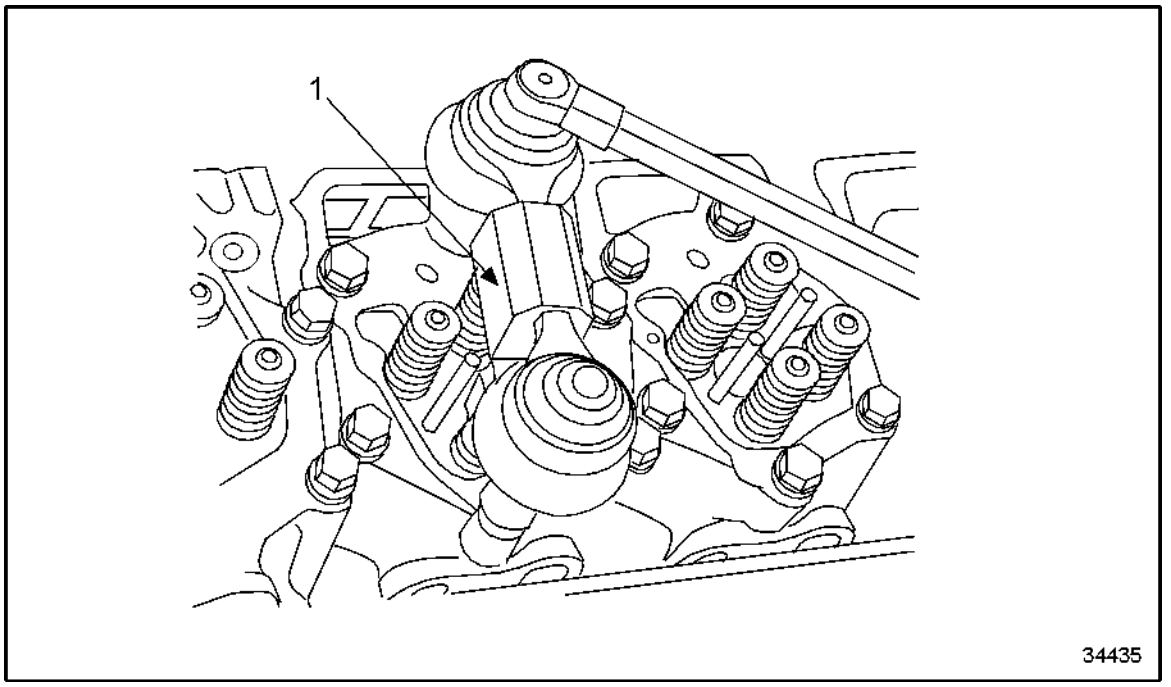
3 = The engine is to remain installed.

Table 37 Before-Removal Operations

C 041.05.05 – REMOVAL OF CYLINDER HEAD

Perform the following steps to remove the cylinder head:

1. Use a large ratchet or power assist to unscrew hex bolts from cylinder head evenly. See Figure 345.



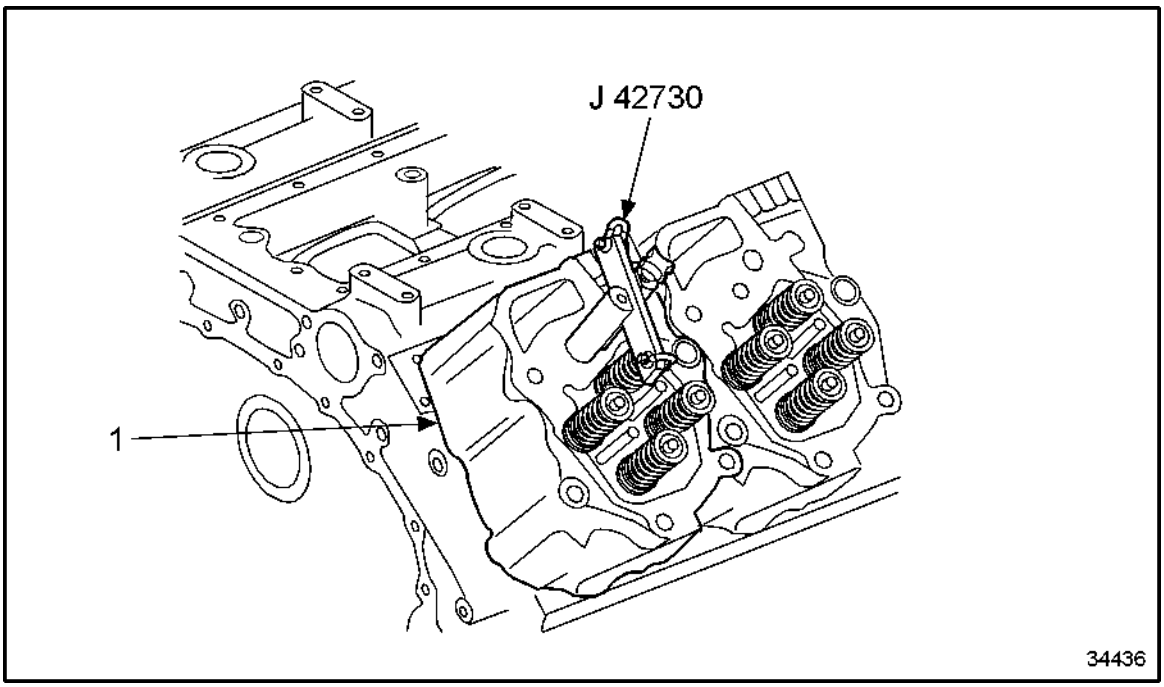
1. Hydraulic Torque Wrench

Figure 345 Unscrewing Hex Bolts on Cylinder Head

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

2. Using lifting device, lift cylinder head (1) off of the cylinder block and place it on a suitable base. See Figure 346.

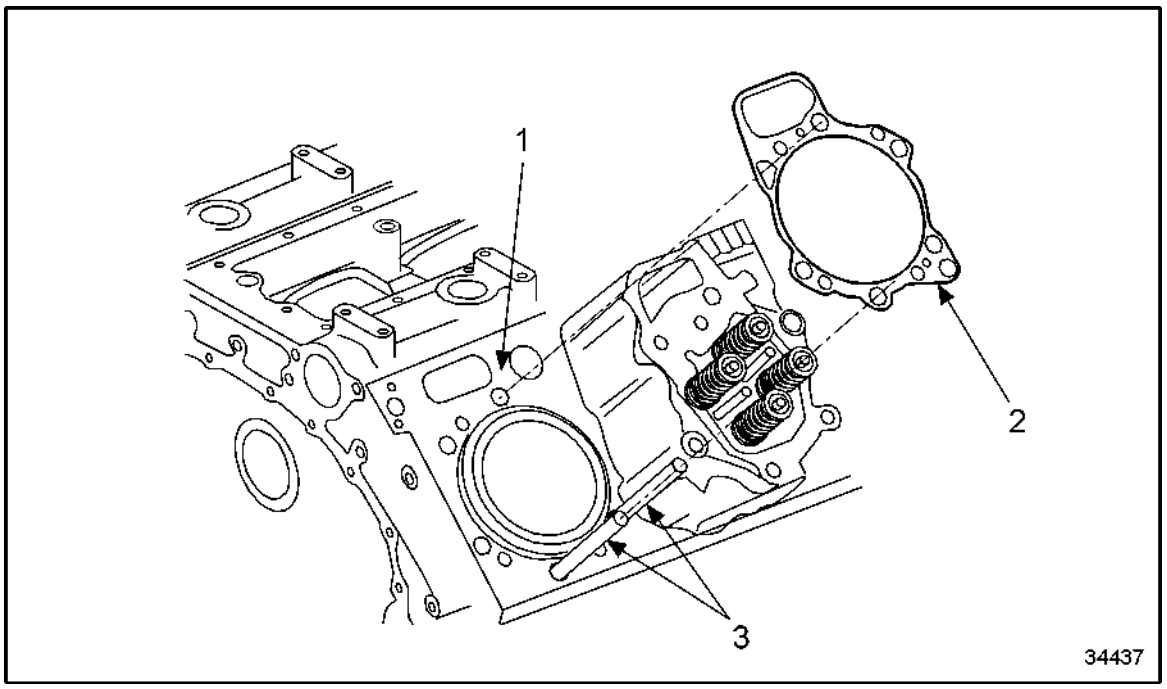


1. Cylinder Head

Figure 346 Lifting Cylinder Head with Lifting Device

NOTE:
With injector installed, place cylinder head to the side. Injector protrudes at bottom of cylinder head, so surface should be flat.

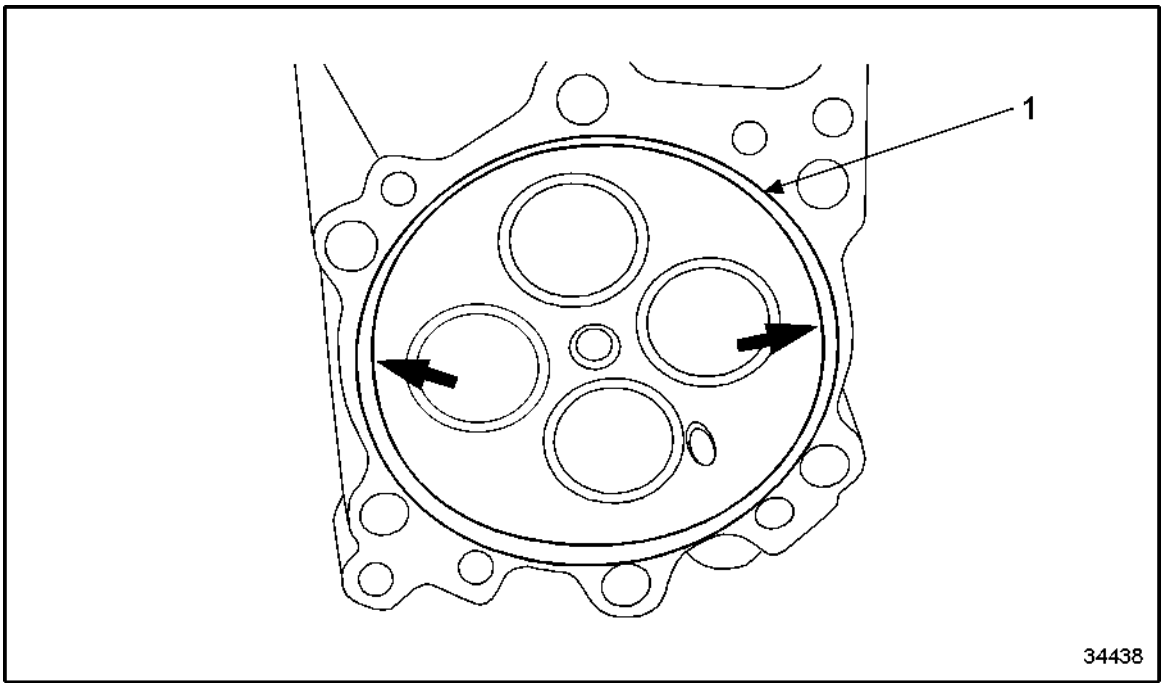
3. Remove cylinder head gasket (2) from cylinder block mating surface. See Figure 347.



1. Cylinder Block Mating Surface
2. Cylinder Head Gasket
3. Cylinder Head Studs

Figure 347 Removing Cylinder Head Gasket

4. Using appropriate tools, carefully lever sealing ring (1) out of cylinder head lower section. See Figure 348.



1. Sealing Ring

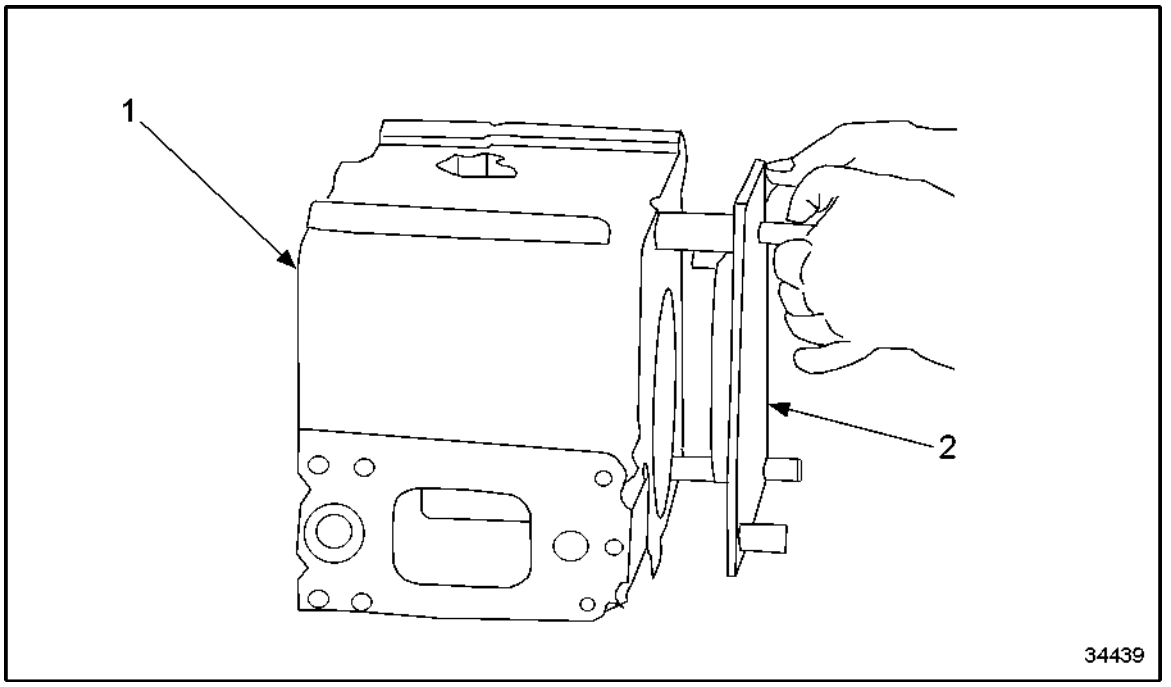
Figure 348 Removing Cylinder Head Sealing Ring

5. For screwdriver contact point (arrow), see Figure 348.

C 041.05.06 – DISASSEMBLY OF CYLINDER HEAD

Perform the following steps to disassemble the cylinder head:

1. Place cylinder head (1) on the base plate (2) of the valve spring relief device. See Figure 349.

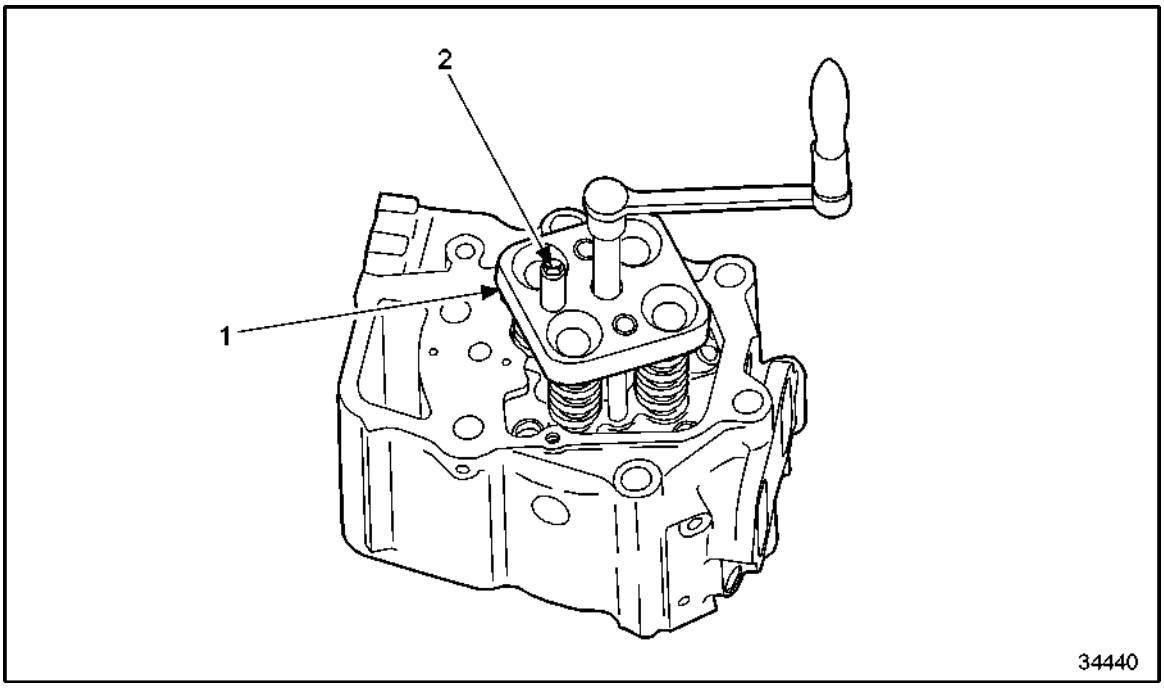


1. Cylinder Head
2. Base Plate

Figure 349 Placing Cylinder Head on Base Plate of Valve Spring Relief Device

2. Align cylinder head on the guide pins so that valve heads lie beside the plastic plate. See Figure 349.

3. Place pressure plate (1) on valve spring retainer and secure to the base plate with hex bolt (2). See Figure 350.



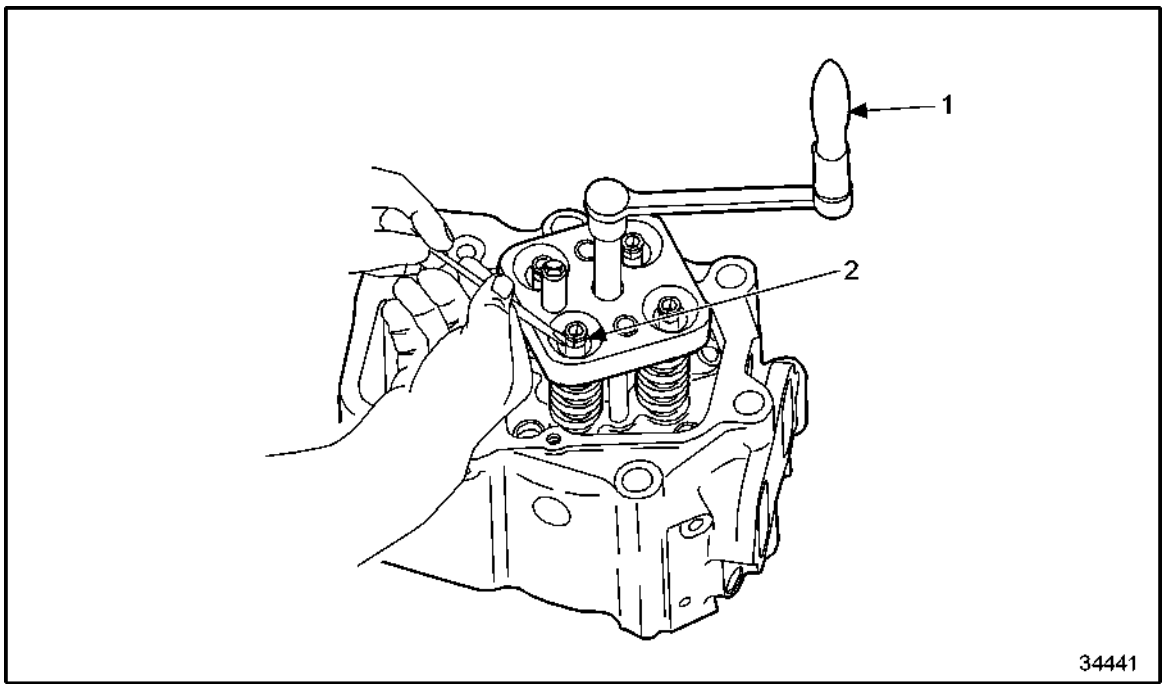
1. Pressure Plate
2. Hex Bolt

Figure 350 Securing Pressure Plate to Base Plate

CAUTION:

To avoid personal injury when using a valve spring compressor, wear adequate eye protection (safety glasses or faceplate).

4. Rotate the hand spindle (1) and press the pressure plate onto the spring retainer until valve locks are loose. See Figure 351.

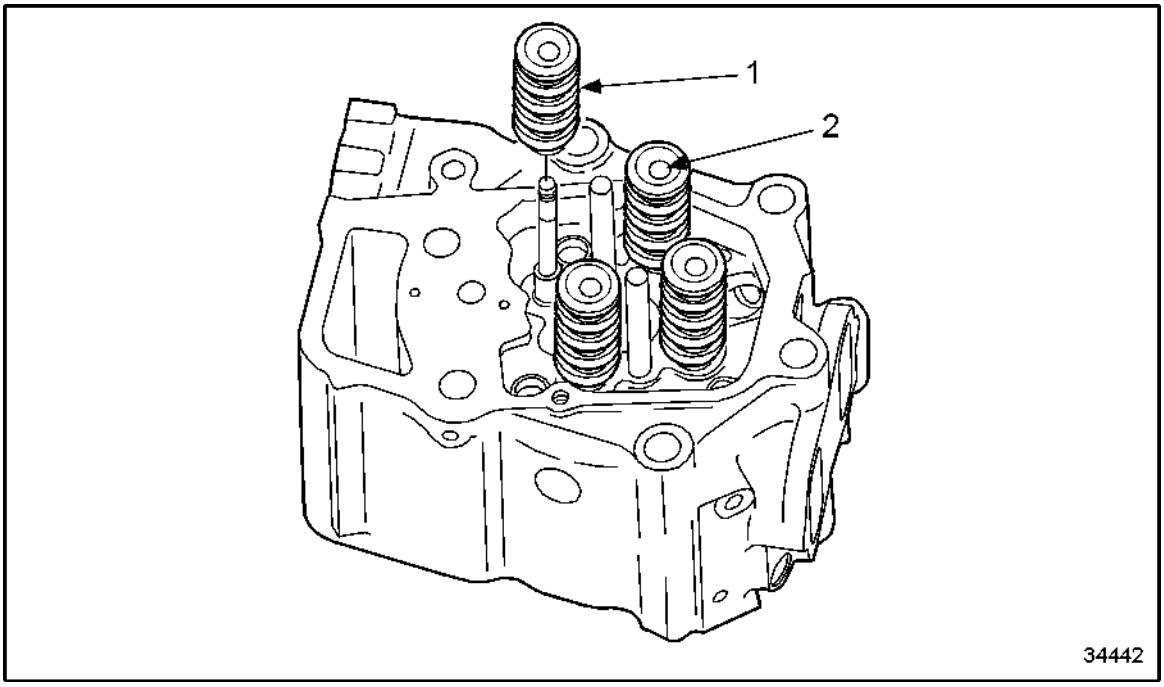


1. Hand Spindle
2. Valve Lock

Figure 351 Removing Valve Locks

5. Using bar magnet, take out valve locks (2).
6. Release valve spring.
7. After all valve locks have been removed, remove pressure plate and spindle.

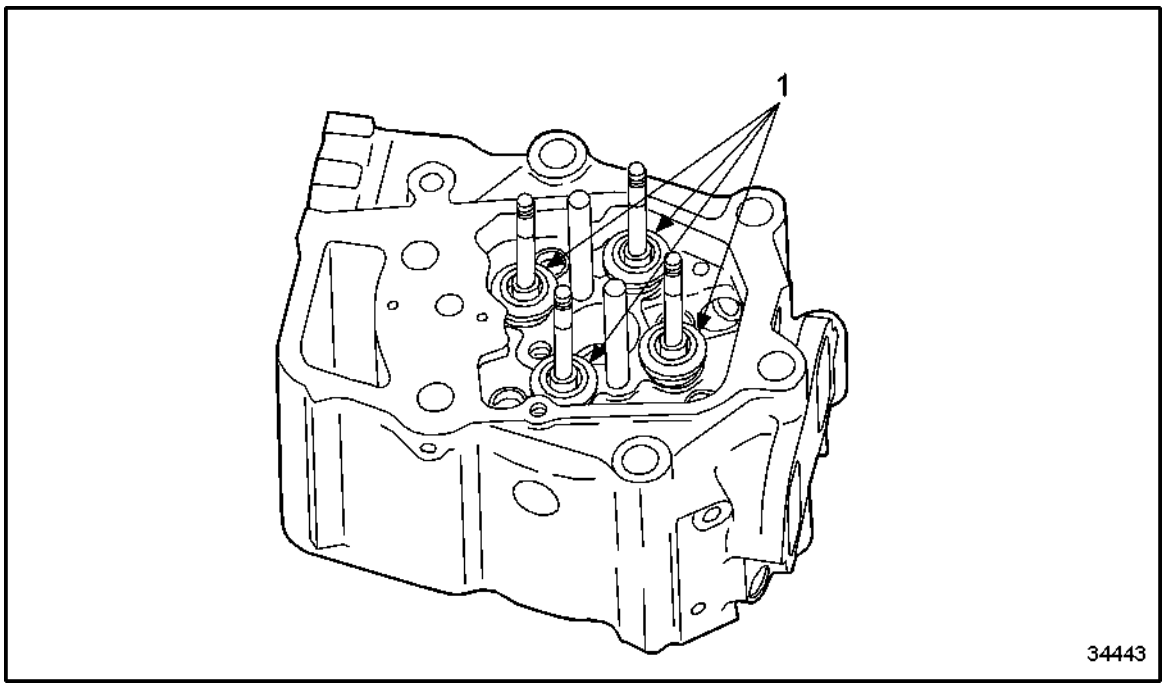
8. Remove valve spring retainer and valve springs. See Figure 352.



1. Outer Valve Spring
2. Valve Spring Retainer

Figure 352 Removing Valve Spring Retainer and Valve Springs

9. Remove valve rotator. See Figure 353.



1. Valve Rotators

Figure 353 Removing Valve Rotator

10. Lay cylinder head on its side.

11. Remove base plate of the valve spring tensioner from the cylinder head. See Figure 354.

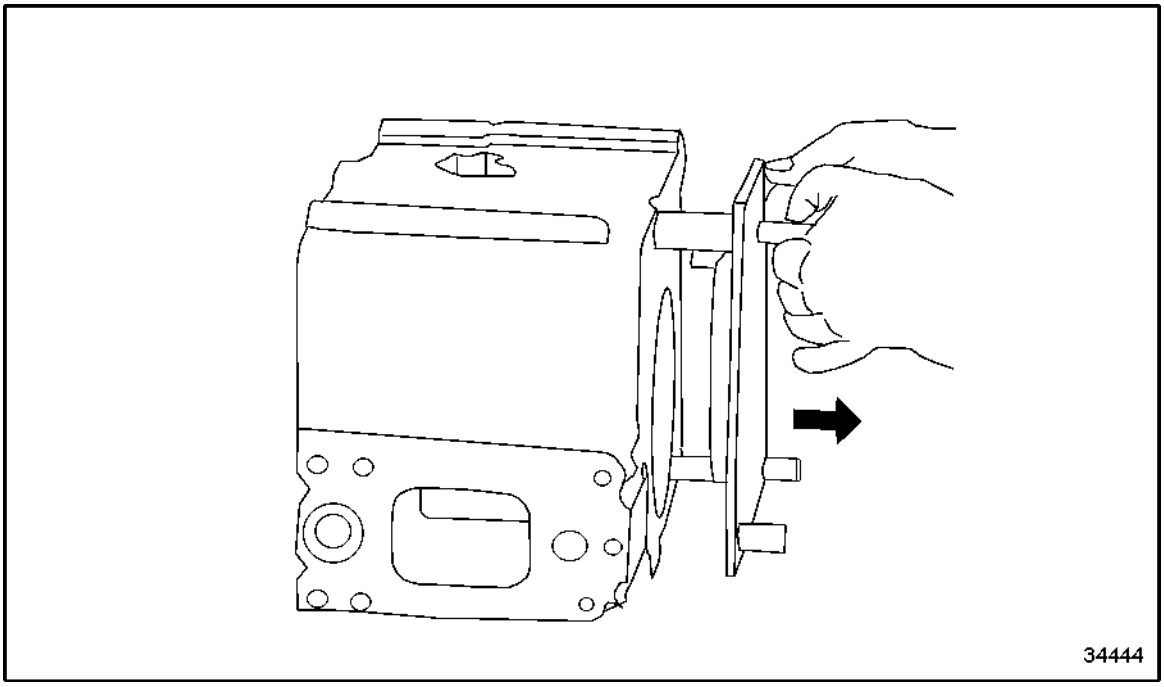
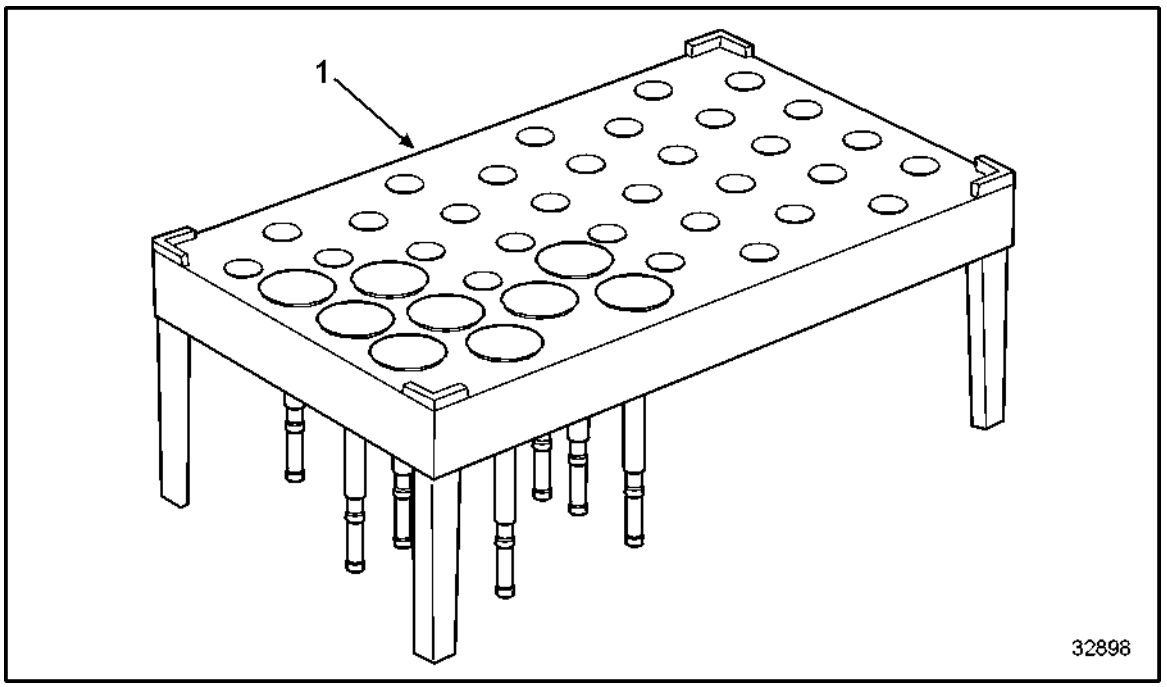


Figure 354 Removing Base Plate from Cylinder Head

12. Remove valves from valve guides.

13. Place valves in storage frame (1) to protect them from damage. See Figure 355.

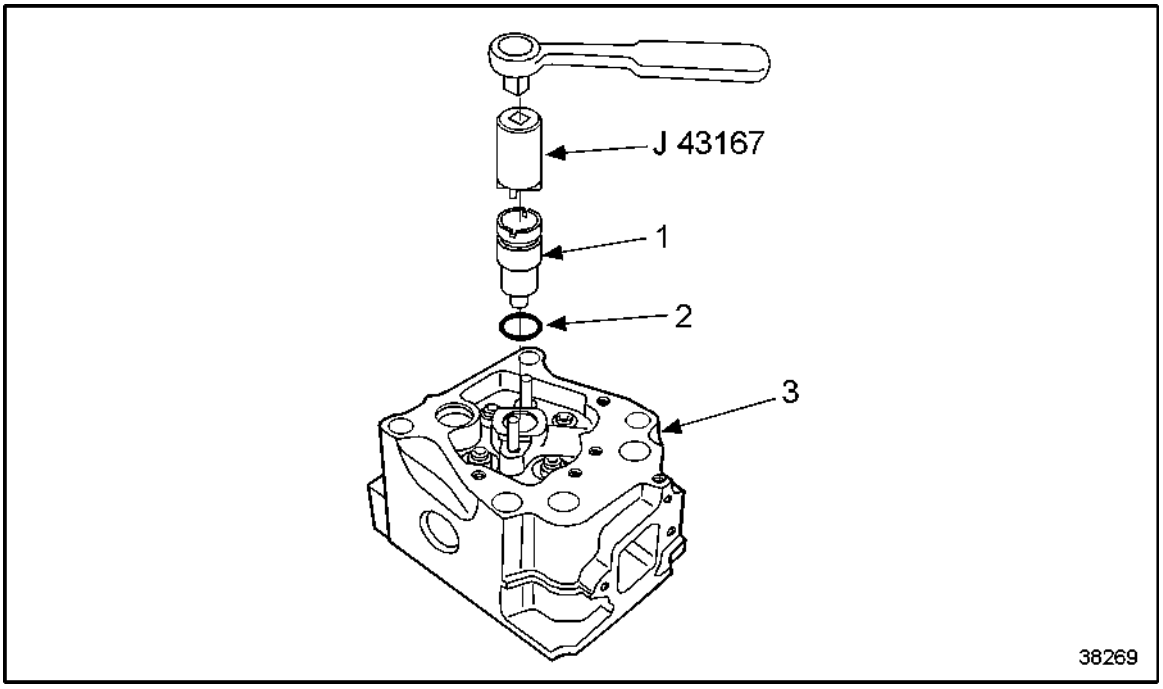


1. Storage Frame

Figure 355 Placing Valves in Storage Frame

14. Clamp cylinder head in retaining base.

15. Use socket wrench to unscrew injector sleeve (1) from cylinder head. See Figure 356.



1. Sleeve
2. O-ring
3. Cylinder Head

Figure 356 Removing Protective Sleeve

NOTE:
Ensure that socket is correctly engaged in sleeve groove.

16. To remove bridge pin with engine removed, install slide hammer puller to bridge pin. Remove pin.

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

NOTE:
Count the number of pulls required to remove pin. If pin was removed with few pulls or removed with little resistance, see step 17.

17. 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.
18. 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.

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.

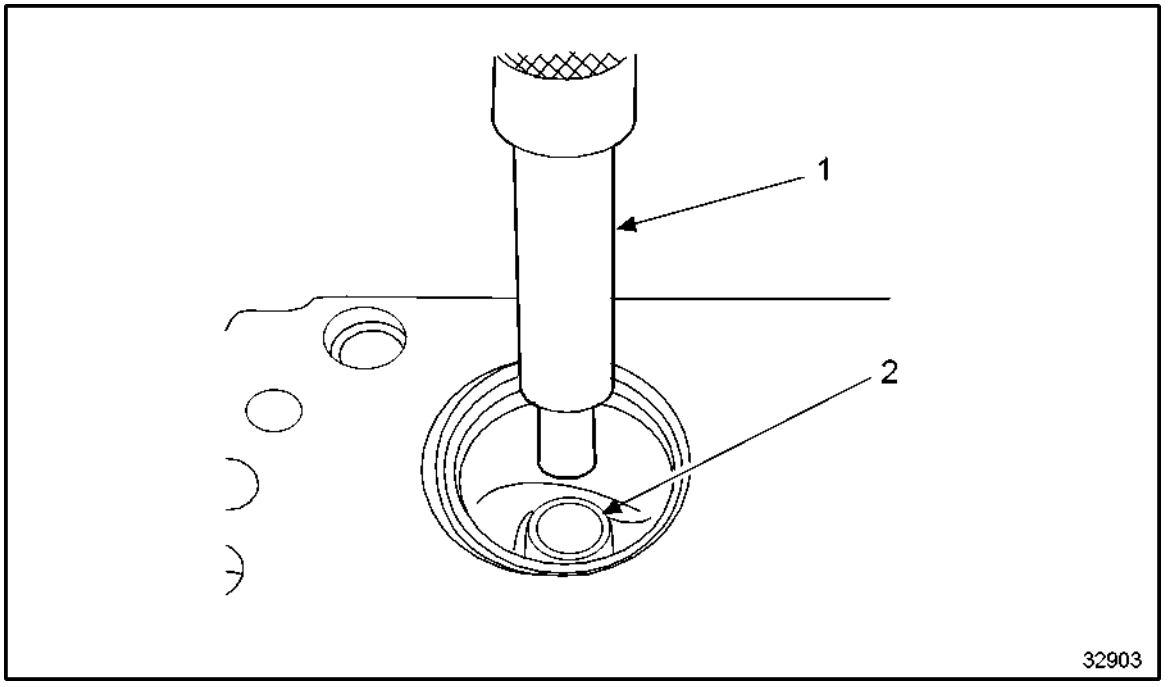
Measure bridge pin bore using pin bore digital measuring tool. Measure bore at three locations; bottom, middle and top. Record values to a data sheet.

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.



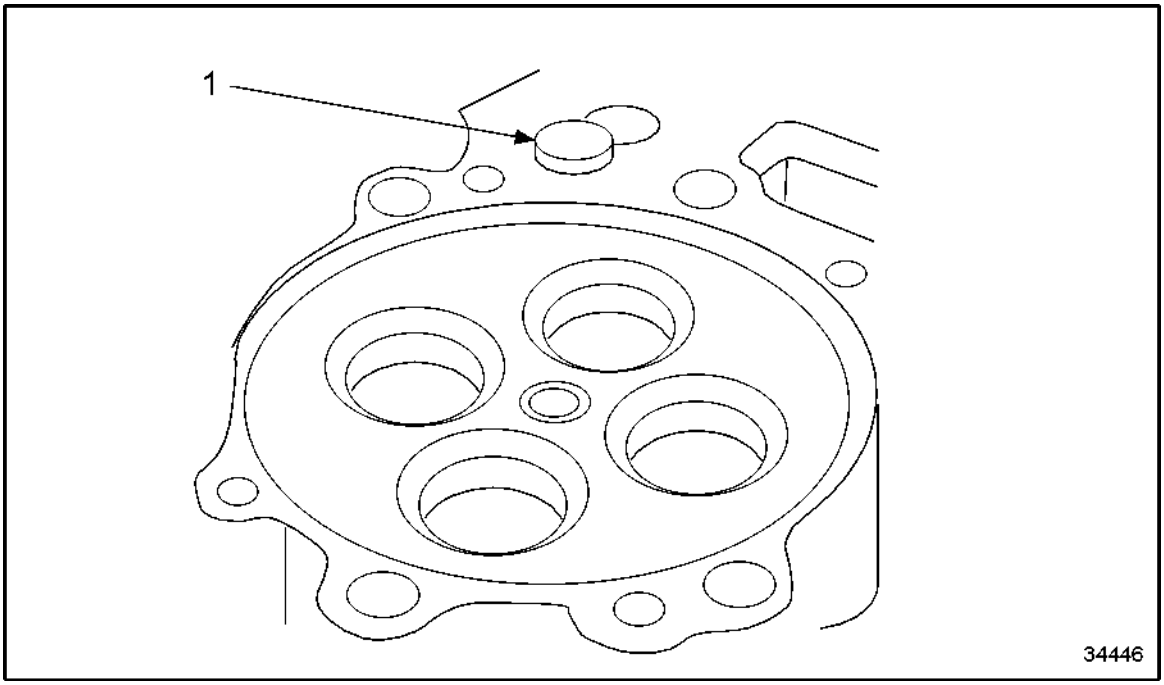
1. Removal Brass Drift
2. Valve Guide

Figure 357 Removing Valve Guides

23. Ensure that mating surface for valve gear housing is seated correctly.
24. From the combustion side, press valve guide out of cylinder head with removal brass drift.

NOTE:
Remove cap plug only if necessary (e.g., in event of leakage).

25. To remove cap plug, use brass drift to carefully knock the edge of one side of the cap plug (1) inwards until it tilts in the bore. See Figure 358.



1. Cap Plug

Figure 358 Removing Cap Plug

26. Withdraw cover with pliers.
27. When removing, take care that cover does not fall into bore and that sealing surface of bore is not damaged.

NOTICE:
Never drill cap plug, as metal chips in coolant jacket of cylinder head can cause localized overheating.

C 041.05.08 – INSPECTION AND REPAIR

Perform the following subsections to inspect and repair the cylinder head:

Clean Cylinder Head

Perform the following steps to clean the cylinder head:

1. Clean all components with cold cleaner.

CAUTION:

To avoid personal injury when using the chemical substances listed below, it is essential to observe the manufacture's instructions for use, safety instructions and waste disposal specifications.

- ☐ **Emery cloth**
- ☐ **Magnifying glass**
- ☐ **Vasoline, petroleum jelly (white)**
- ☐ **Multipurpose grease, Shell Retinax**
- ☐ **Engine oil**
- ☐ **Cleaning agent, Solvclean**
- ☐ **Corrosion preventive, Caramaba Express**
- ☐ **Kerosene or diesel fuel**

2. If necessary, pretreat oil-carbon deposits on valves and cylinder heads with carbon-deposit remover.
3. After cleaning with carbon-deposit remover, rinse components in water until there is no further residue.
4. Measure cylinder head overall height.
   [a] If values are below minimum permissible height, replace cylinder head.
   [b] If values are not below minimum permissible height, continue inspection.
5. Visually inspect cylinder head interfaces (combustion chamber side) for unevenness or damage.
   [a] If cylinder head interfaces are uneven or damaged, recondition as necessary.
   [b] If cylinder head interfaces are not damaged or uneven, continue inspection.

NOTE:
Surface quality (roughness height, shaft height) of cylinder head interfaces must be maintained.

NOTE:
Do not remove material below minimum permissible height.

6. Visually inspect mating surface of injector sleeve in cylinder head for scoring and wear.
   [a] If mating surface of injector sleeve is scored or worn, rub down.
   [b] If mating surface of injector sleeve is excessively worn, replace components as necessary.
   [c] If mating surface of injector sleeve is not scored or worn, continue inspection.
7. Inspect thread of injector sleeve in cylinder head for ease of movement and wear.
   [a] If thread of injector sleeve does not show ease of movement or is worn, rub down or replace as necessary.
   [b] If thread of injector sleeve shows ease of movement and is not worn, continue inspection.
8. Visually inspect valve seat in the cylinder head for wear and pitting.
   [a] If valve seat is worn or pitted, recondition as necessary.
   [b] If valve seat is not worn or pitted, continue inspection.
9. Visually inspect washers and tapers for wear.
   [a] If washers or tapers are worn, replace as necessary.
   [b] If washers or tapers are not worn, continue inspection.
10. Visually inspect all threads in cylinder head for ease of movement.
    [a] If threads do not show ease of movement, rechase threads as necessary.
    [b] If threads show ease of movement, continue inspection.
11. Replace cylinder head gaskets and O-rings.
12. Replace valve guides during W6 overhaul.

Checking Cylinder Head Bolts

Perform the following steps to check cylinder head bolts:

1. Check that thread and bolt head mating surfaces are in perfect condition.
   [a] If thread and bolt head mating surfaces are not in perfect condition, replace bolts as necessary.

[b] If thread and bolt head mating surfaces are in perfect condition, continue inspection.

2. Measure shaft length of the cylinder head bolt with depth gage. See Figure 359.

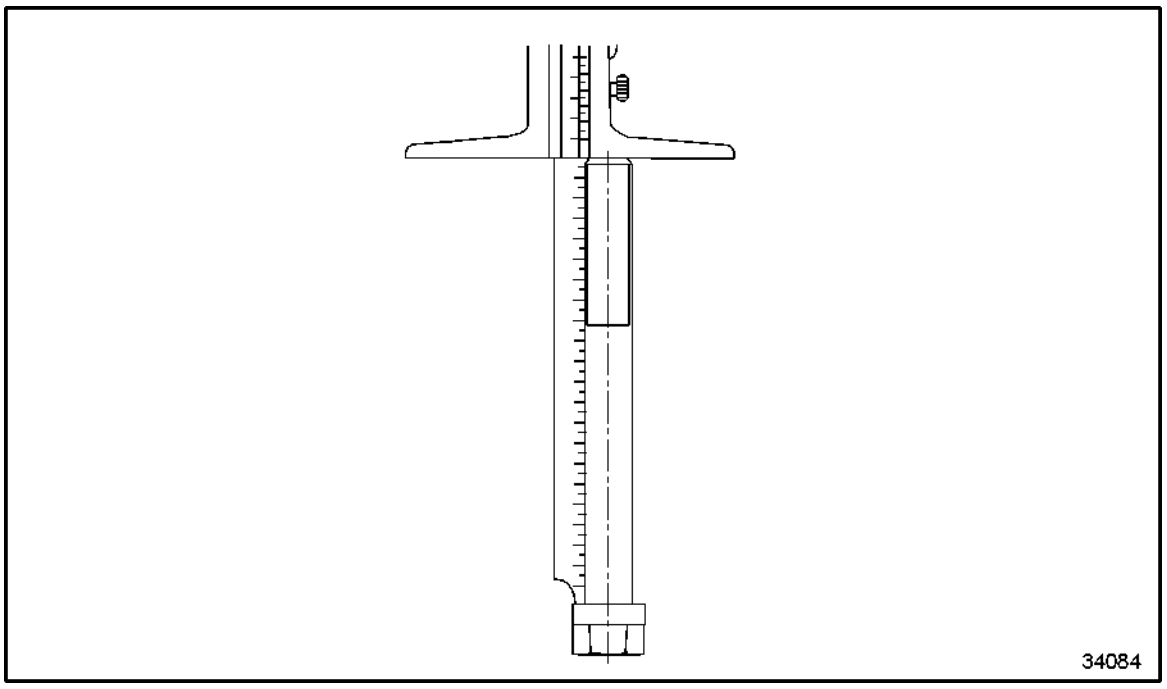


Figure 359 Measuring Cylinder Head Bolt Length

3. For maximum permissible shaft length, refer to sectionA 003.

Inspecting Bridge Guide

Perform the following steps to inspect bridge guide:

1. Visually inspect bridge guide for damage and wear.
   [a] If bridge guide is damaged or worn, replace as necessary.
   [b] If bridge guide is not damaged or worn, continue inspection.

See Figure 360.

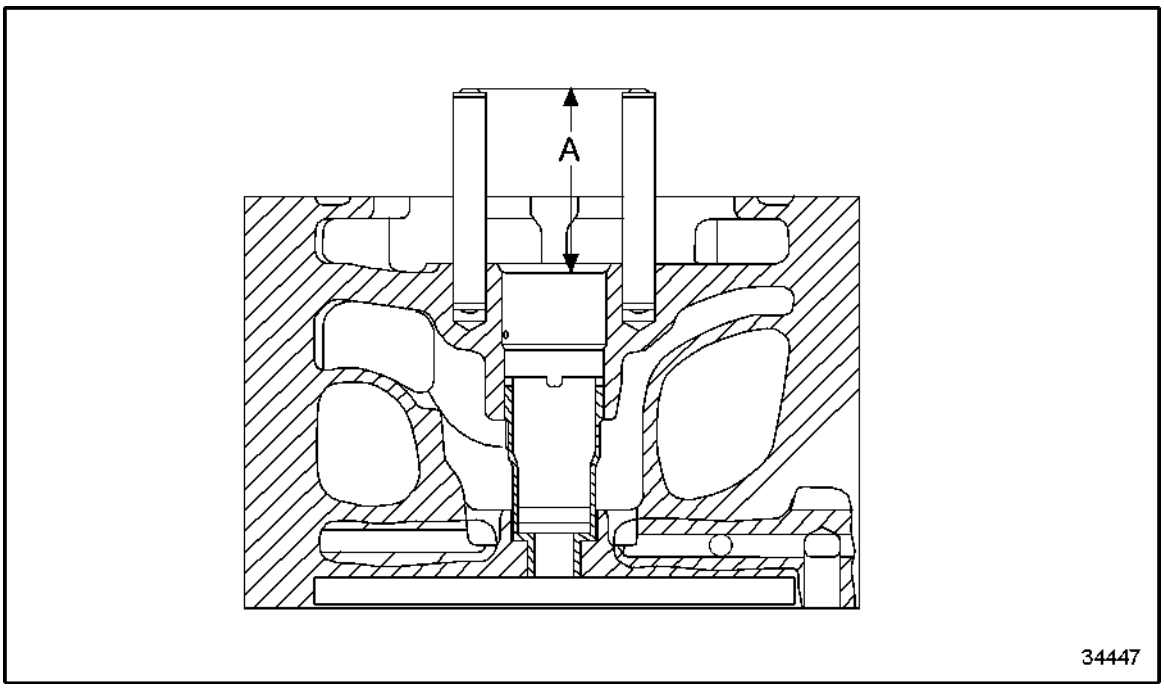


Figure 360 Inspecting Bridge Guide

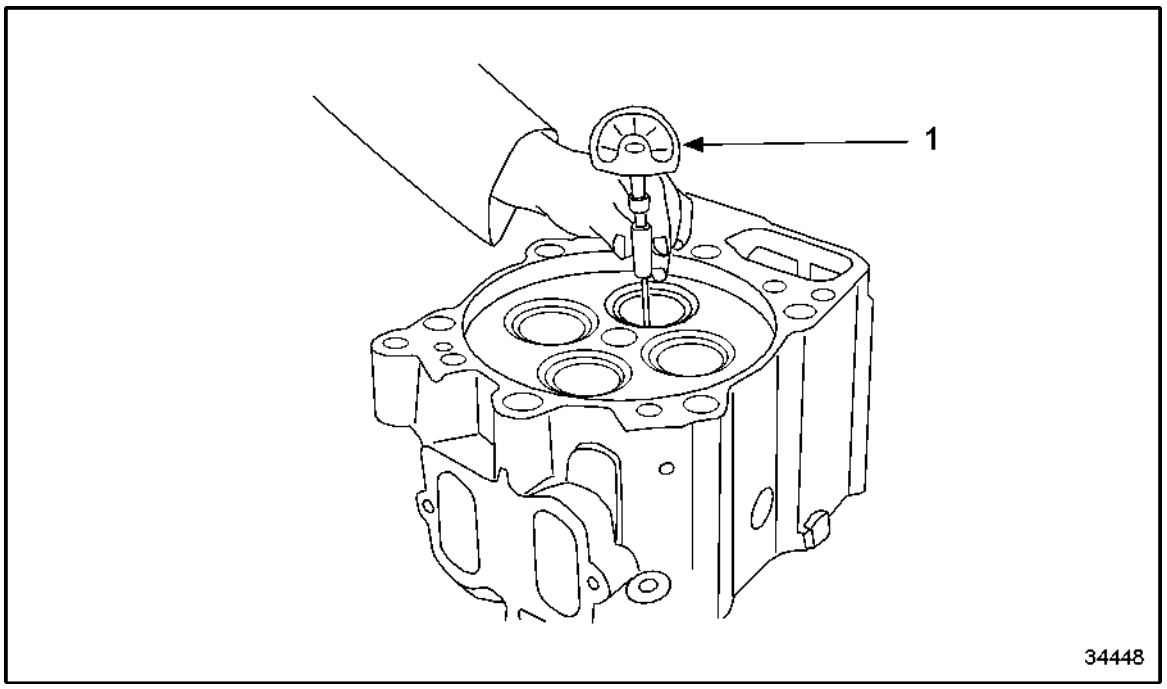
2. Measure outside diameter of bridge guide with micrometer.
   [a] If limit value is not achieved, replace bridge guide as necessary.
   [b] If limit value is achieved, continue inspection.
3. Measure protrusion A of bridge guide.
4. A = 78 mm (3.0708 in.) ± 0.5 mm (0.0197 in.). See Figure 360.

Checking Valve Guides

Perform the following steps to check valve guides:

1. Clean bores of valve guides with valve guide cleaning brush.
2. Check all valve guides for wear and damage.
   [a] If valve guides are worn or damaged, replace components as necessary.

[b] If valve guides are not worn or damaged, continue inspection. See Figure 361.



1. Plug Gage, Design A

Figure 361 Checking Valve Guides with Plug Gage

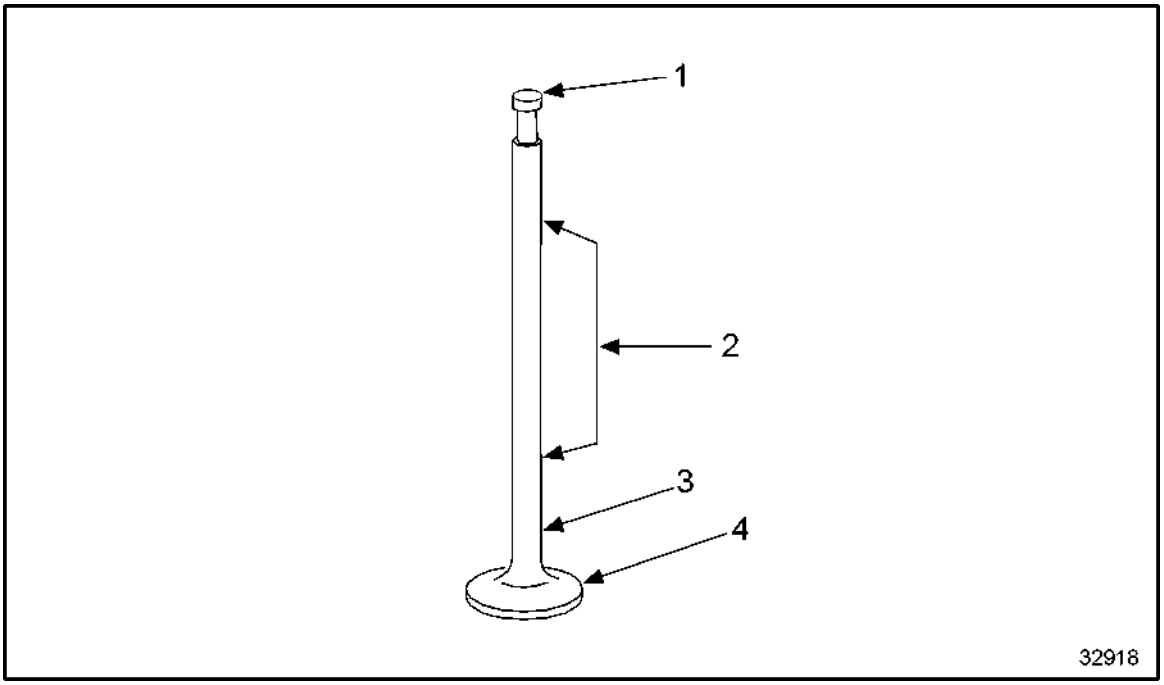
3. To check valve guides with plug gage, design A (1), perform the following:
   [a] Nominal diameter of plug gage should be 11.009 ± 0.009.
   [b] Length of go-end should be 103 mm (4.0551 in.).
4. Go-end plug gage must move easily through the whole valve guide.
5. No-go-side plug gage must not rub.

Checking Valves

Perform the following steps to check valves:

1. Visually inspect valves for damage such as pitting, scoring and indentations on valve stem (2), head (4), neck (3) and bridge contact area (1).
   [a] If valves are damaged, replace as necessary.

[b] If valves are not damaged, continue inspection. See Figure 362.



1. Bridge Contact Area
2. Valve Stem
3. Neck
4. Head

Figure 362 Checking Valves

2. Visually inspect chrome plating on valves for damage and wear.
   [a] If chrome plating is damaged or worn through, replace valves as necessary.
   [b] If chrome plating is not damaged or worn, continue inspection.
3. Visually inspect valve stems for indentations and scoring.
   [a] If indentations or scoring are found, replace valves stems.
   [b] If no indentations or scoring is found, continue inspection.
4. Visually inspect for pitting at transition from valve head to valve stem.
   [a] If pitting is found at transition from valve head to valve stem, replace valves as necessary.
   [b] If no pitting is found, continue inspection.

NOTE:
Valve keyways must not be damaged and valve seats must not be burnt.

5. Inspect valves for concentricity and dimensional accuracy.

[a] If valves are not within acceptable limits of concentricity and dimensional accuracy, replace valves.

[b] If valves are within acceptable limits, continue inspection.

6. Inspect valve seats for minor deviations in concentricity.

[a] If minor deviations in concentricity are found, regrind valve sealing area on a valve grinding machine or replace valve as necessary.

[b] If no minor deviations in concentricity are found, continue inspection.

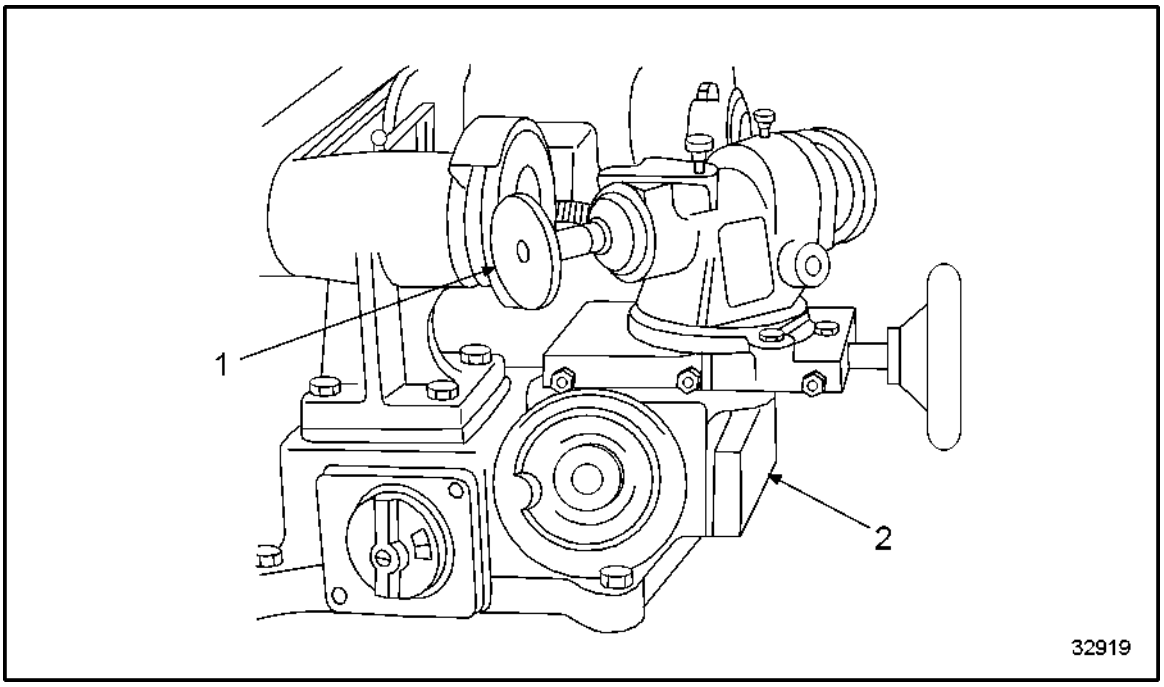
NOTE:
Do not straighten valves.

Regrinding Valve Sealing Area

Perform the following steps to regrind valve sealing area:

NOTE:
Do not remove more material than is absolutely necessary to achieve perfect valve sealing.

1. Clamp valve (1) in valve grinding machine (2) as close as possible behind the valve head (to prevent vibrations). See Figure 363.

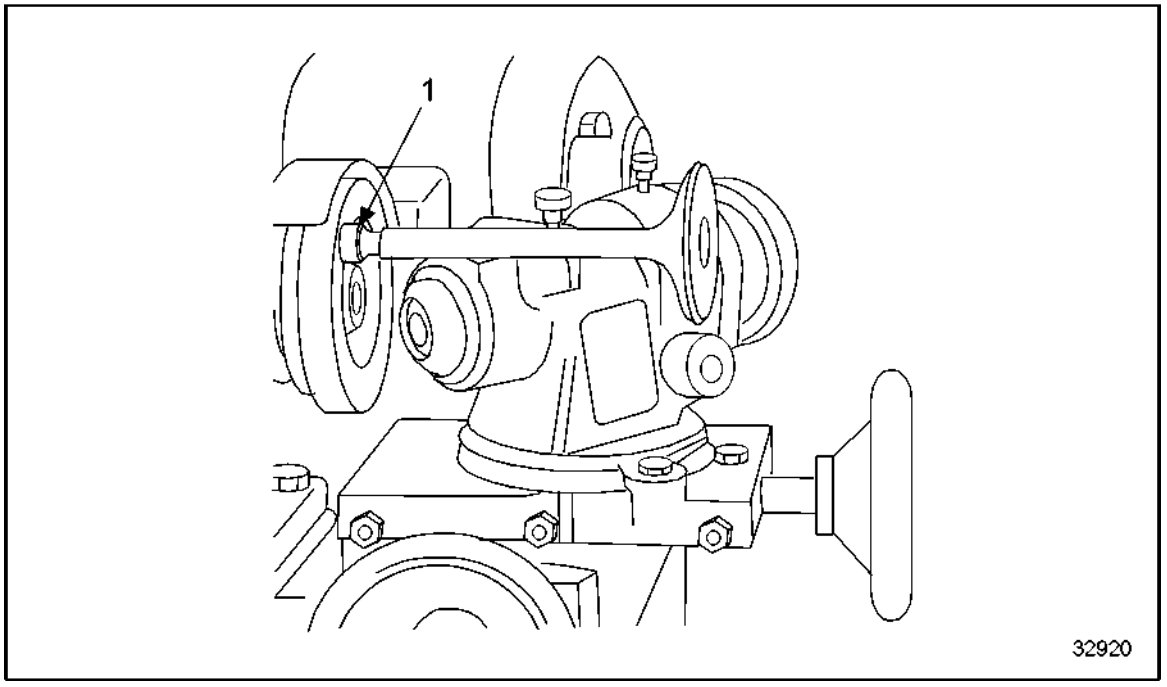


1. Valve
2. Valve Grinding Machine

Figure 363 Regrinding Valve Sealing Area

2. Set valve grinding angle on valve grinding machine.
3. Grind valve with slight advance until valve is smooth and free from chatter marks over the entire circumference.
4. Measure height of external edge on valve and valve sealing width.
   [a] If limit values are exceeded, replace valve.
   [b] If limit values are not exceeded, continue inspection.

5. If necessary, recondition valve stem end (1) on device provided on valve grinding machine. See Figure 364.



1. Valve Stem End

Figure 364 Reconditioning Valve Stem End

6. Measure valve length.
   [a] If limit values are not achieved, replace valve as necessary.
   [b] If limit values are achieved, continue inspection.
7. Using the surface crack-testing method with fluorescent penetrant dye, check valves for cracks.
   [a] If cracks are found, replace valves as necessary.
   [b] If no cracks are found, continue inspection.

Inspecting Valve Springs

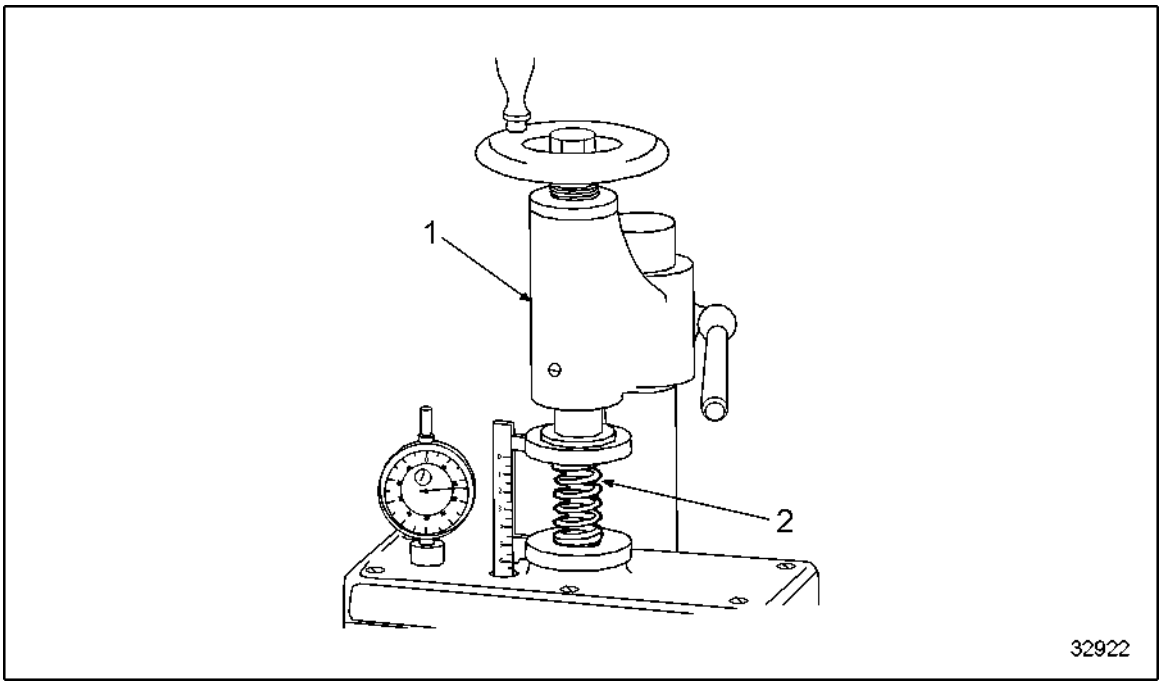
Perform the following steps to inspect the valve springs:

1. Visually inspect valve springs for surface cracks or broken coils.
   [a] If surface cracks or broken coils are found, replace valve springs as necessary.
   [b] If no surface cracks or broken coils are found, continue inspection.
2. Visually inspect valve springs for indentations, flatness, burring and deformation.

[a] If indentations, flatness, burring or deformation is found, replace valve springs as necessary.

[b] If no indentations, flatness, burring or deformation is found, continue inspection.

3. Inspect valve spring (2) with valve spring test device (1). See Figure 365.



1. Valve Spring Test Device
2. Valve Spring

Figure 365 Inspecting Valve Springs

4. Measure valve springs.

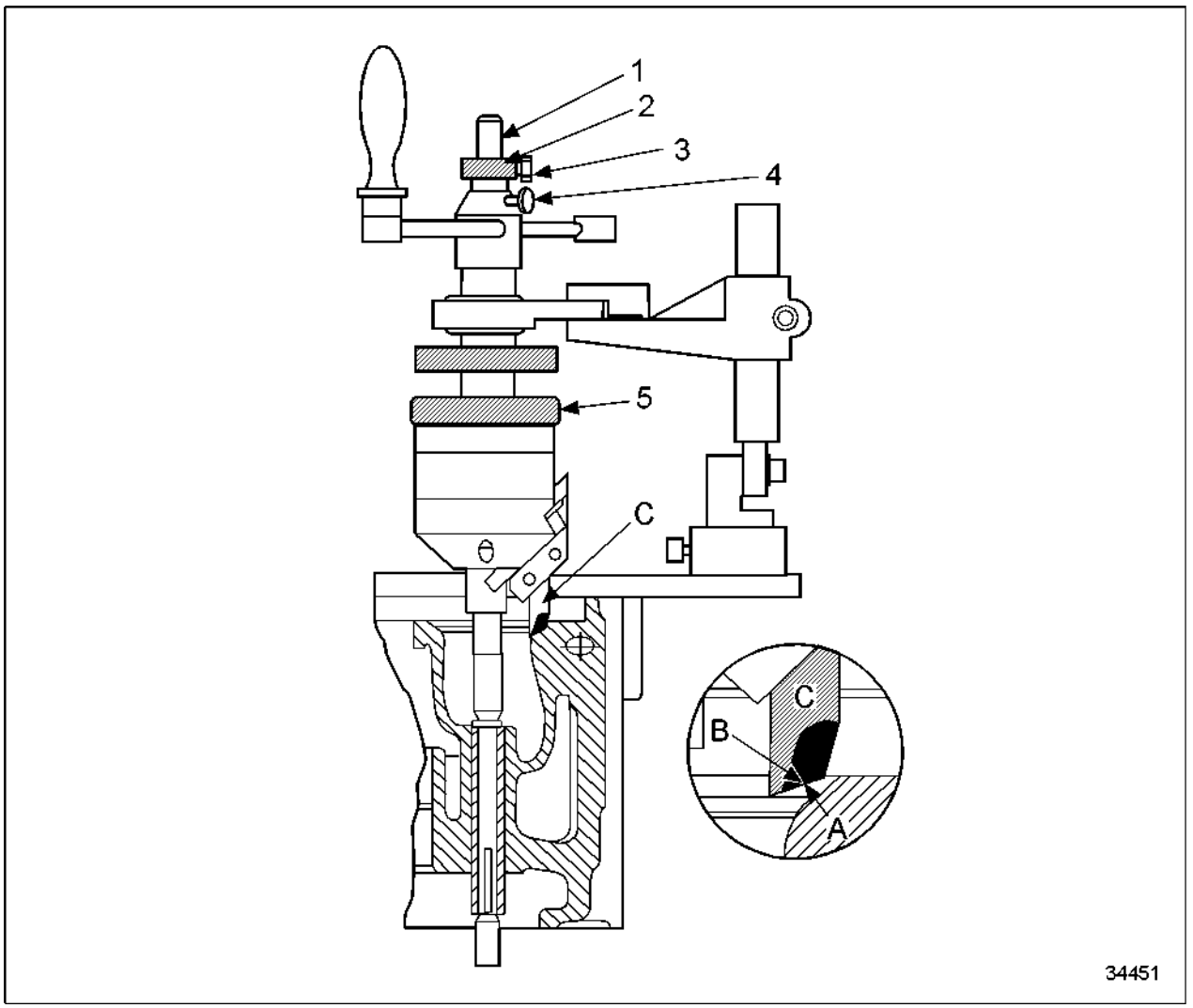
[a] If limit values are exceeded, replace valve spring as necessary.

[b] If limit values are not exceeded, continue inspection.

Externally Correcting Valve Seat

Perform the following steps to the externally correcting valve seat:

1. Raise rotator and release locking bolt (3) of stop pin (1). See Figure 366.



1. Stop Pin
2. Knurled-head Bolt
3. Locking Bolt for Stop Pin
4. Locking Bolt for Knurled-head Bolt
5. Rapid Adjuster

Figure 366 Externally Correcting Valve Seat

2. Turn rapid adjuster (5) to bring trail edge B of turning tool C into contact with the outer edge A of the valve seat. See Figure 366.

NOTE:
Carefully lower rotator onto valve seat edge.

3. Gently press stop pin down against the tap pilot and tighten locking bolt.

4. Loosen locking bolt (4) and turn knurled-head bolt (2) half a gradation counterclockwise. See Figure 366.
5. Retighten locking bolt (4).
6. Hold crank arm in one hand, and opposite side of crank arm in other hand; turn rotator in stages around tap pilot.
7. Press rotator slightly downwards until the outer edge A (of the valve seat) is cut to the set depth.
8. Repeat machining procedure until the required valve seat width is achieved.

Inspecting Cylinder Head for Leaks

Perform the following steps to inspect the cylinder head for leaks:

1. Carefully clean cylinder head after machining.

NOTE:
The injector sleeve must be installed in order to test the cooling system for leaks. The coolant must be treated with corrosion inhibitor for pressure testing.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

2. Place cylinder head in an 80°C (176°F) hot water bath until cylinder head has warmed.

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.

3. Install pressure-testing equipment.
4. Pressure-test cylinder head with 0.5 bar (7.2518 psi) compressed air.
5. Cylinder head must remain under pressure for at least 30 minutes, during which no air bubbles must appear.
6. Remove pressure test tool.
7. Replace cap plug if leaking.

NOTE:
The water for pressure testing must be treated with anti-corrosive agent.

C 041.05.10 – ASSEMBLY OF CYLINDER HEAD

Perform the following subsections to assemble the cylinder head:

Installing Bridge Pin

CAUTION:
To avoid personal injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

CAUTION:
To avoid injury, wear protective clothing and eye protection.

Perform the following operations to assemble the bridge pin:

1. Place bridge pins into dry ice or liquid nitrogen to freeze parts.

NOTICE
Ensure to install bridge pins to specification. Improperly seated pins will cause cylinder head damage.

2. Place pin into cylinder head bore and install using pin driving tool.

NOTE:
Walking the pin may be required along with a couple of hits. Count the number of hits. Replace pin(s) requiring excessive hits and remeasure bore. Tolerance is 13.984 – 14.00 mm (0.550 – 0.551).

Installing Valve Guides

Perform the following steps to install valve guides:

NOTE:
The water for pressure testing must be treated with anti-corrosive agent.

CAUTION:

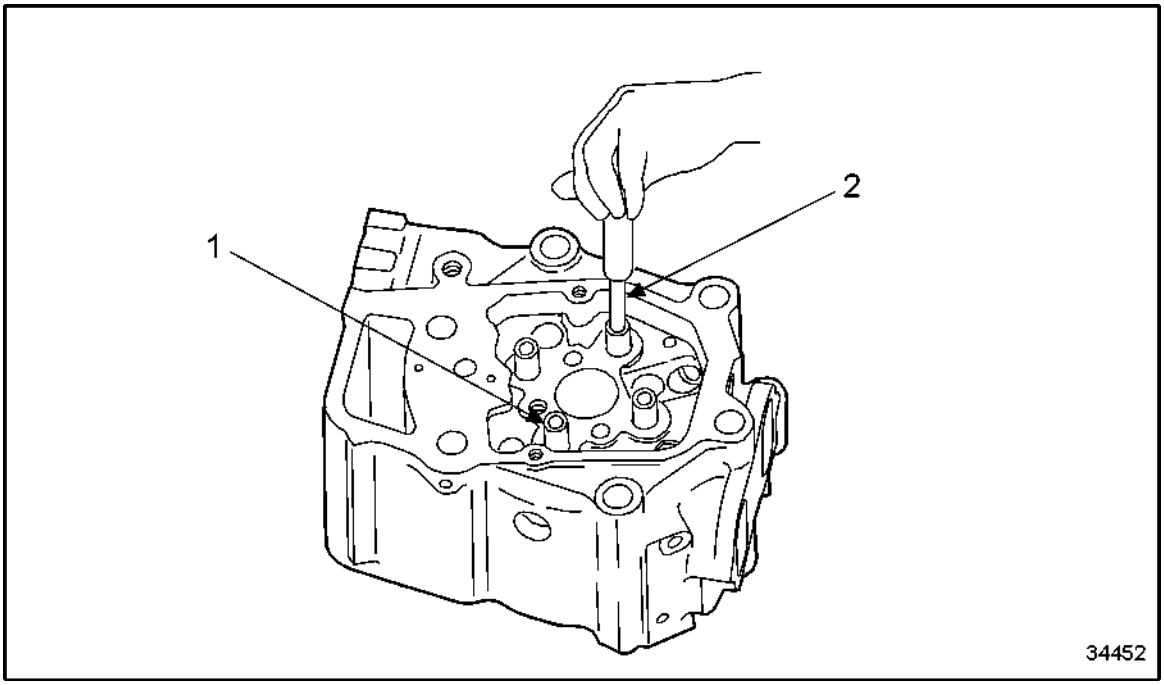
To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

1. Place cylinder head in an 80°C (176°F) hot water bath until cylinder head has warmed.

CAUTION:

To avoid personal injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts will occur.

2. Cool valve guides (1) with liquid nitrogen. See Figure 367.



1. Valve Guide
2. Brass Drift

Figure 367 Installing Valve Guides

3. Mount warmed-up cylinder head on assembly device.
4. Using brass drift, press chilled valve guides into bore in cylinder head until guide is seated on assembly plate.

5. Measure distance between compression surface and valve guide. See Figure 368.

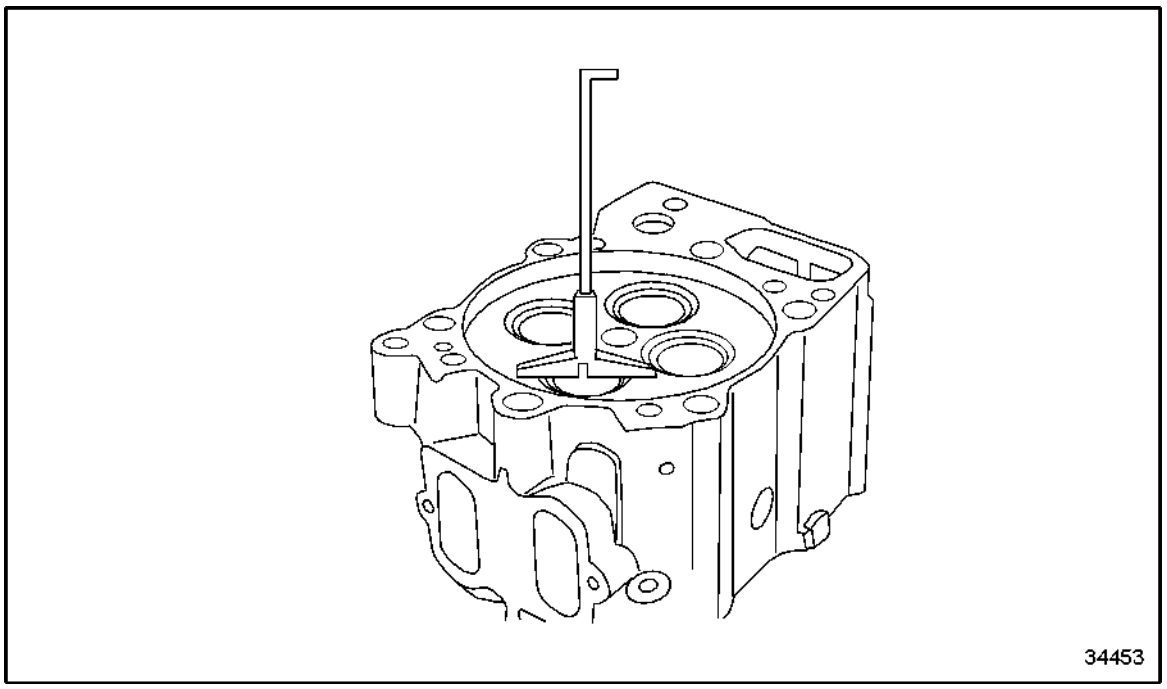
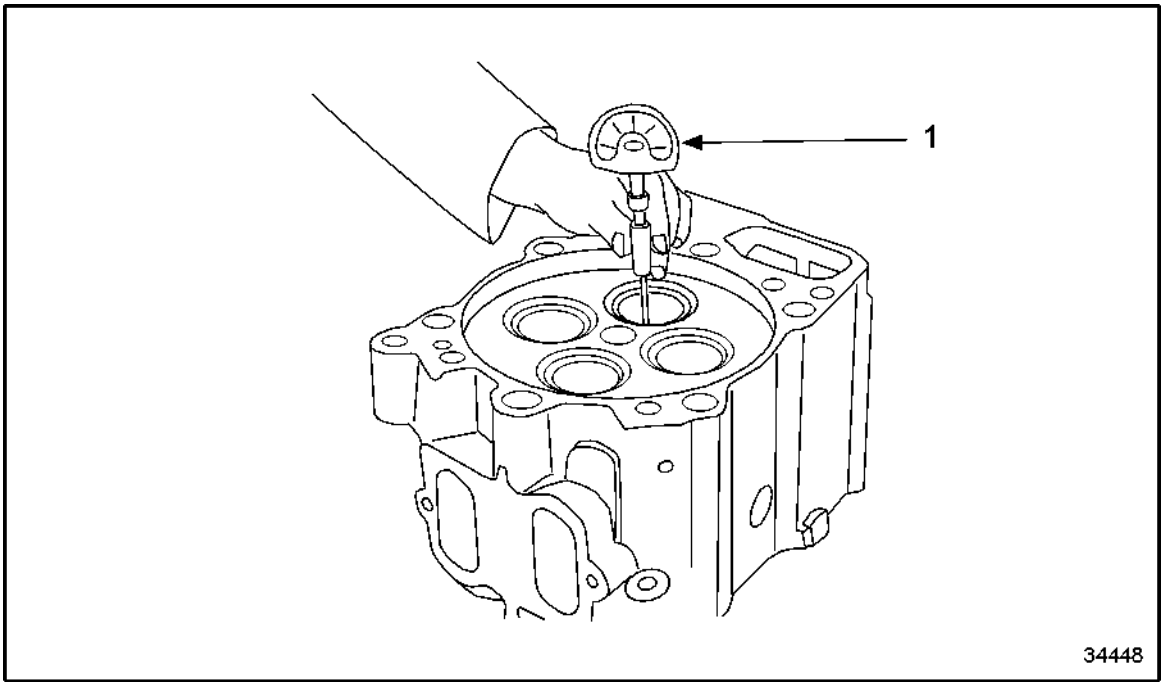


Figure 368 Measuring Distance between Compression Surface and Valve Guide

6. Replace valve guide if necessary.
7. Check inner diameter of valve guide with bore gage. See Figure 369.



1. Plug Gage, Design A

Figure 369 Checking Valve Guide Inner Diameter

[a] If diameter is outside limits, replace valve guide.

[b] If diameter is not outside limits, continue to next step.

NOTE:
Instead of bore gage, a plug gage (version A) may also be used. Nominal diameter of plug gage: 11.009 ± 0.009. Length of go-end: 103 mm (4.0551 in.). Go-end plug gage must move easily through the whole valve guide. No-go-side plug gage must not rub.

Installing Cap Plug

Perform the following steps to install cap plug:

1. Clean and degrease sealing surface on new cap plug and cylinder head bore.
2. Coat sealing surface of cylinder head bore with thread-locking agent.
3. Using a brass drift, insert cap plug flush with bore in cylinder head. See Figure 370.

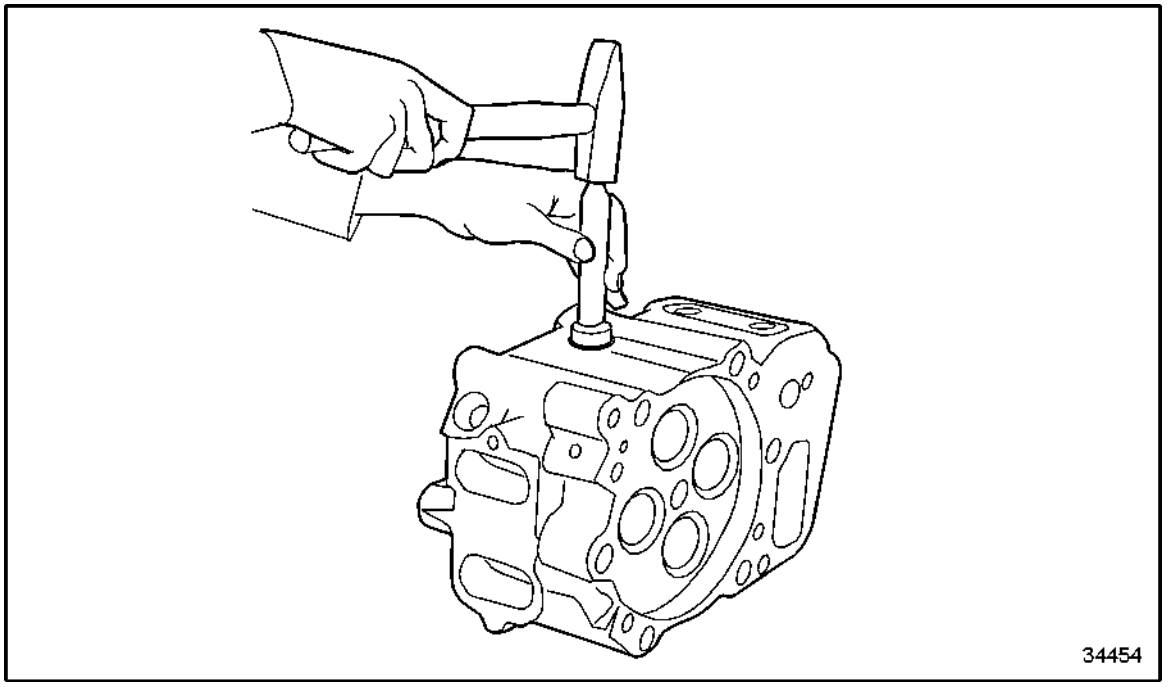


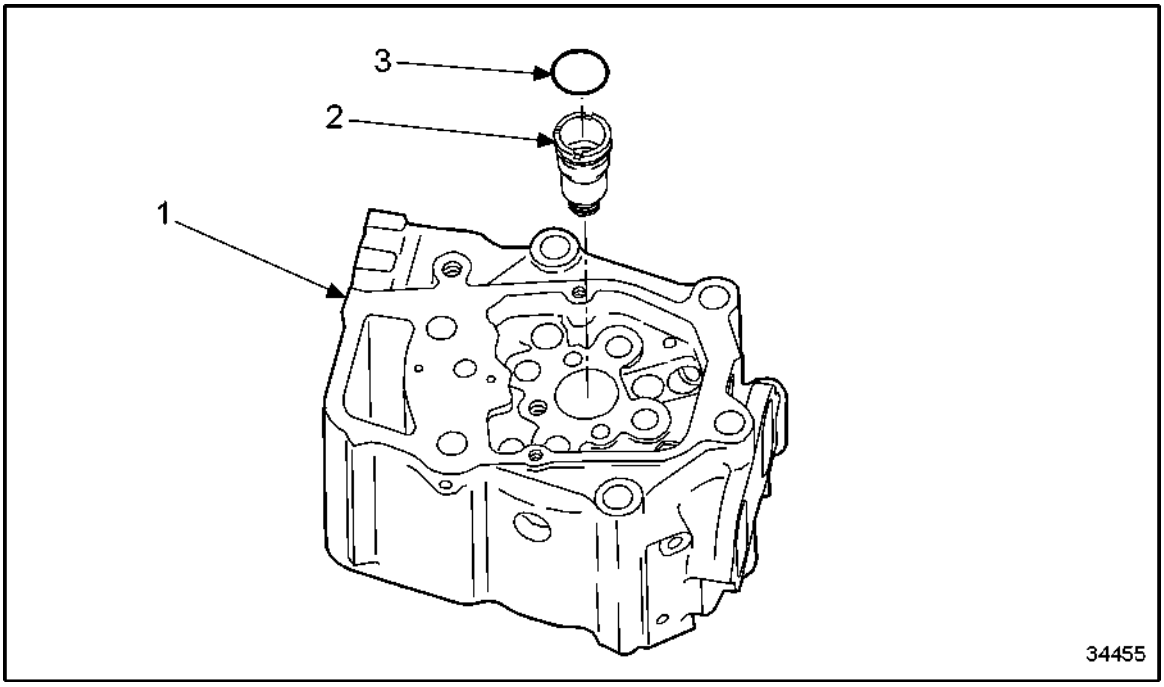
Figure 370 Installing Cap Plug

NOTE:
Ensure correct final strength of thread-locking agent. Refer to section A 003.

Installing Injector Sleeves

Perform the following steps to install the injector sleeves:

1. Clean sealing surface of injector sleeve. See Figure 371.

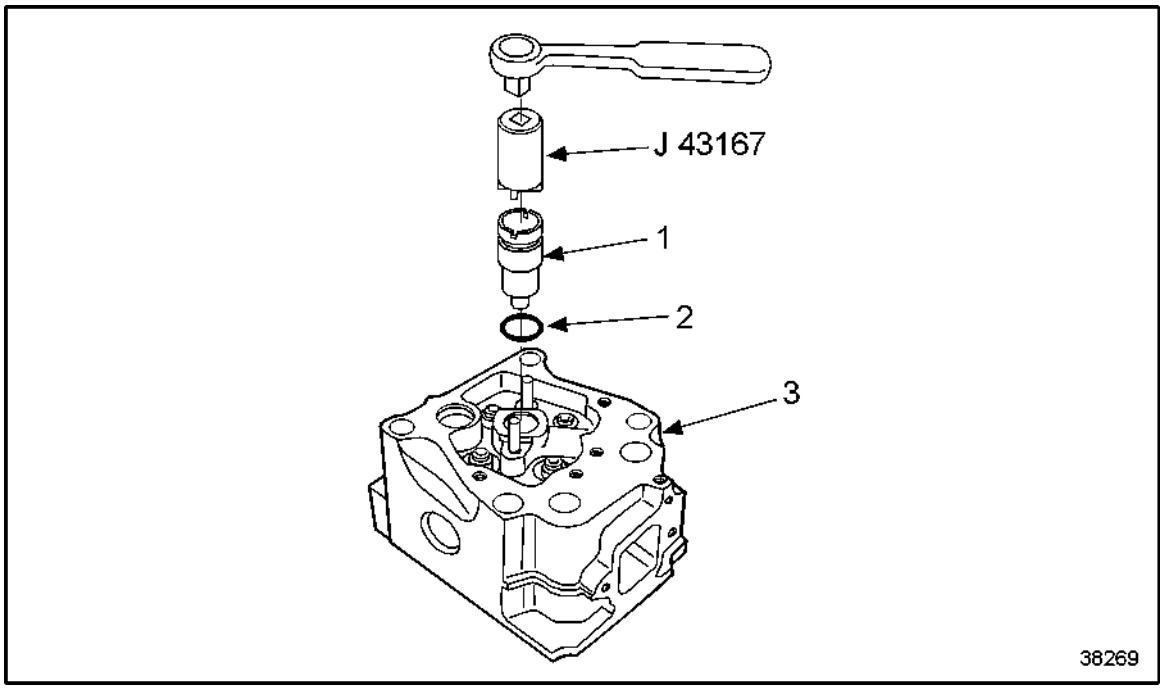


1. Cylinder Head
2. Injector Sleeve
3. O-ring

Figure 371 Installing Injector Sleeves

2. Coat O-ring (3) with petroleum jelly and insert into the injector sleeve bore. See Figure 371.
3. Clamp cylinder head on the assembly plate.

4. Clean sealing surface of cylinder head.
5. Using socket wrench, tighten injector sleeve to specification. Refer to section A 003.See Figure 372.



1. Sleeve
2. O-ring
3. Cylinder Head

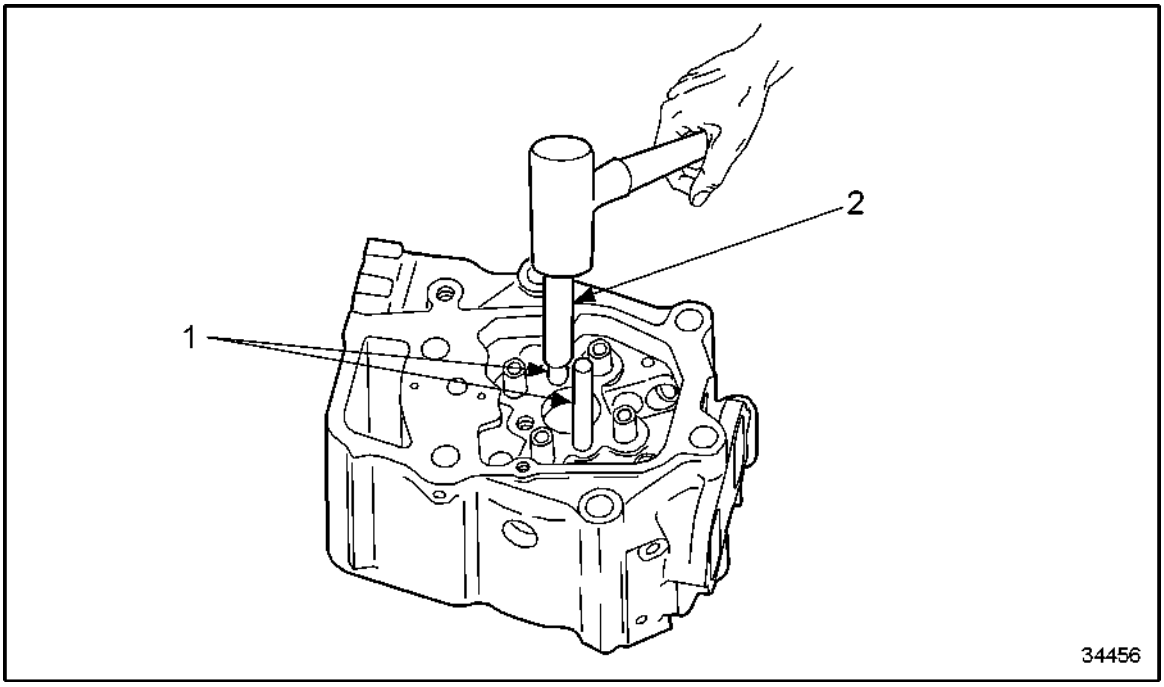
Figure 372 Tightening Injector Sleeve

NOTE:
Ensure that socket is correctly engaged in sleeve groove.

Installing Bridge Guide

Perform the following steps to install bridge guide:

1. Clean and degrease support bores on cylinder head and surface of bridge guide.
2. Insert bridge guide into insertion brass drift. See Figure 373.

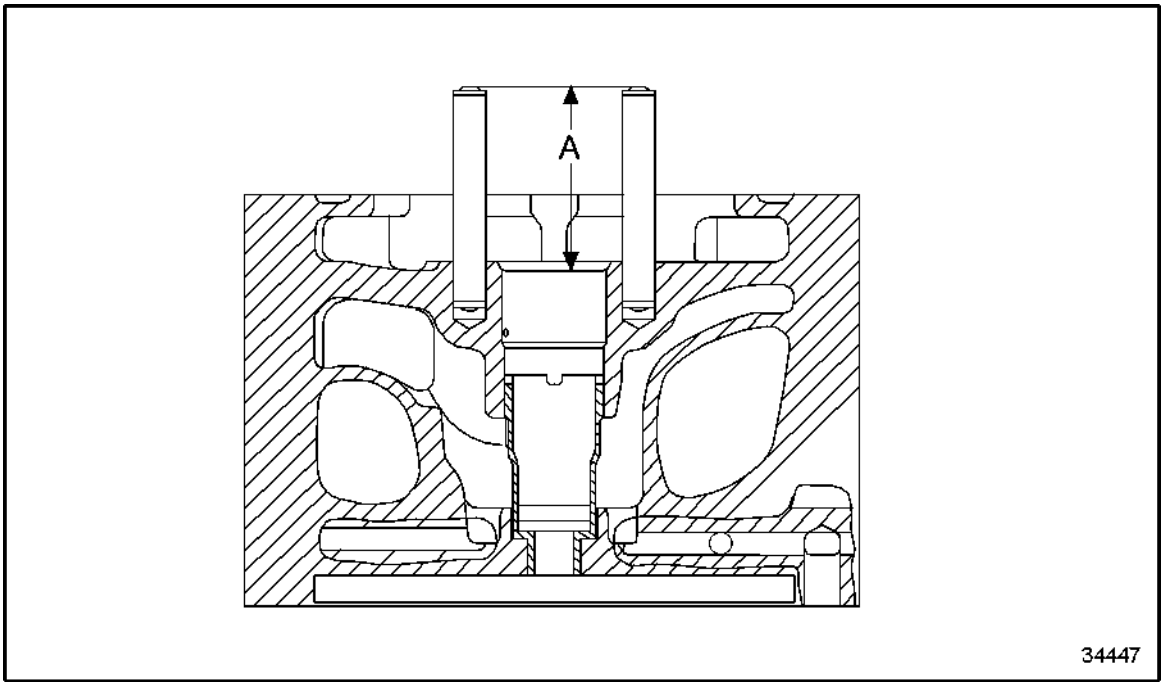


1. Bridge Guides
2. Insertion Brass Drift

Figure 373 Installing Bridge Guide

3. Position bridge guide (1) with fitted insertion brass drift (2) as vertically as possible on support bore.
4. Drive bridge guide into support bore by gently tapping assembly brass drift with hammer until assembly brass drift is resting on cylinder head.

5. Remove assembly brass drift.
6. Measure protrusion A of bridge guide. See Figure 374.



A = 78 mm (0.031 in.) ± 0.5 mm (0.0197 in.)

Figure 374 Measuring Protrusion of Bridge Guide

Installing Valves

Perform the following steps to install the valves:

NOTE:
Ensure parts are perfectly clean.

1. Lay cylinder head on its side. See Figure 375.

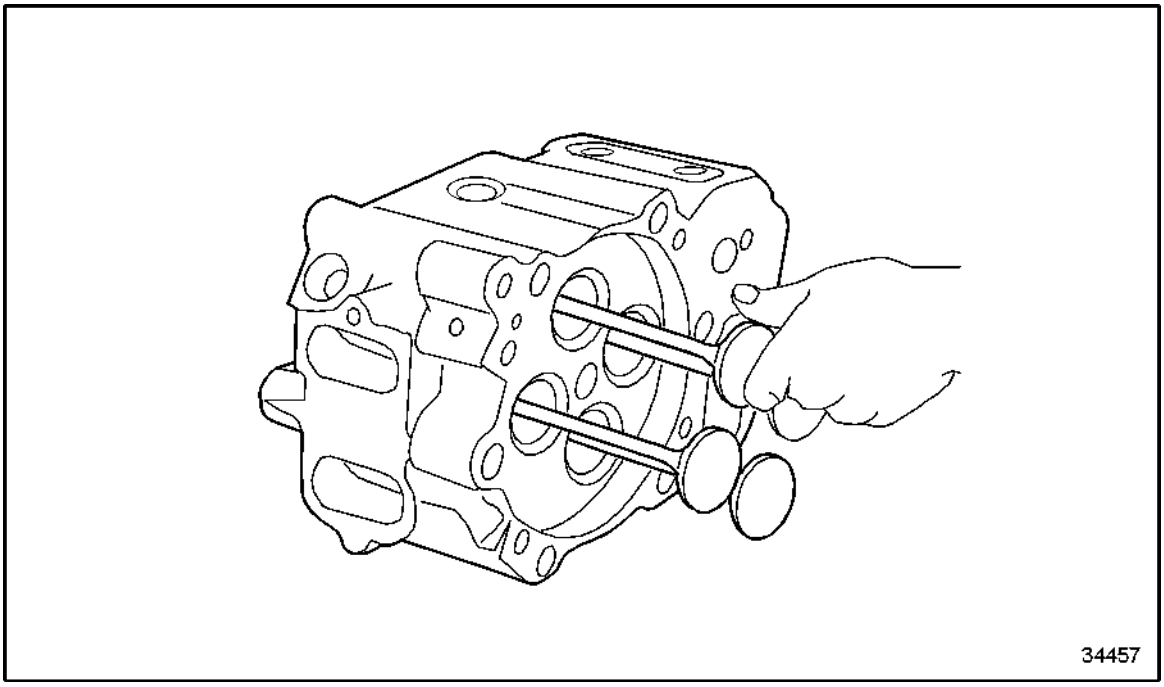
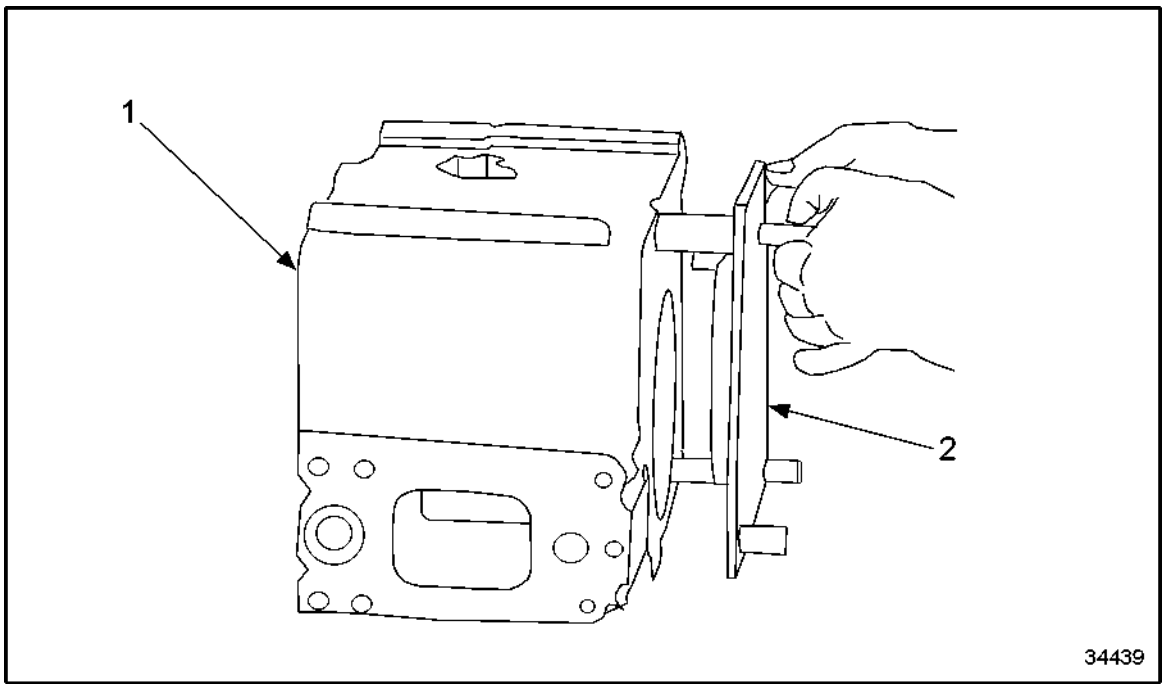


Figure 375 Installing Valves into Valve Guides

2. Clean valves and coat valve stems with engine oil.
3. Install valves into valve guides.
4. Ensure that valves are correctly installed (inlet/exhaust).

NOTE:
Valve markings at stem end: “IN” = inlet and “EX” = exhaust. Exhaust valves are nonmagnetic. Valve heads and stems are magnetic.

5. Position base plate (2) of the valve spring tensioner on cylinder head (1). See Figure 376.

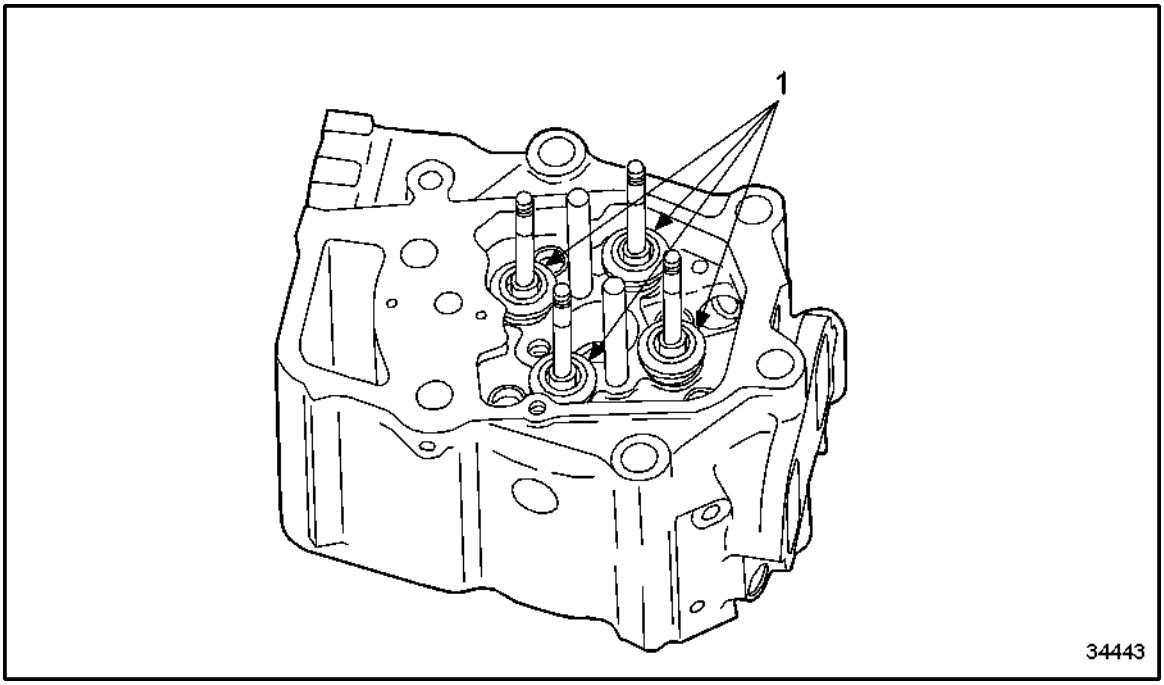


1. Cylinder Head
2. Base Plate

Figure 376 Positioning Cylinder Head on Base Plate

6. Align cylinder head on the guide pins so that valve heads lie beside the plastic plate. See Figure 376.

7. Install valve rotators on valve guides. See Figure 377.



1. Valve Rotators

Figure 377 Installing Valve Rotators on Valve Guides

8. Visually inspect valve rotators for damage or wear at spring seat or in valve guide bore.
   [a] If valve rotators show wear or damage, repair or replace as necessary.
   [b] If valve rotators do not show damage or wear, continue inspection.
9. Place valve rotators between fingers of both hands and with light pressure, rotate valve rotator.
   [a] If there is any resistance or valve rotator stops, replace component.
   [b] If there is no resistance and valve rotator does not stop, continue inspection.
10. Install outer and inner valve springs.

NOTE:
Valve springs have no "Top/Bottom" marking. Installation position does not matter.

11. Install valve spring retainers.
12. Install pressure plate on valve spring retainer and bolt to base plate.
13. Install manual spindle in valve spring tensioner.

CAUTION:

To avoid personal injury when using a valve spring compressor, wear adequate eye protection (safety glasses or faceplate).

14. By turning manual spindle (direction of arrow), press pressure plate onto valve springs until spring retainers expose groove on valve stem end. See Figure 378.

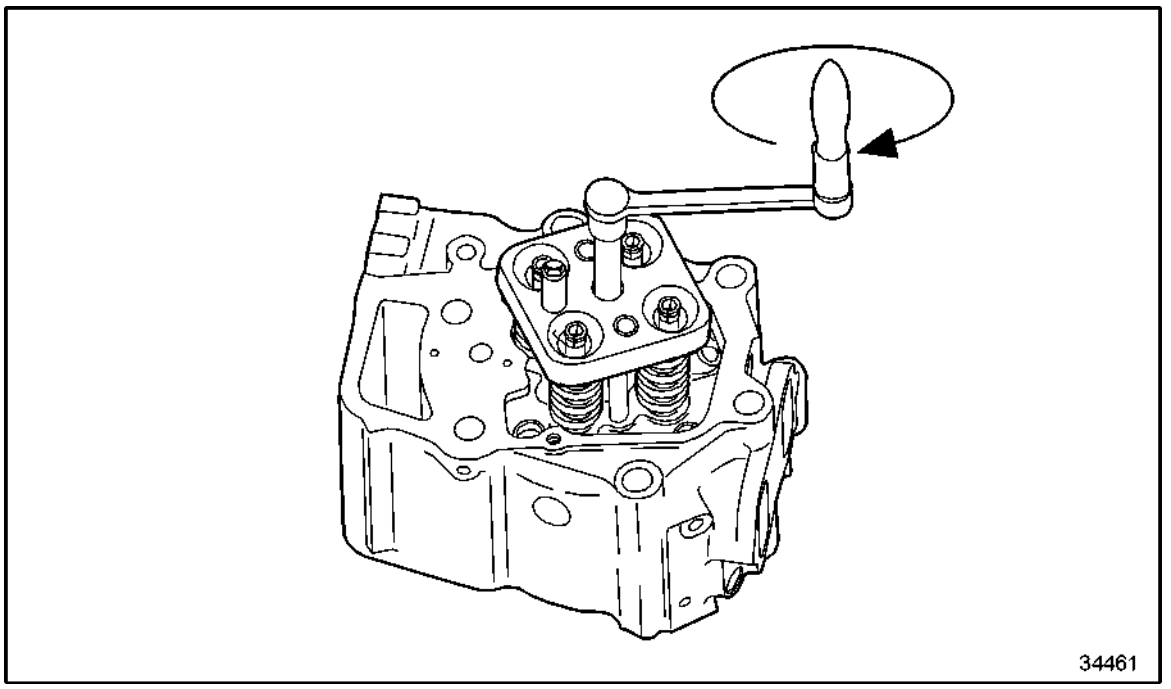


Figure 378 Rotating Hand Spindle of Valve Spring Pretensioner

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

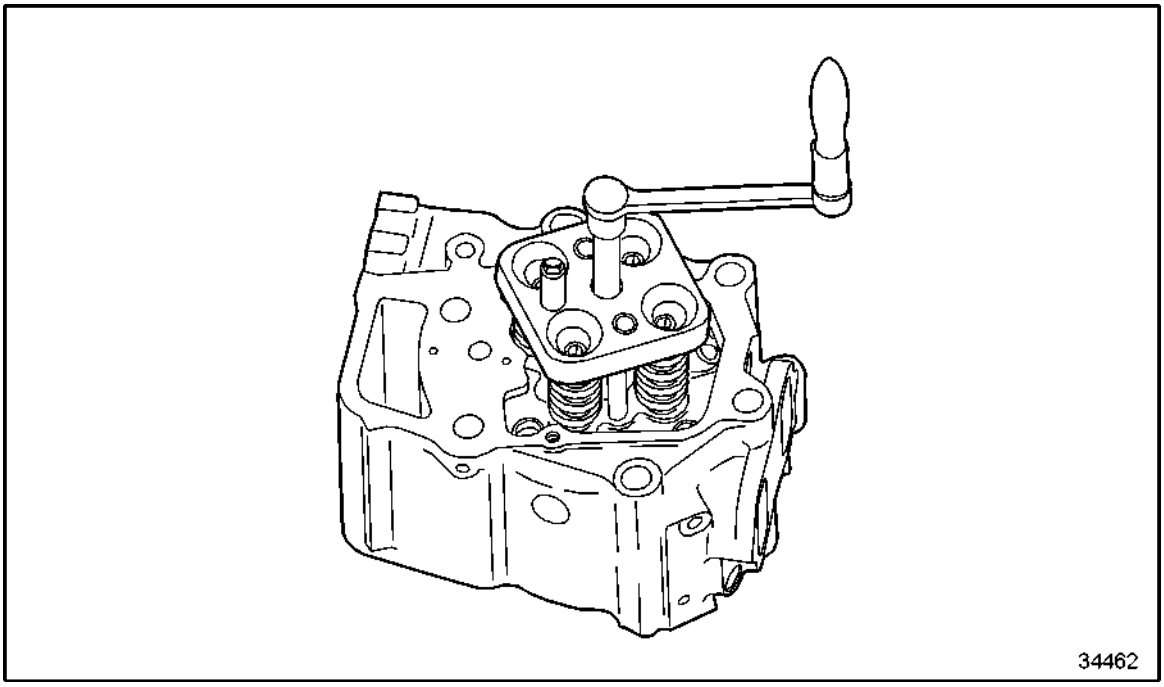


Figure 379 Installing Valve Locks

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.

20. Place cylinder head on suitable base. See Figure 380.

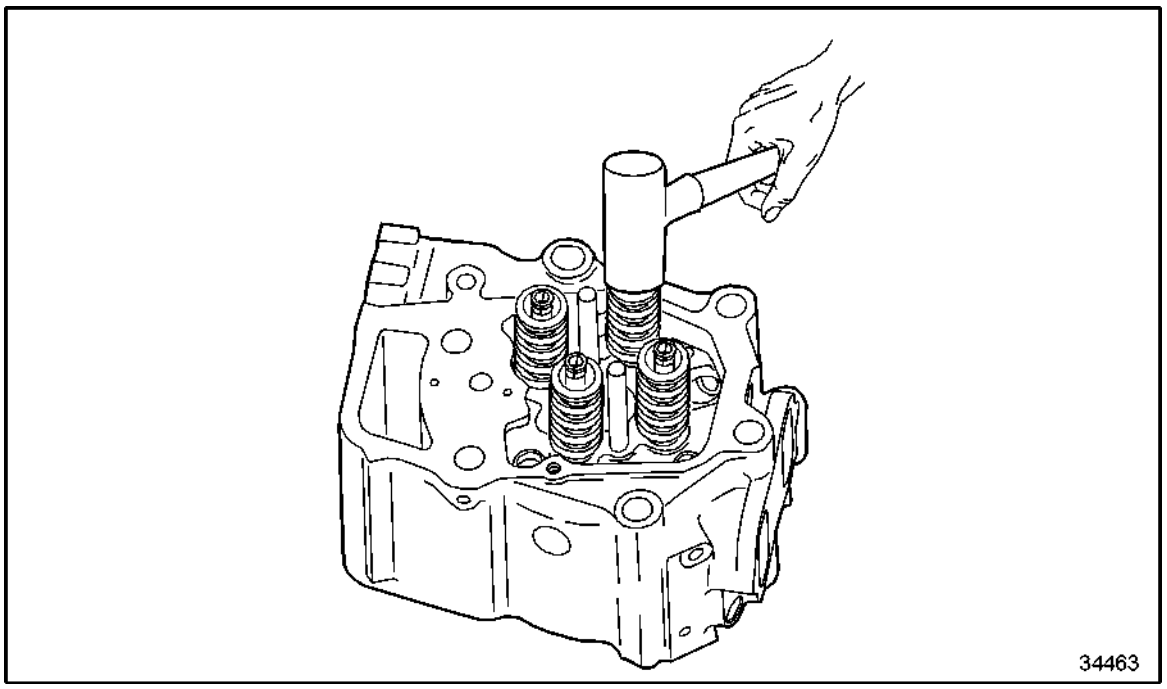


Figure 380 Positioning Valve Locks

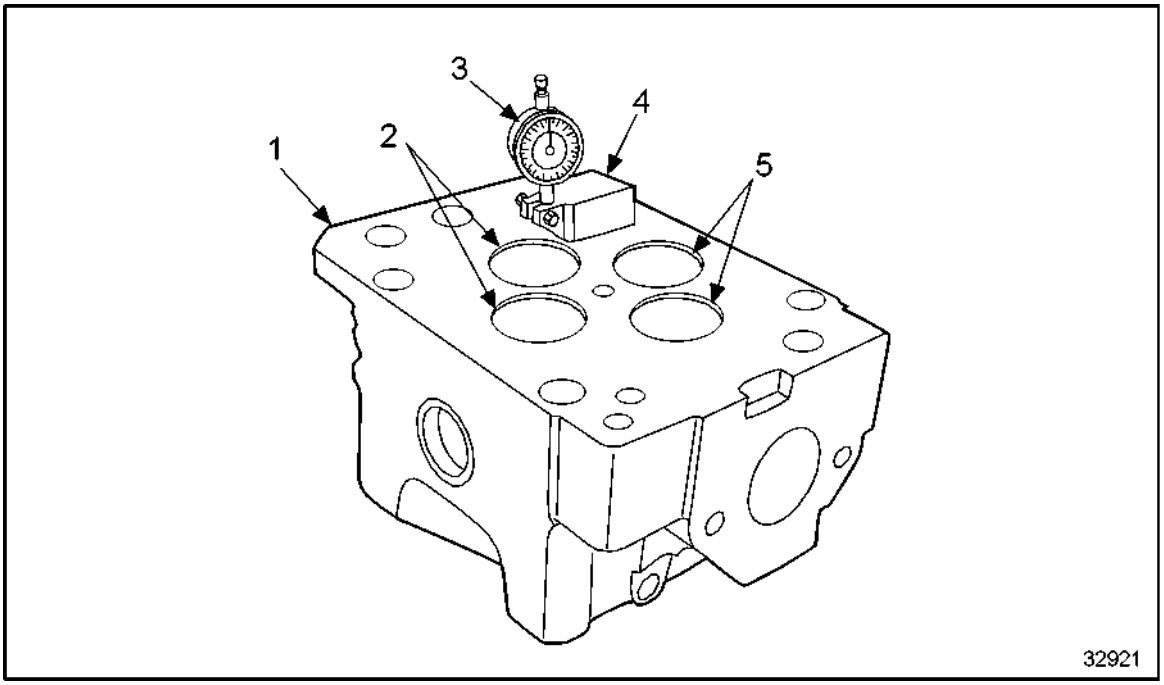
21. Using a plastic mallet, lightly tap valve stem so that valve locks are positioned correctly on valve stem.

NOTE:
Verify that valve locks are in correct position before proceeding. Repeat installation of valve locks on any valve which does not appear to be seated properly using additional new valve locks.

Measuring Valve Clearance to Cylinder Head

Perform the following steps to measure valve clearance to cylinder head:

1. Install dial gage (3) on dial gage sled (4). See Figure 381.



1. Cylinder Head
2. Inlet Valves
3. Dial Gage
4. Dial Gage Sled
5. Exhaust Valves

Figure 381 Measuring Valve Clearance to Cylinder Head

2. Adjust the dial gage with preload on end surface of cylinder head.
3. Set dial gage scale to zero.
4. Position stylus on valve heads of inlet valves (2) and exhaust valves (5) and measure valve clearance. See Figure 381.
   [a] If valve clearances are beyond limits, replace valve heads of inlet valves.
   [b] If valve clearances are not beyond limits, continue to next step.
5. Valve sealing area on cylinder head and valve head must be checked.

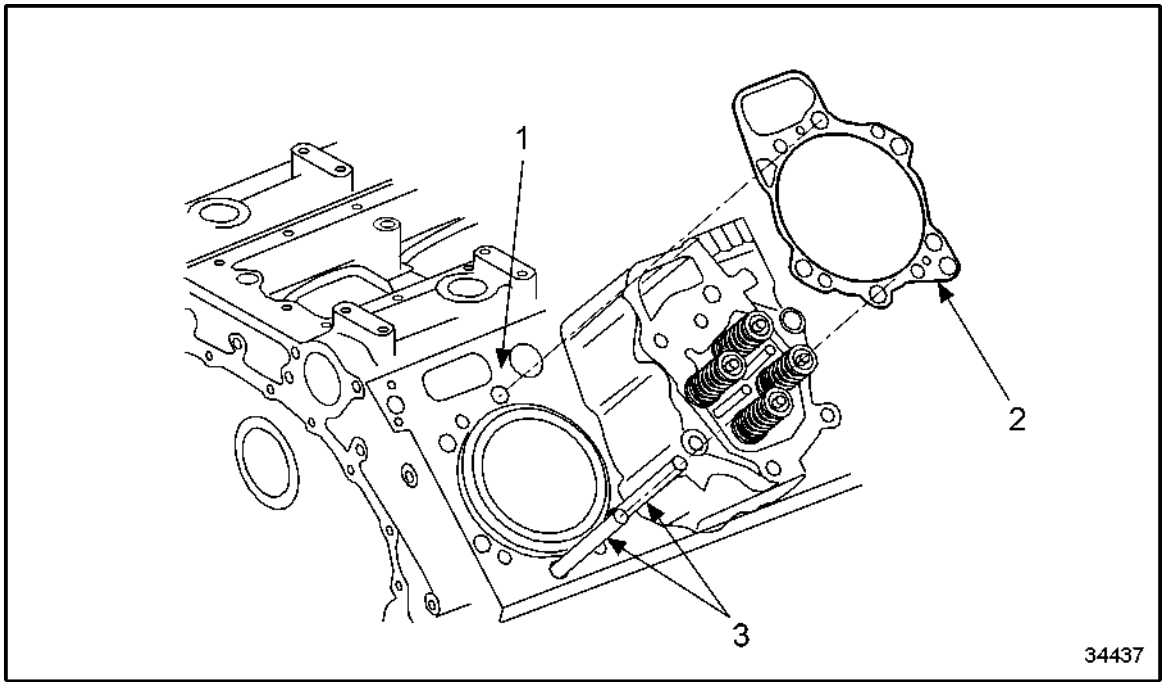
C 041.05.11 – INSTALLATION OF CYLINDER HEAD

Perform the following steps to install the cylinder head:

1. Ensure that cylinder head mating surface and cylinder block are in perfect condition.
2. Clean as necessary.

NOTE:
Always use new cylinder head gaskets.

3. Install cylinder head gaskets (2). See Figure 382.

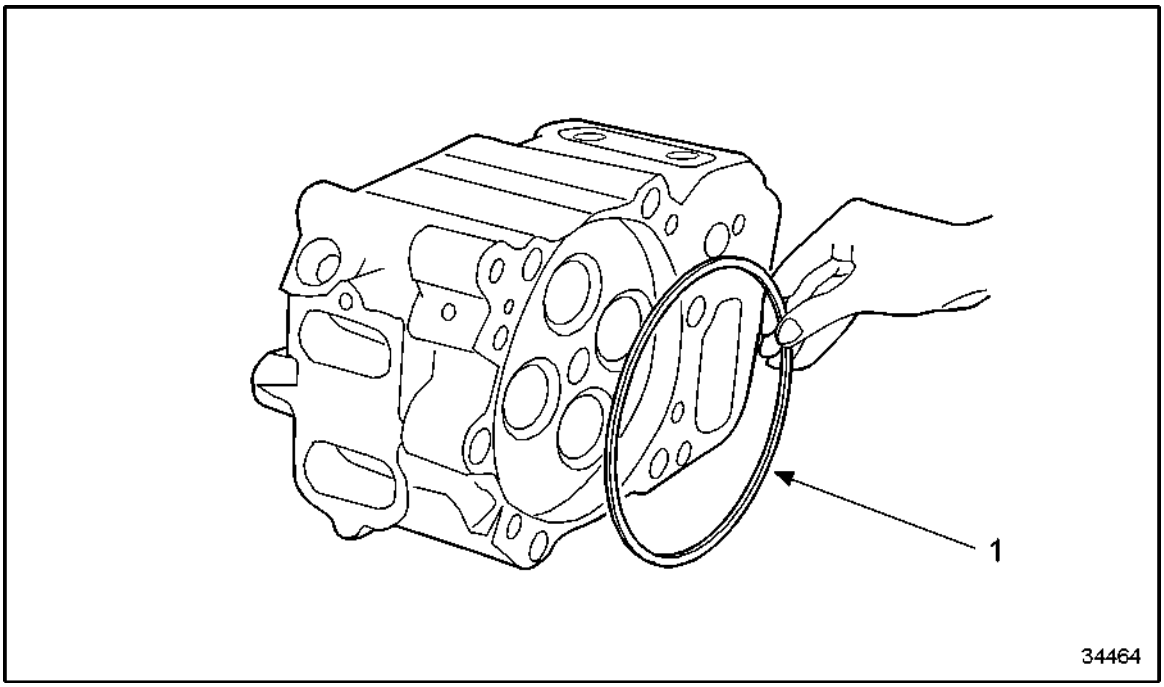


1. Cylinder Block Fire Deck
2. Cylinder Head Gasket
3. Cylinder Head Studs

Figure 382 Installing Cylinder Head Gasket

4. Install guide pin for positioning cylinder head gasket and cylinder head to cylinder block. See Figure 382.

5. Ensure that compression ring will stay in the cylinder head; if not, use tool to compress sealing ring (1) by 0.5 mm (.019685 in.) to form a slightly oval shape. See Figure 383.

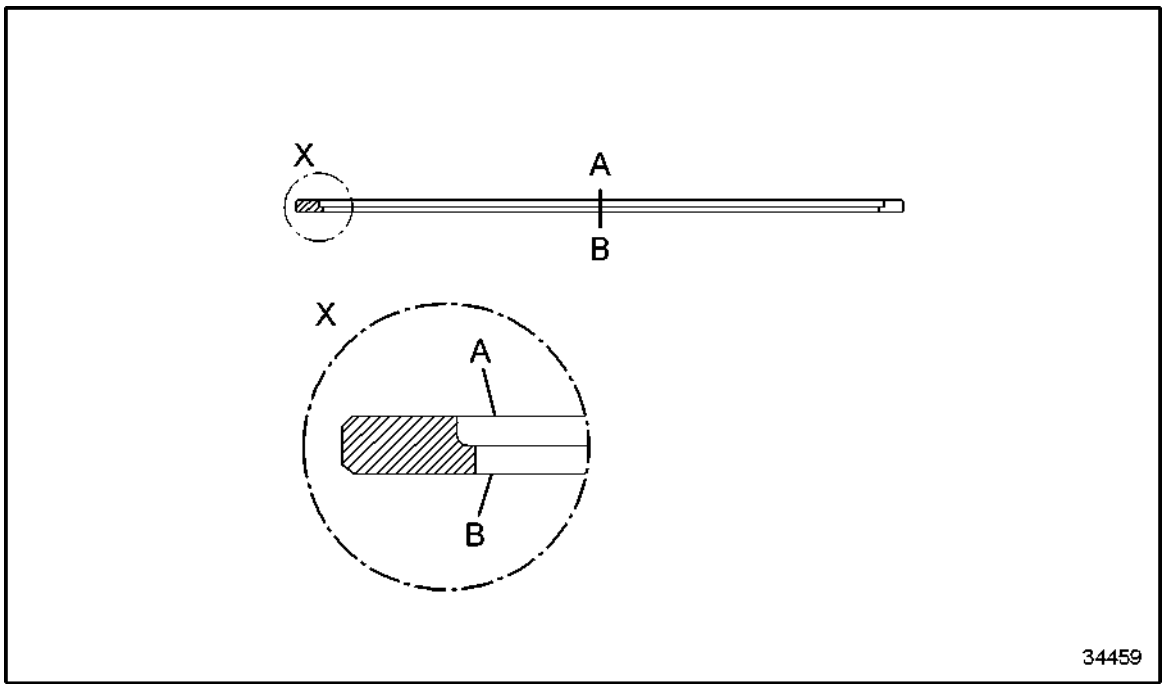


1. Sealing Ring

Figure 383 Installing Sealing Ring

6. Install sealing ring in recess on combustion chamber side of cylinder head. See Figure 383.

7. Ensure that sealing ring is fitted correctly. See Figure 384.



A = Cylinder Head Side

B = Piston Side

Figure 384 Ensuring Sealing Ring Fit

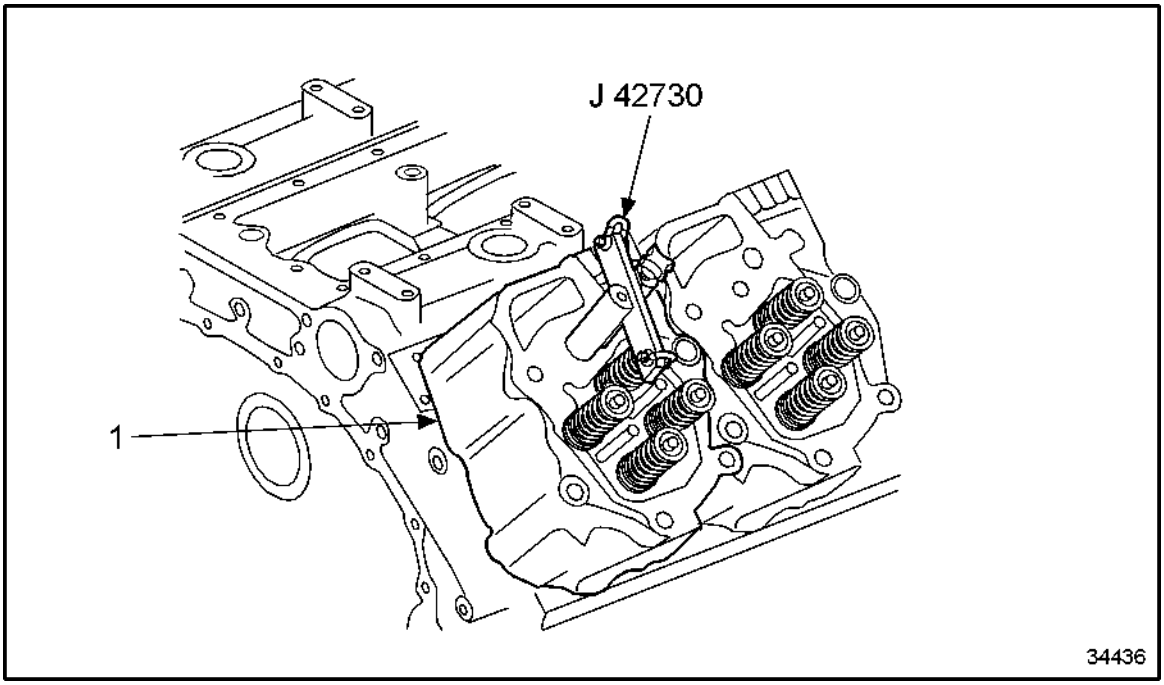
CAUTION:

To avoid a hand injury while handling 'sharp edged' components, wear protective gloves. Handle components only when wearing protective gloves.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

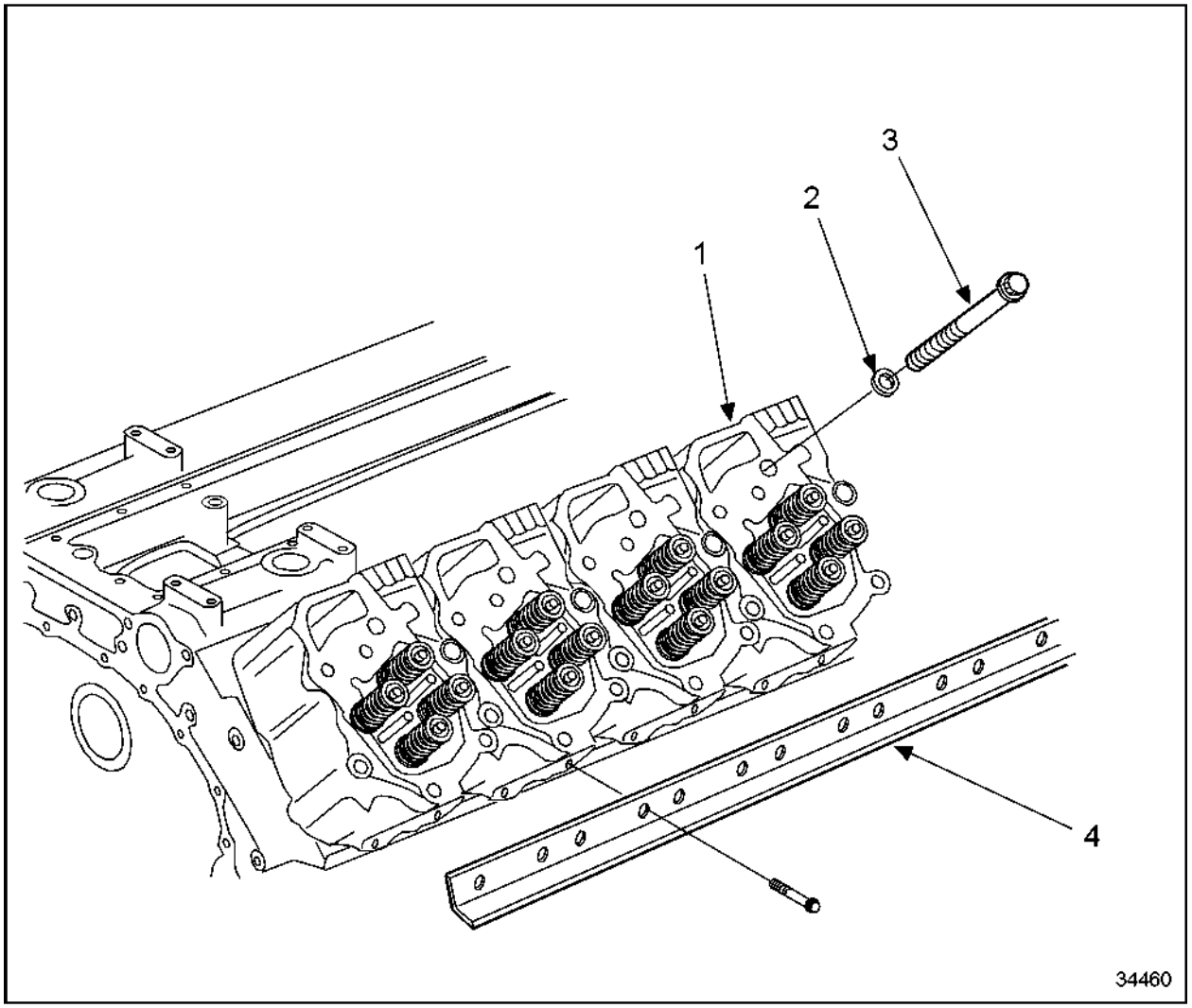
8. Using lifting device and special lifting tool, install cylinder head (1) on cylinder block five deck. See Figure 385.



1. Cylinder Head

Figure 385 Installing Cylinder Head on Cylinder Block

9. Coat cylinder head thread, head (1) and shaft of cylinder head bolts (3) with engine oil. See Figure 386.



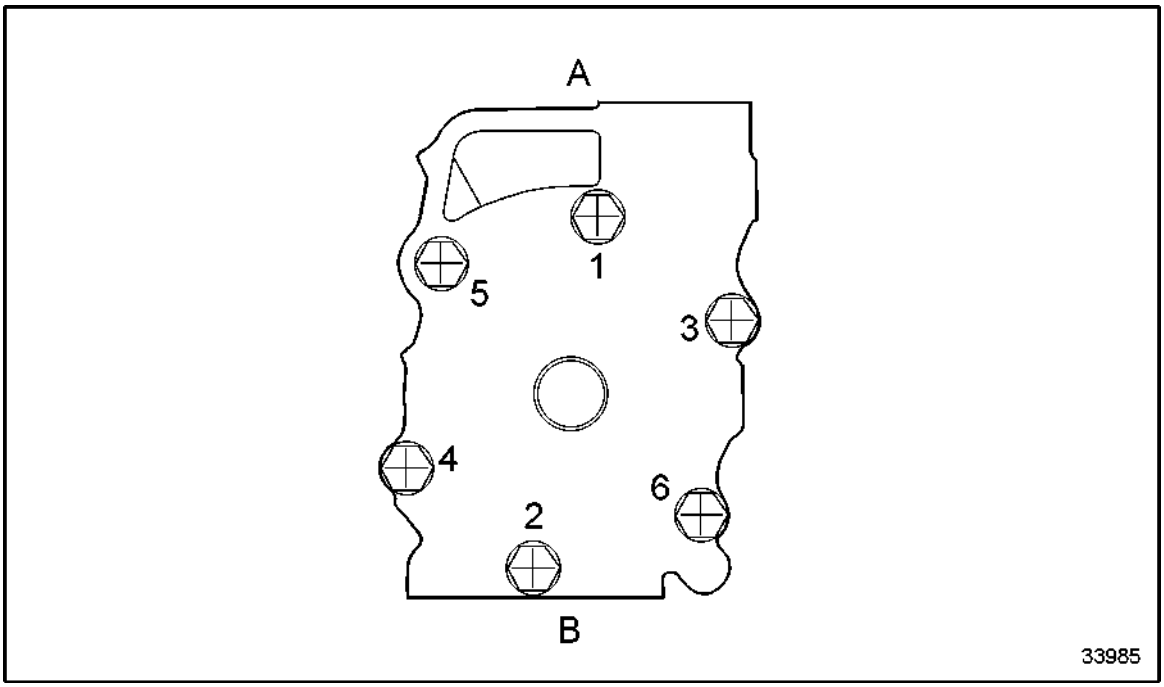
1. Cylinder Head
2. Alignment Tool
3. Cylinder Head Bolt
4. Alignment Tool

Figure 386 Installing Cylinder Head Bolts

10. Install cylinder head bolts (3) with washers manually in cylinder block.
11. Install alignment tool (4) on inlets of cylinder heads and tighten. See Figure 386.

NOTICE:
To avoid deformation or cracks in exhaust and intake manifolds, carry out cylinder head alignment carefully.

12. Use large ratchet and socket wrench to tighten cylinder head bolts to specification. Refer to section A 003. See Figure 387.

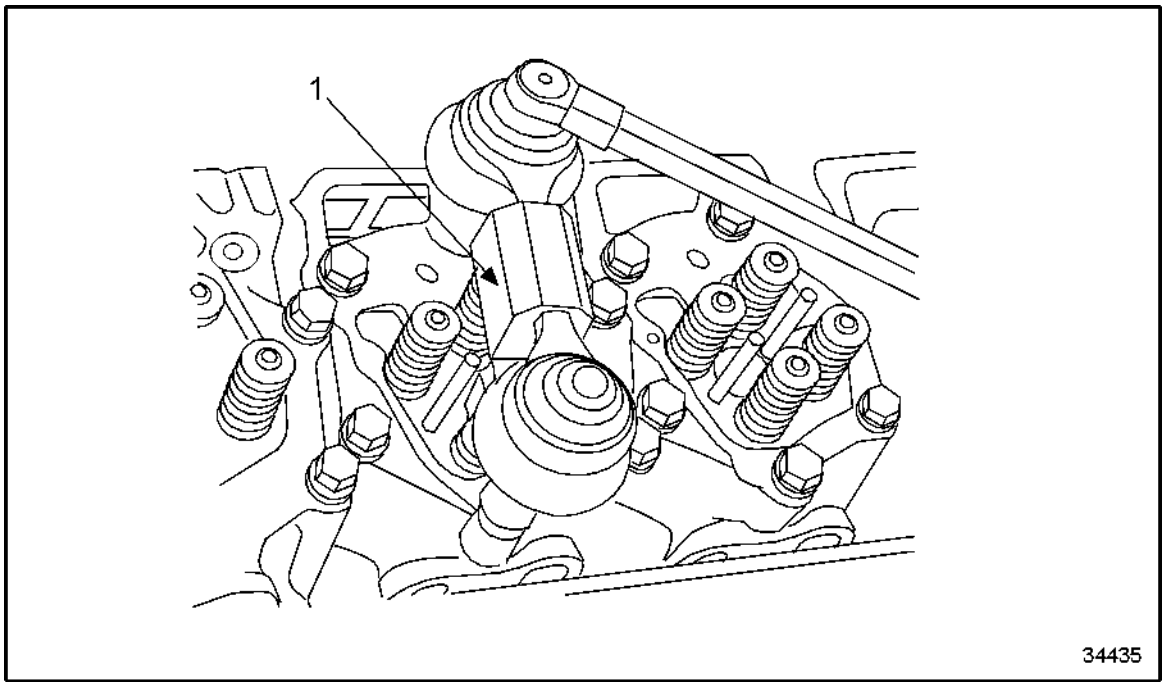


A = Exhaust Side

B = Inlet Side

Figure 387 Cylinder Head Torque Diagram

13. Remove alignment tool (1). See Figure 388.



1. Hydraulic Torque Wrench

Figure 388 Installing Hex Bolts on Cylinder Head

NOTE:
Before tightening cylinder head bolts to additional angle of rotation, apply marks to bolt heads to allow angle of rotation check.

C 041.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 38 are the After-Installation Operations for the cylinder head.

Level of Maintenance	Operation	Reference
1, 2, 3	Install valve bridges	Refer to section C 055.05.11
1, 2, 3	Install swing arm brackets and pushrods	Refer to section C 055.05.11
1, 2, 3	Adjust valve clearance	Refer to section C 055.05.11
1, 2, 3	Install fuel injector	Refer to section C 086.05.11
1, 2, 3	Install high- pressure line between cylinder head and rail	Refer to section C 073.05.11
1, 2, 3	Connect electric cable at injector	Refer to section C 501.05 M
1, 2, 3	Install fuel return lines	Refer to section C 086.05.11
1, 2, 3	Install charge air manifolds	Refer to section C 124.05.11
1, 2, 3	Install exhaust manifold bolts	Refer to section C 015.05.11
1, 2, 3	Install turbocharger	Refer to section C 101.05.11
1, 2, 3	Install exhaust Y-pipe	Refer to section C 141.05.11
1, 2, 3	Install air filter	Refer to section C 221.05.11
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Enable engine power	Refer to Operators Guide
1, 2, 3	Vent fuel system	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.

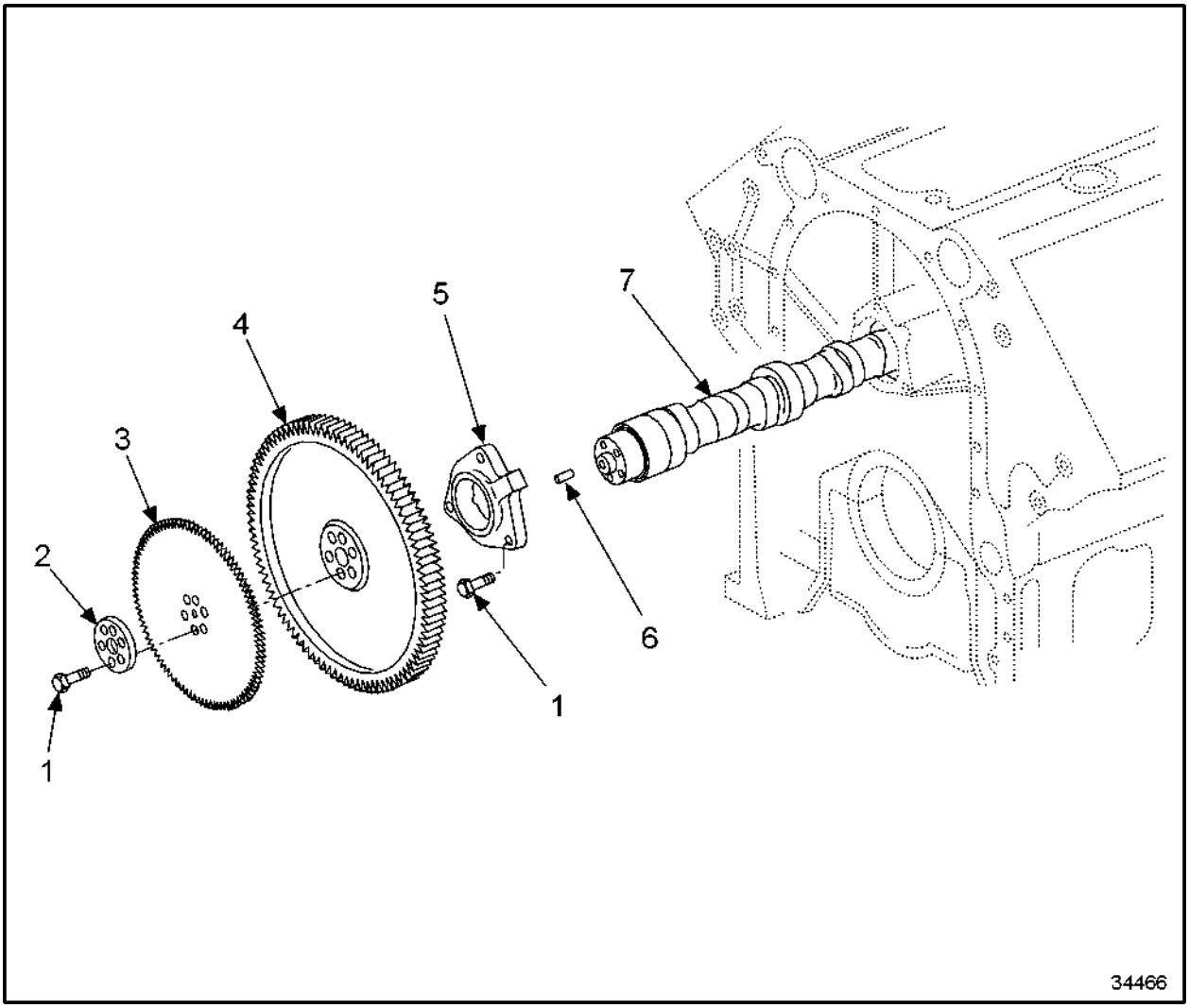
Table 38 After-Installation Operations

C 050 – VALVE OPERATING MECHANISM

C 051.05 – CAMSHAFT

C 051.05.01 – GENERAL VIEW

See Figure 389 for a general view of camshaft components.



1. Hex Bolt
2. Spacer
3. SRS Pulse Wheel
4. Camshaft Gear
5. Thrust Bearing Flange
6. Dowel Pin
7. Camshaft

Figure 389 General View of Camshaft

C 051.05.02 – SPECIAL TOOLS

Listed in Table 39 are the special tools required for maintenance on camshaft.

Designation - Application	Number
Camshaft guide sleeve	—
Camshaft locating device	—
Camshaft installation removal	—
Piston measuring device	—
Index plate with pointer	—

Table 39 Special Tools

C 051.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 40 are the Before-Removal Operations for the camshaft.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Removal of camshaft not scheduled	-

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 40 Before-Removal Operations

C 051.05.05 – REMOVAL OF CAMSHAFT

Removing Camshaft

Perform the following steps to remove camshaft:

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 mark and arrow on flywheel housing are aligned.
2. If rocker arms on cylinder A1 are unloaded, the piston is in firing TDC. See Figure 390.

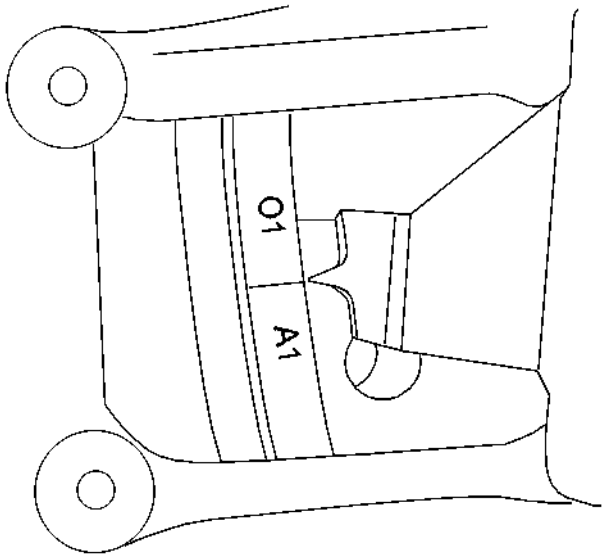
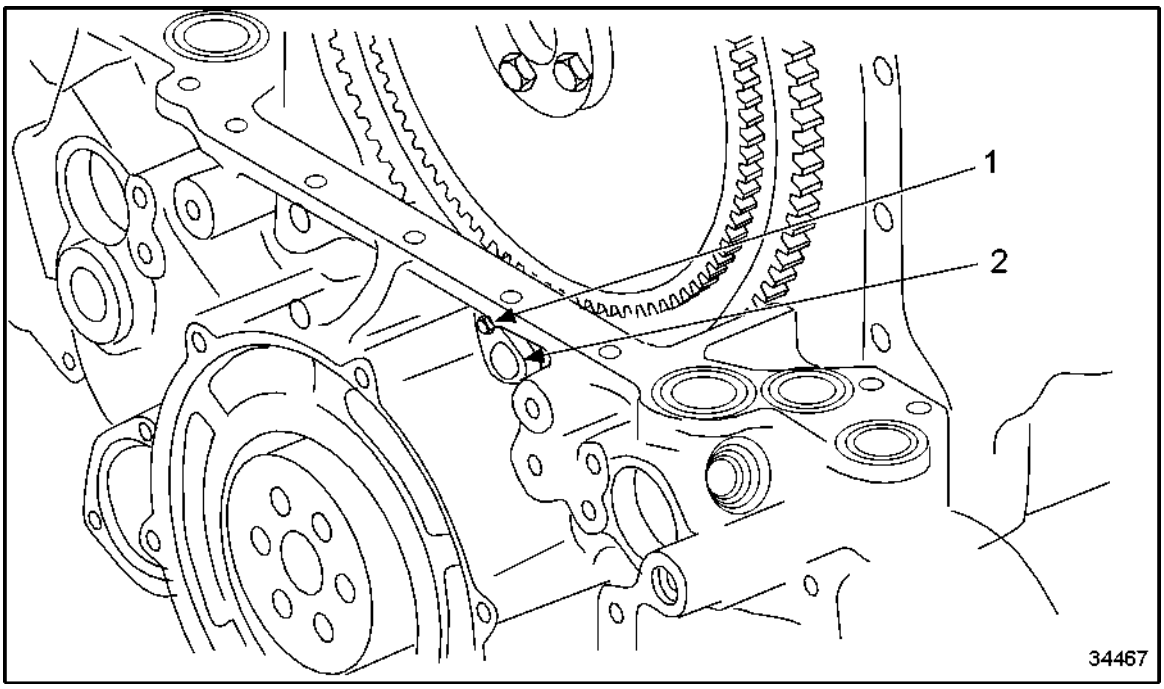


Figure 390 Removing Camshaft (Marine only)

3. If rocker arms on cylinder A1 are loaded, the piston is in overlap TDC.
4. Remove valve drive. Refer to section C 055.05.05.
5. Determine TDC on DDEC engines using a dial gage in cylinder A1. Refer to section C 037.05.05.
6. Separate electrical plug-in connection.

7. Remove hex bolt. See Figure 391.



1. Hex Bolt
2. Speed Sensor

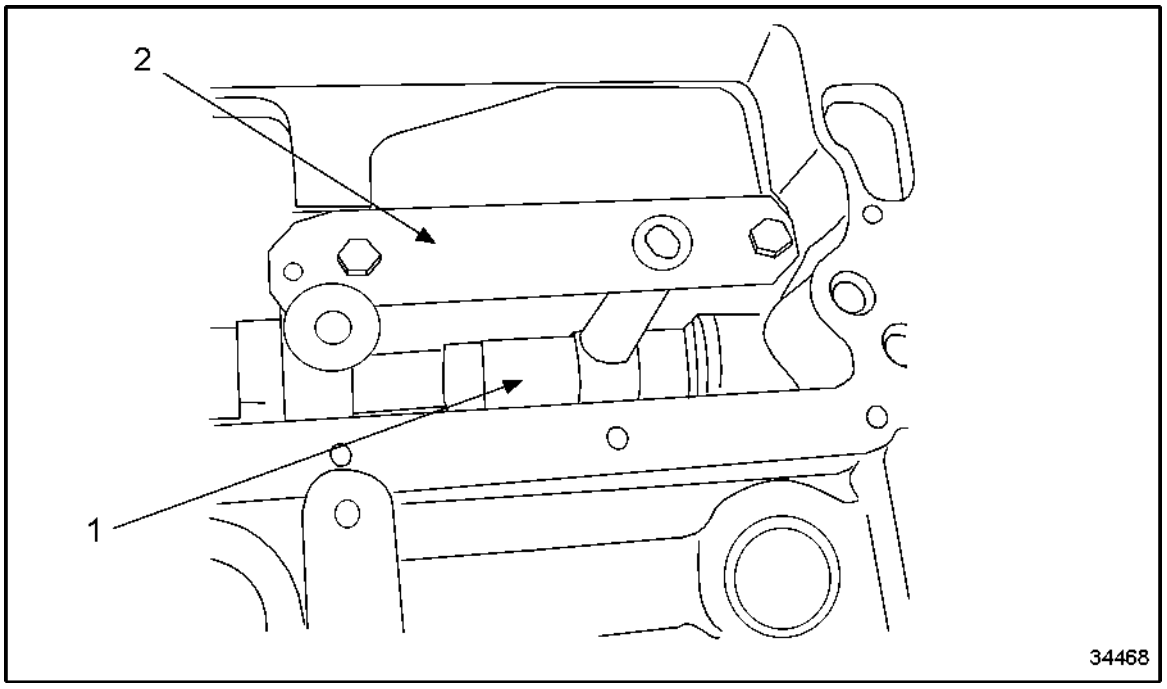
Figure 391 Removing SRS Sensor from Housing Bore

8. Turn SRS sensor (2) slightly to remove from housing bore.
9. If shims are installed on the sensor, save all shims for re-installation.

Removing Timing Wheel or SRS Wheel (Camshaft Gear)

Perform the following operations to remove the timing wheel or SRS wheel (camshaft gear).

1. Position locating tool (2) on bolting surface of the rocker shaft (flywheel end). See Figure 392.



1. Camshaft
2. Locating Tool

Figure 392 Removing SRS Wheel (Camshaft Gear)

2. Insert dowel pin of locating tool (2) into camshaft bore.
3. Screw locating tool into place.

4. Find dowel pin hole (arrow) for locating tool (driving end). See Figure 393.

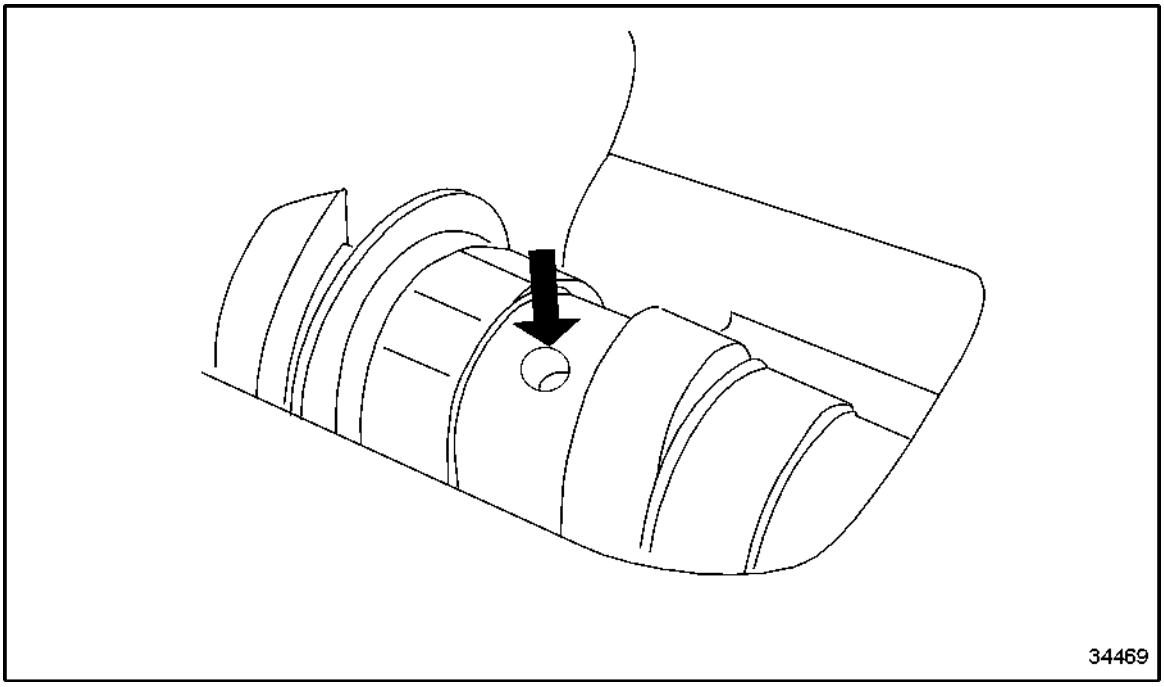
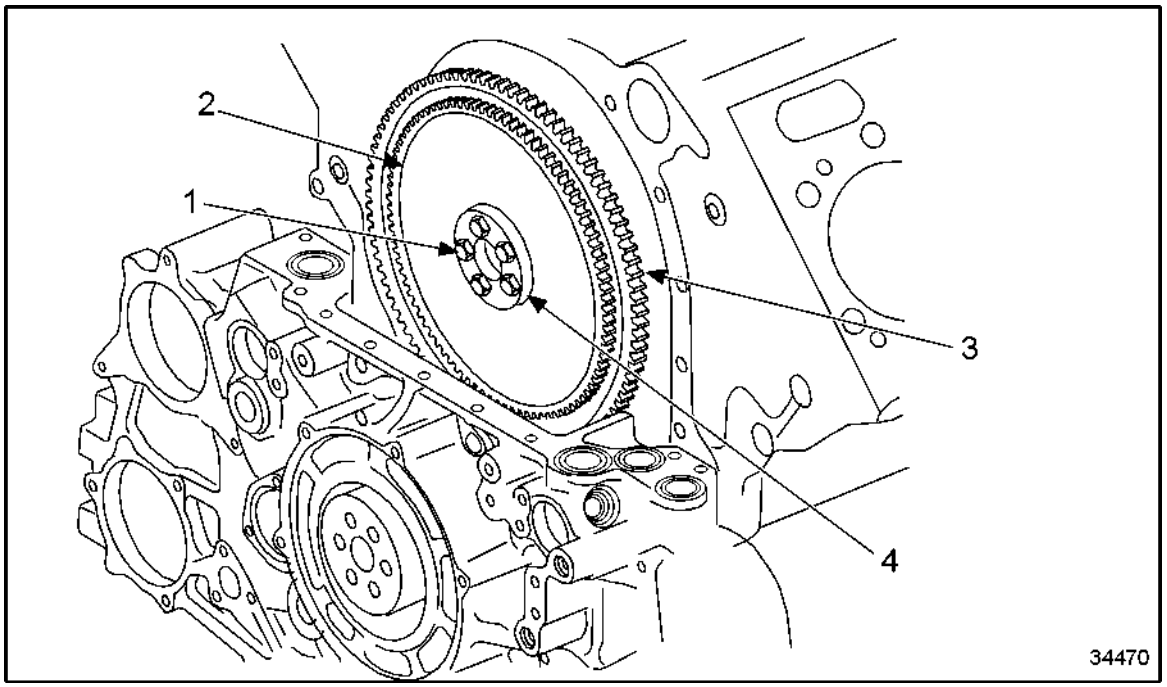


Figure 393 Locating Bore for Locating Tool

5. Remove hex bolts (1), spacer (4), SRS wheel (2) and camshaft gear (3) from housing. See Figure 394.



1. Hex Bolt
2. SRS Wheel
3. Camshaft Gear
4. Spacer

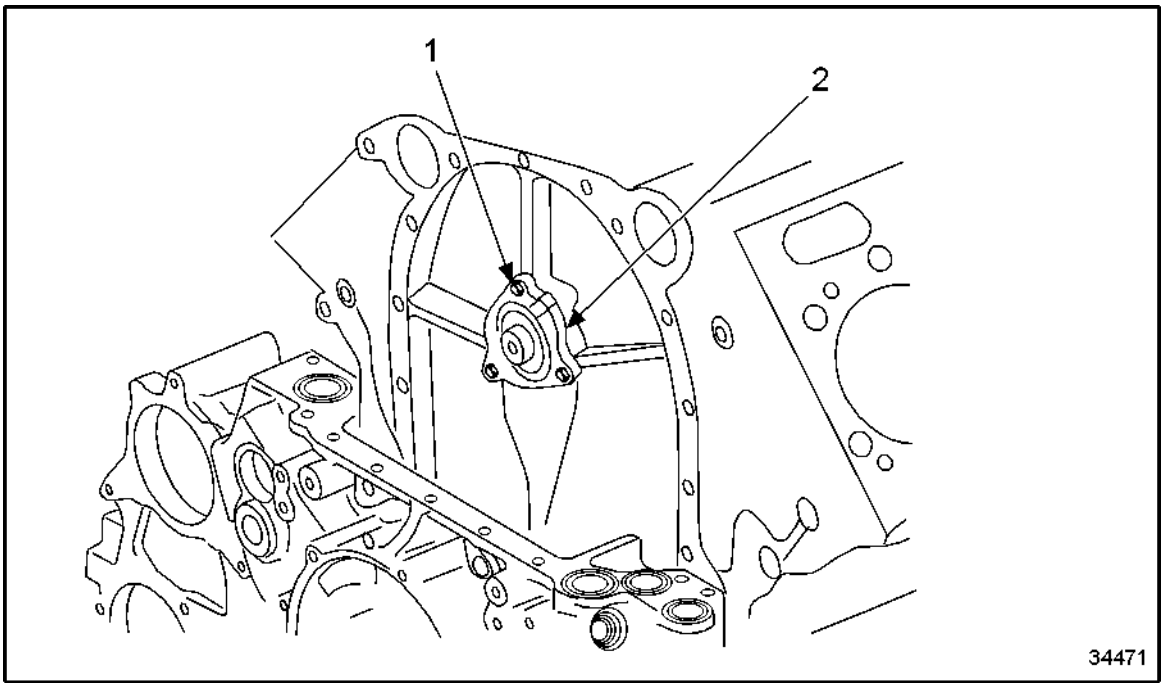
Figure 394 Removing Hex Bolts, Spacer, SRS Wheel and Camshaft Gear

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

6. Remove locating tool.

7. Remove hex bolts (1) and thrust bearing flange (2). See Figure 395.

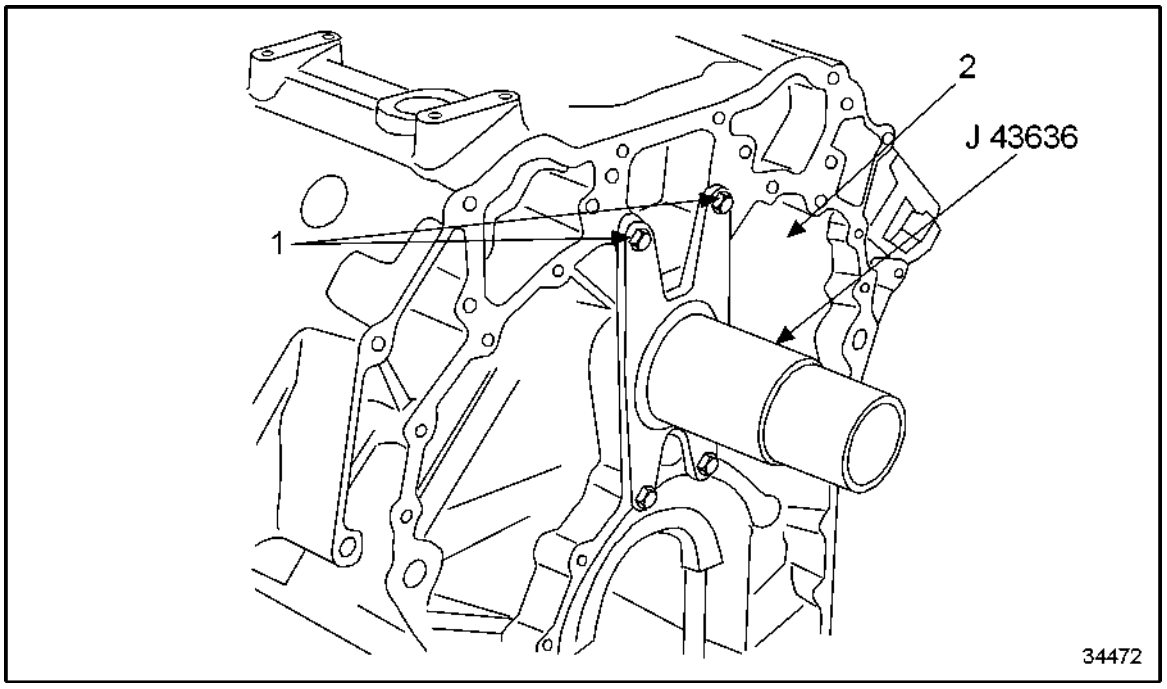
NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.



1. Hex Bolt
2. Thrust Bearing Flange

Figure 395 Removing Hex Bolts and Thrust Bearing Flange

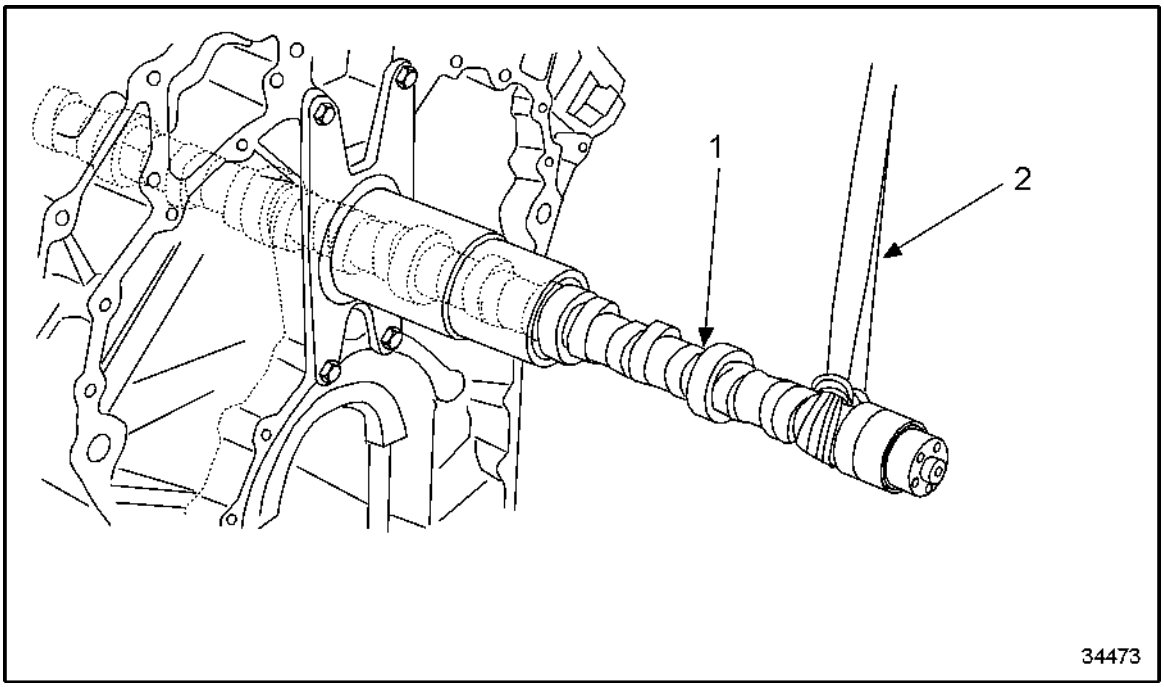
8. Install camshaft guide (3) to rear of cylinder block (2) (flywheel end) to guide camshaft to be removed with hex bolts (1). See Figure 396.



1. Hex Bolts
2. Cylinder Block

Figure 396 Securing Camshaft Guide

9. Carefully withdraw camshaft (1) from cylinder block so that bearings are not damaged. See Figure 397.



1. Camshaft
2. Lifting Sling

Figure 397 Withdrawing Camshaft from Cylinder Block

10. To facilitate handling, it is advisable to install a sliding block. When removing camshaft, its weight must be supported by the sliding block.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device to lift heavy objects and follow the manufacturer's operator procedures.

11. Attach lifting sling (2) midway along camshaft.
12. Take up slack and continue carefully withdrawing camshaft from cylinder block.
13. Remove insertion sleeve (not shown).

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:

1. Check hardness of cam (inlet and exhaust swing arm roller) and camshaft journal using Microdur testing unit or another suitable hardness testing unit. See Figure 398.

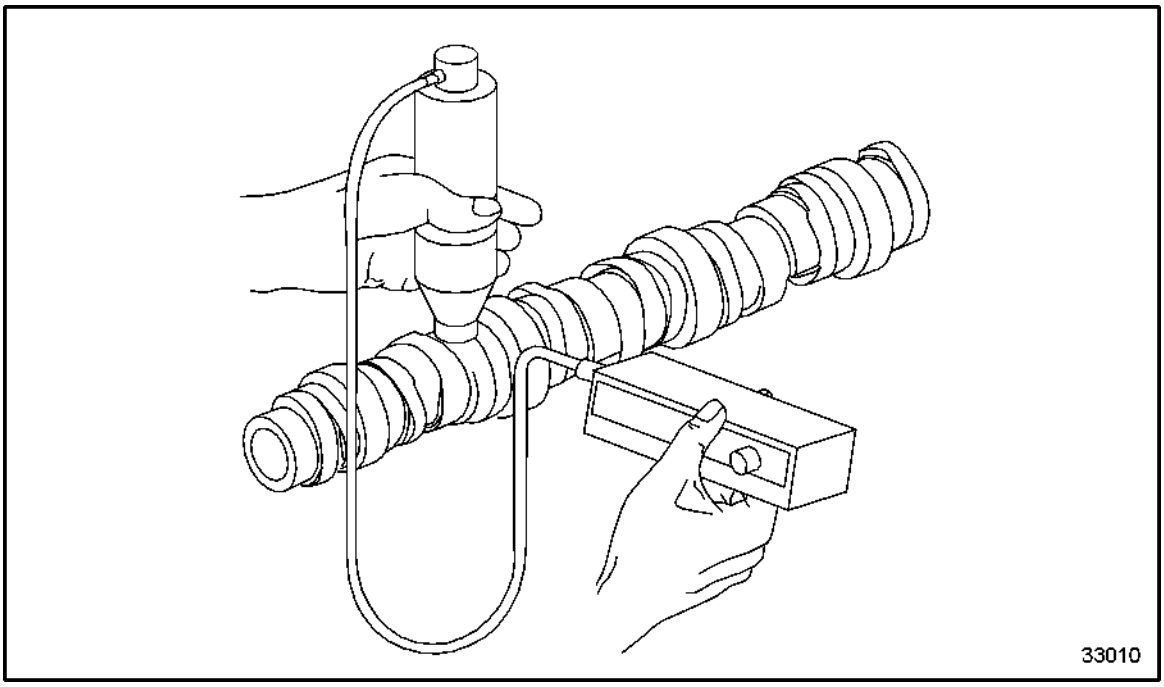


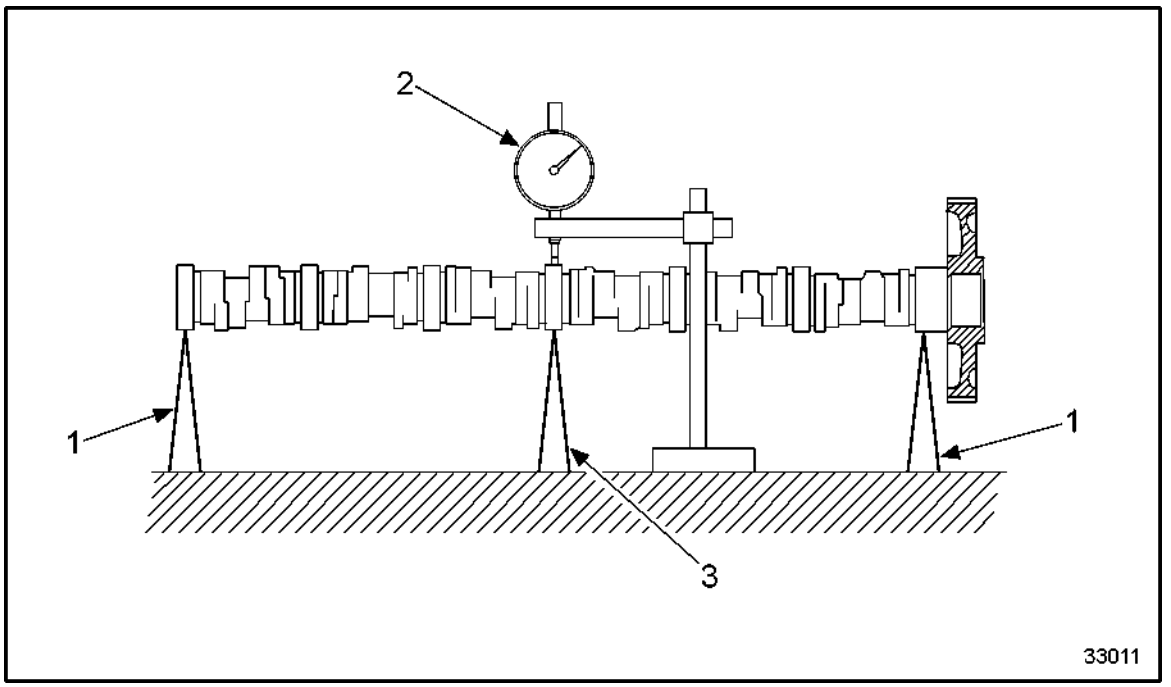
Figure 398 Checking Hardness of Cam and Journal

2. Test hardness of each journal at four points, at 90 - degree intervals around circumference.
   [a] If limit values are not achieved, machine camshaft to specifications, or replace if necessary.
   [b] If limit values are achieved, continue inspection.
3. Required hardness is 61 HRC ± 2 HRC.

Checking Concentricity and Bearing Journals

Perform the following steps to check concentricity and bearing journals:

1. Set camshaft at outer journals on V-blocks (2) or roller stands. See Figure 399.



1. V-block
2. Dial Gage
3. Supporting Mount

Figure 399 Checking Concentricity and Bearing Journals

2. Place supporting mount (3) at center journal.
3. Measure radial runout of cam base circle journals with dial gage (1).
4. Measure cam lift over base circle diameter of valve lobes with dial gage.
   [a] If limit values are not achieved, machine camshaft to DDC specifications.
   [b] If specified limit values cannot be achieved by machining, replace camshaft.
   [c] If limit values are achieved, continue inspection.

C 051.05.11 – INSTALLATION OF CAMSHAFT

Installing Camshaft

Perform the following subsections to install camshaft.

NOTE:
Ensure all components are perfectly clean.

1. Attach camshaft guide (1) (flywheel end of cylinder block) and center to camshaft bearings. See Figure 400.

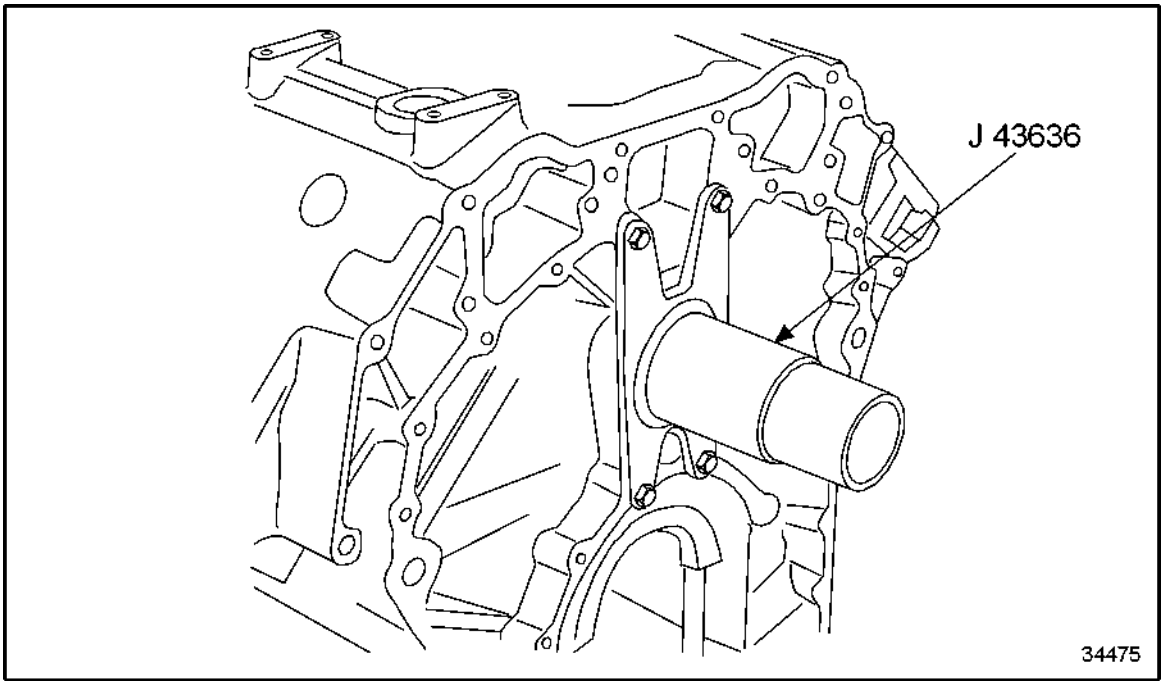
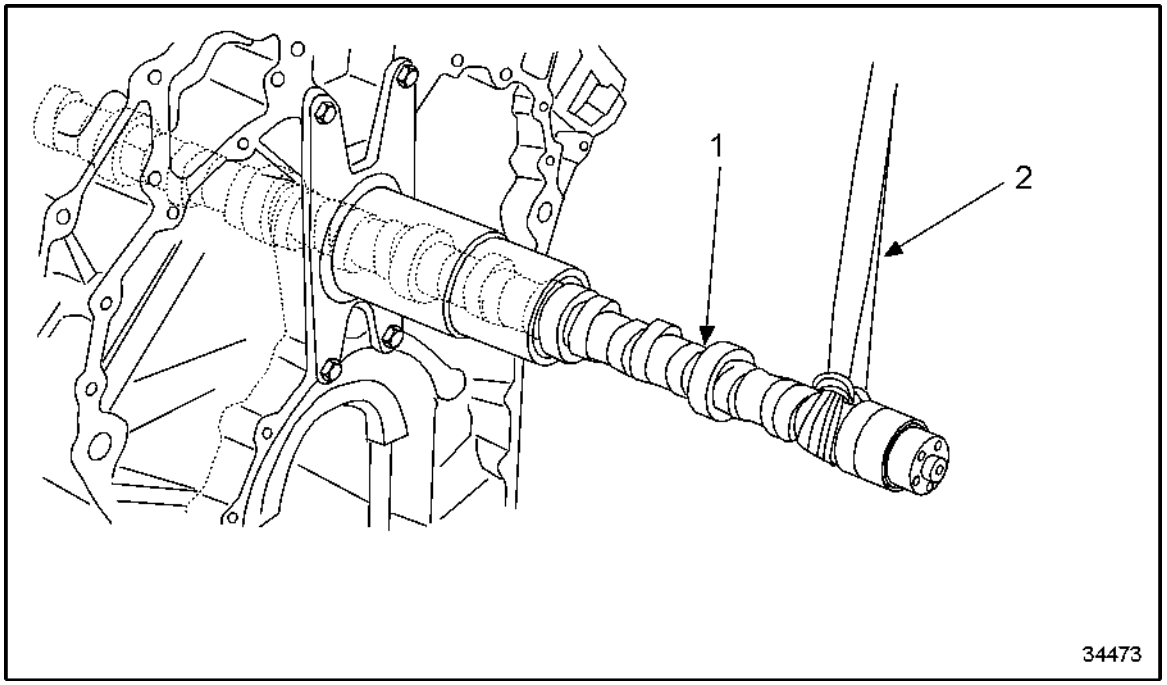


Figure 400 Attaching Camshaft Guide

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.

2. Attach camshaft (1) in center with lifting sling (2) and clean. See Figure 401.

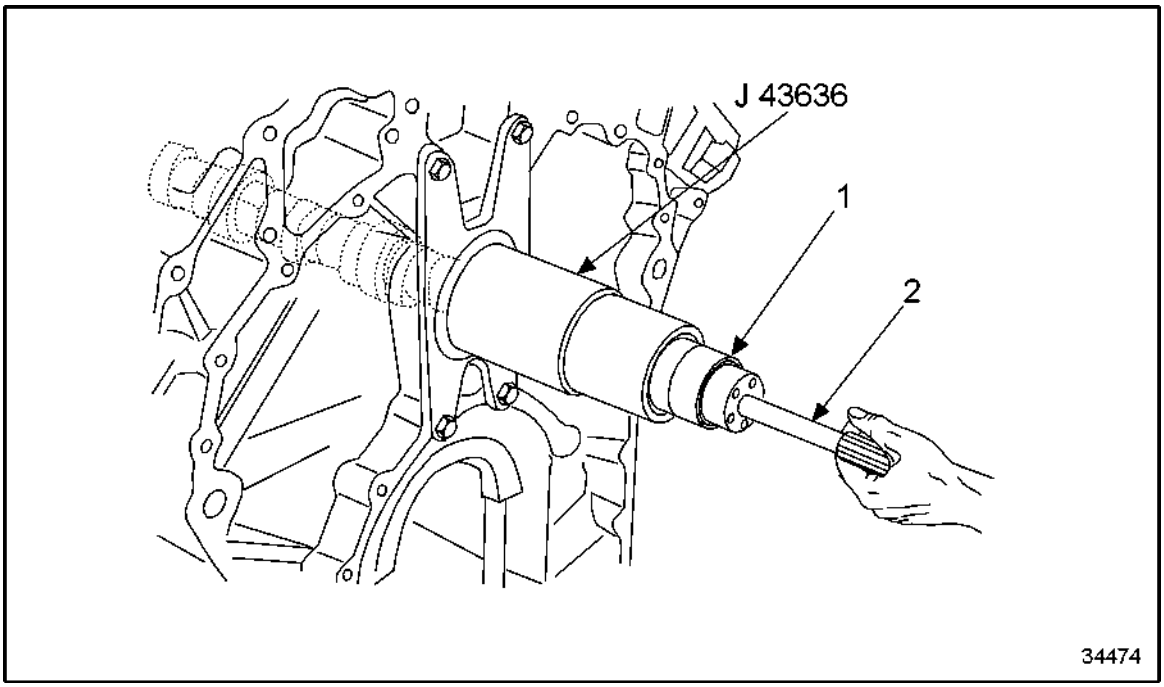


1. Camshaft
2. Lifting Sling

Figure 401 Withdrawing Camshaft from Cylinder Block

3. Spray camshaft, camshaft bearing, and guide sleeve with engine oil.
4. Install sliding block at outermost cam on camshaft.
5. Taking care not to damage bearings, slowly install camshaft into cylinder block up to the second-to-the-last bearing.

6. Position assembly extension (3) on camshaft (2) and insert camshaft up to last bearing. See Figure 402.



1. Camshaft
2. Assembly Extension

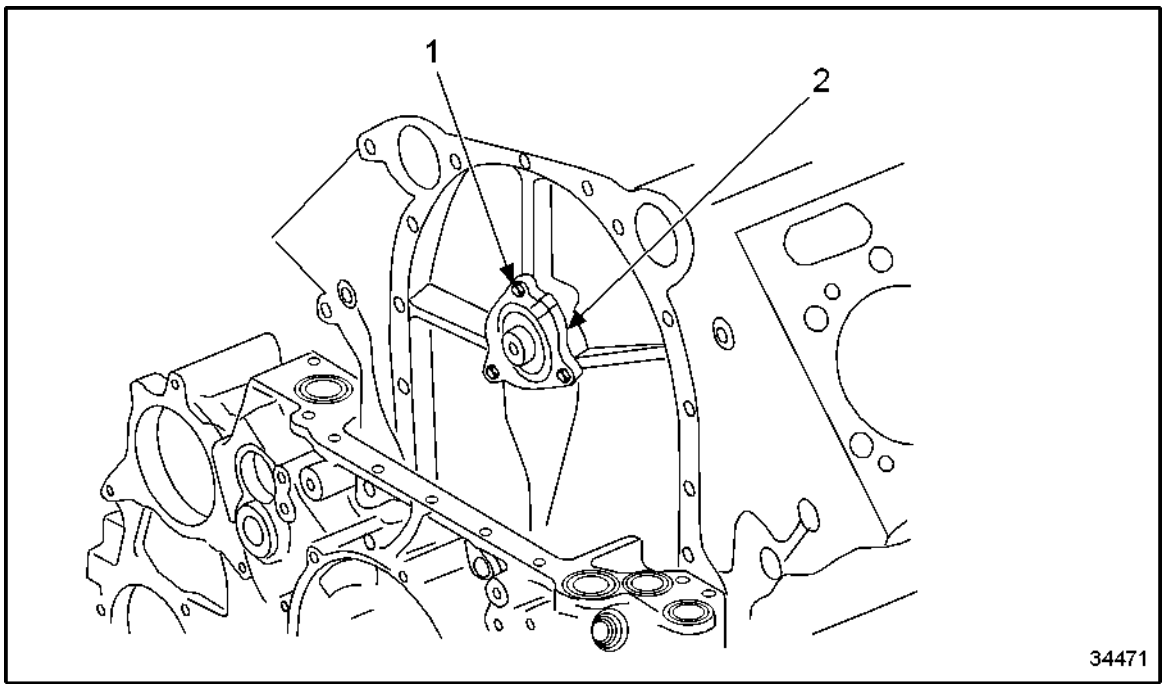
Figure 402 Positioning Assembly Extension on Camshaft

7. Remove camshaft guide and assembly extension.

Installing Camshaft Thrust Bearing

Perform the following steps to install camshaft thrust bearing:

1. Coat thrust surfaces with engine oil. See Figure 403.



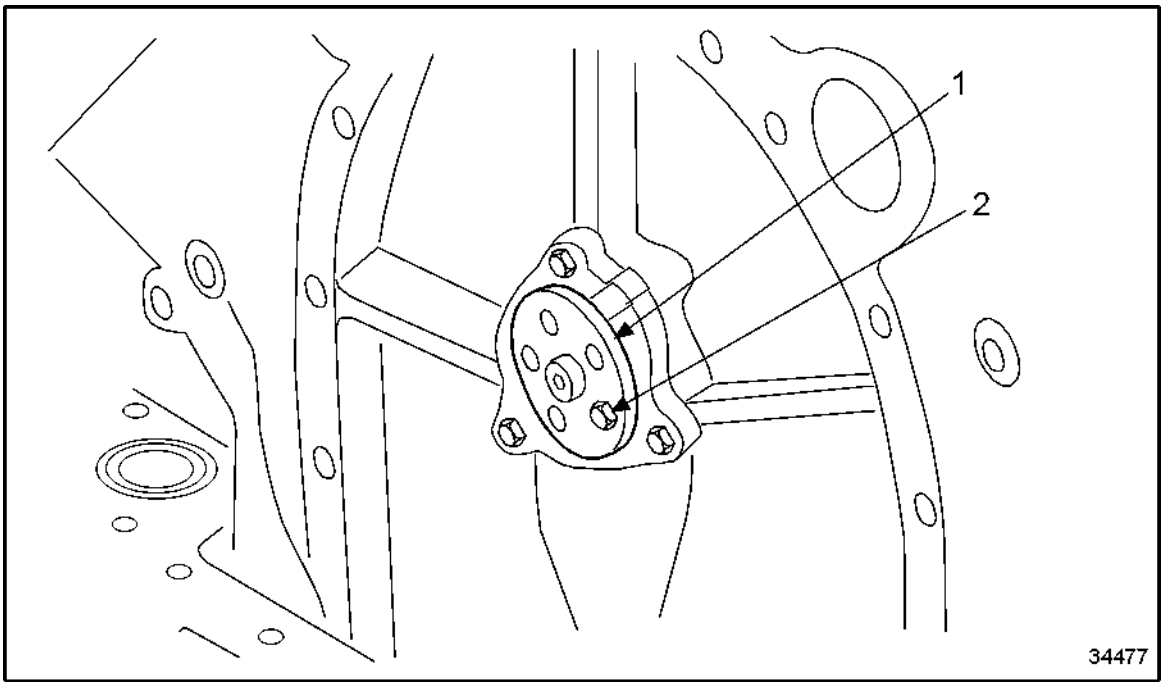
1. Hex Bolt
2. Thrust Bearing Flange

Figure 403 Installing Hex Bolts and Thrust Bearing Flange

2. Tighten thrust bearing flange (2) with hex bolts (1).

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

3. Install spacer (1) with hex bolt (2) on camshaft. See Figure 404.



1. Spacer
2. Hex Bolt

Figure 404 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.

4. Turn camshaft until locating bore (flywheel end) (arrow) is visible and at position shown. See Figure 405.

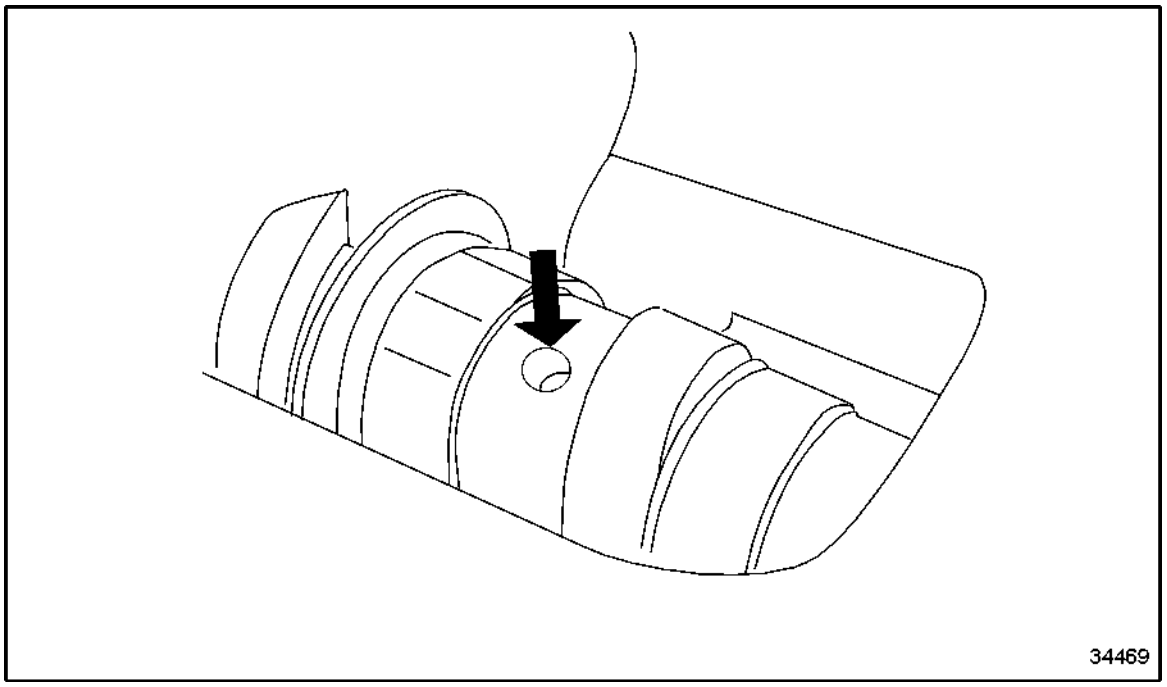
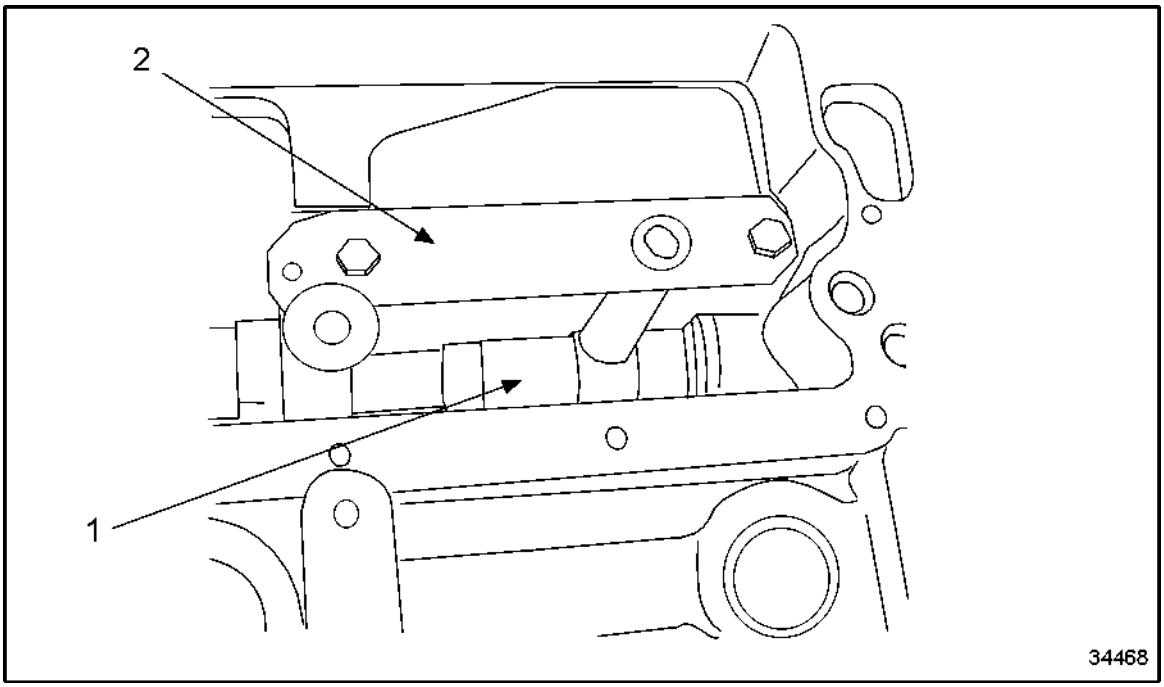


Figure 405 Locating Bore for Locating Tool

Installing Locating Tool

Perform the following steps to install locating tool:

1. Position locating tool (2) on bolting surface of the rocker shaft (flywheel end). See Figure 406.

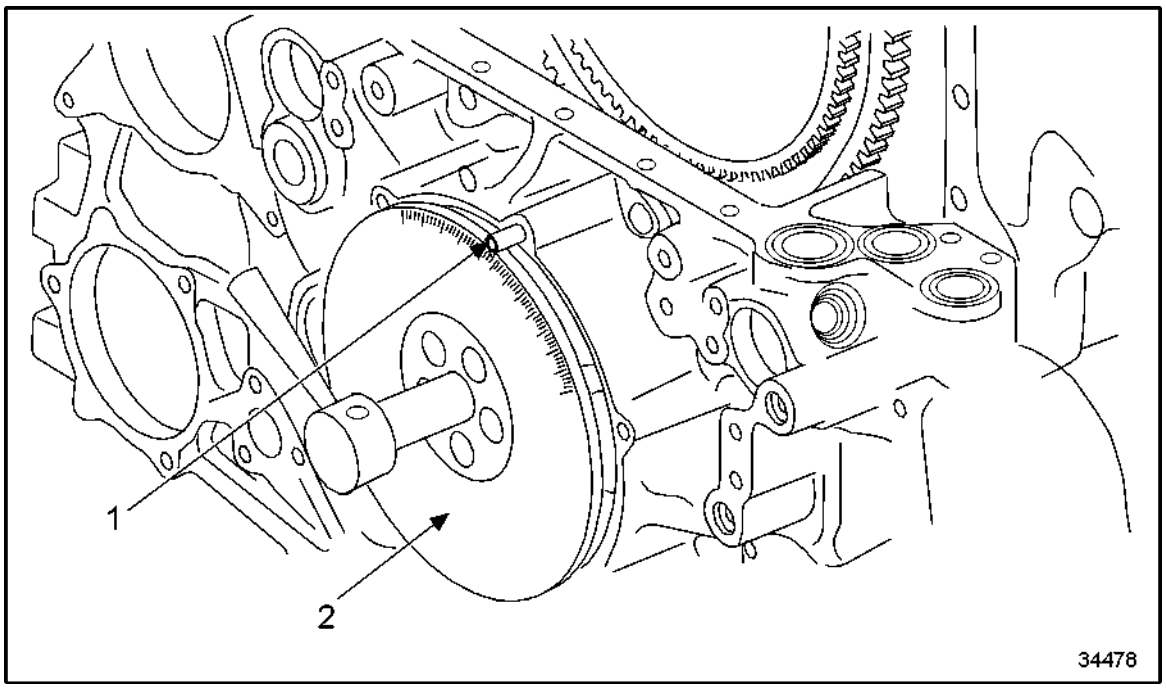


1. Camshaft
2. Locating Tool

Figure 406 Installing Locating Tool

2. Insert dowel pin of locating tool (2) into camshaft bore (3) and screw locating tool into place.

3. Install pointer (1) on gear case. See Figure 407.

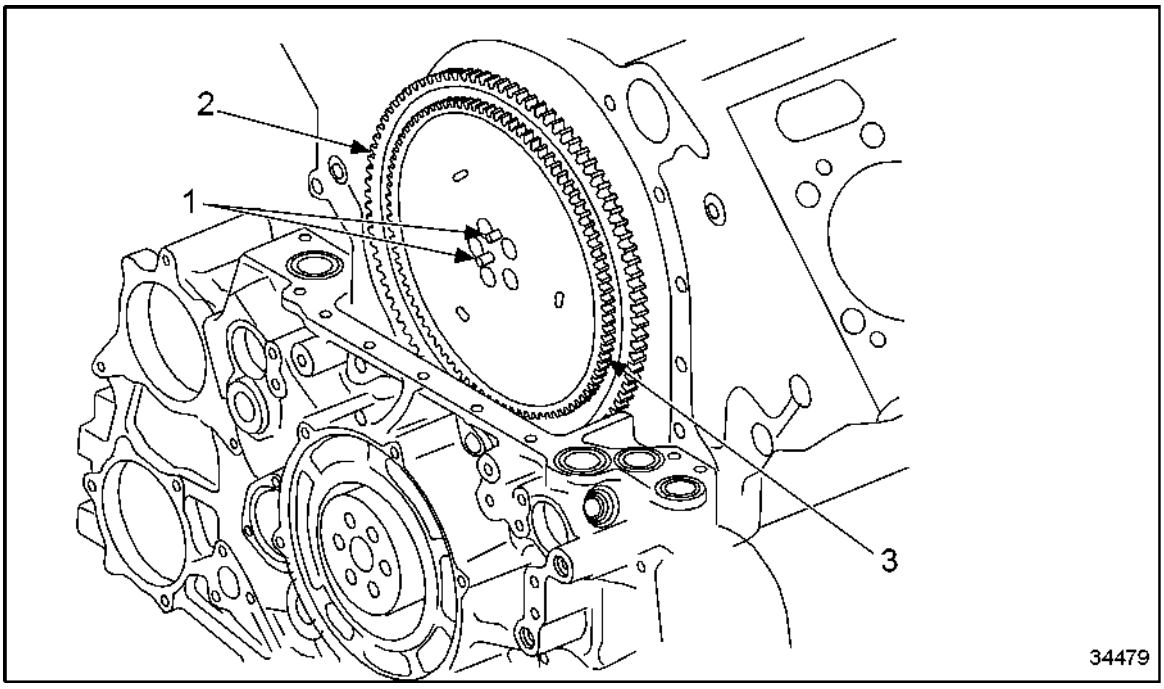


1. Pointer
2. Index Plate

Figure 407 Installing Pointer on Gear Case

4. Install index plate with barring tool on crankshaft, set to TDC marking of A1 and tighten.
5. Set piston A1 to firing TDC. Refer to section C 037.05.05.

6. Install camshaft gear (2) into camshaft so that dowel pins (1) engage in camshaft gear bore in a vertical line; ensure there is gear lash in both directions. See Figure 408.



1. Dowel Pin
2. Camshaft Gear
3. SRS Wheel

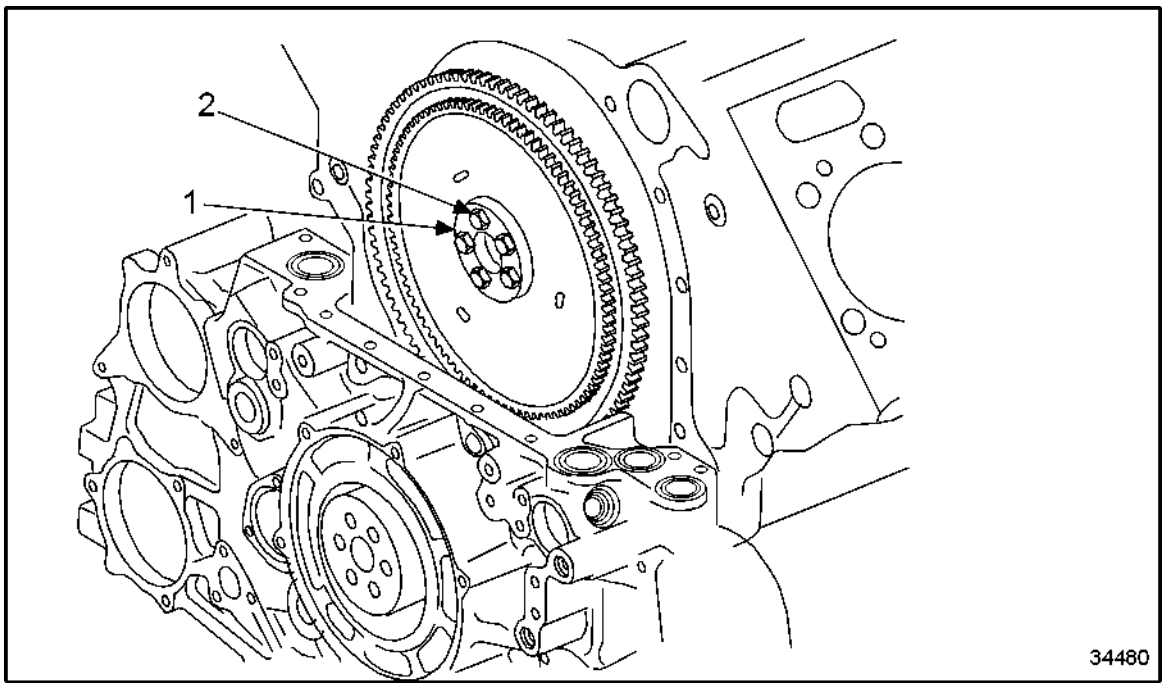
Figure 408 Installing SRS Wheel via Dowel Pins

7. Install SRS Wheel (3) via dowel pins.

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

8. Remove all gear lash in the direction of rotation before tightening the bolts.
9. Screw in and tighten spacer (1) with hex bolts (2).

NOTE:
Ensure that dowel pin (6) and bolt bores are aligned. See Figure 409



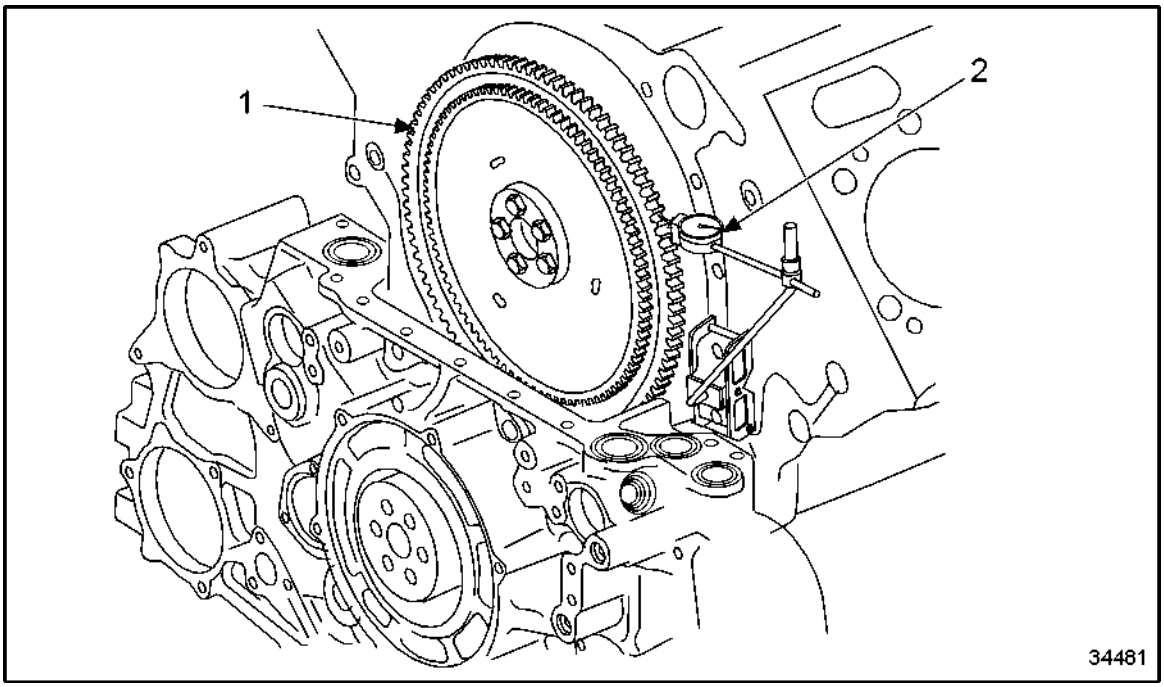
1. Spacer
2. Hex Bolt

Figure 409 Installing Spacer with Hex Bolts

Measuring Backlash

Perform the following steps to measure backlash:

1. Mount magnetic dial gage holder with dial gage on cylinder block (gear case end). See Figure 410.



1. Camshaft Gear
2. Magnetic Dial Gage

Figure 410 Measuring Backlash

2. Position dial gage stylus with low preload on one tooth flank of camshaft gear.
3. Set dial gage to zero.
4. Check backlash by moving camshaft gear back and forth.
5. For backlash, refer to section C 024.05.

Measuring Camshaft End Play

Perform the following steps to measure camshaft end play:

1. Mount magnetic dial gage holder with dial gage on cylinder block (gear case end). See Figure 411.

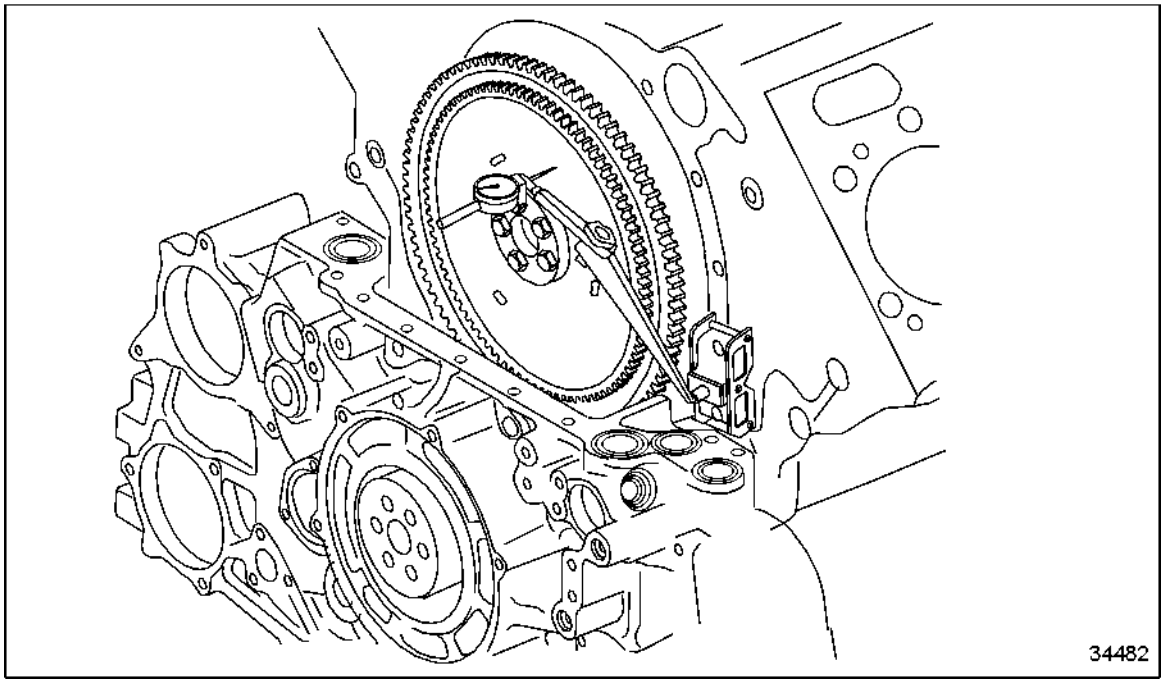


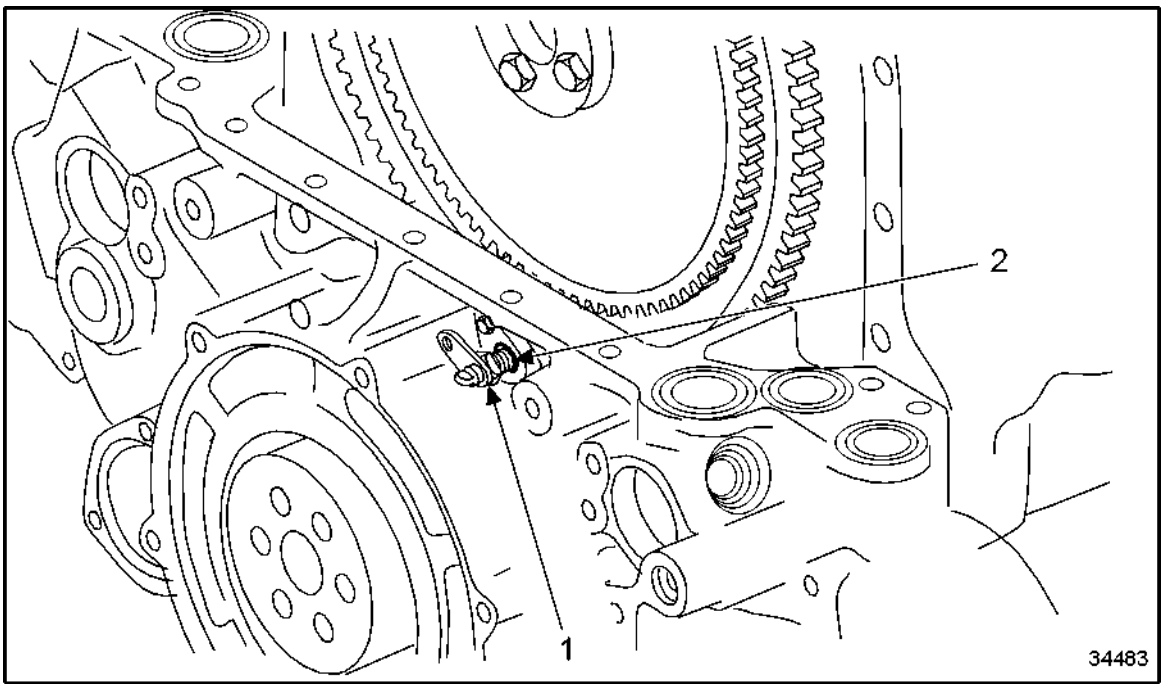
Figure 411 Measuring Camshaft End Play

2. Place dial gage stylus on SRS wheel.
3. Push camshaft on camshaft gear horizontally as far as it will go.
4. Set dial gage with preload to zero.
5. Move camshaft from stop to stop and record measured value (end play).
6. For axial clearance, refer to section C 024.05.

Installing SRS Sensor

Perform the following steps to install SRS sensor:

1. Replace O-ring and coat with petroleum jelly. See Figure 412.



1. SRS Sensor
2. O-ring

Figure 412 Installing SRS Sensor

2. Turn SRS sensor (1) slightly to install in housing bore.
3. If shims had previously been installed, re-install those shims.

Checking SRS Sensor Clearance

Perform the following steps to check SRS sensor clearance:

1. Pull camshaft on camshaft gear horizontally (large arrow) as far as it will go. See Figure 413.

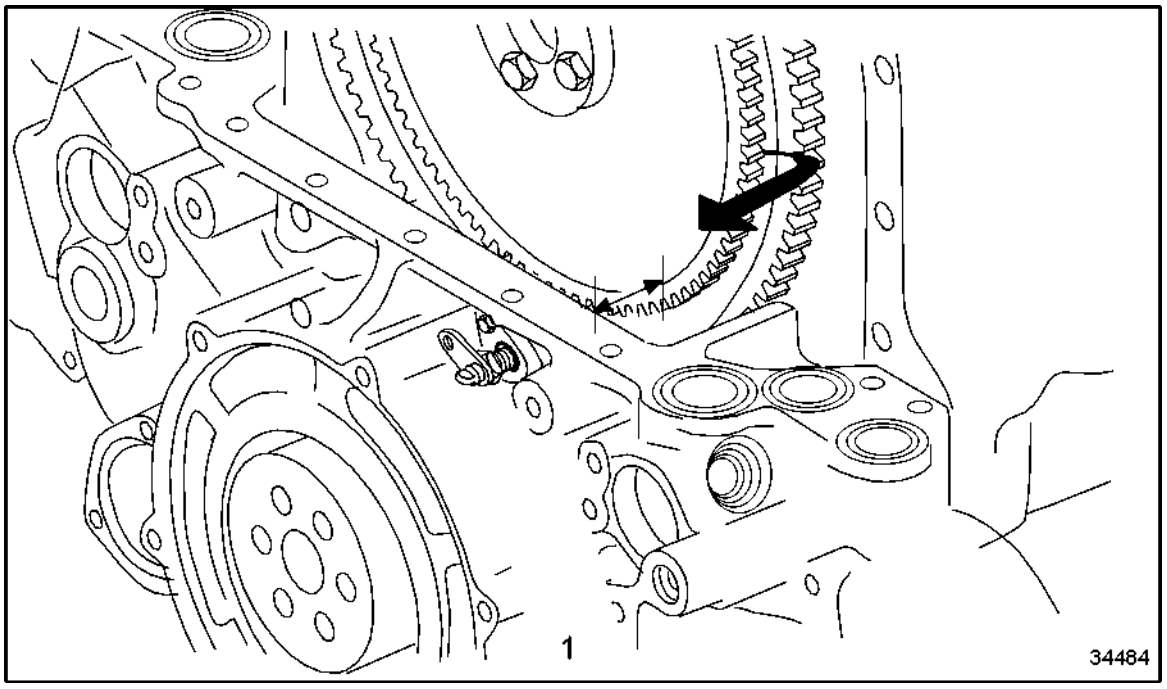
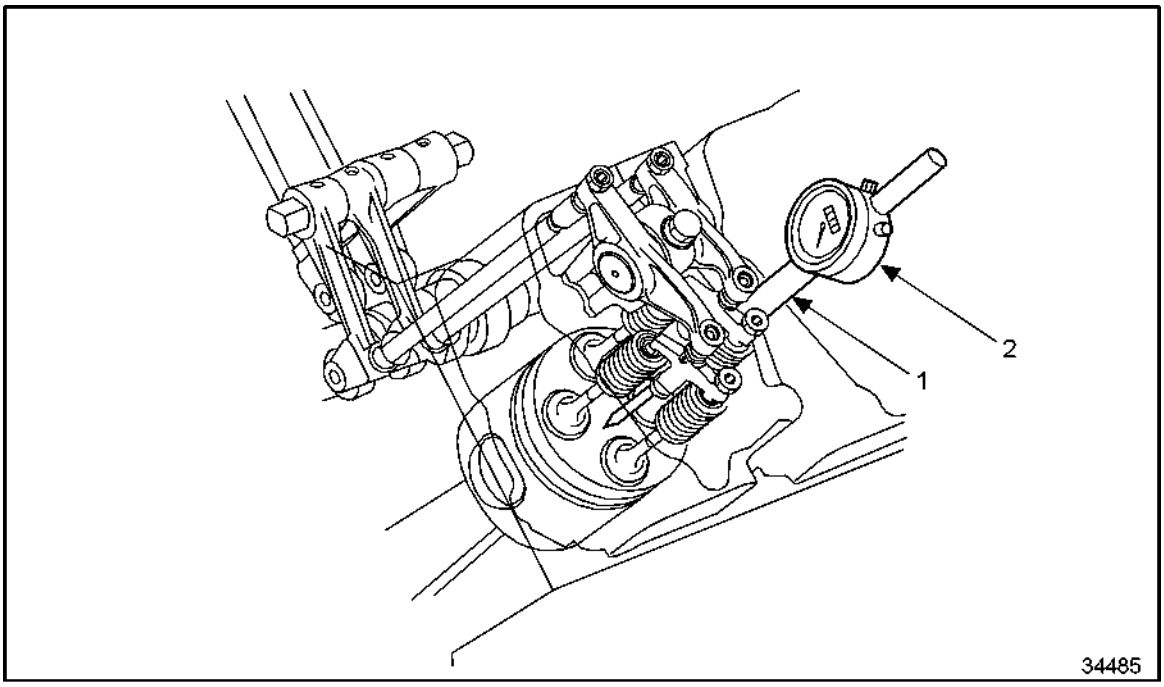


Figure 413 Checking Speed Sensor Clearance

2. Measure distance (small arrows); specified value is 0.3 mm to 1 mm.
3. If distance is less than 0.3 mm, fit appropriate number of adjusting shims of 0.3 mm thickness.
4. Measure distance.

Checking Camshaft Timing

NOTE:
Check timing with cylinder head and valve drive installed. See Figure 414.



1. Measuring Device
2. Dial Gage

Figure 414 Checking Camshaft Timing

1. Determine TDC position of piston as follows:
   [a] Install measuring device (1) with dial gage (2), starting at cylinder head A1.
   [b] To apply TDC mark (index plate) on flex coupling flange or crankshaft journal (gear case end), install suitable TDC pointer on gear case (flywheel end) or cylinder block.

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.

[c] Using the barring tool, bar the engine until the piston of cylinder A1 is in the firing TDC.

NOTE:
The piston is at firing TDC when both rocker arms are unloaded, i.e. have clearance.

2. Move piston several times up and down through TDC until needle of dial gage registers its highest reading.
3. Set dial gage to zero.
4. Turn crankshaft against normal direction of rotation to 10 degrees.
5. Turn crankshaft in direction of rotation to 0.3 mm (on dial gage) before TDC.
6. Apply exact mark to index plate (flywheel end) or to crankshaft journal (gear case end), opposite TDC pointer.
7. To take up bearing play, bar crankshaft in direction of rotation past TDC to approximately 10 degrees.
8. Bar crankshaft in direction opposite to normal direction of rotation to 0.3 mm after TDC.
9. Apply second mark to index plate (flywheel end) or to crankshaft journal (gear case end).

NOTE:
To eliminate bearing clearance, the piston must always move in direction of TDC.

10. Apply third mark at exact center between previous two marks.
11. Align index plate so that mark for cylinder A1 corresponds to pointer.
12. Again check TDC position.
13. Remove measuring device with dial gage.

Measuring Intake Valve Stroke

Perform the following steps to measure intake valve stroke:

1. Start from cylinder A1, turning cylinder A1 to firing TDC.
2. Release locknuts (arrows) and insert adjusting screws until there is no more play.

3. Slightly tighten locknuts.

NOTE:
To obtain valid measurements, ensure that there is no valve play.

4. Mount magnetic-base indicator holder with dial gage on cylinder A1.
5. Position dial gage stylus, with low preload, on valve bridge of inlet valve; set scale to zero.
6. Slowly turn crankshaft further in direction of engine rotation 360 degrees, to exactly overlap TDC in accordance with applied mark.
7. Read valve stroke dial gage and record readings in Data Sheet.
8. Position dial gage stylus on valve bridge of exhaust valve; set scale to zero.
9. Further turn crankshaft slowly in direction of engine rotation, until pointer of dial gage no longer moves.
10. Read valve stroke from dial gage and record readings in Data Sheet.
    [a] If readings are outside limits, machine as necessary.
    [b] If correct limits cannot be obtained by machining, replace component.
    [c] If readings are not outside limits, continue to next step.
11. Remove magnetic-base indicator holder with dial gage and TDC indicator.
12. Set valve clearance on cylinder A1. Refer to section C 051.05.11.

C 051.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 41 are the After-Installation Operations for the crankshaft.

Level of Maintenance	Operation	Reference
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.

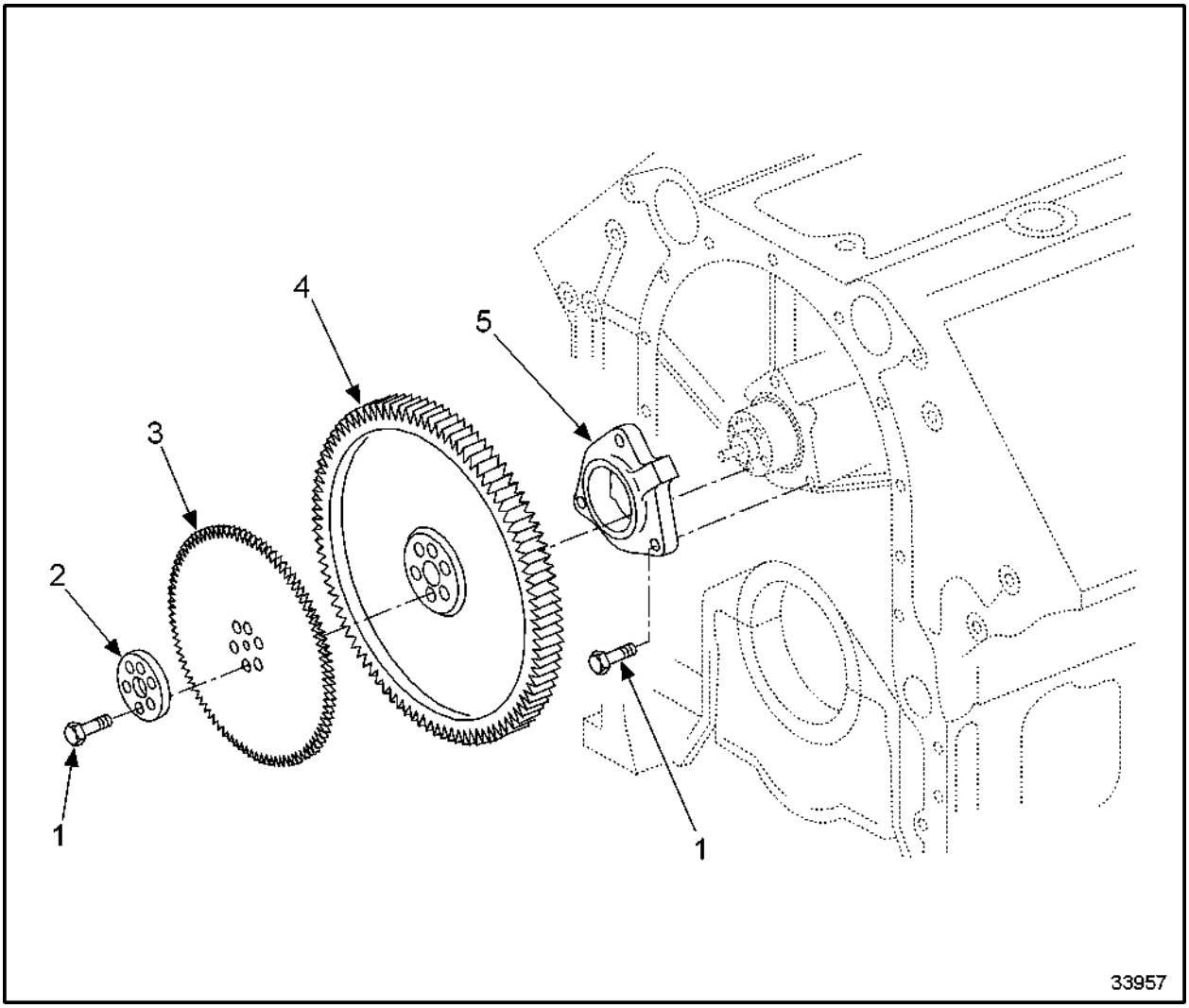
3 = The engine is to remain installed.

Table 41 After-Installation Operations

C 052.05 – CAMSHAFT DRIVE

C 052.05.01 – GENERAL VIEW

See Figure 415 for a general view of camshaft drive components.



1. Hex Bolt
2. Spacer
3. SRS Wheel
4. Camshaft Gear
5. Thrust Bearing Flange

Figure 415 General View of Camshaft Drive Components

C 052.05.02 – SPECIAL TOOLS

Listed in Table 42 are the special tools required for maintenance on the camshaft drive.

Application	Number
Piston measuring device	—
Index plate with pointer	—
Camshaft locating device	—

Table 42 Special Tools

C 052.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 43 are the Before-Removal Operations for the camshaft drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Removal of camshaft not scheduled	-
1, 2, 3	Drain engine coolant	Operator Guide
1, 2, 3	Drain charge air coolant	Refer to section C 206.05.05
1, 2, 3	Remove fan drive	Refer to section C 221.05.05
1, 2, 3	Remove engine carrier, (gear case)	Refer to section C 231.05.05
1, 2, 3	Remove vibration damper (as required)	Refer to section C 035.05.05
1, 2, 3	Remove Y-pipe from exhaust outlet housing	Refer to section C 141.05.05
1, 2, 3	Remove intake air system from turbocharger to charge air cooler	Refer to section C 125.05.05
1, 2, 3	Remove oil supply lines for turbochargers	Refer to section C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05
1, 2, 3	Remove exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove charge air coolant lines (low temperature)	Refer to section C 207.05.05
1, 2, 3	Remove engine coolant vent line	Refer to section C 205.05.05
1, 2, 3	Remove charge air coolant vent lines	Refer to section C 205.05.05
1, 2, 3	Remove coolant lines	Refer to section C 203.05.05
1, 2, 3	Remove oil heat exchanger with coolant distribution housing and thermostat	Refer to section C 185.05.05
1, 2, 3	Remove valve covers	Refer to section C 056.05.05
1, 2, 3	Remove valve gear	Refer to section C 055.05.05
1, 2, 3	Remove pushrods	Refer to section C 055.05.05

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 43 Before-Removal Operations

C 052.05.05 – REMOVAL OF CAMSHAFT DRIVE

Removing Camshaft Drive

Perform the following steps to remove the camshaft drive:

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. Using barring tool, turn engine in normal direction of rotation until TDC mark and arrow on flywheel housing are aligned. See Figure 416.

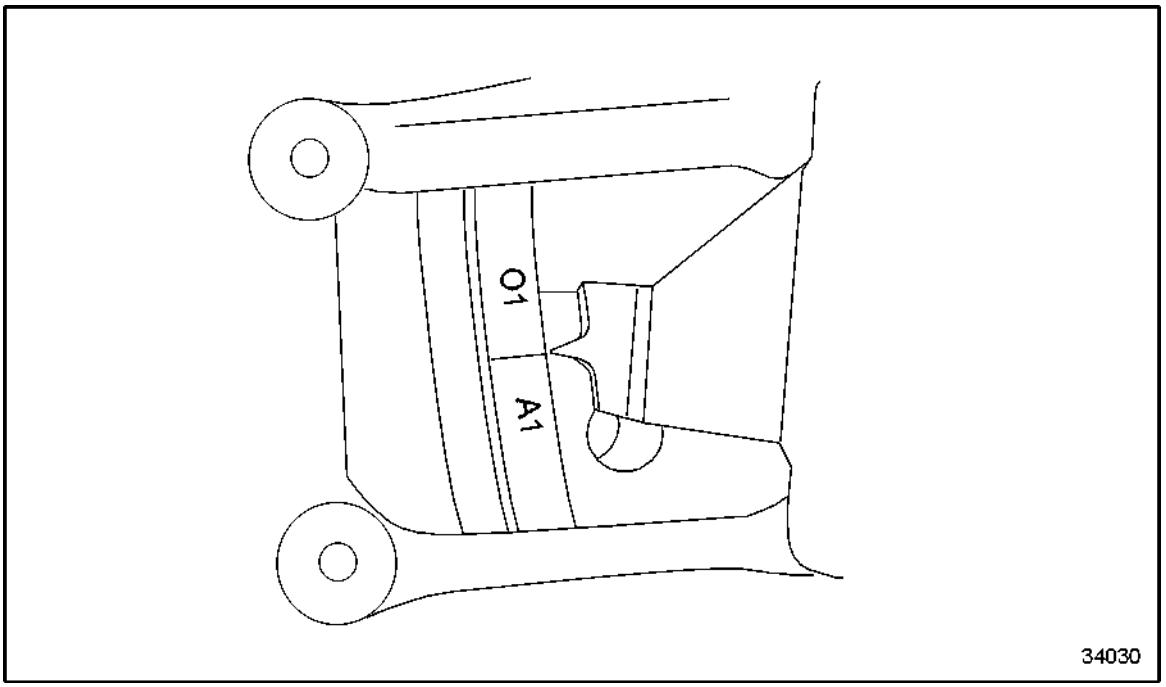
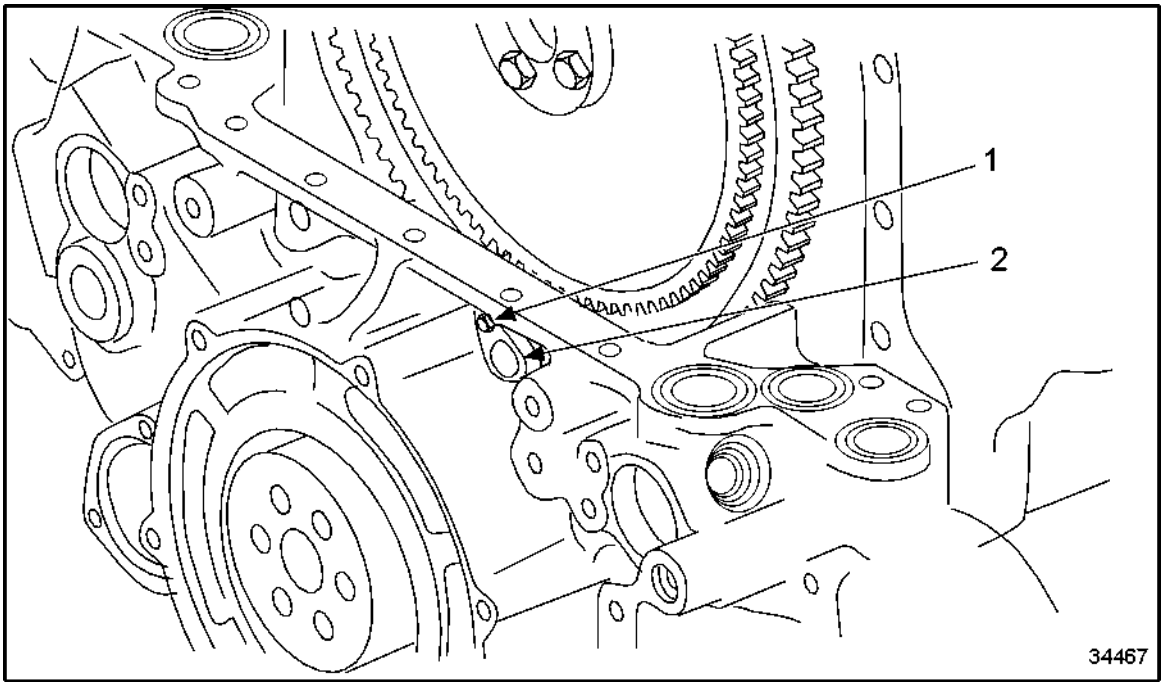


Figure 416 Barring Engine to Align TDC-A1 and Flywheel Markings (Marine only)

2. If rocker arms on cylinder A1 are unloaded, the piston is in firing TDC.
3. If rocker arms on cylinder A1 are loaded, the piston is in overlap TDC.
4. Remove valve drive. Refer to section C 055.05.05.
5. On DDEC engines, use a dial gage in the A1 cylinder kit to determine TDC. Refer to section C 037.05.05.
6. Separate electrical plug-in connection.

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

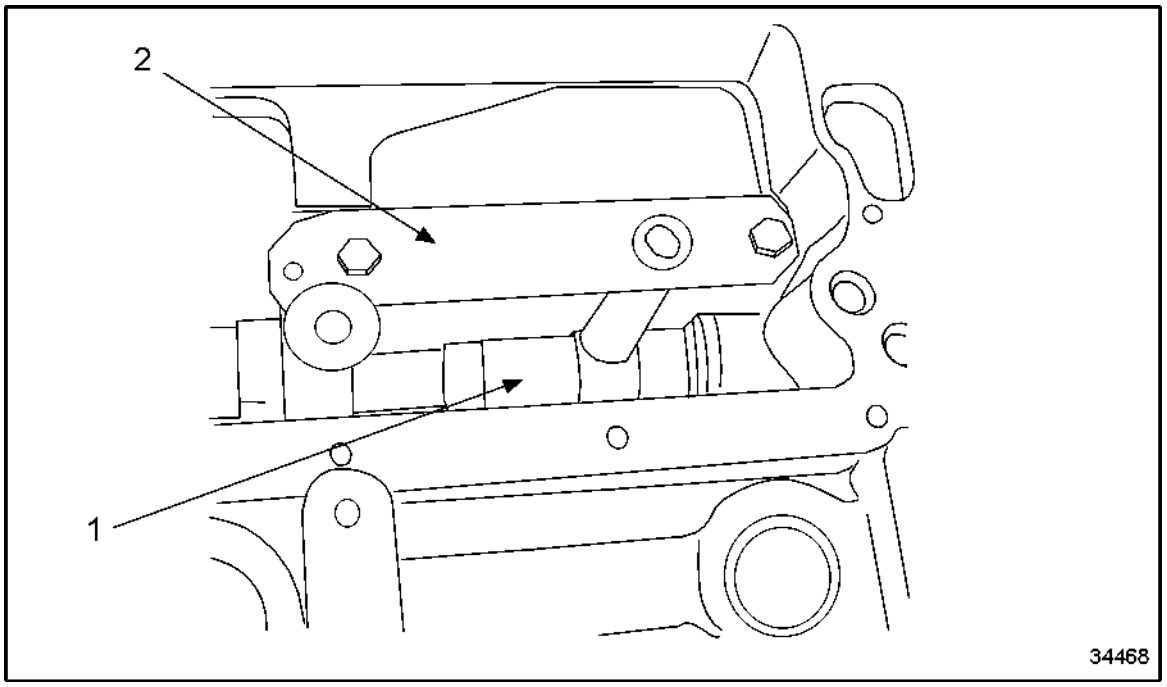
Figure 417 Turning SRS Sensor

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.



1. Camshaft
2. Locating Tool

Figure 418 Removing SRS Wheel

2. Insert dowel pin of locating tool (2) into camshaft bore and bolt locating tool into place. See Figure 419.

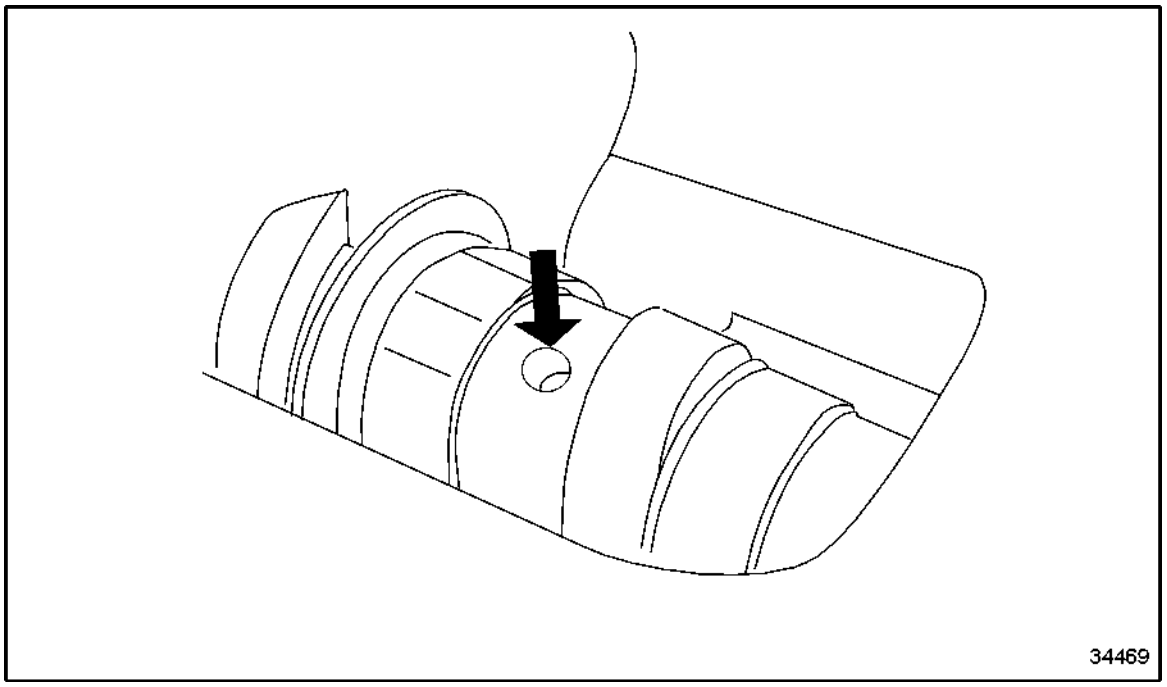
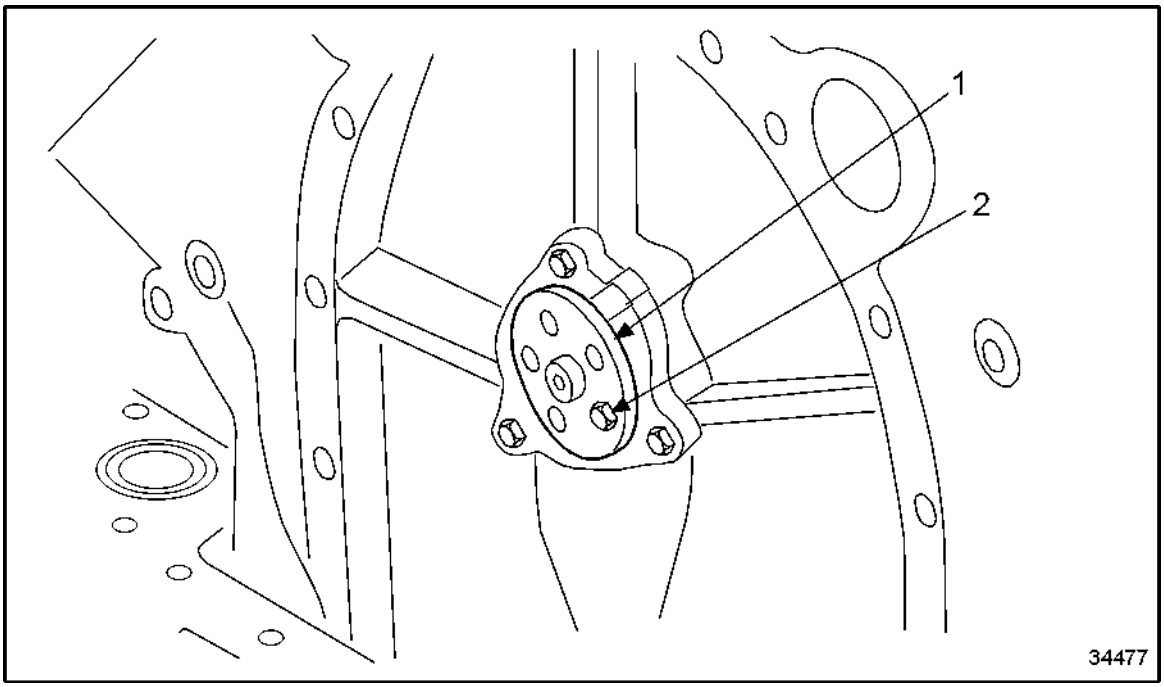


Figure 419 Locating Bore for Locating Tool

3. Locate bore (arrow) for locating tool pin. See Figure 419.
4. Remove hex bolts (1), spacer (4), SRS wheel (2) and camshaft gear (3) from camshaft. See Figure 420.

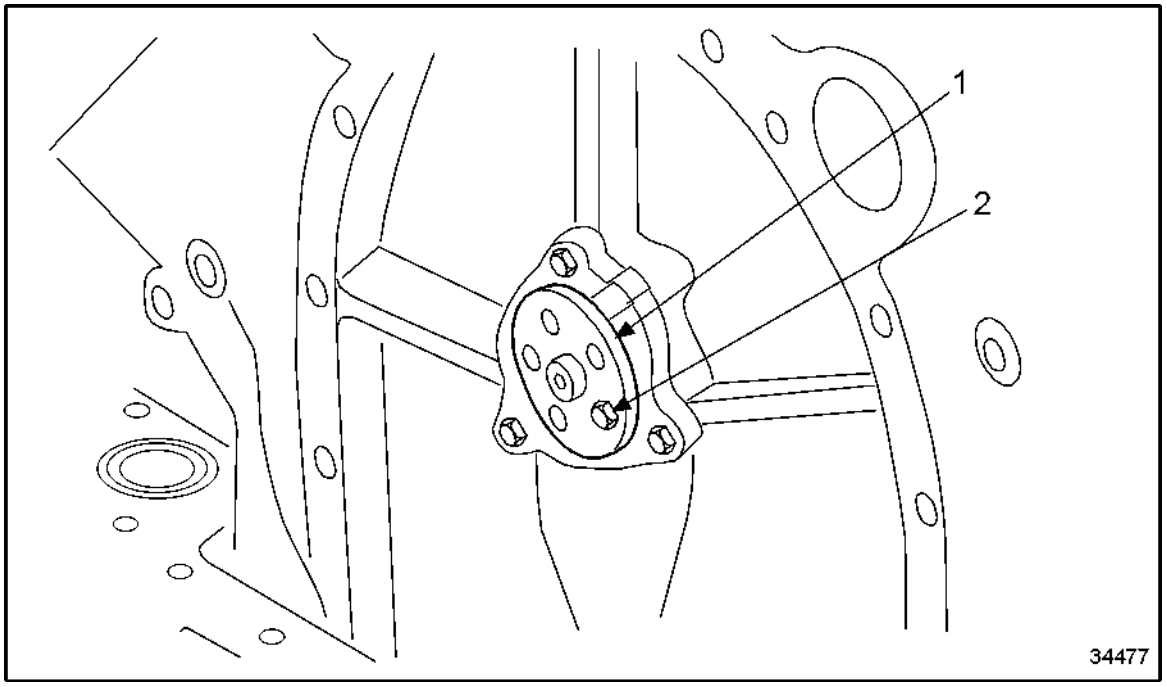


1. Ring
2. Hex Bolt

Figure 420 Removing Hex Bolts, SRS Wheel and Camshaft Gear

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

5. Remove locating tool.
6. Install spacer (1) with hex bolt (2) on camshaft. See Figure 421.



1. Spacer
2. Hex Bolt

Figure 421 Installing Spacer with Hex Bolt on Camshaft

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

C 052.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the camshaft drive.

1. Clean camshaft gear.
2. Inspect surface condition of camshaft gear teeth with magnifying glass.
   [a] If teeth are worn or damaged, replace gear. Refer to section C 052.05.11.
   [b] If teeth are not worn or damaged, continue inspection.
3. Inspect camshaft for minor scoring, wear and indentations.
   [a] If camshaft is damaged, polish with emery cloth or machine.
   [b] If wear or damage is too severe, replace camshaft.
   [c] If no damage is found, continue inspection.
4. Measure camshaft against limit values.
   [a] If limit values are exceeded, replace components as necessary.
   [b] If limit values are not exceeded, continue inspection.

NOTE:
Ensure parts are perfectly clean.

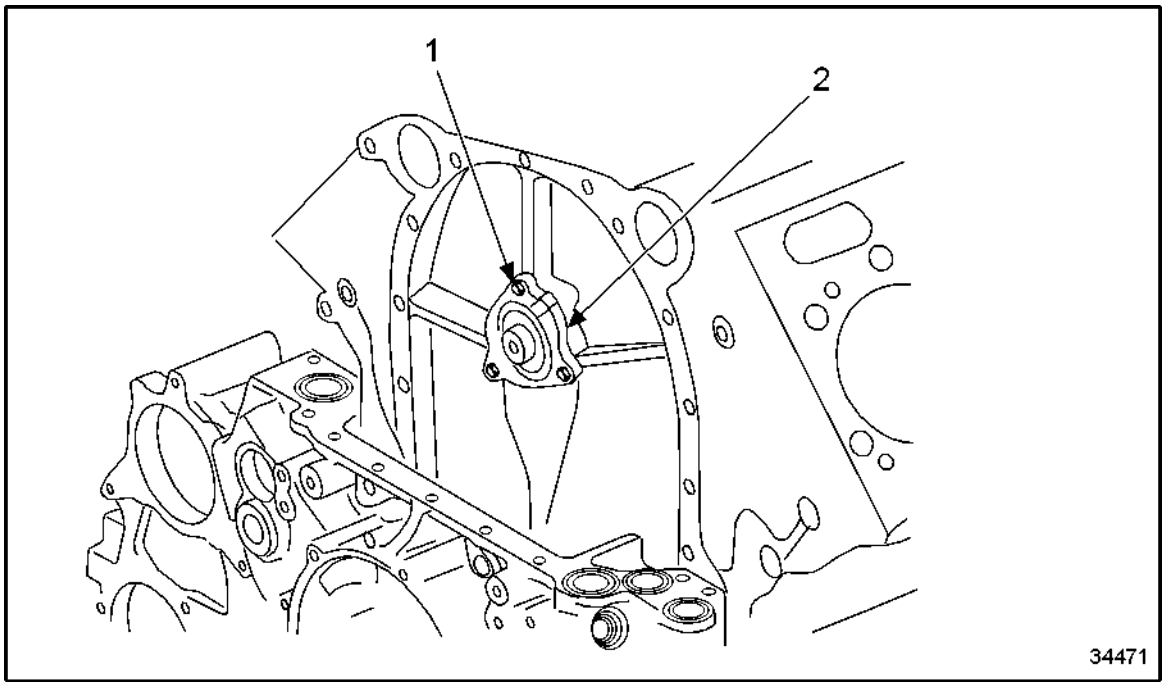
C 052.05.11 – INSTALLATION OF CAMSHAFT DRIVE

Perform the following steps to install camshaft drive:

Installing Camshaft Thrust Bearing

Perform the following steps to install the camshaft thrust bearing:

1. Coat thrust surfaces with engine oil. See Figure 422.



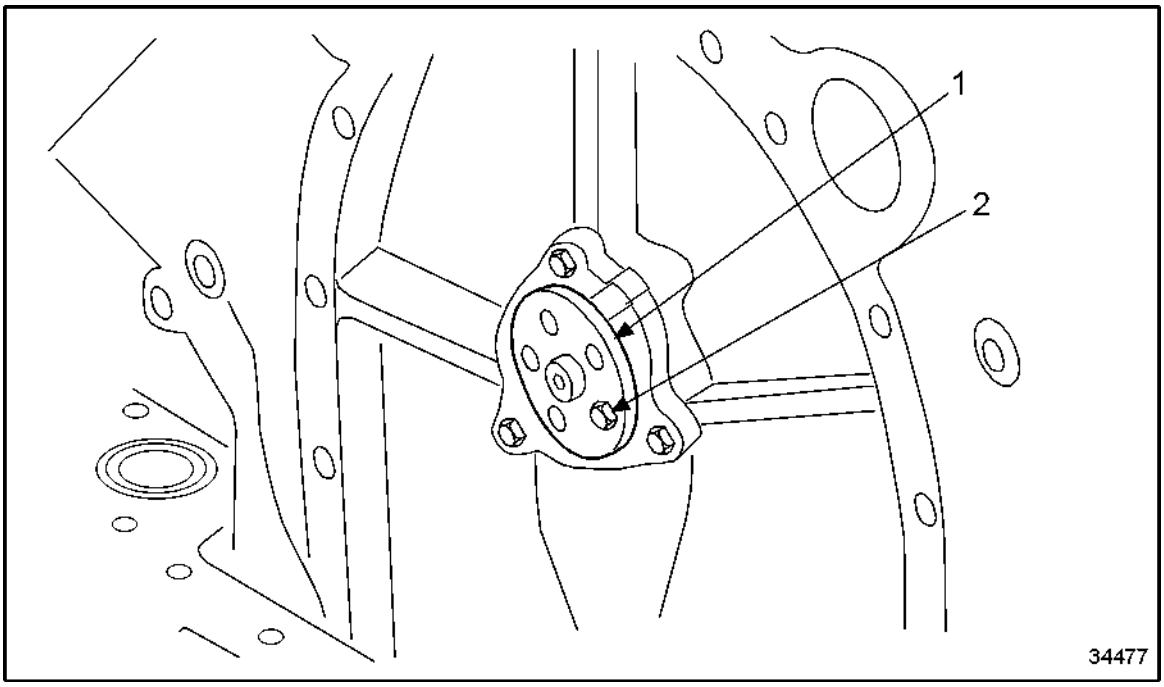
1. Ring
2. Hex Bolt

Figure 422 Coating Thrust Surfaces with Engine Oil

2. Tighten thrust bearing flange with hex bolts to specification. Refer to section A 003.

NOTE:
Cover bottom of gear case so that no screws can fall into housing.

3. Install spacer (1) with hex bolt (2) on camshaft. See Figure 423.



1. Spacer
2. Hex Bolt

Figure 423 Removing 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.

4. Turn camshaft until flywheel end of locating bore (arrow) is visible and at position shown. See Figure 424.

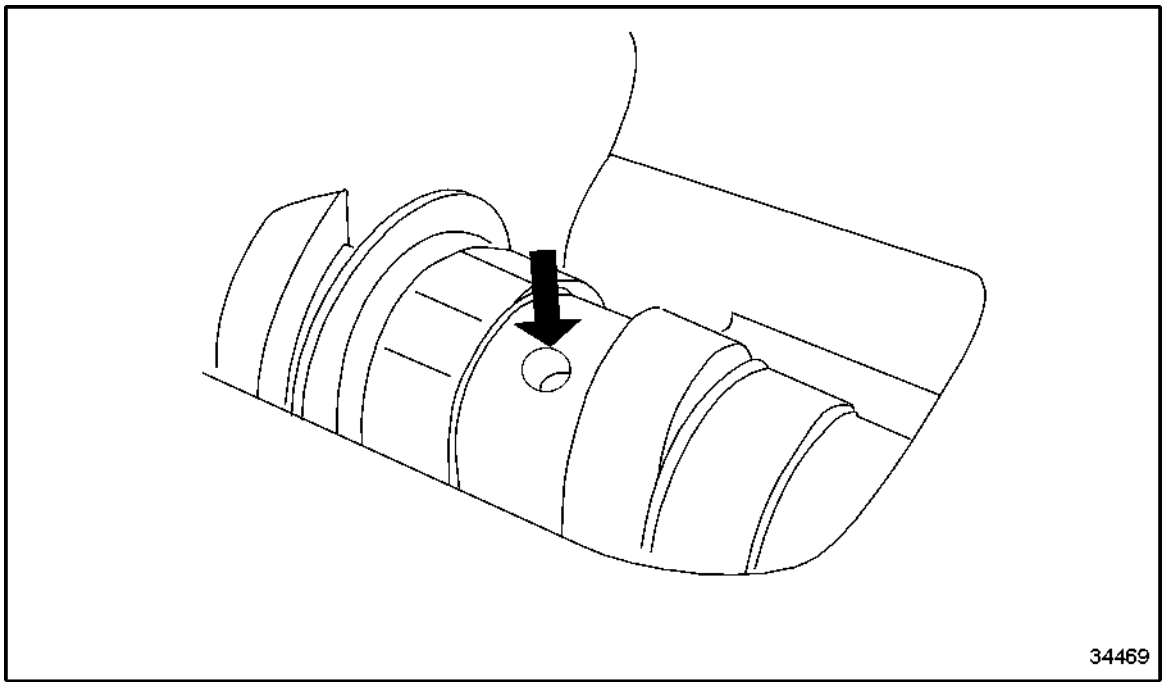
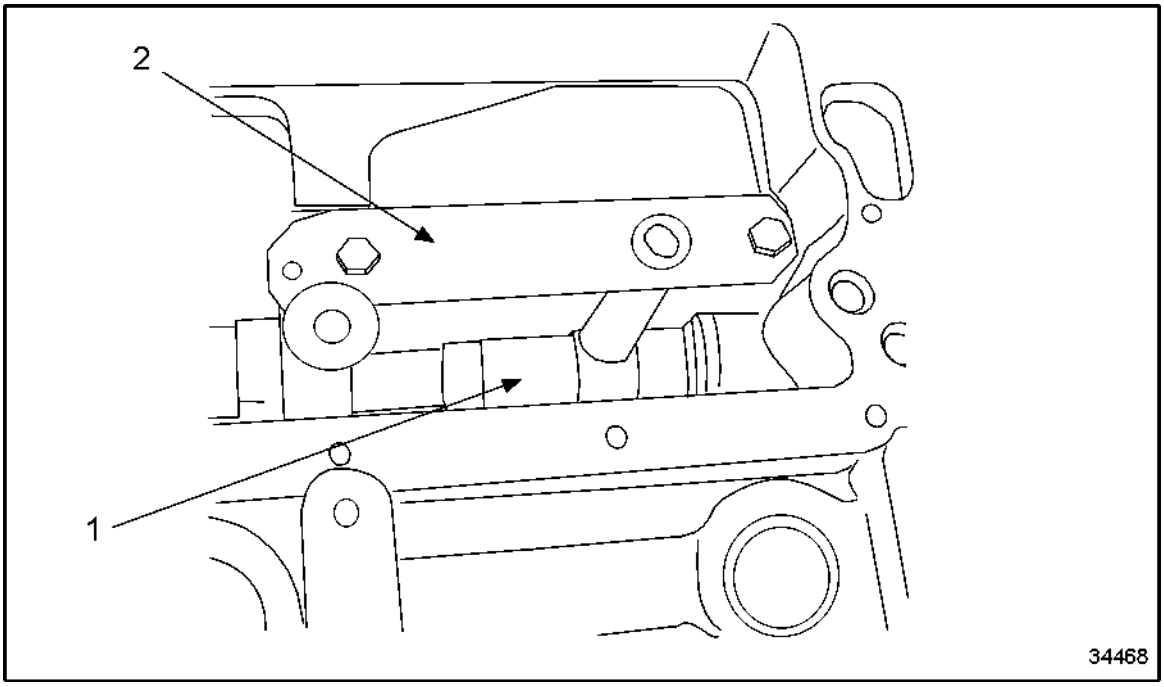


Figure 424 Locating Bore for Locating Tool

Installing Locating Tool

Perform the following steps to install locating tool:

1. Position locating tool on bolting surface of the rocker shaft (flywheel end). See Figure 425.

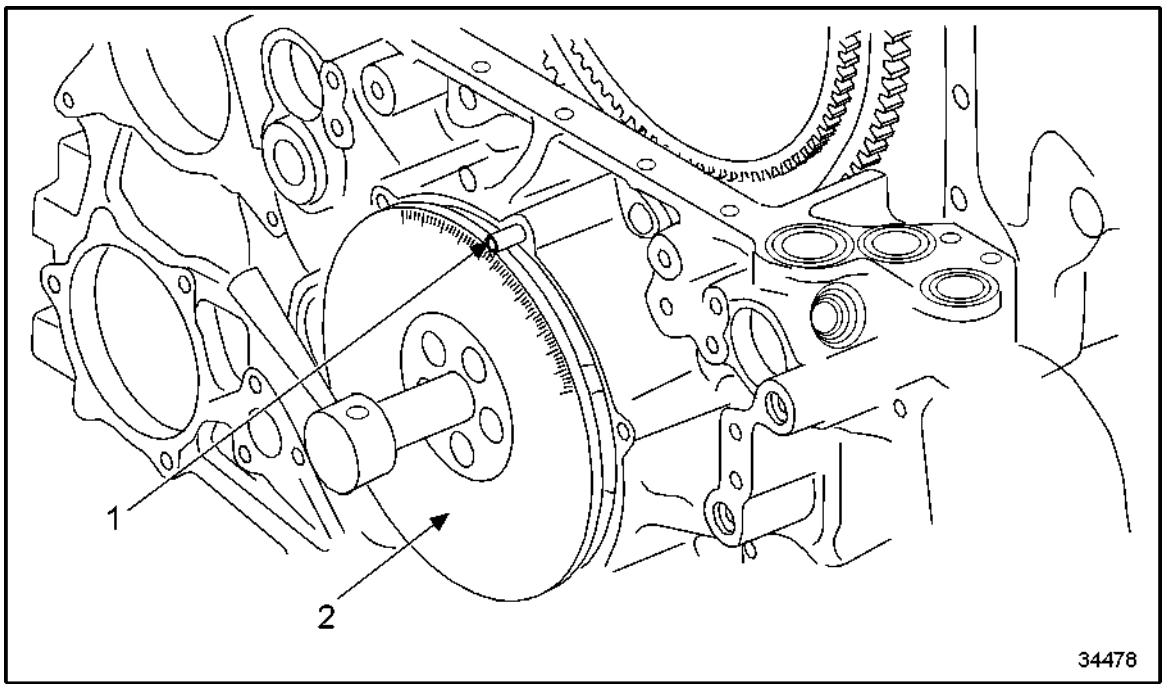


1. Camshaft
2. Locating Tool

Figure 425 Installing Locating Tool

2. Insert dowel pin of locating tool into camshaft bore and screw locating tool into place.

3. Install pointer (1) on gear case. See Figure 426.

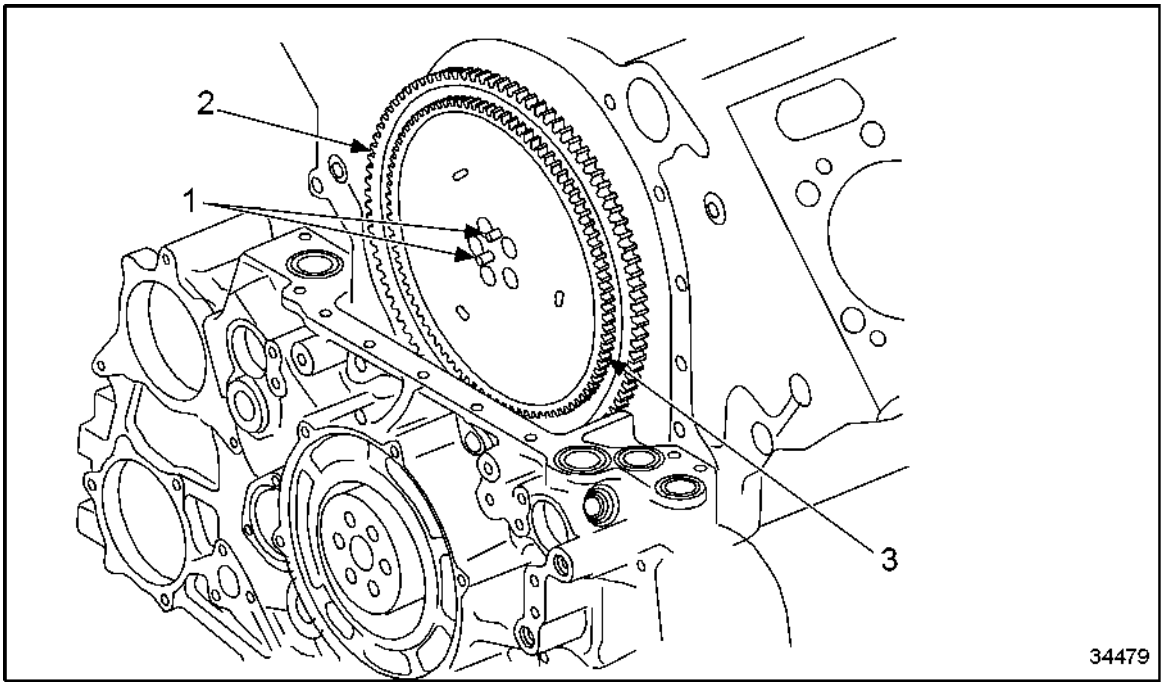


1. Pointer
2. Index Plate

Figure 426 Installing Pointer on Gear Case

4. Install index plate (2) with barring tool on crankshaft, set to TDC marking of A1 and tighten.
5. Set piston A1 to firing TDC. Refer to section C 037.05.05.
6. Insert camshaft gear (2) into camshaft so that dowel pins (1) engage camshaft gear bore in a vertical line; be sure there is gear lash in both directions.

7. Install SRS wheel (3) via dowel pins. See Figure 427.

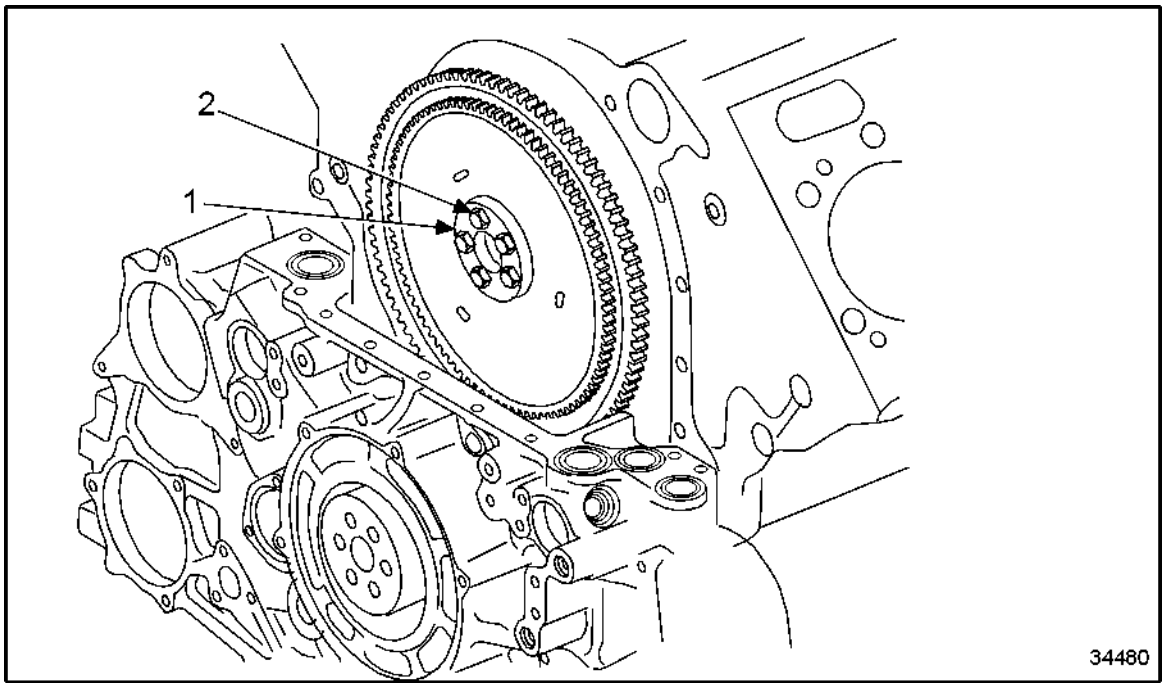


1. Dowel Pin
2. Camshaft Gear
3. SRS Wheel

Figure 427 Installing SRS Wheel via Dowel Pins

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

8. Remove all gear lash in the direction of rotation before tightening the bolts.
9. Refer to sectionC 052.05.01to screw in ring (1) and tighten with hex bolts (2). See Figure 428.



1. Spacer
2. Hex Bolt

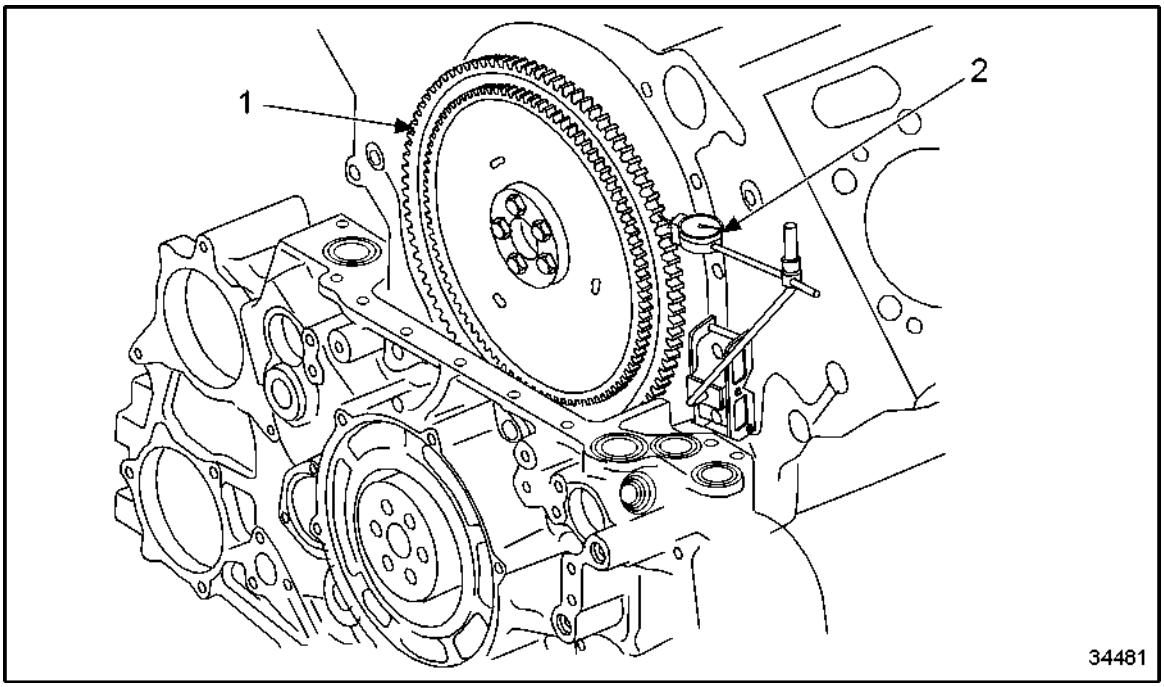
Figure 428 Screwing in and Tightening Spacer with Hex Bolts

NOTE:
Ensure that dowel pin and bolt bores are aligned.

Measuring Backlash

Perform the following steps to measure backlash:

1. Mount magnetic dial gage holder with dial gage on gear case end of cylinder block. See Figure 429.



1. Camshaft Gear
2. Magnetic Dial Gage

Figure 429 Mounting Magnetic Dial Gage Holder

2. Position dial gage stylus with low preload on one tooth flank of camshaft gear.
3. Set dial gage to zero.
4. Check backlash by moving camshaft gear back and forth.
5. For backlash, refer to section C 024.05.

Measuring Camshaft End Play

Perform the following steps to measure camshaft end play:

1. Mount magnetic dial gage holder with dial gage on gear case end of cylinder block. See Figure 430.

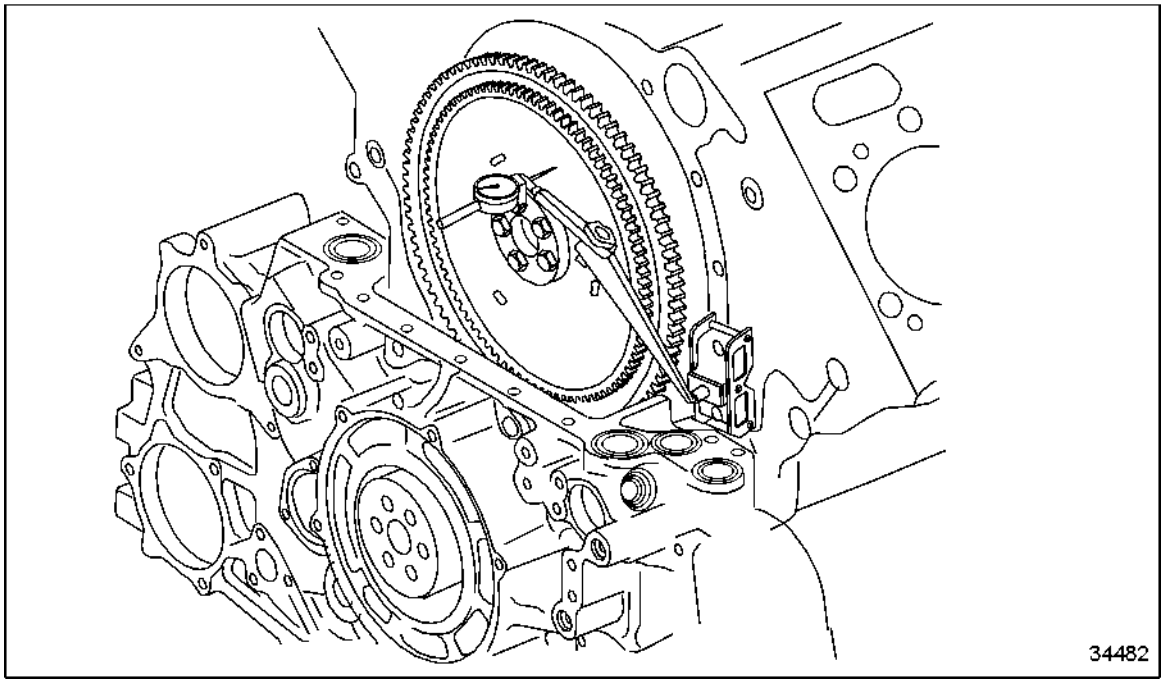


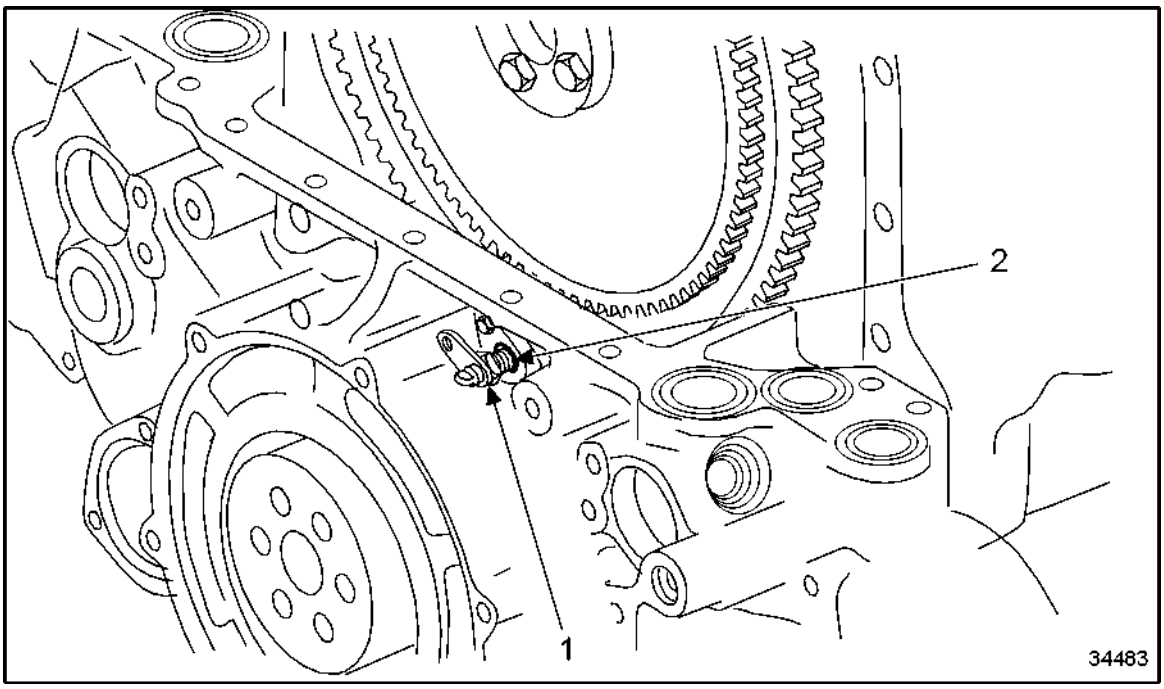
Figure 430 Measuring Camshaft End Play

2. Place dial gage stylus on SRS wheel.
3. Push camshaft on camshaft gear horizontally as far as it will go.
4. Set dial gage with preload to zero.
5. Move camshaft from stop to stop and record measured value (end play).
6. For axial clearance, refer to section C 024.05.
7. For measuring camshaft timing and valve stroke, refer to section C 051.05.11.

Installing SRS Sensor

Perform the following steps to install SRS sensor:

1. Replace O-ring (2) and coat with petroleum jelly. See Figure 431.



1. SRS Sensor
2. O-ring

Figure 431 Installing SRS Sensor

2. Turn SRS sensor (1) slightly to install in housing bore; if shims had previously been installed, re-install those shims.
3. Screw in hex bolt.

Checking SRS Sensor Clearance

Perform the following steps to check SRS sensor clearance:

1. Pull camshaft on camshaft gear axially (large arrow) as far as it will go. See Figure 432.

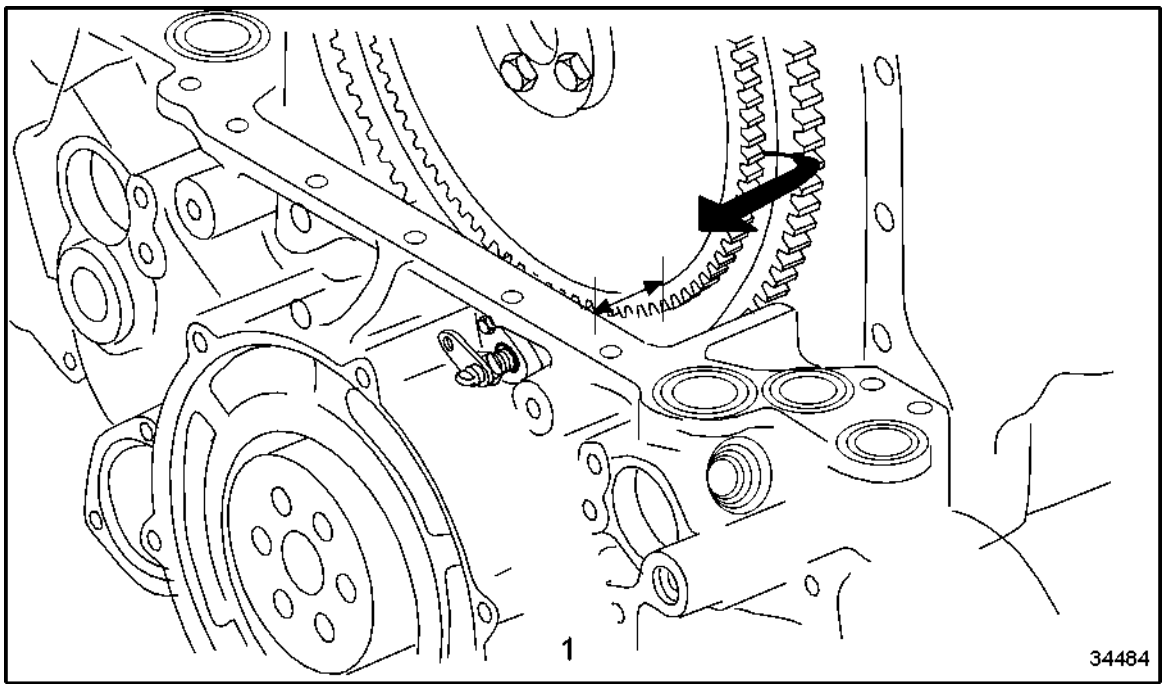


Figure 432 Checking SRS Sensor Clearance

2. Measure distance (smaller arrows); specified value is 0.3 mm to 1 mm
3. If distance is less than 0.3 mm, fit appropriate number of adjusting shims of 0.3 mm thickness.
4. Measure distance.

C 052.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 44 are the After-Installation Operations for the camshaft drive.

Level of Maintenance	Operation	Reference
1, 2 ,3	Install pushrods	Refer to section C 055.05.11
1, 2 ,3	Install valve gear	Refer to section C 055.05.11
1, 2 ,3	Install rocker covers	Refer to section C 056.05.11
1, 2 ,3	Install oil heat exchanger with coolant distribution housing and thermostat	Refer to section C 185.05.11
1, 2 ,3	Install turbocharger	Refer to section C 101.05.11
1, 2 ,3	Install oil supply line for turbochargers	Refer to section C 187.05.11
1, 2 ,3	Install oil return lines for turbochargers	Refer to section C 188.05.11
1, 2 ,3	Install coolant lines	Refer to section C 203.05.11
1, 2 ,3	Install charge air coolant vent lines	Refer to section C 205.05.11
1, 2 ,3	Install engine coolant vent lines	Refer to section C 205.05.11
1, 2 ,3	Install charge air coolant lines (low temperature)	Refer to section C 207.05.11
1, 2 ,3	Install intake air system from turbocharger to charge air cooler	Refer to sectionC 125.05.11
1, 2 ,3	Install Y-pipe at exhaust outlet housing	Refer to section C 141.05.11
1, 2 ,3	Install vibration damper (if removed)	Refer to section C 035.05.11
1, 2 ,3	Install engine carrier, gear case end	Refer to section C 231.05.11
1, 2 ,3	Install fan drive	Refer to section C 221.05.11
1, 2 ,3	Fill charge air coolant system	Operator Guide
1, 2 ,3	Fill engine coolant system	Operator 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.

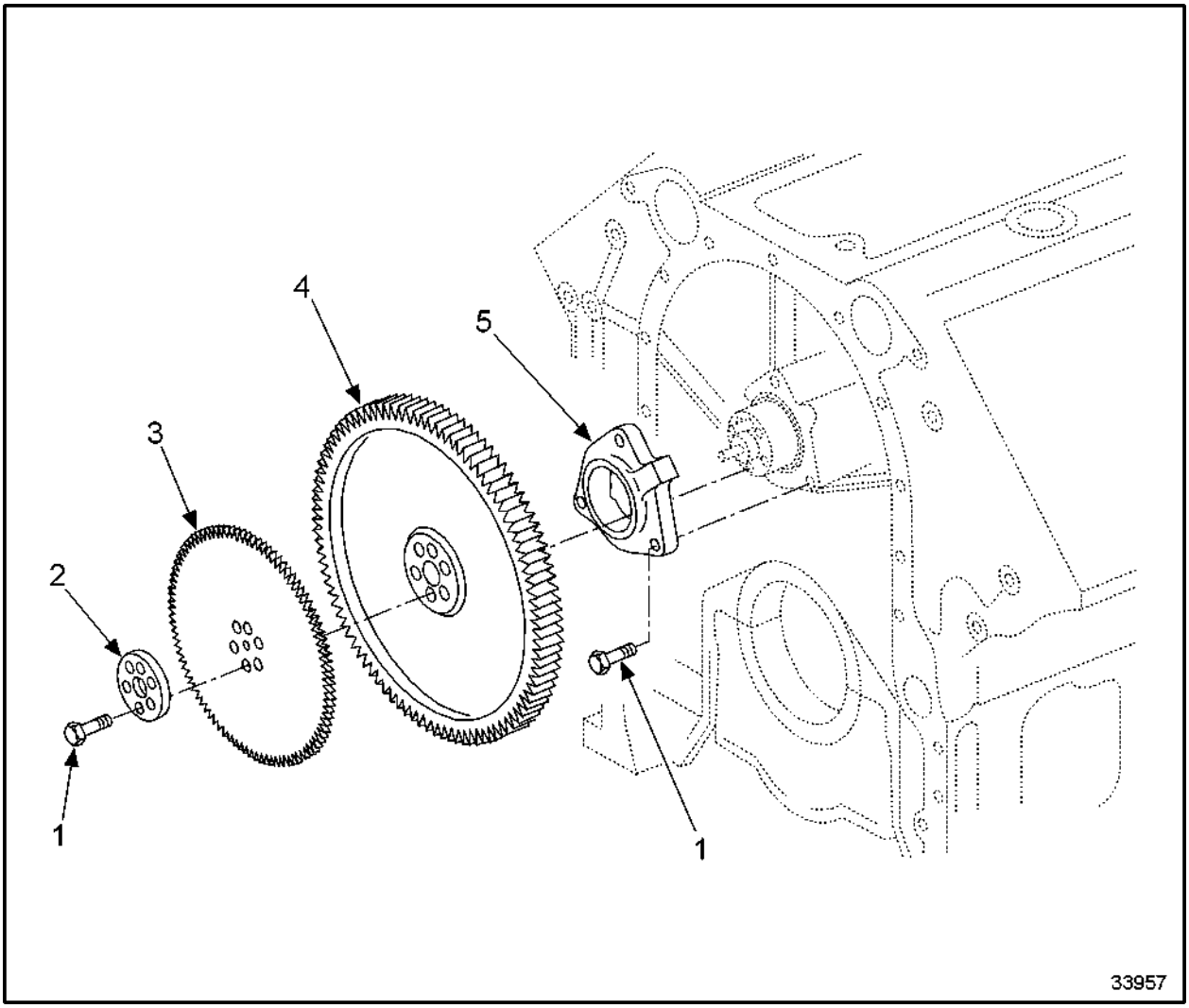
3 = The engine is to remain installed.

Table 44 After-Installation Operations

C 053.05 – CAMSHAFT THRUST BEARING

C 053.05.01 – GENERAL VIEW

See Figure 433 for a general view of camshaft thrust bearing.



1. Screw
2. Ring
3. Metering Wheel
4. Camshaft Gear
5. Thrust Bearing Flange

Figure 433 General View of Camshaft Thrust Bearing

C 053.05.02 – SPECIAL TOOLS

Listed in Table 45 are the special tools required for maintenance on the camshaft thrust bearing.

Application	Number
Piston measuring device	—
Index plate with pointer	—
Camshaft locating device	—

Table 45 Special Tools

C 053.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 46 are the Before-Removal Operations for the camshaft thrust bearing.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Removal of camshaft thrust bearing not scheduled	-
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain charge air coolant	Refer to section C 206.05.05
1, 2, 3	Remove fan drive	Refer to section C 221.05.05
1, 2, 3	Remove engine carrier, gear case end	Refer to section C 231.05.05
1, 2, 3	Remove vibration damper (as required)	Refer to section C 035.05.05
1, 2, 3	Remove Y-pipe from exhaust outlet housing	Refer to section C 141.05.05
1, 2, 3	Remove intake air system from turbocharger to charge air cooler	Refer to section C 125.05.05
1, 2, 3	Remove oil supply lines for turbochargers	Refer to section C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05
1, 2, 3	Remove exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove charge air coolant lines (low temperature)	Refer to section C 207.05.05
1, 2, 3	Remove engine coolant vent line	Refer to section C 205.05.05
1, 2, 3	Remove charge air coolant vent lines	Refer to section C 205.05.05
1, 2, 3	Remove coolant lines	Refer to section C 203.05.05
1, 2, 3	Remove oil heat exchanger with coolant distribution housing and thermostat	Refer to section C 185.05.05
1, 2, 3	Remove valve covers	Refer to section C 056.05.05
1, 2, 3	Remove valve gear	Refer to section C 055.05.05
1, 2, 3	Remove pushrods	Refer to section C 055.05.05

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 46 Before-Removal Operations

C 053.05.05 – REMOVAL OF CAMSHAFT THRUST BEARING

Removing Camshaft Thrust Bearing

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.

Perform the following steps to remove the camshaft thrust bearing:

1. Using barring tool, turn engine in normal direction of rotation until TDC mark and arrow on flywheel housing are aligned. See Figure 434.

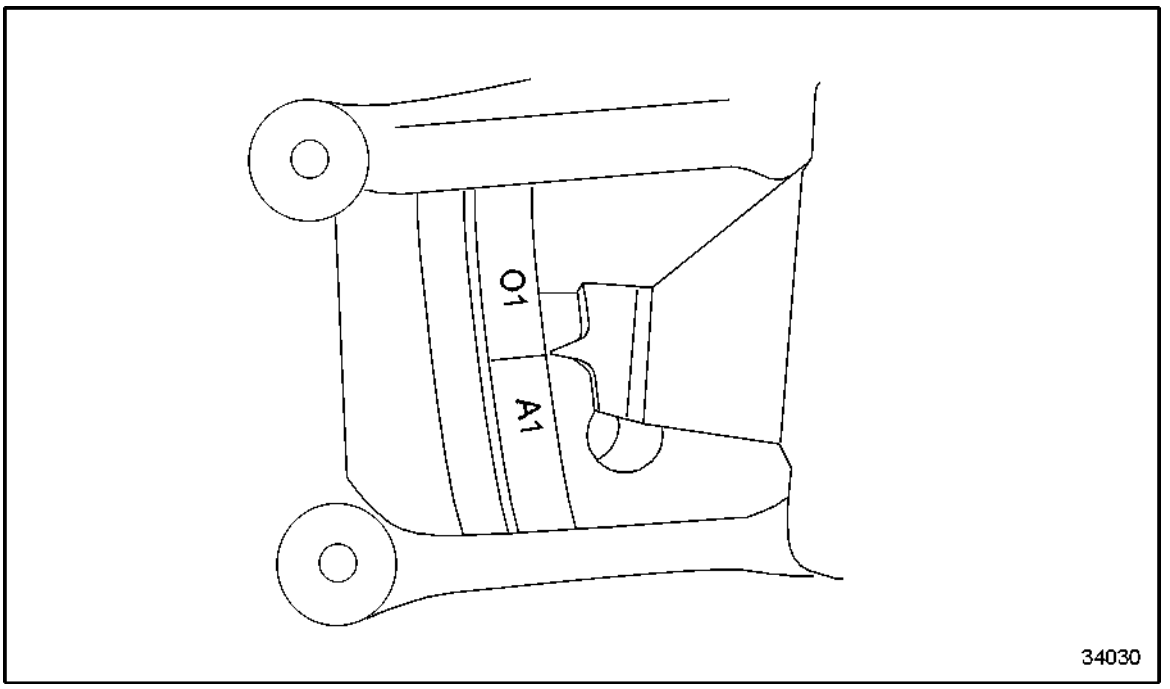
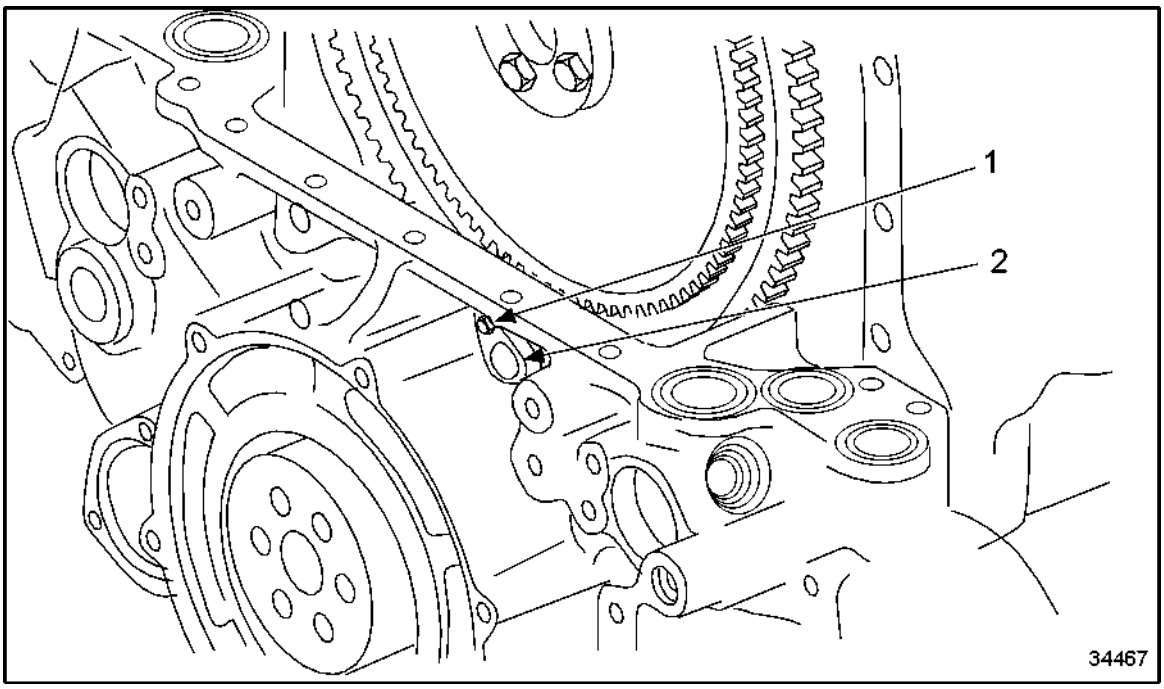


Figure 434 Removing Camshaft Thrust Bearing (Marine only)

2. If rocker arms on cylinder A1 are unloaded, the piston is in firing TDC.
3. If rocker arms on cylinder A1 are loaded, the piston is in overlap TDC.
4. Remove valve drive. Refer to section C 055.05.05.
5. On DDEC engines, use a dial gage in the A1 cylinder kit to determine TDC. Refer to section C 037.05.05.

6. Separate electrical plug-in connection. See Figure 435.



1. Hex Bolt
2. SRS Sensor

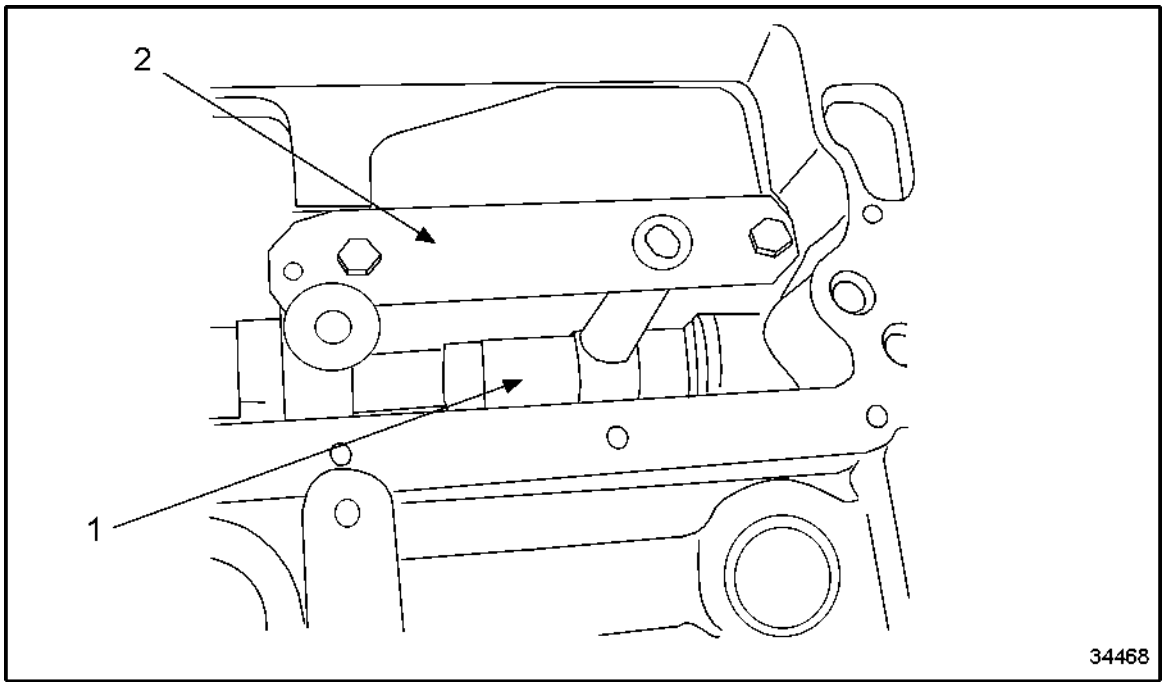
Figure 435 Turning SRS Sensor

7. Remove hex bolt (1).
8. Turn SRS sensor (2) slightly to remove from housing bore.
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 436.



1. Camshaft
2. Locating Tool

Figure 436 Removing SRS Wheel

2. Insert dowel pin of locating tool (2) into camshaft bore and bolt locating tool into place. See Figure 437.

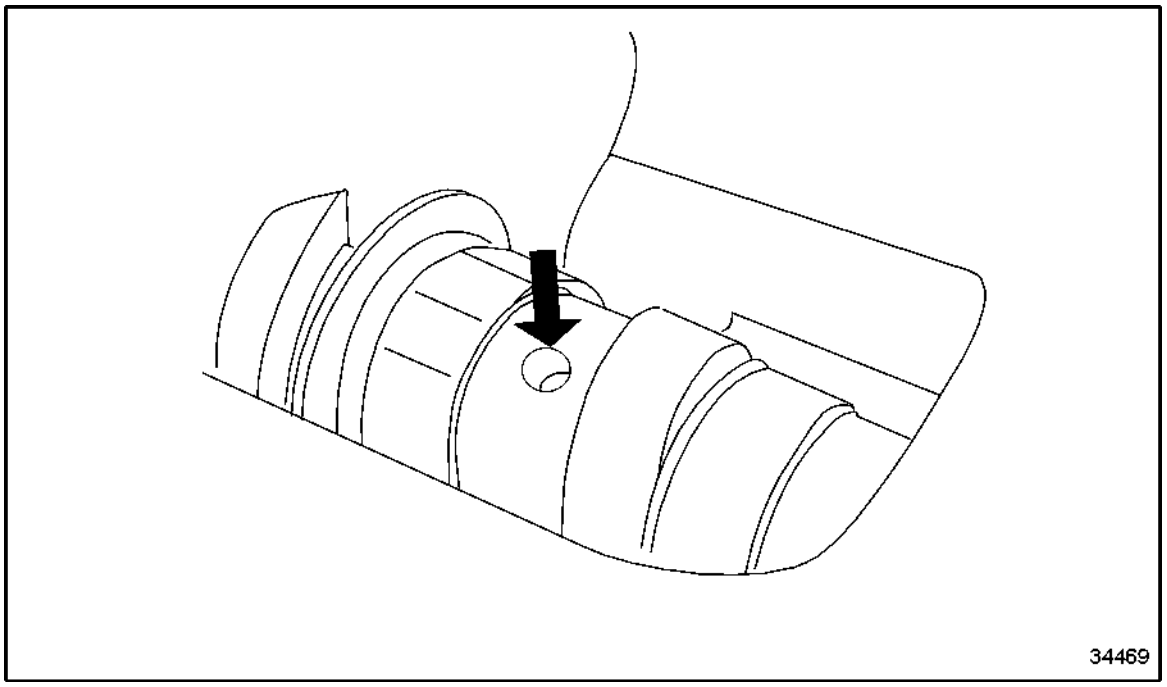
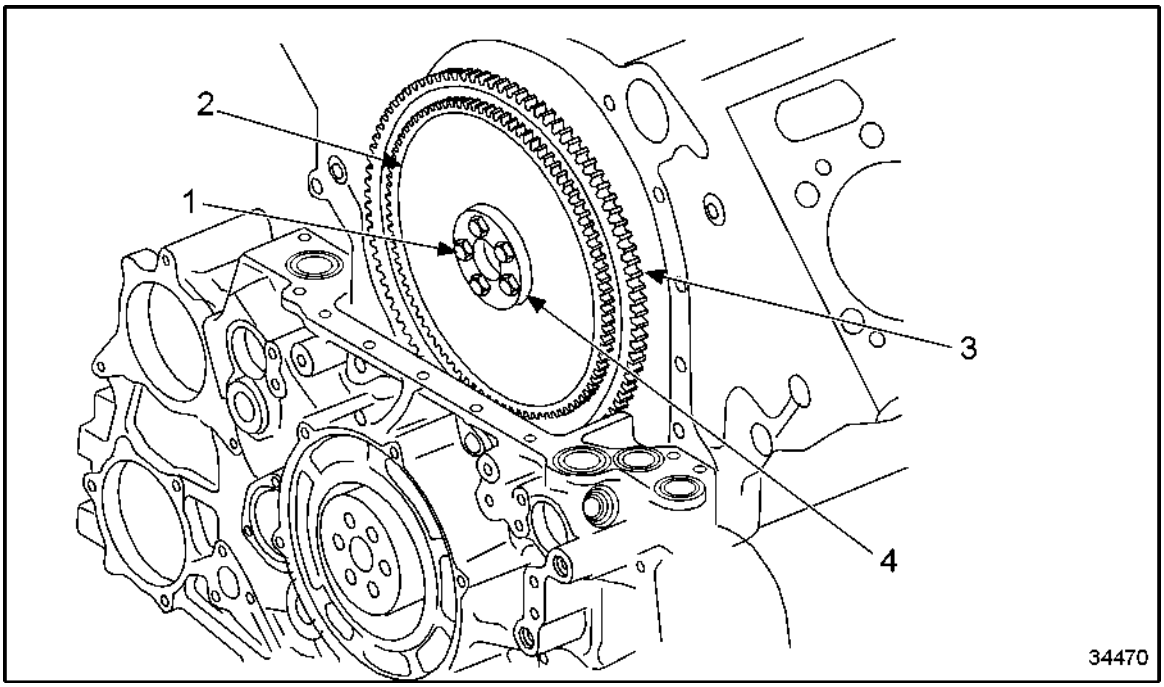


Figure 437 Locating Bore for Locating Tool

3. Locate bore (arrow) for locating tool pin.
4. Remove hex bolts (1), spacer (4), SRS wheel (2) and camshaft gear (3) from camshaft. See Figure 438.

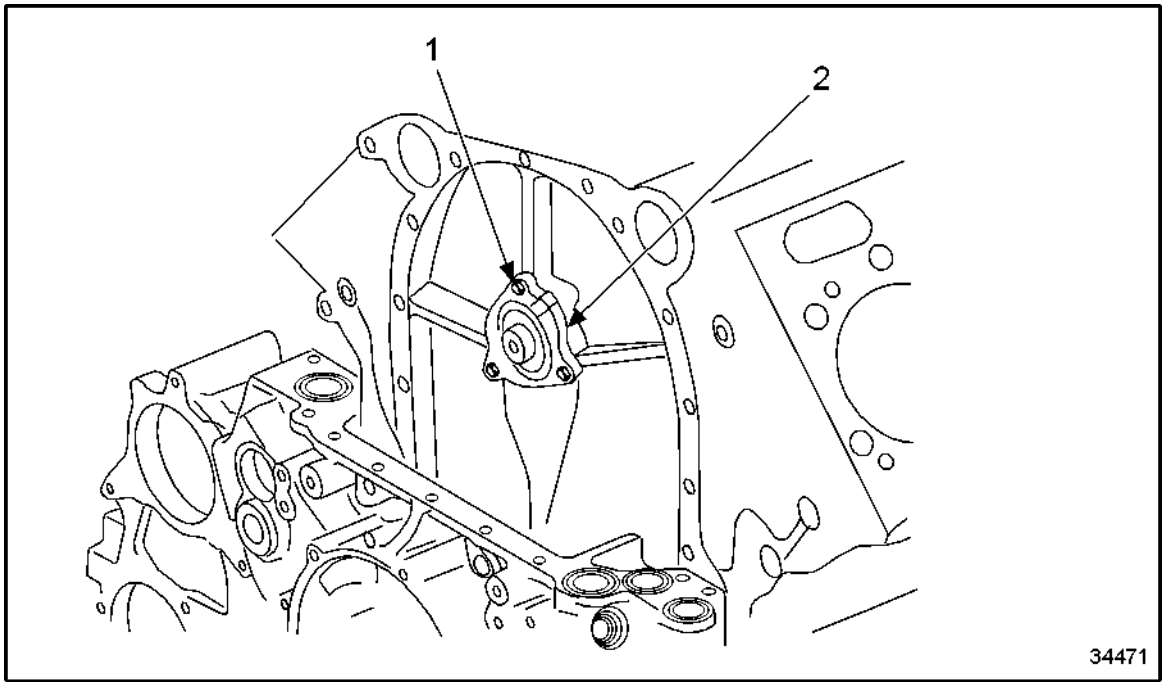


1. Hex Bolt
2. SRS Wheel
3. Camshaft Gear
4. Spacer

Figure 438 Removing Hex Bolts, Spacer, SRS Wheel and Camshaft Gear

NOTICE:
To prevent gear damage, cover bottom of gear case so that no bolts can fall into housing.

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 053.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the camshaft thrust bearing:

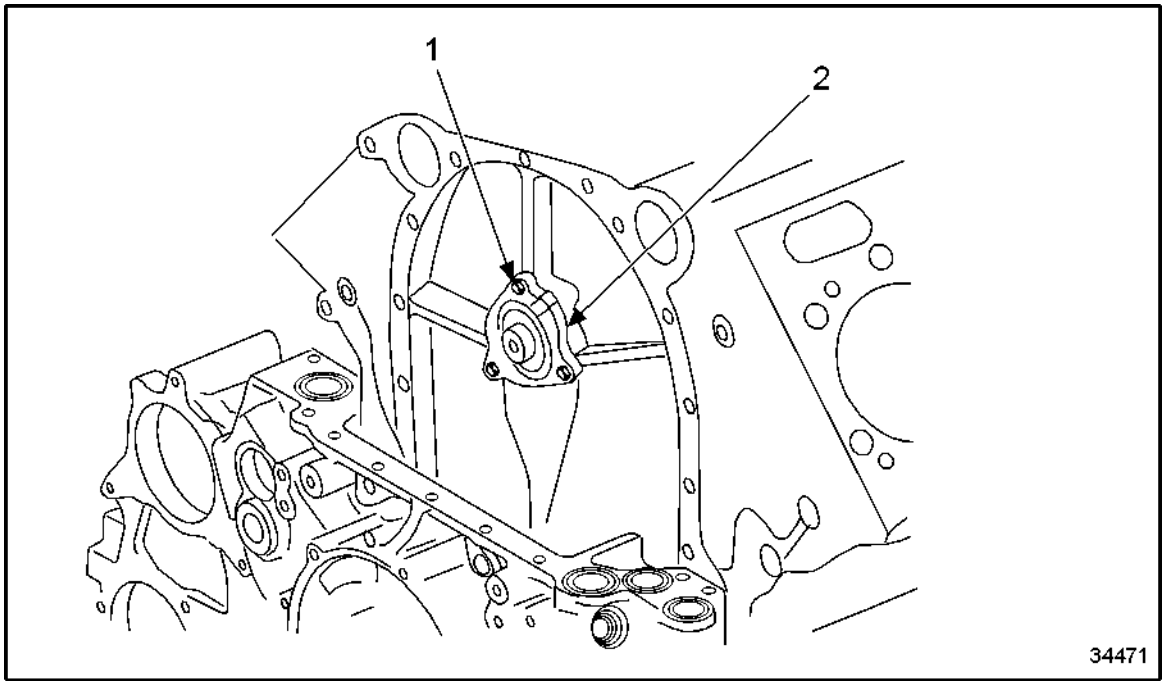
1. Clean all components.
2. Using the surface crack-testing method with red penetrant dye, inspect housing and thrust bearing flange.
   [a] If cracks are detected, replace part.
   [b] If no cracks are detected, continue inspection.
3. Inspect all mating surfaces, running surfaces and fits; rub down with oilstone or emery cloth as necessary.
4. Inspect all components for damage or excessive wear.
   [a] If damage or excessive wear is found, replace components
   [b] If no damage or excessive wear is found, continue inspection.
5. Measure camshaft thrust bearing against limit values.
   [a] If camshaft thrust bearings are outside limits, machine as necessary.
   [b] If correct limits cannot be achieved by machining, replace component
   [c] If camshaft thrust bearings are not outside limits, continue inspection.
6. Inspect thread of hex bolts for ease of movement.
   [a] If threads are damaged, replace bolts as necessary.
   [b] If no damage is found, continue inspection.

NOTE:
Make sure parts are perfectly clean.

C 053.05.11 – INSTALLATION OF CAMSHAFT THRUST BEARING

Perform the following steps to install camshaft thrust bearing.

1. Coat thrust surfaces with engine oil. See Figure 440.



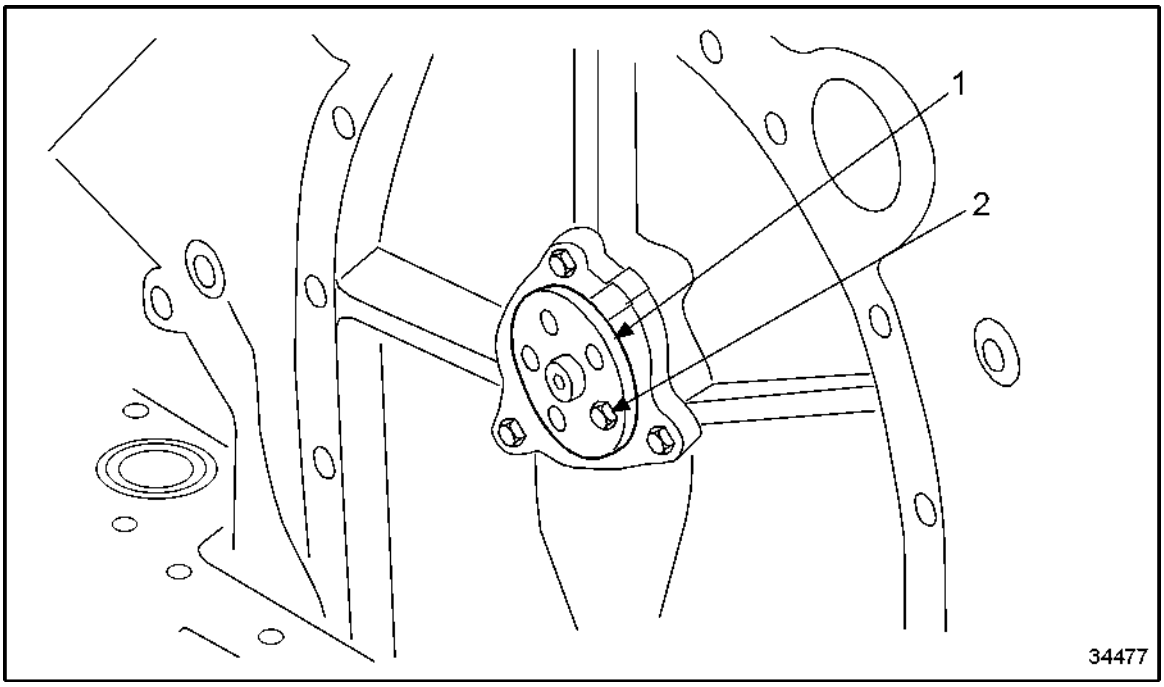
1. Hex Bolt
2. Thrust Bearing Flange

Figure 440 Removing Hex Bolts and Thrust Bearing Flange

2. Tighten thrust bearing flange with hex bolts to specification. Refer to section A 003.

NOTICE:
To avoid damage to gears, cover bottom of gear case so that no bolts can fall into housing.

3. Install spacer (1) with hex bolt (2) on camshaft. See Figure 441.



1. Spacer
2. Hex Bolt

Figure 441 Installing Ring with Hex Bolt on Camshaft

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

4. Turn camshaft until locating bore (arrow) is visible and at position shown. See Figure 442.

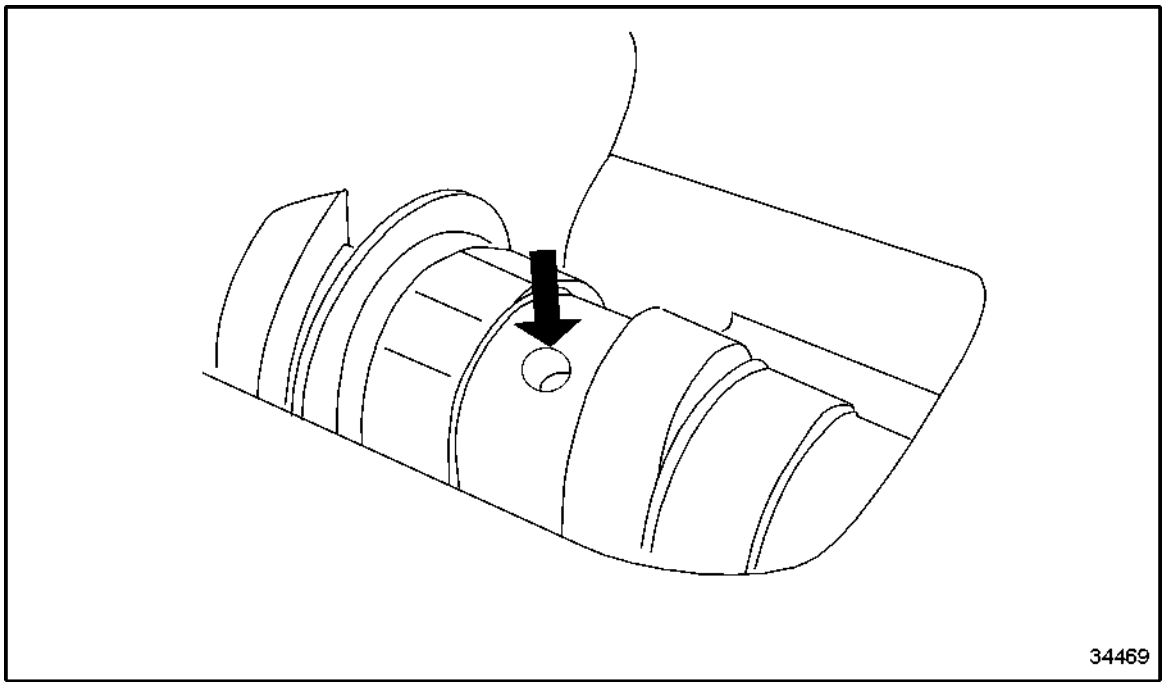
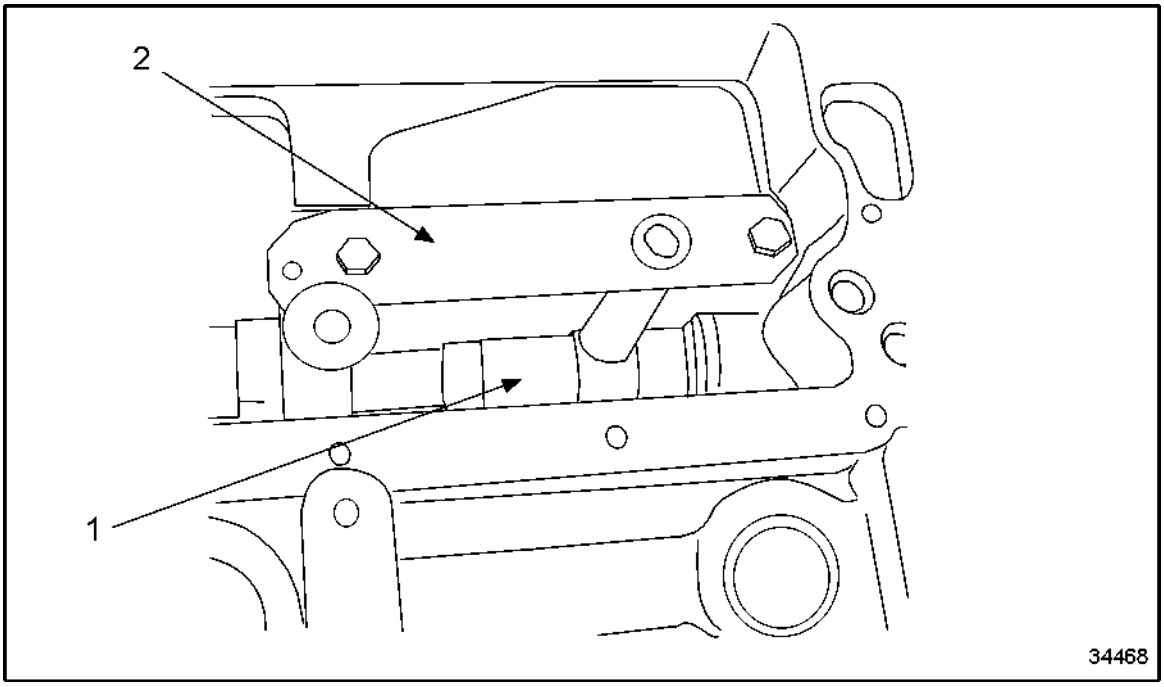


Figure 442 Locating Bore for Locating Tool

Installing Locating Tool

Perform the following steps to install locating tool:

1. Position locating tool on bolting surface of the rocker shaft (flywheel end). See Figure 443.

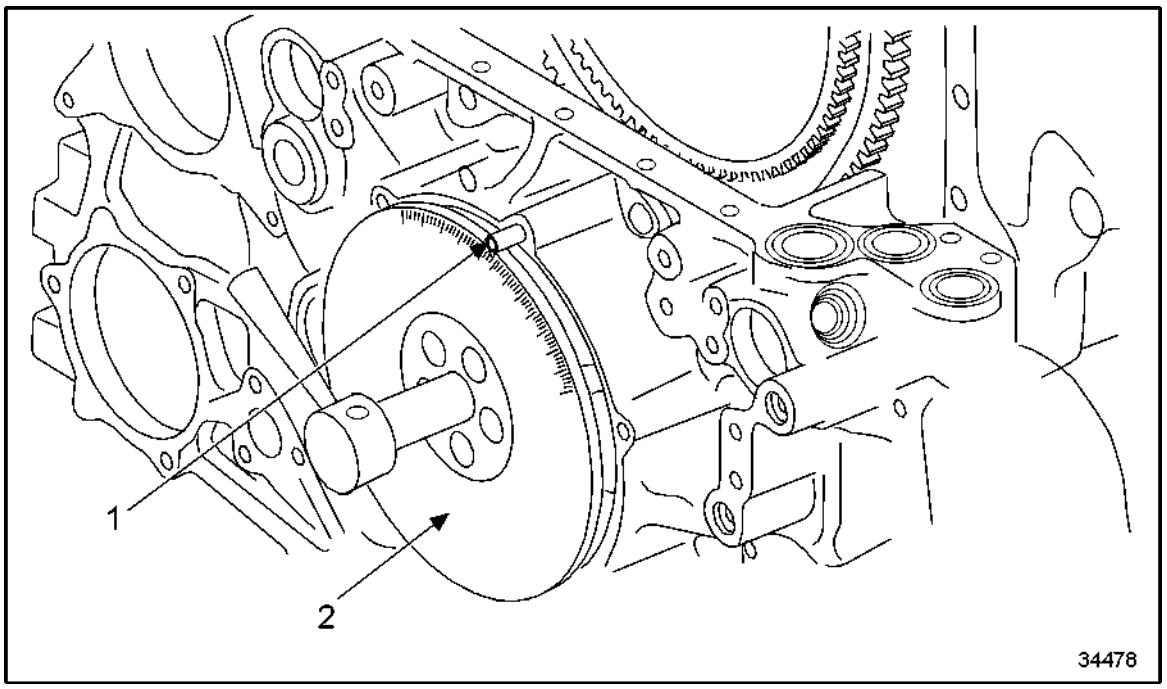


1. Camshaft
2. Locating Tool

Figure 443 Installing SRS Wheel

2. Insert dowel pin of locating tool into camshaft bore and screw locating tool into place.

3. Install pointer (1) on gear case. See Figure 444.

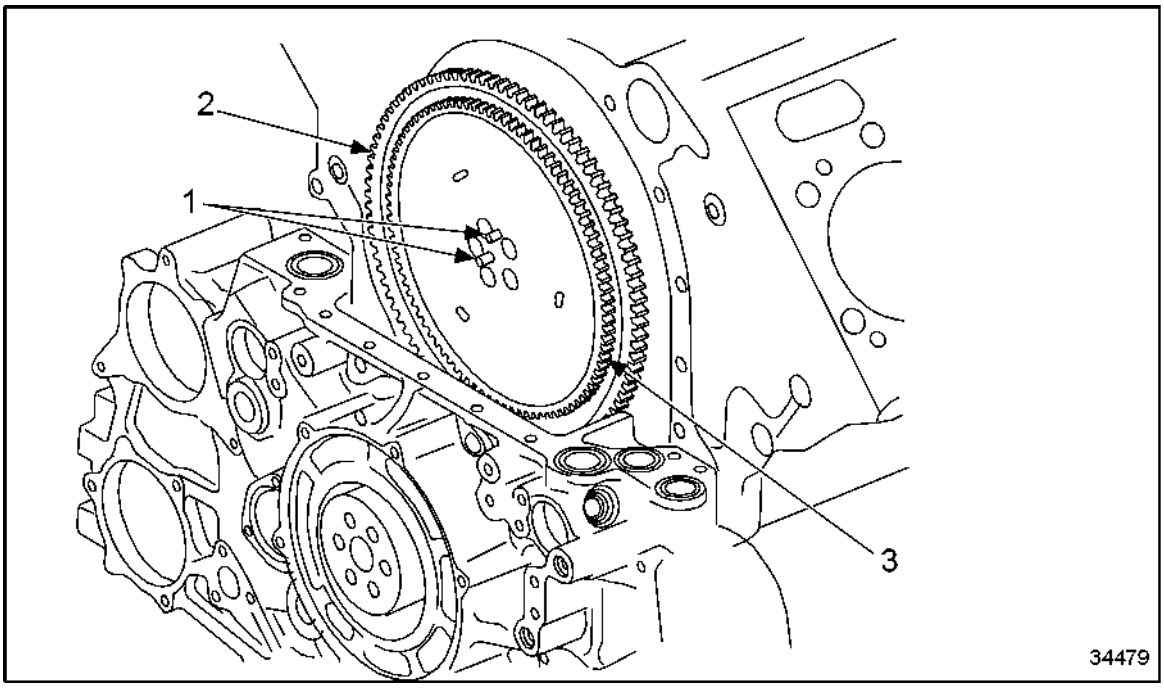


1. Pointer
2. Index Plate

Figure 444 Installing Pointer on Equipment Carrier

4. Install index plate (2) with barring tool on crankshaft, set to TDC marking of A1 and tighten.
5. Set piston A1 to firing TDC. Refer to section C 037.05.05.

6. Insert camshaft gear (2) into camshaft so that dowel pins (1) engage camshaft gear bore in a vertical line; be sure there is gear lash in both directions. See Figure 445.



1. Dowel Pin
2. Camshaft Gear
3. Graduated Disc

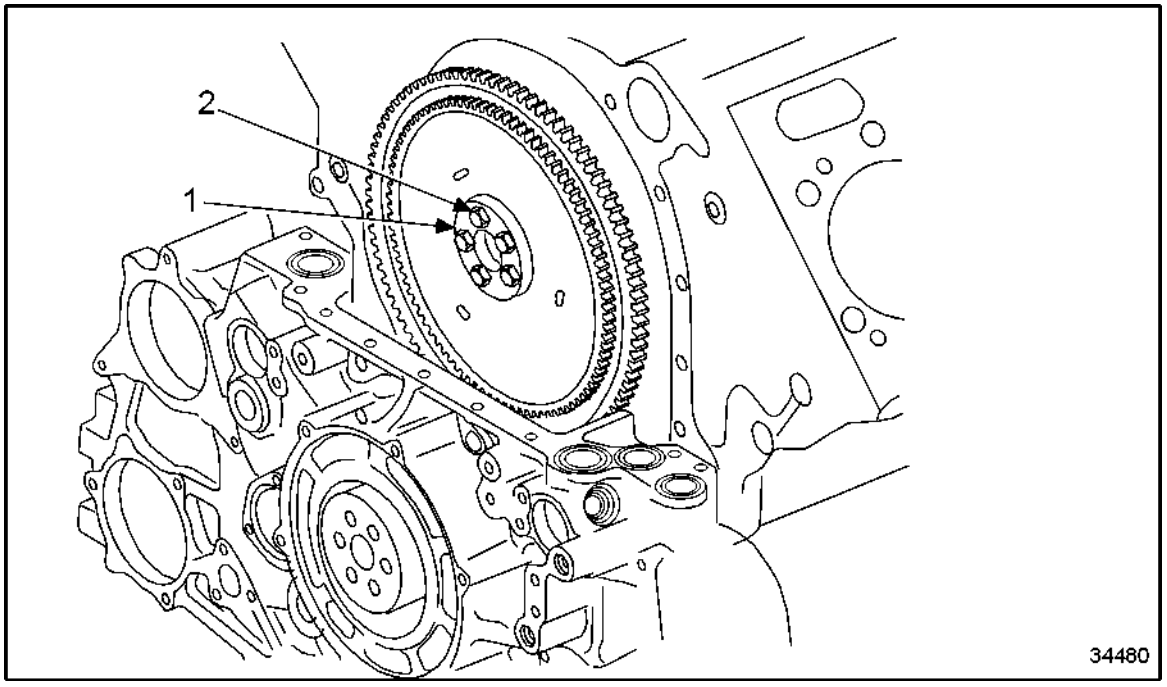
Figure 445 Installing Graduated Disc via Dowel Pins

7. Install SRS wheel (3) via dowel pins.

NOTICE:
To avoid gear damage, cover bottom of gear case so that no bolts can fall into housing.

8. Remove all gear lash in the direction of rotation before tightening the bolts.
9. Screw in ring (1) and tighten with hex bolts (2). Refer to section C 052.05.01.

NOTE:
Ensure that dowel pin and bolt bores are aligned. See Figure 446.



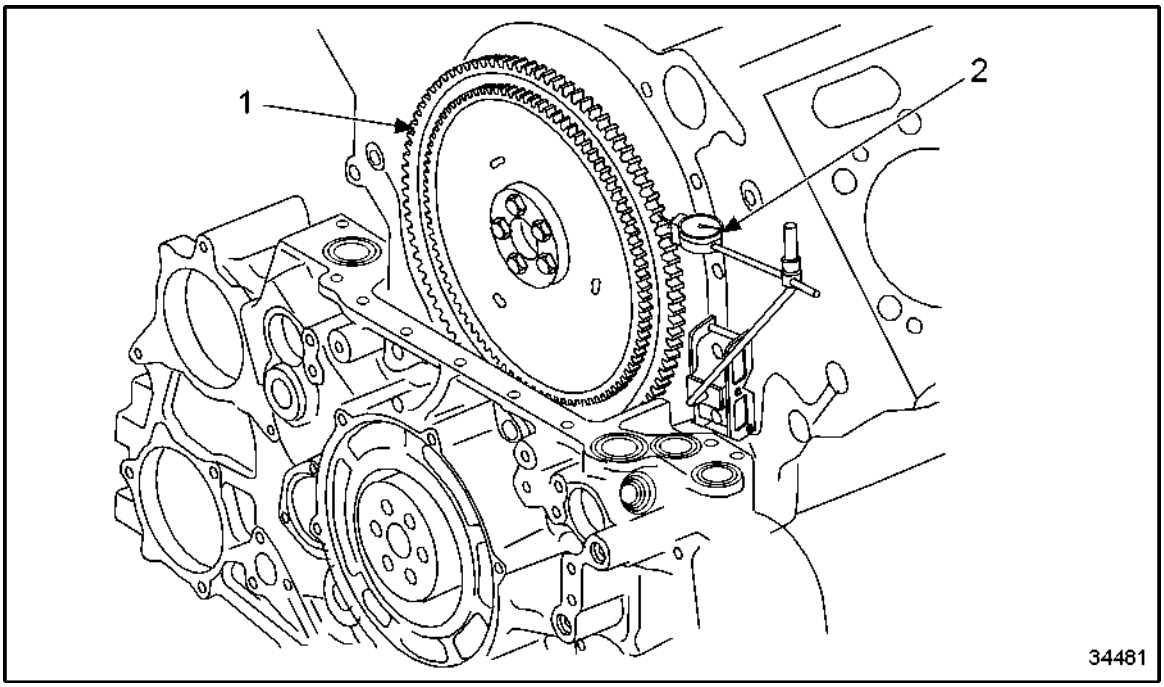
1. Spacer
2. Hex Bolt

Figure 446 Screwing in and Tightening Spacer with Hex Bolts

Measuring Backlash

Perform the following steps to measure backlash:

1. Mount magnetic dial gage holder with dial gage on gear case end of cylinder block. See Figure 447.



1. Camshaft Gear
Magnetic Dial Gage

Figure 447 Measuring Backlash

2. Position dial gage stylus with low preload on one tooth flank of camshaft gear.
3. Set dial gage to zero.
4. Check backlash by moving camshaft gear back and forth.
5. For backlash, refer to section C 024.05.

Measuring Camshaft End Play

Perform the following steps to measure camshaft end play:

1. Mount magnetic dial gage holder with dial gage on gear case end of cylinder block. See Figure 448.

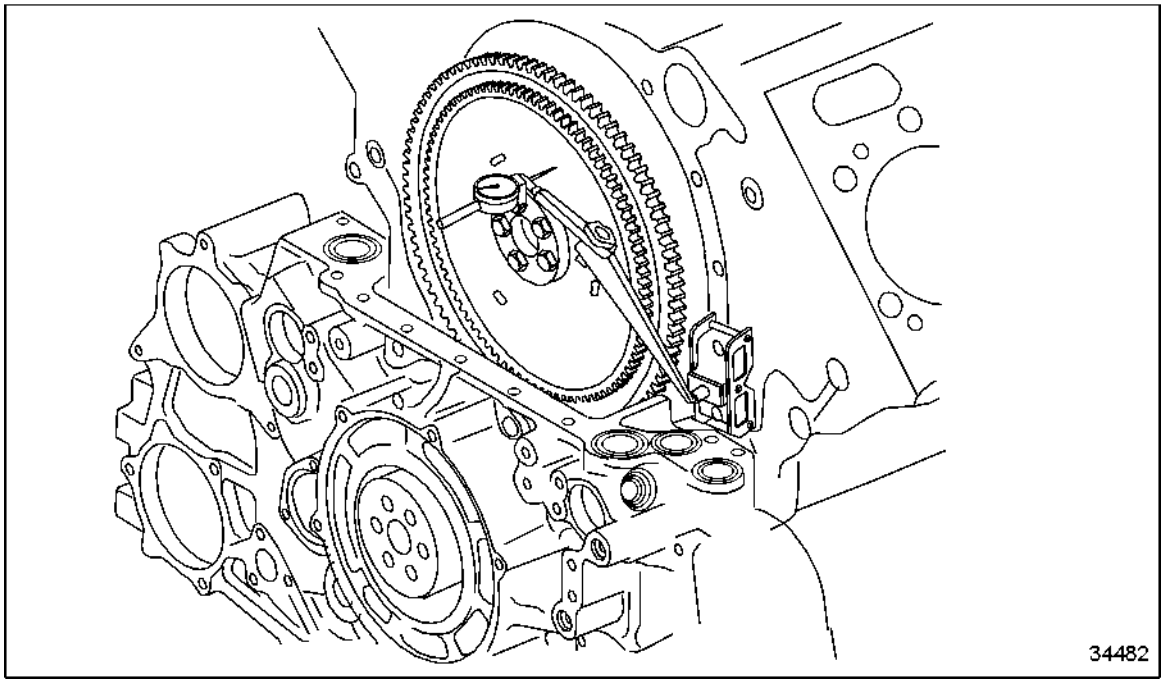


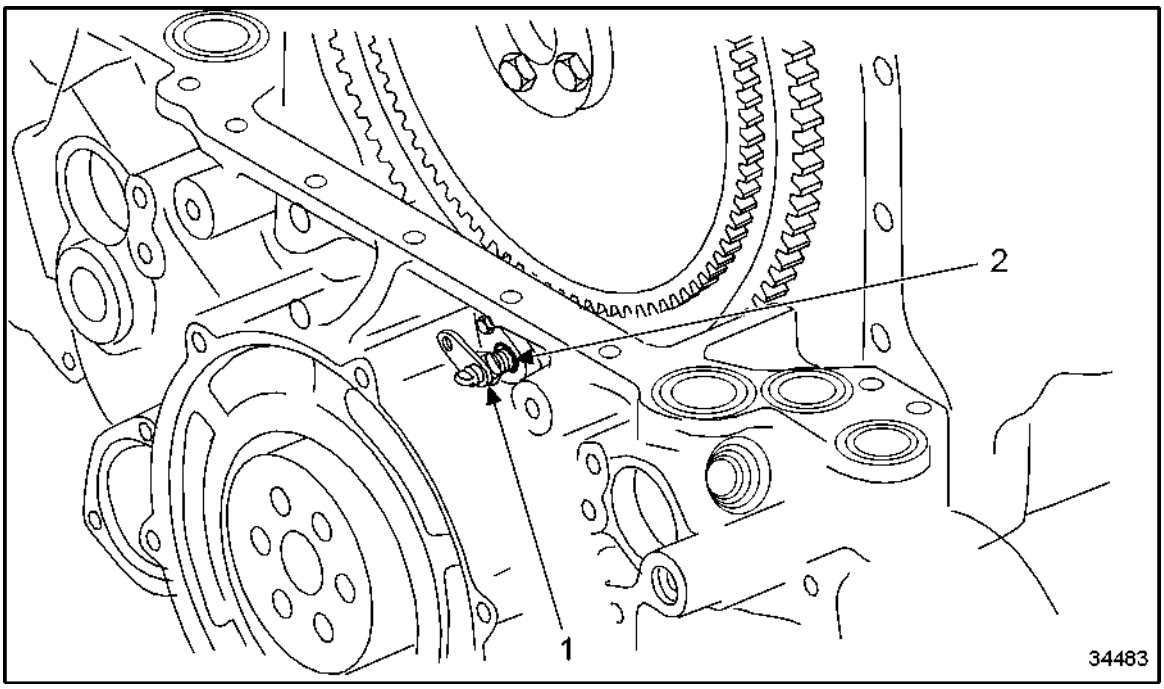
Figure 448 Measuring Camshaft End Play

2. Place dial gage stylus on SRS wheel.
3. Push camshaft on camshaft gear horizontally as far as it will go.
4. Set dial gage with preload to zero.
5. Move camshaft from stop to stop and record measured value (end play).
6. For axial clearance, refer to section C 024.05.
7. For measuring camshaft timing and valve stroke, refer to section C 051.05.11.

Installing SRS Sensor

Perform the following steps to install SRS sensor:

1. Replace O-ring (2) and coat with petroleum jelly. See Figure 449.



1. SRS Sensor
2. O-ring

Figure 449 Installing Speed Sensor

2. Turn SRS sensor slightly to install in housing bore; if shims had previously been installed, re-install those shims.
3. Screw in hex bolt.

Checking SRS Sensor Clearance

Perform the following steps to check SRS sensor clearance.

1. Pull camshaft on camshaft gear axially (large arrow) as far as it will go. See Figure 450.

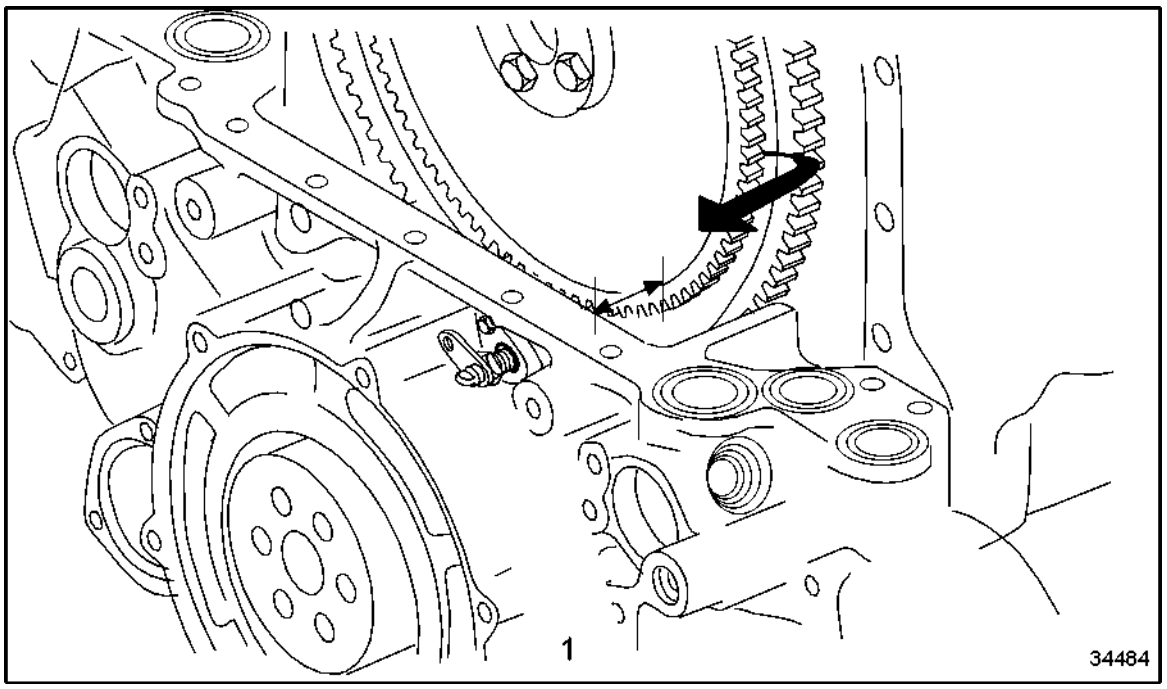


Figure 450 Checking SRS Sensor Clearance

2. Measure distance (small arrows); specified value is 0.3 mm to 1 mm.
3. If distance is less than 0.3 mm, fit appropriate number of adjusting shims of 0.3 mm thickness.
4. Measure distance.

C 053.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 47are the After-Installation Operations for the camshaft thrust bearing.

Level of Maintenance	Operation	Reference
1, 2, 3	Install pushrods	Refer to section C 055.05.11
1, 2, 3	Install valve gear	Refer to section C 055.05.11
1, 2, 3	Install valve covers	Refer to section C 056.05.11
1, 2, 3	Install oil heat exchanger with coolant distribution housing and thermostat	Refer to section C 185.05.11
1, 2, 3	Install turbocharger	Refer to section C 101.05.11
1, 2, 3	Install oil supply line for turbochargers	Refer to section C 187.05.11
1, 2, 3	Install oil return lines for turbochargers	Refer to section C 188.05.11
1, 2, 3	Install coolant lines	Refer to section C 203.05.11
1, 2, 3	Install charge air coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install engine coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install charge air coolant lines (low temperature)	Refer to section C 207.05.11
1, 2, 3	Install intake air system from turbocharger to intercooler	Refer to sectionC 125.05.11
1, 2, 3	Install Y-pipe at exhaust outlet housing	Refer to section C 141.05.11
1, 2, 3	Install vibration damper (if removed)	Refer to section C 035.05.11
1, 2, 3	Install engine carrier (gear case)	Refer to section C 231.05.11
1, 2, 3	Install fan drive	Refer to section C 221.05.11
1, 2, 3	Fill charge air coolant system	Refer to section C 206.05.11
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Enable engine start	Refer to Operators Guide

1 = The engine is to be completely disassembled.

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

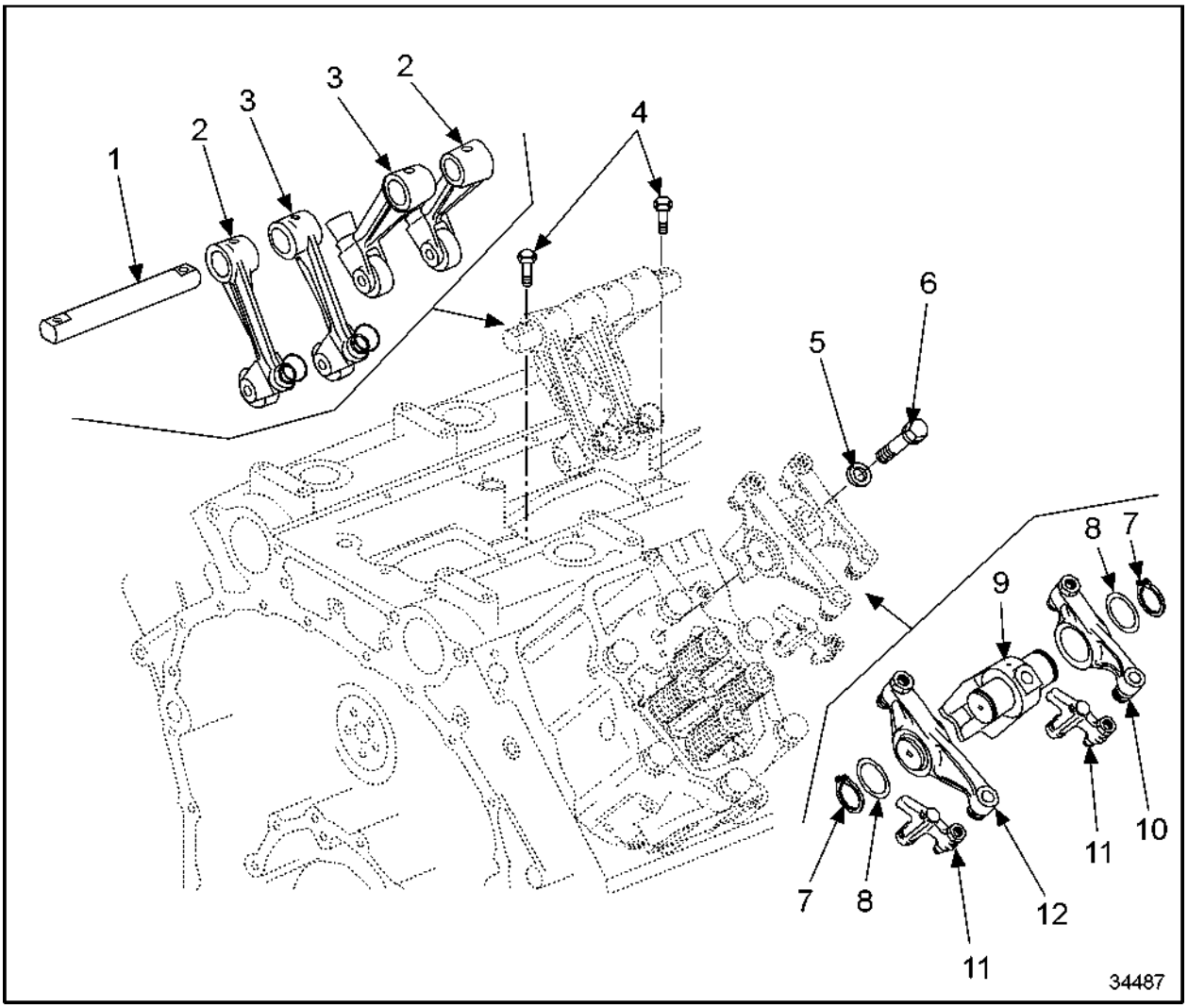
3 = The engine is to remain installed.

Table 47 After-Installation Operations

C 055.05 – VALVE OPERATING MECHANISM

C 055.05.01 – GENERAL VIEW

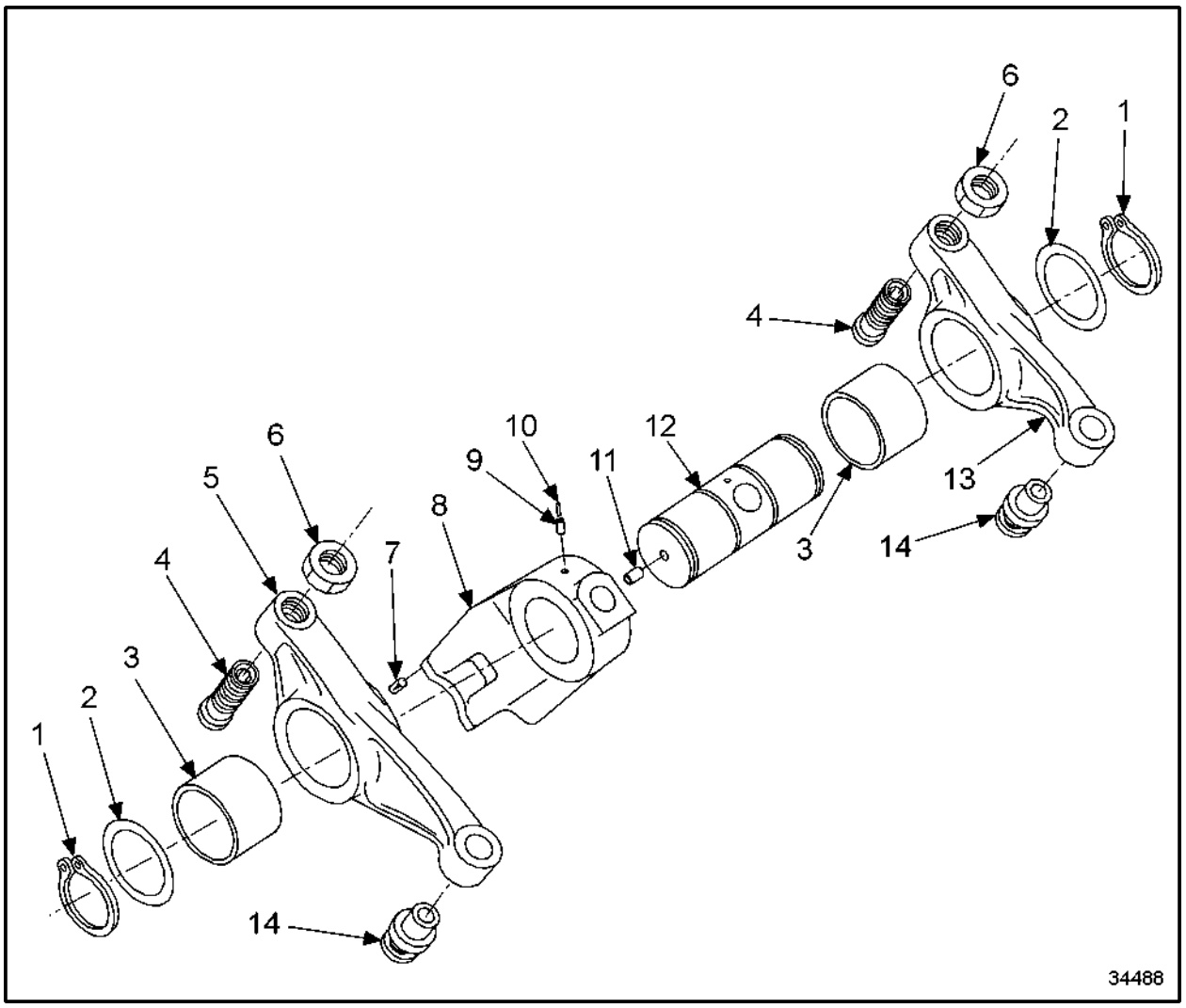
See Figure 451 for a general view of valve operating mechanism.



1. Swing Shaft
2. Swing Arm, Intake
3. Swing Arm, Exhaust
4. Hex Bolt
5. Washer
6. Rocker Bolt
7. Snap Ring
8. Adjusting Shim
9. Rocker Shaft Bracket
10. Rocker Arm, Exhaust
11. Valve Bridge
12. Rocker Arm, Intake

Figure 451 Valve Operating Mechanism

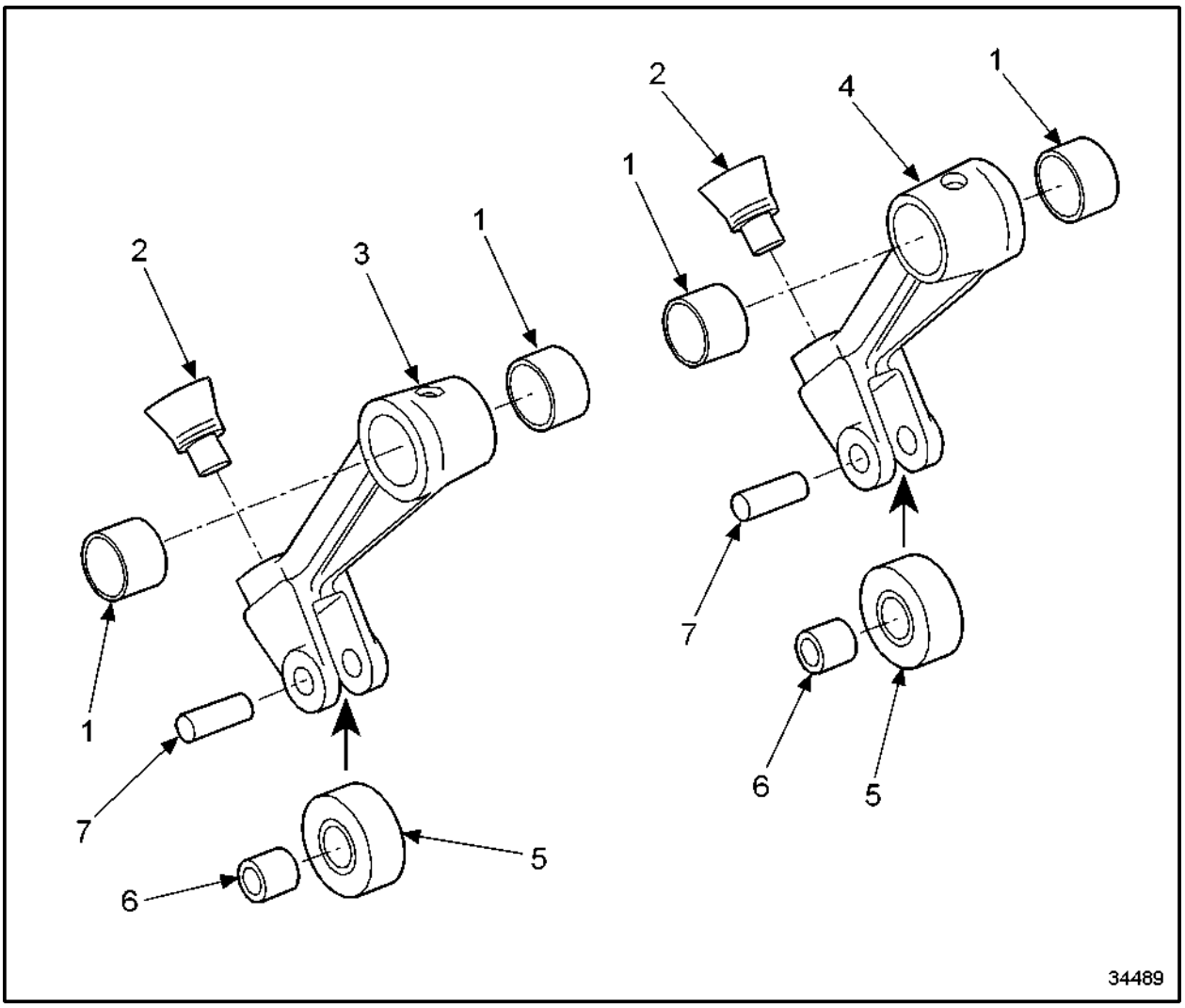
See Figure 452 for a general view of rocker shaft bracket.



1. Snap Ring
2. Adjusting Shim
3. Bushing
4. Adjusting Bolt
5. Intake Rocker Arm
6. Nut
7. Grooved Pin
8. Rocker Shaft Bracket
9. Spring Pin
10. Spring Pin
11. Blanking Plug
12. Rocker Shaft
13. Exhaust Rocker Arm
14. Thrust Pad

Figure 452 Rocker Shaft Bracket

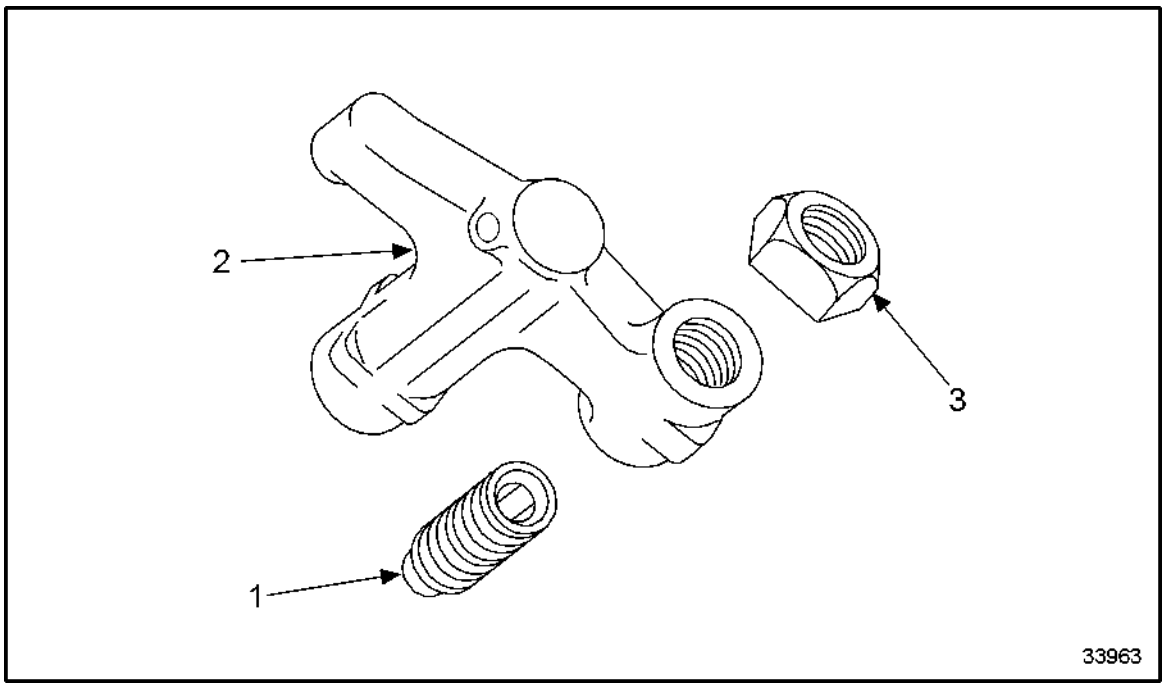
See Figure 453 for a general view of swing arm.



1. Bushing
2. Ball Socket
3. Roller Arm, Exhaust
4. Roller Arm Intake
5. Roller
6. Bushing
7. Pin

Figure 453 Swing Arm

See Figure for a general view of valve bridge.



1. Adjusting Bolt
2. Valve Bridge
3. Hex Nut

Figure 454 Valve Bridge

C 055.05.02 – SPECIAL TOOLS

Listed in Table 48 are the special tools required for maintenance on the valve drive.

Application	Number
Valve clearance adjustment gage 0.2 mm/0.5 mm	—
Allen key, 8 A/F, for valve clearance adjustment	—
Engine barring tool	—

Table 48 Special Tools

C 055.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 49 are the Before-Removal Operations for the valve drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine start	Refer to Operators Guide
1, 2, 3	Drain engine coolant (high temperature)	Refer to Operators Guide
1, 2, 3	Drain charge air coolant (low temperature)	Refer to section C 206.05.05
1, 2, 3	Remove Y-pipe from exhaust outlet housing	Refer to section C 141.05.05
1, 2, 3	Remove oil supply lines for turbochargers	Refer to section C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05
1, 2, 3	Remove intake air system from turbocharger to intercooler	Refer to sectionC 125.05.05
1, 2, 3	Remove coolant lines (high temperature)	Refer to section C 203.05.05
1, 2, 3	Remove exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove charge air coolant vent lines (low temperature)	Refer to section C 205.05.05
1, 2, 3	Remove engine coolant vent lines (high temperature)	Refer to section C 205.05.05
1, 2, 3	Remove charge air coolant line (low temperature)	Refer to section C 207.05.05
1, 2, 3	Remove valve covers	Refer to section C 056.05.05

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.

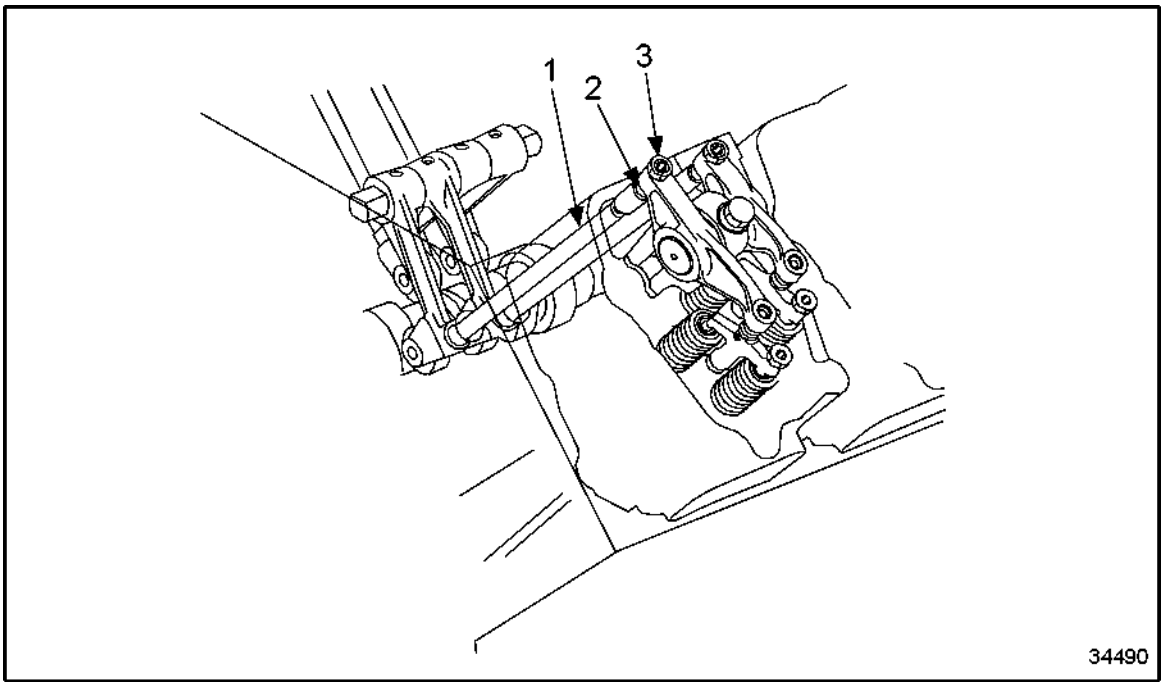
Table 49 Before-Removal Operations

C 055.05.05 – REMOVAL OF VALVE OPERATING MECHANISM

Removing Rocker Arm Assembly

Perform the following steps to remove rocker arm assembly:

1. Release nuts (3) of adjusting bolts (2) on rocker arm, and back off adjusting bolts. See Figure 455.



1. Pushrod
2. Adjusting Bolt
3. Nut

Figure 455 Releasing Adjusting Bolts to Remove Pushrods

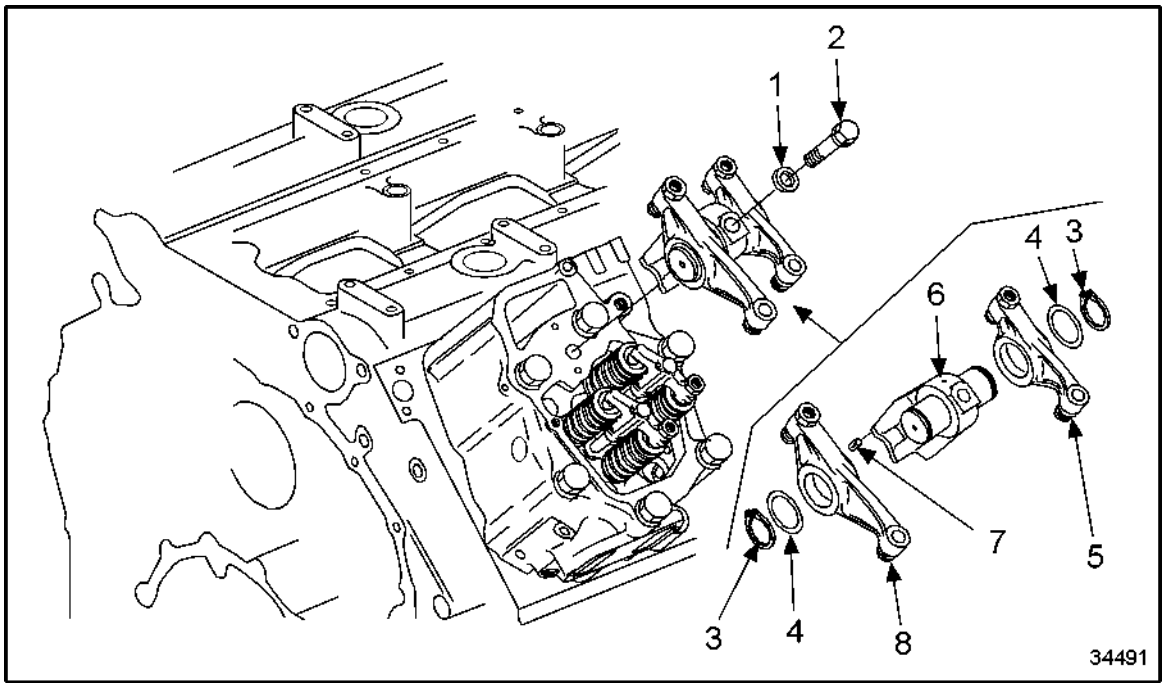
2. Remove pushrods (1) from ball sockets of rocker arms.

NOTE:
Ensure not to drop pushrod into oil pan.

3. Mark pushrods.

4. Remove rocker shaft bolt (2) and remove rocker bracket (6) from cylinder head.

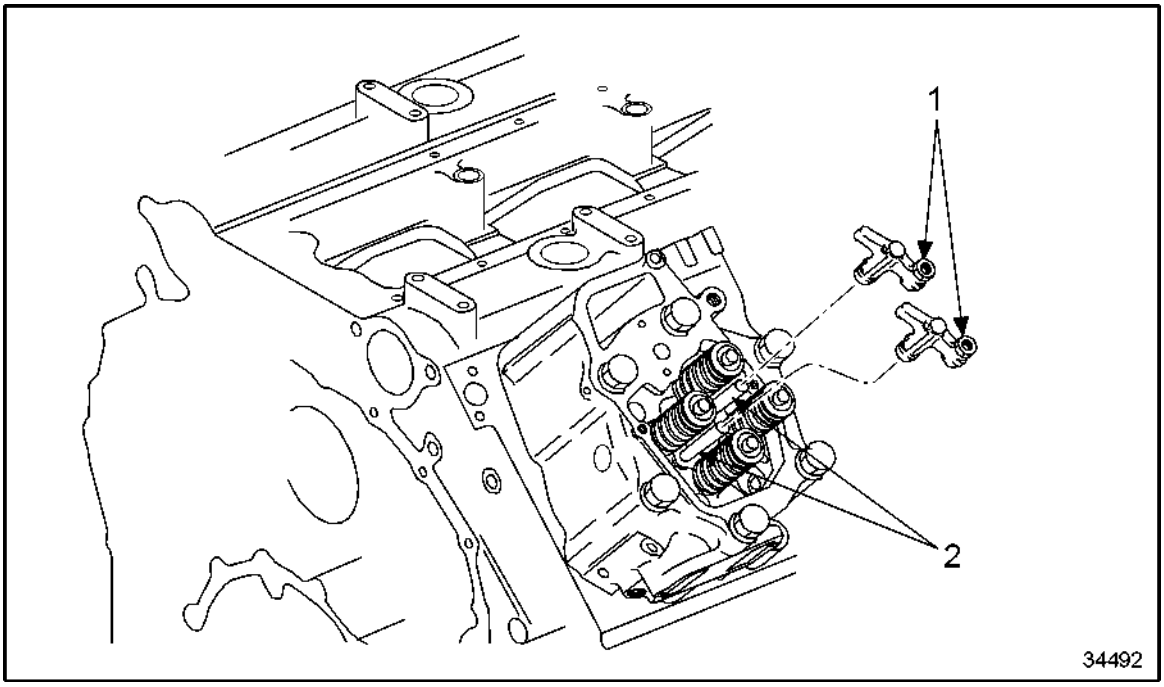
NOTE:
Take care not to damage grooved pin. See Figure 456.



1. Washer
2. Rocker Shaft Bolt
3. Snap Ring
4. Adjusting Shim
5. Rocker Arm, Exhaust
6. Rocker Shaft Bracket
7. Grooved Pin
8. Rocker Arm, Intake

Figure 456 Removing Rocker Shaft Bolt and Rocker Shaft Bracket from Cylinder Head

5. Mark valve bridges (1) and remove from bridge guide in cylinder head. See Figure 457.



1. Valve Bridges
2. Bridge Pin

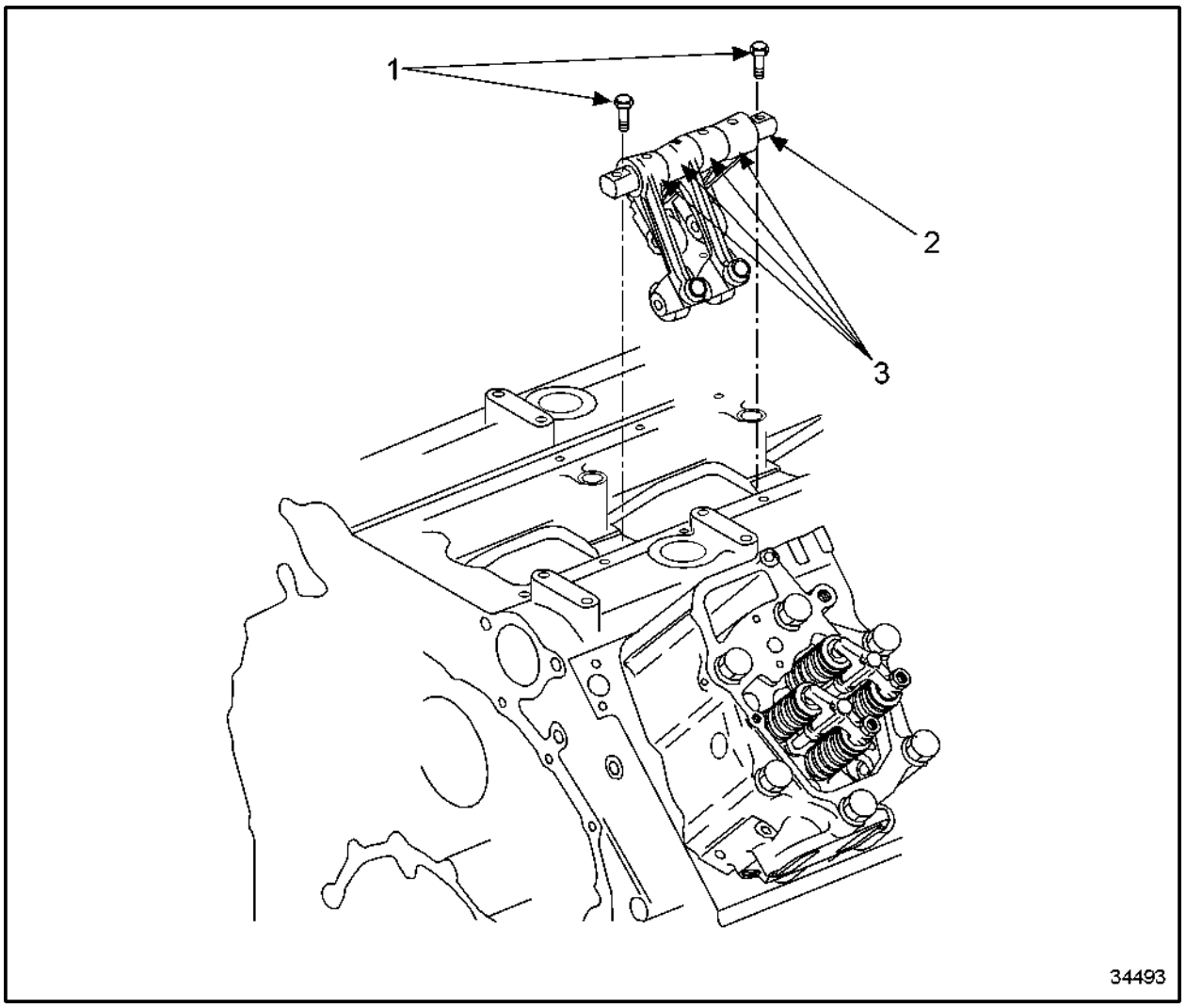
Figure 457 Marking Valve Bridges and Removing from Bridge Pin

6. Remove pushrods.

Removing Swing Arms

Perform the following steps to remove swing arms:

1. Remove hex bolts (1). See Figure 458.



1. Hex Bolts
2. Swing Shaft
3. Swing Arm

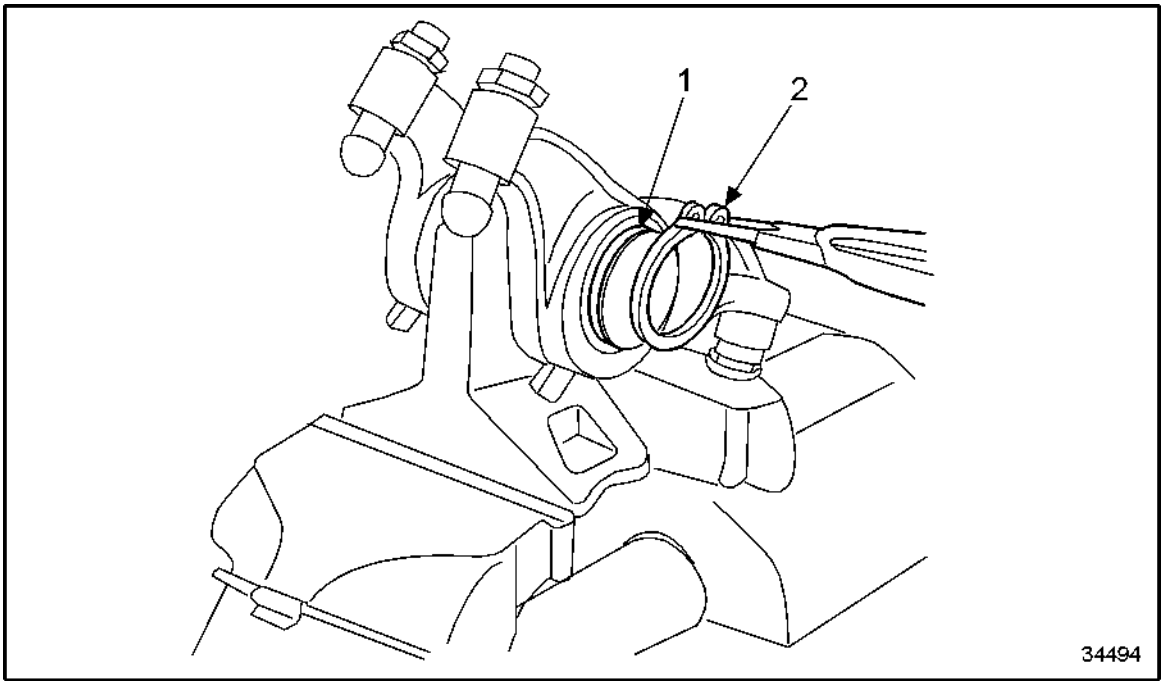
Figure 458 Removing Hex Bolts and Swing Arm Shaft from Cylinder Block

2. Remove swing arm shaft (2) with swing arm (3) from cylinder block.

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.

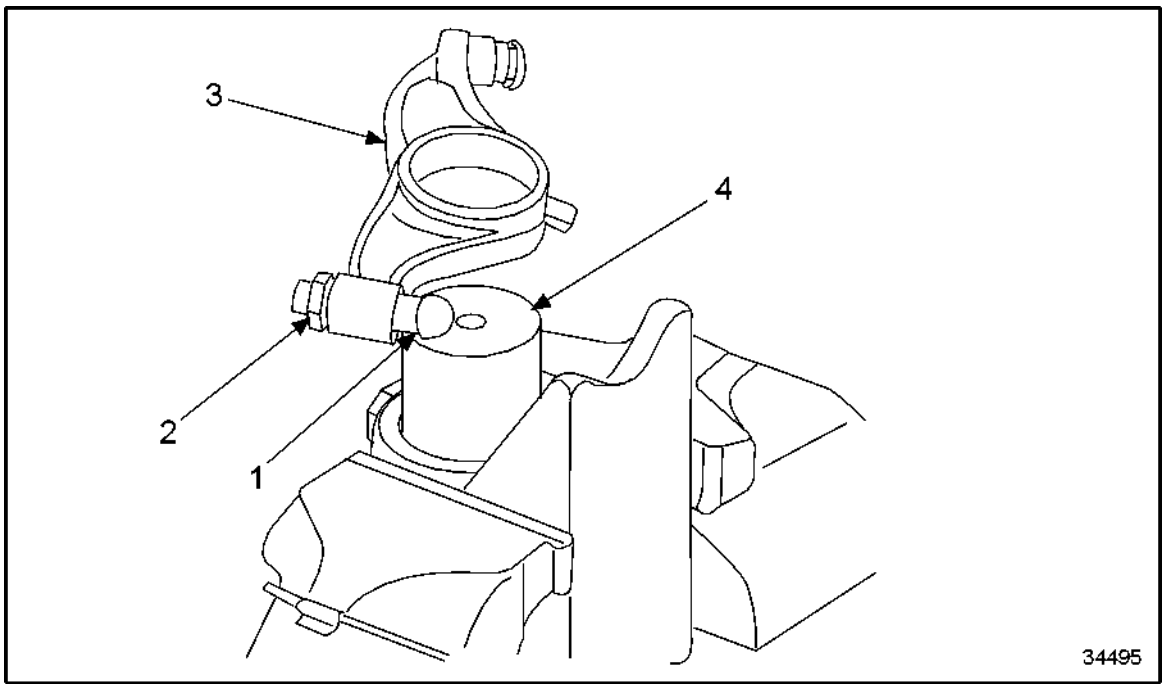


1. Washer
2. Snap Ring

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).

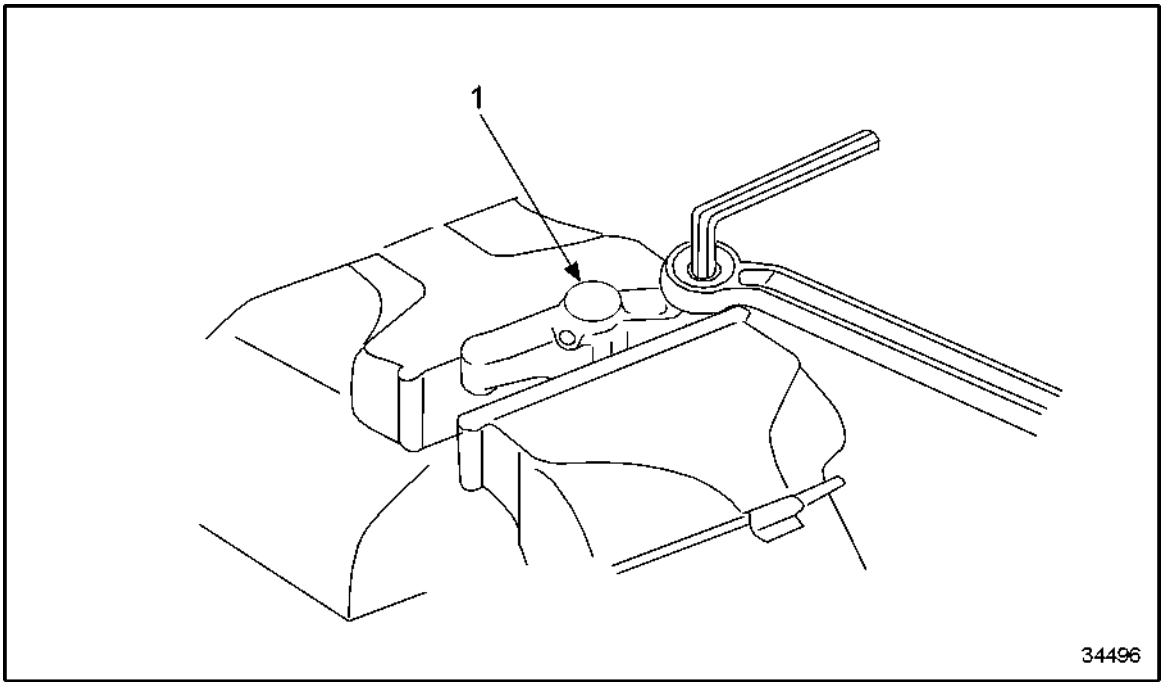
4. Remove rocker arm (3) from rocker shaft. See Figure 460.



1. Adjusting Bolt
2. Nut
3. Rocker Arm
4. Rocker Shaft

Figure 460 Removing Rocker Arm, Nut and Adjusting Bolt from Rocker Shaft

5. Clamp valve bridge (1) in vice with aluminum jaws. See Figure 461.



1. Valve Bridge

Figure 461 Clamping Valve Bridge in Vice and Removing Nut and Adjusting Bolt

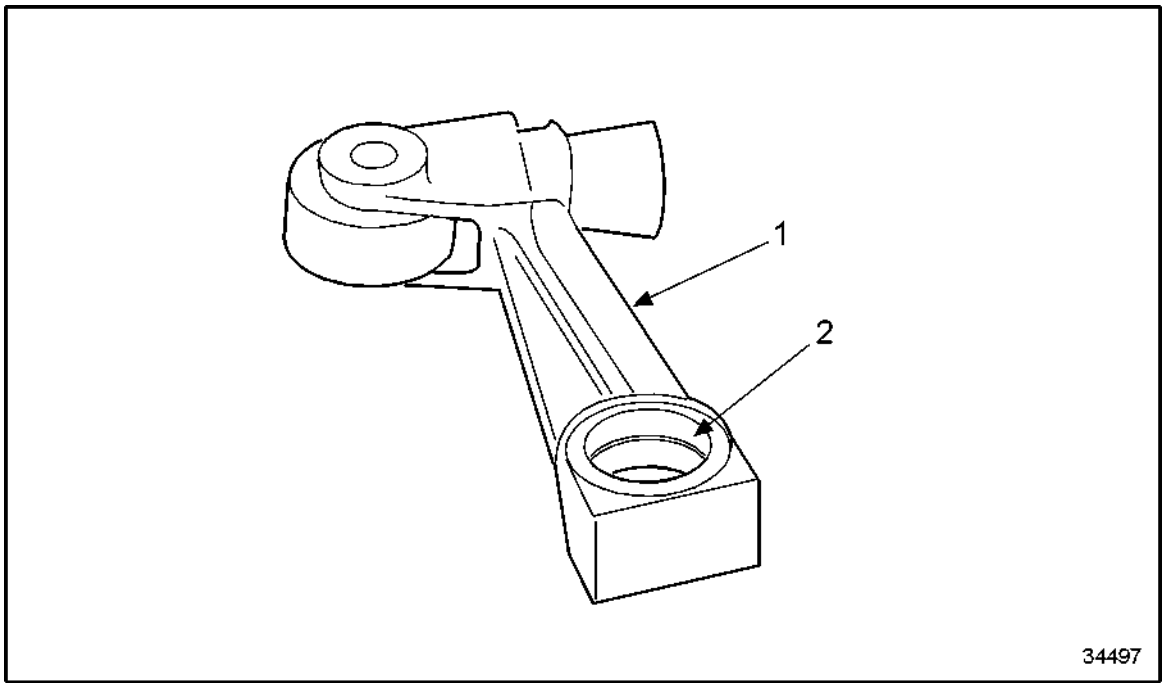
6. Loosen nut and remove adjusting bolt.

Removing Swing Arm Bushing

Perform the following steps to remove swing arm bushing:

NOTE:
Remove swing arm bushing only if necessary. Refer to section C 055.05.08.

1. Use brass drift and hydraulic press to remove swing arm bushing (2) from swing arm (1). See Figure 462.



1. Swing Arm
2. Swing Arm Bushing

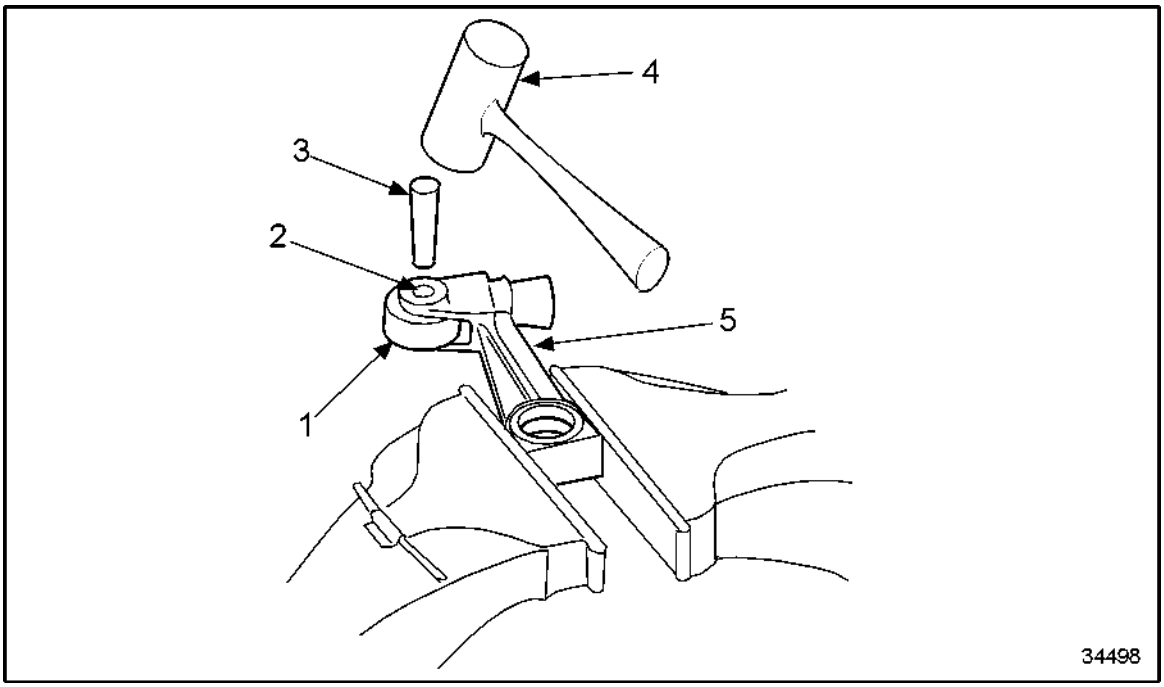
Figure 462 Removing Swing Arm Bushing

Removing Pin and Roller

Perform the following steps to remove pin and roller:

NOTE:
Remove pin and roller only if necessary. Refer to section C 055.05.08.

1. To remove pin, place swing arm between two supports so that both sides of pin bore have sufficient support. See Figure 463.



1. Roller
2. Pin Location
3. Brass Drift
4. Hammer
5. Swing Arm

Figure 463 Removing Pin and Roller

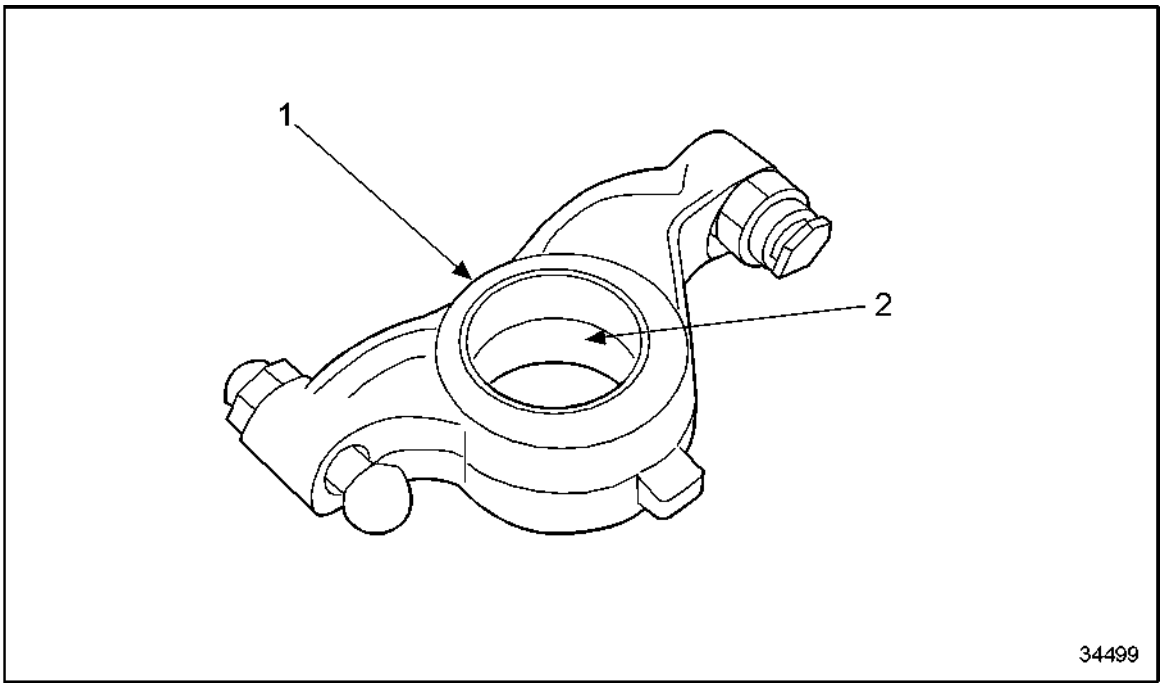
2. Use brass drift (3) to remove pin from swing arm (5).
3. Remove roller (1) from bore.

Removing Rocker Arm Bushings

Perform the following steps to remove exhaust rocker arm bushings:

NOTE:
Remove exhaust rocker arm bushing only if necessary. Refer to section C 055.05.08.

1. Use brass drift and hydraulic press to remove exhaust rocker arm bushing (2) from rocker arm (1). See Figure 464.



1. Rocker Arm
2. Bushing

Figure 464 Removing Rocker Arm Bushing

C 055.05.08 – INSPECTION AND REPAIR

Perform the following subsections to inspect and repair valve operating mechanism.

1. Clean all components.
2. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect swing arm shaft supports and shafts, swing arms, valve bridges, rollers, pins, hex bolts and adjusting bolts for cracks.
   [a] If cracks are found, replace damaged components.
   [b] If no cracks are found, continue inspection.
3. Inspect cylinder head covers for condition and damage.
   [a] If in poor condition or damaged, replace cylinder head covers.
   [b] If in good condition and undamaged, continue inspection.
4. Inspect mating and sealing surfaces of cylinder head cover.
   [a] If necessary, rub down with oilstone or emery cloth if necessary.
   [b] If not necessary, continue inspection.
5. Inspect running surfaces of shafts, rollers, valve bridges and rocker arms for wear, indentations and scoring.
   [a] If wear, indentations or scoring are found, polish with emery cloth or replace components as necessary.
   [b] If wear, indentations or scoring are not found, continue inspection.
6. Inspect snap rings and washers for damage and wear.
   [a] If components are damaged or worn, replace as necessary.
   [b] If no damage or wear is found, continue inspection.
7. Inspect mating surfaces on rocker shaft bracket.
   [a] If mating surfaces are worn, burnish with oilstone as necessary.
   [b] If surfaces are not worn, continue with inspection.
8. Inspect axle snap ring grooves for wear and damage.
   [a] If axle snap ring grooves are worn or damaged, replace rocker shaft bracket as necessary.
   [b] If axle snap ring grooves are not worn or damaged, continue inspection.
9. Inspect tapers and adjusting bolt slots for wear and damage.
   [a] If tapers and adjusting bolt slots are worn or damaged, replace as necessary.
   [b] If tapers and adjusting bolt slots are not worn or damaged, continue inspection.
10. Inspect heads and seating surfaces of nuts for damage.
    [a] If heads or seating surfaces of nuts are damaged, replace as necessary.

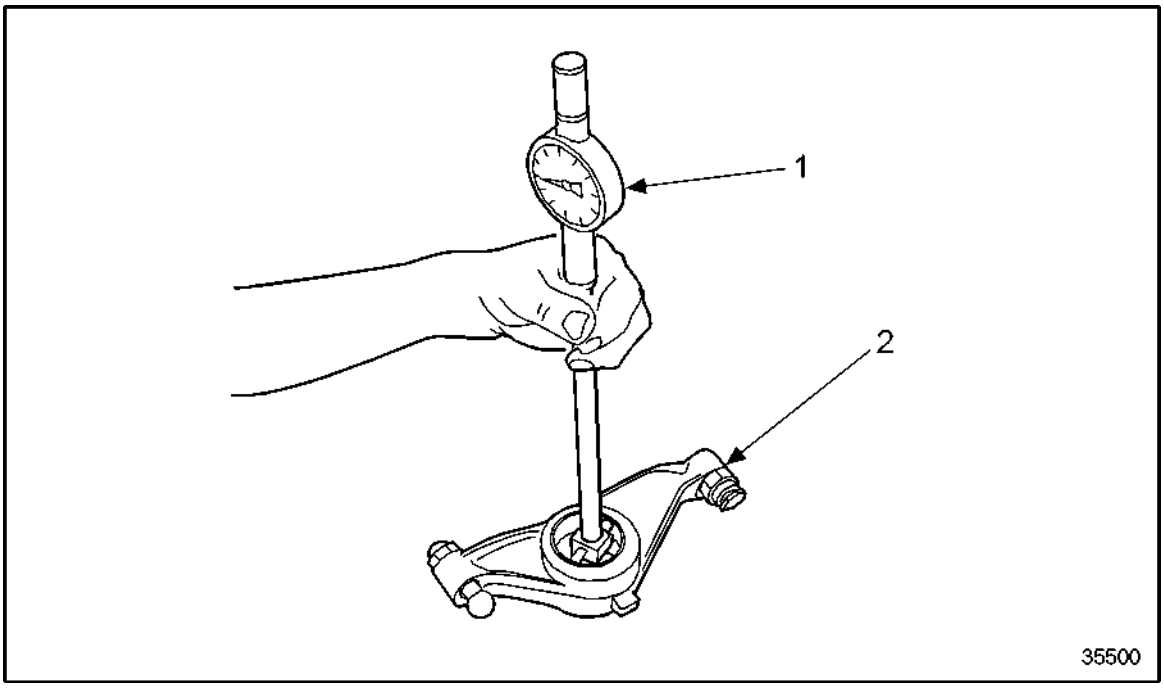
[b] If heads or seating surfaces of nuts are not damaged, continue inspection.

11. Inspect threads of nuts, adjusting bolts and collar bolts for ease of movement.
    [a] If nuts, adjusting bolts and collar bolts do not move easily, replace as necessary.
    [b] If nuts, adjusting bolts and collar bolts move easily, continue inspection.
12. Inspect threaded bores in rocker arms and valve bridges for ease of movement.
    [a] If threaded bores and valve bridges do not move easily, re-machine if necessary.
    [b] If threaded bores and valve bridges move easily, continue inspection.
13. Measure register bores in valve bridges with bore gage.
    [a] If register bores in valve bridges are outside limits, machine as necessary.
    [b] If correct limits cannot be achieved by machining, replace component.
    [c] If register bores in valve bridges are not outside limits, continue inspection.
14. Check bridge guides in cylinder heads for wear and protrusion. Refer to section C 041.05.08.
15. Replace gaskets and sealing washers during W6 overhaul.
16. Ensure that all components are perfectly clean and that flow through lube oil bores is unobstructed.

Measuring Diameter of Bushing Bore in Rocker Arm

Perform the following steps to measure diameter of bushing bore in rocker arm:

1. Adjust bore gage to basic size of bushing bore and measure diameter of bore. See Figure 465.



1. Dial Bore Gage
2. Rocker Arm

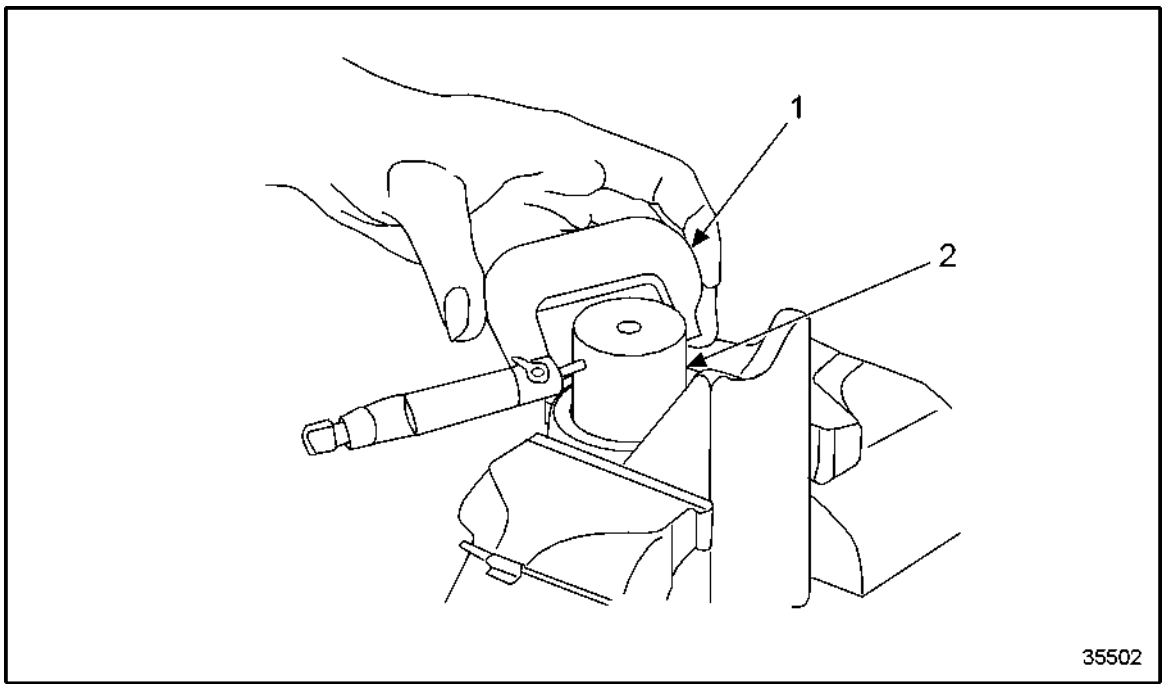
Figure 465 Measuring Diameter of Bushing Bore in Rocker Arm

2. Adjust bore gage to basic size of bushing bore and measure diameter of bore.
   [a] If bushing bores are outside limits, replace component.
   [b] If bushing bore are not outside limits, continue inspection.
3. Measure bushing bore against limit values.
4. If limit values are exceeded, replace bushings.

Measuring Diameter of Rocker Shaft

Perform the following steps to measure diameter of rocker shaft:

1. Using micrometer, measure outside diameters of bearings. See Figure 466.



1. Micrometer
2. Bearing Pedestal Shaft

Figure 466 Removing Rocker Arm from Shaft and Nut from Adjusting Bolt

2. Measure bearing pedestal shaft against limit values.
   [a] If bearing pedestal shafts are outside limits, machine as necessary.
   [b] If correct limits cannot be achieved by machining, replace component.
   [c] If bearing pedestal shafts are not outside limits, continue inspection.

Inspecting Hex Bolts for Rocker Shaft Support

Perform the following steps to inspect hex bolts for rocker shaft support:

1. Measure shaft length of hex bolt. See Figure 467.

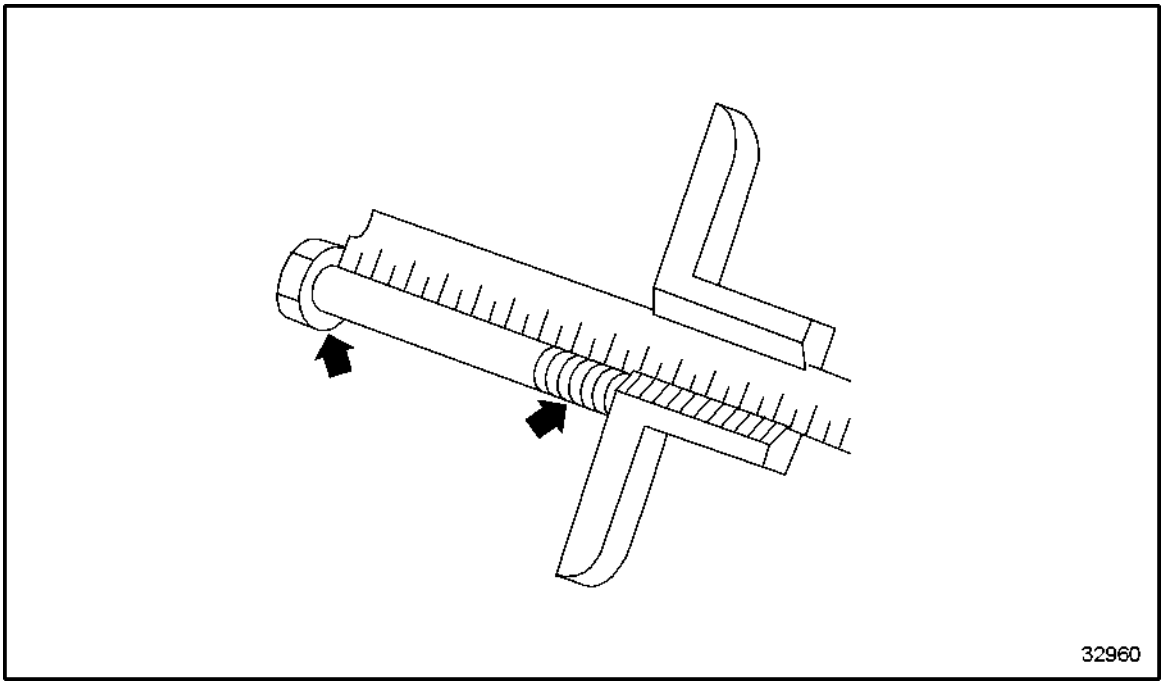


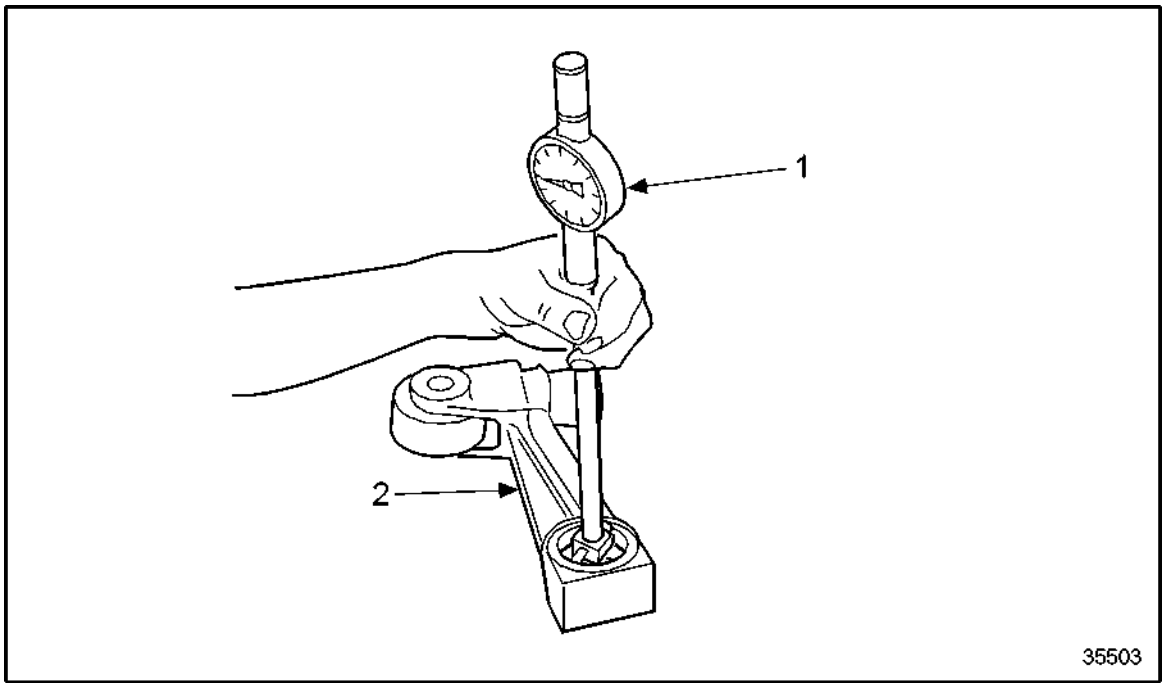
Figure 467 Measuring Roller Diameter with Outside Micrometer

2. For maximum shaft length, refer to section C 055.05.01.
3. Inspect threads and bolt head mating surface.
   [a] If threads or bolt head mating surface are damaged, replace bolt.
   [b] If threads or bolt head mating surface are not damaged, continue inspection.

Measuring Swing Arm

Perform the following steps to measure swing arm:

1. Adjust bore gage to basic size of bushing bore and measure diameter of bore. See Figure 468.



1. Dial Bore Gage
2. Swing Arm

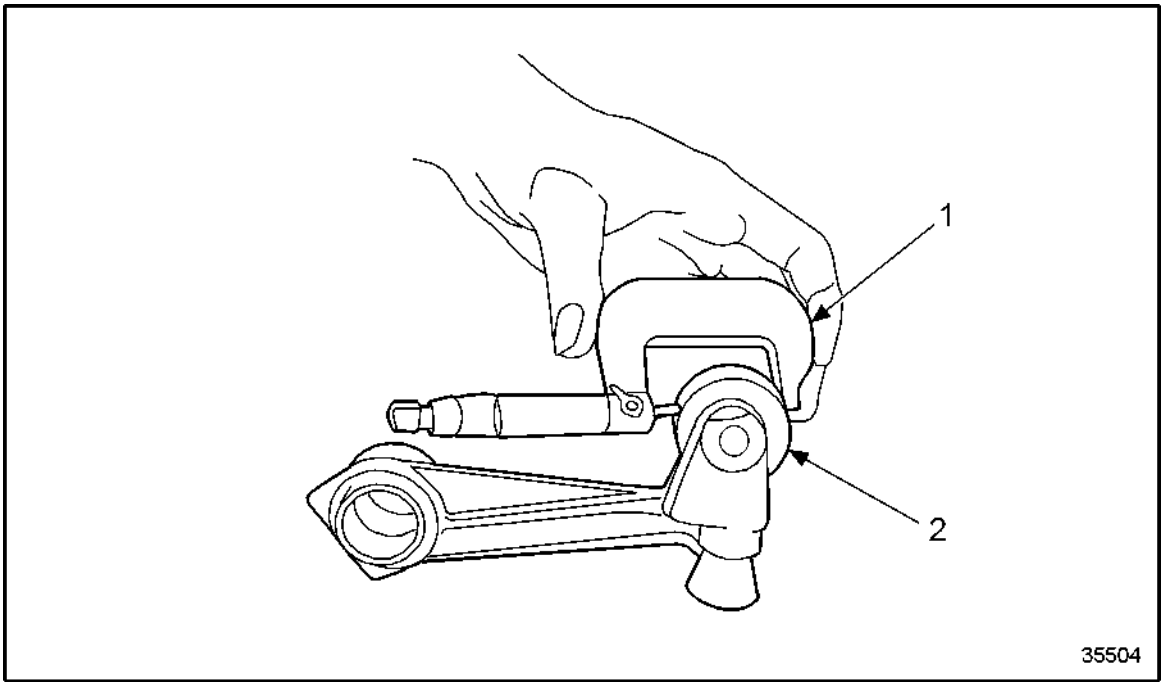
Figure 468 Measuring Swing Arm

2. Measure inlet swing arm against limit values.
   [a] If inlet swing arms are outside limits, machine as necessary.
   [b] If correct limits cannot be achieved by machining, replace component.
   [c] If inlet swing arms are not outside limits, continue inspection.

Measuring Roller Diameter

Perform the following steps to measure roller diameter:

1. Using outside micrometer, measure outside diameter of roller at bearings. See Figure 469.



1. Micrometer
2. Swing Arm Roller

Figure 469 Measuring Roller Diameter

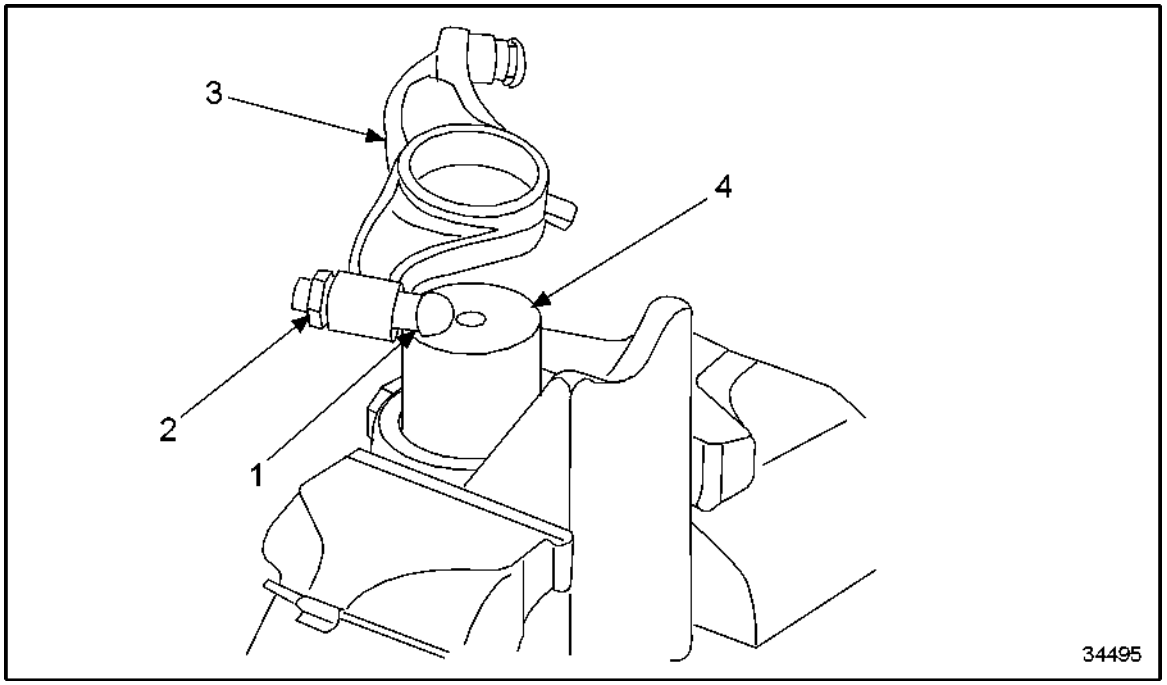
2. Measure roller diameter against limit values.
   [a] If roller diameter is outside limits, machine as necessary.
   [b] If correct limits cannot be achieved by machining, replace component.
   [c] If roller diameter is not outside limits, continue inspection.

C 055.05.10 – ASSEMBLY OF ROCKER ARM ASSEMBLY

Assembling Rocker Arm Assembly

Perform the following steps to assemble rocker arm assembly:

1. Clamp rocker shaft bracket in vice with aluminum jaws. See Figure 470.



1. Adjusting Bolt
2. Nut
3. Rocker Arm
4. Rocker Shaft

Figure 470 Assembling Rocker Arm Assembly

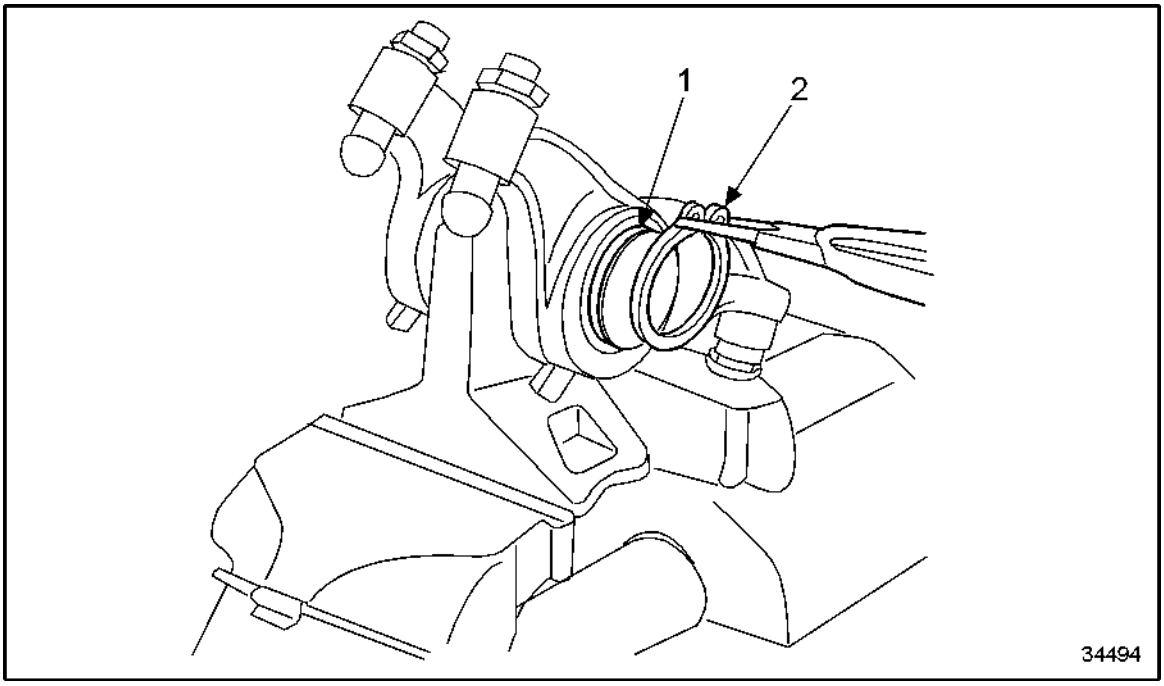
NOTE:
Ensure parts are perfectly clean.

2. Insert adjusting bolt (1) into rocker arm (3).
3. Attach nut (2) to adjusting bolt; do not tighten.
4. Coat shaft on rocker shaft support bracket and bushings of rocker arm with engine oil.
5. Install rocker arm on shaft.
6. Install second rocker arm in same way.

CAUTION:

To avoid personal injury when removing or installing pretensioned snap rings, use circlip pliers. Always wear adequate eye protection (safety glasses or faceplate).

7. Install washer (1) and secure with snap ring (2). See Figure 471.

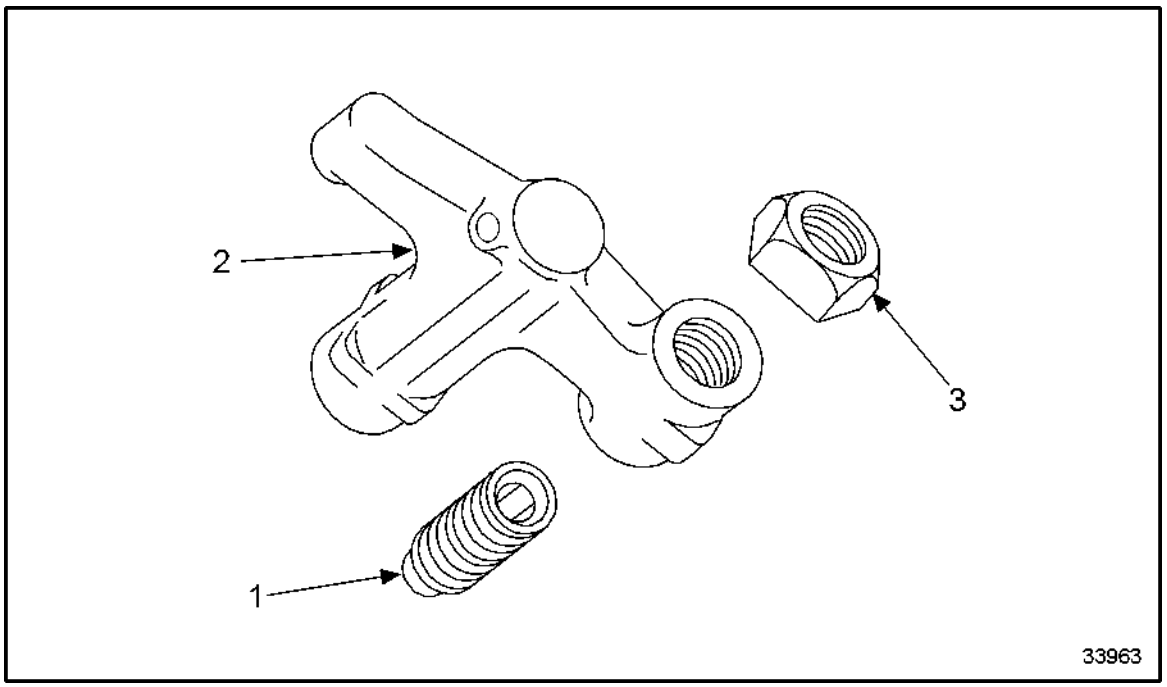


1. Washer
2. Snap Ring

Figure 471 Installing Snap Ring and Washer Rocker Shaft

8. Ensure that snap ring is correctly seated.
9. Check minimum end play of rocker arm.
10. Install second rocker arm in the same way.

11. Insert adjusting bolt (1) into valve bridge (2). See Figure 472.



1. Adjusting Bolt
2. Valve Bridge
3. Hex Nut

Figure 472 Inserting Adjusting Bolt into Valve Bridge

12. Attach hex nut (3) to adjusting bolt; do not tighten.

Assembling Swing Arms

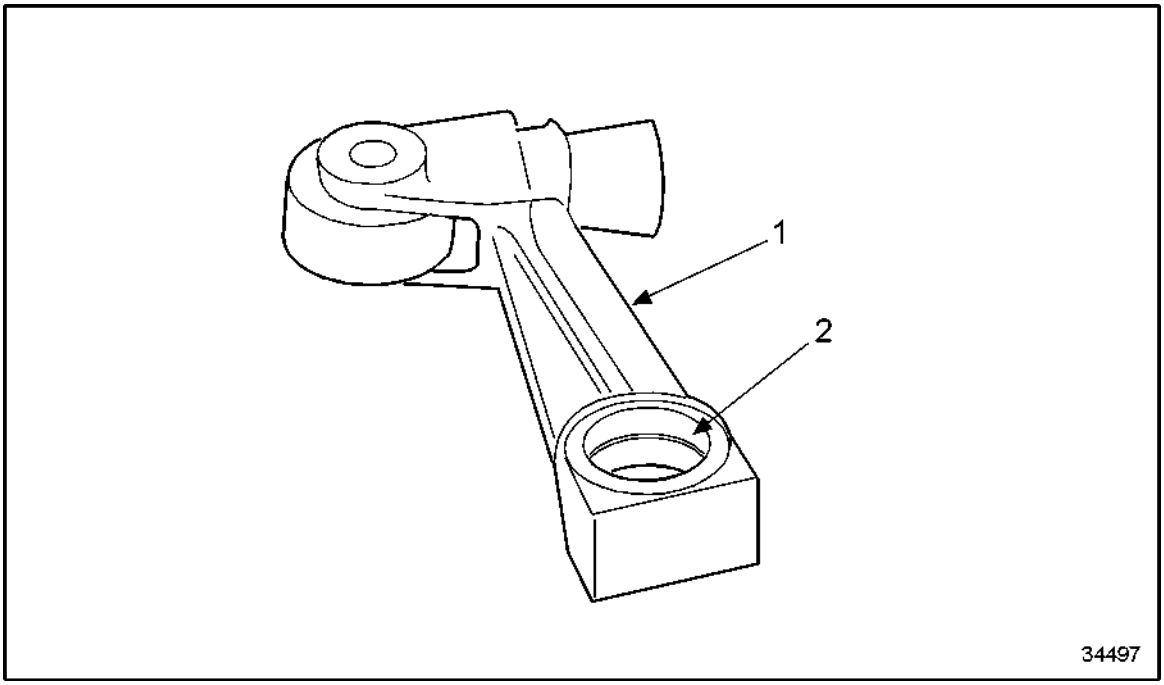
Perform the following steps to assemble swing arms:

NOTE:
Ensure parts are perfectly clean.

CAUTION:

To avoid personal injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts will occur.

1. Chill swing arm bushing (2) in liquid nitrogen and insert flush in swing arm (1). See Figure 473.



1. Swing Arm
2. Swing Arm Bushing

Figure 473 Assembling Swing Arm Bushing

2. Bushing must not protrude above arm.

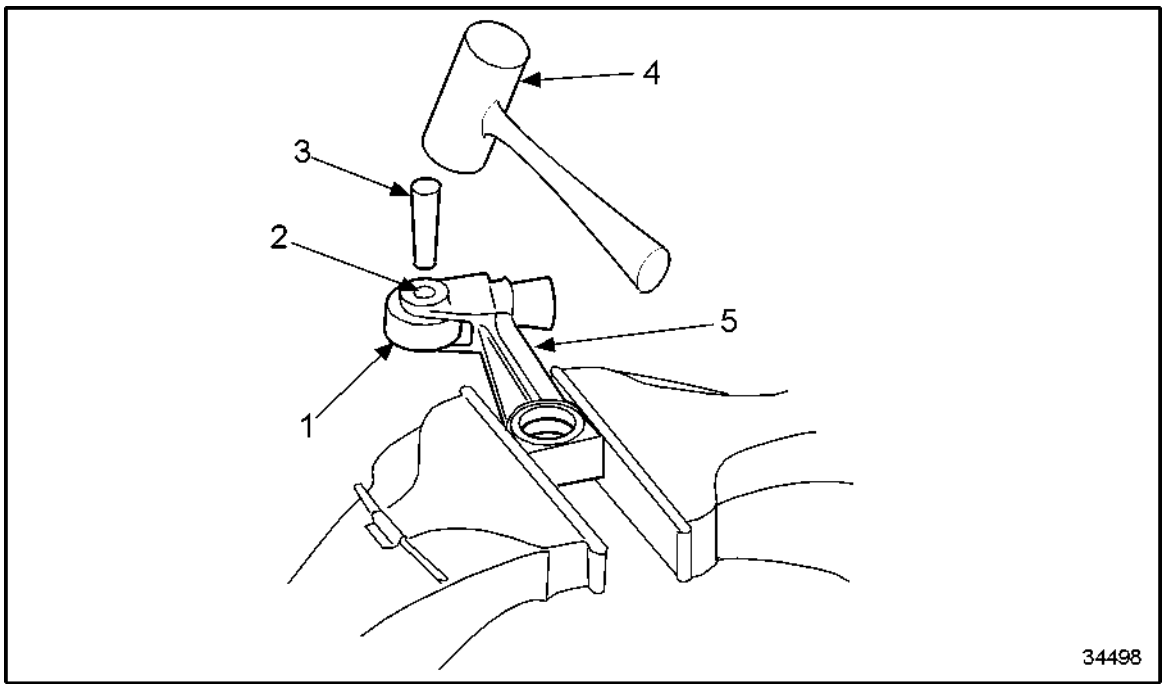
NOTE:
Check that bore is correctly aligned.

CAUTION:

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

NOTE:
Ensure parts are perfectly clean.

3. Blow out bore in swing arm with compressed air. See Figure 474.



1. Roller
2. Pin Location
3. Brass Drift
4. Hammer
5. Swing Arm

Figure 474 Inserting Pin and Roller

4. Heat swing arm to approximately 100°C.
5. Insert roller (1) in swing arm (5).

CAUTION:

To avoid personal injury when using liquid nitrogen, wear protective clothing, gloves and closed shoes. Do not allow the liquid nitrogen to come into contact with exposed body parts. Danger of freezing body parts and suffocation will occur.

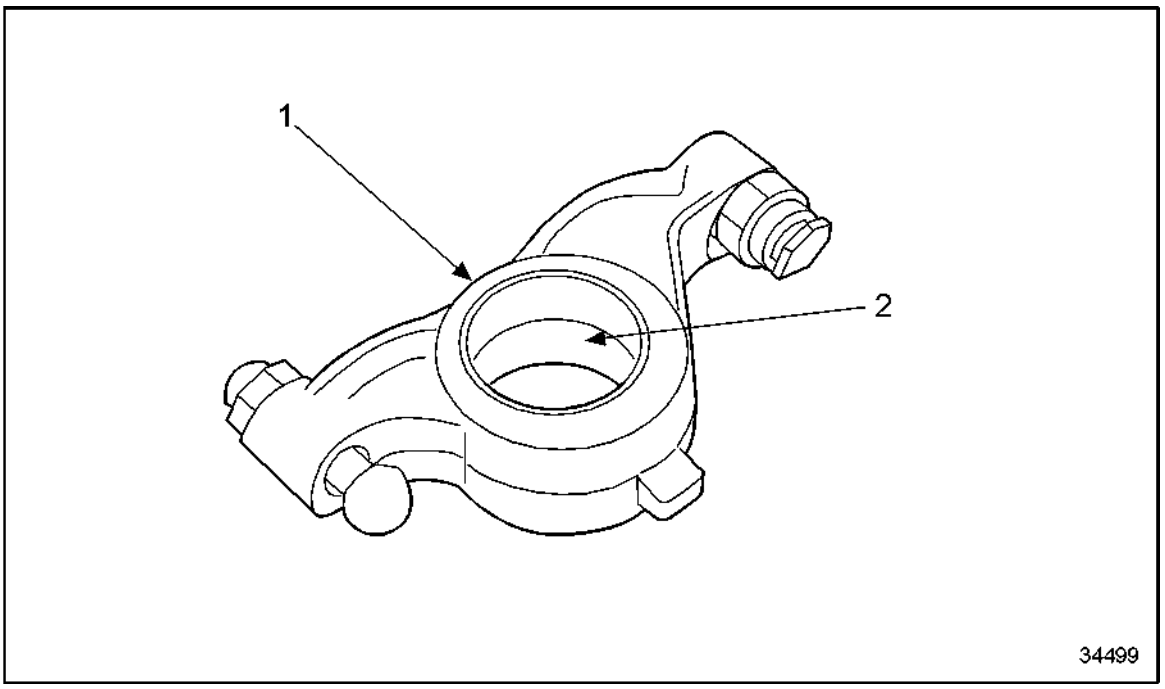
6. Chill pin (2) in liquid nitrogen and insert flush in swing arm (5). See Figure 474.
7. Use hammer (4) and brass drift (3) to position pin.
8. Pin must not protrude above arm.

Assembling Rocker Arm

Perform the following steps to assemble rocker arm:

NOTE:
Ensure parts are perfectly clean.

1. Chill bushing (2) in liquid nitrogen. See Figure 475



1. Rocker Arm
2. Bushing

Figure 475 Inserting Rocker Arm Bushing

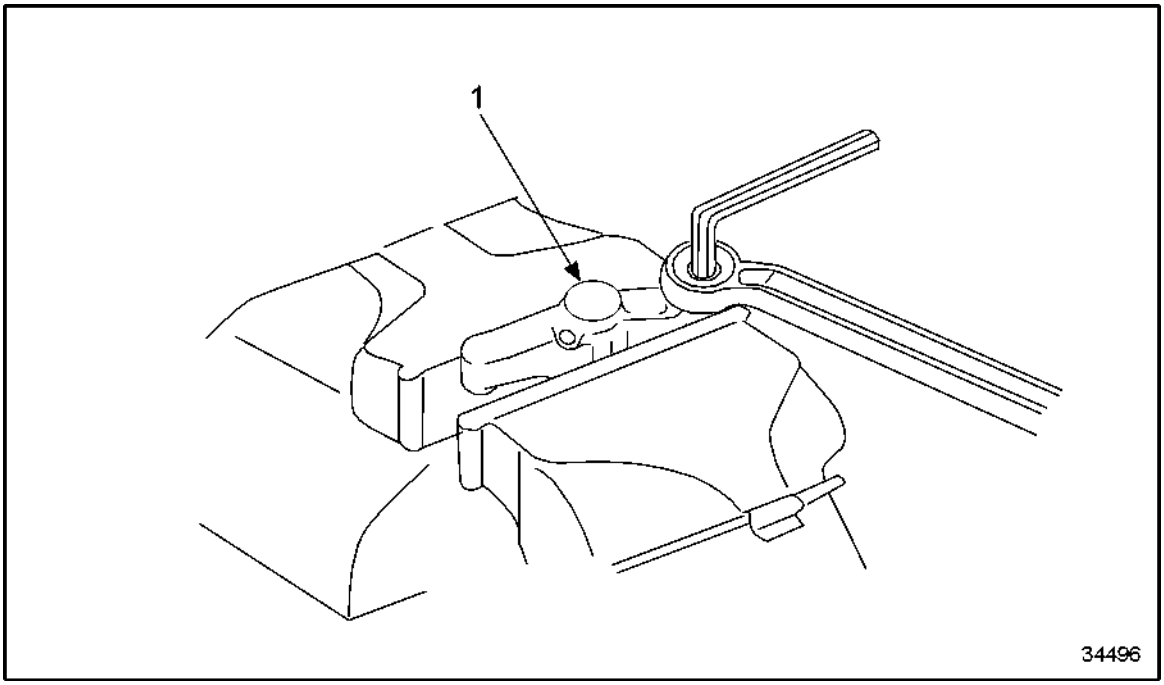
2. Heat rocker arm to approximately 200°C.
3. Insert bushing so that it is flush.
4. Bushing must not protrude above arm.

C 055.05.11 – INSTALLATION OF VALVE DRIVE

Adjusting and Installing Valve Bridges

Perform the following steps to adjust and install valve bridges:

NOTE:
Ensure parts are perfectly clean. Make adjustment only when engine is cold or heated to 40°C. See Figure 476.



1. Valve Bridge

Figure 476 Clamping Valve Bridge in Vice and Removing Nut and Adjusting Bolt

1. Measure projection of sliding pins with respect to cylinder head. Refer to section C 041.05.08.

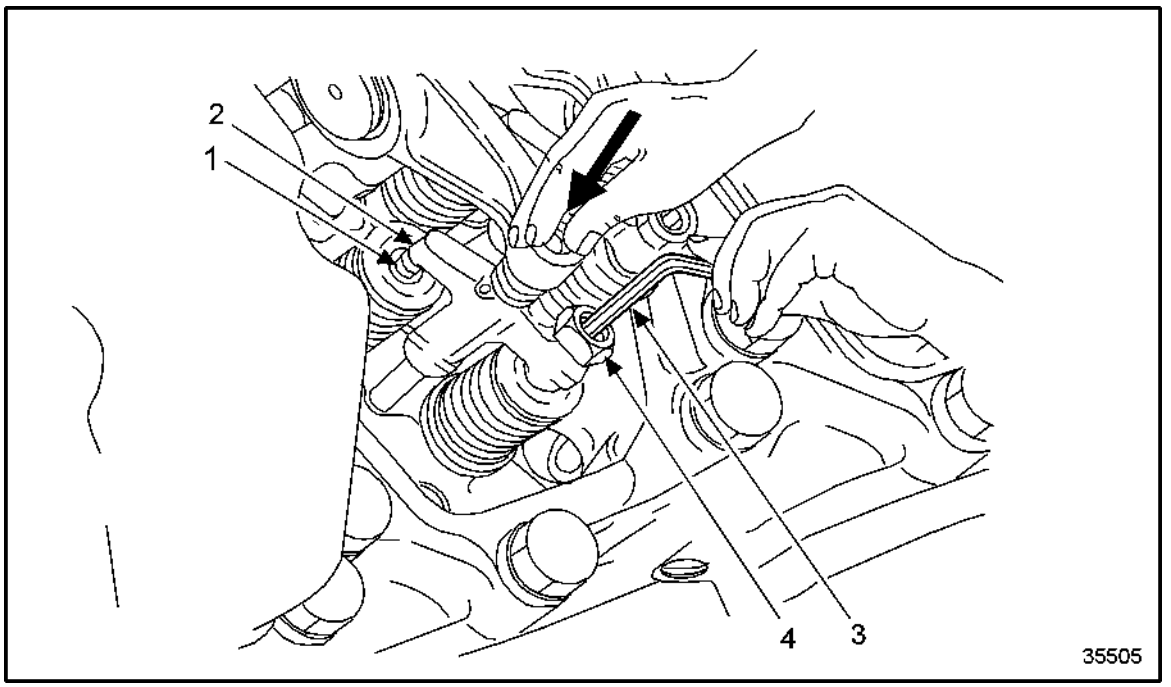
NOTE:
If valve seats in cylinder head or valves have been machined, valve bridges must be adjusted.

2. Secure valve bridge (1) in vice with aluminum jaws, release locknut and back off adjusting bolt by approximately 3 revolutions.
3. Ensure oil bore is perfectly clean.

CAUTION:

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

4. Blow lube-oil bores of valve bridges clear with compressed air to check for obstructions.
5. Set valve bridge on bridge guide in cylinder head according to the markings (installation location). See Figure 477.



1. Adjusting Bolt
2. Valve Bridge
3. Allen Wrench
4. Locknut

Figure 477 Installing Adjusting Bolt

6. Adjusting bolt points to charge air manifold.
7. Press valve bridge downward (arrow) and hold. Valve bridge must be in contact with valve stem.
8. With valve bridge pressed down, install adjusting bolt (1) with Allen wrench (3) until adjusting bolt slightly contacts valve stem and a pressure point is noticeable.

9. Turn adjusting bolt further, approximately 20 degrees to compensate clearance.

NOTE:
Valve bridges are set and must not be interchanged during installation.

10. Hold adjusting bolt firmly with Allen wrench and tighten locknut (4) by hand to valve bridge.
11. Remove valve bridge from valve head and place in vice with aluminum jaws.
12. Torque bridge nut to specifications.
13. The Allen wrench must not turn. For tightening torque, refer to section A 003.
14. Re-install valve bridge on valve head.
15. Inspect clearance with 0.1 mm feeler gage under each locknut. If equal drag does not occur, readjust bridge.
16. Coat shaft and bushings of swing arm with engine oil. See Figure 478.

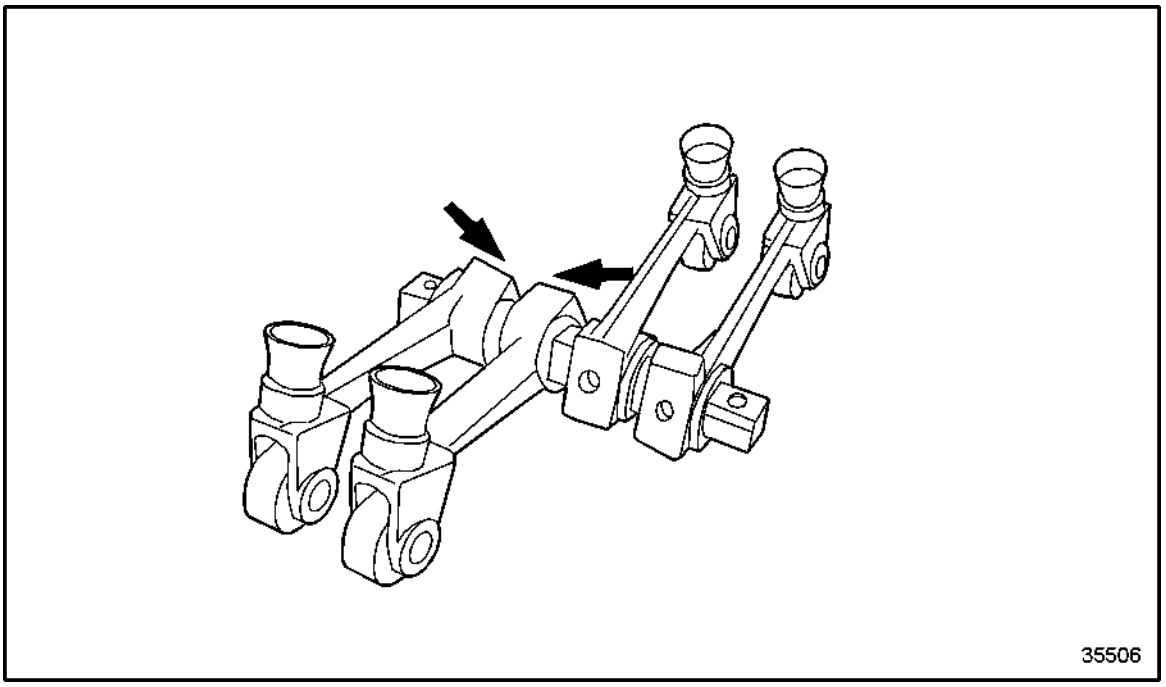
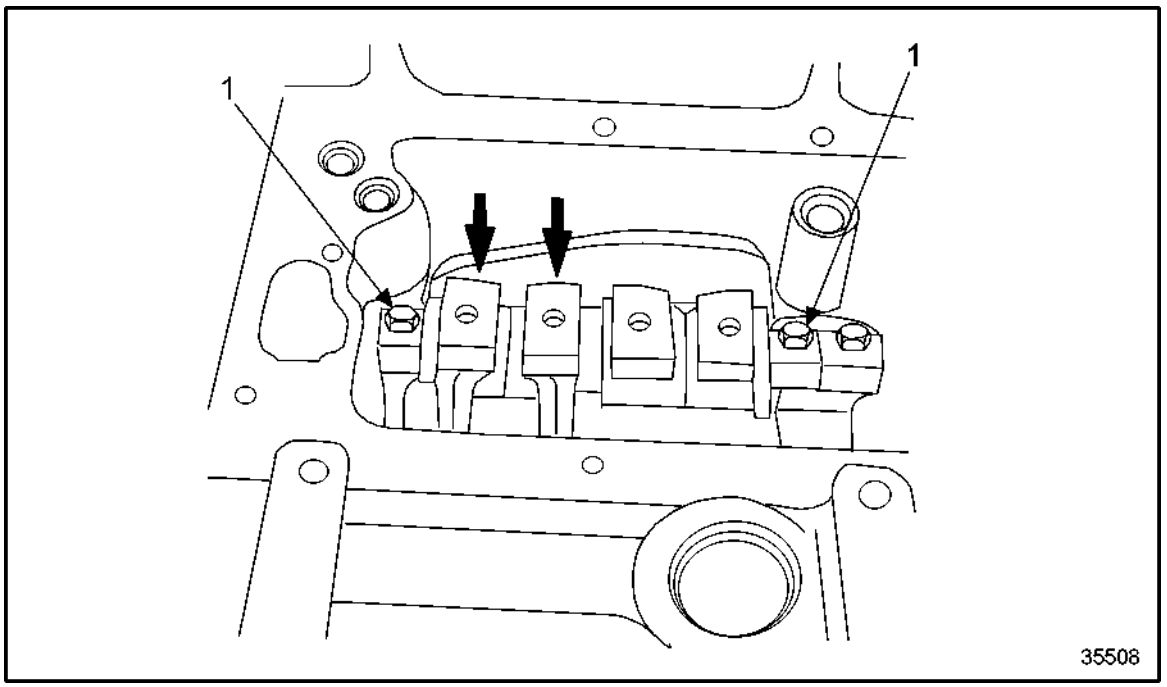


Figure 478 Installing Swing Roller Arms on Swing Shaft

17. Install swing arms on swing shaft, making sure they are positioned correctly (arrow).
18. Coat rollers and camshaft lobes with engine oil.
19. Match swing arms to left and right cylinder banks; carefully insert into camshaft chamber.
20. Screw in hex bolts (1) and tighten to specified torque. Refer to section A 003.

21. For correct installation position (arrows), see Figure 479.



1. Hex Bolts

Figure 479 Installation Position of Swing Arm Follower

22. Coat ball sockets of pushrods with engine oil and insert pushrods.
23. Measure shaft length of hex bolt; for maximum shaft length, refer to section A 003.

24. Coat thread and mating surface of hex bolts (arrows) with engine oil. See Figure 480.

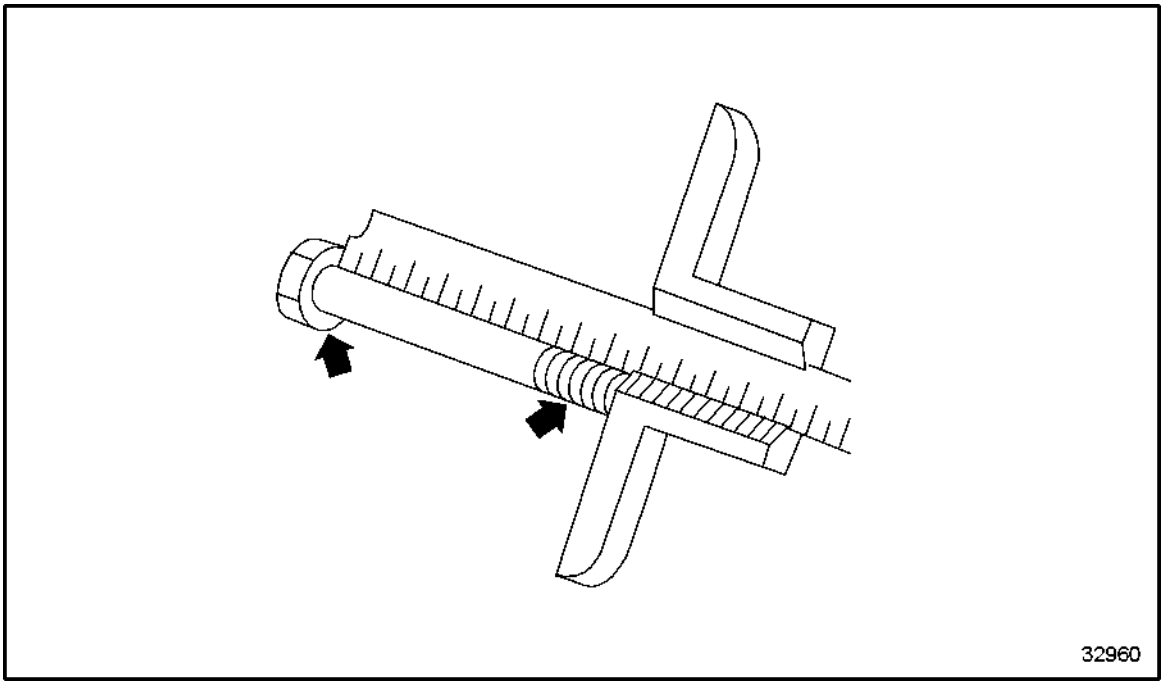
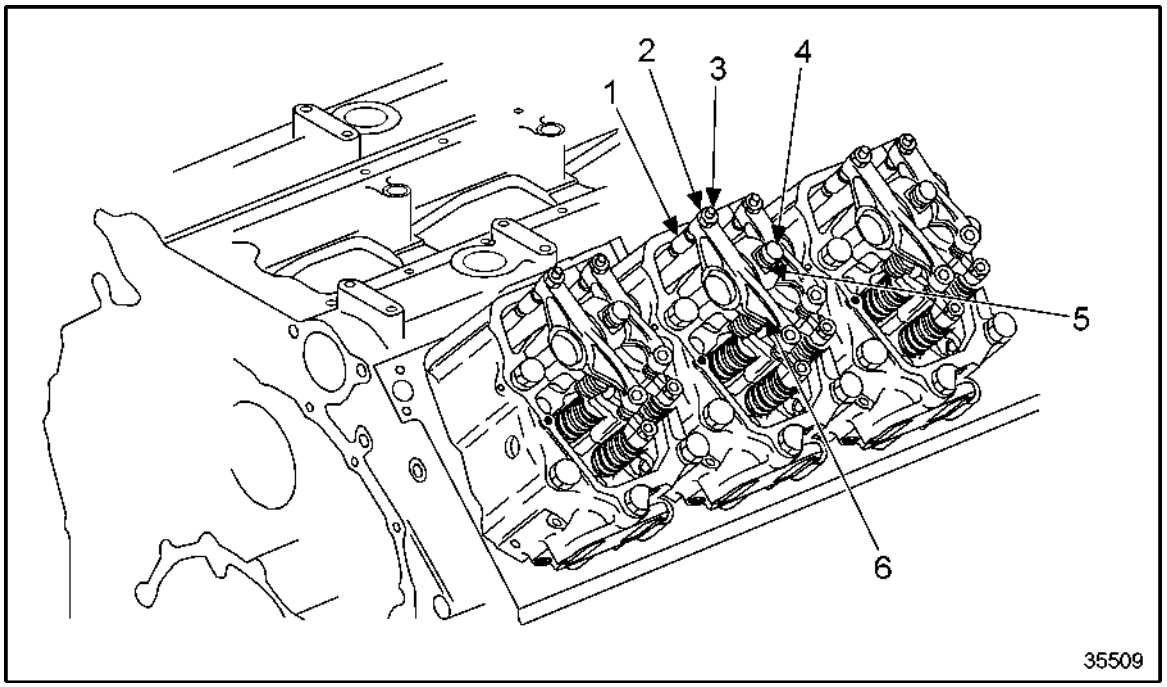


Figure 480 Measuring Shaft Length of Hex Bolt

25. Release nuts (2) of adjusting bolts (3) on rocker arms, and back off adjusting bolts. See Figure 481.



1. Pushrod
2. Nut
3. Adjusting Bolt
4. Rocker Shaft Bolt
5. Washer
6. Rocker Arm

Figure 481 Releasing Nuts of Adjusting Bolts on Rocker Arms

26. Fit rocker shaft bracket on cylinder head and check fit of grooved pins.
27. Check position of ball joints in pushrods (1).
28. Install rocker shaft bolt (4) with washer (5) in cylinder head and tighten to specified torque. Refer to section A 003.

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.

29. Using the barring tool, set piston of cylinder to be checked to firing TDC. See Figure 482.

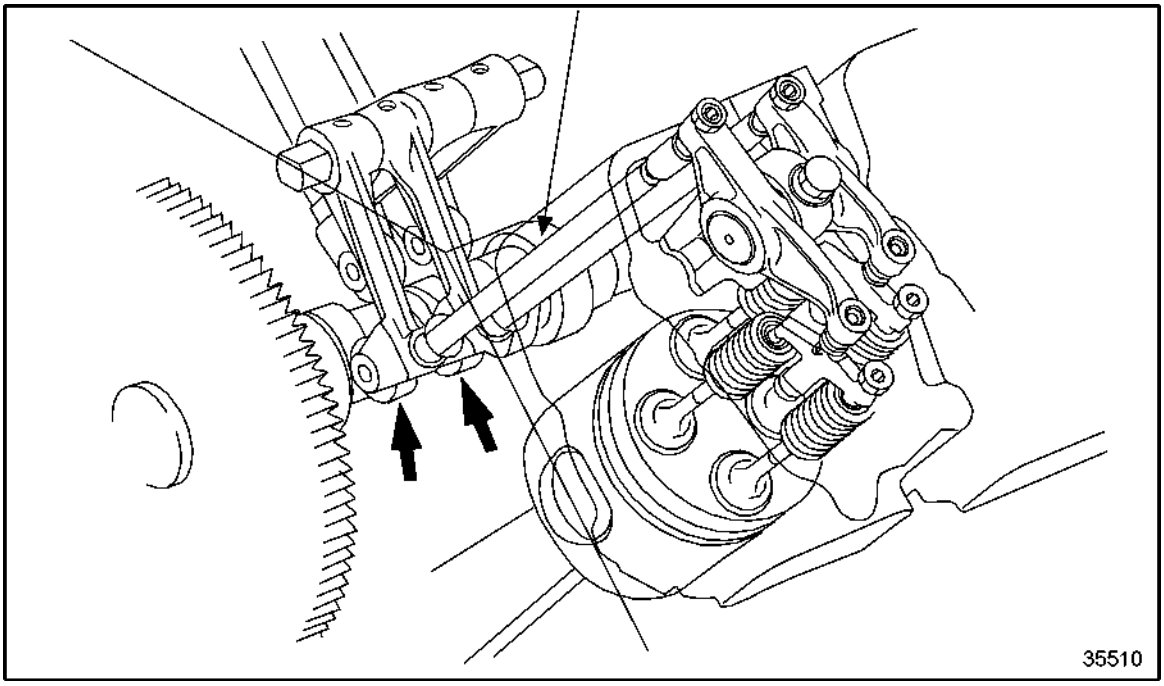


Figure 482 Position of Swing Arm Rollers at Firing TDC

NOTE:
At firing TDC, both rollers of swing arm of respective cylinder are in base circle (arrow) of camshaft.

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.

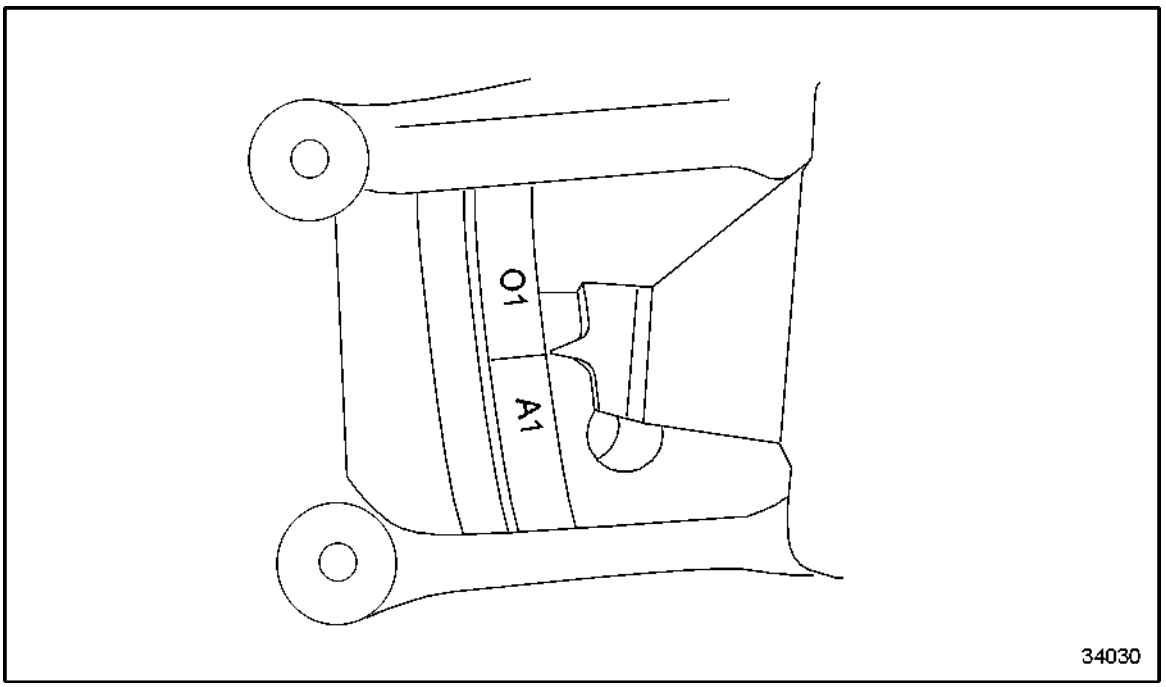


Figure 483 Adjusting Valve Clearance (Marine only)

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:

1. If swing arms on cylinder A1 are unloaded, the piston is in firing TDC. See Figure 484.

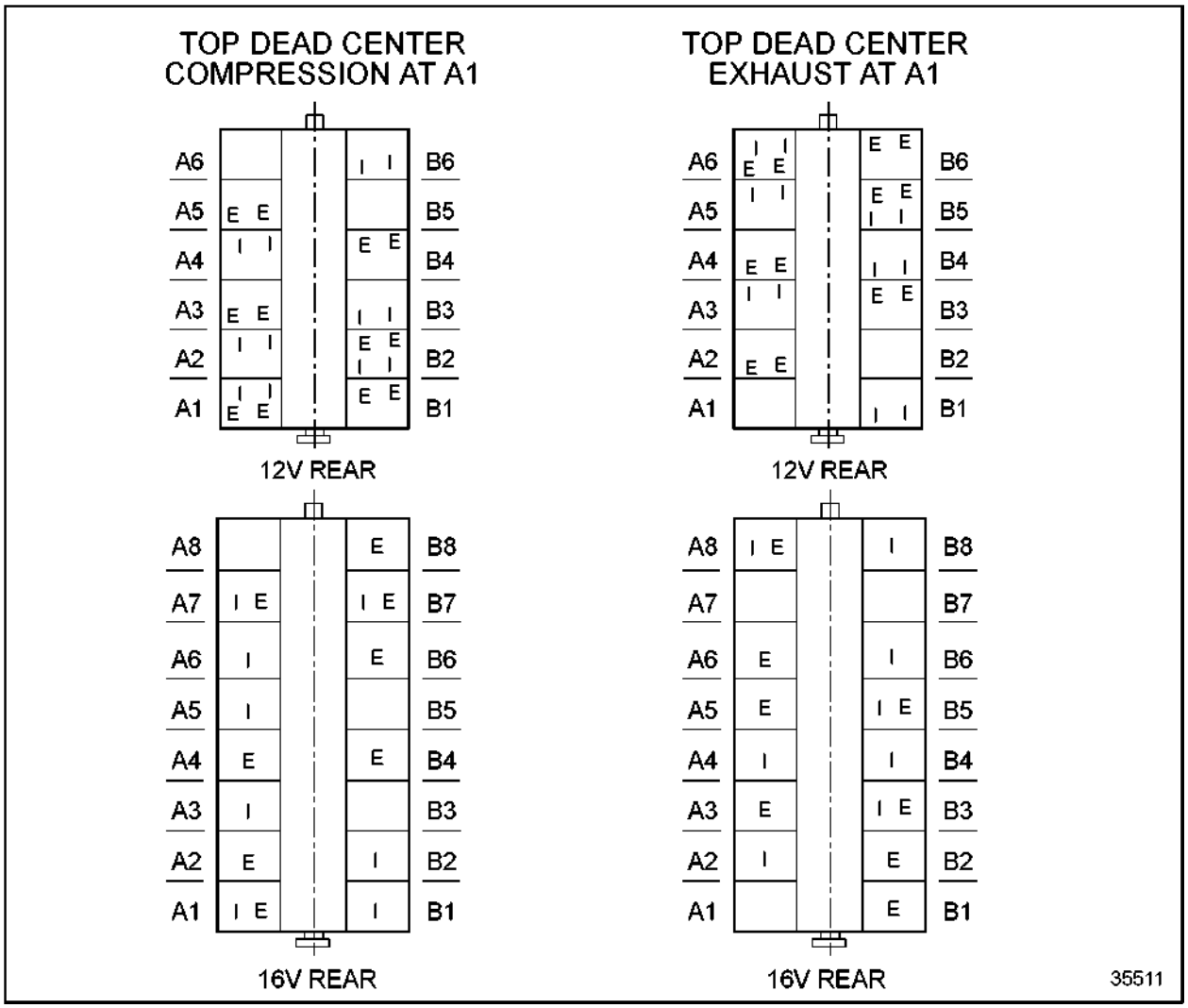


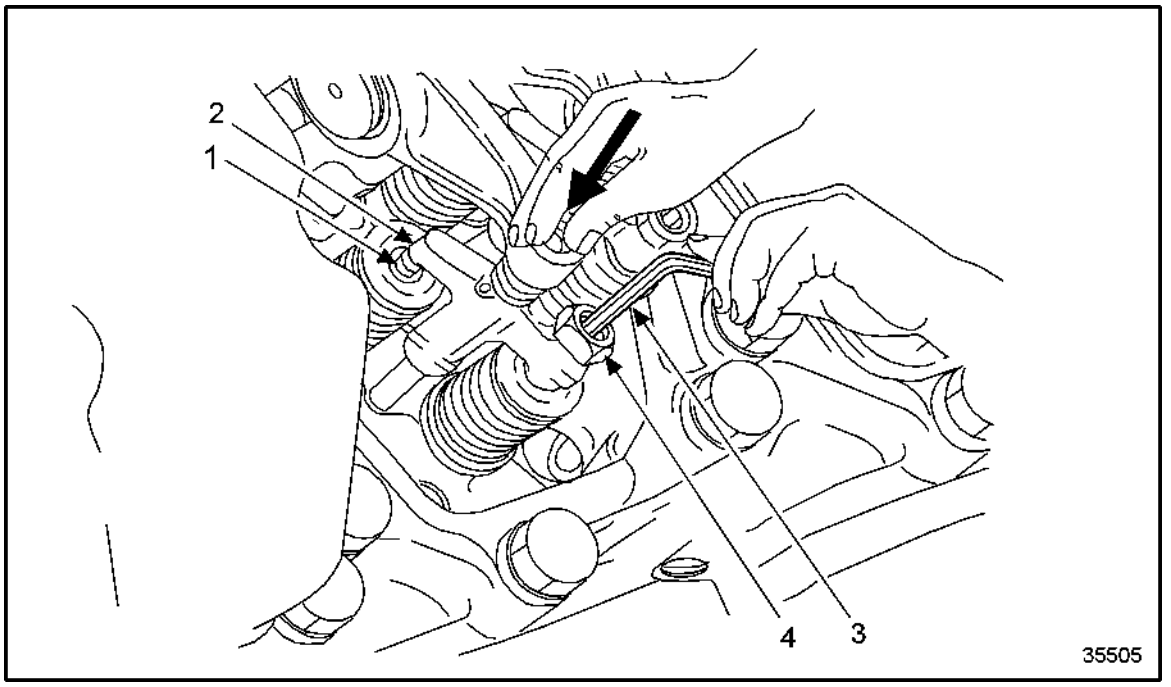
Figure 484 Adjusting Valve Clearance in Two Crankshaft Positions

2. If swing arms on cylinder A1 are loaded, the piston is in overlap TDC.
3. Check all valve clearances at two crankshaft positions (firing TDC and overlap TDC, cylinder A1) in accordance with Figure .
4. Turn crankshaft in direction of engine rotation.
5. 1 = Firing TDC at cylinder A1; 2 = Overlap TDC at cylinder A1; X = Exhaust value; 0 = Inlet valve.

Adjusting Valve Bridge

Perform the following steps to adjust the valve bridge:

1. Loosen locknut (4), holding valve bridge (2) firm with an open-end wrench. See Figure 485.



1. Adjusting Bolt
2. Valve Bridge
3. Allen Wrench
4. Locknut

Figure 485 Adjusting Locknut

2. Turn adjusting bolt (1) back until it no longer contacts the valve stem.
3. Press valve bridge (2) downward (arrow) via the swing arm and hold in position.

NOTE:
The valve bridge must not contact the stem.

4. With pressure applied to the valve bridge, use an Allen wrench to install the adjusting bolt (1) until the adjusting bolt lightly contacts the valve stem.
5. Rotate approximately 20 to 30 degrees to compensate clearance.
6. Hold adjusting bolt (1) and tighten locknut slightly.
7. Tighten locknut with torque wrench to specification, holding valve bridge firmly in place with open-end wrench.Refer to section A 003.

NOTE:
Use engine oil as lubricant.

Inspecting Valve Clearance in Two Positions

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

1. If swing arms on cylinder A1 are unloaded, the piston is in firing TDC. See Figure 486.

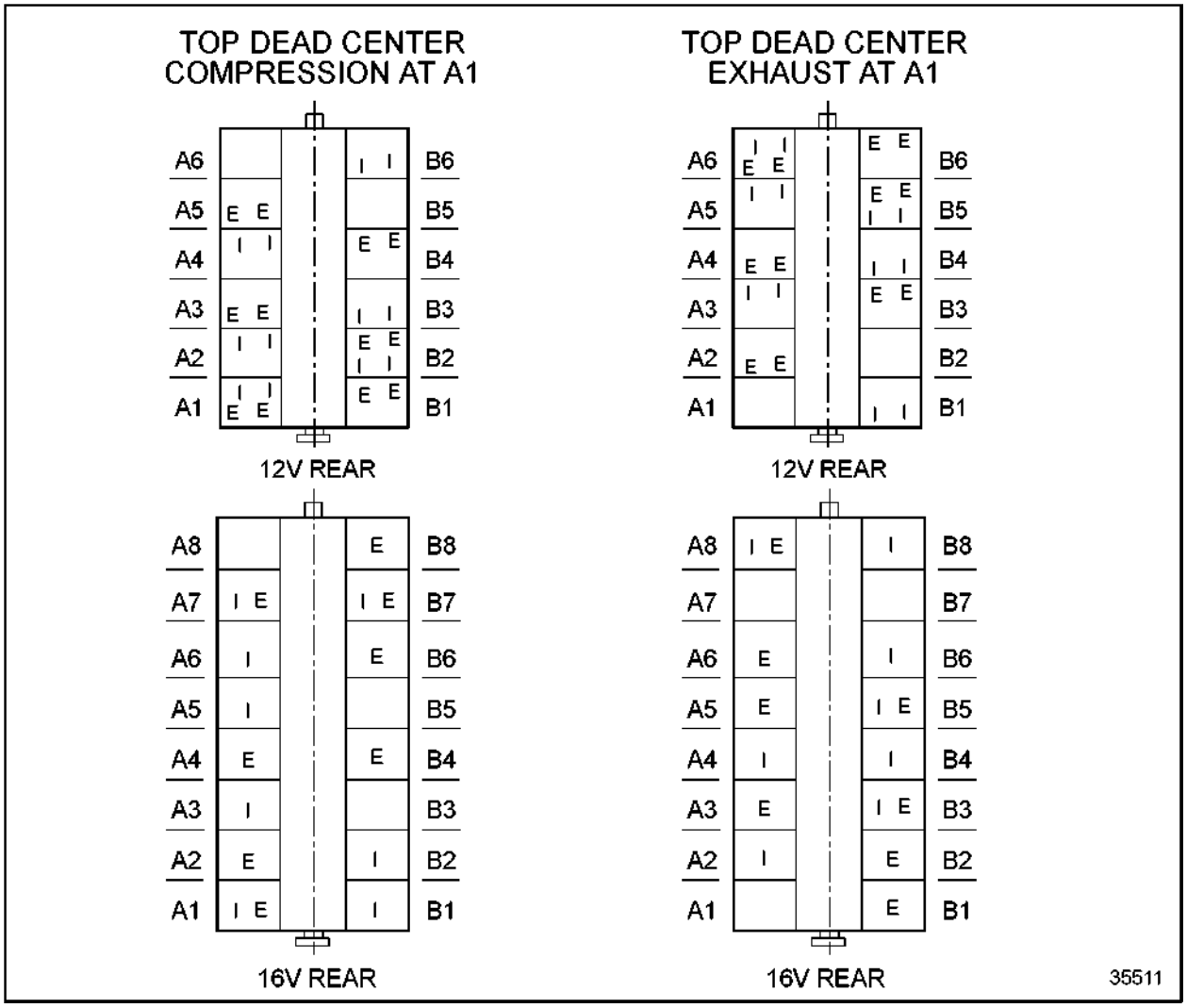


Figure 486 Inspecting Valve Clearance in Two Crankshaft Positions

2. If swing arms on cylinder A1 are loaded, the piston is in overlap TDC.
3. Check all valve clearances at two crankshaft positions (firing TDC and overlap TDC, cylinder A1) in accordance with Figure .
4. Turn crankshaft in direction of engine rotation.
5. 1 = Firing TDC at cylinder A1; 2 = Overlap TDC at cylinder A1; X = Exhaust value; 0 = Inlet valve.

6. Use feeler gage to check distance between valve bridge and swing arm. See Figure 487.

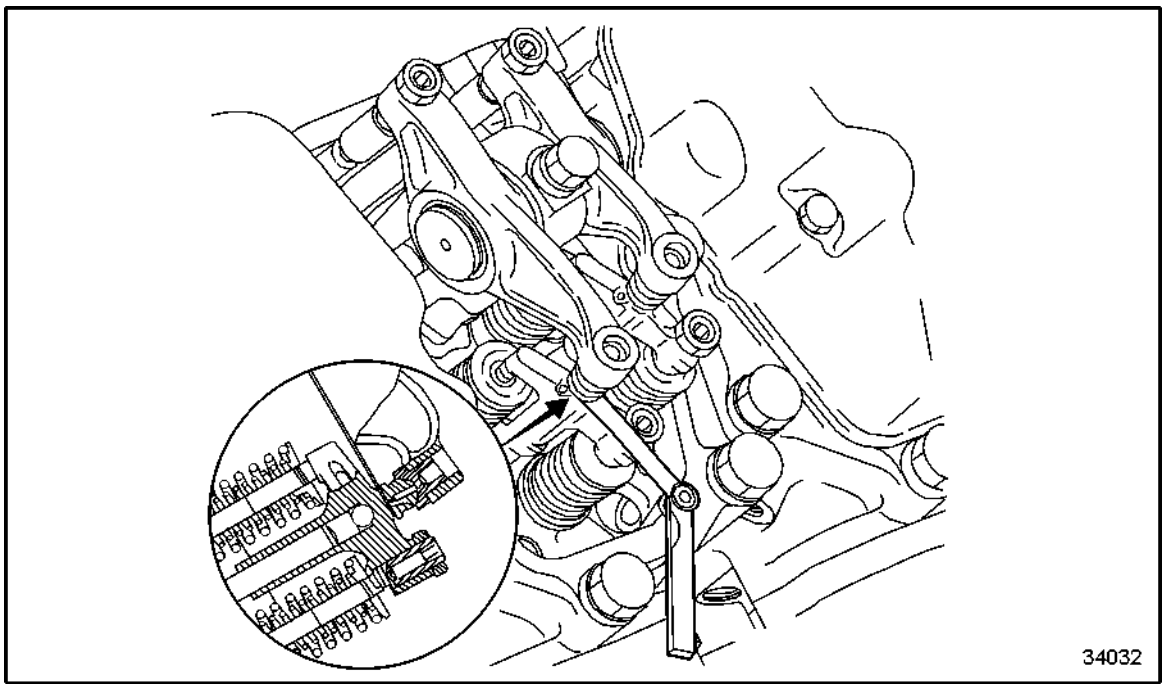


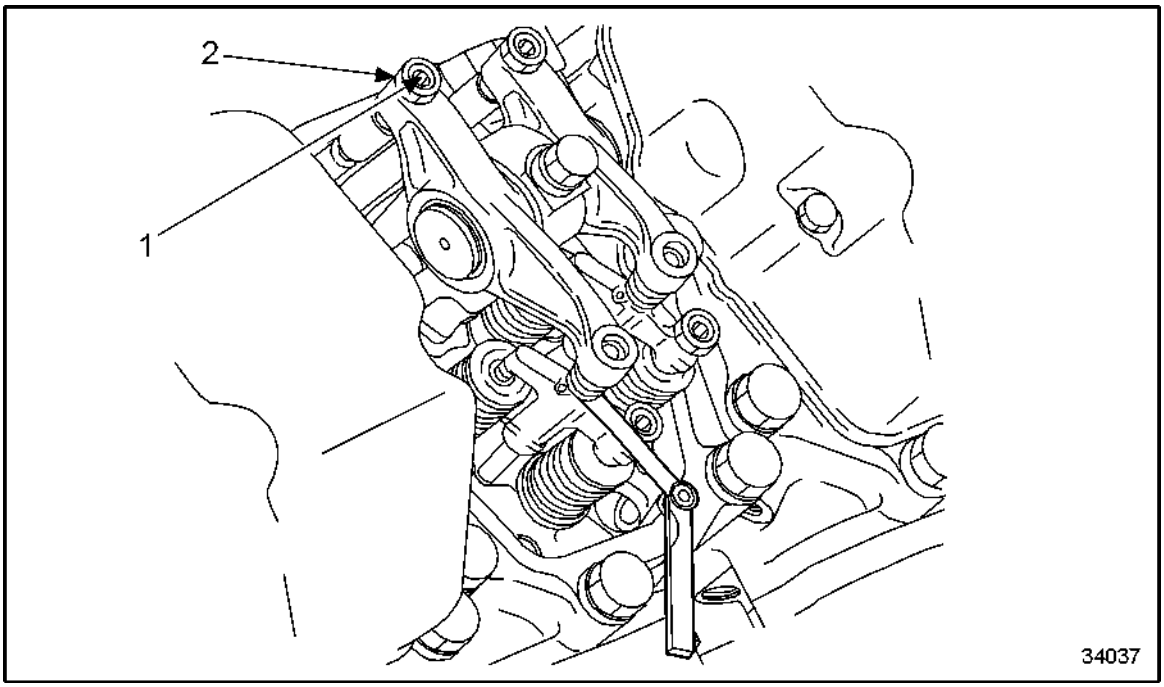
Figure 487 Using Feeler Gage

7. Valve clearance on inlet valve (long swing arm) = 0.2 mm (cold engine).
8. Valve clearance on exhaust valve (short swing arm) = 0.5 mm (cold engine).

NOTE:
It must still be possible to pull feeler gage through.

9. If deviation from specified value is more than 0.1 mm, adjust valve clearance.

10. Release locknut (1) and readjust adjusting bolt (2) with Allen key until feeler gage can be pulled through. See Figure 488.



1. Locknut
2. Adjusting Bolt

Figure 488 Readjusting Adjusting Bolt

11. Valve clearance on inlet valve (long swing arm) = 0.2 mm (cold engine).
12. Valve clearance on exhaust valve (short swing arm) = 0.5 mm (cold engine).
13. Holding adjusting bolt firmly, again tighten locknut to specified torque.
14. For tightening torque, refer to section A 003.
15. Again check valve clearance.

C 055.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 50 are the After-Installation Operations for the valve drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Install valve covers	Refer to section C 055.05.11
1, 2, 3	Install charge air coolant lines (low temperature)	Refer to section C 207.05.11
1, 2, 3	Install turbocharger	Refer to section C 101.05.11
1, 2, 3	Install oil supply line for turbochargers	Refer to section C 187.05.11
1, 2, 3	Install oil return lines for turbochargers	Refer to section C 188.05.11
1, 2, 3	Install coolant lines (high temperature)	Refer to section C 203.05.11
1, 2, 3	Install charge air coolant vent lines (low temperature)	Refer to section C 205.05.01
1, 2, 3	Install engine coolant vent lines (high temperature)	Refer to section C 205.05.01
1, 2, 3	Install intake air system from turbocharger to charge air cooler	Refer to sectionC 125.05.11
1, 2, 3	Install Y-pipe at exhaust outlet housing	Refer to section C 141.05.11
1, 2, 3	Add charge air coolant (low temperature)	Refer to section C 206.05.11
1, 2, 3	Add engine coolant (high temperature)	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.

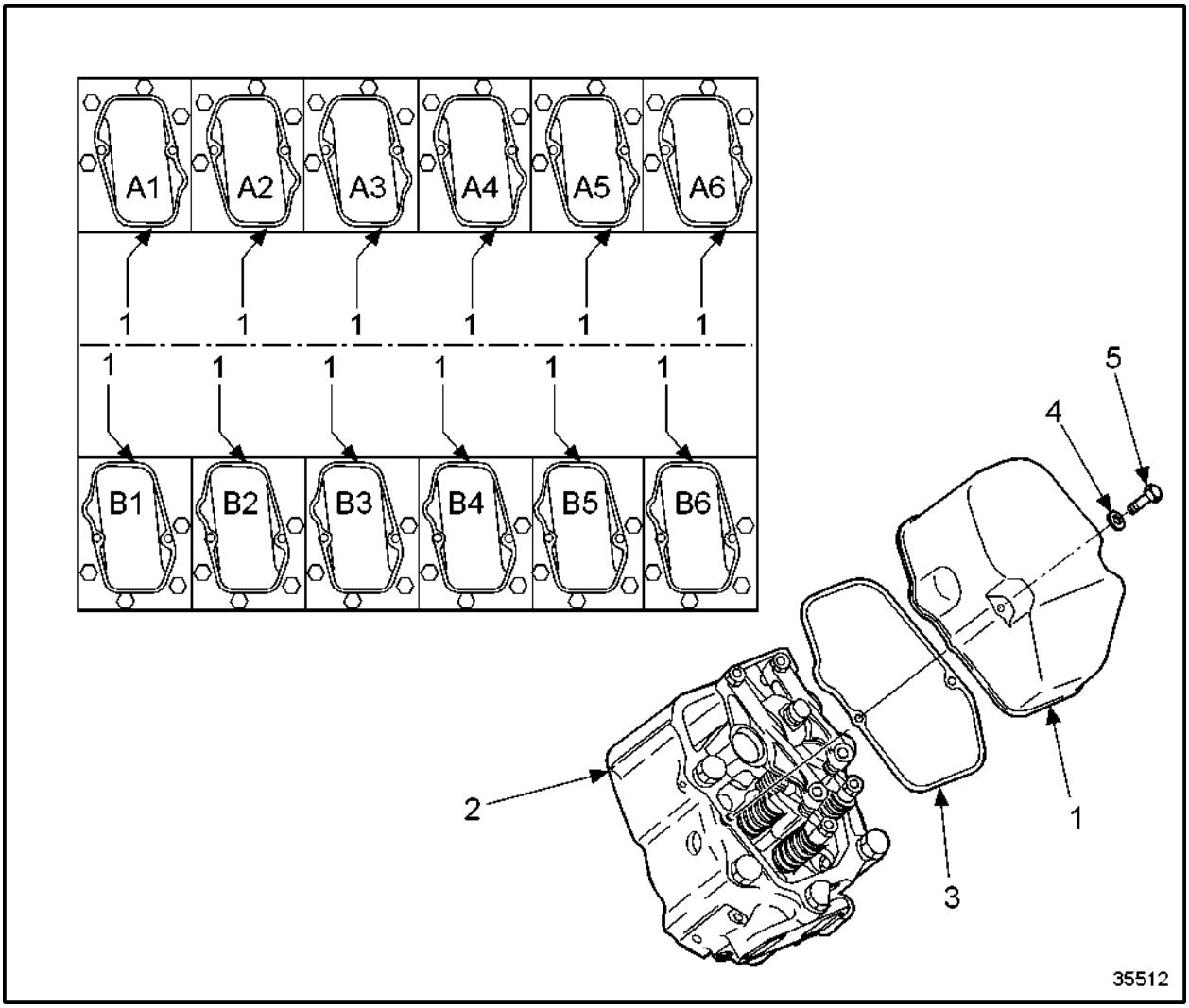
3 = The engine is to remain installed.

Table 50 After-Installation Operations

C 056.05 – CYLINDER HEAD COVER

C 056.05.01 – GENERAL VIEW

See Figure 489for a general view of rocker cover arrangement (12V).



1. Rocker Cover
2. Cylinder Head
3. Gasket
4. Washer
5. Hex Bolt

Figure 489 General View of Rocker Cover Arrangement (12V)

C 056.05.02 – SPECIAL TOOLS

Listed in Table 51 are the special tools required for maintenance on the rocker cover.

Application	Number
Valve clearance adjustment gage 0.2 mm/0.5 mm	—
Allen Key, 8 A/F, for valve clearance adjustment	—
Engine barring tool	—

Table 51 Special Tools

C 056.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 52 are the Before-Removal Operations for the rocker cover.

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.

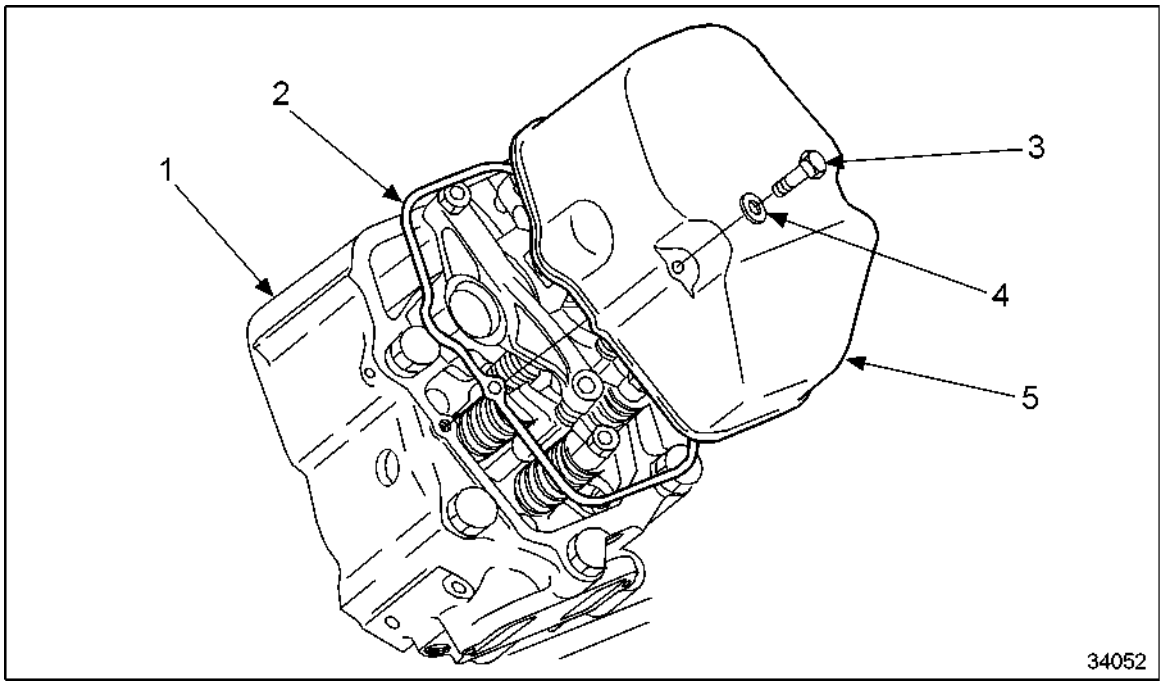
Table 52 Before-Removal Operations

C 056.05.05 – REMOVAL OF THE ROCKER COVER

Removing Rocker Cover

Perform the following steps to remove rocker cover:

1. Remove hex bolts. See Figure 490.



1. Cylinder Head
2. Profile Gasket
3. Hex Head Bolt
4. Washer
5. Rocker Cover

Figure 490 Removing Rocker Cover

2. Remove rocker cover and gasket.

C 056.05.08 – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the rocker cover.

1. Clean rocker cover with cleaner, blow out with compressed air and make sure it is perfectly clean.

> **CAUTION:**
>
> **To avoid an eye injury when blow drying parts, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.**

2. Visually inspect cylinder head cover for wear and damage, paying particular attention to the mating and sealing surfaces.
   [a] If rocker cover is worn or damaged, rub down with emery cloth or oilstone; replace as necessary.
   [b] If rocker cover is not worn or damaged, continue inspection.
3. Clean hex bolts and inspect for wear or damage.
   [a] If hex bolts are worn or damaged, replace as necessary.
   [b] If hex bolts are not worn or damaged, continue inspection.
4. Inspect threads of hex bolts for ease of movement.
   [a] If hex bolts do not move easily, replace as necessary.
   [b] If hex bolts move easily, continue inspection.
5. Replace gaskets during W6 maintenance.

C 056.05.11 – INSTALLATION OF THE ROCKER COVER

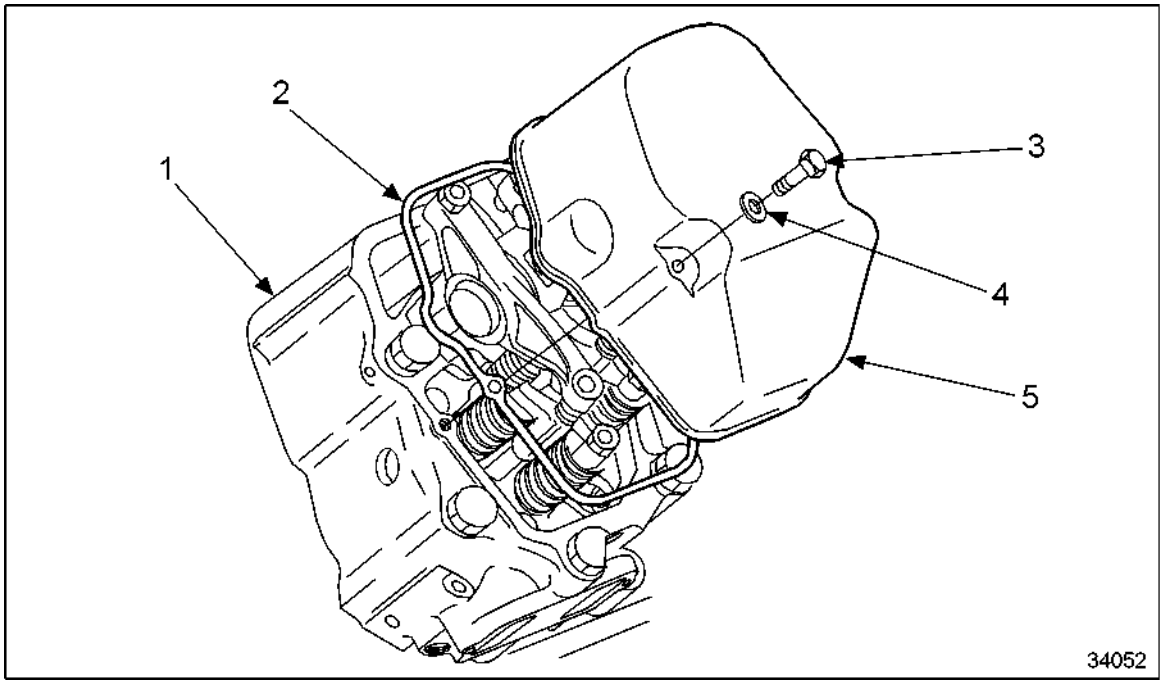
Installing Rocker Cover

Perform the following steps to install the rocker head cover:

NOTE:
Ensure that parts are perfectly clean.

1. Inspect mating surface; clean if necessary.
2. Verify that profile gasket (2) in rocker cover (5) is in perfect condition, replace if necessary.
3. Place rocker (5) on cylinder head (1).
4. Insert hex head bolts (3) with washers and tighten with torque wrench holding valve bridge firmly in place with open-end wrench. Refer to section A 003.See Figure 491.

NOTE:
Use engine oil as lubricant.



1. Cylinder Head
2. Profile Gasket
3. Hex Head Bolt
4. Washer
5. Rocker Cover

Figure 491 Installing Rocker Cover

5. Release engine start.

C 056.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 53 are the After-Installation Operations for the valve drive rocker cover.

Level of Maintenance	Operation	Reference
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 53 After-Installation Operations

C 070 – FUEL SYSTEM - HIGH-PRESSURE

The purpose of the fuel system is to keep the fuel clean and free from air or water, and to deliver fuel to the engine at correct pressures.

Fuel System Description

A unique, common rail fuel injection system is a major feature of the Series 4000. The Series 4000 common rail system does not require cam driven unit injectors or an injection pump with separate cam driven plungers for each injector. Instead, the Series 4000 fuel system relies on a single high-pressure fuel pump that provides a continuous supply of fuel, at injection pressure, to all of the injectors.

A complete Series 4000 fuel system consists of:

- ☐ Low-pressure fuel pump
- ☐ Low-pressure fuel lines
- ☐ Remote mounted fuel filter(s)
- ☐ Engine mounted fuel filter(s)
- ☐ High-pressure fuel pump
- ☐ High-pressure fuel rails
- ☐ Fuel injection nozzle assemblies
- ☐ Low-pressure return fuel rails
- ☐ Fuel cooler (optional)
- ☐ Electronic control module (ECM)
- ☐ All necessary piping

Fuel is drawn from the tank and into the fuel junction block by the fuel pump. Fuel is then pumped at low pressure to the fuel filter(s) and onward to the high pressure fuel pump. The high pressure fuel pump supplies fuel, at high pressure, to the high pressure fuel supply rails, which in turn feed each injector. Fuel that spills from the injectors flows through the return rails back to the fuel junction block to the fuel tank by a single return line. See Figure 492.

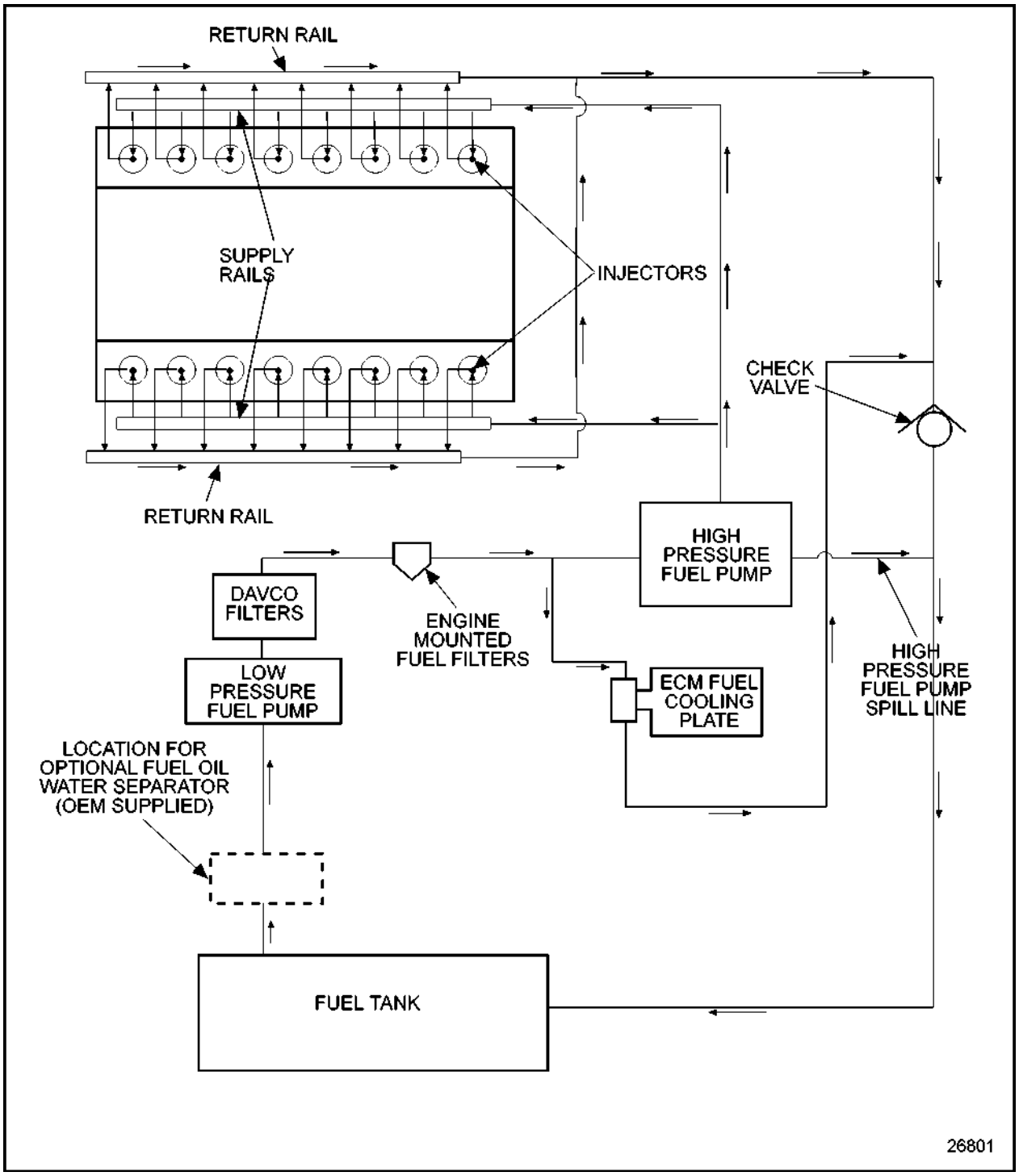
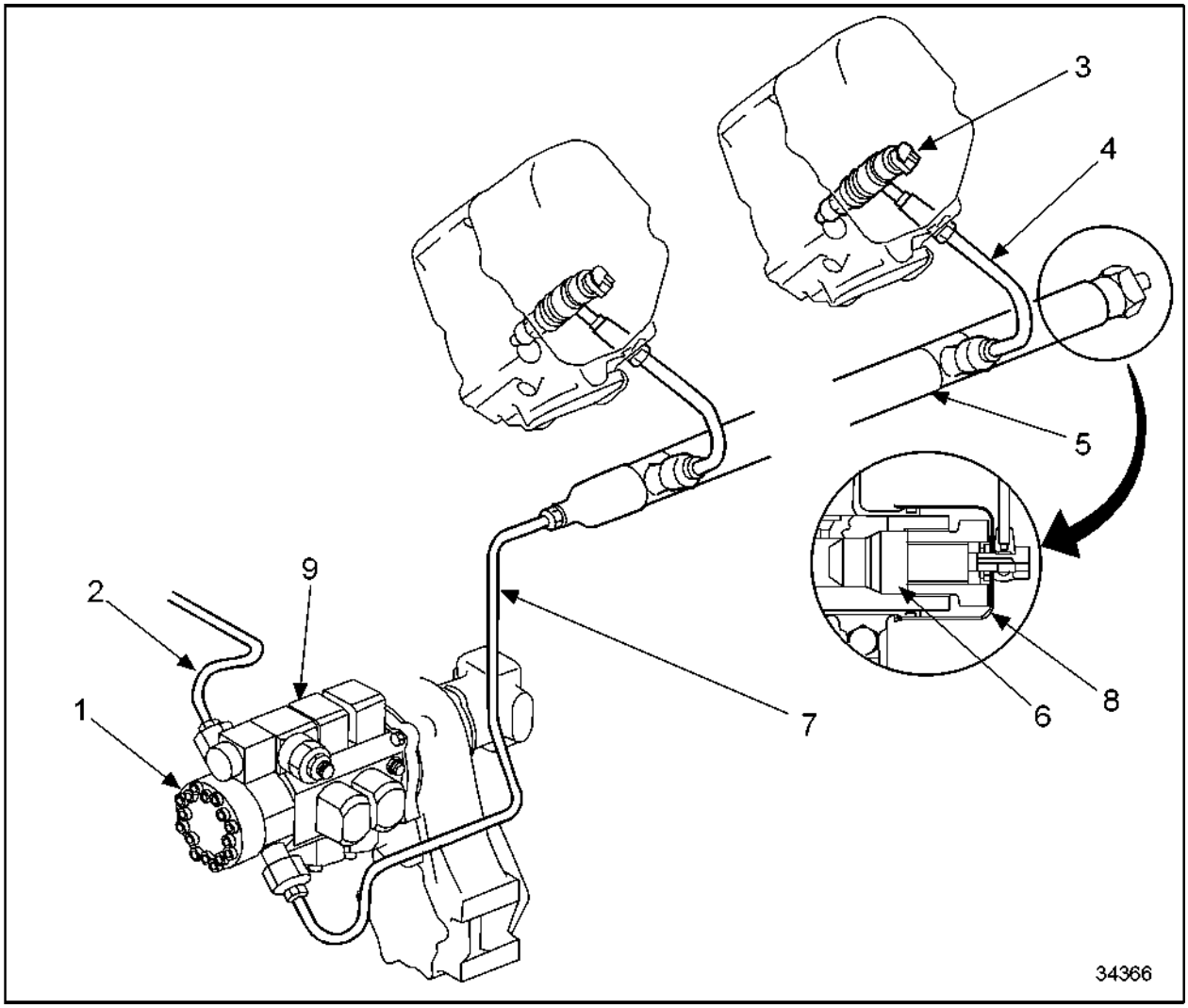


Figure 492 Schematic Diagram of the Series 4000 Fuel System

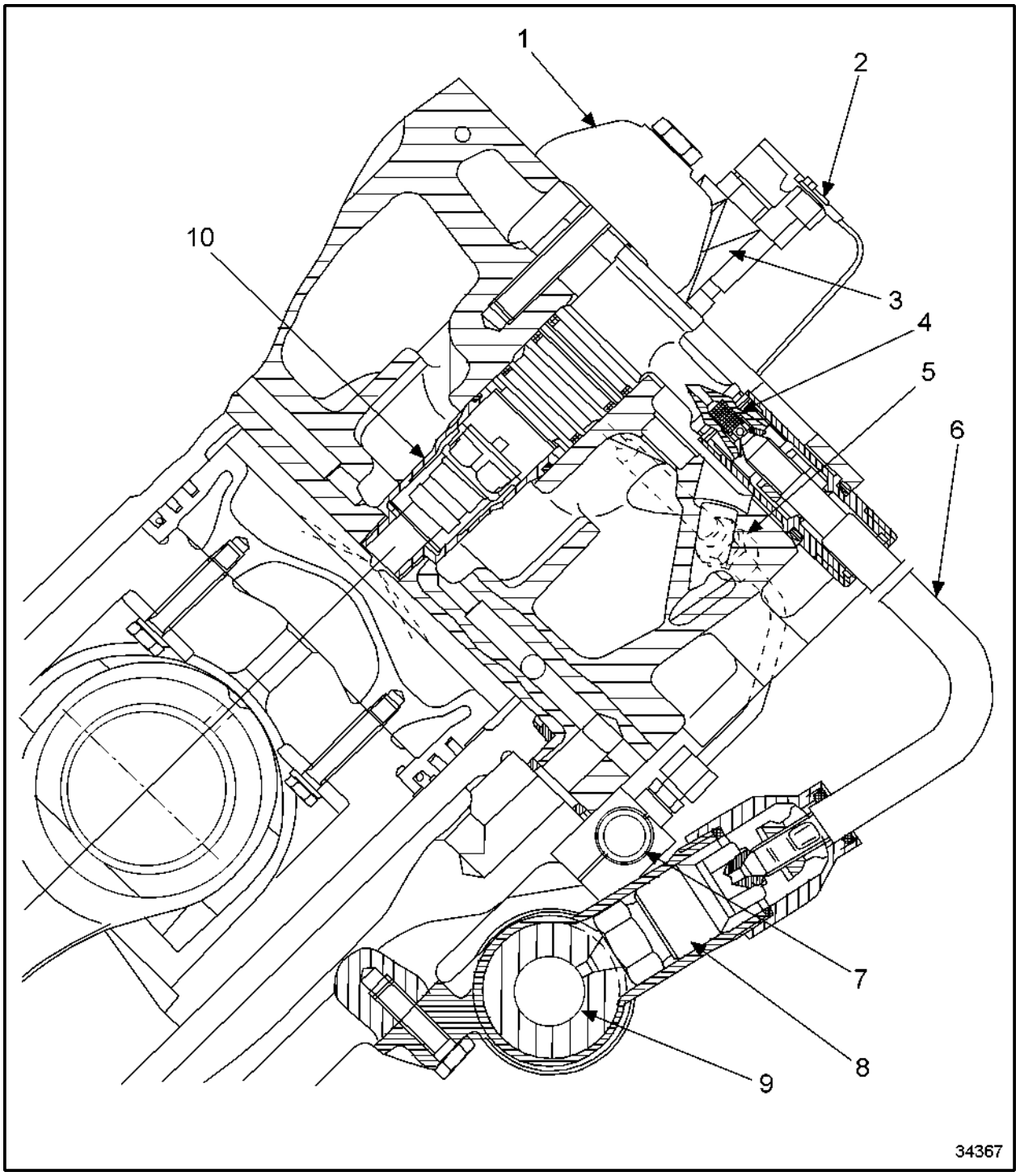
See Figure 493 for a general view of the high-pressure fuel system.



1. High-Pressure Pump
2. High-Pressure Line
3. Injector
4. High-Pressure Jumper Line
5. High-Pressure Rail
6. Pressure Relief Valve
7. High-Pressure Line
8. Protective Cover (Marine and Hydo Frac Only)
9. Control Solenoid

Figure 493 General View of the High-Pressure Fuel System

See Figure 494 for a cutaway view of the high-pressure fuel system.



1. Injector Hold-Down Clamp
2. DDEC Harness Connection
3. Injector
6. High-Pressure Jumper Line
7. Fuel Return Manifold
8. Fuel Flow Limiting Valve

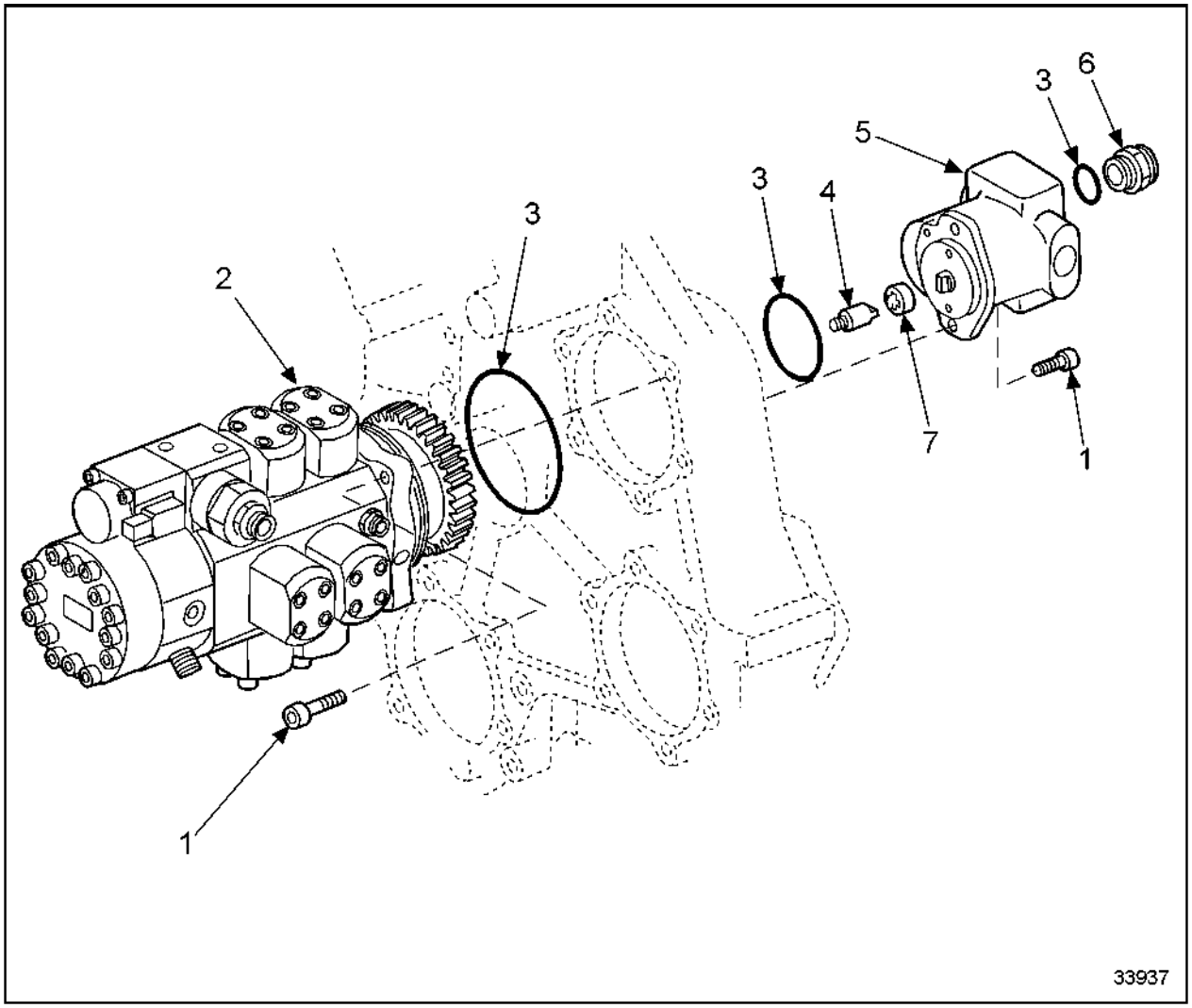
4. Inlet Filter Element
5. Return Fuel Return Line
9. High-Pressure Fuel Rail
10. Injector Hole Tube

Figure 494 Cutaway View of the High-Pressure Fuel System

C 073.05 – HIGH-PRESSURE FUEL PUMP

C 073.05.01 – GENERAL VIEW

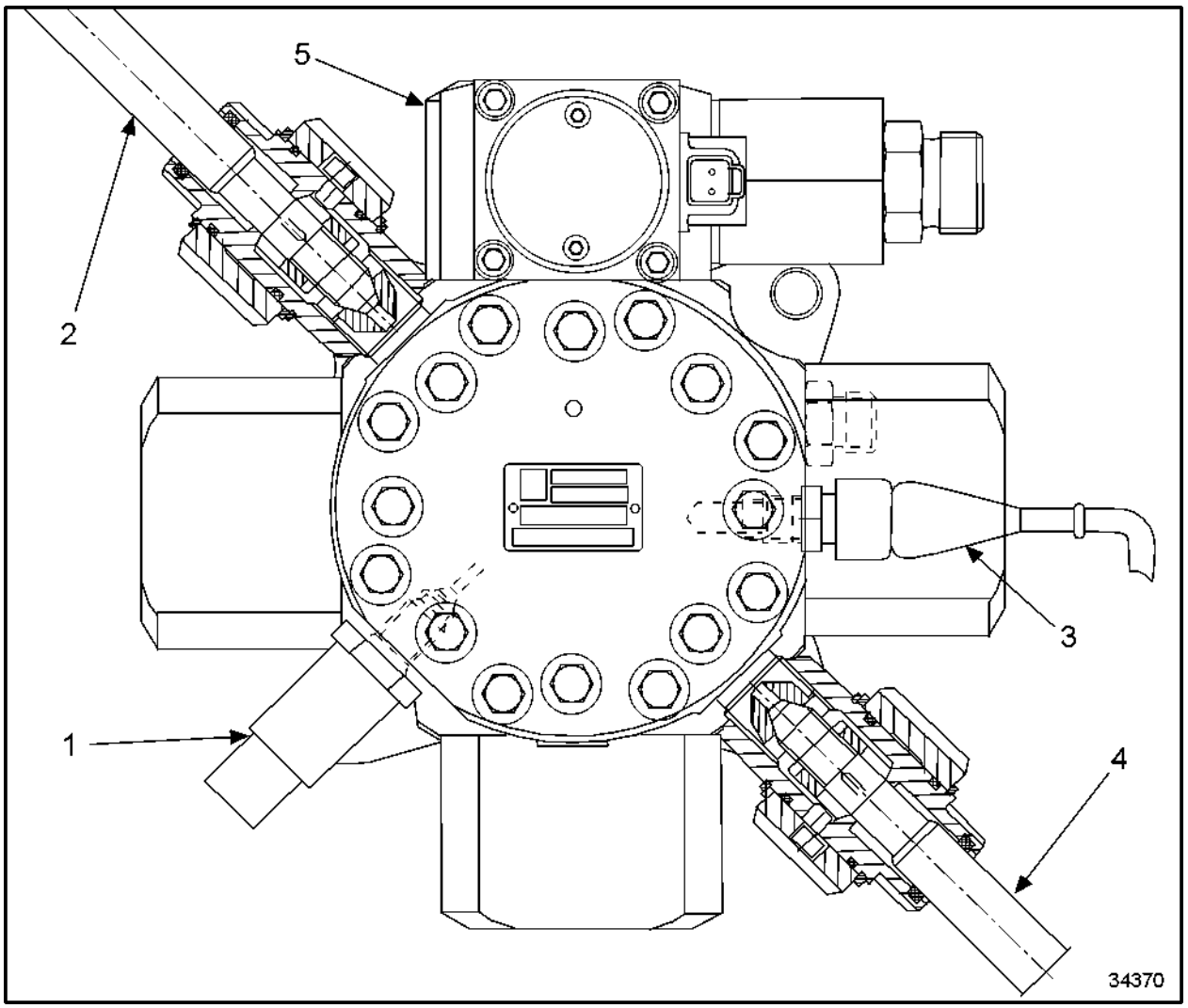
See Figure 495 for a general view of the high-pressure fuel pump.



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

See Figure 496 for a cutaway view of the high-pressure fuel pump.



1. High-Pressure Fuel Sensor
2. High-Pressure Line to "B" Bank
3. Temperature Sensor
4. High-Pressure Line to "A" Bank
5. Control Solenoid

Figure 496 Cutaway View of the High-Pressure Pump

C 073.05.02 – SPECIAL TOOLS

Not applicable.

C 073.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 54 are the Before-Removal Operations for high-pressure fuel pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Disable engine start	Refer to Operators Guide
1, 2, 3	Remove low-pressure fuel pump	Refer to section C 081.05.05
1, 2, 3	Remove low-pressure fuel lines	Refer to section C 083.05.05
1, 2, 3	Remove high-pressure fuel lines	Refer to section C 083.05.05
1, 2, 3	Disconnect DDEC Harness	Refer to section C 501.05 M
1, 2, 3	Remove high-pressure sensor if necessary	Refer to section C 077.05.05
1, 2, 3	Remove temperature sensor if necessary	-

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 54 Before-Removal Operations

C 073.05.05 – REMOVAL OF THE HIGH-PRESSURE FUEL PUMP

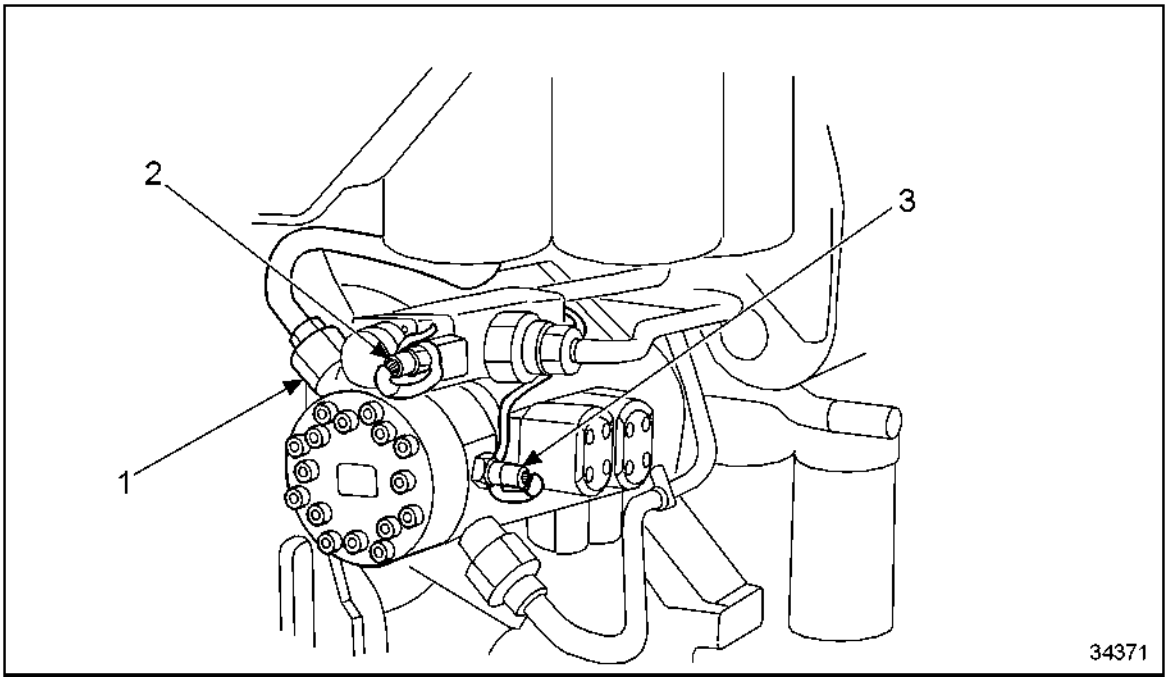
Perform the following steps to remove the high-pressure pump.

NOTE:
Remove the low-pressure pump with drive coupling before removing the high-pressure pump, otherwise satisfactory installation of the high-pressure pump driver may not be possible. Refer to section C 081.05.05.

CAUTION:

To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

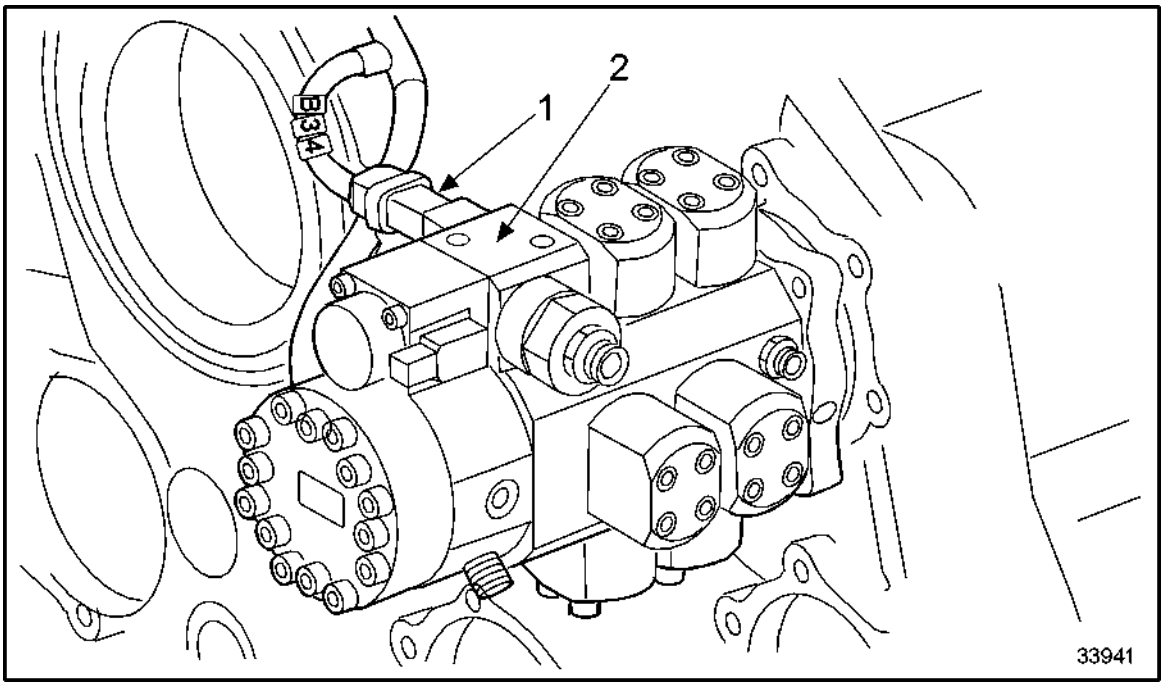
1. Disconnect DDEC Harness connection for solenoid controller at connection. See Figure 497.



1. High-Pressure Line “B” Bank
2. DDEC Harness Connector to Controller Solenoid
3. DDEC Harness Connection to Temperature Sensor

Figure 497 Loosening High-Pressure Line, Right Side, on High-Pressure Fuel Pump and Rail

2. Remove DDEC harness connection to temperature sensor. See Figure 498.

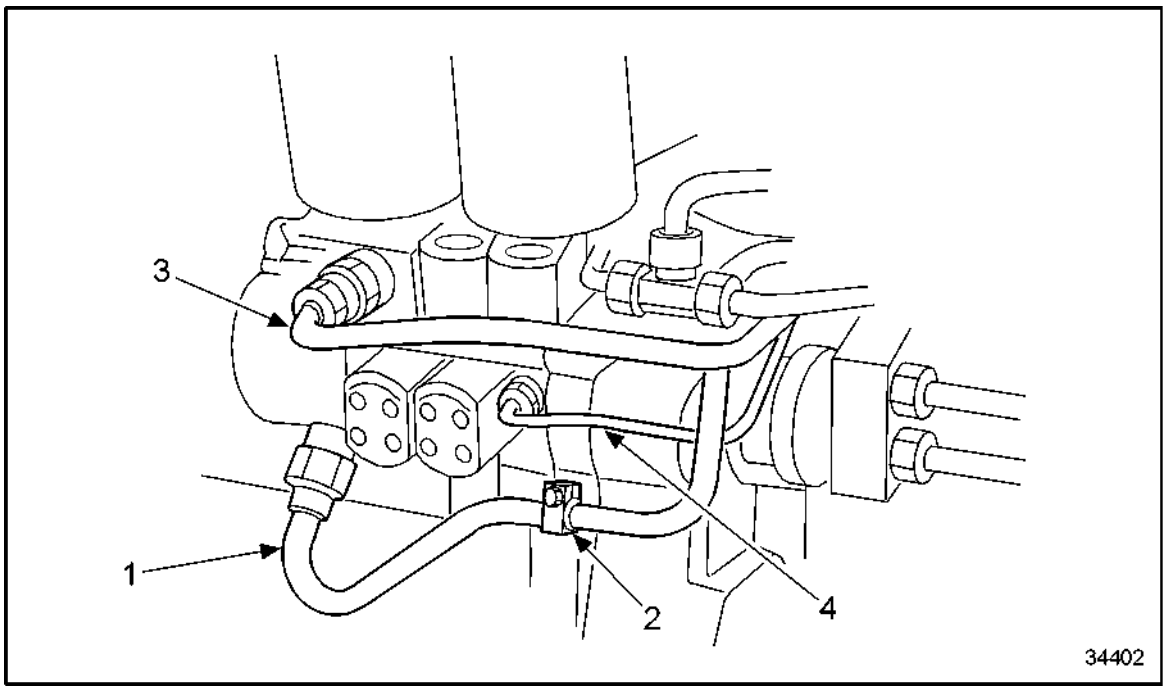


1. B34 (Fuel Pressure Sensor) Connector
2. High-Pressure Pump Controller

Figure 498 Removing DDEC Harness

3. Disconnect low-pressure fuel sensor DDEC harness from sensor.
4. Remove high-pressure line (1), “B” bank.
5. Remove fuel supply (3) and return lines (4).

6. Remove pipe clamp half (2) and high-pressure line (1), “A” bank. See Figure 499.



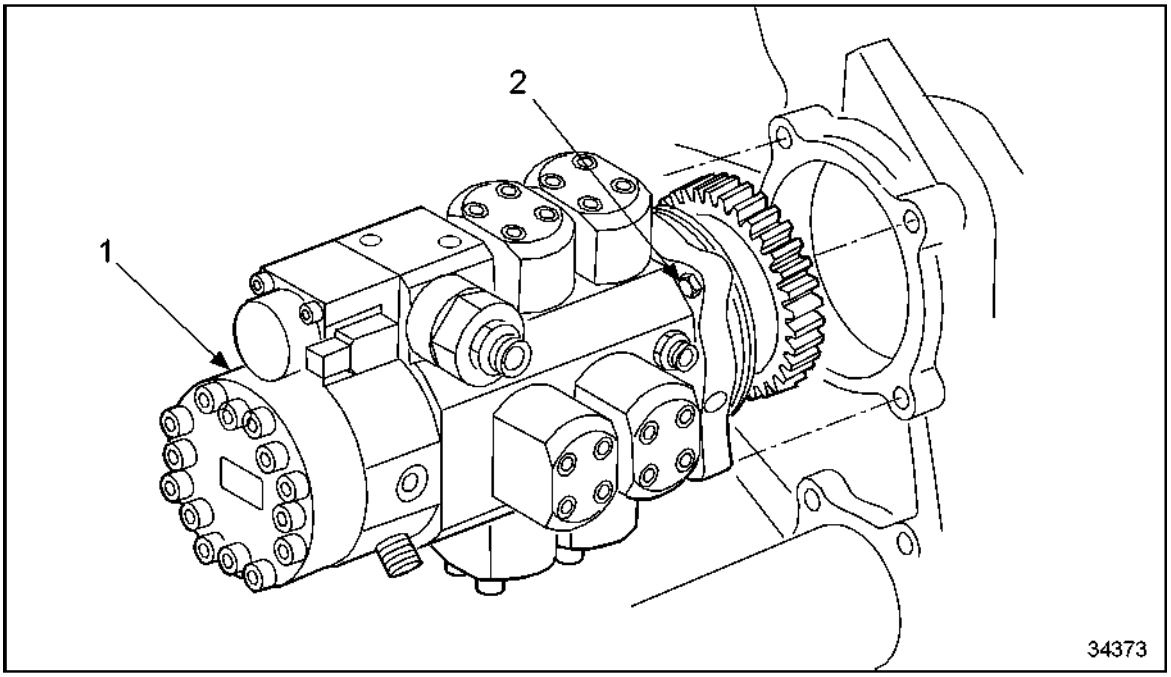
1. High-Pressure Line ("A" Bank)
2. Pipe Half Clamp
3. Fuel Supply
4. Fuel Return

Figure 499 Removing High-Pressure Line, “A” Bank, between High-Pressure Pump and Rail

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device to lift heavy objects and follow the manufacturer's operator procedures.

7. Attach high-pressure pump (1) with a lifting device to a hoist and remove the attaching Allen head bolts (2). See Figure 500.

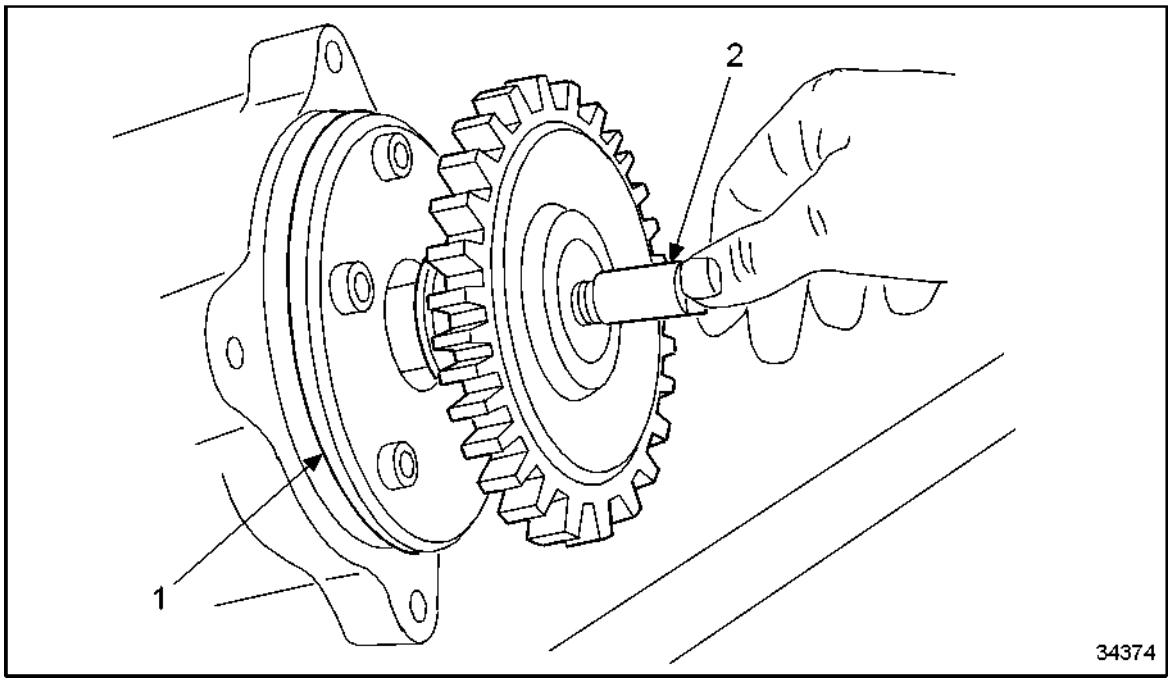


1. High-Pressure Pump
2. Hex Bolt

Figure 500 Attaching High-Pressure Pump to Lifting Device and Removing Bolts

8. If necessary, cover opening in gear case.

9. Remove O-ring (1). See Figure 501.



1. O-ring
2. Drive Adaptor

Figure 501 Removing O-ring/Drive

10. Remove drive adaptor.

NOTE:
When replacing high-pressure fuel pump, note that replacement pump is delivered without drive adaptor.

C 073.05.06 – DISASSEMBLY OF THE HIGH-PRESSURE FUEL PUMP

No provision is made for disassembling the high-pressure pump on site.

High-pressure pumps are serviced only as an assembly by your authorized Detroit Diesel Distributor.

C 073.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the high-pressure pump:

1. Visually inspect high-pressure pump.
   [a] If repairs are necessary, conduct repairs in a specialist workshop or at manufacturers.
   [b] If no repairs are necessary, continue inspection.
2. Visually inspect hex bolts for wear or damage.
   [a] If hex bolts are worn or damaged, replace bolts as necessary.
   [b] If hex bolts are not worn or damaged, continue inspection.
3. Ensure that threads of hex bolts are in perfect condition.
   [a] If hex bolt threads are worn or damaged, replace bolts as necessary.
   [b] If hex bolt threads are not worn or damaged, continue inspection.
4. Visually inspect condition of threads on high-pressure pump for perfect condition and ease of movement.
   [a] If threads on high-pressure pump are worn or damaged or do not show ease of movement, rechase threads.
   [b] If threads on high-pressure pump are not worn or damaged and show ease of movement, continue inspection.
5. Visually inspect drive gear.
   [a] If drive gear is worn or damaged, replace as necessary.
   [b] If drive gear is not worn or damaged, continue inspection.
6. Visually inspect condition of wiring.
   [a] If wiring is worn or damaged, replace as necessary.
   [b] If wiring is not worn or damaged, continue inspection.
7. Visually inspect weep hole for oil and fuel discharge. See Figure 502.
   [a] If weep hole is contaminated with oil and fuel discharge, clean as necessary.
   [b] If oil or fuel emerges from weep hole, replace high-pressure pump.

[c] If weep hole is not contaminated with oil and fuel discharge, continue inspection.

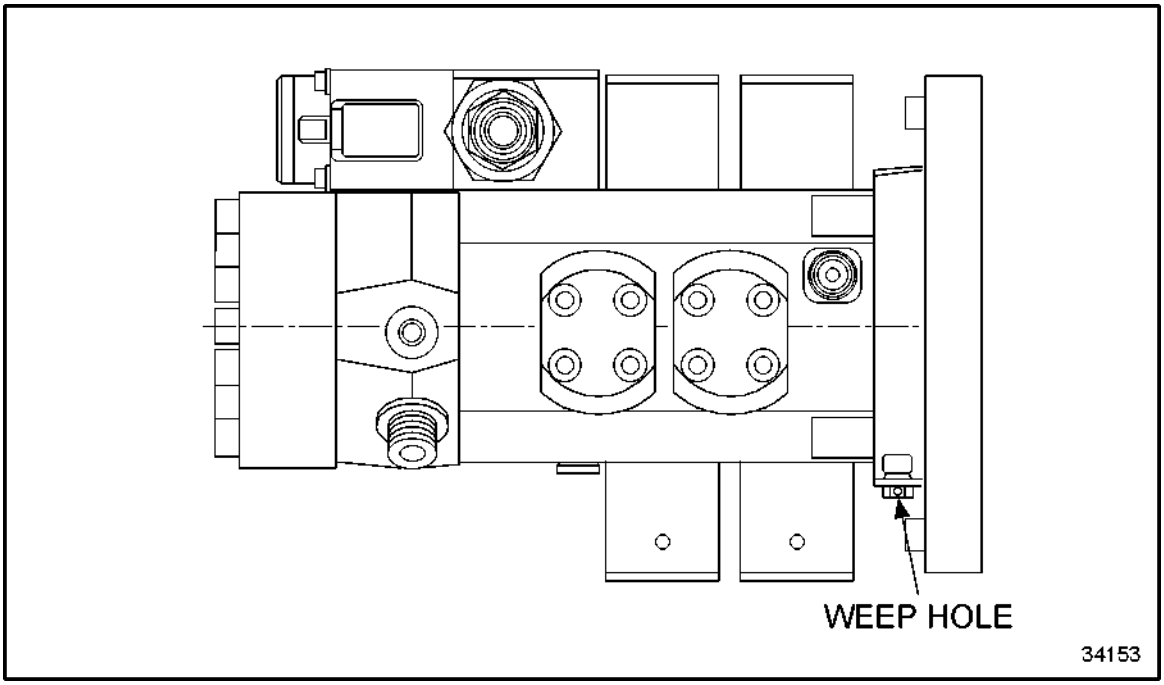


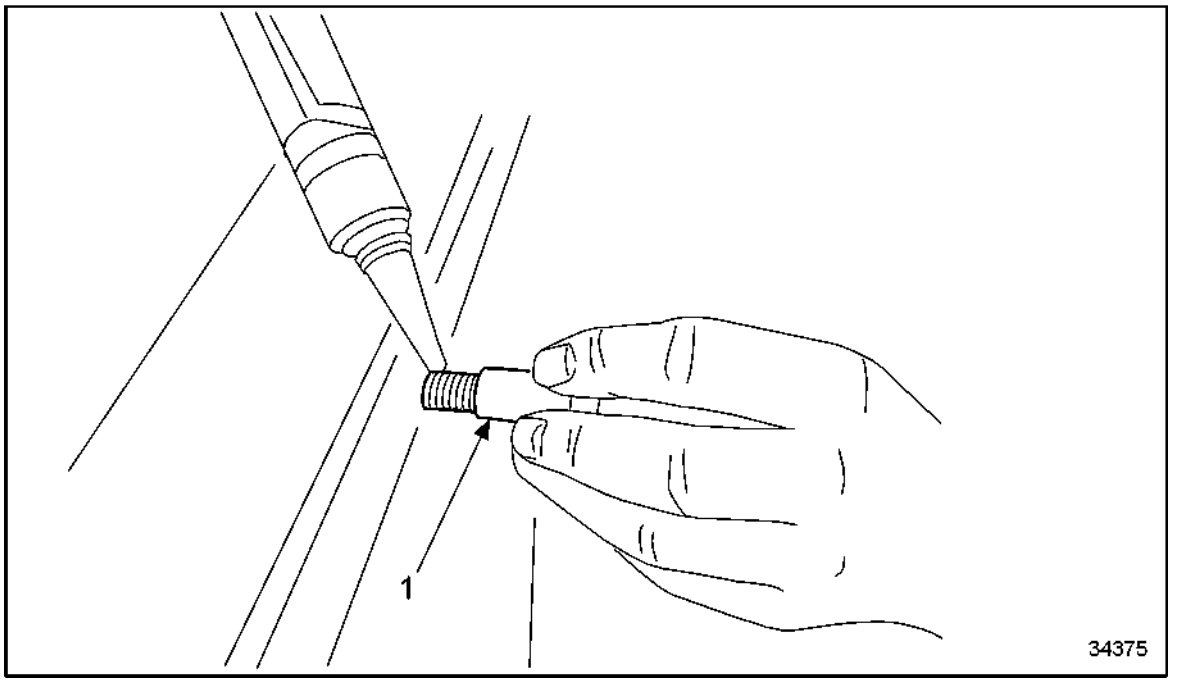
Figure 502 Visually Inspecting Weep Hole for Oil and Fuel Discharge

8. Replace O-ring after each removal.

C 073.05.11 – INSTALLATION OF THE HIGH-PRESSURE FUEL PUMP

Perform the following steps for installation of the high-pressure fuel pump:

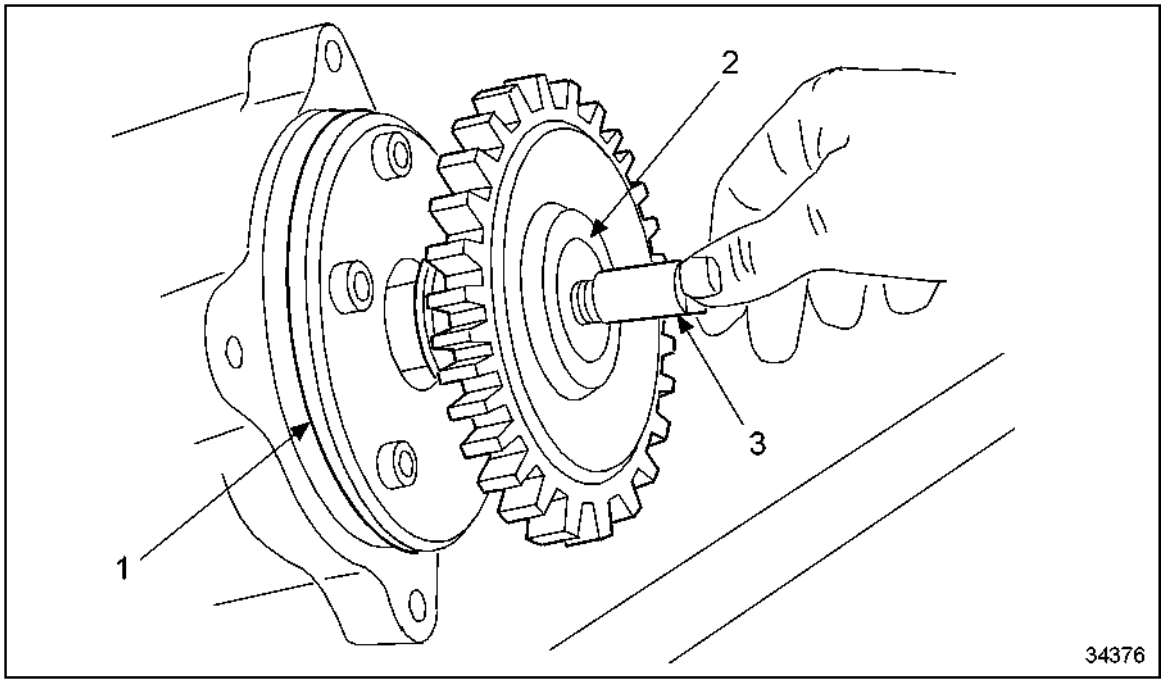
1. Coat thread of drive adaptor (1) with Loctite 270. See Figure 503.



1. Drive Adaptor

Figure 503 Coating Thread of Driver with Loctite 270

2. Screw driver (2) into pump shaft (3). See Figure 504.



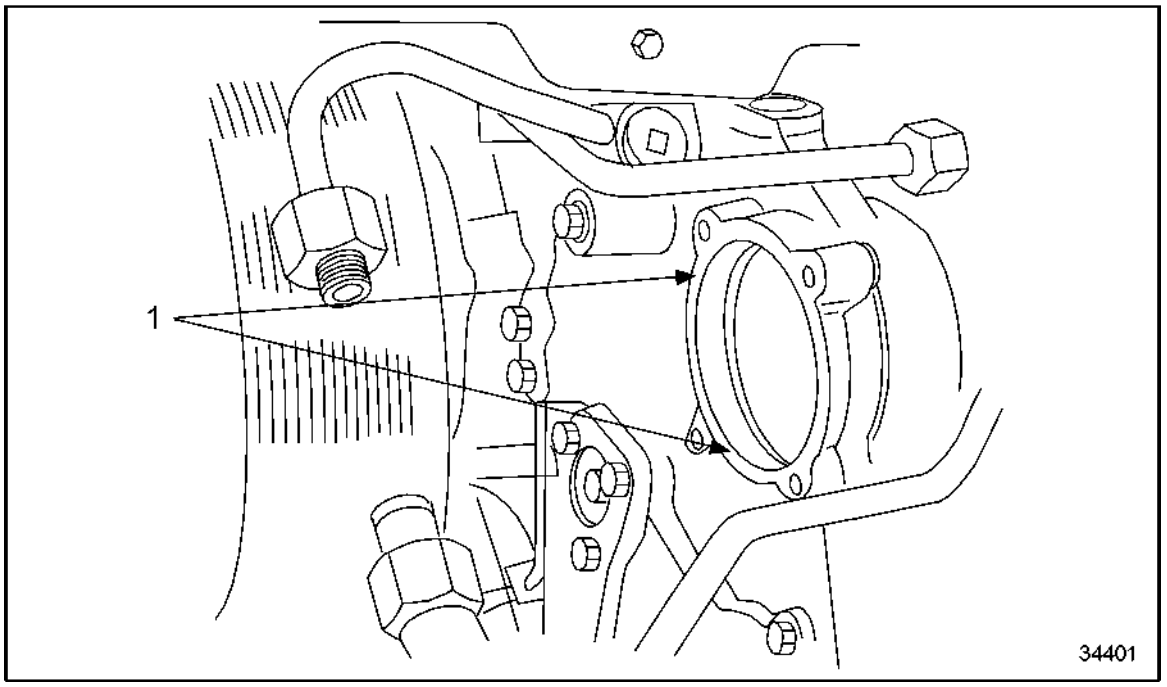
1. O-ring
2. Pump Shaft
3. Drive Adaptor

Figure 504 Screwing Driver into Pump Shaft

3. Coat O-ring (1) with petroleum jelly and install on high-pressure pump.

NOTE:
Ensure that pump drive gear is in its outer most position (toward end of shaft).

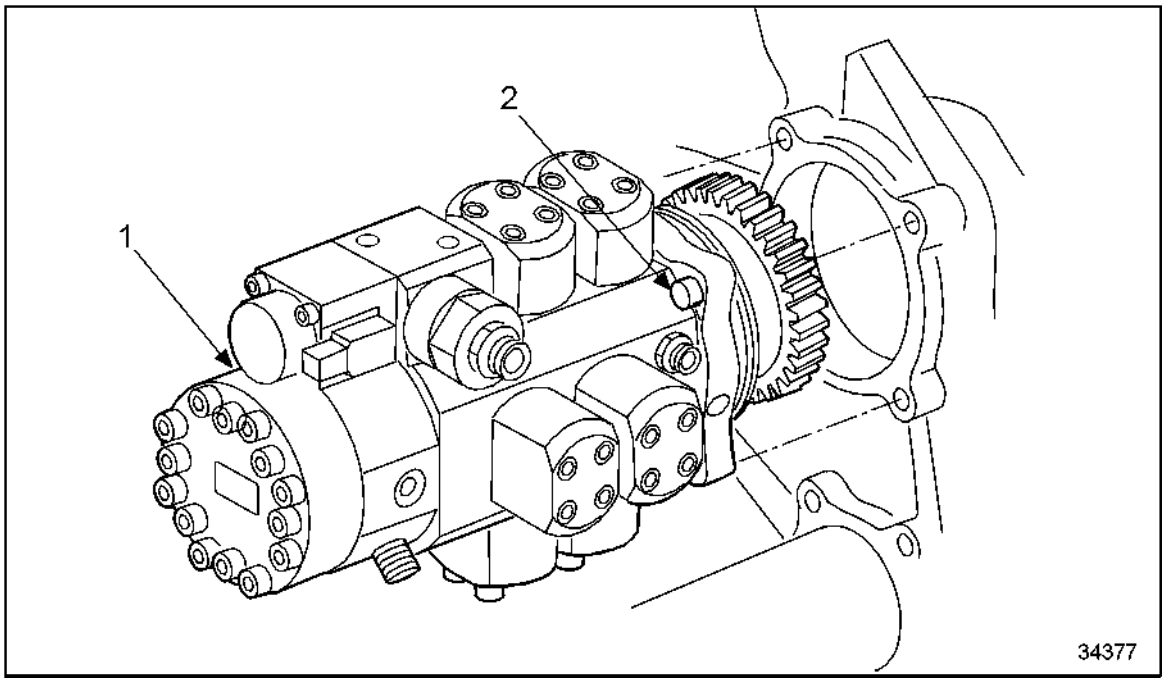
4. Clean and check sealing surface (1) in support bore of gear case. See Figure 505.



1. Sealing Surface

Figure 505 Cleaning and Checking Sealing Surface in Support Bore of Gear Case

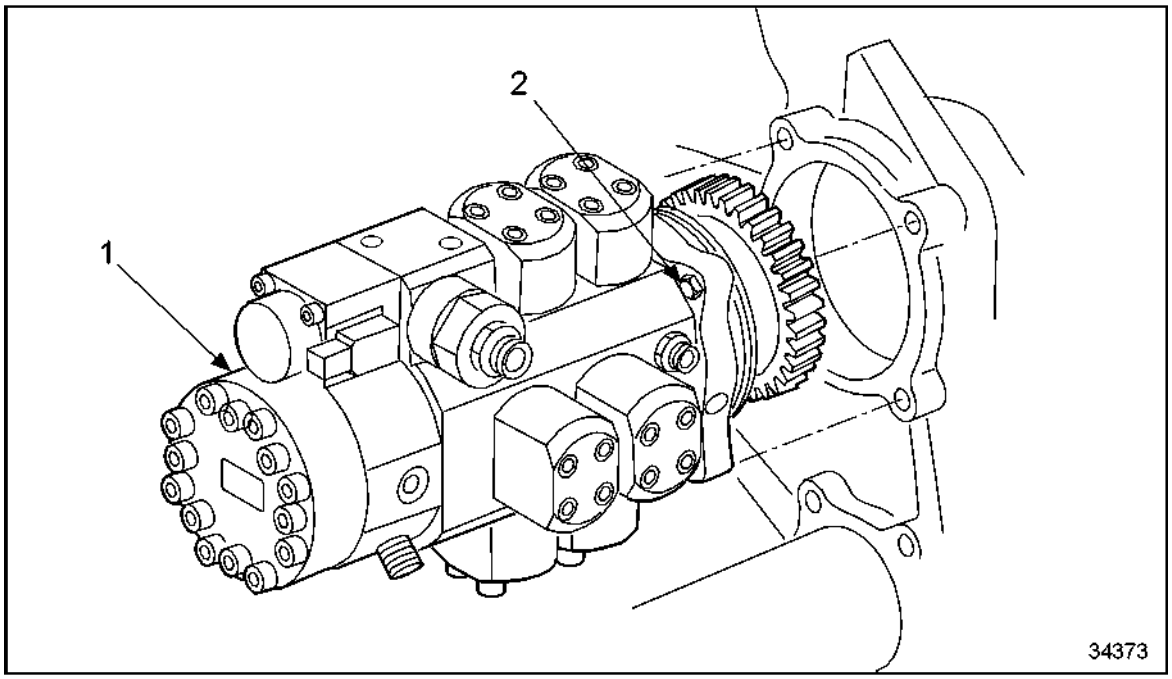
5. Carefully install high-pressure pump (1) in gear case bore. See Figure 506.



1. High-Pressure Pump

Figure 506 Installing High-Pressure Pump in Gear Case Bore

6. Insert four Allen head bolts (2) with socket and extension. See Figure 507.

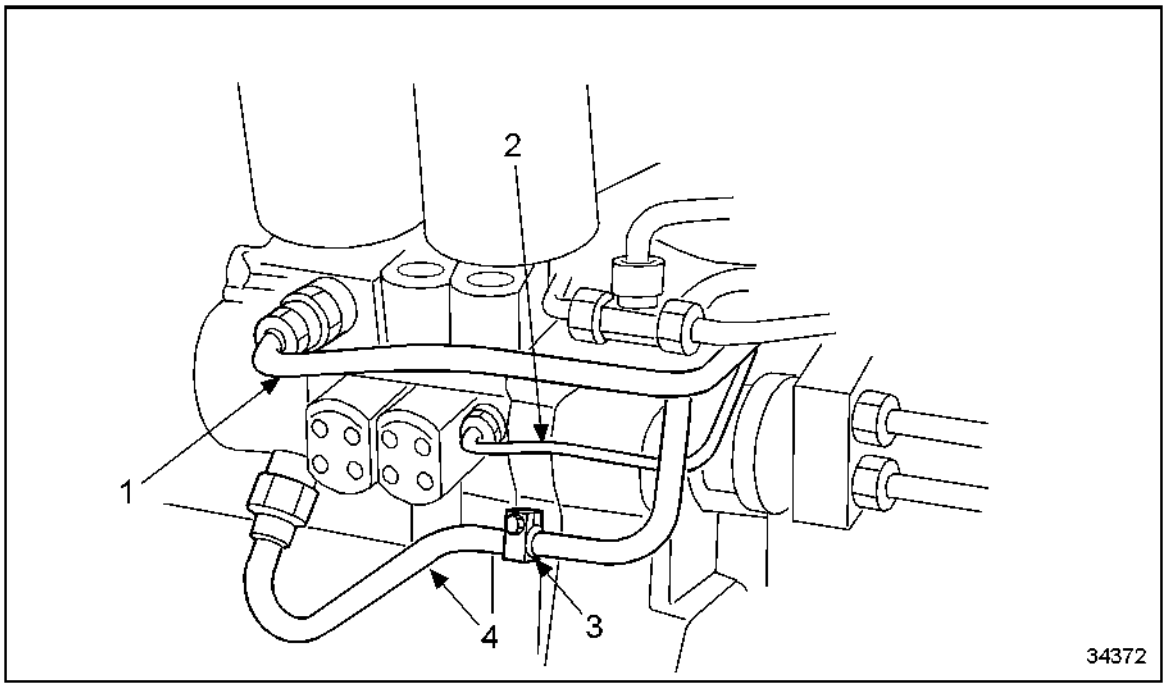


1. High-Pressure Pump
2. Allen Head Bolt

Figure 507 Inserting and Torquing Allen Head Bolts

7. Torque Allen head bolts to specification. Refer to section A 003.

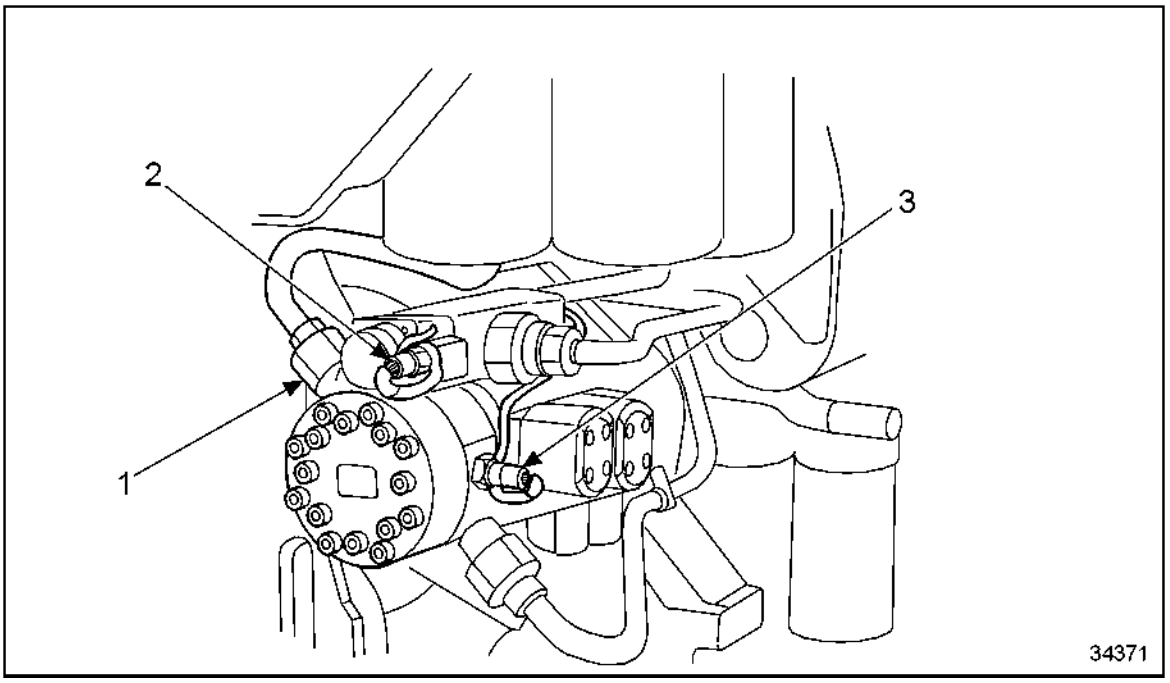
8. Install fuel supply lines (1) and fuel return lines (2). See Figure 508.



1. Fuel Supply Line
2. Fuel Return Line
3. Pipe Clamp Half
4. High-Pressure Line

Figure 508 Installing Fuel Supply and Return Lines, Removing High-Pressure Line (Left Side)

9. Connect DDEC harness connection to controller solenoid (2). See Figure 509.



1. High-Pressure Line "B" Bank
2. DDEC Harness Connection to Controller Solenoid
3. DDEC Harness Connection to Temperature Sensor

Figure 509 Connecting DDEC Harness Connection to Controller Solenoid and Temperature Sensor

10. Connect DDEC harness connection to temperature sensor (3).
11. Install high-pressure line (1), “B” bank.

C 073.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 55 are the After-Installation Operations for the high-pressure fuel pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Install low-pressure fuel lines	Refer to sectionC 083.05.11
1, 2, 3	Install high-pressure fuel lines	Refer to sectionC 083.05.11
1, 2, 3	Connect DDEC Harness	Refer to sectionC 501.05 M
1, 2, 3	Connect high-pressure sensor, if necessary	Refer to sectionC 077.05.11
1, 2, 3	Install temperature sensor, if necessary	-
1, 2, 3	Install low-pressure fuel pump	Refer to sectionC 081.05.11
1, 2, 3	Fill fuel system, prime System	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.

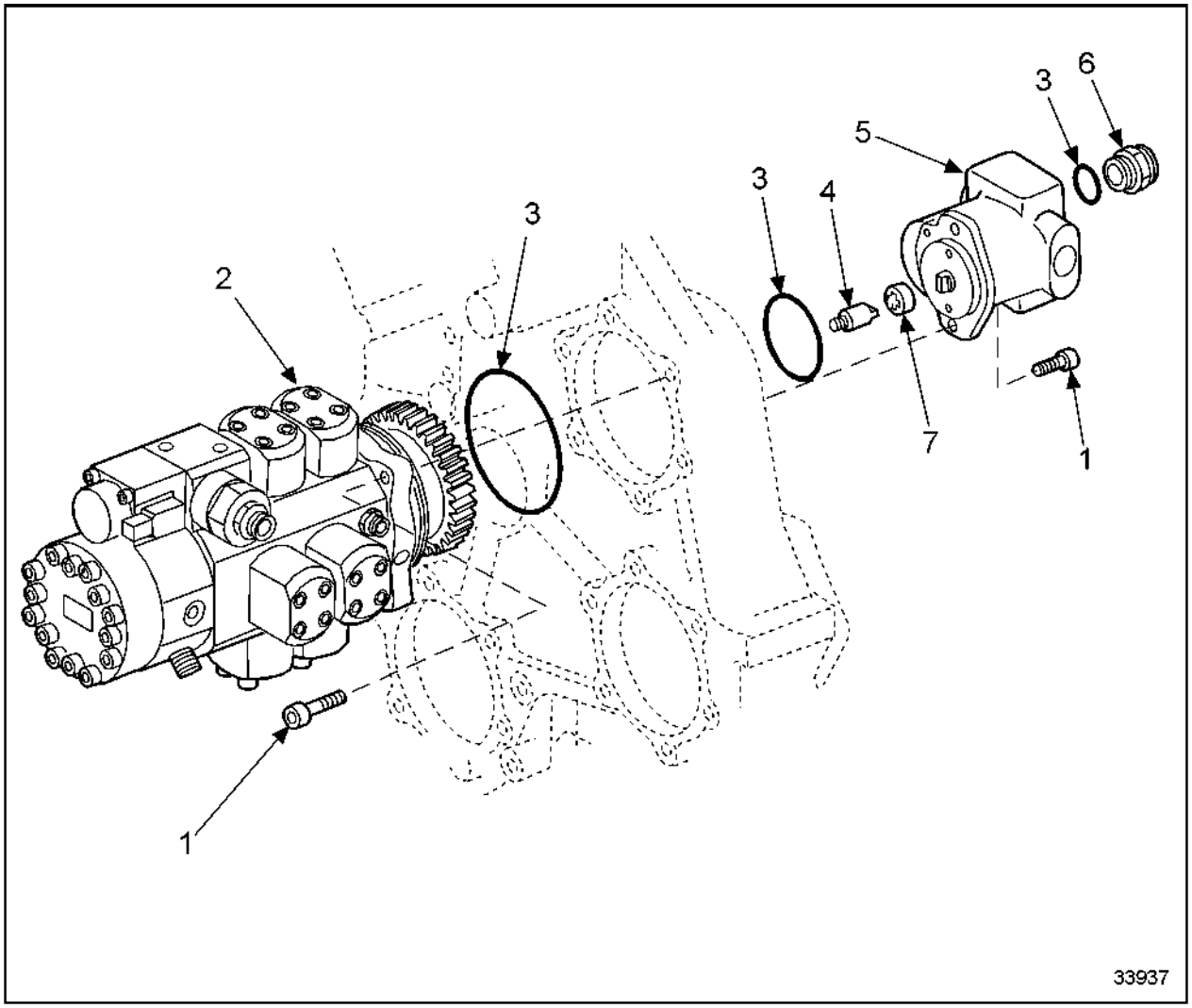
3 = The engine is to remain installed.

Table 55 After-Installation Operations

C 073.05 M – FUEL INJECTION PUMP

C 073.05.01 M – GENERAL VIEW

For an overview of the marine high-pressure fuel pump, see Figure 510.



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

Figure 510 Marine High-Pressure Pump

C 073.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 56are the Before-Removal Operations for the Marine high-pressure fuel pump.

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.

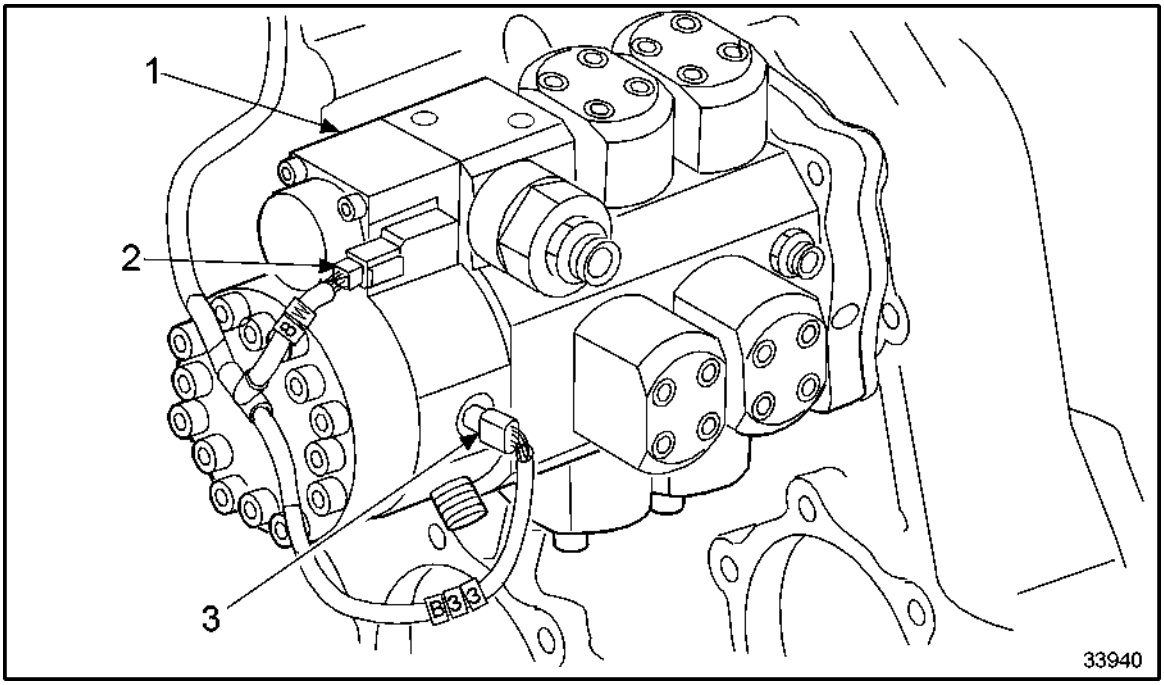
3 = The engine is to remain installed.

Table 56 Before-Removal Operations for the Marine High-Pressure Fuel Pump

C 073.05.05 M – REMOVAL OF THE MARINE FUEL INJECTION PUMP

Perform the following steps to remove the high-pressure fuel pump.

1. Disconnect the 8W connector (2) from the high-pressure fuel controller. See Figure 511.

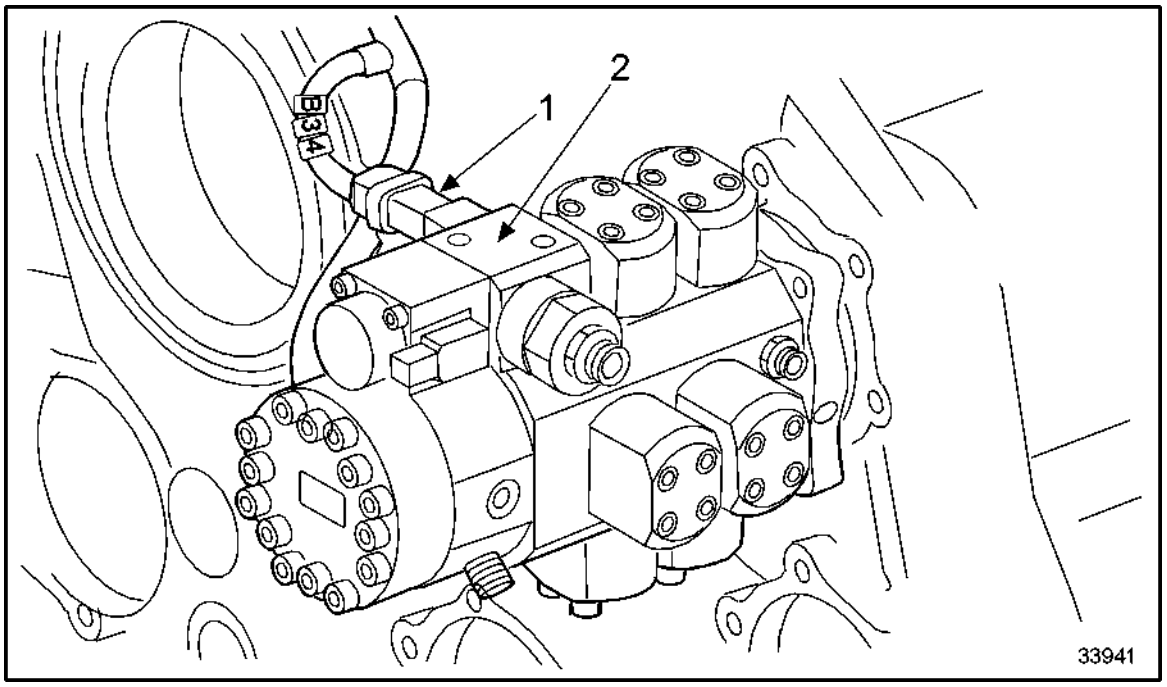


1. High-Pressure Fuel Controller
2. High-Pressure Fuel Controller Connector
3. B33 (High-Pressure Fuel Temp. Sensor) Connector

Figure 511 Disconnecting High-Pressure Fuel Pump Wiring Harness

2. Disconnect B33 (3) (high-pressure fuel temperature sensor) wiring harness from the high-pressure fuel pump (1). See Figure 511.

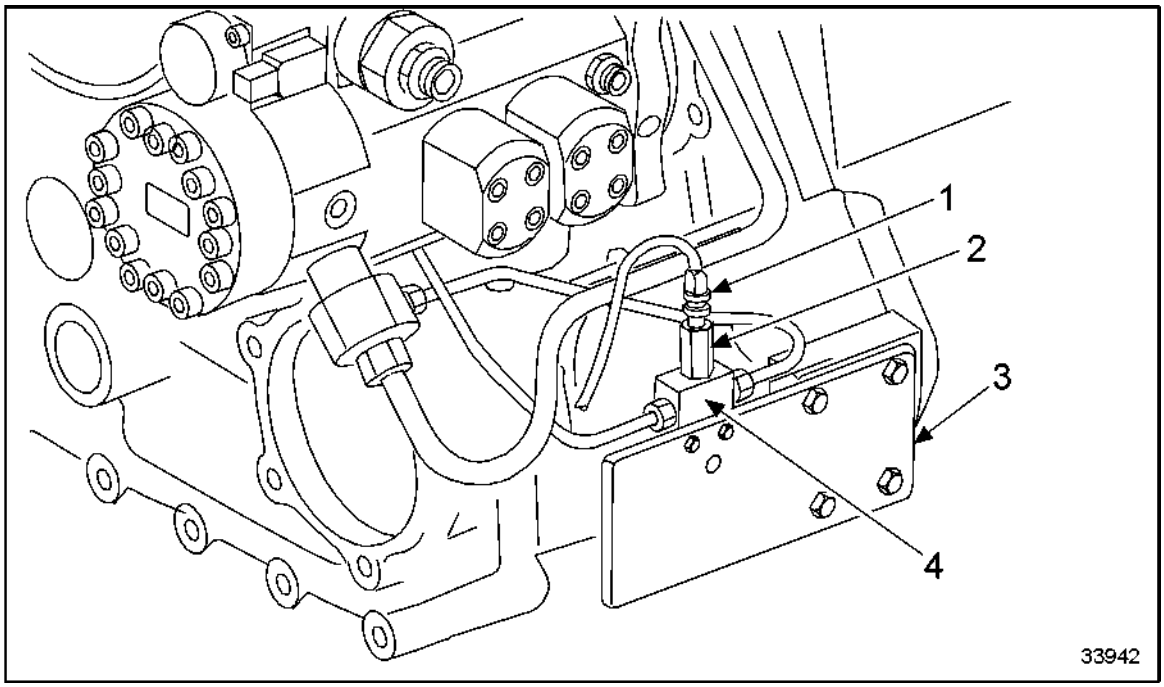
3. Disconnect B34 (1) (low fuel pressure sensor) wiring harness from the high pressure fuel pump controller solenoid (2). See Figure 512.



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

Figure 512 Disconnecting Low Fuel Pressure Sensor

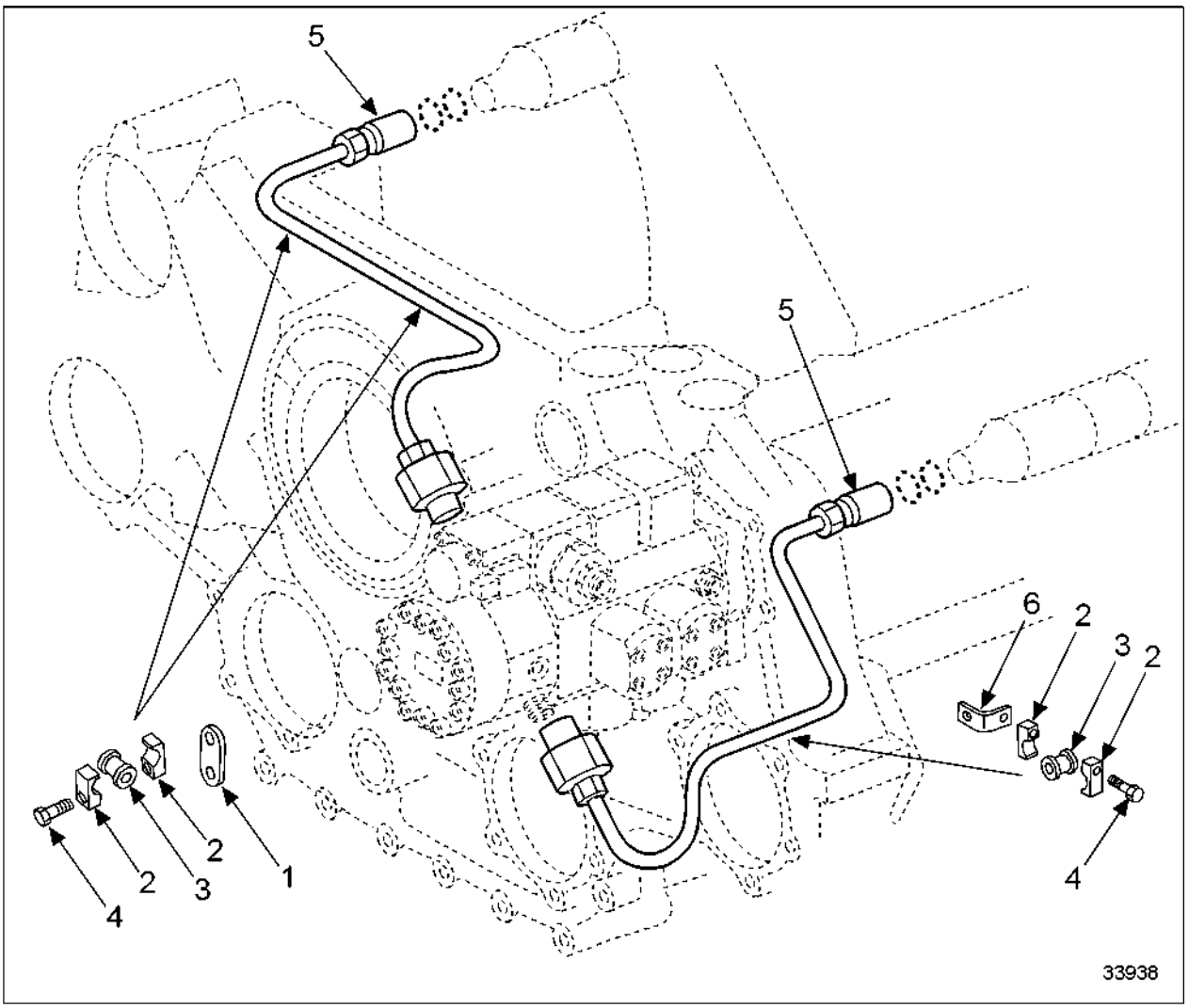
4. Disconnect F46 (1) (fuel leakage monitor sensor) wiring harness from the high-pressure fuel pump. See Figure 513.



1. F46 (Fuel Leakage Monitor Sensor) Connector
2. Leakage Sensor
3. Mount Plate for Leakage Sensor Reservoir
4. Fuel Reservoir

Figure 513 Removing Fuel Leakage Monitor Sensor (F46)

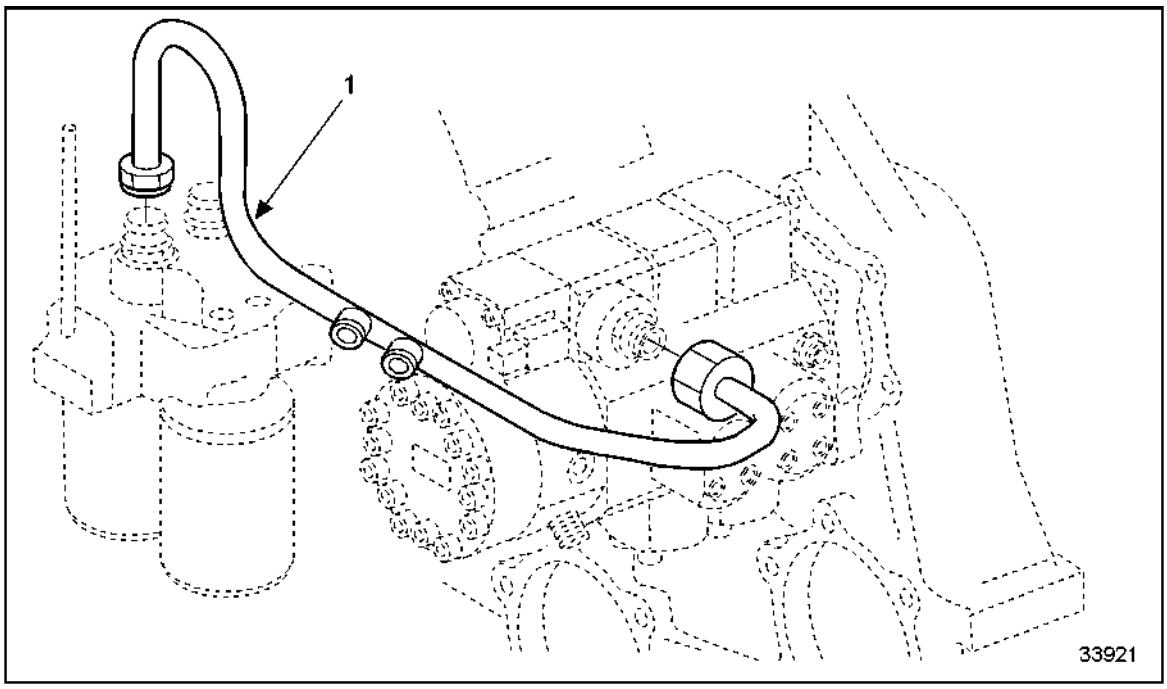
5. Disconnect high-pressure fuel lines (5). See Figure 514.



1. Mounting Bracket
2. Pipe Half Clamp
3. Grommet
4. Bolt
5. High Pressure Fuel Line
6. Mounting Bracket

Figure 514 Disconnecting High-Pressure Fuel Lines, 12V Marine Engine

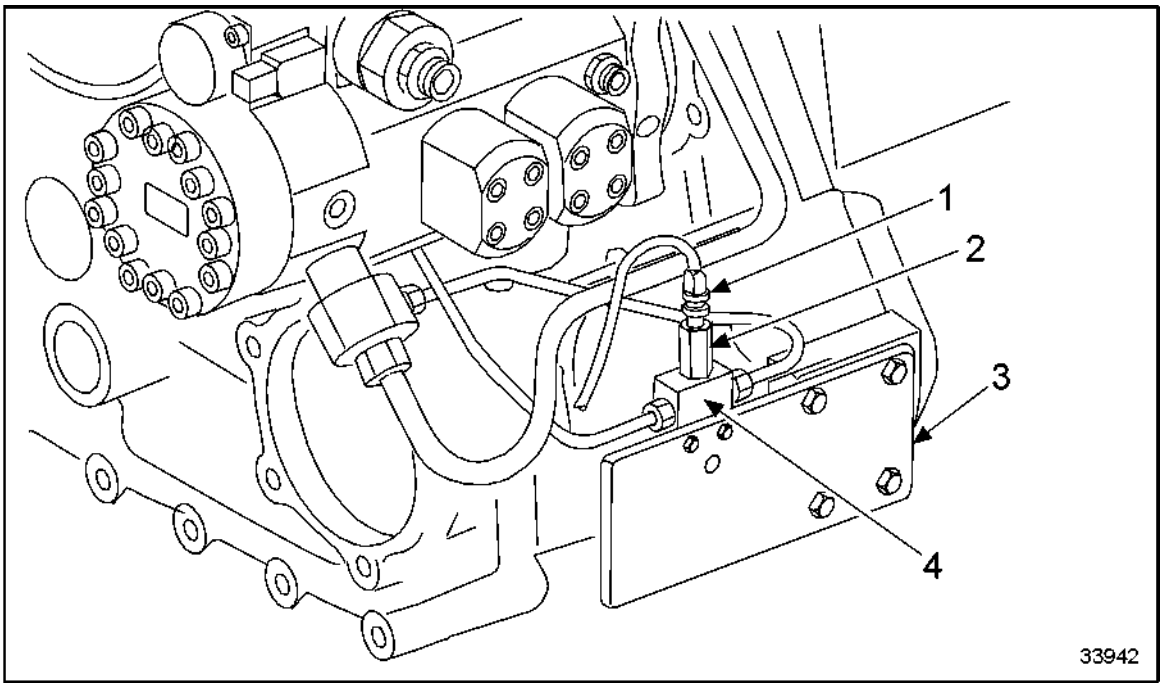
6. Disconnect low-pressure fuel lines (1). See Figure 515.



1. Low Pressure Fuel Line

Figure 515 Disconnecting Low-Pressure Fuel Lines, 12V Marine Engine

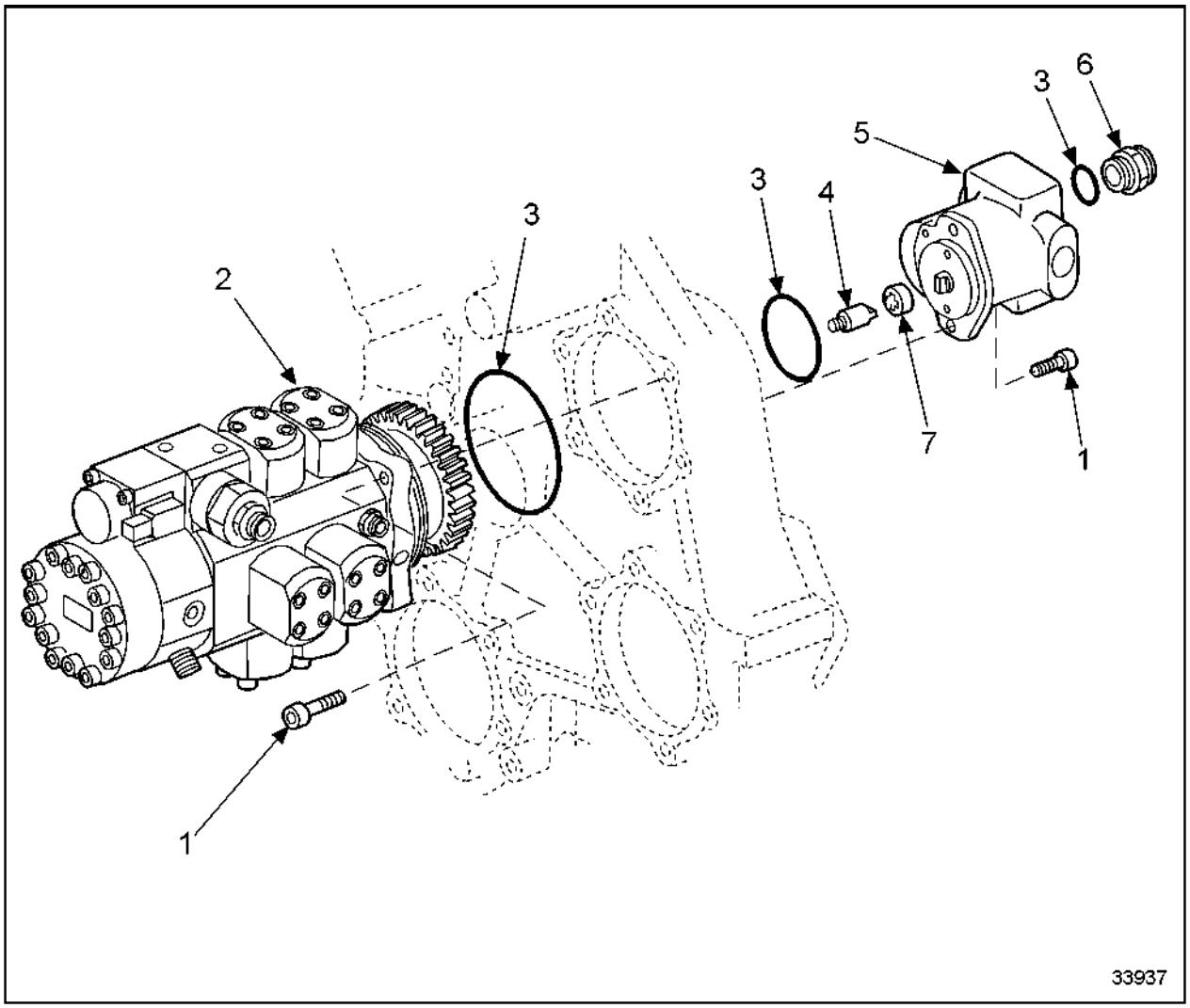
7. Remove four bolts securing the F46 (fuel leakage monitor sensor) plate (2) from the front cover. See Figure 516.



1. F46 (Fuel Leakage Monitor Sensor) Connector
2. Leakage Sensor
3. Mount Plate for Leakage Sensor Reservoir
4. Fuel Reservoir

Figure 516 Removing Fuel Leakage Monitor Sensor (F46), 12V Marine Engine

8. Remove four Allen head bolts (1) securing the high-pressure fuel pump (2) to the front cover. See Figure 517.



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

Figure 517 Removing High-Pressure Fuel Pump, 12V Marine Engine

9. Remove O-ring (3).
10. Remove the high pressure fuel pump (2).
11. If necessary, remove the sensors.

C 073.05.08 M – INSPECTION AND REPAIR

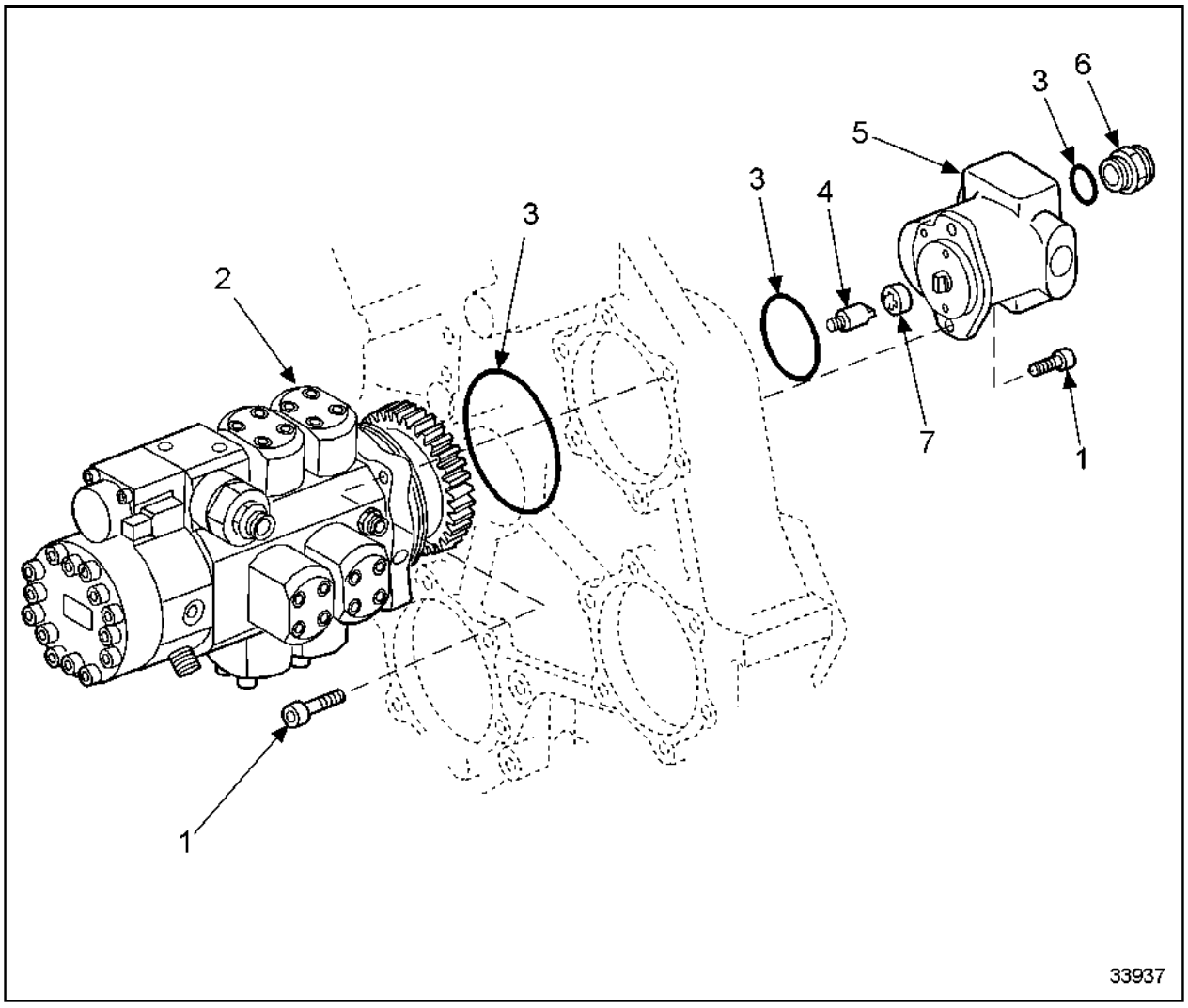
Perform the following steps to inspect and repair the marine fuel injection pump:

1. Clean bolts and inspect the condition of the bolts. Ensure threads are in perfect condition.
   [a] If threads are not in perfect condition, replace bolts as necessary.
   [b] If threads are in perfect condition, continue inspection.
2. Inspect connection thread on high-pressure pump for perfect condition and ease of movement.
   [a] If threads are not in perfect condition or do not show ease of movement, replace component as necessary.
   [b] If threads are in perfect condition and show ease of movement, continue inspection.
3. Visually inspect drive gear for wear and damage.
   [a] If drive gear is worn or damaged, replace gear as necessary.
   [b] If drive gear is not worn or damaged, continue inspection.
4. Visually inspect wiring for wear and damage.
   [a] If wiring is worn or damaged, replace as necessary.
   [b] If wiring is not worn or damaged, continue inspection.
5. Replace O-ring after each removal.

C 073.05.11 M – INSTALLATION OF THE MARINE FUEL INJECTION PUMP

Perform the following steps to install the high-pressure fuel pump.

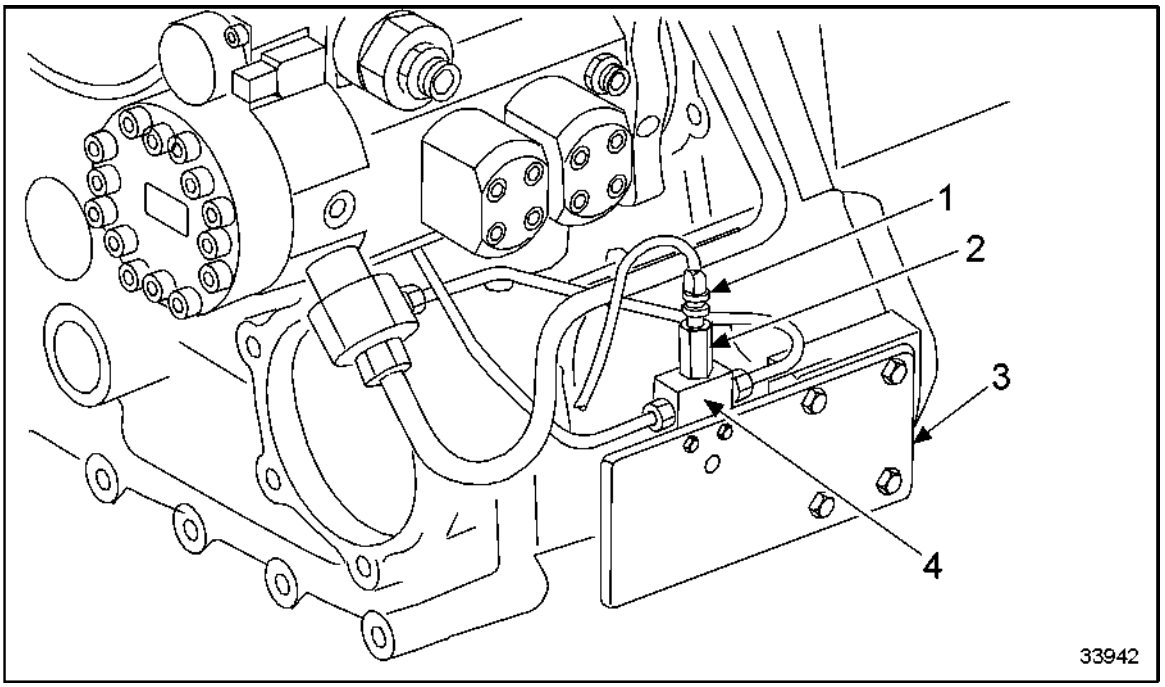
1. If previously removed, install the sensors.
2. Coat new O-ring (3) with petroleum jelly and fit on high-pressure fuel pump. See Figure 518.



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

Figure 518 Installing High-Pressure Fuel Pump, 12V Marine Engine

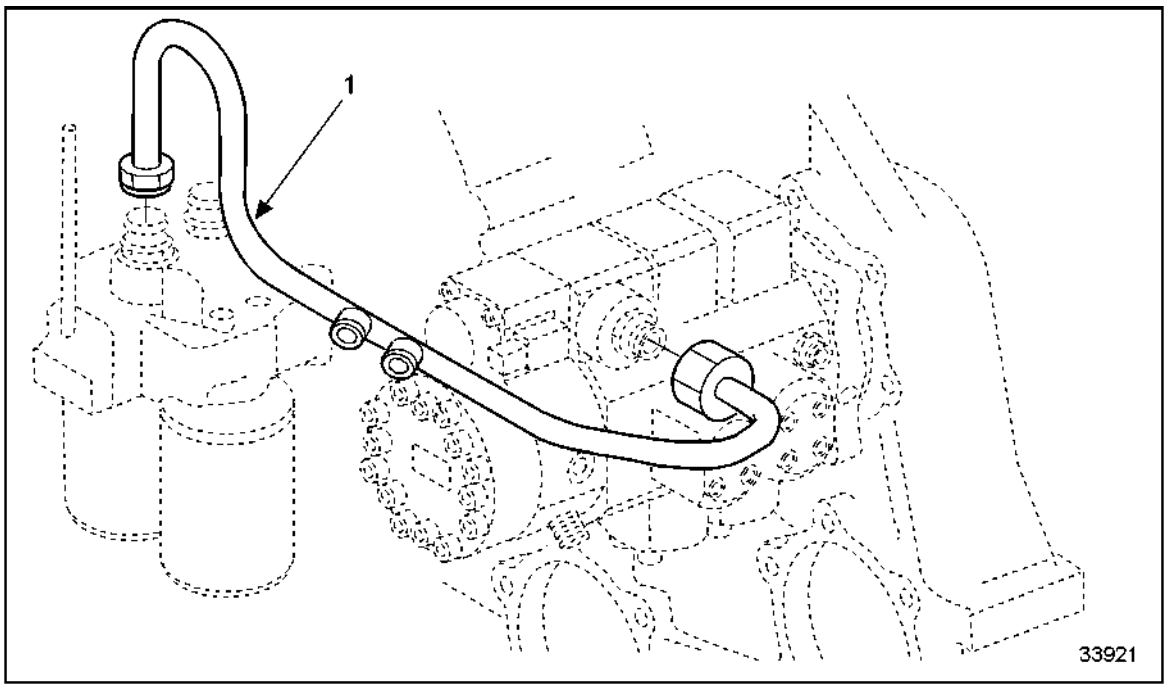
3. Install the high-pressure fuel pump (2) to the front cover and secure with four Allen head bolts (1). Torque bolts to 74–82 N·m (55–60 lb·ft)
4. Install the F46 (fuel leakage monitor sensor) plate (2) and secure with four bolts. Torque bolts to 25–30 N·m (18–22 lb·ft). See Figure 519.



1. F46 (Fuel Leakage Monitor Sensor) Connector
2. Leakage Sensor
3. Mount Plate for Leakage Sensor Reservoir
4. Fuel Reservoir

Figure 519 Installing Fuel Leakage Monitor Sensor (F46), 12V Marine Engine

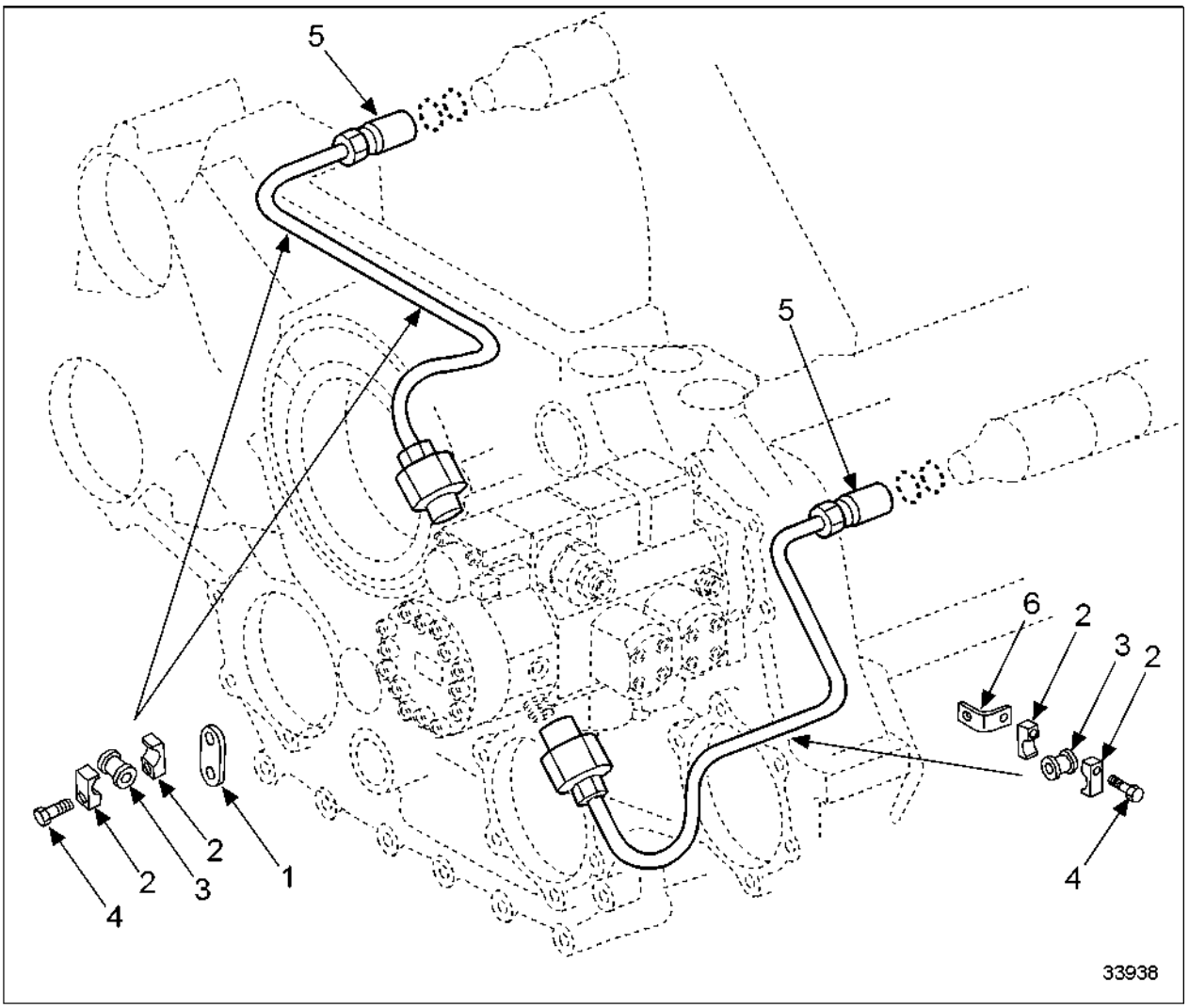
5. Connect low-pressure fuel lines (1). See Figure 520.



1. Low Pressure Fuel Line

Figure 520 Connecting Low Pressure Fuel Lines, 12V Marine Engine

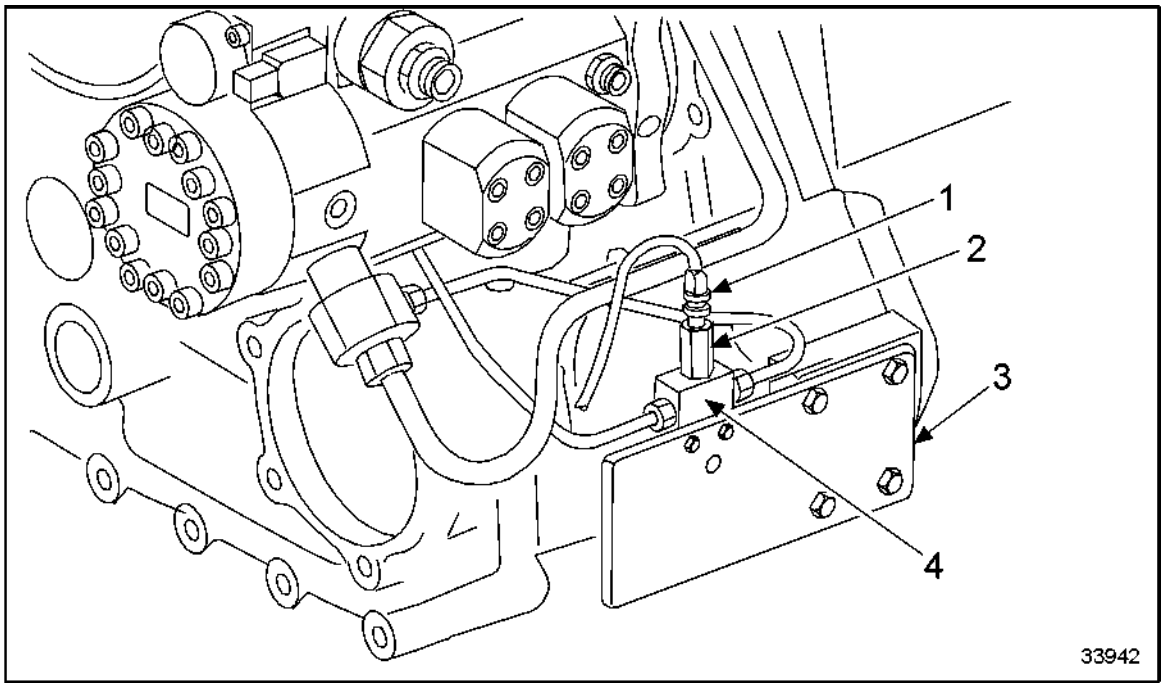
6. Connect high-pressure fuel lines (5). See Figure 521.



1. Mounting Bracket
2. Pipe Half Clamp
3. Grommet
4. Bolt
5. High Pressure Fuel Line
6. Mounting Bracket

Figure 521 Connecting High-Pressure Fuel Lines, 12V Marine Engine

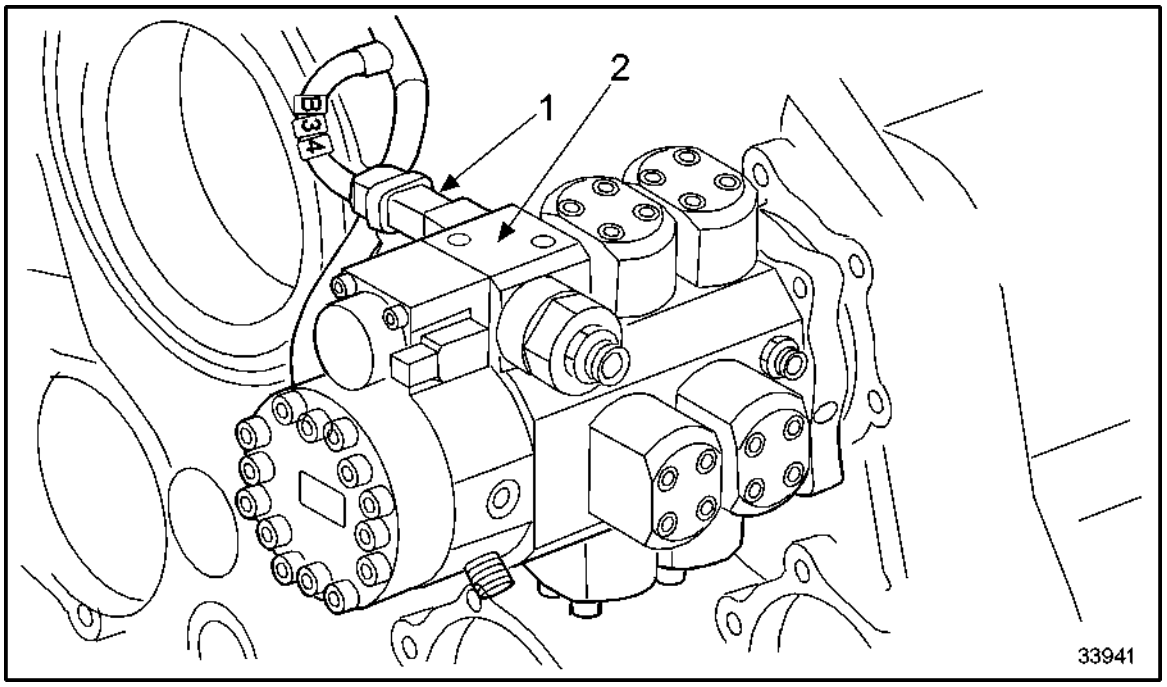
7. Connect the F46 (fuel leakage monitor sensor) wiring harness from the high pressure fuel pump; see Figure 522.



1. F46 (Fuel Leakage Monitor Sensor) Connector
2. Leakage Sensor
3. Mount Plate for Leakage Sensor Reservoir
4. Fuel Reservoir

Figure 522 Installing Fuel Leakage Monitor Sensor (F46), 12V Marine Engine

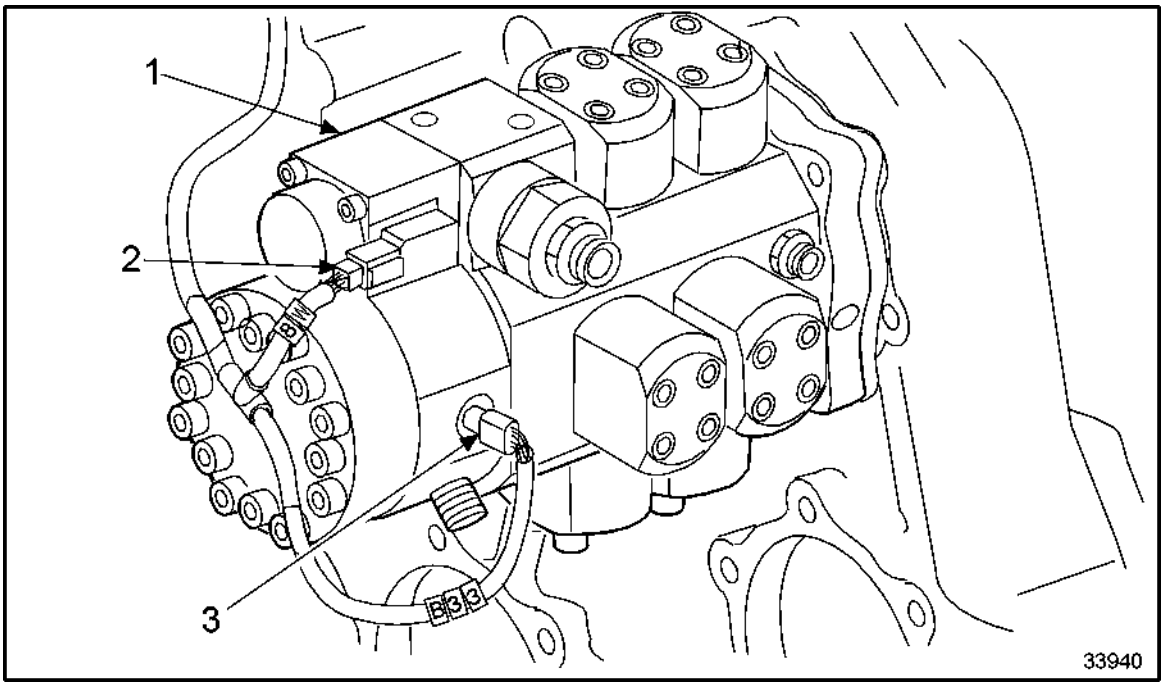
8. Connect the B34 (low fuel pressure sensor) wiring harness (1) to the high-pressure fuel pump controller solenoid (2). See Figure 523.



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

Figure 523 Connecting Low Fuel Pressure Sensor

9. Connect the B33 (high-pressure fuel temperature sensor) wiring harness (3) from the high pressure fuel pump (1). See Figure 524.



1. High-Pressure Fuel Controller
2. High-Pressure Fuel Controller Connector
3. B33 (High-Pressure Fuel Temp. Sensor) Connector

Figure 524 Connecting Marine High-Pressure Pump Wiring Harness

10. Connect the 8W wiring harness (2) from the high-pressure fuel pump (1).
11. Verify repair or replacement of the high-pressure fuel pump.
12. Prime fuel system. See Operators Guide.

C 073.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 57are the After-Installation Operations for the marine high pressure fuel pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Prime engine	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.

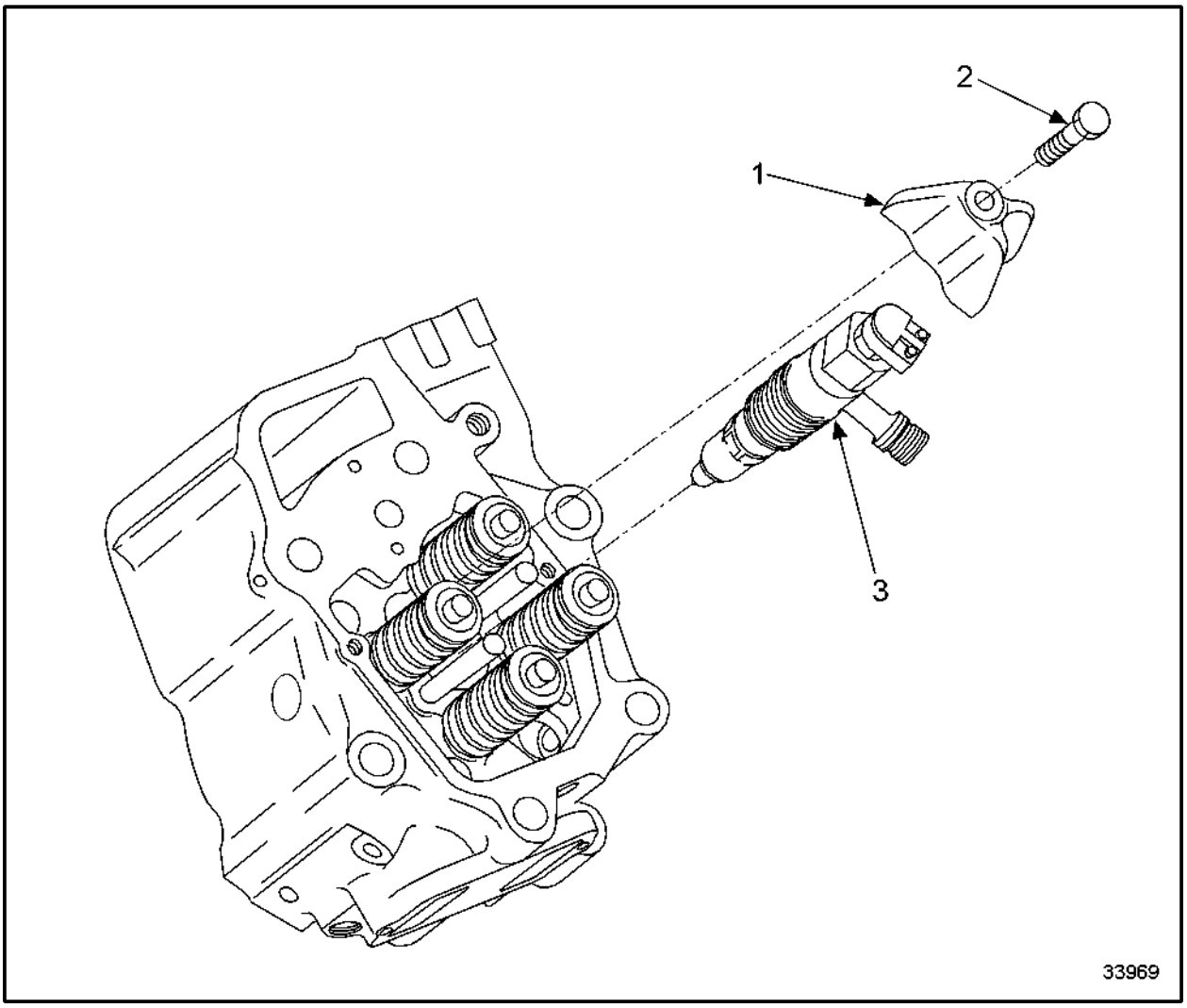
3 = The engine is to remain installed.

Table 57 After-Installation Operations for the Marine High Pressure Fuel Pump

C 075.05 – INJECTOR

C 075.05.01 – GENERAL VIEW

See Figure 525 for a general view of the injector.



1. Injector Hold-Down Clamp
2. Injector Hold Down Clamp Bolt
3. Injector

Figure 525 General View of the Injector

C 075.05.02 – SPECIAL TOOLS

Listed in Table 58 are the special tools required for maintenance on the injector.

Application	Number
Ring wrench insert for injection line	—
Removal tool for injector	—
Installation tool for injector	—

Table 58 Special Tools

C 075.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 59 are the Before-Removal Operations for the injector.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove rocker cover	Refer to section C 056.05.05
1, 2, 3	Remove high-pressure fuel line	Refer to section C 083.05.05

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 59 Before-Removal Operations

C 075.05.05 – REMOVAL OF THE INJECTOR

Perform the following steps for removal of the injector:

1. Loosen fuel return line fitting at cylinder head from which injector is to be removed. This will relieve fuel pressure to the injector.
2. Remove high-pressure fuel jumper line from the high-pressure rail to the injector being removed.
3. Inspect removed high-pressure fuel jumper line for carbon build-up. If carbon is present at flow limiter end of high-pressure fuel jumper line, replace line.
4. Tighten left-hand threaded retainer nuts at each end of high-pressure fuel jumper line. Properly protect seating areas on both ends of high-pressure line from damage while removing.
5. Remove flow limiter valve, inspect and clean. Protect seating areas from damage.
6. Protect flow limiter opening in high-pressure rail from debris or damage during injector replacement.
7. Loosen DDEC injector harness terminal bolts on injector and remove DDEC injector harness terminals (arrows). See Figure 526.

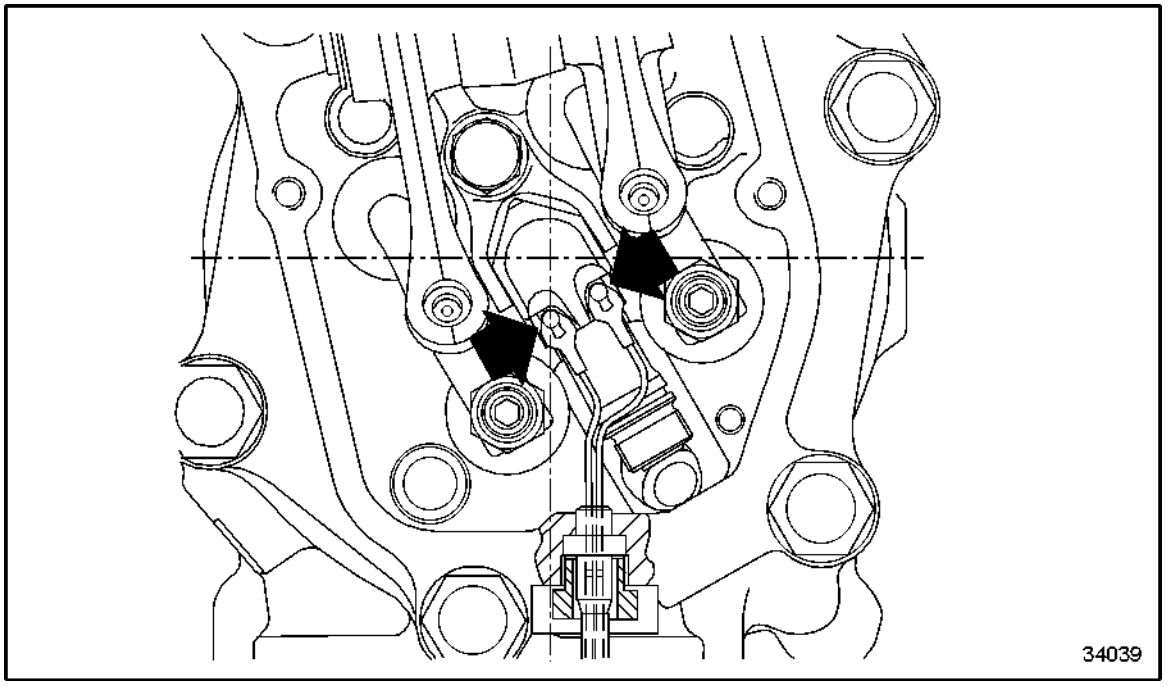


Figure 526 Removing DDEC Injector Harness Terminals

8. Use a torque wrench to break bolt torque and note breaking torque. Remove bolt from hold-down clamp and take off hold-down clamp. See Figure 527.

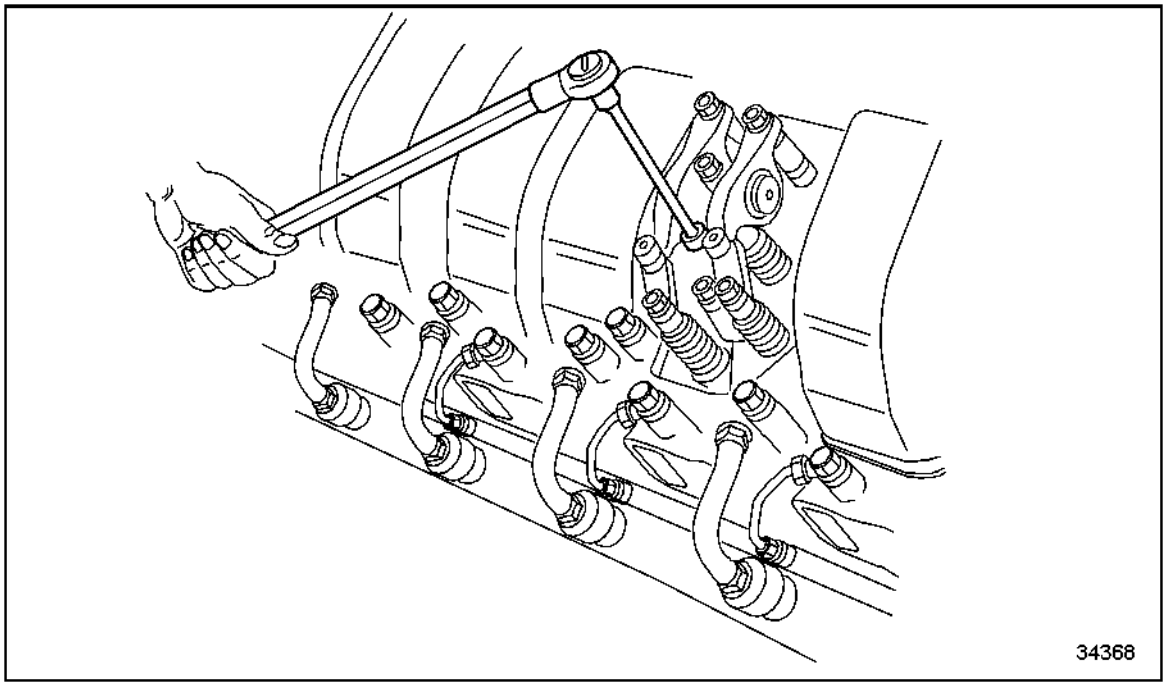
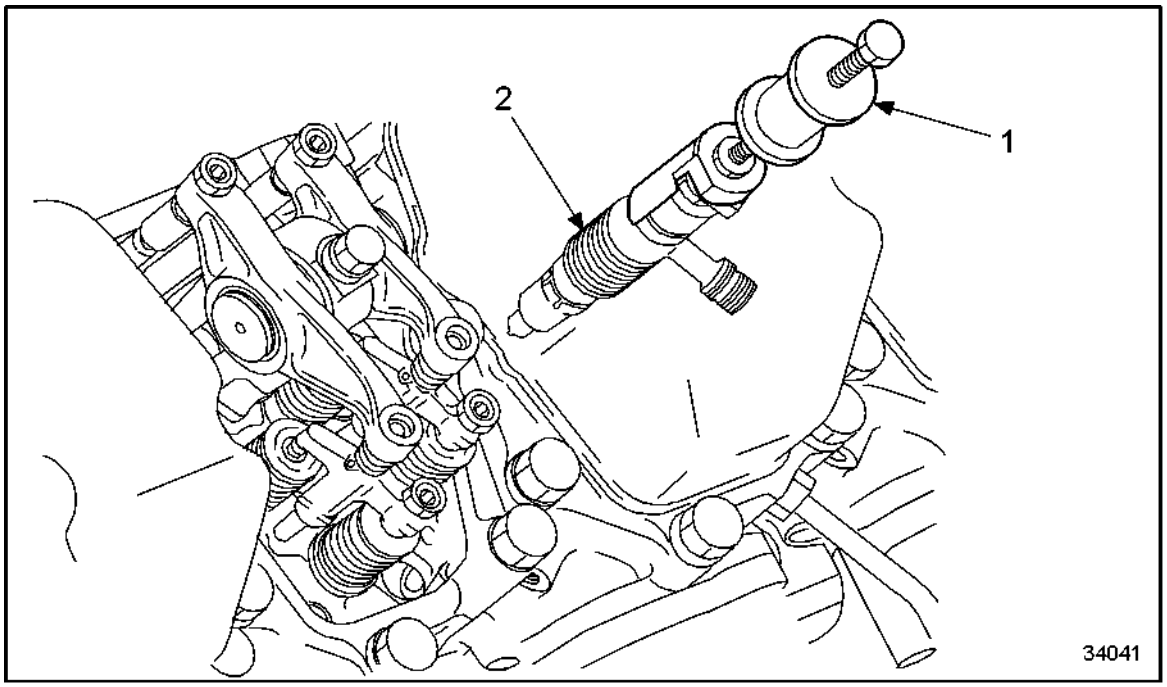


Figure 527 Removing Hold-Down Clamp

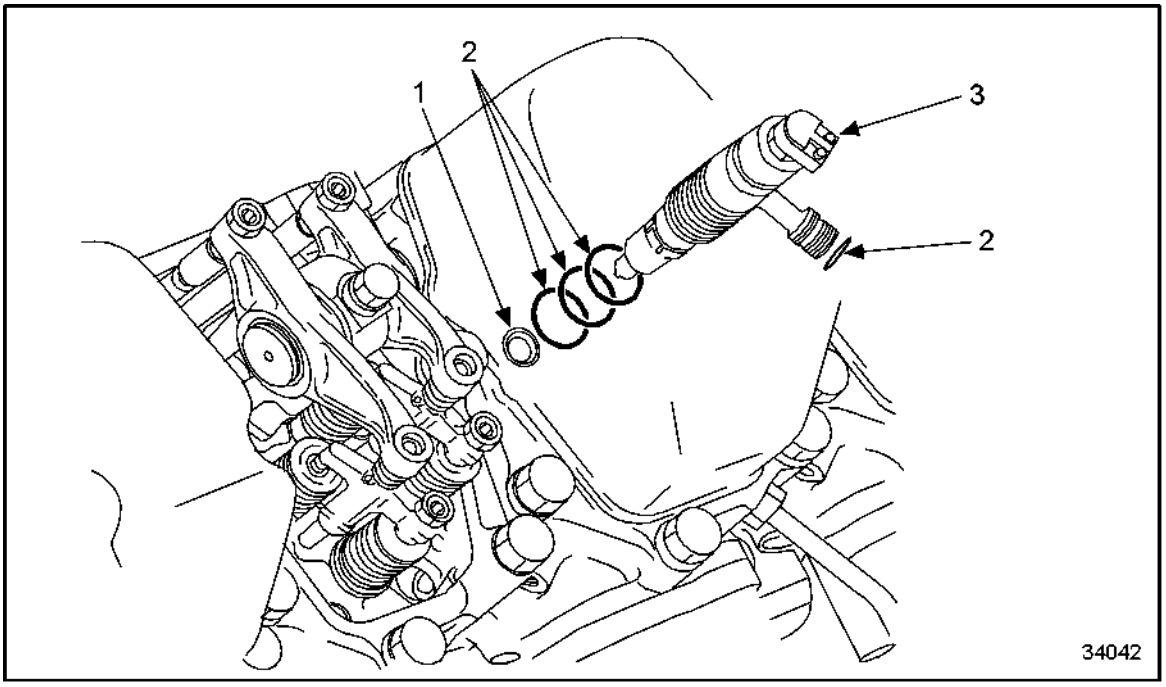
9. Install injector removal tool (1) on injector and loosen injector (2) from the bore. See Figure 528.



1. Injector Removal Tool J 42732
2. Injector

Figure 528 Removing Injector from Bore

10. Remove injector (2) manually from bore.
11. Remove O-ring (2) from injector (3). See Figure 529.



1. CE Ring
2. O-ring
3. Injector

Figure 529 Removing O-ring and C–E Ring from Injector

NOTE:
After removing injector, ensure that no C–E support ring remains in bore for injector in cylinder head.

C 075.05.06 – DISASSEMBLY OF THE INJECTOR

Injectors are serviced only as an assembly by your authorized Detroit Diesel Distributor.

C 075.05.08 – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the injector:

1. Clean all components.
2. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect injector hold down bolt and clamping element for cracks.
   [a] If injector hold down bolt and clamping element are cracked, replace as necessary.
   [b] If injector hold down bolt and clamping element are not cracked, continue inspection.
3. Inspect threads on injector hold down bolt and injector for ease of movement.
   [a] If threads on injector hold down bolt or injector do not show ease of movement, replace component as necessary.
   [b] If threads on injector hold down bolt and injector show ease of movement, continue inspection.

NOTE:
When inspecting injector, ensure that it is perfectly clean.

4. Visually inspect mating surfaces of hold-down clamp for wear or damage.
   [a] If mating surfaces of hold-down clamp are worn or damaged, rub down with emery cloth or oilstone.
   [b] If rubbing down with emery cloth or oilstone does not remove wear or damage, replace hold-down clamp as necessary.
   [c] If mating surfaces of hold-down clamp are not worn or damaged, continue inspection.
5. Visually inspect injector O-ring surface of injector (in cylinder head) for wear or damage.
   [a] If O–ring sealing or cylinder head surface of injector is worn or damaged, rub down with emery cloth or oilstone.
   [b] If rubbing down with emery cloth or oilstone does not remove wear or damage, replace injector as necessary.
   [c] If O–ring sealing and cylinder head surface of injector are not worn or damaged, continue inspection.
6. Visually inspect DDEC injector harness connections for damage.
   [a] If DDEC injector harness connections are damaged, replace as necessary.
   [b] If DDEC injector harness connections are not damaged, continue inspection.
7. Visually inspect injector hole tube for wear and damage.
   [a] If injector hole tube is worn or damaged, replace as necessary.
   [b] If injector hole tube is not worn or damaged, continue inspection.
8. Replace C-E rings and O-rings at every assembly.

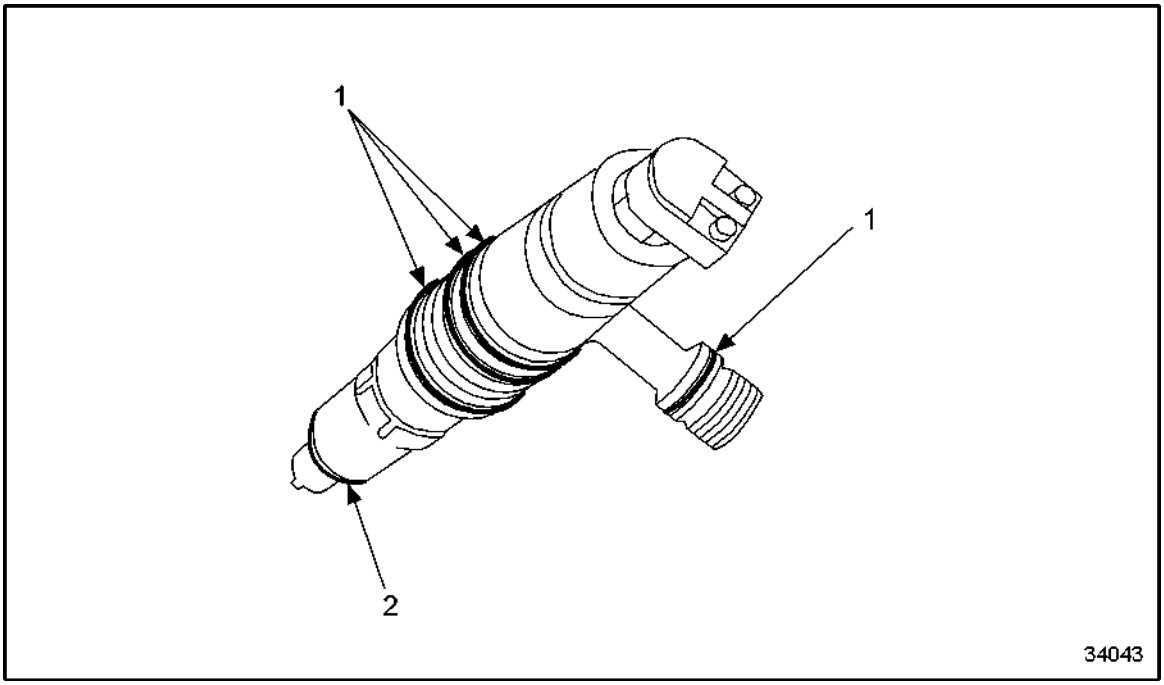
C 075.05.10 – ASSEMBLY OF THE INJECTOR

Injectors are serviced only as an assembly by your authorized Detroit Diesel Distributor.

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

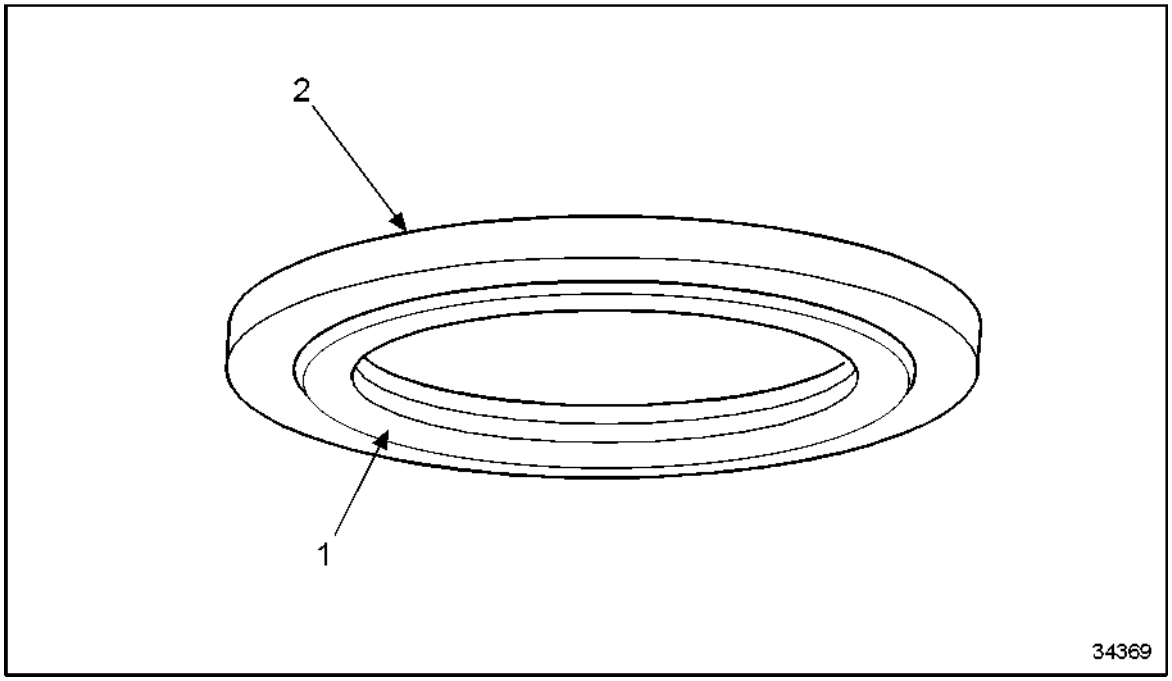


1. O-ring 2. C-E Ring

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.



1. C-E Ring
2. Sealing Surface of C-E Ring

Figure 531 CE Ring

NOTE:
Ensure that fuel lines and rails are perfectly clean. Prior to installation, remove all protective covers.

CAUTION:

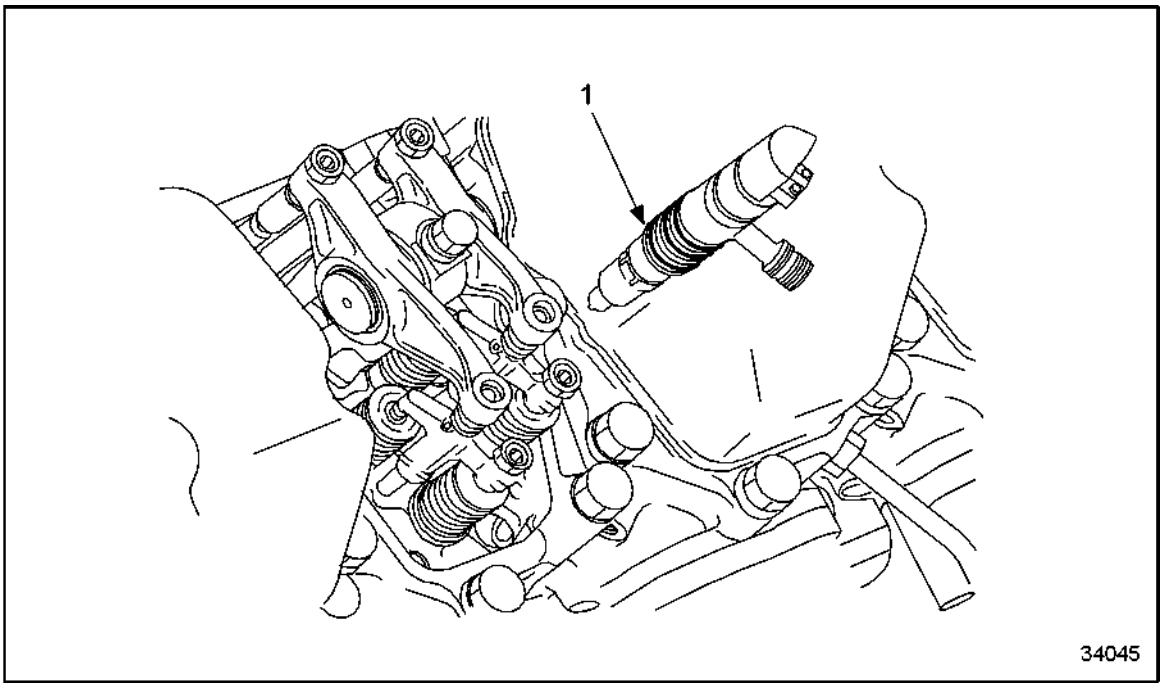
To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

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.

3. bar engine several times to blow out any remaining fuel.
4. Inspect sealing surface on cylinder head and injector hole tube.
   [a] Clean sealing surface on cylinder head or hole tube if necessary.
   [b] If sealing surface on cylinder head or hole tube does not require cleaning, continue inspection.

5. Install injector (1) into cylinder head, ensuring that high-pressure line connection is correctly aligned. Toward the high-pressure rail. See Figure 532.



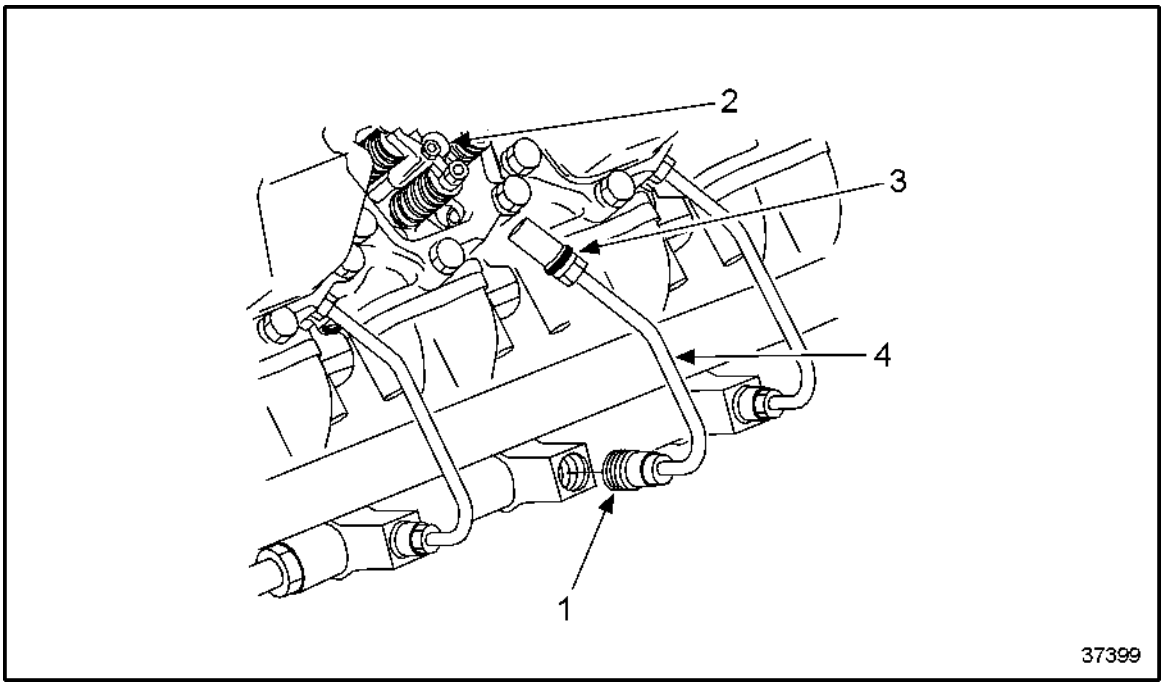
1. Injector

Figure 532 Installing Injector into Cylinder Head

6. Using firm pressure, press injector (1) into cylinder head.
7. Place hold-down clamp in position on injector.
8. Install injector hold-down bolt finger tight for installation of the high-pressure fuel line.

NOTE:
Hex bolt of hold-down clamp is not fully tightened until high-pressure line is installed. Refer to sectionC 077.05.11.

9. Install new O-rings (3) at each end of high-pressure jumper line and coat with petroleum jelly See Figure 533.



1. Flow Limiting Valve Connector
2. Injector
3. O-ring
4. High-Pressure Jumper Line

Figure 533 Installing High-Pressure Jumper Line

10. Install flow limiting valve in high-pressure rail.
11. Install high-pressure jumper line (4) at injector (2) and connector (flow limiting valve) (1).

NOTE:
The high-pressure jumper line must not be bent. Ensure that the installation position is correct.

NOTE:
For ease of installation, connect both ends of high-pressure jumper line before tightening.

12. If connector at injector end will not align and start thread engagement, re-inspect injector, C-E ring and seating area for proper installation.

13. Tighten bolt of injector hold-down clamp with torque wrench to specification. Refer to sectionA 003. See Figure 534.

NOTE:
Use engine oil as lubricant.

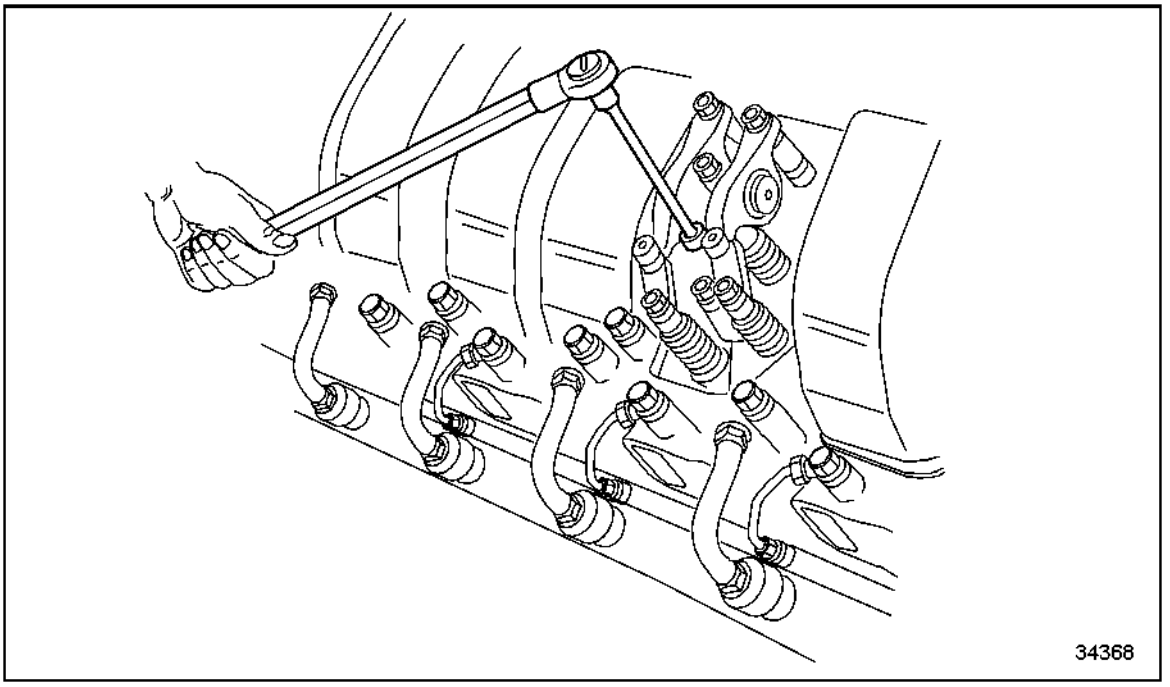
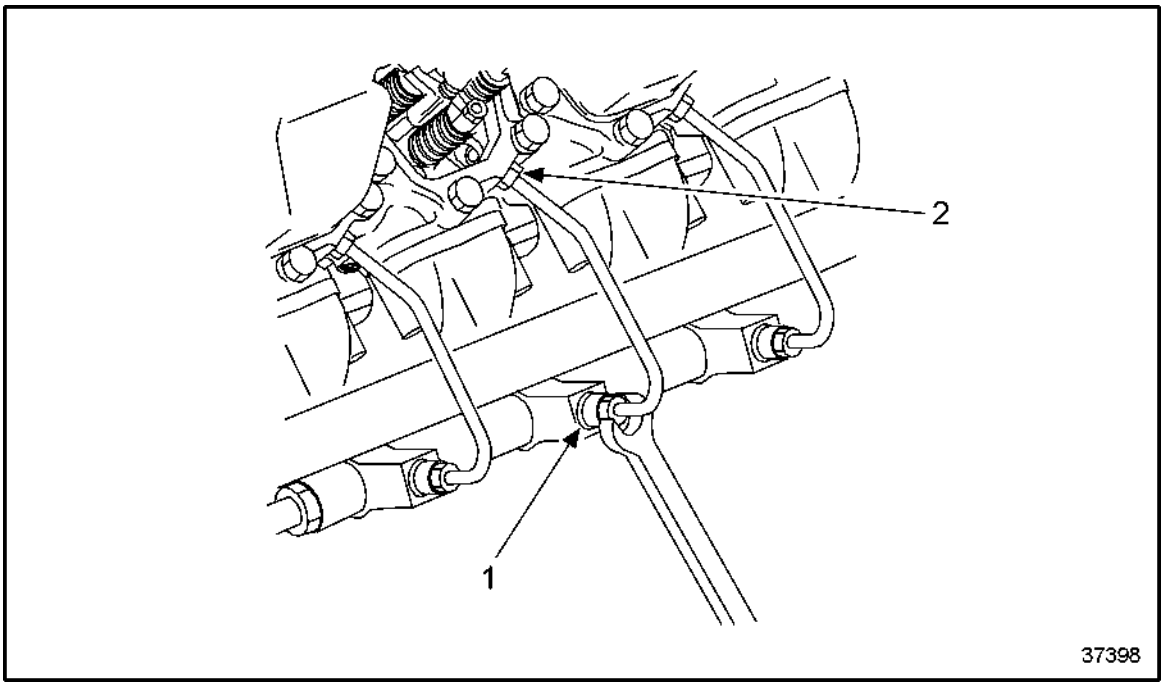


Figure 534 Tightening Bolt of Injector Hold-down Clamp

14. Using torque wrench, tighten connector of high-pressure jumper line at injector (2) and flow limiting valve connector (1) to specification. Refer to section A 003. See Figure 535

NOTE:
Use engine oil as lubricant.

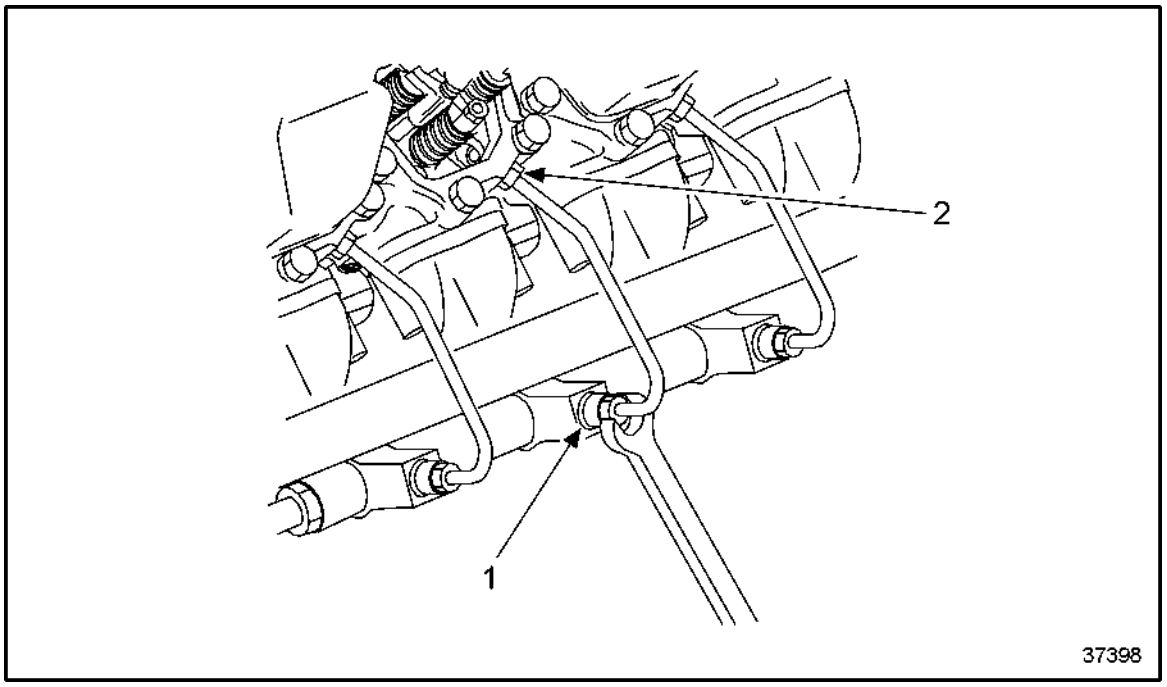
NOTE:
The high-pressure jumper line must not be bent. Ensure that the installation position is correct.



1. Flow Limiting Valve Connector
2. Injector

Figure 535 Tightening Threaded Connection of High-Pressure Jumper Line at Injector

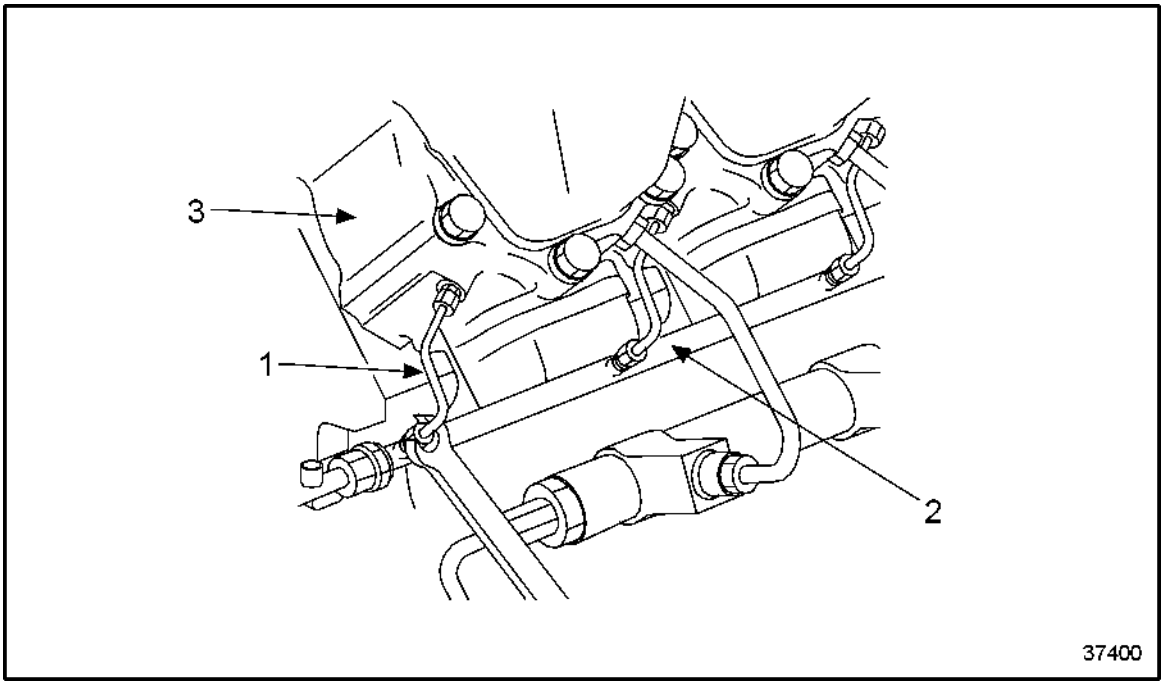
15. Install DDEC injector harness terminals under bolts on injector solenoid and tighten. Care should be taken not to overtighten. Refer to section A 003. See Figure 536.



1. Flow Limiting Valve Connector
2. Injector

Figure 536 Installing DDEC Injector Harness Terminals under Bolts on Injector Solenoid

16. Attach fuel return line (1) between cylinder head and return rail and tighten. 537



1. Fuel Return Line
2. Fuel Return Rail
3. Cylinder Head

Figure 537 Attaching Fuel Return Line Between Cylinder Head and Fuel Return Rail

17. Open fuel supply to engine. Prime fuel system. Refer to Operators Guide.
18. Release engine start.
19. Inspect for leaks.

C 075.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 60 are the After-Installation Operations for the injector.

Level of Maintenance	Operation	Reference
1, 2, 3	Install high-pressure fuel line	Refer to section C 083.05.11
1, 2, 3	Install cylinder head cover	Refer to section C 056.05.11
1, 2, 3	Prime engine	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.

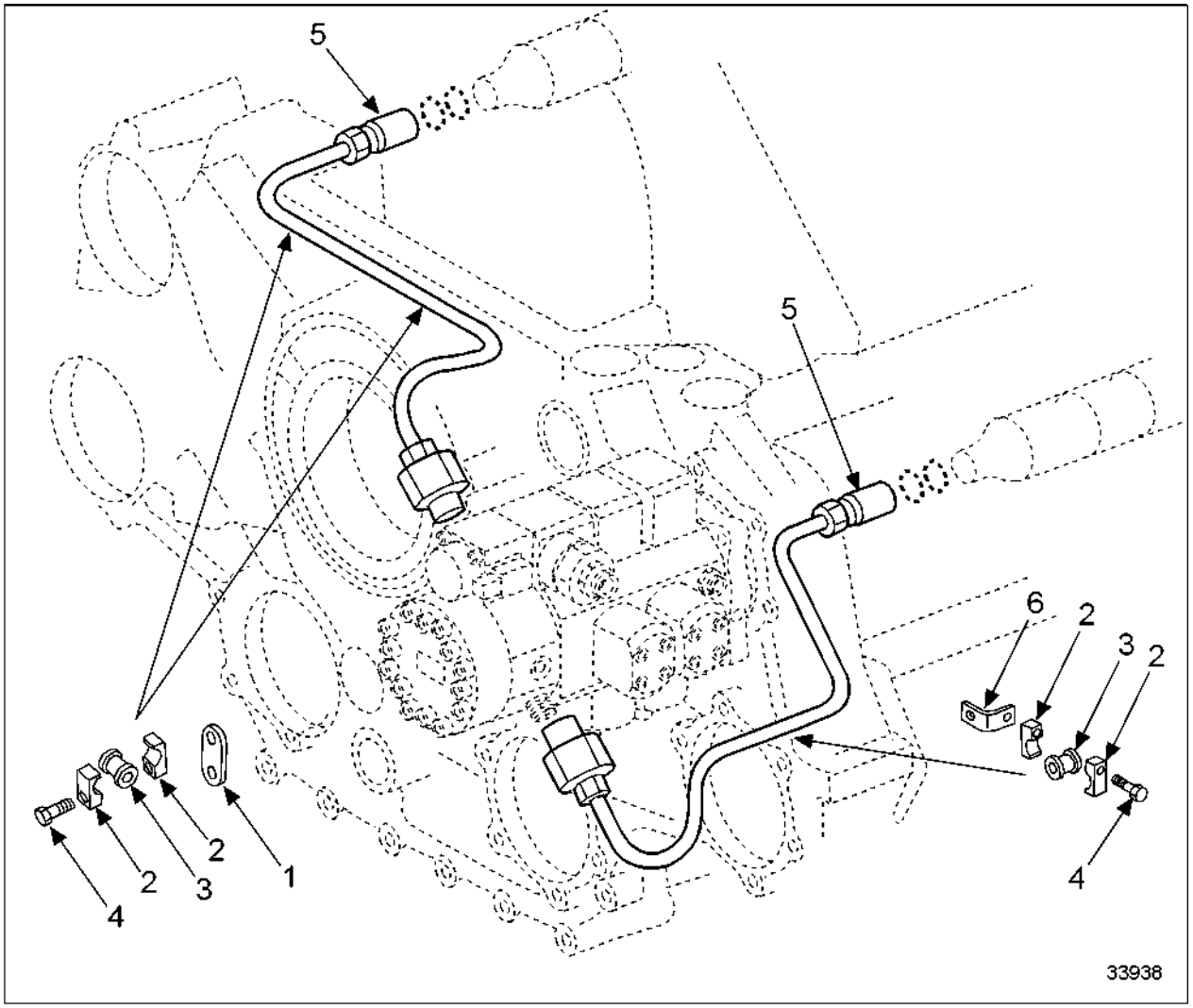
3 = The engine is to remain installed.

Table 60 After-Installation Operations

C 077.05 – HIGH-PRESSURE RAILS AND LINES

C 077.05.01 – GENERAL VIEW

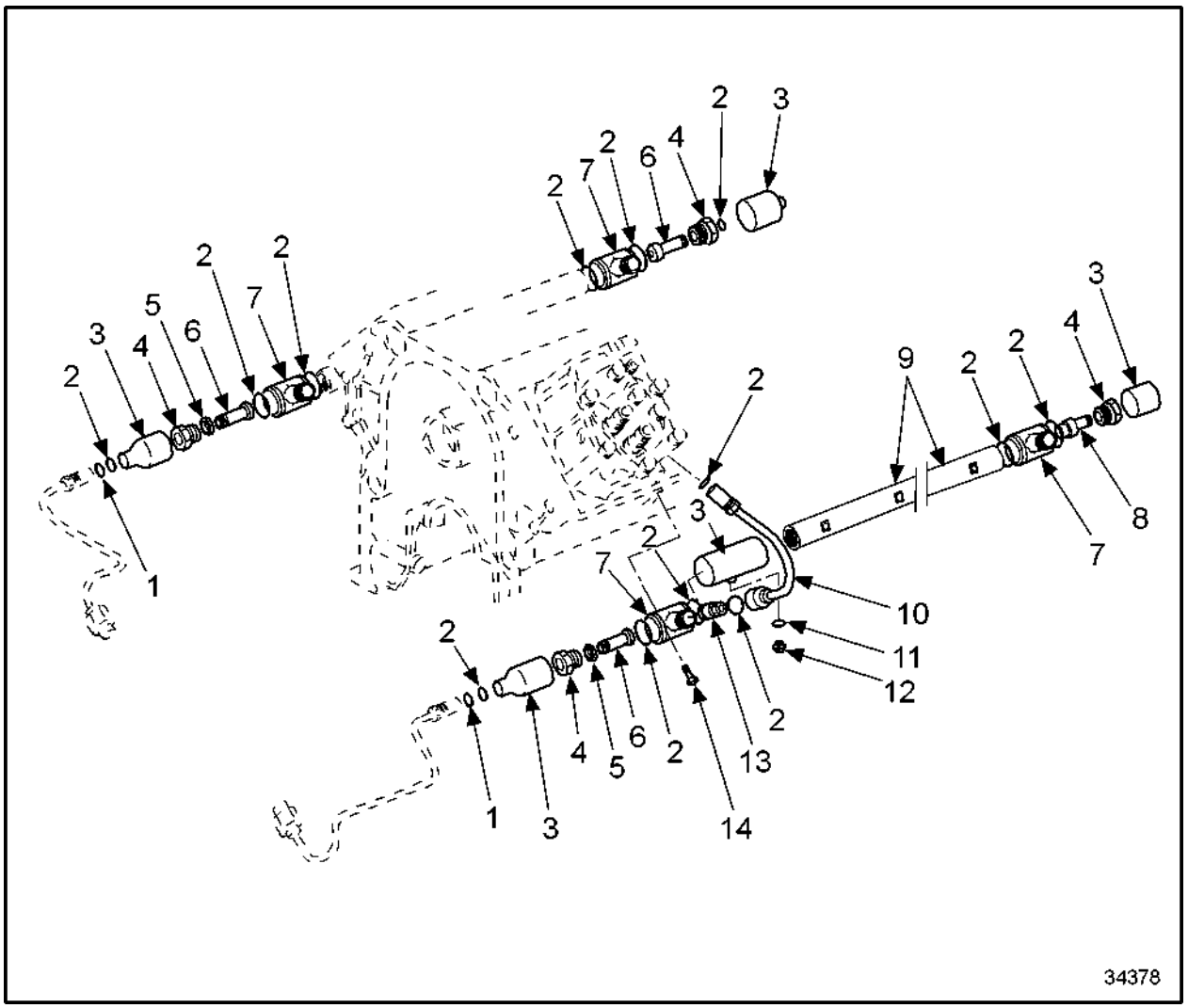
See Figure 538 for a general view of the high-pressure rails and lines.



1. Mounting Bracket
2. Pipe Half Clamp
3. Grommet
4. Bolt
5. High-Pressure Fuel Line
6. Mounting Bracket

Figure 538 General View of High-Pressure Lines from the High-Pressure Rails

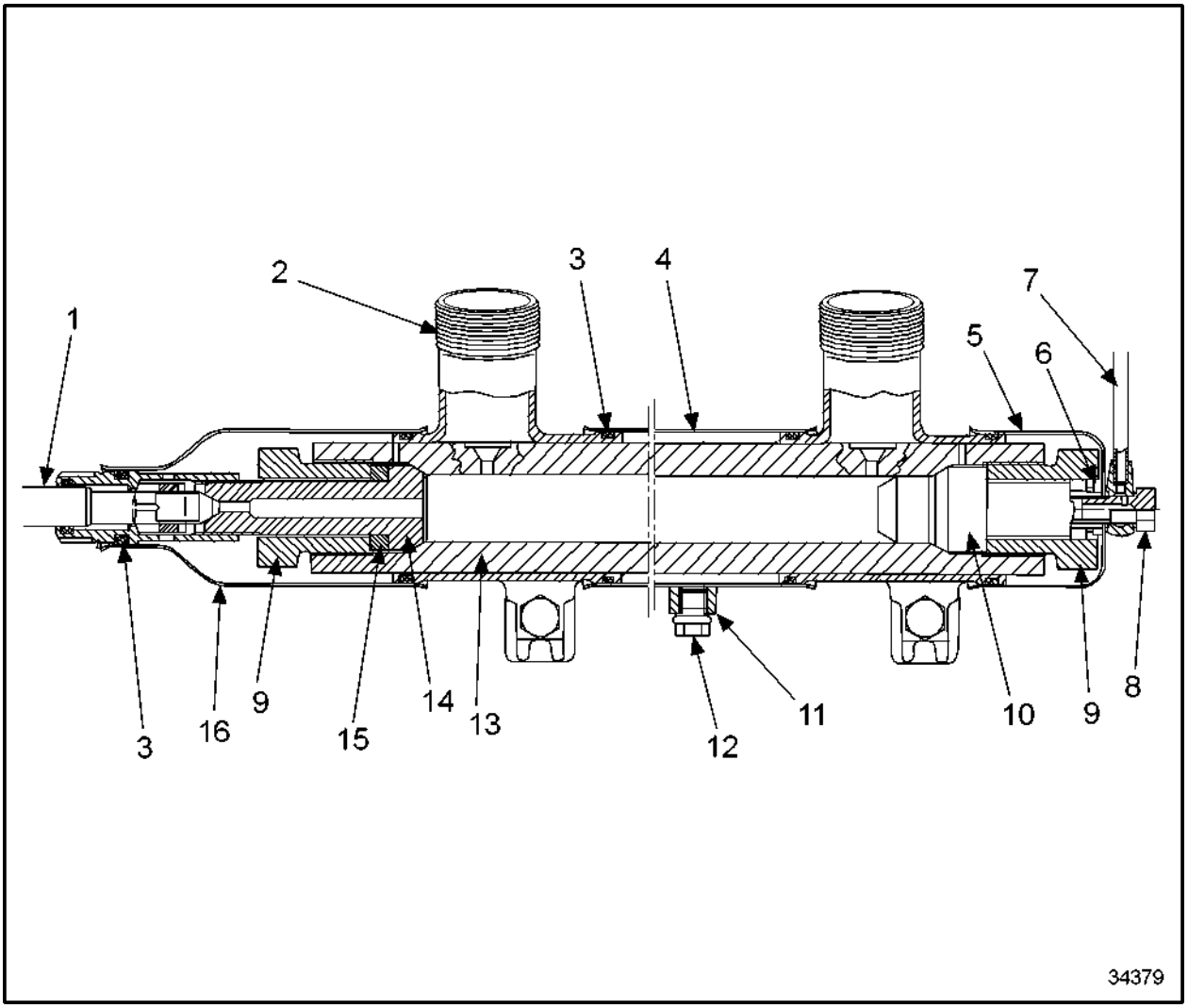
See Figure 539 for a general view of the high-pressure rails and related parts.



1. Snap Ring (Marine and HydroFrac only)
2. O-ring
3. Plug-in Pipe (Marine and HydroFrac only)
4. Thrust Bolt
5. Washer
6. Thrust Pad
7. Connector
8. Pressure Relief Valve
9. High-Pressure Rail
10. High-Pressure Jumper Line
11. Sealing Ring
12. Plug
13. Fuel Flow Limiting Valve
14. Hex Bolt

Figure 539 General View of High-Pressure Rail and Related Parts

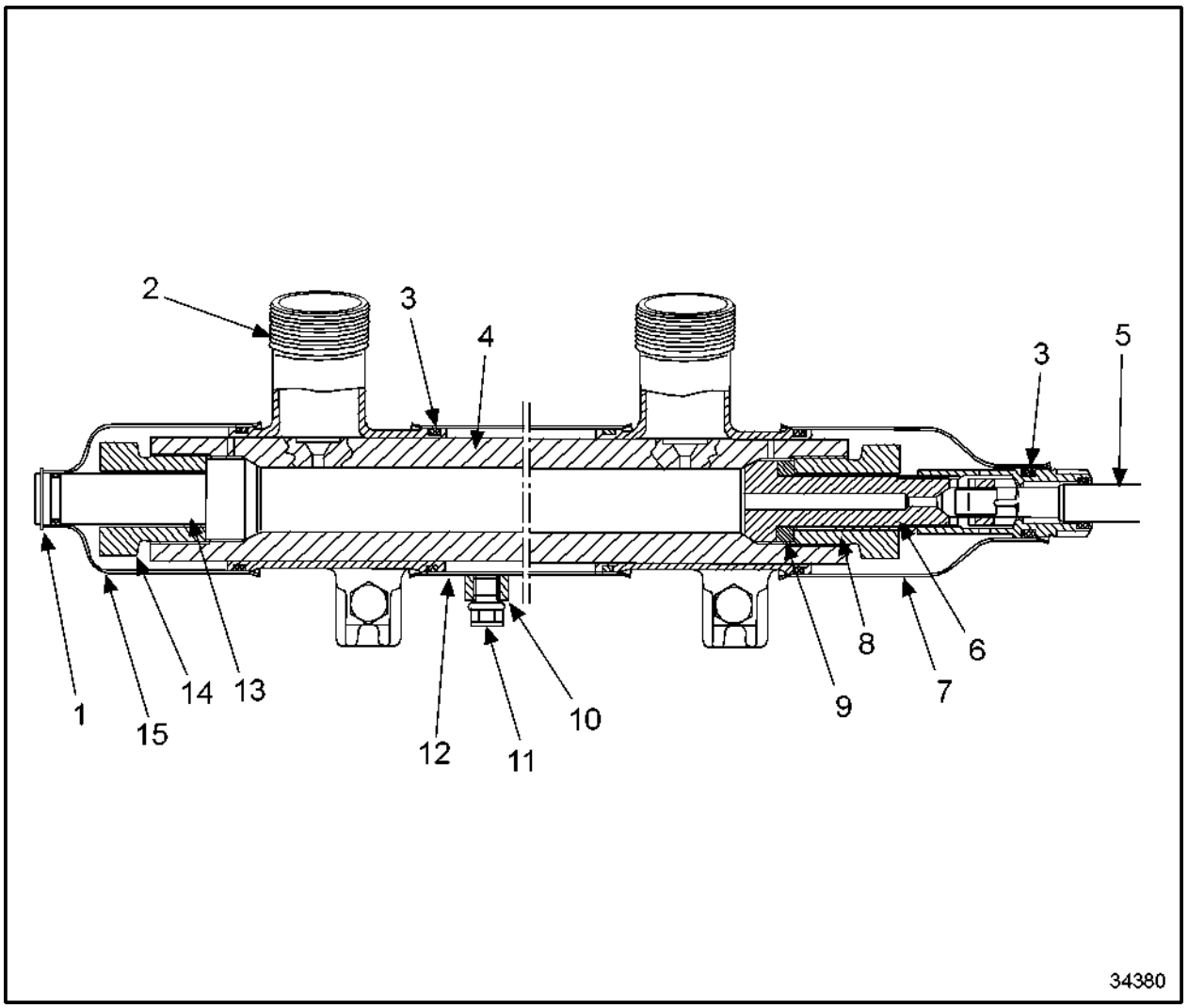
See Figure 540 for a general view of the high-pressure rail, “A” engine side.



1. High-Pressure Fuel Line
2. Saddle
3. O-ring
4. Plug-in Pipe (Marine and Hydro Frac only)
5. Plug-in Pipe (Marine and Hydro Frac only)
6. Sealing Ring
7. Fuel Line
8. Banjo Bolt
9. Thrust Bolt
10. Pressure Relief Valve
11. Washer, Drain Plug (Marine and Hydro Frac only)
12. Drain Plug (Marine and Hydro Frac only)
13. High-Pressure Rail
14. Thrust Pad
15. Washer
16. Plug-in Pipe (Marine and Hydro Frac only)

Figure 540 General View of High-Pressure Rail, Left Engine Side

See Figure 541 for a general view of the high-pressure rail, right engine side.



1. Snap Ring (Marine and Hydro Frac only)
2. Connector
3. O-ring
4. High-Pressure Rail
5. High-Pressure Fuel Line
6. Thrust Pad
7. Plug-in Pipe (Marine and Hydro Frac only)
8. Thrust Bolt
9. Thrust Ring
10. Washer, Drain Plug
11. Hex Bolt, Drain Plug
12. Thrust Pad
13. Thrust Bolt
14. Cover
15. Plug-in Pipe

Figure 541 General View of High-Pressure Rail, “B” Bank

C 077.05.02 – SPECIAL TOOLS

Listed in Table 61 are the special tools required for the maintenance on the high-pressure rails and lines.

Application - Designation	Number
Retaining device for installing rail	—
Ring insert for high-pressure fuel line	—
Alignment tool	—

Table 61 Special Tools

C 077.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 62 are the Before-Removal Operations for the high-pressure rails and lines.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove charge air manifolds	Refer to section C 124.05.05
1, 2, 3	Remove rocker cover	Refer to section C 056.05.05
1, 2, 3	Remove part of fuel return line to drain fuel from rails	Refer to section C 083.05.05

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 62 Before-Removal Operations

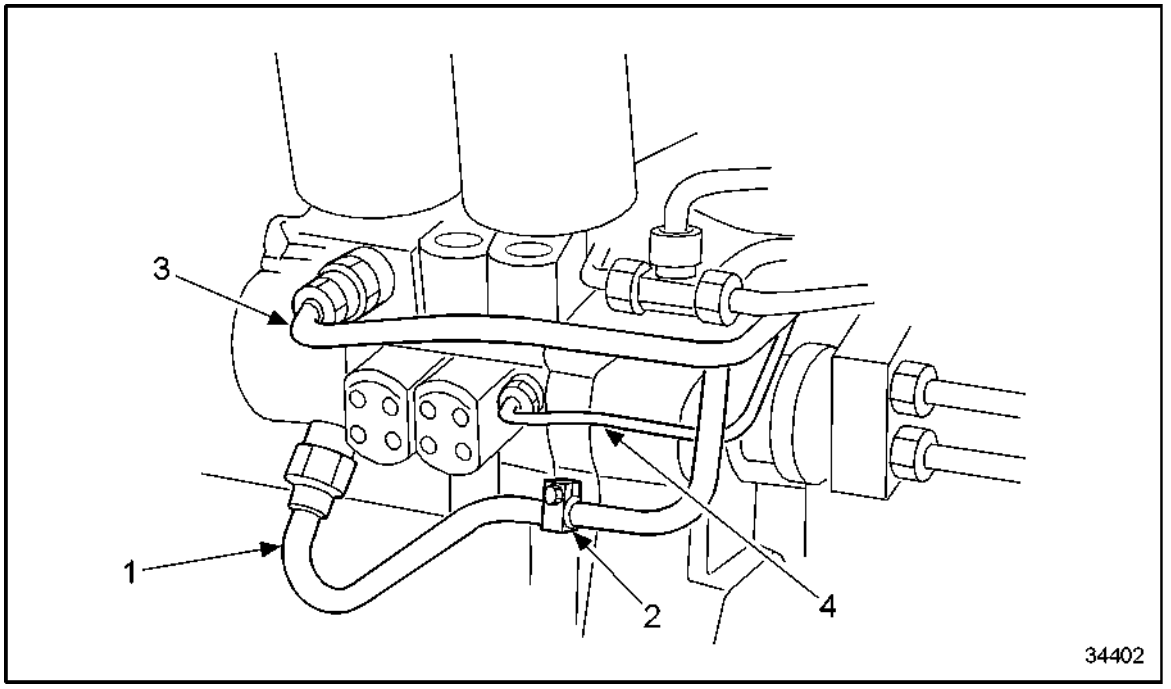
C 077.05.05 – REMOVAL OF THE HIGH-PRESSURE FUEL RAILS

Perform the following steps for the removal of the high-pressure rails.

CAUTION:

To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

1. Loosen fuel return line (4) at high-pressure fuel pump to relieve fuel pressure from high-pressure rails. See Figure 542.
2. To remove high-pressure line between high-pressure pump and high-pressure rail, remove pipe clamp half (2).

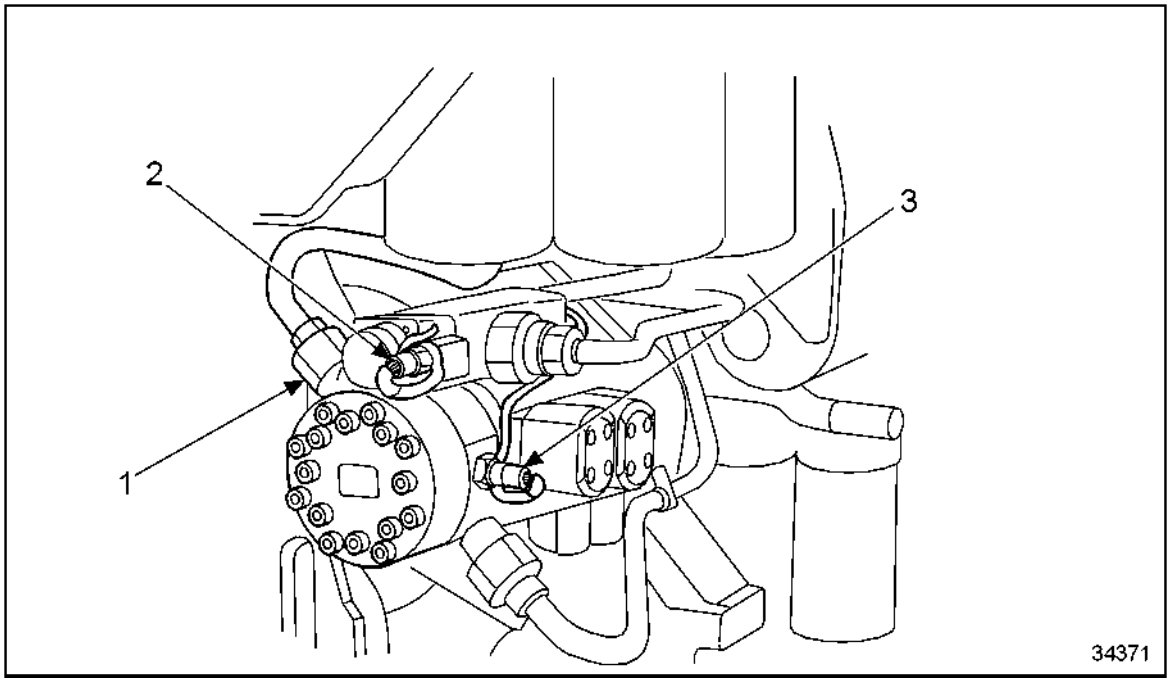


1. High-Pressure Line ("A" Bank)
2. Pipe Half Clamp
3. Low Pressure Fuel Supply Line
4. High Pressure Pump Fuel Return Line

Figure 542 Removing High-Pressure Line Between High-Pressure Pump and High-Pressure Rail

3. Unscrew and remove high-pressure line (1), “B” bank, on high-pressure pump and high-pressure rail.

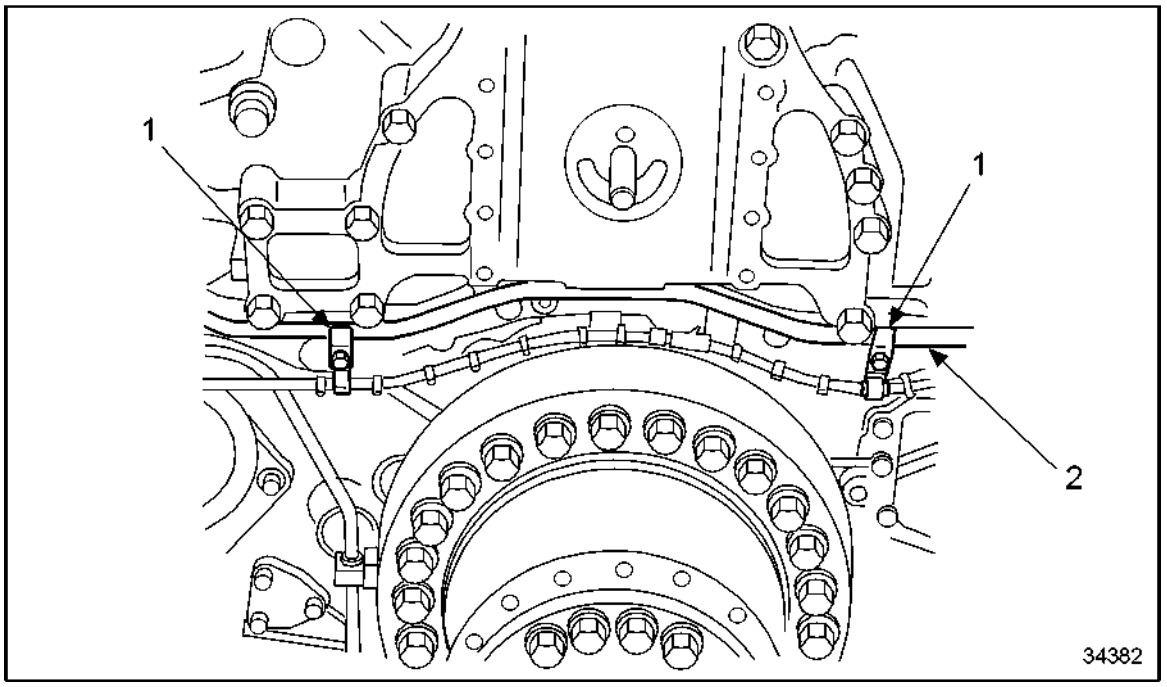
4. Loosen high-pressure line (1), “B” bank, on high-pressure pump and high-pressure rail. See Figure 543.



1. High-Pressure Line “B” Bank
2. DDEC Harness Connector to Controller Solenoid
3. DDEC Harness Connection to Temperature Sensor

Figure 543 Loosening High-Pressure Line, “B” Bank, on High-Pressure Pump and Rail

5. Loosen pipe clamp halves (1) of high-pressure line (2), “B” bank side. See Figure 544.



1. Pipe Clamp Half
2. High-Pressure Line

Figure 544 Loosening Pipe Clamp Halves of High-Pressure Line, Right Side

NOTE:
When replacing an individual high-pressure injector jumper line on an engine that is not disassembled, it is not necessary to release the hold-down clamps or to remove the high-pressure rail.

6. Loosen high-pressure fuel jumper lines between injector and high-pressure rail on injector side. See Figure 545.

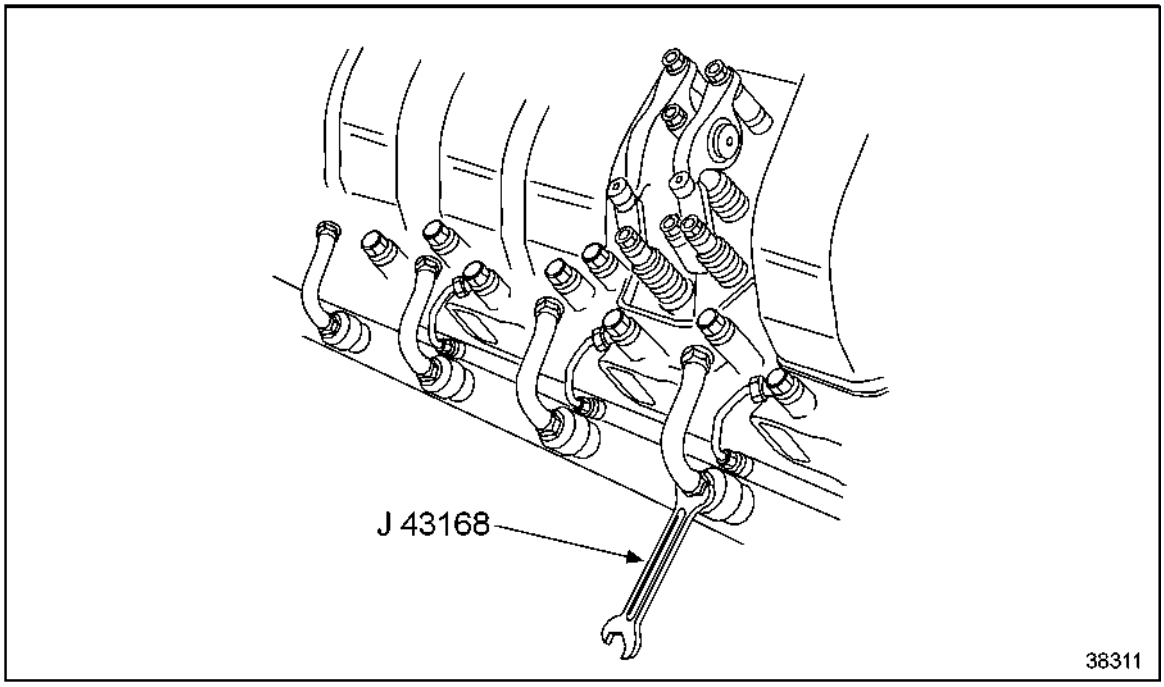


Figure 545 Removing Injector High-pressure Jumper Lines

NOTE:
The pressure in the high-pressure system is reduced automatically. However, it is advisable to open the high-pressure system carefully.

7. Loosen high-pressure fuel jumper lines at the high-pressure rail connector, and remove high-pressure fuel lines. See Figure 546.

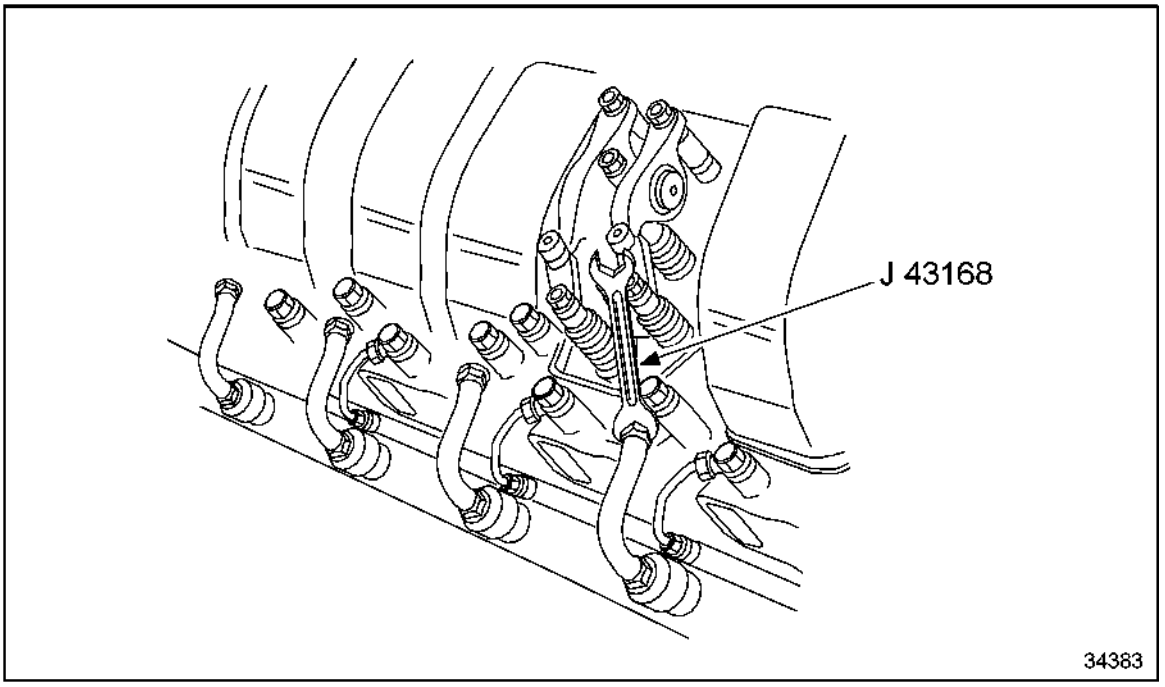
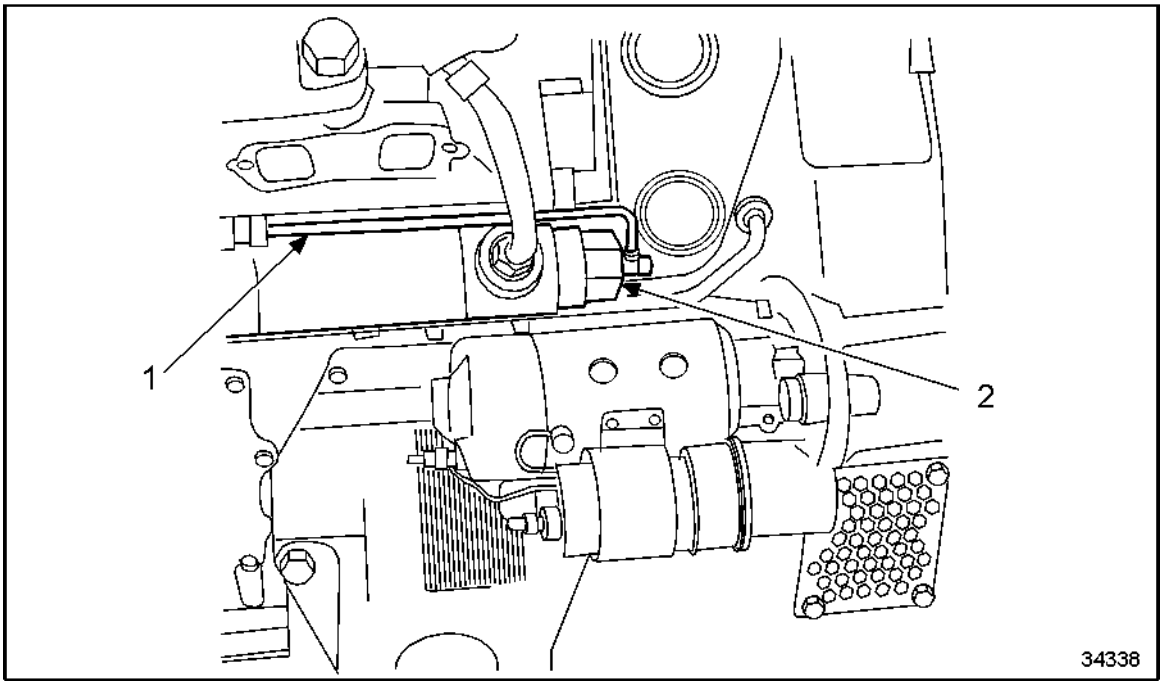


Figure 546 Loosening High-pressure Fuel Jumper Lines between Injector and High-pressure Rail

8. Remove O-rings.

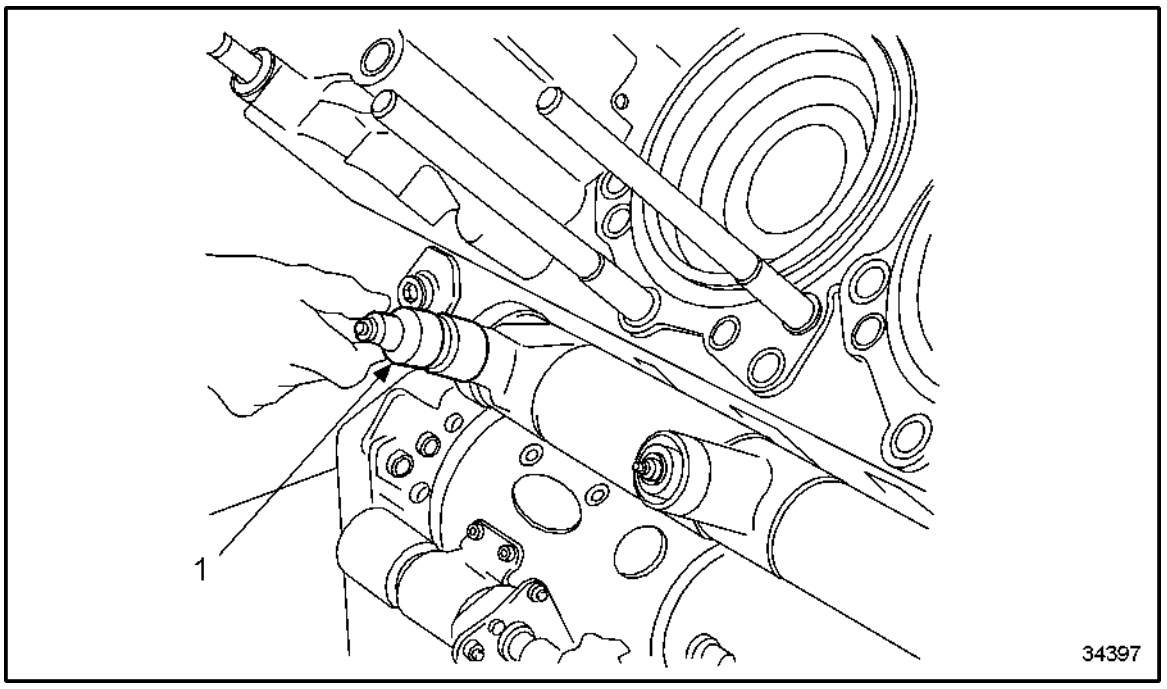
9. To remove the high-pressure rail, remove fuel relief line on “A” bank high-pressure rail (flywheel end). See Figure 547.



1. Fuel Return Line (Fuel Relief Line)
2. High-pressure Rail Relief Valve

Figure 547 Removing Fuel Relief Line on High-Pressure Rail (Flywheel End)

10. Remove flow limiting valves (1) from high-pressure rail connectors. See Figure 548.



1. Flow Limiting Valve

Figure 548 Removing Flow Limiting Valves from High-pressure Rail Connectors

11. Remove high-pressure rail attaching hex bolts from cylinder block. See Figure 549.

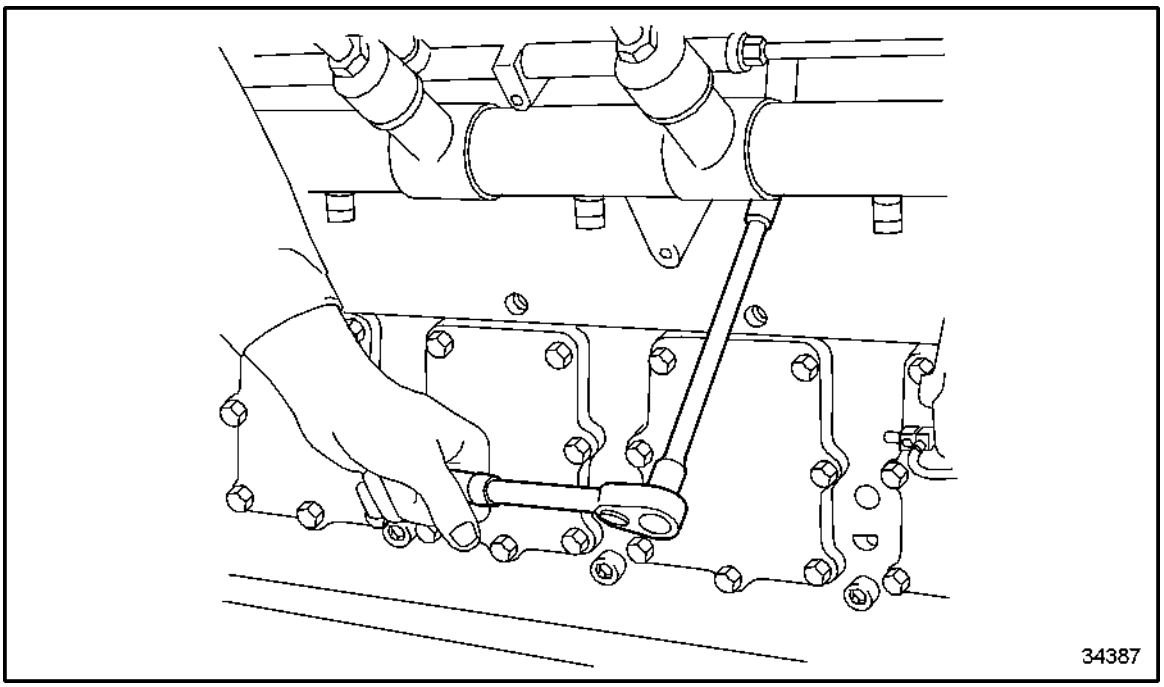


Figure 549 Removing High-pressure Rail Attaching Hex Bolts from Cylinder Block

12. Remove plug-in pipes.
13. Remove connector from high-pressure rails.
14. Remove O-rings from connectors.
15. Remove protective covers. (Marine and Hydro Frac only.)
16. Clean exterior of rails thoroughly.

NOTE:
Sand rails to remove corrosion and pain if necessary.

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.

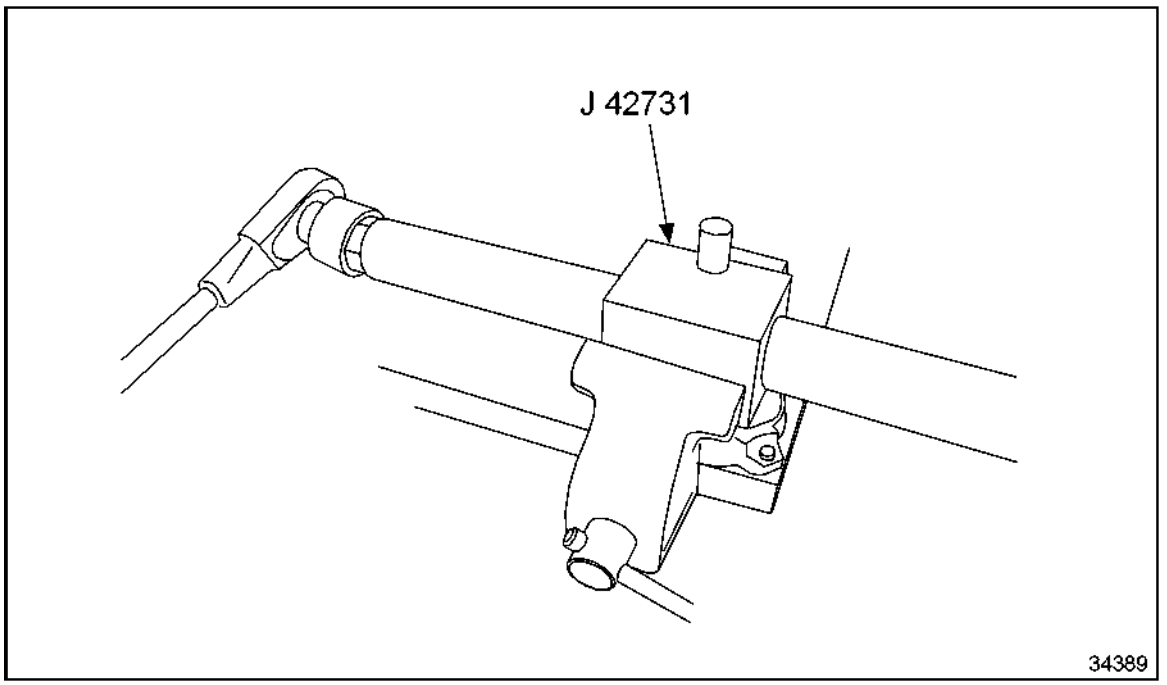


Figure 550 Clamping High-Pressure Rail in Vise

2. Remove thrust bolts. See Figure 551.

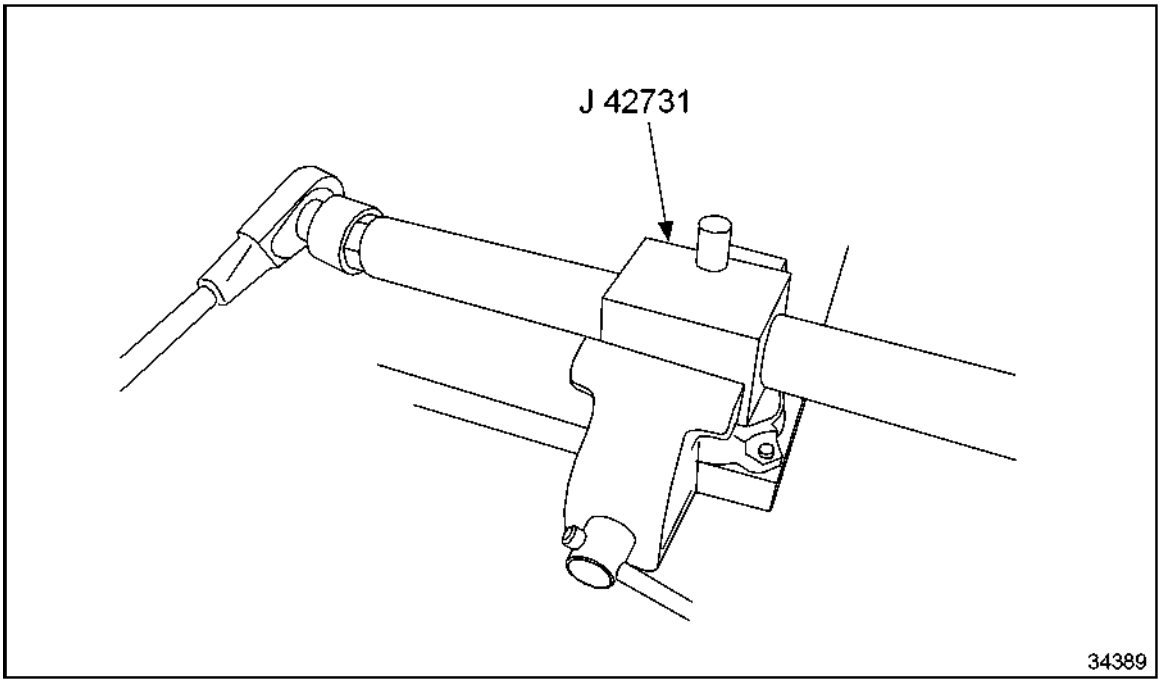
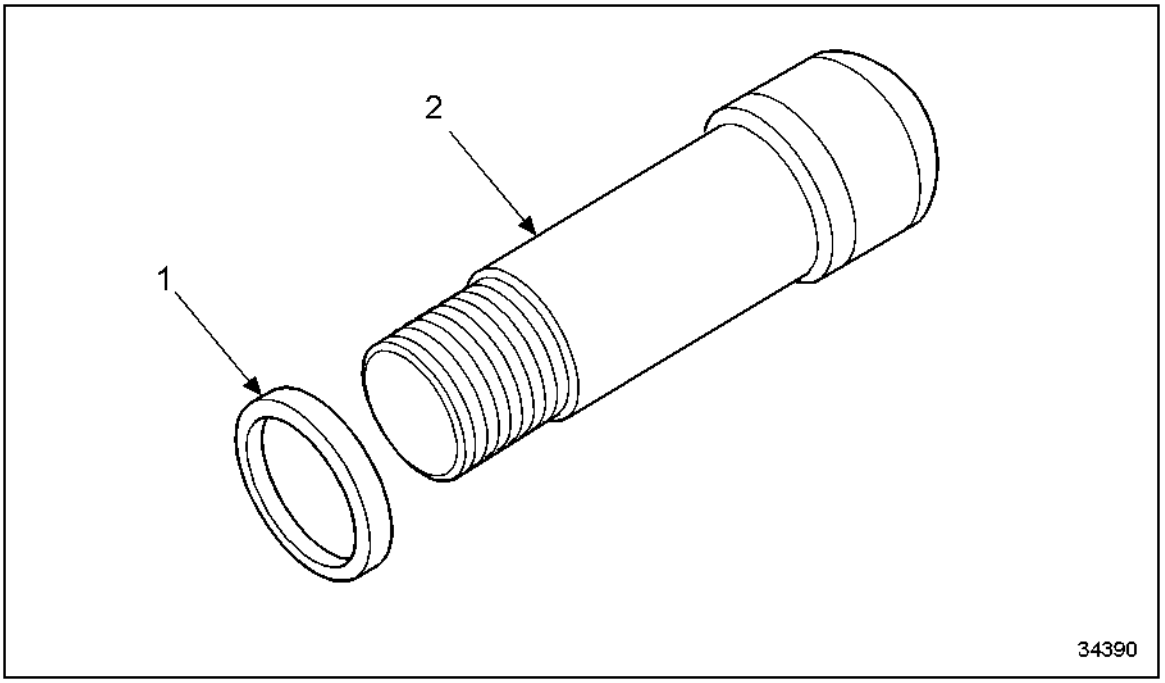


Figure 551 Removing Thrust Bolts, Thrust Pad and Pressure Relief Valve

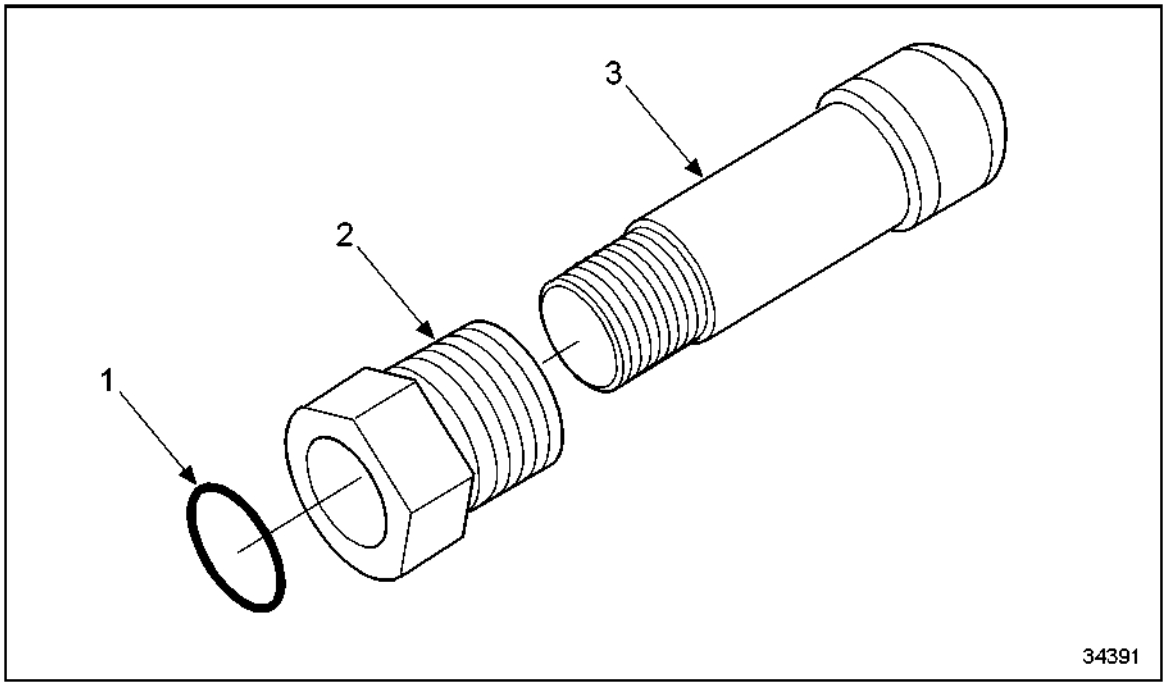
3. Remove thrust ring from thrust pad. See Figure 552.



1. Thrust Ring
2. Thrust Pad

Figure 552 Removing Thrust Ring from Thrust Pad

4. Remove O-ring from thrust pad. See Figure 553.



1. O-ring
2. Thrust Bolt
3. Thrust Pad

Figure 553 Removing O-ring and Thrust Bolt from Thrust Pad

C 077.05.07 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the injection line.

1. Clean all components.
2. Visually inspect threads of hex bolts for damage.
   [a] If threads of hex bolts are damaged, replace bolts as necessary.
   [b] If threads of hex bolts are not damaged, continue inspection.
3. Visually inspect condition of threads of high-pressure lines and connectors for ease of movement.
   [a] If threads of high-pressure lines and connectors do not show ease of movement, replace components as necessary.
   [b] If threads of high-pressure lines and connectors show ease of movement, continue inspection.
4. Visually inspect sealing cones of thrust pads and pressure release valve for wear or damage.
   [a] If sealing cones of thrust pads are worn or damaged, replace components as necessary.
   [b] If sealing cones of thrust pads are not worn or damaged, continue inspection.
5. Visually inspect sealing taper of high-pressure rail for wear and damage.
   [a] If sealing taper of high-pressure rail is worn or damaged, replace component as necessary.
   [b] If sealing taper of high-pressure rail is not worn or damaged, continue inspection.
6. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect high-pressure rail for cracks.
   [a] If high-pressure rail is cracked, replace component as necessary.
   [b] If high-pressure rail is not cracked, continue inspection.
7. Visually inspect high-pressure lines, plug-in pipes and fuel return line for wear and damage.
   [a] If high-pressure lines, plug-in pipes or fuel return line is worn or damaged, replace components as necessary.
   [b] If high-pressure lines, plug-in pipes or fuel return line is not worn or damaged, continue inspection.
8. Ensure that high-pressure lines and high-pressure rail are perfectly clean.

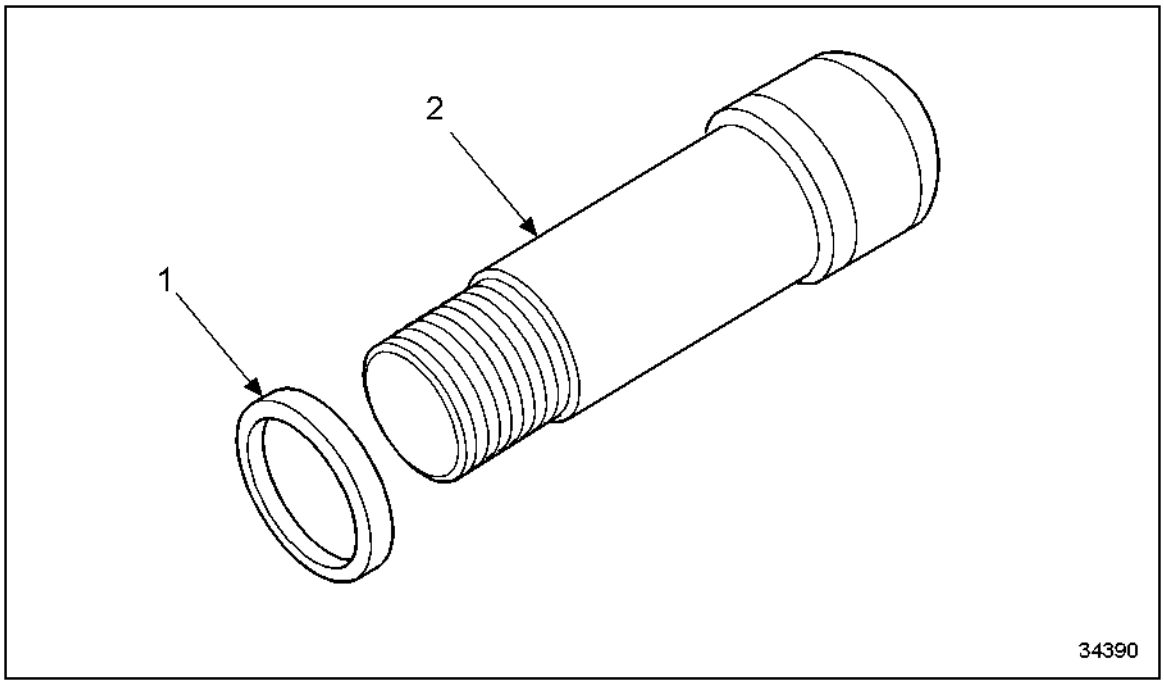
NOTE:
Do not bend the injection line.

9. Replace sealing rings and O-rings at every assembly.

C 077.05.10 – ASSEMBLY OF THE HIGH-PRESSURE RAILS

Perform the following steps for assembly of the high-pressure rails:

1. Install thrust ring on thrust pad. See Figure 554.



1. Thrust Ring
2. Thrust Pad

Figure 554 Installing Thrust Ring on Thrust Pad

NOTE:
Ensure that thrust pads are provided with through bore.

2. Coat cone area of the thrust pad with grease. See Figure 555.

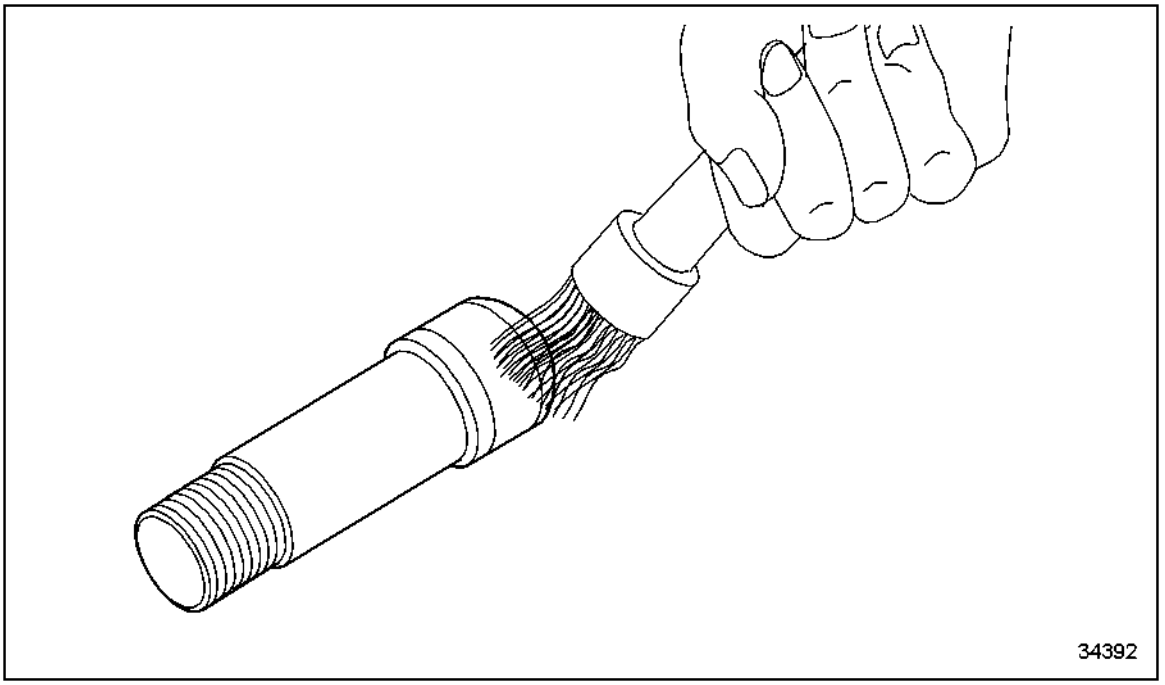


Figure 555 Coating Cone Area of Thrust Pad with Grease

3. Coat thread of the thrust bolt with oil. See Figure 556.

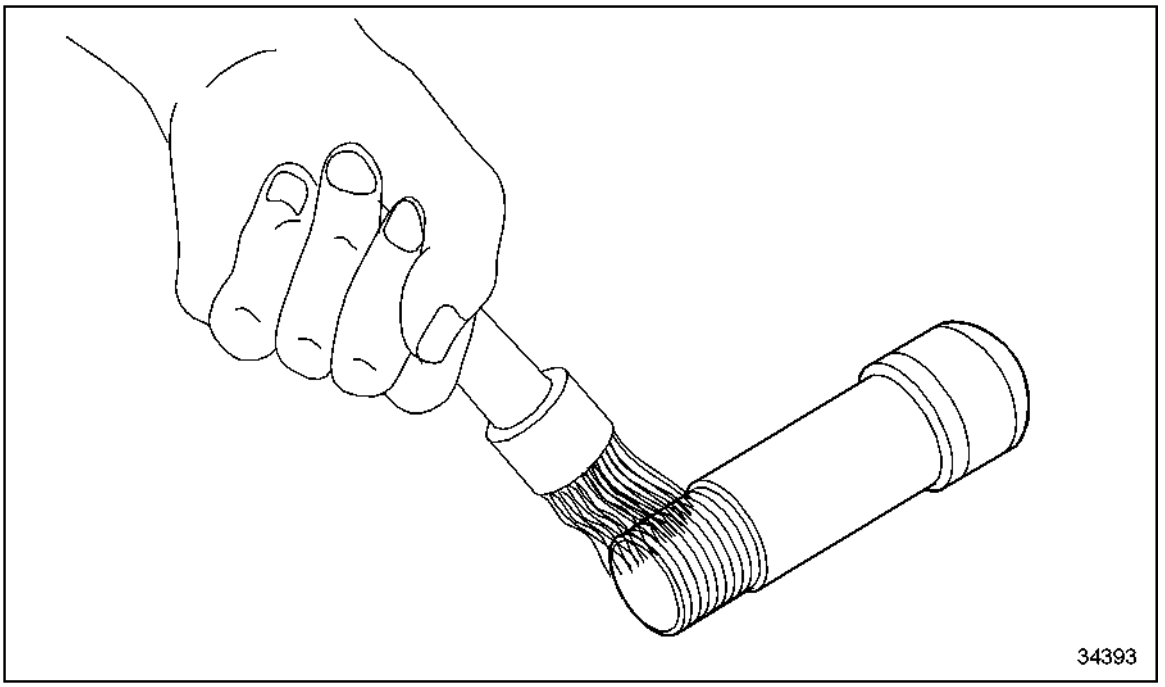
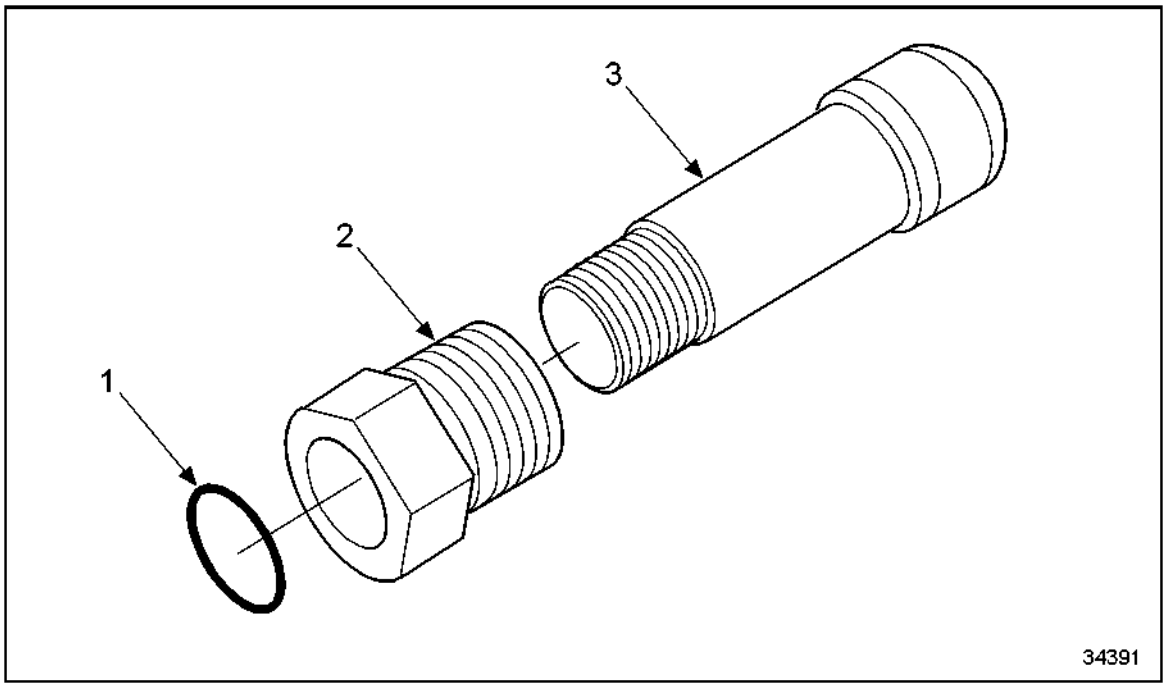


Figure 556 Coating Thread of Thrust Bolt with Oil

4. Coat O-ring with petroleum jelly and install on thrust pad. See Figure 557.



1. O-ring
2. Thrust Bolt
3. Thrust Pad

Figure 557 Installing O-ring and Thrust Bolt onto Thrust Pad

5. Slide thrust ring onto thrust pad.

6. To preassemble high-pressure rail, “B” Bank, use special tool to clamp high-pressure rail in vise. See Figure 558.

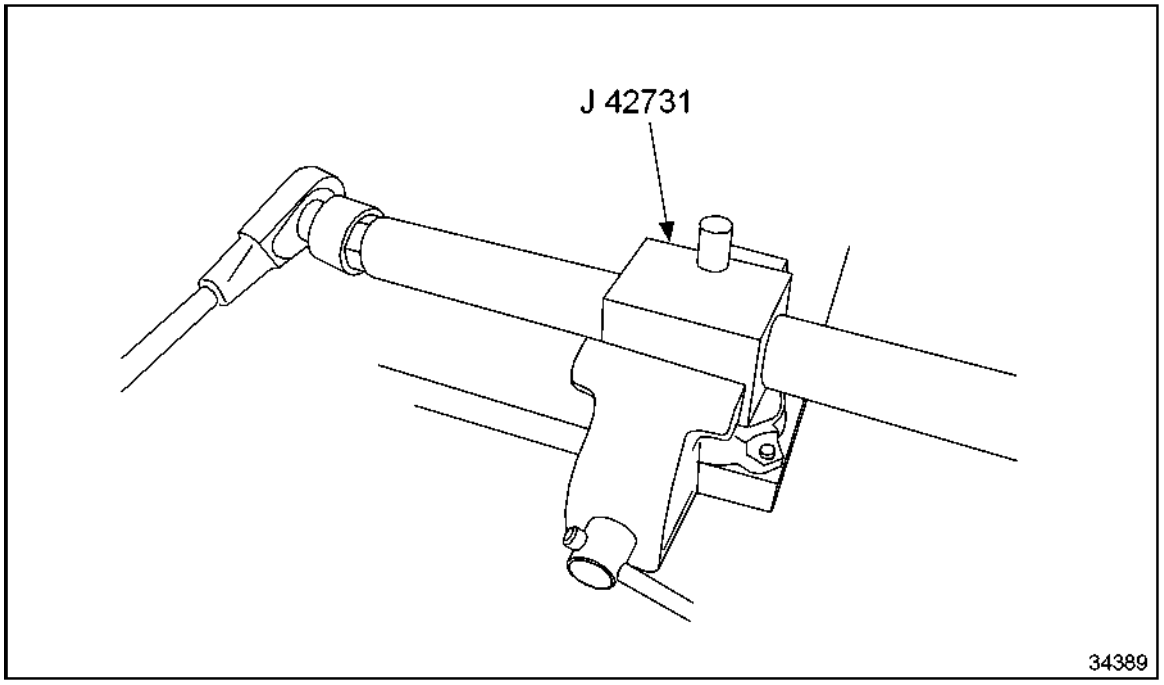


Figure 558 Preassembling High-Pressure Rail, “B” Bank

7. Insert prepared thrust pad in the bore.
8. Install thrust bolt and tighten to specification. Refer to section A 003.
9. Install pressure relief valve in opposite end bore of high-pressure rail.
10. Install thrust bolt and tighten to specification. Refer to section A 003.

11. To preassemble high-pressure rail, “A” bank, use special tool to clamp rail in vice. See Figure 559.

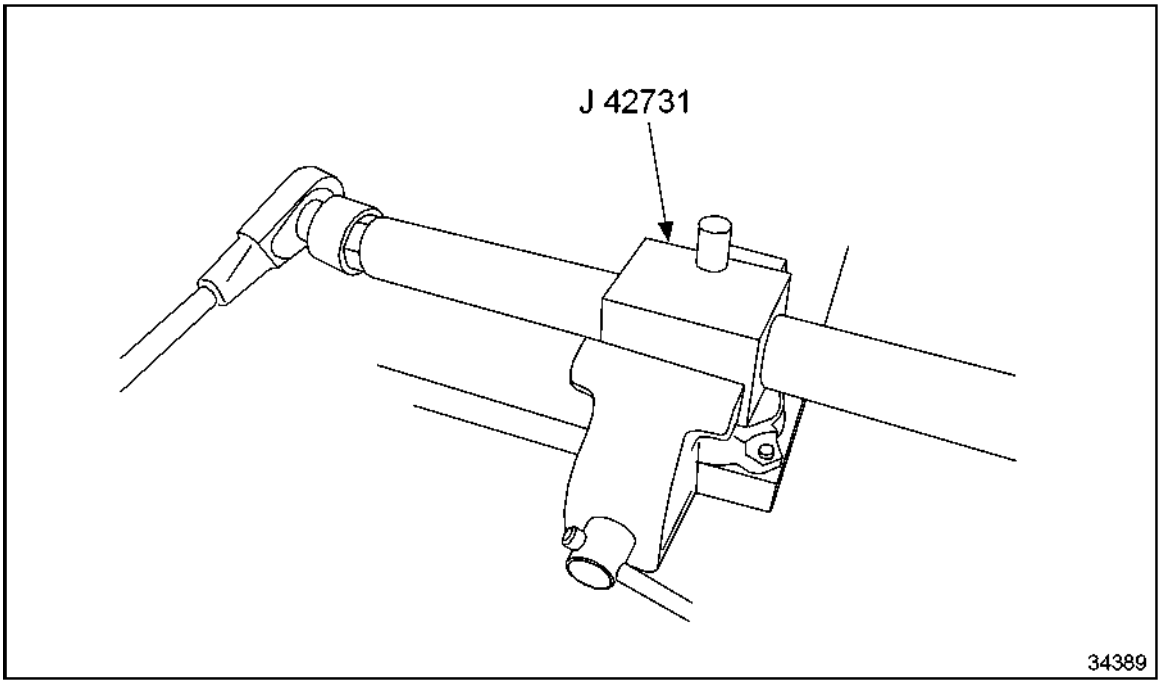
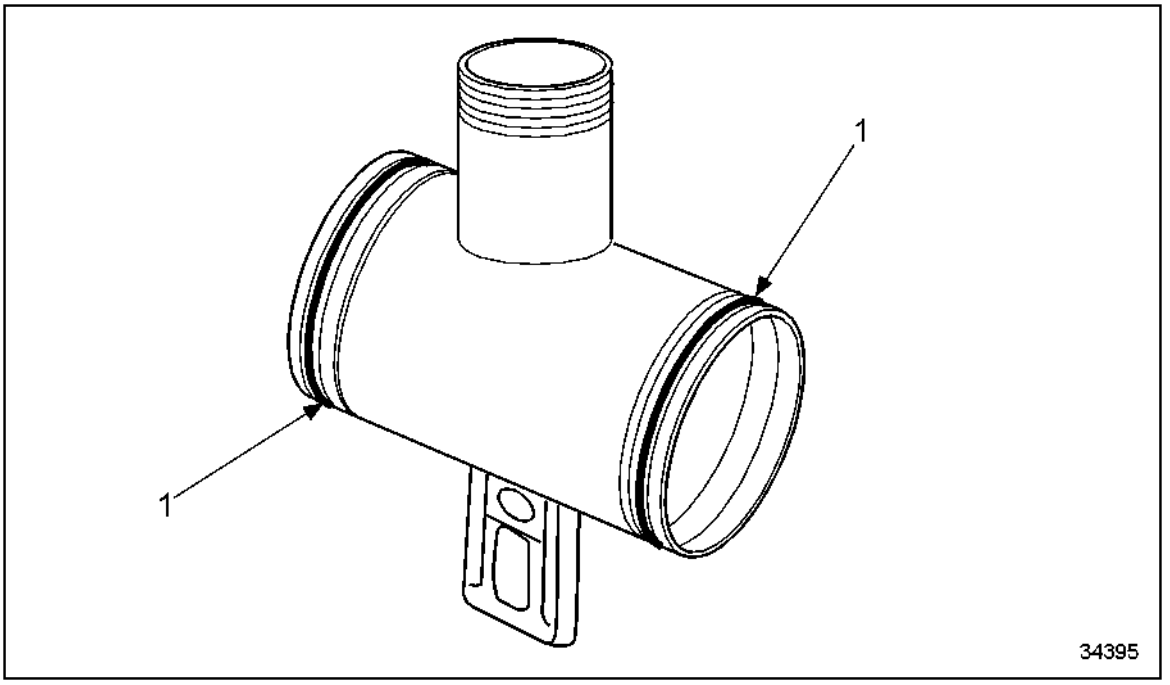


Figure 559 Preassembling High-Pressure Rail, “A” Bank

12. Install prepared thrust pad in the bore.
13. Install thrust bolt and tighten to specification. Refer to section A 003.
14. Install seal in opposite end bore of high-pressure rail.

15. Install thrust bolt and tighten to specification. Refer to section A 003.
16. To prepare connectors for marine or Hydro Frac, coat O-rings with petroleum jelly and insert in grooves on connector. See Figure 560.



1. O-ring

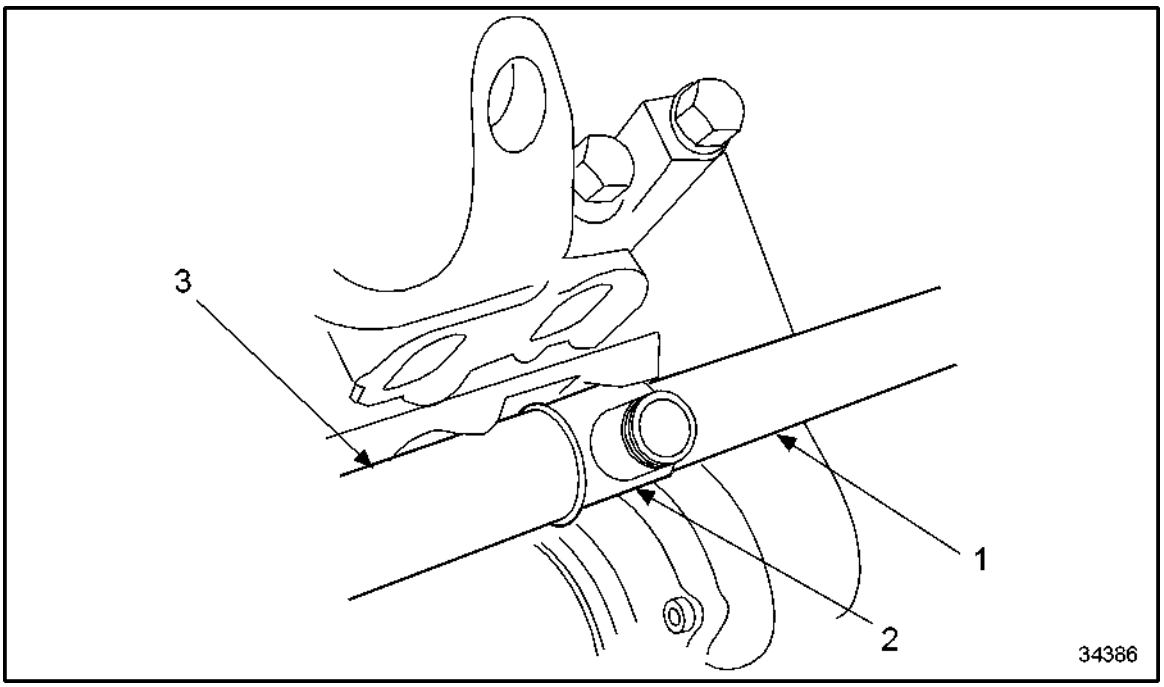
Figure 560 Inserting O-ring in Grooves on Connector

C 077.05.11 – INSTALLATION OF THE HIGH-PRESSURE RAILS

Perform the following steps for the installation of the high-pressure rails:

NOTE:
For Marine or Hydro Frac, perform step2 through step6.

1. Install connections to pipe. See Figure 561.



1. High-Pressure Rail
2. Connector
3. Plug-in Pipe

Figure 561 Installing Plug-In Pipes and Connectors to Cylinder Block

2. Install connectors and plug-in pipes together in alternating sequence.
3. Install protective covers over O-rings on the connectors.

NOTE:
Ensure that mating surface of connector is correctly positioned with regard to cylinder block, corresponding to left or right engine side.

4. To secure connector on cylinder block, install hex bolts in first and last connector on each engine side.
5. Tighten to specification. Refer to section A 003.

6. Carefully insert high-pressure rail in pre-assembled connector and plug-in pipe assembly. See Figure 562.

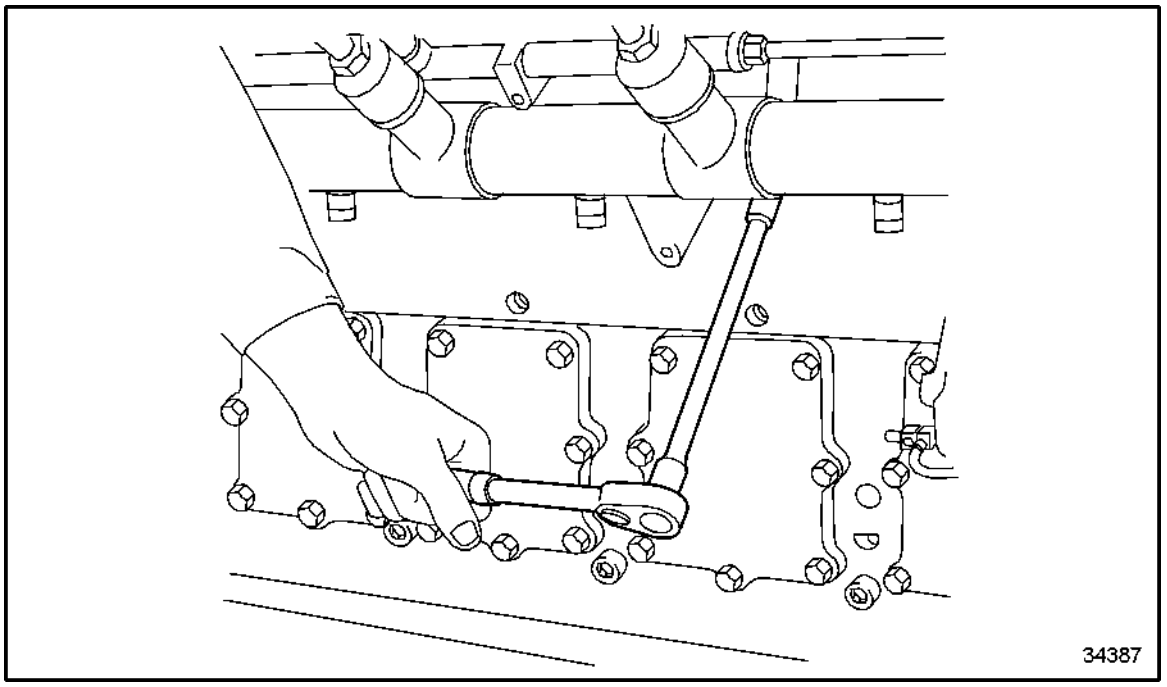
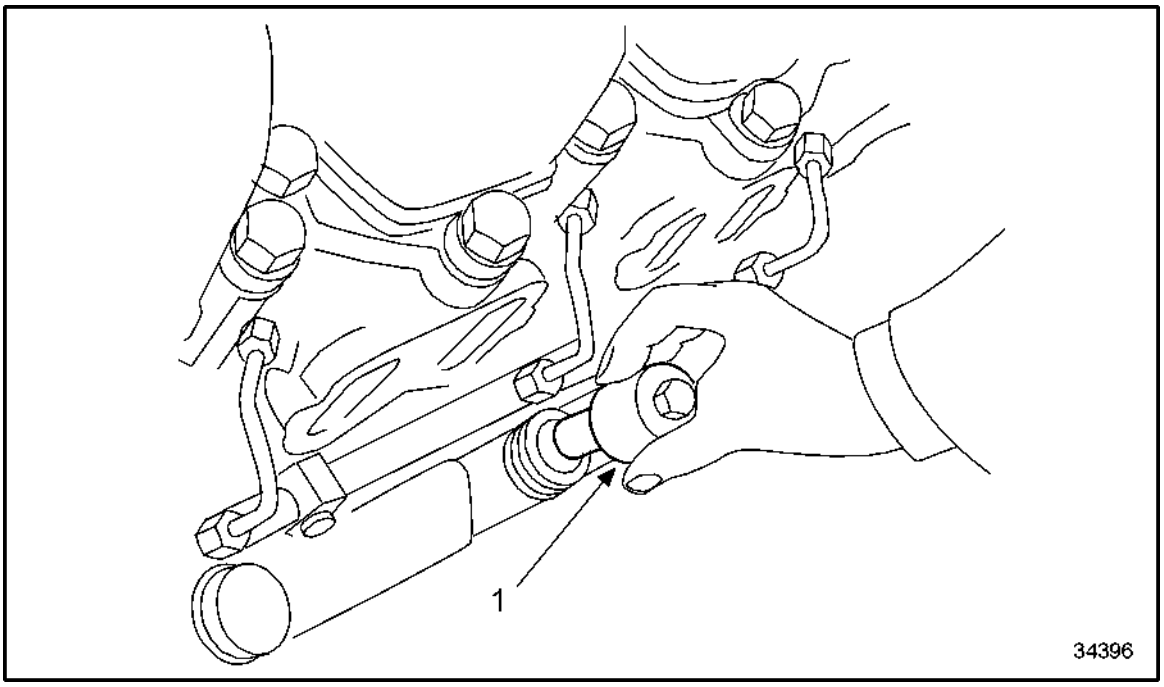


Figure 562 Inserting High-Pressure Rail in Connector and Plug-In Pipe

NOTE:
Ensure that high-pressure rail is correctly positioned.

7. Position alignment tools (1) in tightened connectors (first and last connector of respective engine side). See Figure 563.

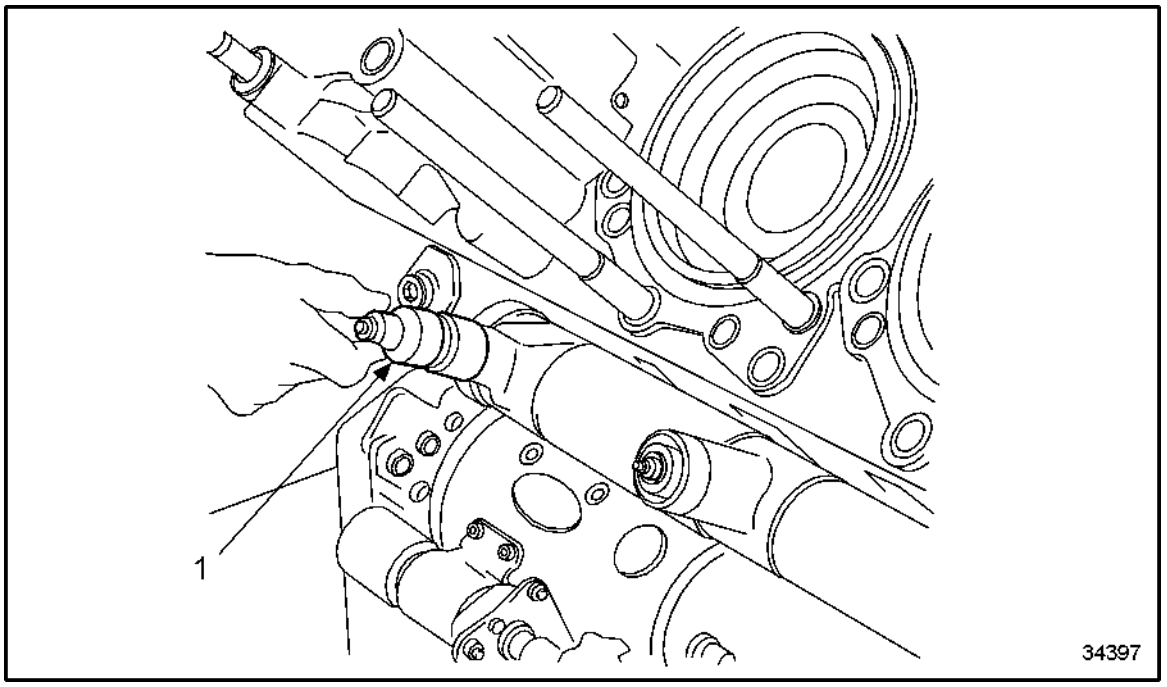


1. Alignment Tool

Figure 563 Positioning Alignment Tools in Tightened Connectors

8. Align high-pressure rail until alignment tool taper is centered in bore of high-pressure rail.
9. Carefully tighten alignment tool.

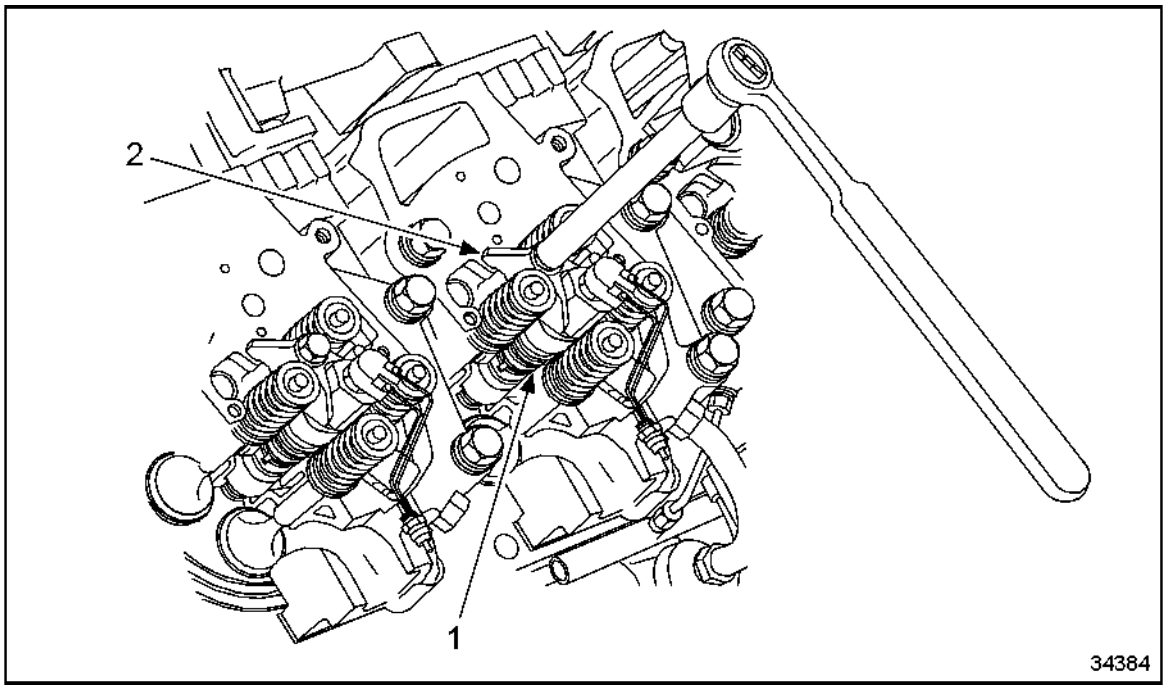
10. Install flow limiting valve (1) in outlet openings of all connectors in which no alignment tool is installed. See Figure 564.



1. Flow Limiting Valve

Figure 564 Installing Flow Limiting Valve in Outlet Openings of all Connectors

11. Pretighten all injectors, and then loosen to allow proper alignment of high-pressure lines. See Figure 565. Refer to sectionC 077.05.11.



1. Injector
2. Injector Crab

Figure 565 Pretightening Injectors

12. Install high-pressure fuel lines between high-pressure rail and injector. See Figure 566.

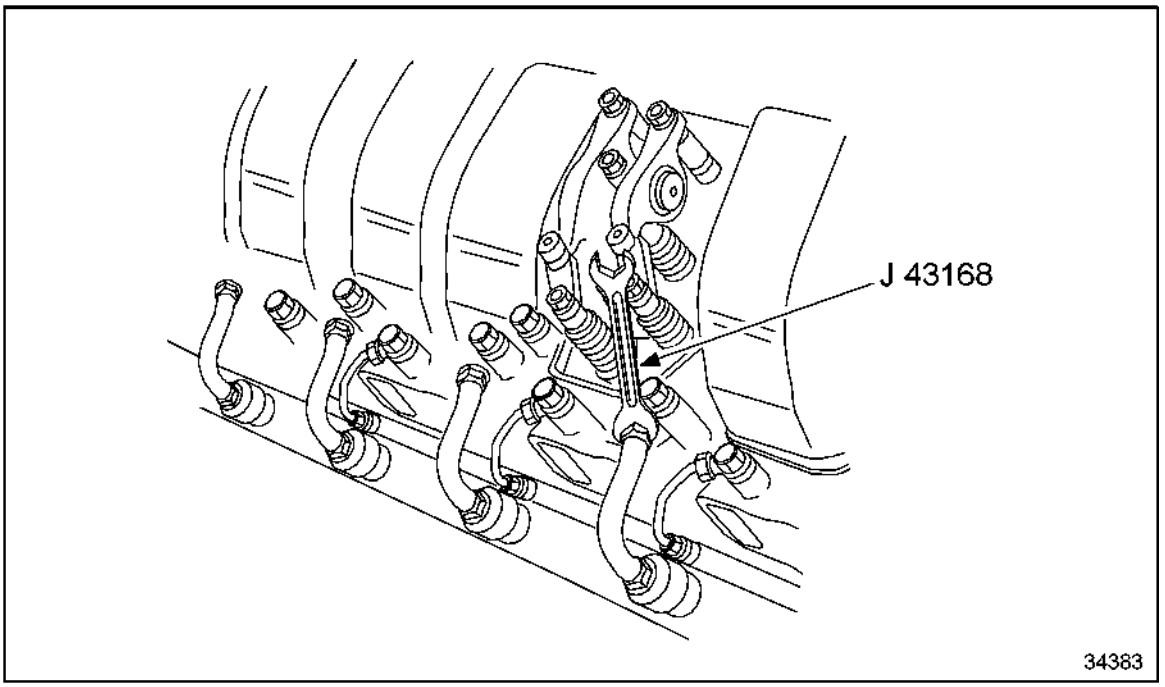


Figure 566 Pretightening and then Loosening Line at Injectors

13. Tighten on injector side to specification. Refer to section A 003.

NOTE:
Tighten only high-pressure fuel lines on which flow limiting valves have already been installed.

14. Install high-pressure fuel lines between high-pressure rail and injector. See Figure 567.

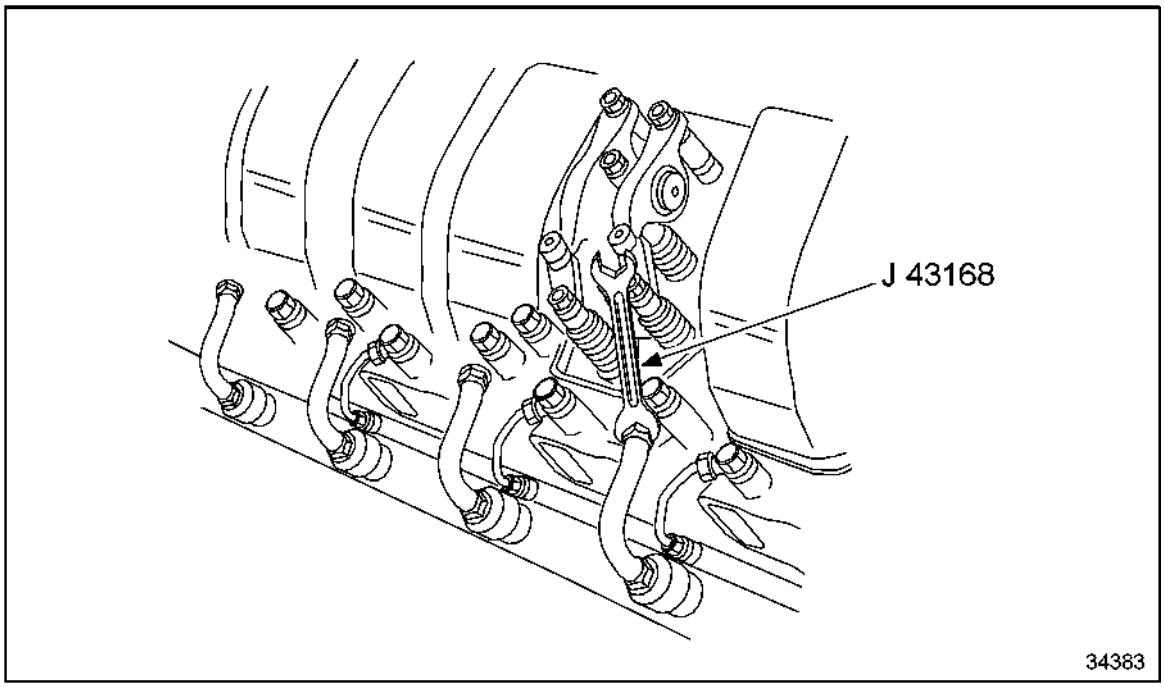


Figure 567 Installing High-Pressure Fuel Lines between Injector and High-Pressure Rail

15. Install all hex bolts securing connector to cylinder block. See Figure 568.

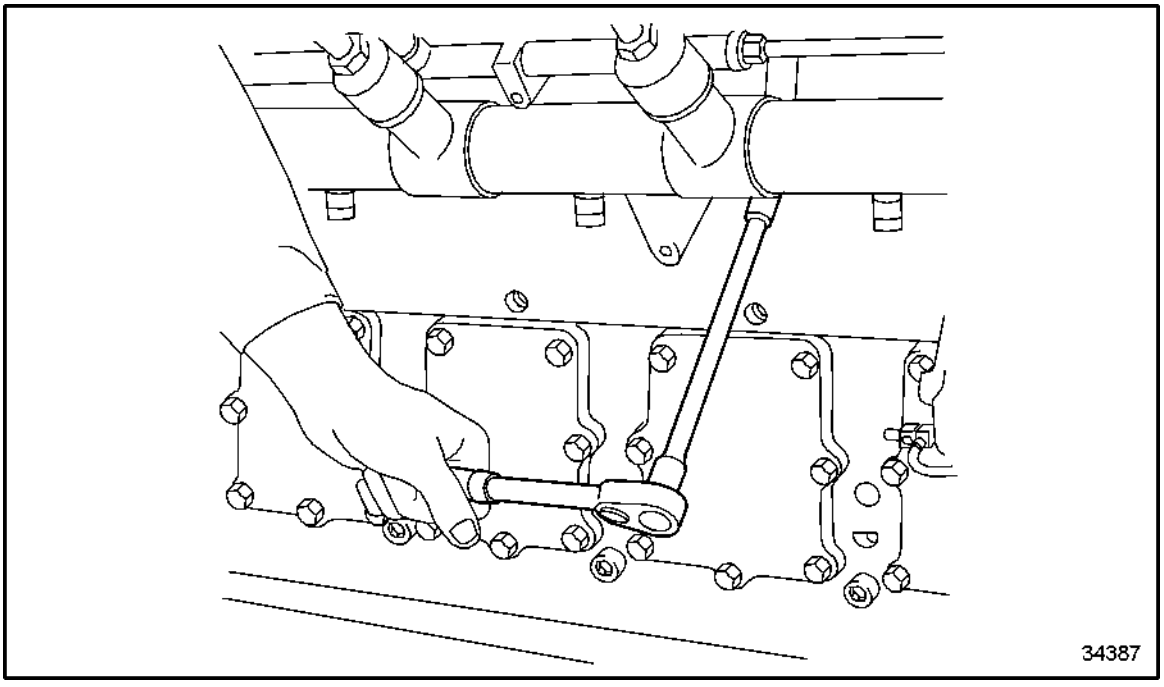


Figure 568 Installing Plug-In Pipes and Connectors from Cylinder Block

16. Tighten injectors to high-pressure lines that are fitted to specification. Refer to sectionA 003. See Figure 569.

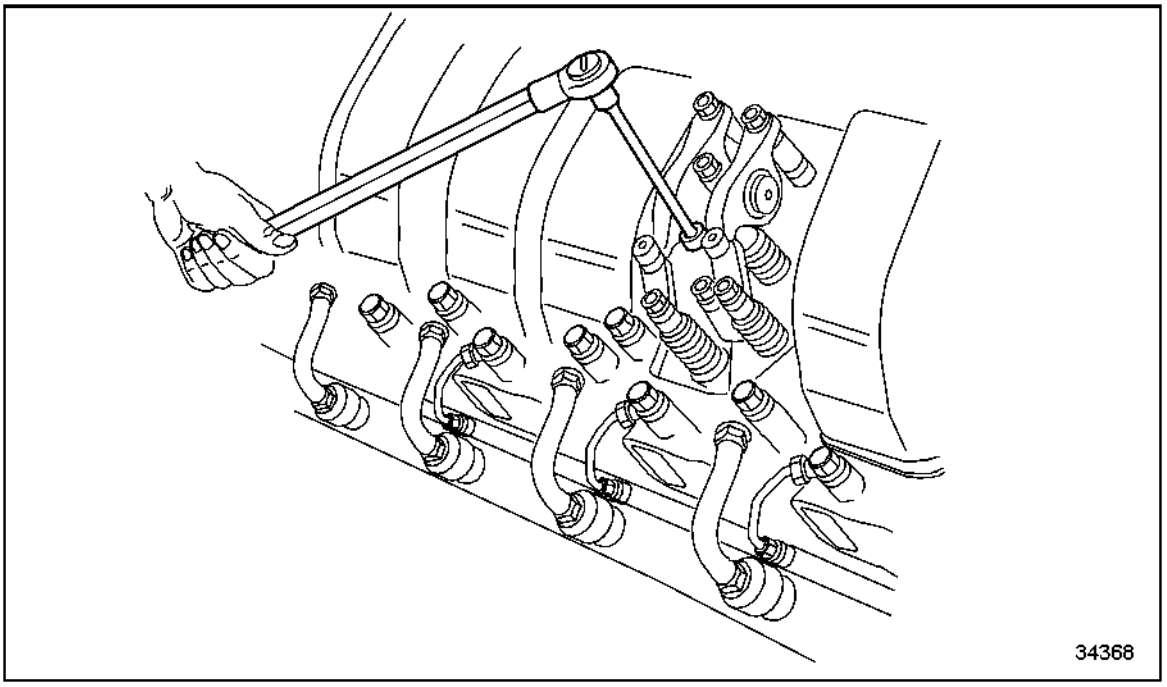


Figure 569 Tightening High-Pressure Line Injectors

17. Tighten high-pressure fuel lines between high-pressure rail and injector on injector side to specification. Refer to section A 003. See Figure 570.

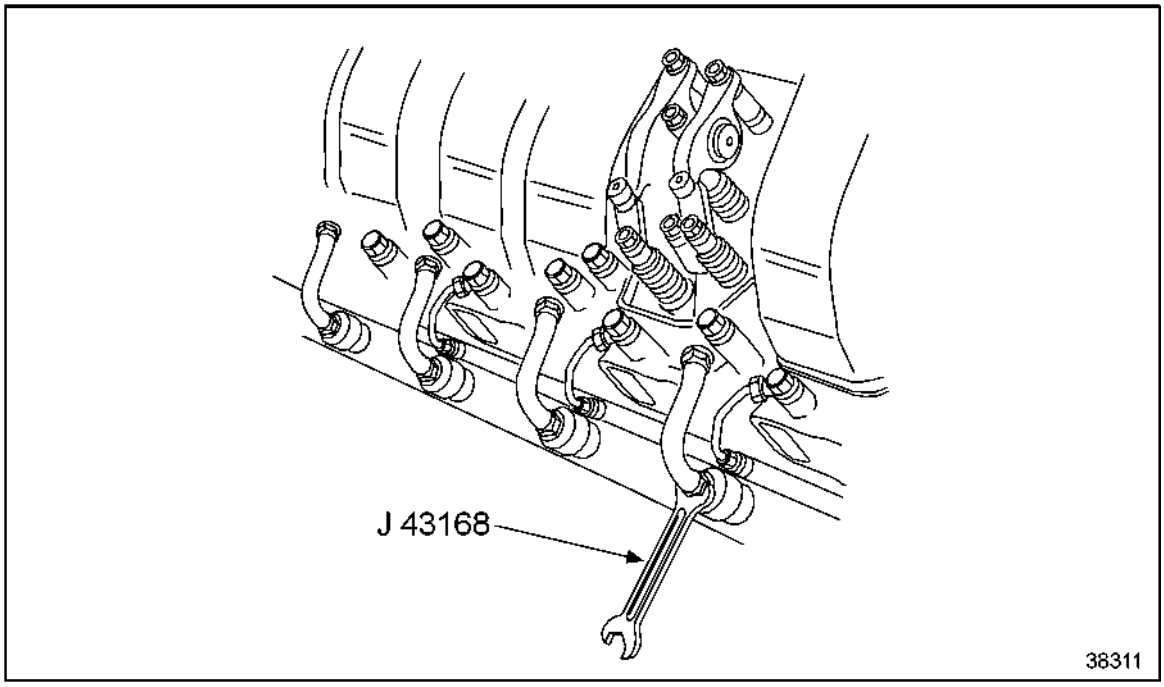


Figure 570 Installing Injection Lines

NOTE:
Tighten only high-pressure fuel lines on which flow limiting valves have already been installed.

18. Tighten high-pressure fuel lines between high-pressure rail and injector on high-pressure rail side to specification. Refer to section A 003. See Figure 571.

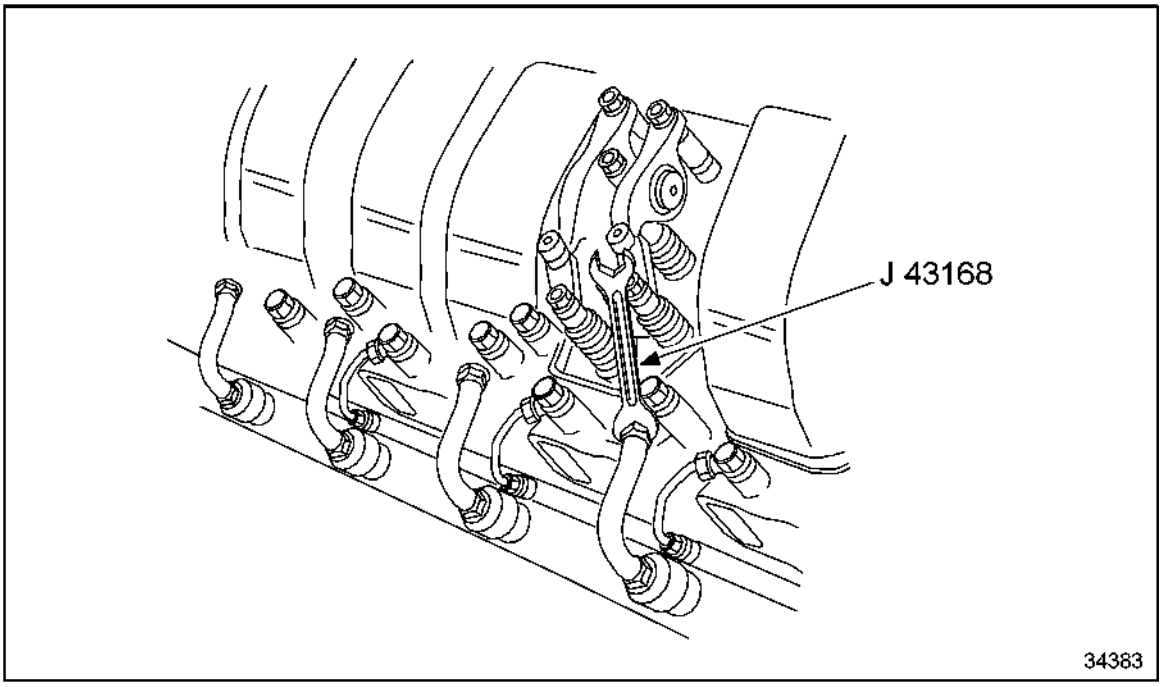
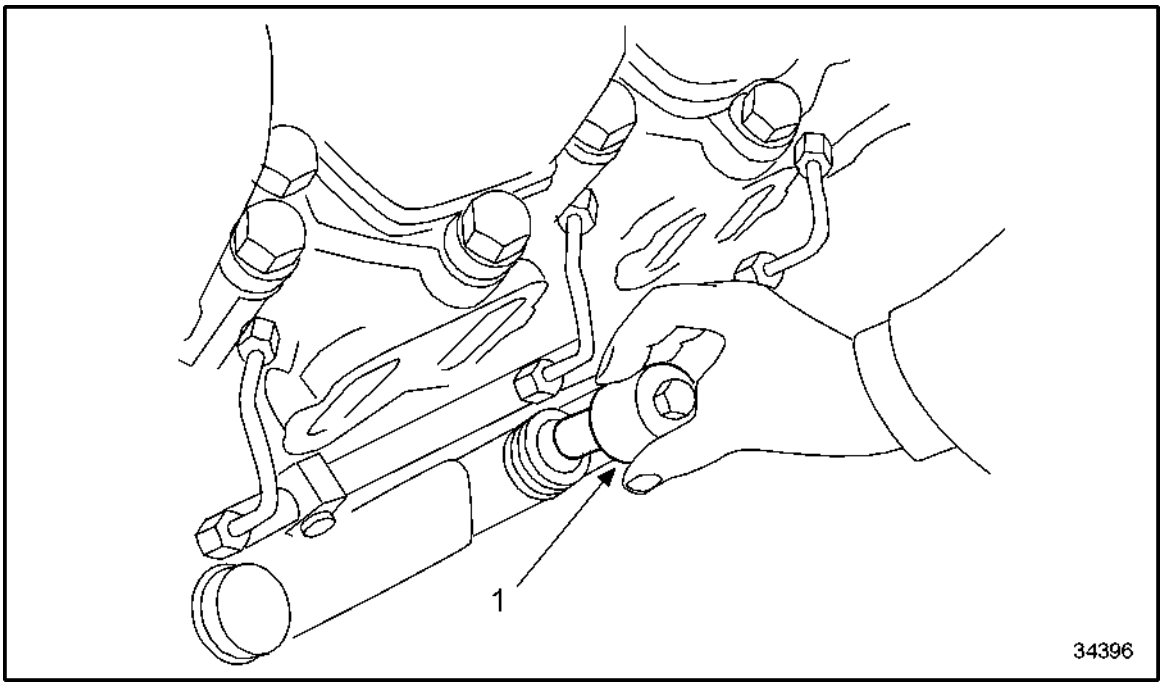


Figure 571 Tightening High-Pressure Fuel Lines between Injector and High-Pressure Rail

NOTE:
Tighten only high-pressure fuel lines on which flow limiting valves have already been installed.

19. Remove alignment tools from connectors at the front and rear of the high-pressure rail. See Figure 572.

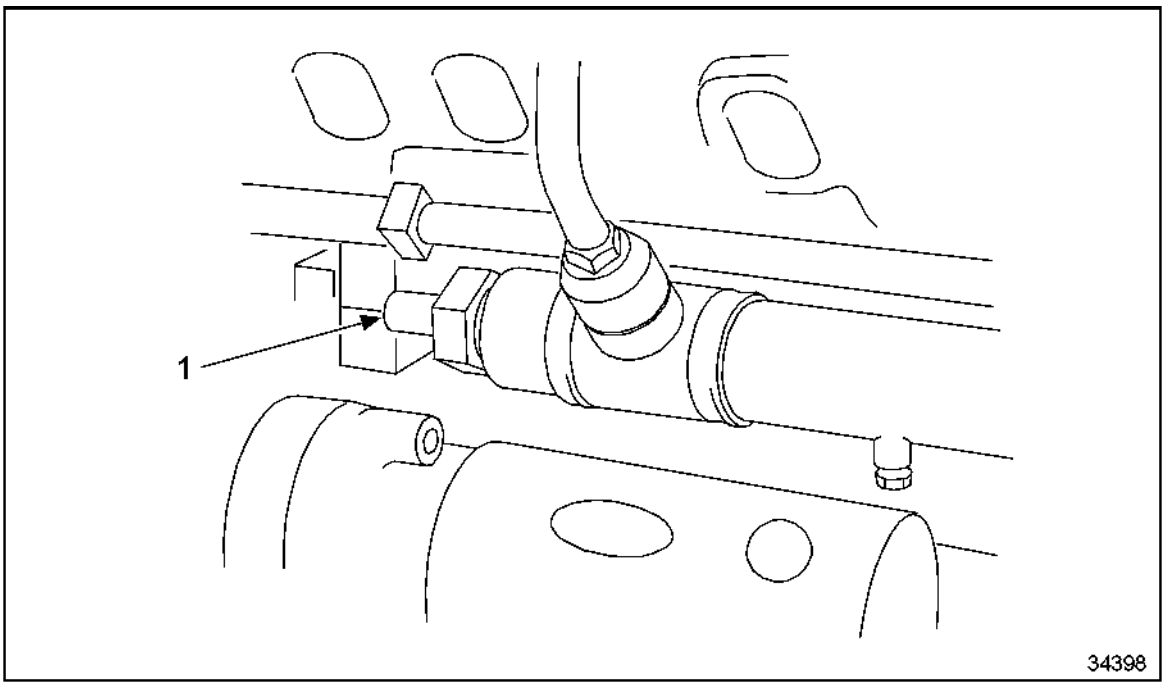


1. Alignment Tool

Figure 572 Removing Alignment Tool from Connector

20. Insert remaining limiting valves.
21. Install remaining high-pressure fuel lines between high-pressure rail and injector.
22. Tighten injectors to high-pressure lines that are fitted to specification. Refer to sectionA 003.
23. Tighten all high-pressure fuel lines on injector side to specification. Refer to section A 003.
24. Tighten all high-pressure fuel lines on high-pressure rail side to specification. Refer to section A 003.

25. Install thrust bolt at flywheel end of high-pressure rail of “B” bank. See Figure 573.



1. Plug-in Pipe

Figure 573 Installing Thrust Bolt at End of “B” Bank (Flywheel End)

26. Install thrust bolt at flywheel end of high-pressure rail of “A” bank.

27. Tighten all hex bolts securing connector to cylinder block to specification. Refer to sectionA 003. See Figure 574.

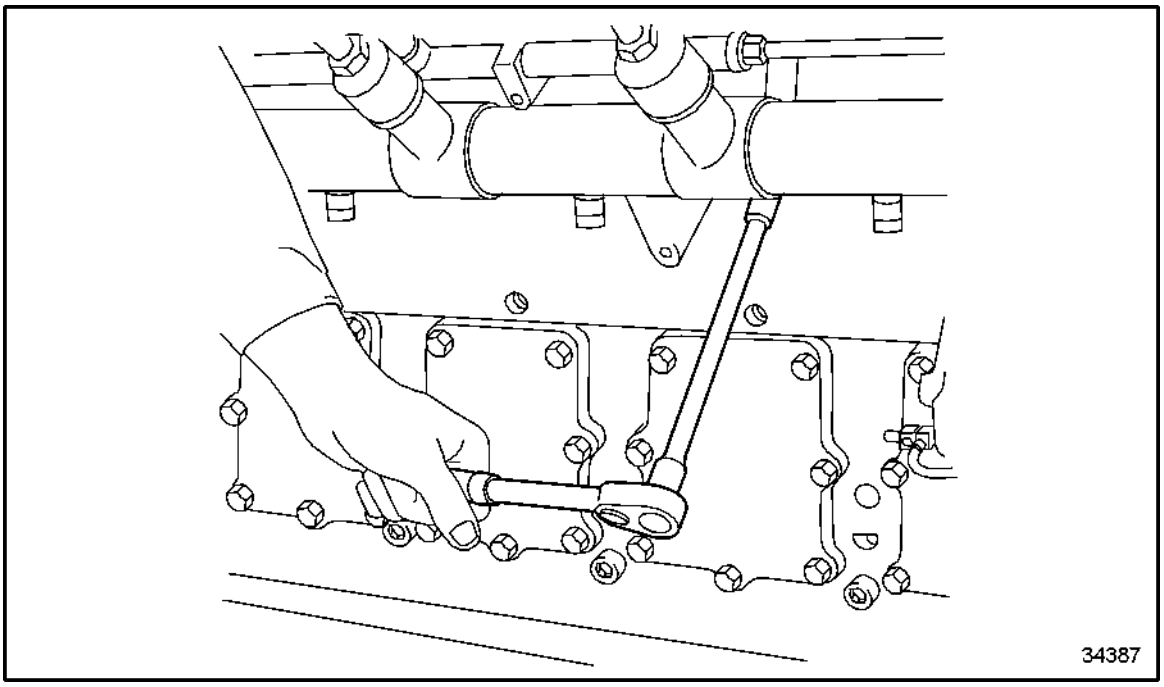
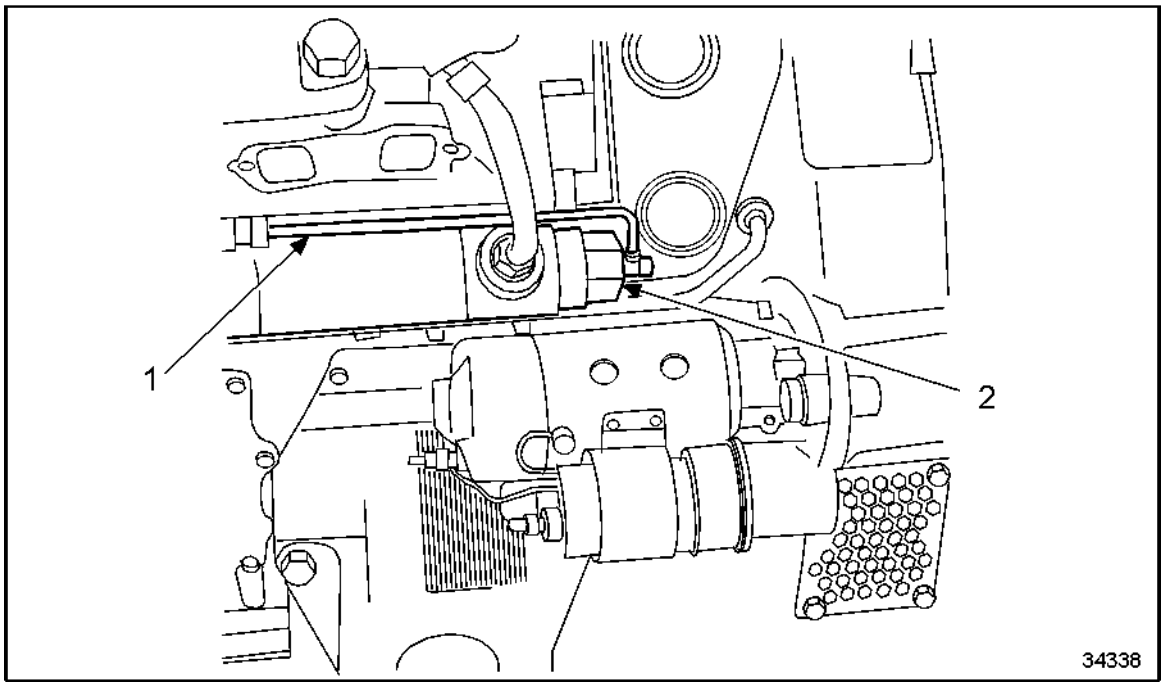


Figure 574 Tightening Hex Bolts Securing Connector to Cylinder Block

28. Install plug-in pipe end section (2) on high-pressure rail of “A” bank end. See Figure 575.

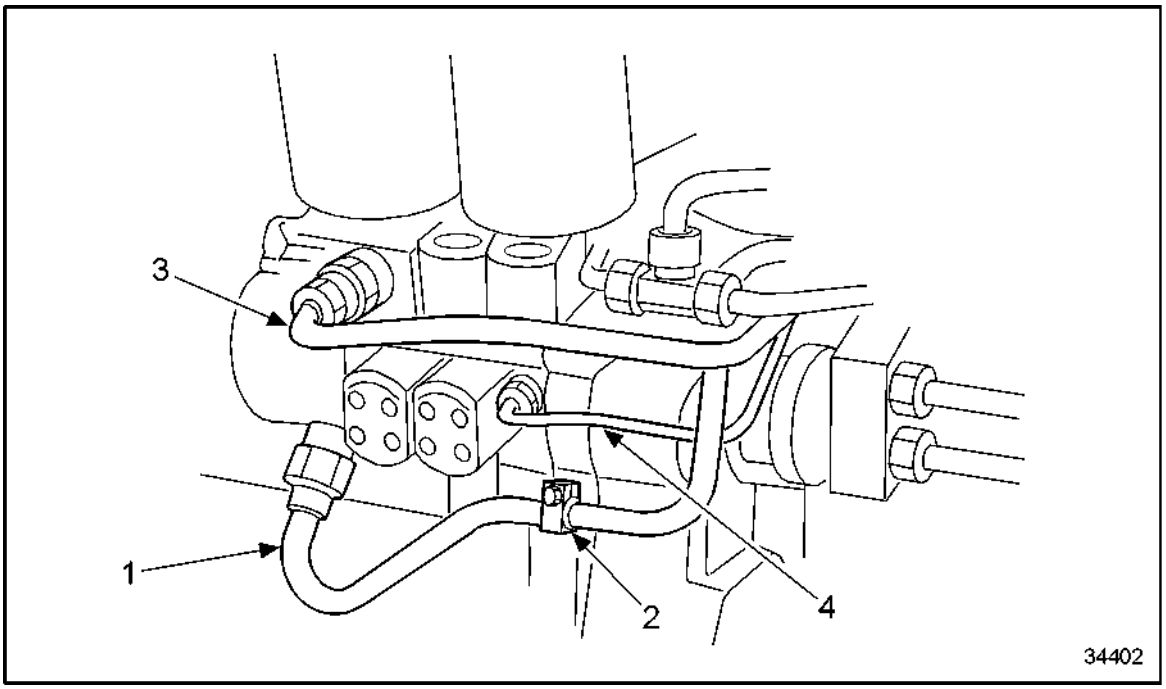


1. Fuel Return Line (Fuel Relief Line)
2. High Pressure Rail Relief Valve

Figure 575 Installing Plug-In Pipe End Section and Fuel Return Line

29. Install fuel return line (1) on high-pressure rail of “A” bank end.

30. To install high-pressure line between high-pressure pump and high-pressure rail, install plug-in pipe end section on connector (gear case end). See Figure 576.

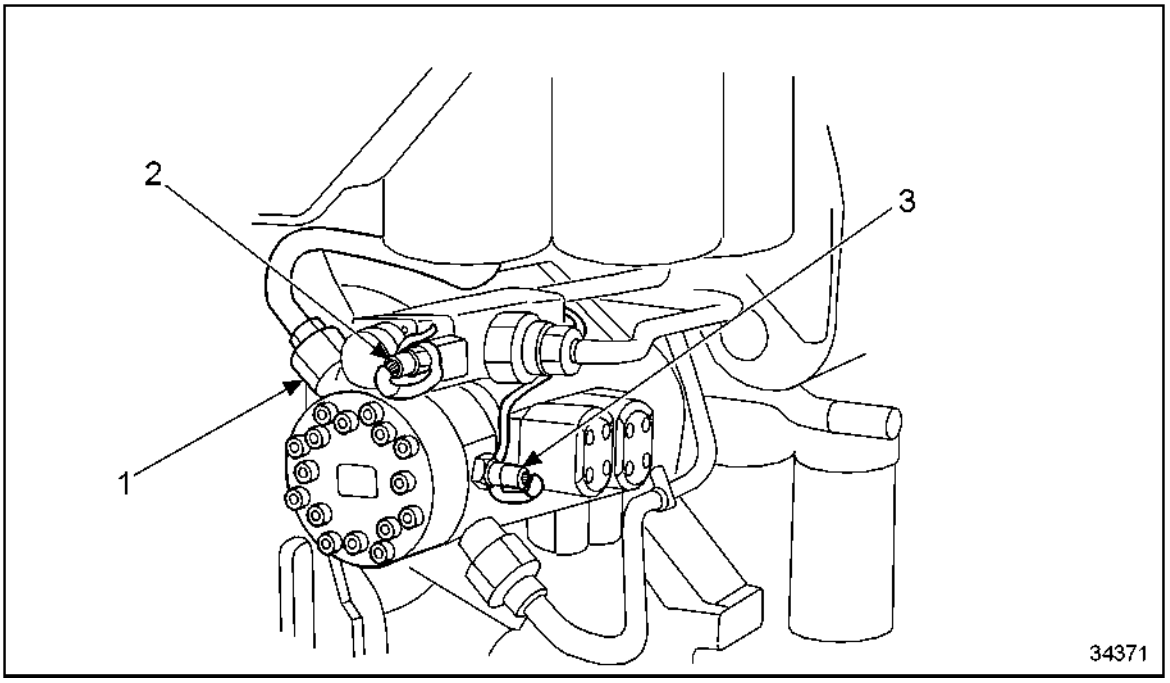


1. High-Pressure Line ("A" Bank)
2. Pipe Half Clamp
3. Low Pressure Fuel Supply Line
4. High Pressure Pump Fuel Return Line

Figure 576 Installing High-Pressure Line between High-Pressure Pump and High-Pressure Rail

31. Fully tighten high-pressure fuel line (1), left side, on high-pressure pump and high-pressure rail to specification. Refer to section A 003.
32. Install pipe clamp half (2).

33. Install plug-in pipe end section on first (gear case end) connector of high-pressure rail, “B” bank end. See Figure 577.

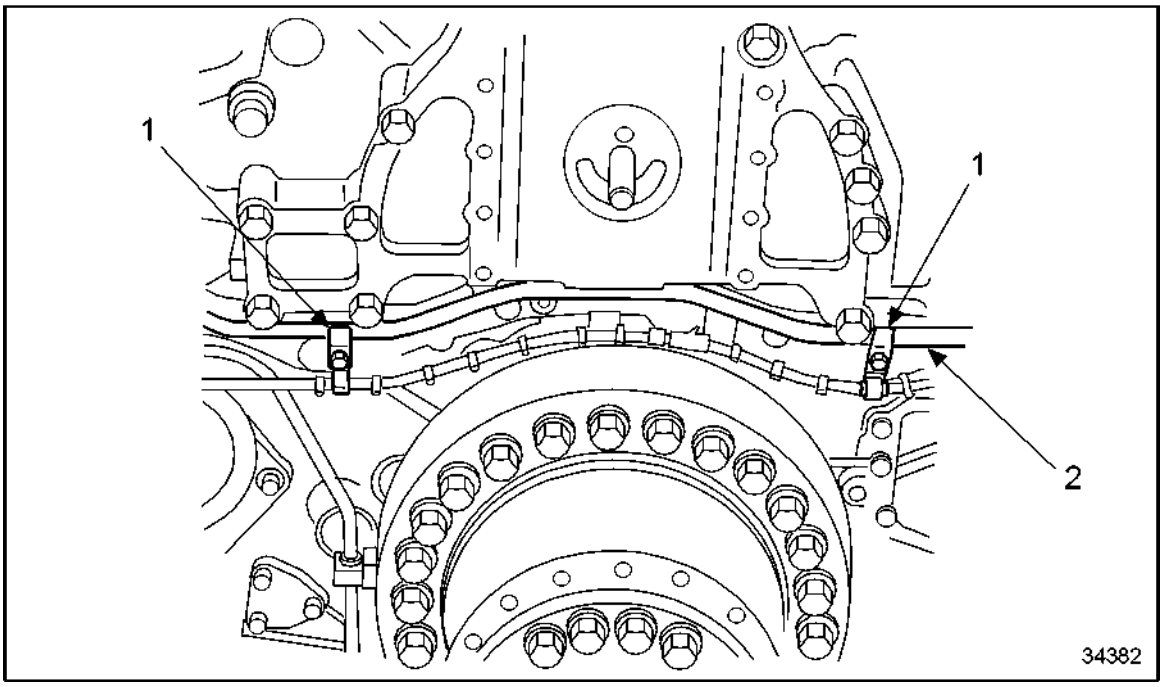


1. “B” Bank High-Pressure Line
2. DDEC Harness Connector to Controller Solenoid "B" bank
3. Temperature Sensor

Figure 577 Installing High-Pressure Line, “B” Bank, on High-Pressure Pump and Rail

34. Tighten high-pressure fuel line (1), “B” bank, on high-pressure pump and high-pressure rail to specification. Refer to section A 003.

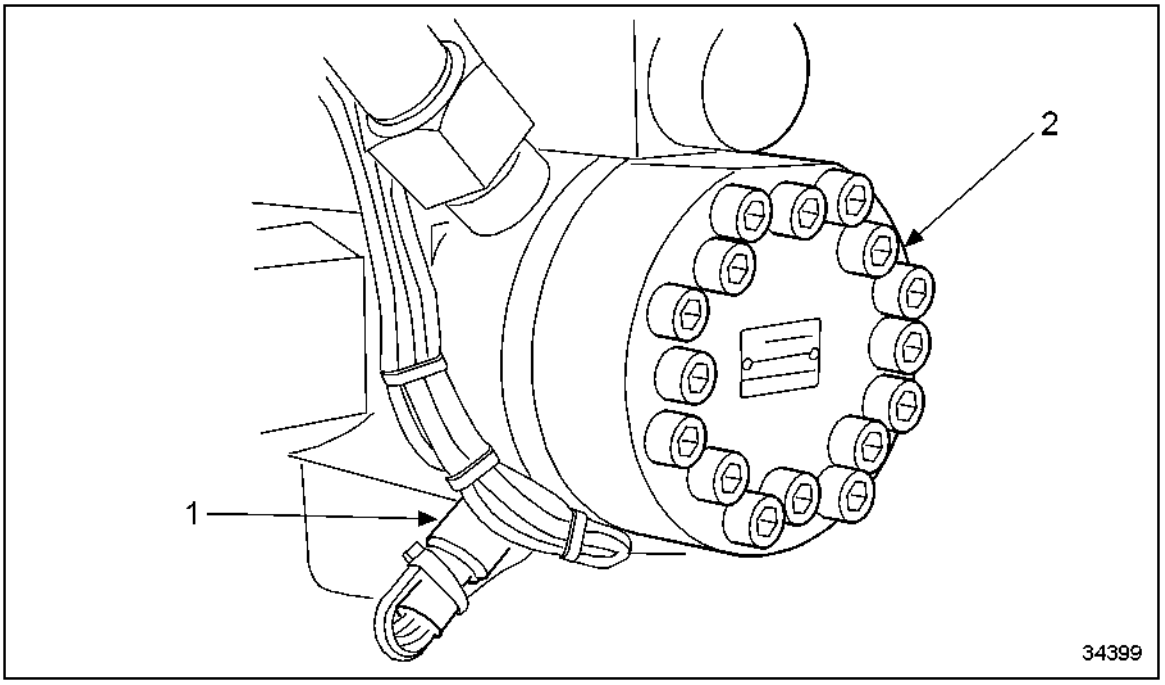
35. Install pipe clamp halves (1) of high-pressure line (2), “B” bank. See Figure 578.



1. Pipe Clamp Half
2. High-Pressure Line

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

36. To leak-check common rail system, remove pressure sensor (1) from high-pressure pump (2). See Figure 579.



1. Hydraulic Pressure Fuel Sensor
2. High-Pressure Pump

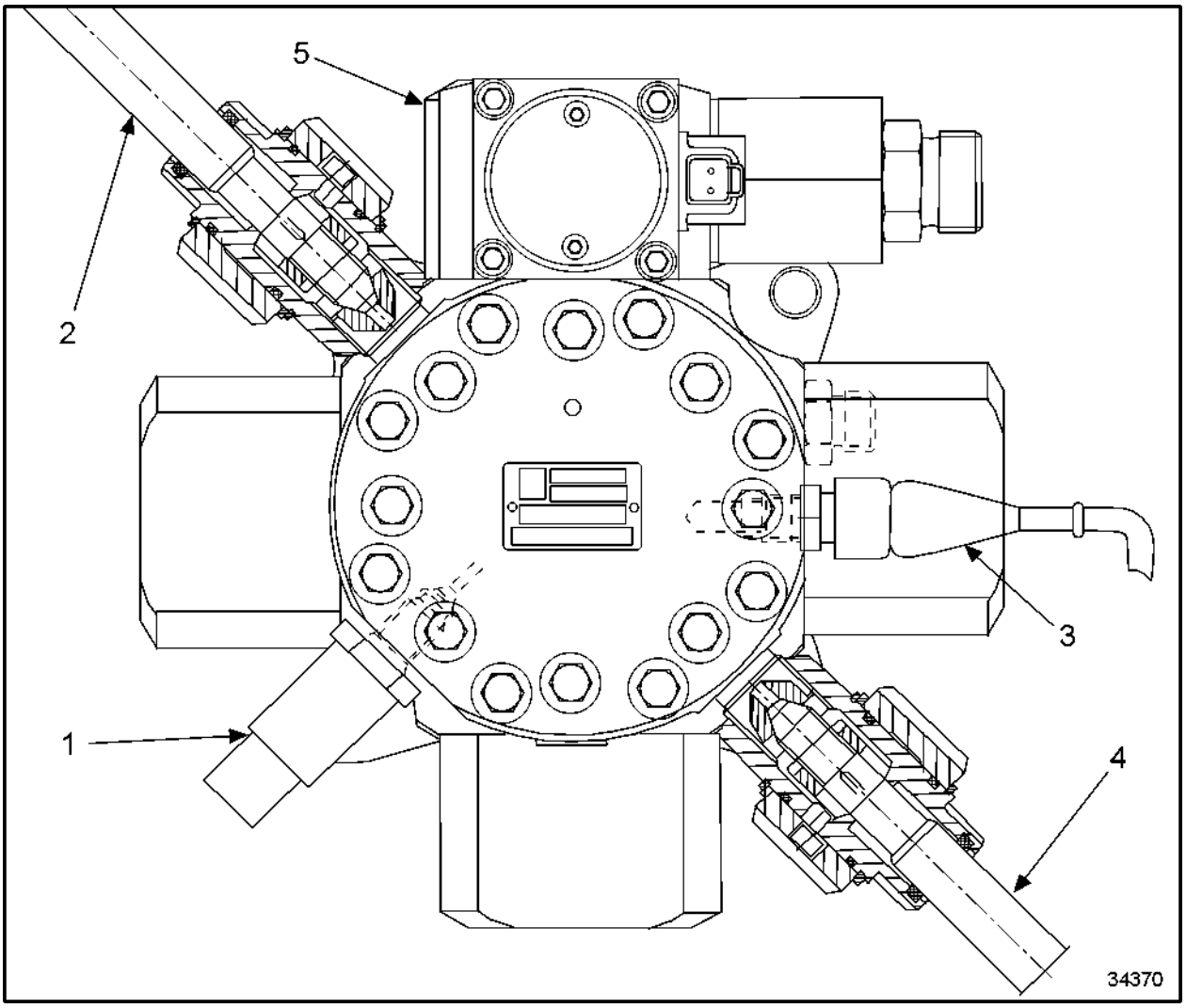
Figure 579 Leak-Checking Common Rail System

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.

37. Install high-pressure line and apply pressure to system.
38. Check all threaded connections in system for leaks.

39. Again remove high-pressure testing line from high-pressure pump.
40. Install high-pressure sensor to high-pressure pump and tighten to specification. Refer to sectionA 003. See Figure 580.



1. High Pressure Fuel Sensor
2. High Pressure Line to “B” Bank Side
3. Temperature Sensor
4. High Pressure Line to “A” Bank Side
5. Control Solenoid

Figure 580 Installing High-Pressure Sensor to High-Pressure Pump

C 077.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 63 are the After-Installation Operations for the injection line.

Level of Maintenance	Operation	Reference
1, 2, 3	Tighten hold-down clamps	Refer to sectionC 075.05.11
1, 2, 3	Install cylinder head cover	Refer to sectionC 056.05.11
1, 2, 3	Install charge air manifolds	Refer to sectionC 124.05.11
1, 2, 3	Install fuel return line if necessary	Refer to sectionC 083.05.11
1, 2, 3	Fill fuel system	Refer to Operators Guide
1, 2, 3	Prime system	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.

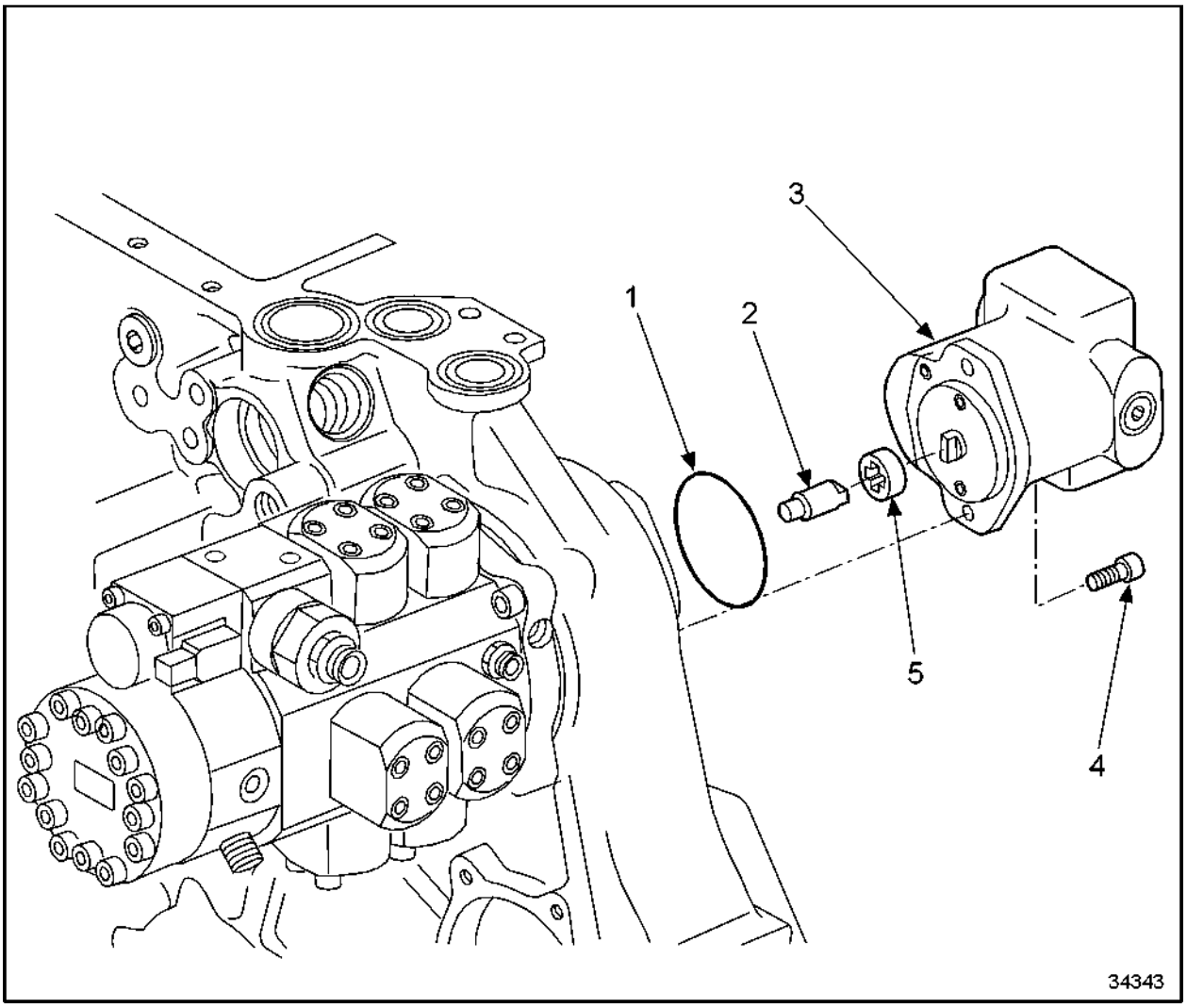
Table 63 After-Installation Operations

C 080 – FUEL SYSTEM — LOW-PRESSURE

C 081.05 – FUEL PUMP

C 081.05.01 – GENERAL VIEW

See Figure 581 for a general view of the fuel pump assembly.



1. O-ring
2. Drive Adaptor
3. Fuel Pump
4. Socket-Head Bolt

Figure 581 Fuel Pump Assembly

C 081.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 64 are the Before — Removal Operations for the low-pressure fuel pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine start	Refer to Operators Guide
1, 2, 3	Remove charge air manifold	Refer to section C 124.05.05
1, 2, 3	Remove fuel supply line	Refer to section C 083.05.05
1, 2, 3	Remove plug-in pipes	Refer to section C 083.05.05

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 64 Before-Removal Operations

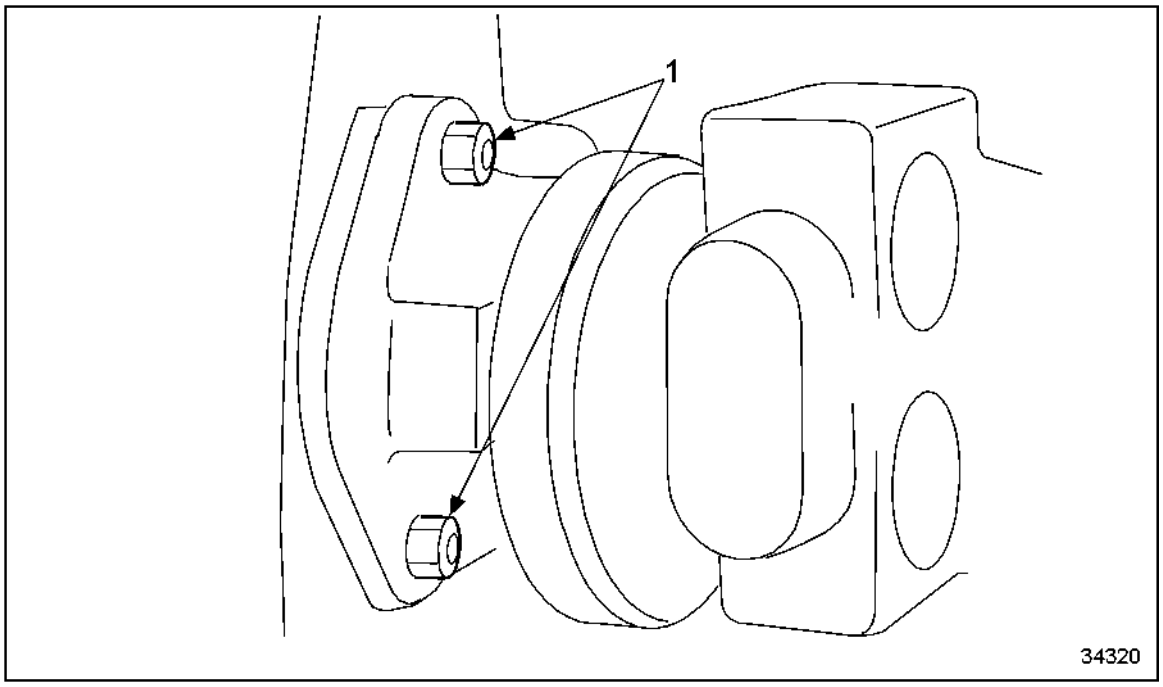
C 081.05.05 – REMOVAL OF LOW-PRESSURE FUEL PUMP

Perform the following steps to remove the low-pressure fuel pump:

CAUTION:

To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

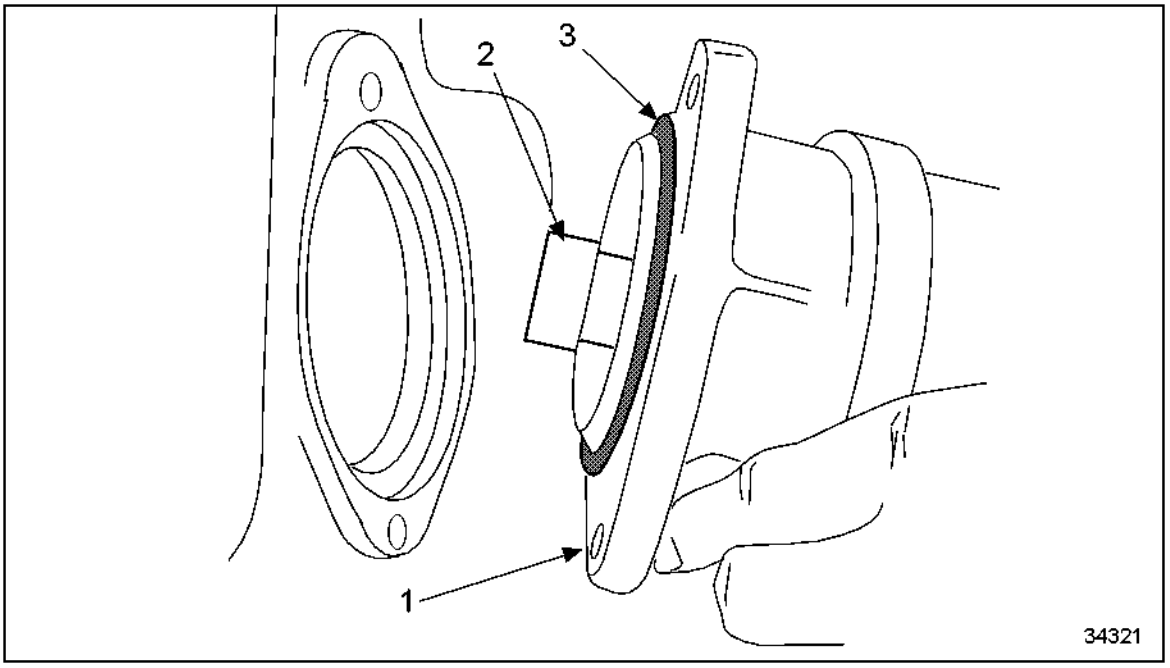
1. Remove Allen-head bolts (1). See Figure 582.



1. Allen-Head Bolt

Figure 582 Removing Allen-Head Bolts

2. Remove fuel delivery pump (1) from gear case. See Figure 583.



1. Fuel Delivery Pump
2. Coupling
3. O-ring

Figure 583 Removing Fuel Delivery Pump

3. Remove coupling (2) from the drive shaft of the fuel delivery pump (1). See Figure 583.
4. Remove O-ring (3). See Figure 583.

C 081.05.06 – DISASSEMBLY OF LOW-PRESSURE FUEL PUMP

Low–pressure fuel pumps are serviced only as an assembly by your authorized Detroit Diesel Distributor.

C 081.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect the low-pressure fuel pump:

NOTE:
Ensure that fuel-carrying components are perfectly clean.

1. Visually inspect low-pressure fuel pump externally for damage and general condition.
   [a] If pump is damaged or in poor condition, replace or repair as required.
   [b] If pump is not damaged and is in good condition, continue inspection.
2. Visually inspect securing bolts for damage and wear.
   [a] If bolts are damaged or worn, replace as necessary.
   [b] If bolts are not damaged or worn, continue inspection.
3. Inspect threads of securing bolts for ease of movement.
   [a] If bolt threads do not show ease of movement, replace bolts as necessary.
   [b] If bolt threads show ease of movement, continue inspection.
4. Visually inspect coupling for wear and damage.
   [a] If coupling is worn or damaged, replace coupling element.
   [b] If coupling is not worn or damaged, continue inspection.
5. Visually inspect pump shaft driver for wear.
   [a] If pump shaft driver is worn, rub down with an emery cloth or oilstone.
   [b] If damage is beyond repair; replace pump shaft driver.
   [c] If pump shaft driver is not worn, continue inspection.

C 081.05.10 – ASSEMBLY OF LOW-PRESSURE FUEL PUMP

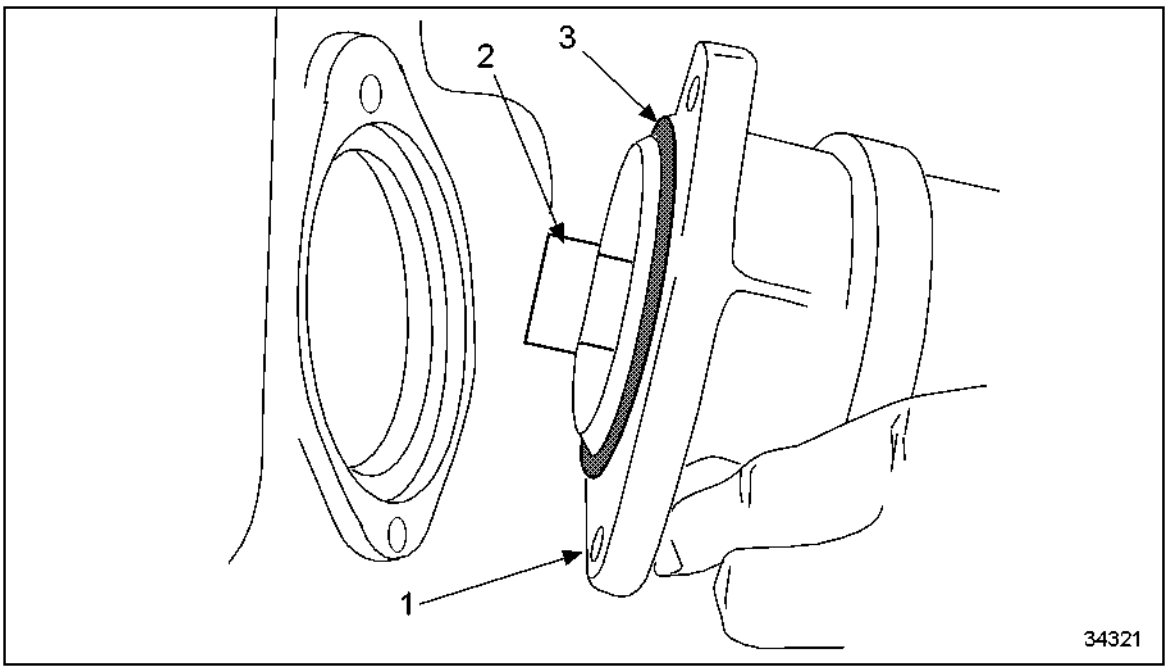
Low–pressure fuel pumps are serviced only as an assembly by your authorized Detroit Diesel Distributor.

C 081.05.11 – INSTALLATION OF LOW-PRESSURE FUEL PUMP

Perform the following steps to install the low-pressure fuel pump:

NOTE:
Ensure that fuel-carrying components are perfectly clean.

1. Coat O-ring (3) with petroleum jelly and install onto fuel delivery pump (1). See Figure 584.



1. Fuel Delivery Pump
2. Coupling
3. O-ring

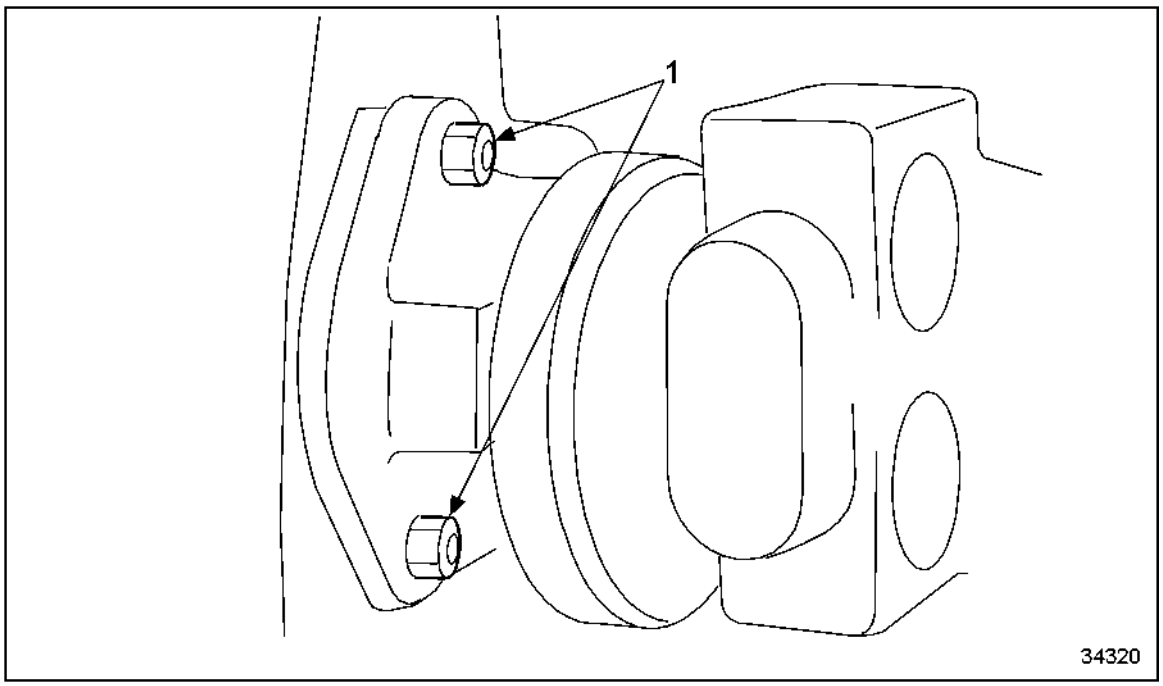
Figure 584 Installing Low-Pressure Fuel Pump

2. Install coupling (2) onto driver of high-pressure pump. See Figure 584.
3. Install high-pressure pump driver into the coupling (2). See Figure 584.

4. Install fuel delivery pump (1) into gear case bore. See Figure 584.

NOTE:
If the pump does not move in as far as the stop, withdraw the pump and check the position of the driver with regard to the coupling.

5. Secure with Allen-head bolts and torque socket-head bolts (1) to specification. Refer to sectionA 003. See Figure 585.



1. Allen-Head Bolts

Figure 585 Installation of Allen-Head Bolts

C 081.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 65 are the After-Installation Operations for the low-pressure fuel pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators Guide
1, 2, 3	Vent fuel system	Refer to Operators Guide

1 = The engine is to be completely disassembled.

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

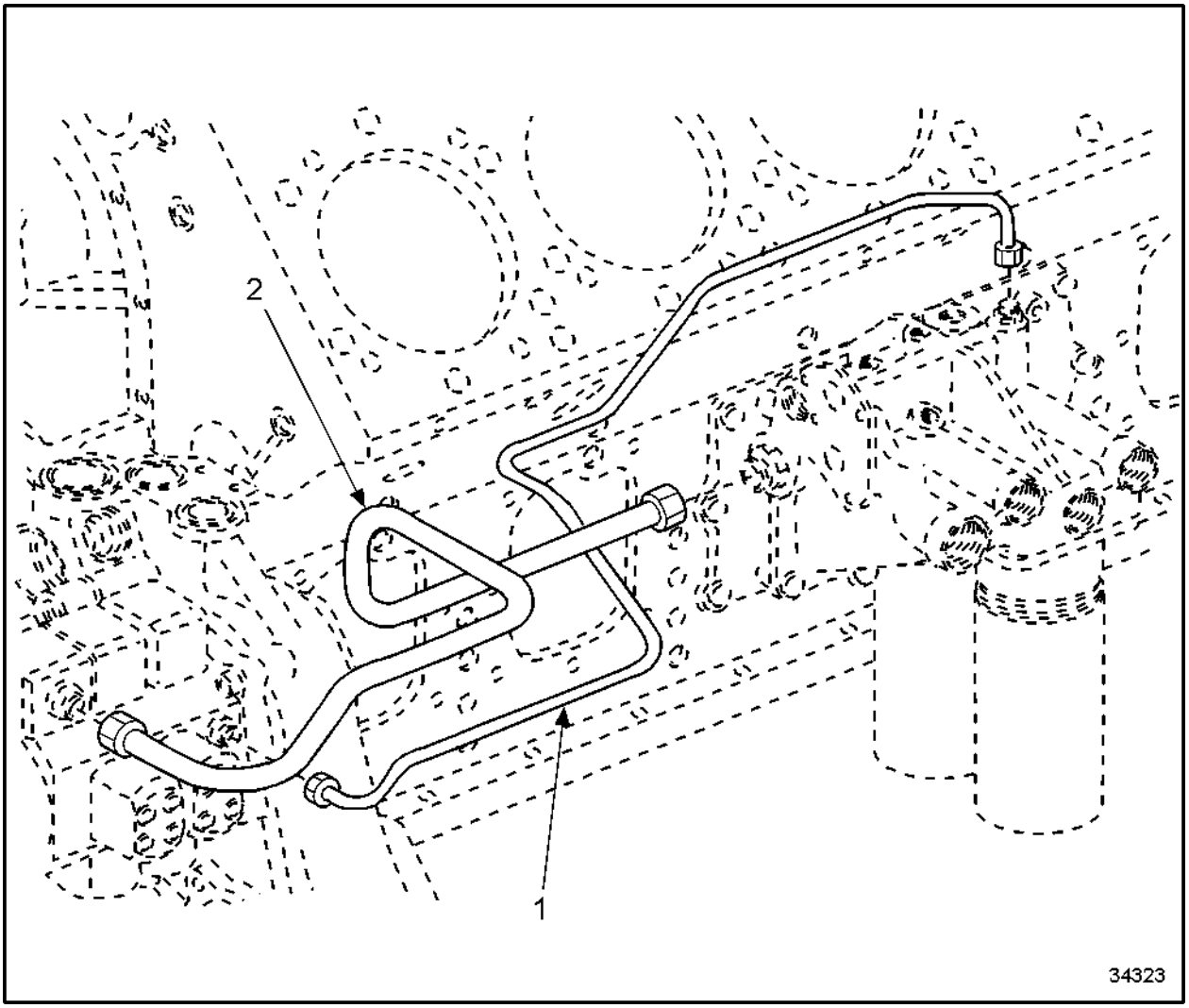
3 = The engine is to remain installed.

Table 65 After-Installation Operations

C 083.05 – FUEL FILTER

C 083.05.01 – GENERAL VIEW

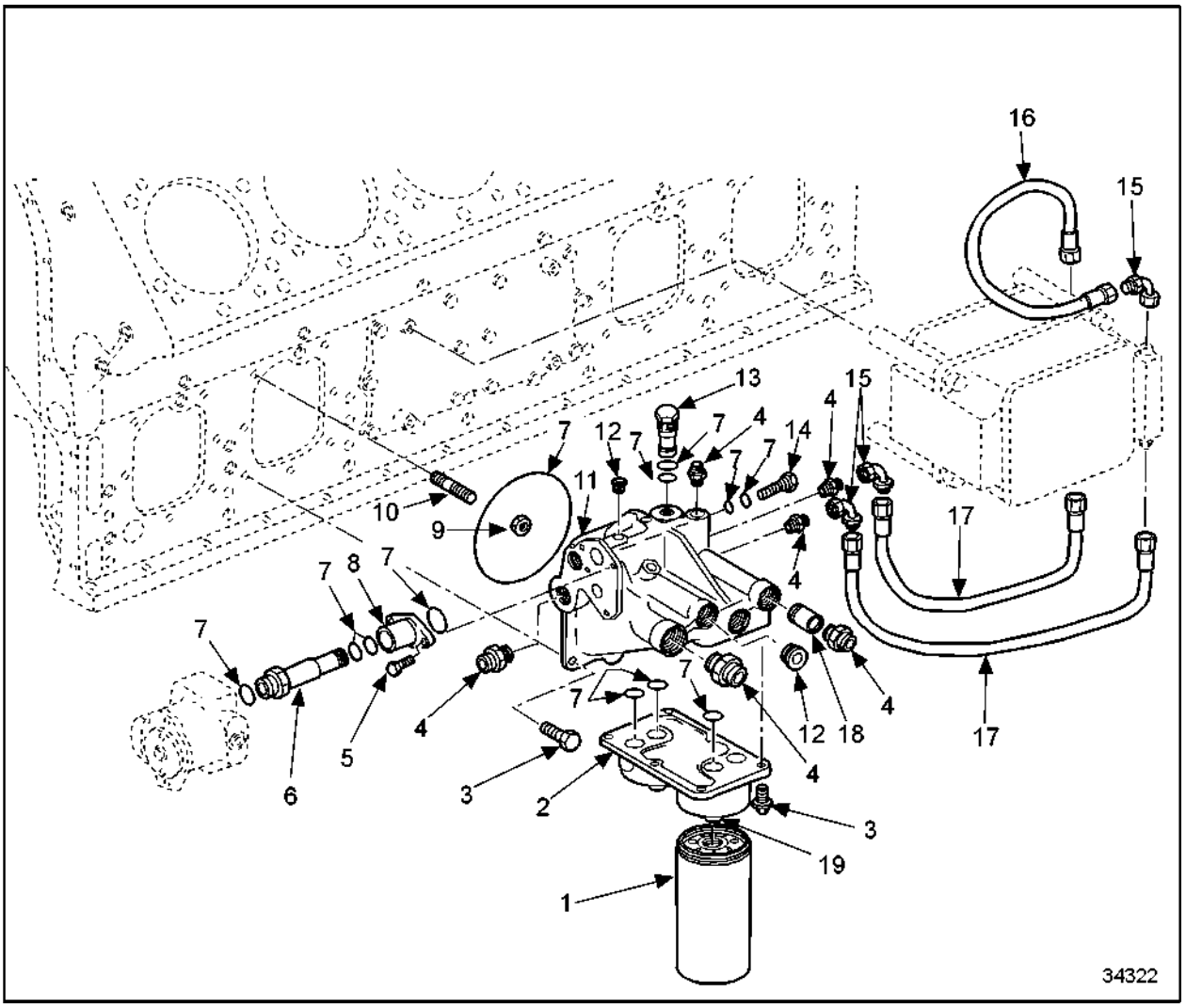
See Figure 586 for a general view of the fuel lines.



1. Fuel Return Line

Figure 586 General View of Fuel Lines

See Figure 587 for general view of the fuel line components.



1. Fuel Filter
2. Filter Head
3. Hex Bolt
4. Adaptor
5. Bolt
6. Plug-in Pipe
7. O-ring
8. Flange
9. Nut
10. Stud
11. Fuel Junction Block
12. Blanking Plug
13. Pressure Regulator (2 bar)
14. Valve (1.7 bar)
15. Connector
16. Fuel Line
17. Fuel Hose
18. Valve (0.1 bar)
19. Bracket

Figure 587 Fuel Line Components

C 083.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 66 are the Before-Removal Operations for the fuel filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove charge air manifold	Refer to section C 124.05.05
1, 2, 3	Remove fuel supply line	Refer to section C 083.05.05
1, 2, 3	Remove plug-in pipes	Refer to section C 083.05.05

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 66 Before-Removal Operations

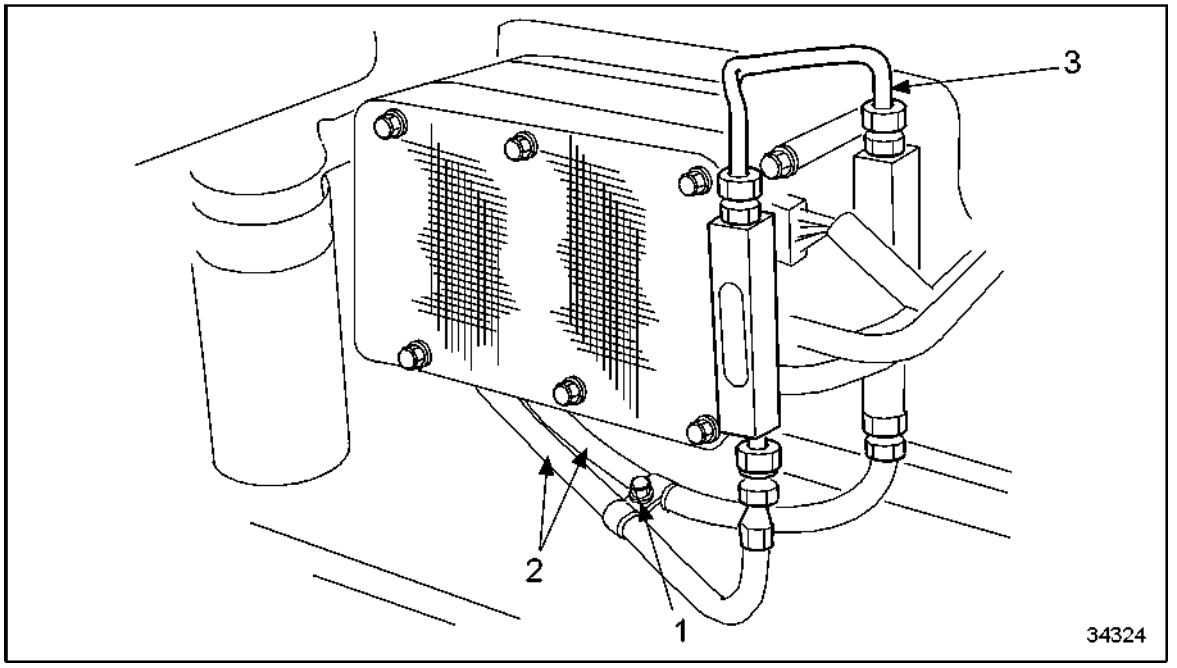
C 083.05.05 – REMOVAL OF FUEL FILTER

CAUTION:

To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

Perform the following steps to remove fuel filter:

1. Remove fuel line bracket (1). See Figure 588



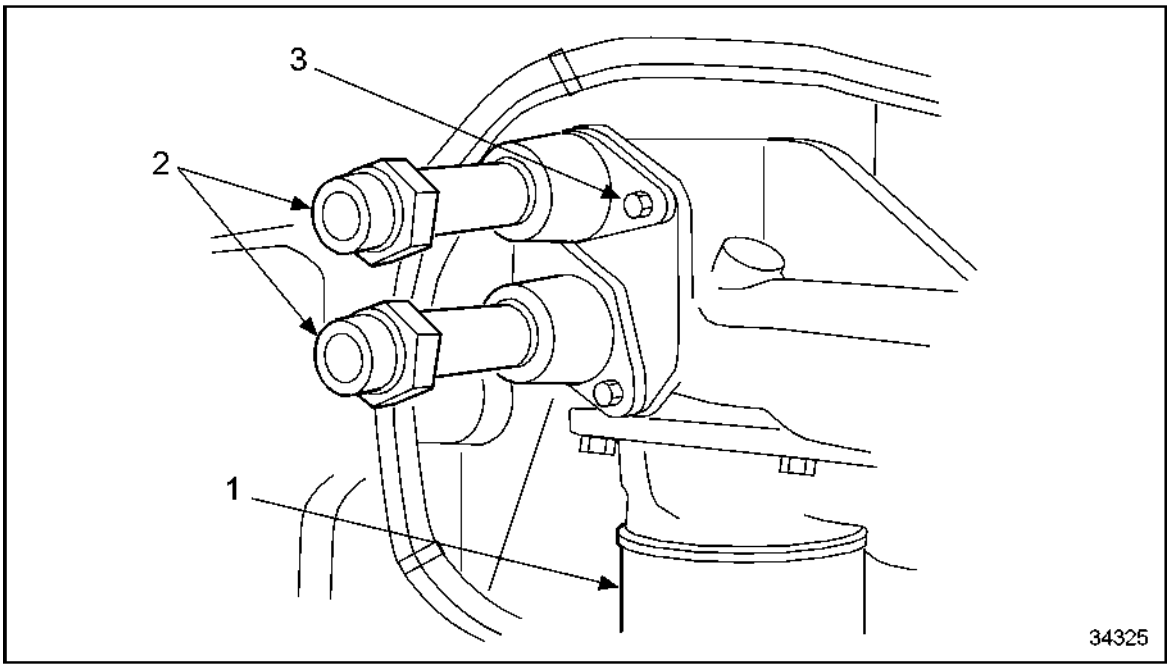
1. Bracket
2. Fuel Lines
3. Fuel Line at ECM

Figure 588 Removing Fuel Lines at Fuel Distribution Housing and ECM

NOTE:
When releasing the threaded connections of the fuel lines, catch any fuel that emerges in suitable containers.

2. Remove the fuel line (3) at ECM.

3. Remove the plug-in pipes (2) and O-rings. See Figure 589.

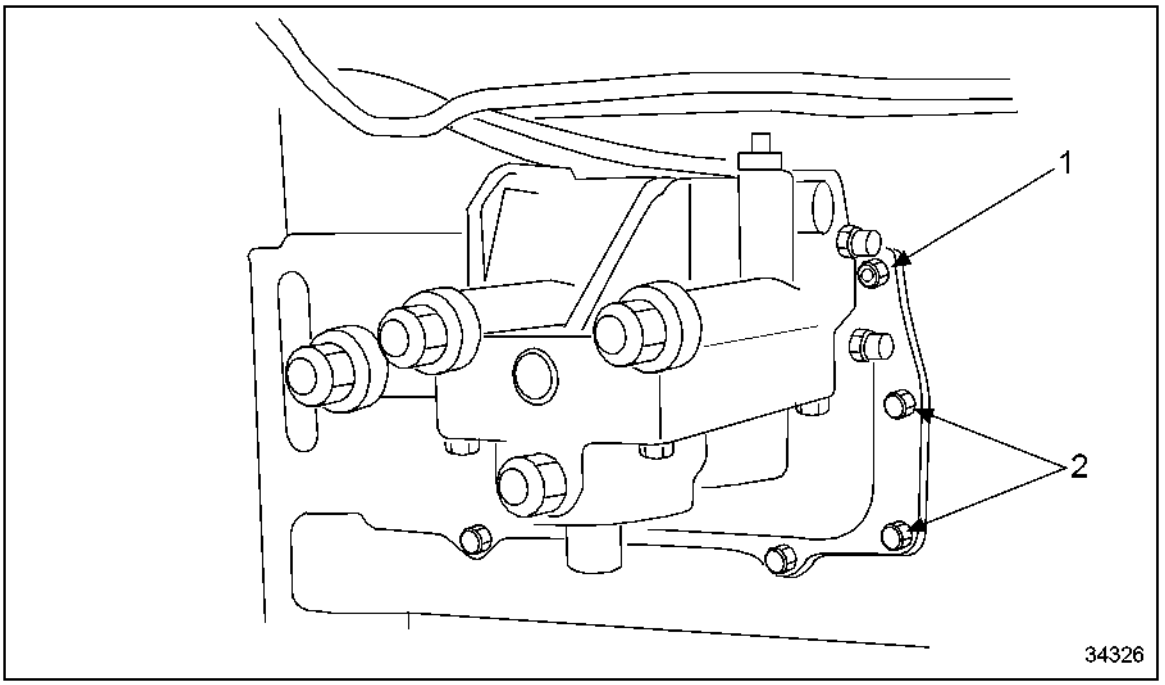


1. Fuel Filter
2. Plug-in Pipes
3. Hex Bolt

Figure 589 Removing Plug-In Pipes and O-rings

4. Remove hex bolts (3) and flanges.
5. Remove fuel filter (1).

6. Remove nuts (1) and hex bolts (2). See Figure 590.

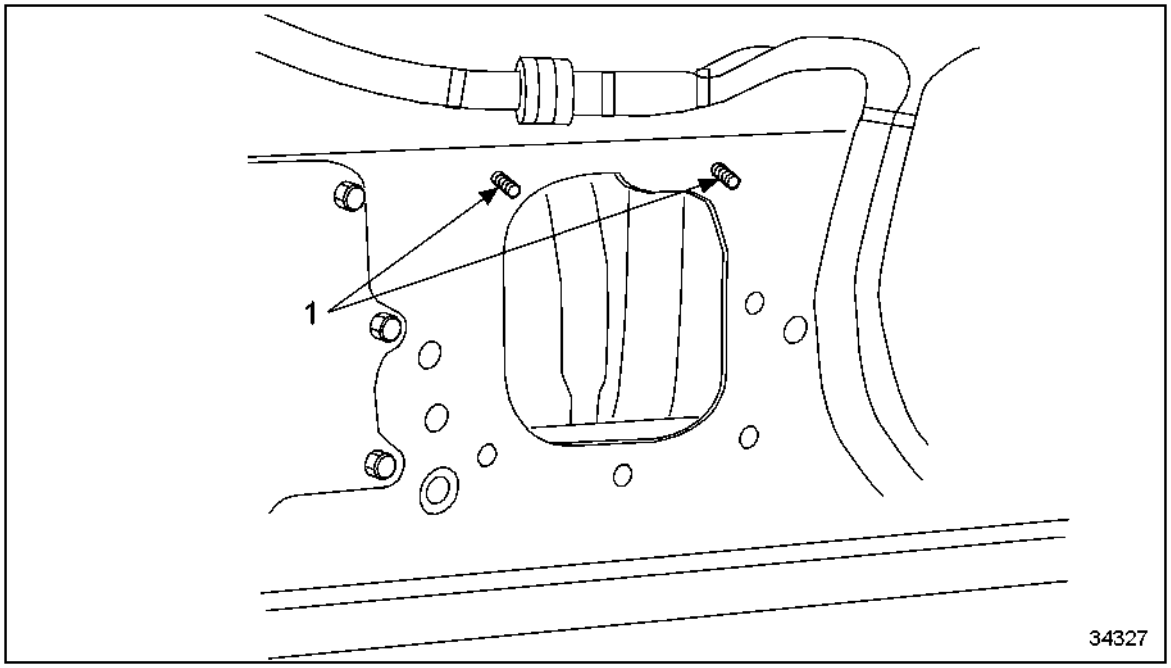


1. Nut
2. Hex Bolt

Figure 590 Removing Nuts and Hex Bolts and Removing Fuel Junction Block

7. Remove fuel junction block.

NOTE:
Remove studs (1) only if necessary. See Figure 591.



1. Studs

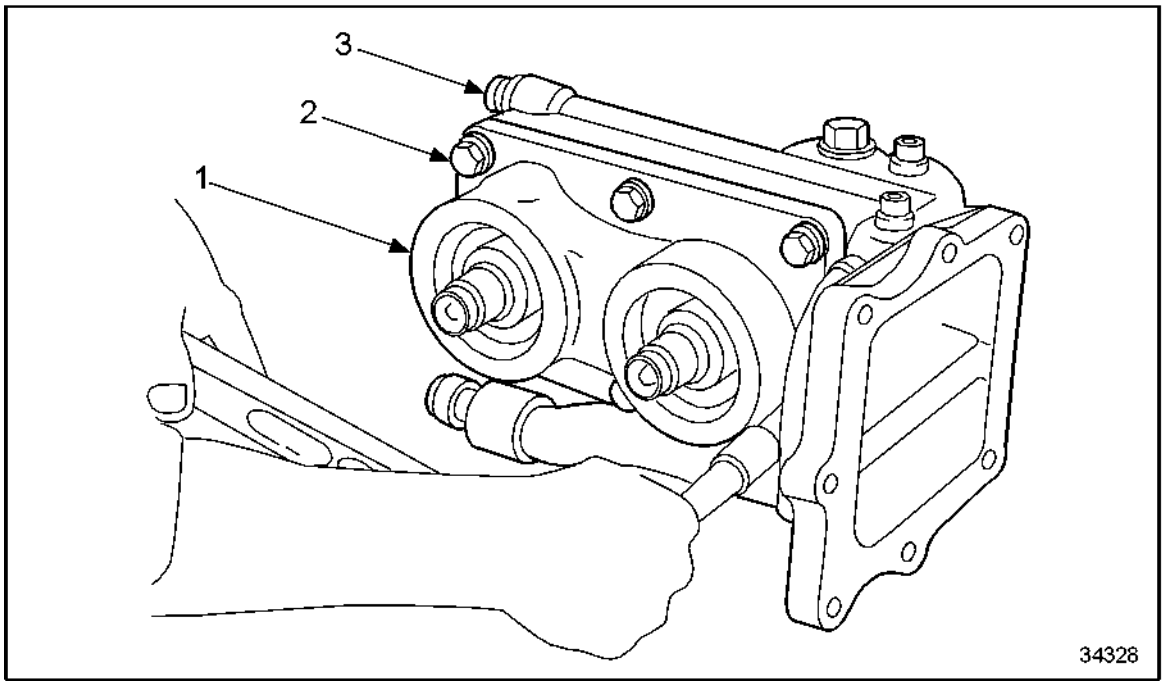
Figure 591 Removing Studs

8. Install nut on stud and lock with locknut.
9. Remove stud.
10. Install a protective cover over inspection hole in cylinder block.

C 083.05.06 – DISASSEMBLY OF FUEL FILTER

Perform the following steps to disassemble the fuel filter:

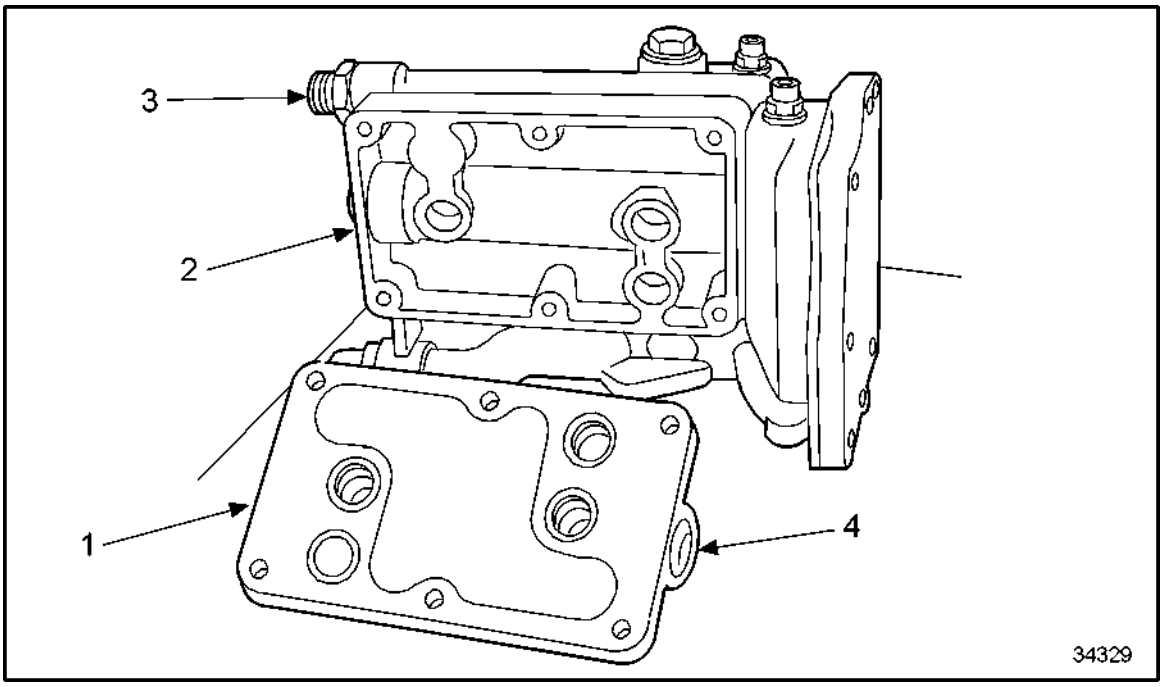
1. Remove hex bolts (2) and separate filter head (1) from junction block (3). See Figure 592.



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. Filter Head
2. Junction Block
3. Threaded Connection
4. Blanking Plug

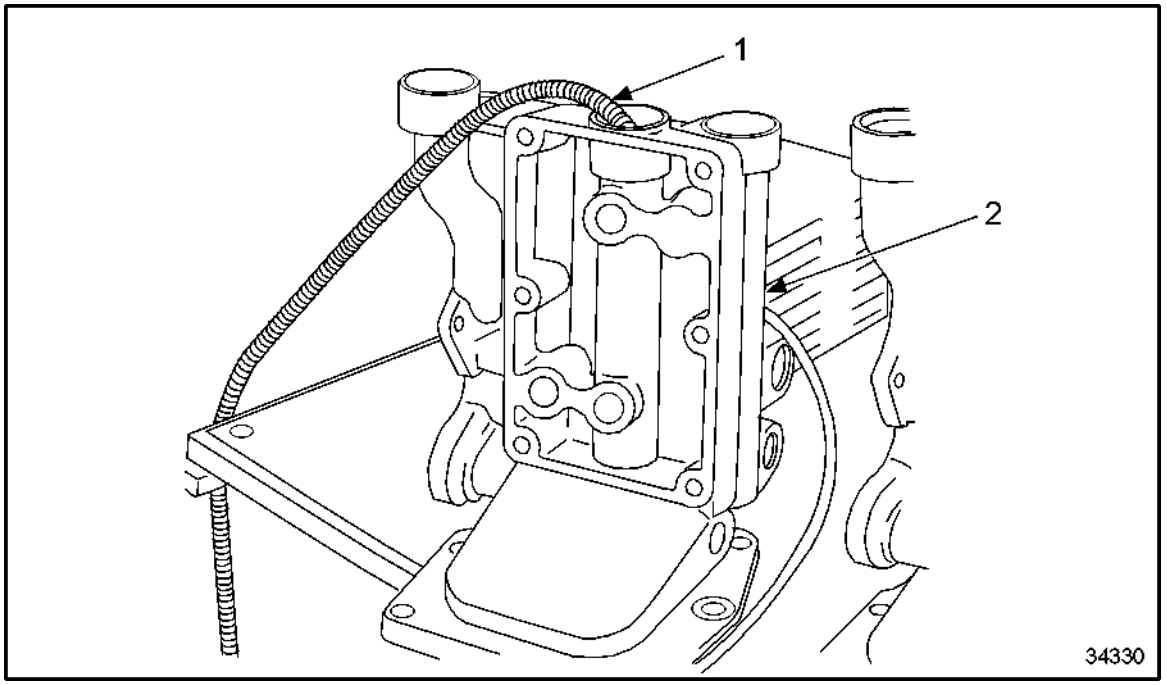
Figure 593 Removing Blanking Plug and Threaded Connection from Filter Head and Junction Block

3. Remove pressure regulator valve from bore on junction block.
4. Remove delivery valve from filter base.

C 083.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the fuel filter:

1. Examine all channels with cold light and check for contamination. See Figure 594.



1. Cold Light Source
2. Fuel Junction Block

Figure 594 Examining All Channels with Cold Light Source

NOTE:
Ensure fuel-carrying components are perfectly clean.

2. Clean fuel line with cleaner.
3. Visually inspect fuel line for general condition and damage.
   [a] If fuel line is in poor condition or is damaged, replace fuel line as necessary.
   [b] If fuel line is in good condition and is not damaged, continue inspection.

CAUTION:

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

4. Blow out fuel line with compressed air and make sure it is perfectly clean.
5. Inspect fuel line with air under water for leakage.
   [a] If leakage is found, replace fuel line.
   [b] If no leakage is found, continue inspection.
6. Coolant temperature minimum is 30°C; components must also be at this temperature.
7. If component must be held in hands, coolant temperature maximum is 40°C.
8. Test pressure is 0.5 bar.
9. Visually inspect securing elements of fuel line for wear and damage.
   [a] If securing elements of fuel line are worn or damaged, replace components as necessary.
   [b] If securing elements of fuel line are not worn or damaged, continue inspection.
10. Inspect threads of adaptor nuts and single-ended adaptors for ease of movement.
    [a] If threads of adaptor nuts and single-ended adaptors do not show ease of movement, recondition or replace parts as necessary.
    [b] If threads of adaptor nuts and single-ended adaptors show ease of movement, continue inspection.
11. Inspect securing bolts for general condition and bolt threads for ease of movement.
    [a] If securing bolts are not in good condition or threads do not show ease of movement, replace bolts as necessary.
    [b] If securing bolts are in good condition and threads show ease of movement, continue inspection.
12. Inspect cylinder block studs for general condition and stud threads for ease of movement.
    [a] If cylinder block studs are not in good condition or threads do not show ease of movement, replace studs as necessary.
    [b] If cylinder block studs are in good condition and threads show ease of movement, continue inspection.
13. Visually inspect sealing and mating surfaces for damage and defects.
    [a] If sealing and mating surfaces are damaged or defective, rub down with oilstone as necessary.
    [b] If sealing and mating surfaces are not damaged or defective, continue inspection.

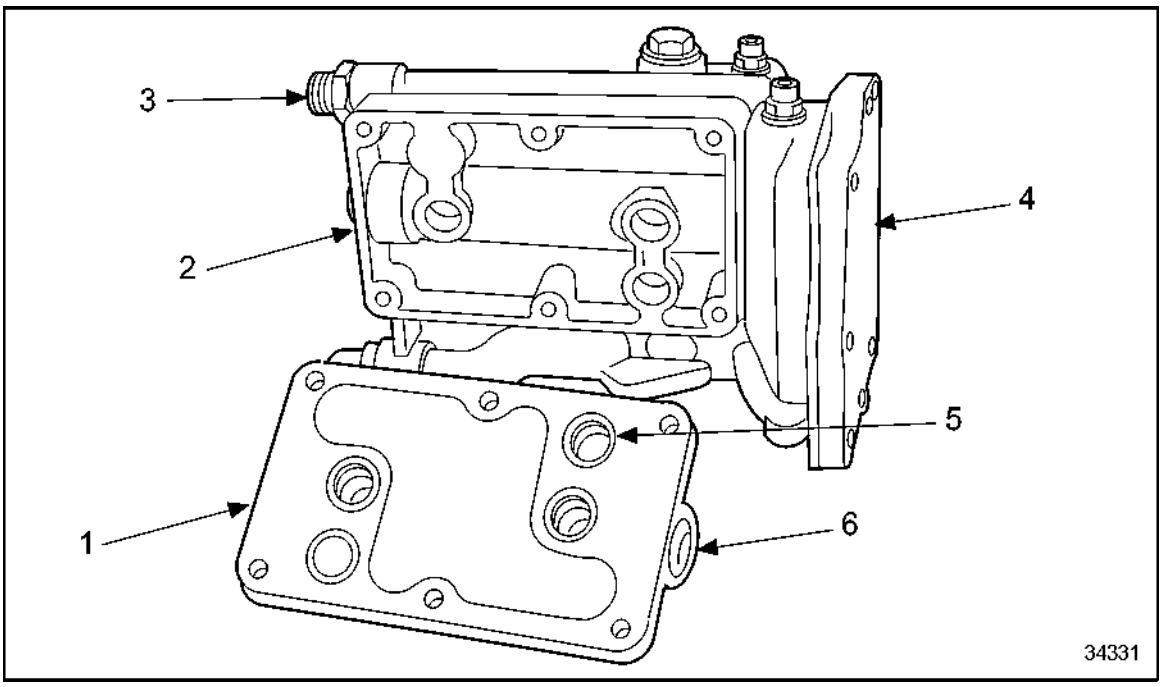
14. Visually inspect sealing tapers for damage or indentations.
    [a] If sealing tapers are damaged or indented, replace as necessary.
    [b] If sealing tapers are not damaged or indented, continue inspection.
15. Replace sealing rings.
16. Replace hose lines as part of every W6 overhaul.

C 083.05.10 – ASSEMBLY OF FUEL FILTER

Perform the following steps to assemble the fuel filter:

NOTE:
Ensure that fuel-carrying components are perfectly clean.

1. Install the pressure regulator valve in bore on junction block. See Figure 595.

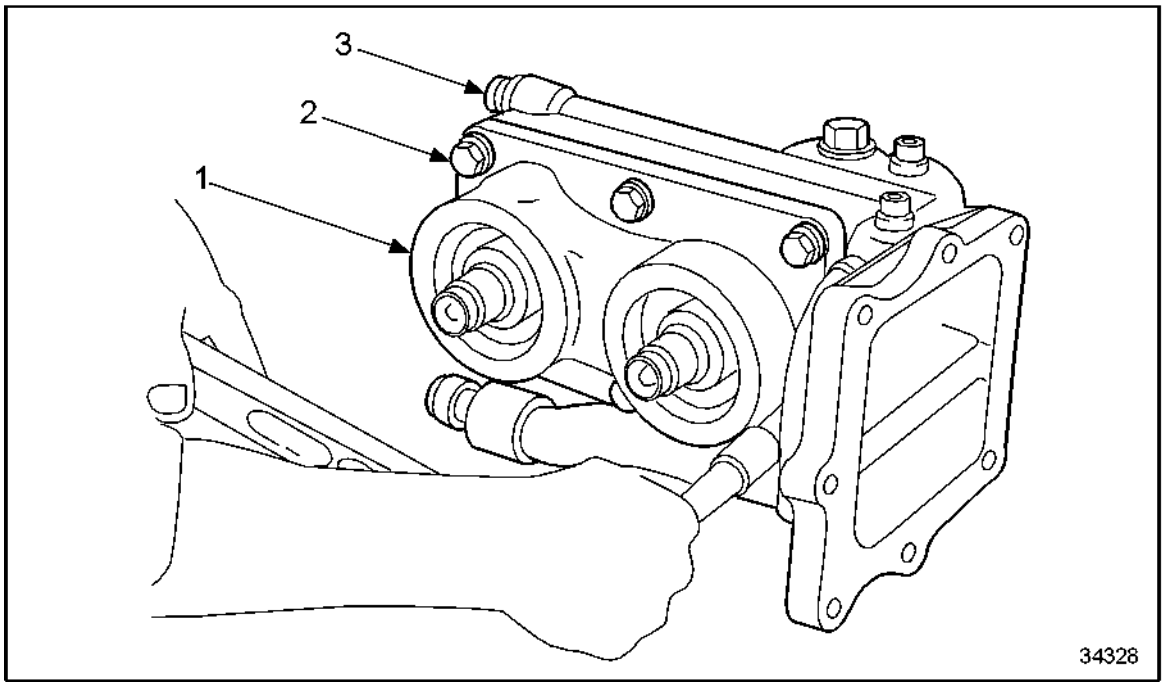


1. Filter Head
2. Junction Block
3. Threaded Connection
4. O-ring
5. O-ring
6. Blanking Plug

Figure 595 Installing Blanking Plug and Threaded Connection into Filter Head or Junction Block

2. Install blanking plug (6) and threaded connection (3) into filter head (1) and junction block (2).
3. Tighten to specification. Refer to section A 003.
4. Install delivery valve into filter base.
5. Tighten to specification. Refer to section A 003.
6. Coat O-rings (5) with petroleum jelly, and install in filter head (1).
7. Coat O-ring (4) with petroleum jelly, and install in the groove at the junction block.

8. Place filter head (1) on junction block (3). See Figure 596.



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

Figure 596 Installing Hex Bolts and Filter Head onto Junction Block

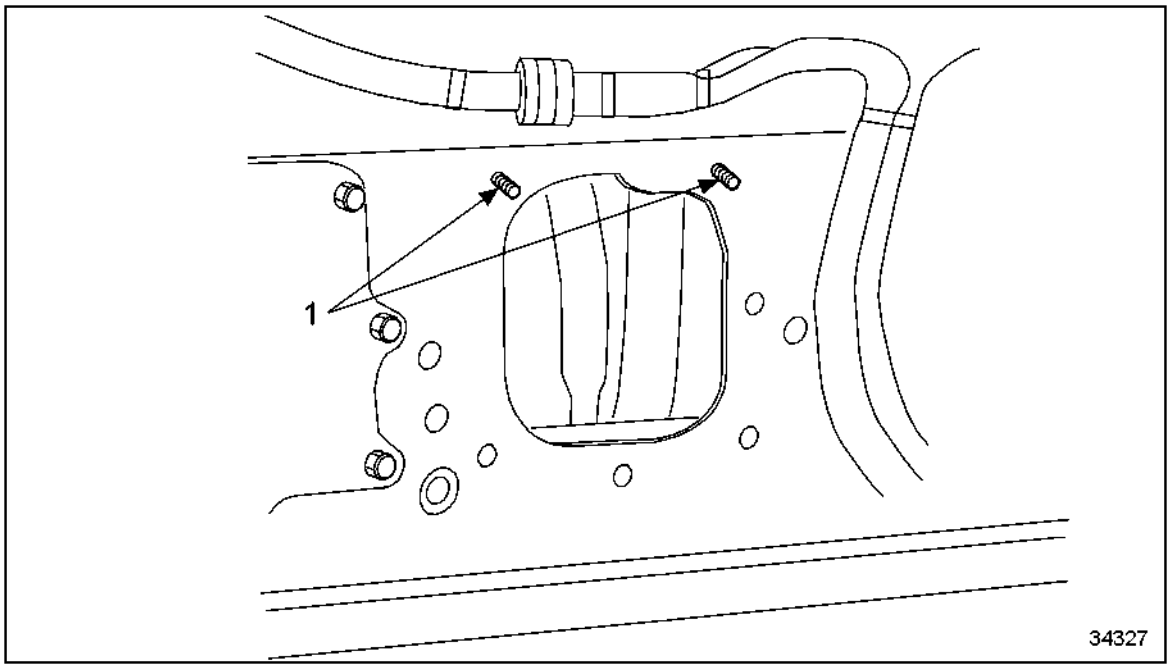
9. Install hex bolts (2); tighten diagonally and evenly to specification. Refer to section A 003.

C 083.05.11 – INSTALLATION OF FUEL FILTER

Perform the following steps to install the fuel filter:

NOTE:
Ensure that fuel-carrying components are perfectly clean.

See Figure 597.

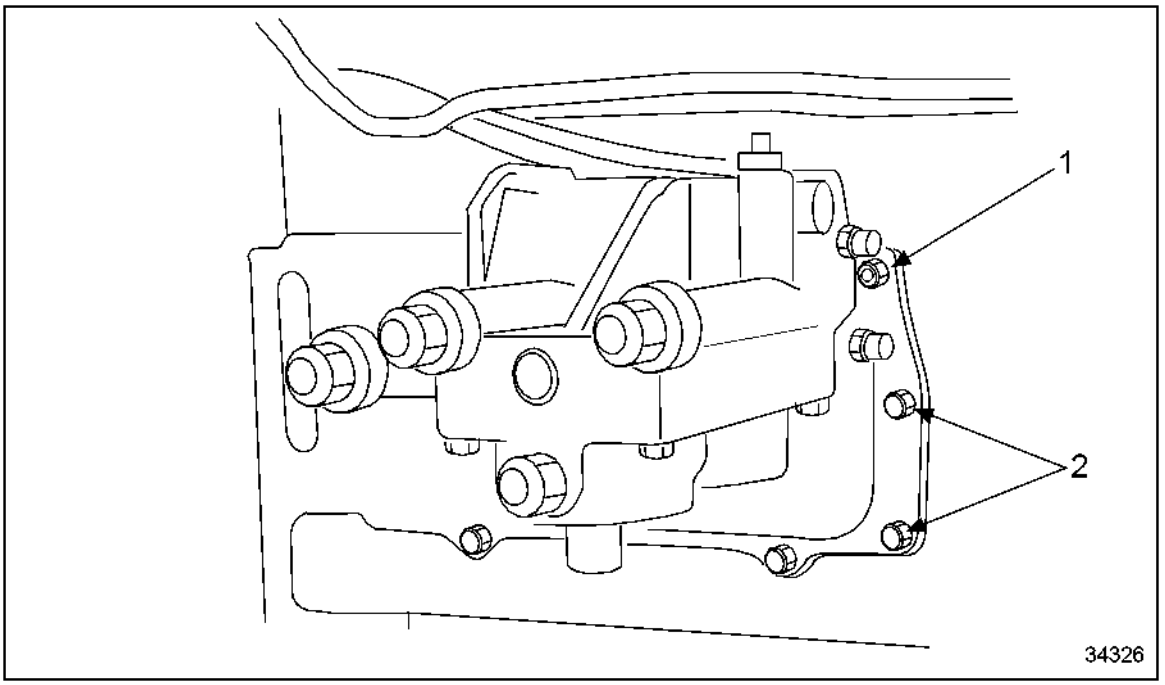


1. Studs

Figure 597 Cylinder Block Studs

1. Remove protective cover over inspection hole in cylinder block
2. Install nut on stud and lock with locknut.
3. Rotate stud (1) into cylinder block as far as it will go.
4. Tighten studs to specification. Refer to section A 003.
5. Remove nut and locknut.

6. Install fuel junction block onto studs on cylinder block. See Figure 598.



1. Nut
2. Hex Bolt

Figure 598 Installing Fuel Junction Block

7. Install hex bolts (2).

8. Tighten nuts and hex bolts to specification. Refer to section A 003.
9. Install fuel filter. See Figure 599.

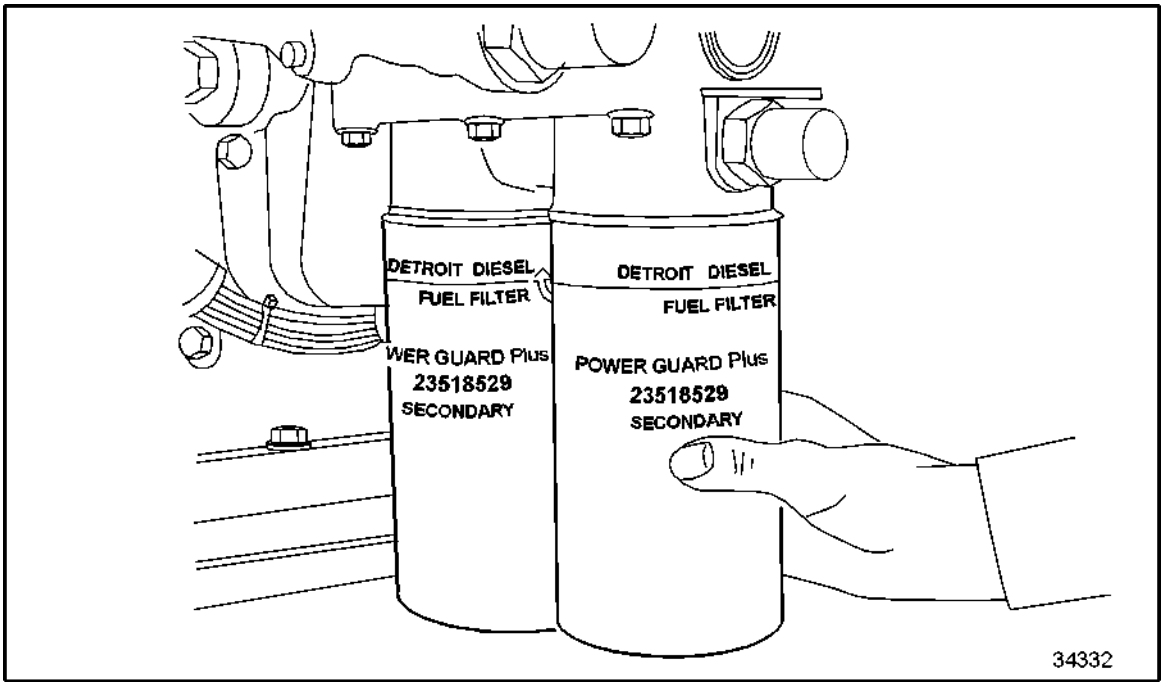


Figure 599 Installing Fuel Filter

C 083.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 67 are the After-Installation Operations for the fuel filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Install engine	Refer to OEM Guidelines
1, 2, 3	Release engine start	Refer to Operators Guide
1, 2, 3	Prime fuel system	Refer to Operators Guide
1, 2, 3	Vent fuel system	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.

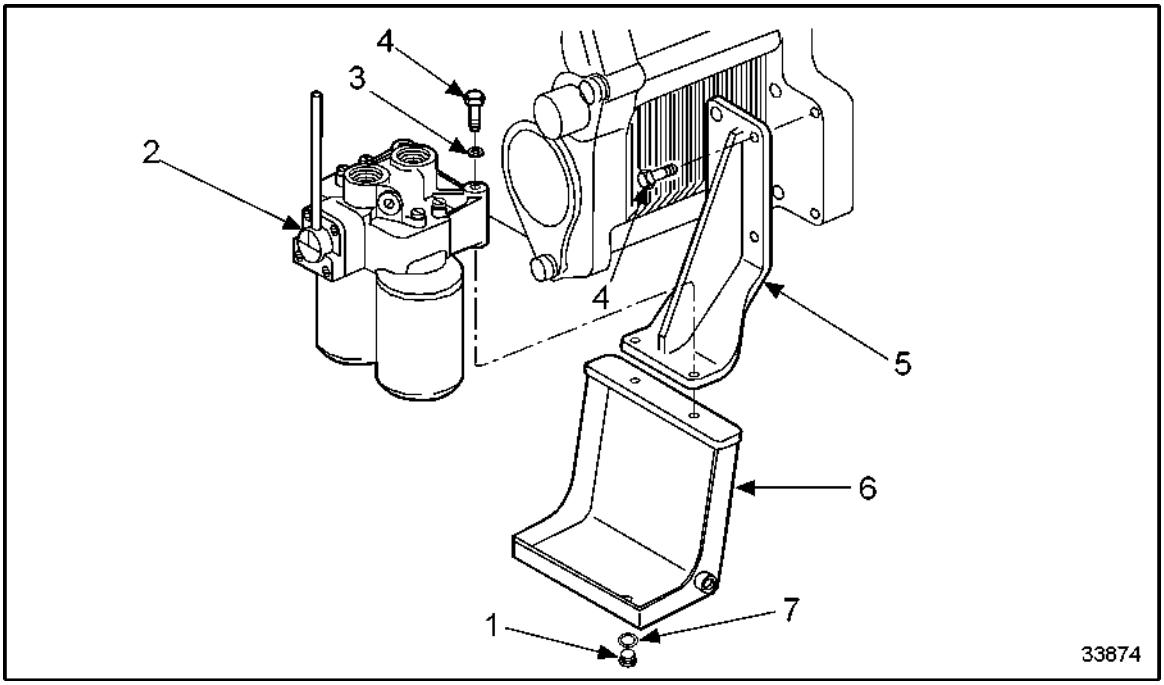
3 = The engine is to remain installed.

Table 67 After-Installation Operations

C 083.05 M – FUEL FILTER BRACKET

C 083.05.01 M – GENERAL VIEW

For an exploded view of the fuel filters and bracket assembly, see Figure 600.



1. Plug
2. Fuel Filter
3. Washer
4. Bolt
5. Mounting Bracket
6. Collecting Trough
7. Sealing Ring

Figure 600 Fuel Filters and Bracket Assembly, 12V Marine Engine

C 083.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 68are the Before-Removal Operations for the marine fuel filters and bracket.

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.

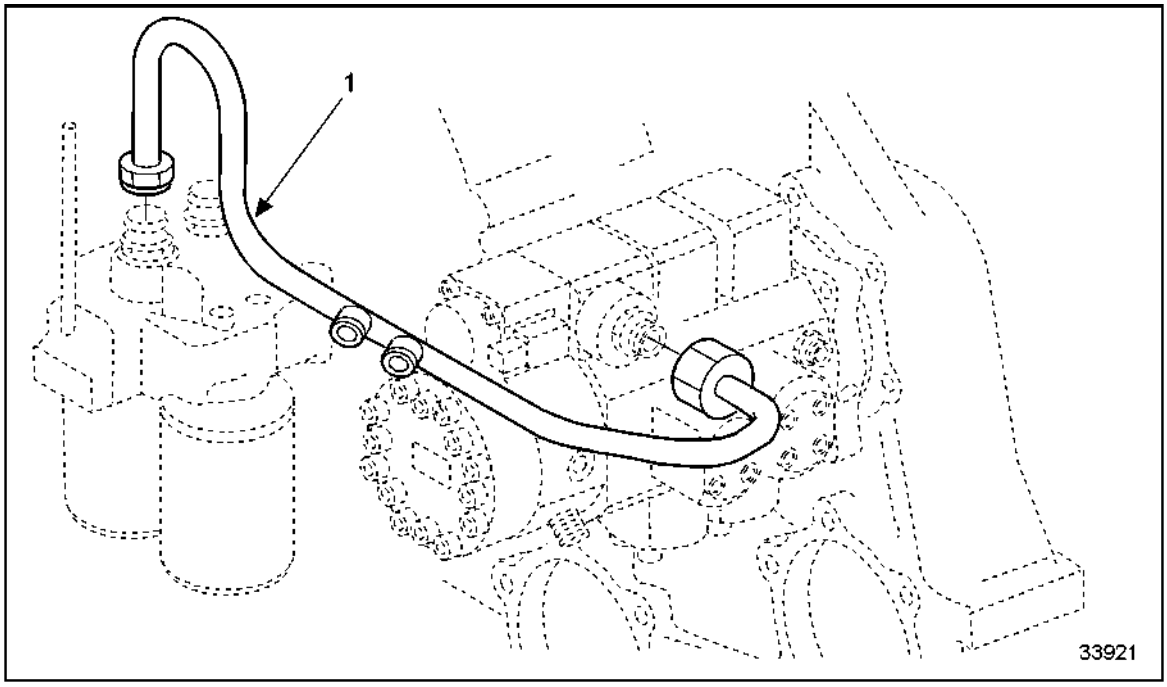
3 = The engine is to remain installed.

Table 68 Before-Removal Operations for the Marine Fuel Filter Bracket

C 083.05.05 M – REMOVAL OF THE MARINE FUEL FILTER AND BRACKET

Perform the following steps to remove the fuel filters and bracket.

1. Drain the fuel from the fuel lines; drain into a suitable container.
2. Disconnect the fuel lines. See Figure 601.

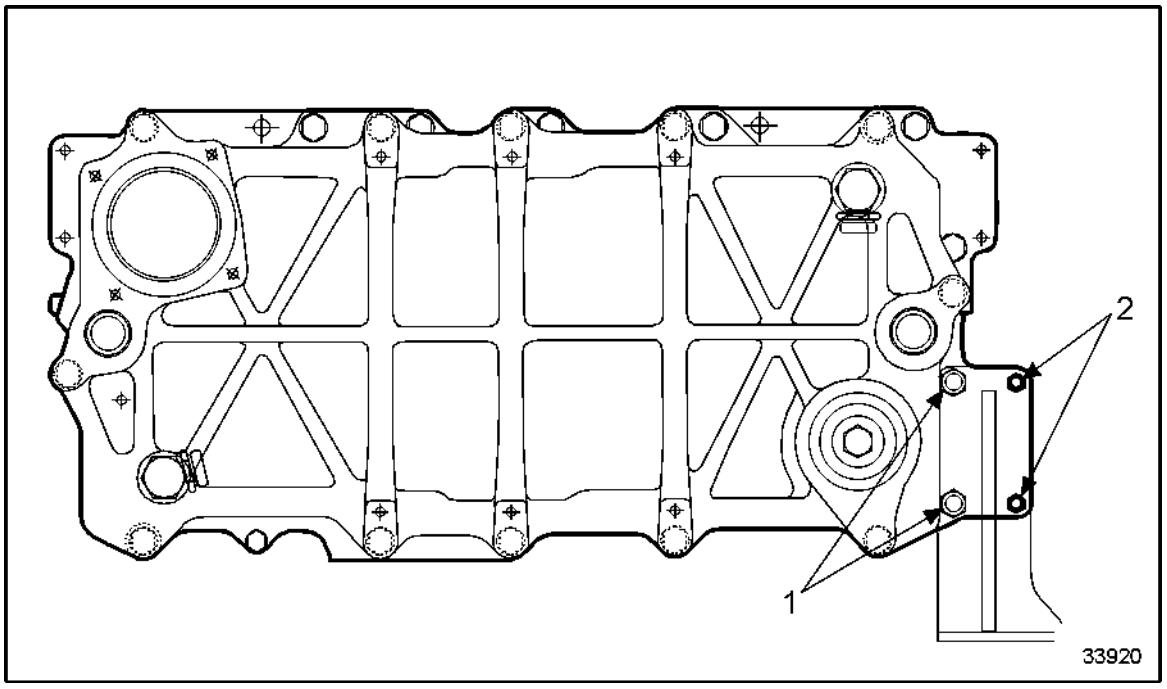


1. Low-Pressure Fuel Line

Figure 601 Disconnecting Low-Pressure Fuel Supply Line from the Filter to the Injection Pump, 12V Marine Engine

3. Remove fuel filters, and dispose of them in accordance with local specifications.

4. Remove two 80 mm bolts (1) securing the bracket assembly to the rear coolant plate. See Figure 602.



1. 80 mm Bolts
2. 30 mm Bolts

Figure 602 Removing Marine Filter Bracket Bolts

5. Remove two 30 mm bolts (2) securing the bracket to the front cover.
6. Remove the fuel bracket assembly.

C 083.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the marine fuel filter bracket.

1. Ensure that all fuel-carrying components are perfectly clean.

CAUTION:

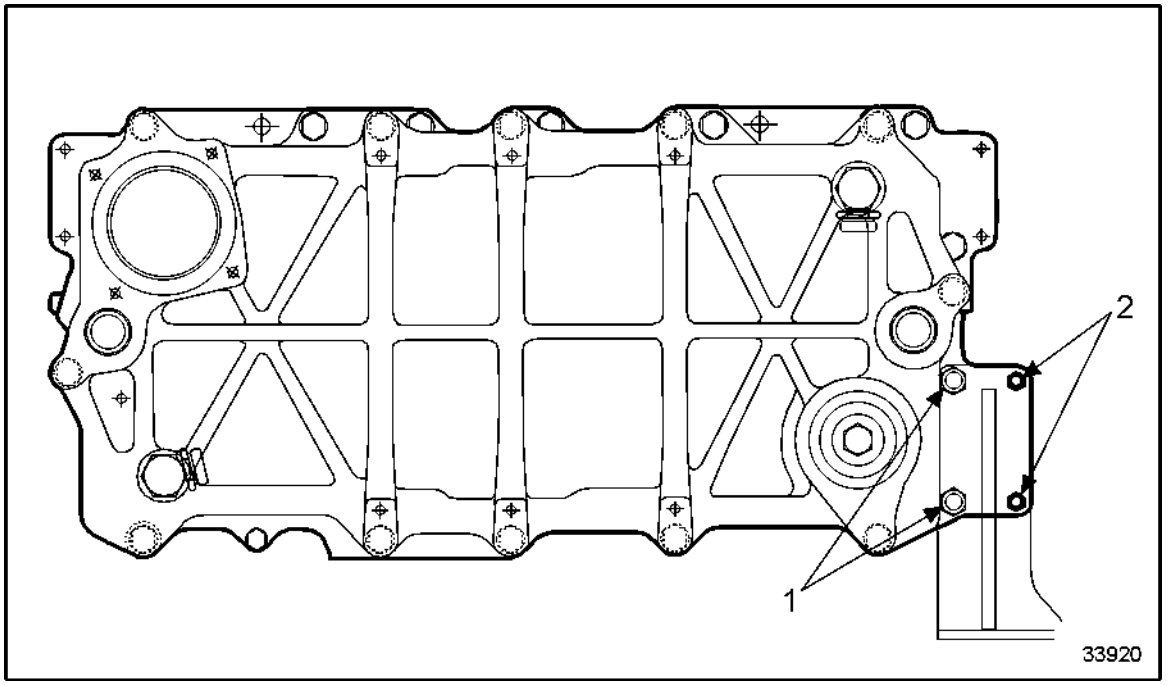
To avoid an eye injury when blow drying parts, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

2. Clean all components with compressed air.
3. Visually inspect all components for damage and defects.
   [a] If components are damaged or defective, replace as necessary.
   [b] If components are not damaged or defective, proceed to installation.

C 083.05.11 M – INSTALLATION OF THE MARINE FUEL FILTER AND BRACKET

Perform the following steps to install the fuel filter and bracket.

1. Install the fuel bracket assembly.
2. Install two 30 mm bolts (2), securing the bracket to the front cover. See Figure 603.

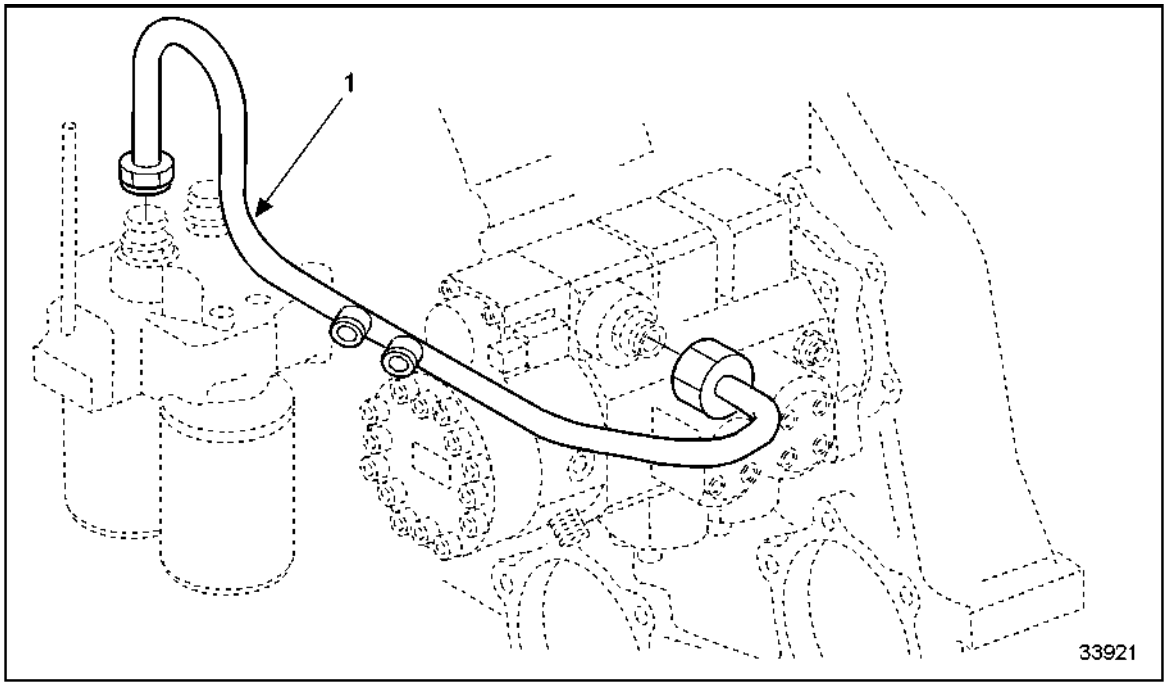


1. 80 mm Bolts
2. 30 mm Bolts

Figure 603 Marine Filter Bracket Bolts

3. Tighten bolts to specification. Refer to section A 003.
4. Install two 80 mm bolts (1) securing the bracket assembly to the rear coolant plate.
5. Tighten bolts to specification. Refer to section A 003.

6. Install new fuel filters.
7. Connect the fuel lines. See Figure 604.



1. Low Pressure Fuel Line

Figure 604 Connecting Low-Pressure Fuel Supply Line from the Filter to the Injection Pump, 12V Marine Engine

C 083.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 69are the After-Installation Operations for fuel filter and bracket.

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

1 = The engine is to be completely disassembled.

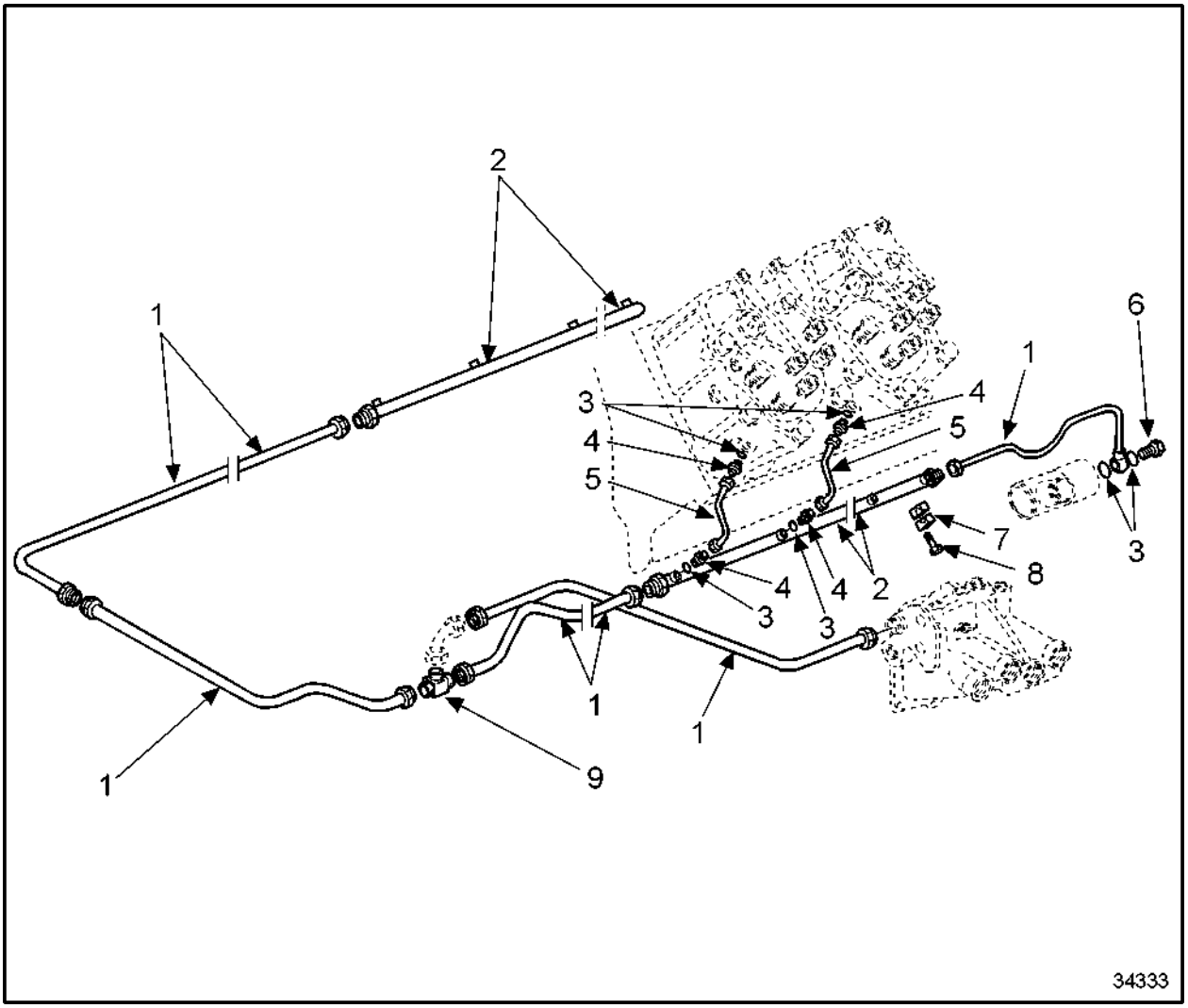
2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 69 After-Installation Operations for Marine Fuel Filter and Bracket

C 086.05 – FUEL RETURN RAILS AND LINES

C 086.05.01 – GENERAL VIEW



1. Fuel Return Line
2. Fuel Return Rail
3. Sealing Ring
4. Adaptor
5. Fuel Return Line
6. Banjo Bolt
7. Pipe Half Clamp
8. Hex Bolt
9. T-piece

Figure 605 Return Rails and Lines

C 086.05.02 – SPECIAL TOOLS

Not applicable.

C 086.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 70 are the Before-Removal Operations for fuel return rails and lines.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove charge air manifold	Refer to section C 124.05.05
1, 2, 3	Remove fuel supply line	Refer to section C 083.05.05
1, 2, 3	Remove plug-in pipes	Refer to section C 083.05.05

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 70 Before-Removal Operations

C 086.05.05 – REMOVAL OF THE FUEL RETURN RAIL SYSTEM

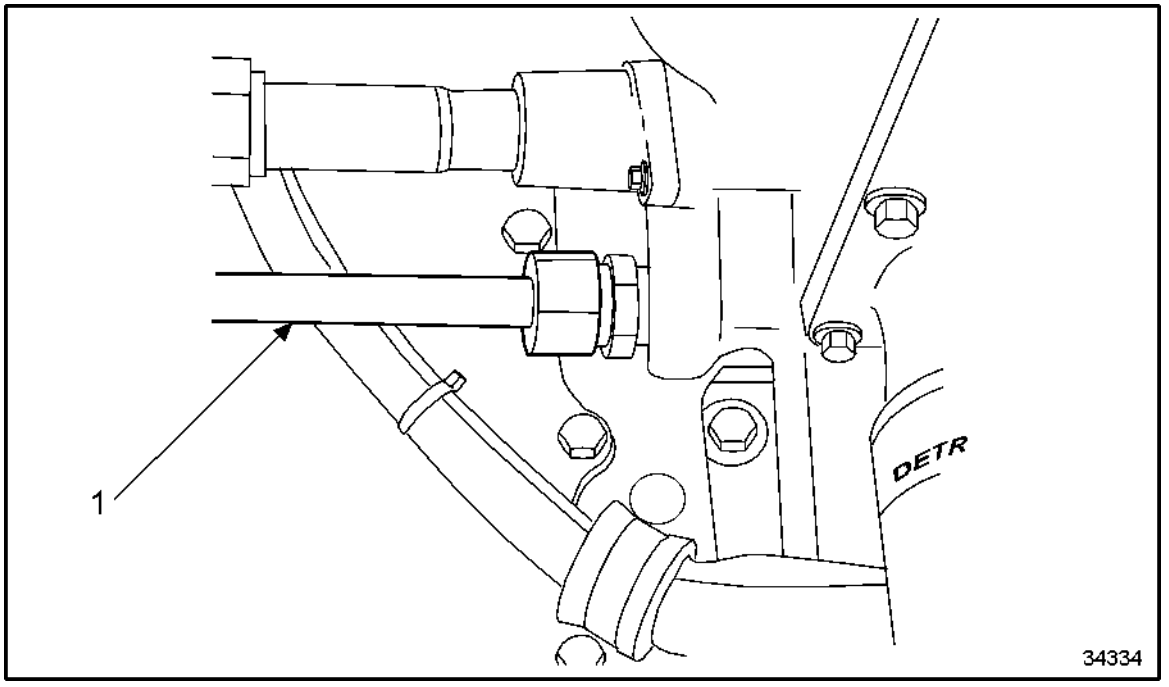
Perform the following steps to remove the fuel return rail system:

CAUTION:

To avoid personal injury when working on the fuel system, do not smoke, use open flame, or electrical equipment. Diesel fuel is a combustible fluid. Risk of a fire from sparks is probable. Perform maintenance in a well ventilated work area with access to a fire extinguisher.

NOTE:
When removing the fuel lines, catch any fuel that emerges in suitable containers.

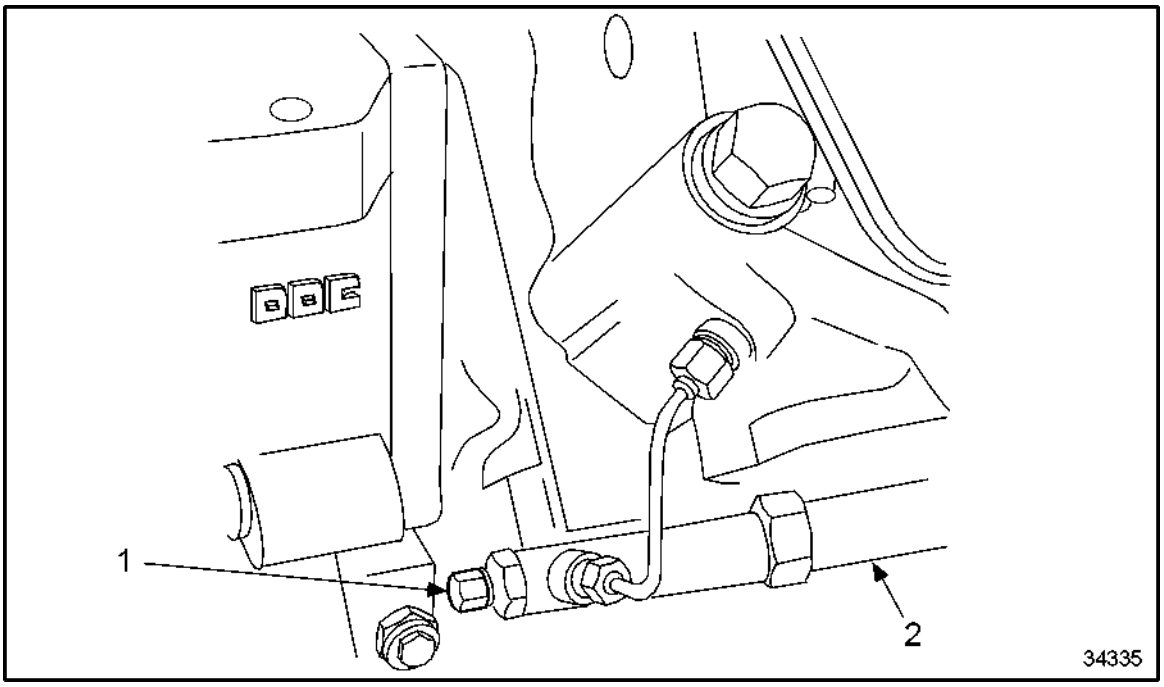
1. Remove fuel return line (1). See Figure 606.



1. Fuel Return Line

Figure 606 Removing Fuel Return Line (High Pressure Pump Body to Junction Block)

2. Remove adaptor nut (1). See Figure 607.

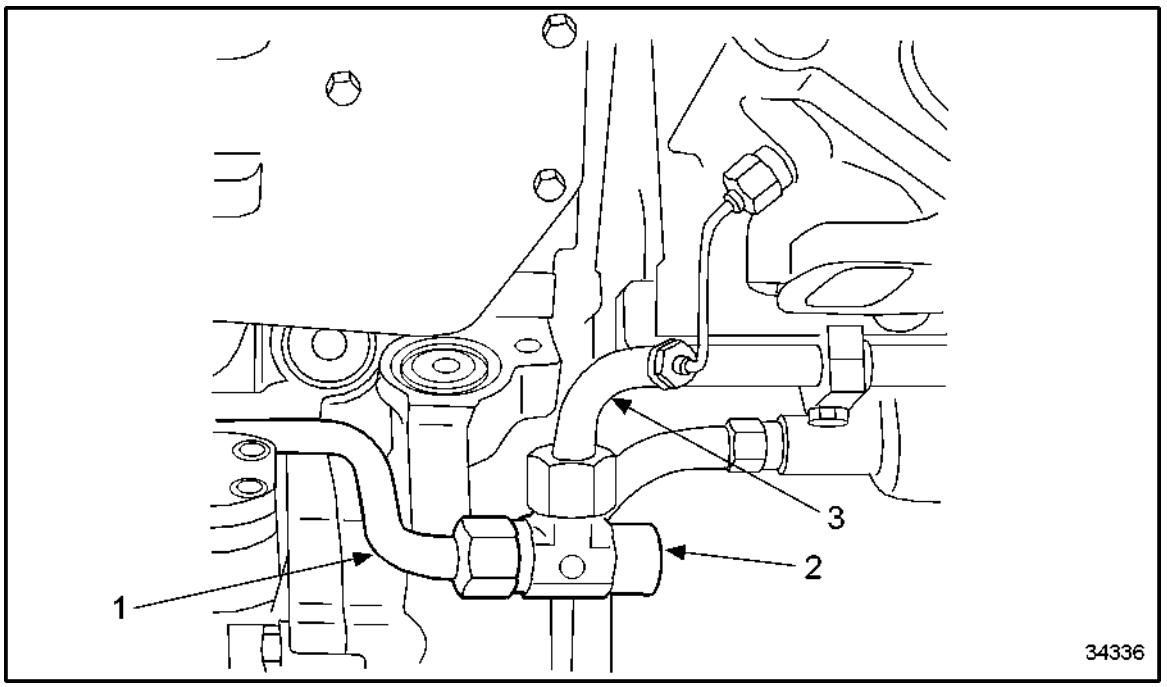


1. Adaptor Nut
2. Fuel Return Rail

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

3. Remove blanking plug from fuel return rail.

4. Remove fuel return line (1) at T-piece. See Figure 608.

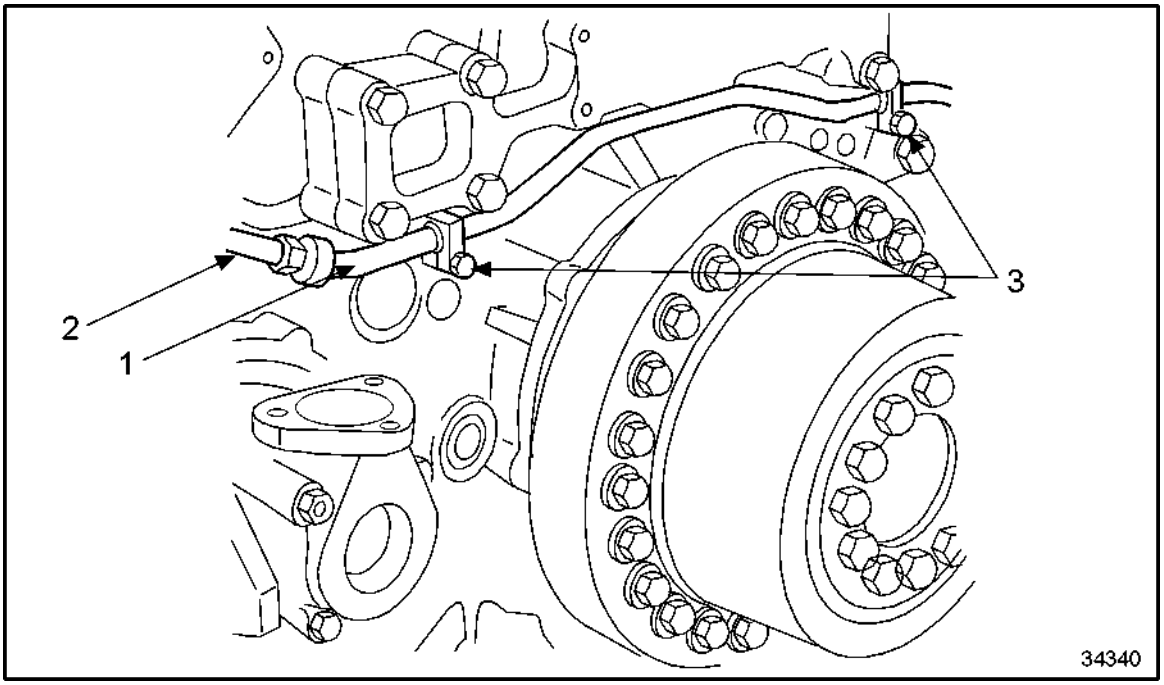


1. Fuel Return Line
2. T-piece
3. Fuel Return Rail

Figure 608 Removing Fuel Return Line at T-Piece

5. Remove T-piece (2).

6. Remove pipe clamp halves (3). See Figure 609.

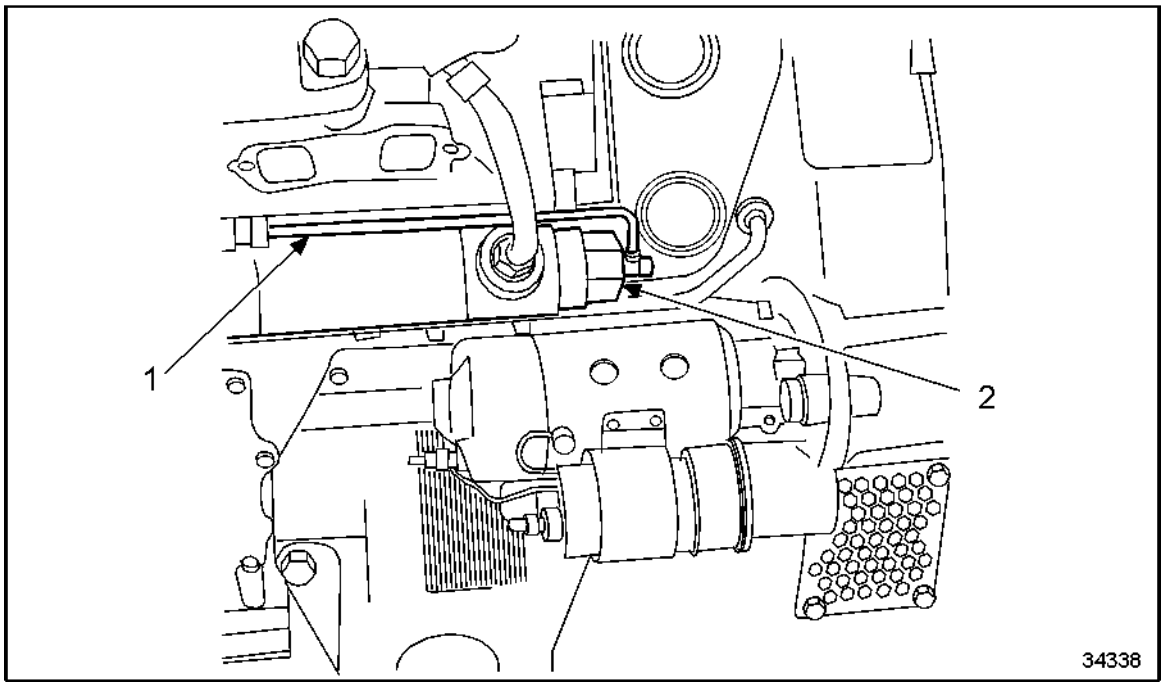


1. Fuel Return Line
2. Connecting Line
3. Pipe Clamp Half

Figure 609 Removing Fuel Line from Connecting Line

7. Remove fuel return line (1) at connecting element.

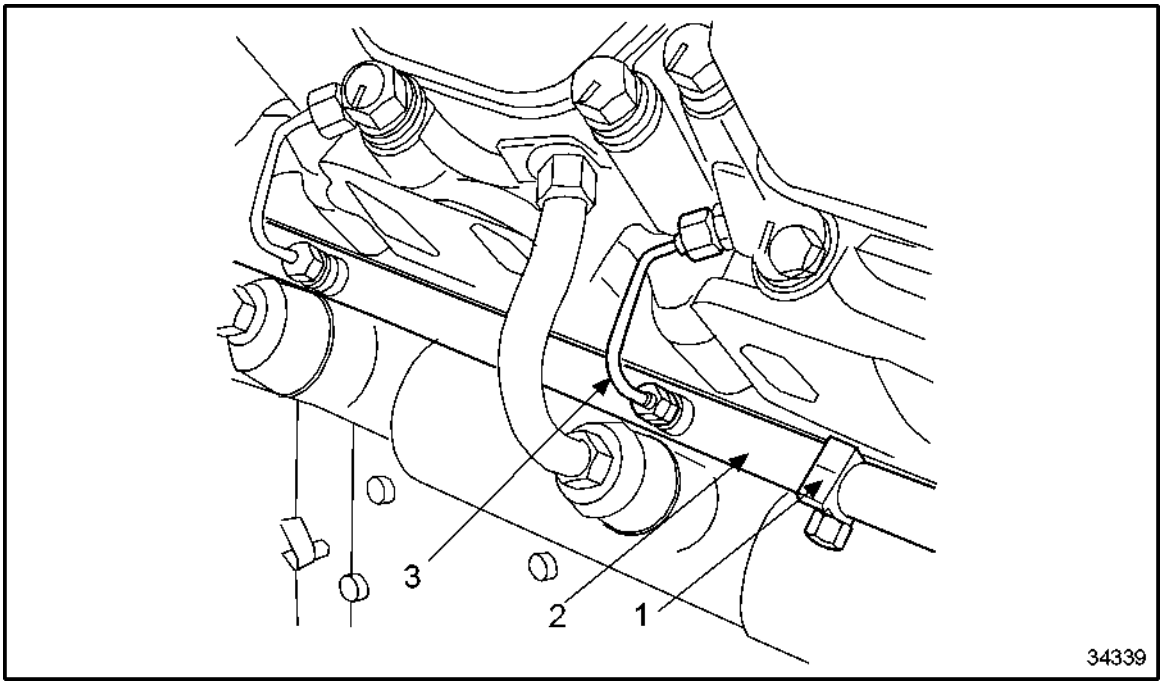
8. Remove fuel return line (1) on high-pressure rail of “A” Bank. See Figure 610.



1. Fuel Return Line (Fuel Relief Line)
2. High-pressure Rail Relief Valve

Figure 610 Removing Fuel Return Line on High-Pressure Rail of “A” Bank

9. Remove fuel return lines (3) between cylinder head and fuel return rail. 611.



1. Pipe Clamp Half
2. Fuel Return Rail
3. Fuel Return Line

Figure 611 Removing Fuel Return Lines Between Cylinder Head and Fuel Return Rail

10. Remove pipe clamp halves (1).
11. Release fuel collecting lines (2) at connecting points.

C 086.05.06 – DISASSEMBLY OF THE FUEL RETURN RAILS AND LINES SYSTEM

This section not applicable.

C 086.05.08 – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the fuel line system:

NOTE:
Ensure that fuel-carrying components are perfectly clean.

1. Clean fuel lines with cleaner.
2. Visually inspect fuel lines for general condition and damage.
   [a] If fuel lines are in poor condition or are damaged, replace fuel lines as necessary.
   [b] If fuel lines are in good condition and are not damaged, continue inspection.

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.

3. Pressure-test fuel lines for leaks with air in water bath.
   [a] If leaks are found, replace fuel lines as necessary.
   [b] If leaks are not found, continue inspection.
4. Coolant temperature is 30°C minimum; components must also be at this temperature.
5. If component must be held in hands, coolant temperature is 40°C maximum.
6. Test pressure is 0.5 bar.
7. Visually inspect condition of banjo bolts and threads for wear and damage.
   [a] If banjo bolts or threads are worn or damaged, replace banjo bolts as necessary.
   [b] If banjo bolts are not worn or damaged, continue inspection.
8. Visually inspect sealing and mating surfaces for damage and defects.
   [a] If sealing and mating surfaces are damaged or defective, rub down with oilstone.
   [b] If damage is too extensive, replace parts as necessary.
   [c] If sealing and mating surfaces are not damaged or defective, continue inspection.
9. Replace sealing rings.

C 086.05.10 – ASSEMBLY OF THE FUEL RETURN RAILS AND LINES SYSTEM

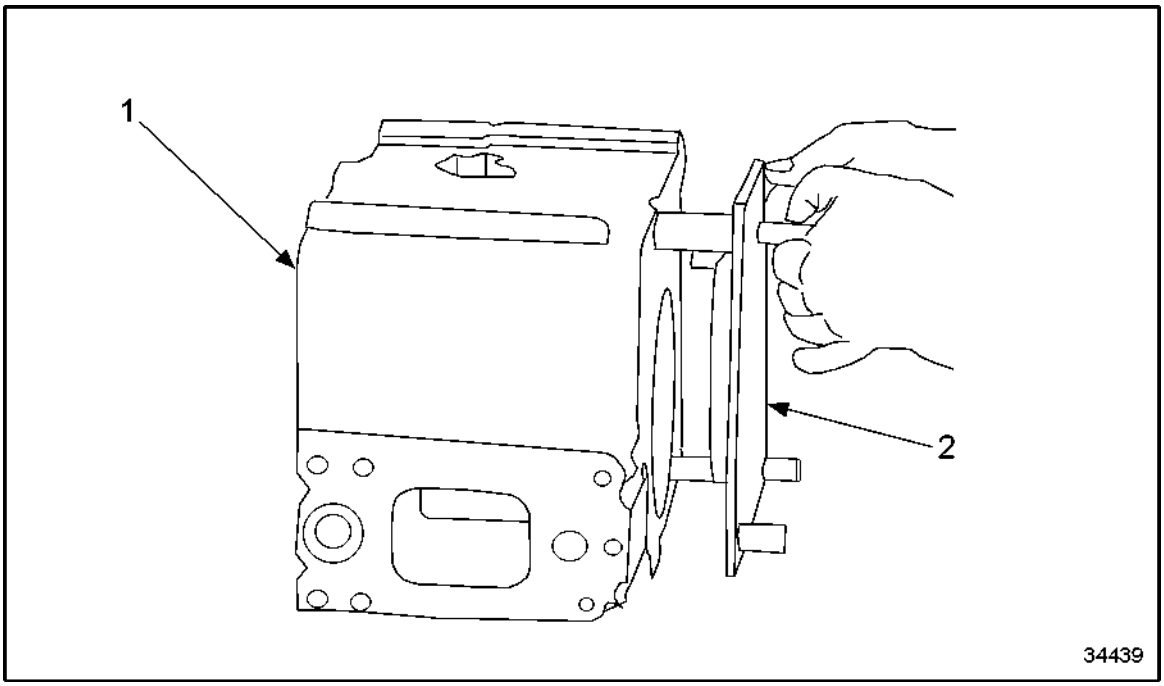
This section not applicable.

C 086.05.11 – INSTALLATION OF FUEL RETURN RAILS AND LINES SYSTEM

Perform the following steps to install the fuel return rails and lines system.

NOTE:
Make sure fuel-carrying components are perfectly clean.

1. Install fuel collecting lines in pipe clamp halves. See Figure 612.

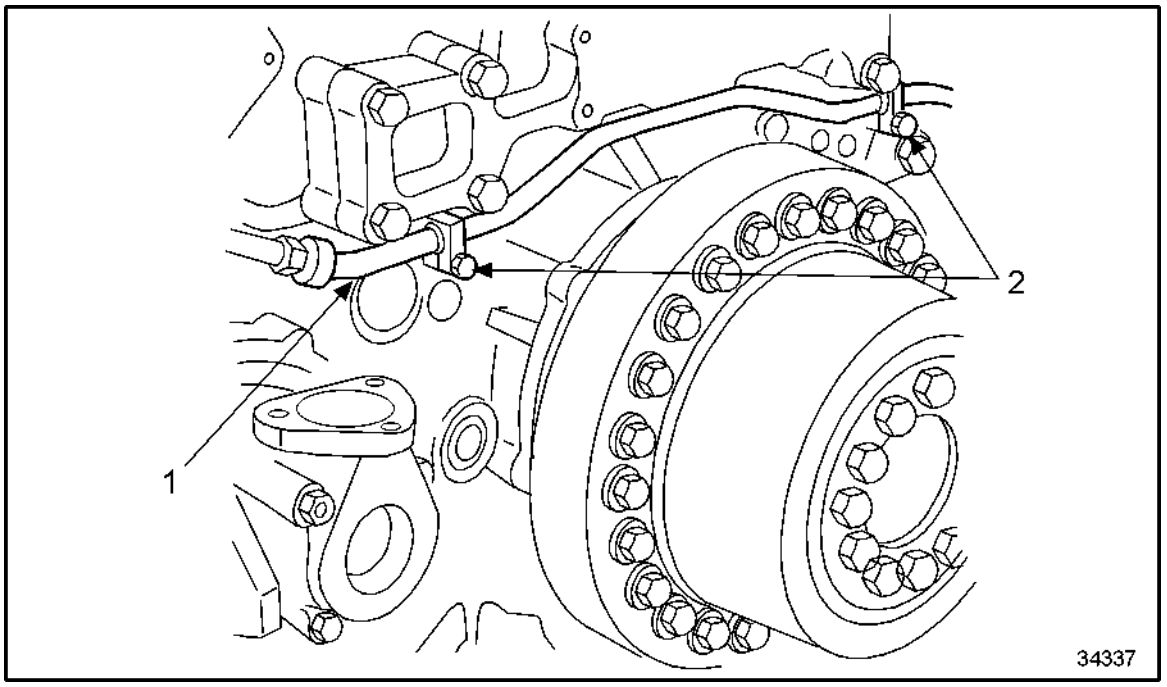


1. Cylinder Head
2. Fuel Return Rail

Figure 612 Installing Fuel Return Lines between Cylinder Head and Fuel Return Rail

2. Loosely install hex bolts on pipe clamp halves so that fuel collecting line can still be turned. See Figure 612.
3. Install fuel return lines (2) between cylinder head (1) and fuel return rail and tighten to specification. Refer to section A 003. See Figure 612.
4. Tighten hex bolts of pipe clamp halves (1). See Figure 612.

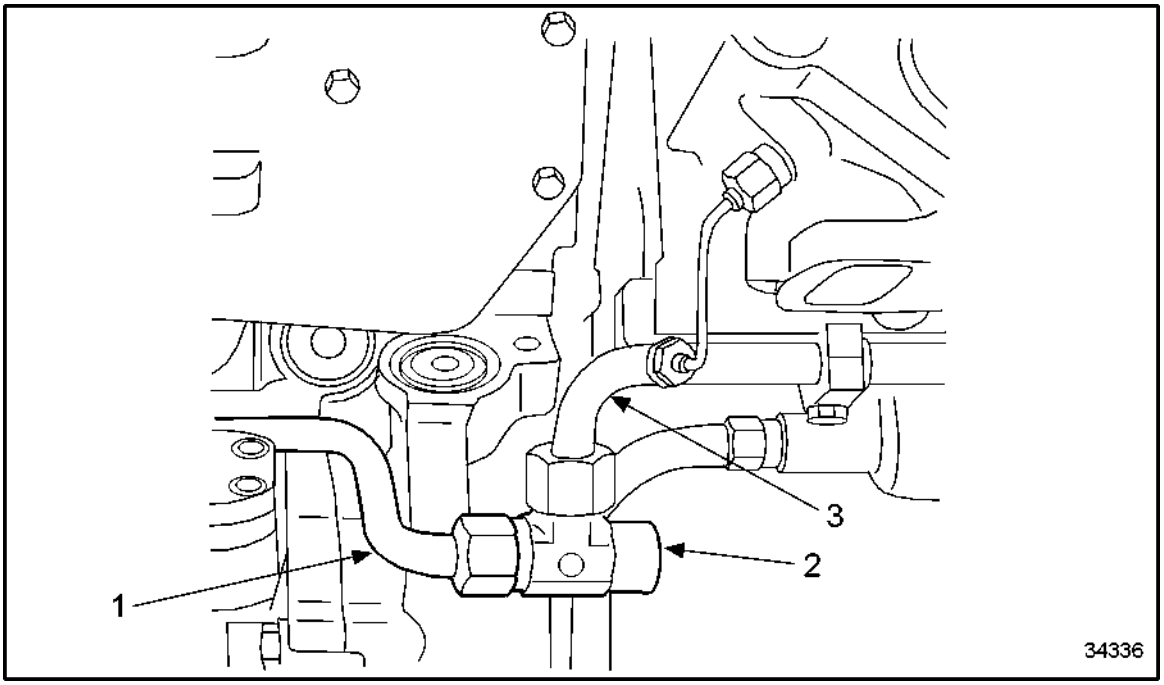
5. Install fuel return line (1) to return rail and install them on engine with pipe clamp half and bolt (2). See Figure 613.



1. Fuel Return Line
2. Pipe Clamp Half and Bolt

Figure 613 Installing Fuel Return Line at Connecting Element

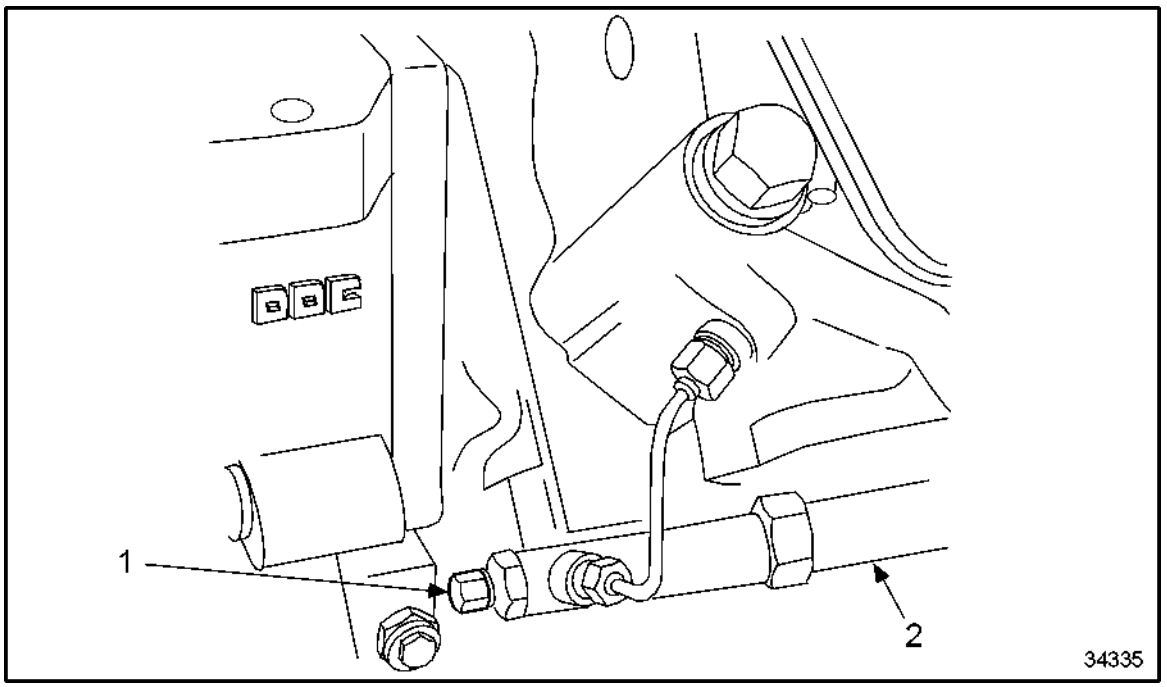
6. Install the T-piece (2) to fuel return line (1) and fuel return rail (3). See Figure 614.



1. Fuel Return Line
2. T-Piece
3. Fuel Return Rail

Figure 614 Installing Fuel Return Line at T-Piece

7. Install blanking plugs in fuel return rail. See Figure 615.



1. Adaptor Nut
2. Fuel Return Rail

Figure 615 Installing Blanking Plugs and Adaptor Nuts

8. Install adaptor nut and tighten to specification. Refer to section A 003.
9. Install fuel return line on high-pressure rail “A” Bank end.

C 086.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 71 are the After-Installation Operations for the fuel return rails and lines.

Level of Maintenance	Operation	Reference
1, 2, 3	Vent fuel system	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.

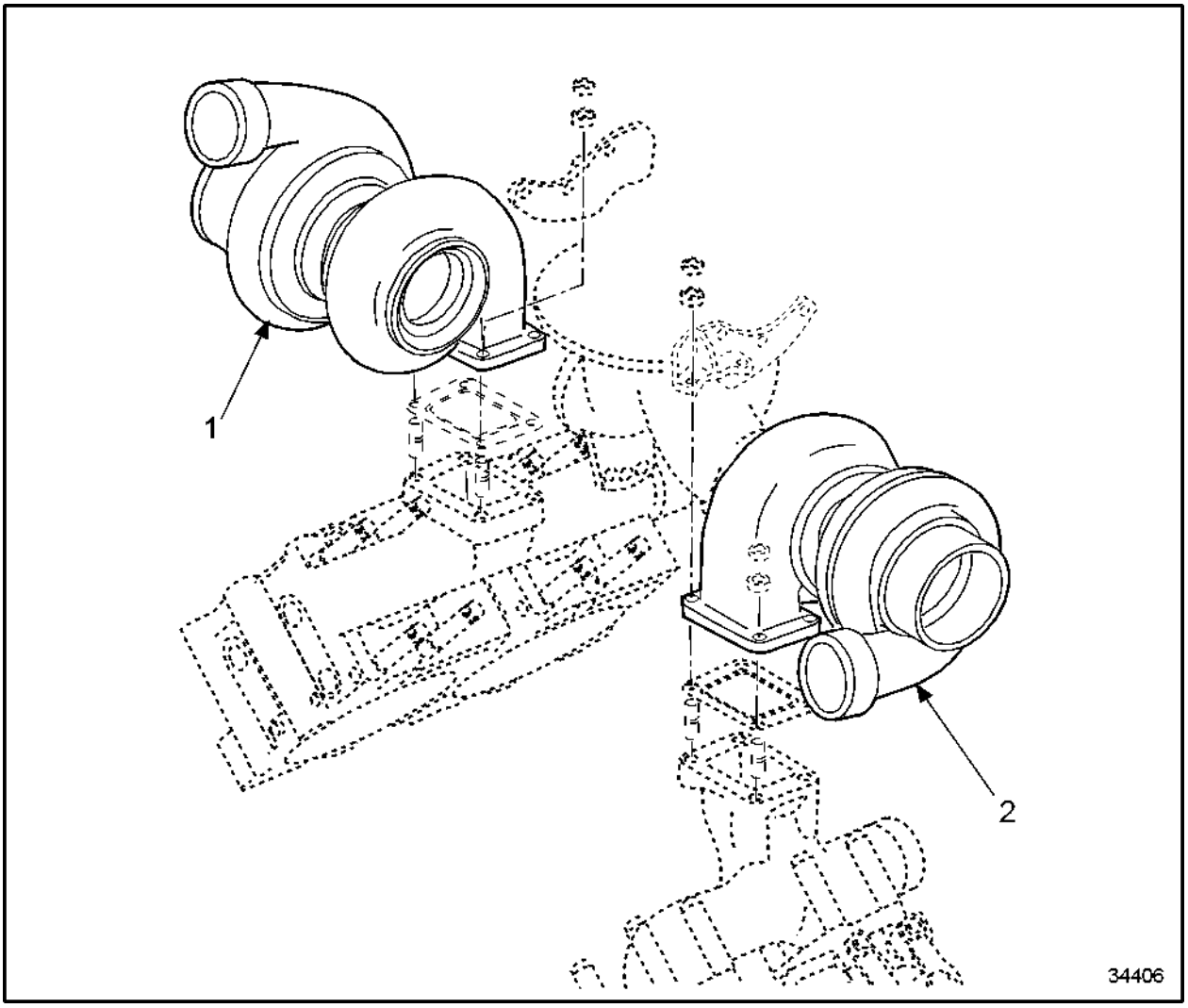
Table 71 After-Installation Operations

C 100 – TURBOCHARGER

C 101.05 – TURBOCHARGER

C 101.05.01 – GENERAL VIEW

See Figure 616 for a general view of the turbocharger.



1. "A" Bank Turbocharger (2X)
2. "B" Bank Turbocharger (2X)

Figure 616 General View of Turbocharger

C 101.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 72 are the Before-Removal Operations for the exhaust turbocharger.

Level of Maintenance	Operation	Reference
1, 2, 3	Remove air system before exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove exhaust system after Y-pipe	Refer to section C 141.05.05C 141.05.05
1, 2, 3	Remove intermediate element of charge air manifold on exhaust turbocharger	Refer to section C 124.05.05 C 124.05.05
1, 2, 3	Remove oil supply lines for turbocharger	Refer to section C 187.05.05 C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05 C 188.05.05
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.

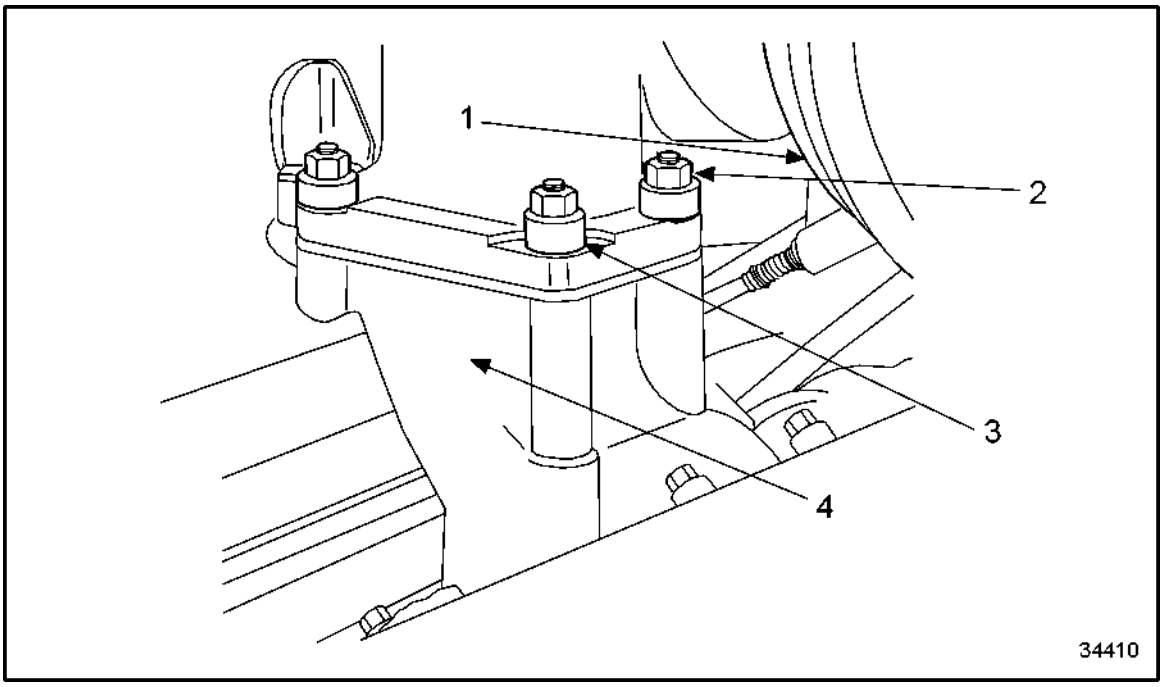
3 = The engine is to remain installed.

Table 72 Before-Removal Operations

C 101.05.05 – REMOVAL OF THE EXHAUST TURBOCHARGER

Perform the following steps to remove the turbocharger:

1. To remove turbocharger, remove hex nuts (1) from flange on both turbochargers (2). See Figure 617.



1. Hex Nut
2. Turbocharger
3. Spacer Bushing
4. Exhaust Manifold

Figure 617 Exhaust Turbocharger

2. Remove spacer sleeves (3).

NOTE:
Two different length of spacers are used.

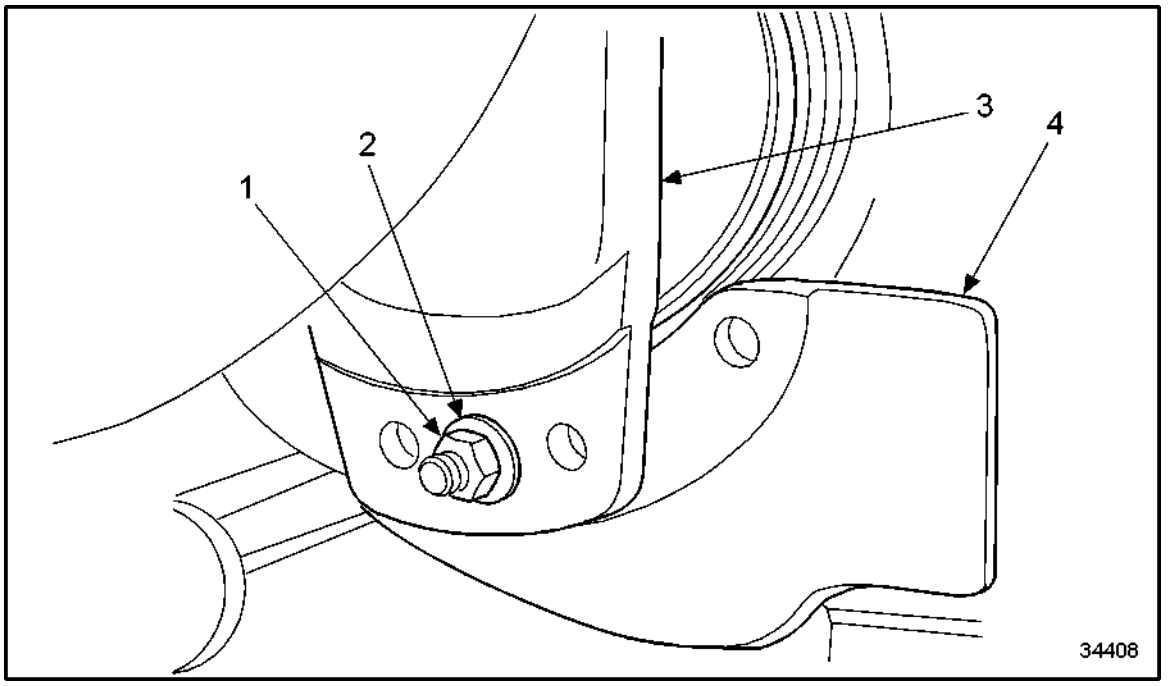
CAUTION:

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.

3. Attach turbocharger with lifting device to crane and carefully lift from studs.
4. If necessary, loosen bracket bolt slightly to facilitate removal of exhaust outlet (Y-pipe) from turbocharger.

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

5. Remove exhaust outlet (Y-pipe).
6. Remove gasket from exhaust manifold turbocharger flange.
7. Remove hex bolt and washer (2) from exhaust outlet (Y-pipe) (3) and bracket (4). See Figure 618.



1. Hex Nut
2. Washer
3. Exhaust Outlet (Y-pipe)
4. Bracket

Figure 618 Removing Hex Bolt and Washer from Exhaust Outlet (Y-pipe) and Bracket

8. Remove bracket (4).
9. Remove piston rings from exhaust outlet (Y-pipe) (3).

C 101.05.06 – DISASSEMBLY OF THE EXHAUST TURBOCHARGER

At present, no provision is made for turbocharger disassembly on site.

C 101.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the turbocharger:

1. Clean all components and visually inspect for damage and defects.
   [a] If components show damage or defects, replace as necessary.
   [b] If components do not show damage or defects, continue inspection.
2. Inspect turbocharger for ease of movement.
   [a] If turbocharger does not show ease of movement, repair or replace as necessary.
   [b] If turbocharger does show ease of movement, continue inspection.
3. Visually inspect axial clearance and radial clearance.
   [a] If axial clearance and radial clearance are beyond specified limits, repair or replace component as necessary.
   [b] If axial clearance and radial clearance are not beyond specified limits, continue inspection.
4. Visually inspect turbocharger for external damage, in particular in area of turbine and compressor wheels.
   [a] If turbocharger shows damage, replace component as necessary.
   [b] If turbocharger does not show damage, continue inspection.
5. Visually inspect all sealing and seating surfaces for damage and irregularities.
   [a] If sealing or seating surfaces show damage or irregularities, rub down with an oilstone or emery cloth as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If sealing and seating surfaces do not show damage or irregularities, continue inspection.
6. Inspect thread of studs for ease of movement.
   [a] If threads do not show ease of movement, replace studs as necessary.
   [b] If threads show ease of movement, continue inspection.
7. Always replace nuts securing turbocharger, sealing rings and gaskets.
8. Major overhaul of turbocharger is scheduled during W6 maintenance.

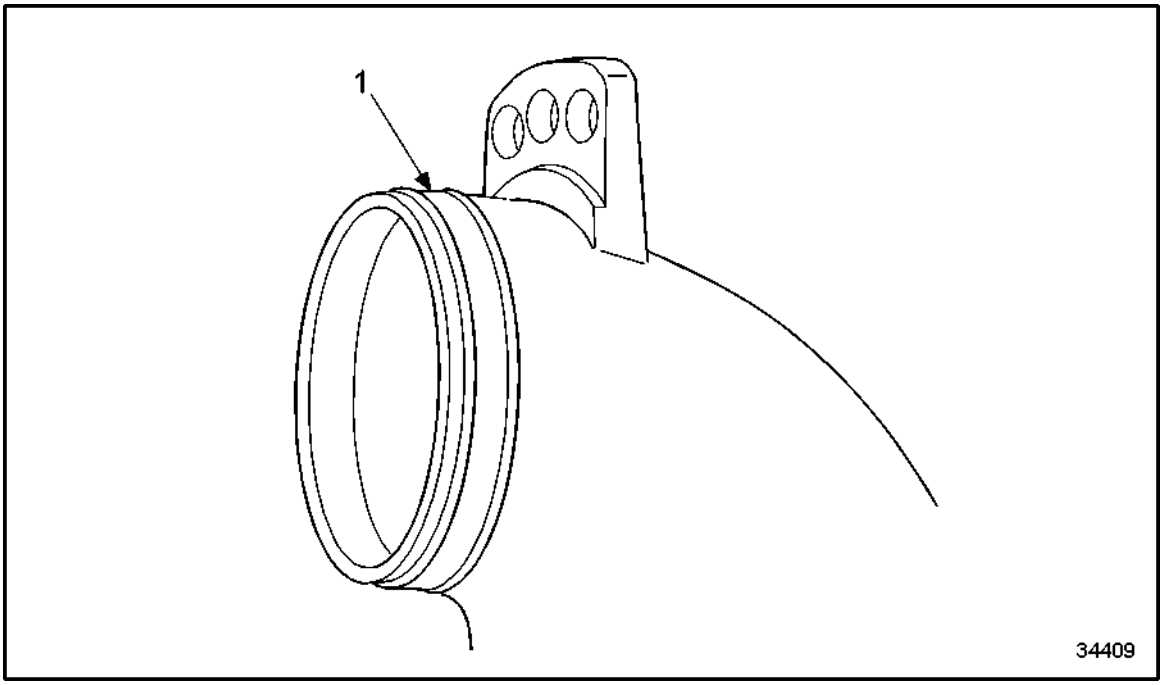
C 101.05.10 – ASSEMBLY OF TURBOCHARGER

Refer to section C 101.05.06.

C 101.05.11 – INSTALLATION OF THE TURBOCHARGER

Perform the following steps to install the turbocharger.

1. Install piston rings in groove (1) provided on exhaust outlet (Y-pipe). See Figure 619.

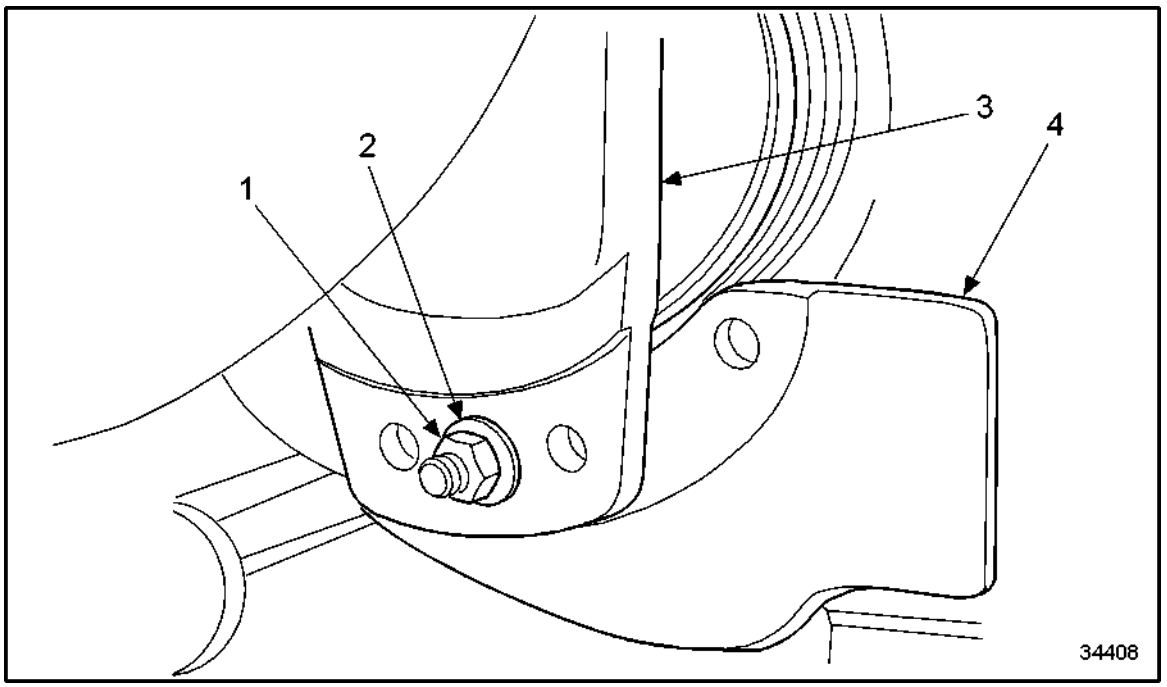


1. Groove

Figure 619 Installing Piston Ring in Groove on Exhaust Outlet (Y-pipe)

2. Coat outer surface of piston rings with sealing compound.

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.

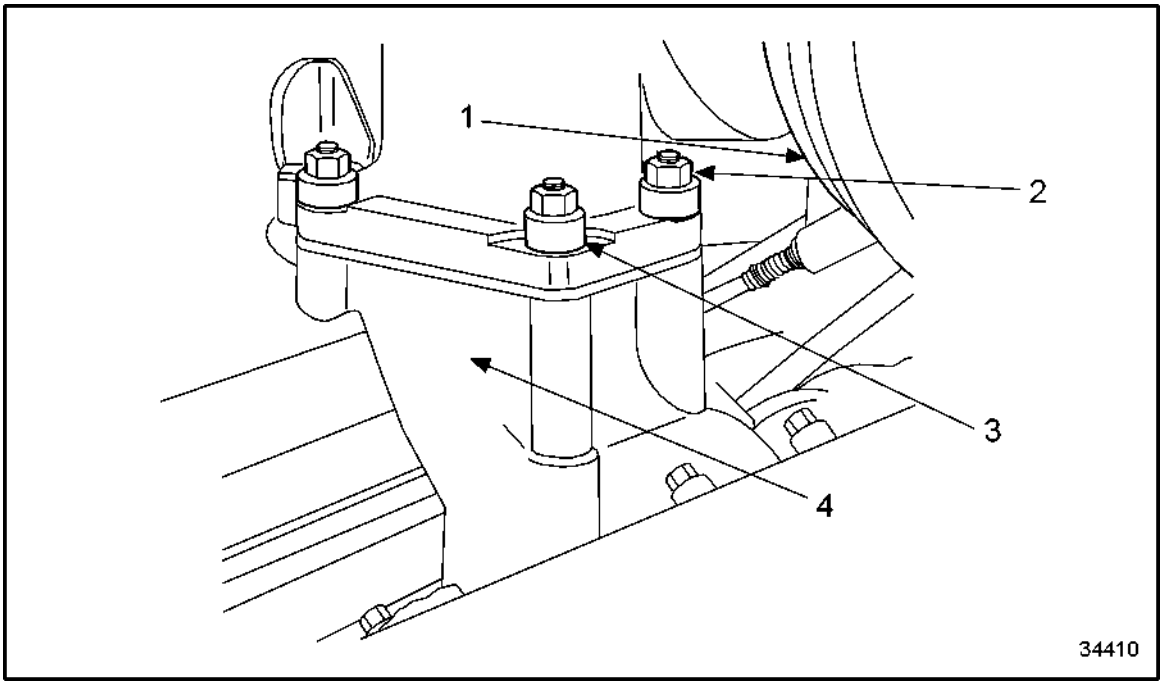
CAUTION:

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.

NOTE:
High altitude applications require a Helicoflex® gasket and spacer installed between the turbocharger and exhaust manifold.

Helicoflex® is a registered trademark of Garlock Helicoflex™, a subsidiary of B.F. Goodrich Aerospace®.

5. Attach turbocharger (1) to crane and, together with bracket, carefully install on the studs. See Figure 621.



1. Turbocharger
2. Hex Nut
3. Spacer Bushing
4. Exhaust Manifold

Figure 621 Tightening Turbocharger Diagonally with Hex Nuts

6. Install spacer bushings (3) and nuts.
7. Tighten hex nuts (2) on the turbocharger flange diagonally and evenly to specification. Refer to section A 003 .

C 101.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 73 are the After-Installation Operations for the exhaust turbocharger.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine start	Refer to Operators Guide
1, 2, 3	Install oil supply lines for turbochargers	Refer to section C 187.05.11 C 187.05.11
1, 2, 3	Install oil return lines for turbochargers	Refer to section C 188.05.11 C 188.05.11
1, 2, 3	Install intermediate charge air element of manifold on exhaust turbocharger.	Refer to section C 124.05.11 C 124.05.11
1, 2, 3	Install exhaust system after exhaust outlet (Y-pipe)	Refer to section C 141.05.11 C 141.05.11
1, 2, 3	Install air system before exhaust turbocharger	Refer to section C 101.05.11

1 = The engine is to be completely disassembled.

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

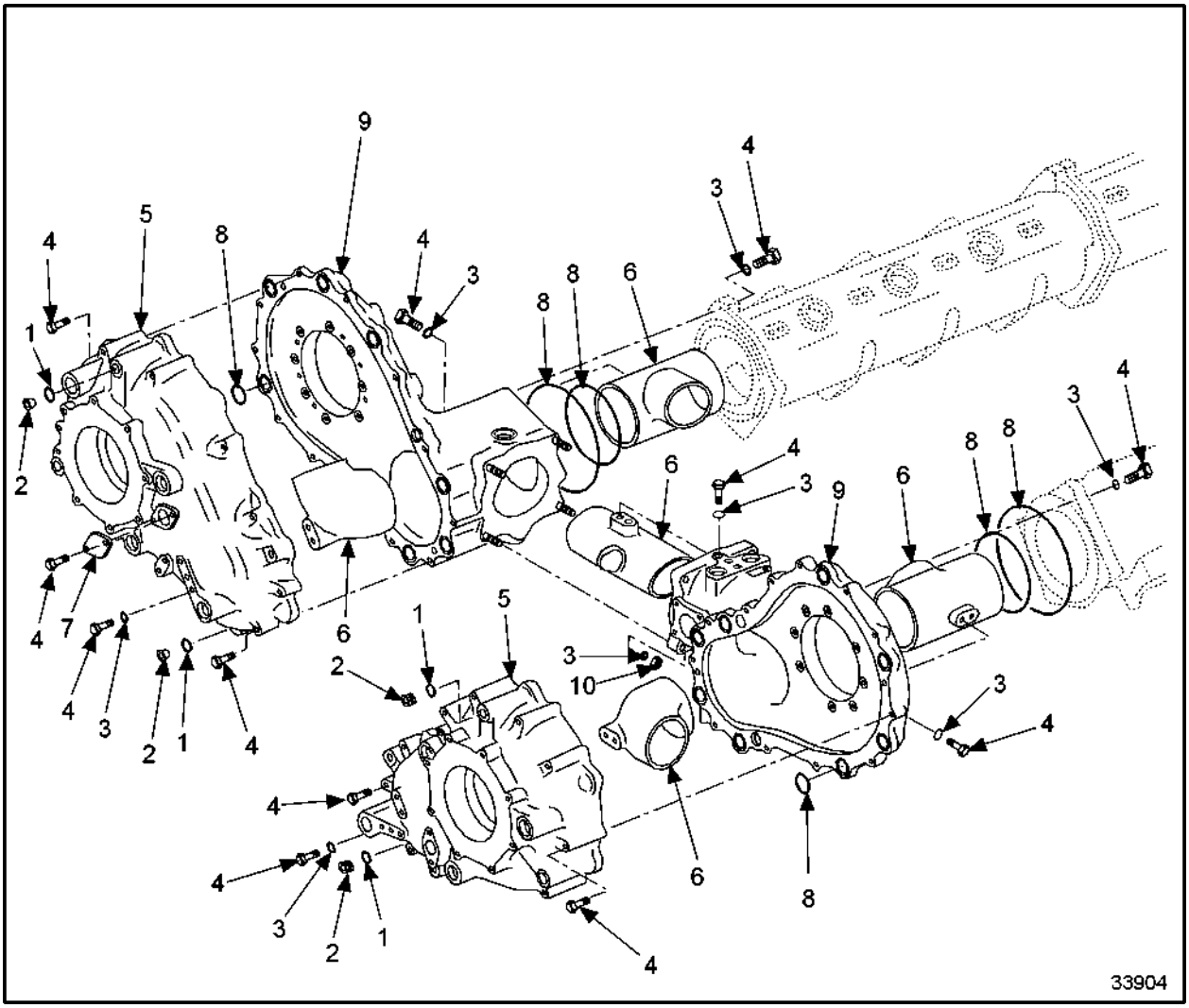
3 = The engine is to remain installed.

Table 73 After-Installation Operations

C 101.05 M – TURBOCHARGER (MARINE)

C 101.05.01 M – GENERAL VIEW

See Figure 622for a general view of the turbocharger (marine).



1. Sealing Ring
2. Plug
3. Washer
4. Bolt
5. Carrier Housing Cover
6. Exhaust Line
7. Cover
8. O-ring
9. Carrier Housing
10. Hex Nut

Figure 622 General View of Turbocharger Parts Location

C 101.05.04 M – BEFORE-REMOVAL OPERATIONS (MARINE)

Listed in Table 74are the Before-Removal Operations for the left intake housing (marine).

Level of Maintenance	Operation	Reference
1, 2, 3	Remove air system before exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove exhaust system after Y-pipe	Refer to section C 141.05.05
1, 2, 3	Remove intermediate element of charge air manifold on exhaust turbocharger	Refer to section C 124.05.05
1, 2, 3	Remove oil supply lines for turbocharger	Refer to section C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05
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.

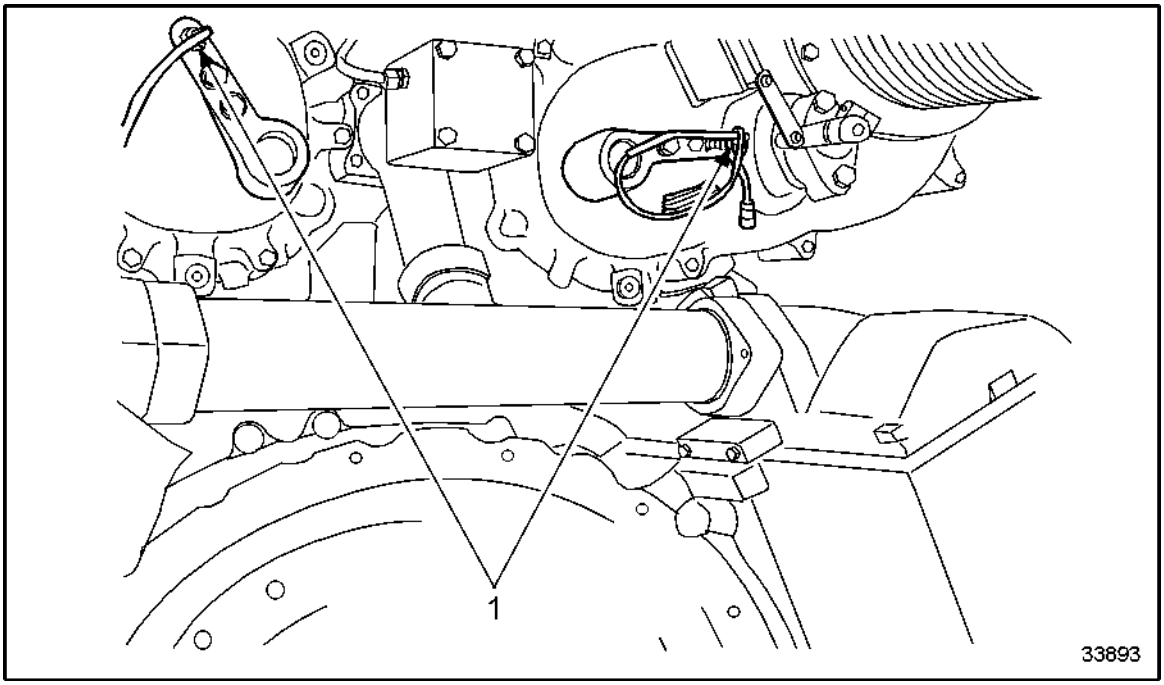
3 = The engine is to remain installed.

Table 74 Before-Removal Operations

C 101.05.05 M – REMOVAL OF THE TURBOCHARGER (MARINE)

Perform the following steps to remove the turbocharger:

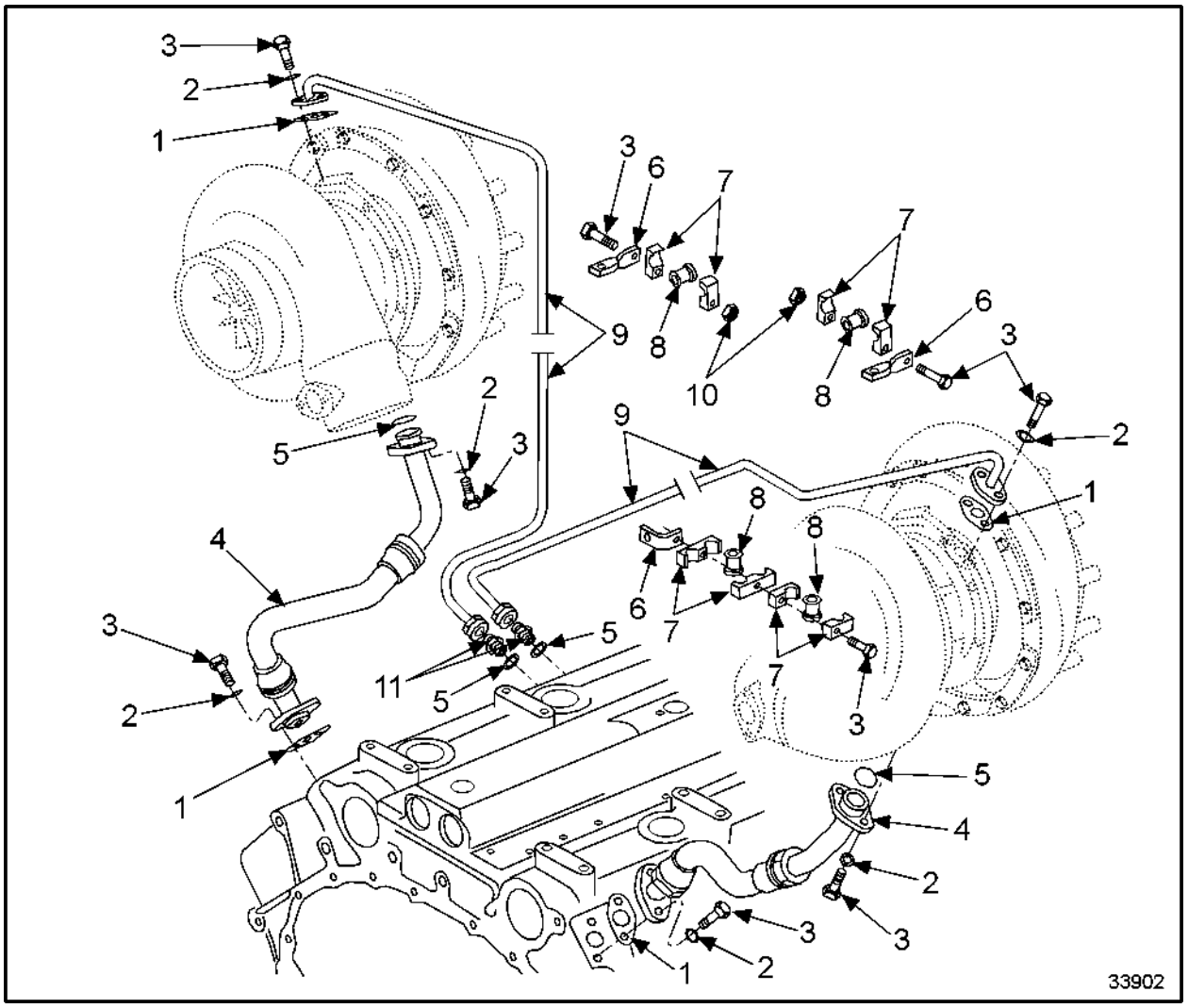
1. Remove the exhaust pyrometer (1) from the turbocharger housing. See Figure 623.



1. Exhaust Pyrometer

Figure 623 Removing Exhaust Pyrometer

2. Disconnect the turbocharger oil drain line. See Figure 624.

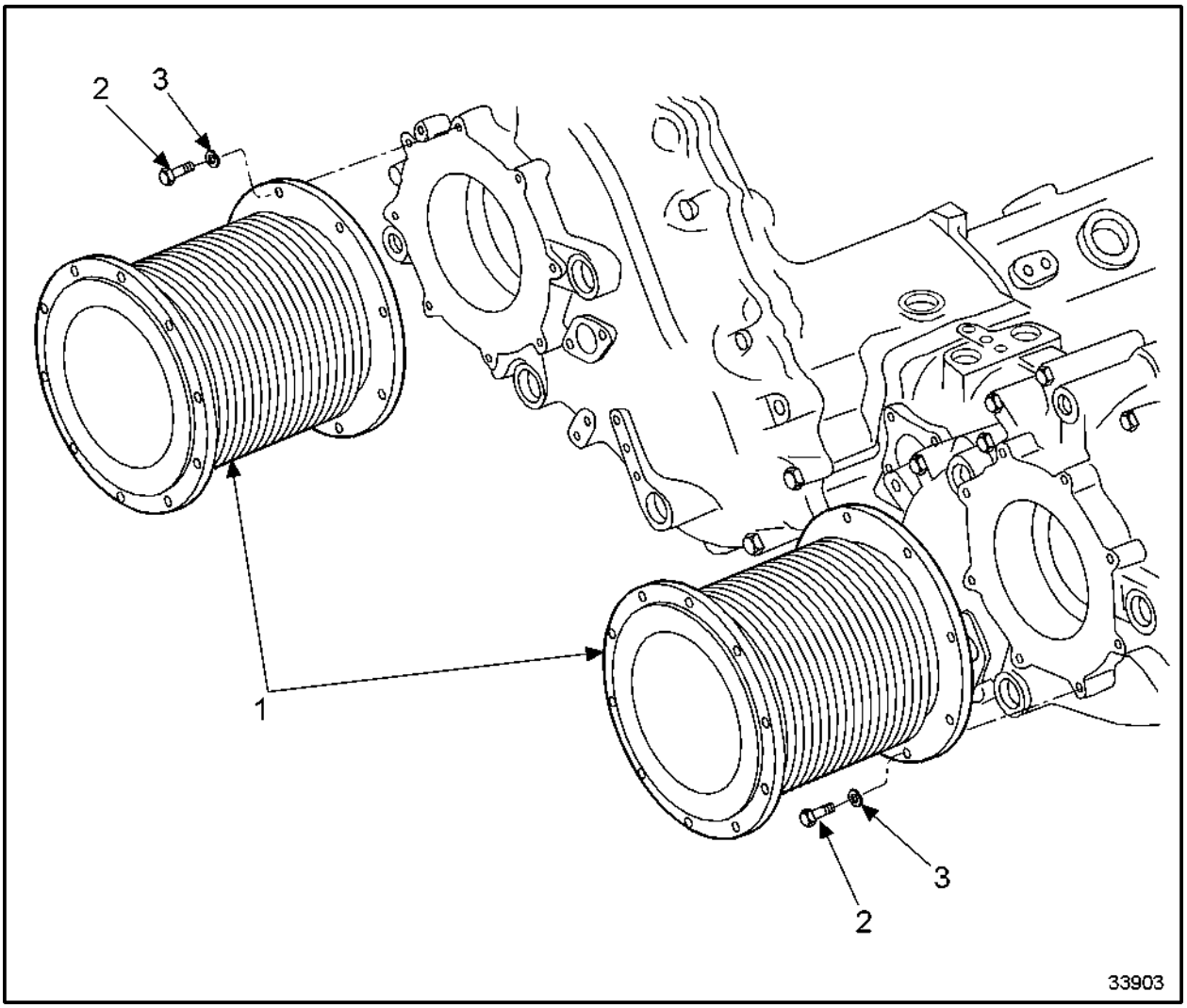


1. Gasket
2. Washer
3. Bolt
4. Hose
5. O-ring
6. Mounting Bracket
7. Half Clamp
8. Grommet
9. Pipe
10. Hex Nut
11. Adaptor

Figure 624 Removing Oil Drain and Feed Lines (Marine)

3. Disconnect the turbocharger oil feed lines. See Figure 624.

4. Remove bolts (2) and washers (3) securing the exhaust bellow to the turbocharger and remove the exhaust bellow (1). See Figure 625.

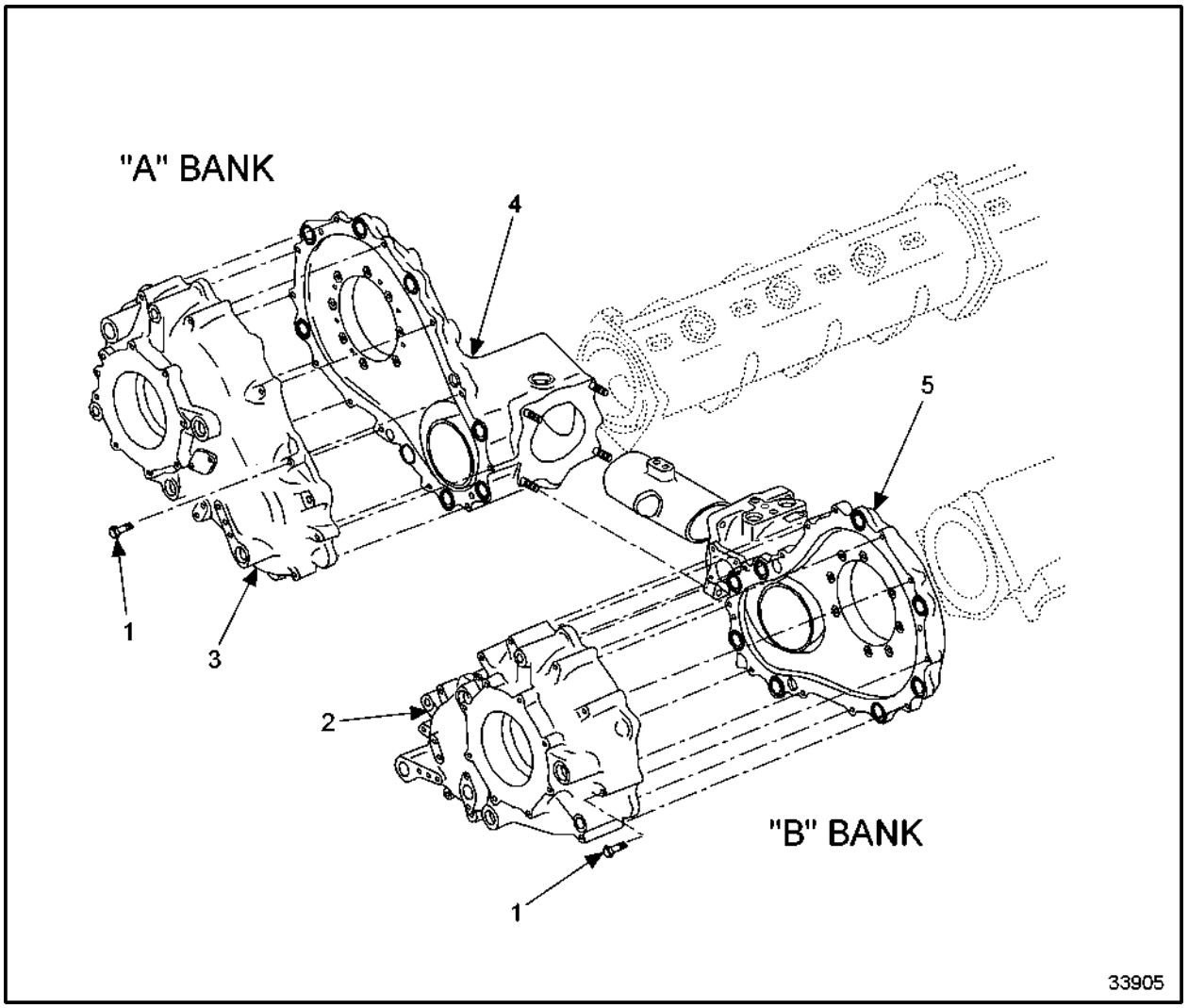


1. Exhaust Pipe Bellow
2. Bolt
3. Washer

Figure 625 Removing Exhaust Bellows (Marine)

5. Remove bolts (1) securing the left carrier housing (4) to the left rear turbocharger carrier housing (4) and remove the carrier housing. See Figure 626.

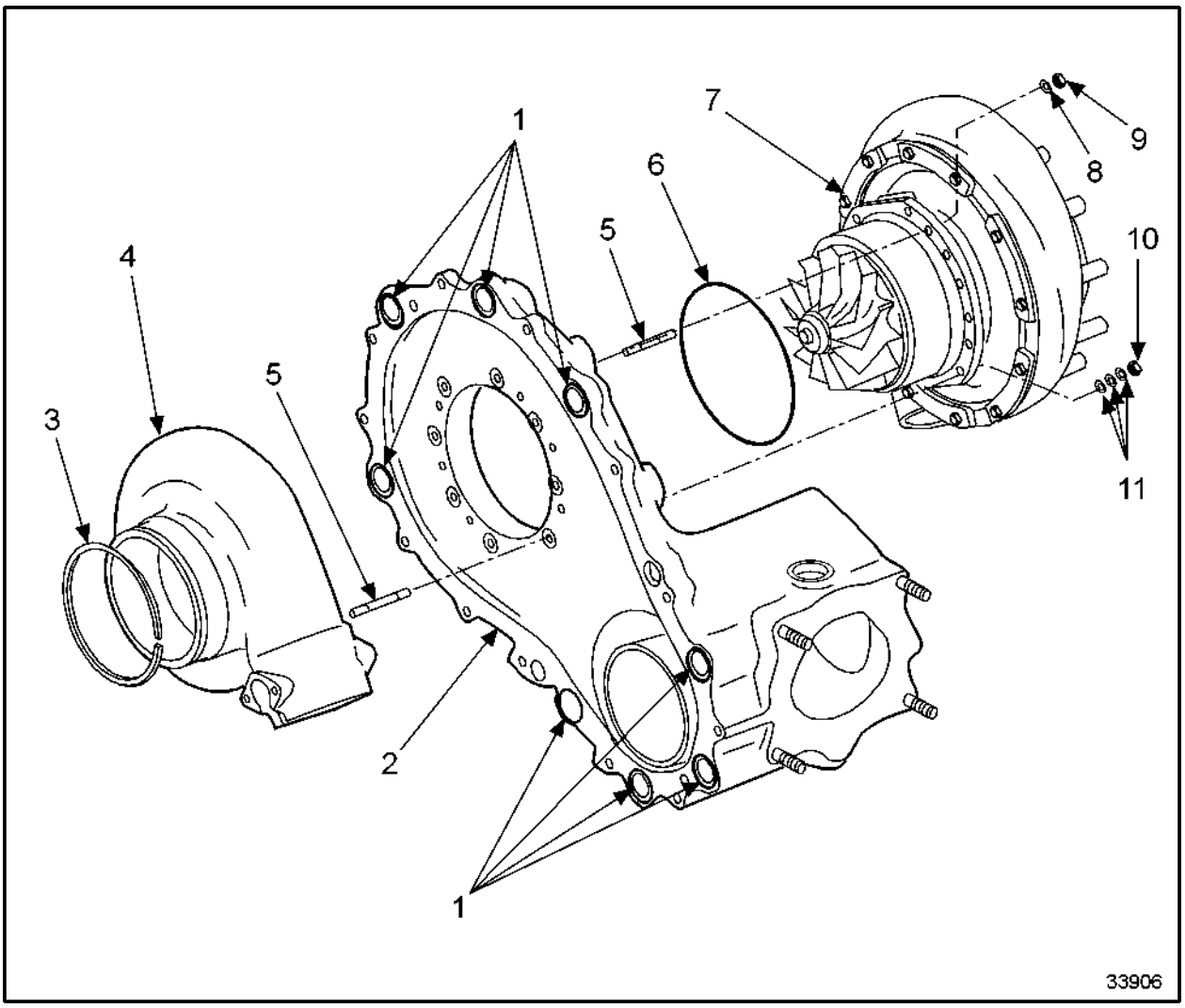
NOTE:
Label bolts for length for assembly.



1. Bolt
2. Right Front Turbocharger Carrier Housing
3. Left Front Turbocharger Carrier Housing
4. Left Rear Turbocharger Carrier Housing
5. Right Rear Turbocharger Carrier Housing

Figure 626 Removing Left Rear Turbocharger Carrier Housing (Marine)

6. Remove eight O-rings (1) from the rear carrier housing (2). See Figure 627.

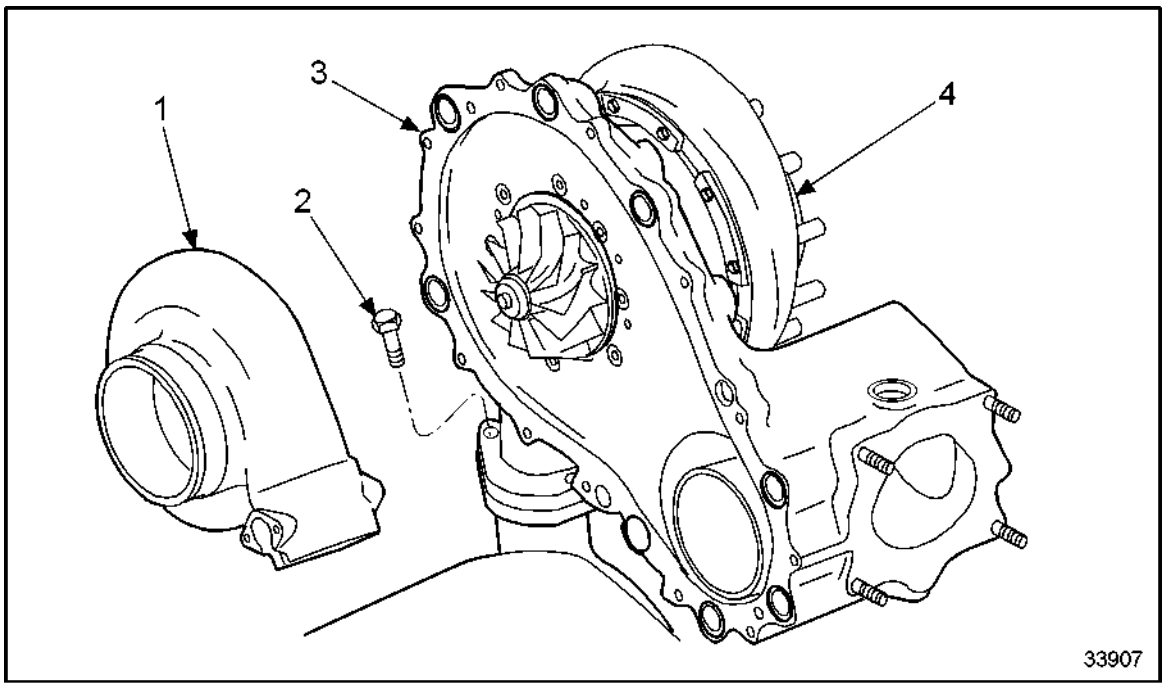


1. O-rings
2. Rear Carrier Housing
3. Snap Ring
4. Turbine Housing
5. Stud
6. O-ring
7. Turbocharger Compressor Housing
8. Washer
9. Hex Nut (10 mm - 6)
10. Hex Nut (8 mm - 8)
11. Tapered Washers

Figure 627 Removing Turbocharger Housing O-rings (Marine)

7. Remove eight 8 mm nuts (10) from the turbocharger compressor housing (7). See Figure 627.

8. Remove the turbine housing (1) from the turbocharger carrier housing (3). See Figure 628.

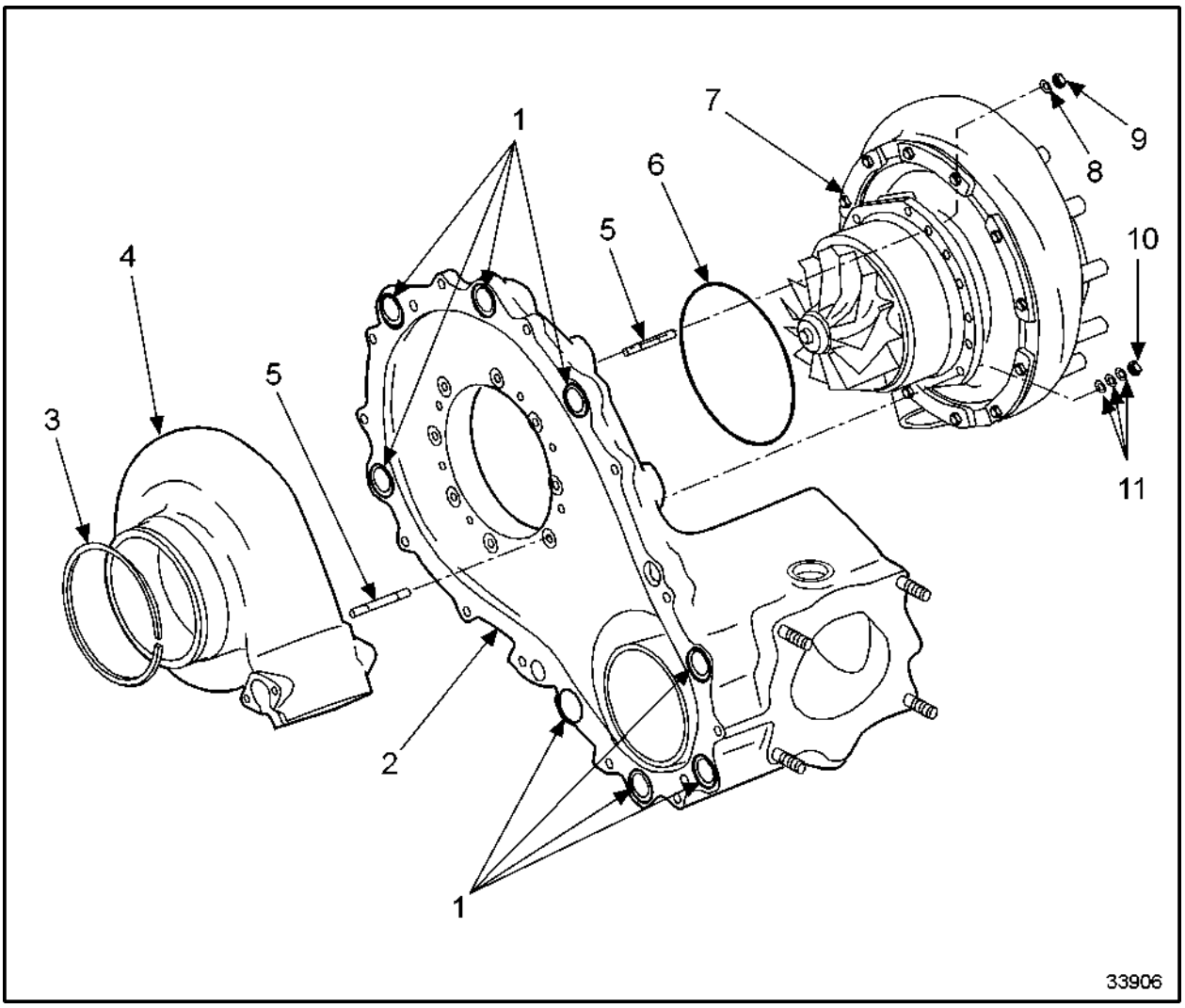


1. Turbine Housing
2. Bolt
3. Turbocharger Carrier Housing
4. Turbocharger Compressor Housing

Figure 628 Removing Turbine Housing (Marine)

9. Remove two bolts (2) securing the out-flange for the compressor to the turbocharger carrier housing (3). See Figure 628.
10. Remove six 10 mm nuts from the turbocharger carrier housing.
11. Slide the turbocharger assembly (4) forward to remove from the turbocharger carrier housing (3). See Figure 628.

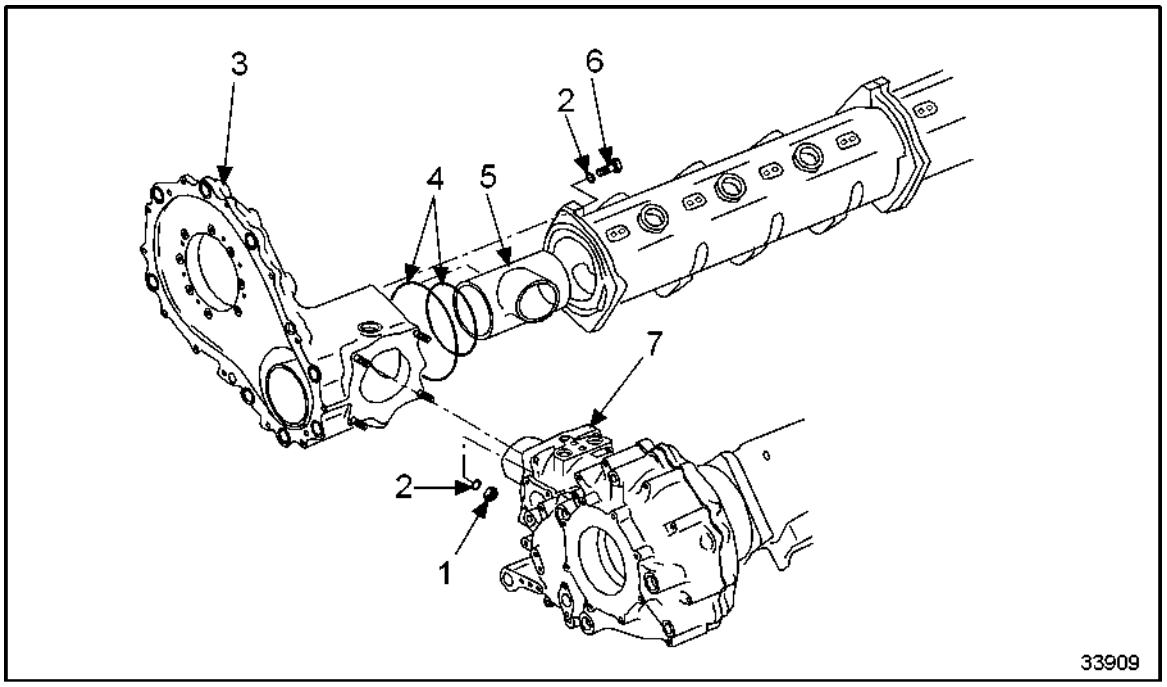
12. Remove O-ring (16) from the turbocharger compressor housing (7). See Figure 629.



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 629 Removing Turbocharger Housing O-rings (Marine)

13. Remove four bolts (6) and washers (2) securing the left turbocharger housing (3) to the exhaust manifold. See Figure 630.



1. Nut (10 mm)
2. Washer
3. Left Turbocharger Carrier Housing
4. O-rings
5. Exhaust Line
6. Bolt
7. Crossover

Figure 630 Removing Housing from Exhaust Manifold (Marine)

14. Remove four 10 mm nuts (1) securing the left turbocharger housing to the crossover (7). See Figure 630.
15. Remove O-rings (4) between the left turbocharger carrier housing (3) and the exhaust manifold. See Figure 630.

C 101.05.06 M – DISASSEMBLY OF THE TURBOCHARGER (MARINE)

Disassemble the turbocharger compressor housing as follows:

1. Refer to OEM guidelines for disassembly procedures.

C 101.05.08 M – INSPECTION AND REPAIR (MARINE)

Inspect and repair the turbocharger as follows:

1. Check turbocharger compressor housing for ease of movement.
2. Check axial clearance and gap clearance. Refer to OEM guidelines.
3. Visually check the turbocharger externally for damage, in particular in the area of the turbine and compressor wheels; replace the turbocharger if damage is found.
4. Clean and visually check all components for damage and defects; replace as necessary.
5. Visually check all sealing and seating surfaces for damage and surface irregularities; rub down with an oilstone or emery cloth as necessary.
6. Visually check studs for damage; replace studs as necessary.

C 101.05.10 M – ASSEMBLY OF THE TURBOCHARGER (MARINE)

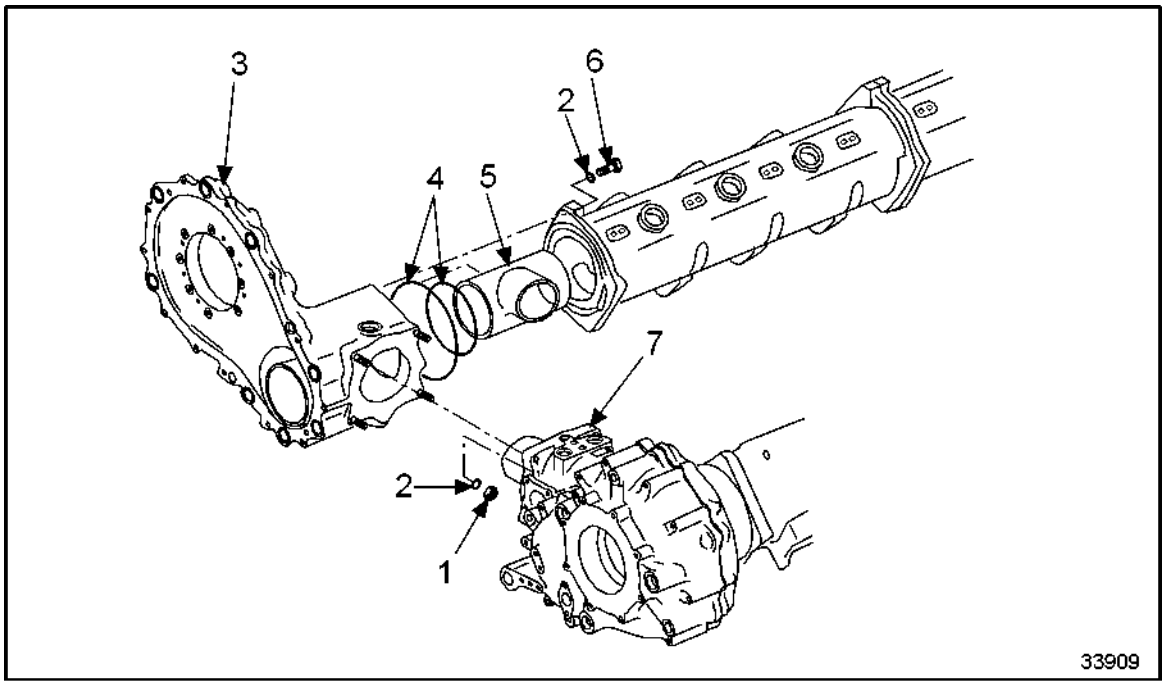
Assemble the turbocharger as follows:

1. Refer to OEM guidelines for assembly procedures.

C 101.05.11 M – INSTALLATION OF THE TURBOCHARGER (MARINE)

Perform the following steps to install the turbocharger:

1. Install new O-rings (4) between the left turbocharger carrier housing (3) and the exhaust manifold. See Figure 631.



1. Nut
2. Washer
3. Left Turbocharger Carrier Housing
4. O-rings
5. Exhaust Line
6. Bolt
7. Crossover

Figure 631 Installing Carrier Housing Components (Marine)

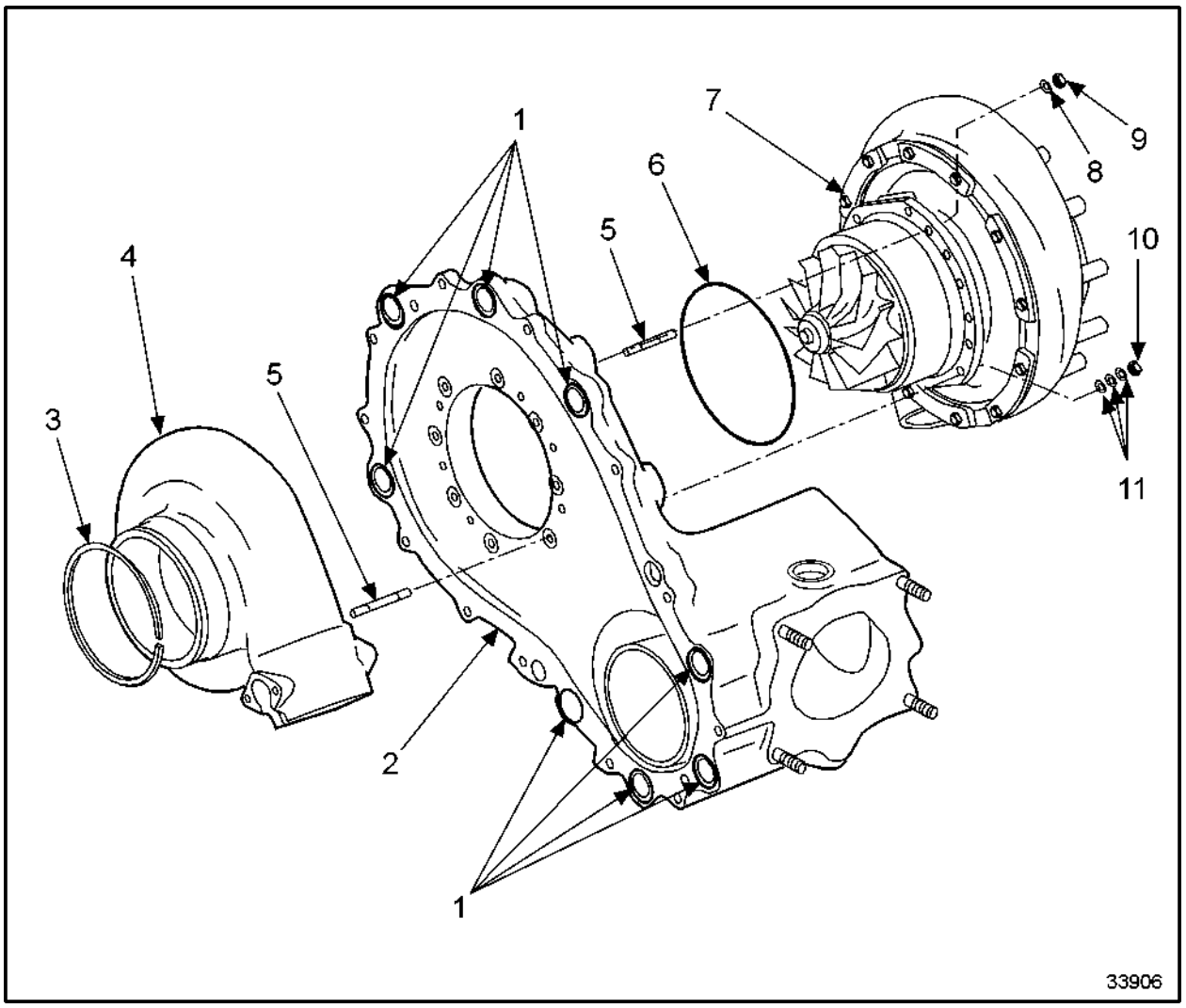
2. Coat the left turbocharger carrier housing-to-the-crossover with Loctite adhesive sealant. See Figure 631.
3. Install four 10 mm nuts (1) and washers (2) to secure the left turbocharger housing (3) to the crossover (7). Torque nuts to 72–84 N·m (53–62 lb·ft). See Figure 631.

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.

4. Install the left turbocharger carrier housing (3) to the exhaust manifold and secure with bolts (6) and washers (2). Torque bolts to 72–84 N·m (53–62 lb·ft). See Figure 631.
5. Coat the turbine housing surface with Loctite adhesive sealant.

6. Install new O-ring (6) onto the turbocharger compressor housing (7). See Figure 632.



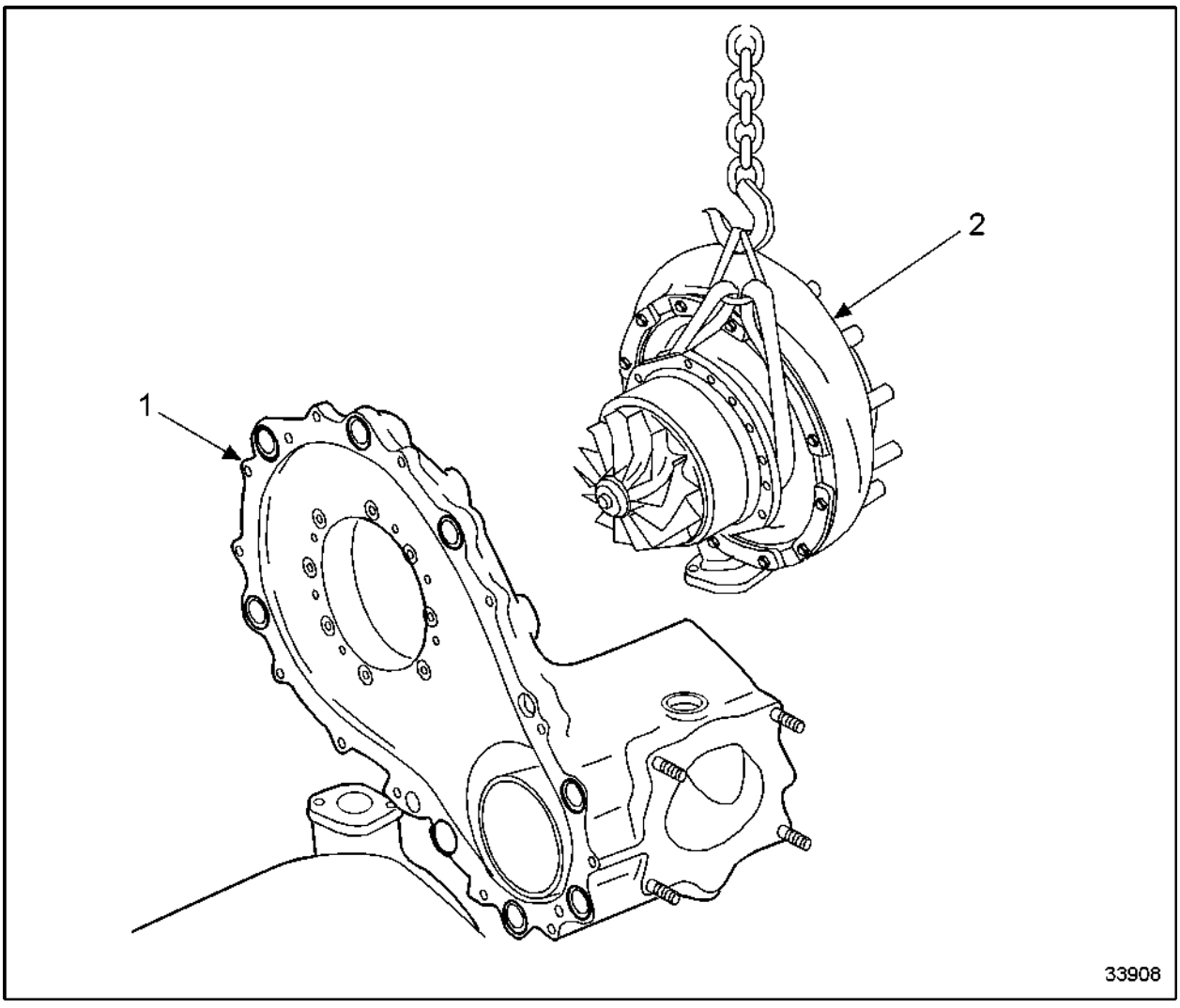
1. O-rings
2. Rear Carrier Housing
3. Snap Ring
4. Turbine Housing
5. Stud
6. O-ring
7. Turbocharger Compressor Housing
8. Washer
9. Hex Nut (10 mm - 6)
10. Hex Nut (8 mm - 8)
11. Tapered Washers

Figure 632 Installing Turbocharger Compressor Housing O-ring (Marine)

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.

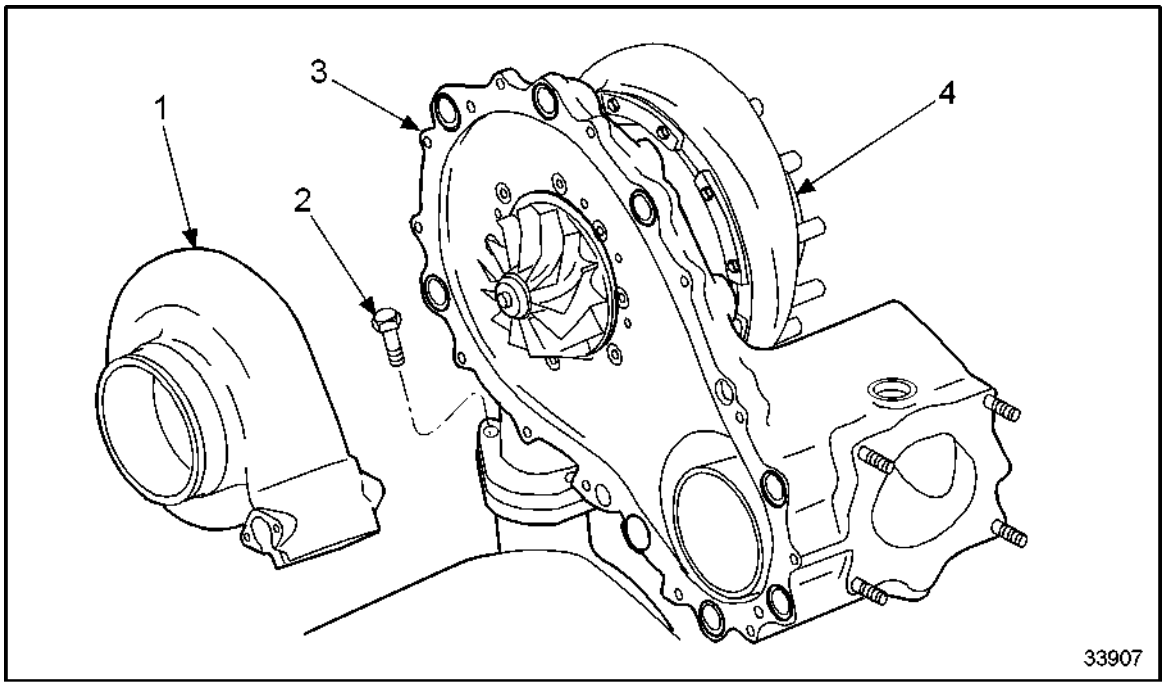
7. Using a suitable lifting device, see Figure 633, install the turbocharger compressor assembly (2) into the turbocharger carrier housing (1) and secure with washers (8) and nuts (9). Torque nuts to 42 N·m (31 lb·ft). See Figure 632.



1. Turbocharger Carrier Housing
2. Turbocharger Compressor Assembly

Figure 633 Installing Turbocharger Compressor Assembly (Marine)

8. Install bolts (2) to secure the compressor-out-flange to the turbocharger carrier housing (3). Torque bolts to 21–24 N·m (15–17 lb·ft). See Figure 634.



1. Turbine Housing
2. Bolt
3. Turbocharger Carrier Housing
4. Turbocharger Compressor Housing

Figure 634 Installing Compressor-out-Flange (Marine)

9. Rotate the turbine in a counterclockwise direction to a stopped position; mark the position. See Figure 635.

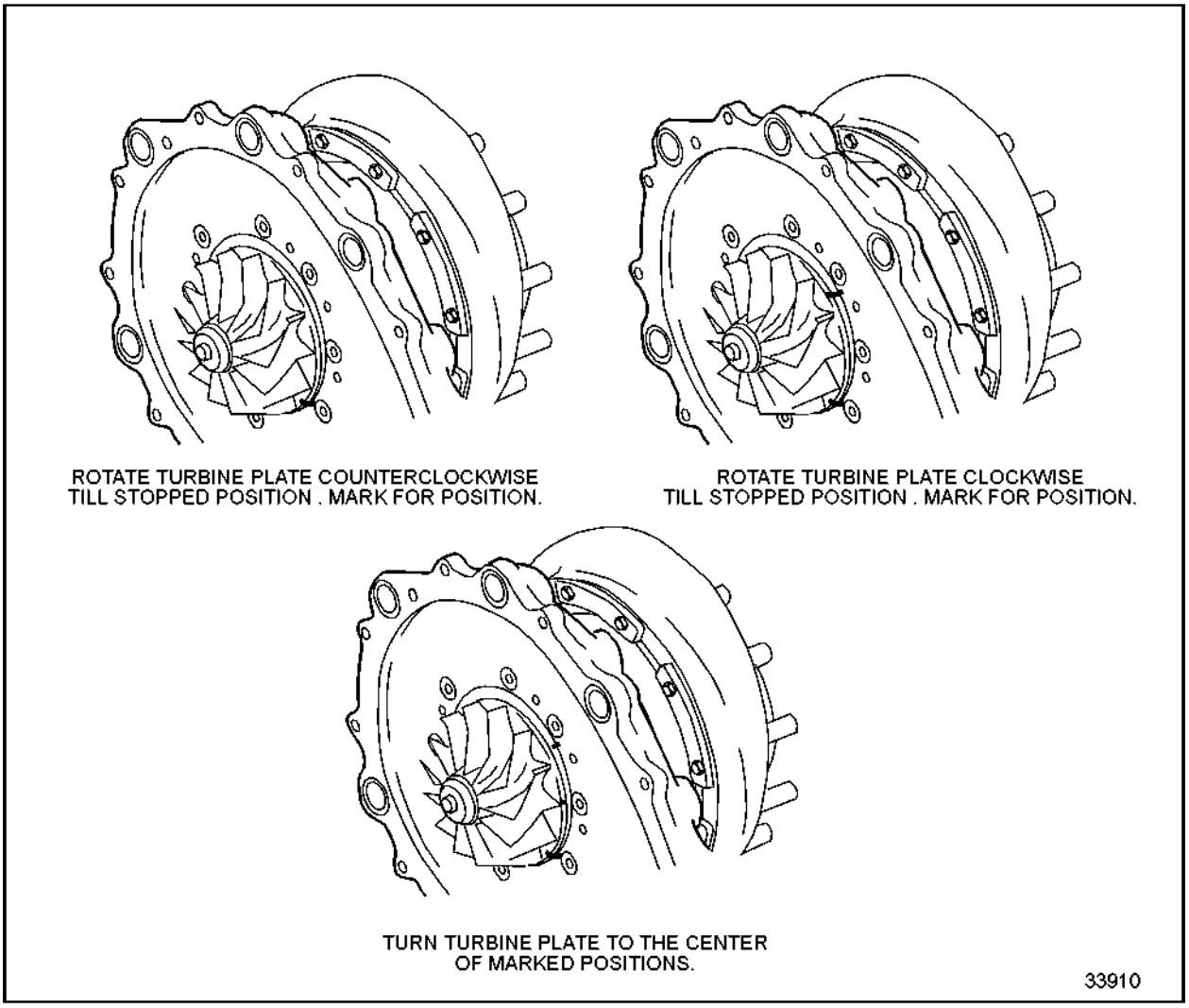
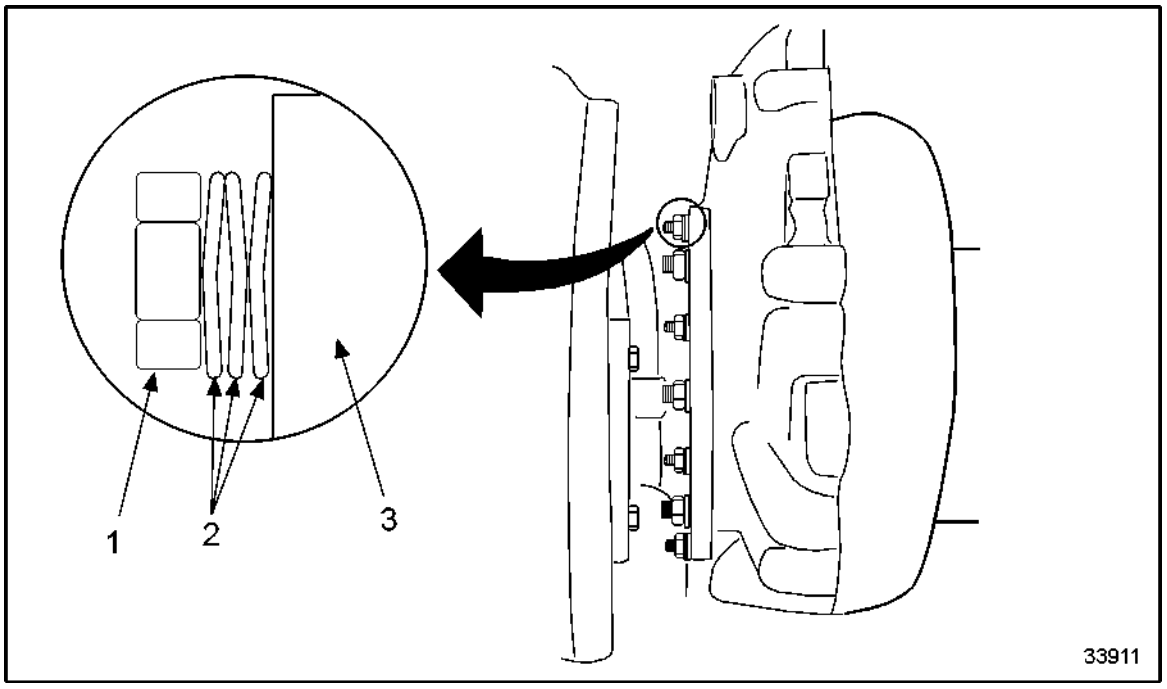


Figure 635 Marking Turbine Plate for Position (Marine)

10. Rotate the turbine plate in clockwise direction to stopped position; mark the position. Turn turbine plate to the center of the marked positions. See Figure 635.

NOTICE
Ensure that the tapered washers are positioned correctly per the installation instructions to avoid damage to the turbocharger.

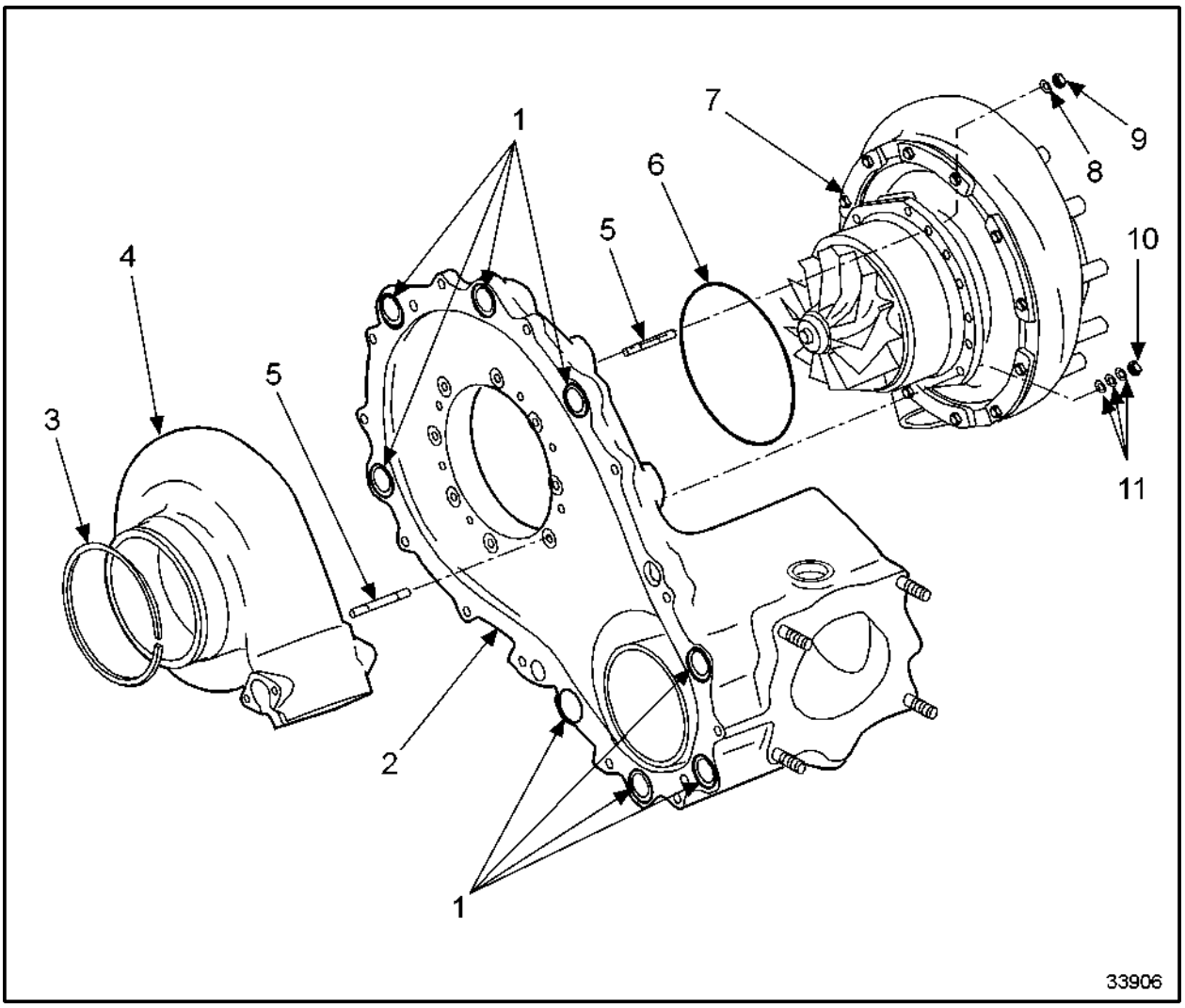
11. Install the turbine housing to the turbocharger carrier housing and secure with nuts (8) and washers (2). Torque nuts to 24 N·m (18 lb·ft). See Figure 636.



1. Nut, 8 mm
2. Tapered Washers
3. Center Housing

Figure 636 Installing Turbine Housing (Marine)

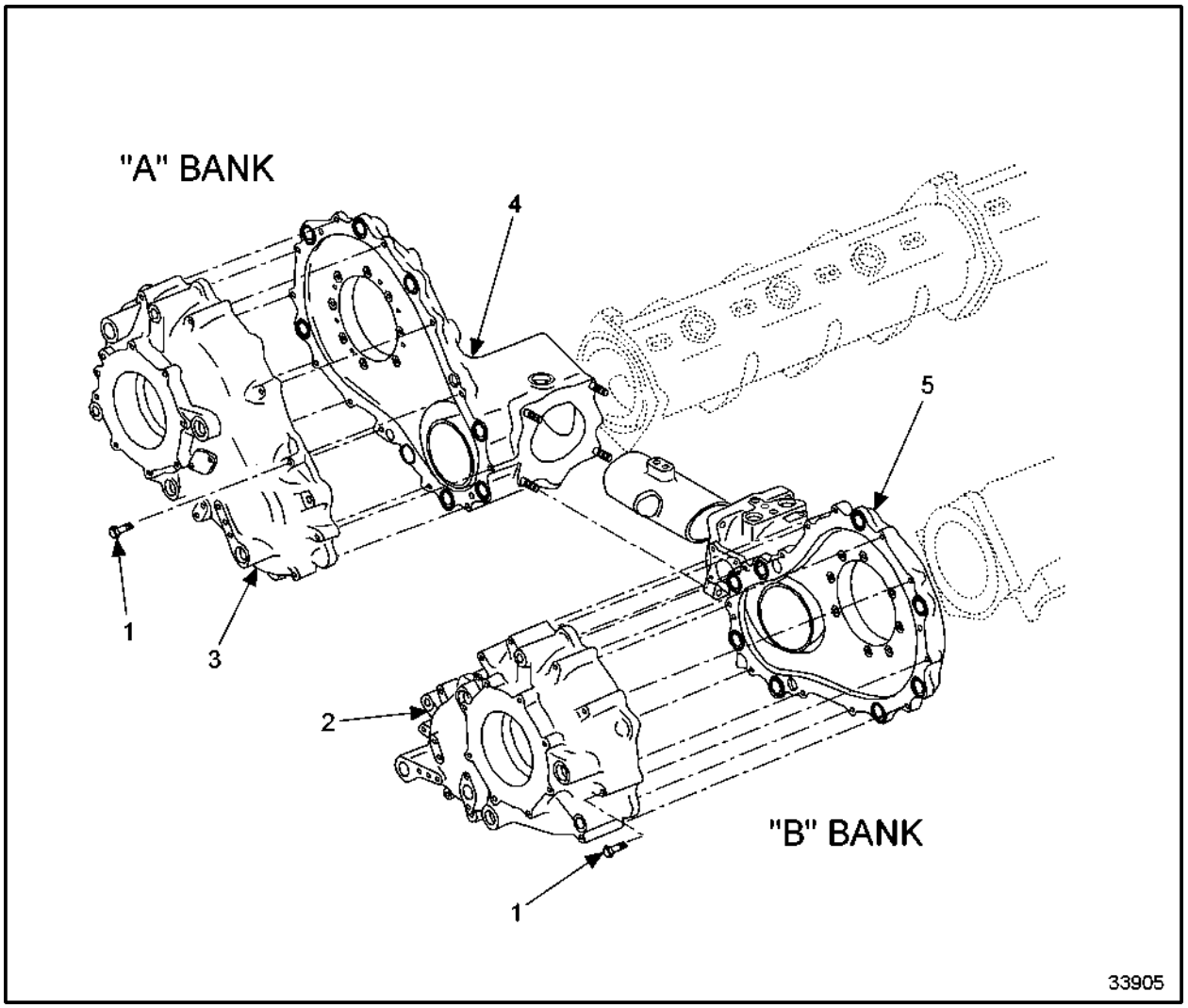
12. Install new O-rings (1) to the rear carrier housing (2). See Figure 637.



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)

13. Install guide studs for installation of the left front turbocharger carrier housing (4). See Figure 638.



1. Bolt
2. Right Front Turbocharger Carrier Housing
3. Left Front Turbocharger Carrier Housing
4. Left Rear Turbocharger Carrier Housing
5. Right Rear Turbocharger Carrier Housing

Figure 638 Installing Turbocharger Carrier Housing (Marine)

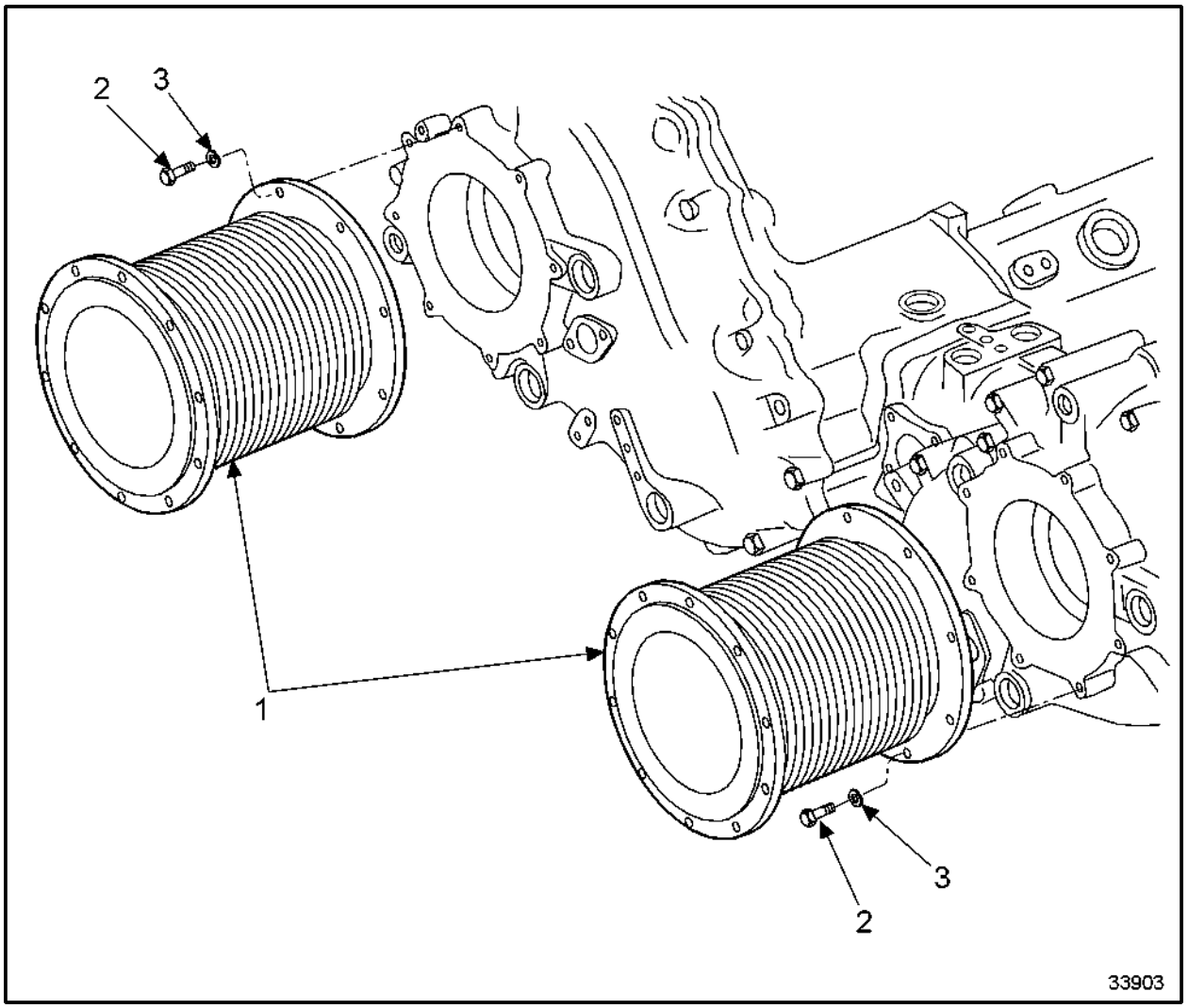
14. Coat the left front turbocharger carrier housing with Loctite adhesive sealant.

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.

15. Using a suitable lifting device, install the left front turbocharger carrier housing (3) to the left rear turbocharger carrier housing (4) and secure with bolts (1). Torque bolts to 42–47 N·m (31–35 lb·ft). See Figure 638.

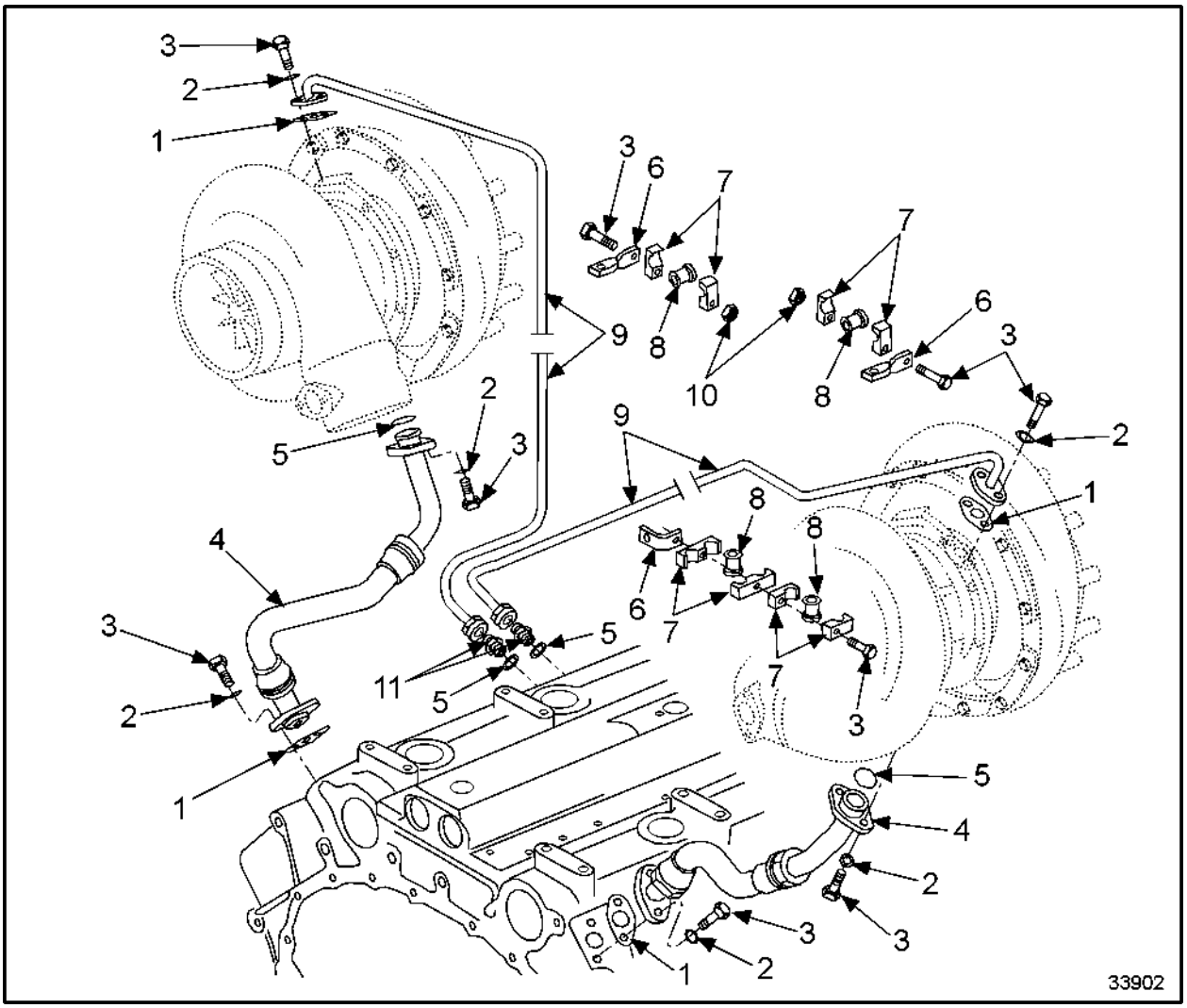
16. Install the exhaust bellow (1) to the turbocharger and secure with washers (3) and bolts (2). Torque bolts to 42–47 N·m (31–35 lb·ft). See Figure 639.



1. Exhaust Pipe Bellow
2. Bolt
3. Washer

Figure 639 Installing Exhaust Bellows (Marine)

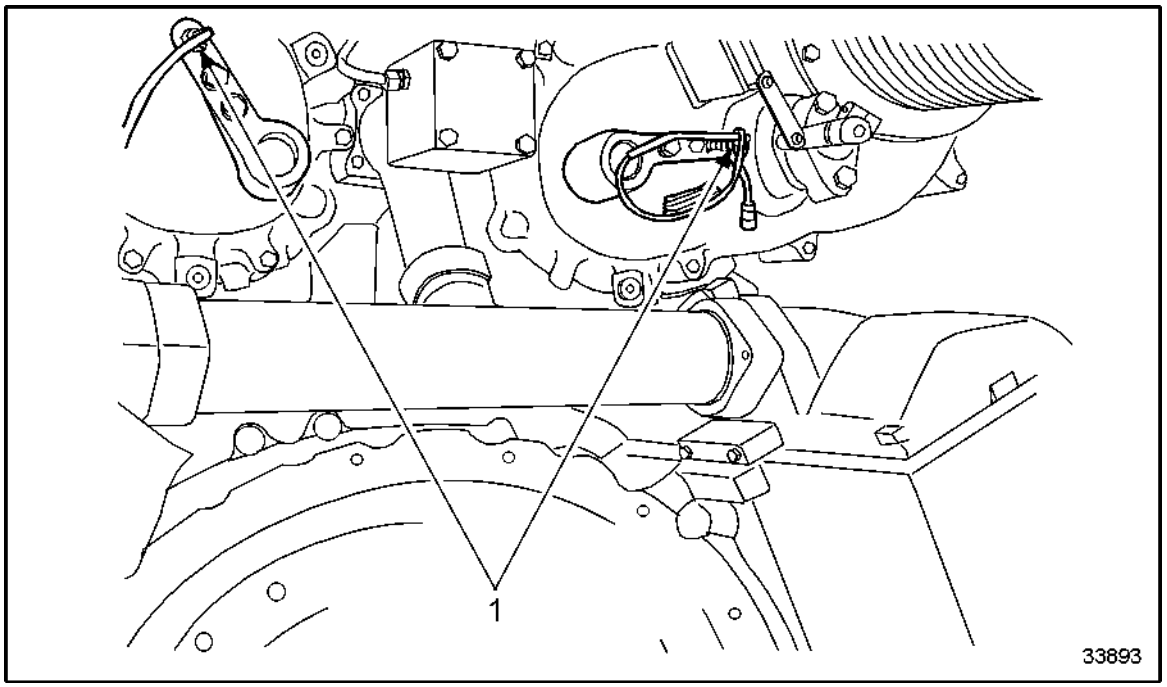
17. Connect the turbocharger oil feed lines. Torque bolts to 42–47 N·m (31–35 lb·ft). See Figure 640.



1. Gasket
2. Washer
3. Bolt
4. Hose
5. O-ring
6. Mounting Bracket
7. Pipe Clamp Half
8. Grommet
9. Pipe
10. Hex Nut
11. Adaptor

Figure 640 Installing Oil Drain and Feed Lines (Marine)

18. Connect the turbocharger oil drain line. Torque bolts to 42–47 N·m (31–35 lb·ft). See Figure 640.
19. Install the exhaust pyrometer (1) to the turbocharger housing. See Figure 641.



1. Exhaust Pyrometer

Figure 641 Installing Exhaust Pyrometer (Marine)

C 101.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 75are the After-Installation Operations for the left intake housing (“A” bank).

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine start	Refer to Operators Guide
1, 2, 3	Install oil supply lines for turbochargers	Refer to section C 187.05.11
1, 2, 3	Install oil return lines for turbochargers	Refer to section C 188.05.11
1, 2, 3	Install intermediate charge air element of manifold on exhaust turbocharger.	Refer to section C 124.05.11
1, 2, 3	Install exhaust system after Y-pipe	Refer to section C 141.05.11
1, 2, 3	Install air system before exhaust turbocharger	Refer to section C 101.05.11

1 = The engine is to be completely disassembled.

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

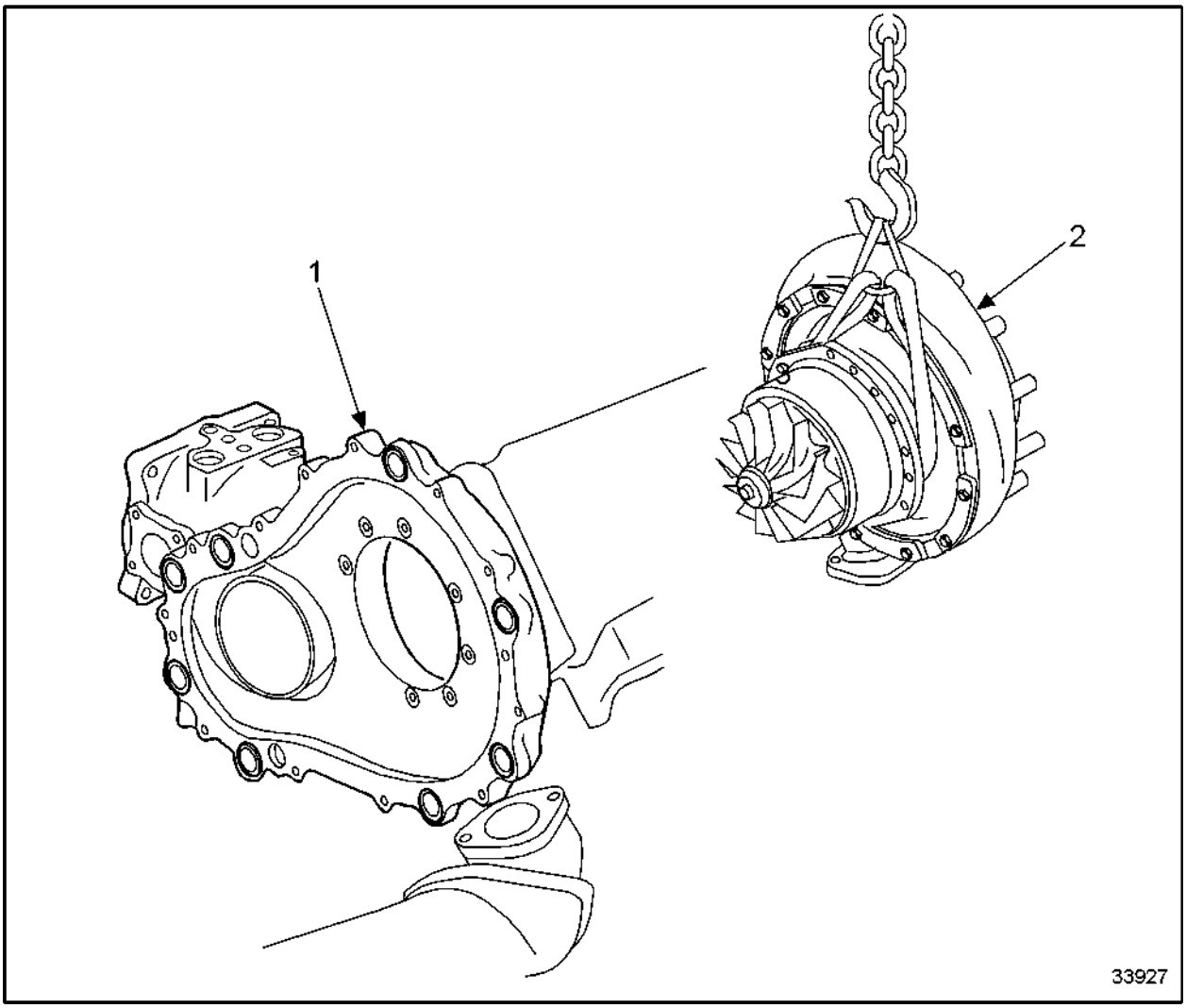
3 = The engine is to remain installed.

Table 75 After-Installation Operations

C 103.05 M – MARINE TURBOCHARGER ACTUATOR

C 103.05.01 M – GENERAL VIEW

See Figure 642 for a general view of the turbocharger actuator (marine).



1. Bushing
2. Bolt
3. Shaft
4. Exhaust Flap
5. Shaft
6. Sealing Ring
7. Sealing Flange
8. Nut
9. Washer
10. Lever
11. Spacer
12. Actuator Rod
13. Spring Pin
14. Mounting Bracket
15. Actuator Cylinder

Figure 642 General View of Turbocharger Actuator (Marine)

C 103.05.04 M – BEFORE – REMOVAL OPERATIONS

Listed in Table 76are the Before – Removal Operations for turbocharger actuator (marine).

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.

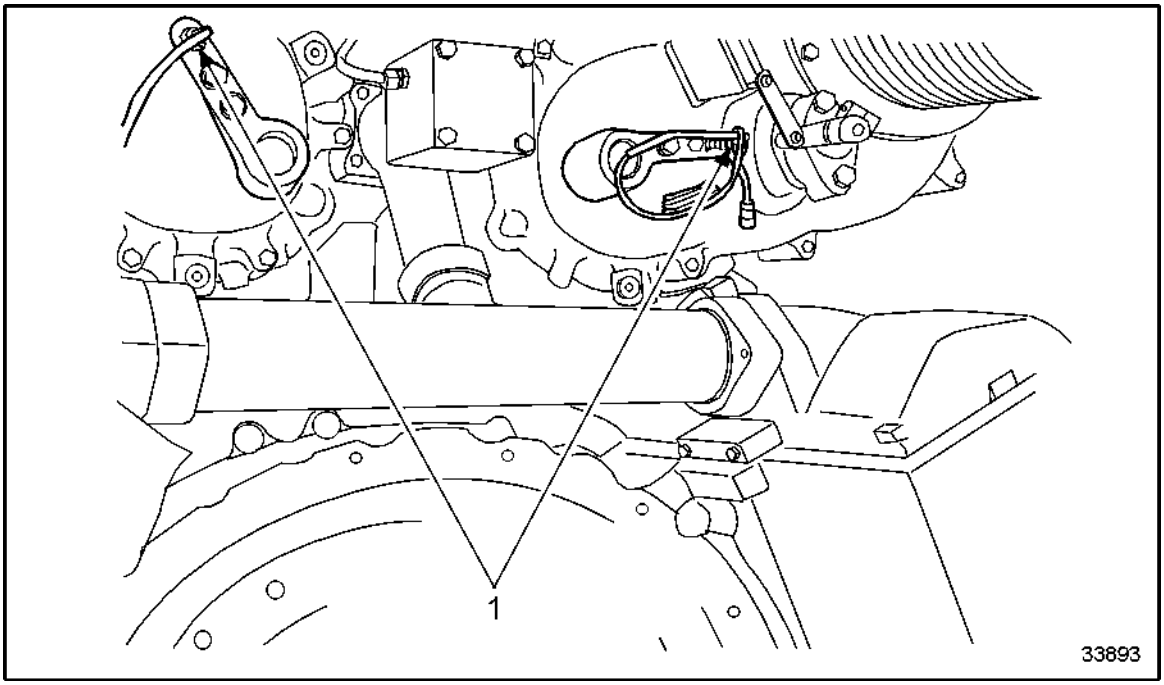
3 = The engine is to remain installed.

Table 76 Before – Removal Operation

C 103.05.05 M – REMOVAL OF TURBOCHARGER ACTUATOR (MARINE)

Perform the following steps to remove the turbocharger actuator:

1. Disconnect the pyrometer wiring harness. See Figure 643.

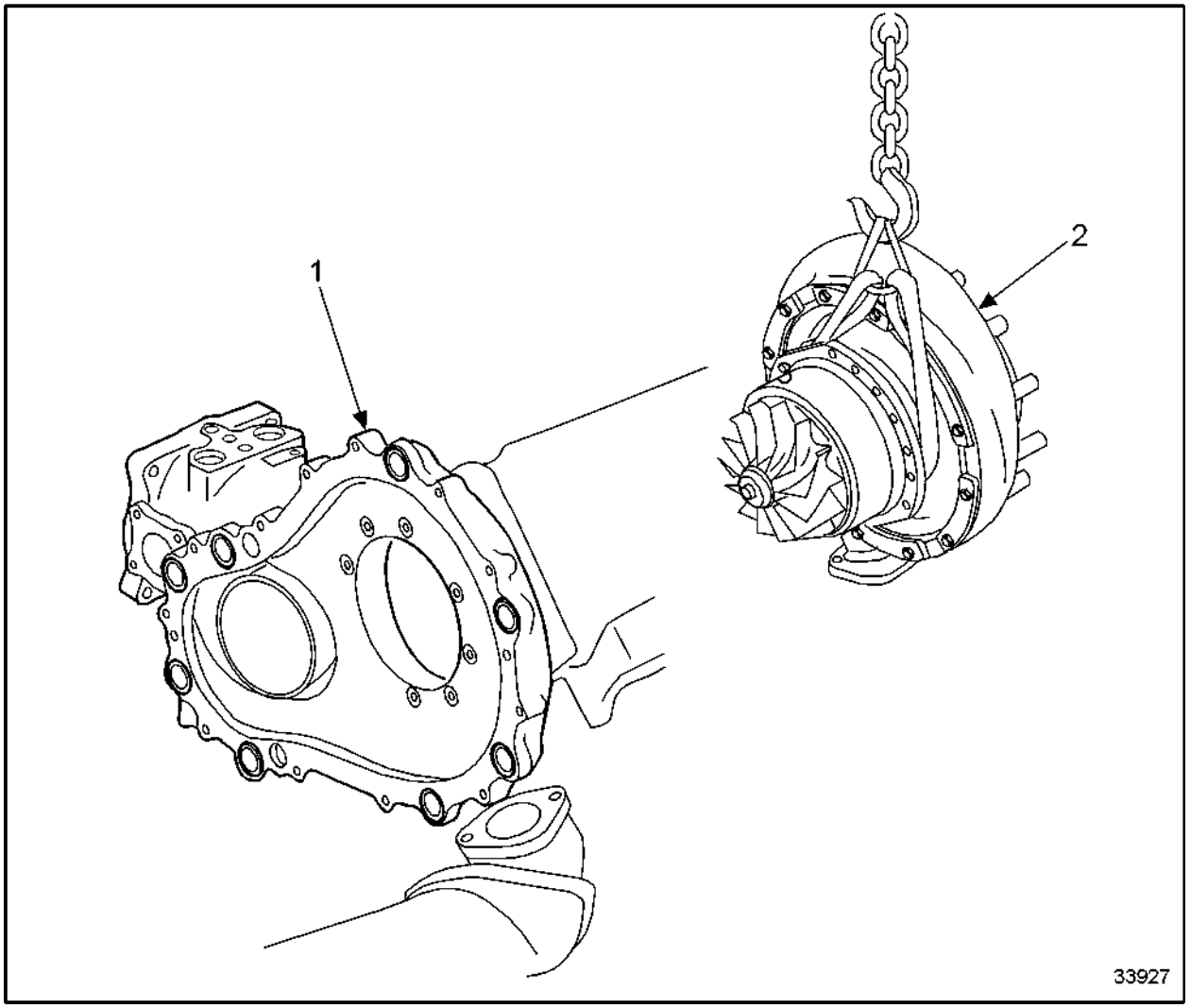


1. Exhaust Pyrometer

Figure 643 Removing Exhaust Pyrometer and Supply Line (Marine)

2. Remove the exhaust pyrometer (1) from the turbocharger. See Figure 643.
3. Disconnect the oil supply lines; refer to section C 186.05.01.

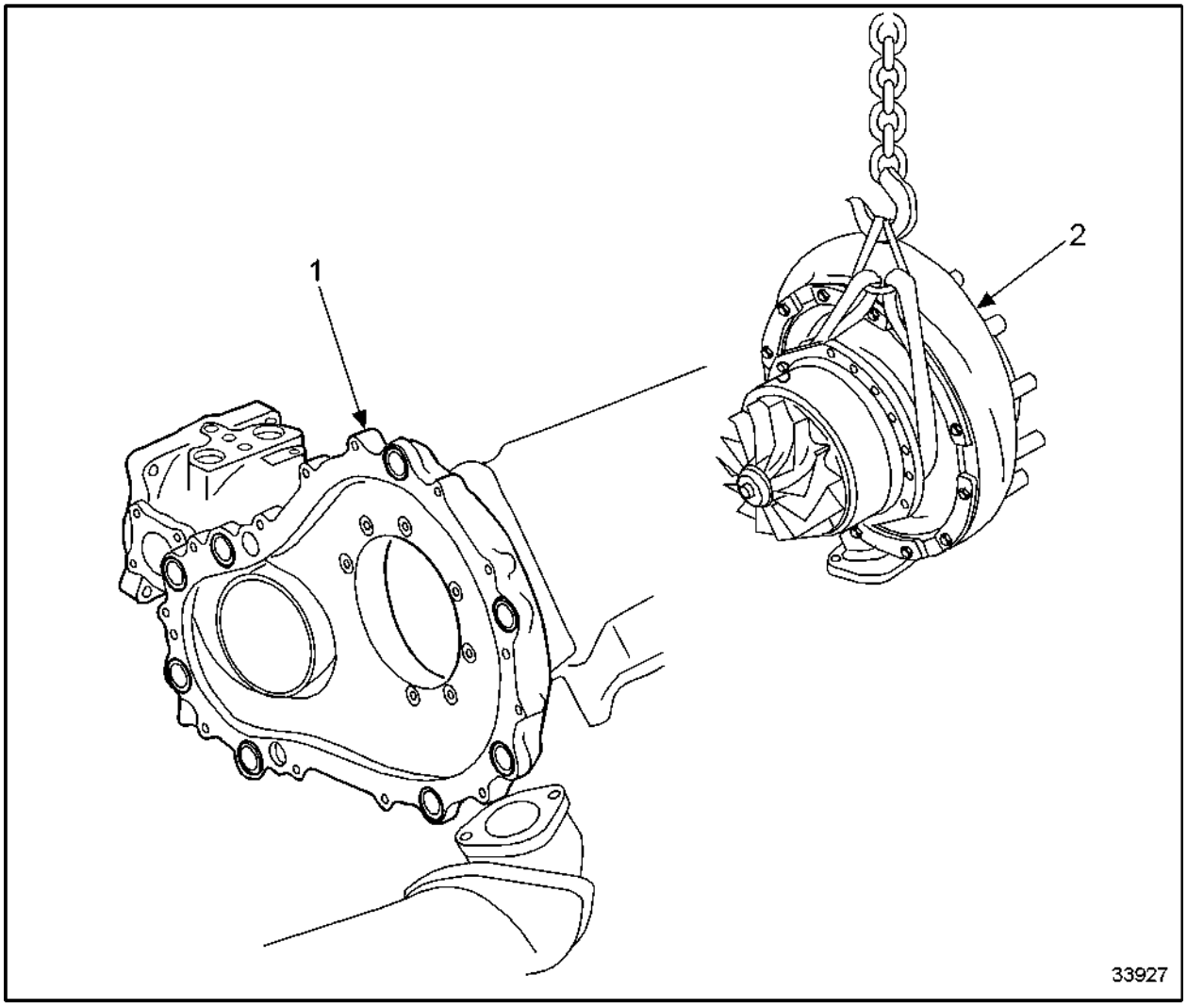
4. Remove nuts (8), washers (9), spacer (11), and bolts (2) securing the actuating rod (12) to lever (10). See Figure 644.



1. Bushing
2. Bolt
3. Shaft
4. Exhaust Flap
5. Shaft
6. Sealing Ring
7. Sealing Flange
8. Nut
9. Washer
10. Lever
11. Spacer
12. Actuator Rod
13. Spring Pin
14. Mounting Bracket
15. Actuator Cylinder

Figure 644 Removing Turbocharger Actuator (Marine)

5. Remove bolt (2), spacer (11), washer (9), and nut (8) and remove the actuator rod (12) from the actuator cylinder (15). See Figure 644.
6. Remove bolts (2) securing mounting bracket (14) to the turbocharger and remove the mounting bracket. See Figure 644.
7. Remove bolts (2) securing the actuator cylinder (15) to the mounting bracket (14) and remove the actuator. See Figure 645.



1. Bushing
2. Bolt
3. Shaft
4. Exhaust Flap
5. Shaft
6. Sealing Ring
7. Sealing Flange
8. Nut
9. Washer
10. Lever
11. Spacer
12. Actuator Rod
13. Spring Pin
14. Mounting Bracket
15. Actuator Cylinder

Figure 645 Removing Turbocharger Actuator (Marine)

C 103.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the turbocharger actuator:

NOTE:
Ensure that all components are perfectly clean.

CAUTION:

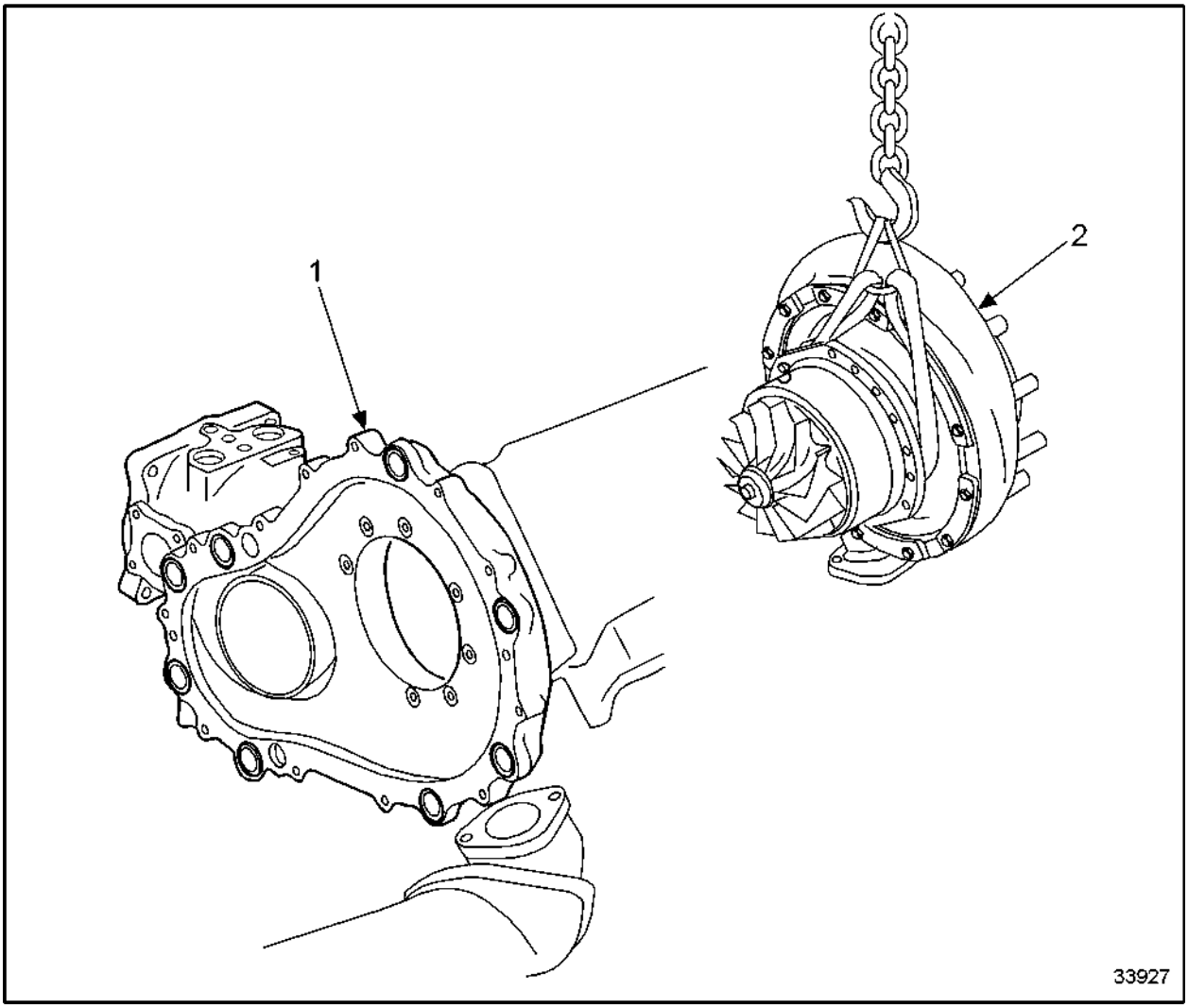
To avoid personal injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

1. Clean all components using diesel fuel and blow dry with compressed air.
2. Visually inspect mounting bracket for wear, cracks and damage.
   [a] If mounting bracket shows wear, cracks or damage, recondition or replace as necessary.
   [b] If mounting bracket does not show wear, cracks or damage, continue inspection.
3. Visually inspect actuating cylinder for function and condition.
   [a] If actuating cylinder does not function or is in poor condition, replace component.
   [b] If actuating cylinder does function or is in good condition, continue inspection.

C 103.05.11 M – INSTALLATION OF TURBOCHARGER ACTUATOR (MARINE)

Perform the following steps to install the turbocharger actuator:

1. Install the actuator cylinder (15) to the mounting bracket (14) and secure with bolts (2). Torque bolts to specification. Refer to section A 003. See Figure 646.

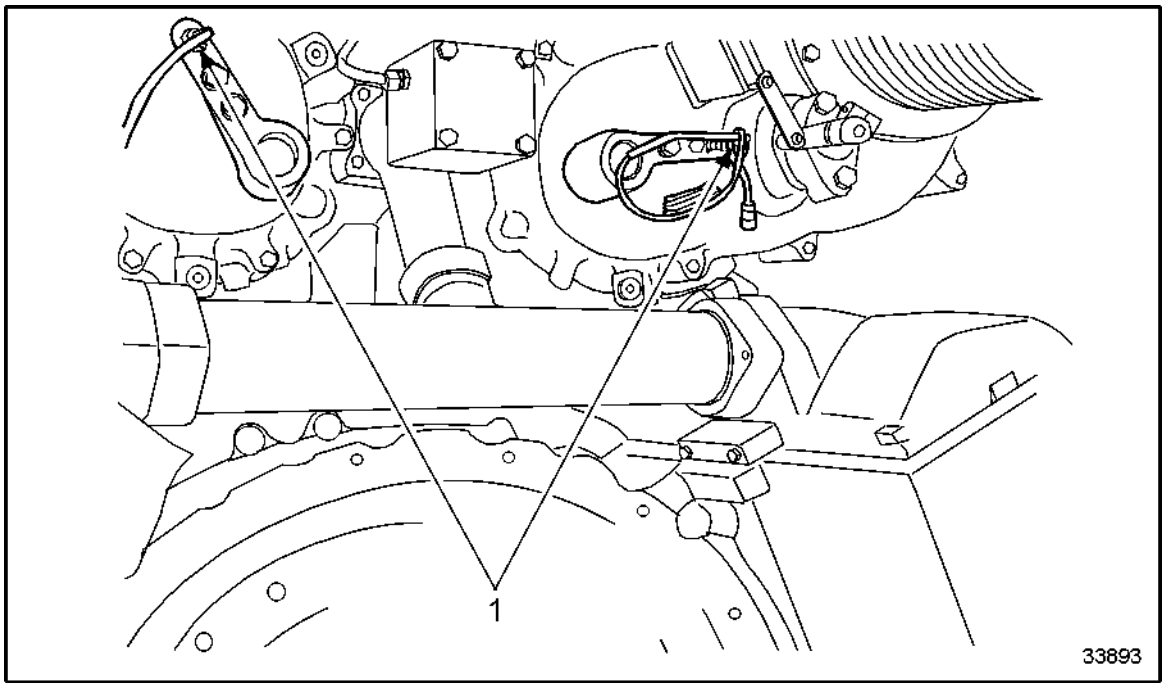


1. Bushing
2. Bolt
3. Shaft
4. Exhaust Flap
5. Shaft
6. Sealing Ring
7. Sealing Flange
8. Nut
9. Washer
10. Lever
11. Spacer
12. Actuator Rod
13. Spring Pin
14. Mounting Bracket
15. Actuator Cylinder

Figure 646 Installing Turbocharger Actuator (Marine)

2. Install the mounting bracket (14) to the turbocharger and secure using bolts (2). Torque bolts to specification. Refer to section A 003. See Figure 646.
3. Install actuator rod (12) to lever (10) and secure with bolts (2), spacer (11), washers (9), and nuts (8). Torque bolts to specification. Refer to sectionA 003. See Figure 646.

4. Install actuator rod (12) to actuator cylinder (15) and secure with bolts (2), spacer (11), washers (9), and nuts (8). Torque bolts to specification. Refer to section A 003. See Figure 646.
5. Connect oil supply lines; refer to section C 187.05.11.
6. Install the pyrometer (1) to the turbocharger. See Figure 647.



1. Exhaust Pyrometer

Figure 647 Installation of Pyrometer (Marine)

7. Install the pyrometer wiring harness. See Figure 647.

C 103.05.12 M – AFTER – INSTALLATION OPERATIONS (MARINE)

Listed in Table 77are the After – Installation Operation for the turbocharger actuator (marine).

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine start	Refer to Operator's Guide

1 = The engine is to be completely disassembled.

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

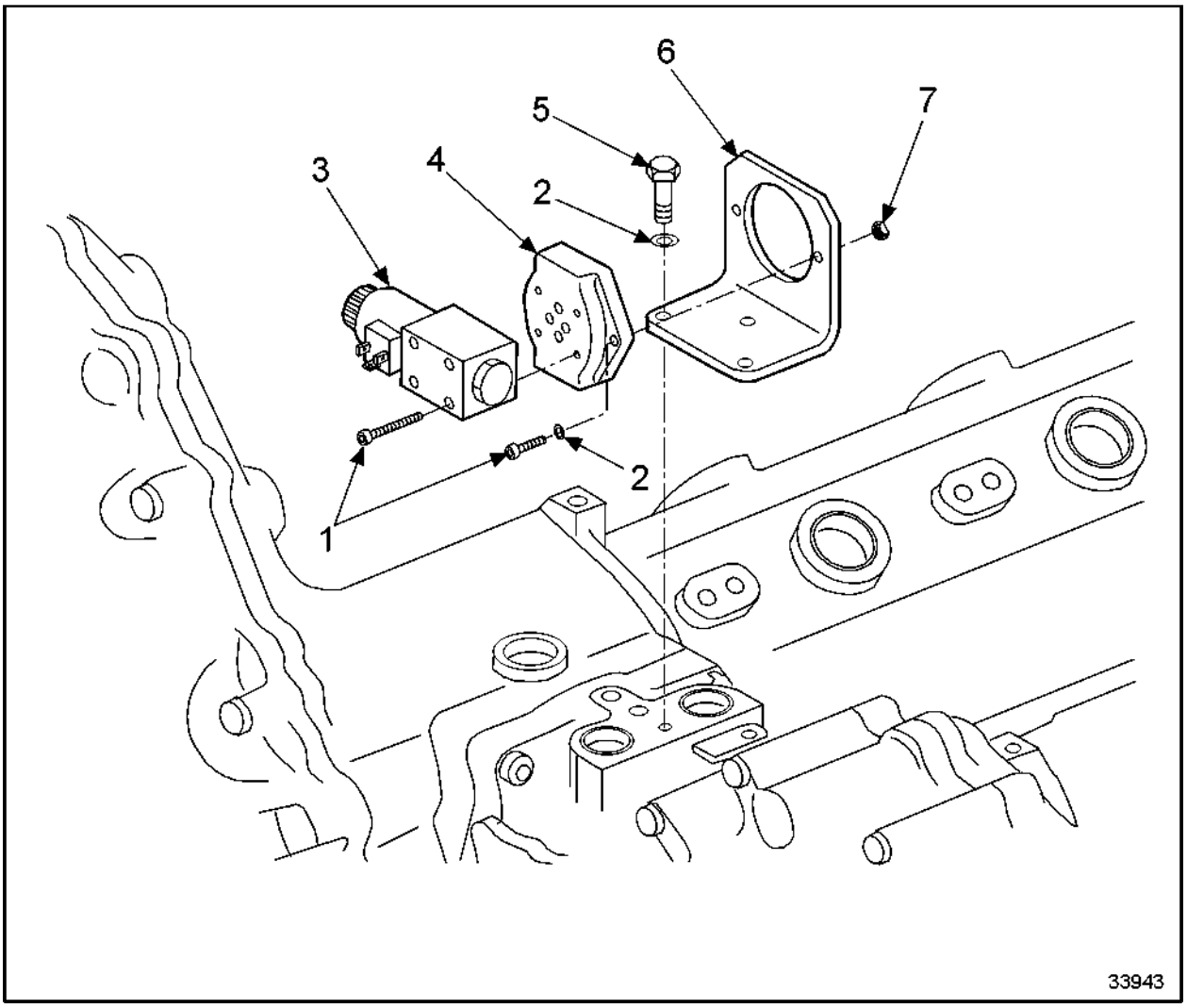
3 = The engine is to remain installed.

Table 77 After – Installation Operation

C 104.05 M – TURBOCHARGER ACTUATOR CONTROL SOLENOID VALVE (MARINE)

C 104.05.01 M – GENERAL VIEW (MARINE)

See Figure 648 for a general view of the turbocharger actuator control solenoid valve parts location.



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

Figure 648 General View of Turbocharger Actuator Control Solenoid Valve (Marine)

C 104.05.04 M – BEFORE – REMOVAL OPERATIONS (MARINE)

Listed in Table 78are the Before – Removal Operation for the turbocharger actuator control solenoid valve.

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.

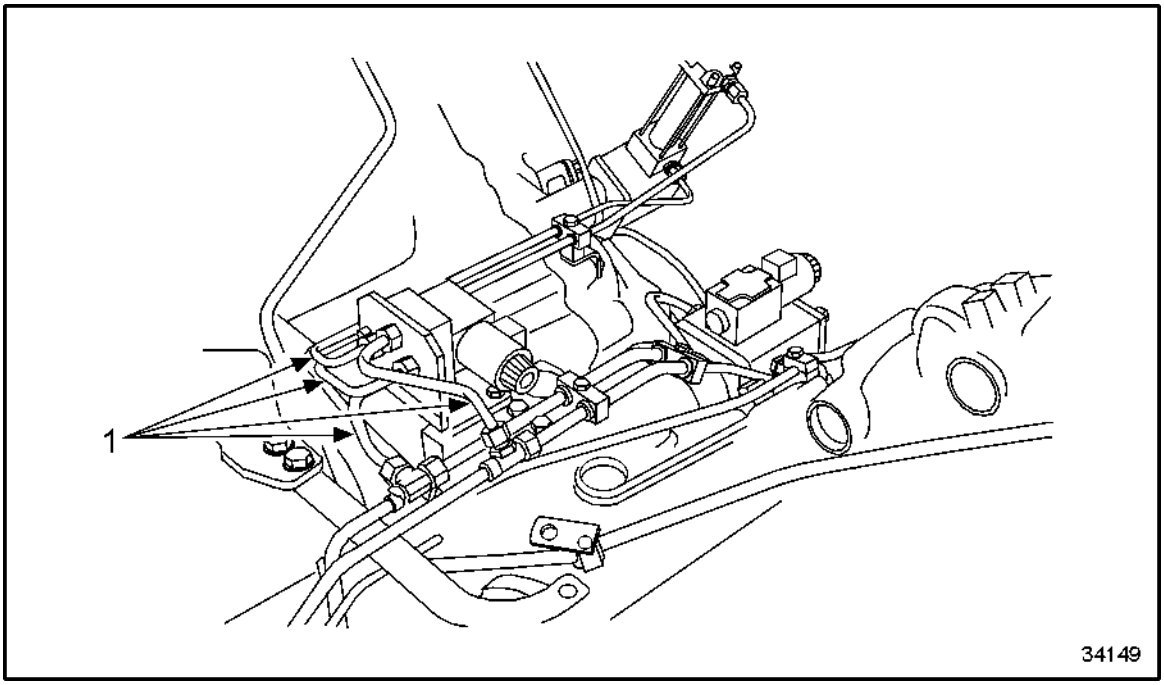
3 = The engine is to remain installed.

Table 78 Before – Removal Operation

C 104.05.05 M – REMOVAL OF THE TURBOCHARGER ACTUATOR CONTROL SOLENOID VALVE (MARINE)

Perform the following steps to remove the turbocharger actuator control solenoid valve: See Figure 649.

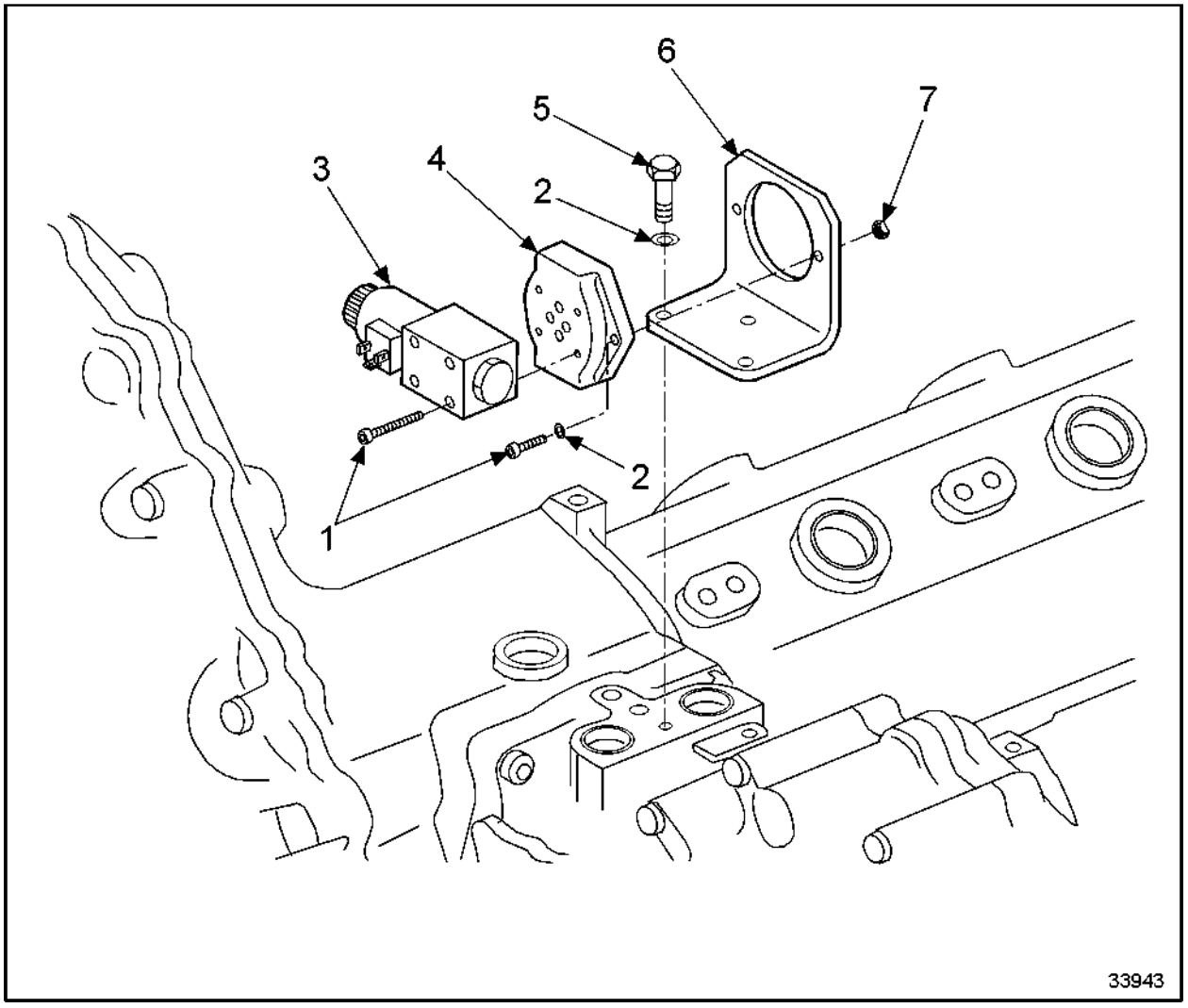
1. Remove the turbocharger actuator control solenoid valve oil feed lines (1). See Figure 649.



1. Oil Feed Lines

Figure 649 Removing Turbocharger Actuator Control Solenoid Valve Oil Feed Lines (Marine)

2. Remove bolt (1) and washers (2) securing the turbocharger actuator control solenoid valve (3) and mounting plate (4) to the mounting bracket (6). See Figure 650.



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 104.05.08 M – INSPECTION AND REPAIR (MARINE)

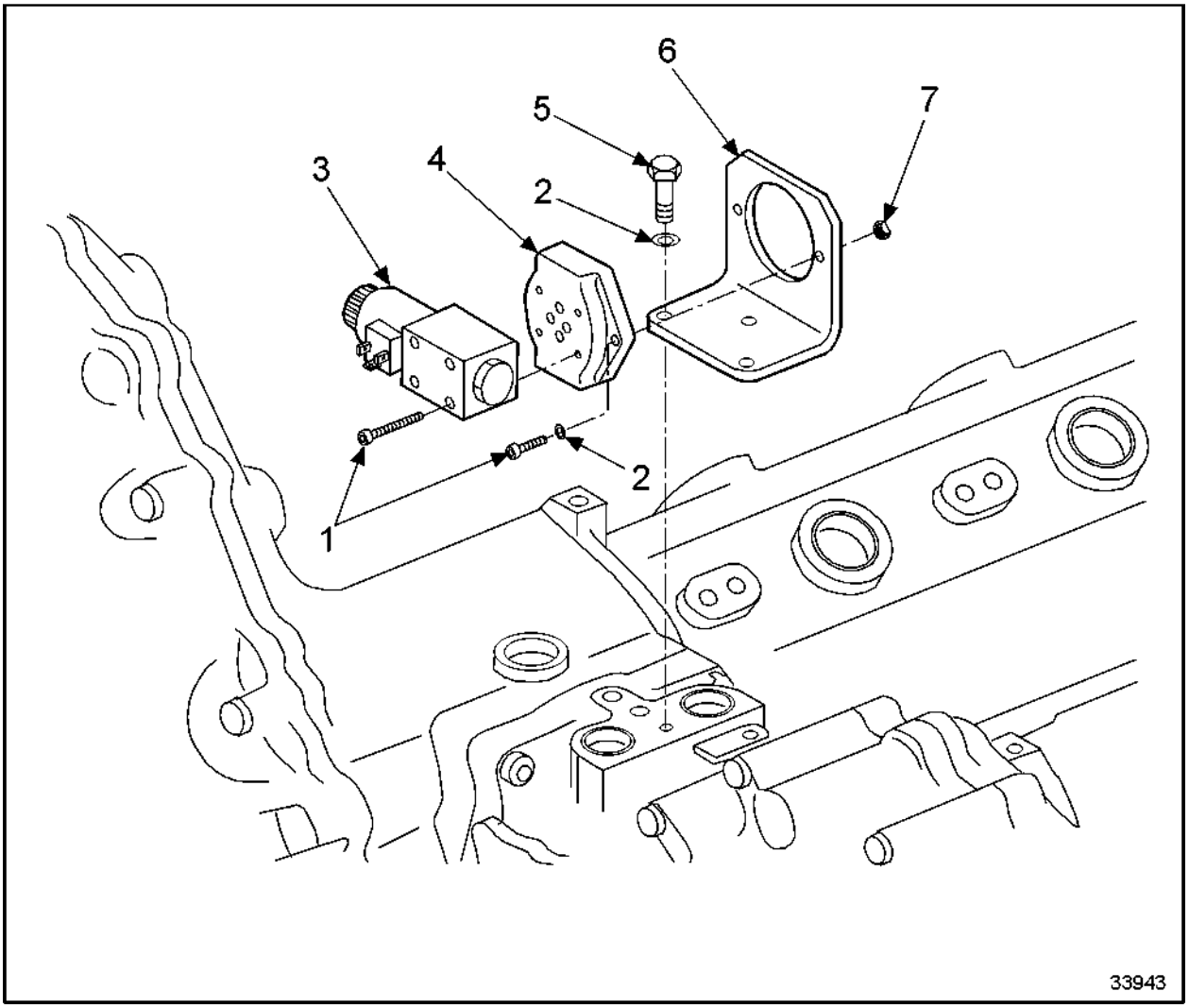
Perform the following steps to inspect and repair the turbocharger actuator control solenoid valve:

1. Use clean diesel fuel to remove dirt and debris from the turbocharger actuator control solenoid valve and blow dry with compressed air.
2. Visually inspect components for damage.
   [a] If any components are damaged, replace as necessary.
   [b] If no components are damaged, continue inspection.

C 104.05.11 M – INSTALLATION OF THE TURBOCHARGER ACTUATOR CONTROL SOLENOID VALVE (MARINE)

Perform the following steps to install the turbocharger actuator control solenoid valve:

1. Install mounting bracket (6) to the exhaust crossover housing and secure with bolts (5) and washers (2). Torque bolts to specification. Refer to section A 003. See Figure 651.

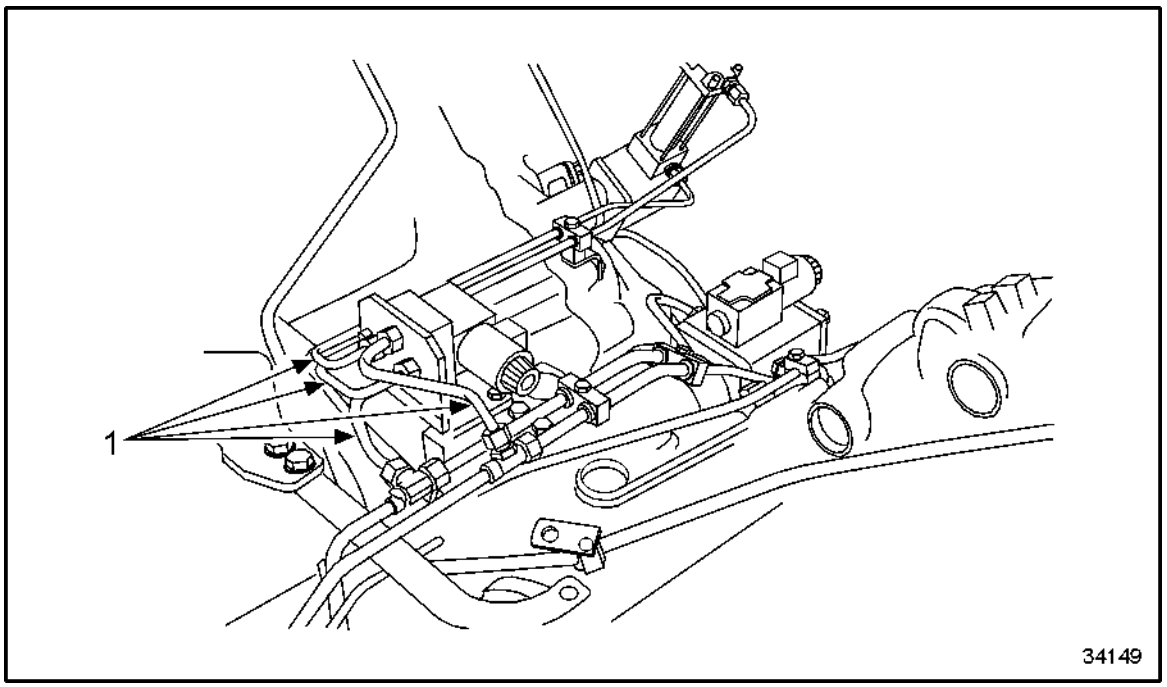


1. Bolt
2. Washer
3. Turbocharger Actuator Control Solenoid Valve
4. Mounting Plate
5. Bolt
6. Mounting Bracket
7. Nut

Figure 651 Installation of Turbocharger Actuator Control Solenoid Valve (Marine)

2. Install the mounting plate (4) and turbocharger actuator control solenoid valve (3) to mounting bracket (6) and secure with washers (2) and bolts (1). Torque bolts to specification. Refer to section A 003. See Figure 651.

3. Connect the turbocharger actuator control valve oil feed lines (1). See Figure 652.



1. Oil Feed Lines

Figure 652 Installing Turbocharger Actuator Control Solenoid Valve Oil Feed Lines (Marine)

4. Verify repair of the turbocharger actuator control solenoid valve.

C 104.05.12 M – AFTER – INSTALLATION OPERATIONS (MARINE)

Listed in Table 79are the After – Installation Operation for the turbocharger actuator control solenoid valve.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable Engine Power	Refer to Operator's 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 79 After – Installation Operation

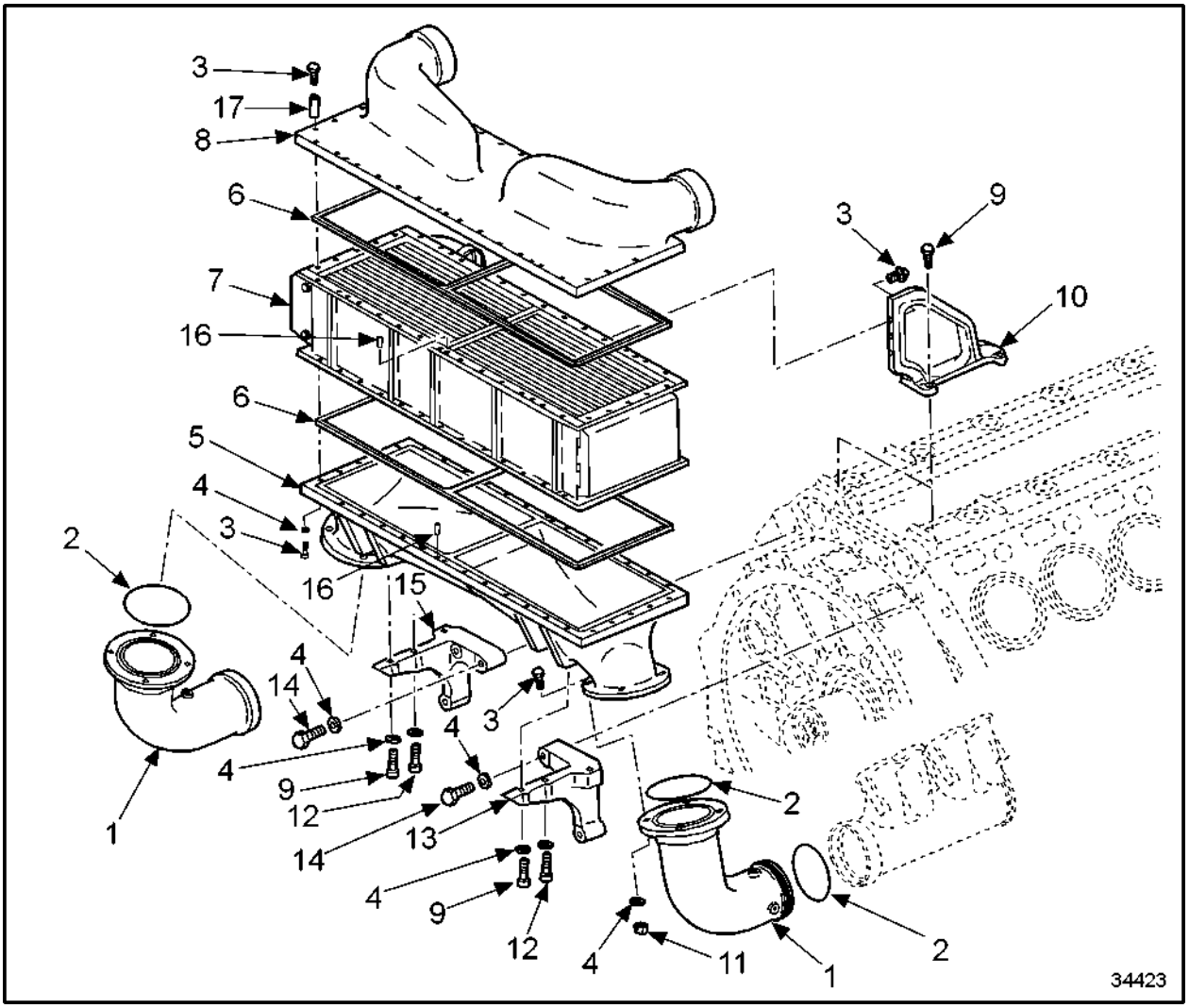
C 110 – CHARGE AIR COOLING

Section **Page**

C 111.05 – CHARGE AIR COOLER

C 111.05.01 – GENERAL VIEW

See Figure 653 for a general view of the charge air cooler.



1. Outlet Elbow
2. O-ring
3. Hex Bolt
4. Washer
5. Bottom Outlet Housing
6. Rubber Seal Ring
7. Charge Air Cooler
8. Top Inlet Housing
9. Bolt M12 X 47
10. Bracket
11. Nut M12
12. Bolt M12 X 65
13. Right Bracket
14. Bolt M16 X 110
15. Left Bracket
16. Dowel Pin
17. Spacer

Figure 653 General View of Charge Air Cooler

C 111.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 80 are the Before-Removal Operations for the charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove DDEC harness and sensors	Refer to section C 501.05 M
1, 2, 3	Remove charge air manifolds	Refer to section C 124.05.05
1, 2, 3	Remove coolant vent line	Refer to section C 205.05.05
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Remove coolant lines	Refer to section C 204.05.05

1 = The engine is to be completely disassembled.

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

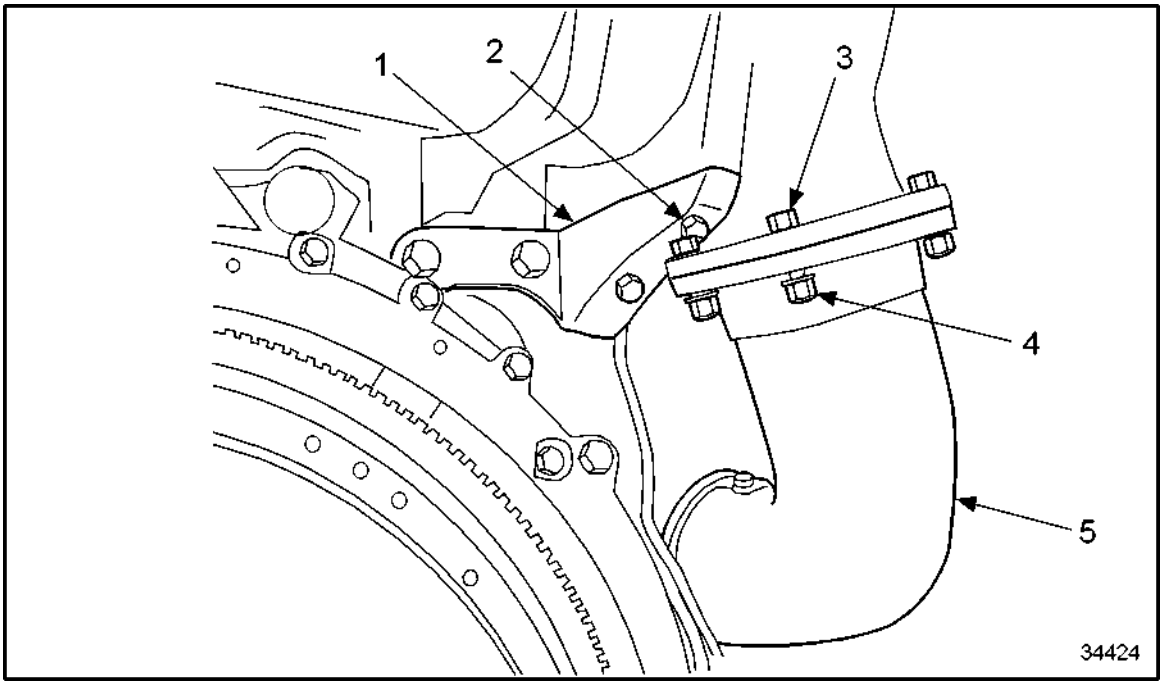
3 = The engine is to remain installed.

Table 80 Before-Removal Operations

C 111.05.05 – REMOVAL OF CHARGE AIR COOLER

Perform the following steps to remove the charge air cooler:

1. Remove hex bolts (2) from bracket (1). See Figure 654.

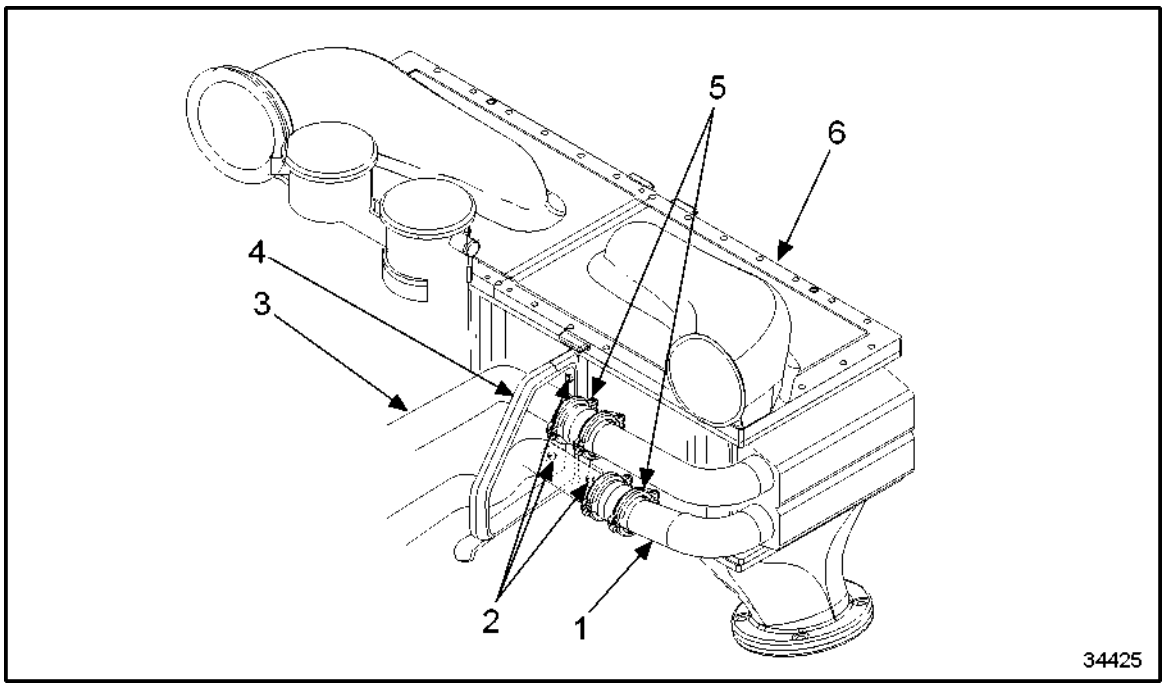


1. Bracket
2. Hex Bolt
3. Nut
4. Hex Bolt
5. Outlet Elbow

Figure 654 Removing Charge Air Cooler

2. Remove nuts (3) from hex bolts (4) and remove outlet elbow (5).

3. Loosen pipe clamps (2) from coolant tubes. See Figure 655.



1. Securing Bolts
2. Bracket Bolts
3. Return Pipe
4. Bracket
5. Clamp, Seal and Coupling
6. Charge Air Cooler

Figure 655 Loosening Pipe Clamps from Coolant Tubes

4. Remove securing bolts (1) between charge air cooler and bracket.

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.

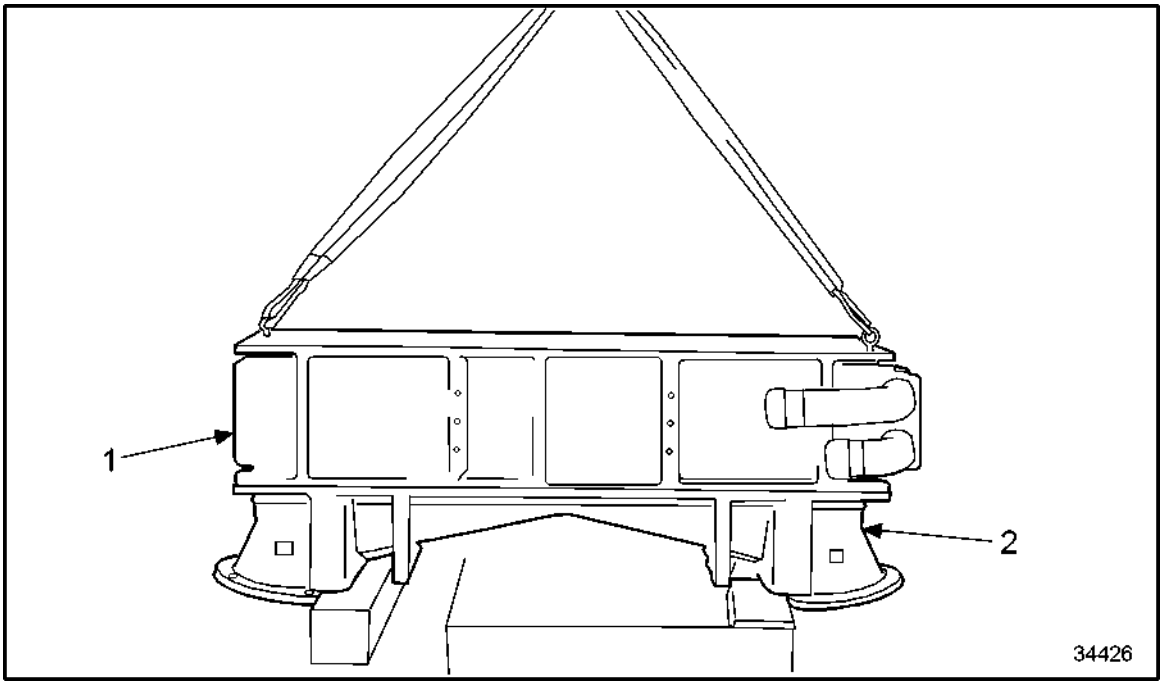
5. Attach charge air cooler to crane with lifting device and carefully raise from engine.

NOTE:
After removing charge air cooler, seal all connections on engine with suitable plugs and covers.

C 111.05.06 – DISASSEMBLY OF CHARGE AIR COOLER

Perform the following steps to disassemble the charge air cooler:

1. Remove hex bolts (1) between charge air cooler and inlet housing, top. See Figure 656.



1. Charge Air Cooler
2. Outlet Housing, Bottom

Figure 656 Removing Charge Air Cooler from Connecting Housing Bottom

2. Lift off inlet housing.
3. Remove hex bolts between outlet housing, bottom (2) and charge air cooler (1).
4. Remove charge air cooler from outlet housing, bottom.
5. Remove rubber seal ring from inlet and outlet housings.

NOTICE
Protect charge air cooler (in particular the cooling fins) from mechanical damage (e.g. jolts, etc. by covering fins with firm cardboard.

C 111.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the charge air cooler:

1. Clean all components and visually inspect for damage and defects.
   [a] If components are damaged or defective, replace as necessary.
   [b] If components are not damaged or defective, continue inspection.
2. Visually inspect inlet and outlet housing for cracks using surface crack – testing method with red penetrant dye.
   [a] If inlet or outlet housing is cracked, replace component.
   [b] If inlet and outlet housing are not cracked, continue inspection.
3. Clean all sealing, contact and mating surfaces of remaining particles of seal and inspect for damage and unevenness.
   [a] If sealing, contact or mating surfaces is damaged or uneven, smooth with oilstone or emery cloth as necessary.
   [b] If sealing, contact or mating surface is not damaged or uneven, continue inspection.
4. Inspect threads in charge air cooler and inlet housing for ease of movement.
   [a] If threads in charge air cooler and inlet housing do not show ease of movement, recondition as necessary.
   [b] If threads in charge air cooler and inlet housing do show ease of movement, continue inspection.
5. Replace sealing rings and gaskets.
6. Clean inlet and outlet housings.
7. Clean air and coolant sides of charge air cooler.

Cleaning Air Side of Charge Air Cooler

Perform the following steps to clean the air side of the charge air cooler:

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.

1. Blow through cooler with a compressed air jet or spray a powerful water jet in the opposite direction to the cooling air flow. The jet must be directed parallel to the cooling fins in order to prevent the fins from being deformed.

NOTICE

It is imperative to avoid damaging the cooler, especially the cooling fins.

CAUTION:

To avoid personal injury take special care when using a high pressure water jet. Never direct the water jet at humans, equipment, or electric components. Always wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

2. If greasy or oily deposits have formed, cooler must be cleaned with steam cleaner.
3. Use nozzle for multi-point water jet. Operating pressure of high-pressure cleaning unit should be approximately 80 bar. Use clear water at a temperature of approximately 70°C to prevent steam.
4. Flow direction for vapor blast cleaning should be in the opposite direction to the cooling air flow.
5. After cleaning, blow through cooling air ducts with compressed air in vertical direction.

Cleaning Coolant Side of Charge Air Cooler

Perform the following steps to clean coolant side of charge air cooler:

NOTE:
Examine extent of contamination of water side prior to cleaning coolant side. The water side must be cleaned if there are visible deposits on the water side (inlet area) due to mineral deposits and oil deposits.

1. Fill cooler with descaling agent.

CAUTION:

To avoid personal injury when using any chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

2. Use an agent which is not aggressive to metal surfaces to remove deposited material.
3. Follow the OEM Guidelines precisely when preparing the descaling solution.
4. Duration of charge air cooler immersion in cleaning bath depends on condition and temperature of cleaning agent and nature and degree of deposit build up.
5. After cleaning, flush the cooler with water until pH values of clean water and rinsing water are approximately the same (difference of 1 pH).

NOTE:
Normal water can be used for flushing purposes.

6. Ensure that charge air cooler is clean.
   [a] If charge air cooler is not clean, repeat procedure for cleaning coolant side.
   [b] If charge air cooler is clean, continue cleaning coolant side.
7. If cooler is not put into operation immediately afterward, the water side must be dried and preserved after this cleaning.
8. Dry in a drying oven between 110°C and 120°C for approximately three hours.
9. Spray a suitable preservation agent into cooler. The preservation agent condenses and falls to form a protective layer over the inner surfaces.

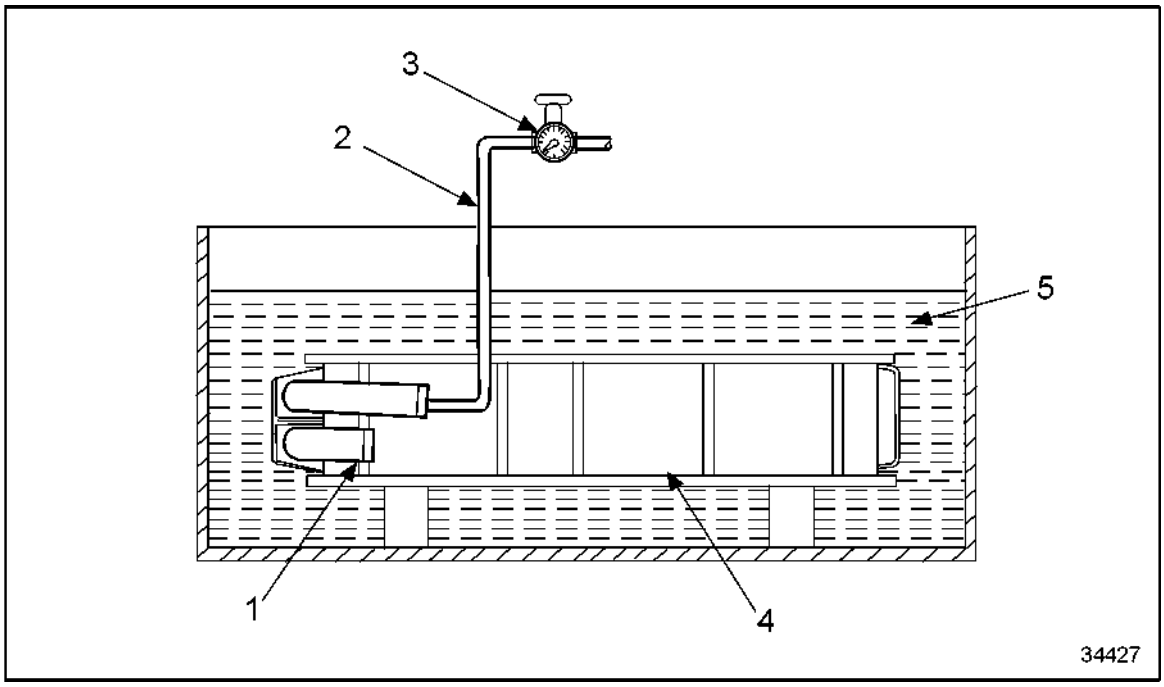
NOTE:
Ensure that dosages of preservation agent are correct.

10. After preservation, seal all openings with suitable airtight cap plugs.

Inspecting Charge Air Cooler for Leaks

To inspect charge air cooler for leaks, perform the following steps.

1. Seal cooling system connections on charge air cooler with suitable sleeves, blank plugs (1), plug with connection (2) and clamps. See Figure 657.



1. Blanking Plugs
2. Plug with Connection
3. Pressure Reducer
4. Charge Air Cooler
5. Test Water

Figure 657 Inspecting Charge Air Cooler for Leaks

2. At plug with connection, install compressed air line.
3. Soak charge air cooler in test basin filled with water heated to 80°C.
4. Open compressed air supply and set pressure reducer (3) to 0.5 bar.

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.

5. Pressure test charge air cooler for leaks with air in water bath.
   [a] If bubbles emerge, replace charge air cooler.
   [b] If no bubbles emerge, continue inspection of charge air cooler.

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.

6. After inspecting, blow through cooling air ducts with compressed air in vertical direction. Refer to section C 111.05.10.

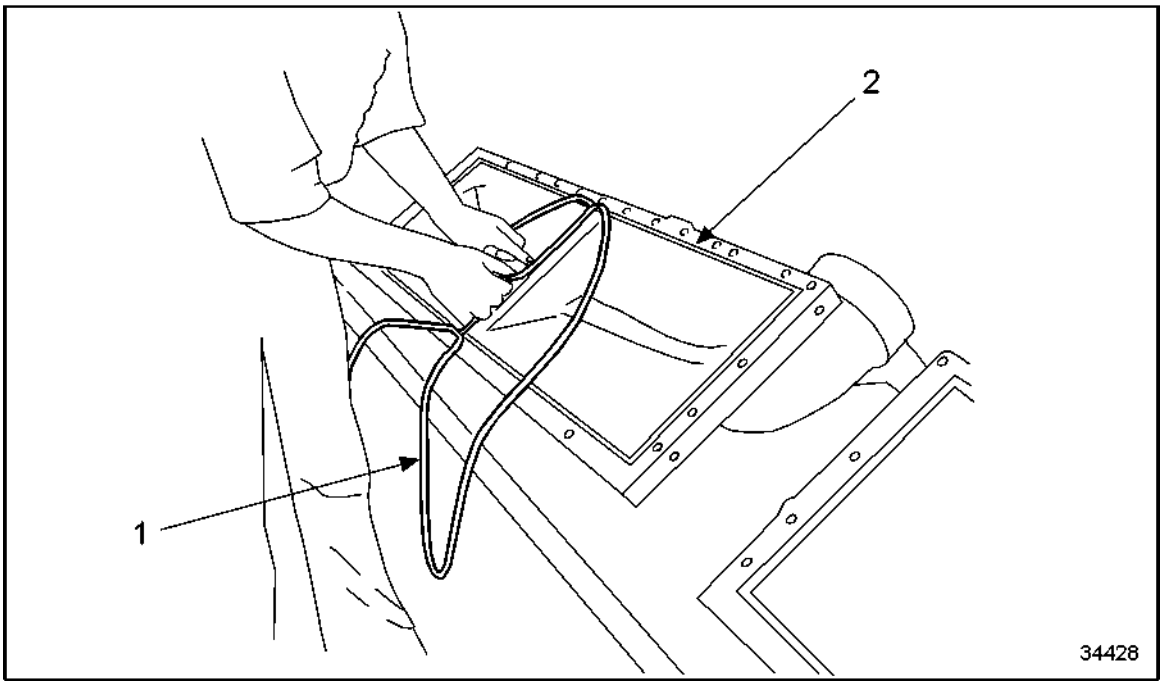
C 111.05.10 – ASSEMBLY OF CHARGE AIR COOLER

Perform the following steps to assemble the charge air cooler:

1. To prepare inlet and outlet housing, insert rubber seal ring (1) in groove on outlet and inlet housings (2). See Figure 658.

NOTE:
Insert dry rubber seal ring. Insert T-shaped seal ring with wide slot into groove.

NOTE:
Before installation, remove all plugs and verify that air carrying components are perfectly clean.



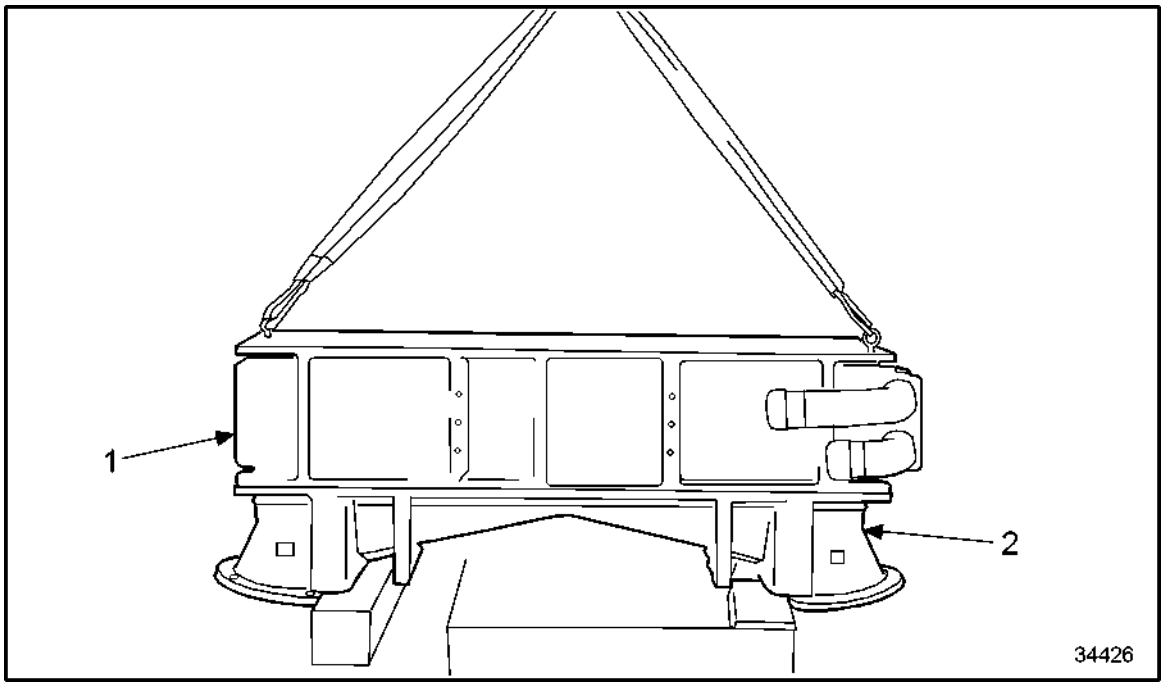
1. Rubber Seal Ring
2. Groove in Outlet and Inlet Housing

Figure 658 Preparing Connecting Housing

C 111.05.11 – INSTALLATION OF CHARGE AIR COOLER

Perform the following steps to install the charge air cooler:

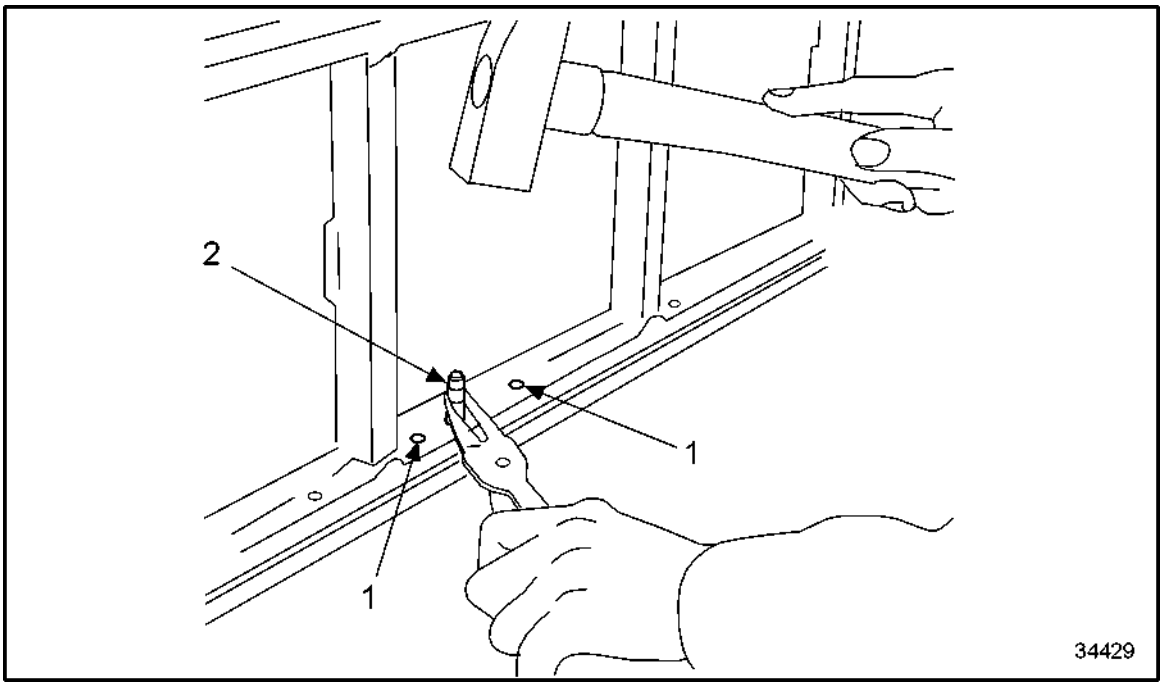
1. To install charge air cooler (1) on outlet housing, bottom (2), mount charge air cooler on the outlet housing. See Figure 659.



1. Charge Air Cooler
2. Outlet Housing, Bottom

Figure 659 Installing Charge Air Cooler on Outlet Housing, Bottom

2. Install two hex bolts (1) in center of front and rear of charge air cooler (i.e. immediately to left and right of bore for dowel pin (2)) and hand-tighten. See Figure 660.

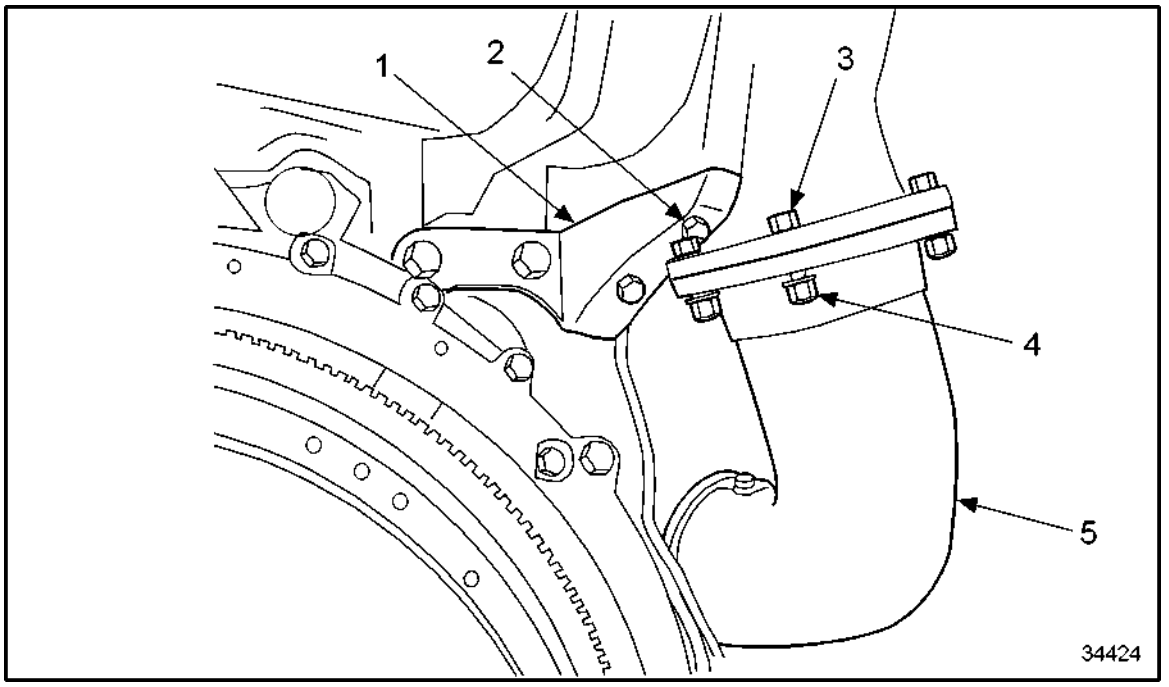


1. Hex Bolt
2. Dowel Pin

Figure 660 Driving Dowel Pins into Bore Provided

3. Drive dowel pin into bore provided.
4. Start in center on both front and rear of charge air cooler and secure four hex bolts from center in both directions, tightening in several stages to specification. Refer to section A 003.
5. Tighten all other hex bolts in sequence to tightening torque.
6. Install inlet housing on charge air cooler, align on dowel pins.
7. Ensure inlet cover seal ring remains in place.
8. Apply Loctite to attaching bolts.
9. Install hex bolts with spacers all around.
10. Proceed as with installing outlet housing.
11. Start in center on both front and rear of charge air cooler and secure four hex bolts from center in both directions, tightening in several stages to specification. Refer to section A 003.
12. Tighten all other hex bolts in sequence to tightening torque.

13. To install charge air cooler on engine, coat O-ring with petroleum jelly and install on outlet elbow flange. See Figure 661.



1. Bracket
2. Hex Bolt
3. Nut
4. Hex Bolt
5. Outlet Elbow

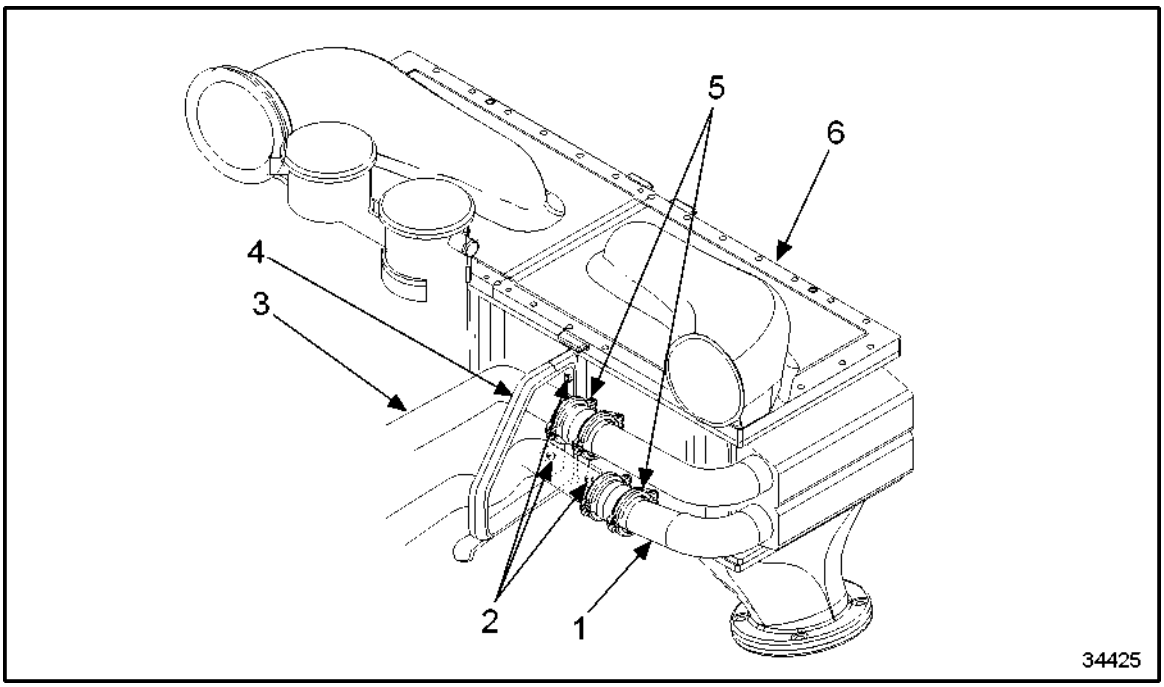
Figure 661 Installing Charge Air Cooler

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.

14. Attach charge air cooler to crane with lifting device and place on engine.
15. Install hex bolts (2) in bracket (1).
16. Secure outlet elbow (5) with hex bolts (4) and nuts (3) on charge air cooler.

17. Install securing bolts (1) between charge air cooler and bracket (2). See Figure 662.



1. Securing Bolts
2. Pipe Clamps

Figure 662 Installing Securing Bolts between Charge Air Cooler and Bracket

18. Install inlet and outlet coolant couplings, seals and clamps.
19. Tighten clamps for coolant couplings.

C 111.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 81 are the After-Installation Operations for the charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Install engine	Refer to OEM Guidelines
1, 2, 3	Install charge air manifolds	Refer to section C 124.05.11
1, 2, 3	Install coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install DDEC sensors and harness	Refer to section C 501.05 M
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Inspect for leaks	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.

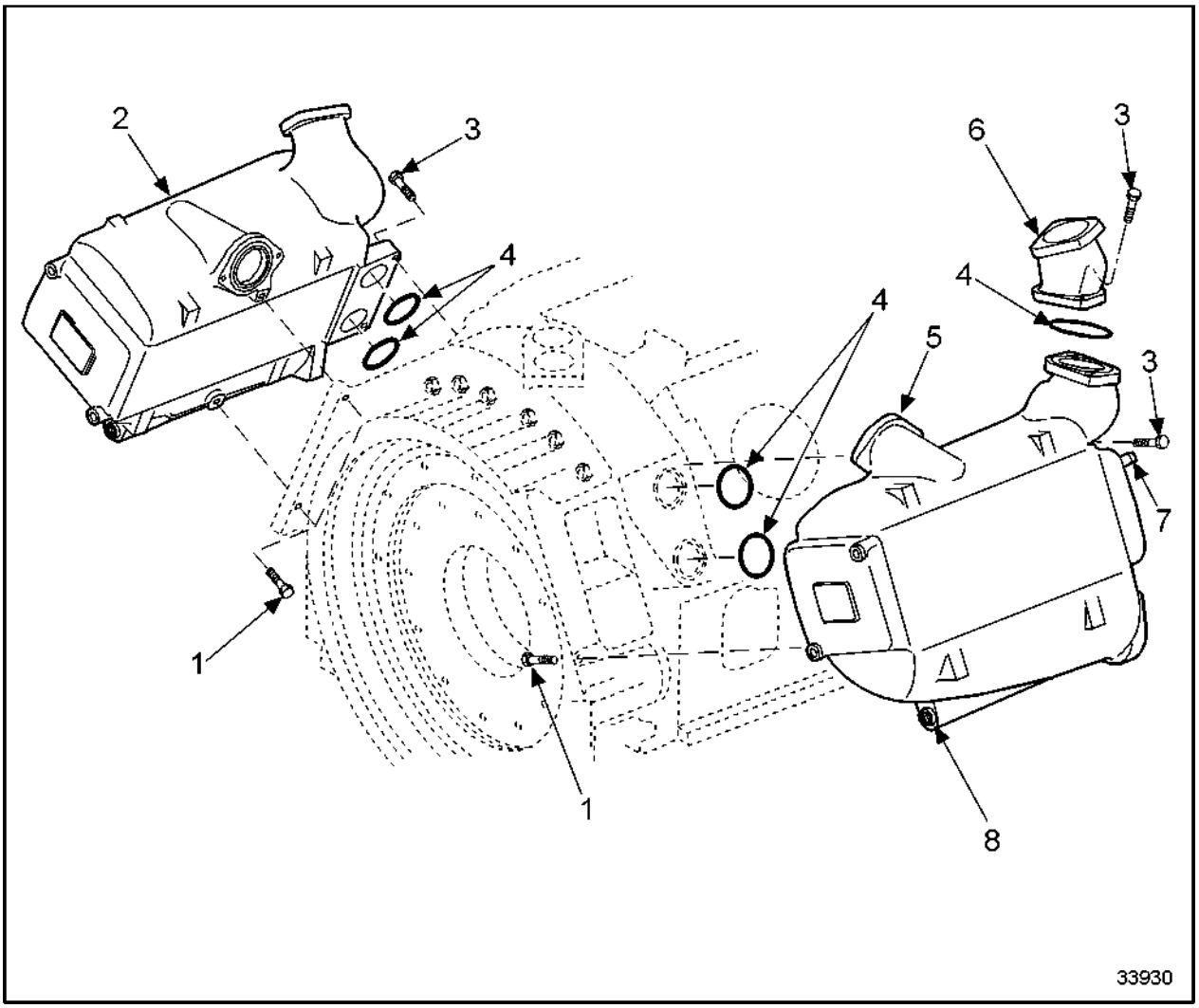
3 = The engine is to remain installed.

Table 81 After-Installation Operations

C 111.05 M – CHARGE AIR COOLER

C 111.05.01 M – GENERAL VIEW

See Figure 663 for the charge air cooler parts location.



1. Bolt
2. Left “A” Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right “B” Bank Charge Air Cooler
6. Elbow-“B” Bank side only
7. Bolt
8. Vent Line Location

Figure 663 Exploded View of Marine Charge Air Cooler Assembly

C 111.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 82are the Before-Removal Operations for the marine charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove monitoring system	Refer to C 501.05 M
1, 2, 3	Remove charge air manifolds	Refer to C 124.05.05
1, 2, 3	Remove coolant vent line	Refer to C 206.05.05 M
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Remove coolant lines	Refer to C 203.05.05

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 82 Before-Removal Operations for the Marine Charge Air Cooler

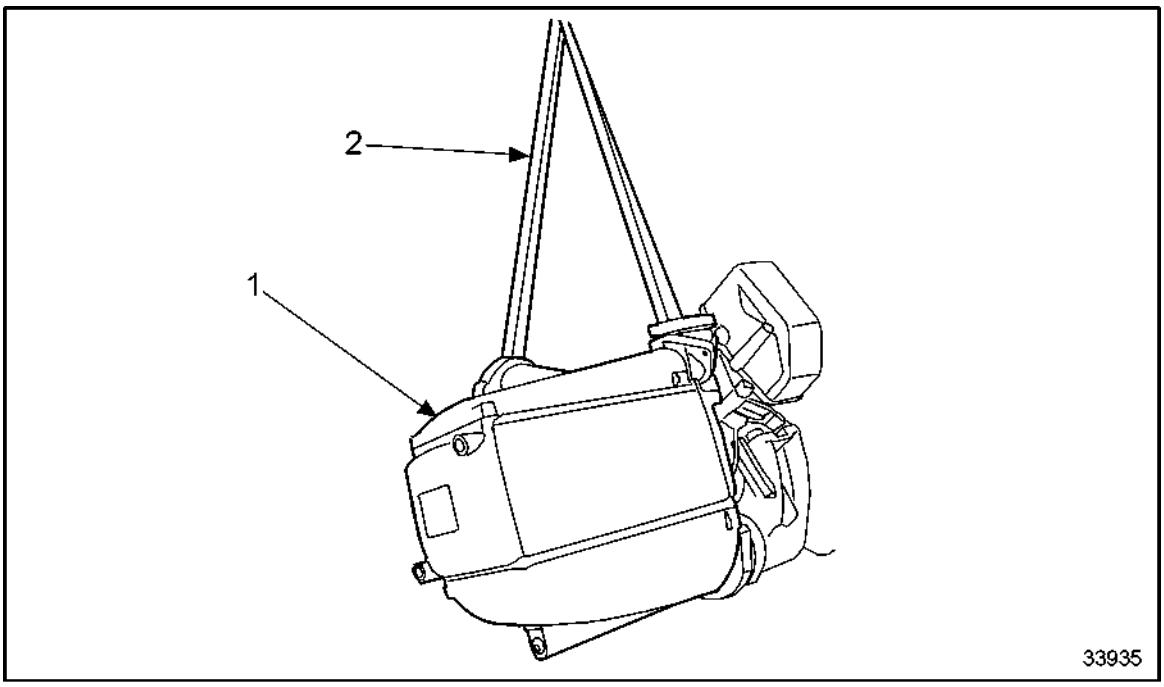
C 111.05.05 M – REMOVAL OF MARINE CHARGE AIR COOLER

Perform the following steps to remove the charge air cooler:

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.

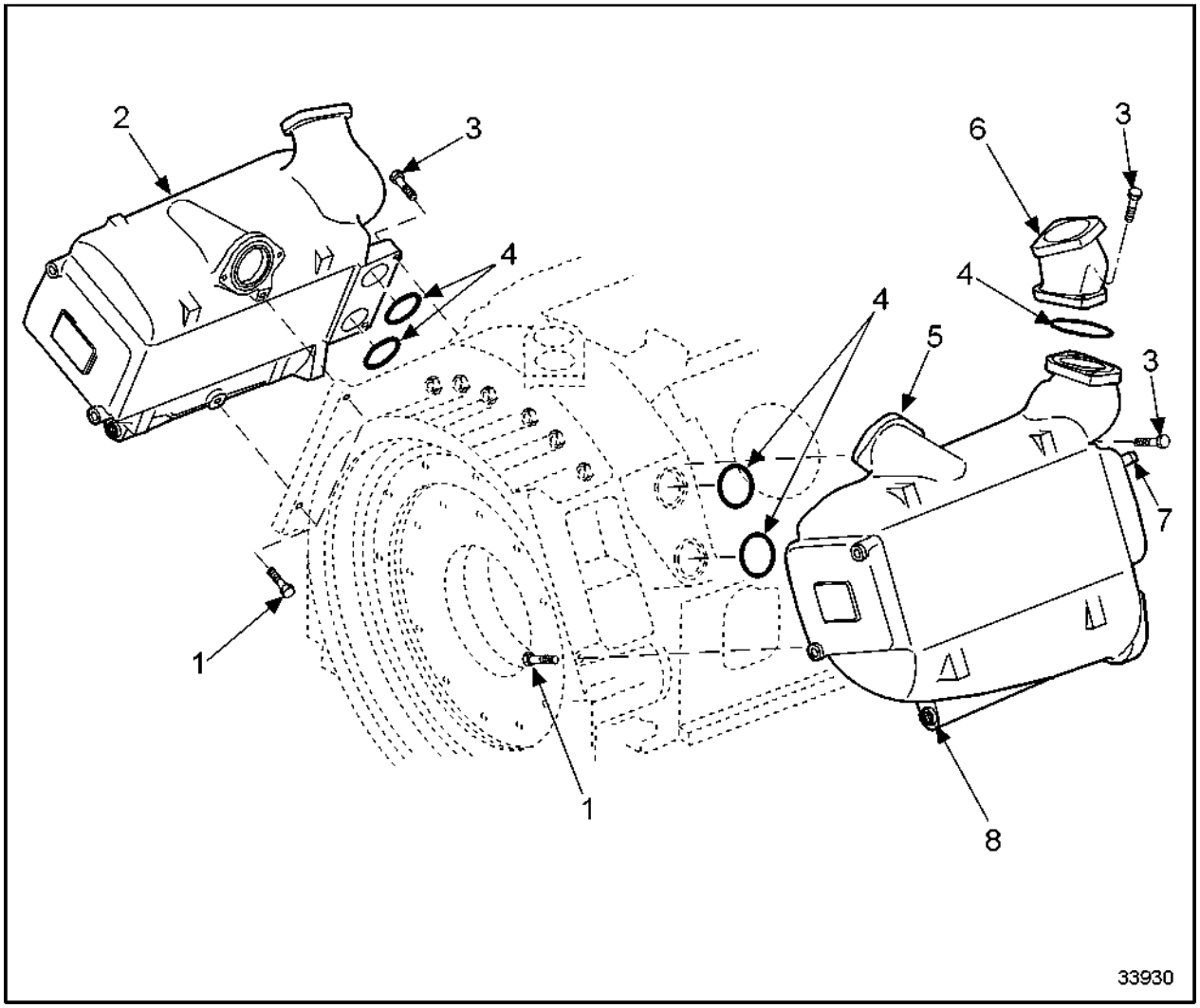
1. Attach a suitable lifting device to the charge air cooler (1). See Figure 664.



1. Charge Air Cooler
2. Lifting Sling

Figure 664 Removing Charge Air Cooler from Engine

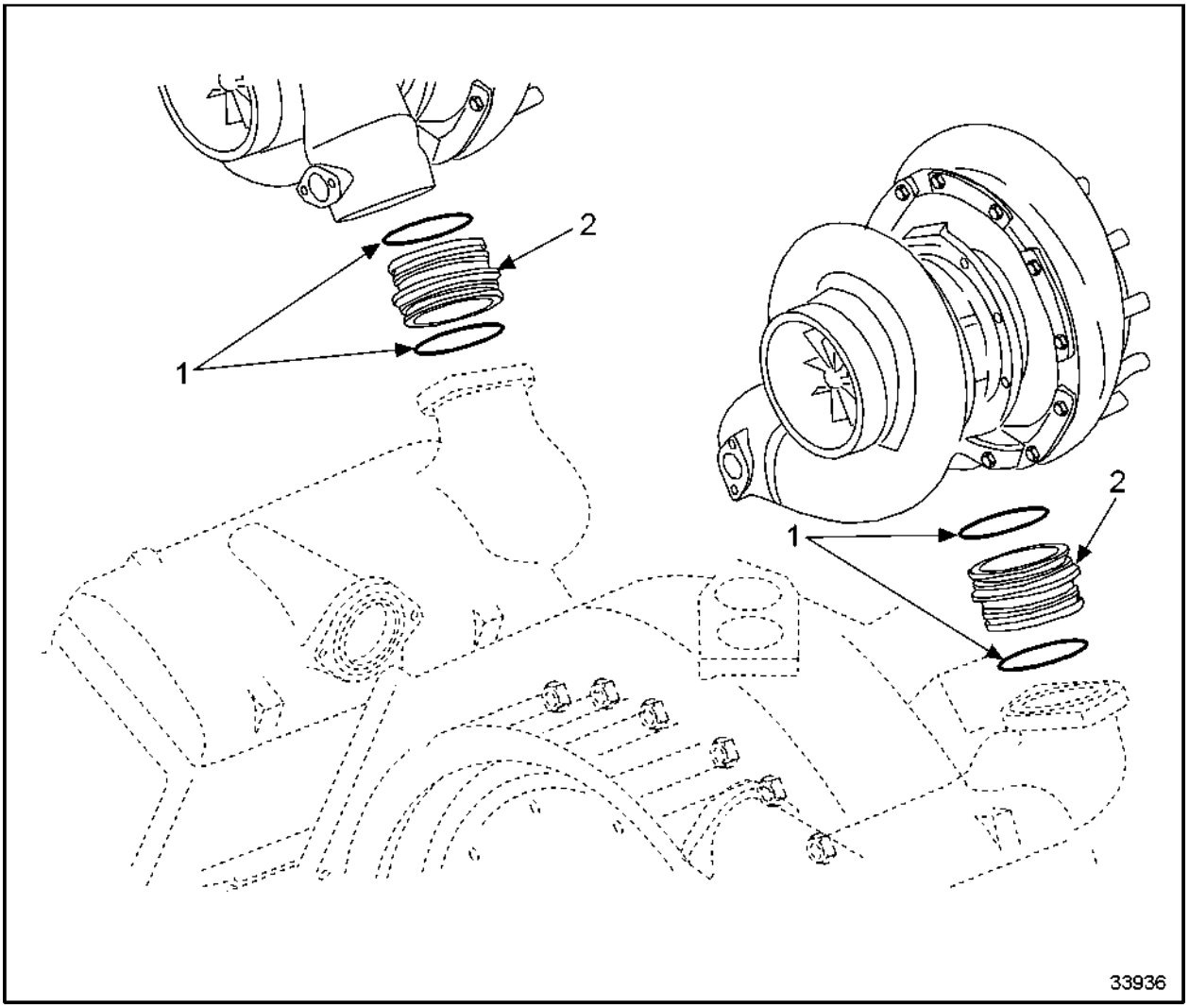
2. Disconnect water vent line (7). See Figure 665.



1. Bolt
2. Left “A” Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right “B Bank Charge Air Cooler
6. Elbow-“B” Bank side only
7. Bolt
8. Vent Line Location

Figure 665 Disconnecting Water Vent Line on Charge Air Cooler Assembly

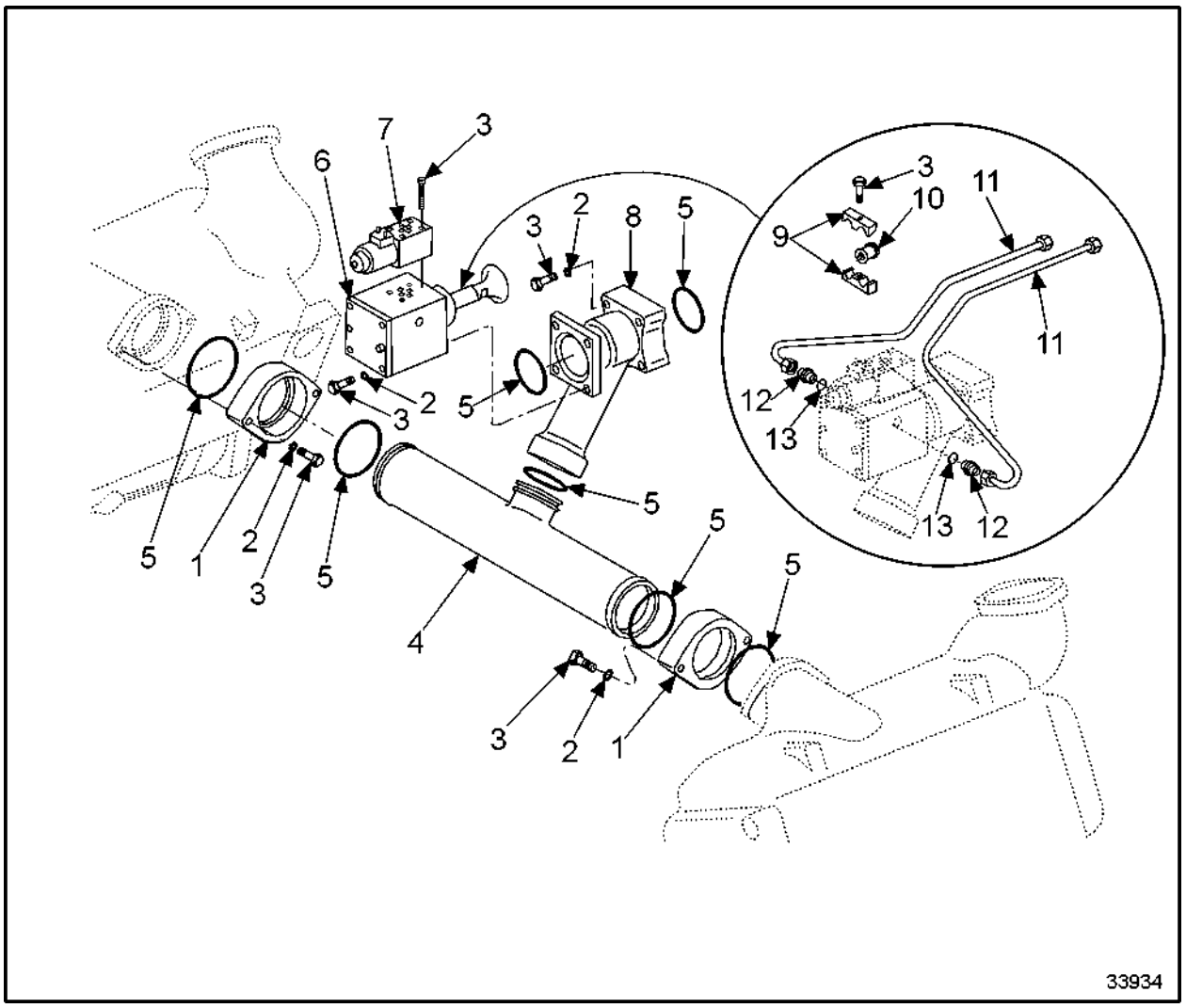
3. Disconnect connection tube (2) from the compressor housing to the charge air cooler. See Figure 666.



1. O-ring
2. Connection Tube

Figure 666 Charge Air Cooler Assembly

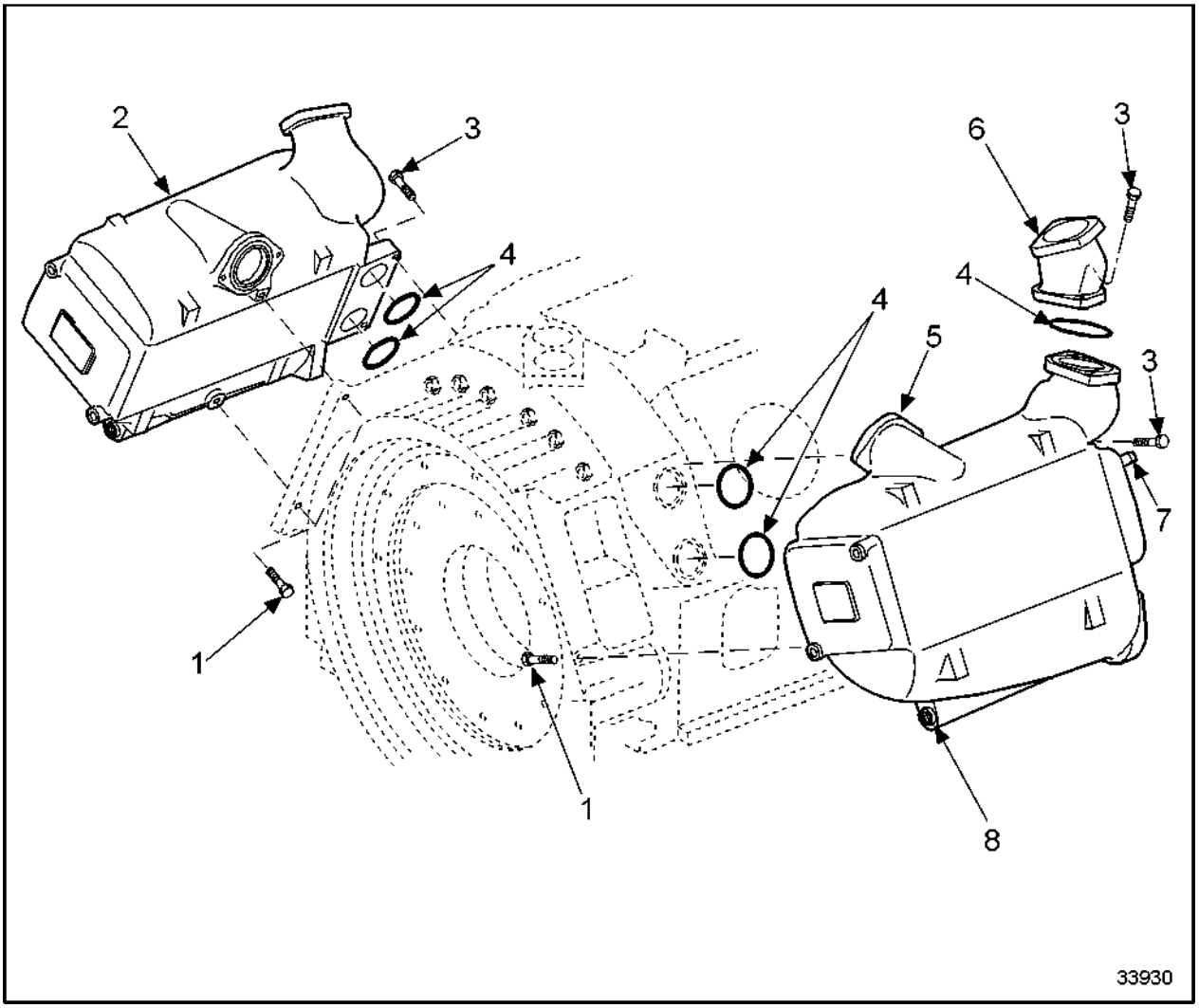
4. Remove four bolts (3) and four washers (2) securing the crossover tube (4). See Figure 667.



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 667 Removing Bolts and Washers Securing Crossover Tube

5. Remove two 70 mm (2.8 in.) bolts (3) securing the charge air cooler (2, 5) to the flywheel housing. See Figure 668.

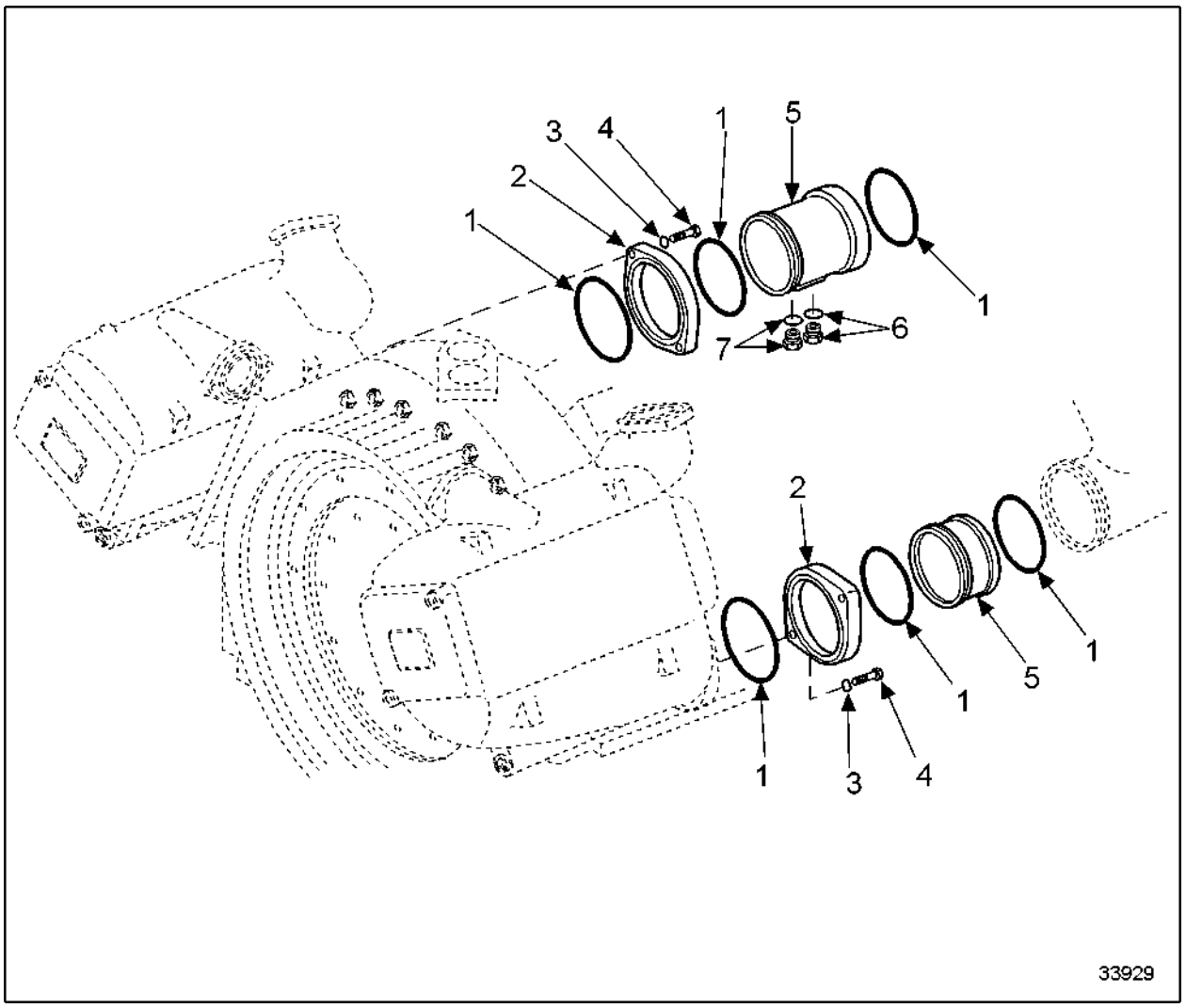


1. Bolt
2. Left “A” Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right “B” Bank Charge Air Cooler
6. Elbow-“B” Bank side only
7. Bolt
8. Vent Line Location

Figure 668 Removing Bolts Securing Charge Air Cooler Assembly to Flywheel Housing

6. Remove three 55 mm (2.2 in.) bolts (3) securing the charge air cooler to the flywheel housing. See Figure 668.

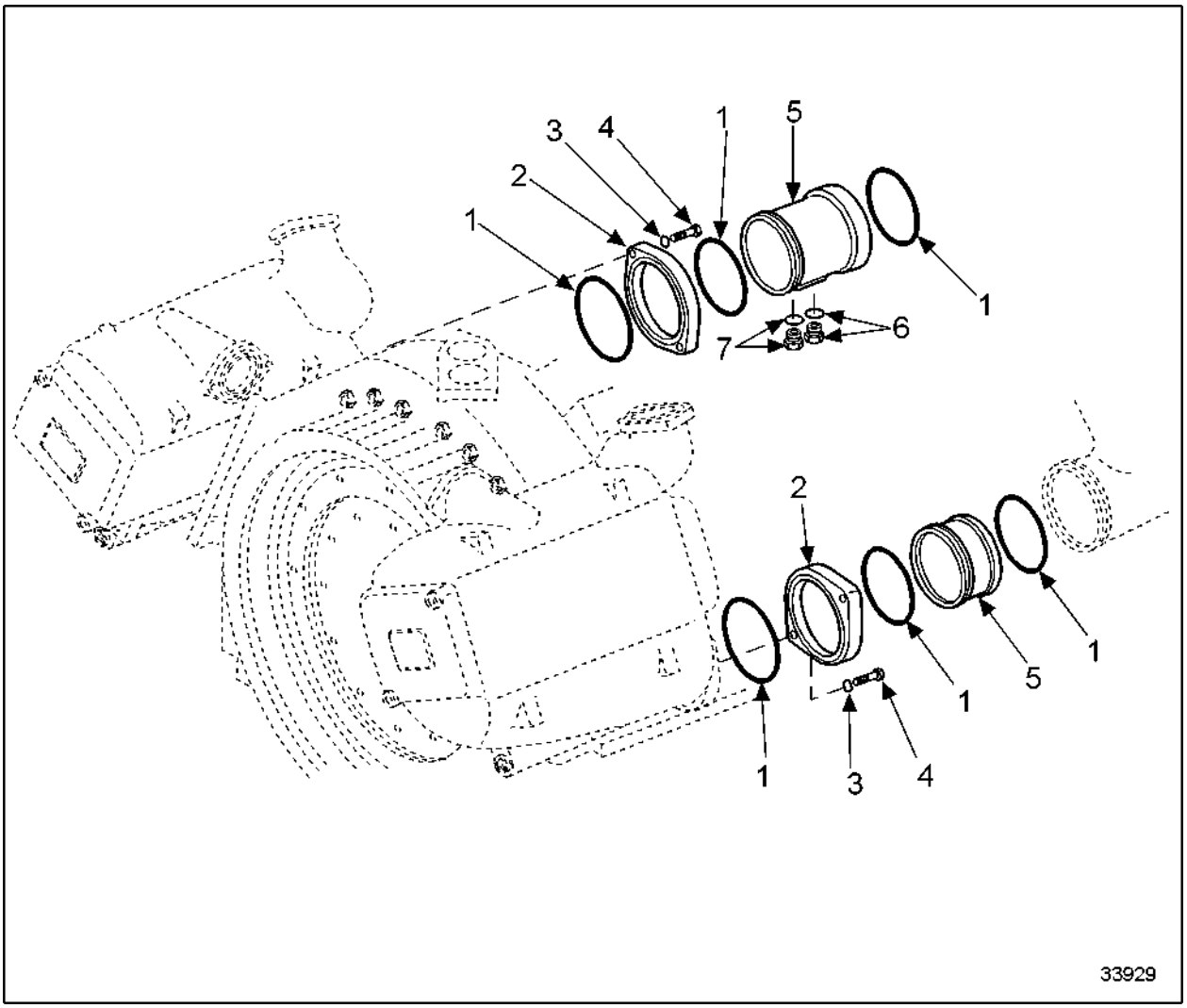
7. Remove two O-rings (1). See Figure 669.



1. O-ring
2. Flange
3. Washer
4. Bolt
5. Connection Tube
6. Sealing Ring/Threaded Bushing or Air Intake Temperature Sensor Location
7. Sealing Ring/Threaded Bushing or Turbocharger Boost Sensor Location

Figure 669 Removing Bolts Securing Charge Air Cooler Assembly to Flywheel Housing

8. Remove two bolts (4) securing intake manifold flange (2) to the charge air cooler. See Figure 670.

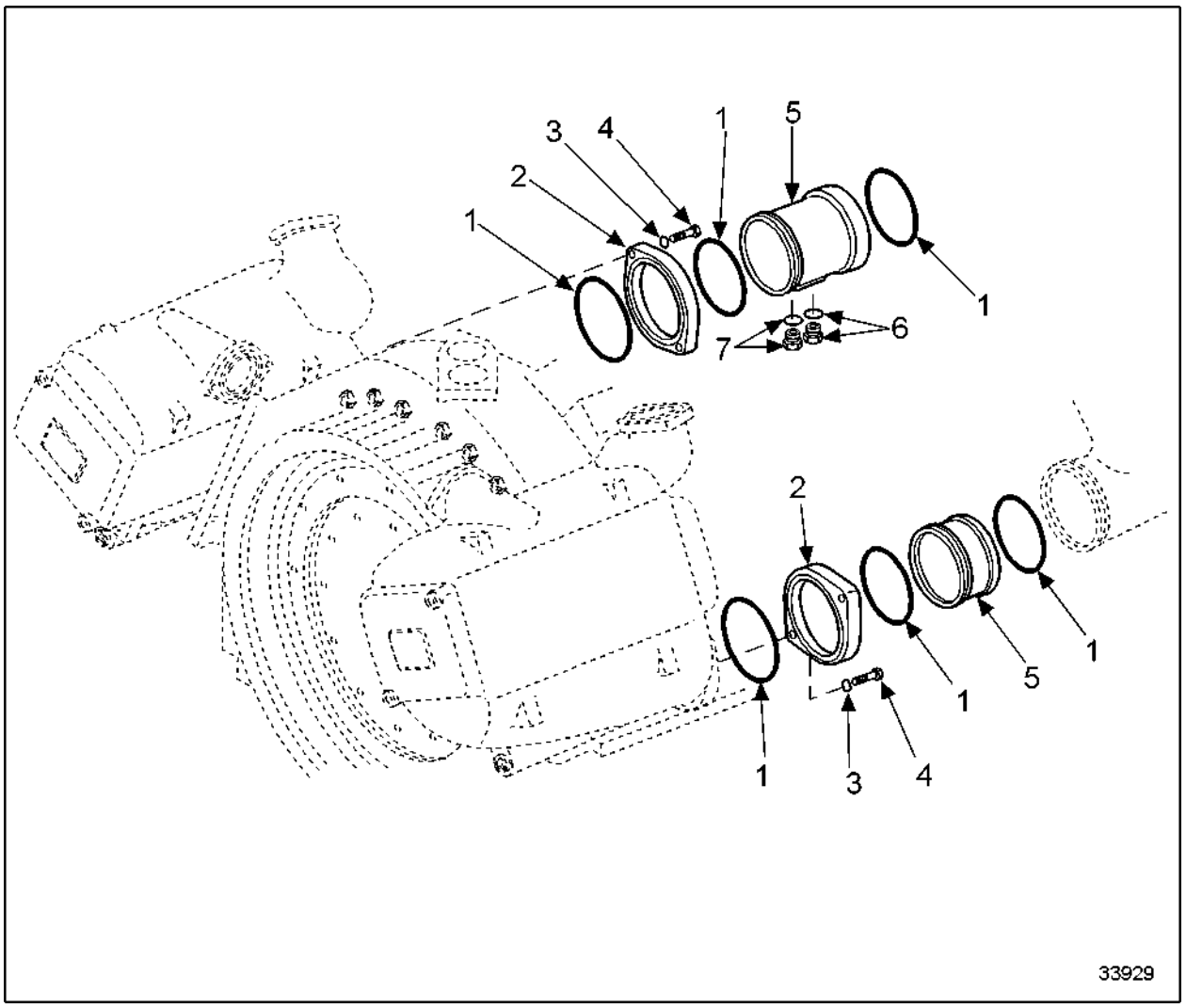


1. O-ring
2. Flange
3. Washer
4. Bolt
5. Connection Tube
6. Sealing Ring/Threaded Bushing or Air Intake Temperature Sensor Location
7. Sealing Ring/Threaded Bushing or Turbocharger Boost Sensor Location

Figure 670 Removing Bolts Securing Intake Manifold Flange to Charge Air Cooler

9. Remove the charge air cooler.

10. Remove two O-rings (1) from the flywheel housing. See Figure 671.

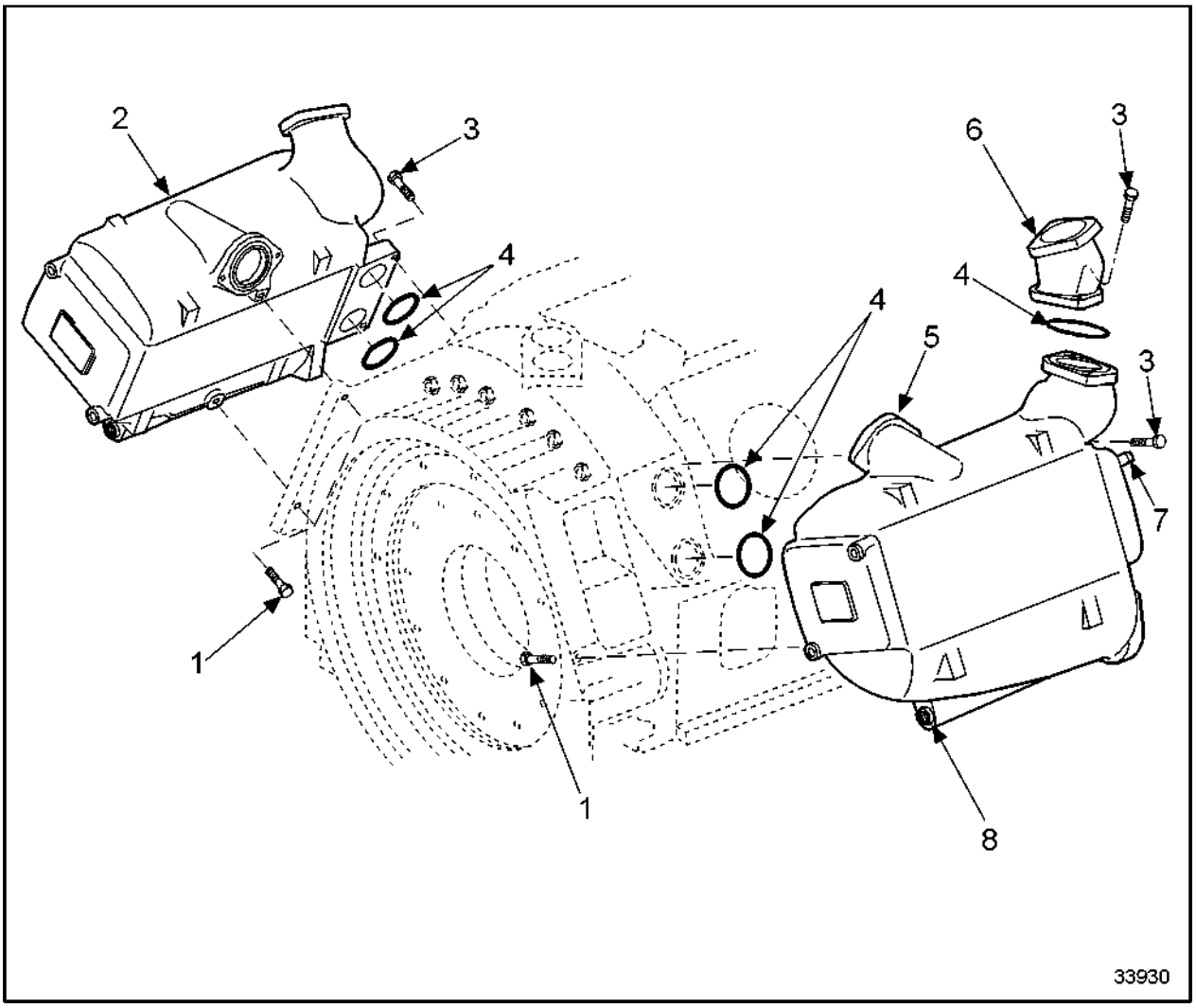


1. O-ring
2. Flange
3. Washer
4. Bolt
5. Connection Tube
6. Sealing Ring/Threaded Bushing or Air Intake Temperature Sensor Location
7. Sealing Ring/Threaded Bushing or Turbocharger Boost Sensor Location

Figure 671 Removing O-rings from Flywheel Housing

NOTE:
Perform step 11 through step 13 only for the “B” bank.

11. Remove two bolts (3) securing elbow (6) to the charge air cooler (5). See Figure 672.



1. Bolt
2. Left "A" Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right “B” Bank Charge Air Cooler
6. Elbow-"B" Bank Side only
7. Bolt
8. Vent Line Location

Figure 672 Removing Bolts Securing Elbow to Charge Air Cooler

12. Remove the elbow (5).
13. Remove O-ring (4).

C 111.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the charge air cooler:

1. Clean all sealing, contact and mating surfaces, removing particles of seal.
2. Visually inspect all sealing, contact and mating surfaces for damage and unevenness.
   [a] If sealing, contact or mating surfaces are damaged or uneven, smooth with an oilstone or emery cloth.
   [b] If damage is beyond repair, replace component.
   [c] If there is no damage or unevenness, or it has been repaired, continue inspection.

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.

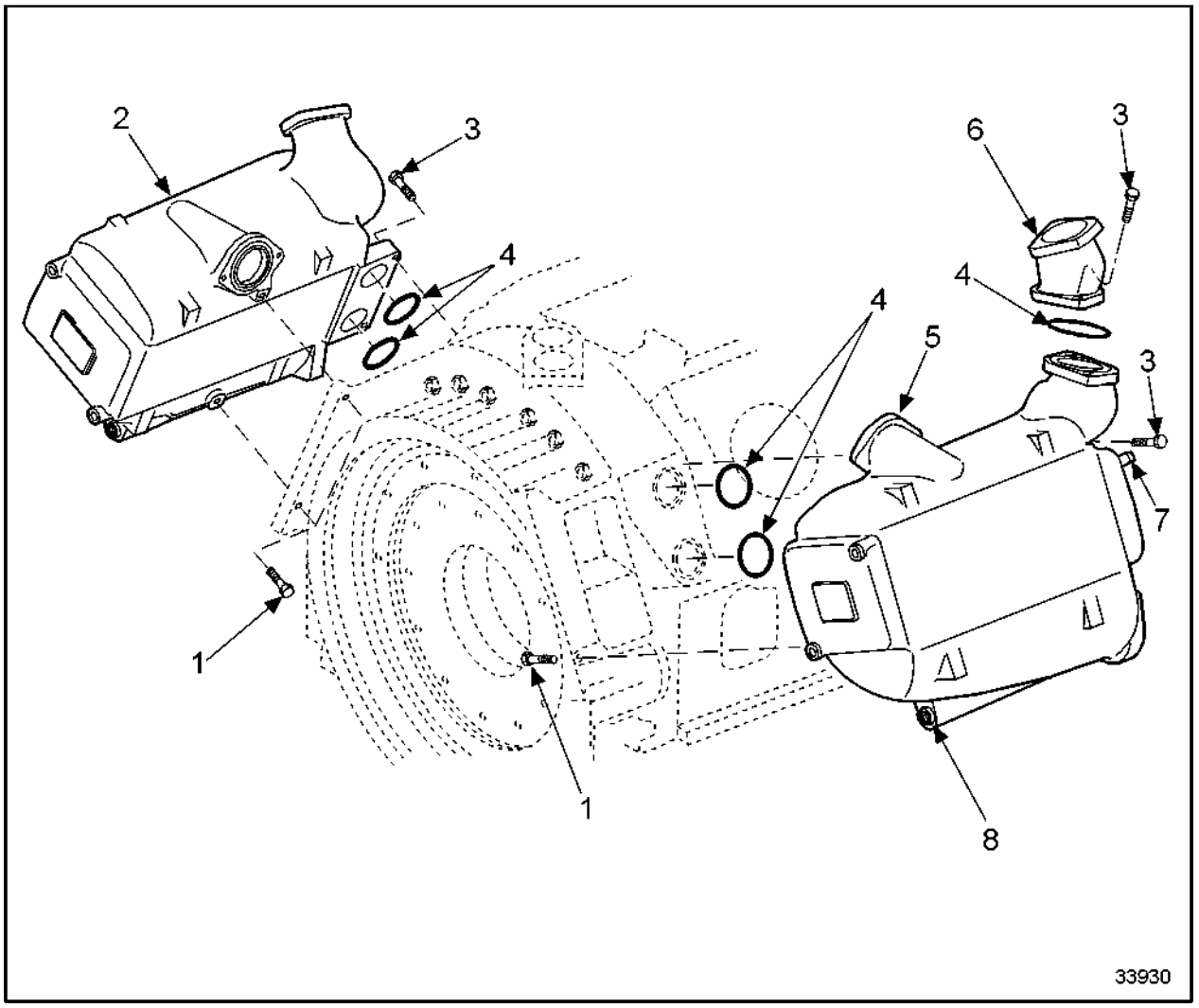
3. Using compressed air, clean all components.
4. Visually inspect all components for damage and defects.
   [a] If damage or defects are found, replace components as necessary.
   [b] If no damage or defects are found, continue inspection.
5. Inspect threads in connecting housing for ease of movement.
   [a] If threads do not show ease of movement, recondition as necessary.
   [b] If threads show ease of movement, continue inspection.
6. Replace sealing rings and gaskets.

C 111.05.11 M – INSTALLATION OF MARINE CHARGE AIR COOLER

Perform the following steps for the installation of the charge air cooler:

NOTE:
Perform step 1 through step3 only for the “B” bank.

1. Install new O-ring (4) to elbow (6). See Figure 673.



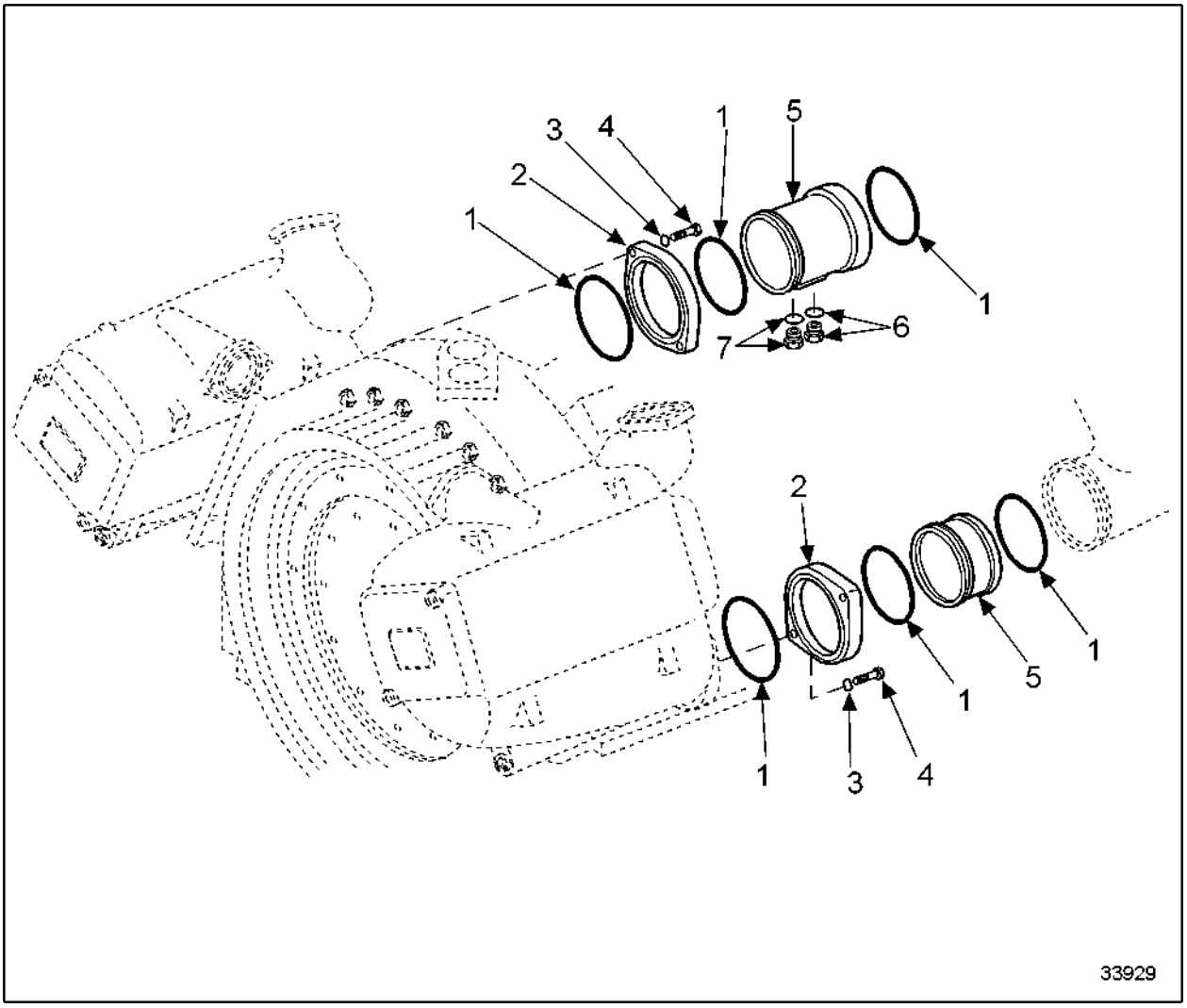
1. Bolt
2. Left "A" Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right "B" Bank Charge Air Cooler
6. Elbow-"B" side only
7. Bolt
8. Vent Line Location

Figure 673 Installing New O-ring to Elbow

2. Install charge air cooler to turbocharger elbow (6) and secure with two bolts (3). Torque bolts to 21-24 N·m (15–18 lb·ft).
3. Install two new O-rings (4) to the flywheel housing.

NOTE:
"A" bank only.

4. Install intake manifold flange (2) to the charge air cooler. See Figure 674.



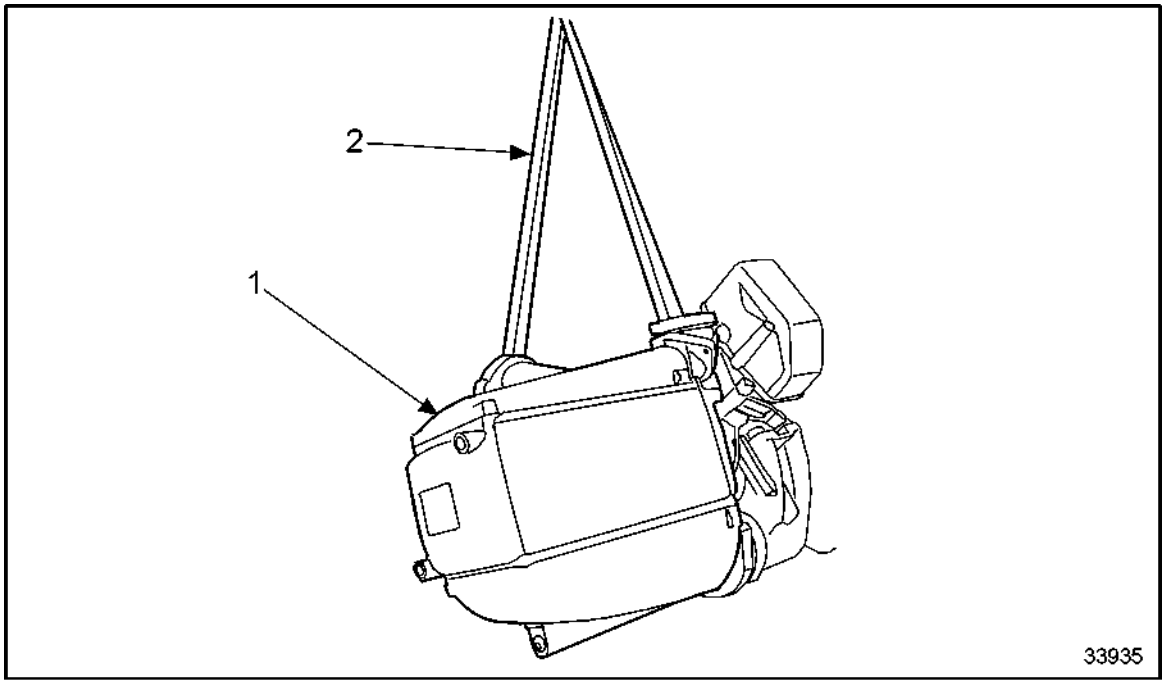
1. O-ring
2. Flange
3. Washer
4. Bolt
5. Connection Tube
6. Sealing Ring/Threaded Bushing or Air Intake Temperature Sensor Location
7. Sealing Ring/Threaded Bushing or Turbocharger Boost Sensor Location

Figure 674 Installing Intake Manifold Flange to Charge Air Cooler

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.

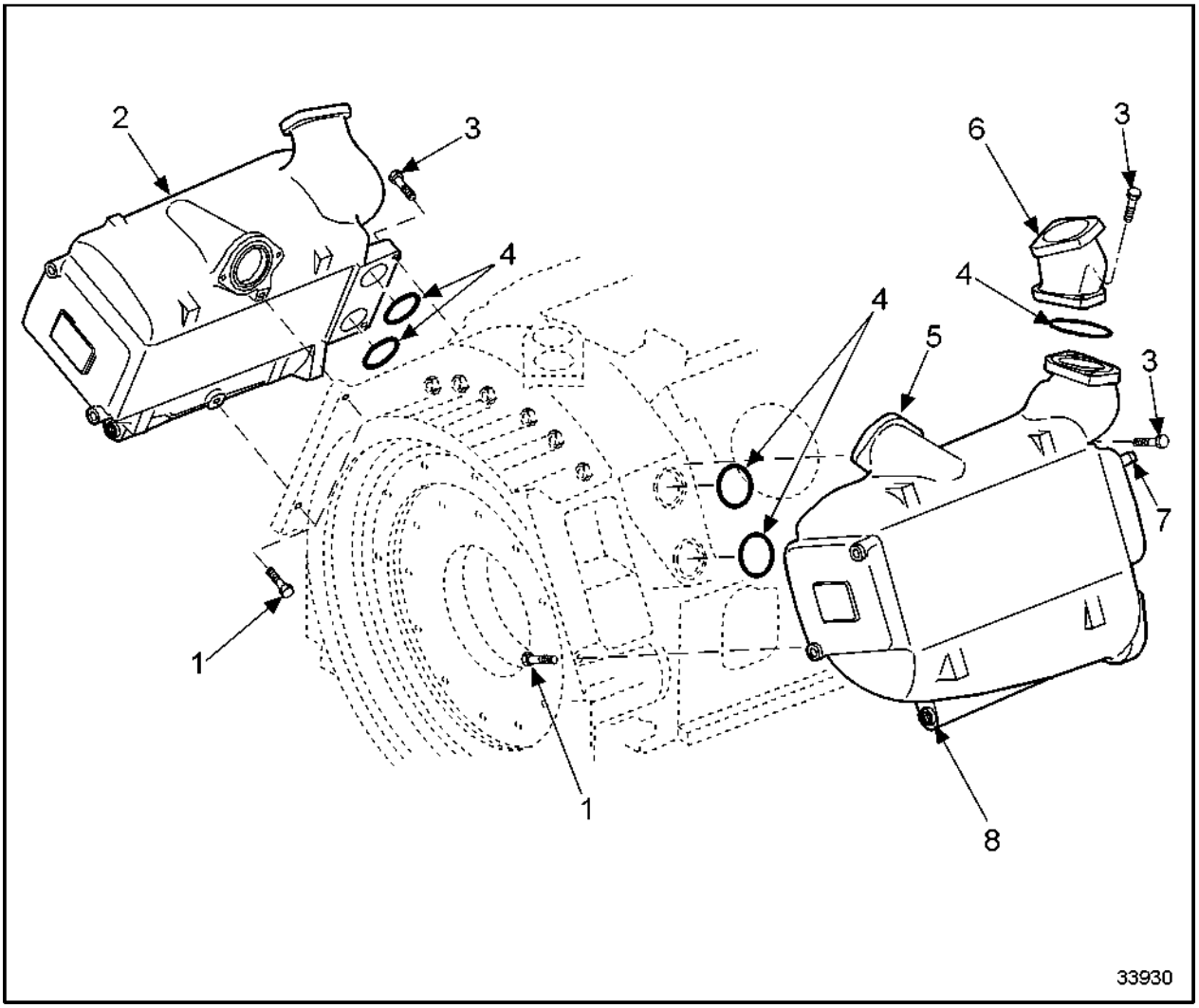
5. Using a suitable lifting device (2), install the charge air cooler (1). See Figure 675.



1. Charge Air Cooler
2. Lifting Device

Figure 675 Installing Charge Air Cooler to Engine

6. Secure charge air cooler with three 55 mm (2.2 in.) bolts (3). Torque bolts to 74-82 N·m (55-60 lb·ft). See Figure 676.

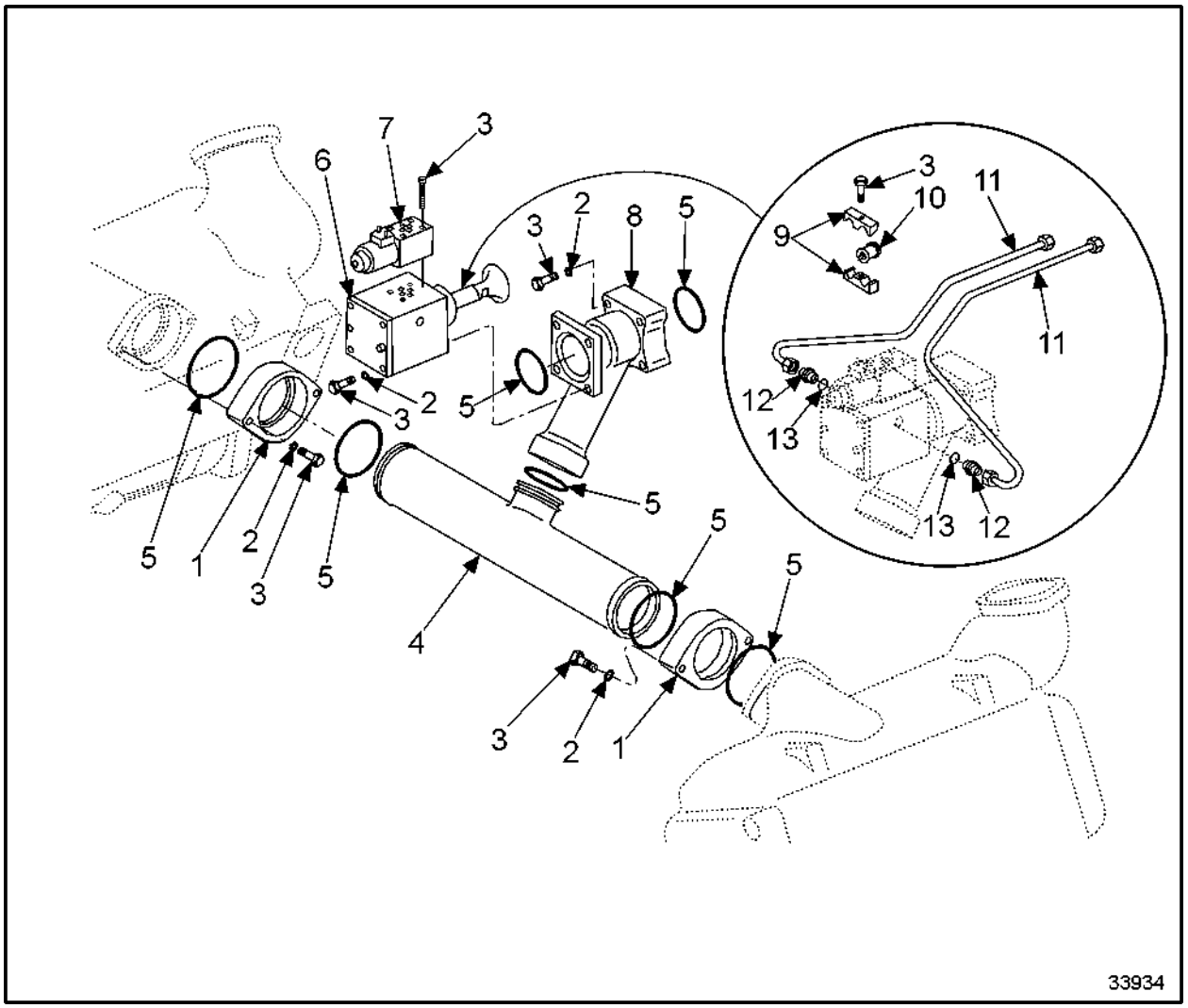


1. Bolt
2. Left "A" Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right "B" Bank Charge Air Cooler
6. Elbow - "B" side only
7. Bolt
8. Vent Line Location

Figure 676 Securing Charge Air Cooler with Bolts

7. Install two 70 mm (2.8 in.) bolts (3). Torque bolts to 74-82 N·m (55-60 lb·ft).

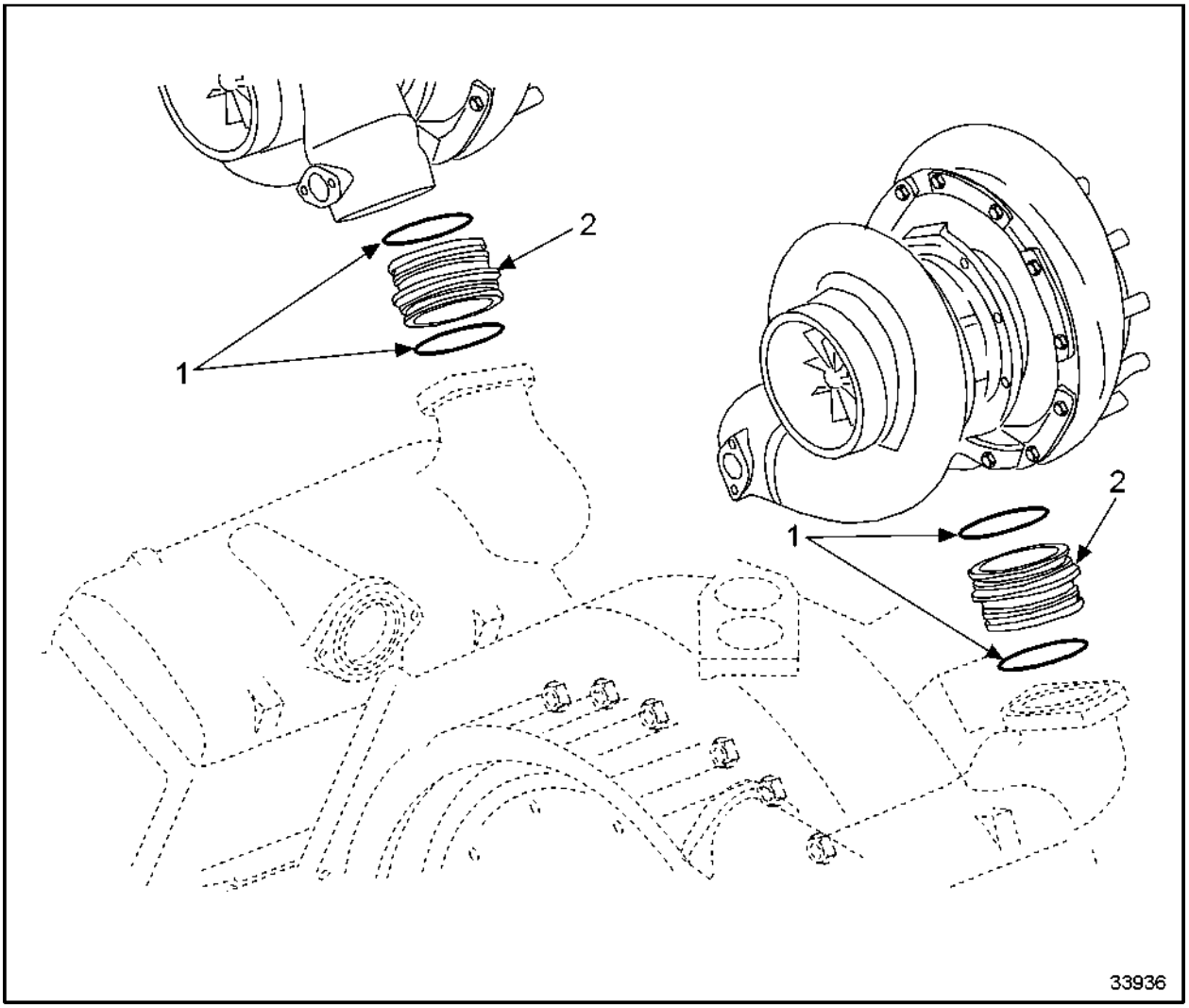
8. Install crossover tube (4) and secure with four bolts (3) and washers (2). Torque bolts to 25–30 N·m (18–22 lb·ft). See Figure 677.



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. Adapter
13. Sealing Ring

Figure 677 Installing Crossover Tube and Securing with Bolts

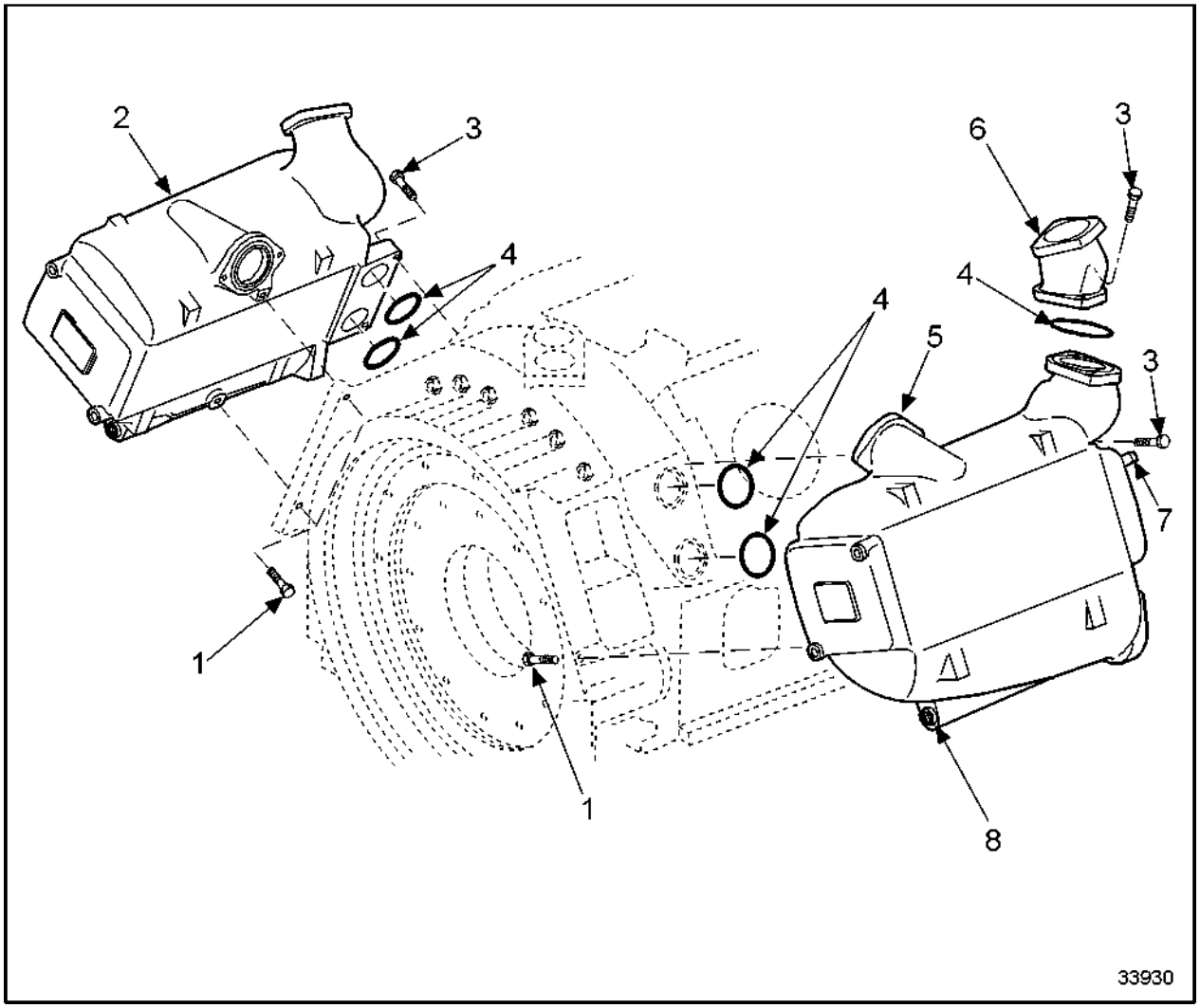
9. Install connection tube (2) between the compressor housing to charge air cooler. See Figure 678.



1. O-ring
2. Connection Tube

Figure 678 Installing Connection Tube between Compressor Housing and Charge Air Cooler

10. Connect vent lines (7). See Figure 679.



1. Bolt
2. Left "A" Bank Charge Air Cooler
3. Bolt
4. O-ring
5. Right "B" Bank Charge Air Cooler
6. Elbow - "B" side only
7. Bolt
8. Vent Line Location

Figure 679 Connecting Vent Lines

C 111.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 83are the After-Installation Operations for the charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Install charge air manifolds	Refer to C 124.05.11
1, 2, 3	Install coolant vent lines	Refer to C 206.05.11 M
1, 2, 3	Install monitoring system	Refer to C 501.05 M
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Enable engine power	Refer to Operators Guide

1 = The engine is to be completely disassembled.

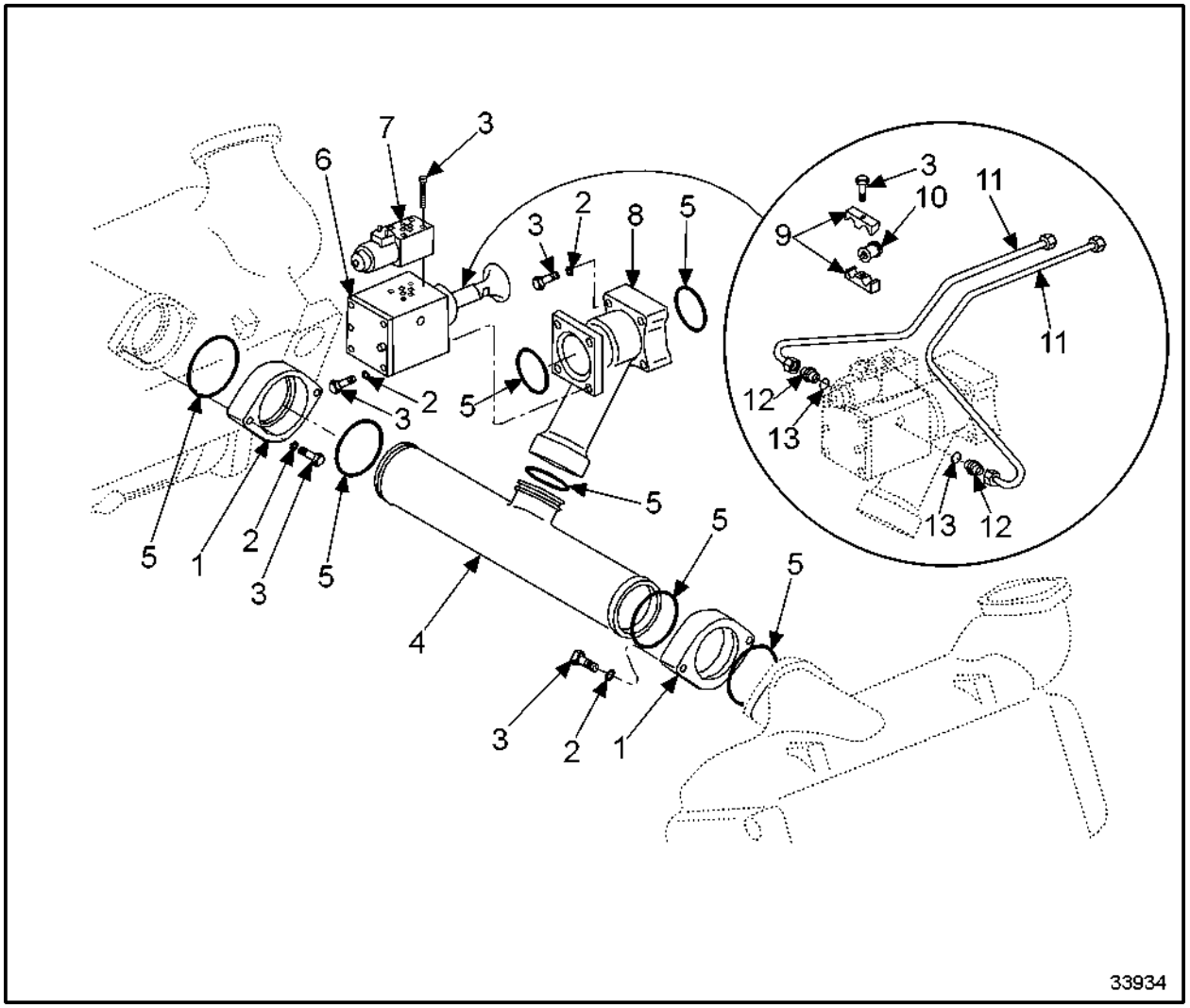
2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 83 After-Installation Operations for the Marine Charge Air Cooler

C 113.05.01 M – MARINE BOOST BYPASS VALVE

See Figure 680 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 680 Boost Bypass Valve Assembly

C 113.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 84 are the Before-Removal Operations for the marine boost bypass valve.

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.

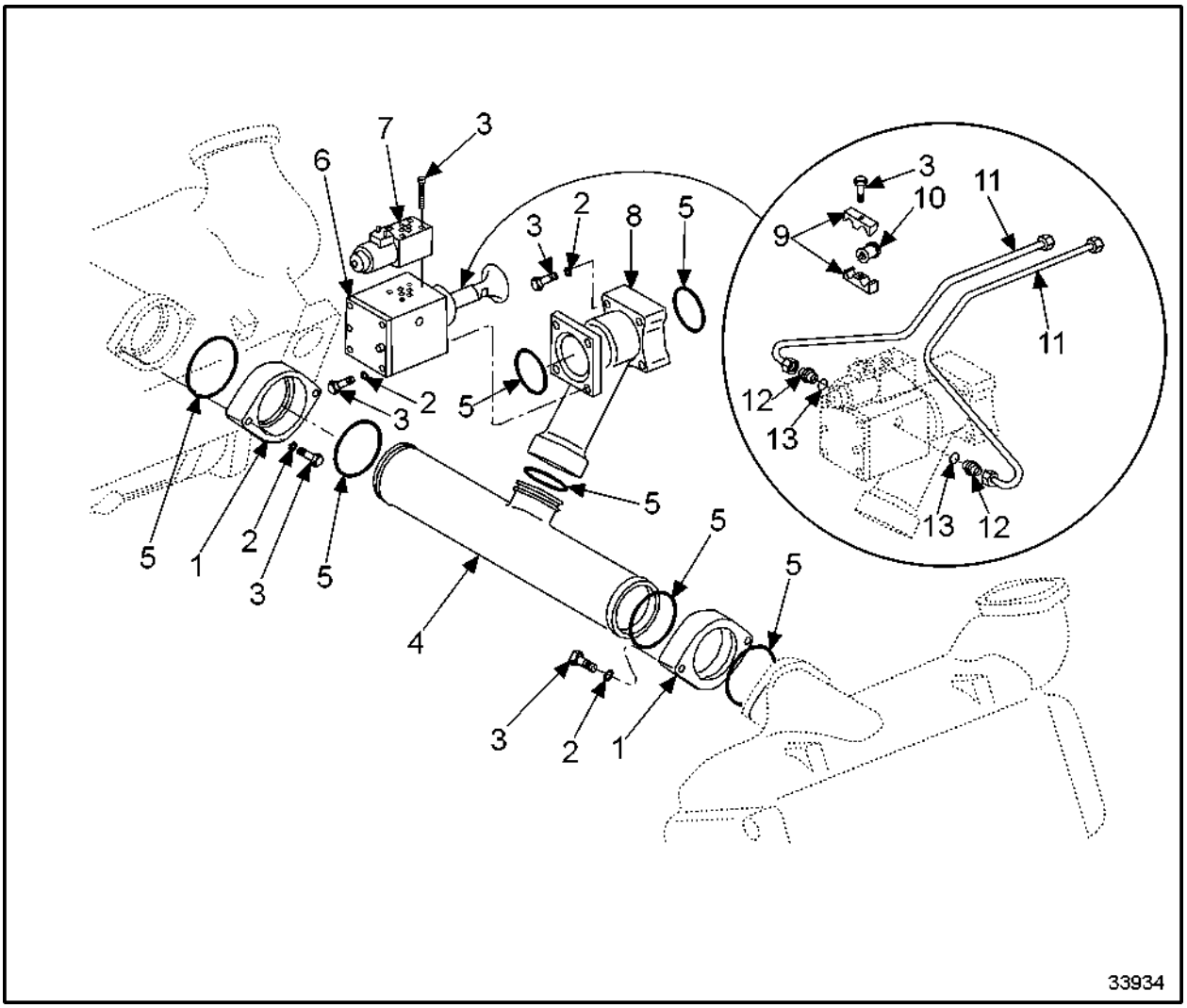
3 = The engine is to remain installed.

Table 84 Before-Removal Operations for the Boost Bypass Valve

C 113.05.05 M – REMOVAL OF THE BOOST BYPASS VALVE

Perform the following steps to remove the boost bypass valve.

1. Remove four bolts (3) and four washers (2) securing the crossover tube (4) to the intercooler. See Figure 681.

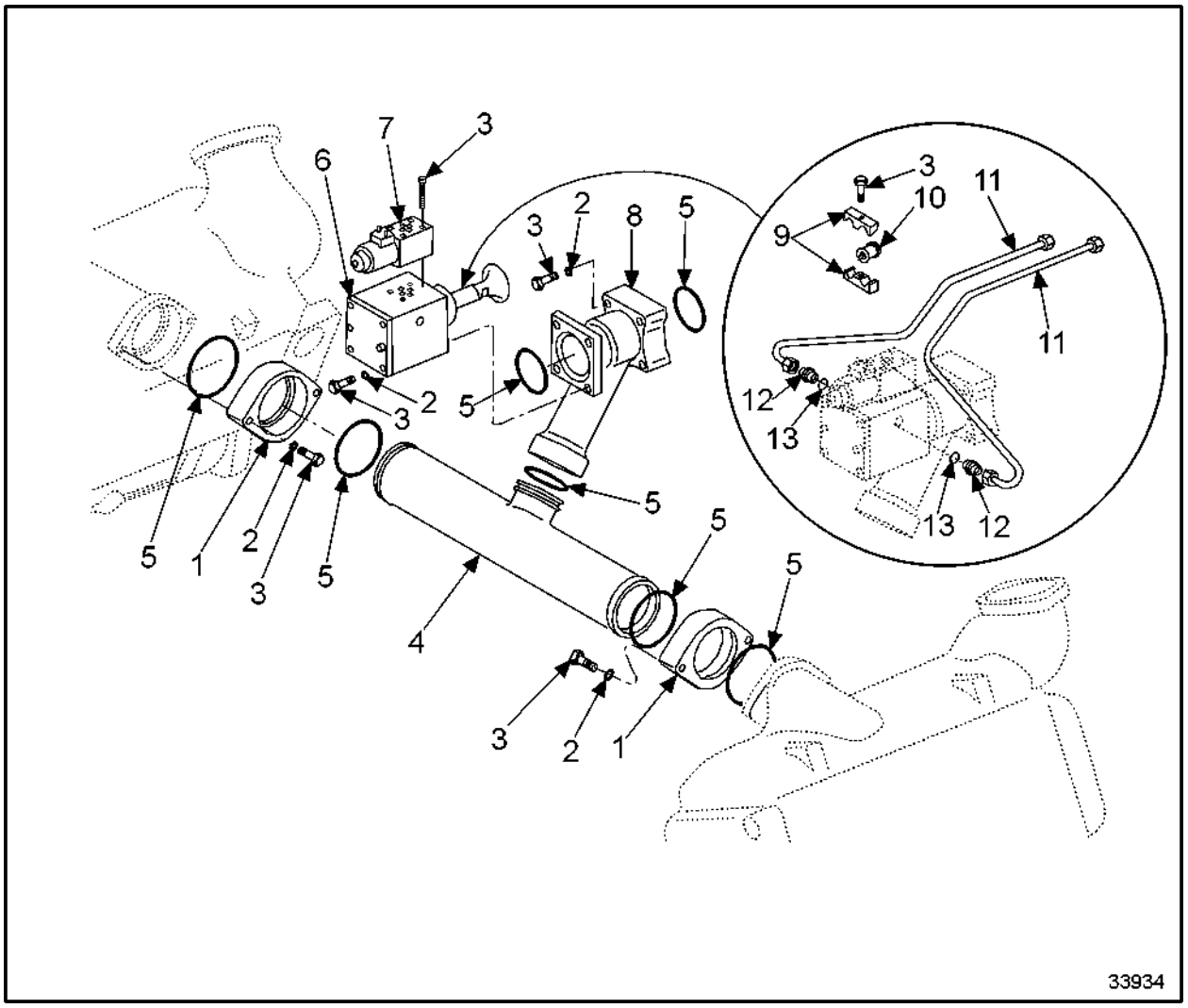


1. Flange
2. Washer
3. Bolt
4. Crossover Tube
5. O-ring
6. Actuating Cylinder
7. Boost Bypass Valve
8. Elbow
9. Pipe Half Clamp
10. Grommet
11. Oil Feed Line
12. Adaptor
13. Sealing Ring

Figure 681 Removing Boost Bypass Valve and Crossover Tube

2. Remove crossover tube (4).
3. Remove O-ring (5) from crossover tube (4).

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

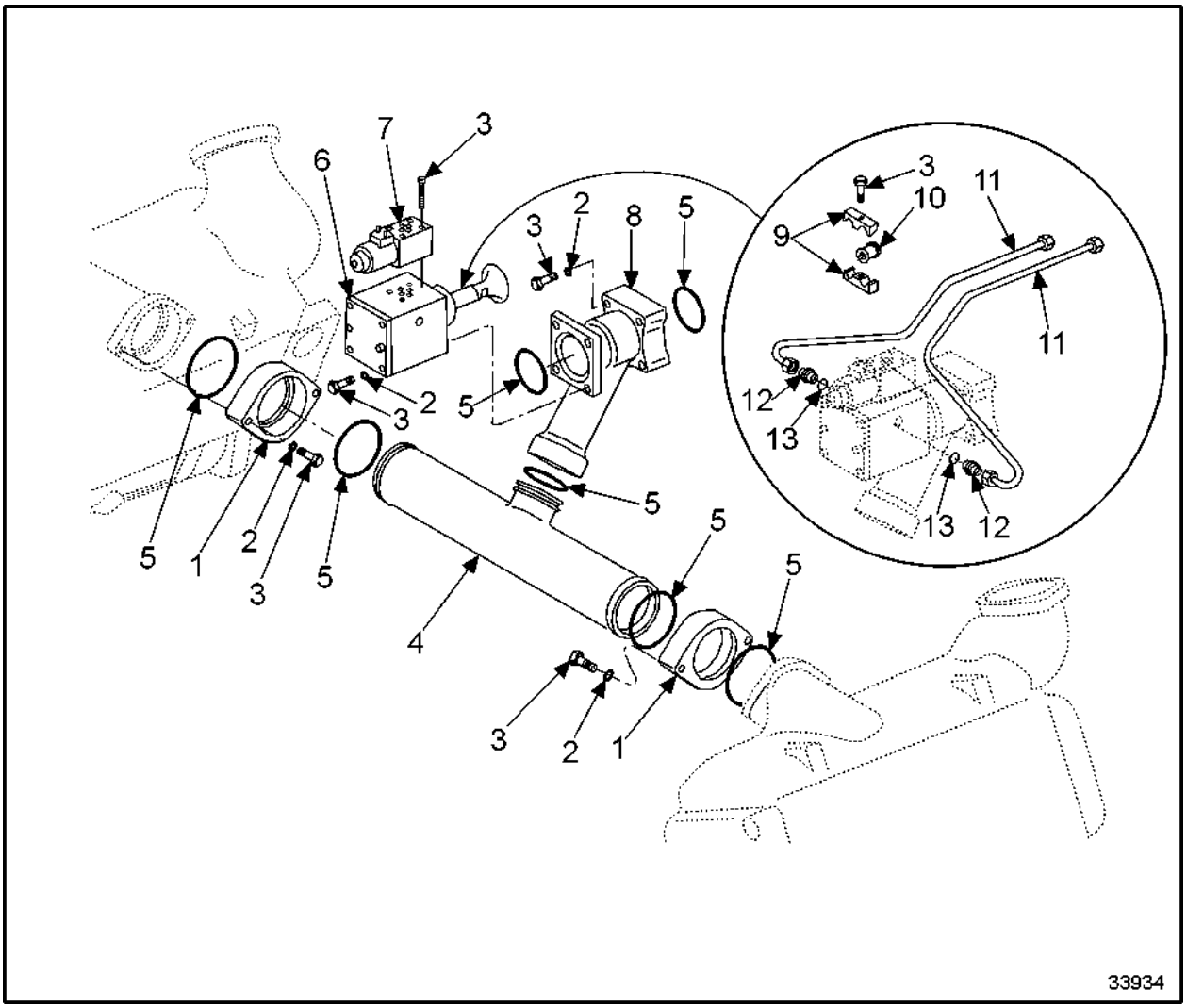


1. Flange
2. Washer
3. Bolt
4. Crossover Tube
5. O-ring
6. Actuating Cylinder
7. Boost Bypass Valve
8. Elbow
9. Pipe Half Clamp
10. Grommet
11. Oil Feed Line
12. Adaptor
13. Sealing Ring

Figure 682 Removing Boost Bypass Valve and Crossover Tube

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

6. Remove four bolts (3) and four washers (2) securing boost bypass valve elbow (8) to exhaust manifold crossover tube (4).
7. Remove boost bypass valve assembly. See Figure 683.



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 683 Removing Boost Bypass Valve and Crossover Tube

8. Remove O-ring (5). See Figure 683.

9. Remove four bolts (3) and four washers (2) securing actuating cylinder (6) to elbow (8). See Figure 683.
10. Remove elbow. See Figure 683.

C 113.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the intercooler:

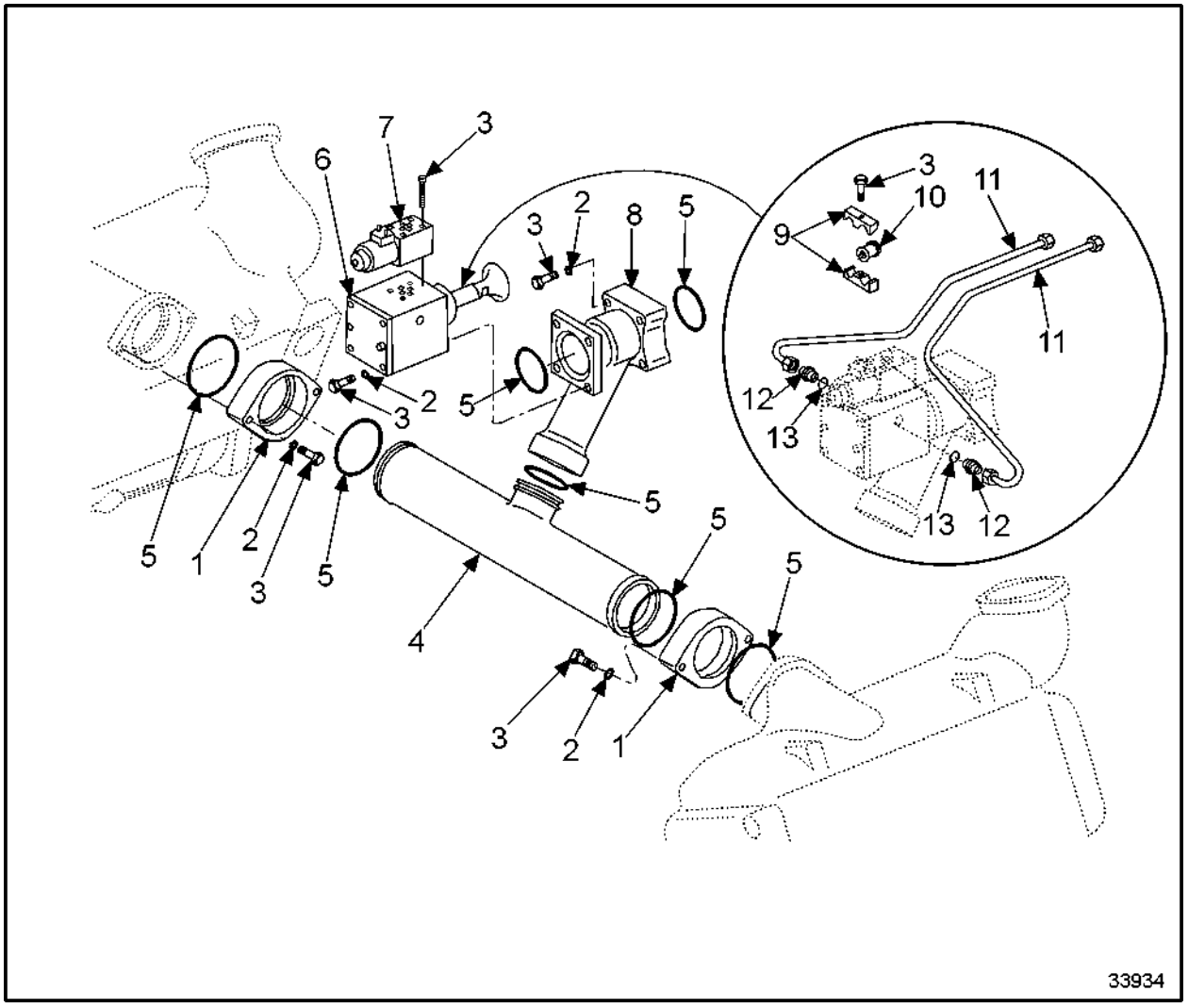
CAUTION:

To avoid personal injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

1. Using compressed air, clean all components and visually inspect for damage and defects.
   [a] If components are damaged or defective, replace as necessary.
   [b] If components are not damaged or defective, continue inspection.
2. Check thread in connecting housing for ease of movement.
   [a] If thread does not show ease of movement, recondition as necessary.
   [b] If thread does show ease of movement, continue inspection.

C 113.05.11 M – INSTALLATION OF THE BOOST BYPASS VALVE

Perform the following steps to install the boost bypass valve. See Figure 684 for the boost bypass valve location.

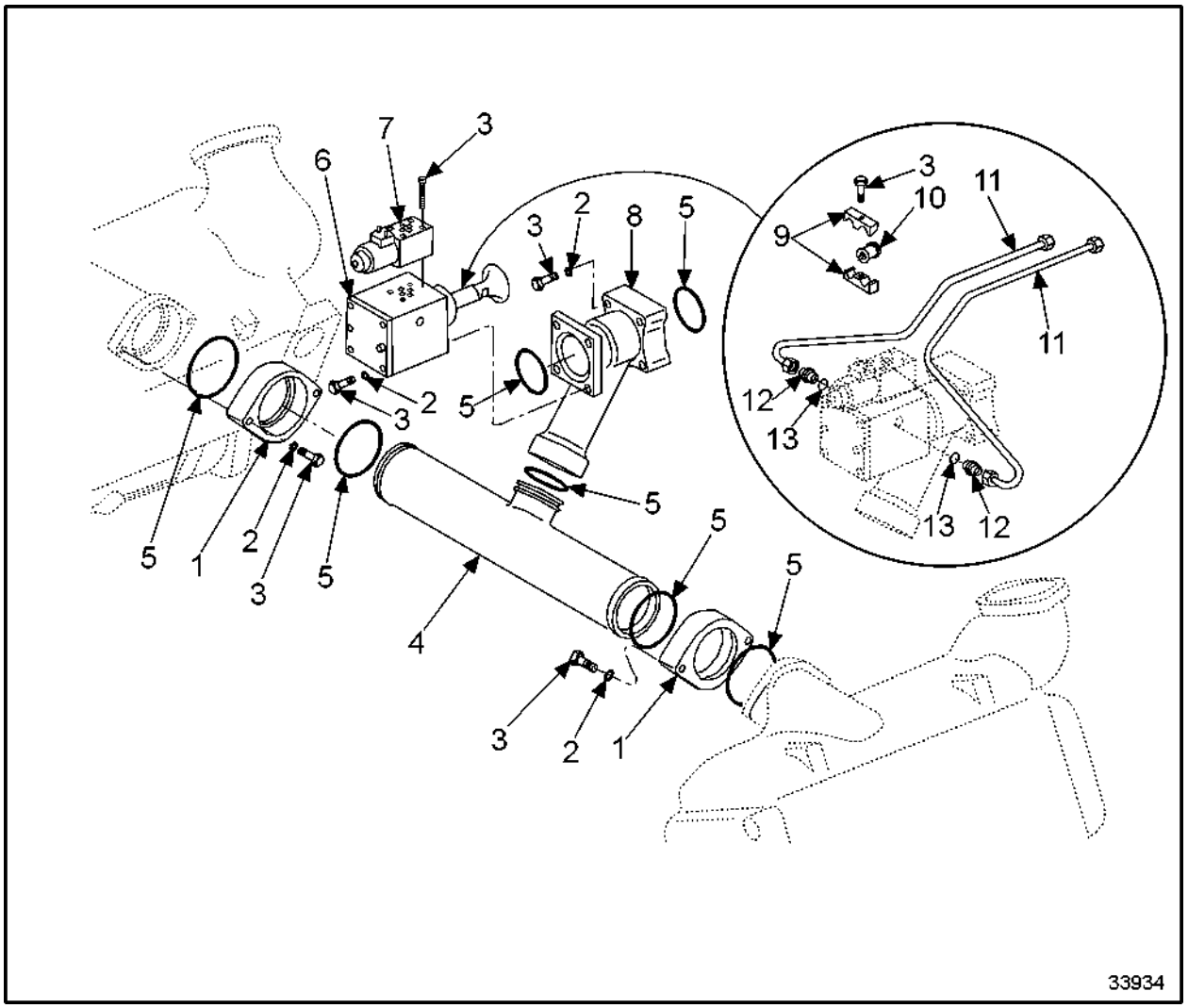


1. Flange
2. Washer
3. Bolt
4. Crossover Tube
5. O-ring
6. Actuating Cylinder
7. Boost Bypass Valve
8. Elbow
9. Pipe Half Clamp
10. Grommet
11. Oil Feed Line
12. Adaptor
13. Sealing Ring

Figure 684 Installing Boost Bypass Valve

1. Install new O-ring (5) to bypass elbow. See Figure 684.
2. Install boost bypass valve (7) to turbocharger crossover tube and secure with four bolts.
3. Tighten bolts to specified torque in accordance with specifications. Refer to section A 003.

4. Install actuating cylinder (6) to boost bypass valve (7) and secure with socket head cap screw. See Figure 685.

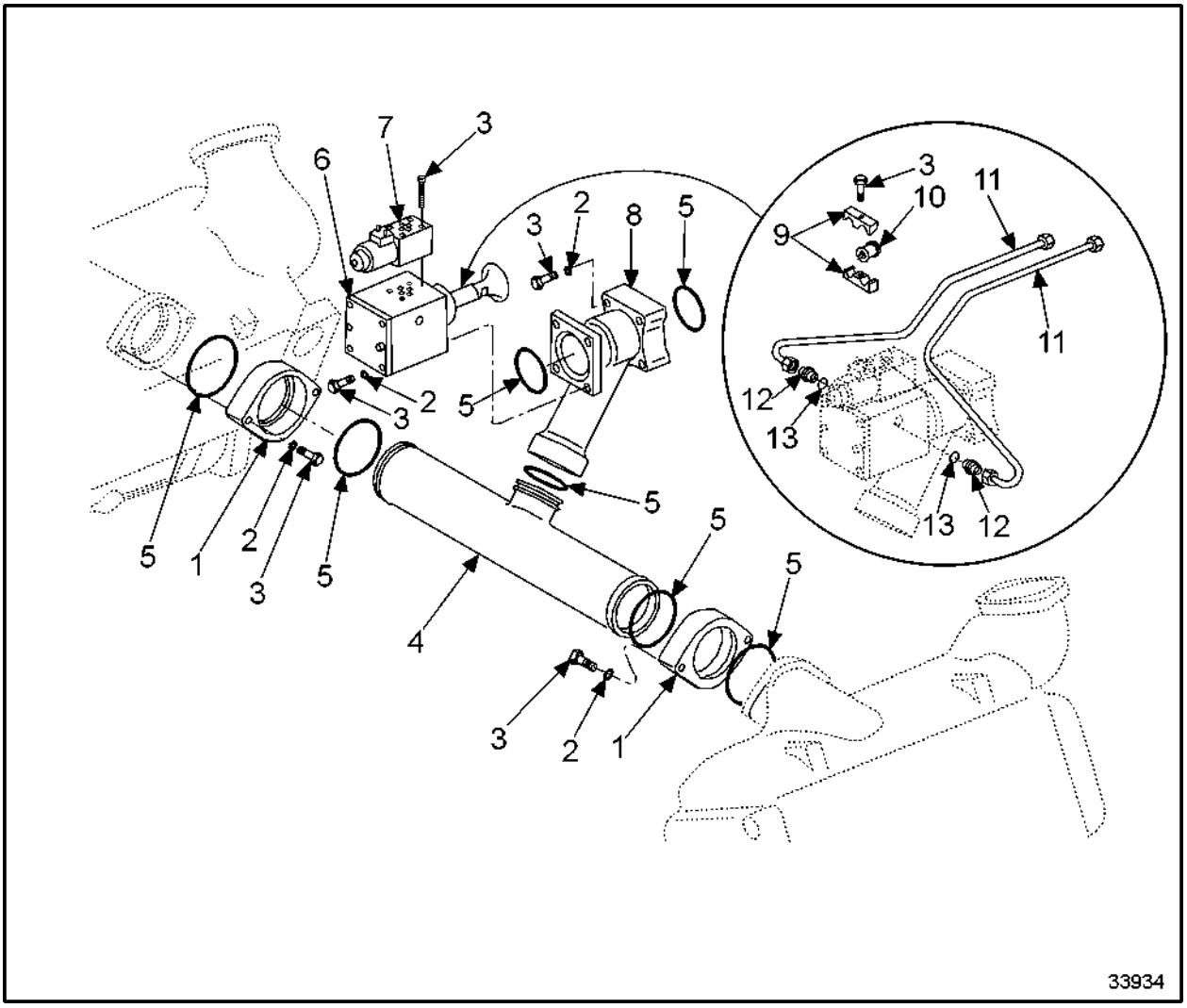


1. Flange
2. Washer
3. Bolt
4. Crossover Tube
5. O-ring
6. Actuating Cylinder
7. Boost Bypass Valve
8. Elbow
9. Pipe Half Clamp
10. Grommet
11. Oil Feed Line
12. Adaptor
13. Sealing Ring

Figure 685 Installing Boost Bypass Valve

5. Tighten bolts to specified torque in accordance with specification. Refer to section A 003. See Figure 685.

6. Connect vent lines.
7. Install new crossover tube O-rings (5) to intercooler. See Figure 685.
8. Install new O-ring (5) to crossover tube (4) neck. See Figure 686.



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 686 Installing Boost Bypass Valve

9. Install crossover tube (4) and secure with four bolts (3) and washers (2).
10. Tighten bolts to specified torque in accordance with *Torque Specifications,* 028T4000.
11. Verify repair of boost bypass valve.

C 113.05.04 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 85 are the After-Installation Operations for the marine boost bypass valve.

Level of Maintenance	Operation	Reference
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 85 After-Installation Operations for the Marine Boost Bypass Valve

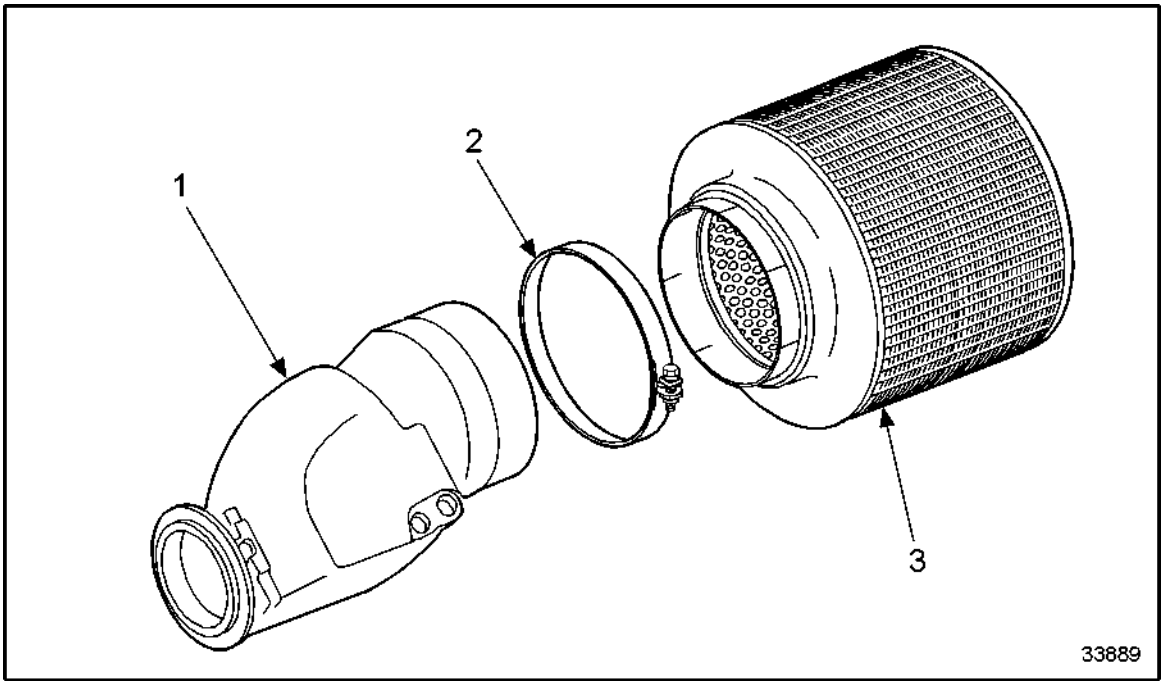
C 120 – AIR INTAKE SUPPLY

Section **Page**

C 121.05 M – MARINE AIR FILTER

C 121.05.01 M – GENERAL VIEW

For a general view of the marine air filter, see Figure 687.



1. Intake Housing
2. Clamp
3. Air Filter

Figure 687 General View of Marine Air Filter

C 121.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 86are the Before-Removal Operations for the marine air filter.

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.

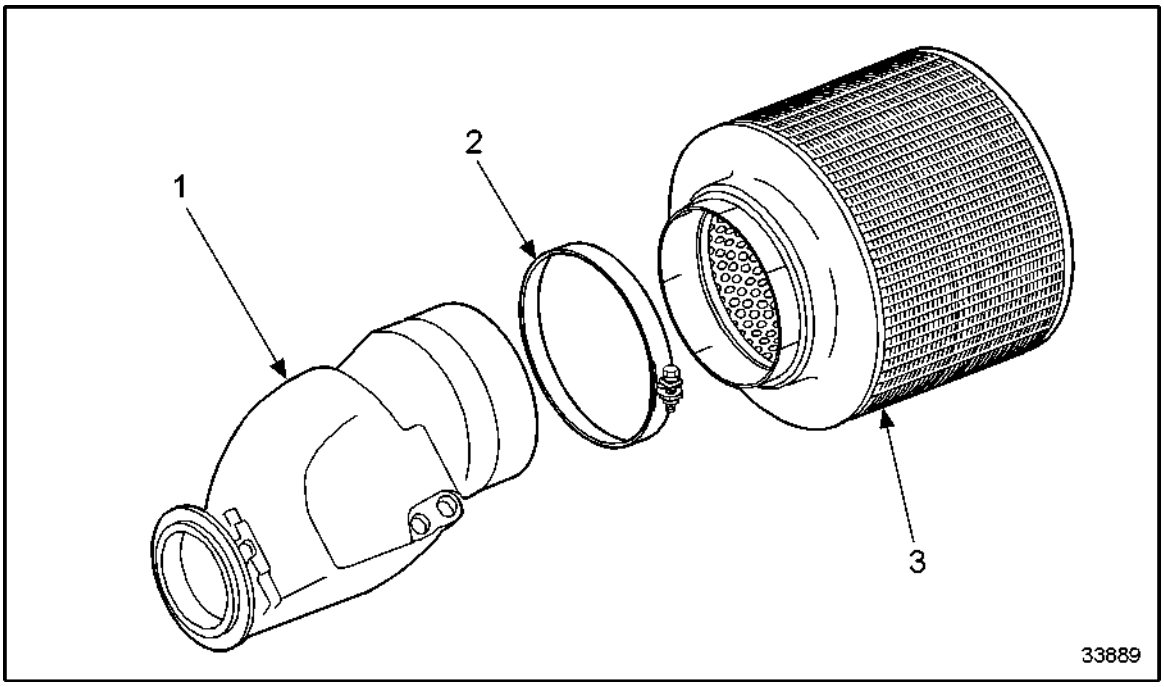
3= The engine is to remain installed.

Table 86 Before-Removal Operations for the Marine Air Filter

C 121.05.05 M – REMOVAL OF THE AIR FILTER

Perform the following steps to remove the air filter element:

1. Loosen the V-band clamp (2) securing the air filter (3) to the intake housing (1); see Figure 688.



1. Intake Housing
2. V-band Clamp
3. Air Filter

Figure 688 Loosening V-band Clamp

2. Remove the air filter (3) and V-band clamp (2); see Figure 688.

C 121.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the marine air filter:

1. Clean clamps.
2. Visually inspect clamps for damage or wear.
   [a] If clamps are damaged or worn, replace component as necessary.
   [b] If clamps are not damaged or worn, continue inspection.
3. Inspect bolts for ease of movement.
   [a] If bolts do not show ease of movement, replace component as necessary.
   [b] If bolts show ease of movement, continue inspection.
4. Visually inspect air filter for contamination.
   [a] If air filter is contaminated, replace component.
   [b] If air filter is not contaminated, continue inspection.

NOTE:
Replace air filter at appropriate maintenance intervals.

CAUTION:

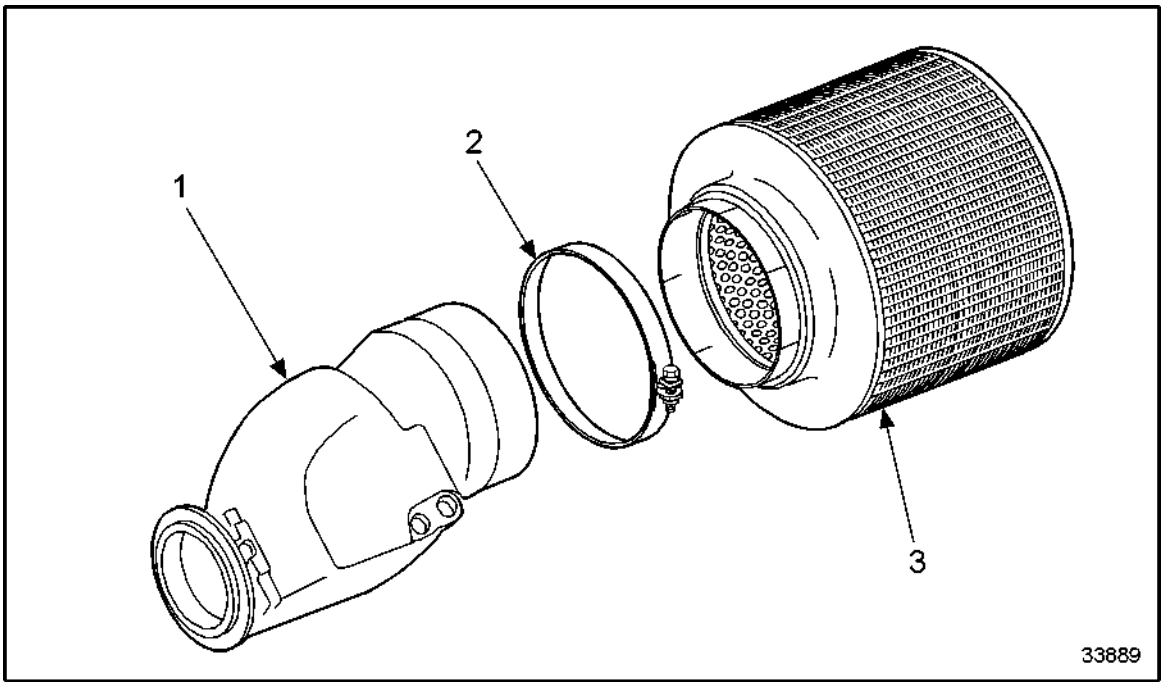
To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

5. Ensure all components are clean. Clean with compressed air.

C 121.05.11 M – INSTALLATION OF THE MARINE AIR FILTER

Perform the following steps to install the marine air filter:

1. Install the marine air filter element and V-band clamp.
2. Finger-tighten the V-band clamp (2) securing the air filter (3) to the intake housing (1); see Figure 689.



1. Intake Housing
2. V-band Clamp
3. Air Filter

Figure 689 Installing V-band Clamp

C 121.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 87are the After-Installation Operations for the marine air filter.

Maintenance Level	Operation	Reference
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.

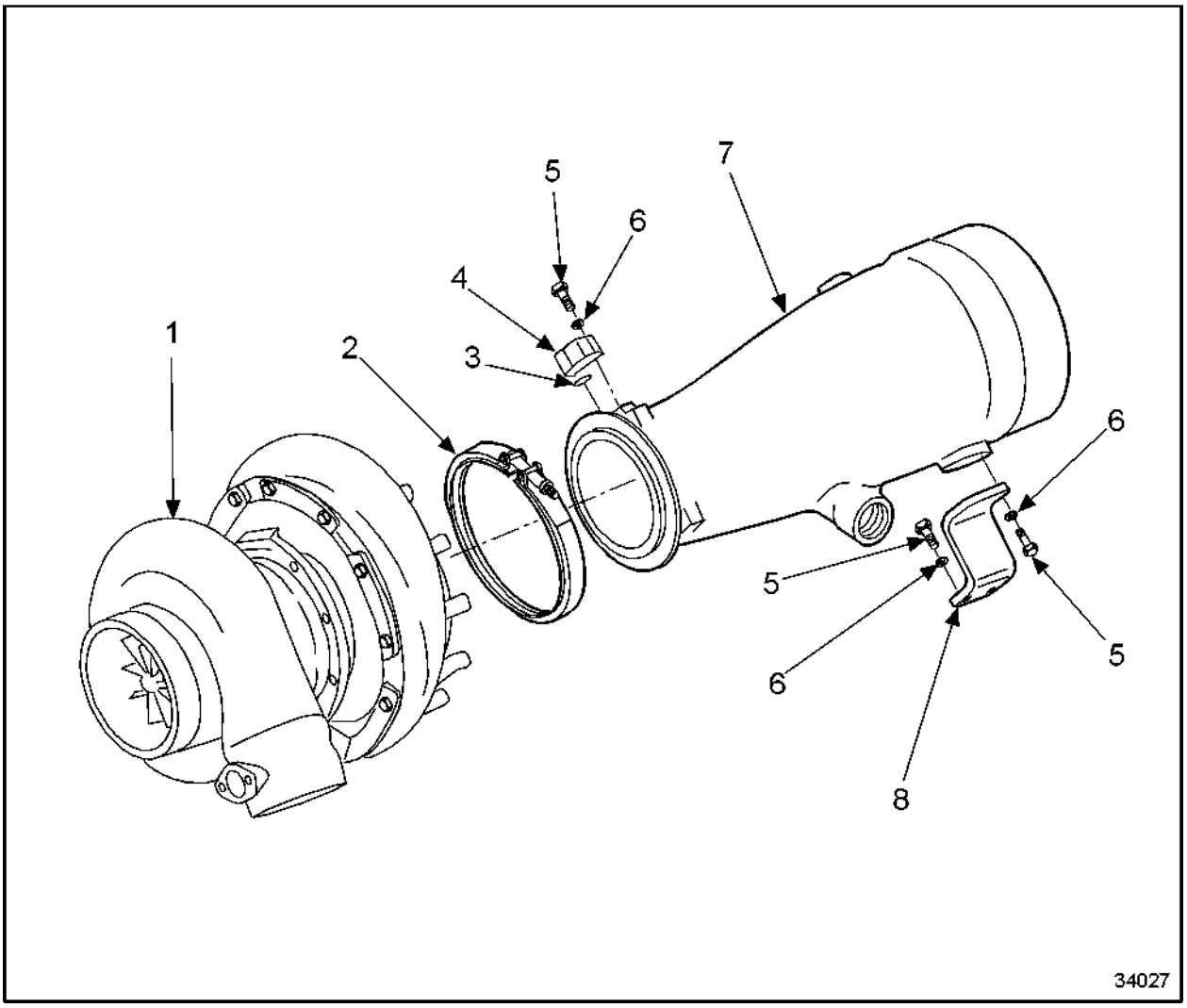
3= The engine is to remain installed.

Table 87 After-Installation Operations for the Marine Air Filter

C 123.05 M – MARINE INTAKE HOUSING

C 123.05.01 M – GENERAL VIEW

See Figure 690 for a general view of the intake housing.



1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 690 General View of Intake Housing

C 123.05.04 M – BEFORE – REMOVAL OPERATIONS

Listed in Table 88 are the Before – Removal Operations for the intake housing.

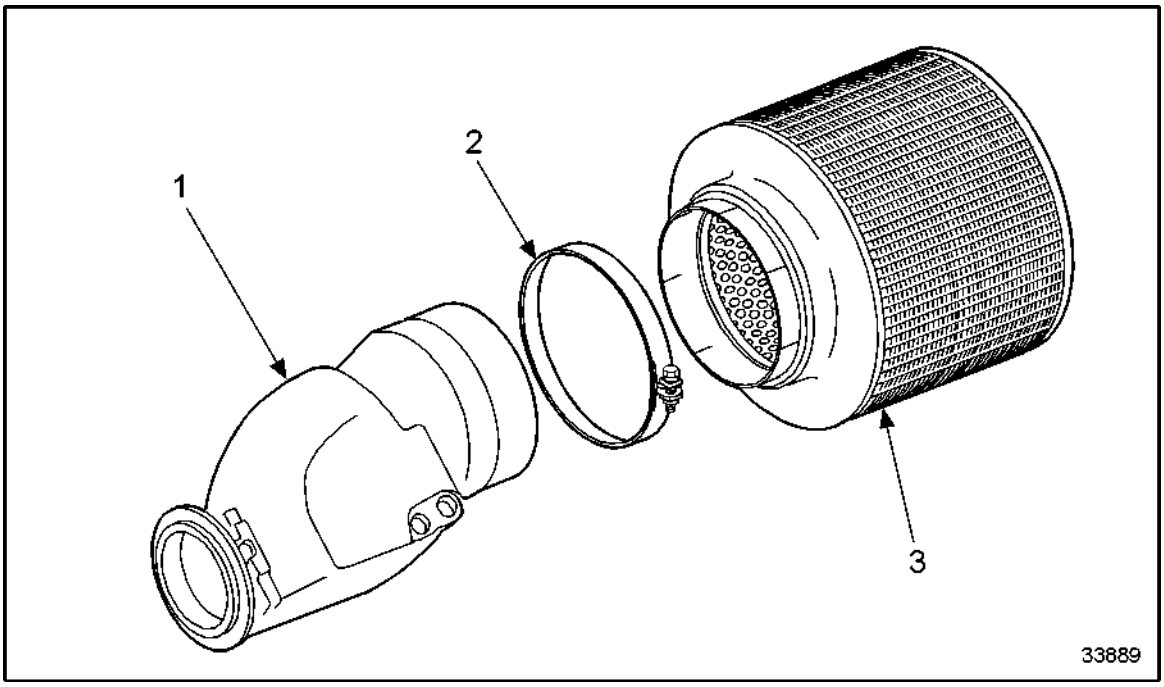
Level of Maintenance	Operation	Reference
3	Disable engine power	Refer to Operators Guide

Table 88 Before – Removal Operations

C 123.05.05 M – REMOVAL OF THE INTAKE HOUSING

Perform the following steps to remove the intake housing:

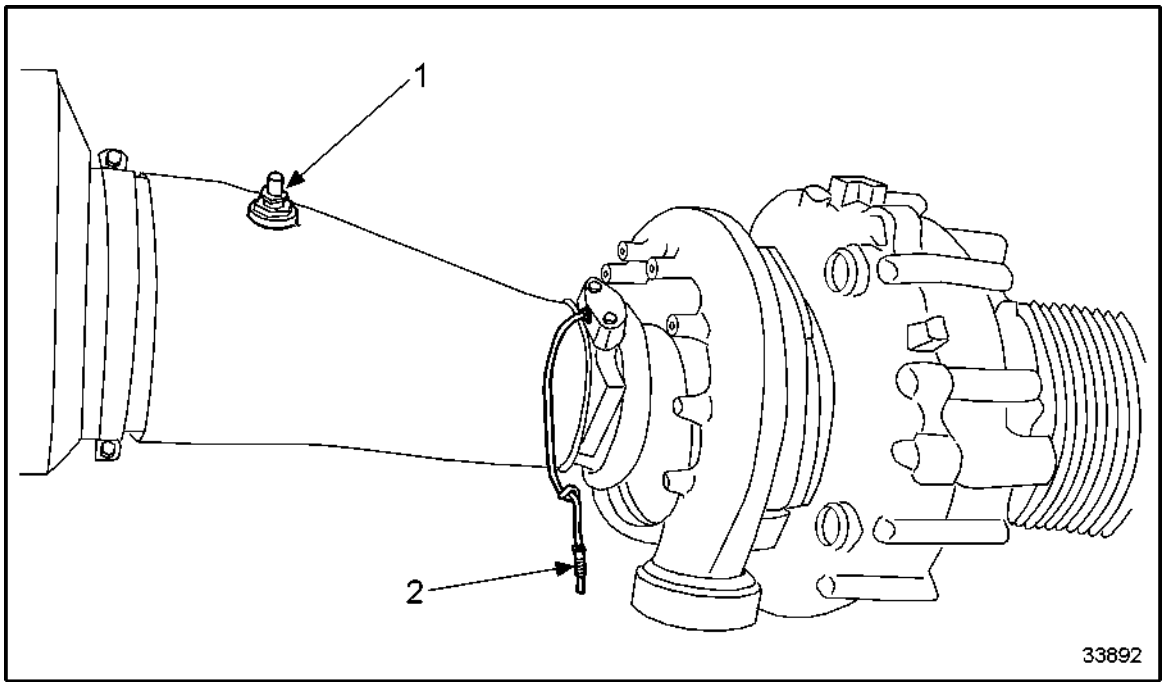
1. Release the clamp (2) and remove the air filter element from the air intake housing (1). See Figure 691.



1. Intake Housing
2. Clamp
3. Air Filter

Figure 691 Removing Air Filter Element from Air Intake Housing

2. Disconnect the B3 (air temperature sensor) wiring harness. See Figure 692.

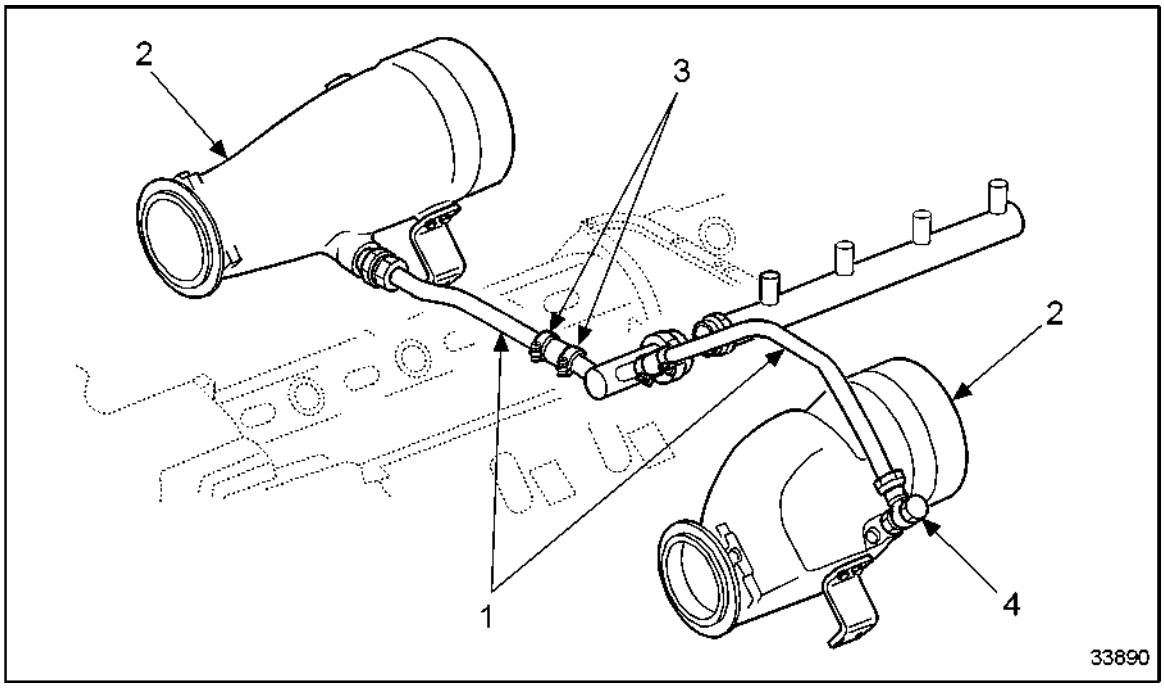


1. Air Temperature Sensor
2. Turbocharger Speed Sensor

Figure 692 Disconnecting the B3 (Air Temperature Sensor) Wiring Harness

3. Disconnect the B44 (turbocharger speed sensor) wiring harness. See Figure 692.

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

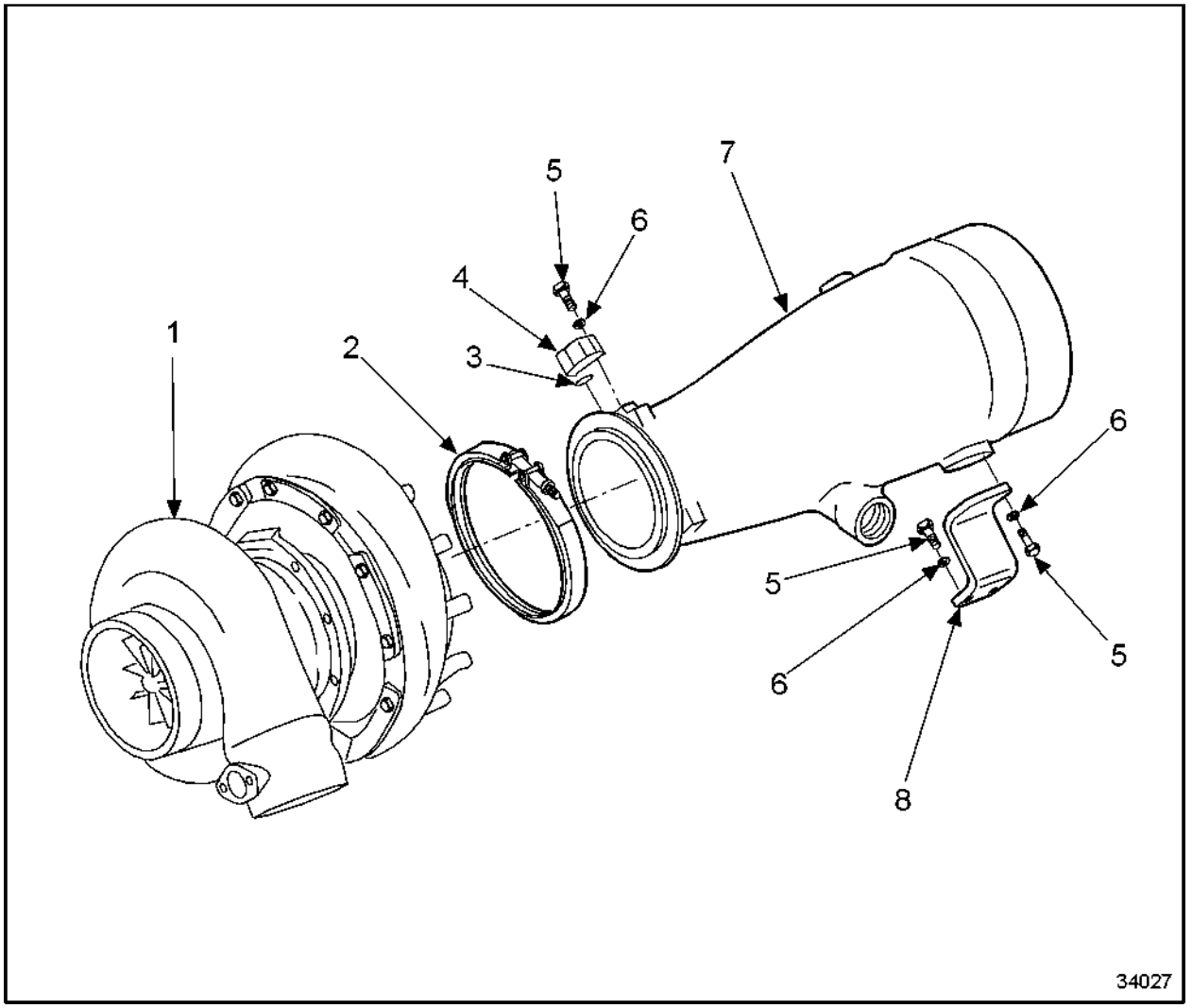


1. Air Intake Vent Tube
2. Intake Housing
3. Clamps
4. Vent Tube Fitting

Figure 693 Removing Air Intake Vent Tube

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

6. Release band clamp (2) securing the intake housing (7) to the turbocharger (1) and remove the intake housing and clamp. See Figure 694.



1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 694 Removal of Intake Housing Components

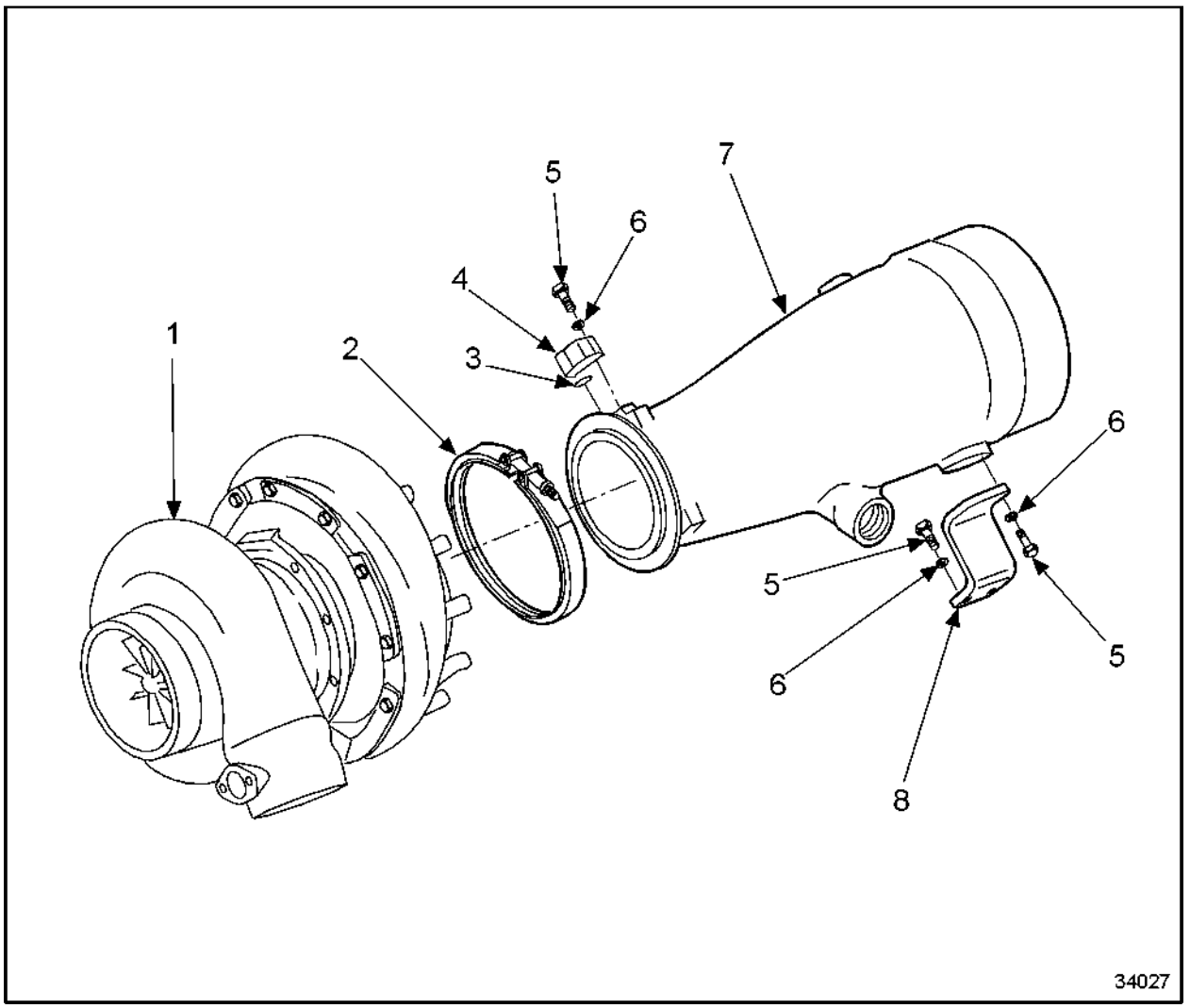
7. Remove bolts (5) and washers (6) securing the air intake housing (7) to the exhaust manifold mounting bracket (8) and remove the intake housing. See Figure 694.
8. Remove bolts (5) and washers (6) securing the mounting bracket to the exhaust manifold. See Figure 694.

9. Remove the air temperature sensor, if necessary.
10. Remove the turbocharger speed sensor, if necessary.

C 123.05.06 M – DISASSEMBLY OF THE INTAKE HOUSING

Perform the following operations to disassemble the intake housing:

1. 1. Remove bolt (5) and washer (6) securing retainer (4) to the intake housing and remove the retainer. See Figure 695.



1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 695 Disassembling Intake Housing

2. Remove O-ring (3) from the intake housing (7).

C 123.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the intake housing:

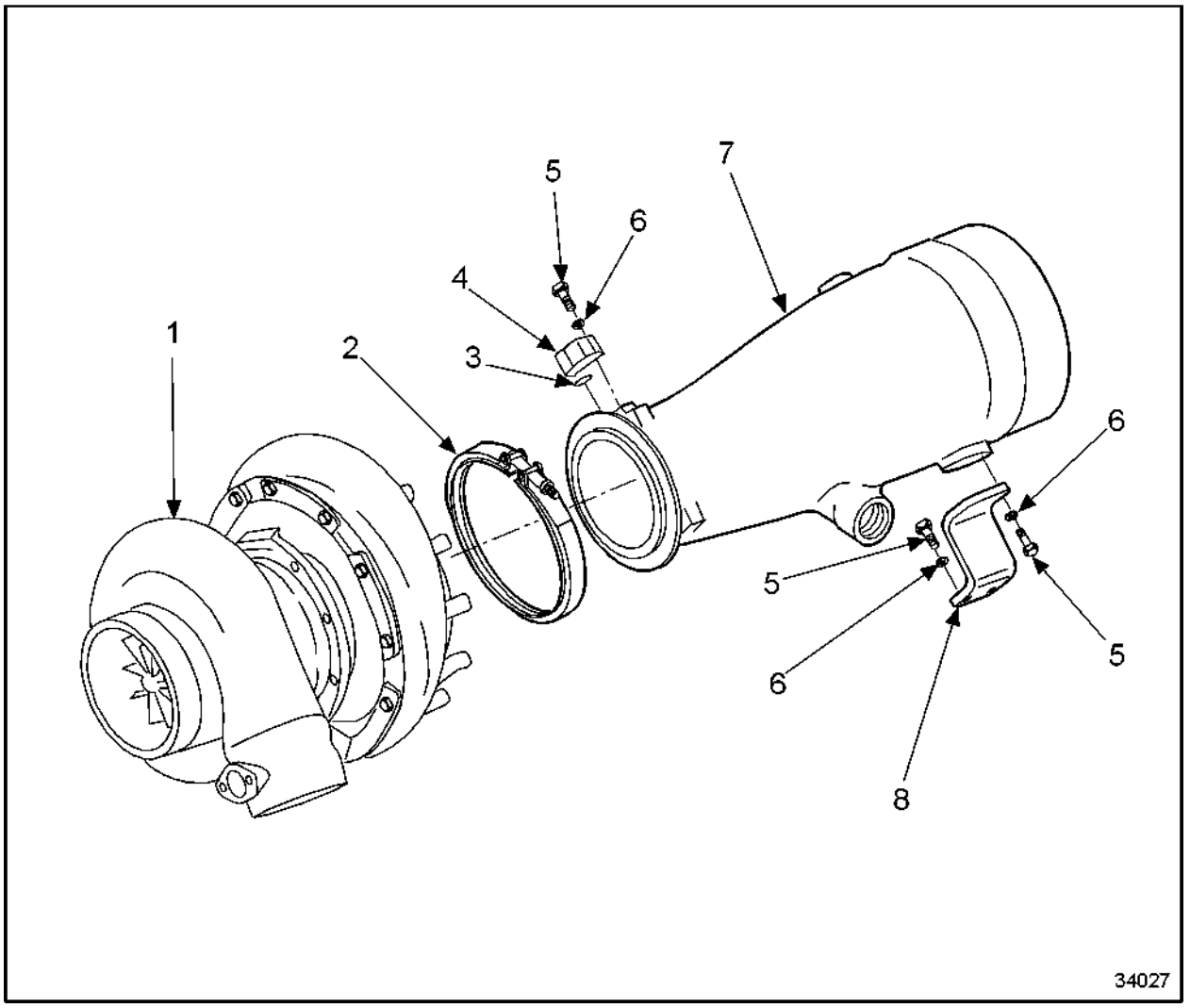
NOTE:
Ensure that air carrying components are perfectly clean.

1. Clean all components
2. Visually inspect shaft for cracks using the surface crack – testing method with fluorescent magnetic powder.
   [a] If cracks are detected, replace component.
   [b] If no cracks are detected, continue inspection.
3. Visually inspect the shaft for cracks using the magnetic crack – testing method with fluorescent magnetic powder.
   [a] If cracks are detected, replace component.
   [b] If no cracks are detected, continue inspection.
4. Visually inspect bracket for wear, cracks and damage.
   [a] If wear, cracks or damage is detected, replace component.
   [b] If wear, cracks and damage are not detected, continue inspection.
5. Visually inspect sealing, mating and seating surfaces on intake housing for damage and surface irregularities.
   [a] If sealing, mating and seating surfaces on intake housing show damage or surface irregularities, rub down with oilstone as necessary.
   [b] If damage is beyond repair, replace component.
   [c] If sealing, mating and seating surfaces on intake housing do not show damage or surface irregularities, continue inspection.
6. Visually inspect fits of shaft and flanged bushing using micrometer.
   [a] If limit values are exceeded, replace components
   [b] If limit values are not exceeded, continue inspection.
7. Visually inspect clamps for wear or damage.
   [a] If clamps show damage or wear, replace component.
   [b] If clamps do not show damage or wear, continue inspection.
8. Inspect bolts for ease of movement.
   [a] If bolts do not show ease of movement, replace component.
   [b] If bolts do show ease of movement, continue inspection.

C 123.05.10 M – ASSEMBLY OF THE INTAKE HOUSING

Perform the following steps to assemble the intake housing.

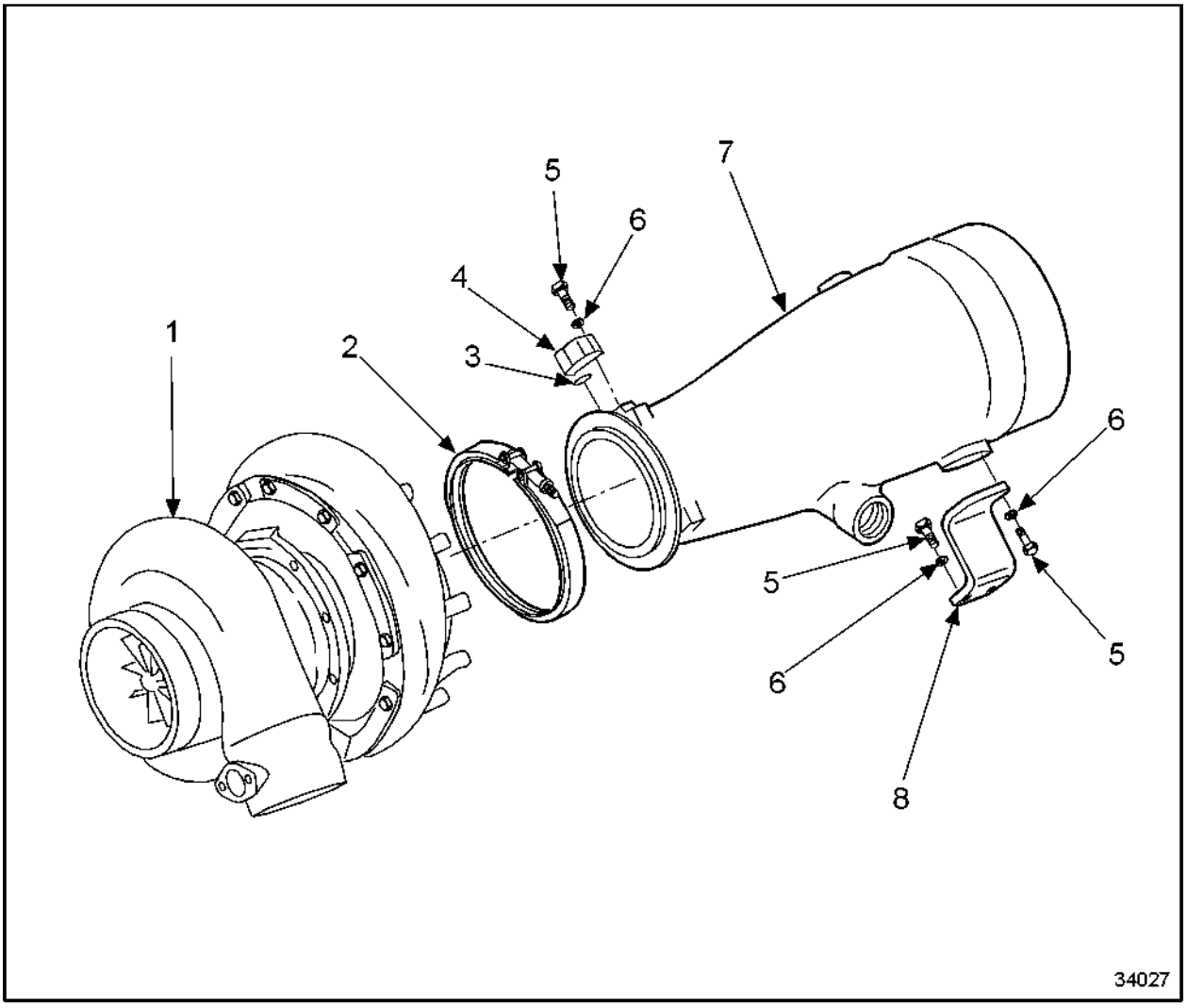
1. Install new O-ring (3) into the intake housing (7). See Figure 696.



1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 696 Assembling Intake Housing

2. Install retainer (4) to the intake housing and secure with washers (6) and bolt (5). Torque bolts to specification. Refer to section A 003. See Figure 697.



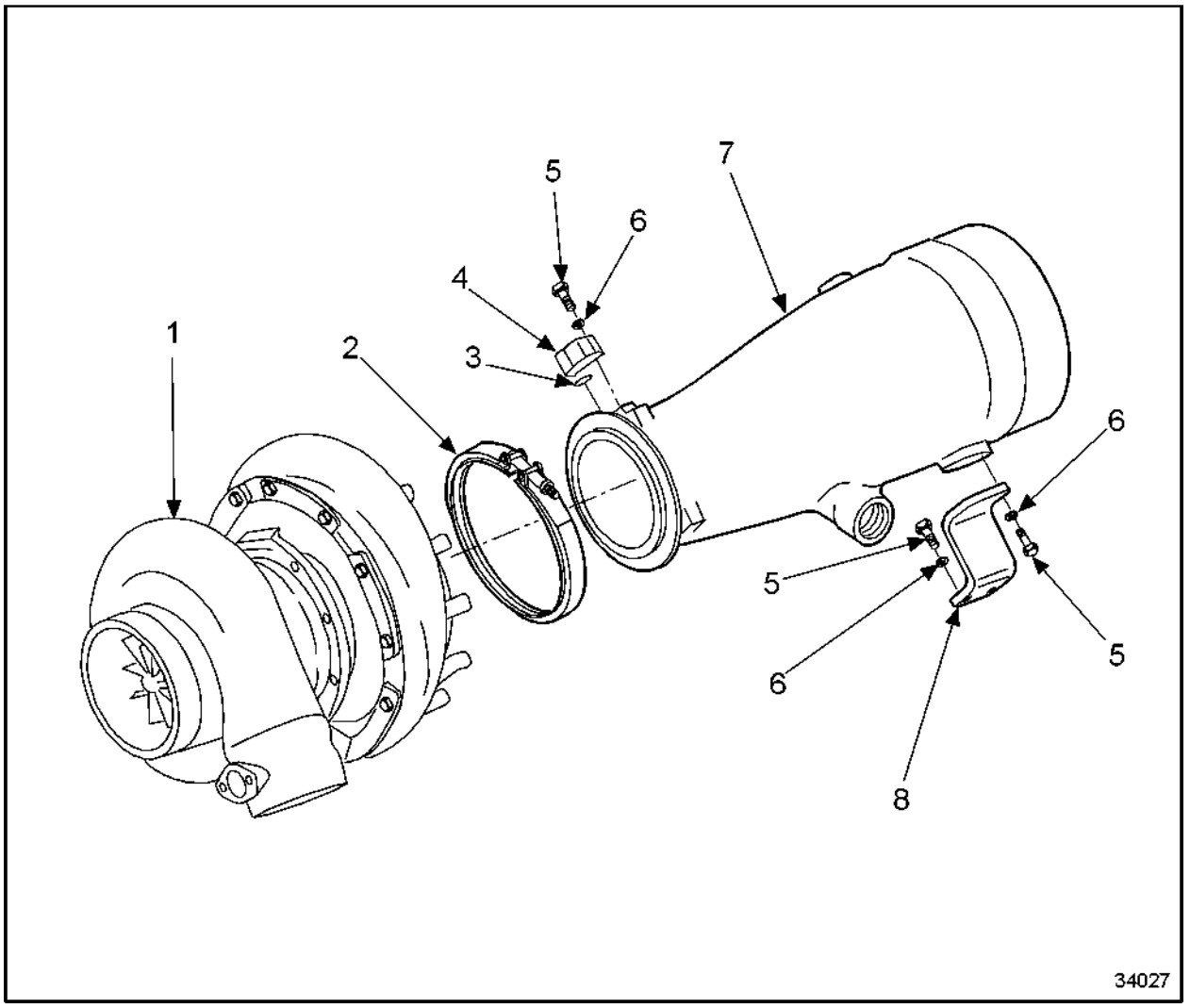
1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 697 Assembling Left Intake Housing

C 123.05.11 M – INSTALLATION OF THE INTAKE HOUSING

Perform the following steps to install the intake housing as follows:

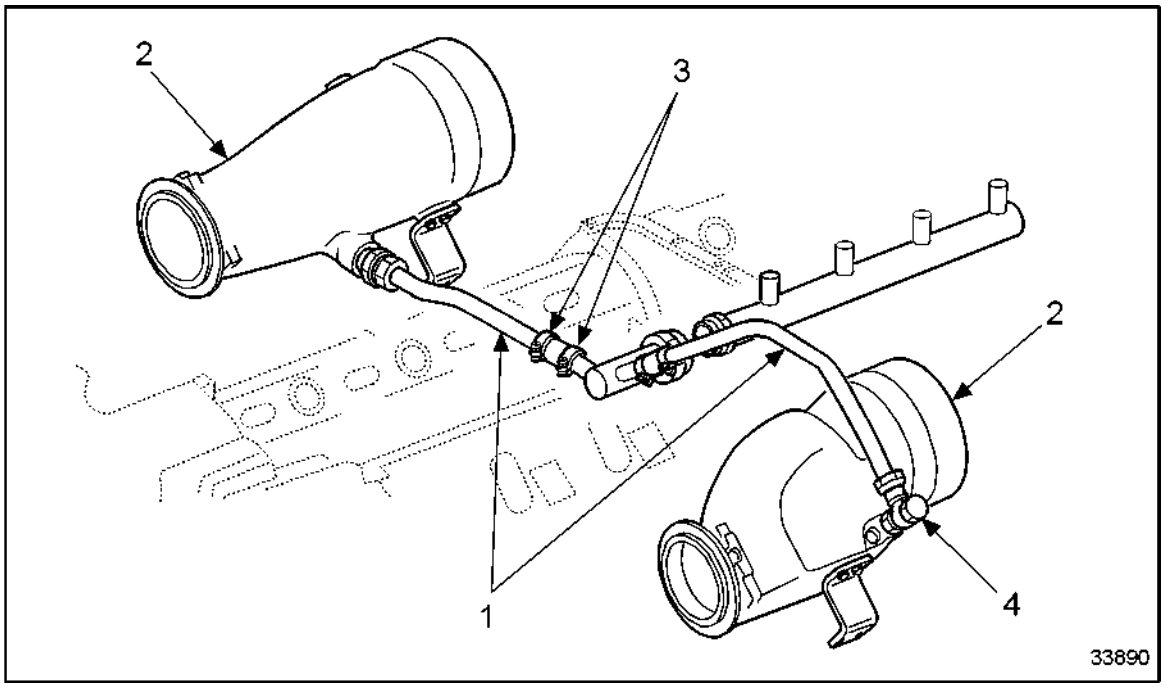
1. Install the turbocharger speed sensor, if removed.
2. Install the air temperature sensor, if removed.
3. Install the intake housing mounting bracket (8) to the exhaust manifold and secure with bolts (5) and washers (6). Torque bolts to specification. Refer to section A 003. See Figure 698.



1. Turbocharger
2. Clamp
3. O-ring
4. Retainer
5. Bolt
6. Washer
7. Intake Housing
8. Mounting Bracket

Figure 698 Installing Intake Housing Components

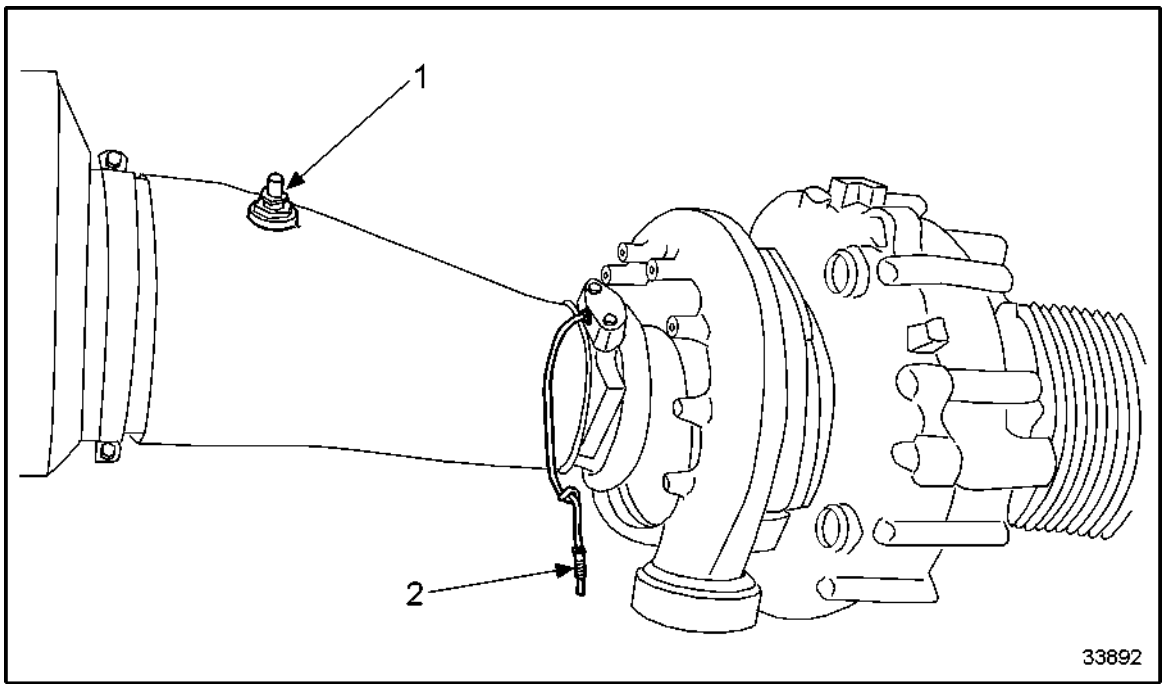
4. Install clamp (2) and the intake housing (7) to the turbocharger (1). Torque bolts to specification. Refer to section A 003.
5. Install the air intake vent tube (1) to the intake housing (2) and secure with clamps (3). Torque clamp nut to specification. Refer to section A 003. See Figure 699.



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

Figure 699 Installing Air Intake Vent Tube

6. Connect B44 (turbocharger speed sensor) (2) wiring harness. See Figure 700.

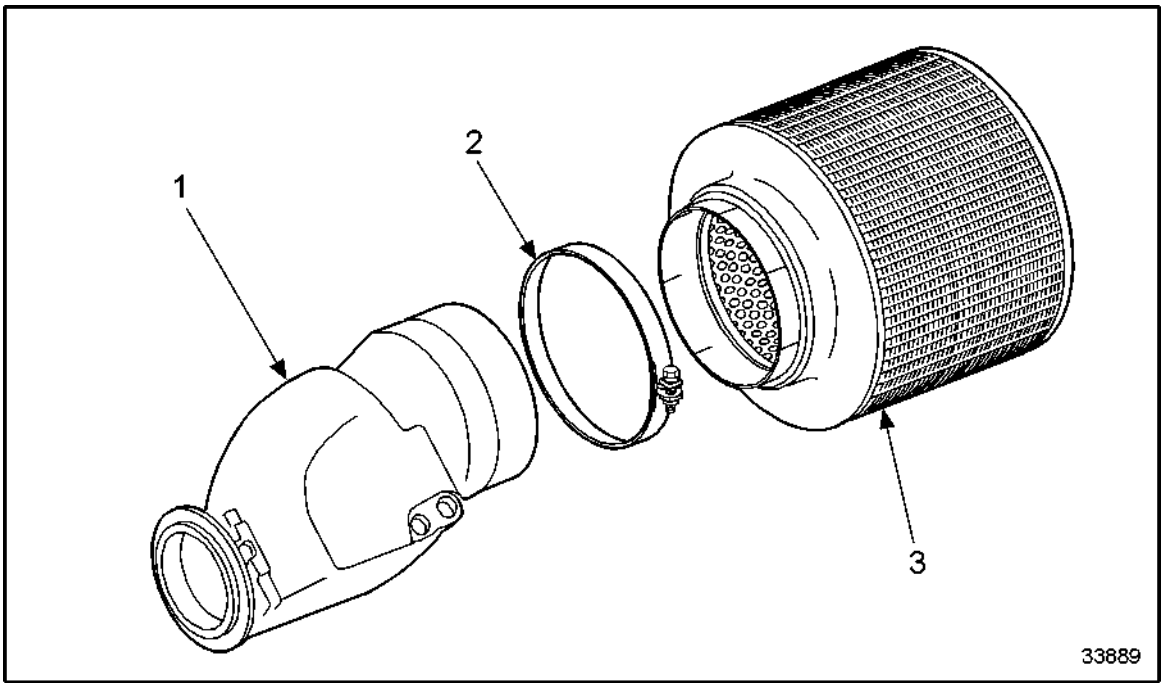


1. Air Temperature Sensor
2. Turbocharger Speed Sensor

Figure 700 Connecting B3 and B44 Wiring Harness.

7. Connect B3 (air temperature sensor) (1) wiring harness. See Figure 700.

8. Install the air filter element to the intake housing (1) and secure with clamp (2). See Figure 701.



1. Intake Housing
2. Clamp
3. Air Filter

Figure 701 Removing Air Filter Element from Air Intake Housing

9. Verify repair of the intake housing.

C 123.05.12 M – AFTER – INSTALLATION OPERATIONS

Listed in Table 89 are the After – Installation Operations for the intake housing.

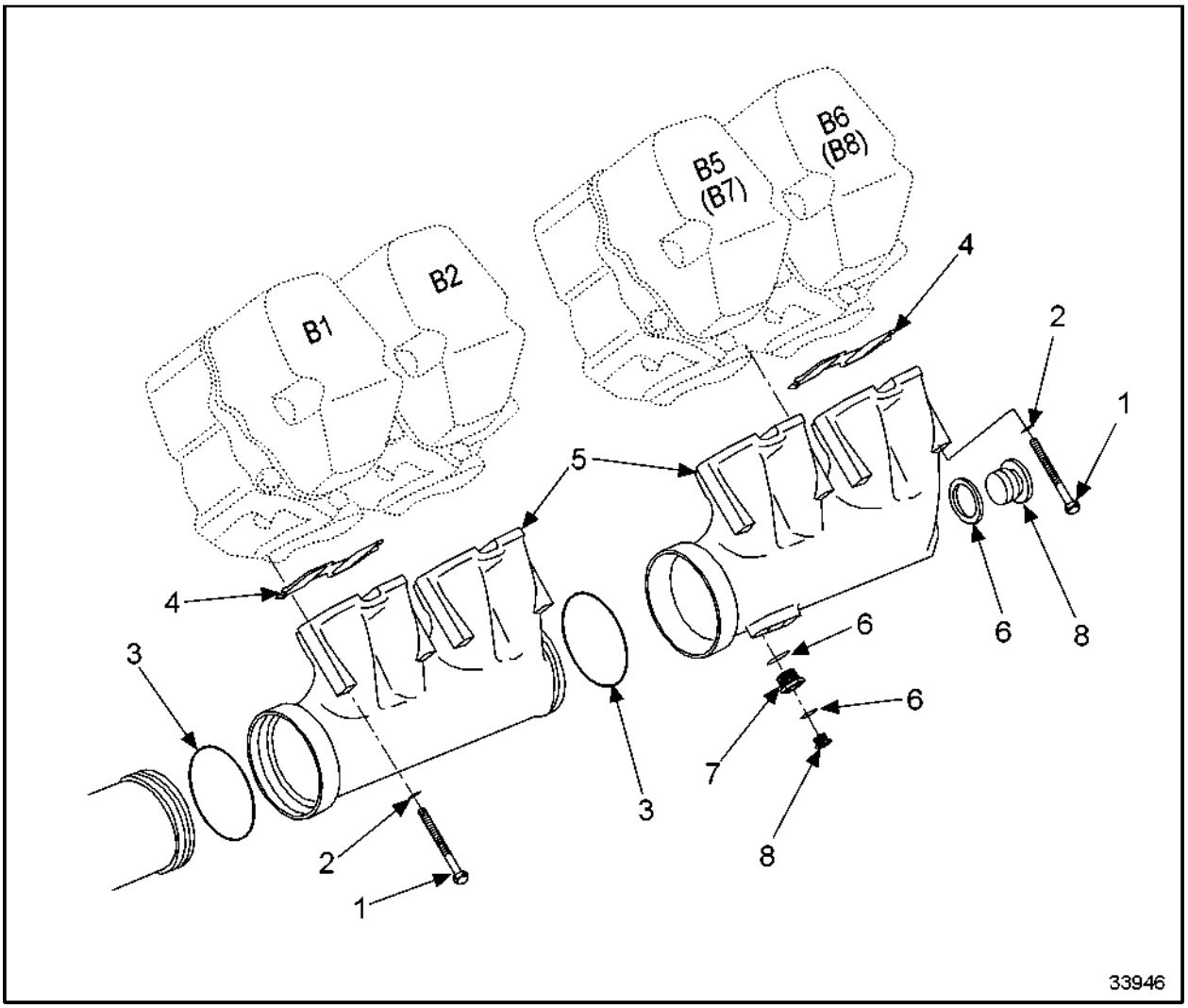
Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators Guide

Table 89 After – Installation Operations

C 124.05 – AIR INTAKE MANIFOLD

C 124.05.01 – GENERAL VIEW

See Figure 702 for a general view of the air intake manifolds.



1. Bolt
2. Washer
3. O-ring
4. Gasket
5. Air Intake Manifold
6. Sealing Ring
7. Adapter
8. Plug

Figure 702 General View of Air Intake Manifold System

C 124.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 90 are the Before-Removal Operations for air intake system manifold to cylinders.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove DDEC harness and sensors	Refer to section C 501.05 M
1, 2, 3	Remove retainer for CA connector on elbow	Refer to section C 501.05 M

1 = The engine is to be completely disassembled.

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

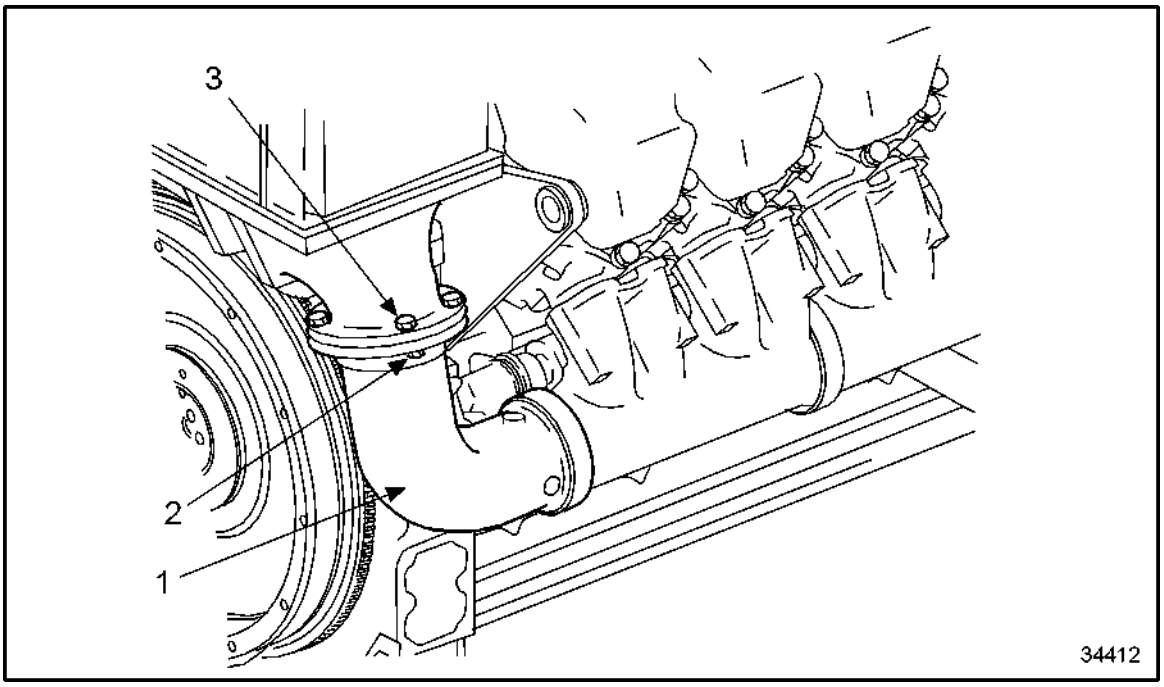
3= The engine is to remain installed.

Table 90 Before-Removal Operations

C 124.05.05 – REMOVAL OF AIR INTAKE MANIFOLD SYSTEM

Perform the following steps for removal of the air supply system to cylinders.

1. Remove hex bolts (2) and hex nuts (3) joining charge air cooler and outlet elbow. See Figure 703.

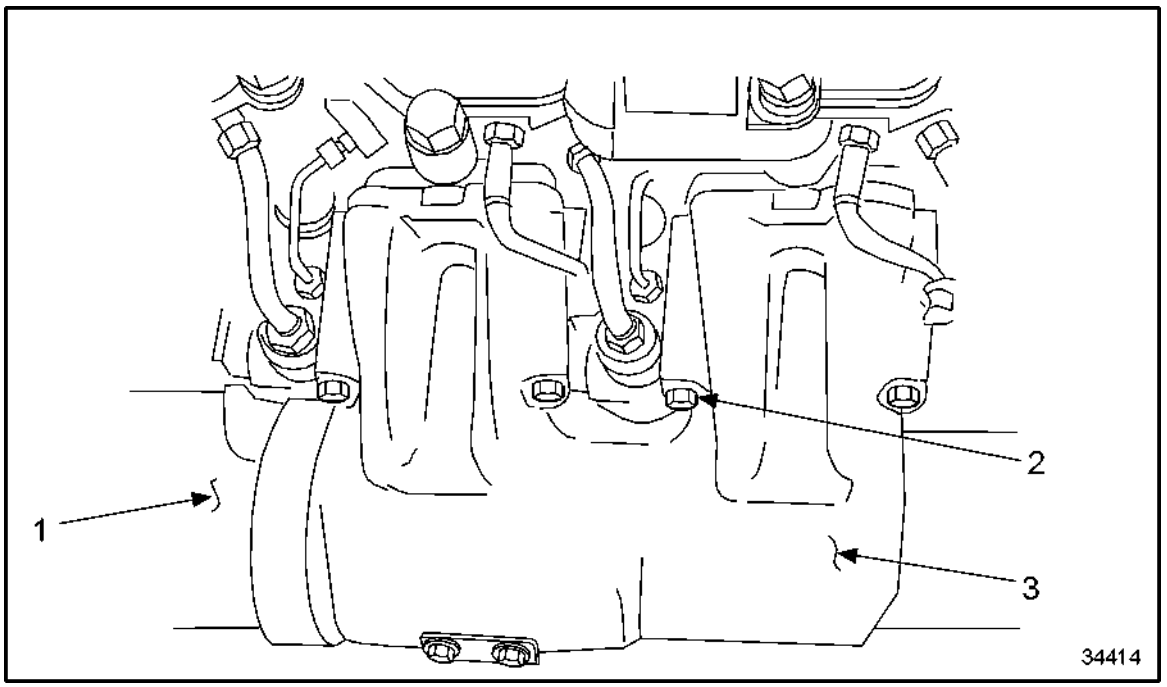


1. Outlet Elbow
2. Hex Bolt
3. Hex Nut

Figure 703 Removing Hex Bolts and Nuts Joining Charge Air Cooler and Outlet Elbow

2. Remove outlet elbow (1) from air intake manifold. See Figure 703.
3. Remove O-rings from outlet elbow.

4. Starting with elbow side, remove hex bolts (1) from air intake manifold. See Figure 704.



1. Adjacent Air Intake Manifold
2. Hex Bolt with Washer
3. Gear Case End of Air Manifold (End Section)

Figure 704 Removing Hex Bolts from Charge Air Manifold and Removing Bracket for Injector Control Cable

5. Remove bracket for injector control cable (2).
6. Remove charge air manifold. If necessary, withdraw from adjacent charge air manifold.
7. Remove gasket.

C 124.05.08 – INSPECTION AND REPAIR

Perform the following steps for cleaning, inspection and repair of the air intake system:

1. Clean all air-carrying components with a suitable cleaning agent.

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.

2. Pressure-test air intake manifold with compressed air in water bath for leaks.
   [a] If leaks are found, replace the air intake manifold.
   [b] If no leaks are found, continue inspection.
3. Inspect air intake manifold for cracks using surface crack-testing method with red penetrant dye.
   [a] If cracks are found, replace the air intake manifold.
   [b] If no cracks are found, continue inspection.
4. Visually inspect all sealing and mating surfaces for wear and damage.
   [a] If sealing and mating surfaces are worn or damaged, rub down the component with an oilstone.
   [b] If wear or damage is beyond repair, replace the component.
   [c] If sealing and mating surfaces are not worn or damaged, continue inspection.
5. Inspect threads for wear and damage.
   [a] If threads are worn or damaged, rechase threads.
   [b] If damage is beyond repair, replace threaded inserts.
   [c] If threads are not worn or damaged, continue inspection.
6. Inspect clamps for wear and damage and bolts for ease of movement.
   [a] If clamps are worn or damaged, or bolts do not show ease of movement, replace clamps and bolts.
   [b] If clamps are not worn or damaged and bolts show ease of movement, continue inspection.
7. Inspect threads of hex bolts for wear and damage.
   [a] If threads of hex bolts are worn or damaged, replace hex bolts.
   [b] If threads of hex bolts are not worn or damaged, continue inspection.
8. Inspect blanking plugs for wear and damage.

[a] If blanking plugs are worn or damaged, replace blanking plugs.

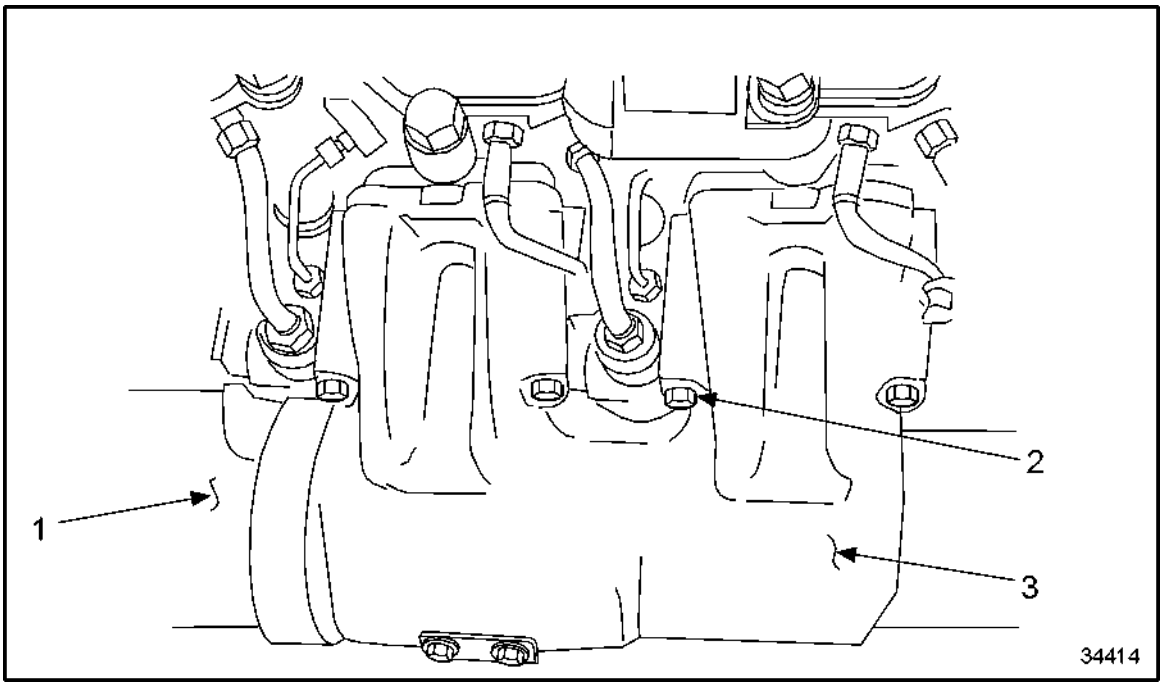
[b] If blanking plugs are not worn or damaged, continue inspection.

9. Replace seals, sealing rings and gaskets.

C 124.05.11 – INSTALLATION OF THE AIR INTAKE MANIFOLD SYSTEM

Perform the following steps for installation of the air intake manifold system.

1. Coat gaskets with petroleum jelly and place on charge air intake manifold sealing surface. See Figure 705.



1. Adjacent Air Intake Manifold
2. Hex Bolt with Washer
3. Gear Case End Air Intake Manifold (End Section)

Figure 705 Installing Charge Air Manifold

2. Place gear case end air intake manifold (end section) (4) on sealing surface of cylinder head.

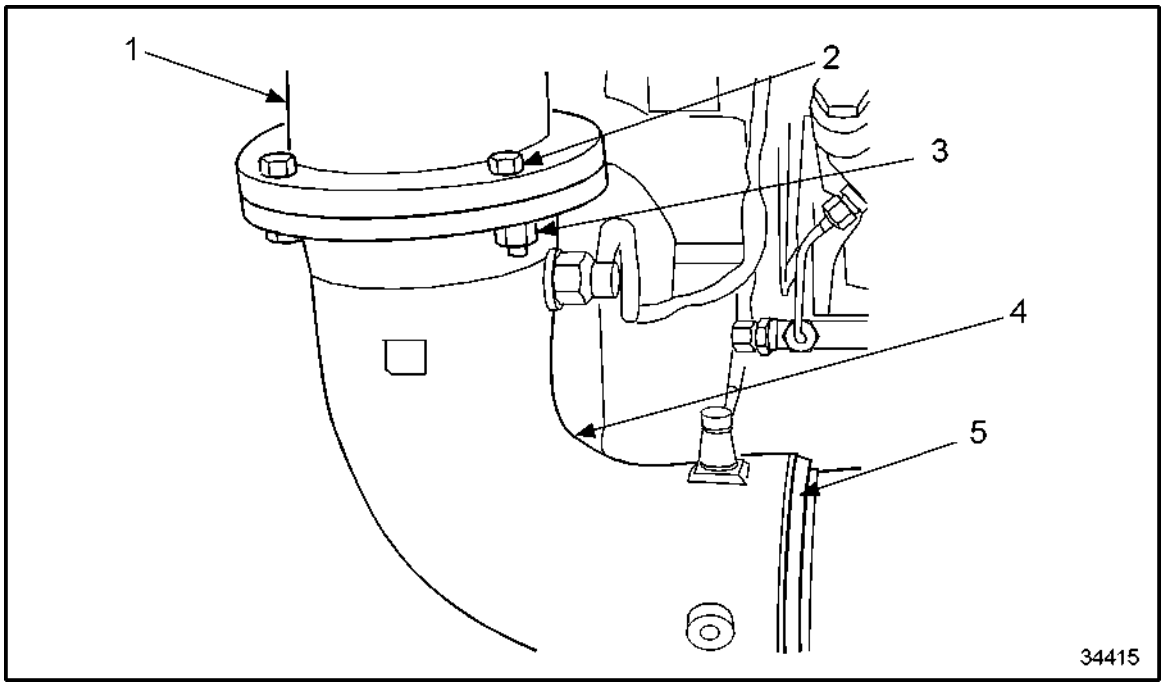
NOTE:
Before tightening hex bolts, check that gasket is correctly positioned.

3. Install hex bolt with washer (3) and retainer (2) and tighten.
4. Before installing adjacent air intake manifold (1), coat O-ring with petroleum jelly and install on air intake manifold.
5. Coat gaskets with petroleum jelly and install on air intake manifold sealing surface.

6. Slide air intake manifold with O-ring into previously installed adjacent air intake manifold (1), and position it on sealing surface of cylinder head.

NOTE:
Before tightening hex bolts, check that gasket is correctly positioned.

7. Install O-ring (5) over charge air cover outlet elbow (4) and coat with petroleum jelly. See Figure 706.



1. Outlet Flange Outlet Charge Air Cooler
2. Hex Bolt
3. Hex Nut
4. Outlet Elbow
5. O-ring

Figure 706 Installing Outlet Elbow in Charge Air Cooler Outlet Flange

8. Coat O-ring (5) with petroleum jelly and insert in outlet elbow flange to charge air cooler (1).
9. Install outlet elbow in charge air intake manifold so that outlet elbow flange is flush with outlet flange on charge air cooler.
10. Install and tighten hex bolts (2) and hex nuts (3) securing elbow and charge air cooler. Torque bolts to specification. Refer to section A 003.

C 124.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 91 are the After-Installation Operations for air supply system to cylinders.

Level of Maintenance	Operation	Reference
1, 2, 3	Install retainer for CA connector on outlet elbow	Refer to OEM Guidelines
1, 2, 3	Install DDEC harness and sensors	Refer to OEM Guidelines
1, 2, 3	Install DDEC harness and sensors	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.

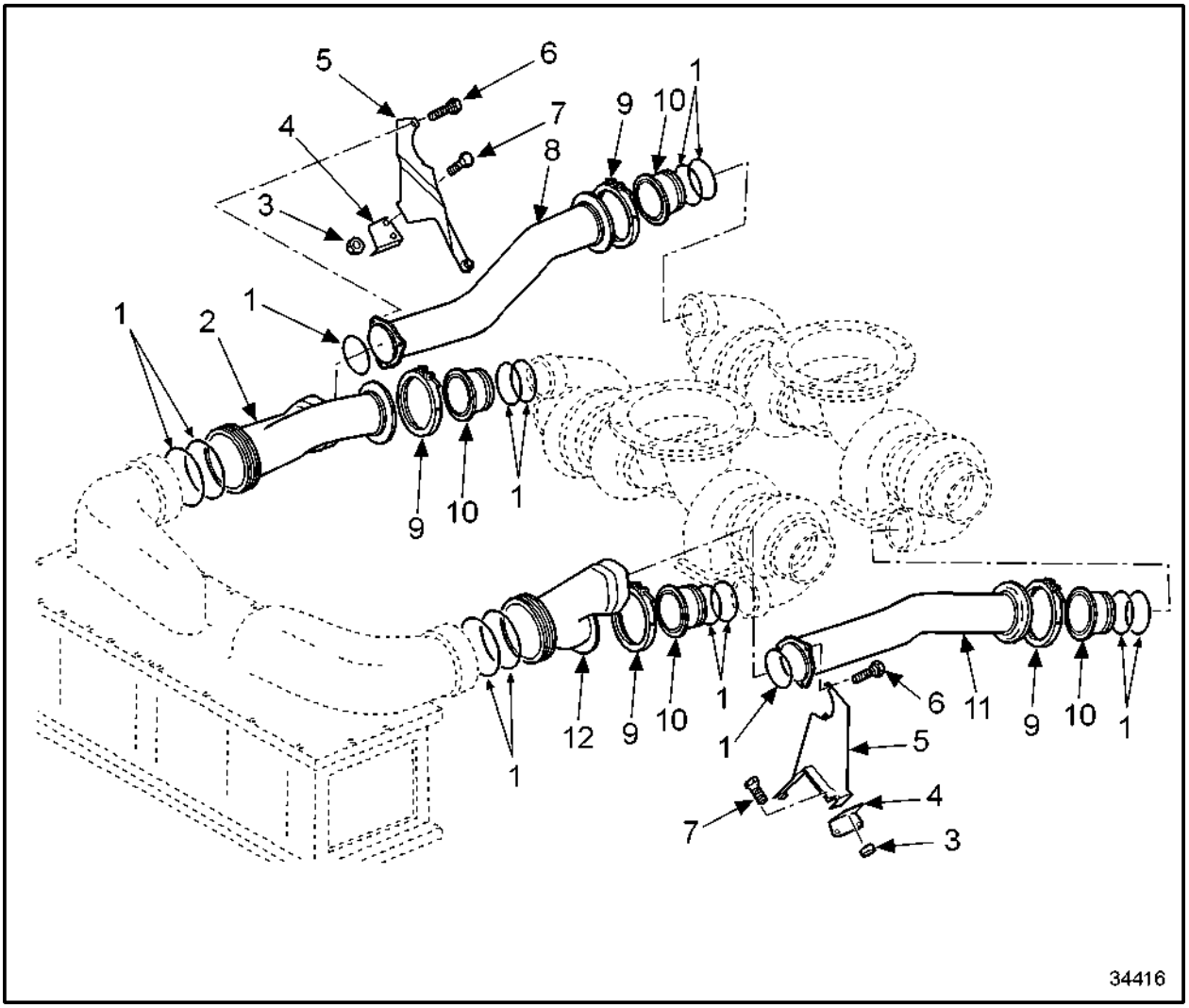
3= The engine is to remain installed.

Table 91 After-Installation Operations

C 125.05 – AIR INTAKE SYSTEM FROM TURBOCHARGER TO CHARGE AIR COOLER

C 125.05.01 – GENERAL VIEW

See Figure 707 for a general view of the air intake system from turbocharger to charge air cooler.



1. O-ring
2. Charge Air Manifold, "A" Bank Side Y-Pipe
3. Nut
4. Bracket
5. Retaining Plate
6. Hex-Bolt
7. Bolt
8. Charge Air Manifold, "A" Bank Side
9. Clamp
10. Adaptor
11. Charge Air Manifold, "B" Bank Side
12. Charge Air Manifold, "B" Bank Side Y-Pipe

Figure 707 General View of Air Intake System from Turbocharger to Charge Air Cooler

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.

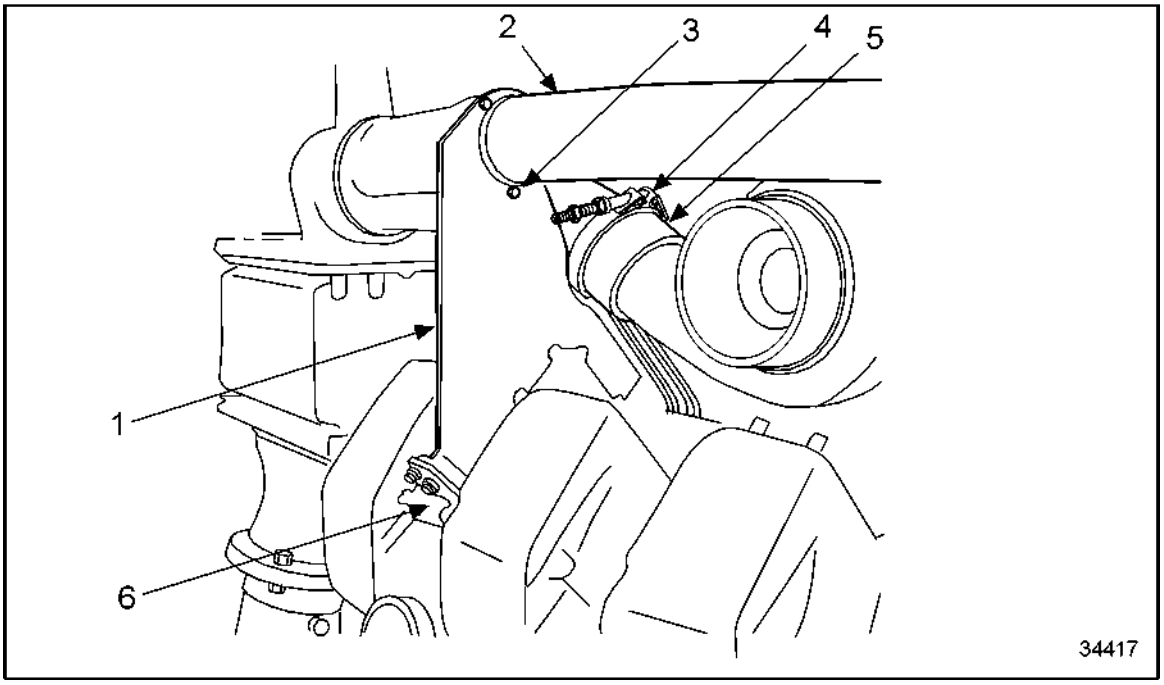
3= The engine is to remain installed.

Table 92 Before-Removal Operations

C 125.05.05 – REMOVAL OF AIR SYSTEM FROM TURBOCHARGER TO CHARGE AIR COOLER

Perform the following steps to remove the air intake system from turbocharger to charge air cooler:

1. Remove clamps (4) on turbocharger and push back adaptor (5) toward turbocharger. See Figure 708.

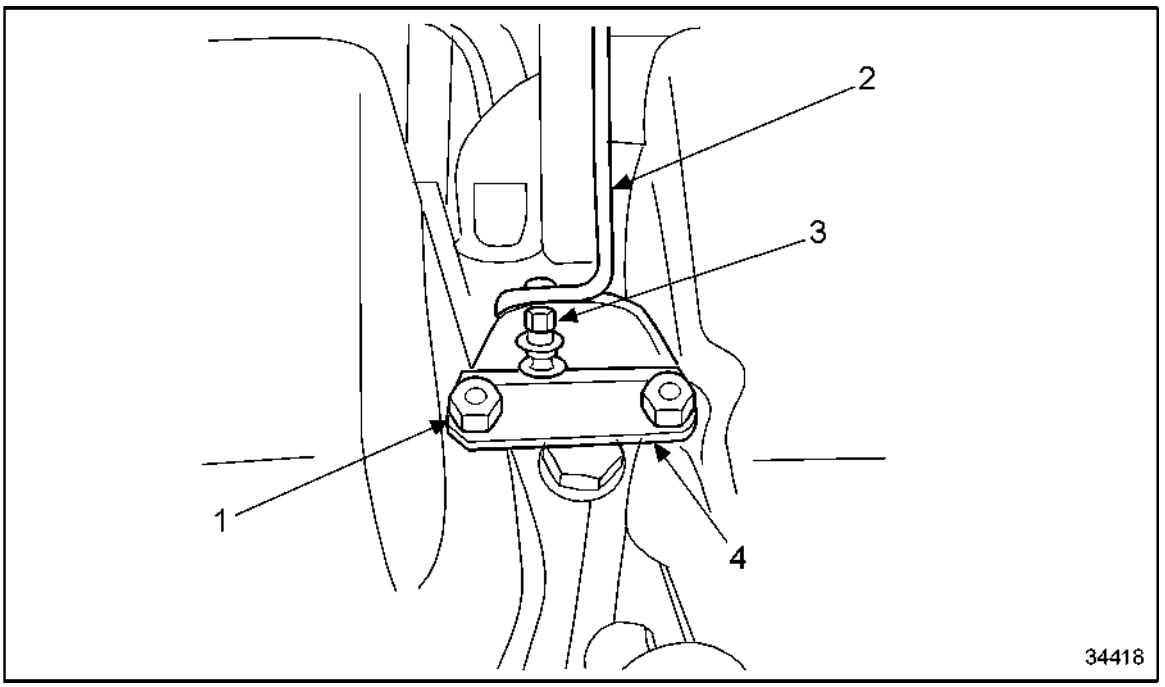


1. Retaining Plate
2. Charge Air Manifold
3. Hex Bolt
4. Clamp
5. Adaptor
6. Bracket

Figure 708 Removing Clamps on Turbocharger and Pushing Back Adaptor Toward Exhaust Turbocharger

2. Remove hex bolts (3) from retaining plate (1).
3. Remove charge air manifold (2).
4. Remove O-rings from charge air manifold.

5. Remove hex bolts (1) securing rocker cover and bracket (4). See Figure 709.

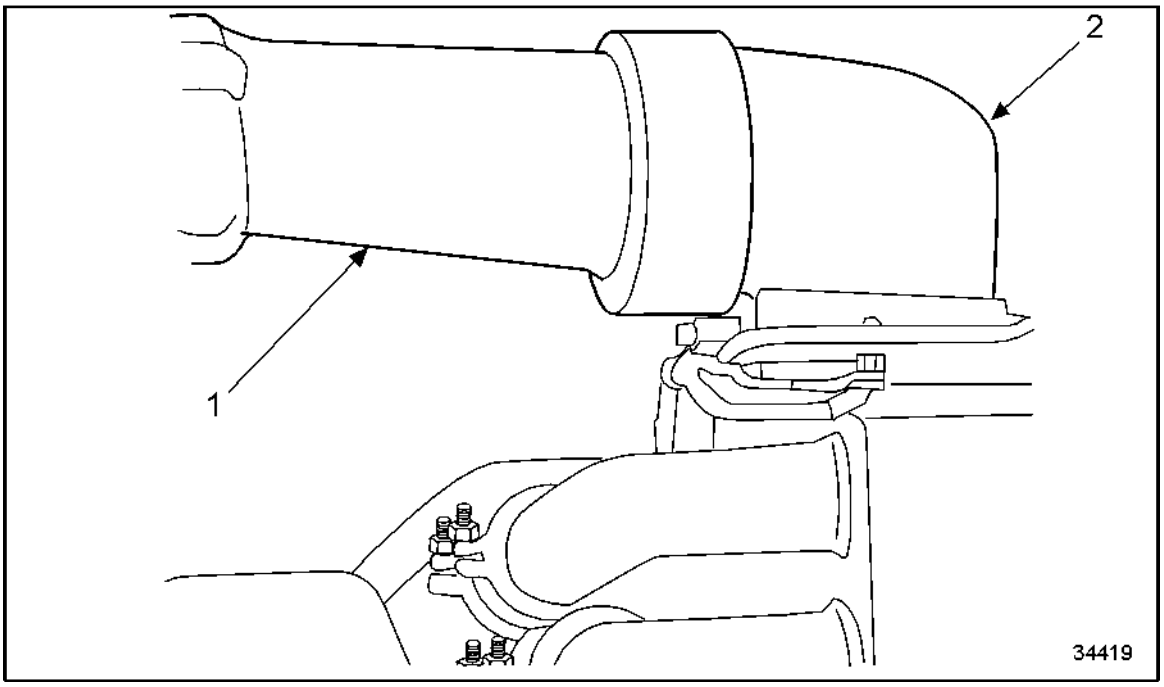


1. Hex Bolt
2. Retaining Plate
3. Hex Nut
4. Bracket

Figure 709 Removing Rocker Cover and Bracket

6. Remove retaining plate (2) along with bracket.
7. If necessary, separate bracket from retaining plate by removing hex nuts (3).
8. If rocker covers are not to be removed, reinstall hex bolts (1) to keep out dirt.

9. Remove charge air manifold “Y” pipe (1) from inlet housing of charge air cooler (2). See Figure 710.



1. Charge Air Manifold "Y" pipe
2. "Y" pipe Inlet Housing of Charge Air Cooler

Figure 710 Removing Charge Air Manifold

10. Remove O-rings.
11. After removing charge air manifold “Y” pipes, protect all openings on the inlet housing with suitable plugs or covers.

C 125.05.08 – CLEANING, INSPECTION AND REPAIR

Perform the following steps for cleaning, inspection and repair of the air intake system from turbocharger to charge air cooler:

1. Clean all air-carrying components with a suitable cleaning agent.

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.

2. Pressure-test charge air manifolds with compressed air in water bath for leaks.
   [a] If leaks are found, replace the charge air manifold.
   [b] If no leaks are found, continue inspection.
3. Inspect charge air manifolds for cracks using surface crack-testing method with red penetrant dye.
   [a] If cracks are found, replace the charge air manifold.
   [b] If no cracks are found, continue inspection.
4. Visually inspect all sealing and mating surfaces for wear and damage.
   [a] If sealing and mating surfaces are worn or damaged, rub down with an oilstone.
   [b] If wear or damage is beyond repair, replace component.
   [c] If sealing and mating surfaces are not worn or damaged, continue inspection.
5. Visually inspect retaining plates and brackets for cracks.
   [a] If cracks are found, replace retaining plates and brackets.
   [b] If no cracks are found, continue inspection.
6. Visually inspect threads for wear and damage.
   [a] If threads are worn or damaged, rechase threads.
   [b] If wear or damage is beyond repair, replace threaded inserts.
   [c] If threads are not worn or damaged, continue inspection.
7. Visually inspect clamps for wear and damage.
   [a] If clamps are worn or damaged, replace as necessary.
   [b] If clamps are not worn or damaged, continue inspection.
8. Inspect bolts for ease of movement.
   [a] If bolts do not show ease of movement, replace as necessary.

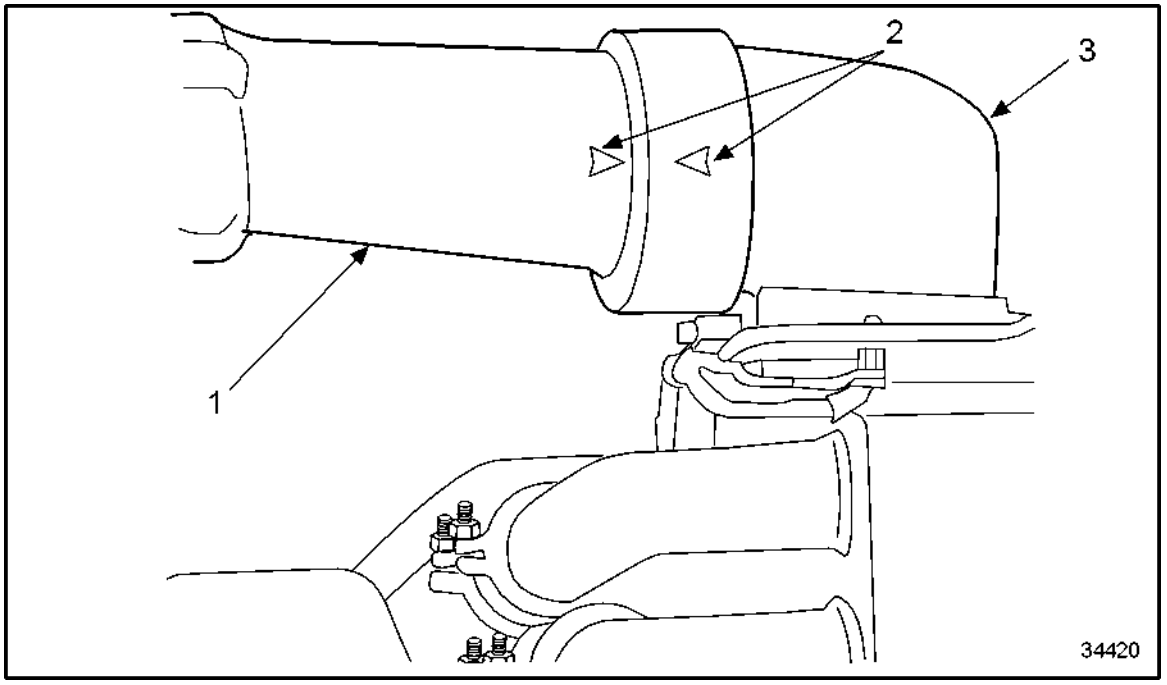
[b] If bolts do show ease of movement, continue inspection.

9. Visually inspect hex bolts and blanking plugs for wear and damage.
   [a] If hex bolts or blanking plugs are worn or damaged, replace as necessary.
   [b] If hex bolts or blanking plugs are not worn or damaged, continue inspection.
10. Replace seals, sealing rings and gaskets.

C 125.05.11 – INSTALLATION OF AIR INTAKE SYSTEM FROM TURBOCHARGER TO CHARGE AIR COOLER

Perform the following steps to install the air intake system from the turbocharger to the charge air cooler.

1. Before installation, remove all covers and threaded connections installed to keep out dirt. See Figure 711.

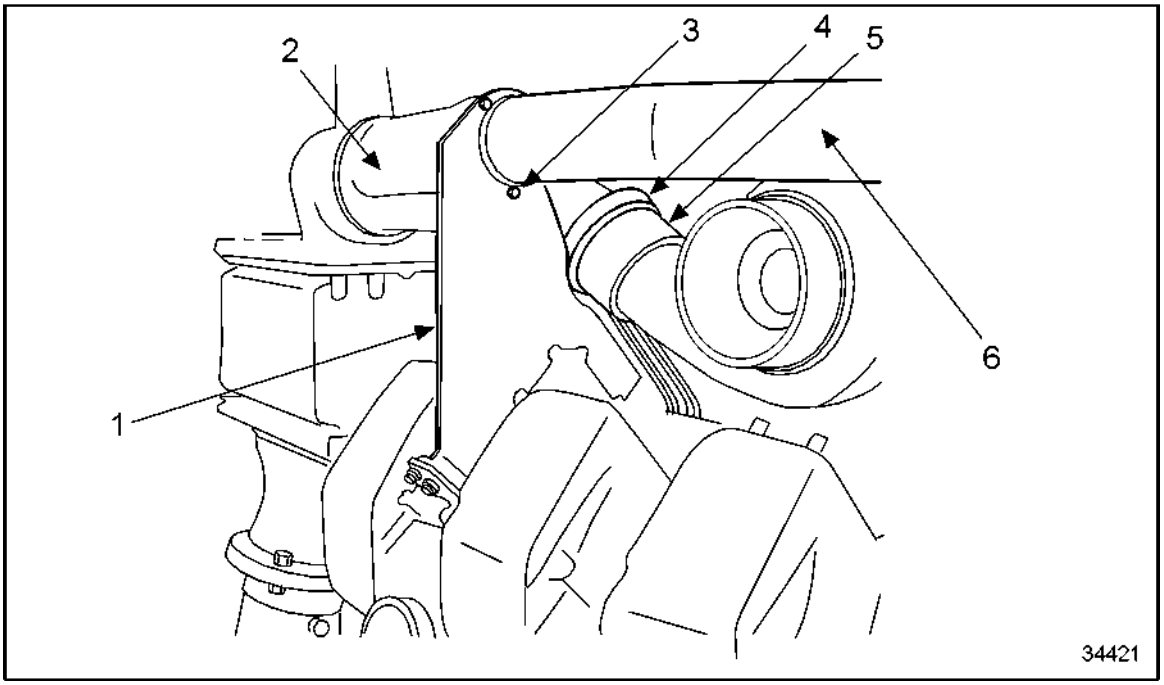


1. "Y" Pipe Charge Air Manifold
2. Cast-on Arrows
3. Inlet Housing of Charge Air Cooler

Figure 711 Installing Charge Air Manifold “Y” Pipes

2. Coat O-rings with petroleum jelly and install on charge air manifolds “Y” pipes (1).
3. Insert charge air manifold “Y” pipes in openings on upper inlet housing (3) of charge air cooler.
4. At same time, align charge air manifold “Y” pipes with inlet housing in accordance with cast-on arrows (2).

5. Install charge air manifolds (6) with triangular flange side on charge air manifold “Y” pipes (2). See Figure 712.

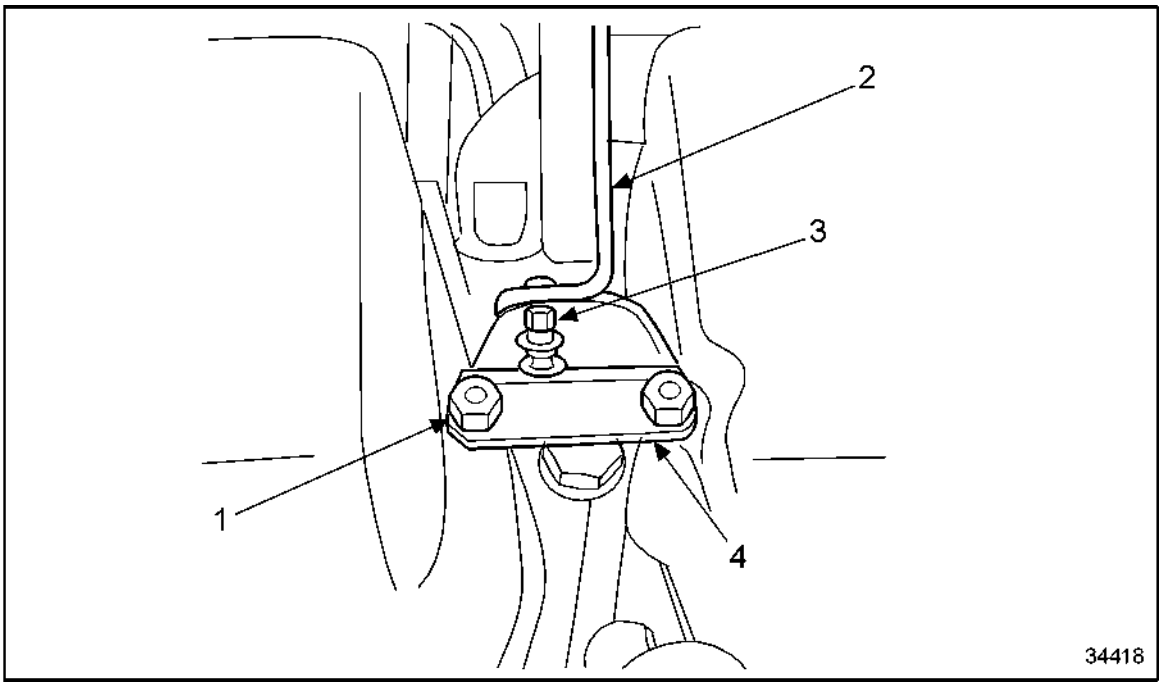


1. Retaining Plate
2. Charge Air Manifold "Y" Pipe
3. Hex Bolt
4. Pipe Clamp
5. Adaptor
6. Charge Air Manifold

Figure 712 Installing Charge Air Manifolds with Triangular Flange Side on Forked Charge Air Manifold “Y” Pipe

6. Install pipe clamps (4) on round flange ends.
7. Coat O-rings with petroleum jelly and install on adaptors (5).
8. Install adaptors in turbocharger.
9. Position adaptors on charge air manifold ends and secure with pipe clamps (4).
10. Install retaining plate (1) and bracket with hex bolt (3) on charge air manifold.

11. Bolt retaining plate (2) and bracket (4) together with hex bolt (1) and hex nut (3). See Figure .



1. Hex Bolt
2. Retaining Plate
3. Hex Nut
4. Bracket

Figure 713 Securing Retaining Plate and Bracket on Rocker Cover

12. Secure retaining plate (2) and bracket (4) with hex bolts (1) on rocker cover.

C 125.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 93 are the After-Installation Operations for air supply from exhaust turbocharger to charge air cooler.

Level of Maintenance	Operation	Reference
1, 2, 3	Inspect for leaks	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.

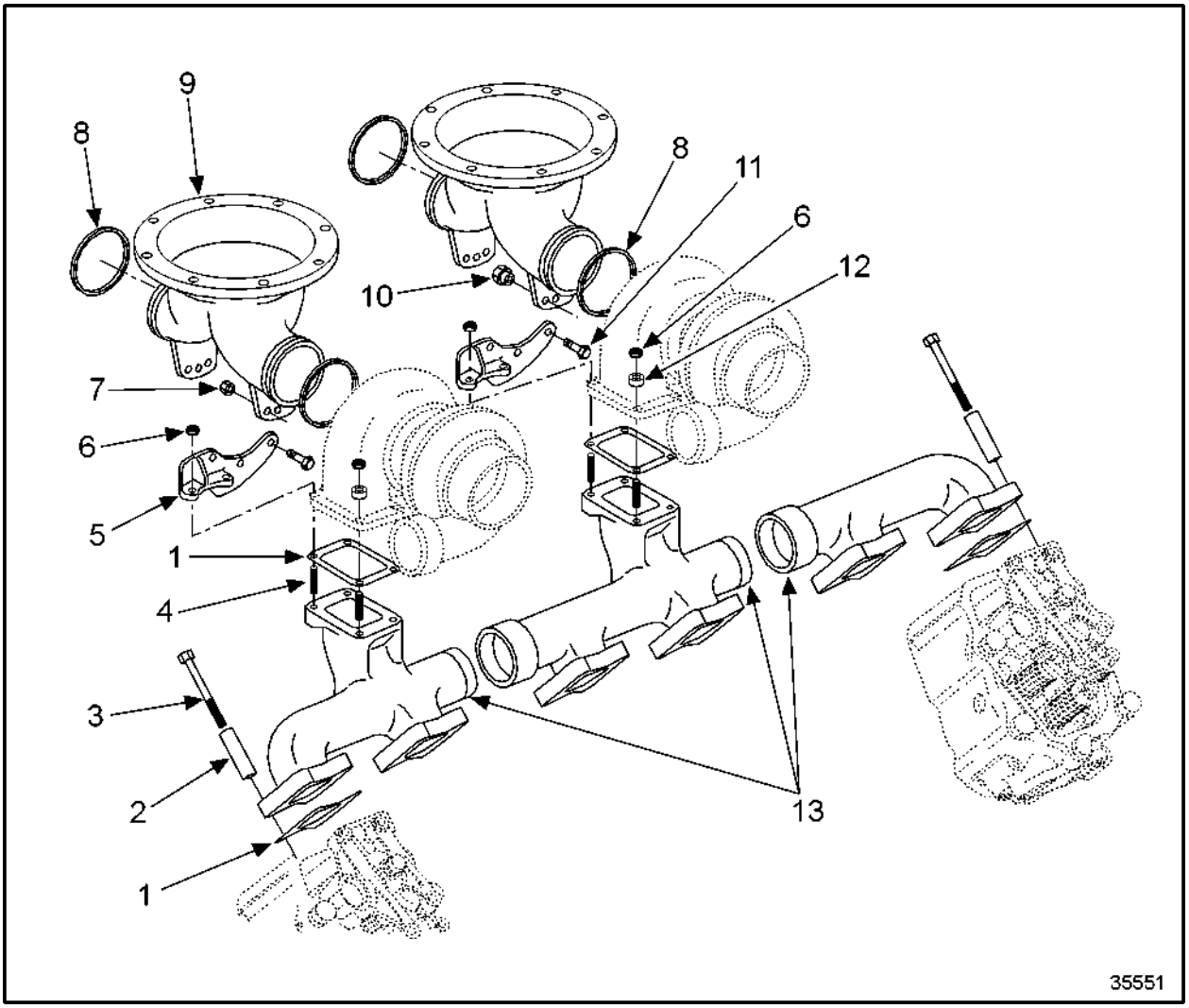
Table 93 After-Installation Operations

C 140 – EXHAUST SYSTEM

C 141.05 – EXHAUST SYSTEM

C 141.05.01 – GENERAL VIEW

See Figure 714 for a general view of the exhaust system (12V).



1. Gasket
2. Spacer
3. Bolt
4. Stud
5. Support Bracket
6. Hex Nut
7. Hex Nut
8. Piston Ring
9. Y-pipe
10. Washer
11. Hex Bolt
12. Spacer Washer
13. Exhaust Manifold

Figure 714 General View of Exhaust System (12V)

C 141.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 94 are the Before-Removal Operations for the exhaust system.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove air system before exhaust turbocharger	Refer to section C 101.05.05
1, 2, 3	Remove exhaust system after Y-pipe	Refer to section C 141.05.05
1, 2, 3	Remove adaptor of charge air manifold on turbocharger	Refer to section C 124.05.05
1, 2, 3	Remove oil supply lines for turbochargers	Refer to section C 187.05.05
1, 2, 3	Remove oil return lines for turbochargers	Refer to section C 188.05.05
1, 2, 3	Remove turbocharger	Refer to section C 101.05.05

1 = The engine is to be completely disassembled.

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

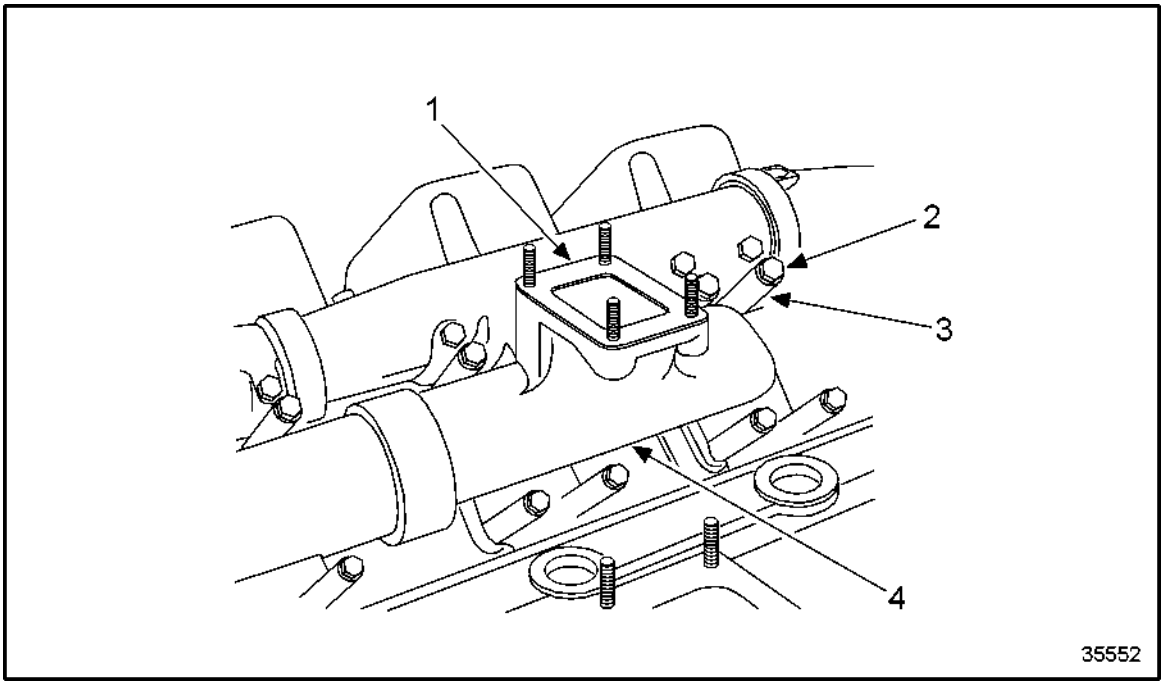
3= The engine is to remain installed.

Table 94 Before-Removal Operations

C 141.05.05 – REMOVAL OF EXHAUST SYSTEM

Perform the following steps for the removal of the exhaust system.

1. Remove gasket (1). See Figure 715.



1. Gasket
2. Hex Bolt
3. Spacer
4. Exhaust Manifold

Figure 715 Removing Gasket (12V)

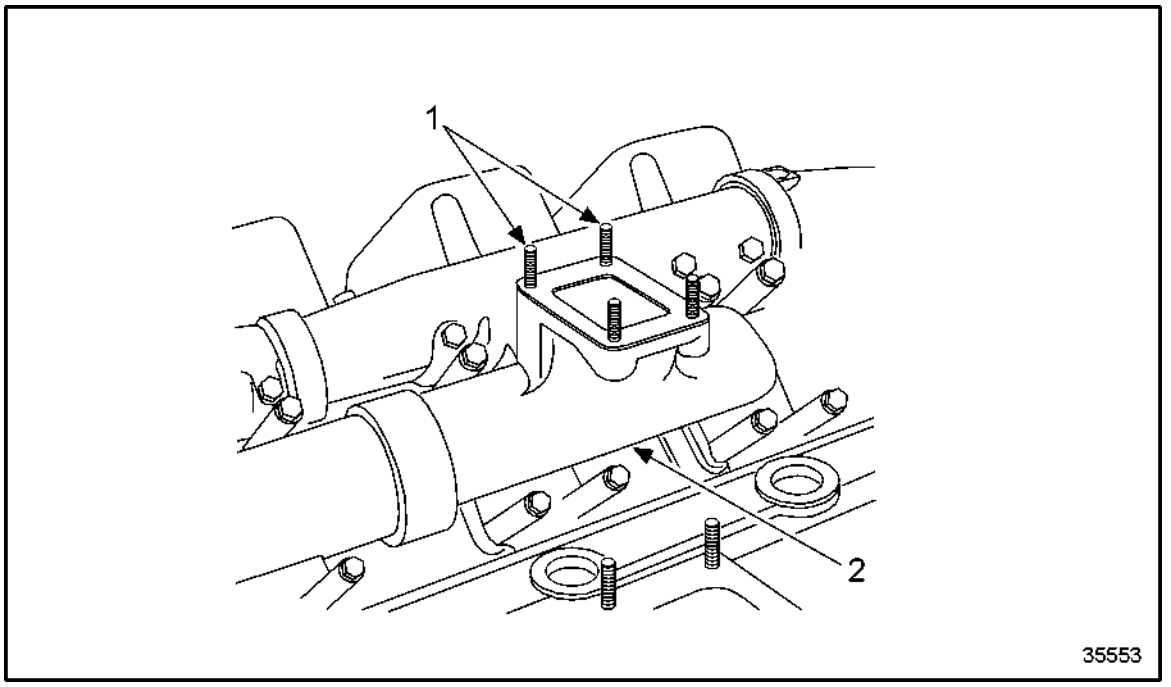
2. Remove all hex bolts (2) securing exhaust manifolds (4) and spacers (3).
3. Lift exhaust manifolds from engine and separate from each other by pulling and twisting at same time.

C 141.05.06 – DISASSEMBLY OF EXHAUST SYSTEM

Perform the following steps to disassemble the exhaust system.

NOTE:
Remove studs from exhaust manifold only if necessary.

1. To remove studs (1) from exhaust manifold, install hex nut on stud and lock with second hex nut. See Figure 716.



1. Stud
2. Exhaust Manifold

Figure 716 Removing Studs (12V)

2. Place open-end wrench on locked hex nut and remove stud.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

NOTE:
If stud cannot be loosened with open-end wrench, slightly heat stud in area of thread. Ensure that only bottom of the adapter is heated.

C 141.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the exhaust system:

1. Clean all components and visually inspect for damage or defects.
   [a] If components are damaged or defective, replace component as necessary.
   [b] If components are not damaged or defective, continue inspection.

CAUTION:

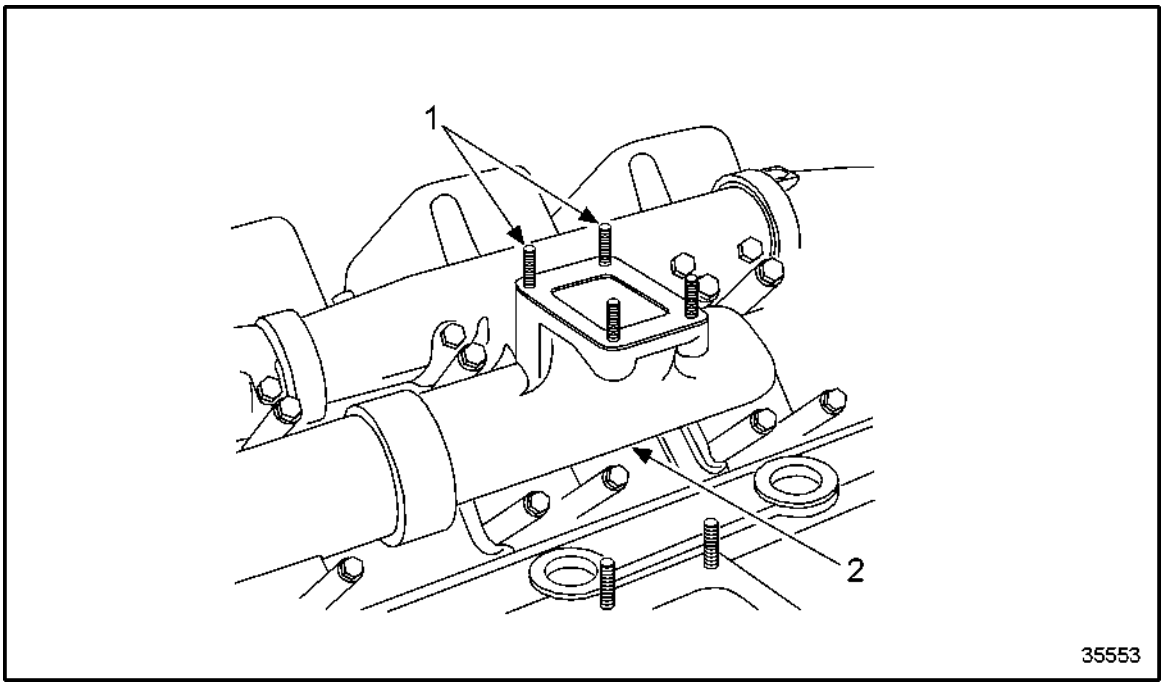
To avoid personal injury when using any chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

2. Place exhaust elbow and exhaust manifolds in a container containing decarbonizer.
3. Duration of exhaust manifold's immersion in cleaning bath depends on thickness of deposit layer.
4. After cleaning with carbon-deposit remover, rinse components in water until no further residues are present.
5. If deposits remain, use synthetic shot-blasting pellets (nominal size 16 to 20) to help cleaning.
6. Visually inspect exhaust manifolds for cracks using the surface crack-testing method with red penetrant dye.
   [a] If exhaust manifold is cracked, replace component.
   [b] If exhaust manifold is not cracked, continue inspection.
7. Visually inspect exhaust manifolds for warping.
   [a] If exhaust manifolds are warped, replace component.
   [b] If exhaust manifolds are not warped, continue inspection.
8. Visually inspect sealing and mating surfaces for damage or wear.
   [a] If sealing and mating surfaces are damaged or worn, rub down with emery cloth or an oilstone as necessary.
   [b] If sealing and mating surfaces are beyond repair, replace component as necessary.
   [c] If sealing and mating surfaces are not damaged or worn, continue inspection.
9. Inspect stud threads for damage and ease of movement.
   [a] If stud threads are damaged or do not show ease of movement, rechase as necessary.
   [b] If stud threads are not damaged and show ease of movement, continue inspection.
10. Replace gaskets, studs and nuts at W6 maintenance.

C 141.05.10 – ASSEMBLY OF THE EXHAUST SYSTEM

Perform the following steps to assemble the exhaust pipework after cylinder head:

1. Install nonlubricated stud (1) in flange of exhaust manifold (2) and tighten to stop by means of locked hex nuts. See Figure 717.



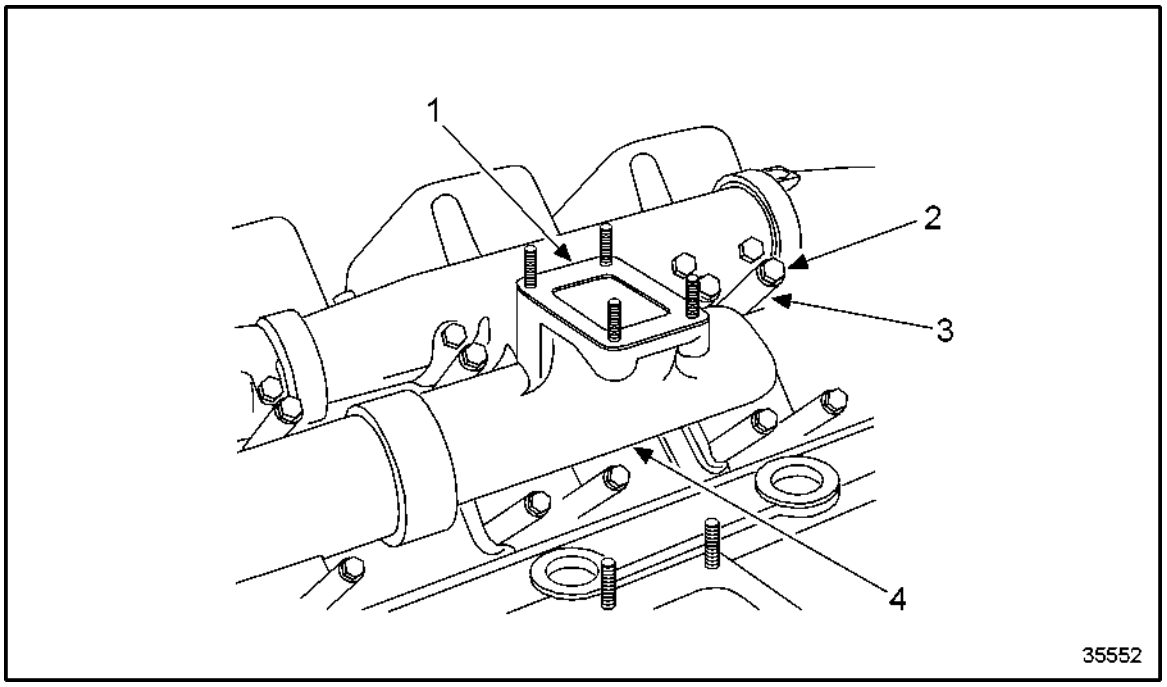
1. Stud
2. Exhaust Manifold

Figure 717 Installing Studs (12V)

C 141.05.11 – INSTALLATION OF EXHAUST SYSTEM

Perform the following steps to install the exhaust system:

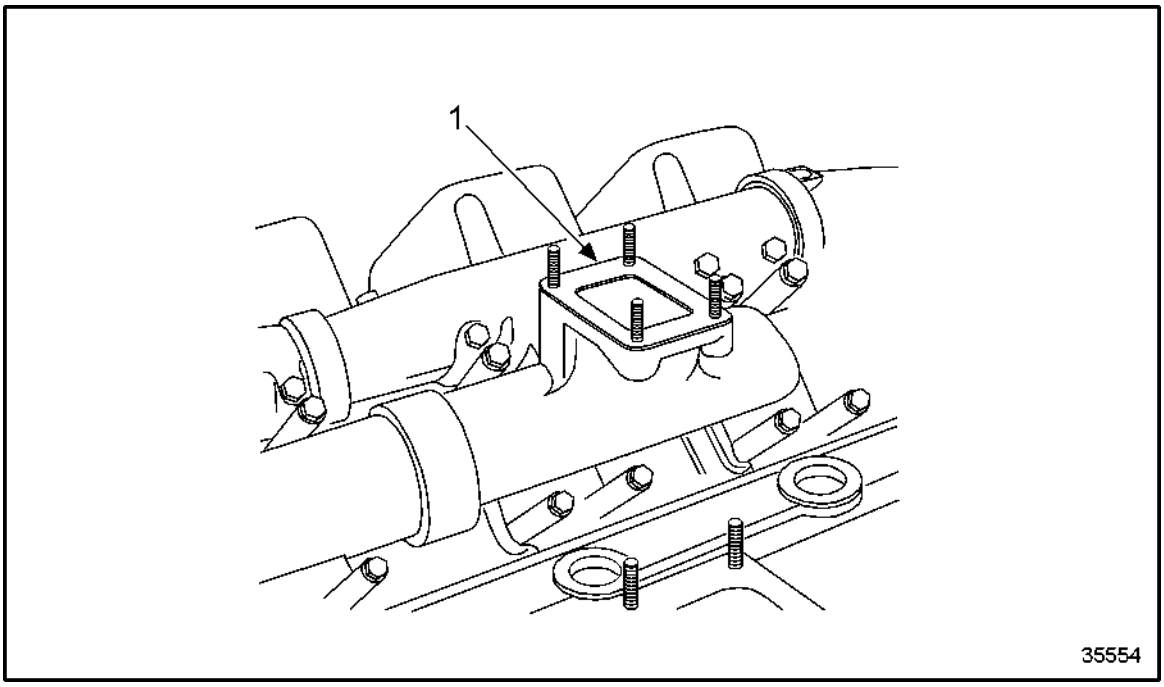
1. Install exhaust manifolds (4) (dry) together. See Figure714.
2. Install exhaust manifolds with gaskets (1) (dry) on mating surfaces on exhaust outlet of cylinder heads. See Figure 718.



1. Gasket
2. Hex Bolt
3. Spacer Bushing
4. Exhaust Manifold

Figure 718 Installing Exhaust Manifold (12V)

3. Install hex bolts (2) with spacer (3) in flanges of exhaust manifolds and tighten diagonally to specification. Torque bolts to specification. Refer to section A 003.
4. Install gaskets (1) (dry) on turbocharger flange. See Figure 719.



1. Gasket

Figure 719 Installing Gaskets (Dry) on Turbocharger Flange (12V)

C 141.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 95 are the After-Installation Operations for the exhaust system.

Level of Maintenance	Operation	Reference
1, 2, 3	Install exhaust turbocharger with Y-pipe	Refer to section C 101.05.11
1, 2, 3	Install oil supply lines for turbochargers	Refer to section C 187.05.11
1, 2, 3	Install oil return lines for turbochargers	Refer to section C 188.05.11
1, 2, 3	Install adaptors of charge air manifold on turbocharger	Refer to section C 124.05.11
1, 2, 3	Install exhaust pipework after Y-pipe	Refer to section C 141.05.11
1, 2, 3	Install air system before turbocharger	Refer to section C 101.05.11
1, 2, 3	Check for leaks	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.

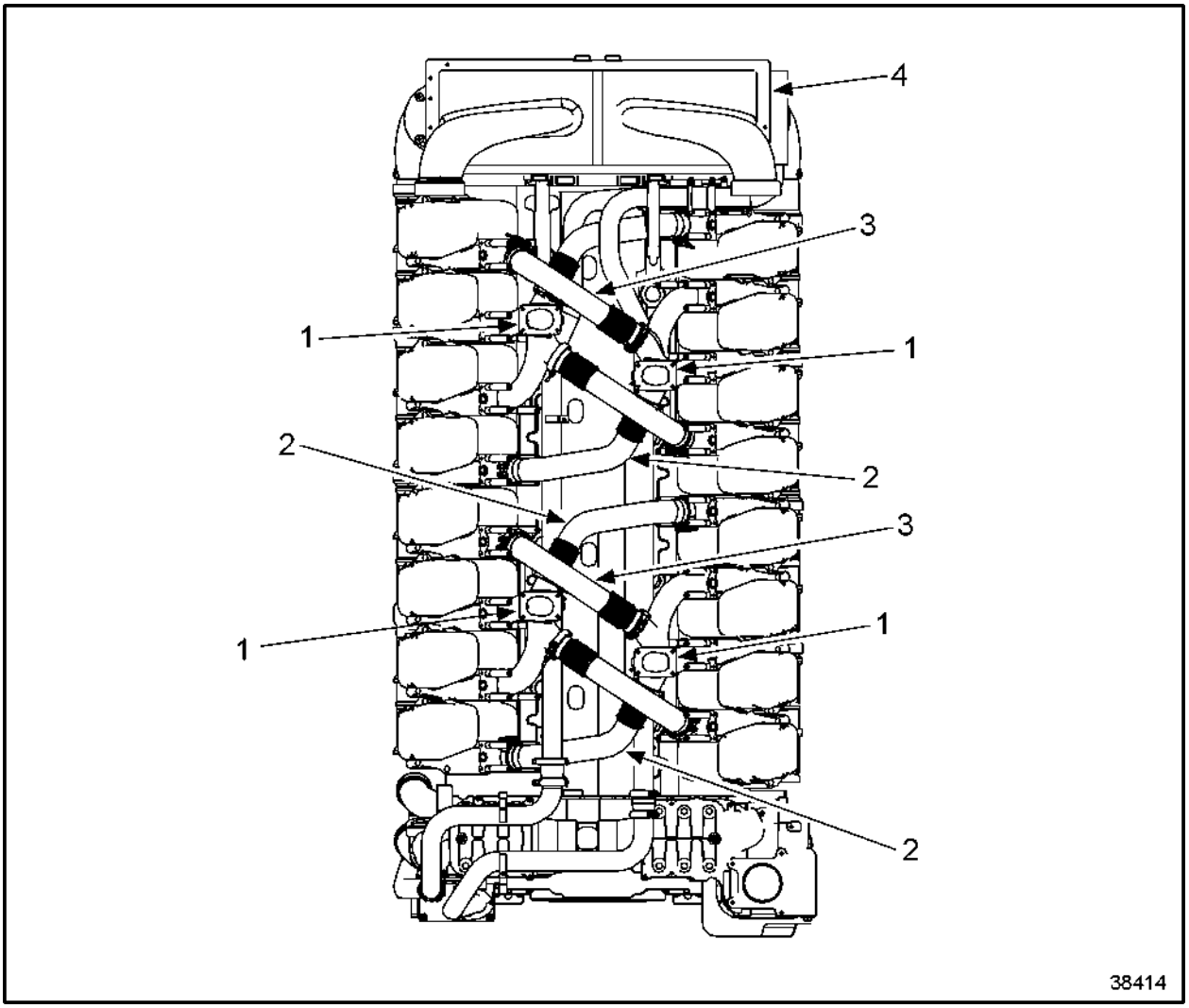
3= The engine is to remain installed.

Table 95 After-Installation Operations

C 141.05 M – MARINE EXHAUST MANIFOLD

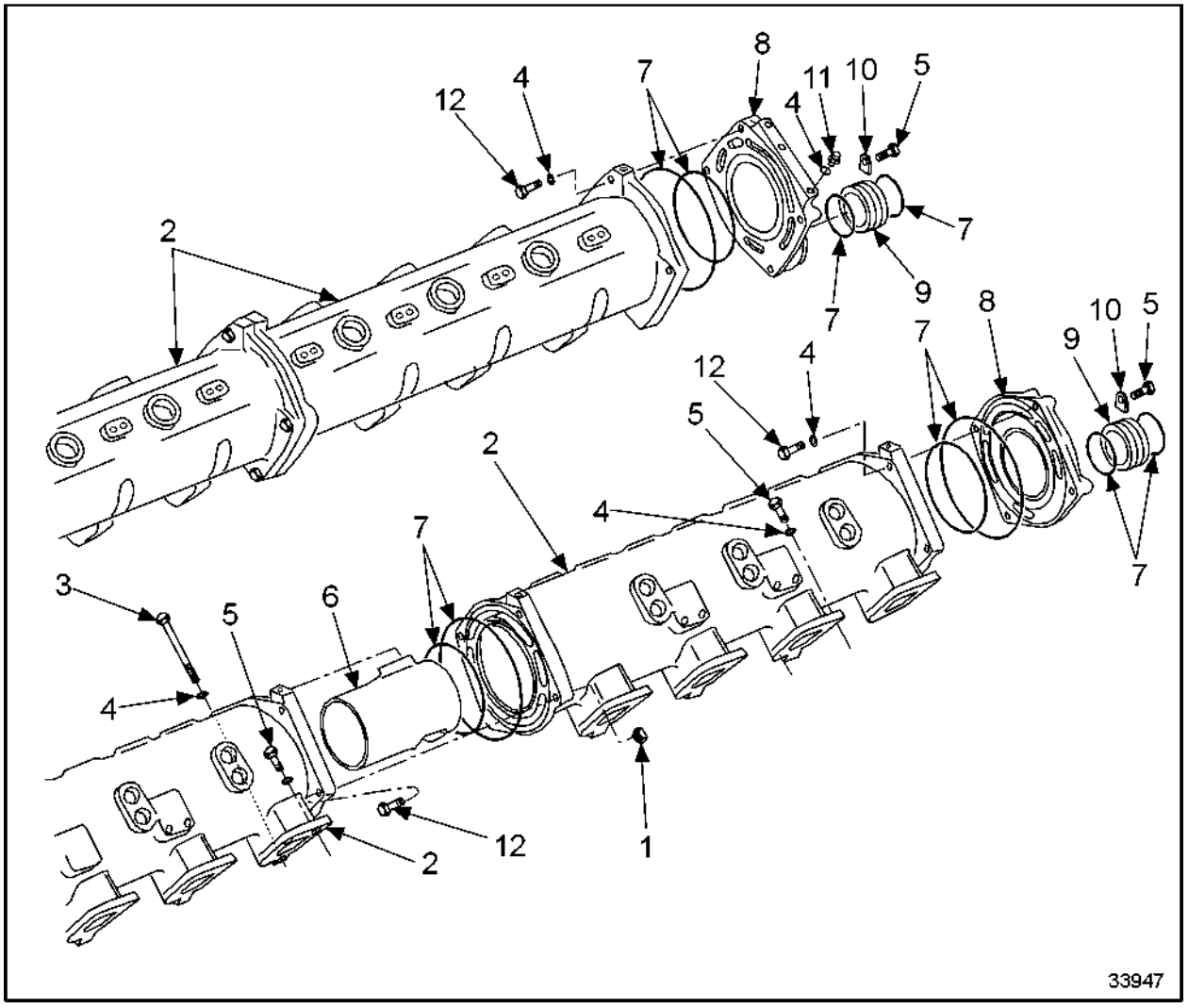
C 141.05.01 M – GENERAL VIEW

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



1. Nut
2. Exhaust Manifold Housing
3. Bolt (120 mm)
4. Washer
5. Bolt (30 mm)
6. Exhaust Line
7. O-ring
8. Cover
9. Plug-in Pipe
10. Stop
11. Adaptor
12. Bolt (8 mm)

Figure 721 General View of Marine Exhaust Manifold Parts Location

C 141.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 96are the Before-Removal Operations for the exhaust manifold.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove air filters	Refer to OEM Guidelines
1, 2, 3	Remove "A" bank intake housing	Refer to OEM Guidelines
1, 2, 3	Remove "B" bank intake housing	Refer to OEM Guidelines

1 = The engine is to be completely disassembled.

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

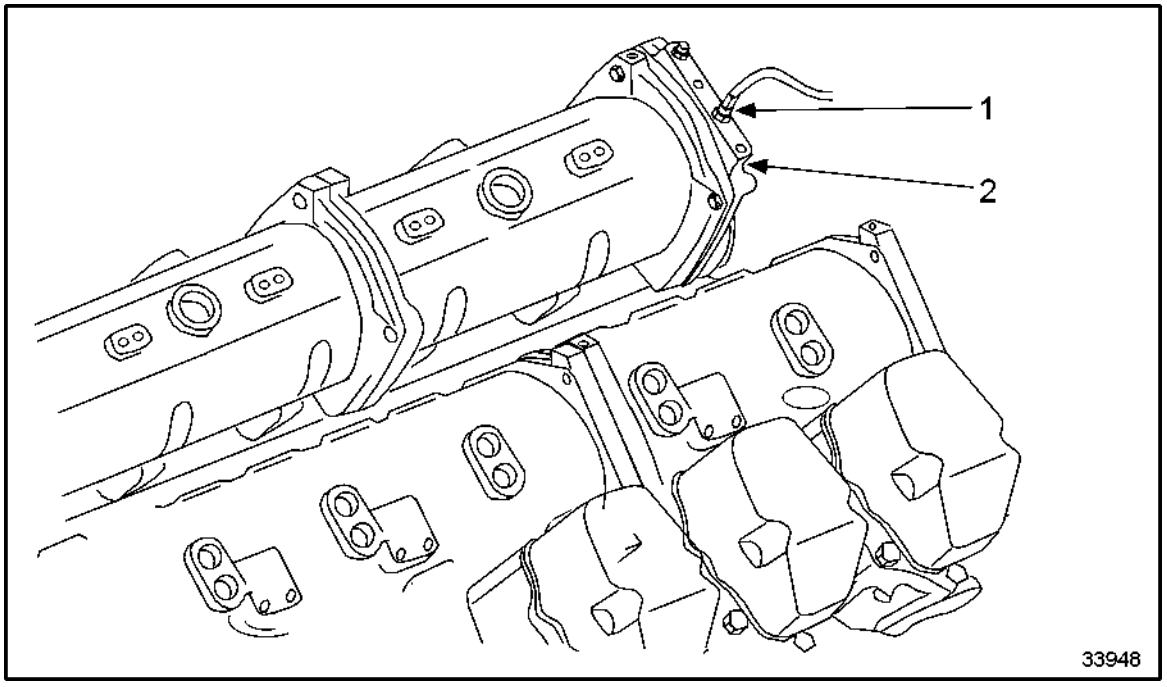
3= The engine is to remain installed.

Table 96 Before-Removal Operations for Exhaust Manifold

C 141.05.05 M – REMOVAL OF THE EXHAUST MANIFOLD

Perform the following steps to remove the exhaust manifold:

1. Disconnect vent lines as required.
2. Disconnect the B6 exhaust coolant temperature sensor, “A” bank. See Figure 722.

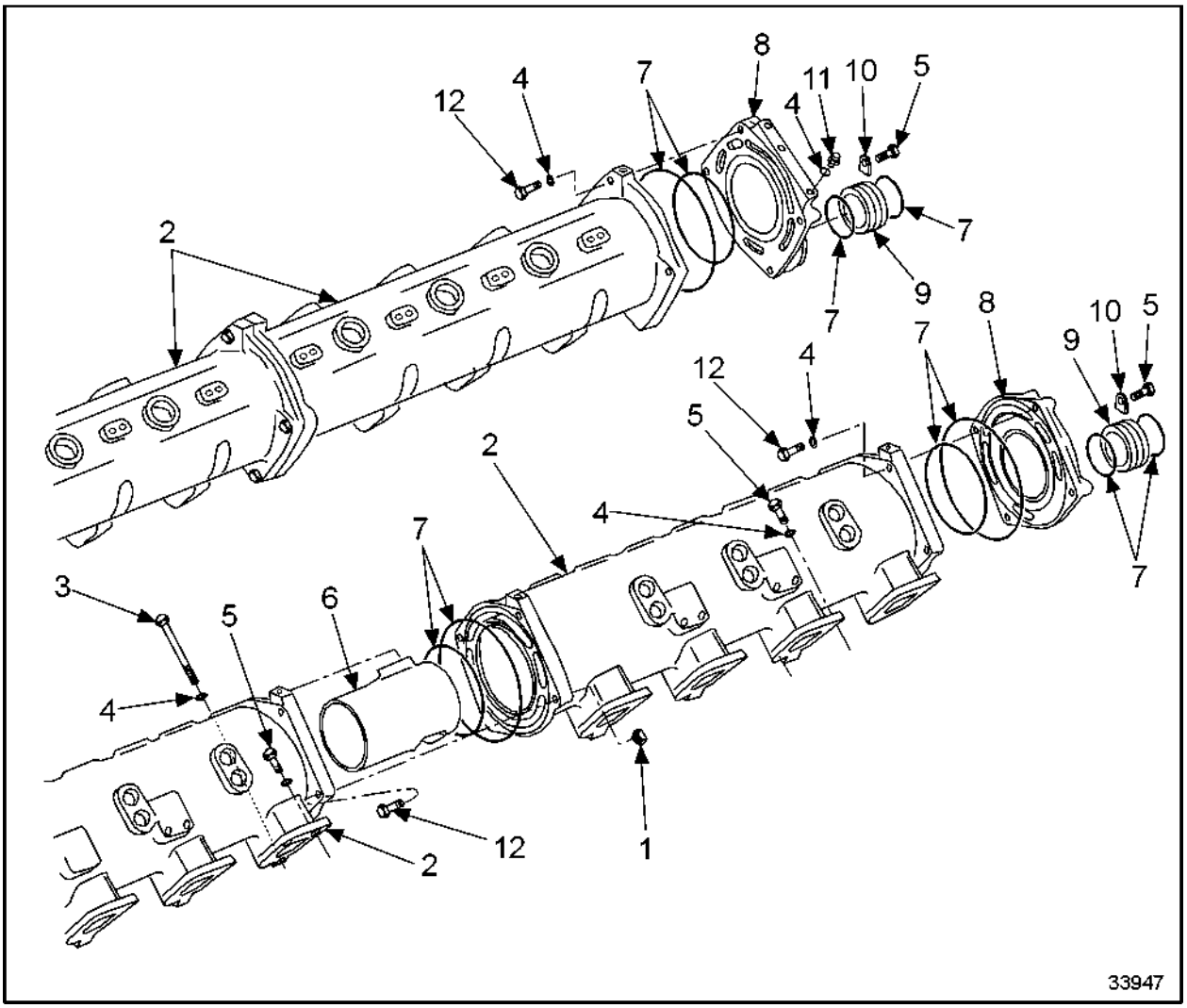


1. Exhaust Coolant Temperature Sensor
2. Exhaust Manifold Cover

Figure 722 Disconnecting B6 Exhaust Coolant Temperature Sensor

3. Remove two (30 mm) bolts (5) and washers (4) securing the exhaust manifold to the cylinder heads. See Figure 723.

NOTE:
Repeat step 3 for each cylinder head.



1. Nut
2. Exhaust Manifold Housing
3. Bolt (120 mm)
4. Washer
5. Bolt (30 mm)
6. Exhaust Line
7. O-ring
8. Cover
9. Plug-in Pipe
10. Stop
11. Adaptor
12. Bolt (8 mm)

Figure 723 Removing Exhaust Manifold Components

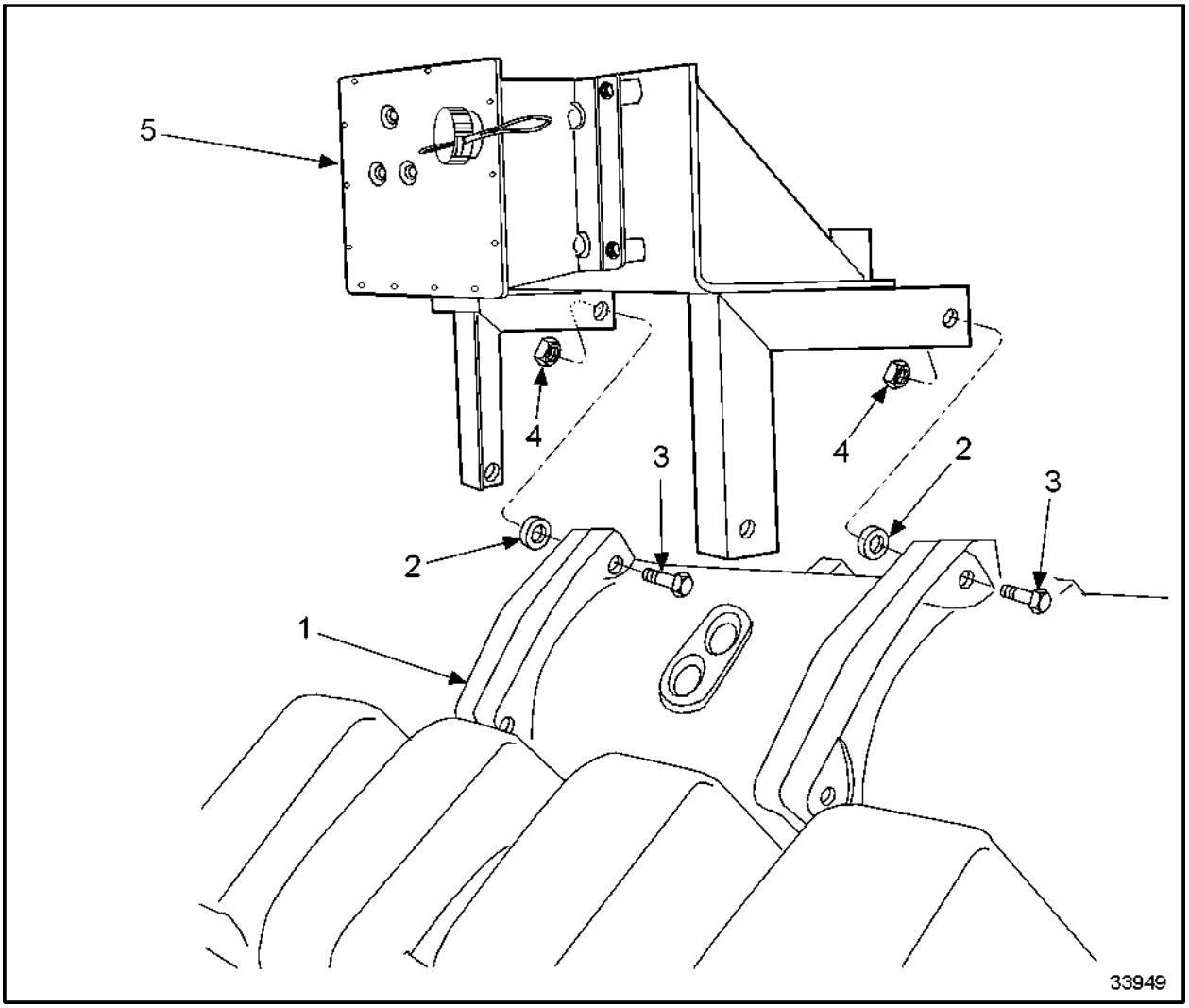
4. Remove one (120 mm) bolt (3) securing the exhaust manifold to the cylinder head. See Figure 723.
5. Remove four (8 mm) bolts (12) and nuts (1) securing the exhaust manifold sections. See Figure 723.

NOTE:
Repeat step 5 for each manifold section as necessary.

NOTE:
Perform step 6 and step 7 for the “A” bank exhaust manifold.

6. Disconnect the marine control box wiring harness.

7. Remove bolts (3) and spacers (2) securing the marine control box to the “A” bank exhaust manifold (1). See Figure 724.



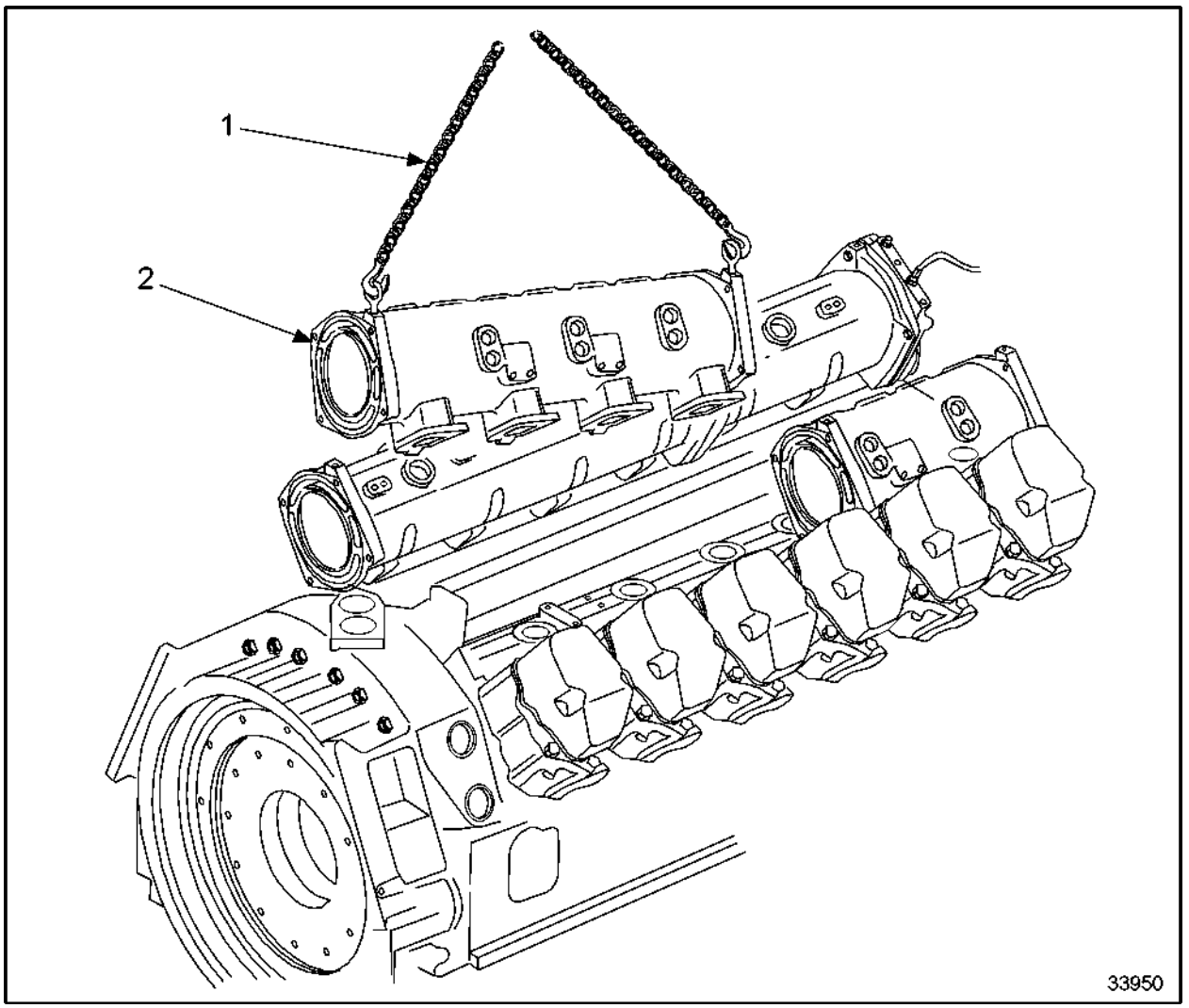
1. "A" Bank Exhaust Manifold
2. Spacer
3. Mounting Bolt
4. Nut
5. Marine Control Box

Figure 724 Removing Marine Control Box

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.

8. Install a suitable lifting device and remove the exhaust manifolds (2) from the cylinder heads. See Figure 725.



1. Lifting Device
2. Exhaust Manifold

Figure 725 Removing Exhaust Manifold

NOTE:
Perform step 9 through step 12 as required.

9. Remove exhaust pipe (6) and O-rings (7) from the exhaust manifold. See Figure 723.
10. Remove bolts (5) and stop (10) securing cover (8) to the exhaust manifold (2). See Figure 723.
11. Remove cover (8) and O-rings (7) from the exhaust manifold. See Figure 723.
12. Remove pipe-in plug (9) and O-rings (7) from the cover (8). See Figure 723.

C 141.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the exhaust manifold:

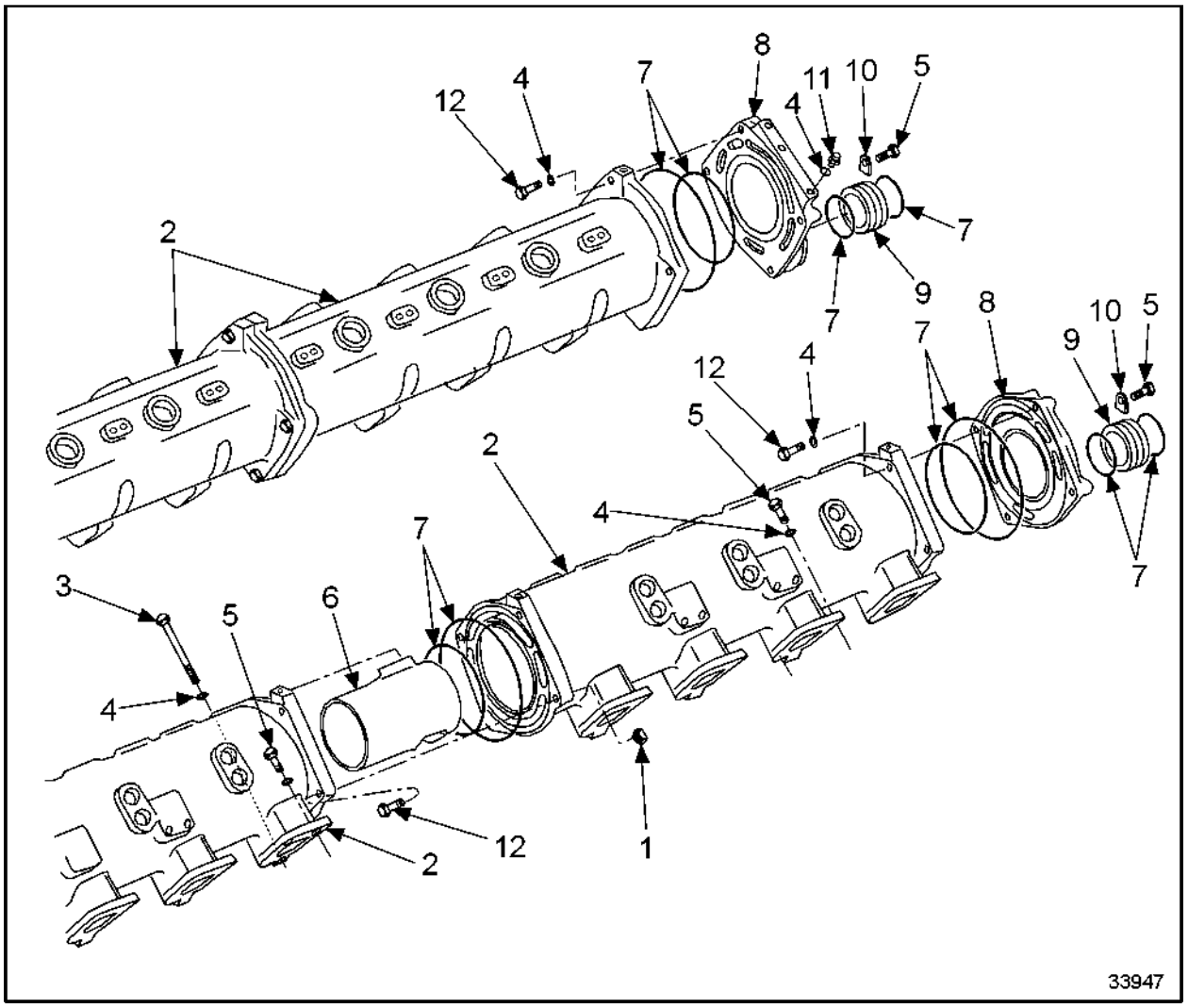
1. Clean all components and visually inspect for damage and defects.
   [a] If components are damage or defective, replace as necessary.
   [b] If components are not damaged or defective, continue inspection.
2. Inspect and repair the exhaust manifold as follows:
   [a] Place exhaust elbow and exhaust pipes in a container containing decarbonizer.
   [b] Duration of exhaust line immersion in cleaning bath depends on thickness of deposit layer.
   [c] After cleaning with carbon-deposit remover, rinse components in water until no further residues are washed off.
   [d] If deposits remain, use synthetic shot-blasting pellets (nominal size 16 to 20) to help cleaning.
3. Visually inspect exhaust lines for cracks using the surface crack-testing method.
   [a] If exhaust lines are cracked, replace component as necessary.
   [b] If exhaust lines are not cracked, continue inspection.
4. Visually inspect exhaust manifolds for warping.
   [a] If exhaust manifolds are warped, replace component.
   [b] If exhaust manifolds are not warped, continue inspection.
5. Visually inspect sealing and mating faces for damage or wear.
   [a] If sealing and mating surfaces are damaged or worn, rub down with emery cloth or an oilstone.
   [b] If sealing and mating surfaces are beyond repair, replace components as necessary.
   [c] If sealing and mating surfaces are not damaged or worn, continue inspection.
6. Inspect stud thread for damage and ease of movement.
   [a] If stud thread is damaged or does not show ease of movement, rechase as necessary.
   [b] If stud thread is not damaged and shows ease of movement, continue inspection.
7. Replace gaskets, studs and nuts as necessary.

C 141.05.11 M – INSTALLATION OF THE EXHAUST MANIFOLD

Perform the following steps to install the exhaust manifold:

NOTE:
Perform step 1 though step 3 as necessary.

1. Install pipe-in plug (9) and O-rings (7) to the cover (8). See Figure 726.



1. Nut
2. Exhaust Manifold Housing
3. Bolt (120 mm)
4. Washer
5. Bolt (30 mm)
6. Exhaust Line
7. O-ring
8. Cover
9. Plug-in Pipe
10. Stop
11. Adaptor
12. Bolt (8 mm)

Figure 726 Installing Exhaust Manifold Components

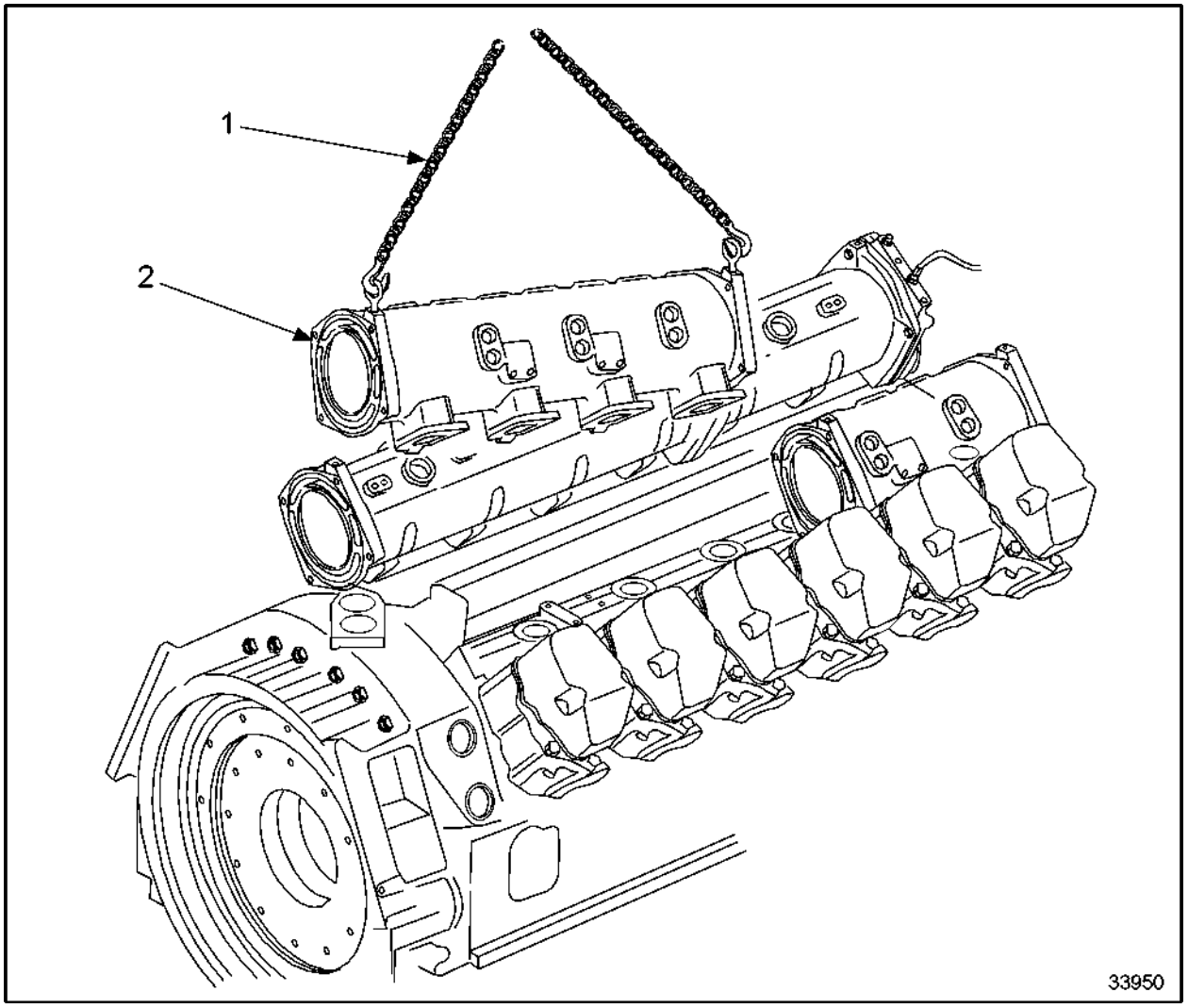
2. Install cover (8) and new O-rings (7) to the exhaust manifold (2) and secure with stops (10) and bolts (5). Torque bolts to specification. Refer to section A 003.See Figure 726.

3. Install exhaust pipe (6) and new O-rings (7) to the exhaust manifold (2) and secure with 8 mm bolts (12) and nuts (1). Torque bolts to specification. Refer to section A 003. See Figure 726.
4. Coat the exhaust manifold machined surfaces with Loctite adhesive sealant.

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.

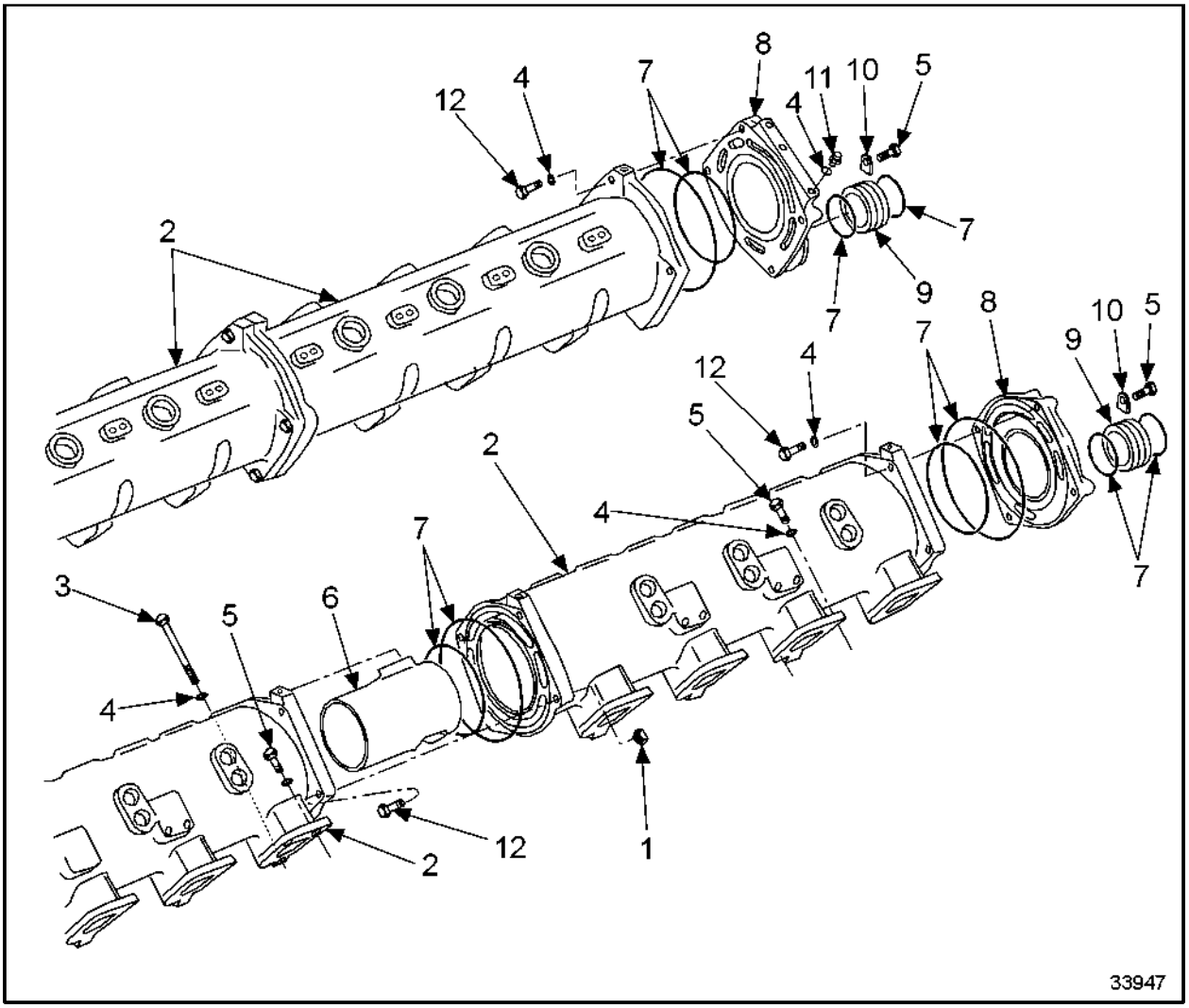
5. Secure a suitable lifting device (1) and install the exhaust manifold sections (2) to the cylinder heads. See Figure 727.



1. Lifting Device
2. Exhaust Manifold

Figure 727 Installing Exhaust Manifold

6. Install 120 mm bolts (3), 30 mm bolts (5), and washers (4) to secure the exhaust manifold to the cylinder heads. Torque bolts to 42–47 N·m (31–35 lb·ft). See Figure 728.

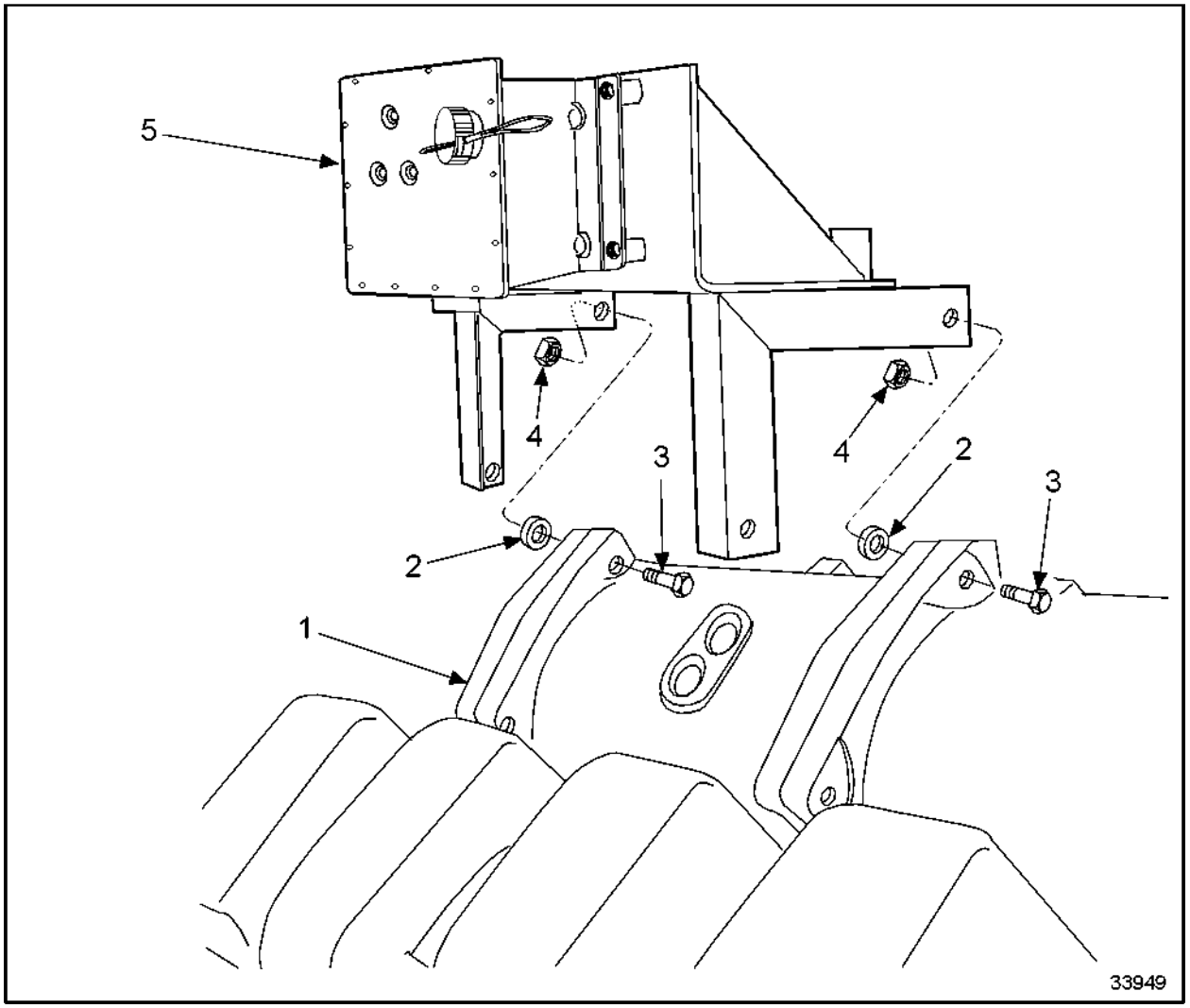


1. Nut
2. Exhaust Manifold Housing
3. Bolt (120 mm)
4. Washer
5. Bolt (30 mm)
6. Exhaust Line
7. O-ring
8. Cover
9. Plug-in Pipe
10. Stop
11. Adaptor
12. Bolt (8 mm)

Figure 728 Installing Exhaust Manifold Components

7. Install 8 mm bolts (12) and nuts (1) to secure the exhaust manifold sections (2) to the cylinder head. Torque bolts to 74–82 N·m (55–60 lb·ft). See Figure 728.

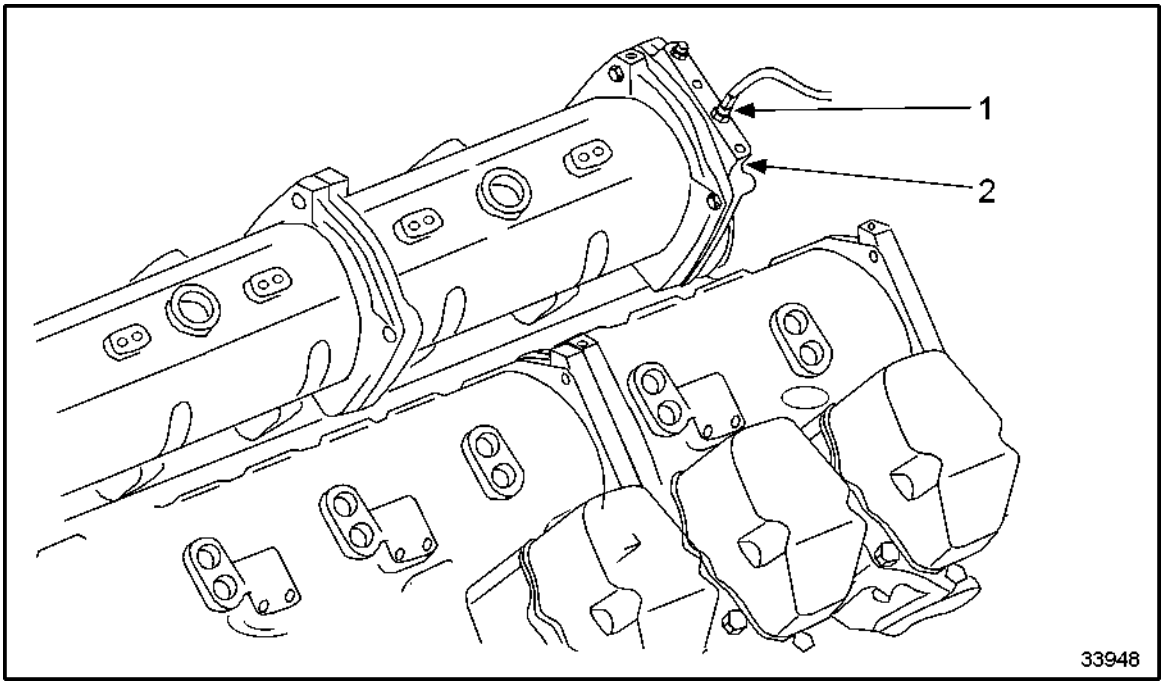
8. Place the marine control box onto the “A” bank exhaust manifold and secure with bolts (3) and spacers (2). Torque bolts to 35–40 N·m (26–30 lb·ft). See Figure 729.



1. "A" Bank Exhaust Manifold
2. Spacer
3. Mounting Bolt
4. Nut
5. Marine Control Box

Figure 729 Installing Marine Control Box

9. Connect the B6 exhaust coolant temperature sensor. See Figure 730.



1. Exhaust Coolant Temperature Sensor
2. Exhaust Manifold Cover

Figure 730 Installing B6 Exhaust Coolant Temperature Sensor

10. Connect the vent lines, as necessary.

C 141.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 97are the After-Installation Operations for the exhaust manifold.

Level of Maintenance	Operation	Reference
1, 2, 3	Install air filters	Refer to OEM Guidelines
1, 2, 3	Install "A" bank intake housing	Refer to OEM Guidelines
1, 2, 3	Install “B” bank intake housing	Refer to OEM Guidelines
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.

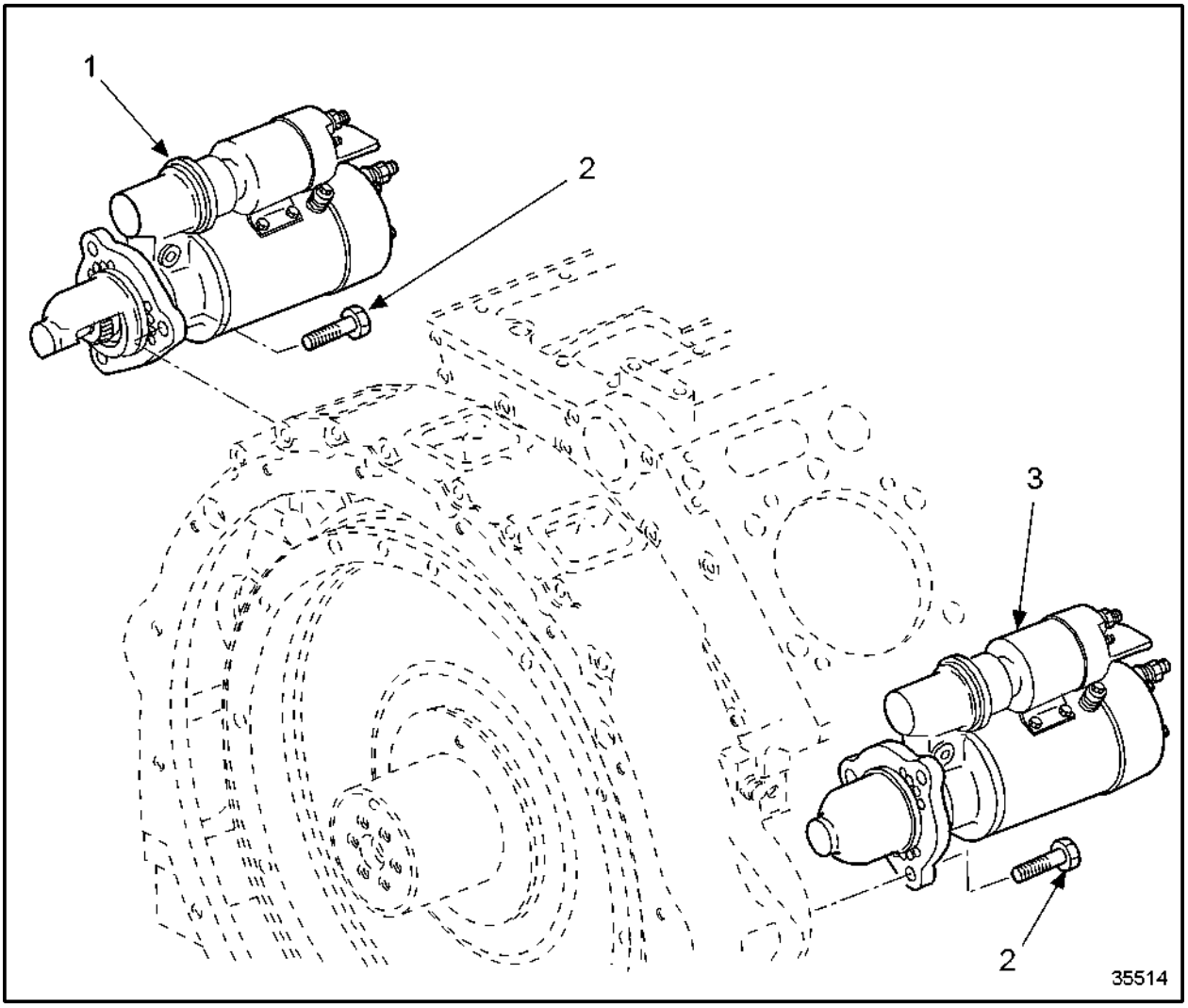
Table 97 After-Installations Operations

C 170 – STARTING SYSTEM

C 172.05 – STARTER

C 172.05.01 – GENERAL VIEW

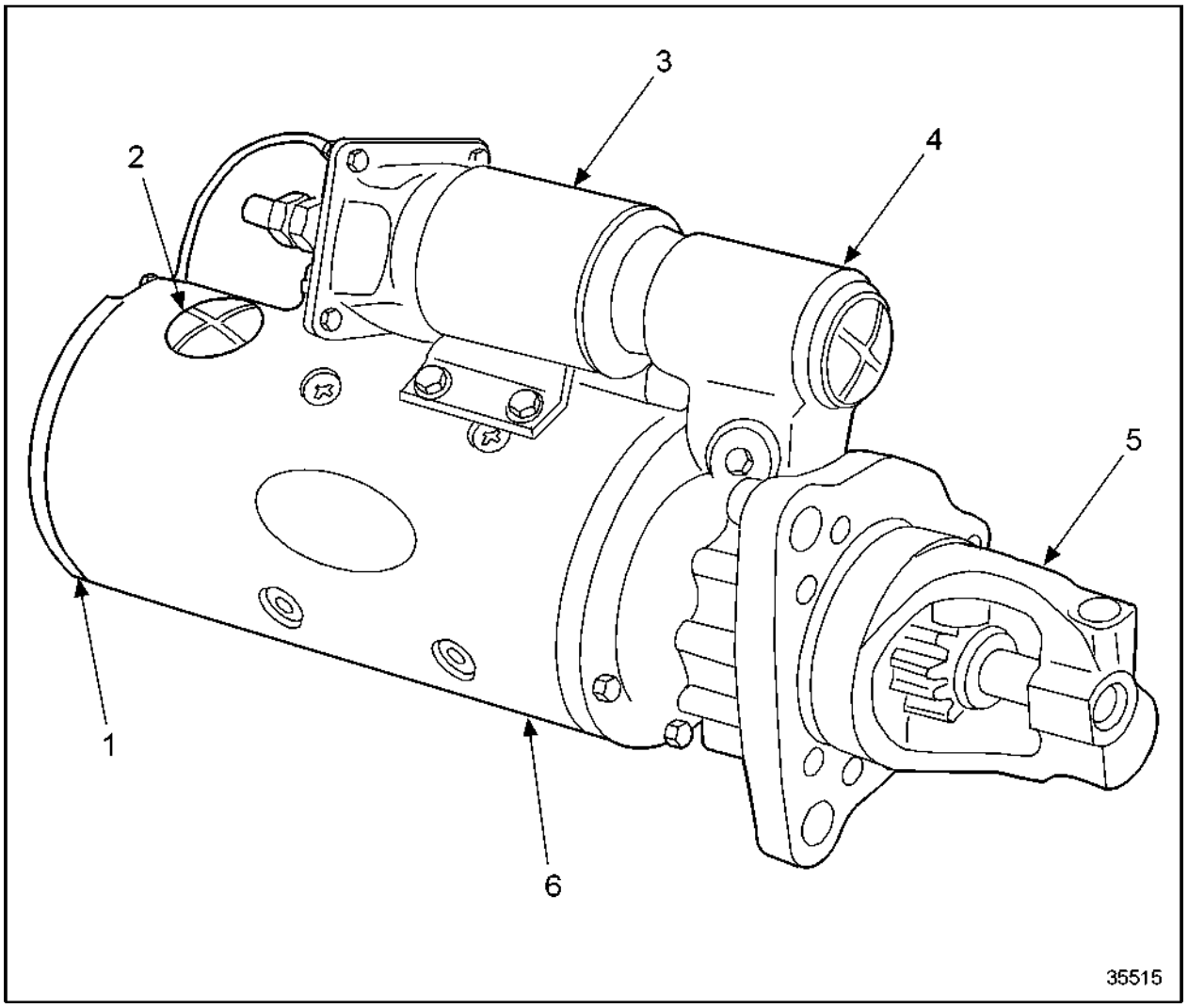
See Figure 731 for a general view of the starter (“A” bank and “B” bank).



1. "A" Bank Starter
2. Hex Socket Bolt
3. "B" Bank Starter

Figure 731 General View of Starter (“A” Bank and “B” Bank)

See Figure 732 for a general view of the starter.



1. Commutator Cover
2. Access Port Cover for Inspecting Carbon Brushes
3. Solenoid
4. Housing for Engagement Lever
5. Bendix Driver Housing
6. Starter Housing

Figure 732 General View of Starter

C 172.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 98 are the Before-Removal Operations for the starter.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove charge air manifold, if necessary	Refer to section C 124.05.05

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.

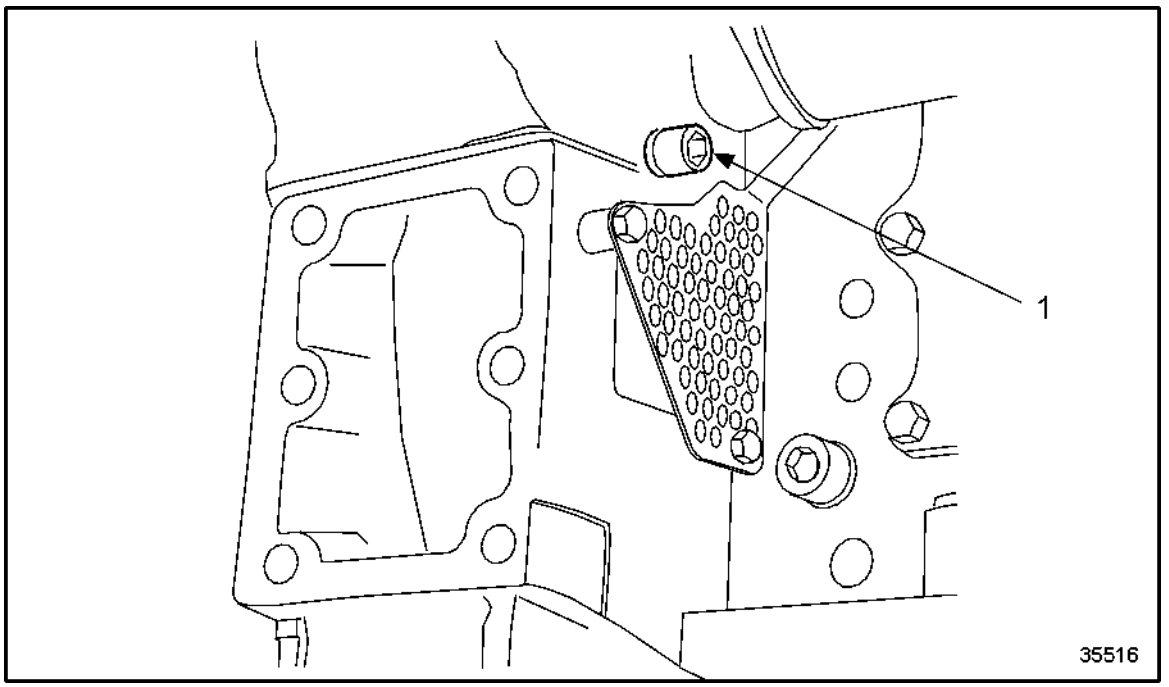
Table 98 Before-Removal Operations

C 172.05.05 – REMOVAL OF STARTER

Perform the following steps to remove the starter:

NOTE:
Before removal, ensure that the battery ground cable is disconnected!

1. Remove the lower hex socket nut (1). See Figure 733.

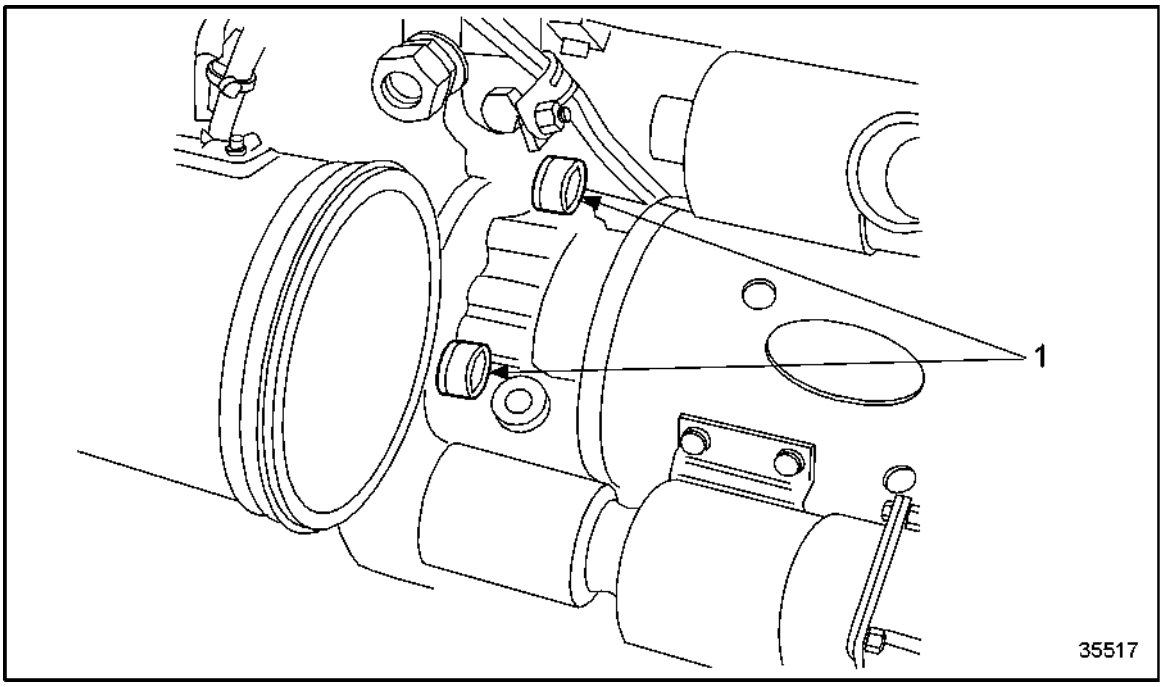


1. Hex Socket Nut

Figure 733 Removing Lower Hex Socket Nut

2. Remove hex socket bolt (1). See Figure 734.

NOTE:
Secure starter to prevent it from falling out.



1. Hex Socket Bolt

Figure 734 Removing Hex Socket Bolt

3. Lift starter out through opening in flywheel housing.

C 172.05.06 – DISASSEMBLY OF STARTER

See OEM Guidelines.

C 172.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the starter:

NOTE:
During cleaning operations, ensure that no moisture can penetrate inner parts of solenoid switch. If moisture penetrates solenoid switch, corrosion and circuit breaks can result.

NOTE:
At present, no provision is made for electric starter disassembly on site. If necessary, send starter to authorized dealer.

1. Inspect individual parts of starter in accordance with OEM Guidelines.
   [a] If individual parts are damaged, repair or replace as necessary.
   [b] If individual parts are not damaged, continue inspection.
2. Visually inspect tooth flanks of pinion for wear, indentations and chipping.
   [a] If tooth flanks of pinion are worn, indented or chipped, recondition component.
   [b] If tooth flanks of pinion are worn, indented or chipped beyond repair, replace component.
   [c] If tooth flanks of pinion are not worn, indented or chipped, continue inspection.
3. Visually inspect nuts and bolts for damage and wear, inspect threads for ease of movement.
4. If nuts and bolts are damaged or worn and threads do not show ease of movement, replace component as necessary.
5. If nuts and bolts are not damaged and worn, and threads show ease of movement, continue inspection.

6. Visually inspect mating surface on flywheel for wear. See Figure 735.

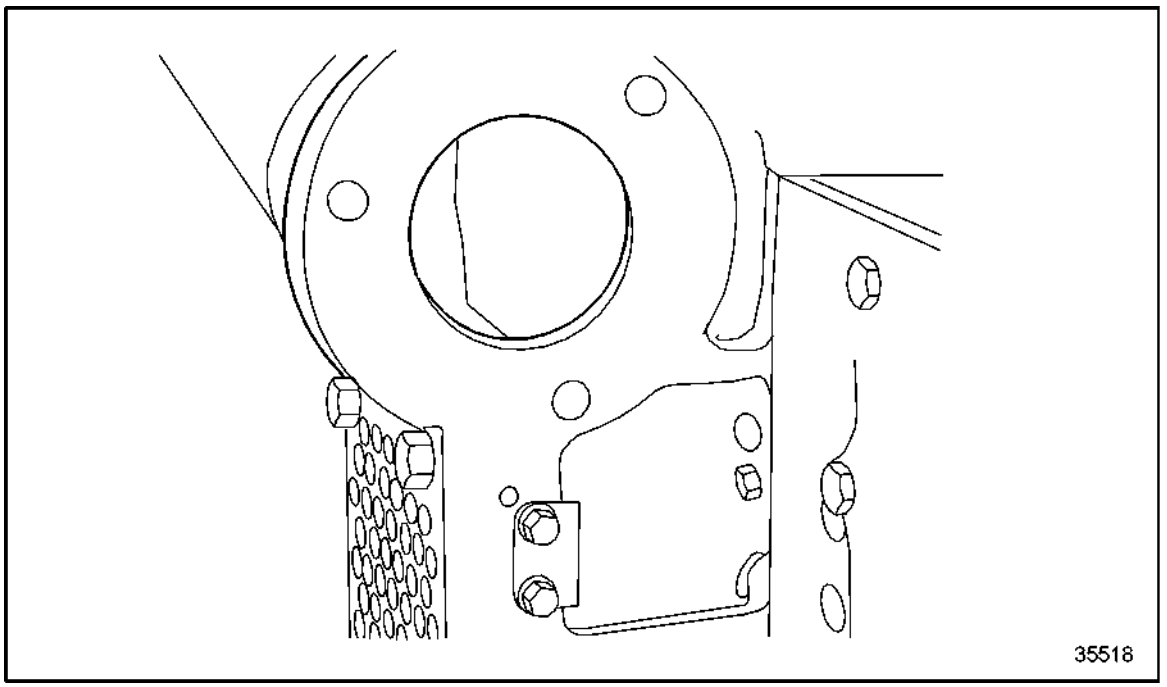


Figure 735 Inspecting Mating Surface on Flywheel Housing for Wear.

[a] If mating surface on flywheel is worn, smooth with an oilstone or emery cloth as necessary.

[b] If mating surface on flywheel is beyond repair, replace component as necessary.

[c] If mating surface on flywheel is not worn, continue inspection.

7. Visually inspect threads for damage or wear.

[a] If threads are damaged or worn, rechase threads as necessary.

[b] If threads are not damaged or worn, continue inspection.

C 172.05.10 – ASSEMBLY OF STARTER

For assembly of starter, Refer to section C 172.05.08.

C 172.05.11 – INSTALLATION OF STARTER

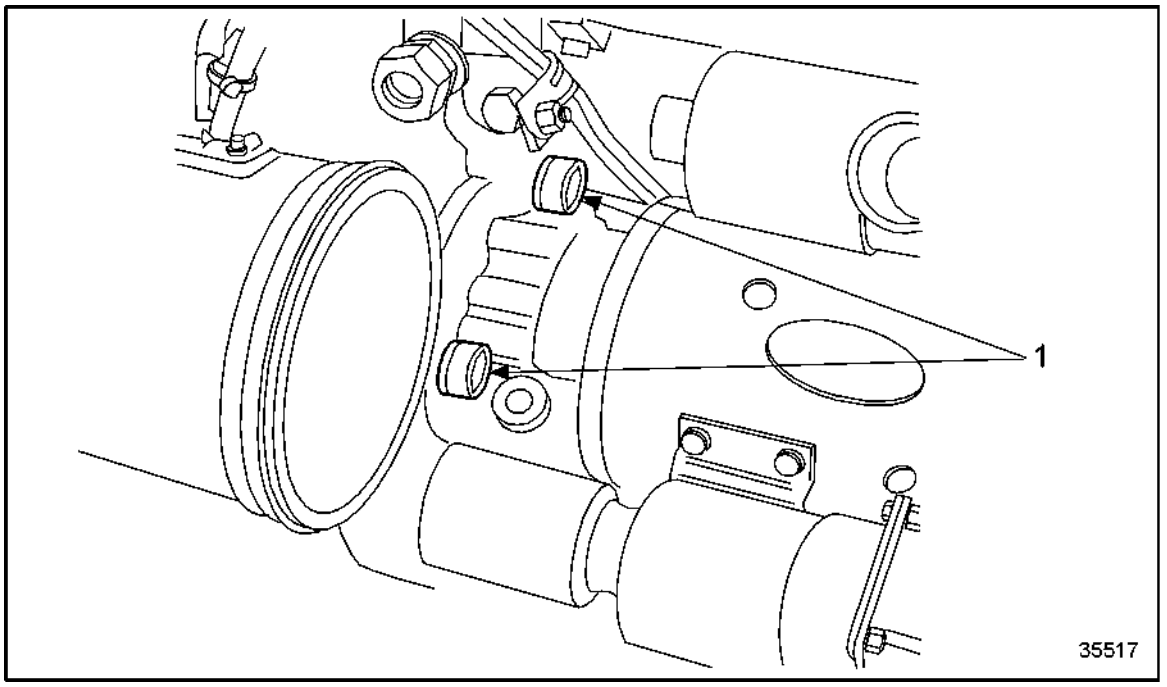
Perform the following steps to install the starter:

NOTE:
Prior to installing starter, coat starter Bendix drive with grease.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

1. Install starter in opening of flywheel housing and align bores in starter flange to support bores. See Figure 736.

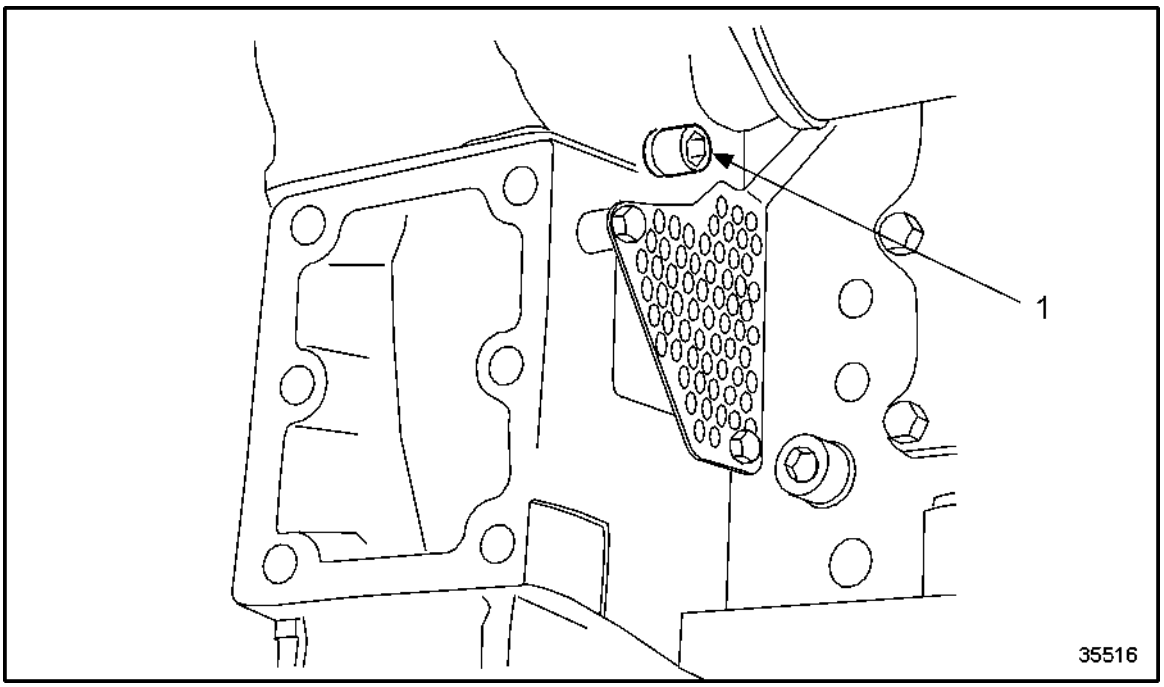


1. Hex Socket Bolt

Figure 736 Installing Starter in Opening of Flywheel Housing

2. Install hex socket bolts.

3. Install the lower hex socket nuts (1). See Figure 737.

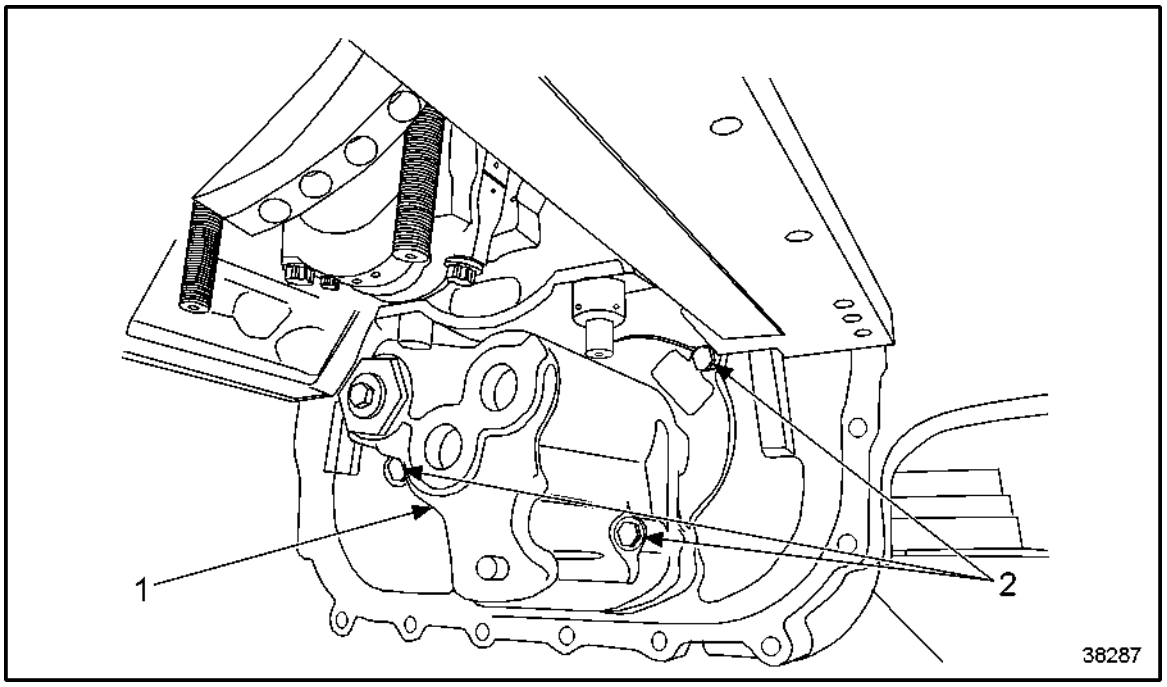


1. Hex Socket Nut

Figure 737 Installing Lower Hex Socket Nut

4. Tighten all hex socket bolts diagonally and evenly to specification. Refer to section A 003.

5. To connect electric starter, connect lines to starter, ensuring that lines to starter are positioned correctly. See Figure 738.



1. Oil Pump
2. Hex Bolts

Figure 738 Connecting Electric Starter

NOTE:
When connecting to ground, ensure that the electric circuit has the correct polarity.

6. Connect battery ground strap.
7. Ensure that starter rotates in proper direction.

C 172.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 99 are the After-Installation Operations for the starter.

Level of Maintenance	Operation	Reference
1, 2, 3	Install charge air manifold, if necessary	Refer to section C 124.05.11
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.

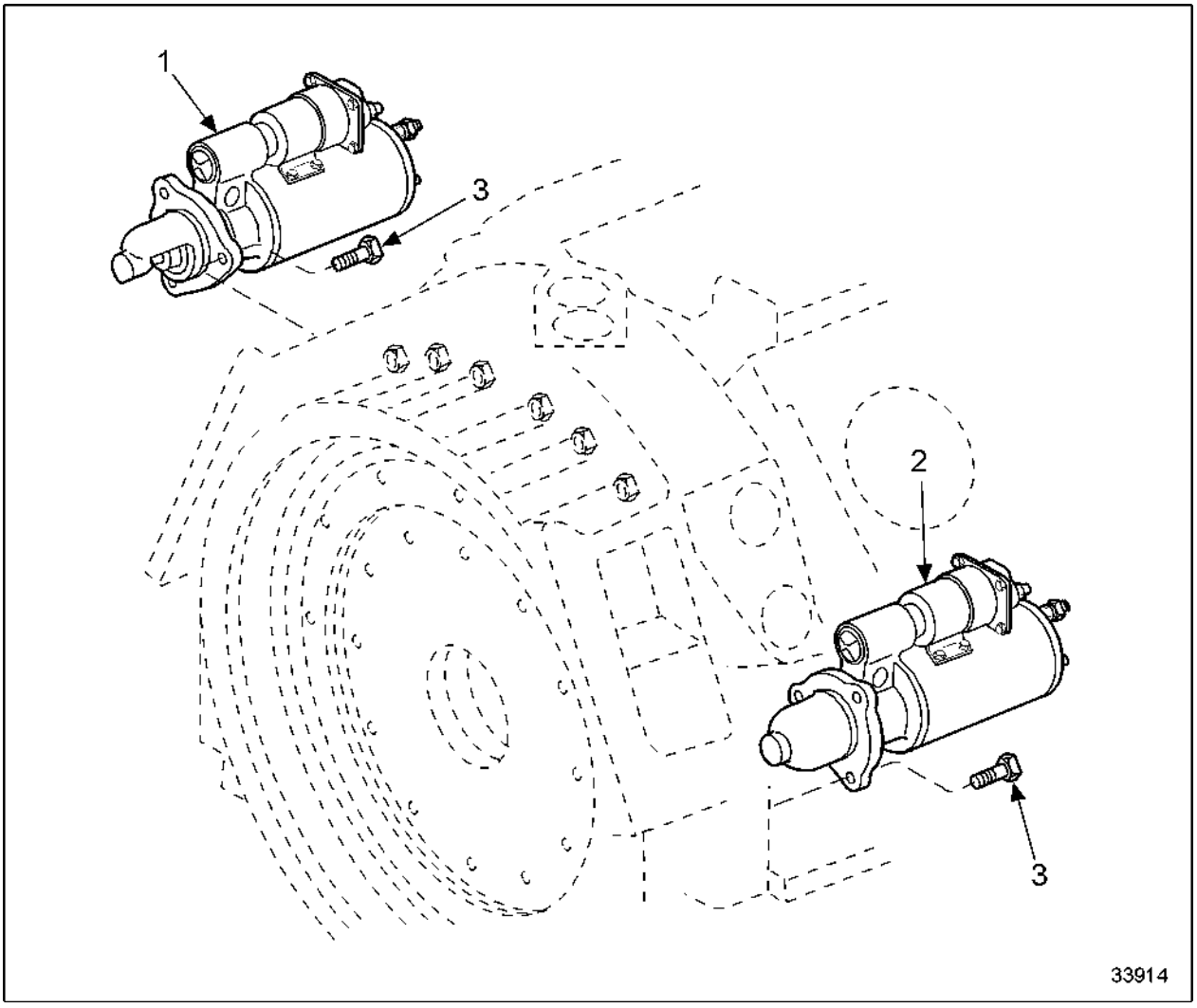
3= The engine is to remain installed.

Table 99 After-Installation Operations

C 172.05 M – MARINE STARTER

C 172.05.01 M – GENERAL VIEW

For location of the marine starter, see Figure 739.



1. "A" Bank Starter
2. "B" Bank Starter
3. Mounting Bolt

Figure 739 General View of Marine Starter

C 172.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 100are the Before-Removal Operations for the marine starter.

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.

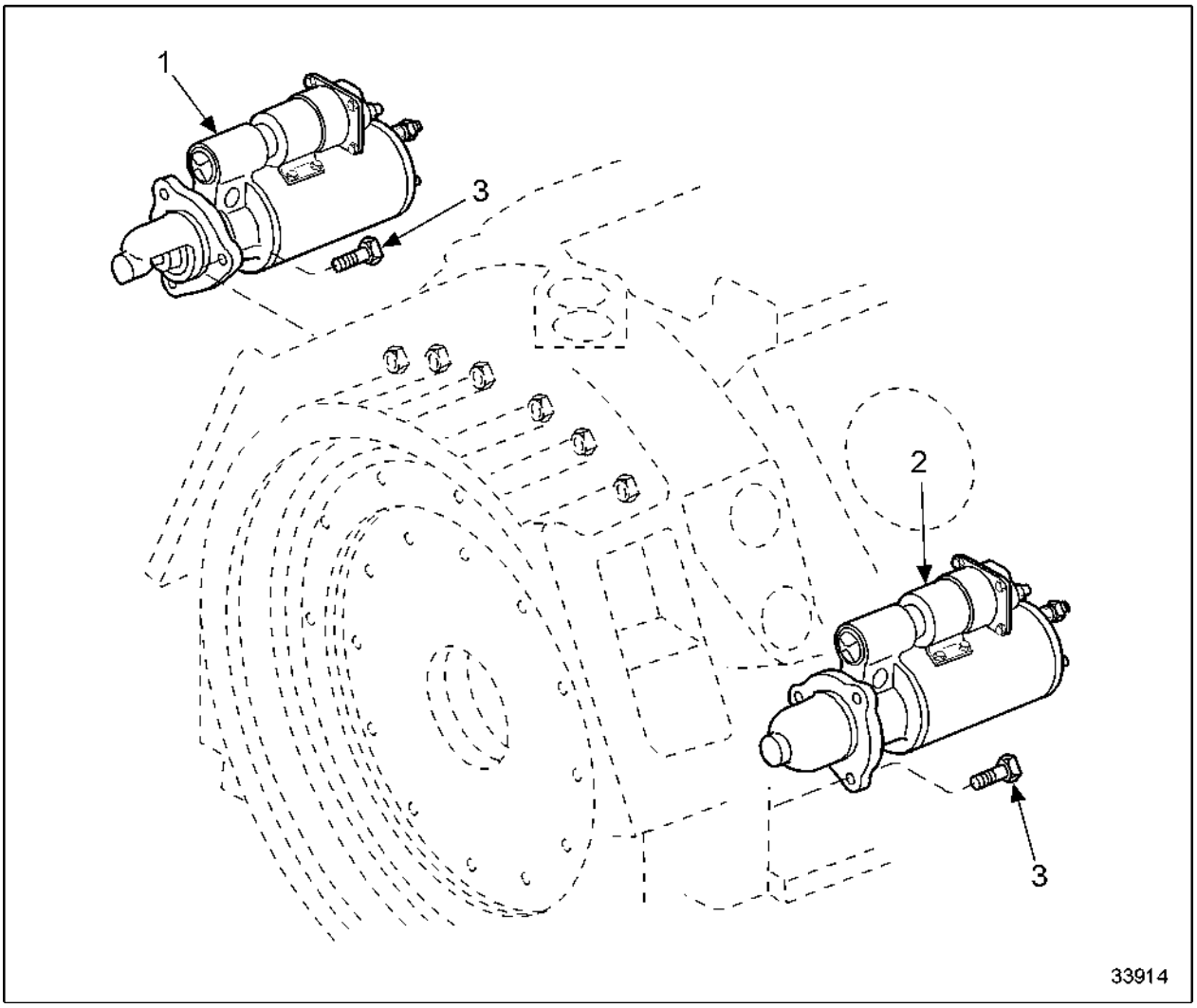
3= The engine is to remain installed.

Table 100 Before-Removal Operations for the Marine Starter

C 172.05.05 M – REMOVAL OF THE MARINE STARTER

NOTE:
Ensure the battery cable is disconnected before removal.

Perform the following steps to remove the starter (“A” and “B” bank). See Figure 740.



1. A Bank Starter
2. B Bank Starter
3. Mounting Bolt

Figure 740 Removing Marine Starter

1. Disconnect the engine electrical system.
2. Tag starter leads for assembly.
3. Disconnect the (1) (“A” bank) starter leads. See Figure 740.
4. Remove three bolts (3) securing the starter to the flywheel housing. See Figure 740.

5. Remove starter (1) (“A” bank) by lifting out through the opening in the flywheel housing. See Figure 740.
6. Disconnect the engine electrical system.
7. Tag starter leads for assembly.
8. Disconnect the (2) (“B” bank) starter leads. See Figure 740.
9. Remove three bolts (3) securing the starter to the flywheel housing. See Figure 740.
10. Remove starter (2) ("B" bank) by lifting out through the opening in the flywheel housing. See Figure 740.

C 172.05.06 M – DISASSEMBLY OF THE MARINE STARTER

Refer to OEM guidelines. At the present time, no provision is made for electric starter disassembly on site. If necessary, send the high-pressure pump to an authorized dealer.

C 172.05.08 M – INSPECTION AND REPAIR

NOTE:
During cleaning operations, ensure that no moisture can penetrate inner parts of solenoid switch. If moistures penetrates solenoid switch, it results in corrosion and circuit breaks.

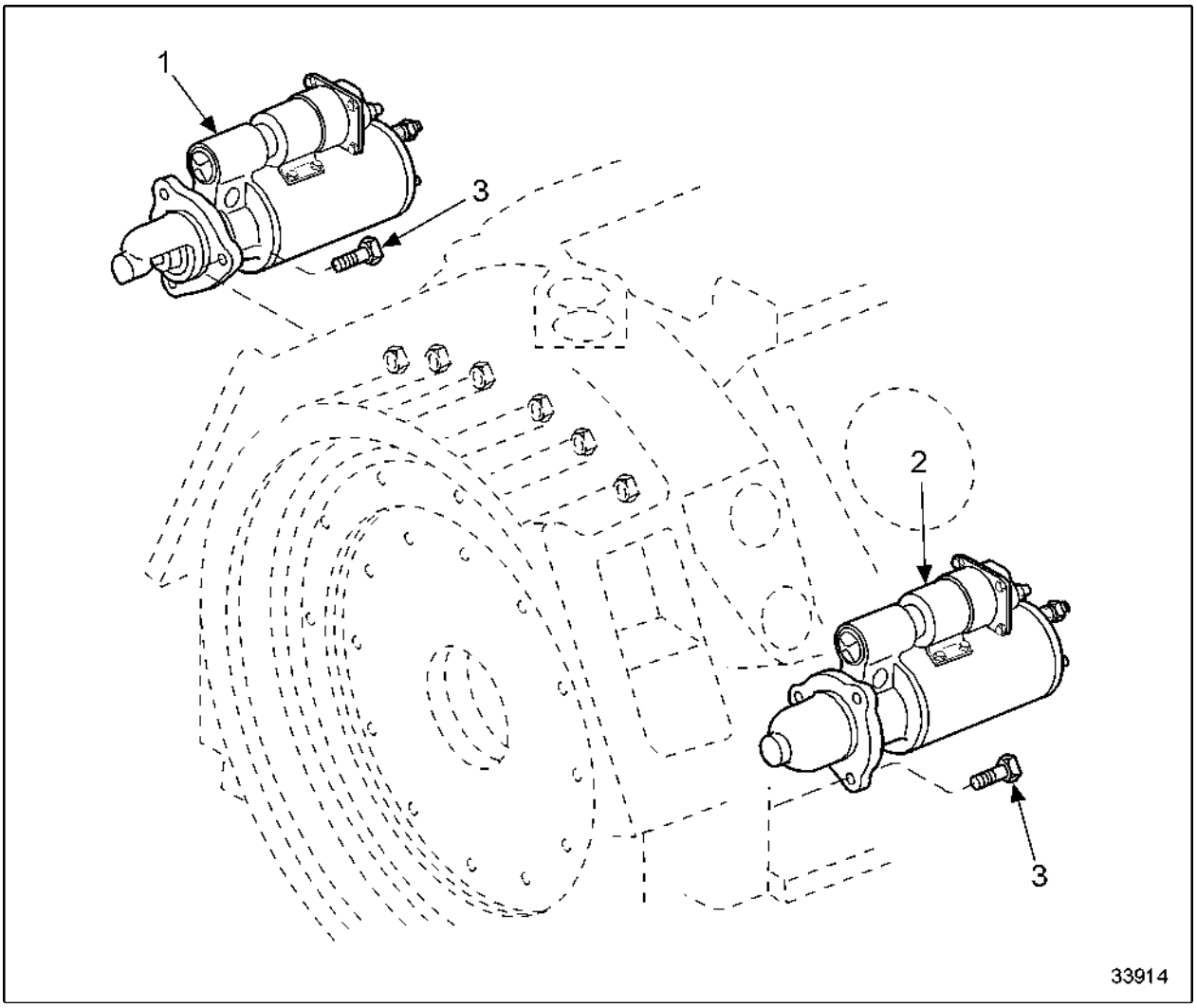
Perform the following steps to inspect and repair the marine starter:

1. Use OEM documentation to inspect and repair the individual parts of the starter.
2. Visually inspect tooth flanks of pinion for wear, indentations and chipping.
   [a] If tooth flanks of pinion are worn, indented or chipped, recondition as necessary.
   [b] If damage is beyond repair, replace as necessary.
   [c] If tooth flanks of pinion are not worn, indented or chipped, continue inspection.
3. Visually inspect nuts and studs for damage.
   [a] If nuts or studs are damaged, replace as necessary.
   [b] If nuts or studs are not damaged, continue inspection.
4. Inspect threads for ease of movement.
   [a] If threads do not show ease of movement, replace as necessary.
   [b] If threads show ease of movement, continue inspection.
5. Visually inspect mating surface on the flywheel housing for wear.
   [a] If mating surface on flywheel is worn, smooth with emery cloth or oilstone as necessary.
   [b] If damage is beyond repair, continue inspection.
   [c] If mating surface on flywheel is not worn, continue inspection.
6. Visually inspect threads for damage or wear.
   [a] If threads are damaged or worn, rechase as necessary.
   [b] If damage is beyond repair, replace as necessary.
   [c] If threads are not damaged or worn, continue inspection.

C 172.05.11 M – INSTALLATION OF THE MARINE STARTER

NOTE:
Prior to installing starter, coat the starter pinion with long-lasting lubricant grease.

Perform the following steps to install the starter (“A” and “B” bank). See Figure 741.



1. "A" Bank Starter
2. "B" Bank Starter
3. Mounting Bolt

Figure 741 Installing Marine Starter

1. Disconnect the engine electrical system.
2. Insert starter (1) (“A” bank) in the opening in the flywheel housing, aligning bores in the starter flange to support bores. See Figure 741.

3. Replace three bolts (3) securing the starter to the flywheel housing. See Figure 741. Torque bolts to specification. Refer to section A 003.
4. Connect the (“A” bank) starter leads.
5. Connect the engine electrical system if only starter (“A” bank) is installed. If starter (“B” bank) was also removed, continue with this procedure.
6. Insert starter (2) (“B” bank) in the opening in the flywheel housing, aligning bores in the starter flange to support bores. See Figure 741.
7. Replace three bolts (3) securing the starter to the flywheel housing. See Figure 741.
8. Connect the ("B" bank) starter leads.
9. Connect the engine electrical system.

C 172.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 101are the After-Installation Operations for the marine starter.

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

1 = The engine is to be completely disassembled.

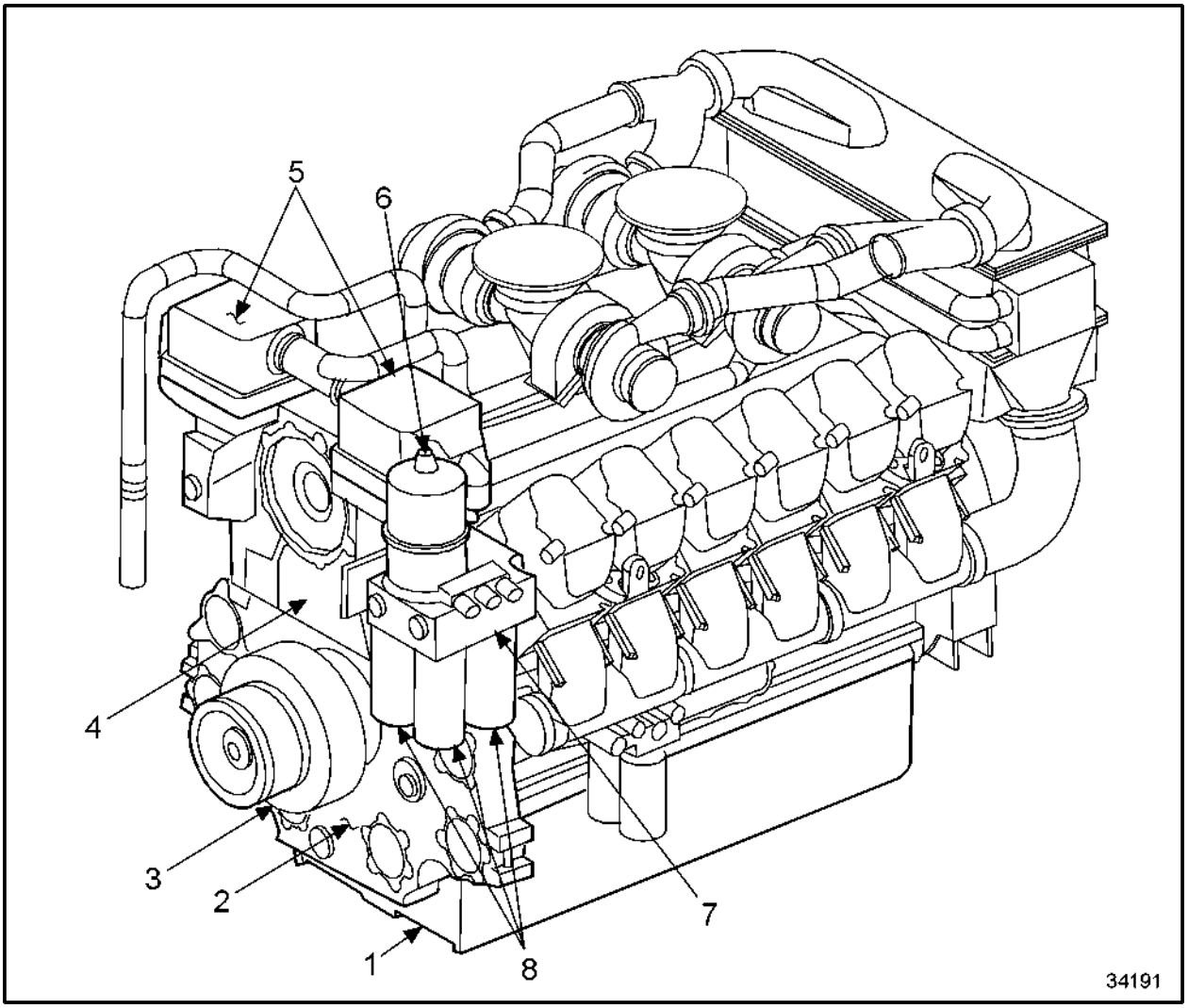
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 101 After-Installation Operations for the Marine Starter

C 180 – LUBE OIL SYSTEM

See Figure 742 for a general view of the lube oil system.



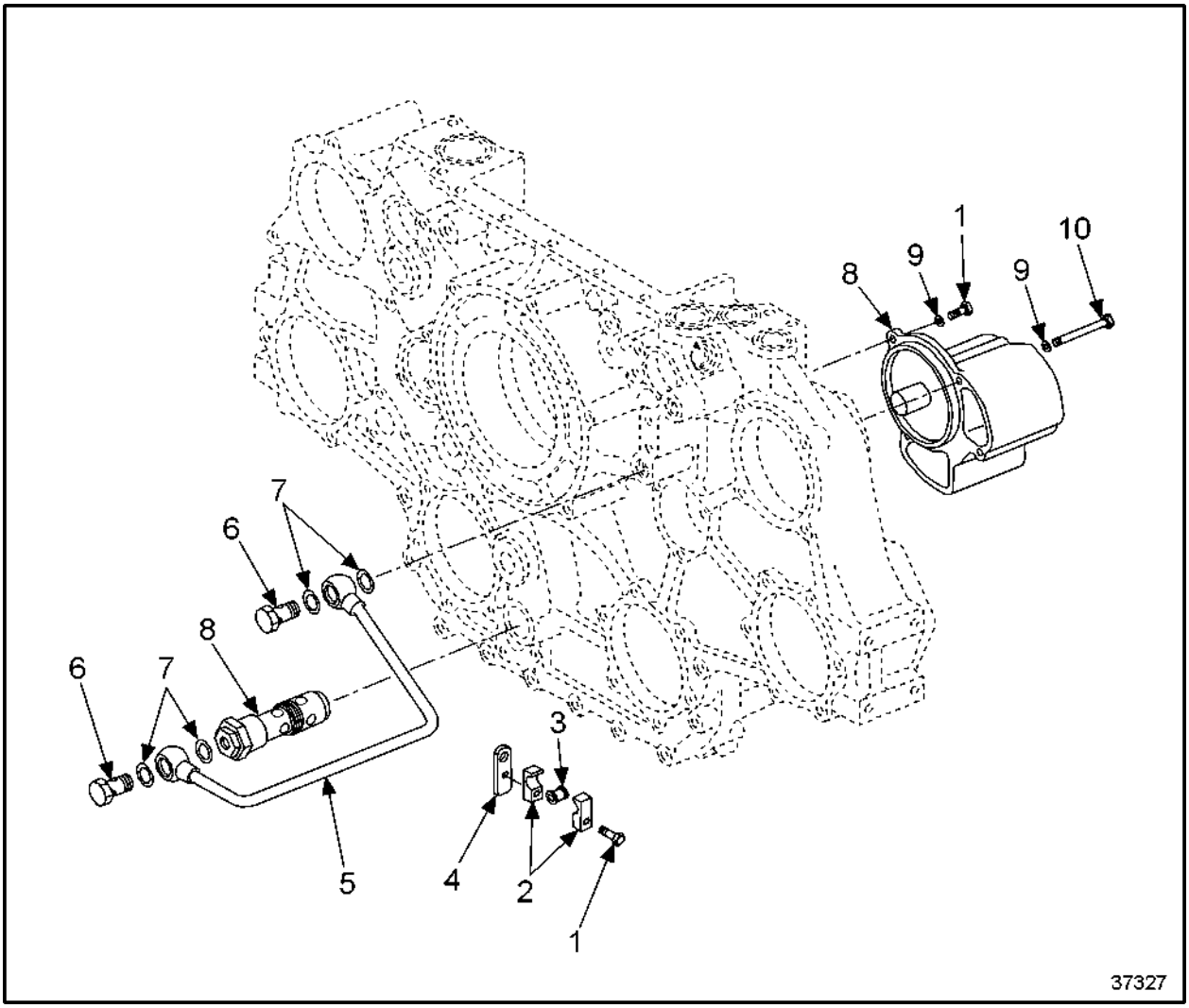
1. Oil Pan
2. Gear Case Containing Oil Pump and Oil Pressure Valves
3. Vibration Damper
4. Distribution Housing Containing Oil Circuits
5. Oil Cooling System (Oil Cooler)
6. Centrifugal Oil Filter
7. Oil Filter Housing
8. Oil Filters

Figure 742 General View of Lube Oil System

C 181.05 – LUBE OIL PUMP WITH DRIVE

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 181.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 102 are the Before-Removal Operations for the lubricating oil pump with drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Remove oil pan	Refer to section C 014.05.05
1, 2, 3	Remove engine mount, gear case end	Refer to section C 231.05.05

1 = The engine is to be completely disassembled.

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

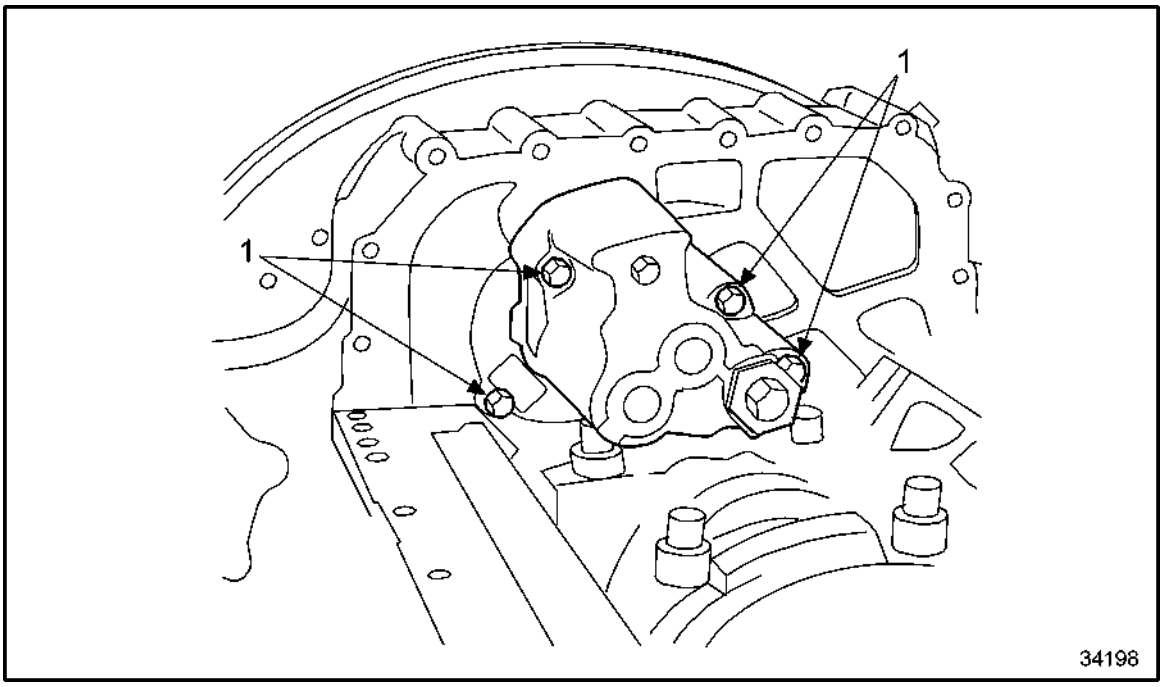
3= The engine is to remain installed.

Table 102 Before-Removal Operations

C 181.05.05 – REMOVAL OF LUBE OIL PUMP WITH DRIVE

Perform the following steps for the removal of the lube oil pump with drive:

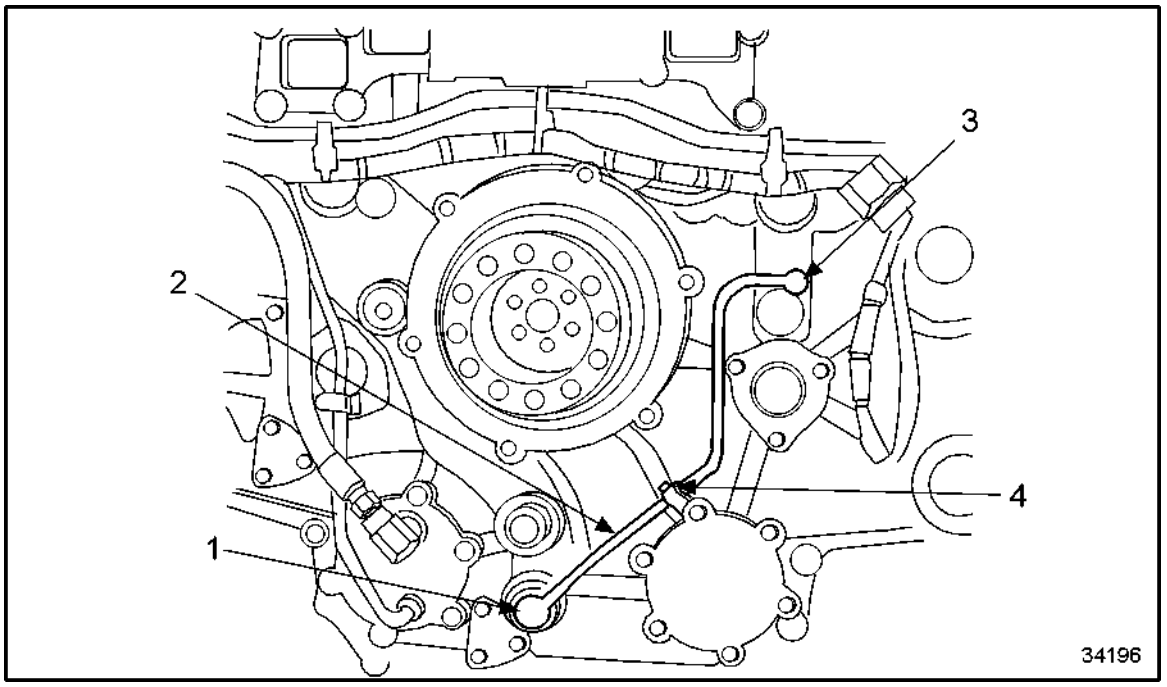
1. To remove oil pump with relief valve, remove hex bolts (1) for oil pump (2) and remove oil pump from gear case. See Figure 744.



1. Hex Bolts

Figure 744 Removing Oil Pump with Relief Valve

2. To remove high-pressure oil line, remove hex bolt (4) and pipe clamp half. See Figure 745



1. Banjo Bolt
2. High-Pressure Oil Line
3. Banjo Bolt
4. Hex Bolt

Figure 745 Removing High-Pressure Oil Line

3. Remove banjo bolt (1) for high-pressure oil line (2) from gear case and banjo bolt (3) from pressure regulator valve.
4. Remove high-pressure oil line.

NOTE:
For a clearer view, the vibration damper has been removed. See Figure 745.

5. Remove gaskets.
6. To remove pressure regulator valve, remove regulator from gear case. See Figure 746.

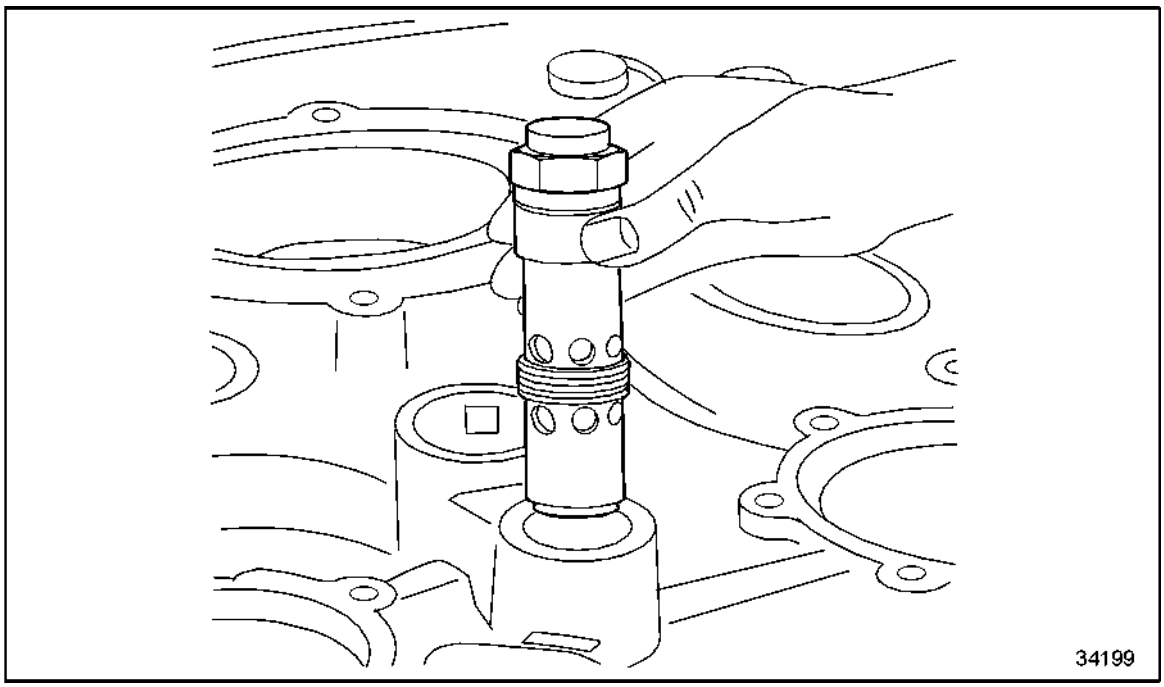


Figure 746 Removing Pressure Regulator Valve

C 181.05.08 – INSPECTION AND REPAIR

High-Pressure Oil Line

Perform the following operations for inspection and repair of the high-pressure oil line:

1. Clean all components.

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.

2. Clean high-pressure oil line with a suitable cleaner and blow clear with compressed air.
3. Visually inspect components for wear and damage.
   [a] If components are worn or damaged, recondition or replace as necessary.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If no wear or damage is found, continue inspection.
4. Visually inspect sealing surfaces for irregularities with ink-check plate.
   [a] If irregularities are found, machine sealing surfaces.
   [b] If no irregularities are found on sealing surfaces, continue inspection.
5. Visually inspect banjo bolts for wear or damage and threads for ease of movement.
   [a] If banjo bolts are worn or damaged, or threads do not show ease of movement, replace bolts as necessary.
   [b] If banjo bolts are not worn or damaged and threads show ease of movement, continue inspection.
6. Replace gaskets.

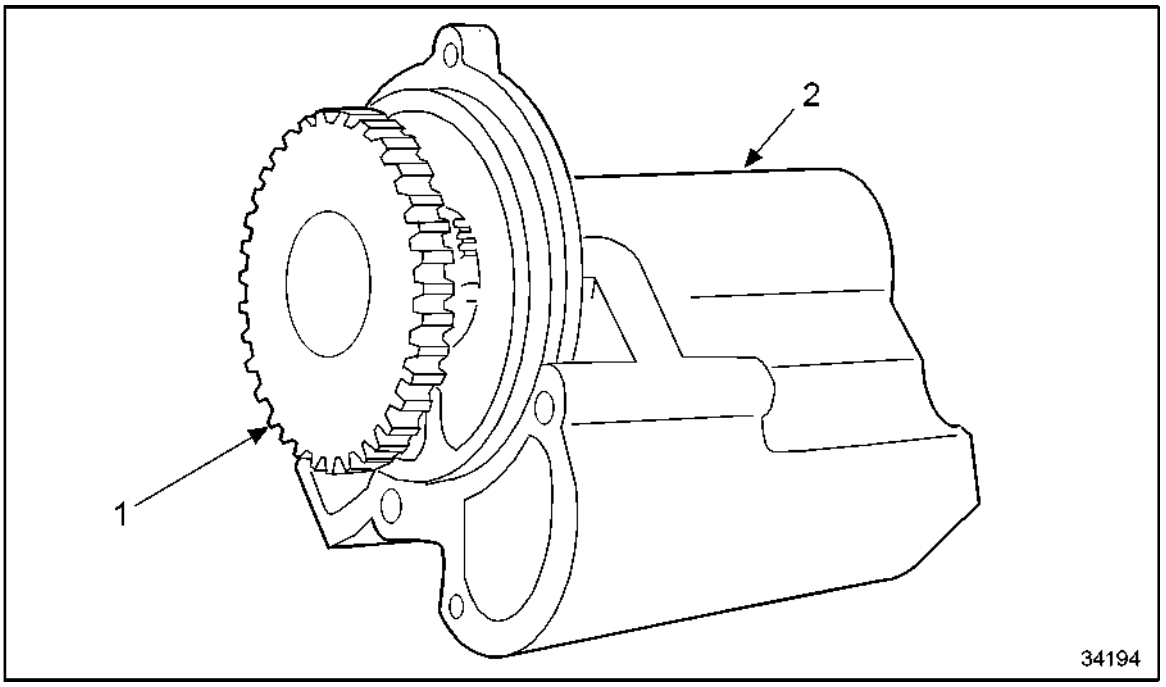
NOTE:
Ensure that parts are perfectly clean.

Oil Pump with Relief Valve

Perform the following steps for inspection and repair of the oil pump with relief valve:

NOTE:
Do not disassemble the oil pump.

1. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect drive gear (1) for cracks. See Figure 747.



1. Drive Gear
2. Oil Pump Housing

Figure 747 Oil Pump with Relief Valve

   [a] If cracks are found, replace drive gear.

   [b] If no cracks are found, continue inspection.

2. Using the surface crack-testing method, inspect oil pump housing (2) for cracks.

   [a] If cracks are found, replace oil pump housing.

   [b] If no cracks are found, continue inspection.

3. Visually inspect teeth of drive gear for wear, indentations and chipping.

   [a] If teeth of drive gear are worn, indented or chipped, rub down with oilstone or emery cloth as necessary.

   [b] If damage is beyond repair, replace drive gear.

   [c] If teeth of drive gear are not worn, indented or chipped, continue inspection.

4. Visually inspect oil pump for minor wear, scoring and indentations.

   [a] If minor wear, scoring or indentations are found, rub down with oilstone or emery cloth.

   [b] If damage is beyond repair, replace oil pump.

   [c] If no wear, scoring or indentations are found, continue inspection.

5. Visually inspect all sealing and mating surfaces for wear, scoring and indentations.
   [a] If sealing or mating surfaces show wear, scoring or indentations, recondition as necessary.
   [b] If sealing or mating surfaces do not show wear, scoring or indentations, continue inspection.
6. Visually inspect securing bolts for wear or damage and threads for ease of movement.
   [a] If bolts are worn or damaged, or threads do not show ease of movement, replace bolts as necessary.
   [b] If banjo bolts are not worn or damaged and threads show ease of movement, continue inspection.

NOTE:
Ensure that parts are perfectly clean.

NOTE:
Opening pressure of relief valve is 15 bar.

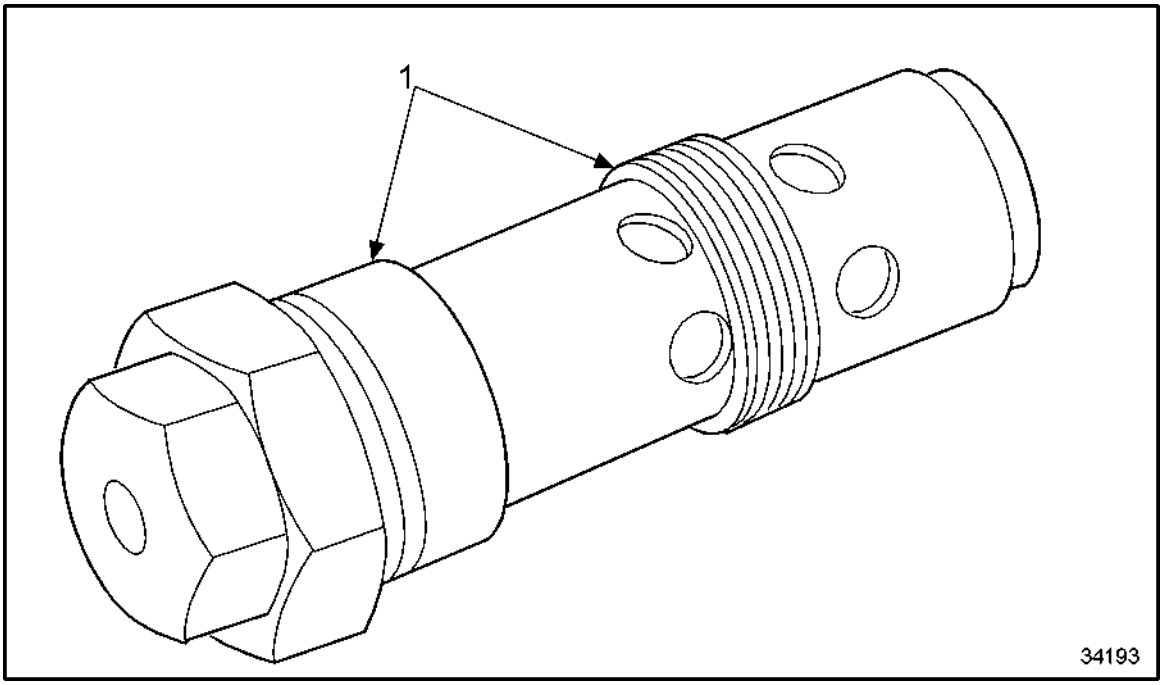
Pressure Regulator Valve

Perform the following steps for the inspection and repair of the pressure regulator valve.

NOTE:
Do not disassemble the oil pressure regulator valve.

1. Visually inspect pressure regulator valve for damage.
   [a] If pressure regulator valve is damaged, replace as necessary.
   [b] If pressure regulator valve is not damaged, continue inspection.
2. Visually inspect sealing surface (1) for unevenness.
   [a] If sealing surface is uneven, smooth with oilstone as necessary.

[b] If sealing surface is not uneven, continue with inspection. See Figure 748.



1. Sealing Surface

Figure 748 Inspecting Sealing Surfaces of Pressure Regulator Valve

CAUTION:

To avoid personal injury, use care when dealing with fluids under pressure. Fluids under pressure have enough force to penetrate the skin. These fluids can cause a minor cut or opening in the skin. If injured by escaping fluid, see a doctor immediately. Serious infection or adverse reaction to the fluid can result if not treated immediately.

3. Visually inspect pressure regulator valve opening pressure.

NOTE:
The valve limits the oil flow so that a constant pressure of 5.5 bar± 1 bar is maintained at the last main bearing. Medium temperature is 90°C to 100°C. Design pressure at n/min n/max of oil pump is 1.5 bar/7 bar.

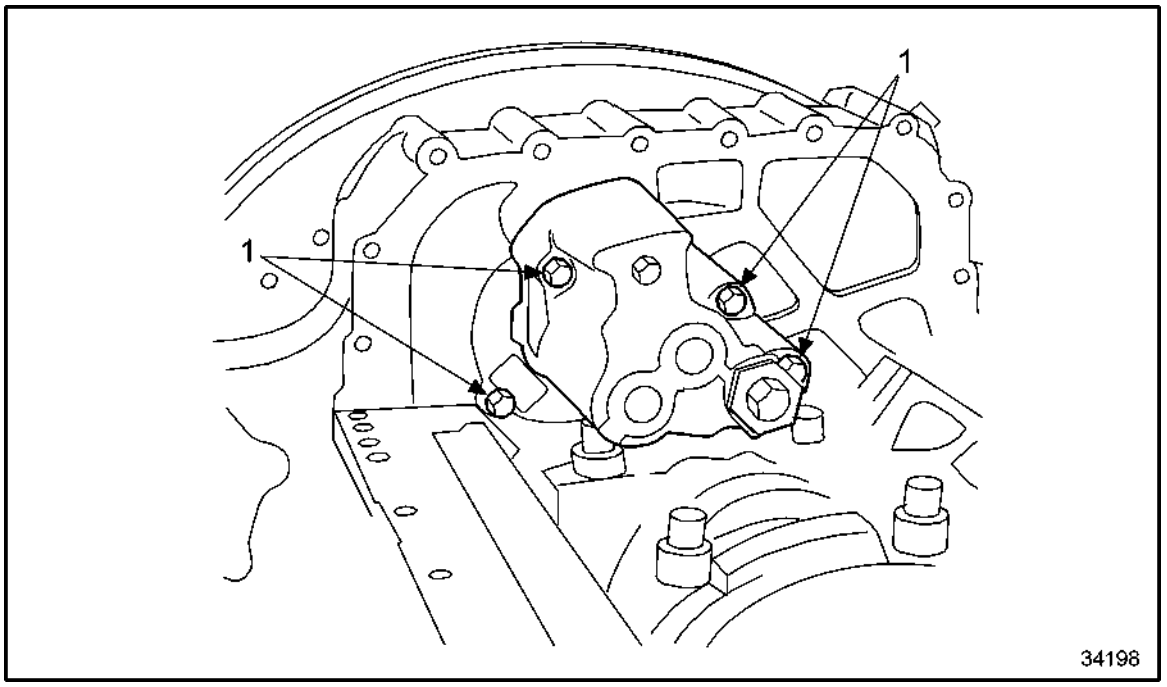
4. If opening pressure is exceeded or not reached, replace pressure regulator valve.

C 181.05.11 – INSTALLATION OF LUBE OIL PUMP WITH DRIVE

Perform the following steps for the installation of the lube oil pump with drive:

1. To install oil pump with relief valve, clean sealing surfaces on gear case. See Figure 749.

NOTE:
When performing any task, ensure that components are perfectly clean.



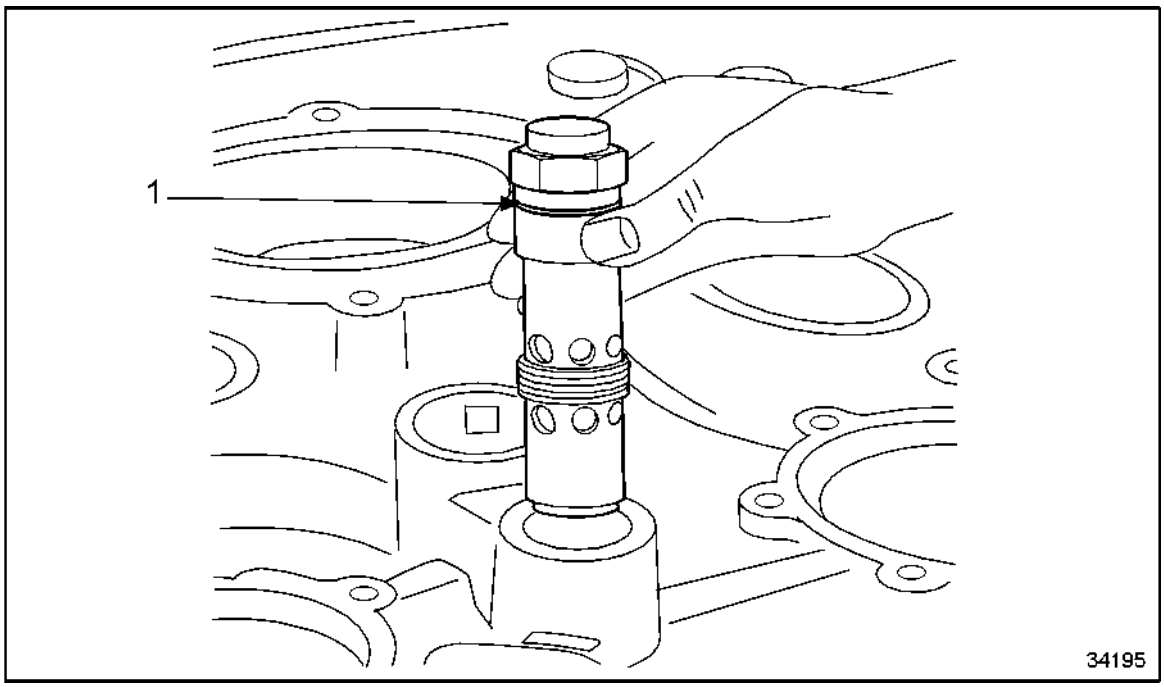
1. Hex Bolts

Figure 749 Installing Oil Pump with Relief Valve

2. Insert oil pump into gear case, ensuring that gears engage correctly.
3. Install hex bolts (1) for oil pump, but not do tighten fully.
4. For torque limits, refer to section A 003.

5. To install pressure regulator valve, coat O-ring with petroleum jelly and install into groove (1) on pressure regulator valve. See Figure 750.

NOTE:
Ensure that parts are perfectly clean.



1. Groove

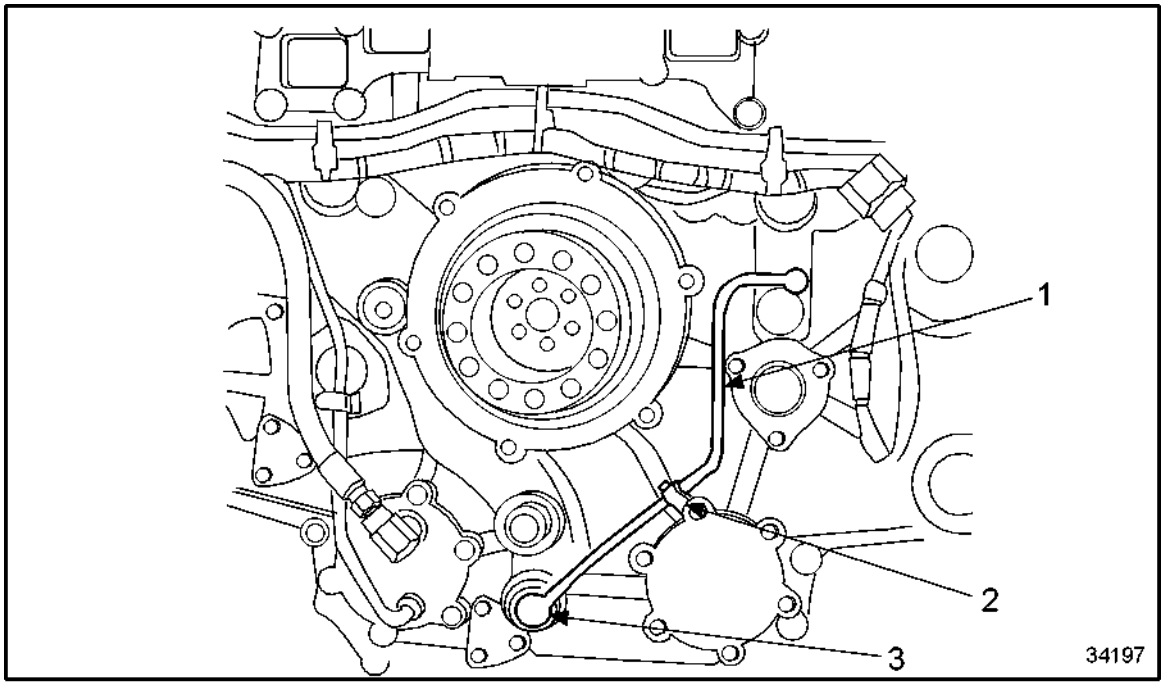
Figure 750 Installing Pressure Regulator Valve

6. Install pressure regulator valve into gear case and tighten to specification. Refer to sectionA 003.

CAUTION:

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

7. To install high-pressure oil line, blow high-pressure oil line (1) through with compressed air and ensure that it is perfectly clean. See Figure 751.



1. High-Pressure Oil Line
2. Pipe Half Clamp
3. Banjo Bolt

Figure 751 Installing High-Pressure Oil Line

8. Install new copper sealing rings.
9. Install banjo bolt (3) on pressure regulator valve and gear case.
10. Do not tighten banjo bolts fully.
11. Mount bracket free of tension. See Figure 743.

12. Install pipe clamp half (2). See Figure 743.
13. Install banjo bolts (3) free of tension. See Figure 743.

NOTE:
On some engines, two copper sealing rings are installed. When reinstalling regulator valves, two copper seals should be used.

C 181.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 103 are the After-Installation Operations for the lubricating oil pump with drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Install oil pan	Refer to section C 014.05.11
1, 2, 3	Install engine mount, gear case end	Refer to section C 231.05.11
1, 2, 3	Fill oil system with engine oil	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.

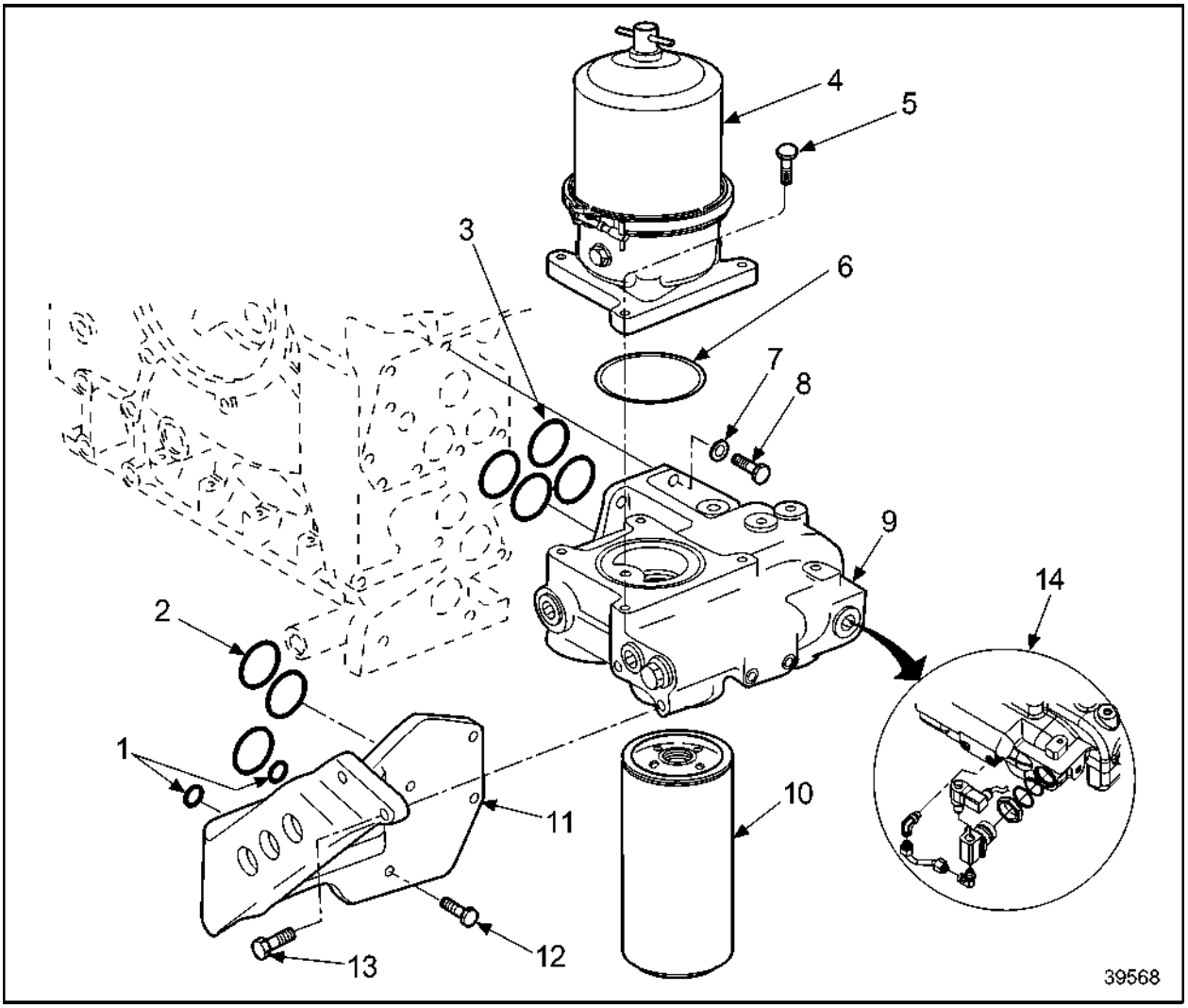
3= The engine is to remain installed.

Table 103 After-Installation Operations

C 183.05 – OIL FILTER

C 183.05.01 – GENERAL VIEW

See Figure 752 for a general view of the oil filter.



1. O-ring
2. O-ring
3. O-ring
4. Centrifugal Oil Filter
5. Hex Bolt
6. O-ring
7. Washer
8. Bolt
9. Oil Filter Housing Assembly
10. Oil Filter Cartridge
11. Oil Filter Mounting Bracket
12. Hex Bolt
13. Hex Bolt
14. Maintenence Alert System

Figure 752 General View of Oil Filter

C 183.05.02 – SPECIAL TOOLS

Listed in Table 104 are the special tools required for maintenance of the oil filter and centrifugal filter.

Application	Number
Strap wrench for oil filter	—
Rotor disassembly tool	23540262 (6906A)
Tube extraction tool	23540261 (6909A)

Table 104 Special Tools

C 183.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 105 are the Before-Removal Operations for the oil filter and centrifugal filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power and enable engine lockout	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain engine oil from centrifugal oil filter	Refer to section C 184.05.05 C 184.05.05

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 105 Before-Removal Operations

C 183.05.05 – REMOVAL OF OIL FILTER AND CENTRIFUGAL OIL FILTER

Removal of Oil Filter

Perform the following steps to remove the oil filter cartridges:

1. Install oil filter strap wrench to a filter cartridge.
2. Turn filter with strap wrench in a counterclockwise direction to remove.
3. After emptying oil filter cartridge, remove with strap wrench. See Figure 753.

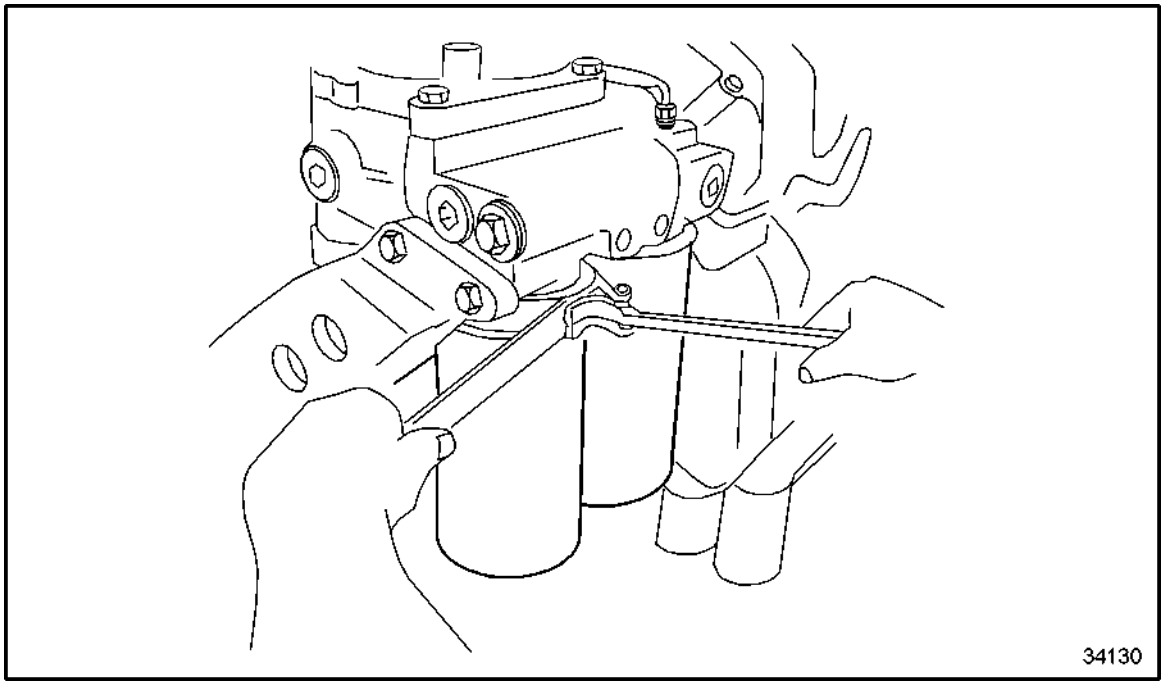
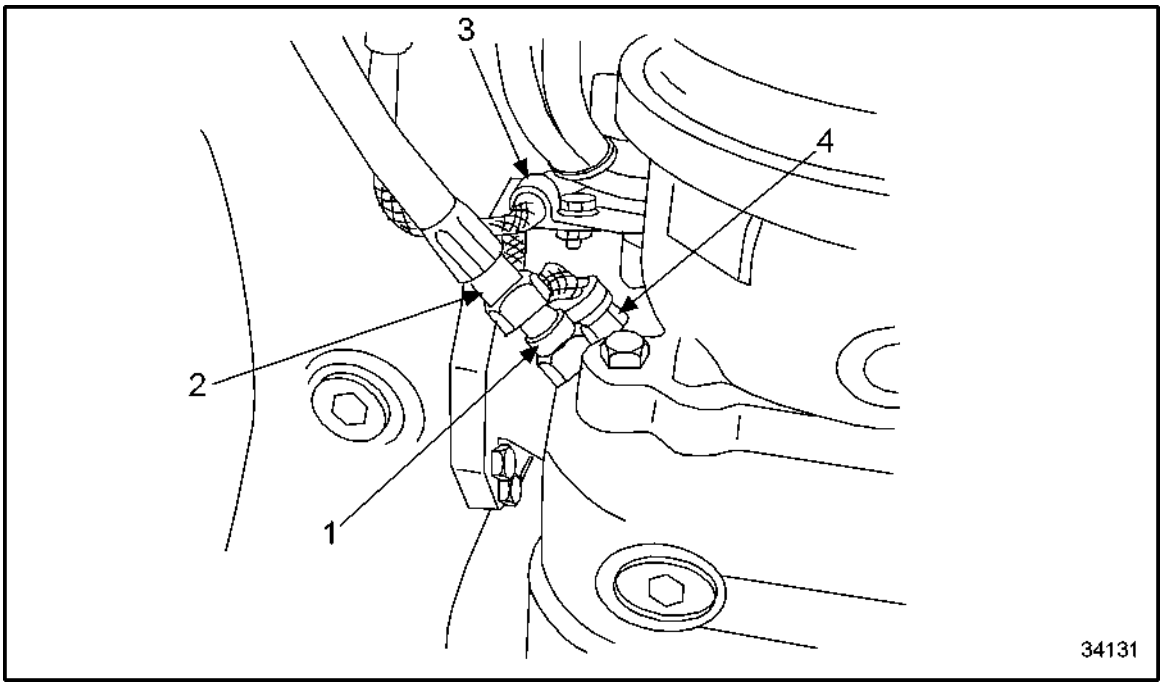


Figure 753 Removing Oil Filter Cartridges with Strap Wrench

4. Repeat step 1through step 2 until all four (4) oil filter cartridges are removed.

5. Hold threaded adaptor (1) firmly with open-end wrench and disconnect oil line. See Figure 754.



1. Threaded Adaptor
2. Oil Line Connection
3. Cable Clamps
4. Lube Oil Pressure Sensor

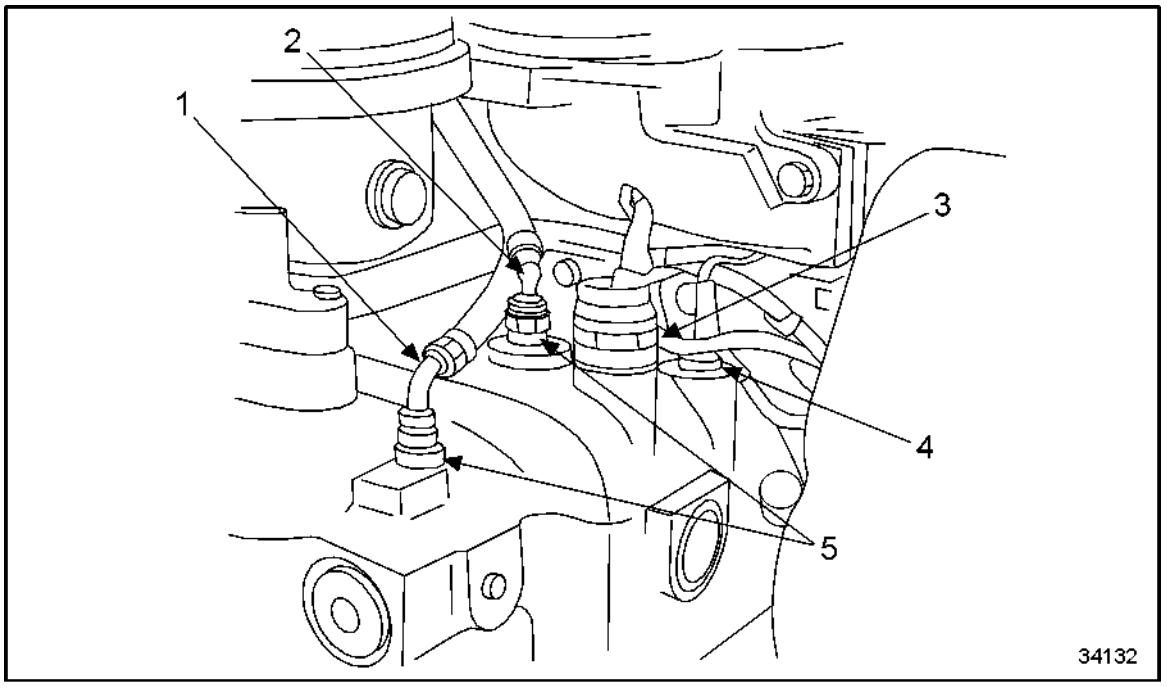
Figure 754 Removing Oil Pressure Sensor

6. Remove cable clamps (3) and separate plug-in connection to lube oil pressure sensor (4).

NOTE:
Make photographic record of cable clamp fixture point for reference to avoid incorrect reinstallation, which could cause engine malfunction.

7. Unscrew lube oil pressure sensor (4).
8. After removal, seal all openings with suitable plugs.

9. Hold threaded adaptor (5) firmly with open-end wrench and disconnect oil lines (1) and (2). See Figure 755.



1. Oil Line (Fan)
2. Oil Line (Fan)
3. Crankcase Pressure Sensor
4. Lube Oil Temperature Sensor
5. Threaded Adaptor

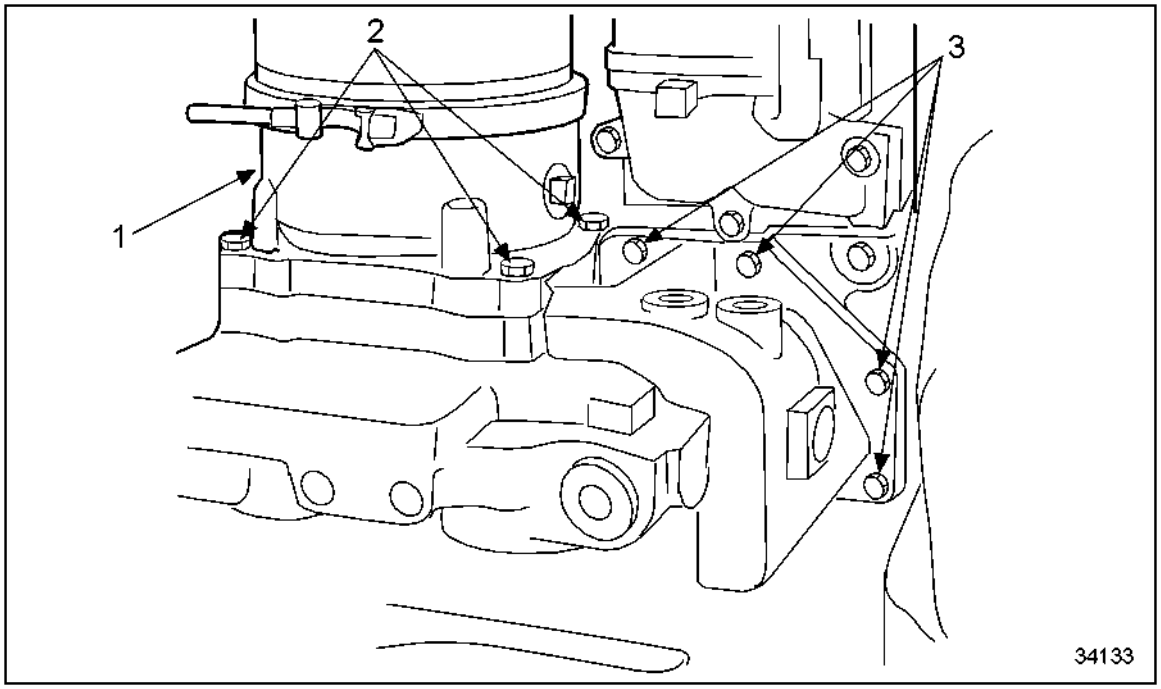
Figure 755 Removing Oil Temperature Sensor and Crankcase Pressure Sensor

10. Remove cable straps and separate plug-in connection to lube oil temperature sensor and crankcase pressure sensor (3).

NOTE:
Make photographic record of cable clamp fixture point for reference to avoid incorrect reinstallation, which could cause engine malfunction.

11. Remove lube oil temperature sensor (4) and cylinder block pressure sensor (3).
12. After removal, seal all openings with suitable plugs.

13. Remove hex bolts for centrifugal oil filter (2) and remove centrifugal oil filter assembly (1) from oil filter housing. See Figure 756.

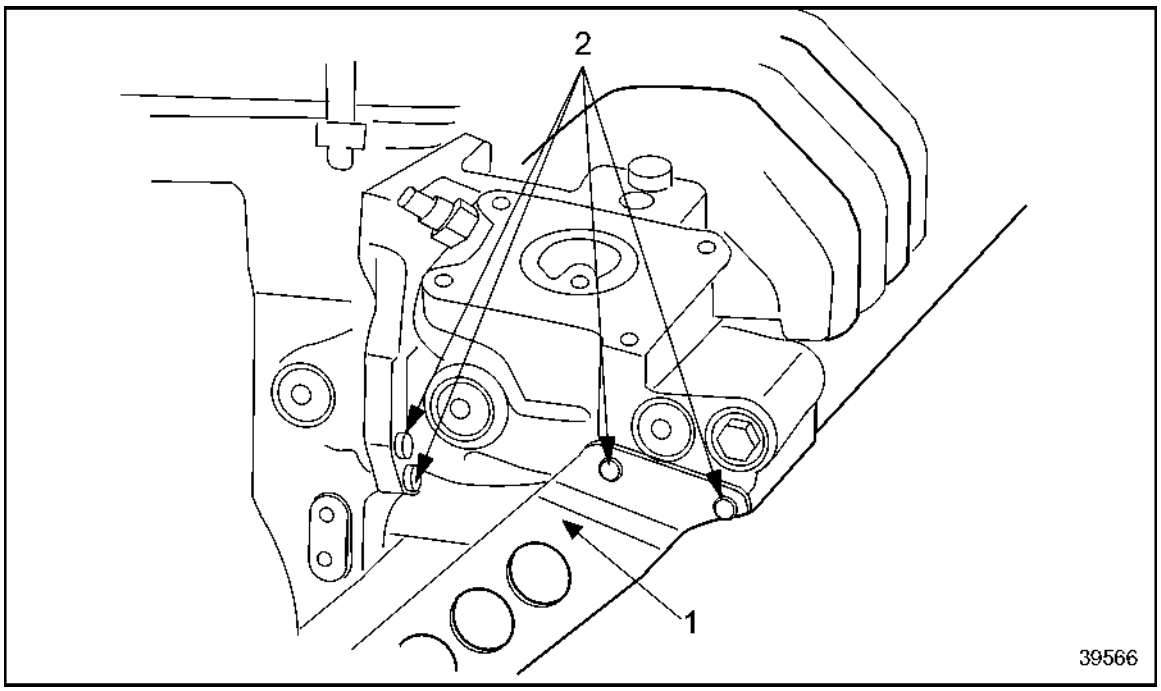


1. Centrifugal Oil Filter Assembly
2. Hex Bolts for Centrifugal Oil Filter
3. Hex Bolts for Oil Filter Housing

Figure 756 Removing Centrifugal Oil Filter Assembly from Oil Filter Housing

14. Remove hex bolts for oil filter housing.

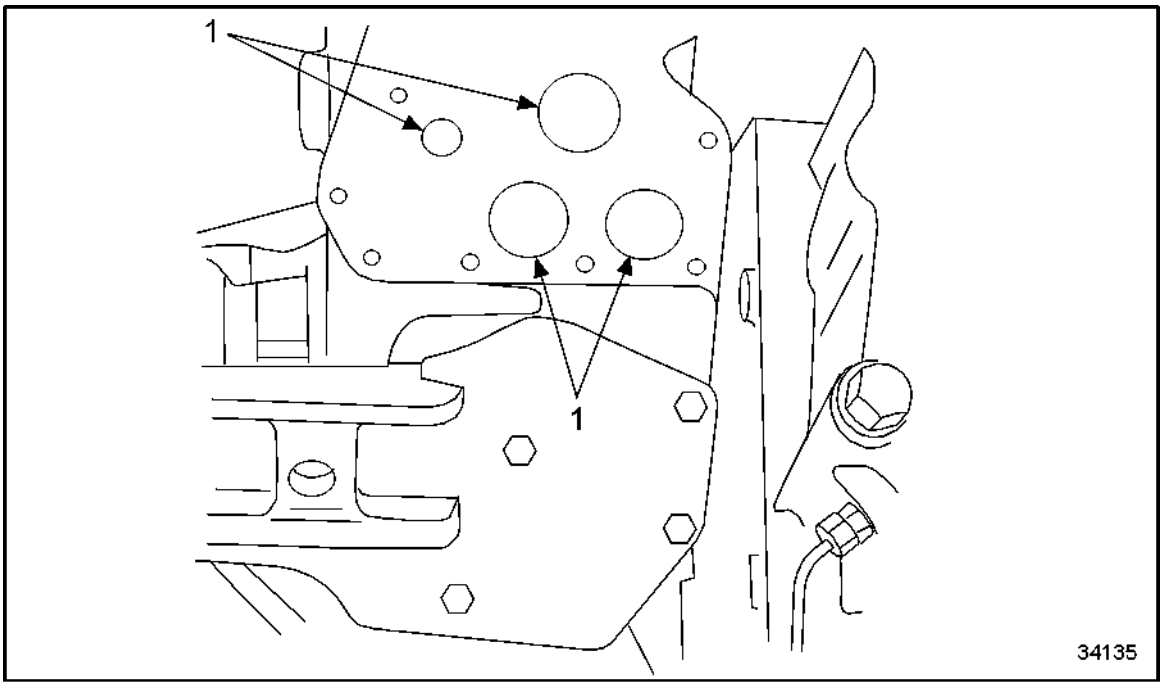
15. Remove hex bolts and washers (2) from oil filter housing and bracket (1). See Figure 757.



1. Bracket
2. Hex Bolts and Washers

Figure 757 Removing Oil Filter Housing Assembly

16. If necessary, seal openings in coolant distribution housing (1) with suitable blanking plugs. See Figure 758.

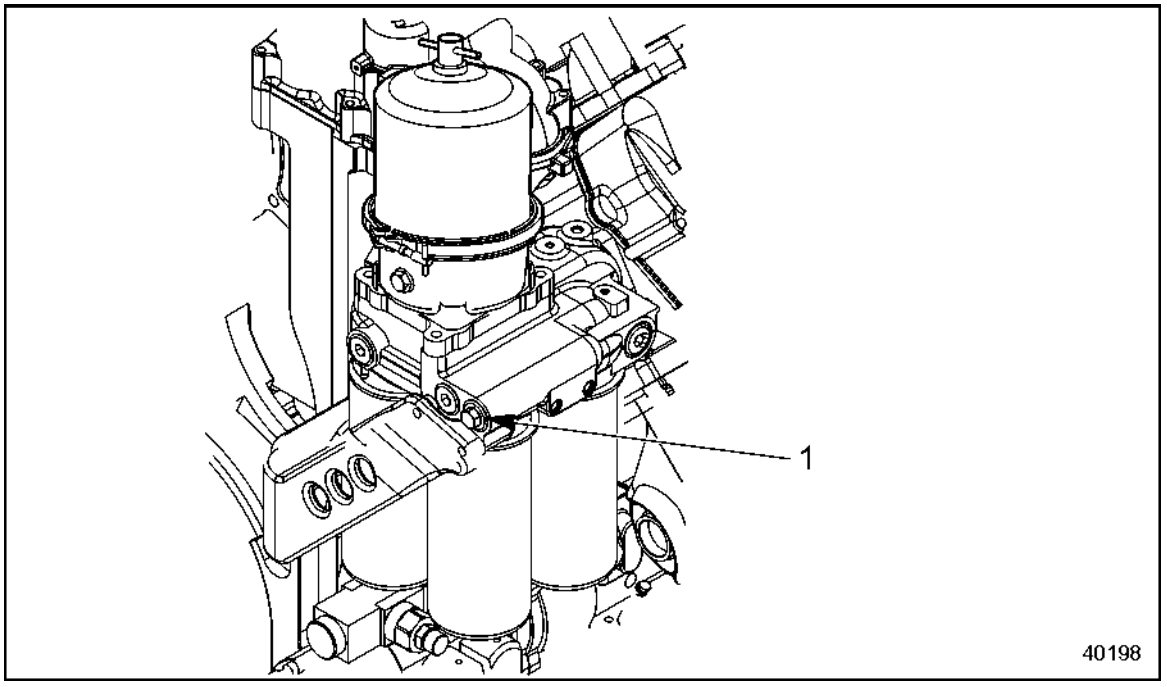


1. Openings in Coolant Distribution Housing

Figure 758 Sealing Openings in Coolant Distribution Housing with Blanking Plugs

Removal of Oil Filter By-Pass Valve and Spring

Perform the following steps for removal of the oil filter and by-pass valve and spring from the oil filter housing assembly. See Figure 759.

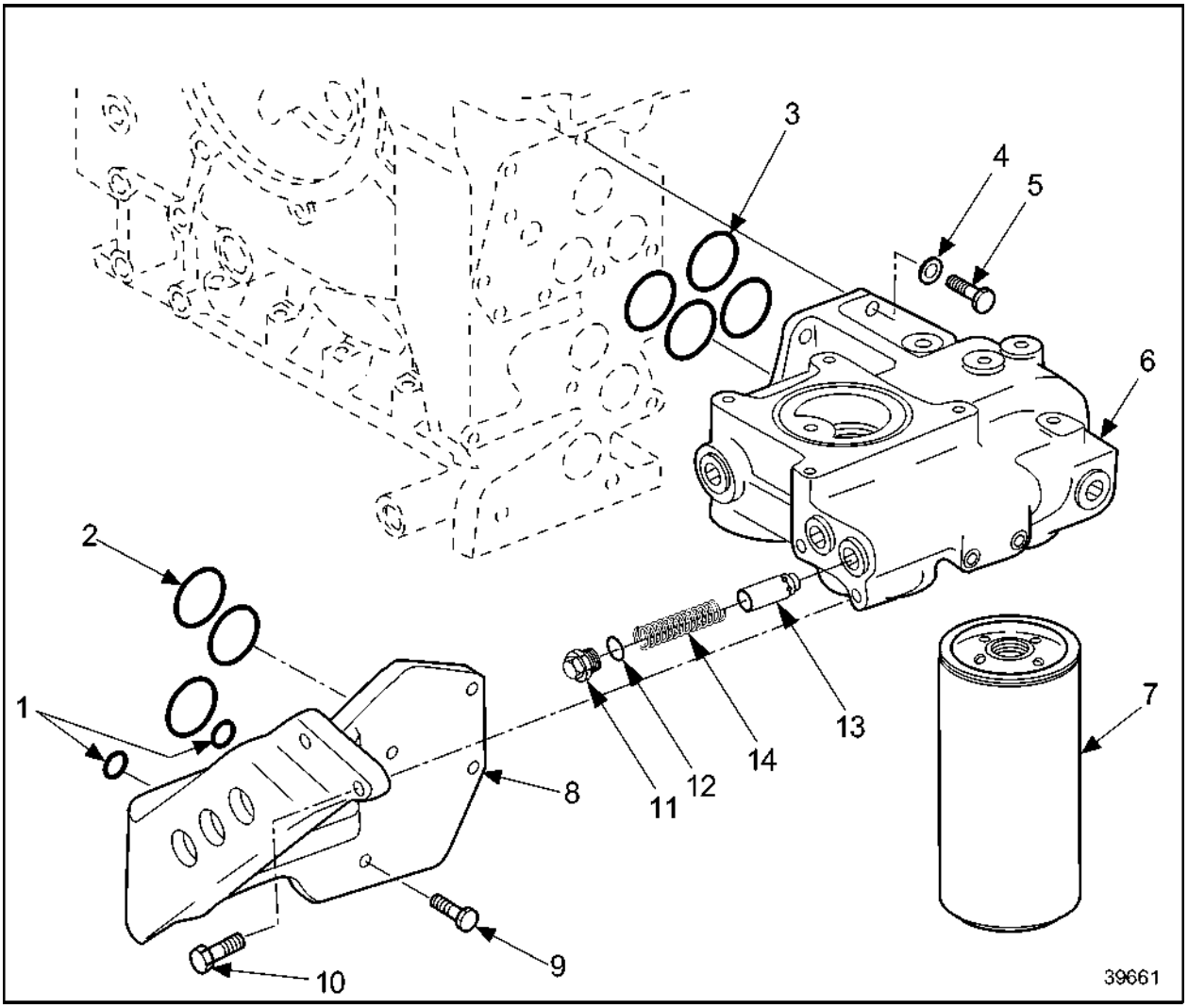


1. Plug

Figure 759 By-Pass Location

1. Remove threaded plug with O-ring from filter housing.

2. Remove by-pass valve spring. See Figure 760.



1. O-ring
2. O-ring
3. O-ring
4. Washer
5. Hex Bolt
6. Oil FIlter Housing Assembly
7. Oil Filter Cartridge
8. Oil Filter Housing Mounting Bracket
9. Hex Bolt
10. Hex Bolt
11. Plug, By-Pass Valve
12. O-ring
13. By-Pass Valve
14. By-Pass Valve Spring

Figure 760 General View of Oil Filter

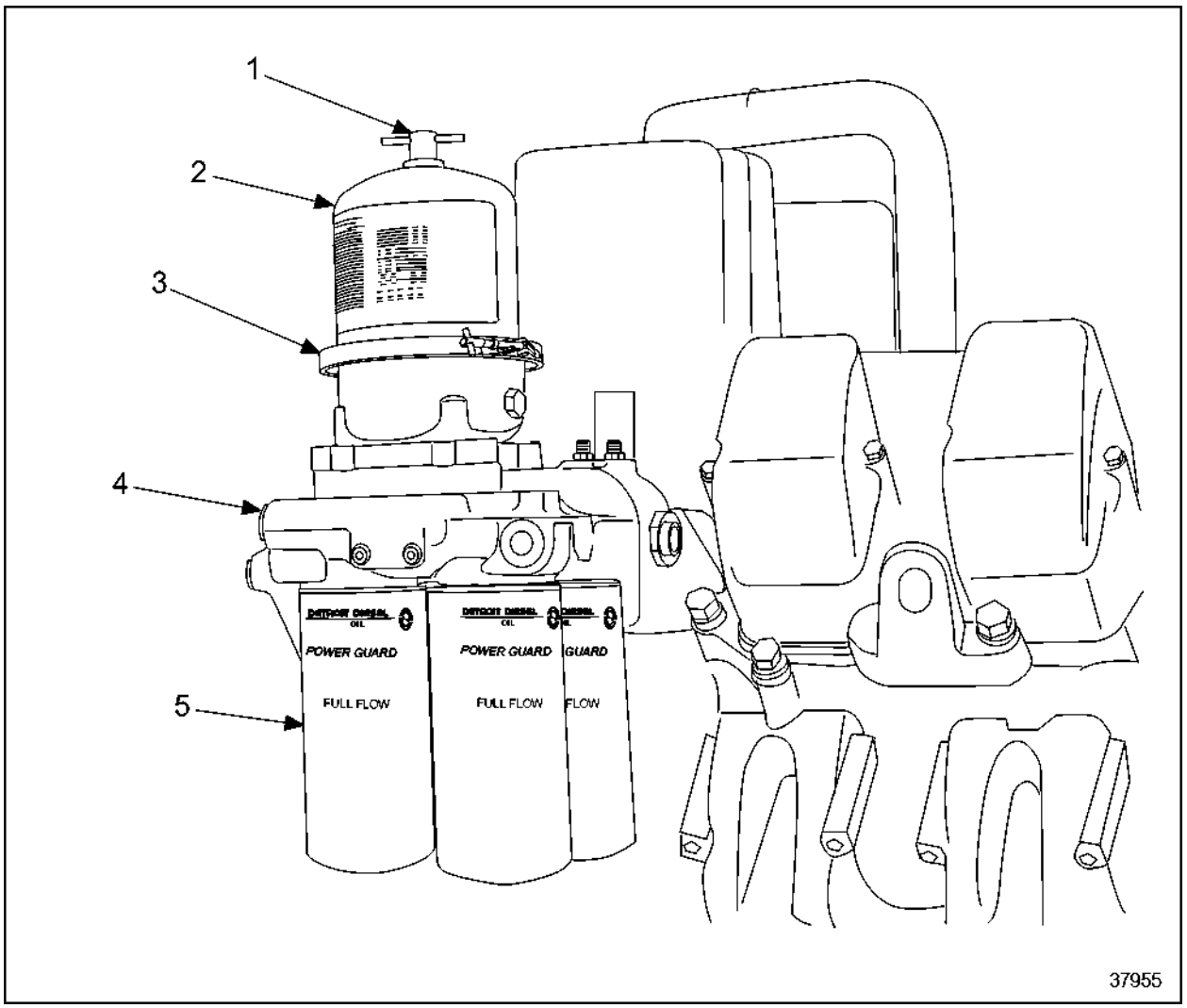
3. Remove by-pass valve from oil filter housing.

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.



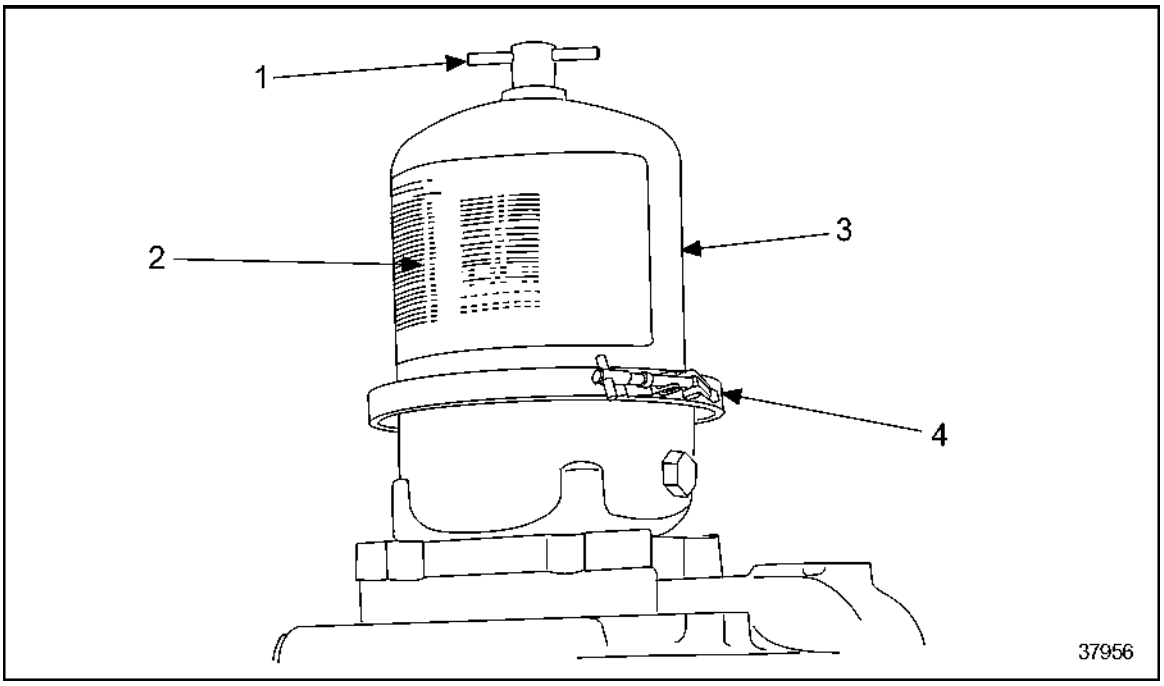
1. Cover Nut
2. Centrifugal Oil Filter
3. T-bolt Clamp
4. Oil Filter Housing Assembly
5. Oil Filter Cartridge

Figure 761 Centrifugal Oil Filter Location

CAUTION:

Engine oil is hot and can contain combustion residues which are harmful to health. To avoid personal injury, wear protective gloves. Avoid extended and intensive contact with skin. Do not inhale oil vapor.

NOTE:
For reference, service instructions are found on the outside of the centrifugal oil filter cover. See Figure 762.



1. Cover Nut
2. Service Instructions
3. Cover Assembly
4. Band Clamp T-Bolt

Figure 762 Removing Band Clamp and Cover Nut

2. Unscrew the cover nut, remove the band clamp.
3. Remove the centrifugal oil filter cover assembly. See Figure 762.
4. Drain oil from the rotor assembly. Raising the rotor on the spindle may assist draining.

5. Withdraw the rotor assembly vertically (upwards) from the spindle.

NOTICE
The rotor should be removed and replaced on the spindle with care in order to ensure that the rotor bearings are not damaged. Use of special tools 23540261 and 23540262 are mandatory to prevent damage during disassembly of the rotor assembly.

6. Secure the rotor assembly and disassembly tool P/N 23540262 (6906A). Unscrew the rotor assembly cover nut and seperate the rotor cover from the body. See Figure 763.

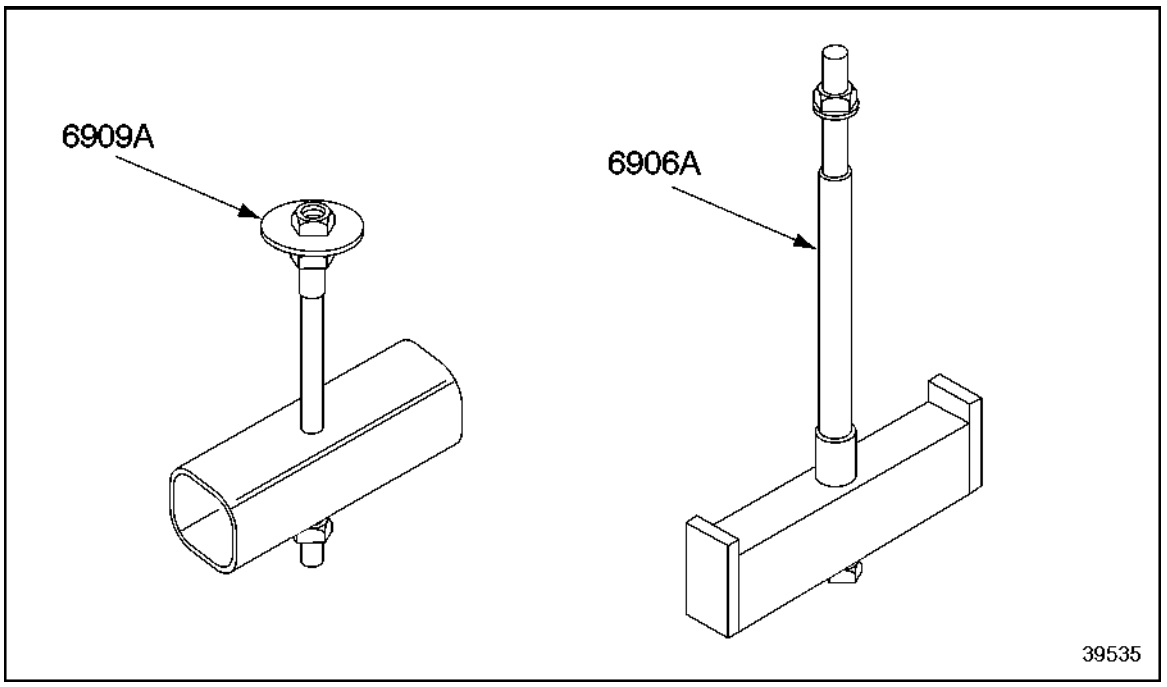
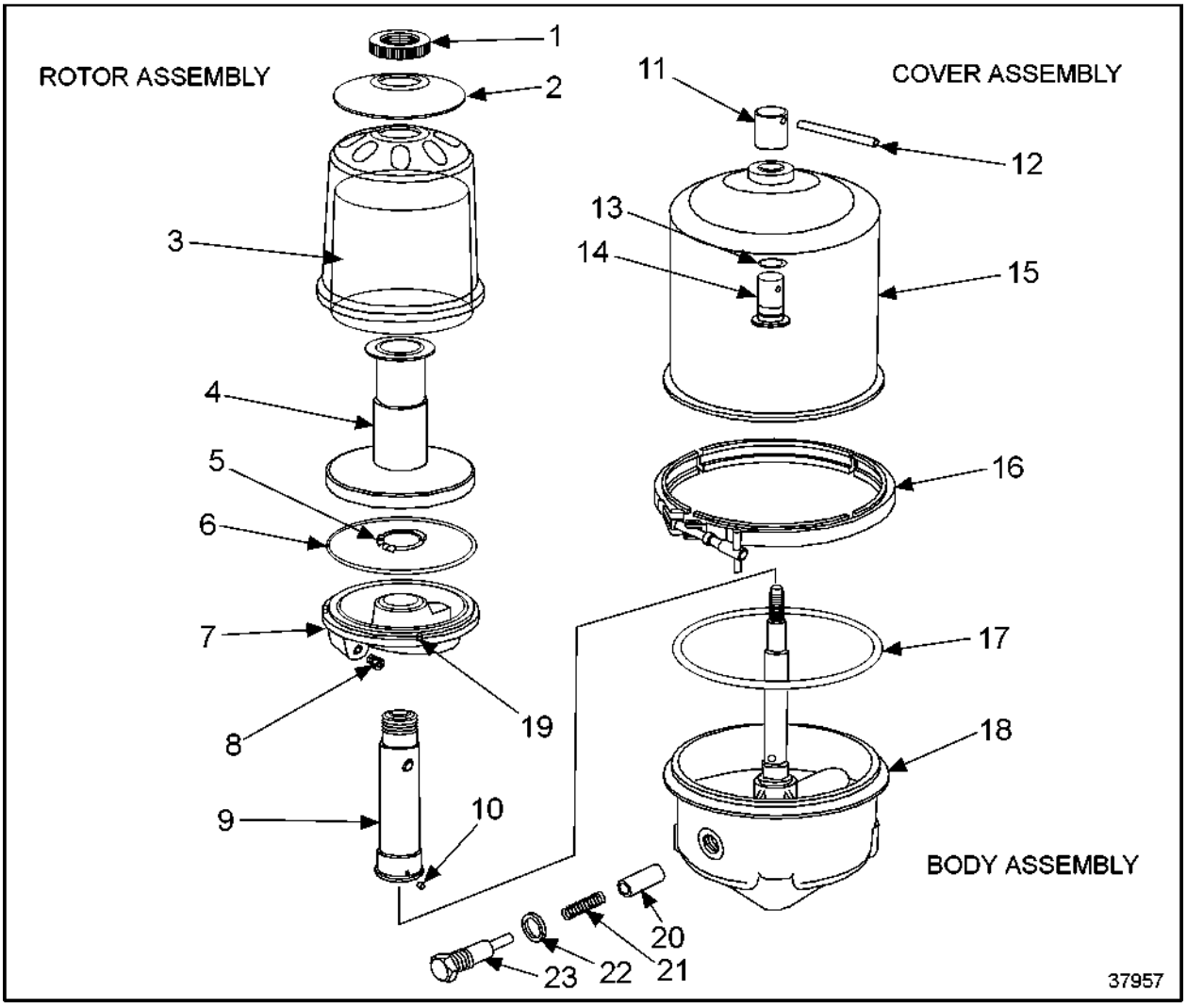


Figure 763 Disassembly and Extraction Tools

7. Remove the stand tube using the stand tube extraction tool P/N 23540261 (6909A). See Figure 764.



1. Rotor Cover Plate
2. Stiffener Plate
3. Paper Insert
4. Stand Tube
5. Snap Ring
6. O-ring
7. Rotor Cover
8. Nozzle
9. Bearing Tube Assembly
10. Pin
11. Cover Nut Tube
12. Pin
13. O-ring
14. Cover Nut
15. Cover Subassembly
16. Band Clamp
17. O-ring
18. Body Assembly
19. Locating Pin
20. Shuttle
21. Spring
22. Washer
23. Plug

Figure 764 Exploded View of Centrifugal Oil Filter

C 183.05.08 – INSPECTION AND REPAIR

Inspection and Repair of Oil Filter Housing Assembly

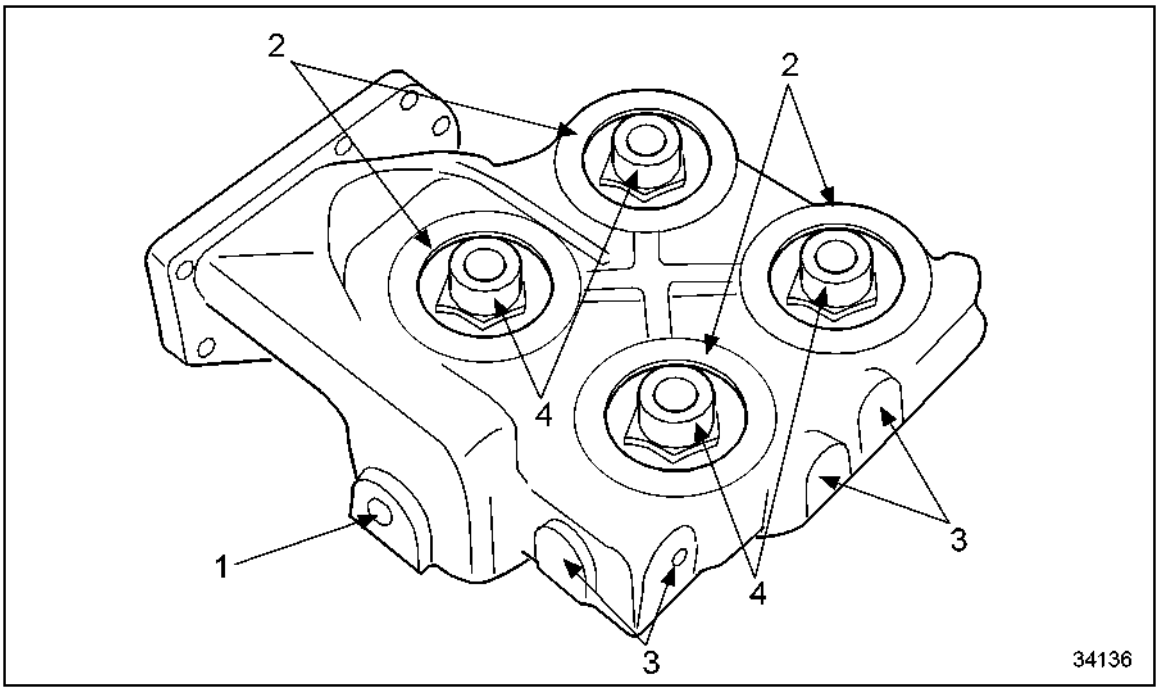
Perform the following steps for inspection and repair of the oil filter housing assembly:

1. Visually inspect all sealing, mating and sliding surfaces for wear, scoring and indentations. See Figure 765. Inspect in particular:
   - □ Threaded studs (4).
   - □ Threaded bores (3).
   - □ Sealing surfaces (2).
   - □ Sealing surface for bracket.
   - □ Threaded adaptor (1).

   [a] If sealing, mating and sliding surfaces are worn, scored or indented, rub down with an emery cloth or an oilstone.

   [b] If damage is beyond repair, replace components as necessary.

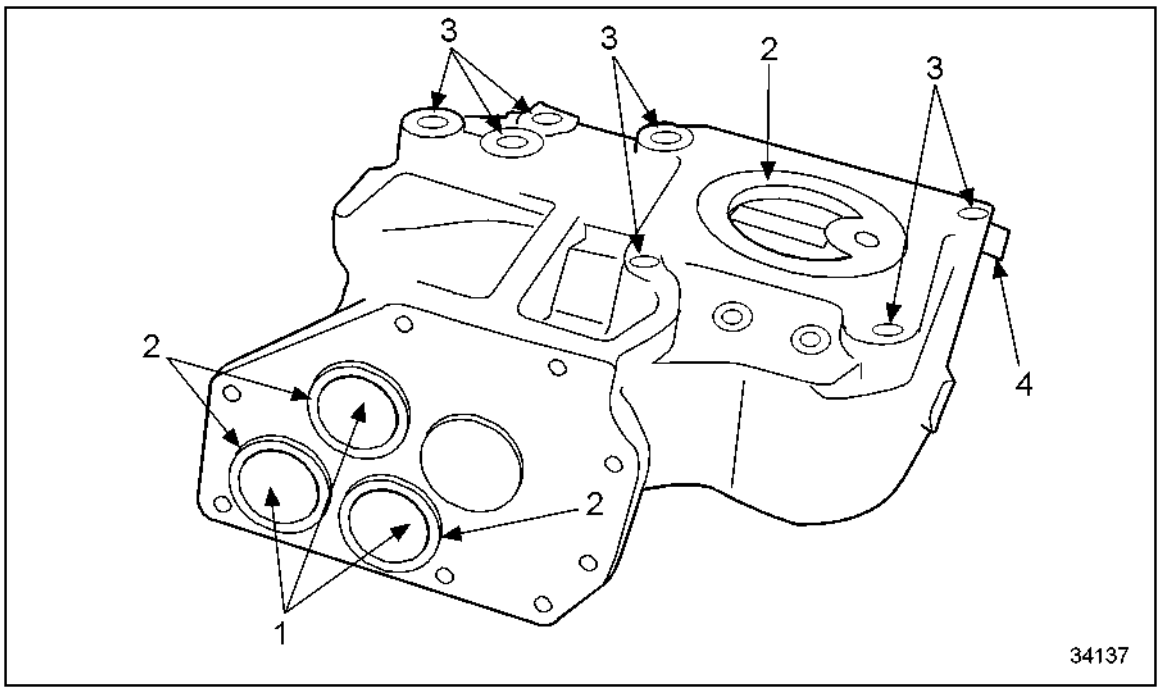
   [c] If sealing, mating and sliding surfaces are not worn, scored or indented, continue inspection.



1. Threaded Adaptor
2. Sealing Surfaces
3. Threaded Bores
4. Threaded Studs

Figure 765 Inspecting Oil Filter Housing Assembly

2. Visually inspect components of oil filter housing for damage, inspecting all sealing, mating and sliding surfaces for wear, scoring and indentations.
   [a] If sealing, mating and sliding surfaces show wear, scoring or indentations, machine as necessary.
   [b] If sealing, mating and sliding surfaces are beyond repair, replace component as necessary.
   [c] If sealing, mating and sliding surfaces do not show wear, scoring or indentations, continue inspection. See Figure 766.



1. Sealing Surface for Bracket
2. Seating Surfaces of O-rings
3. Threaded Bores
4. Plug, By-Pass Valve

Figure 766 Inspecting Oil Filter Housing Assembly

3. Inspect in particular:
   - ☐ Threaded bores (3).
   - ☐ Sealing surface.
   - ☐ Seating surface of O-rings (2).
   - ☐ Sealing surfaces for bracket (1).
4. Inspect components for minor wear, scoring and indentations.
   [a] If wear, scoring or indentations are found, replace components as necessary.
   [b] If no wear, scoring or indentations are found, continue inspection.

5. Inspect threads of components for ease of movement.
   [a] If threads do not show ease of movement, rechase as necessary or replace component with thread insert.
   [b] If threads do not show difficulty in movement, continue inspection.
6. Inspect blanking plugs for leaks.
   [a] If blanking plugs show leaks, replace as necessary.
   [b] If blanking plugs do not show leaks, continue inspection.
7. Replace hose line as part of every W6 overhaul.
8. Replace gaskets, sealing rings and O-rings.
9. Ensure that oil chambers and oil passages are perfectly clean.

Inspection and Repair of Centrifugal Oil Filter Assembly

Perform the following steps to inspect and repair the centrifugal oil filter:

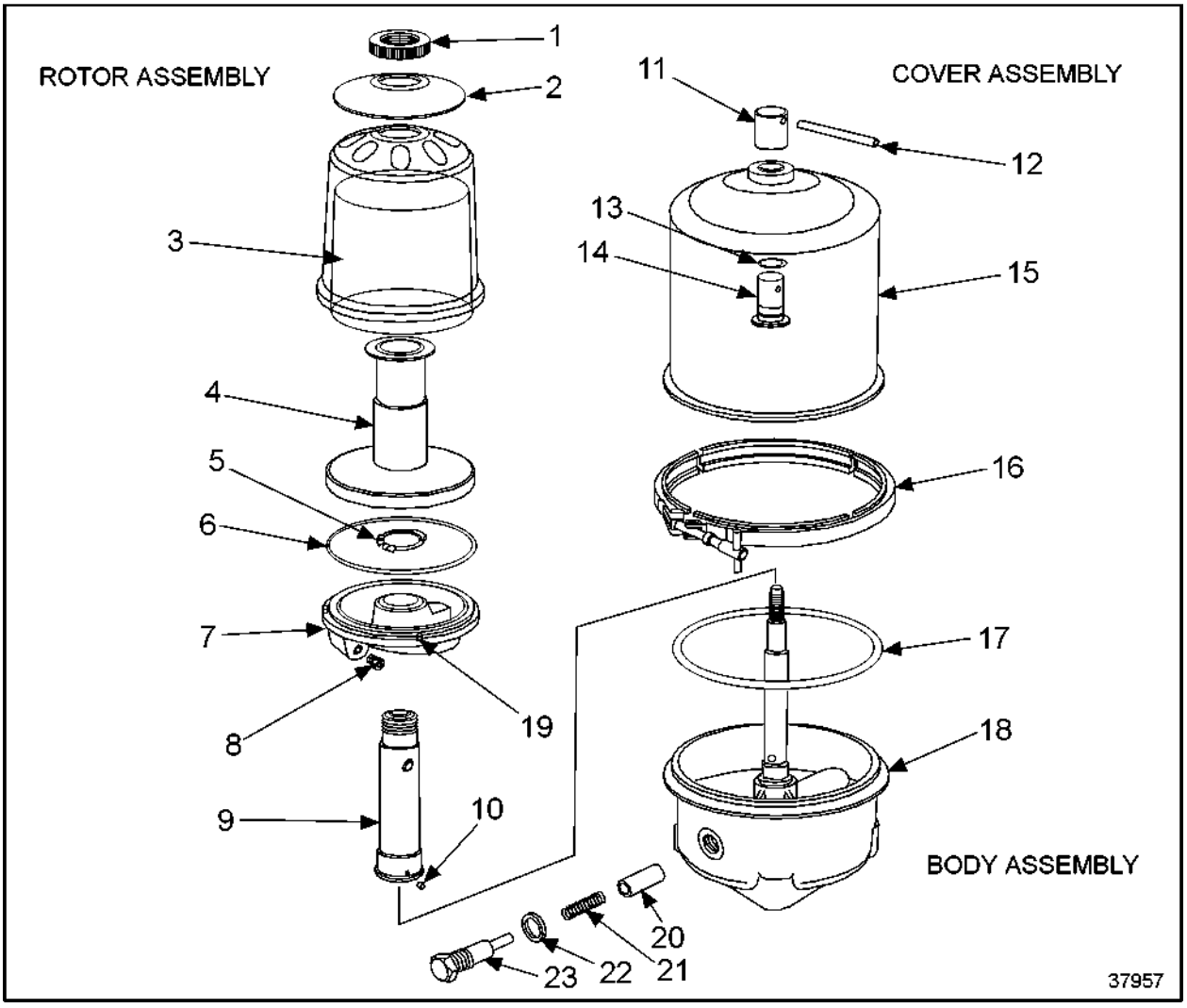
1. Remove sludge deposits from the inside of the rotor cover using a spatula. Sludge deposits should not exceed 35 mm (1.4 in.). See Figure 764.

CAUTION:

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

2. Ensure that all rotor components (including the two nozzles located in the rotor body) are thoroughly cleaned with a suitable cleaning fluid and free from debris before reassembly. If the nozzle is not open, clean with a soft wire. See Figure 767.

NOTE:
Care should be taken when cleaning each component. An unbalanced condition could occur if all debris is not removed.



1. Rotor Cover Plate
2. Stiffener Plate
3. Paper Insert
4. Stand Tube
5. Snap Ring
6. O-ring
7. Rotor Cover
8. Nozzle
9. Bearing Tube Assembly
10. Pin
11. Cover Nut Tube
12. Pin
13. O-ring
14. Cover Nut
15. Cover Subassembly
16. Band Clamp
17. O-ring
18. Body Assembly
19. Locating Pin
20. Shuttle
21. Spring
22. Washer
23. Plug

Figure 767 Exploded View of Centrifugal Oil Filter

3. Visually inspect the rotor assembly for damage.
   [a] If rotor assembly is damaged, replace component.
   [b] If rotor assembly is not damaged, continue inspection.
4. Visually inspect the centrifugal spindle and rotor assembly bearings for wear.
   [a] If centrifugal spindle and rotor assembly bearings are worn, replace component as necessary.
   [b] If centrifugal spindle and rotor assembly bearings are not worn, continue inspection.
5. Disassemble and visually inspect the cut-off valve assembly.
   [a] If the shuttle valve is damaged, replace centrifugal filter body assembly.
   [b] If the shuttle valve is not damaged, continue inspection.
6. Visually inspect the centrifugal filter body O-ring for damage.
   [a] If centrifugal filter body O-ring is damaged, replace component.
   [b] If centrifugal filter body O-ring is not damaged, continue inspection.
7. Visually inspect and clean the O-ring groove on the rotor base.

Inspection and Repair of Oil Filter By-Pass Valve and Spring

Perform the following steps for inspection and repair of oil filter by-pass valve and spring.

1. Inspect opening pressure of the valve. The opening pressure should be 1.79 ±.28 bars (25.96 ±4.06 lb/in.^{2}).
   [a] If opening pressure does not correspond to specified value, disassemble valve and readjust by fitting appropriate adjusting shims until correct value is achieved.
   [b] If opening pressure corresponds to specified value, continue inspection.
2. Clean components thoroughly.
3. Remove by-pass valve plug (4), spring and valve. Inspect threads of components for ease of movement and signs of wear.
   [a] If valve shows excessive signs of wear or does not show ease of movement, replace components.
   [b] If no signs of excessive wear or restrictive movement, continue inspection.
4. Ensure that oil chambers and oil passages are perfectly clean.
5. Inspect blanking plugs for leaks.
   [a] If blanking plugs show leaks, replace as necessary.
   [b] If blanking plugs do not show leaks, continue inspection.
6. Replace O-rings.

C 183.05.10 – ASSEMBLY OF OIL FILTER, CENTRIFUGAL OIL FILTER AND OIL FILTER SERVICE MAINTENANCE ALERT SYSTEM

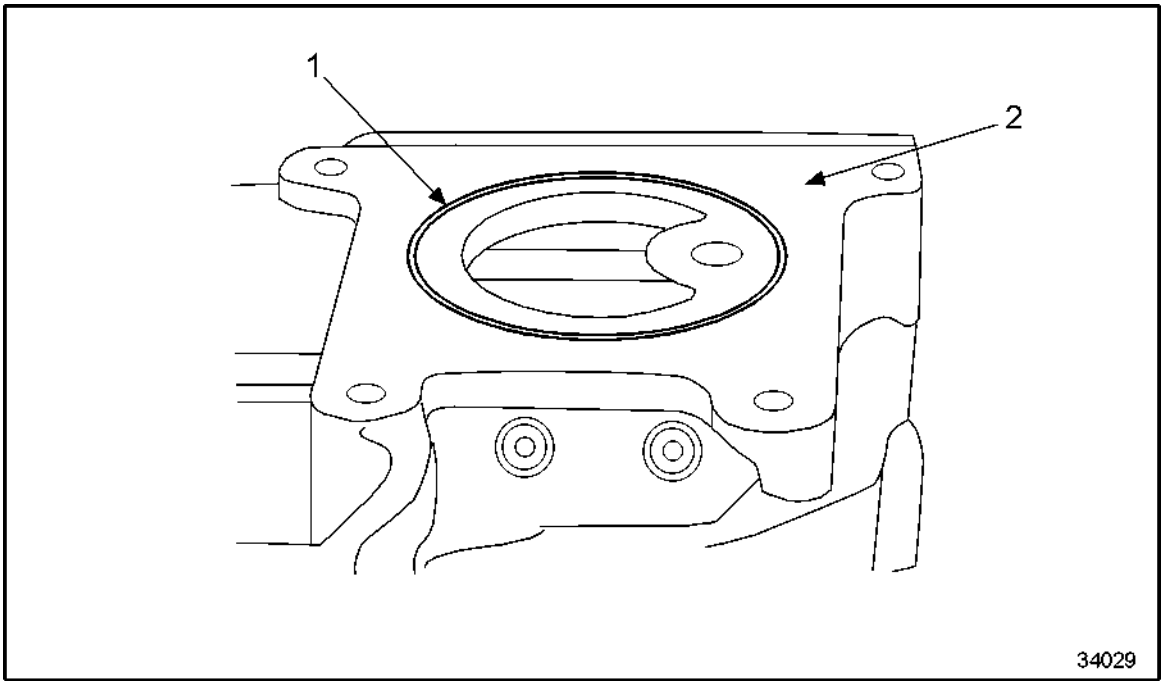
Assembly of Centrifugal Oil Filter

Perform the following steps for the assembly of the centrifugal oil filter:

NOTE:
Ensure that oil chambers and oil passages are perfectly clean.

NOTICE
Care should be taken to properly assemble the centrifugal oil filter to prevent external oil leaks. External oil leaks could result in an engine fire.

1. To install centrifugal filter assembly, coat O-rings with petroleum jelly and insert into groove of oil filter housing. See Figure 768.



1. Groove
2. Oil Filter Housing

Figure 768 Inserting O-rings into Groove of Oil Filter Housing

2. Install a new filter paper onto the rotor cover.

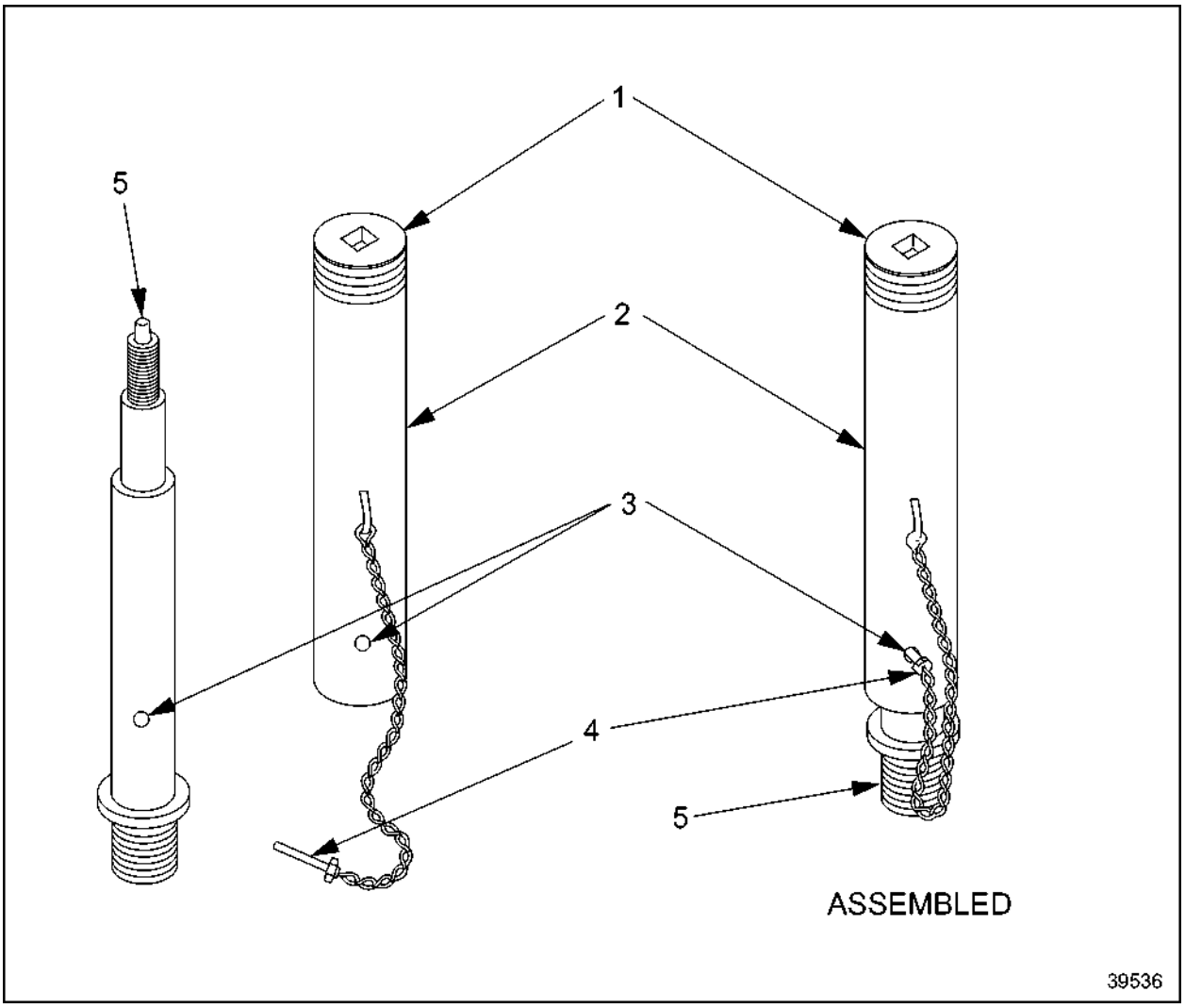
3. Reassemble the rotor assembly, ensuring the rotor cover slot and rotor body pins are aligned. If the pins are missing or damaged, it will be necessary to replace the complete rotor assembly.

NOTICE
Do not interchange rotor covers from other units, as pin alignments may vary, resulting in uneven operation and leakage.

NOTICE
Omittion of stifferner plate during assembling will result in improper component stackup resulting in an external oil leak.

4. Install stiffener plate. If the stiffener plate is missing, replace with new stiffener plate.
5. Install the rotor cover nut and torque to 6 to 7 N·m (4.43 to 5.16 lb·ft).

6. Using the fabricated tool, check the rotor shaft-to-body tightening torque at 40 N·m (29.5 lb·ft). If shaft is loose, replace body assembly. See Figure 769.



1. One Inch Socket Plug Welded to Pipe
2. Pipe 1 in. x 8.5" long
3. Hole 9/32" Drilled Through Pipe, 1/2" from Bottom on Center to Align wIth Hole in Rotor Shaft
4. Bolt 1/4" x 1-1/2" long with Length of Safety Chain for Lock Pin
5. Rotor Shaft

Figure 769 Fabricated Tool

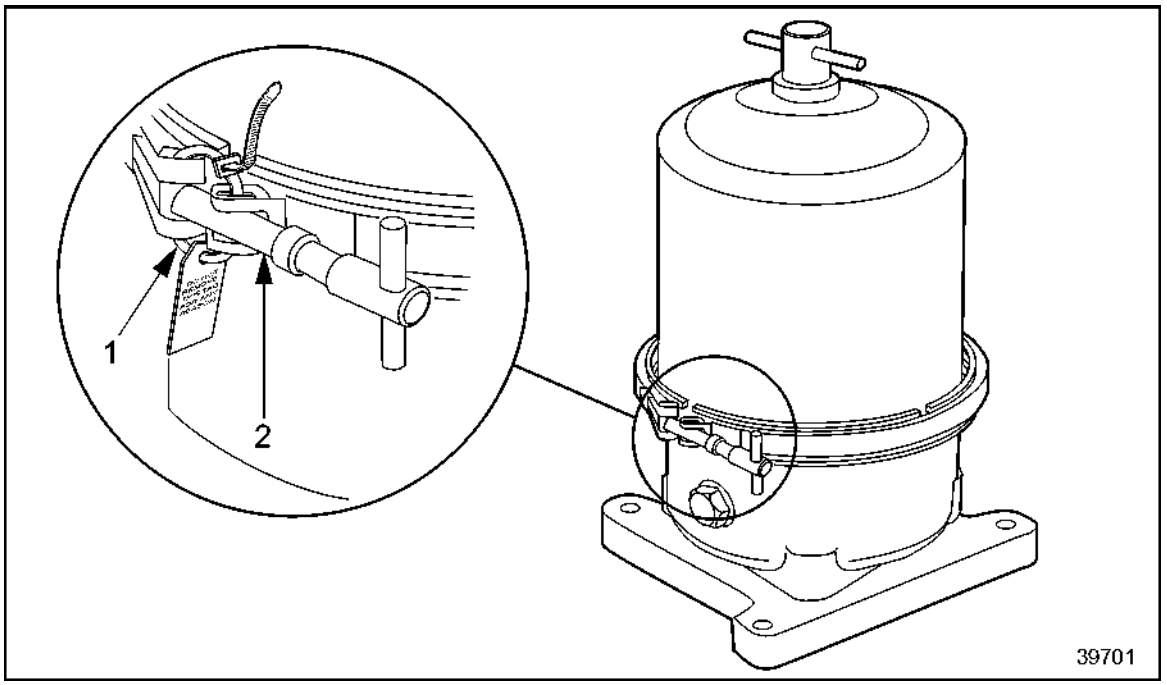
7. Replace the rotor on the spindle and check that the rotor spins freely.
8. Examine the centrifuge body O-ring for damage and replace if necessary.

NOTE:
At 2500 hours, replace the O-ring.

9. Inspect and clean the centrifugal body O-ring groove.
10. Inspect the cover nut. If signs of previous oil leak exist, replace the O-ring.
11. Replace the centrifuge cover and tighten the centrifuge cover nut to a torque of 6 to 7 N·m (4.43 to 5.16 lb·ft).

NOTICE
Insure that the band clamp T-bolt threads are clean to prevent improper clamp torque which could result in external oil leak.

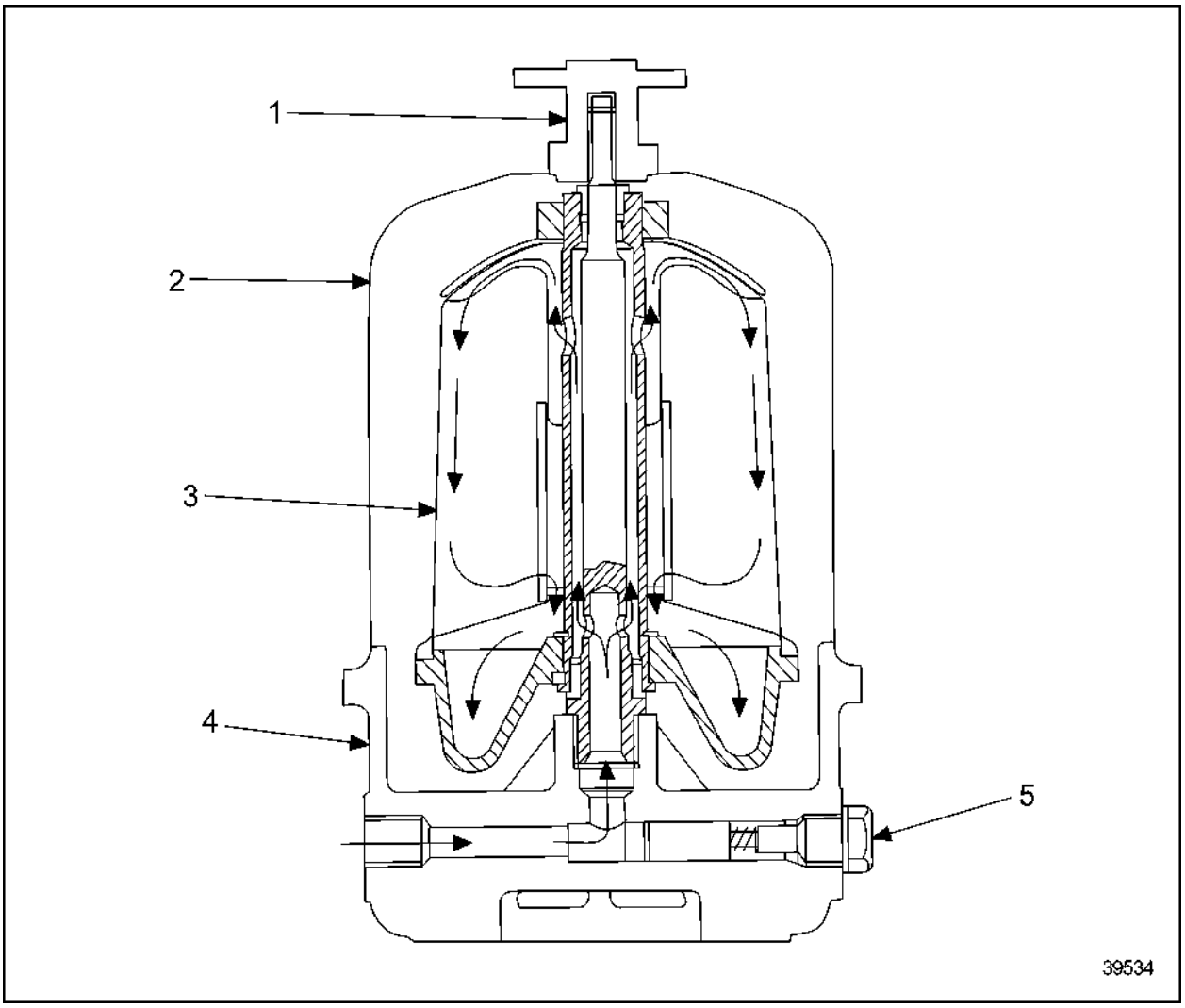
12. Replace the band clamp and torque to 5 to 6 N·m (3.69 to 4.43 lb·ft) maximum. The band clamp must fit securely during operation to prevent oil leaks.
13. Repeat step 11and step 12 to ensure cover nut and band clamp remain tight.
14. Using a tie strap, place a service tag with date and hour of service around both sides of the band clamp bolt and secure tightly. This tie strap will act as a safety tie to insure the band clamp remains secure and in place. See Figure 770.



1. Tie Strap
2. Oil Filter Clamp

Figure 770 Installation of Tie Strap

15. With the engine oil level checked, start the engine and check for leaks or unusual noise. For oil filter operation, see Figure 771.



1. Cover Nut
2. Cover Assembly
3. Rotor Assembly
4. Body Assembly
5. Cut Off Valve

Figure 771 Centrifugal Oil Filter Operation

C 183.05.11 – INSTALLATION OF OIL FILTER, CENTRIFUGAL OIL FILTER AND OIL FILTER SERVICE MAINTENANCE ALERT SYSTEM

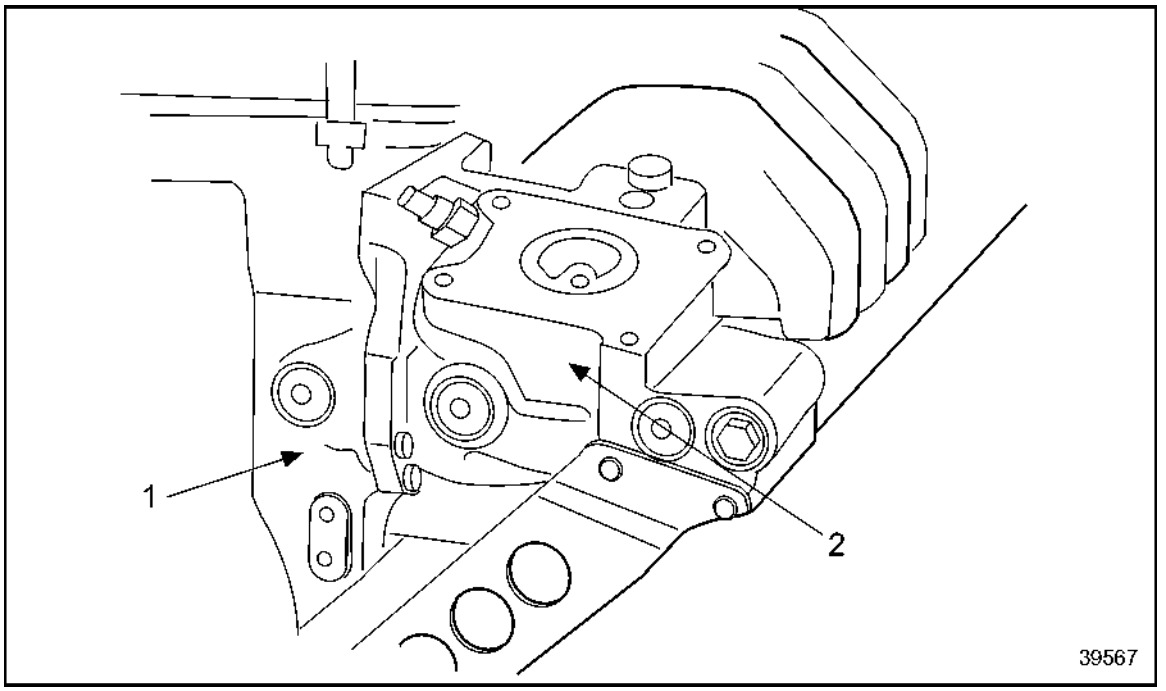
Installation of Oil Filter Housing

Perform the following steps for the installation of the oil filter housing:

NOTE:
Ensure that oil chambers and oil passages are perfectly clean.

NOTE:
Prior to installation, remove all blanking plugs and/or covers.

1. To install oil filter housing, coat O-rings with petroleum jelly before installing. See Figure 772.

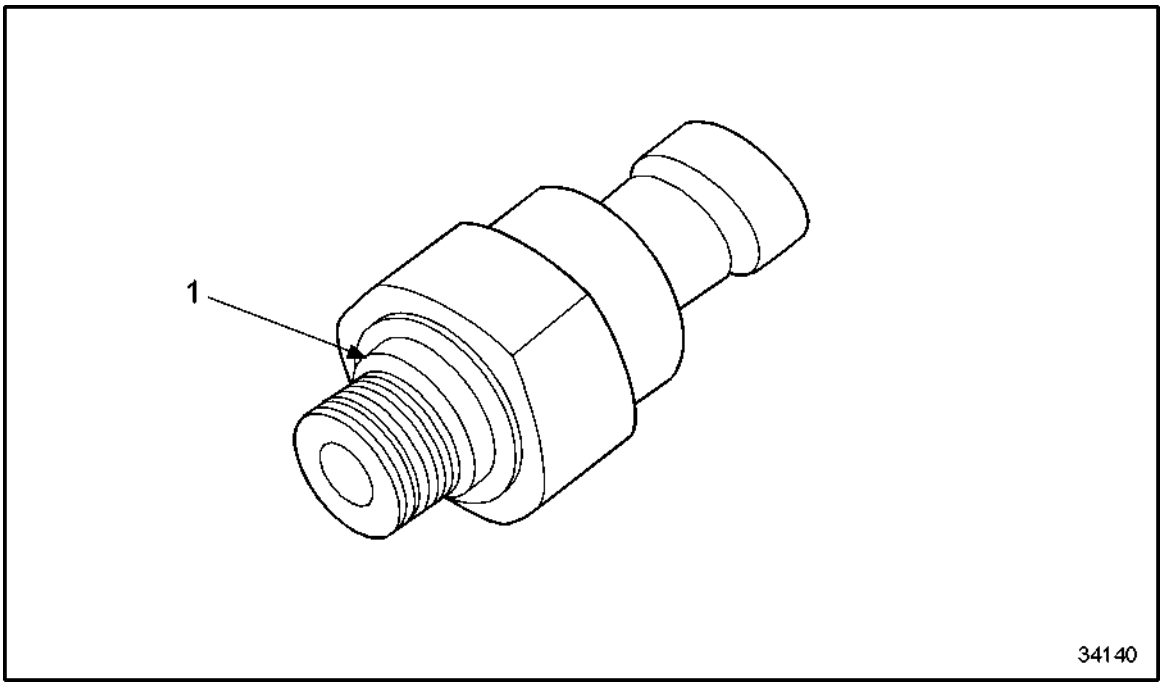


1. Coolant Distribution Housing
2. Oil Filter Housing

Figure 772 Installing Oil Filter Housing

2. Fit O-rings. See Figure 752.
3. Install oil filter housing with washers and hex bolts on coolant distribution housing.

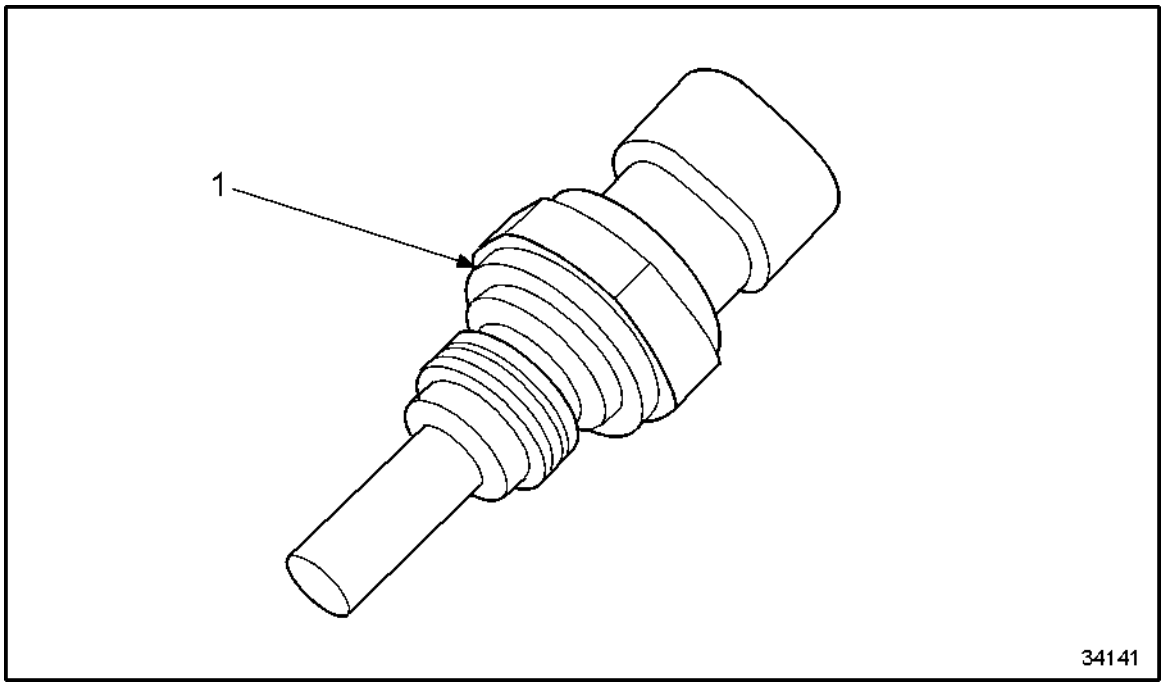
4. To install temperature and pressure sensors, coat O-ring with petroleum jelly and insert in groove on lube oil pressure sensor and cylinder block pressure sensor. See Figure 773.



1. O-ring

Figure 773 Inserting O-ring into Groove on Oil Pressure Sensor

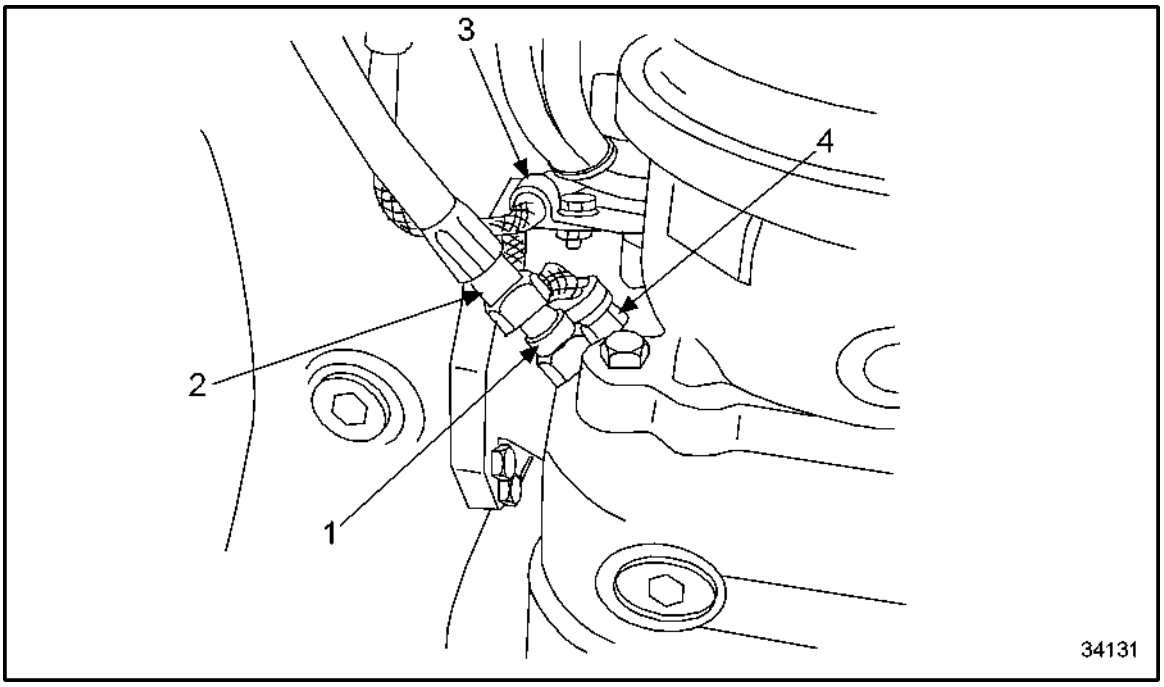
5. Coat O-ring with petroleum jelly and insert in groove on lube oil temperature sensor. See Figure 774.



1. Groove

Figure 774 Inserting O-ring into Groove on Oil Temperature Sensor

6. Install lube oil pressure sensor into oil filter housing and tighten to specification. Refer to section A 003 . See Figure 775.

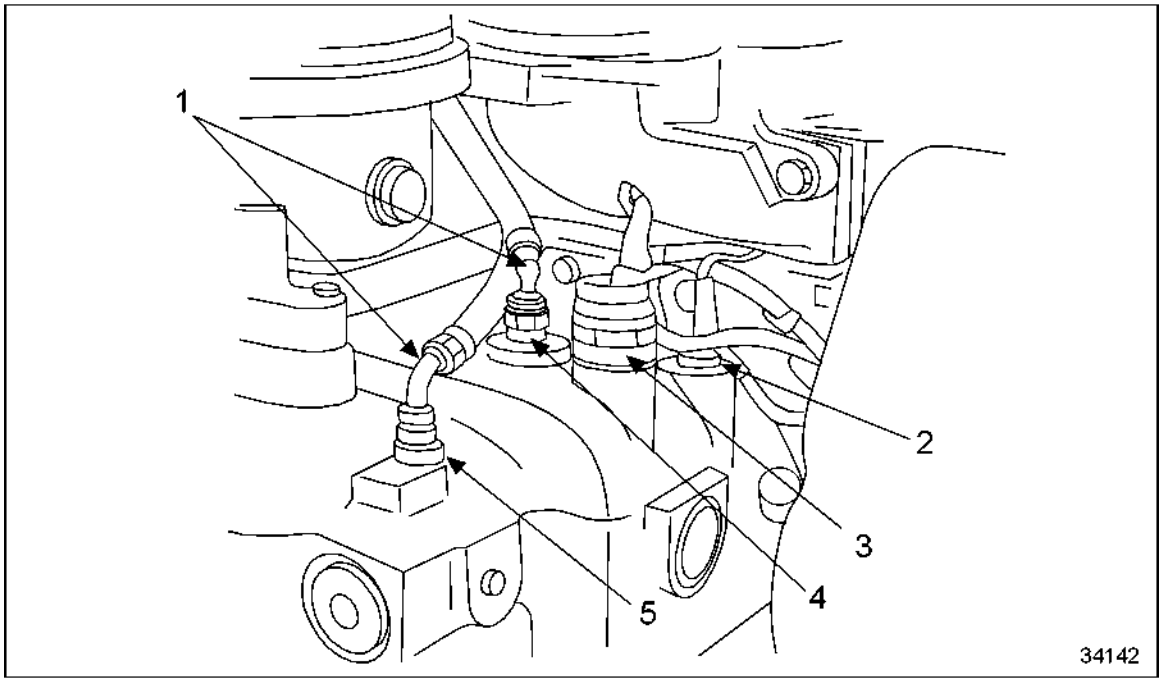


1. Threaded Adaptor
2. Oil Line Connection
3. Cable Clamps
4. Lube Oil Pressure Sensor

Figure 775 Installing Oil Line Threaded Adaptor into Oil Filter Housing

7. Install new O-ring on threaded adaptor (1) and coat with petroleum jelly.
8. Install threaded adaptor (1) into oil filter housing.
9. Hold threaded adaptor (1) firmly with open-end wrench and install oil line.
10. Attach cable connector and secure with cable clamps (3).

11. Install lube oil temperature sensor (2) into oil filter housing and tighten to specification. Refer to section A 003 . See Figure 776.



1. Oil Line (Fan)
2. Oil Temperature Sensor
3. Crankcase Pressure Sensor
4. Threaded Adaptor
5. Threaded Adaptor

Figure 776 Installing Sensors into Oil Filter Housing

12. Install cylinder block pressure sensor (3) into oil filter housing and tighten to specification. Refer to section A 003 .
13. Coat O-ring with petroleum jelly and insert in groove on threaded adaptors (4) and (5).
14. Install threaded adaptor into oil filter housing.
15. Hold threaded adaptors (4) and (5) firmly with open-end wrench and install oil lines (1).

NOTE:
Use only DDC branded oil filters cartridges.

16. To install oil filter cartridges, visually inspect sealing ring of new oil filter cartridge, clean as necessary and coat with oil. See Figure 777.

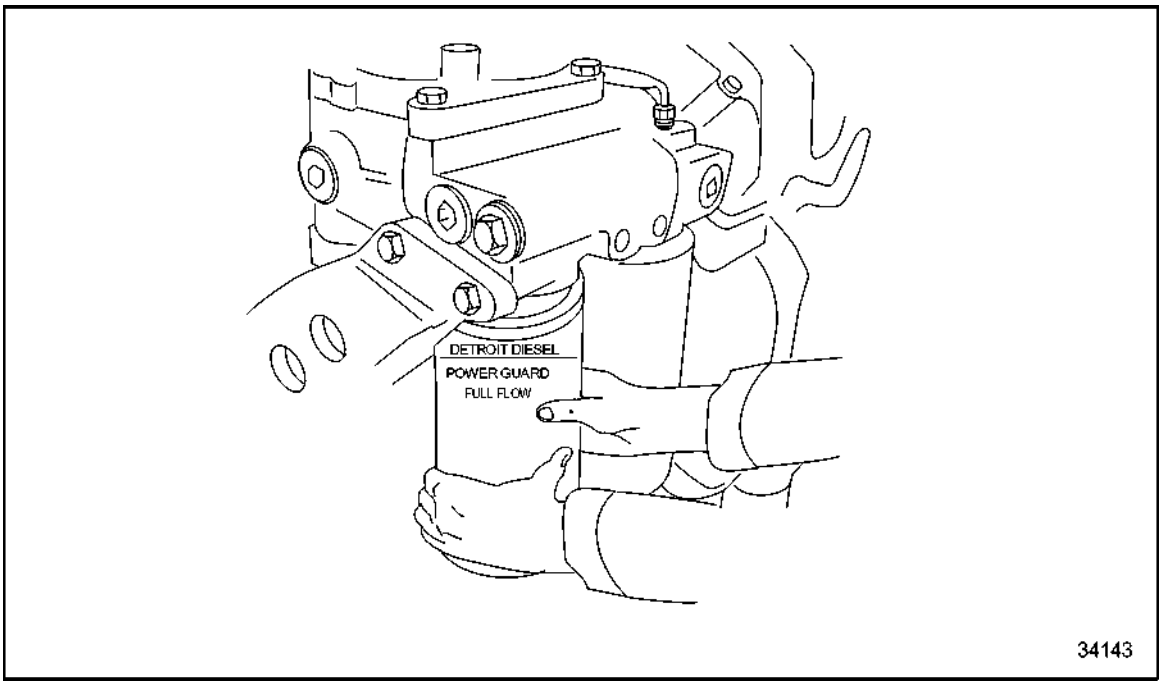


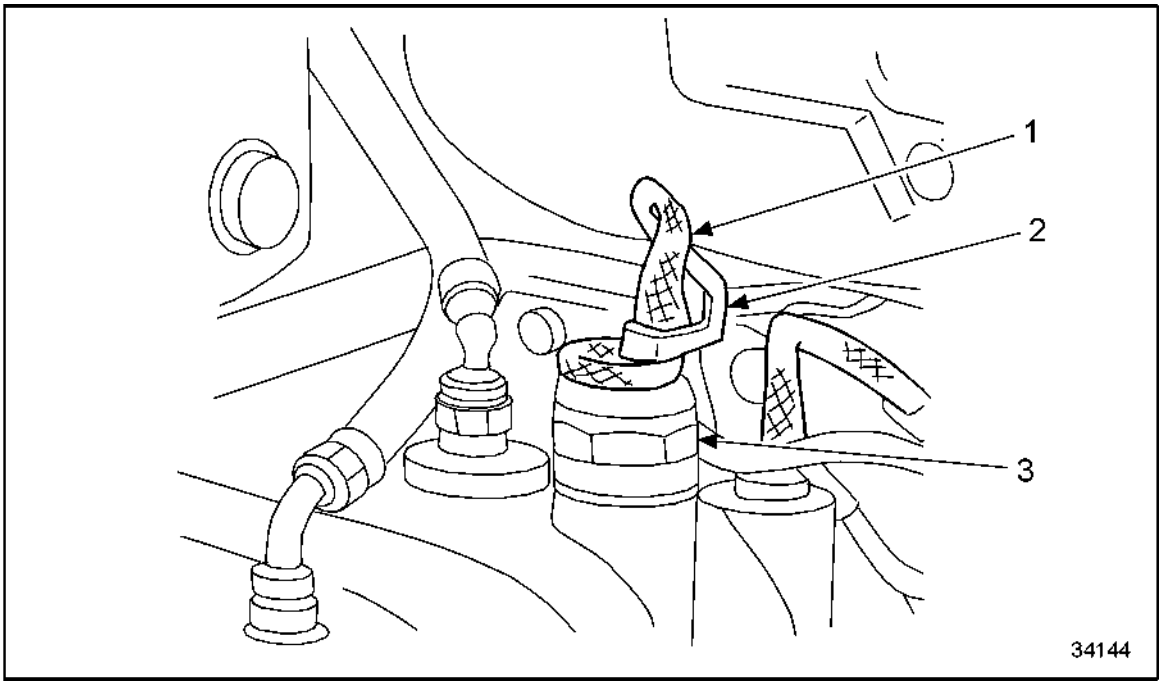
Figure 777 Installing New Oil Filter Cartridge

NOTE:
Coat O-rings with petroleum jelly before installing.

17. Install new oil filter cartridges and tighten manually.

NOTE:
Do not use any tool to attach oil filter cartridges.

18. After test run, inspect oil filters for leaks.
    [a] If a oil filter is leaking, retighten manually as necessary.
    [b] If the oil filters are not leaking, continue installation.
19. Install tie strap (2) so that connector grommet and harness are connected by a tight loop. See Figure 778.



1. Harness
2. Tie Strap
3. Crankcase Pressure

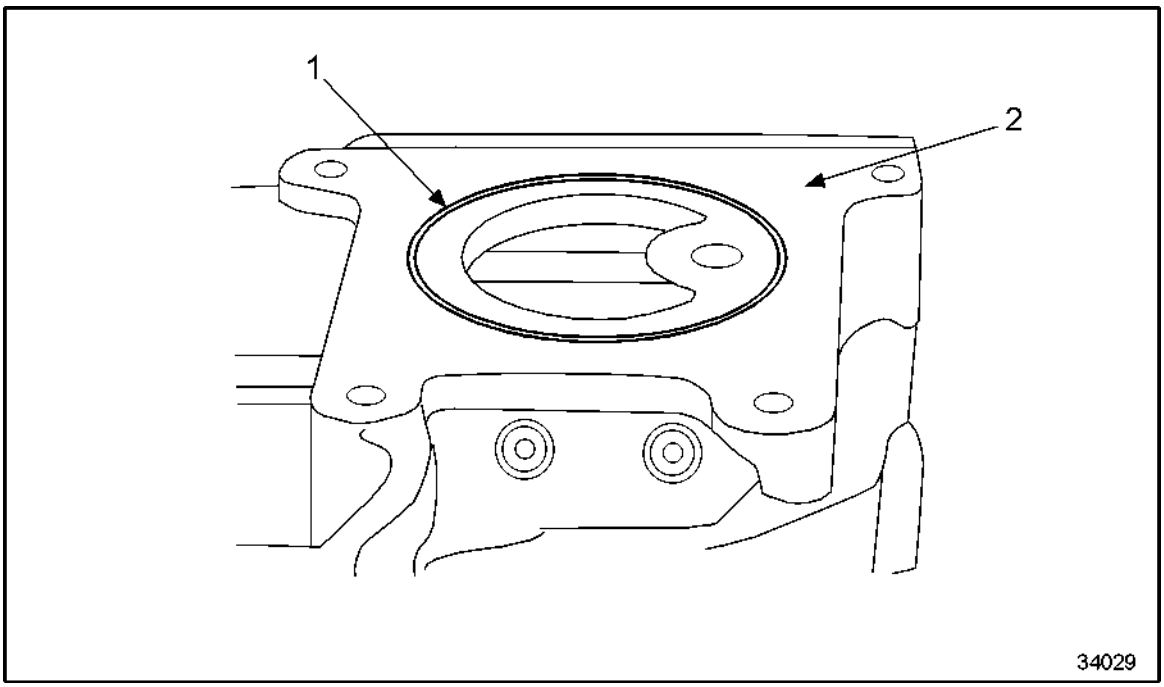
Figure 778 Installing Harness Tie Strap

NOTE:
The harness must not slip out through the connector during engine operation.

Installation of Centrifugal Oil Filter Assembly to Oil Filter Housing Assembly

Perform the following steps to install the centrifugal oil filter:

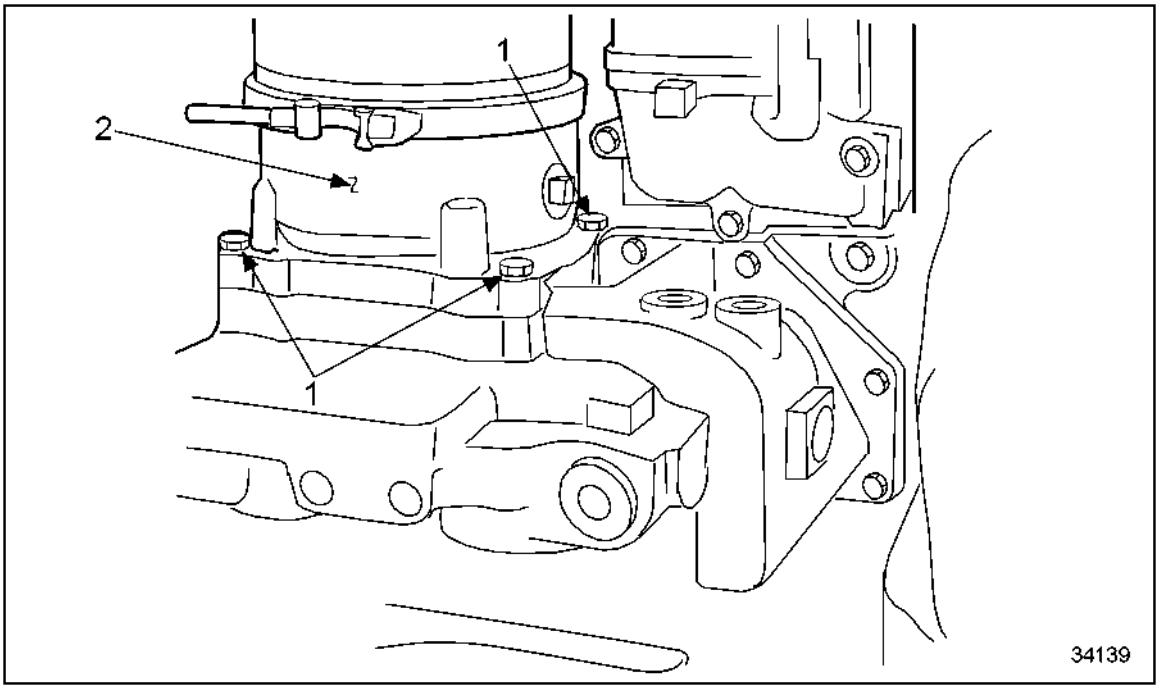
1. To install centrifugal filter assembly, coat O-rings with petroleum jelly and insert into groove of oil filter housing. See Figure 779.



1. Groove
2. Oil Filter Housing

Figure 779 Inserting O-rings into Groove of Oil Filter Housing

2. Install centrifugal oil filter assembly and secure with washers and hex bolts. See Figure 780. Refer to section A 003 .



1. Hex Bolts
2. Centrifugal Oil Filter Assembly

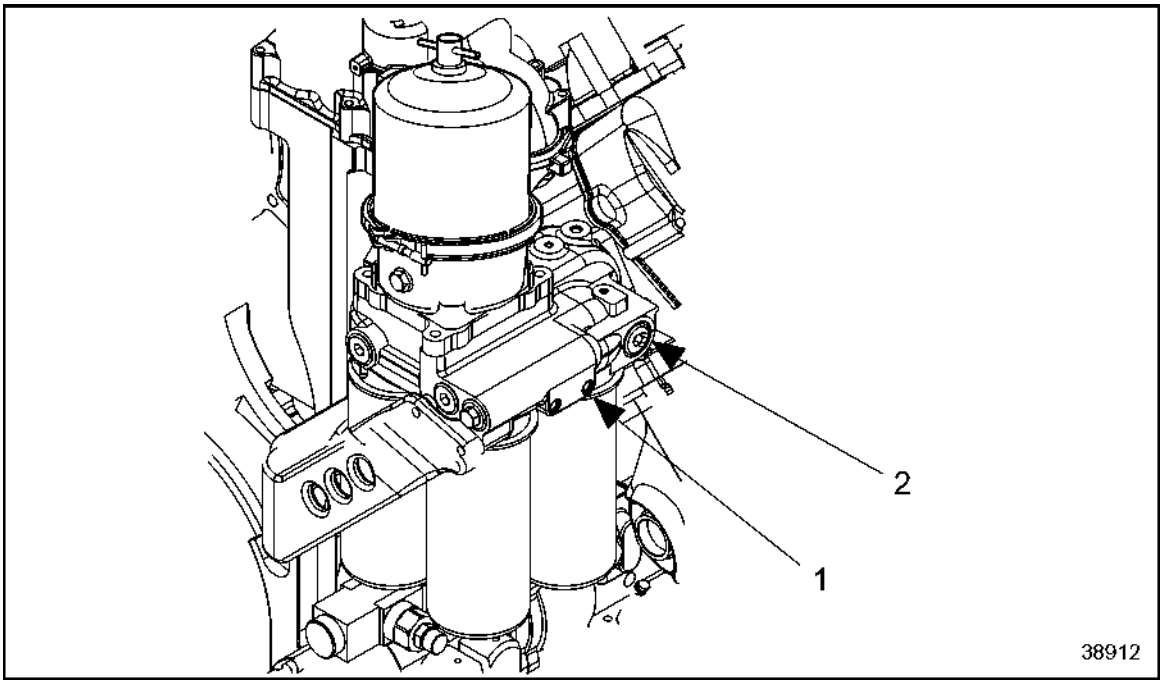
Figure 780 Assembly of Centrifugal Oil Filter Assembly to the Oil Filter Housing

Installation of Oil Filter Service Maintenance Alert System

Perform the following steps to install the oil filter service maintenance alert system.

NOTE:
The engine must be shut down with the safety lockout in place.

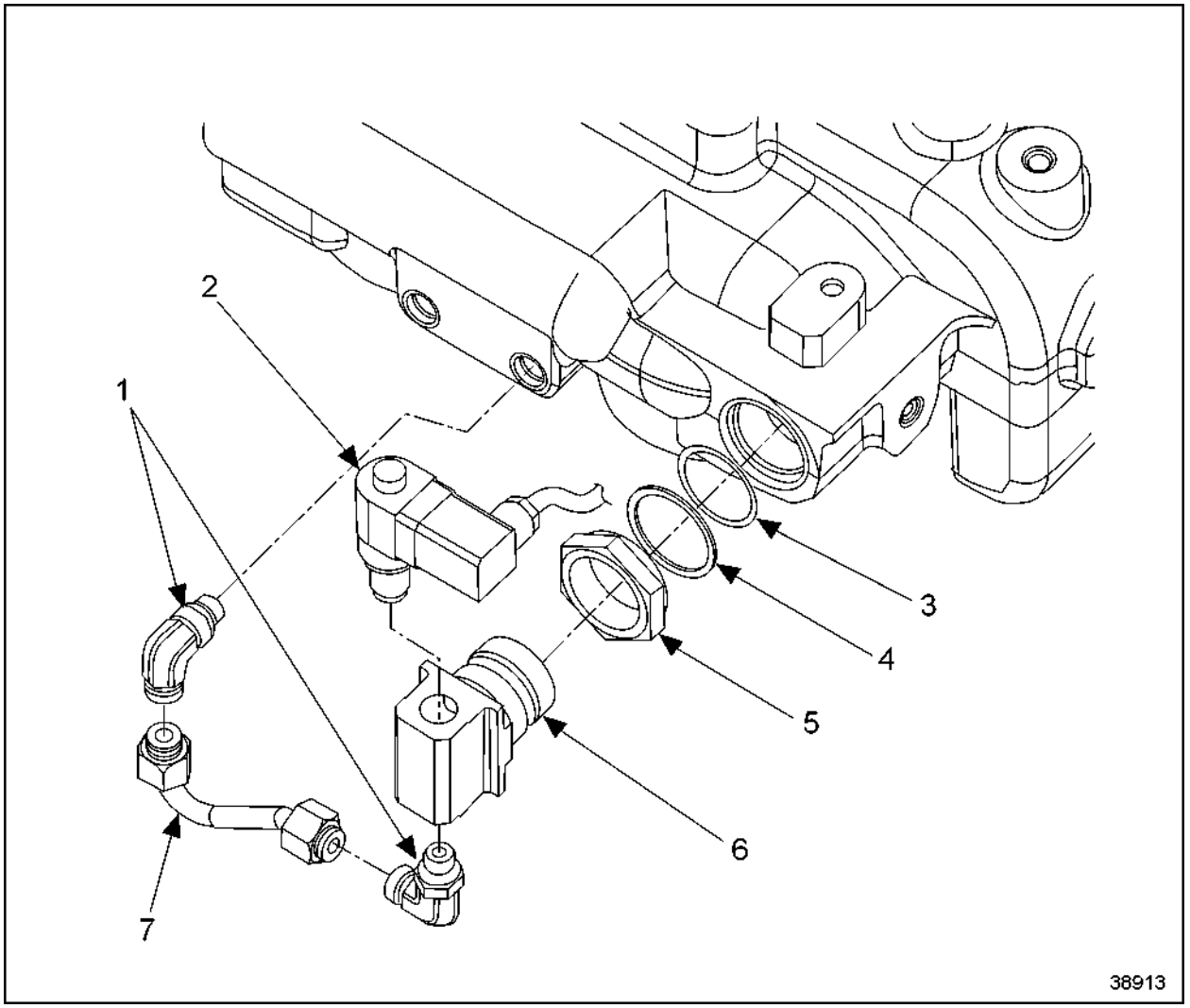
1. Remove the plug #1 and #2 from oil filter adaptor. See Figure 781.



1. Plug
2. Plug

Figure 781 Oil Filter Adaptor Plug Locations

2. Insure the sealing O-ring is in place and not damaged. Coat sealing O-ring with a light film of lubricating oil. Install (1) fitting in location 1 loose. Install (1) adaptor assembly into location #2 and torque to 110–121 N·m (81–89 lb·ft). See Figure 782.



1. Fitting (Elbow) Assembly
2. Sensor
3. Seal Ring
4. Washer
5. Nut
6. Adaptor
7. Oil Feed Tube Assembly

Figure 782 Oil Filter Service Maintenance Alert System

3. The sensor assembly includes a 30–foot wiring harness and a compression seal at the sealing point. Install (1) sensor assembly to the top of adaptor assembly by turning the sensor body nut and leave loose.

NOTE:
The entire sensor body will rotate!

NOTICE
Do not attempt to separate the wiring harness from the sensor assembly, as the waterproof sealing will be damaged.

4. Insure the sealing O-ring is in place and not damaged. Coat sealing O-ring with a light film of lubrication oil. Install (1) fitting in the bottom of the adaptor assembly.
5. Connect (1) oil feed tube to the two fittings and hand tighten.
6. Torque fittings to 15–18 N·m (11–13 lb·ft). Torque adaptor to 110–121 N·m (81–89 lb·ft). Torque sensor assembly to 37 N·m (27 lb·ft).
7. Connect the black wire from the sensor harness to the #953 ground circuit.
8. Connect the red wire from the sensor harness to #419 default circuit. This will differ depending on the OEM's control circuit.
9. Test to insure proper installation of switch as follows: Reconnect battery power. Then, using a small screwdriver, depress the delta pressure switch through the base of the adaptor.
10. With the ignition on and the engine off, the "Check Engine" light should illuminate.
11. Start and run engine and check for leaks. Retighten fittings as required.

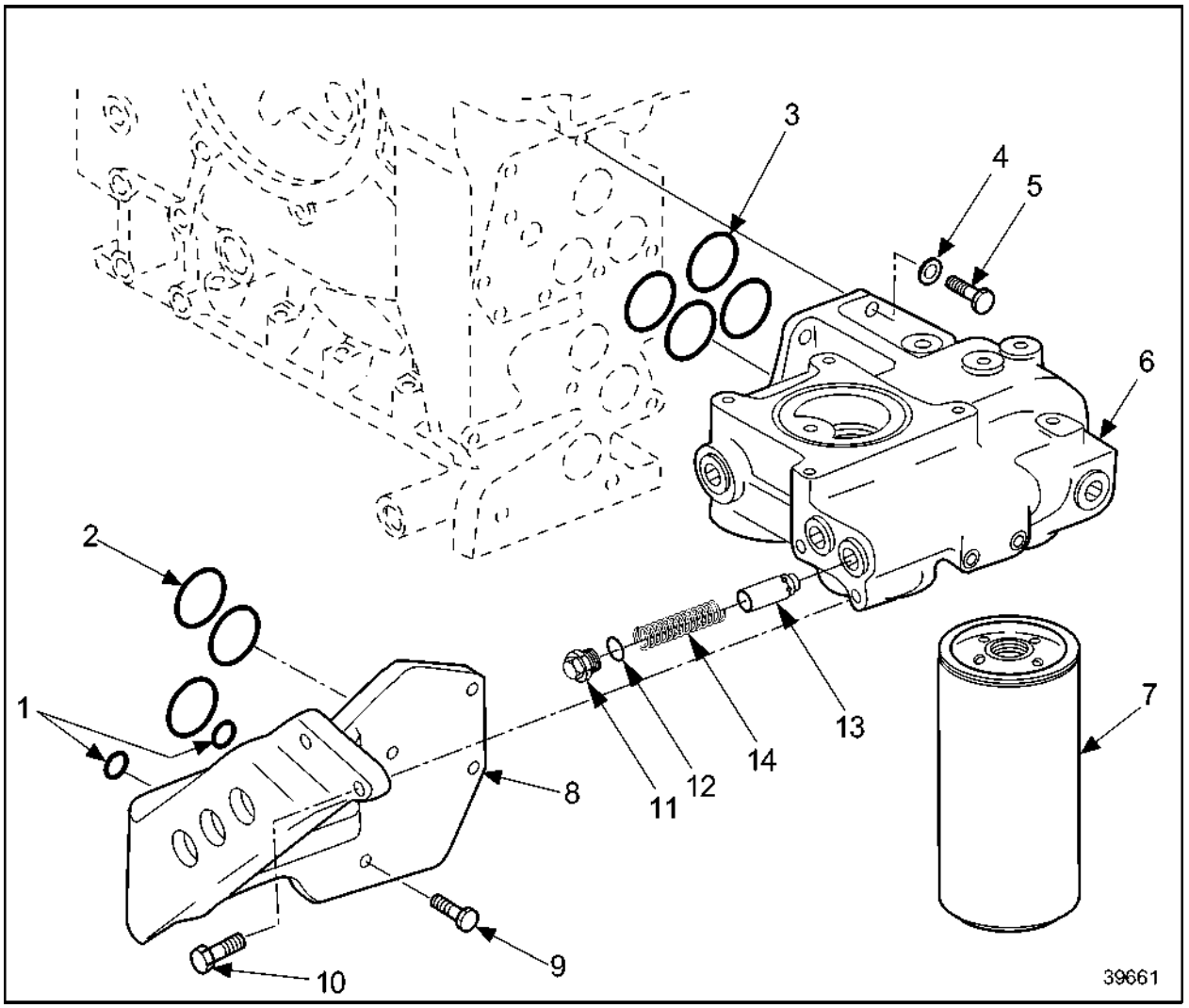
NOTE:
Installation of the oil filter service maintenance alert system kit without including the update of the oil filter bypass valve and spring may result in incorrect operation of the oil filter service maintenance alert system. Refer to SIB 8–4000–00.

NOTE:
Refer to Detroit Diesel brochure 7SE273 for engine service fluid and filter requirements.

Installation of Oil Filter By-Pass Valve and Spring

Perform the following steps for installation of oil filter by-pass valve and spring into the oil filter housing.

1. Install by-pass valve spring into oil filter housing. See Figure 783.



1. O-ring
2. O-ring
3. O-ring
4. Washer
5. Hex Bolt
6. Oil FIlter Housing Assembly
7. Oil Filter Cartridge
8. Oil Filter Mounting Bracket
9. Hex Bolt
10. Hex Bolt
11. Plug
12. O-ring
13. By-Pass Valve
14. By-Pass Valve Spring

Figure 783 Installation of Oil Filter By-Pass Valve and Spring

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).

C 183.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 106 are the After-Installation Operations for the oil filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Fill engine oil in centrifugal filter as necessary	Refer to section C 184.05.11C 184.05.11
1, 2, 3	Inspect for leaks or unusual noise.	—
1, 2, 3	Fill engine coolant system	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.

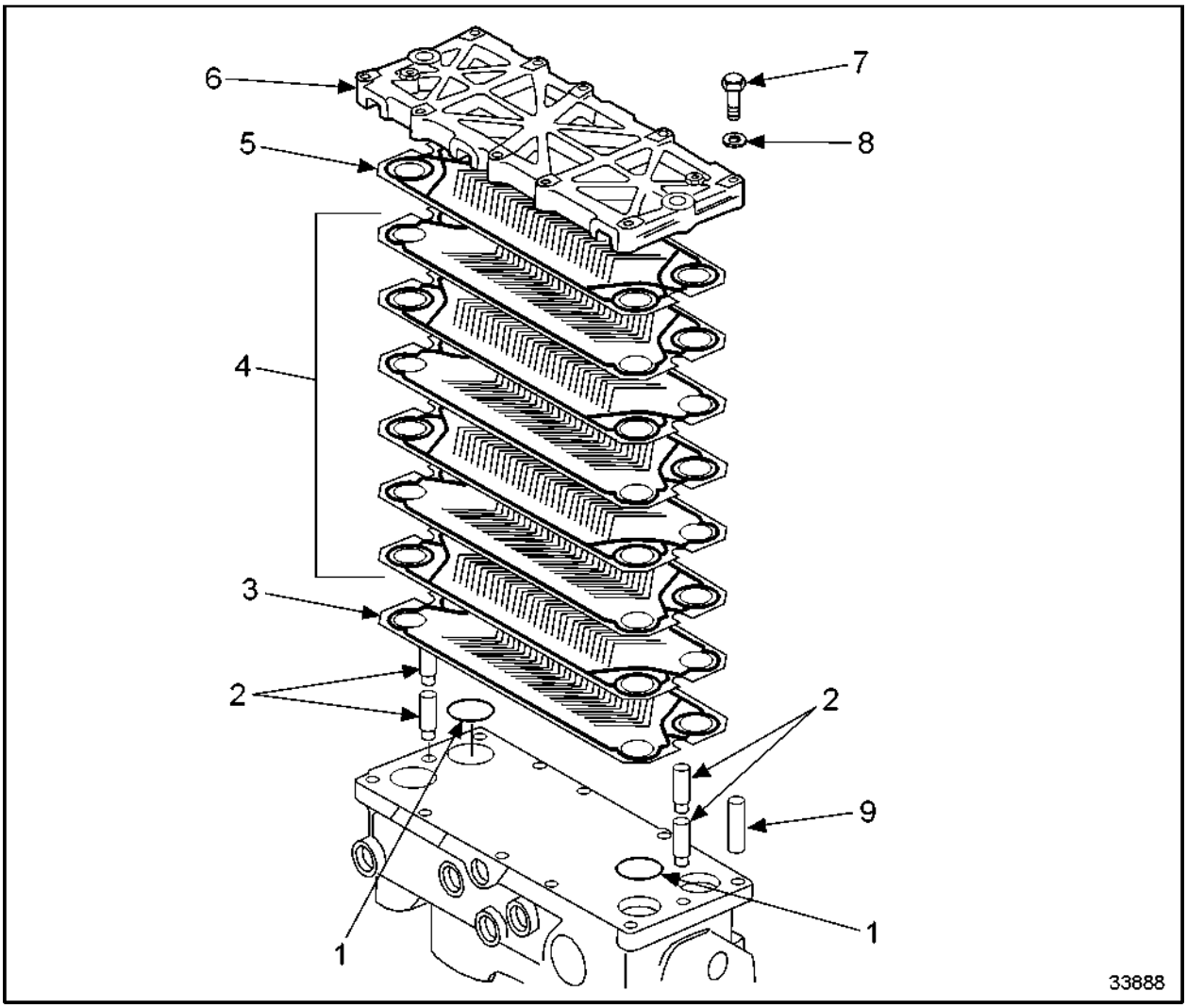
3= The engine is to remain installed.

Table 106 After-Installation Operations

C 183.05 M – MARINE OIL HEAT EXCHANGER

C 183.05.01 M – GENERAL VIEW

See Figure 784 for a general view of the oil heat exchanger components.



1. O-ring
2. Guide Bushing
3. End Plate
4. Oil Cooler Plate
5. First Plate
6. Cover Plate
7. Bolt
8. Washer
9. Spacer Bushing

Figure 784 General View of Oil Heat Exchanger Components

C 183.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 107are the Before-Removal Operations for the oil heat exchanger.

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.

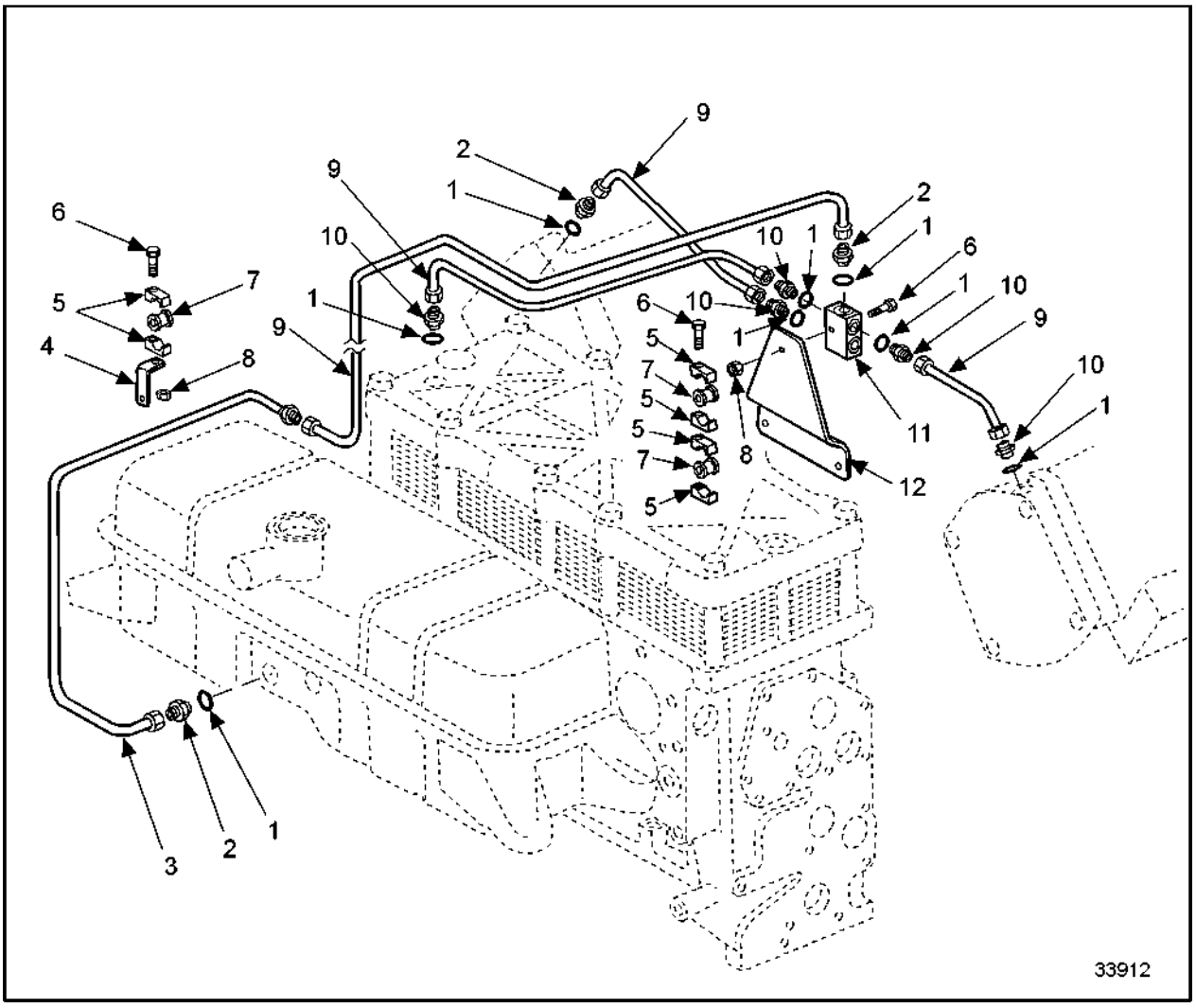
3= The engine is to remain installed.

Table 107 Before-Removal Operations for Oil Heat Exchanger

C 183.05.05 M – REMOVAL OF THE OIL HEAT EXCHANGER

Perform the following steps to remove the oil heat exchanger:

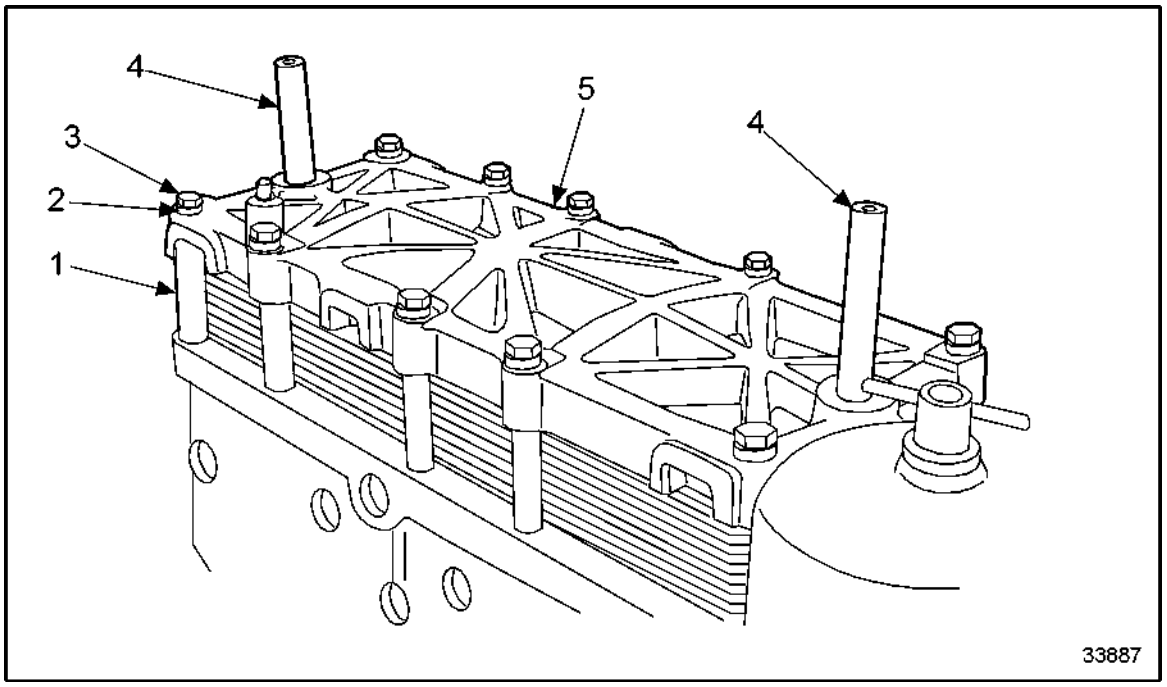
1. Disconnect vent lines as necessary. See Figure 785.



1. Sealing Ring
2. Adapter
3. Bleed Line
4. Bracket
5. Half Clamp
6. Bolt
7. Grommet
8. Hex Nut
9. Pipe
10. Adaptor
11. Distributor
12. Distributor Bracket

Figure 785 Disconnecting Vent Lines

2. Install guide studs (4) to aid in the removal of the oil heat exchanger plates. See Figure 786.

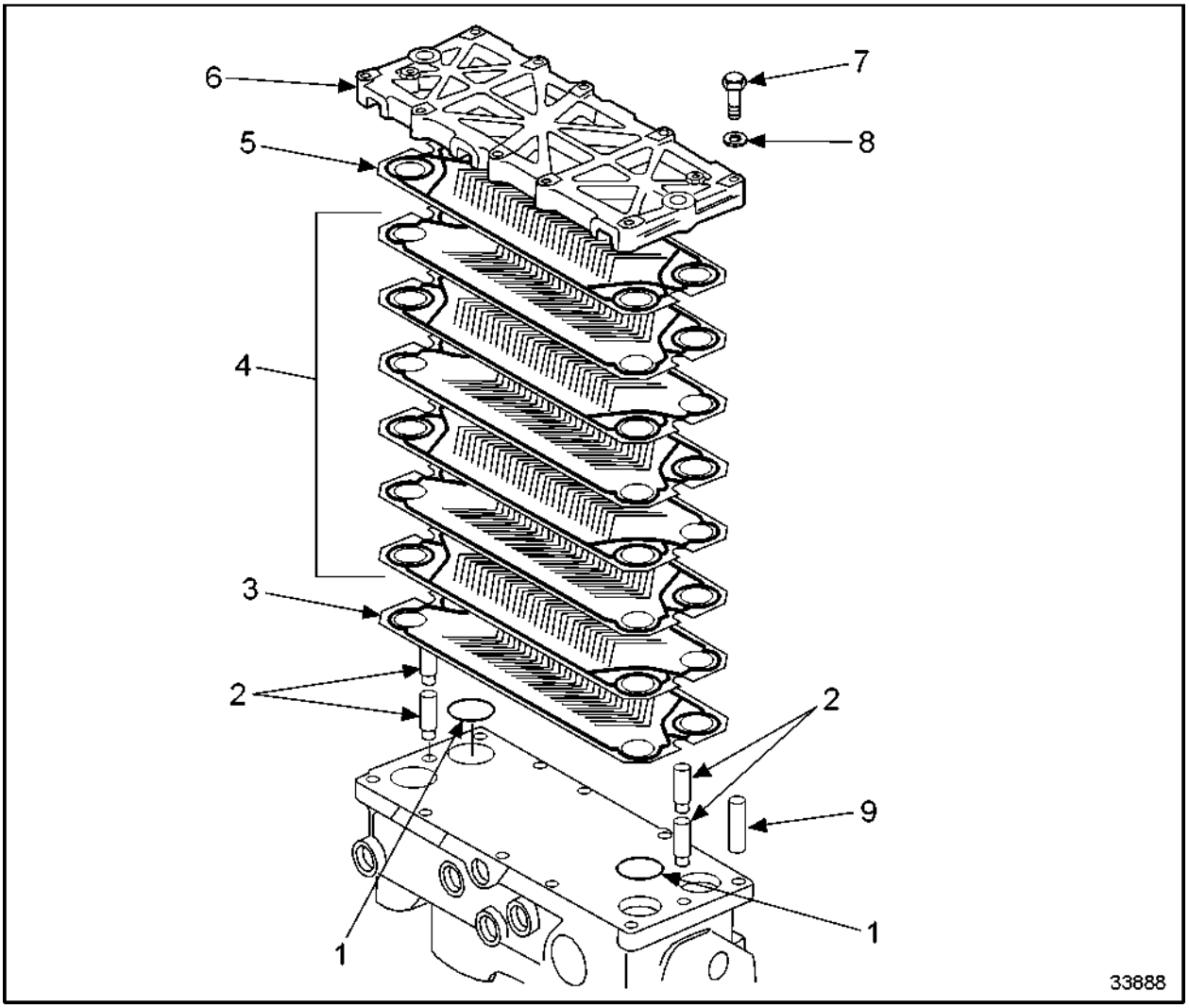


1. Spacer
2. Washer
3. Bolt
4. Guide Stud
5. Oil Heat Exchanger

Figure 786 Installing of Guide Studs

NOTICE:
Remove the bolts in a uniform manner to avoid bolt binding and damage to the heat exchanger plates.

3. Remove bolts (7), washers (8) and spacer bushings (9) securing the cover plate (6) to the front cover. See Figure 787.



1. O-ring
2. Guide Bushing
3. End Plate
4. Oil Cooler Plate
5. First Plate
6. Cover Plate
7. Bolt
8. Washer
9. Spacer Bushing

Figure 787 Removing Cover Plate

4. Remove the cover plate (6).

NOTICE:
Place the oil heat exchanger plates on a clean flat surface to avoid bending and gasket damage.

5. Remove the oil cooler plates (4) and place on a clean flat surface. See Figure 786.
6. Remove the guide studs.

C 183.05.08 M – INSPECTION, CLEANING AND REPAIR

Perform the following tasks to clean the oil heat exchanger plates:

1. Clean all parts with clean diesel fuel.

CAUTION:

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

2. Dry the parts with compressed air.

Perform the following steps to clean the front cover and base of the oil heat exchanger:

1. Clean the front cover plate and base with clean diesel fuel and a brush.

NOTE:
Use a soft brush to avoid damaging the plate and the base faces.

CAUTION:

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

2. Dry the parts with compressed air.

Perform the following steps to inspect the oil heat exchanger:

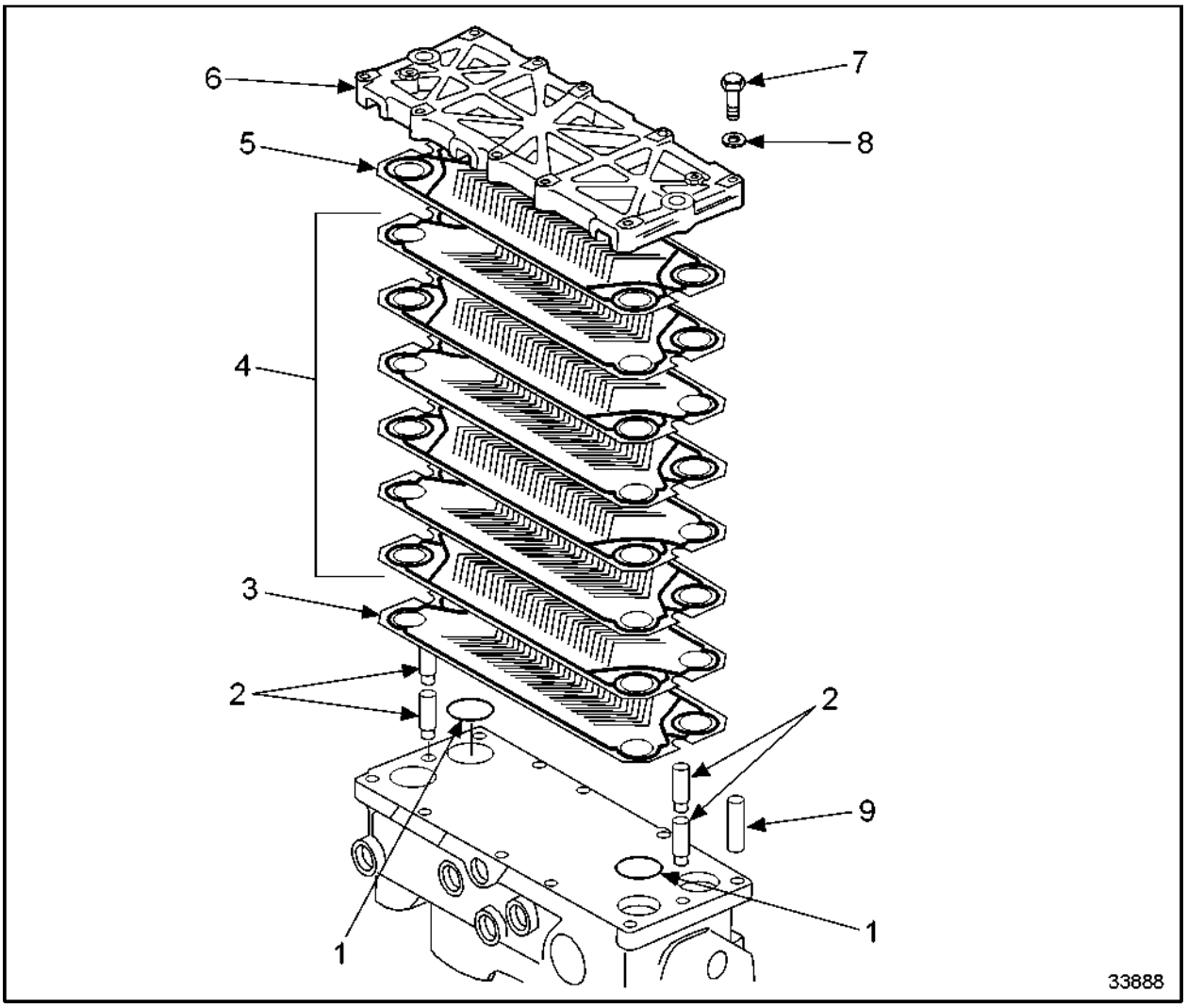
1. Visually inspect oil cooler plates and front cover with red penetrant dye or fluorescent penetrant dye for cracks.
   [a] If oil cooler plates or front cover is cracked, replace component as necessary.
   [b] If oil cooler plates and front cover are not cracked, continue inspection.
2. Visually inspect all mating surfaces, sealing surfaces, bores of cover plate and base of front cover for wear and damage.
   [a] If mating surfaces, sealing surfaces, bores of cover plate or base of front cover are worn or damaged, rub down with oilstone as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If mating surfaces, sealing surfaces, bores of cover plate and base of front cover are not worn or damaged, continue inspection.

3. Visually inspect the oil plate seals for damage; replace as necessary.
4. Replace all O-rings.

C 183.05.11 M – INSTALLATION OF THE OIL HEAT EXCHANGER

Perform the following steps to install the oil heat exchanger:

1. Install new O-rings (1) to the base of the coolant heat exchanger. See Figure 788.



1. O-ring
2. Guide Bushing
3. End Plate
4. Oil Cooler Plate
5. First Plate
6. Cover Plate
7. Bolt
8. Washer
9. Spacer Bushing

Figure 788 Installing O-rings to Coolant Heat Exchanger

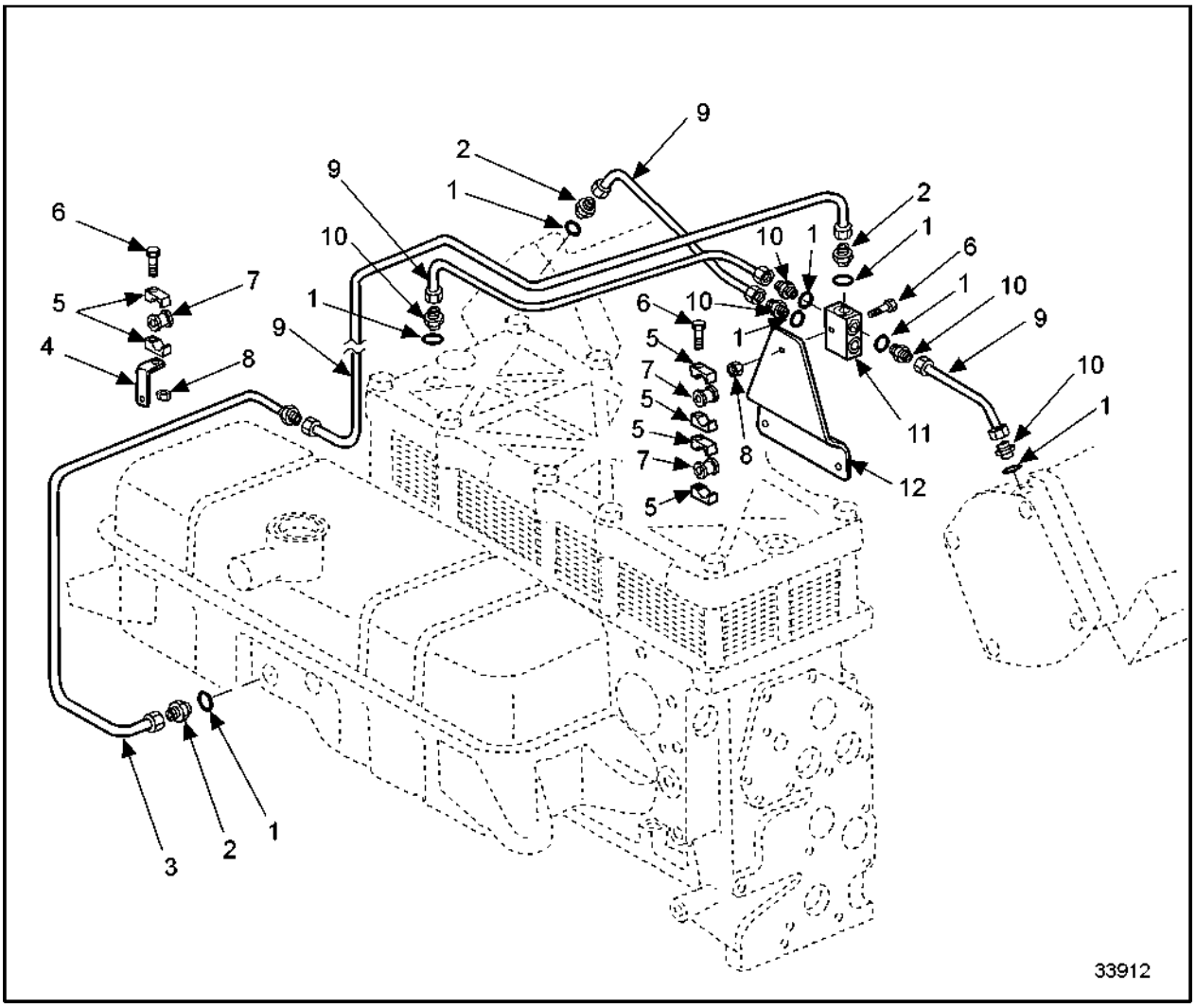
NOTICE:
Ensure that the oil heat exchanger plate gaskets are properly aligned during installation to prevent damage and leakage.

2. Insert the guide studs and install the oil cooler plates (4) in the order in which they were removed. See Figure 788.

NOTE:
Ensure order of oil cooler plates is correct.

3. Install the cover plate (6). See Figure 788.
4. Install spacer bushing (9), washers (8), and bolts (7) to secure the oil heat exchanger assembly to the coolant heat exchanger. See Figure 788.
5. Tighten bolts from the center of the plate cover to the ends in a uniform pattern to compress the plates to the required torque specification, 180 N·m (133 lb·ft).

6. Connect vent lines (9). See Figure 789.



1. Sealing Ring
2. Adapter
3. Bleed Line
4. Bracket
5. Clamp Half
6. Bolt
7. Grommet
8. Hex Nut
9. Vent Lines
10. Adaptor
11. Distributor
12. Distributor Bracket

Figure 789 Connecting the Vent Lines

7. Verify repair of the oil heat exchanger.

C 183.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 108are the After-Installation Operations for the oil heat exchanger.

Level of Maintenance	Operation	Reference
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.

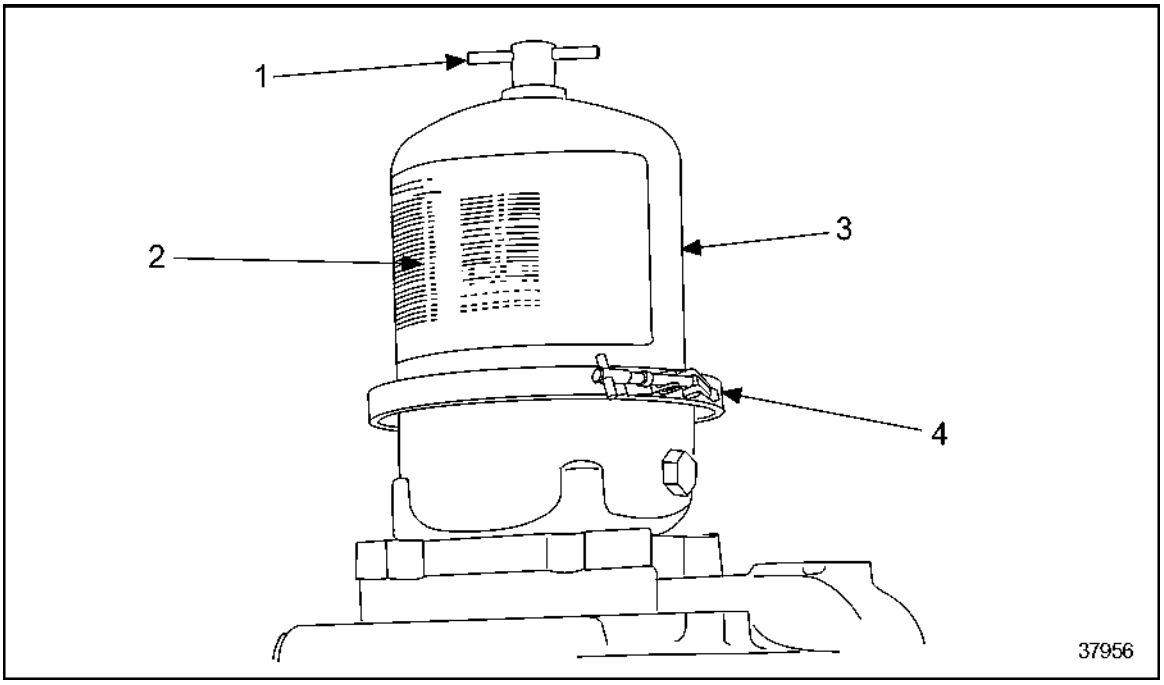
3= The engine is to remain installed.

Table 108 After-Installations Operations

C 184.05 – CENTRIFUGAL OIL FILTER

C 184.05.01 – GENERAL VIEW

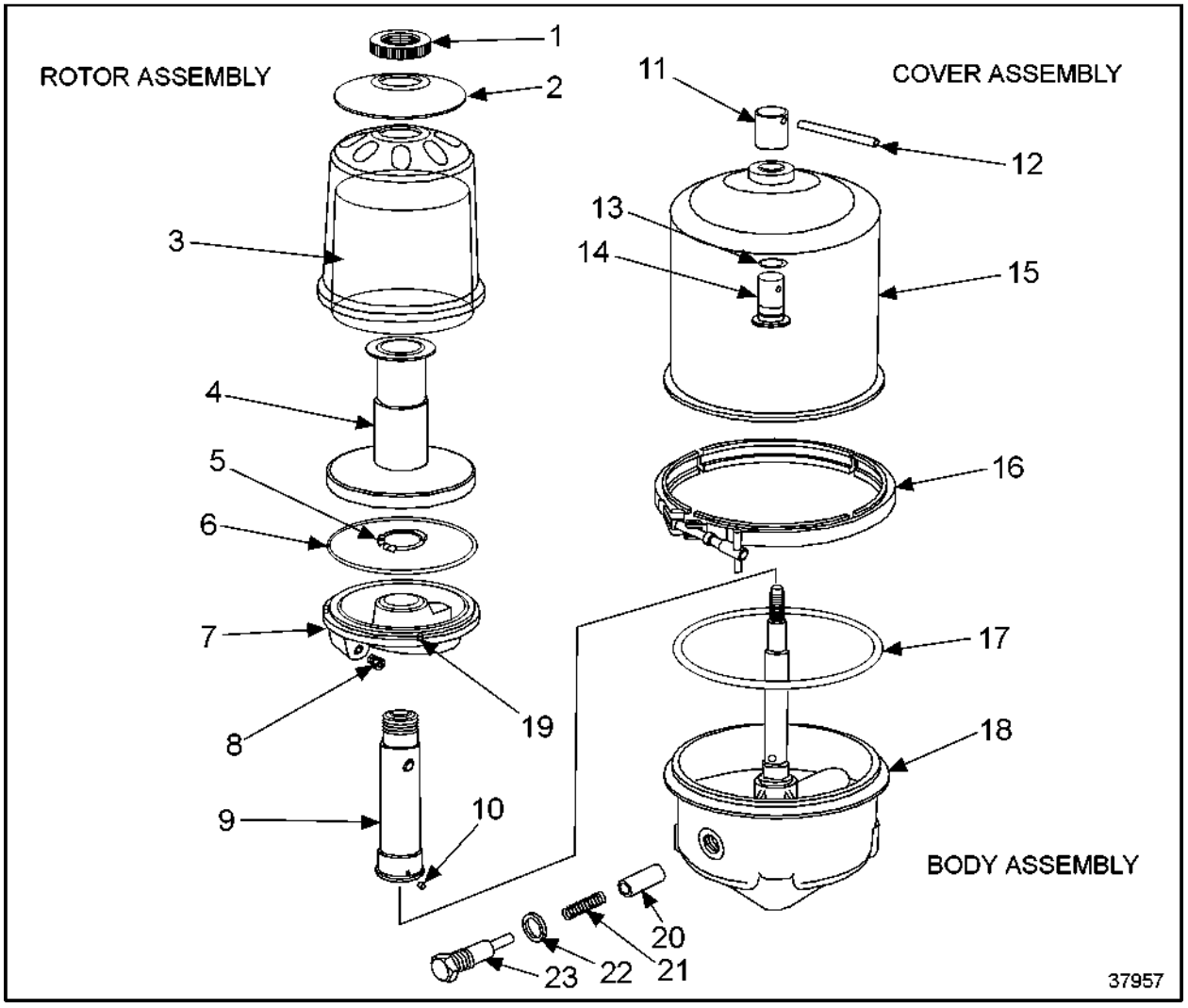
See Figure 790 for a general view of the centrifugal oil filter assembly.



1. Cover Nut
2. Service Instructions
3. Cover Assembly
4. Band Clamp T-Bolt

Figure 790 General View of Centrifugal Oil Filter Assembly

See Figure 791 for a general view of the centrifugal oil filter.



1. Cover Nut
2. Stiffener Plate
3. Paper Insert
4. Stand Pipe
5. Snap Ring
6. O-ring
7. Rotor Cover
8. Nozzle
9. Bearing Tube Assembly
10. Pin
11. Cover Nut Tube
12. Pin
13. O-ring
14. Cover Nut
15. Cover
16. Band Clamp
17. O-ring
18. Body Assembly
19. Locating Pin
20. Shuttle
21. Spring
22. Washer
23. Plug

Figure 791 General View of the Centrifugal Oil Filter

C 184.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 109 are the Before-Removal Operations for the centrifugal oil filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine oil from centrifugal oil filter	Refer to section C 184.05.05

1 = The engine is to be completely disassembled.

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

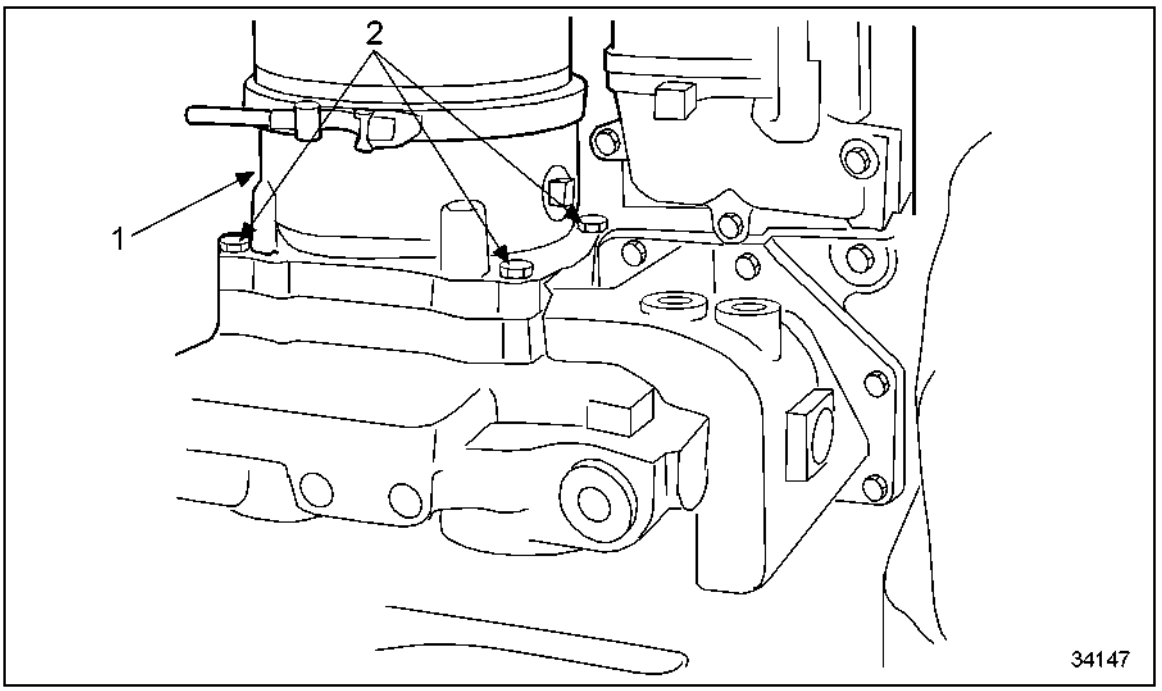
3= The engine is to remain installed.

Table 109 Before-Removal Operations

C 184.05.05 – REMOVAL OF CENTRIFUGAL OIL FILTER

Perform the following steps for the removal of the centrifugal oil filter:

1. Remove hex bolts (2) for centrifugal oil filter (1) and remove centrifugal oil filter from oil filter housing. See Figure 792.



1. Centrifugal Oil Filter
2. Hex Bolts

Figure 792 Removing Centrifugal Oil Filter

2. Seal openings (arrow) in oil filter housing with suitable plugs. See Figure 793.

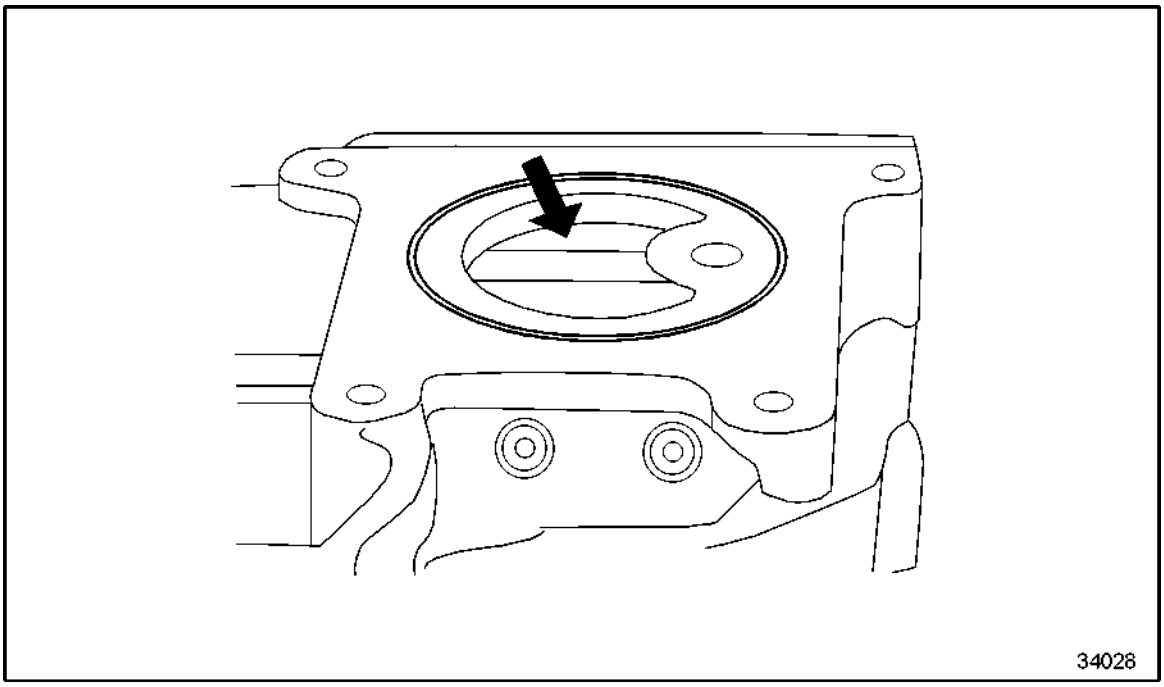


Figure 793 Sealing Openings in Oil Filter Housing with Suitable Plugs

NOTE:
Plugs are used to keep contamination out of opening.

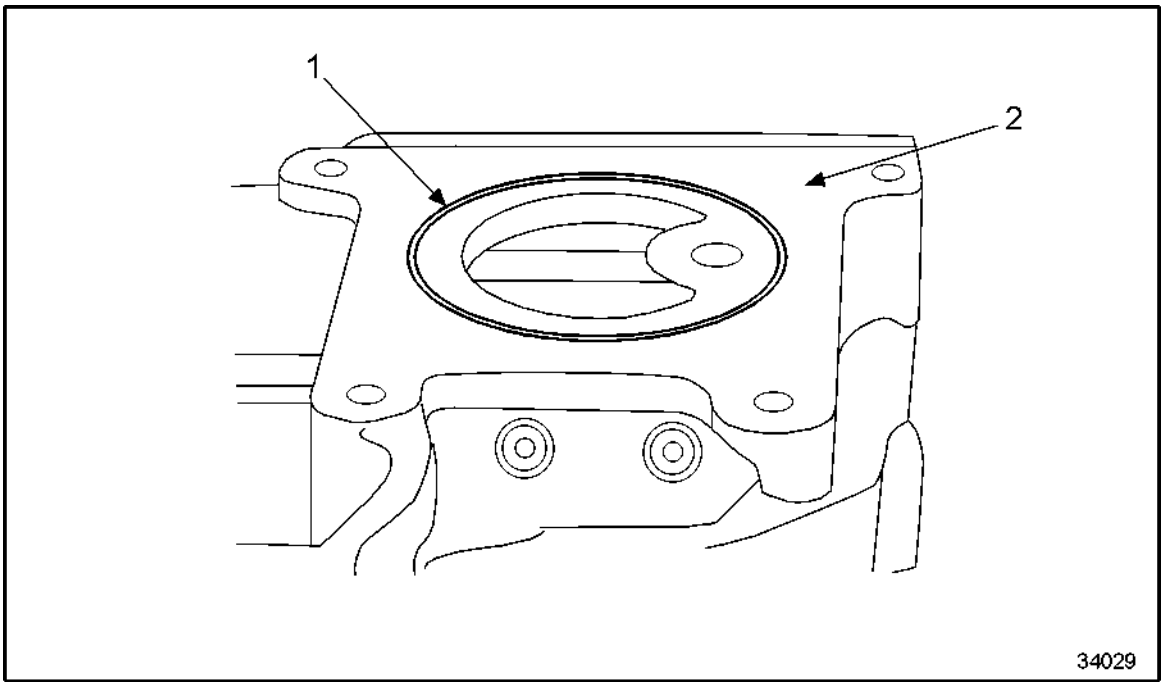
C 184.05.06 – DISASSEMBLY OF CENTRIFUGAL OIL FILTER

See OEM Guidelines.

C 184.05.11 – INSTALLATION OF CENTRIFUGAL OIL FILTER

Perform the following steps for the installation of the centrifugal oil filter:

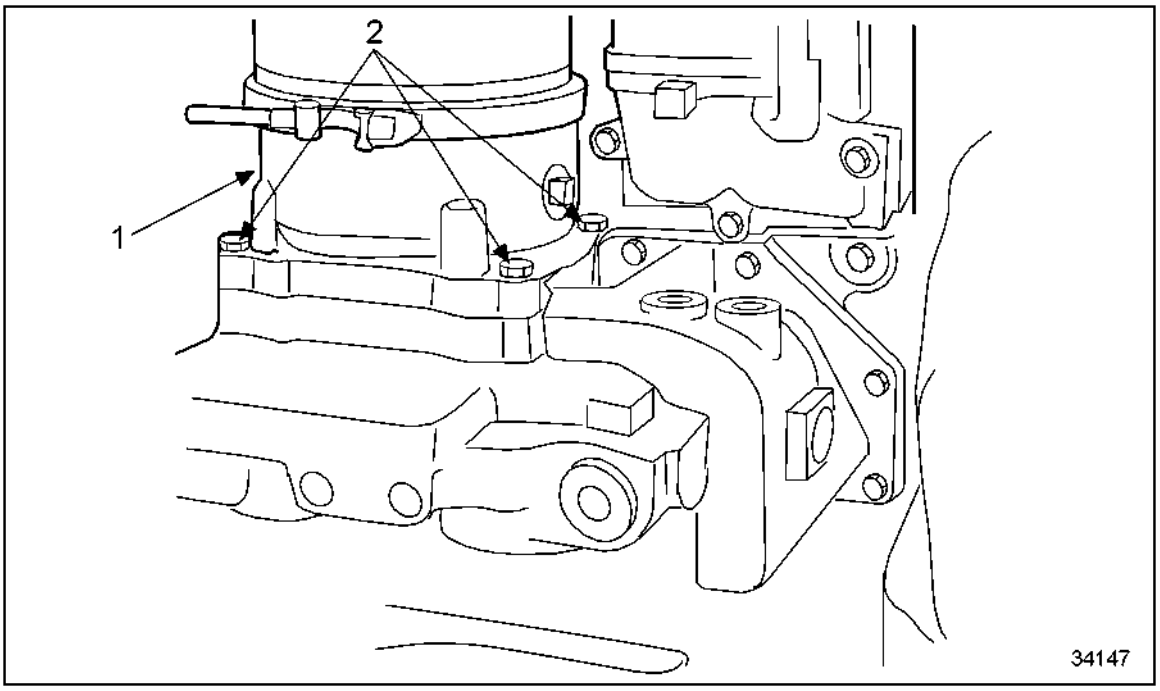
1. Remove plugs.
2. Coat O-ring with petroleum jelly and insert into groove (1) of oil filter housing (2). See Figure 794.



1. Groove
2. Oil Filter Housing

Figure 794 Coating O-ring with Petroleum Jelly and Inserting into Groove of Oil Filter Housing

3. Install centrifugal oil filter (1) and secure with washers and hex bolts (2). See Figure 795.



1. Centrifugal Oil Filter
2. Hex Bolts

Figure 795 Installing Centrifugal Oil Filter

4. Tighten hex bolts to specification. Refer to section A 003.

C 184.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 110 are the After-Installation Operations for the centrifugal oil filter.

Level of Maintenance	Operation	Reference
1, 2, 3	Fill engine oil as necessary	Refer to section C 184.05.11
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.

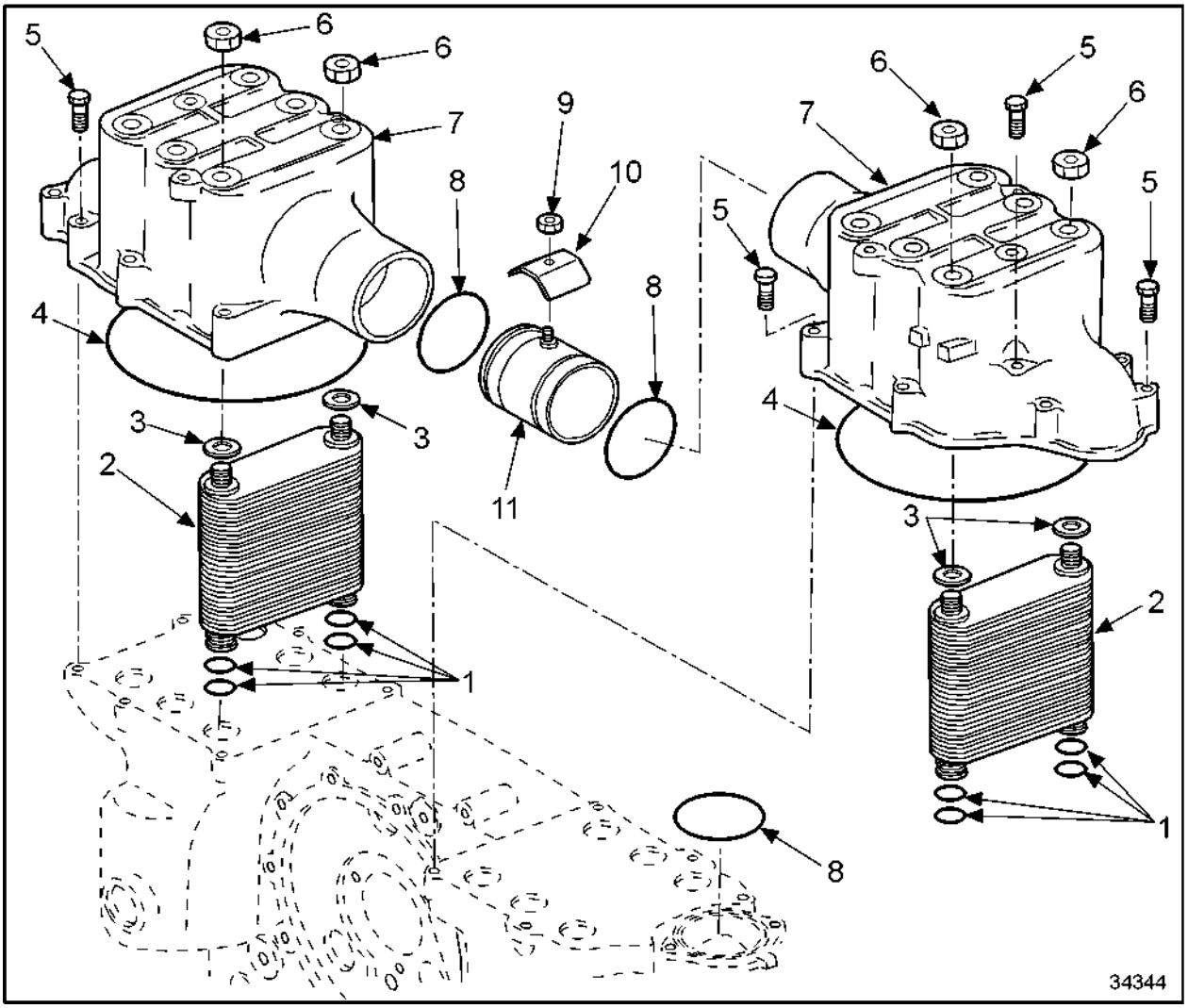
3= The engine is to remain installed.

Table 110 After-Installation Operations

C 185.05 – OIL COOLING

C 185.05.01 – GENERAL VIEW

See Figure 796 for a general view of the oil cooling system.



1. O-ring
2. Cooler Core
3. Sealing Washer
4. O-ring
5. Hex Bolt
6. Nut for Coolant
7. Oil Cooler Housing
8. O-ring
9. Nut
10. Bracket
11. Plug-in Pipe

Figure 796 General View of Oil Cooling System

C 185.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 111 are the Before-Removal Operations for the oil cooling system.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain charge air coolant	Refer to section C 206.05.05

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.

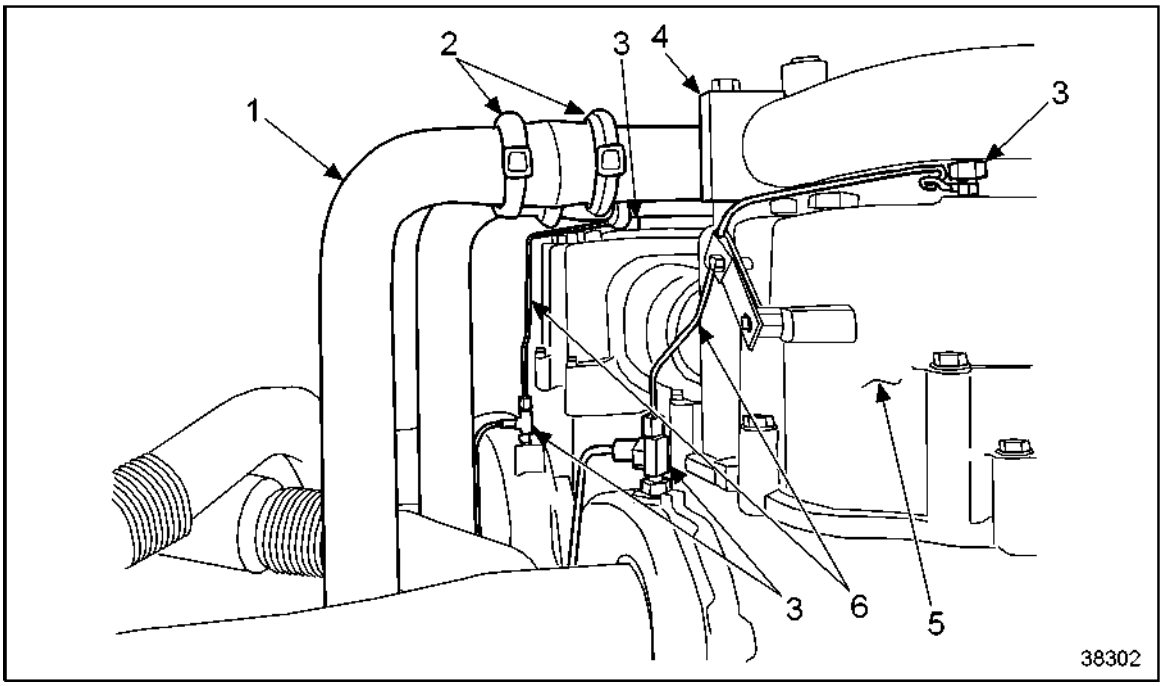
Table 111 Before-Removal Operations

C 185.05.05 – REMOVAL OF OIL COOLING SYSTEM

Perform the following steps for the removal of the oil cooling system.

NOTE:
Before removing coolant lines, it is advisable to photograph the engine from all sides or attach metal tags to the lines and fixtures so that they can be reinstalled in their original positions.

1. To remove coolant lines, disconnect vent lines (3). See Figure 797.

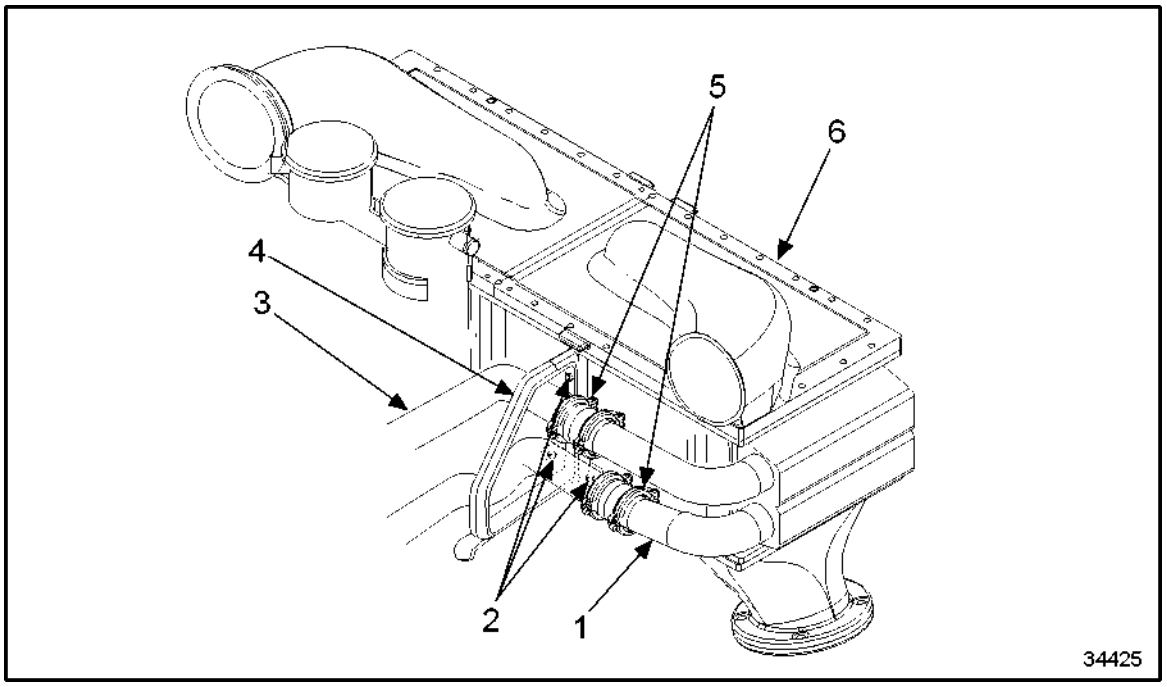


1. Charge Air Cooler Pipe
2. Coupling
3. Vent Lines Connection
4. Charge Air Cooler Pipe Support Bracket
5. Oil Cooler Housing
6. Vent Lines

Figure 797 Removing Pipe to Charge Air Cooler

2. Unscrew hex nuts (2) for pipe connections. See Figure 797.
3. Remove V-clamps and reattach pipe connections to respective remaining pipe. See Figure 797.
4. Remove hex bolt (2) and bracket with spacer washer (1).
5. Remove pipe to charge air cooler (4).

6. Remove the hex bolts (3) for clamps (4) and rubber sleeve (1), and reattach rubber sleeve over pipe end. See Figure 798.

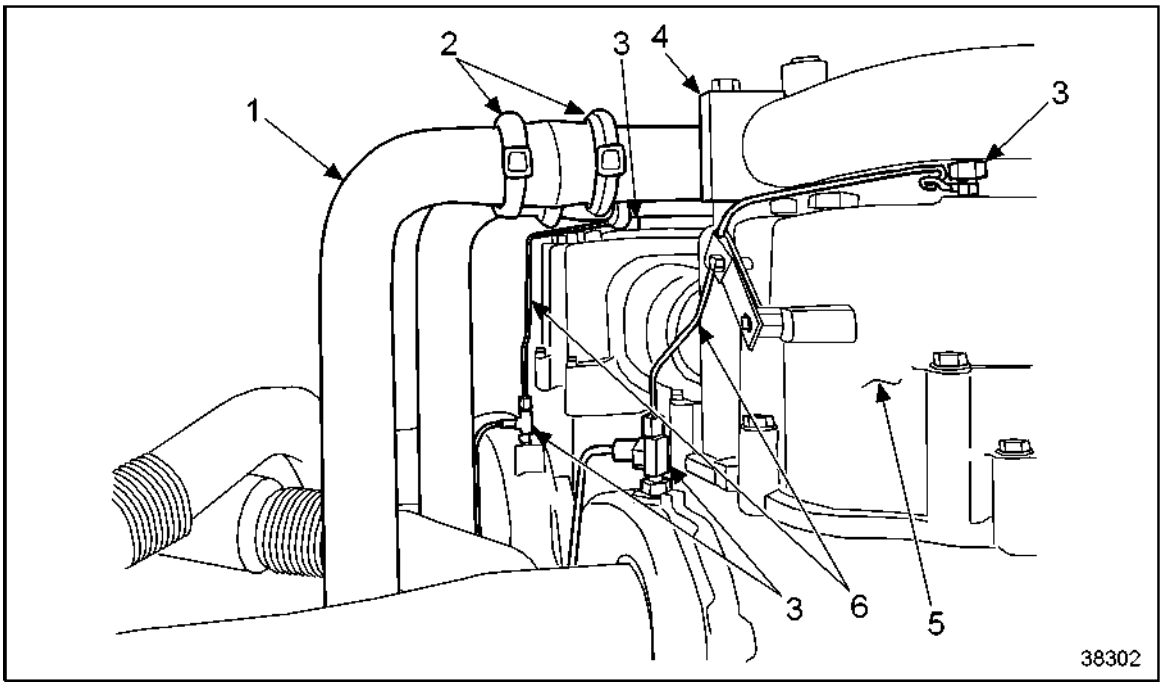


1. Charge Air Cooler Pipe
2. Bracket Bolts
3. Return Pipe
4. Bracket
5. Clamp, Seal and Coupling
6. Charger Air Cooler

Figure 798 Removing Clamps and Bracket

7. Remove clamps.
8. Remove hex bolt (2) from bracket and remove bracket.

9. Remove hex bolts from clamps. See Figure 799.

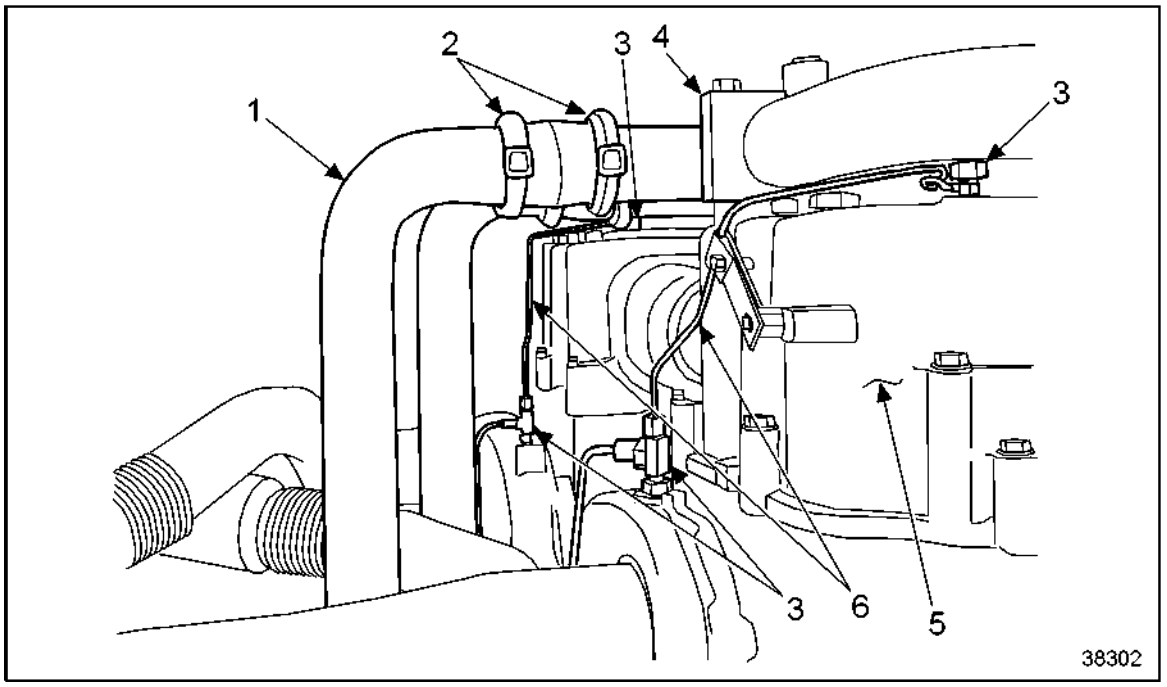


1. Charge Air Cooler Pipe
2. Coupling
3. Vent Lines Connection
4. Charge Air Cooler Pipe Support Bracket
5. Oil Cooler Housing
6. Vent Lines

Figure 799 Removing Vent Line

10. Reattach rubber sleeve over remaining pipe end (1).
11. Remove clamps (2).
12. Remove vent line (3).

13. Remove hex nuts (4) from V-clamps (1). See Figure800.

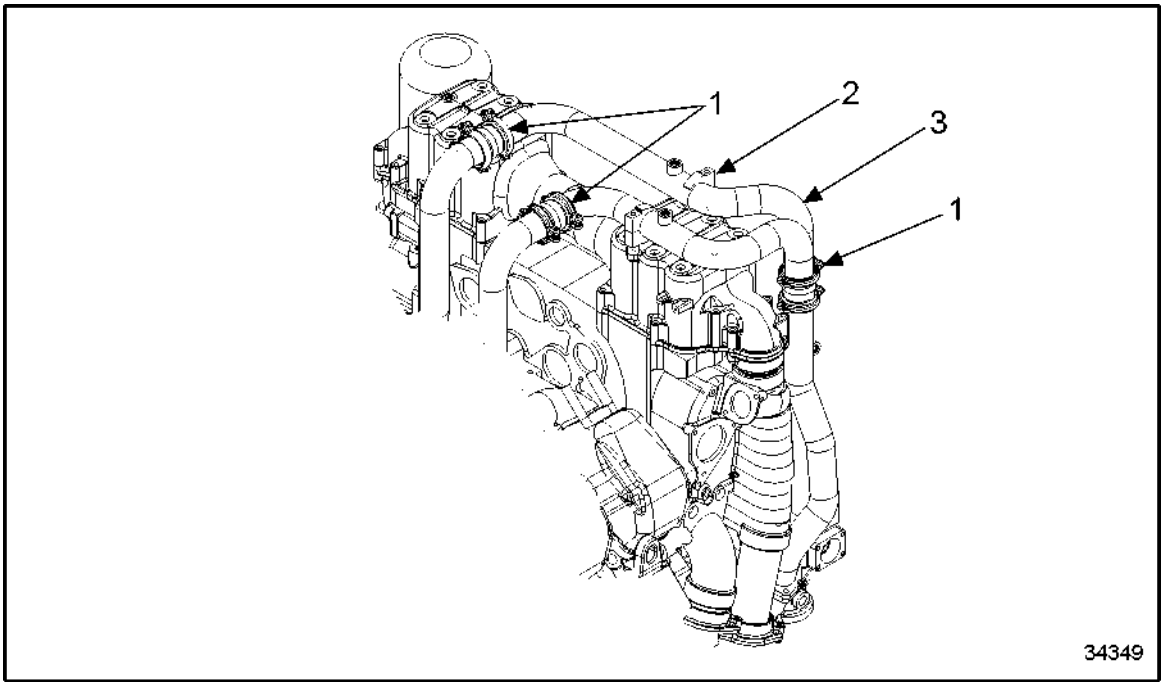


1. Charge Air Cooler Pipe
2. Coupling
3. Vent Lines Connection
4. Charge Air Cooler Pipe Support Bracket
5. Oil Cooler Housing
6. Vent Lines

Figure 800 Removing Vent Lines and Pipe

14. Reattach pipe connection on pipe from charge air cooler (3).
15. Separate vent line at connecting points and remove.
16. Remove pipe from charge air cooler.

17. Remove hex nuts for pipe connection. See Figure 801.

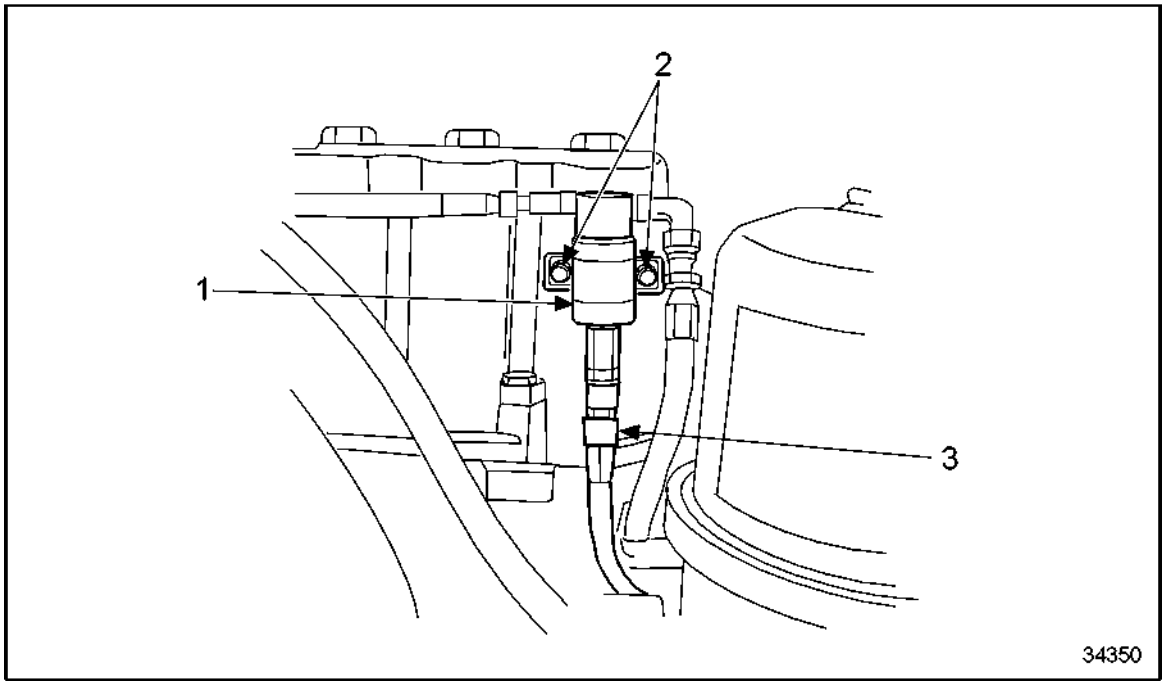


1. V-clamp
2. Retainer
3. Pipe from Intercooler

Figure 801 Removing Pipe from Charge Air Cooler

18. Remove V-clamps (1) and reattach pipe connection to respective remaining pipe (3).
19. Remove hex bolt with bracket (2) and spacer washer.
20. Remove pipe (3).

21. To remove oil cooler housing, remove hex bolt (2) from fan control solenoid and bracket. See Figure 802.

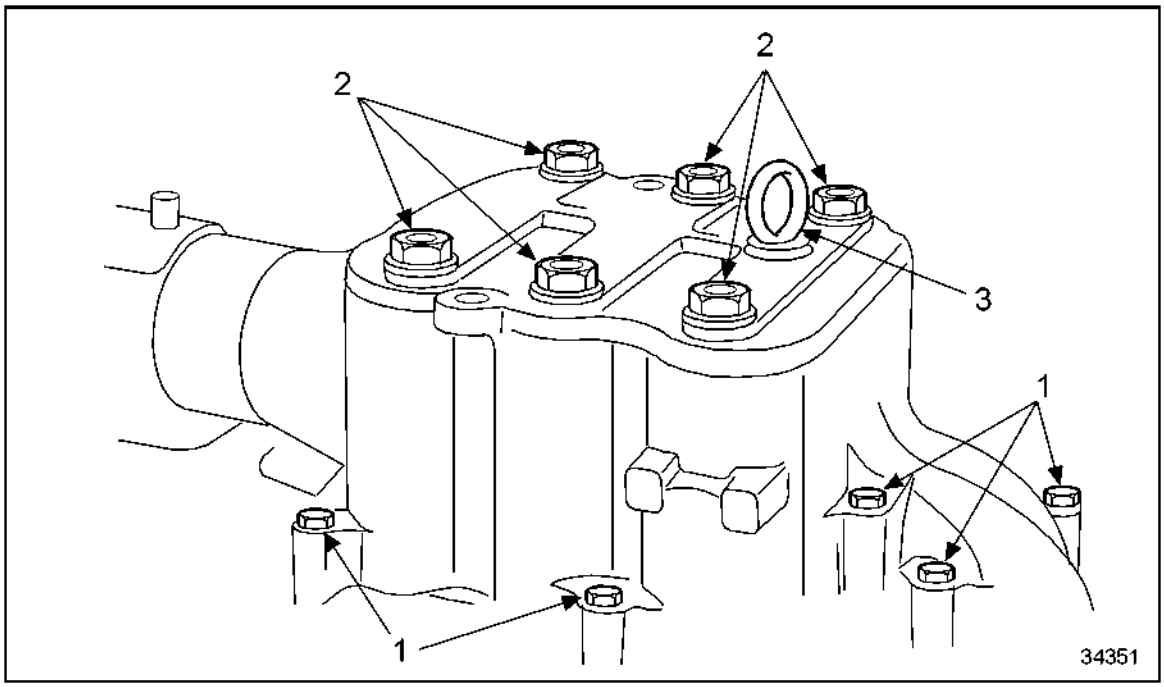


1. Fan Control Solenoid and Bracket
2. Hex Bolts
3. DDEC Harness Connector

Figure 802 Removing Fan Control Solenoid and Bracket From Cooler Housing

22. Lay (1) fan control solenoid back from oil cooler housing.

23. Remove hex bolts (1) from oil cooler housing. See Figure 803.



1. Hex Bolts
2. Nut
3. Lifting Eye

Figure 803 Removing Oil Cooler Housing from Coolant Distribution Housing

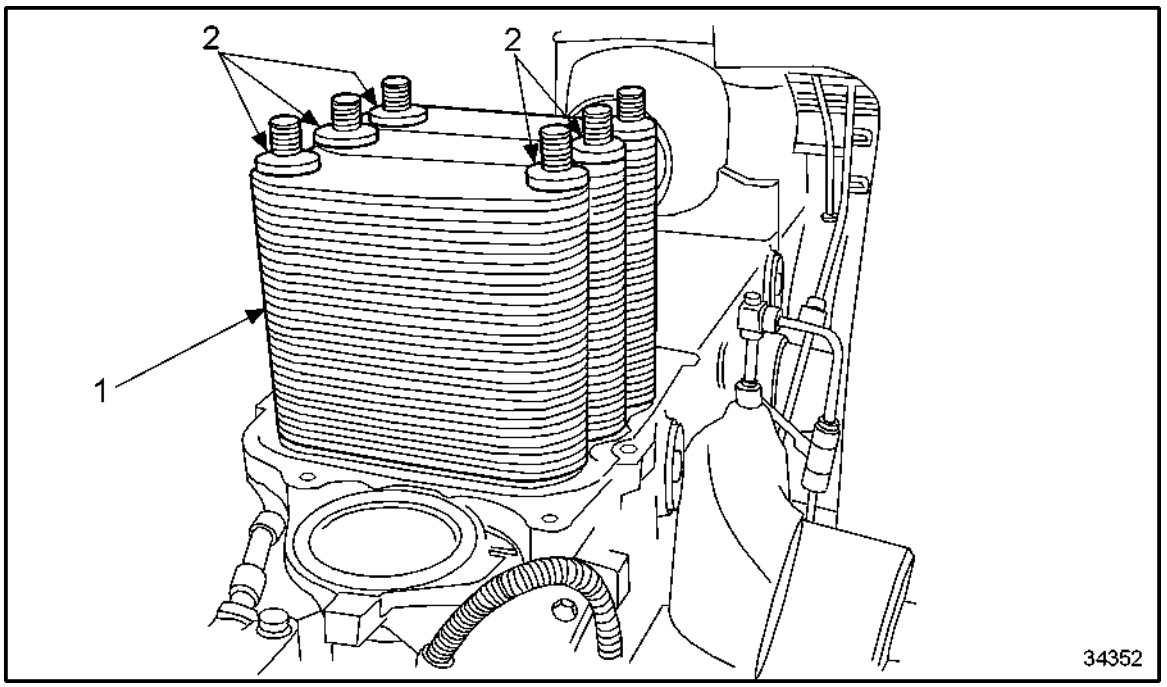
24. Screw lifting eye (3) into left and right oil cooler housing.

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.

25. Using crane and suitable lifting device, remove oil cooler housing from coolant distribution housing.

26. Remove sealing washers (2). See Figure 804.



1. Oil Cooler Cores
2. Sealing Washers

Figure 804 Lifting Oil Cooler Cores out of Distribution Housing Bore

27. Carefully lift oil cooler cores vertically out of distribution housing bore.

C 185.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the air cooling system:

1. Visually inspect oil filter cores for metal contamination.
   [a] If oil filter cores show metal contamination, replace cores as necessary.
   [b] If oil filter cores do not show metal contamination, continue inspection.
2. Clean all components.
3. Visually inspect components for damage.
   [a] If components are damaged, machine components as necessary.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If components are not damaged, continue inspection.
4. Visually inspect cooler insert for damage.
   [a] If cooler insert is damaged, replace component.
   [b] If no damage is found, continue inspection.
5. Visually inspect oil cooler housing for cracks with red penetrant dye.
   [a] If cracks are detected, replace component.
   [b] If no cracks are detected, continue inspection.
6. Visually inspect all sealing, mating and sliding surfaces for wear, scoring and indentations.
   [a] If sealing, mating and sliding surfaces are worn, scored or indented, remove minor damage by rubbing down with an emery cloth or an oilstone.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If sealing, mating and sliding surfaces are not worn, scored or indented, continue inspection.
7. Visually inspect threads of components for wear or damage.
   [a] If threads are worn or damaged, rechase threads.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If threads are not worn or damaged, continue inspection.
8. Replace gaskets, sealing rings and O-rings.
9. Ensure that oil chambers and oil passages are perfectly clean.

Cleaning Cooler Cores on Coolant Side

Perform the following steps for cleaning cooler cores in coolant side:

NOTE:
The oil cooler housing must be replaced if metal debris has penetrated the engine oil system, for example, in event of piston scuffing or damage to bearings.

1. Visually examine extent of contamination of coolant side prior to cleaning.
2. The coolant side must be cleaned if there are any visible deposits due to contamination and oil residue.

CAUTION:

To avoid personal injury when using any chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

3. Soak cooler element in a cleaning bath containing dissolved cleaning agent.

NOTE:
An agent which is not aggressive to metal surfaces must only be used to remove deposited material.

4. Prepare the descaling solution as per OEM guidelines.
   - Soaking time depends on the condition and temperature of the solution and the nature and type of the deposits.

CAUTION:

To avoid personal injury when working near a high pressure hydraulic hose during installation and removal of components, wear protective gloves, safety mask, and safety glasses.

   - The cleaning process is completed when loosened contaminants can be flushed away with a powerful water jet.
5. After cleaning, flush cooler with water until pH values of clean water and rinsing water are approximately the same (within a difference of 1 pH).

NOTE:
Normal water can be used for flushing purposes.

Cleaning Cooler Cores on Oil Side

Perform the following steps for cleaning cooler cores on oil side:

1. Connect oil side to sealed, forced-circulation flushing system equipped with a filter (0.05 mm mesh).
2. Flush with cleaning agent in opposite direction of oil flow in normal operation.

CAUTION:

To avoid personal injury when using any chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

3. For suitable descaling agents, use buffered alkaline agents.
4. Use ultrasonic equipment for improved cleaning.

CAUTION:

To avoid personal injury when working near a high pressure hydraulic hose during installation and removal of components, wear protective gloves, safety mask, and safety glasses.

5. After cleaning, oil side must be flushed with water until pH values of fresh water and flushing water are roughly equal (within a difference of 1 pH).

NOTE:
Contaminants are released, particularly particles from wearing parts, and are flushed away with the water.

NOTE:
Flushing pressure should be within 3 bars (43.51 lb/inch^2) to 4 bars (58.01 lb/inch^2) with a flow of 150 to 300 liters/minute.

NOTE:
If the cooler is not put into operation immediately, dry oil side, preserve and seal the openings airtight with suitable cap plugs.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

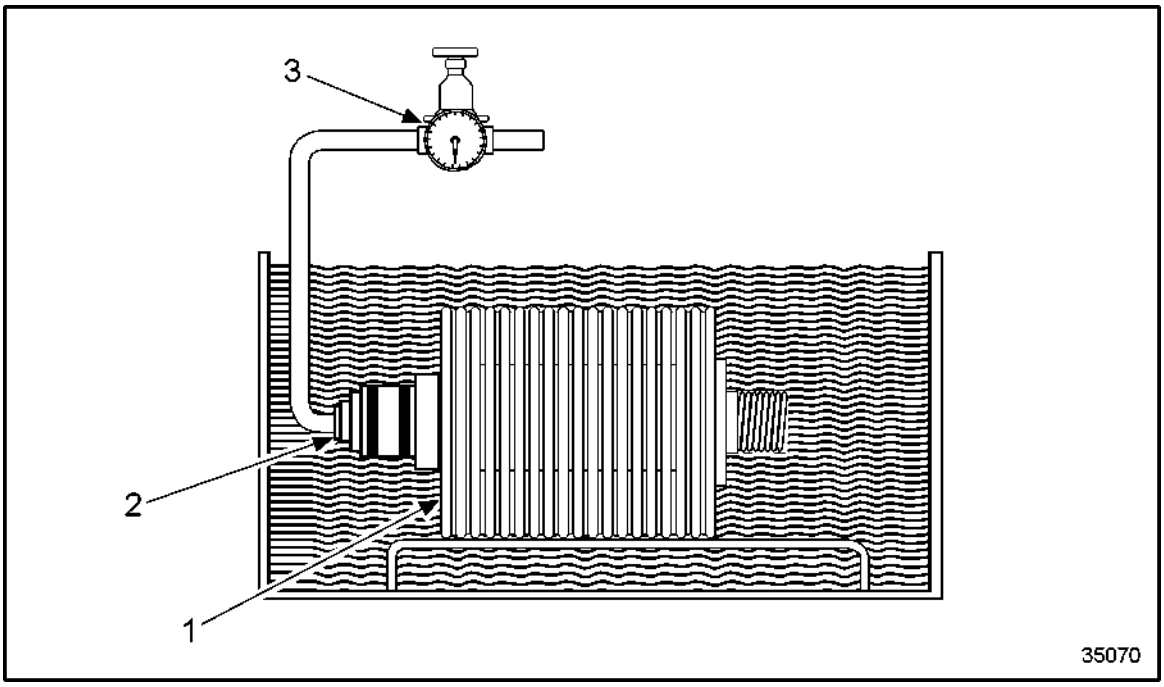
6. Dry in a drying oven between 110 °C (230 °F) and 120° C (248 °F) with an oven drying time of approximately 3 hours.
7. Spray preservation agent into cooler. The preservation agent condenses and falls to form a protective layer over the inner surfaces.

NOTE:
Ensure dosages are correct.

Inspection of Cooler Core for Leaks

Perform the following steps to inspect cooler core for leaks:

1. Seal oil chamber connections of cooler core (1) with suitable sleeves, blanking plugs, plugs with connection (2) and clamps. See Figure 805.



1. Cooler Core
2. Plug with Connection
3. Pressure Reducer

Figure 805 Inspecting Cooler Core for Leaks

2. At plug with connection (2), seal compressed air line. See Figure 805.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

3. Soak cooler core (1) in test basin filled with water heated to 80 °C (176 °F). See Figure 805.

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.

4. Open compressed air supply and set pressure reducer (3) to 0.5 bar. See Figure 805.
5. Pressure-test charge air cooler for leaks with air in water bath and inspect for emerging bubbles, indicating leaks.
   [a] If bubbles emerge, replace cooler core.
   [b] If no bubbles emerge, continue inspection.
6. After testing, remove compressed air line, sleeves and plugs.

CAUTION:

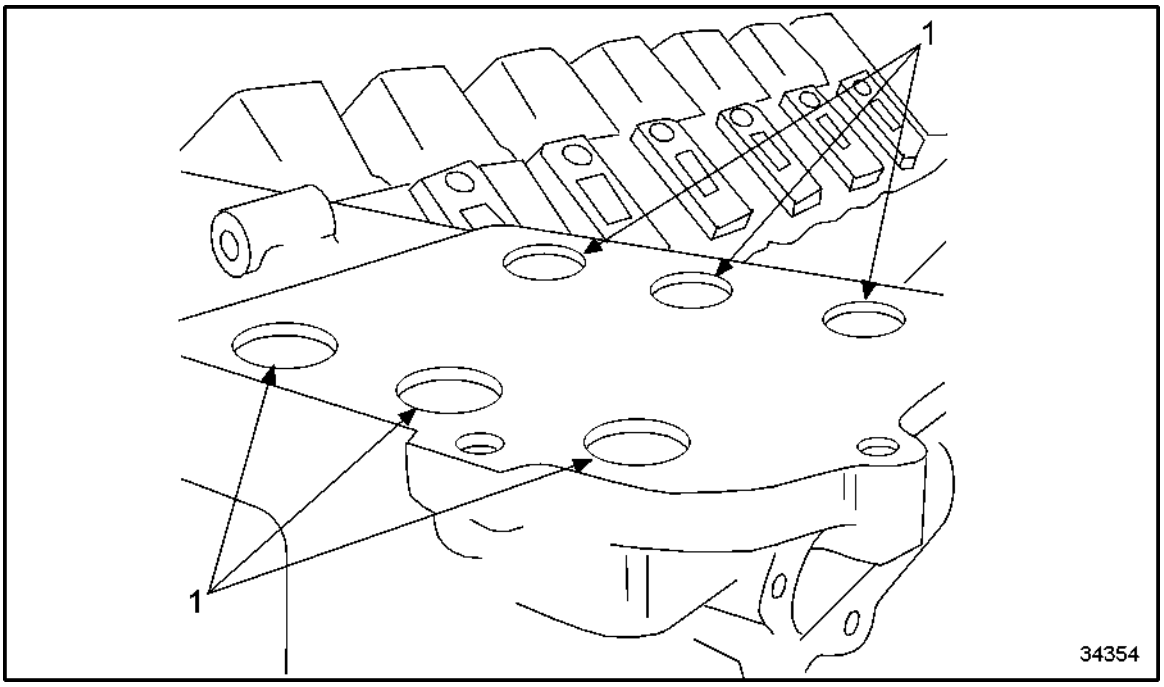
To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

7. Blow out cooling fins of cooler core (1) with compressed air in vertical direction. See Figure 805.

C 185.05.11 – INSTALLATION OF OIL COOLING SYSTEM

Perform the following steps for the installation of the oil cooling system:

1. To install oil cooler core, first ensure that oil chambers and oil bores (1) are perfectly clean. See Figure 806.

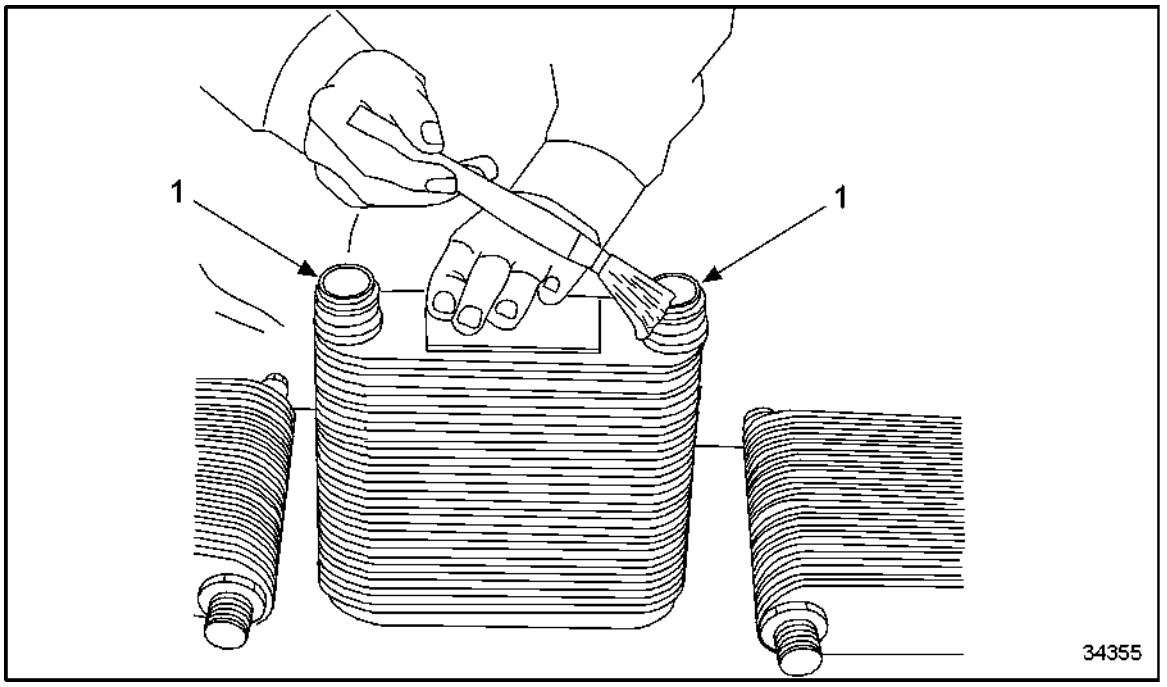


1. Oil bores

Figure 806 Inspecting Oil Chambers and Bores

NOTE:
Prior to installation, remove all blanking plugs and/or covers.

2. Before installing oil cooler core, coat O-rings (1) with petroleum jelly. See Figure 807.



1. O-ring

Figure 807 Coating O-rings of Oil Cooler Core with Petroleum Jelly

3. If necessary, remove blanking plugs and/or covers in cooler core.
4. Install oil cooler core in coolant distribution housing. See Figure 808.

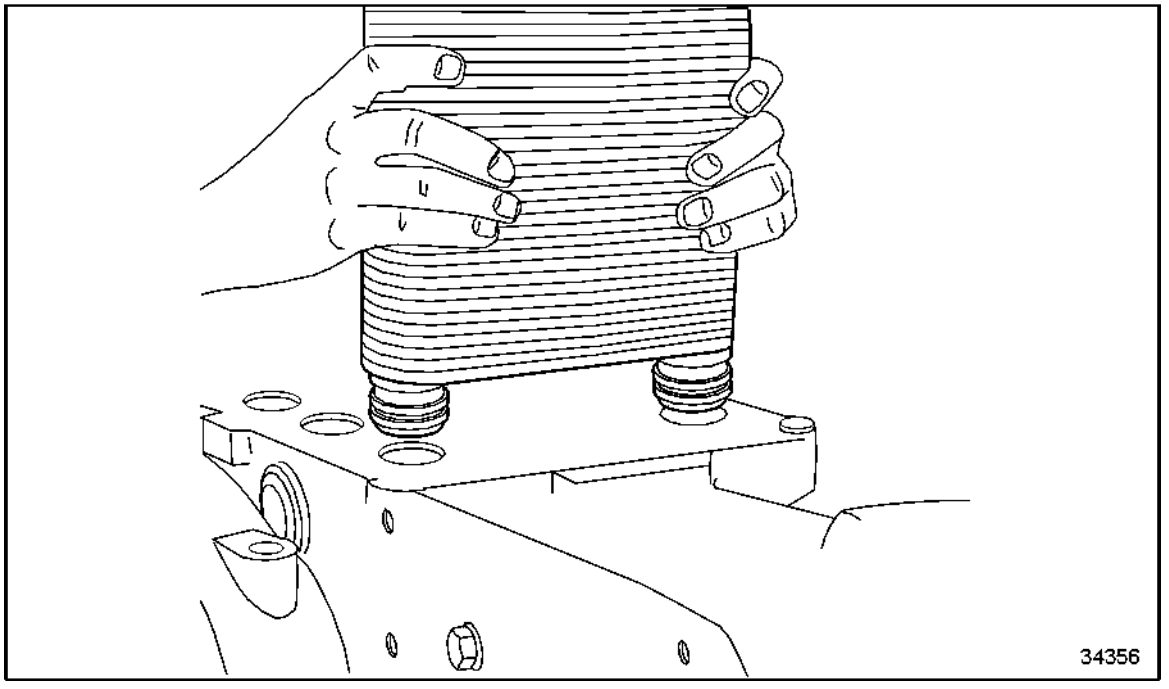
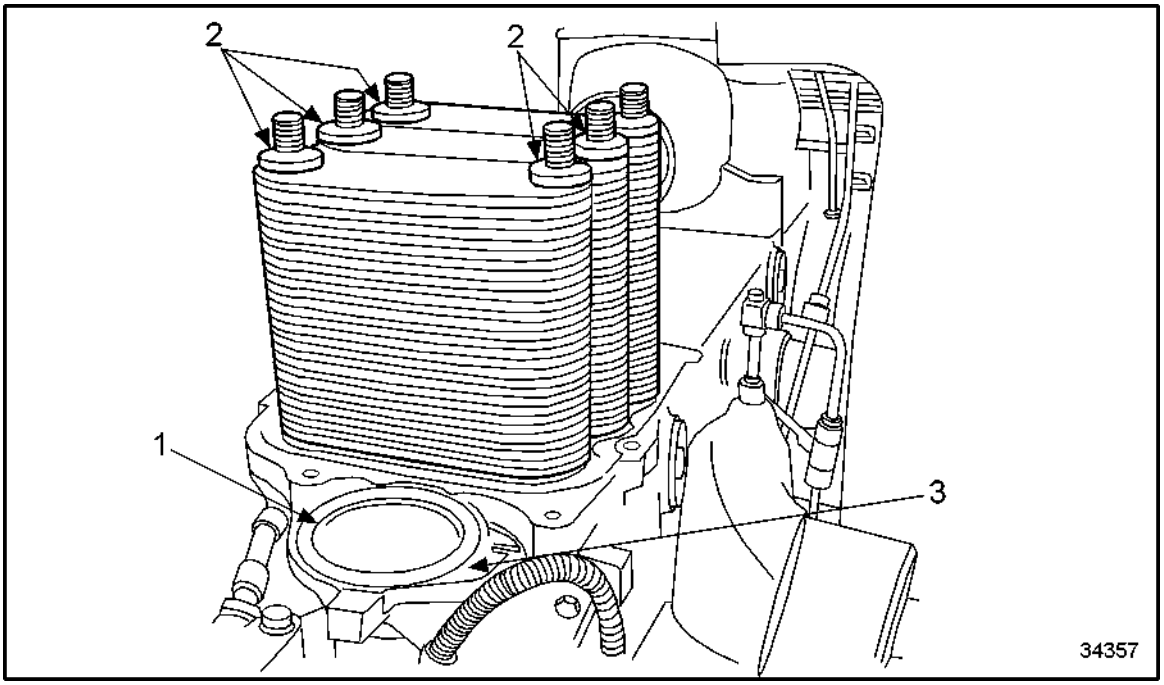


Figure 808 Installing Oil Cooler Core

5. Place sealing washers (2) over thread of oil cooler core. See Figure 809.

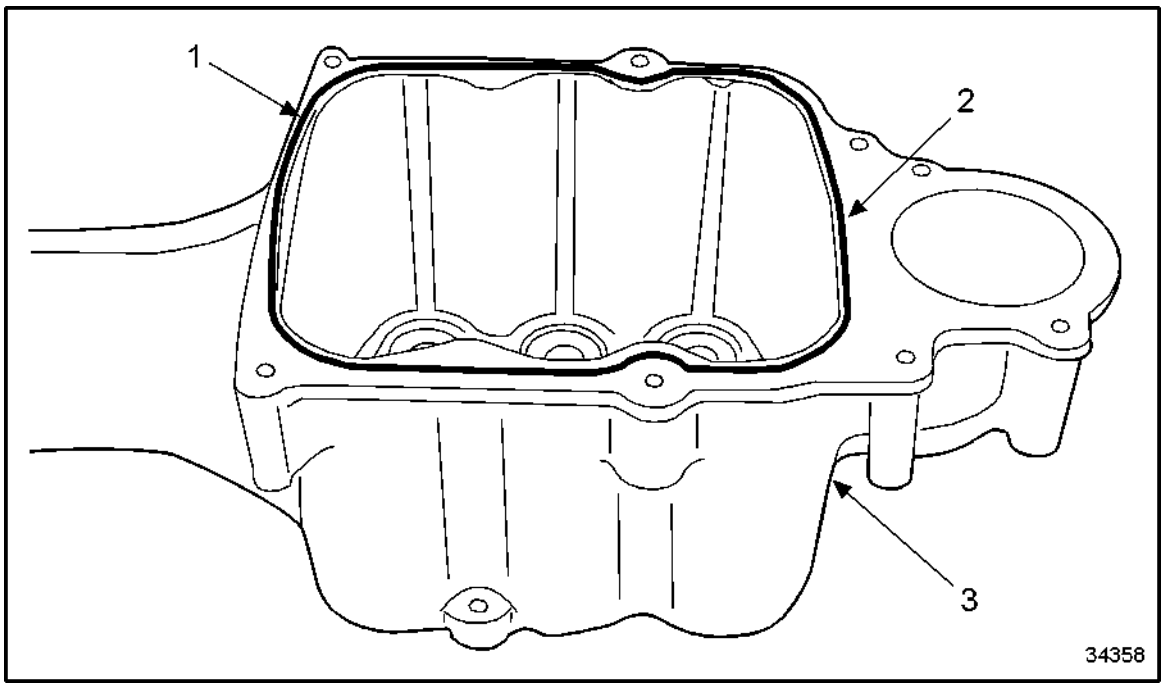


1. O-Ring
2. Sealing Washers
3. Elbow Groove

Figure 809 Placing Sealing Washers over Thread of Oil Cooler Core

6. Coat O-ring (1) with petroleum jelly and insert in elbow groove.

7. Clean O-ring groove (1). See Figure 810.



1. O-ring Groove
2. O-ring
3. Oil Cooler Housing

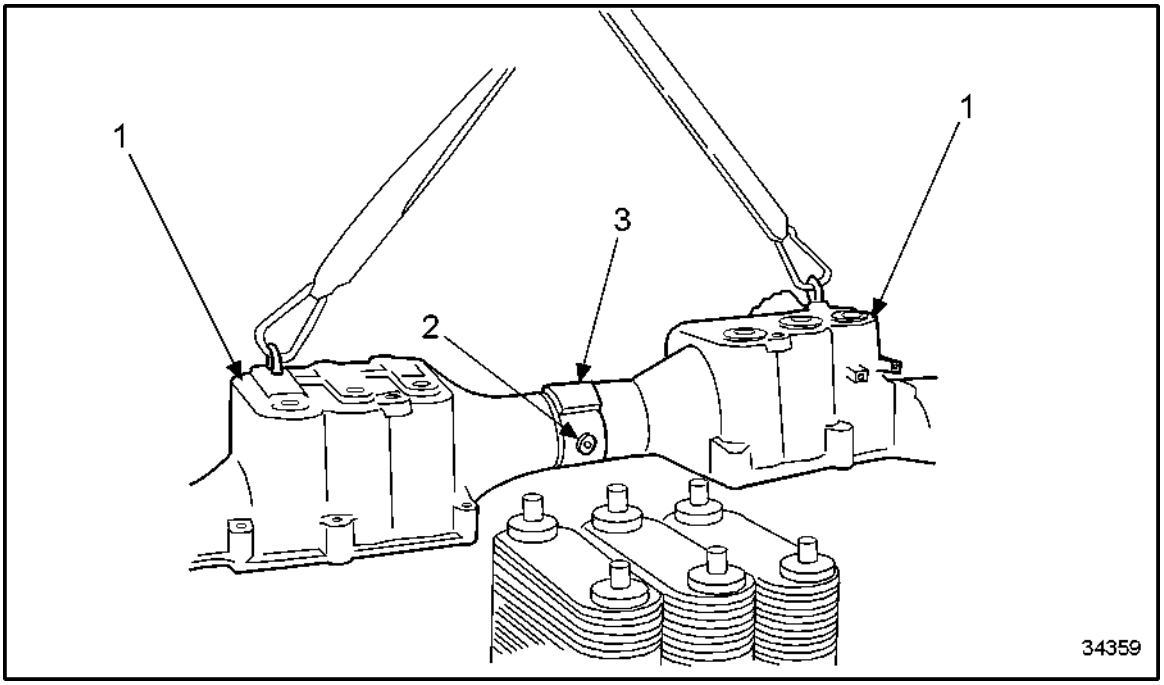
Figure 810 Inserting O-ring in Groove on Oil Cooler Housing

8. Coat O-ring (2) with petroleum jelly and insert in groove on oil cooler housing (3).

NOTE:
Early engine (sealed oil cooler housing with gasket) assembly sequence is the same as with O-ring.

9. Ensure that sealing surface of distribution housing is perfectly clean.

10. Before installing plug-in pipe (2), coat O-rings with petroleum jelly. See Figure 811.



1. Oil Cooler Housing
2. Plug-in Pipe
3. Bracket

Figure 811 Lifting Oil Cooler Housing and Installing on Coolant Distribution Housing

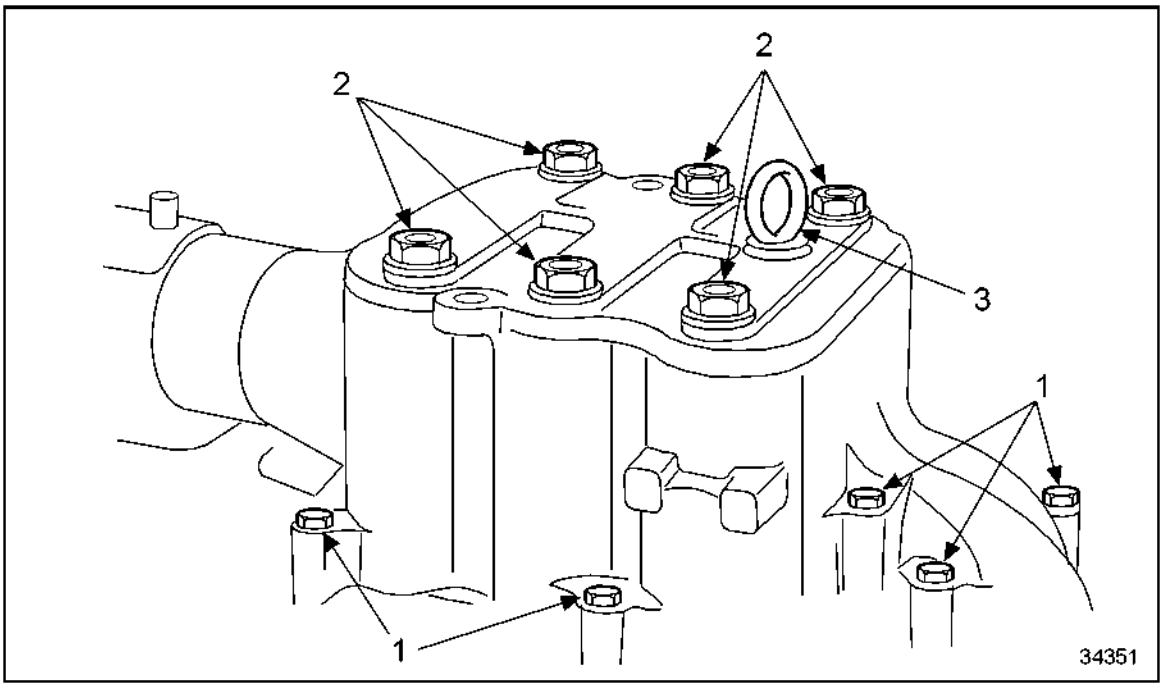
11. Install plug-in pipe (2) with bracket (3) on oil cooler housing. See Figure 811. Also See Figure 796for general view.

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.

12. Attach oil cooler housing with lifting eyes (3), suitable lifting device, and install on coolant distribution housing with hex bolts (1).

13. Remove lifting eye (3). See Figure 812.

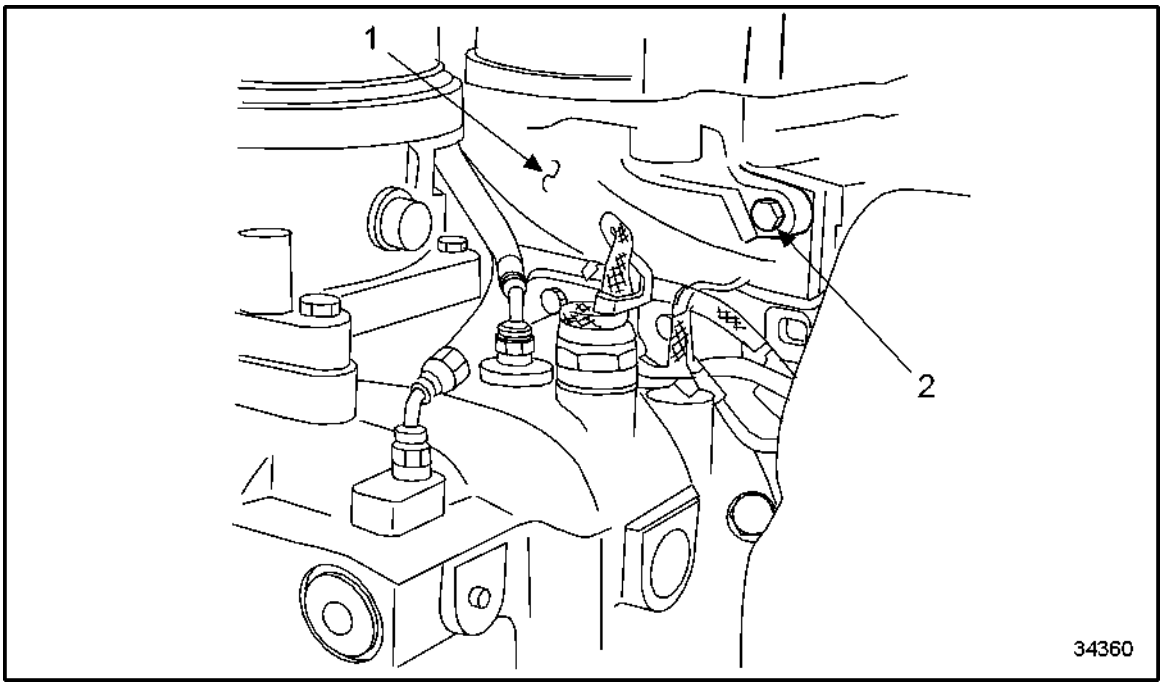


1. Hex Bolt
2. Nut
3. Lifting Eye

Figure 812 Torquing Bolts and Nuts on Oil Cooler Housing

14. Tighten hex bolts (1) to specification. Refer to section A 003.
15. Install nuts (2) and tighten to specification. Refer to section A 003.

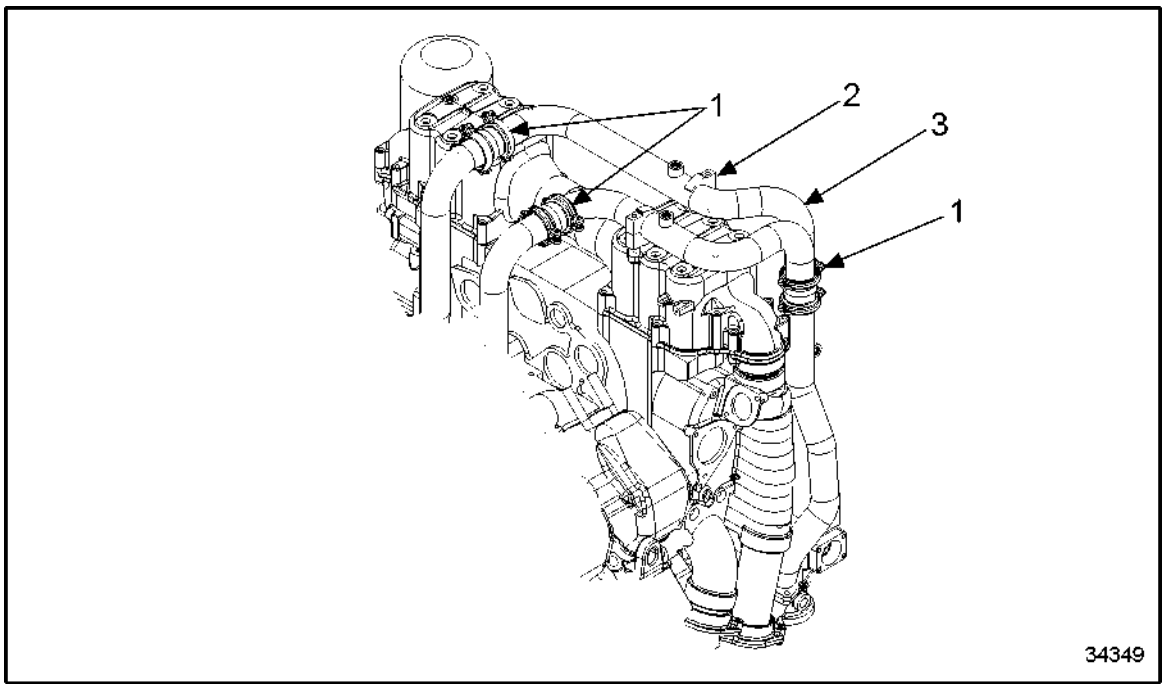
16. Tighten hex bolts (2) for elbow (1) of coolant pipework to specification. Refer to section A 003. See Figure 813.



1. Elbow
2. Hex Bolts

Figure 813 Torquing Hex Bolts for Elbow of Coolant Pipework

17. To install coolant lines, first install pipe from charge air cooler (3). See Figure 814.

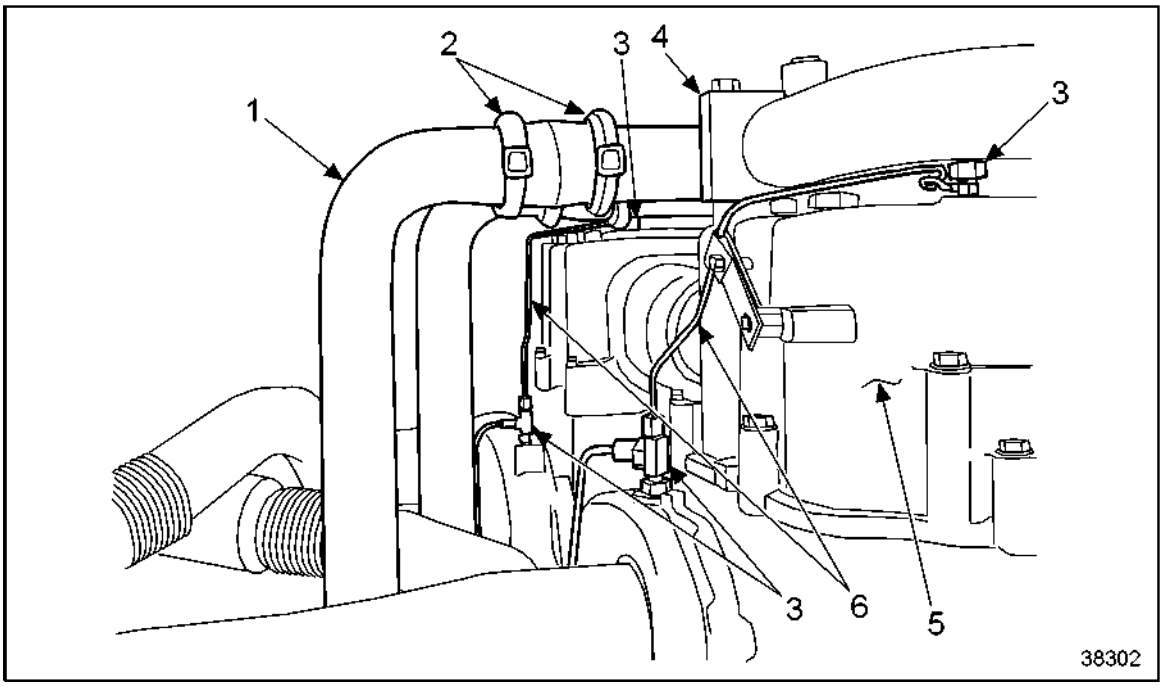


1. V-clamp
2. Retainer
3. Pipe from Intercooler

Figure 814 Installing Pipe from Charge Air Cooler

18. Coat seal (arrow) with petroleum jelly.
19. Install and center V-clamps (1) and pipe connection (3) on pipe.
20. Install hex bolts for V-clamps, but do not tighten.
21. Install bracket (2) with hex bolt and nut, but do not tighten.

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

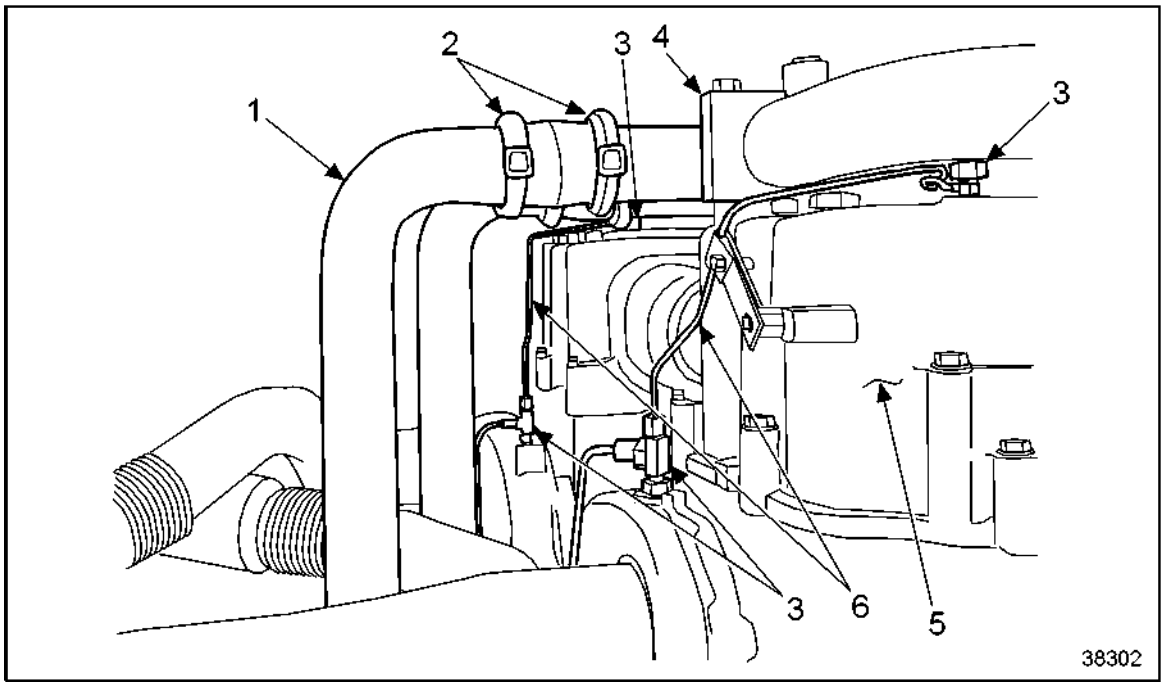


1. Charge Air Cooler Pipe
2. Coupling
3. Vent Lines Connection
4. Charge Air Cooler Pipe Support Bracket
5. Oil Cooler Housing
6. Vent Lines

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).

26. Install pipe to charge air cooler. See Figure 816.



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 816 Installing Pipe to Charge Air Cooler

27. Coat seal with petroleum jelly.
28. Install and center V-clamps (5) and pipe connection (6) on pipe.
29. Install hex nuts for V-clamps (5), but do not tighten.
30. Install vent lines (3) tension-free.
31. Install bracket with spacer shim (1) and hex bolt, but do not tighten.

C 185.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 112 are the After-Installation Operations for the oil cooling system.

Level of Maintenance	Operation	Reference
1, 2, 3	Fill charge air coolant system	Refer to section C 206.05.11
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Enable engine start	Refer to Operators Guide

1 = The engine is to be completely disassembled.

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

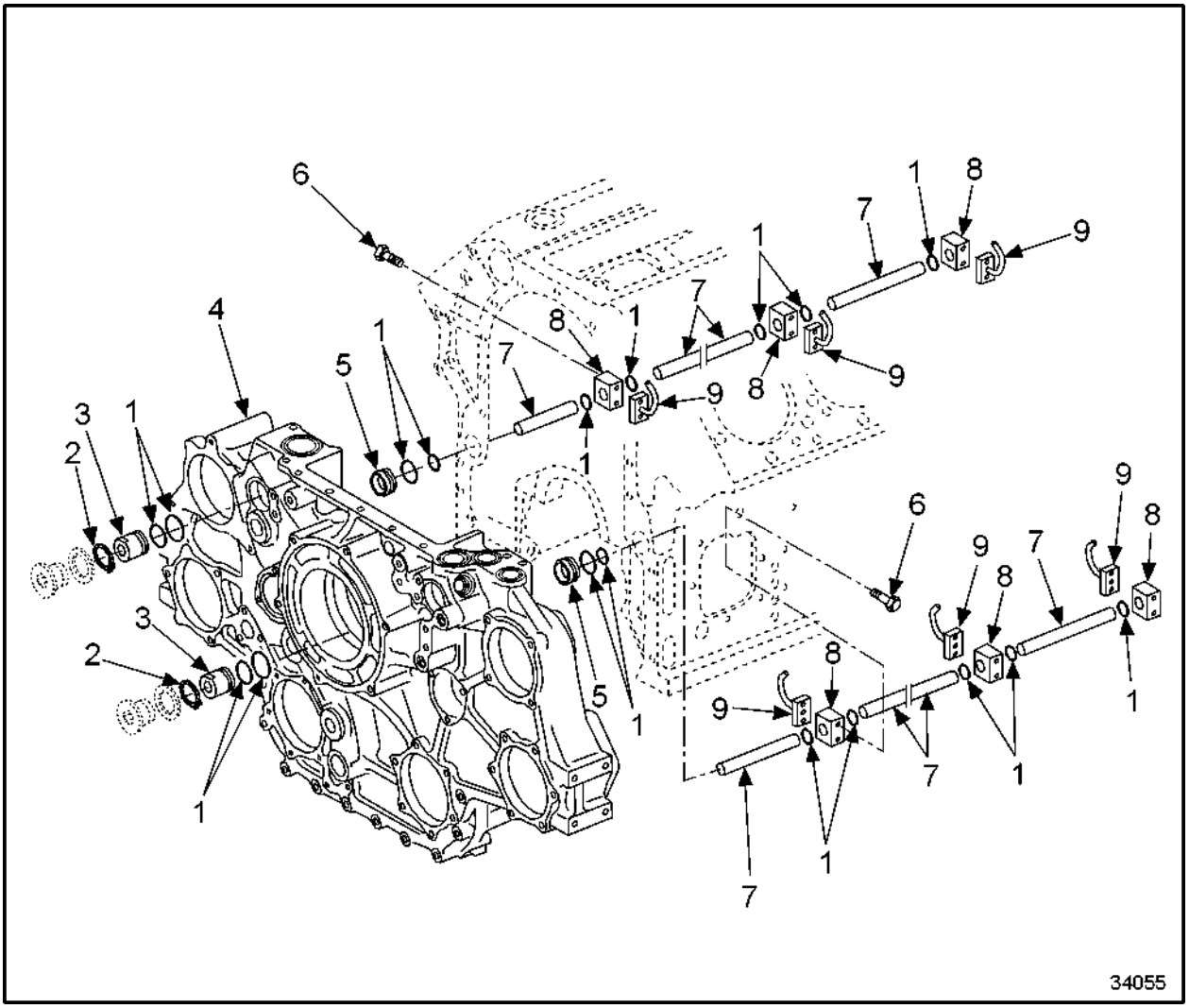
3= The engine is to remain installed.

Table 112 After-Installation Operations

C 186.05 – OIL SYSTEM FOR PISTON COOLING

C 186.05.01 – GENERAL VIEW

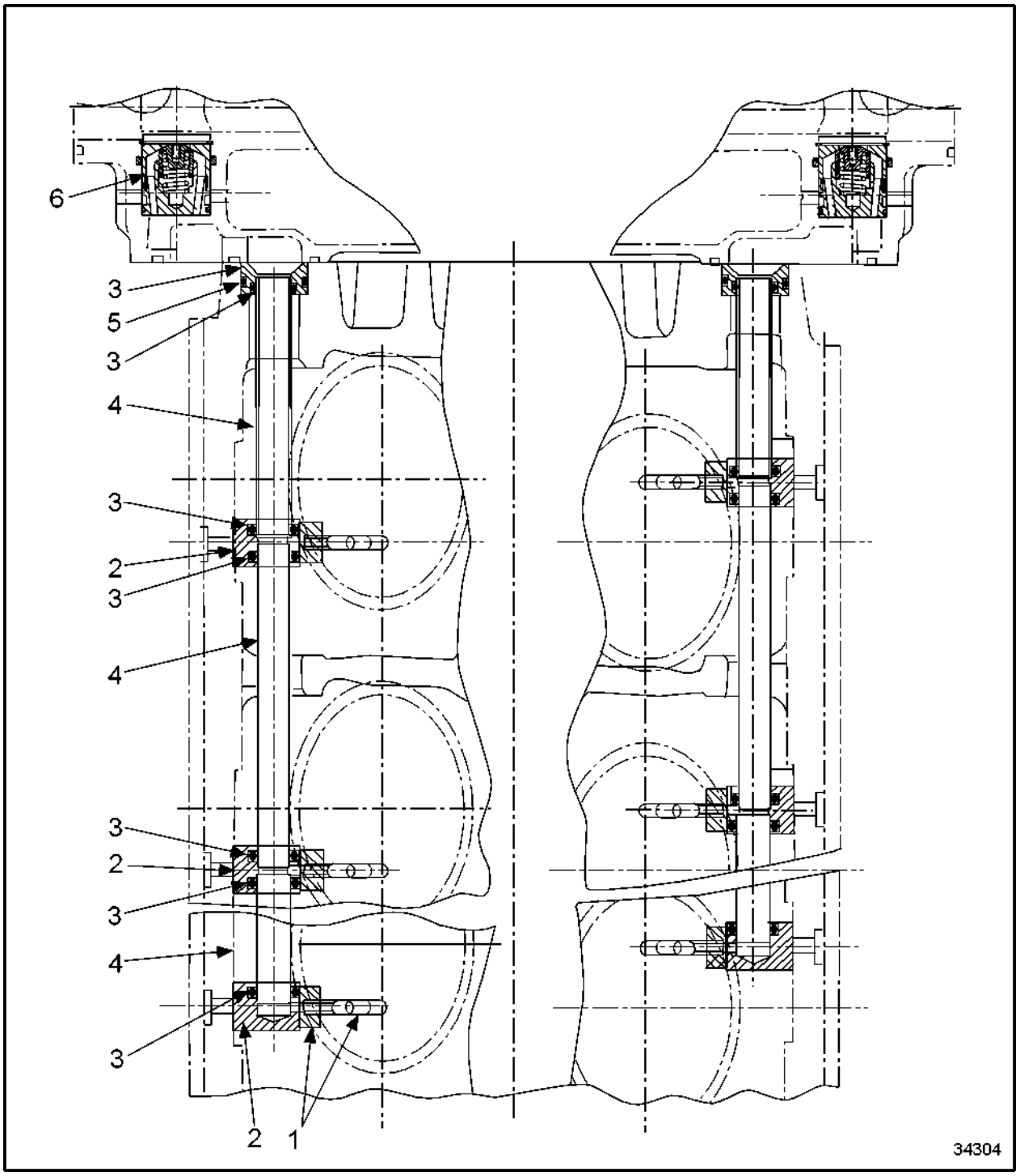
See Figure 817 for a general view of the oil system for piston cooling.



1. O-ring
2. Snap Ring
3. Delivery Valve
4. Gear Case Cover
5. Washer
6. Hex Bolt
7. Pipe
8. Bracket
9. Oil Spray Nozzle

Figure 817 General View of Oil System for Piston Cooling

See Figure 818 for a cross section view of the oil system for piston cooling.



1. Oil Spray Nozzle
2. Bracket
3. O-ring
4. Pipe
5. Washer
6. Delivery Valve

Figure 818 Cross Section of Oil System for Piston Cooling

C 186.05.02 – SPECIAL TOOLS

Listed in Table 113 are the special tools required for maintenance on the oil system in for piston cooling.

Application	Number
Gage for oil spray nozzle	—
Engine barring tool	—

Table 113 Special Tools

C 186.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 114 are the Before-Removal Operations for the oil system for piston cooling.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant *	Refer to Operators Guide
1, 2, 3	Drain charge air coolant *	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil *	Refer to Operators Guide
1, 2, 3	Remove fan drive *	Refer to section C 221.05.05
1, 2, 3	Remove engine trunnion mount	Refer to section C 231.05.05
1, 2, 3	Remove vibration damper *	Refer to section C 035.05.05
1, 2, 3	Remove coolant lines (high-temperature) *	Refer to section C 204.05.05
1, 2, 3	Remove charge air coolant lines (low-temperature) *	Refer to section C 207.05.05
1, 2, 3	Mark and disconnect DDEC harness	Refer to section C 501.05 M
1, 2, 3	Remove front drive hub (gear case end) from crankshaft *	Refer to section C 035.05.05
1, 2, 3	Remove SRS wheel*	Refer to section C 032.05.05
1, 2, 3	Remove gear case	Refer to section C 024.05.05
1, 2, 3	Remove oil pan *	Refer to section C 014.05.05

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.

The tasks marked * are not applicable for work on the oil spray nozzle.

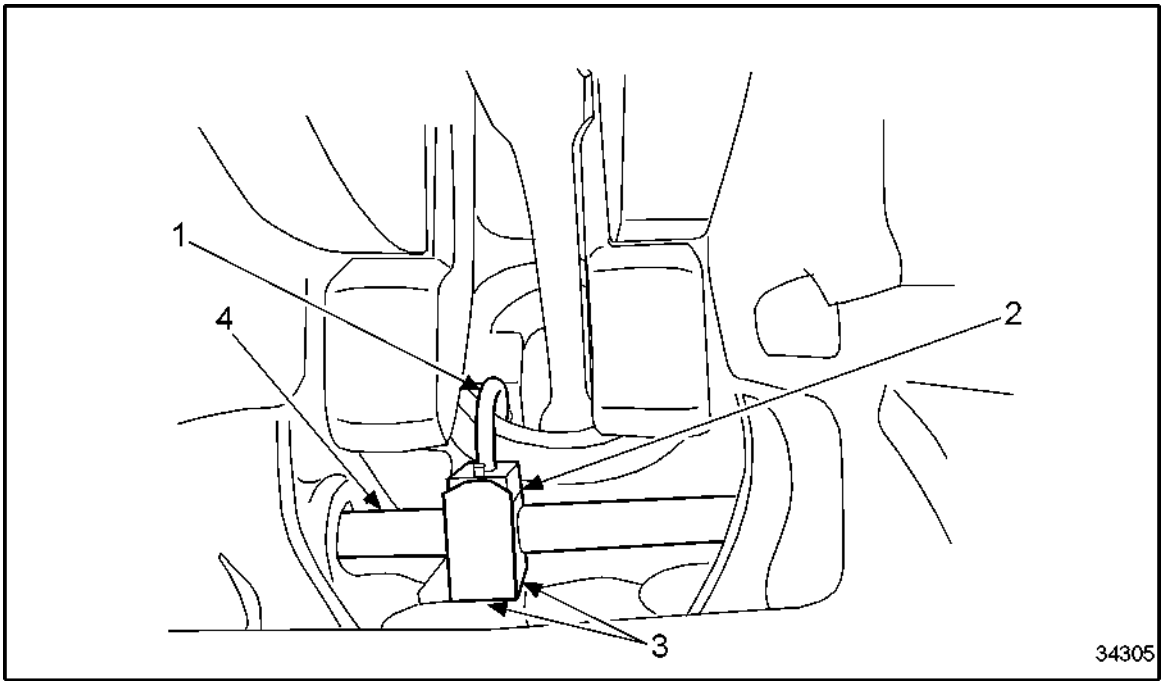
Table 114 Before-Removal Operations

C 186.05.05 – REMOVAL OF OIL SYSTEM FOR PISTON COOLING

Removal of Oil Spray Nozzle

Perform the following steps for the removal of the oil spray nozzle:

1. To remove oil spray nozzle, remove appropriate access port cover.
2. Turn crankshaft until oil spray nozzle (1) to be removed is accessible. See Figure 819.

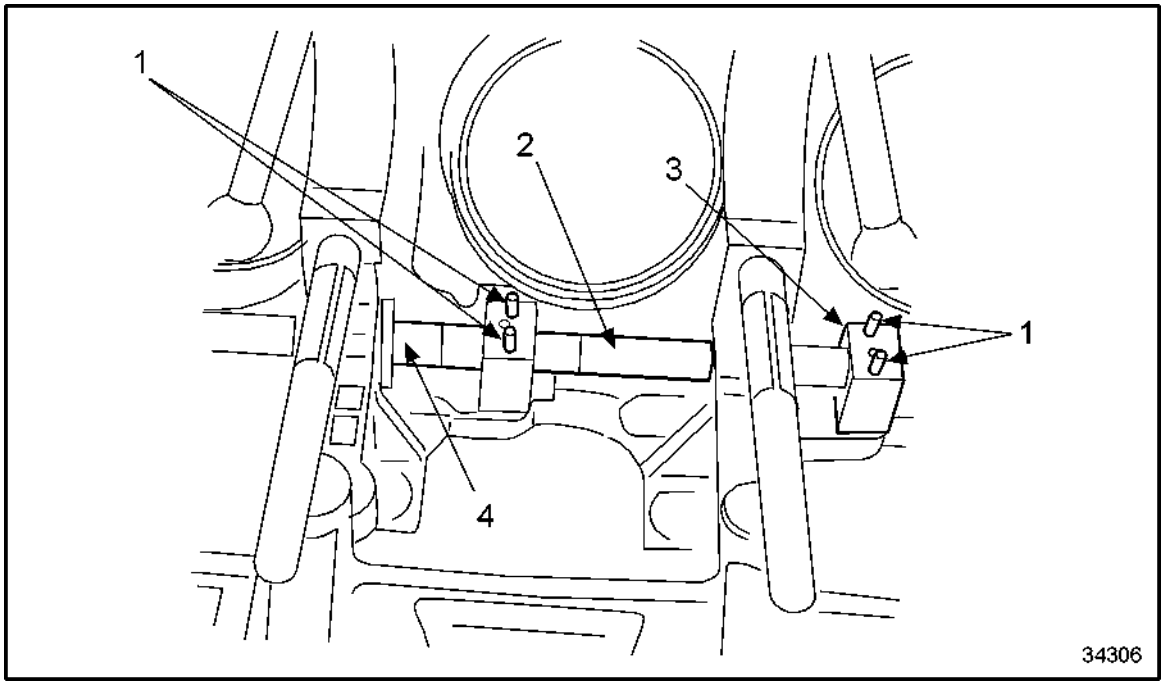


1. Oil Spray Nozzle
2. Bracket
3. Hex Bolt Location
4. Oil Pipe

Figure 819 Removing Oil Spray Nozzle

3. Starting at cylinder A1 or B1, remove hex bolts (3).
4. Remove oil spray nozzle (1) from bracket (2).
5. Remove bracket from oil pipe (4).

6. Turn crankshaft until oil spray nozzle to be removed next is accessible.
7. Remove oil pipe from bracket (3). See Figure 820.



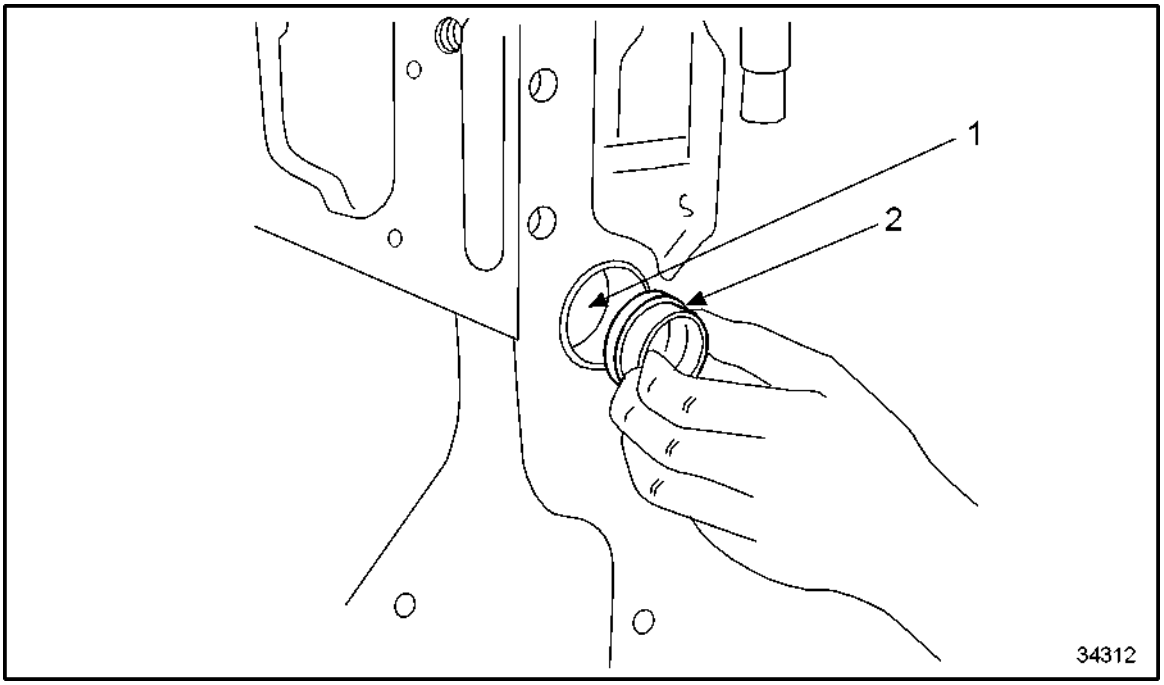
1. Aligning Pins
2. Oil Pipe
3. Bracket
4. Oil Pipe

Figure 820 Removing Oil Pipe from Release Bracket

Removal of Seal Washer

Perform the following steps to remove the seal washer:

1. Remove seal washer (2) from cylinder block. See Figure 821.



1. Oil Pipe
2. Seal Washer

Figure 821 Installing Seal Washer Manually in Cylinder Block

2. Remove O-rings on seal washer.

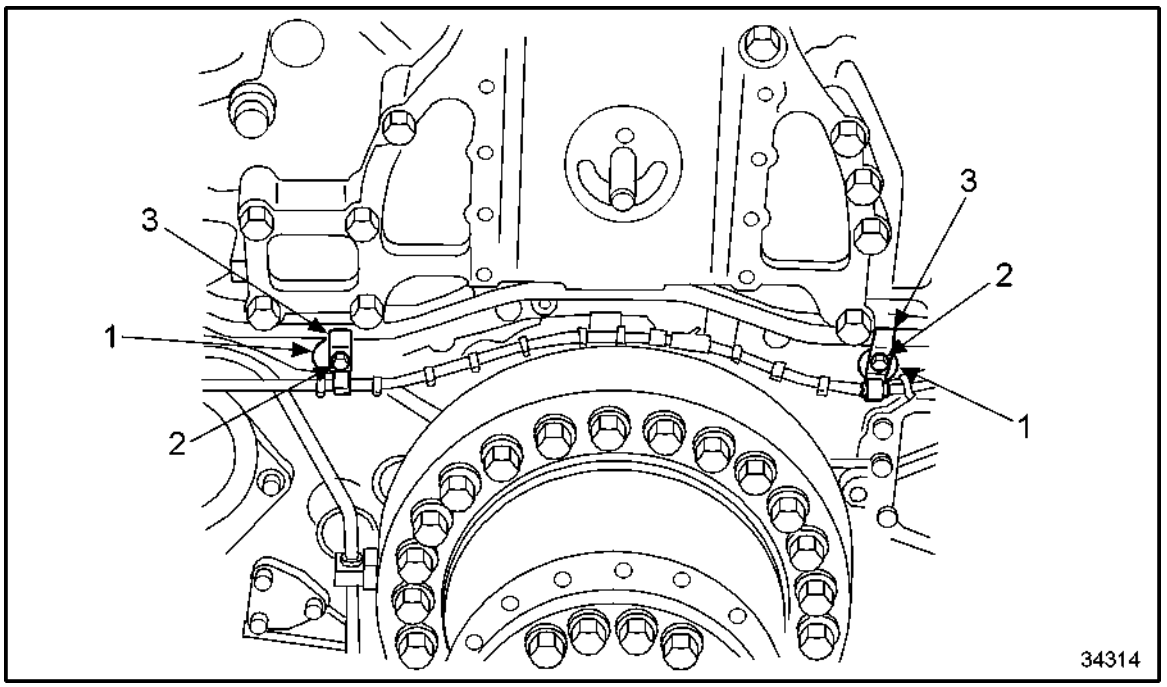
Removal of Delivery Valve

Perform the following steps to remove the delivery valve.

NOTE:
For removal of fan drive, refer to section C 221.05.05.

NOTE:
For removal of trunnion mounts, gear case end, refer to section C 231.05.05.

1. Remove hex bolts (2). See Figure 822.

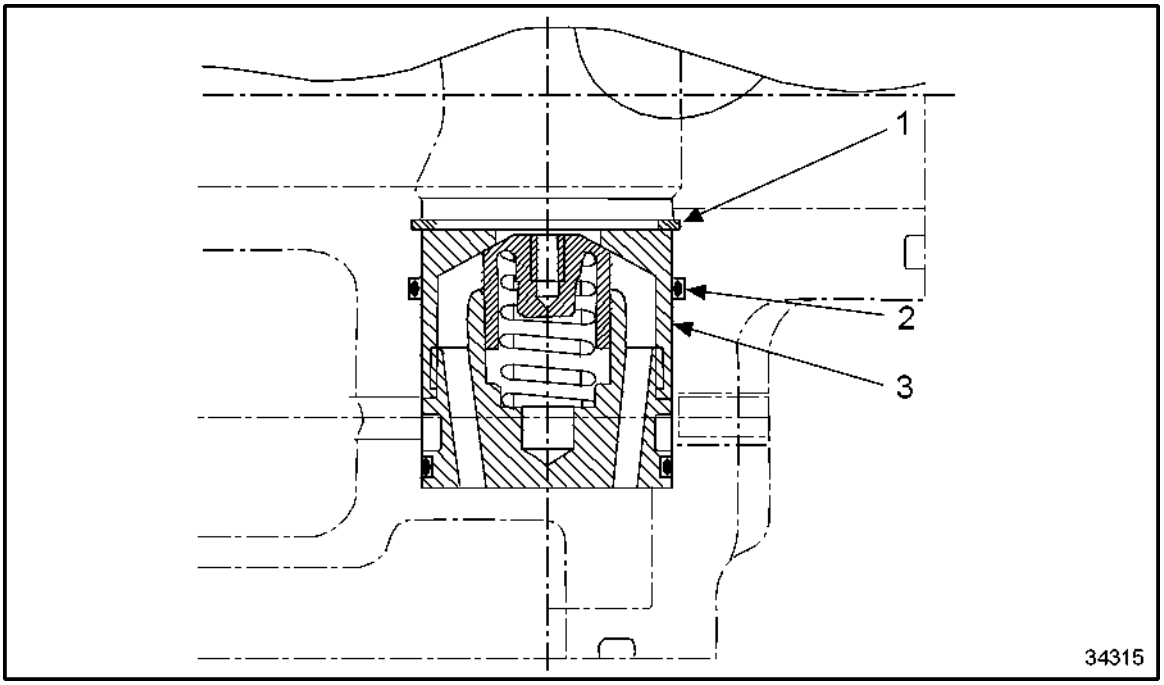


1. Plug
2. Hex Bolt
3. Pipe Clamp Half

Figure 822 Removing Hex Bolts

2. Remove pipe clamp halves (3)
3. Remove plugs (1) under high-pressure fuel line.

4. Remove snap ring (1) from housing. See Figure 823.



1. Snap Ring
2. O-ring
3. Delivery Valve

Figure 823 Removing Snap Ring

5. Remove delivery valve (3) from housing.

C 186.05.08 – INSPECTION AND REPAIR

Inspection and Repair

Perform the following steps for the inspection and repair of oil spray nozzle:

NOTE:
Ensure that parts are perfectly clean.

CAUTION:

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

1. Clean oil spray nozzle, bracket and oil pipe with a suitable cleaner and carefully blow clear with dry air.
2. Visually inspect oil spray nozzle for damage and defects.
   [a] If oil spray nozzle shows damage or defects, replace component as necessary.
   [b] If oil spray nozzle does not show damage or defects, continue inspection.
3. Visually inspect oil spray nozzle for surface cracks using red penetrant dye.
   [a] If oil spray nozzle is cracked, replace nozzle as necessary.
   [b] If oil spray nozzle is not cracked, continue inspection.

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.

4. Pressure-test oil pipe lines for leaks with compressed air in water bath as necessary.
   [a] If oil pipe lines show leaks, replace lines as necessary.
   [b] If oil pipe lines do not show leaks, continue inspection.

NOTE:
Test pressure is 0.5 bar.

CAUTION:

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

5. Blow dry oil pipe lines after pressure testing with compressed air.

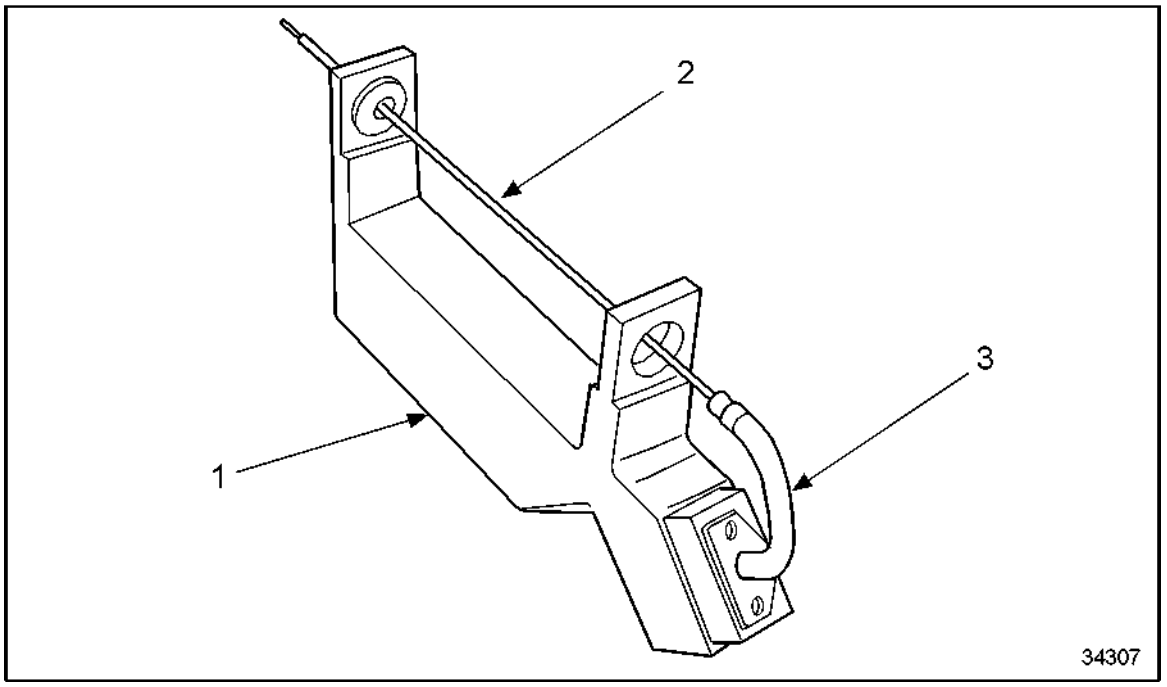
NOTE:
Component and coolant temperature minimum is 30°C (86°F). Maximum temperature is 40°C if component must be held in hands.

6. Visually inspect threads of components for wear and damage.
   [a] If threads are damaged or worn, rechase threads as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If threads are not damaged or worn, continue inspection.
7. Visually inspect sealing and mating surfaces of oil spray nozzle for wear and damage.
   [a] If sealing and mating surfaces of oil spray nozzle are worn or damaged, rub down with emery cloth or oilstone as necessary.
   [b] If damage is beyond repair, replace oil spray nozzle.
   [c] If sealing and mating surfaces are not damaged, reuse the oil spray nozzle.
8. Visually inspect oil bore of oil spray nozzle for obstructions, and ensure that it is perfectly clean.

Inspecting Spray Direction of Oil Spray Nozzle

Perform the following steps to check inspect direction of oil spray nozzle:

1. Attach oil spray nozzle (3) to gage (1). See Figure 824.



1. Gage
2. Aligning Brass Drift
3. Oil Spray Nozzle

Figure 824 Inspecting Spray Direction of Oil Spray Nozzle

2. Inspect direction of spray with aligning brass drift (2). See Figure 824.
   [a] If oil spray nozzle (3) is bent, correct nozzle as necessary.
   [b] If oil spray nozzle (3) is beyond repair, replace component as necessary.
   [c] If the oil spray pipe is not bent, continue inspection.

Inspection and Repair

Perform the following steps to inspect and repair the seal washer:

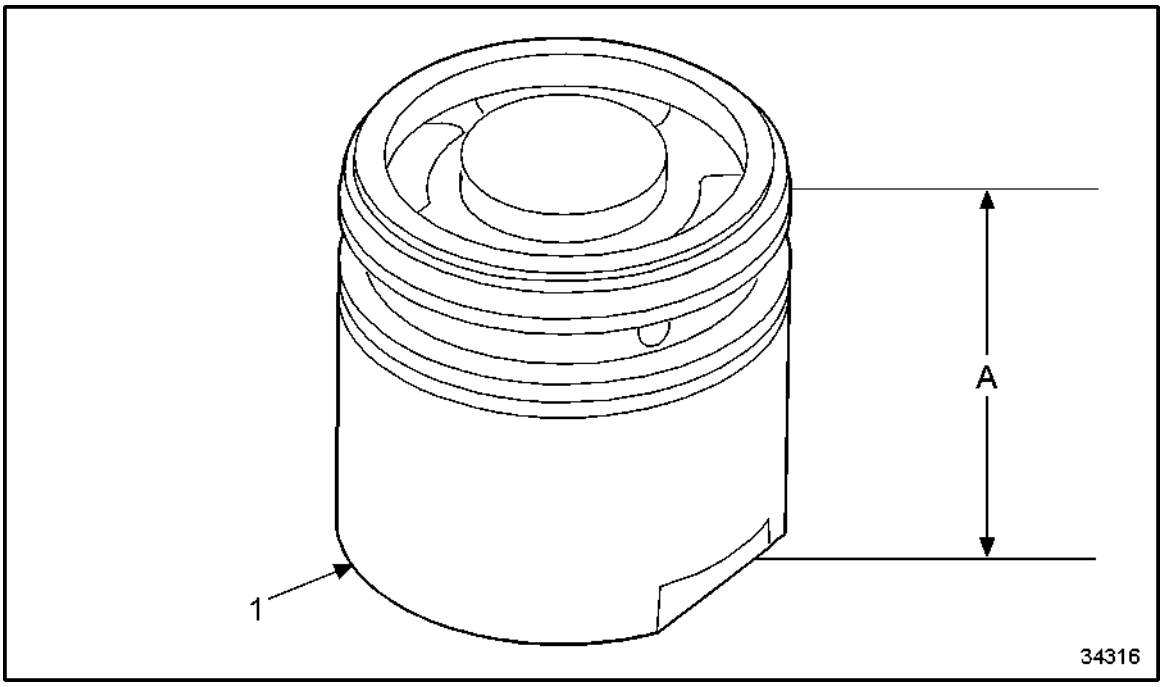
1. Clean seal washer.
2. Visually inspect seal washer for wear, cracks and damage.
   [a] If seal washer is worn, cracked or damaged, replace as necessary.
   [b] If seal washer is not worn, cracked or damaged, continue inspection.
3. Visually inspect bore in cylinder block for wear.
   [a] If bore in cylinder block shows wear, smooth with emery cloth as necessary.
   [b] If bore in cylinder block does not show wear, continue inspection.

Inspection and Repair

Perform the following steps to inspect and repair the delivery valve:

NOTE:
Do not disassemble delivery valve.

1. Visually inspect delivery valve for damage.
   [a] If delivery valve is damaged, replace component.
   [b] If delivery valve is not damaged, continue inspection.
2. Visually inspect sealing surface (1) for unevenness. See Figure 825.
   [a] If sealing surface is uneven, smooth with oilstone as necessary.
   [b] If sealing surface is not uneven, continue inspection.



1. Sealing Surface

Figure 825 Visually Inspecting Sealing Surface

NOTE:
"A" is 49.8 mm +0.1 mm/-0.3 mm.

CAUTION:

To avoid personal injury, use care when dealing with fluids under pressure. Fluids under pressure have enough force to penetrate the skin. These fluids can cause a minor cut or opening in the skin. If injured by escaping fluid, see a doctor immediately. Serious infection or adverse reaction to the fluid can result if not treated immediately.

3. Ensure that delivery valve opening pressure is 2.50 bar ± 0.25 bar.
   [a] If values are outside specified limits, replace delivery valve.
   [b] If values are within specified limits, continue inspection.

NOTE:
Opening pressure is marked in valve seat.

NOTE:
Earlier engines had delivery valves without O-rings and opened at 1.50 bar ± 0.25 bar.

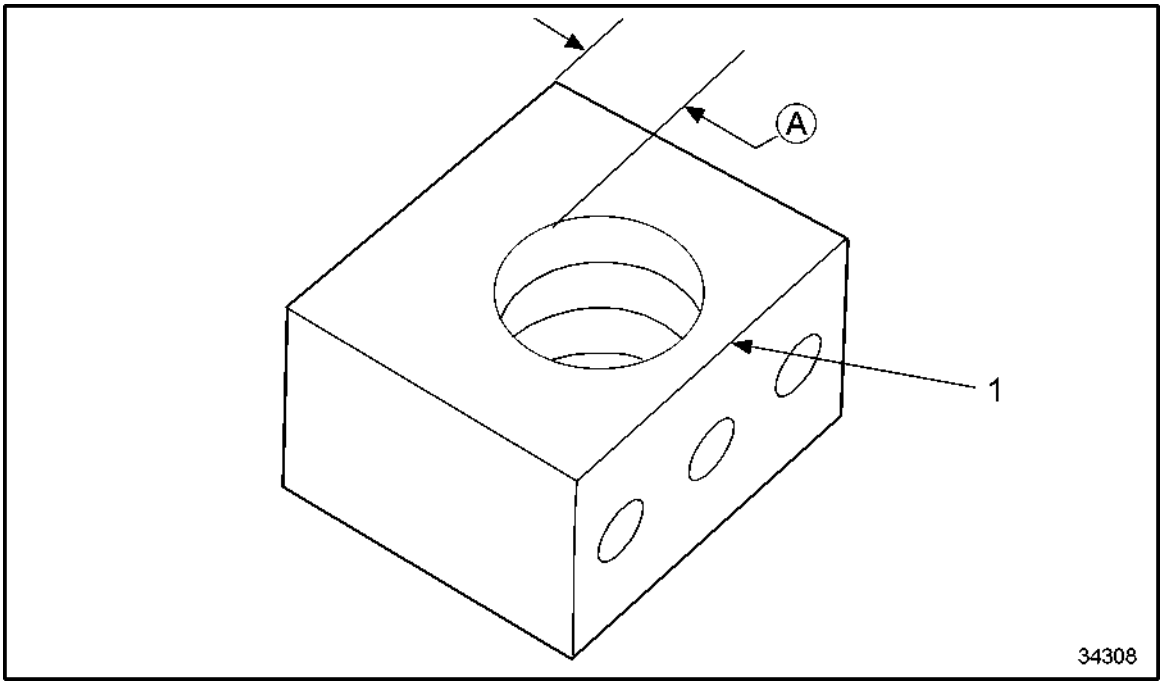
C 186.05.11 – INSTALLATION OF OIL SYSTEM FOR PISTON COOLING

Installation of Oil Spray Nozzle

Perform the following steps to install the oil spray nozzle:

NOTE:
Ensure that all components are perfectly clean.

1. Coat O-rings with petroleum jelly and insert into grooves on oil pipes. See Figure 826. Also See Figure 817 for a general view of the oil system for piston cooling.



1. Bracket

Figure 826 Installing Oil Spray Nozzle

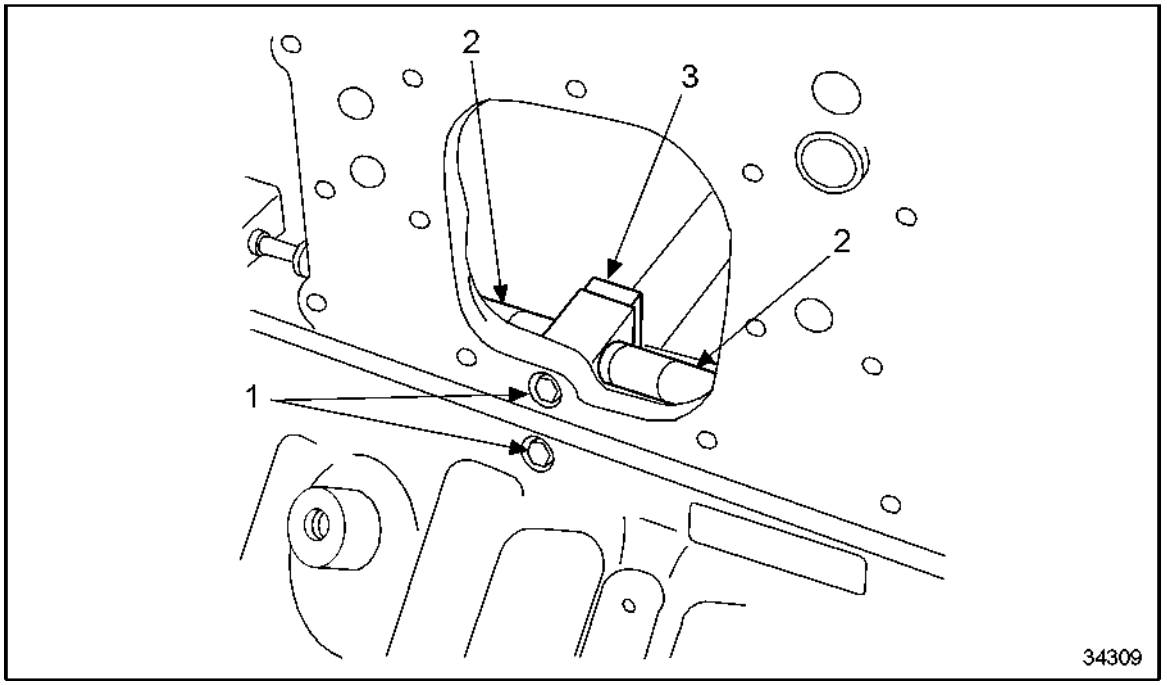
NOTE:
Distance “A” from bracket (1) is to cylinder block.

2. Ensure that bracket (1) is correctly positioned. See Figure 826. Also see Figure 817for a general view of the oil system for piston cooling.

NOTE:
Ensure that all components are perfectly clean.

3. Coat O-rings with petroleum jelly and insert into grooves on oil pipes. See Figure 817 for a general view of the oil system for piston cooling.

4. Install oil pipe(s) (2) in oil spray nozzle brackets (3) and secure with hex bolts (1) through cylinder block. See Figure 827.



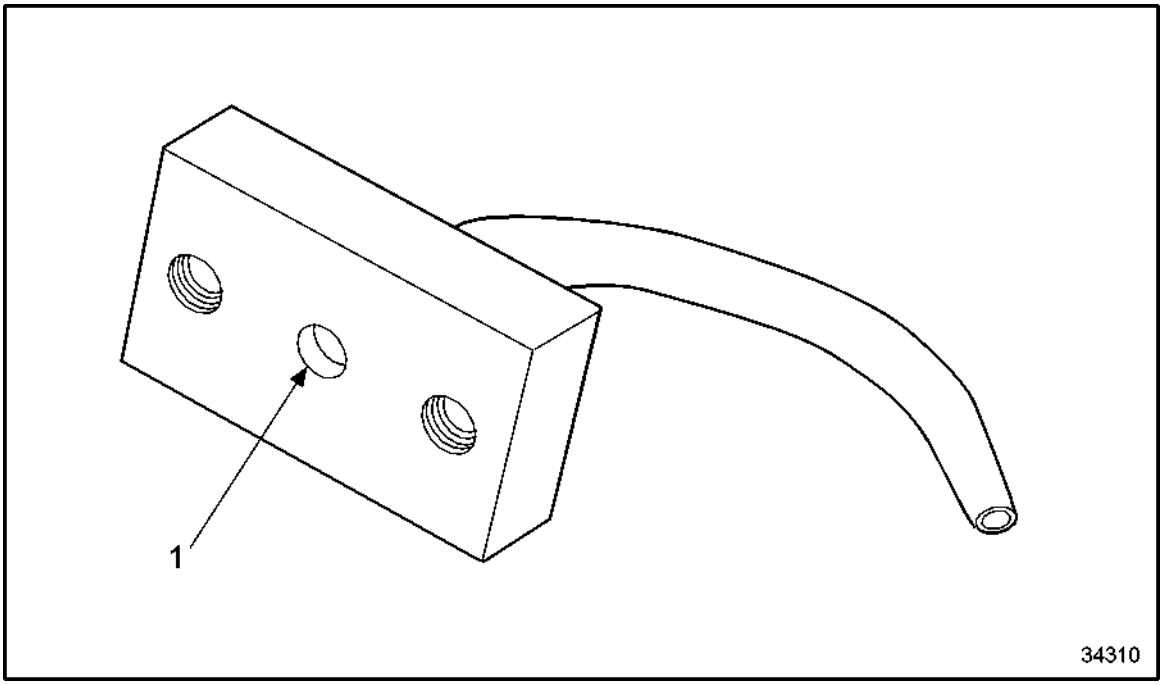
1. Hex Bolts
2. Oil Pipe
3. Oil Spray Nozzle Bracket

Figure 827 Installing Oil Pipes

CAUTION:

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

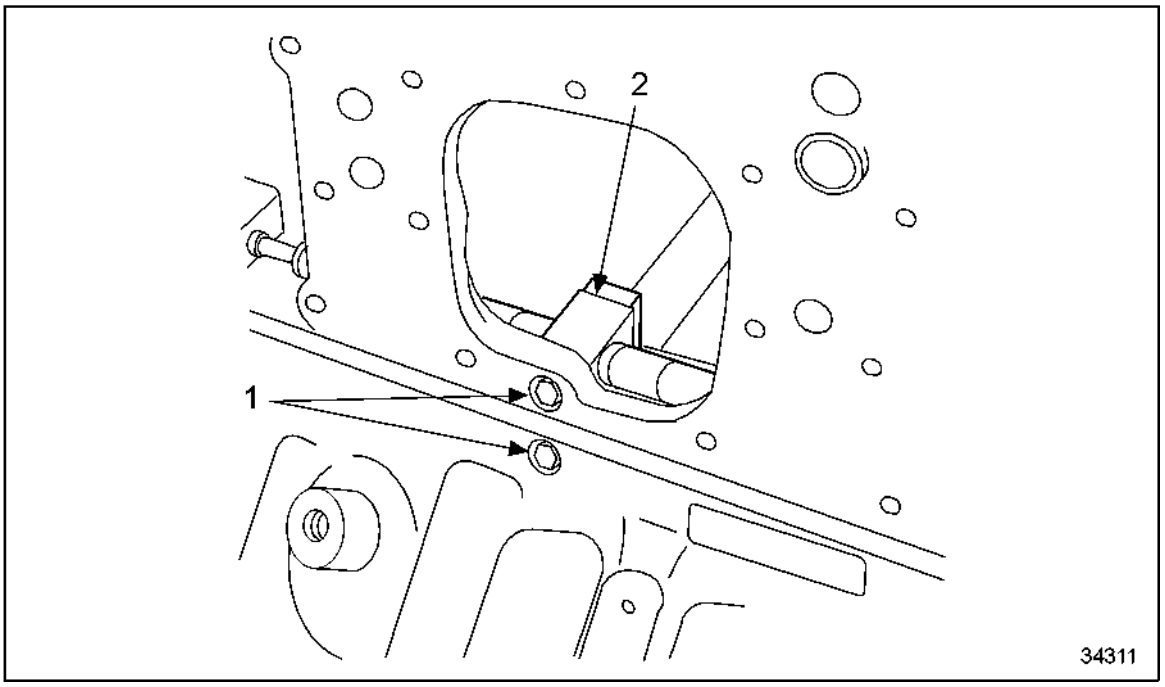
5. Blow out oil bore (1) for oil spray nozzle with compressed air and ensure that it is perfectly clean and not obstructed. See Figure 828.



1. Oil Bore

Figure 828 Blowing Out Oil Bore with Compressed Air

6. Install oil spray nozzle (2). See Figure 829.



1. Hex Bolts
2. Oil Spray Nozzle

Figure 829 Installing Oil Spray Nozzle/Tightening Hex Bolts

7. Tighten hex bolts (1) to specification. Refer to section A 003.

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.

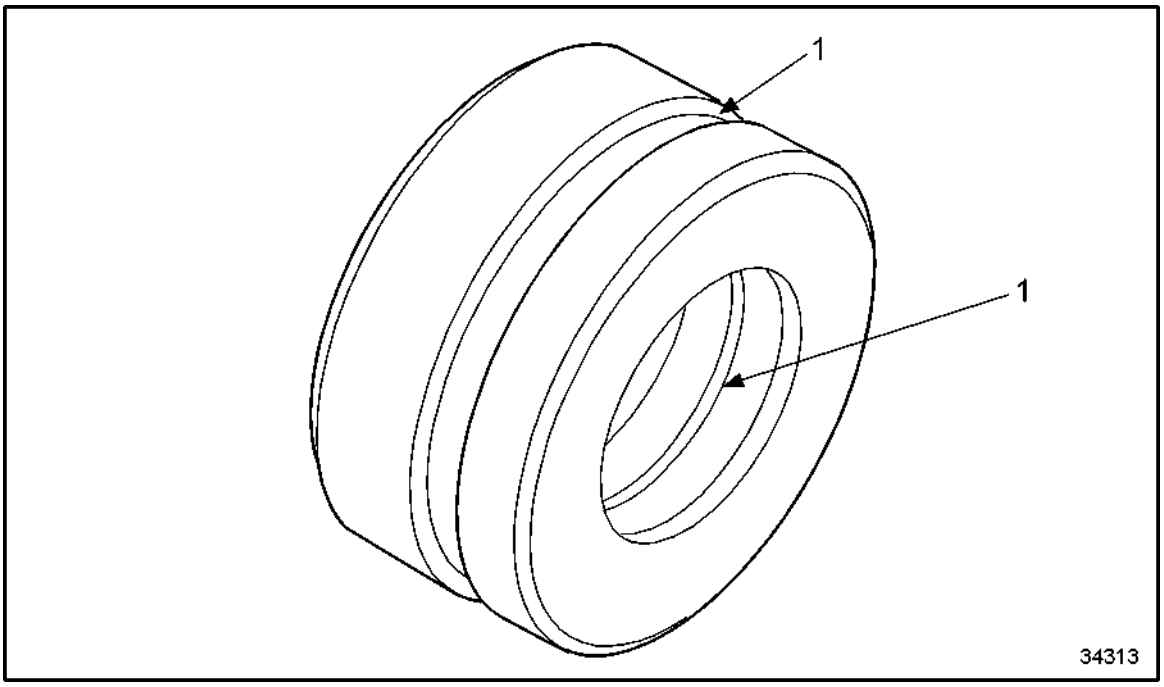
8. After installing, bar engine and ensure that there is clearance between oil spray nozzle and piston, and that oil nozzle is perfectly centered in oil bore of piston.
9. Install access port cover.

Installation of Seal Washer

Perform the following steps to install the seal washer:

NOTE:
Ensure that all components are perfectly clean.

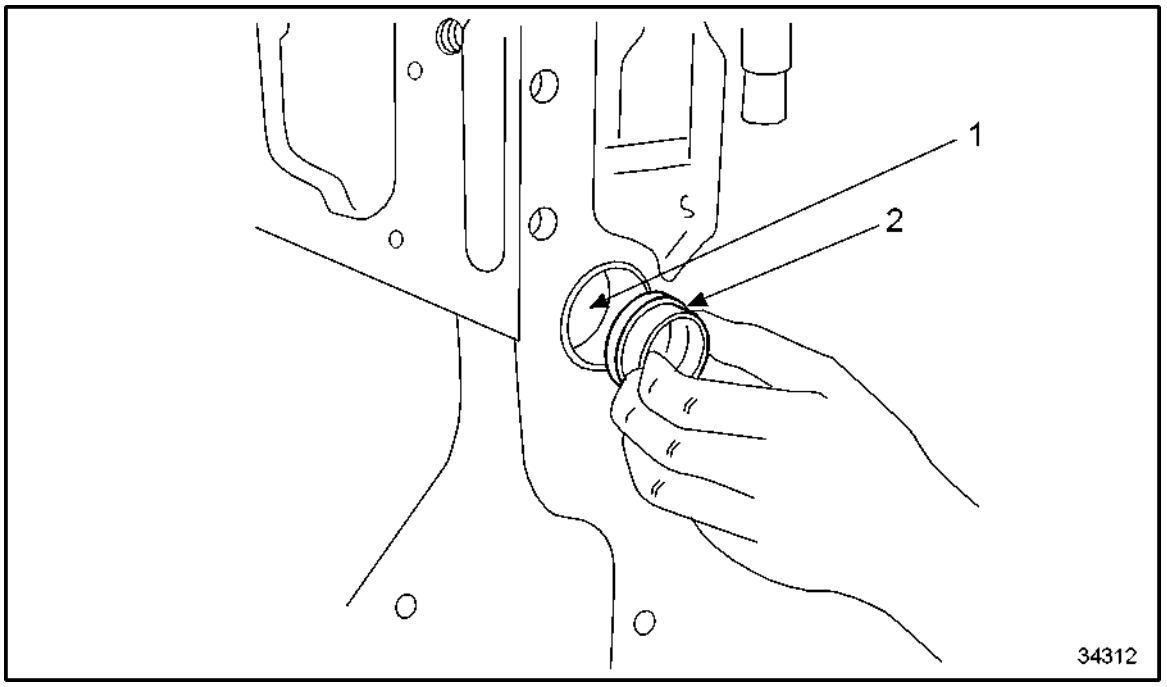
1. Coat O-rings with petroleum jelly and insert them into grooves (1) on seal washer. See Figure 830.



1. Groove

Figure 830 Installing O-rings on Seal Washer

2. Align oil pipe (1) so that inner O-ring is not damaged. See Figure 831.



1. Oil Pipe Location
2. Seal Washer

Figure 831 Pressing Seal Washer into Cylinder Block

3. Press seal washer over the oil pipe into cylinder block.

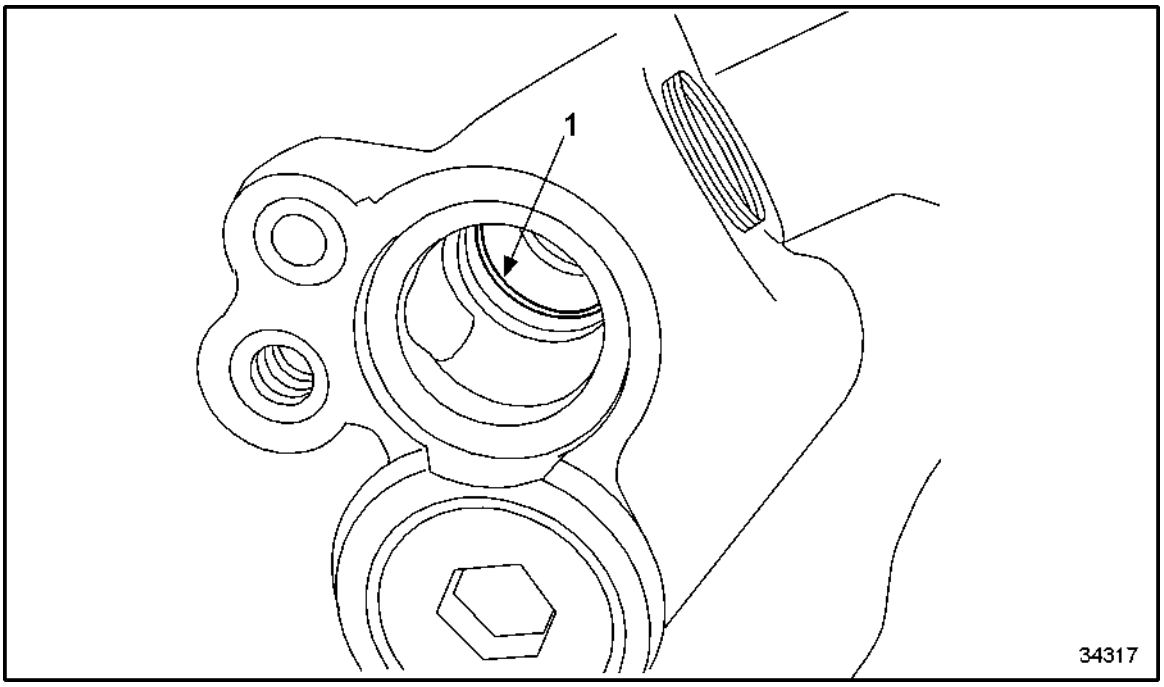
NOTE:
For further steps, refer to section C 186.05.12.

Installation of Delivery Valve

Perform the following steps to install the delivery valve:

NOTE:
Ensure parts are perfectly clean

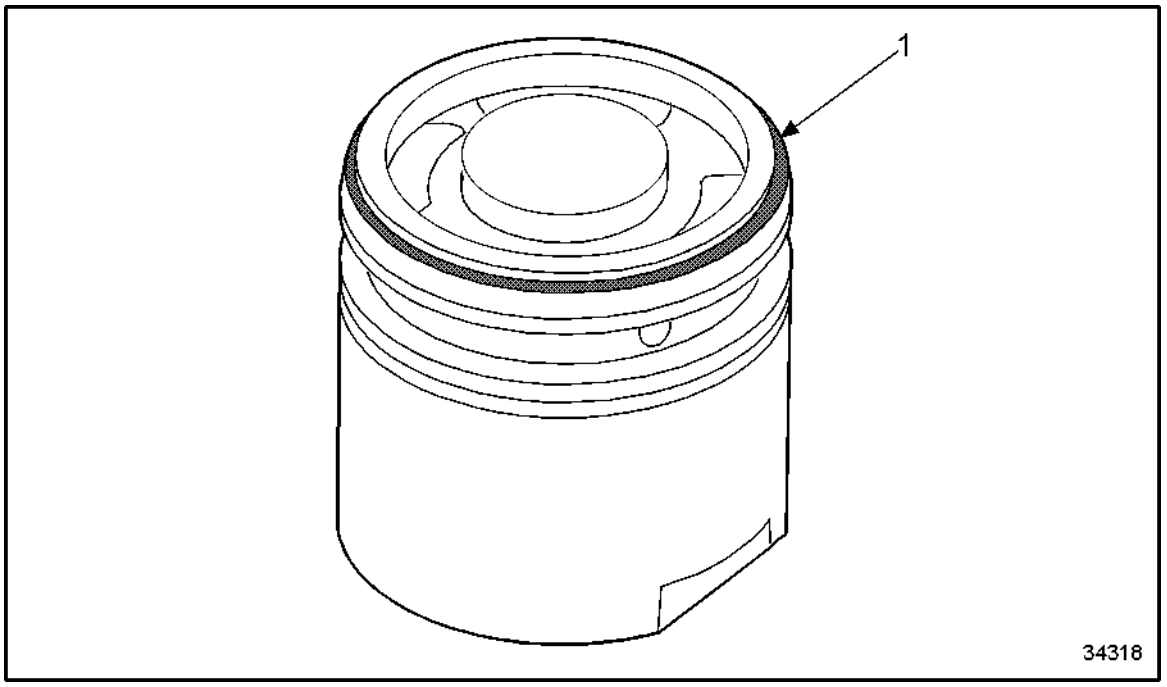
1. Coat O-ring with petroleum jelly and insert into groove (1). See Figure 832.



1. Groove

Figure 832 Installing Delivery Valve

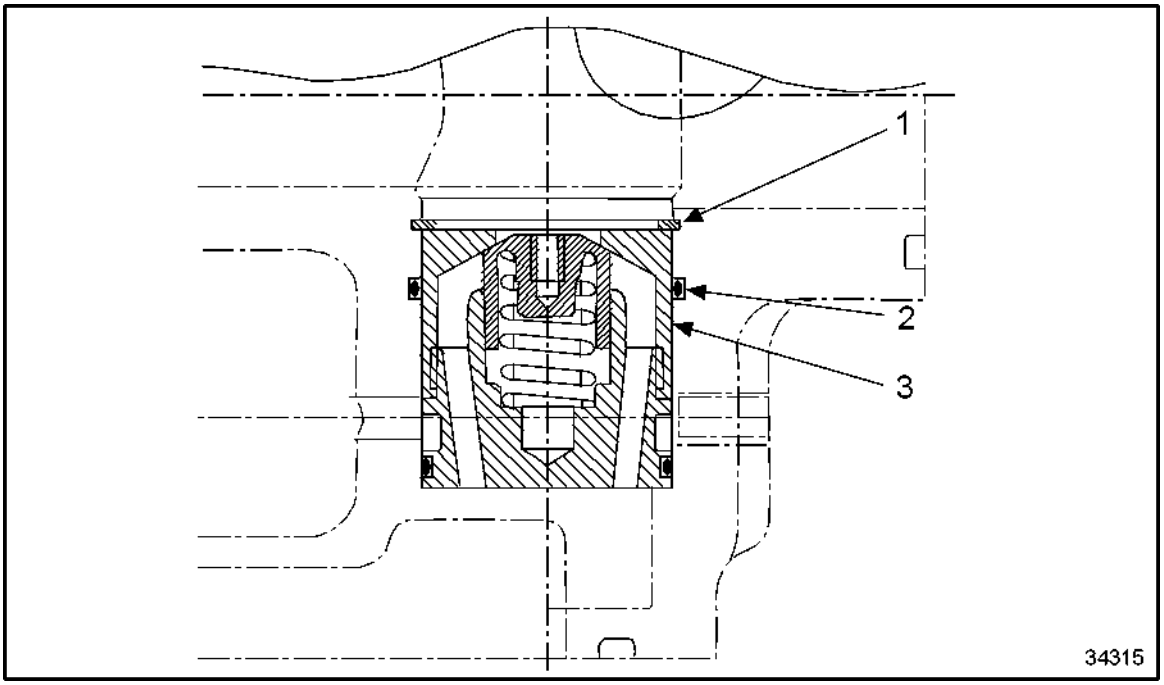
2. Coat O-ring (1) with petroleum jelly and insert into groove on delivery valve. See Figure 833.



1. O-ring

Figure 833 Installing O-rings on Delivery Valve

3. Insert delivery valve (3) completely into bore of housing. See Figure 834.



1. Snap Ring
2. O-ring
3. Delivery Valve

Figure 834 Installing Delivery Valve into Bore of Housing

4. Secure delivery valve (3) with snap ring (1).
5. Visually inspect sealing and mating surfaces of plug for cleanness.
   [a] If sealing and mating surfaces are not clean, clean as necessary.
   [b] If sealing and mating surfaces are clean, continue inspection.
6. Tighten plug with new sealing ring to specification. Refer to section A 003.

NOTE:
For installation of trunnion mounts, refer to section C 231.05.11.

NOTE:
For installation of fan drive, refer to section C 221.05.11.

C 186.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 115 are the After-Installation Operations for the oil system for piston.

Level of Maintenance	Operation	Reference
1, 2, 3	Install gear case, gear case end	Refer to section C 024.05.11
1, 2, 3	Connect DDEC harness	Refer to section C 501.05 M
1, 2, 3	Install SRS Wheel	Refer to section C 032.05.11
1, 2, 3	Install front drive hub (gear case end) on crankshaft	Refer to section C 035.05.11
1, 2, 3	Install vibration damper	Refer to section C 035.05.11
1, 2, 3	Install trunnion mounts	Refer to section C 231.05.11
1, 2, 3	Install coolant lines (high-temperature)	Refer to section C 204.05.11
1, 2, 3	Install charge air coolant line (low temperature)	Refer to section C 207.05.11
1, 2, 3	Install oil pan	Refer to section C 014.05.11
1, 2, 3	Install fan drive	Refer to section C 221.05.11
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Fill charge air coolant system	Refer to section C 206.05.11
1, 2, 3	Fill oil system with engine oil	Refer to Operators Guide
1, 2, 3	Inspect for leaks	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.

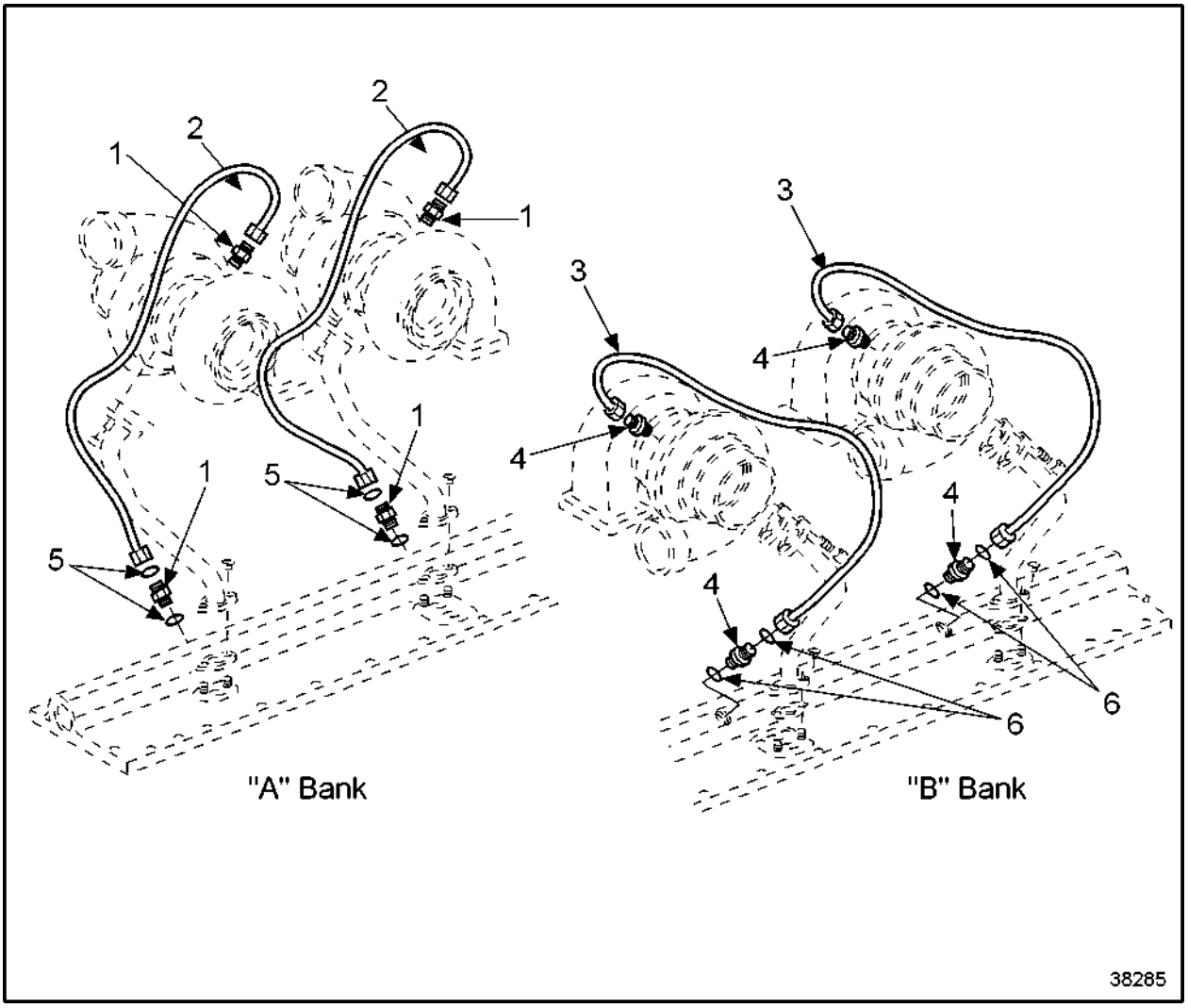
3= The engine is to remain installed.

Table 115 After-Installation Operations

C 187.05 – OIL SUPPLY LINES FOR EXHAUST TURBOCHARGER

C 187.05.01 – GENERAL VIEW

See Figure 835 for a general view of the oil supply lines for exhaust turbocharger.



1. Adapter
2. "A" Bank Oil Supply Lines
3. "B" Bank Oil Supply Lines
4. Adapter Fitting
5. O-rings for "A" Bank
6. O-rings for "B" Bank

Figure 835 General View of Oil Supply Lines for Turbocharger

C 187.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 116 are the Before-Removal Operations for the oil supply lines for exhaust turbocharger.

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.

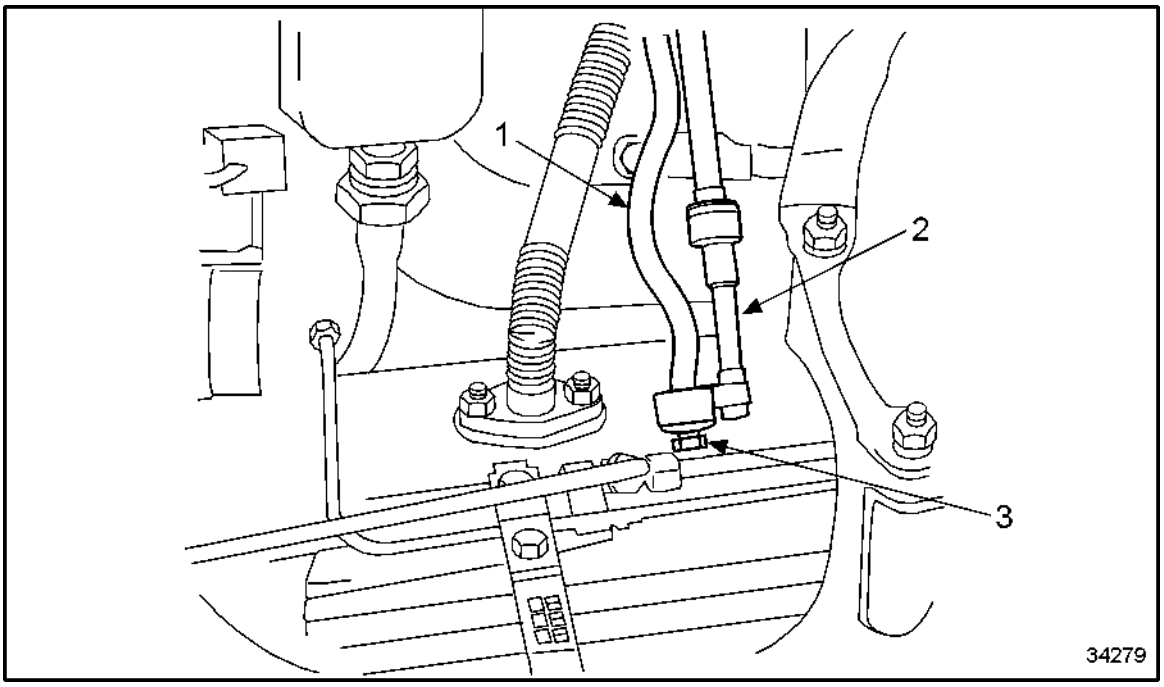
3= The engine is to remain installed.

Table 116 Before-Removal Operations

C 187.05.05 – REMOVAL OF OIL SUPPLY HOSES FOR EXHAUST TURBOCHARGER

Perform the following operations to remove oil supply hoses for turbocharger:

1. Remove bracket on appropriate oil supply hose (1). See Figure 836.



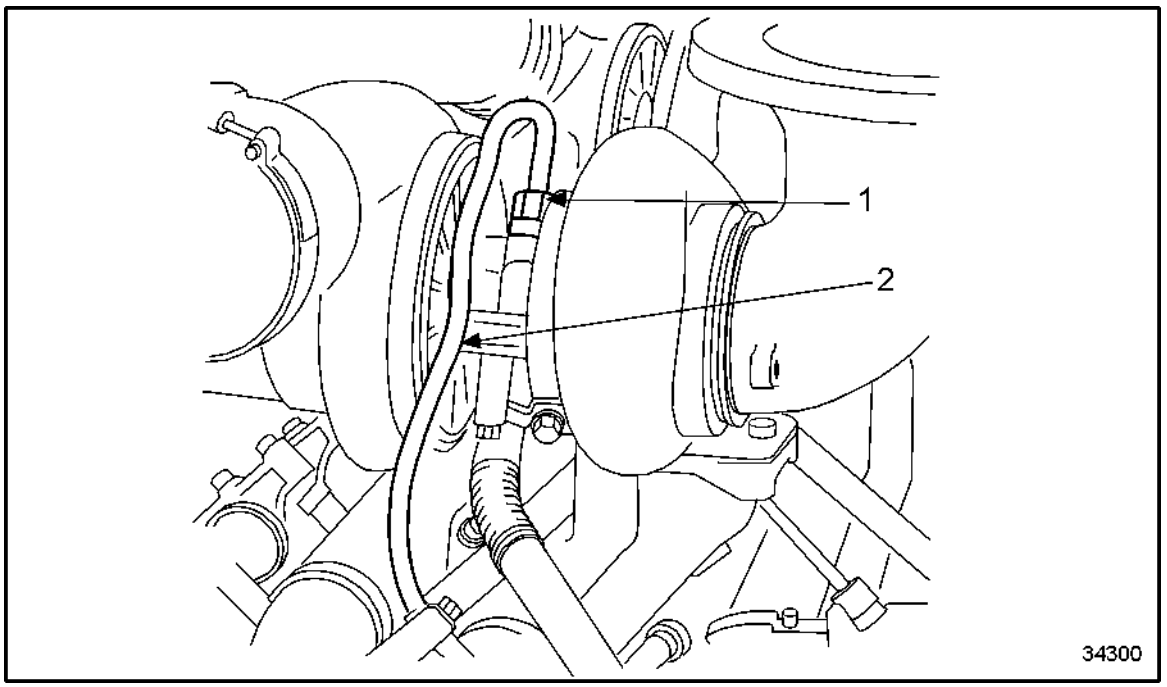
1. Turbocharger Oil Supply Hose
2. Box Wrench
3. Adaptor Fitting

Figure 836 Removing Turbocharger Oil Supply Hose

2. Use box wrench (2) and extension to loosen connector from turbocharger oil supply hose.

NOTE:
Adapter fitting must not rotate. Use a suitable tool to hold the adapter fitting in position.

3. Loosen connector (1) and remove turbocharger oil supply hose (2). See Figure 837.



1. Adaptor
2. Oil Supply Hose

Figure 837 Loosening Threaded Adaptor and Removing Turbocharger Oil Supply Hose

4. Protect connections with suitable blanking plugs.
5. Protect oil line from damage.

C 187.05.08 – INSPECTION AND REPAIR

NOTE:
Ensure parts are perfectly clean.

Perform the following steps to inspect and repair the oil supply lines for turbocharger:

1. Clean oil lines with a suitable cleaner.
2. Visually inspect oil supply lines for turbocharger for damage.
   [a] If oil supply lines for turbocharger are damaged, replace lines as necessary.
   [b] If oil supply lines for turbocharger are not damaged, continue inspection.

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.

3. Pressure-test oil supply lines for turbocharger for leaks with compressed air.
   [a] If oil supply lines for turbocharger show leaks, replace lines as necessary.
   [b] If oil supply lines for turbocharger do not show leaks, continue inspection.

NOTE:
Test pressure is 0.5 bar.

CAUTION:

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

4. Blow dry oil supply lines for turbocharger after pressure testing with compressed air.

NOTE:
Component and coolant temperature minimum is 30°C (86°F). Maximum temperature 40°C if component must be held in hands.

5. Visually inspect connecting components and fixtures for damage and wear.
   [a] If connecting components and fixtures show damage or wear, replace components as necessary.
   [b] If connecting components and fixtures do not show damage or wear, continue inspection.

6. Visually inspect sealing and mating surfaces for damage or wear.
   [a] If sealing or mating surfaces show damage or wear, smooth with an oilstone or emery cloth as necessary.
   [b] If sealing or mating surfaces do not show damage or wear, continue inspection.
7. Visually inspect threads of components for damage or wear.
   [a] If threads of components are damaged or worn, machine as necessary.
   [b] If threads of components are beyond repair, replace component as necessary.
   [c] If threads of components are not damaged, continue inspection.
8. Replace sealing rings and gaskets.

C 187.05.11 – INSTALLATION OF THE OIL SUPPLY LINES FOR TURBOCHARGER

Perform the following steps to install the oil supply lines for turbocharger.

NOTE:
Prior to installation, remove all protective blanking plugs.

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.

1. Blow out oil supply lines for turbocharger with compressed air and ensure that they are perfectly clean.
2. Replace sealing O-rings on adaptor fitting.
3. Install oil supply lines for exhaust turbocharger and plugs with new sealing rings and gaskets. Align and tighten to specification. Refer to section A 003.
4. Install brackets. Align and tighten to specification. Refer to section A 003.

C 187.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 117 are the After-Installation operations for the oil supply lines for the exhaust turbocharger.

Level of Maintenance	Operation	Reference
1, 2, 3	Inspect for leaks	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.

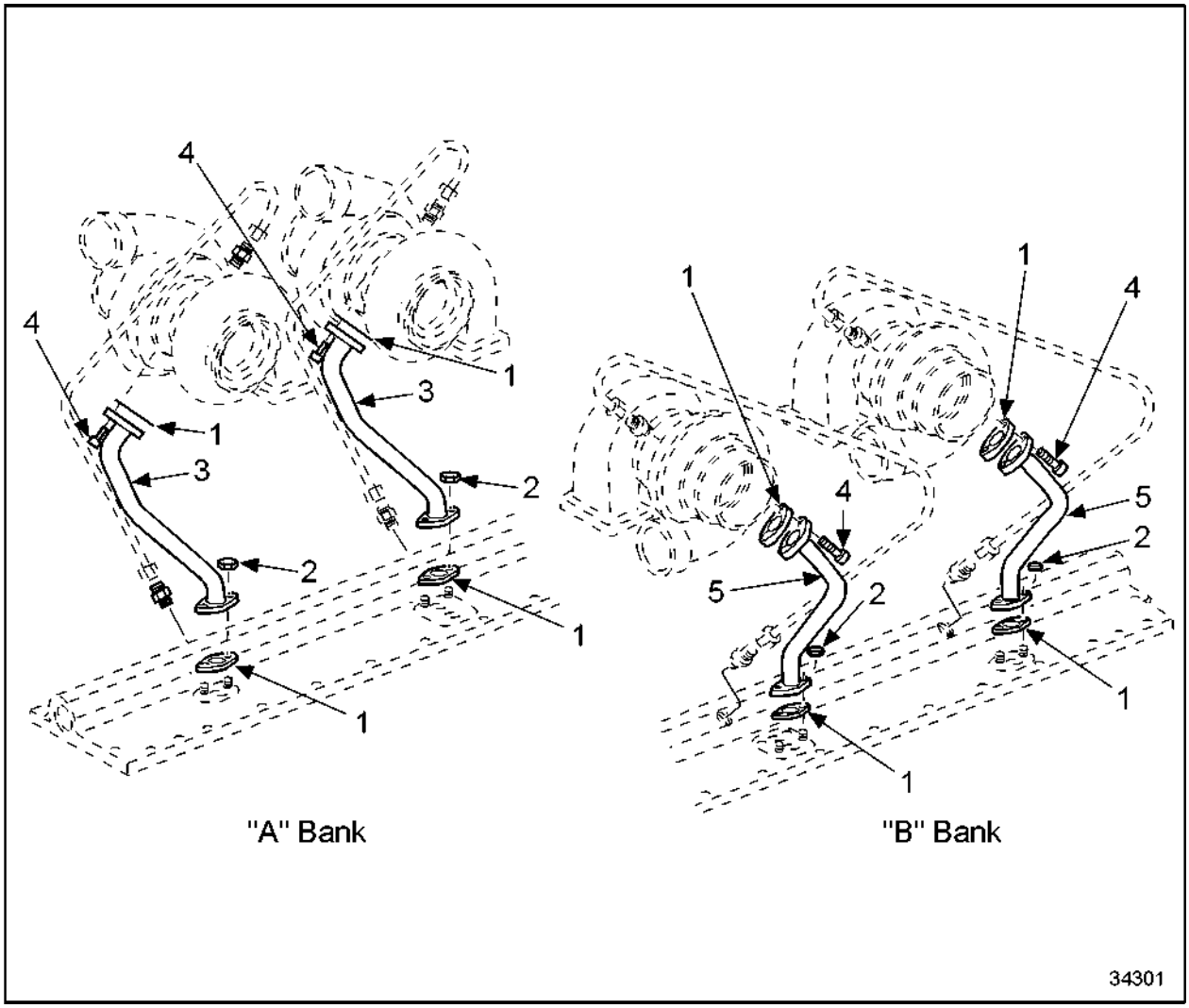
3= The engine is to remain installed.

Table 117 After-Installation Operations

C 188.05 – OIL RETURN LINES FOR TURBOCHARGER

C 188.05.01 – GENERAL VIEW

See Figure 838 for a general view of the oil return lines for turbocharger.



1. Gasket
2. Hex Nut
3. Left Pipework
4. Hex Bolt
5. Right Pipework

Figure 838 General View of Oil Return Lines for Turbocharger

C 188.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 118 are the Before-Removal Operations for the oil return lines for turbocharger.

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.

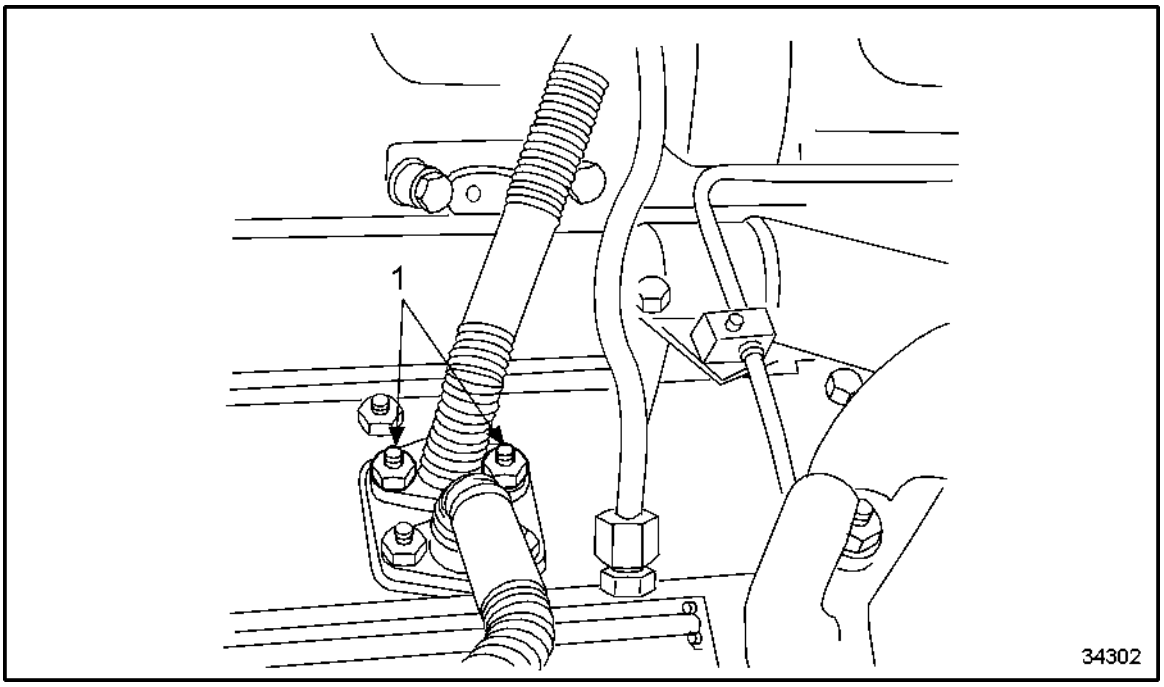
3= The engine is to remain installed.

Table 118 Before-Removal Operations

C 188.05.05 – REMOVAL OF THE OIL RETURN LINES FOR TURBOCHARGER

For removal of the oil return lines for turbocharger, perform the following steps:

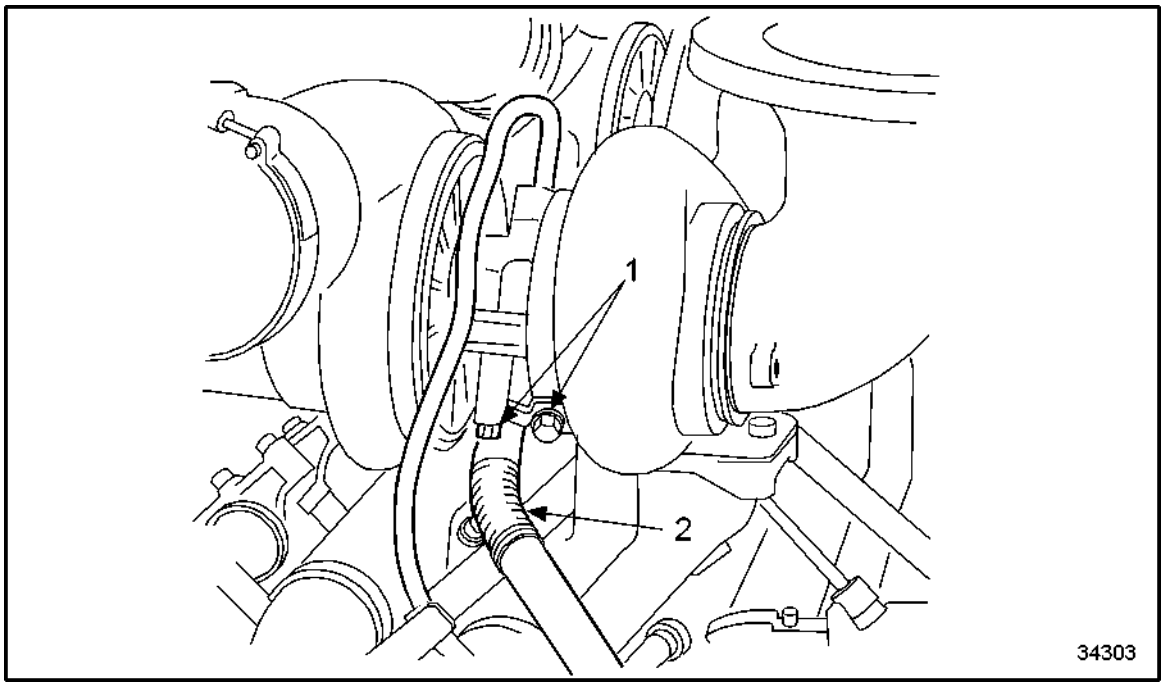
1. Remove hex nut (1). See Figure 839.



1. Hex Nut

Figure 839 Removing Hex Nut

2. Remove hex bolt (1). See Figure 840.



1. Hex Bolts
2. Oil Return Hose

Figure 840 Removing Hex Bolts

3. Remove oil return hose (2) with gaskets.
4. Protect connections with suitable plugs.

C 188.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the oil return lines for turbocharger:

NOTE:
Ensure parts are perfectly clean.

1. Clean oil return lines for exhaust turbocharger with cleaner.
2. Inspect condition of oil return lines for turbocharger for damage.
   [a] If oil return lines for turbocharger are damaged, replace component as necessary.
   [b] If oil return lines for turbocharger are not damaged, continue inspection.

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.

3. Pressure-test oil return lines for turbocharger for leaks with compressed air in water bath as necessary.
   [a] If oil return lines for turbocharger show leaks, replace lines as necessary.
   [b] If oil return lines for turbocharger do not show leaks, continue inspection.

NOTE:
Test pressure is 0.5 bar.

CAUTION:

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

4. Blow dry oil return lines for turbocharger after pressure testing with compressed air.

NOTE:
Component and coolant temperature minimum is 30°C (86°F). Maximum temperature is 40°C, if component must be held in hands.

5. Visually inspect connecting components of oil return lines for turbocharger for damage and wear.
   [a] If oil return lines for turbocharger show damage or wear, replace component as necessary.

[b] If oil return lines for turbocharger do not show damage or wear, continue inspection.

6. Visually inspect sealing and mating surfaces for damage or wear.

   [a] If sealing and mating surfaces show damage or wear, rub down with an oilstone or emery cloth as necessary.

   [b] If sealing and mating surfaces do not show damage or wear, continue inspection.

7. Replace gaskets, sealing rings and gaskets.

C 188.05.11 – INSTALLATION OF THE OIL RETURN LINES FOR TURBOCHARGER

Perform the following steps to install oil return lines for turbocharger:

NOTE:
Prior to installation, remove all protective blanking plugs.

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.

1. Blow out oil lines with compressed air and ensure that they are perfectly clean.
2. Install oil return lines for turbocharger with new gaskets and sealing rings. Align properly and tighten to specification. Refer to section A 003.

NOTE:
After engine start, visually inspect oil return lines for turbocharger for leaks.

C 188.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 119 are the After-Installation Operations for the oil return lines for the turbocharger.

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

1 = The engine is to be completely disassembled.

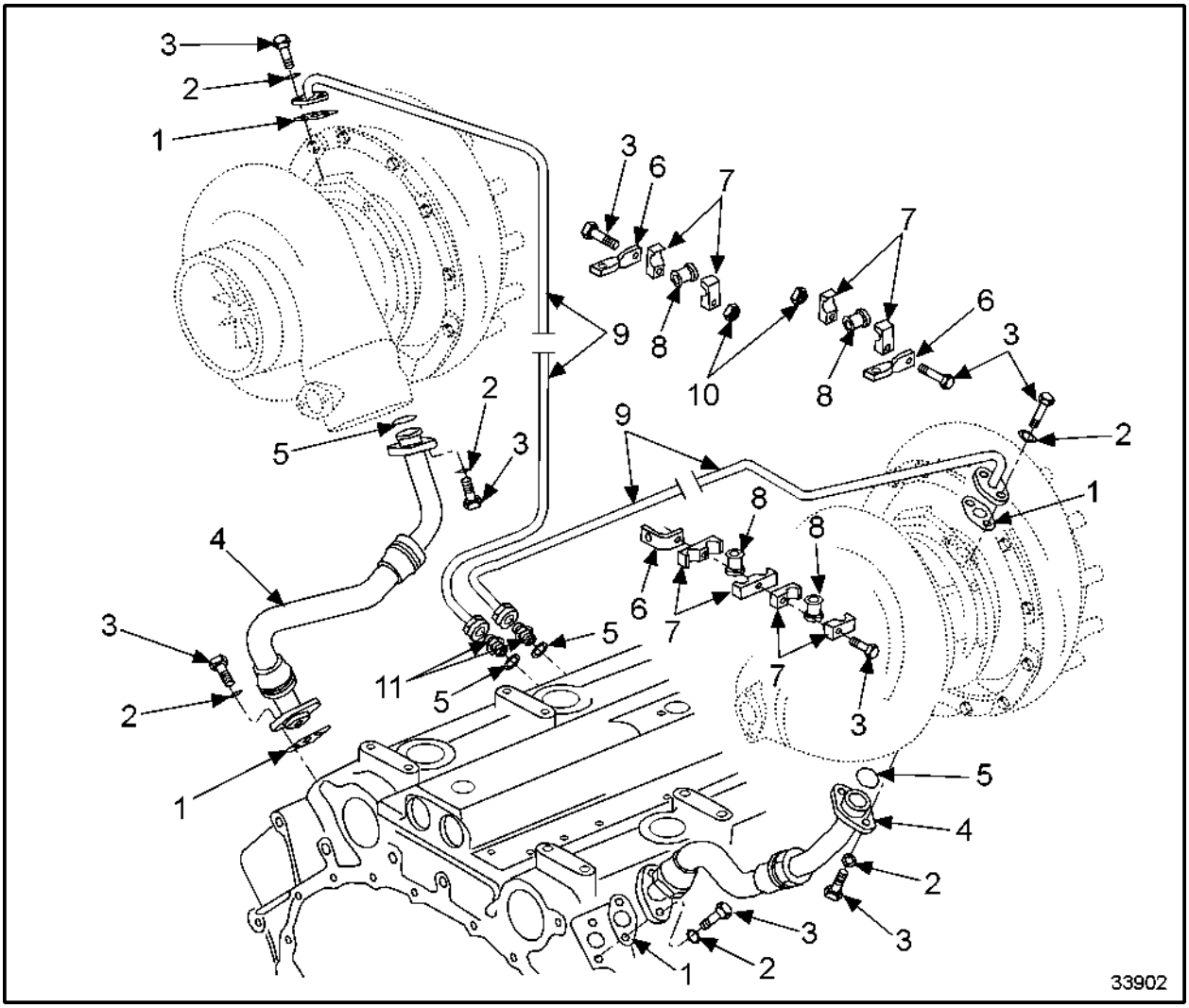
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 119 After-Installation Operations

C 185.10.01 M – MARINE OIL SUPPLY LINES FOR TURBOCHARGER

See Figure 841 for a general view of the oil supply lines parts location.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 841 General View of Oil Supply Lines for Turbocharger

C 185.10.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 120 are the Before-Removal Operations for the oil supply lines for the turbocharger.

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.

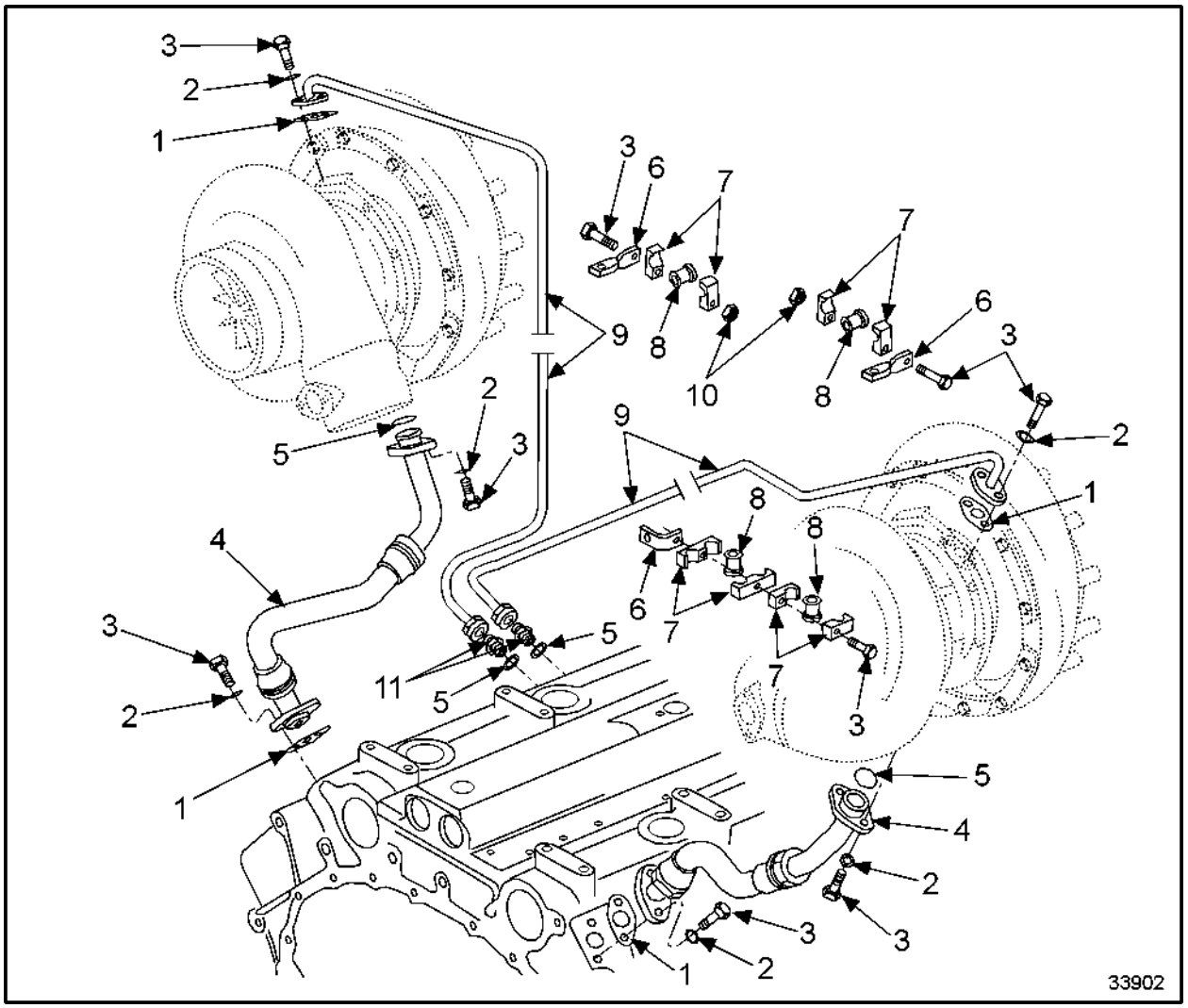
3 = The engine is to remain installed.

Table 120 Before-Removal Operations for Oil Supply Lines

C 185.10.05 M – REMOVAL OF THE OIL SUPPLY LINES FOR TURBOCHARGER

Perform the following steps to remove the oil supply lines:

1. Remove bolts (3) and washers (2) securing the oil supply line (9) to the “A” bank turbocharger. See Figure 842.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 842 Removing Oil Supply Lines

2. Repeat step for the “B” bank turbocharger. See Figure 842.
3. Remove O-rings (5) from the “A” bank turbocharger.

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.

C 185.10.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the oil supply lines:

NOTE:
Ensure that all oil supply line parts are clean prior to inspection and repair.

CAUTION:

To avoid personal injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

1. Clean oil supply lines with diesel fuel and blow dry with compressed air.
2. Visually inspect oil supply lines for damage.
   [a] If oil lines are damaged, replace as necessary.
   [b] If oil lines are not damaged, continue inspection.

CAUTION:

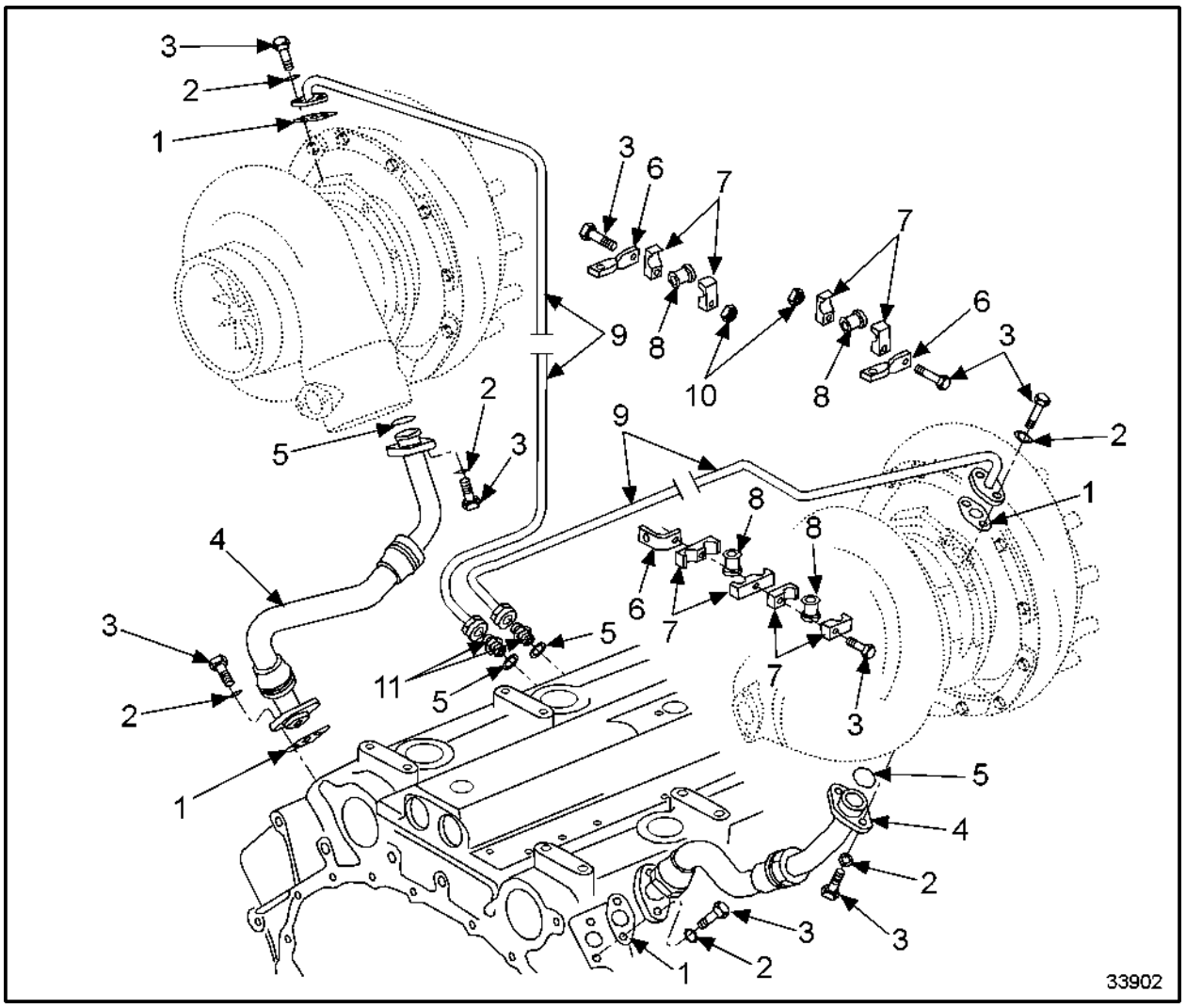
To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

3. Pressure test oil supply lines at 0.5 bar (7 lb/in.^{2}) with compressed air in a water bath to check for leaks.
   [a] If leaks are found, replace oil line(s).
   [b] If leaks are not found, continue inspection.
4. Visually inspect new drains for plugs or obstructions.
   [a] If plugs or obstructions are present, clean as required.
   [b] If no plugs or obstructions are present, continue inspection.

C 185.10.11 M – INSTALLATION OF THE OIL SUPPLY LINES FOR TURBOCHARGER

Perform the following steps to install the oil supply lines:

1. Install mounting brackets (6) and pipe half clamps (7) as necessary. See Figure 843.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 843 Installing Oil Supply Lines

2. Install a new gasket (1) for the “A” bank turbocharger.
3. Repeat step for “B” bank turbocharger. See Figure 843.
4. Install new O-rings (5) for the “A” bank turbocharger.

5. Repeat step for “B” bank turbocharger. See Figure 843.
6. Install washers (2) and bolts (3) to secure oil supply line (9) to the “A” bank turbocharger.
7. Repeat step for “B” bank turbocharger. See Figure 843.
8. Tighten bolt to specified torque in accordance with specifications. Refer to section A 003.

C 185.10.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 121are the After-Installation Operations for the oil supply lines for the turbocharger.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine start	Refer to Operators Guide

1 = The engine is to be completely disassembled.

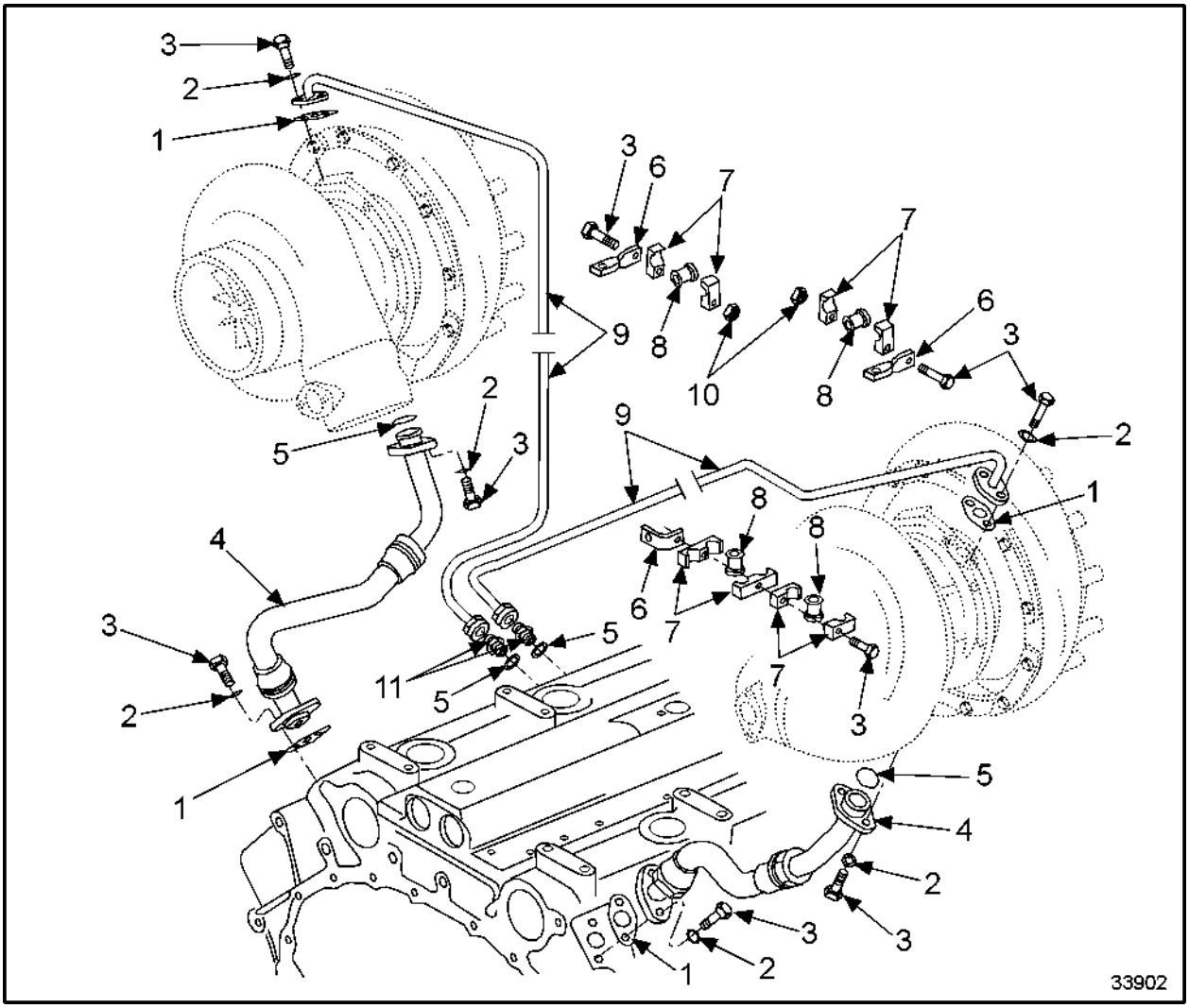
2 = The engine is to be removed but not completely disassembled.

3 = The engine is to remain installed.

Table 121 After-Installation Operations for Oil Supply Lines

C 185.25.01 M – MARINE OIL RETURN LINES FOR TURBOCHARGER

See Figure 844 for a general view of the oil return lines parts location.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 844 General View of the Oil Return Lines

C 185.25.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 122 are the Before-Removal Operations for the oil supply lines for the turbocharger.

Level of Maintenance	Operation	Reference
1	Disable engine power	Refer to Operator's Guide

1 = The engine is to be completely disassembled.

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

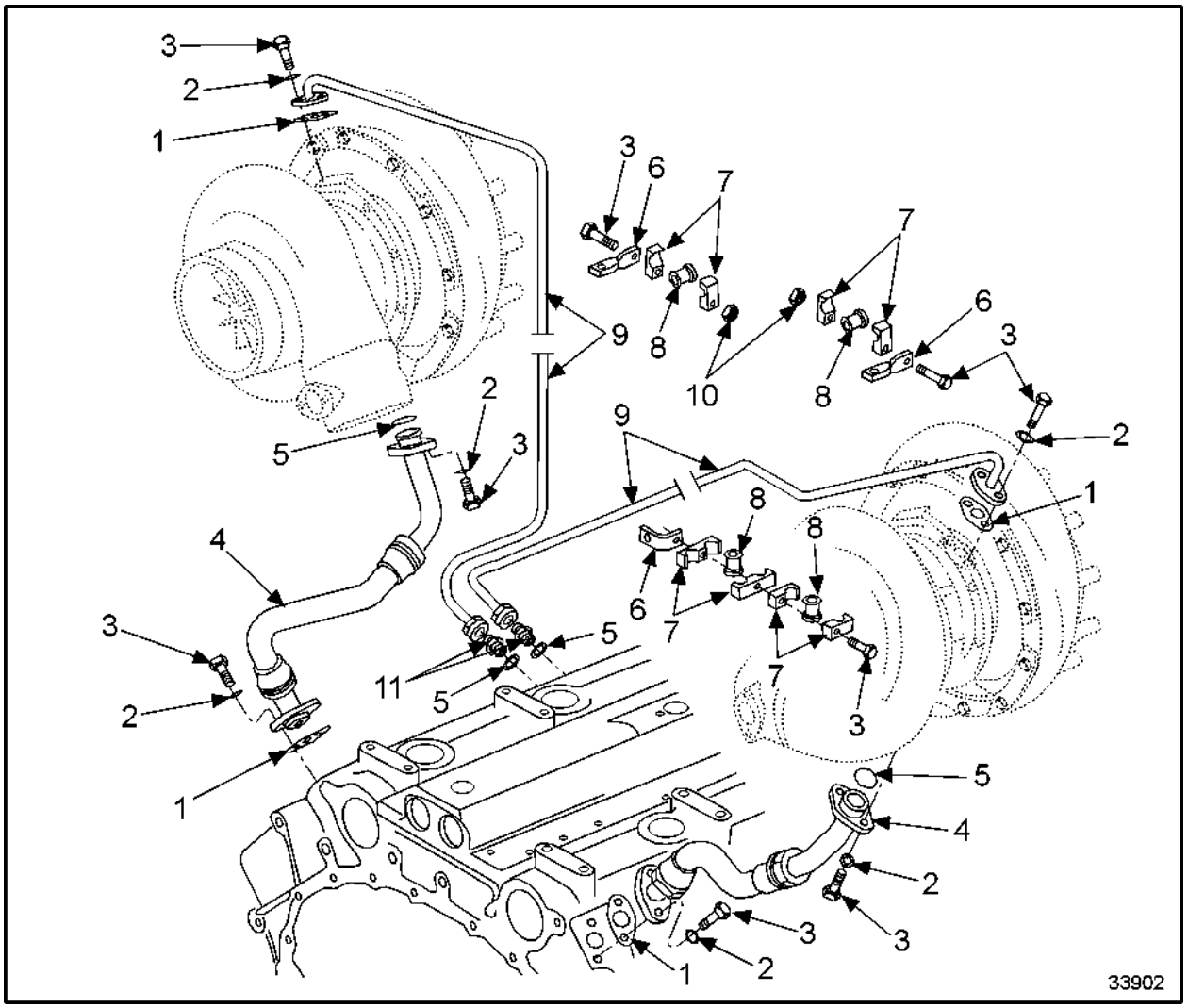
3 = The engine is to remain installed.

Table 122 Before-Removal Operations for Oil Return Lines

C 185.25.05 M – REMOVAL OF THE OIL RETURN LINES FOR TURBOCHARGER

Perform the following steps to remove the oil return lines:

1. Remove bolts (3), washers (2), and gasket (1) connecting oil return line (4) to cylinder block. See Figure 845.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 845 Removing Oil Return Lines

2. Repeat step for the “B” bank turbocharger. See Figure 845.

3. Remove bolts (3), washers (2), and O-ring (5) connecting oil return line to the “A” bank turbocharger.
4. Repeat step for the “B” bank turbocharger. See Figure 845.

C 185.25.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the oil return lines:

CAUTION:

To avoid personal injury when blow drying, wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

1. Clean oil return lines with diesel fuel and blow dry with compressed air.

CAUTION:

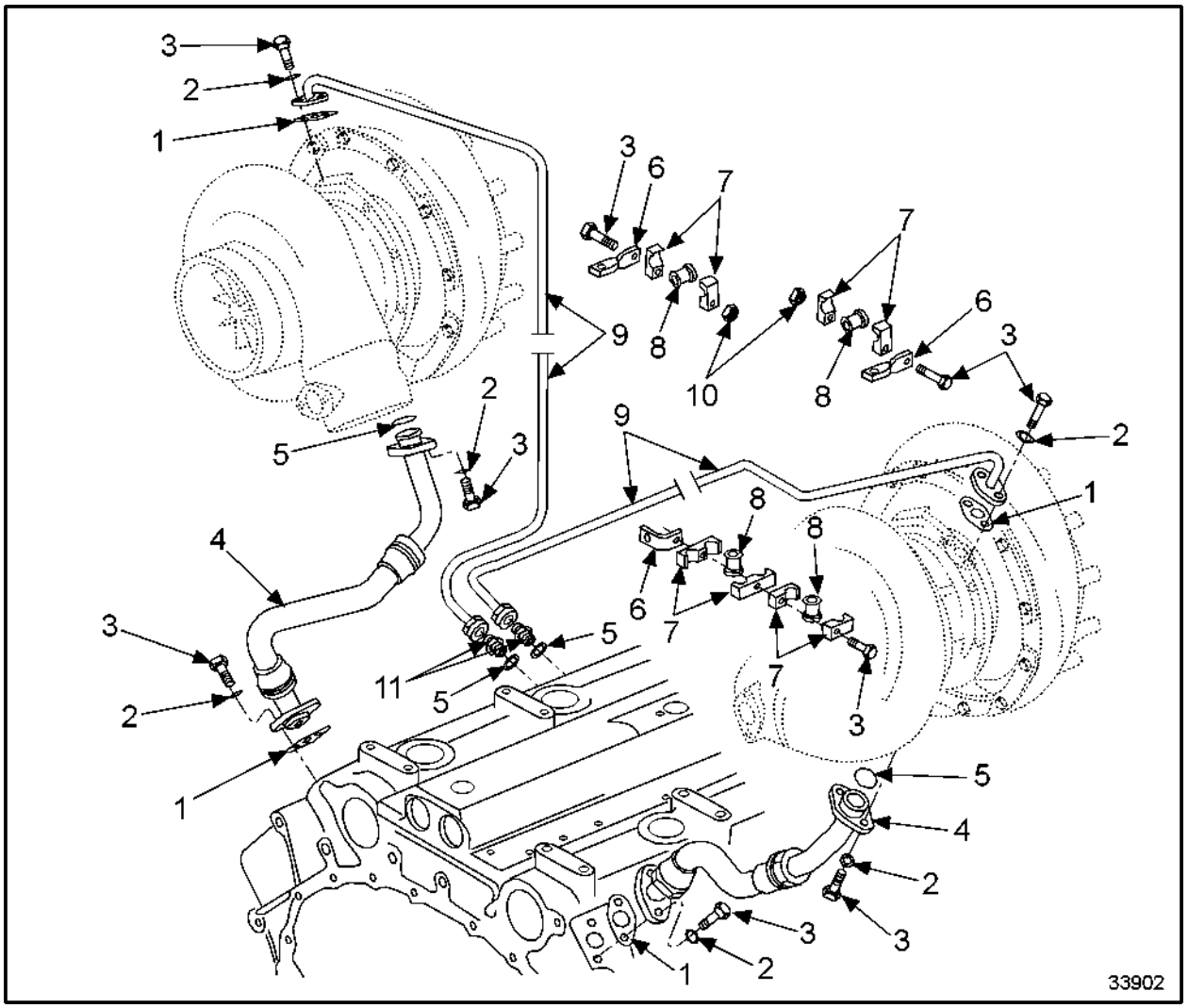
To avoid an eye injury when using compressed air, wear adequate eye protection (safety glasses or faceplate) and do not exceed 276 kPa (40 lb/in.^{2}) air pressure.

2. Visually inspect oil return lines for damage.
   [a] If oil lines are damaged, replace as necessary.
   [b] If oil lines are not damaged, continue inspection.
3. Pressure test oil return lines at 0.5 bar (7 lb/in.^{2}) with compressed air in a water bath to check for leaks.
   [a] If leaks are found, replace oil line(s).
   [b] If leaks are not found, continue inspection.

C 185.25.11 M – INSTALLATION OF THE OIL RETURN LINES FOR TURBOCHARGER

Perform the following steps to install the oil return lines:

1. Install new O-ring (5) and oil return line (4) to the “A” bank turbocharger and secure with washers (2) and bolts (3). See Figure 846.



1. Gasket
2. Washer
3. Bolt
4. Oil Return Line
5. O-ring
6. Mounting Bracket
7. Pipe Half Clamp
8. Grommet
9. Oil Supply Line
10. Hex Nut
11. Adaptor

Figure 846 Installing Oil Return Lines

2. Repeat step for the “B” bank turbocharger. See Figure 846.
3. Tighten bolt to specified torque. Refer to section A 003.

4. Install new gasket (1) and oil return line (4) to cylinder block and secure with washers (2) and bolts (3). See Figure 846.
5. Repeat step for the “B” bank turbocharger. See Figure 846.
6. Tighten bolt to specified torque. Refer to section A 003.

C 185.25.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 123are the After-Installation Operations for the oil return lines for the turbocharger.

Level of Maintenance	Operation	Reference
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 123 After-Installation Operations for Oil Return Lines

C 200 – COOLING SYSTEM

CAUTION:

To avoid personal injury when using any chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

Listed in Table 124are the materials and consumables for the cooling system.

Materials and Consumables	Designation	Remarks
Magnifying glass	-	-
Inspection lamp	-	-
Emery Cloth	-	-
Activator	Loctite No. 7649	-
Vaseline	Petroleum jelly, white	-
Thread-locking compound	Loctite No. 270	Final strength at 20°C ≈ 12 h
Surface sealant	Loctite No. 573	Final strength ≈ 48 h
Engine oil	-	-
Cleaning agent	Solvclean KW	-
Decalcifying agent	Porodox or Euron 1308	-
Hydrochloric acid	-	-
Corrosion preventive	Pfinder AP 11 F	-
Denatured ethanol	-	-
Thin-film lubricant	Molycote g-N plus	-
Multipurpose grease	Shell Retinax A	-
Kerosene or diesel fuel	-	-
Sealing Paste	Elastosil N 189	-
Engineer's blue	blue	-
Antifriction bearing grease	Texando F020	-
Corrosion preventive	Caramba Express	-
Dry compressed air	-	-
Magnetic crack-testing equipment with fluorescent magnetic powder	-	-
Surface crack-testing equipment with red penetrant dye	-	-

Table 124 Materials and Consumables

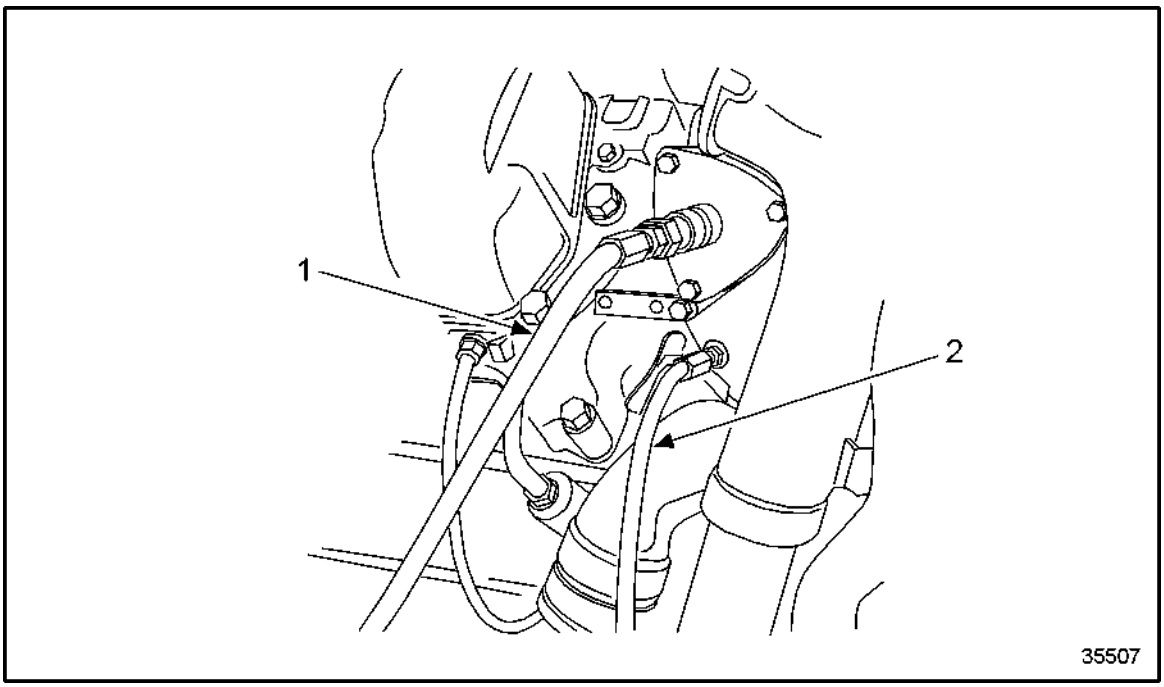
C 200.05 – COOLING SYSTEM

C 200.00 – PRELIMINARY PRESSURE-TESTING COOLING SYSTEM

This section to be performed before any maintenance in the cooling system.

NOTE:
Only use hydraulic pressure testing device specified by Manufacturer. Observe specified safety and accident prevention regulations.

NOTE:
After assembling engine, pressure-test cooling system with water and check for leaks. See Figure 847.

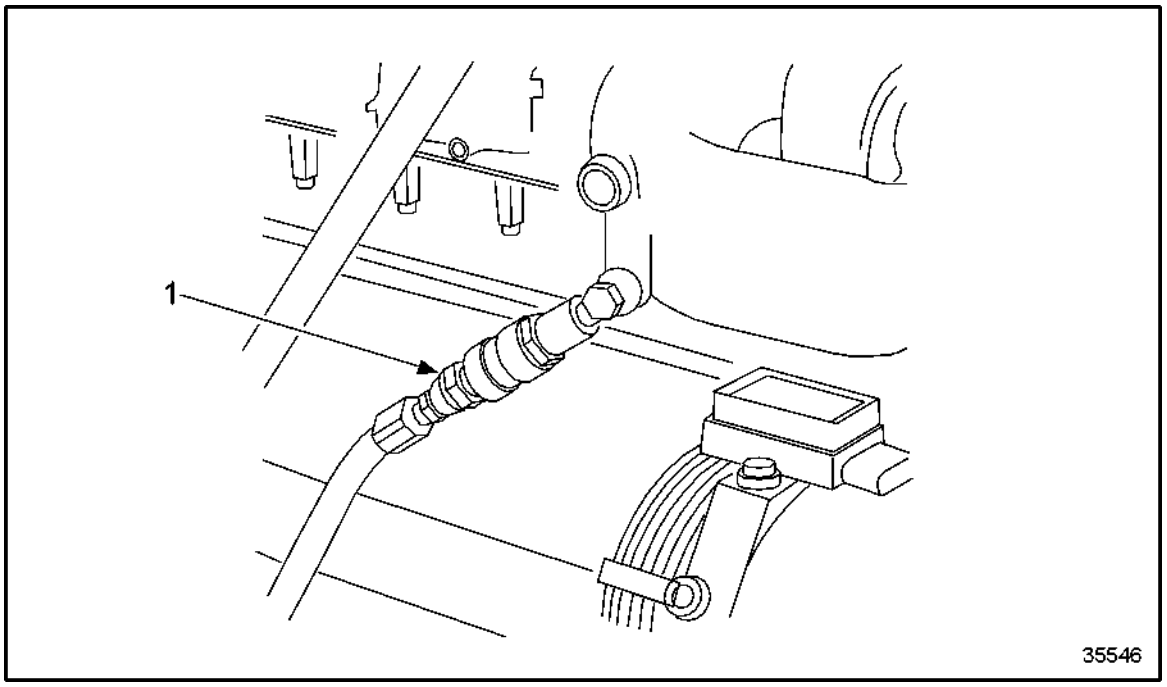


1. Supply Hose Line
2. Vent Line

Figure 847 Pressure-Testing Cooling System

1. To allow for the checking of internal components, remove plugs from the following components:
   - □ Inspection port cover
   - □ Charge air manifold, “A” Bank and “B” Bank engine side
   - □ Exhaust elbow, “A” Bank and “B” Bank engine side
2. Connect supply hose line (1) of coolant pressure testing device to thermostat housing.
3. Connect vent line (2) to thermostat housing.

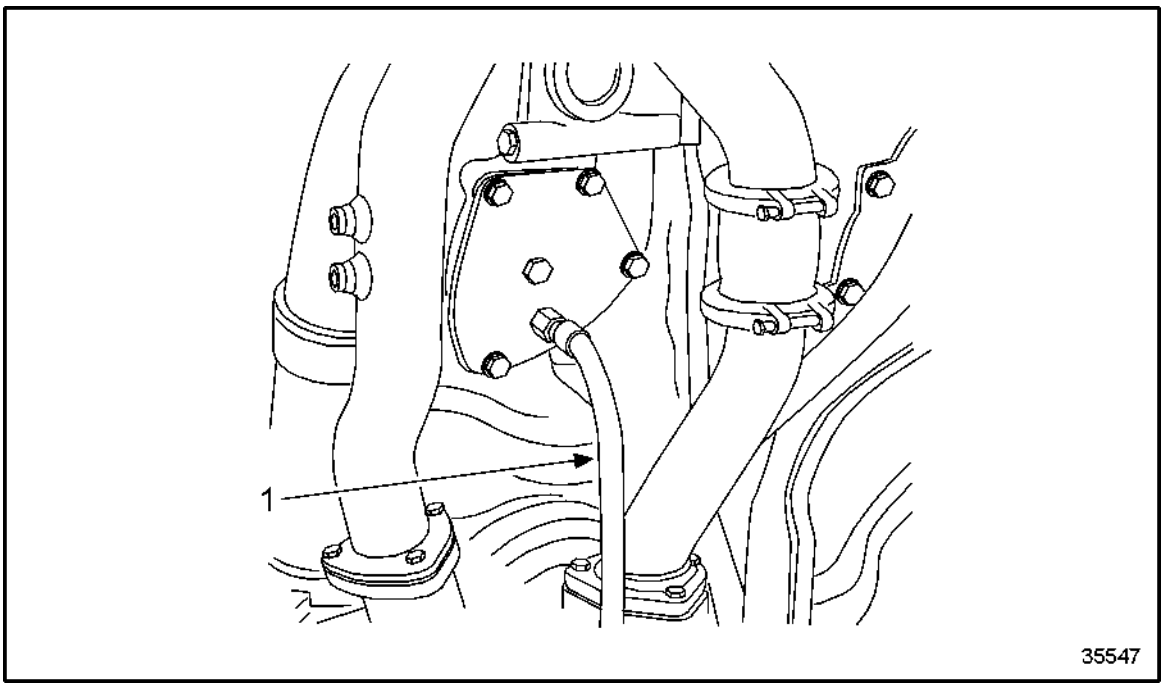
4. Connect vent line (1) to elbow of engine high – temperature water pump (2). See Figure 848.



1. Vent Line

Figure 848 Connecting Vent Line

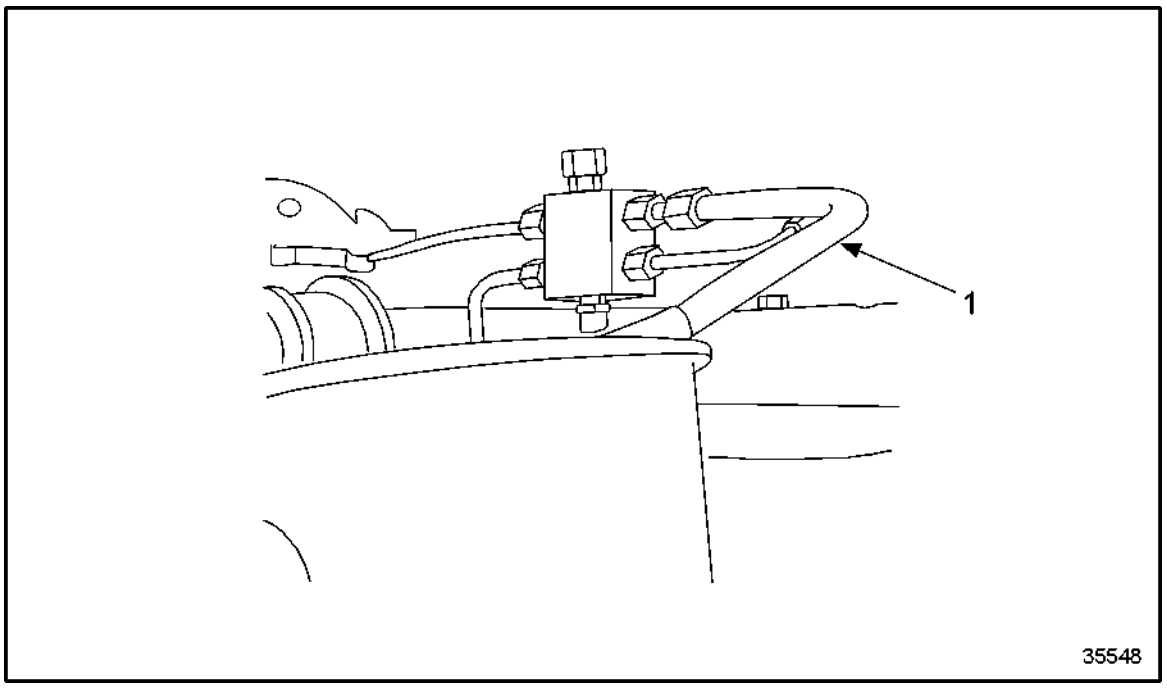
5. Connect vent line (1) to thermostat housing coolant outlet flange. See Figure 849.



1. Vent Line

Figure 849 Connecting Vent Line to Thermostat Housing Coolant Outlet Flange

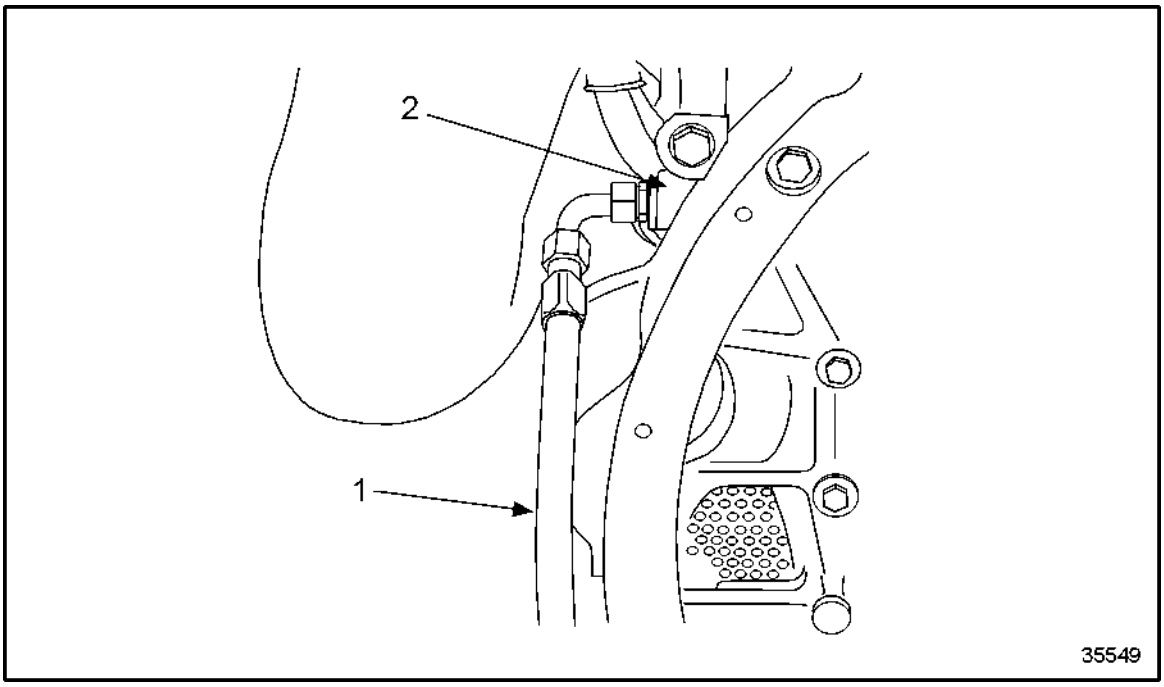
6. Connect vent line (1) of coolant pressure-testing device to engine vent. See Figure 850.



1. Vent Line

Figure 850 Connecting Vent Line to Coolant Pressure Testing Device

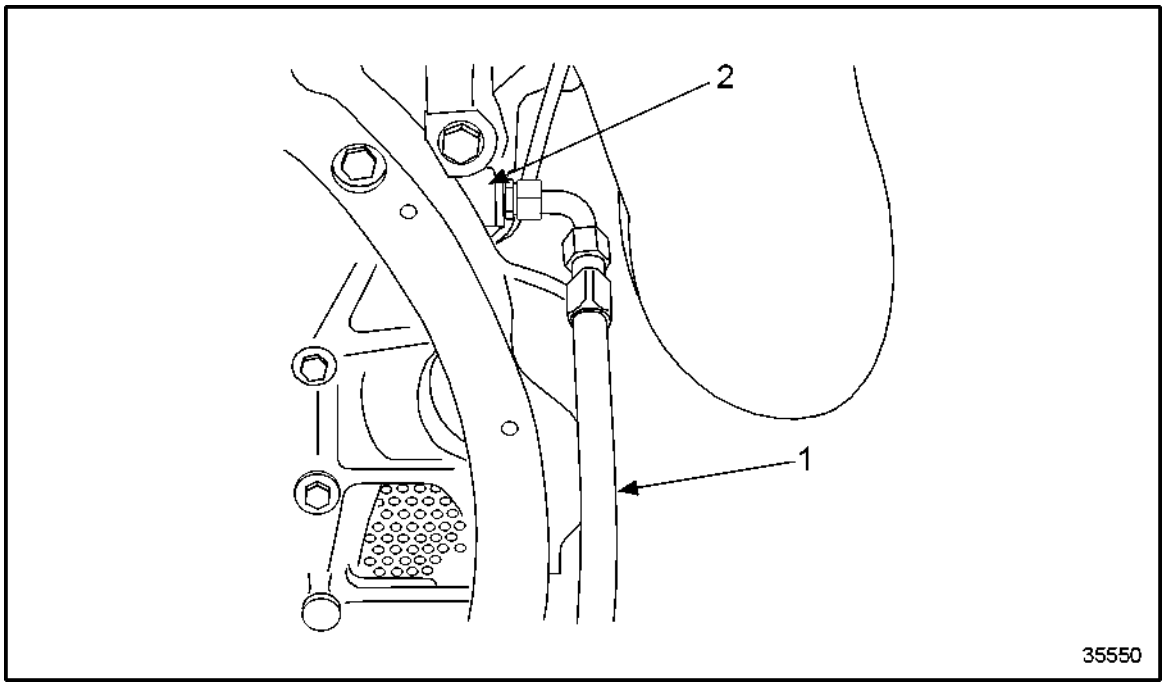
7. Connect drain hose line (1) of coolant pressure testing device to coolant port in cylinder block “A” bank engine side (flywheel end). See Figure 851.



1. Drain Hose Line
2. Coolant Port in Cylinder Block

Figure 851 Connecting Drain Hose Line of Hydraulic Pressure Testing Device to Coolant Port in Block (“A” Bank)

8. Connect drain hose line (1) of coolant pressure testing device to coolant port in cylinder block in “B” bank engine side (flywheel end). See Figure 852.



1. Drain Hose Line
2. Coolant Port in Cylinder Block ("B" Bank)

Figure 852 Connecting Drain Hose Line of Pressure Testing Device to Coolant Port in Black (“B” Bank)

9. Connect pressure unit and fill engine cooling system with treated coolant.
10. Pressure cooling system.

CAUTION:

To avoid personal injury, use care when dealing with fluids under pressure. Fluids under pressure have enough force to penetrate the skin. These fluids can cause a minor cut or opening in the skin. If injured by escaping fluid, see a doctor immediately. Serious infection or adverse reaction to the fluid can result if not treated immediately.

11. Pressure-test cooling system with water at 80°C for one hour.

NOTE:
Test pressure with water is 5 bar; test pressure with air is 1.3 bar.

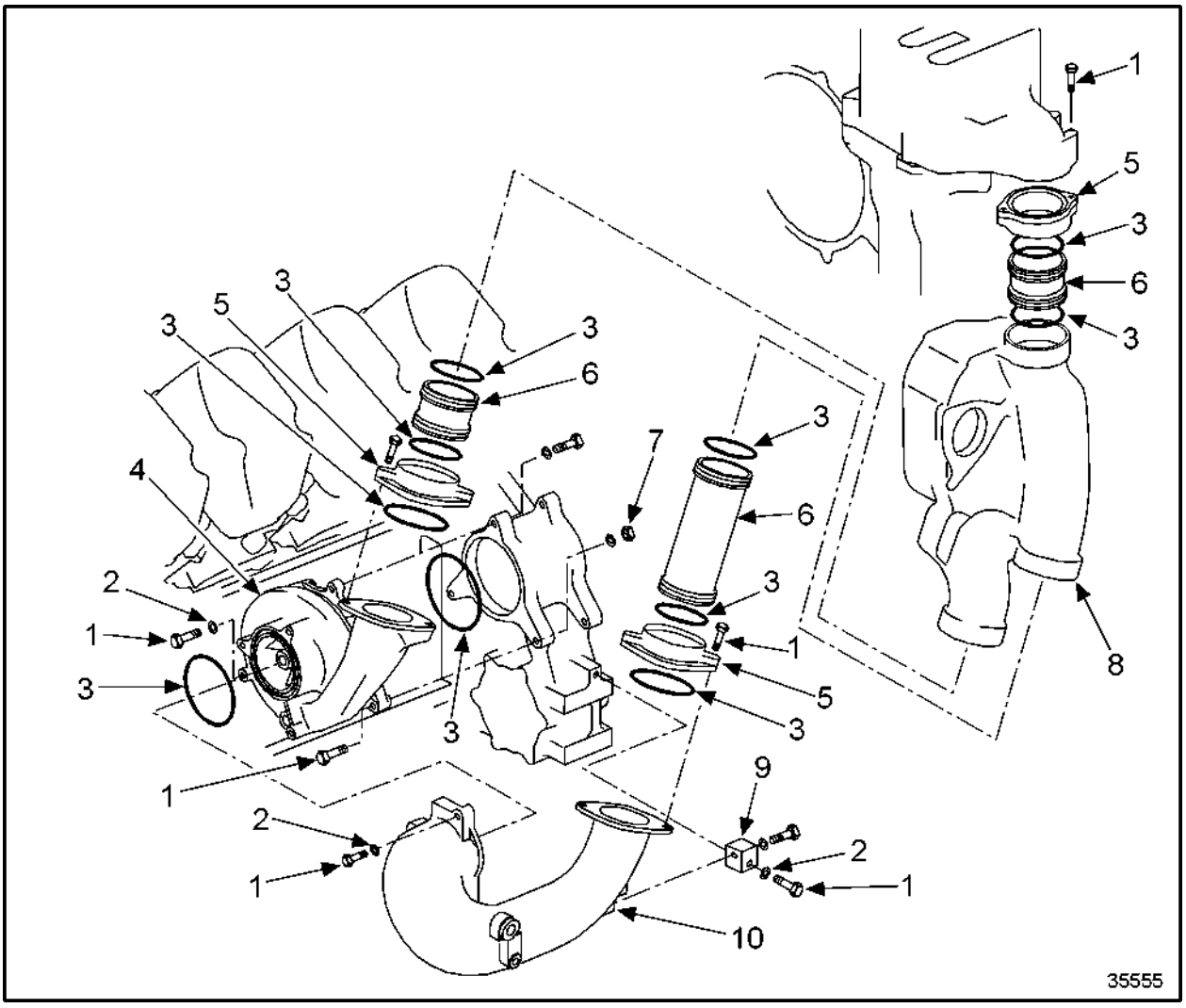
12. Inspect all coolant-retaining components for leaks.
    [a] If leaks are found, replace components as necessary.
    [b] If no leaks are found, continue inspection.
13. Release test pressure.
14. Drain system.
15. Remove removal tool.
16. Reinstall plugs.
17. Reinstall properly-treated engine coolant as per Operators Guide

C 202.05 – HIGH–TEMPERATURE WATER PUMP WITH ATTACHMENTS

C 202.05.01 – GENERAL VIEW

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

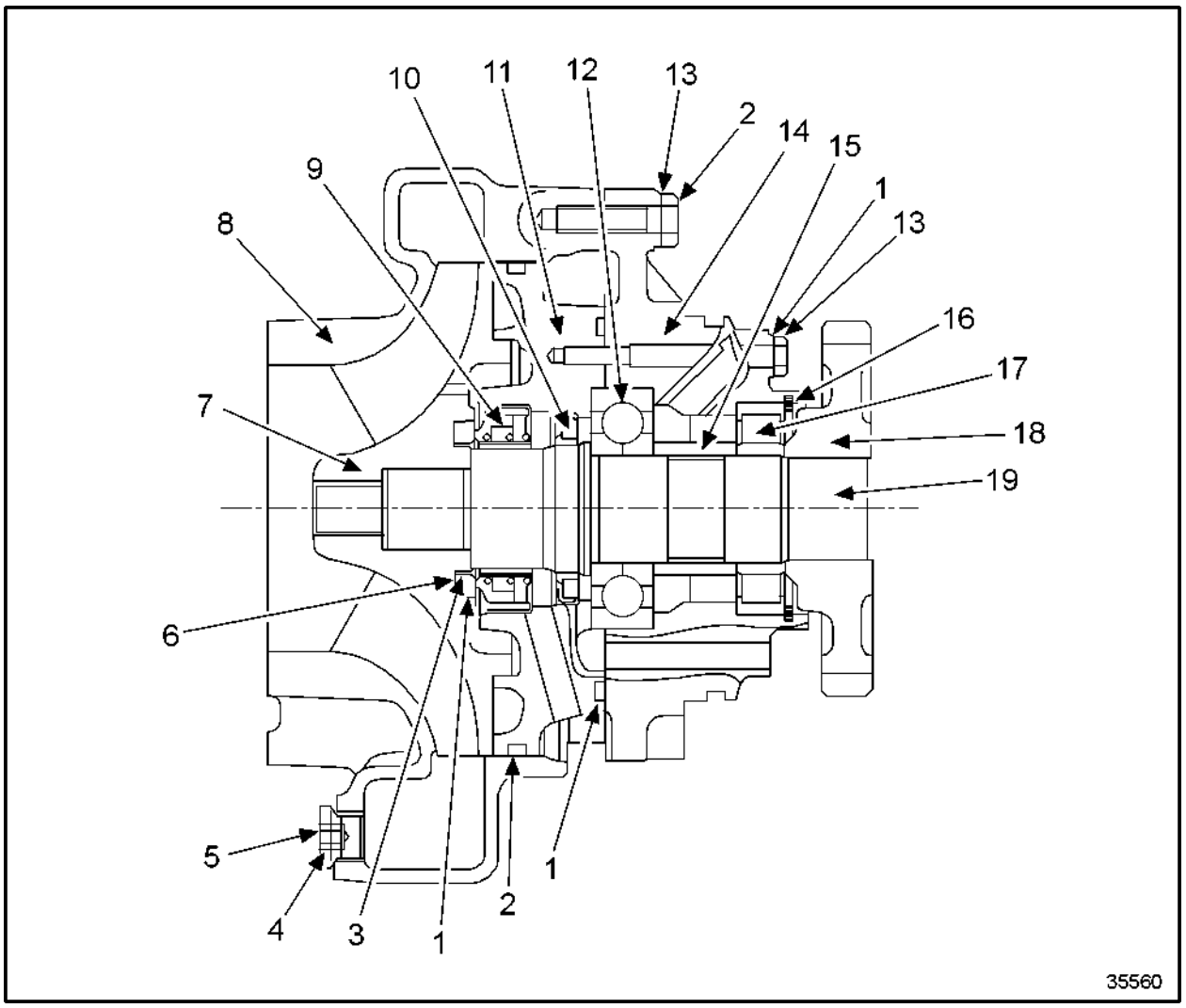
See Figure 853 for a general view of the coolant high-temperature water with attachments.



1. Hex Bolt
2. Washer
3. O-ring
4. High-Temperature Water Pump
5. Flange
6. Plug-in Pipe
7. Nut
8. Thermostat Housing
9. Bracket
10. Elbow

Figure 853 General View of High—Temperature Water Pump with Attachments

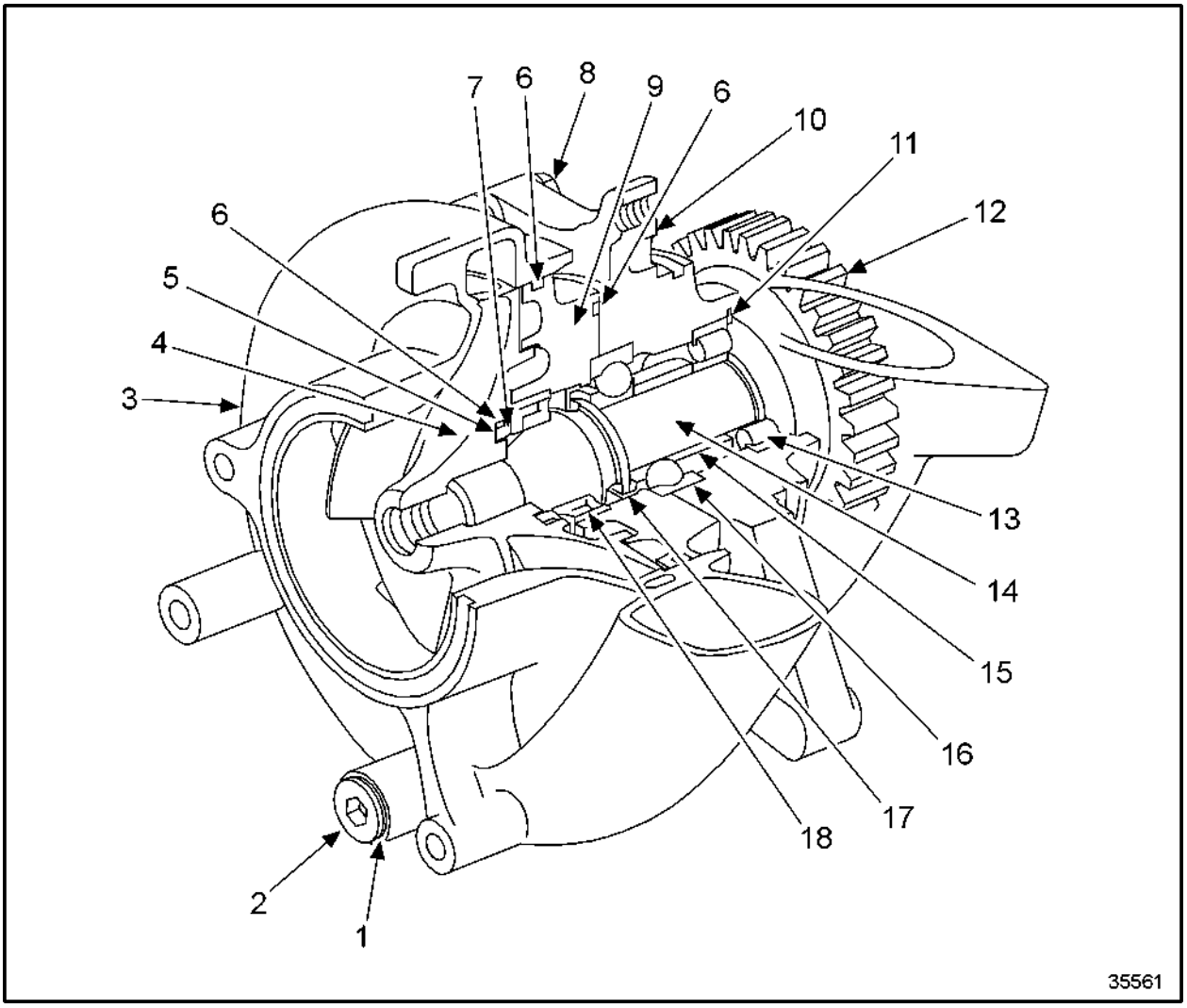
See Figure 854 for a cutaway view of the high—temperature water pump.



1. O-ring
2. Hex Bolt
3. Thrust Ring
4. Sealing Ring
5. Plug
6. Metal Ring
7. Impeller
8. Impeller
9. Rotary Seal
10. Shaft Seal
11. Seal Carrier
12. Angular-Contact Ball Bearing
13. Washer
14. Bearing Housing
15. Spacer Sleeve
16. Circlip
17. Cylindrical Roller Bearing
18. Gear
19. Water Pump Shaft

Figure 854 Cutaway View of High-Temperature Water Pump

See Figure 855 for a three-dimensional overview of the high–temperature water pump.



1. Washer
2. Plug
3. Impeller Housing
4. Impeller
5. Metal Ring
6. O-Ring
7. Thrust Ring
8. Hex Bolt
9. Seal Carrier
10. Bearing Housing
11. Circlip
12. Gear
13. Cylindrical Roller Bearing
14. Water Pump Shaft
15. Spacer Sleeve
16. Angular-Contact Ball Bearing
17. Shaft Seal
18. Rotary Seal

Figure 855 Three-Dimensional Overview of High-Temperature Water Pump

C 202.05.02 – SPECIAL TOOLS

Listed in Table 125 are the special tools required for maintenance of the high—temperature water pump.

Application	Number
Removal tool for impeller	—
Underlay sleeve for shaft	—
Underlay sleeve for housing	—
Installation tool for shaft	—
Installation tool for drive gear	—

Table 125 Special Tools

C 202.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 126 are the Before-Removal Operations for the high–temperature water pump.

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

1 = The engine is to be completely disassembled.

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

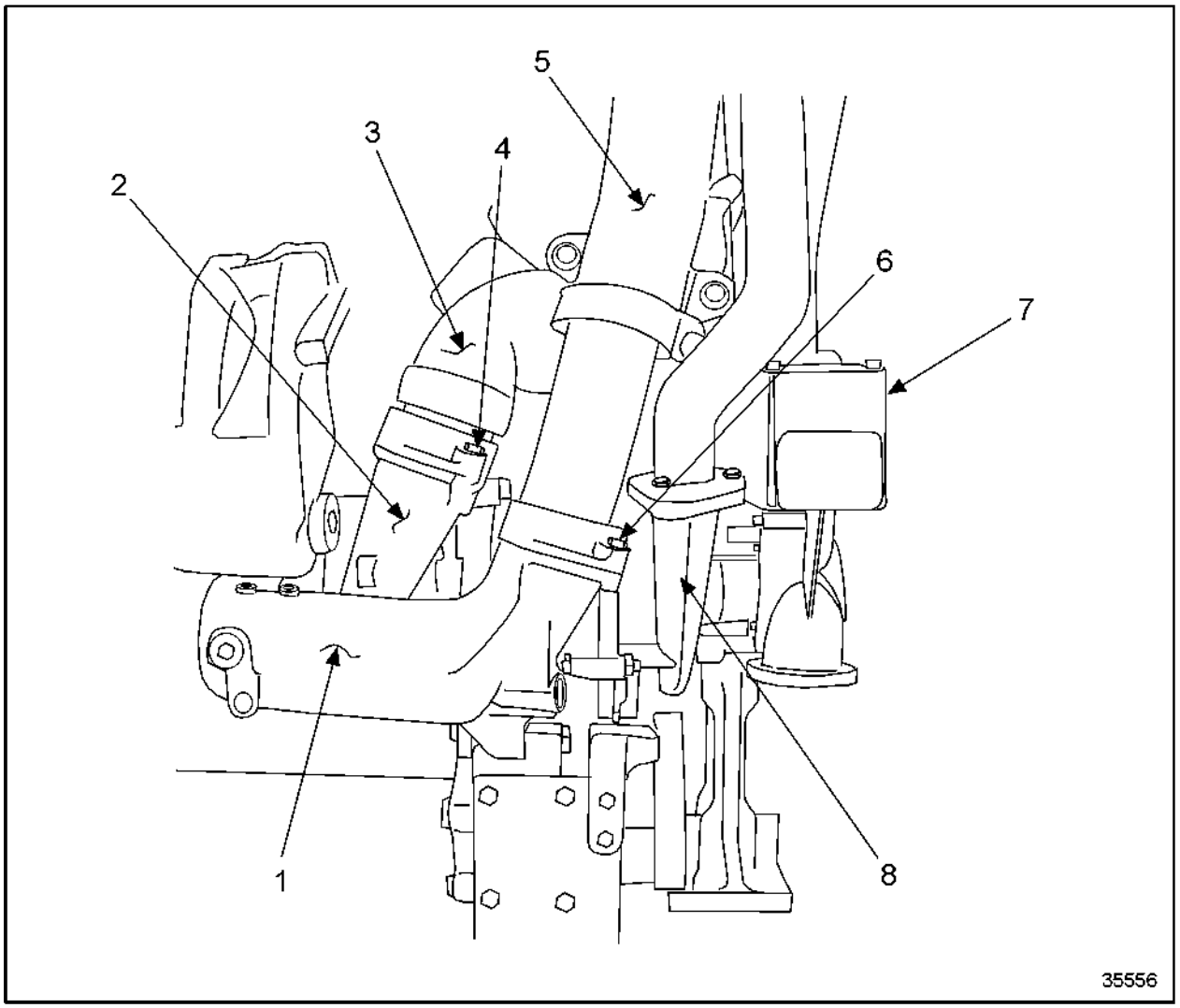
3 = The engine is to remain installed.

Table 126 Before-Removal Operations

C 202.05.05 – REMOVAL OF HIGH—TEMPERATURE WATER PUMP

Perform the following steps for the removal of the high—temperature water pump.

1. Remove coupling for charge air cooler (7). See Figure 856.



1. Water Pump Outlet Elbow
2. High Temperature Water Pump
3. Water Pump Inlet Elbow
4. Bolt
5. High Temperature Thermostat Housing
6. Bolt
7. Low Temperature Thermostat Housing
8. Low Temperature Water Pump

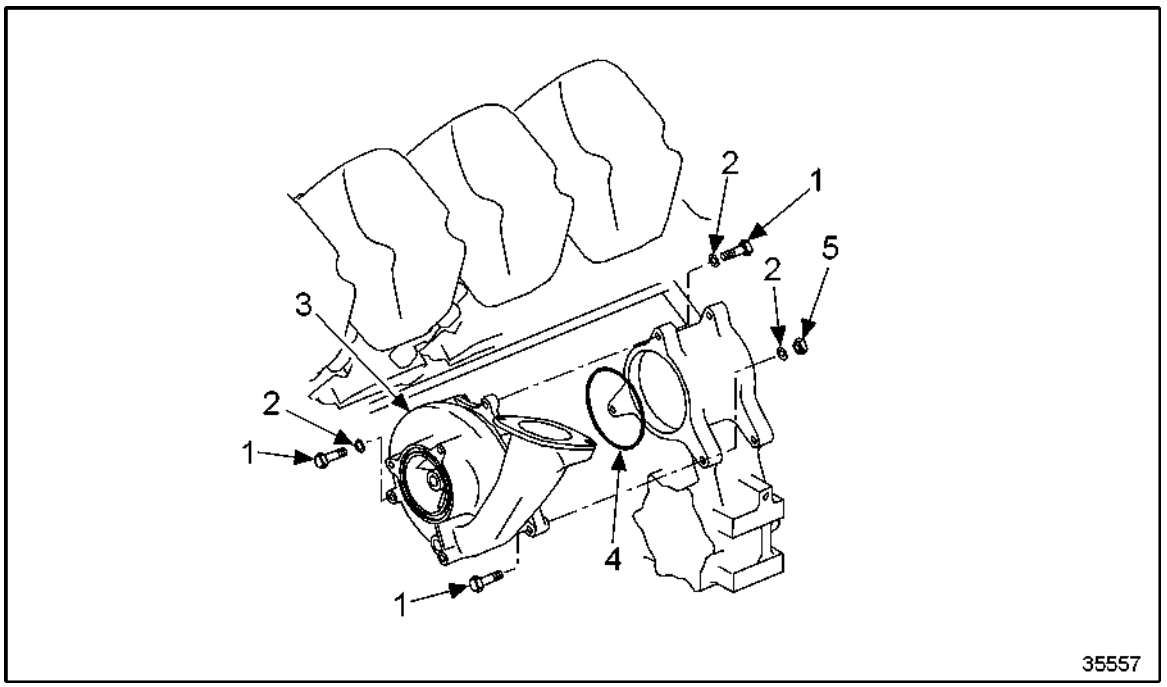
Figure 856 Removing Charge Air Cooler Pipe

2. Remove charge cooler pipe flange hex bolts and remove charge air cooler pipe (6).

3. Remove flange hex bolts at pump inlet (4).
4. Remove flange hex bolts on elbow (1).
5. Remove elbow (1).

C 202.05.06 – DISASSEMBLY OF HIGH-TEMPERATURE PUMP

1. Remove attaching bolts (1). See Figure 857.

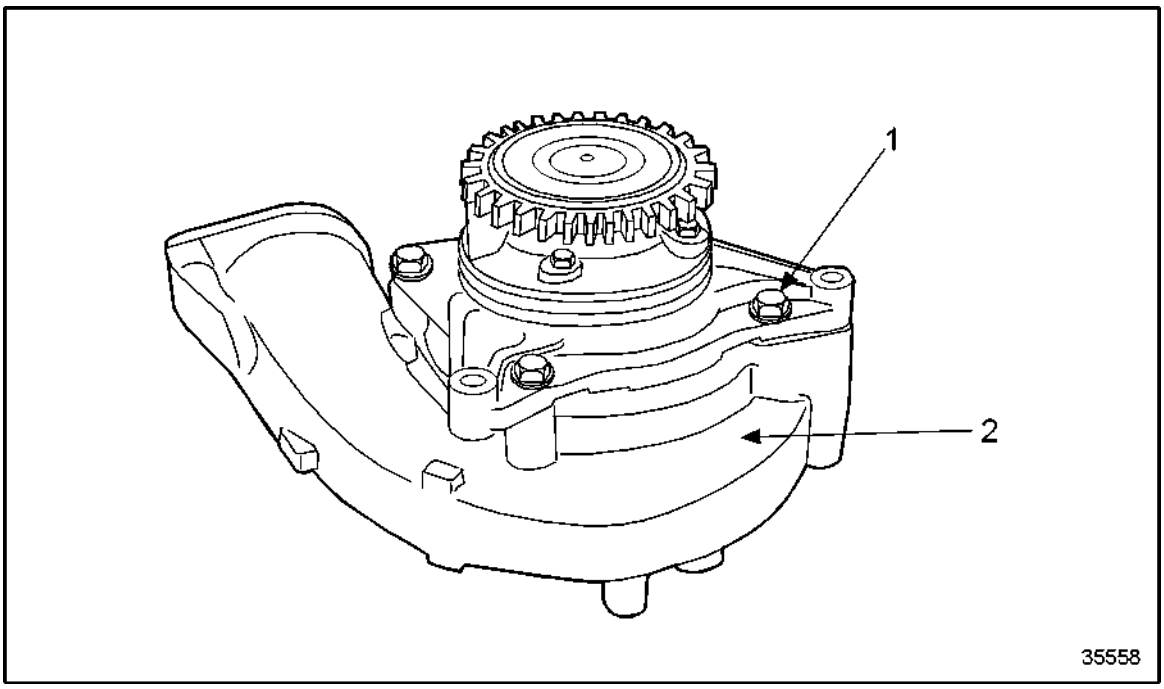


1. Hex Bolt
2. Washer
3. Pump Housing
4. O-ring
5. Hex Nut

Figure 857 Removing High—Temperature Water Pump from Gear Case

2. Use prybar to remove high-temperature water pump from gear case.
3. Remove O-ring from high—temperature water pump.

4. Remove securing bolts (1) from pump housing to seal carrier. See Figure 858.

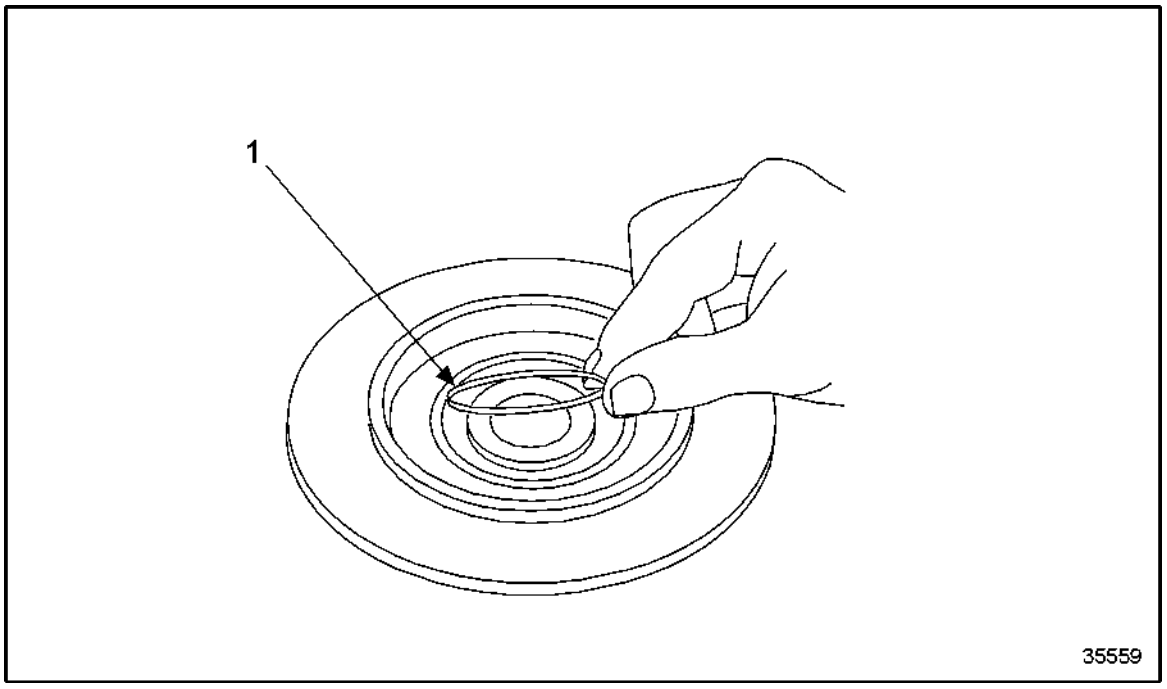


1. Securing Bolt
2. Coolant Pump Housing

Figure 858 Removing Attaching Bolts from Pump Housing to Seal Carrier and Removing Pump Housing

5. Using a pry bar, carefully remove pump housing (2).
6. Using a jack screw, remove the impeller from the pump shaft.

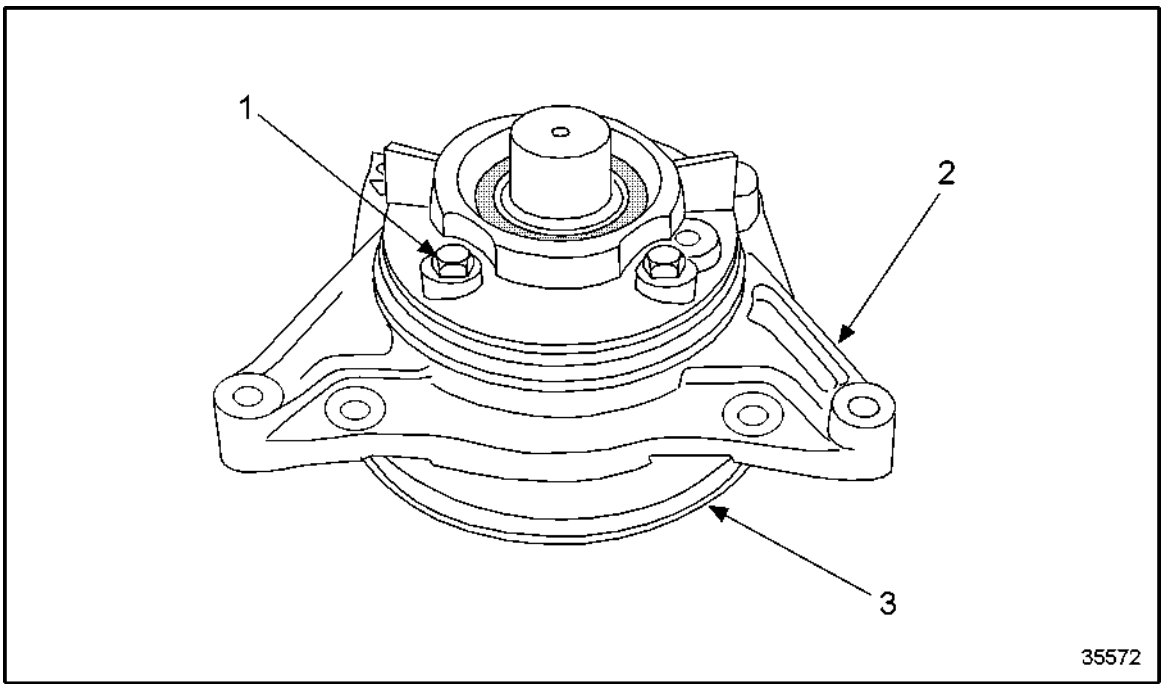
7. Remove thrust ring with inserted O-ring and metal ring from groove on back of impeller. See Figure 859.



1. Metal Ring

Figure 859 Removing Thrust Ring with Inserted O-ring and Metal Ring from Groove on Back of Impeller.

8. Use a suitable removal tool to remove gear from coolant pump shaft. See Figure 860.



1. Securing Bolt
2. Seal Carrier
3. Bearing Housing

Figure 860 Removing Securing Bolt between Seal Carrier and Bearing Housing

9. Remove thrust ring with inserted O-ring and metal ring from groove on back of impeller.

NOTE:
Due to the interference fit of gear hub and shaft, the shaft will be heavily scored when the gear is removed.

10. Remove securing bolt (1) between seal carrier (2) and bearing housing (3). See Figure 860.
11. Using a pry bar, carefully remove bearing housing from seal carrier.

12. Remove the pump shaft with roller bearing, spacer sleeve and bearing inner race from seal carrier. See Figure 861.

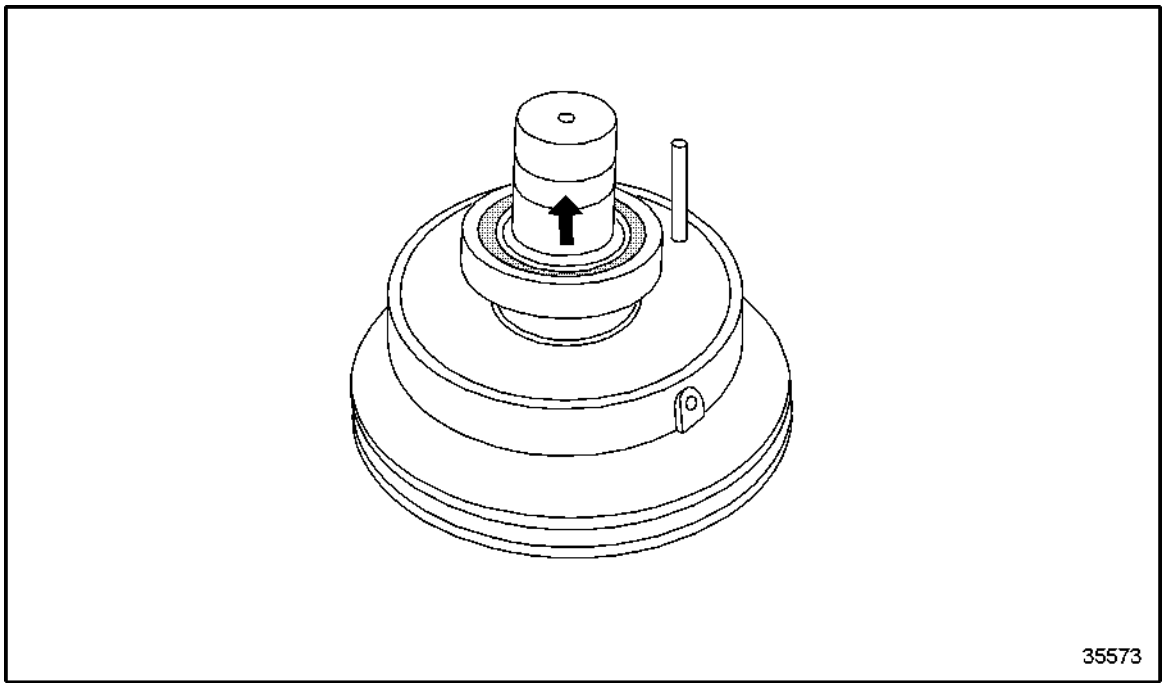
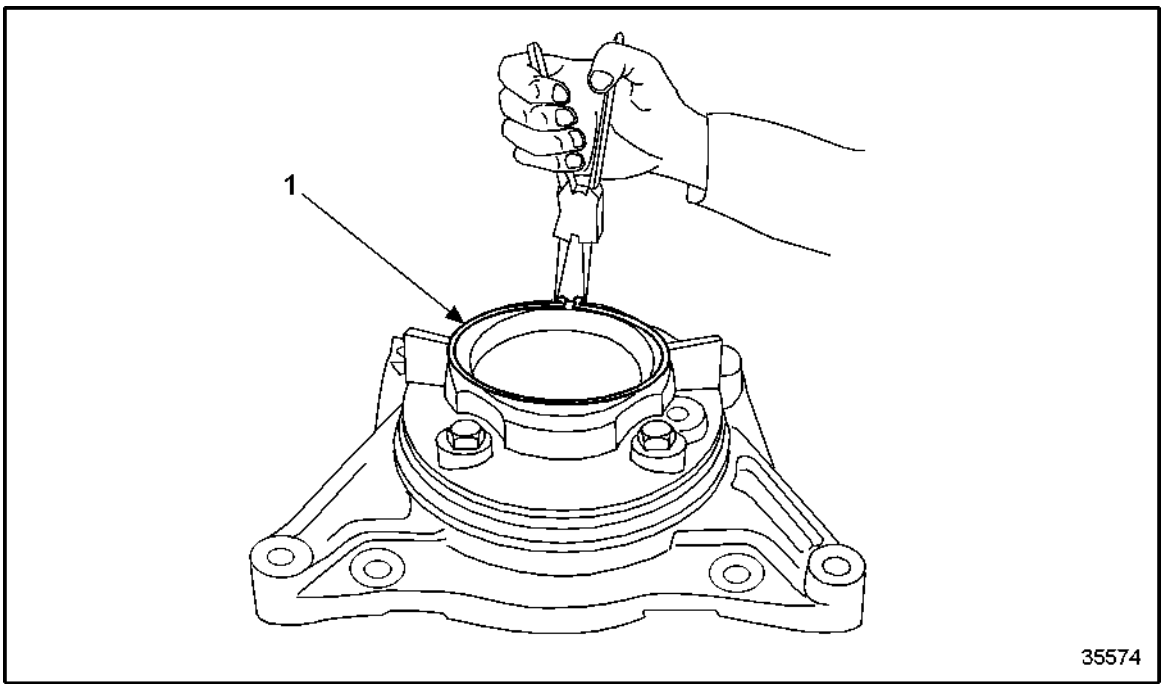


Figure 861 Removing Pump Shaft with Roller Bearing, Spacer Sleeve and Bearing Inner Race from Seal Carrier

13. Remove O-rings from seal carrier.
14. Use a suitable tool to remove bearing inner race, spacer sleeve and roller bearing from pump shaft.

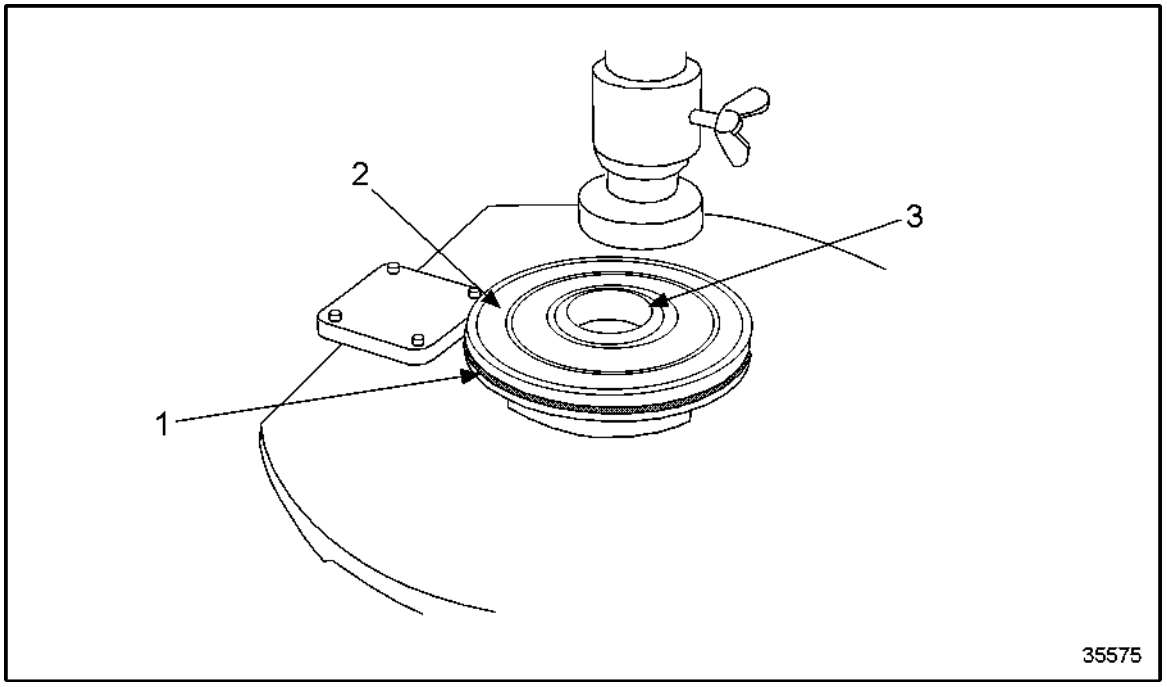
15. Remove snap ring (1) from bearing housing. See Figure 862.



1. Snap Ring

Figure 862 Removing Snap Ring from Bearing Housing

16. Withdraw bearing cage with outer race of cylindrical roller bearing from bearing housing.
17. Remove rotary seal (3) and shaft seal behind it from seal carrier (2). See Figure 863.



1. O-ring
2. Seal Carrier
3. Rotary Seal

Figure 863 Removing Rotary Seal and Shaft Seal from Seal Carrier

C 202.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the high–temperature water pump:

1. Clean all components.
2. Using surface crack-testing method and red penetrant dye, inspect impeller for cracks.
   [a] If cracks are found, repair or replace impeller.
   [b] If no cracks are found, continue inspection.
3. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect pump shaft and gear for cracks.
   [a] If pump shaft or gear is cracked, repair or replace components as necessary.
   [b] If pump shaft or gear is not cracked, continue inspection.
4. Visually inspect sealing surfaces and/or annular grooves on elbow, housing, impeller and inlet connection for wear, indentations and pitting.
   [a] If sealing surfaces and/or annular grooves are worn, indented or pitted, rub down with emery cloth or an oilstone.
   [b] If damage is beyond repair, replace component.
   [c] If sealing surfaces and/or annular grooves are not worn or damaged, continue inspection.
5. Visually inspect elbow, housing, impeller and inlet adaptor for pitting.
   [a] If pitting is over 1 mm in depth, replace component.
   [b] If pitting is under 1 mm in depth, continue inspection.

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.

6. Visually inspect elbow, inlet adapter and housing for leaks with compressed air under water.
   [a] If elbow, inlet adaptor or housing show leaks, repair or replace components as necessary.
   [b] If elbow, inlet adaptor or housing do not show leaks, continue inspection.

NOTE:
Water temperature should be within a minimum of 30 °C (86 °F) to a maximum of 40 °C (104 °F).

7. Visually inspect shaft for wear and damage.

[a] If shaft is worn or damaged, smooth out slight wear and damage with an emery cloth.

[b] If damage is beyond repair, replace shaft.

[c] If shaft is not worn or damaged, continue inspection.

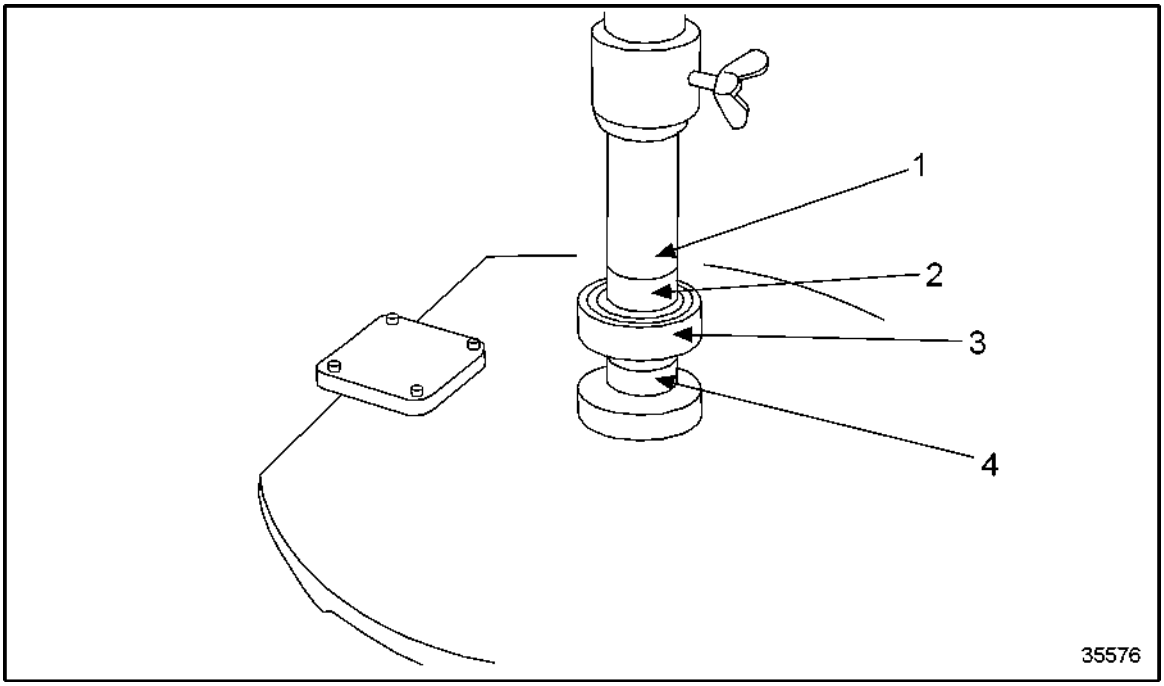
8. Visually inspect gear for indentations and wear.
   [a] If gear is indented or worn, rub down with an oilstone or an emery cloth.
   [b] If damage is beyond repair, replace gear.
   [c] If gear is not worn or indented, continue inspection.
9. Visually inspect threads for wear and damage.
   [a] If threads are worn or damaged, rechase components.
   [b] If damage is beyond repair, replace component.
   [c] If threads are not worn or damaged, continue inspection.
10. Adjust bore gage and measure bearing bores in housing.
   [a] If bearing bores are not within specified limits, replace components as necessary.
   [b] If bearing bores are within specified limits, continue inspection.
11. Using micrometer, measure bearing seat on shaft.
   [a] If limit values are exceeded, replace components as necessary.
   [b] If limit values are not exceeded, continue inspection.
12. Replace cylindrical roller bearing and grooved ball bearing as part of every W6 overhaul.
13. After every pump disassembly, replace gaskets, O-rings, rotary seal and radial-lip shaft seal.

C 202.05.10 – ASSEMBLY OF HIGH-TEMPERATURE WATER PUMP

Perform the following steps to assemble the high-temperature water pump.

NOTE:
Ensure that oil-retaining parts are perfectly clean.

1. To prepare pump shaft, degrease contact surfaces of pump shaft (4), angular-contact ball bearing (3), spacer sleeve (2) and inner race (1) of cylindrical roller bearing. See Figure 864.



1. Inner Race
2. Spacer Sleeve
3. Angular-Contact Ball Bearing
4. Pump Shaft

Figure 864 Pressing Angular-Contact Ball Bearing, Spacer Sleeve and Inner Race of Cylindrical Roller Bearing on Pump Shaft

2. Place shaft contact washer in manual press.
3. Place pump shaft so that mating surface for angular-contact ball bearing surfaces up.
4. Press the angular-contact ball bearing, spacer sleeve and inner race of cylindrical roller bearing on pump shaft.

5. Coat pump shaft in running area of shaft seal (arrow) with Molykote. See Figure 865.

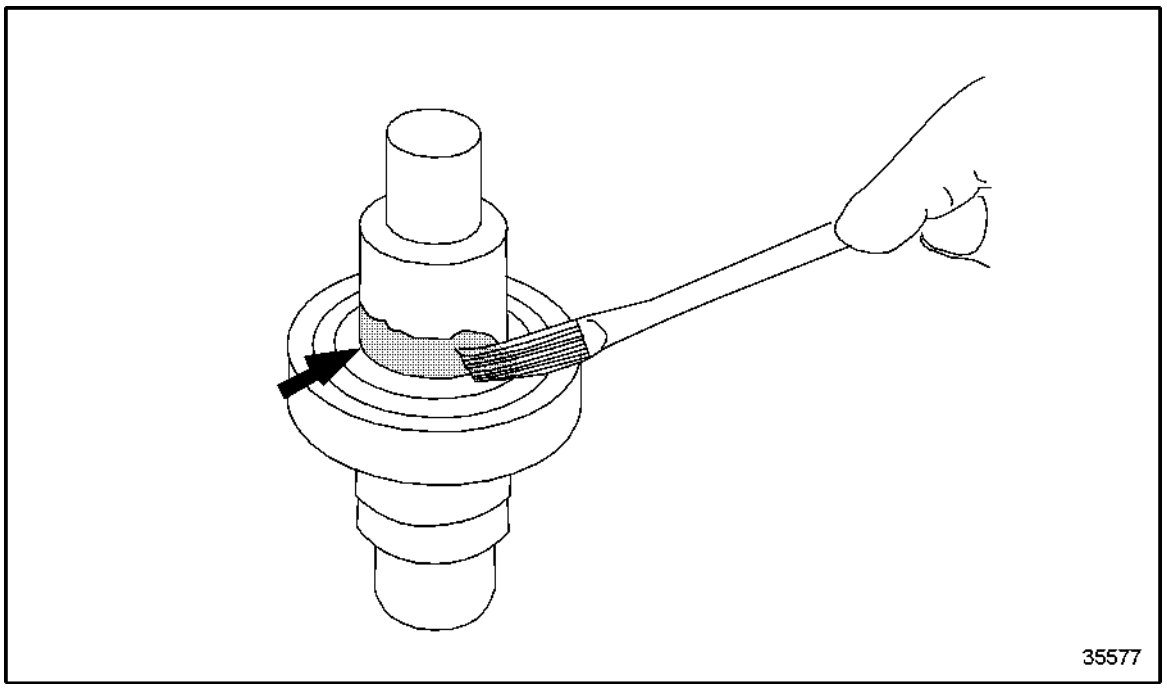


Figure 865 Coating Pump Shaft with Molykote

6. To prepare bearing housing, degrease contact surfaces of cylindrical roller bearing in bearing housing.

7. Install cylindrical roller bearing evenly to the stop. See Figure 866.

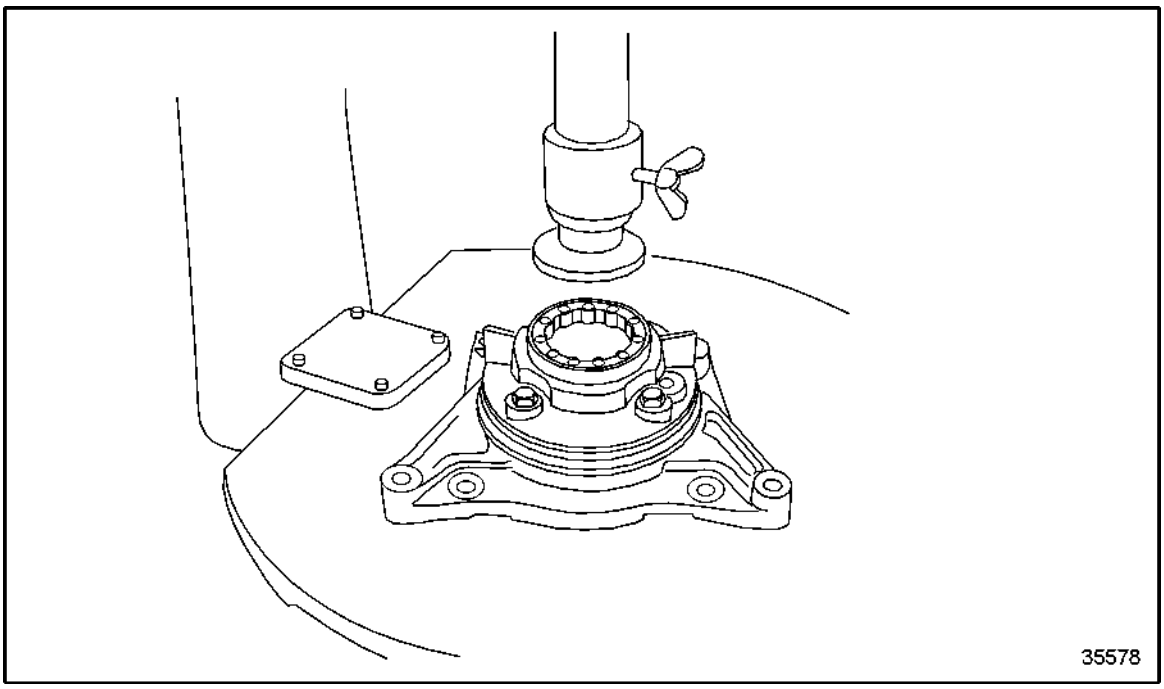
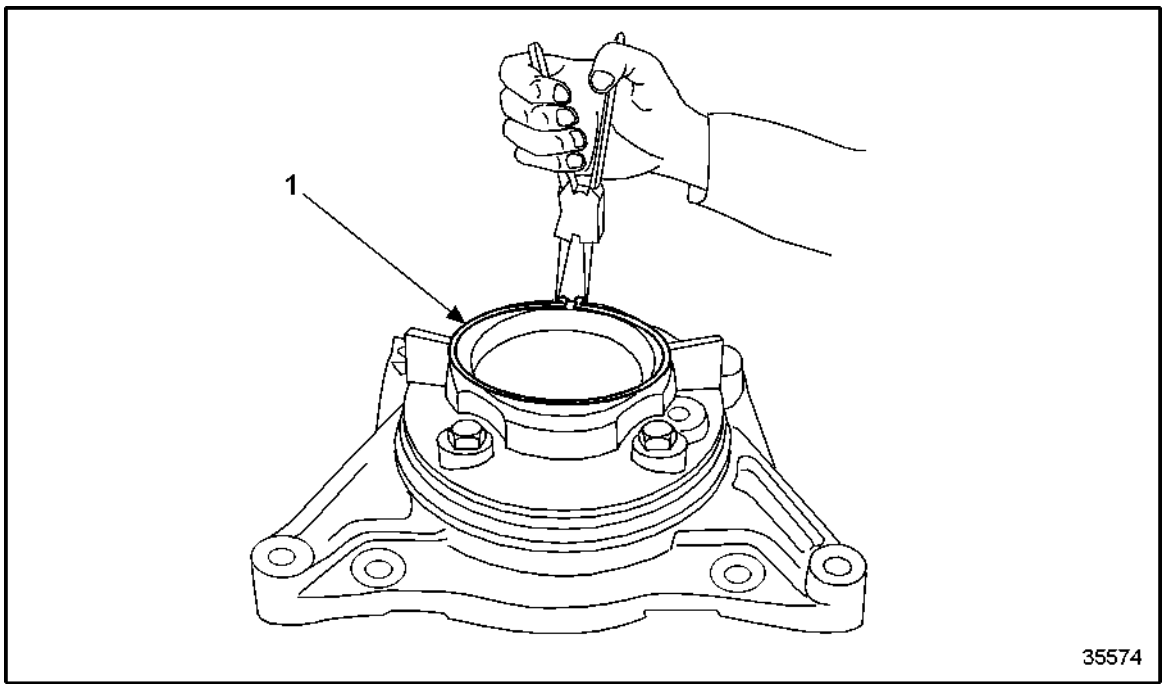


Figure 866 Installing Cylindrical Roller Bearing

8. Insert snap ring (1) for cylindrical roller bearing in bearing housing. See Figure 867.

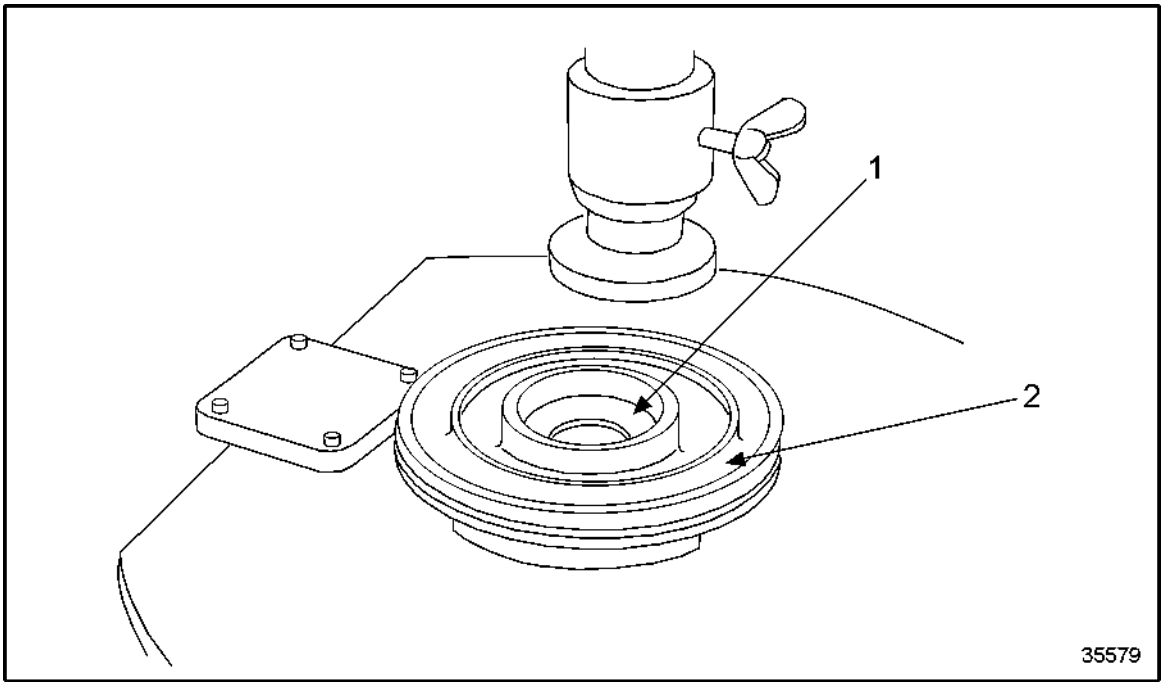


1. Snap Ring

Figure 867 Inserting Snap Ring into Bearing Housing

9. To prepare seal carrier, degrease contact surfaces of shaft seal.

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.

12. Coat outer surface of rotary seal with sealant. See Figure 869.

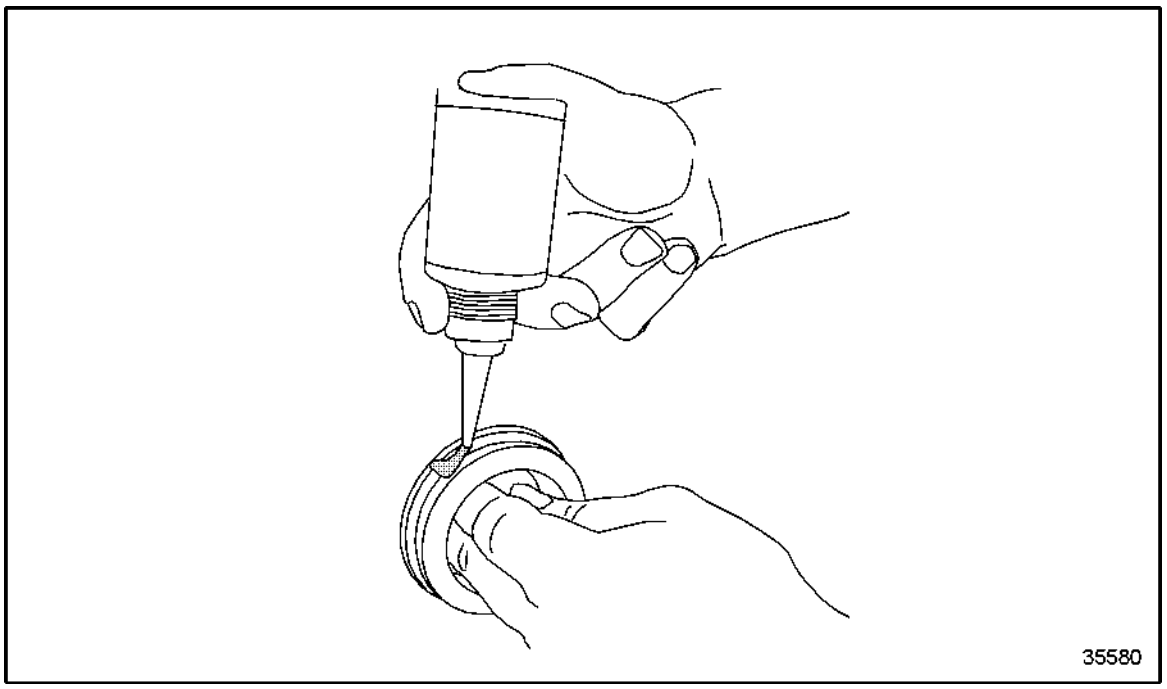
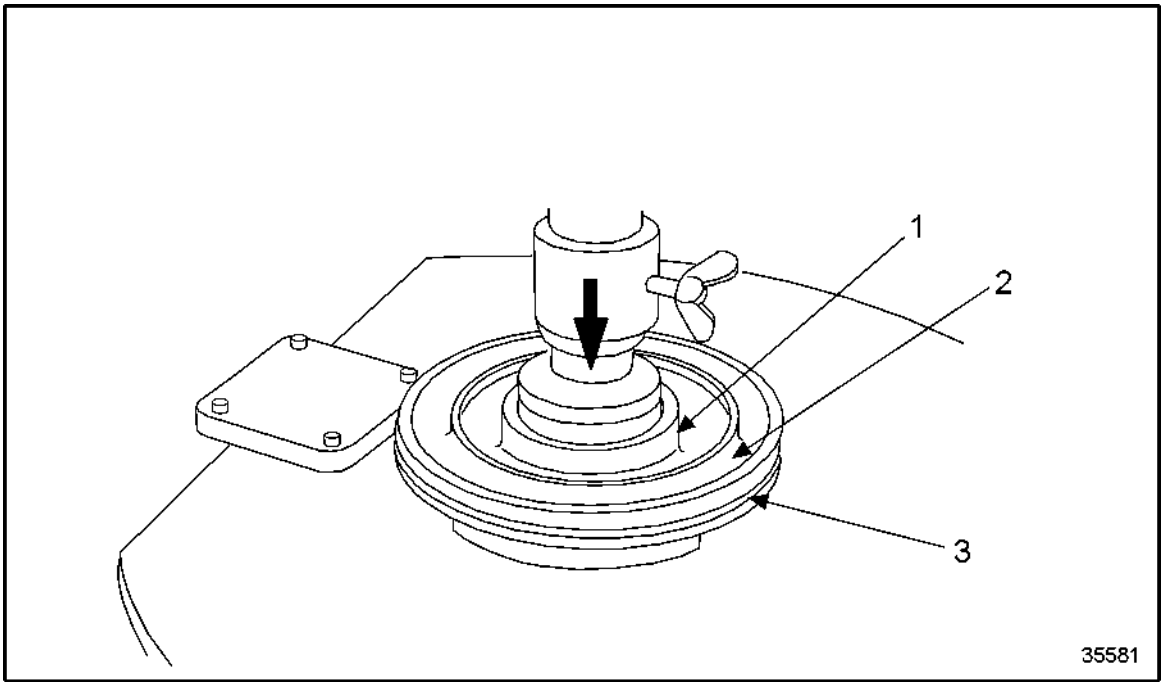


Figure 869 Coating Outer Surface of Rotary Seal with Surface Sealant

13. Install rotary seal (1) evenly in seal carrier. See Figure 870.

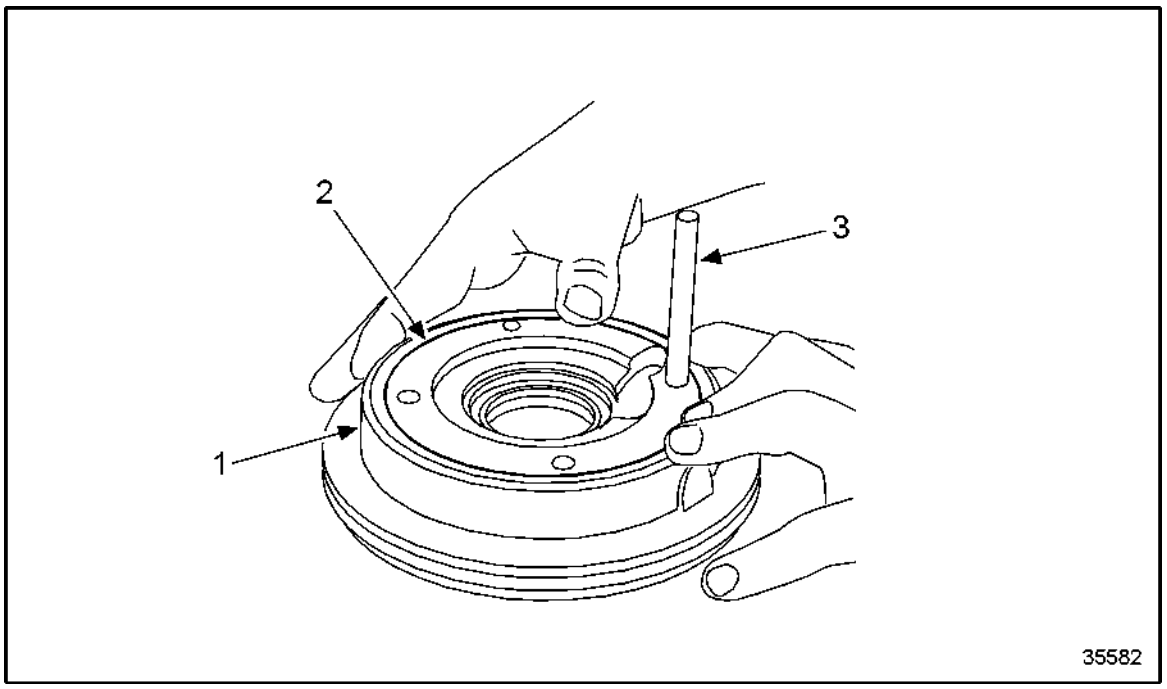


1. Rotary Seal
2. Seal Carrier
3. O-ring

Figure 870 Inserting Rotary Seal in Seal Carrier

14. Coat O-ring (3) with petroleum jelly and insert into groove in seal carrier (2).

15. Turn seal carrier over to work on the other side. See Figure 871.



1. Seal Carrier
2. O-ring
3. Guide Pin

Figure 871 Turning Seal Carrier Over

NOTE:
Ensure that bore of seal carrier comes to rest over an opening in working plate, so that pump shaft is not obstructed during subsequent installation.

16. Coat O-ring (2) with petroleum jelly and insert into groove provided on seal carrier (1). See Figure 871.
17. Screw in guide pin (3). See Figure 871.

18. Install prepared pump shaft in seal carrier. See Figure 872.

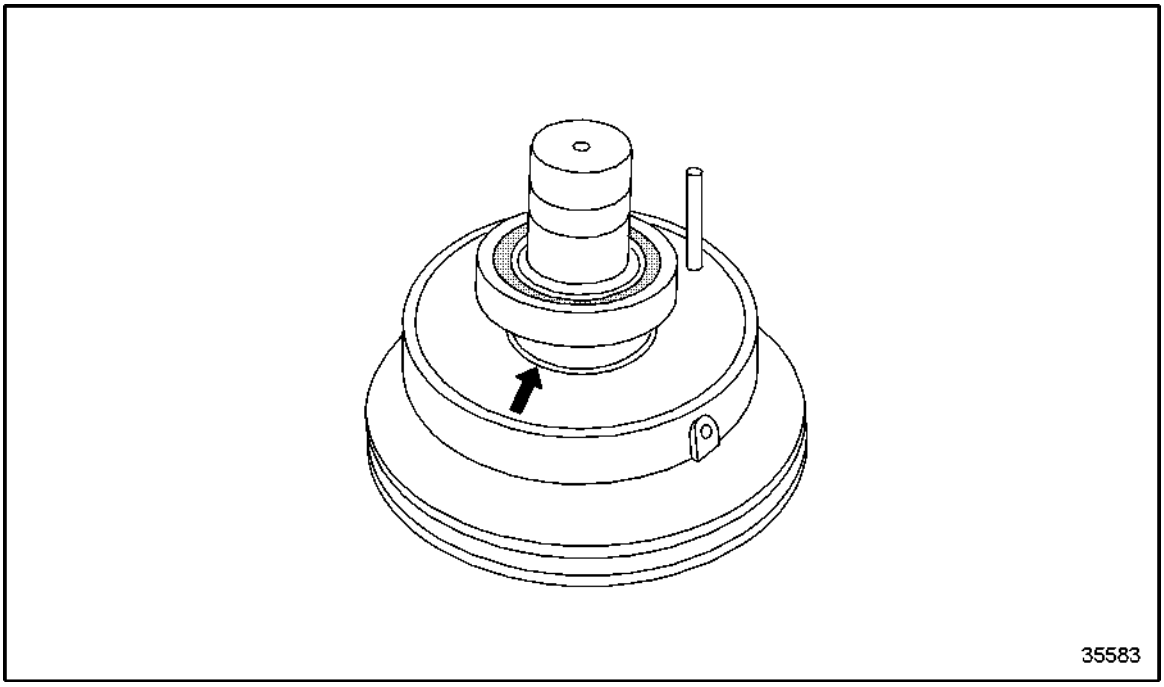
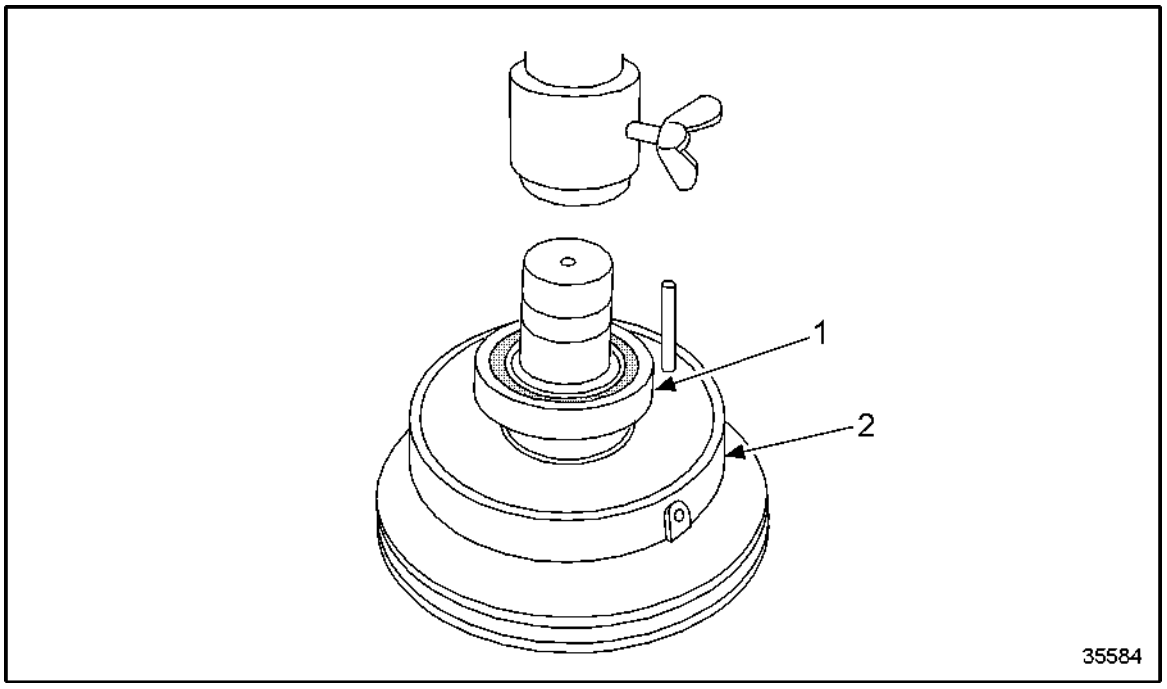


Figure 872 Installing Pump Shaft

19. Insert part of shaft coated with Molykote (arrow) first.
20. Ensure that lip of shaft seal is not damaged.

21. Check that pump shaft with angular-contact ball bearing is correctly positioned in seal carrier (1). See Figure 873.

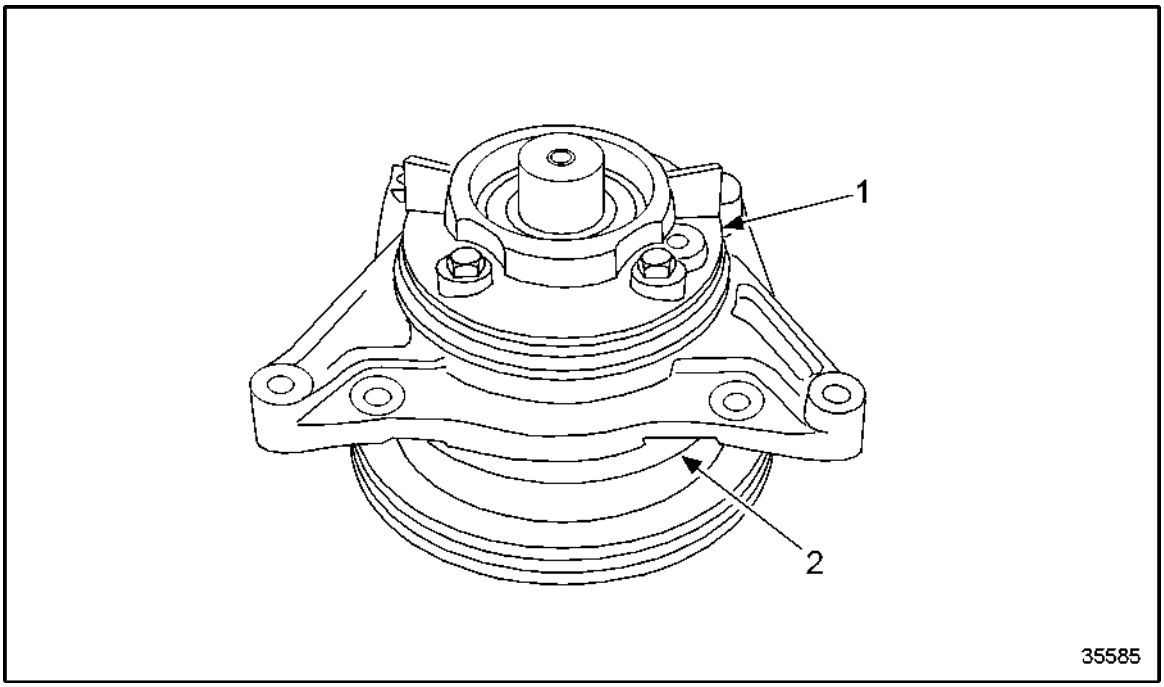


1. Seal Carrier
2. Ball Bearing

Figure 873 Checking Pump Shaft Positioning

22. Angular-contact ball bearing (2) must be flat.

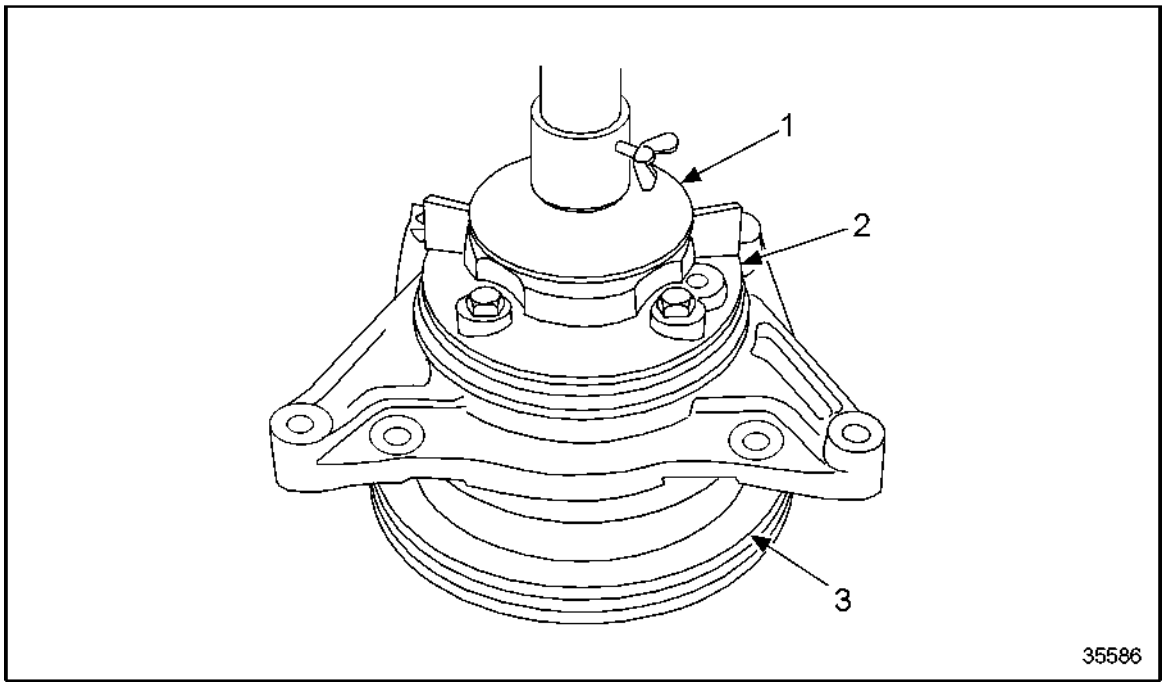
23. Install bearing housing (1) on guide pins and place loosely on sealing ring flange (2). See Figure 874.



1. Bearing Housing
2. Sealing Ring Flange

Figure 874 Installing Bearing Housing on Guide Pin and Placing Loosely on Sealing Ring Flange

24. Place brass drift adapter for seal carrier (3) in manual press. See Figure 875.

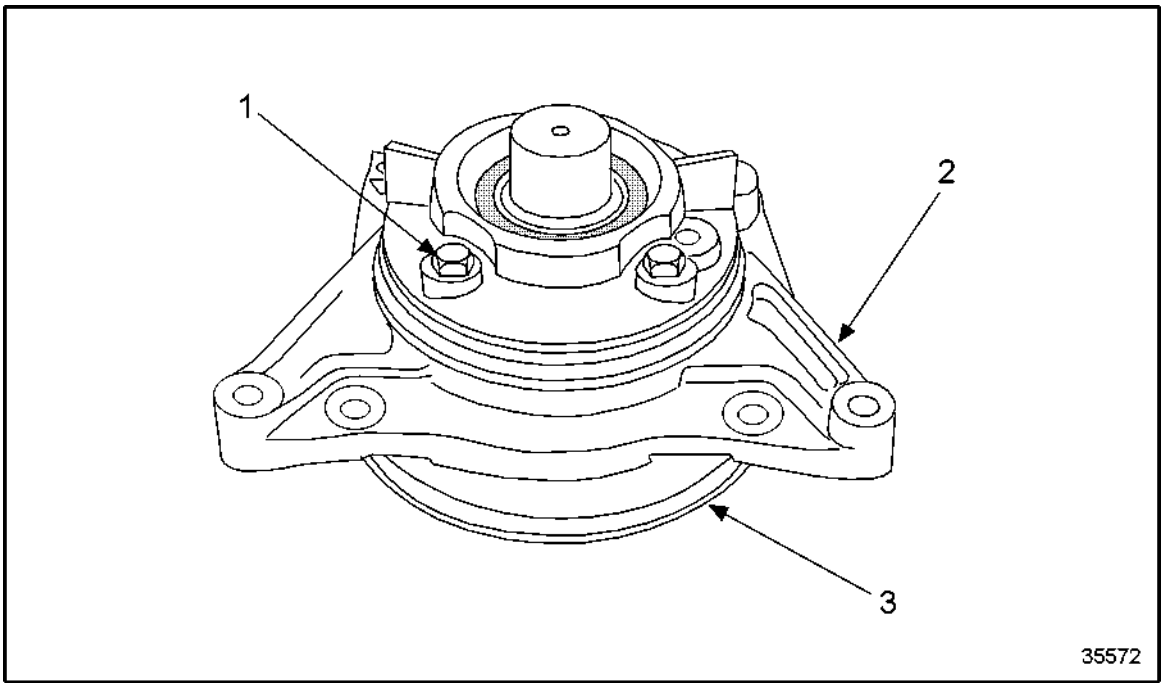


1. Brass Drift Adapter
2. Bearing Housing
3. Seal Carrier

Figure 875 Pressing Bearing Housing onto Seal Carrier

25. Use press to press bearing housing (2) onto seal carrier (3) to the stop.

26. Remove guide pin and locate bearing housing (2) with hex bolt (1) against seal carrier (3). See Figure 876.



1. Hex Bolt
2. Bearing Housing
3. Seal Carrier

Figure 876 Locating Bearing Housing with Hex Bolt against Seal Carrier

27. Tighten hex bolt to specification. Refer to section A 003.

28. To install drive gear, first degrease contact surface on drive gear. See Figure 877.

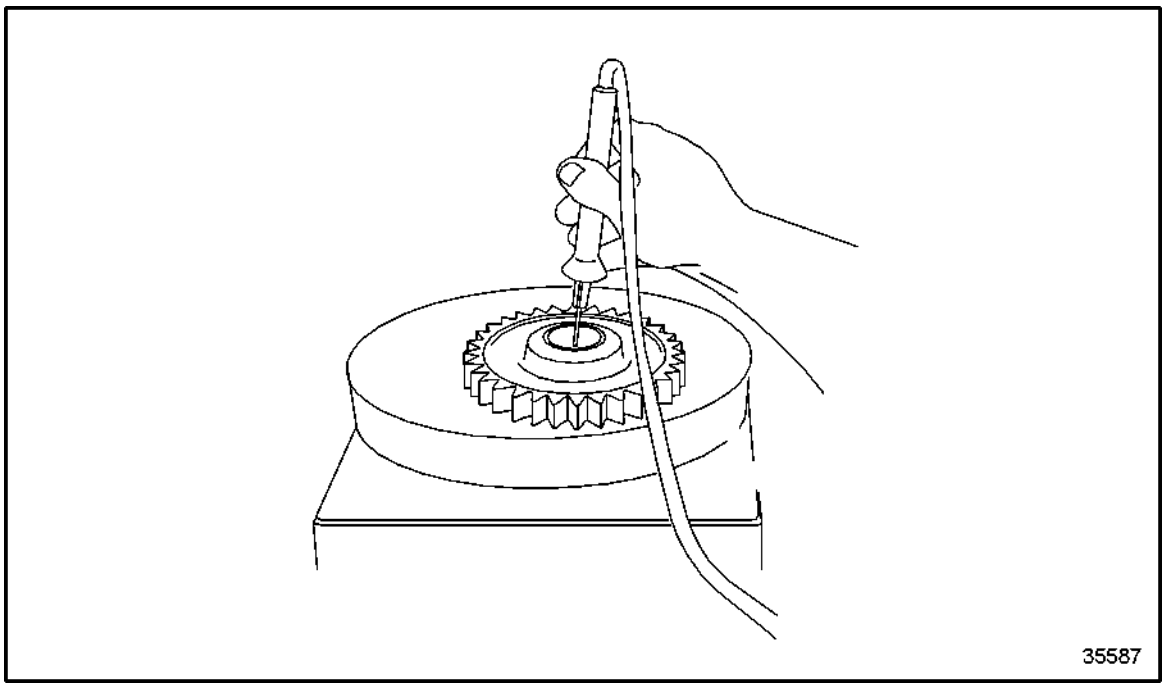


Figure 877 Degreasing Drive Gear

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

29. Preheat drive gear uniformly to 180°C.
30. Degrease contact surfaces on drive gear and pump shaft.

31. Place brass drift adapter for pump shaft in manual press. See Figure 878.

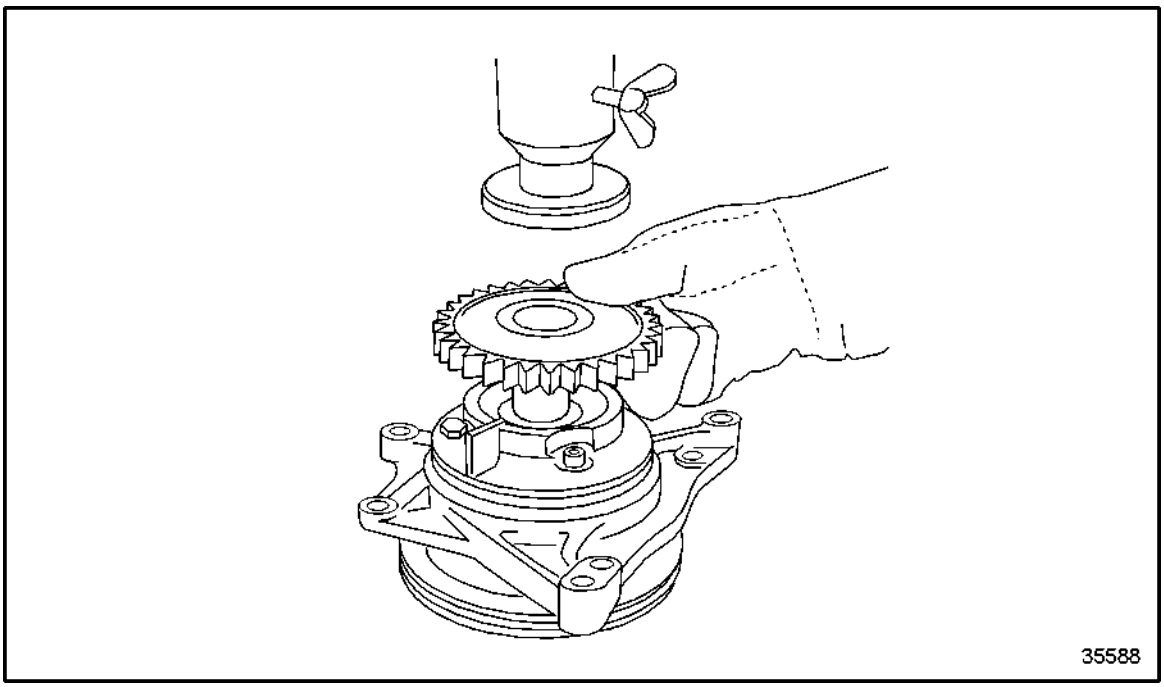


Figure 878 Installing Drive Gear

32. Place installed pump shaft on adapter so that bearing housing faces up.
33. Place preheated gear on pump shaft and press into place to the stop.

34. Maintain pressure until shaft-gear (shrink-on) connection is firm. See Figure 879.

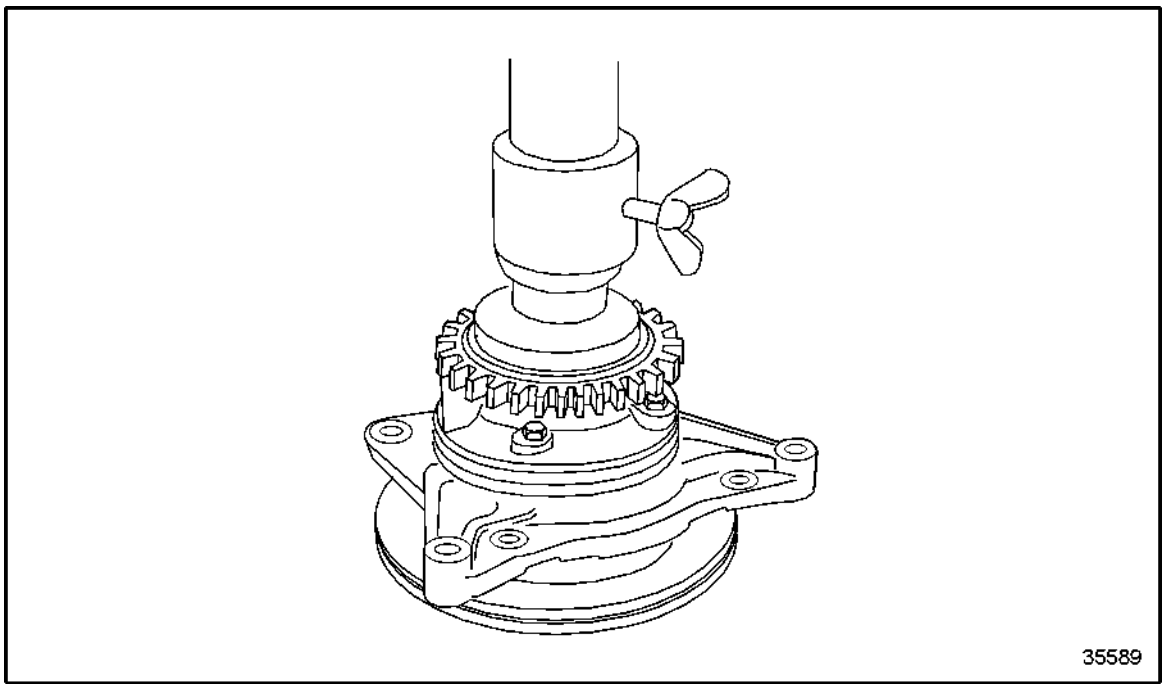


Figure 879 Press-Fitting Drive Gear

35. Turn pump assembly over to complete the installation.
36. To install impeller, first degrease contact surface between pump shaft and impeller.

37. Place pump on manual press with drive gear facing down. See Figure 880.

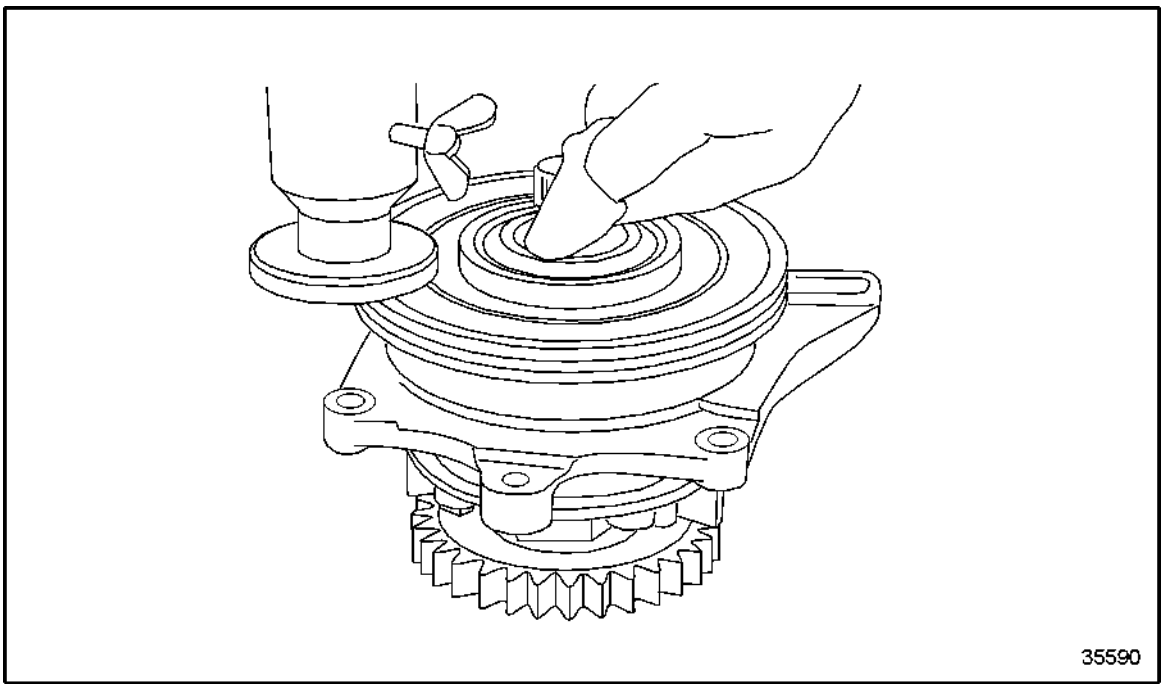
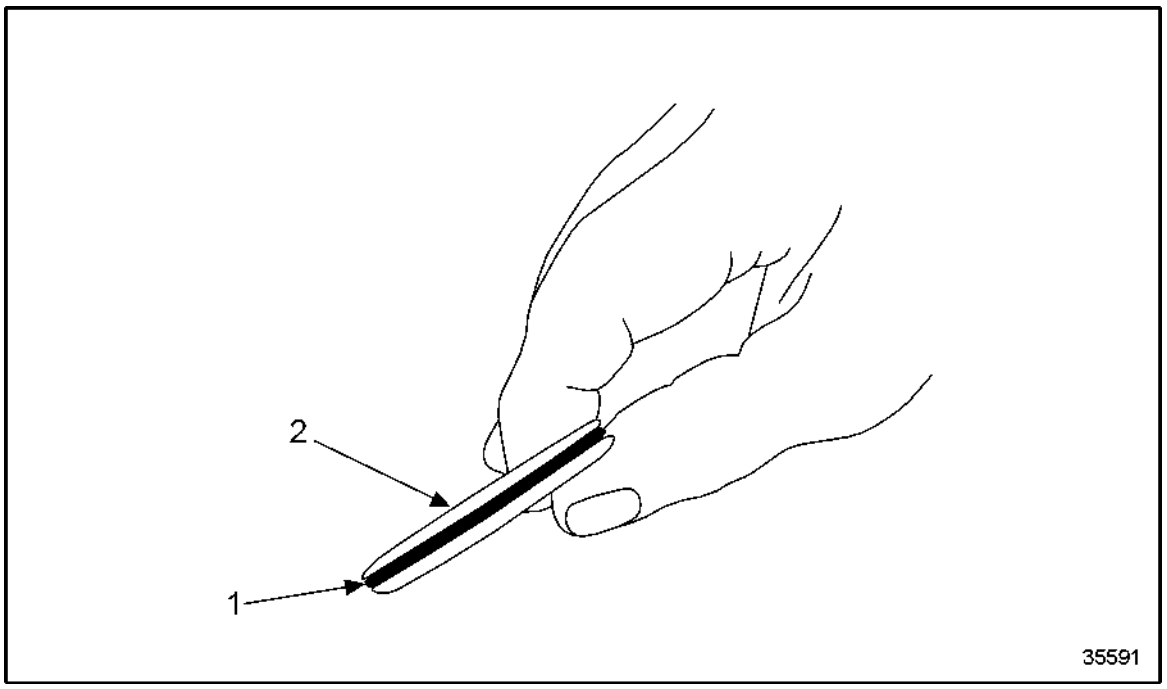


Figure 880 Installing Impeller and Cleaning Rotary Seal Surface

38. Clean rotary seal surface with ethanol.

39. Coat O-ring (1) with petroleum jelly and install on thrust ring (2). See Figure 881.



1. O-ring
2. Thrust Ring

Figure 881 Coating O-ring and Fitting on Thrust Ring

NOTE:
Ensure that O-ring is perfectly seated against shoulder of thrust ring.

40. Degrease impeller in area of shaft bore and mating surface of thrust ring. See Figure 882.

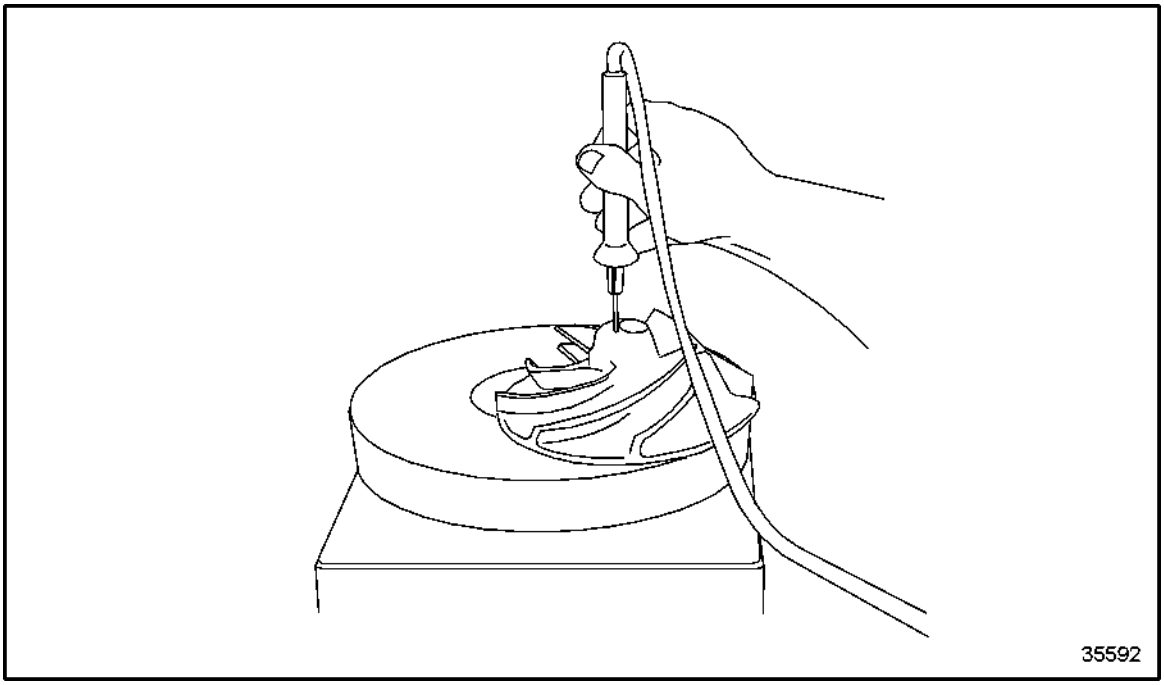


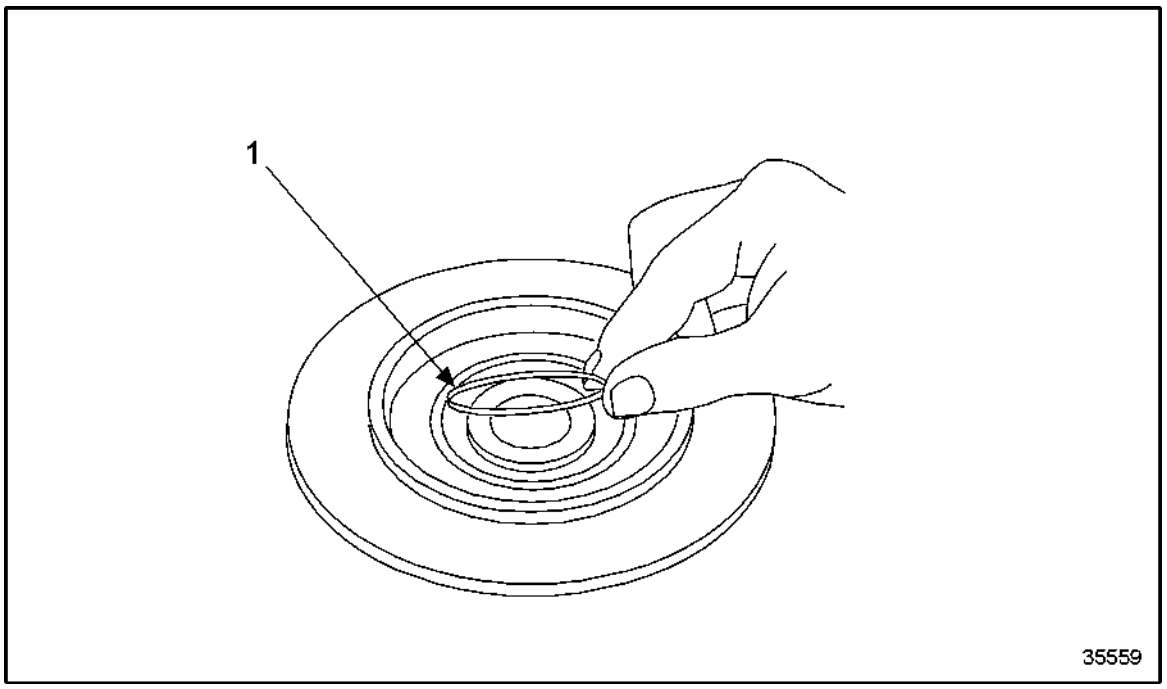
Figure 882 Degreasing Impeller

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

41. Preheat impeller uniformly to 210°C.

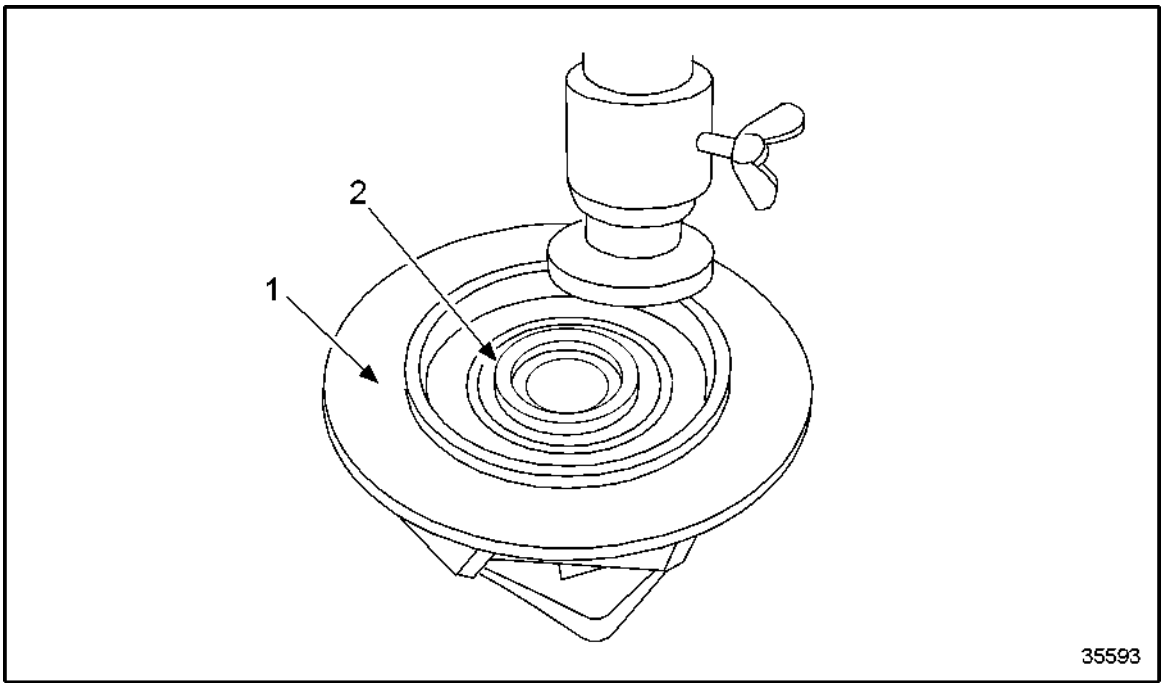
42. Install metal ring (1) in groove on back of impeller. See Figure 883.



1. Metal Ring

Figure 883 Installing Metal Ring in Groove on Back of Impeller

43. Press thrust ring (2) (with fitted O-ring) into groove on back of impeller (1). See Figure 884.



1. Impeller
2. Thrust Ring

Figure 884 Pressing Thrust Ring into Groove on Back of Impeller

44. Clean inside surface of thrust ring with ethanol.

45. Place preheated impeller on pump shaft. See Figure 885.

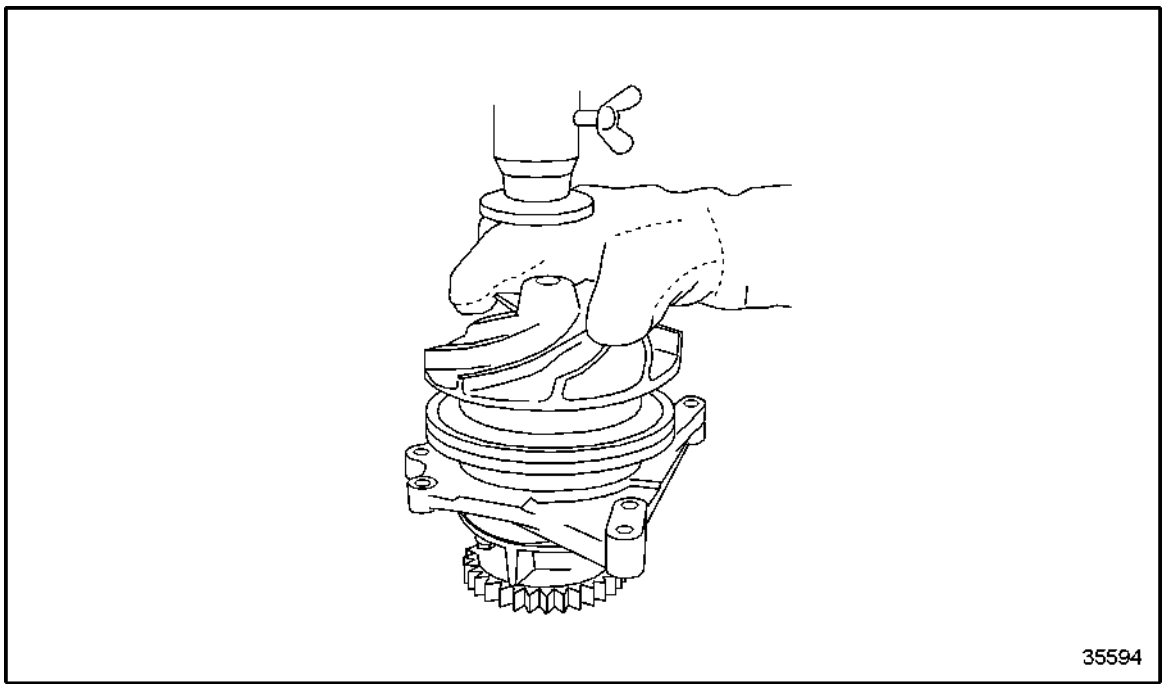


Figure 885 Placing Preheated Impeller on Pump Shaft

46. Use manual press to press impeller to stop and maintain pressure until shaft to gear (shrink-on) connection is secure. See Figure .

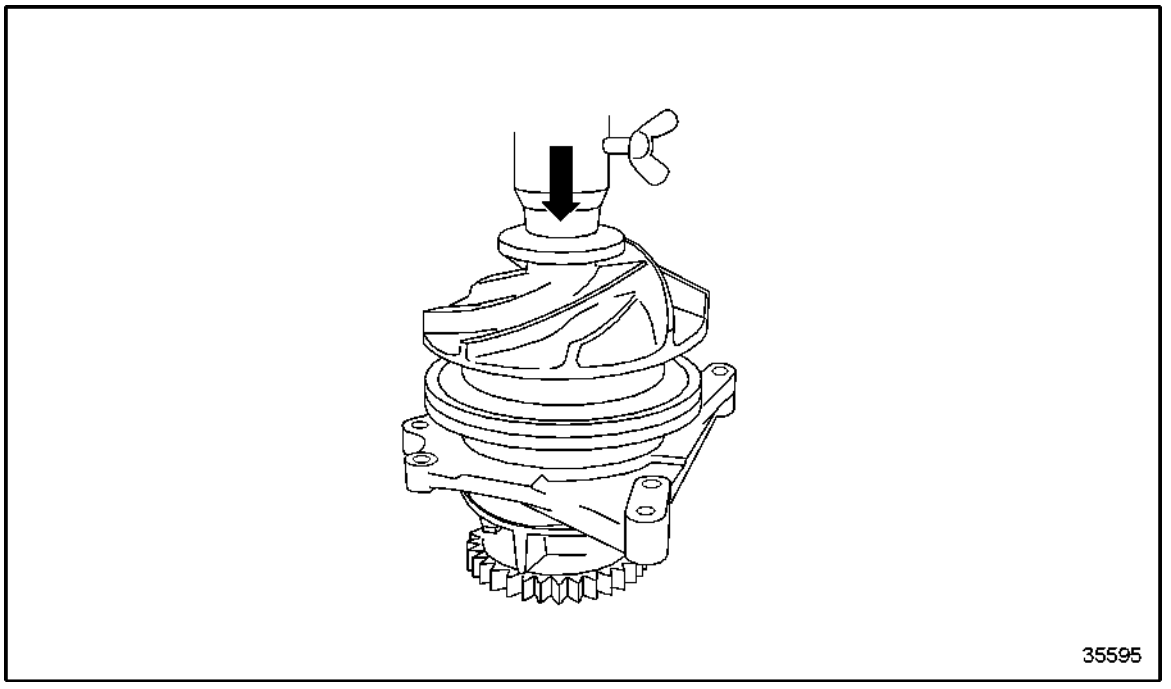


Figure 886 Securing Impeller

47. To install pump housing, first coat pump housing with petroleum jelly at contact surface to O-ring (arrow). See Figure 887.

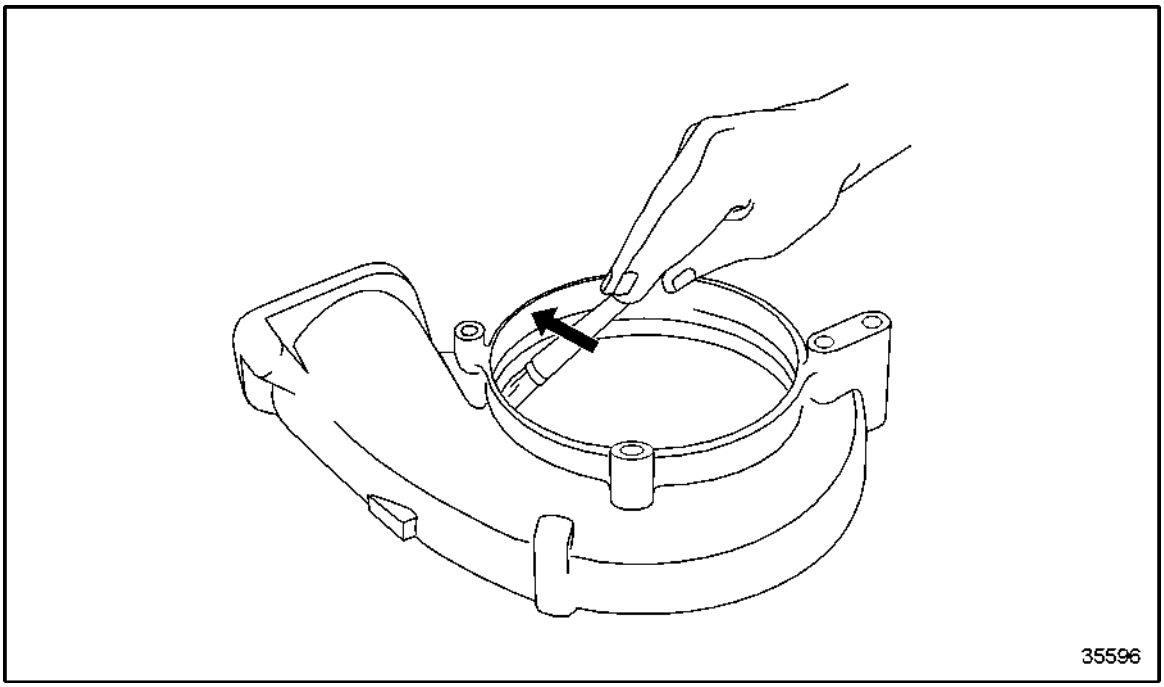


Figure 887 Coating Pump Housing

48. Carefully place seal carrier with impeller side on pump housing.

49. Position pump housing on bearing housing, tapping lightly with hammer or by means of light press pressure. See Figure 888.

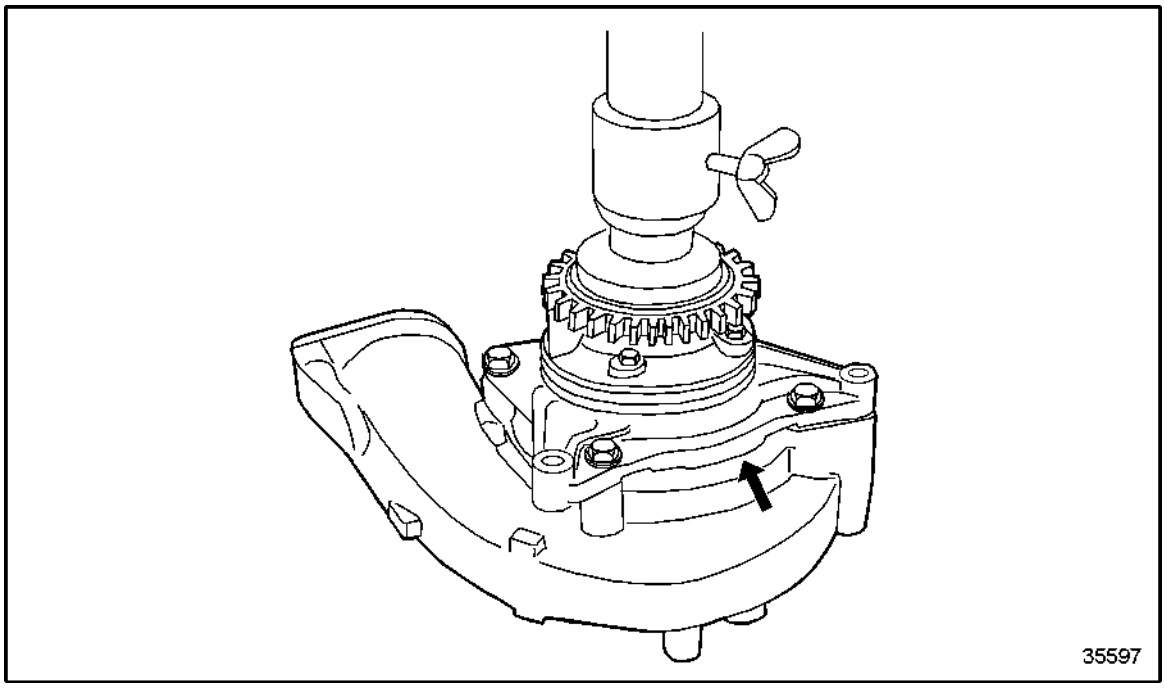
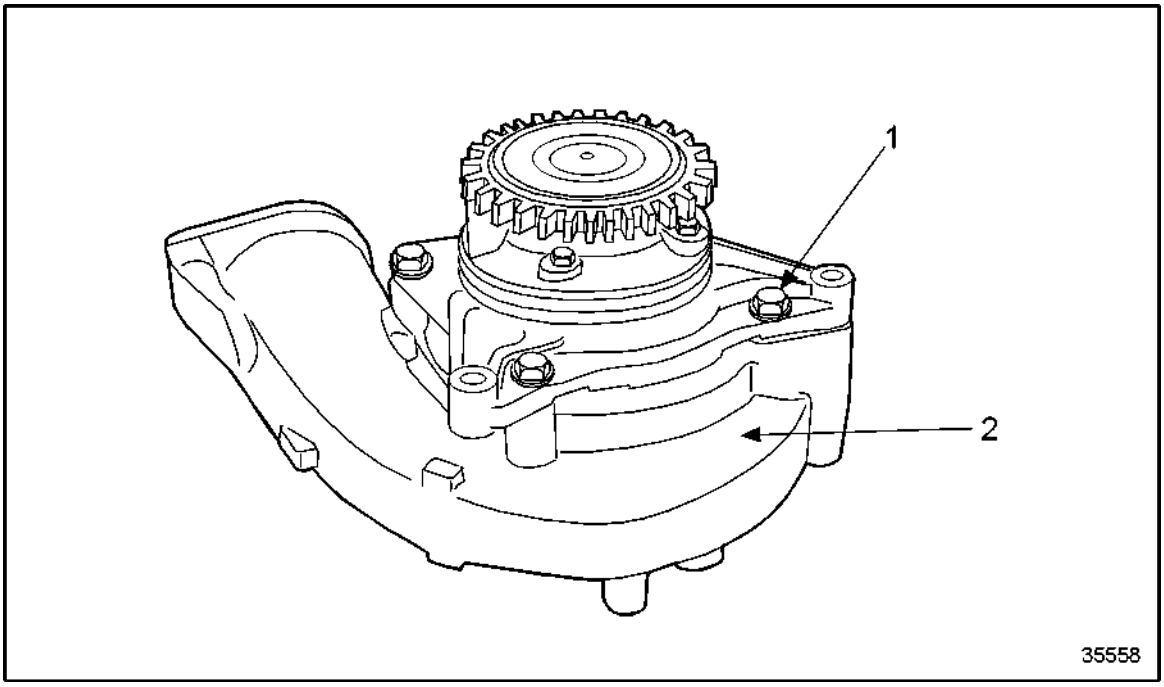


Figure 888 Positioning Pump Housing on Bearing Housing

50. Ensure that O-ring (arrow) is not damaged.
51. Install pump housing to seal carrier with hex bolts (1). See Figure 889.



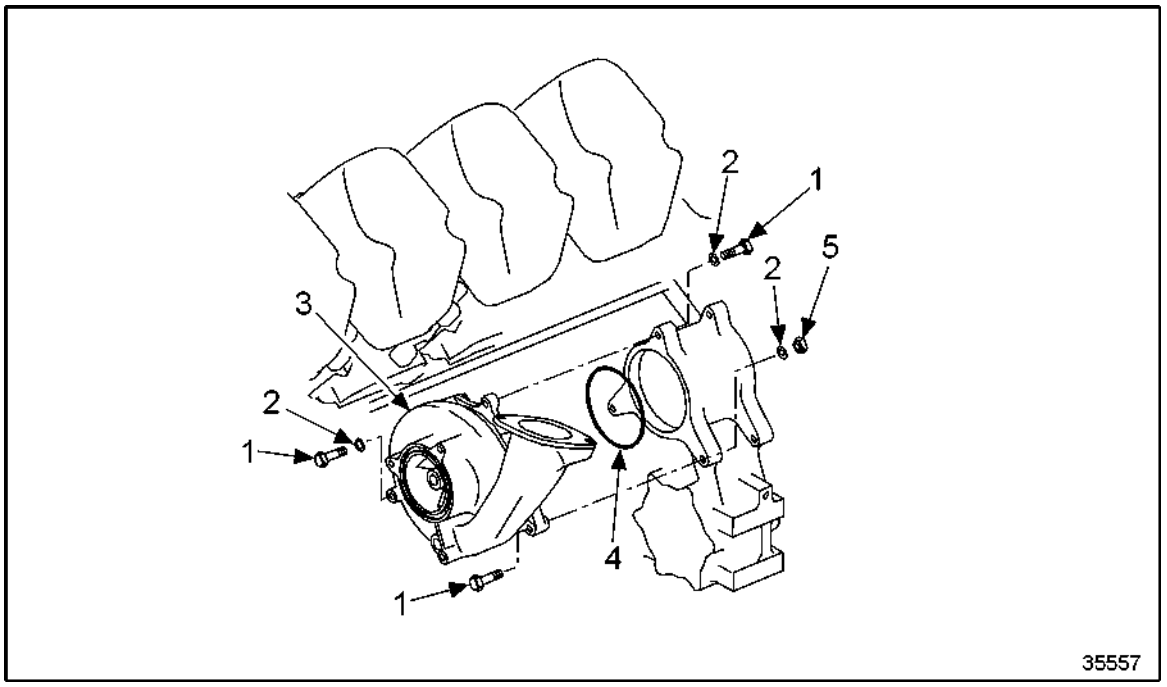
1. Hex Bolt
2. Coolant Pump Housing

Figure 889 Installing Pump Housing to Seal Carrier

C 202.05.11 – INSTALLATION OF HIGH-TEMPERATURE WATER PUMP

Perform the following steps to install the high – temperature water pump:

1. Coat O-ring (4) with petroleum jelly and insert in groove on bearing housing of high–temperature water pump. See Figure 890.

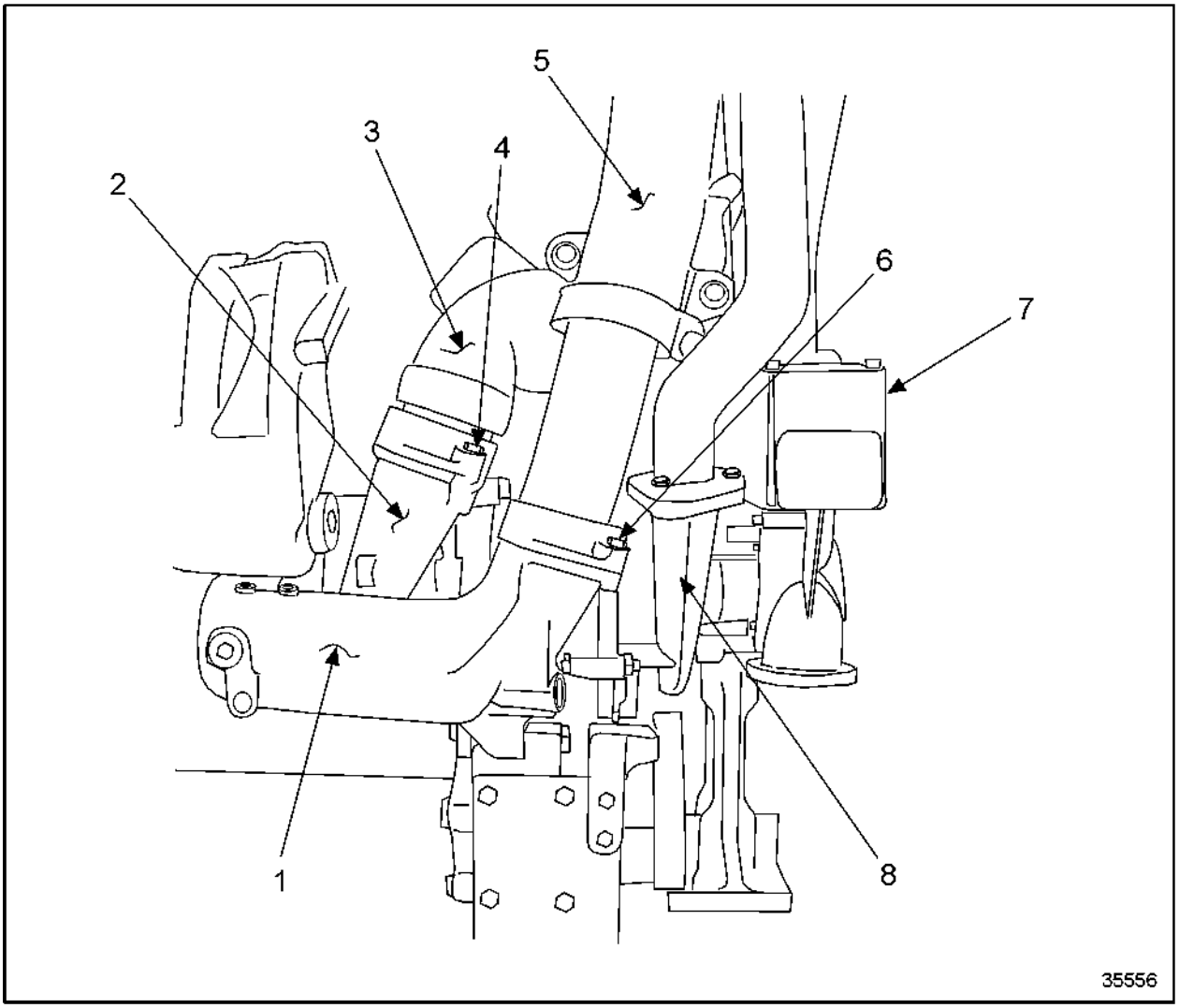


1. Hex Bolt
2. Washer
3. Pump Housing
4. O-ring
5. Hex Nut

Figure 890 Installing High – Temperature Water into Bore in Gear Case

2. Position water pump correctly and install into bore in gear case, ensuring that gear engages.
3. Check gear lash.

4. Install hex bolts (2) with washers and tighten uniformly to specification. Refer to sectionA 003.
5. Install charge air cooler pipe (6). See Figure 891.



1. Water Pump Outlet Elbow
2. High Temperature Water Pump
3. Water Pump Inlet Elbow
4. Bolt
5. High Temperature Thermostat Housing
6. Bolt
7. Low Temperature Thermostat Housing
8. Low Temperature Water Pump

Figure 891 Installing Charge Air Cooler Pipe, Flange to Elbow and Bracket to Elbow

C 202.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 127 are the After-Installation operations for the engine coolant pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Inspect for leaks	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.

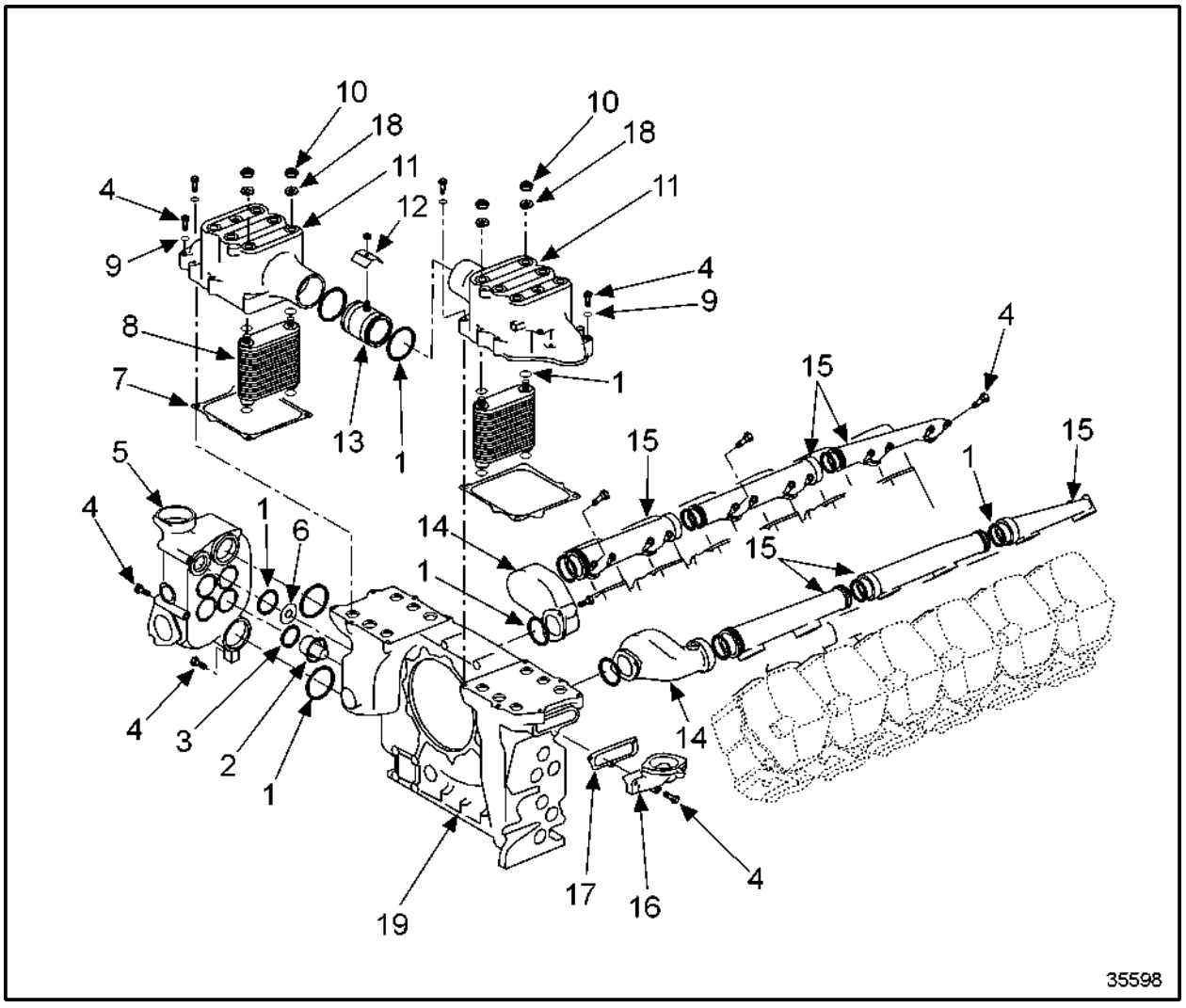
Table 127 After-Installation Operations

C 203.05 – ENGINE COOLANT SYSTEM PIPEWORK

C 203.05.01 – GENERAL VIEW

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

See Figure 892 for a general view of the engine cooling system pipework.



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 203.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 128 are the Before-Removal Operations for the engine cooling system pipework.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	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 128 Before-Removal Operations

C 203.05.05 – REMOVAL OF ENGINE COOLING SYSTEM PIPEWORK

Perform the following steps to disconnect engine cooling system pipework:

NOTE:
Before removing lines, it is advisable to photograph the engine from all sides or attach metal tags to the lines and fixtures so that they can be reinstalled in their original positions.

1. Remove all monitoring units installed in coolant lines.
2. After removing lines, seal all open connections by installing suitable plugs.

C 203.05.08 – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the engine cooling system pipework:

1. Clean lines with cold cleaner and brush.
2. Visually inspect plug-in connections and ring grooves in elbows and connecting lines for wear, indentations and pitting.
   [a] If plug-in connections, ring grooves or connecting lines shown wear, indentations or pitting, rub down with emery cloth or oilstone.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If no wear, indentations or pitting is found, continue inspection.
3. Visually inspect all mating and sealing surfaces for wear and damage.
   [a] If mating or sealing surfaces are worn or damaged, rub down with emery cloth or oilstone as necessary.
   [b] If damage is beyond repair, replace components as necessary.
   [c] If no wear or damage is found, continue inspection.
4. Visually inspect sealing cones and banjo adaptors for damage, indentations or corrosion.
   [a] If sealing cones or banjo adaptors show damage, indentations or corrosion, replace components as necessary.
   [b] If sealing cones or banjo adaptors are not damaged, indented or corroded, continue inspection.
5. Replace rubber sleeves as part of every W6 overhaul.
6. Visually inspect clamps and rubber sleeves for damage.
   [a] If clamps or rubber sleeves are damaged, replace components as necessary.
   [b] If clamps or rubber sleeves are not damaged, continue inspection.
7. Replace O-rings, gaskets and sealing rings.
8. Visually inspect lines for damage and general condition.
   [a] If lines are damaged or in poor condition, repair or replace as necessary.
   [b] If lines are not damaged and are in good condition, continue inspection.

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.

9. Pressure-test lines with air in water bath for leaks using corrosion inhibitor.
10. Water temperature: min. 30°C, max. 40°C.
11. After welding or hot-bending pipework, allow pipework to cool slowly, removing from engine if necessary.

CAUTION:

To avoid an eye or skin injury and suffocation when using hydrochloric acid, always wear protective clothing, protective gloves, goggles, and safety mask. Work in a well ventilated area.

12. Pickle pipework in hydrochloric acid solution (9 parts water and 1 part hydrochloric acid). Do not use on aluminum lines.
13. Pickle up to 2 hours, depending on layer of scale or rust.
14. After pickling, wash lines with hot water.

CAUTION:

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

15. Blow dry lines with compressed air.
16. Preserve lines in oil bath and allow to drip dry.

C 203.05.11 – INSTALLATION OF ENGINE COOLING SYSTEM PIPEWORK

Perform the following steps for the installation of the engine cooling system pipework:

1. Prior to installing, remove all protective plugs.

CAUTION:

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

2. Blow coolant lines clear with compressed air.
3. Before assembling, coat O-rings with petroleum jelly.
4. Install coolant lines with new gaskets, sealing rings and O-rings, with fixtures free of tension.

C 203.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 129 are the After-Installation Operations for the engine coolant system pipework.

Level of Maintenance	Operation	Reference
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Inspect for leaks	—
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.

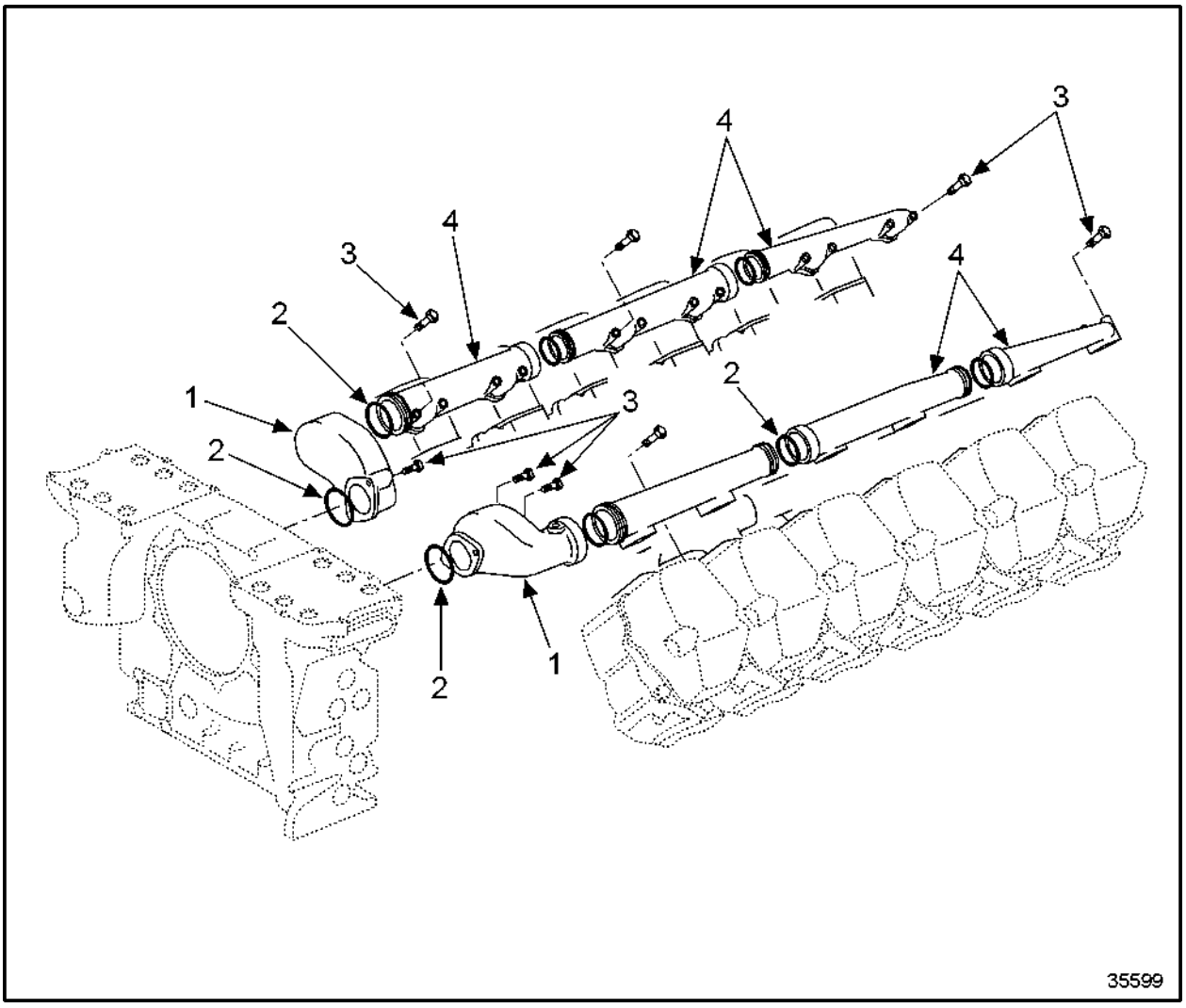
Table 129 After-Installation Operations

C 204.05 – ENGINE COOLANT SYSTEM

C 204.05.01 – GENERAL VIEW

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

See Figure 893 for a general view of engine coolant pipework after cylinder head.



1. Connector
2. O-ring
3. Hex Bolt
4. Coolant Collecting Line

Figure 893 General View of Engine Coolant Pipework after Cylinder Head

C 204.05.04 – BEFORE-REMOVAL OPERATIONS

Refer to section C 203.05.04 for the Before-Removal Operations for the engine coolant pipework after cylinder head.

C 204.05.05 – REMOVAL OF ENGINE COOLANT SYSTEM

Refer to section C 203.05.05 for removal of the engine coolant pipework after cylinder head.

C 204.05.08 – INSPECTION AND REPAIR

Refer to section C 203.05.08 for inspection and repair of the engine coolant pipework after cylinder head.

C 204.05.11 – INSTALLATION OF ENGINE COOLANT SYSTEM

Refer to section C 203.05.11 for installation of the engine coolant pipework after cylinder head.

C 204.05.12 – AFTER-INSTALLATION OPERATIONS

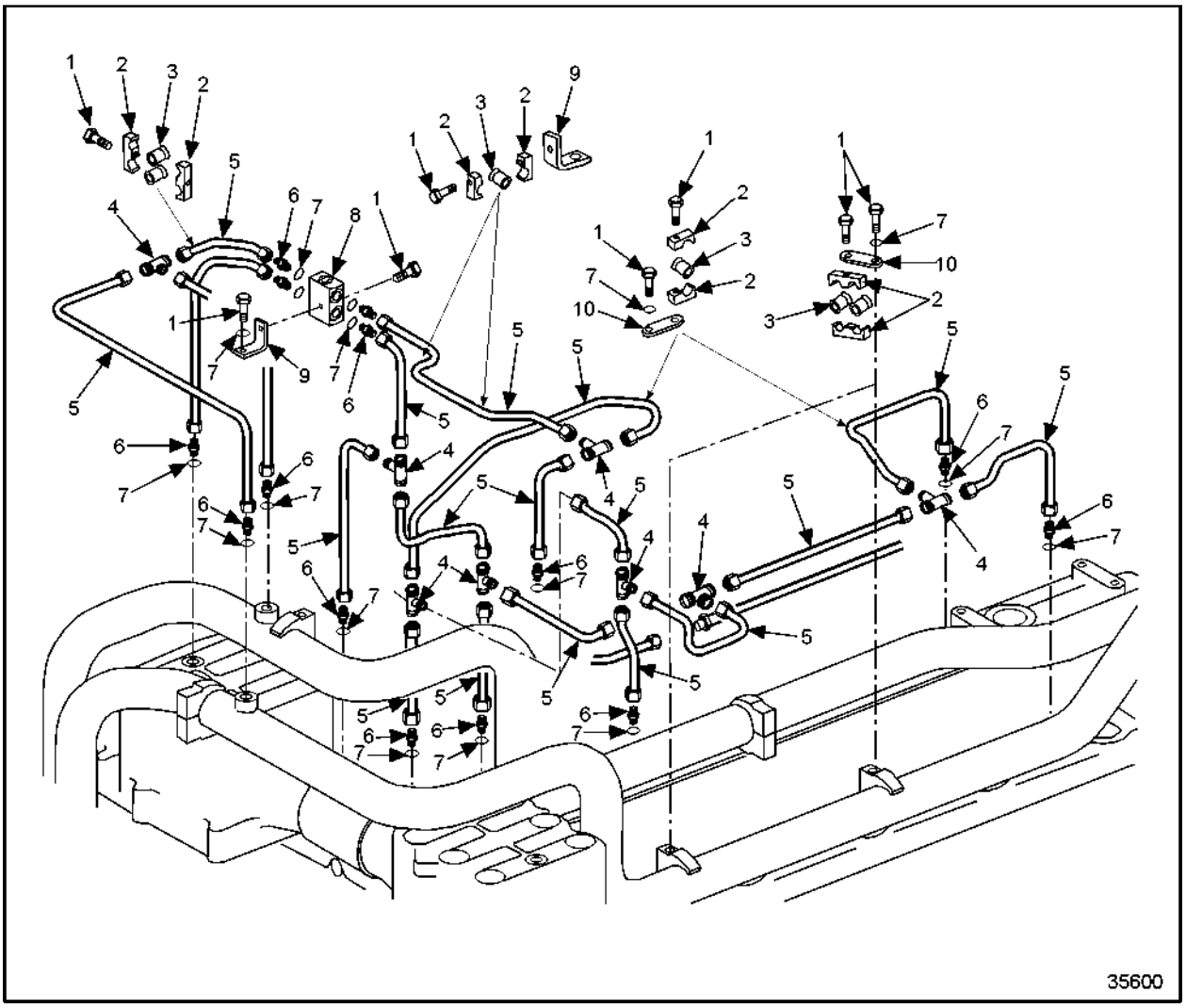
Refer to section C 203.05.12 for the After-Installation Operations for the engine coolant pipework after cylinder head.

C 205.05 – VENT LINES

C 205.05.01 – GENERAL VIEW

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

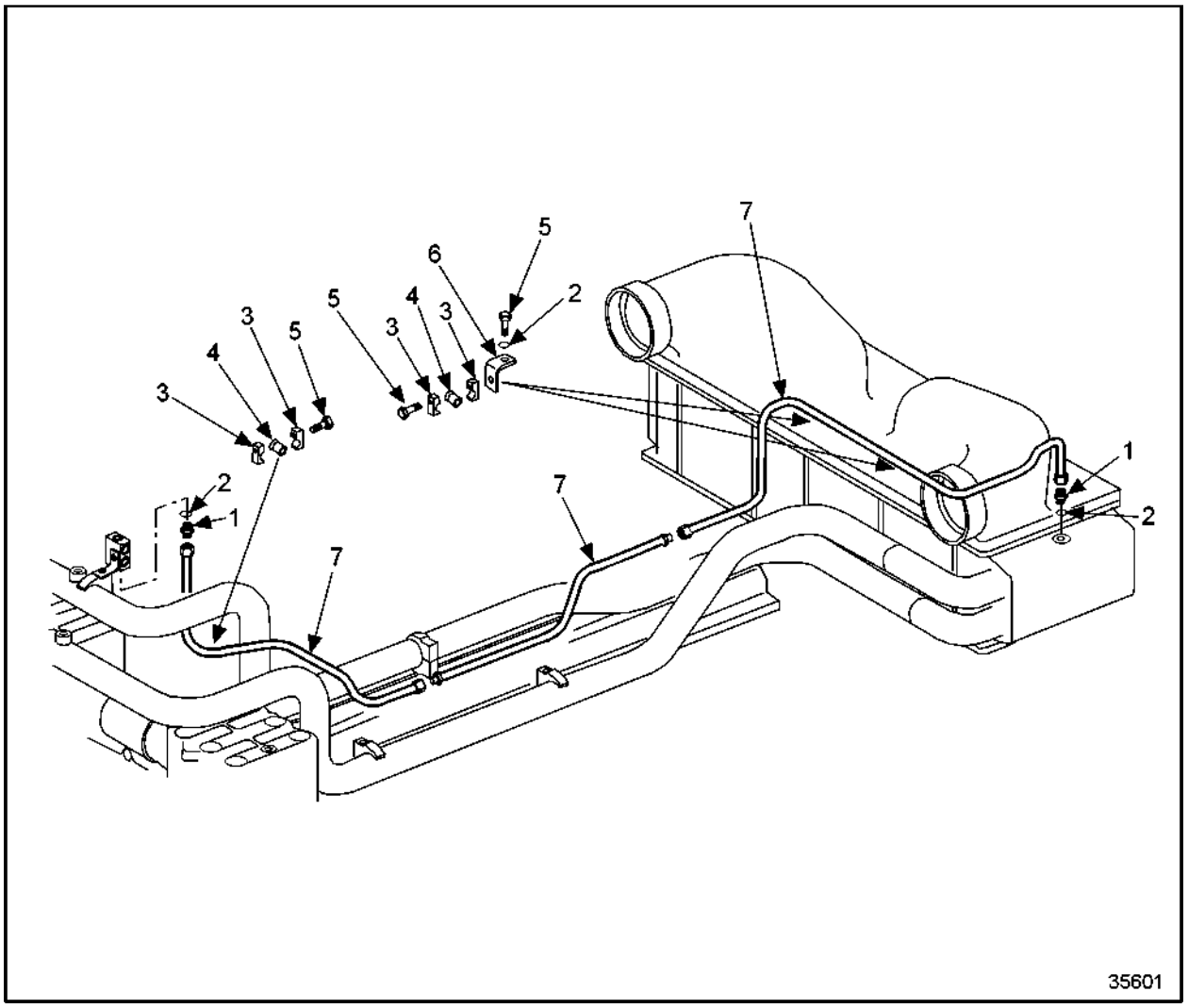
See Figure 894 for a general view of the high-temperature cooling system vent lines.



1. Hex Bolt
2. Pipe Clamp Half
3. Grommet
4. T-piece
5. Vent Line
6. Reduction Adaptor
7. Washer
8. Distributor Block
9. Angled Bracket
10. Straight Bracket

Figure 894 General View of High-Temperature Cooling System Vent Lines

See Figure 895 for a general view of the low-temperature cooling system vent lines.



1. Reduction Washer
2. Washer
3. Pipe Clamp Half
4. Grommet
5. Hex Bolt
6. Angled Bracket
7. Vent Line

Figure 895 General View of Low-Temperature Cooling System Vent Lines

C 205.05.04 – BEFORE-REMOVAL OPERATIONS

Refer to section C 203.05.04 for the Before-Removal Operations for the high – and low-temperature cooling system vent lines.

C 205.05.05 – REMOVAL OF VENT LINES

Refer to section C 203.05.05 for the removal of the high – and low-temperature cooling system vent lines.

C 205.05.08 – INSPECTION AND REPAIR

Refer to section C 203.05.08 for the inspection and repair of the high- and low-temperature cooling system vent lines.

C 205.05.11 – INSTALLATION OF VENT LINES

Refer to section C 203.05.11 for the installation of the high – and low-temperature cooling system vent lines.

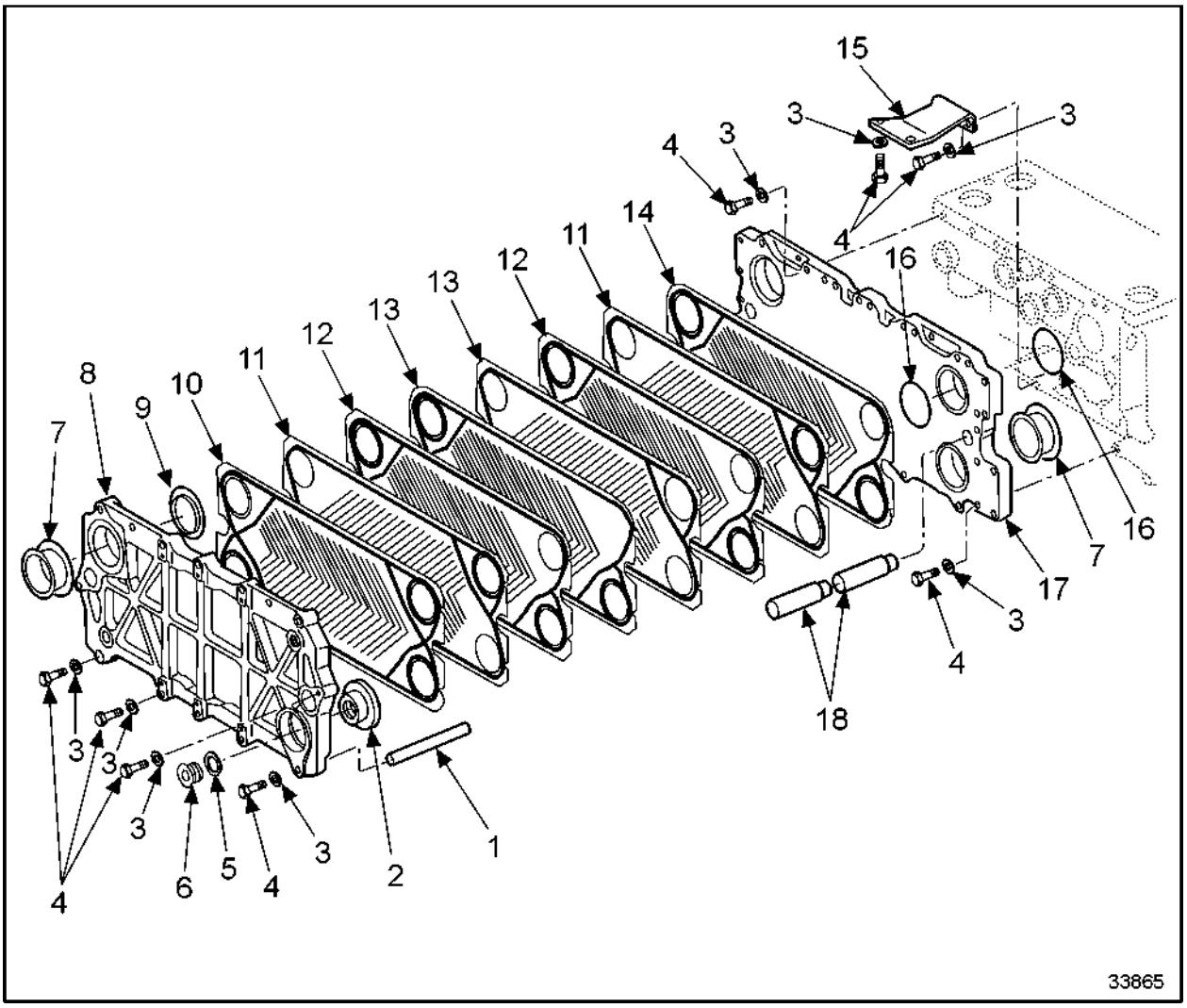
C 205.05.12 – AFTER-INSTALLATION OPERATIONS

Refer to section C 203.05.12 for the After-Installation Operations for the high– and low-temperature cooling system vent lines.

C 205.05 M – COOLANT HEAT EXCHANGER

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

C 205.05.04 M – BEFORE-REMOVAL OPERATIONS

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove surge tank	Refer to OEM Guidelines
1, 2, 3	Remove fuel filter assembly	Refer to OEM Guidelines
1, 2, 3	Remove the electronic control unit	Refer to OEM Guidelines

1 = The engine is to be completely disassembled.

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

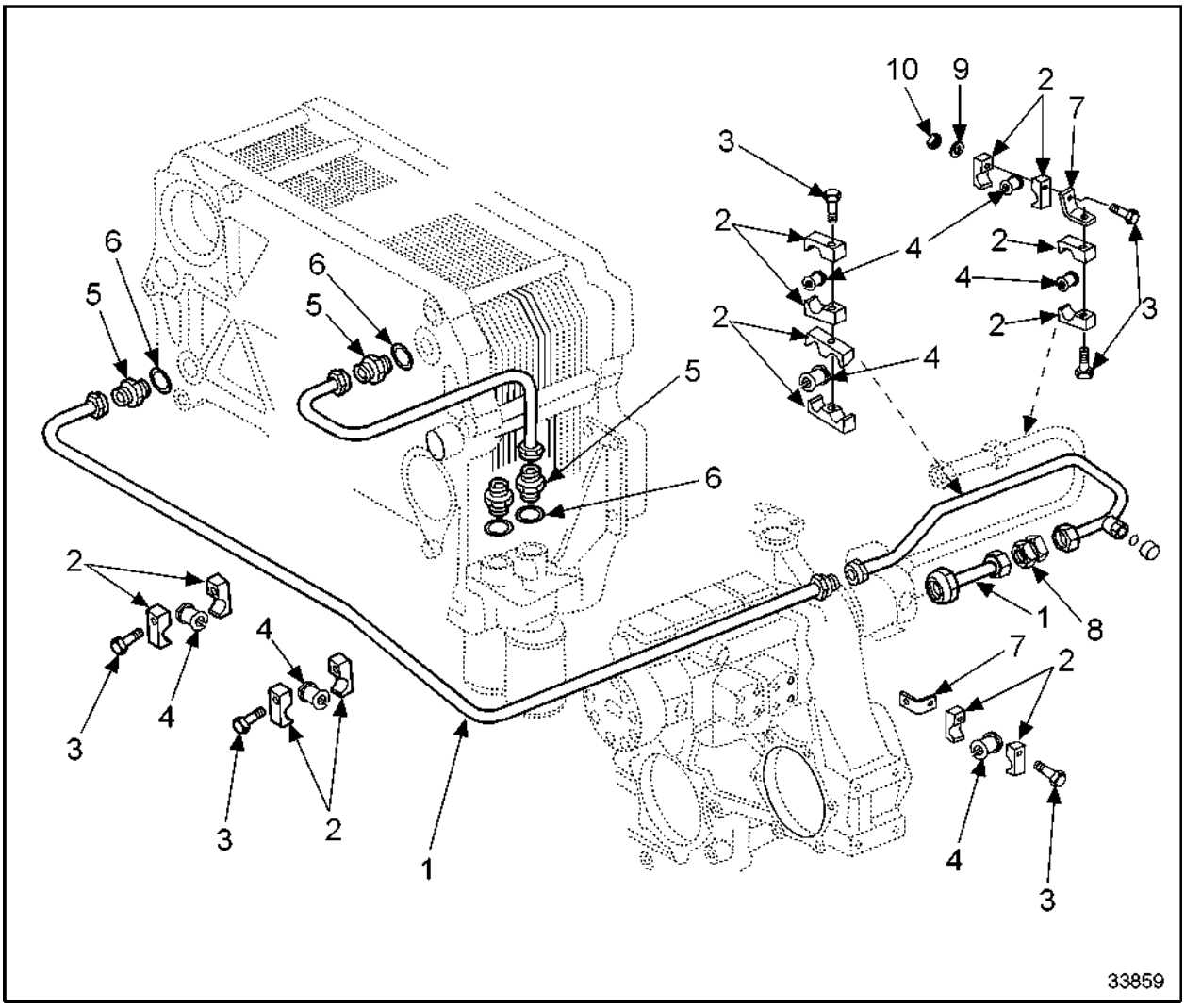
3 = The engine is to remain installed.

Table 130 Before-Removal Operations

C 205.05.05 M – REMOVAL OF THE COOLANT HEAT EXCHANGER

Perform the following steps to remove the coolant heat exchanger:

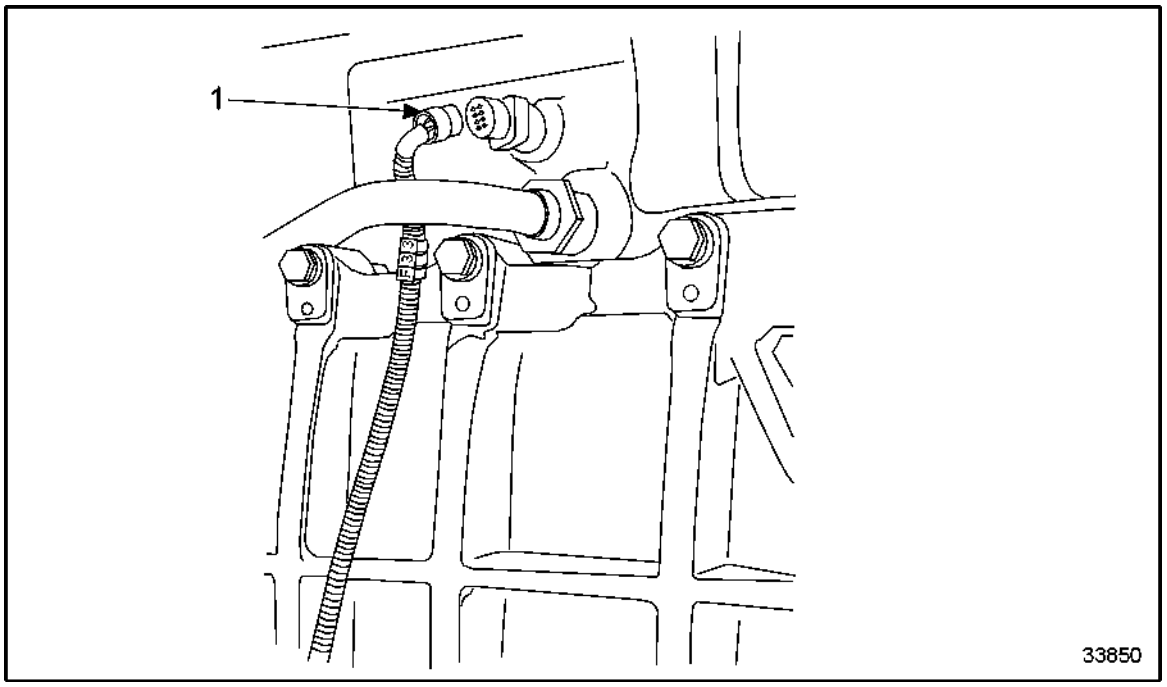
1. Remove fuel lines (1) connected to and from the heat exchanger. See Figure 897.



1. Fuel Line
2. Half-clamp
3. Bolt
4. Grommet
5. Adaptor
6. Sealing Ring
7. Bracket
8. Check Valve
9. Washer
10. Hex Nut

Figure 897 Removing Fuel Lines

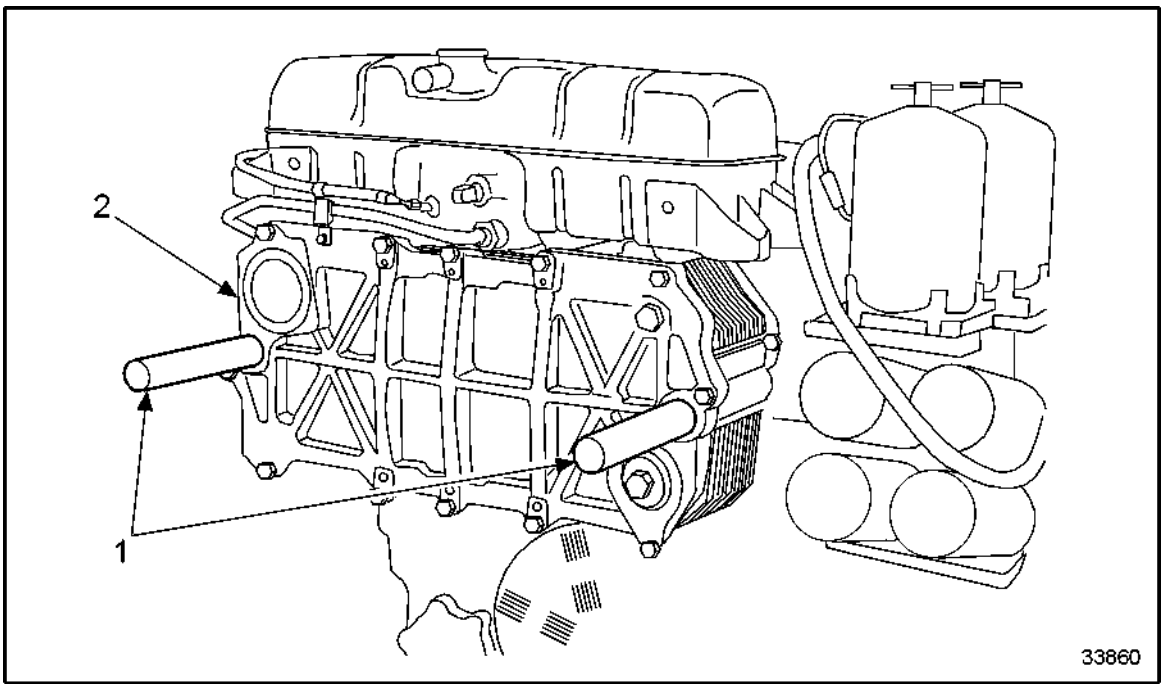
2. Remove the coolant level sensor (1). See Figure 898.



1. Coolant Level Sensor

Figure 898 Removing Coolant Level Sensor

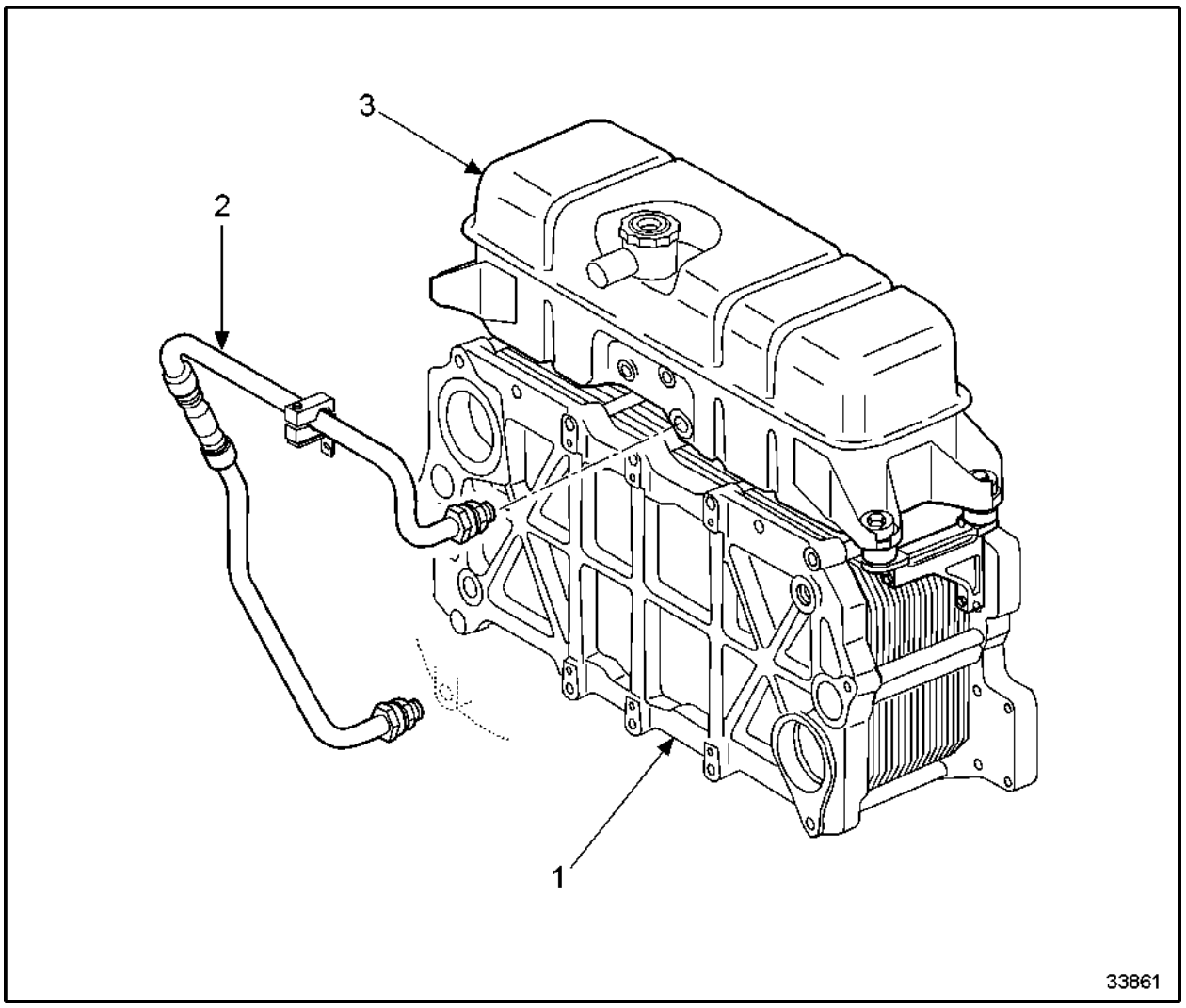
3. Install the guide studs (1). See Figure 899.



1. Guide Studs
2. Heat Exchanger

Figure 899 Installing Guide Studs

4. Remove the static fill line (2). See Figure 900.

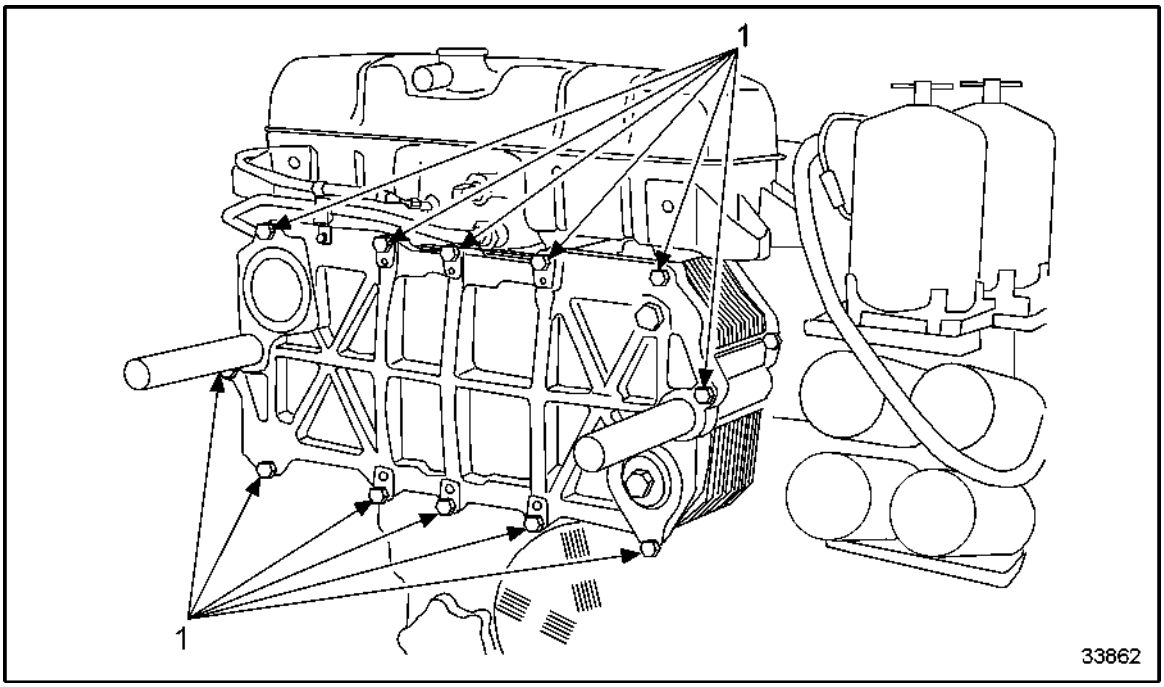


1. Heat Exchanger
2. Static Fill Line
3. Surge Tank

Figure 900 Removing Static Fill Line

5. Mark the coolant heat exchanger bolts for reassembly.

6. Remove 12 bolts, washers, and spacers (1) securing the front heat exchanger plate to the base plate. See Figure 901.



1. Mounting Bolts, Washers, and Spacers

Figure 901 Removing Front Coolant Heat Exchanger Plate

NOTE:
Back bolts off evenly during removal.

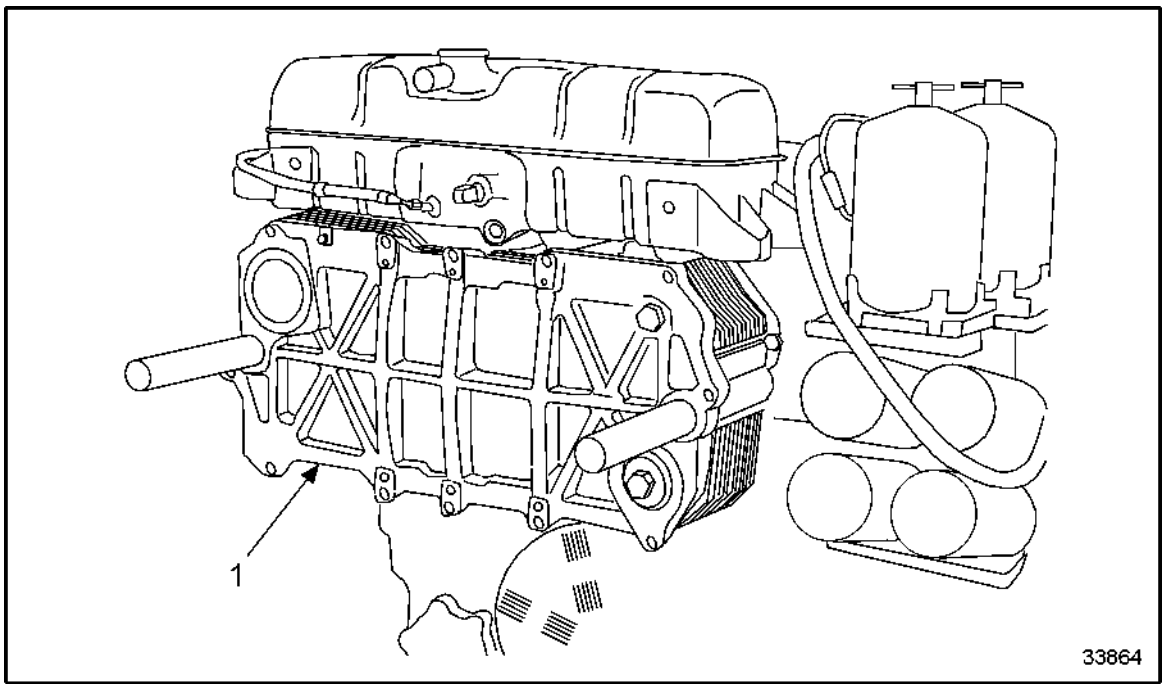
CAUTION:

When removing the front coolant heat exchanger plate, ensure that the removal tool is securely in place to avoid dropping the plate and causing personal injury.

NOTICE:

Use care when removing the coolant plates to avoid damaging the coolant plate gaskets.

7. Remove the front exchanger plate (1). See Figure 902.



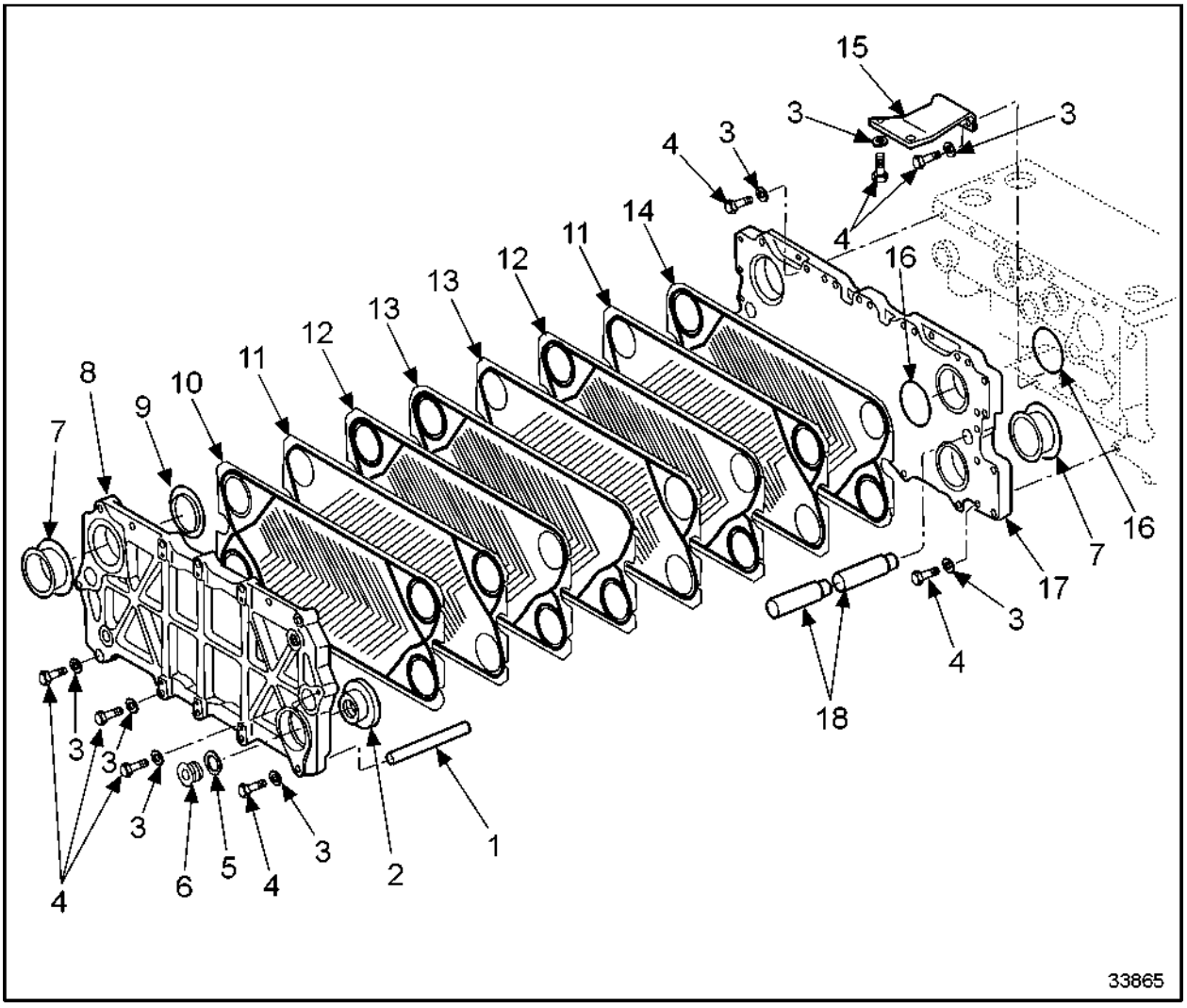
1. Front Plate

Figure 902 Removing Front Coolant Heat Exchanger Plate

8. Remove coolant plates and place on a flat surface. See Figure 903.

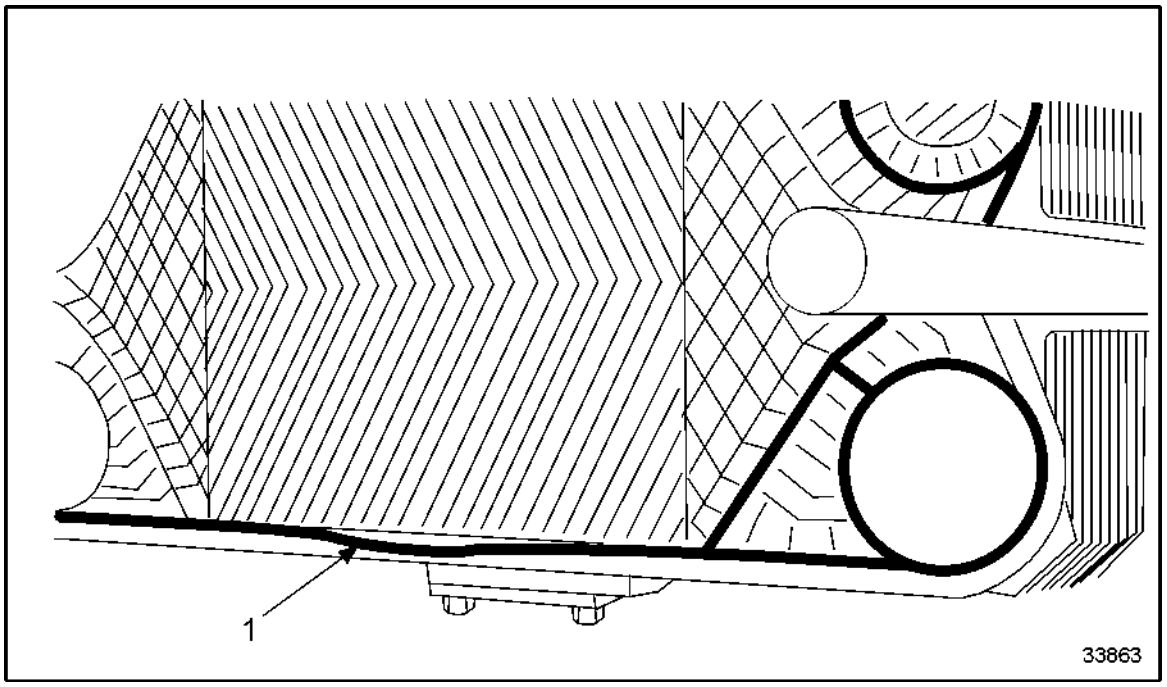
NOTE:
Do not damage coolant plate gaskets (1) during removal.

See Figure 904.



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 903 Removing Base Plate

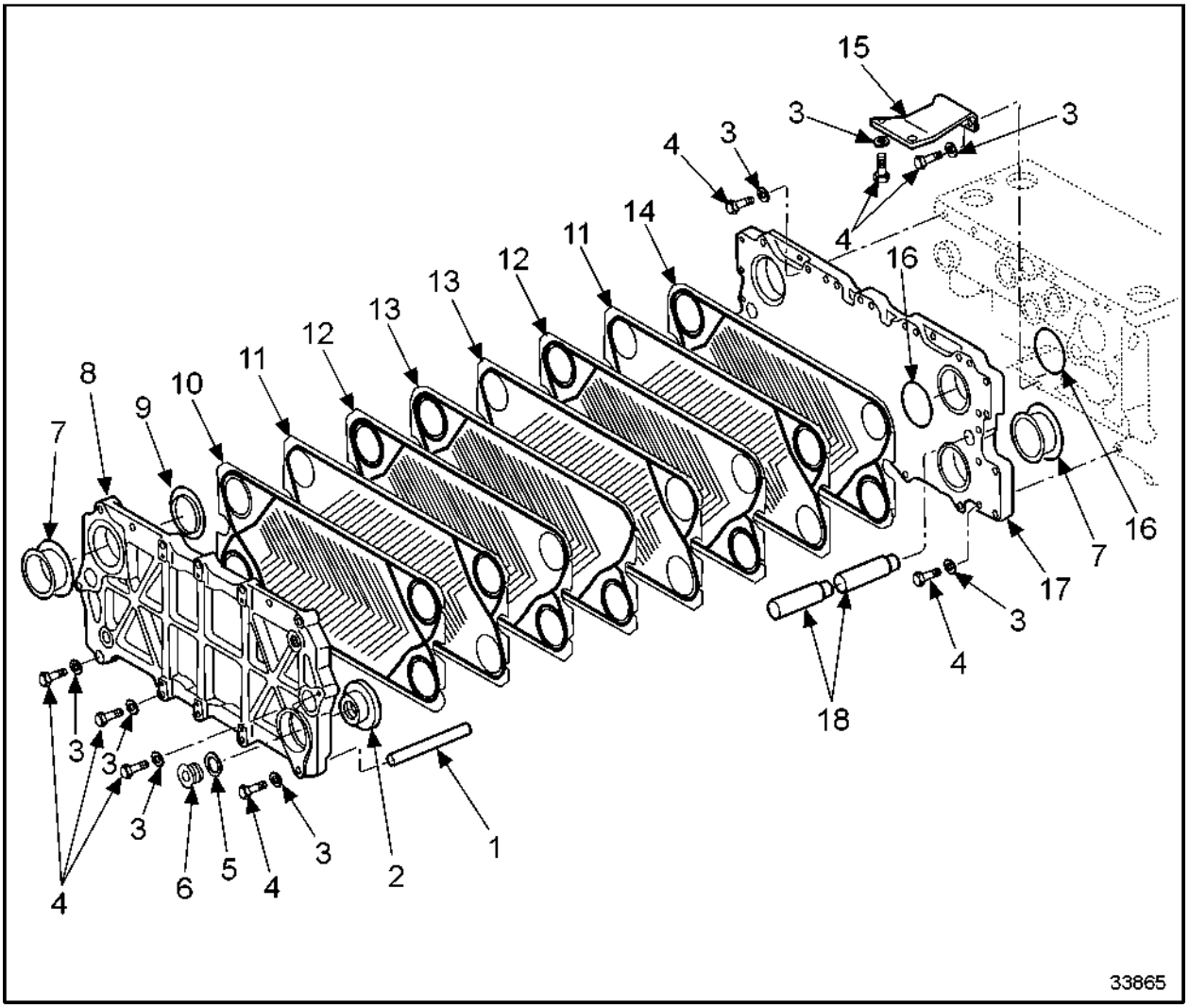


1. Coolant Plate Gasket

Figure 904 Removing Coolant Plates

9. Remove the guide studs.

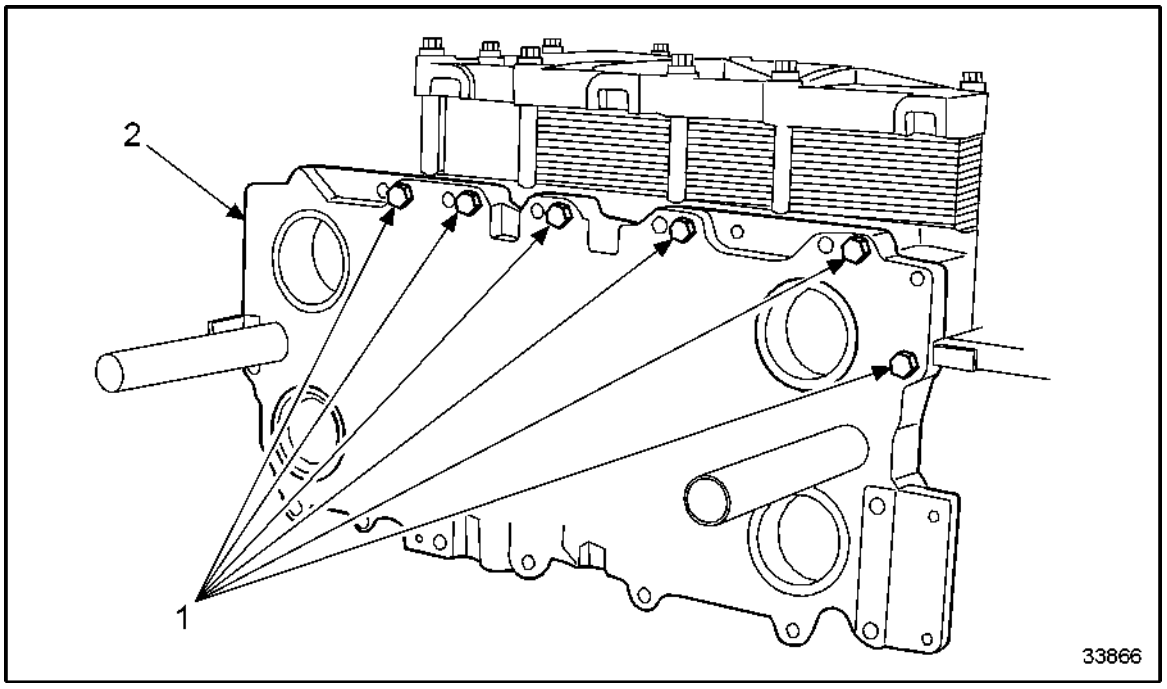
10. Remove the two 40 mm bolts (4) securing the mounting bracket (15) to the base plate (17). See Figure 905.



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 905 Removing Mounting Bracket

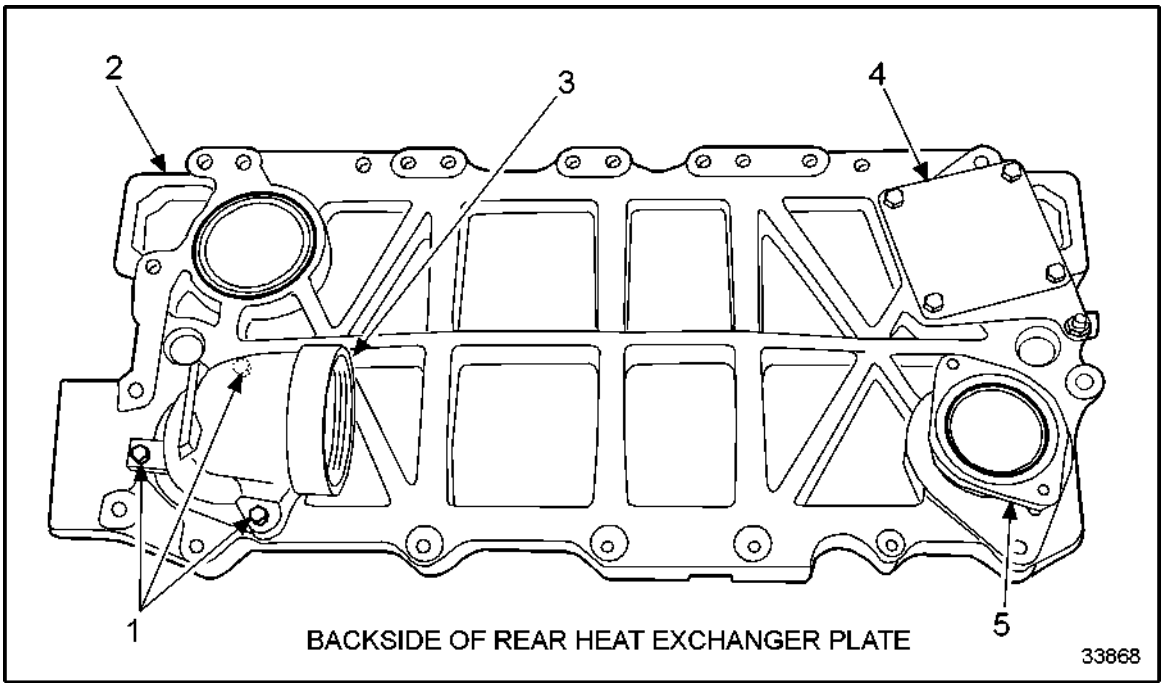
11. Remove six 80 mm bolts (1) and washers securing the base plate (2) to the front cover and remove the base plate. See Figure 906.



1. Bolts, 80 mm
2. Base Plate

Figure 906 Removing Base Plate

12. Remove the three bolts (1) securing the fresh water elbow (3) to the base plate (2) and remove the elbow. See Figure 907.



1. Bolts
2. Base Plate
3. Fresh Water Elbow
4. Base Plate Option Plate
5. Thermostat Housing Flange

Figure 907 Removing Base Plate Components

13. Remove thermostat housing flange O-ring.
14. Remove the thermostat housing flange (5). See Figure 907.
15. Remove the O-ring.
16. Remove the base plate option plate (4) and O-ring, if necessary. See Figure 907.

C 205.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the coolant cooler:

Cleaning the Cooler Plates

There are two types of cleaning processes for cooler plates; refer to section Mechanical Cleaning and refer to section Stream Jet Cleaning.

Mechanical Cleaning

Perform the following step for the mechanical cleaning of the coolant cooler:

NOTICE:
Use soft brushes to avoid damage to plates.

1. Clean cooler plates only with a soft brush and flowing water. See Figure 908.

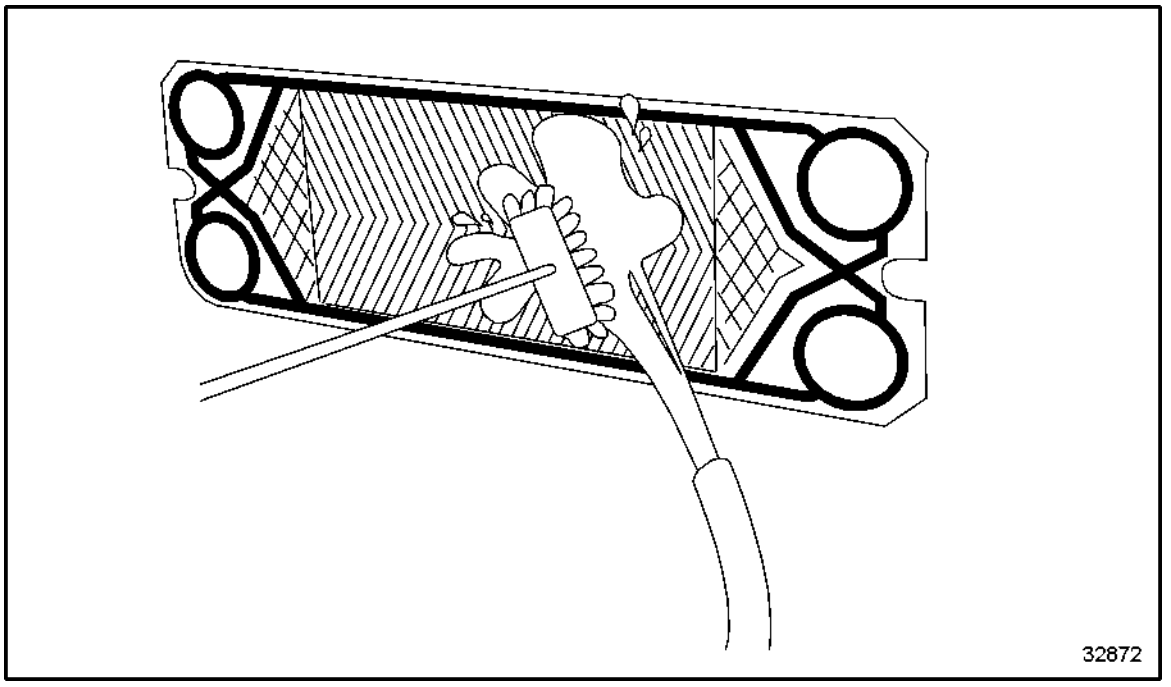


Figure 908 Cleaning Cooler Plate

Stream Jet Cleaning

Perform the following step to stream jet clean the coolant cooler:

CAUTION:

To avoid personal injury take special care when using a high pressure water jet. Never direct the water jet at humans, equipment, or electric components. Always wear adequate eye protection (safety glasses or face plate) and do not exceed 276 kPa (40 lb/in. ^{2}) air pressure.

NOTICE:

Maintain specified service pressure and minimum spraying distance to avoid damaging plates. Observe Operator Guide of equipment manufacturer.

1. Remove deposits with a high pressure spraying jet.

   See Figure 909.

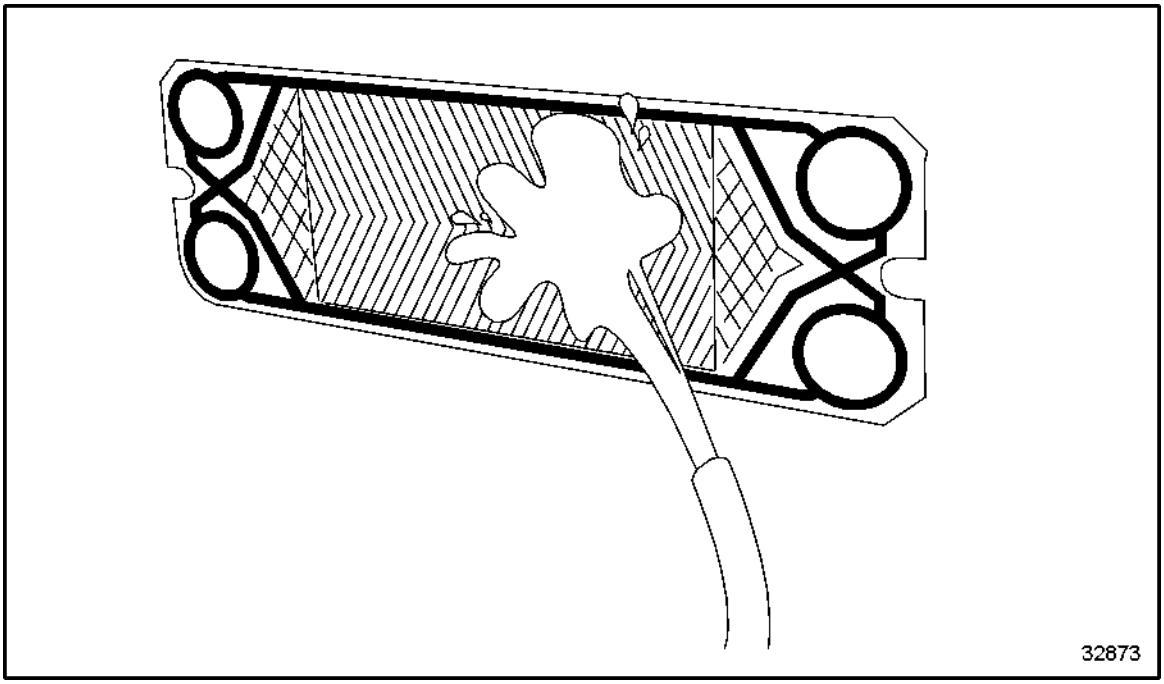


Figure 909 Removing Deposits

Chemical Cleaning the Coolant Cooler

Perform the following steps for the chemical cleaning of the coolant cooler:

CAUTION:

To avoid personal injury when using these chemical substances, it is essential to observe the manufacturer's instructions for use, safety instructions and waste disposal specifications.

- ☐ **Caustic soda**
- ☐ **Sodium bicarbonate**
- ☐ **Nitric acid**
- ☐ **Citric acid**
- ☐ **Phosphoric acid**
- ☐ **Sodium polyphosphate**
- ☐ **Parafin or naphtha**

NOTE:
Do not use the following solutions: Ketone, ester, halogenized hydrocarbon (e.g. chlorothene, carbon tetrachloride, freon), aromatic compounds, benzine, toluene.

1. To clean biological growth and sludge, use alkaline cleaning agent.
   [a] Caustic soda

[b] Sodium bicarbonate

NOTE:
Concentration maximum 4 %; Temperature maximum. 80°C.

NOTE:
After chemical cleaning, flush cooling plates with water and dry with a cloth. See Figure 910.

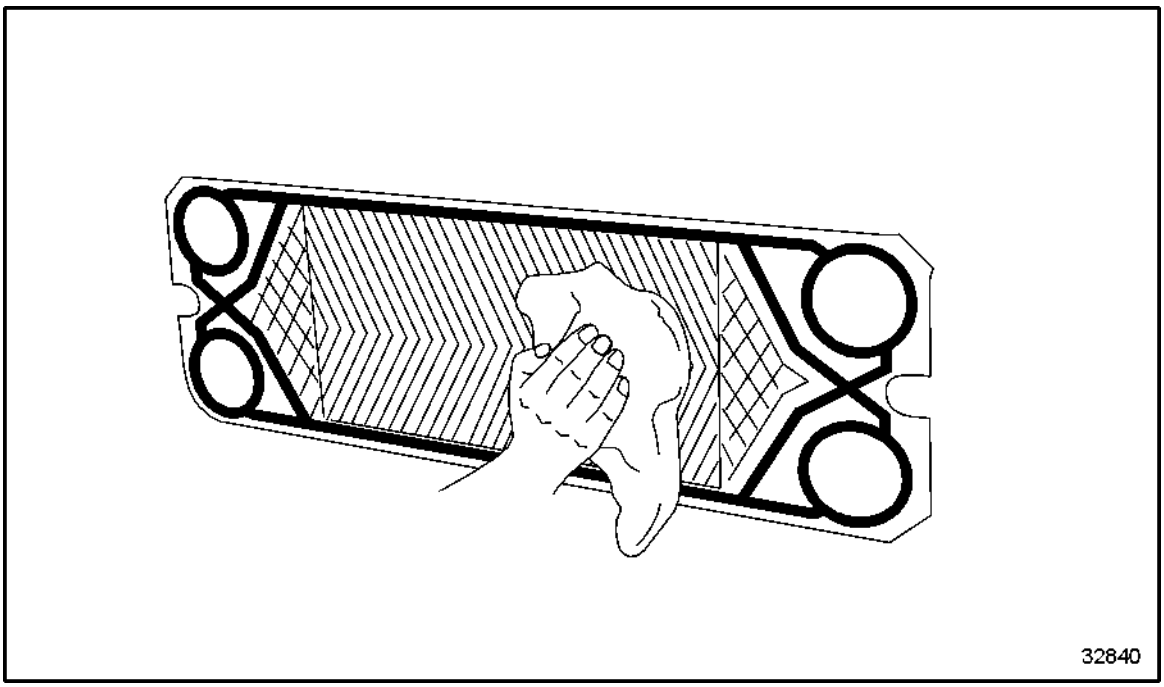


Figure 910 Chemical Cleaning

2. To clean encrustation-scale and sediment (calcium bicarbonate, calcium sulphate, corrosion products and metallic oxides) use:
   [a] Nitric acid
   [b] Citric acid
   [c] Phosphoric acid
   [d] Sodium polyphosphate

NOTE:
Remove scale with a descaling product.

NOTE:
After chemical cleaning, flush cooling plates with water and dry with a cloth. See Figure 910.

3. To clean carbon-hydrogen deposits use a solution with:
   □ Parafin basis

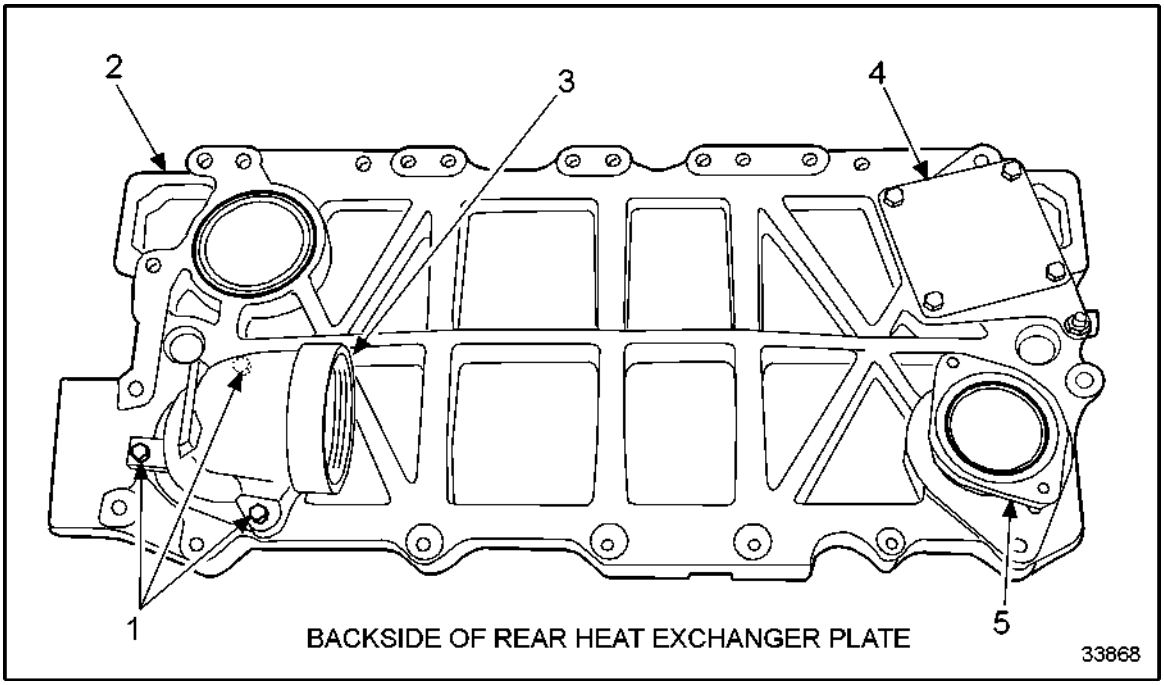
- Naphtha basis (See Figure 910.)

NOTE:
After chemical cleaning, flush cooling plates with water and dry with a cloth.

C 205.05.11 M – INSTALLATION OF THE COOLANT HEAT EXCHANGER

Perform the following steps to install the coolant heat exchanger:

1. Install the base plate option plate (4) and O-ring, if removed. See Figure 911.

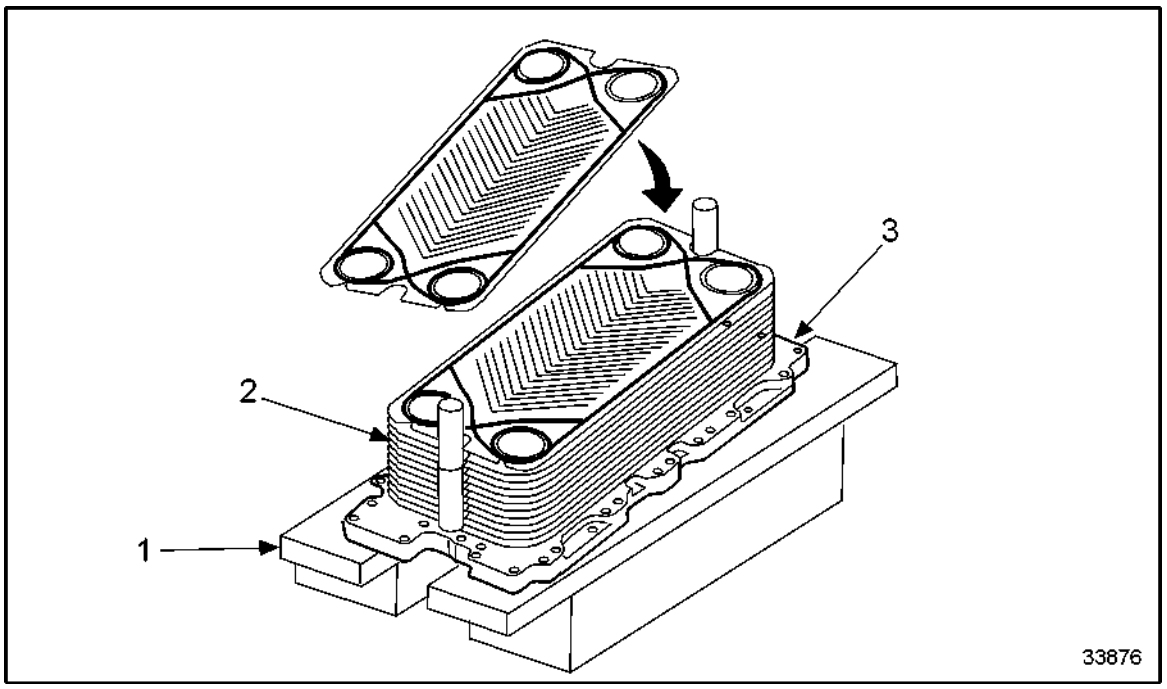


1. Bolts
2. Base Plate
3. Fresh Water Elbow
4. Base Plate Option Plate
5. Thermostat Housing Flange

Figure 911 Installing Base Plate Option Plate

2. Install the thermostat housing flange (5) and O-rings to the base plate. See Figure 911.
3. Install the fresh water elbow (3) to the base plate and secure with 3 bolts. Torque bolts to 21–25 N·m (15–18 lb·ft).
4. Install new O-rings onto the base plate (2). See Figure 911.

5. Place the base plate (3) on blocks of wood (1) for assembly. See Figure 912.



1. Wood Blocks
2. Cooler Plates
3. Base Plate

Figure 912 Placing Base Plate on Blocks of Wood

6. Install guide studs to the base plate.

NOTICE:
When assembling the coolant heat exchanger, ensure that the coolant plate gaskets are properly aligned to avoid coolant leaks.

7. Install the cooler plates onto the base plate in the order in which they were removed. See Figure 913.

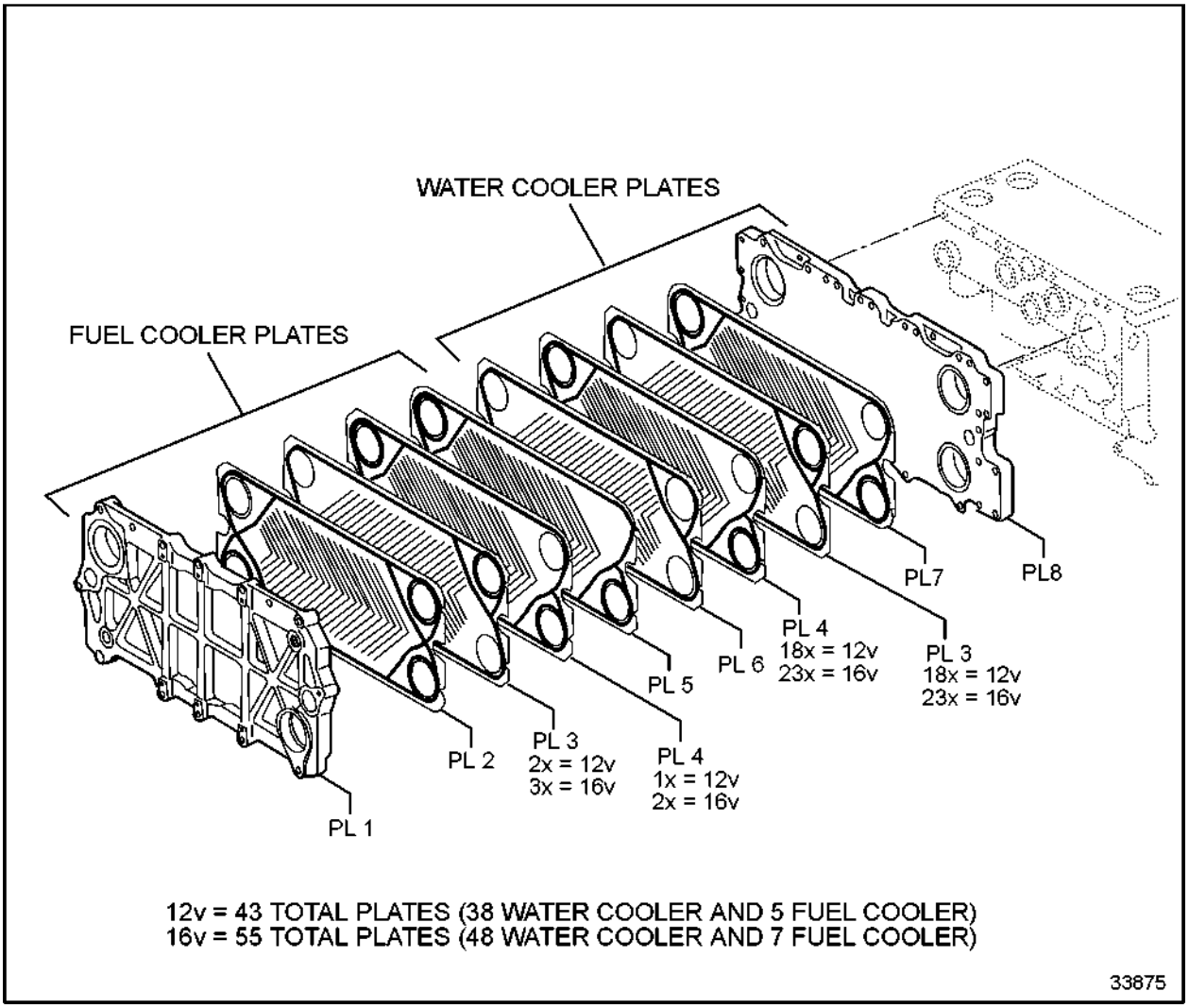
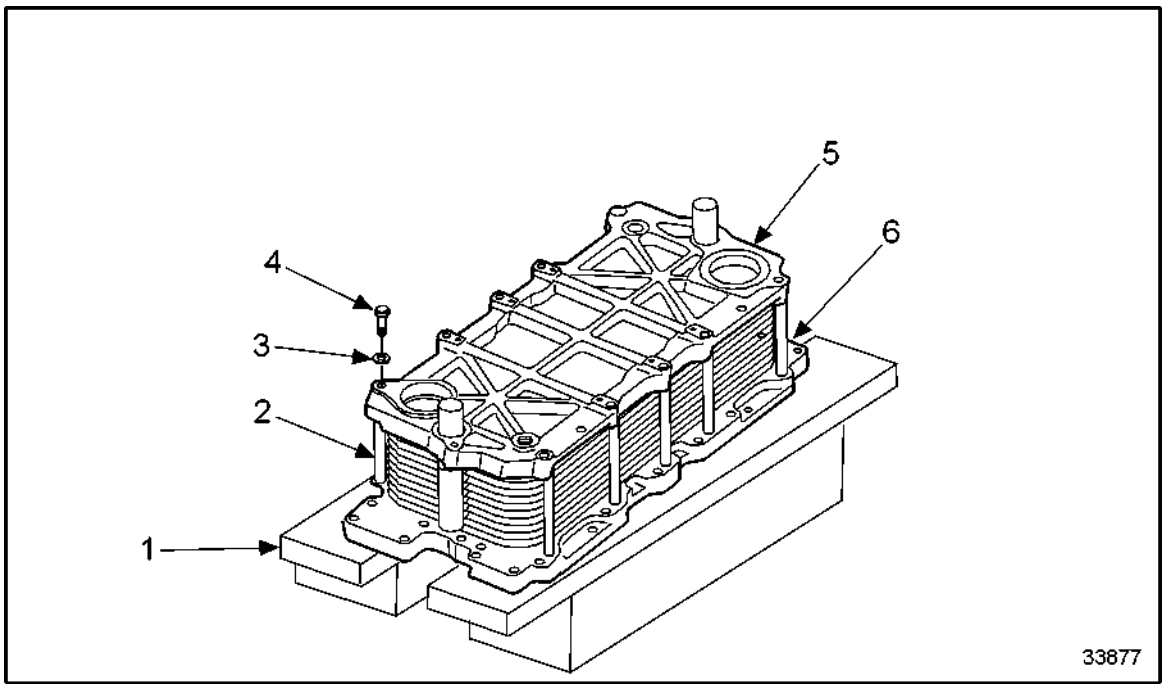


Figure 913 Installing Cooler Plates onto Base Plate

8. Install the front coolant heat exchanger plate (5) to the assembly. See Figure 914.



1. Wood Blocks
2. Spacer
3. Washer
4. Bolt
5. Front Heat Exchanger Plate
6. Rear Heat Exchanger Plate

Figure 914 Installing Front Coolant Heat Exchanger Plate

9. Install the spacers (2), washers (3), and bolts (4) to secure the front coolant heat exchanger plate (5) to the base plate. See Figure 914.

NOTE:
Finger tighten bolts. Do not torque bolts.

NOTICE:
Ensure that the front coolant heat exchanger bolts are torqued in a uniform pattern. This will ensure that the coolant plates are properly seated together preventing coolant leaks.

10. Torque the coolant heat exchanger plate bolts from the center of the plate to the edges in a crossing pattern to specification. Refer to section A 003. See Figure 915.

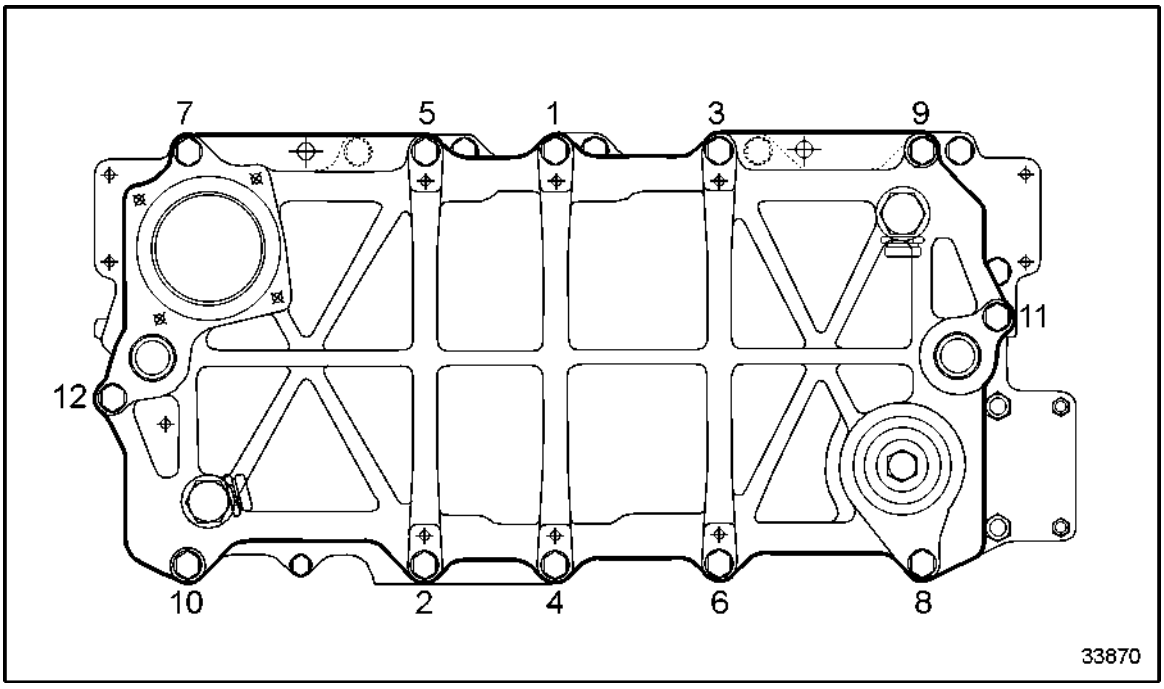
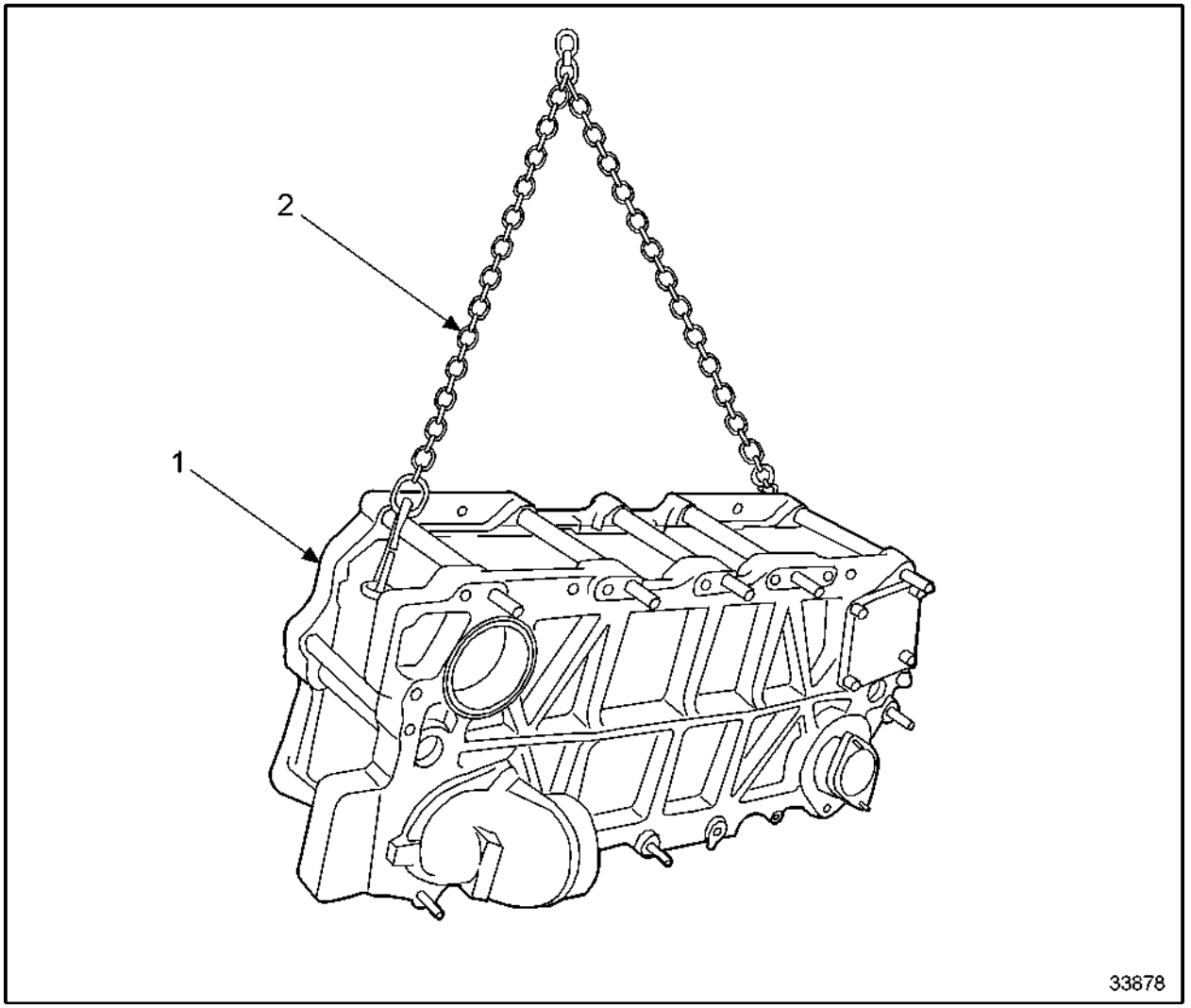


Figure 915 Torquing Coolant Heat Exchanger Bolts

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.

11. Install a lifting device (2) to the coolant heat exchanger (1). See Figure 916.



1. Coolant Heat Exchanger
2. Lifting Device

Figure 916 Supporting Coolant Heat Exchanger Assembly

12. Lift the coolant heat exchanger assembly and align for installation onto the front cover.

13. Install the coolant heat exchanger assembly to the front cover and secure with six bolts. Torque bolts to specification. Refer to section A 003. See Figure 917.

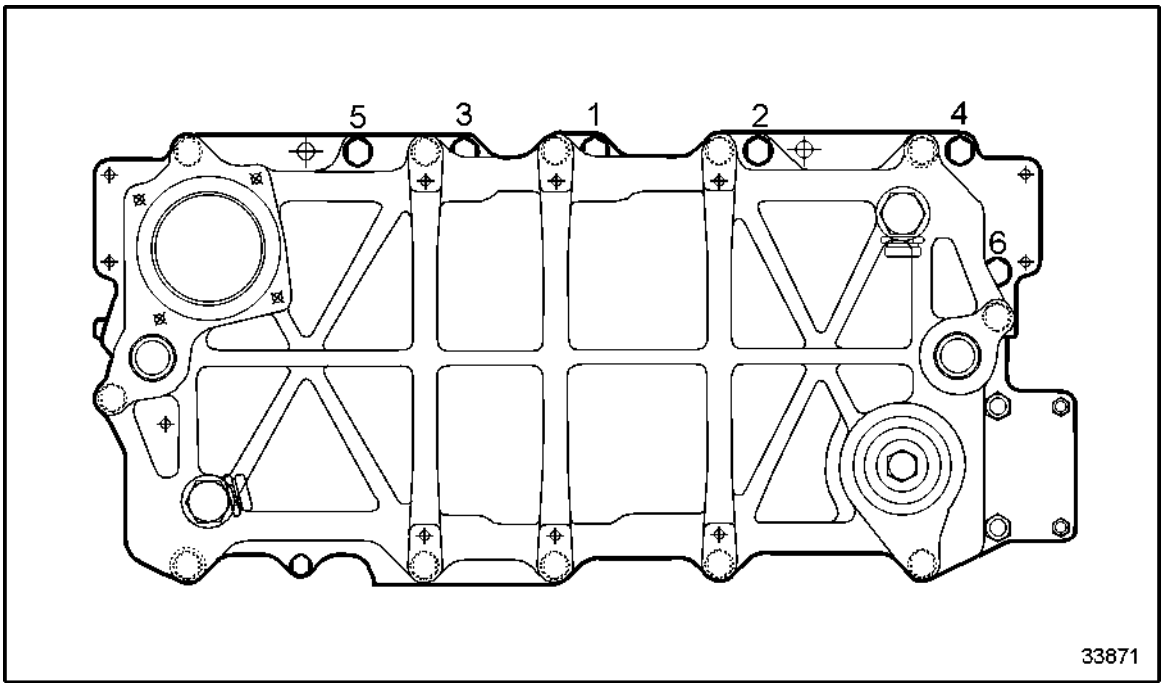
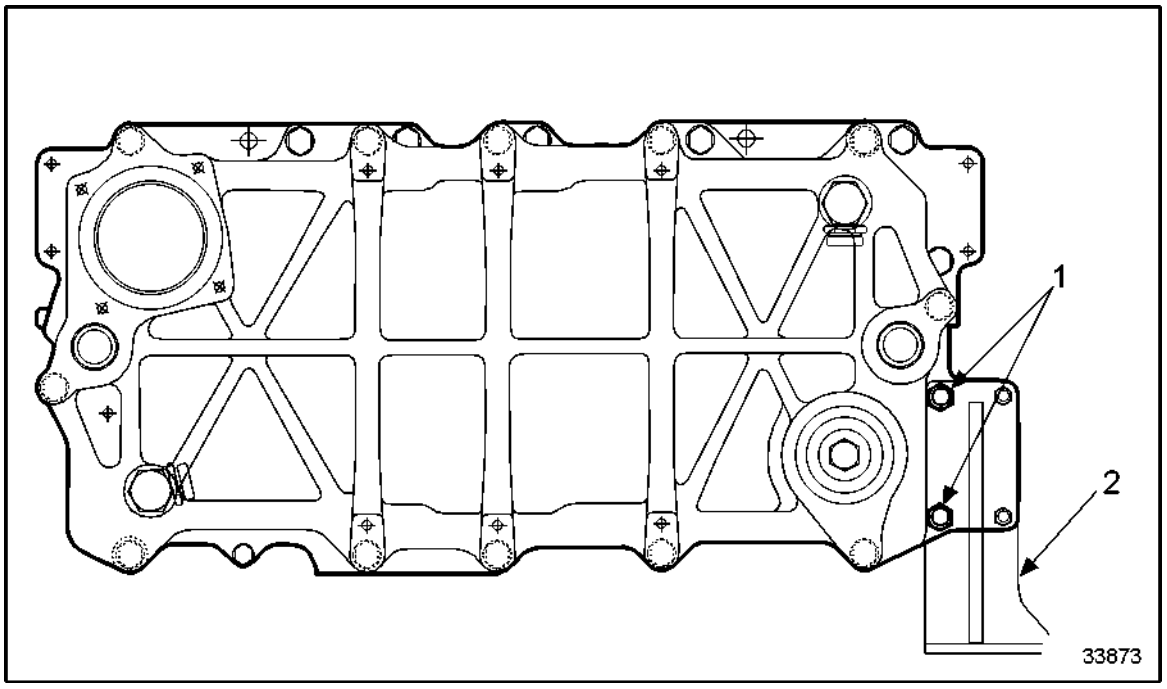


Figure 917 Torquing Sequence for Base Plate to Front Cover

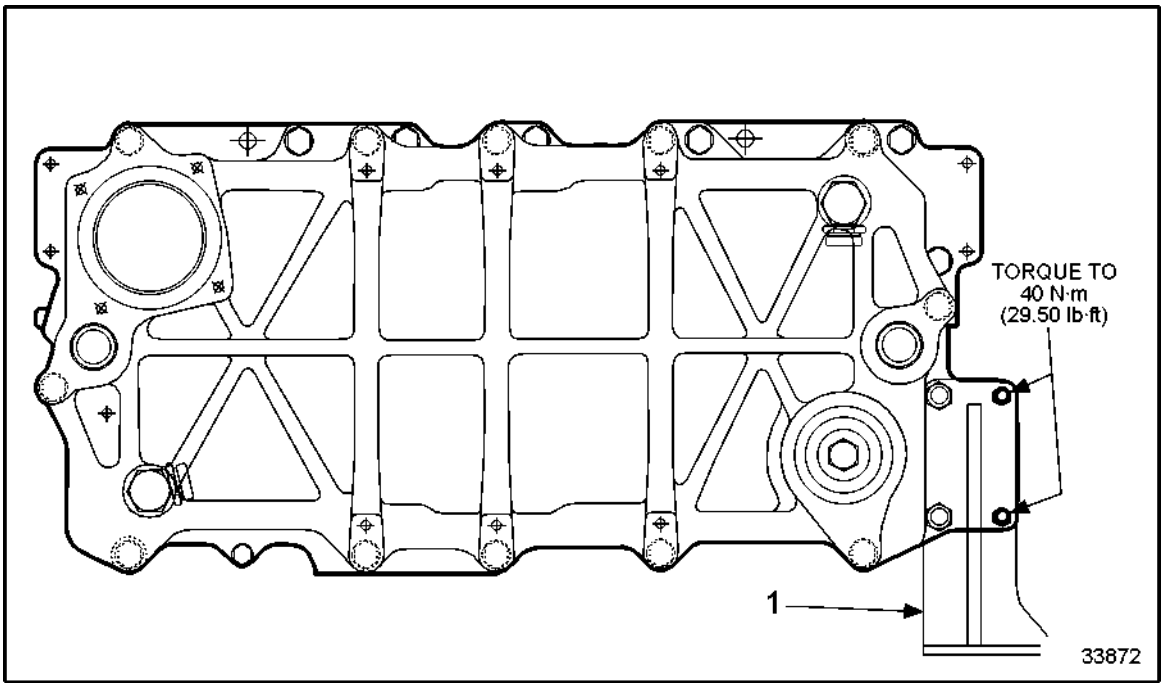
14. Install two bolts (1) and washers to secure the fuel assembly bracket (2) to the front cover. Torque bolts to specification. Refer to section A 003. See Figure 918.



1. Bolts
2. Fuel Filter Assembly Bracket

Figure 918 Torquing Location for Fuel Filter Assembly

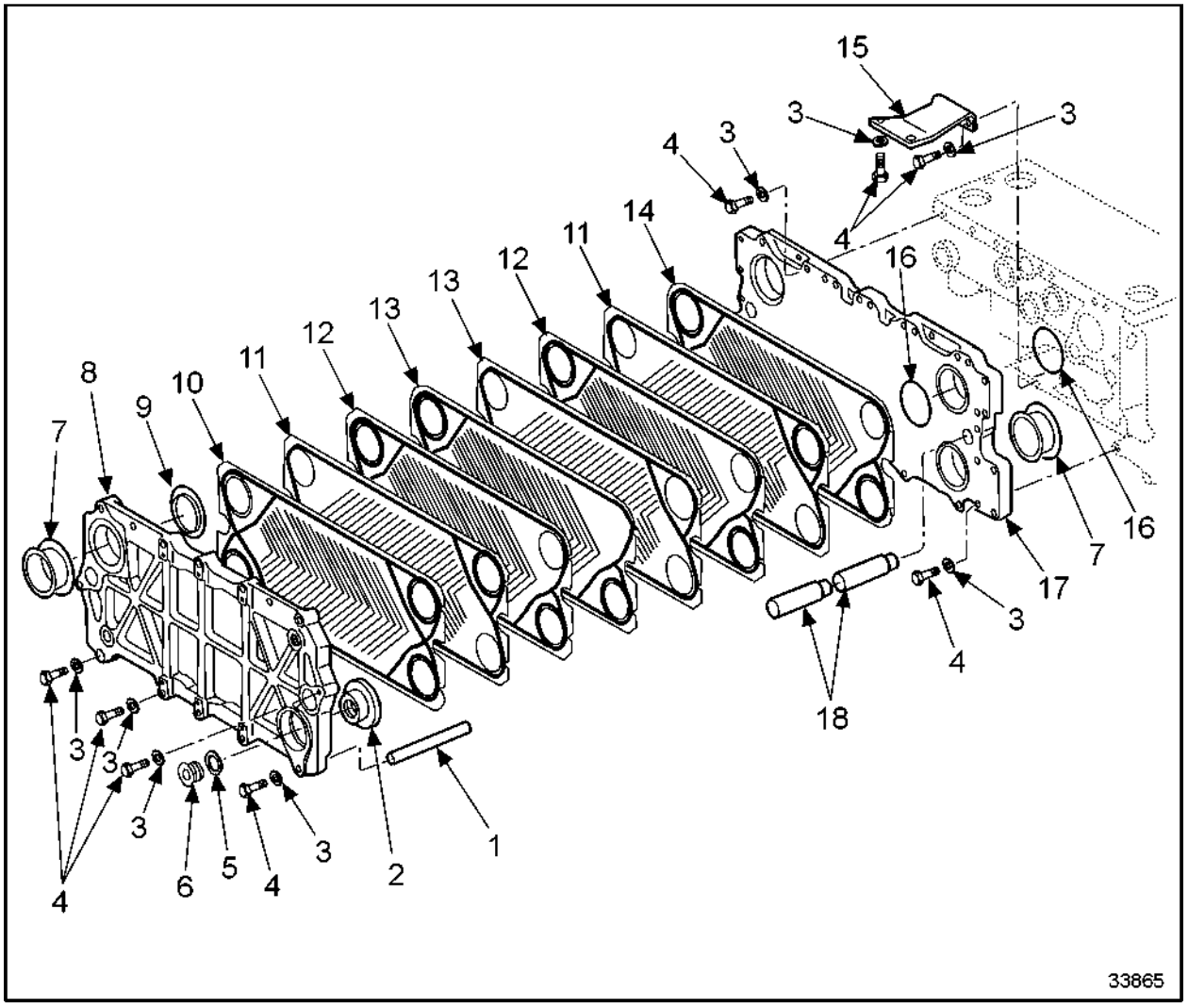
15. Install two bolts and washers to secure the fuel filter assembly (1) to the front cover. See Figure 919.



1. Fuel Filter Assembly Bracket

Figure 919 Torquing Location and Values for the Fuel Filter Bracket

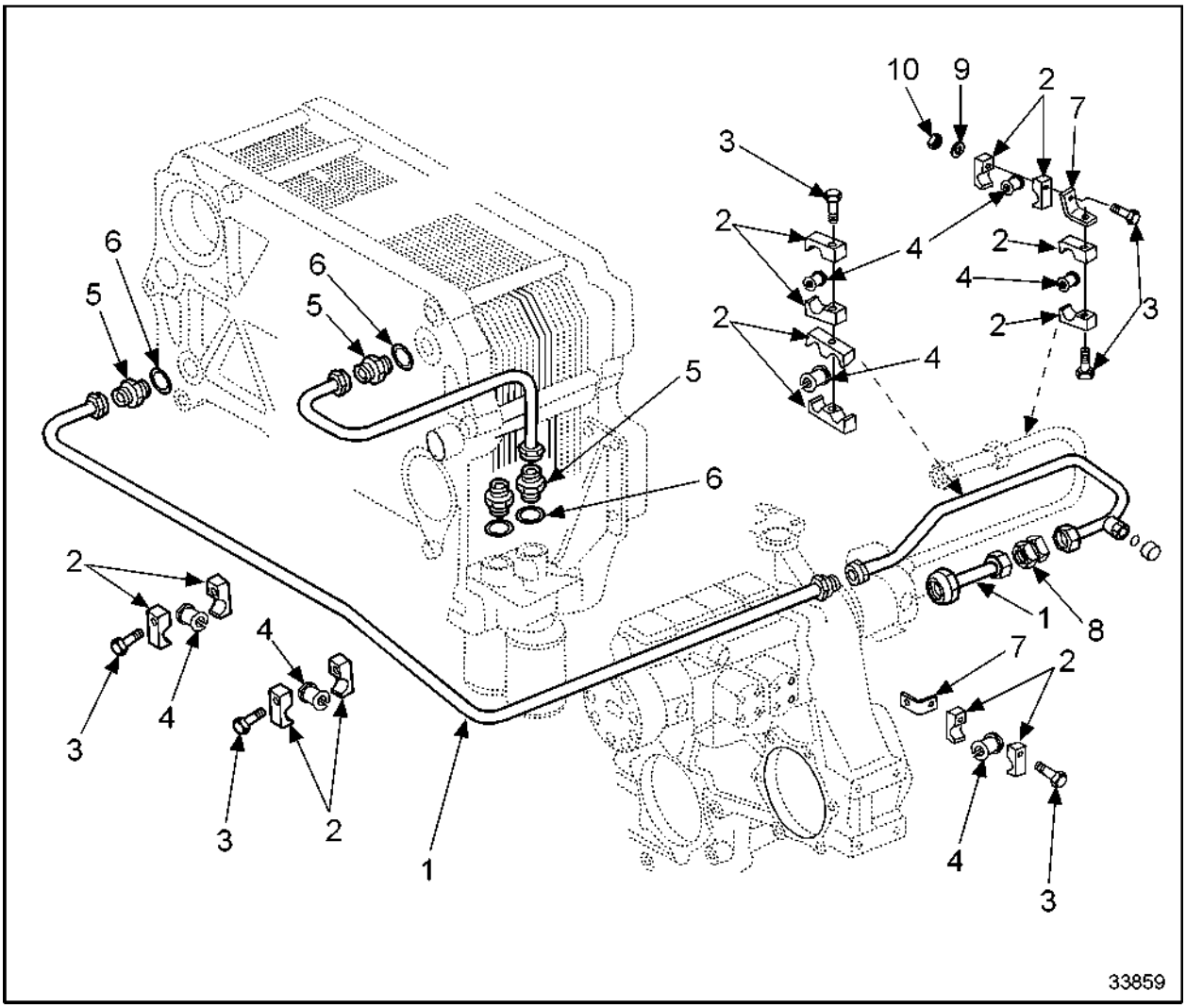
16. Install the coolant heat exchanger mounting bracket (15) and secure with two bolts (4) and washers (3) to the front cover. See Figure 920.



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

17. Connect fuel lines (1). See Figure 921.



1. Fuel Line
2. Half-clamp Pipe
3. Bolt
4. Grommet
5. Adapter
6. Sealing Ring
7. Bracket
8. Check Valve
9. Washer
10. Hex Nut

Figure 921 Connecting Fuel Lines

18. Verify repair of the coolant heat exchanger.

C 205.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 131are the After-Installation Operations for the coolant heat exchanger.

Level of Maintenance	Operation	Reference
1, 2, 3	Install the electronic control unit	Refer to OEM Guidelines
1, 2, 3	Install the surge tank	Refer to OEM Guidelines
1, 2, 3	Install fuel filter Assembly	Refer to OEM Guidelines
1, 2, 3	Enable engine power	Refer to Operators Guide

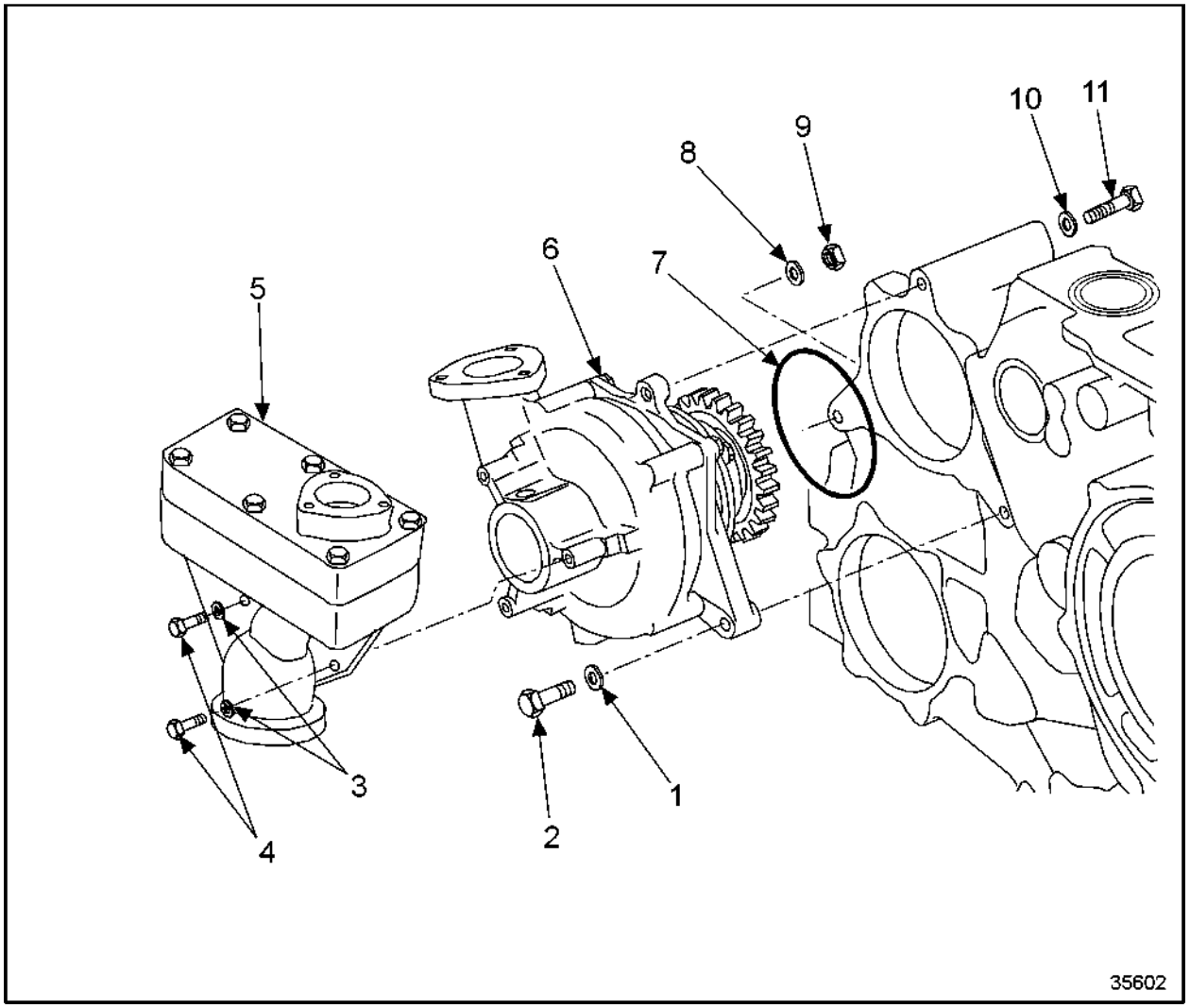
Table 131 After-Installation Operations

C 206.05 – CHARGE AIR COOLING SYSTEM (LOW-TEMPERATURE)

C 206.05.01 – GENERAL VIEW

NOTE:
Refer to section before beginning any work in the charge air cooling system (low-temperature).

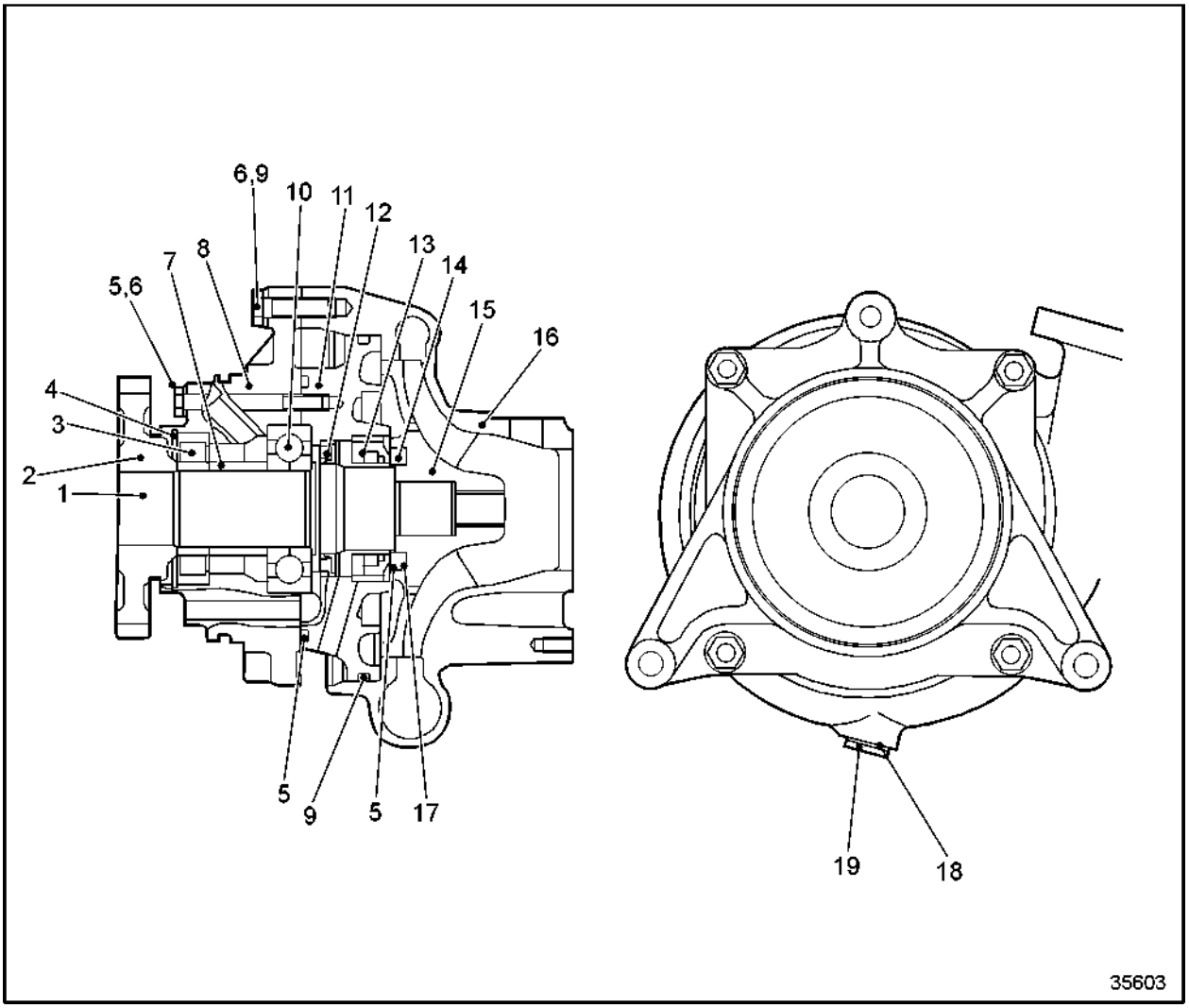
See Figure 922 for a general view of the charge air coolant pump with attachments to charge air cooling system (low-temperature).



1. Washer
2. Mounting Bolt
3. Washer
4. Bolt
5. Low Temperature Thermostat Housing
6. Charge Air Coolant Pump
7. O-ring
8. Washer
9. Nut
10. Washer
11. Bolt

Figure 922 General View of Charge Air Coolant Pump with Attachments Charge Air Cooling System (Low-Temperature)

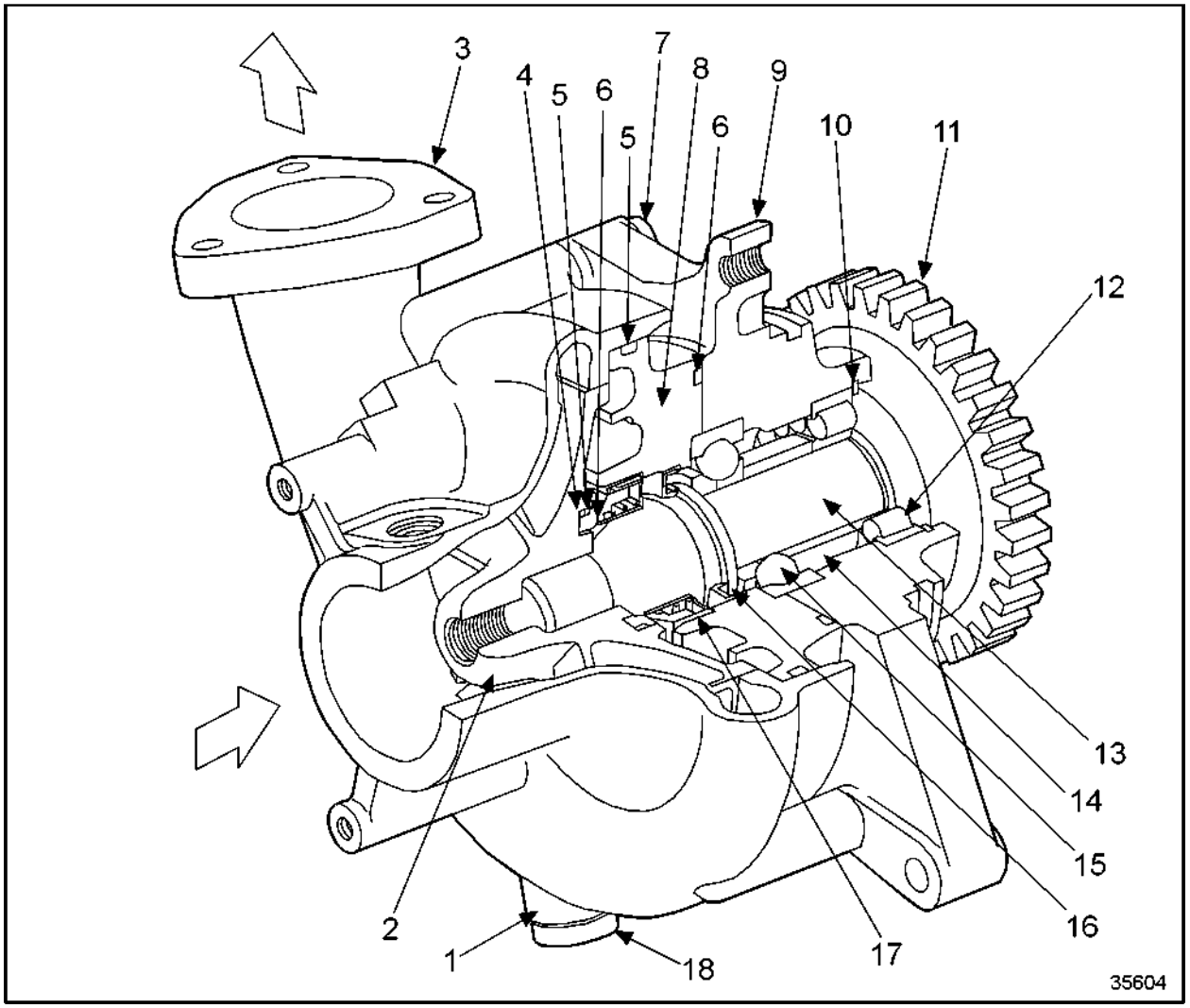
See Figure 923 for a cutaway view of the charge air coolant pump charge air cooling system (low-temperature).



1. Pump Shaft
2. Gear
3. Cylindrical Roller Bearing
4. Snap Ring
5. O-ring
6. Washer
7. Spacer Sleeve
8. Bearing Housing
9. Hex Bolt
10. Angular-contact Ball Bearing
11. Seal Carrier
12. Shaft Seal
13. Rotary Seal
14. Countering
15. Impeller
16. Impeller Housing
17. Metal Ring
18. Sealing Ring
19. Plug

Figure 923 Cutaway View of Charge Air Cooling System (Low-Temperature)

See Figure 924 for a three-dimensional overview of the charge air cooling system (low-temperature).



1. Washer
2. Impeller
3. Impeller Housing
4. Metal Ring
5. O-ring
6. Countering
7. Hex Bolt
8. Seal Carrier
9. Bearing Housing
10. Snap Ring
11. Gear
12. Cylindrical Roller Bearing
13. Pump Shaft
14. Spacer Sleeve
15. Angular-Contact Ball Bearing
16. Shaft Seal
17. Rotary Seal
18. Plug

Figure 924 Three-Dimensional Overview of Charge Air Cooling System (Low-Temperature)

C 206.05.02 – SPECIAL TOOLS

Listed in Table 132 are the special tools required for maintenance on the charge air cooling system (low-temperature).

Application	Number
Removal tool for impeller	—
Washer for shaft	—
Washer for housing	—
Press-fit sleeve for pump shaft	—
Installation tool for drive gear/impeller	—

Table 132 Special Tools

C 206.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 133 are the Before-Removal Operations for the charge air cooling system (low-temperature).

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Remove temperature switch	Refer to section C 208.05.05
1, 2, 3	Separate coolant supply from cooler	Refer to section C 204.05.05
1, 2, 3	Separate coolant return from cooler	Refer to section C 204.05.05
1, 2, 3	Release flange, coolant pipe to pump inlet	Refer to section C 202.05.05
1, 2, 3	Release flange, coolant pipe to pump outlet	Refer to section C 202.05.05

1 = The engine is to be completely disassembled.

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

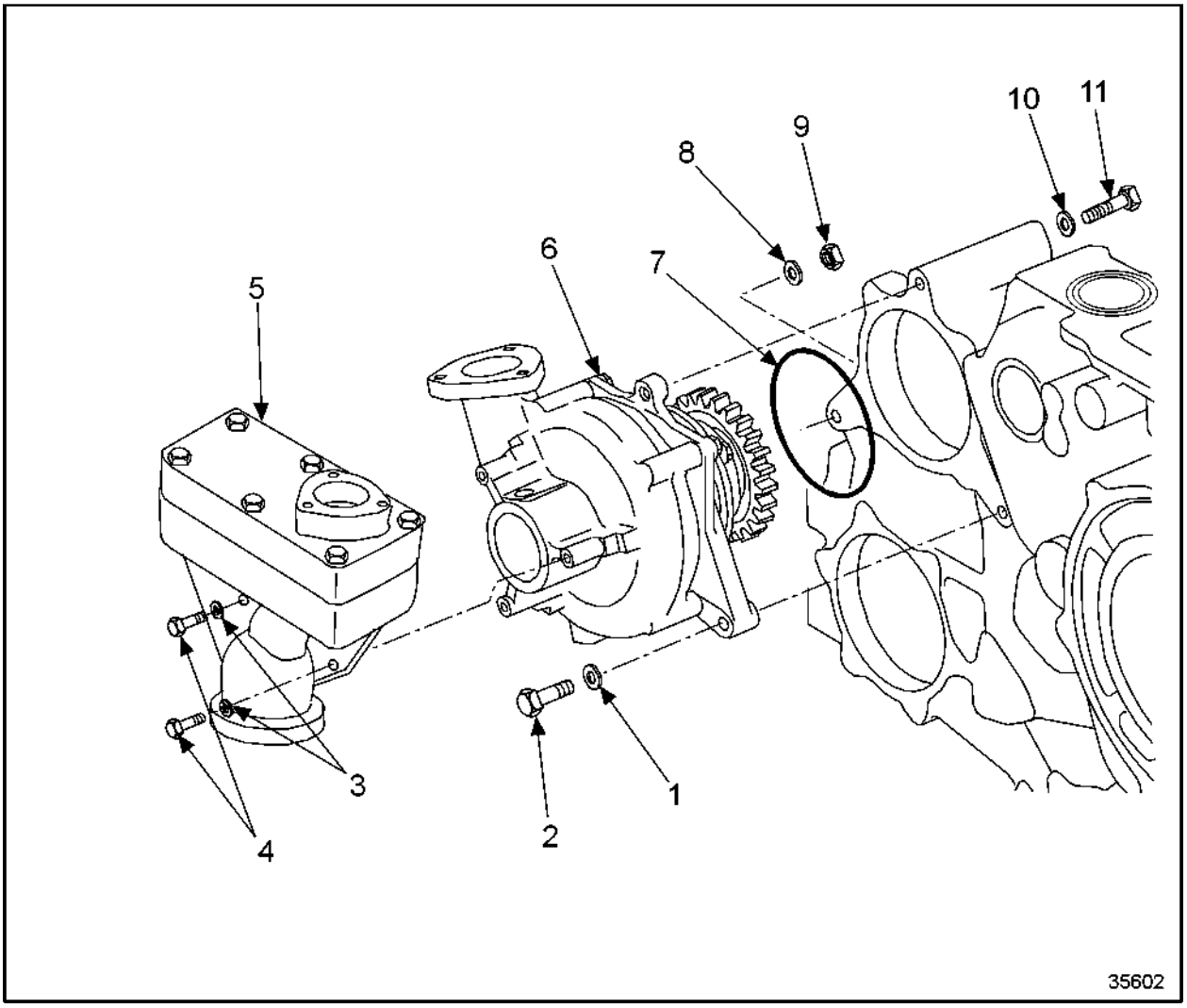
3 = The engine is to remain installed.

Table 133 Before-Removal Operations

C 206.05.05 – REMOVAL OF CHARGE AIR COOLING SYSTEM (LOW-TEMPERATURE)

Perform the following steps to remove the charge air cooling system (low-temperature).

1. Loosen pipe connections on charge air coolant outlet (1) and return (2). See Figure 925.

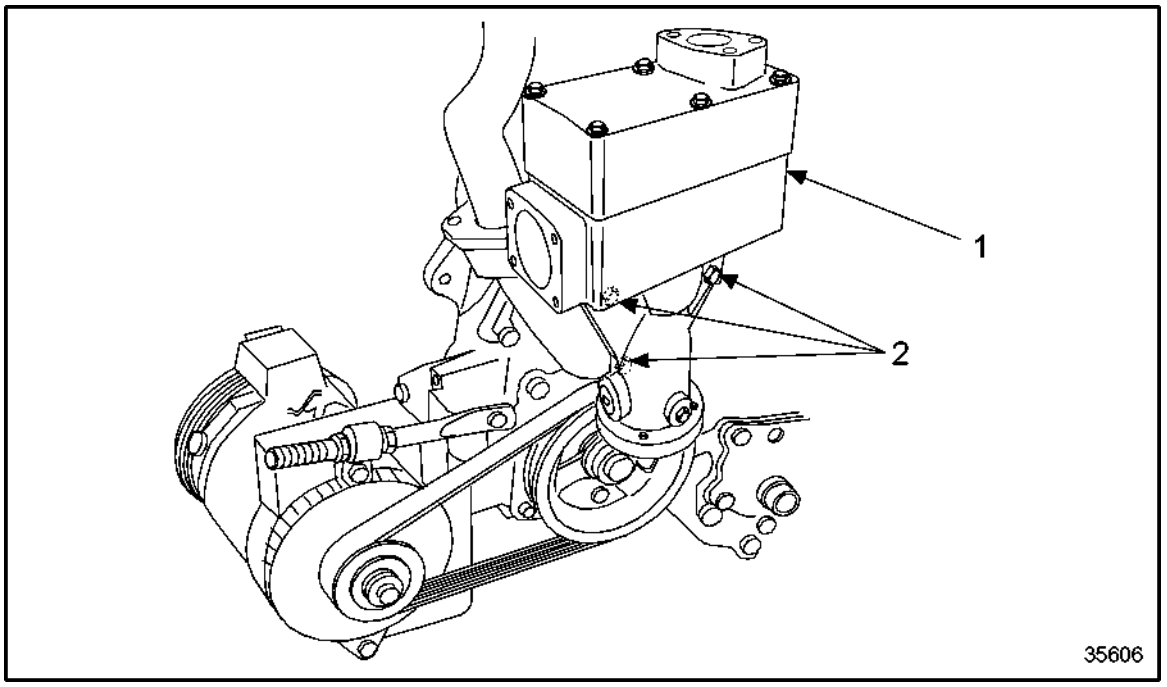


1. Pump Outlet Pipe
2. Coolant Return
3. Coolant Supply
4. Pump Inlet Pipe

Figure 925 Loosening Pipe Connections on Charge Air Coolant Supply and Return

2. Loosen coolant pipes at pump inlet (4) and supply (3) and couplings on charge air coolant pipes.

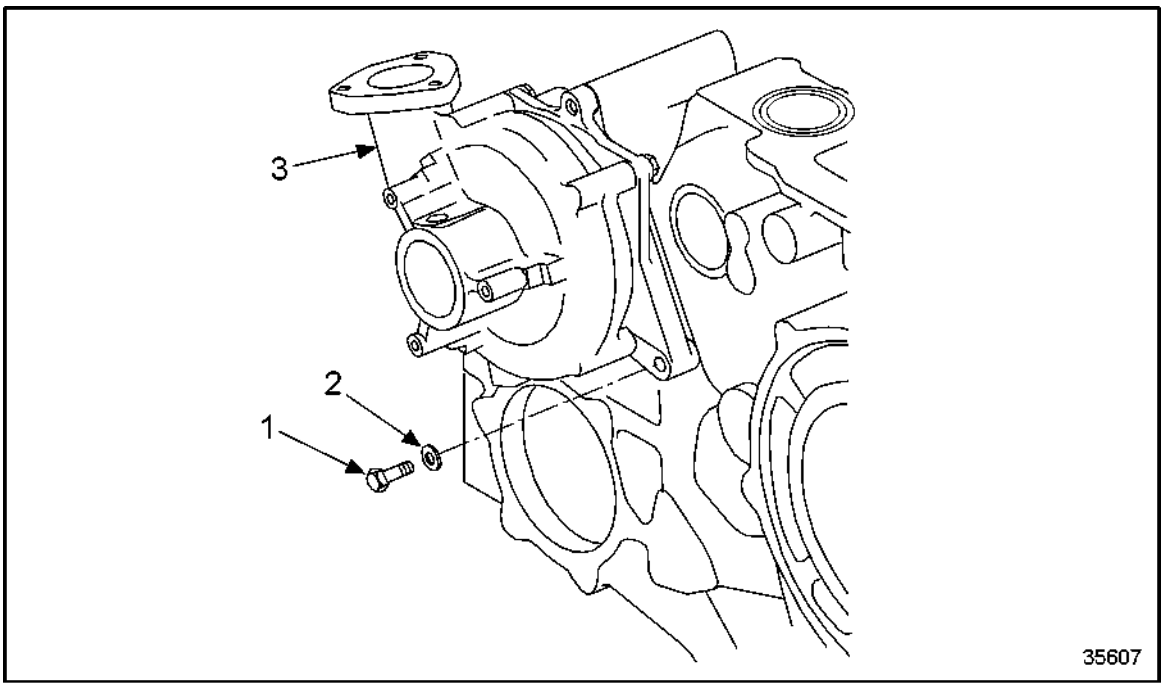
3. Loosen attaching bolts (1) of thermostat housing (2) and remove thermostat housing with thermo-element and thermostat seal. See Figure 926.



1. Thermostat Housing

Figure 926 Removing Thermostat Housing

4. Loosen securing bolts (2). See Figure 927.



1. Low-Temperature Thermostat Housing
2. Bolt

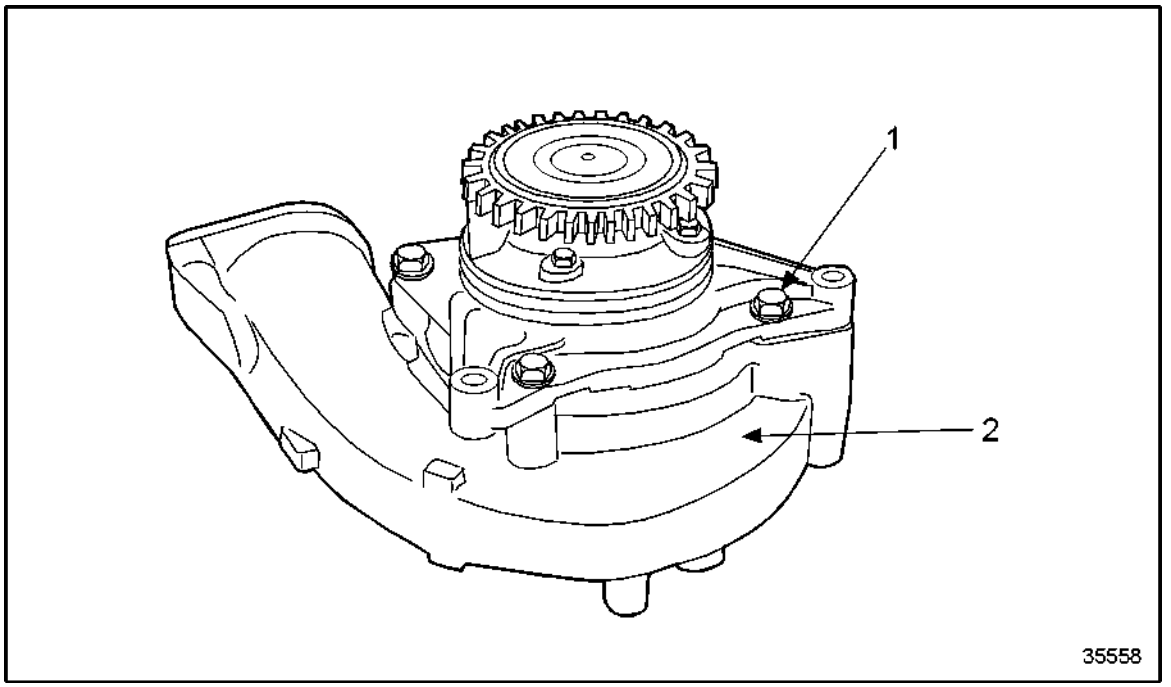
Figure 927 Removing Charge Air Coolant Pump from Gear Case

5. Carefully loosen charge air coolant pump (3) from gear case and remove.
6. Remove O-ring from charge air coolant pump.

C 206.05.06 – DISASSEMBLY OF CHARGE AIR COOLING SYSTEM (LOW-TEMPERATURE)

Perform the following steps to perform the disassembly of charge air cooling system:

1. Loosen securing bolts (1) from pump housing (2) to seal carrier. See Figure 928.

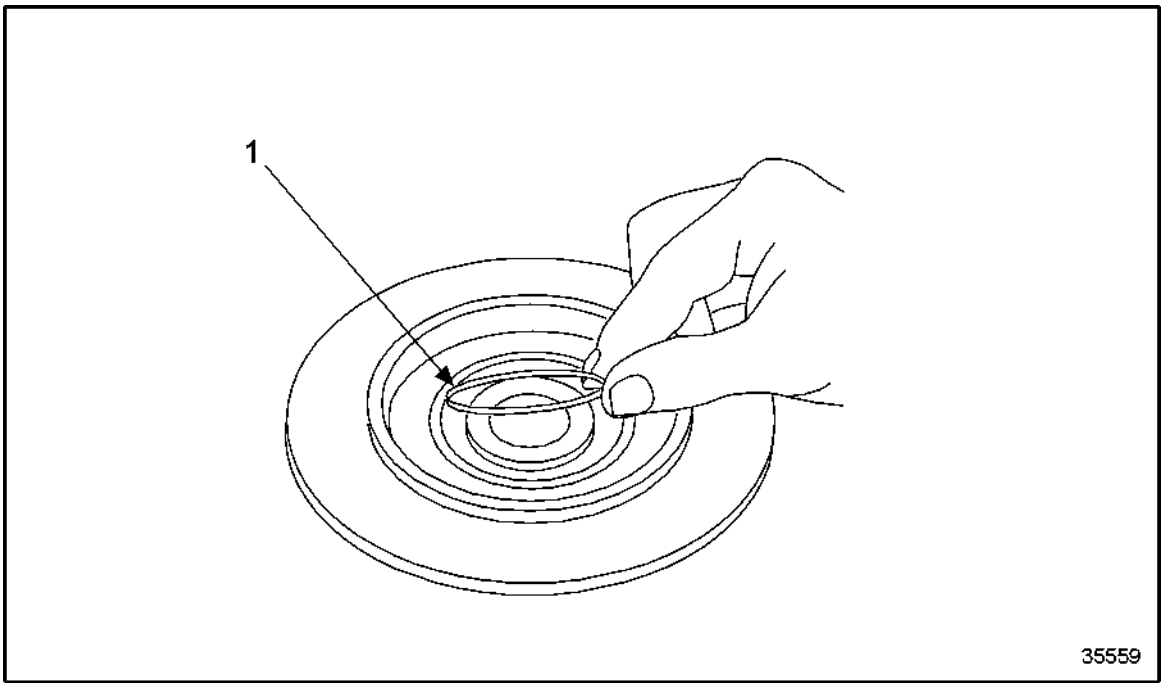


1. Securing Bolts
2. Pump Housing

Figure 928 Removing Securing Bolts from Pump Housing to Seal Carrier

2. Carefully remove pump housing with pry bar.
3. Use a suitable removal tool to remove impeller from charge air coolant pump shaft.

4. Remove thrust ring with inserted O-ring and metal ring (1) from groove on back on impeller. See Figure 929.



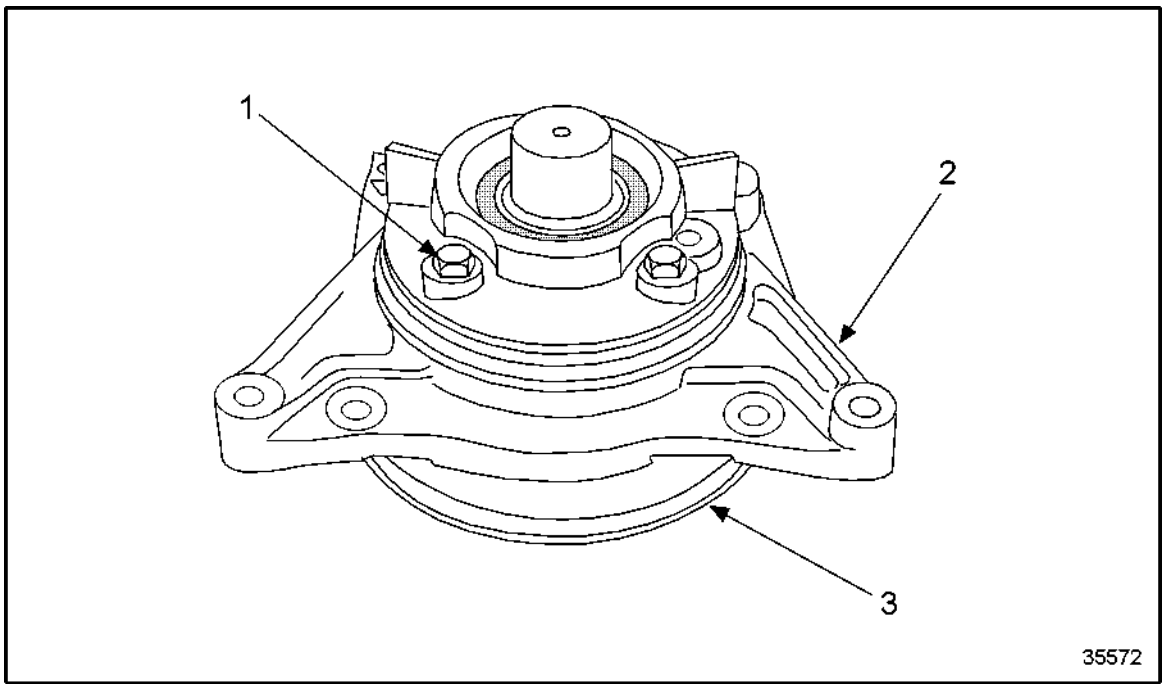
1. Metal Ring

Figure 929 Removing Metal Ring from Groove on Back of Impeller

5. Use a suitable removal tool to remove gear from charge air coolant pump shaft.

NOTE:
Due to interference fit of gear hub and shaft, shaft will be heavily scored when gear is removed.

6. Remove securing bolt (1) between seal carrier (2) and bearing housing (3). See Figure 930.



1. Securing Bolt
2. Seal Carrier
3. Bearing Housing

Figure 930 Removing Securing Bolt between Seal Carrier and Bearing Housing

7. Using a pry bar, carefully remove bearing housing (3) from seal carrier.

8. Remove pump shaft with roller bearing, spacer sleeve and bearing inner race from seal carrier. See Figure 931.

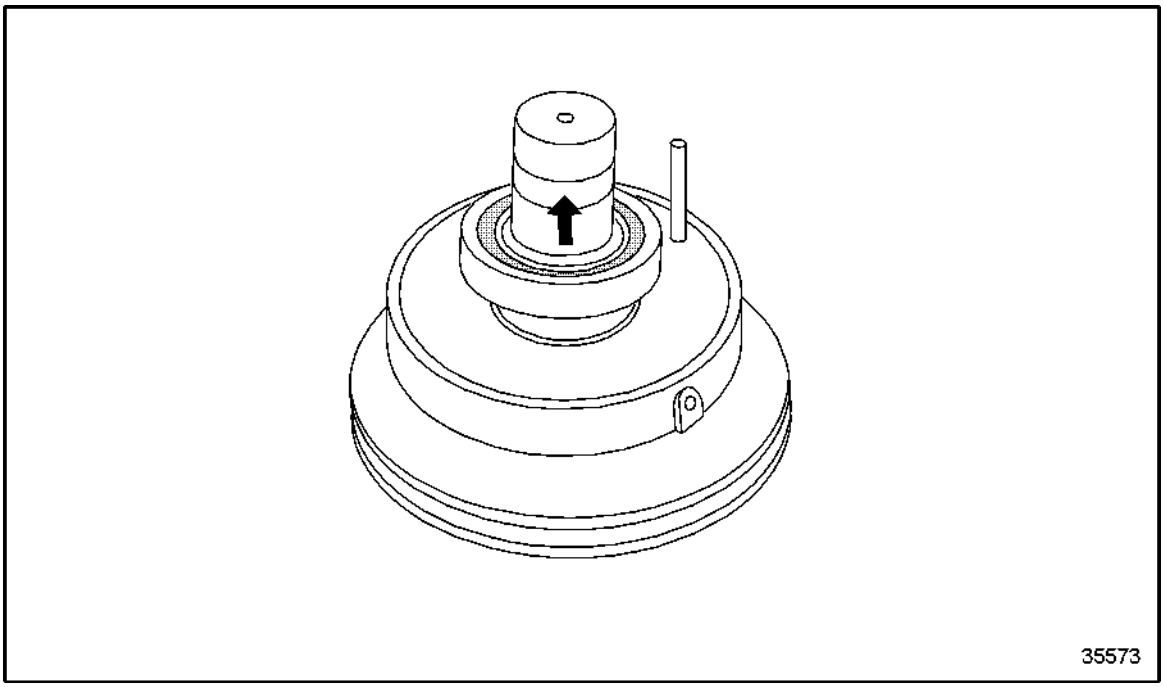
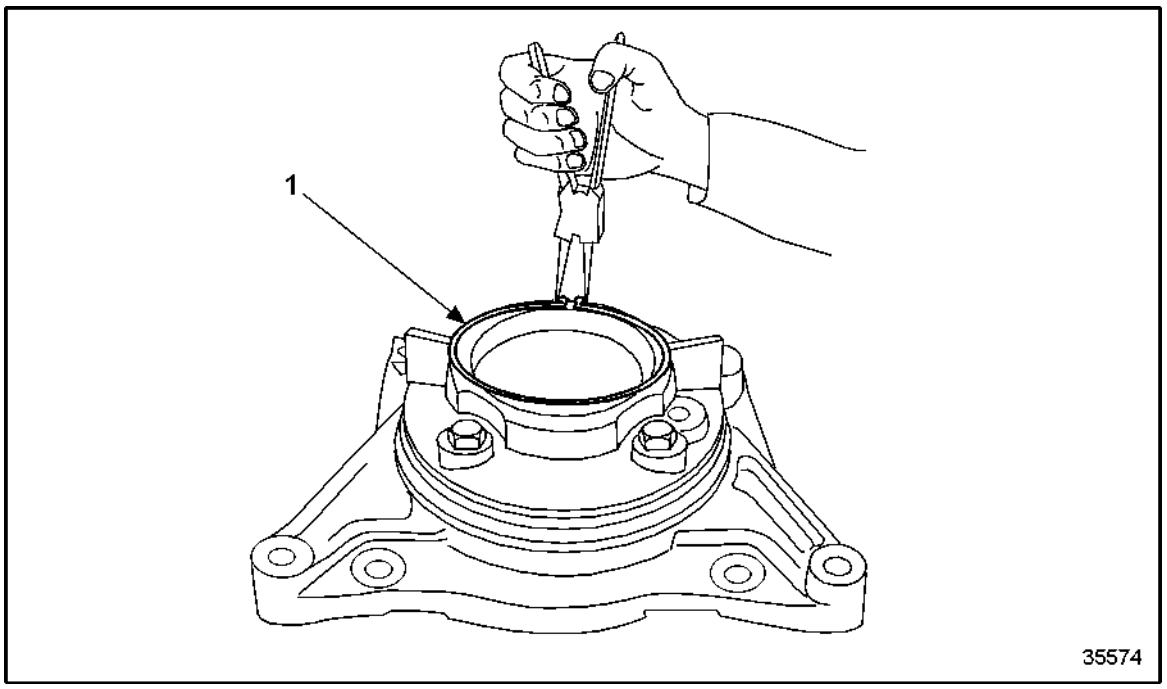


Figure 931 Removing Pump Shaft from Seal Carrier

9. Remove O-rings from seal carrier.
10. Use a suitable tool to remove bearing inner race, spacer sleeve and roller bearing from charge air coolant pump shaft.

11. Remove snap ring (1) from bearing housing. See Figure 932.

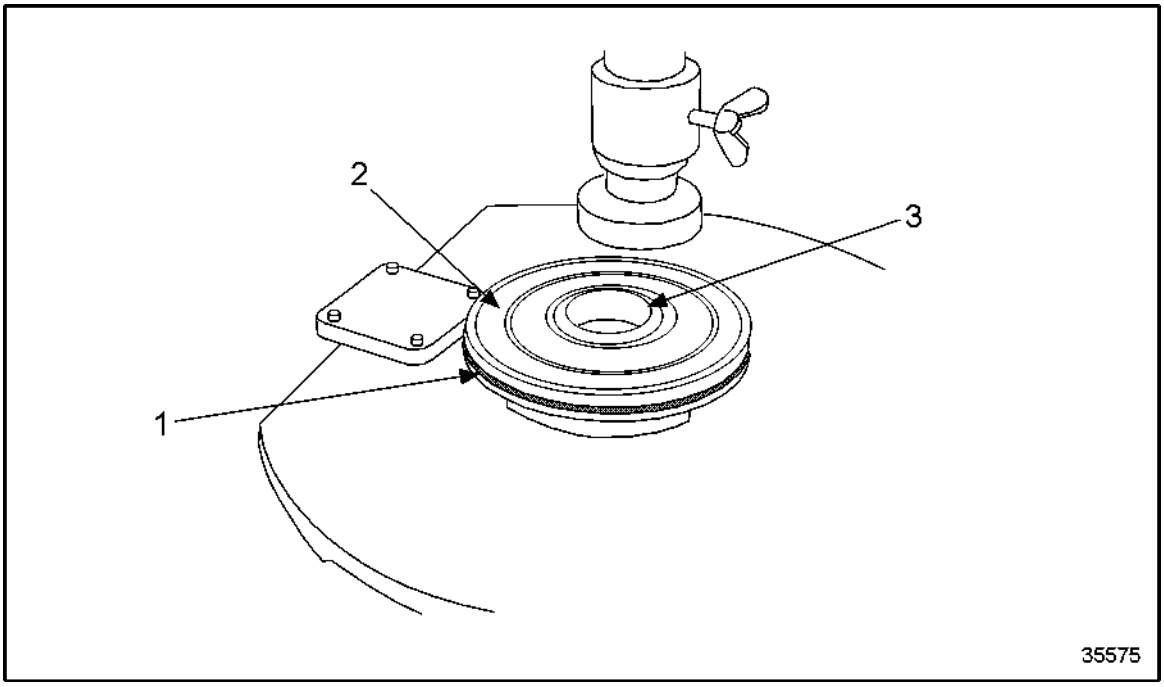


1. Snap Ring

Figure 932 Removing Snap Ring from Bearing Housing

12. Remove bearing cage with outer race of cylindrical roller bearing from bearing housing.

13. Remove rotary seal (3) and thermostat seal behind it from seal carrier (2). See Figure 933.



1. O-ring
2. Seal Carrier
3. Rotary Seal

Figure 933 Removing Rotary Seal and Shaft Seal from Seal Carrier

14. Remove O-ring (1) from outer collar.

C 206.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the charge air cooling system (low-temperature):

1. Clean all components.
2. Using surface crack-testing method and red penetrant dye, inspect impeller for cracks.
   [a] If cracks are found, repair or replace impeller.
   [b] If no cracks are found, continue inspection.
3. Using the magnetic crack-testing method with fluorescent magnetic powder, inspect pump shaft and gear for cracks.
   [a] If pump shaft or gear are cracked, replace components as necessary.
   [b] If pump shaft or gear are not cracked, continue inspection.
4. Visually inspect sealing surfaces and/or annular grooves on elbow, housing, impeller and inlet connection for wear, indentations and pitting.
   [a] If sealing surfaces and/or annular grooves on elbow and housing, impeller and inlet connection show wear, indentations or pitting, rub down with emery cloth or an oilstone.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If sealing surfaces and/or annular grooves on elbow and housing, impeller and inlet connection do not show wear, indentations or pitting, continue inspection.
5. Visually inspect elbow, housing, impeller and inlet adapter for pitting.
   [a] If pitting is over 1 mm in depth, replace component.
   [b] If pitting is under 1 mm in depth, reuse component.

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.

6. Visually inspect elbow, inlet adapter and housing for leaks with compressed air under water.
   [a] If elbow, inlet adapter or housing show leaks, repair or replace components as necessary.
   [b] If elbow, inlet adapter or housing do not show leaks, continue inspection.

NOTE:
Water temperature should be within a minimum of 30°C to a maximum of 40°C.

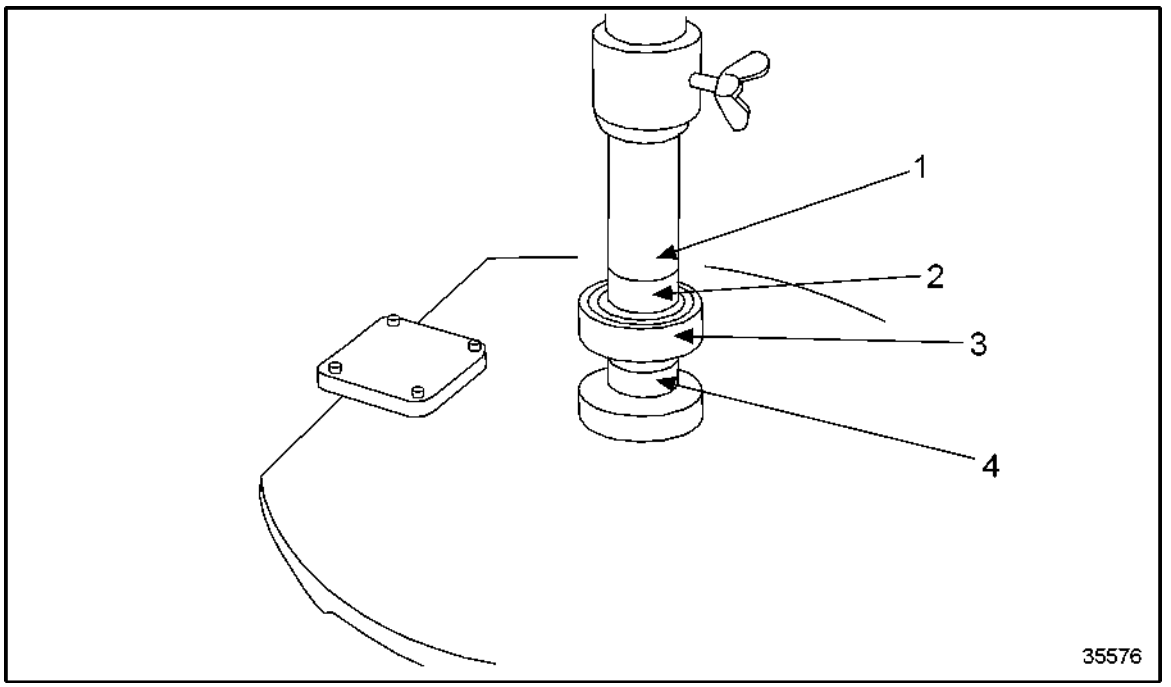
7. Visually inspect shaft for wear and damage.
   [a] If shaft is worn or damaged, smooth out slight wear and damage with an emery cloth.
   [b] If damage is beyond repair, replace shaft.
   [c] If no wear or damage is found, continue inspection.
8. Visually inspect gear for indentations and wear.
   [a] If gear is indented or worn, rub down with an oilstone or an emery cloth.
   [b] If damage is beyond repair, replace gear.
   [c] If gear is not worn or indented, continue inspection.
9. Visually inspect threads for wear and damage.
   [a] If threads are worn or damaged, rechase components.
   [b] If damage is beyond repair, replace component.
   [c] If threads are not worn or damaged, continue inspection.
10. Adjust bore gage and measure bearing bores in housing.
   [a] If bearing bores are not within specified limits, replace components as necessary.
   [b] If bearing bores are within specified limits, continue inspection.
11. Using micrometer, measure bearing seat on shaft.
   [a] If limit values are exceeded, replace components as necessary.
   [b] If limit values are not exceeded, continue inspection.
12. Replace cylindrical roller bearing and grooved ball bearing as part of every W6 overhaul.
13. After every pump disassembly, replace gaskets, O-rings, rotary seal and radial-lip shaft seal.

C 206.05.10 – ASSEMBLY OF CHARGE AIR COOLING SYSTEM (LOW-TEMPERATURE)

Perform the following steps to assemble the charge air cooling system (low-temperature):

NOTE:
Ensure that oil-retaining parts are perfectly clean.

1. To prepare pump shaft, degrease contact surfaces of pump shaft (4), angular-contact ball bearing (3), spacer sleeve (2) and inner race (1) of cylindrical roller bearing .See Figure 934.



1. Inner Race
2. Spacer Sleeve
3. Angular-Contact Ball Bearing
4. Pump Shaft

Figure 934 Pressing Angular-Contact Ball Bearing, Spacer Sleeve and Inner Race of Cylindrical Roller Bearing on Pump Shaft

2. Place shaft contact washer in manual press.
3. Place pump shaft (4) so that mating surface for angular-contact ball bearing faces up. See Figure 934.
4. Press the angular-contact ball bearing (3), spacer sleeve (2) and inner race (1) of cylindrical roller bearing on pump shaft.

5. Coat pump shaft in running area of shaft seal (arrow) with Molykote. See Figure 935.

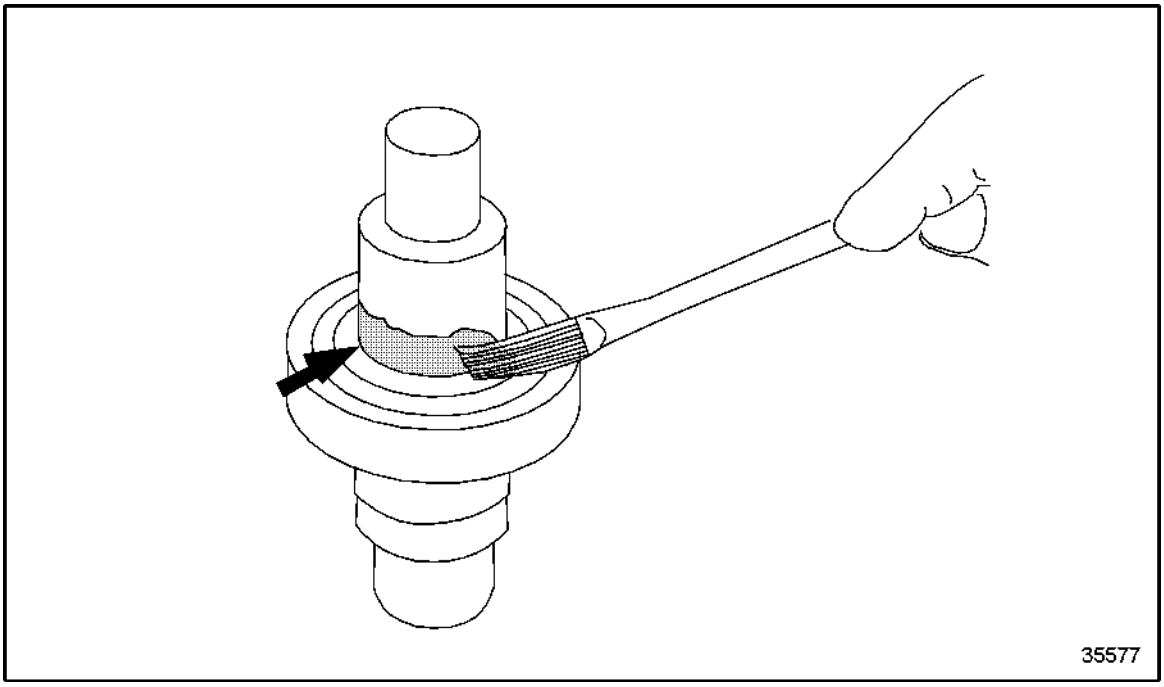


Figure 935 Coating Pump Shaft with Molykote

6. To prepare bearing housing, degrease contact surfaces of cylindrical roller bearing in bearing housing.

7. Install cylindrical roller bearing evenly to the stop. See Figure 936.

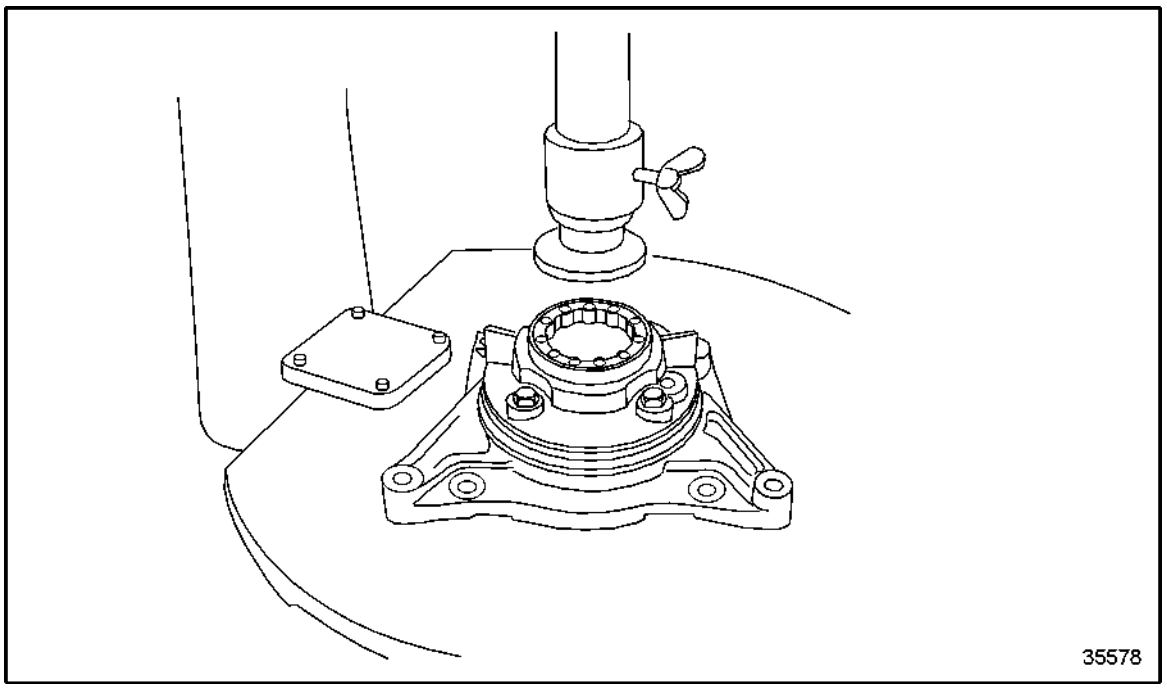
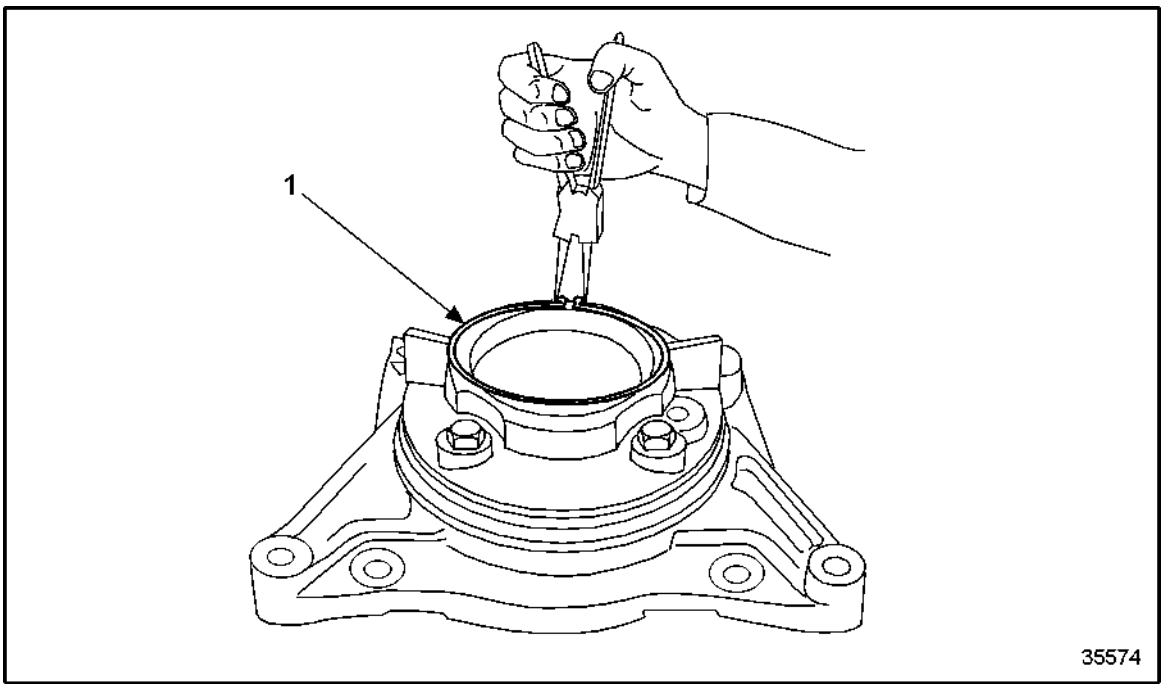


Figure 936 Installing Cylindrical Roller Bearing

8. Insert snap ring (1) for cylindrical roller bearing in bearing housing. See Figure 937.

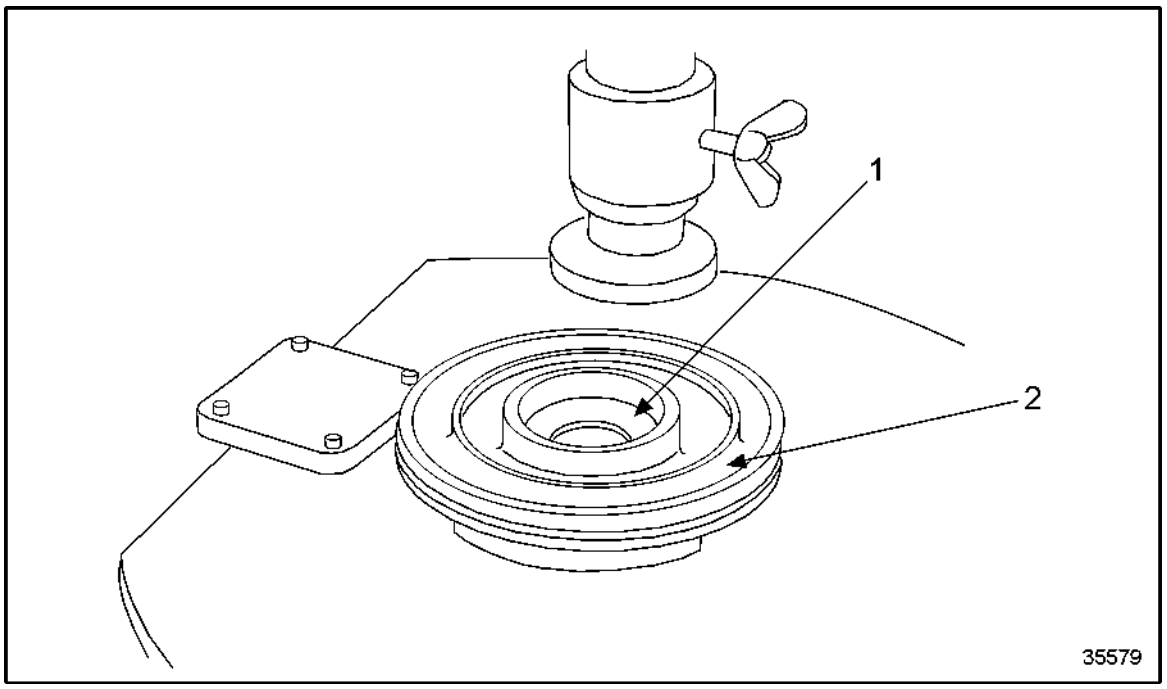


1. Snap Ring

Figure 937 Inserting Snap Ring into Bearing Housing

9. To prepare seal carrier, degrease contact surfaces of shaft seal.

10. Insert shaft seal (1) evenly in seal carrier (2). See Figure 938.



1. Shaft Seal
2. Seal Carrier

Figure 938 Inserting Shaft Seal in Seal Carrier

11. Clean bore and bearing surfaces with ethanol.

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

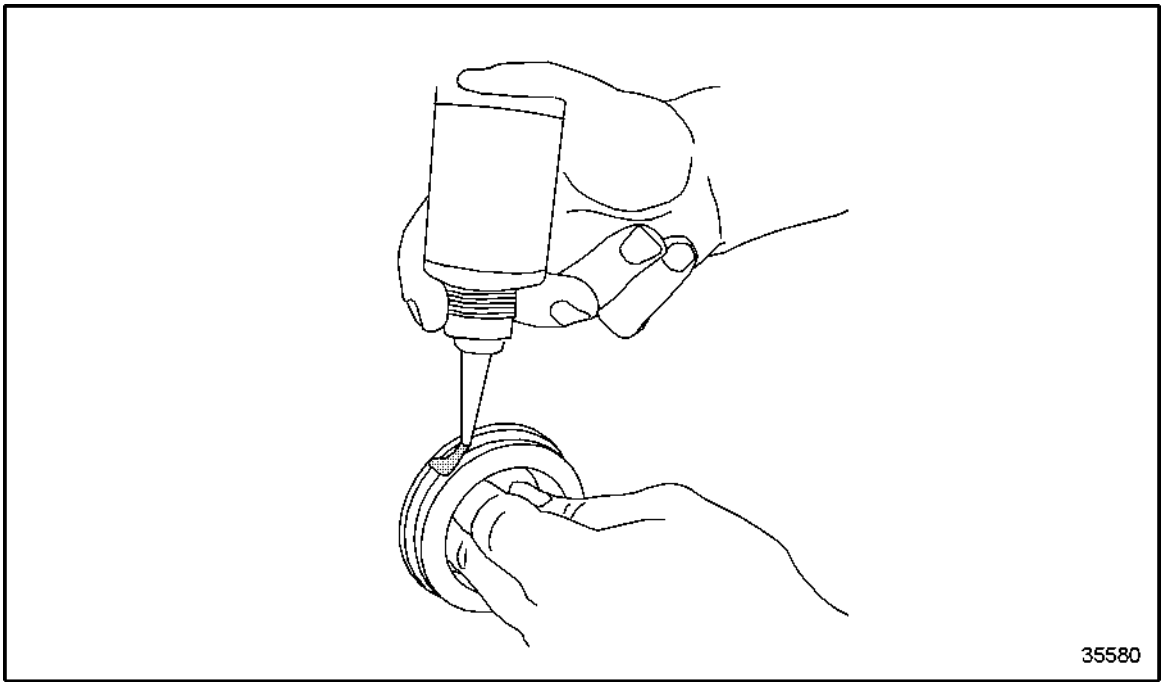
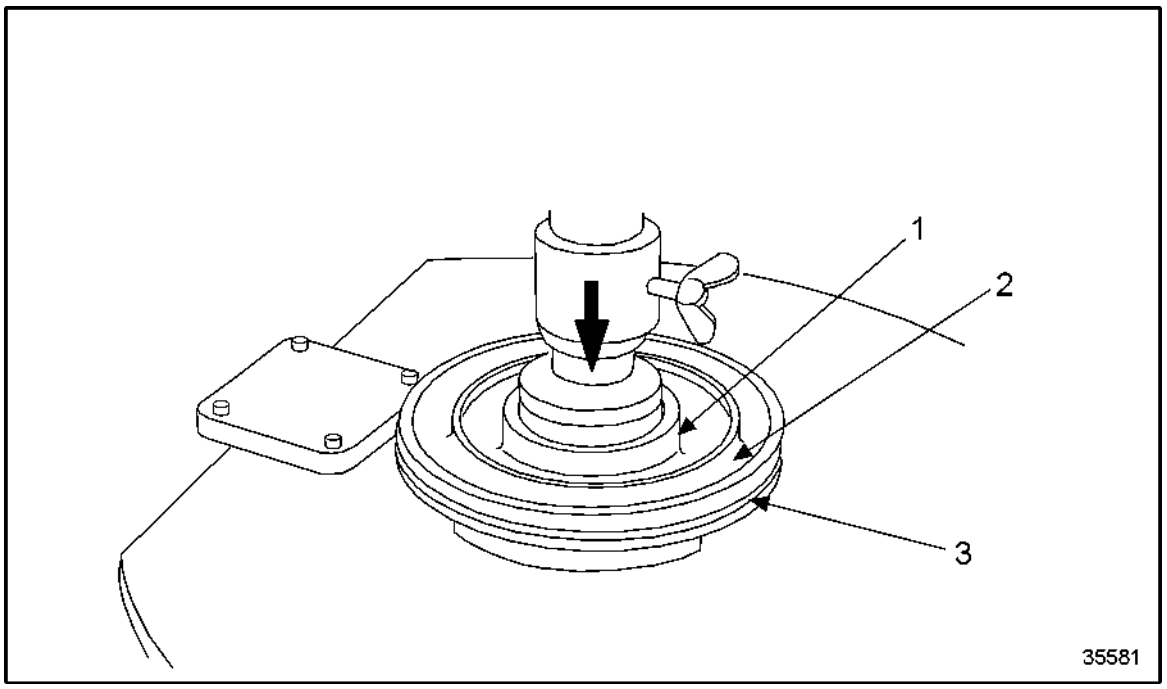


Figure 939 Coating Outer Surface of Rotary Seal with Sealant

13. Install rotary seal (1) evenly in seal carrier. See Figure 940.

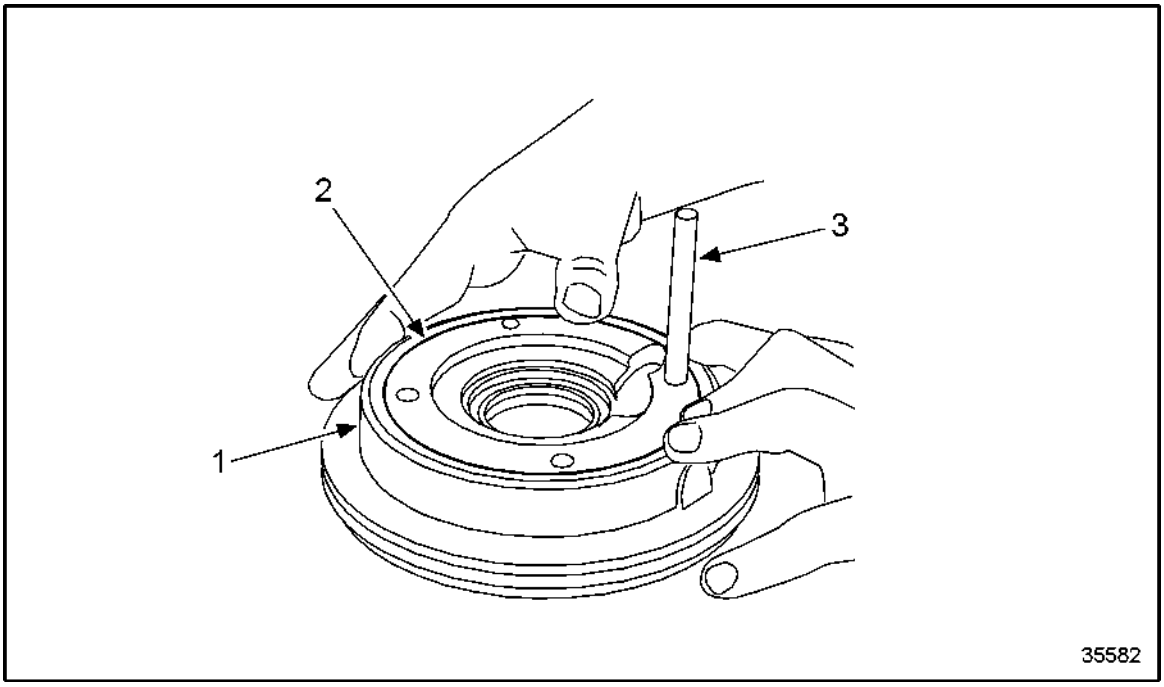


1. Rotary Seal
2. Seal Carrier
3. O-ring

Figure 940 Inserting Rotary Seal in Seal Carrier

14. Coat O-ring (3) with petroleum jelly and install into groove in seal carrier (2).

15. Turn seal carrier over to work on the other side. See Figure 941.



1. Seal Carrier
2. O-ring
3. Guide Pin

Figure 941 Turning Seal Carrier Over

NOTE:
Ensure that bore of seal carrier comes to rest over an opening in working plate, so that pump shaft is not obstructed during subsequent installation.

16. Coat O-ring (2) with petroleum jelly and insert into groove provided on seal carrier (1).
17. Screw in guide pin (3).

18. Install prepared pump shaft in seal carrier. See Figure 942.

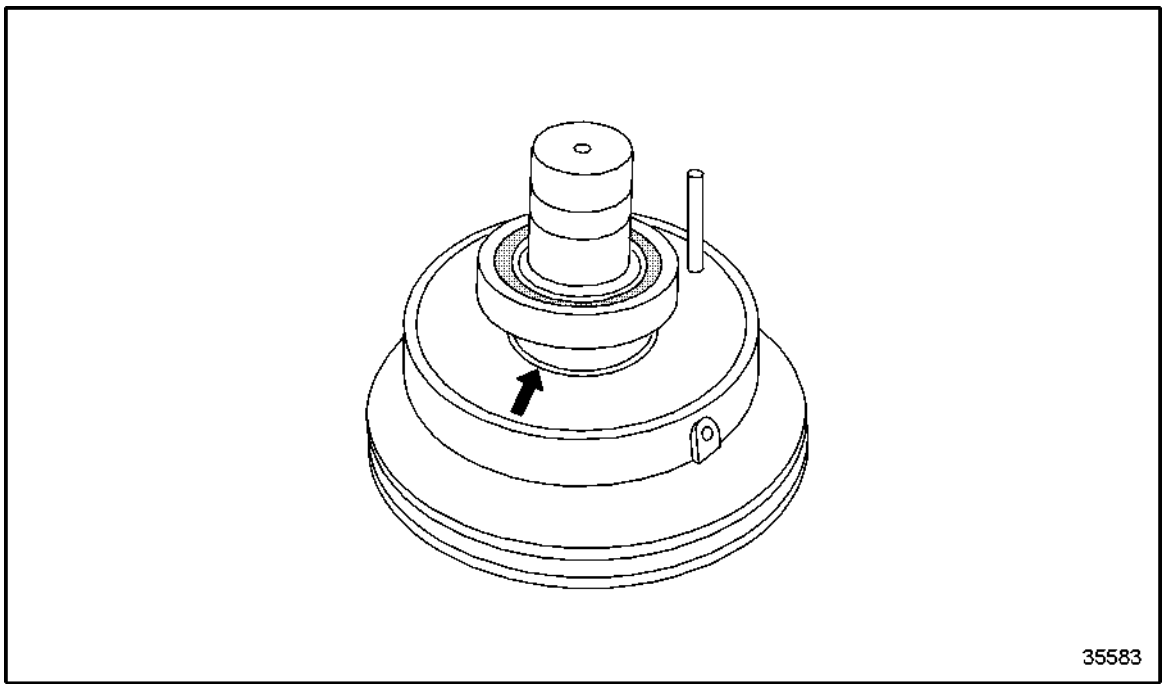
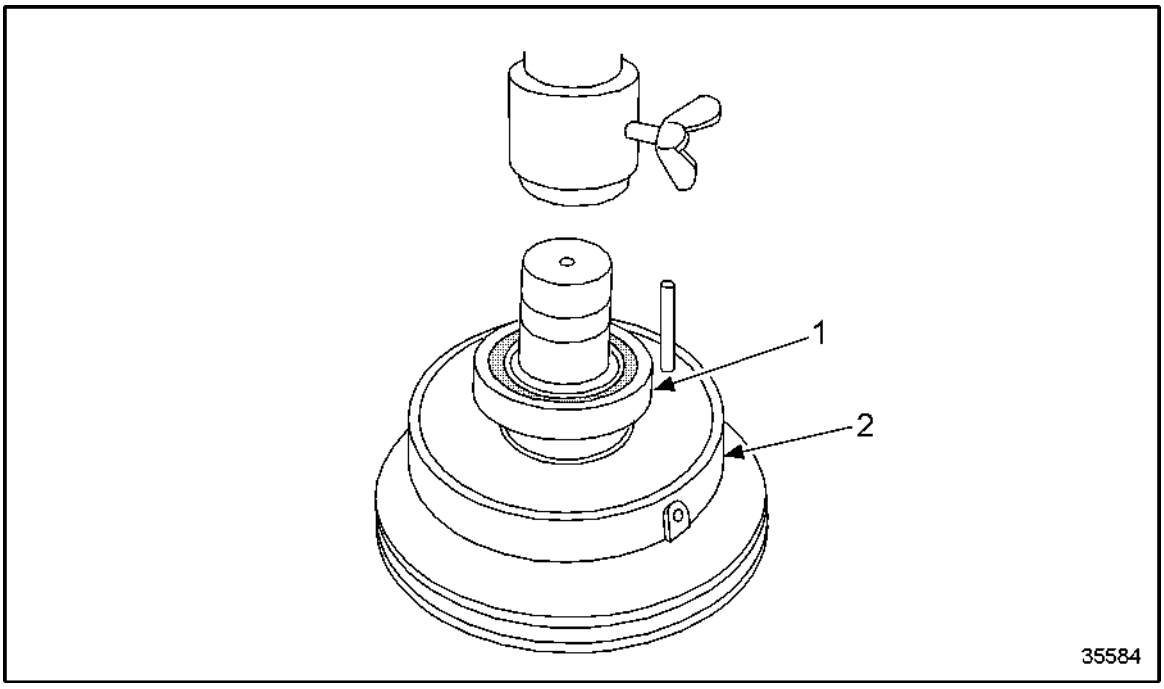


Figure 942 Installing Pump Shaft

19. Install part of shaft coated with Molykote (arrow) first.
20. Ensure that lip of shaft seal is not damaged.

21. Verify that pump shaft with angular-contact ball bearing is correctly positioned in seal carrier (1). See Figure 943.

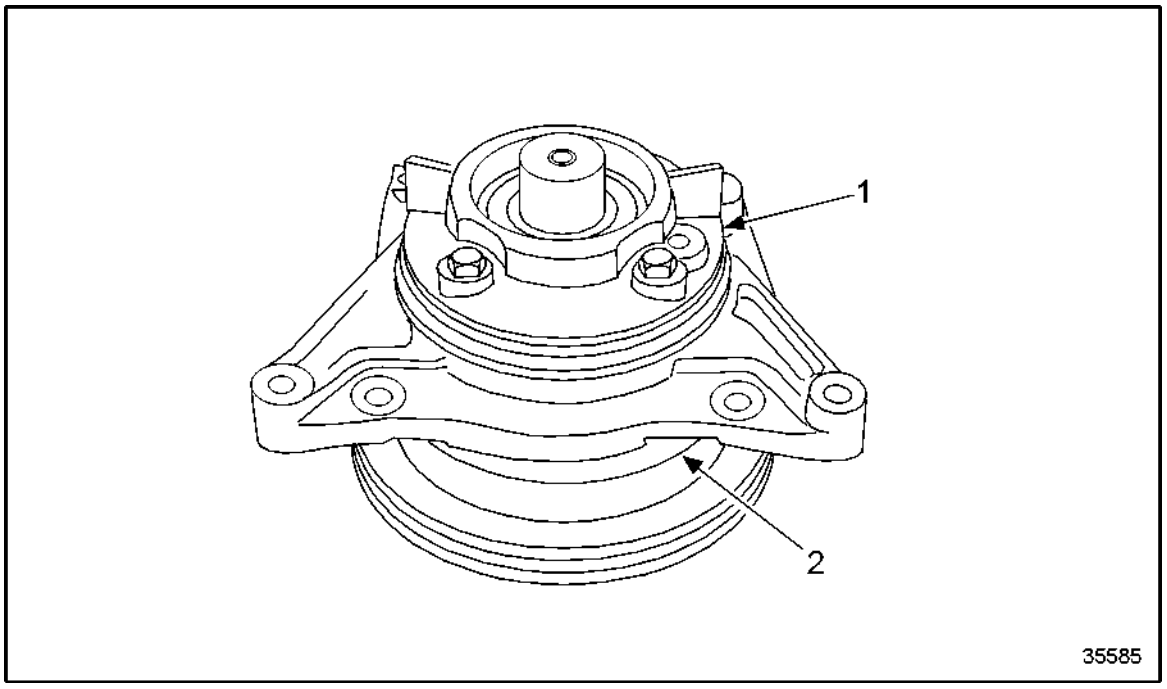


1. Seal Carrier
2. Ball Bearing

Figure 943 Verifying Pump Shaft Positioning

22. Angular-contact ball bearing (2) must be flat.

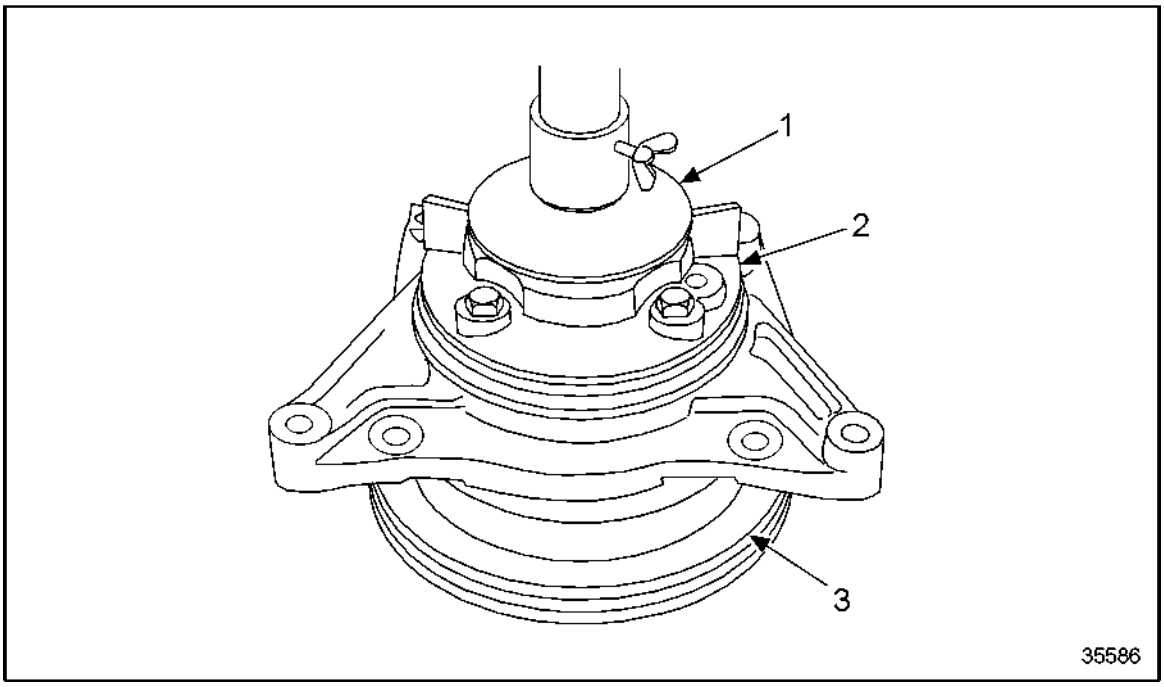
23. Install bearing housing (1) on guide pins and place loosely on sealing ring flange (2). See Figure 944.



1. Bearing Housing
2. Sealing Ring Flange

Figure 944 Installing Bearing Housing

24. Place brass drift adapter (1) for seal carrier (3) in manual press. See Figure 945.

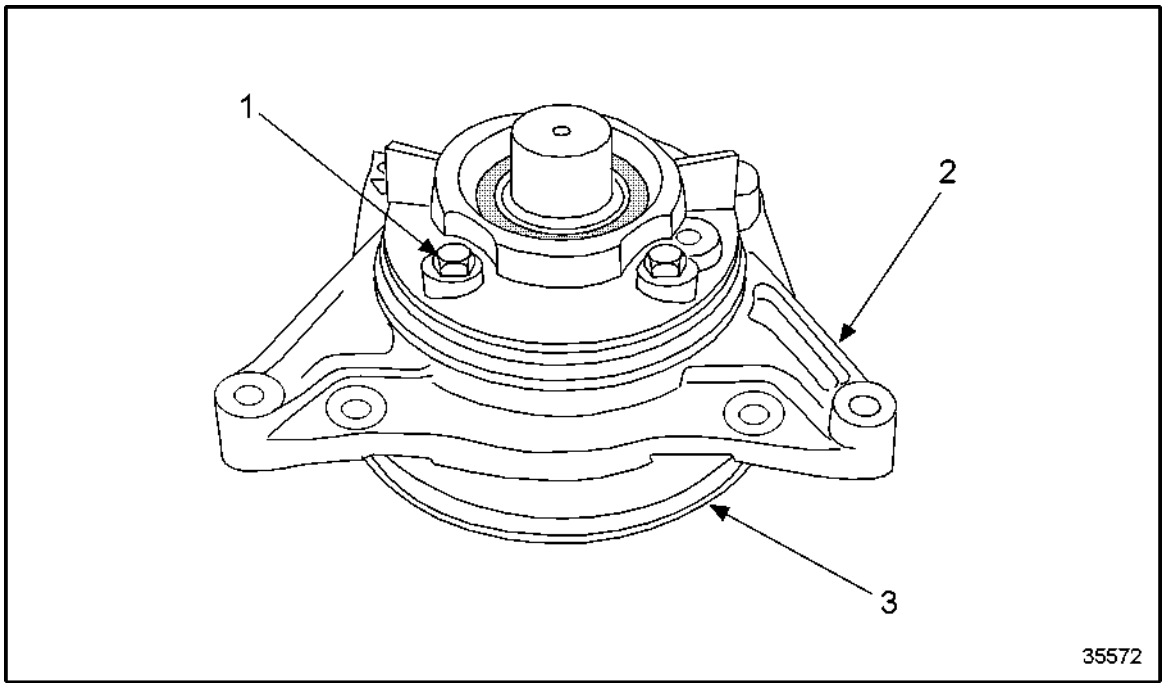


1. Brass Drift Adapter
2. Bearing Housing
3. Seal Carrier

Figure 945 Pressing Bearing Housing onto Seal Carrier

25. Use press to press bearing housing (2) onto seal carrier (3) to the stop.

26. Remove guide pin and locate bearing housing (2) with hex bolt (1) against seal carrier (3). See Figure 946.



1. Hex Bolt
2. Bearing Housing
3. Seal Carrier

Figure 946 Locating Bearing Housing with Hex Bolt against Seal Carrier

27. Tighten hex bolt to specification. Refer to section A 003.

28. To install drive gear, first degrease contact surface on drive gear. See Figure 947.

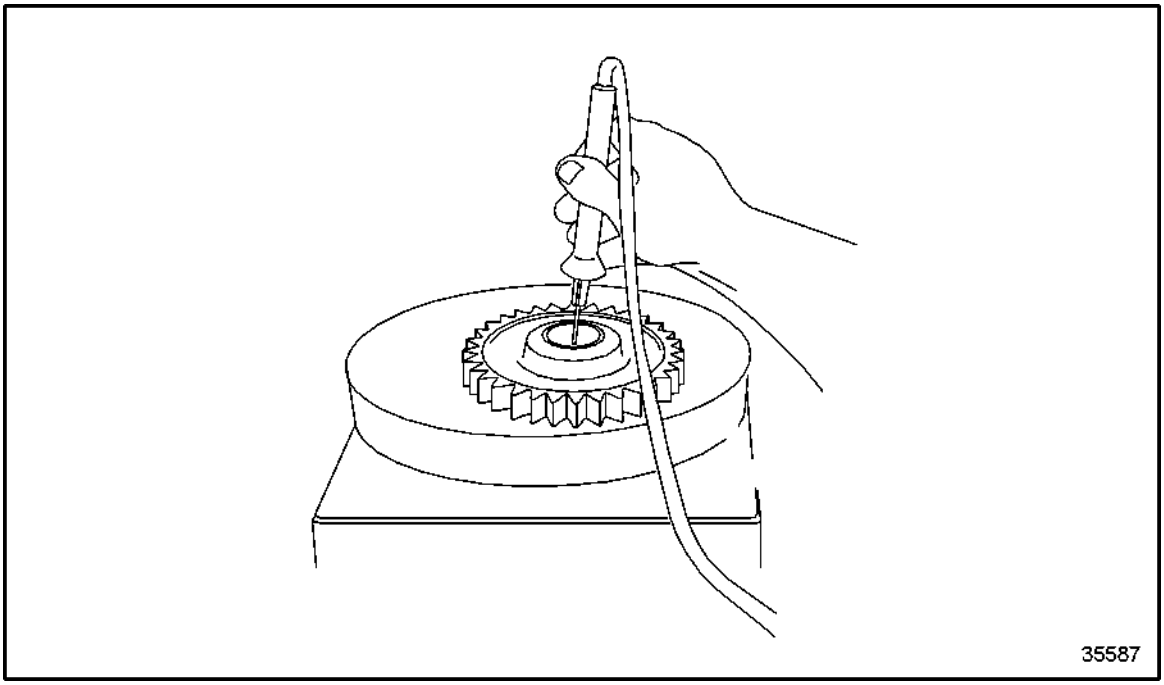


Figure 947 Degreasing Drive Gear

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

29. Preheat drive gear uniformly to 180°C.
30. Degrease contact surfaces on drive gear and pump shaft.

31. Place brass drift adapter for pump shaft in manual press. See Figure 948.

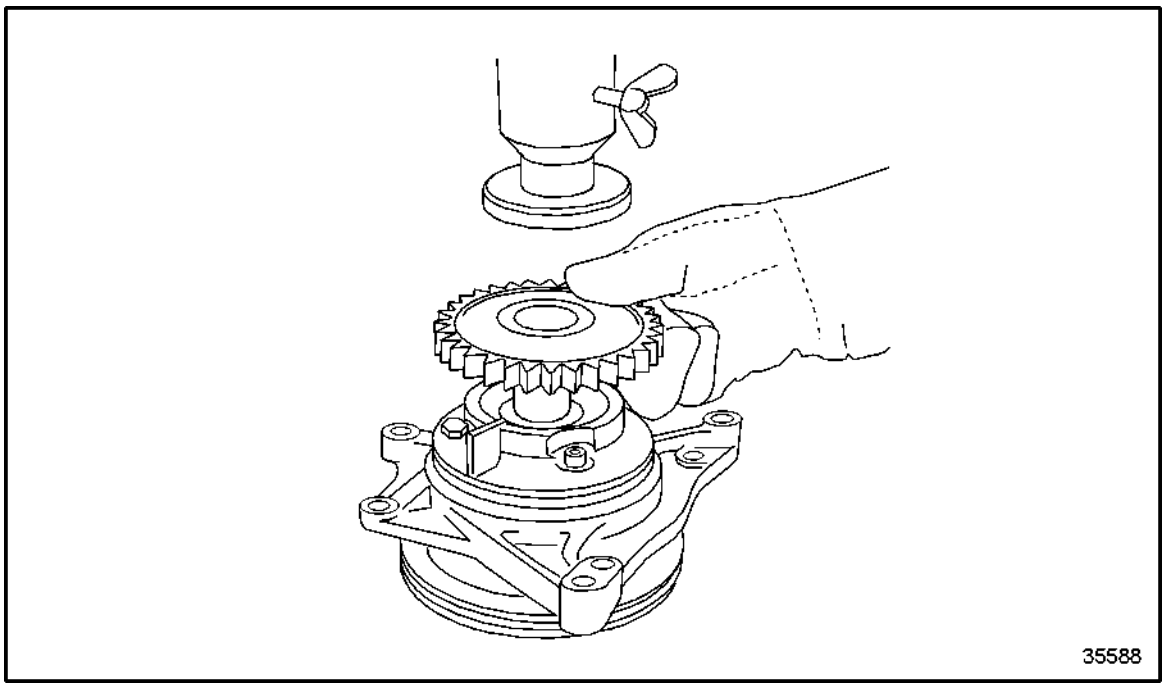


Figure 948 Installing Drive Gear

32. Place installed pump shaft on adapter so that bearing housing faces up.
33. Place preheated gear on pump shaft and press into place to the stop.

34. Maintain pressure until shaft-gear (shrink-on) connection is firm. See Figure 949.

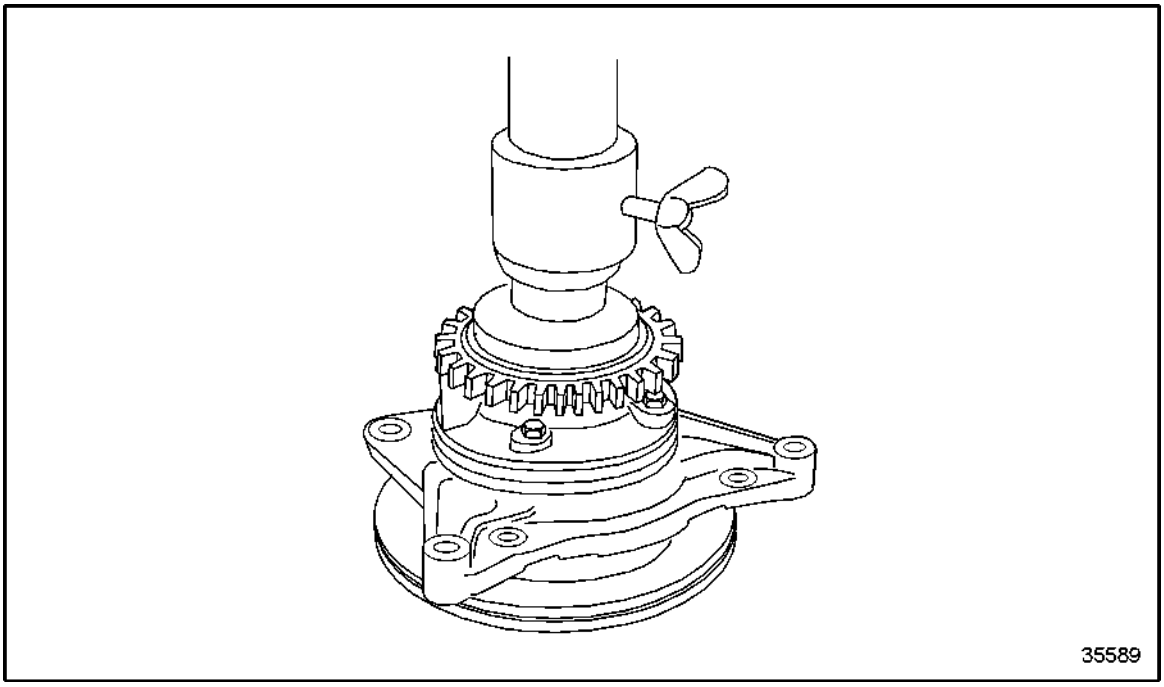


Figure 949 Press-Fitting Drive Gear

35. Turn pump assembly over to complete the installation.
36. To install impeller, first degrease contact surface between pump shaft and impeller.

37. Place pump on manual press with drive gear facing down. See Figure 950.

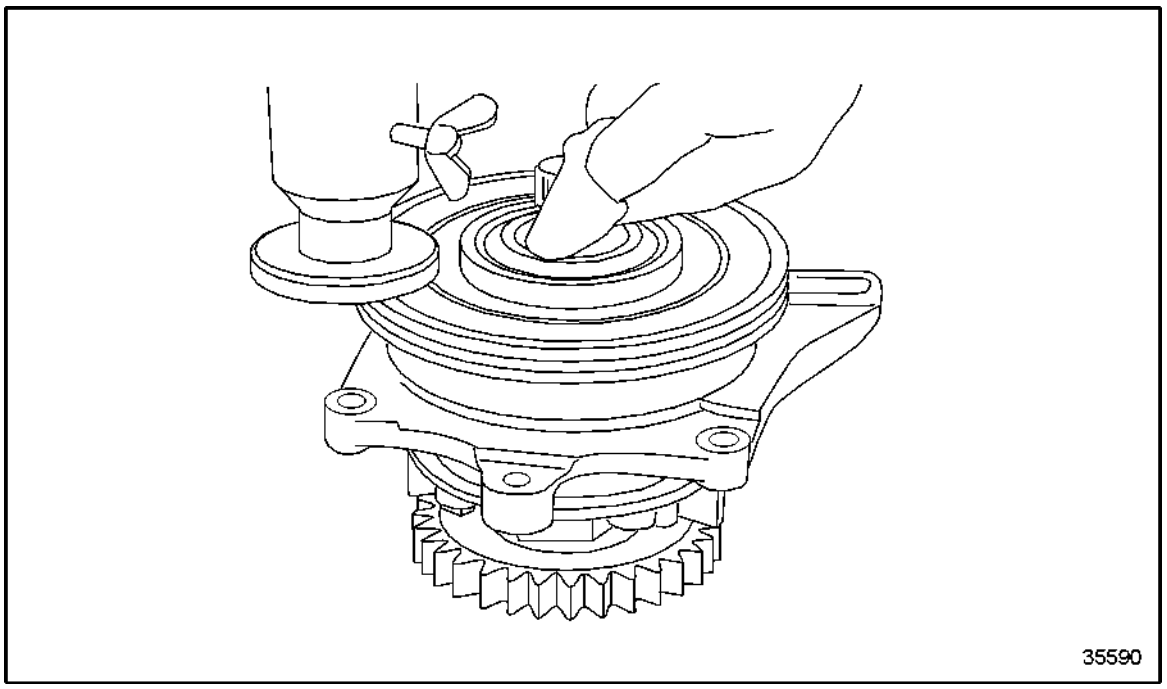
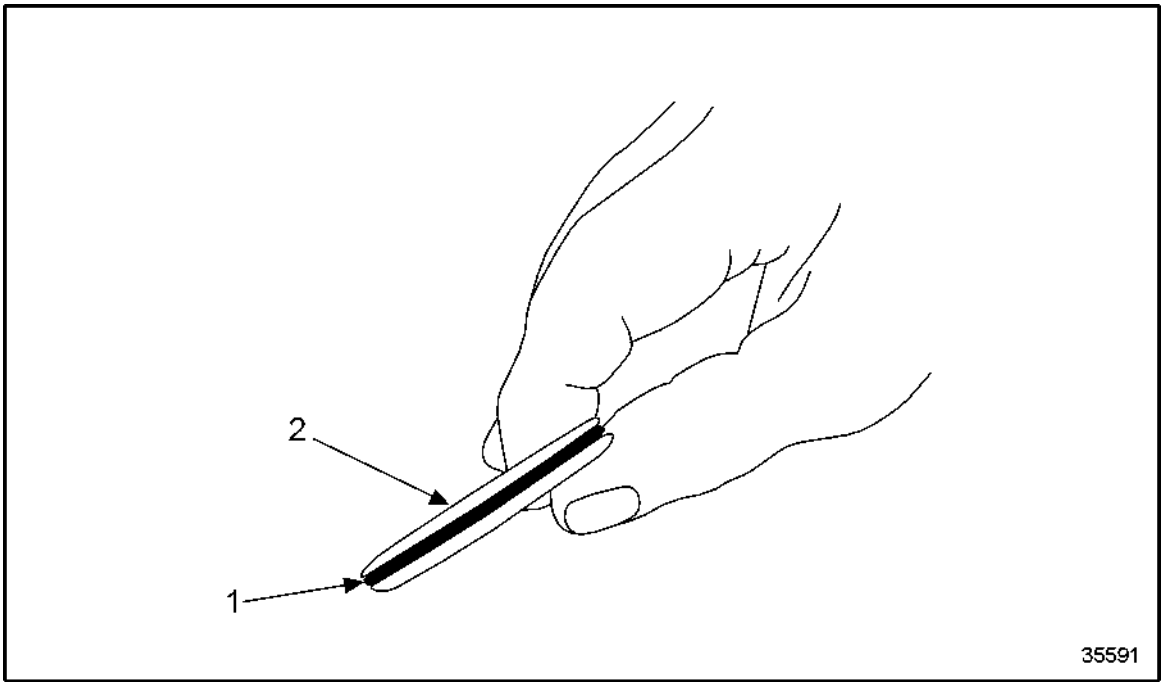


Figure 950 Installing Impeller

38. Clean rotary seal surface with ethanol.

39. Coat O-ring (1) with petroleum jelly and install on thrust ring (2). See Figure 951.



1. O-ring
2. Thrust Ring

Figure 951 Coating O-ring

NOTE:
Ensure that O-ring is perfectly seated against shoulder of thrust ring.

40. Degrease impeller in area of shaft bore and mating surface of thrust ring. See Figure 952.

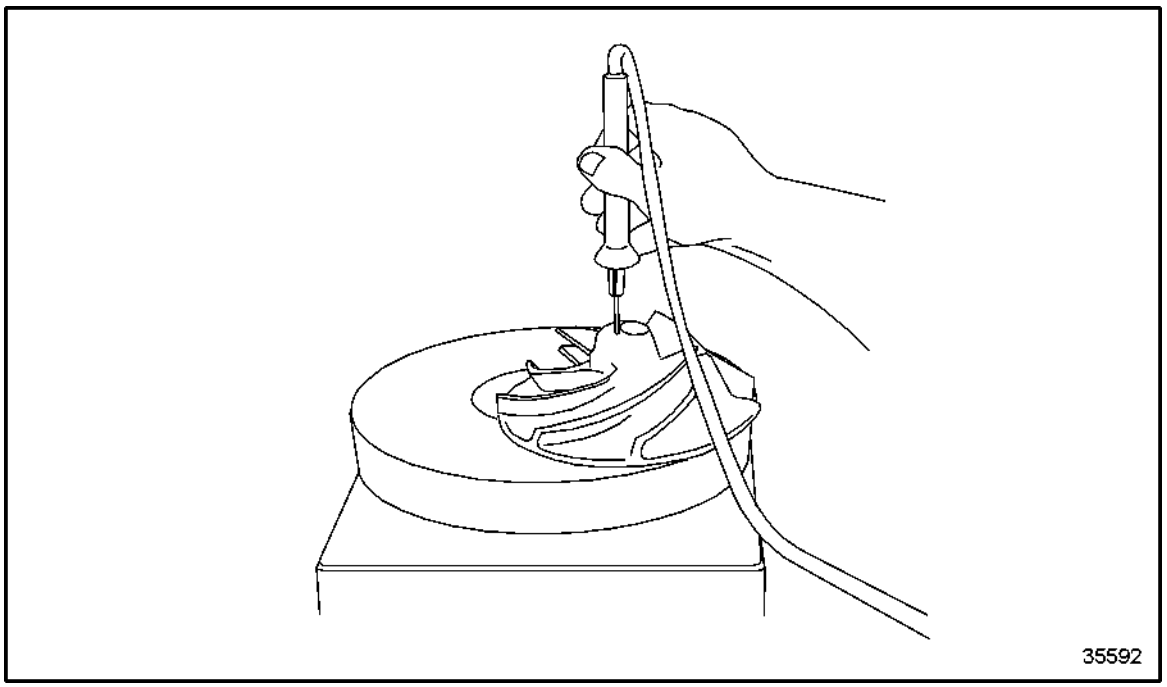


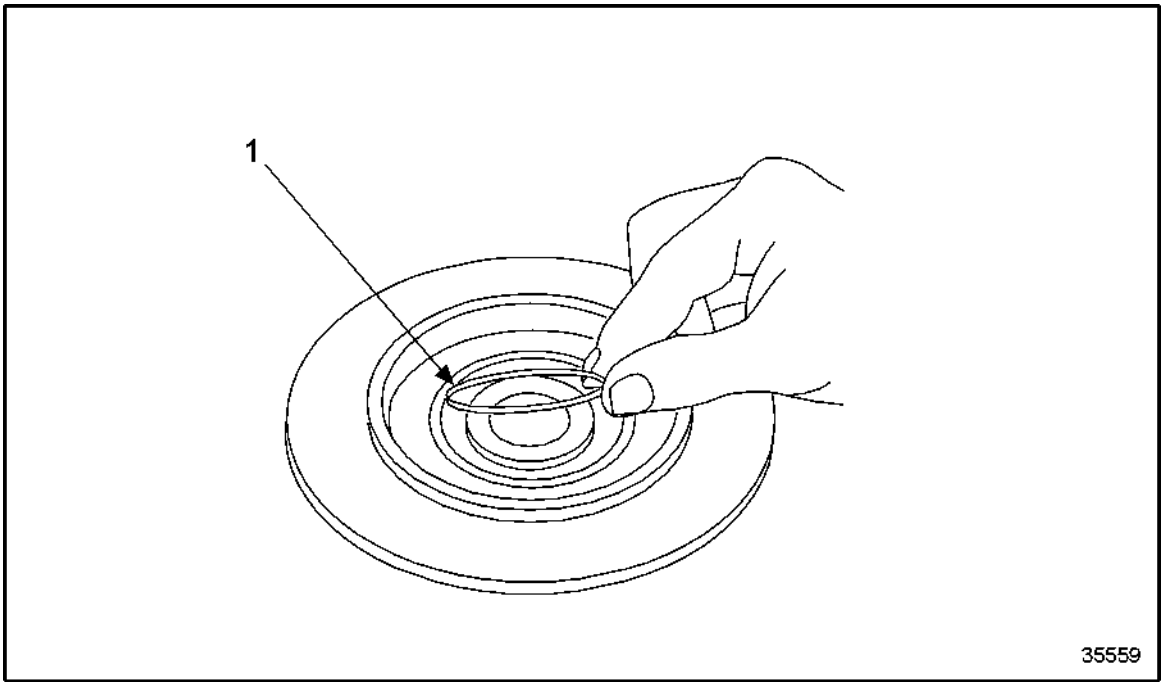
Figure 952 Degreasing Impeller

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

41. Preheat impeller uniformly to 210°C.

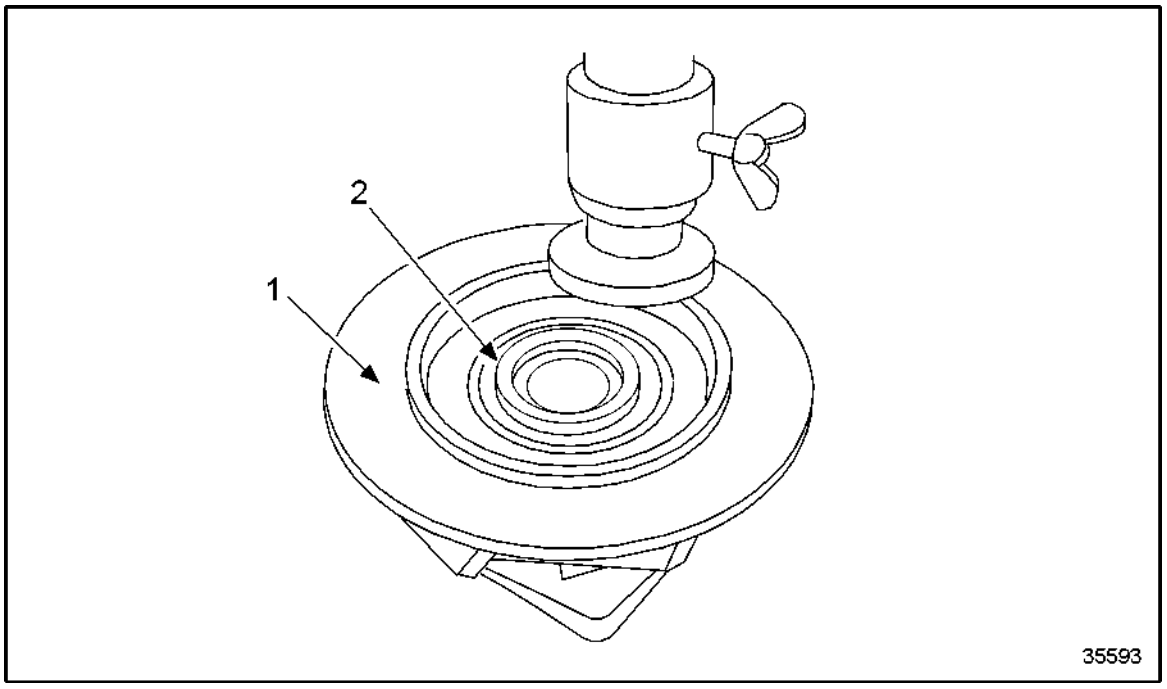
42. Install metal ring (1) in groove on back of impeller. See Figure 953.



1. Metal Ring

Figure 953 Installing Metal Ring in Groove on Back of Impeller

43. Press thrust ring (2) (with fitted O-ring) into groove on back of impeller (1). See Figure 954.



1. Impeller
2. Thrust Ring

Figure 954 Pressing Thrust Ring into Groove on Back of Impeller

44. Clean inside surface of thrust ring with ethanol.

45. Place preheated impeller on pump shaft. See Figure 955.

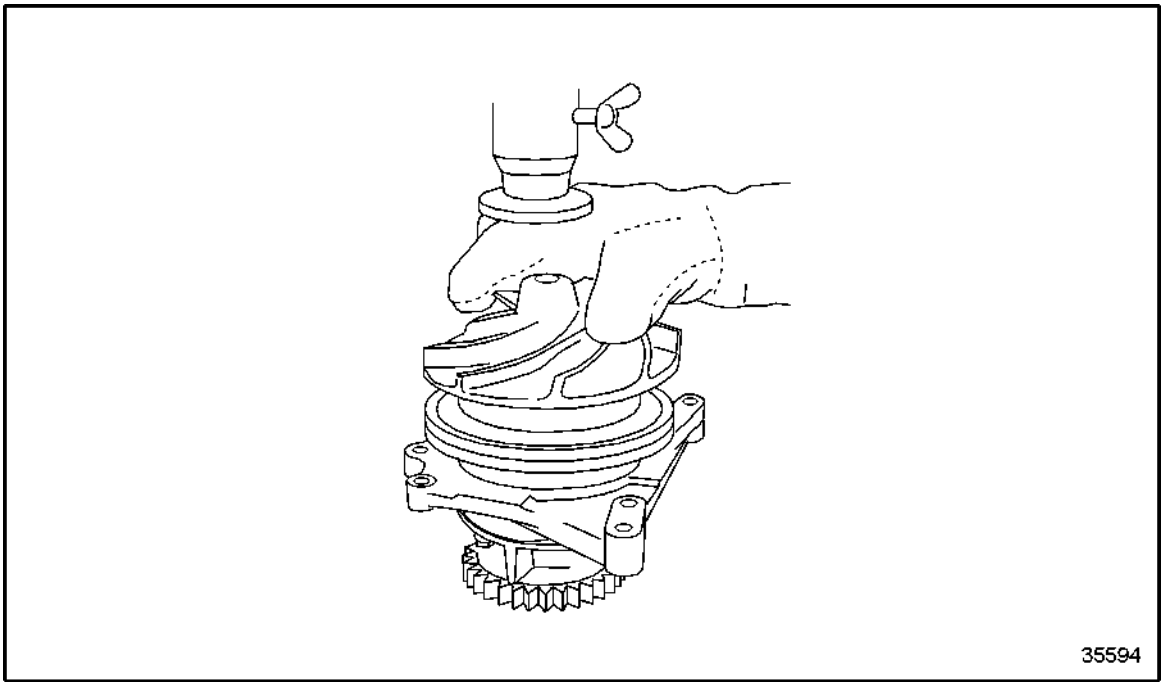


Figure 955 Placing Preheated Impeller on Pump Shaft

46. Use manual press to press impeller to stop and maintain pressure until shaft to gear (shrink-on) connection is secure. See Figure 956.

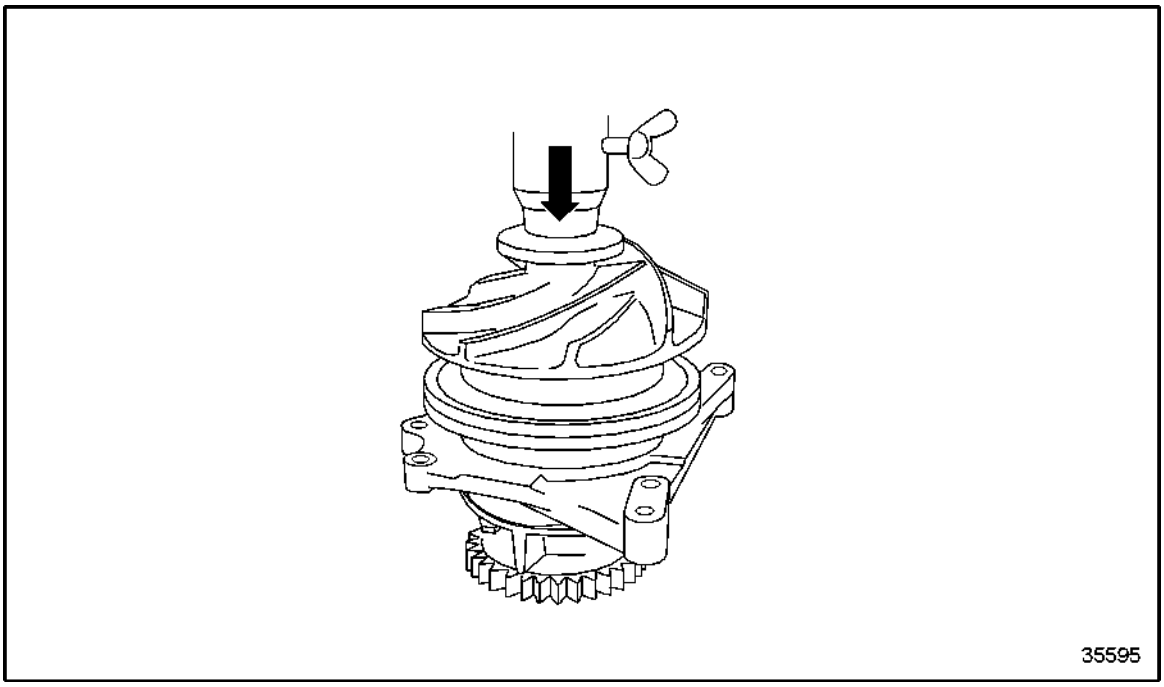


Figure 956 Installing Impeller

47. To install pump housing, first coat pump housing with petroleum jelly at contact surface to O-ring (arrow). See Figure 957.

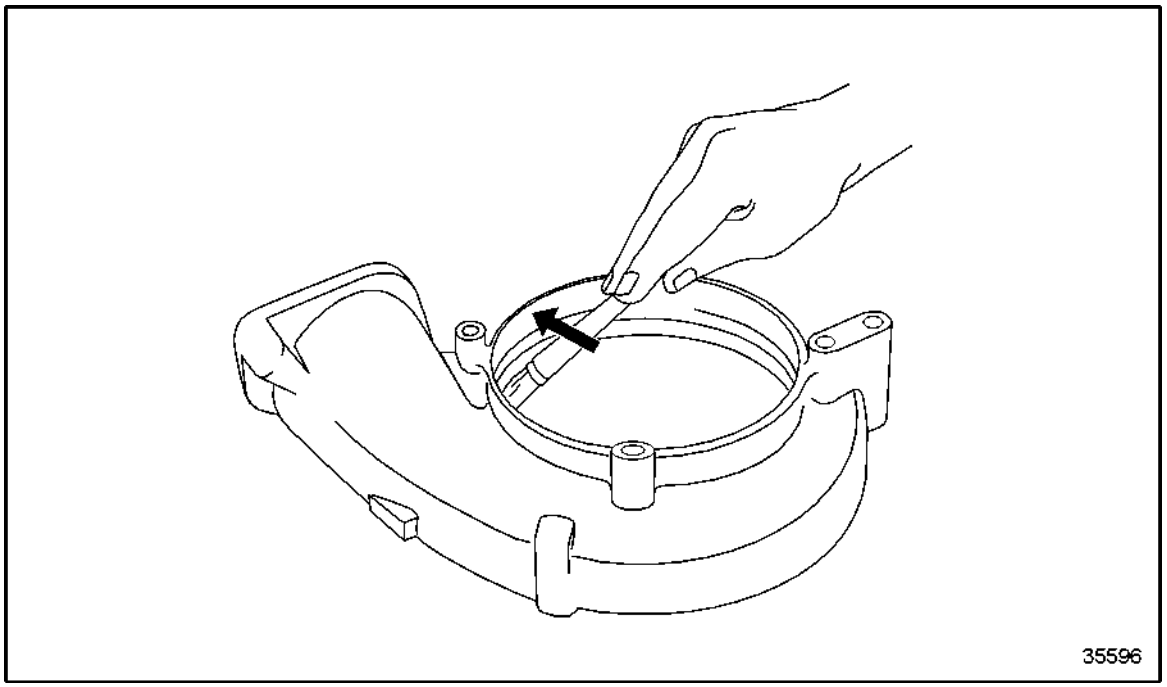


Figure 957 Coating Pump Housing

48. Carefully place seal carrier with impeller side on pump housing.

49. Position pump housing on bearing housing, tapping lightly with hammer or by means of light press pressure. See Figure 958.

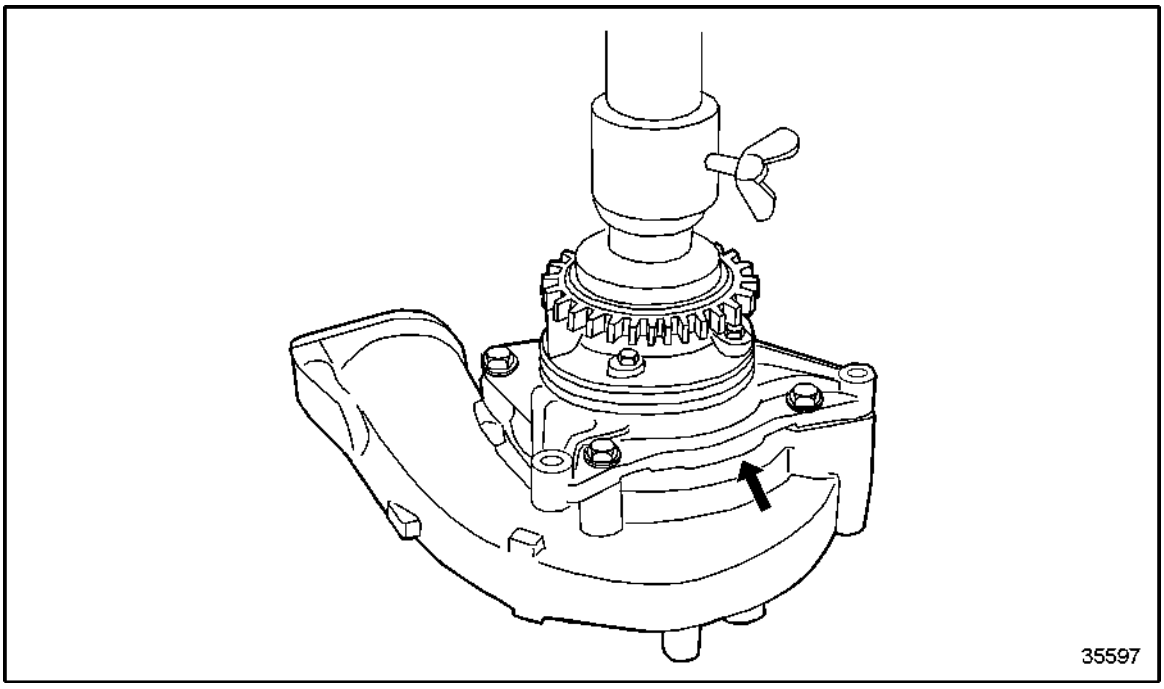
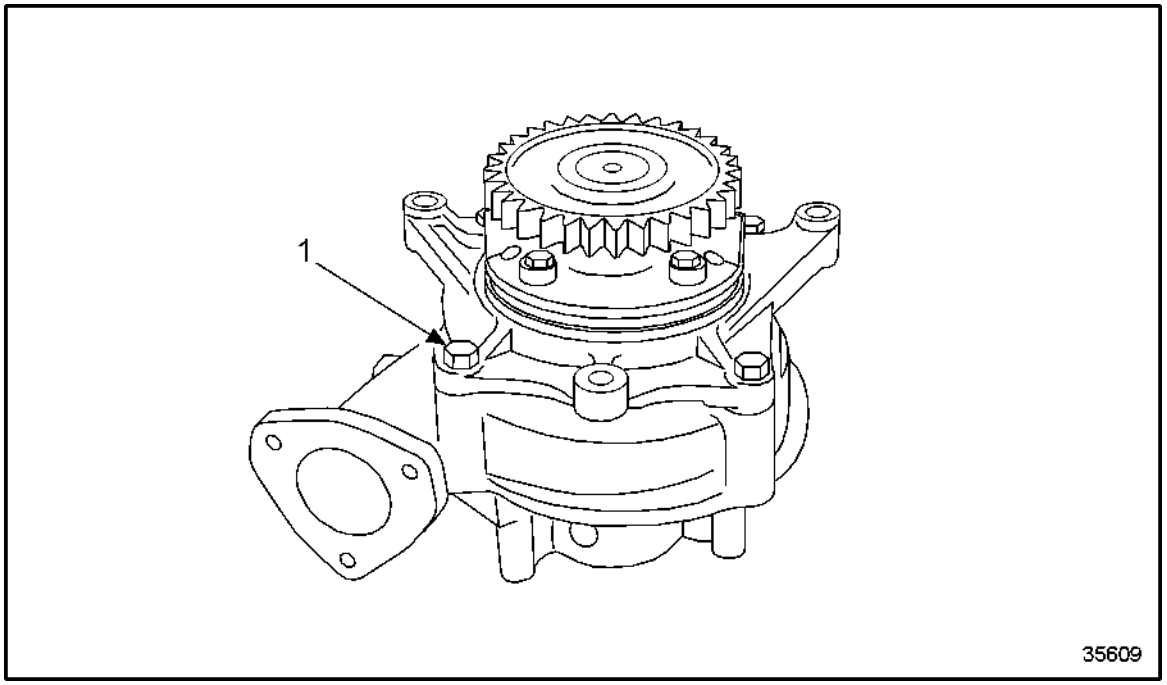


Figure 958 Positioning Pump Housing on Bearing Housing

50. Ensure that O-ring (arrow) is not damaged.
51. Install pump housing to seal carrier with hex bolts (1). See Figure 959.



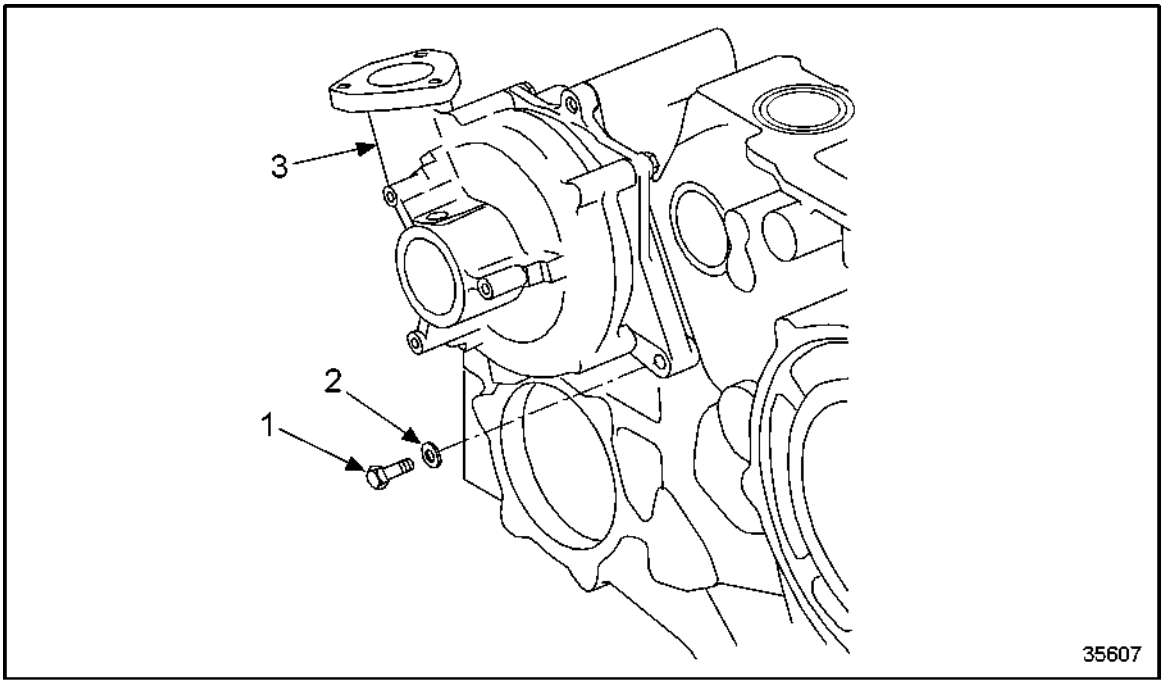
1. Securing Hex Bolt

Figure 959 Install Pump Housing to Seal Carrier

C 206.05.11 – INSTALLATION OF CHARGE AIR COOLING SYSTEM (LOW-TEMPERATURE)

Perform the following steps for the installation of the charge air cooling system (low-temperature):

1. Coat O-ring with petroleum jelly and insert in groove on pump housing of charge air coolant pump.
2. Install charge air coolant pump (2) into bore in gear case, ensuring that gear engages. See Figure 960.

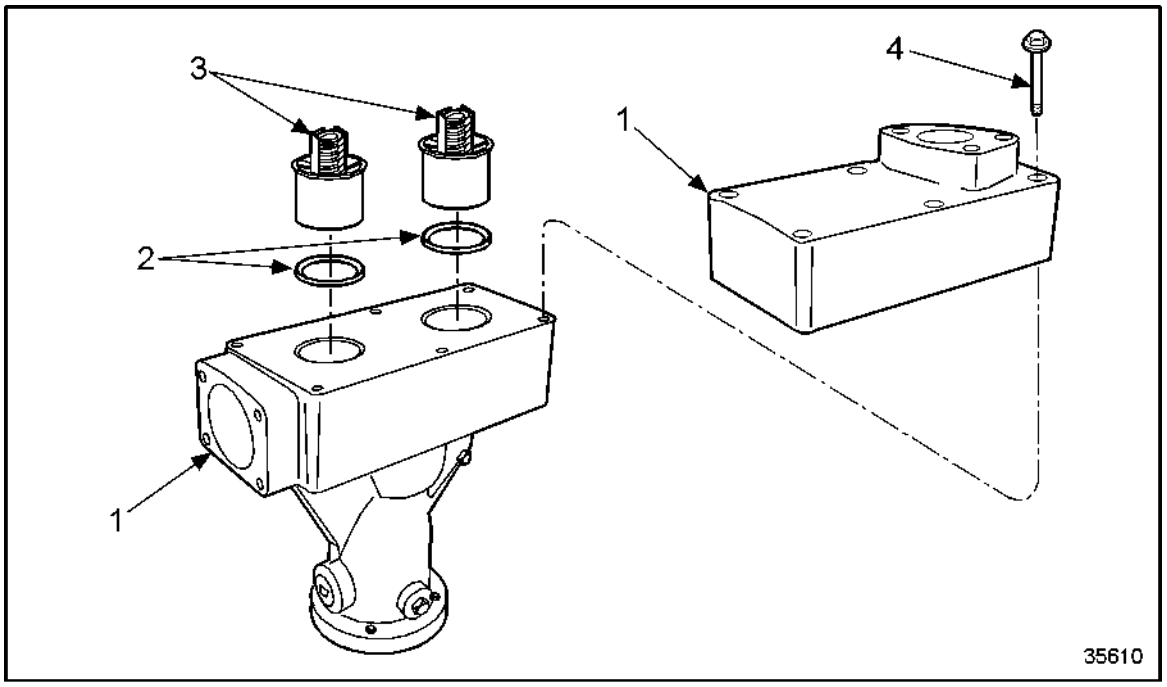


1. Bolt
2. Washer
2. Charge Air Coolant Pump

Figure 960 Installing Charge Air Coolant Pump into Gear Case

3. Inspect gear lash.
4. Install hex bolts (2) with washers and tighten uniformly to specification. Refer to sectionA 003.

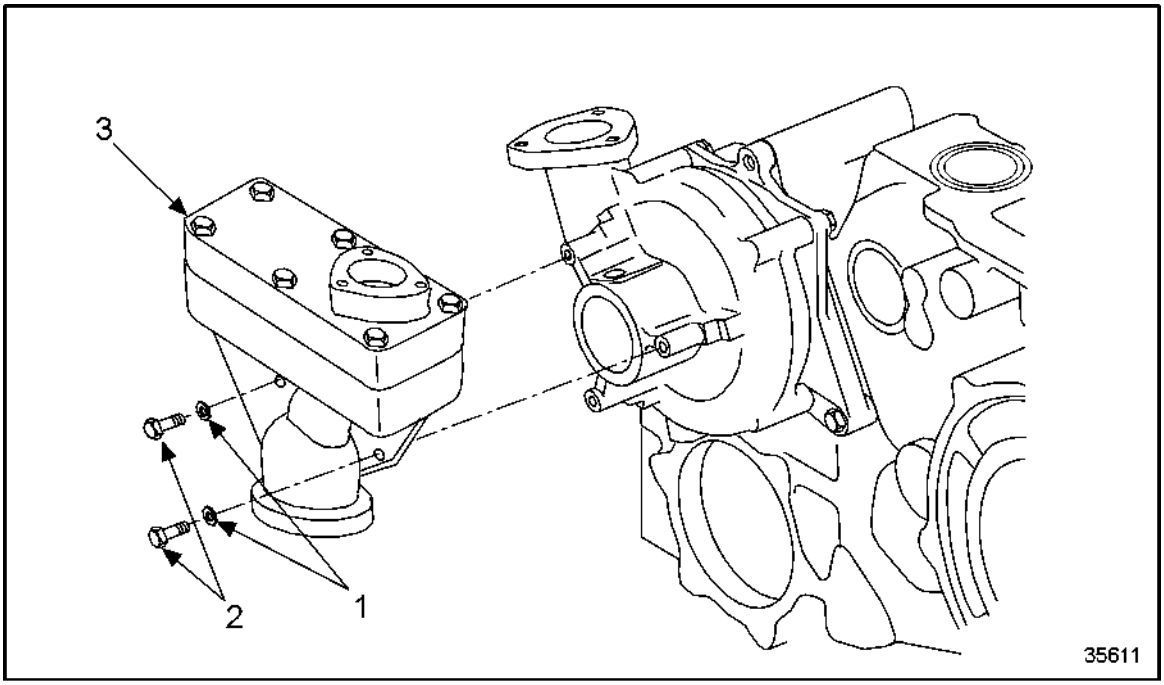
5. To install thermostat housing, install sealing ring and thermostat element dry in thermostat housing. See Figure 961.



1. Thermostat Housing
2. Sealing Ring
3. Thermostat
4. Mounting Bolt

Figure 961 Installing Sealing Ring and Thermostat Element in Thermostat Housing

6. Install thermostat housing on charge air coolant pump housing. See Figure 962.

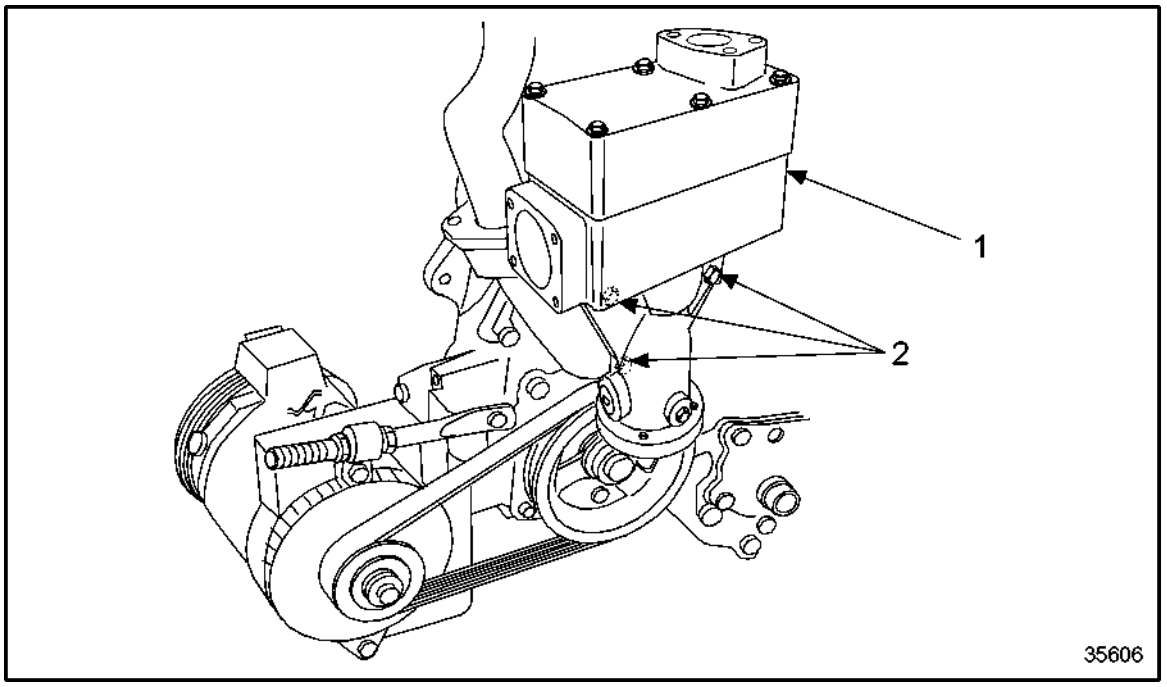


1. Washer
2. Bolt
3. Thermostat Housing

Figure 962 Installing Thermostat Housing on Charge Air Coolant Pump Housing

7. Align with charge air coolant piping.
8. Ensure that thermostat element is properly seated.

9. Use hex bolts to secure thermostat housing to charge air coolant pump housing. See Figure 963.



1. Low-Temperature Thermostat Housing
2. Bolt

Figure 963 Securing Thermostat Housing to Charge Air Coolant Pump Housing

10. Tighten hex bolts to specification. Refer to section A 003.

C 206.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 134 are the After-Installation Operations for the charge air cooling system (low-temperature).

Level of Maintenance	Operation	Reference
1, 2, 3	Secure flange, charge air coolant pipe to pump inlet	Refer to section C 202.05.11
1, 2, 3	Secure flange, charge air coolant pipe to pump outlet	Refer to section C 202.05.11
1, 2, 3	Install temperature switch	Refer to section C 208.05.11
1, 2, 3	Connect coolant supply to cooler	Refer to section C 204.05.11
1, 2, 3	Connect coolant return from cooler	Refer to section C 204.05.11
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Inspect for leaks	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.

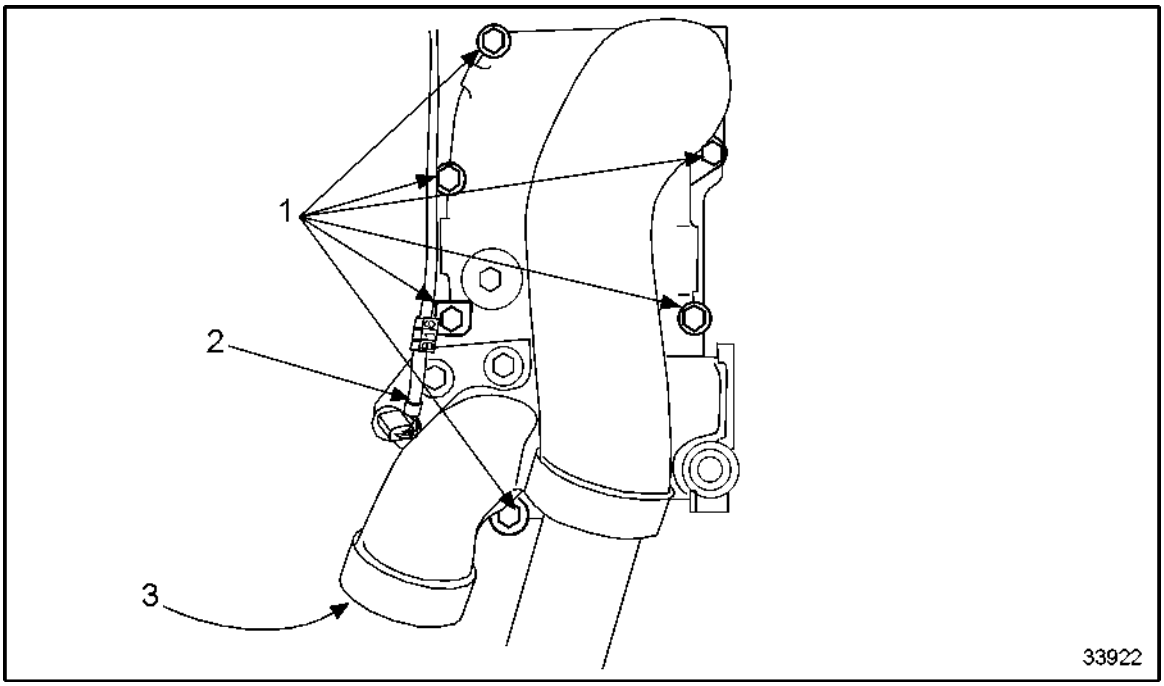
Table 134 After-Installation Operations

C 206.05 M – MARINE COOLANT DISTRIBUTION HOUSING AND THERMOSTAT

C 206.05.01 M – GENERAL VIEW

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

See Figure 964 for a general view of the marine coolant distribution housing thermostat assembly.



1. Bolts
2. Coolant Pressure Sensor
3. Input Tube (Fresh Water Pump)

Figure 964 General View of Thermostat Housing for Marine Engines

C 206.05.04 M – BEFORE – REMOVAL OPERATIONS

Listed in Table 135are the Before – Removal Operation for the marine thermostat housing.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Operator's Guide

1 = The engine is to be completely disassembled.

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

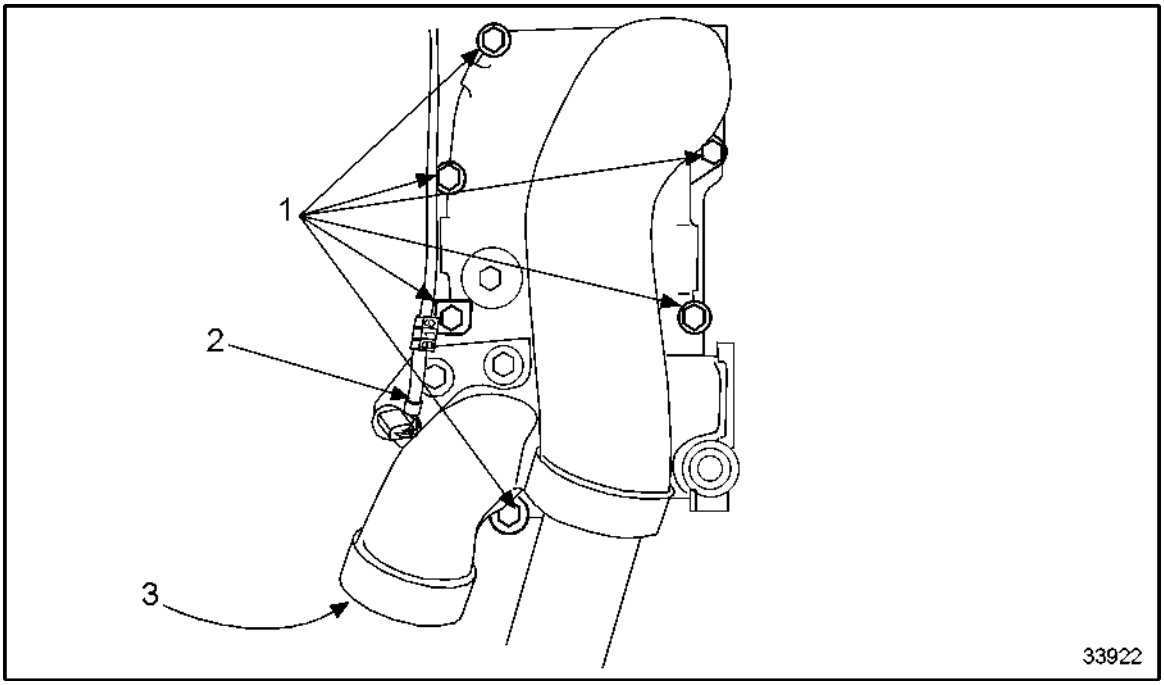
3 = The engine is to remain installed.

Table 135 Before – Removal Operations for the Marine Thermostat

C 206.05.05 M – REMOVAL OF THE COOLANT DISTRIBUTION HOUSING THERMOSTAT

Perform the following steps to remove the marine coolant distribution housing thermostat:

1. Drain the coolant system.
2. Disconnect the coolant pressure sensor (2). See Figure 965.

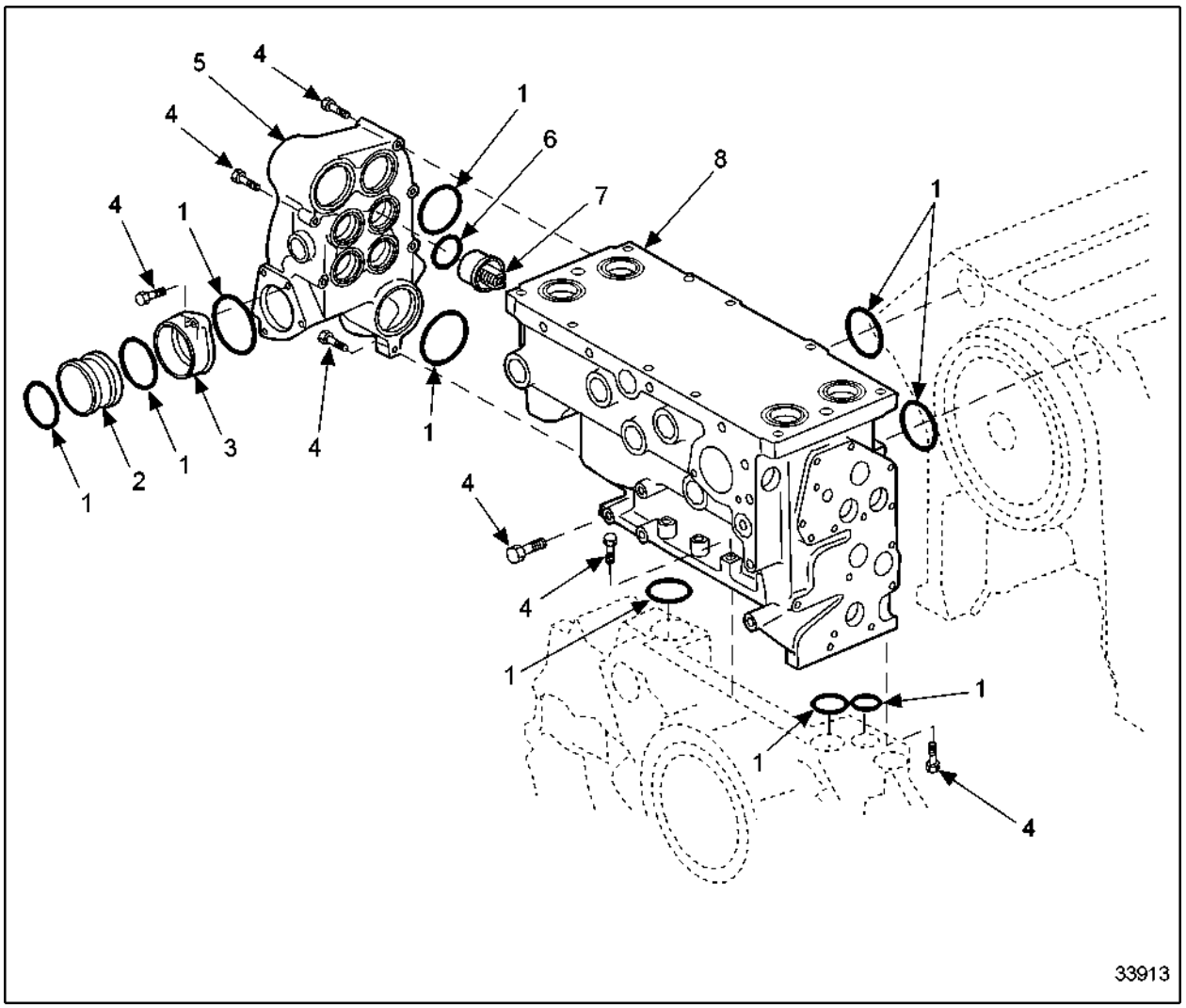


1. Bolts
2. Coolant Pressure Sensor
3. Input Tube (Fresh Water Pump)

Figure 965 Disconnecting the Coolant Pressure Sensor

3. Remove the fresh water supply line (input) (4) and connector. See Figure 965.

4. Remove three O-rings (1). See Figure 966.

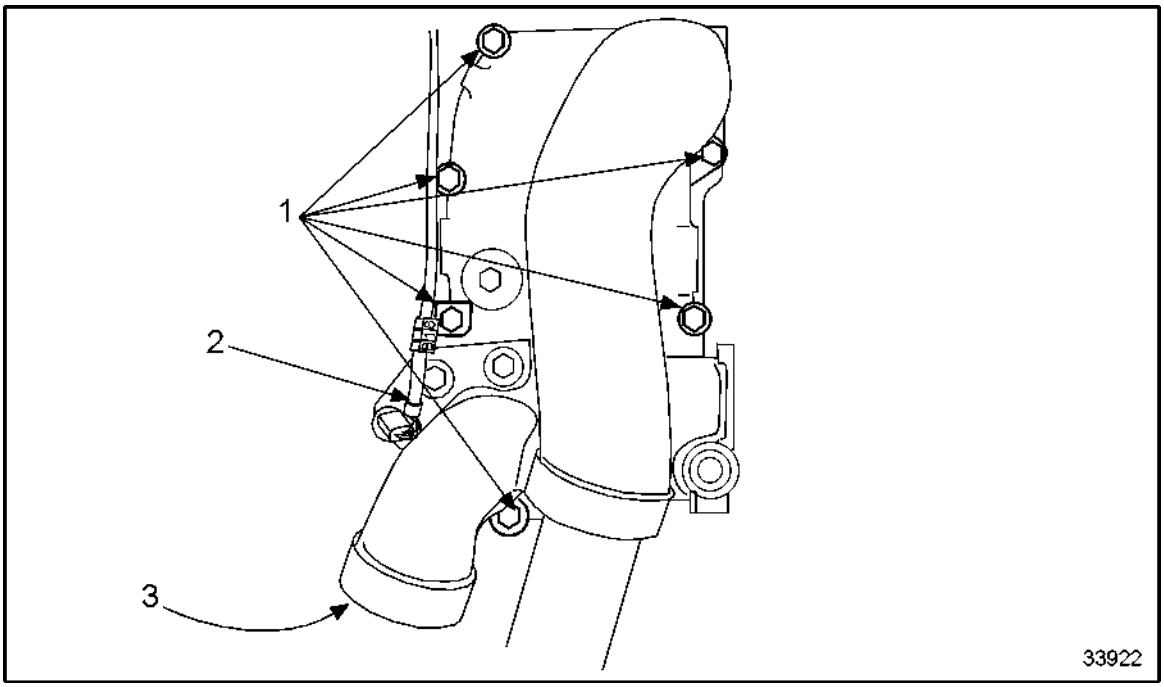


1. O-ring
2. Plug-in Pipe
3. Flange
4. Bolt
5. Thermostat Housing
6. Sealing Ring
7. Thermostat
8. Distribution Housing

Figure 966 Removing O-rings

5. Remove two 40 mm bolts securing the fresh water distribution housing flange (3) to the fresh water pump.

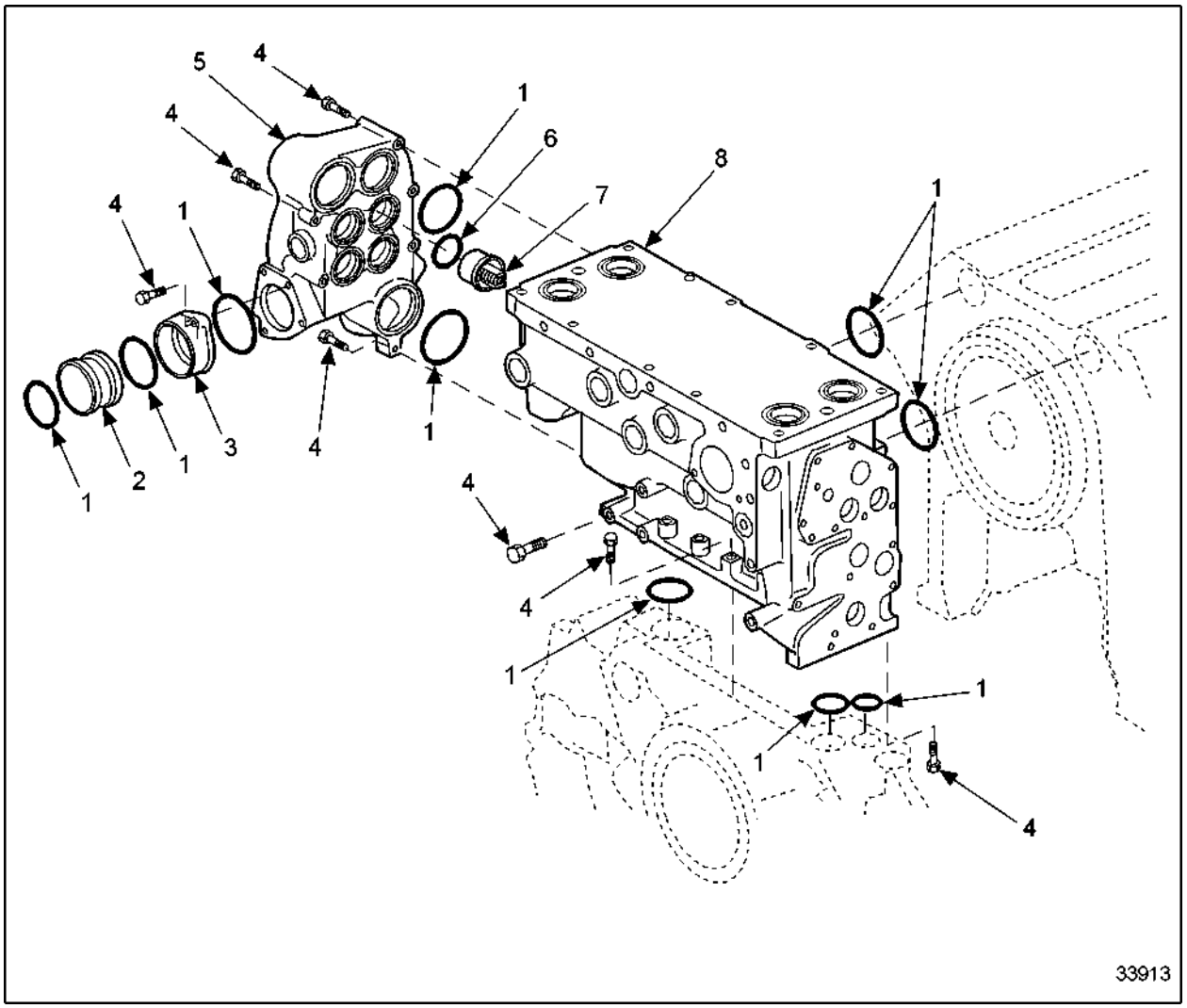
6. Remove six bolts (1) securing the thermostat housing to the water distribution housing. See Figure 967.



1. Bolts
2. Coolant Pressure Sensor
3. Input Tube (Fresh Water Pump)

Figure 967 Removing Bolts Securing Thermostat Housing

7. Remove the thermostat housing and O-rings (1) from the distribution housing. See Figure 968.



1. O-ring
2. Plug-in Pipe
3. Flange
4. Bolt
5. Thermostat Housing
6. Sealing Ring
7. Thermostat
8. Distribution Housing

Figure 968 Removing Thermostat Housing and O-rings

8. Remove the four thermostats (7) and sealing rings (6) from the thermostat housing (5). See Figure 968.

NOTE:
Perform step 9 and step10 only if required.

9. Remove bolts (4) for securing the flange (3) and O-ring (1) to the thermostat housing (5). See Figure 968.
10. Remove the plug-in pipe (2) and O-rings (1) connected to flange (3). See Figure 968.

C 206.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the thermostat housing:

1. Clean all parts with cold cleaner.
2. Visually inspect components for damage and defects.
   [a] If damage or defects are detected, replace components as necessary.
   [b] If no damage or defects are detected, continue inspection.
3. Using the surface crack-testing method with red penetrant dye, visually inspect the coolant distribution housing and thermostat housing for cracks.
   [a] If cracks are detected, replace component.
   [b] If no cracks are detected, continue inspection.

CAUTION:

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

4. If necessary, pressure test the coolant and oil chambers of the coolant distribution housing with air in water bath (with corrosion inhibitor) for leaks (except cooling system to cooling system).

NOTE:
Test Pressure: 0.5 bar

   [a] If bubbles emerge, replace component as necessary.
   [b] If bubbles do not emerge, continue inspection.
5. Visually inspect all mating surfaces for wear and damage.
   [a] If wear or damage is detected, rub down with oilstone or emery cloth.
   [b] If wear and damage are beyond repair, replace component as necessary.
   [c] If no damage or wear is detected, continue inspection.
6. Visually inspect condition of thread in coolant distribution housing.
   [a] If thread is worn or damaged, rechase threads as necessary.
   [b] If thread is not worn or damaged, continue inspection.
7. Replace hose and clamps as part of every W6 overhaul.
8. Replace gaskets, sealing rings and O-rings.

Inspection of Coolant Thermostat

Perform the following steps to inspect the coolant thermostat:

1. Measure distance from the coolant thermostat collar to the main valve head.
2. Hang the coolant thermostat on a wire in a container filled with water. The coolant thermostat must not contact the container.
3. Heat water with suitable heat source. As of approximately 10°C (50°F) under start of opening, the heating speed must not exceed 1°C (34°F) per minute. Start of opening is 69 – 73°C (156 —163°F).

NOTE:
Never use a welding torch or a blow torch to heat the coolant thermostat.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

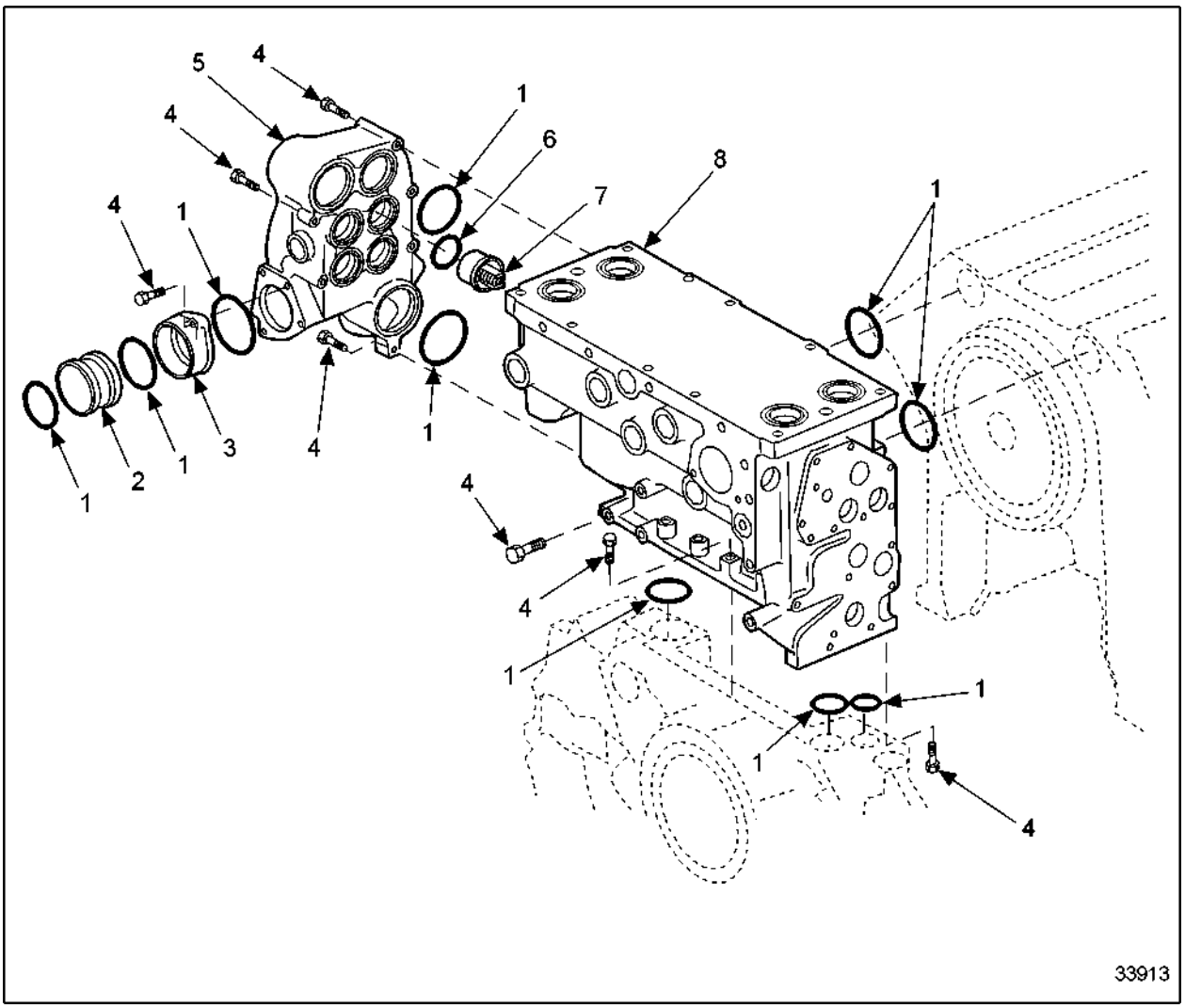
4. Visually inspect coolant thermostat for start of opening with heat supply uniform and water constantly circulated.
   [a] If results of inspection are not desired replace thermostat.
   [b] If results are desired, continue inspection.
5. Reheat coolant to 85°C (185°F) (complete opening).
6. After six to eight minutes, measure distance from cooling thermostat collar to main valve head.
7. Compare distance with the first measurement.
8. The stroke must be at least 8 mm (0.3 in.); if not, replace the coolant thermostat.

C 206.05.11 M – INSTALLATION OF THE COOLANT DISTRIBUTION HOUSING THERMOSTAT

Perform the following steps to install the coolant distribution thermostats:

NOTE:
Perform step 1 and step 2 only if required.

1. Install the plug-in pipe (2) and O-rings (1) connected to flange (3). See Figure .

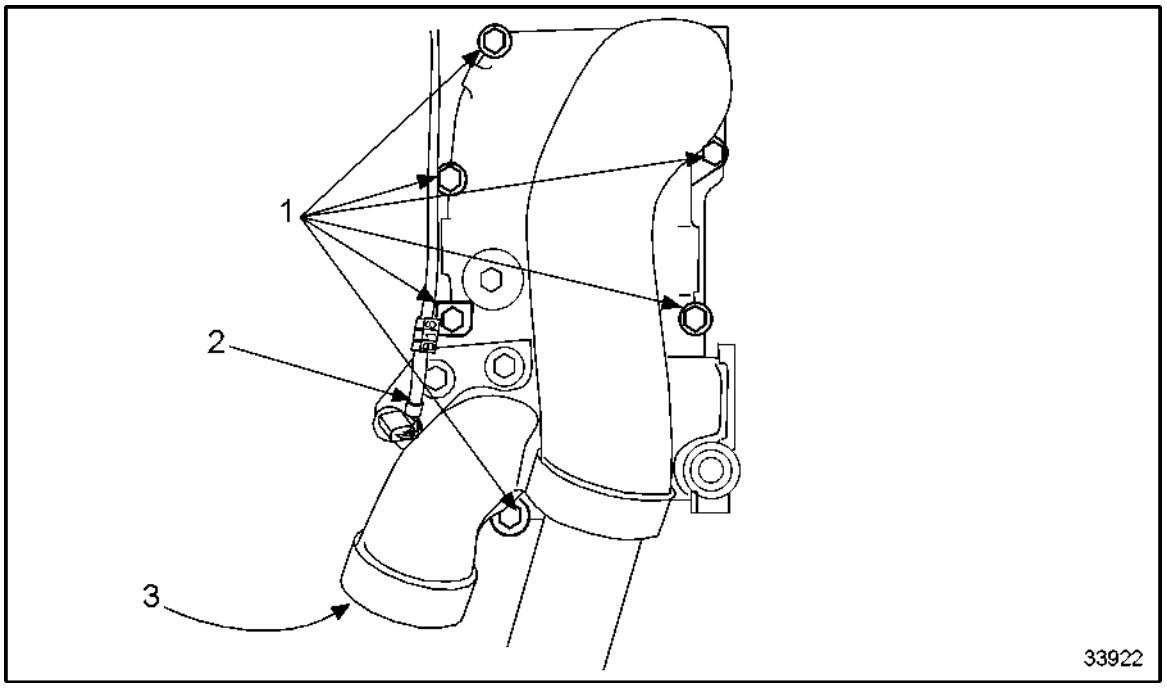


1. O-ring
2. Plug-in Pipe
3. Flange
4. Bolt
5. Thermostat Housing
6. Sealing Ring
7. Thermostat
8. Distribution Housing

Figure 969 Installing Plug-in Pipe and O-rings

2. Install bolts (4) to secure the flange (3) and O-ring (1) to the thermostat housing (5). Torque bolts to specification. Refer to section A 003. See Figure 969.
3. Install the four thermostats (7) and sealing rings (6) to the thermostat housing (5). See Figure .
4. Install the thermostat housing and new O-rings (1) to the coolant heat exchange housing (8). See Figure 969.

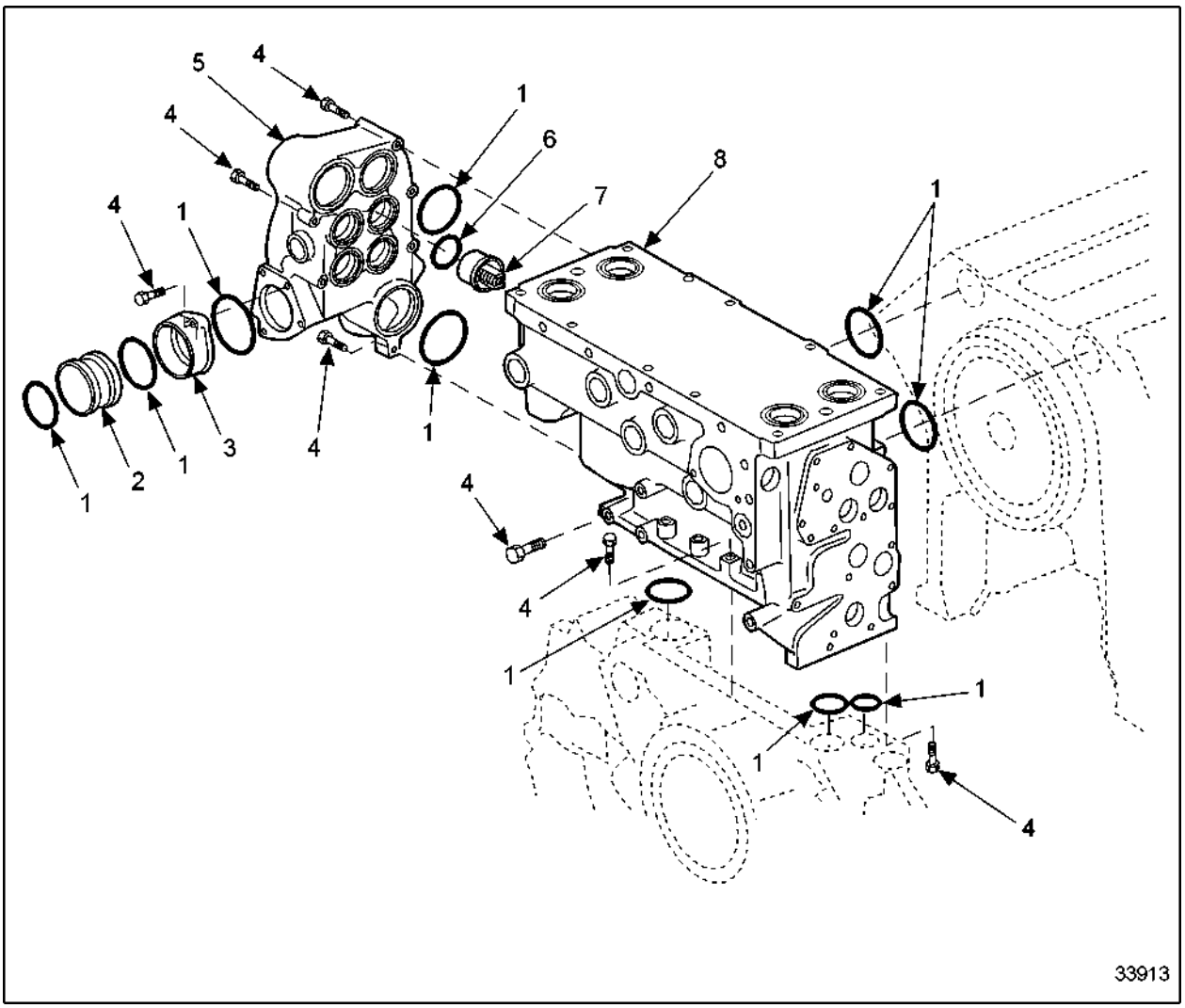
5. Install six bolts (1) to secure the thermostat housing to the water distribution housing (4). Torque bolts to specification. Refer to section A 003. See Figure 970.



1. Bolts
2. Coolant Pressure Sensor
3. Input Tube (Fresh Water Pump)

Figure 970 Installing Bolts

6. Install three O-rings (1). See Figure 971.

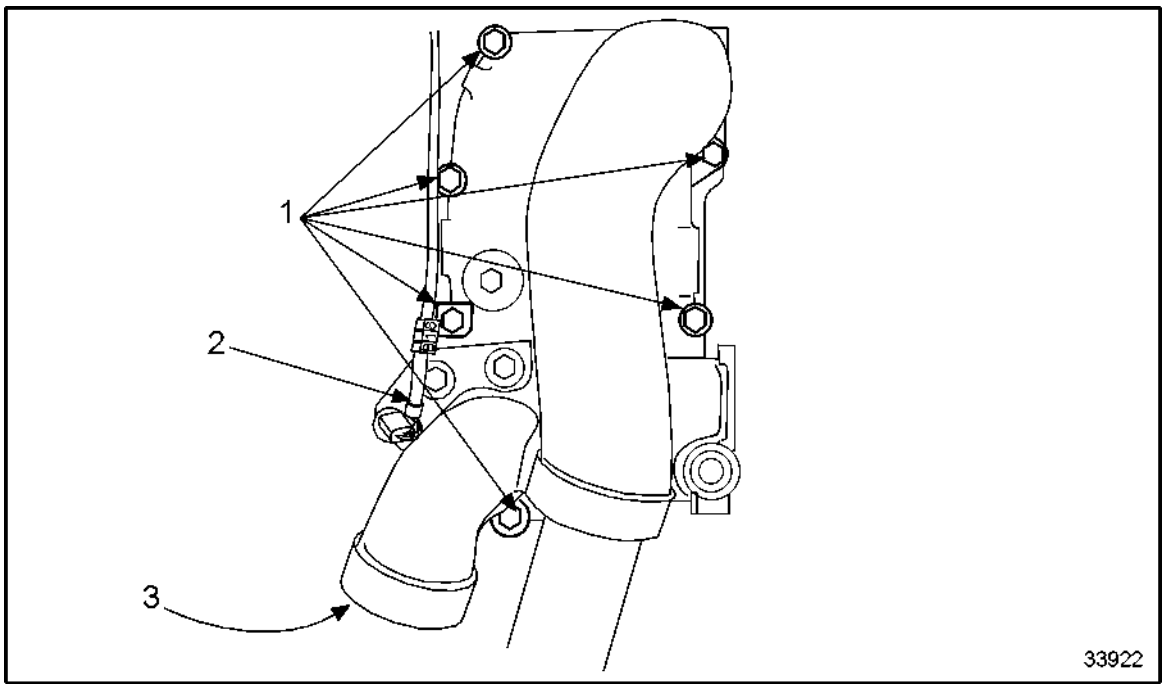


1. O-ring
2. Plug-in Pipe
3. Flange
4. Bolt
5. Thermostat Housing
6. Sealing Ring
7. Thermostat
8. Distribution Housing

Figure 971 Installing O-rings

7. Install two 40 mm bolts to secure the fresh water distribution housing flange to the fresh water pump. Torque bolts to specification. Refer to section A 003.

8. Connect the coolant pressure sensor (2). See Figure 972.



1. Mounting Bracket
2. Coolant Pressure Sensor
3. Input Tube (Fresh Water Pump)

Figure 972 Connecting Coolant Pressure Sensor

9. Connect the fresh water supply line (input) (4).

C 206.05.12 M – AFTER – INSTALLATION OPERATIONS

Listed in Table 136are the After – Installation Operations for the marine thermostat housing.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operator's Guide

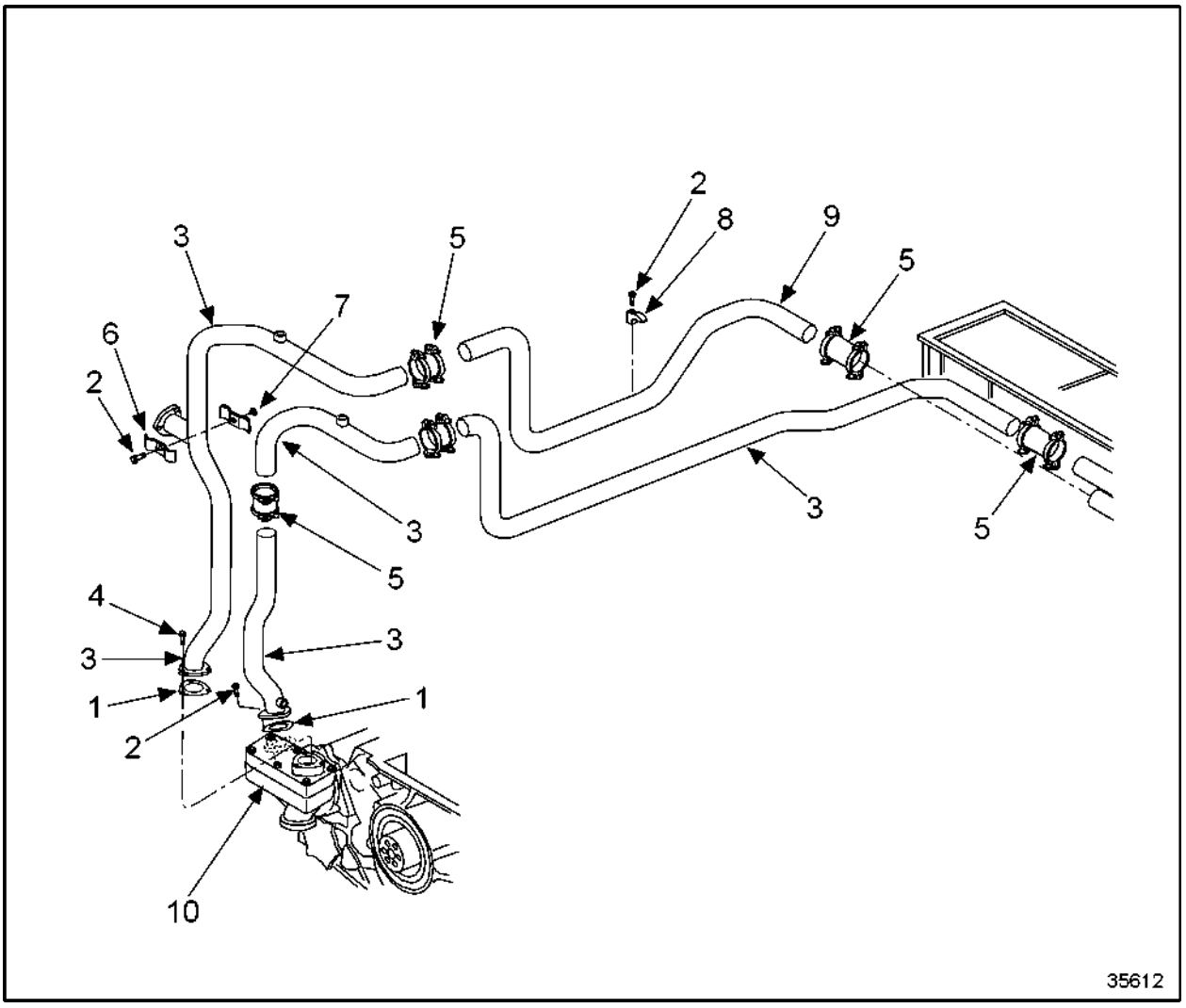
Table 136 After – Installation Operations for the Marine Thermostat

C 207.05 – CHARGE AIR COOLER COOLING SYSTEM PIPEWORK

C 207.05.01 – GENERAL VIEW

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

See Figure 973 for a general view of the charge air cooler cooling system pipework.



1. Gasket
2. Bolt
3. Pipe
4. Hex Bolt
5. Coupling Assembly
6. Bracket
7. Nut
8. Bracket
9. Return Line
10. Thermostat Housing

Figure 973 General View of Charge Air Cooler Cooling System Pipework

C 207.05.04 – BEFORE-REMOVAL OPERATIONS

Refer to section C 203.05.04 for the Before-Removal Operations for the charge air cooler cooling system pipework.

C 207.05.05 – REMOVAL OF CHARGE AIR COOLER COOLING SYSTEM PIPEWORK

Refer to section C 203.05.05 for the removal of the charge air cooler cooling system pipework.

C 207.05.08 – INSPECTION AND REPAIR

Refer to section C 203.05.08for the inspection and repair of the charge air cooler cooling system pipework.

C 207.05.11 – INSTALLATION OF CHARGE AIR COOLER COOLING SYSTEM PIPEWORK

Refer to section C 203.05.11for the installation of the charge air cooler cooling system pipework.

C 207.05.12 – AFTER-INSTALLATION OPERATIONS

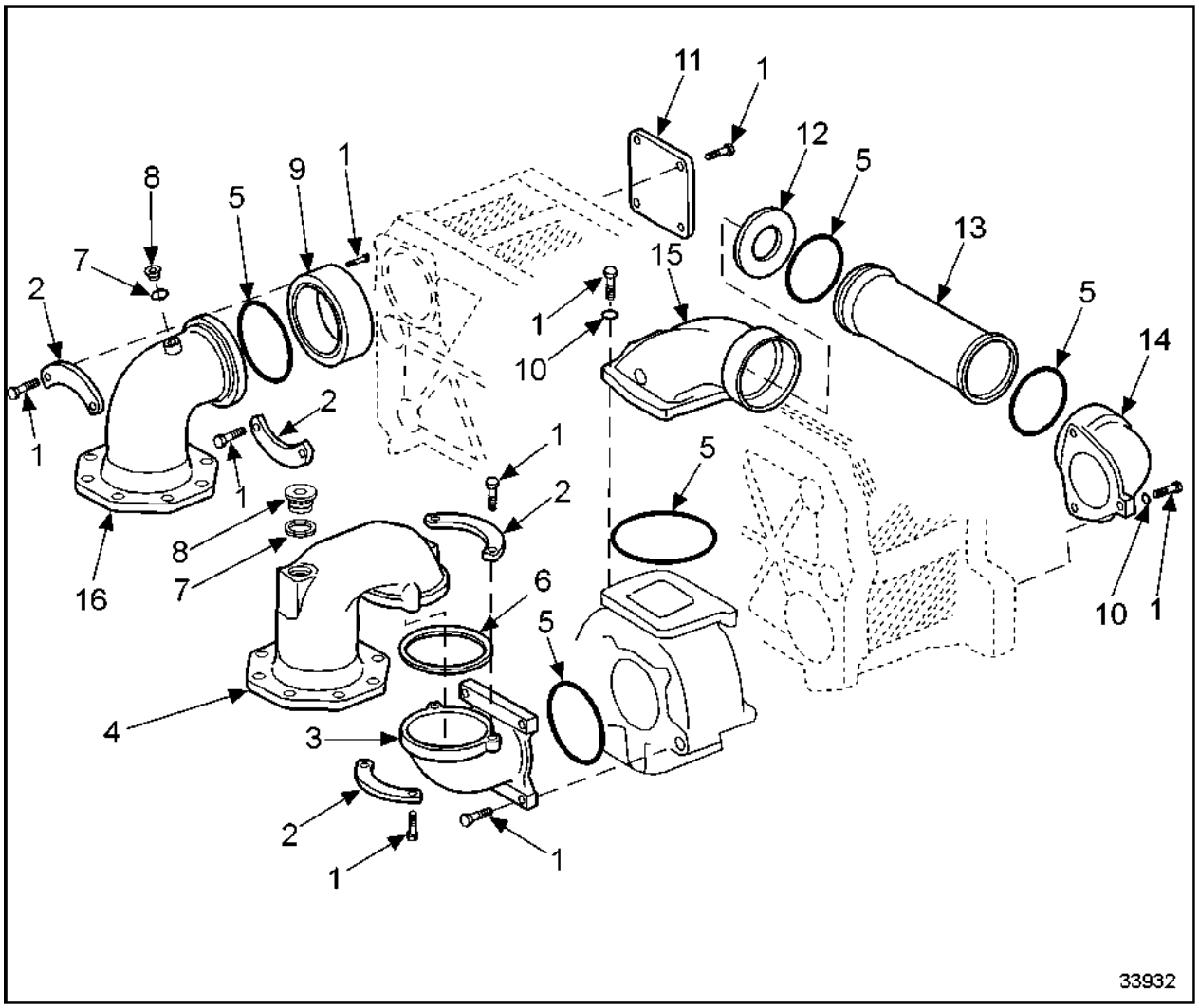
Refer to section C 203.05.12 for the After-Installation Operations for the charge air cooler cooling system pipework.

C 207.05 M – MARINE RAW WATER PUMP WITH CONNECTIONS

C 207.05.01 M – GENERAL VIEW

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

See Figure 974 for a general view of the raw water pump for the marine engine.



1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 974 General View of Marine Water Pump Connections

C 207.05.04 M – BEFORE – REMOVAL OPERATIONS

Listed in Table are the Before – Removal Operations for the marine raw water pump.

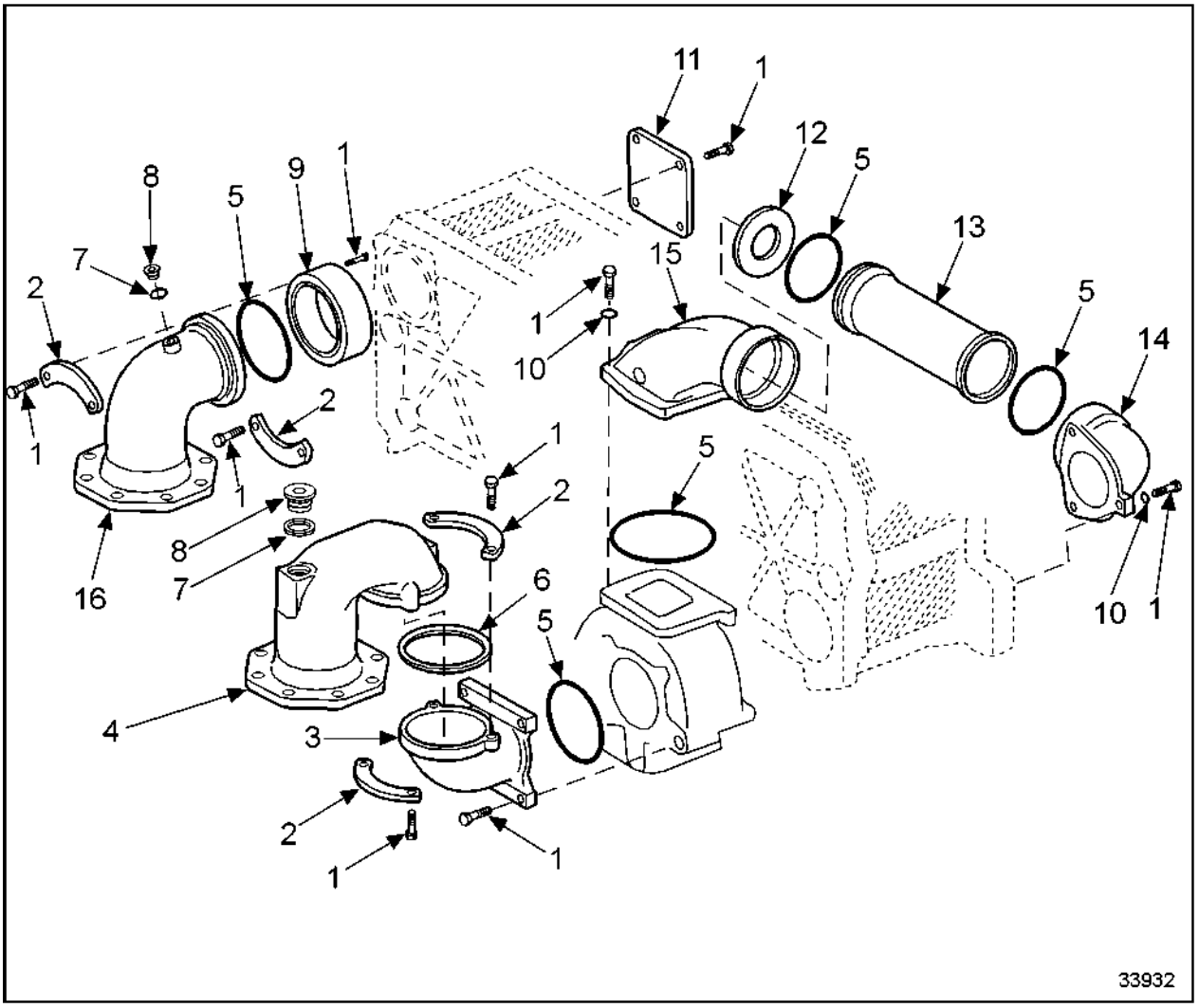
Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operator's Guide
1, 2, 3	Cut-out raw water supply	Refer to Operator's Guide
1, 2, 3	Raw water draining	Refer to Operator's Guide
1, 2, 3	Disconnect electric wiring	—

Table 137 Before – Removal Operations of the Marine Raw Water Pump

C 207.05.05 M – REMOVAL OF THE MARINE RAW WATER PUMP WITH CONNECTIONS

Perform the following steps to remove the raw water pump:

1. Drain the coolant system. See Figure 975.

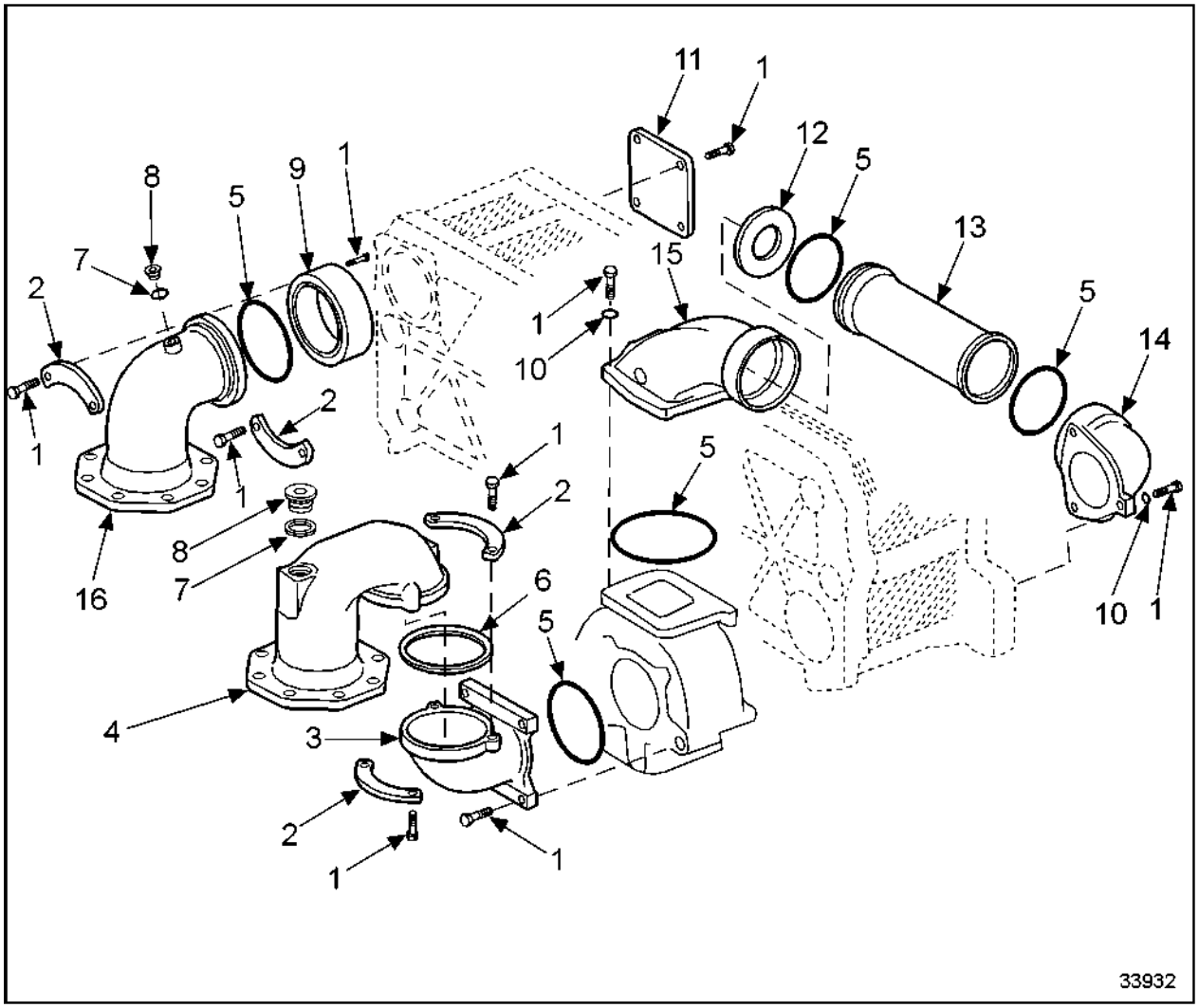


1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 975 Draining the Cooling System

2. Remove four bolts (1) and half-clamps (2) securing the raw water pump intake elbow (4) to the raw water pump elbow (3)

3. Remove four bolts (1) securing the raw water pump elbow (3) to the raw water pump. See Figure 976.

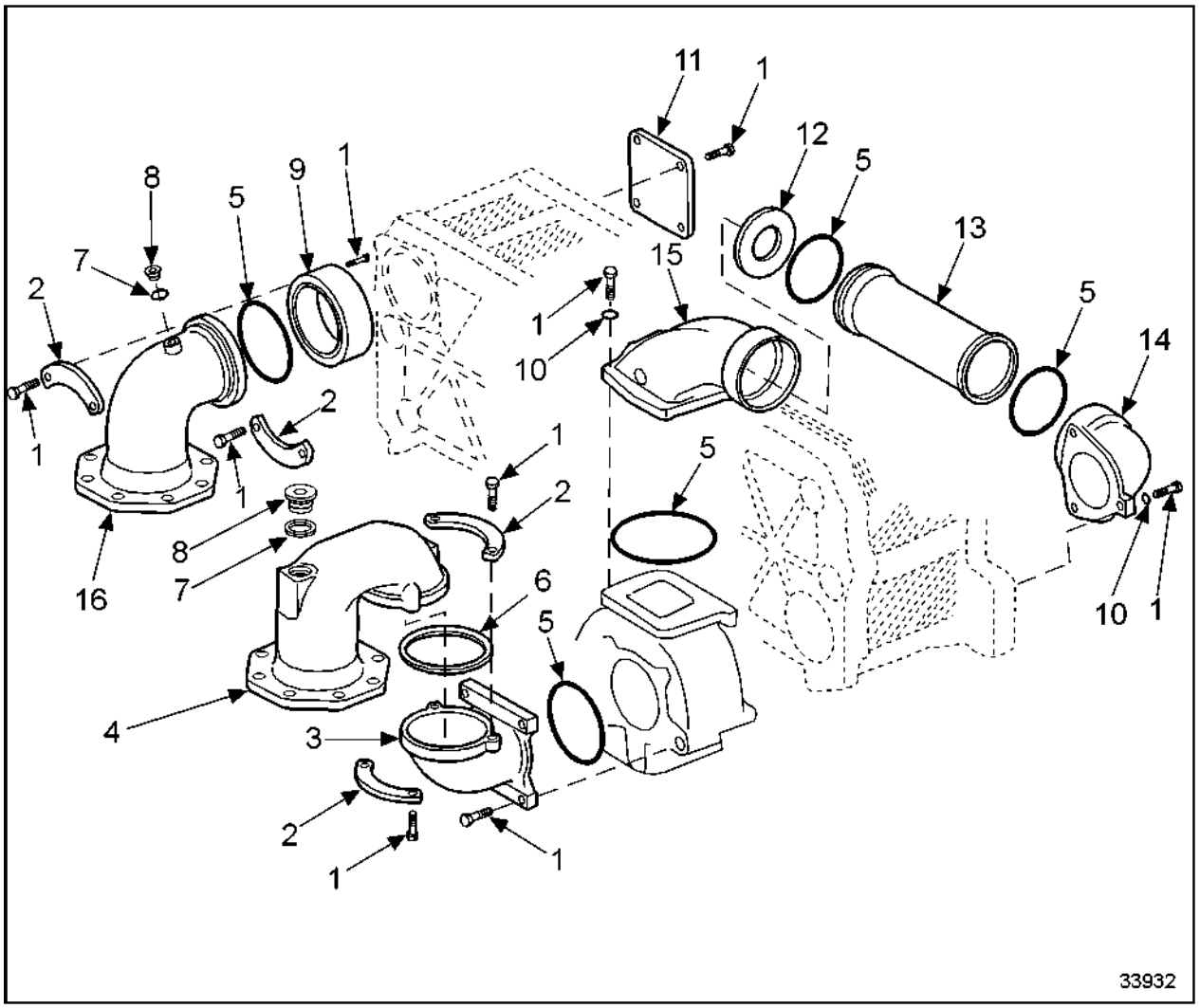


1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 976 Removing Four Bolts Securing the Raw Water Pump Elbow to the Raw Water Pump

4. Remove O-ring (5). See Figure 976.
5. Remove five bolts (1) securing the raw water pump to the raw water supply tube elbow (15).
6. Remove three bolts (1) securing the raw water pump to the front cover (11).
7. Remove the raw water pump.

8. Remove the raw water pump gasket (6). See Figure 977.



1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 977 Removing the Raw Water Pump Gasket

9. Remove the raw water supply tube. See Figure 977.

10. Remove the raw water supply connector (14). See Figure 977.
11. Remove two O-rings (5). See Figure 977.

C 207.05.08 M – INSPECTION AND REPAIR

Perform the following steps to clean and inspect the raw water lines:

1. Clean lines with cold cleaner and brush.
2. Visually inspect plug-in connections and ring grooves in elbows and connecting lines for wear, indentations and pitting.
   [a] If wear, indentations or pitting is present, rub down with oilstone or emery cloth as necessary.
   [b] If damage is beyond repair, replace component.
   [c] If wear, indentations and pitting are not present, continue inspection.
3. Visually inspect the sealing surfaces for evenness.
   [a] If sealing surface is uneven, smooth with emery cloth as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If sealing surface is even, continue inspection.
4. Replace clamps and rubber sleeve as part of W6 overhaul.
5. Visually inspect clamps and rubber sleeves for damage.
   [a] If rubber clamps are worn or damaged, replace component.
   [b] If rubber clamps are not worn or damaged, continue inspection.
6. Replace O-rings, gaskets and sealing rings.

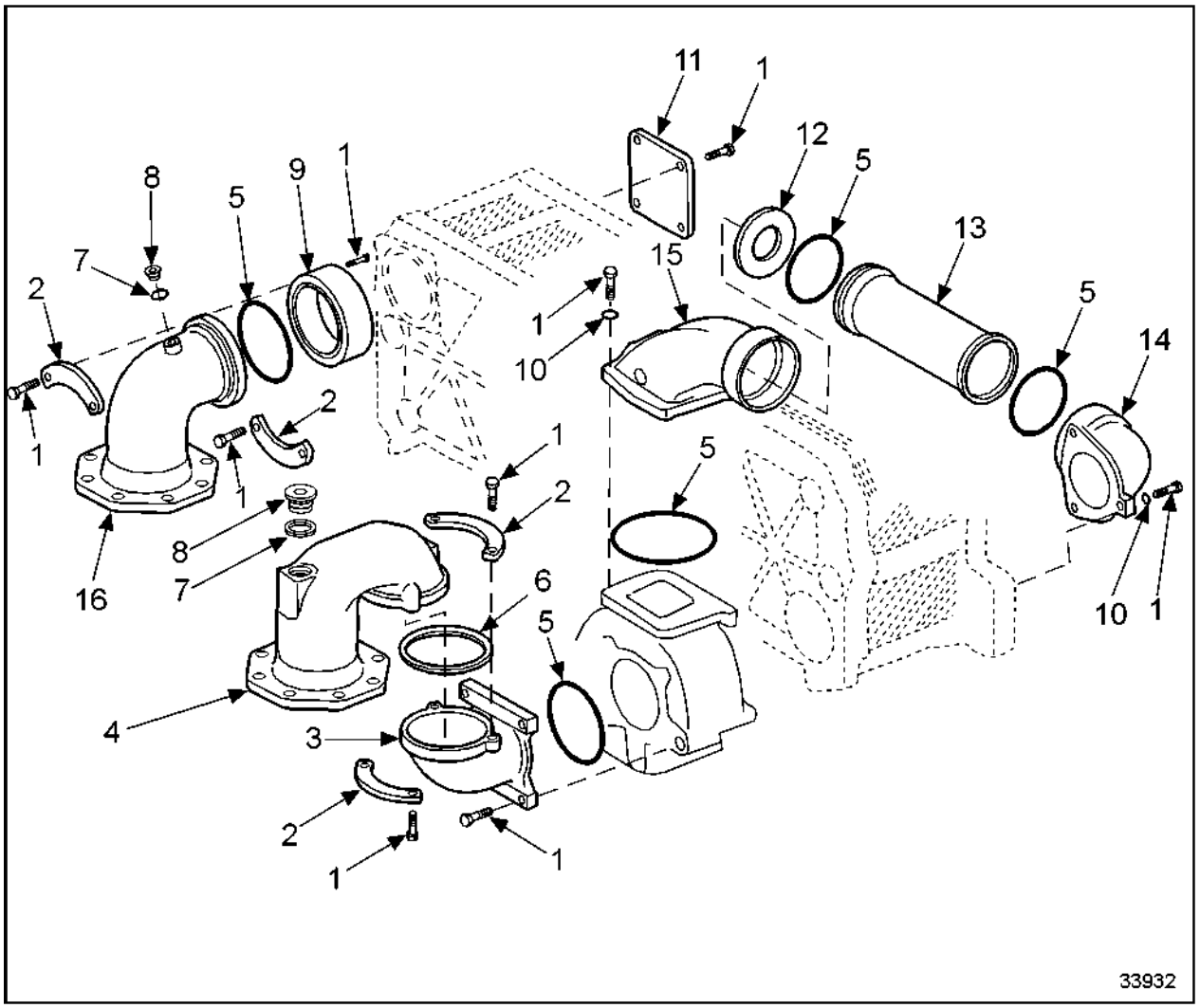
Perform these steps to clean and inspect the raw water pump:

1. Clean all components.
2. Visually inspect the spiral housing, impeller, intermediate element and bearing housing for cracks using the surface crack-testing method with red penetrant dye.
3. Visually inspect the pump shaft and gear for cracks using the magnetic crack-testing method with fluorescent magnetic powder.
   [a] If cracks are present, replace component.
   [b] If cracks are not present, continue inspection.
4. Visually inspect for cracks.
   [a] If part is cracked, replace as necessary.
   [b] If part is not cracked, continue inspection.
5. Visually inspect spiral housing and impeller for cavitation.
   [a] If pitting is over 1 mm in depth, replace component.
   [b] If pitting is not over 1 mm in depth, continue inspection.

C 207.05.11 M – INSTALLATION OF THE MARINE RAW WATER PUMP WITH CONNECTIONS

Perform the following steps to install the marine raw water pump:

1. Install two new O-rings (5). Remove the raw water pump gasket (6). See Figure 978.

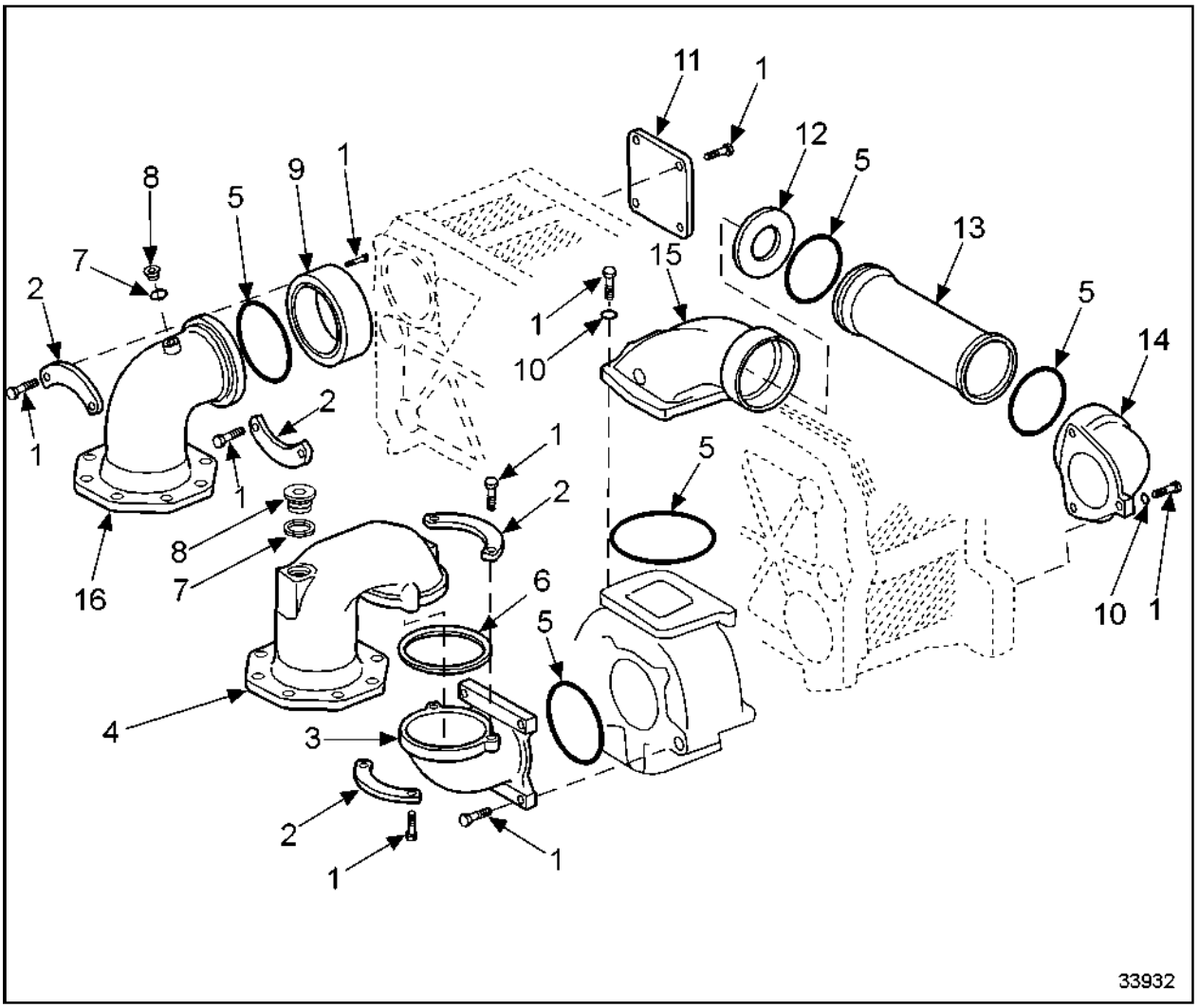


1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 978 Installing Two New O-rings

2. Install the raw water supply connector (14). See Figure 978.
3. Install the raw water supply tube (13). See Figure 978.

4. Install the raw water pump gasket (6). See Figure 979.

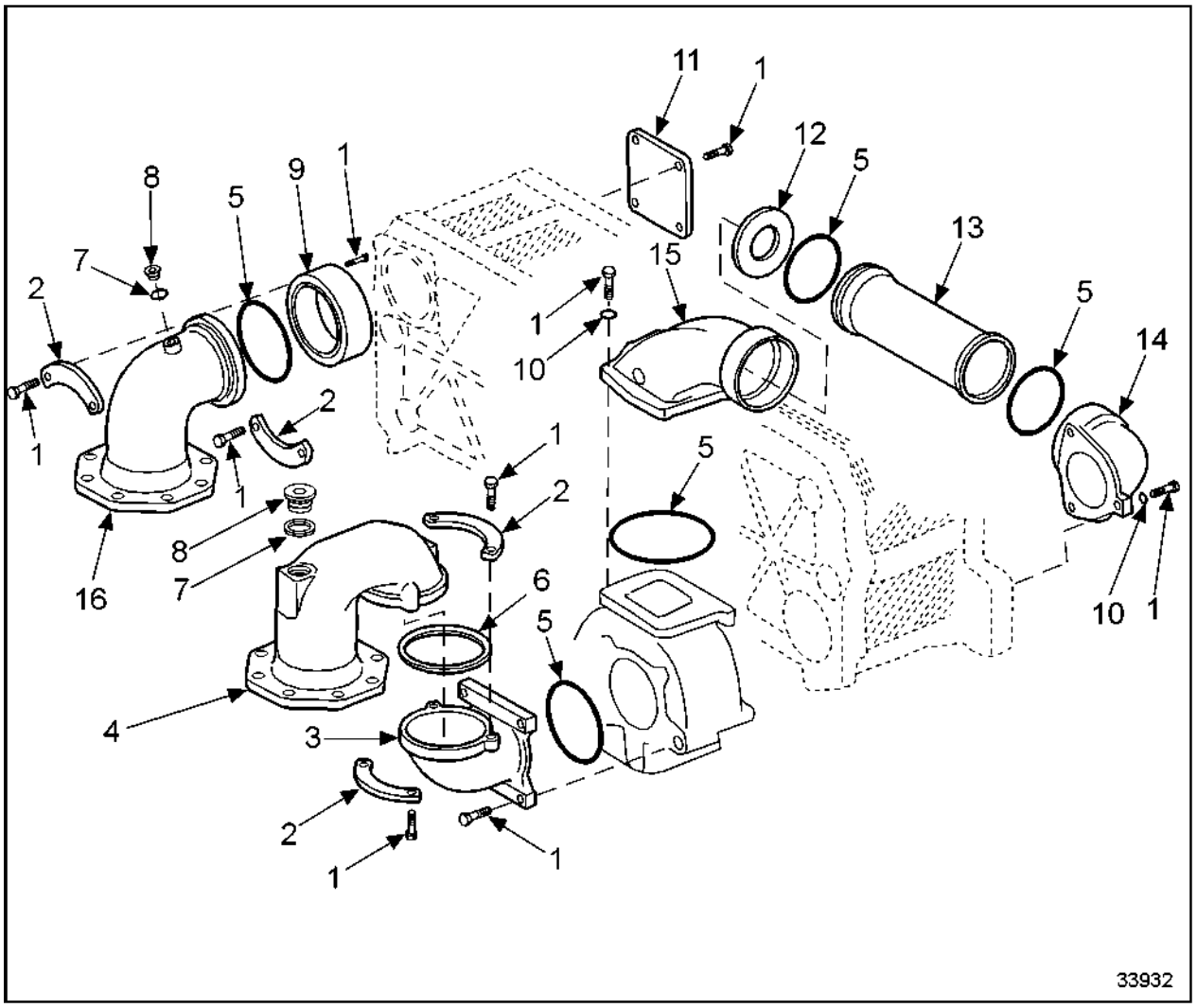


1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 979 Installing Raw Water Pump Gasket

5. Install the raw water pump and secure with three bolts (1) to the front cover (11). Torque bolts to specification. Refer to section A 003. See Figure 979.

6. Install five bolts (1) to secure the raw water pump to the raw water supply tube (13). See Figure 979.
7. Install new O-ring (5) to the raw water pump elbow (3) and secure with four bolts (1). Torque bolts to specification. Refer to section A 003. See Figure 980.



1. Bolt
2. Half-Clamp
3. Raw Water Pump Elbow
4. Raw Water Pump Intake Elbow
5. O-ring
6. Gasket
7. Sealing Ring
8. Plug
9. Spacer
10. Washer
11. Cover
12. Restrictor
13. Raw Water Supply Tube
14. Raw Water Supply Connector
15. Raw Water Supply Elbow
16. Elbow

Figure 980 Installing New O-ring

8. Install the raw water pump elbow (3) and secure with clamps and four bolts (1). Torque bolts to specification. Refer to section A 003. See Figure 980.
9. Fill the coolant system and verify repair of raw water pump.

C 207.05.12 M – AFTER – INSTALLATION OPERATIONS

Listed in Table 138are the After – Installation Operations for the marine raw water pump.

Level of Maintenance	Operation	Reference
1, 2, 3	Connect electric cables	—
1, 2, 3	Connect raw water lines	—
1, 2, 3	Cut in raw water supply	Refer to Operator's Guide
1, 2, 3	Fill raw water pump	Refer to Operator's Guide
1, 2, 3	Enable engine power	Refer to Operator's Guide

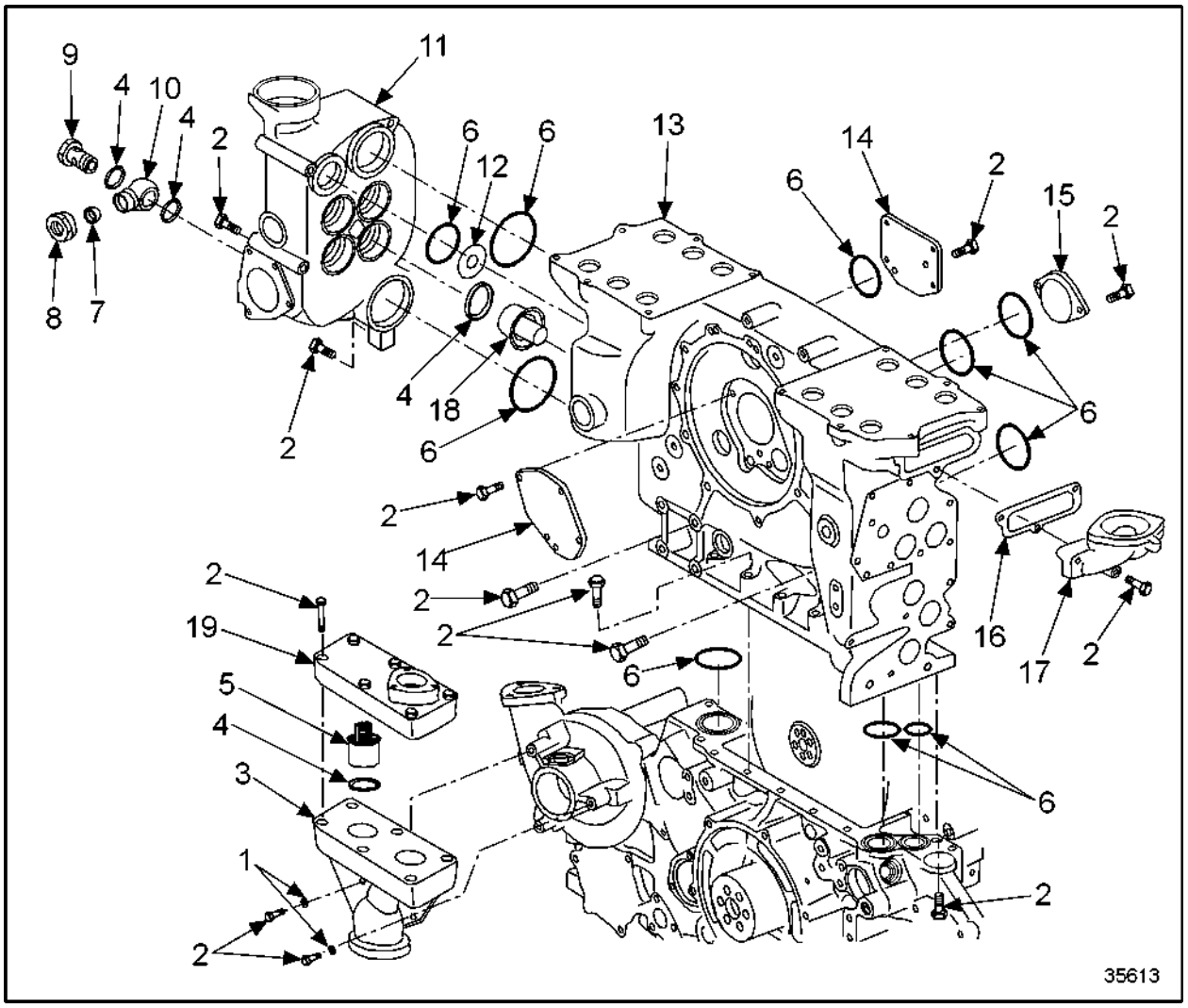
Table 138 After – Installation Operations for Marine Water Pump

C 208.05 – COOLANT PIPEWORK WITH THERMOSTAT

C 208.05.01 – GENERAL VIEW

NOTE:
Refer to section before beginning any work in the coolant chambers.

See Figure 981 for a general view of the cooling system thermostat and distribution housings.



1. Washer
2. Hex Bolt
3. Thermostat Housing (Low-temperature Circuit)
4. Sealing Ring
5. Thermostat Element (low-temperature Circuit)
6. O-ring
7. Sealing Cone
8. Nut
9. Screw
10. Union
11. Thermostat Housing (High-temperature Circuit)
12. Restrictor
13. Coolant Distribution Housing
14. Cover
15. Blanking Flange
16. Gasket
17. Elbow
18. Thermostat (High-temperature Circuit)
19. Thermostat Housing Cover (Low-temperature)

Figure 981 General View of Cooling System Thermostat and Distribution Housings

C 208.05.02 – SPECIAL TOOLS

Listed in Table 139 are the special tools required for maintenance on the cooling system distribution housing and thermostat.

Application	Number
Installation tool, restrictor installation/removal, coolant distribution housing	—
Guide journal for restrictor	—
Guide journal for restrictor	—
Guide journal for restrictor	—
Guide journal for restrictor	—

Table 139 Special Tools

C 208.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 140 are the Before-Removal Operations for the cooling system distribution housing and thermostat.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Drain or draw off engine oil	Refer to Operators Guide
1, 2, 3	Drain engine coolant	Refer to Operators Guide
1, 2, 3	Drain fuel from fuel guide rail, flywheel end	Refer to Operators Guide
1, 2, 3	Remove oil filter	Refer to section C 183.05.05
1, 2, 3	Remove oil centrifuge	Refer to section C 184.05.05
1, 2, 3	Remove engine oil heat exchanger	Refer to section C 185.05.05
1, 2, 3	Disconnect electric wiring	Refer to section C 501.05 M
1, 2, 3	Remove fan drive	Refer to section C 221.05.05
1, 2, 3	Remove engine mounts (KGS)	Refer to section C 231.05.05
1, 2, 3	Remove coolant lines	Refer to section C 204.05.05

1 = The engine is to be completely disassembled.

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

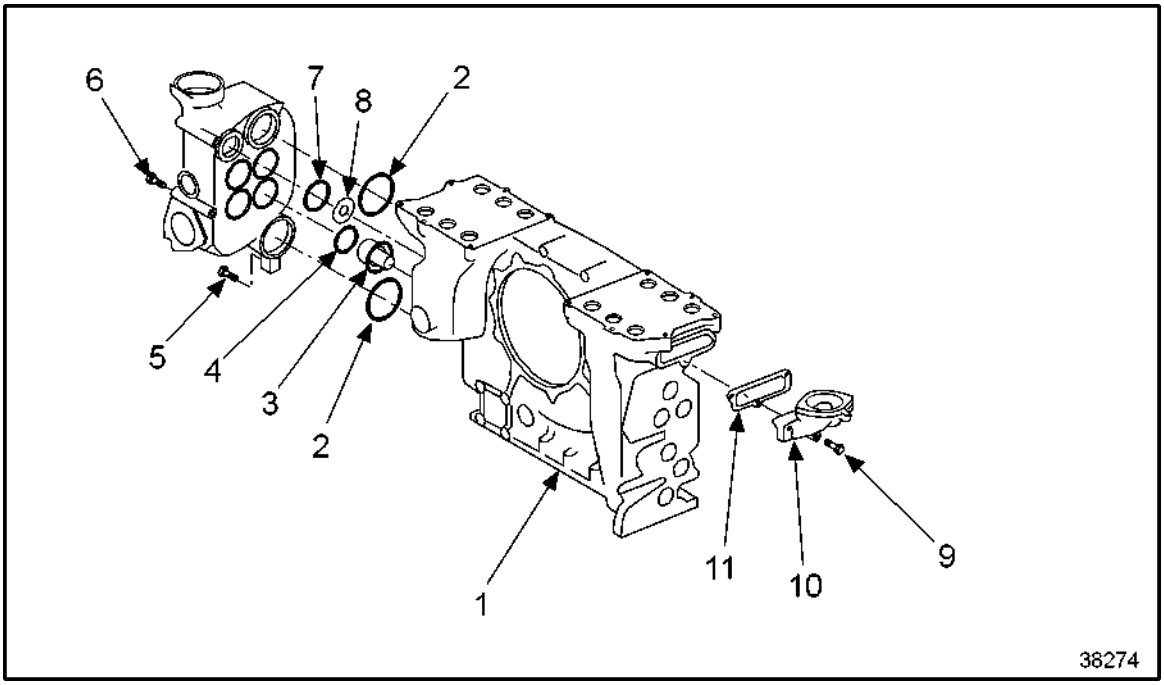
3 = The engine is to remain installed.

Table 140 Before-Removal Operations

C 208.05.05 – REMOVAL OF COOLING SYSTEM THERMOSTAT AND DISTRIBUTION HOUSINGS

Perform the following steps for the removal of the coolant pipework and thermostat:

1. To remove high-temperature thermostat housing, remove hex bolts (not shown). See Figure 982.



1. Thermostat Housing

Figure 982 Removing High-temperature Thermostat Housing

2. Remove thermostat housing (1).

3. Remove restrictor, four thermostats with sealing rings, and O-rings. See Figure 983.

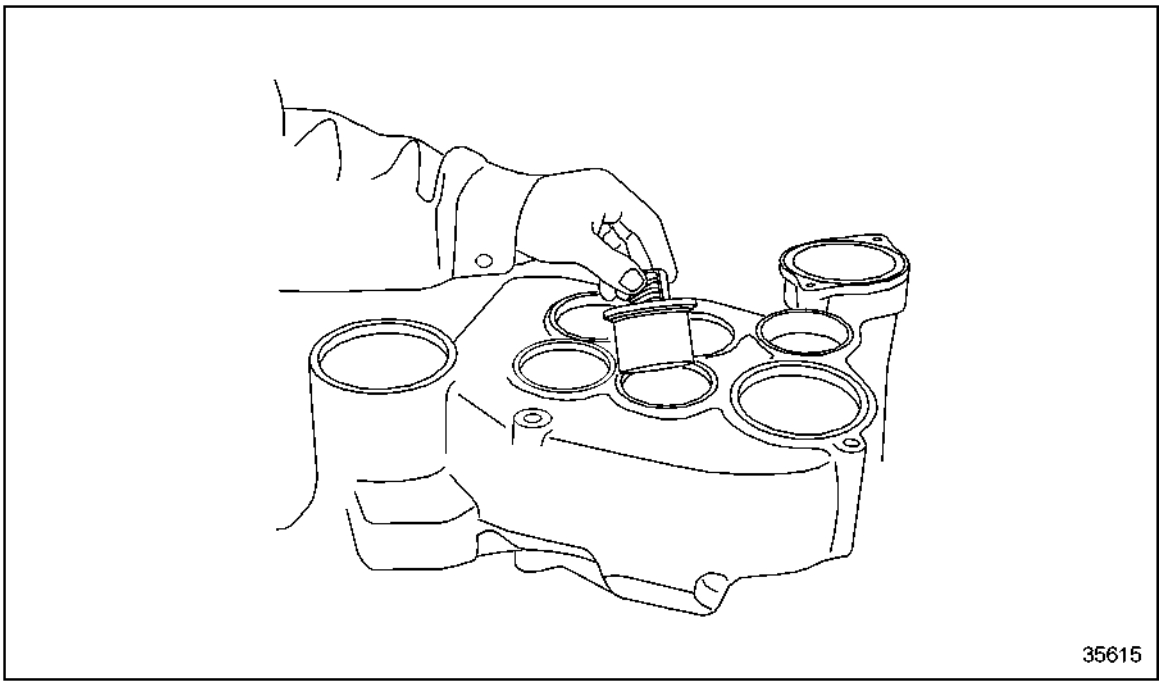
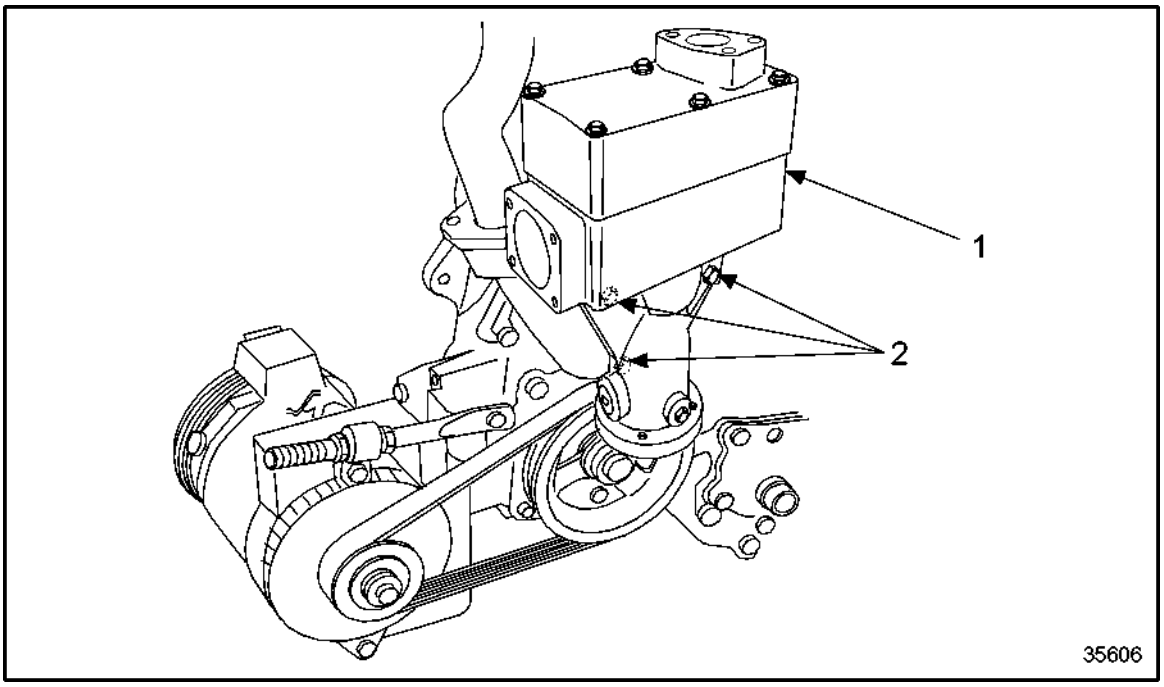


Figure 983 Removing Restrictor, Thermostats with Sealing Rings, O-rings

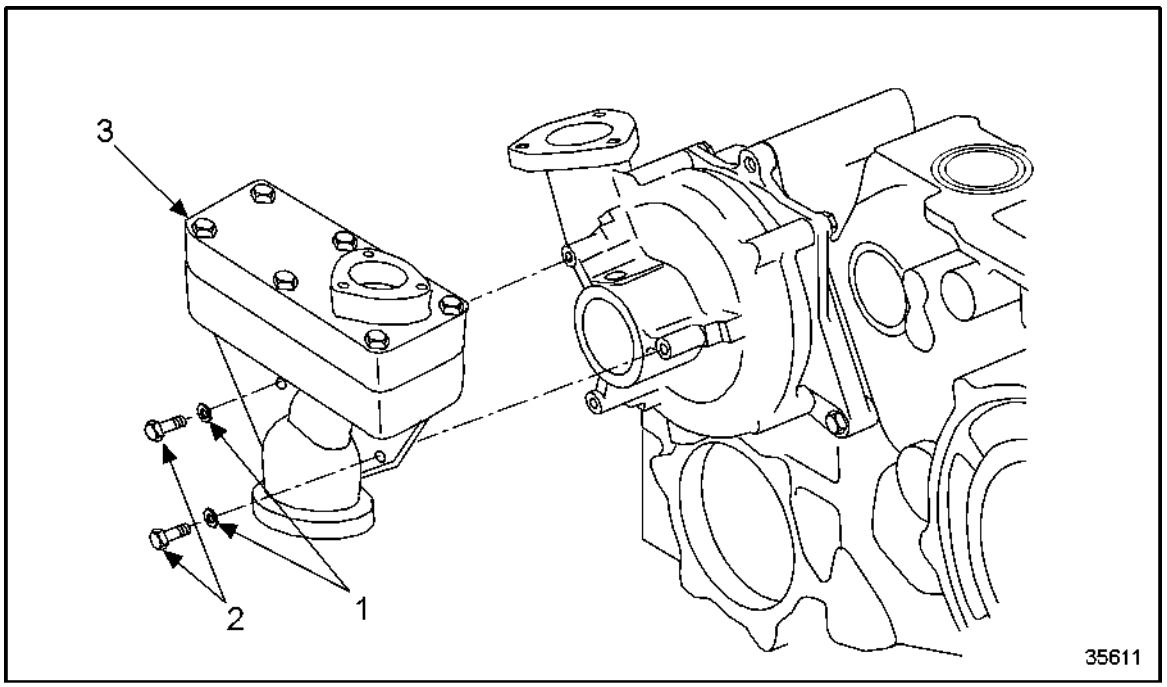
4. To remove low–temperature thermostat housing remove hex bolts (3) attaching thermostat housing (2) to water pump (1) of the low-temperature circuit. See Figure 984.



1. Low-Temperature Thermostat Housing
2. Bolt

Figure 984 Removing Low—temperature Thermostat Housing

5. Remove thermostat housing (2). See Figure 985.



1. Washer
2. Bolt
3. Thermostat Housing

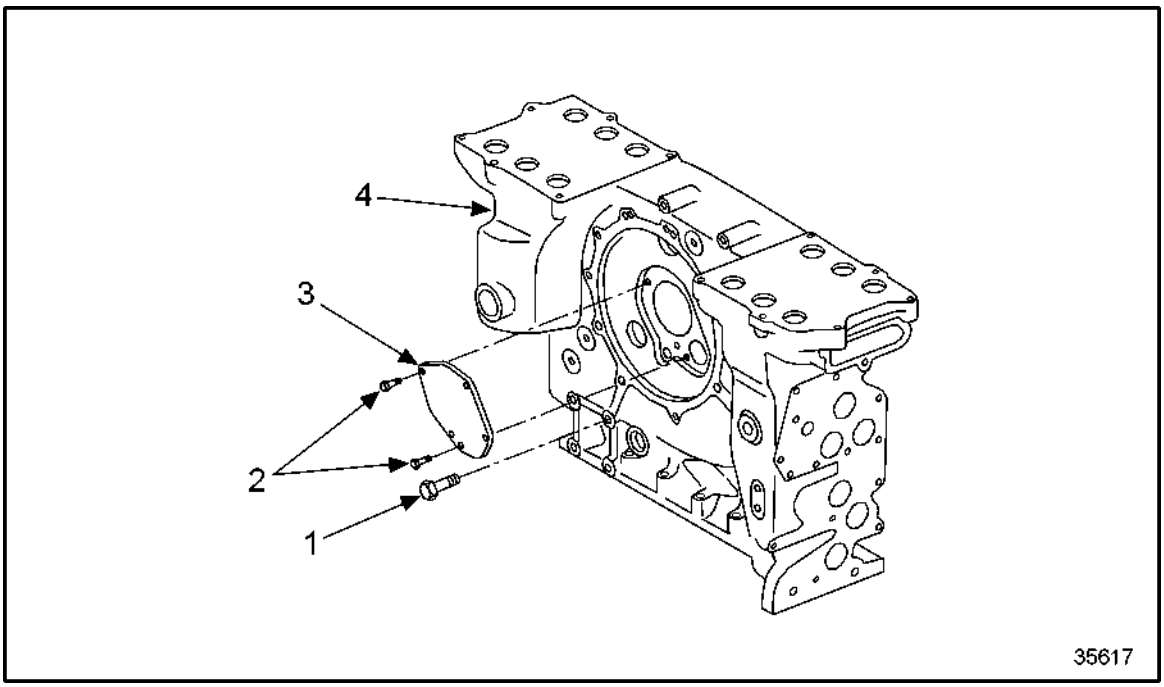
Figure 985 Removing Thermostat Housing

6. Remove thermostat (4) with sealing ring.

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.

7. To remove distribution housing, attach housing (4) with a lifting device, slightly tensioned, to crane. See Figure 986.



1. Hex Bolts
2. Hex Bolts
3. Cover
4. Distribution Housing

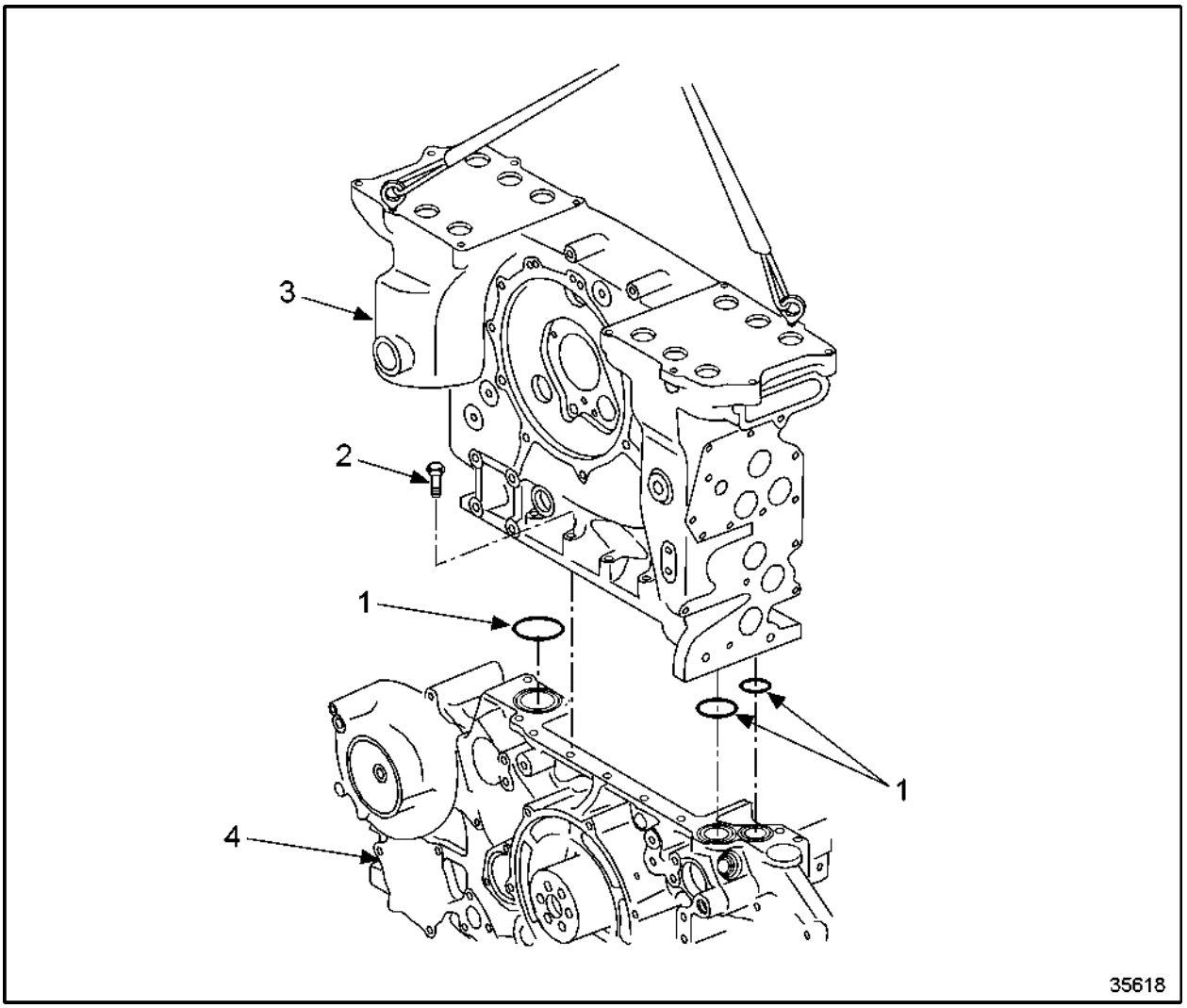
Figure 986 Removing Distribution Housing

8. Remove hex bolts (2) and cover (3).
9. Remove hex bolts (1).

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

11. Remove O-rings.
12. Remove elbow. (Not shown. Refer to section C 208.05.01.)

C 208.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the cooling system thermostat and distribution housings:

1. Clean all parts with suitable cleaning solvent.
2. Visually inspect components for damage and defects.
   [a] If any component is damaged or defective, repair or replace as necessary.
   [b] If no damage or defect is found, continue inspection.
3. Using the surface crack-testing method with red penetrant dye, visually inspect coolant distribution housing for cracks.
   [a] If distribution housing is cracked, repair or replace the housing as necessary.
   [b] If distribution housing is not cracked, continue inspection.
4. Using the surface crack-testing method with red penetrant dye, inspect thermostat housing for cracks.
   [a] If thermostat housings are cracked, repair or replace the housings as necessary.
   [b] If thermostat housings are not cracked, continue inspection.
5. Visually inspect all mating and sealing surfaces for wear and damage.
   [a] If mating or sealing surfaces are worn or damaged, rub down with an emery cloth or an oilstone as necessary.
   [b] If damage is beyond repair, replace component.
   [c] If mating or sealing surfaces are not worn or damaged, continue inspection.
6. Visually inspect support bores of thermostat housings for damage.
   [a] If support bores of thermostat housings are damaged, rub down with an emery cloth or an oilstone as necessary.
   [b] If damage is beyond repair, replace thermostat housings.
   [c] If support bores are not damaged, continue inspection.
7. Visually inspect condition of threads in distribution housing for wear and damage.
   [a] If threads in distribution housing are worn or damaged, rechase threads as necessary.
   [b] If threads in distribution housing are not worn or damaged, continue inspection.
8. Replace gaskets, sealing rings and O-rings.
9. Ensure that oil chambers are perfectly clean.

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.

10. Pressure test coolant and lube oil passages of distribution housing for leaks with compressed air in water bath (with corrosion inhibitor).
    [a] If lube oil passages or coolant passages in the distribution housing show leaks, repair or replace the housing as necessary.
    [b] If lube oil passages or coolant passages in the distribution housing do not show leaks, continue inspection.

Inspection of Thermostats

Perform the following steps for inspection of thermostats:

1. Measure distance from thermostat collar to main valve head. See Figure 988.

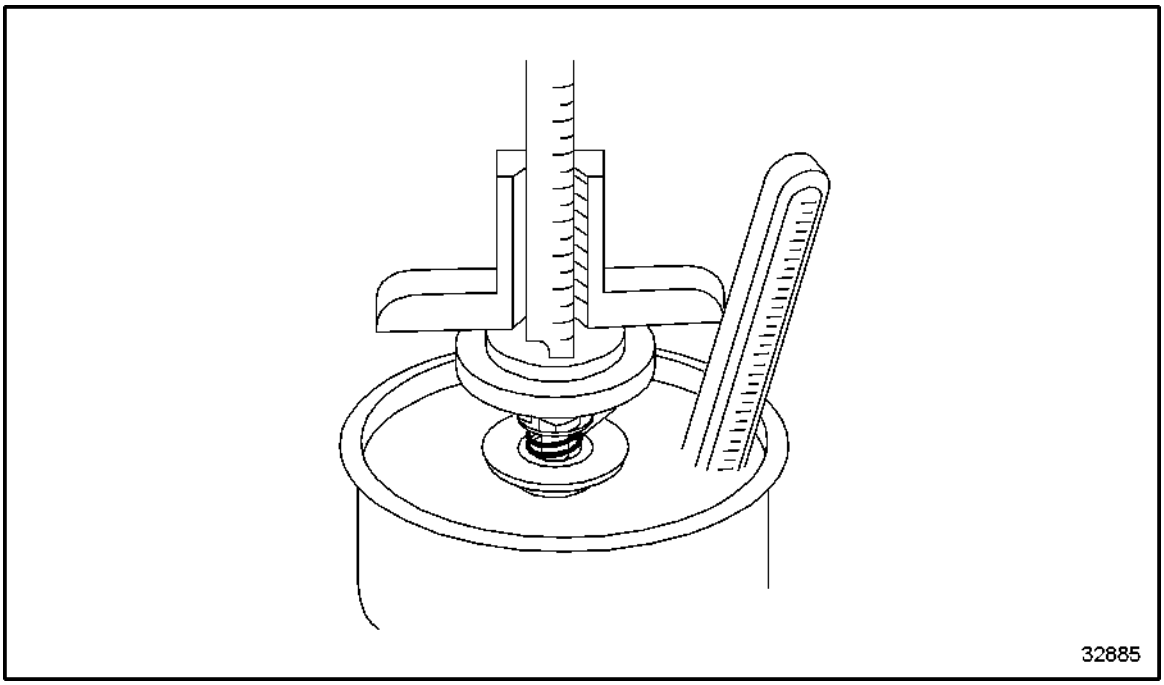


Figure 988 Inspection of Thermostats

2. Hang thermostat on a wire in a container filled with water.

NOTE:
Thermostat must not contact container.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

3. Heat water with suitable heat source to approximately 10°C (50°F) under start of opening. The temperatures for different stages should be as follows:
   - ☐ High-temperature thermostat:

   [a] Starts to open: 75°C (167°F) ± 2°.

   [b] Fully open: 88°C (190.4°F) ± 2°.

   [c] Lift when fully open: 9.5 mm (Min).

   - ☐ Low-temperature thermostats:

   [a] Starts to open: 45°C (113°F) ± 2°.

   [b] Fully open: 58°C (136.4°F) ± 2°.

   [c] Lift when fully open: 9.5 mm (Min).

NOTE:
The heating rate must not exceed 1°C per minute.

NOTE:
Never use welding torch or blow torch to heat coolant thermostat.

CAUTION:

To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

1. Inspect thermostat housing for start of opening with heat supply uniform and water constantly circulated.

   [a] If the thermostat housing does not open within specified tolerance limits, inspect and repair mechanism or replace thermostat housing as necessary.

   [b] If start of opening is within specified limits, heat water further to 88°C (190.4°F) (fully open).

2. After six to eight minutes, measure distance from coolant thermostat collar to main valve head. Compare distance with first measurement. See Figure 988.

3. Verify that lift is within specified tolerance limits.

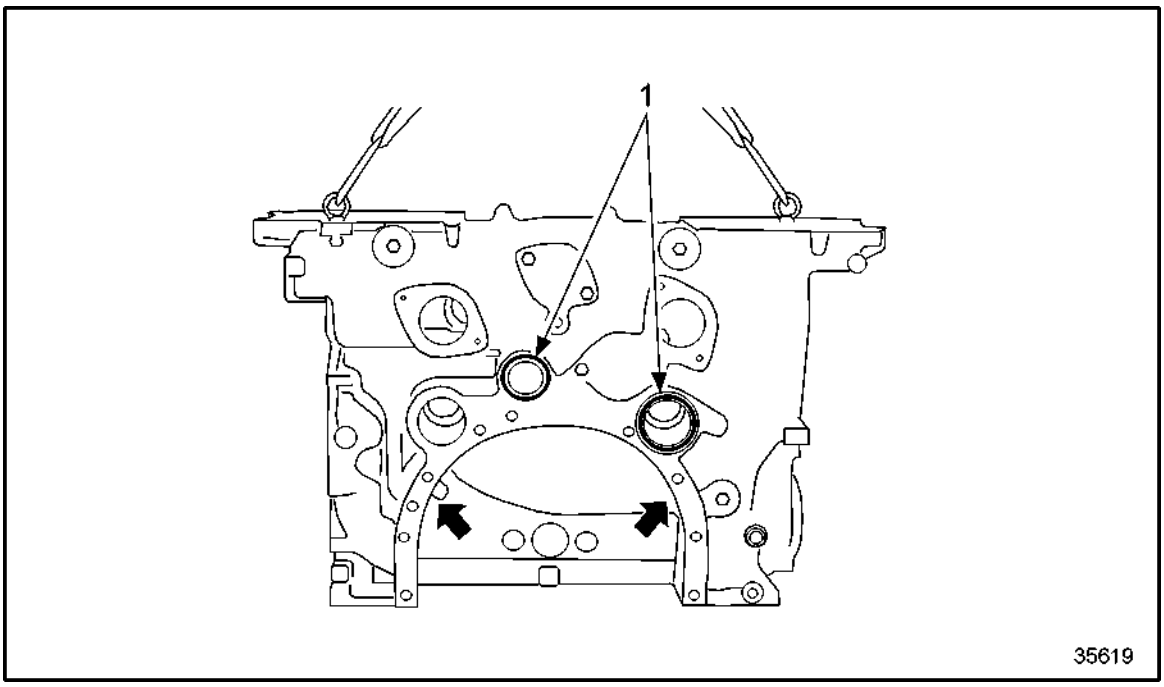
   [a] If lift is not within specified tolerance limits, replace the coolant thermostat housing.

   [b] If limit is within specified tolerance limits, continue inspection.

C 208.05.11 – INSTALLATION OF COOLING SYSTEM THERMOSTAT AND DISTRIBUTION HOUSINGS

Perform the following steps for the installation of the cooling system thermostat and distribution housings:

1. To assemble and install distribution housing, install elbow (Not shown. Refer to sectionC 208.05.01) on distribution housing. See Figure 989.

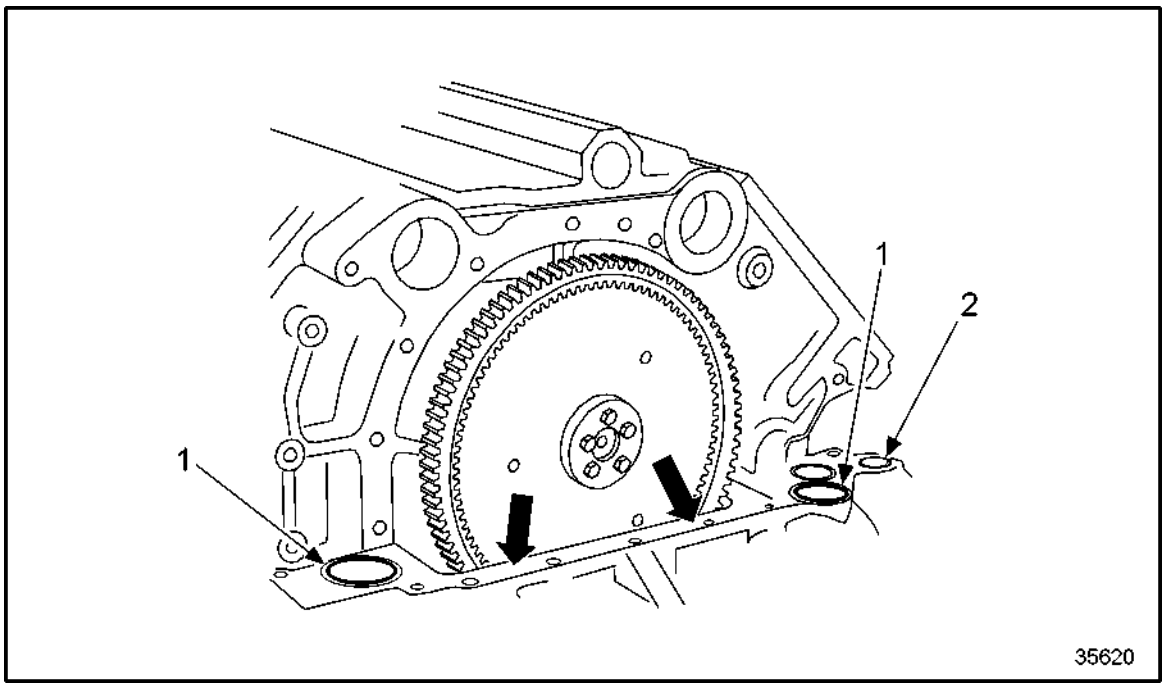


1. O-ring

Figure 989 Installing O—rings on Distributor Housing

2. Bolt cap plugs onto distribution housing and tighten.
3. Coat O-rings (1) with petroleum jelly and install on back of distribution housing.
4. Coat mating surface (arrow) between rear of distribution housing and cylinder block with gasket eliminator.

5. Coat O-rings (1) with petroleum jelly and insert into grooves in gear case. See Figure 990.



1. O-rings
2. Blanking Plugs

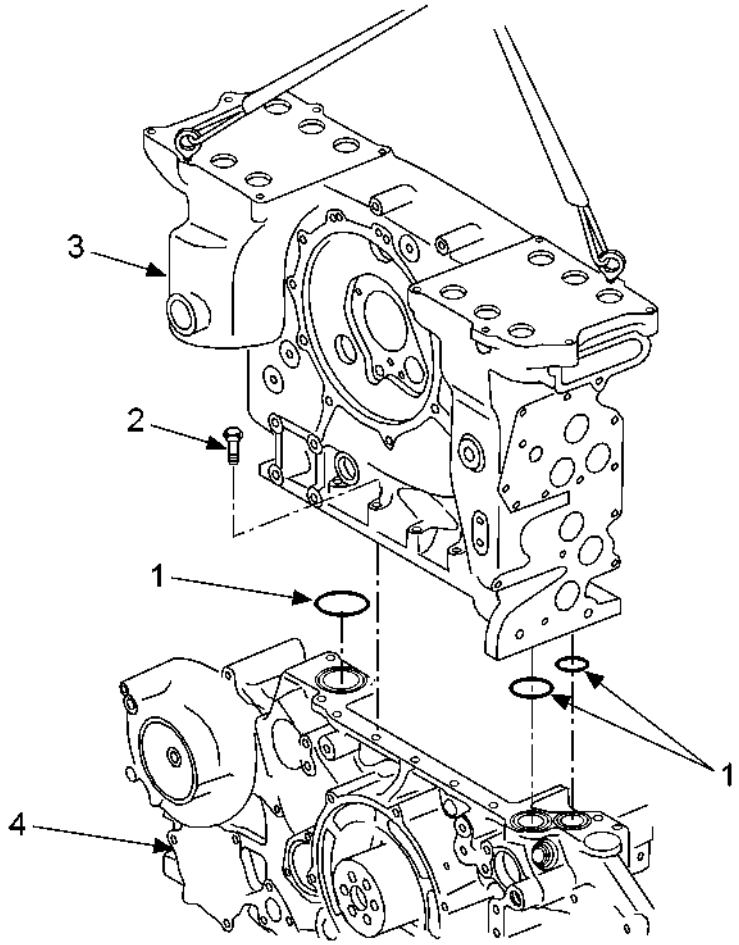
Figure 990 Inserting O-rings into Grooves in Gear Case

6. Install blanking plugs (2) on gear case if previously removed.
7. Coat mating surface of distribution housing on gear case (arrow) with gasket eliminator.

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.

8. Install lifting eyes into distribution housing. See Figure 991.



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

Figure 991 Placing Housing on Gear Case

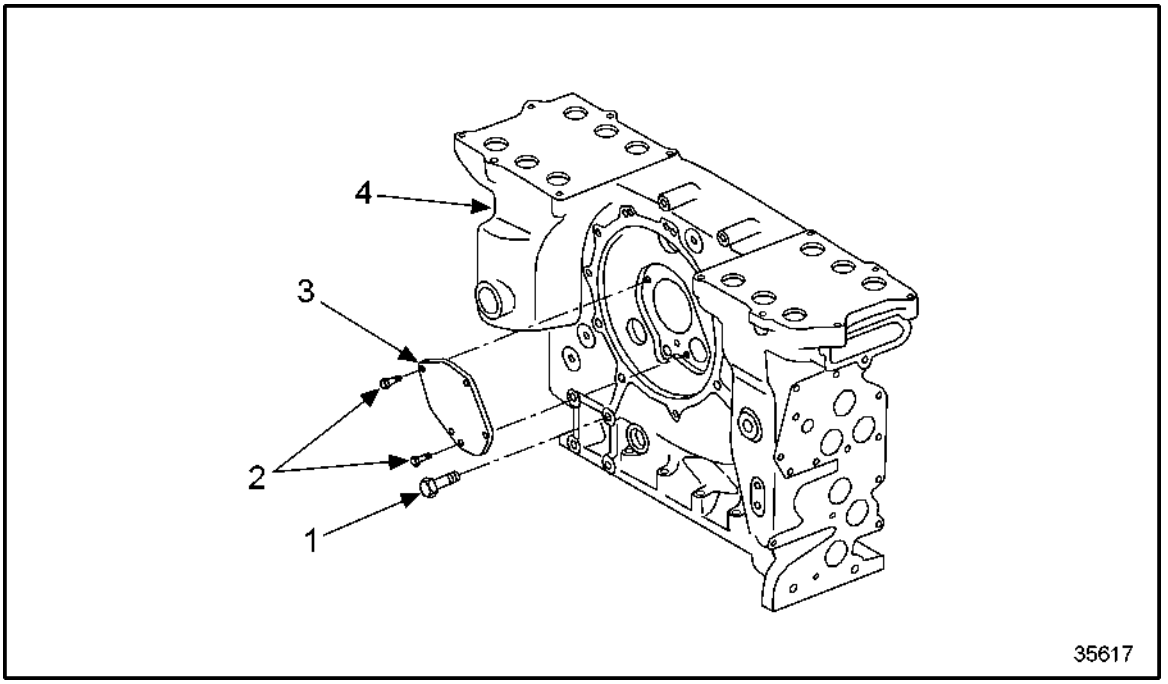
CAUTION:

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.

9. Carefully align distribution housing, attached to crane with suitable lifting device.
10. Place distribution housing on gear case.

NOTE:
When positioning distribution housing, ensure that O-rings on back of housing are not damaged.

11. Install hex bolts (1, 2) on distribution housing (1). See Figure 992.



1. Hex Bolt
2. Hex Bolt
3. Cover
4. Distribution Housing

Figure 992 Installing Hex Bolts and Distribution Housing Cover

12. Install distribution housing cover (2).
13. Tighten hex bolts (1) to specification. Refer to section A 003.
14. To install high-temperature thermostat, inspect sealing and mating surfaces for contamination.

[a] If sealing or mating surfaces are contaminated, clean as necessary.

[b] If sealing or mating surfaces are not contaminated, continue installation.

15. Install thermostats in thermostat housing bores. See Figure 993.

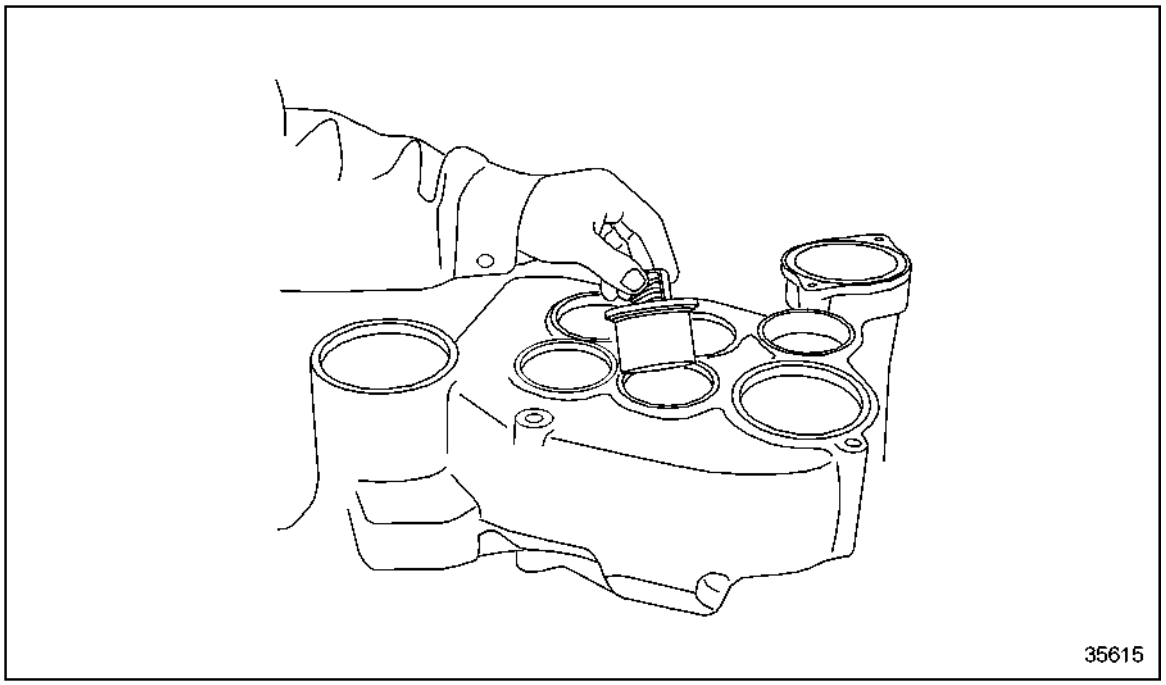
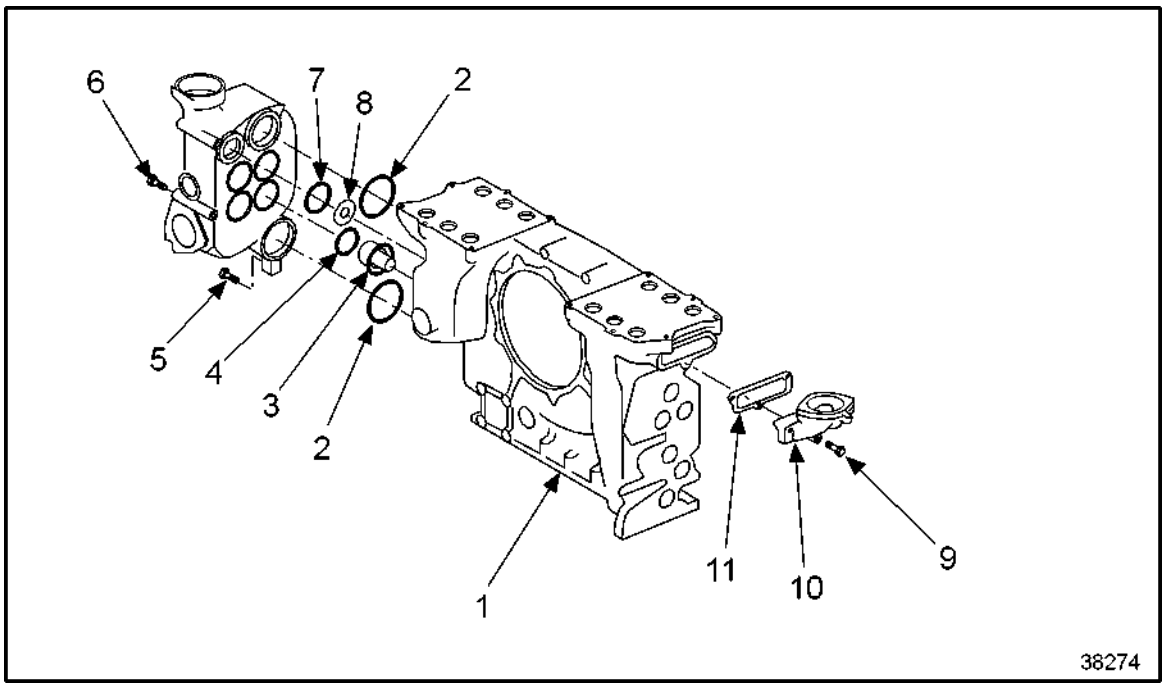


Figure 993 Installing Thermostats into Thermostat Housing

16. Coat O-rings with petroleum jelly and insert into annular grooves.

17. Install restrictor into thermostat housing bore. 994.

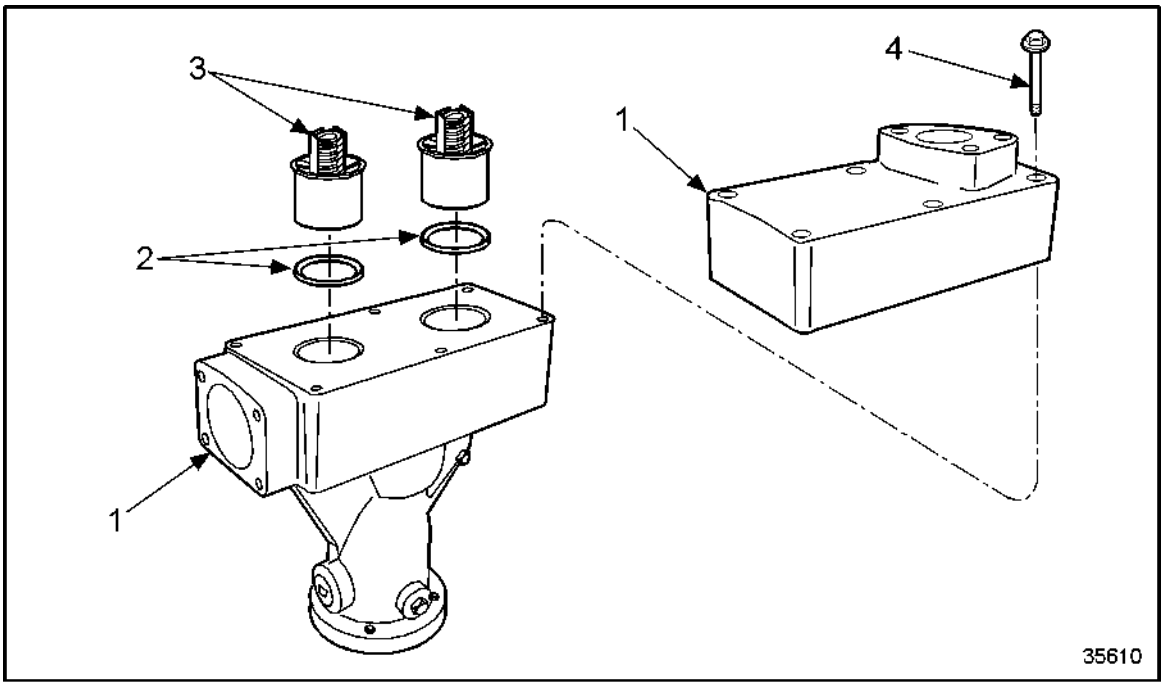


1. Thermostat Housing

Figure 994 Installing Restrictor into Thermostat Housing Bore

18. Install thermostat housing on coolant distribution housing by means of guide pins.
19. Remove guide pins.
20. Install hex bolts to secure thermostat housing. Refer to section C 208.05.01.
21. Tighten hex bolts to specification. Refer to section A 003.

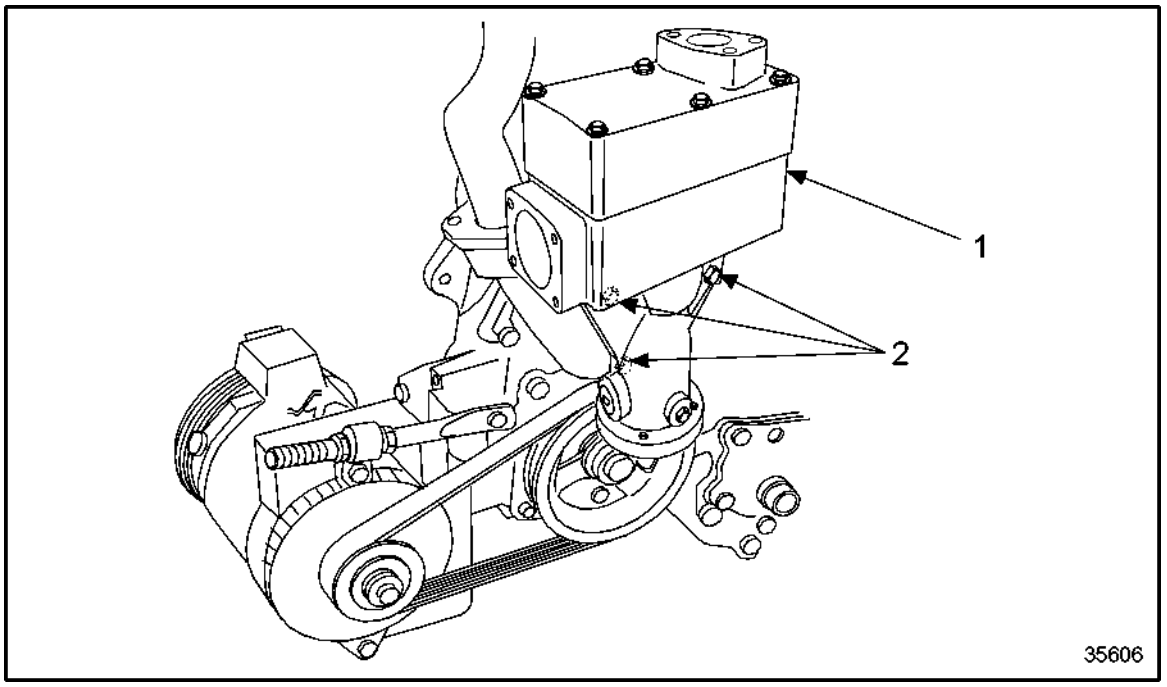
22. To install low-temperature thermostat install sealing ring and thermostat element dry in thermostat housing. See Figure 995.



1. Thermostat Housing
2. Sealing Ring
3. Thermostat
4. Mounting Bolt

Figure 995 Installing Sealing Ring and Thermostat Element in Thermostat Housing

23. Install thermostat housing (2) with hex bolts (3) on charge air coolant pump (1). See Figure 996.



1. Low-Temperature Thermostat Housing
2. Bolt

Figure 996 Installing Thermostat Housing on Charge Air Coolant Pump

24. Tighten hex bolts to specification. Refer to section A 003.

C 208.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 141 are the After-Installation Operations for the coolant distribution housing.

Level of Maintenance	Operation	Reference
1, 2, 3	Install oil filter	Refer to section C 183.05.11
1, 2, 3	Install engine oil heat exchanger	Refer to section C 185.05.05
1, 2, 3	Connect coolant lines	Refer to section C 204.05.11
1, 2, 3	Connect coolant vent lines	Refer to section C 205.05.11
1, 2, 3	Install oil centrifuge	Refer to section C 184.05.11
1, 2, 3	Connect electric cables	Refer to section C 501.05 M
1, 2, 3	Install engine mounts (KGS)	Refer to section C 231.05.11
1, 2, 3	Install fan drive	Refer to section C 221.05.11
1, 2, 3	Fill oil system with engine oil	Refer to Operators Guide
1, 2, 3	Fill engine coolant system	Refer to Operators Guide
1, 2, 3	Release engine start	Refer to Operators Guide
1, 2, 3	Vent fuel system	Refer to Operators Guide
1, 2, 3	Check for leaks	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.

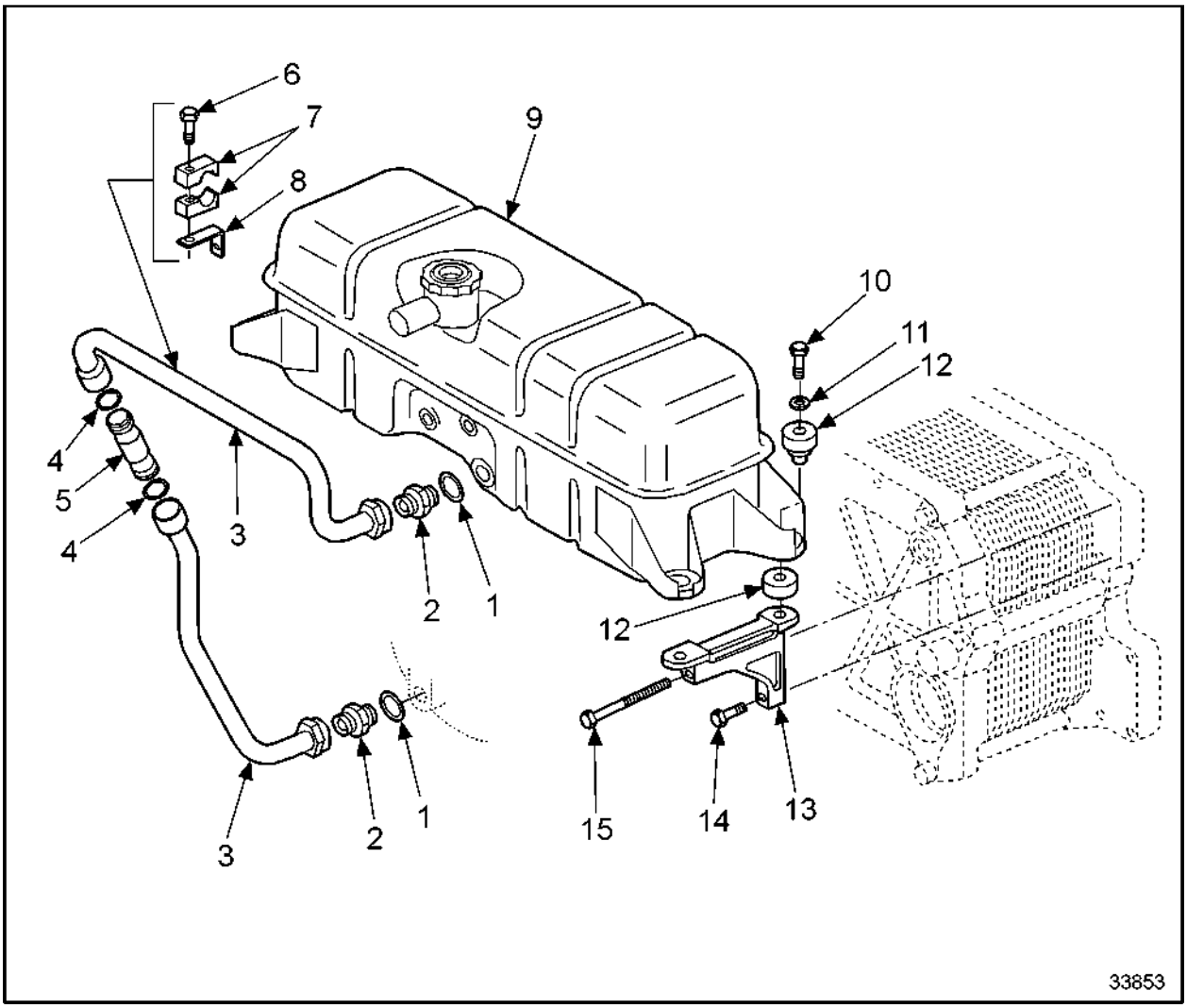
3 = The engine is to remain installed.

Table 141 After-Installation Operations

C 208.05 M – MARINE SURGE TANK

C 208.05 M – GENERAL VIEW

See Figure 997 for the surge tank parts location.



1. Sealing Ring
2. Union
3. Coolant Line
4. O-ring
5. Plug-in Pipe
6. Bolt
7. Half Pipe Clamp
8. Retainer Bracket
9. Expansion Tank
10. Bolt
11. Washer
12. Shock Mount
13. Support
14. Short Support Bolt
15. Long Support Bolt

Figure 997 General View of Surge Tank

C 208.05.04 M – BEFORE – REMOVAL OPERATIONS

Listed in Table 142are the Before – Removal Operations for the surge tank.

Level of Maintenance	Operations	Reference
1, 2, 3	Disable engine power	Refer to Operator's Guide

1 = The engine is to be completely disassembled.

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

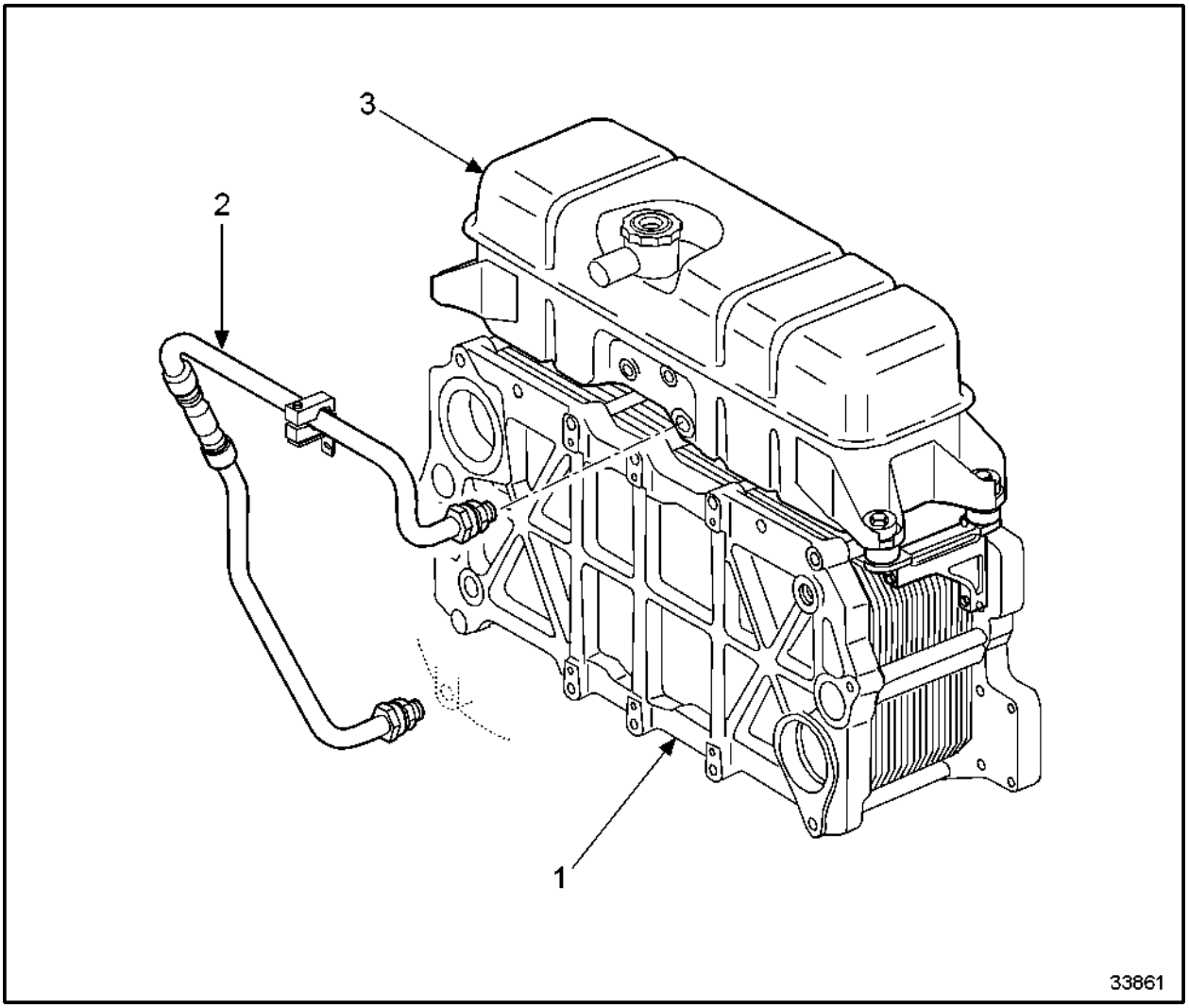
3 = The engine is to remain installed.

Table 142 Before – Removal Operations for the Surge Tank

C 208.05.05 M – REMOVAL OF THE SURGE TANK

Perform the following steps to remove the surge tank:

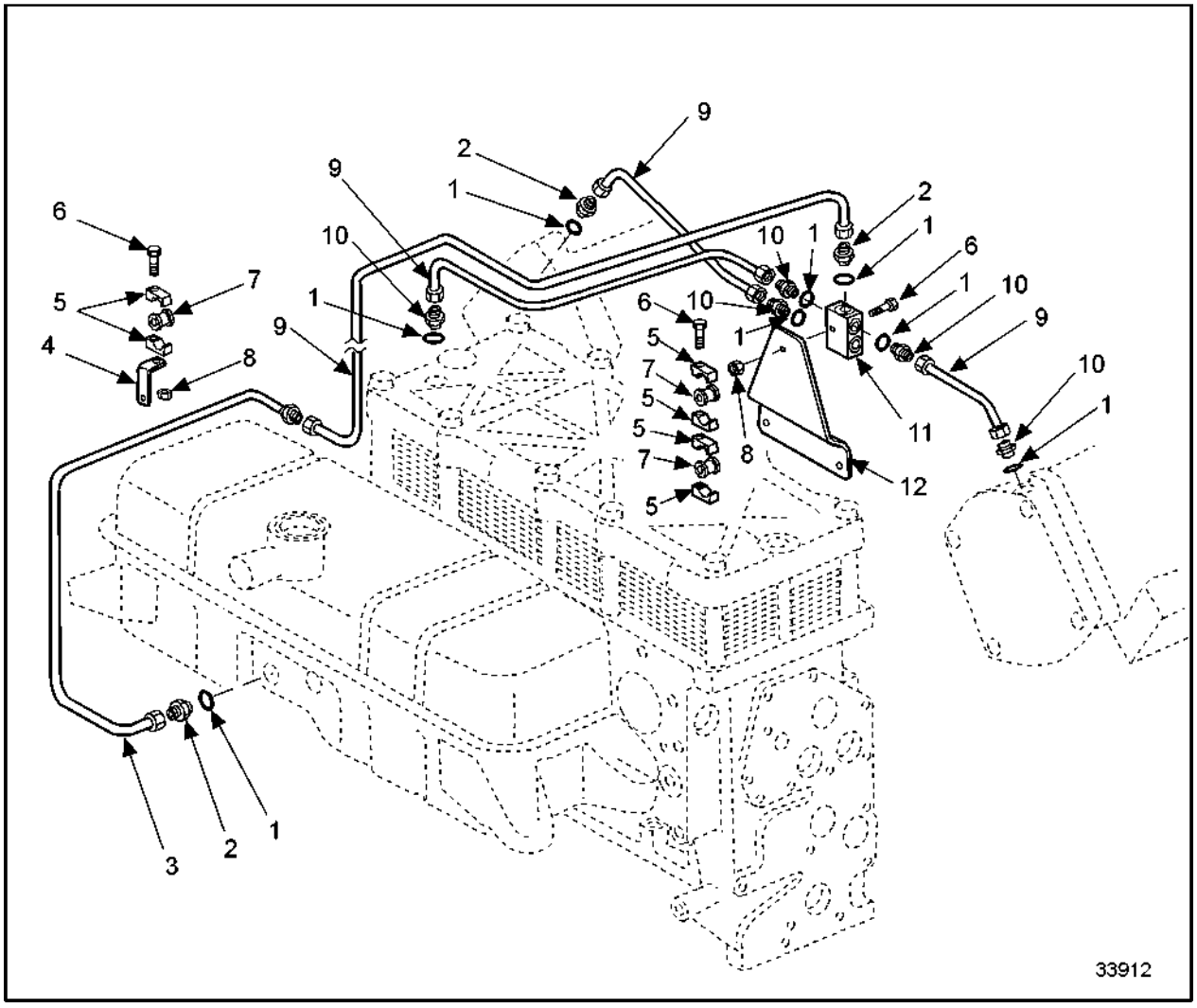
1. Disconnect the static fill line (2). See Figure 998.



1. Coolant Heat Exchanger
2. Static Fill Line
3. Surge Tank

Figure 998 Removing Static Fill Line

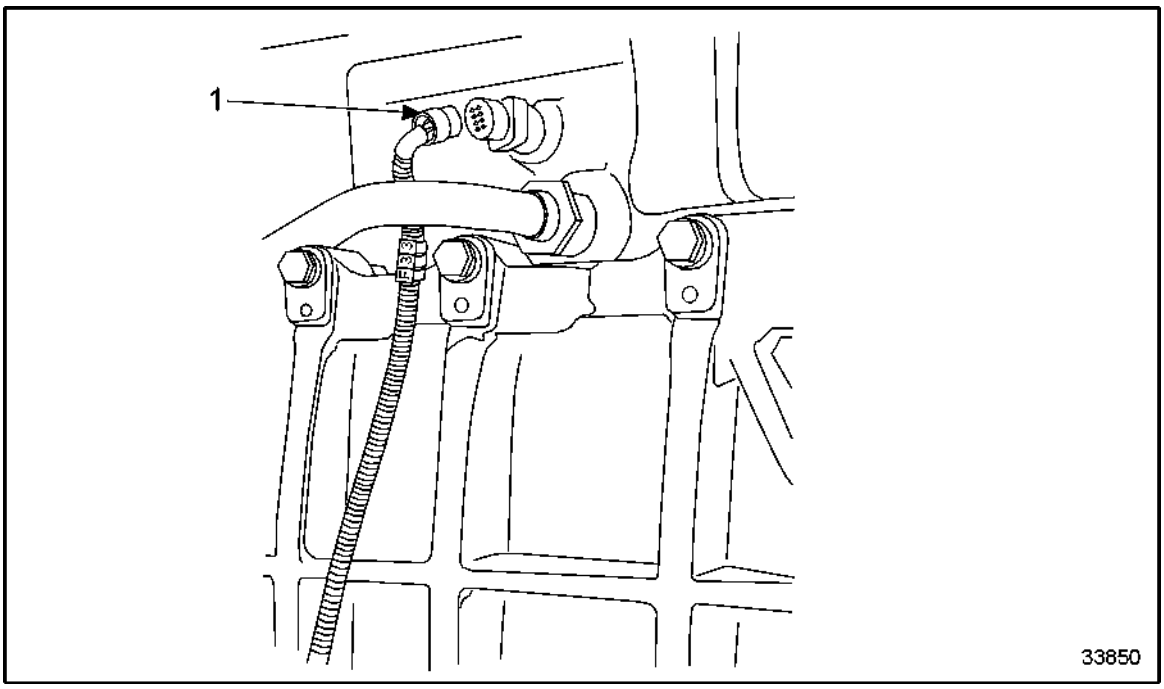
2. Disconnect the bleed line tube (3). See Figure 999.



1. Sealing Ring
2. Adaptor
3. Bleed Line
4. Bracket
5. Half Clamp
6. Bolt
7. Grommet
8. Hex Nut
9. Pipe
10. Union
11. Distributor
12. Distributor Bracket

Figure 999 Disconnecting the Bleed Line Tube

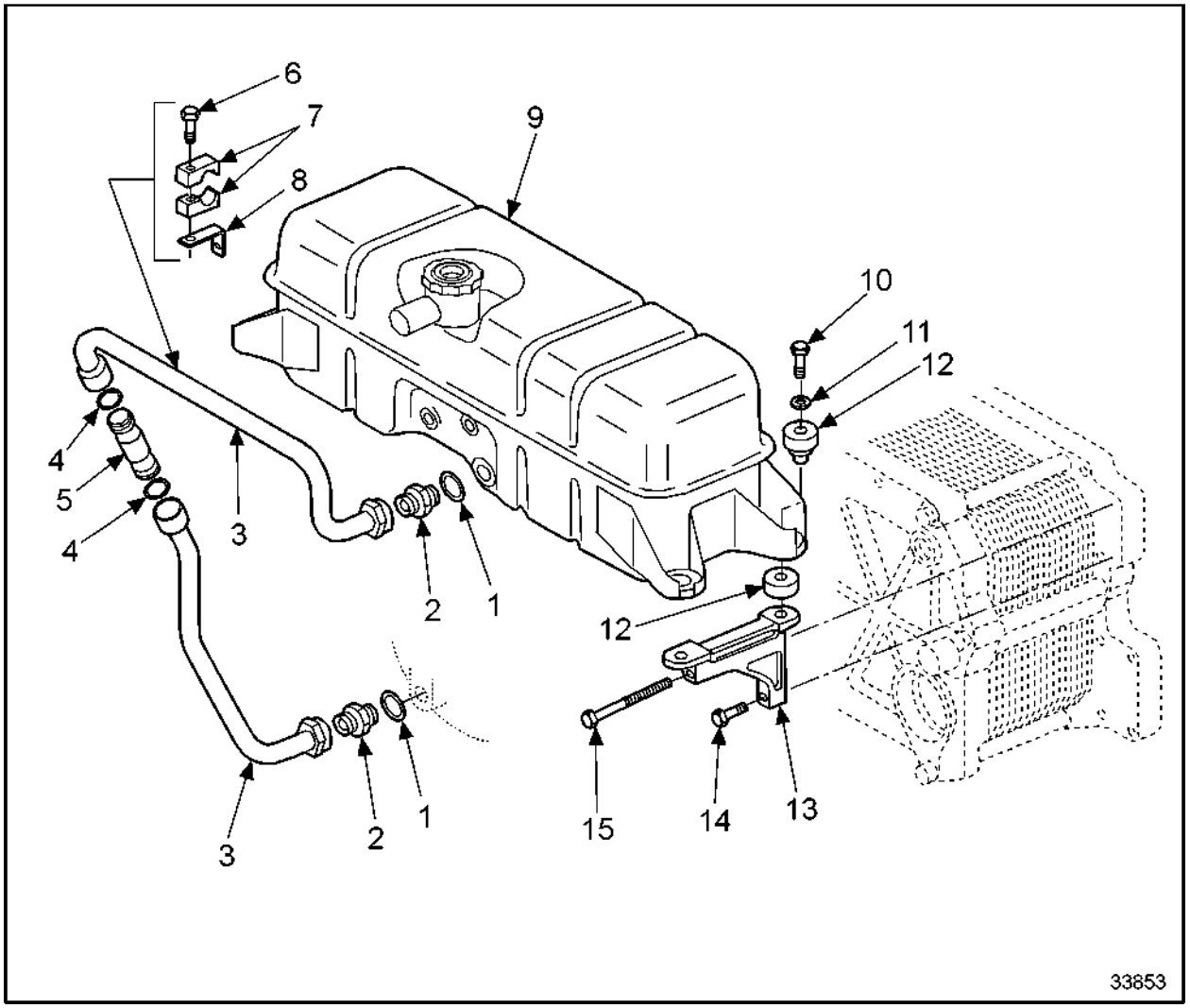
3. Disconnect the coolant level sensor (1). See Figure 1000.



1. Coolant Level Sensor

Figure 1000 Disconnecting the Coolant Level Sensor

4. Remove the four bolts (10), washers (11) and rubber mounts (12) securing the surge tank (9) to the mounting brackets (13). See Figure 1001.



1. Sealing Ring
2. Union
3. Coolant Line
4. O-ring
5. Plug-in Pipe
6. Bolt
7. Half Pipe Clamp
8. Retainer Bracket
9. Expansion Tank
10. Bolt
11. Washer
12. Shock Mount
13. Support
14. Short Support Bolt
15. Long Support Bolt

Figure 1001 Removing Surge Tank Mounting Hardware

5. Remove surge tank (9). See Figure 1001.
6. Remove the four bolts (15) and (14) securing the supports (13) to the coolant heat exchanger base plate. See Figure 1001.

C 208.05.08 M – CLEANING, INSPECTION AND REPAIR

Exterior of the Surge Tank

Perform the following steps to clean, inspect and repair the exterior of the surge tank:

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.

1. Using a cloth soaked with diesel fuel, wipe the exterior of the surge tank clean and dry with compressed air.
2. Visually inspect the surge tank for damage.
   [a] If damage is found, repair as necessary.
   [b] If damage is beyond repair, replace the surge tank.
   [c] If no damage is found, reuse the surge tank.

Interior of the Surge Tank

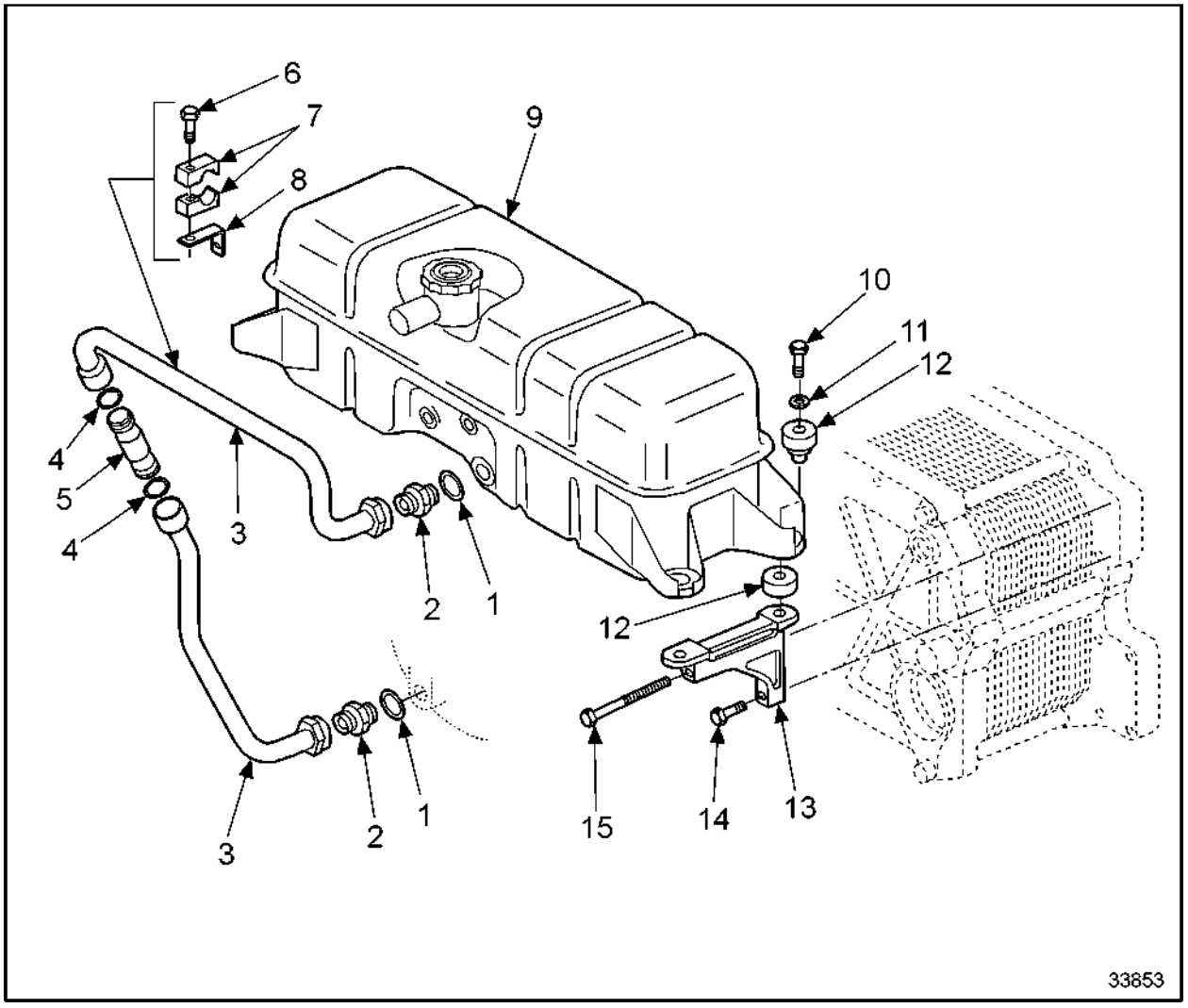
Perform the following steps to clean, inspect and repair the interior of the surge tank:

1. Rinse the interior of the surge tank with a solution of water and soap.
2. Rinse the interior of the surge tank with clean water.
3. Perform a pressure test of the surge tank to check for leaks.
   [a] If leaks are found, repair the surge tank as necessary.
   [b] If no leaks are found, reuse the surge tank.

C 208.05.11 M – INSTALLATION OF THE SURGE TANK

Perform the following steps to install the surge tank:

1. Install the supports (13) to the coolant heat exchanger base plate and secure with four bolts (15). Torque bolts to specification. Refer to section A 003. See Figure 1002.

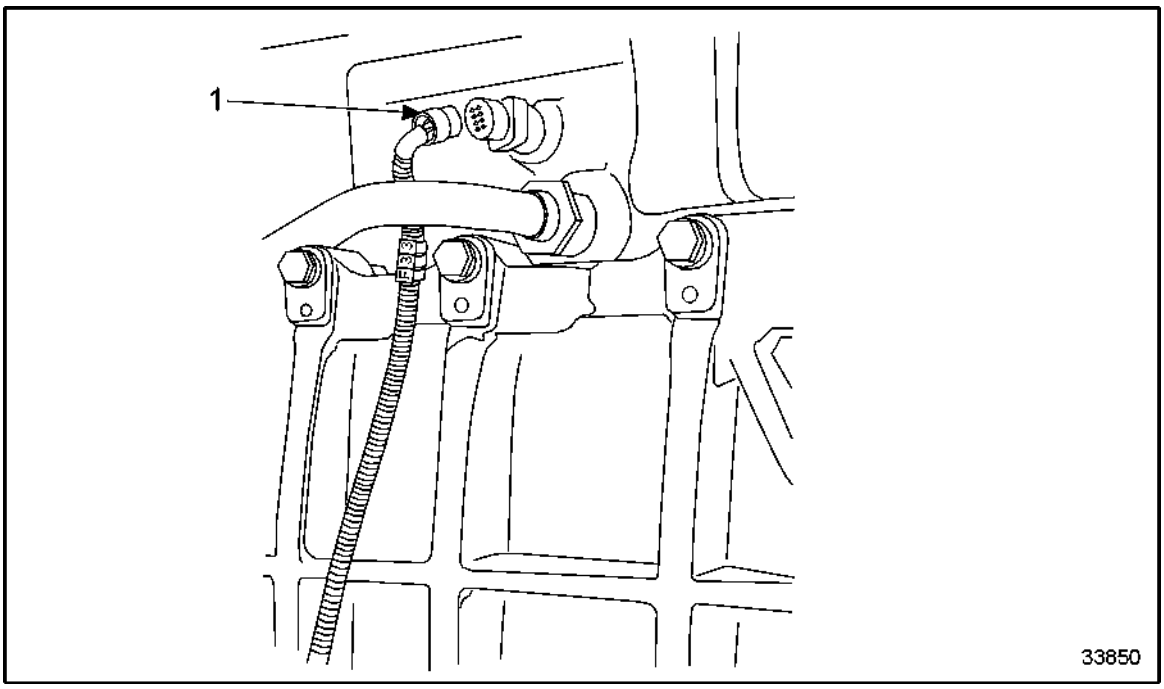


1. Sealing Ring
2. Union
3. Coolant Line
4. O-ring
5. Plug-in Pipe
6. Bolt
7. Half Pipe Clamp
8. Retainer Bracket
9. Expansion Tank
10. Bolt
11. Washer
12. Shock Mount
13. Support
14. Short Support Bolt
15. Long Support Bolt

Figure 1002 Installing Supports

2. Install the supports (13) to the coolant heat exchanger base plate and secure with four bolts (15). Torque bolts to specification. Refer to section A 003.

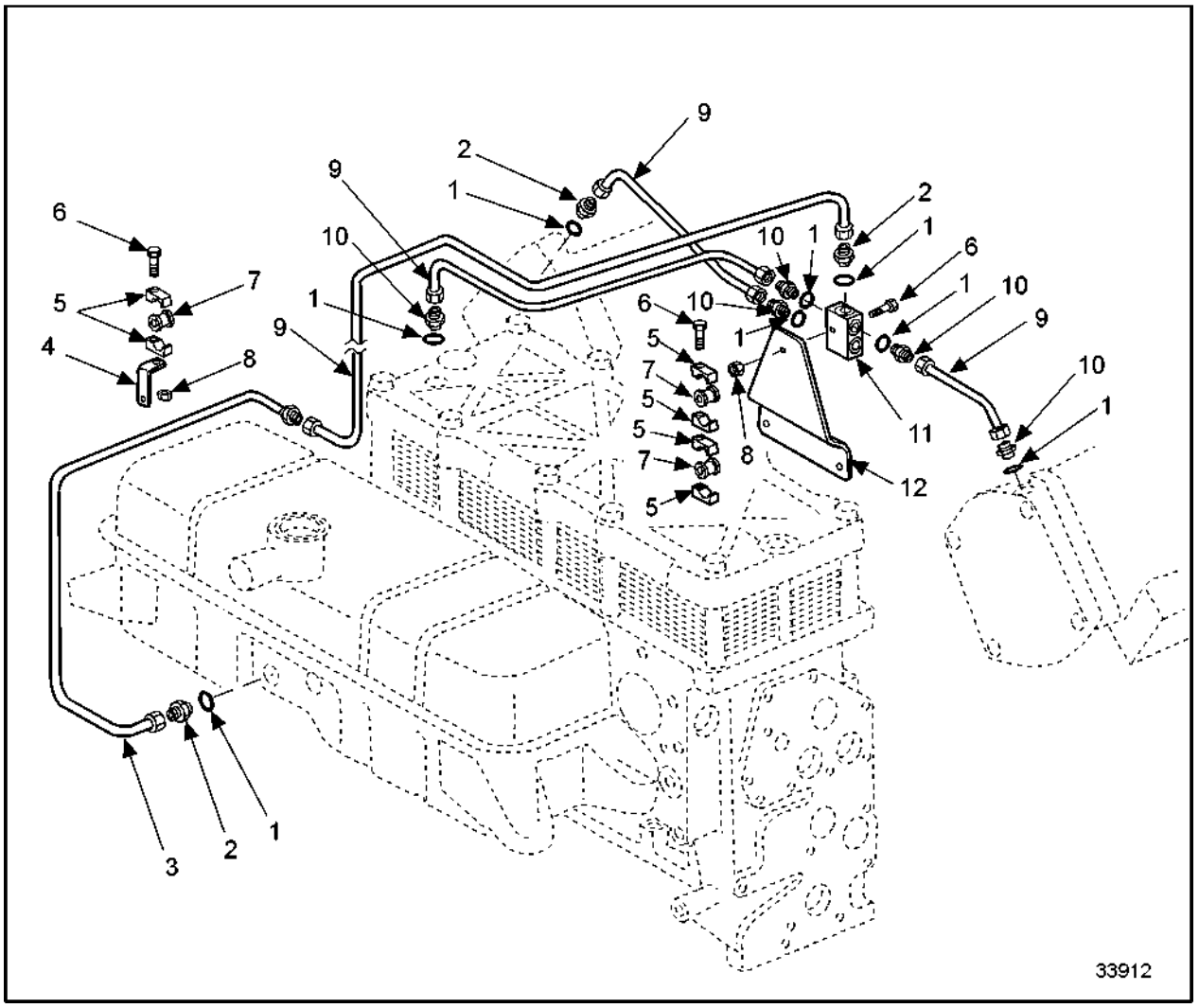
3. Install the coolant level sensor (1) and connect the wiring harness. See Figure 1003.



1. Coolant Level Sensor

Figure 1003 Installing the Coolant Level Sensor

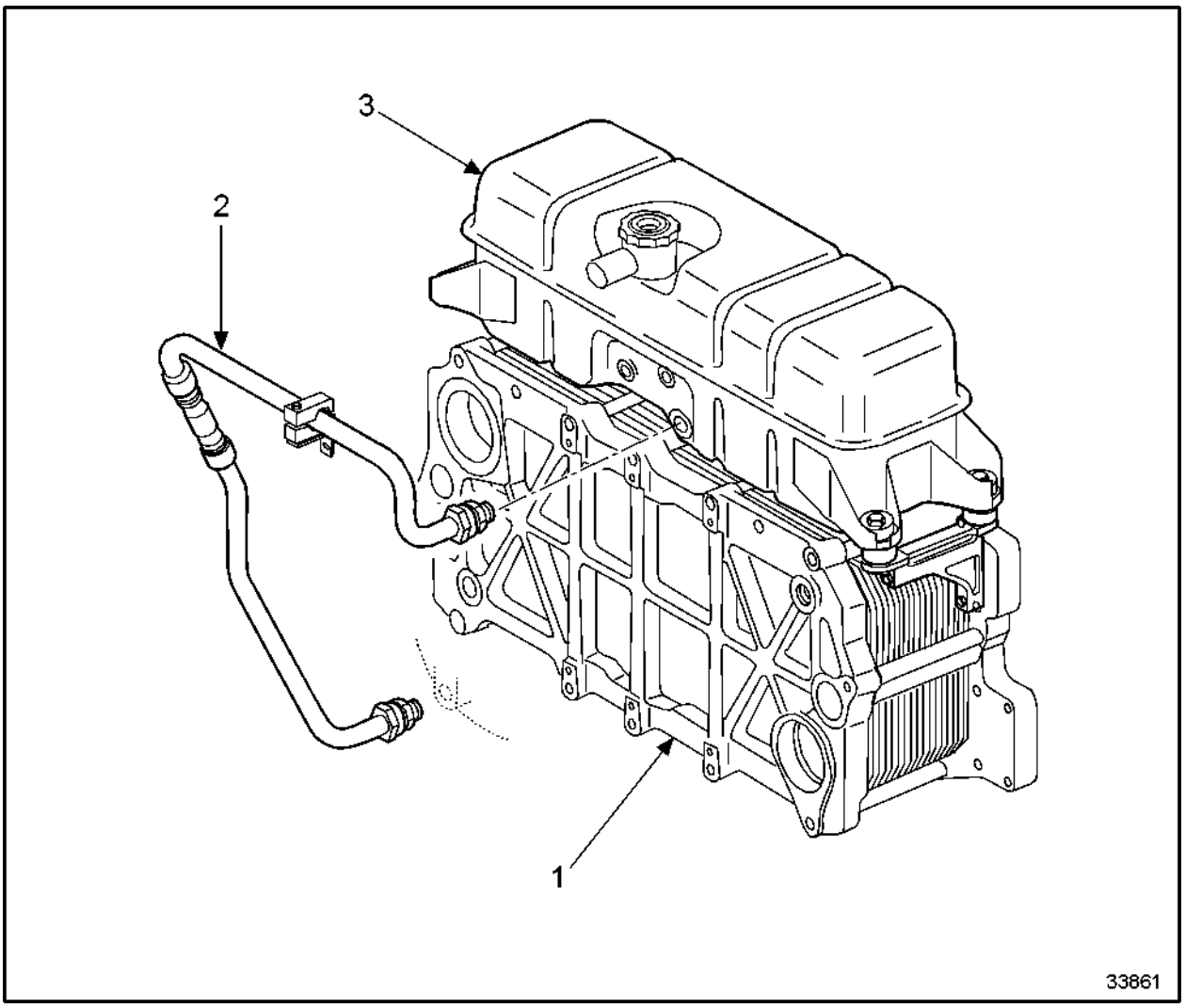
4. Install the bleed line (3). See Figure 1004.



1. Sealing Ring
2. Adaptor
3. Bleed Line
4. Bracket
5. Half Clamp
6. Bolt
7. Grommet
8. Hex Nut
9. Pipe
10. Union
11. Distributor
12. Distributor Bracket

Figure 1004 Installing the Bleed Line Tube

5. Connect the static fill line. See Figure 1005.



1. Coolant Heat Exchanger
2. Static Fill Line
3. Surge Tank

Figure 1005 Installing the Static Fill Line

6. Verify repair of the surge tank.

C 208.05.12 M – AFTER – INSTALLATION OPERATIONS

Listed in Table 143.

Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operator's 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 143 After-Installation Operations for the Surge Tank

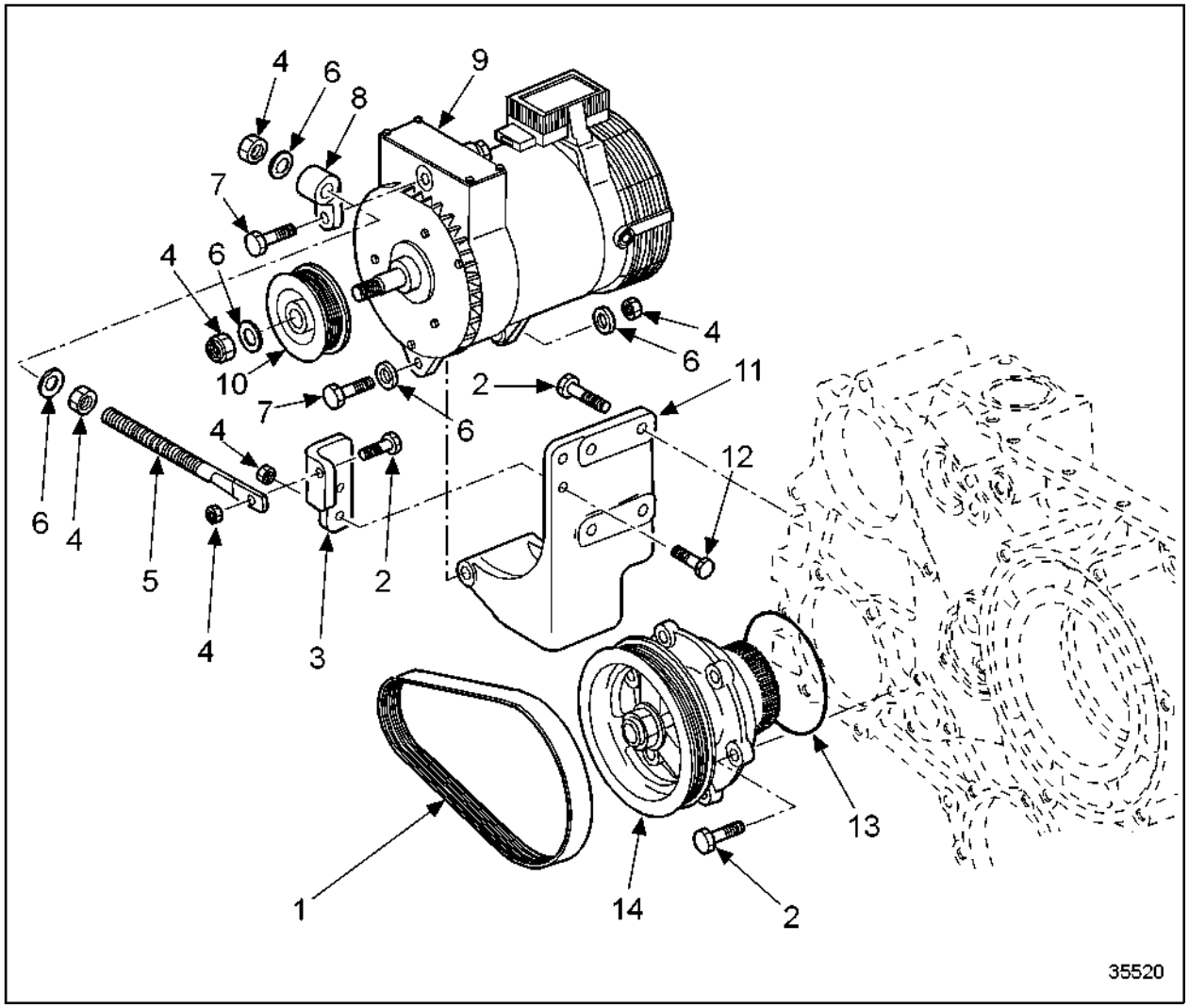
C 210 – BATTERY CHARGING ALTERNATOR

Section **Page**

C 213.05 – ALTERNATOR

C 213.05.01 – OVERVIEW DRAWING OF BATTERY CHARGING ALTERNATOR

See Figure 1006 for a general view of the battery charging alternator.



1. V-Belt
2. Hex Bolt
3. Bracket
4. Hex Nut
5. Stud
6. Washer
7. Bolt
8. Link
9. Alternator
10. Belt Pulley
11. Alternator Mount Bracket
12. Hex Bolt
13. O-ring
14. Alternator Drive

Figure 1006 General View of Battery Charging Alternator

C 213.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 144 are the Before-Removal Operations for the battery charging alternator.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Mark and disconnect electric cables	—
1, 2, 3	Remove protective guard	—

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.

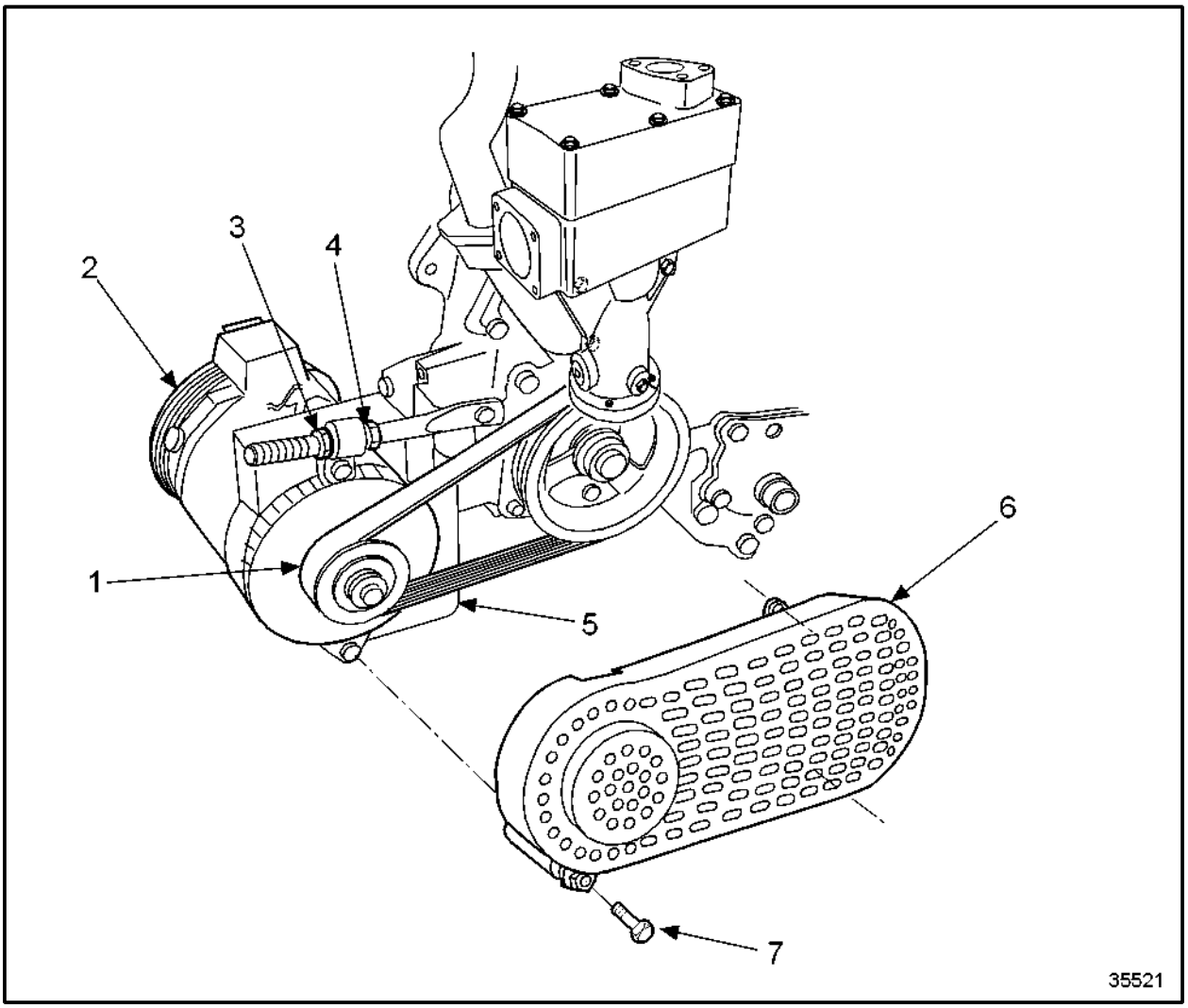
Table 144 Before-Removal Operations

C 213.05.05 – REMOVAL OF BATTERY CHARGING ALTERNATOR

Perform the following steps for the removal of the battery charging alternator:

NOTE:
Before removal, ensure that the negative battery pole is disconnected.

1. Loosen the clamping nut (4). See Figure 1007.

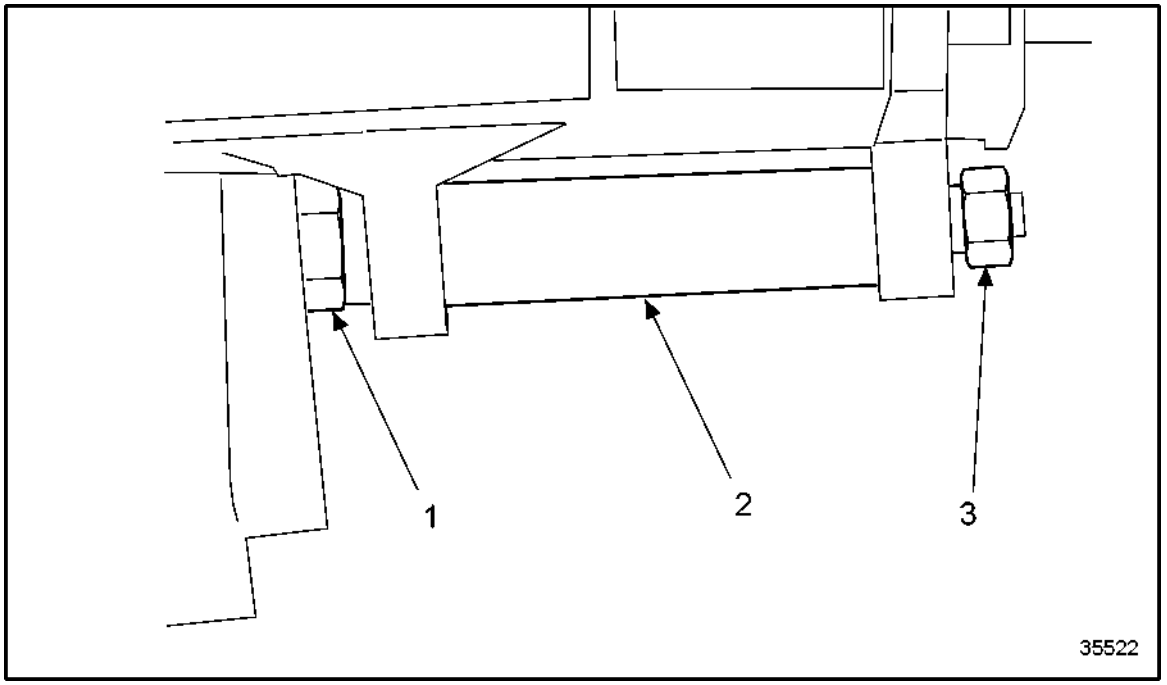


1. V-Belt
2. Alternator
3. Locknut
4. Clamping Nut
5. Alternator Mount Bracket

Figure 1007 Removing V-belt from Alternator

2. Tilt alternator in direction of engine and remove V-belt (1).

3. Loosen locknut (3) from stud.
4. Loosen nut (3) and remove hex bolt (1) from alternator mount bracket (2). See Figure 1008.

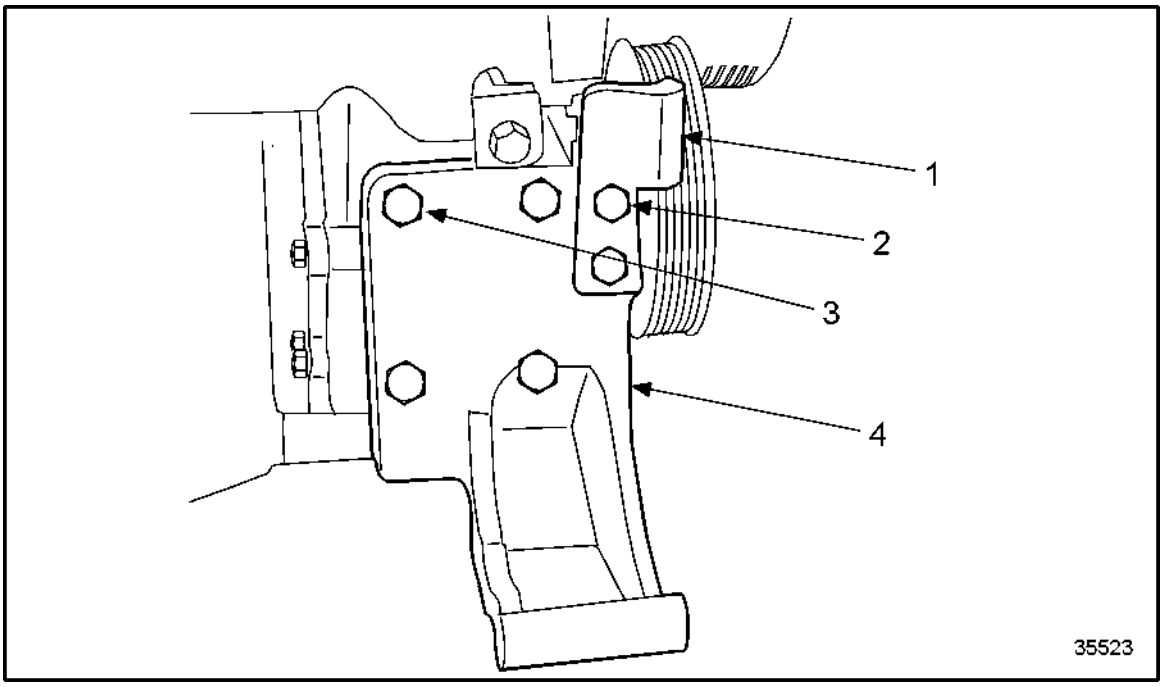


1. Hex Bolt
2. Alternator Mount Bracket
3. Nut

Figure 1008 Removing Nut and Hex Bolt from Alternator Mount Bracket

5. Carefully pull down alternator.

6. To remove the alternator mount bracket, loosen hex bolts (3) and remove alternator mount bracket (4). See Figure 1009.

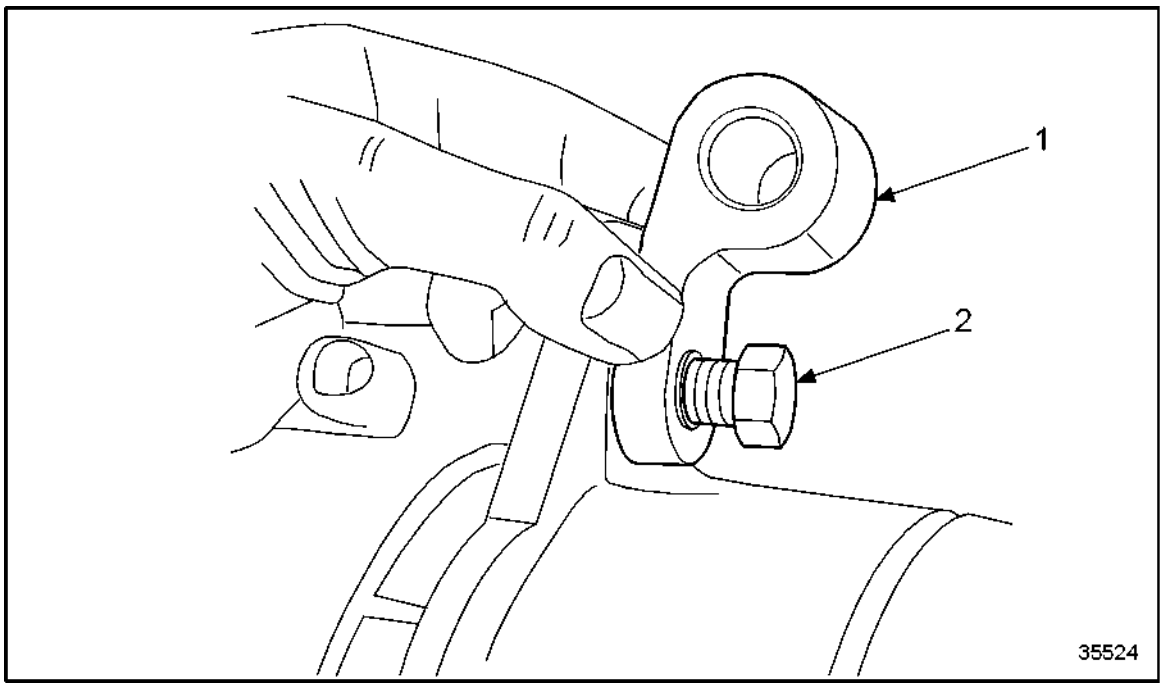


1. Bracket
2. Hex Bolt
3. Hex Bolt
4. Alternator Mount Bracket

Figure 1009 Removing Alternator Mount Bracket

7. Loosen nut (not shown) from hex bolt (2) and remove bracket (1)

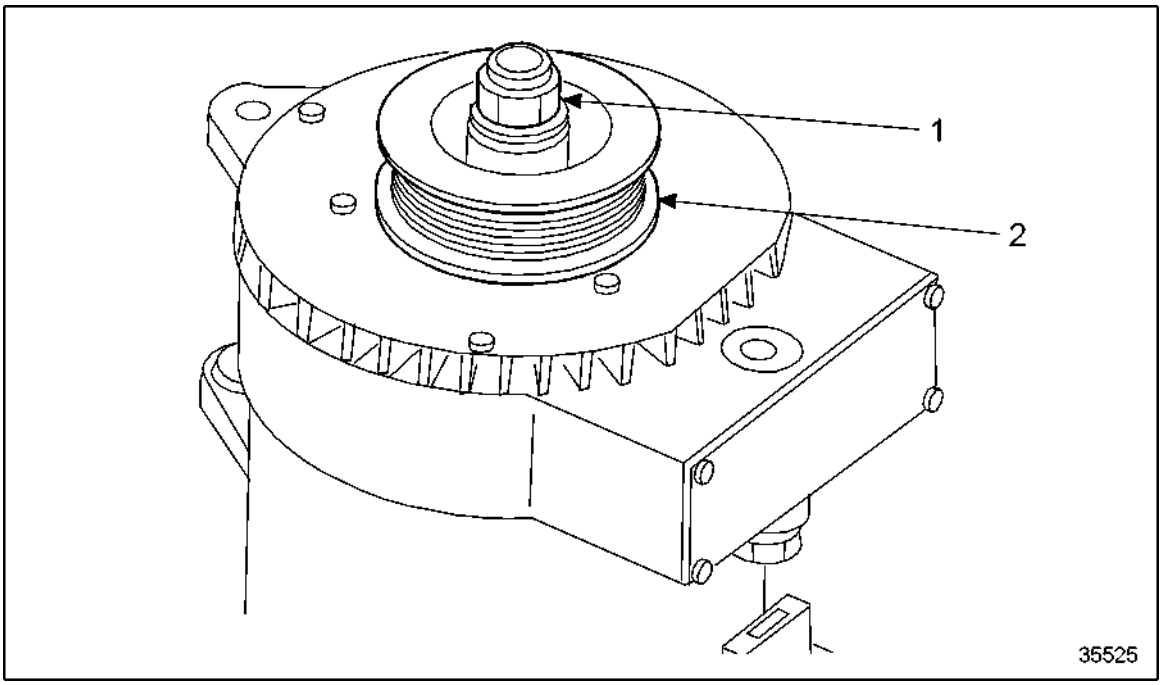
8. Loosen hex bolt (2) and remove link (1) from alternator. See Figure 1010.



1. Link
2. Hex Bolt

Figure 1010 Removing Link from Alternator

9. To remove pulley (2) from alternator, loosen hex nut (1) while holding alternator shaft in position with Allen key. See Figure 1011.

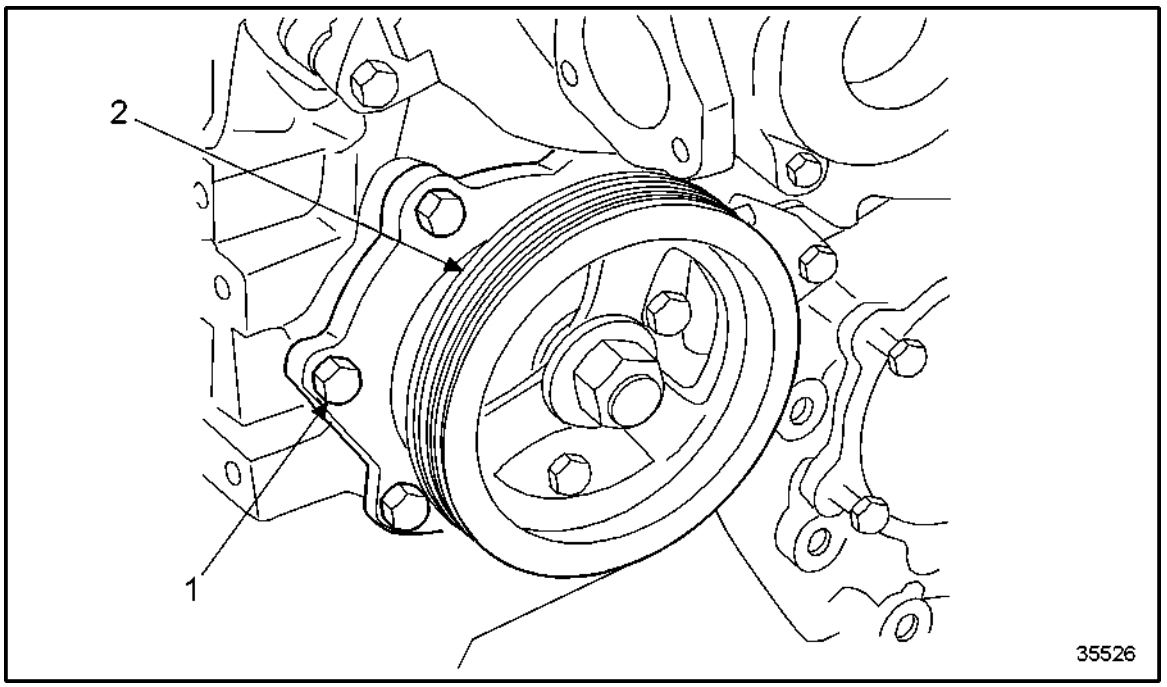


1. Hex Nut
2. Belt Pulley

Figure 1011 Removing Pulley from Alternator

10. Remove pulley (2) from shaft.

11. To remove alternator drive, loosen hex bolts (1). See Figure 1012.



1. Hex Bolt
2. Alternator Drive

Figure 1012 Removing Alternator Drive

12. Carefully remove alternator drive (2) from gear case.

C 213.05.06 – DISASSEMBLY OF BATTERY CHARGING ALTERNATOR

For disassembly of battery charging alternator, refer to OEM guidelines.

C 213.05.08 – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the battery charging alternator:

1. Clean all components and visually inspect for damage.
   [a] If components are damaged, replace as necessary.
   [b] If components are not damaged, continue inspection.
2. Visually inspect outside of alternator for damage and defects.
   [a] If outside of alternator shows damage or defects, replace as necessary.
   [b] If outside of alternator does not show damage or defects, continue inspection.
3. Inspect individual parts of alternator for damage or wear.
   [a] If individual parts of alternator show damage or wear, repair in accordance with OEM Guidelines.
   [b] If individual parts of alternator do not show damage or wear, continue inspection.
4. Visually inspect all mating surfaces for wear or damage.
   [a] If mating surfaces show damage or wear, rub down with oilstone or emery cloth as necessary.
   [b] If damage or wear is beyond repair, replace component as necessary.
   [c] If mating surfaces do not show damage or wear, continue inspection.
5. Visually inspect threads for damage or wear.
   [a] If threads are worn or damaged, rechase as necessary.
   [b] If components are beyond repair, replace as necessary.
   [c] If threads do not show damage or wear, continue inspection.
6. Inspect alternator drive for abnormal running noises.
   [a] If alternator drive exhibits abnormal running noises, replace component if necessary.
   [b] If alternator does not exhibit abnormal running noises, continue inspection.
7. Always replace V-belt during major overhaul.

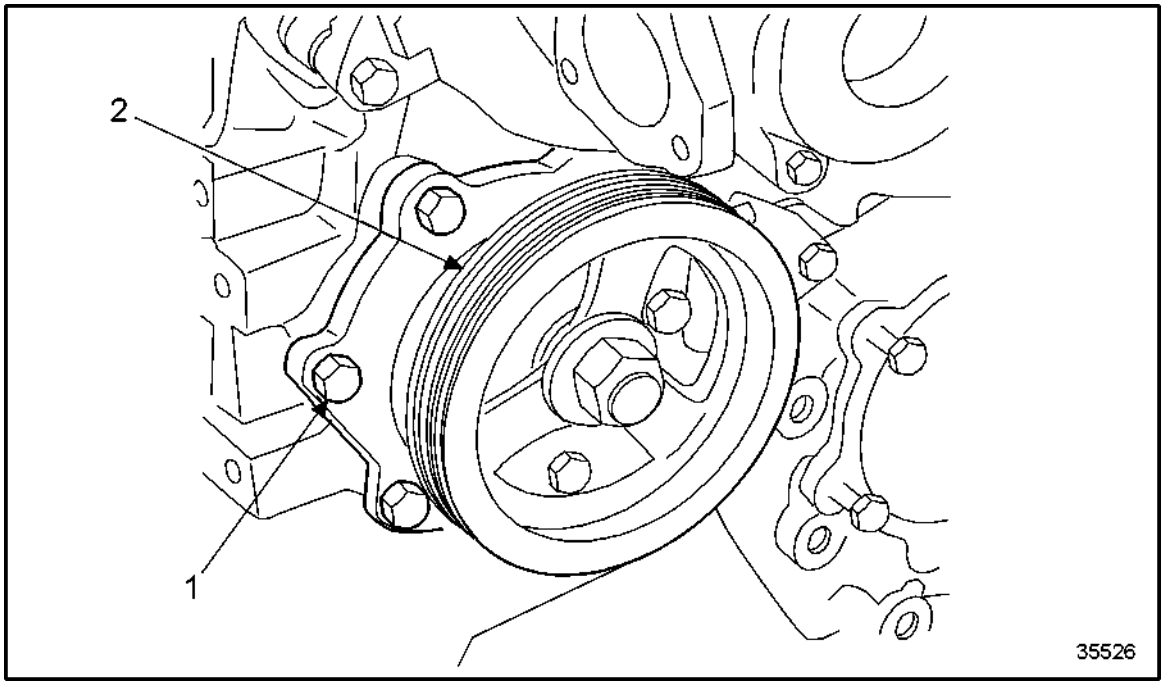
C 213.05.10 – ASSEMBLY OF BATTERY CHARGING ALTERNATOR

For assembly of battery charging alternator, refer to OEM guidelines.

C 213.05.11 – INSTALLATION OF BATTERY CHARGING ALTERNATOR

Perform the following steps for installation of the battery charging alternator:

1. Install alternator drive (2) carefully into gear case. See Figure 1013



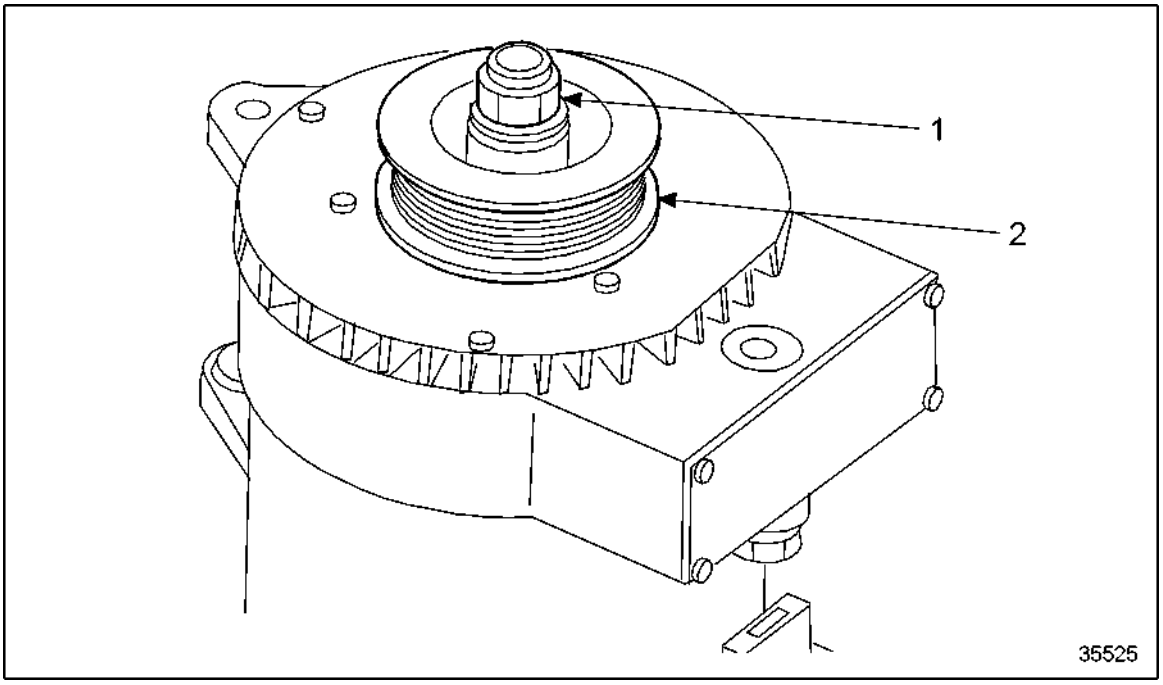
1. Hex Bolt
2. Alternator Drive

Figure 1013 Installing Alternator Drive

NOTE:
Ensure the drive gear engages the idler gear.

2. Install the hex bolts (1) and tighten diagonally and evenly to specification. Refer to sectionA 003.

3. To mount pulley on alternator, place pulley (2) on shaft. See Figure 1014



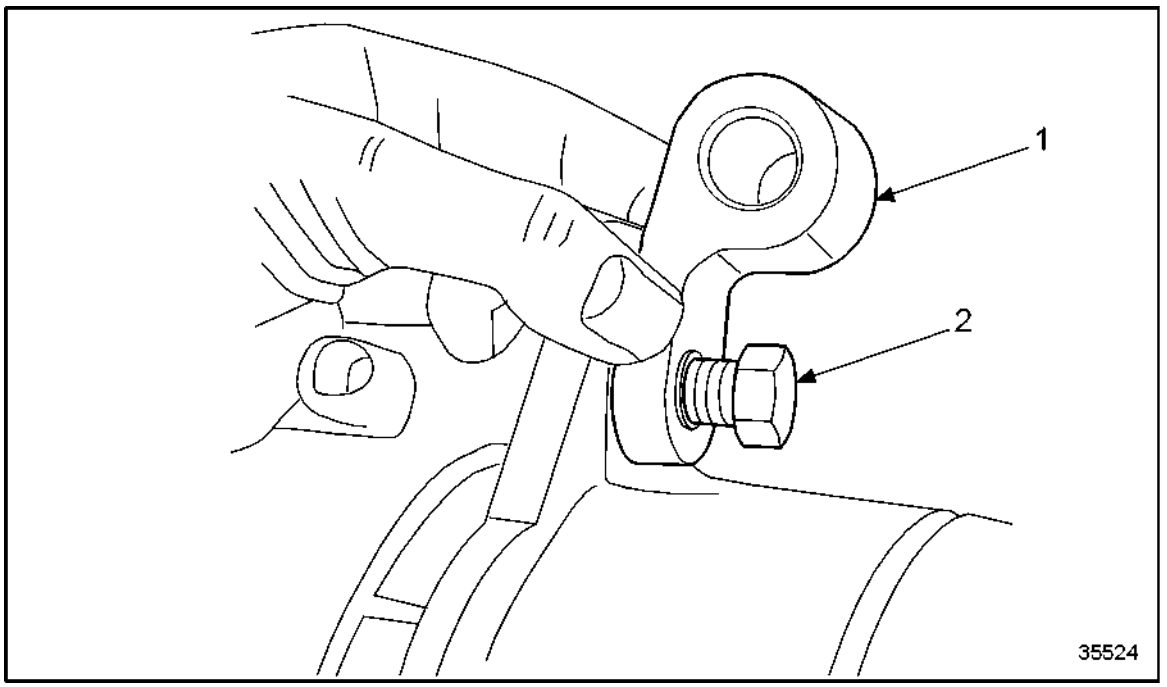
1. Hex Nut
2. Pulley

Figure 1014 Installing Pulley on Alternator

4. Install the hex nut (1) and tighten to specification. Refer to section A 003.

NOTE:
When tightening nut, hold alternator shaft in position with Allen key.

5. Install link (1) with hex bolt (2) on alternator. See Figure 1015



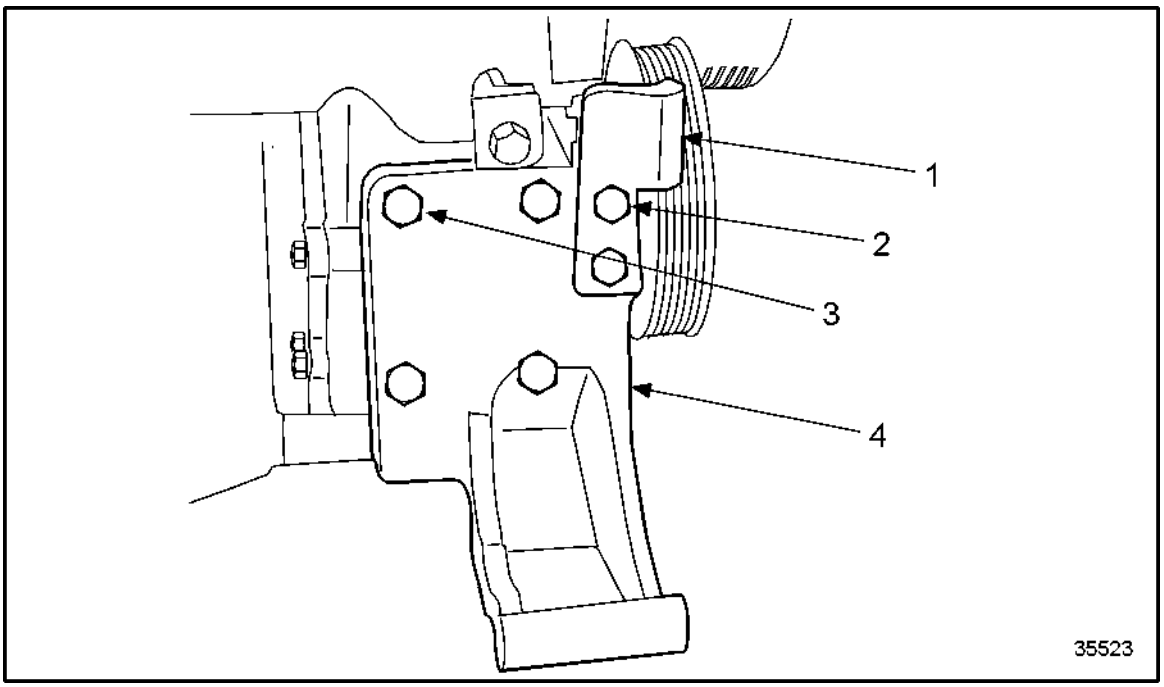
1. Link
2. Hex Bolt

Figure 1015 Installing Link on Alternator

NOTE:
Install hex bolts and hand tighten so that link can be moved to align with alternator.

6. When alternator has been installed, tighten hex bolt to specification. Refer to section A 003.

7. To install alternator mount bracket (4), position bracket on engine. See Figure 1016.



1. Bracket
2. Hex Bolt
3. Hex Bolt
4. Alternator Mount Bracket

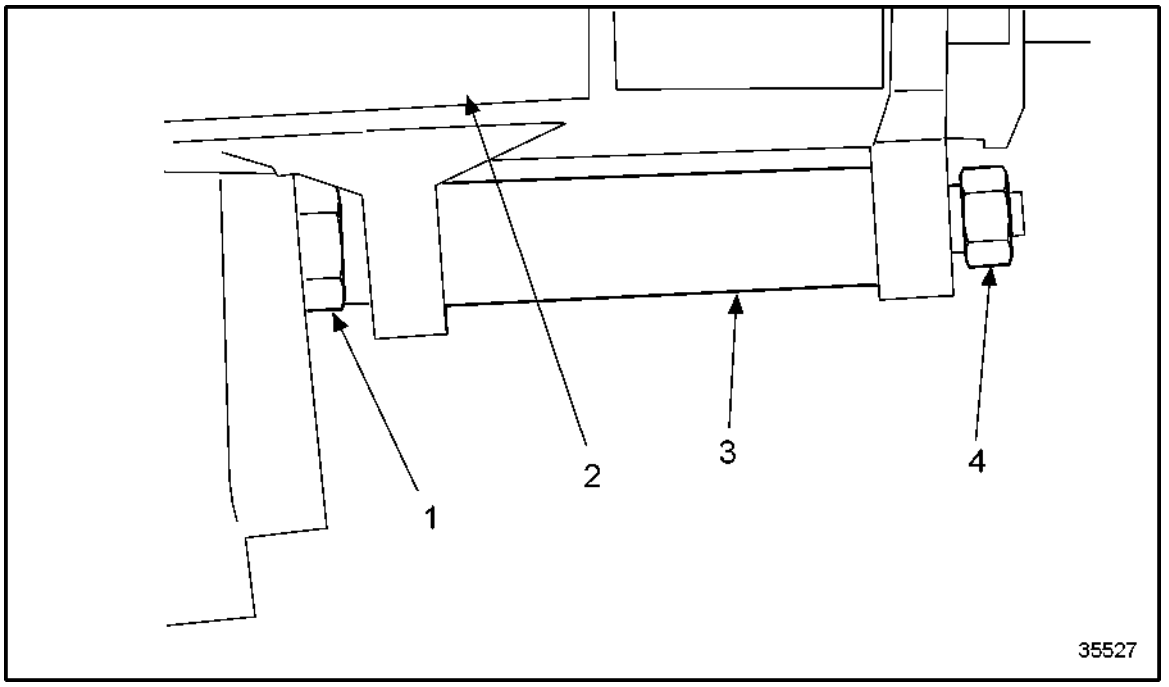
Figure 1016 Installing Alternator Mount Bracket

8. Install hex bolts (3) and tighten to specification. Refer to section A 003.
9. Position stud and mounting bracket on bracket (1).
10. Install hex bolt (2) and tighten to specification. Refer to section A 003.

11. Align alternator (2) with spacer on hinge of bracket (3). See Figure 1017

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

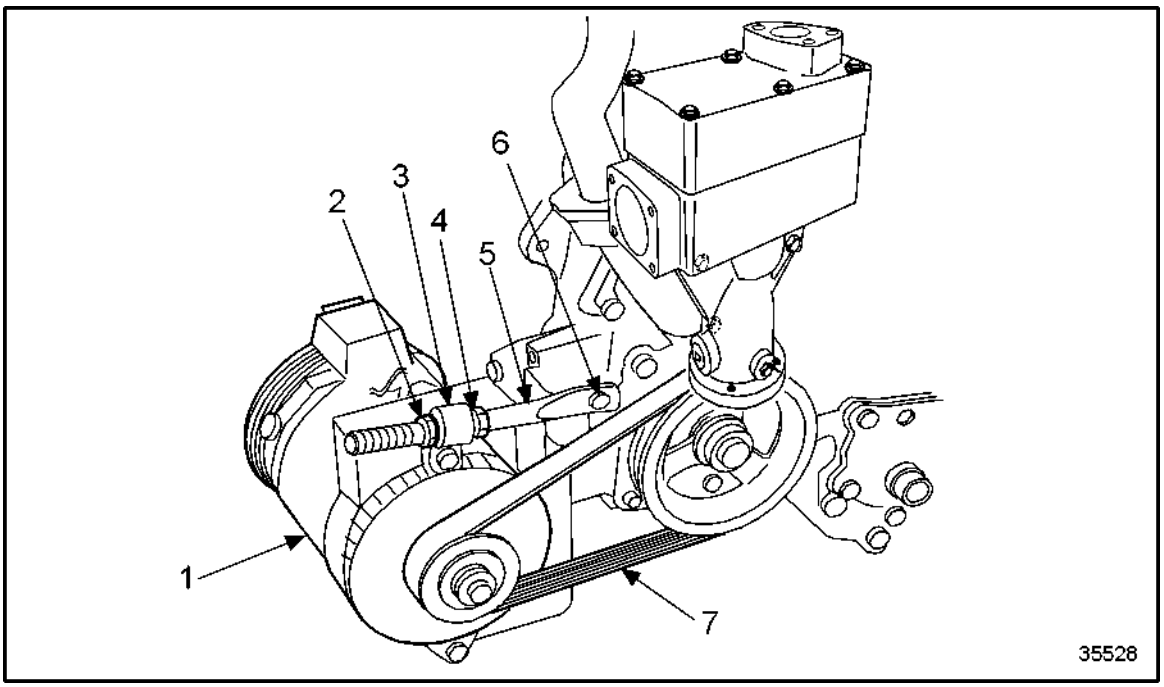


1. Hex Bolt
2. Alternator
3. Alternator Mount Bracket
4. Nut

Figure 1017 Installing Alternator

12. Install hex bolt (1) through spacer and hinge.
13. Install nut (4) on hex bolt and tighten to specification. Refer to section A 003.

14. Install clamping nut (4) on stud (5) and screw on to end of thread. See Figure 1018.

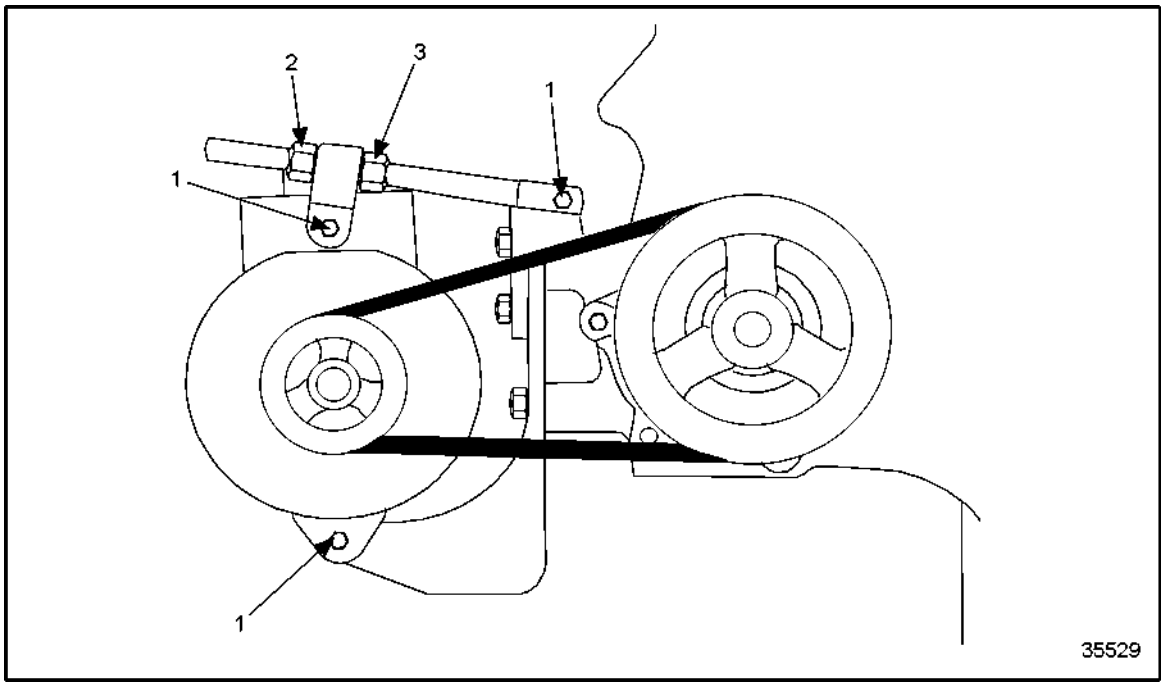


1. Alternator
2. Locknut
3. Link
4. Clamping Nut
5. Stud
6. Hex Nut
7. V-belt

Figure 1018 Installing Clamping Nut on Stud and Screwing on to End of Thread

15. Install stud into link (3) and secure with hex bolt (6) hand-tight on engine.
16. Install locknut (2) on spring pin and screw on until it engages.
17. Move the alternator (1) in direction of engine.
18. Install V-belt and pull alternator away from engine to pretension the V-belt.

19. If measured tension value does not correspond to specified value, V-belt tension must be corrected. See Figure 1019.



1. Hex Bolt
2. Locknut
3. Clamping Nut

Figure 1019 Pretensioning V-Belt

20. Loosen the locknut (2) to allow for tension adjustment
21. Tighten clamping nut (3) to tension V-belt away from engine until value on V-belt tension gage (See Figure 1020) is within the specified range.
22. Retighten locknut (2) to specification. Refer to section A 003. (See Figure 1020)
23. Tighten hex bolts (1) to specification. Refer to section A 003.
24. Again check V-belt tension.

NOTE:
If measured value does not correspond to specified value, retension V-belt.

25. To check V-belt tension, place V-belt tension gage on V-belt in center between belt pulleys. 1020

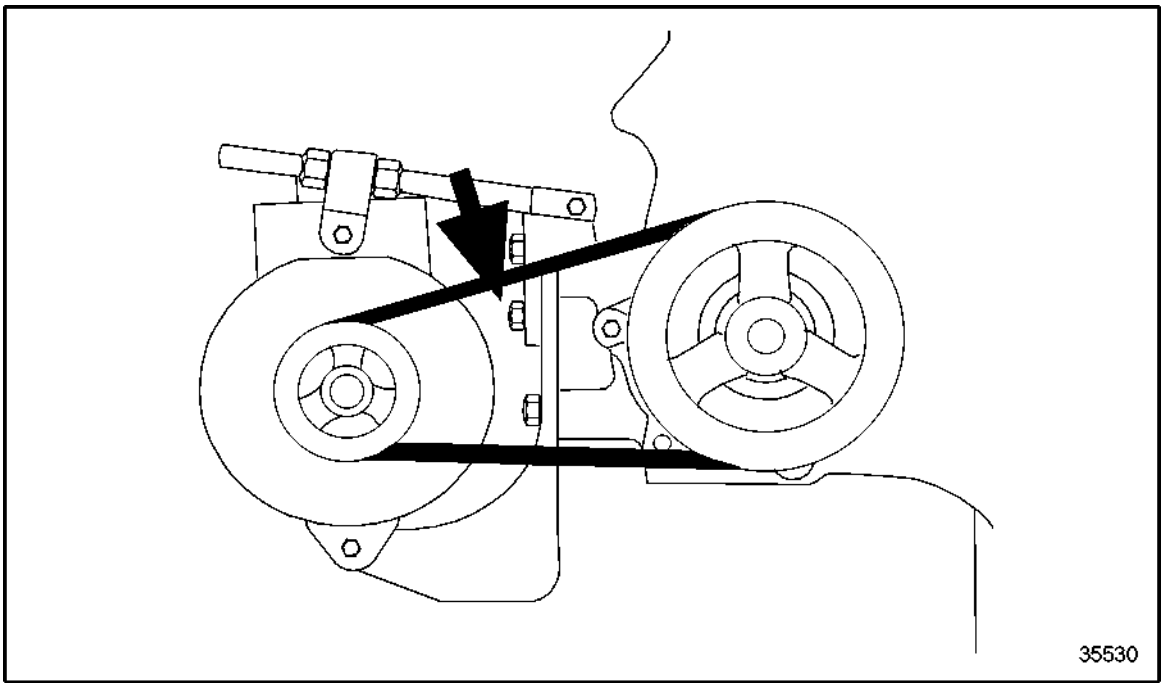


Figure 1020 Checking V-belt Tension

26. Read off measured value on display
27. Settings for new V-belt: 57–70 kg (125–155 lbs). Settings for run-in V-belt: 57–70 kg (125–155 lbs).

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.

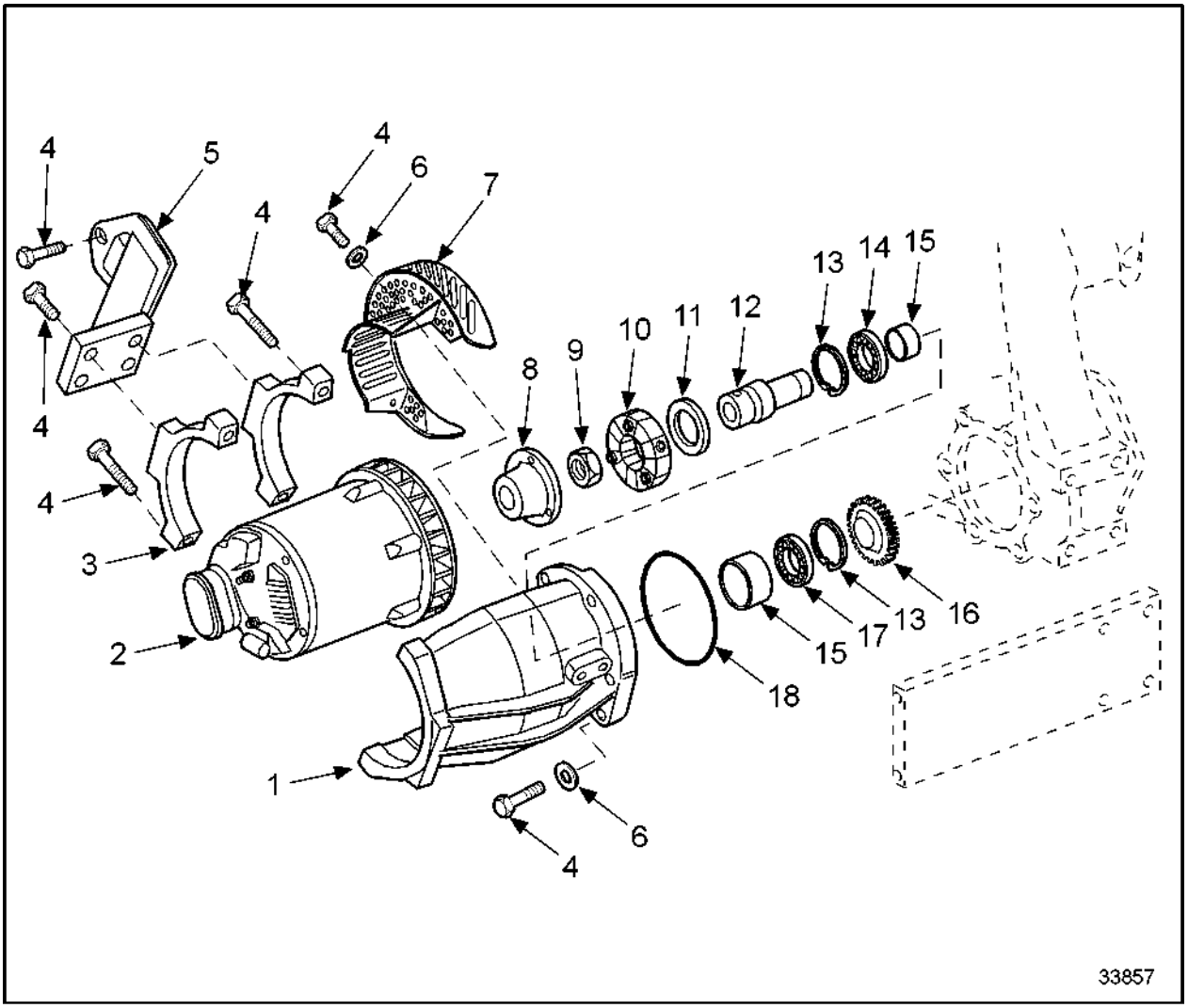
3 = The engine is to remain installed.

Table 145 After-Installation Operations

C 213.05 M – ALTERNATOR

C 213.05.01 M – GENERAL VIEW

See Figure 1021 for a general view of the alternator.



1. Alternator Bracket
2. Alternator
3. Alternator Clamp
4. Bolt
5. Alternator-to-Gear Case Mounting Bracket
6. Washer
7. Heat Shield
8. Flange
9. Hex Nut
10. Coupling
11. Oil Seal
12. Shaft
13. Snap Ring
14. Groove Ball Bearing
15. Spacer Ring
16. Gear
17. Cylinder Roller Bearing
18. O-ring

Figure 1021 General View of Alternator

C 213.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 146are the Before-Removal Operations for the alternator.

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.

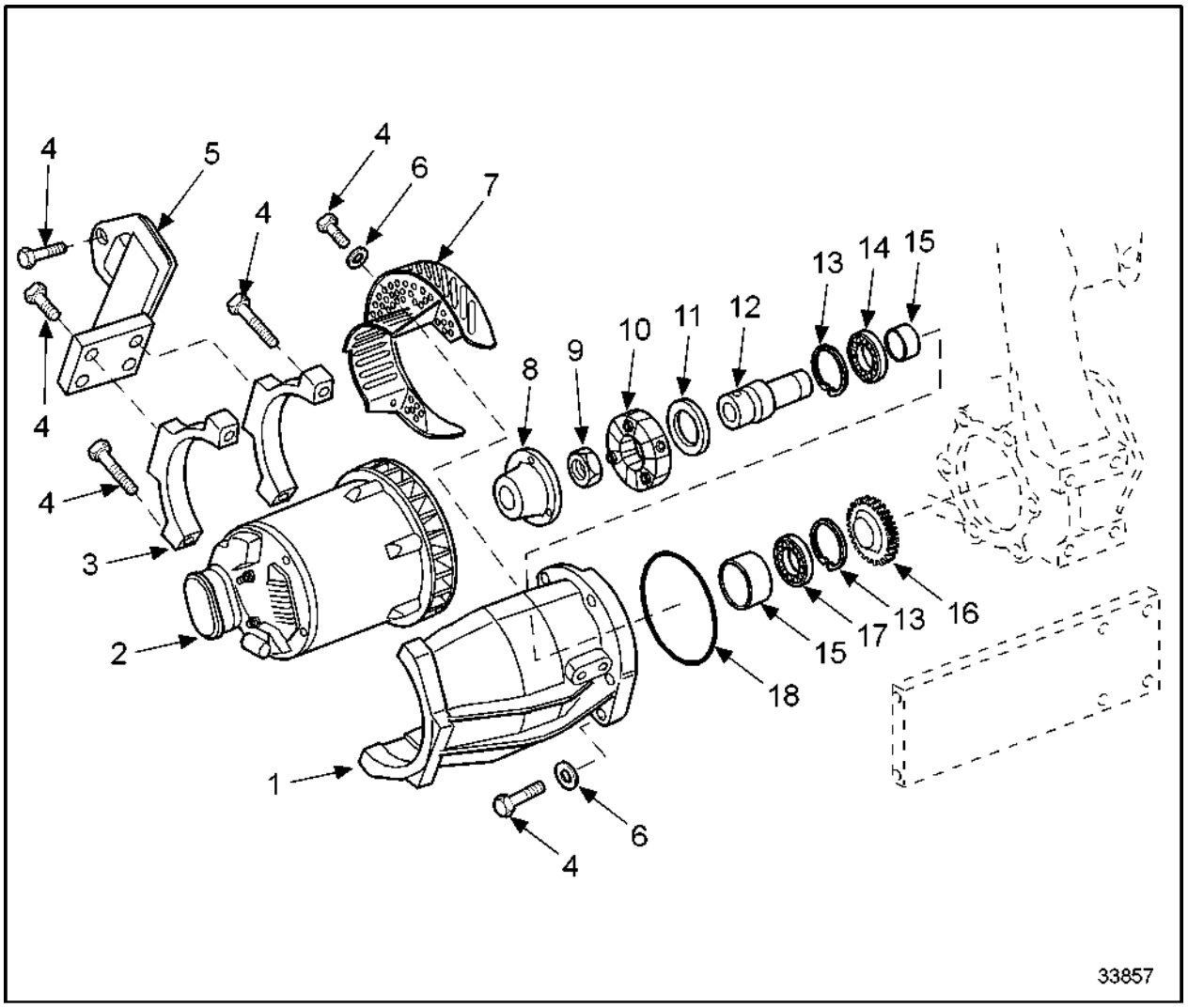
Table 146 Before-Removal Operations for the Alternator

C 213.05.05 M – REMOVAL OF THE ALTERNATOR

Perform the following steps to remove the alternator:

1. Disconnect the battery system from the engine.
2. Tag the alternator electrical leads for assembly.
3. Disconnect the electrical leads from the alternator.
4. Remove the engine harness attached to the alternator.

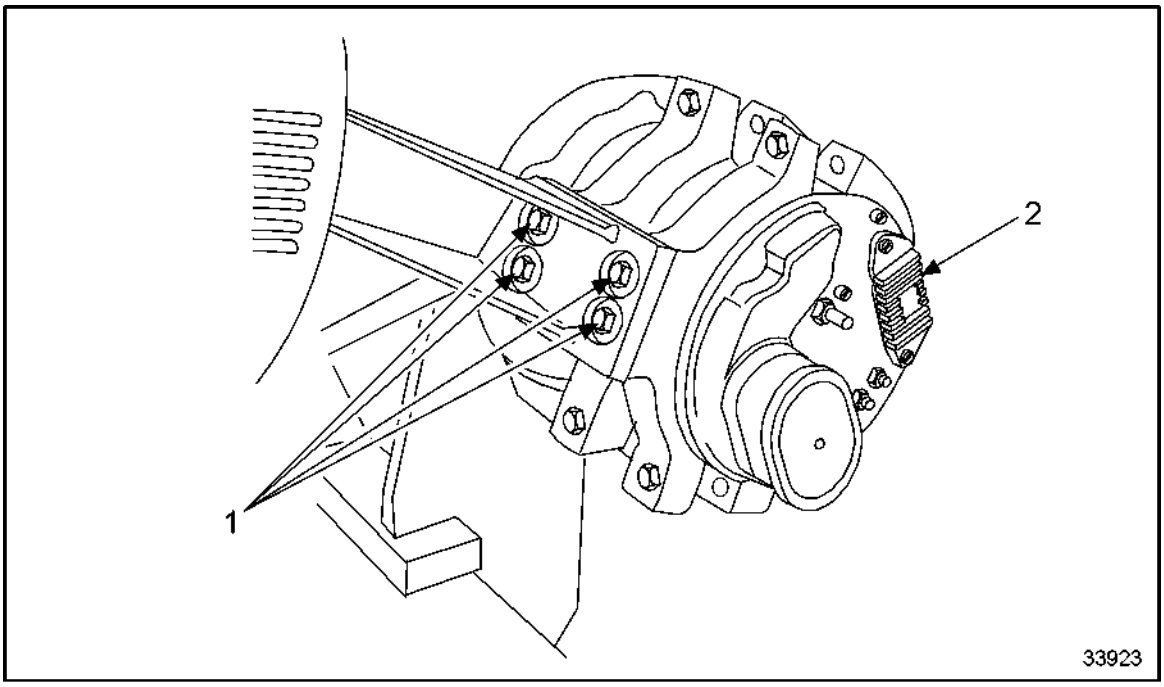
5. Remove three bolts (4) and washers (6) securing the heat shield (7) to the alternator and remove the heat shield. See Figure 1022.



1. Alternator Bracket
2. Alternator
3. Alternator Clamp
4. Bolt
5. Alternator-to-Gear Case Mounting Bracket
6. Washer
7. Heat Shield
8. Flange
9. Hex Nut
10. Coupling
11. Oil Seal
12. Shaft
13. Snap Ring
14. Groove Ball Bearing
15. Spacer Ring
16. Gear
17. Cylinder Roller Bearing
18. O-ring

Figure 1022 Removing Alternator

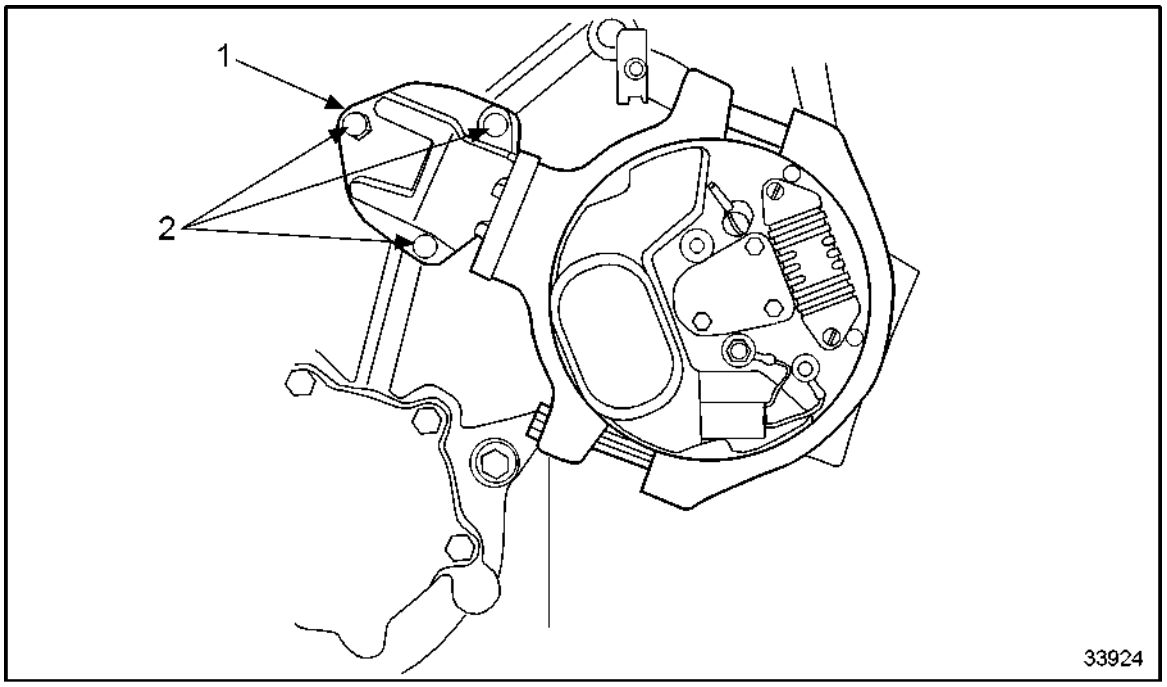
6. Remove four bolts (1) and washers securing the alternator bracket to the alternator (2). See Figure 1023.



1. Mounting Bolts
2. Alternator

Figure 1023 Removing Alternator Bracket to Alternator

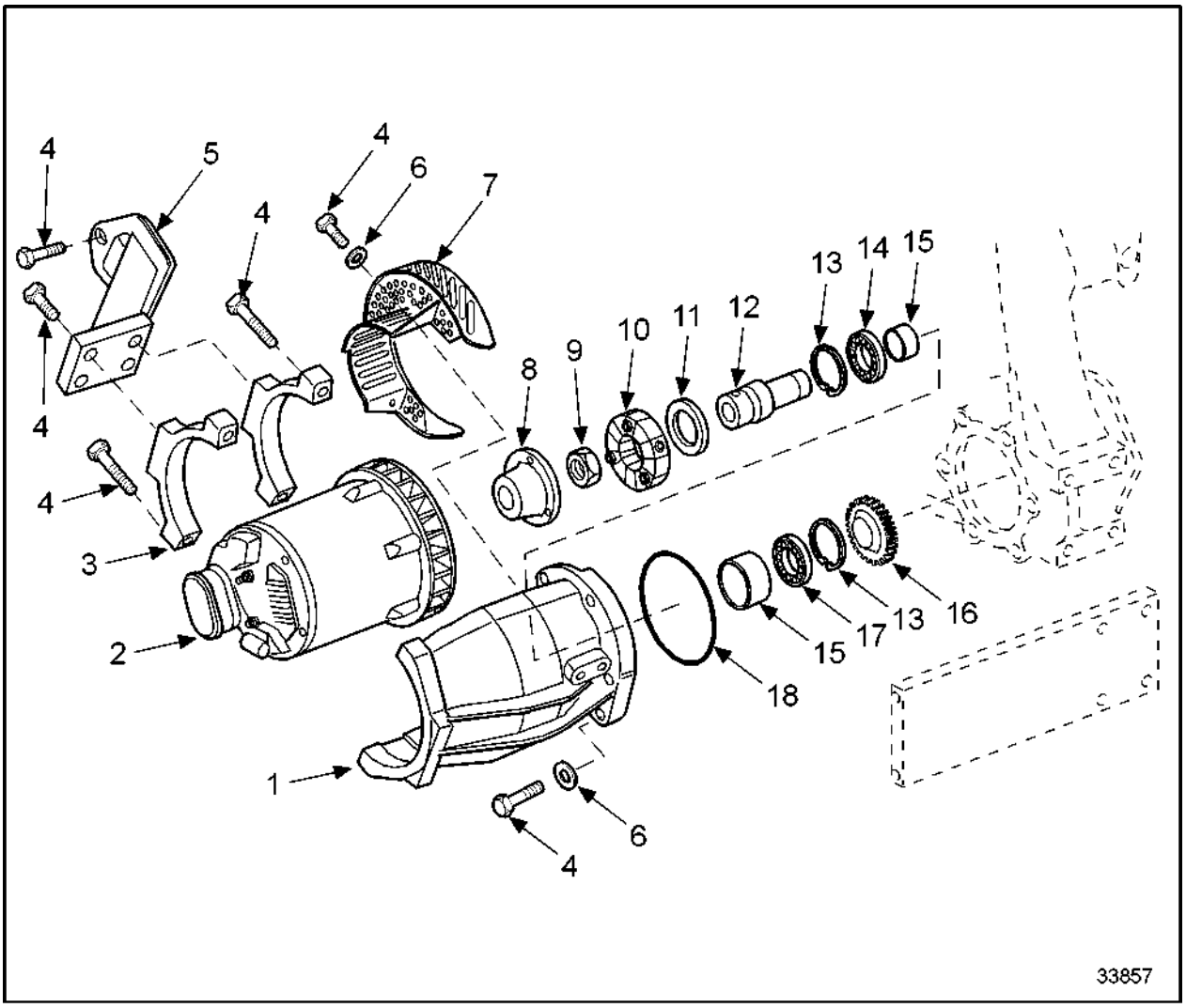
7. Remove three bolts (2) securing the alternator bracket (1) to the front cover, and remove the bracket. See Figure 1024.



1. Alternator Bracket
2. Mounting Bolts

Figure 1024 Removing Alternator Bracket to Gear Case Cover

8. Remove four bolts (4) securing the alternator clamps (3) to the alternator mounting bracket (1); remove the clamps (3). See Figure 1025.



1. Alternator Bracket
2. Alternator
3. Alternator Clamps
4. Bolt
5. Alternator-to-Gear Case Mounting Bracket
6. Washer
7. Heat Shield
8. Flange
9. Hex Nut
10. Coupling
11. Oil Seal
12. Shaft
13. Snap Ring
14. Groove Ball Bearing
15. Spacer Ring
16. Gear
17. Cylinder Roller Bearing
18. O-ring

Figure 1025 Removing Alternator from the Mounting Bracket

9. Remove the alternator (2) from the mounting bracket (5). See Figure 1025.

10. Remove six bolts (4) and spacers securing the alternator mounting bracket to the front cover. See Figure 1025.
11. Remove the alternator mounting bracket (1). See Figure 1025.

C 213.05.06 M – DISASSEMBLY OF THE ALTERNATOR

Refer to OEM guidelines to disassemble the alternator.

C 213.05.08 M – INSPECTION AND REPAIR

Perform the following steps for the inspection and repair of the alternator:

1. Inspect and repair the individual parts of the alternator in accordance with the OEM guidelines.
2. Visually inspect the outside of the alternator for damage and defects.
   [a] If the alternator is damaged or defective, repair as necessary.
   [b] If alternator is not damaged or defective, reuse the component.
3. Clean the carrier and fixtures, and visually inspect for damage.
   [a] If carrier and fixtures are damaged, replace the component as necessary.
   [b] If carrier and fixtures are not damaged, continue inspection.
4. Visually inspect the condition of the threads for damage.
   [a] If threads are damaged, repair as necessary.
   [b] If threads are not damaged, reuse the component.

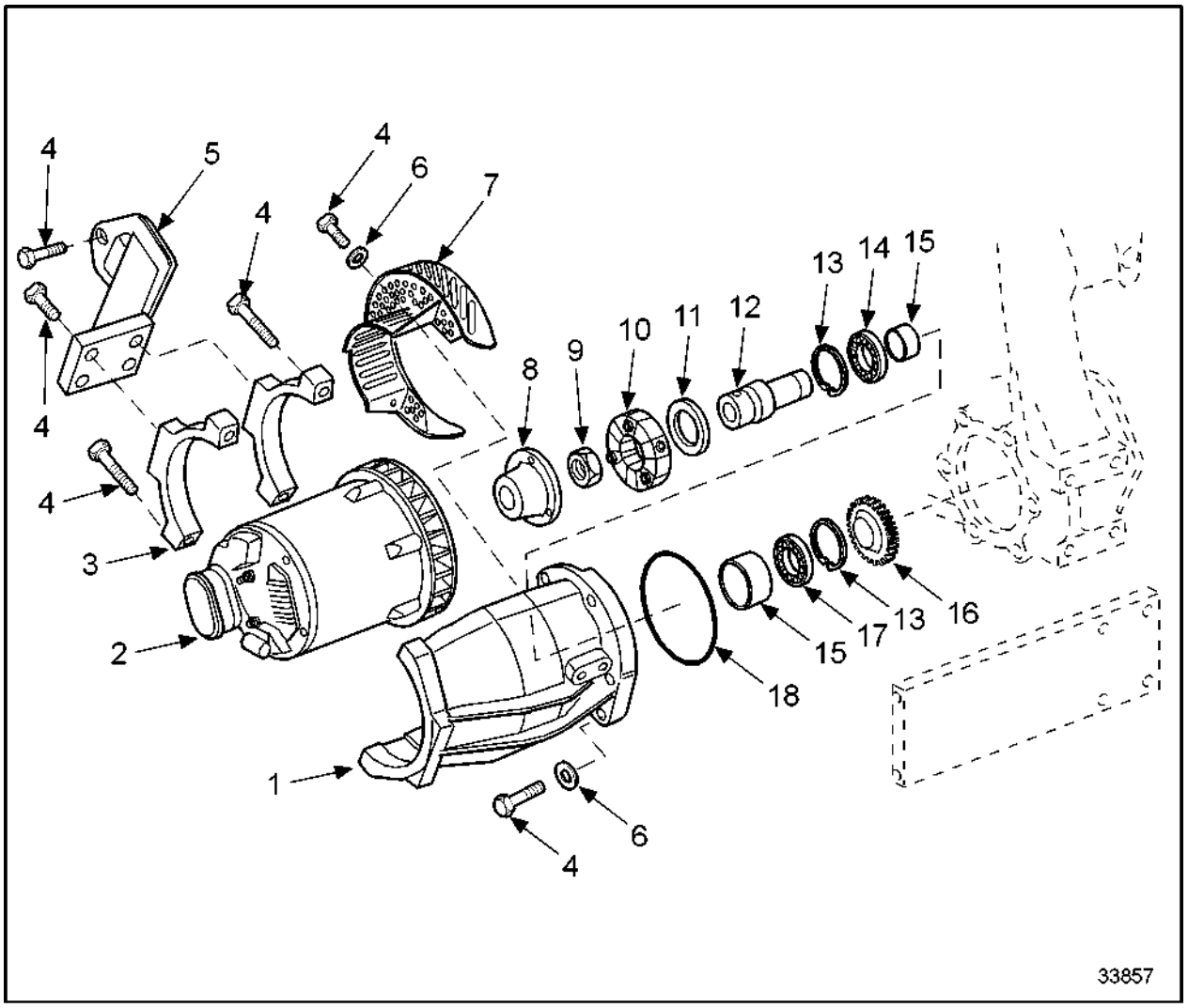
C 213.05.10 M – ASSEMBLY OF THE ALTERNATOR

Refer to OEM guidelines to assemble the alternator.

C 213.05.11 M – INSTALLATION OF THE ALTERNATOR

Perform the following steps to install the alternator:

1. Replace the alternator mounting bracket (1) and secure with six bolts (4) and spacers to the front cover. Torque the bolts to specification. Refer to section A 003. See Figure 1026.

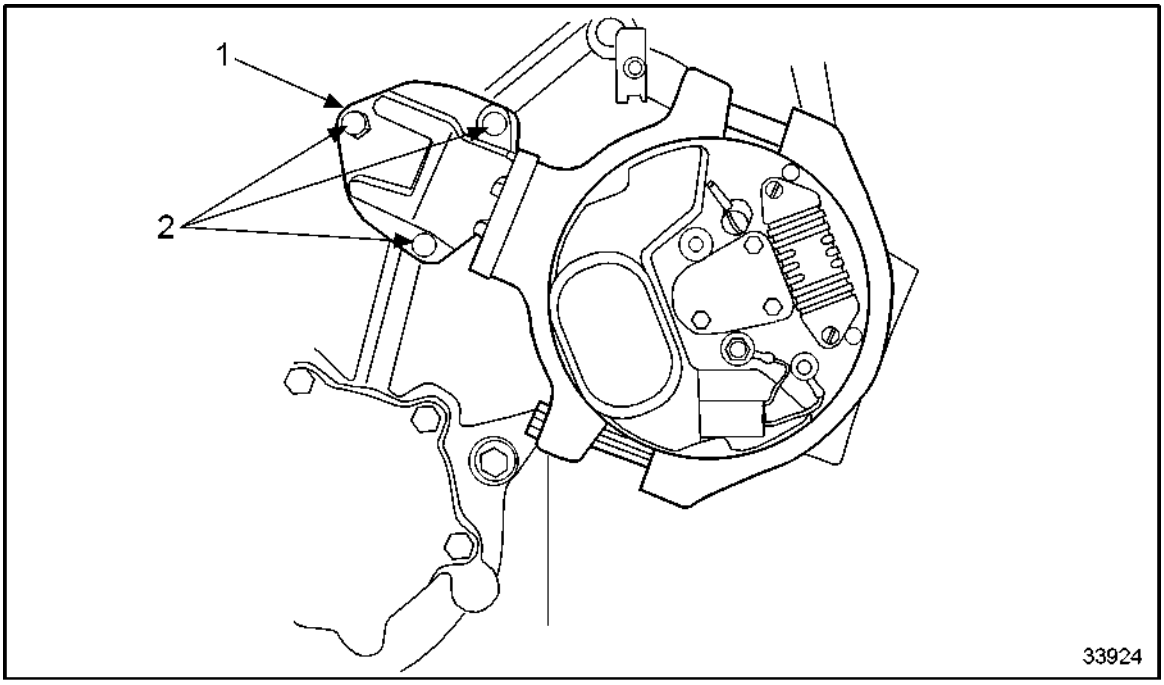


1. Alternator Bracket
2. Alternator
3. Alternator Clamps
4. Bolt
5. Alternator-to-Gear Case Mounting Bracket
6. Washer
7. Heat Shield
10. Coupling
11. Oil Seal
12. Shaft
13. Snap Ring
14. Groove Ball Bearing
15. Spacer Ring
16. Gear

8. Flange
9. Hex Nut
17. Cylinder Roller Bearing
18. O-ring

Figure 1026 Replacing Alternator Mounting Bracket

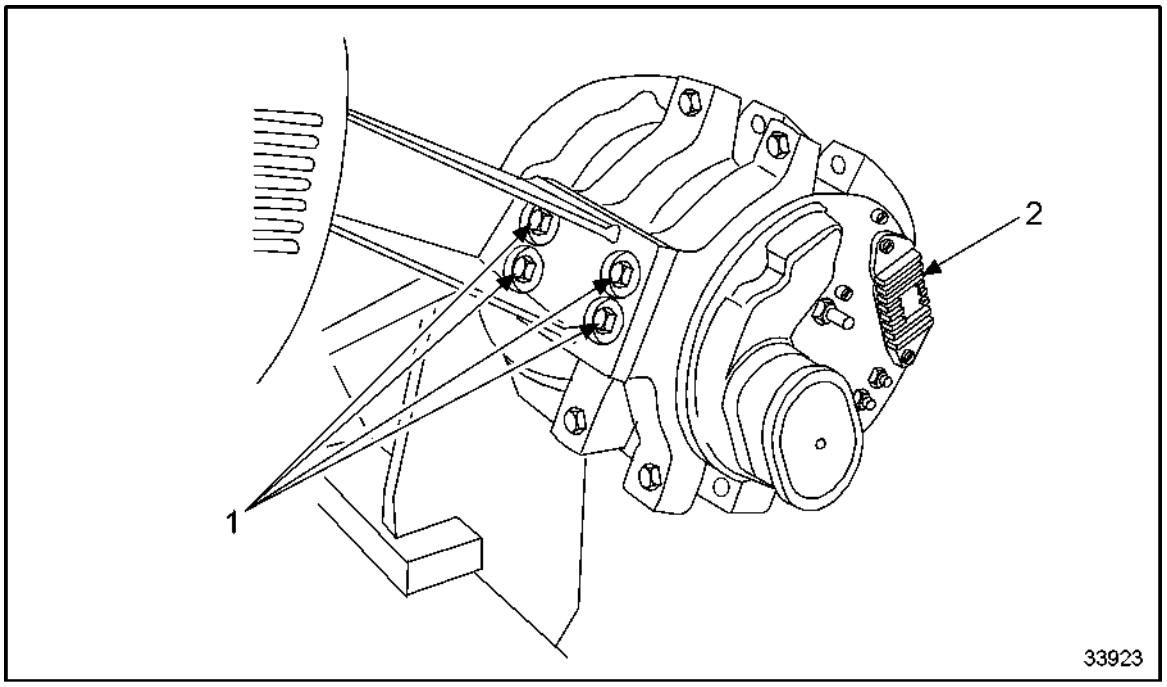
2. Install four bolts (4) to secure the alternator to the mounting bracket (1) with clamps. Torque the bolts to specification. Refer to section A 003. See Figure 1026.
3. Install three bolts (2) to secure the alternator bracket (1) to the front cover. Torque the bolts to specification. Refer to section A 003. See Figure 1027.



1. Alternator Bracket
2. Mounting Bolts

Figure 1027 Installing Alternator Bracket to Gear Case Cover

4. Install four bolts (1) and washers to secure the alternator bracket to the alternator (2). Torque the bolts to specification. Refer to section A 003. See Figure 1028.



1. Mounting Bolts
2. Alternator

Figure 1028 Installing Bracket to Alternator

5. Install three bolts and washers to secure the alternator screen to the alternator. See Figure 1028.
6. Attach the engine harness to the alternator.
7. Connect the electrical leads to the alternator.
8. Connect the electrical leads to the alternator.
9. Connect the engine battery system.
10. Verify repair of the alternator.

C 213.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 147are the After-Installation Operations for the alternator.

Level of Maintenance	Operation	Reference
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.

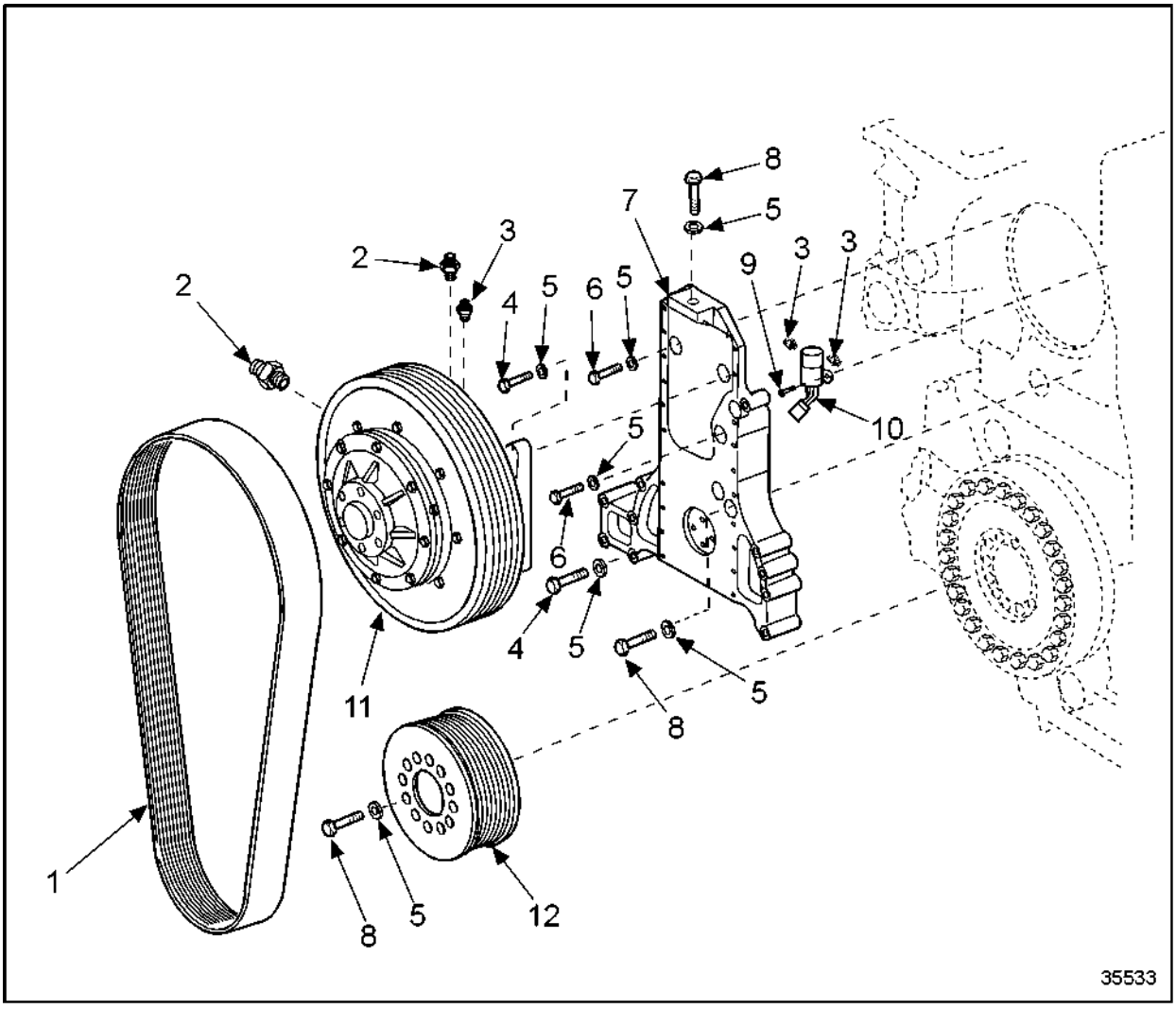
Table 147 Before-Installation Operations for the Alternator

C 220 – FAN DRIVE

C 221.05 – FAN DRIVE

C 221.05.01 – GENERAL VIEW

See Figure 1029 for a general view of the fan drive.



1. Vee-belt
2. Adapter
3. Fitting
4. Bolt
5. Washer
6. Hex Bolt
7. Fan Mounting Bracket
8. Bolt
9. Bolt
10. Fan Control Solenoid
11. Fan Hub Assembly
12. Crankshaft Pulley

Figure 1029 General View of Fan Drive

C 221.05.02 – SPECIAL TOOLS

Listed in Table 148 are the special tools required for maintenance of the fan drive.

Application	Number
Press-in sleeve for bearing outer race in belt pulley	—
Press-in sleeve for cap plugs	—
Removal soft brass drift for ball bearing (belt tensioner)	—
Press-in sleeve for ball bearing (belt tensioner)	—

Table 148 Special Tools

C 221.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 149 are the Before-Removal Operations for the fan drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove protective guard	Refer to Operators Guide
1, 2, 3	Remove fan	Refer to section C 221.05.05

1 = The engine is to be completely disassembled.

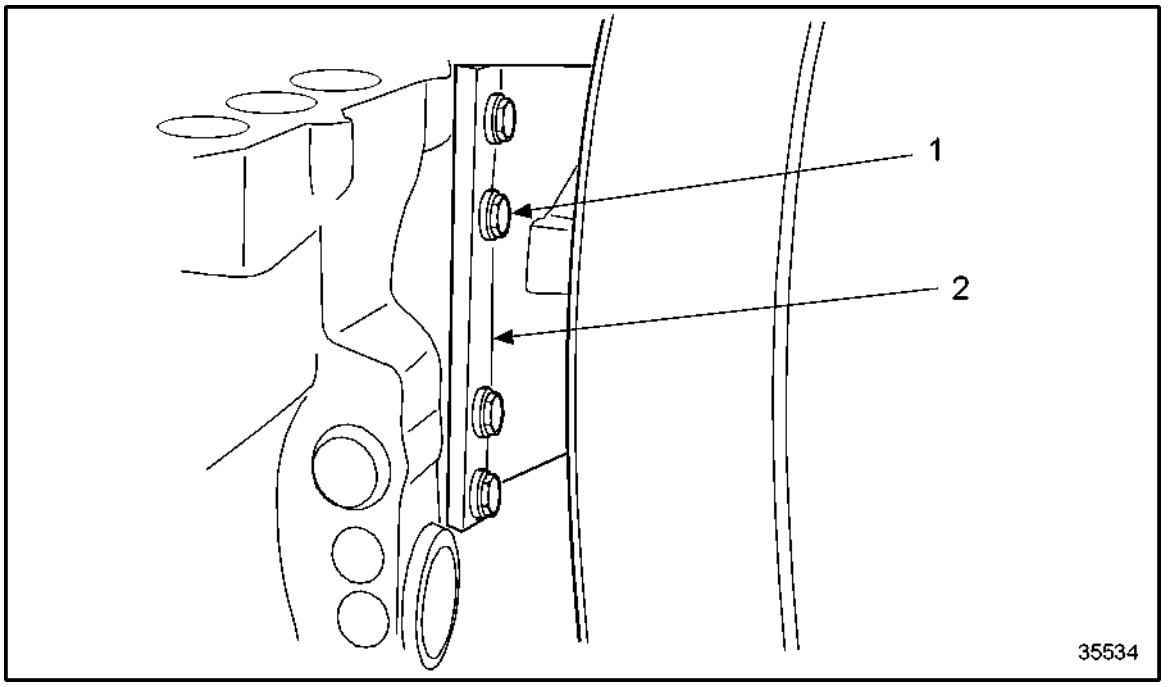
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 149 Before-Removal Operations

C 221.05.05 – REMOVAL OF FAN DRIVE

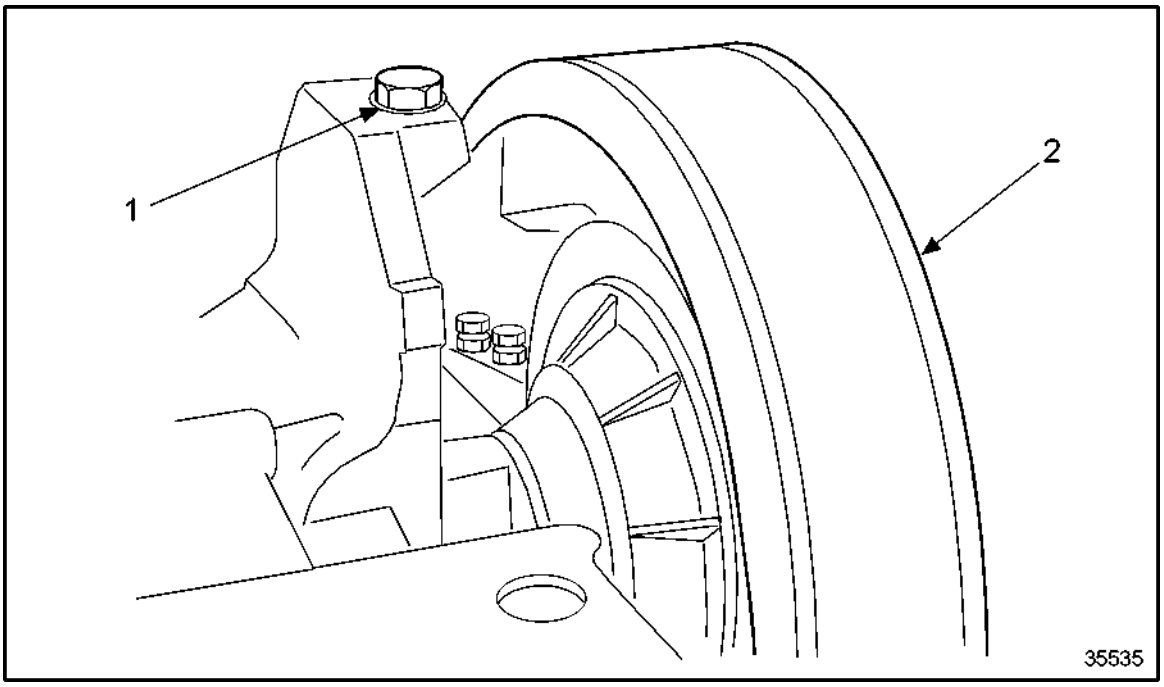
1. To remove Vee-belt, loosen hex bolts (1) of fan hub bracket (2), but do not fully remove. See Figure 1030.



1. Hex Bolt
2. Fan Hub Bracket

Figure 1030 Removing Vee-belt

2. Loosen the adjusting bolt (1) to release Vee-belt pretensioner. See Figure 1031.



1. Adjusting Bolt
2. Vee-belt

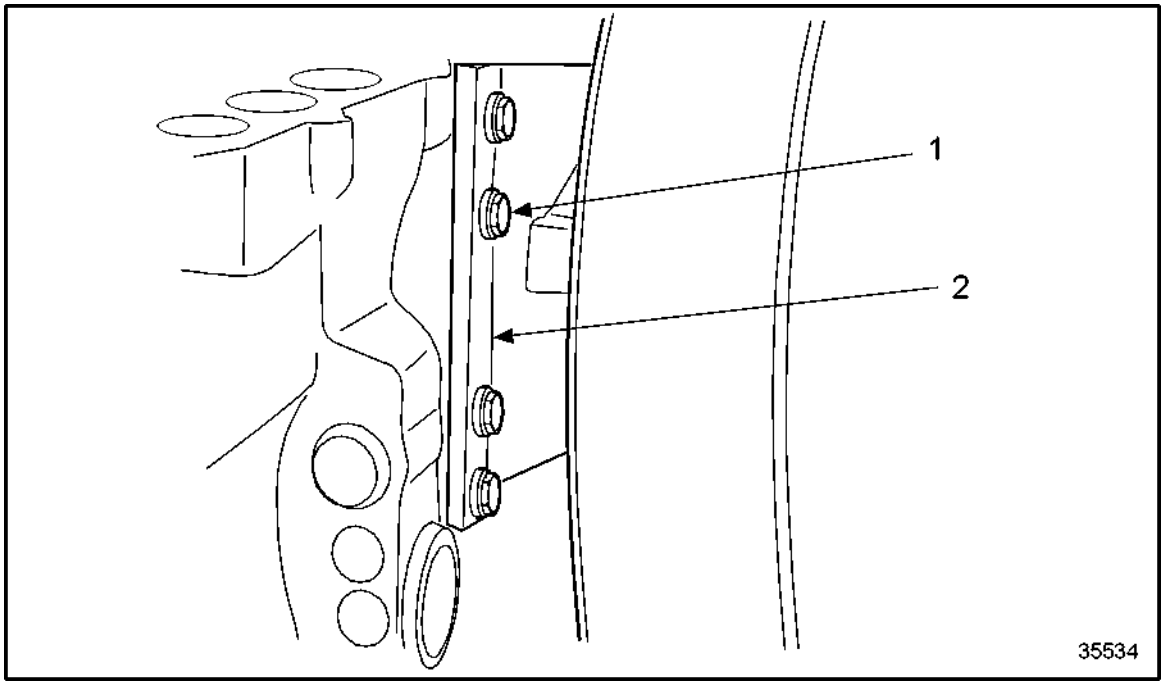
Figure 1031 Loosening Adjusting Bolt

3. Remove Vee-belt (2).

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.

4. Attach fan hub assembly (2) to crane with lifting device and slightly pretension lifting device. See Figure 1032.

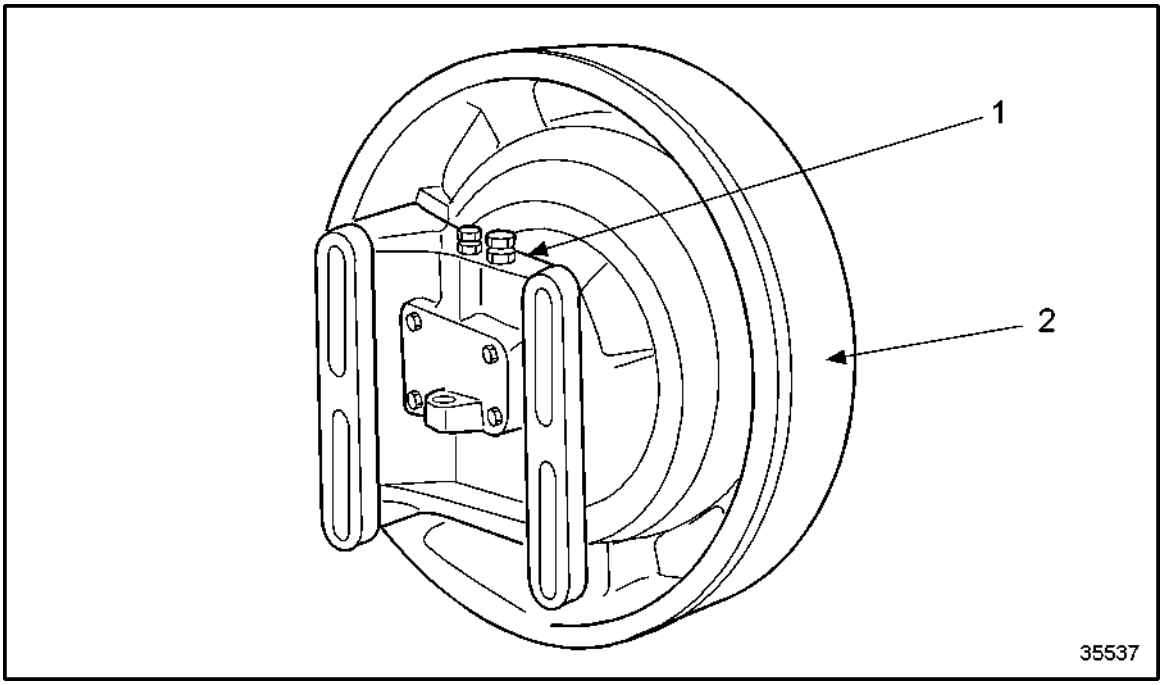


1. Hex Bolt
2. Fan Hub Assembly

Figure 1032 Removing Hex Bolts and Fan Hub Assembly

5. Remove hex bolts (1) and remove fan hub assembly (2).

6. Remove adapter (1) from fan hub assembly. See Figure 1033



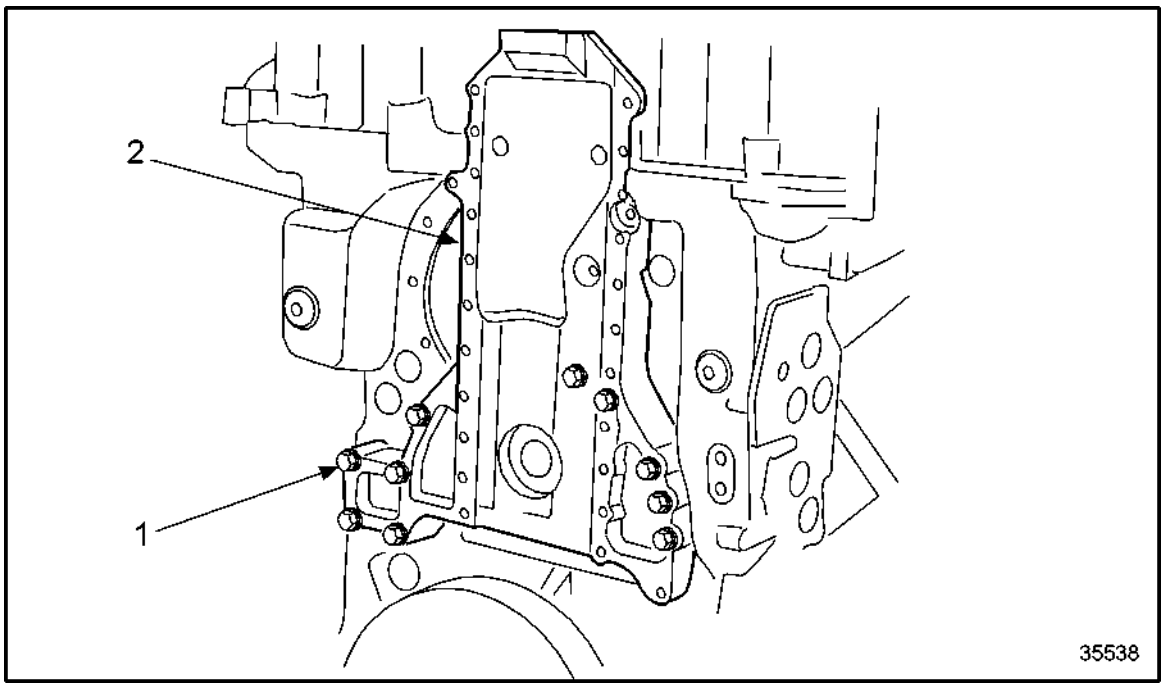
1. Adapter
2. Fan Hub Assembly

Figure 1033 Removing Adapter from Hub Assembly

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.

7. To remove fan mounting bracket (2), attach fan mounting bracket to suitable lifting device, slightly tensioned to crane. See Figure 1034

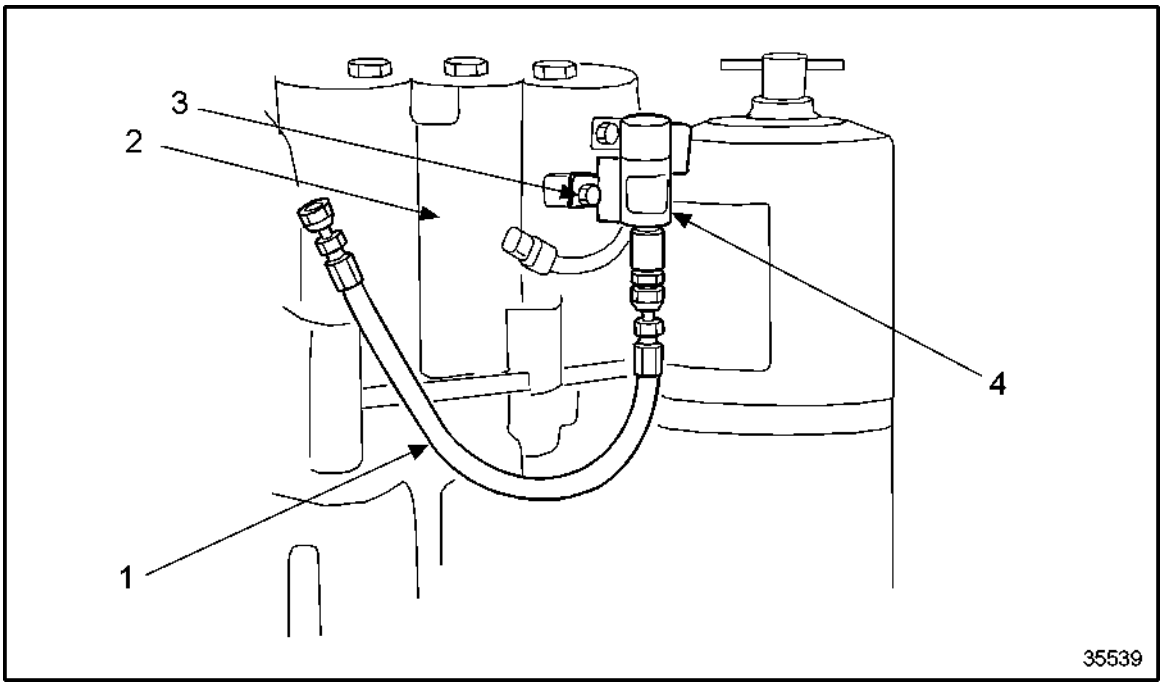


1. Hex Bolt
2. Fan Mounting Bracket

Figure 1034 Removing Fan Mounting Bracket

8. Remove all hex bolts (1).
9. Remove fan mounting bracket with crane.

10. To remove fan control solenoid, remove high-pressure line (1) from fan control solenoid (4). See Figure 1035.

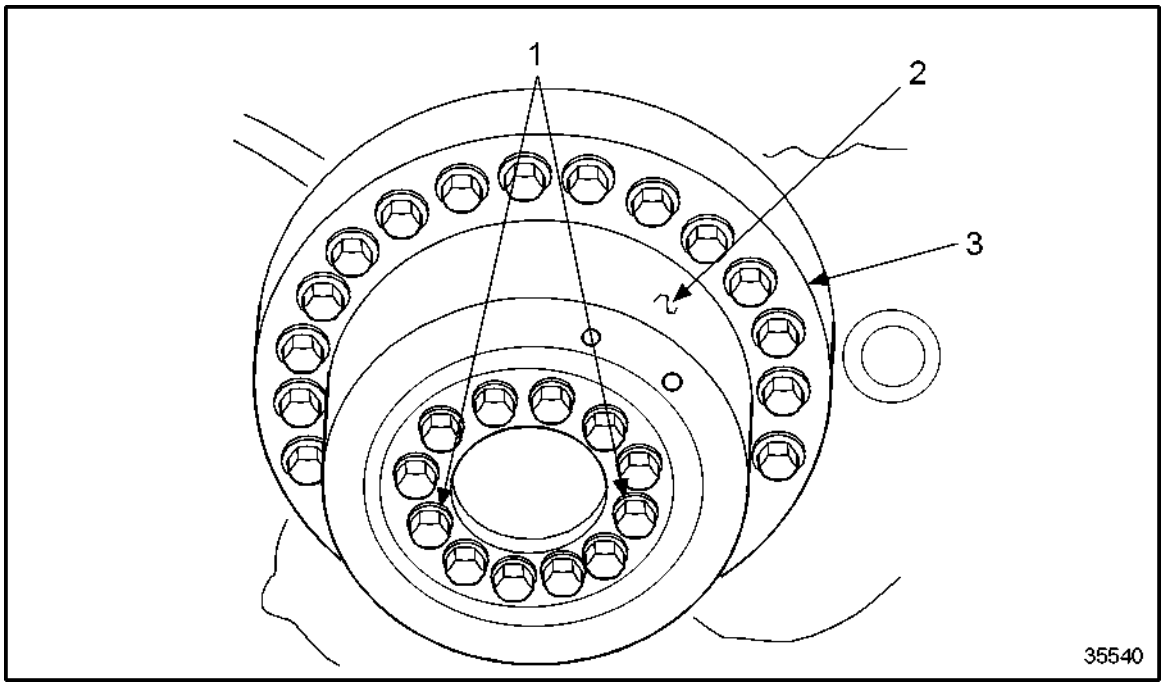


1. High-Pressure Line
2. Oil Cooler Housing
3. Hex Bolt
4. Solenoid Valve

Figure 1035 Removing Fan Control Solenoid

11. Loosen hex bolts (3) securing fan control solenoid on oil cooler housing (2). See Figure 1035.
12. Remove fan control solenoid (4). See Figure 1035.

13. To remove crankshaft pulley, remove two opposite hex bolts (1) and insert guide pins in their place. See Figure 1036.



1. Hex Bolts
2. Crankshaft Pulley
3. Vibration Damper

Figure 1036 Removing Crankshaft Pulley

14. Remove all other hex bolts.

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.

15. Attach crankshaft pulley (2) with suitable lifting device to crane and remove via guide pins.

C 221.05.06 – DISASSEMBLY OF FAN DRIVE

Refer to section C 222.05.05 for overhaul of the Rockford Series 270 fan clutch.

C 221.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the fan drive:

1. Clean all components.
2. Inspect fan hub assembly for ease of movement.
   [a] If fan hub assembly does not show ease of movement, replace component.
   [b] If fan hub assembly does show ease of movement, continue inspection.
3. Inspect fan hub assembly for abnormal noises.
   [a] If fan hub assembly exhibits abnormal noises, replace component.
   [b] If fan hub assembly does not exhibit abnormal noises, continue inspection.
4. Replace fan hub assembly during W6 maintenance.
5. Visually inspect fan mounting bracket for cracks using surface crack-testing method.
   [a] If bracket shows damage, wear or cracks, replace component.
   [b] If bracket does not show damage, wear or cracks, continue inspection.
6. Visually inspect hex bolts for damage or wear.
   [a] If hex bolts show damage or wear, replace as necessary.
   [b] If hex bolts do not show wear or damage, continue inspection.
7. Visually inspect all mating surfaces for damage or wear.
   [a] If mating surfaces show damage or wear, rub down with emery cloth or oilstone as necessary.
   [b] If mating surfaces are beyond repair, replace component as necessary.
   [c] If mating surfaces do not show damage or wear, continue inspection.
8. Visually inspect condition of threads for damage or wear.
   [a] If threads show damage or wear, rechase threads.
   [b] If damage is beyond repair, replace bolts as necessary.
   [c] If threads do not show damage or wear, continue inspection.
9. Replace Vee-belt during W6 overhaul.

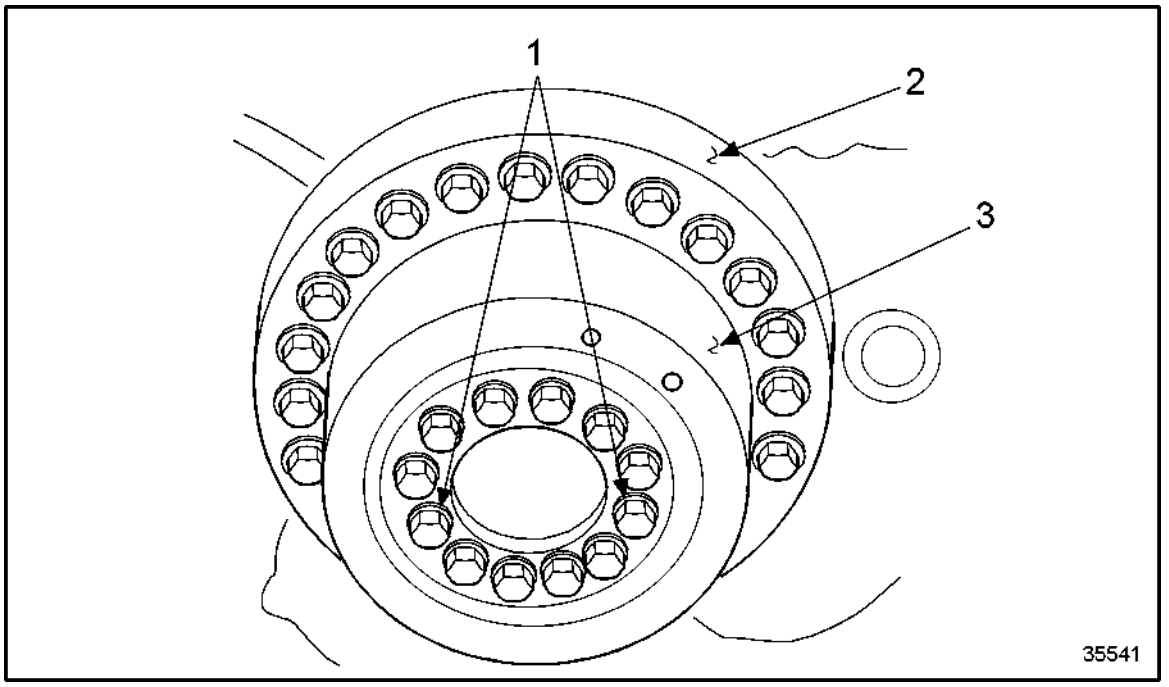
C 221.05.10 – ASSEMBLY OF FAN DRIVE

Check fan hub assembly in a specialist workshop or at Manufacturer's; have repaired in necessary. Refer to section C 222.05.05 for overhaul of the Rockford Series 270 fan clutch.

C 221.05.11 – INSTALLATION OF FAN DRIVE

Perform the following steps to install the fan drive.

1. To install crankshaft pulley, install guide pins at two opposite points in inner collar of vibration damper hub (2). See Figure 1037.



1. Hex Bolt
2. Vibration Damper
3. Crankshaft Pulley

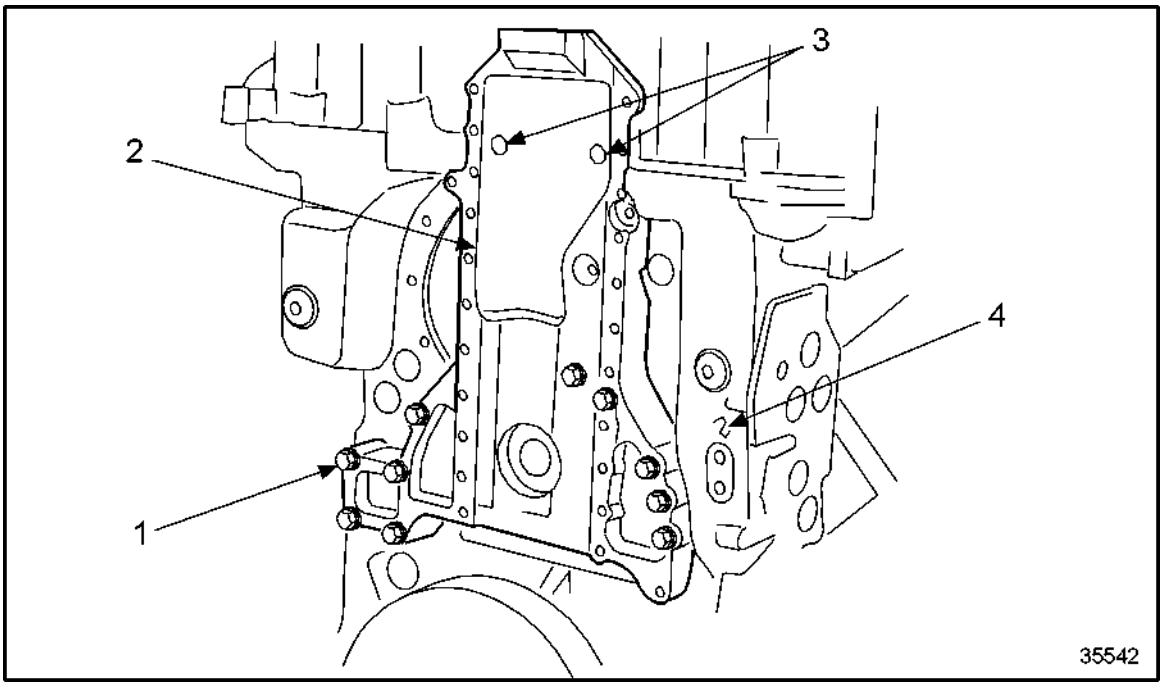
Figure 1037 Installing Crankshaft Pulley

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.

2. Attach crankshaft pulley (3) with suitable lifting device to crane, install over the guide pins and push against vibration damper (2).
3. Insert hex bolts (1) and tighten by hand.
4. Remove guide pins and install two hex bolts in their place.
5. Tighten all hex bolts diagonally and evenly to specification. Refer to section A 003 .

6. To install fan mount bracket, install two guide pins in distribution housing (4). See Figure 1038.



1. Hex Bolt
2. Fan Mount Bracket
3. Guide Pins in Distribution Housing
4. Distribution Housing

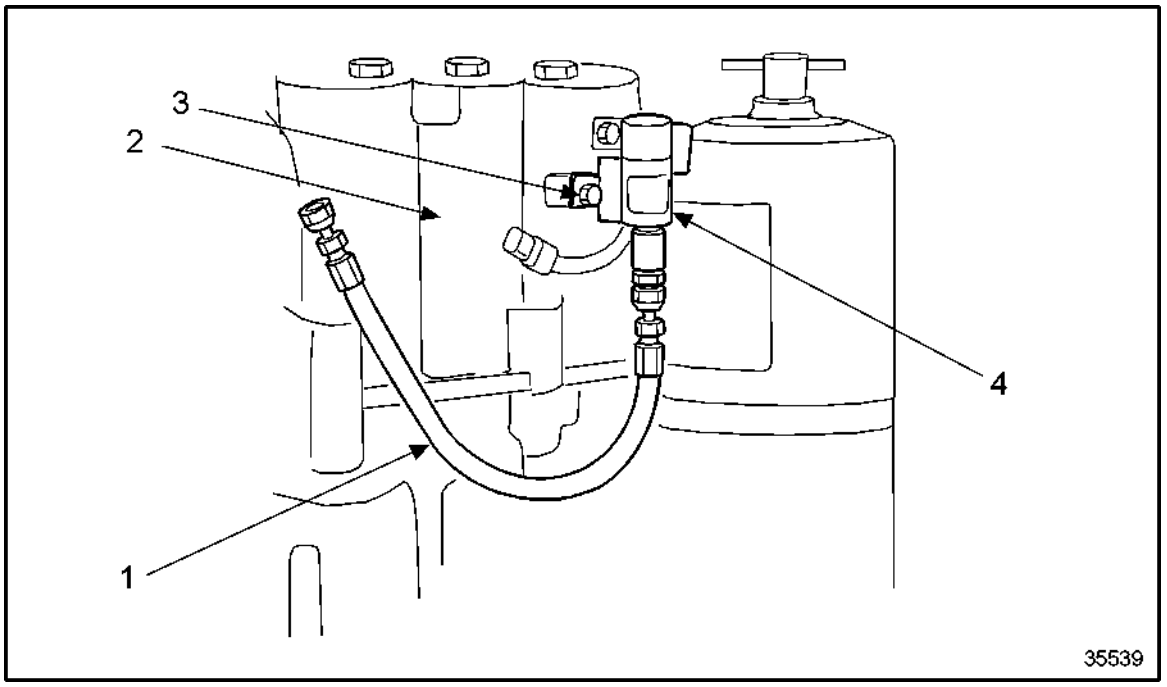
Figure 1038 Installing Fan Mount Bracket

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.

7. Attach fan bracket (2) with a suitable lifting device and install on distribution housing (4) via guide pins. See Figure 1038.
8. Install hex bolts (1) and tighten by hand. See Figure 1038.
9. Remove guide pins and install hex bolts (1) in their place, tightening by hand. See Figure 1038.
10. Tighten all hex bolts (1) to specification. Refer to section A 003 .

11. To install fan control solenoid (4), position fan control solenoid on securing location of oil cooler housing (2). See Figure 1039.

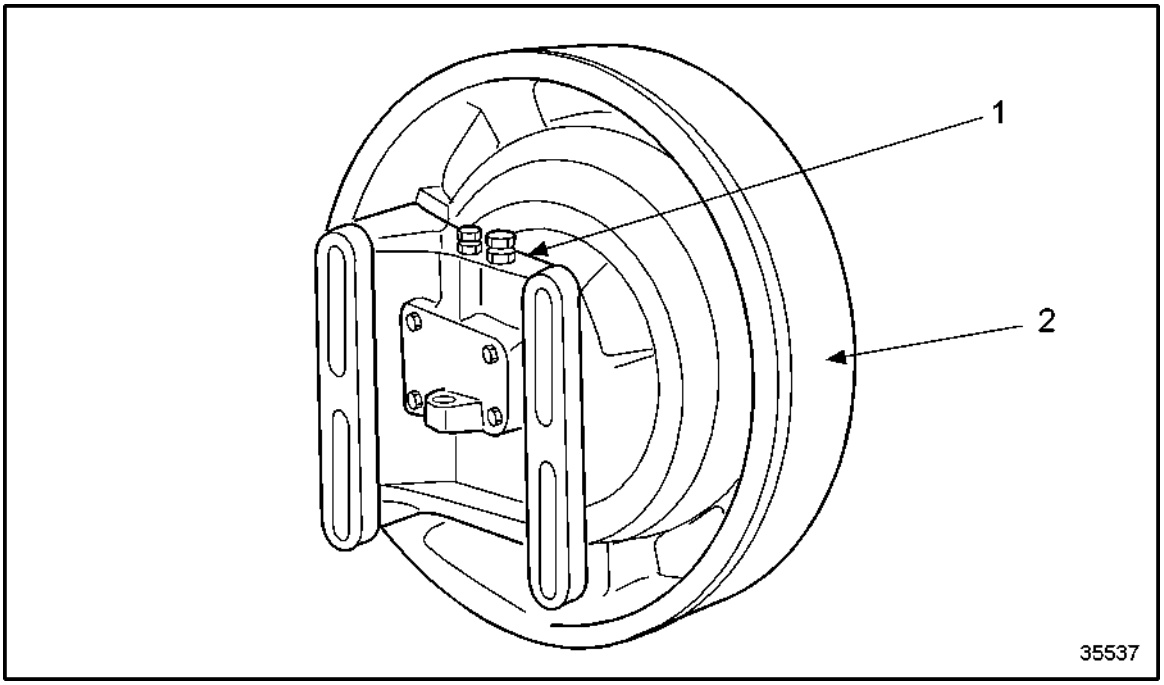


1. High-Pressure Line
2. Oil Cooler Housing
3. Hex Bolt
4. Fan Control Solenoid

Figure 1039 Installing Fan Control Solenoid Valve

12. Install hex bolts (3) attaching fan control solenoid and tighten to specification. Refer to section A 003 . See Figure 1039.
13. Install the high-pressure line (1) onto fan control solenoid (4). See Figure 1039.

14. Install adapter (1) on fan hub assembly and tighten. See Figure 1040.



1. Adapter
2. Fan Hub Assembly

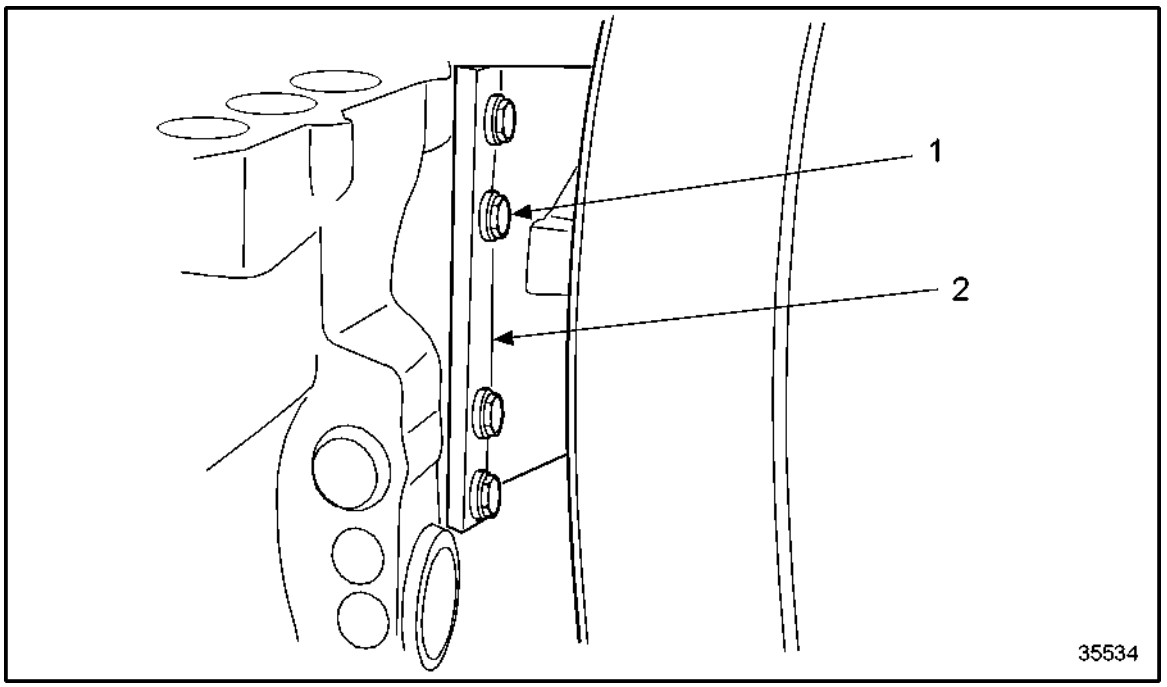
Figure 1040 Installing Adapter on Fan Hub Assembly

15. Install guide pins at two opposite securing locations on fan mount bracket.

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.

16. Attach fan hub assembly (2) with suitable lifting device to crane and push on fan mount bracket via guide pins. See Figure 1041.



1. Hex Bolt
2. Fan Hub Assembly

Figure 1041 Installing Hex Bolts

17. Install hex bolts (1) and tighten by hand.

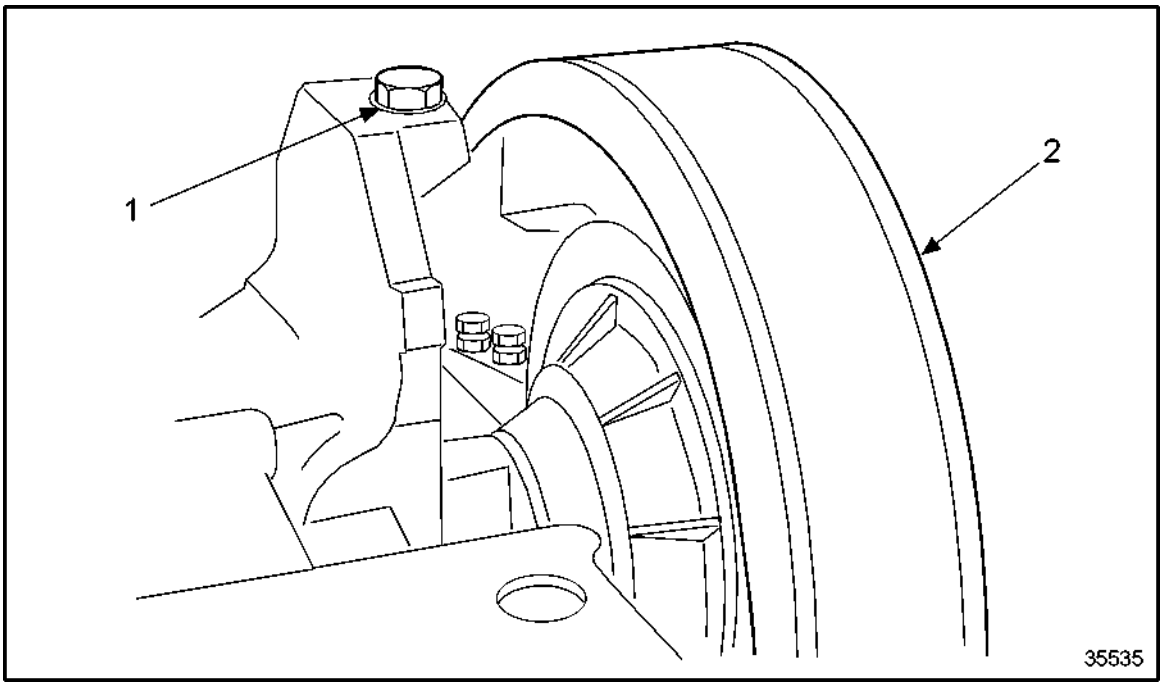
NOTE:
Do not release pretension on lifting device until adjusting bolt is installed. See Figure 1042.

NOTICE:
Ensure all eight fan hub assembly bolts have been installed and tightened to specification. If all eight bolts are not installed and properly tightened, the fan hub assembly could loosen and engine damage could result.

18. Remove guide pins and install two hex bolts in their place, tightening by hand.

NOTE:
Ensure all eight bolts are installed and have been tightened to specification; refer to section A 003 .

19. Install Vee-belt (2). See Figure 1042.



1. Adjusting Bolt
2. Vee-belt

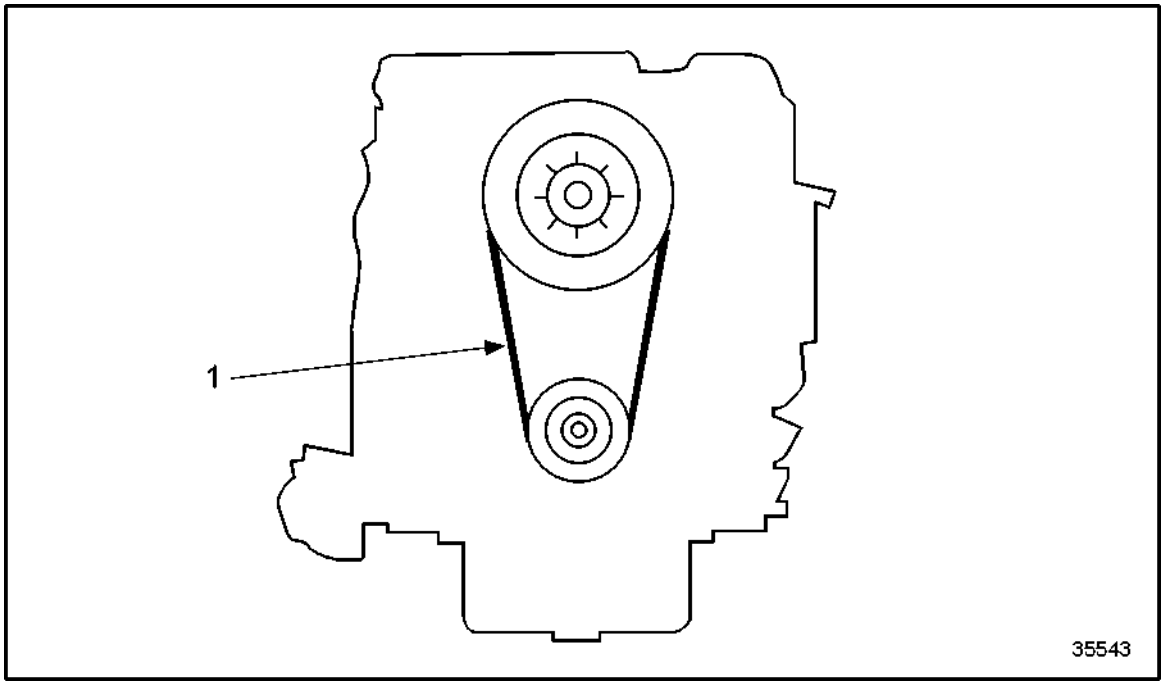
Figure 1042 Installing Vee-belt

20. Install adjusting bolt (1) and tighten by hand.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

21. Remove lifting device.
22. To tension Vee-belt (1), position Vee-belt tension gage in center between Vee-belt pulleys on Vee-belt. See Figure 1043.

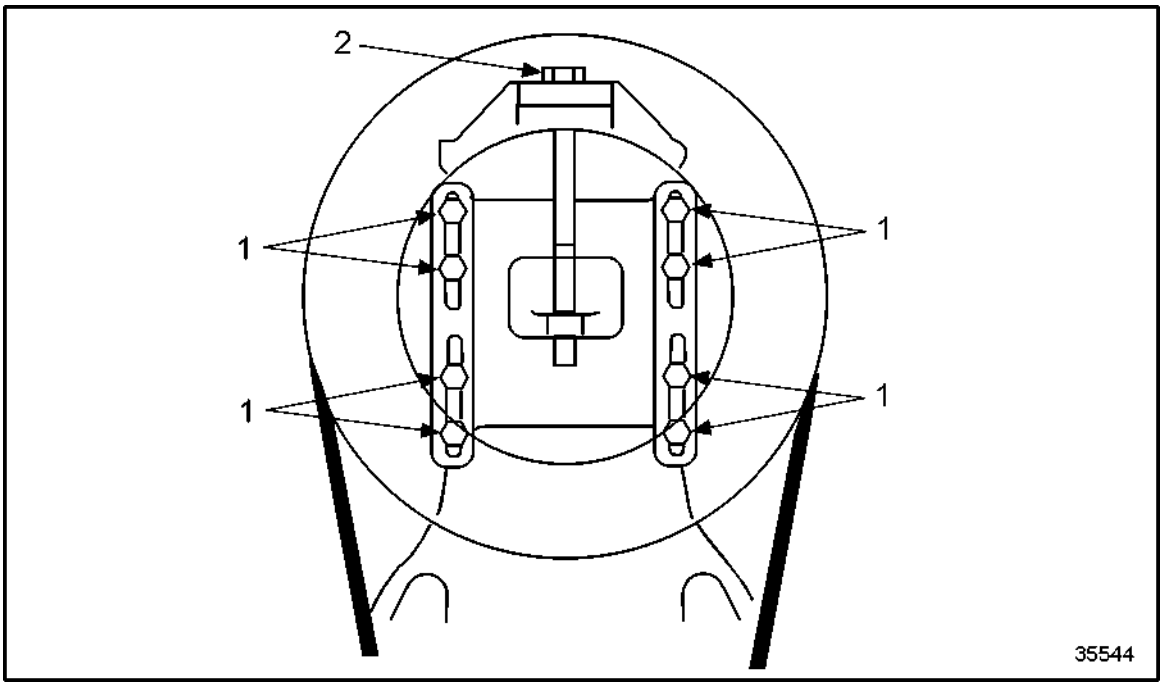


1. Vee-belt

Figure 1043 Tensioning Vee-belt

23. Read pretension value on gage.

24. Turn adjustment bolt (2) until reading on Vee-belt tension tester corresponds to specified value. See Figure 1044.



1. Adjustment Bolt
2. Securing Bolt

Figure 1044 Tightening Adjustment Bolts

25. Tighten securing bolts (1) of fan coupling to specification. Refer to section A 003 .
26. Recheck Vee-belt tension with the tension tester.
27. Settings for the new Vee-belt: 250 – 295 kg. (550 – 650 lbs). Settings for run-in Vee-belt: 250 – 295 kg. (550 – 650 lbs).

NOTE:
If measured value does not correspond to specified value, retension Vee-belt.

C 221.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 150 are the After-Installation Operations for the mechanical fan drive.

Level of Maintenance	Operation	Reference
1, 2, 3	Install fan	Refer to section C 221.05.11
1, 2, 3	Mount protective guard	Refer to Operators Guide
1, 2, 3	Enable engine start	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 150 After-Installation Operations

C 222 – ROCKFORD SERIES 270 FAN CLUTCH

C 222.05.01 – OPERATION OF ROCKFORD SERIES 270 FAN CLUTCH AND GENERAL VIEWS

Introduction

The Rockford Fan Drive Clutch is an oil pressure actuated, oil cooled and lubricated, multiplate clutch designed for infinite fan-to-engine pulley speed ratios assuring prescribed engine coolant temperatures and minimum engine horsepower losses. Engine oil is supplied to the fan clutch to provide maximum cooling and lubrication. Some applications may use transmission oil instead of engine oil.

Engine cooling temperature demands are transmitted to the clutch either by a Rockford fan clutch thermal sensor located to sense the engine coolant temperature, or by the engine's electronic control system. The fan clutch automatically adjusts the fan speed to maintain specified coolant temperature. It is controlled by the thermal sensor and solenoid valve which cause the fan speed to be increased or decreased smoothly without shock loads. Oil cooled plates permit clutch slippage which allows variable fan speeds. See Figure 1045.

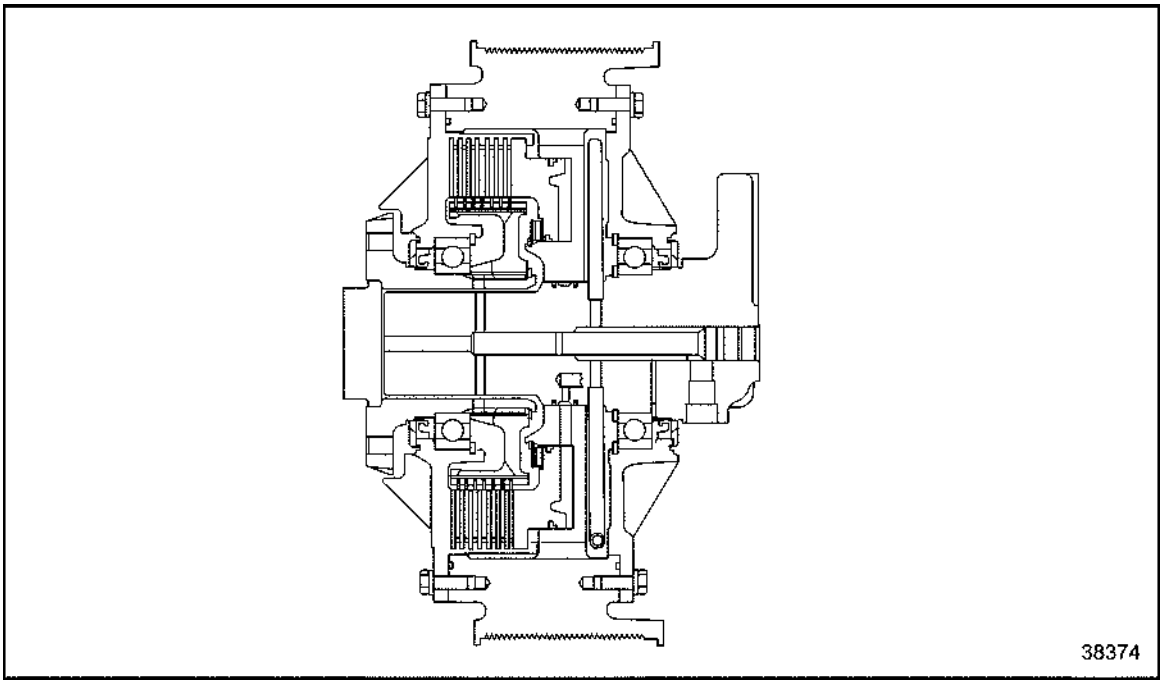
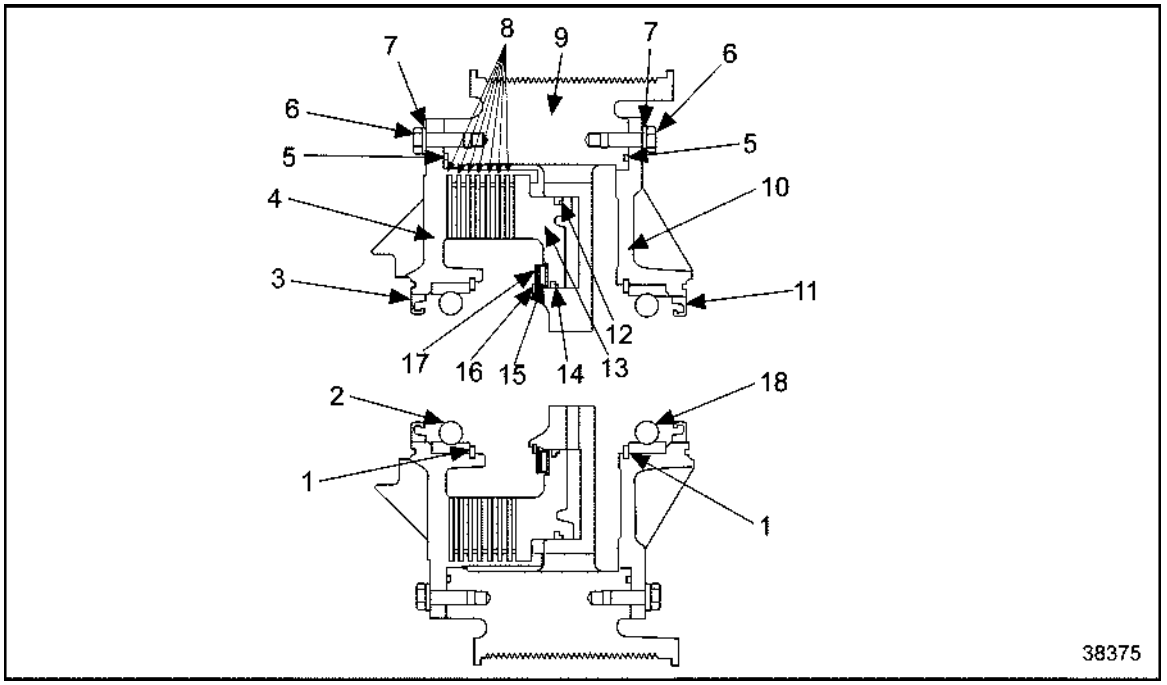


Figure 1045 Rockford Series 270 Fan Clutch

The fan clutch shaft acts as a bearing surface for the moving parts. Internal ports and orifices distribute lubricating/cooling oil, and oil control pressure controls fan speed and modulates the engagement and disengagement of the fan clutch.

Input Components

The fan clutch is driven by the fan belt, which drives the fan clutch pulley. The pulley (9) is bolted to the pulley adapter, which is bolted to the bearing retainer (4). The pulley and pulley adapter are sometimes manufactured as a single component as illustrated below. Lubricating oil inside the fan clutch is sealed by rotating seals (3 and 11). The pulley (or pulley adapter) and bearing retainer are supported by ball bearings (2 and 18). See Figure 1046.



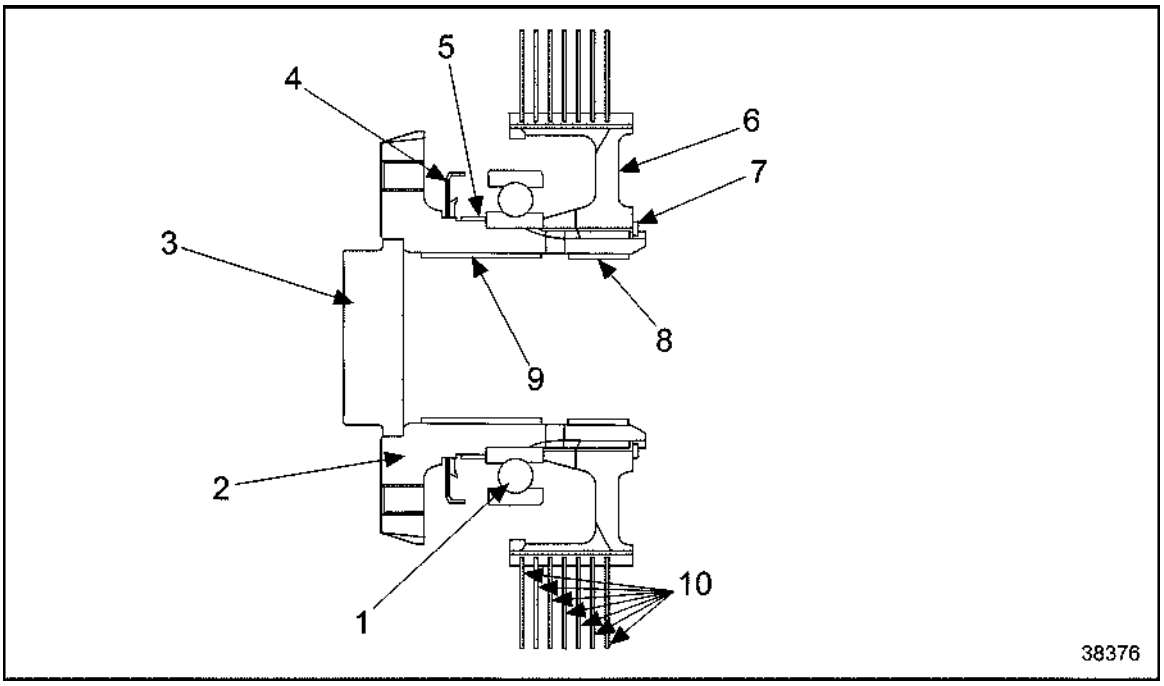
1. Internal Snap Ring
2. Front Main Bearing
3. Front Oil Seal
4. Front Bearing Retainer
5. O-ring Seal
6. Bolt
7. Washer
8. Steel Clutch Plates
9. Pulley
10. Rear Bearing Retainer
11. Rear Oil Seal
12. Large Seal Ring
13. Piston
14. Small Seal Ring
15. Spring Washer
16. External Snap Ring
17. Shim
18. Rear Main Bearing

Figure 1046 Input Components

The slotted cup section of the bearing retainer drives the externally tanged steel clutch plates (8). As the clutch facing plates and steel clutch plates are clamped together by movement of the piston (13), the input components transmit power to the output components of the fan clutch assembly. See Figure 1046.

Output Components

The output for the clutch is through the clutch facing plates (10) which are splined to and drive the clutch hub (6). The inside diameter of the hub is splined to and drives the fan mounting hub (2). The fan is bolted to the fan mounting hub. A fan spacer is sometimes used on the fan mounting hub to position the fan relative to the radiator. See Figure 1047.

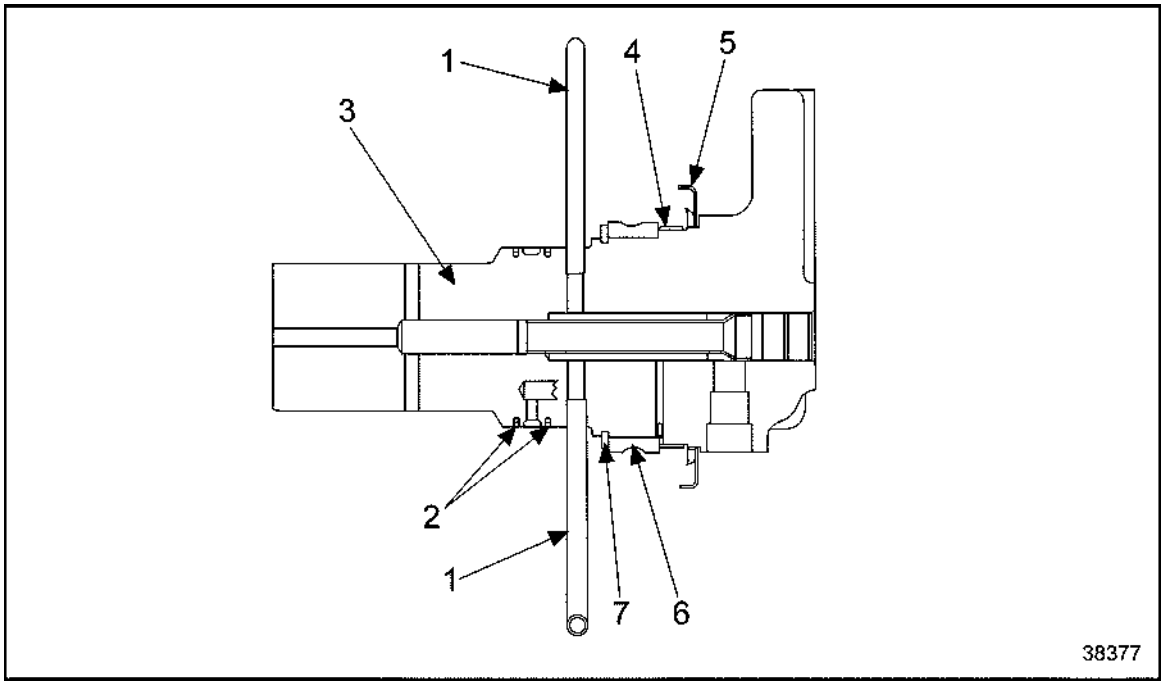


1. Front Main Bearing
2. Fan Mounting Hub
3. End Cap
4. Retainer Seal Assembly
5. Front Wear Sleeve
6. Clutch Hub
7. External Snap Ring
8. Rear Sleeve Bearing
9. Front Sleeve Bearing
10. Facing Plates

Figure 1047 Output Components

Stationary Components

The shaft and bracket assembly (3) is bolted to the engine and supports the fan clutch components. Pitot tubes (1) are secured to the shaft and pump oil from the clutch, directing it through the fan clutch shaft and bracket assembly, back to the oil reservoir (engine oil pan). The rear main bearing (6) is mounted on the fan shaft, as is a retainer/seal assembly which excludes debris and other contaminants from coming in contact with the lip of the rear oil seal. See Figure 1048.



1. Pitot Tubes
2. Hook-Type Seal Rings
3. Shaft and Bracket Assembly
4. Rear Wear Sleeve
5. Retainer Seal Assembly
6. Rear Main Bearing
7. External Snap Ring

Figure 1048 Stationary Components

Operation Modes

The fan clutch is normally controlled by a thermal sensor and solenoid valve. Some engine or machine manufacturers have incorporated the controls for the fan clutch into their own engine or vehicle control systems. Basic fan clutch operational modes are described in the following sections: refer to section DDEC IV Engine Control System, refer to section Fully Released Mode, refer to section Modulated Variable Speed Mode, refer to section Fully Engaged Mode, and refer to section Optional Fan Speed Limiting Systems.

DDEC IV Engine Control System

If the fan clutch control system is incorporated into the system, fan clutch control may also be regulated by numerous operational conditions built into that system's design. See Figure 1049.

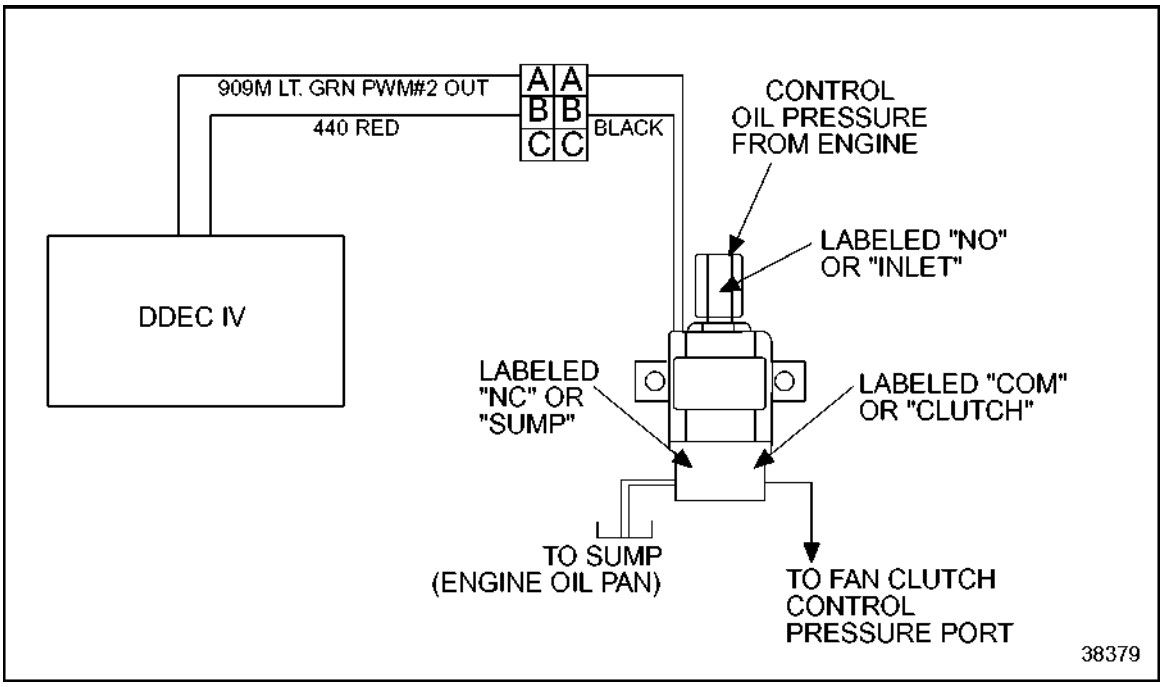


Figure 1049 DDEC IV Fan Clutch Control System

Regardless of the designed function of the specific fan clutch controls, the systems are calibrated to respond within a specified range by sending an electrical signal to drive the solenoid. The infinite slip ratios of (input) pulley speed to (output) fan speed in the fan clutch are controlled by the thermal sensor or ECM's sensitivity, and the solenoid valve's response to that electrical signal, by modulating the oil pressure being used to control the (modulated) engagement of the fan clutch.

Engine lubrication oil enters the solenoid through the inlet ("NO" or "INLET") port. The pressure out ("COM" or "CLUTCH") opening of the solenoid valve is connected by a line to the "CONTROL PRESSURE" port in the fan clutch bracket. The solenoid valve controls the speed of the vehicle cooling fan by regulating the amount of oil pressure supplied to engage, modulate, and allow release of the fan clutch. Oil exiting the fan clutch pressure cavity (and solenoid valve) is directed to the engine oil reservoir (sump) through the ("NC" or "SUMP") port in the solenoid valve.

Fully Released Mode

When engine coolant temperature is at or below the lower limit of the designed temperature range of the thermal sensor (and none of the other thermal sensors or the ECM is sending a signal that creates fan engagement), no oil pressure is directed into the pressure cavity.

Because there is no pressure in the pressure cavity, no clamping force is applied to the clutch plates, and the drive to the fan is disconnected. At this time, the fan rotates at idle speed due to viscous oil drag of the cooling oil passing between the facing plates and steel clutch plates. Idle speed is normally 300-350 rpm or lower when the system is at operating temperature, unless the ECM is designed to control it at a predetermined higher speed; refer to section Optional Fan Speed Limiting Systems.

Modulated Variable Speed Mode

As the engine coolant temperature increases within the designed operating range of the controls, the thermal sensor or ECM system responds, causing the solenoid valve to gradually increase the amount of oil pressure being directed into the fan clutch pressure cavity. Reacting within the pressure cavity, the increased pressure forces the piston to move into contact with the clutch plates and begins to create a connection between the input and output of the fan clutch. Unless the temperature demands require that the fan be operated at full designed speed, the fan clutch, in fact, slips. Increased pressure against the facing creates increased clamping force that decreases amount of clutch slippage, resulting in increased fan speed. The fan will continue to increase in speed until it reaches maximum operational speed, unless the engine temperature stabilizes or begins to decrease as the result of increased cooling created by the fan.

If engine coolant temperature begins to decrease, the above action is reversed. Oil then is slowly allowed to exhaust from the clutch, through the ("NC" or "SUMP") port of the solenoid valve to the engine oil reservoir (sump). The lower pressure inside the pressure cavity reduces the clamping force of the clutch piston. The spring washer pushes the piston away from the facing plates and the clutch is allowed to slip more, reducing fan speed. Should engine coolant temperature stabilize, fan speed stabilizes, but this will rarely occur other than in tightly controlled test cell environments.

When the lower limit of the designed temperature range of the thermal sensor is reached, minimum oil control pressure exists in the pressure cavity. The spring washer forces the piston away from the clutch plates and the fan clutch is allowed to fully release.

Fully Engaged Mode

When engine coolant temperature at the sensor reaches the top of the designed temperature range, full oil pressure is directed by the solenoid valve into the pressure cavity of the fan clutch. The control pressure, reacting within the pressure cavity, forces the piston to move against the clutch plates, clamping the disc stack against the front bearing retainer. When the clutch plates are fully clamped, the input and output are fully connected constituting a 1:1 drive through the clutch, unless the design of the system limits the fan’s maximum speed. The fan is thus driven at fan clutch pulley speed; refer to section Optional Fan Speed Limiting Systems.

Optional Fan Speed Limiting Systems

Some engine or vehicle manufacturers may have designed the fan clutch control system to limit the fan to a maximum speed below that of full fan clutch lock-up speed. In these instances, the fan clutch is designed to never go to full lock-up under any operational conditions, and the minimum fan speed at idle and/or full release may be prevented from decreasing below a prescribed idle speed. In these cases, the fan clutch modulates 100% of the time in operation.

Lubricating and Cooling Oil

Lubricating and cooling oil is supplied to the fan clutch from the engine oil pressure supply system. The fan clutch oil supply originates at an engine oil pressure port which supplies cooled, filtered oil. A flow-limiting orifice in the fan clutch "OIL IN" port of the shaft and bracket assembly regulates the amount of oil supplied through the clutch. Engine oil travels through the oil supply line from the engine to the "OIL IN" port on the fan clutch bracket. See Figure 1050.

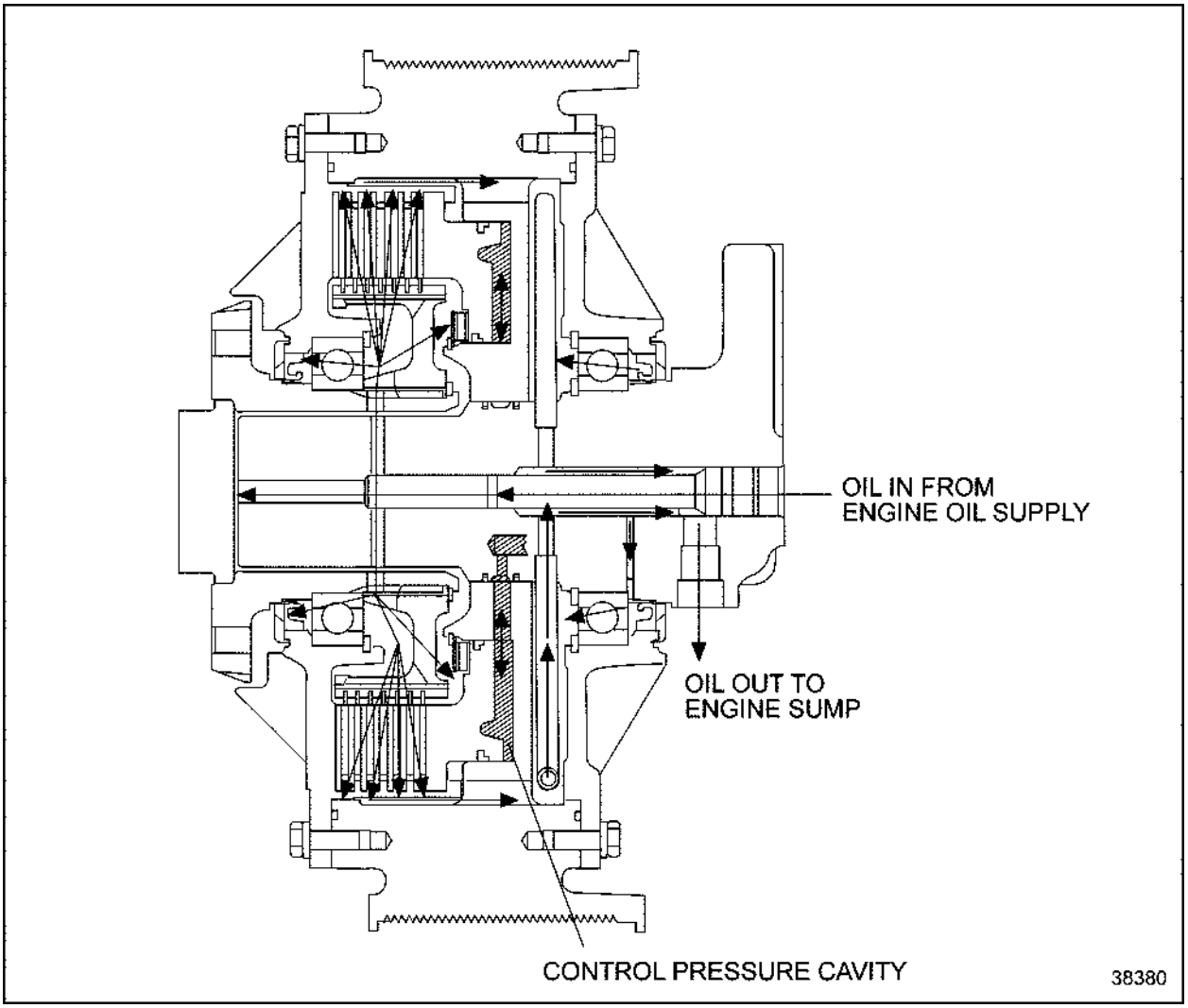


Figure 1050 Lubricating and Cooling Oil Flow

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.

Every Rockford fan clutch is identified with a part number before it leaves the factory. A coded number identifies the part number of the clutch and the date the unit was built. This information is found stamped into a 1/2" X 2 7/8" aluminum tag attached to the fan clutch bracket. See Figure 1051.

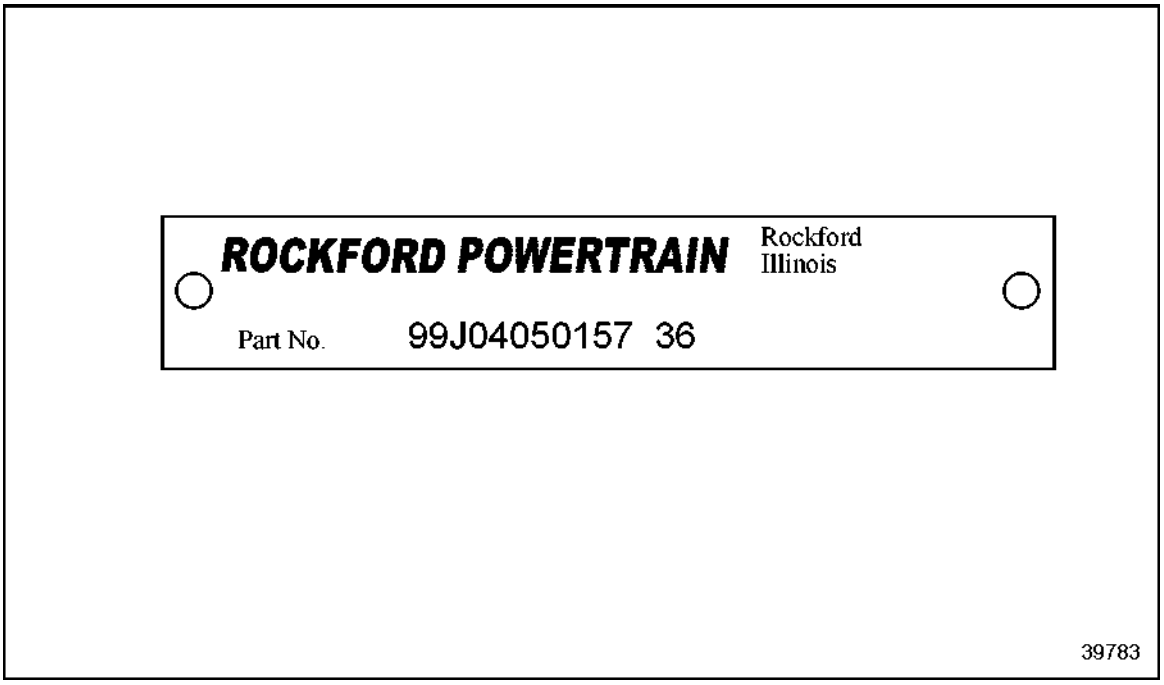


Figure 1051 Name Tag

The code number (see Figure 1051) illustrates the following:

- Part Number-04050157
- Serial Number-36
- Build Date-September, 1999

Rockford fan clutch date codes are listed in Table 151

Coded Date Built							
Year				Month			
3	1993	99	1999	A	January	G	July
4	1994	00	2000	B	February	H	August
5	1995	01	2001	C	March	J	September
6	1996	02	2002	D	April	K	October
7	1997	03	2003	E	May	L	November
8	1998	04	2004	F	June	M	December

Table 151 Rockford Fan Clutch Date Codes

See Figure 1052 for a sectional view of the Rockford 270 Series fan clutch.

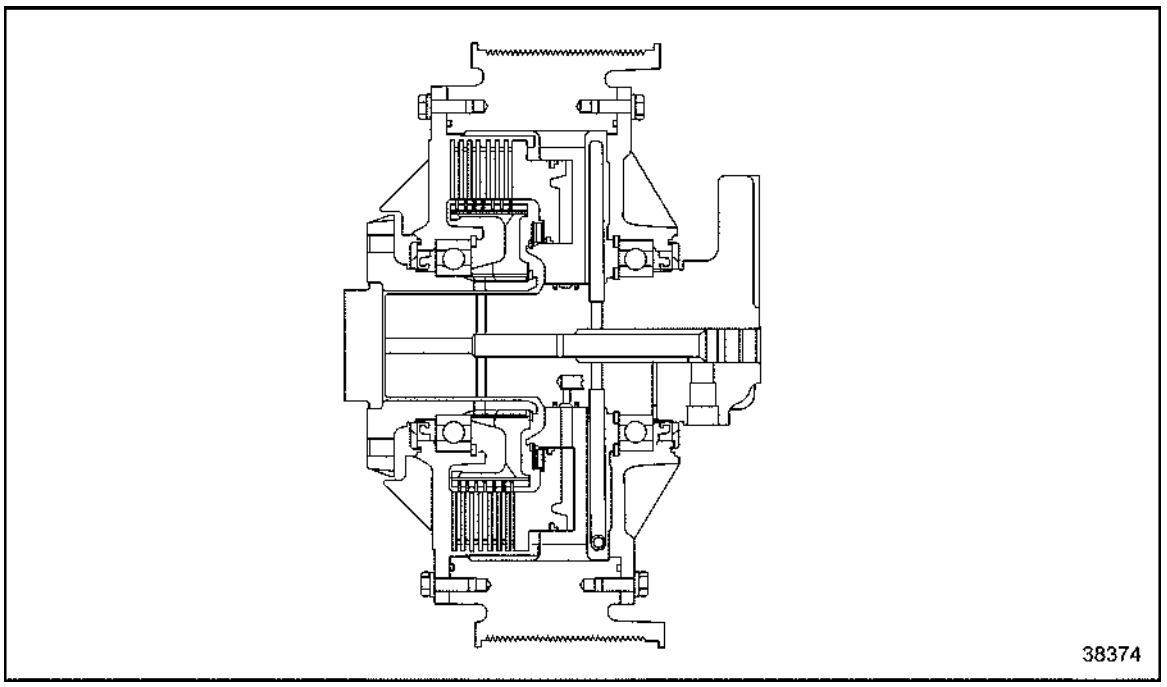
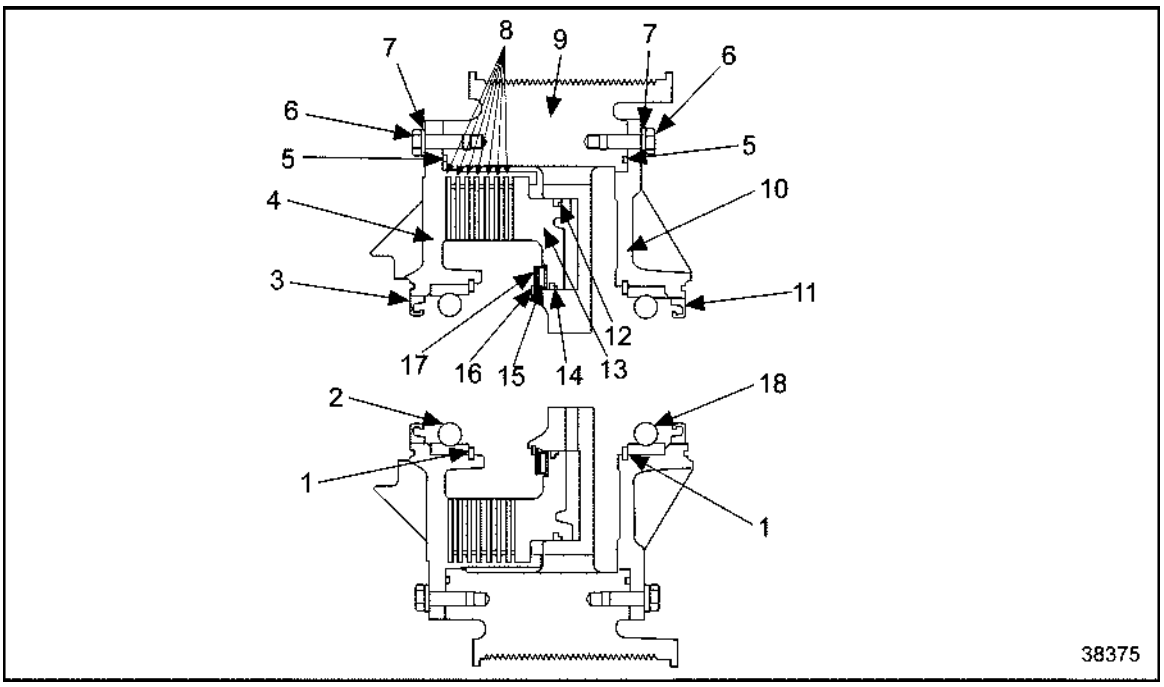


Figure 1052 Sectional View of Rockford Series 270 Fan Clutch

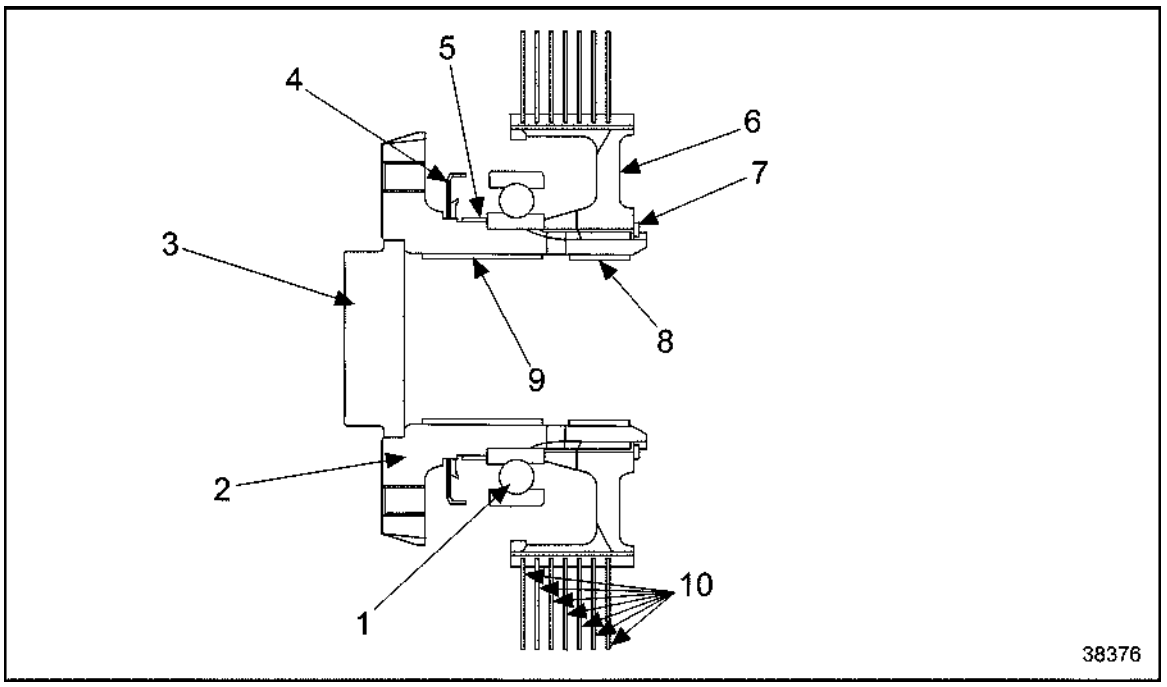
See Figure 1053 for a general view of the Rockford Series 270 fan clutch input components.



1. Internal Snap Ring
2. Main Bearing
3. Oil Seal
4. Front Bearing Retainer
5. O-ring Seal
6. Bolt
7. Washer
8. Steel Clutch Plates
9. Pulley
10. Rear Bearing Retainer
11. Rear Oil Seal
12. Large Seal Ring
13. Piston
14. Small Seal Ring
15. Spring Washer
16. External Snap Ring
17. Shim
18. Rear Main Bearing

Figure 1053 Rockford Series 270 Fan Clutch Input Components

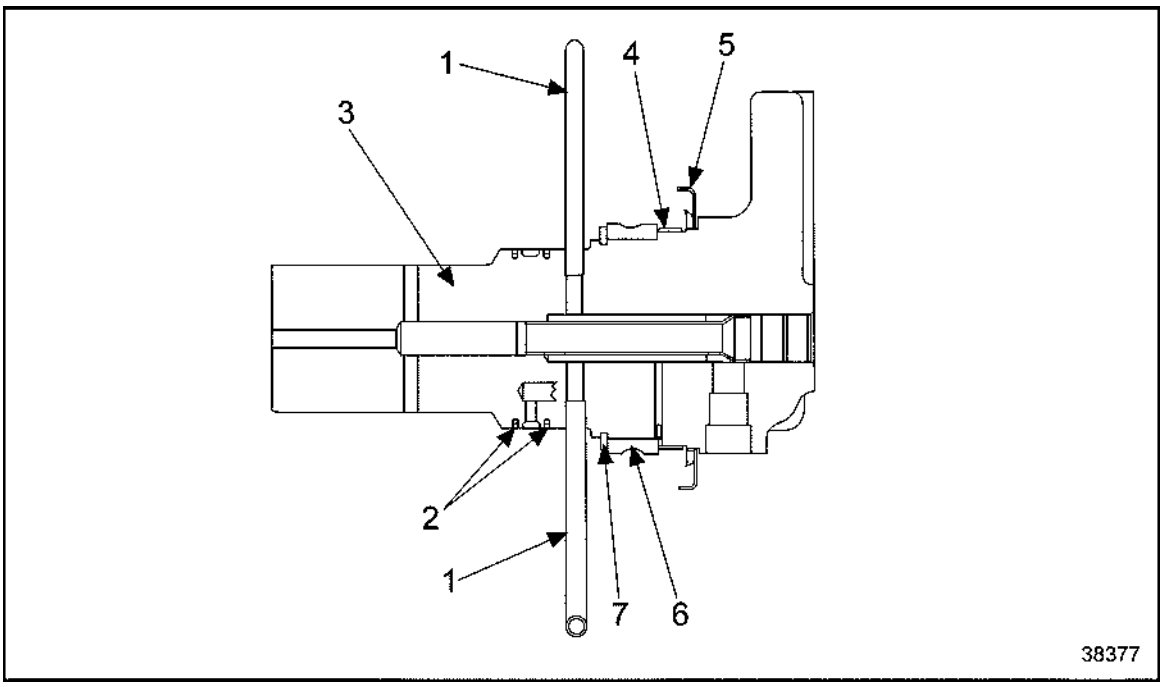
See Figure 1054 for a general view of the Rockford Series 270 fan clutch output components.



1. Front Main Bearing
2. Fan Mounting Hub
3. End Cap
4. Retainer Seal Assembly
5. Front Wear Sleeve
6. Clutch Hub
7. External Snap Ring
8. Rear Sleeve Bearing
9. Front Sleeve Bearing
10. Facing Plates

Figure 1054 Rockford Series 270 Fan Clutch Output Components

See Figure 1055 for a general view of the Rockford Series 270 fan clutch stationary components.



1. Pitot Tubes
2. Hook-type Seal Rings
3. Shaft and Bracket Assembly
4. Rear Wear Sleeve
5. Retainer Seal Assembly
6. Rear Main Bearing
7. Rear Main Bearing
8. External Snap Ring

Figure 1055 Rockford Series 270 Fan Clutch Stationary Components

See Figure 1056 for the DDEC IV™ fan clutch control system.

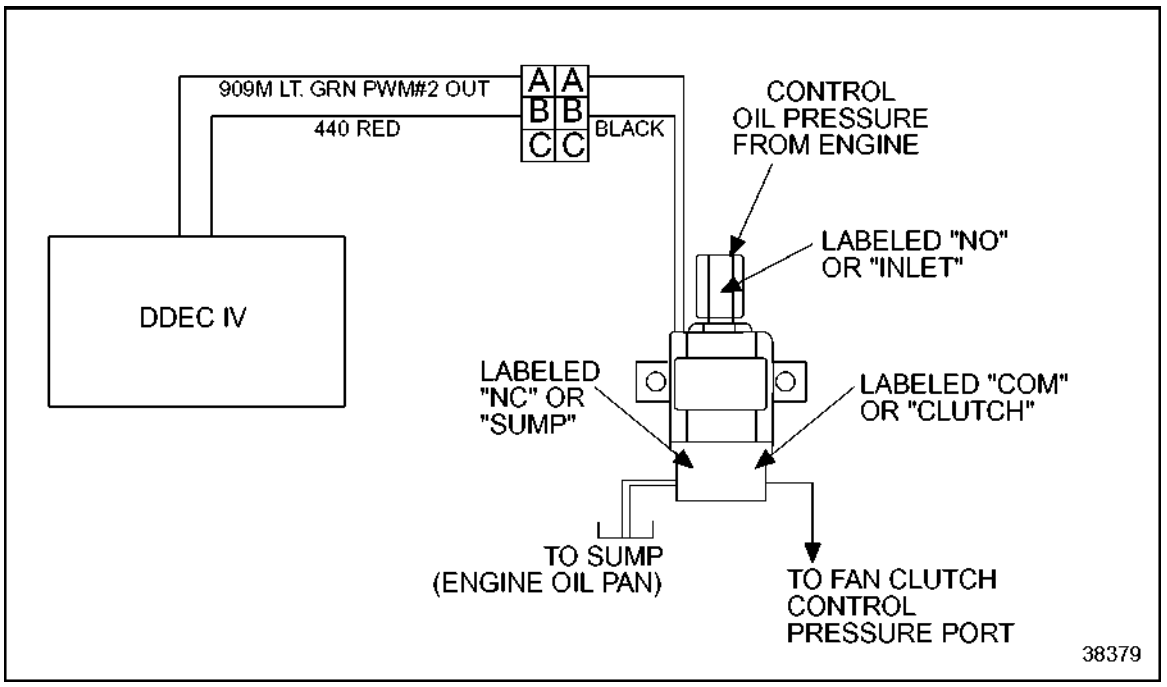


Figure 1056 DDEC IV Fan Clutch Control System

See Figure 1057 for a general view of the Rockford Series 270 fan clutch lubricating and cooling oil flow control pressure oil flow.

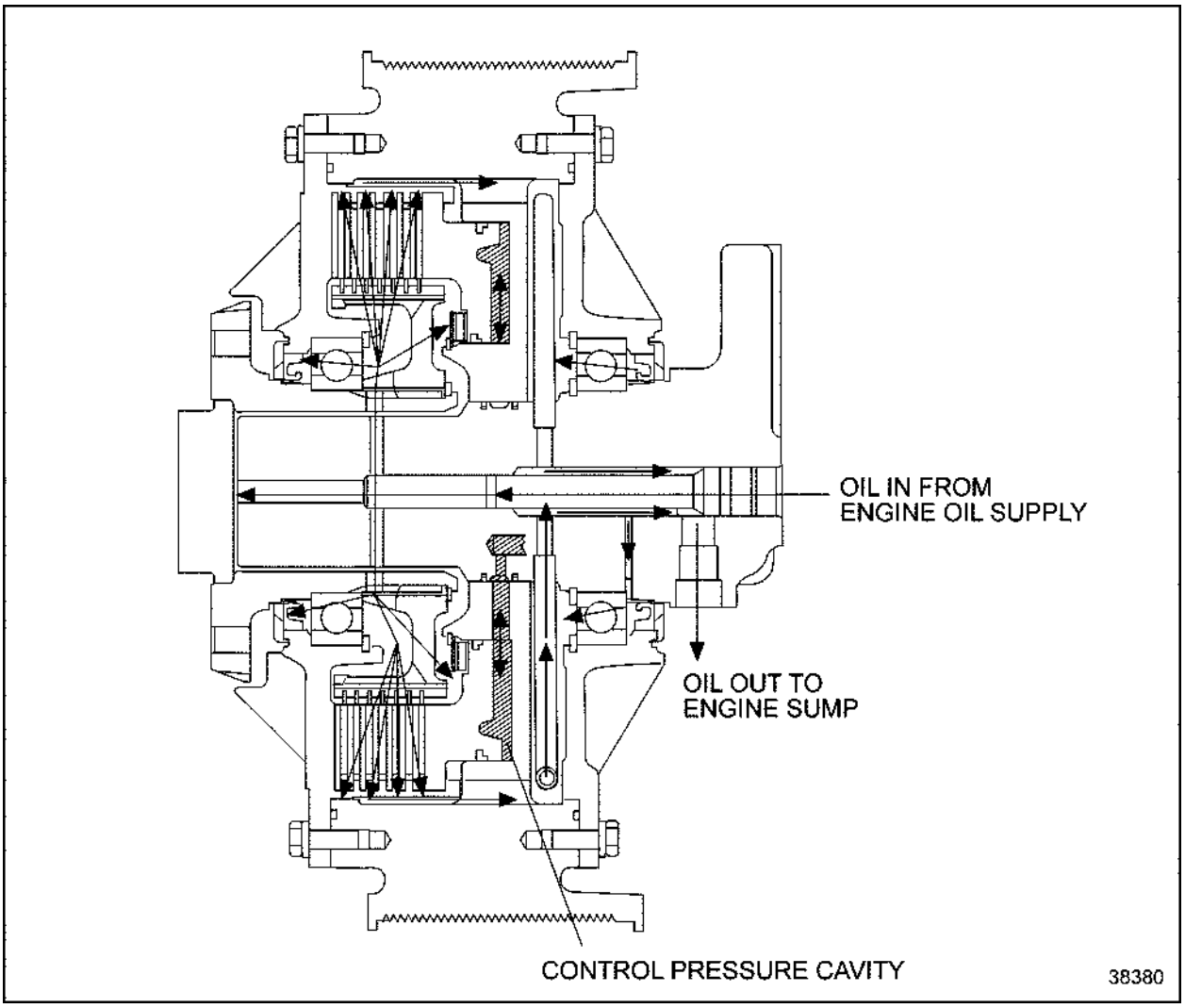


Figure 1057 Rockford Series 270 Fan Clutch Lubricating and Cooling Oil Flow Control Pressure Oil Flow

C 222.05.02 – SPECIAL TOOLS FOR ROCKFORD SERIES 270 FAN CLUTCH

Listed in Table 152 are the special tools required to perform fan clutch maintenance.

Designation	Part Number
Special Tool #1 (Remove and install sleeve bearings)	Special Tool #1, see Figure 1058
Special Tool #2 (Remove bearings and install retainer seal assemblies and wear sleeves)	Special Tool #2, see Figure 1058
Special Tool #3 (Install bearings and oil seals)	Special Tool #3, see Figure 1058

Table 152 Special Tools

NOTE:
All special tools are to be locally fabricated.

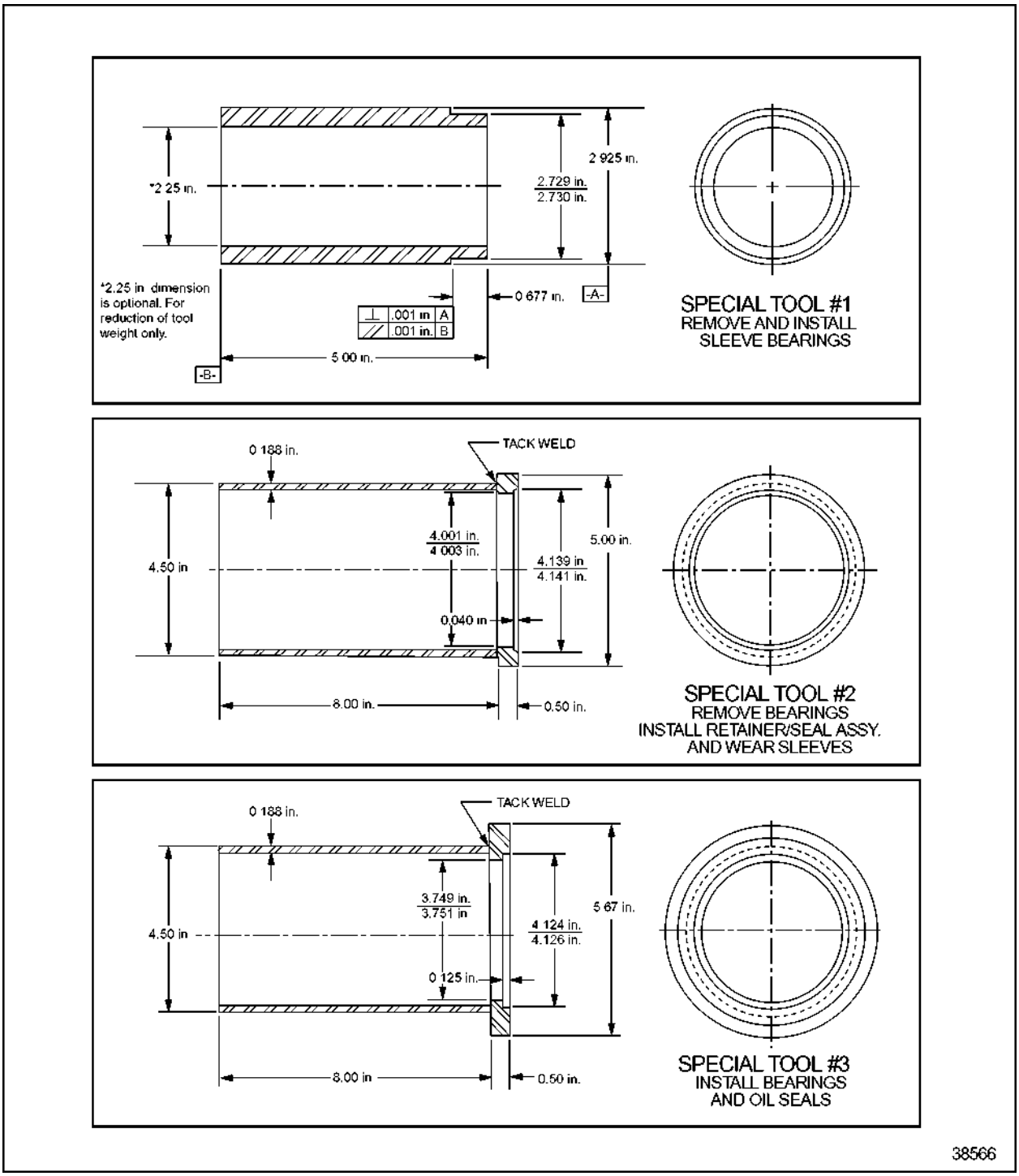


Figure 1058 Special Tools by Designation

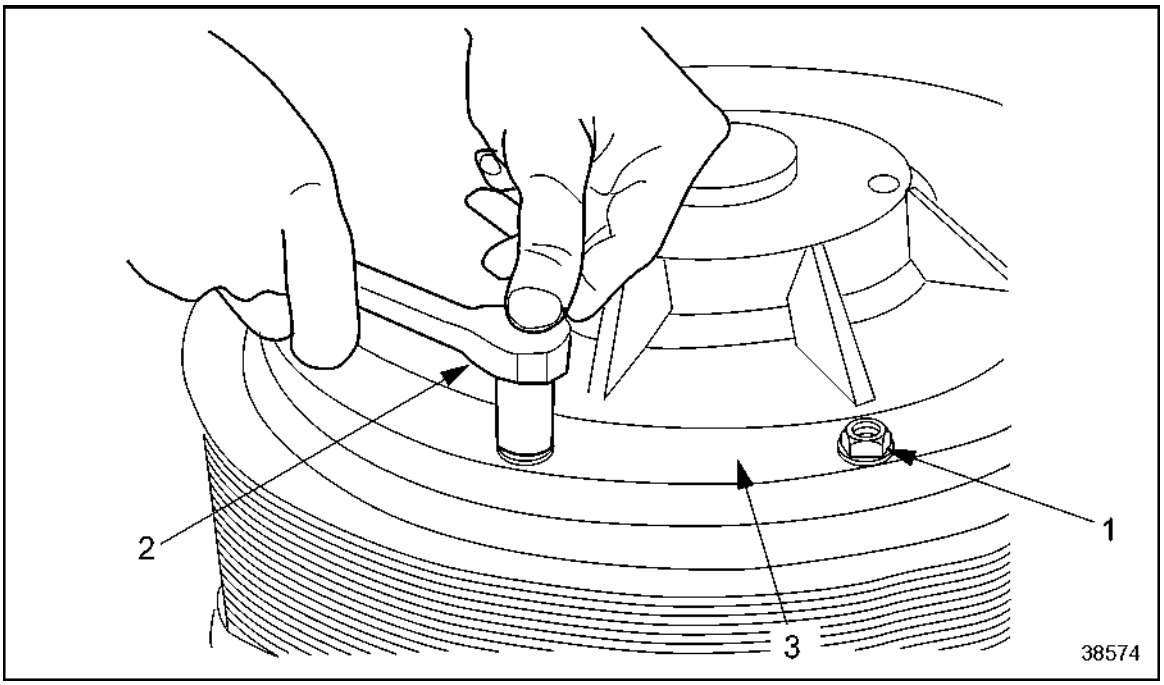
C 222.05.05 – REMOVAL OF ROCKFORD SERIES 270 FAN CLUTCH

Refer to section C 221.05.05 for fan clutch removal procedures.

C 222.05.06 – DISASSEMBLY OF ROCKFORD SERIES 270 FAN CLUTCH

Perform the following steps to disassemble the Rockford® Series 270 fan clutch assembly:

1. Support the fan clutch on a bench with the fan mounting hub facing upwards.
2. Remove bolts and lock washers (1) securing front bearing retainer (3) to the fan clutch. See Figure 1059.



1. Bolt and Washers
2. Socket
3. Front Bearing Retainer

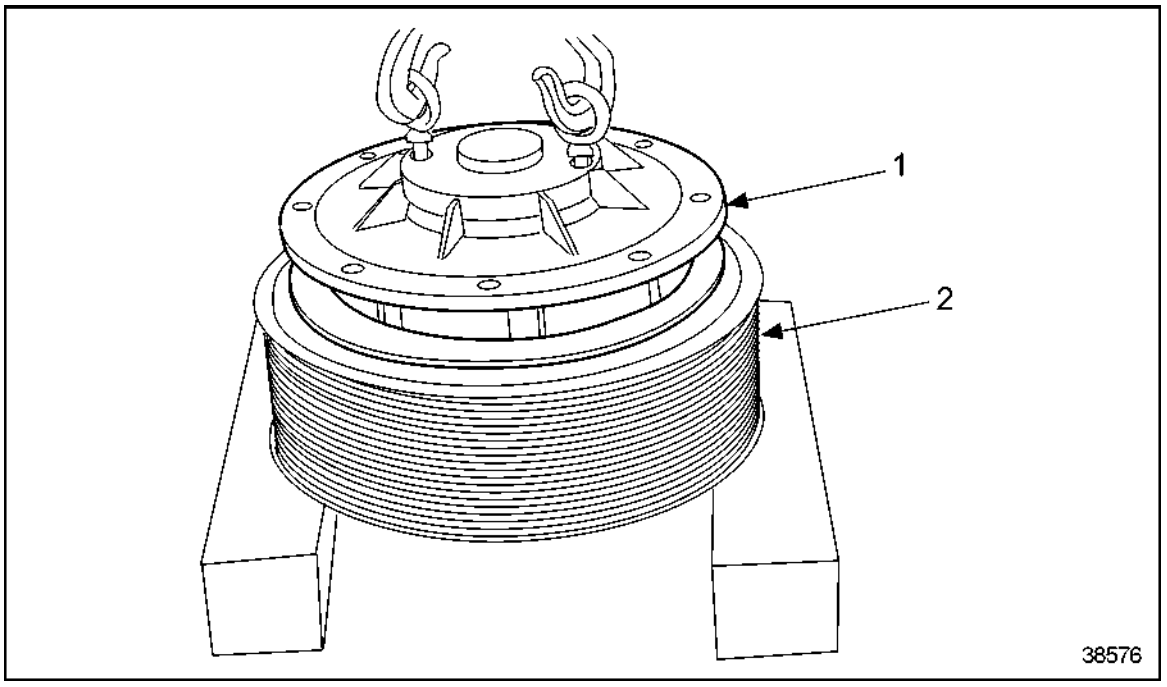
Figure 1059 Removal of Bolts and Washers

CAUTION:

To avoid injury from a falling component while using a lifting device, never stand beneath a suspended load.

3. Install lifting eyes to the front bearing retainer (1) and attach a suitable lifting device. Remove the front bearing retainer from the belt pulley and place on a bench. See Figure 1060.

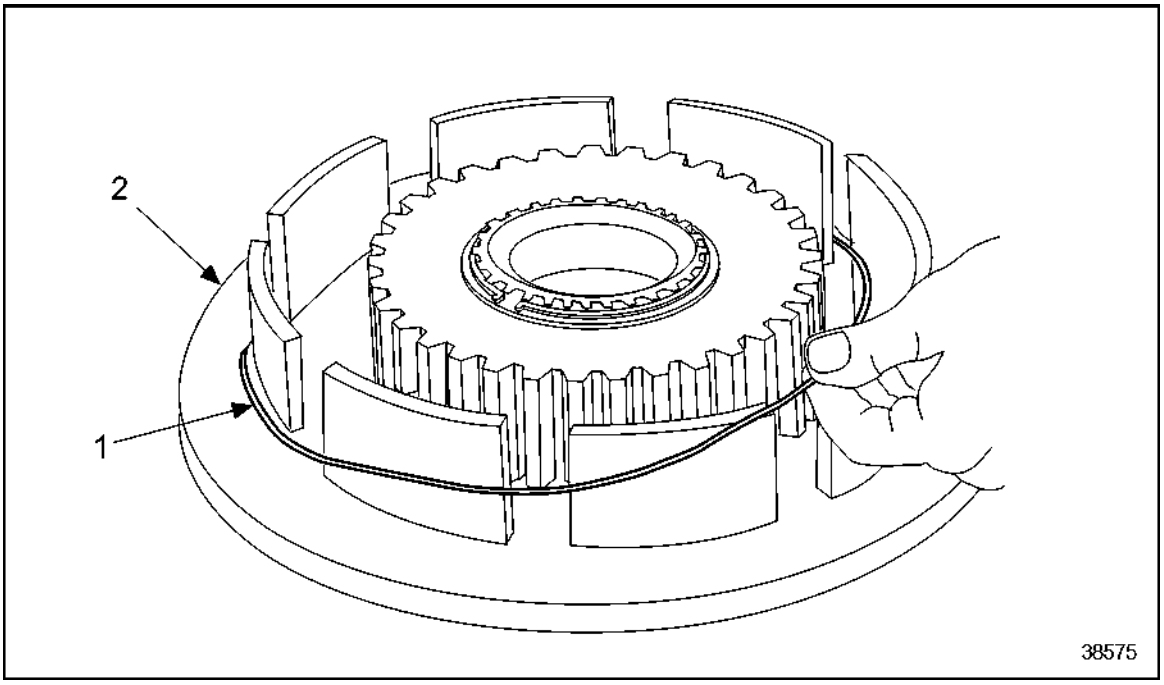
NOTE:
A screwdriver may be used at the split line to break the bearing retainer loose from the pulley.



1. Front Bearing Retainer
2. Belt Pulley

Figure 1060 Removal of Front Bearing Retainer

4. Remove O-ring seal (1) from the front bearing retainer. See Figure 1061.



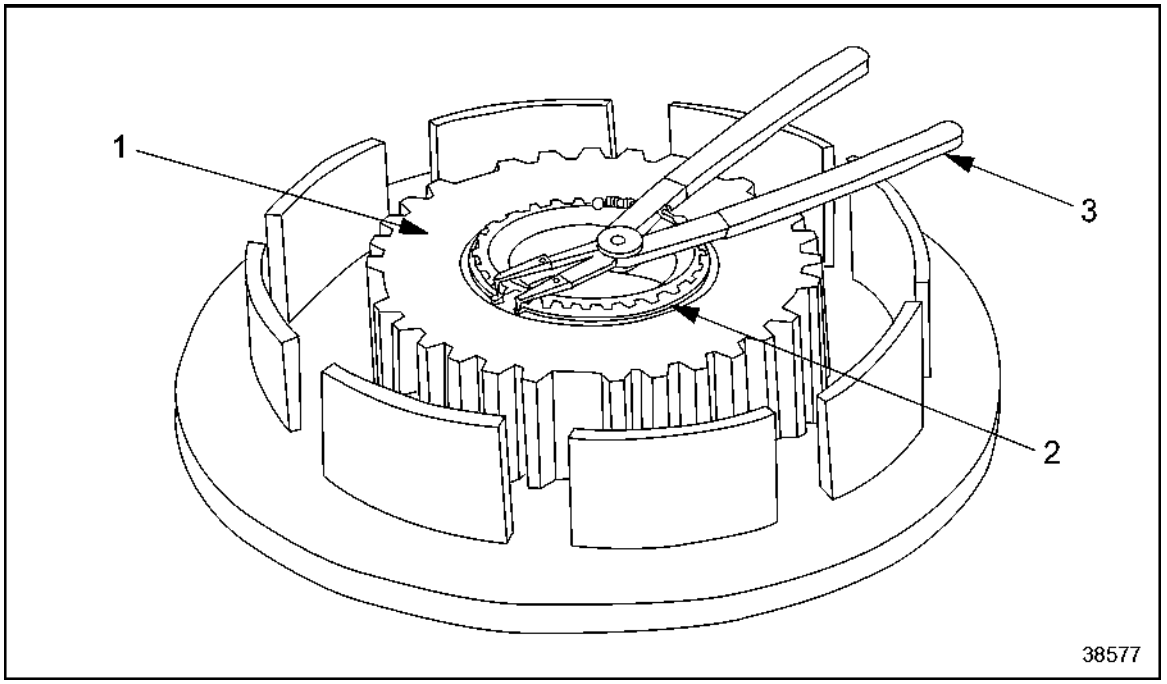
1. O-ring Seal
2. Front Bearing Retainer

Figure 1061 Removal of O-ring Seal

CAUTION:

To avoid injury from flying parts when working with components under spring tension, wear adequate eye protection (face shield or safety goggles).

5. Support the bearing retainer subassembly on a bench with the clutch hub (1) facing upwards. Remove external snap ring (2) from the clutch hub (1). See Figure 1062.



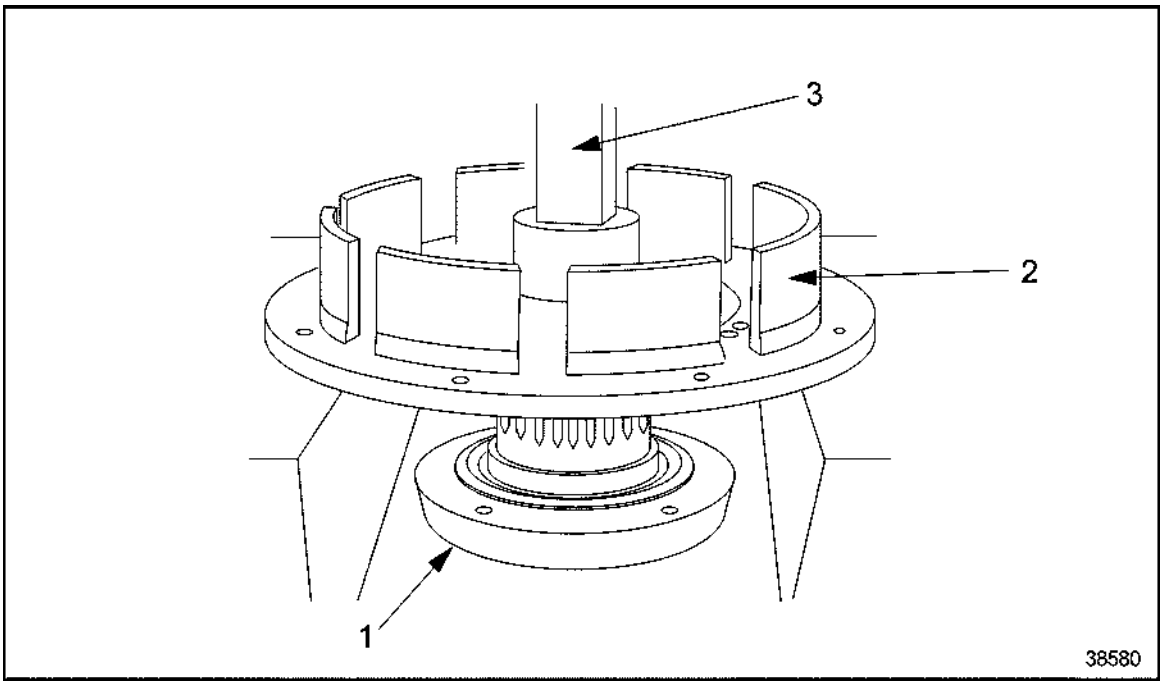
1. Clutch Hub
2. External Snap Ring
3. Snap Ring Pliers

Figure 1062 Removal of External Snap Ring

6. Remove clutch hub (1) from front bearing retainer. See Figure 1062.

7. Position the subassembly beneath hydraulic press ram (3). Press the fan mounting hub (1) out from front bearing retainer (2). See Figure 1063.

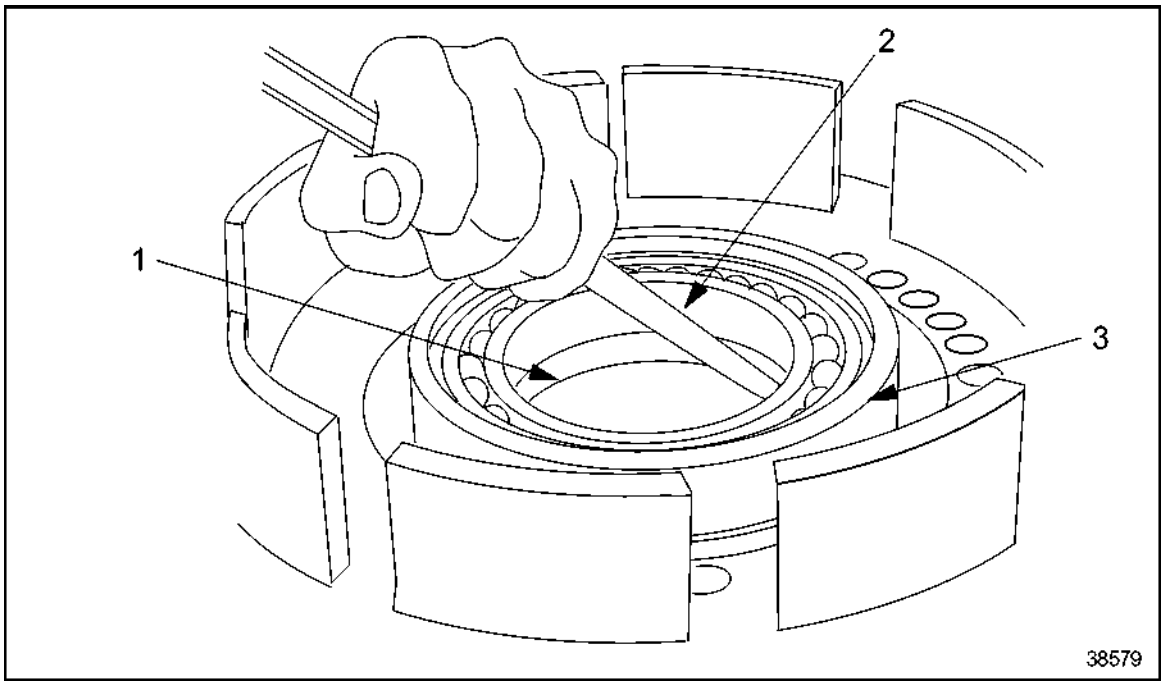
NOTE:
Ensure that there is support beneath the bearing retainer prior to removal.



1. Fan Mounting Hub
2. Front Bearing Retainer
3. Hydraulic Press Ram

Figure 1063 Removal of Front Bearing Retainer Subassembly

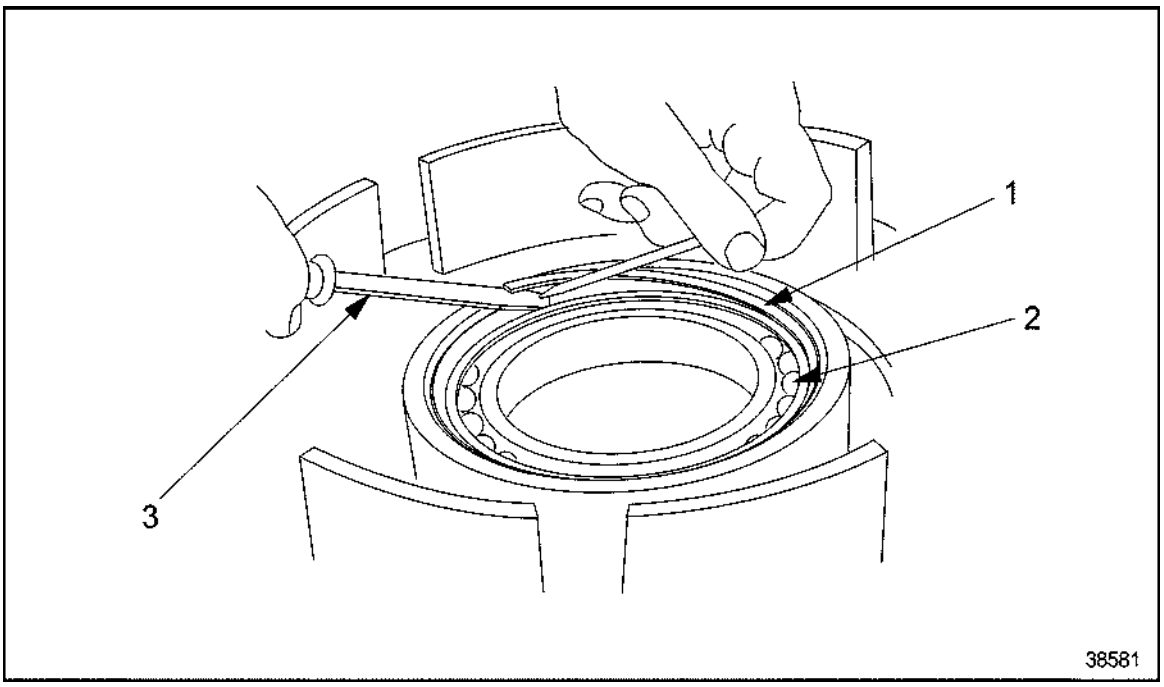
8. Remove front oil seal (1) from front bearing retainer (3) using a punch or drift (2). See Figure 1064.



1. Front Oil Seal
2. Punch or Drift
3. Front Bearing Retainer

Figure 1064 Removal of Front Oil Seal

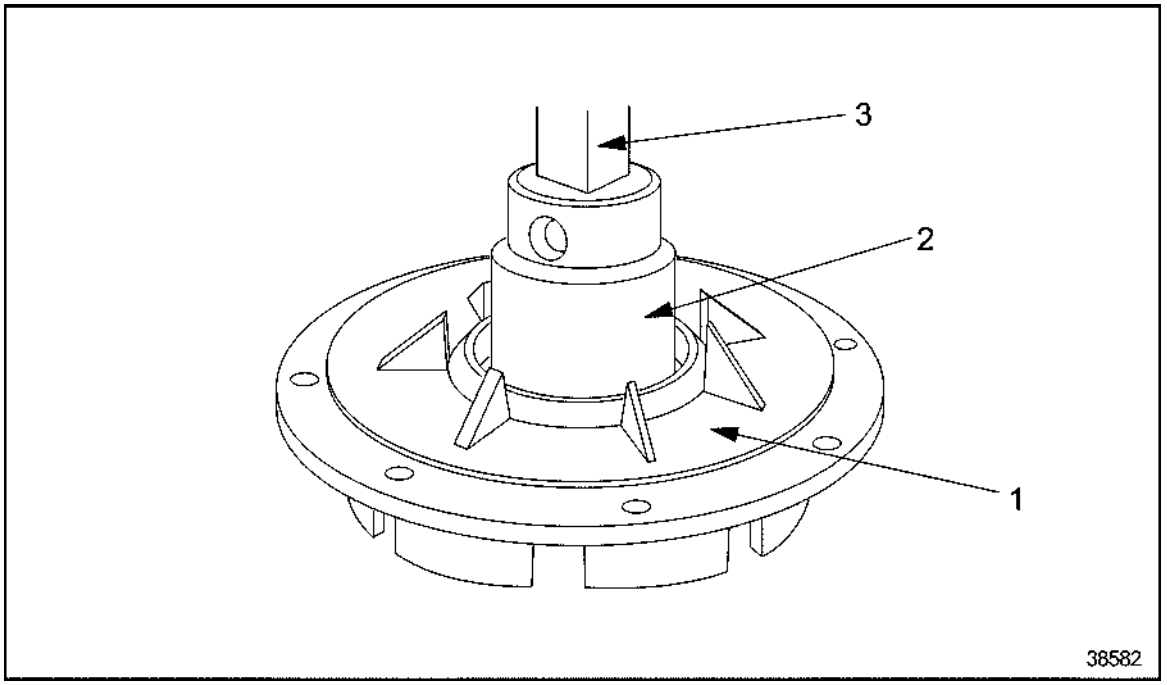
9. Remove internal snap ring (1) from bearing (2) using screwdriver (3). See Figure 1065.



1. Internal Snap Ring
2. Bearing
3. Screwdriver

Figure 1065 Removal of Snap Ring

10. Rotate front bearing retainer (1) on the press bed. Using hydraulic press (3), press the front bearing out from the front bearing retainer (1) with special bearing removal tool #2 (2). See Figure 1066.



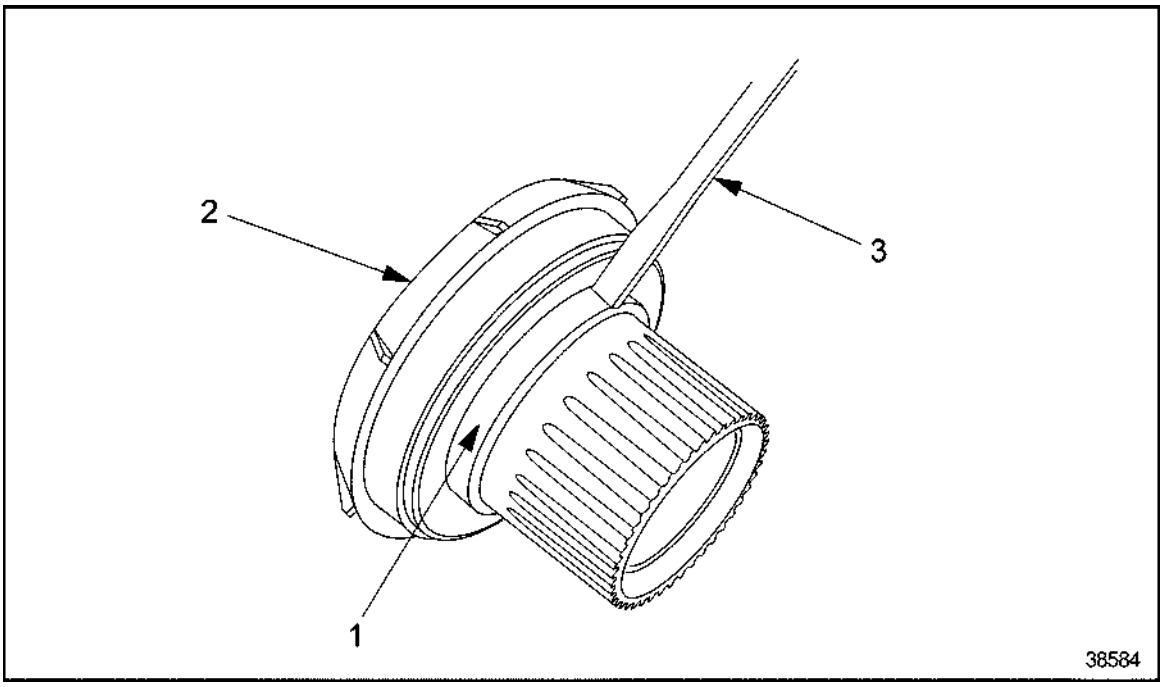
1. Front Bearing Retainer
2. Special Bearing Removal Tool #2
3. Hydraulic Press

Figure 1066 Removal of Front Bearing

NOTICE:
To prevent front mount hub surface damage during removal, ensure to use care to not cut through the wear sleeve with the chisel blade.

11. Use chisel (3) to remove wear sleeve (1) from fan mount hub (2). See Figure 1067.

NOTE:
Use chisel (3) to score wear sleeve (1) with three marks 120 degrees apart.

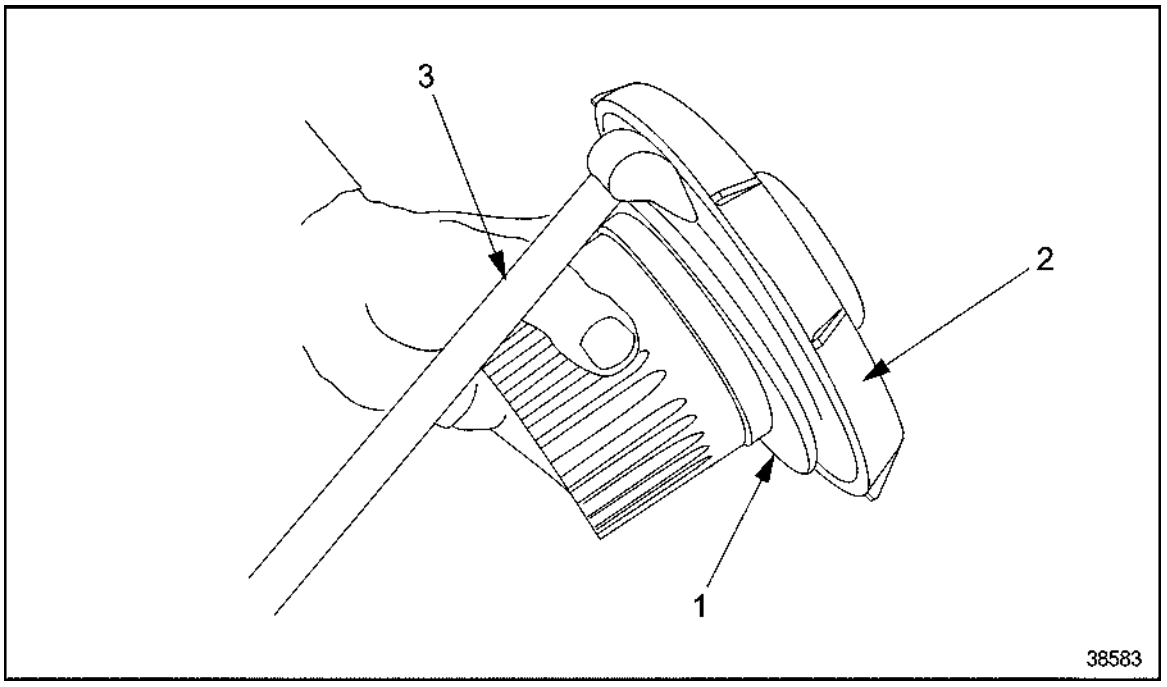


1. Wear Sleeve
2. Fan Mount Hub
3. Chisel

Figure 1067 Removal of Wear Sleeve

NOTE:
Do not perform step 12 if the retainer seal assembly is not damaged, worn or otherwise in need of replacement. Removal of the assembly can be omitted.

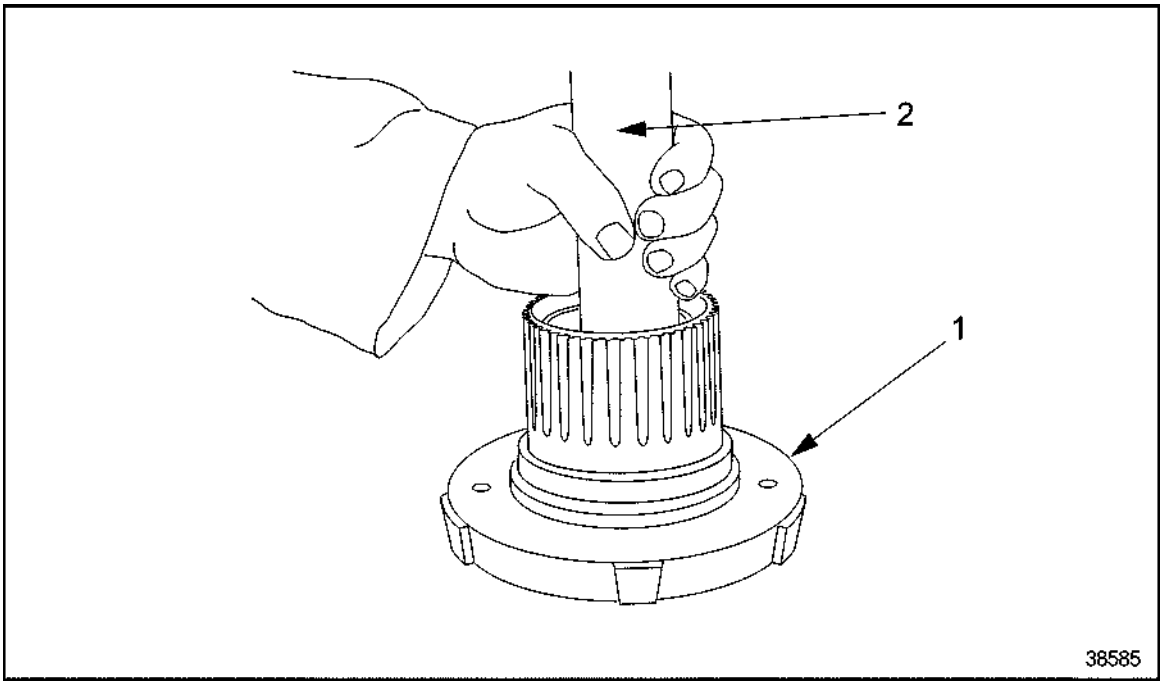
12. Place a crows foot pry bar (3) behind retainer (1) to force it off the fan mount hub (2). Remove the front retainer seal assembly from the fan mount hub. See Figure 1068.



1. Front Bearing Retainer
2. Fan Mount Hub
3. Crows Foot Pry Bar

Figure 1068 Removal of Fan Mount Hub

13. Support fan mount hub (1) on bar stock approximately 2 inches above the press bed. With a piece of round bar stock (1.5–2.5 in. diameter x 7 in. long) placed on the end cap, press the end cap out from fan mount hub (1). See Figure 1069.

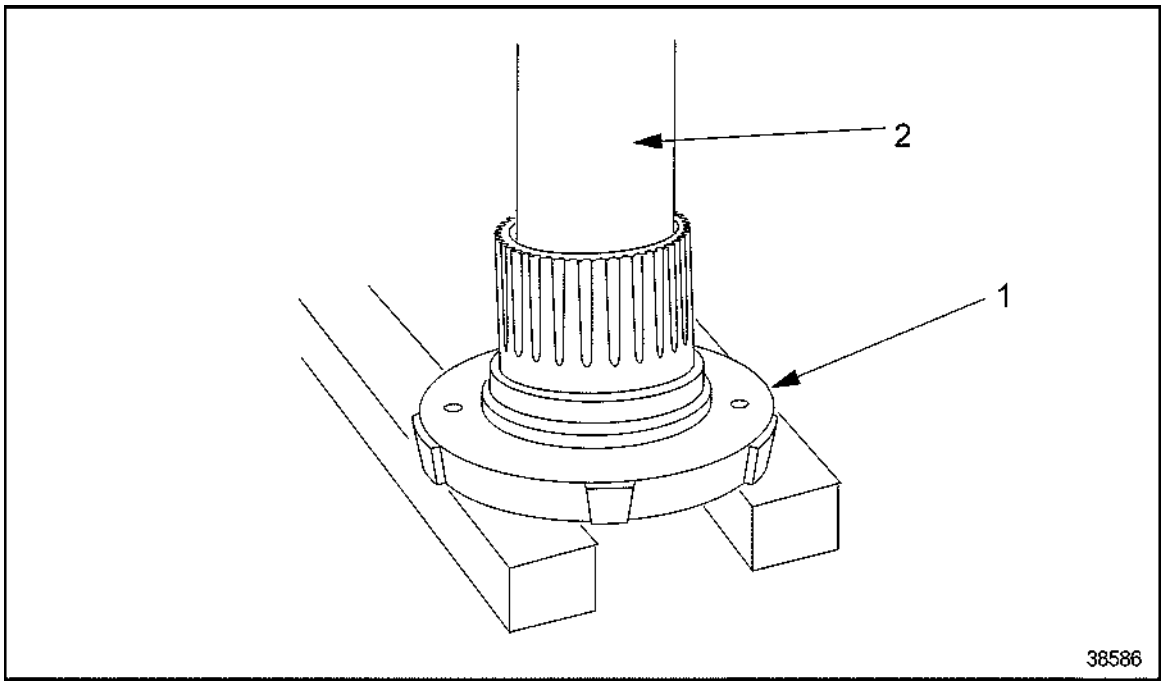


1. Fan Mount Hub
2. Round Bar Stock

Figure 1069 Removal of End Cap

14. Using a hydraulic press and special removal tool #1 (2), press the sleeve bearing downwards to remove it from fan mount hub (1). See Figure 1070.

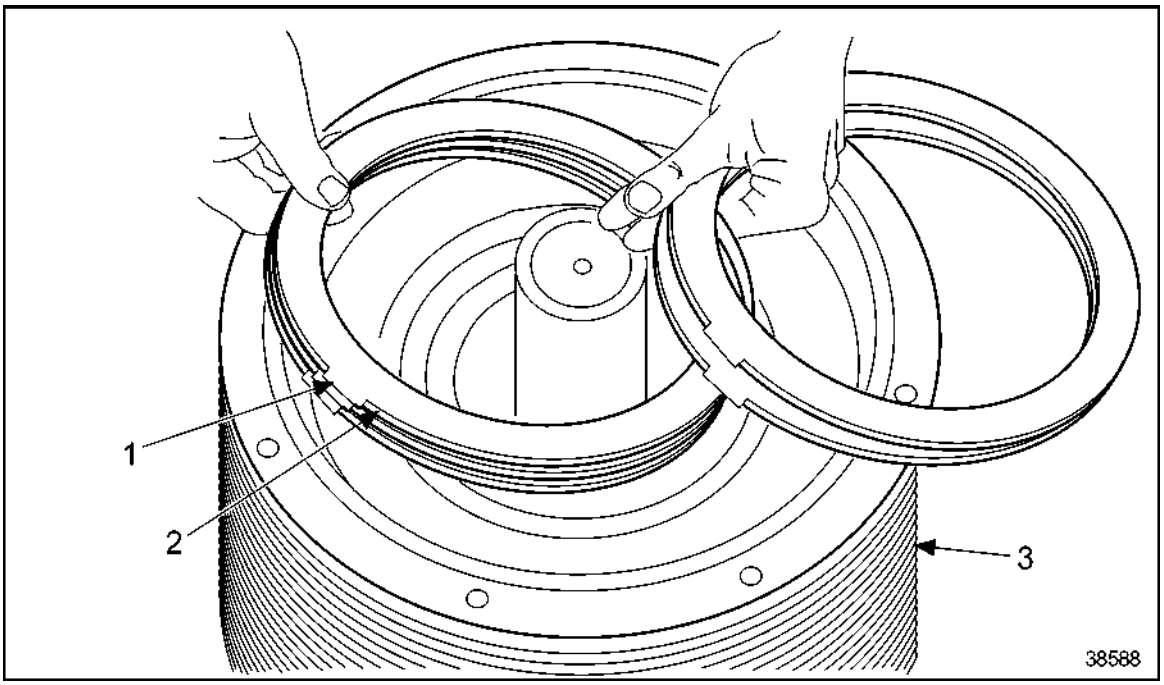
NOTE:
The second sleeve bearing will be pressed out concurrently with the first.



1. Fan Mount Hub
2. Special Removal Tool #1

Figure 1070 Removal of Sleeve Bearing

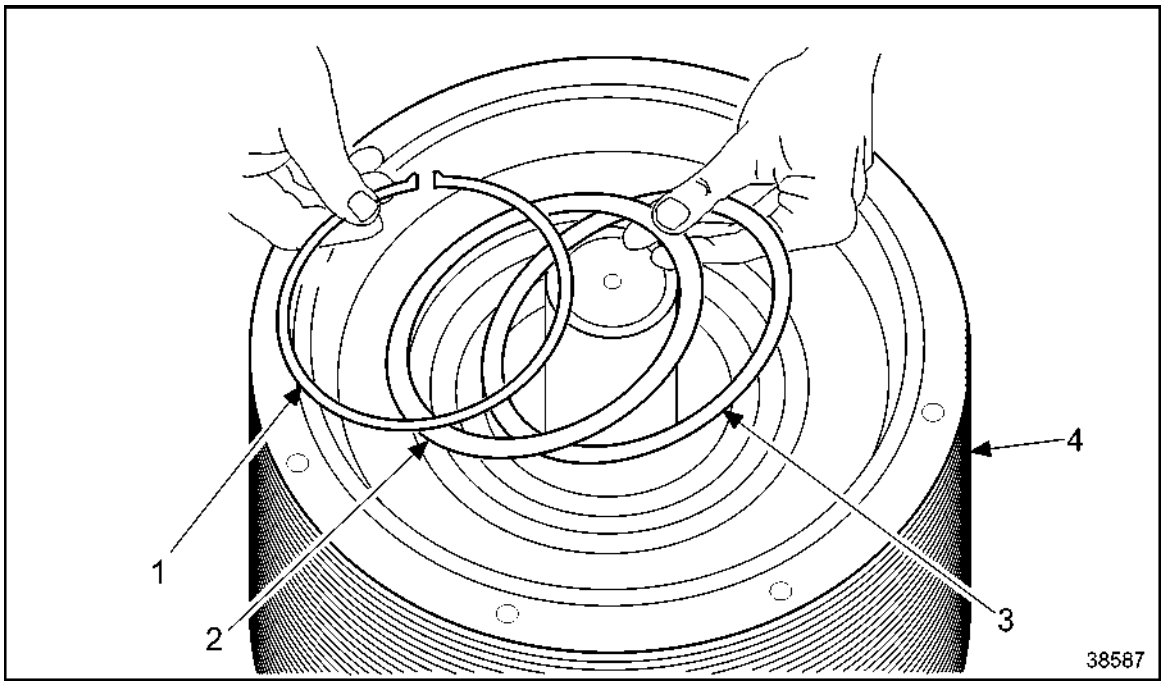
15. Remove facing plates (1) and steel clutch plates (2) from within pulley (3). See Figure 1071.



1. Facing Plates
2. Steel Clutch Plates
3. Pulley

Figure 1071 Removal of Facing Plates and Steel Clutch Plates

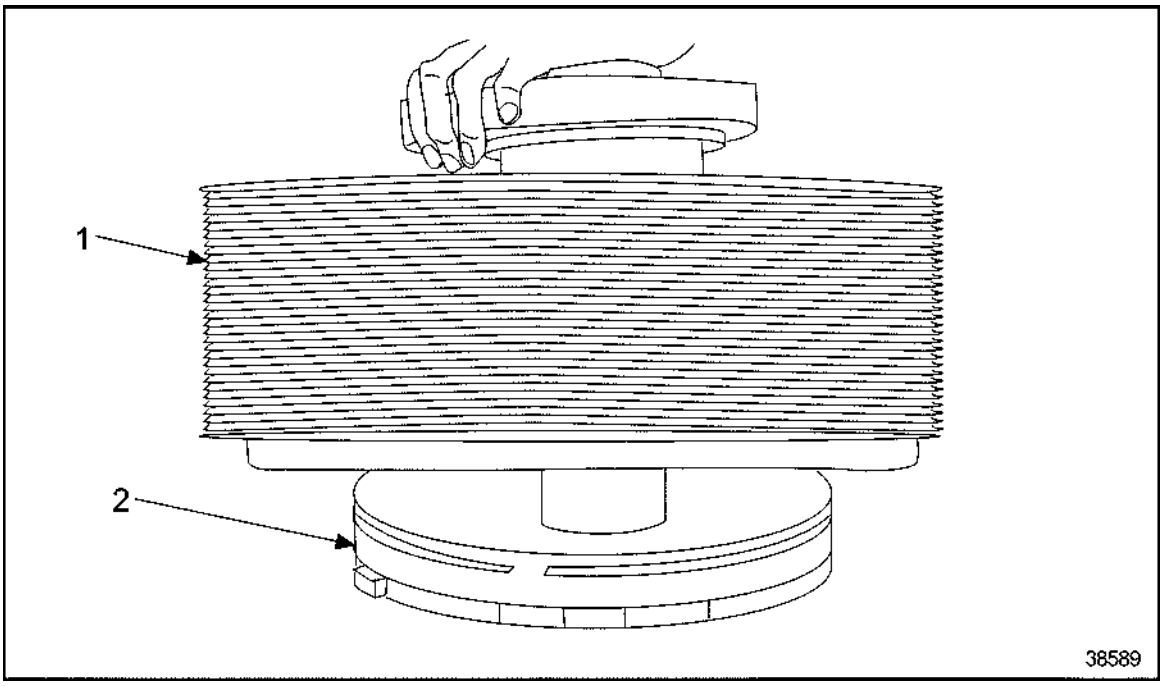
16. Remove external snap ring (1), shim (2), and spring washer (3) from pulley (4). See Figure 1072.



1. External Snap Ring (Spirolock)
2. Shim
3. Spring Washer
4. Pulley

Figure 1072 Removal External Snap Ring

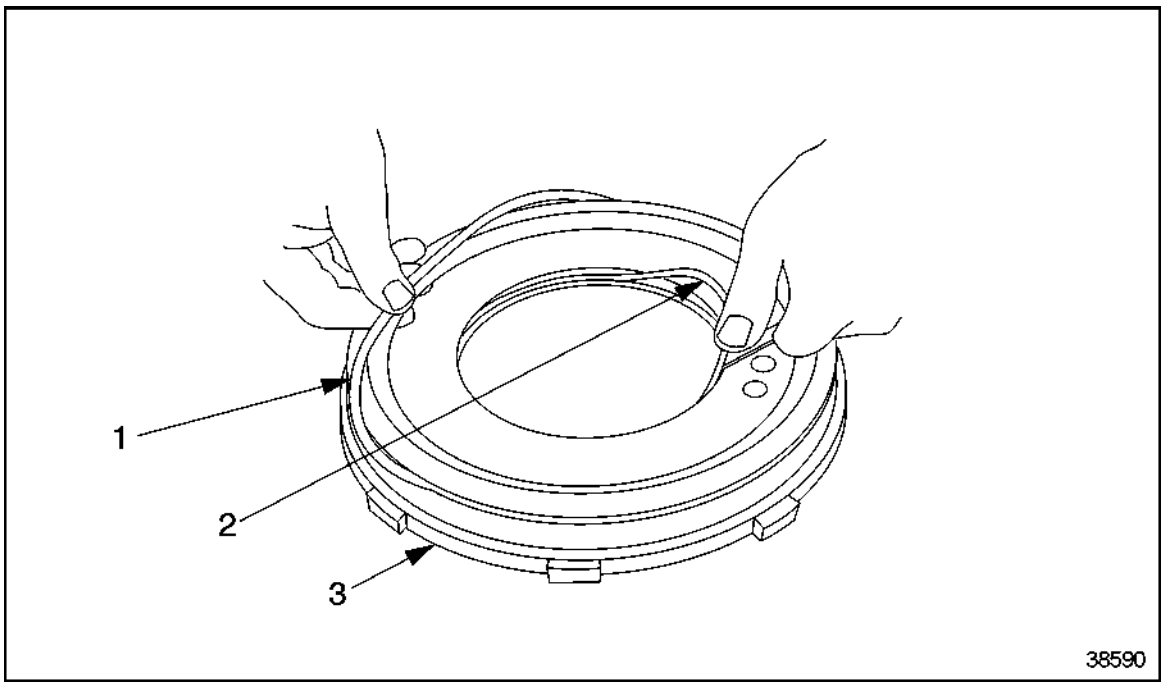
17. Rotate the pulley shaft assembly over on the bench 180 degrees. Lift pulley (1) to allow piston (2) to fall out. See Figure 1073.



1. Pulley
2. Piston

Figure 1073 Removal of Piston

18. Remove large seal ring (1) and small seal ring (2) from piston (3). See Figure 1074.



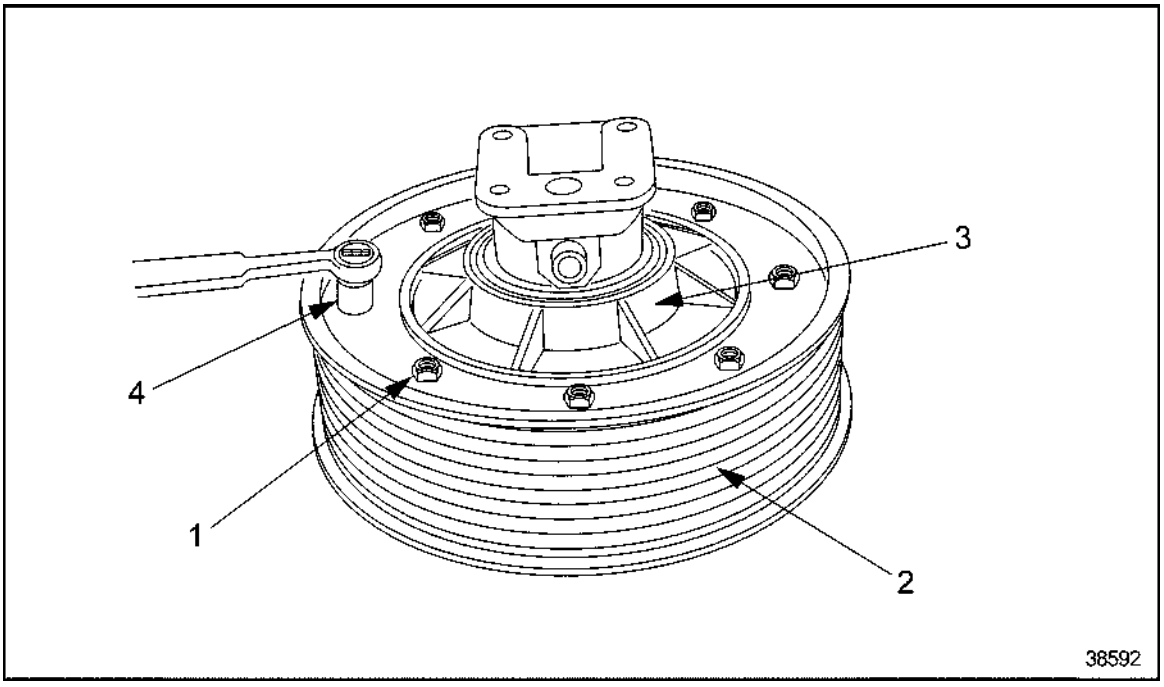
1. Large Seal Ring
2. Small Seal Ring
3. Piston

Figure 1074 Removal of Piston Seal Rings

NOTE:
Ensure that the pulley is properly supported on the bench prior to performing step 19.

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

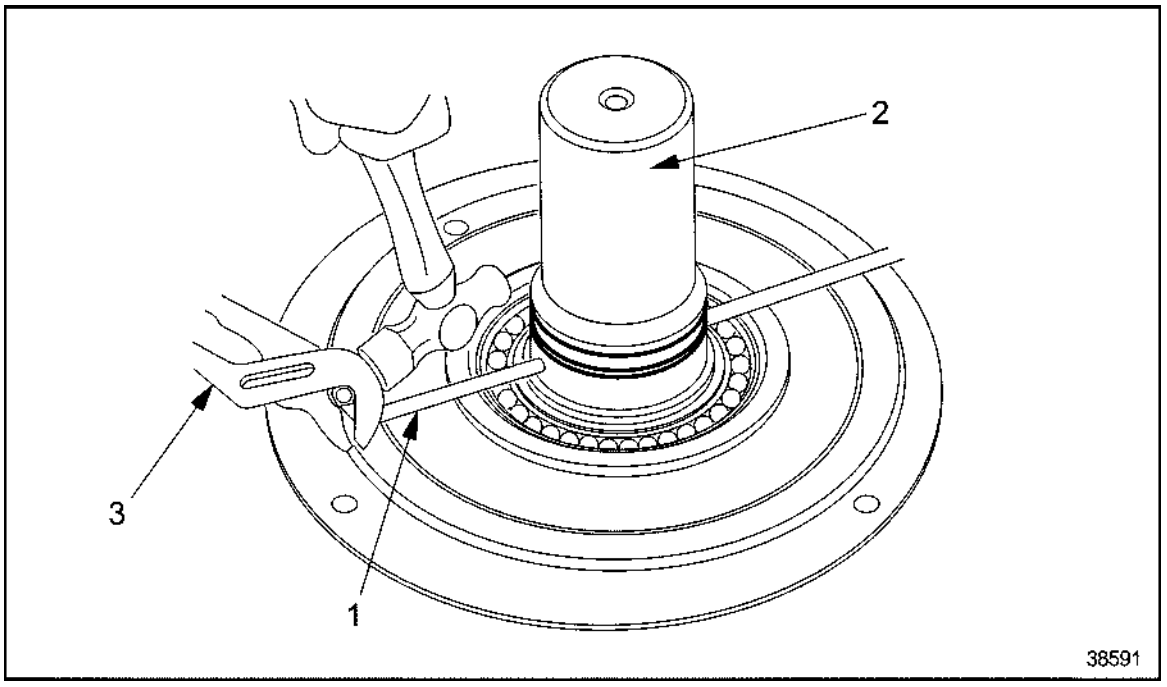
NOTE:
Pulley (2) should not be allowed to drop to the bench when the supports are removed. However, if bearing retainer (3) is not able to be removed from pulley (2), stand the unit on the bench resting on the nose of the shaft. Rap pulley (2) with a soft, but heavy mallet to break it loose from rear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



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

Figure 1075 Removal of Rear Bearing Retainer

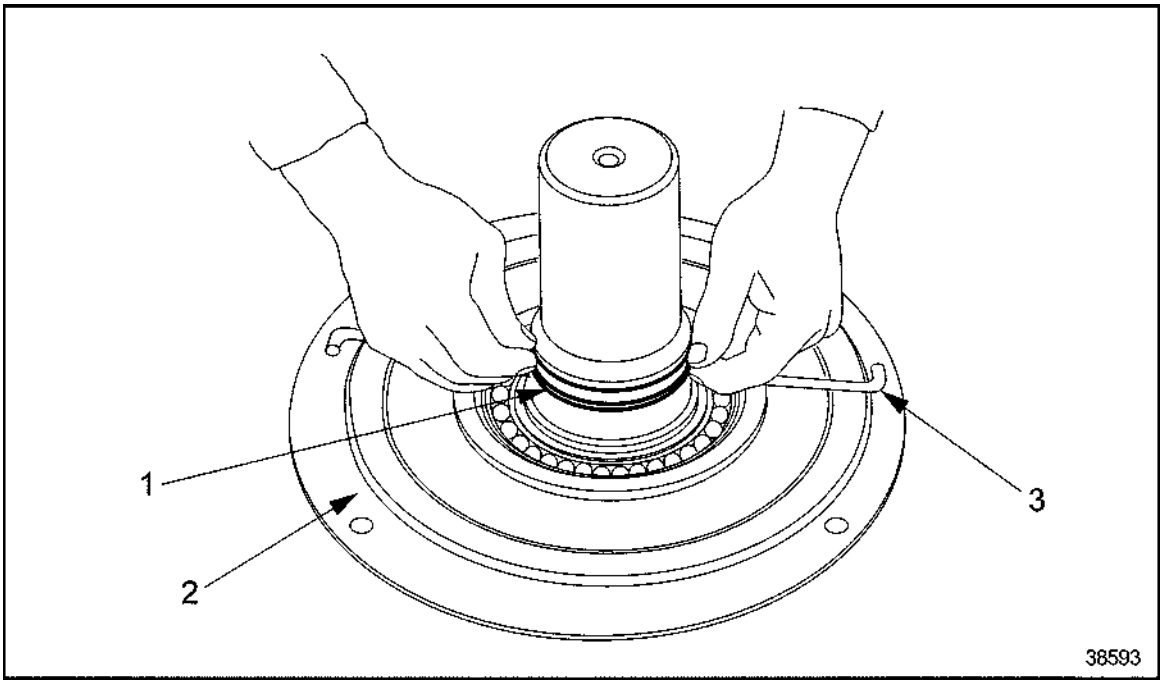
20. Remove pulley shaft (2) and rest it on the mounting bracket with the nose facing up. Insert a Phillips head screwdriver into the pitot tubes (1) to loosen and remove them from the shaft. Rotate pitot tubes (1) until the sealant securing them to the pulley shaft (2) is broken loose. Grip the pitot tubes with a pair of pliers, and gently tap the pliers to remove the pitot tubes from the hole in the shaft. See Figure 1076.



1. Pitot Tubes
2. Pulley Shaft
3. Pliers

Figure 1076 Removal of Pulley Shaft

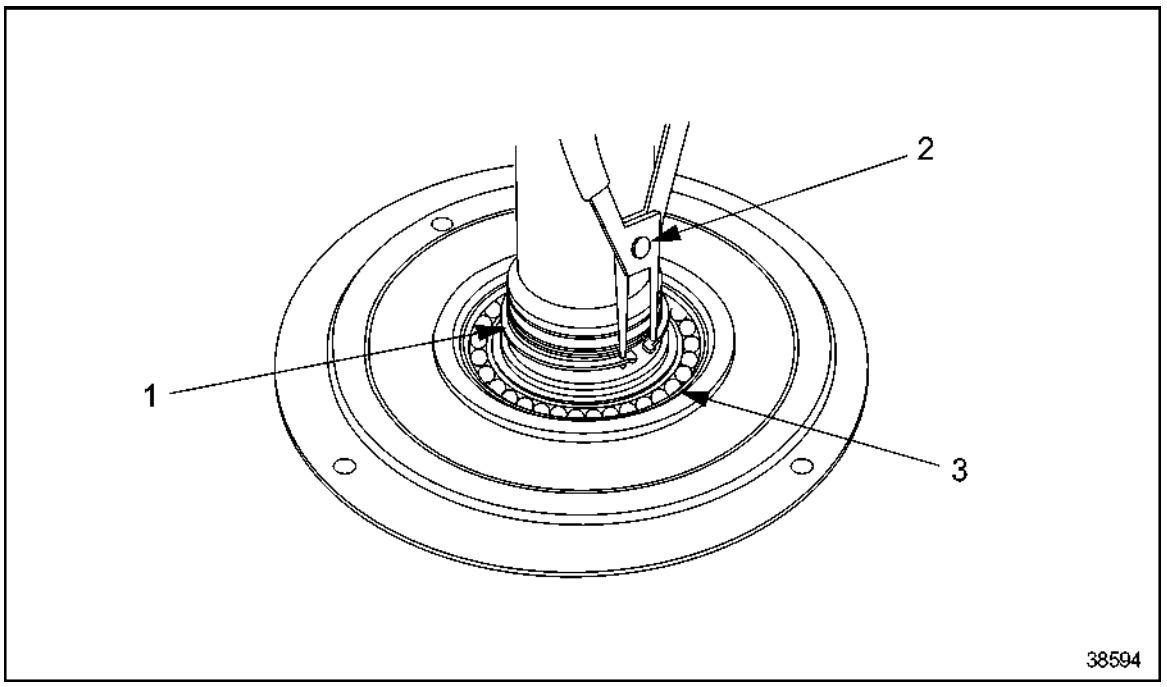
21. Remove seal rings (1) from pulley shaft. See Figure 1077.



1. Seal Rings
2. Rear Bearing Retainer
3. Pitot Tubes

Figure 1077 Removal of Seal Rings from Pulley Shaft

22. Remove external snap ring (1). See Figure 1078.



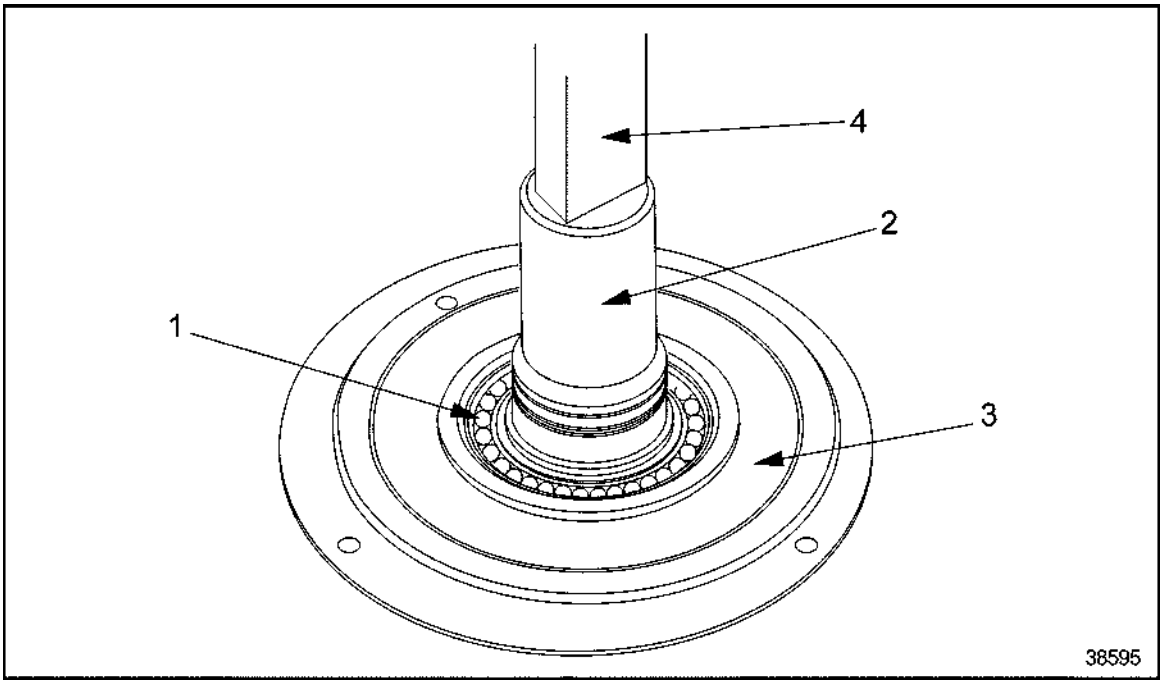
1. External Snap Ring
2. Snap Ring Pliers
3. Internal Snap Ring

Figure 1078 Removal of Snap Ring

23. Remove internal snap ring (3). See Figure 1078.

NOTE:
Ensure that the rear bearing retainer is properly supported prior to removal of the shaft (step 24). The retainer should be supported as close as possible to the bearing bore, but not too close as to damage the retainer seal assembly.

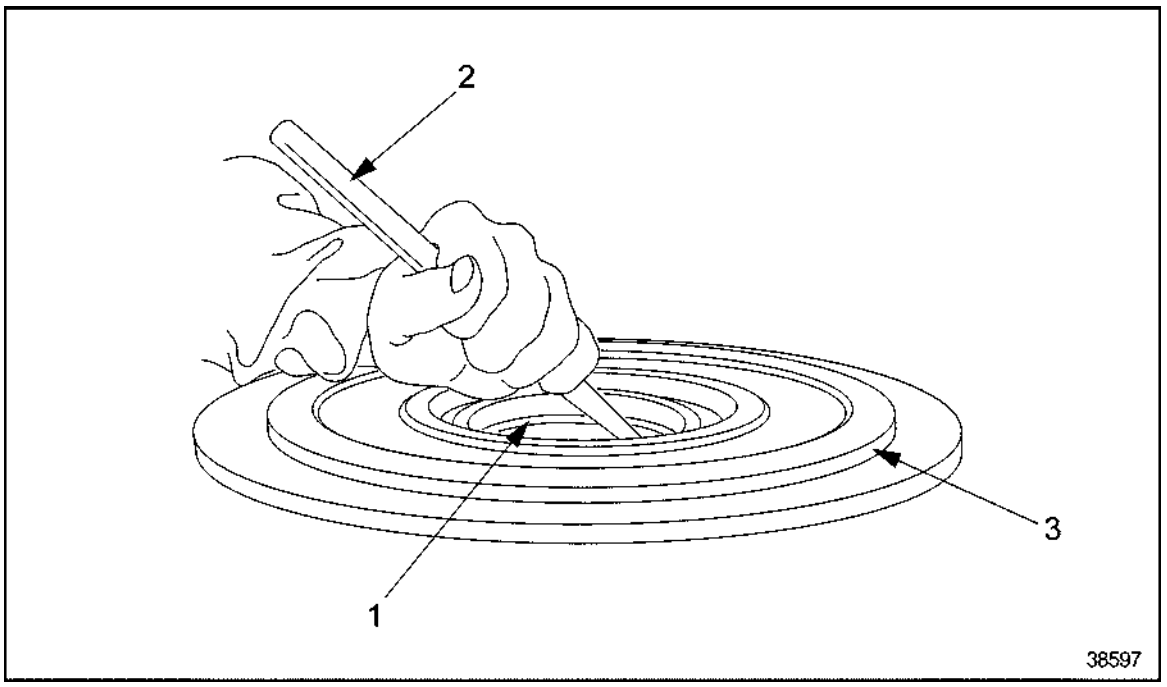
24. Using an hydraulic press (4), press shaft (2) out from bearing (1). See Figure 1079.



1. Bearing
2. Shaft
3. Rear Bearing Retainer
4. Hydraulic Press

Figure 1079 Removal of Bearing

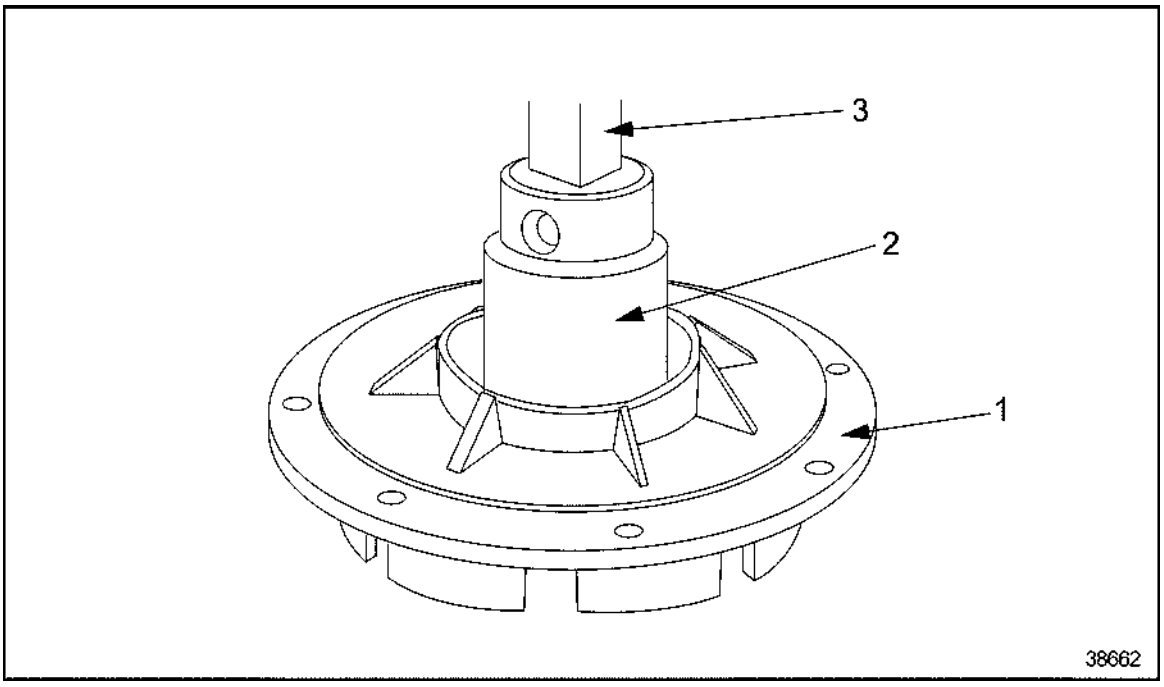
25. Remove oil seal (1) from rear bearing retainer (3). See Figure 1080.



1. Oil Seal
2. Punch or Drift
3. Rear Bearing Retainer

Figure 1080 Removal of Oil Seal

26. Using hydraulic press (3) and special bearing removal tool #2 (2), press the rear bearing out from rear bearing retainer (1). See Figure 1081.



1. Rear Bearing Retainer
2. Special Bearing Removal Tool #2
3. Hydraulic Press

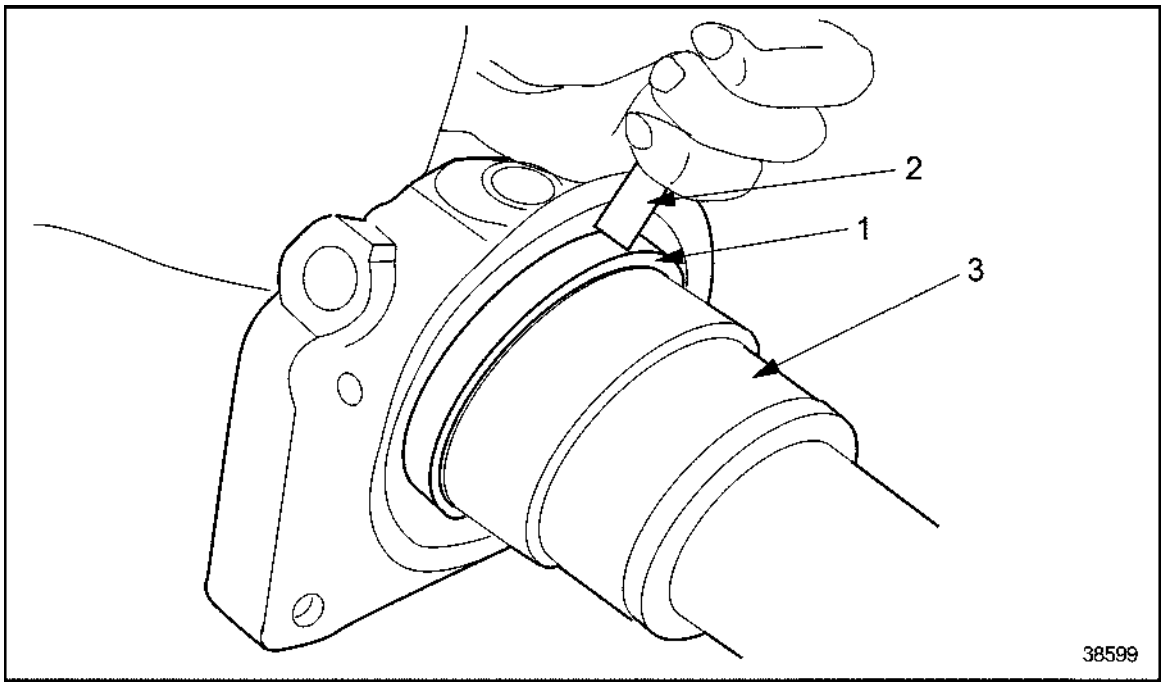
Figure 1081 Removal of Rear Bearing

CAUTION:
To avoid injury, wear protective clothing and eye protection.

NOTICE:
To prevent hub surface damage during removal, do not cut through the wear sleeve with the chisel blade.

27. Remove wear sleeve (1) from shaft (3). See Figure 1082.

NOTE:
Use chisel (2) to score wear sleeve (1) with three marks 120 degrees apart.

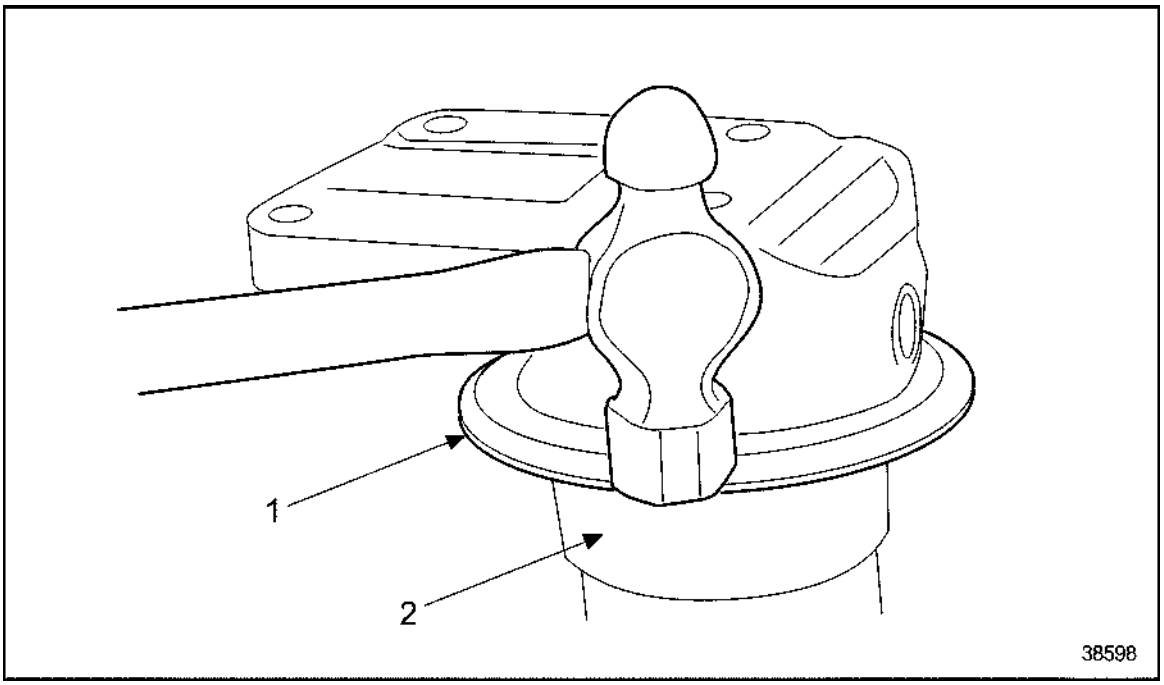


1. Wear Sleeve
2. Chisel
3. Shaft

Figure 1082 Removal of Wear Sleeve

NOTE:
Do not remove retainer seal assembly (step 28) if not damaged, worn, or otherwise in need of replacement.

28. Using an hydraulic press or large chisel, remove the rear retainer seal assembly (1) from the shaft. See Figure 1083.

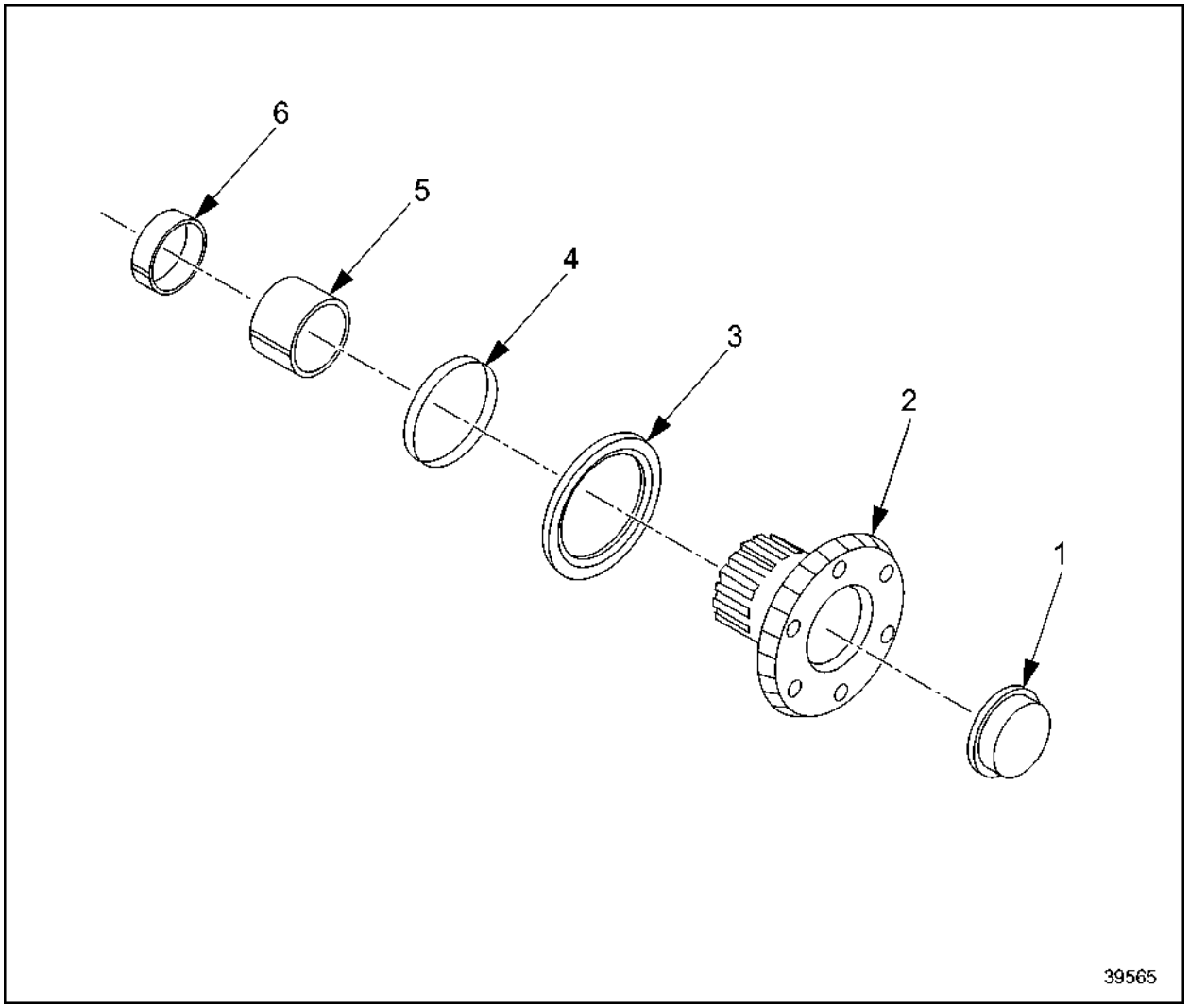


1. Rear Retainer Seal Assembly
2. Shaft

Figure 1083 Removal of Rear Retainer Seal Assembly

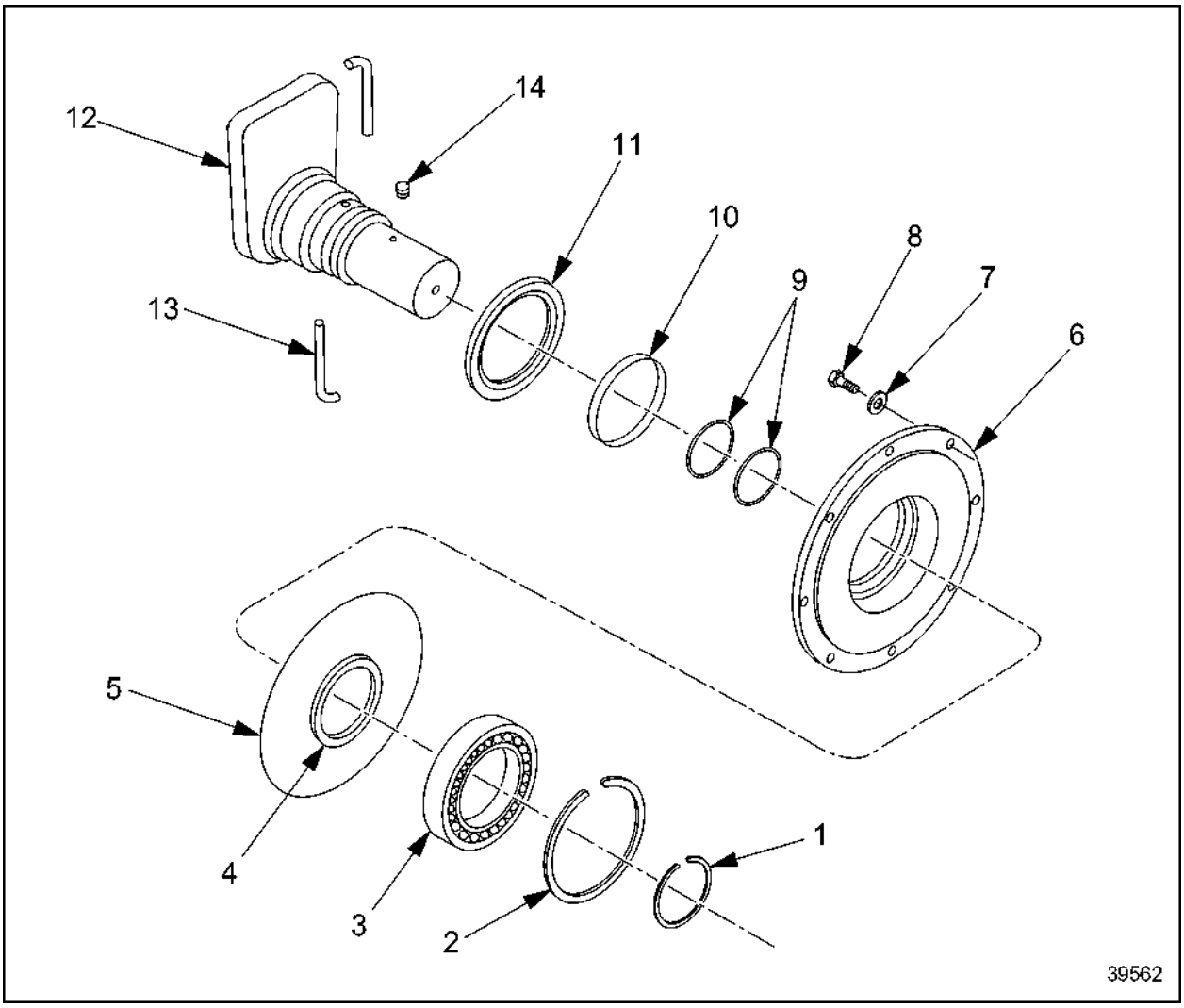
C 222.05.08 – INSPECTION OF ROCKFORD SERIES 270 FAN CLUTCH COMPONENTS

The following graphics support the inspection procedures for the Rockford fan clutch: see Figure 1084, see Figure 1085, see Figure 1086, see Figure 1087, and see Figure 1088.



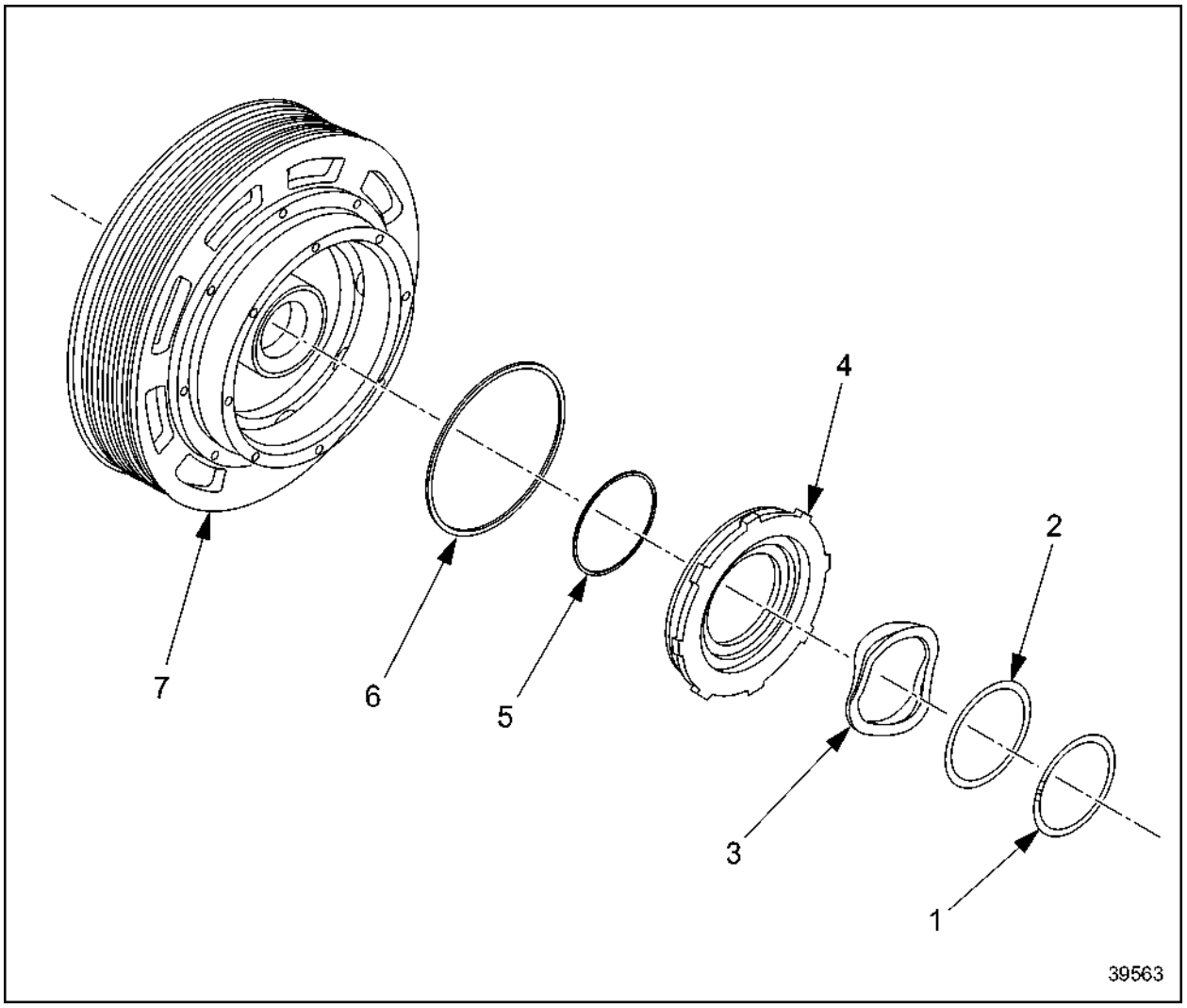
1. End Cap
2. Fan Mounting Hub
3. Front Retainer Seal Assembly
4. Front Wear Sleeve
5. Sleeve Bearing
6. Sleeve Bearing

Figure 1084 Inspection of Fan Clutch (View 1 of 5)



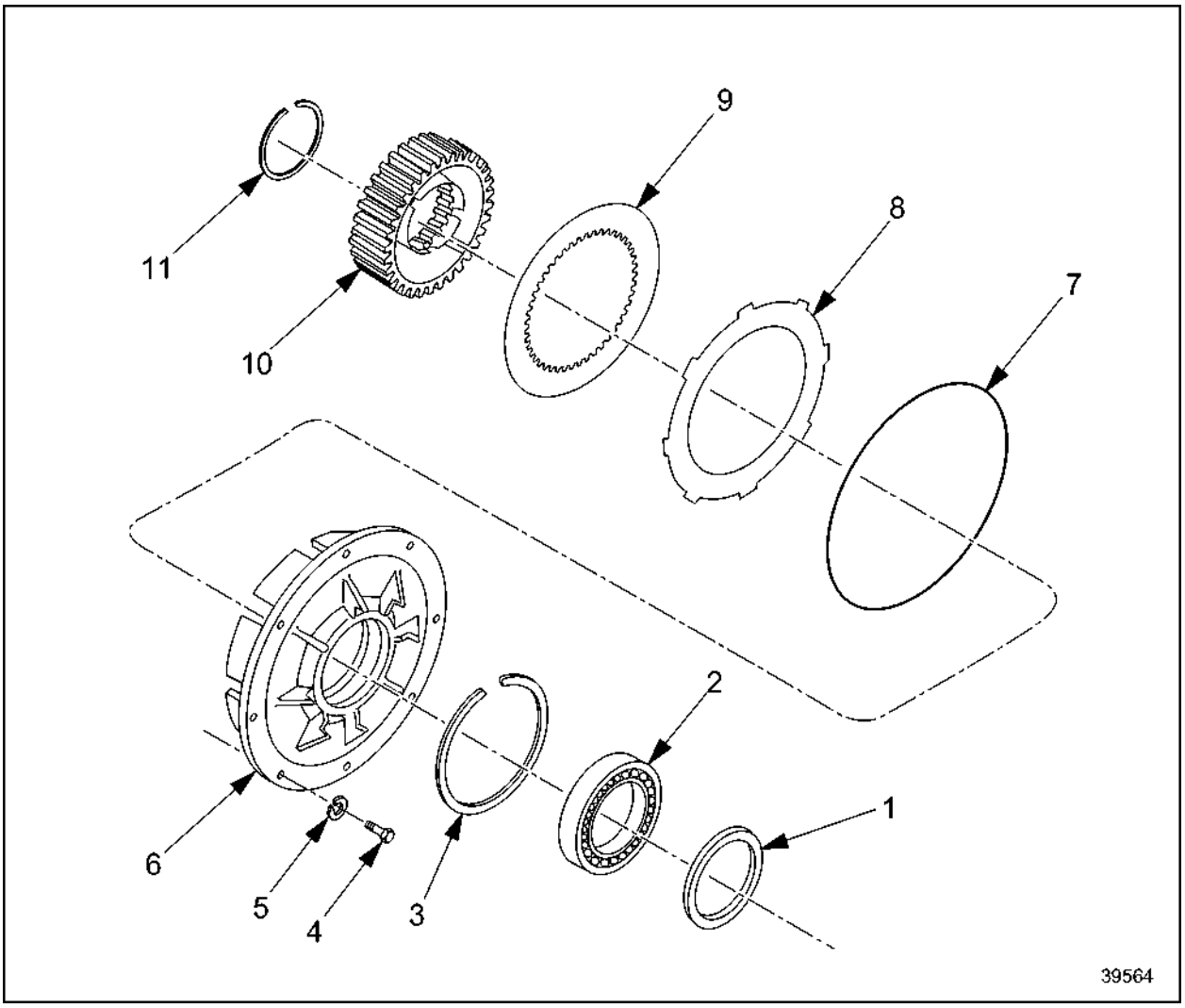
1. External Snap Ring
2. Internal Snap Ring
3. Rear Bearing
4. Rear Oil Seal
5. O-ring Seal
6. Rear Bearing Retainer
7. Lock Washers
8. Bolts
9. Seal Rings
10. Rear Wear Sleeve (notched)
11. Rear Retainer Seal Assembly
12. Shaft Bracket Assembly
13. Pitot Tubes
14. Orifice

Figure 1085 Inspection of Fan Clutch (View 2 of 5)



1. External Snap Ring (Spirolock)
2. Shim
3. Spring Washer
4. Piston
5. Small Seal Ring
6. Large Seal Ring
7. Pulley

Figure 1086 Inspection of Fan Clutch (View 3 of 5)



1. Front Oil Seal
2. Front Bearing
3. Internal Snap Ring
4. Bolts
5. Lock Washers
6. Front Bearing Retainer
7. O-ring Seal
8. Steel Clutch Plates
9. Facing Plates
10. Clutch Hub
11. External Snap Ring

Figure 1087 Inspection of Fan Clutch (View 4 of 5)

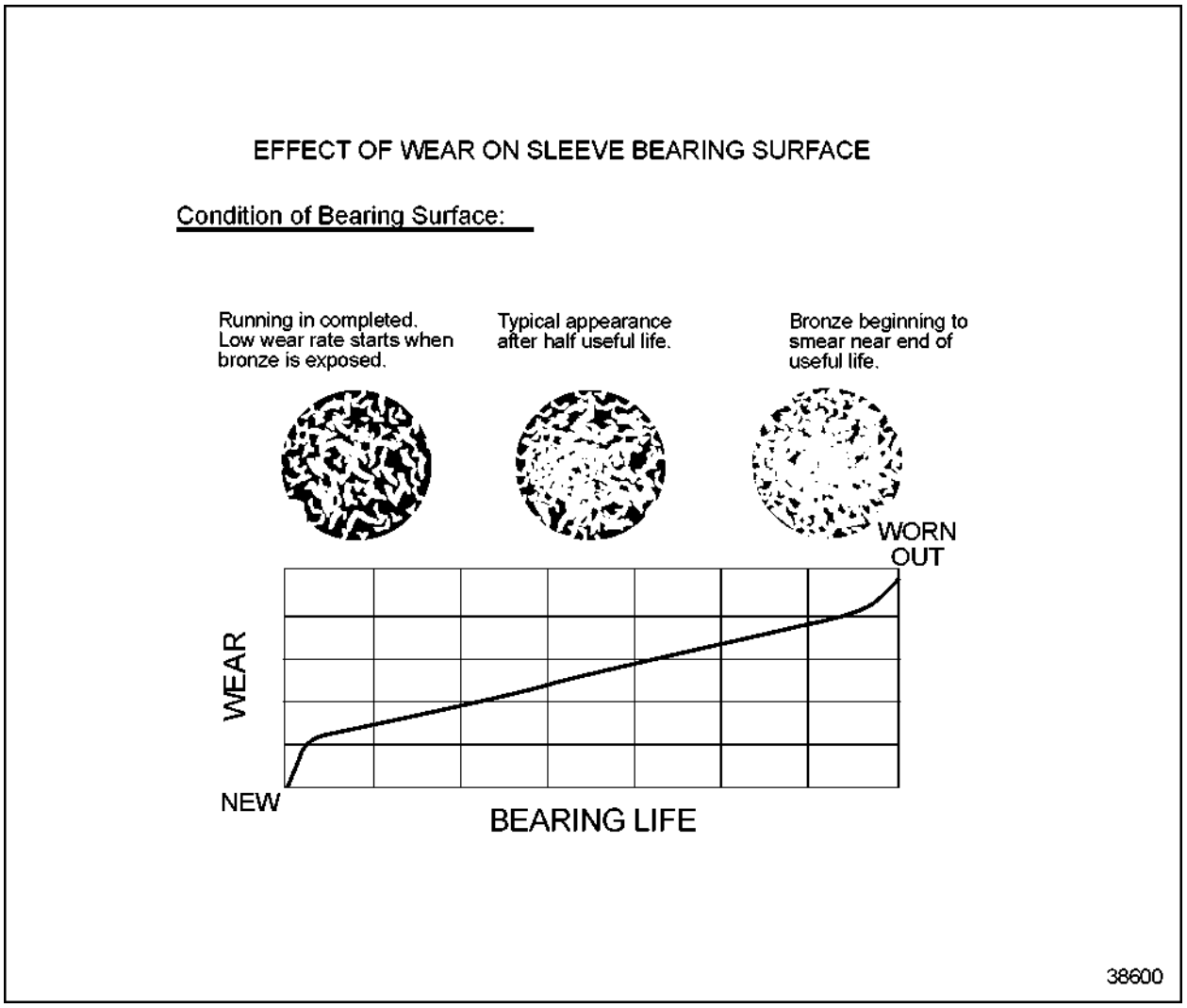


Figure 1088 Inspection of Fan Clutch (View 5 of 5)

Inspection of Shaft and Bracket Assembly

Perform the following inspections listed in Table 153 for the shaft and bracket assembly.

Part Description	Wear Limit
Bearing journal for sleeve bearing (5) and sleeve bearing (6), see Figure 1084	2.7480 in. (69.7992 mm) diameter minimum and no steps in surface
Bearing journal for rear bearing (3), see Figure 1085	* 3.7401 in. (94.9985 mm) diameter minimum
Groove width for external snap ring (1), see Figure 1085	0.145 in. maximum
Wear sleeve diameter	Free of nicks above surface
General	□ Do not separate shaft from bracket □ Do not remove tube from center bore □ Pipe plugs may be removed for cleaning □ Replace with sealant on threads □ Snap ring grooves must have straight sides and square corners

* If the surface has not indicated the bearing has been spinning and is not less than 3.7398 in. (94.9909 mm) diameter, the shaft may be reused. However, the bearing must be installed using Loctite #242 or equivalent.

Table 153 Inspection Criteria for Shaft and Bracket Assembly

Inspection of Shaft Bracket Assembly Orifice

Perform the following inspection (listed in Table 154) for the shaft and bracket assembly orifice:

Part Description	Wear Limit
Orifice (14), see Figure 1085	Reinstall

Table 154 Inspection Criteria for Shaft and Bracket Assembly Orifice

Inspection of Wear Sleeve

Perform the following inspection (listed in Table 155) for the wear sleeve:

Part Description	Wear Limit
Front wear sleeve (4), see Figure 1084	Replace if damaged or worn
Rear wear sleeve (10), see Figure 1085	Replace if damaged or worn

Table 155 Inspection Criteria for Wear Sleeve

Inspection of Front Oil Seal

Perform the following inspections (listed in Table 156) for the front oil seal:

Part Description	Wear Limit
Front oil seal (1), see Figure 1085	Replace front oil seal
Rear oil seal (4), see Figure 1087	Replace rear oil seal

Table 156 Inspection Criteria for Wear Sleeve

Inspection of Pulley

Perform the following inspections (listed in Table 157) for the pulley:

Part Description	Wear Limit
Pulley (7), see Figure 1086	□ Pilot bore for bearing retainer must be free of nicks that extend above the pilot surface. □ Flat surface(s) that mate with bearing retainer must be free of nicks that extend above the surface. □ Pulley grooves must not be severely worn or damaged.

Table 157 Inspection Criteria for Pulley

Inspection of Rear Bearing Retainer

Perform the following inspections (listed in Table 158) for the rear bearing retainer:

Part Description	Wear Limit
Bore for rear bearing (3), see Figure 1085	For large bearing 6.6921 in. (169.9793 mm) and 5.7079 in. (144.9807 mm) diameter maximum
Bore for rear oil seal (4), see Figure 1085	5.1265 in. (130.213 mm) diameter maximum
General	□ Bearing bore must have straight sides, square bottom, and not be oval due to wear. □ Oil seal bore must not have nicks that extend above the bore surface. All sealants must be removed. □ Flat surface that mates with pulley must be free of nicks that extend above the surface. □ Pilot diameter for pulley must be free of nicks that extend above the pilot surface.

Table 158 Inspection of Criteria for Rear Bearing Retainer

Inspection of Bolts and Lock Washers

Perform the following inspections (listed in Table 159) for the rear bearing retainer:

Part Description	Wear Limit
Bolts (8) and lock washers (7), see Figure 1085	Reuse unless damaged
Bolts (4) and lock washers (5), see Figure 1087	Reuse unless damaged

Table 159 Inspection Criteria for Bolts and Lock Washers

Inspection of Bearing Assembly

Perform the following inspections (listed in Table 160) for the bearing assembly:

Part Description	Wear Limit
Rear Bearing (3), see Figure 1085	Replace
Front Bearing (2), see Figure 1087	Replace

Table 160 Inspection of Bearing Assembly

Inspection of External Snap Ring

Perform the following inspections (listed in Table 161) for the external snap ring:

Part Description	Wear Limit
External snap ring (1), see Figure 1085	Reuse unless worn, damaged, or distorted
External Snap Ring (11), see Figure 1087	Reuse unless worn, damaged, or distorted
External Snap Ring (Spirolock) (1), see Figure 1086	Reuse unless worn, damaged, or distorted

Table 161 Inspection Criteria for External Snap Ring

Inspection of Seal Rings

Perform the following inspection (listed in Table 162) for the seal rings:

Part Description	Wear Limit
Seal rings (9), see Figure 1085	Replace

Table 162 Inspection Criteria for Seal Rings

Inspection of Piston

Perform the following inspections (listed in Table 163) for the piston:

Part Description	Wear Limit
Piston (4), see Figure 1086	□ Surface should be free of nicks. □ Sealing grooves must be smooth so as not to cut seal rings. □ Outside diameter must not have nicks which extend above the outside diameter surface. □ Inside diameter must not be elongated from wear.

Table 163 Inspection Criteria for Piston

Inspection of Piston Seal Rings

Perform the following inspections (listed in Table 164) for the piston seal rings:

Part Description	Wear Limit
Large seal ring (6), see Figure 1086	Replace
Small seal ring (5), see Figure 1086	Replace

Table 164 Inspection Criteria for Piston Seal Rings

Inspection of Clutch Hub

Perform the following inspections (listed in Table 165) for the clutch hub:

Part Description	Wear Limit
Clutch hub (10), see Figure 1087	□ Replace if inside diameter teeth are severely worn. □ Replace if wear notches made by facing plates have straight sides. □ If the wear marks have smooth entry and exit marks, the notches will not restrict plate movement and the clutch hub can be reused.

Table 165 Inspection Criteria for Clutch Hub

Inspection of Facing Plates

Perform the following inspections (listed in Table 166) for the facing plates:

Part Description	Wear Limit
Facing plates (9), see Figure 1087	□ Must pass between two plates surfaces 11X11 in. spaced 0.188 in. (4.7752 mm) apart, set at 45 degree angle. Facing grooves are 0.005 in. (0.127 mm) minimum depth when new. Plate is worn out at the bottom of the grooves. □ Internal teeth must not be worn in excess of 0.005 in. (0.127 mm) per side and the tooth driving contact surface must not be worn to a point or to a wedge shape.

Table 166 Inspection Criteria for Facing Plates

Inspection of Steel Clutch Plates

Perform the following inspections (listed in Table 167) for the steel clutch plates:

Part Description	Wear Limit
Steel clutch plates (8), see Figure 1087	□ Must pass between two plate surfaces 11X11 in. spaced 0.130 in. (3.302 mm) apart, set at a 45 degree angle. □ Replace if wear on drive surfaces of the external tangs exceeds 0.005 in. (0.127 mm) per side. □ Minimum thickness: 0.121 in. (3.0734 mm). □ Replace if tracked with grooves, darkened or discolored by heat, damaged, or warped.

Table 167 Inspection Criteria for Steel Clutch Plates

Inspection of Fan Mounting Hub

Perform the following inspections (listed in Table 168) for the fan mounting hub:

Part Description	Wear Limit
Groove width for snap ring (3 and 11), see Figure 1087	0.145 in. maximum (3.683 mm)
Wear sleeve diameter	Free of nicks above surface.
Bore for bearings (5 and 6), see Figure 1084	2.9370 in. (74.5998 mm) diameter maximum. Free of nicks or scratches above the surface.
Bearing journal for bearing (2), see Figure 1087	3.7406 in. (95.0112 mm) (if the bearing surface indicates that the bearing has been spinning and is not less than 3.7041 in. (94 9985 mm), shaft may be reused, but the bearing must be reinstalled using Loctite #609 or equivalent).
End cap bore	3.378 in. (85.8012 mm) diameter and free of nicks
General	□ Snap ring grooves must have straight sides and square edges. □ Bearing bore must not have nicks or scratches which extend above the bore surface. □ Spline must not be excessively worn. □ Bore holes must not be worn or damaged severely.

Table 168 Inspection Criteria for Fan Mounting Hub

Inspection of End Cap

Perform the following inspection (listed in Table 169) for the end cap:

Part Description	Wear Limit
End cap (1), see Figure 1084	Outside diameter free of nicks above the surface.

Table 169 Inspection Criteria for End Cap

Inspection of Front Bearing Retainer

Perform the following inspections (listed in Table 170) for the front bearing retainer:

Part Description	Wear Limit
Bore for front bearing (2), see Figure 1087	5.7079 in. (144.9807 mm) diameter maximum
Bore for front oil seal (1), see Figure 1087	5.1265 in. (130.213 mm) diameter maximum
General	□ Bearing bore must have straight sides, square bottom, and not be oval due to wear. □ Oil seal bore must not have nicks that extend above the bore surface. All sealants must be removed. □ Pilot diameter for pulley must be free of nicks that extend above the pilot surface. □ Flat surface that mates with the pulley must be free of nicks that extend above the surface. □ Slots in the bearing retainer must not have worn notches with straight sides. Maximum depth of the wear mark should not exceed 0.020 in. (0.508 mm), but if the notches have smooth entry and exit sides, the notch will not resist movement of the steel plate.

Table 170 Inspection Criteria for Front Bearing Retainer

Inspection of Sleeve Bearing

Perform the following inspections (listed in Table 171) for sleeve bearings:

Part Description	Wear Limit
Sleeve bearing (5), see Figure 1084	Replace if necessary
Sleeve bearing (6), see Figure 1084	See Figure 1088 to determine amount of wear

Table 171 Inspection Criteria for Sleeve Bearing

Inspection of Retainer Seal Assembly

Perform the following inspection (listed in Table 172) for the retainer seal assembly:

Part Description	Wear Limit
Rear retainer seal assembly (11), see Figure 1085	Replace if damaged, worn, or distorted
Front retainer seal assembly (3), see Figure 1084	Replace if damaged, worn, or distorted

Table 172 Inspection Criteria for Retainer Seal Assembly

Inspection of Internal Snap Rings

Perform the following inspections (listed in Table 173) for the internal snap rings:

Part Description	Wear Limit
Internal snap ring (2), see Figure 1085	Reuse unless worn, damaged, or distorted
Internal snap ring (3), see Figure 1087	Reuse unless worn, damaged, or distorted

Table 173 Inspection Criteria for Internal Snap Rings

Inspection of Pitot Tubes

Perform the following inspection (listed in Table 174) for the pitot tubes:

Part Description	Wear Limit
Pitot tubes (13), see Figure 1085	Replace

Table 174 Inspection Criteria for Pitot Tubes

Inspection of O-ring Seal

Perform the following inspections (listed in Table 175) for the O-ring seal:

Part Description	Wear Limit
O-ring seal (5), see Figure 1085	Replace
O-ring seal (7), see Figure 1087	Replace

Table 175 Inspection Criteria for O-ring Seal

Inspection of Spring Washer

Perform the following inspection (listed in Table 176) for the spring washer:

Part Description	Wear Limit
Spring washer (3), see Figure 1086	Replace

Table 176 Inspection Criteria for Spring Washer

Inspection of Shim

Perform the following inspection (listed in Table 177) for the shim:

Part Description	Wear Limit
Shim (2), see Figure 1086	Replace

Table 177 Inspection Criteria for Shim

C 222.05.10 – ASSEMBLY OF ROCKFORD SERIES 270 FAN CLUTCH

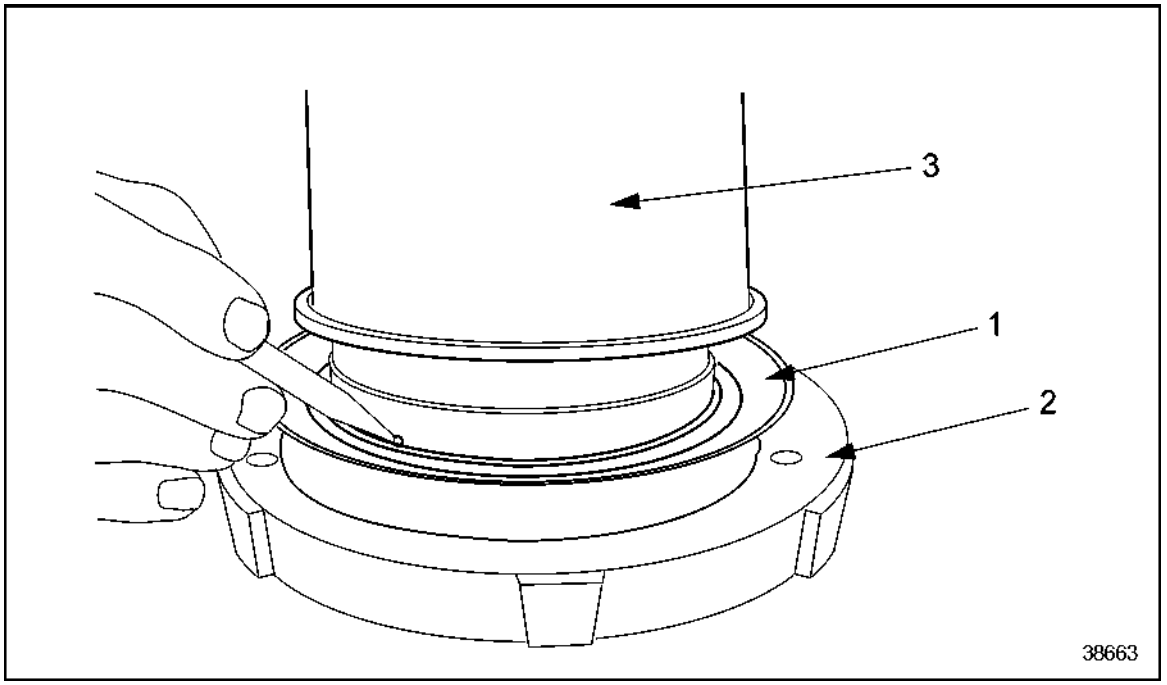
Perform the following steps to assembly the Rockford Series 270 fan clutch:

NOTE:
The fan clutch is assembled using Loctite® 242 (or equivalent) sealants. Follow manufacturer's recommendations regarding minimum cure time to prevent oil from washing the sealant from the sealing surfaces.

NOTICE:
Visually check to ensure the retainer seal assembly is installed straight, and not bent or damaged in any way which will cause interference between it and the bearing retainer after assembly.

1. Using special tool #2 (3), press the front retainer seal assembly (1) onto the fan mounting hub (2). See Figure 1089.

NOTE:
The inner race of the retainer should recess 0.040 in. (1.016 mm) below the shoulder.



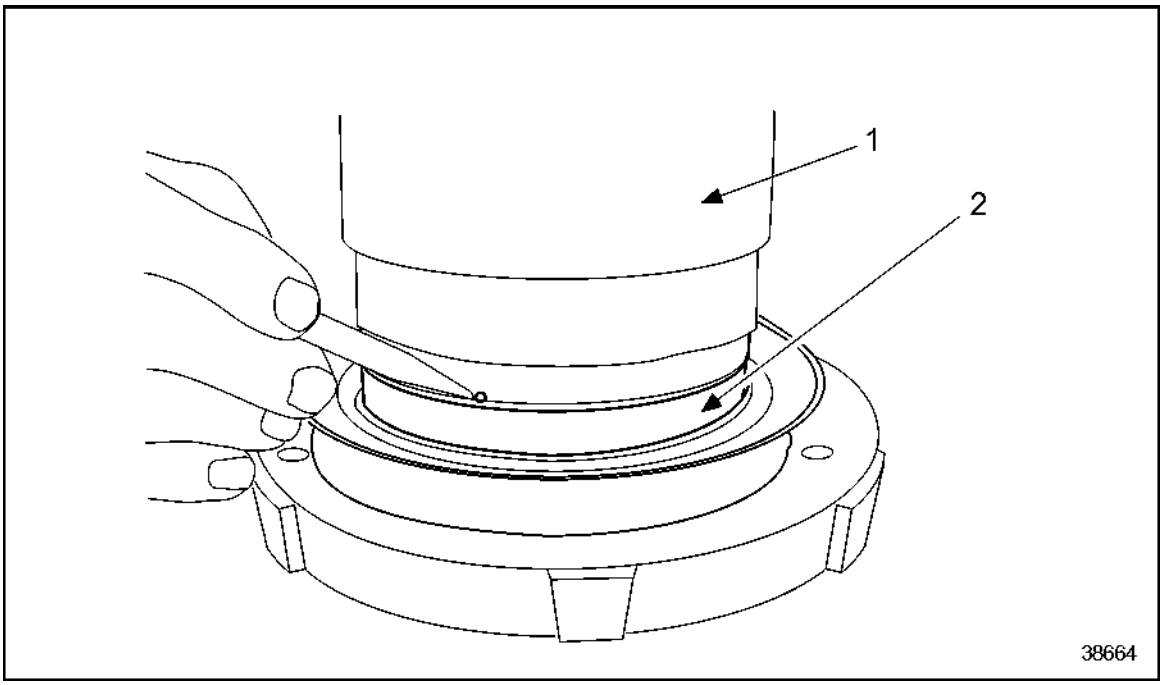
1. Retainer Seal Assembly
2. Fan Mounting Hub
3. Special Tool #2

Figure 1089 Installation of Front Retainer Seal Assembly

2. Coat the inside diameter of the front wear sleeve (2) and the wear sleeve diameter of the shaft with Loctite 242 (or equivalent). Press the front wear sleeve onto the shaft, flush with the shoulder using special tool #2. See Figure 1090.

NOTE:
The front wear sleeve (2) is **not** interchangeable with the rear wear sleeve.

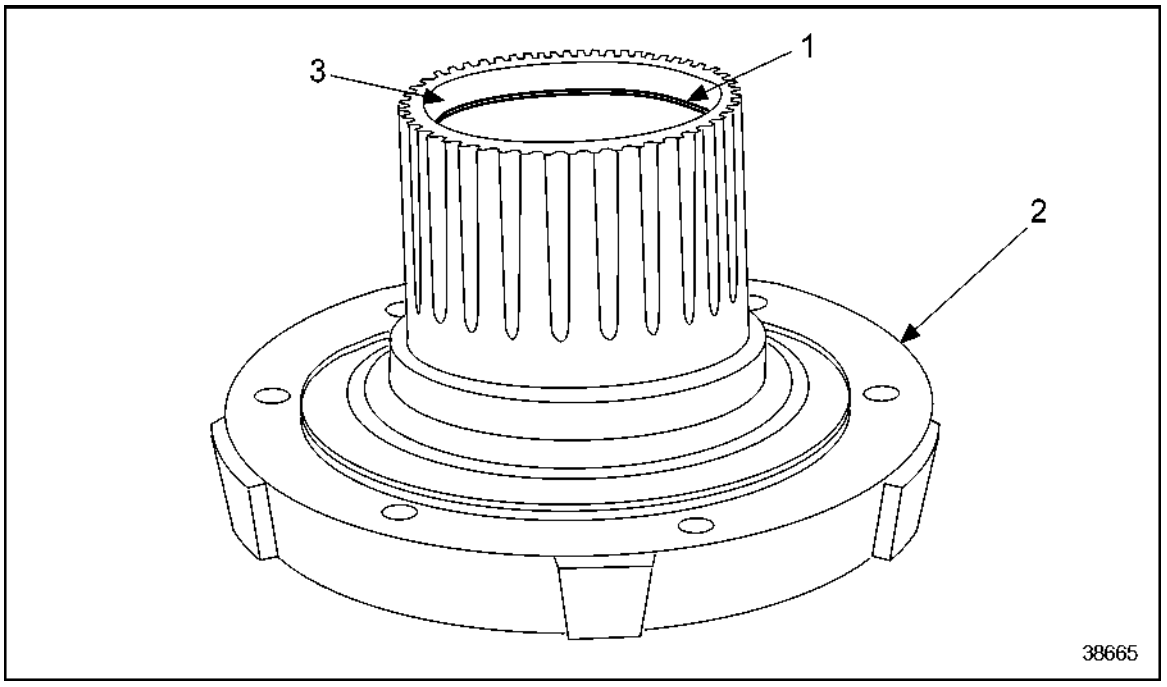
NOTE:
Early fan mounting hubs were manufactured with a small lube hole under the wear sleeve. The new wear sleeve will cover the hole. The hole is no longer required.



1. Special Tool #2
2. Front Wear Sleeve

Figure 1090 Installation of Front Wear Sleeve

3. Using special tool #1 (see Figure 1058), press rear sleeve bearing (1) into fan mounting hub (2) until the rear sleeve bearing is just below chamfer (3). See Figure 1091.

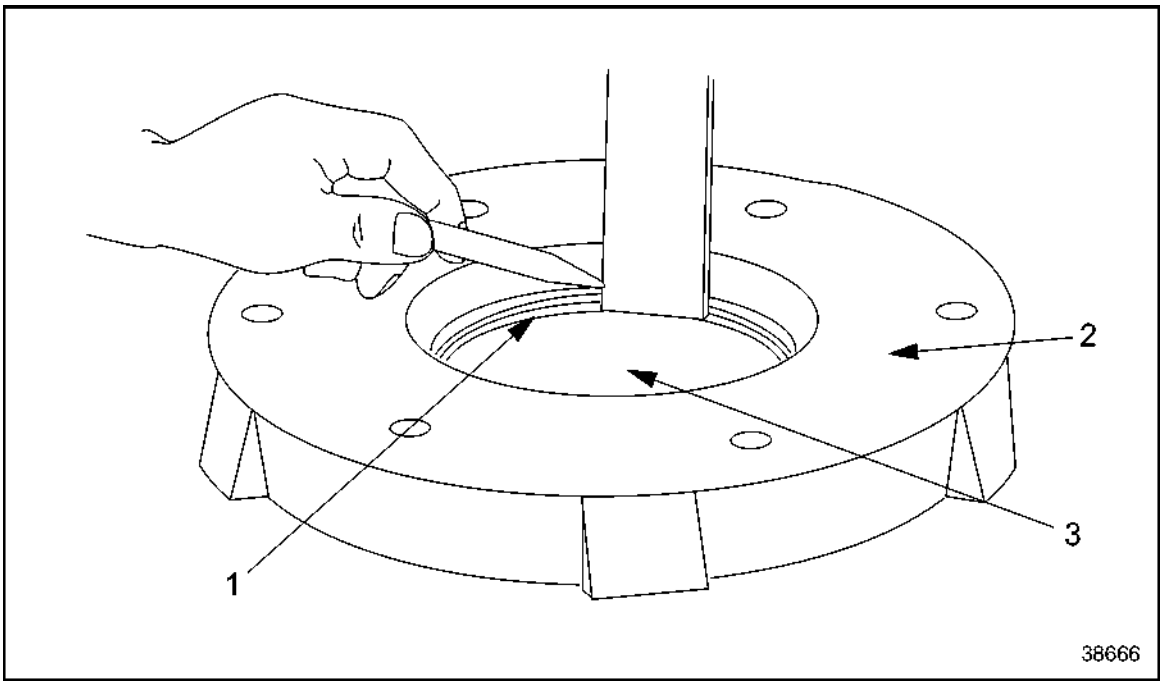


1. Rear Sleeve Bearing
2. Fan Mounting Hub
3. Chamfer

Figure 1091 Installation of Rear Sleeve Bearing

4. Place the front retainer seal assembly with the splined shaft facing down. Using special tool #1 (see Figure 1058), press front sleeve bearing (1) into fan mounting hub (2) until

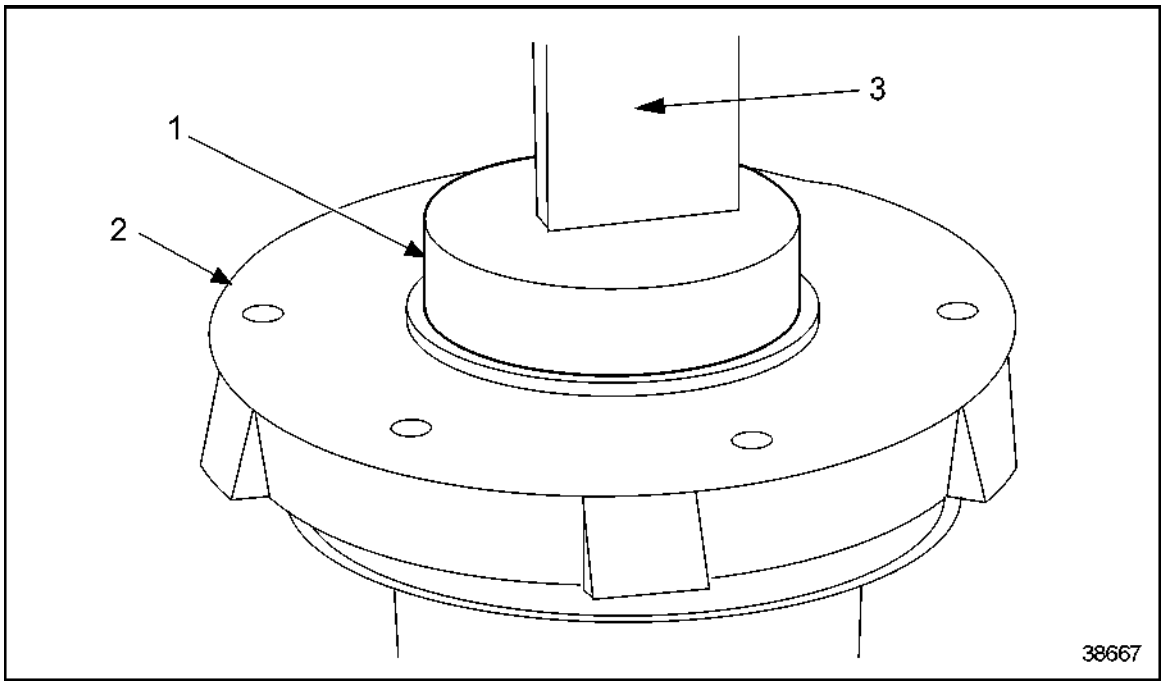
the front end of sleeve bearing is 0.25–0.28 in. (6.35–7.112 mm) below the shoulder. See Figure 1092.



1. Front Sleeve Bearing
2. Fan Mounting Hub
3. Special Tool #1

Figure 1092 Installation of Front Sleeve Bearing

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.

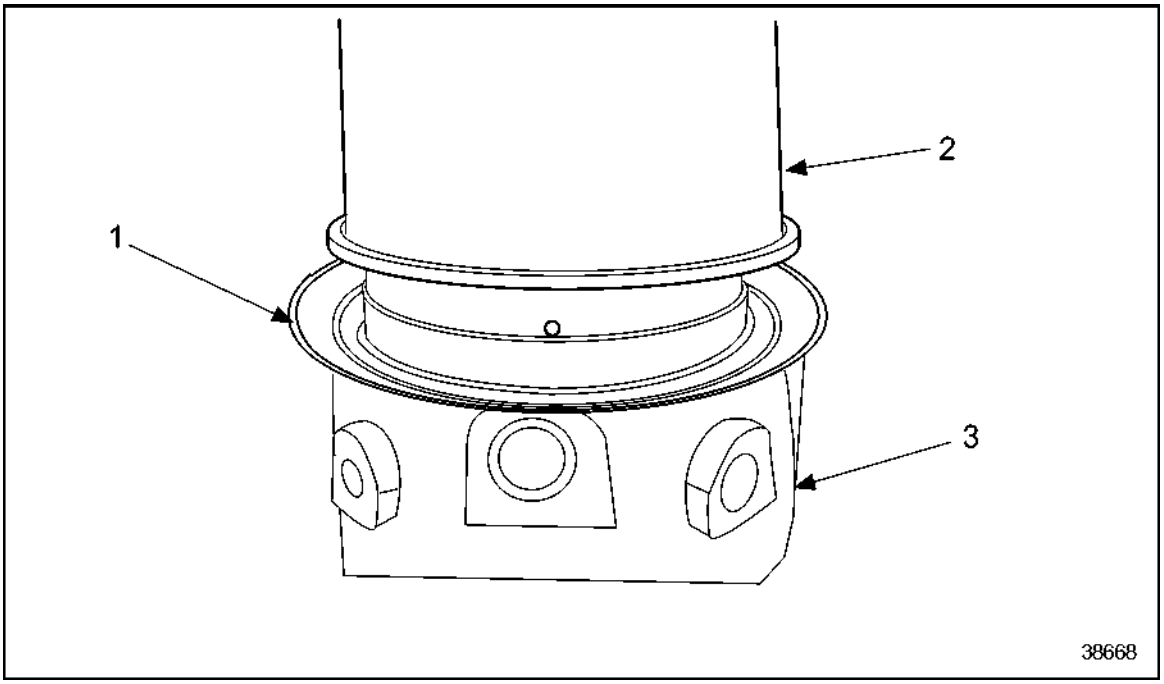
NOTE:
Liquid nitrogen may be used to freeze the end cap.

7. Press end cap (1) into fan mounting hub (2). Stop pressing when the end cap contacts the bottom of the bore. See Figure 1093.

NOTE:
When the end cap is properly seated, it will be flush with or tight against the fan mounting hub's front face.

NOTICE:
Visually check to ensure the retainer seal assembly is installed straight, and not bent or damaged in any way which will cause interference between it and the bearing retainer after assembly.

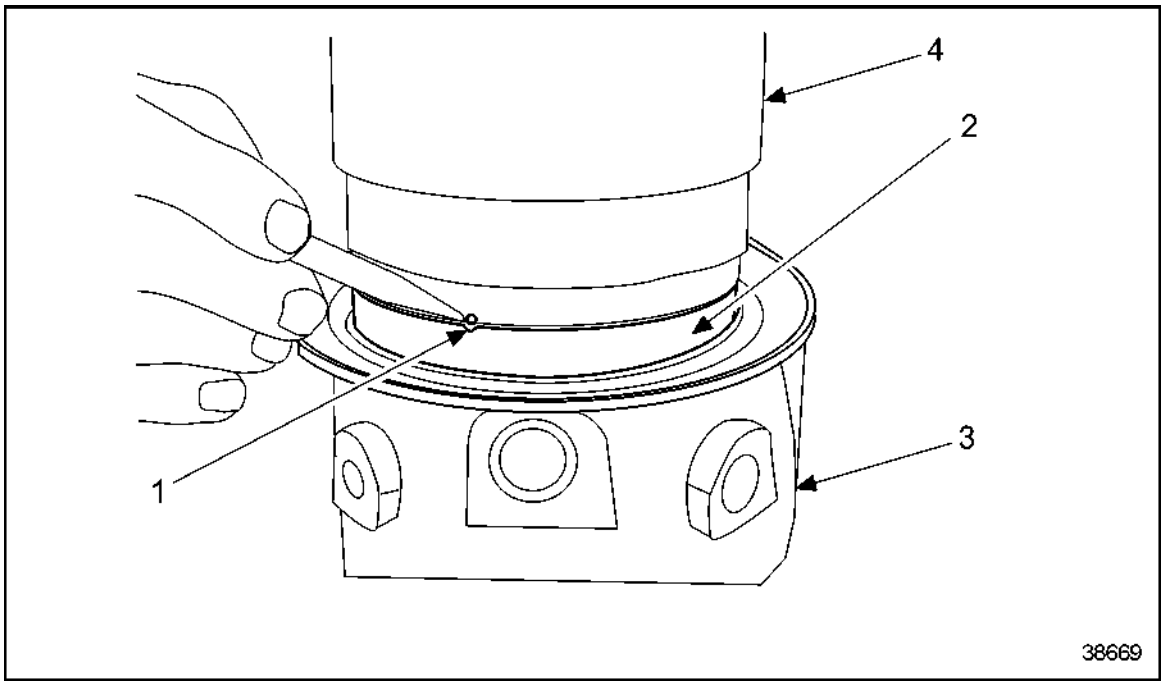
8. Using special tool #2, press rear retainer seal assembly (1) onto shaft (3) 0.40 in. (10.16 mm) below the shoulder. See Figure 1094.



1. Rear Retainer Seal Assembly
2. Special Tool #2
3. Shaft

Figure 1094 Installation of Rear Retainer Seal Assembly

9. Coat the inside diameter of rear wear sleeve (2) and the wear sleeve diameter of the fan mounting hub with Loctite 242 (or equivalent). See Figure 1095.



1. Notch
2. Rear Wear Sleeve
3. Shaft
4. Special Tool #3

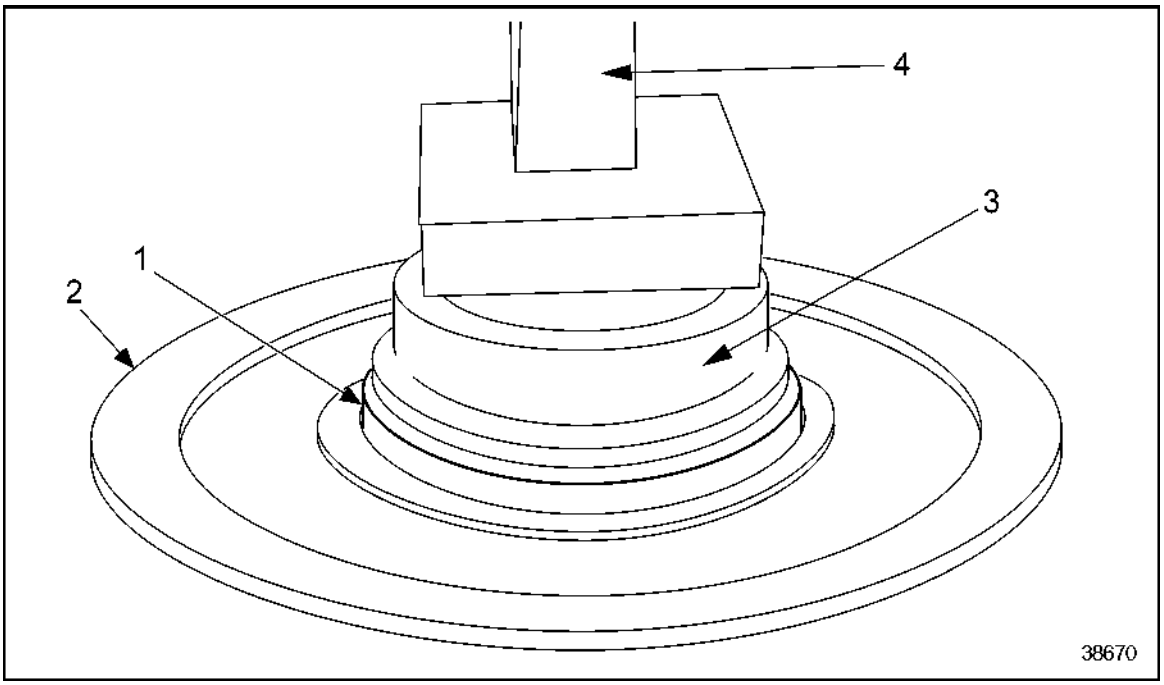
Figure 1095 Installation of Rear Wear Sleeve

NOTICE:
The rear wear sleeve is notched to allow oil to flow from the shaft. This notch *must be aligned* with the hole in the shaft or damage will result.

10. Locate rear wear sleeve (2) so the notch of the sleeve is aligned with the small lube hole in shoulder shaft (3). Using special tool #3 (4), press rear wear sleeve onto the fan mounting hub, flush with the shoulder. See Figure 1095.

NOTICE:
When pressing the rear bearing into the rear bearing retainer, press *only* the outer race of the bearing, and stop pressing when it reaches the bottom of the bore. If the rear bearing is installed incorrectly, bearing damage will occur.

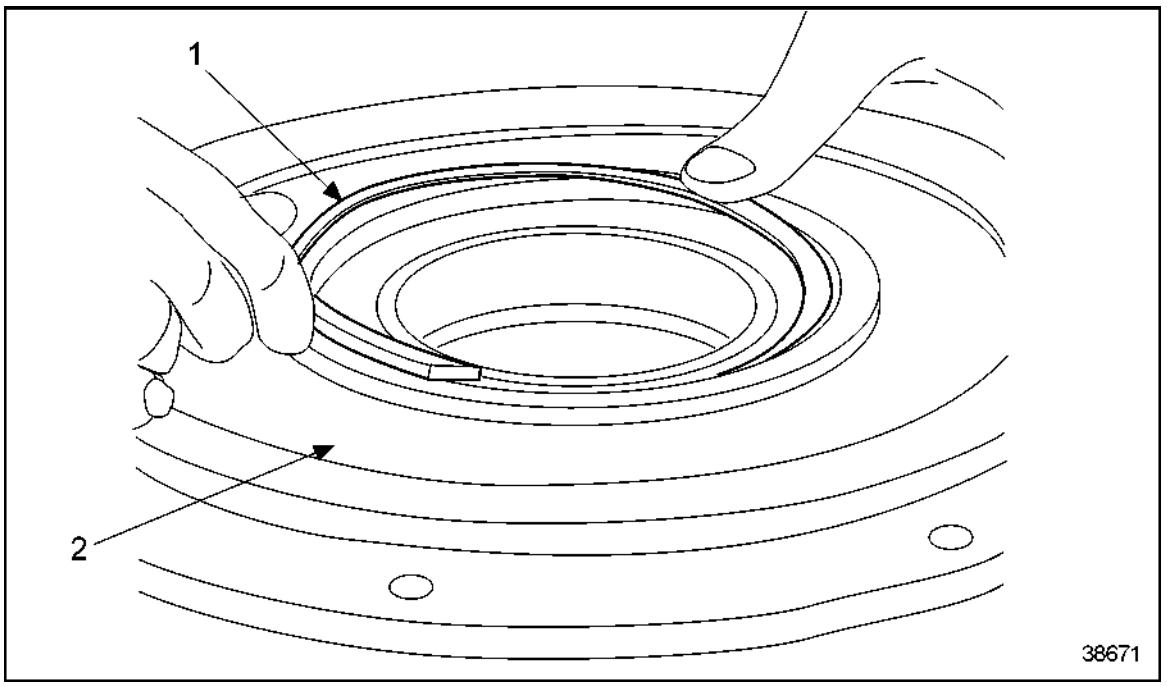
11. Using hydraulic press (4), press rear bearing (1) into rear bearing retainer (2). See Figure 1096.



1. Rear Bearing
2. Rear Bearing Retainer
3. Bearing Press Block
4. Hydraulic Press

Figure 1096 Installation of Rear Bearing

12. Install internal snap ring (1) into rear bearing retainer (2). See Figure 1097

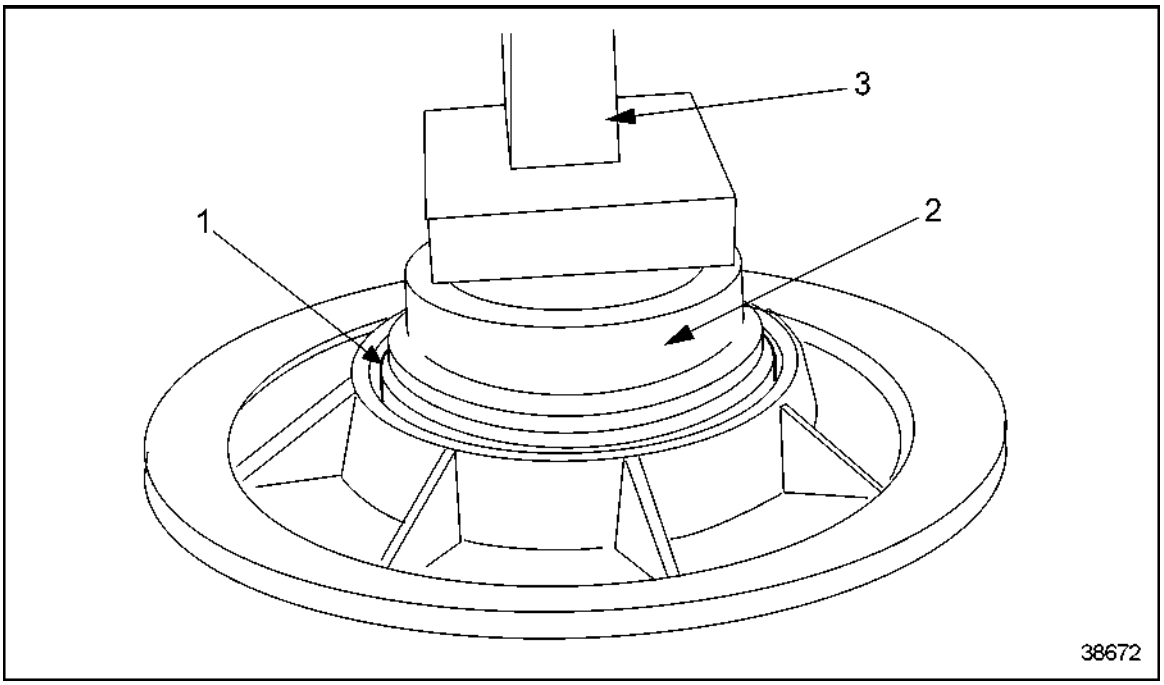


1. Internal Snap Ring
2. Rear Bearing Retainer

Figure 1097 Installation of Internal Snap Ring

13. Rotate the rear bearing retainer. Coat the outside diameter of rear oil seal (1) with Loctite #242 (or equivalent). Using hydraulic press (3), press the rear oil seal into the rear bearing retainer till flush with the rear face. See Figure 1098.

NOTE:
Prior to applying Loctite sealant, ensure that the rear bearing retainer surface is clean and dry.



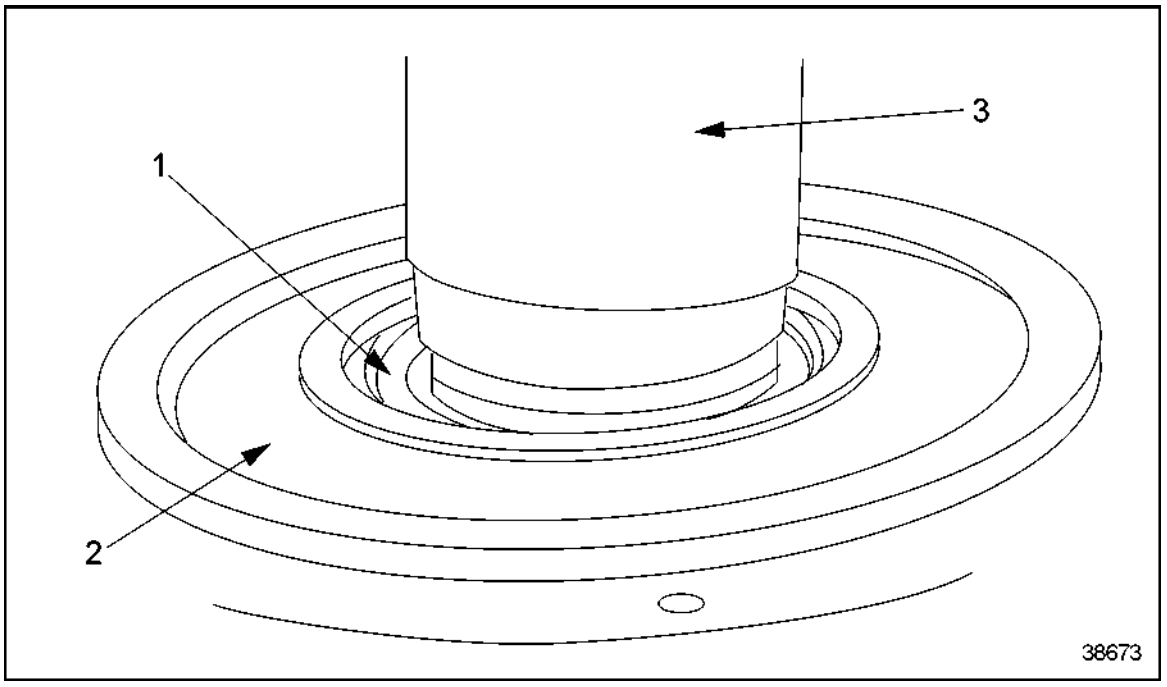
1. Rear Oil Seal
2. Bearing Press Block
3. Hydraulic Press

Figure 1098 Installation of Rear Oil Seal

NOTICE:
Spin the bearing retainer to ensure there is no sound or other indication of contact between the retainer seal assembly and the bearing retainer. If interference is detected, remove the bearing retainer and eliminate the point of interference.

14. Place shaft subassembly on the press bed. Coat the bore of the bearing and also the shaft with Loctite #242 (or equivalent). Install rear bearing retainer subassembly (2) in place on

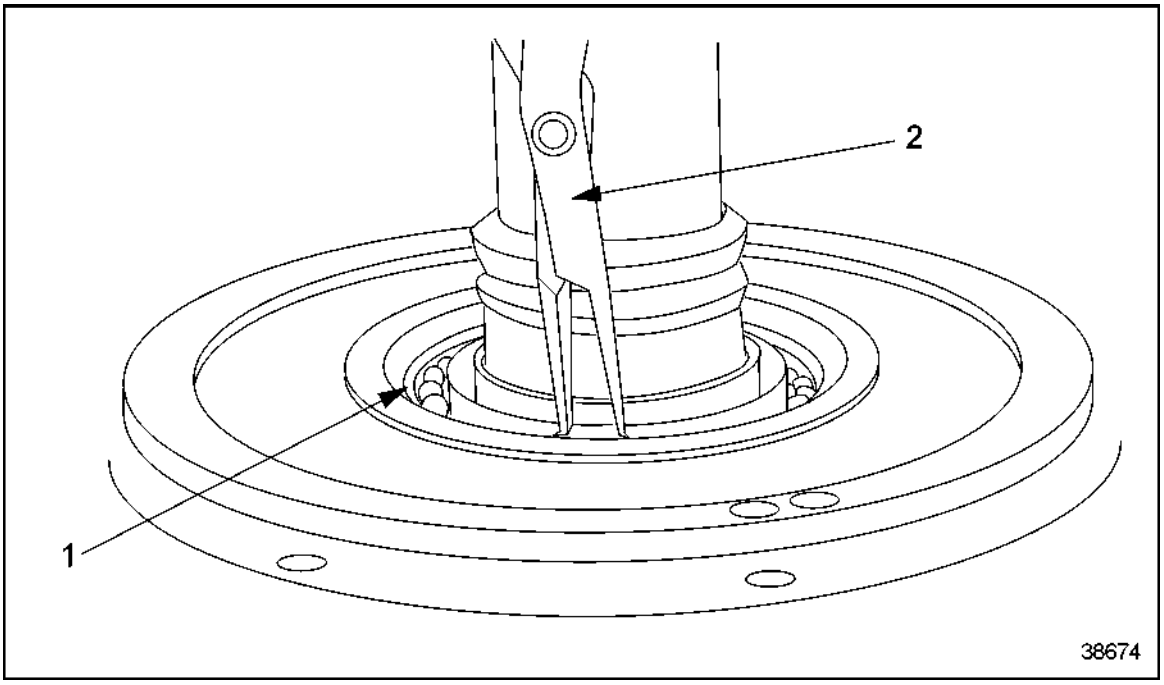
the shaft. Using special tool #3 (3), press bearing (1) onto the shaft until it stops at the bottom of the shoulder. See Figure 1099.



1. Bearing
2. Rear Bearing Retainer
3. Special Tool #3

Figure 1099 Installation of Rear Bearing Retainer Subassembly

15. Using snap ring pliers (2), install external snap ring (1). See Figure 1100.



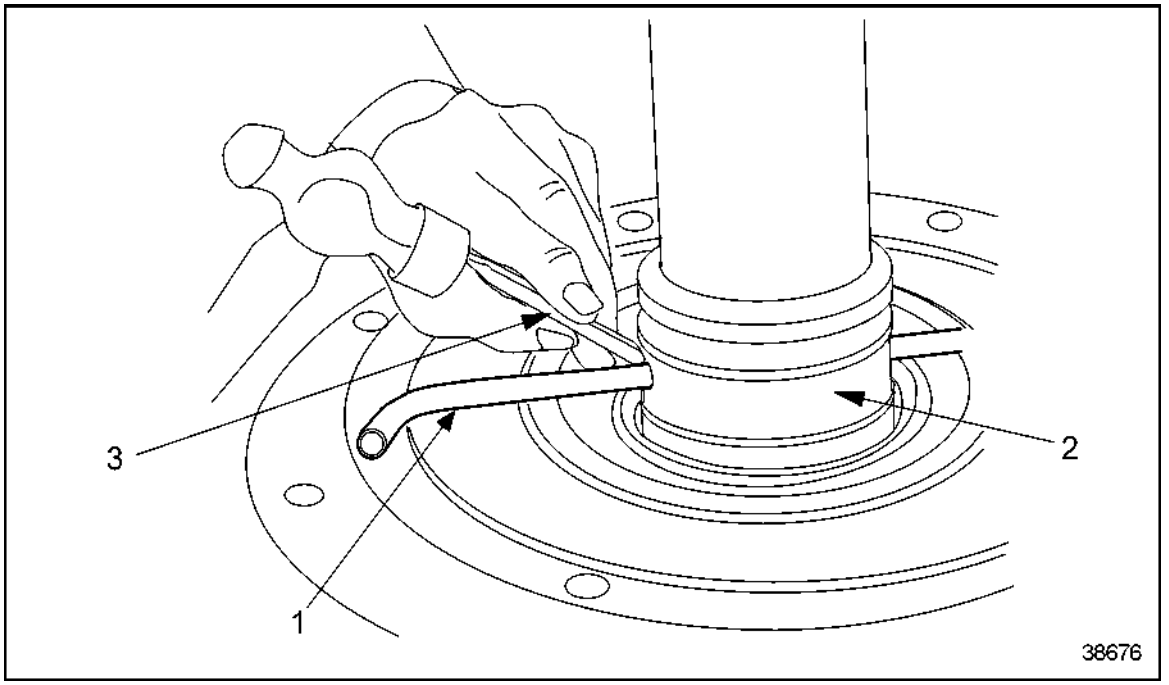
1. External Snap Ring
2. Snap Ring Pliers

Figure 1100 Installation of External Snap Ring

NOTICE:
Ensure the pitot tube holes in the shaft are clean and free of burrs and staking material, so that the pitot tubes will fit into the holes and seat completely to the bottom. Improperly seated pitot tubes will damage the fan clutch assembly.

16. Apply a thin coat of Loctite #242 (or equivalent) on the straight end of one pitot tube (1). See Figure 1101.

NOTE:
Coat the pitot tube to approximately 0.75 in. (19.05 mm) from the end.



1. Pitot Tube
2. Rear Bearing Retainer and Shaft Assembly
3. Punch

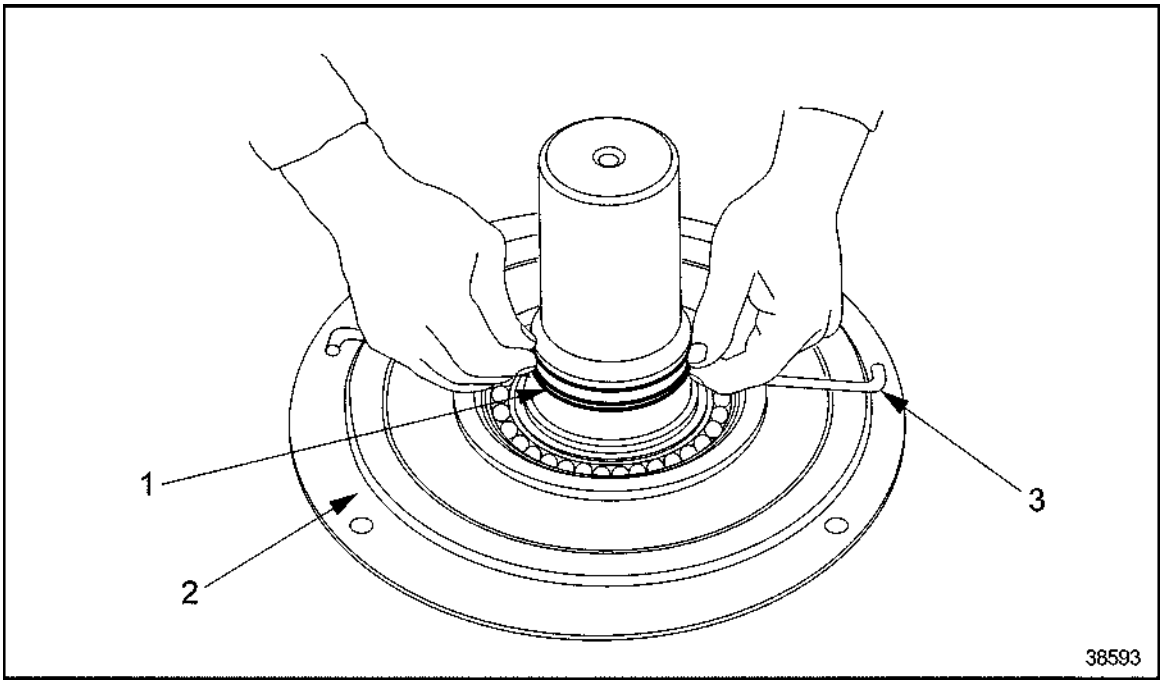
Figure 1101 Installation of Pitot Tube

17. Push the pitot tube (1) to the bottom of the hole. The outer end of pitot tube should be located well within the pulley-locating shoulder of the rear bearing retainer (2).

NOTE:
Rotate the tube so the open, bent end faces in a counterclockwise direction, and is **exactly** parallel to the surface of the rear bearing retainer. (A large Phillips-head screwdriver inserted in the end of the tube can be conveniently used as an alignment gage).

18. Repeat step 17 for the second pitot tube. Using a punch (3), stake each pitot tube in three places (9, 12, and 3 o'clock positions) to prevent the pitot tubes from rotating during operation. See Figure 1101.

19. Install seal rings (1) in the grooves in the shaft.

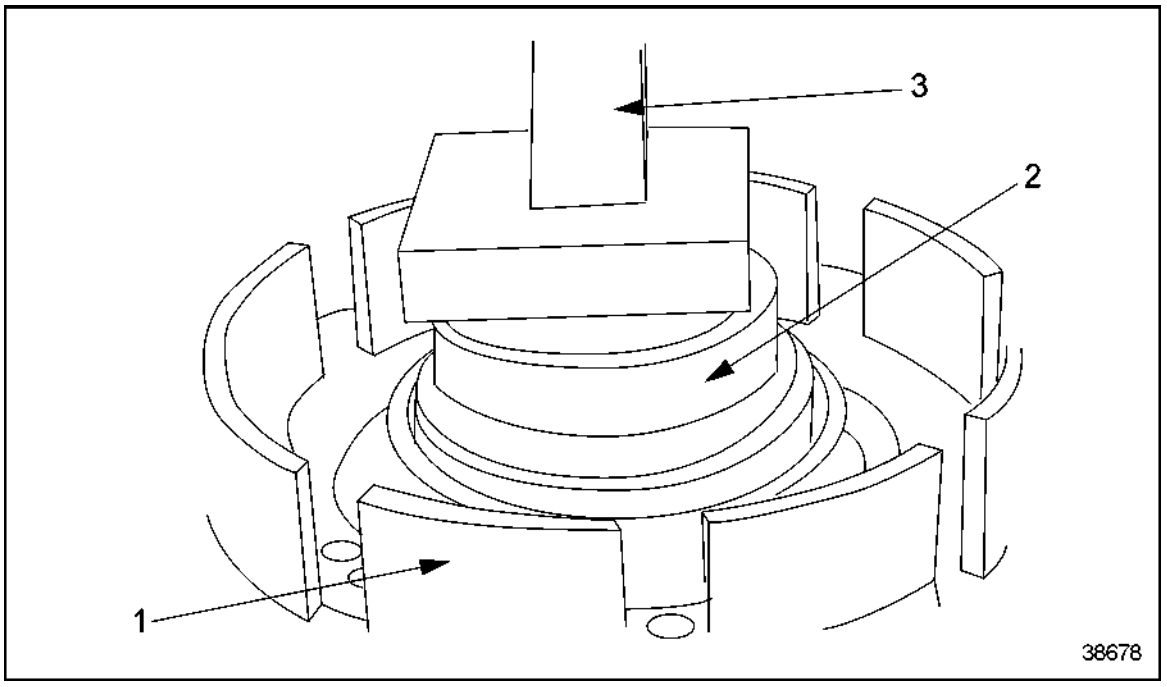


1. Seal Rings
2. Rear Bearing Retainer
3. Pitot Tubes

Figure 1102 Installation of Seal Rings

NOTICE:
Press *only* on the outer race of the bearing, and press it to the bottom of the bore. An improperly seated bearing will cause fan clutch damage.

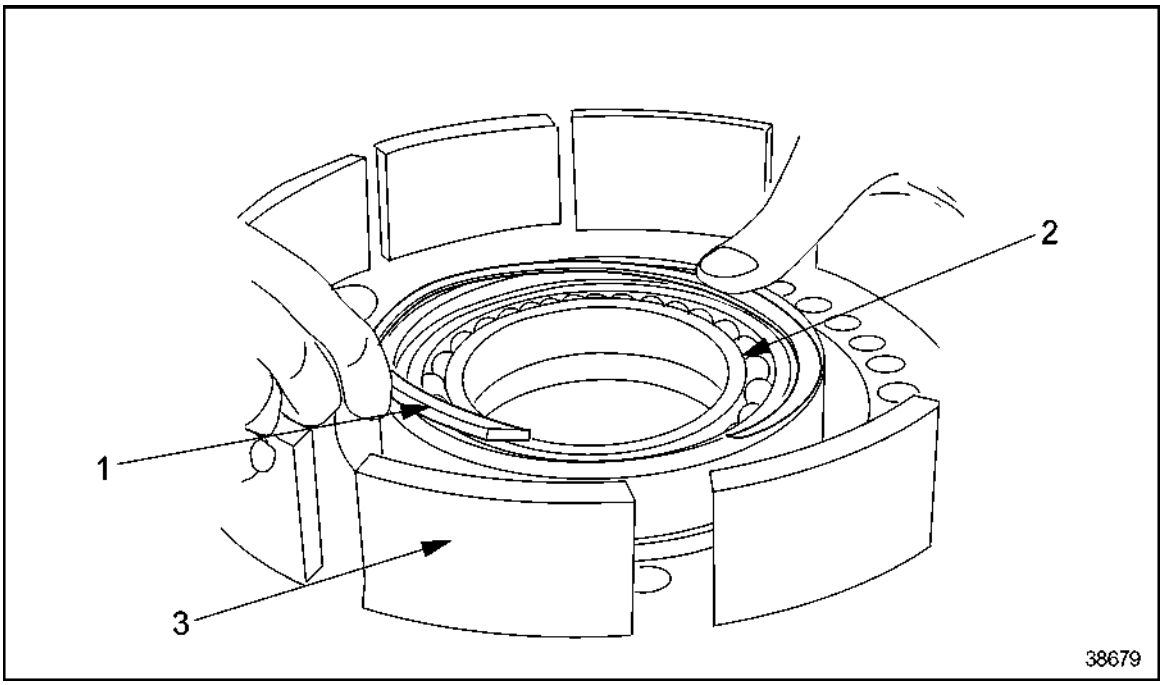
20. Coat outside diameter of front bearing with Loctite #242. Using hydraulic press (3), press front bearing into front bearing retainer (1). See Figure 1103.



1. Front Bearing Retainer
2. Bearing Press Block
3. Hydraulic Press

Figure 1103 Installation of Front Bearing

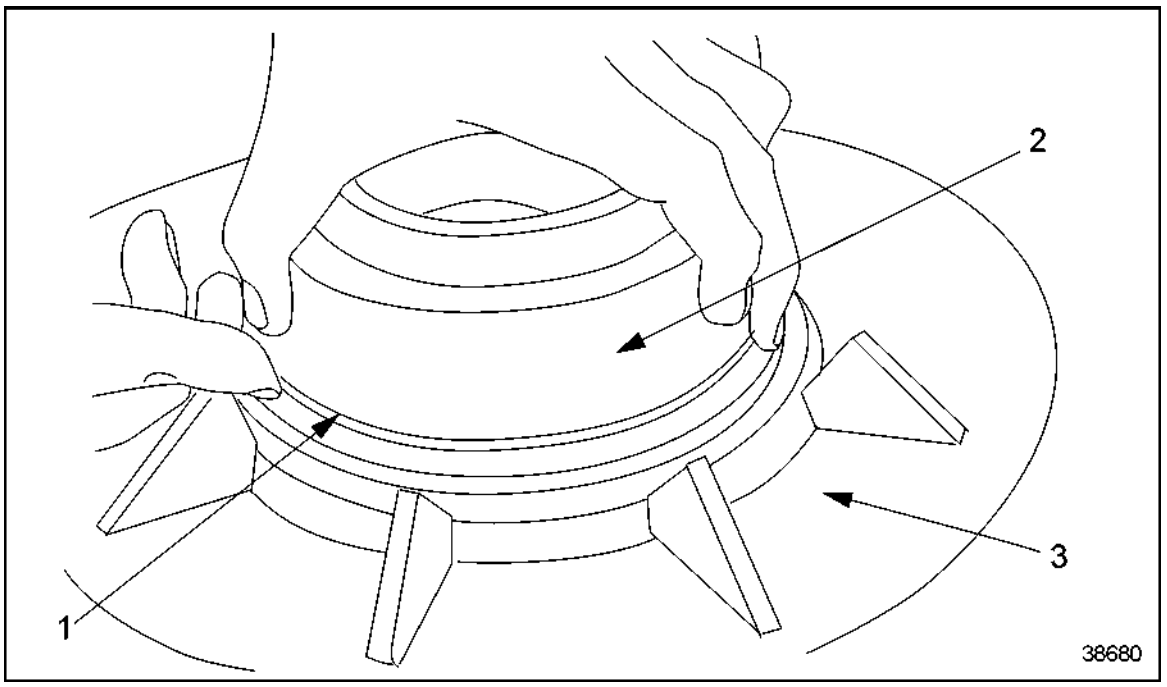
21. Install internal snap ring (1) to secure bearing (2) in front bearing retainer (3). See Figure 1104.



1. Internal Snap Ring
2. Bearing
3. Front Bearing Retainer

Figure 1104 Installation of Internal Snap Ring

22. Rotate front bearing retainer (3) 180 degrees on the press bed. See Figure 1105.

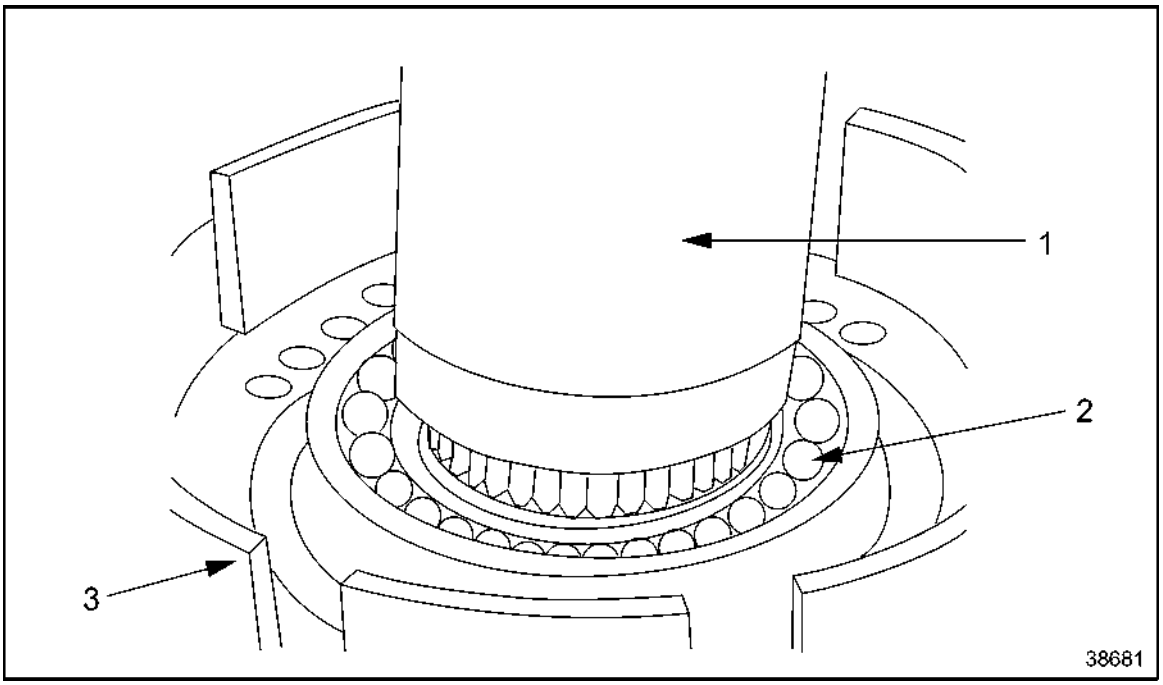


1. Oil Seal
2. Bearing Press Block
3. Front Bearing Retainer

Figure 1105 Installation of Oil Seal

23. Coat the outside diameter of front oil seal (1) with Loctite #242 (or equivalent). Using bearing press block (2), install oil seal (1) in front bearing retainer (3), flush with the front face. See Figure 1105.
24. Place the fan mounting assembly on the press bed.

25. Coat the inside diameter of the bearing bore and bearing (2) with Loctite #242 (or equivalent). See Figure 1106.



1. Special Tool #3
2. Bearing
3. Front Bearing Retainer

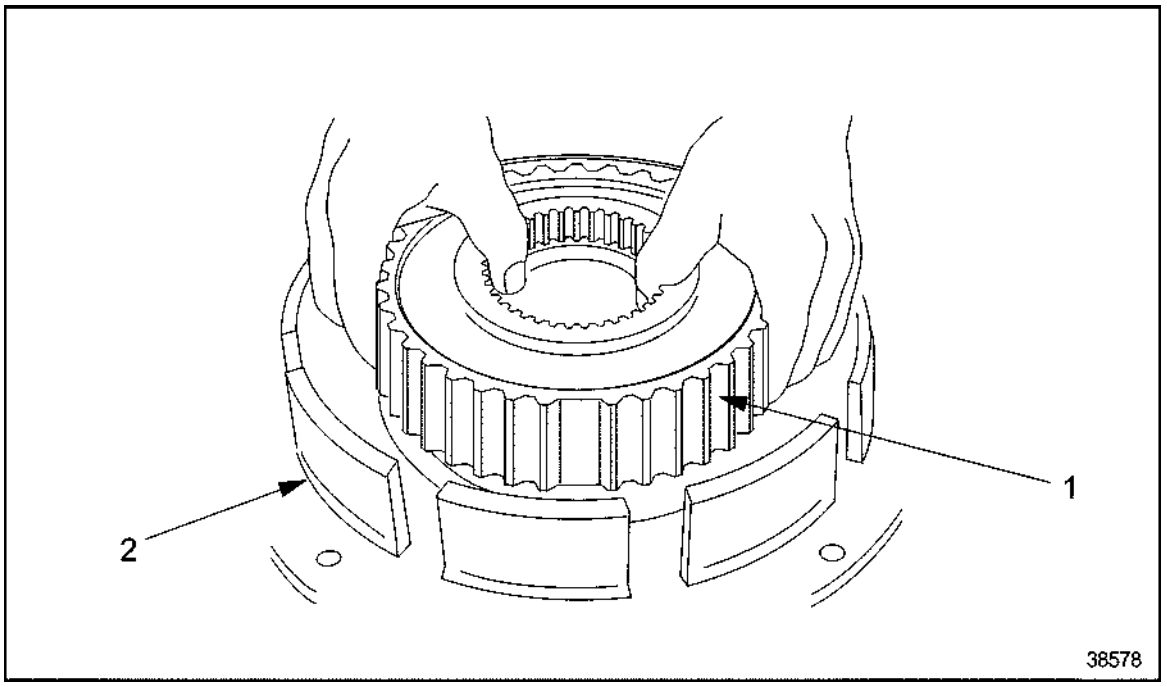
Figure 1106 Installation of Bearing

26. Install front bearing retainer (3) in place on the fan mounting hub. See Figure 1106.
27. Using special tool 3# (1), press bearing (2) down into front bearing retainer (3) until it stops at the bottom of the shoulder. See Figure 1106.
28. Rotate front bearing retainer (3) to ensure that there is no sound or other indication of contact between the retainer seal assembly and front bearing retainer (3). See Figure 1106.

NOTE:
If interference is detected, remove the bearing retainer and eliminate the source of interference.

29. Install clutch hub (1) onto fan mounting hub (2). See Figure 1107.

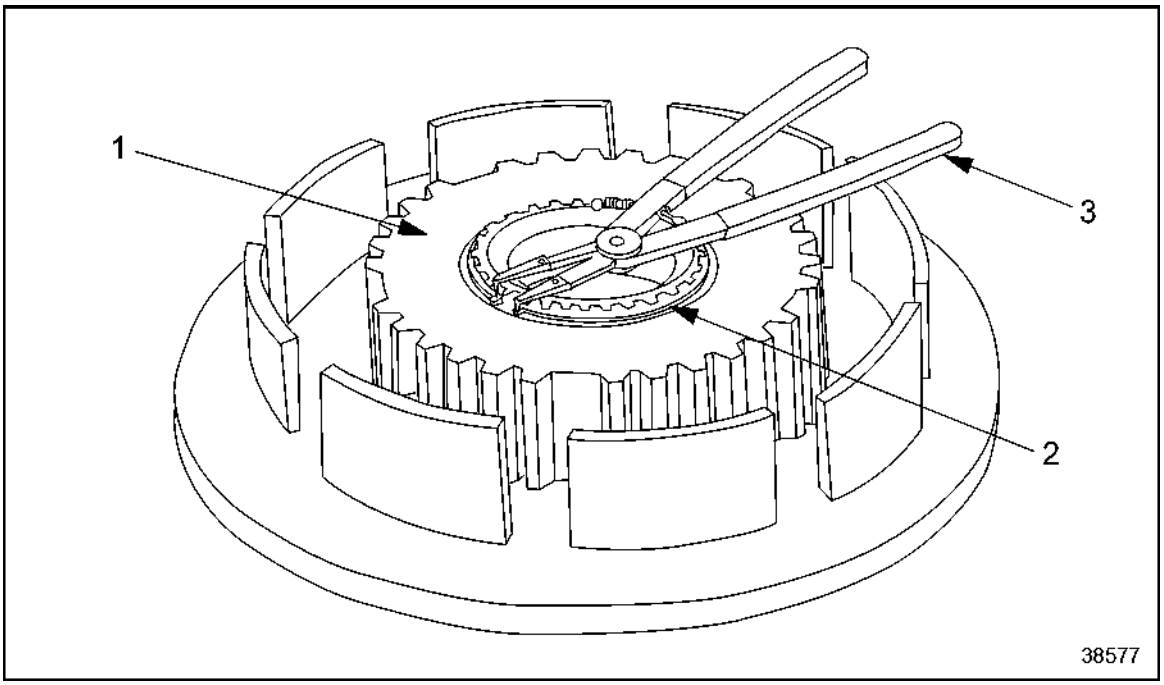
NOTE:
The splines should be open and facing upwards.



1. Clutch Hub
2. Fan Mounting Hub

Figure 1107 Installation of Clutch Hub

30. Using snap ring pliers (3), install external snap ring (2) to secure clutch hub (1) in place. See Figure 1108.

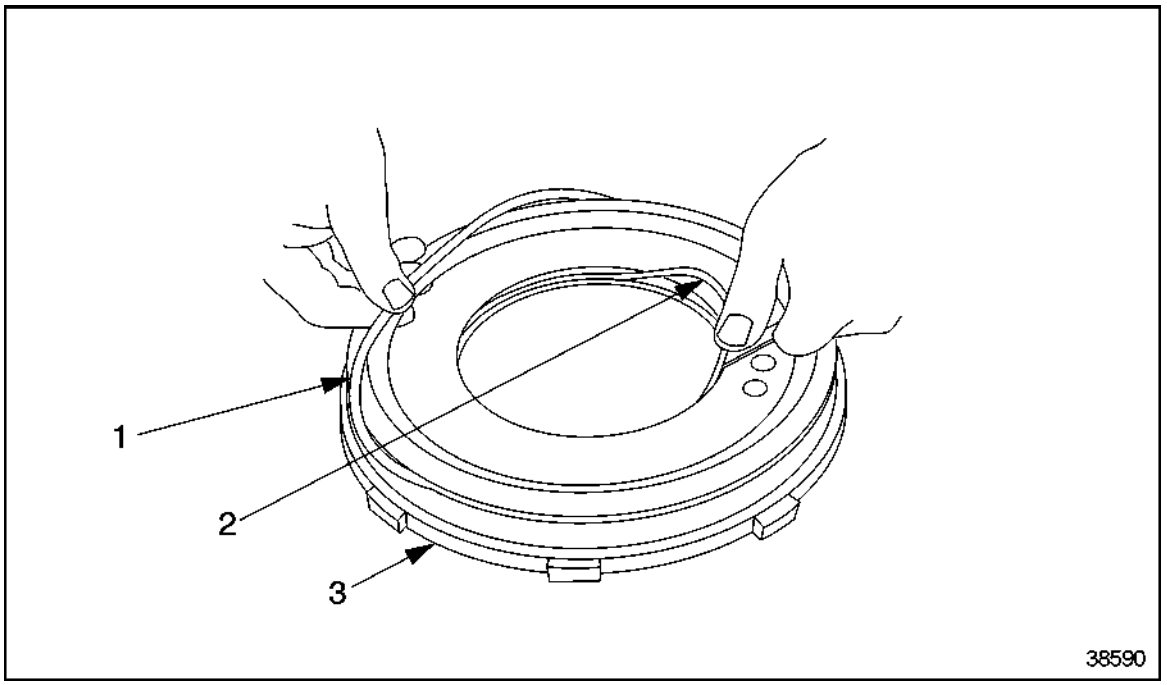


1. Clutch Hub
2. External Snap Ring
3. Snap Ring Pliers

Figure 1108 Installation of Snap Ring

NOTE:
Use an oil-soluble lubricant.

31. Lubricate the seal ring groove with an oil-soluble lubricant. Squeeze the “L” shaped seal ring to form it into a tight “Vee” shape all the way around the diameter. Install small seal ring (2) into the groove. See Figure 1109.

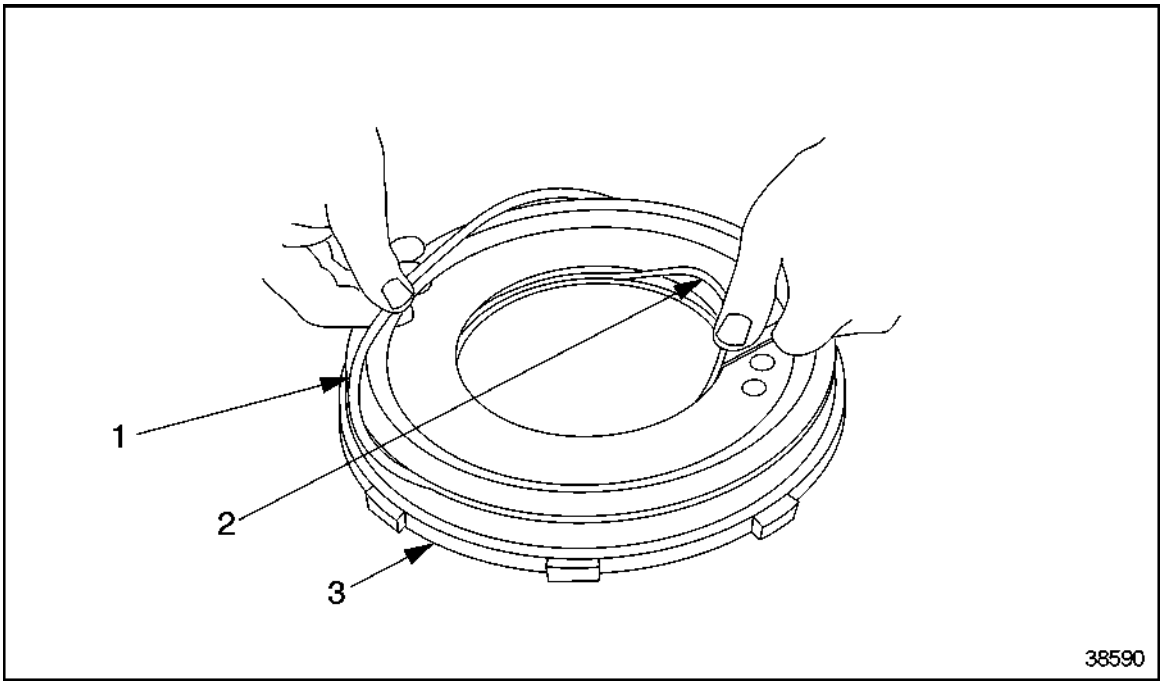


1. Large Ring
2. Small Seal Ring
3. Piston

Figure 1109 Installation of Small Seal Ring

NOTE:
Note the shape of the groove. It will properly accept the small seal ring (2) in only one way. See Figure 1109.

32. Lubricate seal ring groove with an oil-soluble lubricant. Squeeze the “L” shaped seal ring to form it into a tight “Vee” shape all the way around the diameter. Install large seal ring (1) into the groove. See Figure 1110.



1. Large Seal Ring
2. Small Seal Ring
3. Piston

Figure 1110 Installation of Large Seal Ring

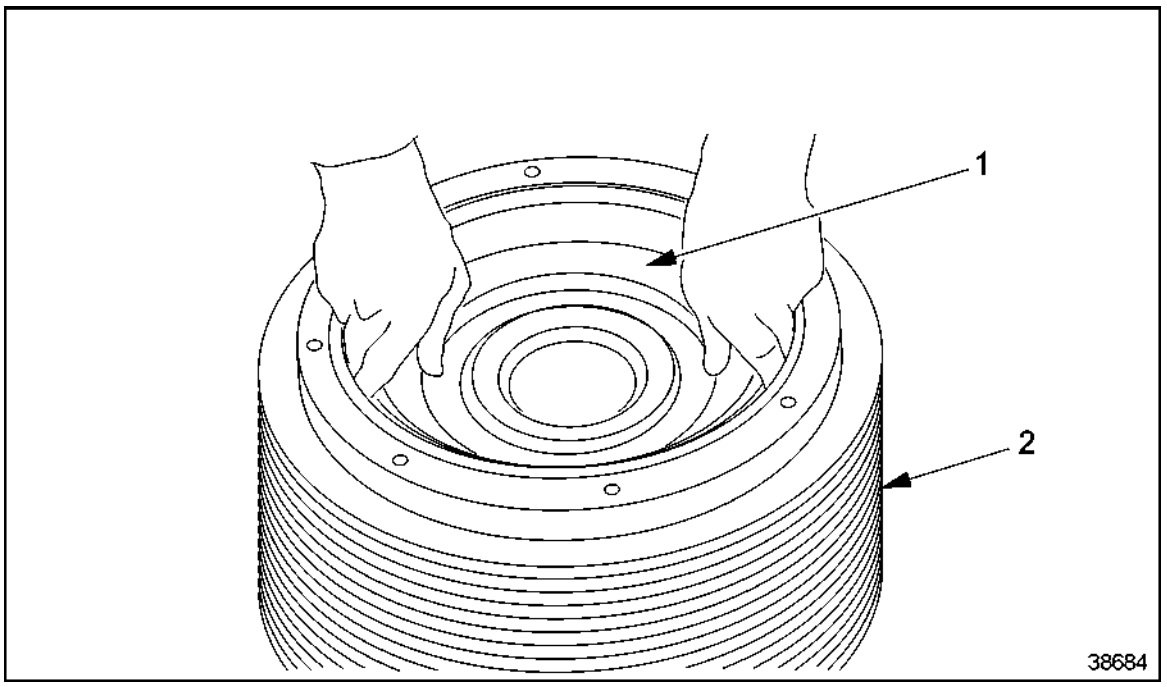
NOTE:
Note the shape of the groove. It will properly accept the seal ring in only one way.

33. Lubricate the internal and external surfaces that the small seal rings (2) and large seal rings (1) will be in contact with. See Figure 1110.

NOTE:
Use an oil-soluble lubricant.

NOTICE:
Do not push the piston into place during installation. Seal ring damage could occur damaging the pulley assembly.

34. Install piston (1) into pulley (2). See Figure 1111.



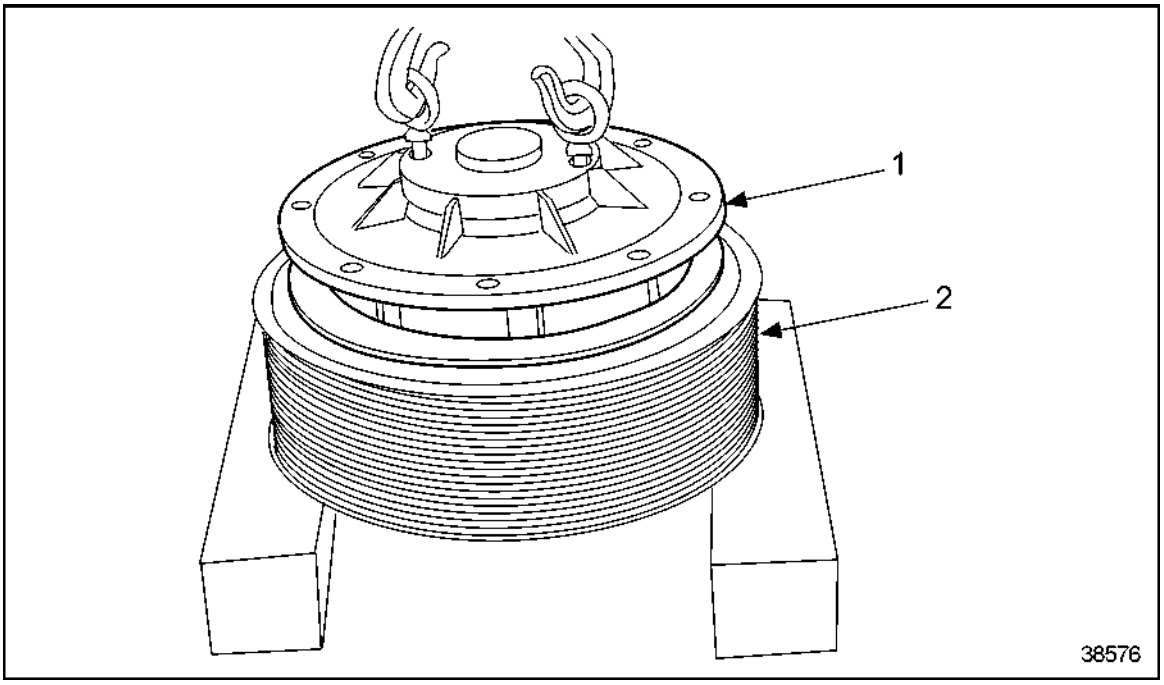
1. Piston
2. Pulley

Figure 1111 Installation of Piston

35. Without pressing down on piston (1), rotate the piston slowly clockwise then counter clockwise until the piston falls into place within the pulley (2). See Figure 1111.

36. Align the tangs of the piston for easy final assembly of the fan clutch. Place front bearing retainer (1) in place on the belt pulley (2). See Figure 1112.

NOTE:
The slots of the front bearing retainer (1) will engage the tangs, and the retainer will rest against belt pulley (2). See Figure 1112.

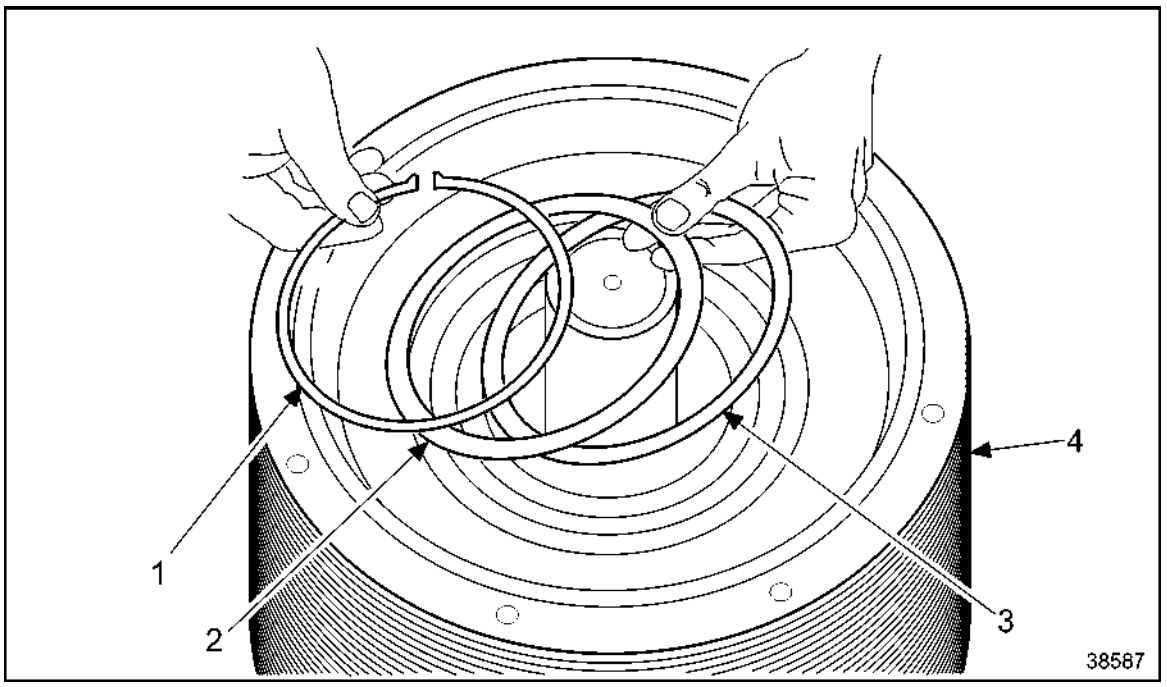


1. Front Bearing Retainer
2. Belt Pulley

Figure 1112 Installation of Fan Clutch Assembly

37. Rotate front bearing retainer (1) until the bolt holes align in the front bearing retainer (1) and belt pulley (2). See Figure 1112.
38. Remove front bearing retainer (1) from belt pulley (2). See Figure 1112.

39. Install spring washer (3). See Figure 1113.



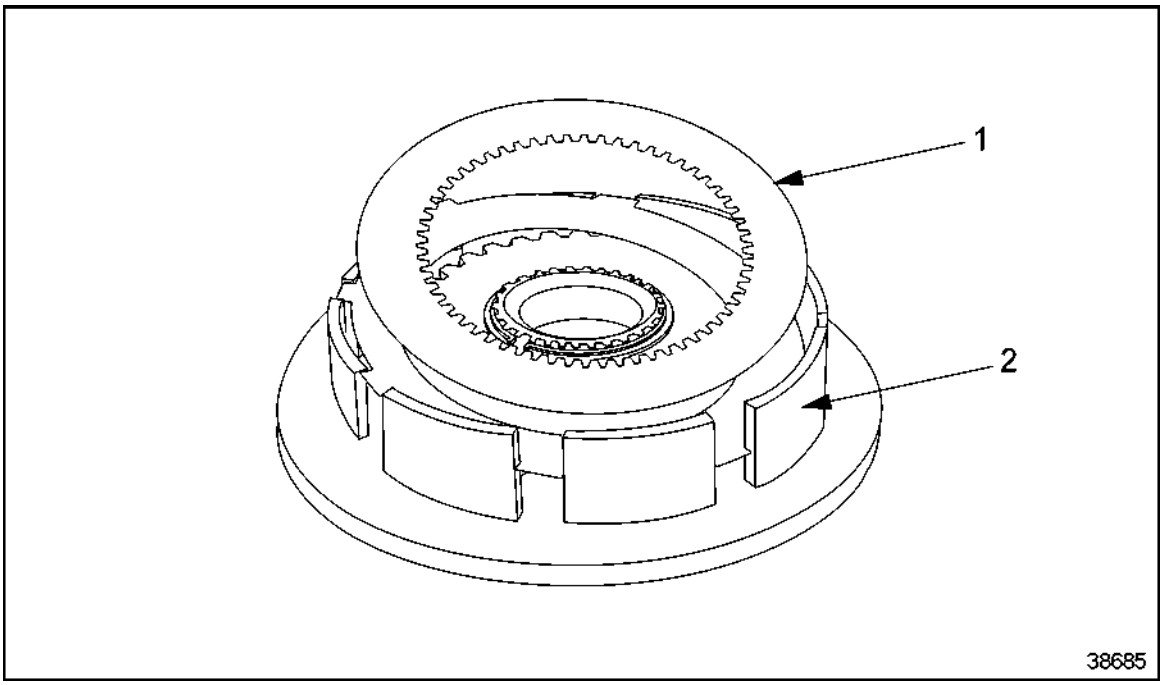
1. External Snap Ring (Spirolock)
2. Shim
3. Spring Washer
4. Pulley

Figure 1113 Installation of Shim, Spring Washer, and External Snap Ring

40. Install shim (2) onto spring washer (3). See Figure 1113.
41. Install external snap ring (1) into groove. See Figure 1113.

NOTE:
The shim must be centered on the spring washer to prevent it from interfering with the movement of the piston.

42. Place the front bearing retainer (2) on the bench with the clutch hub facing upwards. See Figure 1114.



1. Clutch Plate
2. Front Bearing Retainer

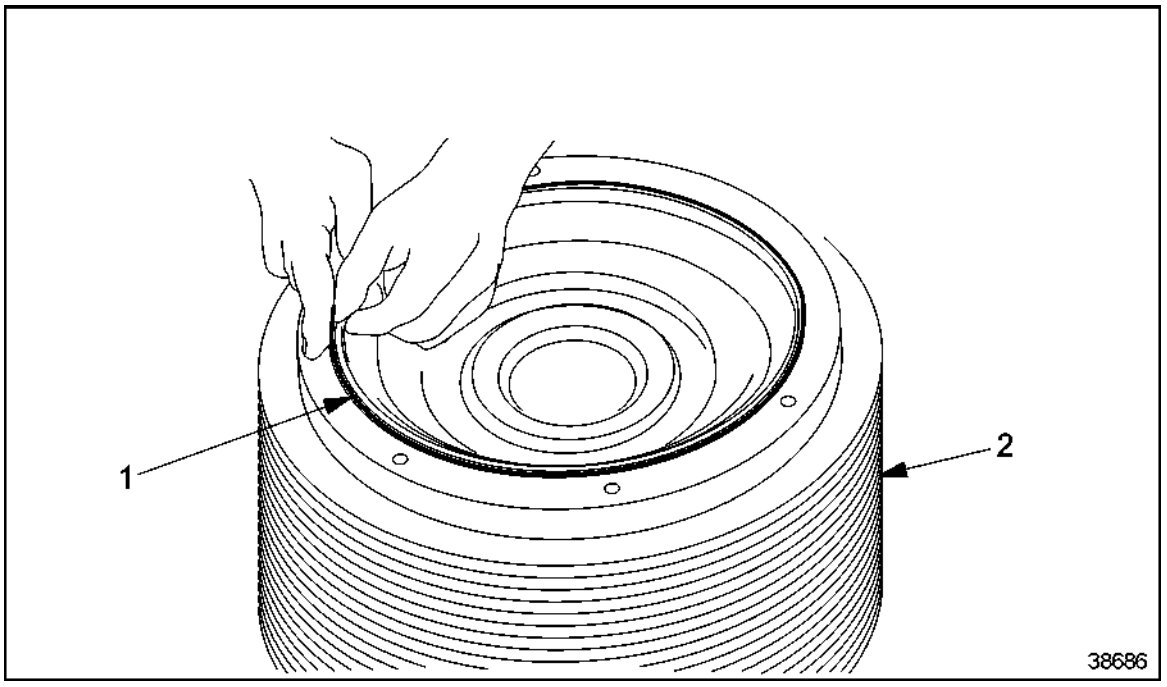
Figure 1114 Installation of Steel Clutch Plate

NOTE:
Dip the facing plates in engine oil to get them wet.

43. Install one steel clutch plate (1) in place in the bearing retainer. Then place one face plate on top of a steel clutch plate (1). See Figure 1114.

NOTE:
Alternately stack the remaining plates until a total of seven plates have been placed on the stack and the top plate is a facing plate.

44. Using petroleum jelly or an oil-soluble grease, place the front O-ring seal (1) into the pulley groove. See Figure 1115.



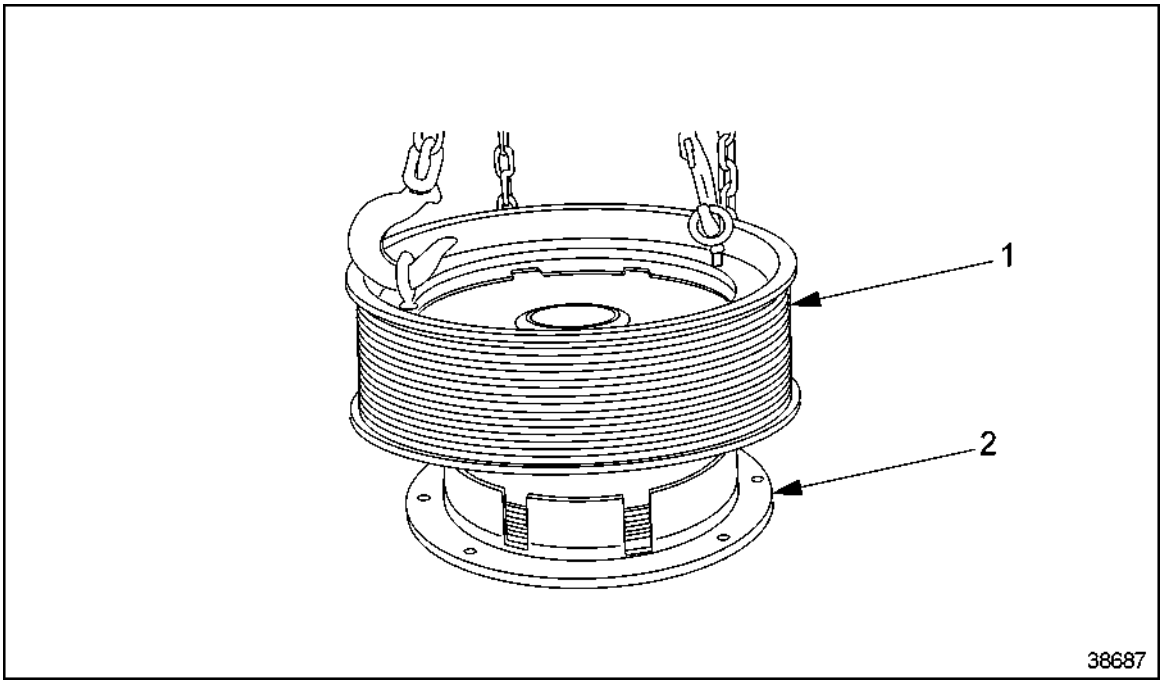
1. O-ring
2. Pulley

Figure 1115 Installation of O-ring

CAUTION:

To avoid injury from a falling component while using a lifting device, never stand beneath a suspended load.

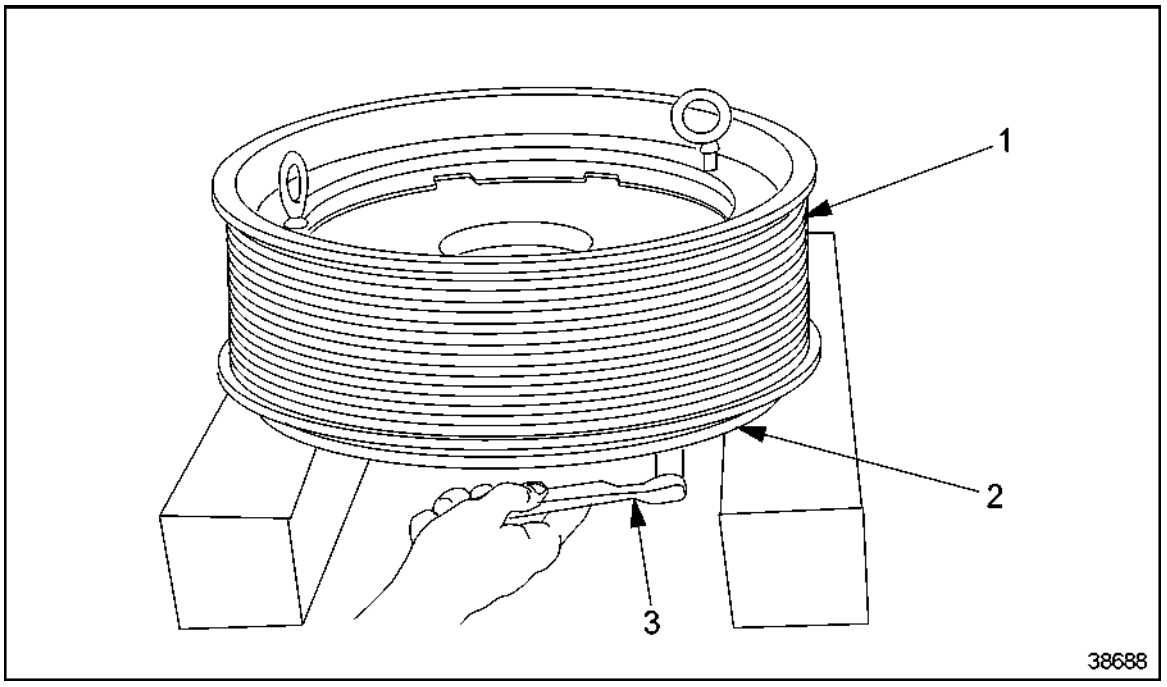
45. Install a guide bolt in one of the bolt holes of the pulley (1). Turn pulley (1) over on the bench and lift with a hoist. Carefully lower pulley (1) until it rests on the front bearing retainer (2). See Figure 1116.



1. Pulley
2. Front Bearing Retainer

Figure 1116 Installation of Pulley

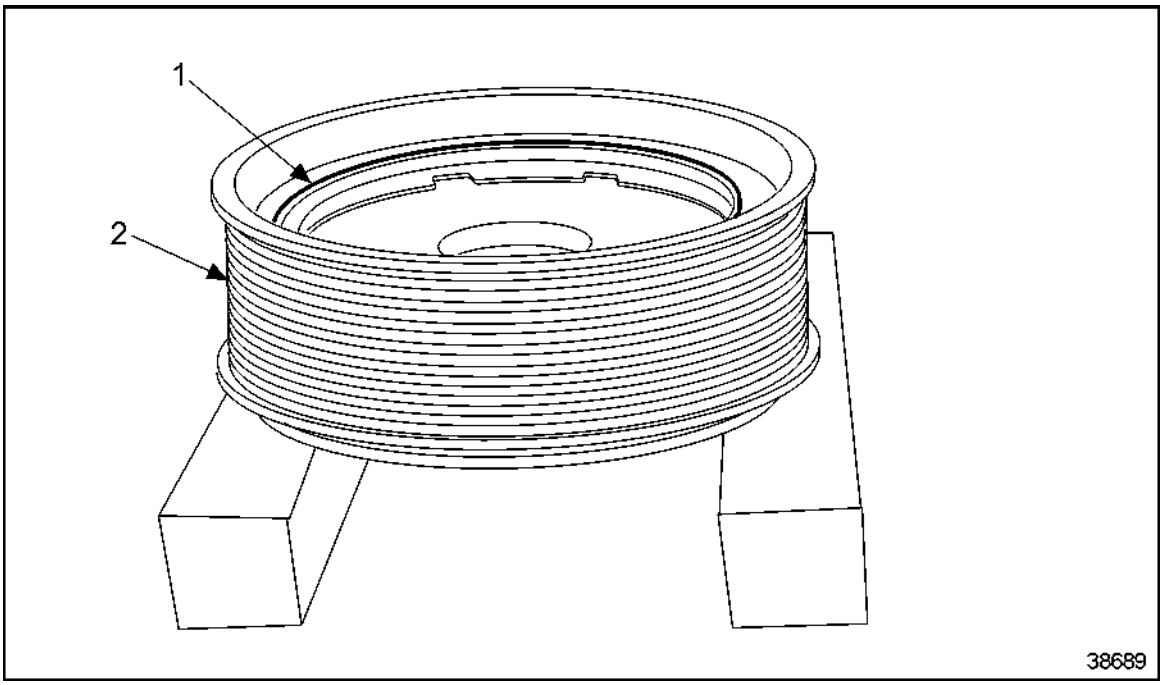
46. Install and tighten three bolts to secure front bearing retainer (2) to the pulley (1). See Figure 1117.



1. Pulley
2. Front Bearing Retainer
3. Socket

Figure 1117 Installation of Bolts

47. Using petroleum jelly or an oil-soluble grease, place O-ring seal (1) in pulley (2). See Figure 1118.

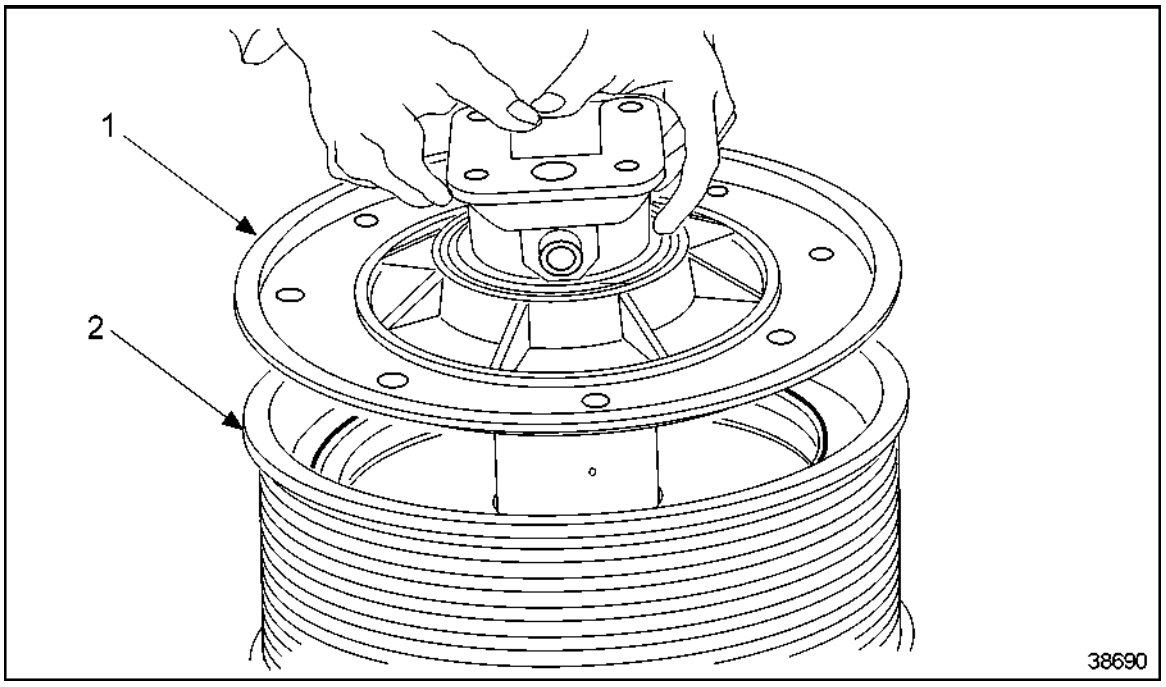


1. O-ring Seal
2. Pulley

Figure 1118 Installation of O-ring Seal

NOTICE:
When installing the shaft subassembly into the pulley, ensure to not nick the sleeve bearings with the shaft. Bearing damage could result in fan clutch failure.

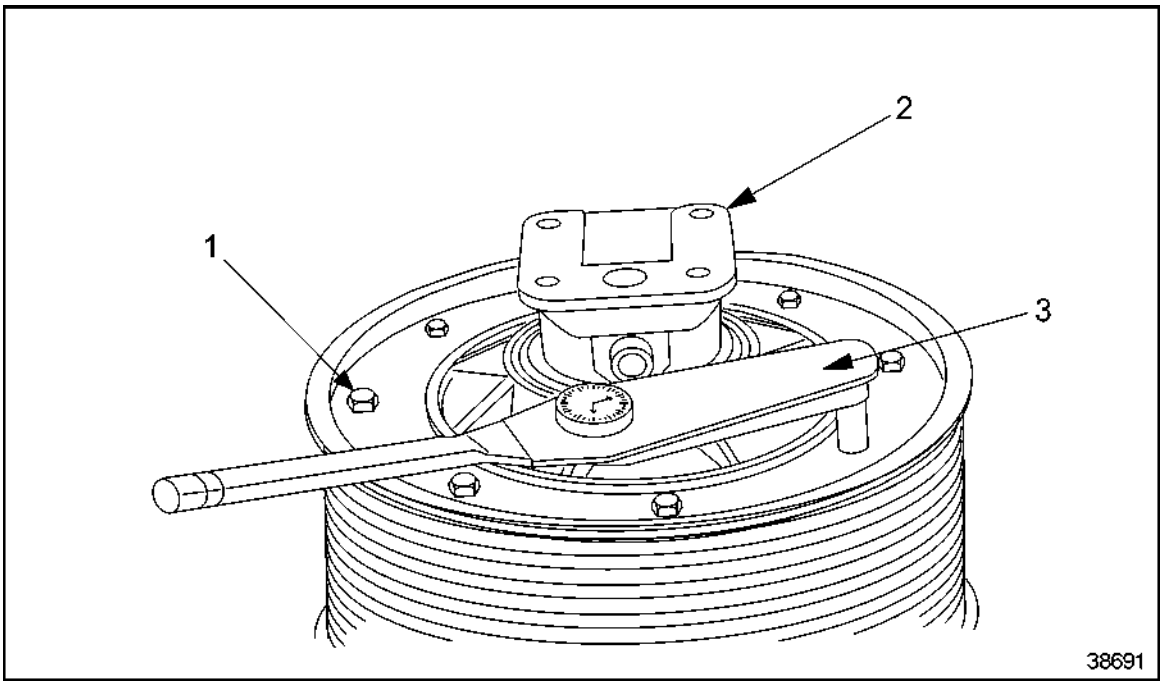
48. Lubricate the bore of the pulley, and carefully lower the shaft subassembly into the pulley bore and onto the pulley until the retainer rests on the pulley. See Figure 1119.



1. Shaft Subassembly
2. Pulley

Figure 1119 Installation of Shaft Subassembly

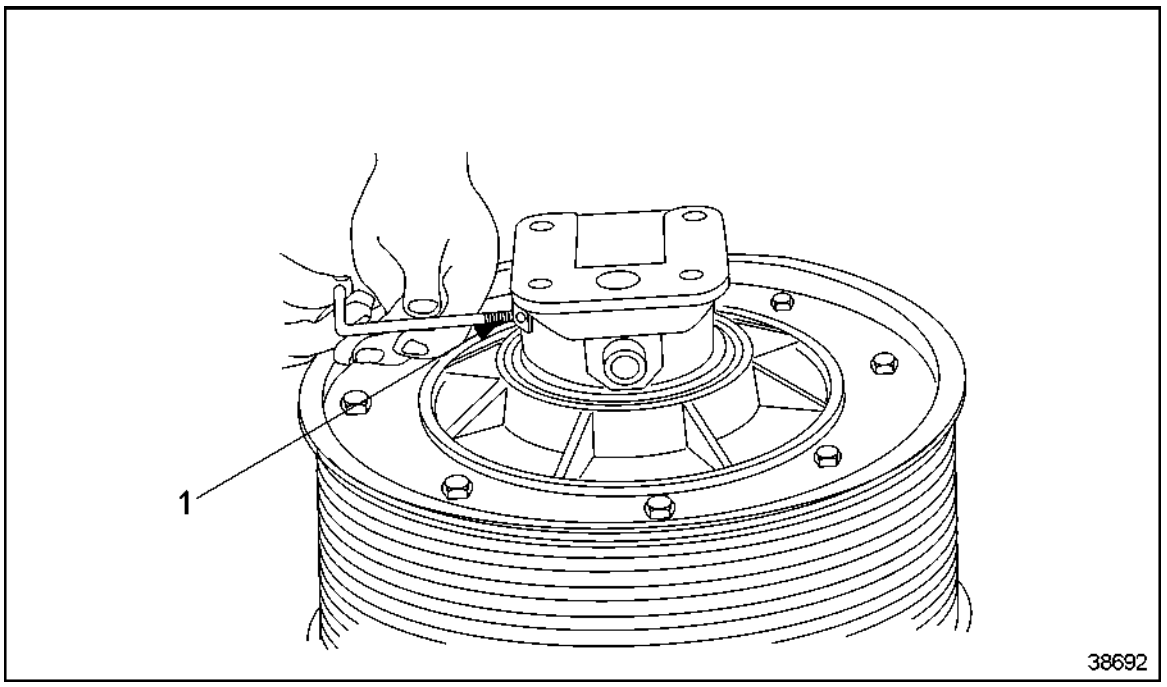
49. Install bolts and lock washers (1) to secure shaft subassembly (2) to the pulley. Torque bolts to 26–32 lb·ft (115–142 N·m). See Figure 1120.



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

Figure 1120 Installation of Bolts and Lock Washers

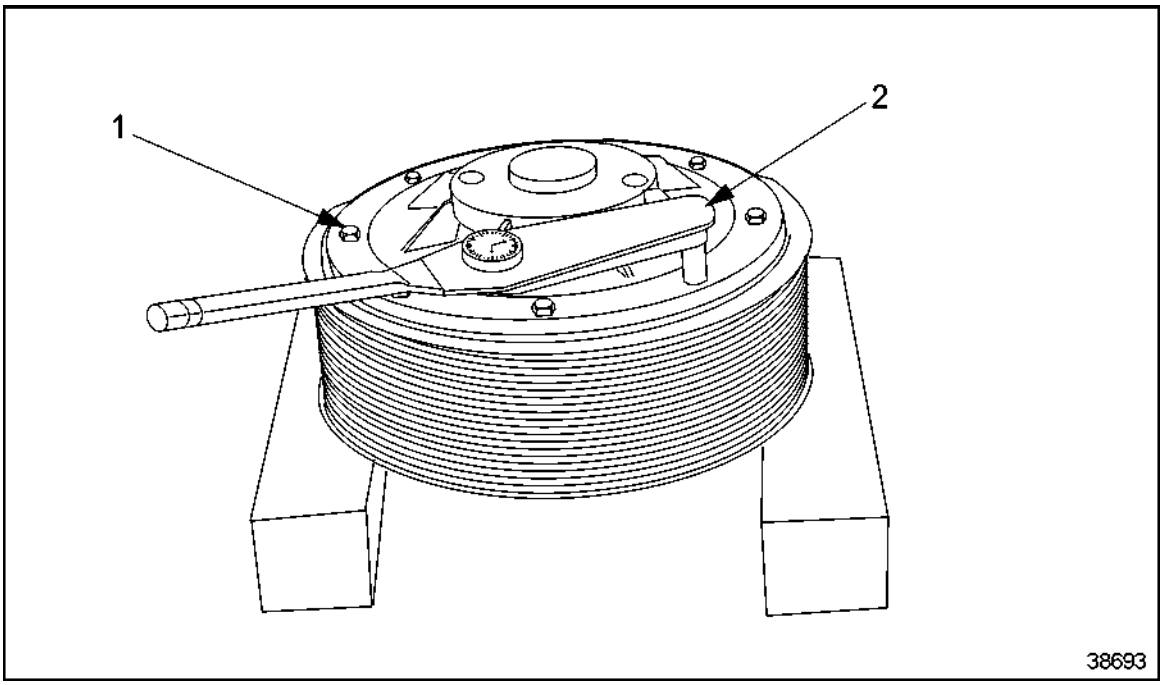
50. Install orifice fitting (1) into the *oil in* port of the bracket. See Figure 1121.



1. Orifice Fitting

Figure 1121 Installation of Orifice Fitting

51. Rotate the assembly on the bench. Install the remaining bolts and lock washers (1). Torque bolts to 26–32 ft·lbs (115–142 N·m). See Figure 1122.



1. Bolts and Lock Washers
2. Torque Wrench

Figure 1122 Installation of Remaining Bolts and Lock Washers

C 222.05.11 – INSTALLATION OF ROCKFORD SERIES 270 FAN CLUTCH

Perform the following step to install the fan clutch assembly:

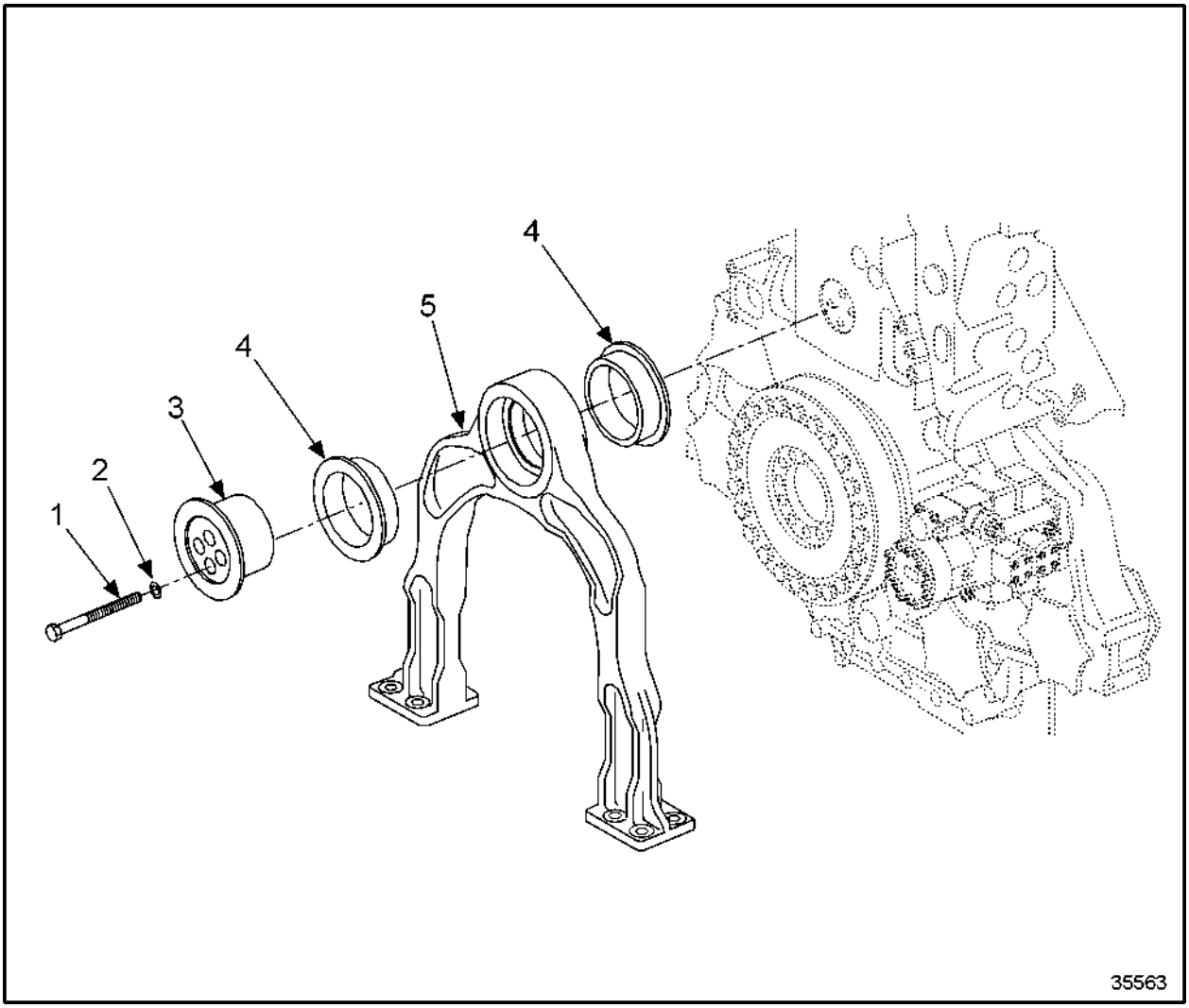
1. Refer to section C 221.05.11 to install the fan clutch assembly.

C 230 – ENGINE MOUNT

C 231.05 – TRUNNION MOUNT

C 231.05.01 – GENERAL VIEW

See Figure 1123



1. Hex Bolt
2. Washer
3. Carrier
4. Isolator
5. Trunnion

Figure 1123 General View of Trunnion Mount

C 231.05.02 – SPECIAL TOOLS

Listed in Table 178 are the special tools required for maintenance on the trunnion mount.

Application	Number
Press-in sleeve for bearing outer race in belt pulley	—
Press-in sleeve for cap plugs	—
Removal soft brass drift for ball bearing (belt tensioner)	—
Press-in sleeve for ball bearing (belt tensioner)	—

Table 178 Special Tools

C 231.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 179 are the Before-Removal Operations for the trunnion mount.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Remove protective guard	Refer to Operators Guide
1, 2, 3	Remove fan wheel	Refer to section C 221.05.05
1, 2, 3	Remove V-belt	Refer to OEM Guidelines

1 = The engine is to be completely disassembled.

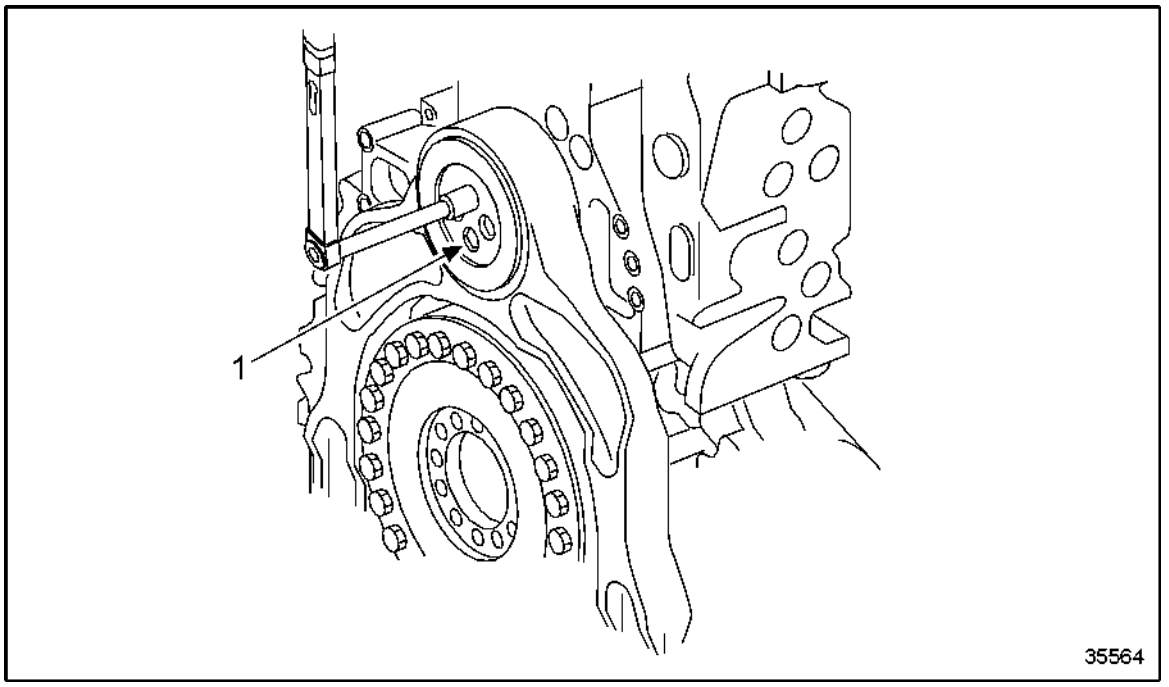
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 179 Before-Removal Operations

C 231.05.05 – REMOVAL OF TRUNNION MOUNT

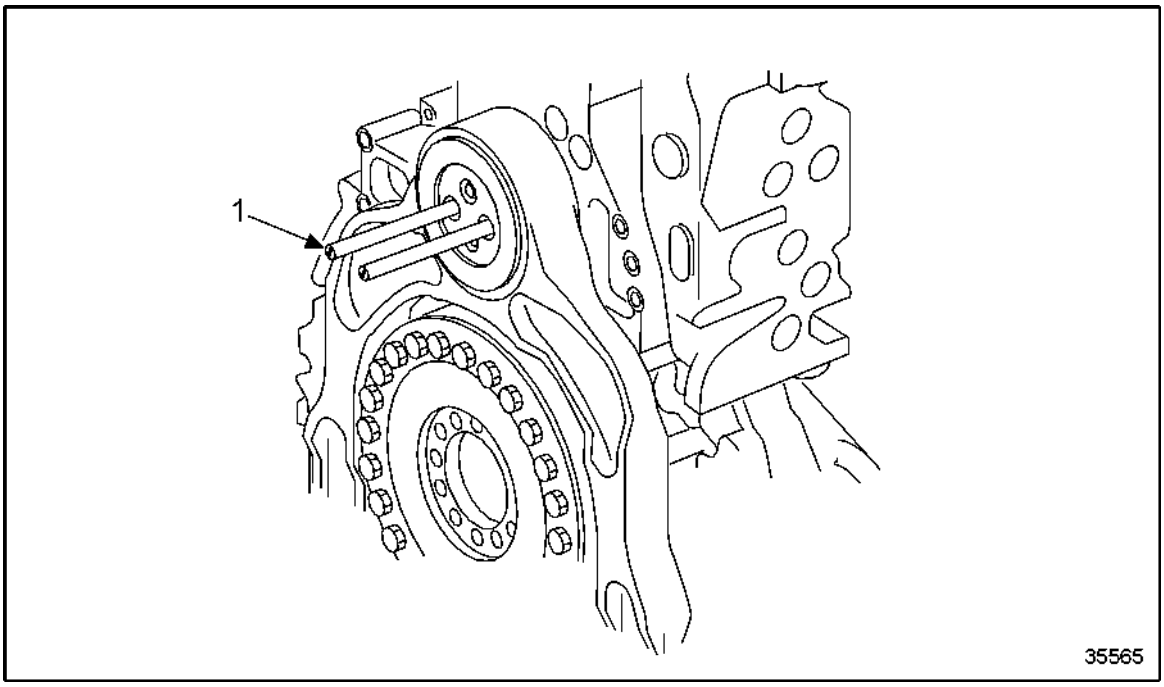
1. To remove trunnion mount, remove two opposite hex bolts (1) from trunnion mount. See Figure 1124.



1. Hex Bolt

Figure 1124 Removing Hex Bolts

2. Install guide pins in place of hex bolts and remove remaining hex bolts. See Figure 1125.



1. Guide Pin

Figure 1125 Installing Guide Pins in Trunnion Mount

CAUTION:

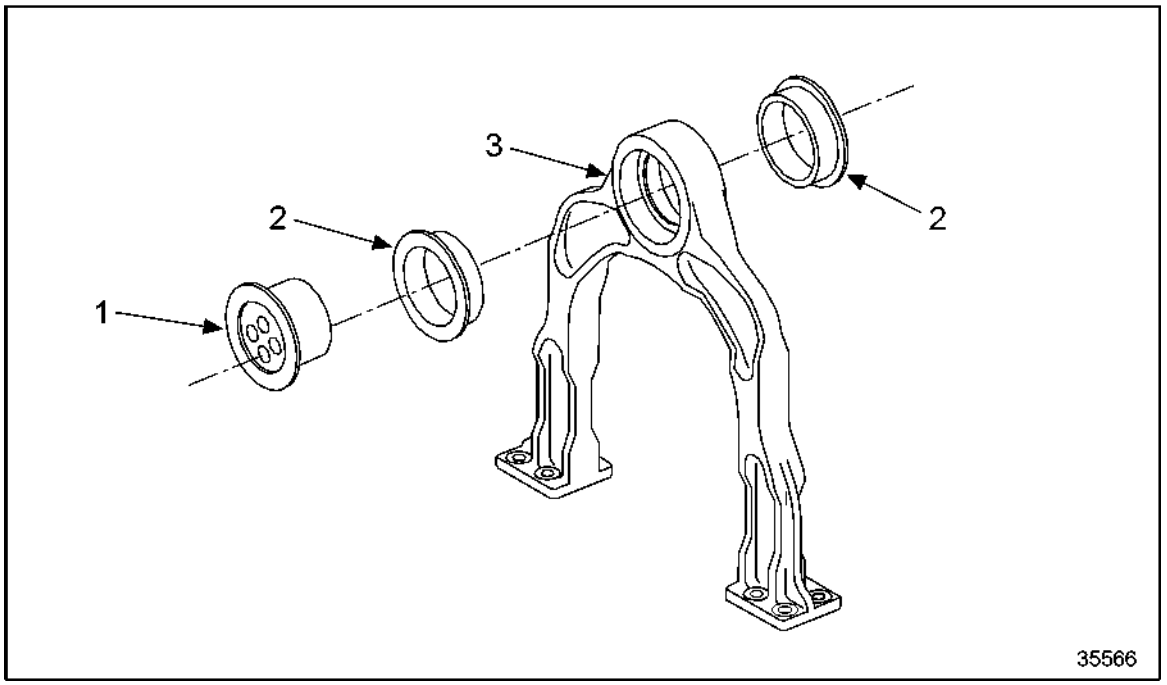
To avoid personal injury while using a lifting device, never stand beneath a suspended load. Use a suitable lifting device and review all manufacturer's cautionary notes.

3. Loosen the trunnion mount from bracket and attach to crane with a lifting device under slight pretension.
4. Remove trunnion mount completely from engine.

C 231.05.06 – DISASSEMBLY OF THE TRUNNION MOUNT

Perform the following steps for disassembly of the alternator.

1. Use soft-iron drift to remove carrier (1) from trunnion mount (3). See Figure 1126.



1. Carrier
2. Isolator
3. Trunnion Mount

Figure 1126 Removing Carrier and Isolator

2. Remove isolator halves (2) from carrier bore in trunnion mount (3), cutting them if necessary.

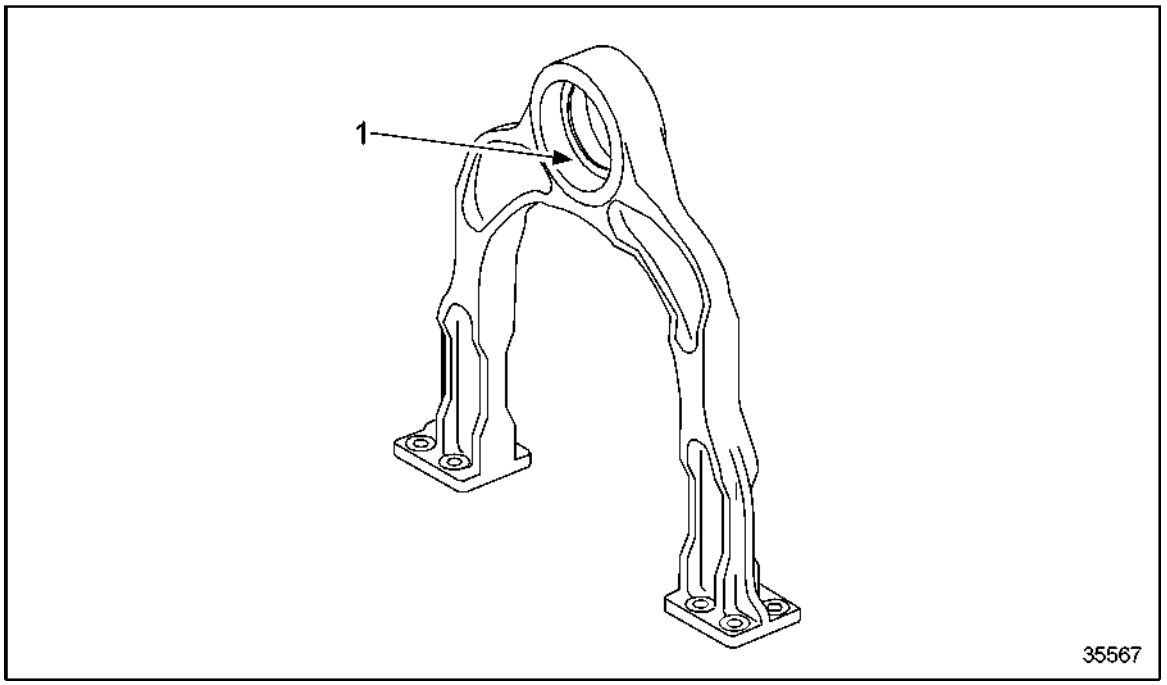
C 231.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the engine mount.

1. Clean all components.
2. Visually inspect components for damage, wear and cracks.
   [a] If components are damaged, worn or cracked, replace as necessary.
   [b] If components are not damaged, worn or cracked, continue inspection.
3. Visually inspect bracket for cracks using surface crack-testing method.
   [a] If bracket is damaged, worn or cracked, replace bracket.
   [b] If bracket is not damaged, worn or cracked, continue inspection.
4. Visually inspect all mating surfaces and fits.
   [a] If mating surfaces and fits are damaged or worn, rub down with oilstone or emery cloth as necessary.
   [b] If mating surfaces and fits are beyond repair, replace components.
   [c] If mating surfaces and fits are not damaged or worn, continue inspection.
5. Visually inspect condition of threads.
   [a] If threads are damaged or worn, rechase threads as necessary.
   [b] If threads are not damaged or worn, continue inspection.
6. Replace protective cap and gasket as part of every disassembly.

C 231.05.10 – ASSEMBLY FOR TRUNNION MOUNT

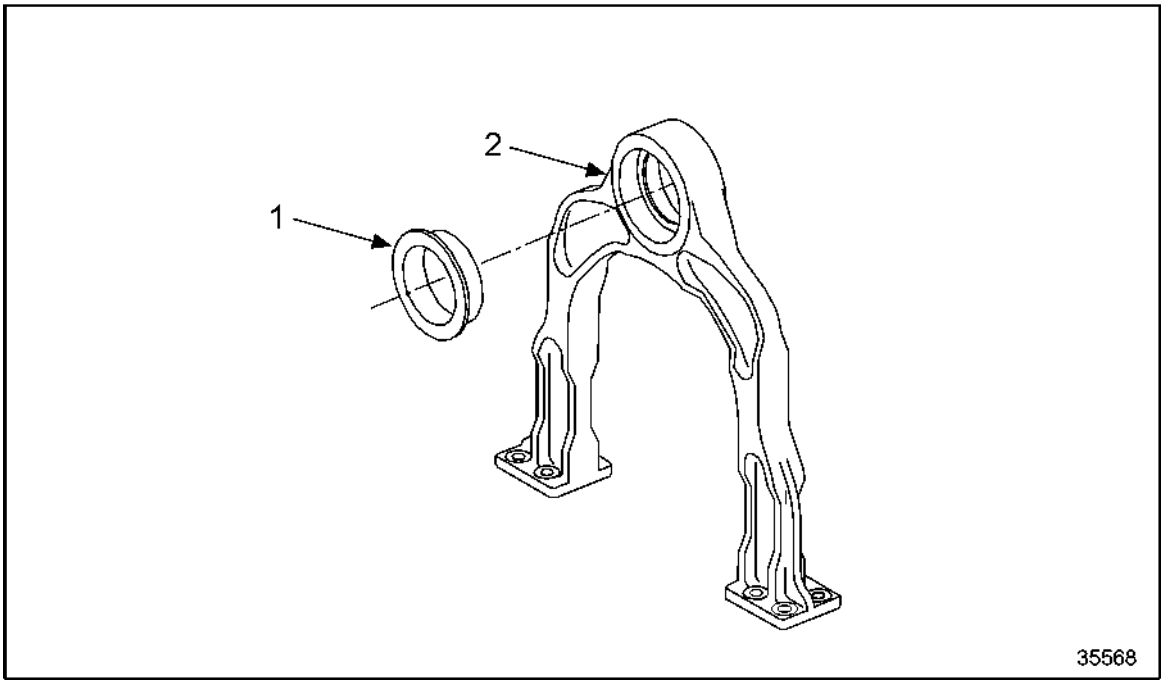
1. Coat carrier bore (1) in trunnion mount with petroleum jelly. See Figure 1127.



1. Carrier Bore

Figure 1127 Coating Carrier Bore

2. Install one isolator half (1) into carrier bore of trunnion mount (2) and press in until it contacts isolator shoulder. See Figure 1128.

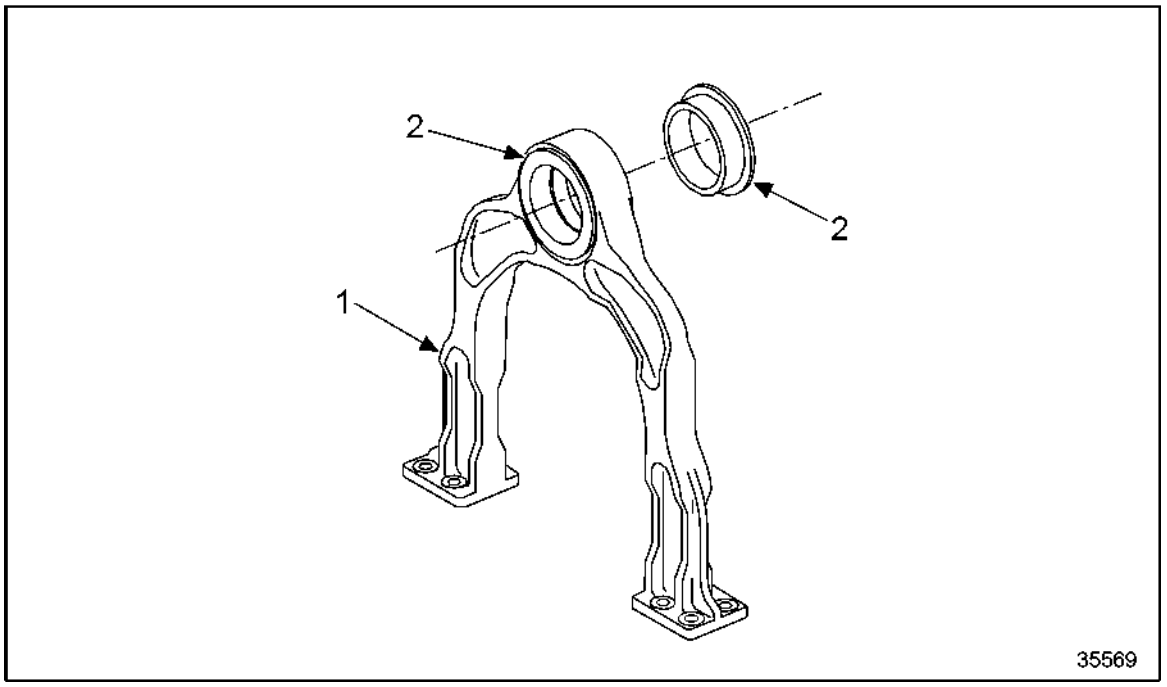


1. Isolator Half
2. Trunion Mount

Figure 1128 Installing First Isolator Half

3. Rotate trunnion mount by 180 degrees.

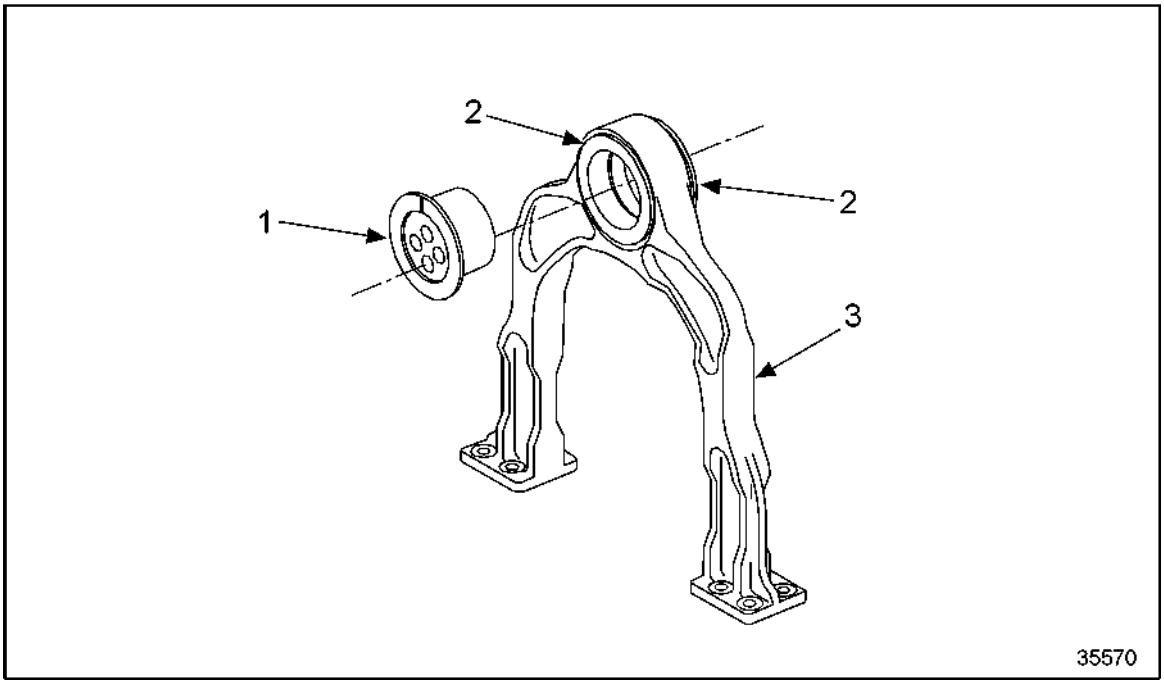
4. Install second isolator half (2) into free side of carrier bore in trunnion mount until shoulder of isolator is approximately 20 mm above mating surface of trunnion mount (1). See Figure 1129.



1. Trunion Mount
2. Isolator

Figure 1129 Installing Second Rubber Bushing

5. Coat inner surface of isolator half (2) with petroleum jelly.
6. Carefully insert carrier (1) into isolator (2). See Figure 1130.

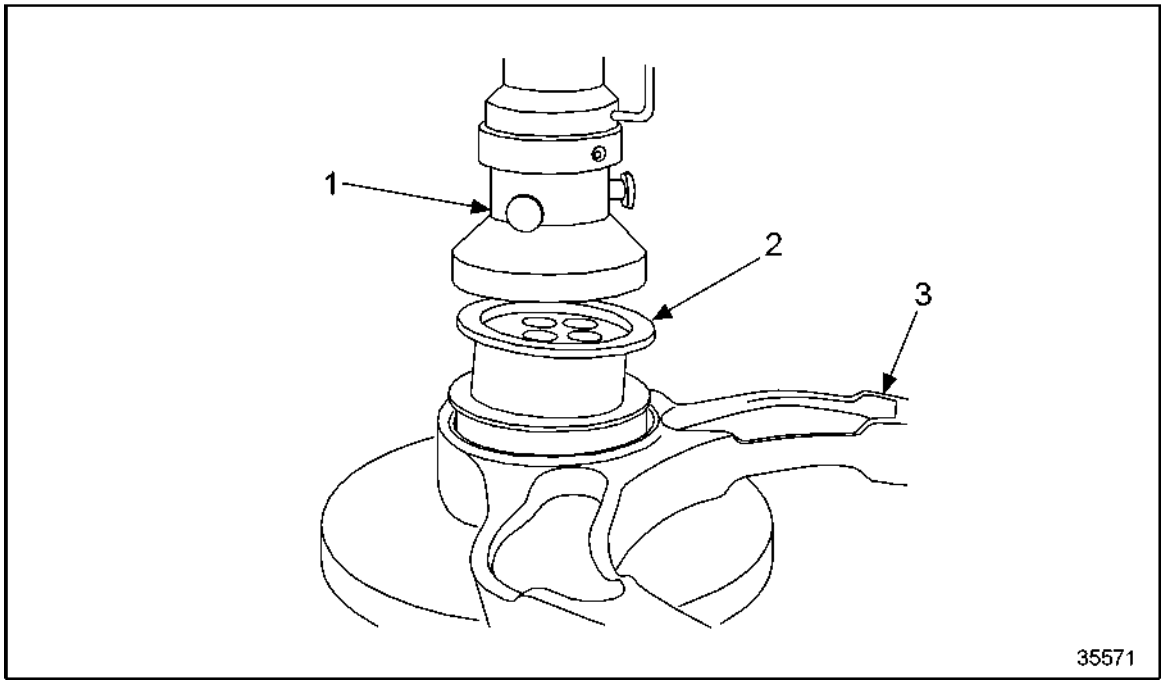


1. Carrier
2. Isolator
3. Trunion Mount

Figure 1130 Inserting Carrier

NOTE:
When aligning carrier to trunnion mount, the “TOP” mark on surface of carrier must face upward.

7. Use press (1) to push carrier (2) into trunnion mount (3) until in contact with shoulder. See Figure 1131.

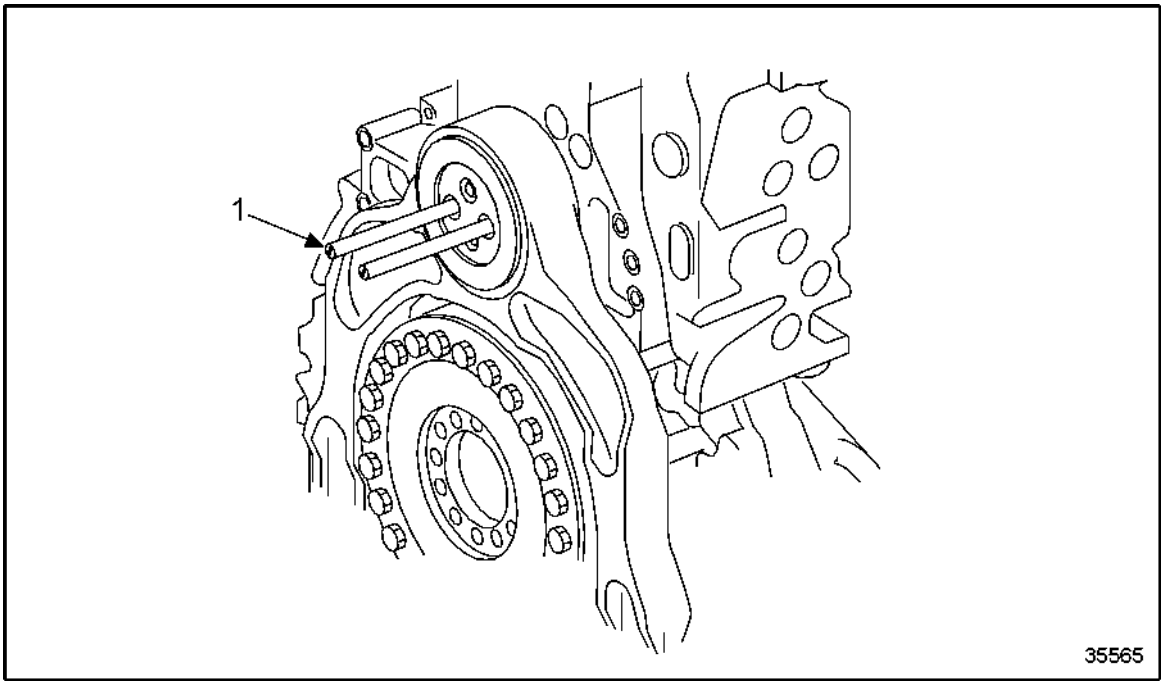


1. Press
2. Carrier
3. Trunion Mount

Figure 1131 Pushing Carrier into Trunnion Mount

C 231.05.11 – INSTALLATION OF TRUNNION MOUNT

1. Install guide pins (1) at two opposite bores of bracket. See Figure 1132.



1. Guide Pin

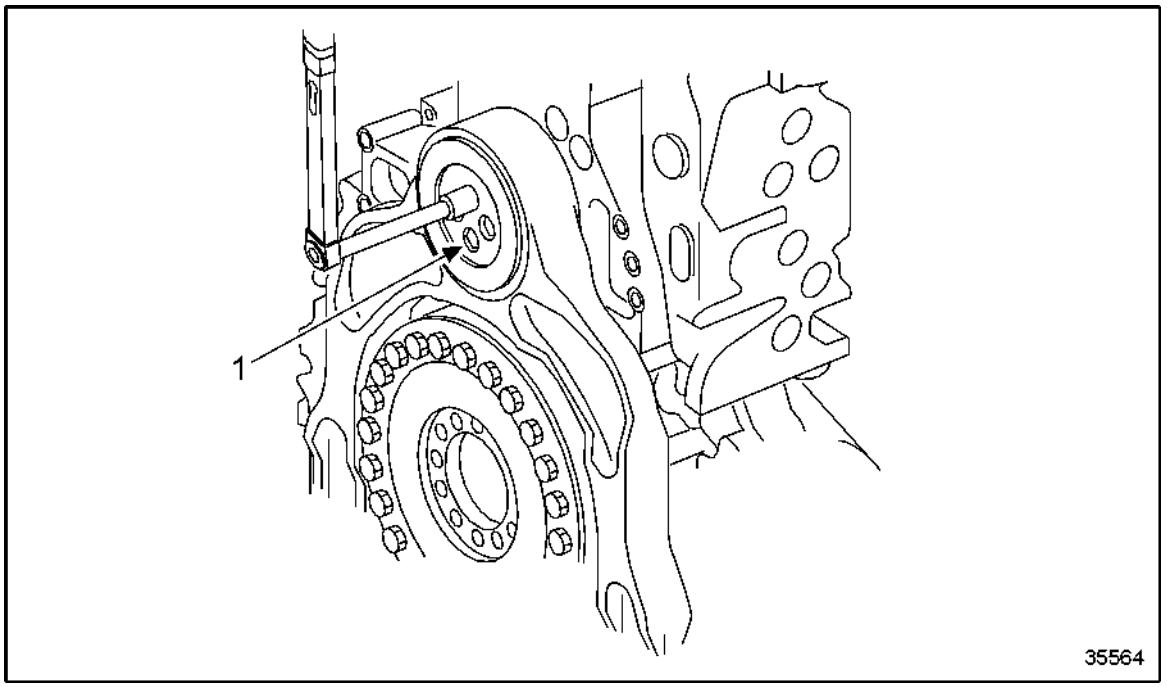
Figure 1132 Installing Guide Pins

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.

2. Attach trunnion mount with lifting device to crane and push toward bracket via guide pins. See Figure 1132.
3. Install hex bolts and tighten by hand. See Figure 1132.

4. Remove guide pins (1) and insert two hex bolts in their place. See Figure 1132.
5. Tighten all hex bolts (1) diagonally and evenly to specification. Refer to section A 003. See Figure 1133.



1. Hex Bolt

Figure 1133 Tightening Hex Bolts

C 231.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 180 are the After-Installation Operations for trunnion mounts.

Level of Maintenance	Operation	Reference
1, 2, 3	Install V-belt and set V-belt tension	Refer to OEM Guidelines
1, 2, 3	Install fan wheel	Refer to section C 221.05.11
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.

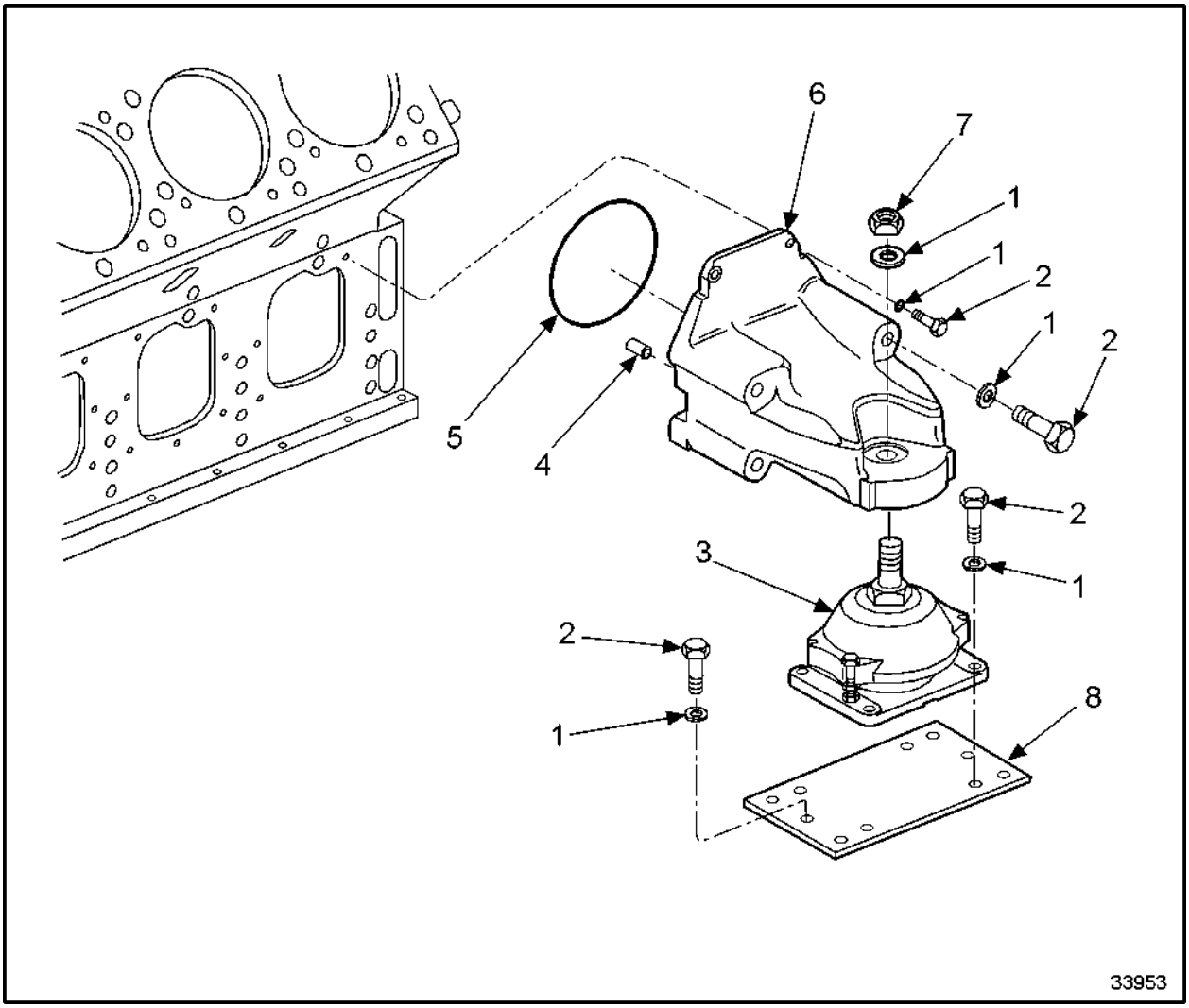
3= The engine is to remain installed.

Table 180 After-Installation Operations

C 231.05 M – ENGINE MOUNTS

C 231.05.01 M – GENERAL VIEW

See Figure 1134for a general view of the marine engine mounts.



1. Washer
2. Bolt
3. Rubber Mount
4. Dowel Pin
5. O-ring
6. Engine Carrier
7. Hex Nut
8. Base Plate

Figure 1134 General View Marine Engine Mounts

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.

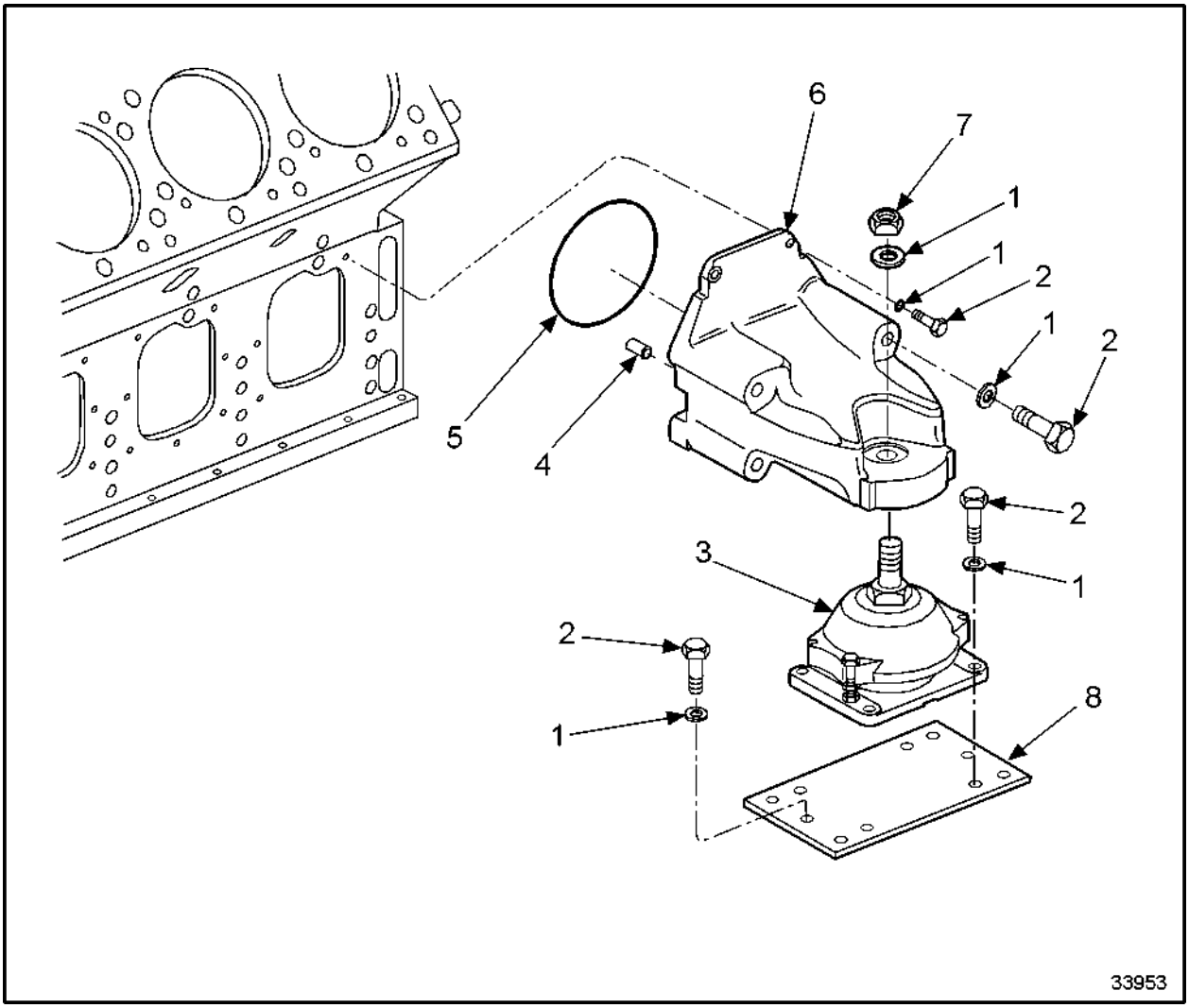
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 181 Before-Removal Operations for the Marine Engine Mounts

C 231.05.05 M – REMOVAL OF THE MARINE ENGINE MOUNTS

Perform the following steps to remove the engine mounts. See Figure 1135.



1. Washer
2. Bolt
3. Rubber Mount
4. Dowel Pin
5. O-ring
6. Engine Carrier
7. Hex Nut
8. Base Plate

Figure 1135 Removing Marine Engine Mounts

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device to lift heavy objects and follow the manufacturer's operator procedures.

1. Lift the engine with a suitable lifting device.
2. Rest the engine on a sturdy support device.
3. Remove bolts (2) and washers (1) securing rubber mount (3) to the base plate (8). See Figure 1135.
4. Remove four bolts (2) and washers (1) securing the engine support bracket to the cylinder block. See Figure 1135.
5. Remove the engine support bracket and O-ring (5). See Figure 1135.

C 231.05.08 M – INSPECTION AND REPAIR

Perform the following steps to inspect and repair the marine engine mounts.

1. Clean all components.

CAUTION:

To avoid personal injury when working with diesel fuel, do not smoke, use open flame, or electrical equipment. Risk of a fire is probable. Diesel fuel is a combustible fluid.

2. Clean bearings with diesel fuel.
3. Visually inspect components, especially bearing roller element, for damage, wear and cracks.
   [a] If components are damaged, worn, or cracked, replace as necessary.
   [b] If components are not damaged, worn or cracked, continue inspection.
4. Visually inspect engine mounts and brackets for cracks using surface crack-testing.
   [a] If engine mounts are cracked, replace the components.
   [b] If engine mounts are not cracked, continue inspection.

NOTE:
Bearing inner race and bearing outer race are considered a single unit and must be replaced in pairs.

5. Visually inspect all mating surfaces and fits for damage or wear.
   [a] If mating surfaces or fits are damaged or worn, rub down with oilstone or emery cloth as necessary.
   [b] If damage is beyond repair, replace component as necessary.
   [c] If mating surface or fits are not damaged or worn, continue inspection.
6. Adjust bore gage and measure bearing bores in belt pulleys.
7. Check tolerance and wear limits.
   [a] If tolerance and wear limits are exceeded, replace component.
   [b] If tolerance and wear limits are not exceeded, continue inspection.
8. Replace protective cap and gasket as part of every disassembly.
9. Replace bearing as part of every W6 overhaul.

C 231.05.11 M – INSTALLATION OF THE MARINE ENGINE MOUNTS

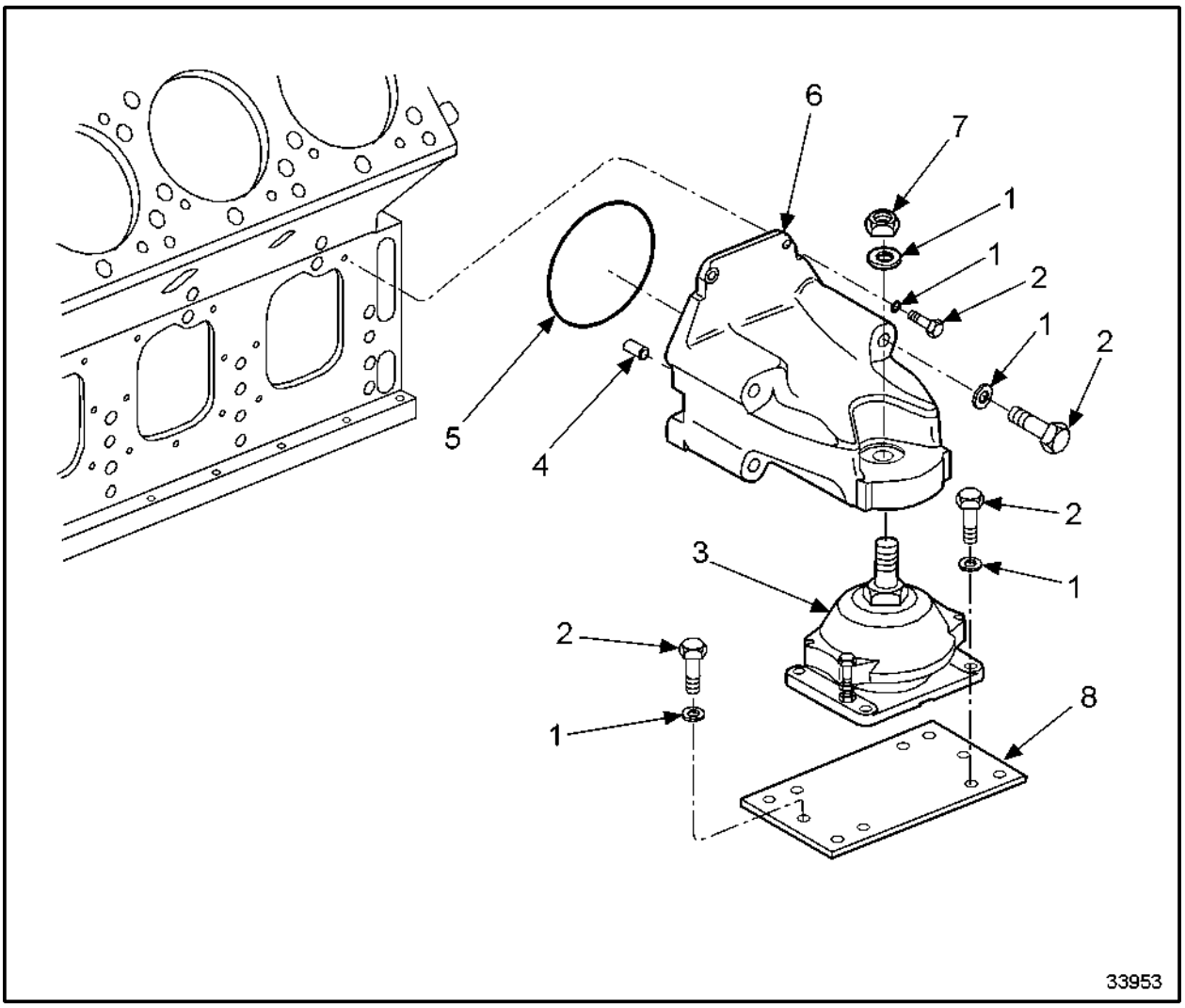
Perform the following steps to install the marine engine mounts.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device to lift heavy objects and follow the manufacturer's operator procedures.

1. Lift the engine with a suitable lifting device.
2. Rest the engine on a sturdy support device, if necessary.

3. Install a new O-ring (5) to the engine support bracket. See Figure 1136.



1. Washer
2. Bolt
3. Rubber Mount
4. Dowel Pin
5. O-ring
6. Engine Carrier
7. Hex Nut
8. Base Plate

Figure 1136 Installing Marine Engine Mounts

4. Install four bolts (2) and washers (1) to secure the engine support bracket to the cylinder block. Torque bolts to 385 N·m (284 lb ft). See Figure 1136.
5. Install bolts (2) and washers (1) to secure rubber mount (3) to the base plate (8). See Figure 1136.

C 231.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 182are the After-Installation Operations for the marine engine mounts.

Level of Maintenance	Operation	Reference
1, 2, 3	Install fan wheel	-
1, 2, 3	Mount protective guard	-
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.

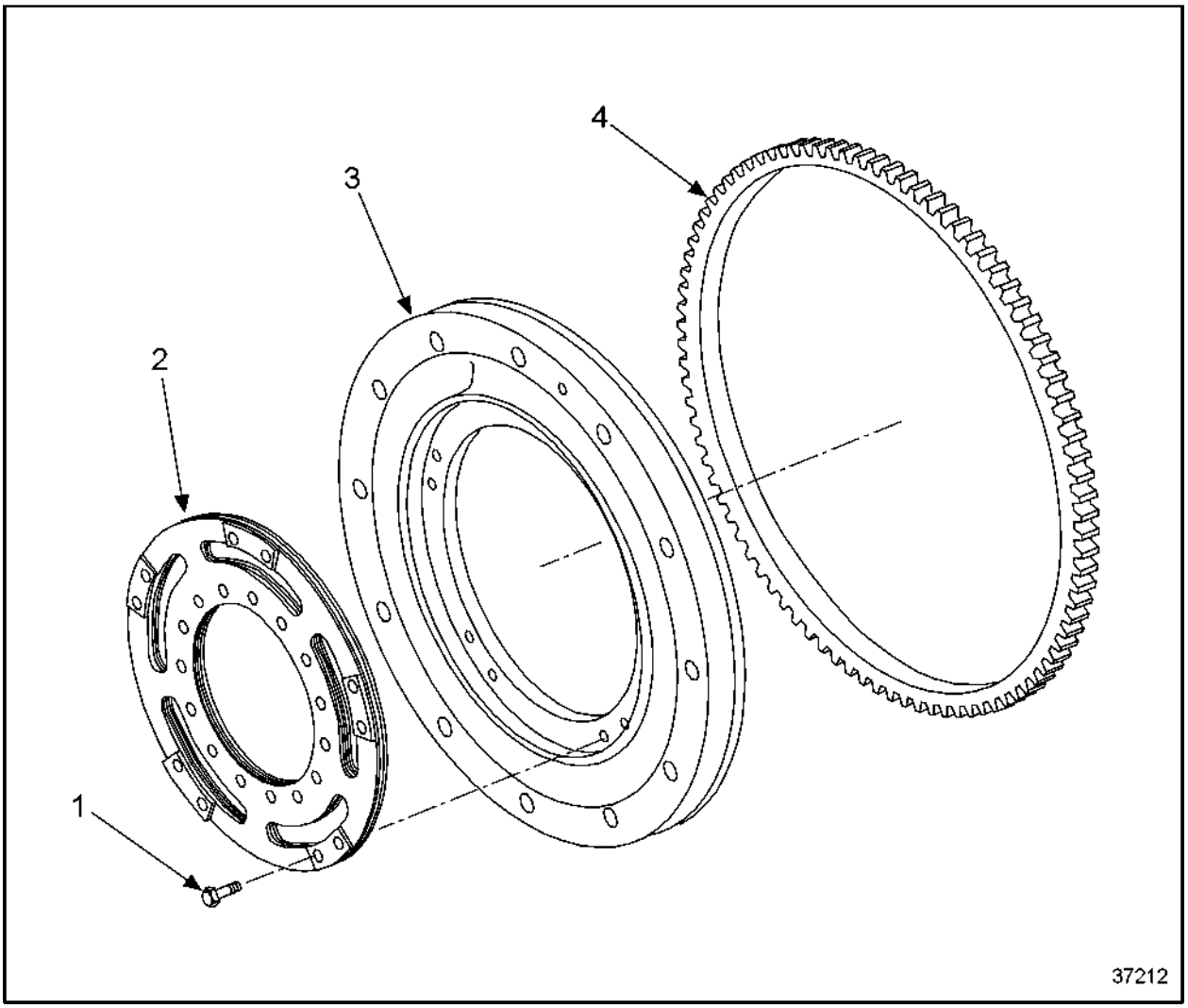
Table 182 After-Installation Operations for the Marine Engine Mounts

C 250 – FLYWHEEL AND FLEX COUPLING

C 255.05 – RESILIENT COUPLING

C 255.05.01 – GENERAL VIEW

See Figure 1137 for a general view of the flex coupling.



1. Hex Head Bolt
2. Flex Coupling
3. Adapter
4. Ring Gear

Figure 1137 General View of the Flex Coupling

C 255.05.04 – BEFORE-REMOVAL OPERATIONS

Listed in Table 183 are the Before-Removal Operations for the flex coupling.

Level of Maintenance	Operation	Reference
1, 2, 3	Disable engine power	Refer to Operators Guide
1, 2, 3	Separate engine from gearbox or alternator	—

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 183 Before-Removal Operations

C 255.05.05 – REMOVAL OF FLEX COUPLING

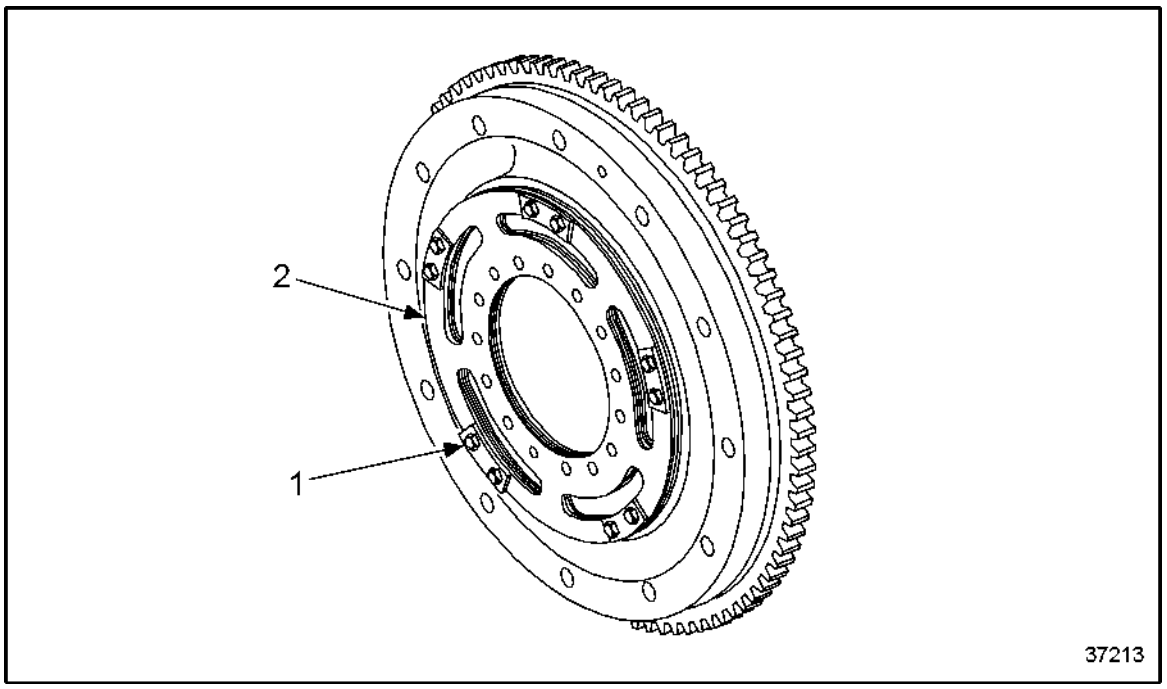
Refer to section .

C 255.05.06 – DISASSEMBLY OF FLEX COUPLING

Perform the following steps to disassemble the flex coupling:

1. To remove flex coupling, loosen hex bolts (1). See Figure 1138.

Notice
Remove flex coupling only if absolutely necessary. Hex bolts are staked in place and may damage adapter when removed



1. Hex Bolts
2. Flex Coupling

Figure 1138 Removing Flex Coupling

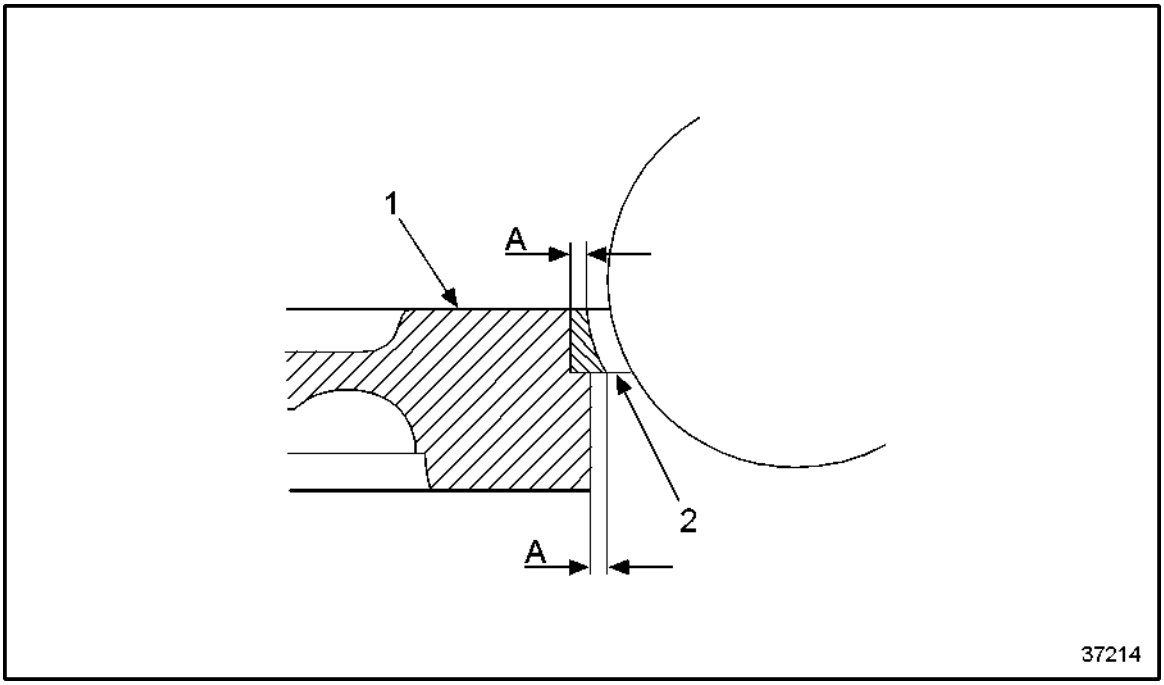
2. Remove flex coupling (2).

NOTE:
Remove ring gear only if it is to be replaced because of damage.

CAUTION:

To prevent possible personal injury while using grinding wheel, adequate eye protection must be worn; faceplate, safety goggles.

3. Grind ring gear (2) at four to six points evenly distributed around ring gear as deeply as possible. See Figure 1139.



1. Adapter
2. Ring Gear

Figure 1139 Removing Ring Gear

NOTE:
Take care not to damage adapter when grinding. The minimum distance of grinding disc to adapter: A=1 mm.

CAUTION:

To avoid personal injury when handling and lifting a heavy object, use a suitable lifting device and follow the manufacturer's operator procedures.

4. Hit ring gear hard with a hammer to loosen from adapter.

NOTE:
If ring gear cannot be loosened by hitting with a hammer, heat uniformly (maximum 170°C) around entire circumference for a brief period to expand.

C 255.05.08 – INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the flex coupling:

1. Clean all components.
2. Visually inspect adapter, ring gear and hex bolts of flex coupling for cracks using magnetic crack-testing method with fluorescent powder.
   [a] If adapter, ring gear or hex bolts of flex coupling are cracked, replace component.
   [b] If adapter, ring gear or hex bolts of flex coupling are not cracked, continue inspection.
3. Visually inspect mating surface on adapter and flex coupling for evenness, wear, scoring and pitting.
   [a] If mating surfaces are uneven, worn, scored or pitted, recondition as necessary.
   [b] If mating surface is beyond repair, replace component as necessary.
   [c] If mating surfaces are not uneven, worn, scored or pitted, continue inspection.
4. Visually inspect flex coupling for scoring or pitting greater than maximum permissible material removal.
   [a] If flex coupling is scored or pitted greater than maximum permissible limit value, replace as necessary.
   [b] If flex coupling is not scored or pitted greater than maximum permissible, continue inspection.
5. Visually inspect seating surface of ring gear on adapter for wear, scoring and pitting.
   [a] If seating surface of ring gear is worn, scored or pitted, smooth with emery cloth or oilstone.
   [b] If damage is beyond repair, replace component.
   [c] If seating surface of ring gear is not worn, scored or pitted, continue inspection.
6. Visually inspect hex bolt threads of flex coupling for wear or damage.
   [a] If hex bolt threads of flex coupling are worn or damaged, replace hex bolts as necessary.
   [b] If hex bolt threads of flex coupling are not worn or damaged, continue inspection.
7. Inspect threads in adapter for condition and ease of movement.
   [a] If threads in adapter are not in perfect condition or do not show ease of movement, recut as necessary.
   [b] If threads in adapter are beyond repair, replace component as necessary.
   [c] If threads in adapter are in perfect condition and show ease of movement, continue inspection.
8. Visually inspect ring gear for chipped tooth flanks and wear.

CAUTION:

To prevent possible personal injury while using grinding wheel, adequate eye protection must be worn; faceplate, safety goggles.

[a] If ring gear is worn or tooth flanks are chipped, regrind as necessary.

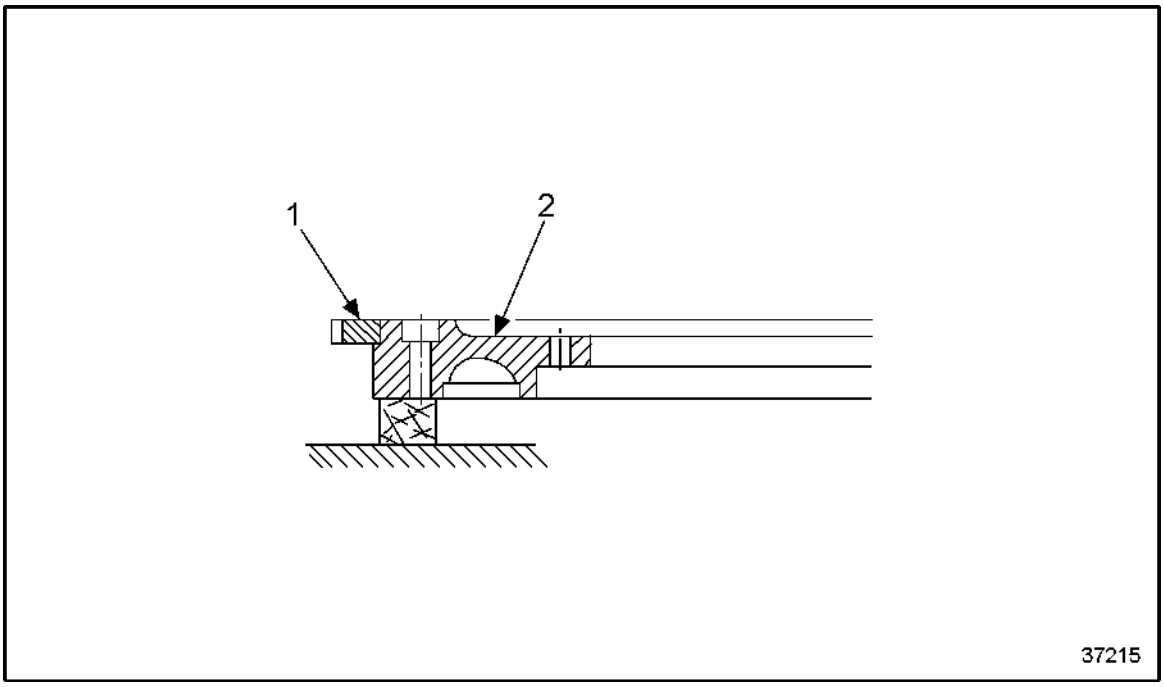
[b] If ring gear wear or tooth flank chips are beyond repair, replace component.

[c] If ring gear is not worn and tooth flanks are not chipped, continue inspection.

C 255.05.10 – ASSEMBLY OF FLEX COUPLING

Perform the following steps to assemble the flex coupling:

1. To install ring gear (2), degrease contact surface on adapter (1) and ring gear. See Figure 1140.



1. Adapter
2. Ring Gear

Figure 1140 Installing Ring Gear

CAUTION:

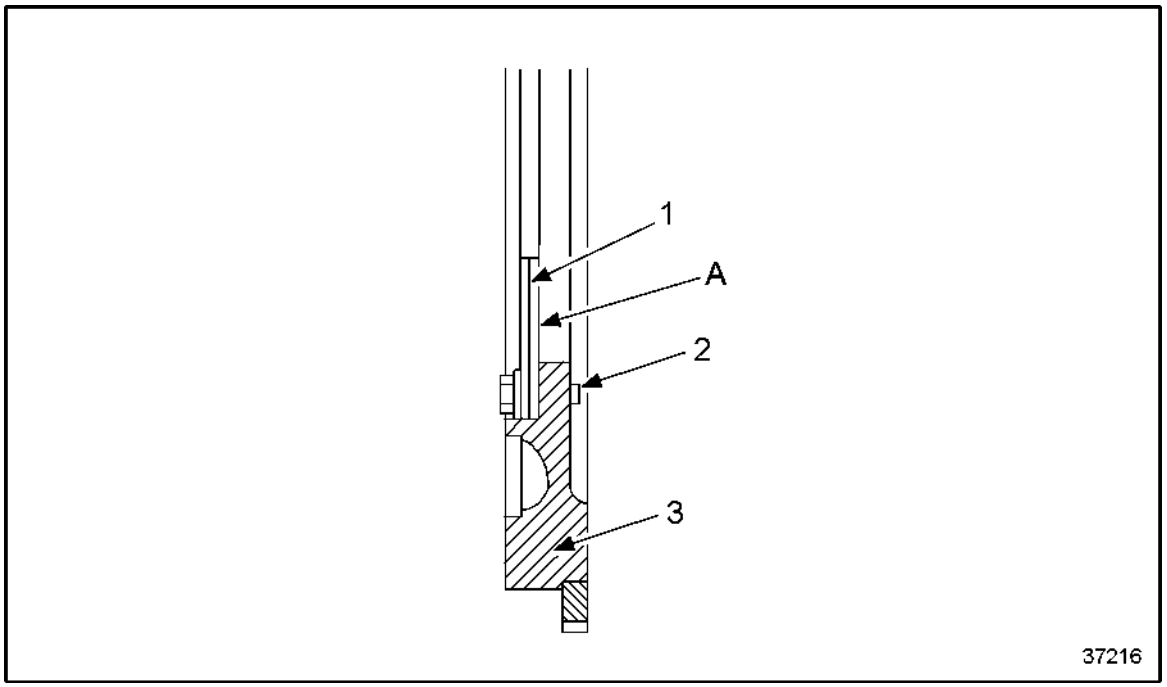
To avoid personal injury while handling 'HOT' components, wear protective gloves and clothing.

2. Heat ring gear uniformly to maximum 200°C and install on adapter.

NOTE:
The ring gear must contact adapter with no gaps around the entire circumference.

3. Install flex coupling in mating surface of adapter. See Figure 1141

NOTE:
Ensure that flex coupling is positioned correctly. “A” (fan side) must face toward fan wheel.



1. Adapter
2. Hex Head Bolt
3. Ring Gear

Figure 1141 Installing Flex Coupling

4. Install hex bolts (2) and tighten diagonally and evenly to specification. Refer to section A 003.
5. Stake hex bolts at projecting thread against adapter (1).

C 255.05.11 – INSTALLATION OF FLEX COUPLING

Refer to section C 032.05.11.

C 255.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 184 are the After-Installation Operations for the flex coupling.

Level of Maintenance	Operation	Reference
1, 2, 3	Connect engine with gearbox alternator	Refer to section C 213.05.11
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.

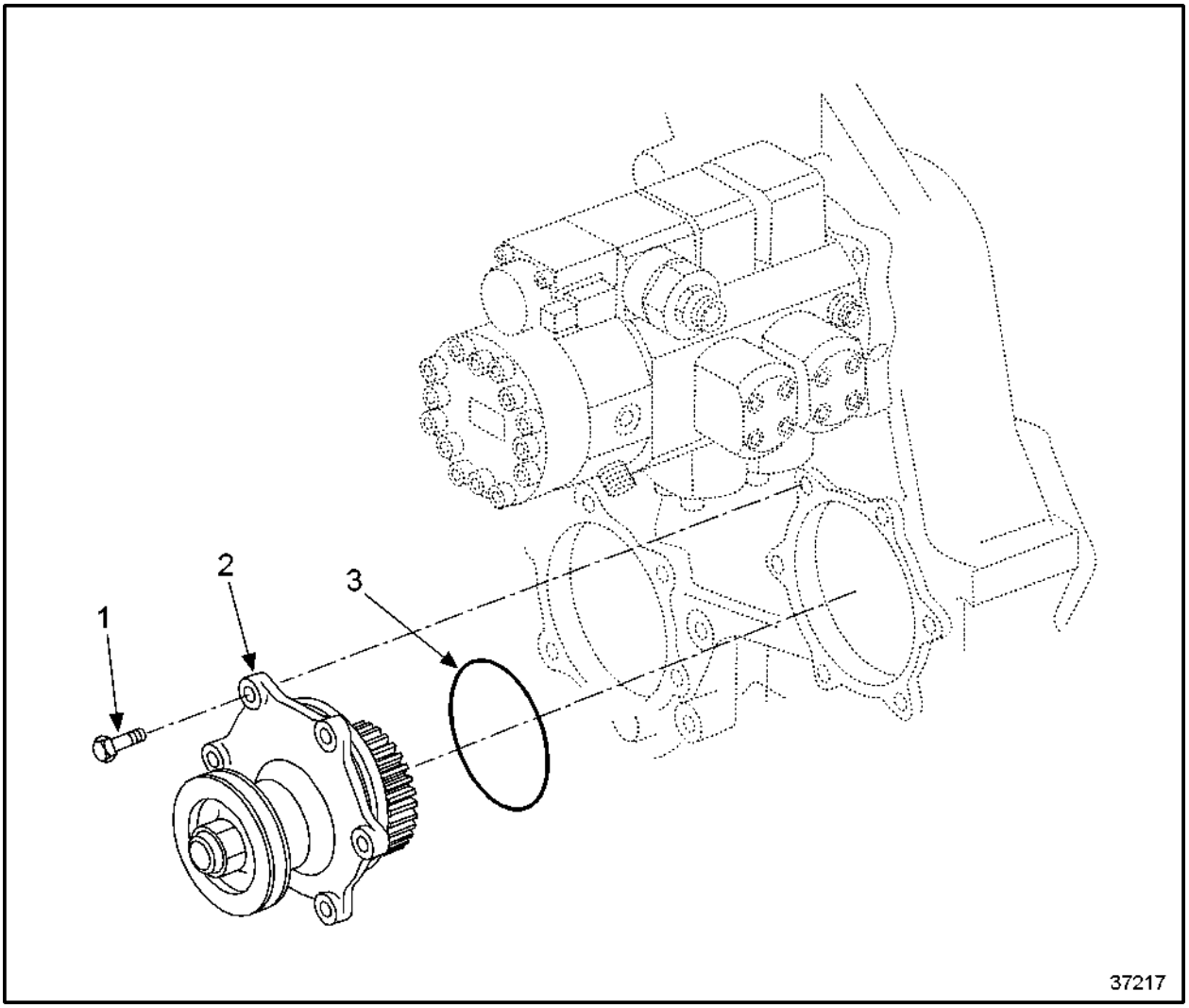
3= The engine is to remain installed.

Table 184 After-Installation Operations

C 259.05 – AUXILIARY PTO ASSEMBLY

C 259.05.01 – GENERAL VIEW

See Figure 1142 for a general view of the auxiliary PTO assembly.



1. Hex Head Bolt
2. Auxiliary PTO Assembly
3. O-ring

Figure 1142 General View of Auxiliary PTO Assembly

C 259.05.02 – SPECIAL TOOLS

Listed in Table 185are the special tools required for maintenance of auxiliary PTO assembly.

Application	Number
Press-in sleeve for bearing outer race in belt pulley	—
Press-in sleeve for cap plugs	—
Removal brass drift for ball bearing (belt tensioner)	—
Press-in sleeve for ball bearing (belt tensioner)	—

Table 185 Special Tools

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.

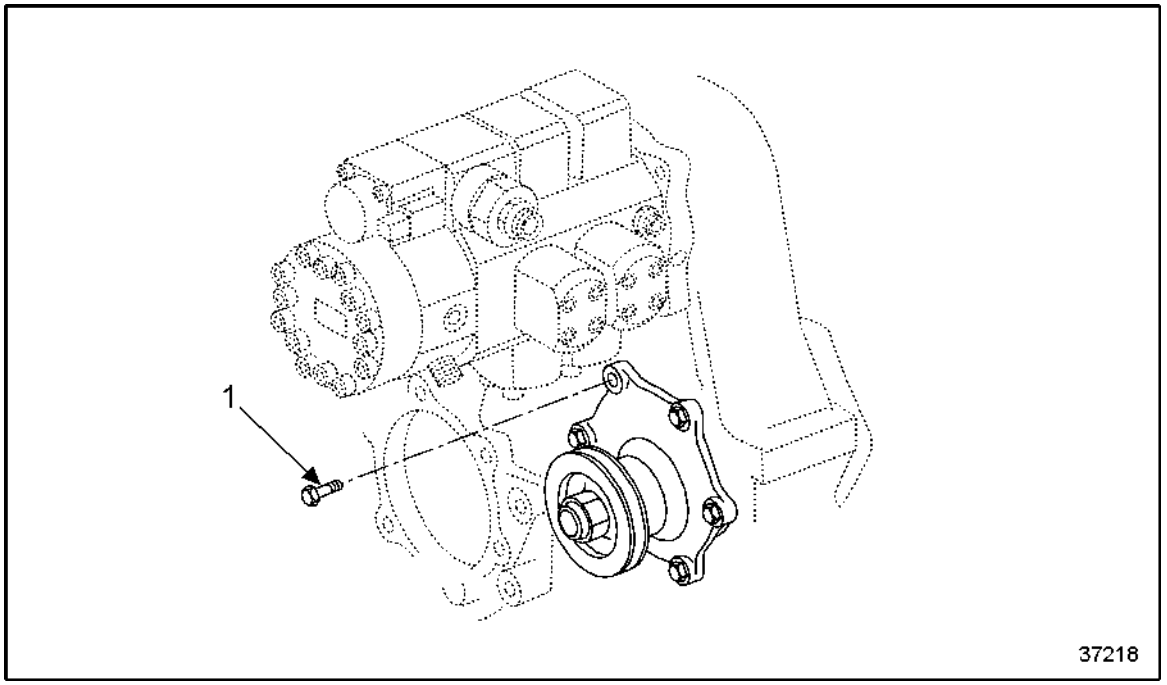
2= The engine is to be removed but not completely disassembled.

3= The engine is to remain installed.

Table 186 Before-Removal Operations

C 259.05.05 – REMOVAL OF THE AUXILIARY PTO ASSEMBLY

1. To remove auxiliary PTO assembly, remove hex bolts (1). See Figure 1143.



1. Hex Bolt

Figure 1143 Removing Hex Bolts

2. Carefully remove auxiliary PTO assembly from gear case.

C 259.05.06 – DISASSEMBLY OF THE AUXILIARY PTO ASSEMBLY

Refer to OEM guidelines.

C 259.05.08 – CLEANING, INSPECTION AND REPAIR

Perform the following steps for inspection and repair of the auxiliary PTO assembly:

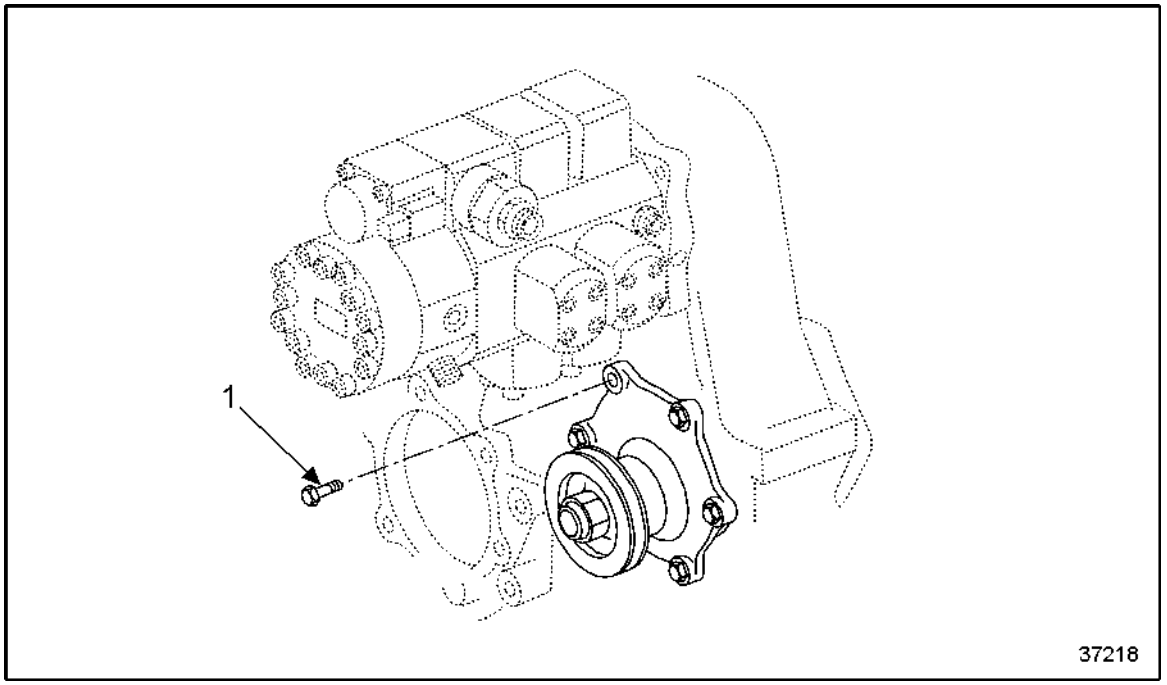
1. Clean all components.
2. Inspect auxiliary PTO assembly for abnormal running noises.
   [a] If auxiliary PTO assembly does exhibit abnormal running noises, replace component as necessary.
   [b] If auxiliary PTO assembly does not exhibit abnormal running noises, continue inspection.
3. Visually inspect auxiliary PTO assembly for ease of movement.
   [a] If auxiliary PTO assembly does not show ease of movement, replace component as necessary.
   [b] If auxiliary PTO assembly does show ease of movement, continue inspection.
4. Visually inspect auxiliary PTO assembly for wear and cracks.
   [a] If auxiliary PTO assembly does show wear or cracks, replace component.
   [b] If auxiliary PTO assembly does not show wear or cracks, continue inspection.
5. Visually inspect mating surfaces for damage or wear.
   [a] If mating surfaces show damage or wear, rub with emery cloth or oilstone as necessary.
   [b] If mating surfaces do not show damage or wear, continue inspection.
6. Visually inspect threads for damage or wear.
   [a] If threads are damaged or worn, rechase as necessary.
   [b] If threads are not damaged or worn, continue inspection.
7. Replace auxiliary PTO assembly during W6 maintenance.

C 259.05.10 – ASSEMBLY OF THE AUXILIARY PTO ASSEMBLY

Refer to OEM guidelines.

C 259.05.11 – INSTALLATION OF THE AUXILIARY PTO ASSEMBLY

1. Carefully install auxiliary PTO assembly in gear case. See Figure 1144.



1. Hex Bolt

Figure 1144 Installing Auxiliary PTO Assembly in Gear Case

2. Inspect gear lash on the drive.
3. Insert hex bolts (1) and tighten diagonally and evenly to specification. Refer to section A 003.

C 259.05.12 – AFTER-INSTALLATION OPERATIONS

Listed in Table 187 are the After-Installation Operations for auxiliary PTO assembly.

Level of Maintenance	Operation	Reference
1, 2, 3	Install V-belt and V-belt tension	Refer to OEM Guidelines
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.

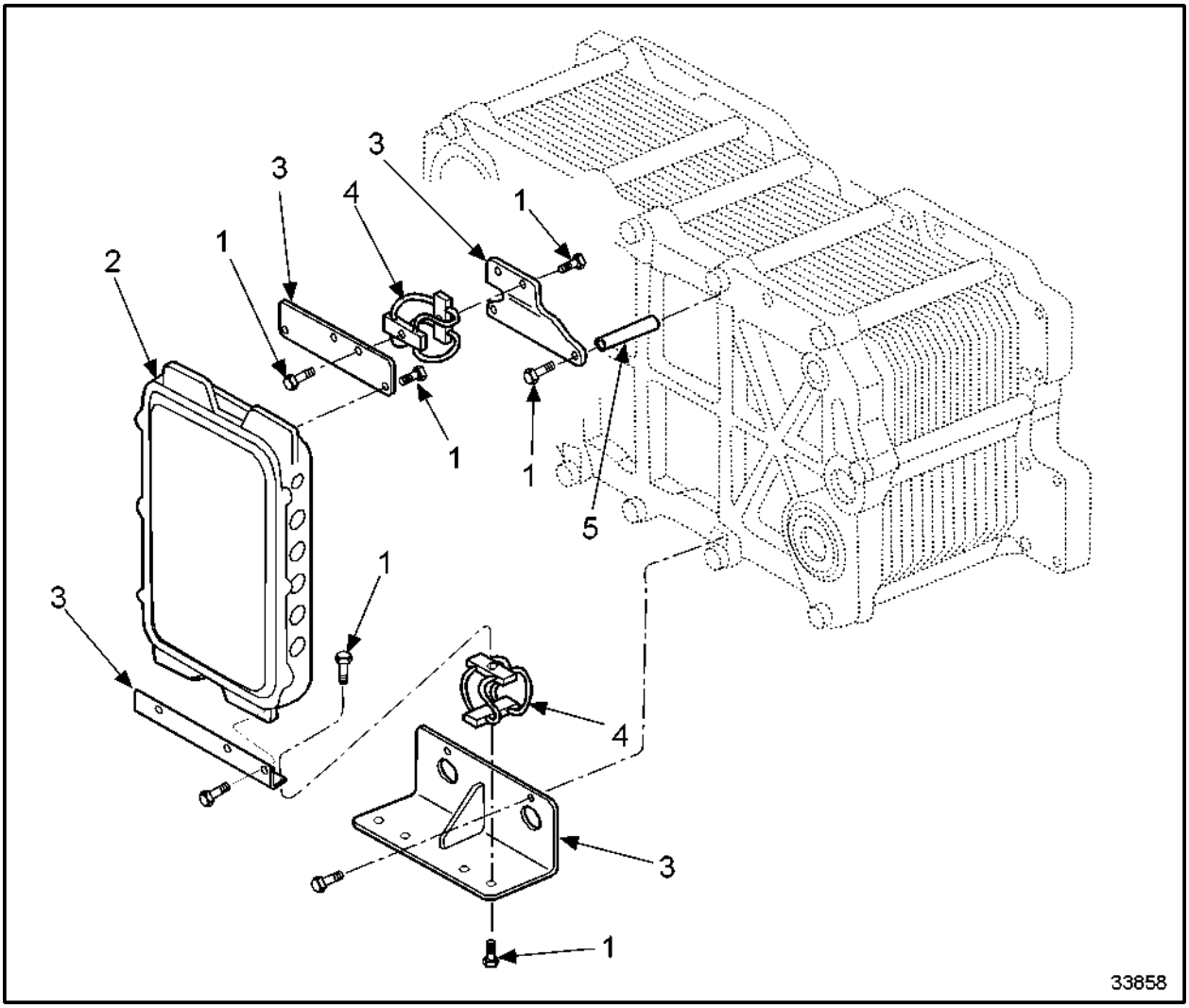
Table 187 After-Installation Operations

C 500 – ELECTRONIC MONITORING SYSTEMS

C 501.05 M – ELECTRONIC CONTROL UNIT

C 501.05.01 M – GENERAL VIEW

See Figure 1145for a general view of the electronic control unit.



1. Bolt
2. Electronic Control Unit
3. Mounting Bracket
4. Damper Element
5. Spacer

Figure 1145 General View of Electronic Control Unit

C 501.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 188are the Before-Removal Operations for the ECU.

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.

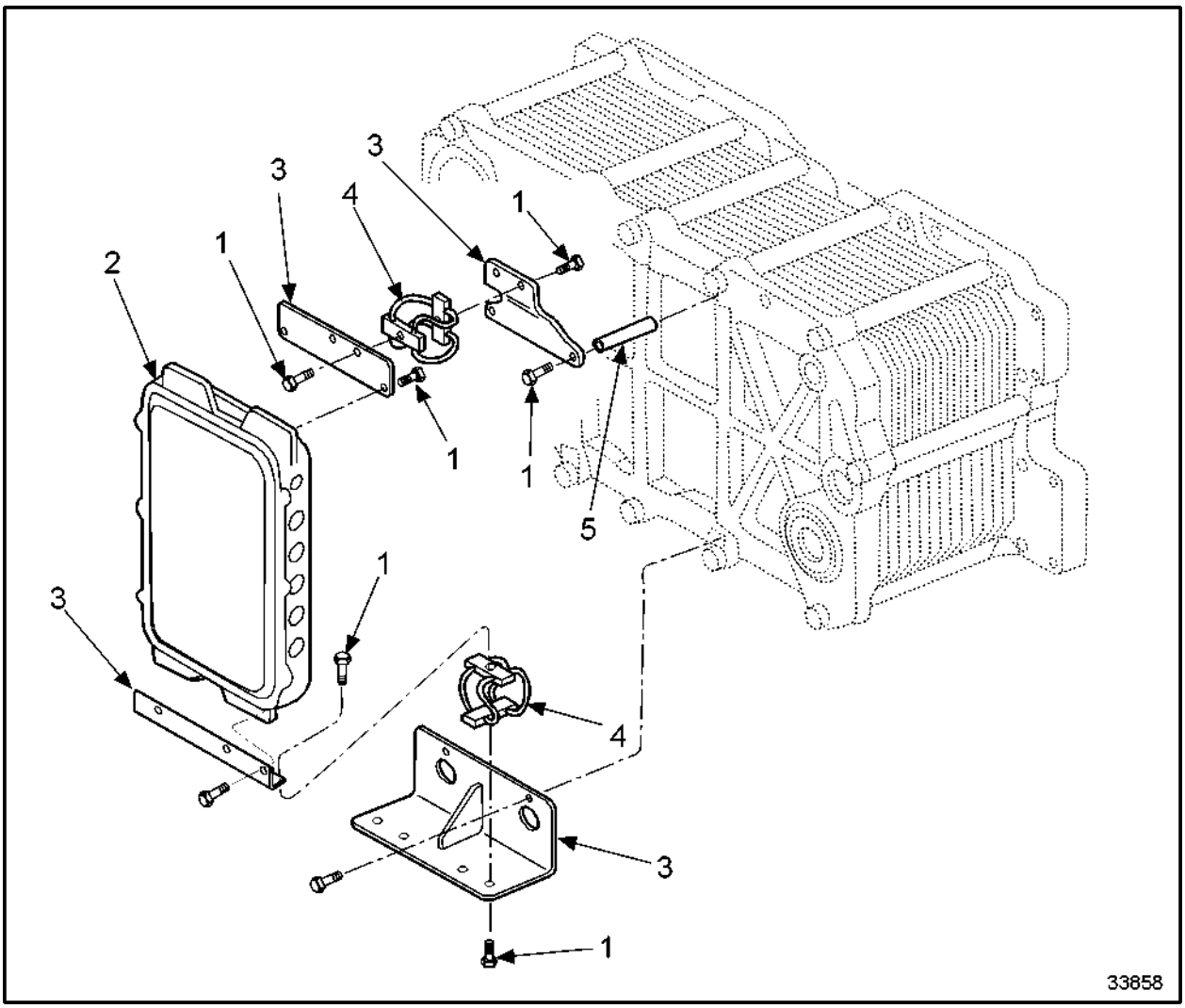
3= The engine is to remain installed.

Table 188 Before-Removal Operations

C 501.05.05 M – REMOVAL OF THE ELECTRONIC CONTROL UNIT

Perform the following steps to remove the ECU:

1. Tag wiring harnesses for reassembly.
2. Disconnect the wiring harnesses from the ECU.
3. Remove the four bolts (1) and spacers (5) securing the ECU to the heat exchanger. See Figure 1146.



1. Bolt
2. Electronic Control Unit
3. Mounting Bracket
4. Damper Element
5. Spacer

Figure 1146 Removing the ECU

4. Remove the ECU (2) from the heat exchanger. See Figure 1146.
5. Remove bolts (1) securing the ECU to the mounting brackets (3) and remove the mounting brackets. See Figure 1146.

C 501.05.06 M – DISASSEMBLY OF THE ELECTRONIC CONTROL UNIT

The ECU is a non-serviceable component. Contact Detroit Diesel Technical Service for further disassembly information.

C 501.05.08 M – INSPECTION AND REPAIR

The ECU is a non-serviceable component. Contact Detroit Diesel Technical Service for further inspection information.

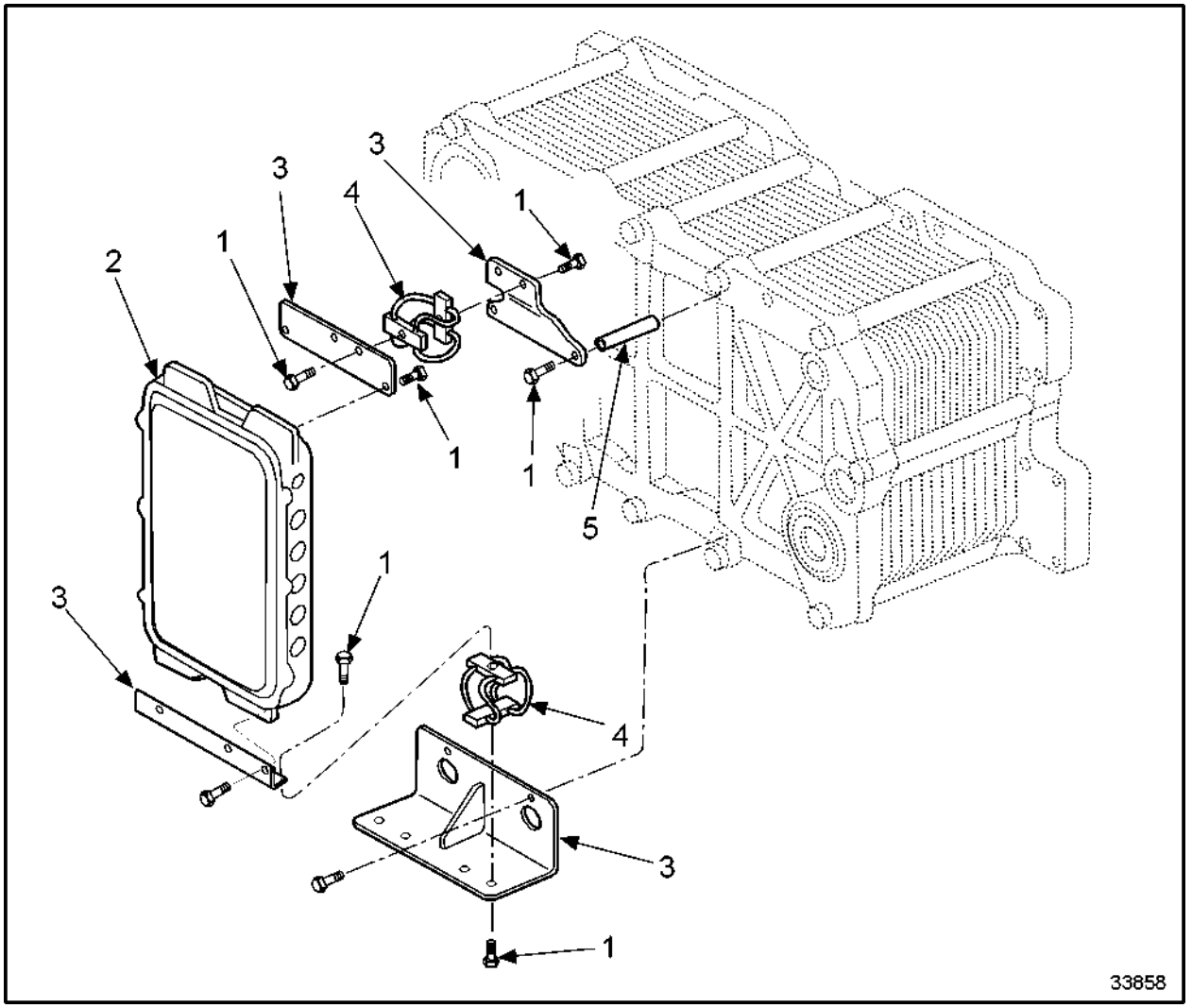
C 501.05.10 M – ASSEMBLY OF THE ELECTRONIC CONTROL UNIT

The ECU is a non-serviceable component. Contact Detroit Diesel Technical Service for further assembly information.

C 501.05.11 M – INSTALLATION OF THE ELECTRONIC CONTROL UNIT

Perform the following steps to install the electronic control unit:

1. Secure the ECU to the mounting brackets (4) with bolts (1). See Figure 1147.



1. Bolt
2. Electronic Control Unit
3. Mounting Bracket
4. Damper Element
5. Spacer

Figure 1147 Installing the ECU

2. Secure the ECU to the heat exchanger with four bolts (1). See Figure 1147.
3. Connect the wiring harnesses to the ECU.
4. Verify repair of the ECU.

C 501.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 189are the After-Installation Operations for the ECU.

Level of Maintenance	Operation	Reference
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 189 After-Installation Operations

C 502.05 – MARINE ENGINE SENSOR HARNESSES

C 502.05.01 M – GENERAL VIEW

See Figure 1148 for the 8/12/16V marine engine sensor harness (S6), see Figure 1149 for the 12V marine engine sensor harness (S8), see Figure 1150for the 12V marine engine injector harness (SB2), and see Figure 1151 for the 16V marine engine injector harness (SB3).

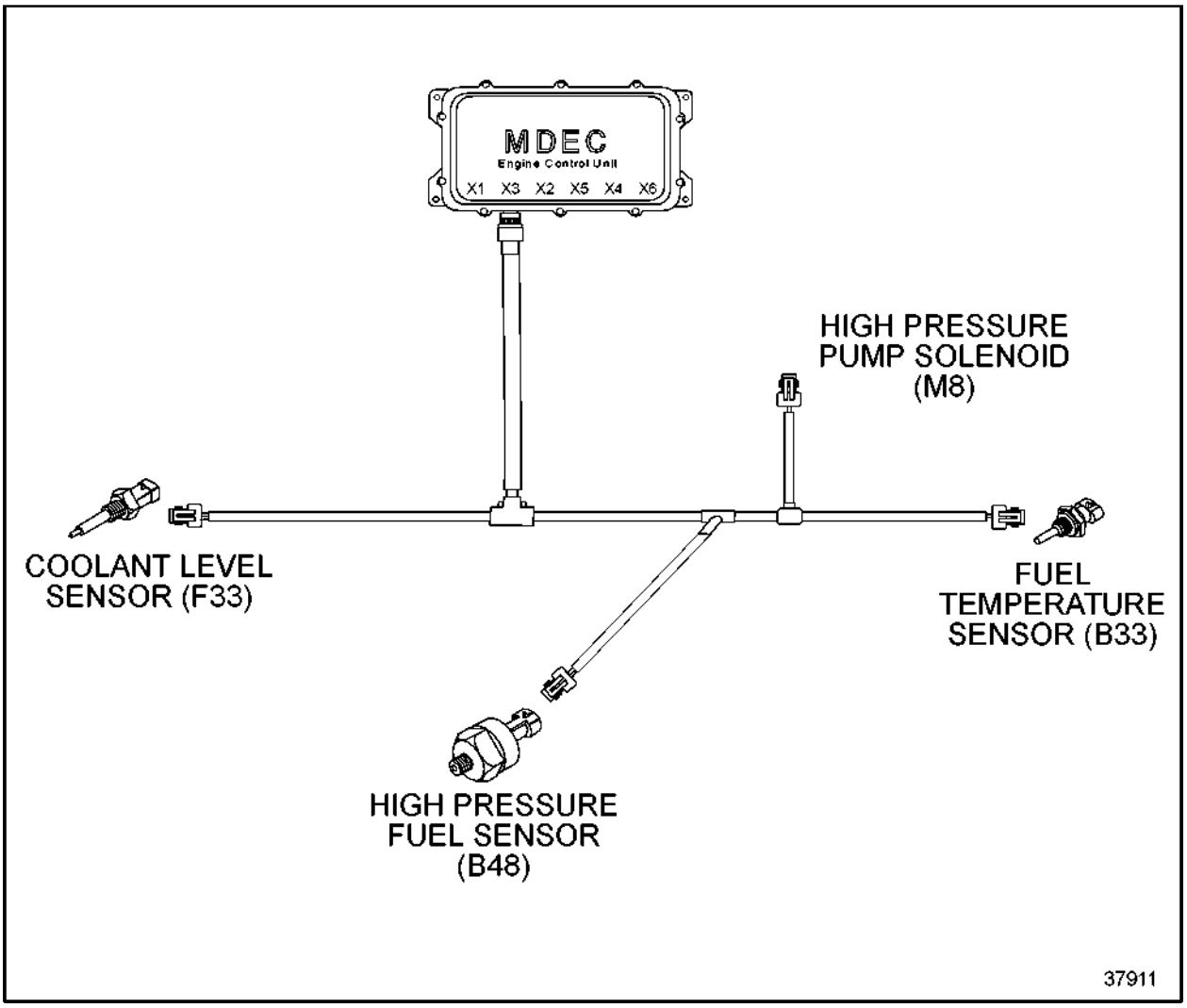


Figure 1148 8/12/16V Marine Engine Sensor Harness (S6)

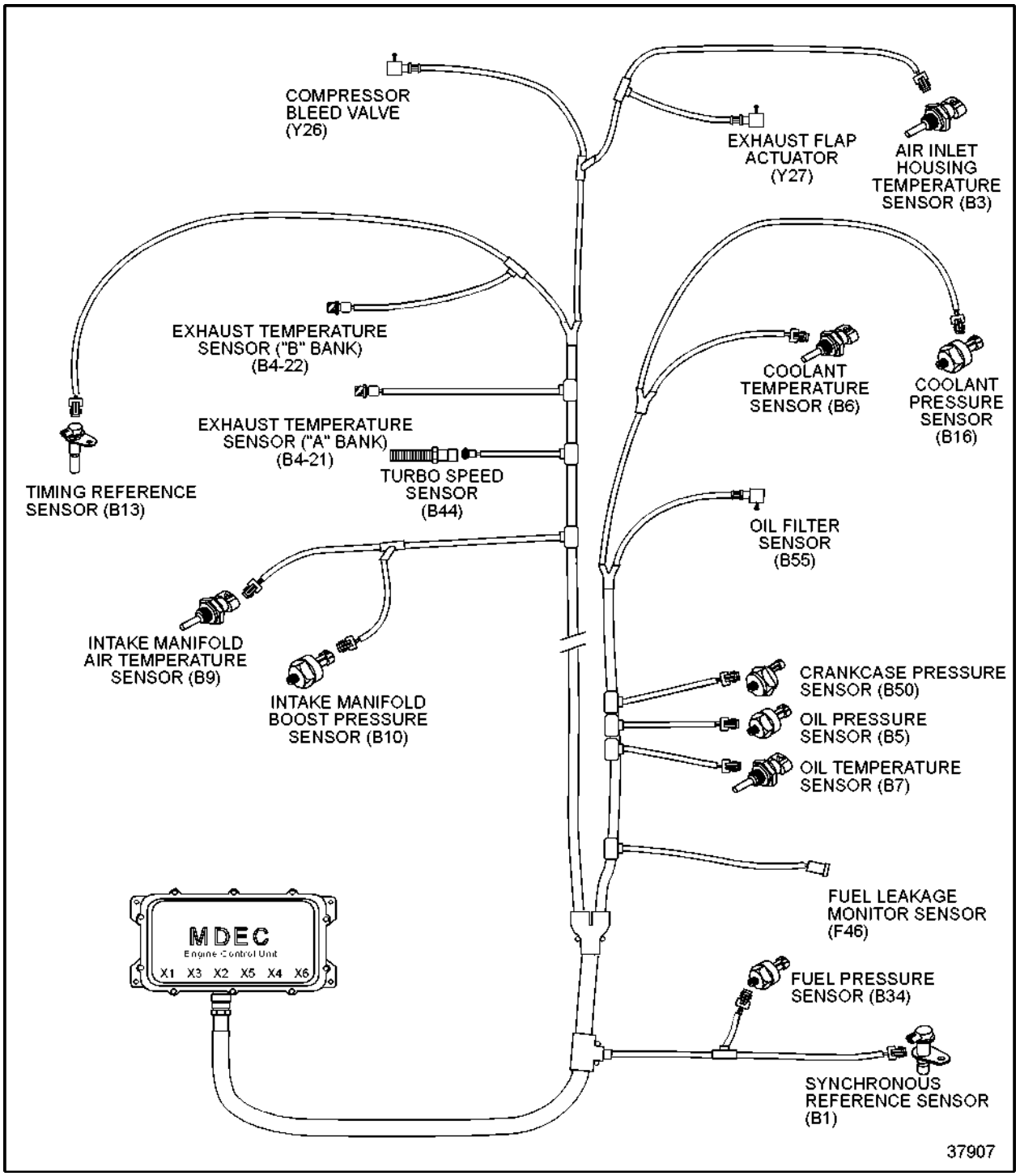


Figure 1149 12V Marine Engine Sensor Harness (S8)

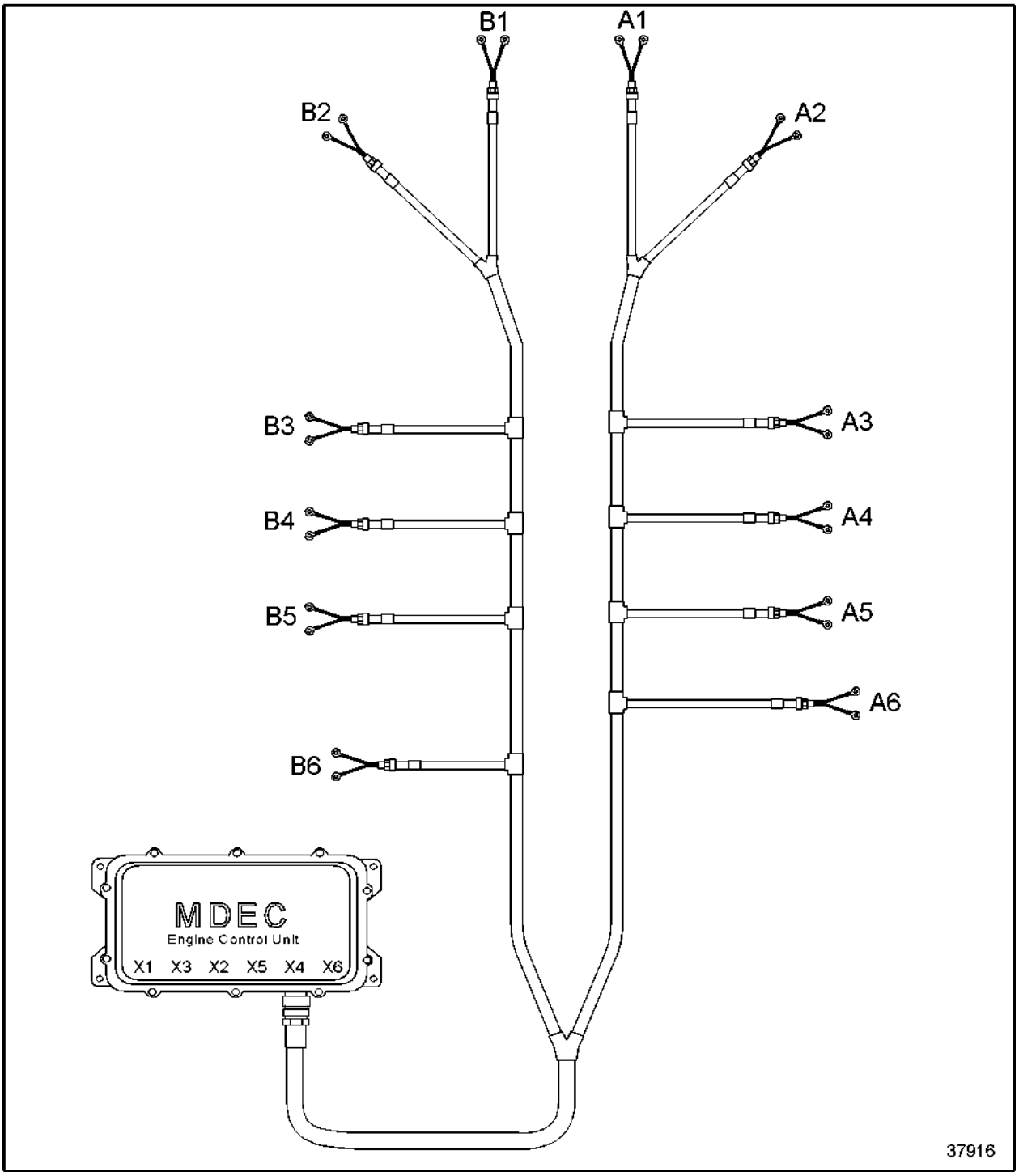


Figure 1150 12V Marine Engine Injector Harness (SB2)

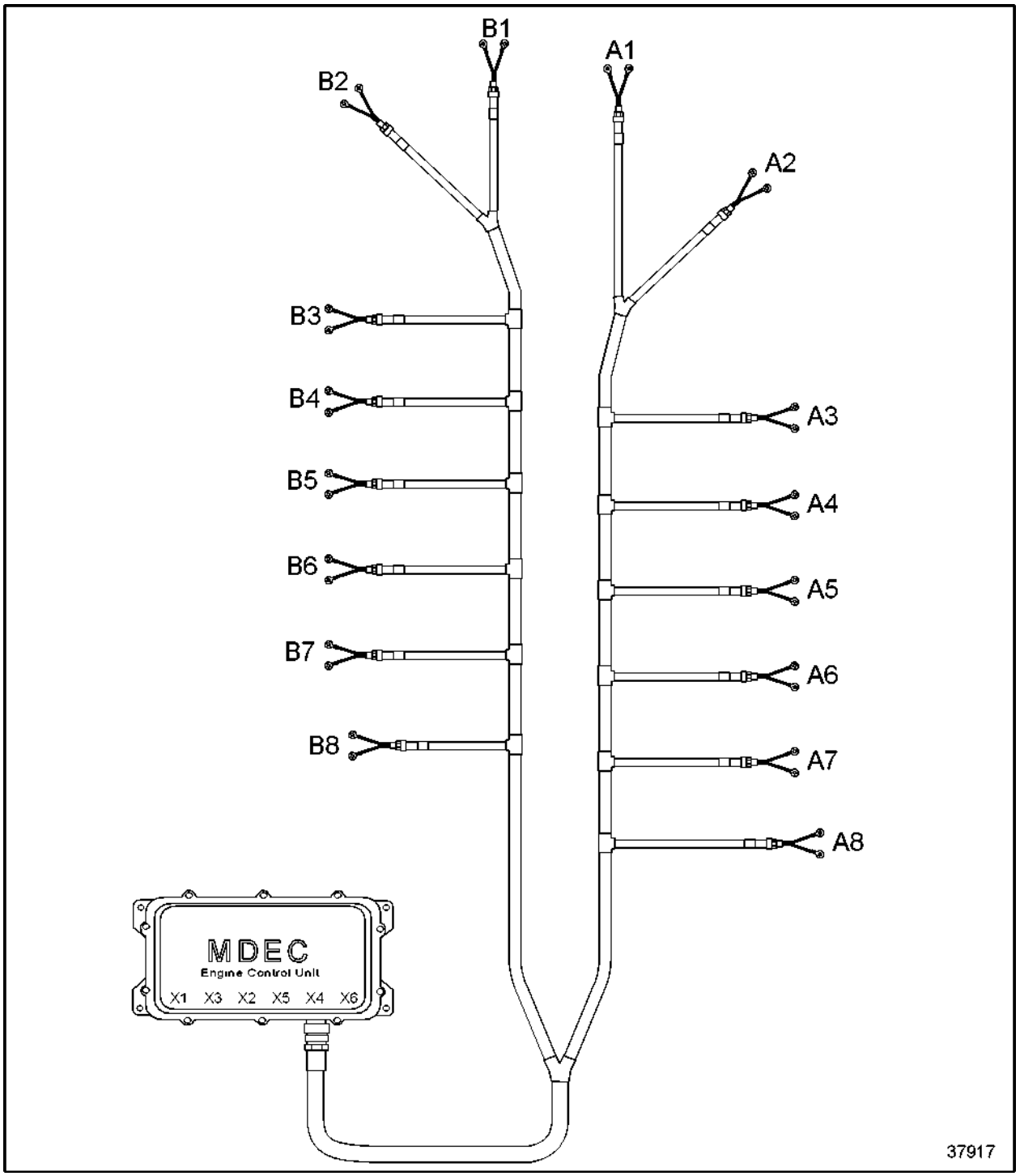


Figure 1151 16V Marine Engine Injector Harness (SB3)

C 502.05.04 M – BEFORE-REMOVAL OPERATIONS

Listed in Table 190 is the Before-Removal Operations for the engine sensor harnesses and engine sensors.

Level of Maintenance	Operation	Reference
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.

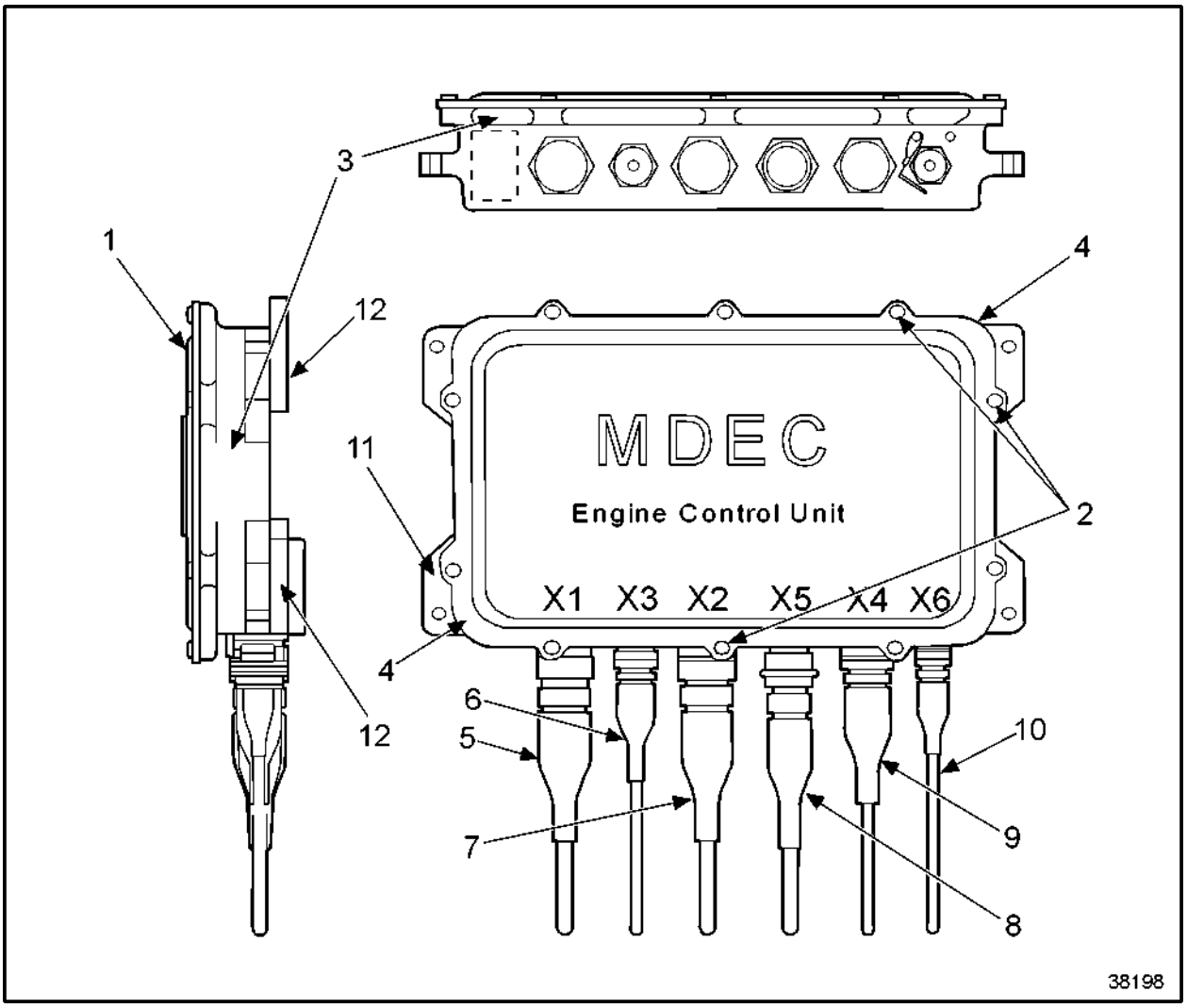
Table 190 Before-Removal Operations

C 502.05.05 M – REMOVAL OF ENGINE SENSORS AND WIRING HARNESSES

Perform the following steps to remove the engine sensors and engine sensor wiring harness:

NOTE:
Tag engine wiring harness connectors and MDEC engine control unit harnesses for identification prior to removal.

1. Disconnect engine sensor harnesses from the MDEC engine control unit. See Figure 1152 for location of harnesses.



1. Cover
2. Cover Screws
3. Housing
4. Seals
5. Engine Connector Plug (LOP-X1)
6. Cable Harness Connector Plug (X3)
7. Sensor Plug (X2)
8. Power Supply Plug (X5)
9. Cable Harness Plug ((X4)
10. Communication Connector Plug (X6)
11. Mounting Bracket
12. Mounting Plate

Figure 1152 Removal of MDEC Engine Control Unit Harnesses

2. Disconnect engine sensor harnesses from the sensor units. See Figure 1148for the 8/12/16V marine engine sensor harness (S6), see Figure 1149 for the 12V marine engine

sensor harness (S8), see Figure 1150for the 12V marine engine injector harness (SB2), and see Figure 1151 for the 16V marine engine injector harness (SB3) for sensor locations.

3. Remove engine sensors, if necessary.

C 502.05.08 M – INSPECTION AND REPAIR

Inspect the sensors and wiring harnesses as follows:

1. Visually inspect wiring harness for exposed wiring and damaged insulation.
   [a] Repair exposed wire and damage as necessary.
   [b] Replace wiring harness if damage is unrepairable.
   [c] Reuse wiring harness if no damage is detected.
2. Visually check connectors for bent and missing pins.
   [a] Repair connectors if damage is detected as necessary.
   [b] Replace wiring harness if connectors are unrepairable.
   [c] Reuse wiring harness if no damage is detected.
3. Visually check each sensor connector for bent or missing pins.
   [a] Repair sensors which have bent pins as necessary.
   [b] Replace sensors which are unrepairable.
   [c] Reuse sensors which are not damaged.

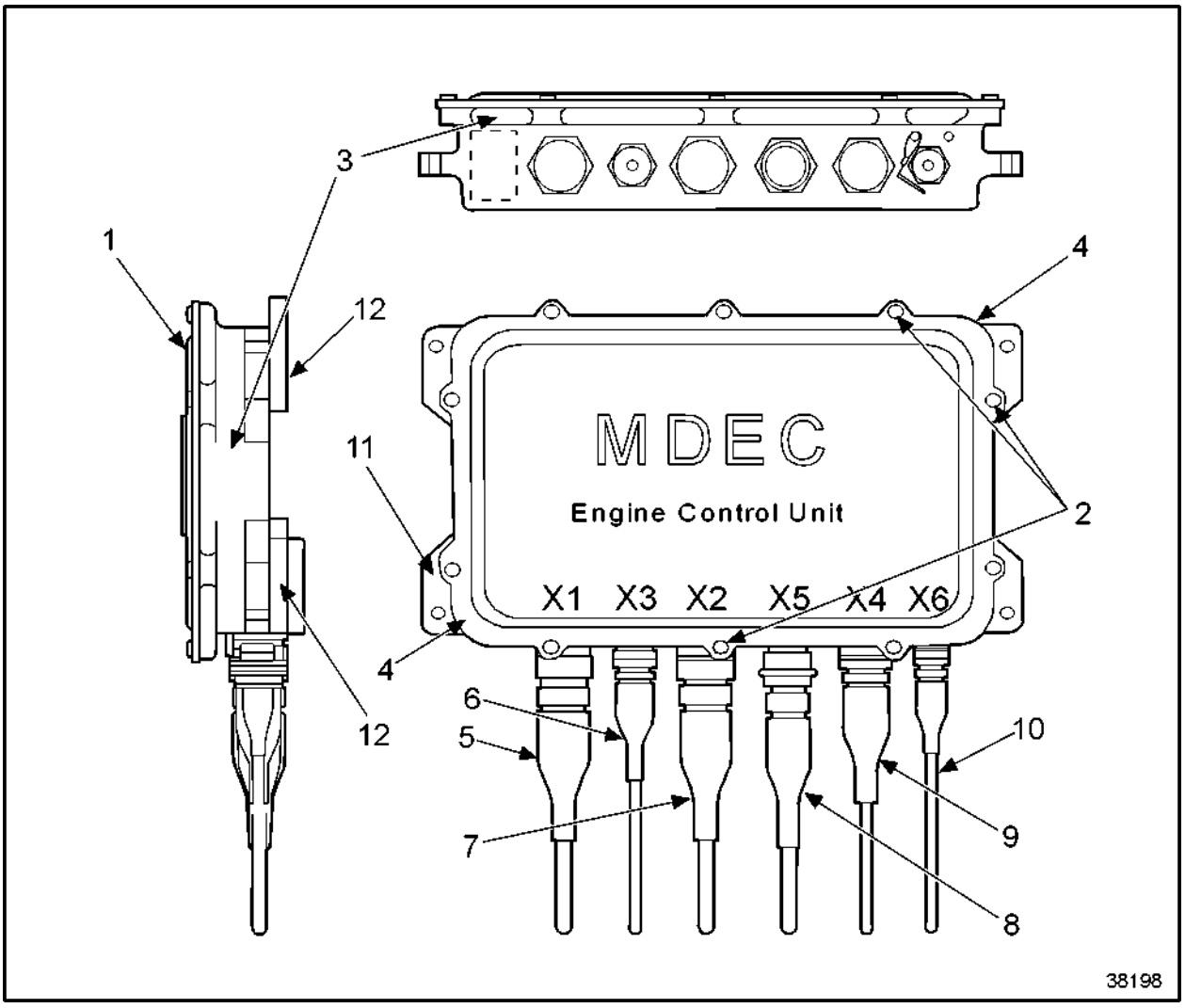
C 502.05.11 M – INSTALLATION OF ENGINE SENSORS AND WIRING HARNESSES

Perform the following steps to install the engine sensors and wiring harnesses:

1. Install engine sensors, if necessary.
2. Connect engine sensor harnesses to the appropriate engine sensors. See Figure 1148for the 8/12/16V marine engine sensor harness (S6), see Figure 1149 for the 12V marine engine

sensor harness (S8), see Figure 1150for the 12V marine engine injector harness (SB2), and see Figure 1151 for the 16V marine engine injector harness (SB3).

3. Connect engine sensor harnesses to the MDEC engine control unit. See Figure 1153.



1. Cover
2. Cover Screws
3. Housing
4. Seals
5. Engine Connector Plug (LOP - X1)
6. Cable Harness Connector Plug (X3)
7. Sensor Plug (X2)
8. Power Supply Plug (X5)
9. Cable Harness Plug ((X4)
10. Communication Connector Plug (X6)
11. Mounting Bracket
12. Mounting Plate

Figure 1153 Installation of MDEC Engine Control Unit Harnesses

C 502.05.12 M – AFTER-INSTALLATION OPERATIONS

Listed in Table 191 is the After-Installation Operations for the engine sensor harnesses and engine sensors.

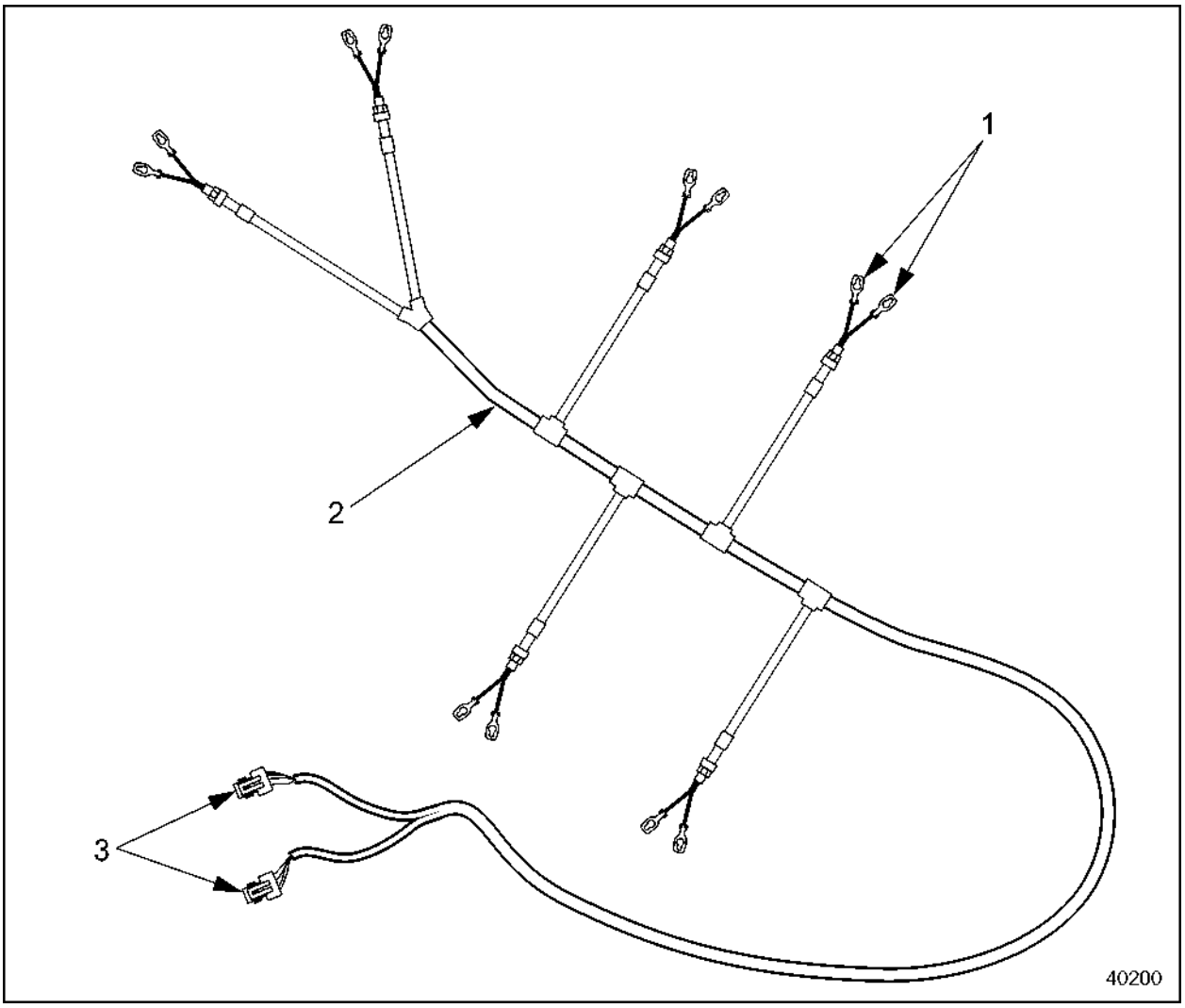
Level of Maintenance	Operation	Reference
1, 2, 3	Enable engine power	Refer to Operators Guide

Table 191 After-Installation Operations

C 503.05 – CONSTRUCTION AND INDUSTRIAL ENGINE INJECTOR HARNESSES-OPTIONAL ROUTING

C 503.05.01 – GENERAL VIEW OF B-SIDE FUEL INJECTOR WIRING HARNESS

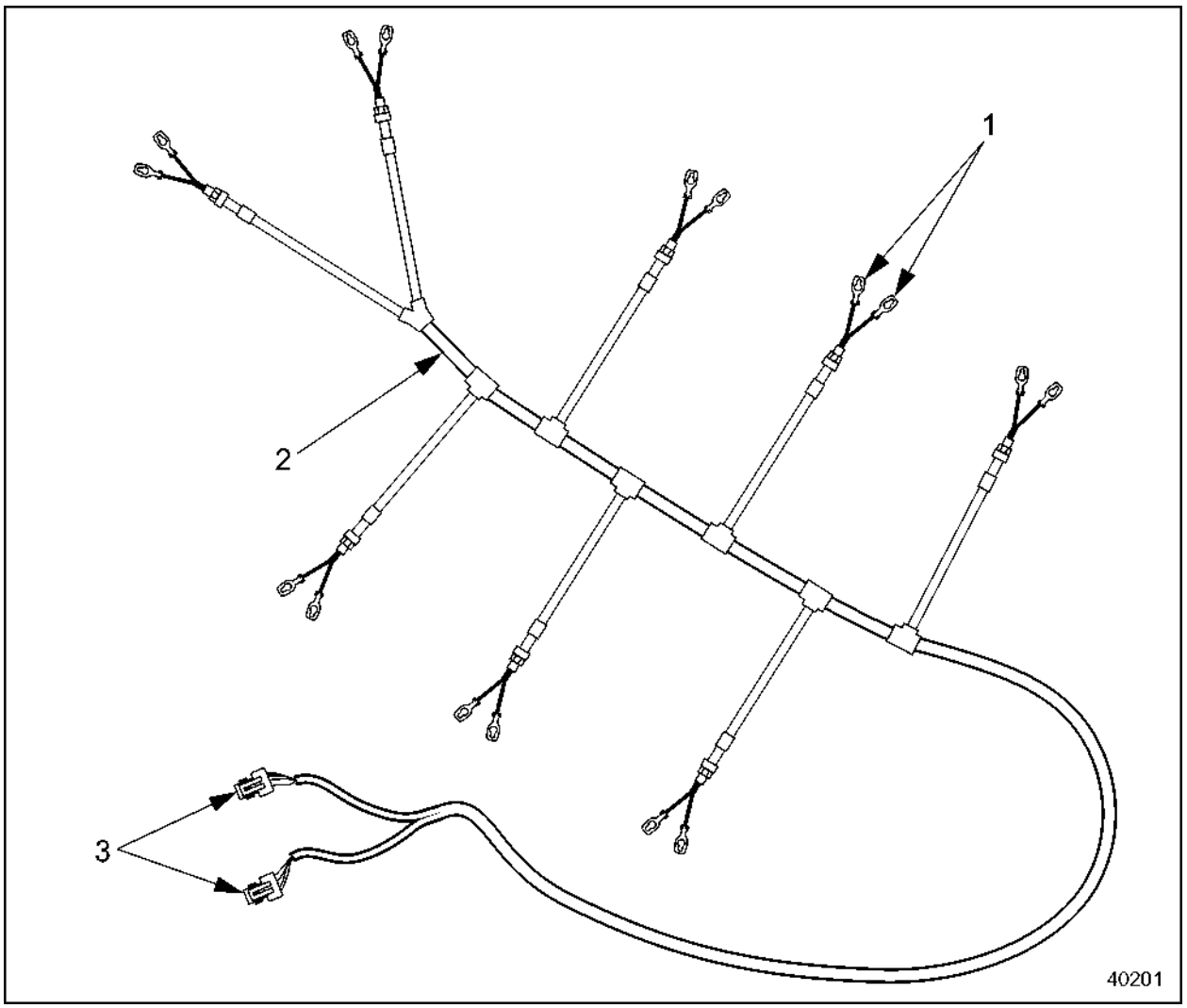
See Figure 1066 for a general view of the 12V construction and industrial fuel injector harness.



1. Wire Terminal Connectors
2. Fuel Injector Harness
3. ECM Connectors

Figure 1066 Construction and Industrial 12V Fuel Injector Harness

See Figure 1067 for a general view of the 16V construction and industrial fuel injector harness.



1. Wire Terminal Connectors
2. Fuel Injector Harness
3. ECM Connectors

Figure 1067 Construction and Industrial 16V Fuel Injector Harness

C 503.05.05 – REMOVAL OF B-SIDE FUEL INJECTOR WIRING HARNESS

Perform the following steps to remove the B-side injector wiring harness:

1. Disconnect the power supply.
2. Refer to section C 124.05.05C 124.05.05 and remove the air intake manifold.
3. Refer to section C 056.05.11C 056.05.05 and remove the rocker covers.
4. Remove the nylon ties securing the fuel injector wiring harness to the jumper line.
5. Remove the fuel injector metal grommet from the cylinder head.
6. Remove the screws securing the wiring harness leads to the injector solenoids and remove the leads.

7. Remove the fuel injector harness from the water pump inlet elbow and from behind the high pressure fuel rail. See Figure 1068, view E.

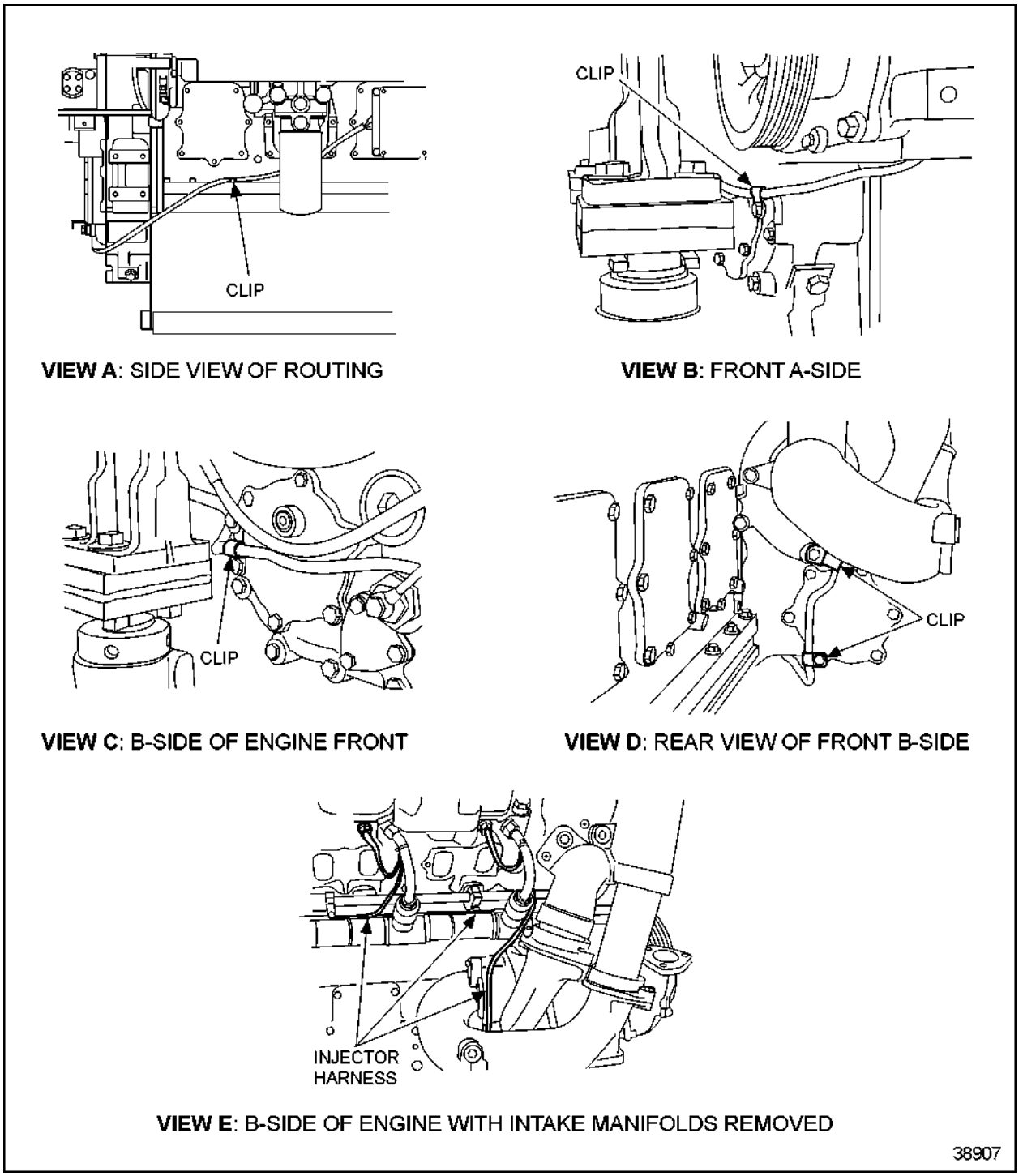


Figure 1068 Removal of Fuel Injector Wiring Harness

8. Remove the clip securing the fuel injector harness to the back of the water pump. See Figure 1068, view D.

9. Remove the bolt and clip securing the fuel injector harness to the cover plate. See Figure 1068, view D.
10. Remove the fuel injector wiring harness from behind the oil bypass line.
11. Remove the front cover plate bolt securing the clip. Remove the clip and wiring harness. See Figure 1068, view B.
12. Remove the third oil pan bolt from the front of the engine and remove the clip. See Figure 1068, view A.
13. Remove the fuel injector harness from behind the fuel filters.
14. Disconnect the fuel injector harness connectors from the ECM.
15. Remove the fuel injector harness from the engine.

C 503.05.08 – INSPECTION AND REPAIR OF B-SIDE FUEL INJECTOR WIRING HARNESS

Inspect the sensors and wiring harness as follows:

1. Visually inspect the fuel injector wiring harness for exposed wiring and damaged insulation.
   [a] Repair damage and exposed wire as necessary.
   [b] Replace wiring harness if damage is unrepairable.
   [c] Reuse wiring harness if no damage is detected.
2. Visually check wiring harness connectors for bent and missing pins.
   [a] Repair connectors if damage is detected.
   [b] Replace wiring harness if connectors are unrepairable.
   [c] Reuse wiring harness if no damage is detected.
3. Visually check each wiring harness connector for bent or missing pins.
   [a] Repair sensor connectors that have bent pins.
   [b] Replace sensor connectors that are unrepairable.
   [c] Reuse sensor connectors that are not damaged.

C 503.05.11 – INSTALLATION OF B-SIDE FUEL INJECTOR WIRING HARNESS

Perform the following steps to install the fuel injector wiring harness:

NOTE:
If the rear B-side accessory drive position is occupied then these instructions will not work. Utilize the standard production wiring harness routing location in this situation.

NOTE:
Removal of the factory installed fuel injector wiring harness **must** be performed prior to performing installation step 1 through step 28. Cut the fuel injector harness into several small sections and remove.

1. Disconnect the power supply from the ECMs.
2. Remove all of the valve covers on the B-side of the engine.
3. Remove the intake manifolds from each cylinder on the B-side of the engine.
4. Disconnect the old wiring harness from all of the injectors and remove the grommet nuts where the wiring harness enters the cylinder head.
5. Disconnect the B-side injector wiring harness from the ECMs as follows:
   [a] 16V engine P/N 0005300934: remove the black connector from the master (outer) ECM and the black connector from the receiver (inner) ECM.
   [b] 12V engine P/N 0005300734: remove the black and gray connector from the receiver (inner) ECM.
6. Remove the old wiring harness.
7. Install the new harness to the ECM where the old harness was connected.
8. Route the wiring harness behind both fuel filters.

9. Loosen the third bolt back from the front on the oil pan. Install the new wiring harness into clip P/N 08923507 and bolt the clip in place between the spacer and bolt. See Figure 1069, view A.

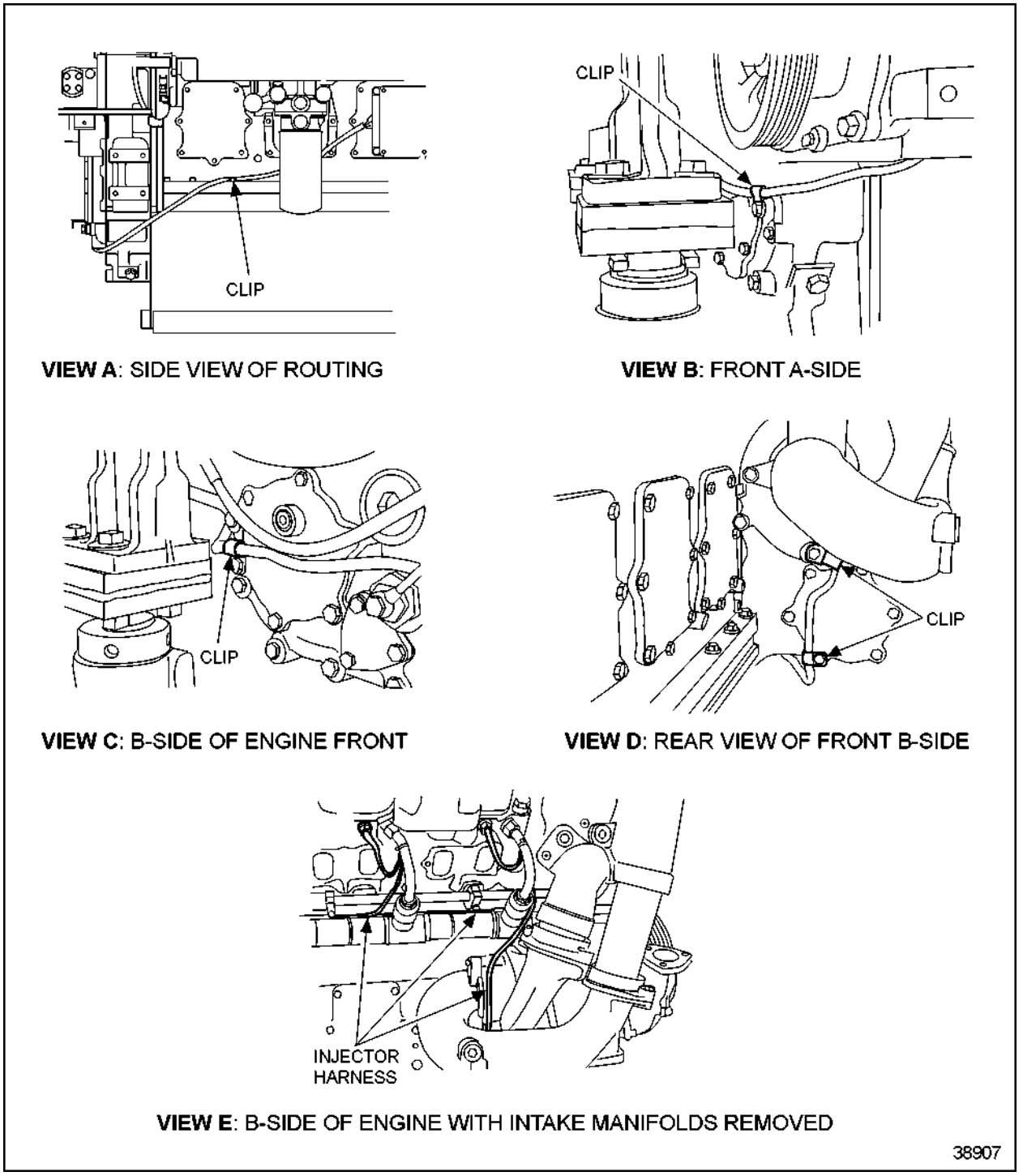


Figure 1069 Removal of B-Side Fuel Injector Harness

10. Tighten the bolt to 60-66 N·m (44-49 lb·ft).

11. Loosen the front cover plate, install the new wiring harness into clip P/N 08923507, and secure the clip with the cover bolt. See Figure 1069, view B.
12. Tighten the bolt to 74-82 N·m (55-61 lb·ft).
13. Route the new wiring harness behind the oil bypass line to the other side of the engine.
14. Repeat step 8 and step 9 for the cover on the B-side of the engine. See Figure 1069.
15. Remove the cover bolt. See Figure 1069, view D.
16. Install the new wiring harness into clip P/N 08923507 and place the bolt through the clip.
17. Secure the bolt and clip onto the cover plate. Tighten the bolt to 74-82 N·m (55-61 lb·ft).
18. Route the wiring harness up behind the water pump and place another clip P/N 08923507 onto the back of the water pump. See Figure 1069, view D.
19. Route the wiring harness up though the water pump inlet elbow and behind the high pressure fuel rail.
20. Pull each individual injector wiring harness portion through the fuel spill line and the high pressure line. Thread the injector metal grommet into the head and fasten the injector wiring harness leads to the injector. Tighten the injector terminal to 1.4-2.0 N·m (1-1.5 lb·ft).
21. Secure the wiring harness to the back of the high pressure fuel rail with nylon ties in-between each fuel jumper line.
22. Refer to section C 056.05.08C 056.05.08 of the service manual and perform rocker cover-related inspection and repair steps as indicated.
23. Refer to section C 056.05.11C 056.05.11 of the service manual and install the rocker covers.

NOTE:
Rocker cover bolt torque is 42-47 N·m (31-35 lb·ft).

24. Refer to section C 124.05.08C 124.05.08 of the service manual and perform air intake manifold component inspection and repair as indicated.

NOTE:
Air intake manifold bolt torque is 42-47 N·m (31-35 lb·ft).

25. Refer to section C 124.05.11C 124.05.11 of the service manual and install air intake manifold components.

NOTICE:
Ensure the injector wiring harness is not resting on any sharp edges that could damage the injector harness after installation has been completed. A damaged injector harness will prevent proper engine operation.

26. Ensure nothing will catch on the wiring harness and that no sharp edges are rubbing against it.
27. Connect the power supply.
28. Start the engine and check for proper operation.

ENGINE TOOLS

ENGINE

Listed in Table 192 are the Kent-Moore tools supporting the engine.

Tool Number	Tool Description	Application
J 9389-04	Injector Nut Carbon Remover Set	V71, 92
J 8152	Injector Fuel Hole Brush	92
J 24405	Adjustable Torque Wrench 3/8 in. Drive (10-250 lb/in.^{2})	92
J 23907-1	Clutch Pilot Bearing Remover	92
J 23907-2	Piston Pin Retainer Leak Detector	92
J 2619-5	Handle and Striker Assembly	92
J 8129	Tension Scale	Universal
J 3154-1A	Driver Handle	53, V53, 71, V71, 92, 149, 8.2L
J 43661	Oil Nozzle Protectors	60 (14L)
J 34317	Rod Bolt Protector	60 (14L)
J 43396	Cylinder Kit Puller	60 (14L)
J 43397	Piston Compression ring	60 (14L)
J A25275	Aftercooler Adaptor Plug Rem/Inst	V71, 92
J 22582	Barring Tool (Starting Mounting Pad)	V71,92,149
J 21850	BLK Core Plug Inst (Water B/P Block)	V71,92
J 21996-01	BLK Plug Remover (Water B/P Block)	V71,92
J 39693	Block And Head Pressure Test Kit	50,50G
J 23019	Block Air Box Core Plug Rem/Inst	V71,92,149
J 29571	Block Air Box Plug Tool	71,V71
J 24542	Block Align Tool	149
J 24543	Block Align Tool	149
J 22486	Block Alignment Tool	149
J 21799	Block Alignment Tool	V71,92
J 25451-B	Block Assembly Wrench Set (16V)	92
J 28651	Block Assembly Wrench Set (16V)	V71
J 26244	Block Head Bolt Hole Depth Gage	V71,92
J 35595	Block Lifting Eye Bolts	50,50G,60
J 24051-B	Block Pressure Test Kit	149
J 24533	Block Torque Adapter	149
PT-2200-30	Counterbore Cutter Plate	71,V71
PT-2200-31	Counterbore Cutter Plate	92
PT-2200-37	Counterbore Cutter Plate	40
PT-2250-B	Counterbore Tool	40,40,V71,92

J 33420	Cup Plug Installer	V71,92
J 41746	Cup Plug Installer	55
J 35653	Cup Plug Installer Set	50,50G,60
J 36223-D	Cyl Head & Block Pressure Kit	50,50G,60
J 41566	Cylinder Block Pressure Kit	55
J 34698	Cylinder Bore Plug Set	71,V71
J 34699	Cylinder Bore Plug Set	92
J 24270	Cylinder Bore Ridge Reamer	8.2L
J 25384	Cylinder Head Bolt Tap	92
PT-2950	Cylinder Head Bolt Tap	8.2L
J 5902-01	Cylinder Hone & Glaze Breaker	40,50,50G,53,60,71,V71,92,149,8.2L
J 5902-18	Cylinder Hone Stones	8.2L
J 24898	Cylinder Liner Depth Gage	92
J 36398	Cylinder Liner Lifter	50.50G,60
PT-5075-B	Deck Checker	30G,40,50,50G,53,V53,55,60,71,V71,92
PT-5071	Deck Checker Conversion	149
J 5347-B	Dial Bore Gage (3 3/32-8" Dia)	30G,40,50,50G,53,V53,60,71,V71,92,149,8.2L
J 36224	Dowel Installer Set	
J 41171	Eng Lift Hook (Use W/3 PT Spreader)	149
J 36237	Engine Barring Tool	50,60,92
J 36130-812	Engine Lifting Bracket	40,50,50G,53,55,60,71,V71,92,8.2L
J 39289-A	Engine Stand Adaptor Plate	40
J 41576	Engine Stand Adapter Plate	55
J 36107	Exhaust Manifold Guide Studs	50,60,50G
J 26816-A	Exhaust Manifest Nut Wrench	149
PT-7276	Gasket Eliminator (Loctite)	50,50G,60
J 38894	Inter Block Seal Installer	149
J 33050-A	Jib Crane (4000 LB Max Lifting Cap)	30G,40,50,50G,53,55,V53,60,71,V71,92
J 41564	Lifting Eye Bolts	55
J 41060	Line Boring Complete Kit	50,60,50G
J 29005	Line Boring Complete Kit (main)	V71,92
J 41061	Line Boring Main BRG-Adapter Kit	50,50G,60
J 21793-B	Liner Hold Down Clamps	53,V53,71,V71
J 24565-02	Liner Hold Down Clamps	92
J 22641-A	Liner Installer	149
J 41441	Liner Installer	55
J 35597-A	Liner Installer & Hold Down	50,50G,60

J 41543	Liner Puller	55
J 21716-01	Liner Remover (Screw Type)	71,V71
J 22431-A	Liner Remover (Screw Type)	50,50G
J 24563-A	Liner Remover (Screw Type)	92
J 35791	Liner Remover (Screw Type)	50,50G,60
J 1918-02	Liner Remover (Screw Type)	71,V71
J 22490	Liner Remover (Slide Hammer Screw Type)	53,V53
PT-6410-B	Liner Removal, Universal Screw Type	30G,40,50,50G,53,V53,55,60,71,V71,92,149
J 41749	Liner Seat Resurfacer Kit	149
PT-8530-1	Main Sad Bushing	92,V71
PT-8531-1	Main Sad Bushing	92,V71
J 8386-01	Master Ring- Cylinder Block Bore	71,V71
J 8385-01	Master Ring-Liner I.D.	53,V53
J 22613	Master Ring-Liner I.D.	149
J 24564	Master Ring-Liner I.D.	92
J 35786	Oil Cooler Guide Studs	50,60
J 38895	Oil Gallery Spacer Installer	149
J 42542	Oil Nozzle Calibration Device	55
J 29109	Overhaul Stand (Less Adapters)	30G,40,50,50G,53,V53,55,60,71,V71,92,8.2L
J 9398-04	Overhaul Stand (Less Adapters)	V71,92
J 29013-A	Overhaul Stand Adapters	8.2L
J 33850	Overhaul Stand Adapters	53,V53,71,V71,92
J 35635-A	Overhaul Stand Adapters	60
J 39652	Overhaul Stand Adapters	50,50G
J 8650	Overhaul Stand Adapters	V71,92
J 6387	Parts Dolly	40,50,50G,53,V53,55,60,71,V71,92
PT-2050-D	Porta Matic Basic	40,V71,92
J 23059-01	Setting Master 3"-8" Dial Bore	40,50,50G,53,V53,55,60,72,V71,92,149,8.2L
J 23059-4	Setting Master Adapter (2"-8")	40,50,50G,53,V53,55,60,71,V71,92,149,8,2L
J 22273-01	Sled Gage	50,50G,53,V53,55,71,V71,92,149
J 36571	Surface Conditioning Set	50,50G,53,V53,60,71,V71,92,149,8,2L
J29011-A	T.D.C. Timing Set	8.2L
J 38359	Thread Repair (CYL HD Bolt Holes)	149
J 29513	Thread Repair -Main BRG/HD Bolt Hole	92
PT-2860-A	Thread Rework Kit-15mm	8.2L
J 39852	Top Liner Cooler Modification Kit	60

J 35371	Torquing Device -Main Bearing Bolts	149
J 24233-01	Water Hole Sleeve Installer	149
J 38893	Water Jacket Spacer Installer	149
J 24597	Water Port Plug Installer	92
J 26541-620	1 1/2 X45 Degree Cutter	55
J 26541-647	1 3/4 X30 Degree Cutter	55
J 33421-A	Cam Follower Service Fixture	53,V53,71,V71,92,8.2L
J 39639	Ceramic Cutter	149
J 36326	Car Plug Install-Rocker Arm Shaft	50,60
J 41746	Cup Plug Installer	55
J 24748	Cylinder Head Guide Studs	92
J 35784	Cylinder Head Guide Studs	50,60
J 9665	Cylinder Head Guide Studs	53,V53,71,V71
J 41588	Cylinder Head Holding Fixture	55
J 3087-01	Cylinder Head Holding Plates	71,V71,92
J 22062-01	Cylinder Head Lifting Fixture	V53,V71,92
J 35641-A	Cylinder Head Lifting Fixture	50,60
J 28511-C	Cylinder Head Locating Pins	149
J 28454	Cylinder Head Pressure Test Fixture	71,V71,92
J 41567	Cylinder Head Pressure Test Kit	55
J 24252	Cylinder Head Puller	55
J 36224	Dowel Installer Set	50,50G,60
J 21545	Fuel Line Nut Wrench (9/16)	149
J 39108	Fuel Line Nut Wrench 11/16"	149
J 38189	Head Bolt Counterbore Cutter	50,60
J 1928-02	Head Bolt Wrench (15/16"X1/2"Drive)	71,V71
J 41169	Head Modification Kit (Bolt Hole SL)	149
J 23741-B	Holding Fixture	149
J 39272	Injector Puller	40
J 29124	Injector Tube Reconditioning Kit	8.2L
J 22342-D	Injector Tube Reconditioning Set	149
J 22515-B	Injector Tube Reconditioning Set	53,V53,71,V71,92
J 24517-B	Injector Tube Reconditioning Set	149
J 33880	Injector Tube Reconditioning Set	50,60
J 22396-A	Injector Vice	53,V53,71,V71,92,149
J 41564	Lifting Eye Bolts	55
J 39264	Nozzle Fixture Clamp Plate	40

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 8165-8	Valve Seat Grind Adapt Kit (2 Valve-71)	71,V71
J 7792-01	Valve Seat Grind ADPT Kit -(4 Valve-53)	53,V53
J 4627-02	Valve Seat Grinder Adapter Kit, 149	149
J 36805	Valve Seat Grinder Adapter Kit, 60	50,60
J 24566	Valve Seat Grinder Adapter Kit, 92	92
J 29645	Valve Seat Grinder Adapter Kit, 8.2L	8.2L
J 8165-3	Valve Seat Grinder Pilot	149
J 7040-A	Valve Seat Grinder -Less Stone/Pilot	53,V53,71,V71,92,149,8.2L
J 41535	Valve Seat Grinding Wheel 21 Degree	149
J 1736	Valve Seat Insert Install (2 Valve)	53,V53
J 6976	Valve Seat Insert Install (2 Valve)	71,V71
J 6568	Valve Seat Insert Install (4 Valve)	53,V53
J 7790	Valve Seat Insert Install, (4 Valve)	53,V53
J 34983	Valve Seat Insert Install, Exhaust	50,60
J 39536	Valve Seat Insert Install, Exhaust	40
J 22711-A	Valve Seat Insert Installer	149
J 24357	Valve Seat Insert Installer	92
J 39535	Valve Seat Insert Installer	40
J 33190	Valve Seat Insert Installer, Intake	50,60
J 41585	Valve Seat Insert Installer, Intake	55
J 23479-35	Valve Seat Insert Puller Assembly	50,53,V53,60,71,V71,92,149
J 23479-37	Valve Seat Insert Puller Body	149
PT-6390-45	Valve Seat Insert Puller Collet	40
J 23479-28	Valve Seat Insert Puller Collet (4 Valve)	53,V53
J 23479-30	Valve Seat Insert Puller Collet (4 Valve)	71,V71
J 23479-27	Valve Seat Insert Puller Collet (2 Valve)	53
J 23479-100A	Valve Seat Insert Puller Collet, Intake	50,60
J 22512-A	Valve Seat Insert Remove-Ceramic HD	149
J 23479-271	Valve Seat Insert Remover	50,60,71,V71
J 23479-492	Valve Seat Insert Remover	92
J 41583	Valve Seat Insert Remover	55
PT-6300	Valve Seat Insert Remover	50,53,V53,60,71,V71,92

J 23479-29	Valve Seat Insert Remover (2 Valve 71)	50,53,V53,60,71,V71,92
J 23479-253	Valve Seat Insert Remover (2 Valve)	53
J 23479-471	Valve Seat Insert Remover (4 Valve)	V71
J 23479-453	Valve Seat Insert Remover (4 Valve)	53,V53
J 23479-460A	Valve Seat Insert Remover (Intake)	50,60
J 23479-33	Valve Seat Insert Remover Collet	92
J 23479-38	Valve Seat Insert Remover Collet	149
J 23479-E	Valve Seat Insert Remover Set	53,V53,71,V71,92
J 41578	Valve Seat Installer, Exhaust	55
J 41822	Valve Seat Installer, Exhaust	50G
PT-6391	Valve Seat Puller (Basic Kit)	40
PT-6399-7	Valve Seat Remover Collet	92
PT-6399-3	Valve Seat Remover Collet (2 Valve 53)	53
PT-6399-4	Valve Seat Remover Collet (2 Valve 53)	53,V53
PT-6399-5	Valve Seat Remover Collet (4 Valve 71)	V71
PT-6399-9	Valve Seat Remover Collet, Intake	50,60
J 23479-49	Valve St Insert Rem (Non-Ceramic HD)	149
PT-6399-6	Valve Seat Remover Collet, (2 Valve 71, EXH)	50,60,71,V71
J 36582	Valve Stem Seal Installer	8.2L
J 39109	Valve Stem Seal Installer	50,60
J 41571	Valve Stem Seal Installer	55
J 41282	Valve Stem Seal Installer (Narrow)	149
J 35373	Valve Stem Seal Installer (4 Valve)	71,V71,92
J 24857-A	Water Nozzle Installer	92
J 21089	Body Reamer "N" & "S" Injections	53,V53,71,V71,92
J 29584	INJ Tip CONC Gage/Rack Free Tester	53,V53,71,V71,92,8.2L
J 22410-696	Injector Calibrator Adaptor-Marine	149
J29136-A	Injector Holding Fixture	8.2L
J 29575	Injector Nut Carbon Remover Set	8.2L
J 22096-02	Injector Nut Carbon Remover Set, 149	149
J 29197	Injector nut Seal Ring Installer	53,V53,71,V71,92
J 22799	Injector Nut Socket	149

J 24760-B	Injector Pop "N" Fixture	50,53,V53,60,71,V71,92
J 34760-150A (Old Num 23010-A)	Injector Pop Fixture (Mechanical Only)	53,V53,71,V71,92
J 23010-265	Injector Pop Fixture Adapter (Marine)	53,V53,71,V71,92
J 34760-145	Injector Pop Fixture Adpt (53,71)	53,V53,71,V71,
J 34760-144	Injector Pop Fixture Adapter, 149	149
J 34760-146	Injector Pop Fixture Adapter, 8.2L	8.2L
J 34760-300	Injector Pop Fixture Power Supply	50,53,V53,71,V71,92,149,8.2L
J 23435-C	Injector Service Set ("N" Injector)	53,V53,71,V71,92
J 22800-01	Injector Spray Tip Carbon Remover	149
J 9462-02	Injector Spray Tip Needle Lift Gage	53,V53,71,V71,92,149,8.2L
J 22885	Injector Spray Tip Wire (.009)	53,V53,71,V71,92,149,8.2L
J 24767	Injector Tag Remover/Installer Set	149
J 23905	Injector Tip Concentricity Gage	53,V53,71,V71,92,149,8.2L
J 22964	Injector Tip Polishing Sticks	149
J 22090–A	Lapping Block Set	53,V53,71,V71,92,8.2L
J 23038	Lapping Compound (Liquid)	53,V53,71,V71,92,149,8.2L
J 35369 (Old Num 26298)	Master Injector Kit	53,V53,71,V71,92
J 29898	Master Injector, 8.2L	8.2L
J 22693-01	Valve Spring Compress-CYL HD Remove	149
J 7455-A	Valve Spring Compressor	53,V53,71,V71,92,8.2L
J 8062	Valve Spring Compressor CYL HD OFF	53,V53,71,V71,92,8.2L
J 22738-02	Valve Spring Tester	50,50G,53,V53,55,60,71,V71,92,8.2L
J 25076-B	Valve Spring Tester (ON Cylinder HD)	50,53,V53,60,71,V71,92,8.2L
J 7453	Valve Bridge Guide (Broken) Remover	71,V71,92,149
J 7482	Valve Bridge Guide Instal (PRSD GDE)	71,V71,92
J 6846	Valve Bridge Guide Install-Threaded	71,V71
J 22487	Valve Bridge Guide Installer	149
J 7091-01	Valve Bridge Guide Remover (Press)	71,V71,92,149
J 21772	Valve Bridge Holding Fixture	71,V71,92,149
J 5437	Valve Guide Cleaning Brush	53,71,V71,92
J 5585	Valve Guide Cleaning Brush	149
J 7793	Valve Guide Cleaning Brush (4 Valve)	53,V53
J 33191-A	Valve Guide Installer	50,60
J 7560	Valve Guide Installer (2 Valve)	53,V53

J 9530	Valve Guide Installer (2 Valve)	71,V71
J 21520	Valve Guide Installer (4 Valve)	71,V71,92
J 24519	Valve Guide Installer (4 Valve)	53,V53
J 22082-01	Valve Guide Installer (Large Stem)	149
J 23458	Valve Guide Remover	149
J 34696-B	Valve Guide Remover	50,60
J 6569-A	Valve Guide Remover	53,V5371,V71,92
J 267-A	Valve Guide Remover (2 Valve)	71,V71
J 7775-A	Valve Guide Remover (4 Valve)	53,V53
J 28612	Valve Guide Remover/Installer	53,V5371,V71,92,8.2L
J 29579	Valve Stem Seal Installer (4 Val 53)	53,V53
J 35642	Crankshaft Gear Remover/Installer	50,50G,60
J 36187-A	Crankshaft Main Bearing Remover	50,50G,60
J 35994	Crankshaft Protector	50,50G,60
J 22898-A	Crankshaft Torque Wrench Adapter	V71,92
J 22897	Crankshaft Torque Wrench Adapter Set	149
J 34728	Front Crankshaft Cup Plug Tester	149
J 35993	Crankshaft Oil Seal Remover	50,50G,60,92,8.2L
J 41599	Front Crankshaft Seal REM/INST	55
J 7454	Front Seal Expander (STD) 6V-53	53,V53
J 29008-B	Front Seal Installer (STD Seal)	8.2L
J 9783	Front Seal Installer (STD Seal)	53,V5371,V71,92
J 22153	Front Seal Installer (STD) 8V-53	V53
J 29007-A	Front Seal Remover	8.2L
J 22524	Front Seal Sleeve Installer (6V-53)	53,V53
J 22518	Front Seal/Bearing Installer (STD)	149
J 22425-B	Front/Rear Seal Expander	V71,92
J 4194-01	Front/Rear Seal Installer	V53,71,V71,92
J 9727-A	Front/Rear Seal Installer	V53,71,V71,92
J 35686-A	Front/Rear Seal/Wear Sleeve Install	50,50G,60
J 4195-01	FRT/RRSeal Expander (Oversize)	V53,71,V71,92
J 41592	Rear Crank Wear Sleeve Remover	55
J 4239	Rear Seal Expander	V71,92
J 22766	Rear Seal Expander (Oversize Seal)	149
J 22605	Rear Seal Expander (Standard Seal)	149
J 29009-A	Rear Seal Expander (STD Seal)	8.2L
J 23341	Rear Seal Expander Adapter	149

J 25002	Rear Seal Expander Guide Studs	92
J 9769	Rear Seal Expander (STD Seal 536V-53)	53,V53
J 22604-B	Rear Seal Insert (STD SL) Cup PLG REM	149
J 21112-B	Rear Seal Instal (Except 6,8,12V71)	V71,92
J 9479	Rear Seal Install (STD Seal 53,6V-53)	53,V53
J 41596	Rear Seal Installer	55
J 29010-B	Rear Seal Installer (STD Seal)	8.2L
J 9727-2	Rear Seal Installer Guide Studs	71,V71
J 9727-5	Rear Seal Installer Guide Studs	71,V71
J 3154-04	Rear Seal Installer & Remover Set	53,V53,71,V71,92,149,8.2L
J 21983	Rear Seal Sleeve Installer	V71,92
J 22676	Rear Seal Sleeve Installer	149
J 33426	Rear Seal Sleeve Installer	8.2L
J 21277	Rear Seal Sleeve Installer (6V53)	53,V53
J 41163	Rear Seal /Sleeve Installer	40
J 33873	Seal Expander (Oversize Seal)	8.2L
J 8682	Seal Expander O S (EX 6,8,12V71)	V71,92
J 24171-A	Seal Remover	50,53,V53,60,71,V71,92,149,8.2L
J 39184	Seal/Wear Sleeve Installer	40
J 39266	Wear Sleeve Installer	40
J 41593	Wear Sleeve Installer-FRT/RR Crank	55
J 37075-A	Wear Sleeve Remover	50,50G,60,V71,92,8.2L
J 35651	Gear Case To Block Alignment Tool	50,50G,60
J 5356	Puller Remover (Rubber Bushed)	71,V71,92
J 29025-A	Pulley & Gear Remover/Installer Set	8.2L
J 7773	Pulley Installer Set	53,V53
J 25026-2	Eye Bolts (2 Pcs)	55
J 36235	Flywheel Guide Studs	50,50G,60
J 25026-A	Flywheel Lifting Fixture	30G,40,50,50G,53,V53,55,60,71,V71,92,149,8.2L Perkins
J 6361-01	Flywheel Lifting Tool	53,V53,71,V71
J 36375-A	Flywheel Lock	50,50G,55,60
J 9737-11	Flywheel Runout Gauge Adapter	55
J 1927-01	Flywheel Housing Alignment Stud Set	71,V71,92
J 7540	Flywheel Housing Alignment Stud ST	53,V53

J 34691-A	Flywheel Housing Guide Studs	55
J 9737-D	Flywheel Housing Runout Gauge Set	30G,40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 9737-11	Flywheel Runout Gauge Adapter	55
J 3172	Feeler Gauge Set	71,V71
J 38088	Pin Retainer Installer	92,
J 25397-B	Piston Crown I.D. Gage	149
J 41971	Piston Crown I.D. Gage	71,71V
J 38609-A	Piston Crown I.D. Gage (3.5MM Fire)	50,50G,60
J 38689-A	Piston Groove Gage (Compression)	50,60
J 24599	Piston Groove Gage (Fire Ring)	71,71V,92
J 35884-A	Piston Groove Gage (Fire Ring)	50,60
J 38390	Piston Pin Alignment Tool	92
J 22387	Piston Ring Compressor	149
J 24227-B	Piston Ring Compressor	92
J 29614-A	Piston Ring Compressor	8.2L
J 3272-03	Piston Ring Compressor	71,V71
J 35598-A	Piston Ring Compressor	50,60
J 6883-A	Piston Ring Compressor	53,V53
J 22405-02	Piston Ring Expander Pliers	149
J 8128	Piston Ring Expander Pliers	53,V53,71,V71,92,8.2L
J 29511	Piston Ring Groove Gage Set	30G,40
J 24421	Piston Seal Ring Compressor	149
J 5438-01	Piston To Liner Feeler Gage Set	53,V53,71,V71,92,149
J 23453	Seal Ring Compressor (Croshd Piston)	53,V53,71,V71,92,149,8.2L
J 35945	Connecting Rod Installation Guides	50,60
J 8995	Connecting Rod Nozzle Remover	53,V53,71,V71
J 24107-01	Pin Retainer Instal (71 TRK TY PST)	71,V71
J 1513-02	Piston & Rod Bushing REM/INST SET	71,V71
J 7587	Piston & Rod Bushing REM/INST Set	53,V53
J 24285	Piston Pin Alignment Tool	71,V71
J 35619	Piston Pin Alignment Tool	53,V53
J 3071-B	Piston Pin Bushing Reamer Kit	71,V71
J 4970-02	Piston Pin Bushing Reamer Kit	53,V53,
J 23762-A	Piston Pin Retainer Installer	53,V53,71,V71,92
J 24274-B	Piston Pin Retainer Installer	149
J 35572	Piston Pin Retainer Installer	53,V53

J 23987-B	Piston Pin Retainer Leak Detector	53,V53,71,V71,92
J 24629	Piston Pin Retainer Leak Test Cup	149
J 41328	Piston Ring Compressor	55
J 36211	Piston/Conn Rod Holding Fixture	50,53,V53,60,71,V71,92,149
J 7632	Rod Holder	53,V53,71
J 29588-53	Connecting Rod Bushing Reaming Set	53,V53
J 41786	Flywheel Lock-Timing	55
J 29893	Generator Gear Dial Indicator	V71,92
J 41167	Lower Idler Gear Socket	40
J 24730	Puller Adapter (Pressed Tach DRVS)	53,V53,71,V71,92,8.2L
J 23068	Tach Drive Alignment Tool Set	53,V53,71,V71,92,8.2L
J 39814-A	Balance Shaft Assembly Support	50,50G
J 39819	Balance Shaft Bushing Inst & Remvr	50,50G
J 39817	Balance Shaft Installation Pilot	50,50G
J 9791	Balance WT Cam Coupling Torque Wrench Adapter	V71,92
J 7593-03	Cam & Bal Shaft Bushg Rem/Install	53,V53
J 29141-A	Cam Bushing Remover & Installer	8.2L
J 28462	Cam Coupling Torque Wrench Adapter	149
J 24094	Cam Cup Plug Installer	53,V53,71,V71
J 34033	Cam Installation Pilot	8.2L
J 39537	Cam Shaft Bushing R & I	30G,40
J 41580	Camshaft Pilot	55
J 7932	Gear/Cam Pulley Remover Adapter	V71,92
J 9790	Upper Front Cover Seal Installer	53,V53
J 35949	Cam Gear Assembly Fixture	50,50G,60
J 1903	Cam Gear Installer	71,V71,92
J 35906	Cam Gear Pilot	50,50G,60
J 1902-B	Cam Gear Puller	53,V53,71,V71,92
J 35652	Cam Gear Retaining Tool	50,60
J 29744	Cam Idler Gear Nut Socket Set	149
J 22556-6	Poly Vee Pulley Hub nut Finger Set	149
J 6202-01	RR Cam Gear Puller Adapt In Chassis	71,71V,92
J 35785	Bull/Cam Idler Gear Guide Studs	50,50G,60
J 35596	Cam & Idler Gear Lash Adapter	50,50G,60
J 22556	Cam/Idler Gear Nut Spanner Wrench	149

J 7557	Timing Gear Installer	53,V53
J 38662	Accessory Drive	50,50G,60
J 21166	Accessory Drive Seal Alignment Tool	71,V71,92
J 36024-C	Accessory Drive Service Set	50,50G,60
J-2901	Abrasive Pads (20)	50,60
J 24542	Block Align Tool (.020 OS,12 & 16V)	149
J 24543	Block Align Tool (.040 OS,12 & 16V)	149
J 41065	Counterbore Cutter Tool Conv. Kit	60
J 43095	Cylinder Sleeve Holding Adapters	40E
PT-2200-83	Depth Collar	50,60
PT-2200-138	Depth Set Collar	50,60
PT-5025	Dial Depth Gauge	50,60
J 41594	Engine Barring Tool	55
J 41997	Engine Barring Tool	55
PT-5020-5SP	Extension Arm Kit	50,60
J 41972	Flex Hone	30G
J 43104	ICP Adapter Plug Kit	40,40E
J 42779	Liner Puller	Cento
J 22490	Liner Remover	53,V53
J 43048	Main Bearing Guide Studs	2000
J 8386-01	Master Ring -Cylinder Block Bore	71,V71
J 8385-01	Master Ring- Liner ID	53,V53
PT-7145-A	Right Angle Drill	50,60
J 38359	Threaded Insert	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
PT-2000-400	X-Long Finish Line	50,60
J 42955	Cylinder Head Alignment Bar	4000
J 41962	Cylinder Head Bolt Bottom Tap	30G
J 42954	Cylinder Head Guide Studs	4000
J 41823	Cylinder Head Lifter Bracket	30G
J 42730	Cylinder Head Lifting Fixture	4000
J 43099	Cylinder Head Magnet Intake Shield	40E
J 42514	Cylinder Headbolt Wrench M12	Cento
J 42637	Cylinder Headbolt Wrench M14	Cento
J 39108	Fuel Line Nut Wrench 11/16"	149
J 43096	Guide Stud Set	40E
PT-7149	Infrared Thermometer (0-1600Deg F)	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 24357	Valve Seat Insert Installer	92
J 41573	Bridge Guide Installer	55

J 41569	Bridge Holding Fixture	55
J 41960	Crankshaft Cup Plug Installer	30G
J 42778	Crankshaft Remover Protector	Cento
J 42196	Front Crankshaft Hub Installer	4000
J 42733	Rear Crankshaft Flange Installer	4000
J 41968	Crank Wear Sleeve Remover	30G
J 42736	Front Crankshaft Hub Seal Installer	4000
J 41966	Front Seal Installer	30G
J 42261	Front Seal Installer	2000
J 42257	Front Wear Sleeve Installer	2000
J 42259	Rear Crankshaft Seal Installer	2000
J 42735	Rear Crankshaft Seal Installer	4000
J 41974	Rear Seal Installer	30G
J 41963	Seal Remover	30G
J 39284	Wear Ring Installer	40
J 41598	Wear Sleeve Remover-Front	55
J 43030-40	Gear Case Bushing Kit (40)	50,60
J 43030	Gearcase Reaming Fixture	50,60
J 42511	Crankshaft Pulley & Gear Remover	Cento
J 42999	Flywheel & Vib damper Guide Studs	4000
J 42953	Flywheel Guide Studs	4000
J 42734	Flywheel Housing Alignment Tool	4000
J 41733	Piston Crown ID Gage	92
J 42256	Piston Ring Compressor	2000
J 42727	Piston Ring Compressor	4000
J 43011	Series 2000 Piston Ring Pliers	2000
J 43012	Series 4000 Piston Ring Pliers	4000
J 42781	Piston & Rod Lifting Tool	4000
J 24274-B	Piston Pin Retainer Installer	149
J 42726	Rod Bearing Adjusting Tool	4000
J 41969	Connecting Rod Guide Caps	30G
J 42258	Cam Follower remover/Installer	2000
J 42264	Camshaft Pilot	2000
J 41570	Nozzle Puller Adapter	55
J 41575	Nozzle Tube Socket	55
J 43100	Valve Guide Installer	40,40E
J 41587	Valve Spring Compressor	55
J 41824	Valve Spring Compressor	30G

J 41595	Flywheel Guide Studs	55
J 34691-A	Flywheel Housing Guide Studs	55
J 41746	Cup Plug Installer	55
J 22410-226	Injector Seat	92
J 43394	Alignment Tool	2000

Table 192 Engine Tools

FUEL SYSTEM-ELECTRONIC

FUEL SYSTEM ELECTRONIC

Listed in Table 193 are the special tools for the fuel system electronic.

Tool Number	Tool Description	Application
J 44191	Injector Timing Gage 1.540	92
J 22410	Injector Seat and Calibrator	92
26400-5B	Injector Test Oil	Universal
J 4983-01	Injector Nut Socket	53, 71, 92
J 1291-02	Injector Spray Tip Driver	71, V71, 92
J 24838	Spray Tip Carbon Remover	53, 71, 92 8.2L
J 8170	Injector Wire Sharpening Stone	Universal
J 8169-03	Injector Spray Hole Cleaner	92
J 21460-01	Spray Hole Wire	53, V53, 71, V71, 92
J 7944	Wire Brush (Brass)	Universal
J 8150	Rack Hole Brush	53, 71, 92
J 9418	Injector Nut Carbon Remover Set	92
J 29196	Spring Tester (0-125 lbs.)	92
J 22525-B	Injector Tube Reconditioning Set	92
J 1508-E	Service Set (DDA Gear-G Torot Type)	92
J 39300	Calibrator	92
J 28611-A	Injector Tube Swagging Tool	92
J 38500-H	Pro-Link DDR for DDEC III and IV	92
J 34930-A	Crank Position Timing Tool	92
J 35888-60A	DDEC Repair Kit	50,60,149
J 35888-A	DDEC Repair Kit	50,60,71,92,149
J 38500-152	Diagnostic Reader CBL ADPT (AMP)	50,60,71,92
J 38500-60A	Diagnostic Reader CBL ADPT (Deutsch)	60,71,92
J 38596-A	ECM Test Harness	60,71,92,149
J 35751	Jumper Wire Set	50,60,71,92,149
J 35889	Prom Remover Tool	50,60,71,92,149
J 36400-5	Push Terminal Release Tool	50,60,71,92,149
J 34182	Terminal Crimper (Deutsch)	50,60,71,92,149
J 35688	Terminal Crimper (Group III)	50,60,71,92,149
J 38125-6	Terminal Crimper (Metri-Pack)	50,60,71,92,149
J 35123	Terminal Crimper (Group 1-Metri-PK)	50,60,71,92,149
J 39848	Terminal Crimper (Metri-Pack 280	50,60,71,92
J 34513	Terminal Remover (Deutsch)	50,60,71,92,149

J 38582-3	Terminal Remover (Deutsch)	50,60,71,92
J 33095	Terminal Remover (Micro-Pack 280)	50,60,71,92,149
J 39125-12A	Terminal Remover (Metri-Pack)	50,60,71,92,149
J 35689-A	Terminal REMV (GRP 1-1Metri Pack 150)	50,60,71,92,149
J 39815	TRS Alignment Tool	71,92
J 41005-149	V.I.M. Adapter Kit	149
J 34520-A	Volt/Ohm Meter Kit	30G,40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 38500-750	DDEC II & DDEC III Cartridge Version 5.0	50,50G,55,60
J 34812-1	Diagnostic Reader CBL ADPT (Packard)	50,60,71,92
J 39298-2	TRS Alignment Tool	V71
J 26617	Fuel Line Wrench Set	149
J 37050-A	Electronic Unit Injector Tester	50,60,71,92
J 41424	Fuel Line Nut Wrench-Internal	55
J 41568	Fuel Nozzle Test Adapter	55
J 34760-147A	Injector Pop Fixture ADP-Electronic	50,60,92
J 24517-B	Injector Tube Reconditioning Set	149
J 6355	Fuel Pressure Gauge (0-100 PSI)	149
J 8151	Fuel Pressure Gauge (100PSI)	53,V53,71,V71,92,149,8.2L
J 34607-A	Fuel Pump Repair Kit	149
J 38767-A	Fuel Pump Repair Kit	50,60
J 4242	Fuel Pump Wrench	53,V53,71,V71,92,149,8.2L
J 41518	GFI Diagnostic Cable	50G
J 33854	Needle Bearing Installer (Barnes Pump)	149
J 33853	Needle Bearing Remover (Barnes Cup)	149
J 34158	Seal Installer (Barnes Cup)	149
J 42732	Fuel Injector Puller	4000
J 42946	Fuel Injector Remover Tool	40E
J 43101	ICP Breakout T Harness	40E
J 42512	Injector Remover/Replacer	Cento
J 43098	Injector Test Harness	40E
J 42947	Fuel Injector Sleeve Installer	40E
J 42945	Fuel Injector Sleeve Remover	40E
J 41795	Fuel Pump Drive Bearing Inst/Remover	55

J 43102	CEC Breakout Box	40E
J 38500-2300	DDC DDEC III & IV PC Card	50,50G,53,V53,55,60,71,V71,92,149
J 35887-1	DDEC Diagnostic Kit	50,50G,55,60,2000,4000
J 39110-A	DDEC Marine Prolink Kit Vers 1.3	60,71,V71,92,2000
J 37164-B	DDEC Sensor Tester	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 39200	Fluke 87 Digital Multimeter Kit	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 38500-1500	Multi Protocol Cartridge V1.70/1.72	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 38500-1DD	Pro Link Diagnostic Reader	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 38500-155	Prolink Adapter-DDEC Marine	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 42980	Series 40E ECM Terminal Crimpers	40E
J 38500-2100	Series 40E PCMCIA (Navistar)	40,40E
J 42731	Fuel Railing Engine Fixture	4000
J 38706	Terminal Crimper	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2

Table 193 Fuel System Electronic Tools

FUEL SYSTEM-MECHANICAL

FUEL SYSTEM MECHANICAL

Listed In Table 194 are the special tools for the fuel system mechanical

Tool Number	Tool Description	Application
J 22690	Body & Nut Thread Recon System	53,V53,71,V71,92
J 1241-07	Injector Service Set	53,V53,71,V71
J 25600-B	Injector Spray Tip & P/B Flow Gauge	53,V53,71,V71,92,149,8.2L
J 22640-A	Injector Tip Assembly Tester	53,V53,71,V71,92,149,8.2L
J 8932-B	Fuel Line Nut Wrench	53,V53,71,V71,92
J 26617-A	Fuel Line Wrench Set	149
J 41787	Torque Wrench Adapter	149
J 8985	Control Link BRG Remove/Install	V53,92,149
J 21068	Cover & Spring Housing Remover	V53,71,92,149
J 21967-01	Gov Weight Shaft Ret Ring Installer	71,V71,92,149
J 36840	Gov Weight Wedge- Static Gap Setting	53,V53,71,V71,92,149
J 35516	Governor Housing Repair Kit	V71,92
PT-7150-A	Governor Housing Repair Kit	V71,92
J 35618	Linkage Gage (Electronic)	8.2L
J 23176	Weight Housing Plug Rem & Replacer	149
J 8984	Weight Spacer (6V-53)	V53
J 4685	Drive Ring Remover	V71,149
J 34998	Master Injector-149	149
J 29097	Nozzle Adapt Kit	30G,40,53,V53,71,V71,92
J 29075	Nozzle Tester	53,V53,55,71,V71,92,149
J 29653-A	Ultrasonic Nozzle Cleaner	30G,40,40E,50,50G,53,V53,55,71,V71,92,149,8.2L,2
J 41994	Fuel Line Nut Wrench-External	55
J 41787	Torque Wrench Adapter	149
J 36325	EEC Variable Speed Cont (Gov.)	53,V53,71,V71,92,149

Table 194 Fuel System Mechanical

LUBRICATION SYSTEM

LUBRICATION SYSTEM

Listed in Table 195are the special tools for the Lubrication System.

Tool Number	Tool Description	Application
J 38858	Water Pump Seal Installer	53, 92, 71
J 4646	Pliers (Tru-Arc)	92
J 25257	Water Pump Drive Gear Installer	92
J 22150-B	Water Pump Seal Remover	92, V71
J 8501	Water Pump Oil Seal Installer	71, 149, 92
J 8550	Thermostat Seal Installer	V71, 149, 92
J 7079-2	Driver Handle	Universal
J 33765	Impeller Slip Test Adaptor	92
J 29140	Bushing - Remover & Installer set	V71,92
J 8968-01	Drive Gear Installer	53,V53
J 23126	Drive Gear Sip TST (TRQ WR ADPT)	53,V53
J 22398	Drive Shaft Dear INST (6.01") (6/8V)	V71,92
J 9380	Gear Instal 5.500" 16V-71/12V-16V92	V71,92
J 9381	Gear Installer	V71,92
J 9382	Gear Installer (8.060") (16V)	V71,92
J 39769	Idler Shaft Wrench	50,50G
J 41975	Oil Cooler Test Plate	30G
J 43097	Oil Cooling Plate	40E
J 29325-4	Oil Pressure Gauge (0-160 PSI)	50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 39816	Oil Pump Gear Holder	50,50G
J 29925	Filter Cutter (Fuel and Lube)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 29917	Lube Oil Filter (Spin-on) Wrench	50,60,71,71V,92
J 24783	Lube Oil Filter (Spin-on) Wrench	53,V53,71,V71,92,149
J 42513	Oil Filter Cooler Base Tool	Cento
J 22775	Oil Filter Wrench AC Large Filters	50,60,8.2L
J 28431-6	6 Fluorescent Oil Additives (1OZ)	30G,40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 41423	Oil Pan Removal Tool	40

Table 195 Lubrication System

COOLING SYSTEM

COOLING SYSTEM

Listed in Table 196are the special tools for the cooling system:

Tool Number	Tool Description	Application
J 39944	Coolant Flow Checker, Air Injection	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 29190-B	Impeller Remover & Installer	8.2L
J 35517-1	Seal Installer (Unitized)	60,8.2L
J 22143	Water Pump Impeller Remover	V71
J 35988-B	Water Pump Service Set	50,50G,60
J 24460-01	Cooling System Pressure Tester	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 29003-A	Radiator Pressure Tester ADPT	53,V53,60,71,V71,92,149,8.2L

Table 196 Cooling System

FUEL, LUBRICATING OIL, COOLANT

FUEL, LUBRICATING OIL, COOLANT

Listed in Table 197are the special tools for the fuel, lubricating oil, coolant:

Tool Number	Tool Description	Application
J 21224	Dial Indicator Adaptor	92
J 34352	Diesel Fuel Hydrometer	30G,40,40E,50,50G,53,53V,55,60,71,V71,92,149,8.2
J 38641-A	Diesel Fuel Quality TSTR-Hydrometer	50,53,V53,55,60,71,71V,92,71,V71,92,149,8.2L
J 23688	Eng Coolant & Batt Fluid Tester	40,50,50G,53,53V,55,60,71,V71,92,149,8.2L
J 26568	Eng Coolant & Batt Fluid Tester	40,50,50G,53,53V,55,60,71,V71,92,149,8.2L
J 29545	Fluorescent Coolant Dye 24-1OZ	30G,40,40E,50,50G,53,53V,55,60,71,V71,92,149,8.2
J 28428-E	High Intensity Black Light Kit	30G,40,40E,50,50G,53,53V,55,60,71,V71,92,149,8.2
J 39258-A	Engine Pre-Luber	30G,40,40E,50,50G,53,53V,55,60,71,V71,92,149,8.2
J 28431-B	Fluorescent Oil Dye 24-1OZ	30G,40,40E,50,50G,53,53V,55,60,71,V71,92,149,8.2

Table 197 Fuel, Lubricating Oil And Coolant

AIR INTAKE SYSTEM

AIR INTAKE SYSTEM

Listed in Table 198are the special tools for the air intake system:

Tool Number	Tool Description	Application
J 28507	Snap Ring Pliers	60 (14L)
J 29086	Turbocharger Support Fixture	60 (14L)
J 29086	Support Fixture	53,V53,71,V71,92,149
J 29090	Thrust Spacer Plug & Sleeve INST	53,V53,71,V71,92,149
J 29149-1	Tool Box	53,V53,71,V71,92,149
J 26554-A	Turbo Inlet (Compress) Shield	30G,50,50G,53,V53,55,60,71,V71,92,149
J 29089-A	Turbo Shaft Check	53,V53,71,V71,92,149
J 39164	Turbo Shaft Checker	50,50G,60
J 41813	Turbocharger Inlet Cap	30G
J 29149	Turbocharger Tool Kit	53,V53,71,V71,92,149
J 37466	By-Pass Valve Service Kit	149
J 41473	Charged Air Cooler Tester	50,60
J 35787-A	Double Lip Seal (OS) & Wear Instal	V71,92
J 38707-A	Double Lip Seal (OS) & Wear SL Instal	149
J 33001	Drive Shaft Alignment Tool	V71,92
J 21843-01	Drive Alignment Set	V71
J 1471	Drive Cam Installer	71,V71
J 5209	Drive Cam Installer	53,V53
J 23641	Drive Gear Hub Socket	149
J 1698-02	Rotor Clearance Feeler Gage Set	53,V53,71,V71,92,149
J 4254	Rotor SHFT REM/INST Set (3,4,6-71)	71
J 22706-C	Service Tool Set	149
J 8147	Service Tool Set (2-71)	71
J 21672	Service Tool Set (8V-53)	V53
J 23679-A	Service Tool Set (EXCEPT 8V-53)	53,V53
J 6270-G	Service Tool Set (Except 2-71)	71,V71,92
J 21223-02	Compressor Impeller Nut Wrench	53,V53,71,V71,92,149
J 9496	Compressor Impeller Remover	53,V53,71,V71,92,149
J 29087	Drill Fixture	53,V53,71,V71,92,149
J 29088	Groove Pin Installer	53,V53,71,V71,92,149
J 29104	Seal Ring Installer	53,V53,71,V71,92,149
J 29105	Seal Ring Installer	53,V53,71,V71,92,149

J 29091	Sled Gage Base	53,V53,71,V71,92,149
J 28507	Snap Ring Pliers (Internal)	53,V53,71,V71,92,149

Table 198 Air Intake System

ELECTRICAL EQUIPMENT

ELECTRICAL EQUIPMENT

Listed in Table 199are the special tools for the electrical system:

Tool Number	Tool Description	Application
J 41723	Alternator Pulley Holder	50,50G,60,92
J 21008-A	Test Light Self Powered	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2

Table 199 Electrical Equipment

SPECIAL EQUIPMENT

SPECIAL EQUIPMENT

Listed in Table 200are the tools for special equipment:

Tool Number	Tool Description	Application
J 35948	Air Compressor Wrench	60(14L)
J 36310-A	Compressor Drive Service Set	50,50G,60
J 29547-A	Freon Leak Detect	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,8.2L,20
J 6714-D	Hysrostarter Accumulator Charge Kit	53,V53,71,V71
J 25447-B	Inlet Valve Stop Remover	50,50G,60
J 36311	Hub Installer	53,V53,71,V71,92,149
J 36309	Hub Remover	53,V53,71,V71,92,149

Table 200 Special Equipment

OPERATION AND VERIFICATION

OPERATION AND VERIFICATION

Listed in Table 201are the special tools for operation and verification:

Tool Number	Tool Description	Application
J 7334-E	Comp Gauge Pack	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 41960	Compression Gauge Adapter	30G
J 38450-5	Printer Paper (5 Roll Pack)	50,60,71,92,149
J 38480	Printer (Portable) 110V Recharger	50,60,71,92,149

Table 201 Operation And Verification

ENGINE TUNE-UP

ENGINE TUNE-UP

Listed in Table 202are the special tools for engine tune-up:

Tool Number	Tool Description	Application
J 22503-C	Compression Gauge Adapter	149
J 41541	Compression Gauge Adapter	55
J 6692-B	Compression Pres GA & Hose Assy	53,V53,60,71,V71,92,149
J 35590	Current Clamp (0-600 AMPS)	40,50,50G,53,V53,60,71,V71,92,149
J 38767-A	Cylinder Compression Test ADPT Set	50,60
J 29006	Cylinder Leak Down Tester	8.2L
J 22506-B	Diagnosis Test Kit	53,V53,60,71,V71,92
J 9531-C	Diagnosis Test Kit	53,V53,60,71,V71,92
J 34680-A	Diagnostic Test Kit	149
J 28838-B	Digital Photo Tach	30G,40,50,50G,53,V53,60,71,V71,92,149,8.2L
J 39422	Digital Pyrometer (-30 to 1800 D F)	53,V53,60,71,V71,92,149,8.2L
J 8397	Dry Air Cleaner Gage	53,V53,60,71,V71,92,149,8.2L
J 22195	Elec Gov Link Setting	V71
J 29534-B	Engine Diagnosis Kit	8.2L
J 29139	Flywheel Timing Pin & Adapter	8.2L
J 28598-B	Governor Adjusting Tool (VHSLS)	V71,92
J 23185	Governor Gap GA Limiting Speed Gov	53,V53,71,V71,92,149
J 5407	Governor Gap Gage (.170")	71
J 23478	Governor Gap Gage (.200")	V71
J 29646-A	Governor Gap Gage (.216")	8.2L
J 34184	Governor Link Dial Indicator	149
J 1652-01	Governor Nut Wrench	71,V71,92
J 5895	Governor Retainer Nut SPNR Wrench	53,V53,71
J 5345-E	Governor Setting Kit	53,V53,71,V72
J 4873-01	Governor Speed Spring Wrench (PSG)	V71
J 23475-01	Hydraulic Governor Linkage GA	149
J 21304	Hydraulic Governor Linkage Gauge	V71,92
J 41162	Injection Pump Plunger Pin	40
J 41161	Injection Pump Timing Pin	40
J 29522	Injector Flooding Bar	8.2L

J 7186-A	Injector Timing Gage (2.710)	110
J 21779	Lever Positioning Pin (16V71 & 92)	V71,92
J 21780	Limiting Speed Mech Linkage Gov GA	V71,92
J 7333-6	Monometer (12"-0-12")	8.2L
J 8639-01	Manometer (18"-0-18")	53,V53,71,V71,92,149
J 9531-23	Manometer (2-1/2"- 0 -2-1/2")	8.2L
J 29021	Manometer (24"-0-24")	53,V53,71,V71,92,149
J 38477-A	Marine Engine Diagnostic Kit	53,V53,71,V71,92,149,8.2L
J 21100-E	Push Rod Adjusting Wrench Set	53,V53,71,V71,92
J 5345-12 (old number J 5345–5)	Spanner Nut Socket Hi Speed Spring	53,V53,71,V71,92,8.2L
J 9531-17	Thermometer (0-300deg F)	53,V53,71,V71,92,149,8.2L
J 25558	Throttle Delay Pin GA, .690GO-.072NG	53,V53,71,V71,92
J 34651-A	Tune Up Kit	149
J 24790-D	Tune Up Kit	53,V53,71,V71,92
J 43028	Crankshaft Position Timing Tool	2000
J 9708-20	Feeler GA (.20)Exhaust VLV Lash	50,60
J 9708-C	Feeler GA Set	53,V53,71,V71,92,149,8.2L
J 9708-21	Feeler Gage (.800) Intake VLV Lach	50,60
J 5956	Fuel System Primer	50,53,V53,60,71,V71,92,149,8.2L
J 29523	Injector Control Rack pin	8.2L
J 26645	Injector Control Rack Gage (.160)	149
J 35586	Injector Rack Gage (.200)	53,V563
J 29825	Injector Rack Gage (.220)	149
J 26646	Injector Rack Gage (.290)	53,149
J 24889	Injector Rack Gage (.345)	V71
J 28779	Injector Rack Gage (.365)	53,V53,149
J 24882	Injector Rack Gage (.385)	71,92
J 35735	Injector Rack Gage (.430)	71,V71,92
J 23190	Injector Rack Gage (.454)	53,V53,71,V71,92,149
J 33156	Injector Rack Gage (.465)	92
J 34080	Injector Rack Gage (.480)_	71,92
J 33157	Injector Rack Gage .490)	92
J 29062	Injector Rack Gage (.504)	92
J 24872	Injector Rack Gage (.520)	92
J 34609	Injector Rack Gage (.550)	71
J 25559	Injector Rack Gage (.570)	53,V53,71,V71,92

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

PREVENTIVE MAINTENANCE

PREVENTIVE MAINTENANCE

Listed in Table 203are the special tools for preventive maintenance:

Tool Number	Too, Description	Application
J 26791	Digital Tachometer	92
J 9531-55	0-30 Vacuum Gauge W/Protective Boot	30G,40,50,50G,53,V53,55,60,71,V71,92,14
J 33889-A	Belt Tension Gauge	149
J 7915-E	Cylinder Compression Gauge Adapter	53,V53,71,V71,92
J 42868	DDC Diagnostic PC Cart	30G,40,50,50G,53,V53,55,60,71,V71,92,14
J 39257	Engine Field Test Kit	40
J 42948	Engine Harness Repair Kit	40E
PT- 7144-A	Infrared Thermometer	30G,40,50,50G,53,V53,55,60,71,V71,92,14
J 35825	Phasar Tach	30G,40,40E50,50G,53,V53,55,60,71,V71,9
J 35603	Terminal Crimping Tool	30G,40,40E,50,50G,53,V53,55,60,71,V71,9
J 42949	Terminal Release Tool Kit	40E

Table 203 Preventive Maintenance

GENERAL TOOLS & SHOP EQUIPMENT

GENERAL TOOLS & SHOP EQUIPMENT

Listed in Table 204are the special tools for general tools and shop equipment:

Tool Number	Tool Description	Application
J 23586	Belt Tension Gage (Poly-Vee Belts)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 8001-3	Dial Indicator	60 (14L)
J 7872-1	Dial Indicator Extension Rod	60 (14L)
J 7872-2	Dial Indicator Base	60 (14L)
J 7872-3	Dial Indicator Extension Rod	60 (14L)
J 25386-B	Belt tension Gauge	50,55,60
BT-3372-DD	Belt tension Gauge	60
BT-3373-F	Belt tension Gauge	60
J 41251-B	Belt tension Gauge	50,50G,60
J 39966	Belt tension Gauge (275-475 LBS)	50,60
BT-3373-F Old No. J 23600-B	Belt tension Gauge (30-180LBS)	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 26900-7	Caliper (0-150 MM) Dial Type	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-6	Caliper (0-6" MM) Dial Type	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-5	Caliper (0-6" MM) Vernier Type	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,
J 23672	Dial Indicator Roller ADPT	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 8001	Dial Indicator Set	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 26900-23	Gauge 11/4-21/8 TE	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 26900-33	Gauge Set 5/16-6"	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 26900-14	Holy Gauge Set ,125-.500	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 7872	Magnetic base Dial Indicator	40,50,50G,53,V53,55,60,71,V71
J 26900-1	Micrometer (Inch & MM) 0-1"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-2	Micrometer (Inch & MM) 1"-2"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-3	Micrometer (Inch & MM) 2"-3"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-4	Micrometer (Inch & MM) 3"-4"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-30	Micrometer (Inch & MM) 4"-5"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-32	Micrometer (Inch & MM)5"-6"	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 4757	Micrometer- Ball Attachment	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 26900-37	Outside Micrm 3"-4"	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 26900-39	Outside Micrm 5"-6"	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 29296	Spring Tester (0-125 LBS)	71,V71,92
J 26900-16	Tele GA .75-1.25"	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 24420-C	Harmonic Balancer Hub Puller	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2
J 35951-175	Hydraulic Ram & Pump (17-1/2 Ton)	50,60

J 35951	Hydraulic Shop Press -17-1/2 Ton	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 5901-01	Slide Hammer Puller Set	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 25031-A	Three Jaw Puller	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000
J 8092	Universal Driver Handle (3/4"-10)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 8190	Universal Puller (Range 13" Dia)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 37990	Torque Angle Meter	149
J 25359-C	Torque Bit & Socket Set	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 23410	Torque Multipier (1000LB)	30G,40,40E,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 23775-01	Torque Wrench (100-600 FT LBS)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 24406	Torque Wrench (15-100 Lbs)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 24407	Torque Wrench (30-250 FT LBS)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L
J 1313-B	Torque Wrench 1/2" 0-150 FT LBS)	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 34755	Great Crate I & Rack System	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 34100	Great Crate I Storage Box	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 35810	Great Crate II & Rack System	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 35805	Great Crate II Storage Box	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 36130-806	Load-Rotor 4000 LB	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
PT-7272 (old number J 26558–242)	Lock-N-Seal	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
PT-7260	Loctite	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 29927	Oil Filter Wrench	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
PT-7271 (old number J 26558–92)	Pipe Sealant	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 6125-B	Slide Hammer pair W/Adapters	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 6471-02	Slide Hammer With Adapters	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 5586-A	Snap Ring Pliers Vacuum Grip	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 35550	Storage Case Variety Set Of 3	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 26520	Thread Repair Kit	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce
J 8051-01	Tube Flaring Set (45")	40,50,50G,53,V53,55,60,71,V71,92,149,8.2L,2000,4000,Ce

Table 204 General Tools & Shop Equipment

Kent-Moore TOOL GRAPHICS

KENT-MOORE TOOL GRAPHICS

This section contains all of the tools supported in the Kent-Moore tool manual.

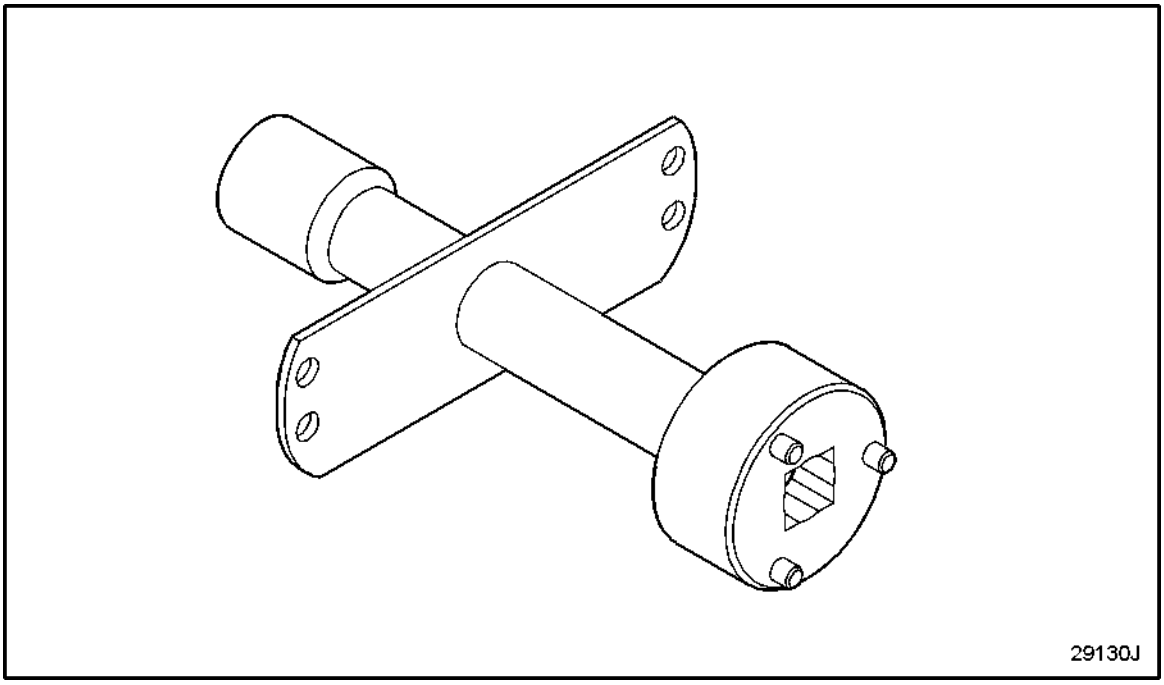


Figure 1070 Aftercooler Adaptor Plug Rem/Inst, J 25275

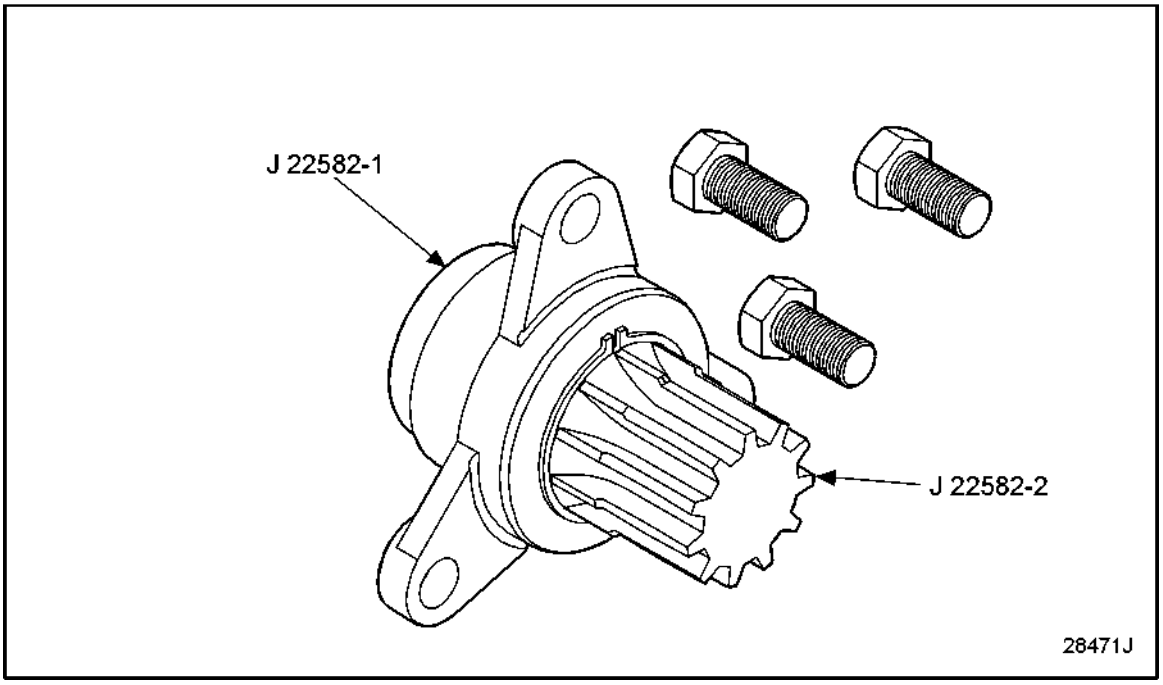


Figure 1071 Barring Tool (Starter Mounting Pad),J 22582

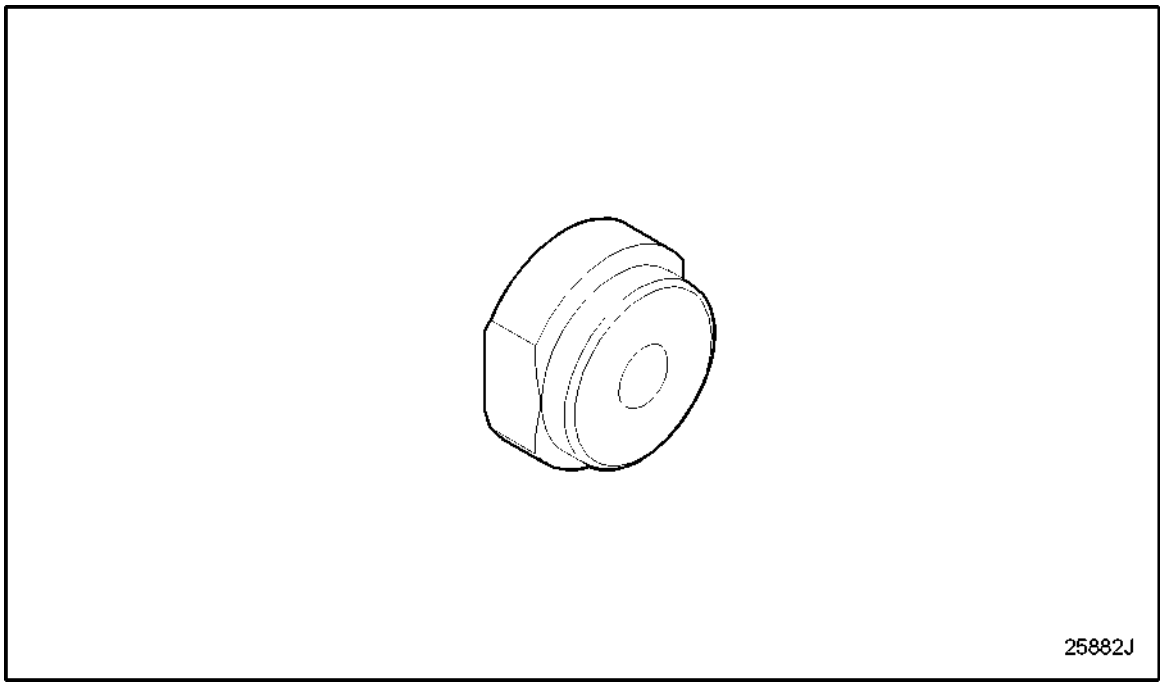


Figure 1072 BLK Core Plug Inst (Water B/P Block),J 21850

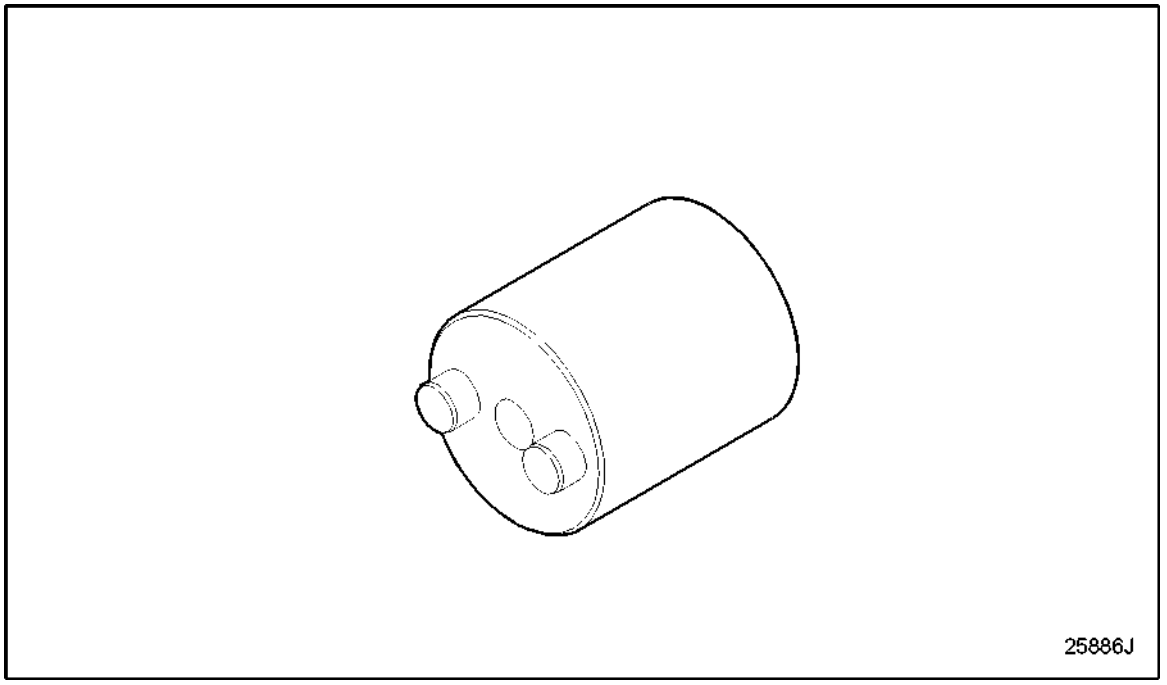


Figure 1073 BLK Plug Remover (Water B/P Block)J 21996–01

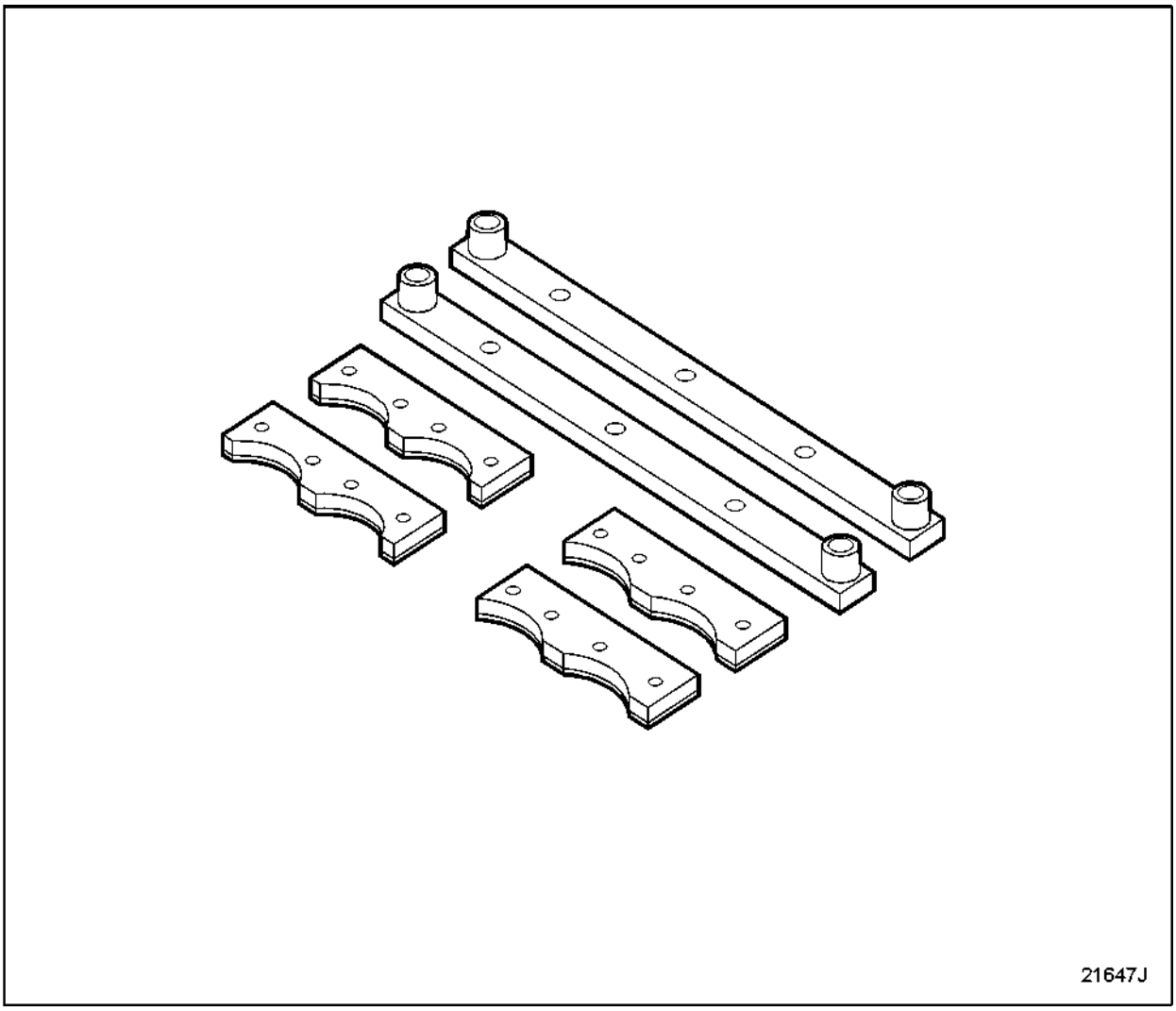


Figure 1074 Block And Head Test Pressure Kit,J 39693

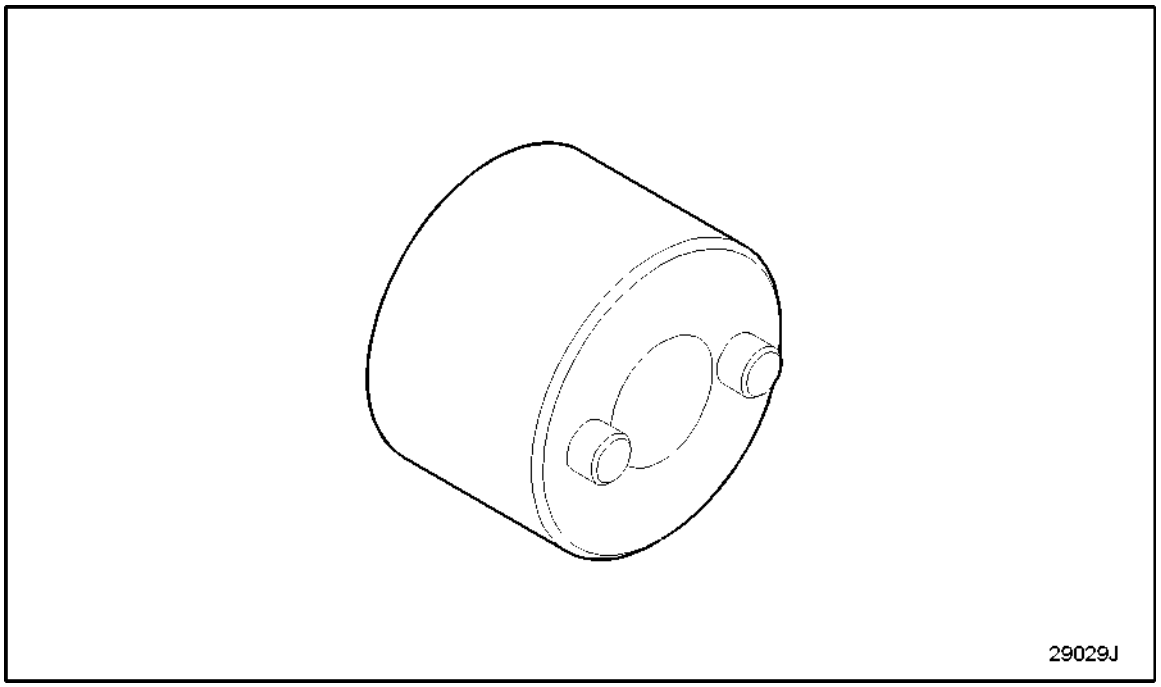


Figure 1075 Block Air Box Core Plug Rem/Inst,J 23019

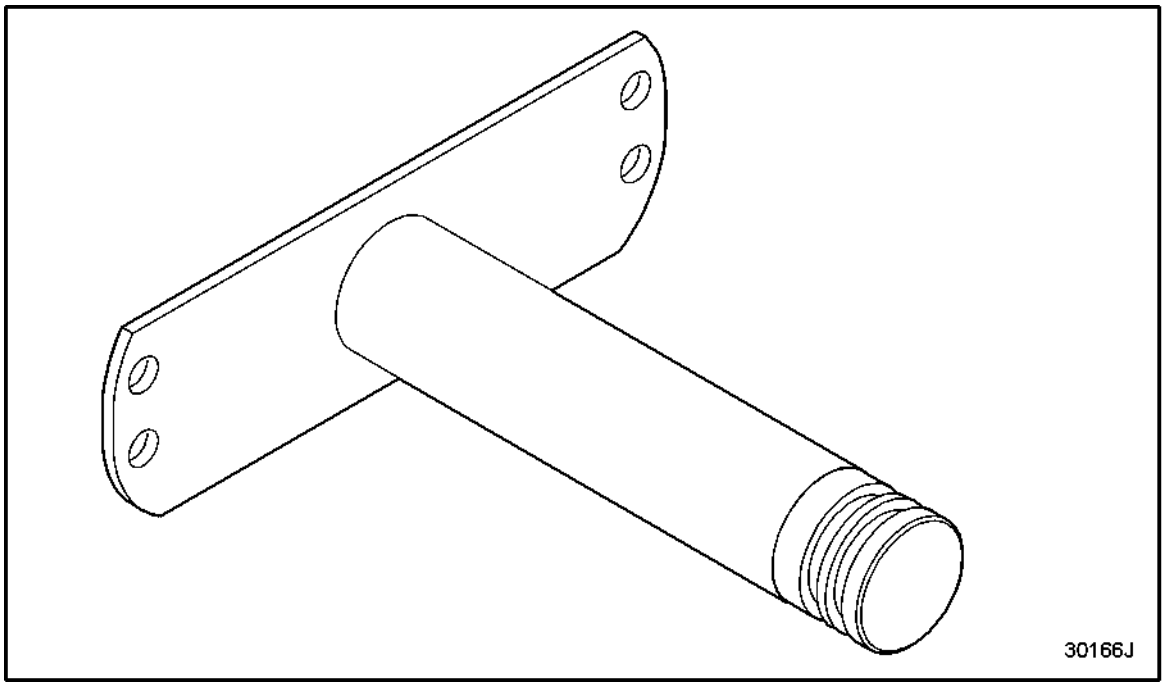


Figure 1076 Block AIr Box Plug Tool,J 29571

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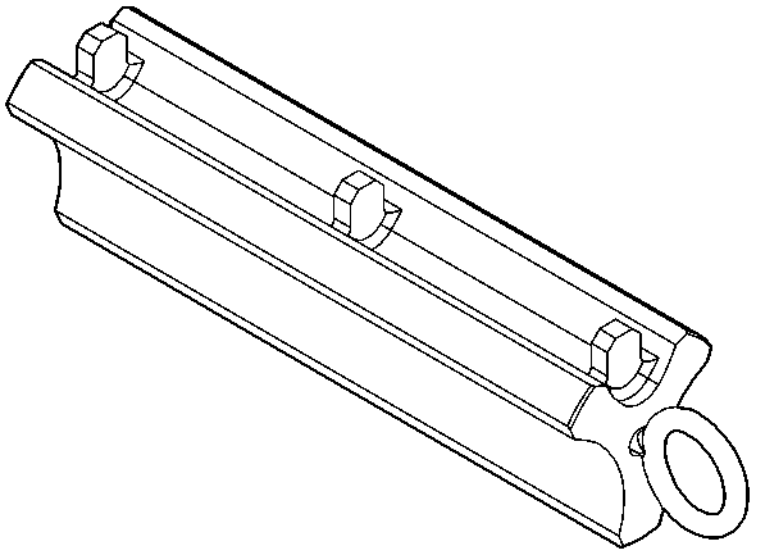
Figure 1077 Block Align Tool,J 24542



28615J

Figure 1078 Block Align Tool,J 24543

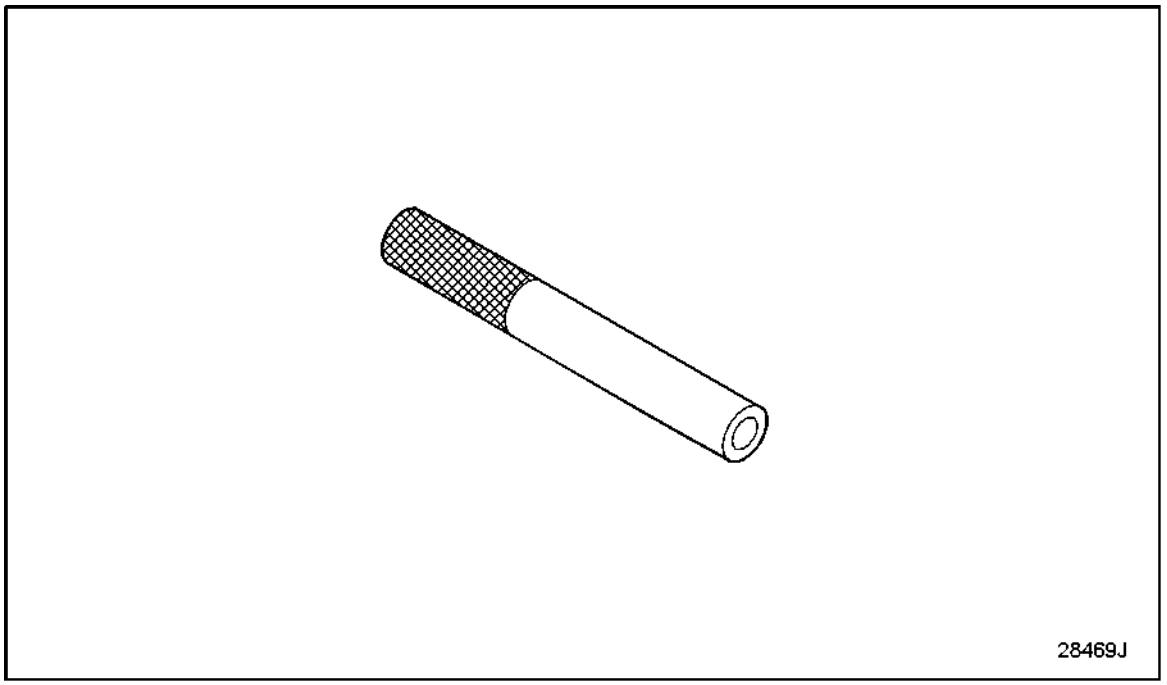


Figure 1079 Block Alignment Tool,J 22486

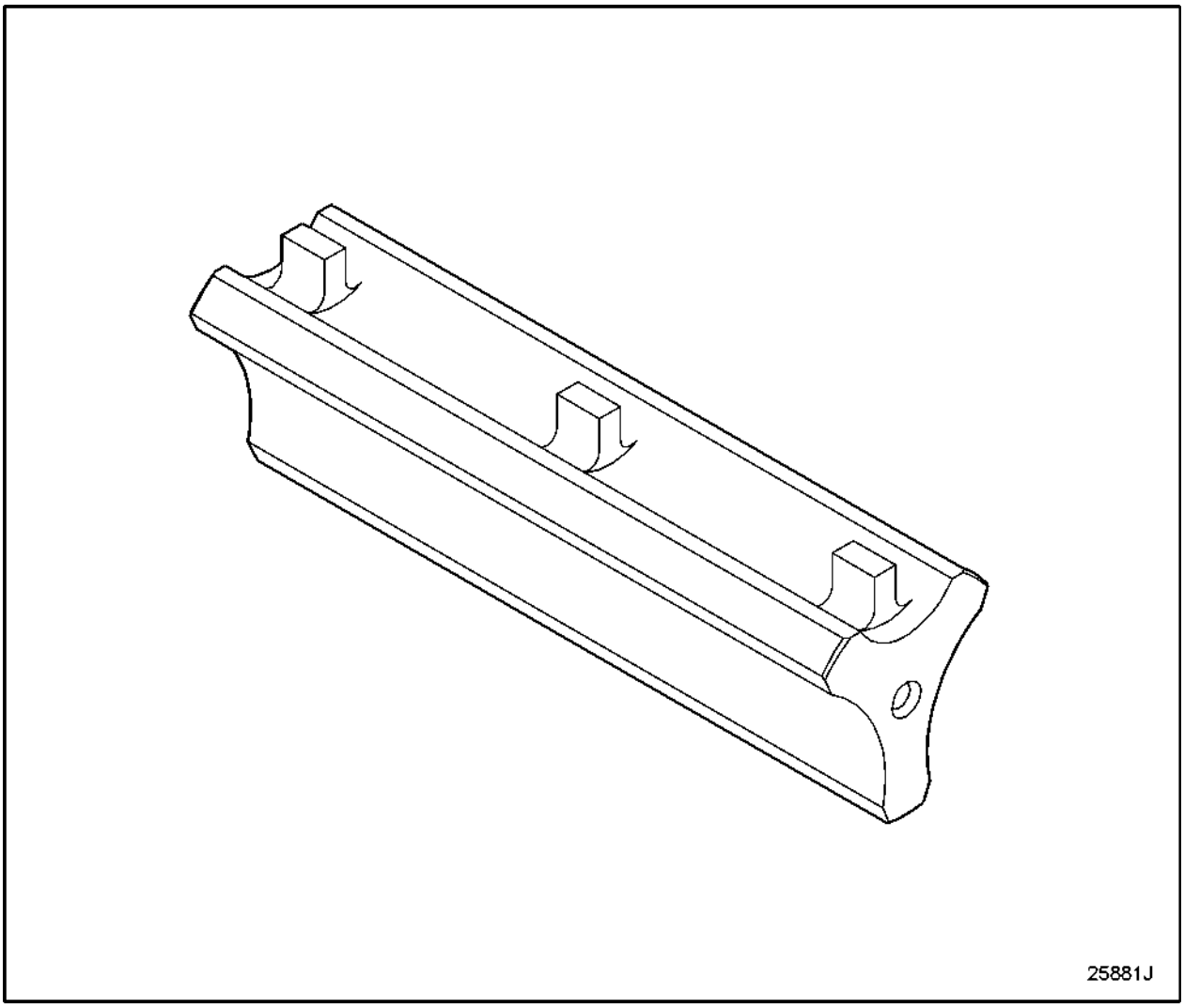


Figure 1080 Block Alignment Tool,J 21799

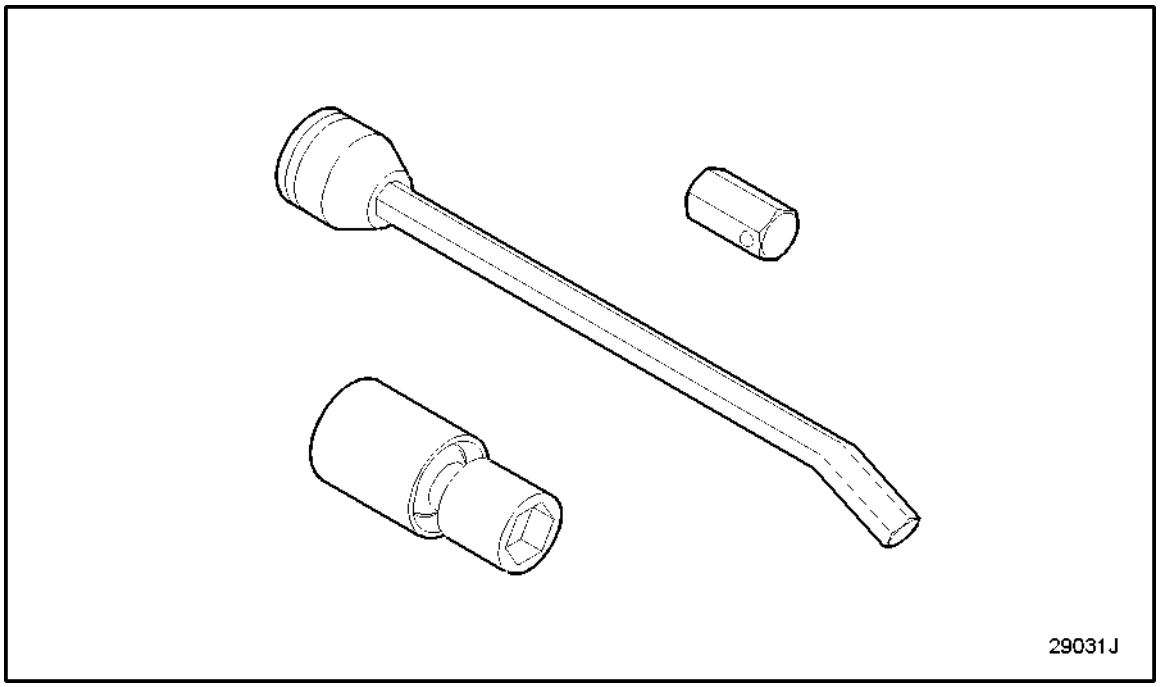


Figure 1081 Block Assembly Wrench Set (16V), J 25451–B

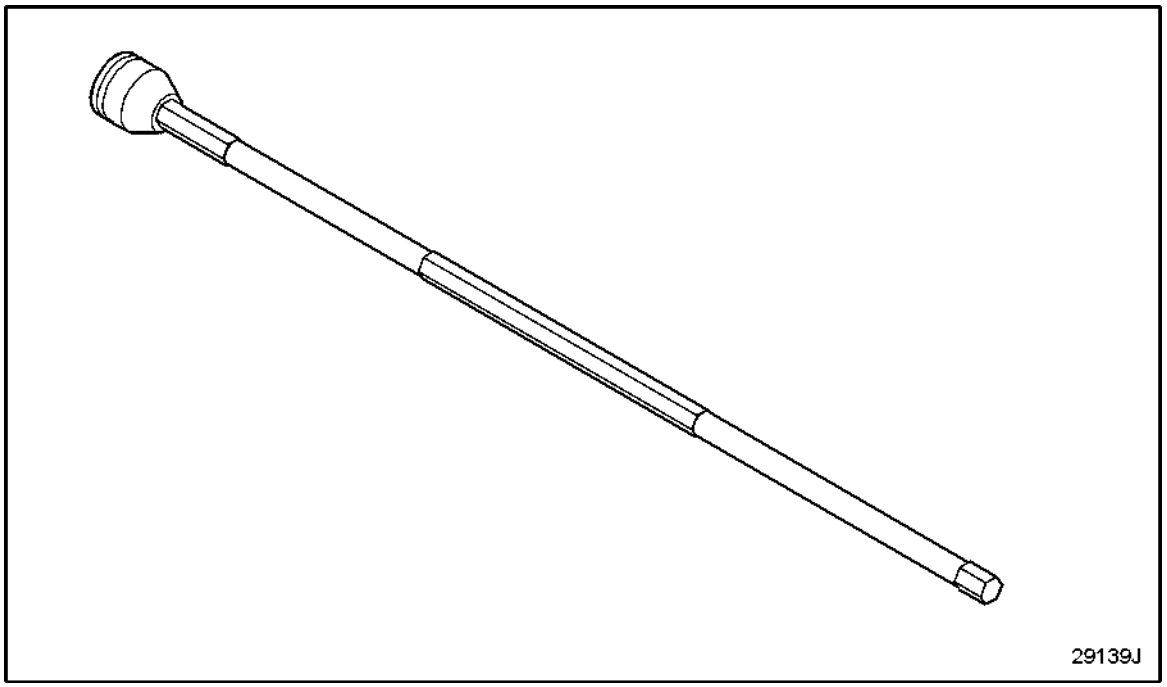


Figure 1082 Block Assembly Wrench Set (16V, J 28651

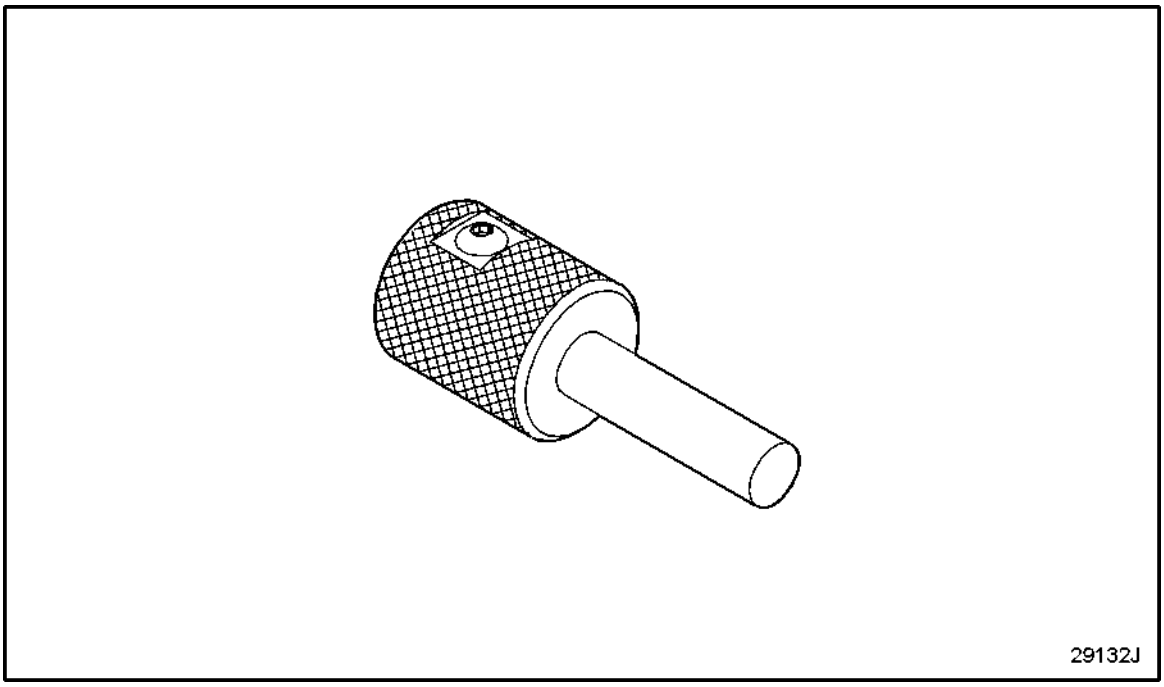


Figure 1083 Block Head Bolt Hole Depth Gage,J 26244

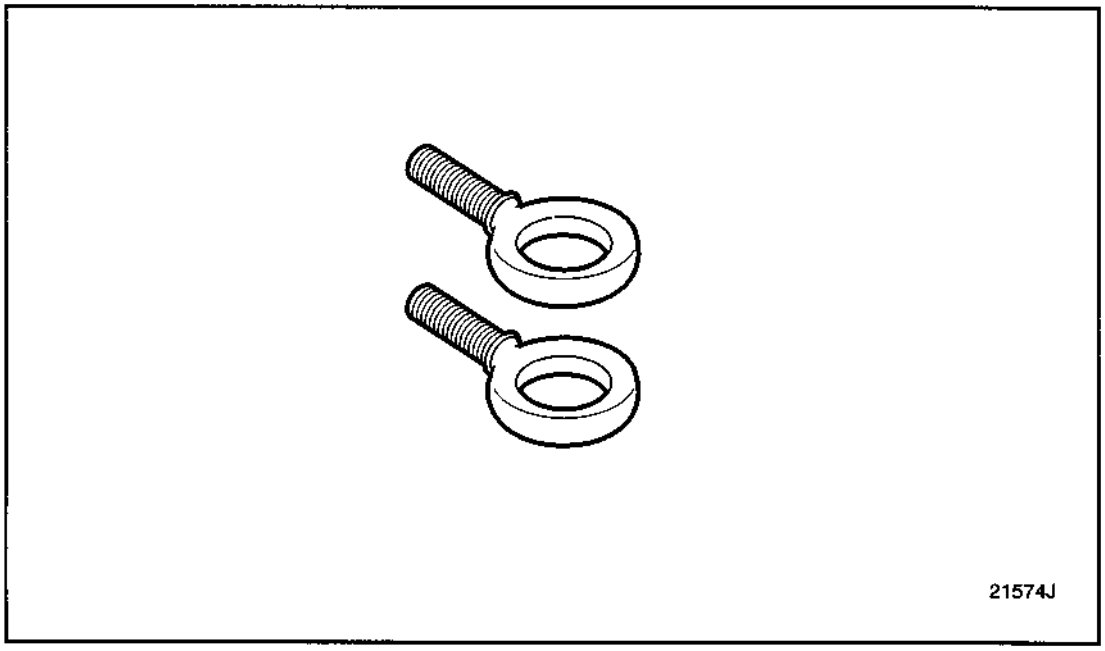


Figure 1084 Block Lifting Eye Bolts,J 35595

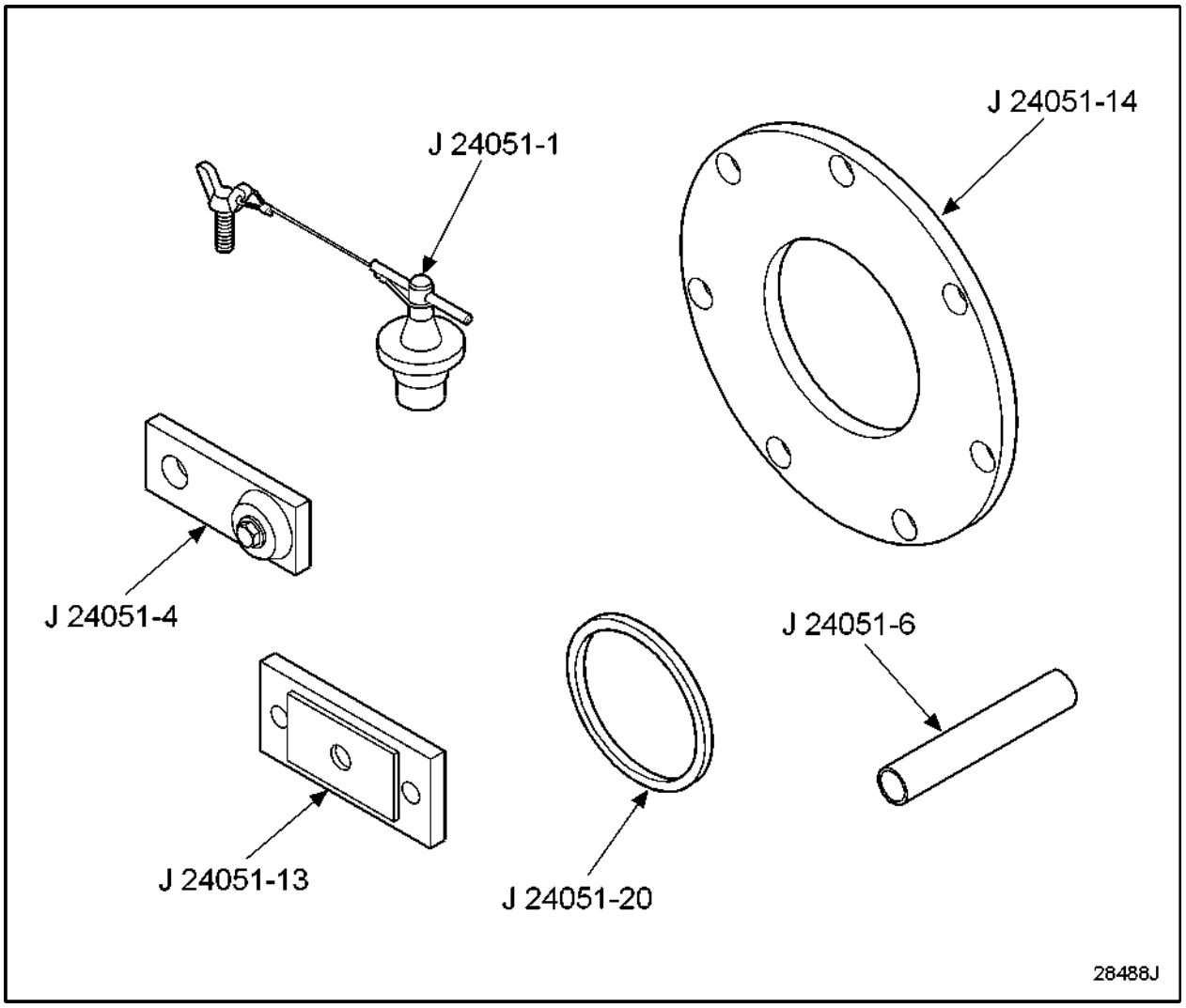


Figure 1085 Block Pressure Test Kit,J 24051–B

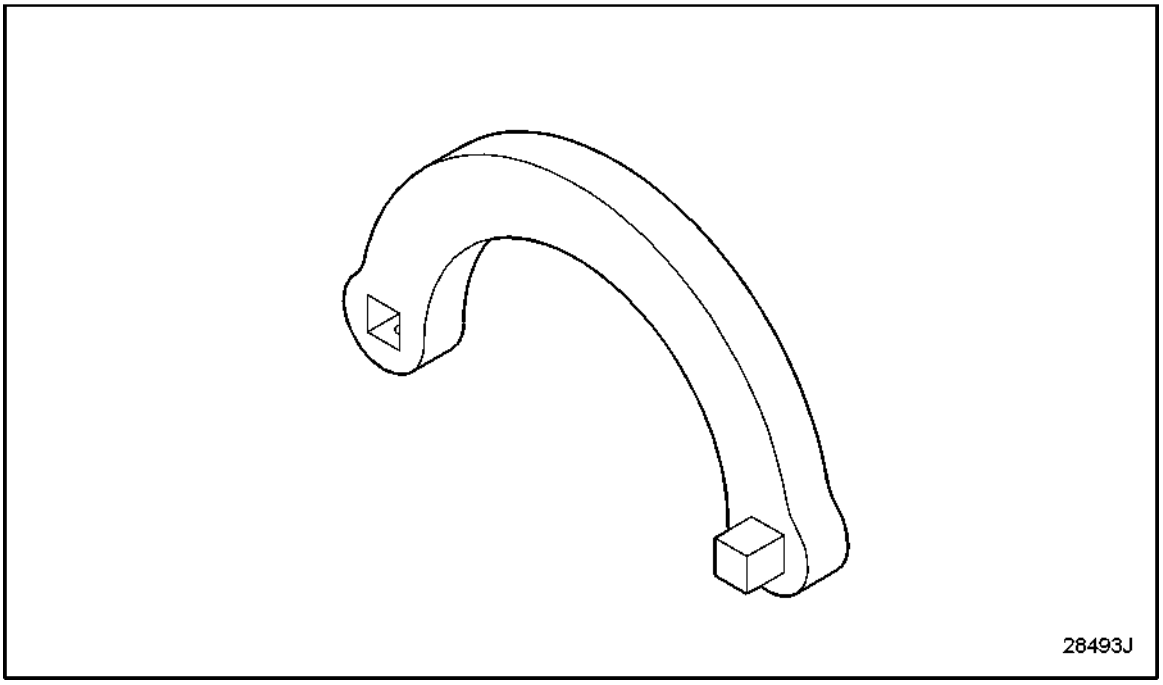


Figure 1086 Block Torque Adapter,J 24533

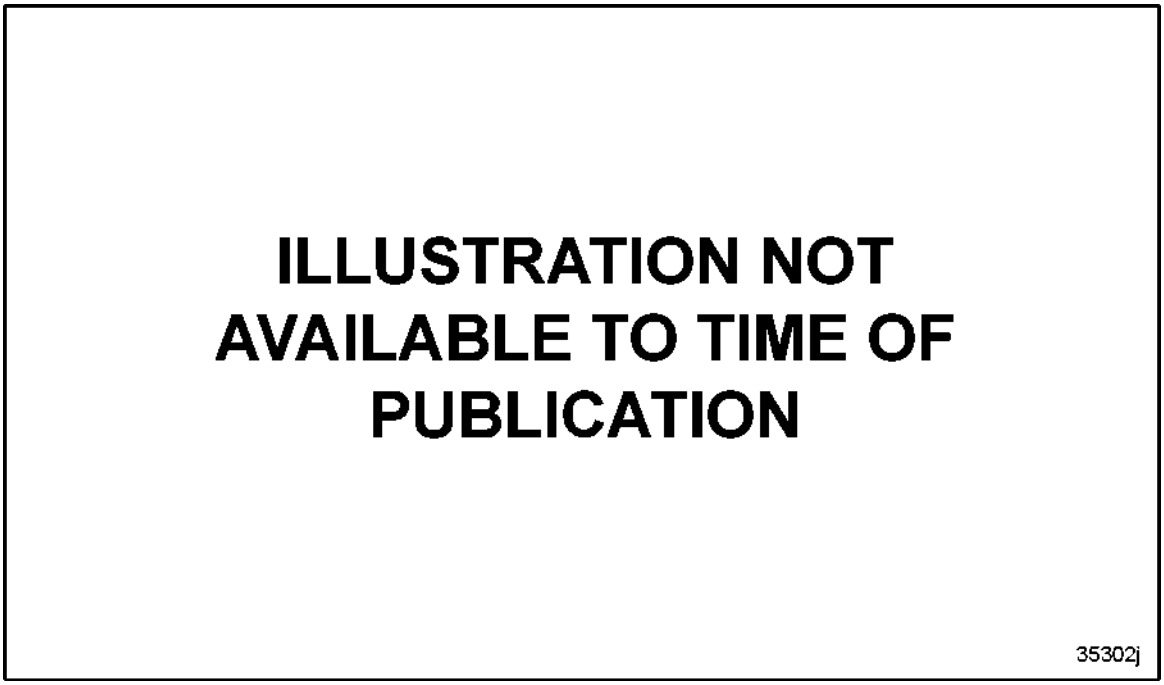


Figure 1087 Counterbore Cutter Plate,PT-2200–30

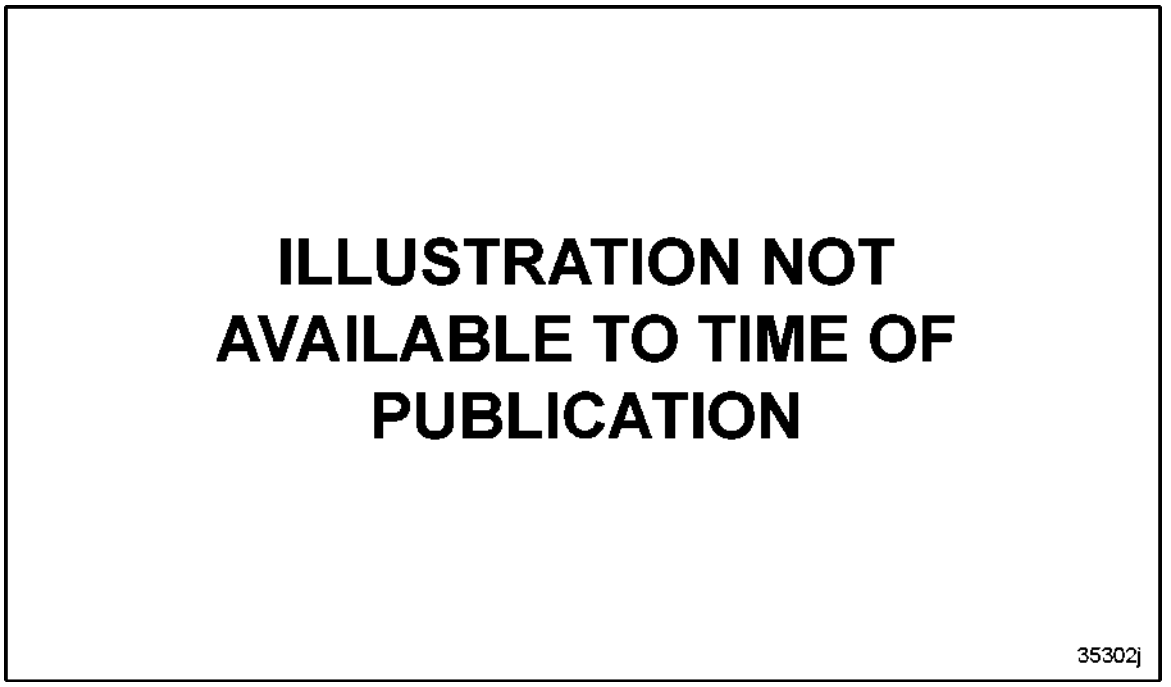


Figure 1088 Counterbore Cutter Plate,PT-2200–31

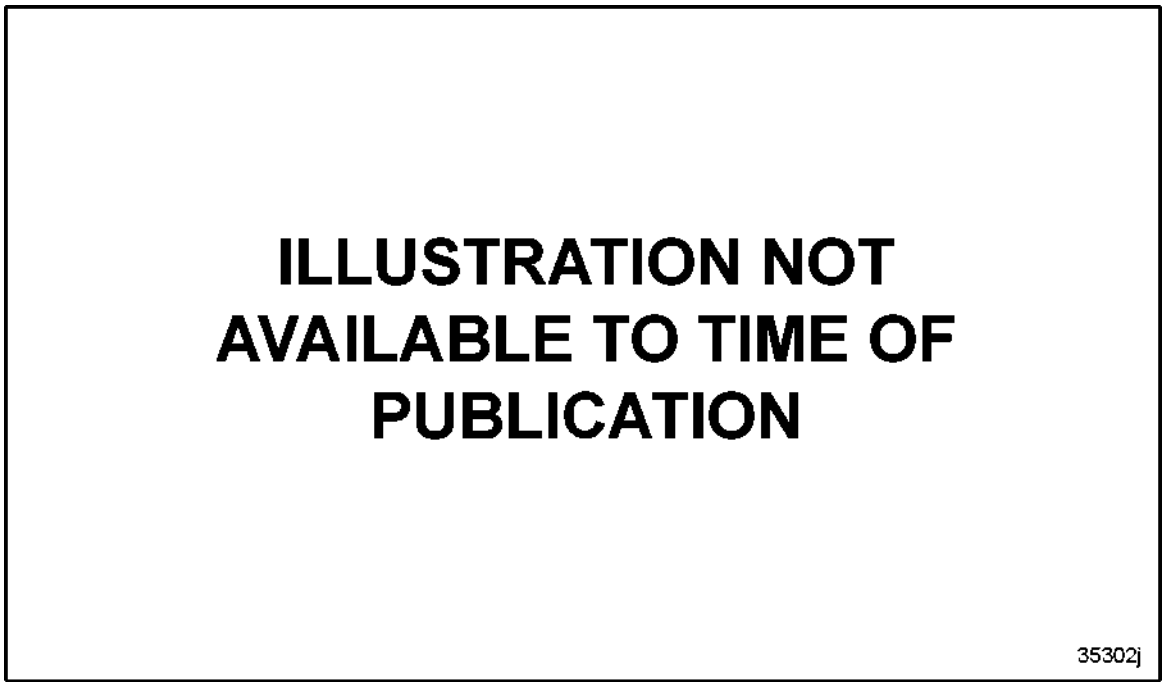


Figure 1089 Counterbore Cutter Pate,PT-2200–37

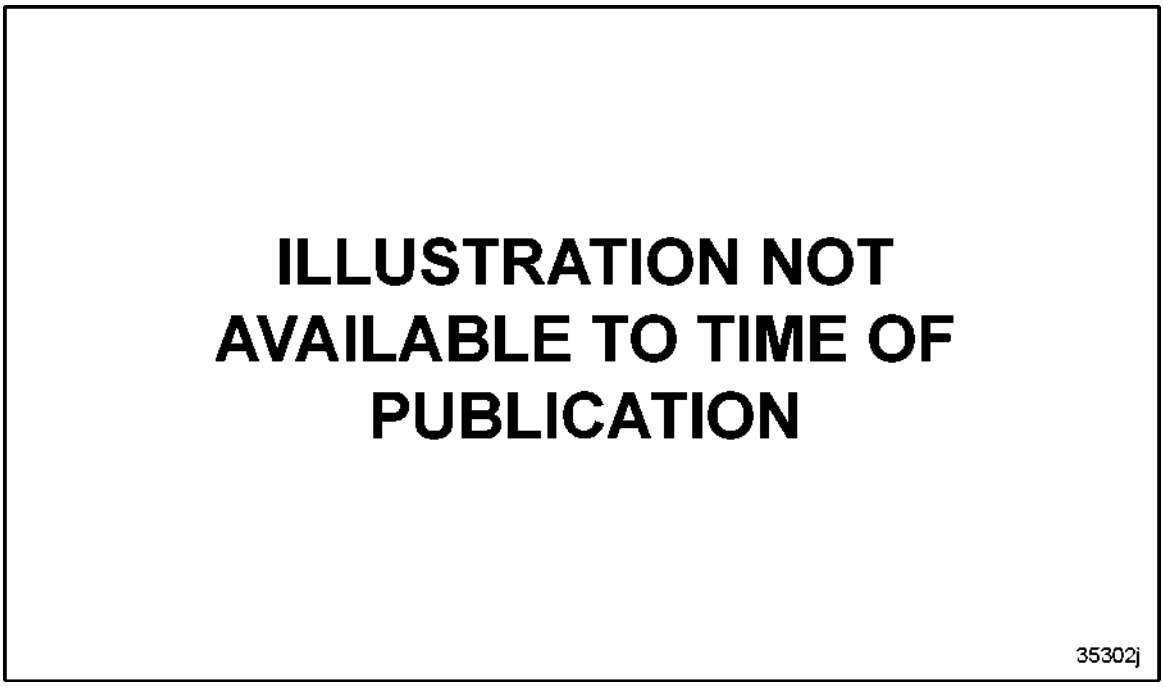


Figure 1090 Counterbore Tool,PT-2250–B

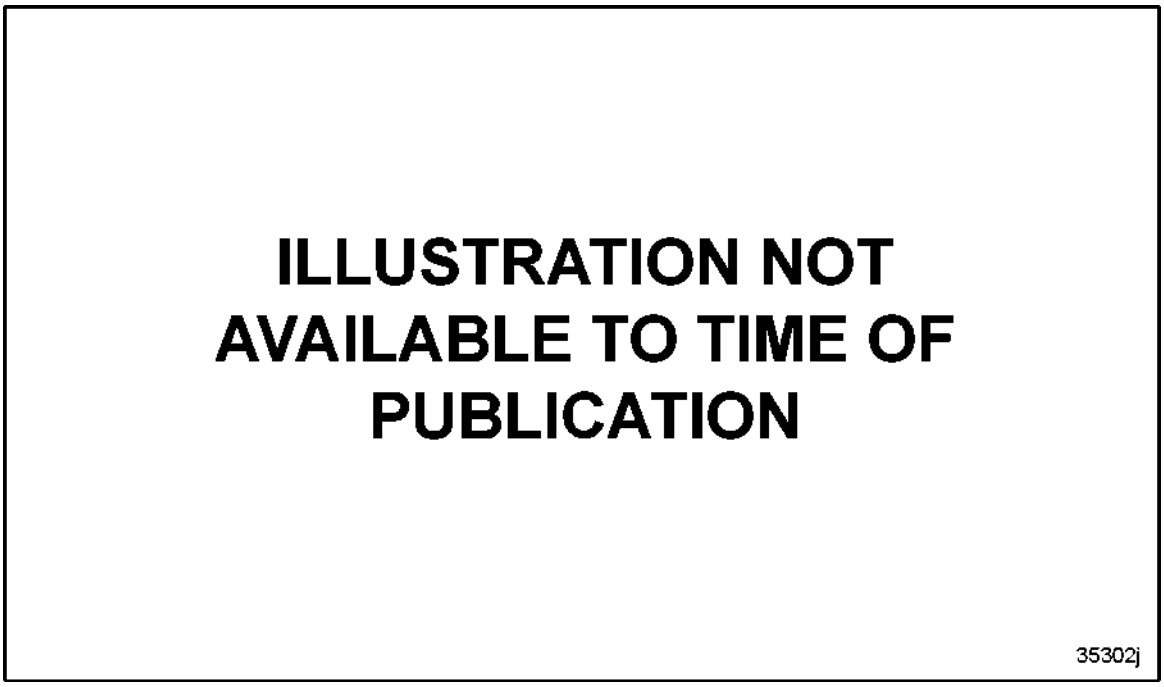


Figure 1091 Cup Plug Installer,J 33420

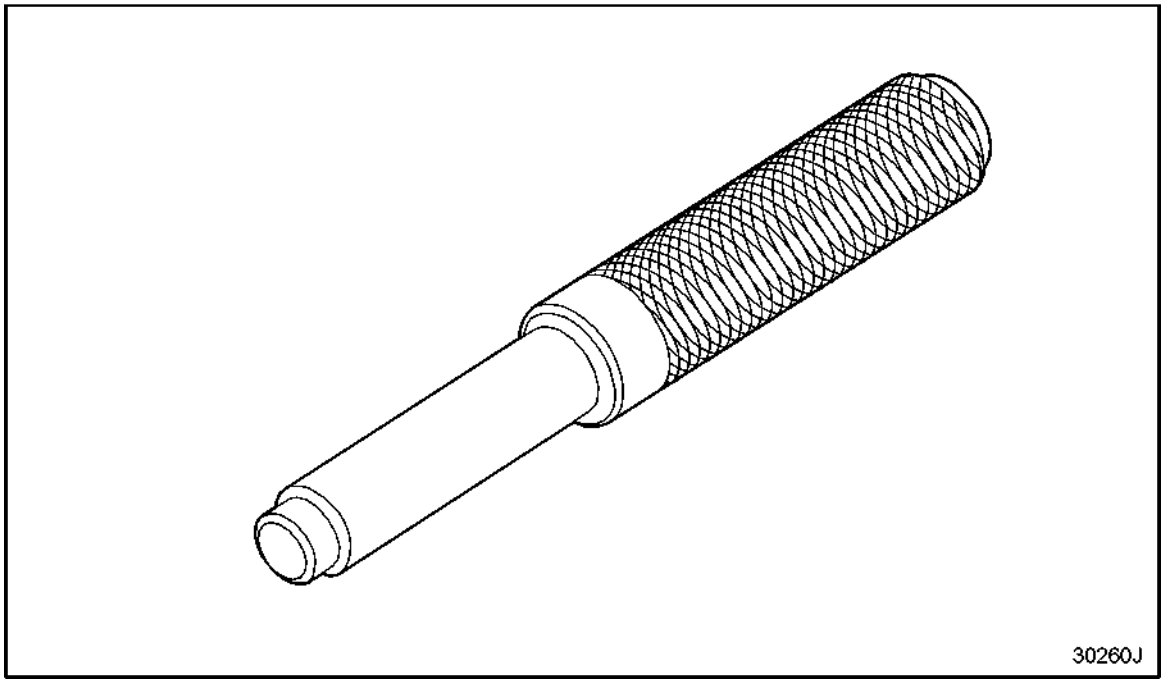


Figure 1092 Cup Plug Installer (requires J 7079–2) ,J 41746

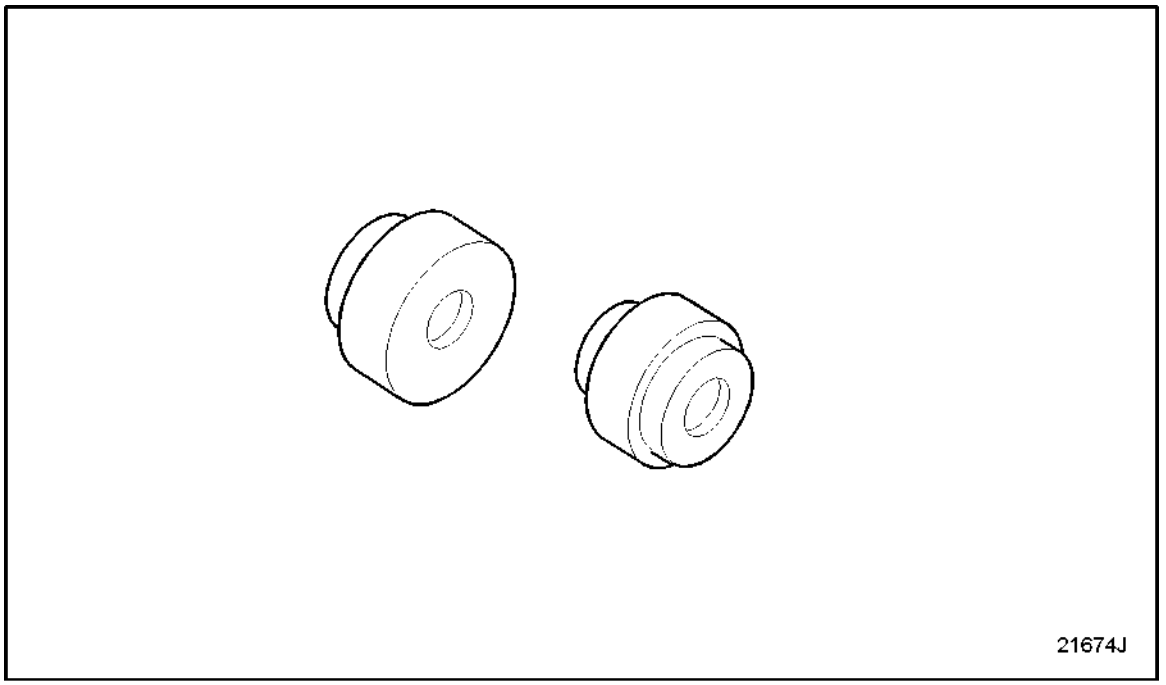


Figure 1093 Cup Plug Installer Set,J 35653

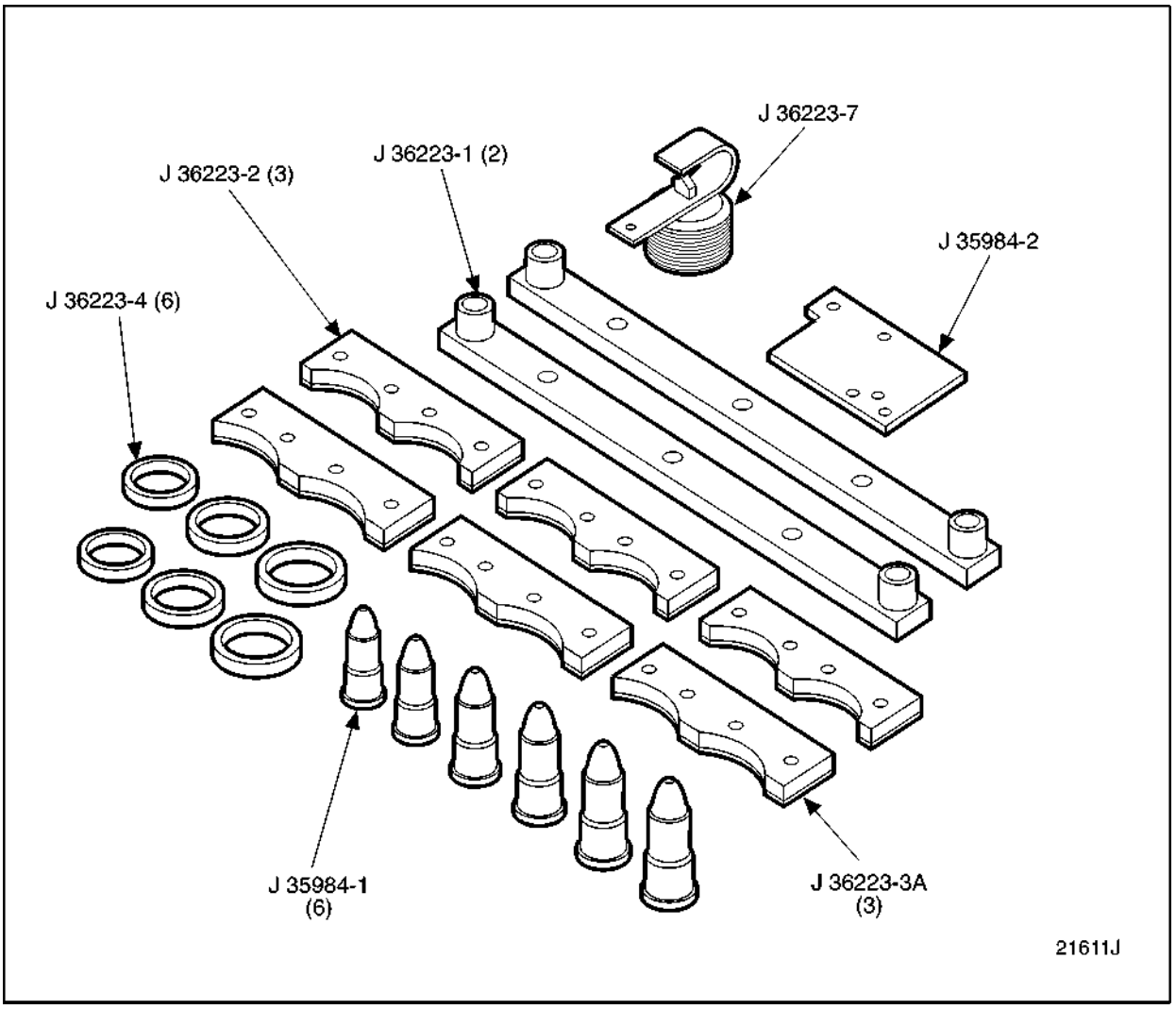


Figure 1094 Cyl Head & Block Pressure Kit,J 36223–D

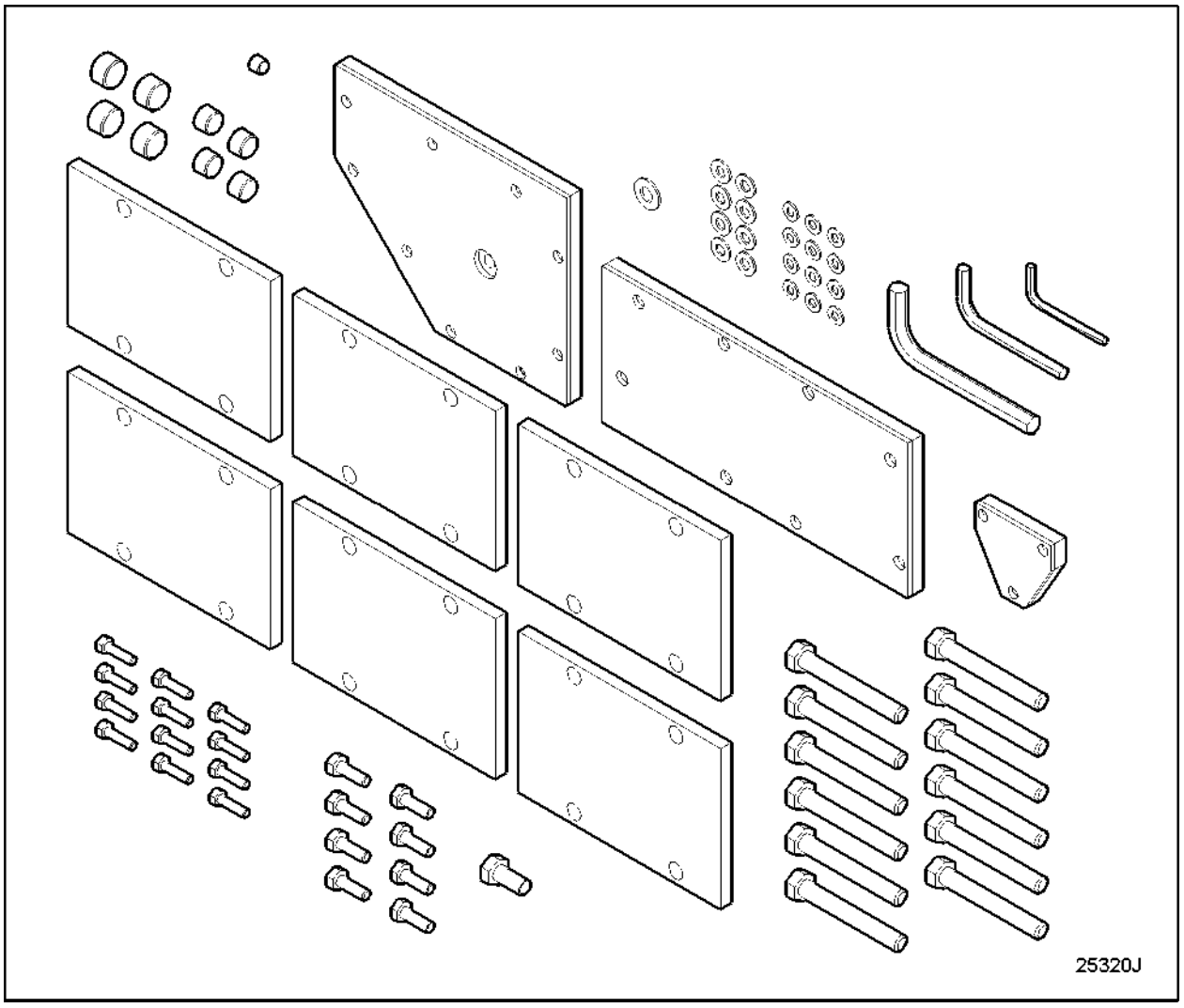


Figure 1095 Cylinder Block Pressure Kit,J 41566

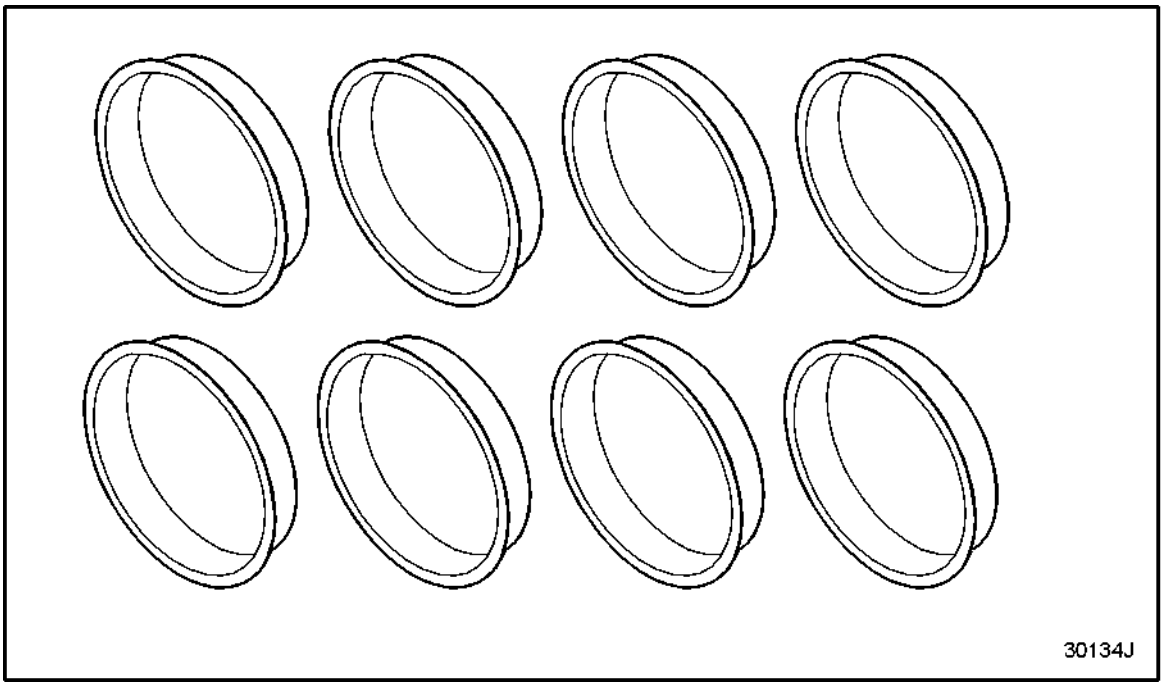


Figure 1096 Cylinder Bore Set,J 34698

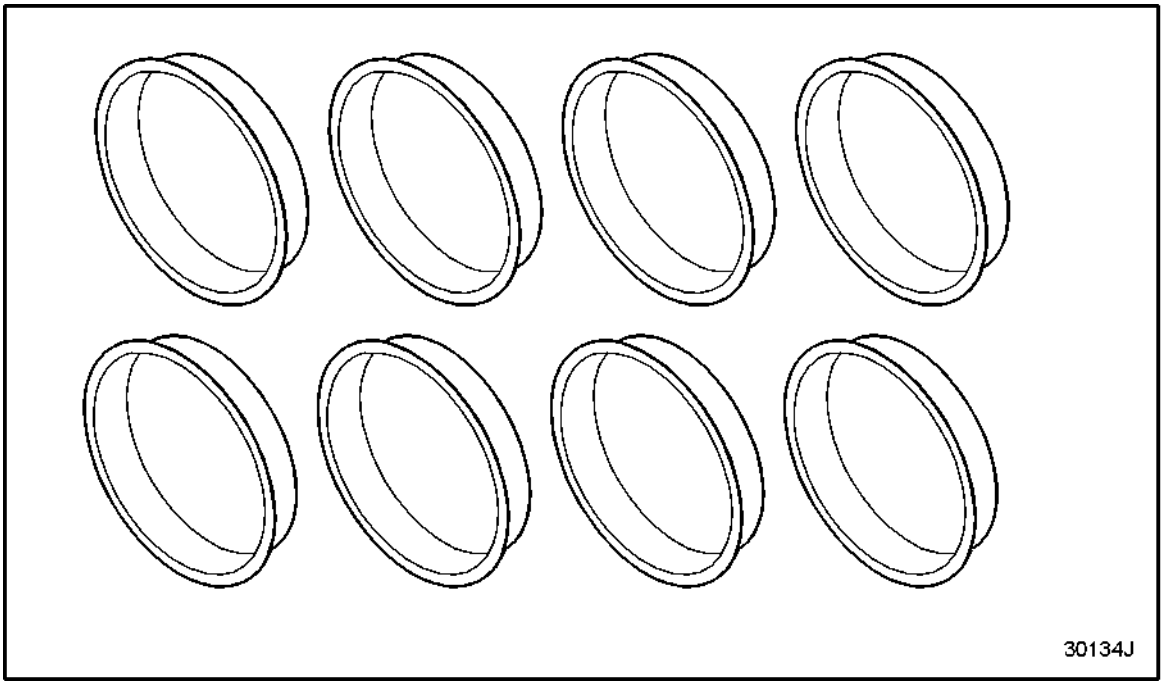


Figure 1097 Cylinder Bore Plug Set,J 34699

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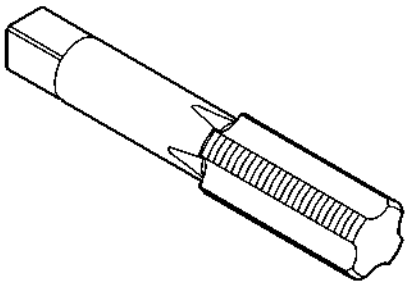
Figure 1098 Cylinder Bore Ridge Reamer,J 24270



29131J

Figure 1099 Cylinder Head Bolt Tap,J 25384

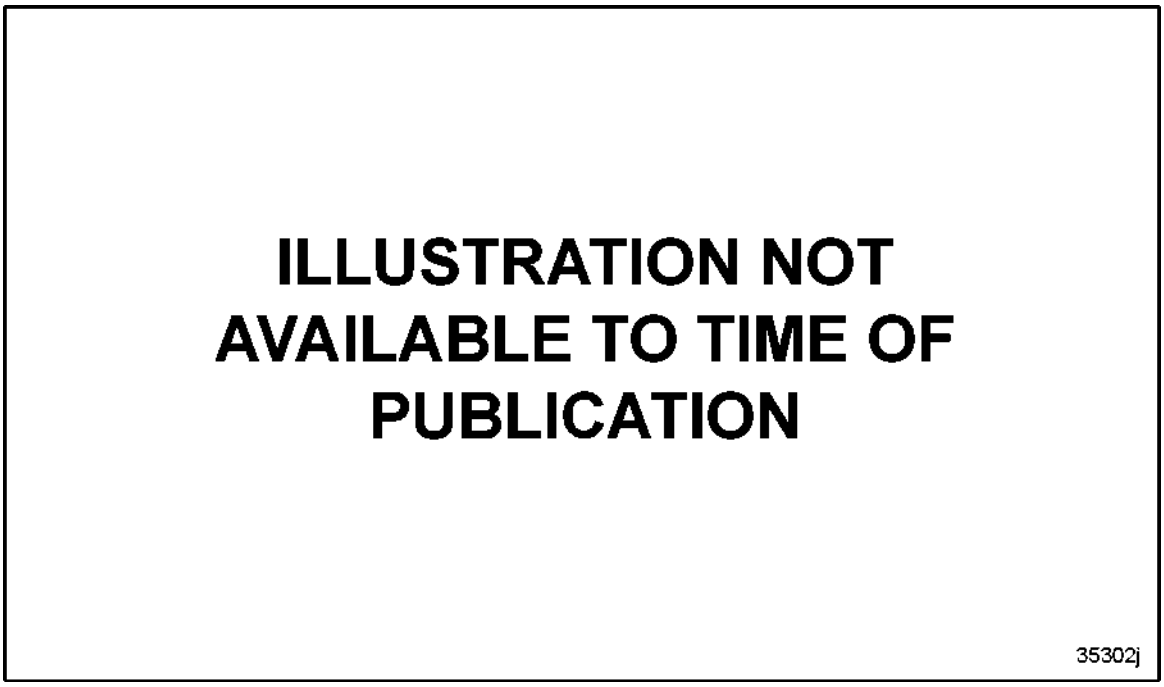


Figure 1100 Cylinder Head Bolt Tap,PT-2950

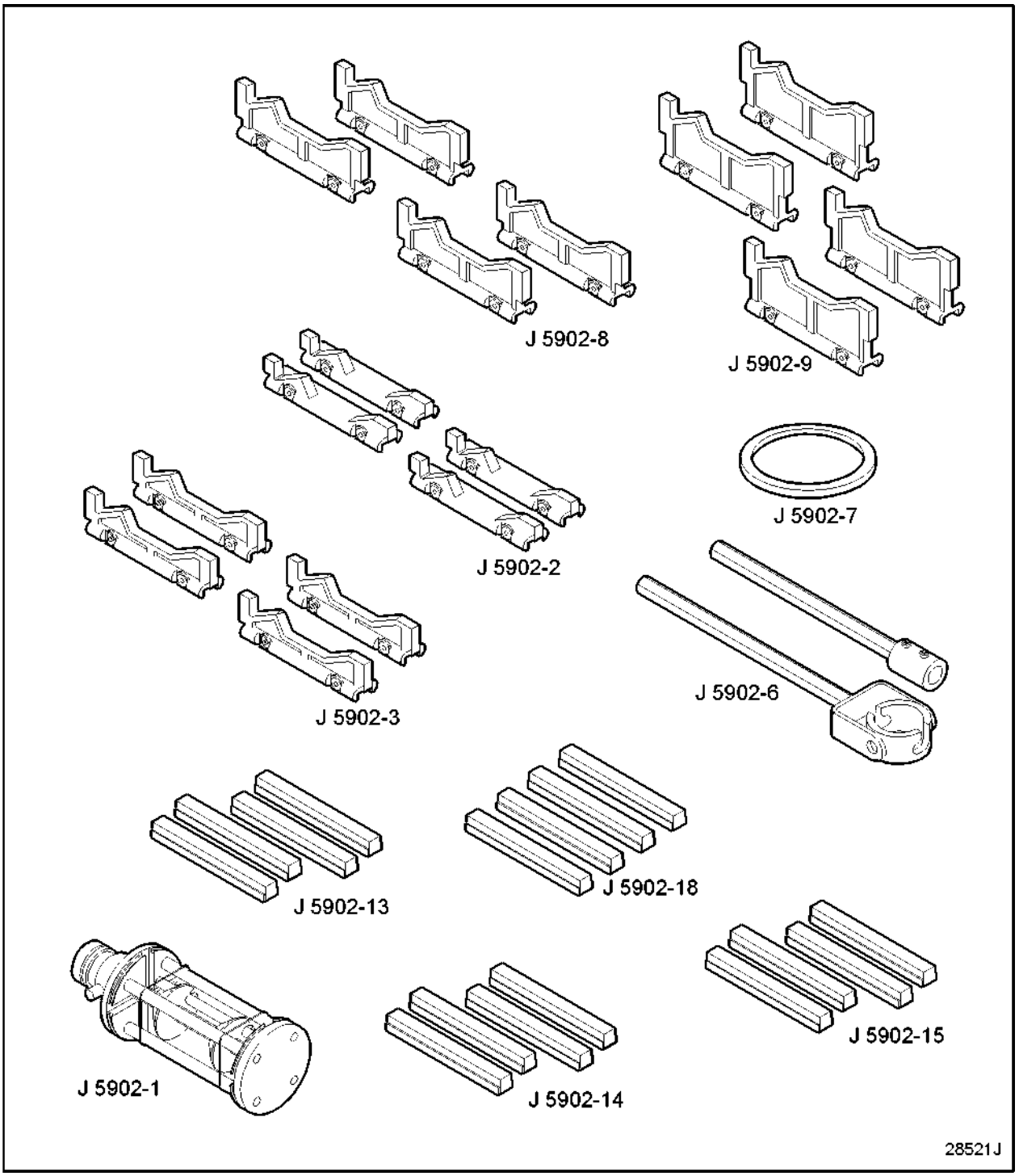


Figure 1101 Cylinder Home & Glaze Breaker,J 5902–01

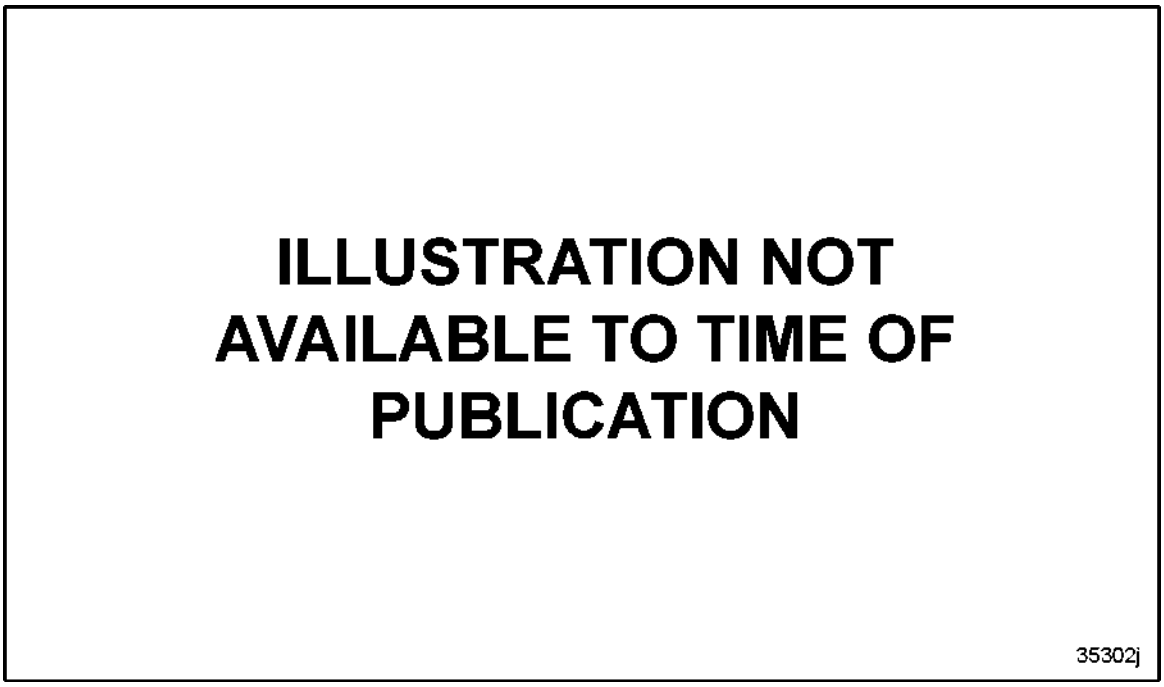


Figure 1102 Cylinder Hone Stones, J 5902–18

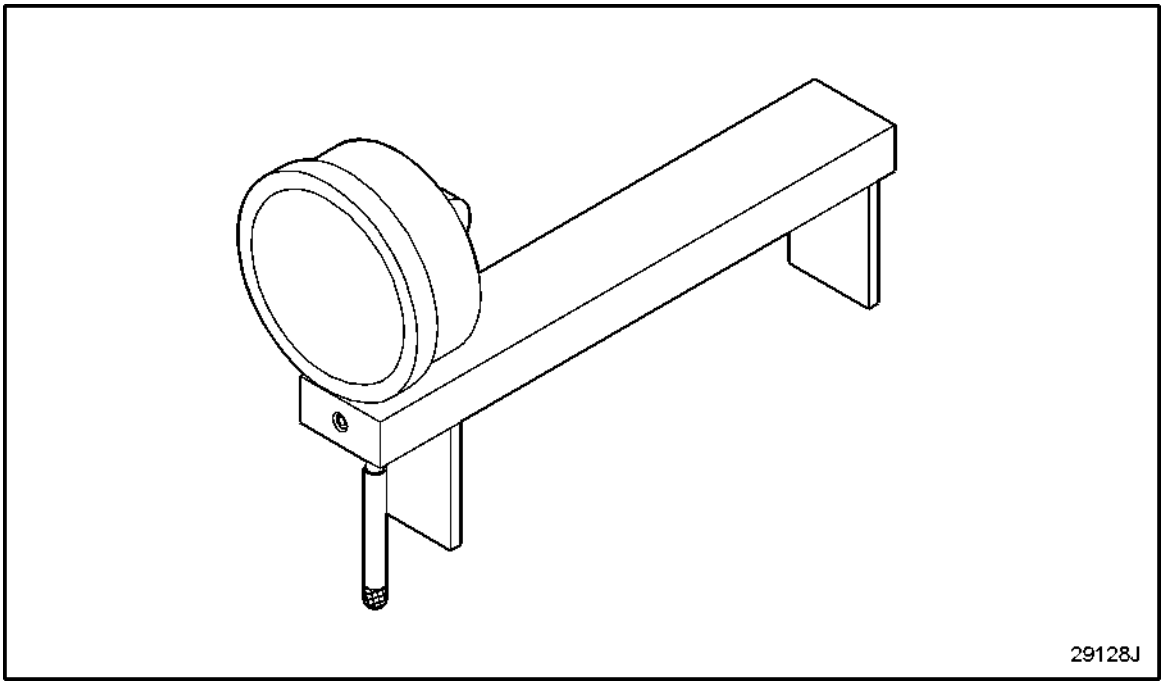


Figure 1103 Cylinder Liner Depth Gage, J 24898

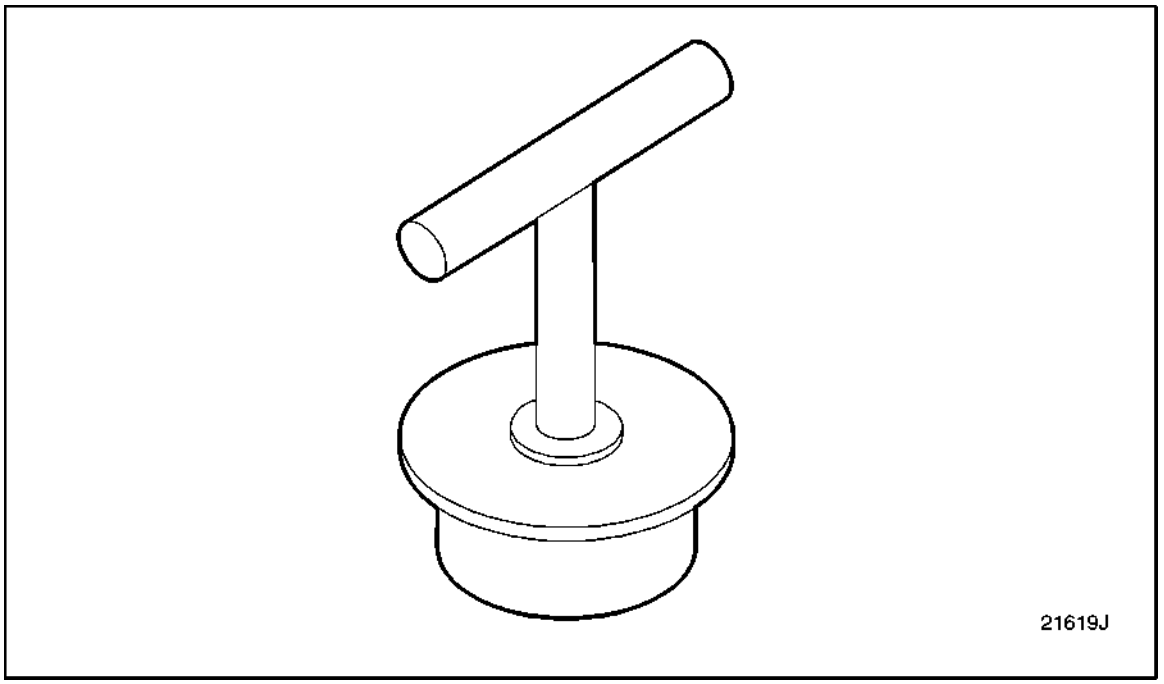


Figure 1104 Cylinder Liner Lifter,J 36398

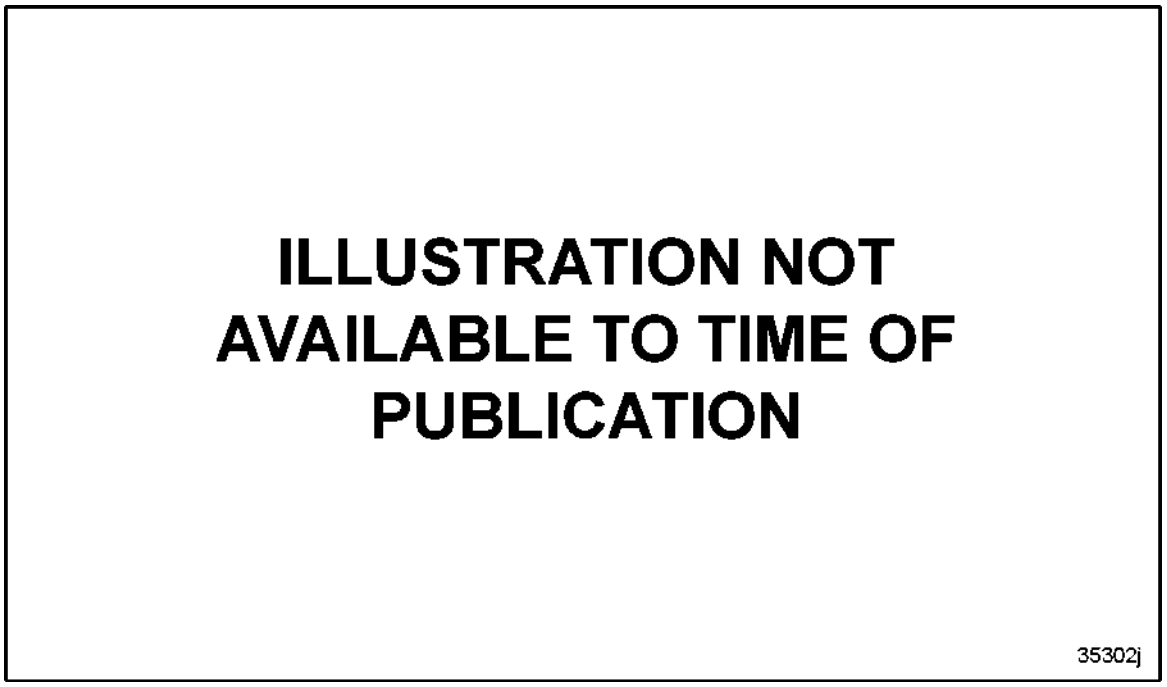


Figure 1105 Deck Checker,PT-5075–B

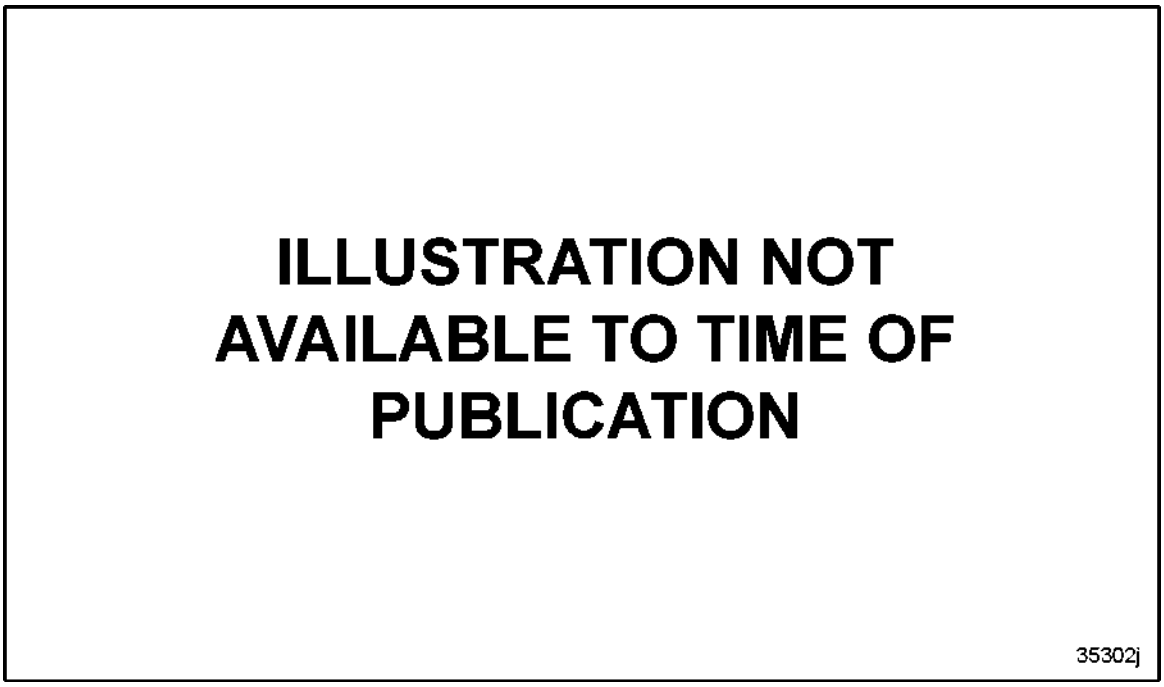


Figure 1106 Deck Checker Conversion, PT-5071

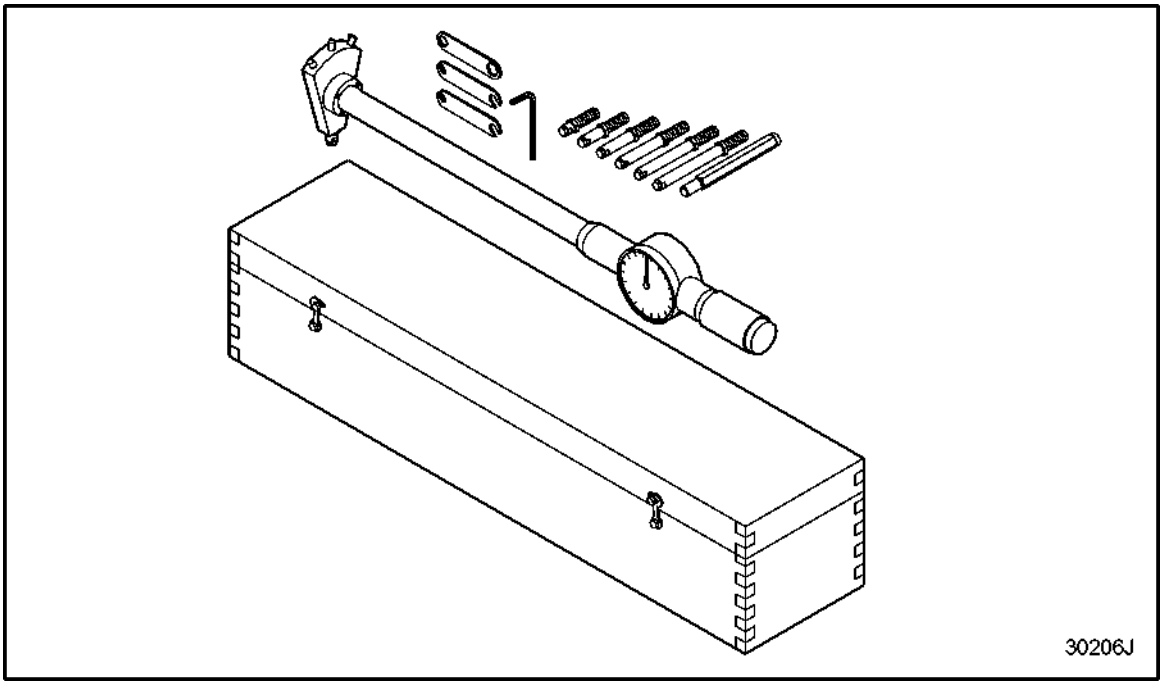


Figure 1107 Dial Bore Gage (3 3/32-8" Dia)J 5347-B

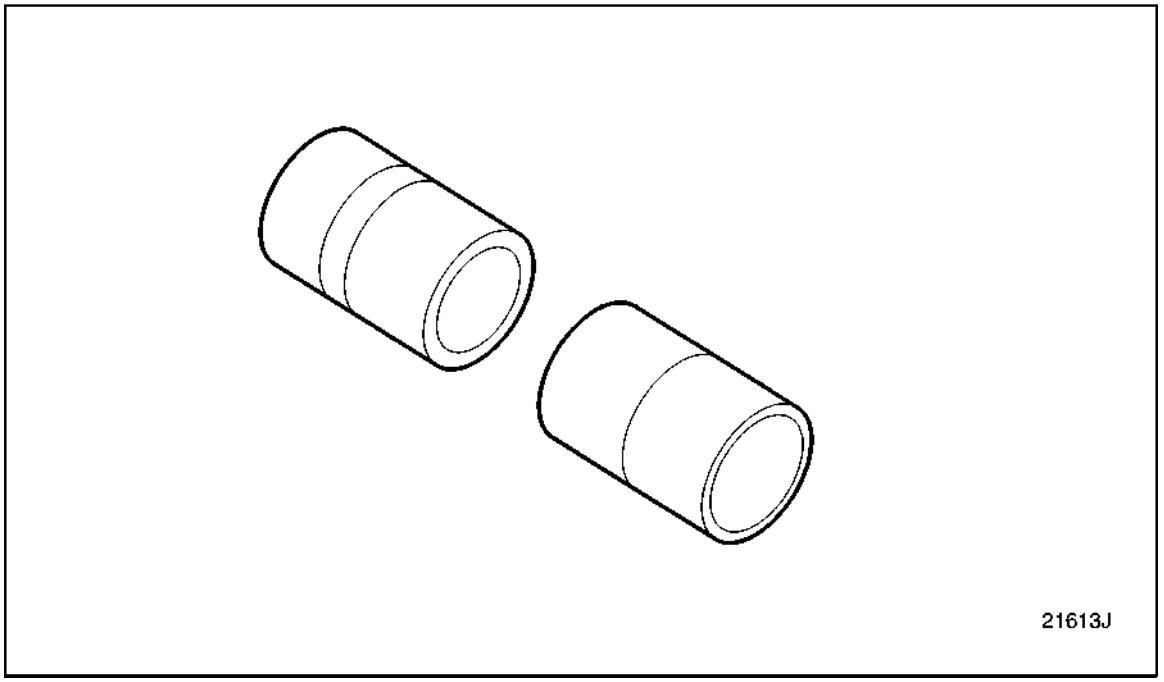


Figure 1108 Dowel Installer Set,J 36224

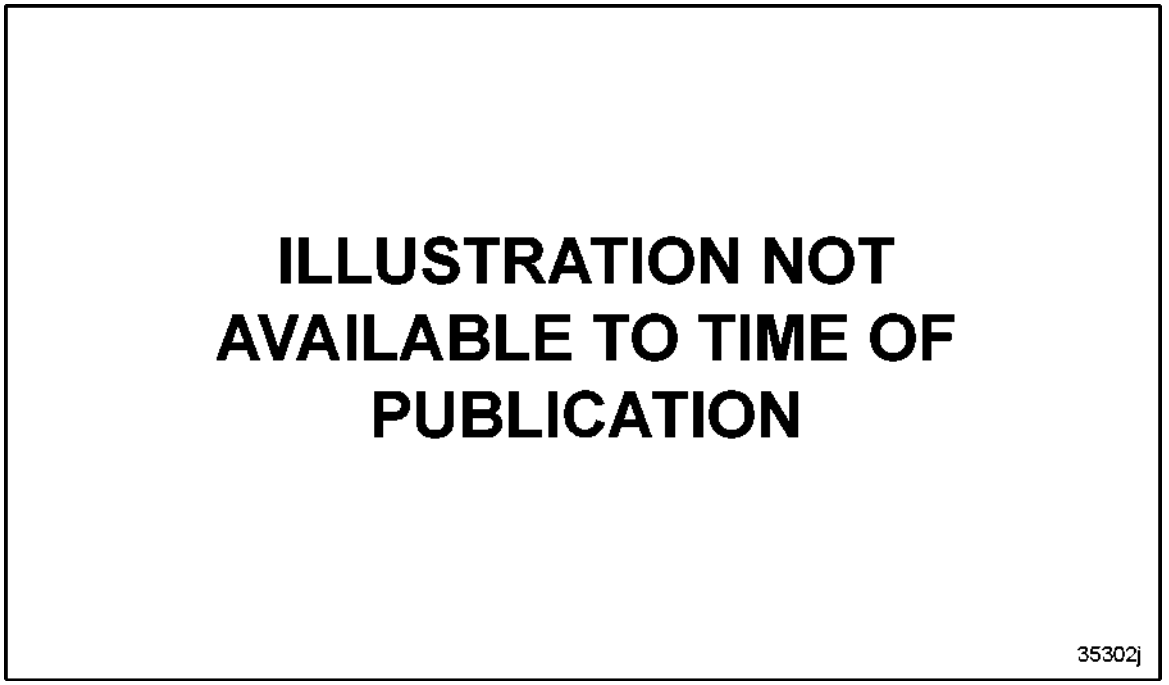


Figure 1109 Eng Lift Hook (Use W/3 PT Spreader)J 41171

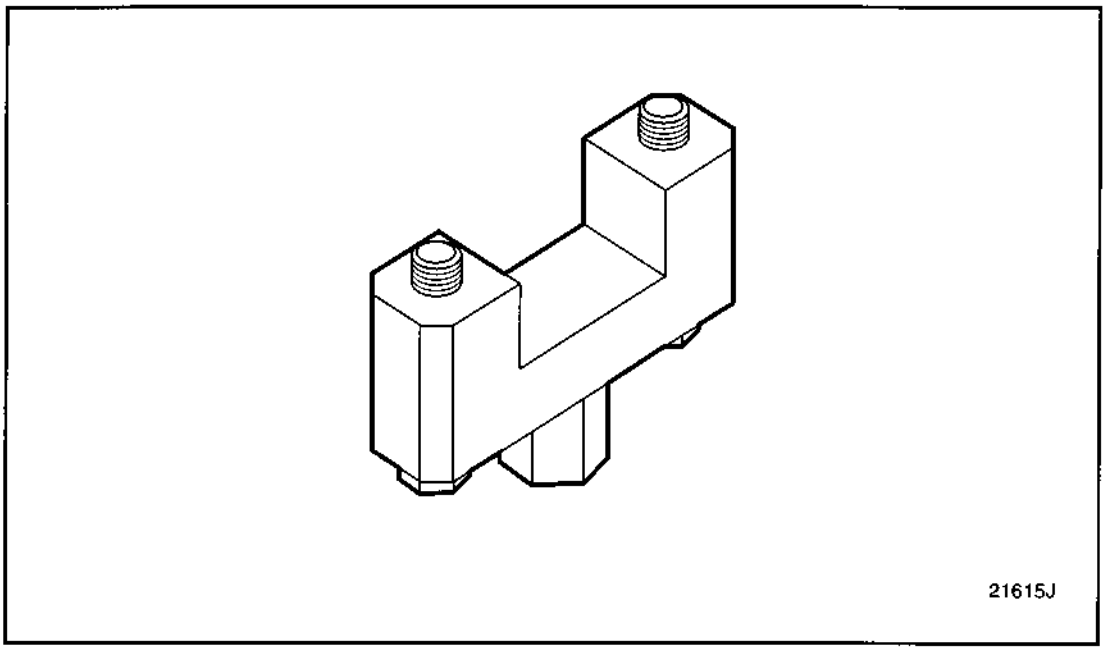


Figure 1110 Engine Barring Tool,J 36237

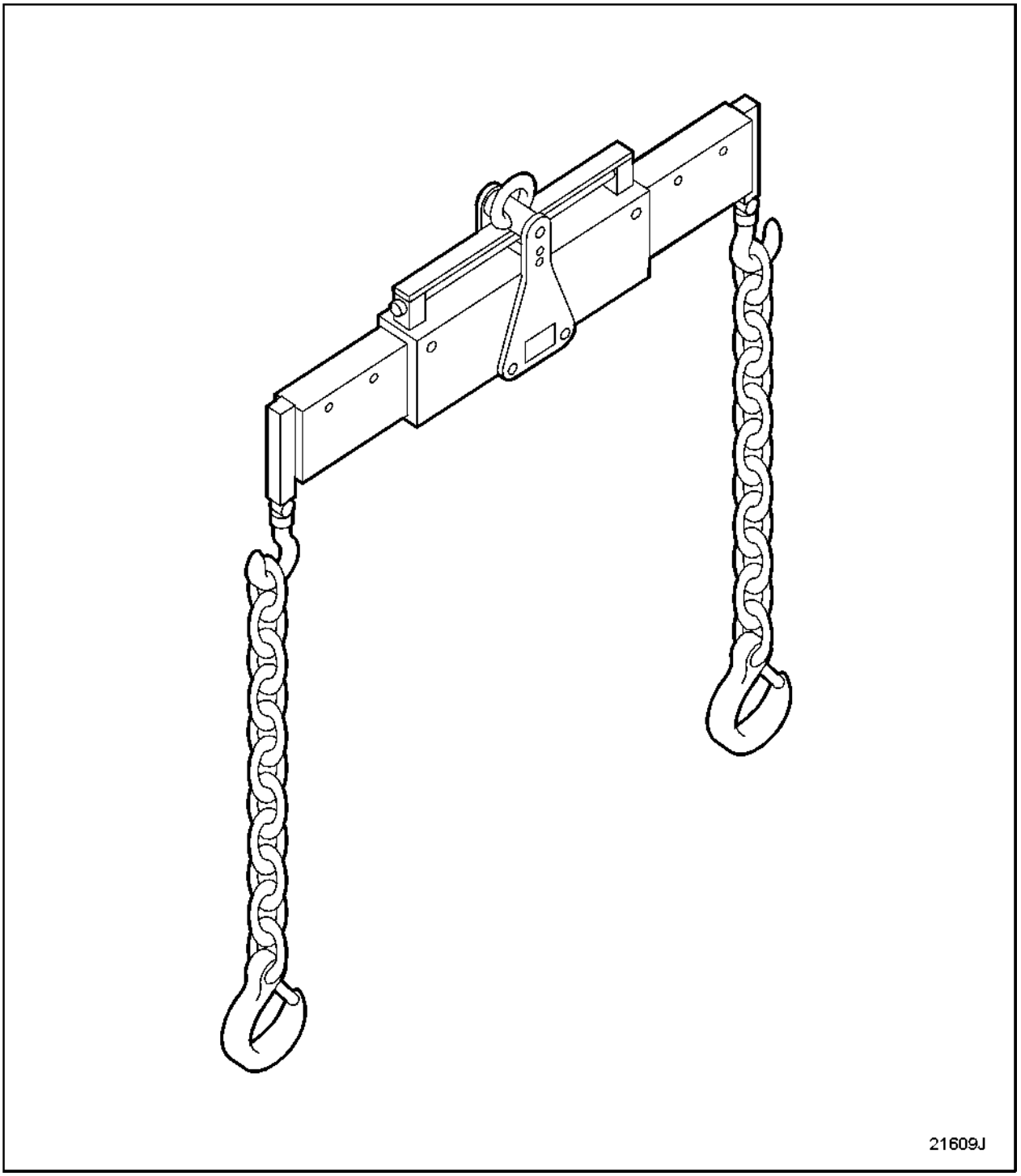


Figure 1111 Engine Lifting Bracket,J 36130–812

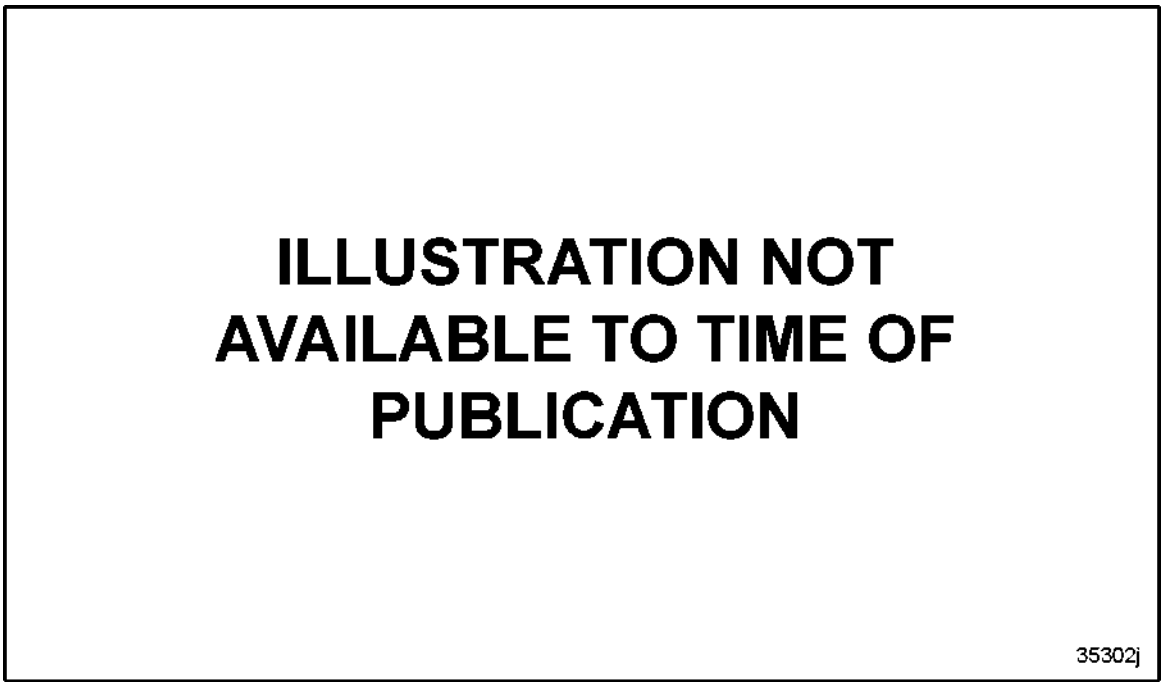


Figure 1112 Engine Stand Adaptor Plate, J 39298–A

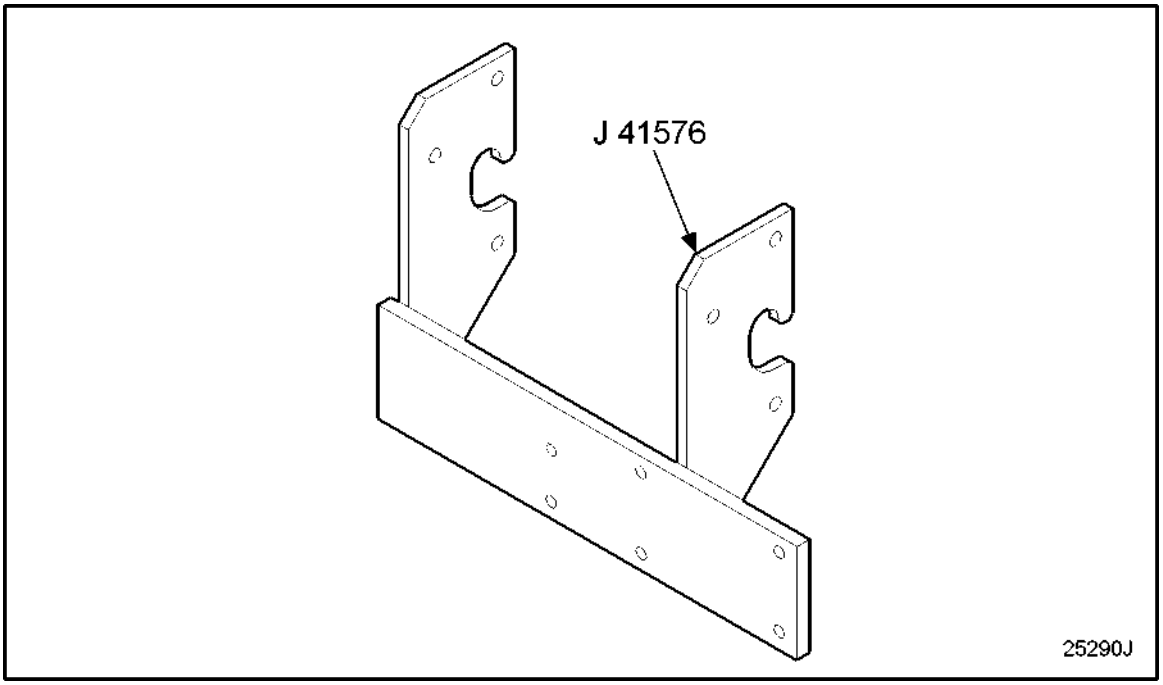


Figure 1113 Engine Stand Adapter Plate, J 41576

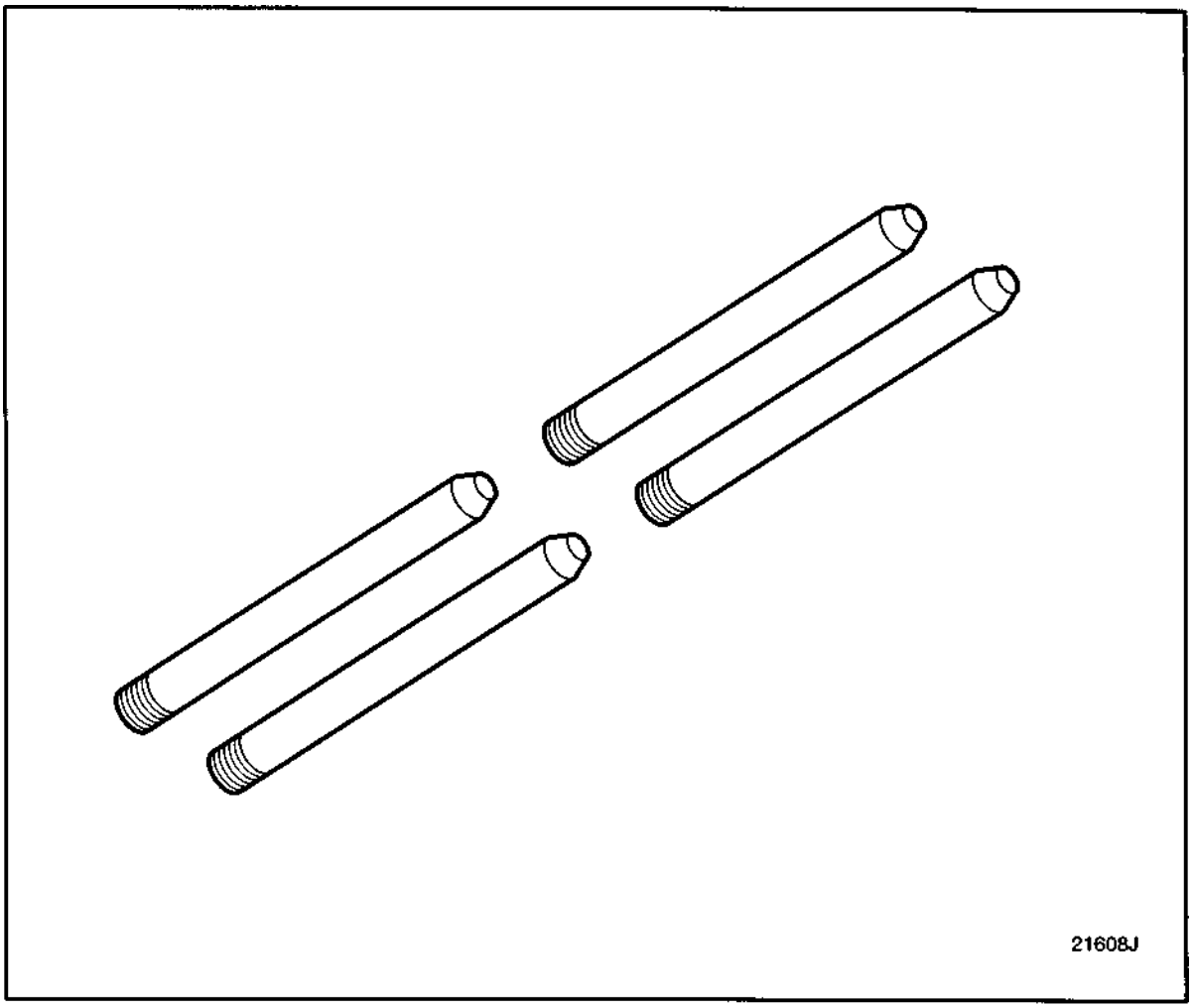


Figure 1114 Exhaust Manifold Guide Studs,J 36107

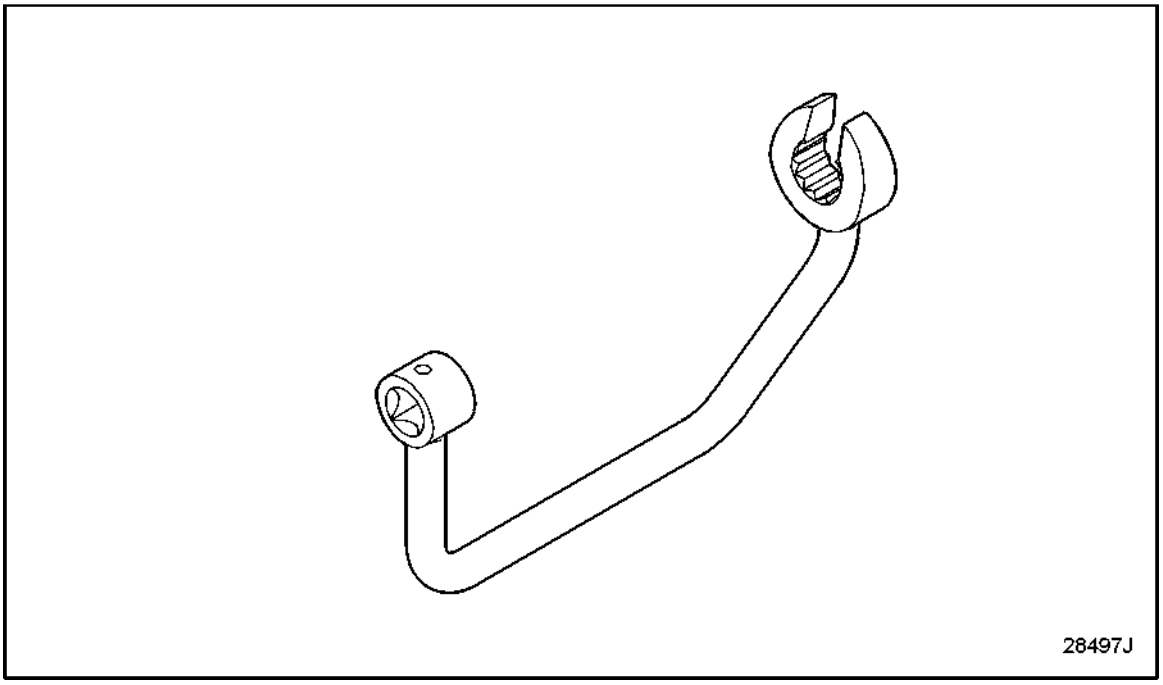


Figure 1115 Exhaust Manifest Nut Wrench.J 26816–A

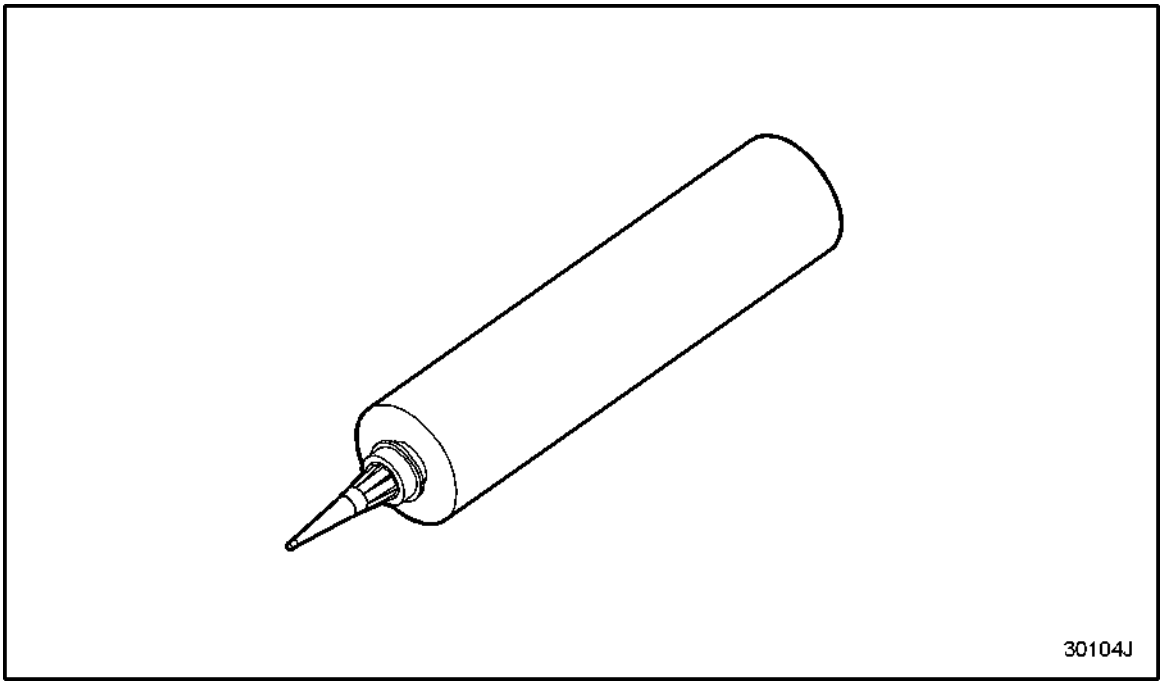


Figure 1116 Gasket Eliminator (Loctite),PT-7276

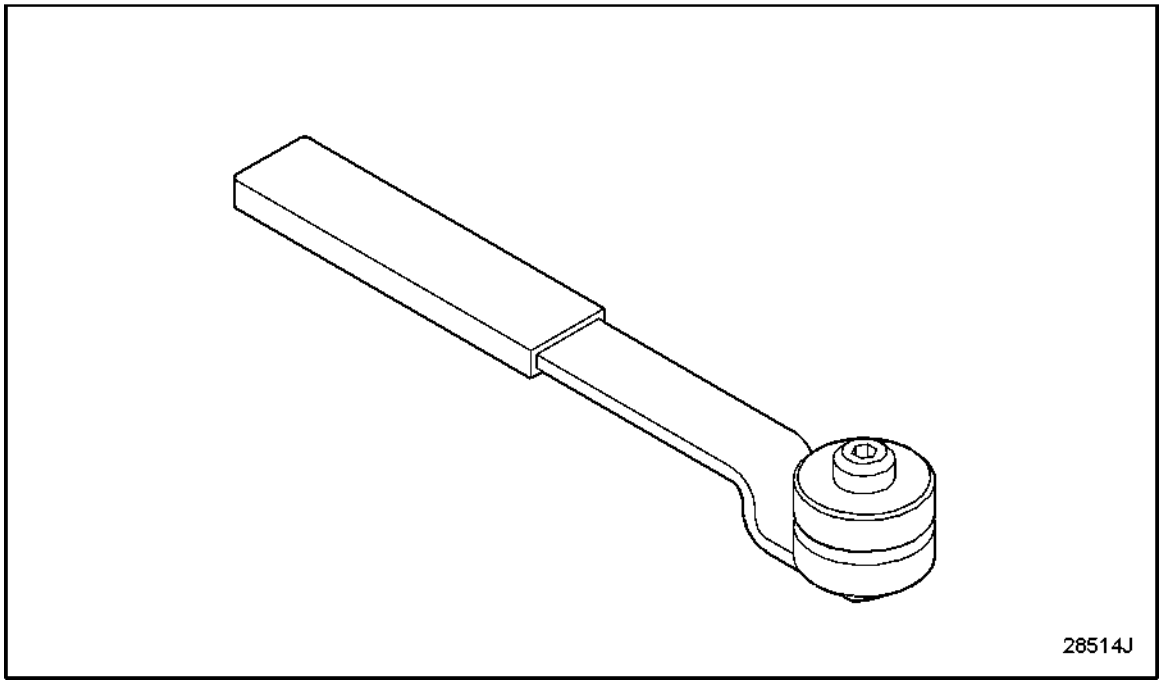


Figure 1117 Inter Block Seal Installer,J 38894

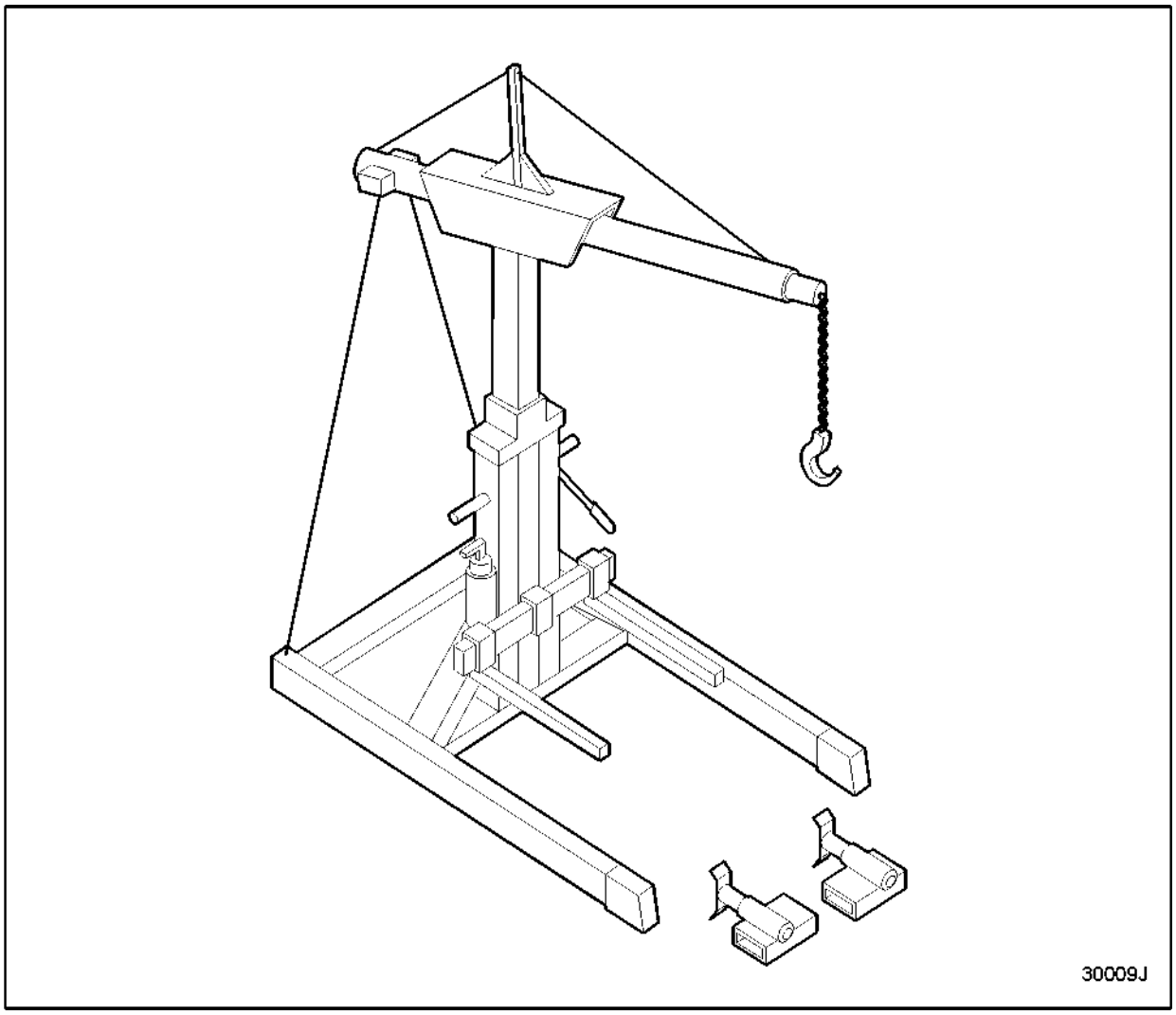


Figure 1118 Jib Crane (4000 LB Max Lifting Cap,J 33050–A

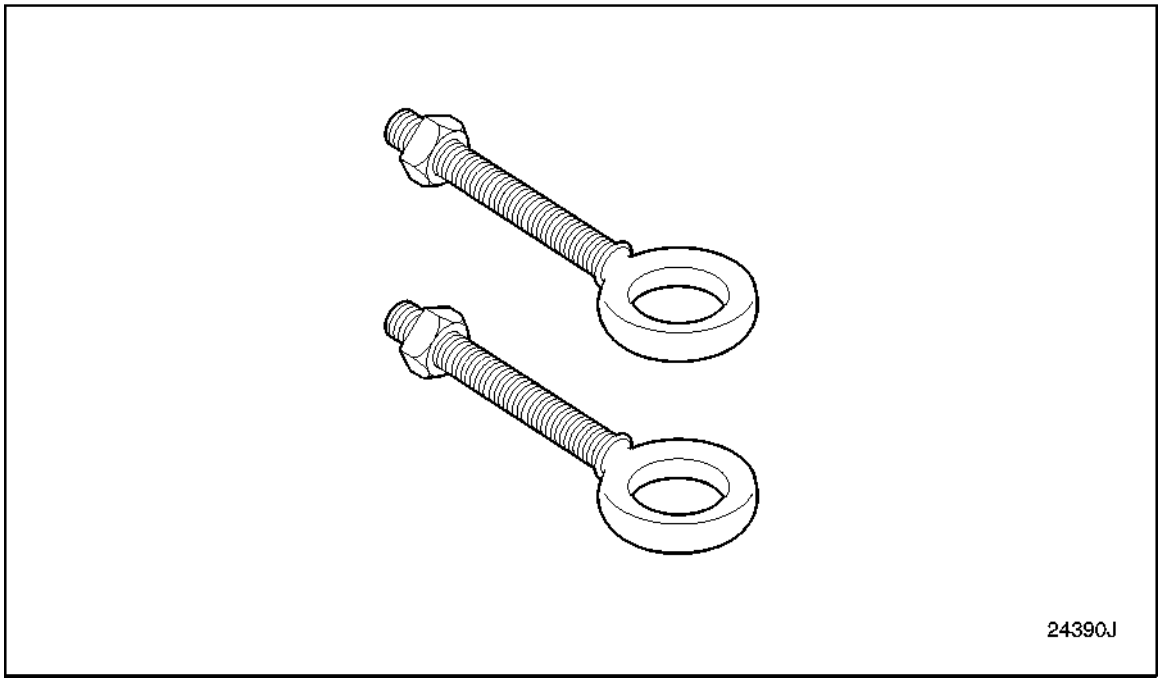


Figure 1119 Lifting Eye Bolts,J 41564

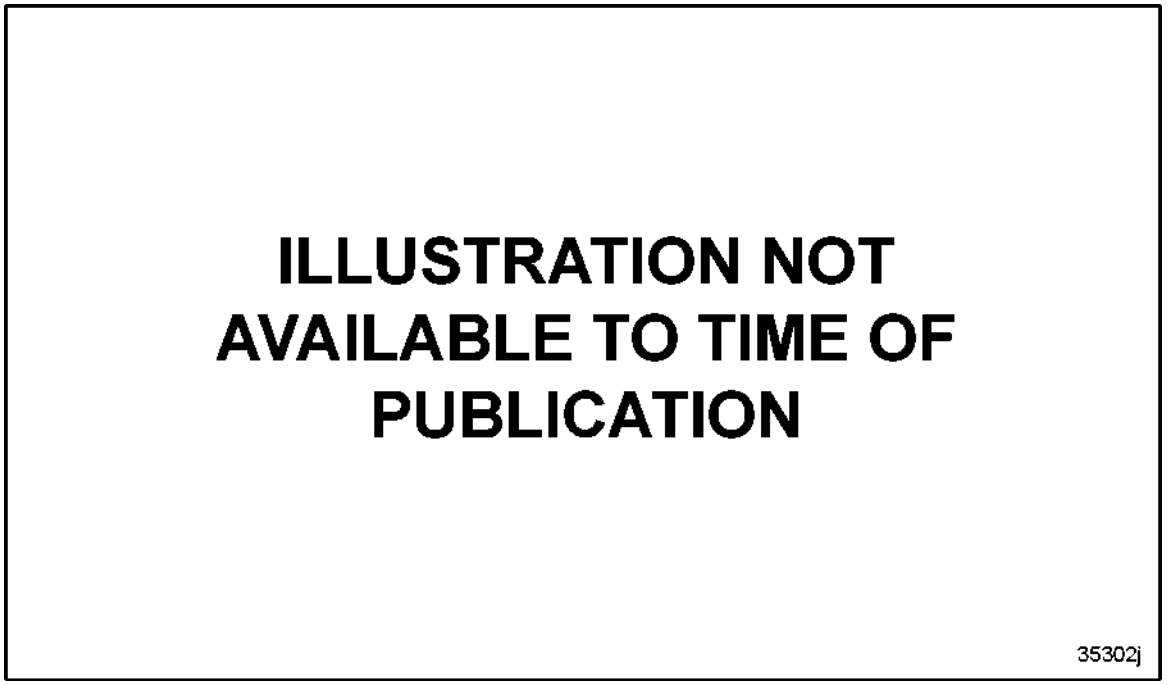


Figure 1120 Line Boring Complete Kit,J 41060

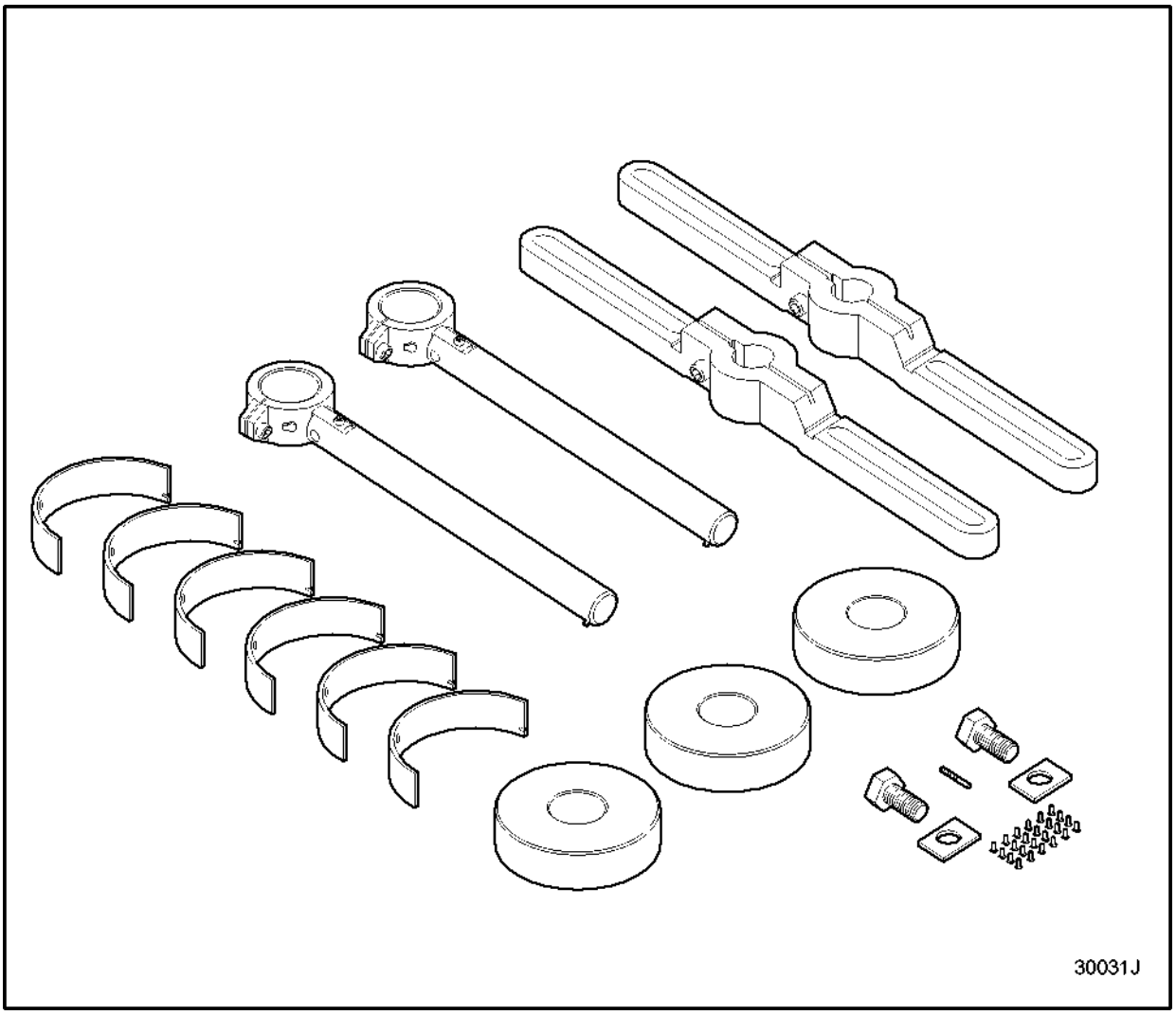


Figure 1121 Line Boring Main BRG-Adapter Kit,J 41061

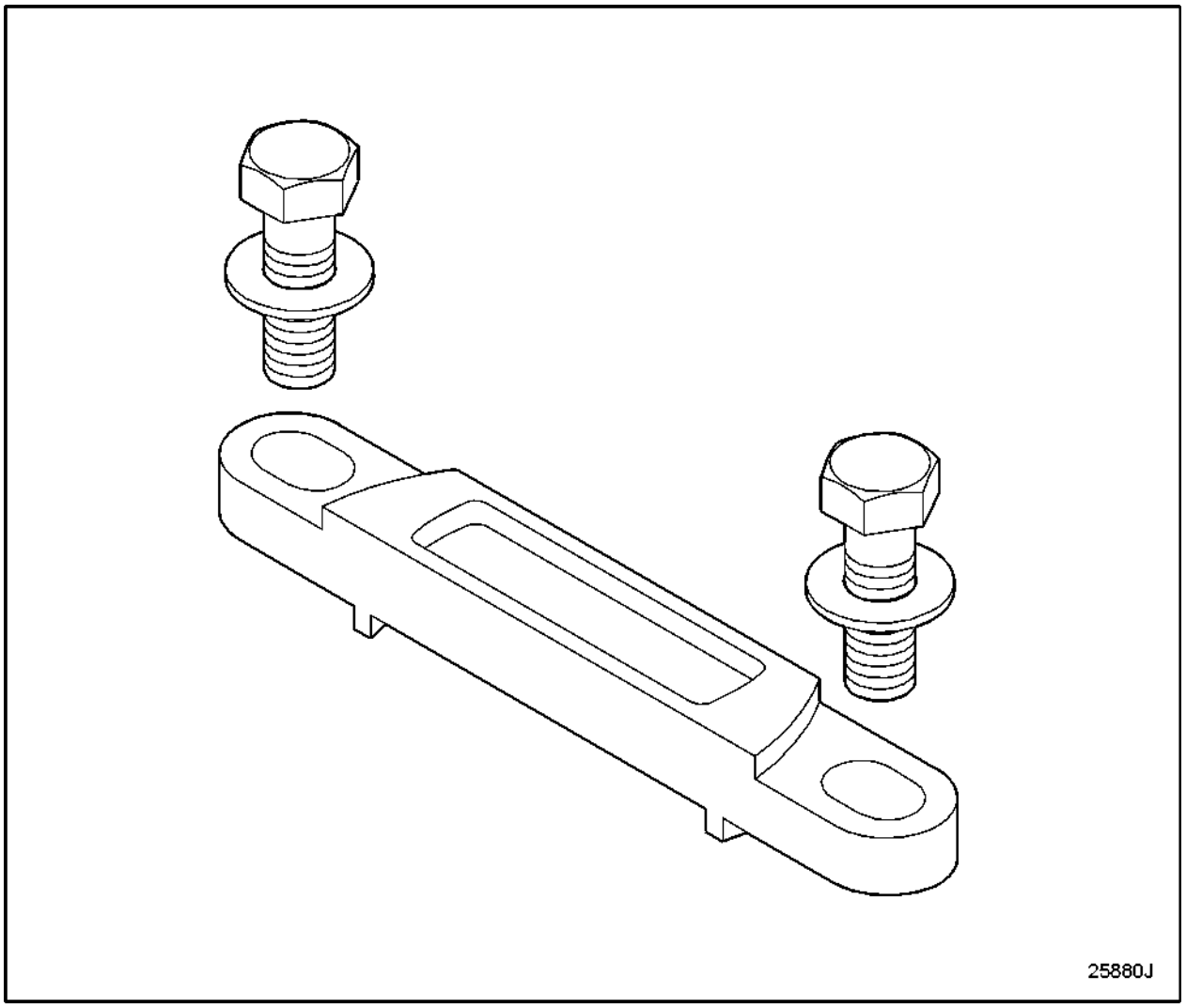


Figure 1122 Liner Hold Clamps Down,J 21793–B

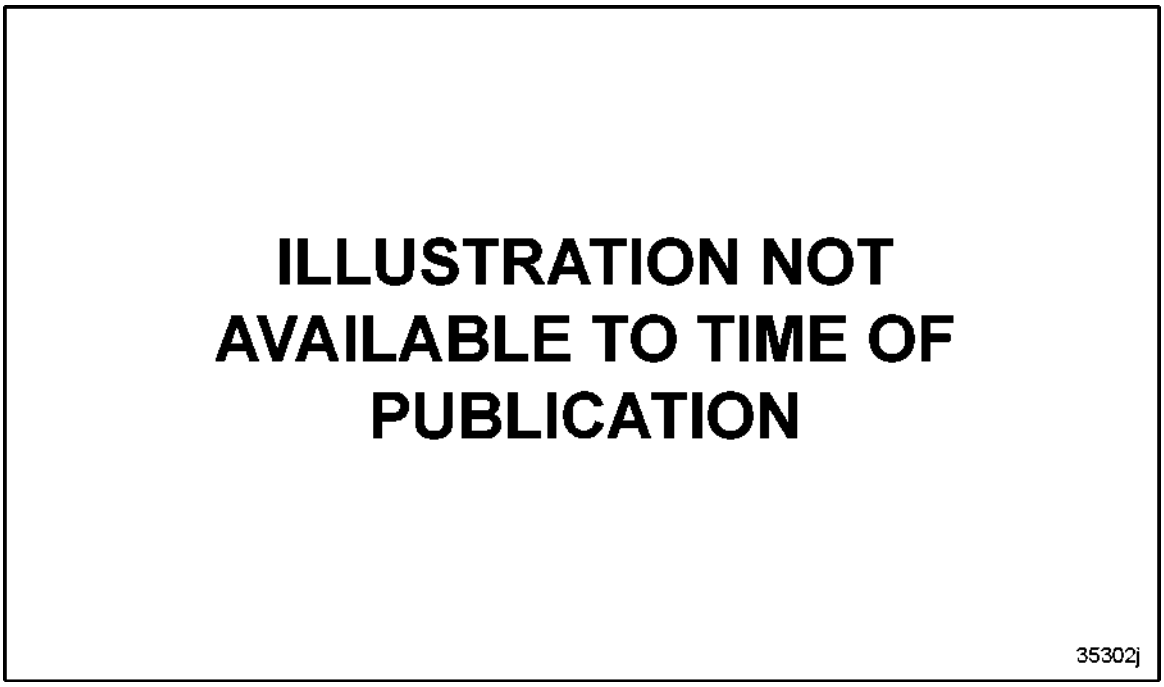


Figure 1123 Liner Hold Down Clamps, J 24565–02

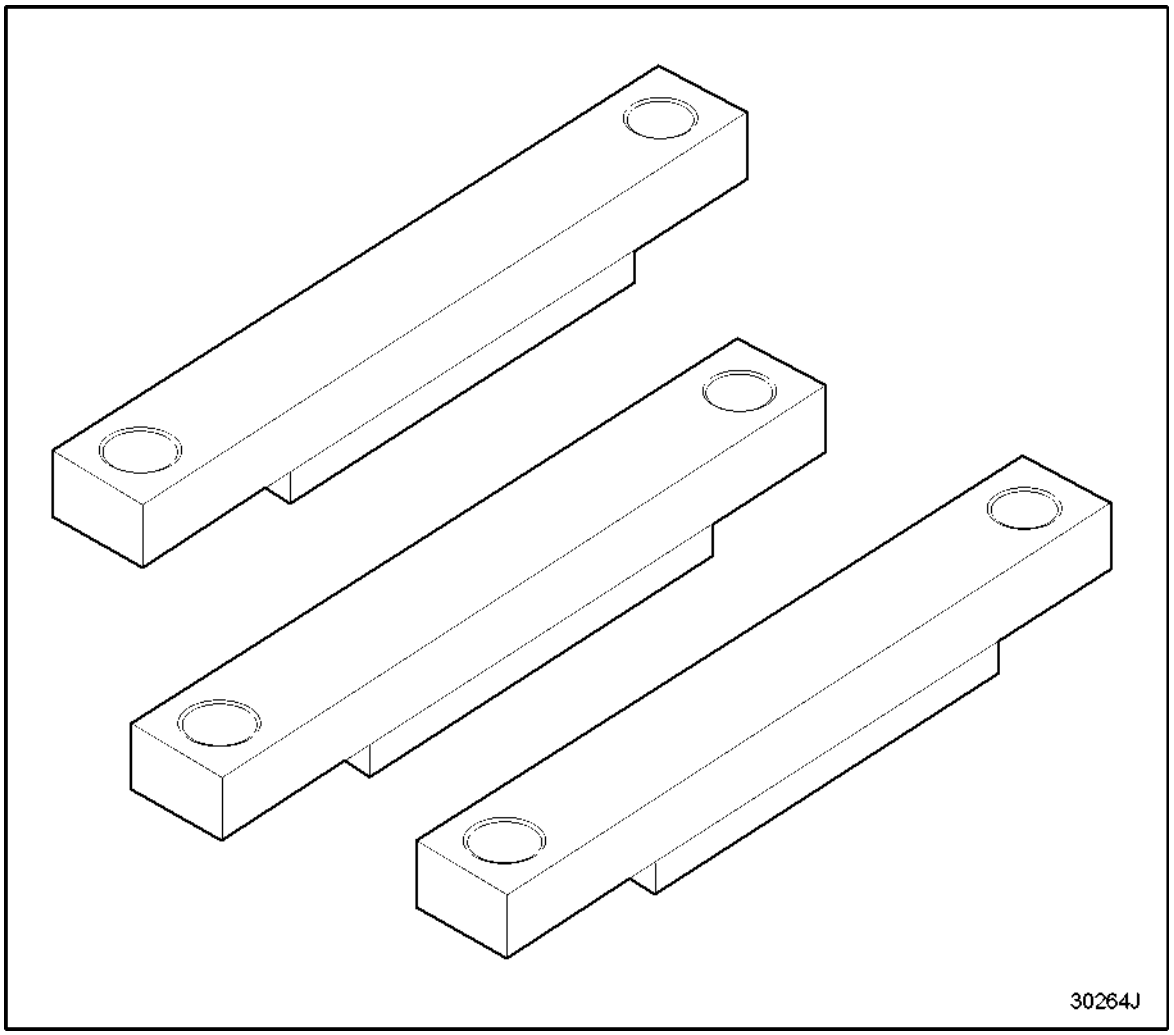


Figure 1124 Liner Installer,J 22461–A

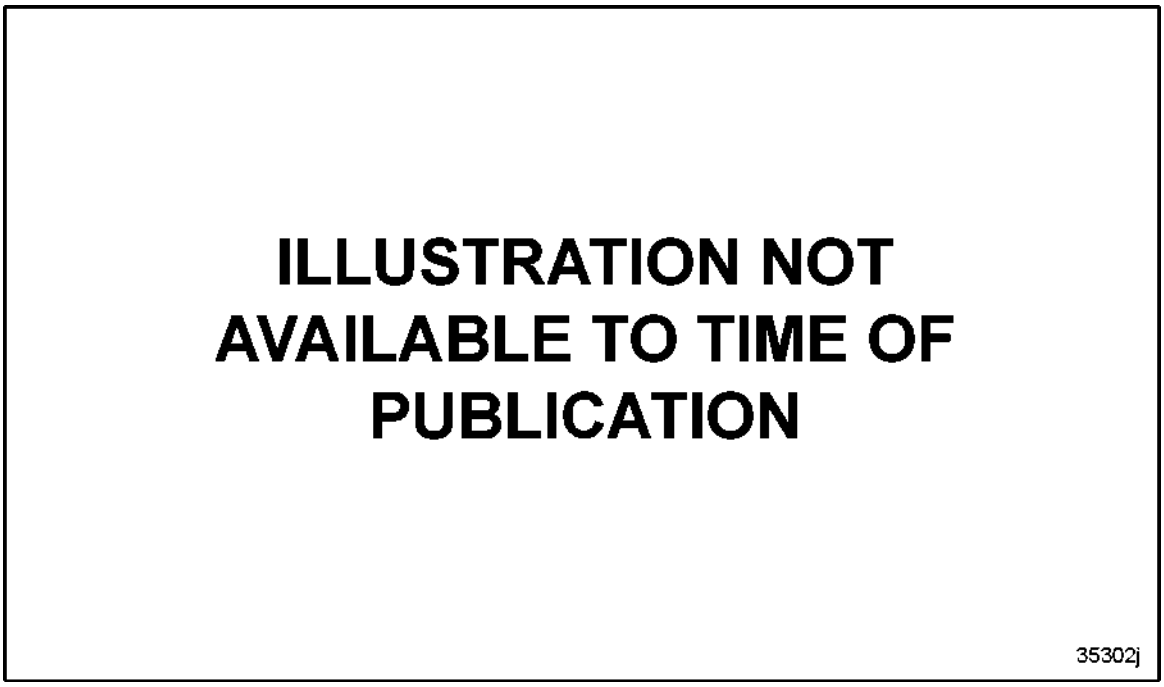


Figure 1125 Liner Installer,J 41441

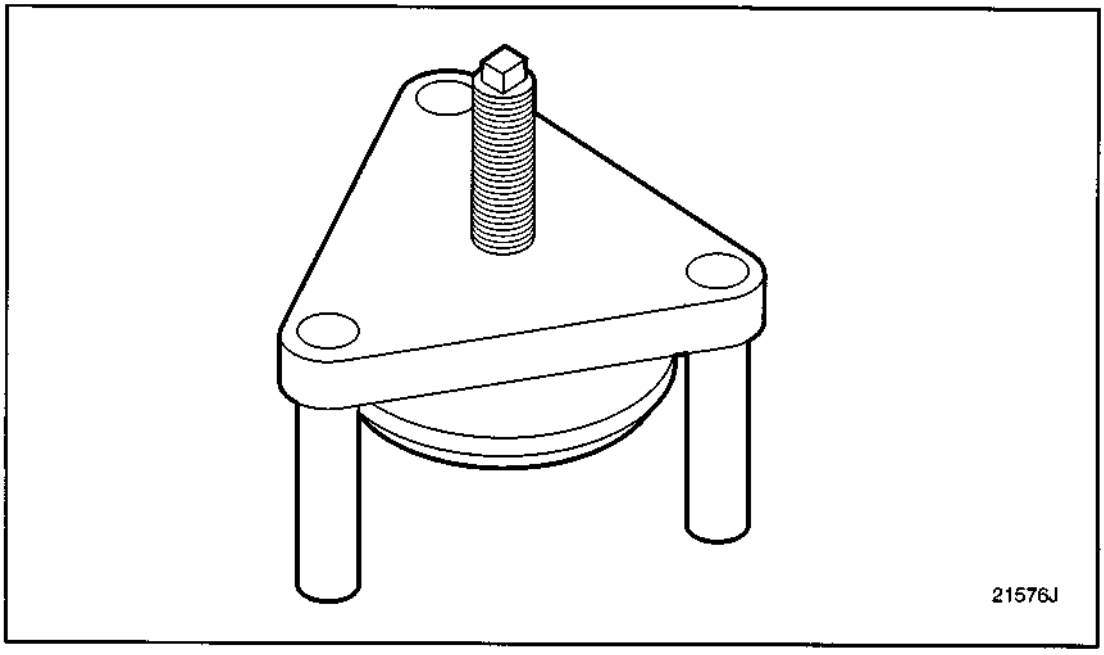


Figure 1126 Liner Installer & Hold Down,J 35597–A

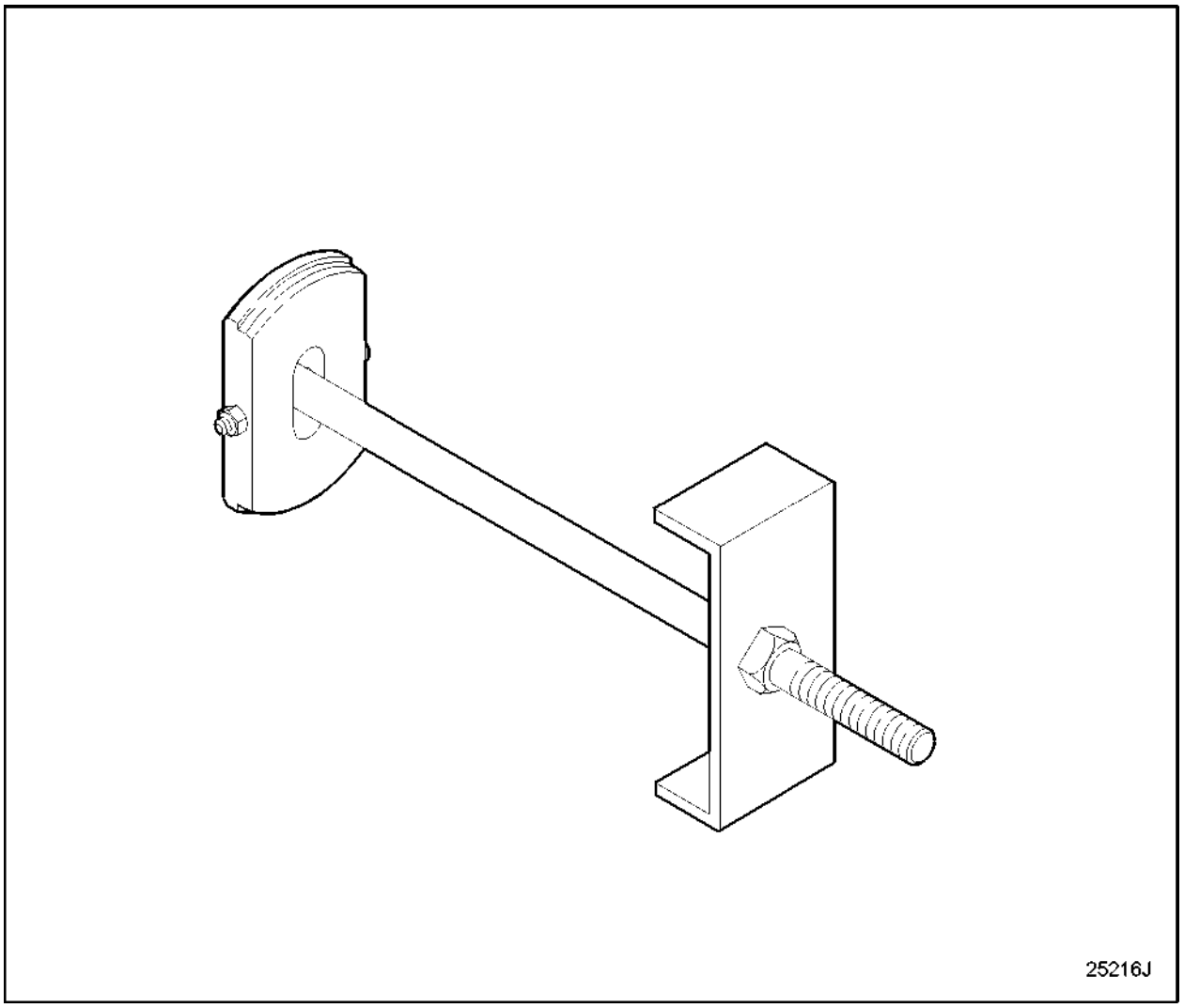


Figure 1127 Liner Puller,J 41543

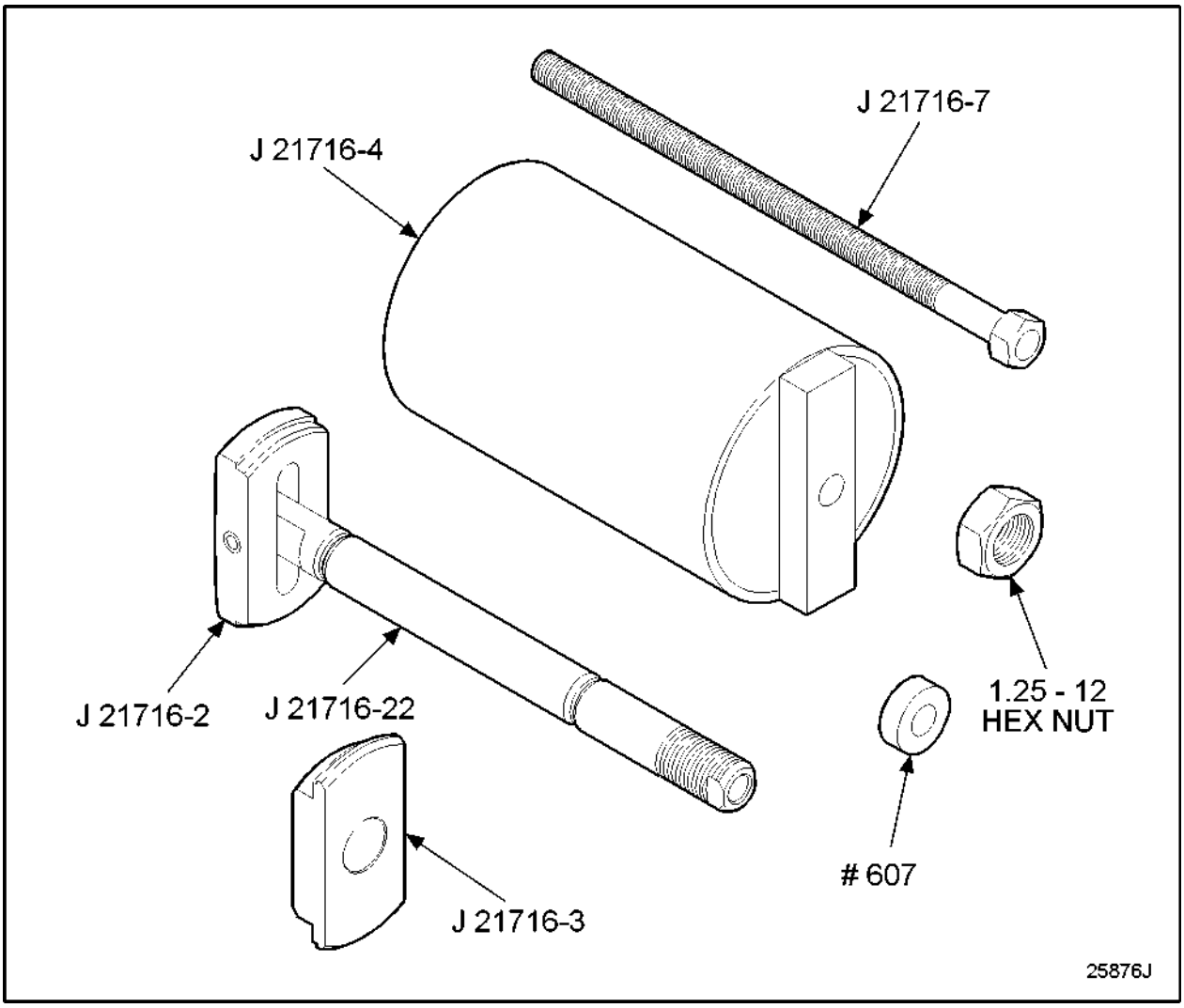


Figure 1128 Liner Remover (Screw Type), J 21716–01

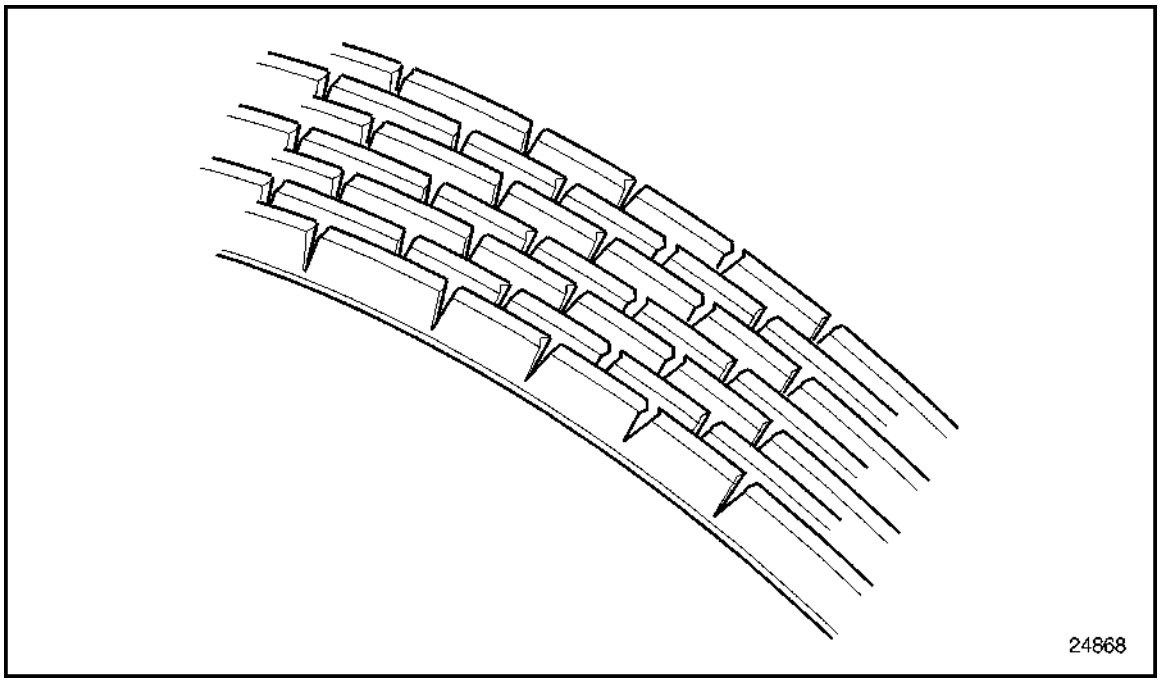


Figure 1129 Liner Remover (Screw Type), J 22431–A

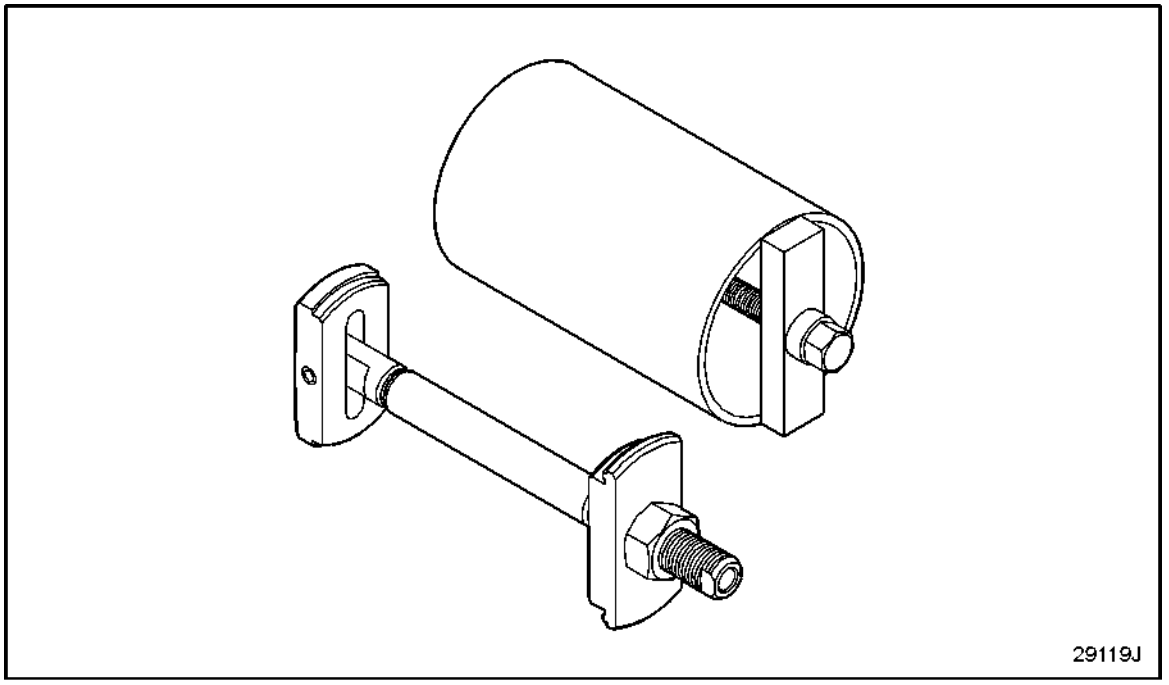


Figure 1130 Liner Remover (Screw Type), J 24563–A

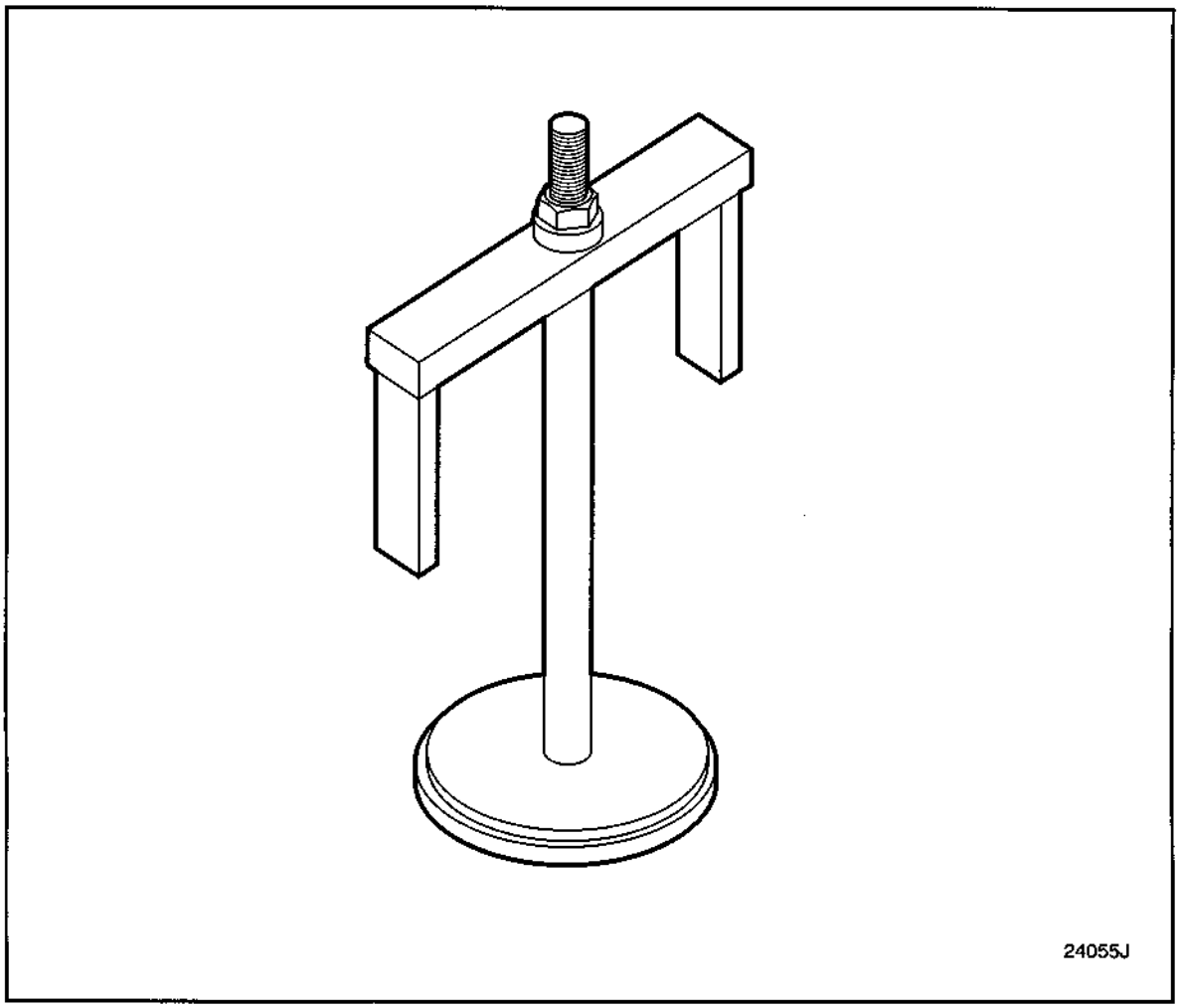


Figure 1131 Liner Remover (Screw Type), J 35791

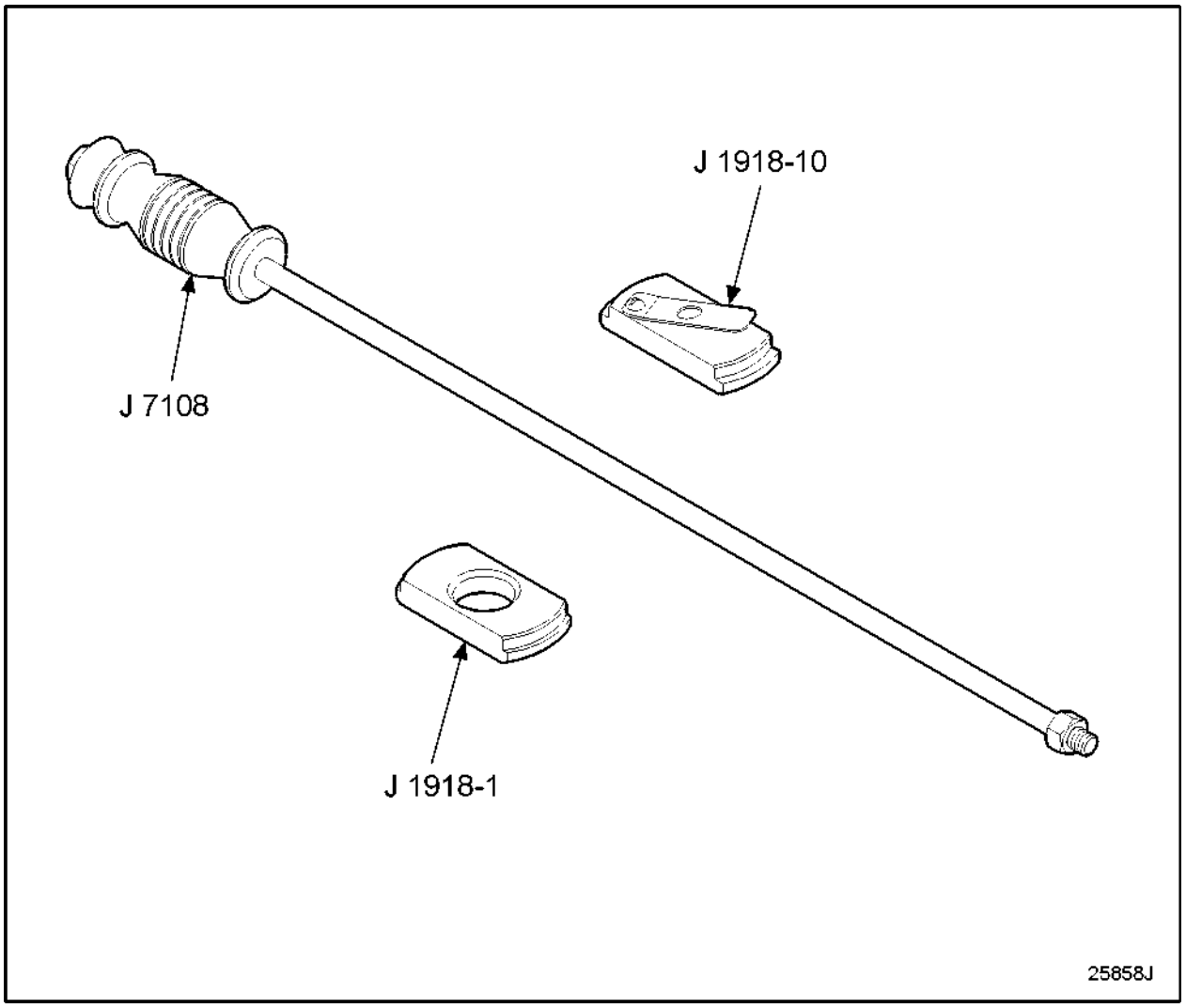


Figure 1132 Liner Remover (Screw Type), J 1918–02

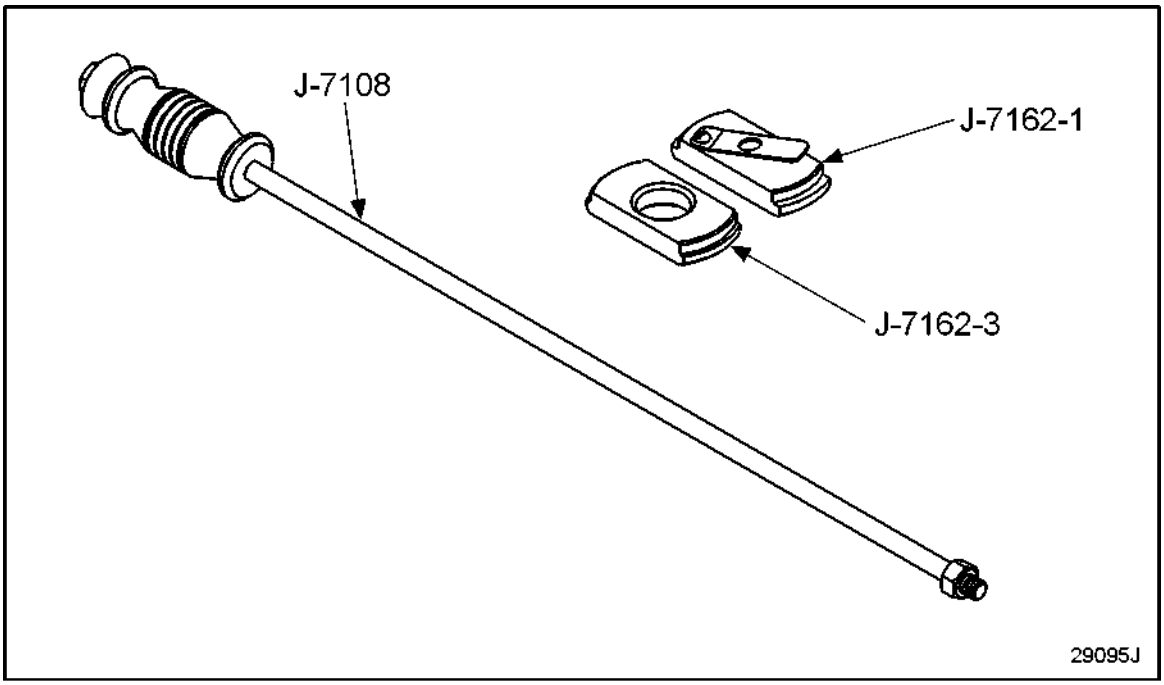


Figure 1133 Liner Remover (Screw Type), J 22490

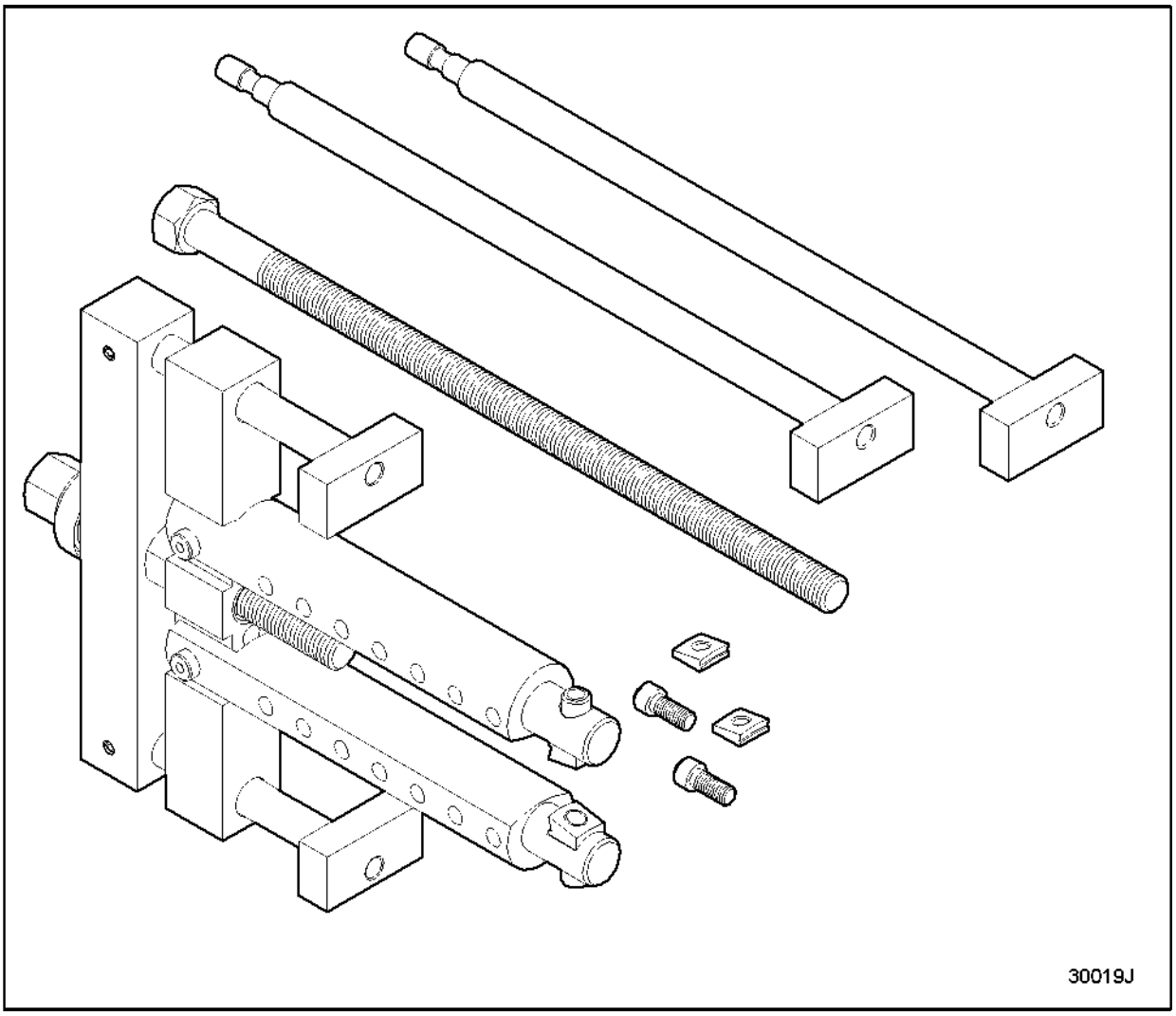


Figure 1134 Liner Removal, Universal Screw Type,PT-6410–B

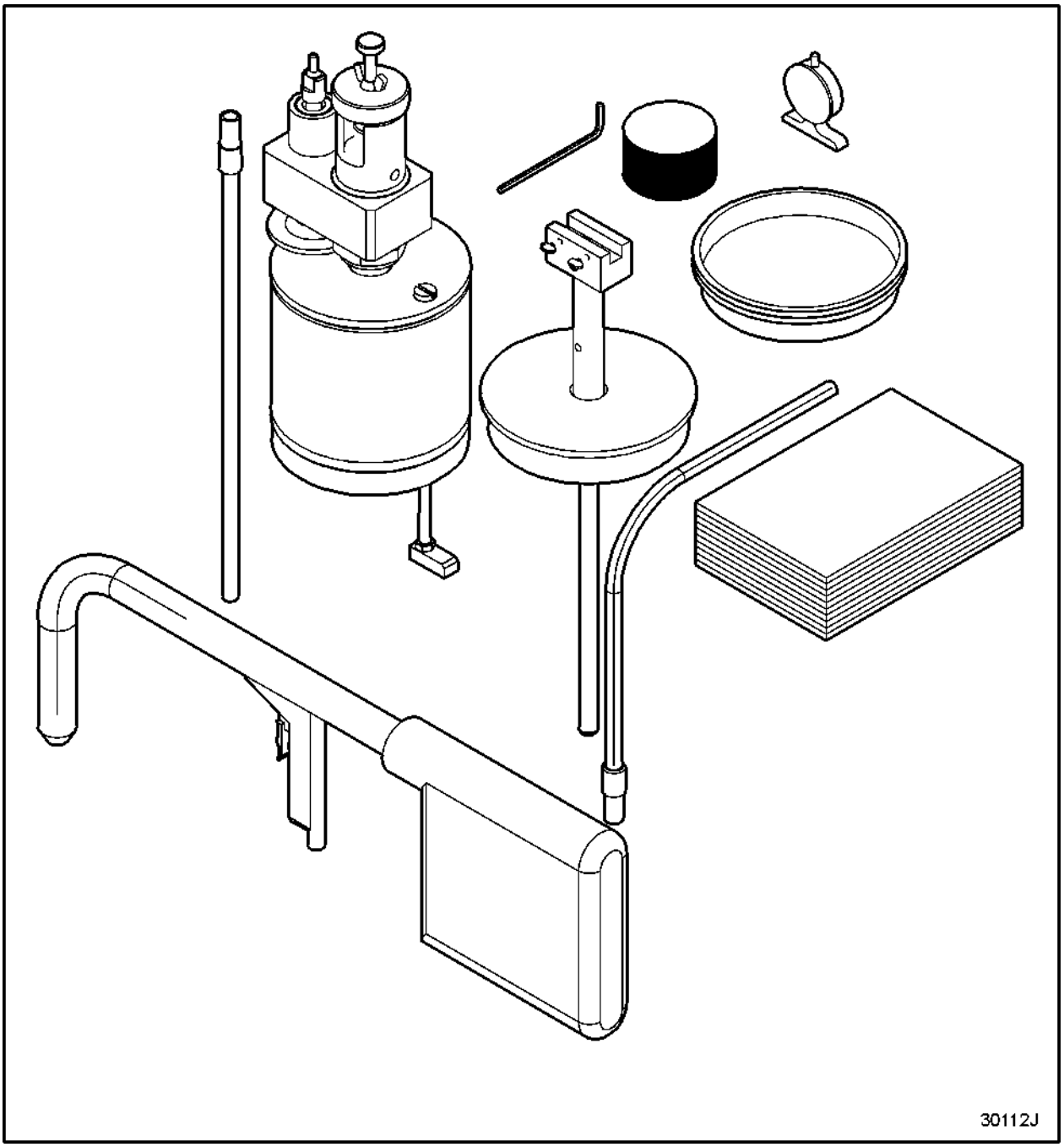


Figure 1135 Liner Seat Resurfacer Kit,J 41749

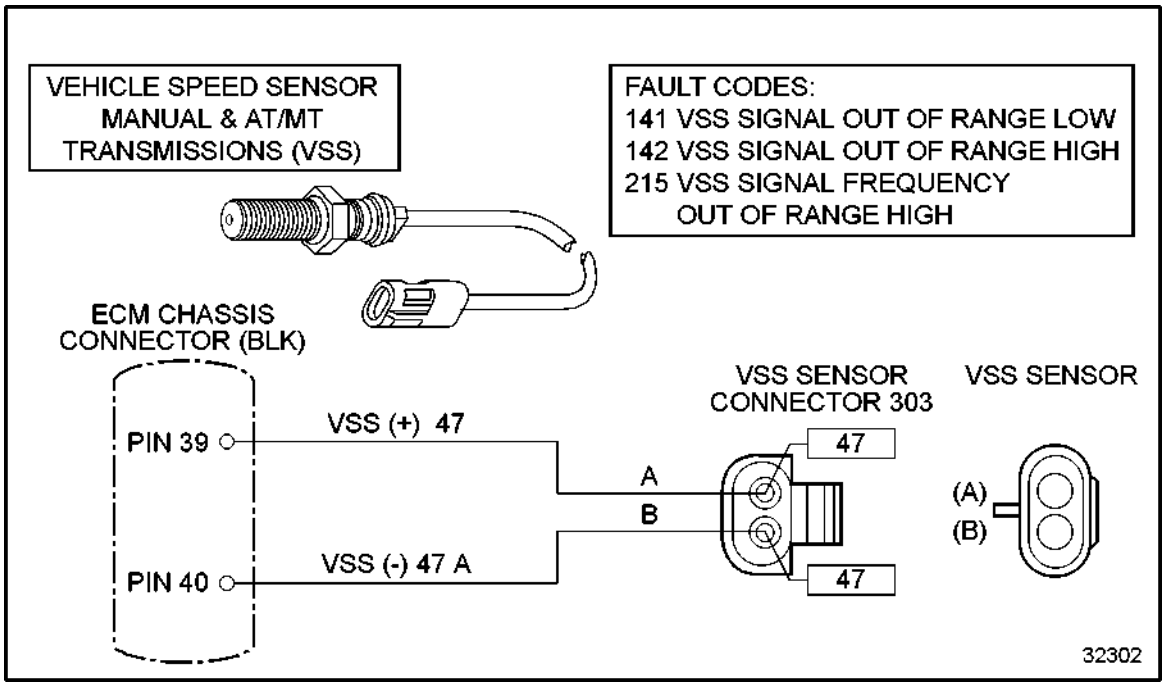


Figure 1136 Main Sad Bushing,PT-8530–1

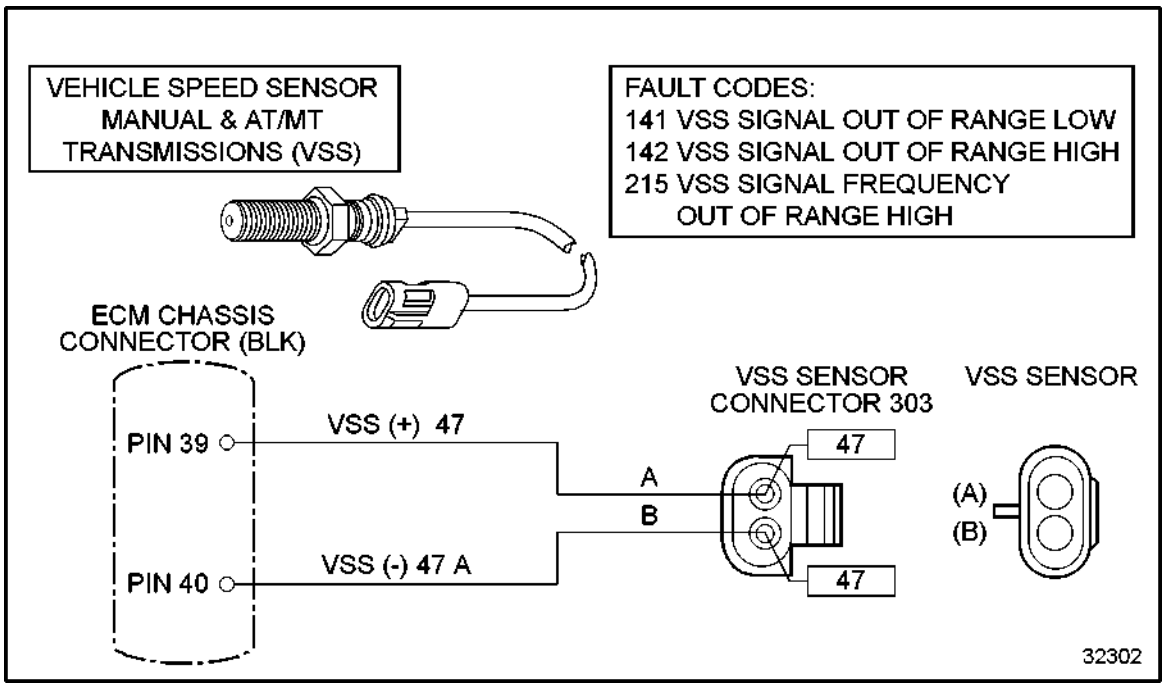


Figure 1137 Main Sad Bushing,PT-8531–1

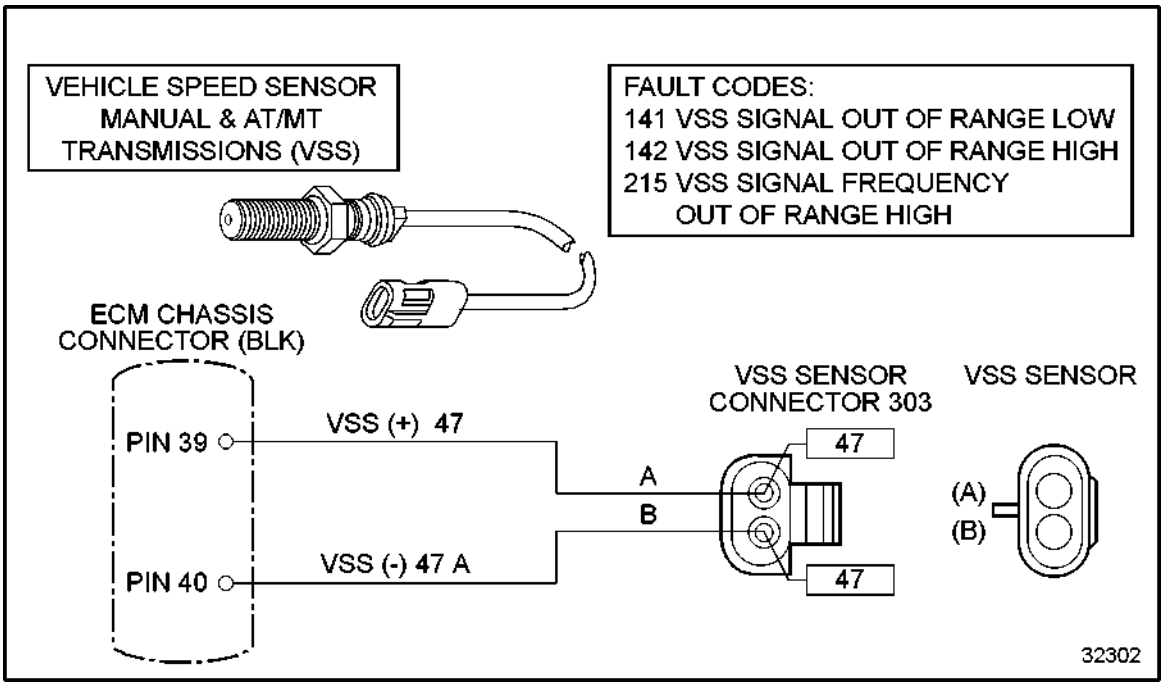


Figure 1138 Master Ring- Cylinder Block Bore,J 8386–01

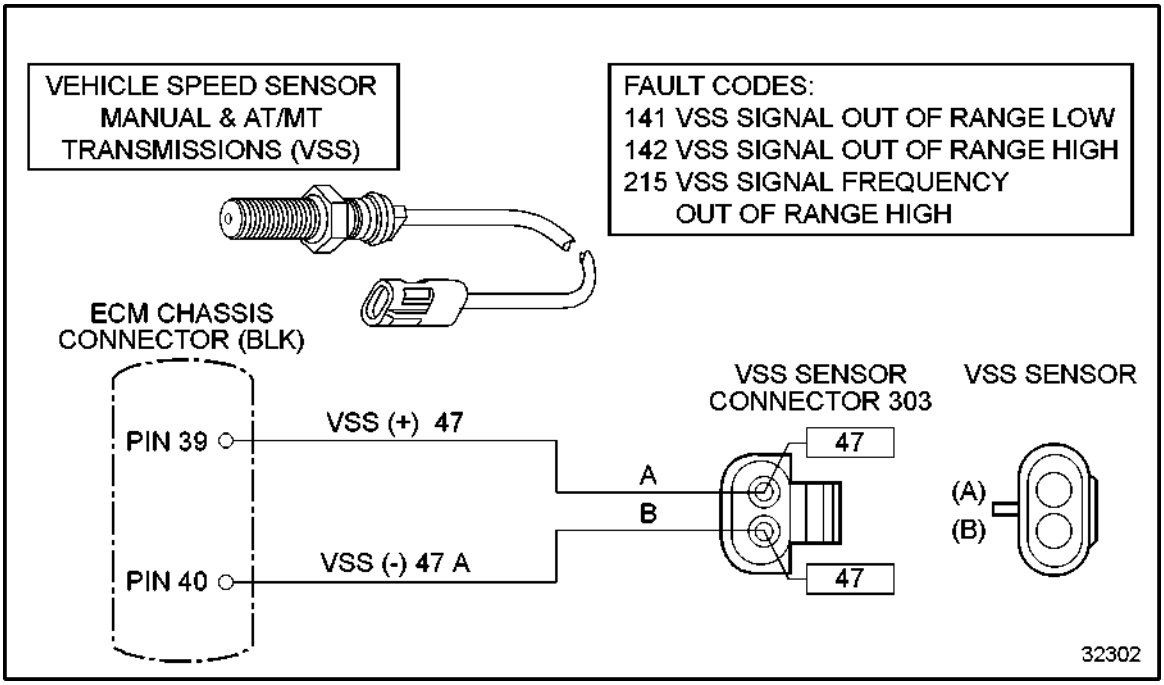


Figure 1139 Master Ring-Liner I.D.,J 8385–01

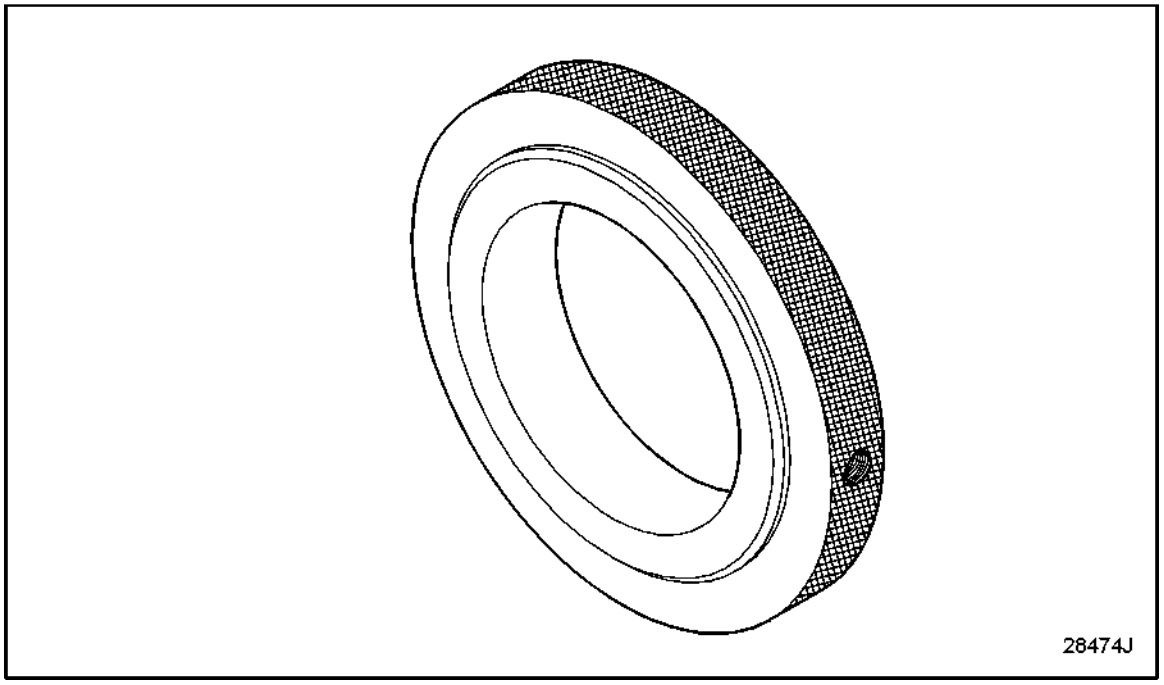


Figure 1140 Master Ring-Liner I.D.,J 22613

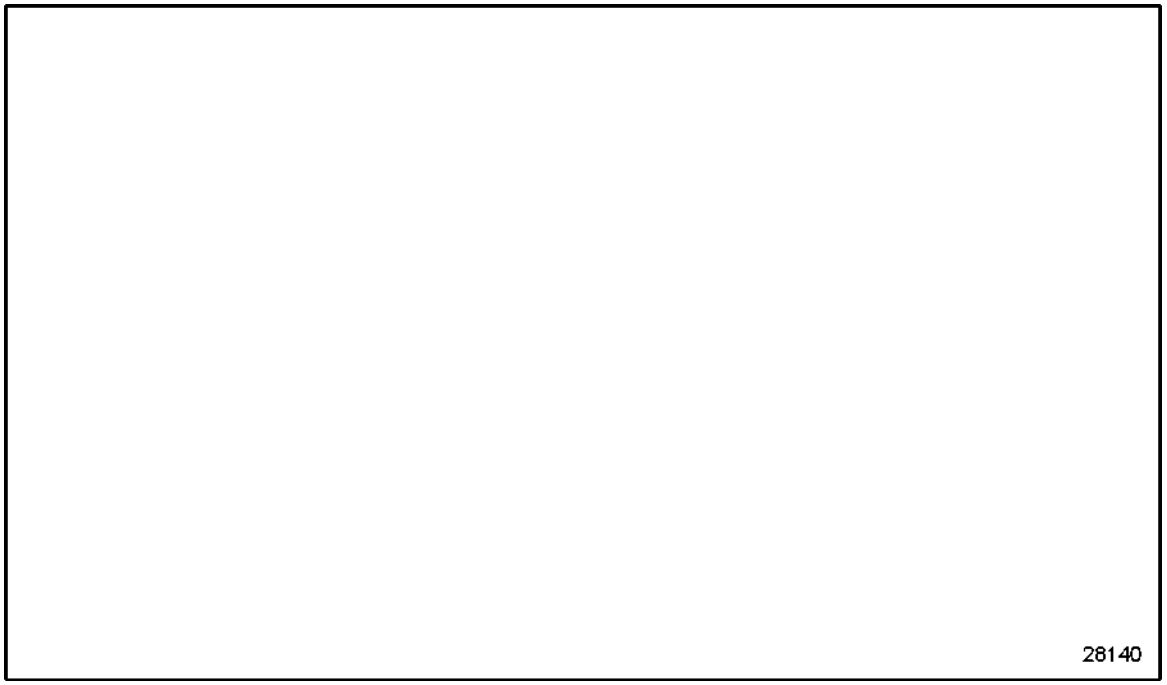


Figure 1141 Master Ring-Liner I.D.,J 24564

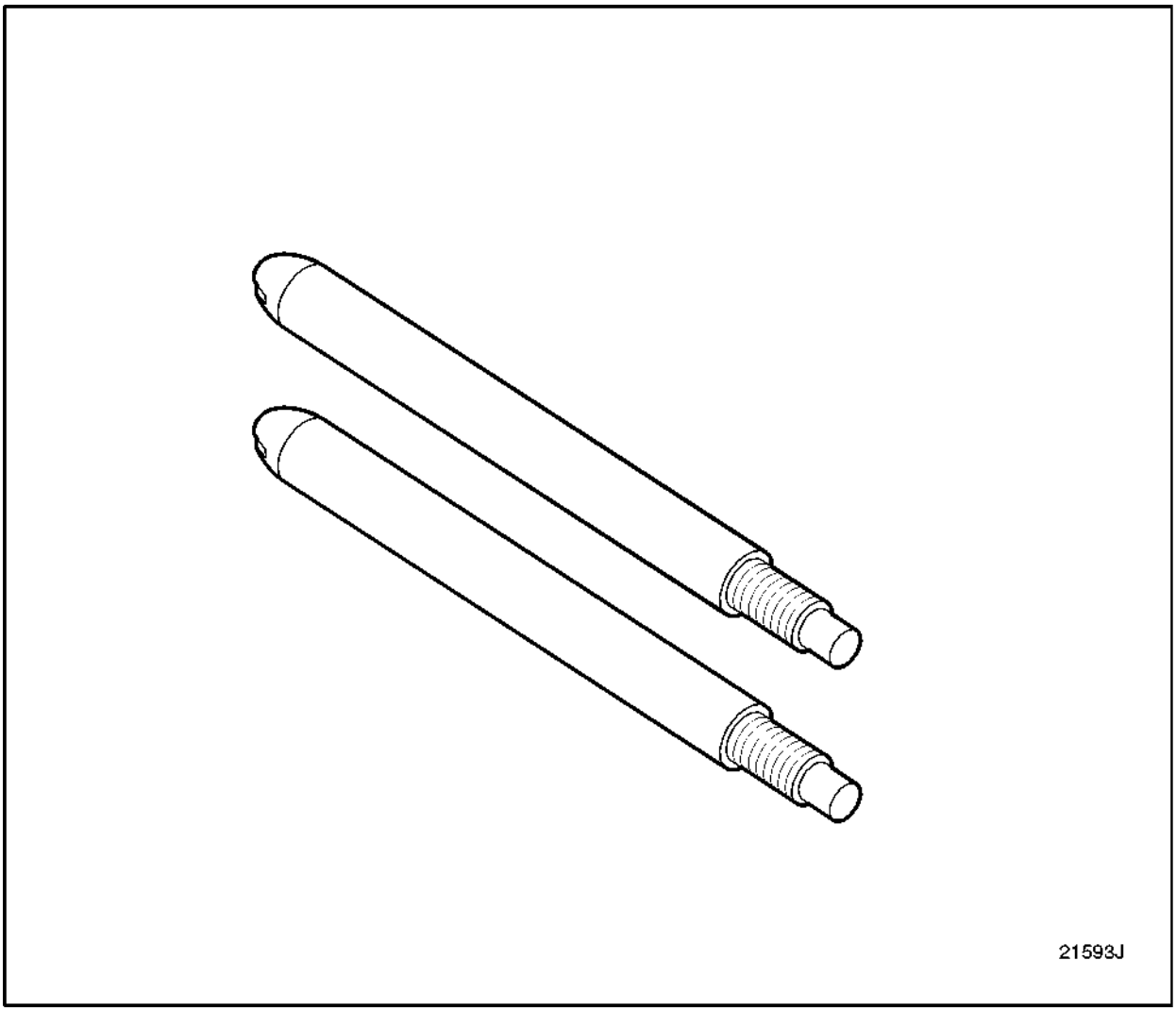


Figure 1142 Oil Cooler Guide Studs,J 35786

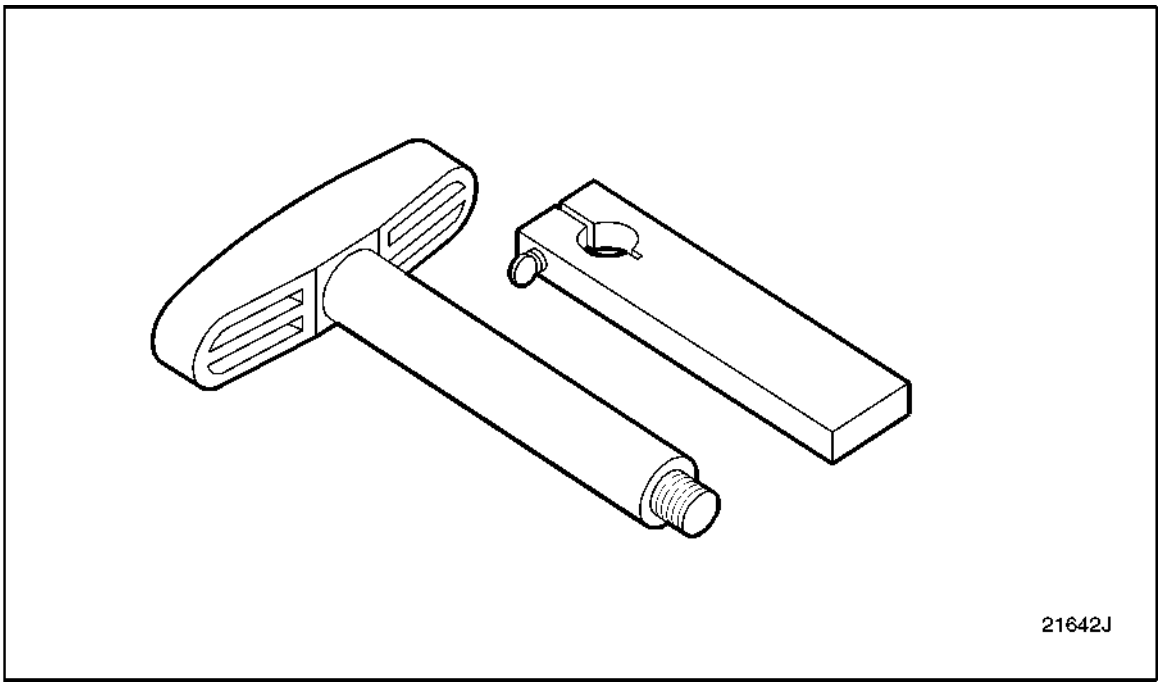


Figure 1143 Oil Gallery Spacer Installer,J 38895

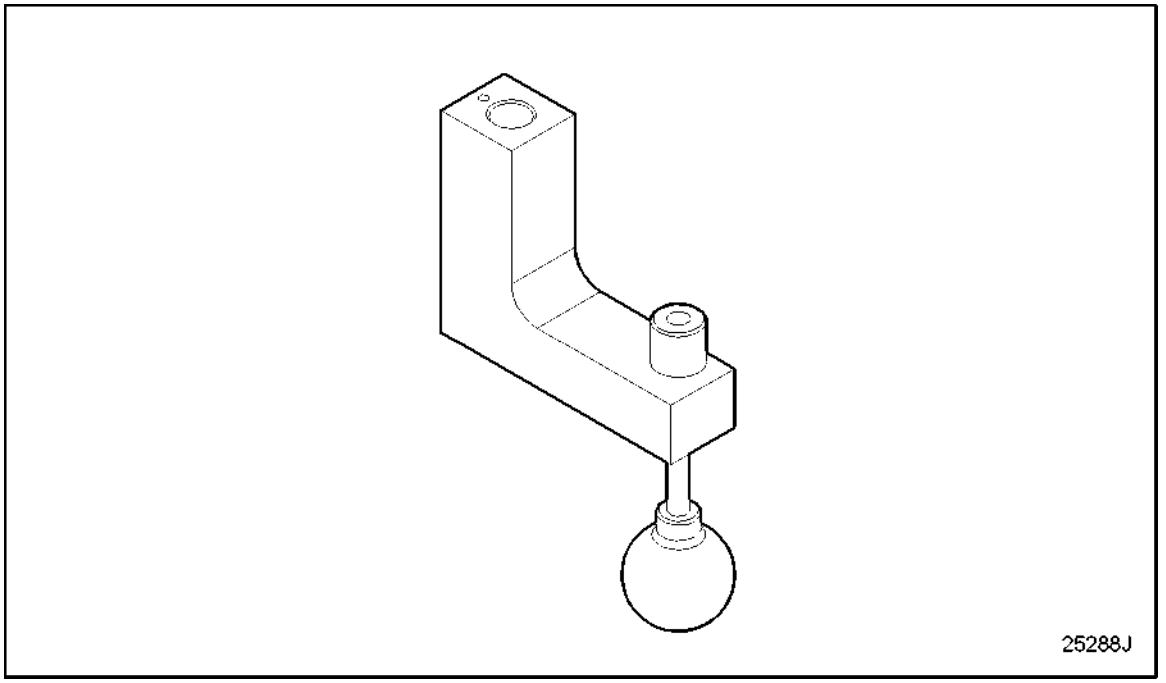


Figure 1144 Oil Nozzle Calibration Device,J 41542

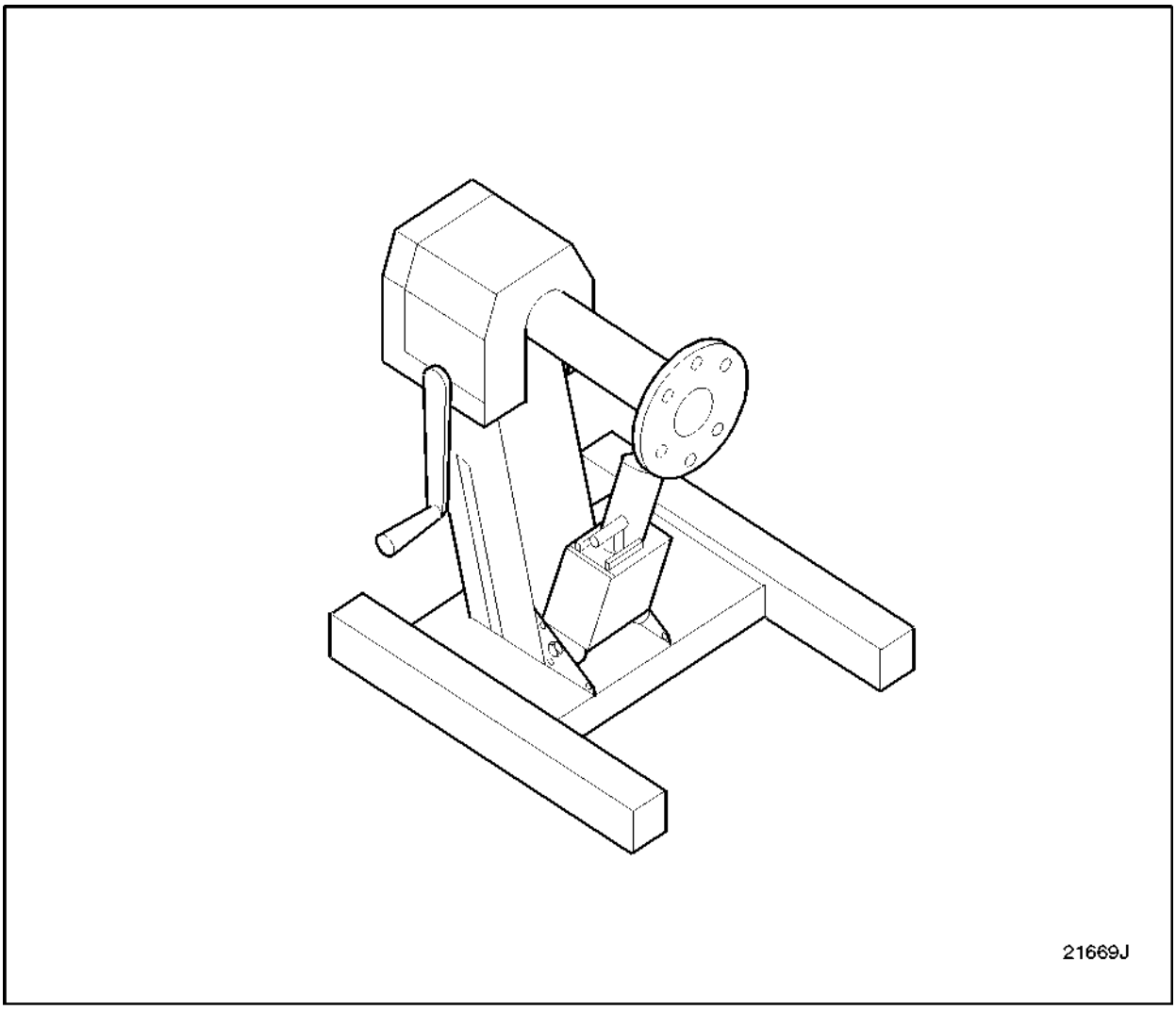


Figure 1145 Overhaul Stand (Less Adapters), J 29109

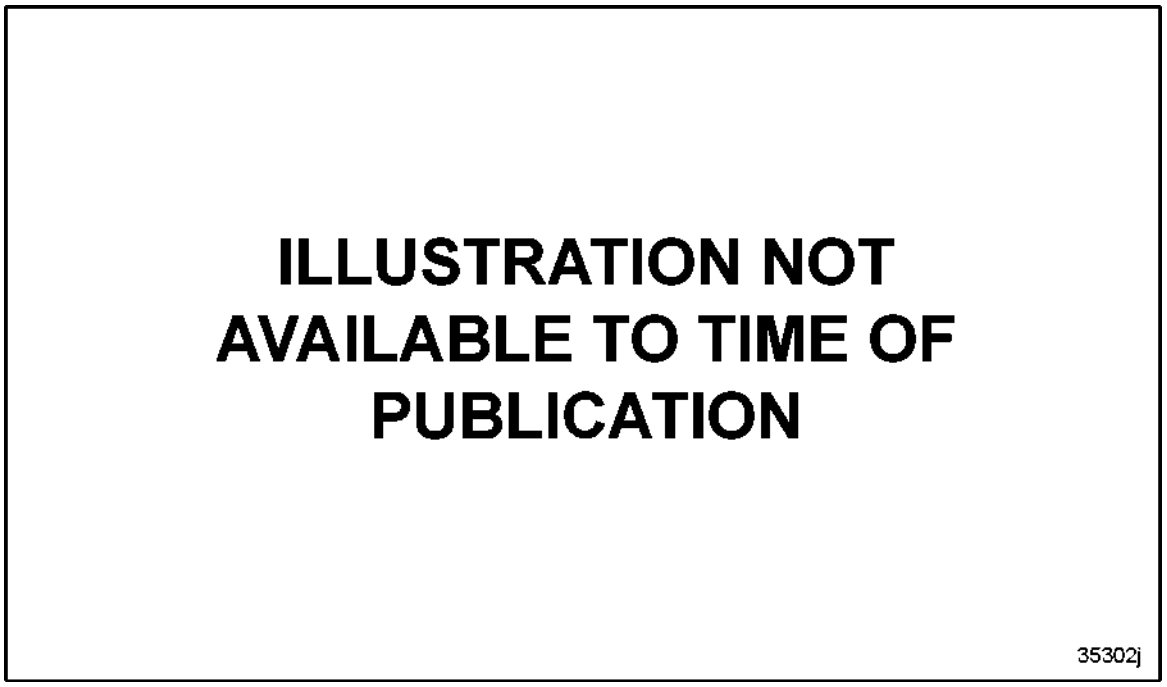


Figure 1146 Overhaul Stand (Less Adapters), J 9398–04

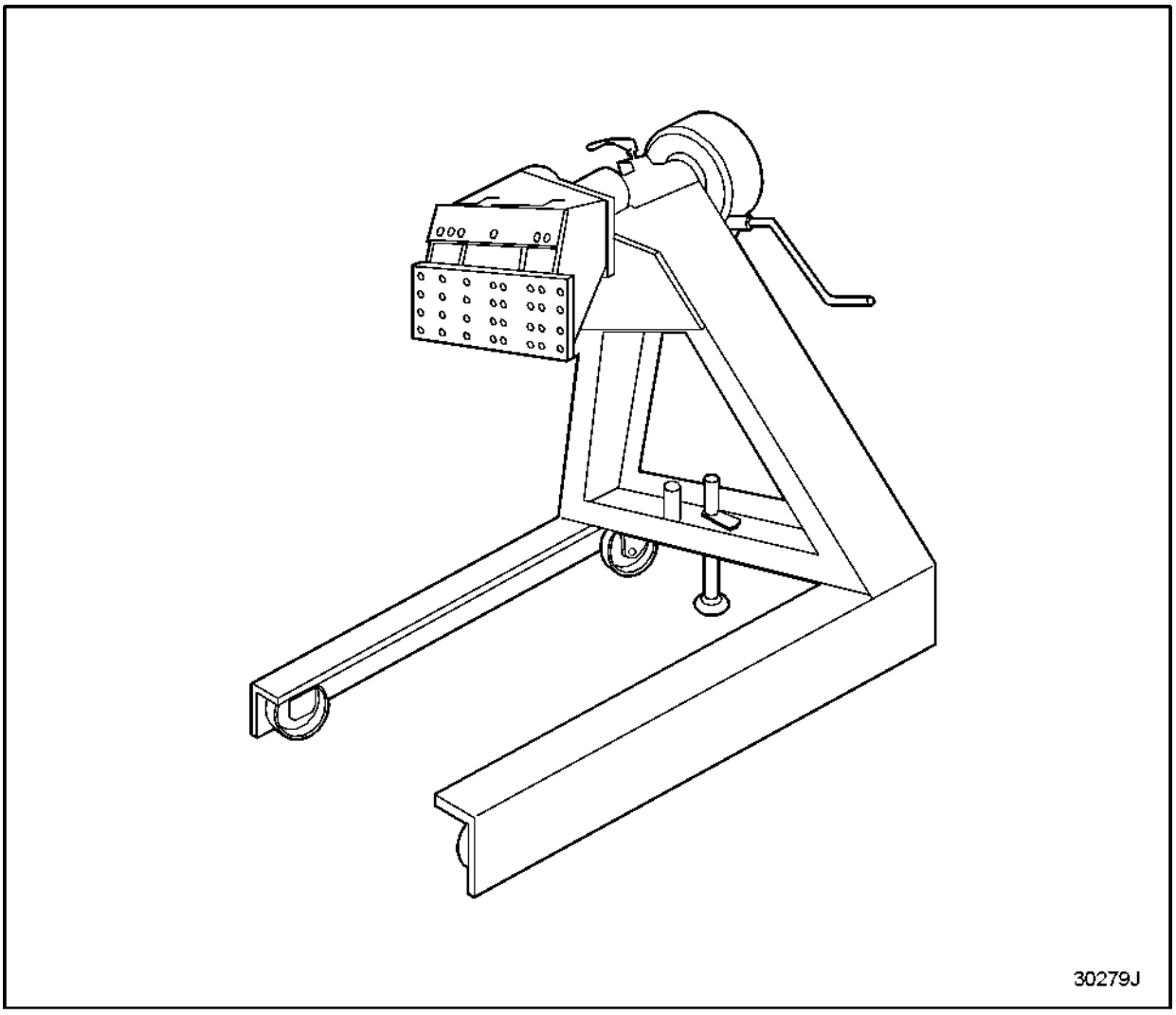


Figure 1147 Engine Overhaul Stand (12V and 16V) J 9389-04

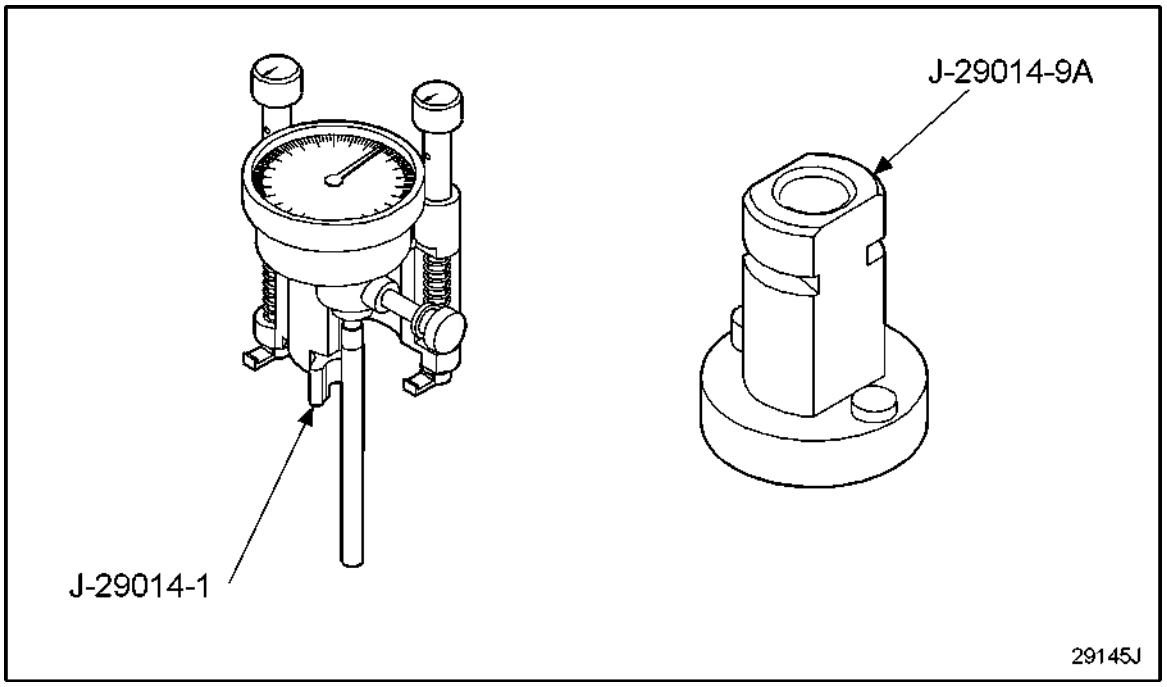


Figure 1148 Overhaul Stand Adapters J 29013–A

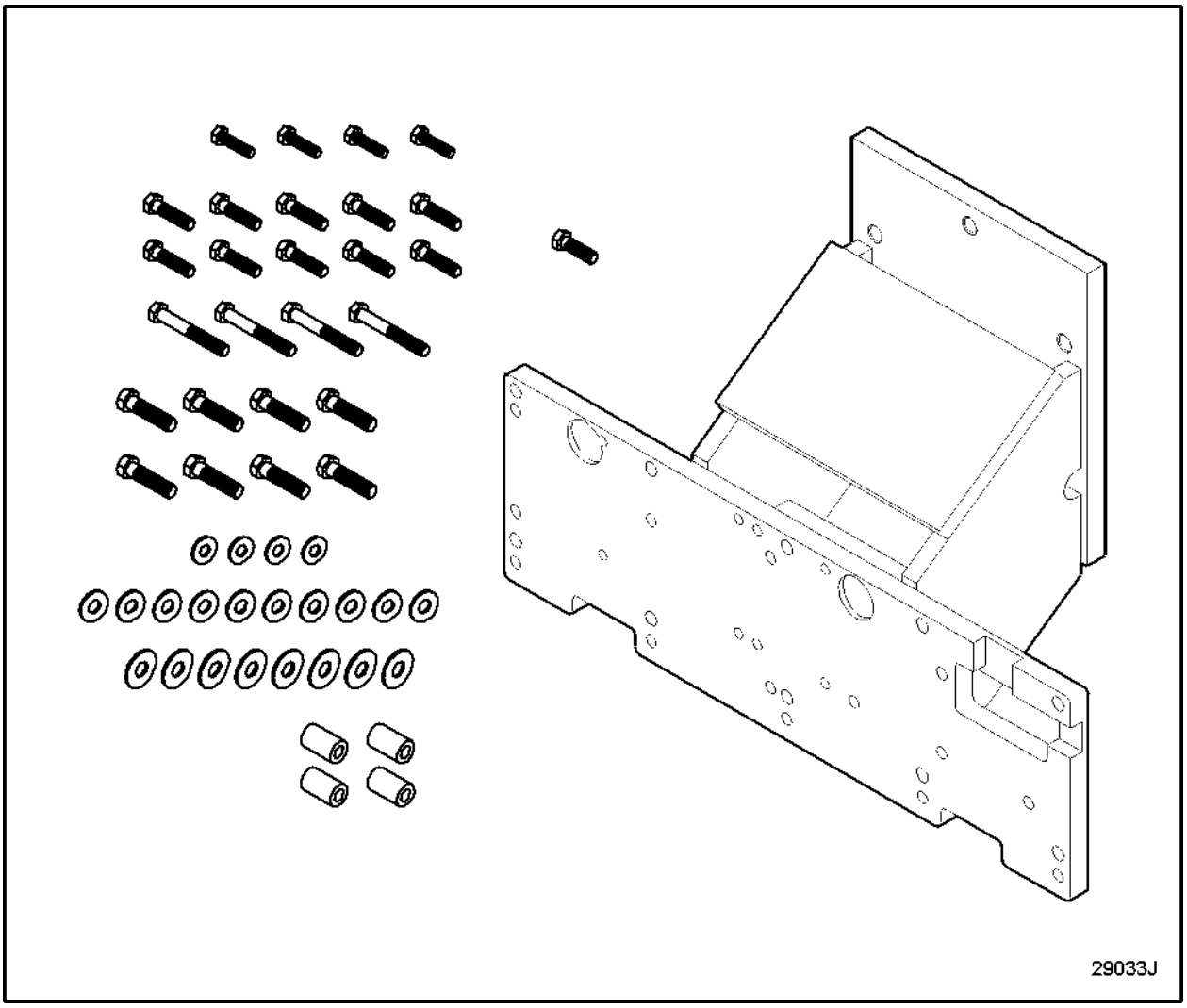


Figure 1149 Overhaul Stand Adapters,J 33850

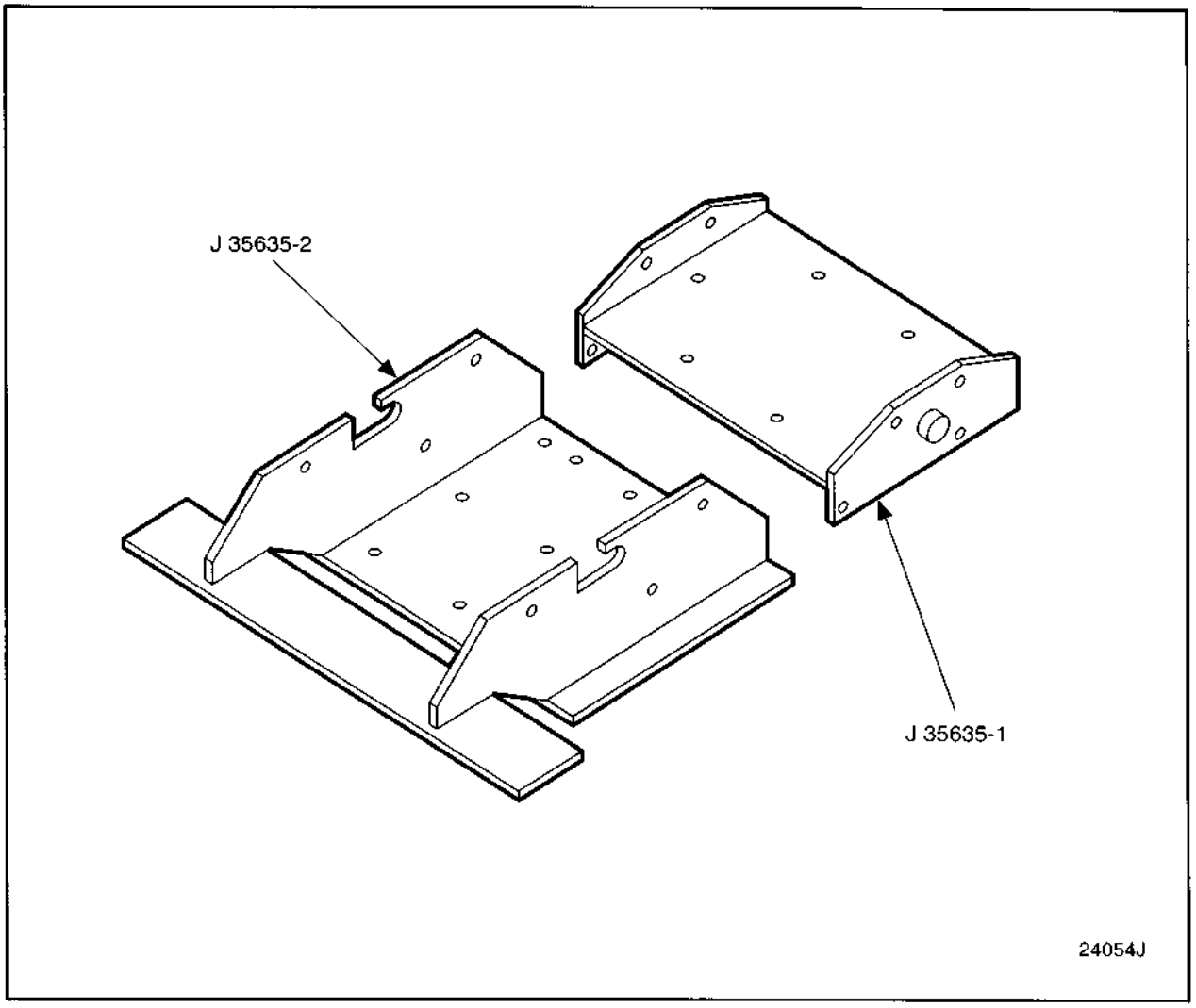


Figure 1150 Overhaul Stand Adapters,J 35635–A

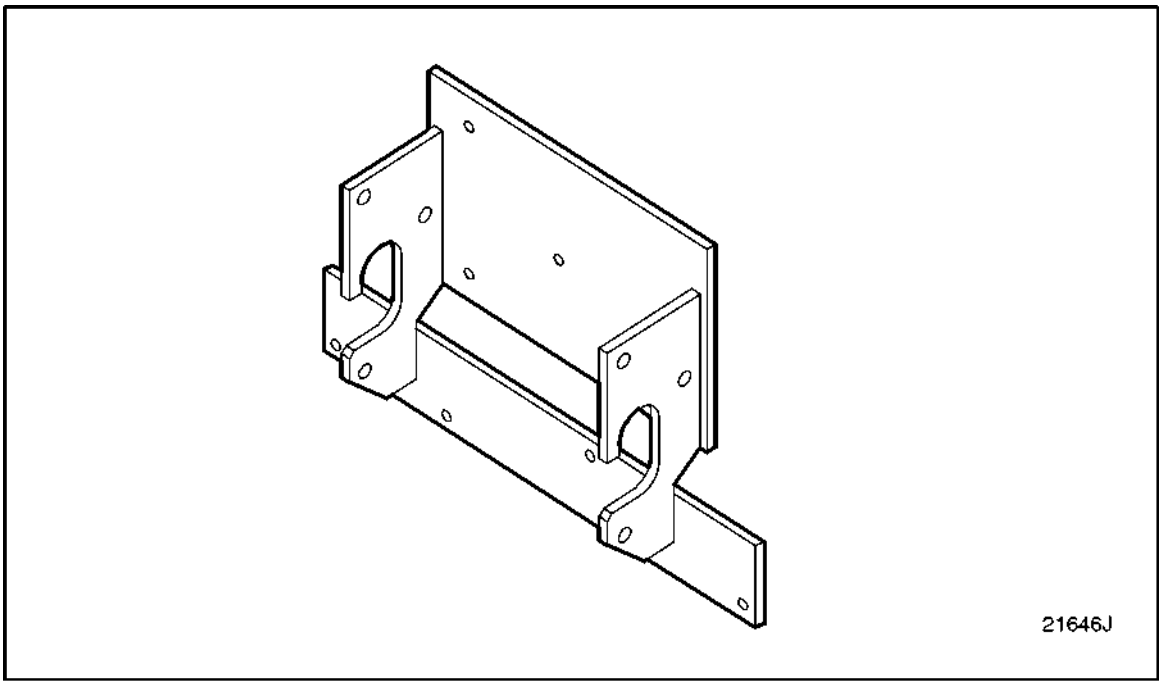


Figure 1151 Overhaul Stand Adapters,J 39652

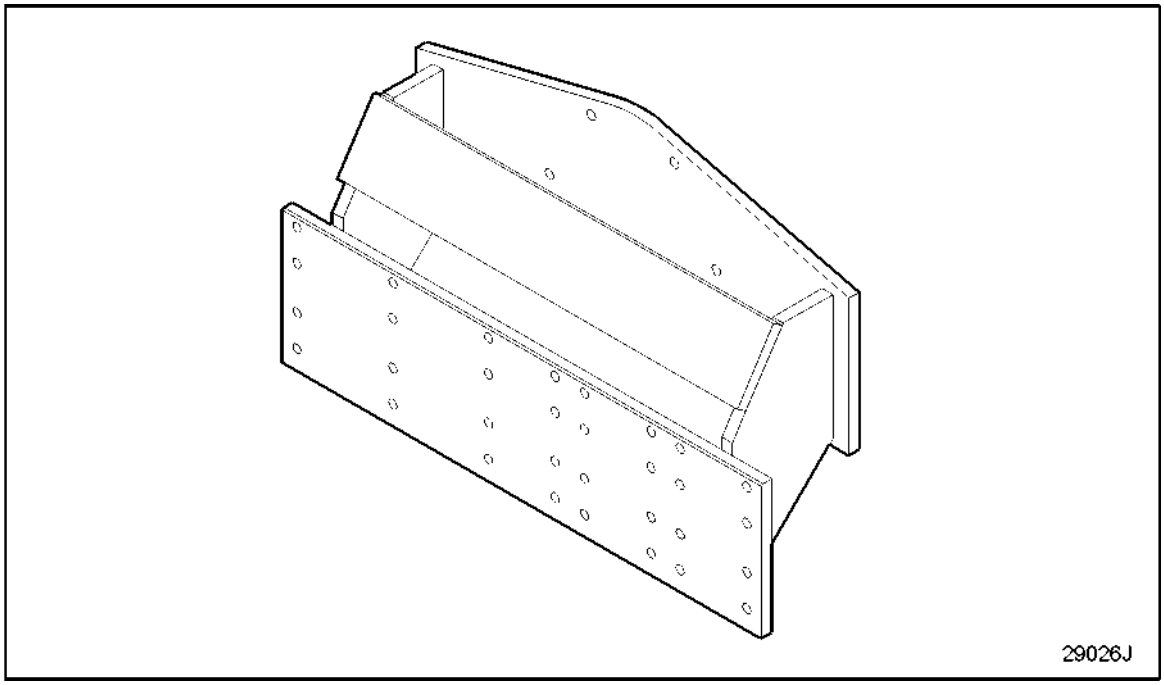


Figure 1152 Overhaul Stand AdaptersJ 8650

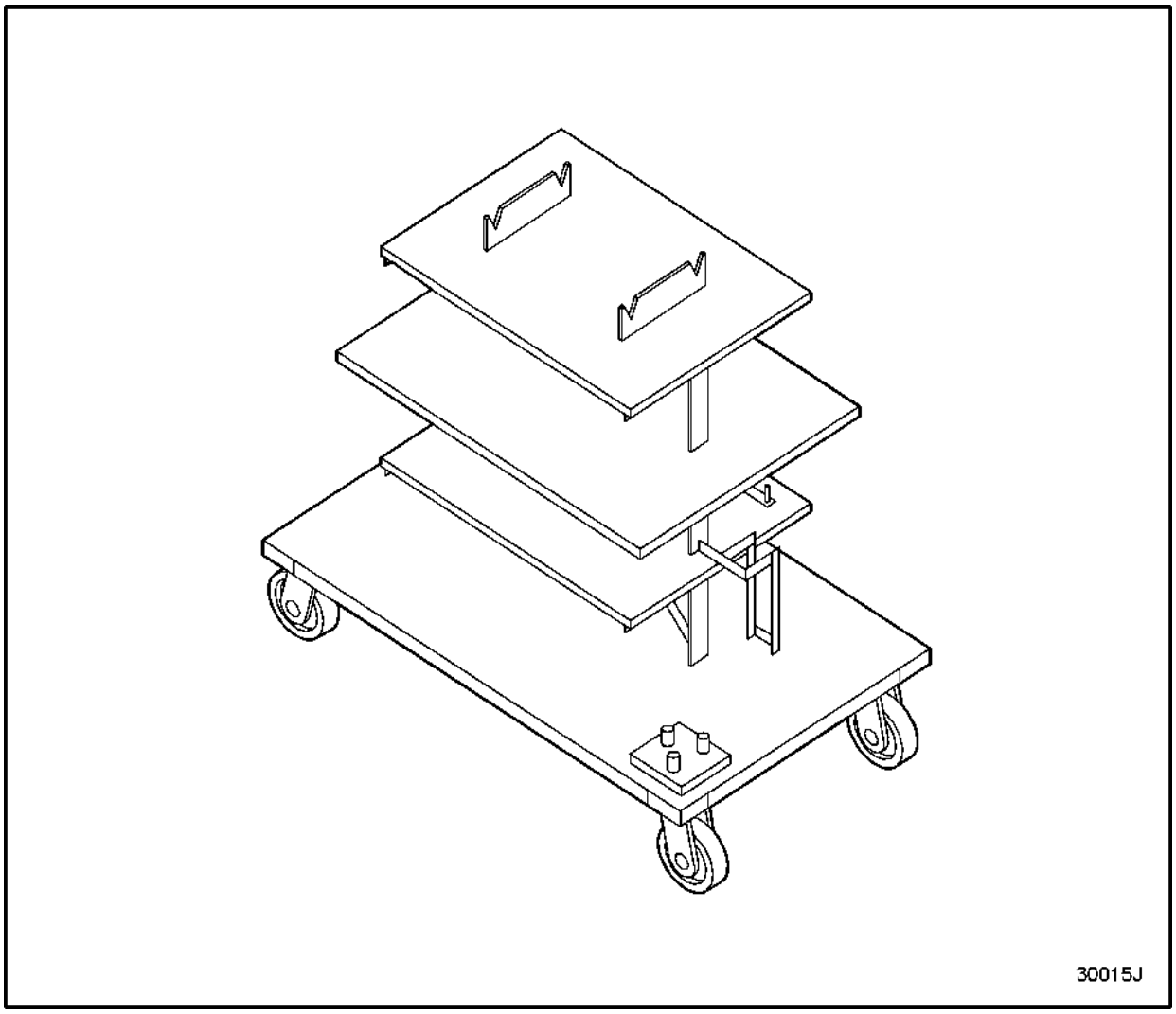


Figure 1153 Parts Dolly, J 6387

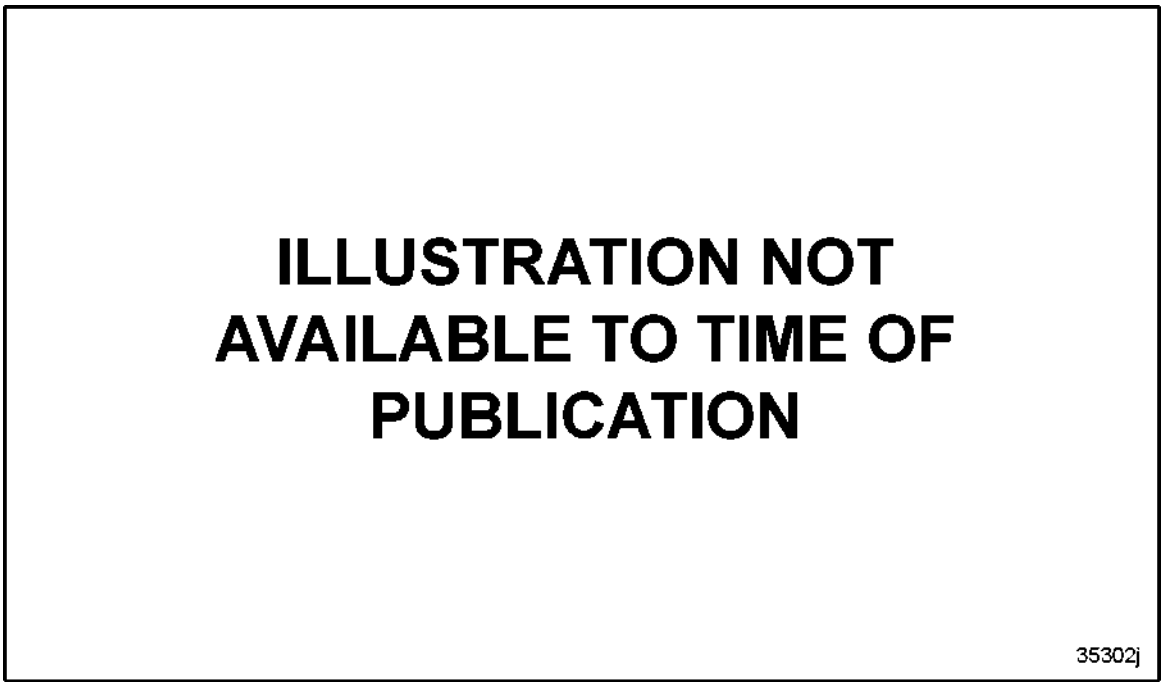


Figure 1154 **Porta Matic Basic,**PT-2050–D

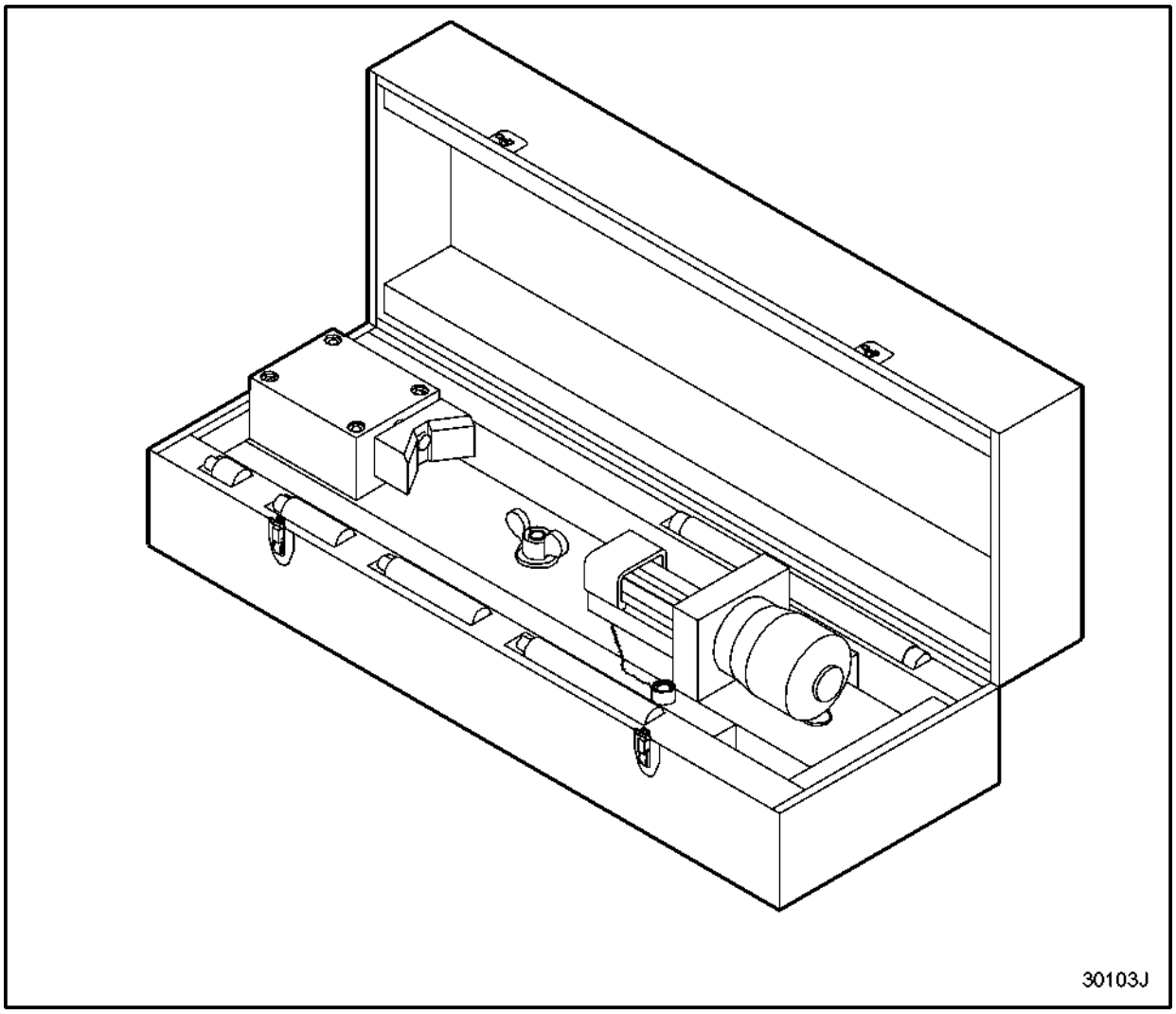


Figure 1155 Setting Master 3"-8" Dial Bore,J 23059–01

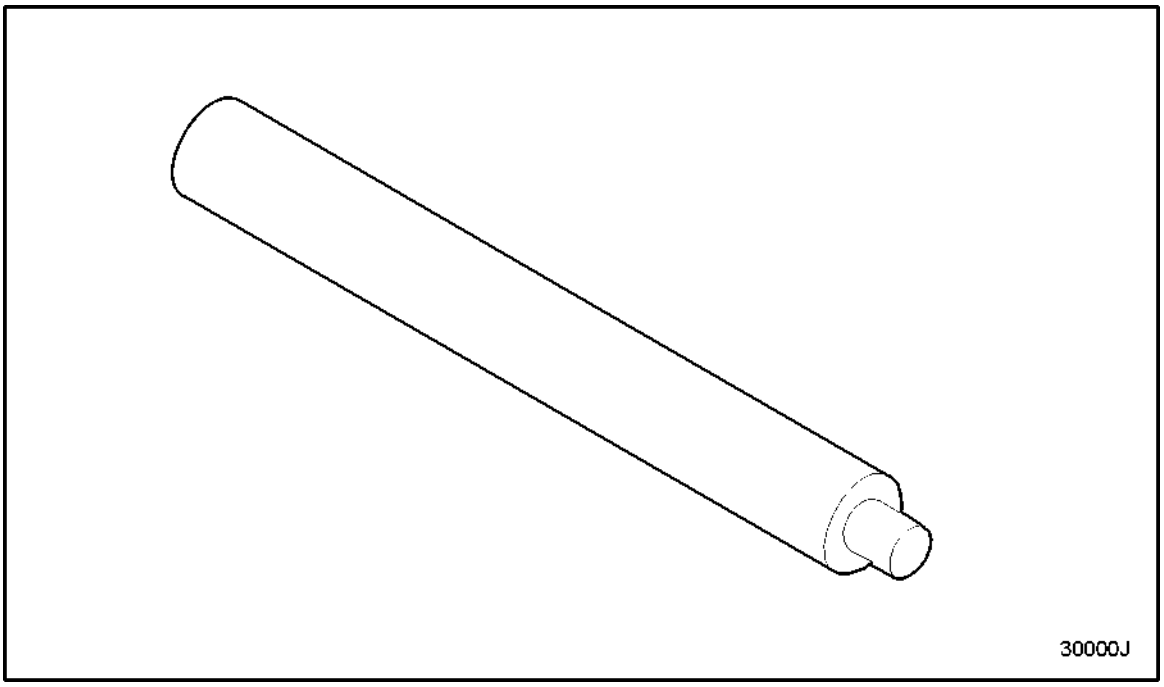


Figure 1156 Setting Master Adapter(2"-8"),J 23059–4

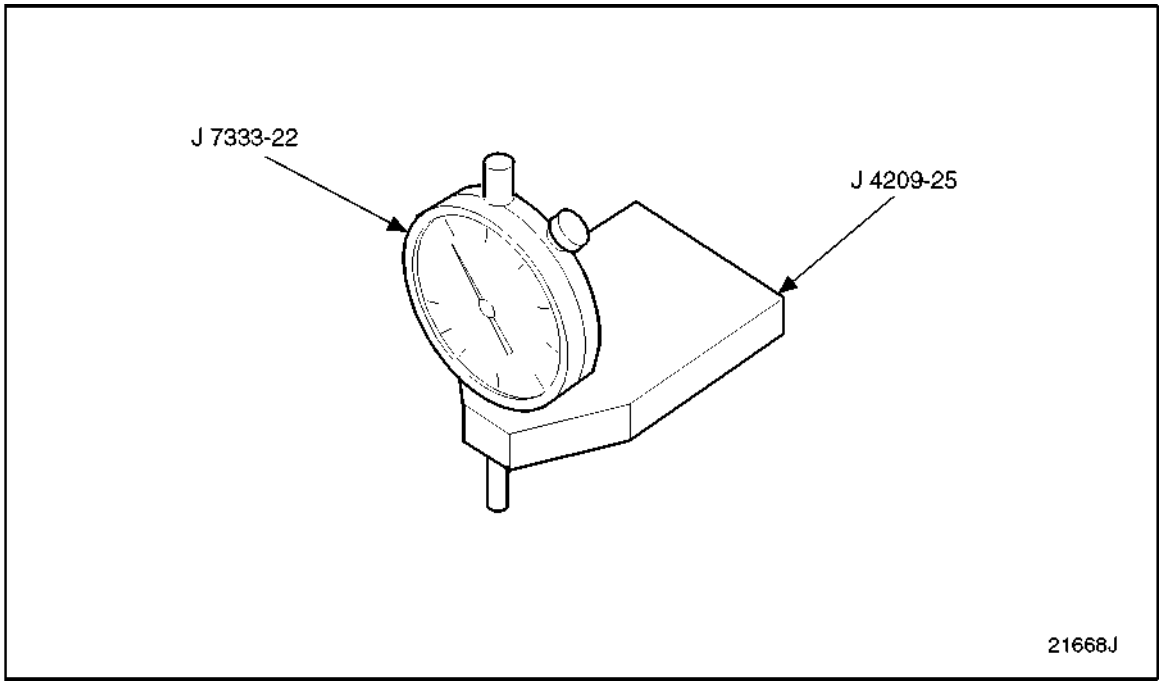


Figure 1157 Sled Gage,J 22273–01

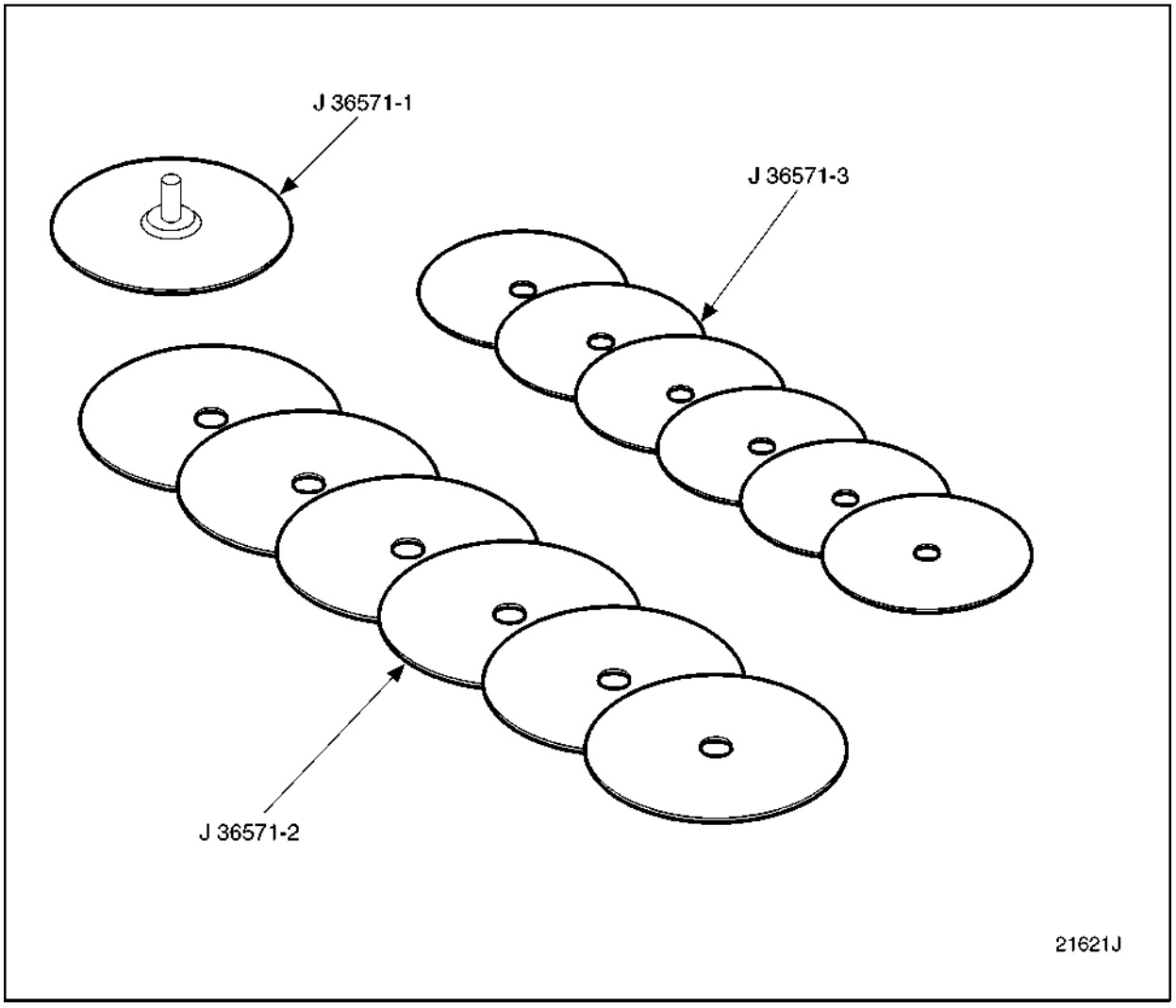


Figure 1158 Surface Conditioning Set,J 36571

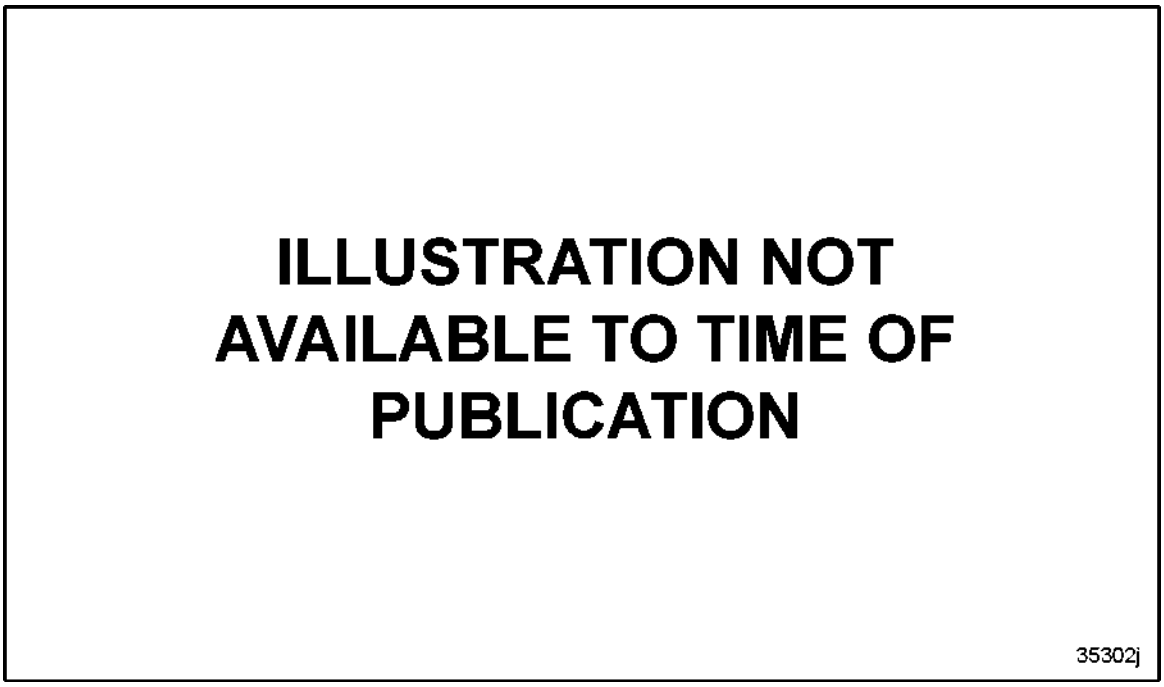


Figure 1159 T.D.C. Timing Set,J 29011–A

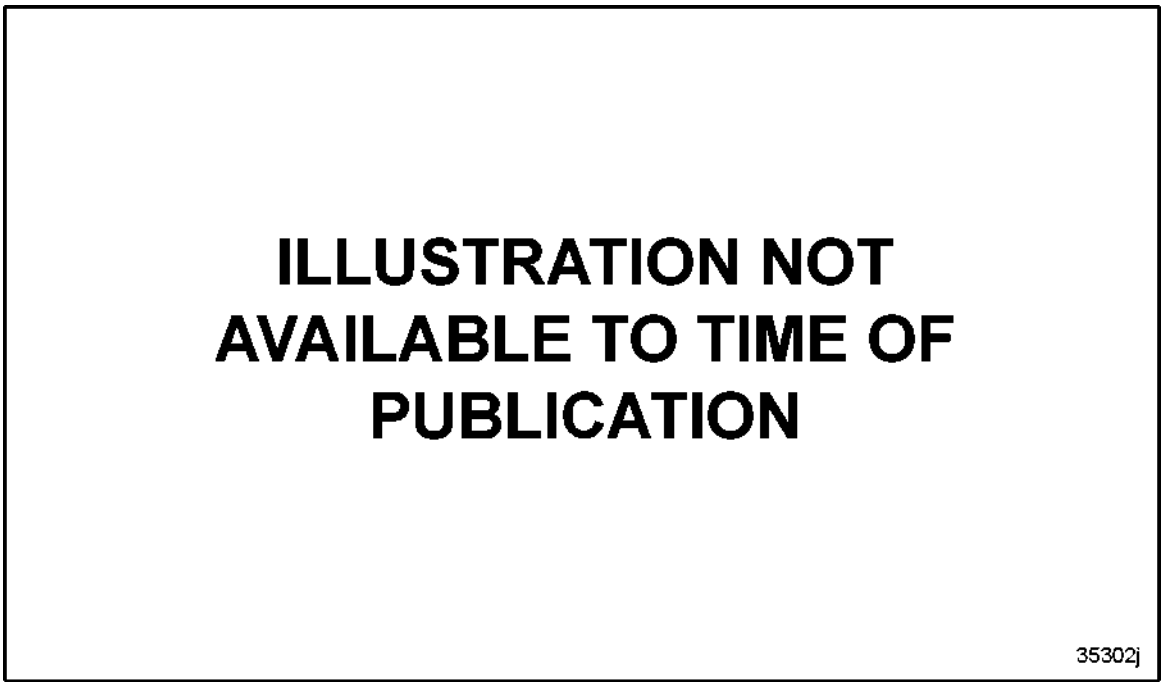


Figure 1160 Thread Repair (CYL HD Bolt Holes),J 38359

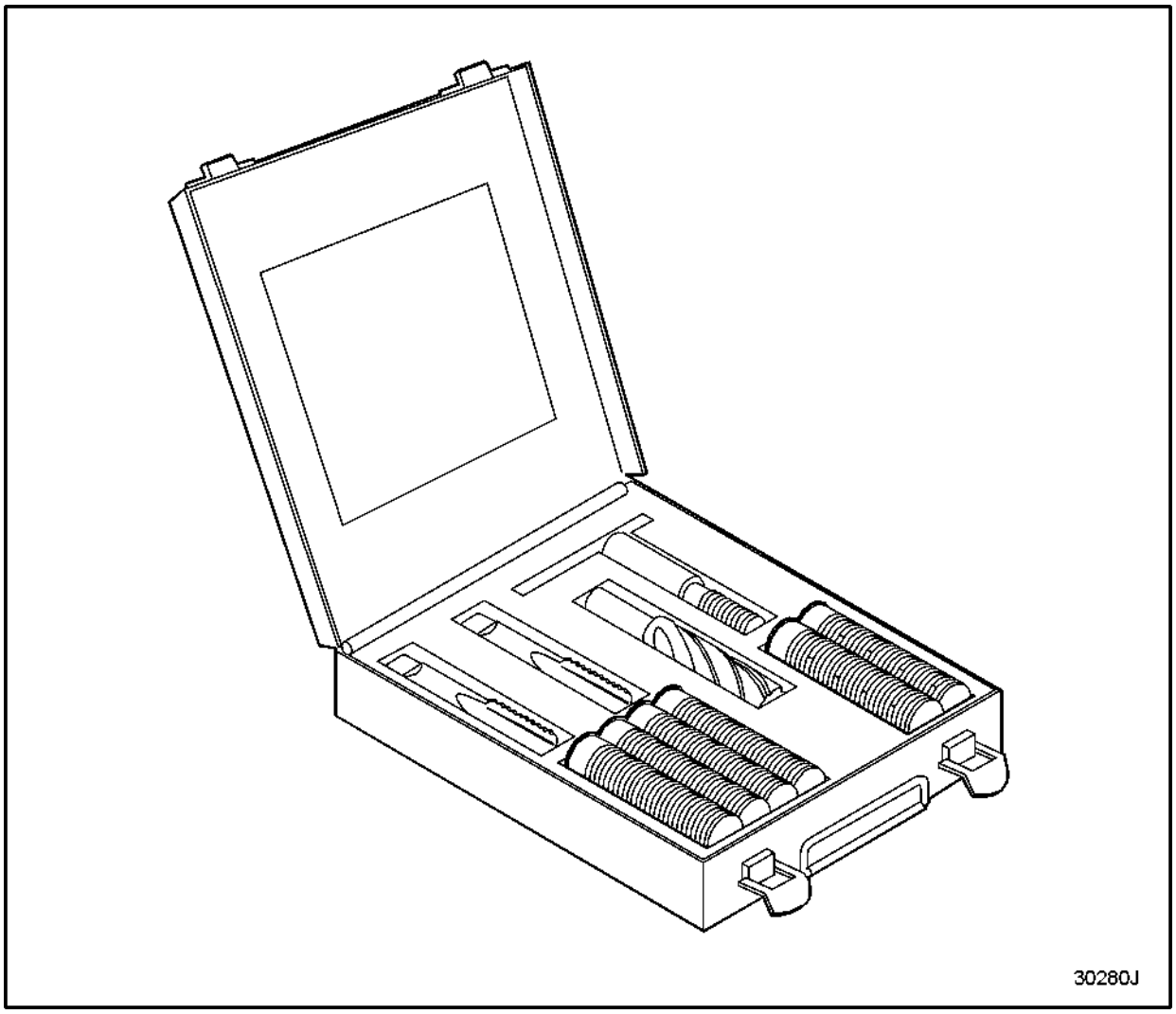


Figure 1161 Thread Repair -Main BRG/HD Bolt Hole,J 29513

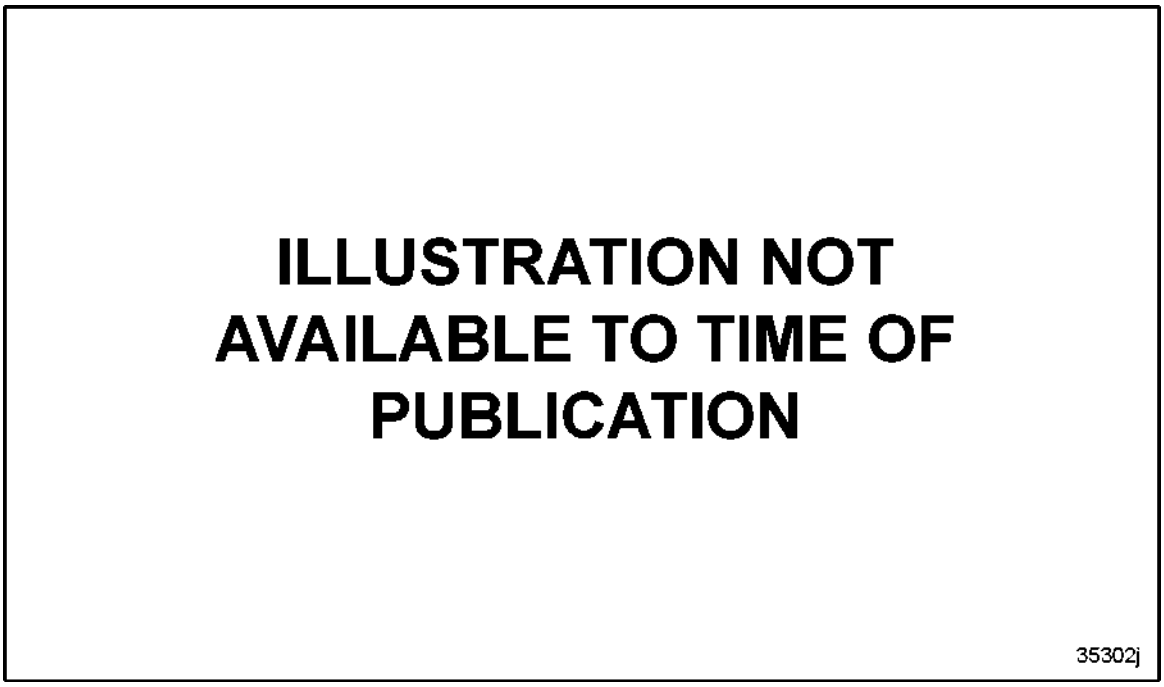


Figure 1162 Thread Rework Kit-15mm,PT-2860–A

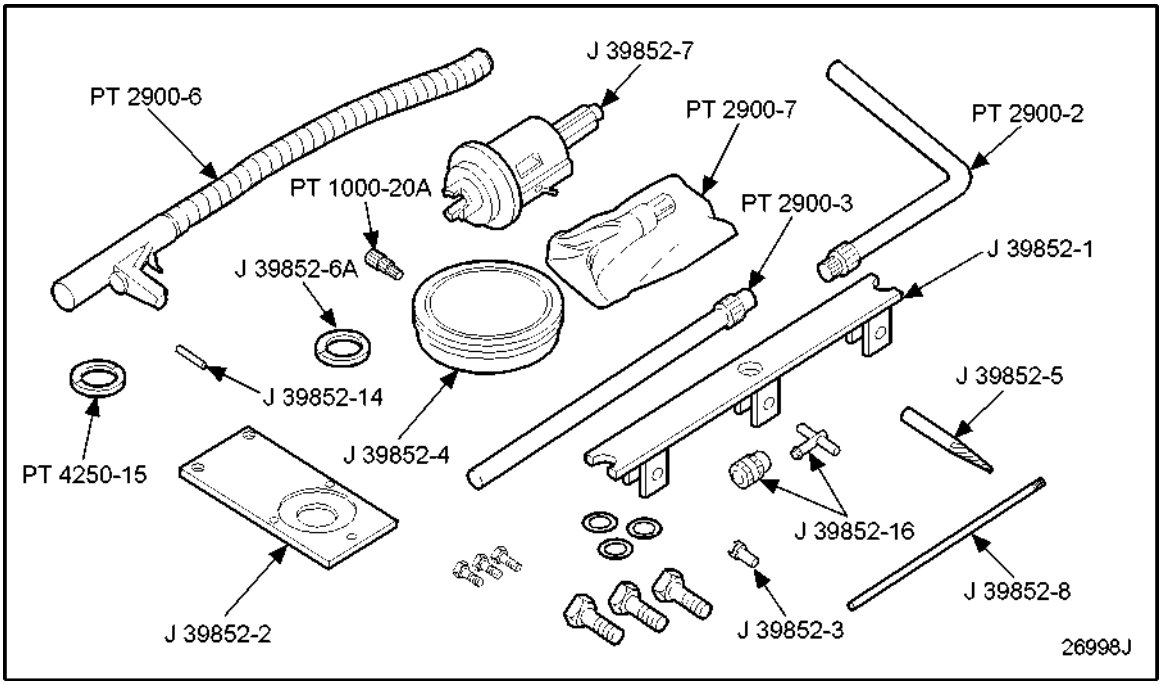


Figure 1163 Top Liner Cooler Modification Kit,J 39852

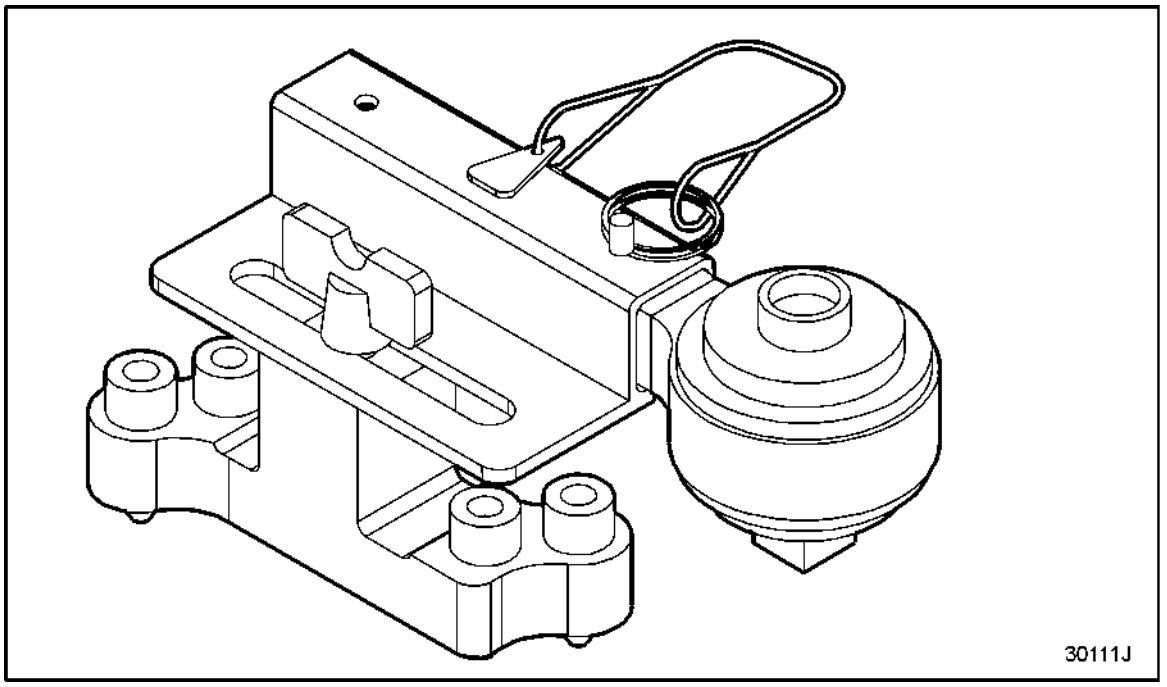


Figure 1164 Torquing Device -Main Bearing Bolts,J 35371

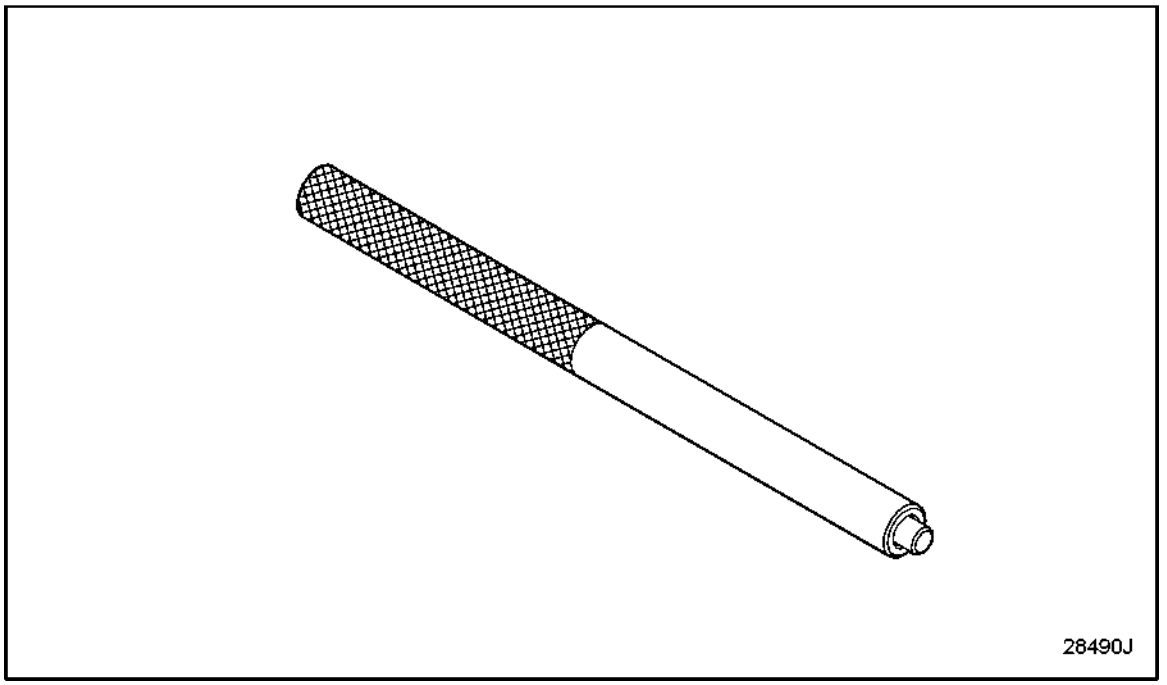


Figure 1165 Water Hole Sleeve Installer,J 24233–01

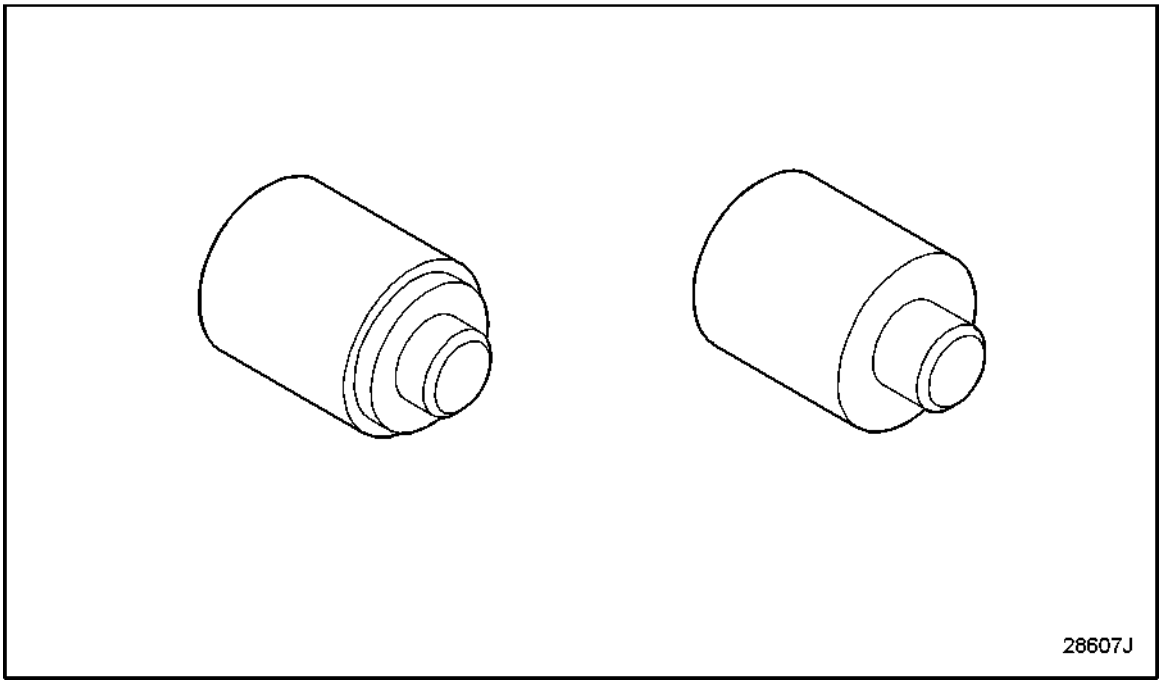


Figure 1166 Water Jacket Spacer Installer,J 38893

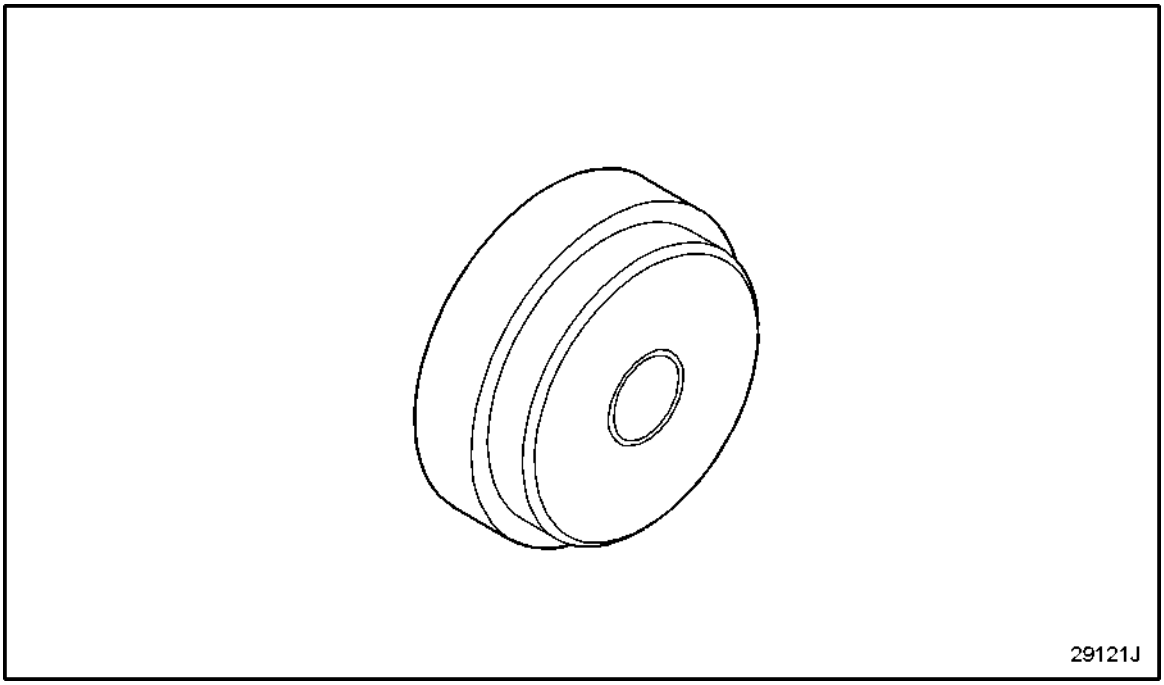


Figure 1167 Water Port Plug Installer,J 24597

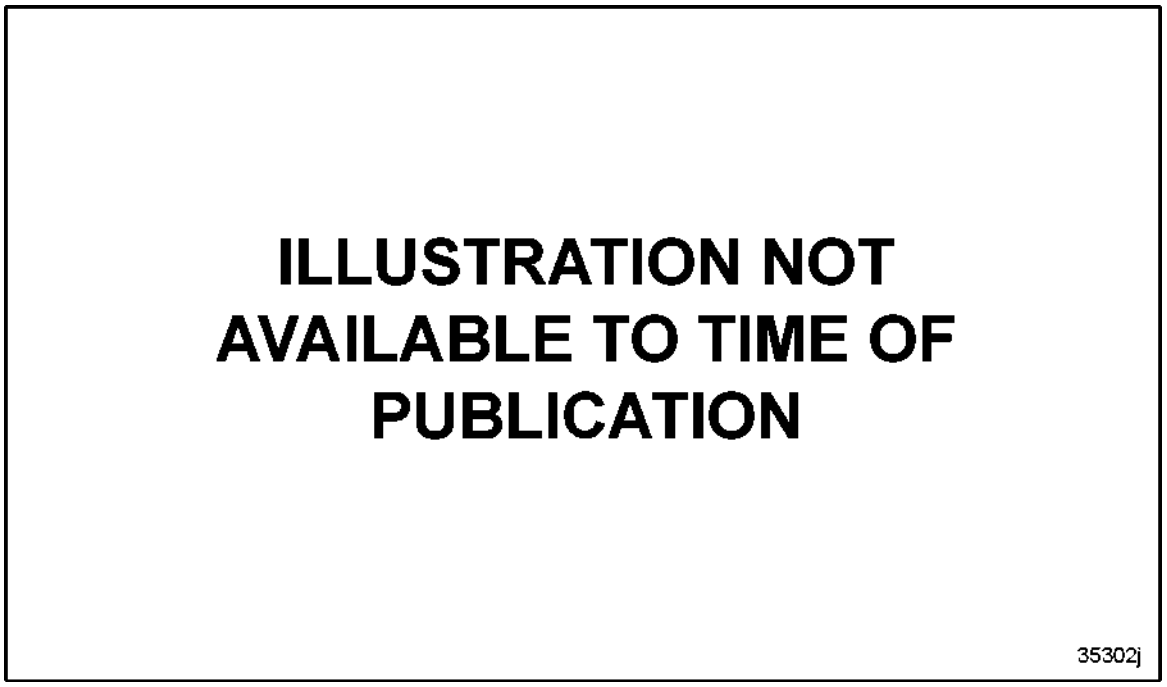


Figure 1168 **1 1/2 X45 Degree Cutter,**J 26541–620

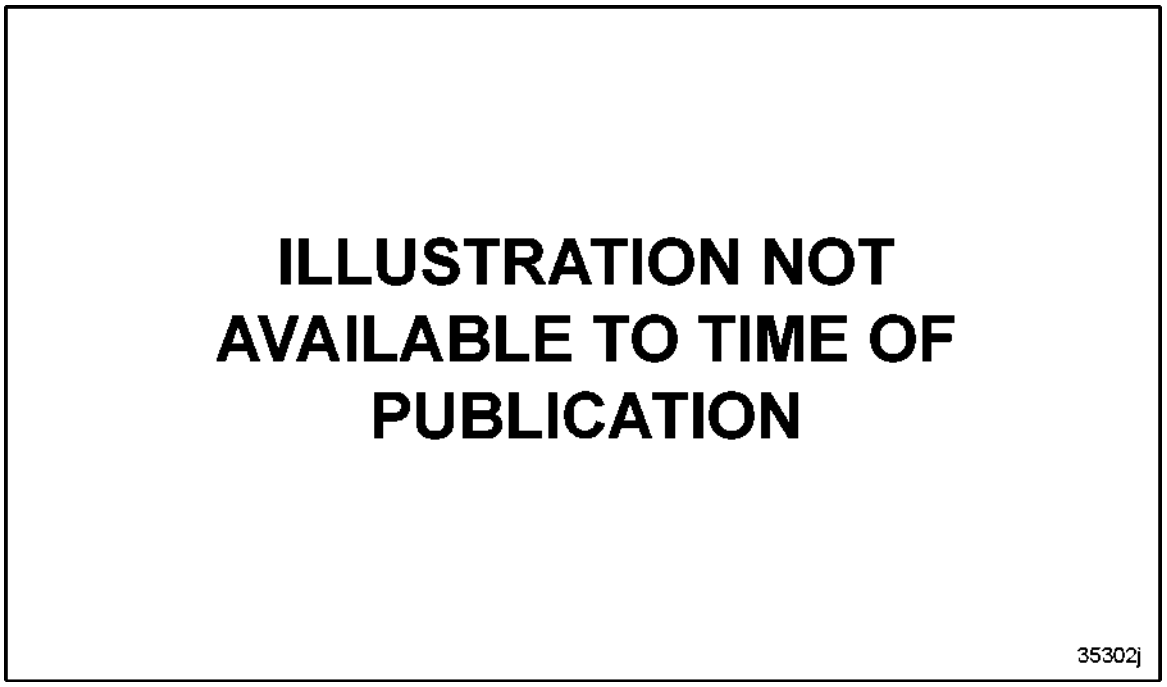


Figure 1169 **1 3/4 X30 Degree Cutter,**J 26541–647

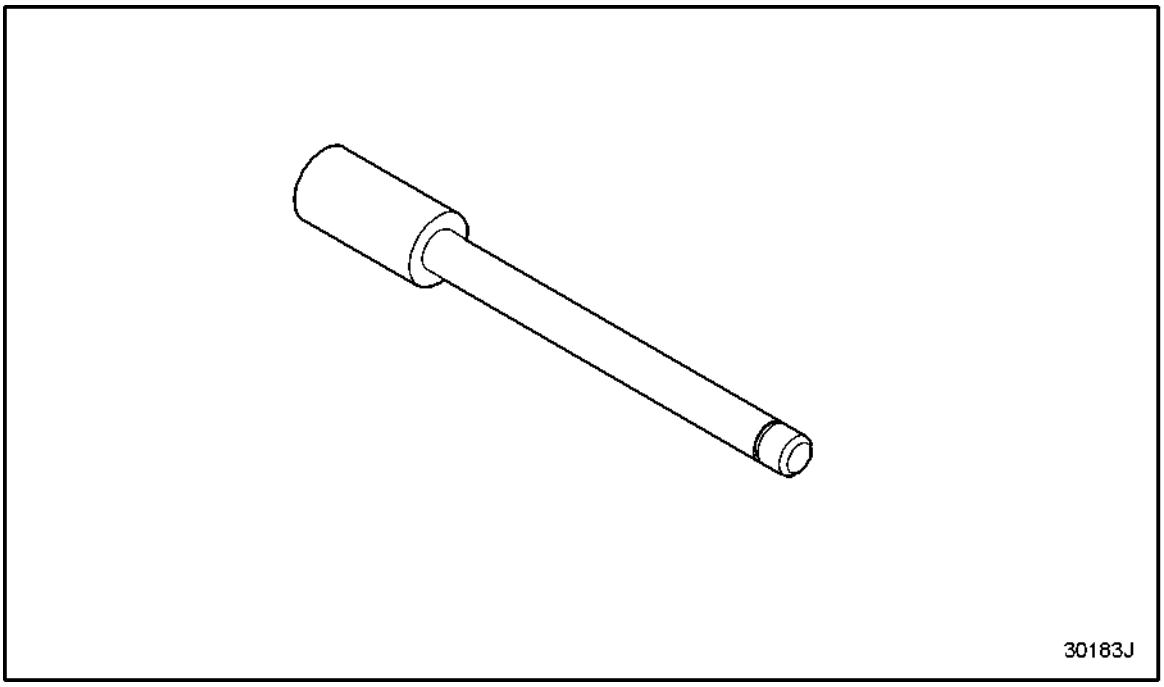


Figure 1170 Cam Follower Service Fixture,J 33421–A

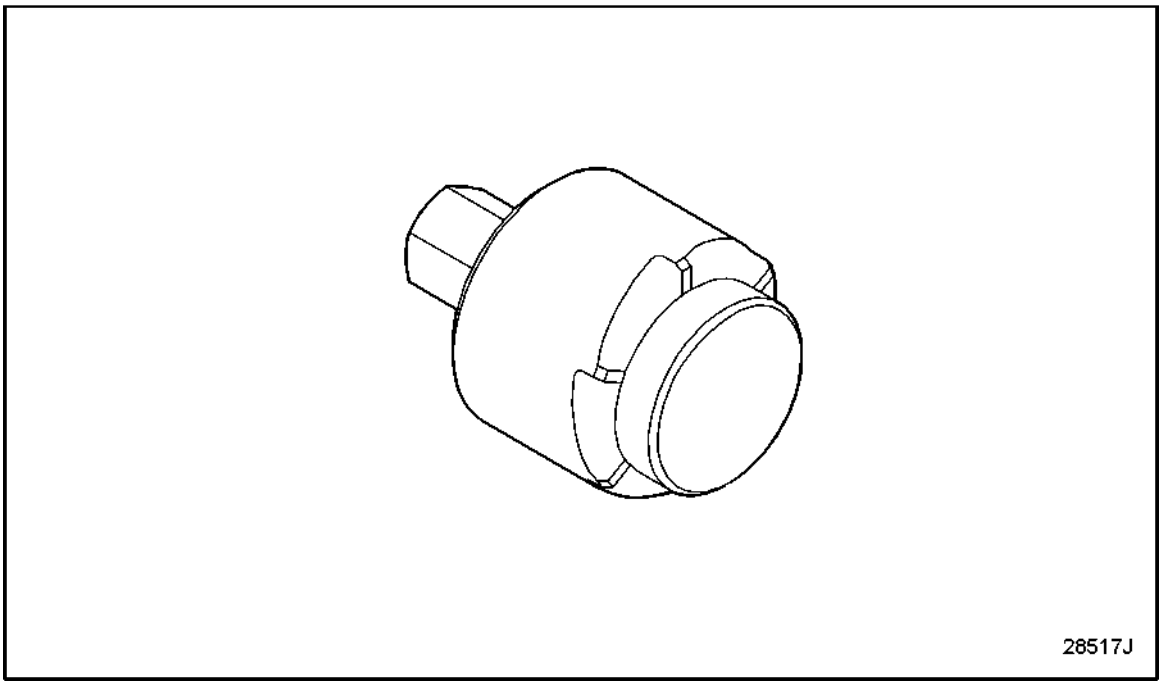


Figure 1171 Ceramic Cutter,J 39639

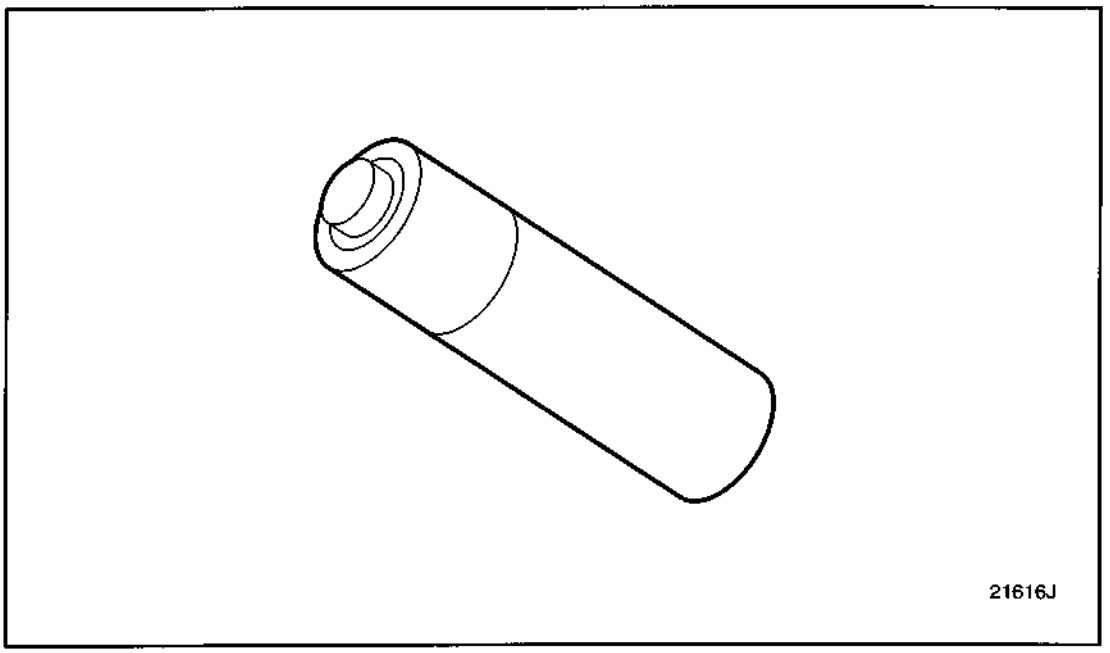


Figure 1172 Car Plug Install-Rocker Arm Shaft,J36326

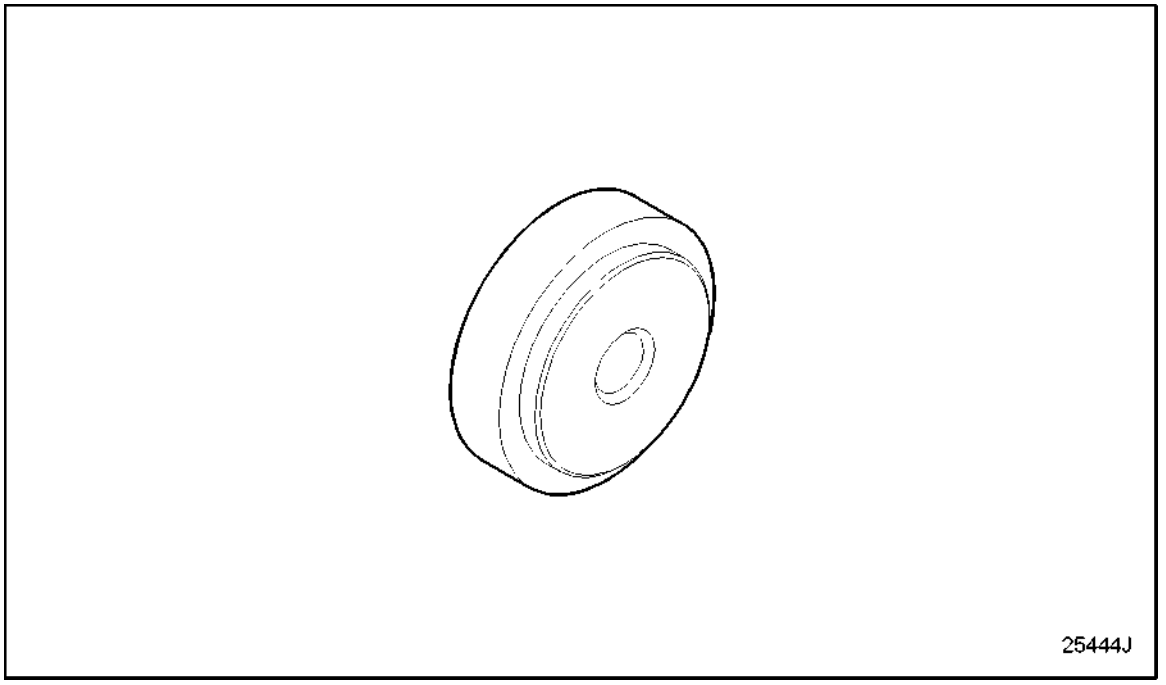


Figure 1173 Cup Plug Installer,J 41746

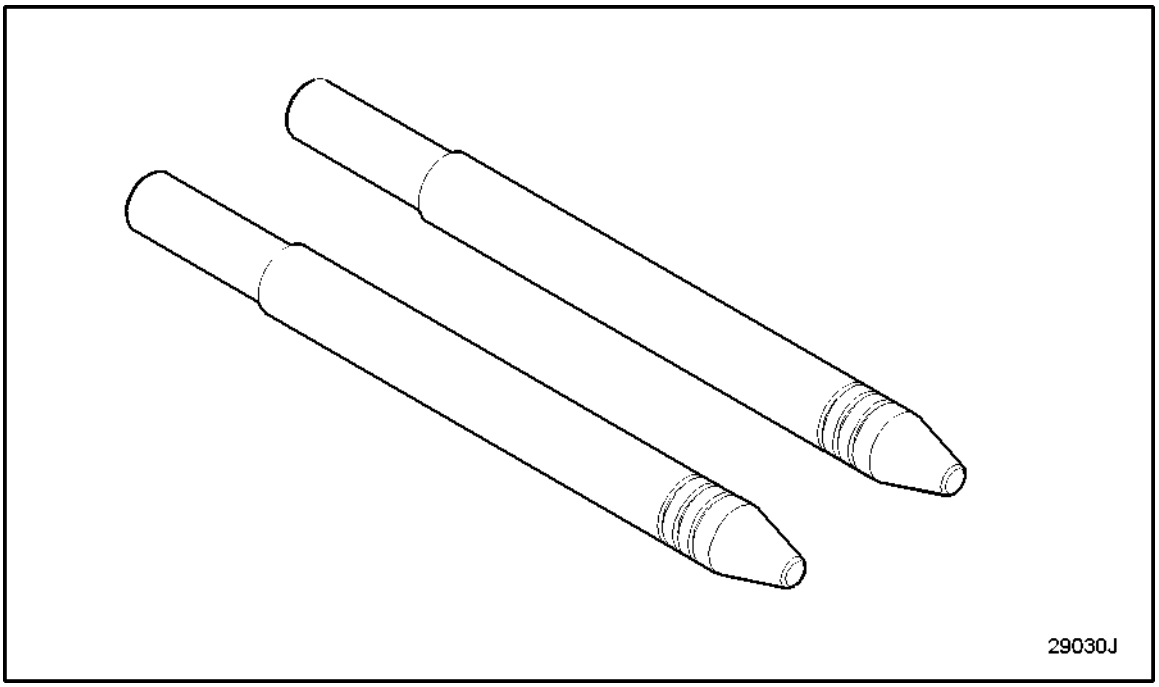


Figure 1174 Cylinder Head Guide Studs, J 24748

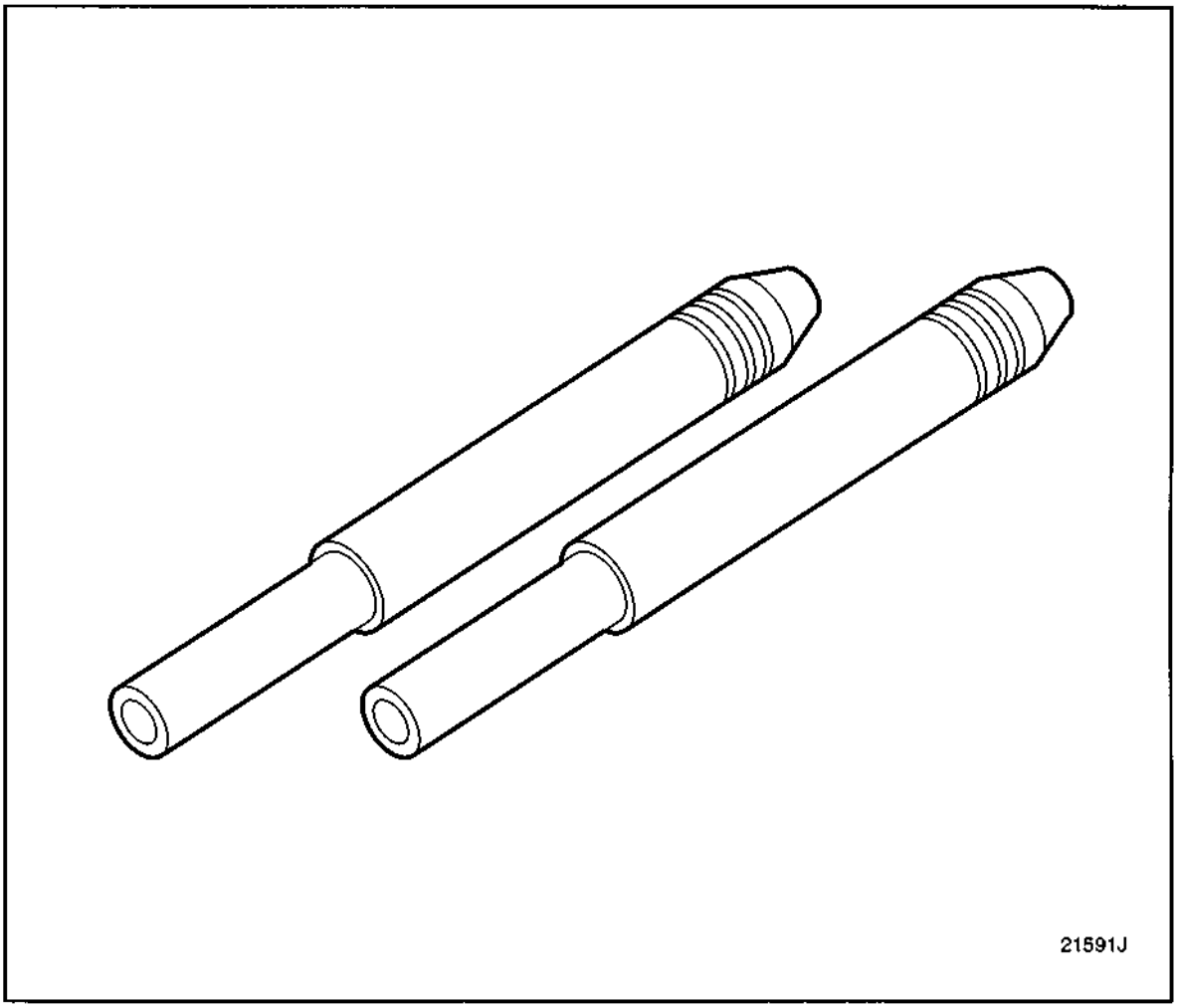


Figure 1175 Cylinder Head Guide Studs, J 35784

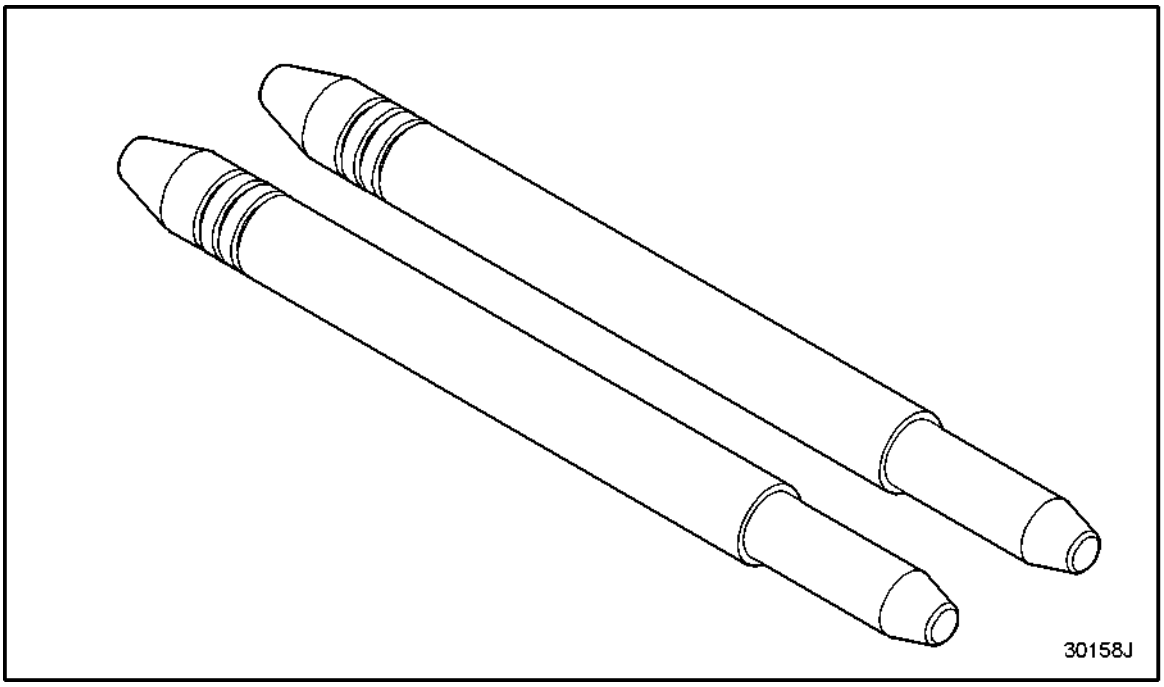


Figure 1176 Cylinder Head Guide Studs,J 9665

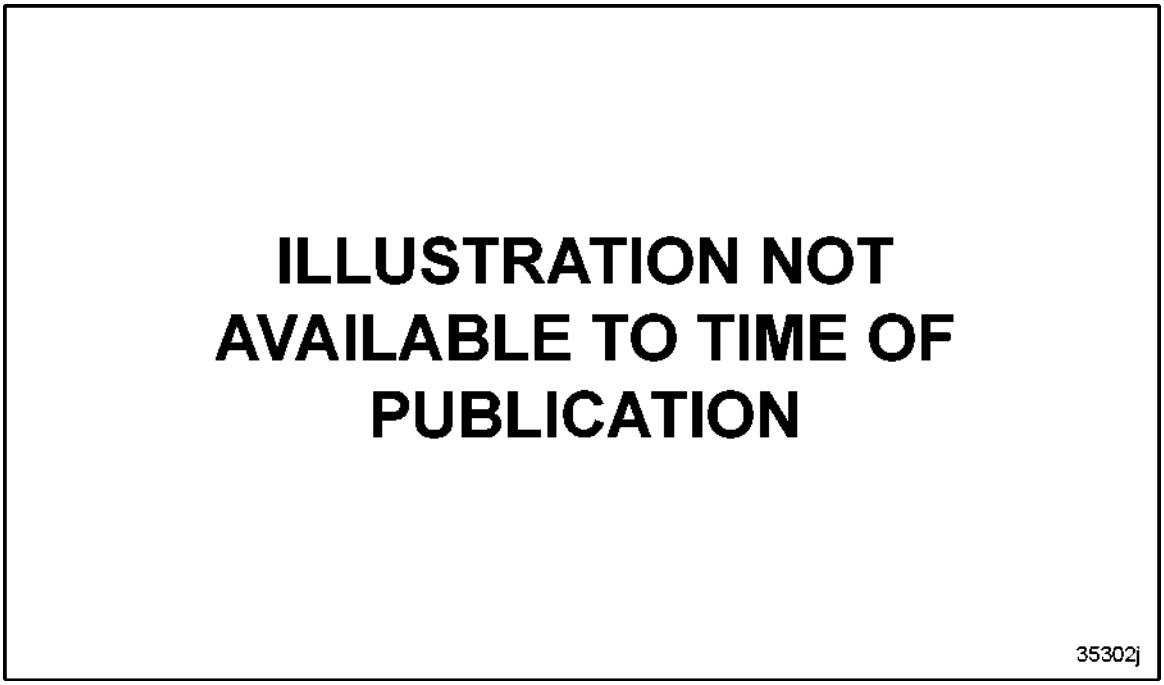


Figure 1177 Cylinder Head Holding Fixture,J 41558

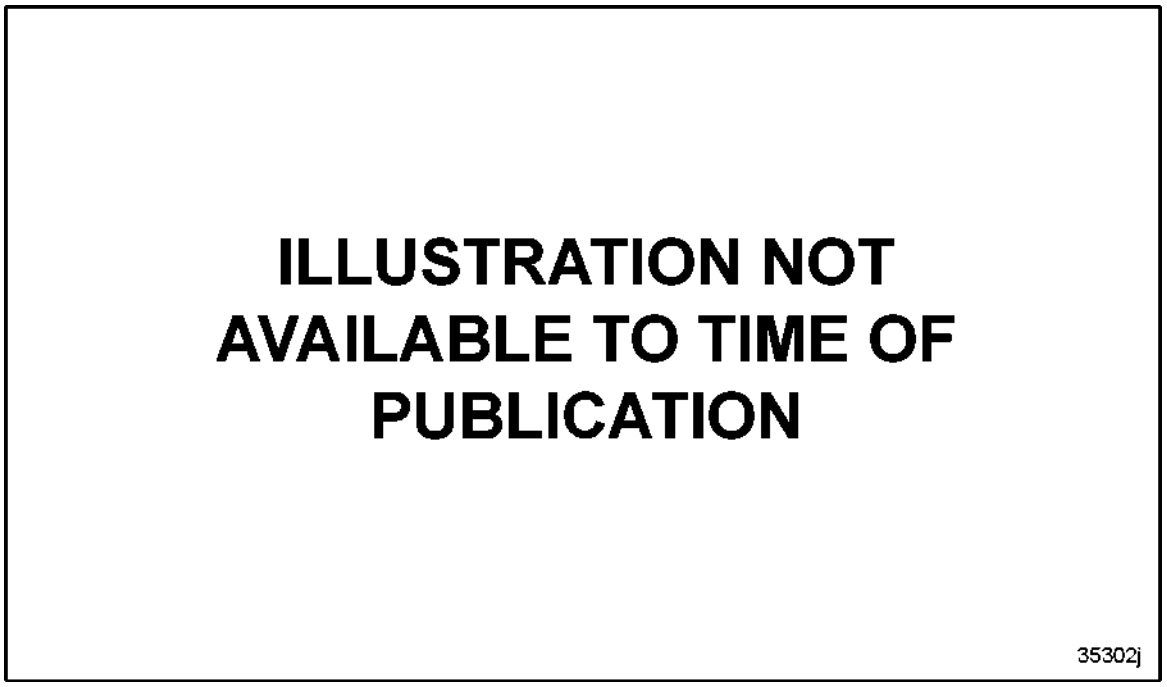


Figure 1178 Cylinder Head Holding Plates, J 3087–01

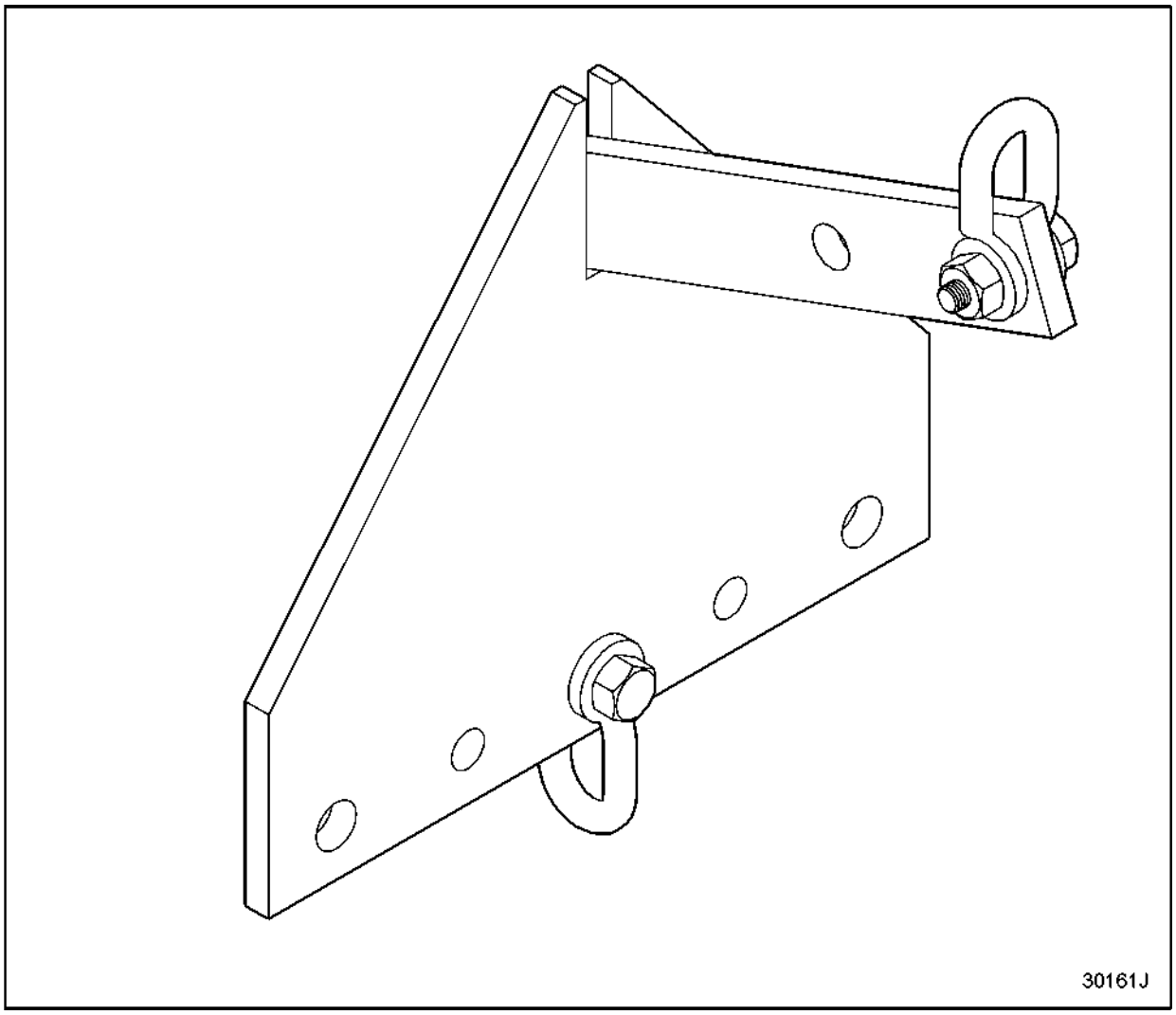


Figure 1179 Cylinder Head Lifting Fixture,J 22062–01

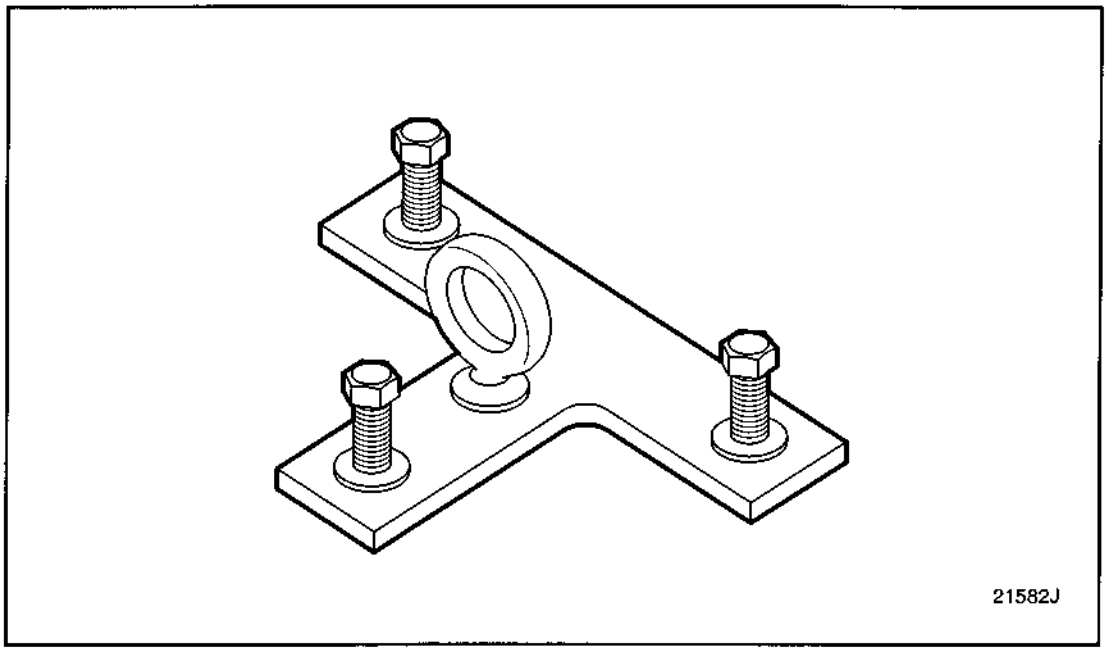


Figure 1180 Cylinder Head Lifting Fixture,J 35641–A

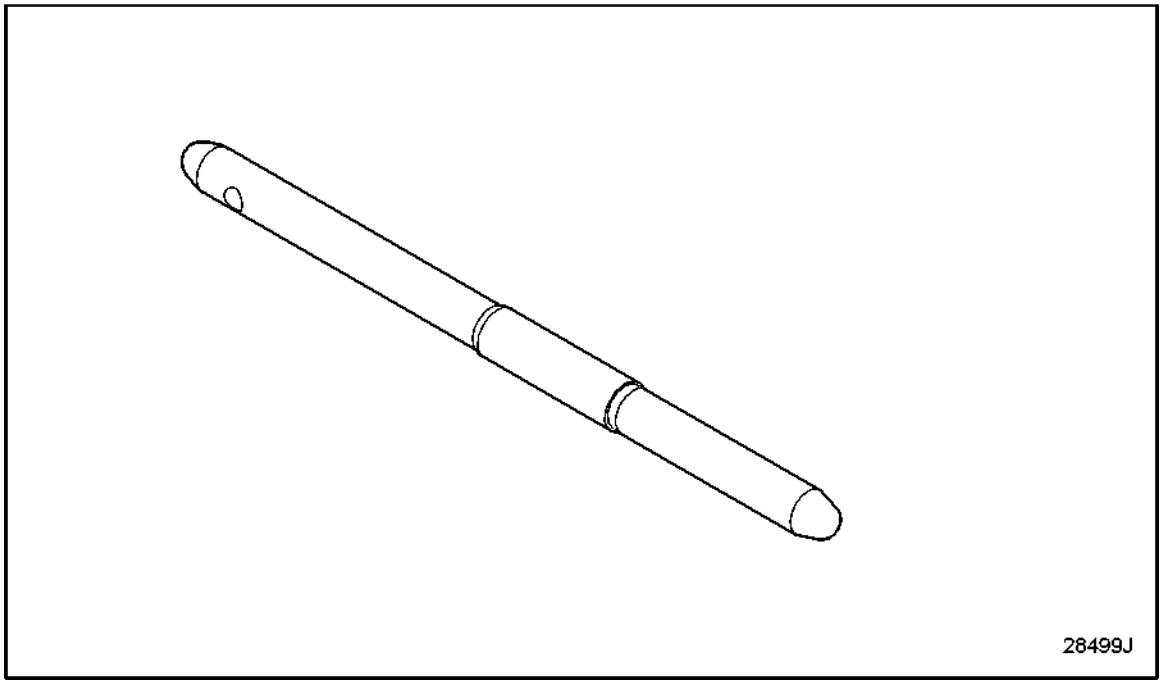


Figure 1181 Cylinder Head Locating Pins,J 28511–C

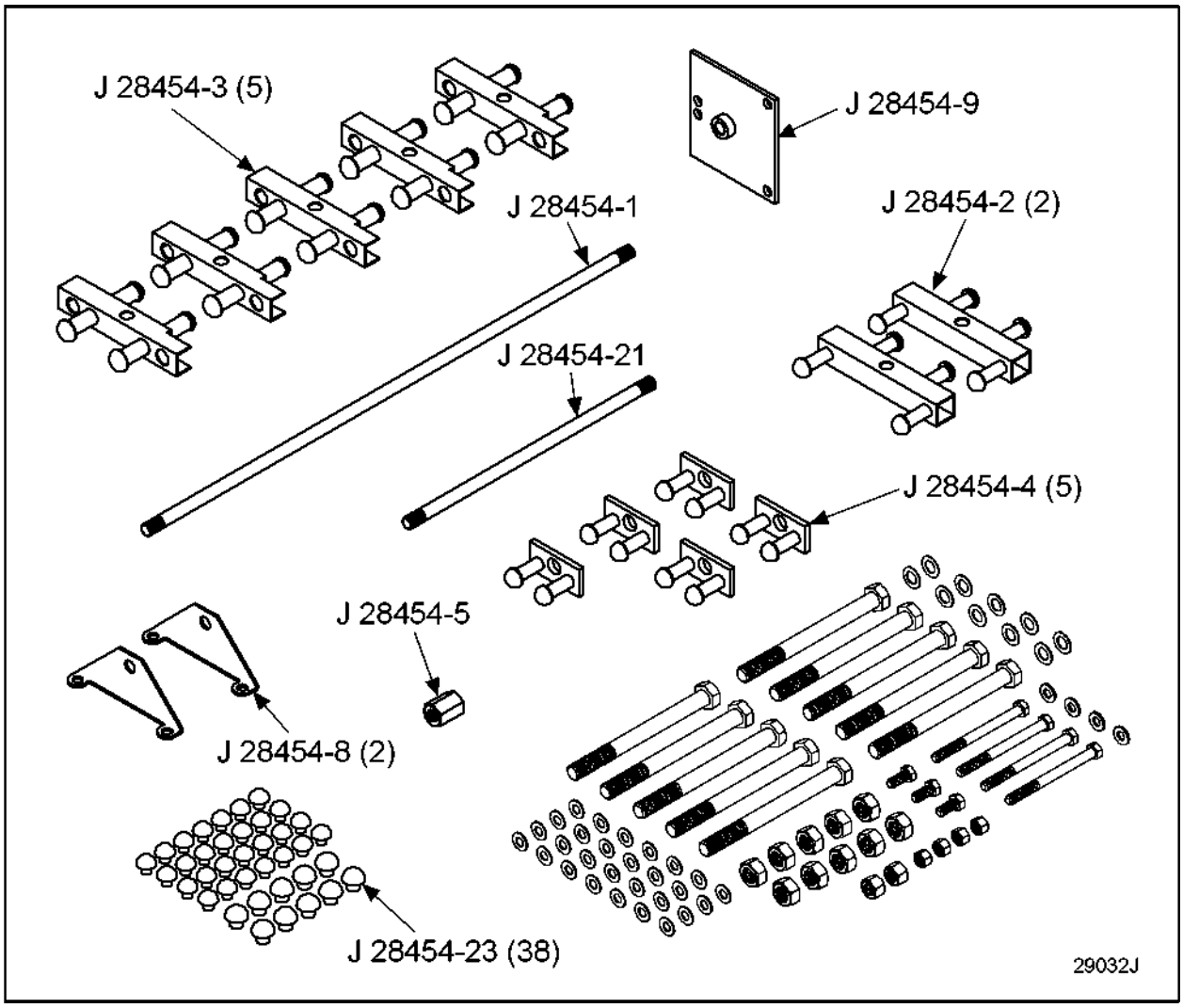


Figure 1182 Cylinder Head Pressure Test Fixture,J 28454

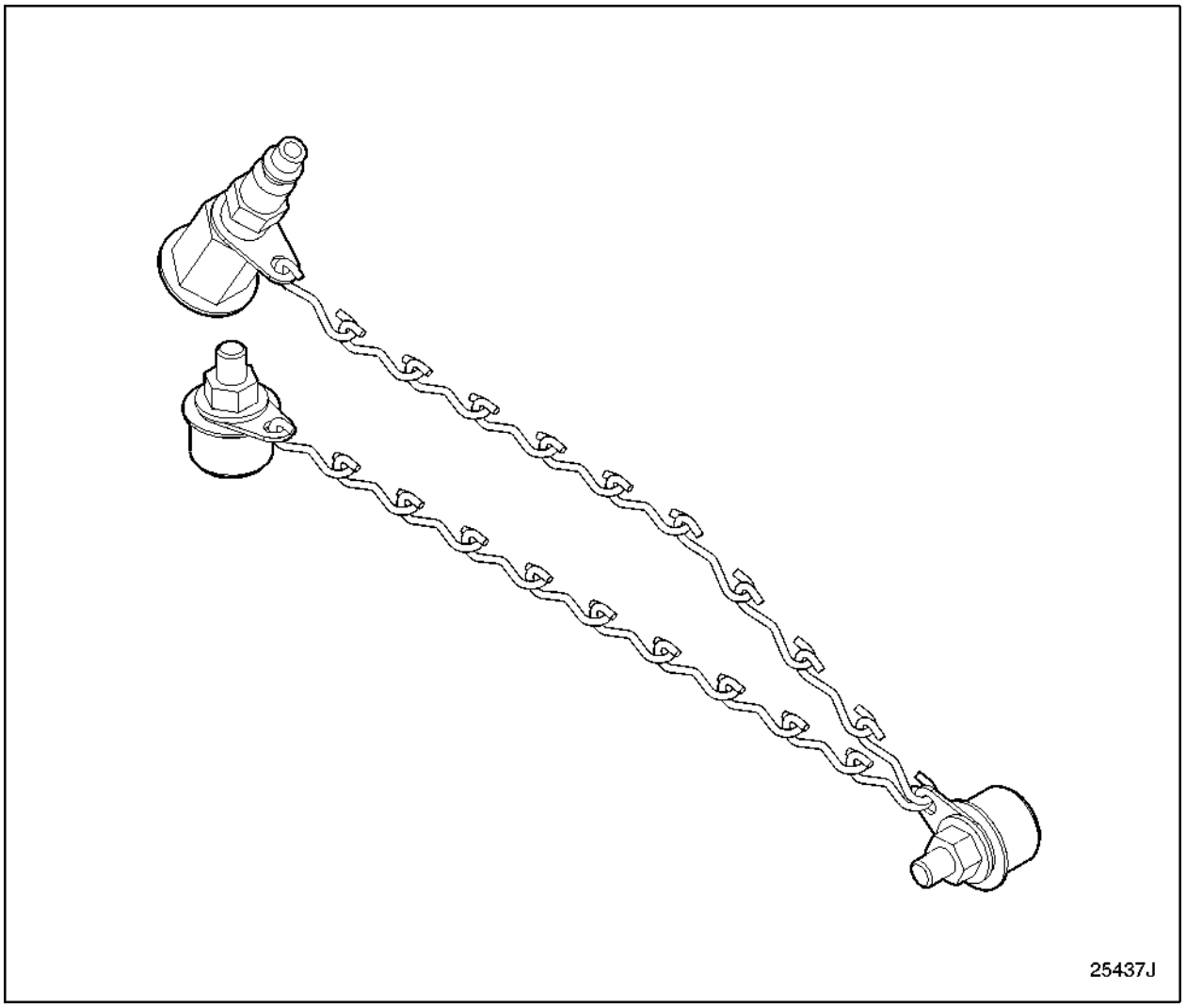


Figure 1183 Cylinder Head Pressure Test Fixture,J 41567

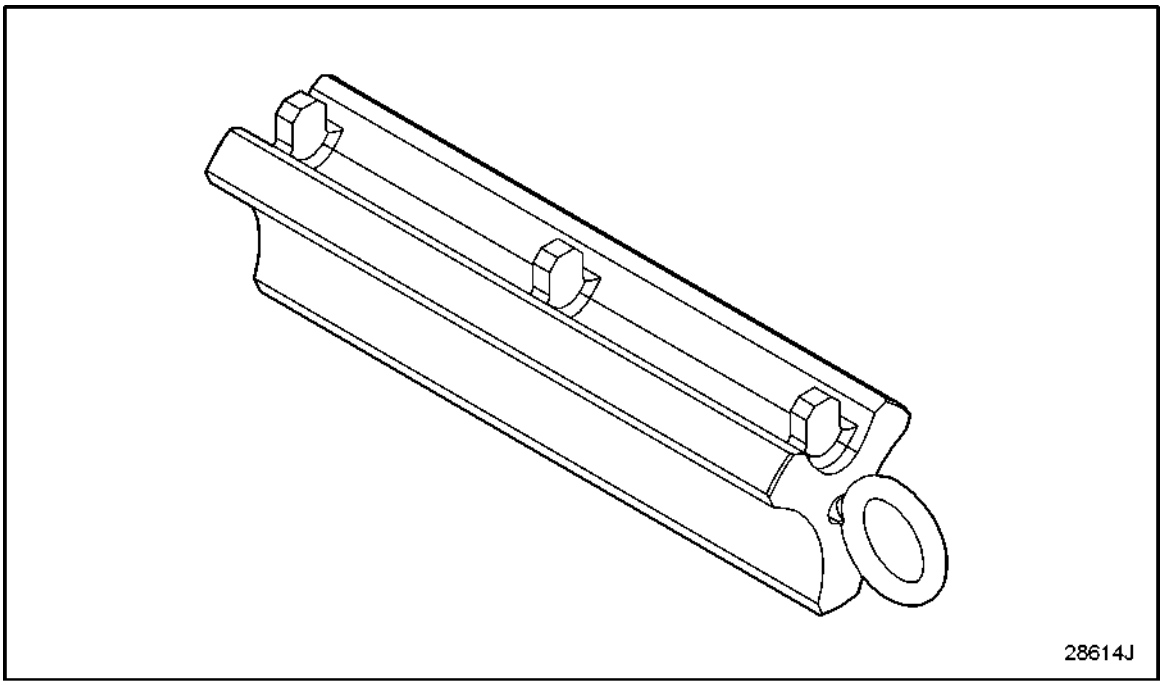


Figure 1184 Cylinder Head Puller,J 24252

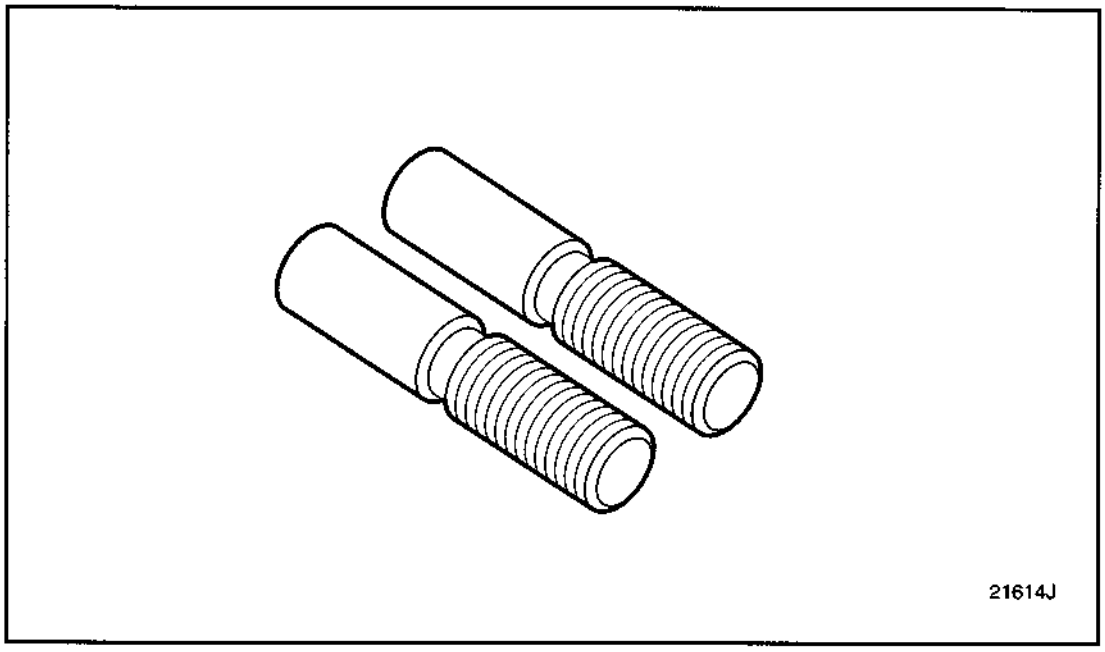


Figure 1185 Dowel Installer Set,J 36224

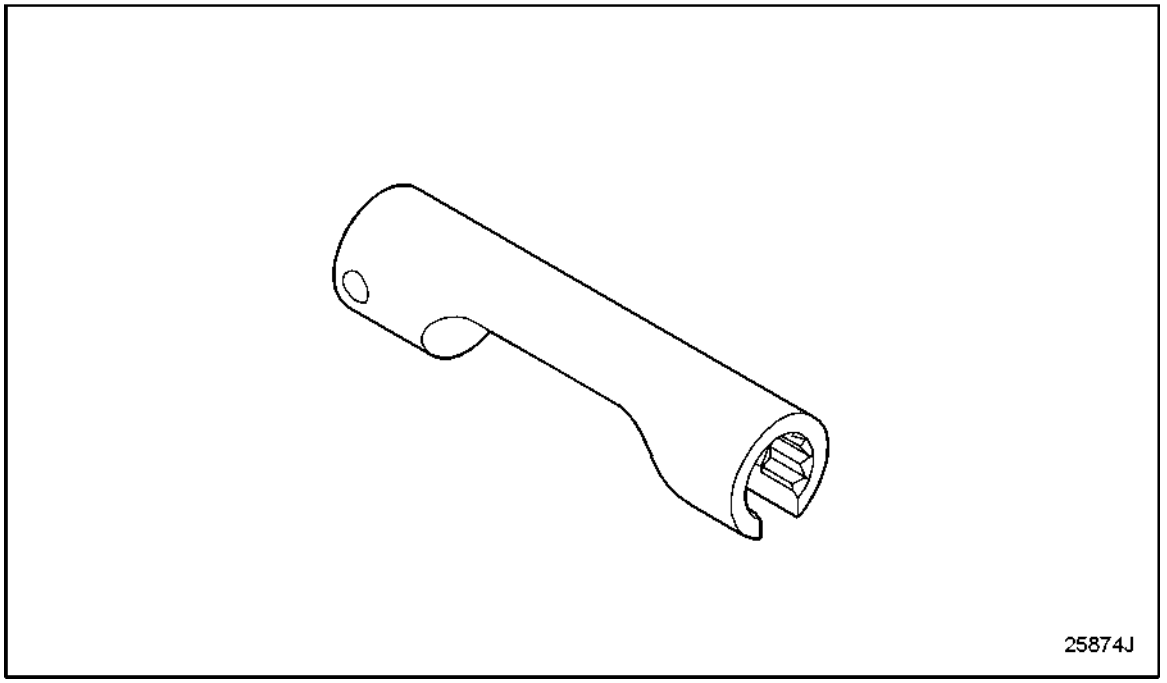


Figure 1186 Fuel Line Nut Wrench (9/16),J 21545

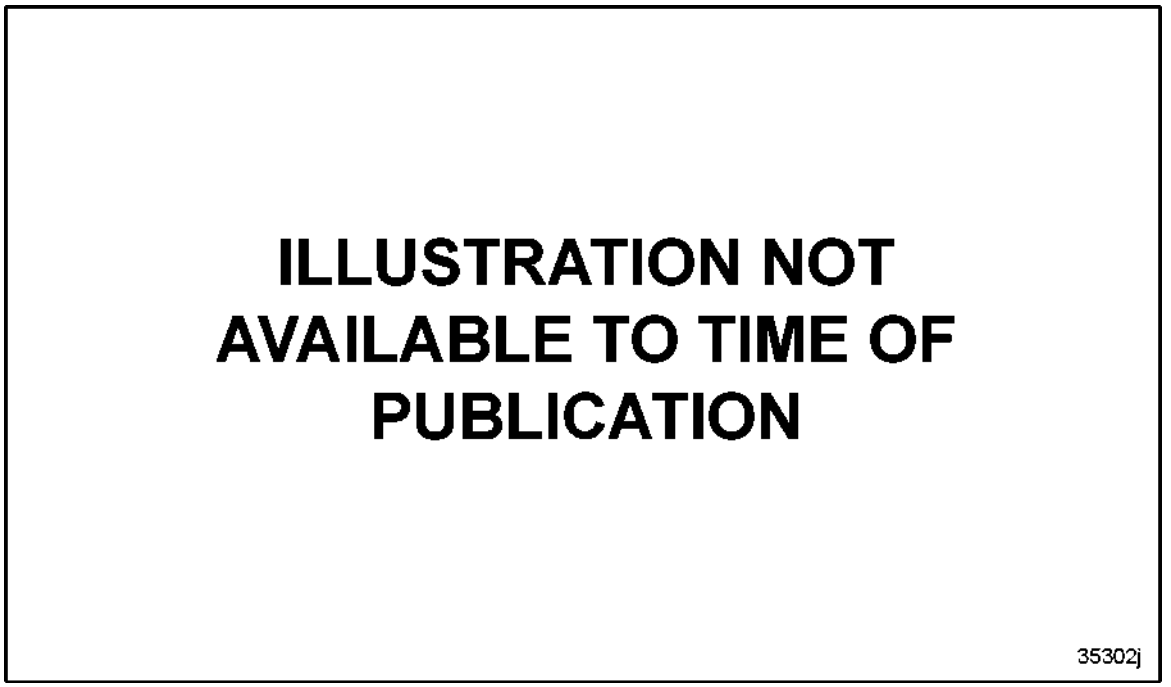


Figure 1187 Fuel Line Nut Wrench 11/16",J 39108

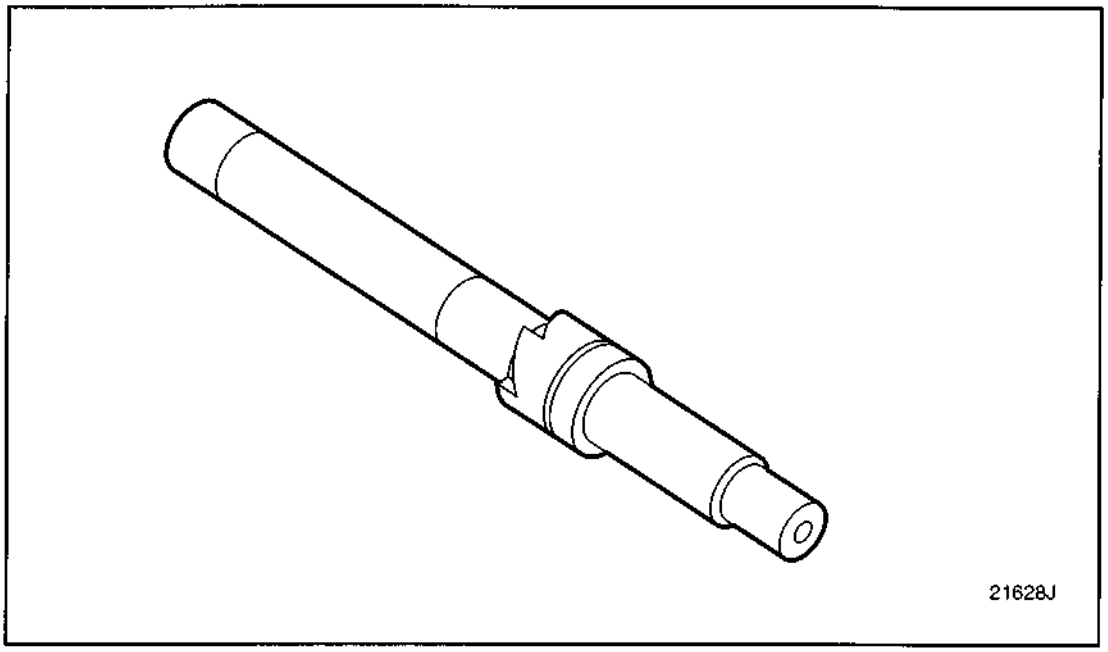


Figure 1188 Head Bolt Counterbore Cutter,J 38189

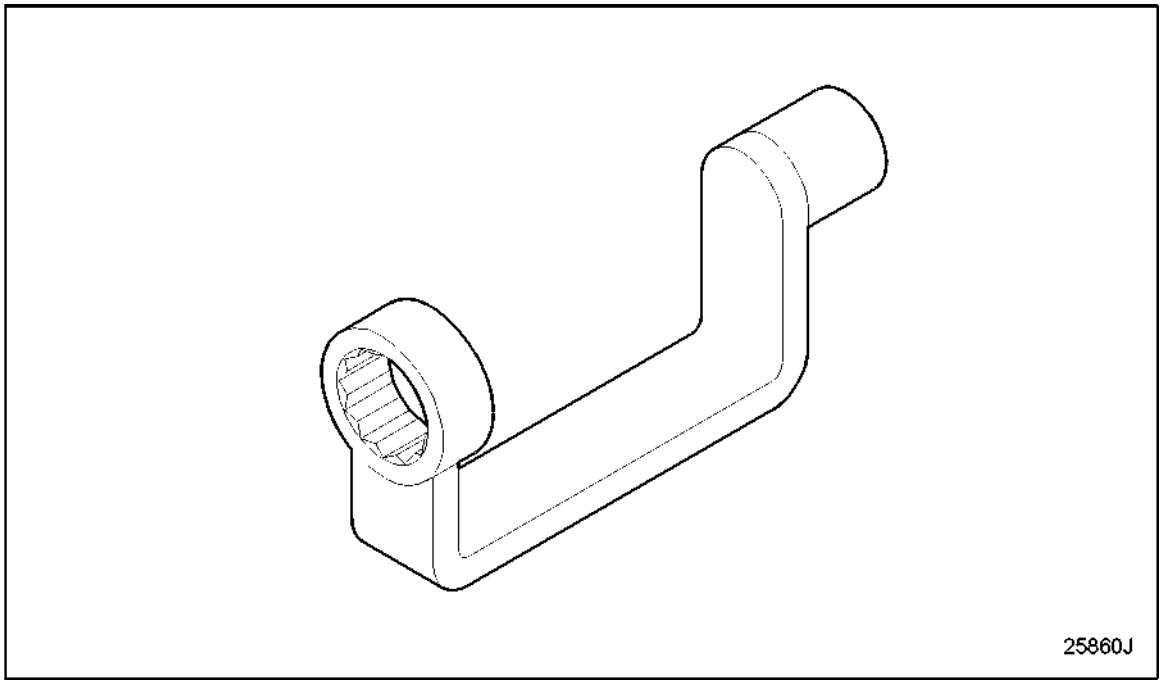


Figure 1189 Head Bolt Wrench (15/16"X1/2"Drive),J 1928–02

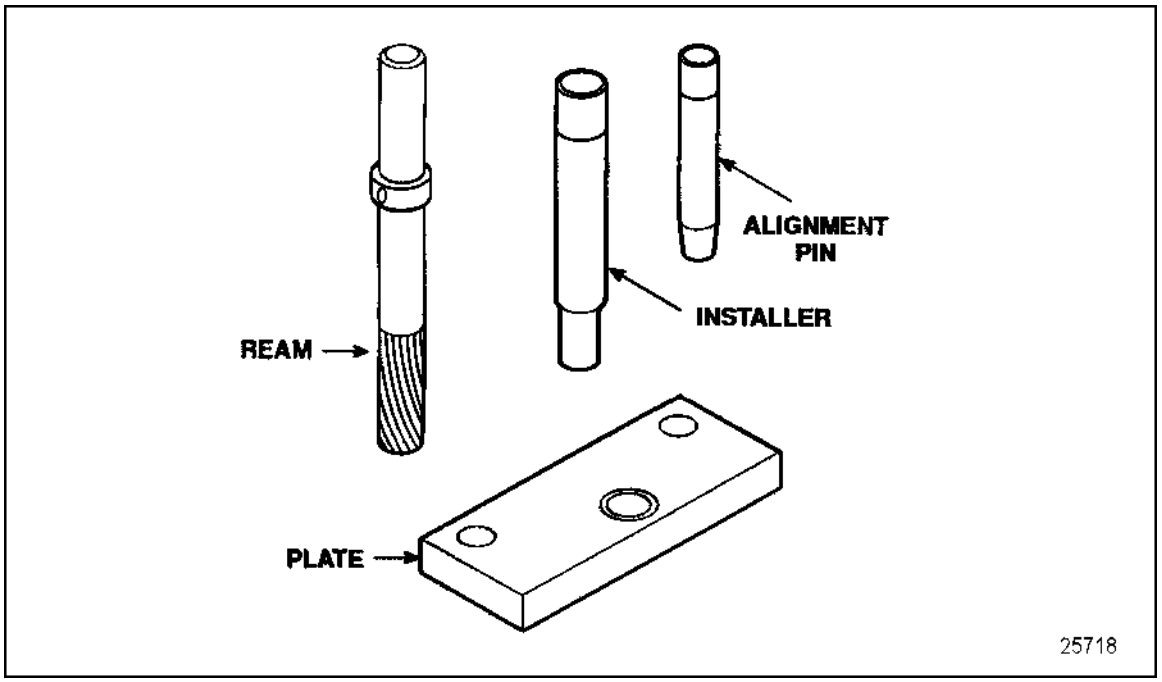


Figure 1190 Head Modification Kit (Bolt Hole SL), J 41169

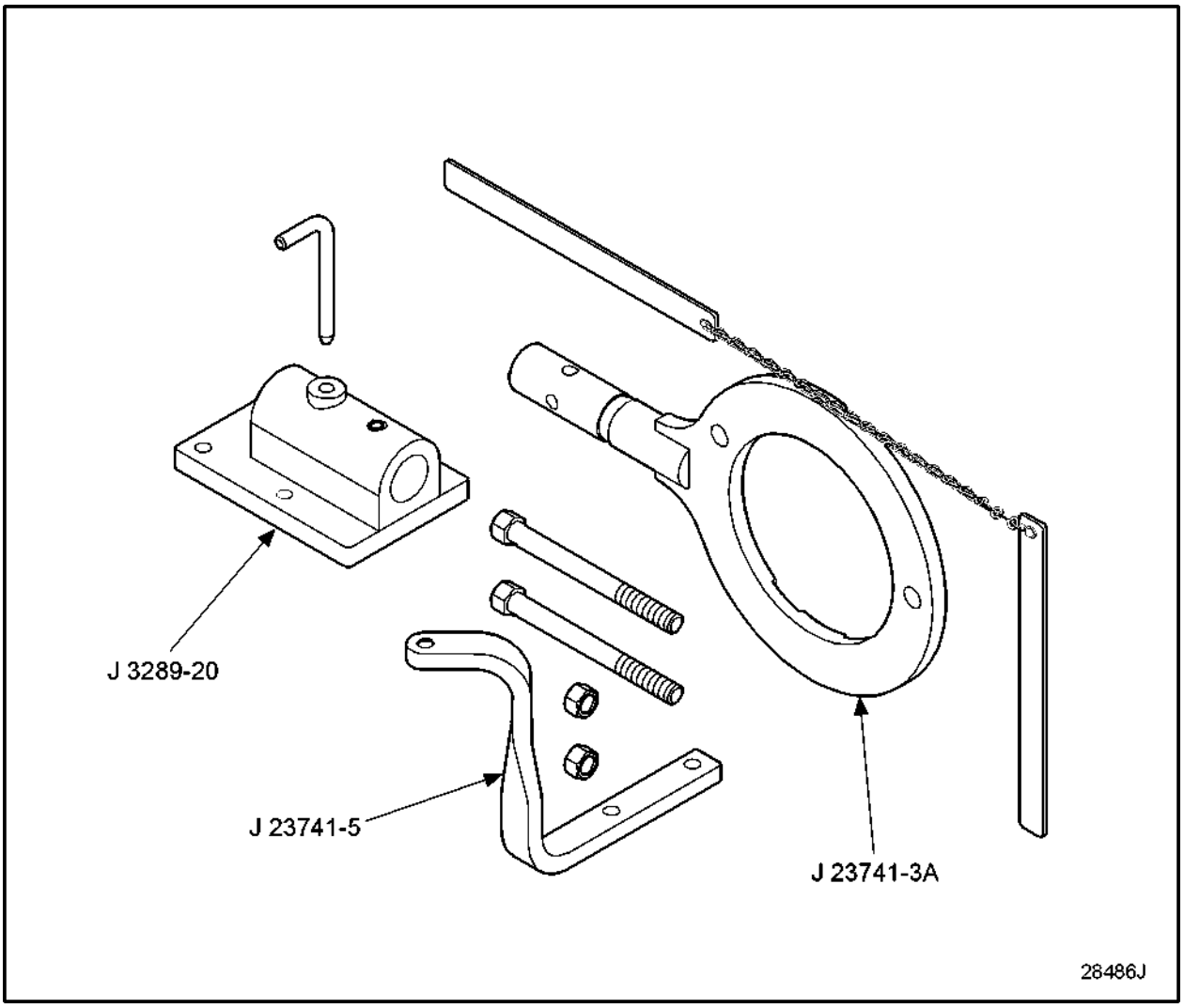


Figure 1191 Holding Fixture, J 23741–B

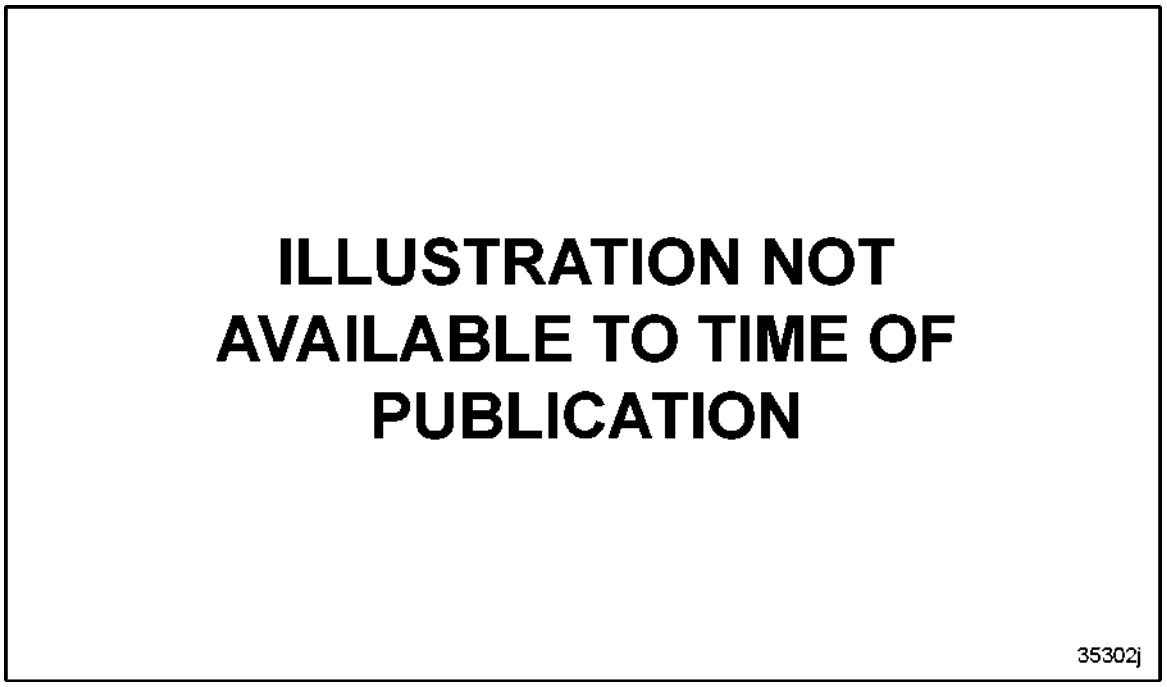


Figure 1192 Injector Puller,39272

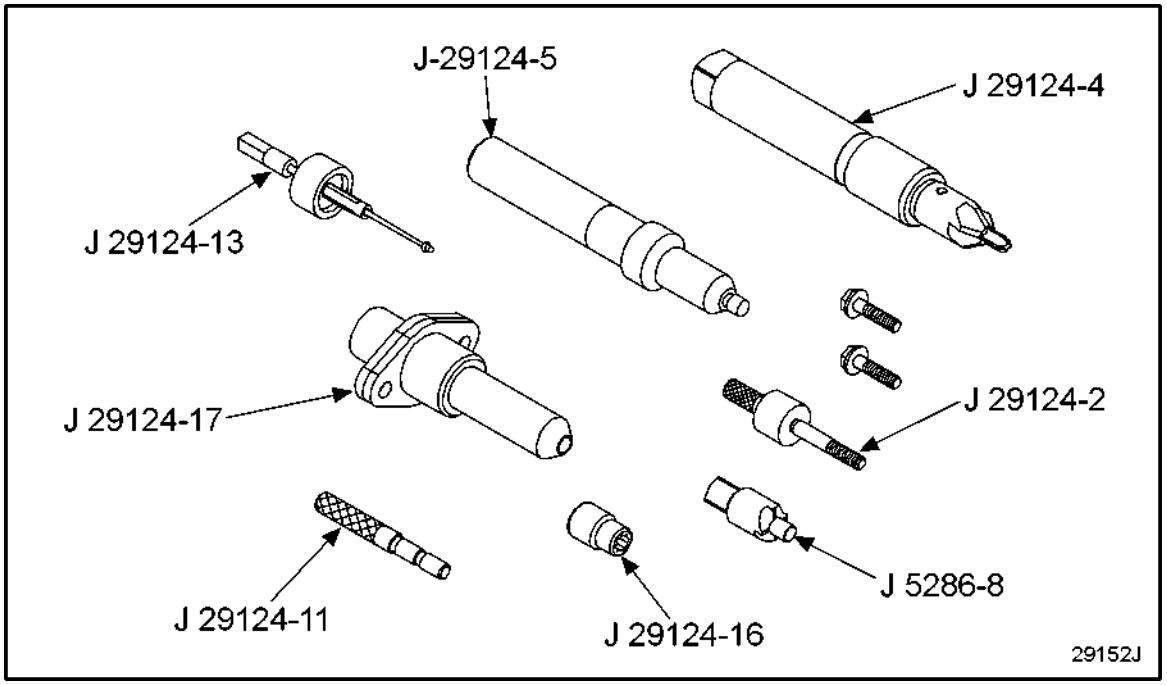


Figure 1193 Injector Tube Reconditioning Kit,J 29124

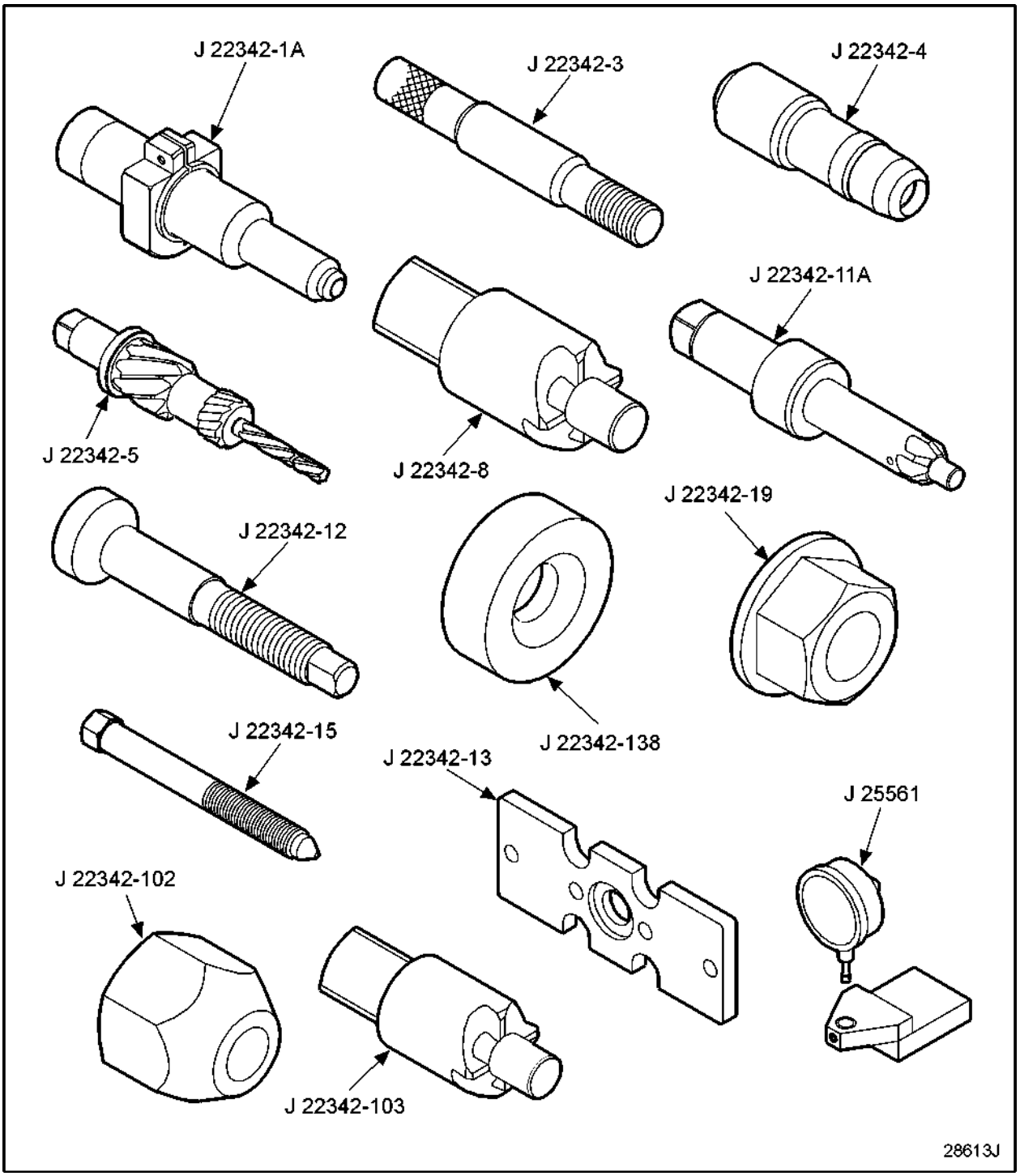


Figure 1194 Injector Tube Reconditioning Set,J 22342–D

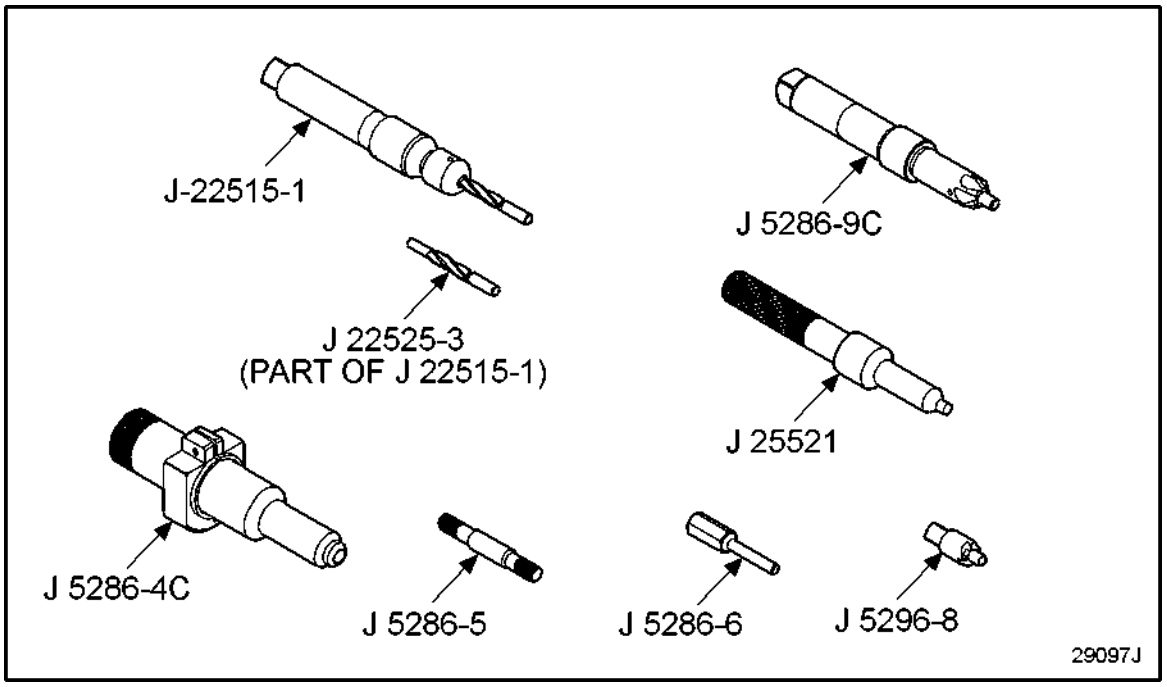


Figure 1195 Injector Tube Reconditioning Set, J 22515–B

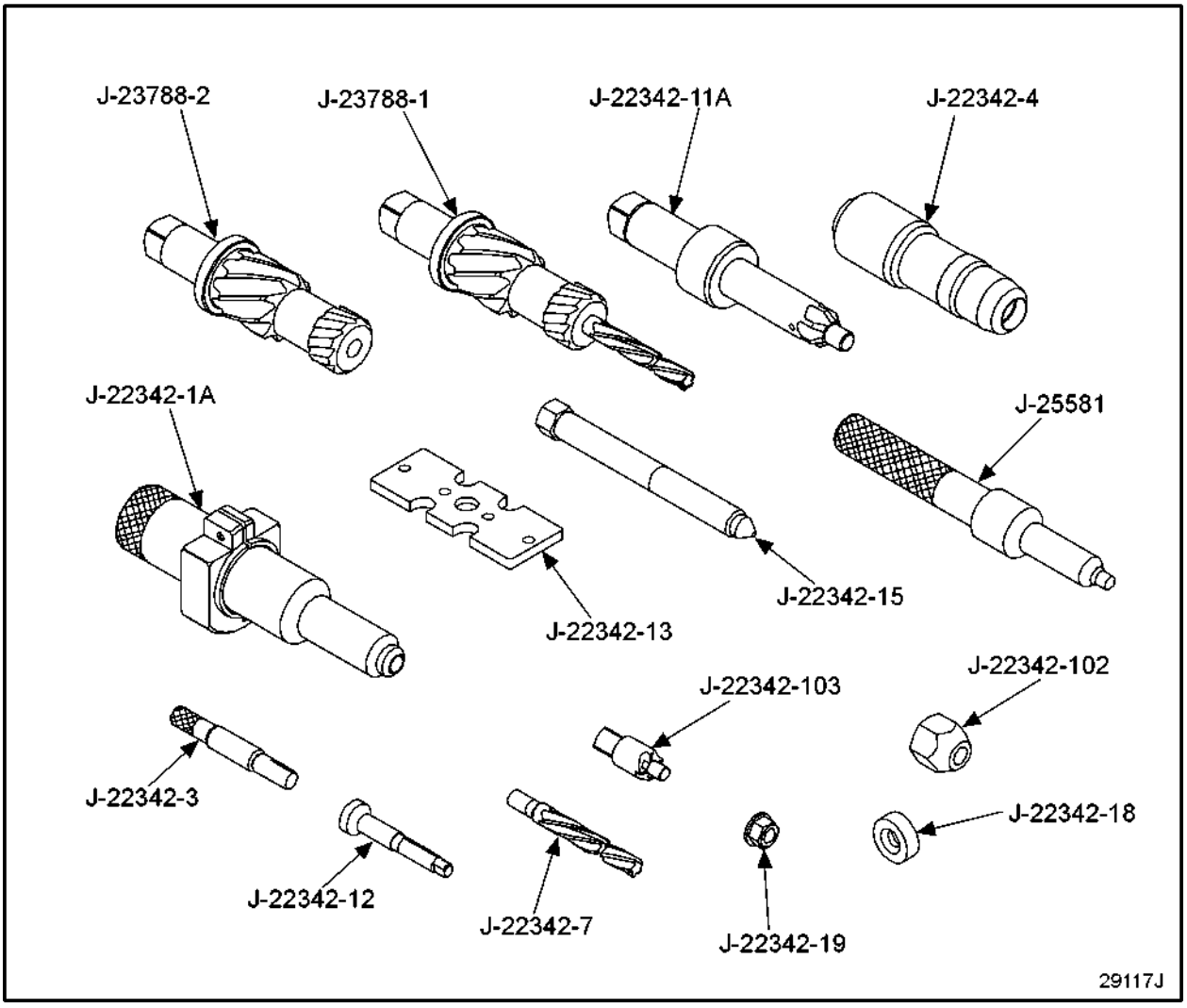


Figure 1196 Injector Tube Reconditioning Set,J 24517–B

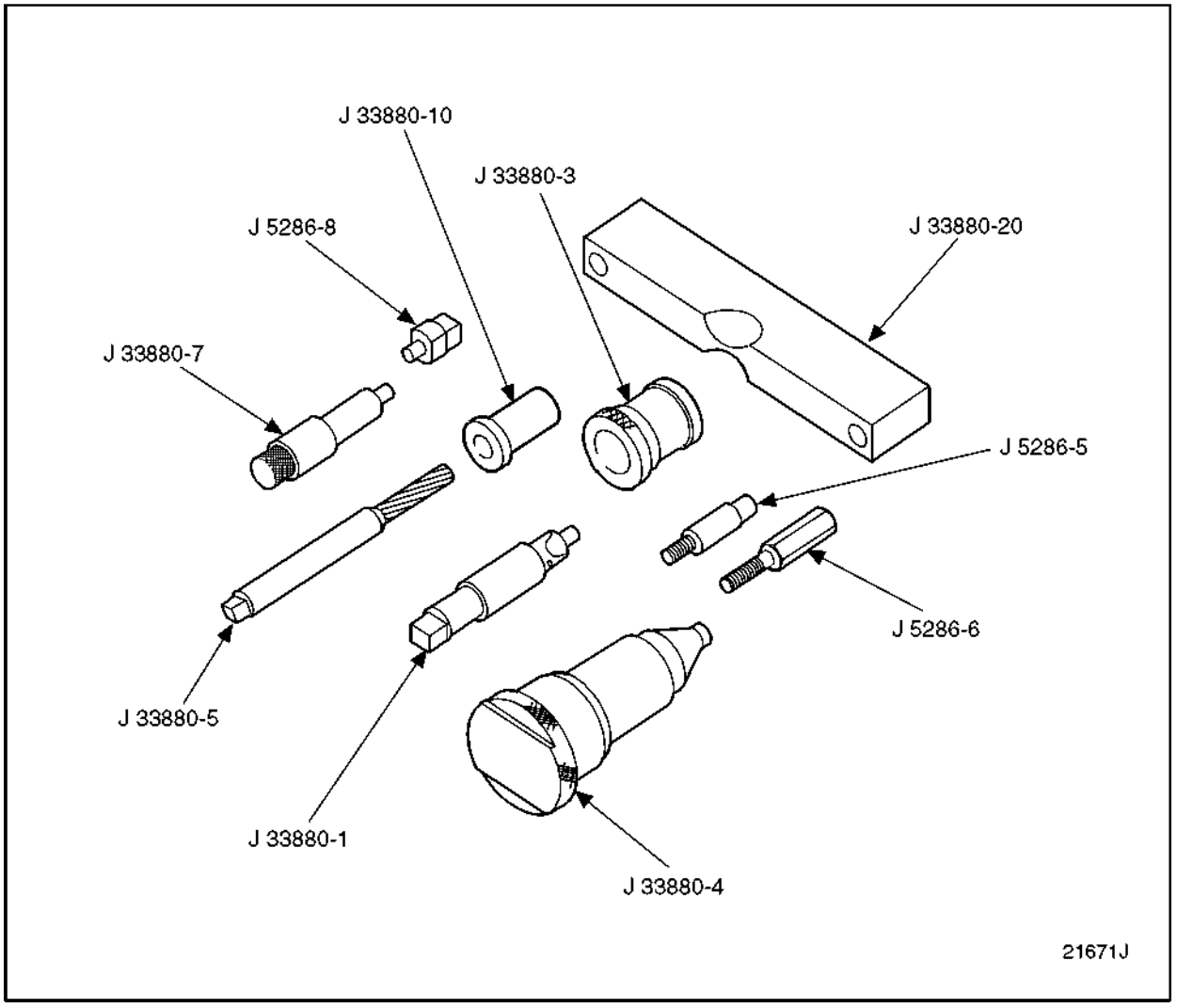


Figure 1197 Injector Tube Reconditioning Set, J 33880

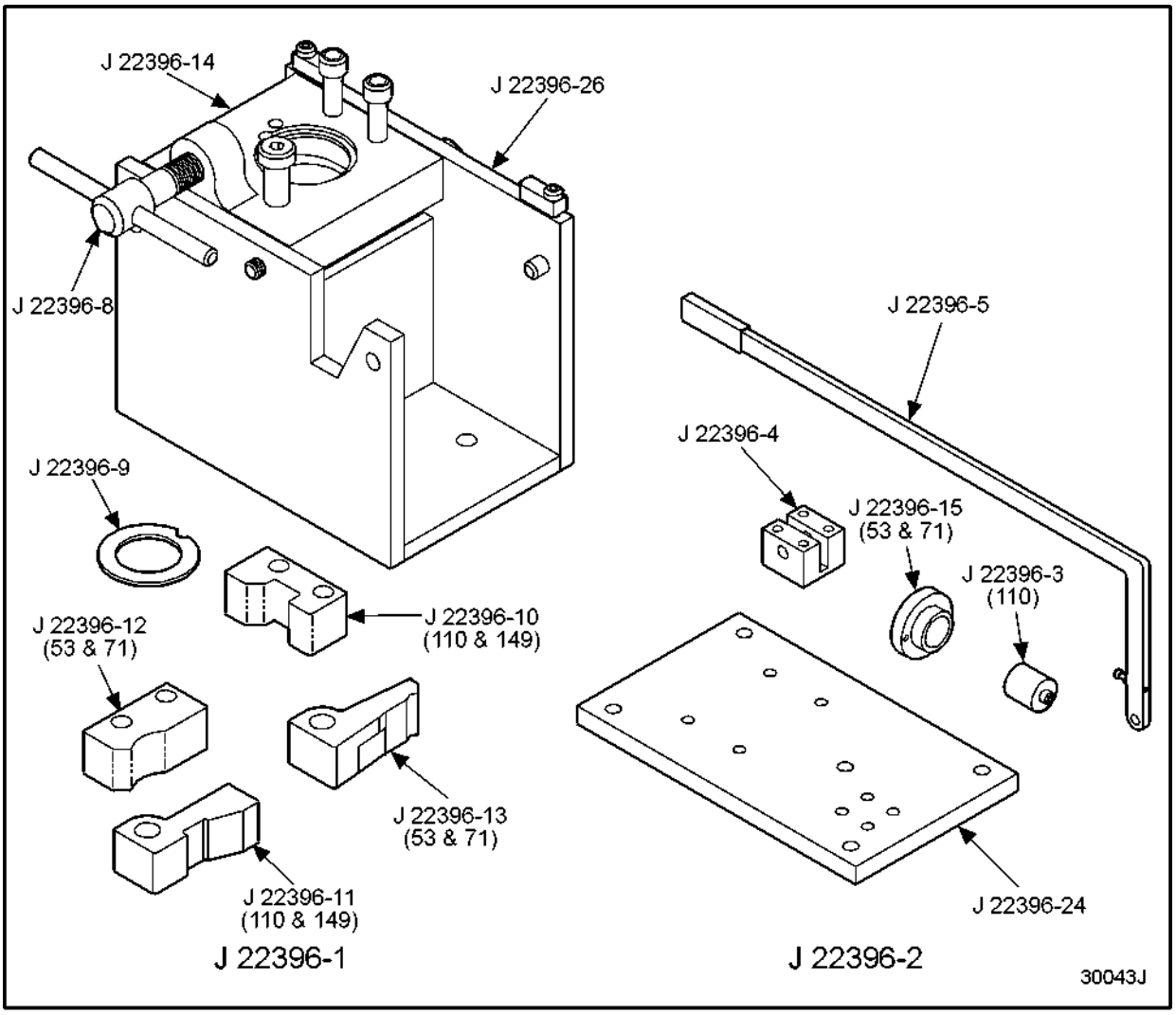


Figure 1198 Injector Vice,J 22396–A

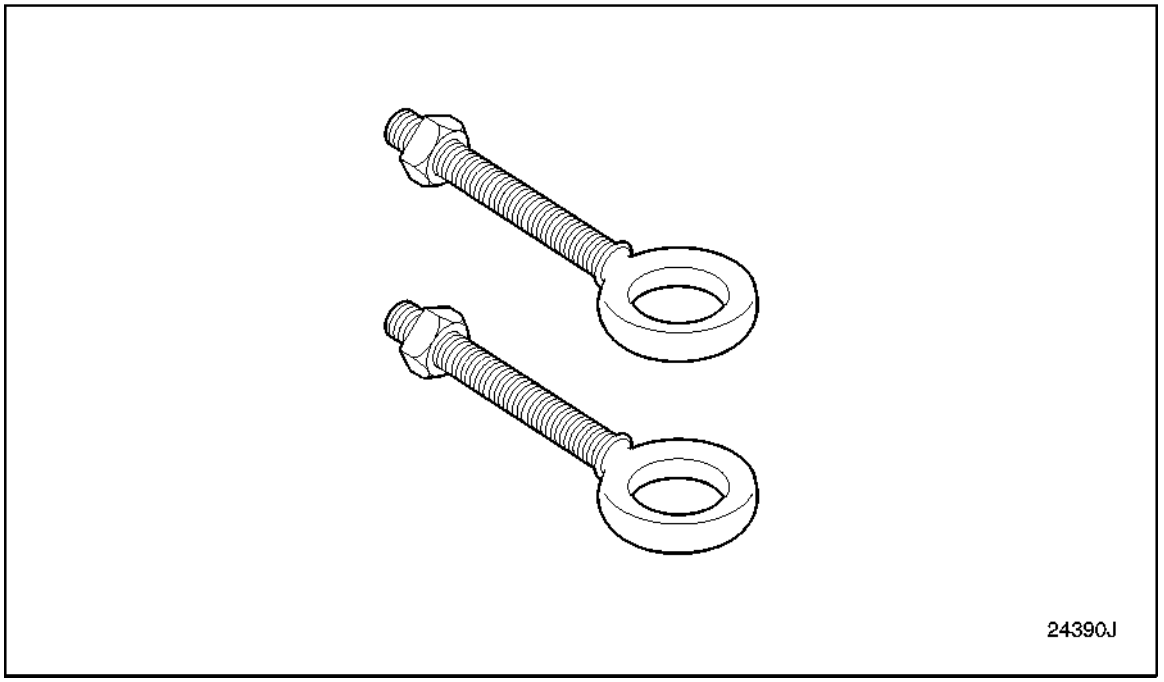


Figure 1199 Lifting Eye Bolts,J 41564

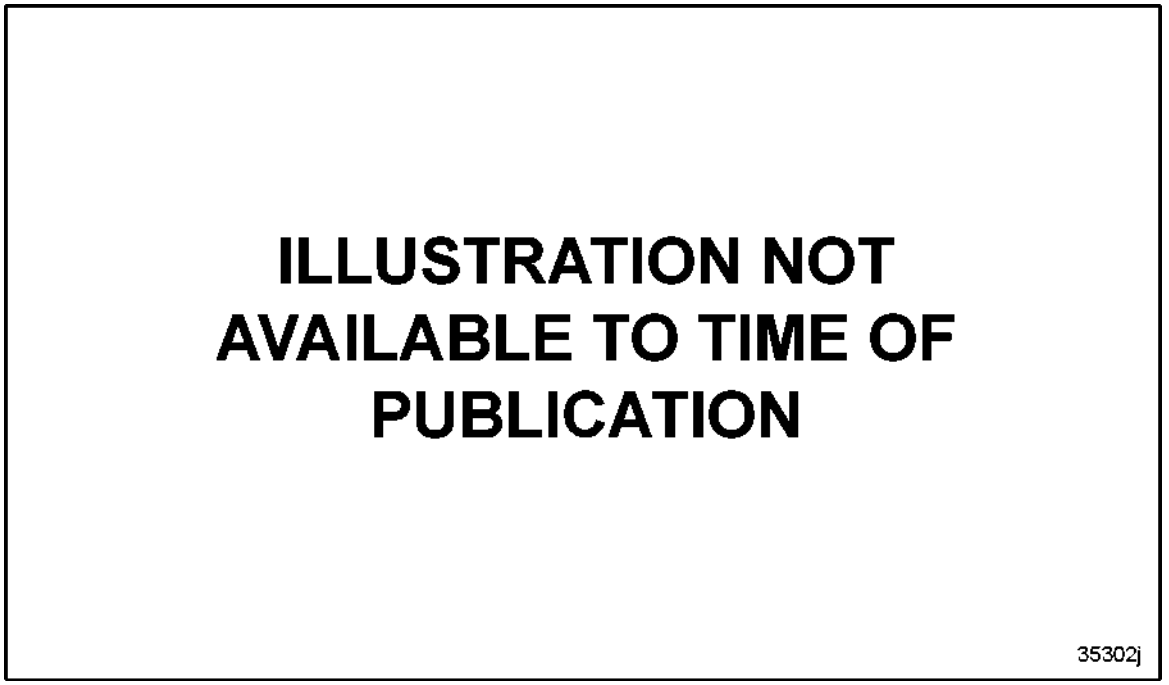


Figure 1200 Nozzle Fixture Clamp Plate,J 39264

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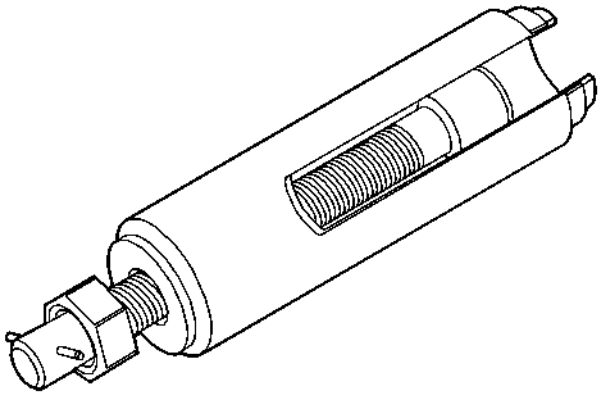
Figure 1201 Nozzle Holding Fixture,J 39263



30273 J

Figure 1202 Nozzle Puller,J 41165

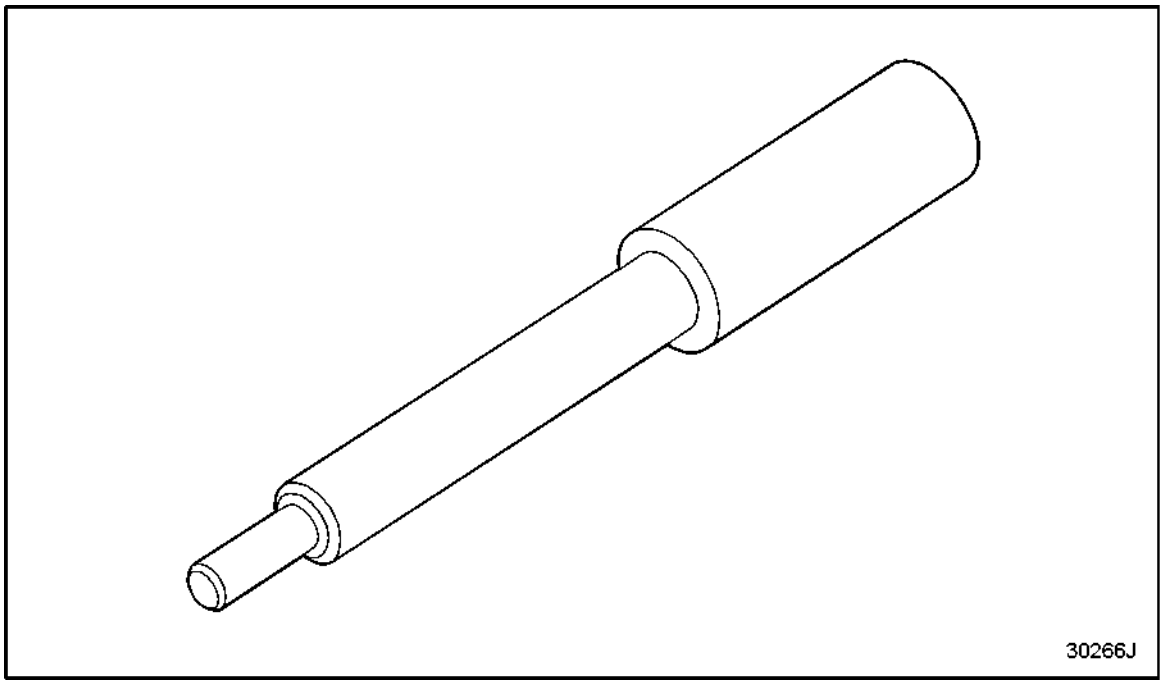


Figure 1203 Nozzle Sleeve Installer,J 39261

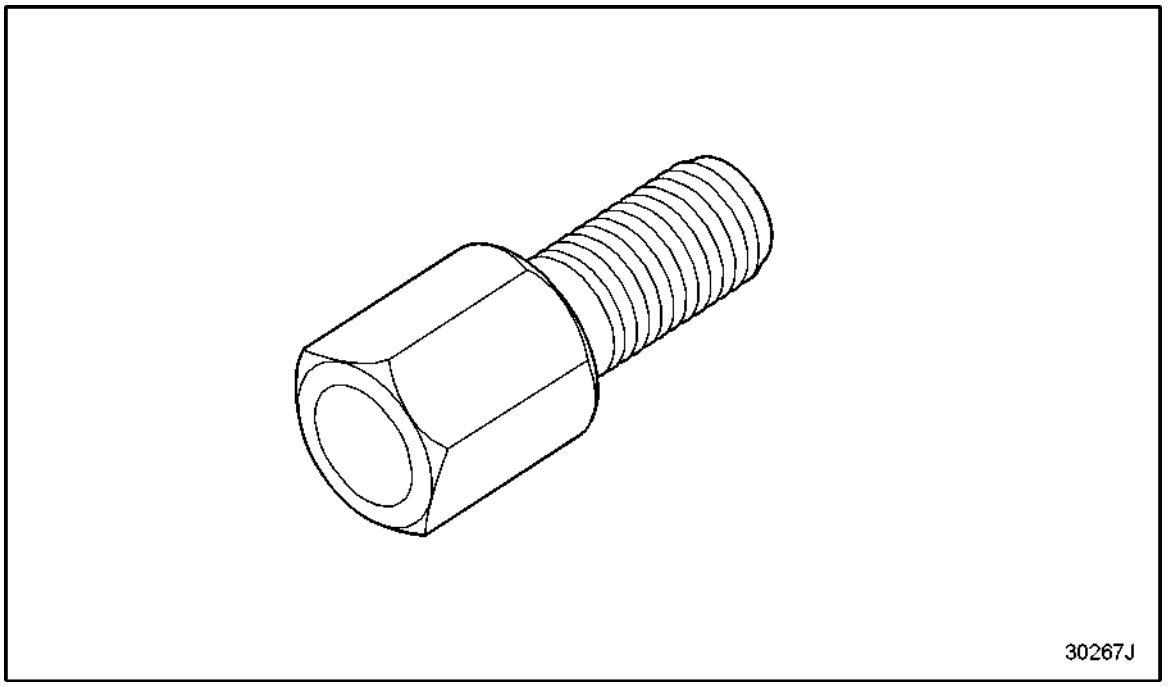


Figure 1204 Nozzle Sleeve Remover,J 39262

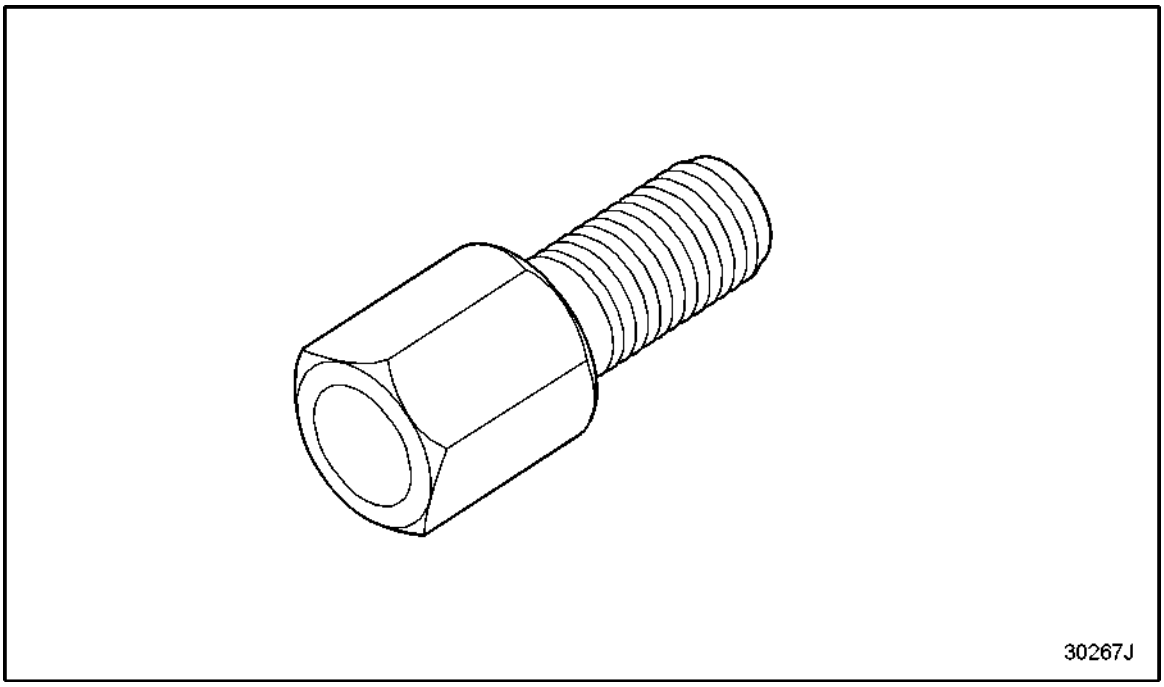


Figure 1205 Overhaul Stand Adaptor-Cyl Head,J 35636–A

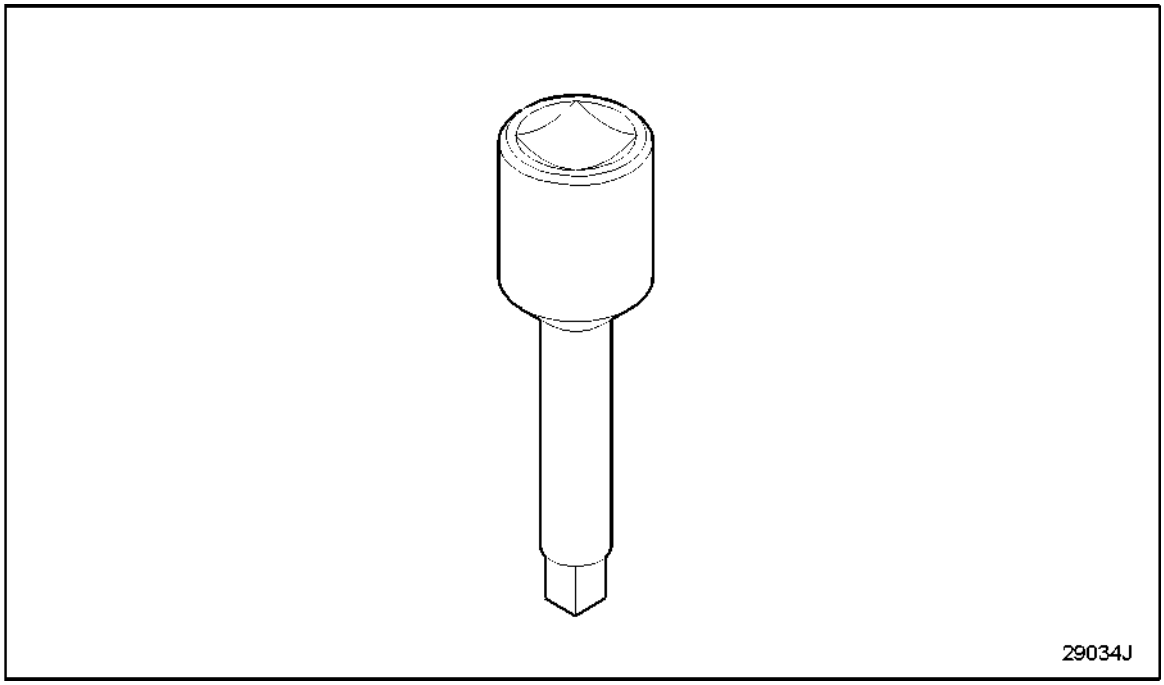


Figure 1206 Pipe Plug Remover (SQ Drive Plug),J 34650

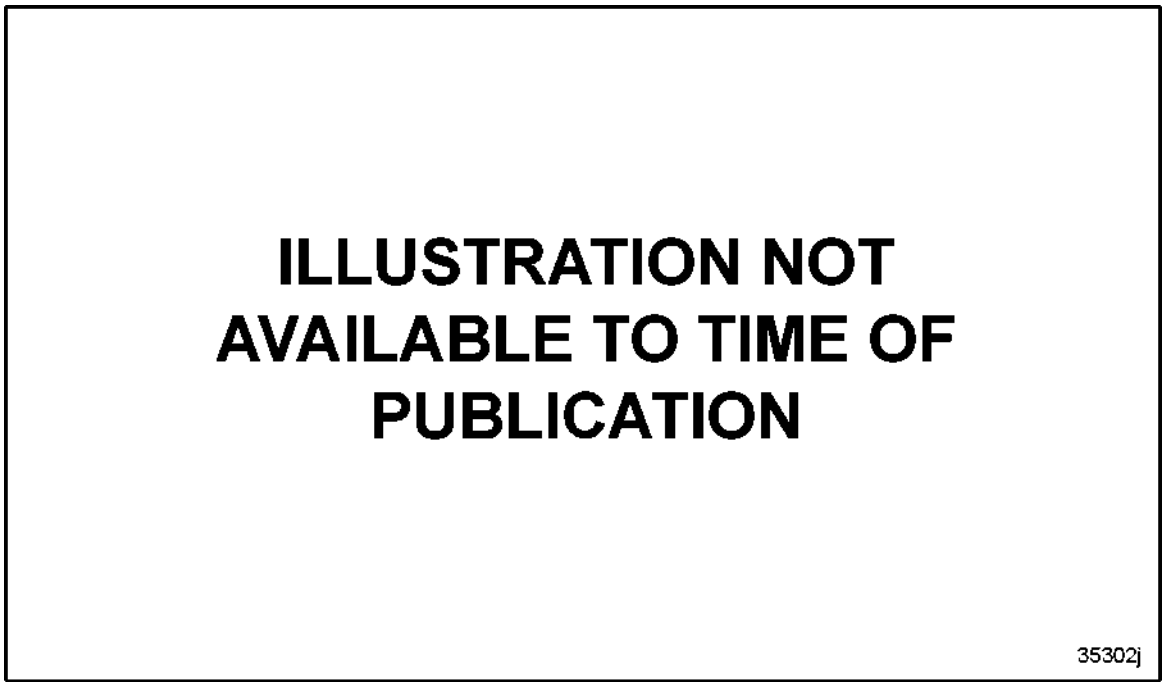


Figure 1207 Push Rod Remover Set,J 3092–01

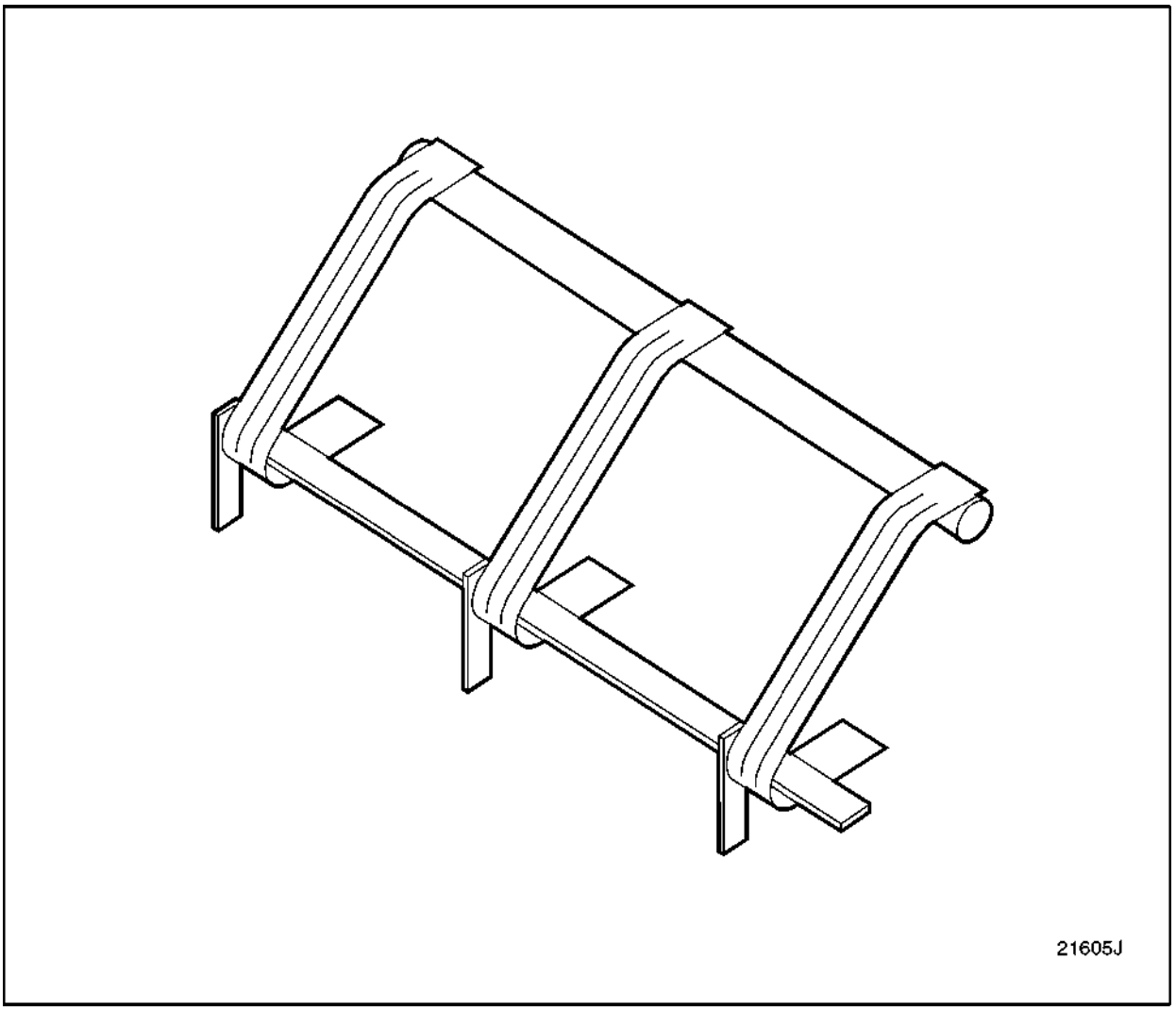


Figure 1208 Rocker Arm Shaft Lifter, J 35996–A

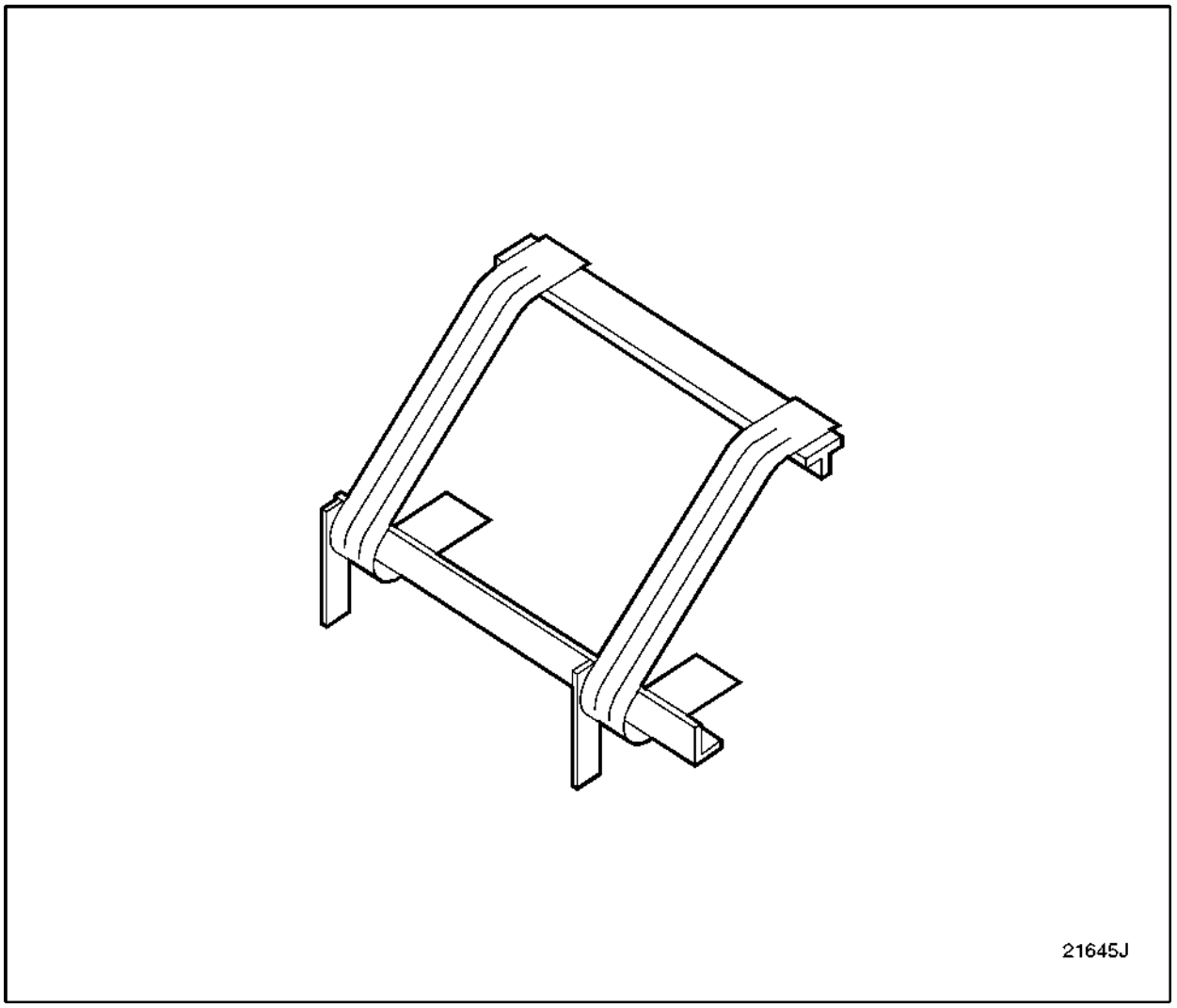


Figure 1209 Rocker Arm Shaft Lifter, J 39647–A

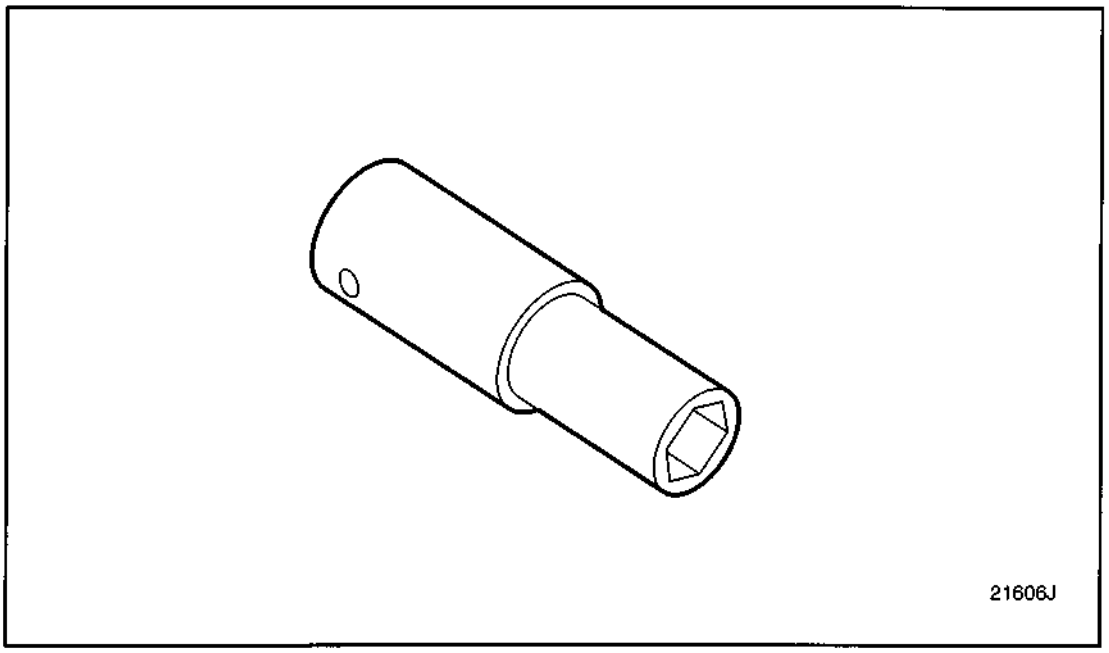


Figure 1210 Rocker Arm Shaft Stud Socket, J 36003–A

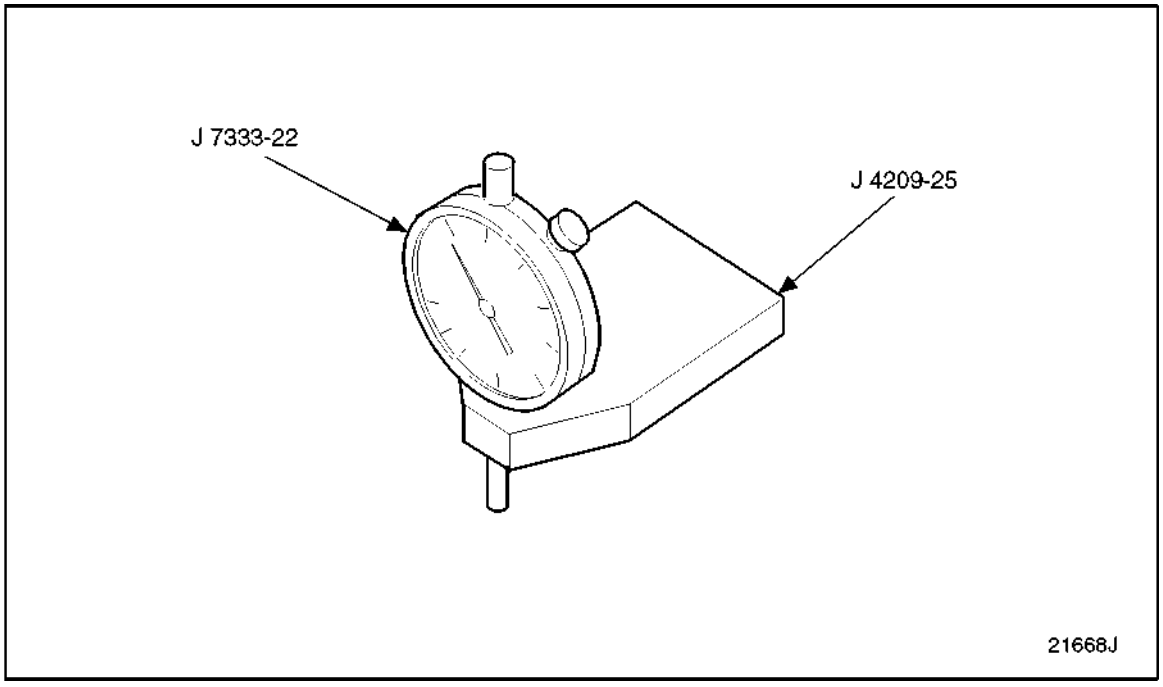


Figure 1211 Sled Gage, J 22273–01

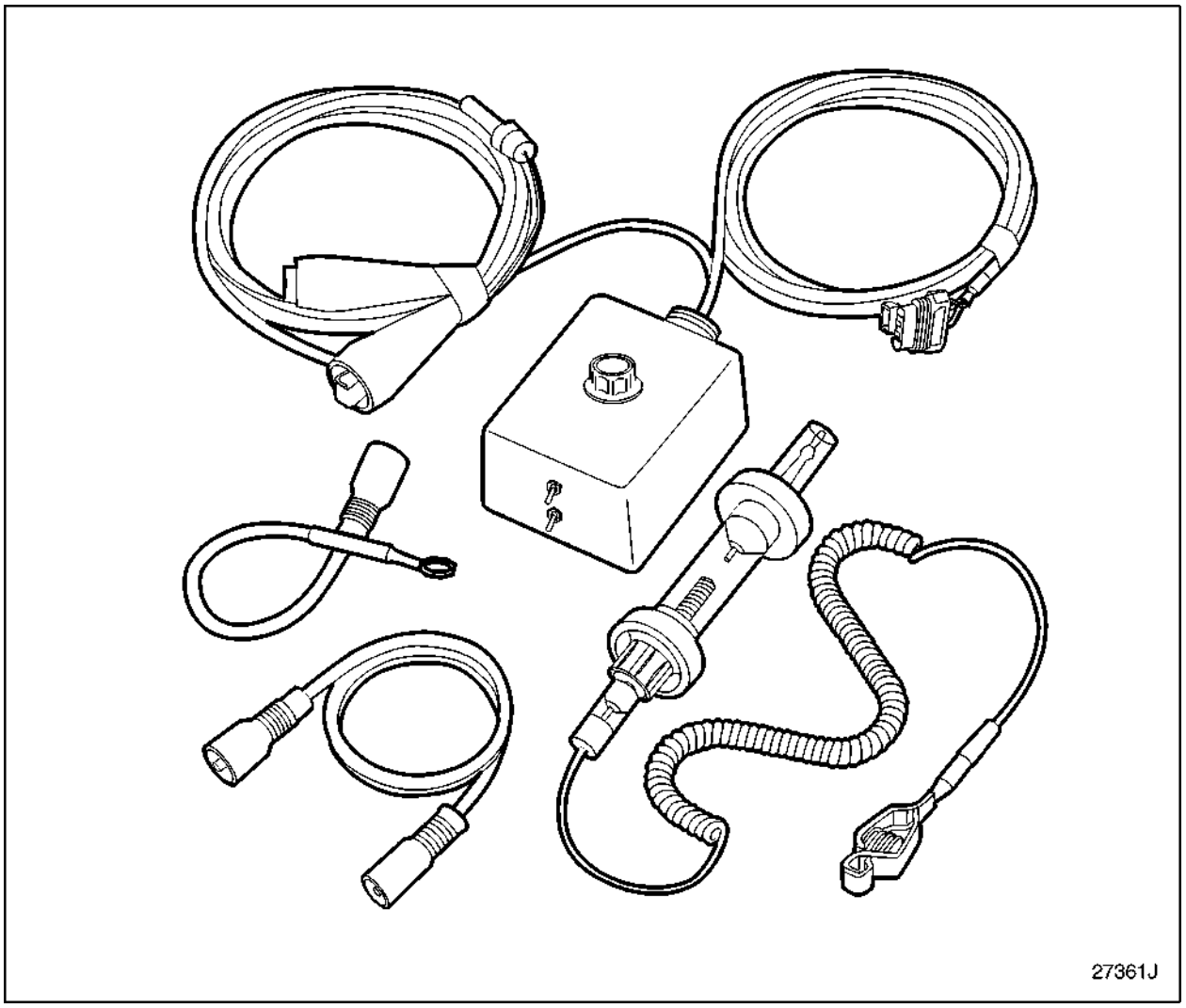


Figure 1212 Spark Plug Adaptor Remover,J 41488

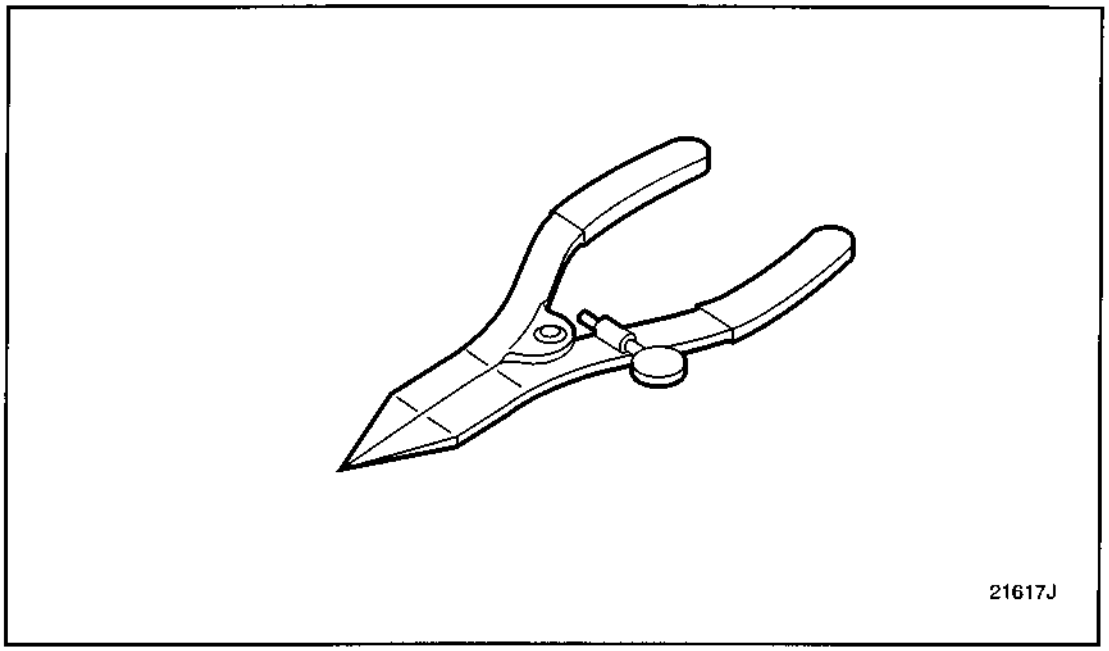


Figure 1213 Valve Button Retainer Expander,J 36347

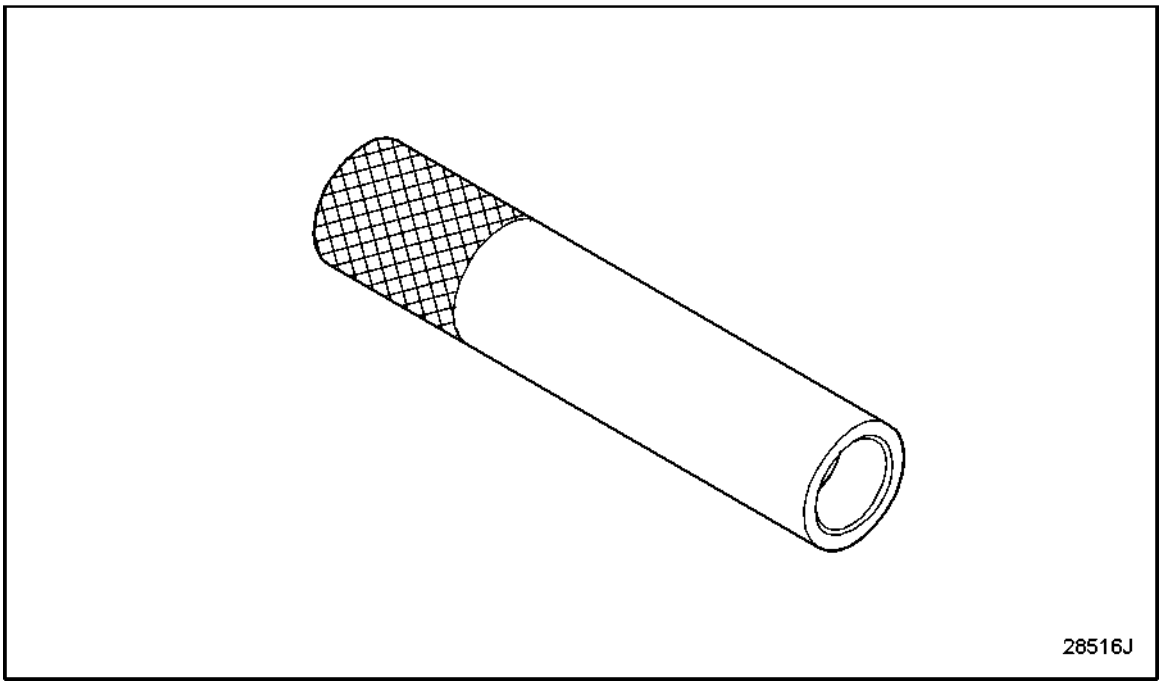


Figure 1214 Valve Button Retainer Expander,J 39196

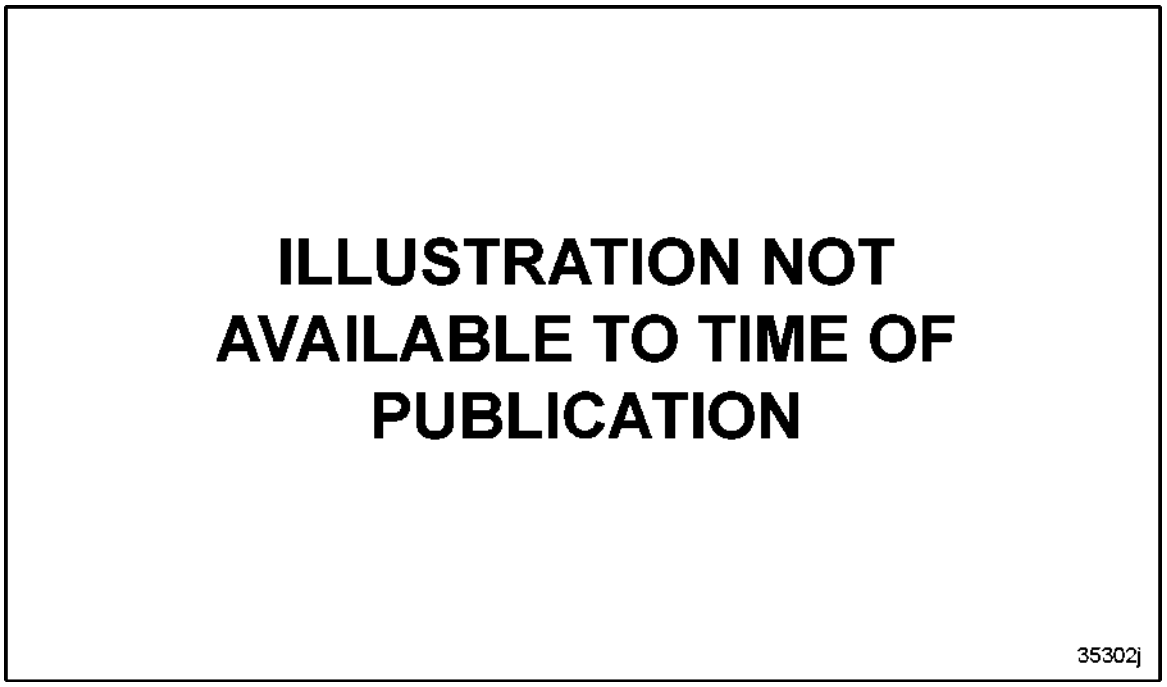


Figure 1215 **Valve Guide Reamer,**J 39260

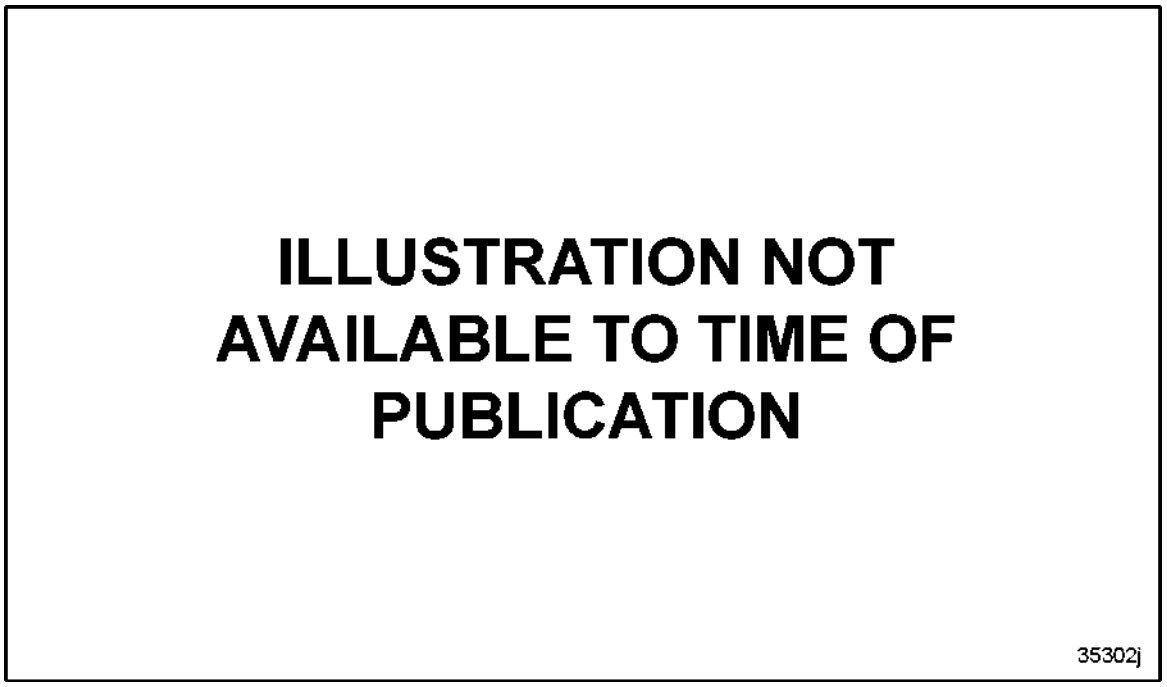


Figure 1216 **Valve Guide Remover,**J 269

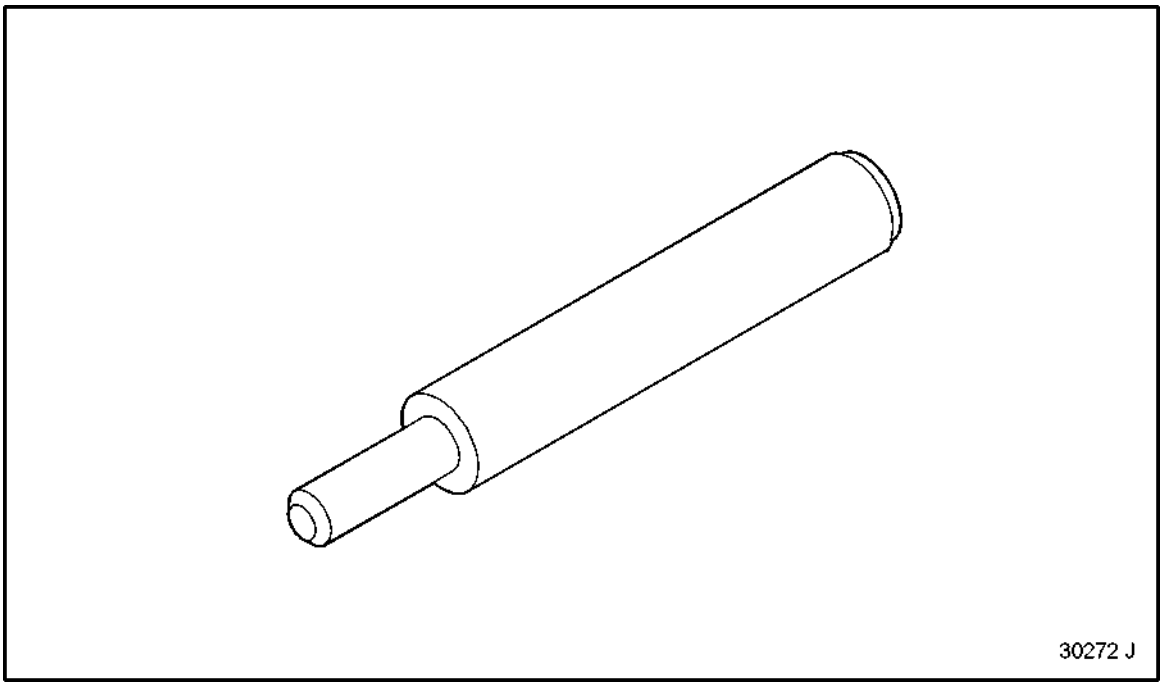


Figure 1217 Valve Guide Remover,J 41164

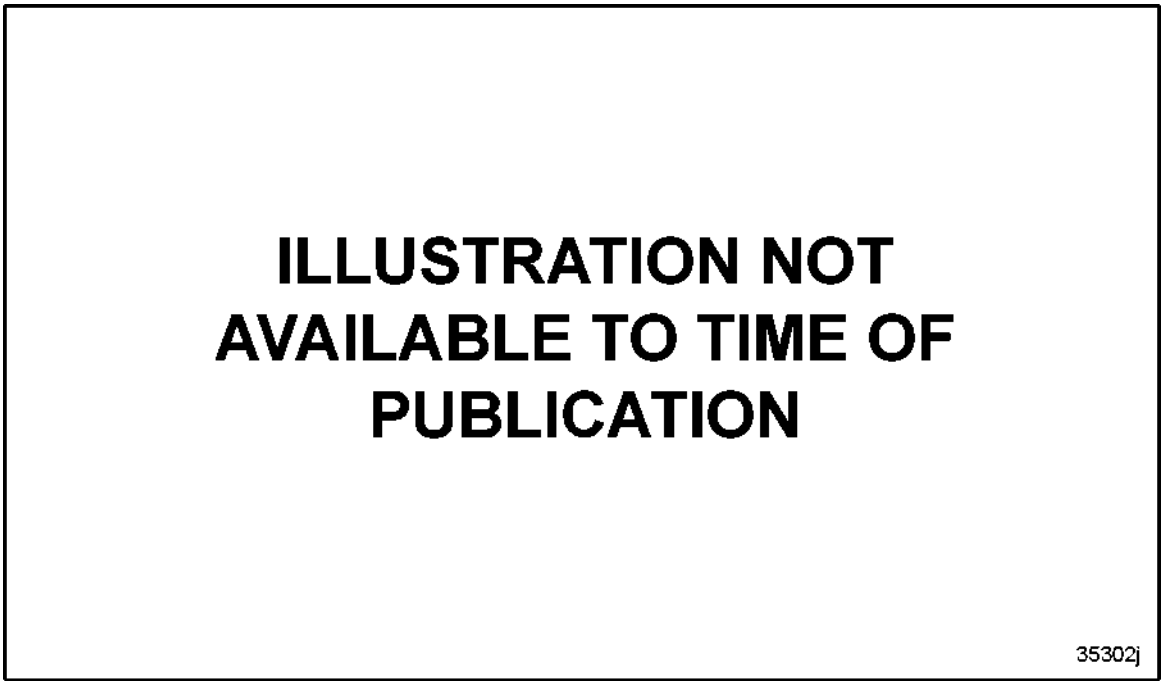


Figure 1218 Valve Seal Installer Set,J 39880–A

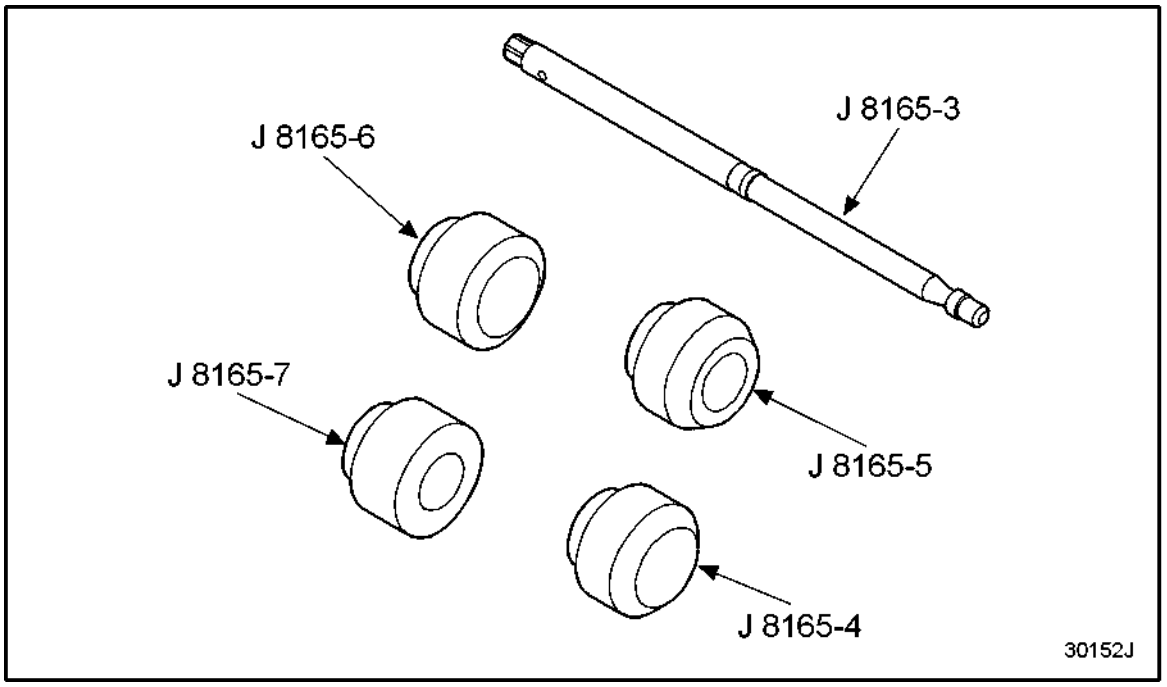


Figure 1219 Valve Seat Concentricity Gage, J 8165–2

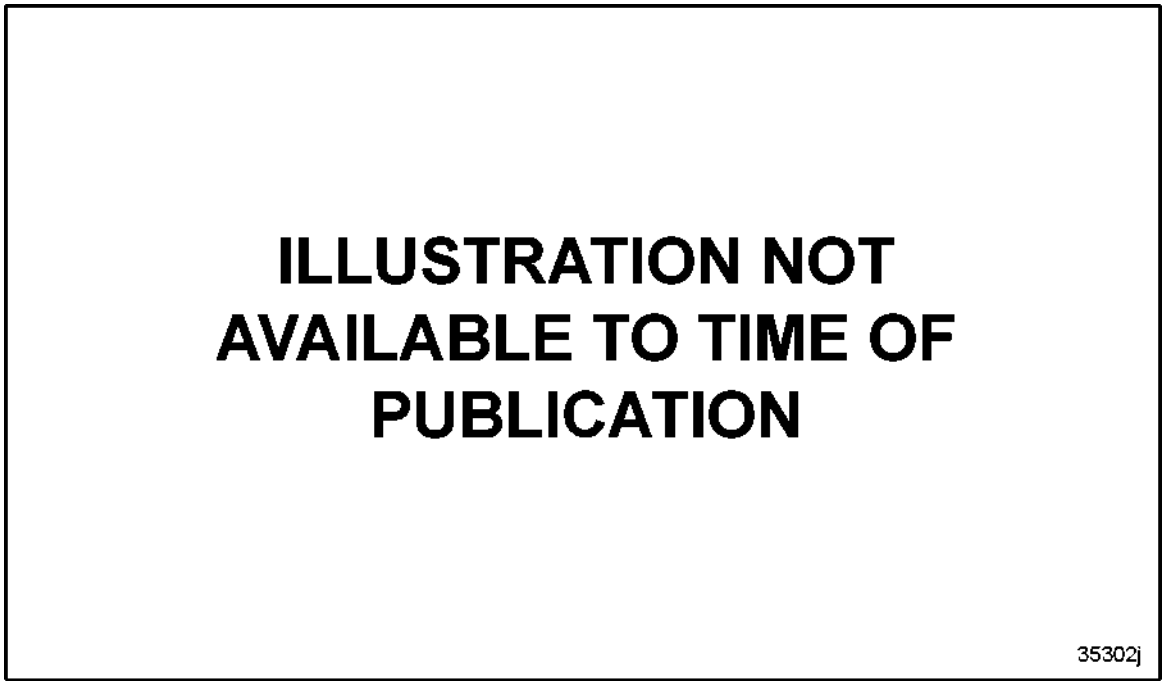


Figure 1220 Valve Seat Cutter 1.50 X 15/60 DegJ 26541–213

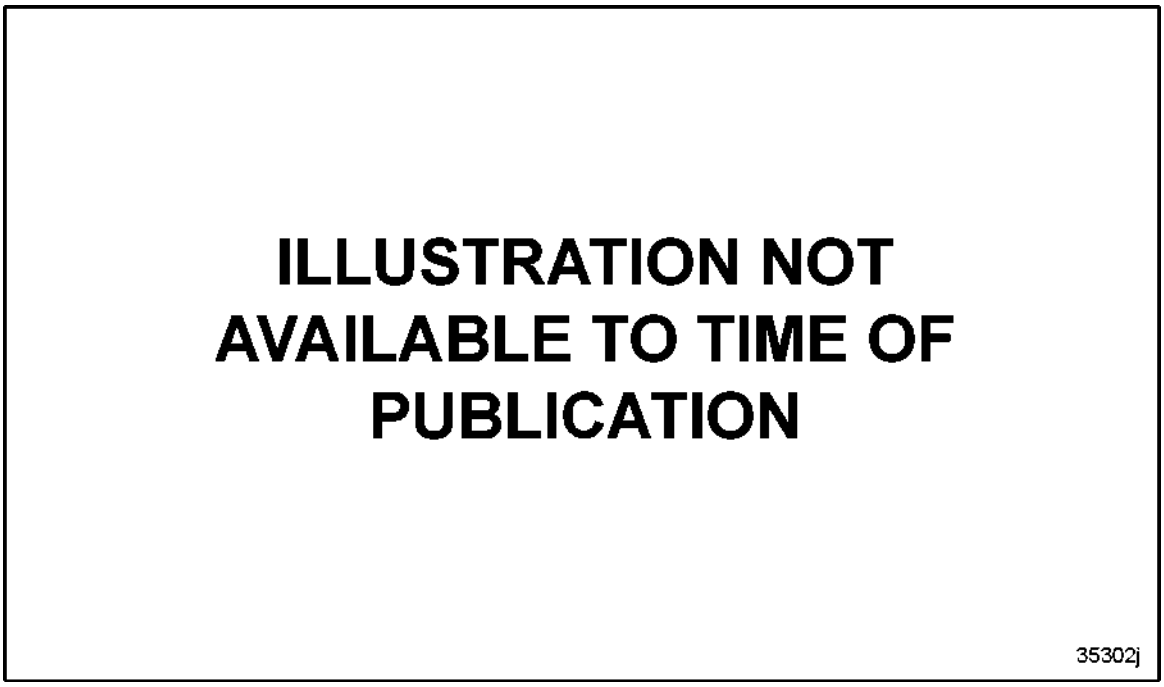


Figure 1221 Valve Seat Cutter 1.50 X 31DegJ 26541–628

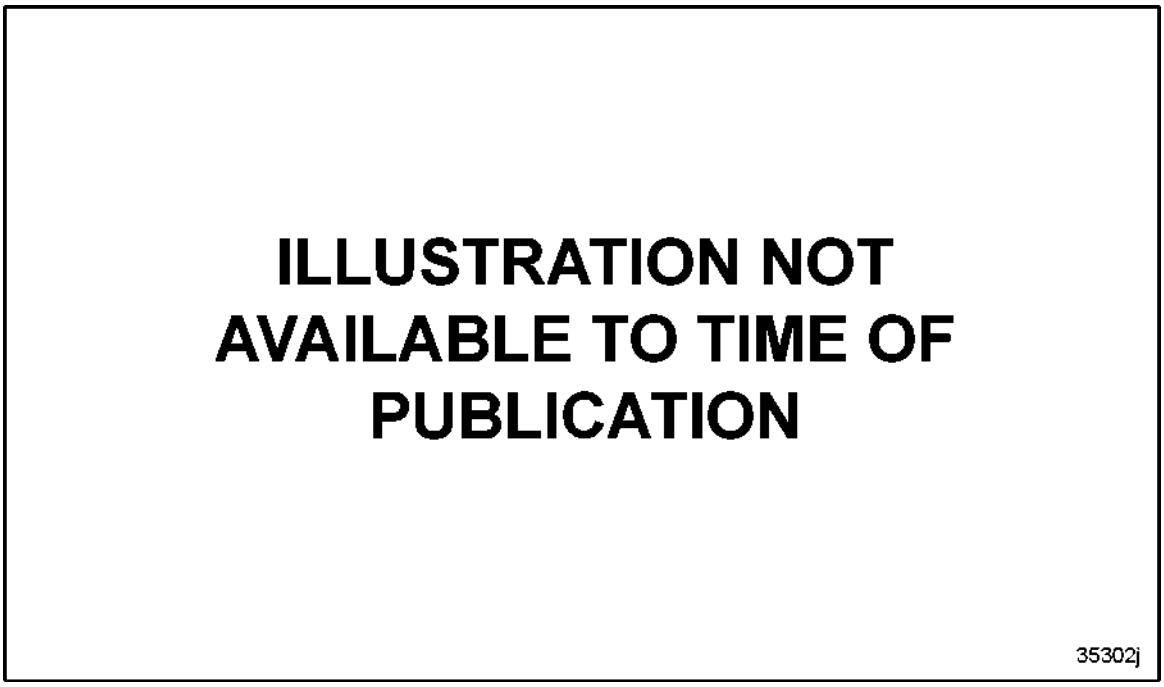


Figure 1222 Valve Seat Cutter 1.75 X 15/60Deg,J 26541–292

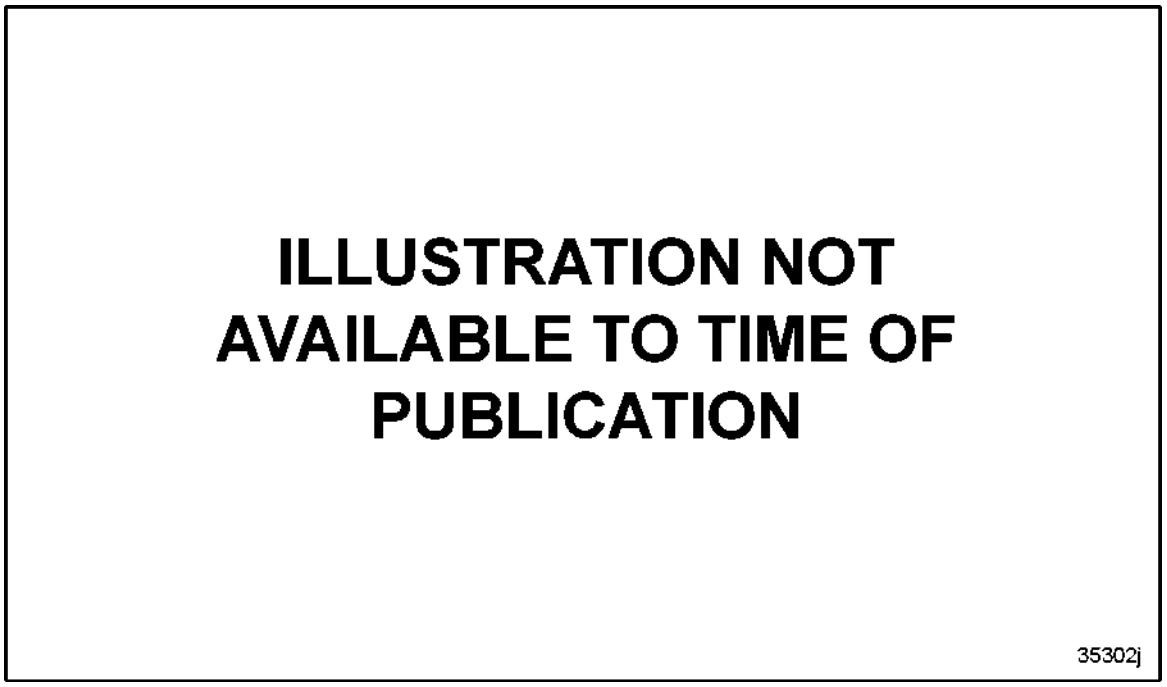


Figure 1223 Valve Seat Cutter 1.75 X 31 Degree,J 26541–649

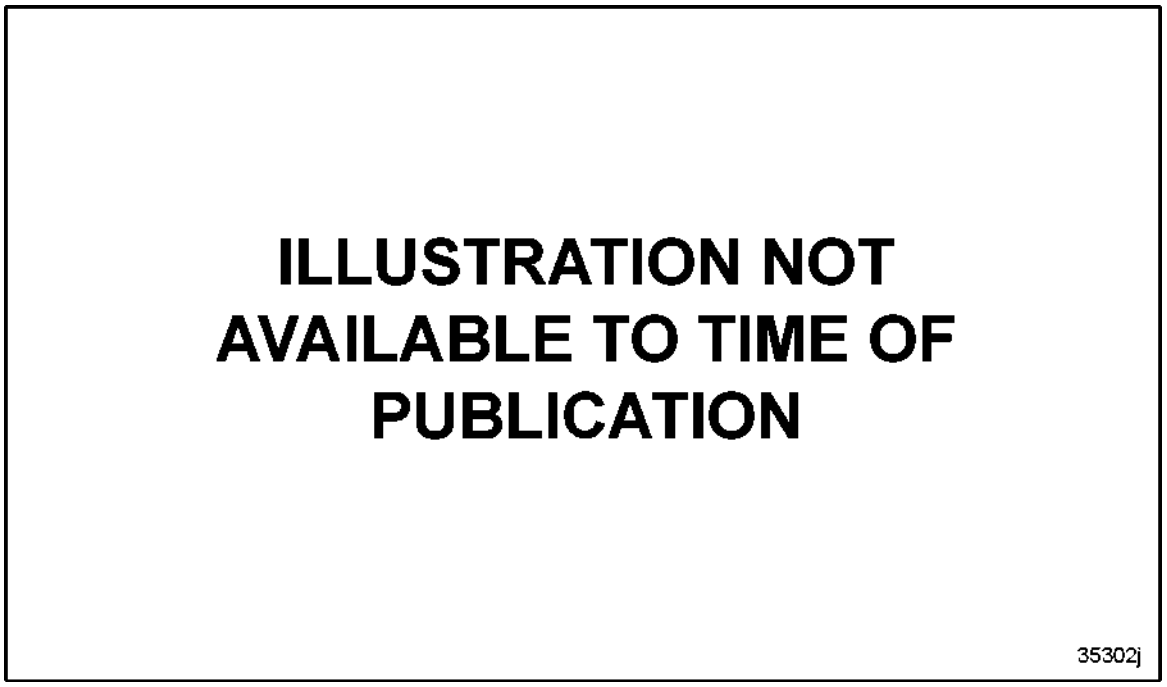


Figure 1224 Valve Seat Cutter Pilot (0.344),J 26541–343

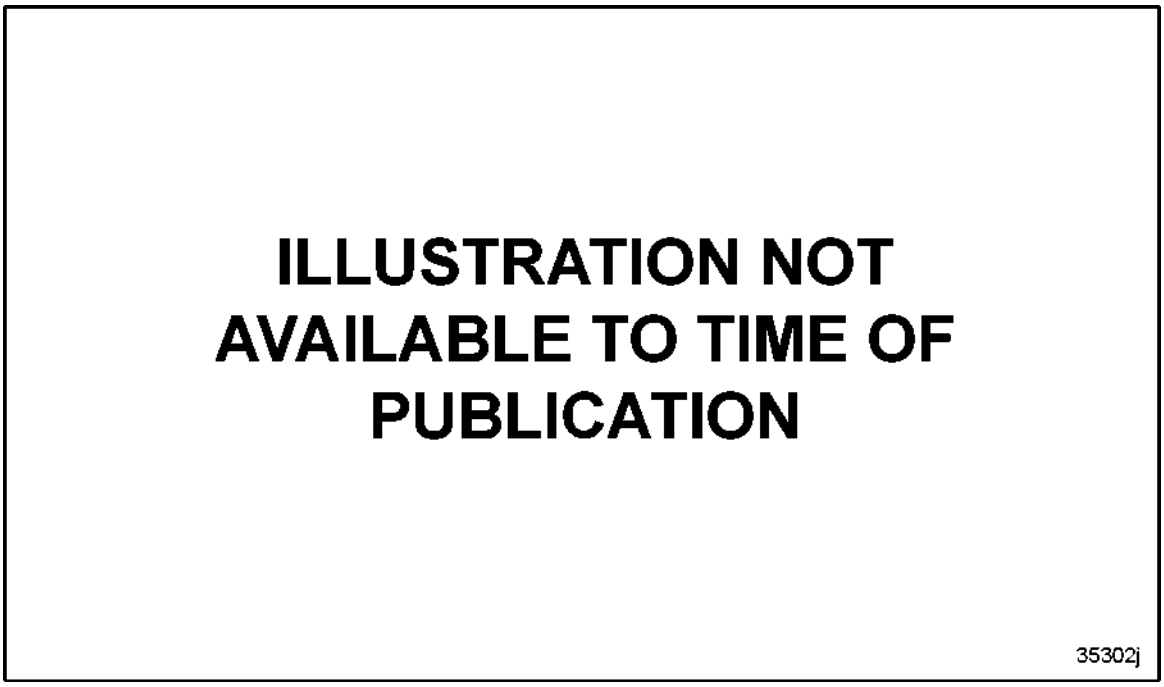


Figure 1225 Valve Seat Cutter Pilot (0.345),J 26541–344

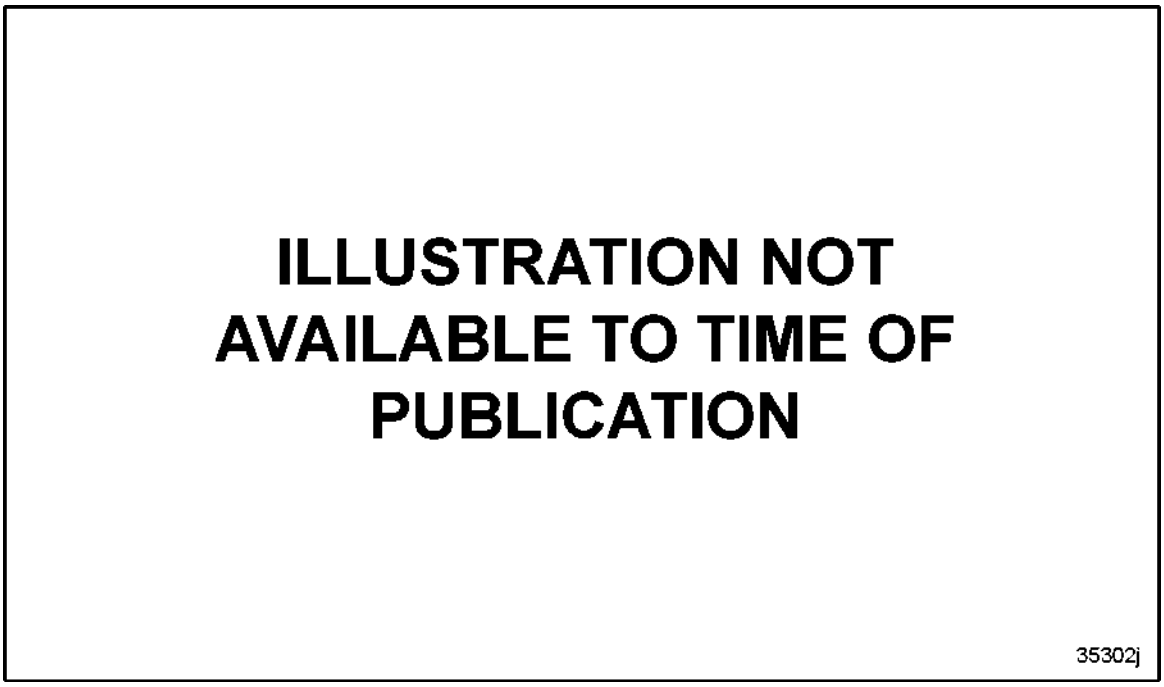


Figure 1226 Valve Seat Cutter Pilot (0.346),J 26541–345

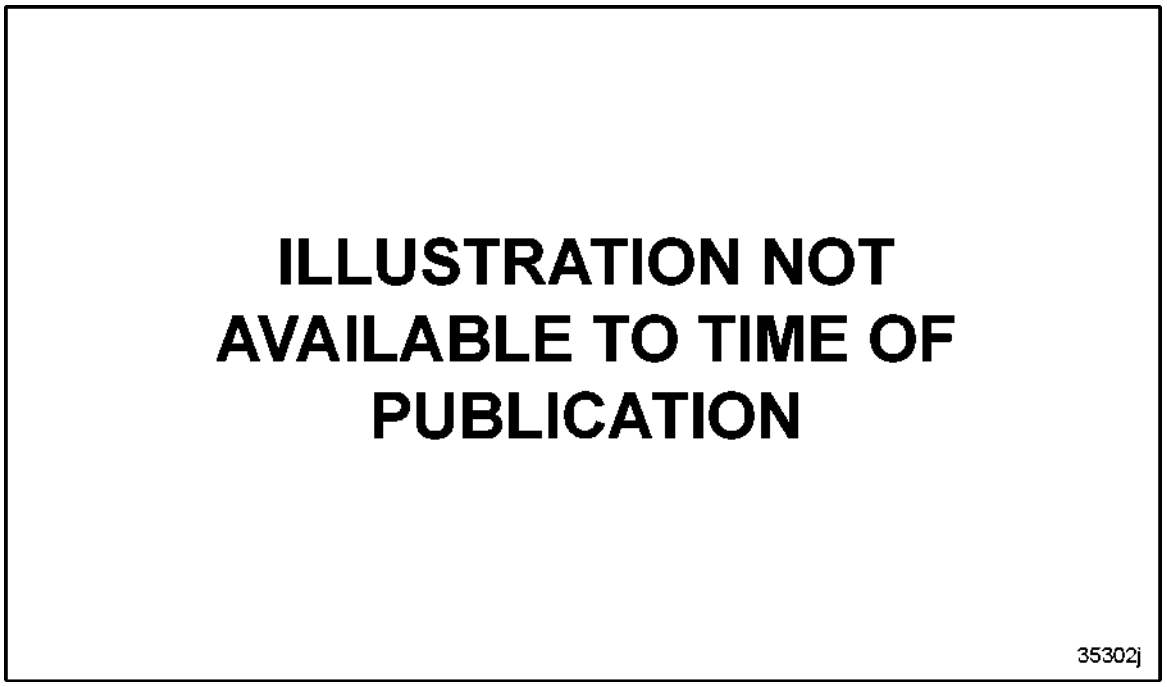


Figure 1227 **Valve Seat Cutter Pilot (0.347),** J 26541–346

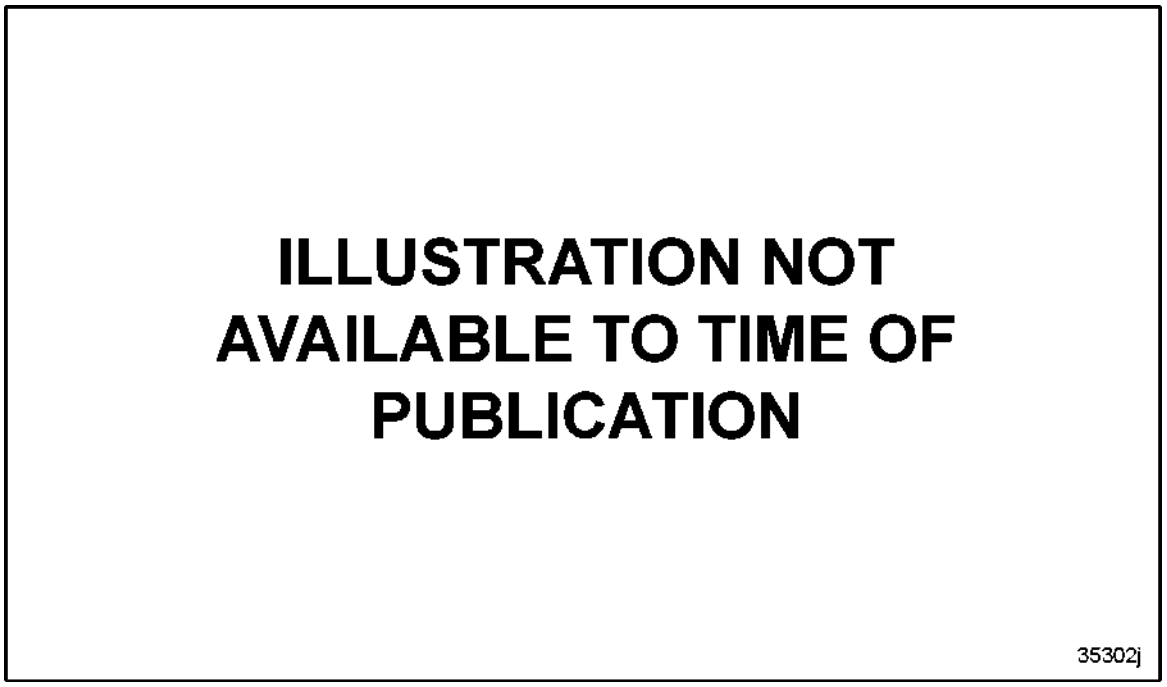


Figure 1228 **Valve Seat Cutter Pilot (0.375),** J 26541–375

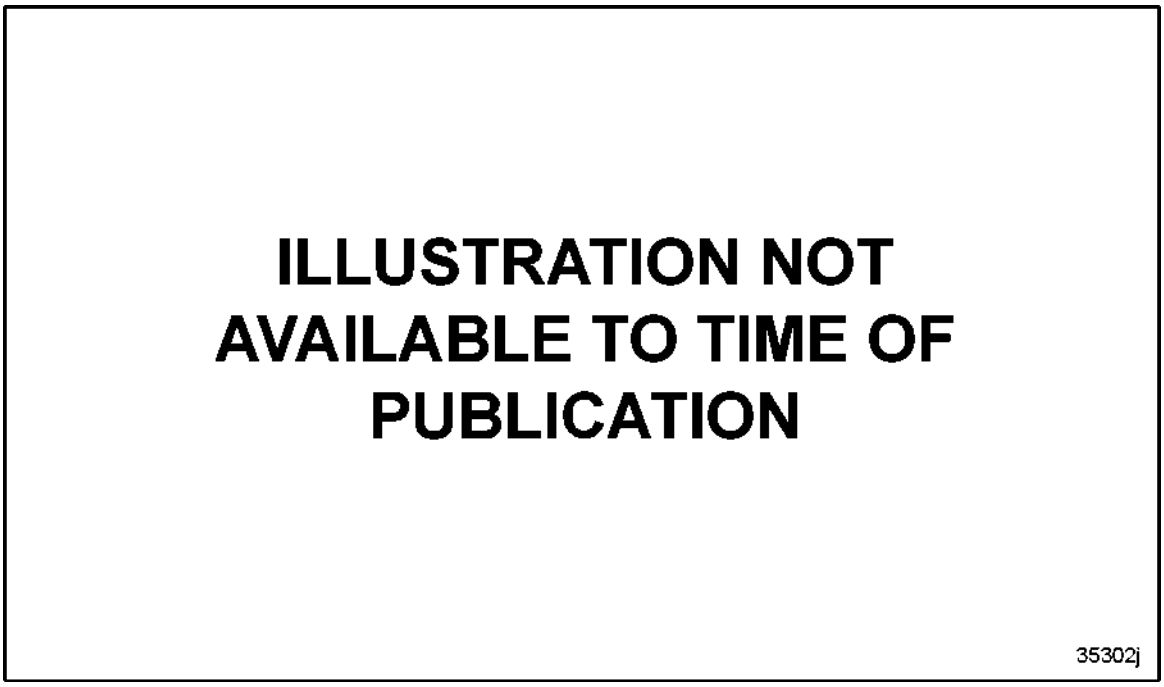


Figure 1229 Valve Seat Cutter Pilot (0.376),J 26541–376

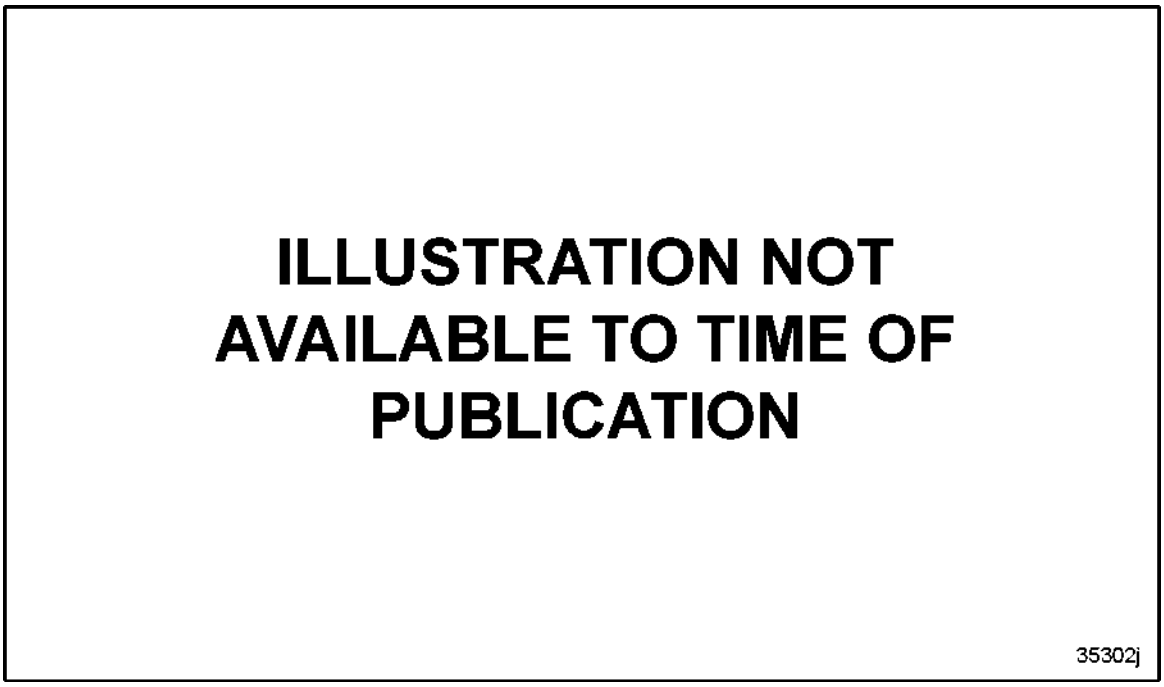


Figure 1230 Valve Seat Cutter Pilot (0.377),J 26541–377

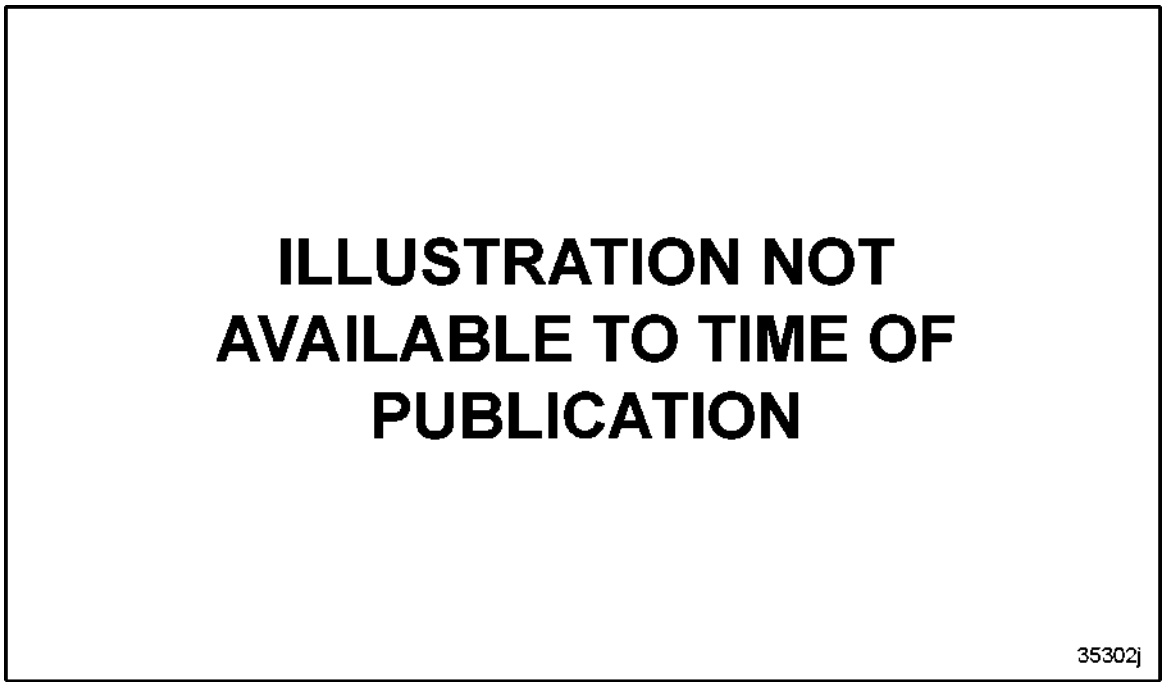


Figure 1231 Valve Seat Cutter Pilot (0.378), J 26541–378

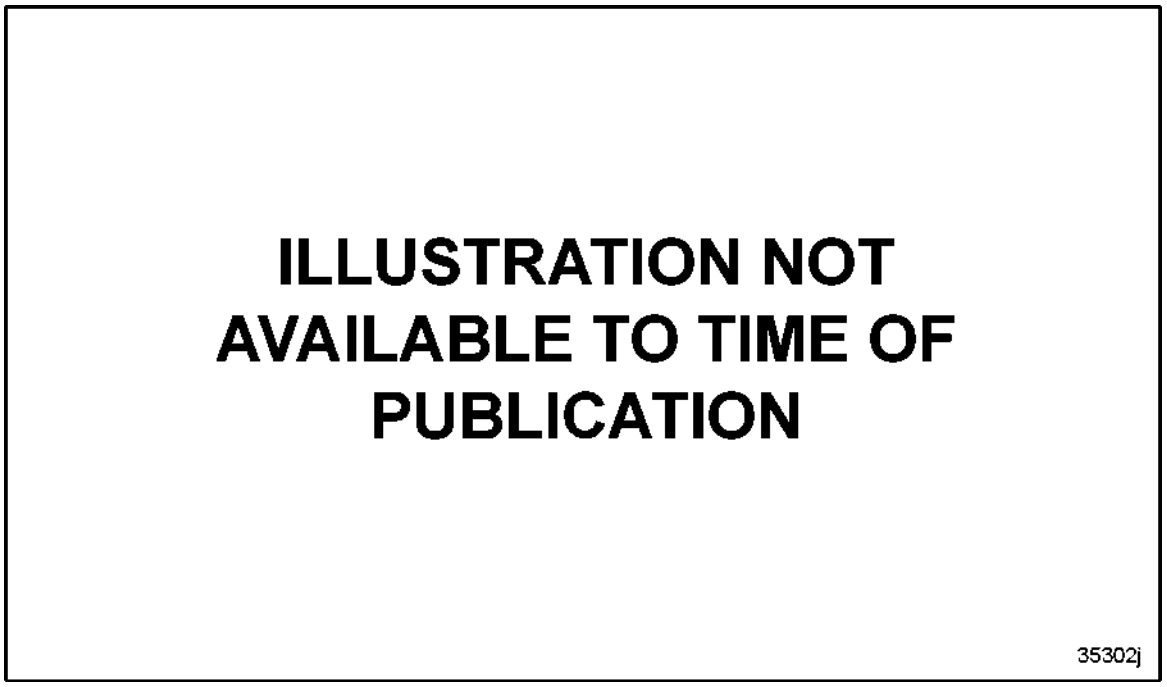


Figure 1232 Valve Seat Cutter Pilot (9 mm) J 26541–354

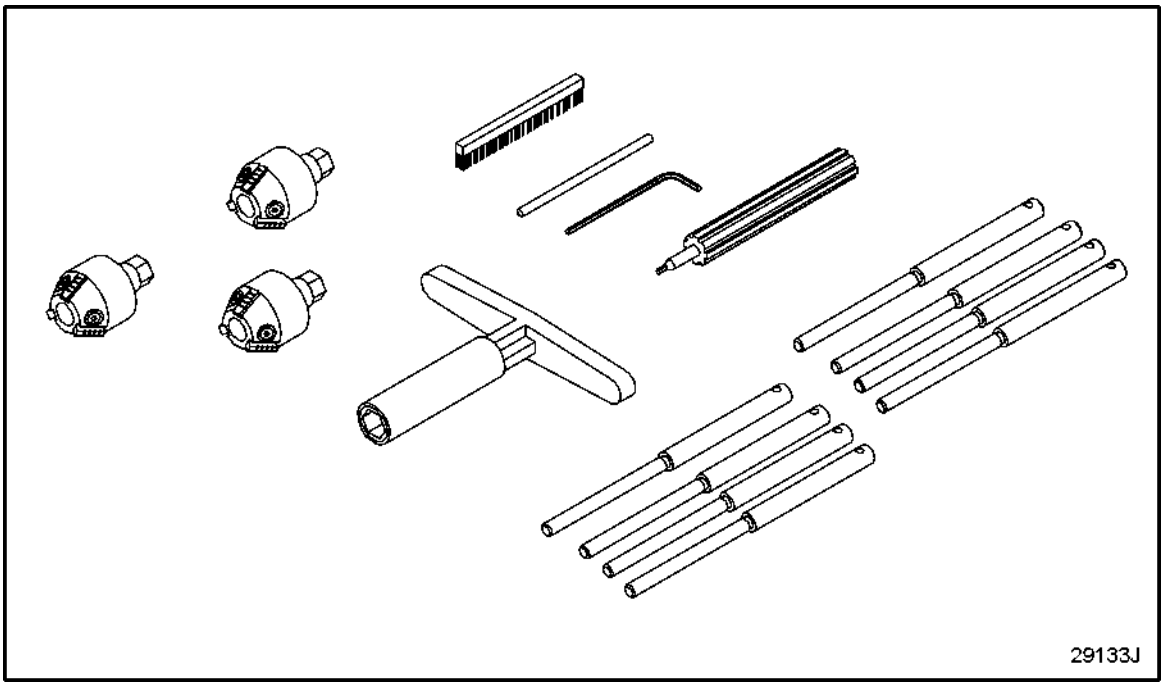


Figure 1233 Valve Seat Cutting Set,J 26541

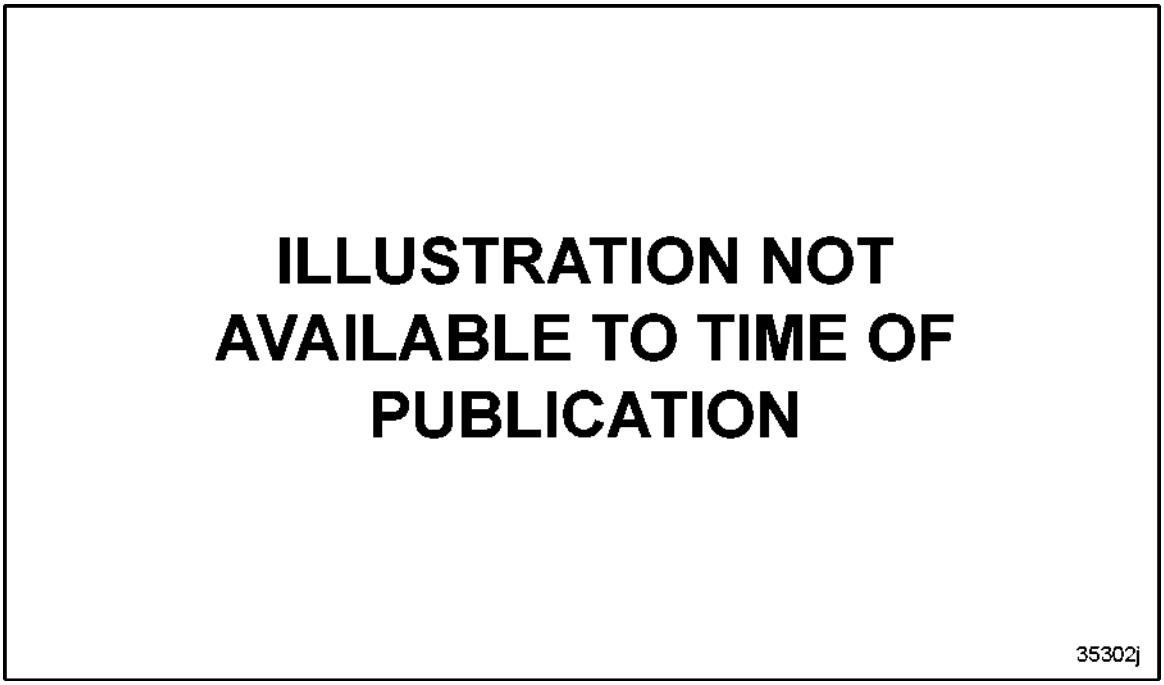


Figure 1234 Valve Seat Cutting Set Power Unit,J 26541–3

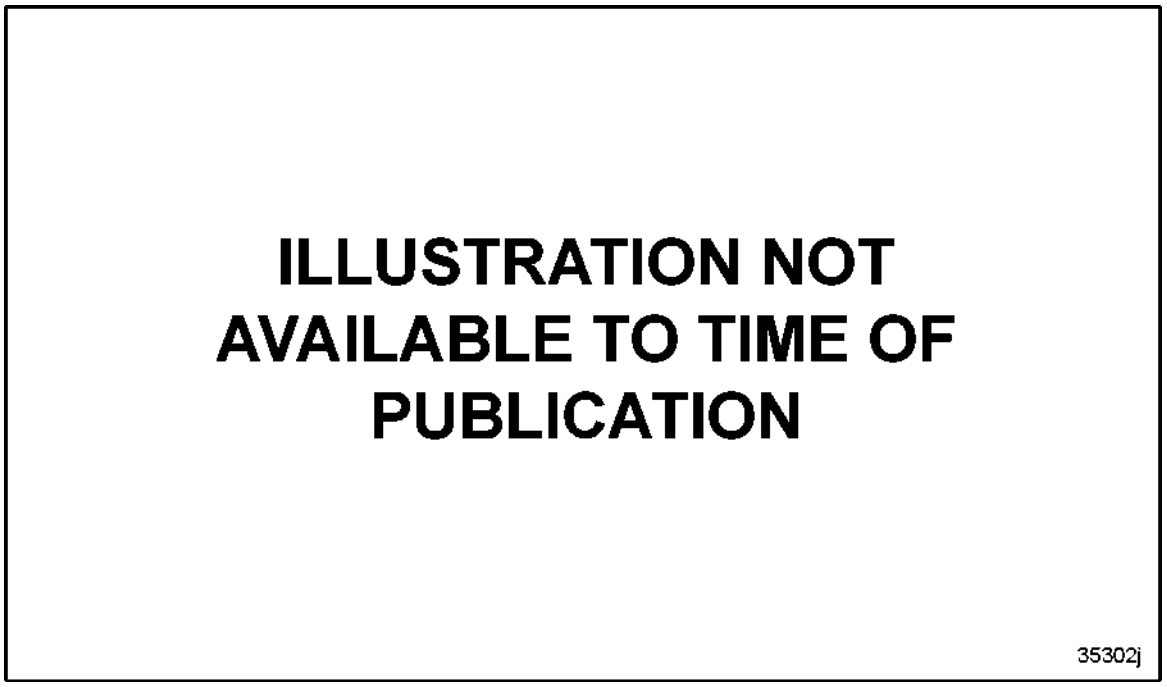


Figure 1235 Valve Seat Grind Adapt Kit 2 Valv-53,J 7924–02

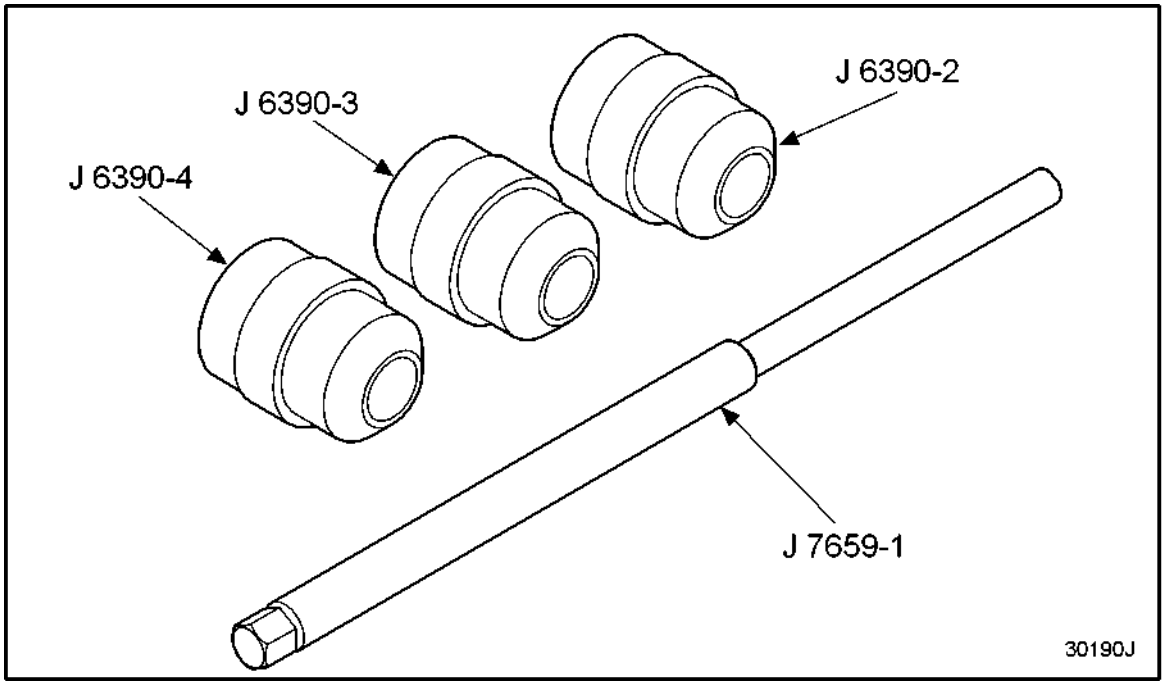


Figure 1236 Valve Seat Grind Adapt Kit 4 Valv-71,J 6390–02

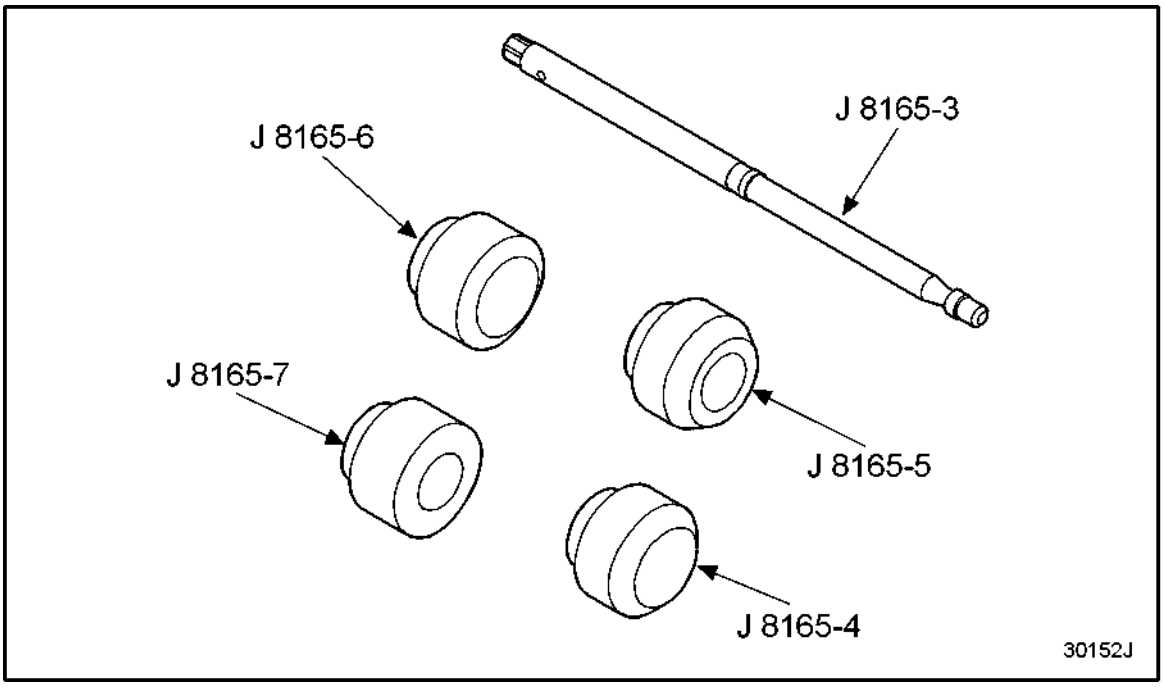


Figure 1237 Valve Seat Grind Adapt Kit 2 Valv-71,J 8165–8

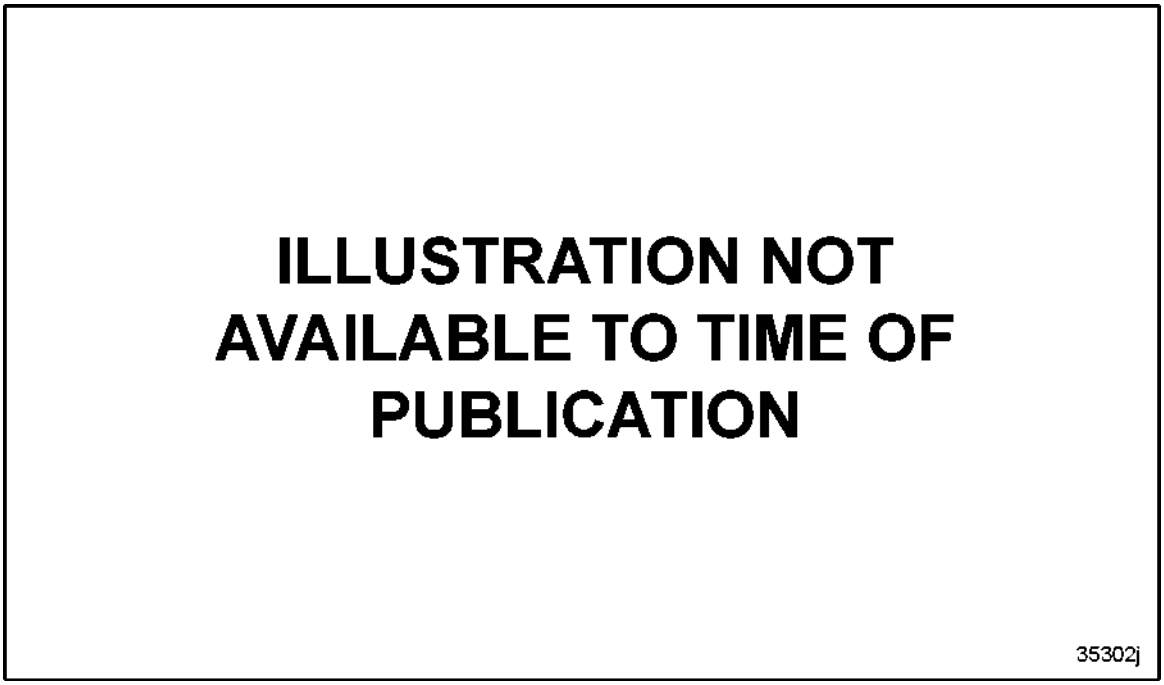


Figure 1238 Valve Seat Grind ADPT Kit 4 Valv-53,J 7792–01

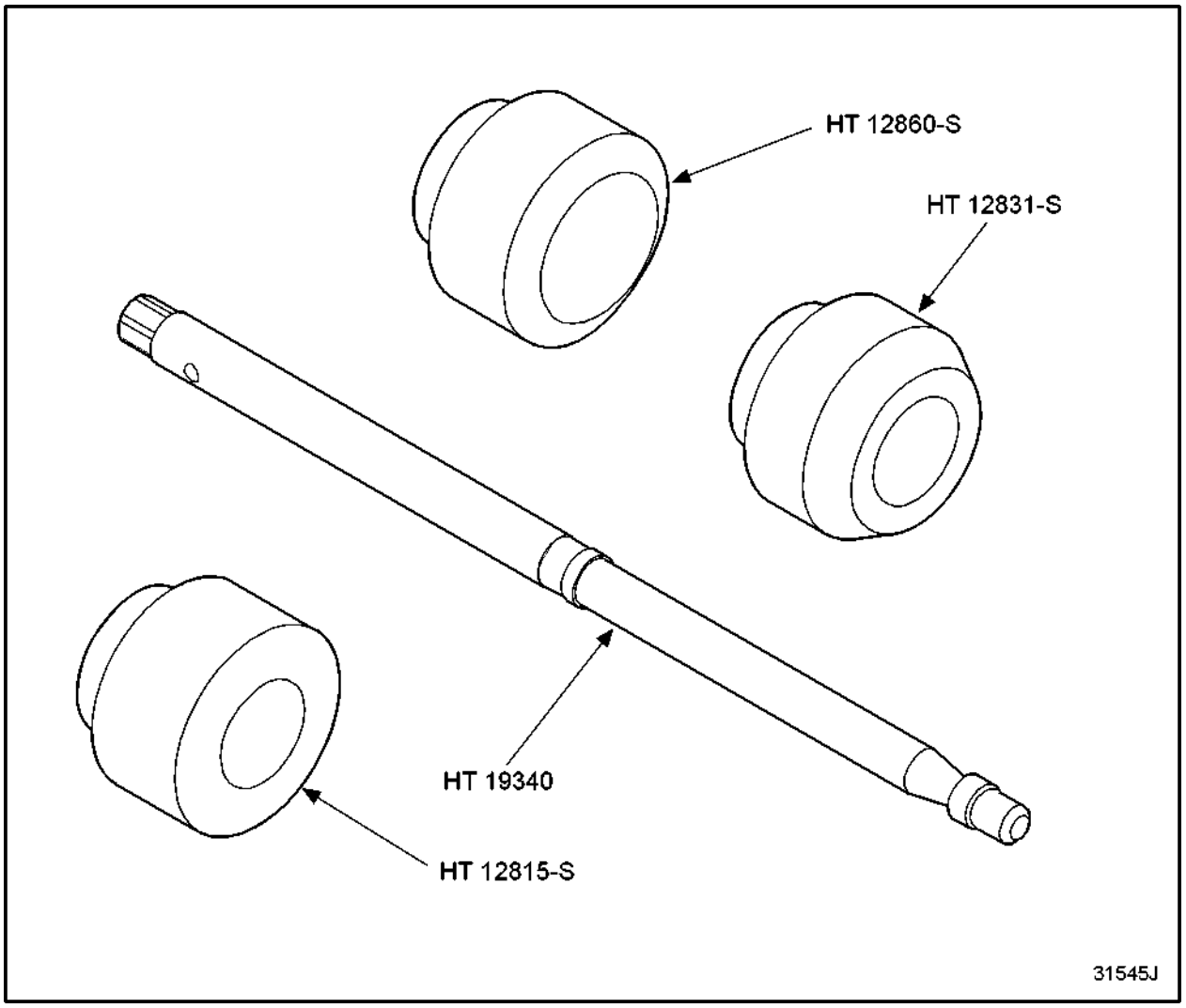


Figure 1239 Valve Seat Grinder Adapter Kit, 149,J 4627–02

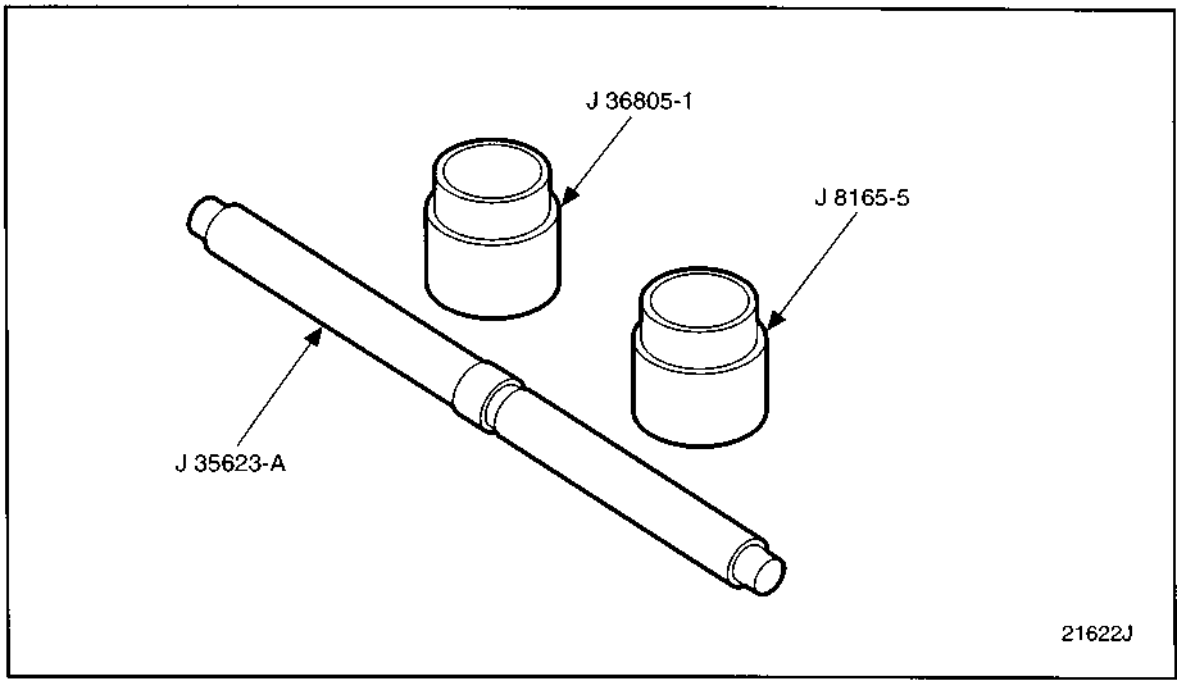


Figure 1240 Valve Seat Grinder Adapter Kit, 60,J 36805

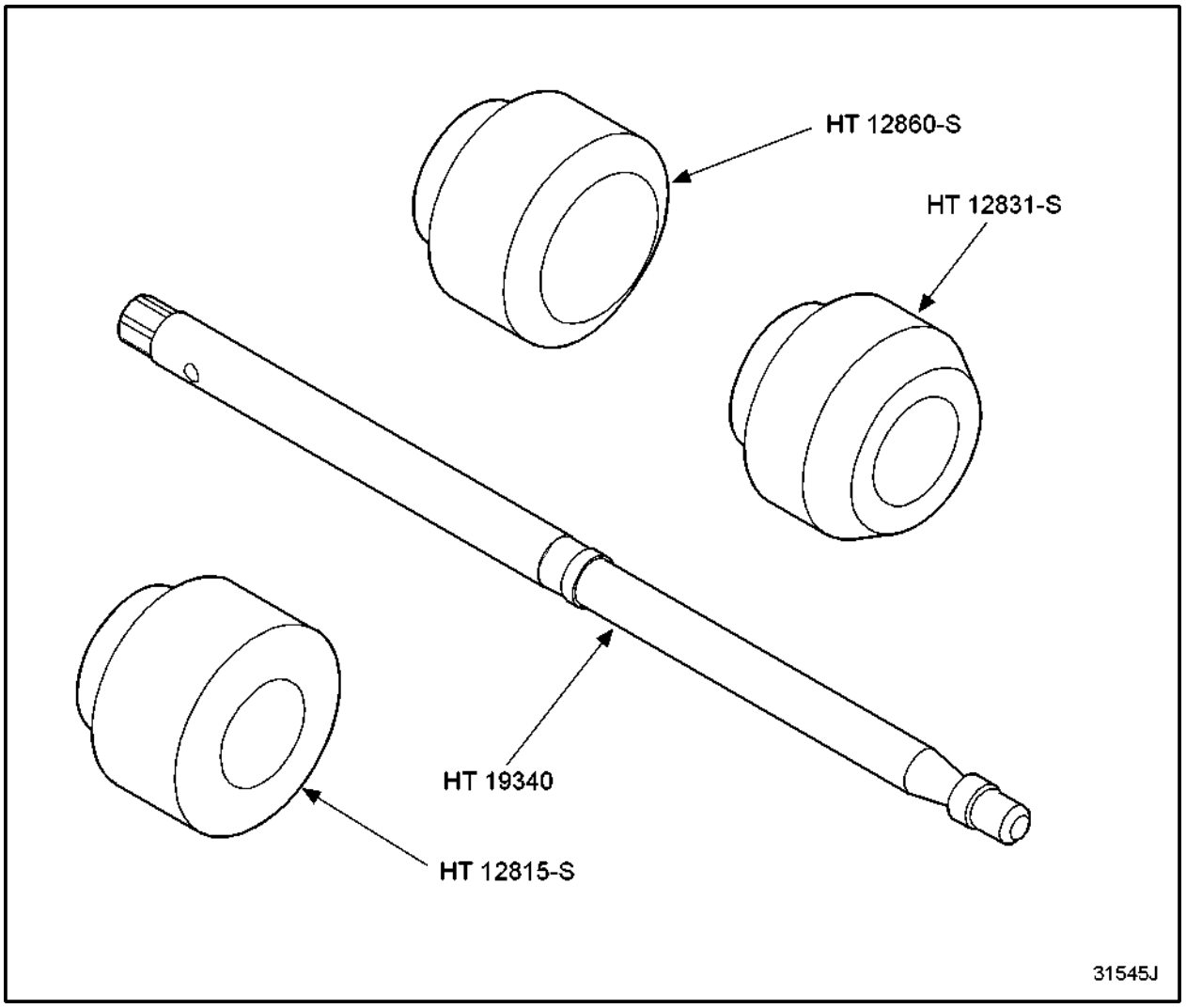


Figure 1241 Valve Seat Grinder Adapter Kit, 92,J 24566

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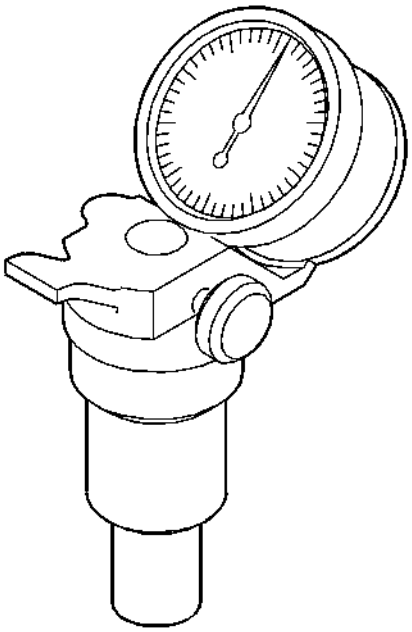
Figure 1242 Valve Seat Grind Adapter Kit, 8.2L,J 29645



30151J

Figure 1243 Valve Seat Grinder Pilot,J 8165–3

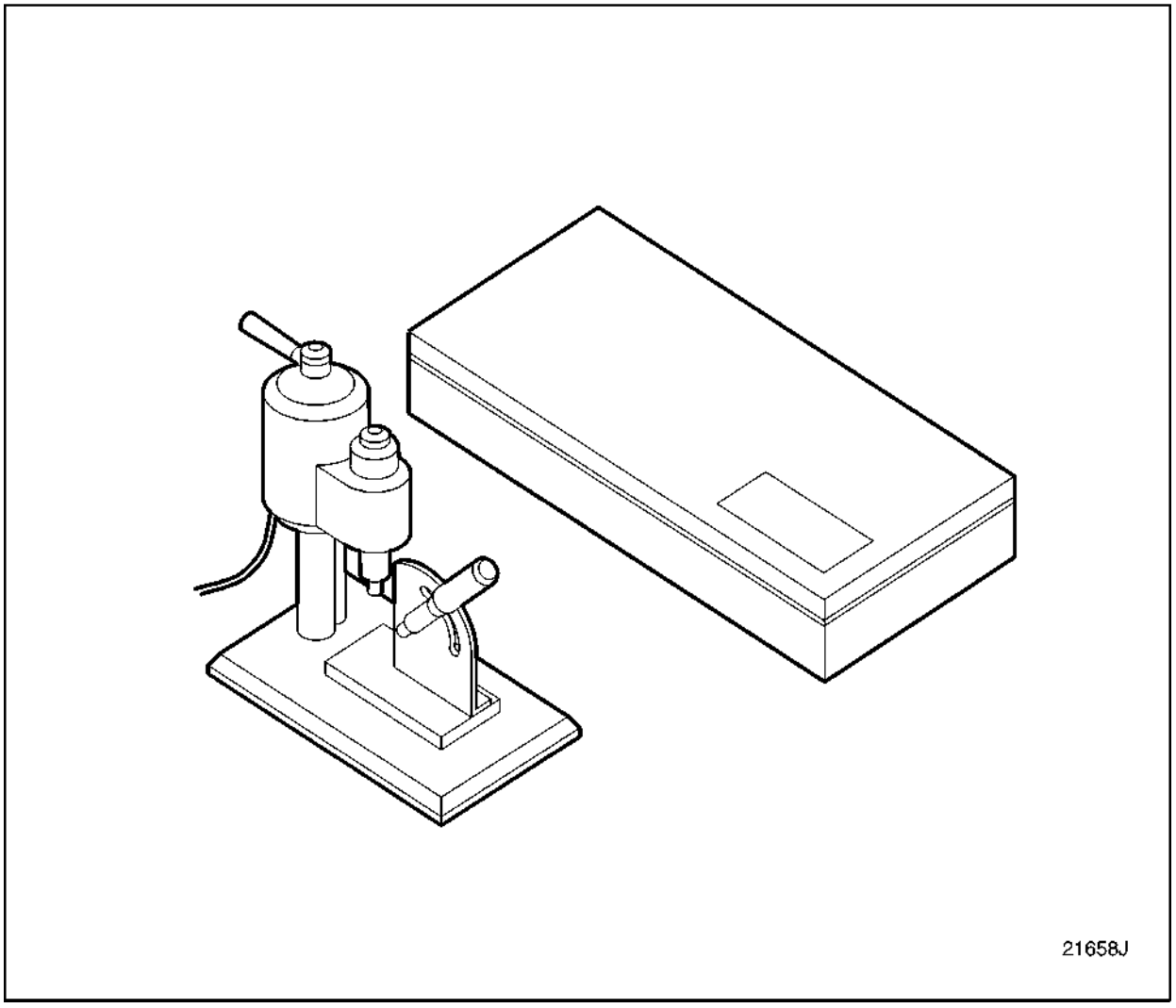


Figure 1244 Valve Seat Grinder -Less Stone/Pilot,J 7040–A

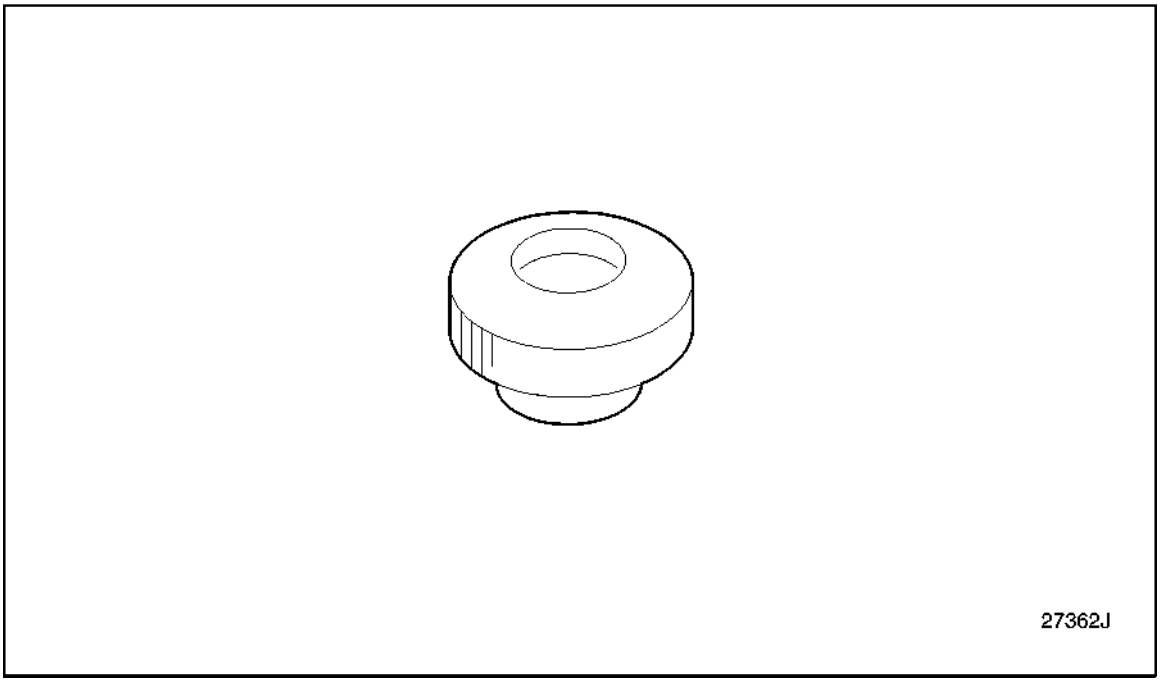


Figure 1245 Valve Seat Grinding Wheel 21 Degree,J 41535

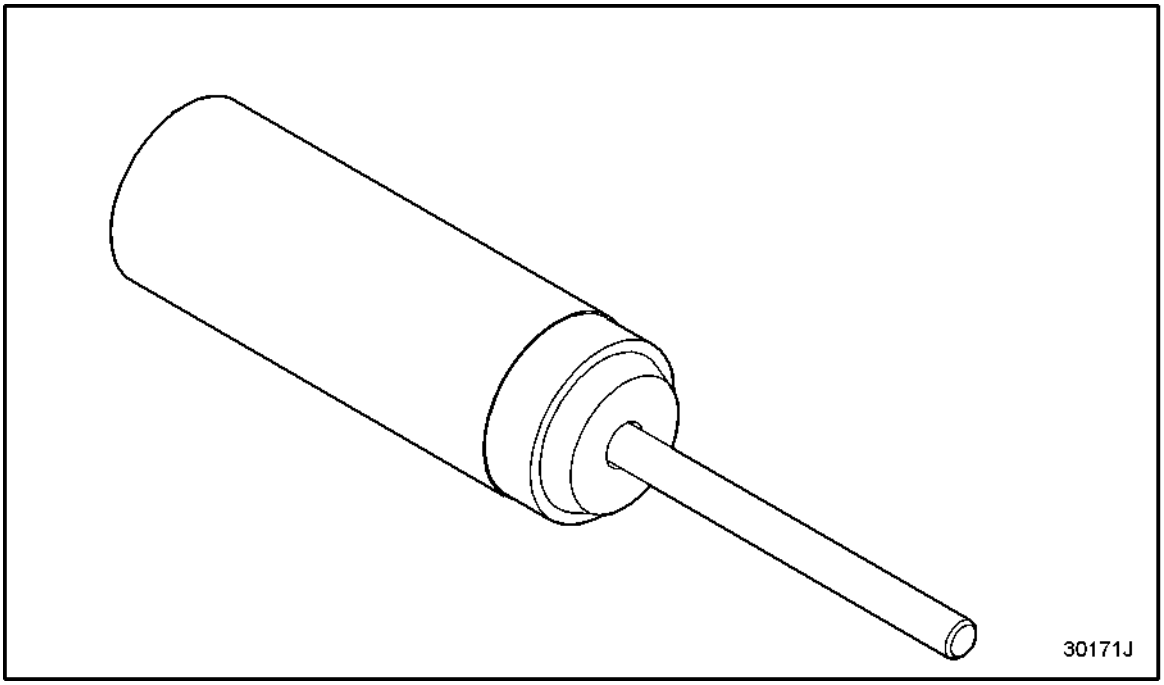


Figure 1246 Valve Seat Insert Install (2 Valve),J 1736

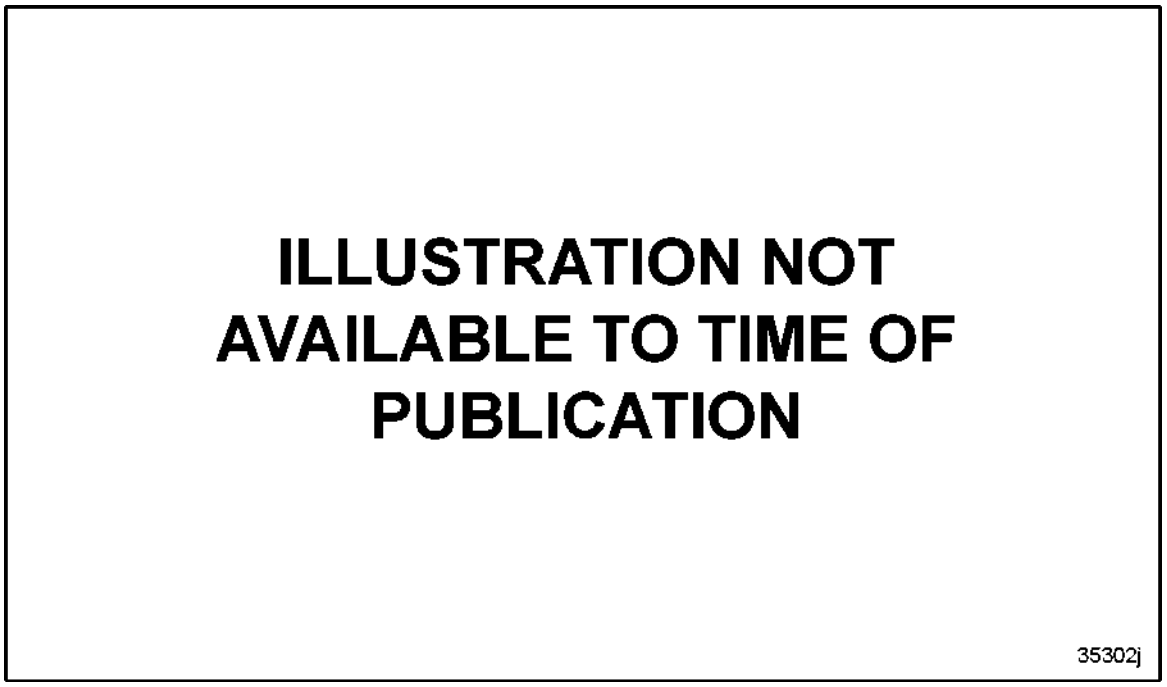


Figure 1247 Valve Seat Insert Install (2 Valve), J 6976

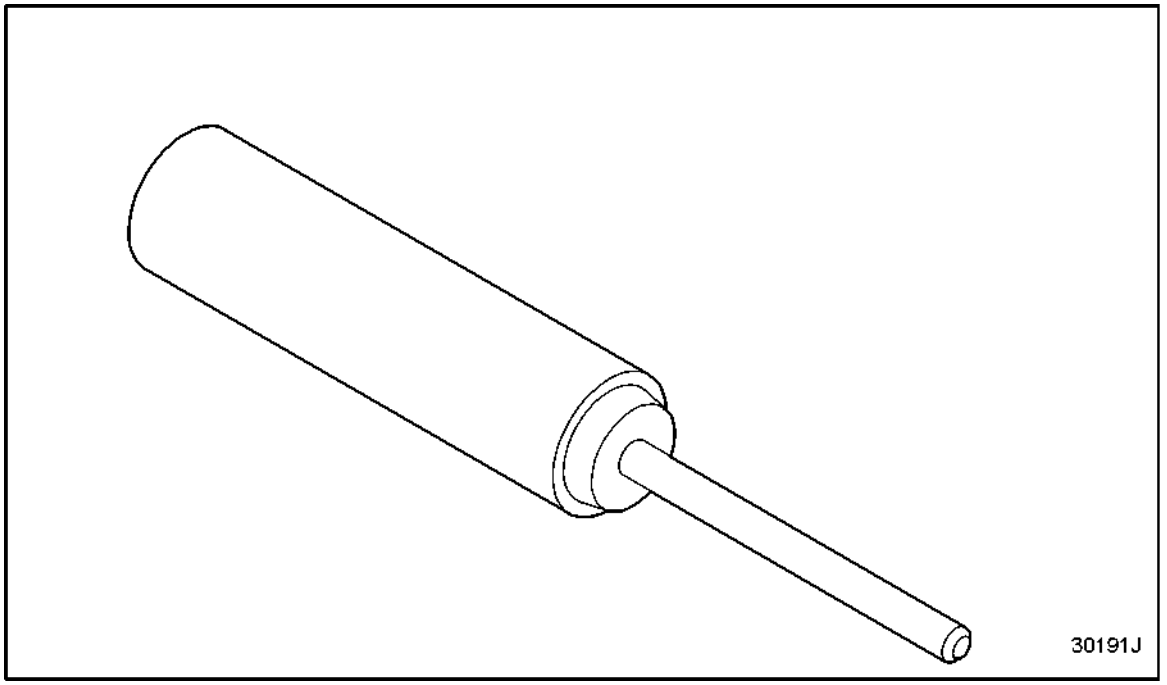


Figure 1248 Valve Seat Insert Install (4 Valve), J 6568

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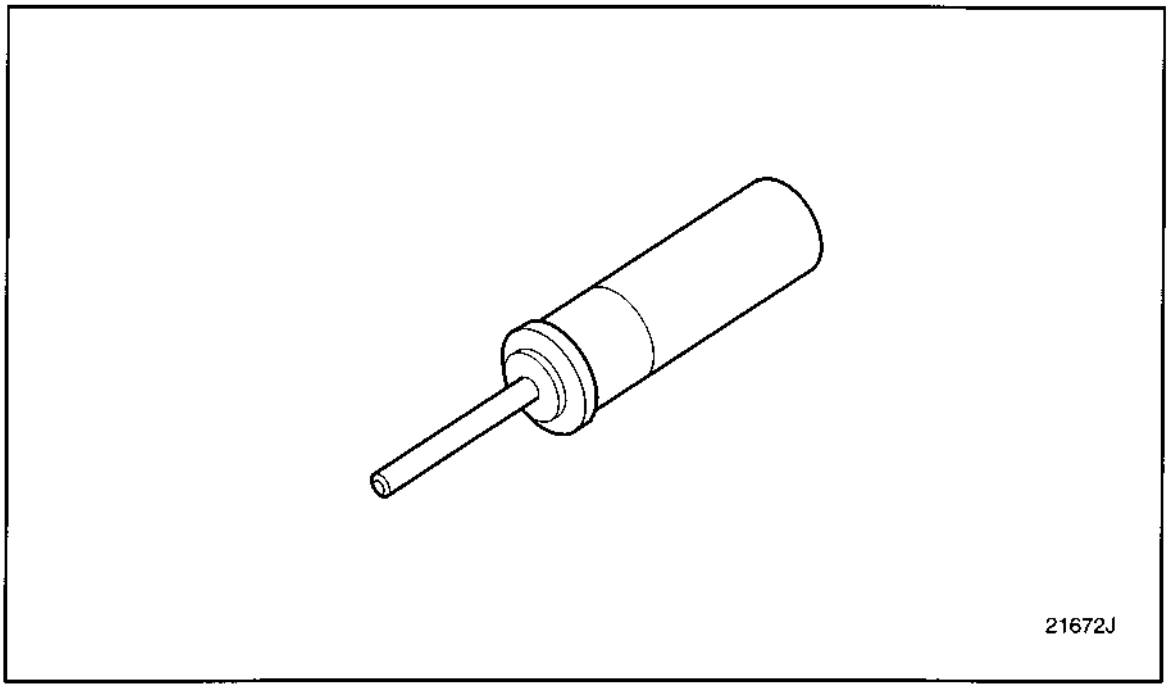
Figure 1249 Valve Seat Insert Install (4 Valve), J 7790



21672J

Figure 1250 Valve Seat Insert Install, Exhaust, J 34983

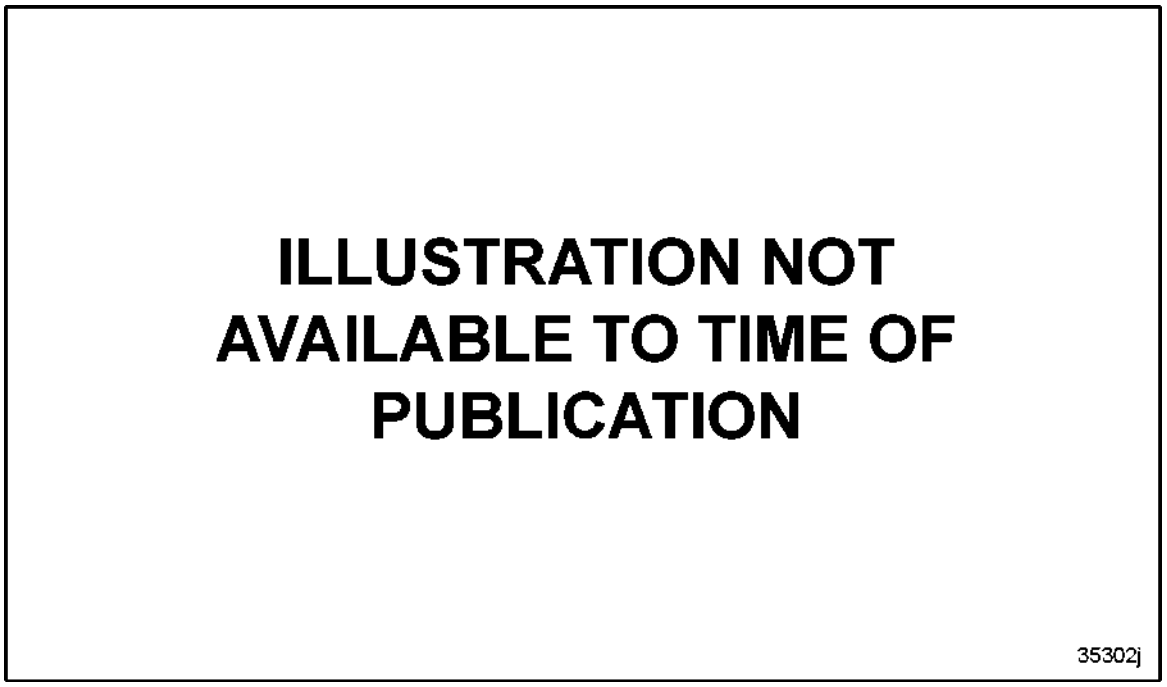


Figure 1251 Valve Seat Insert Install, Exhaust, J 39536

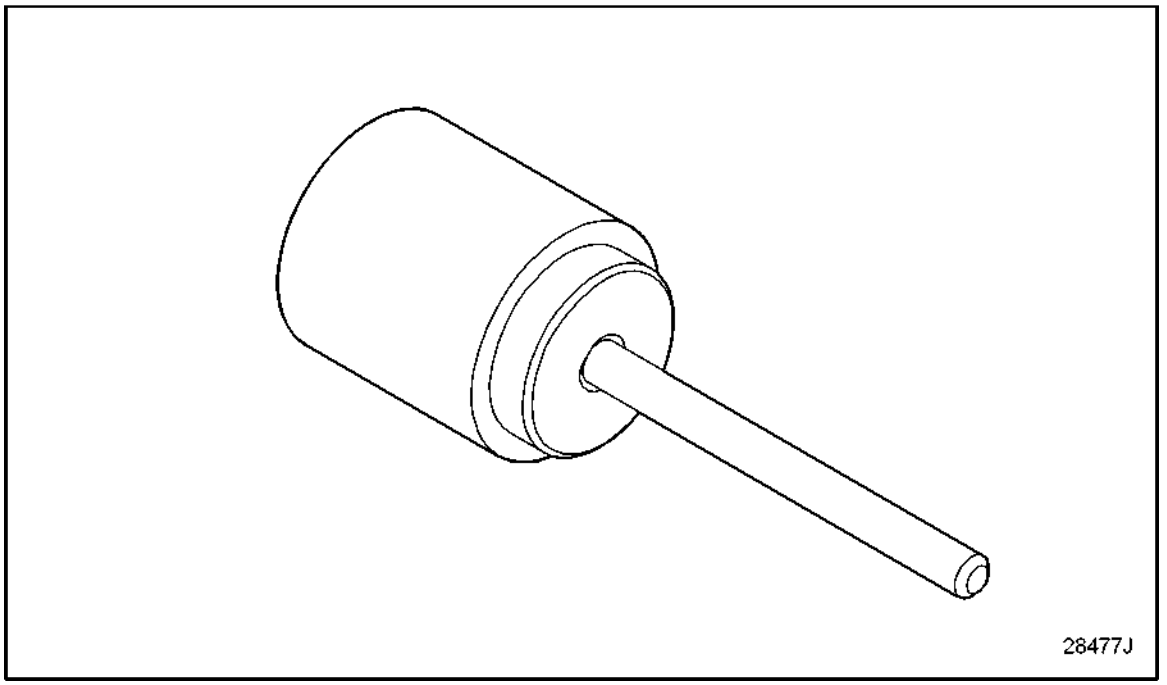


Figure 1252 Valve Seat Insert Installer, J 22711–A

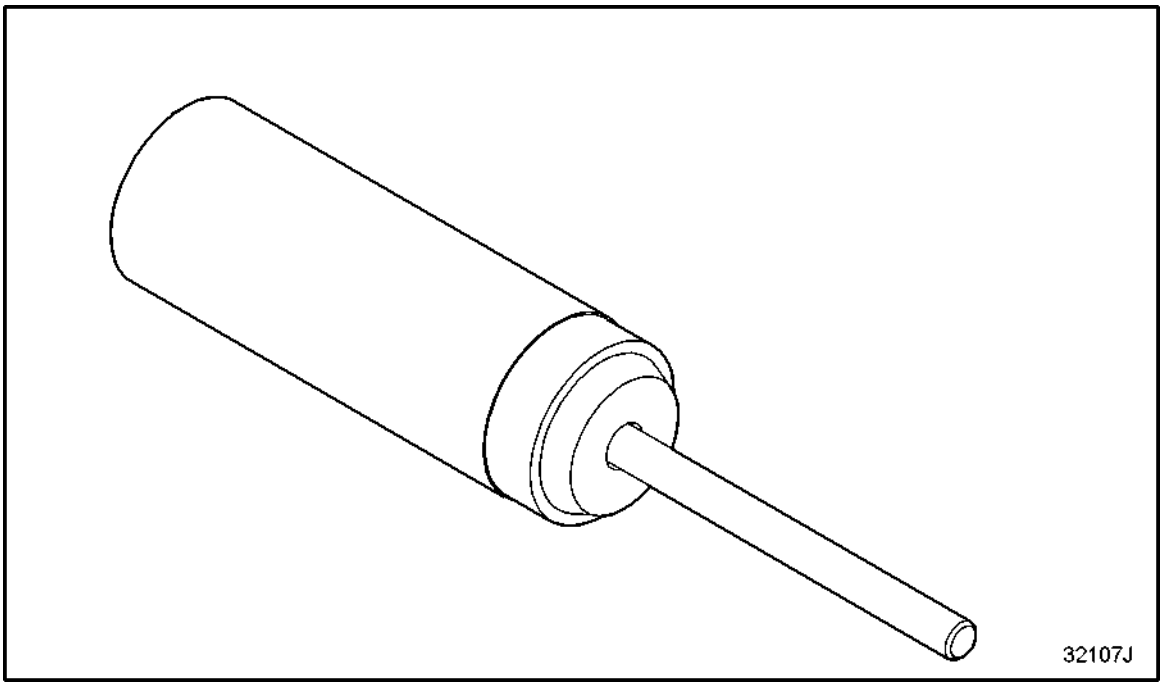


Figure 1253 Valve Seat Insert Installer,J 24357

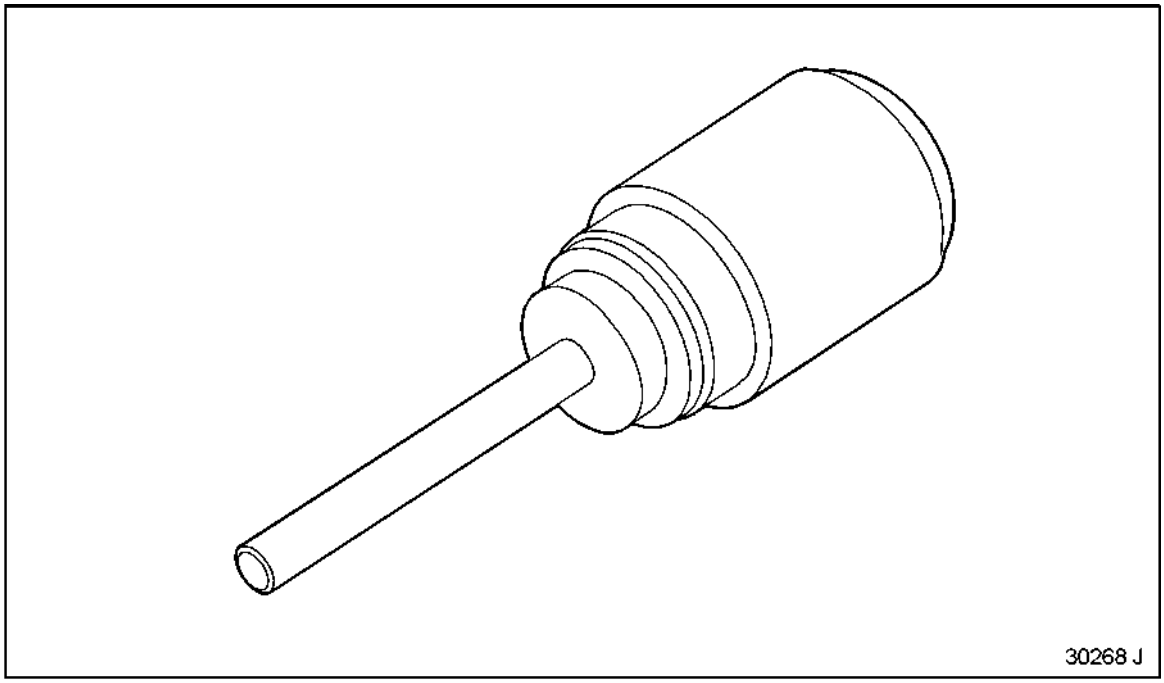


Figure 1254 Valve Seat Insert Installer,J 39535

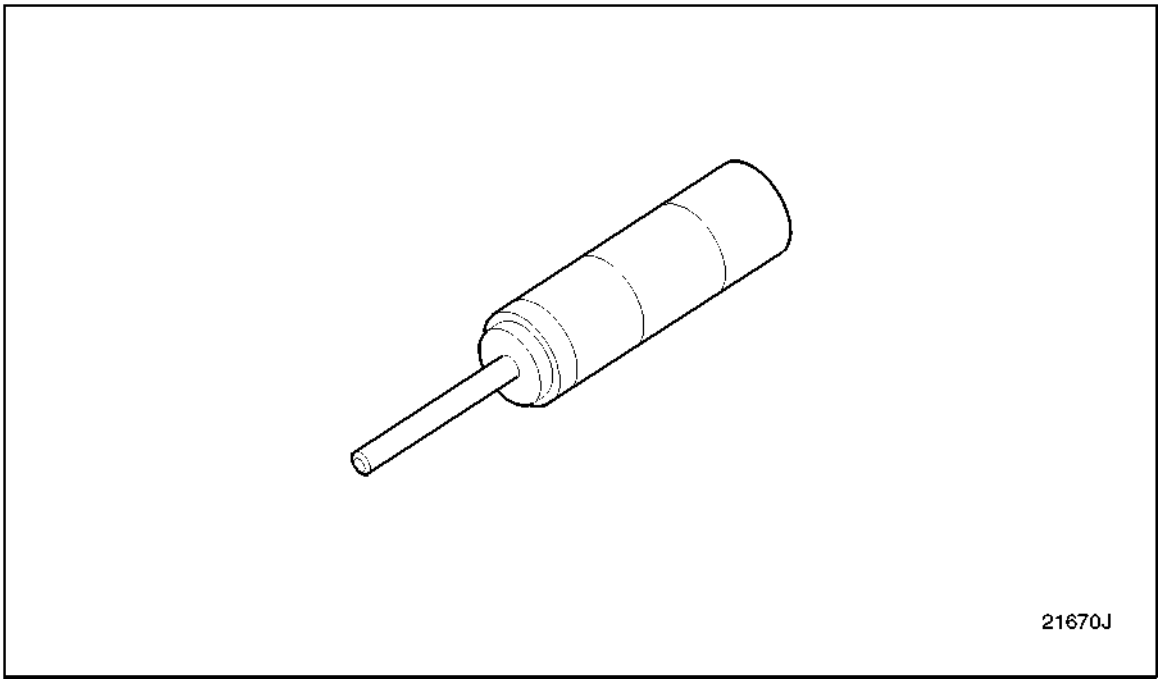


Figure 1255 Valve Seat Insert Installer, Intake, J 33190

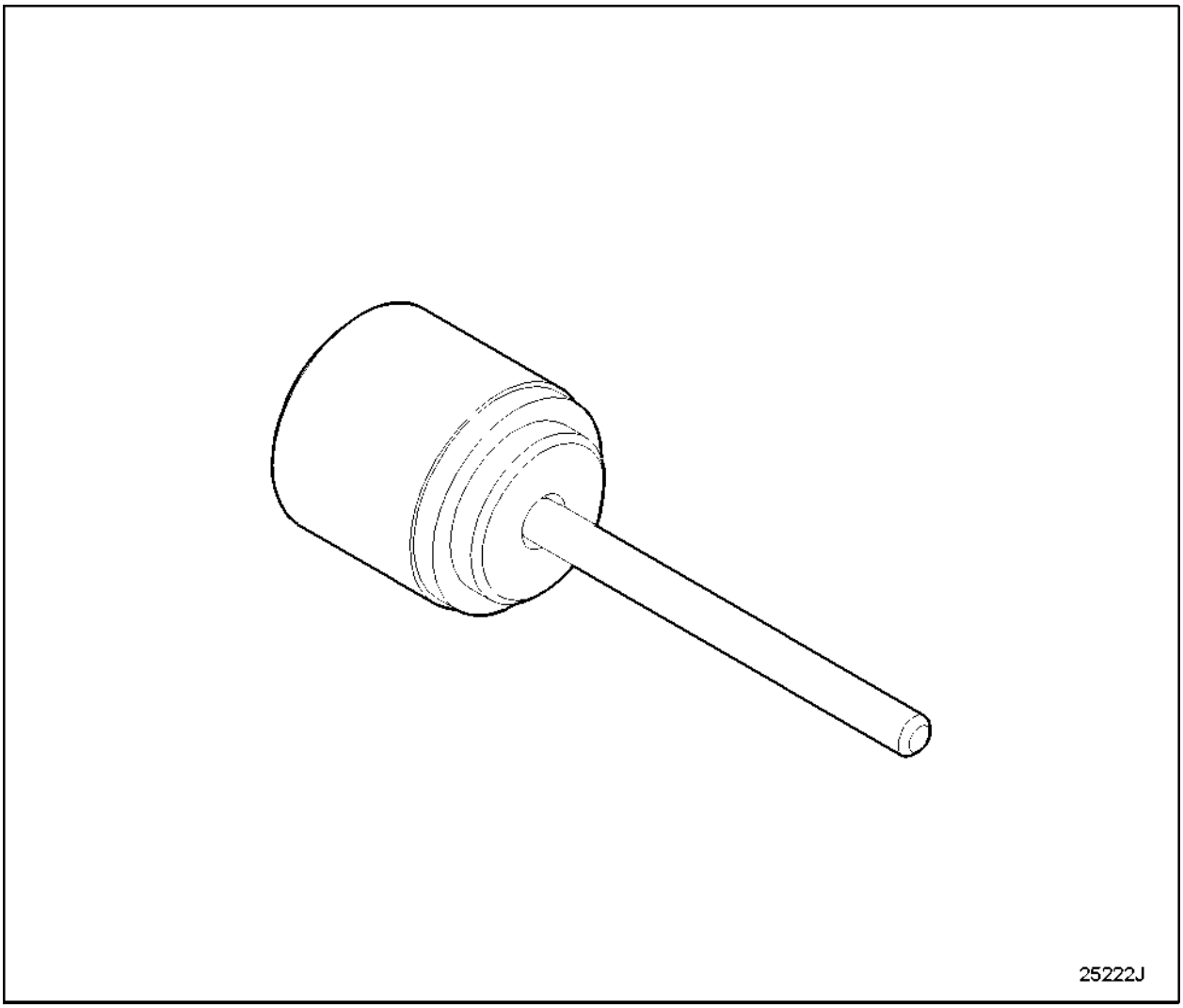


Figure 1256 Valve Seat Insert Installer, Intake, J 41585

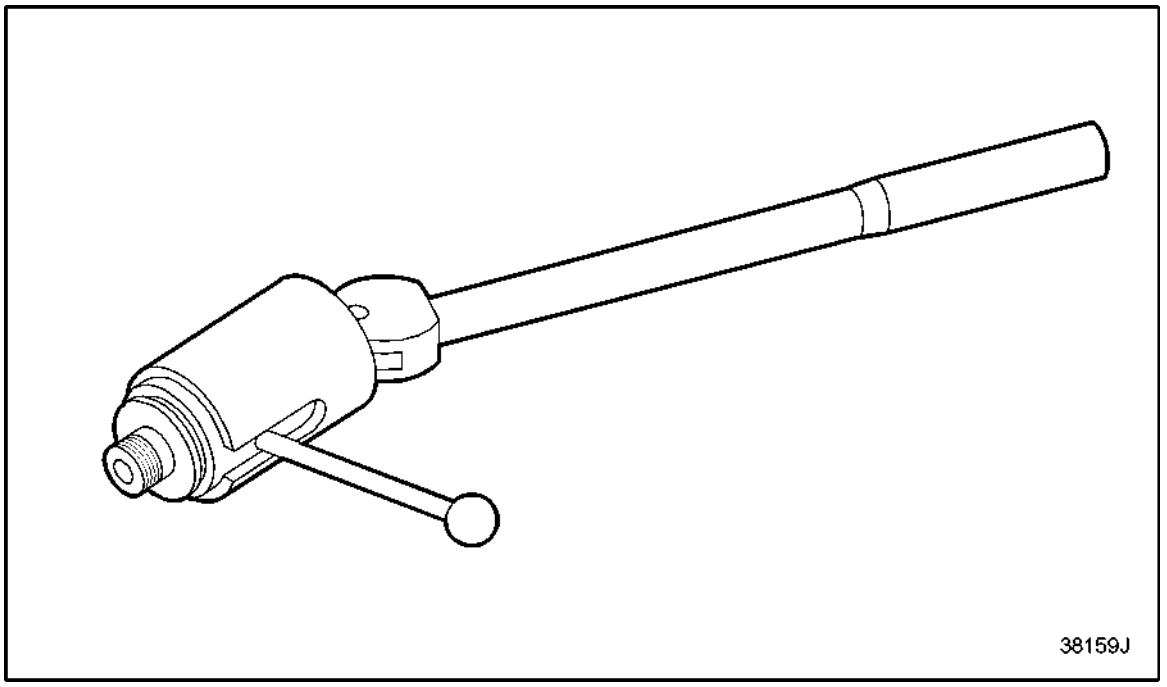


Figure 1257 Valve Seat Insert Puller Assembly,J 23479–35

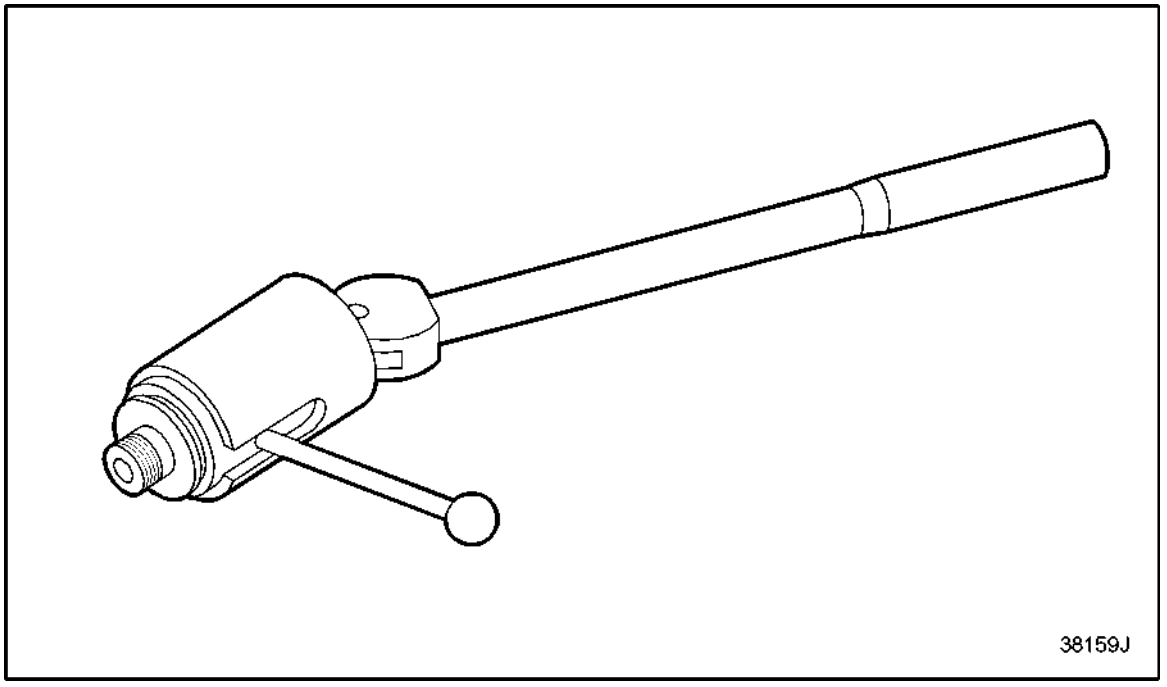


Figure 1258 Valve Seat Insert Puller Body,J 23479–37

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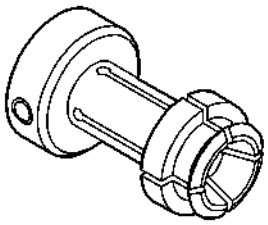
Figure 1259 Valve Seat Insert Puller Collet,PT-6390–45



38158J

Figure 1260 Valve Seat Insert Puller Collet (4 Valv),J 23479–28

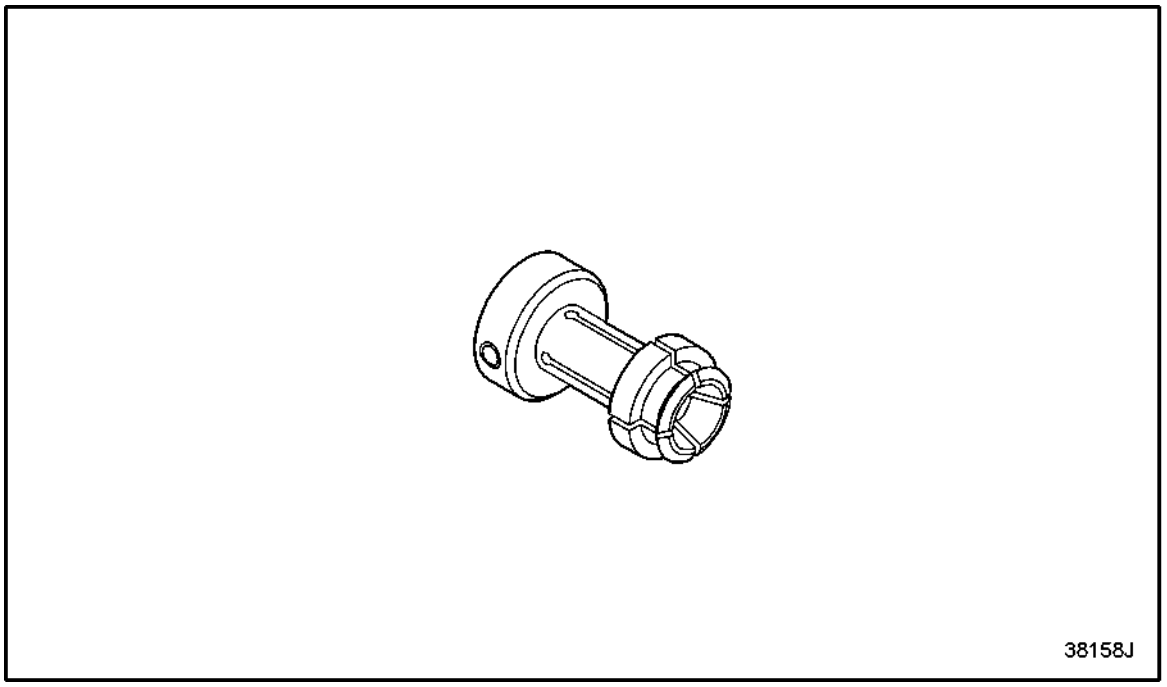


Figure 1261 Valve Seat Insert Puller Collet (4 Valv), J 23479–30

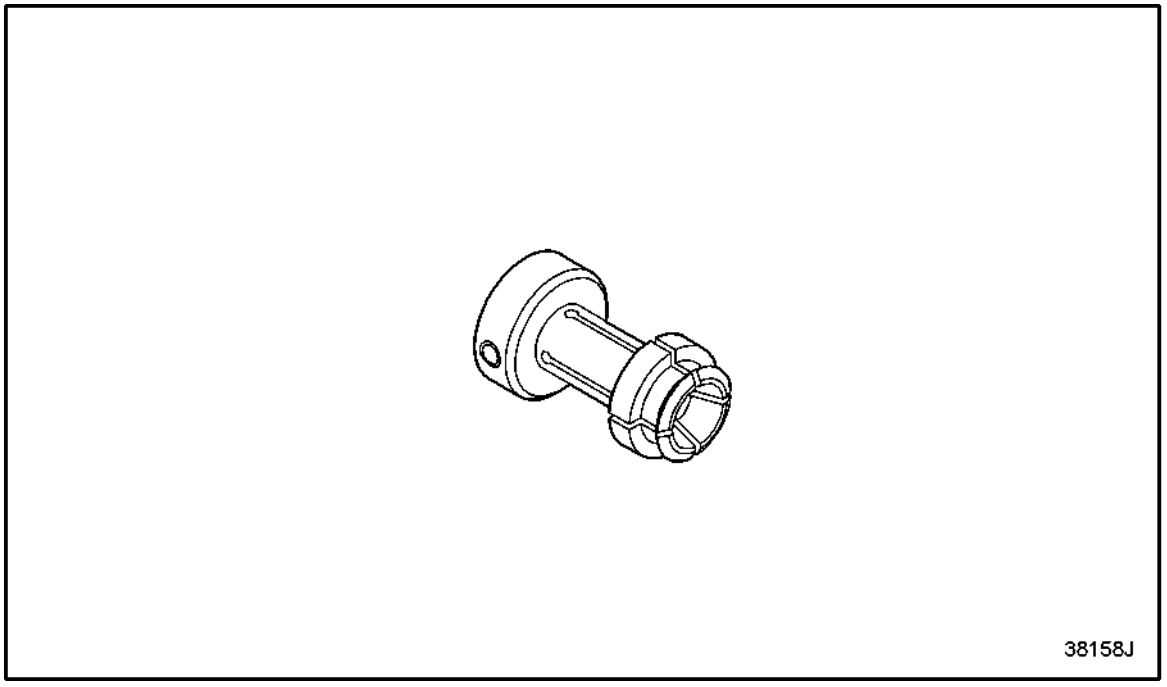


Figure 1262 Valve Seat Insert Puller Collet (2 Valv), J 23479–27

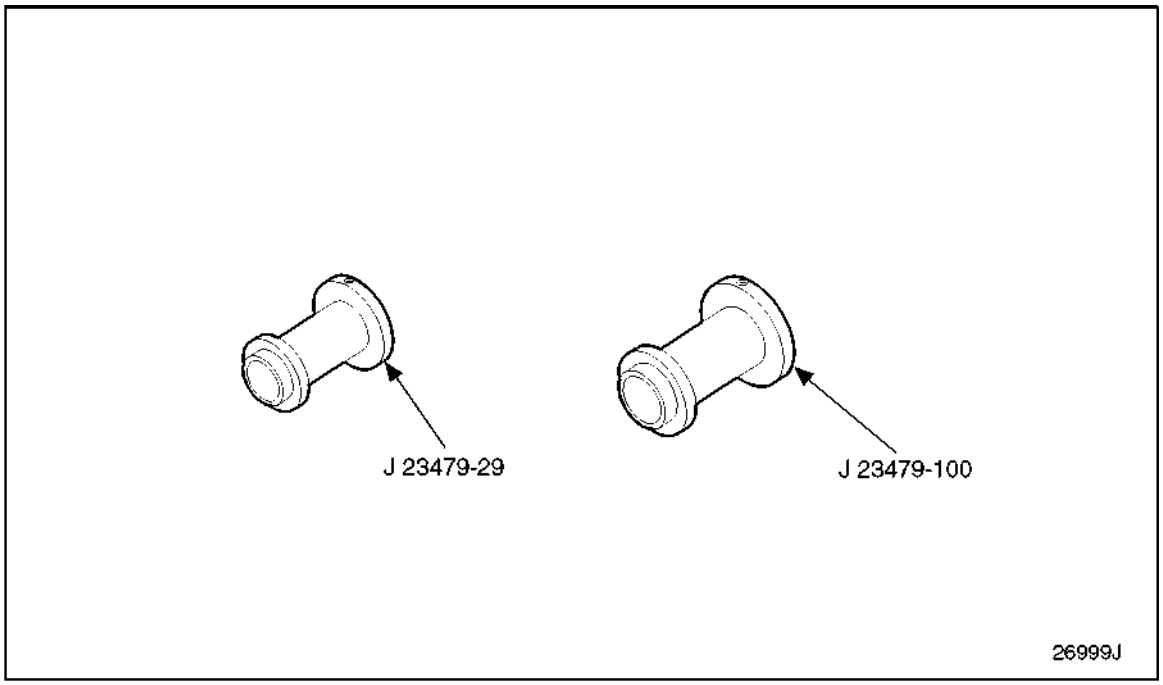


Figure 1263 Valve Seat Insert Puller Collet, Intake, J 23479–100A

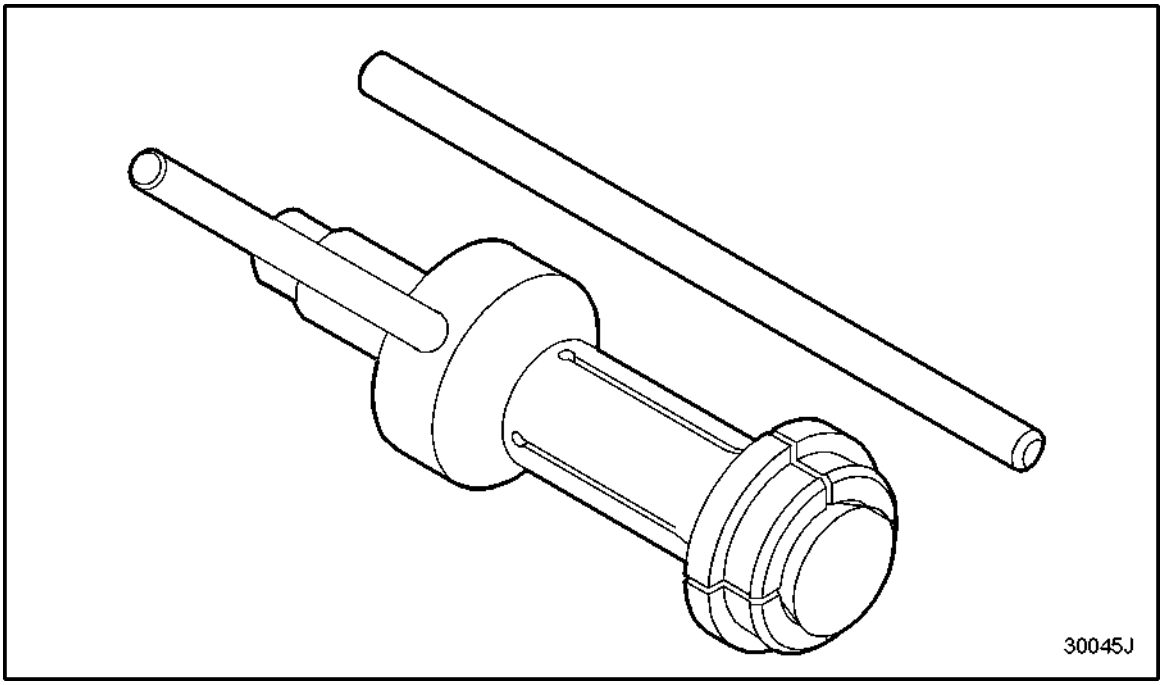


Figure 1264 Valve Seat Insert Remove-Ceramic HD, J 22512–A

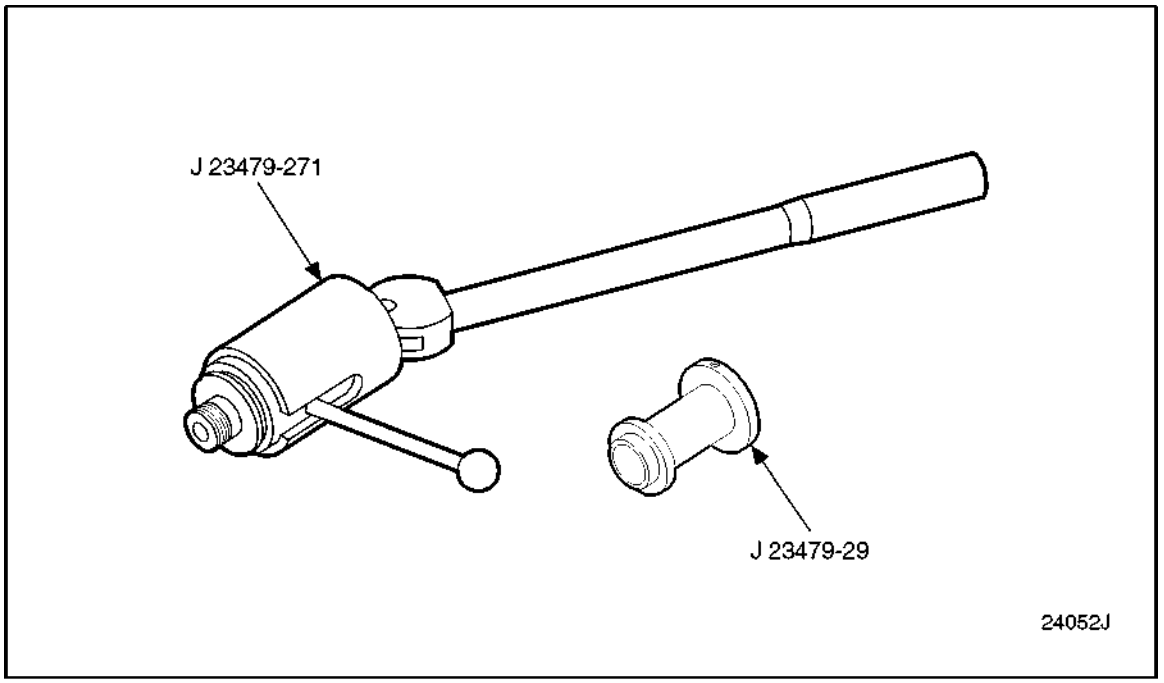


Figure 1265 Valve Seat Insert Remover, J 23479–271

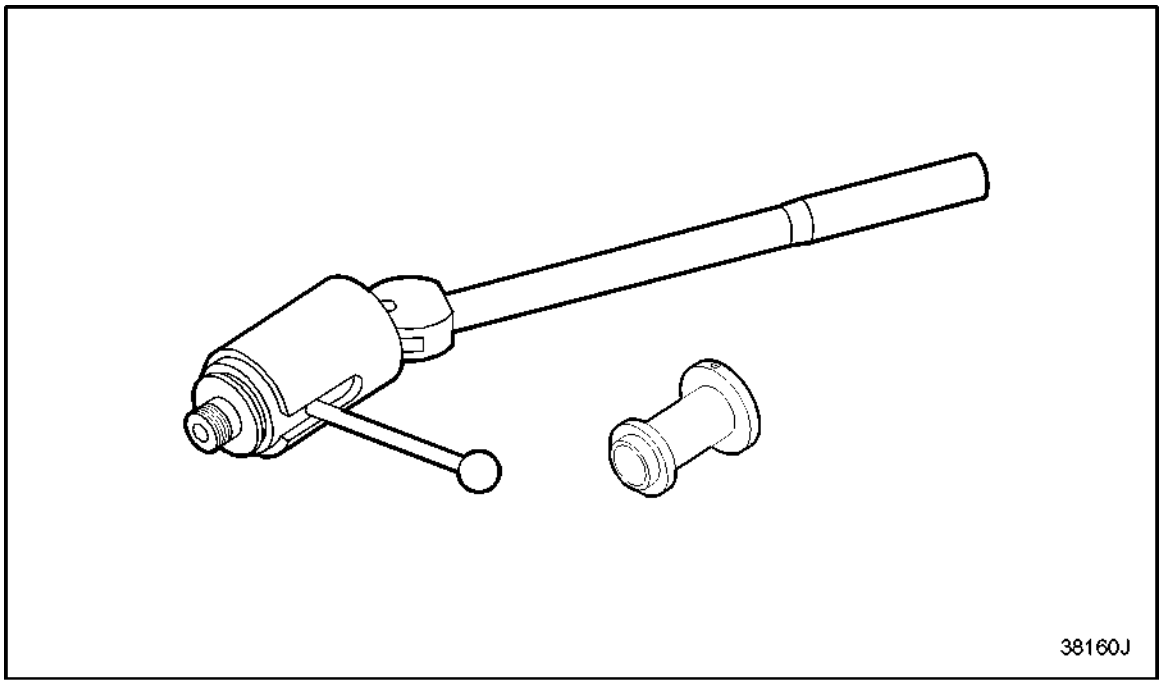


Figure 1266 Valve Seat Insert Remover, J 23479–492

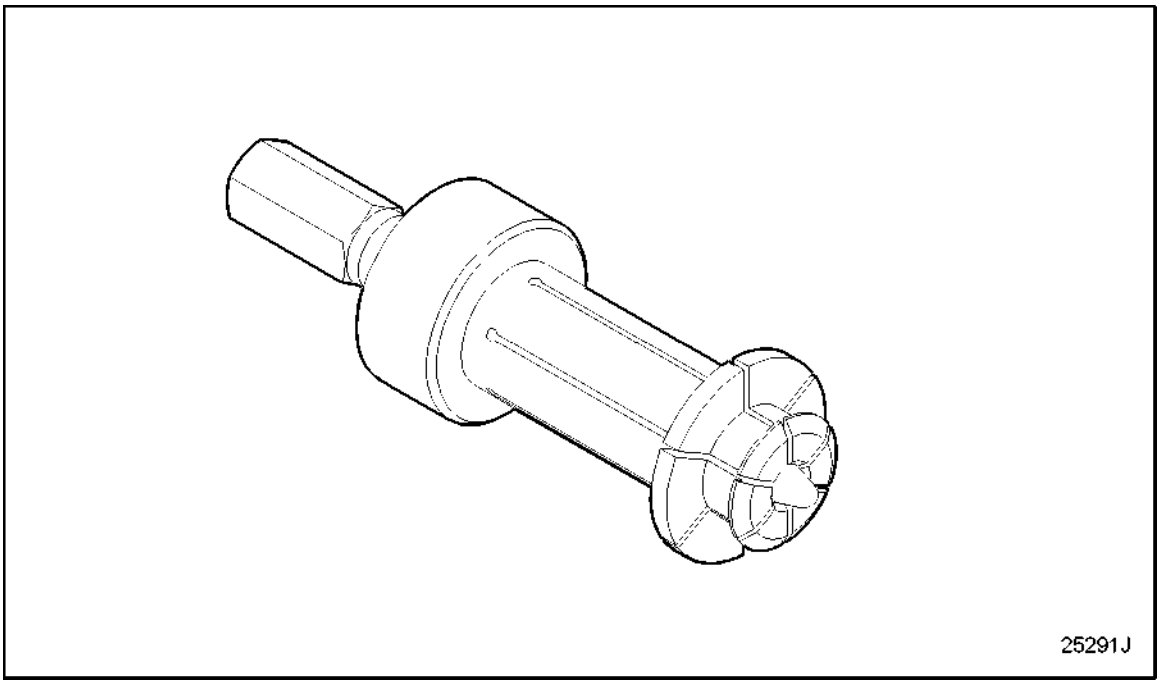


Figure 1267 Valve Seat Insert Remover,J 41583

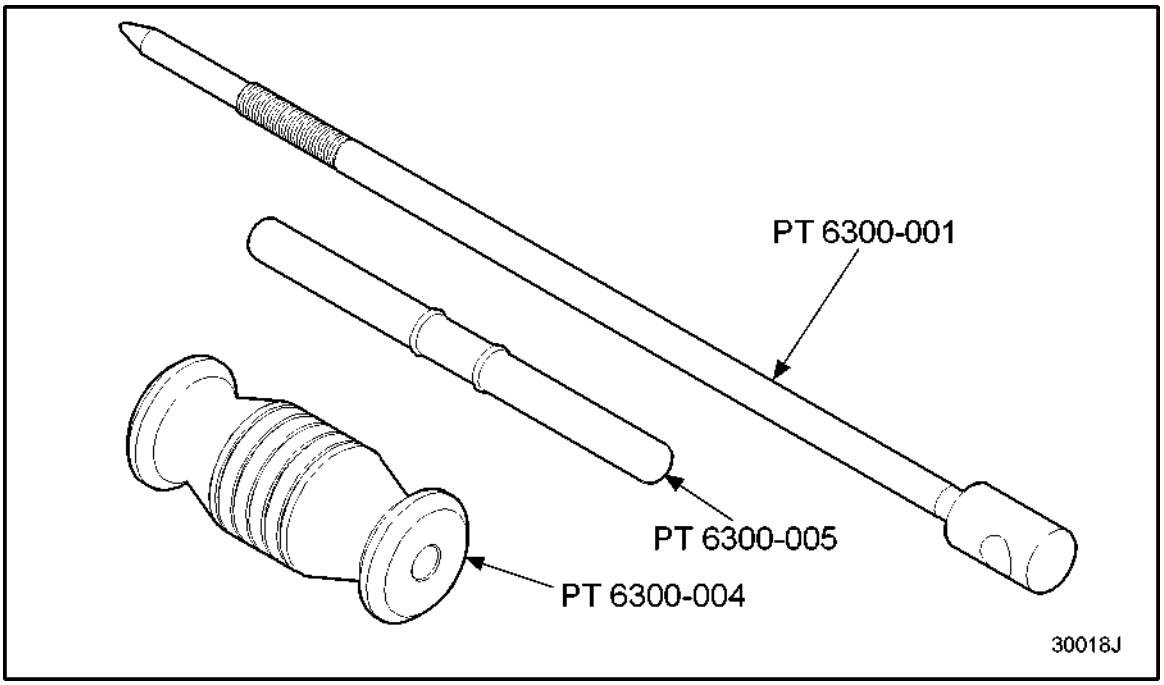


Figure 1268 Valve Seat Insert Remover,PT-6300

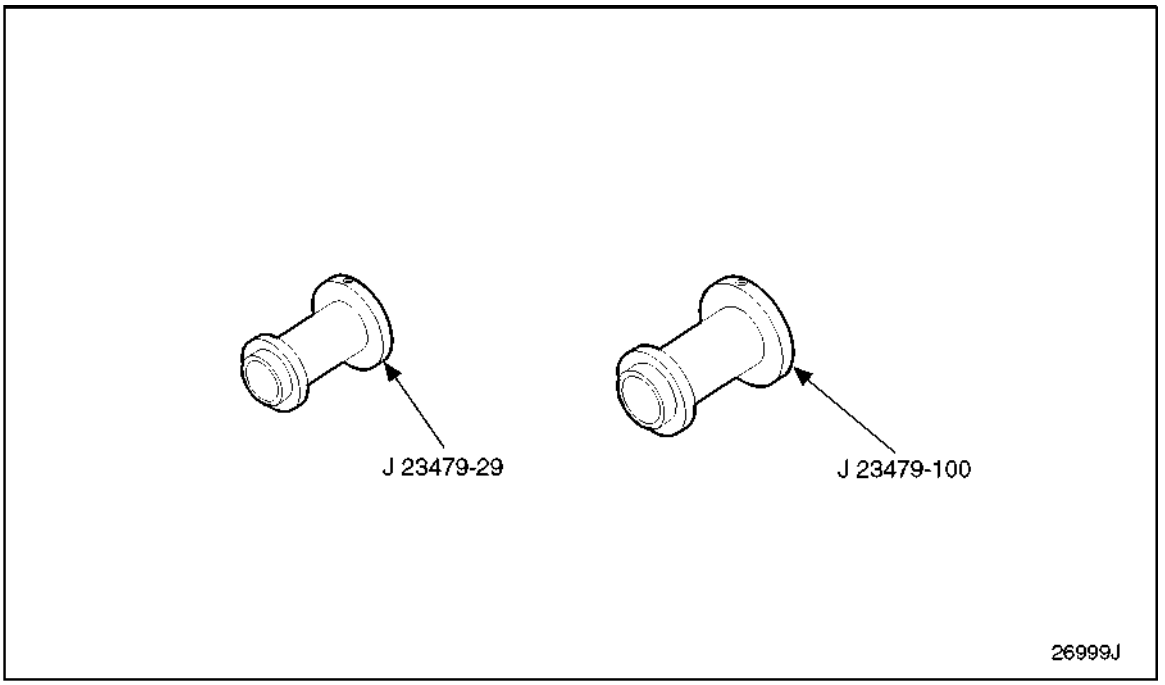


Figure 1269 Valve Seat Insert Remover (2 Valv71), J 23479–29

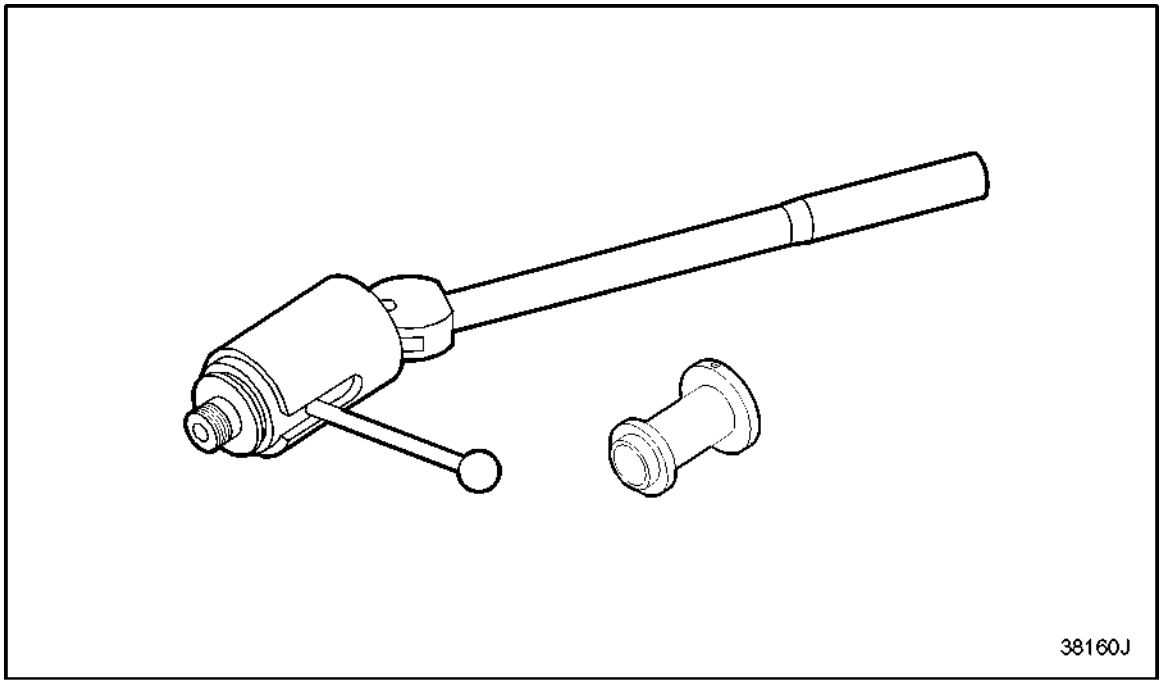


Figure 1270 Valve Seat Insert Remover (2 Valv),J 23479–253

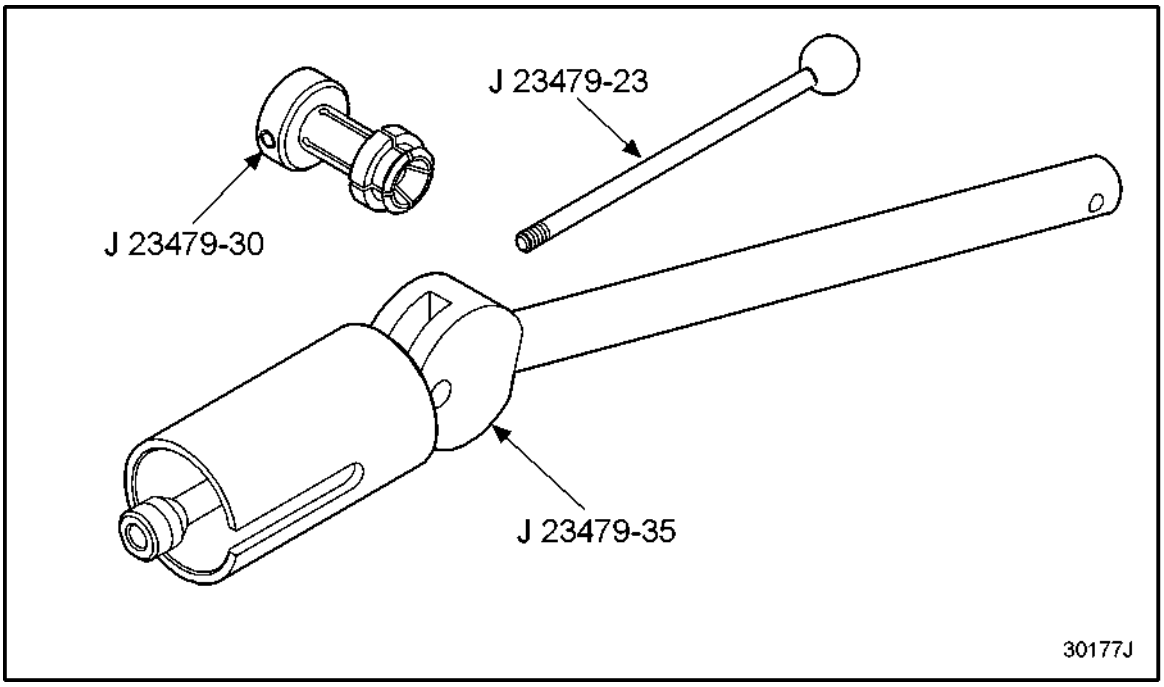


Figure 1271 Valve Seat Insert Remover (4 Valv),J 23479–471

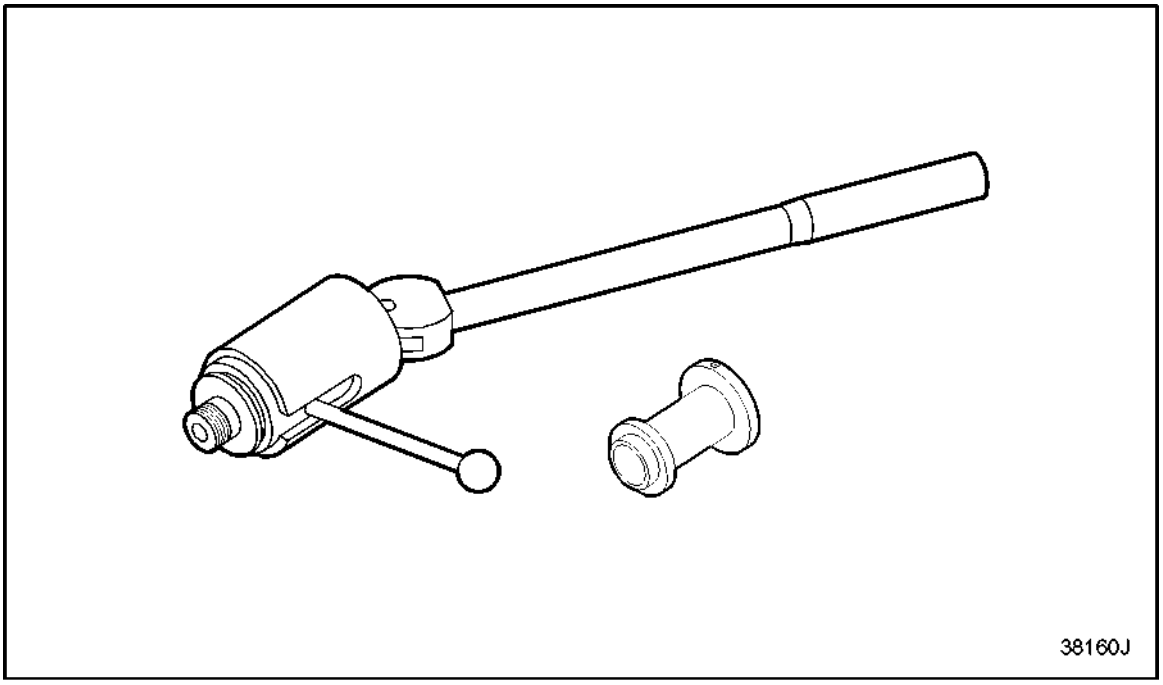


Figure 1272 Valve Seat Insert Remover (4 Valv)J 23479–453

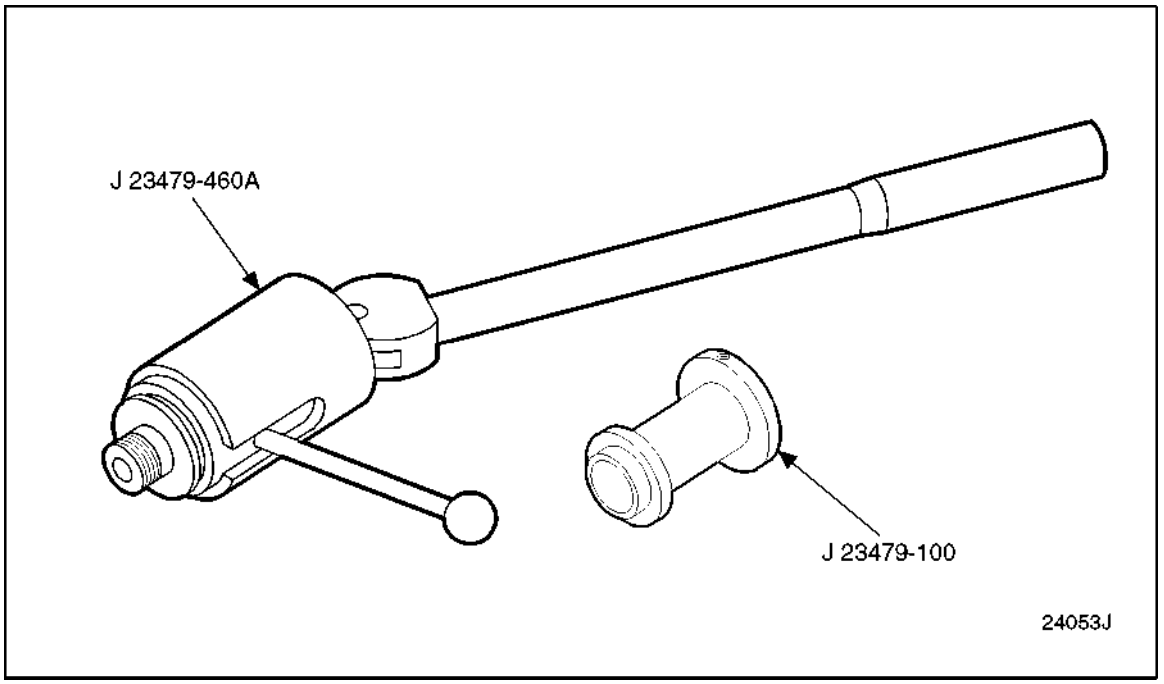


Figure 1273 Valve Seat Insert Remover (Intake) J 23479–460–A

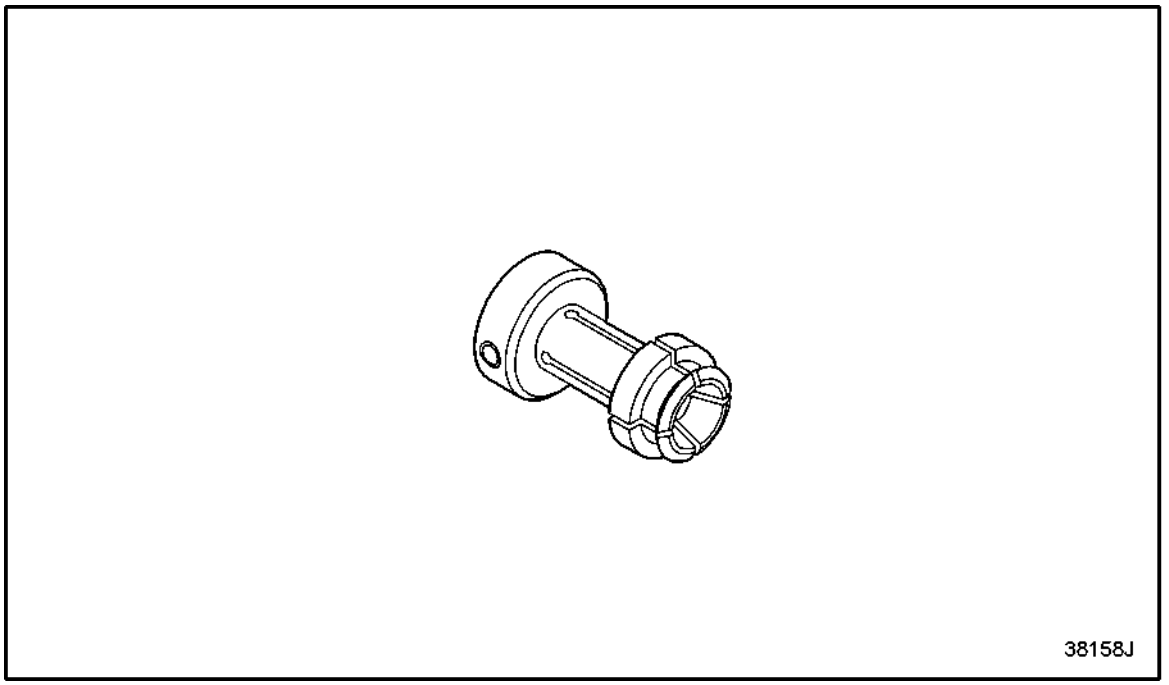


Figure 1274 Valve Seat Insert Remover Collet, J 23479–33

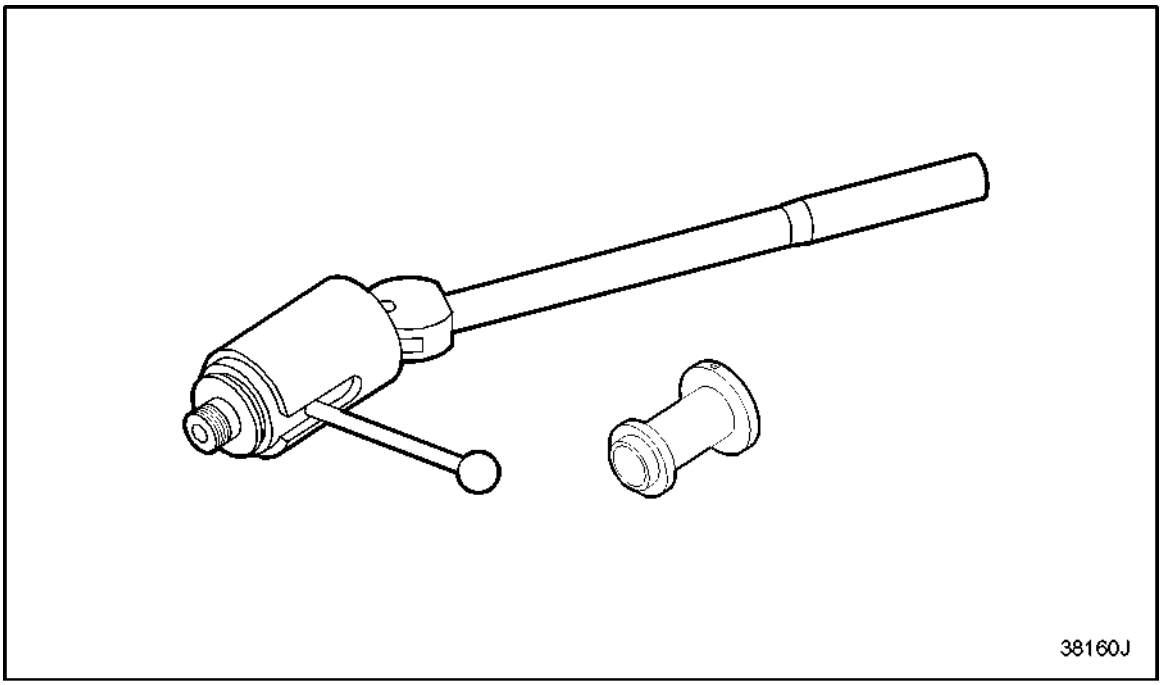


Figure 1275 Valve Seat Insert Remover Collet, J 23479–38

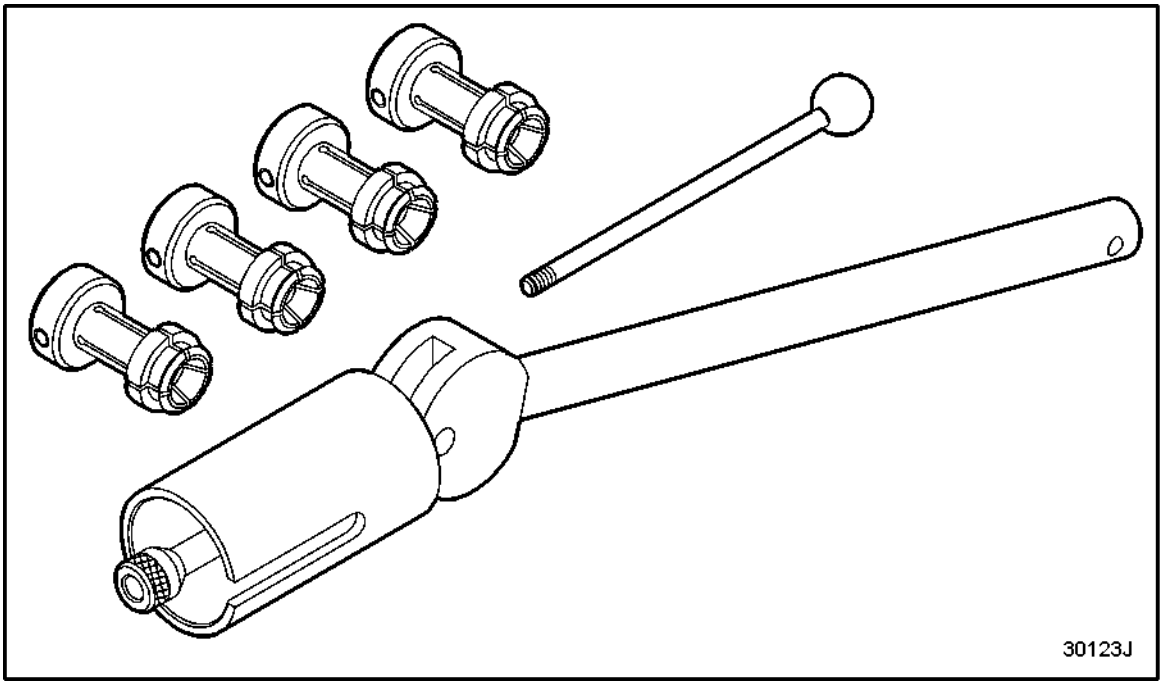


Figure 1276 Valve Seat Insert Remover Set, J 23479–E

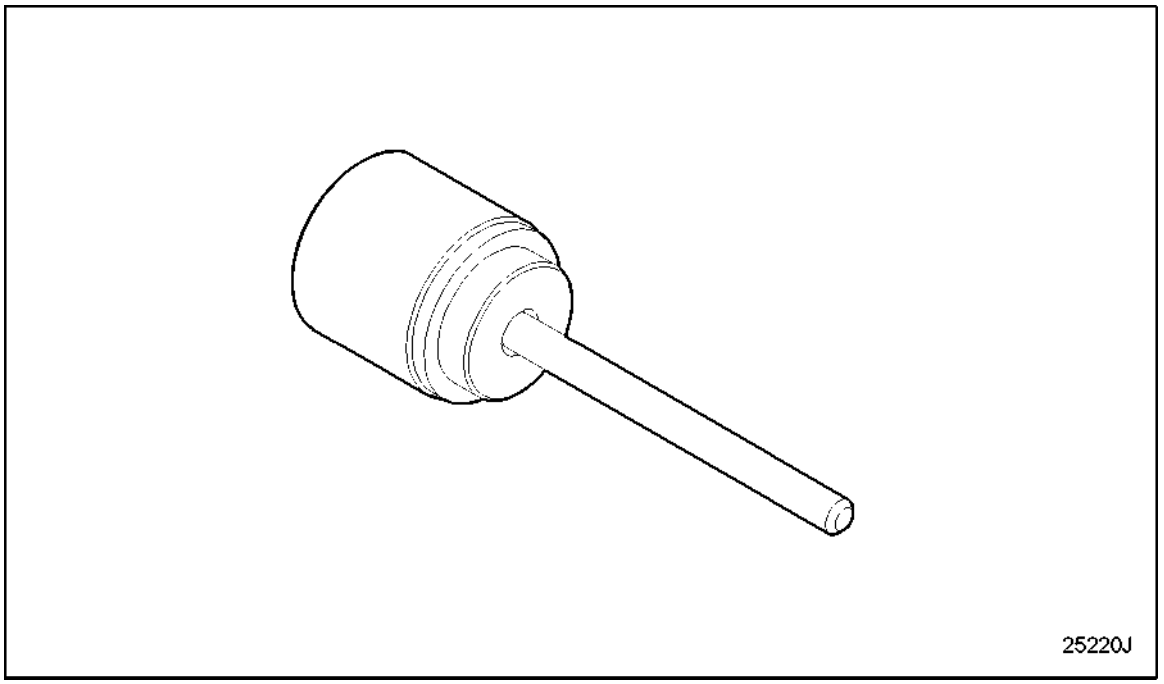


Figure 1277 Valve Seat Installer, Exhaust,J 41578

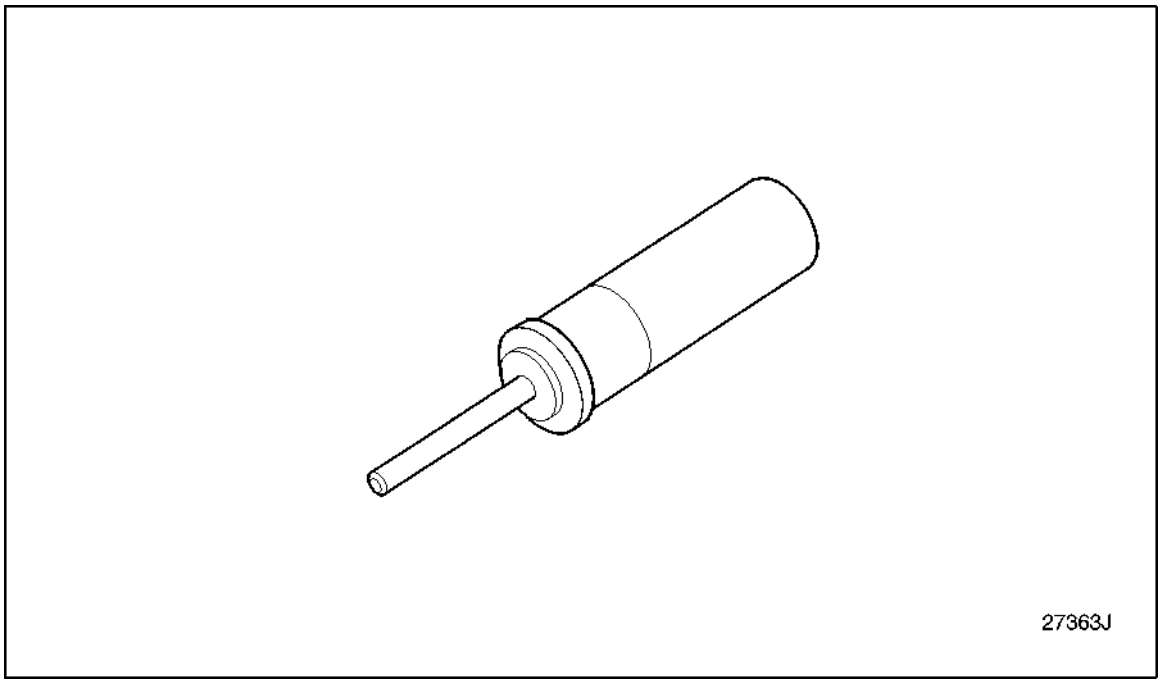


Figure 1278 Valve Seat Installer, Exhaust,J 41822

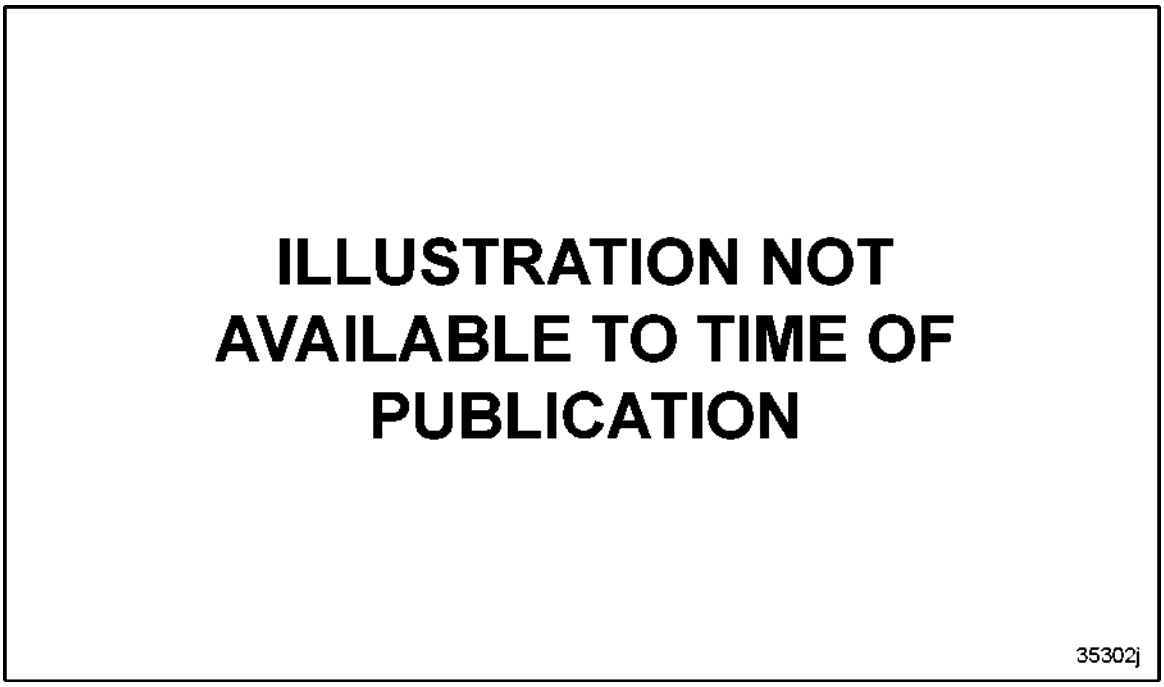


Figure 1279 Valve Seat Puller (Basic Kit),PT-6391

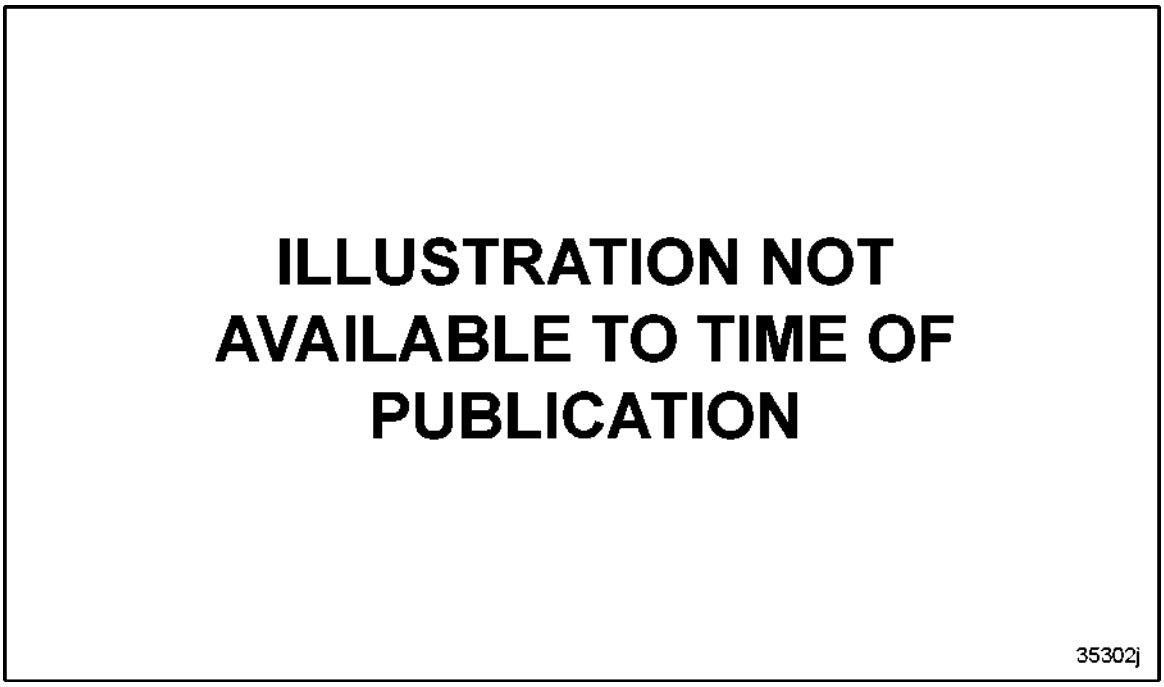


Figure 1280 Valve Seat Remover Collet,PT-6399–7

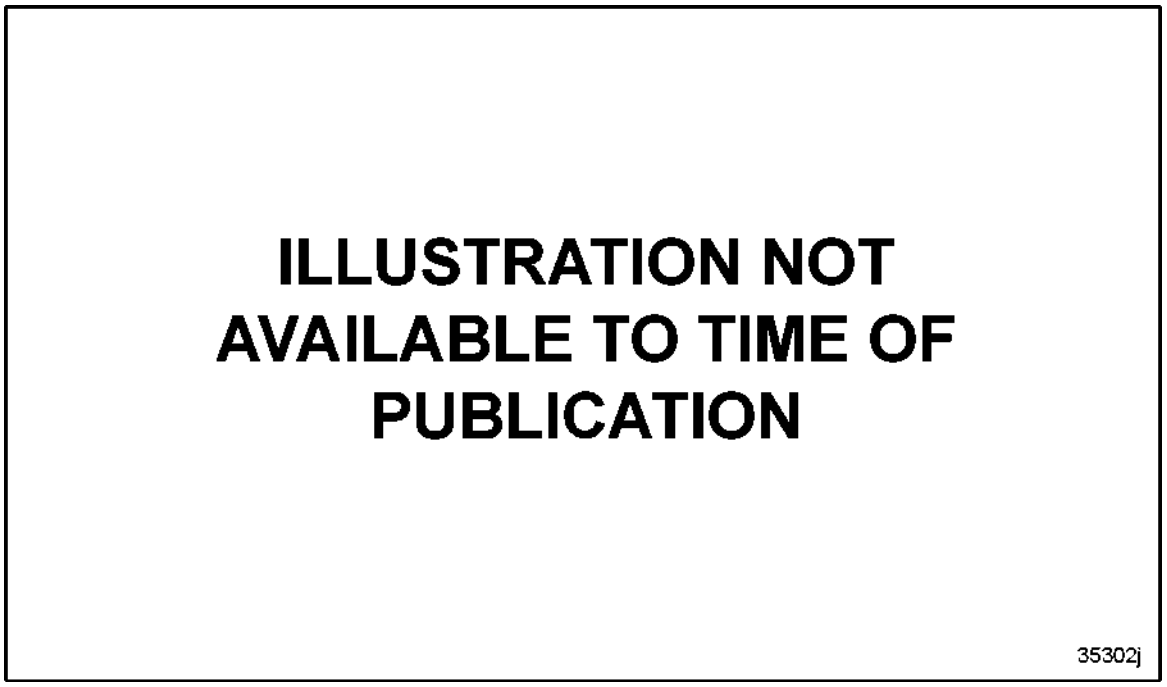


Figure 1281 Valve Seat Remover Collet (2 Valv 53),PT-6399–3

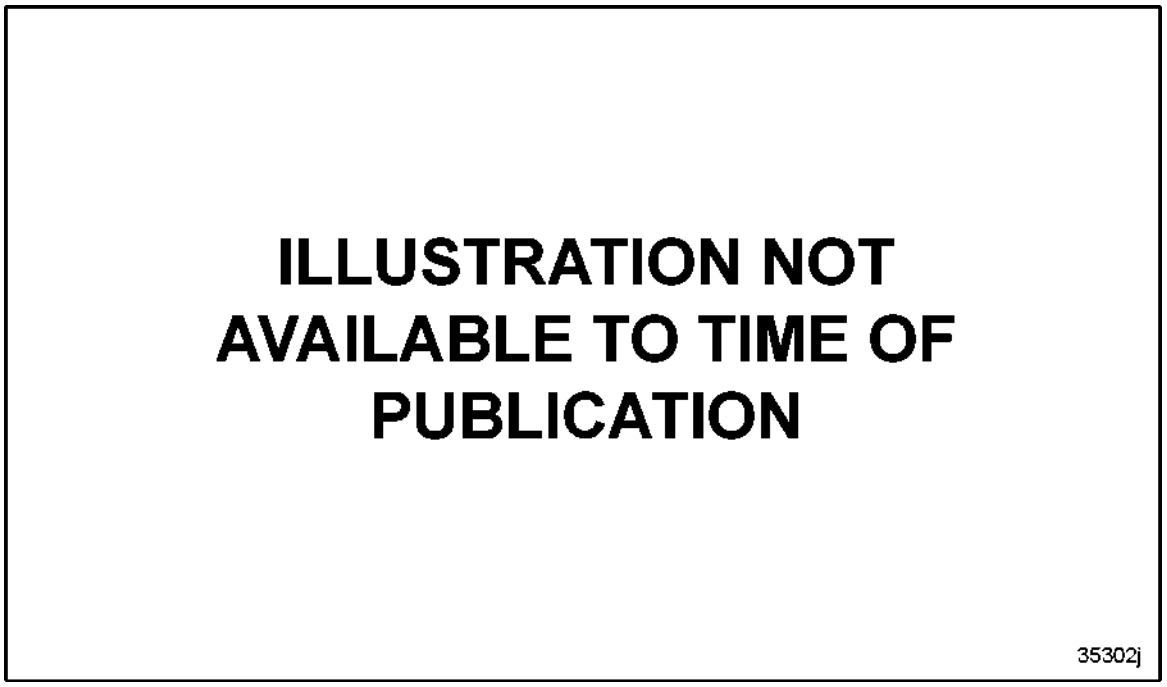


Figure 1282 Valve Seat Remover Collet (2 Valv 53),PT-6399–4

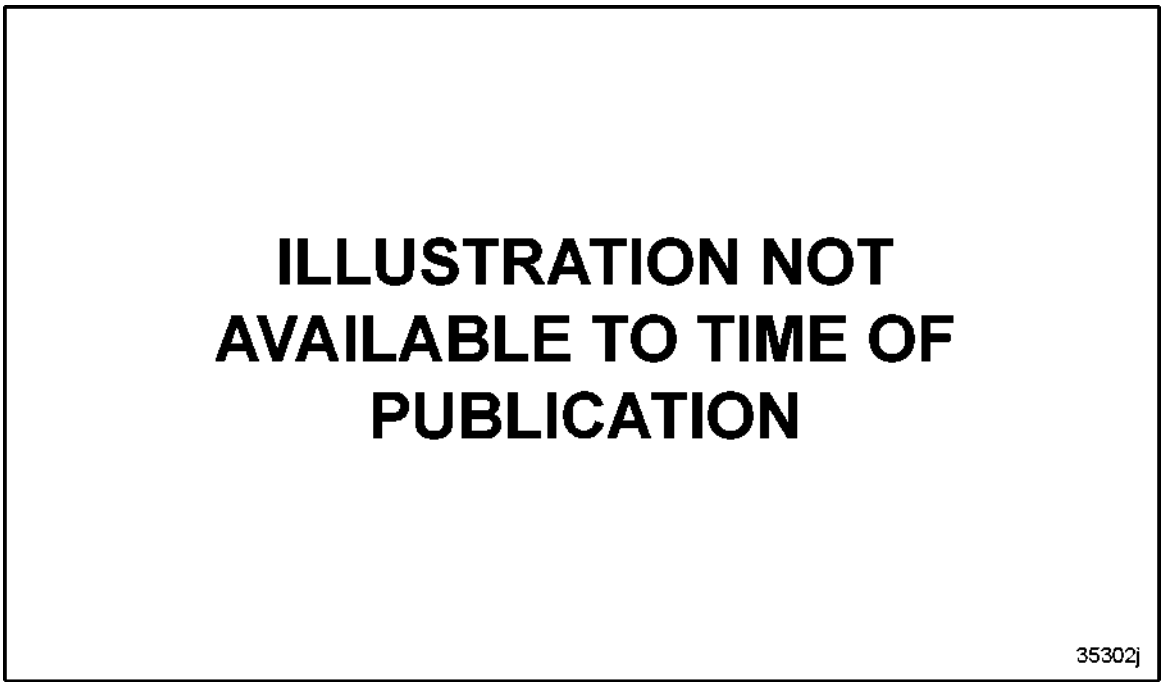


Figure 1283 Valve Seat Remover Collet (4 Valv 71),PT-6399–5

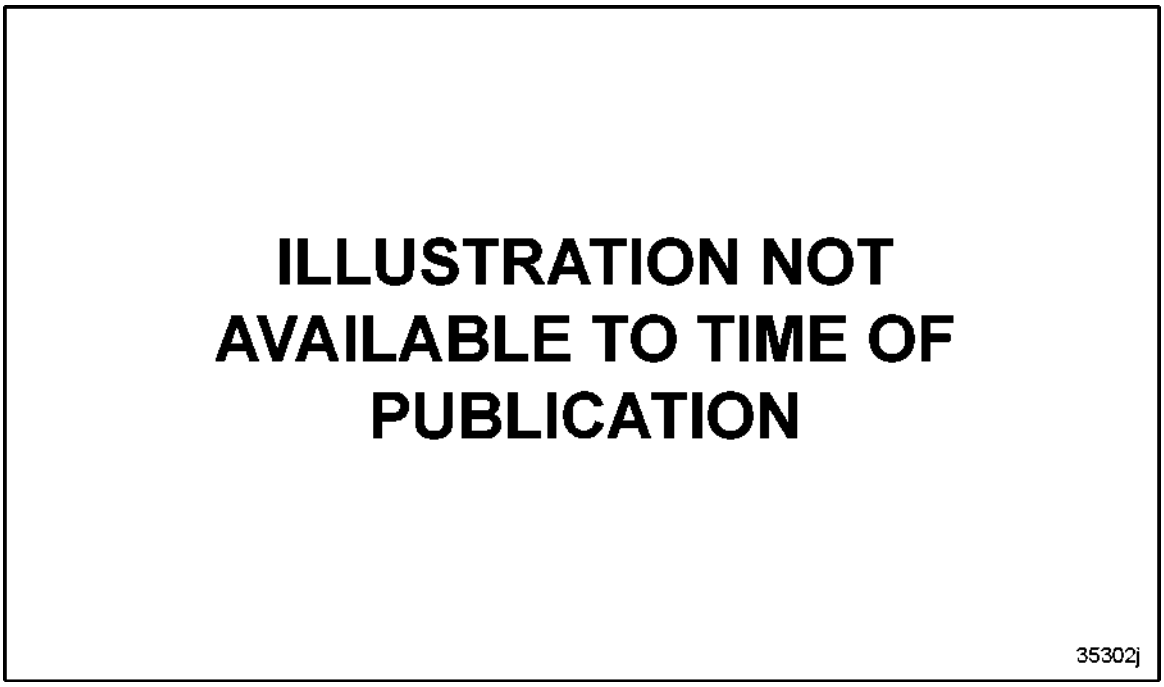


Figure 1284 Valve Seat Remover Collet,PT-6399–9

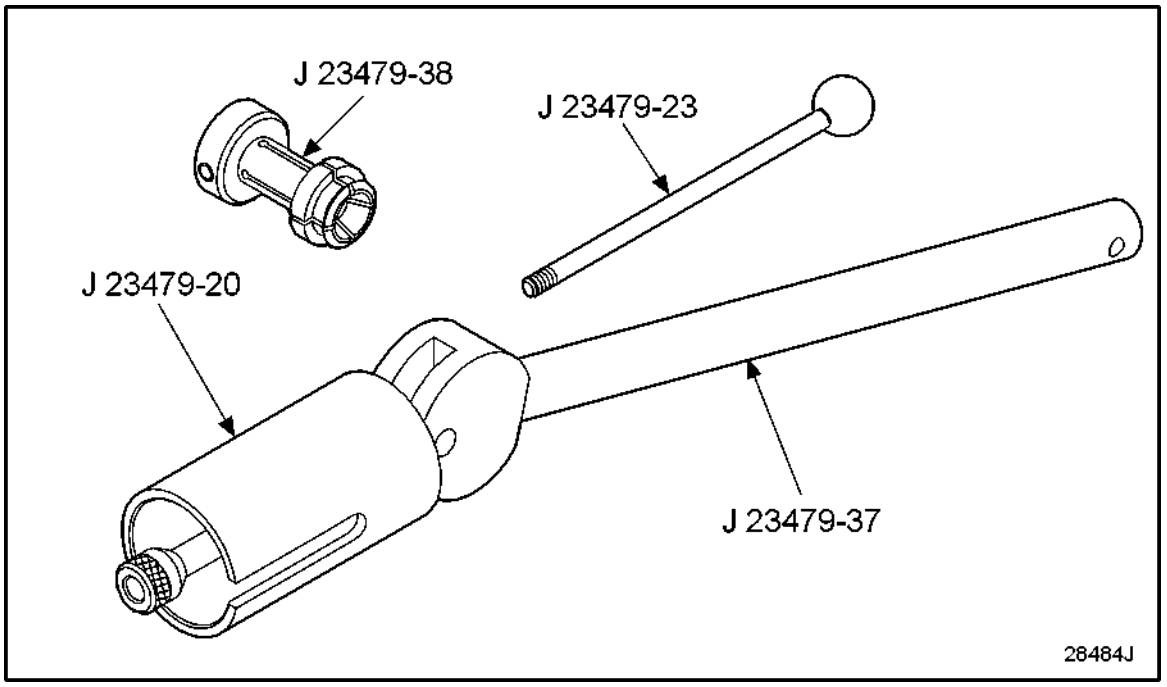


Figure 1285 Valve St Insert Rem (Non-Ceramic HD),J 23479–49

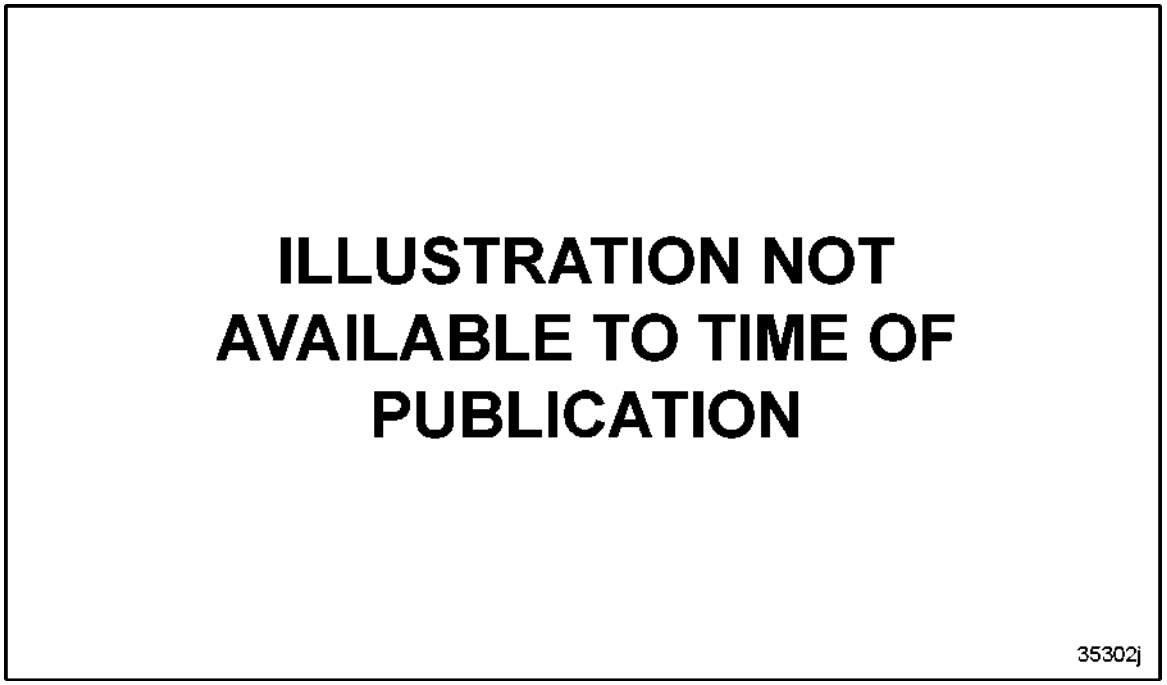


Figure 1286 Valve Seat Remover Collet, (2Valv 71, EXH),PT-6399–6

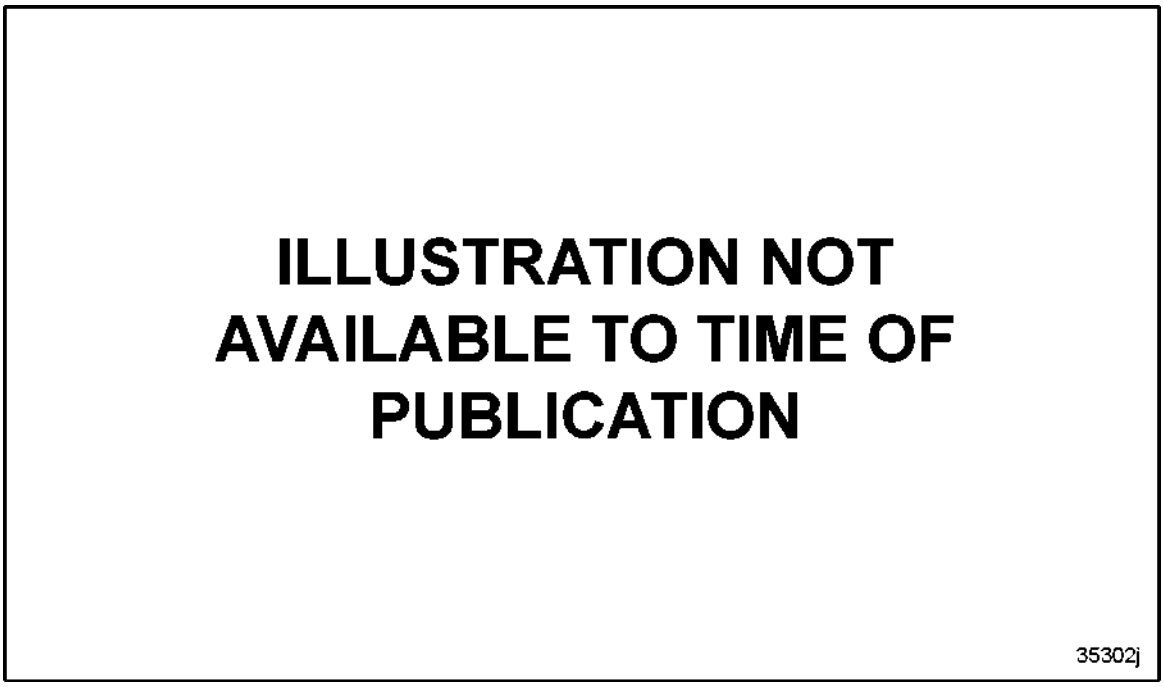


Figure 1287 Valve Stem Seal Installer,J 36582

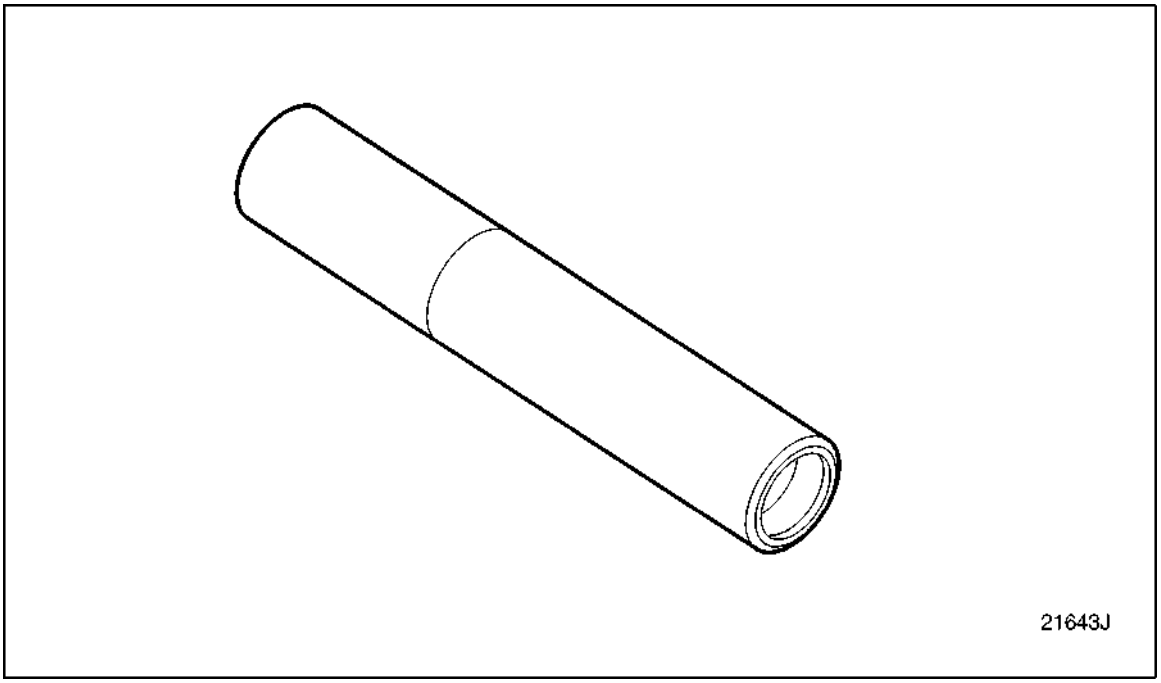


Figure 1288 Valve Stem Seal Installer,J 39109

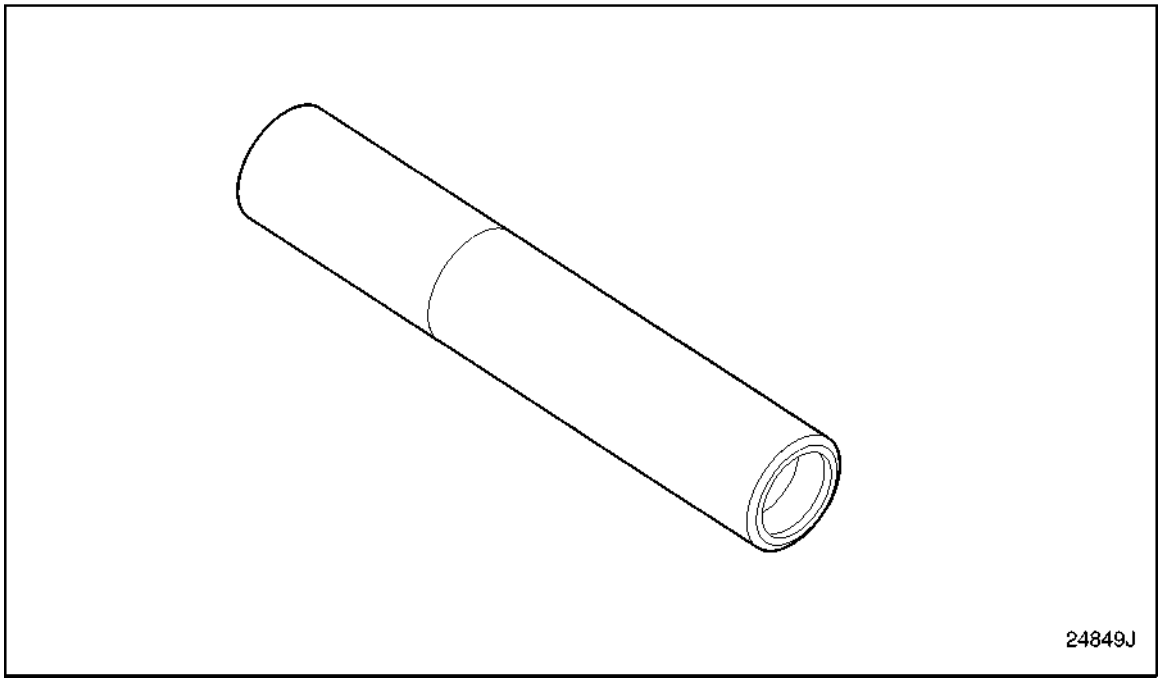


Figure 1289 Valve Stem Seal Installer,J 41571

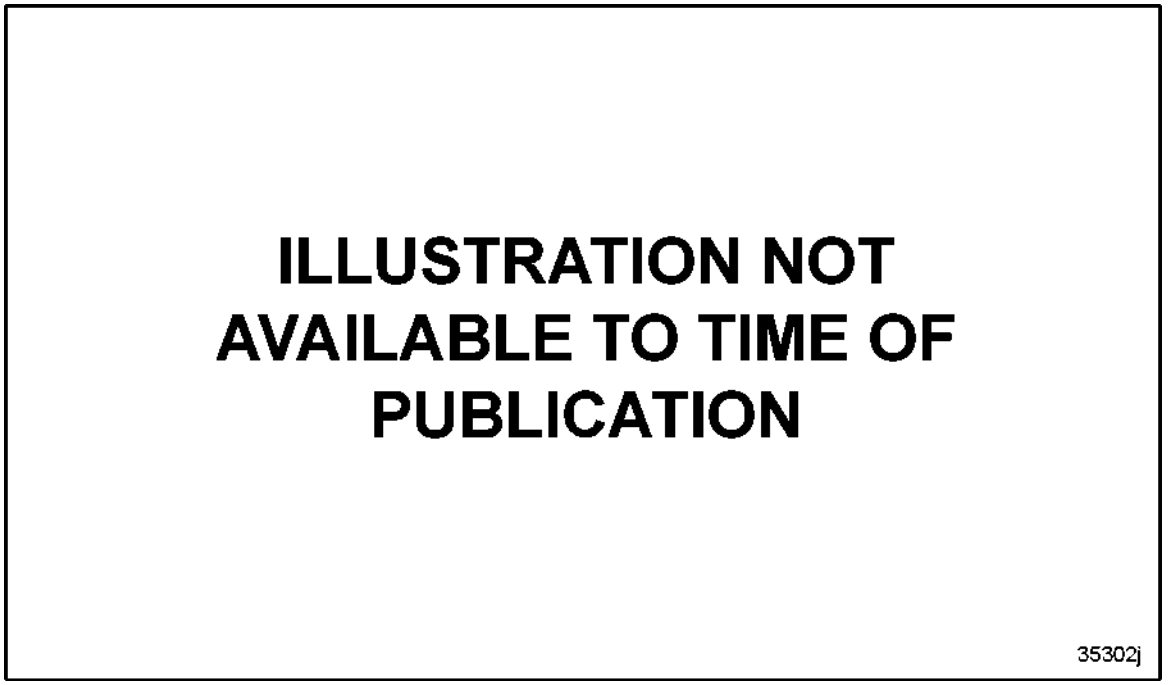


Figure 1290 Valve Stem Seal Installer (Narrow),J 41282

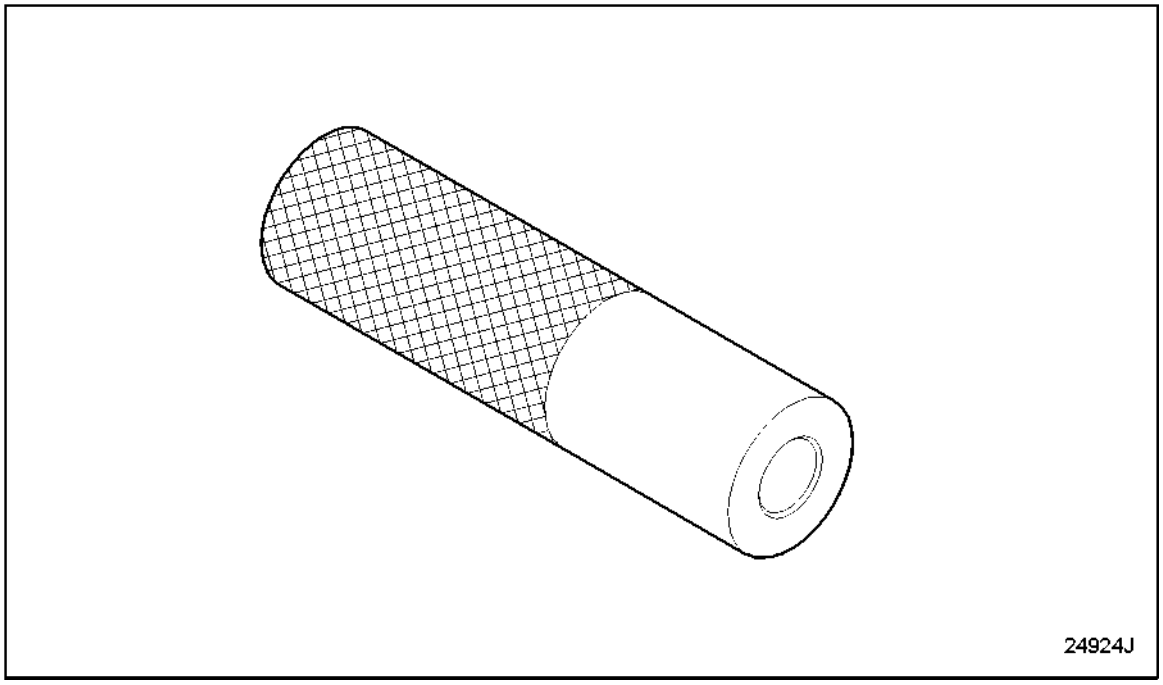


Figure 1291 Valve Stem Seal Installer (4Valv),J 35373

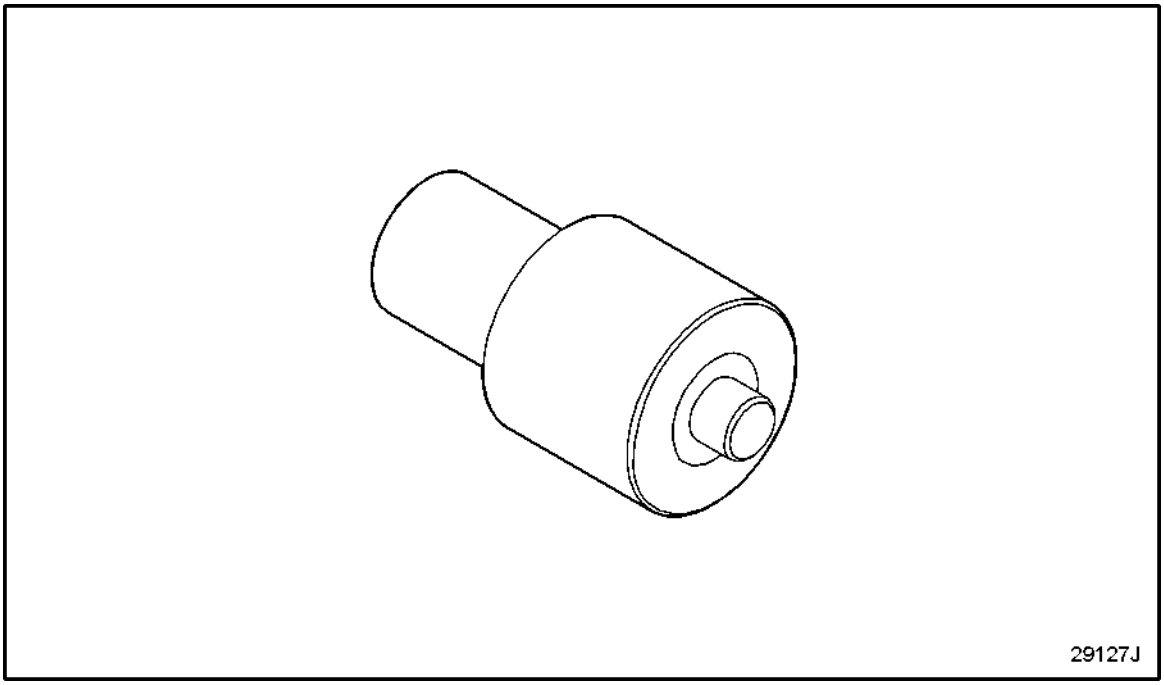


Figure 1292 Water Nozzle Installer,J 24857–A

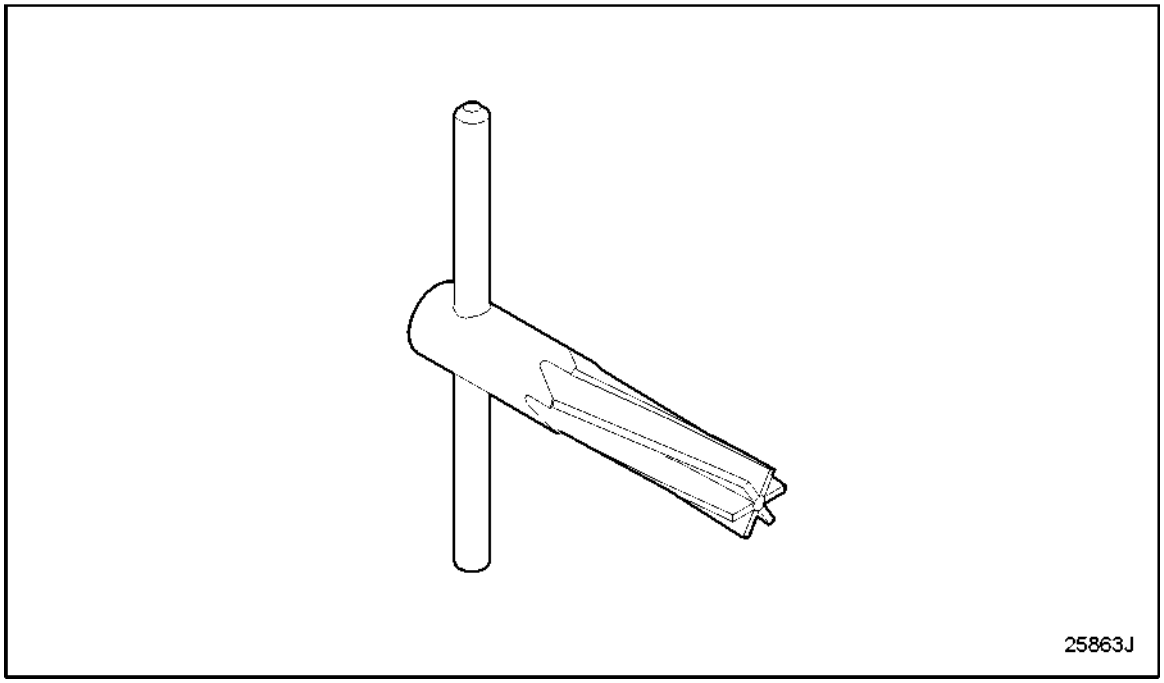


Figure 1293 Body Reamer "N" & "S" Injections, J 21089

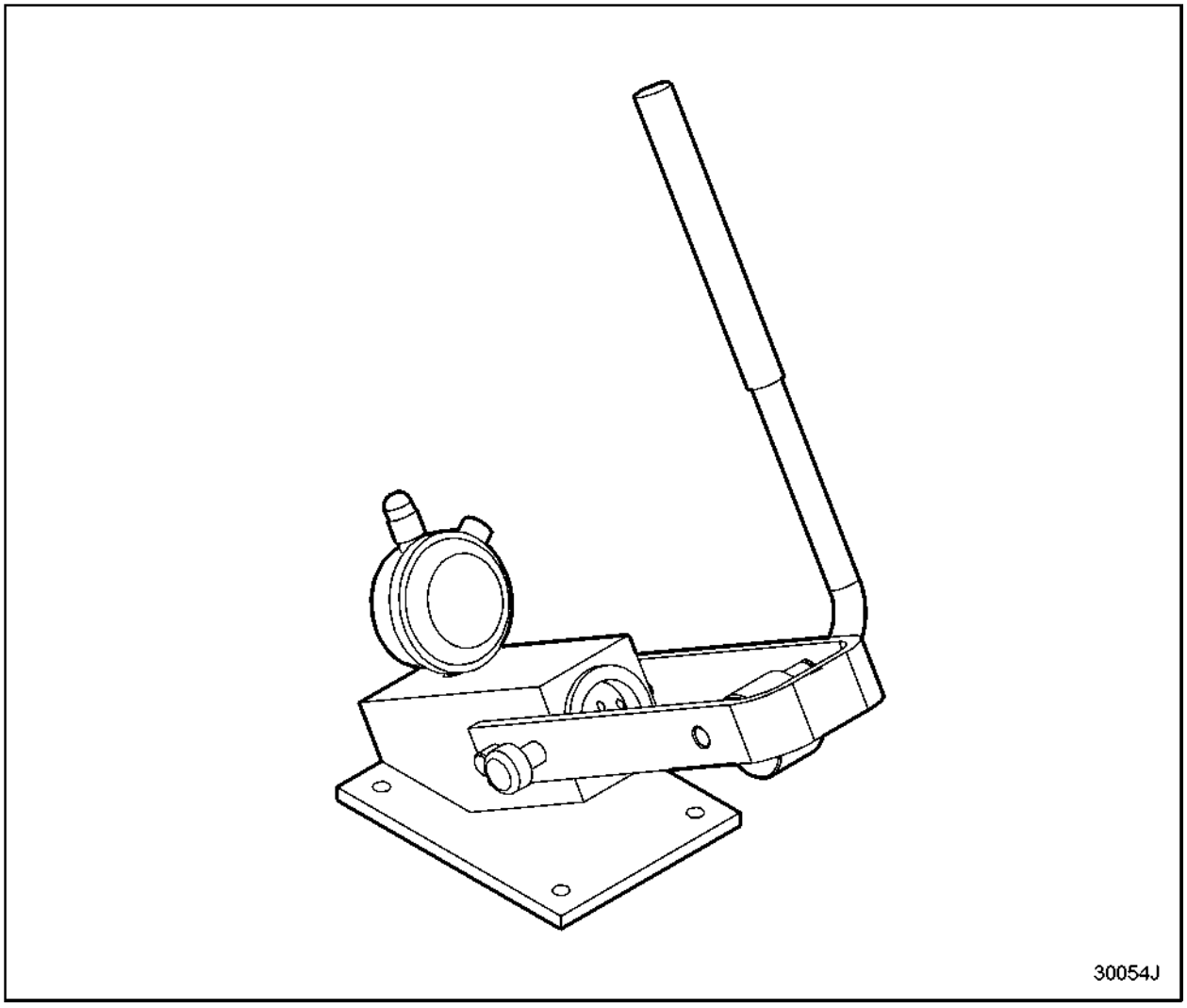


Figure 1294 INJ Tip CONC Gage/Rack Free Tester,J 29584

ILLUSTRATION NOT AVAILABLE TO TIME OF PUBLICATION

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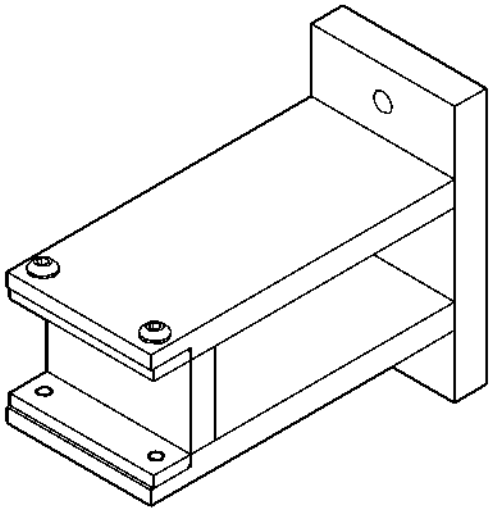
Figure 1295 Injector Calibrator Adaptor-Marine,J 22410–696



29153J

Figure 1296 Injector Holding Fixture,J 29136

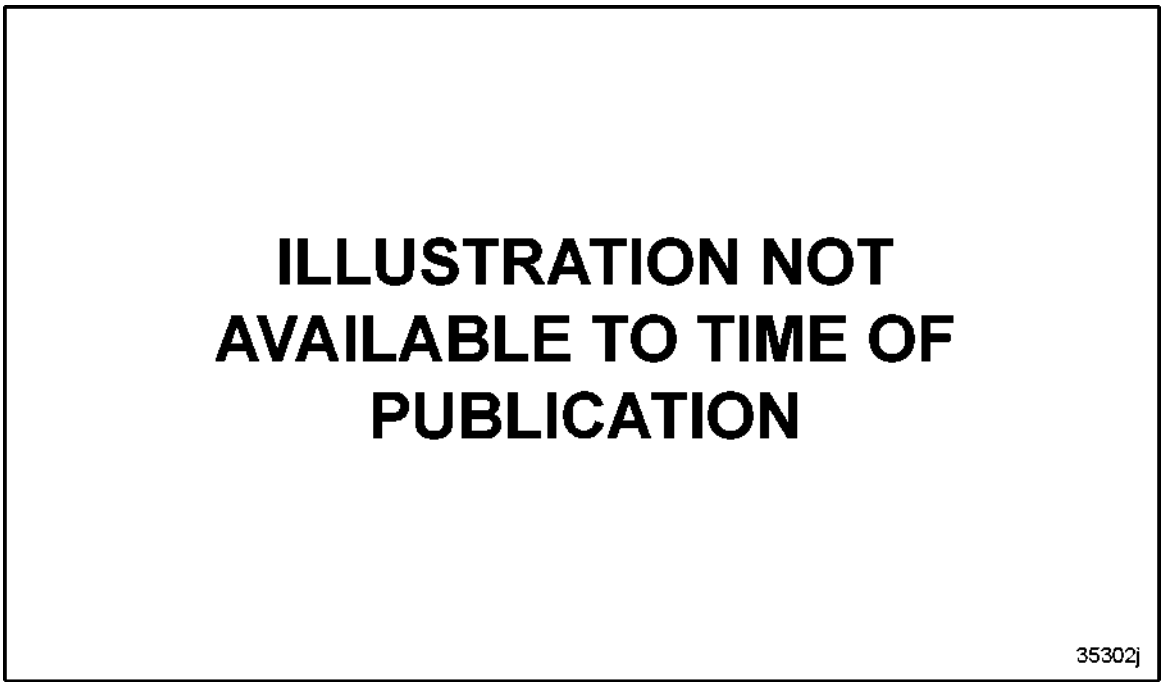


Figure 1297 Injector Nut Carbon Remover Set,J 29575

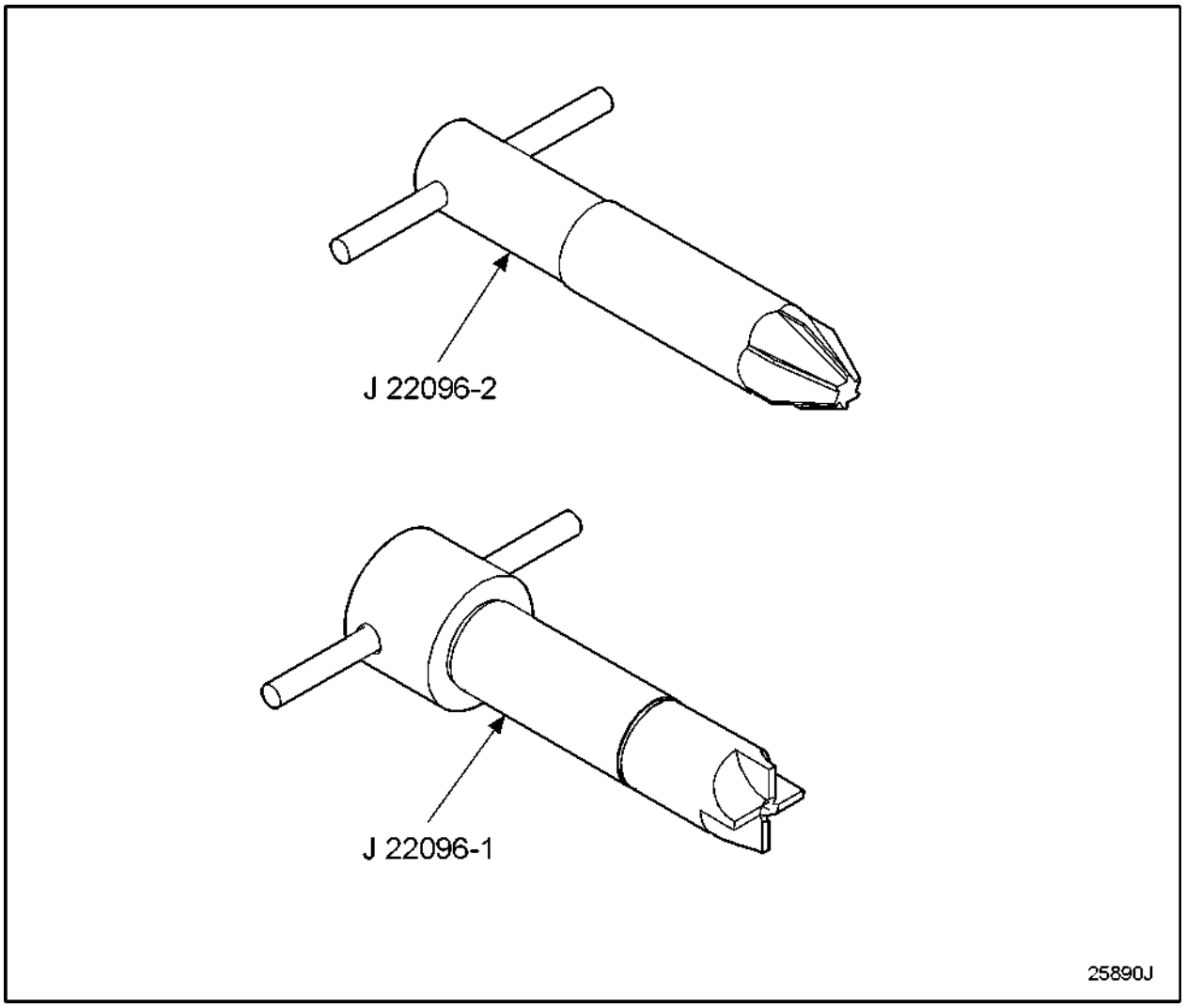


Figure 1298 Injector Nut Carbon Remover Set, 149,J 22096–02

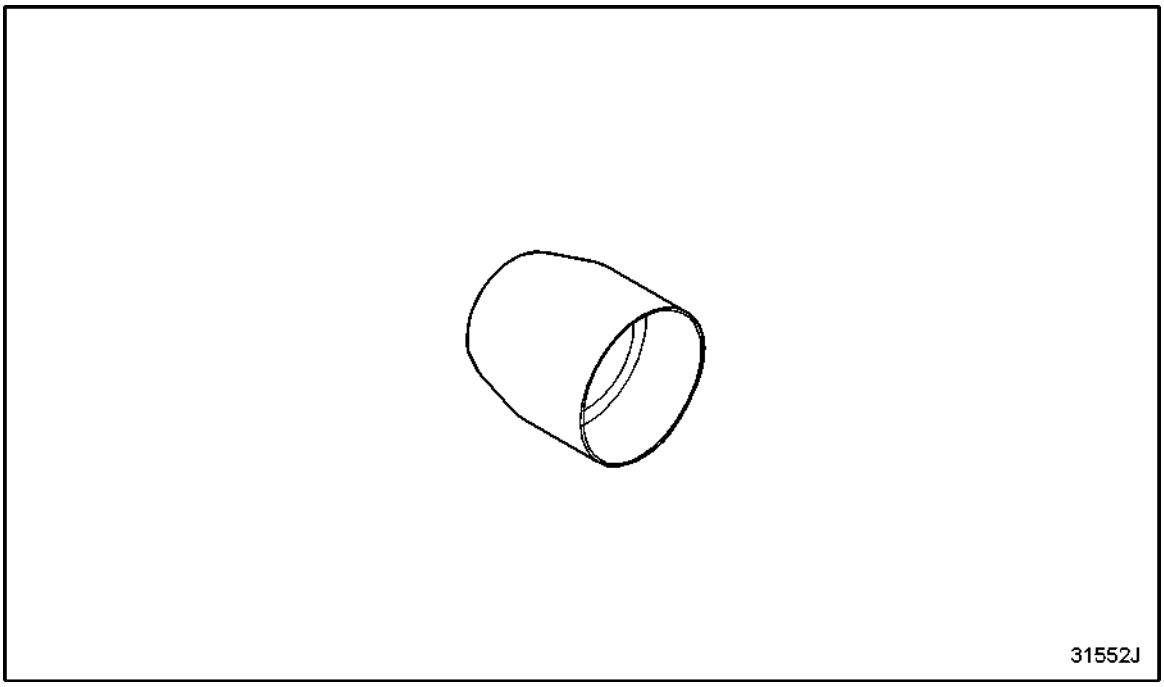


Figure 1299 Injector Nut Seal Ring Installer,J 29197

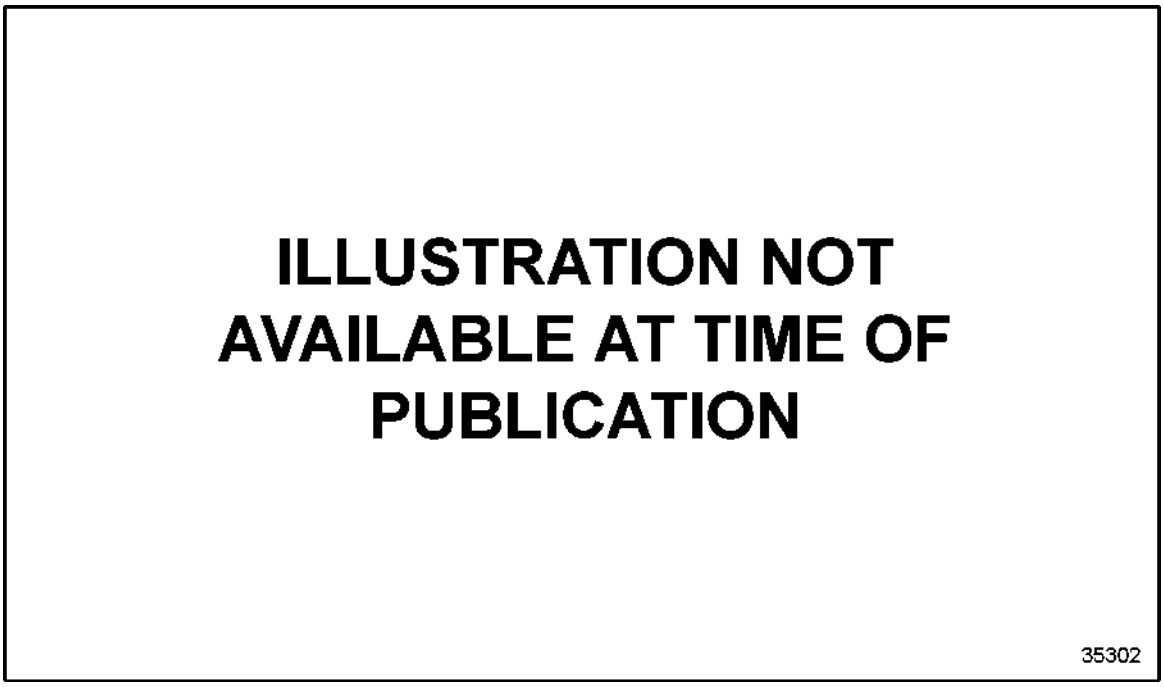


Figure 1300 Injector Nut Socket,J 22799

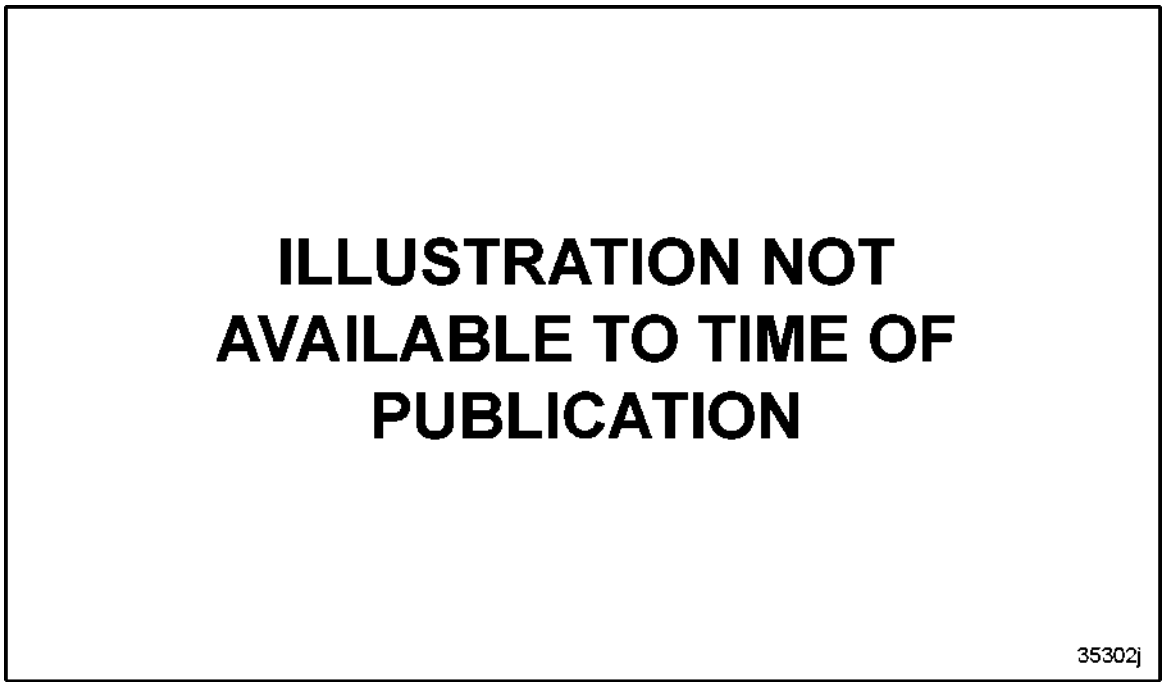


Figure 1301 Injector Pop "N" Fixture,J 24760–B

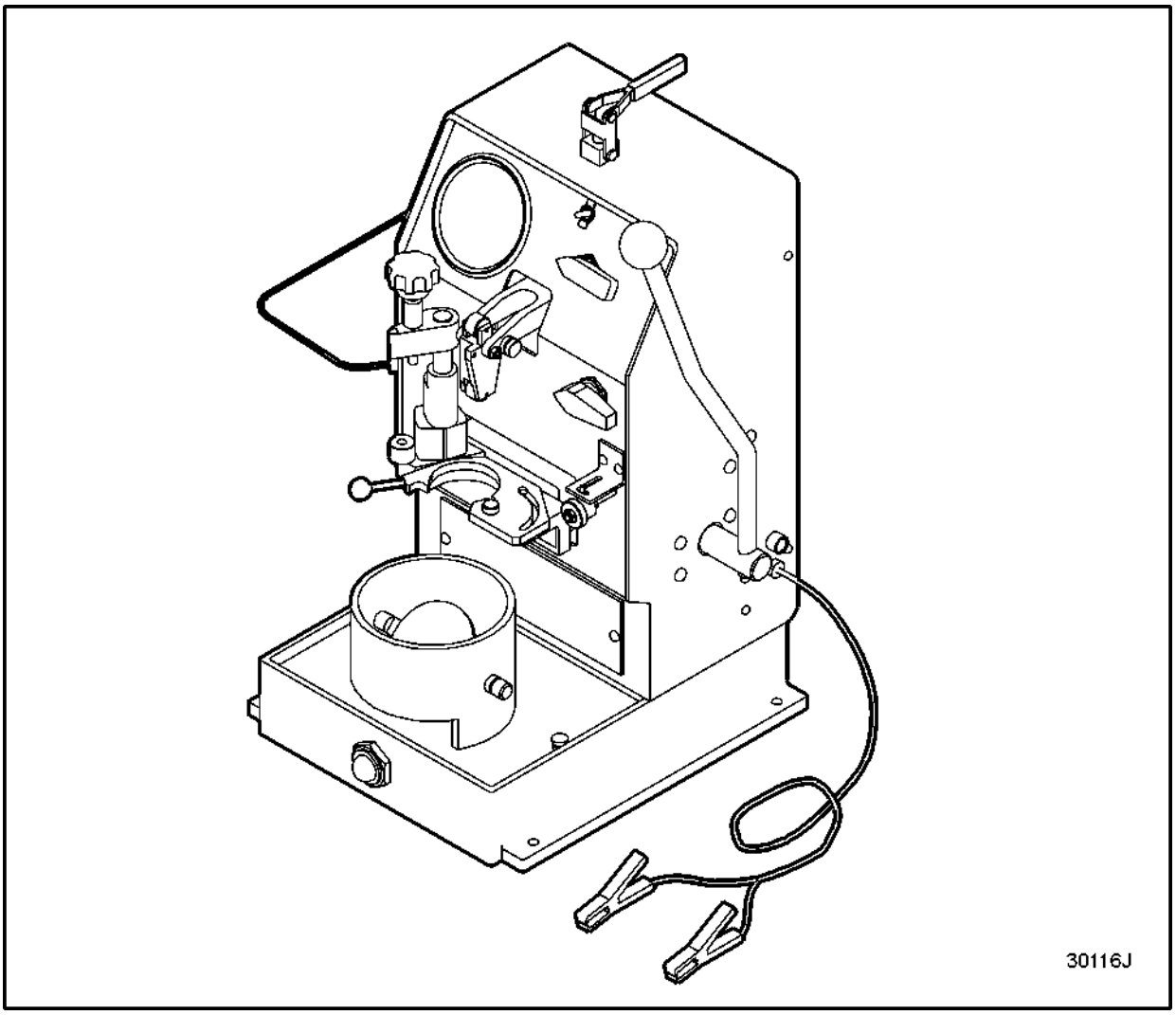


Figure 1302 **Injector Pop Fixt (Mechanical Only),**J 34760–150A (Old Num 23010–A)

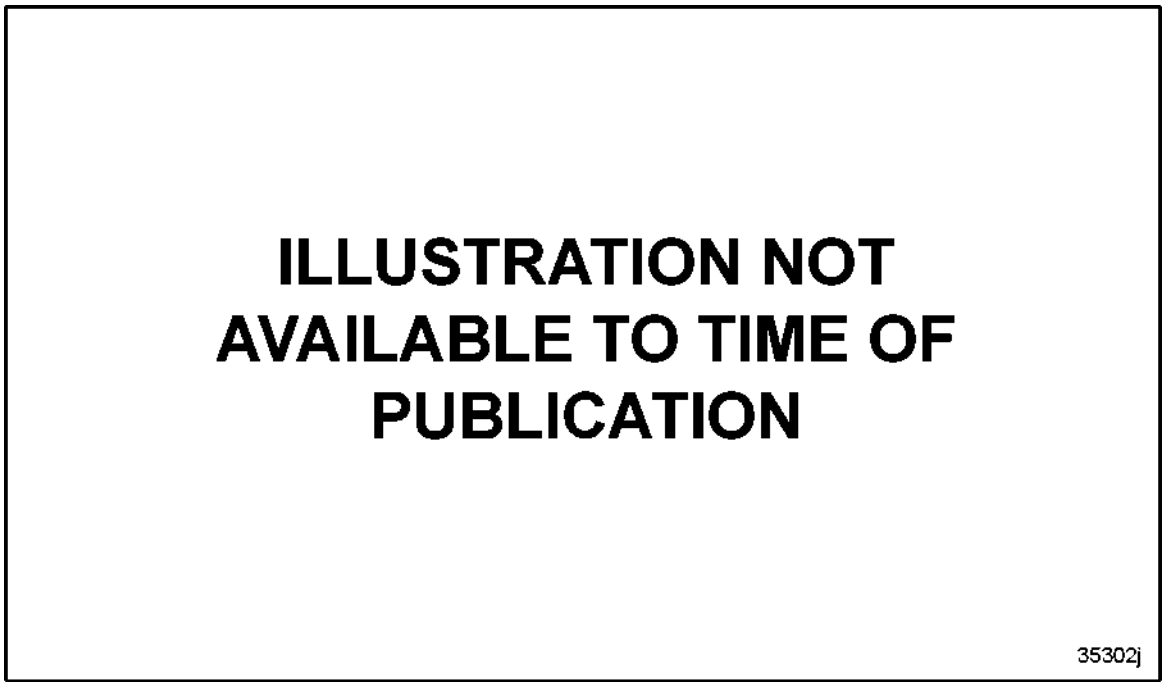


Figure 1303 Injector Pop Fixt Adapter (Marine), J 23010–265

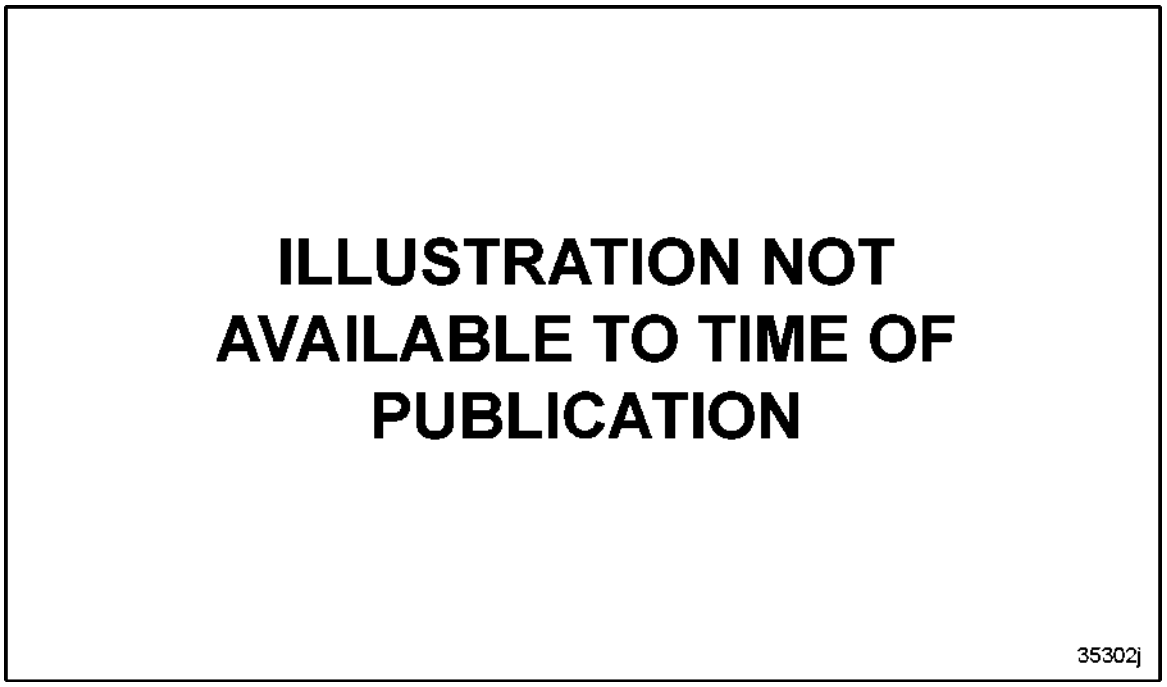


Figure 1304 Injector Pop Fixt Adpt (53,71), J 34760–145

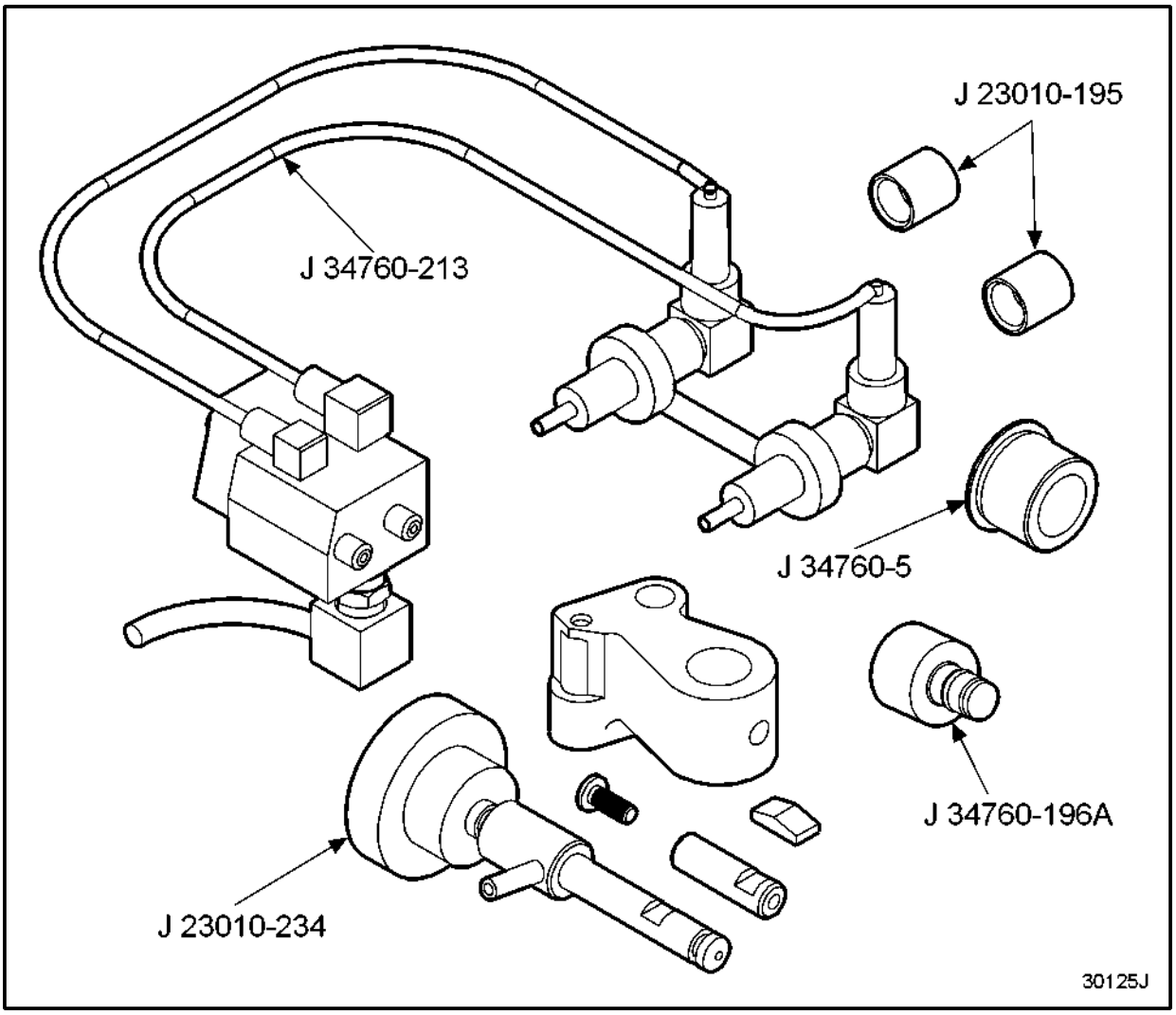


Figure 1305 Injector Pop Fixture Adapter, 149,J 34760–144

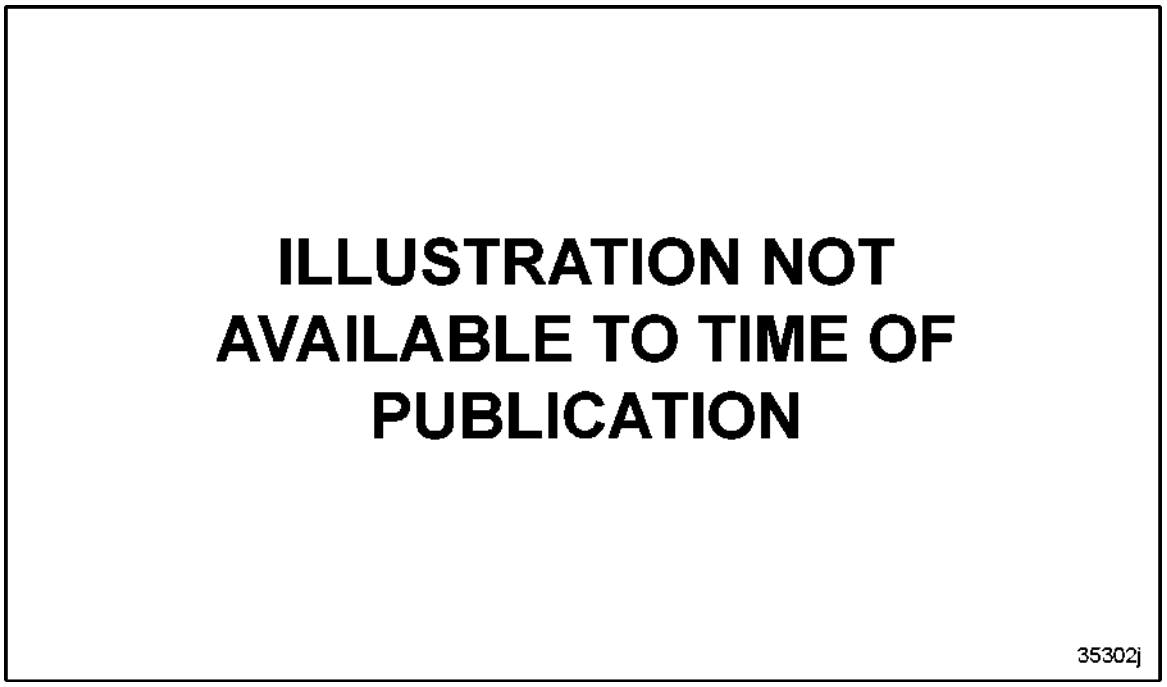


Figure 1306 Injector Pop Fixture Adapter, 8.2L,J 34760–146

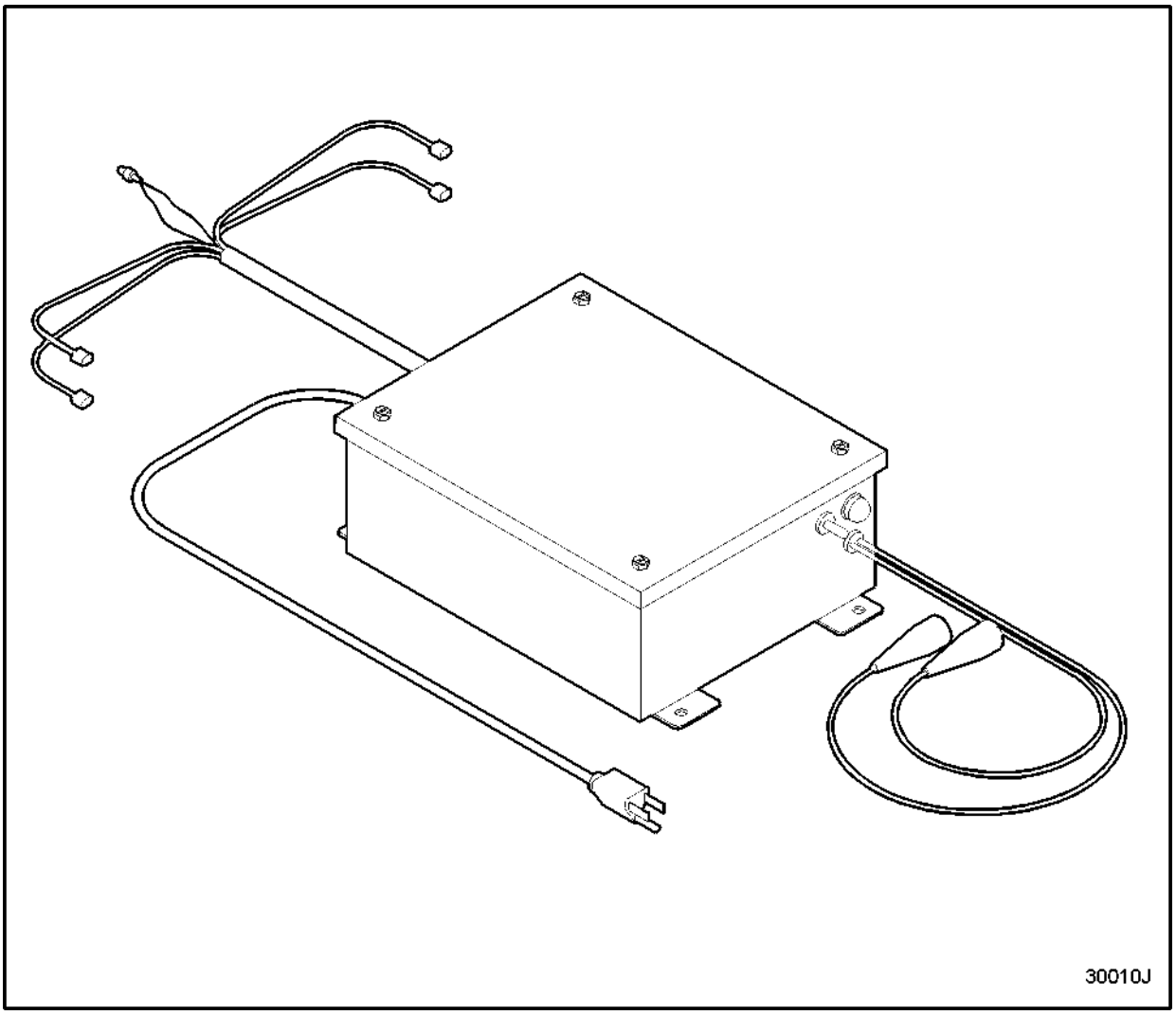


Figure 1307 Injector Pop Fixture Power Supply, J 34760–300

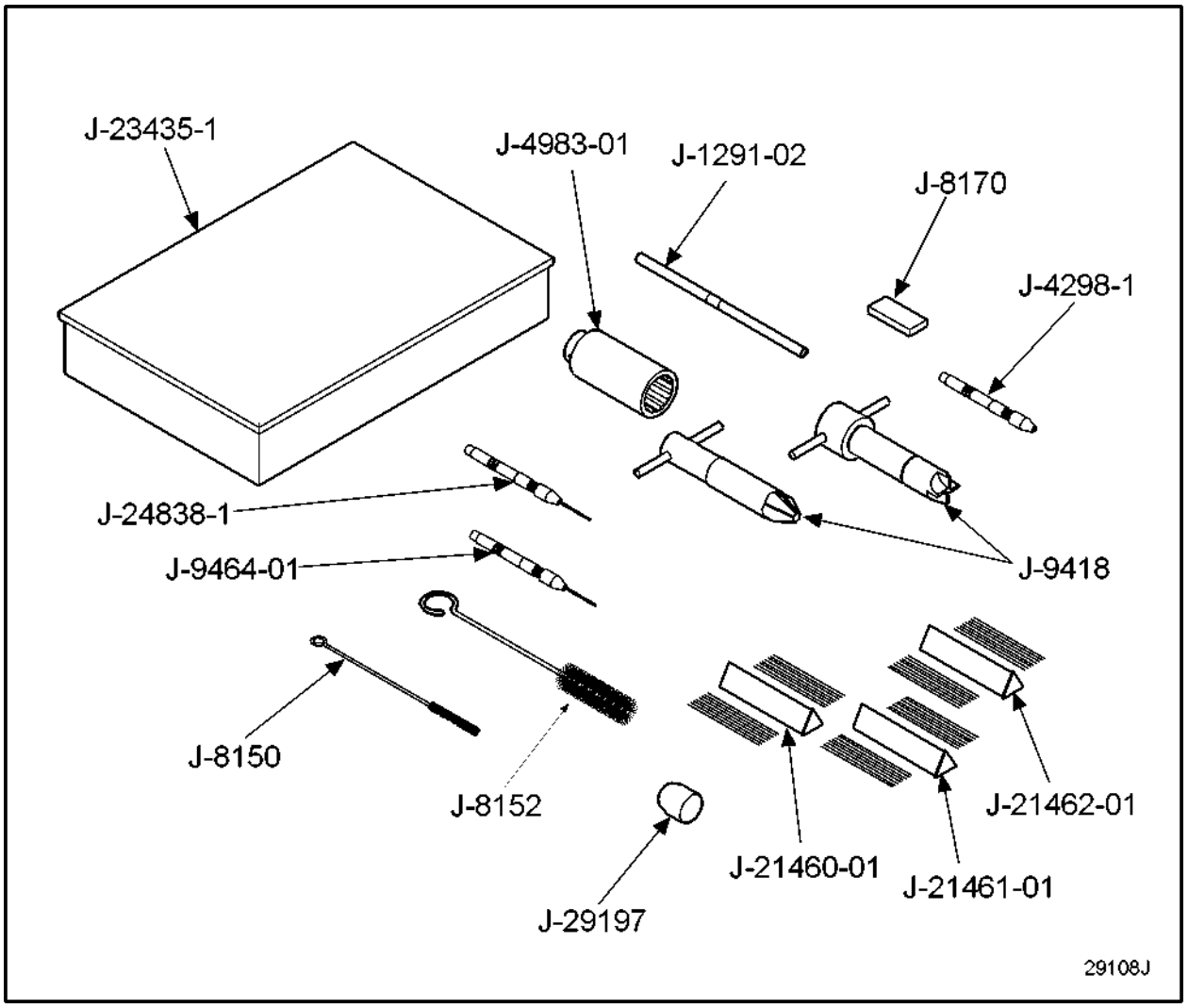


Figure 1308 Injector Service Set ("N" Injector), J 23435–C

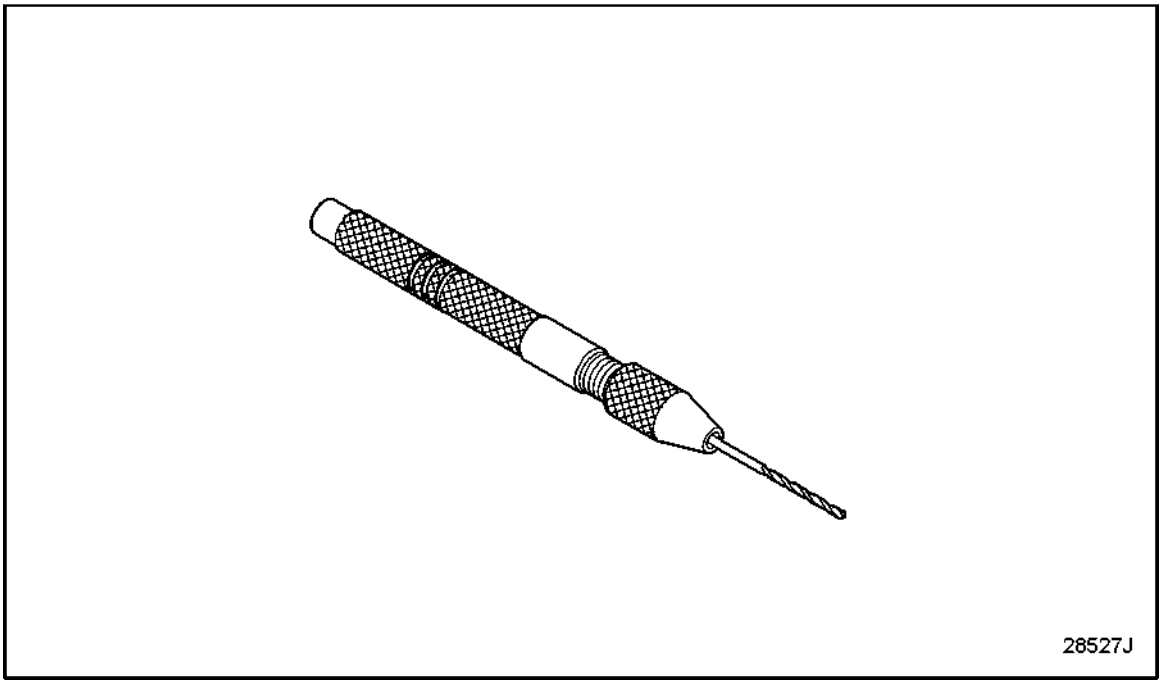


Figure 1309 Injector Spray Tip Carbon Remover,J 22800–01

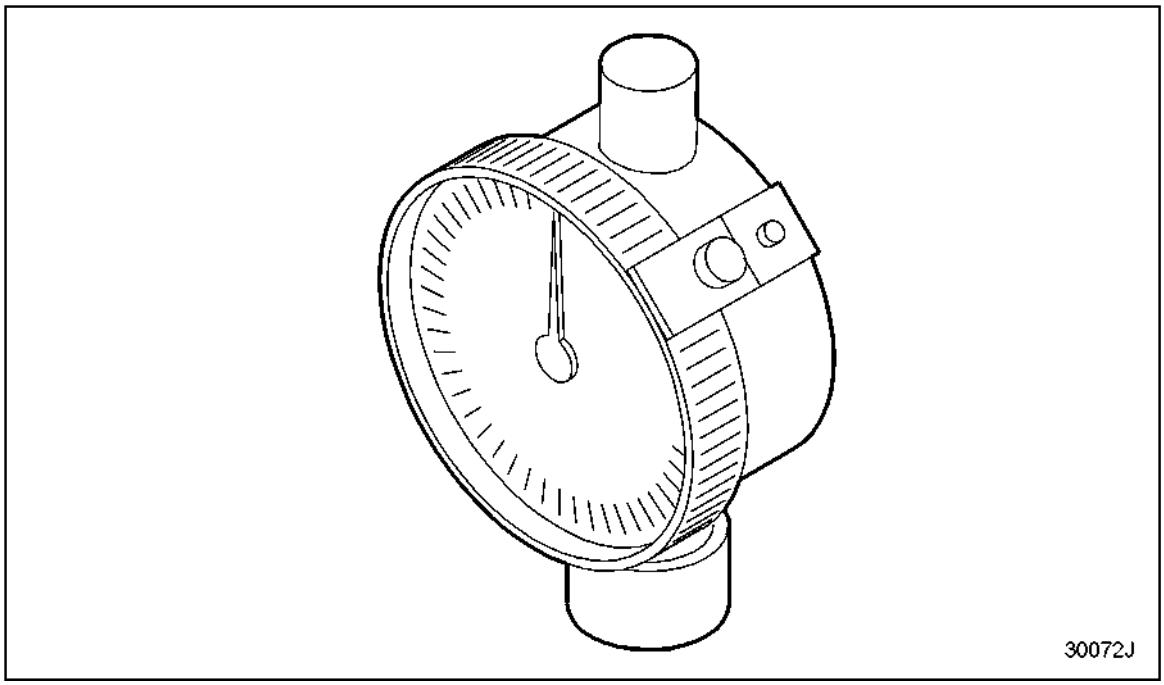


Figure 1310 Injector Spray Tip Needle Lift Gage,J 9462–02

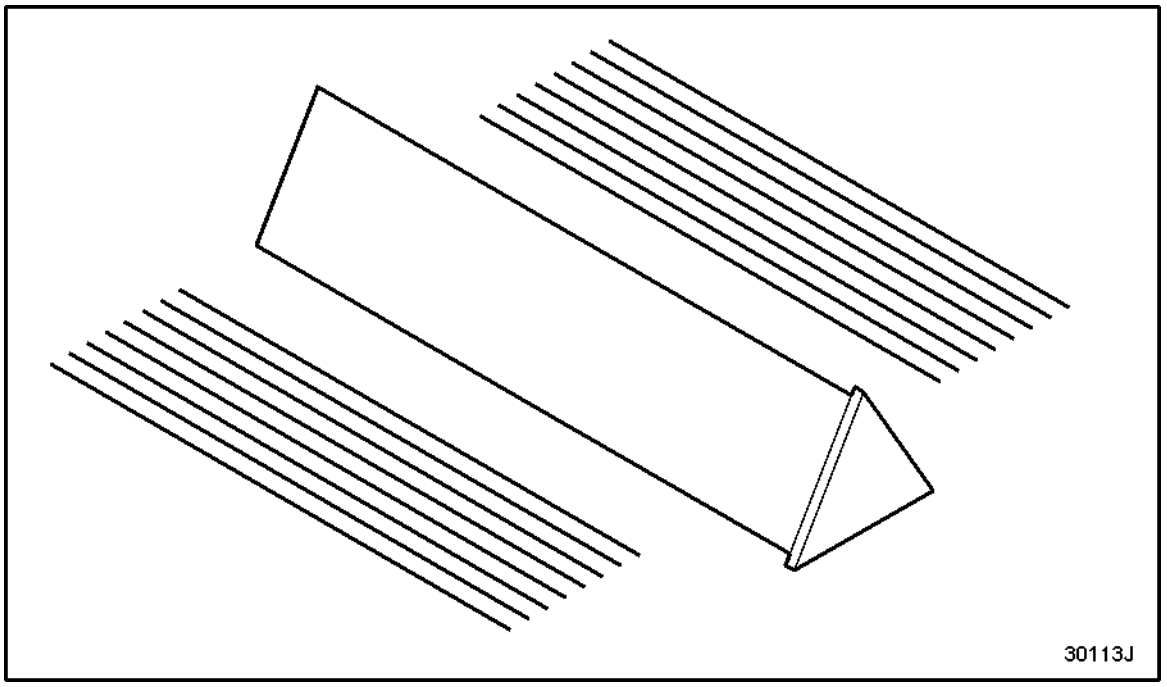


Figure 1311 Injector Spray Tip Wire (.009),J 22885

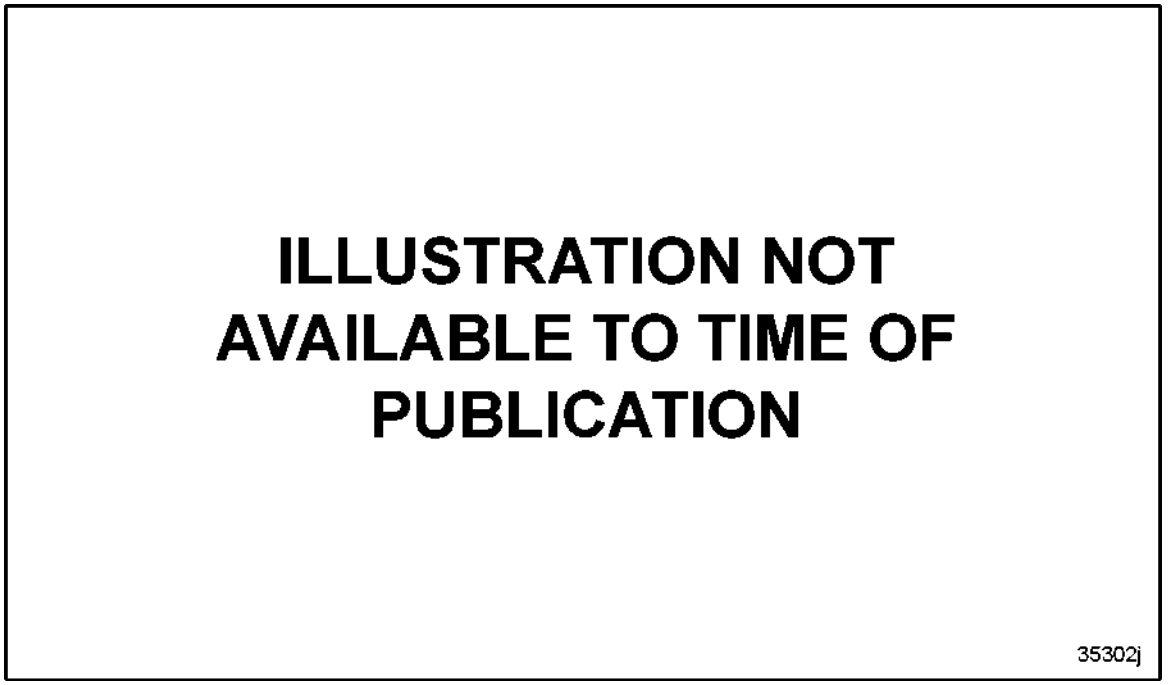


Figure 1312 Injector Tag Remover/Installer Set,J 24767

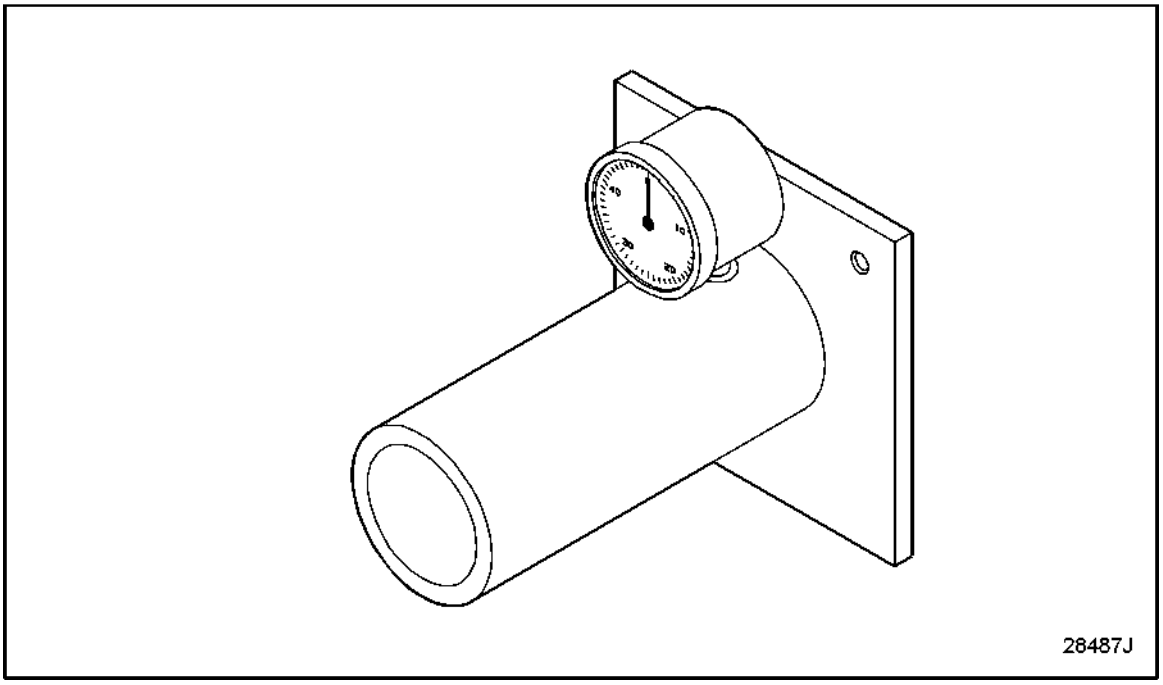


Figure 1313 Injector Tip Concentricity Gage, J 23905

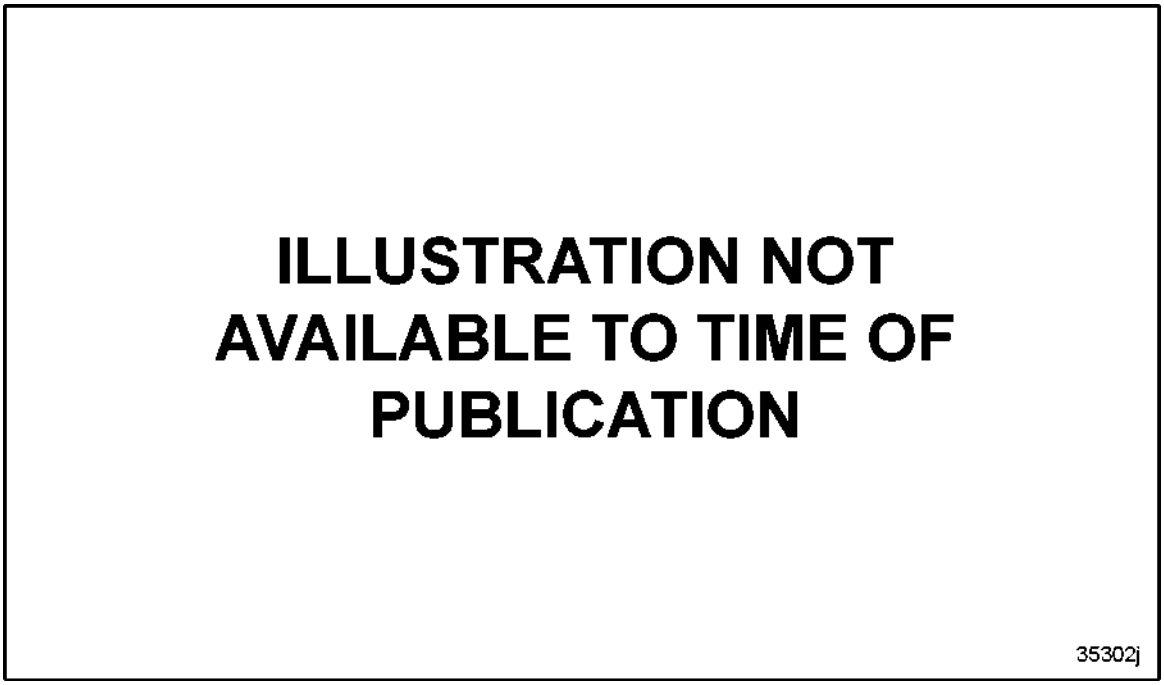


Figure 1314 Injector Tip Polishing Sticks, J 22964

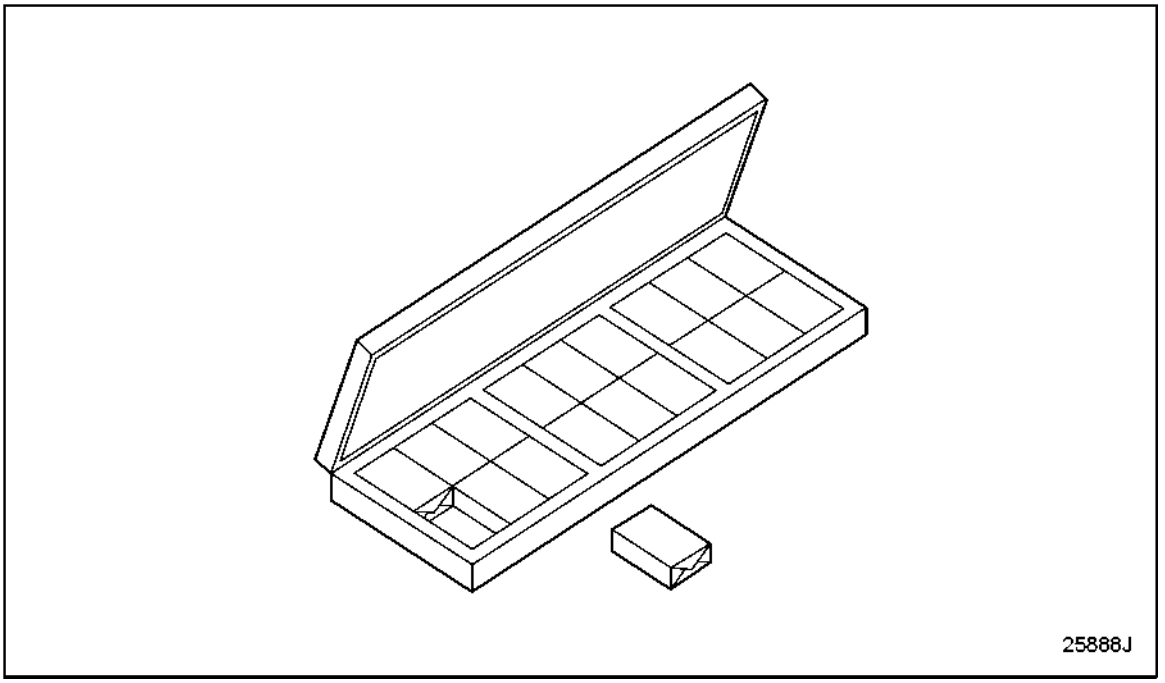


Figure 1315 Lapping Block Set,J 22090–A

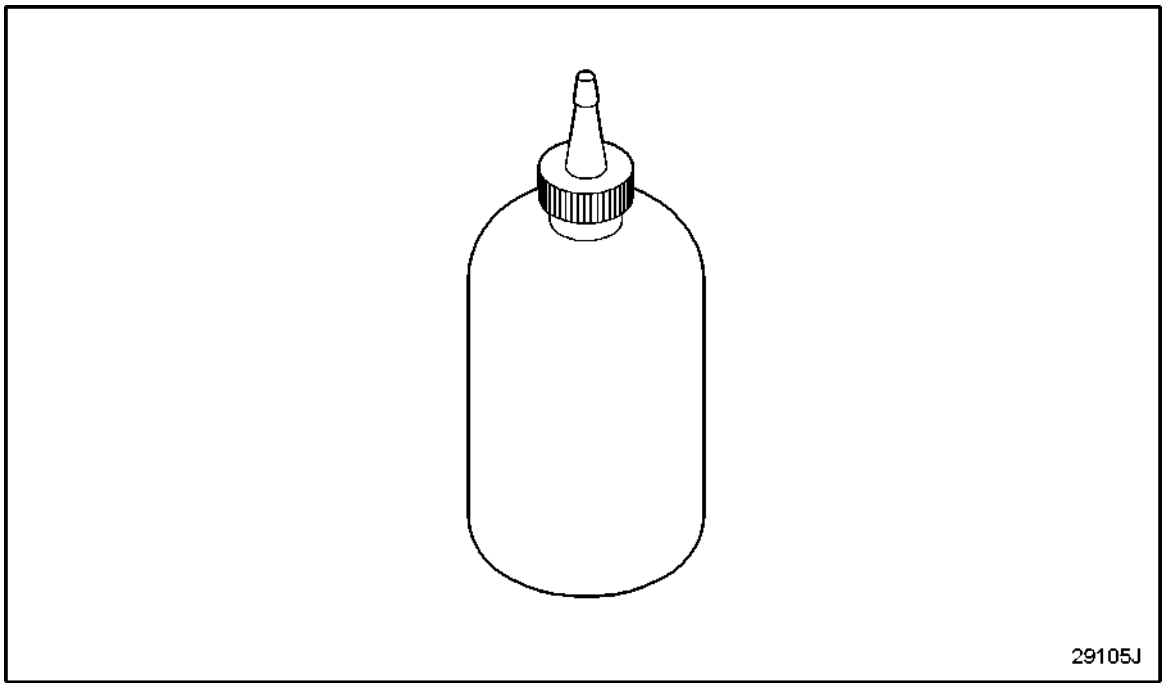


Figure 1316 Lapping Compound (Liquid),J 23038

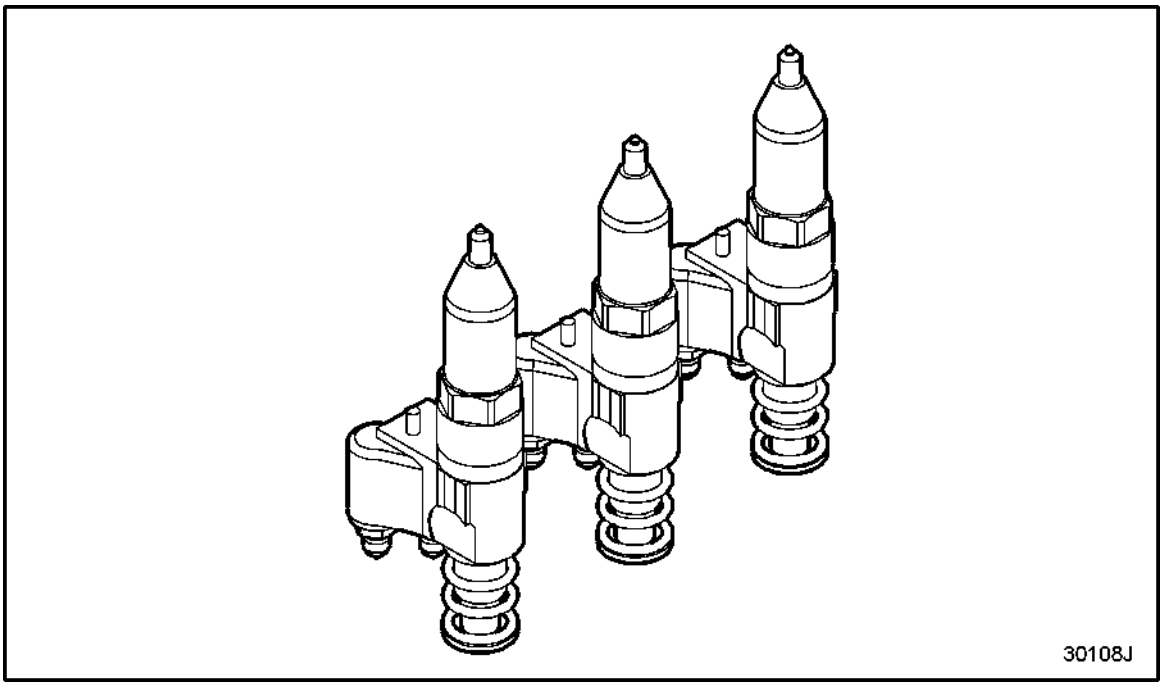


Figure 1317 **Master Injector Kit,**J 35369 (Old Num 26298)

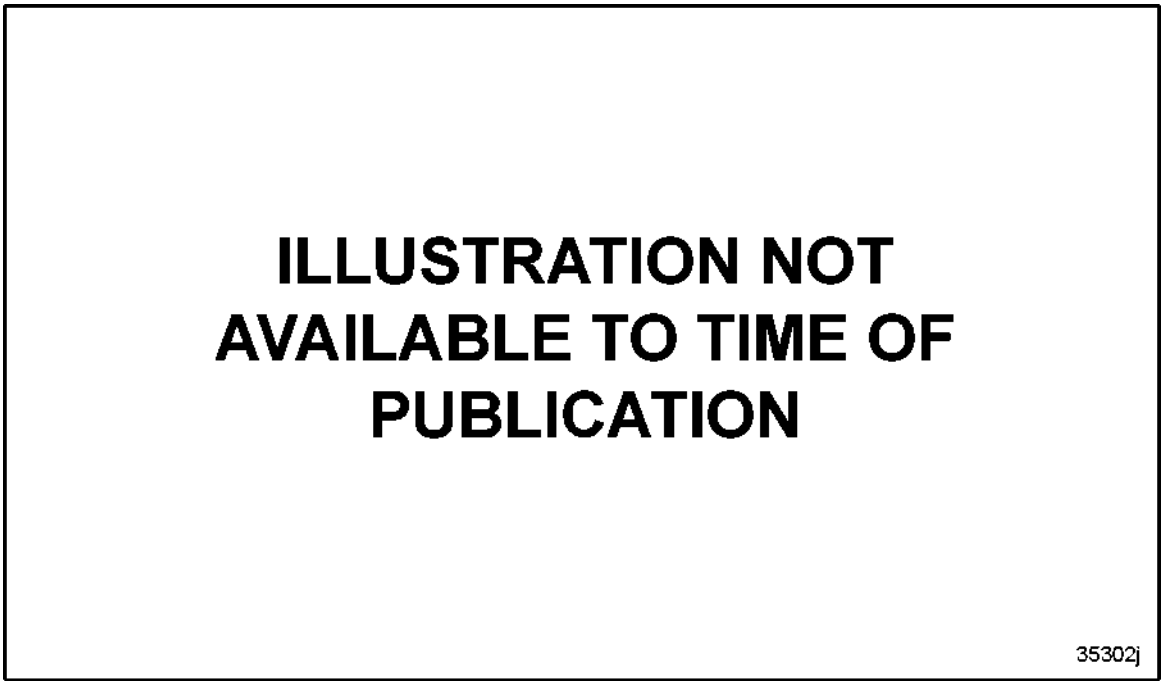


Figure 1318 **Master Injector, 8.2L,**J 29898

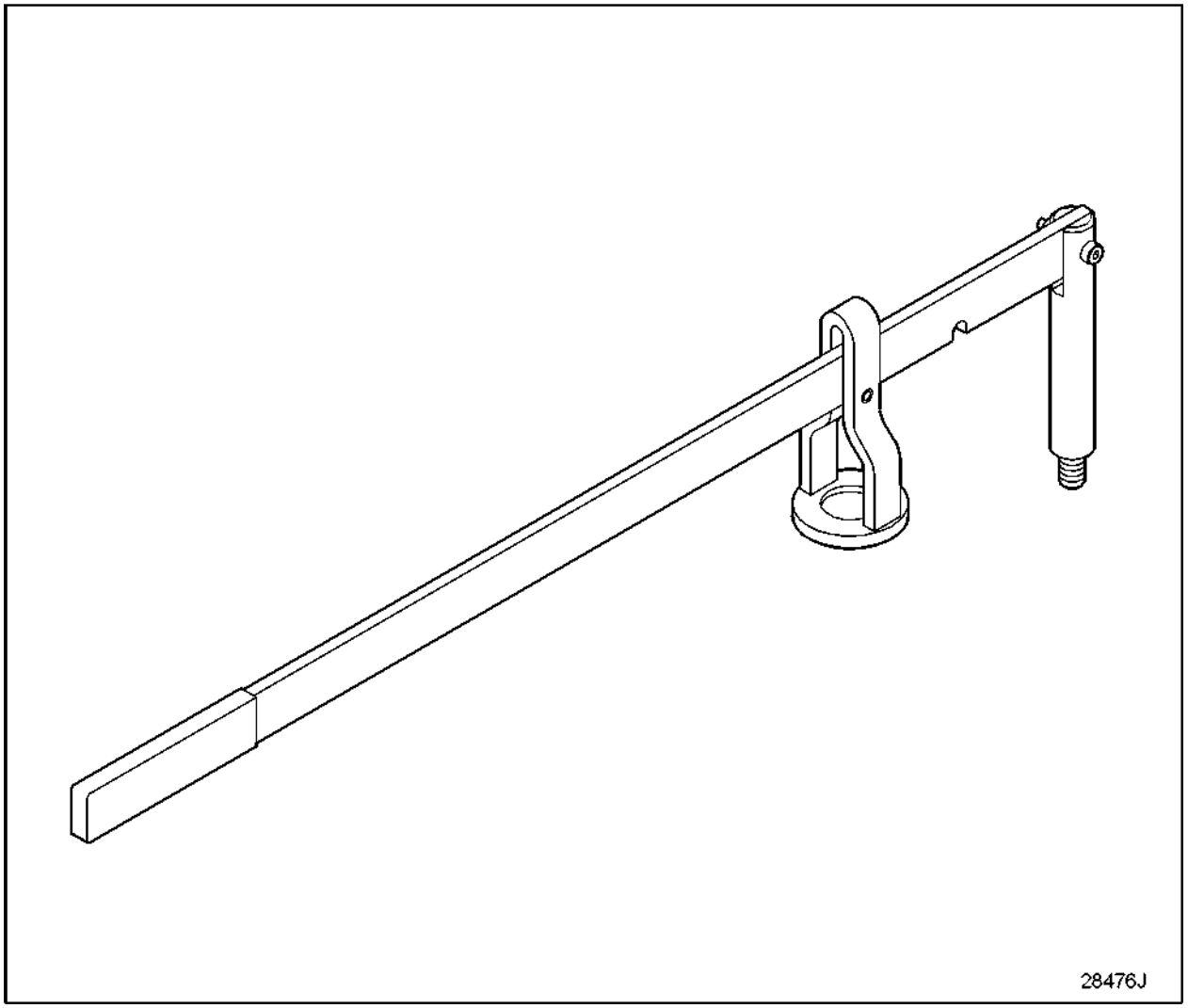


Figure 1319 Valve Spring Compress-CYL HD Remove,J 22693–01

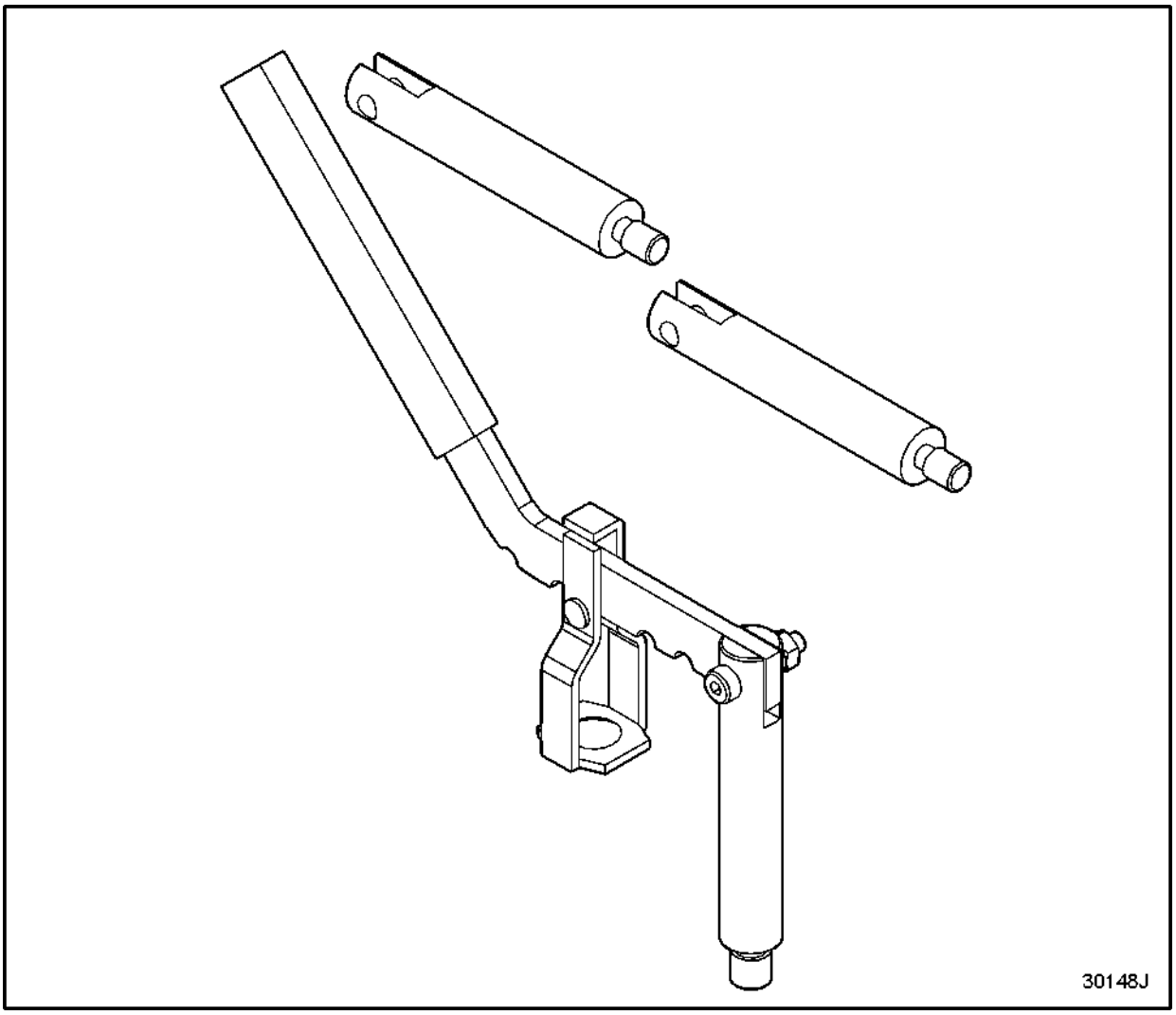


Figure 1320 Valve Spring Compressor,J 7455–A

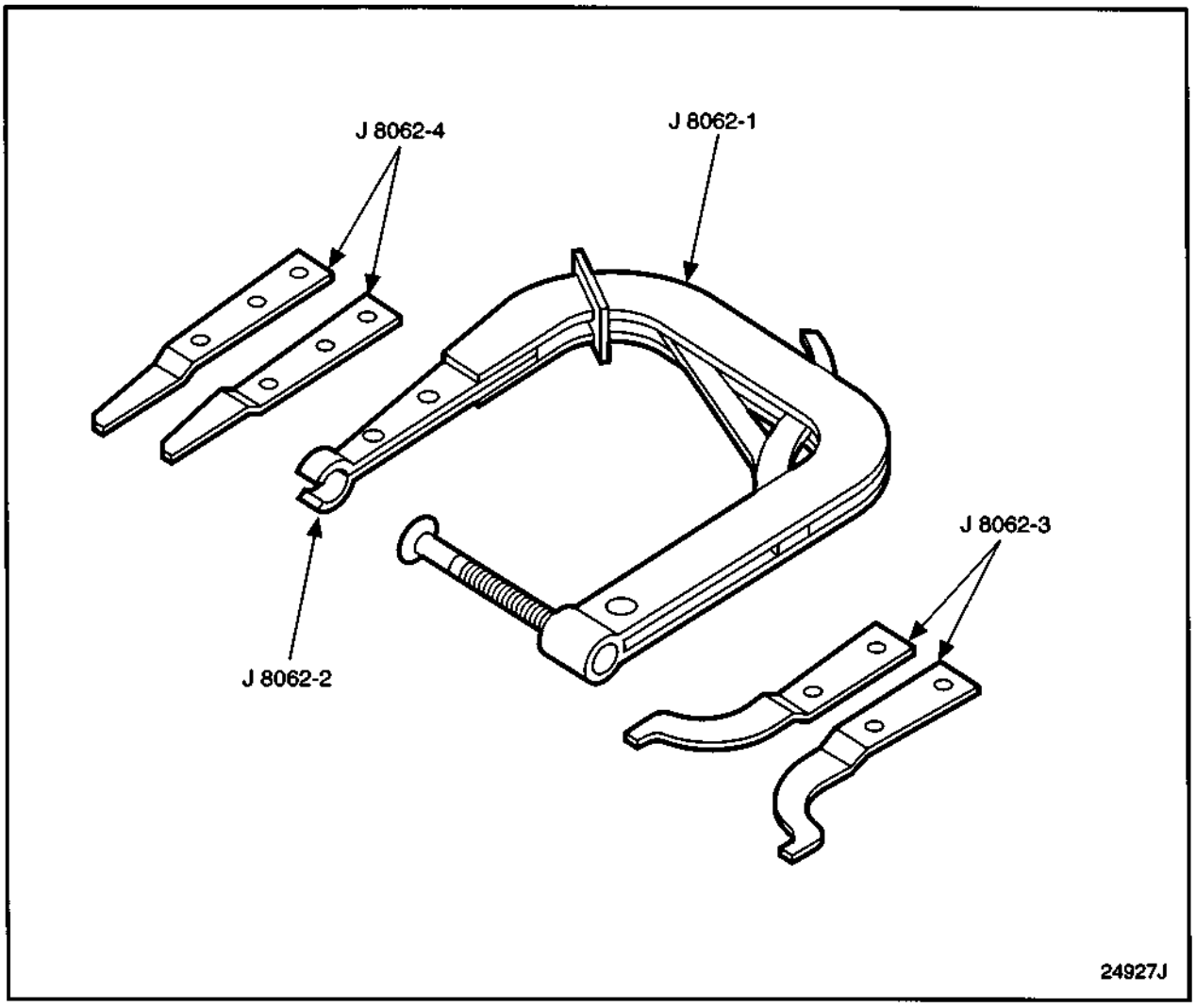


Figure 1321 Valve Spring Compressor CYL HD OFF,J 8062

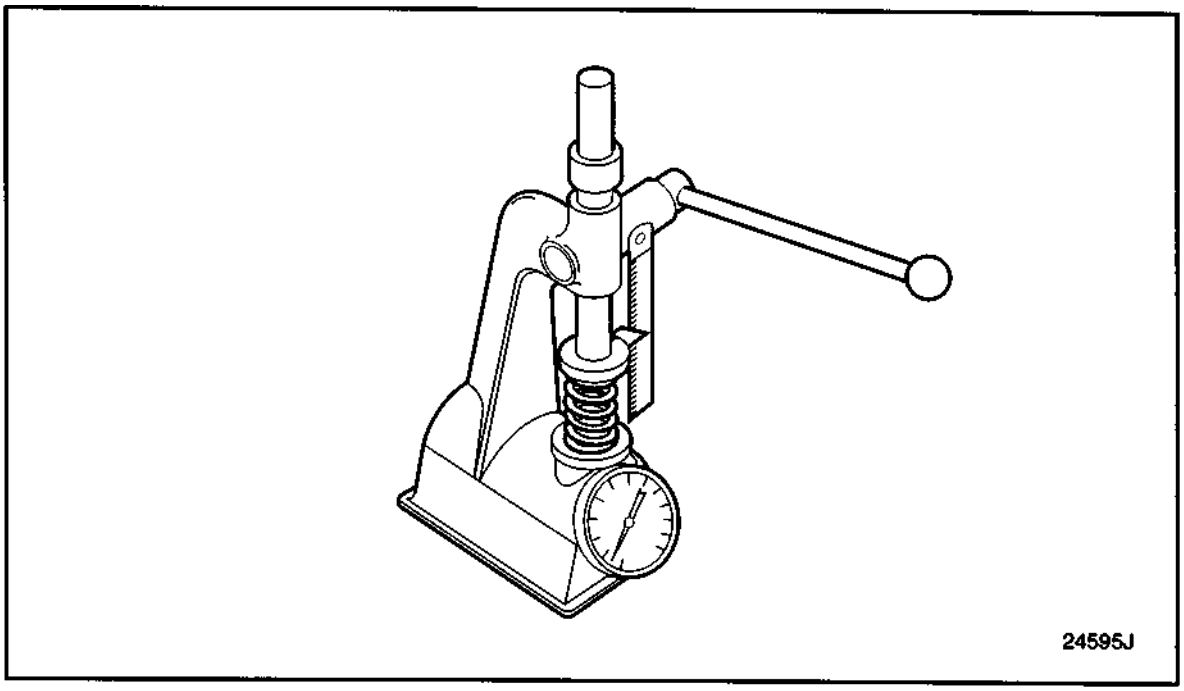


Figure 1322 Valve Spring Tester,J 22738–02

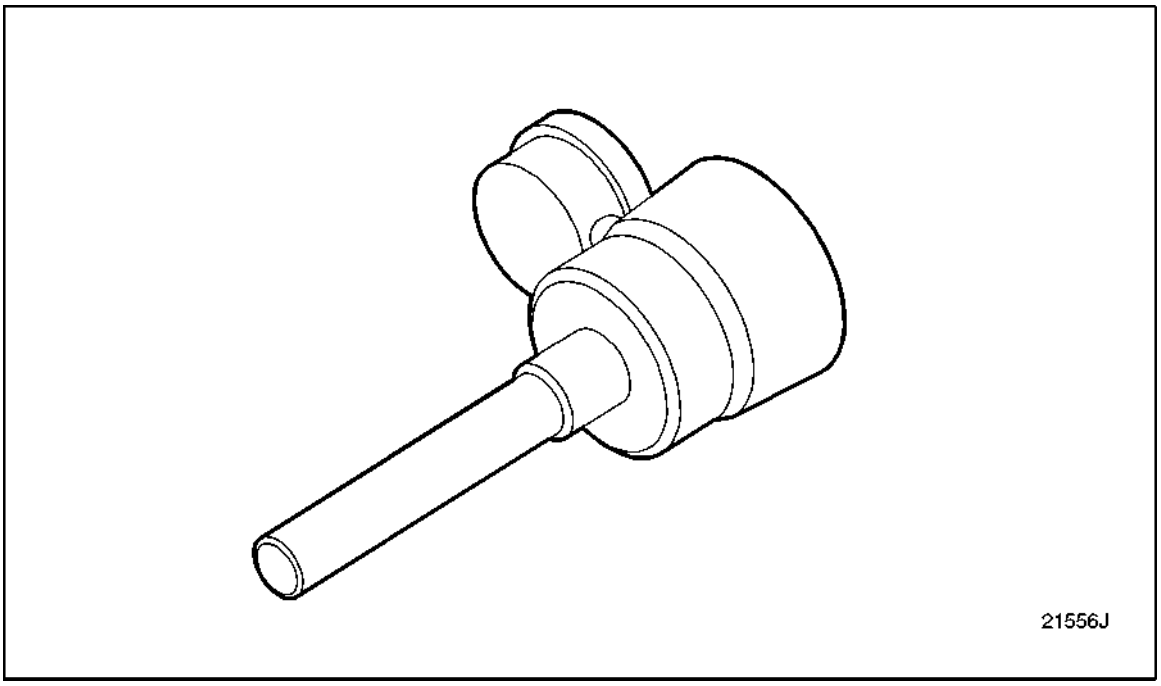


Figure 1323 Valve Spring Tester (ON Cylinder HD),J 25076–B

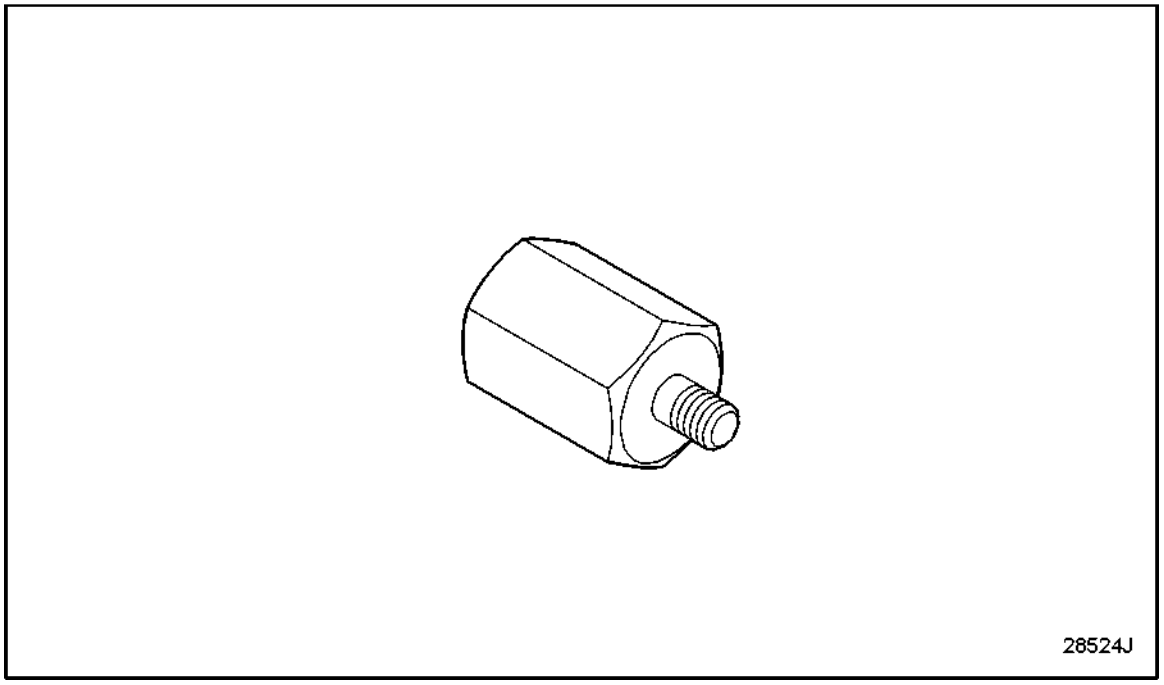


Figure 1324 Valve Bridge Guide (Broken) Remover,J 7453

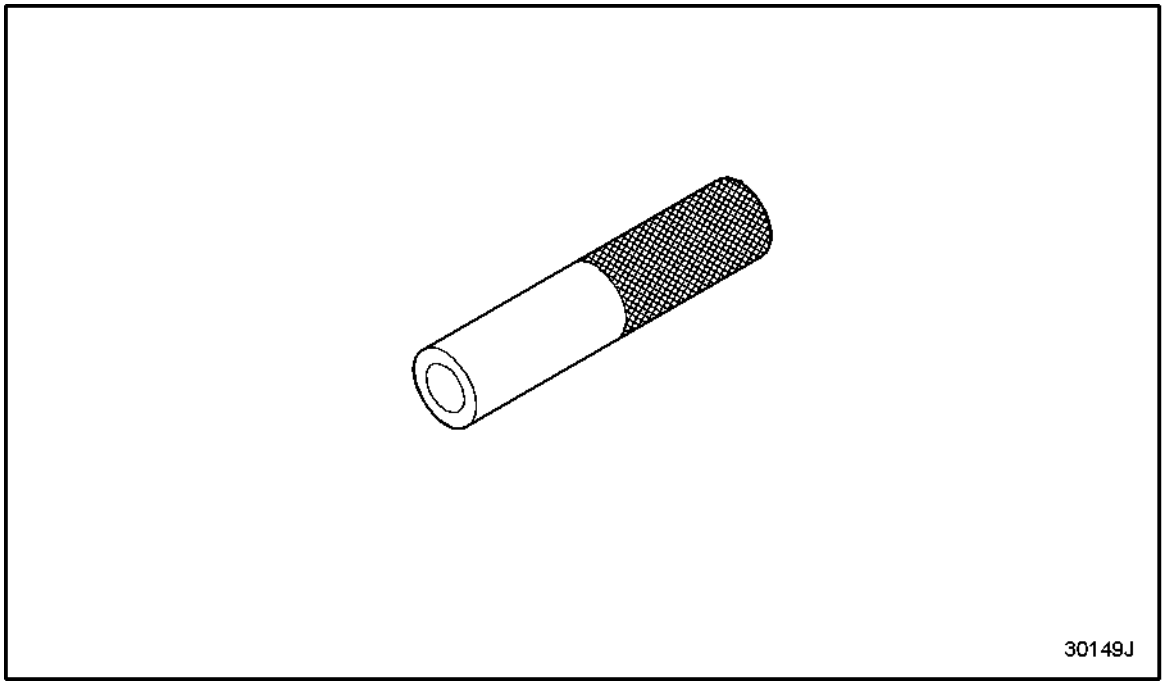


Figure 1325 Valve Bridge Guide Instal (PRSD GDE),J 7482

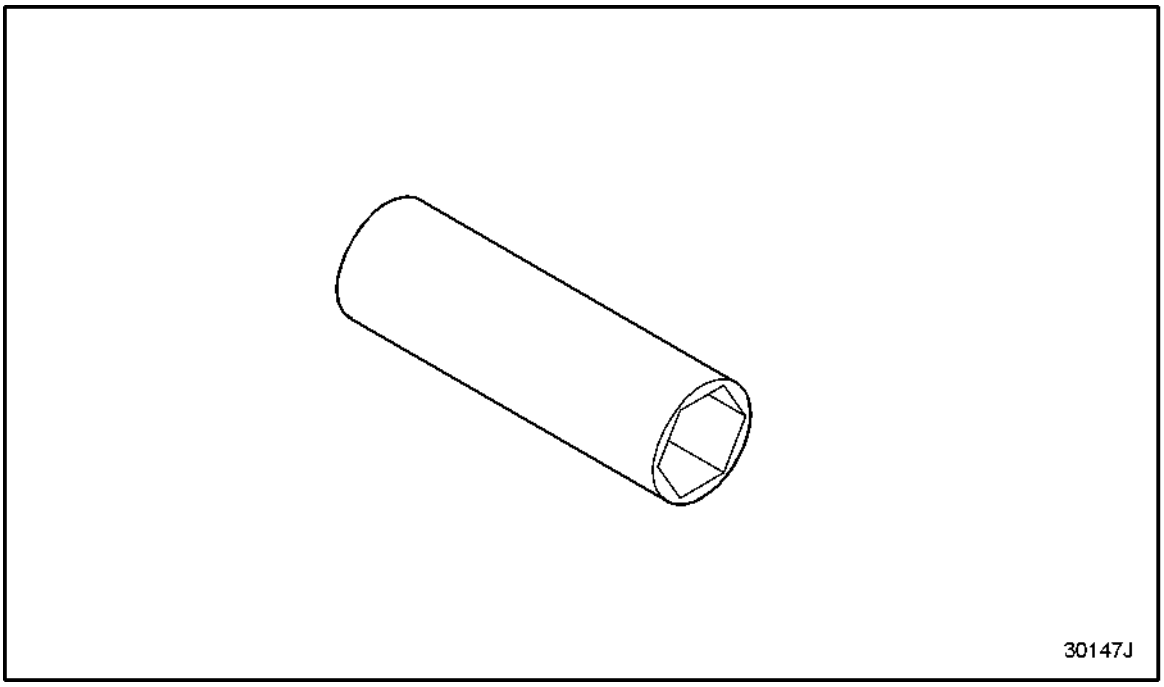


Figure 1326 Valve Bridge Guide Install-Threaded, J 6846

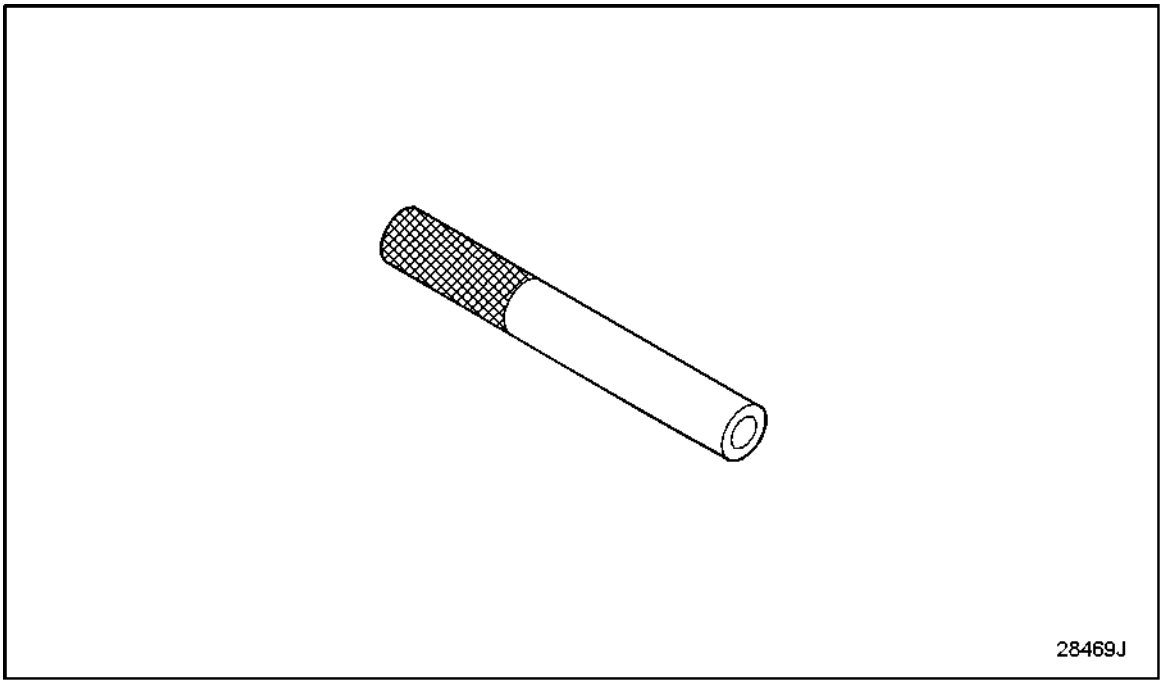


Figure 1327 Valve Bridge Guide Installer, J 22487

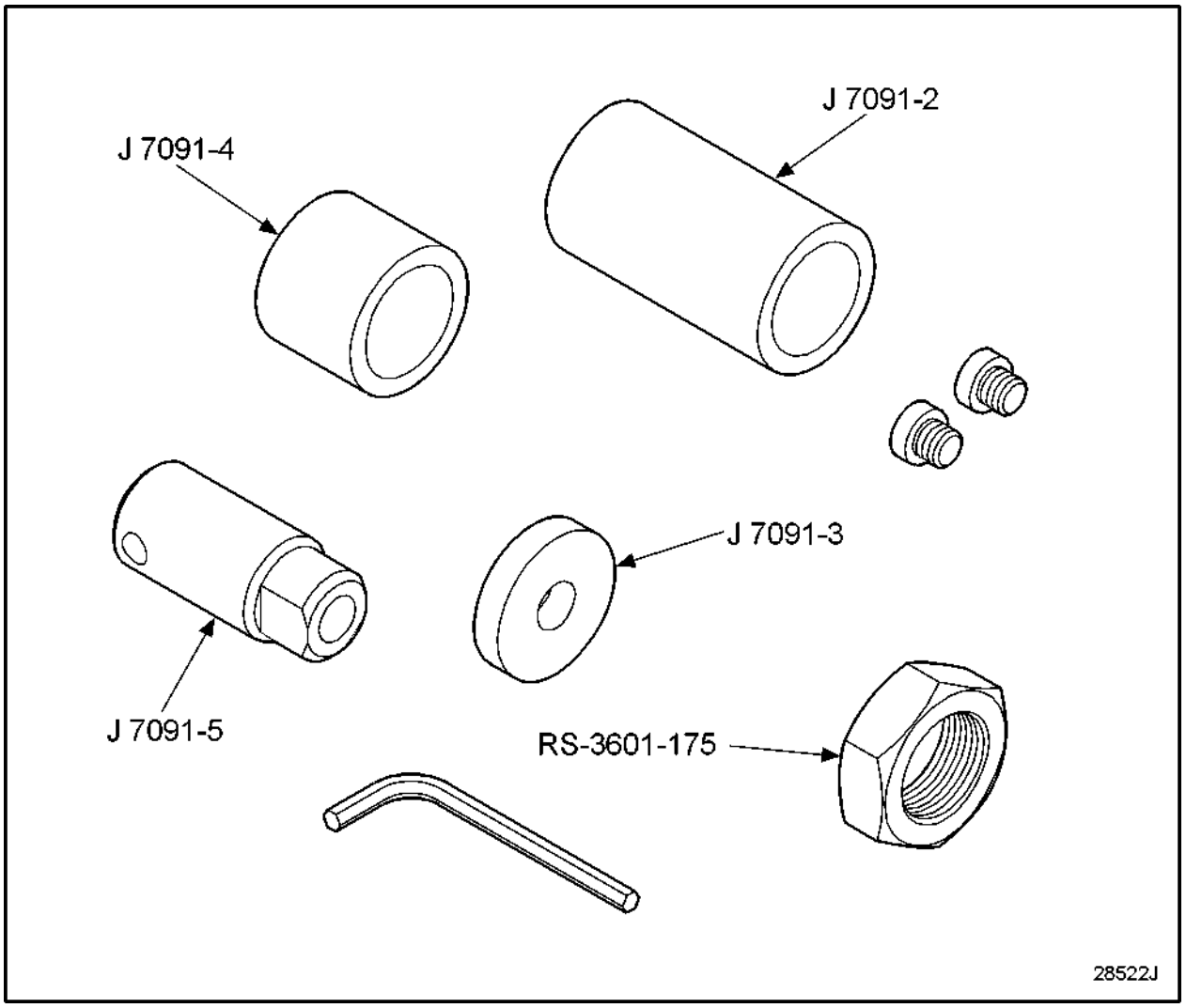


Figure 1328 Valve Bridge Guide Remover (Press), J 7091–01

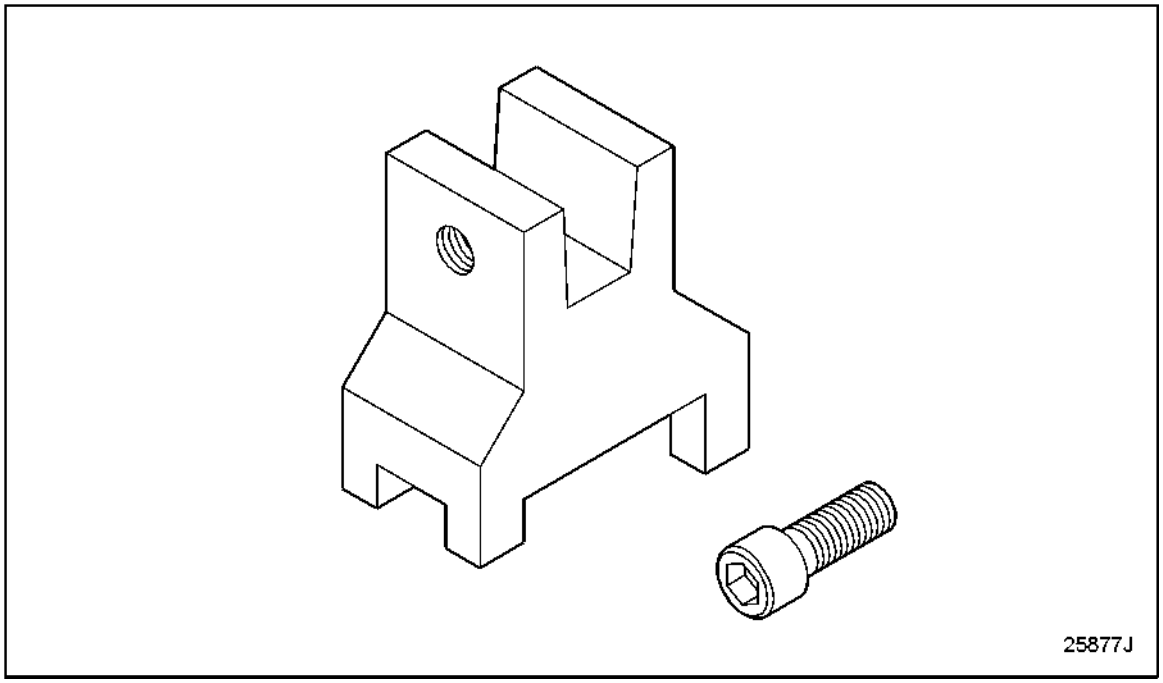


Figure 1329 Valve Bridge Holding Fixture,J 21772

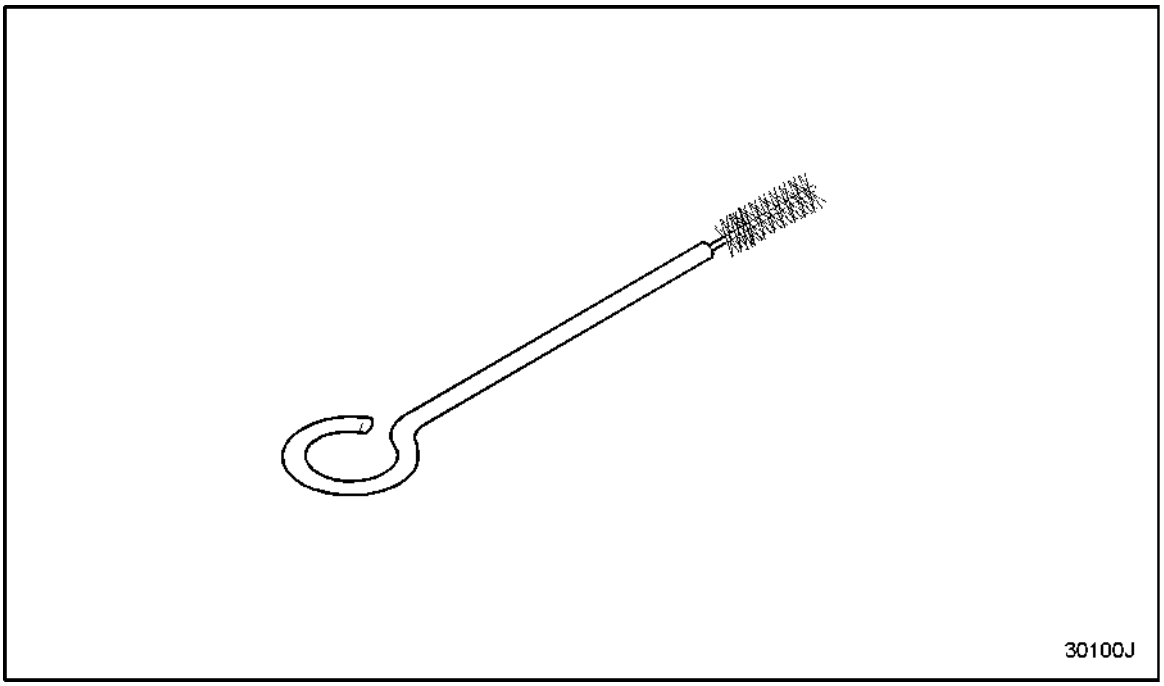


Figure 1330 Valve Guide Cleaning Brush,J 5437

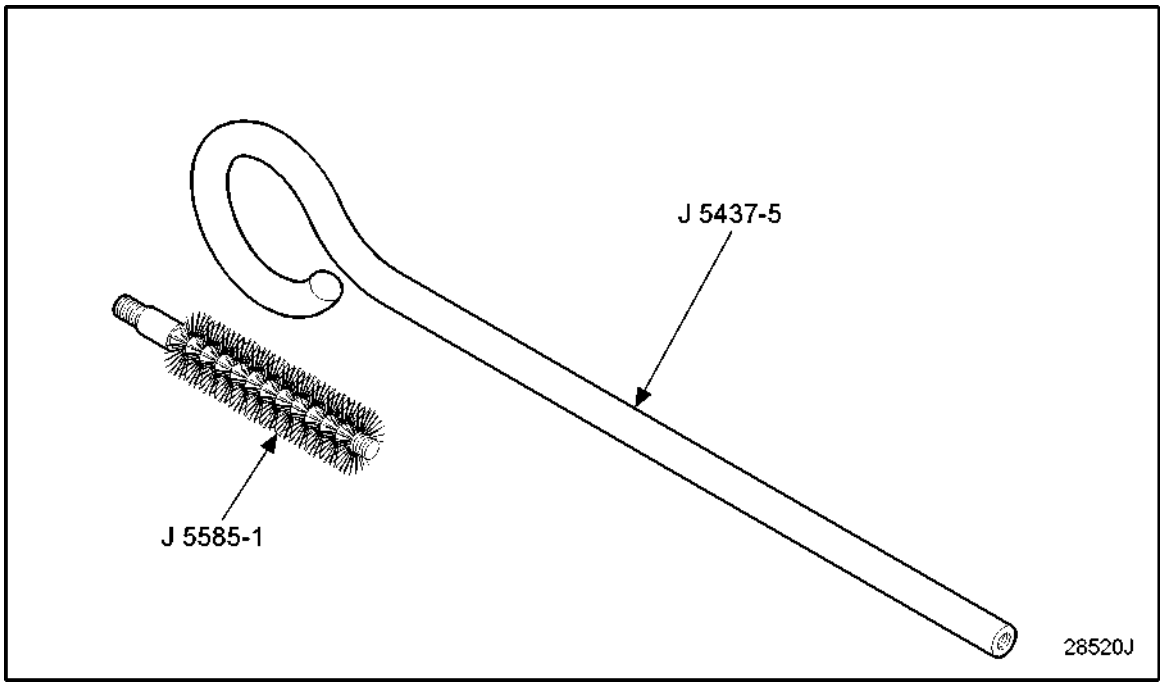


Figure 1331 Valve Guide Cleaning Brush,J 5585

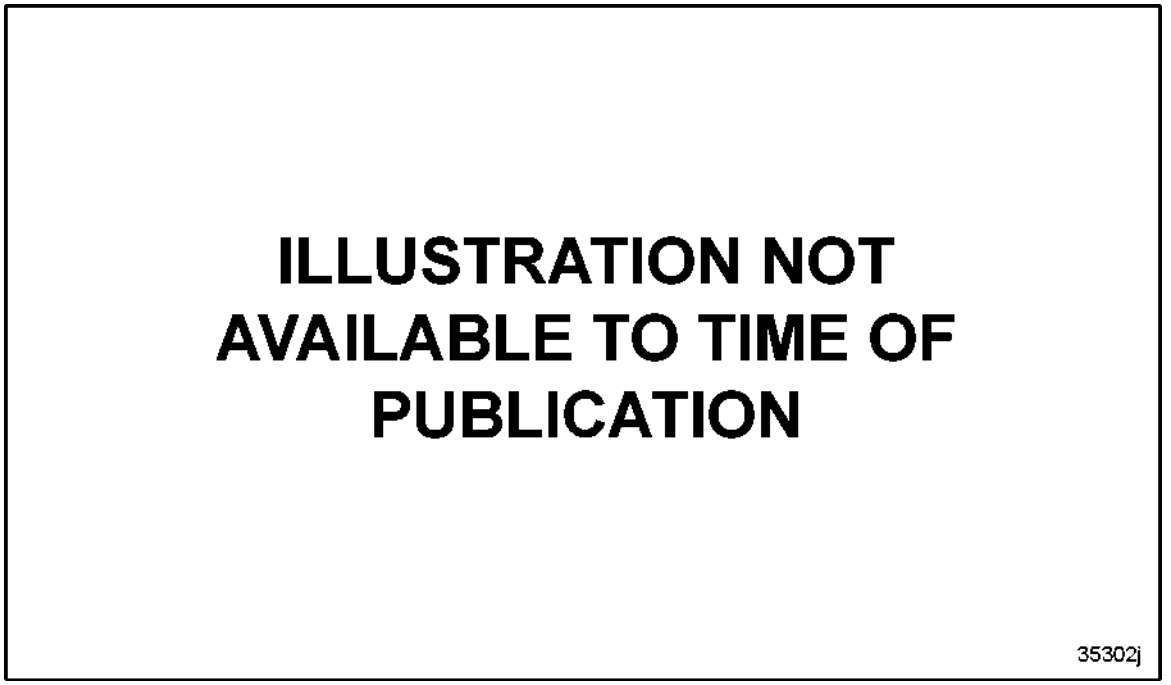


Figure 1332 Valve Guide Cleaning Brush (4 Valv),J 7793

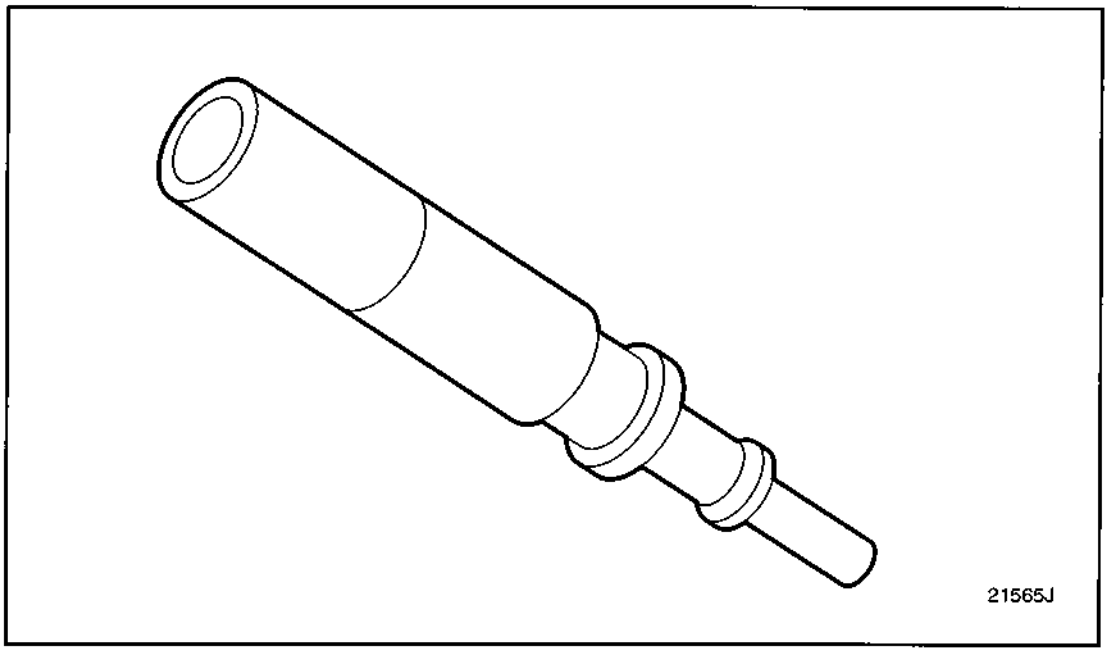


Figure 1333 Valve Guide Installer,J 33191–A

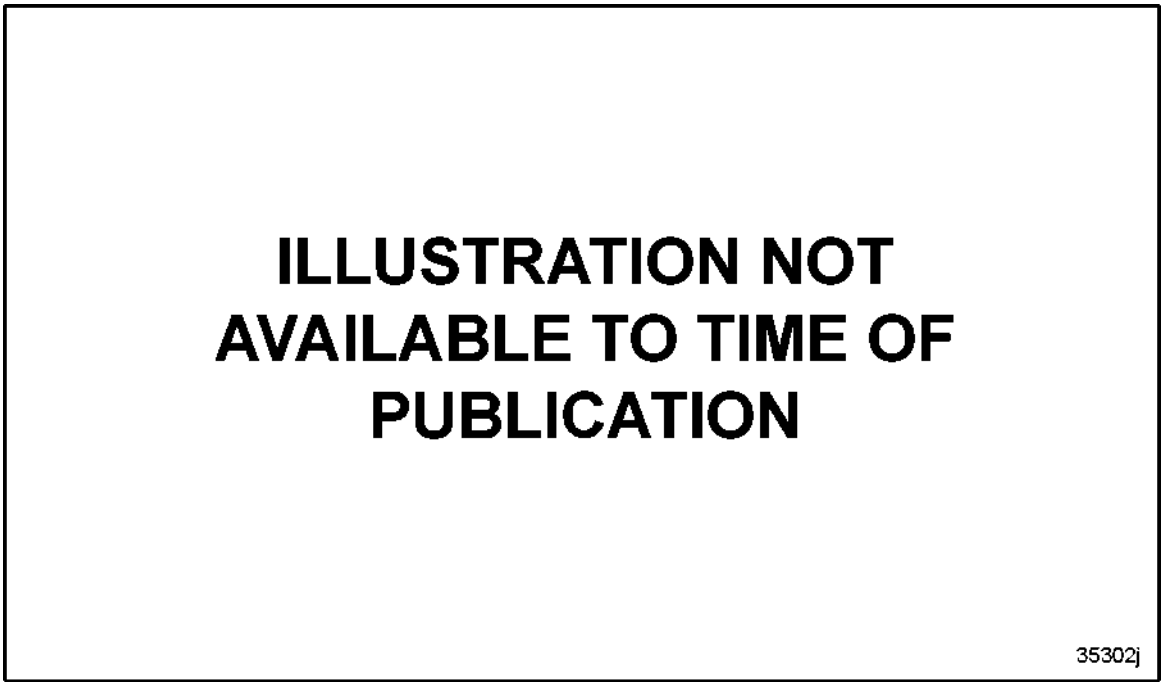


Figure 1334 Valve Guide Installer (2 Valve),J 7560

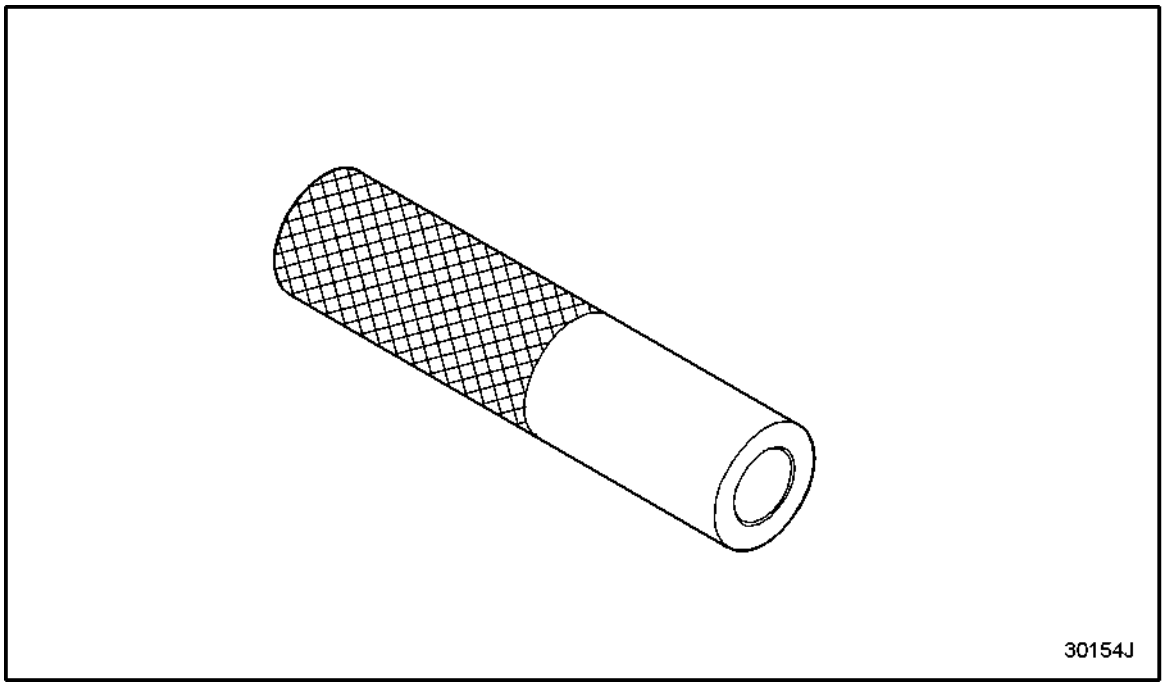


Figure 1335 Valve Guide Installer (2 Valve),J 9530

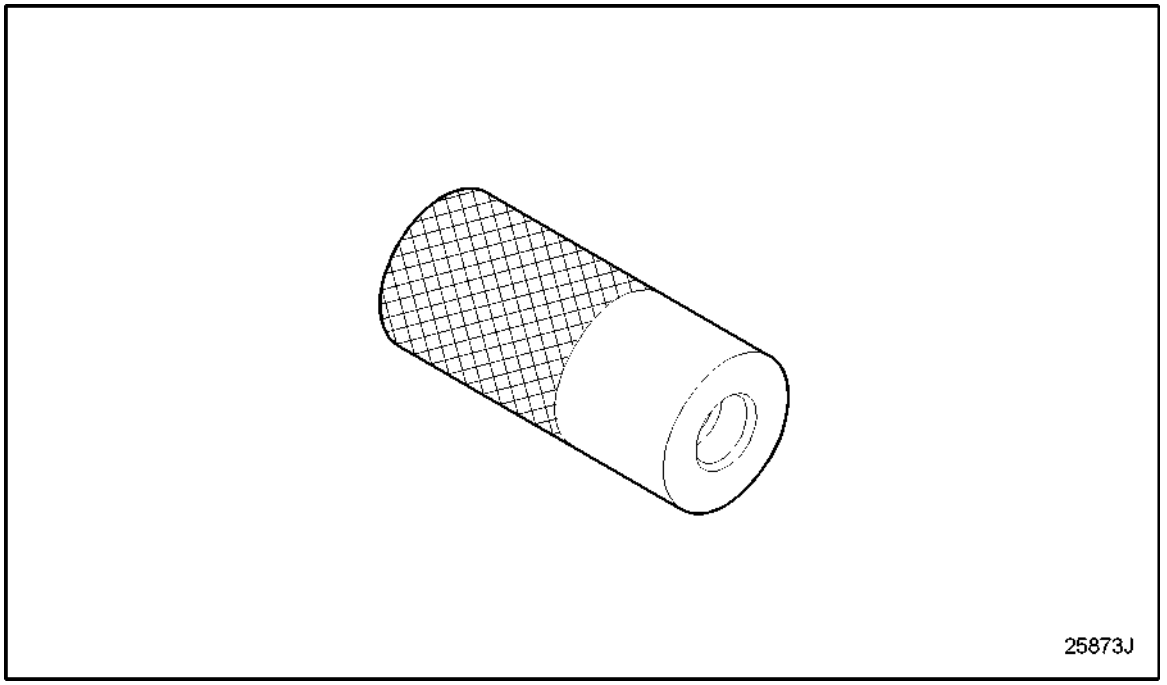


Figure 1336 Valve Guide Installer (4 Valve),J 21520

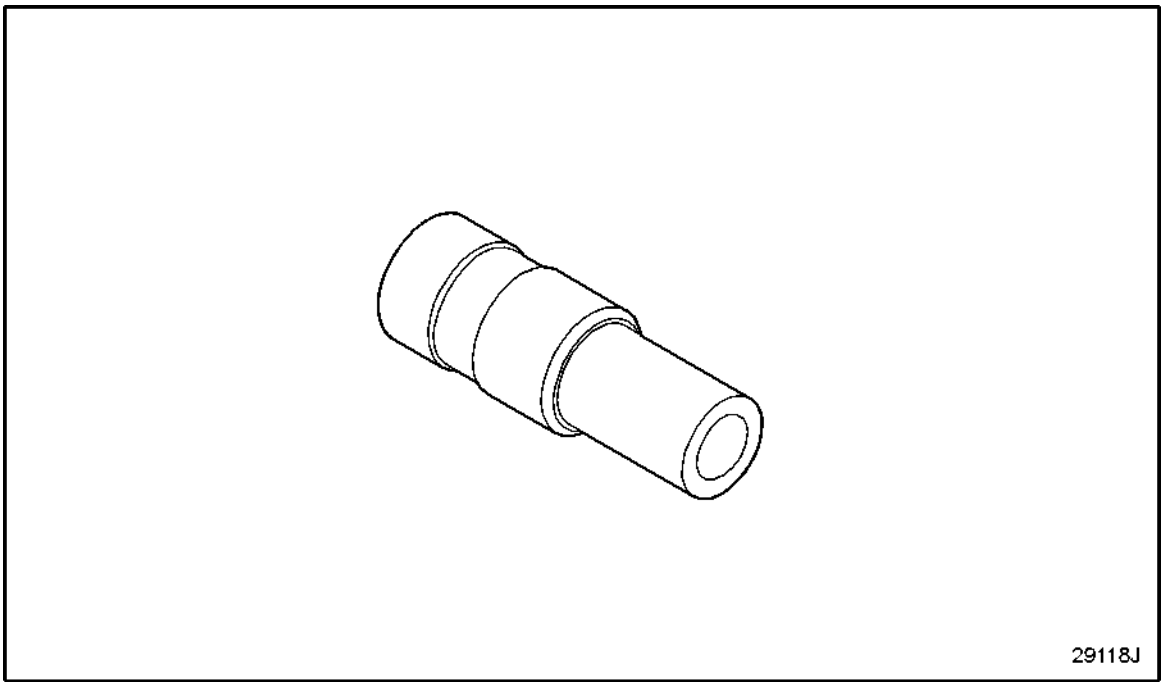


Figure 1337 Valve Guide Installer (4 Valve),J 24519

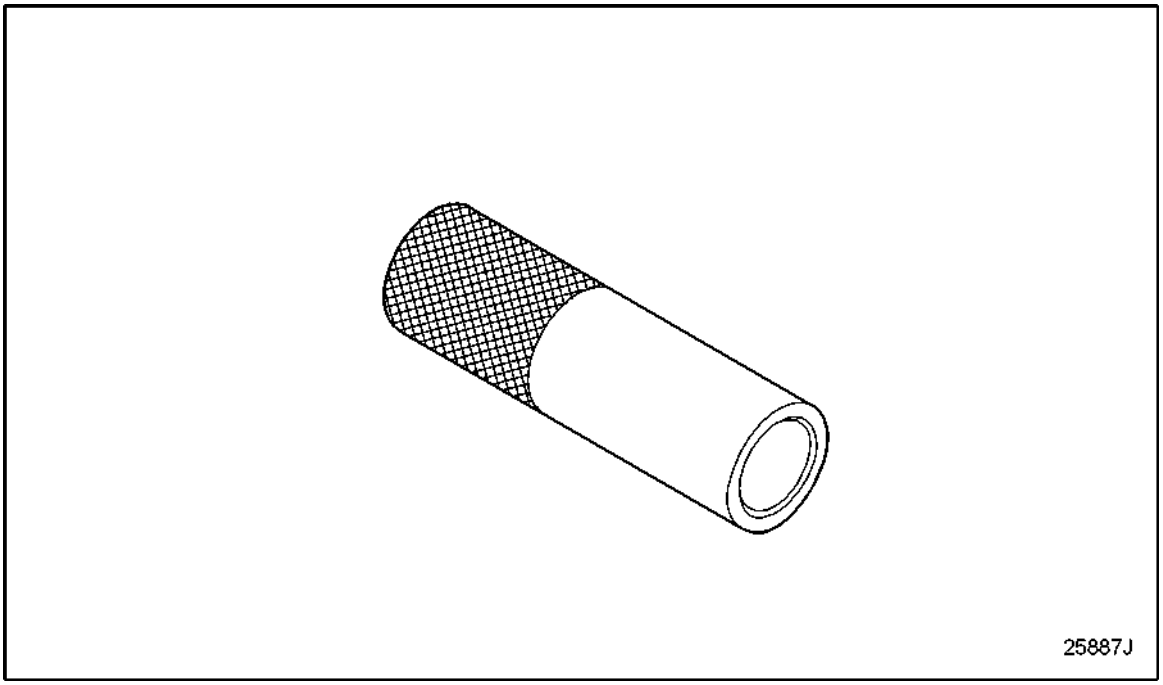


Figure 1338 Valve Guide Installer (Large Stem),J 22082–01

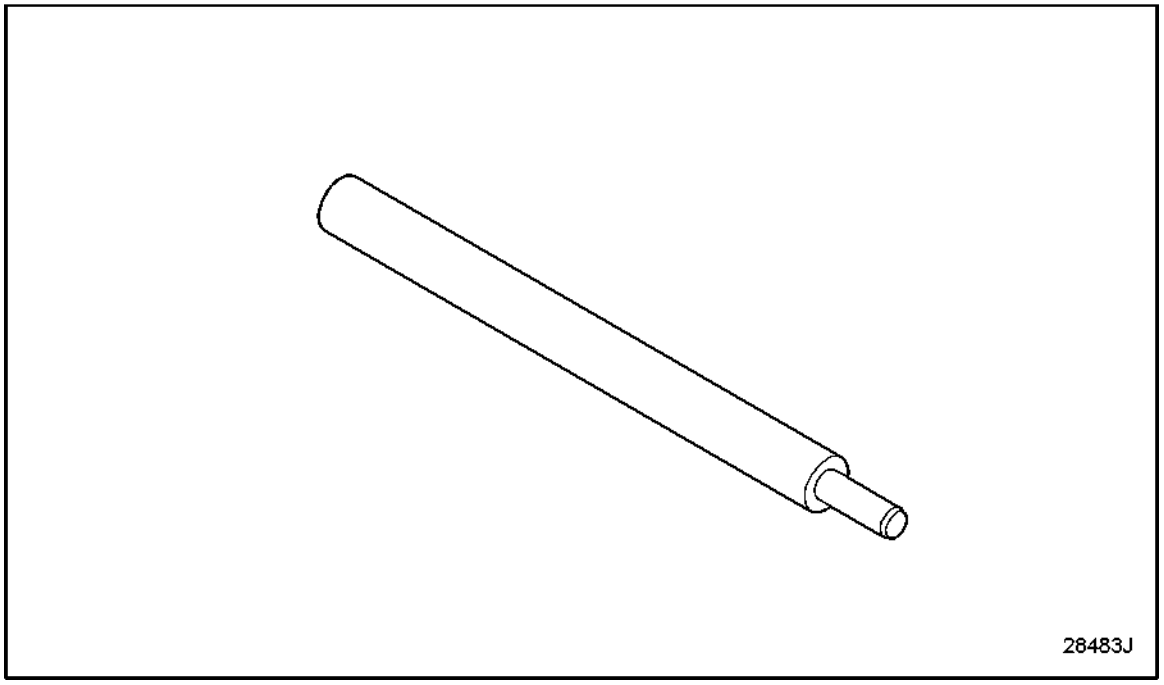


Figure 1339 Valve Guide Remover,J 23458

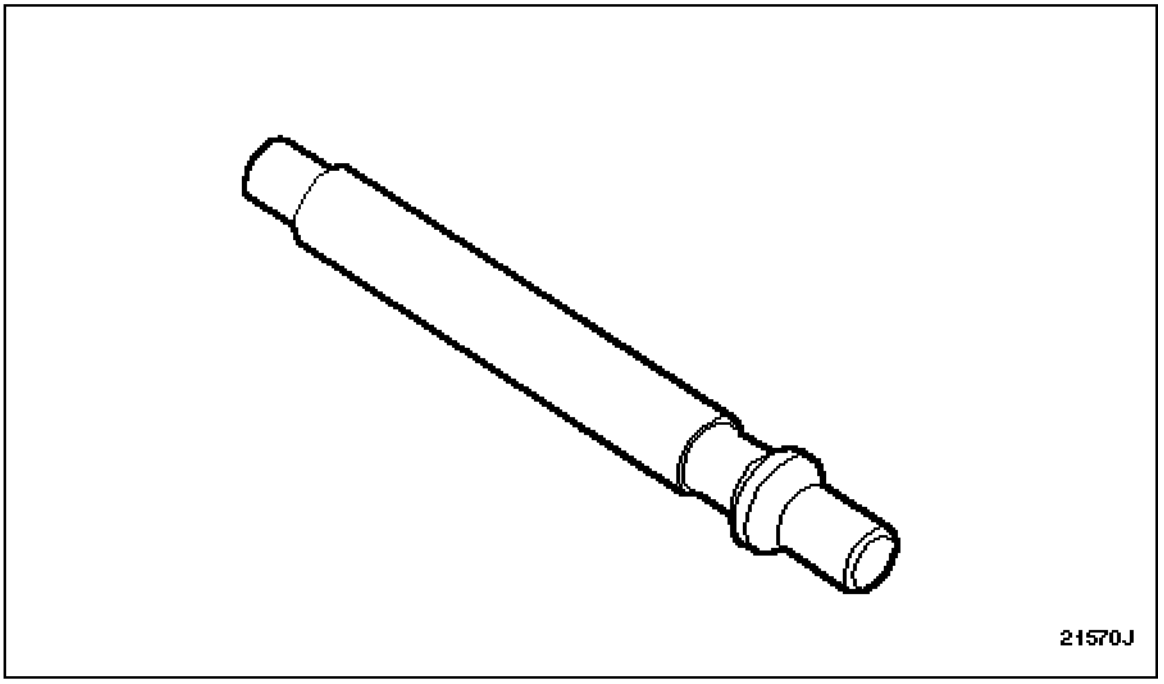


Figure 1340 Valve Guide Remover,J 34696–B

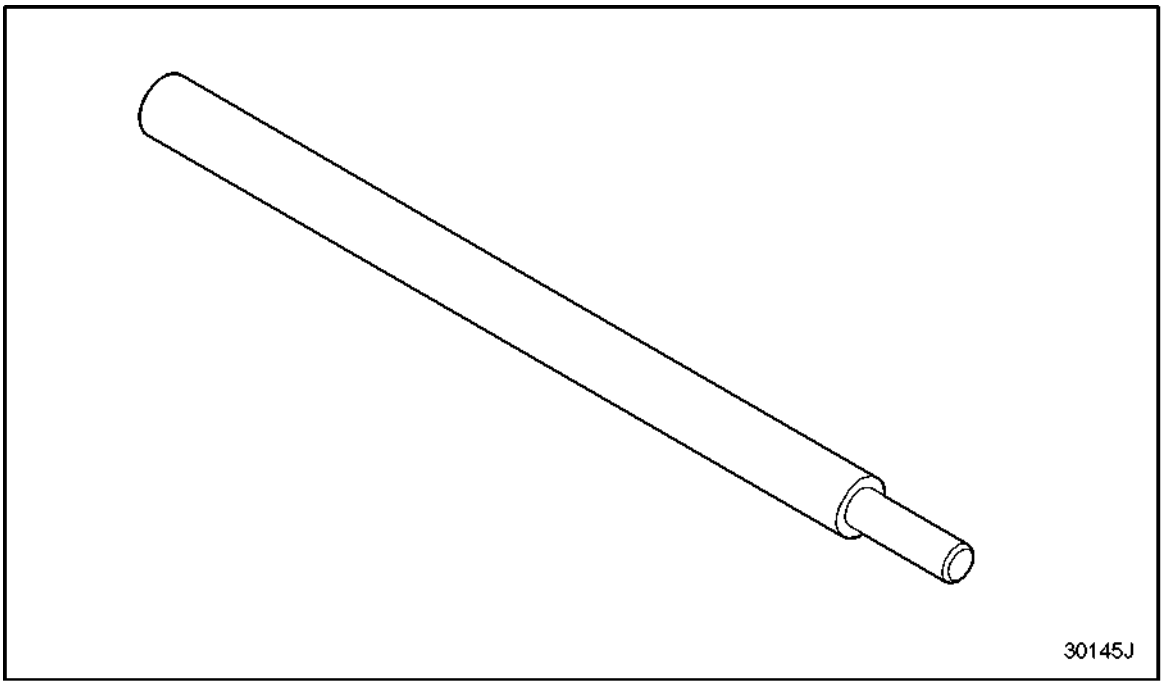


Figure 1341 Valve Guide Remover,J 6569–A

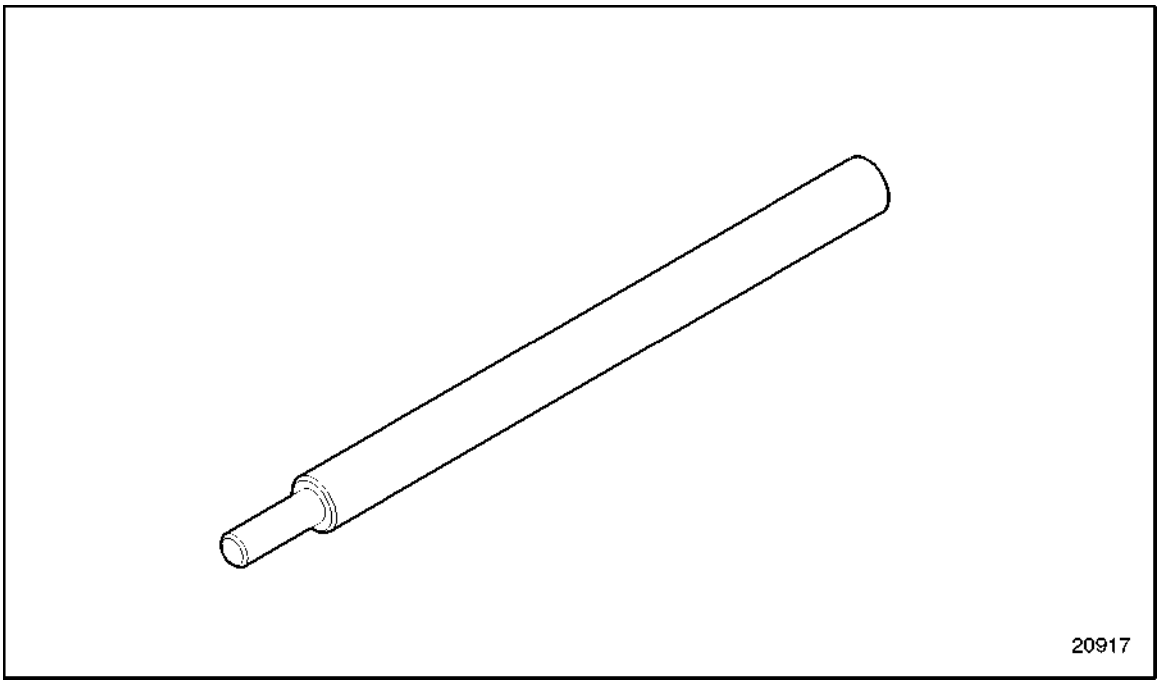


Figure 1342 Valve Guide Remover (2 Valve),J 267–A

ILLUSTRATION NOT AVAILABLE TO TIME OF PUBLICATION

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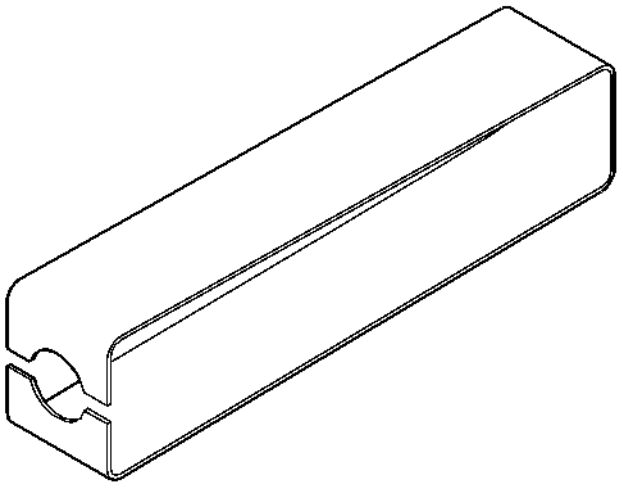
Figure 1343 Valve Guide Remover (4 Valve), J 7775–A



29137J

Figure 1344 Valve Guide Remover/Installer, J 28612

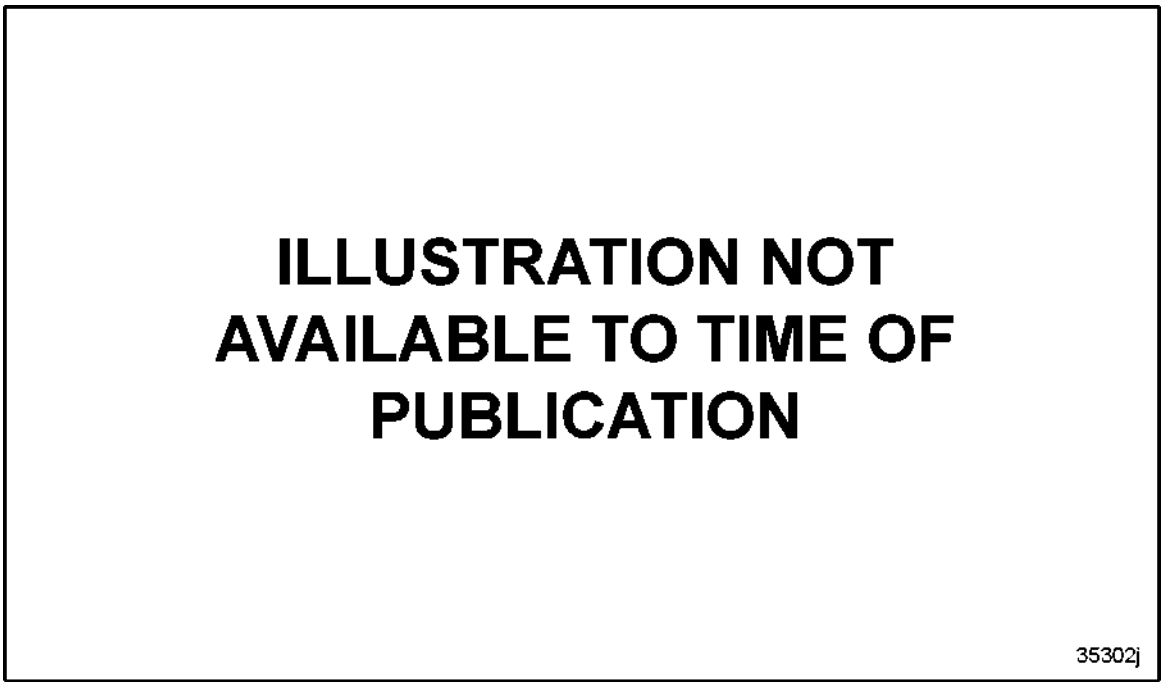


Figure 1345 Valve Stem Seal Installer (4 Val 53), J 29579

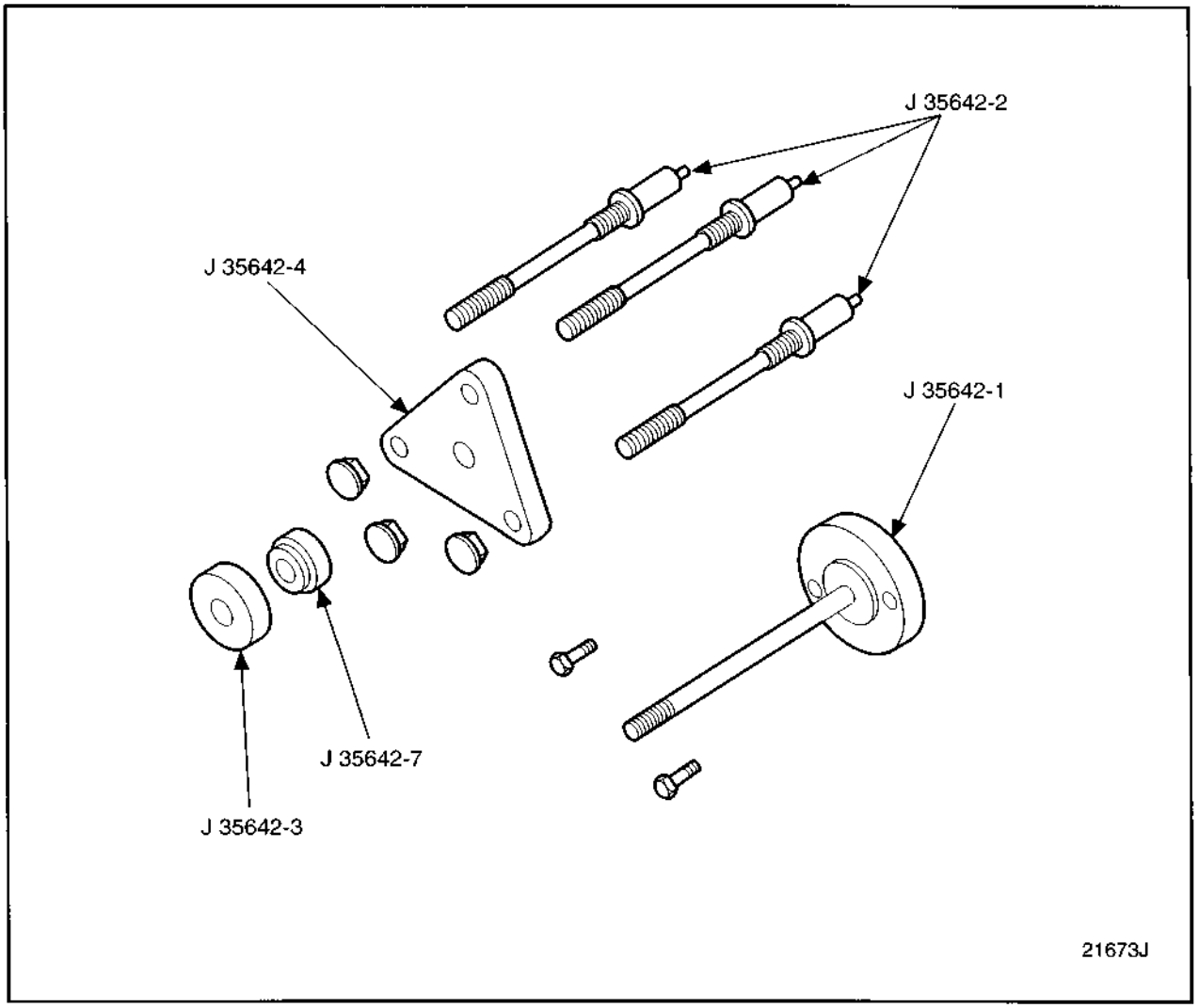


Figure 1346 Crankshaft Gear Remover/Installer,J 35642

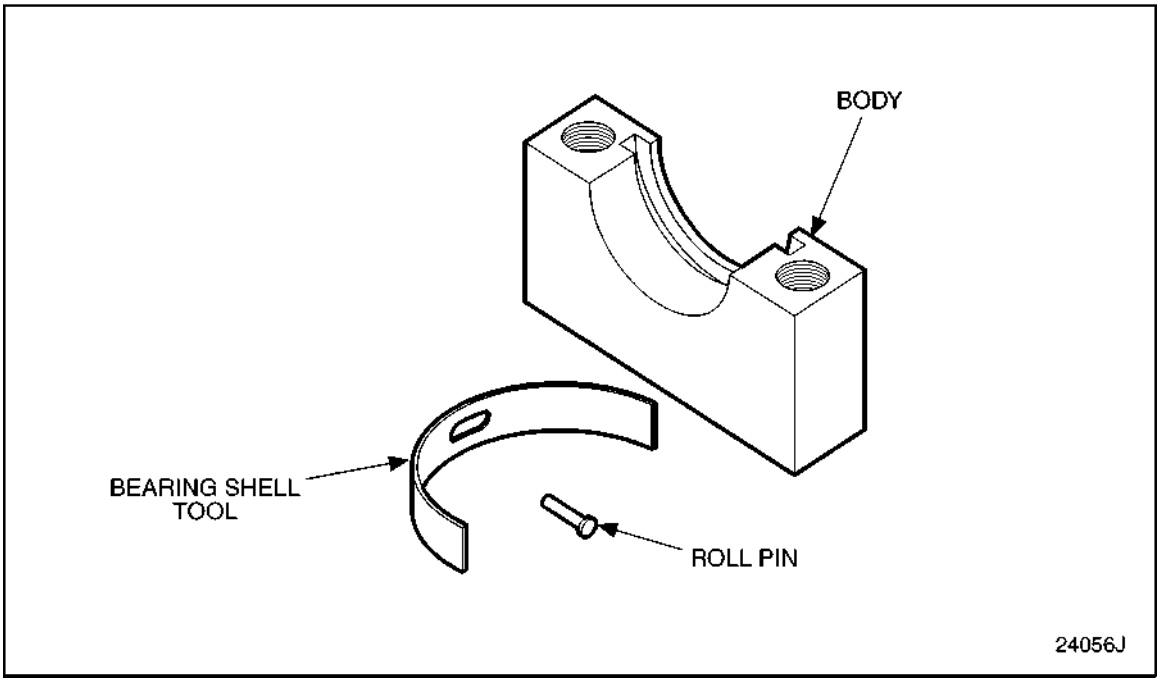


Figure 1347 Crankshaft Main Bearing Remover,J 36187–A

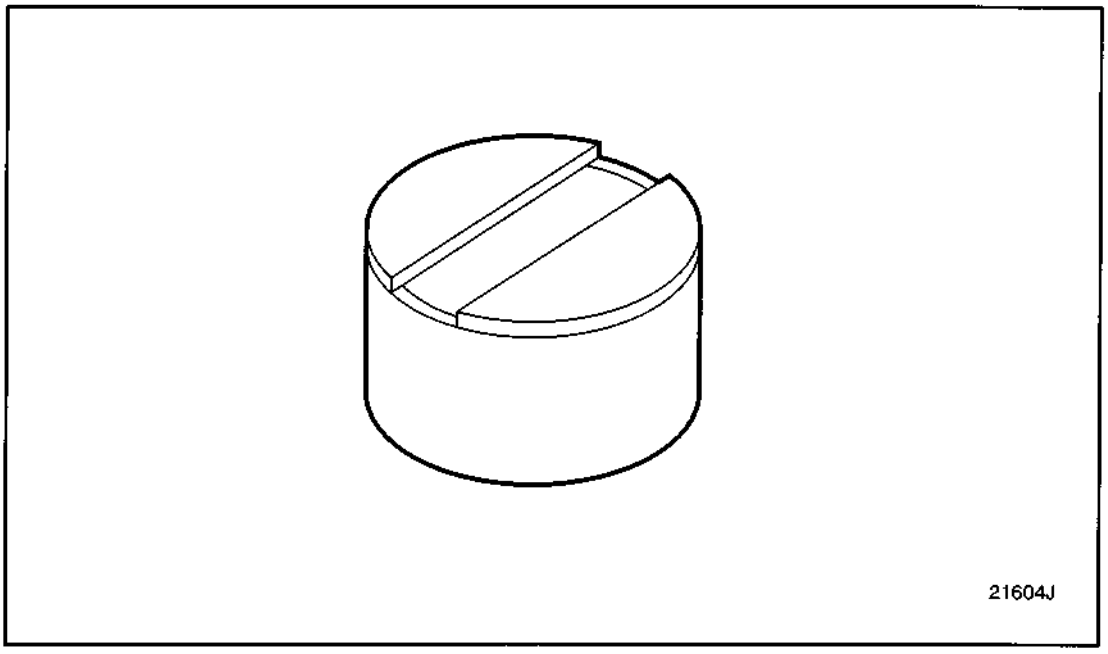


Figure 1348 Crankshaft Protector,J 35994

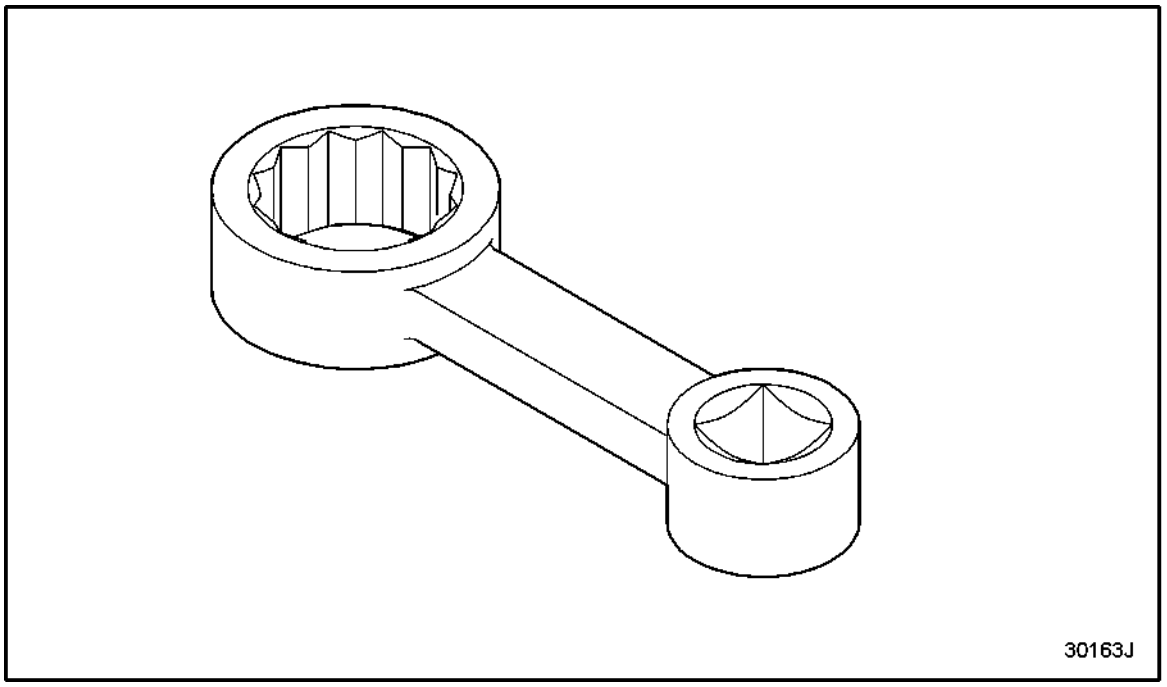


Figure 1349 Crankshaft Torque Wrench Adapter,J 22898–A

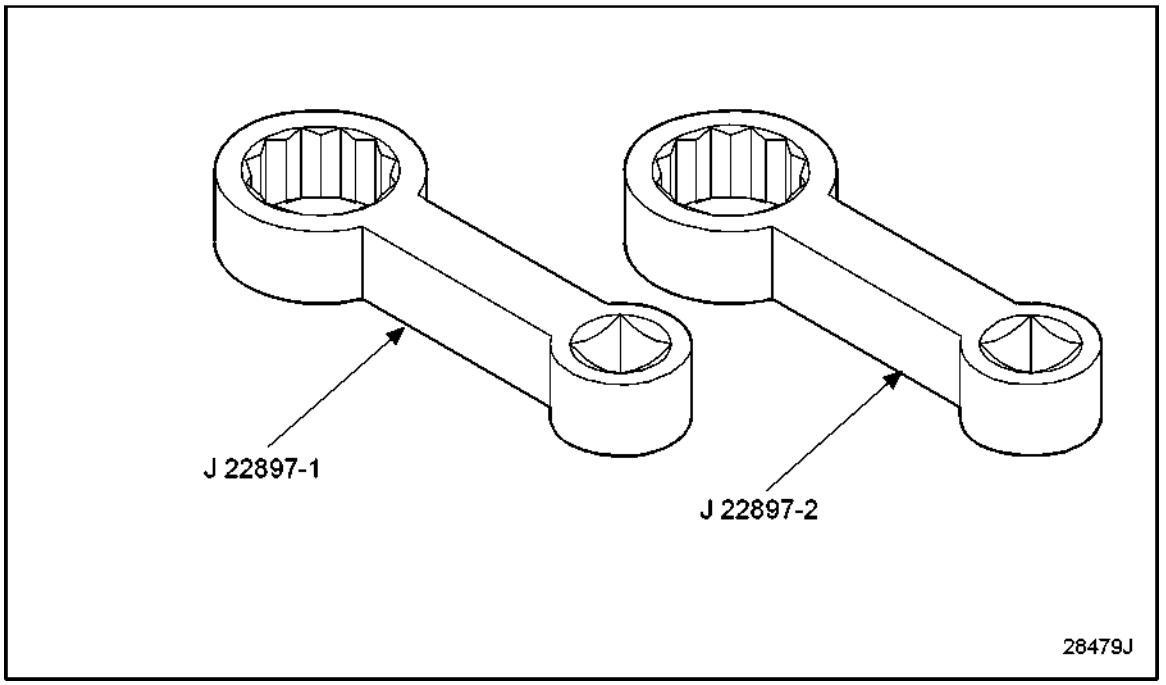


Figure 1350 Crankshaft Torque Wrench Adapter Set,J 22897

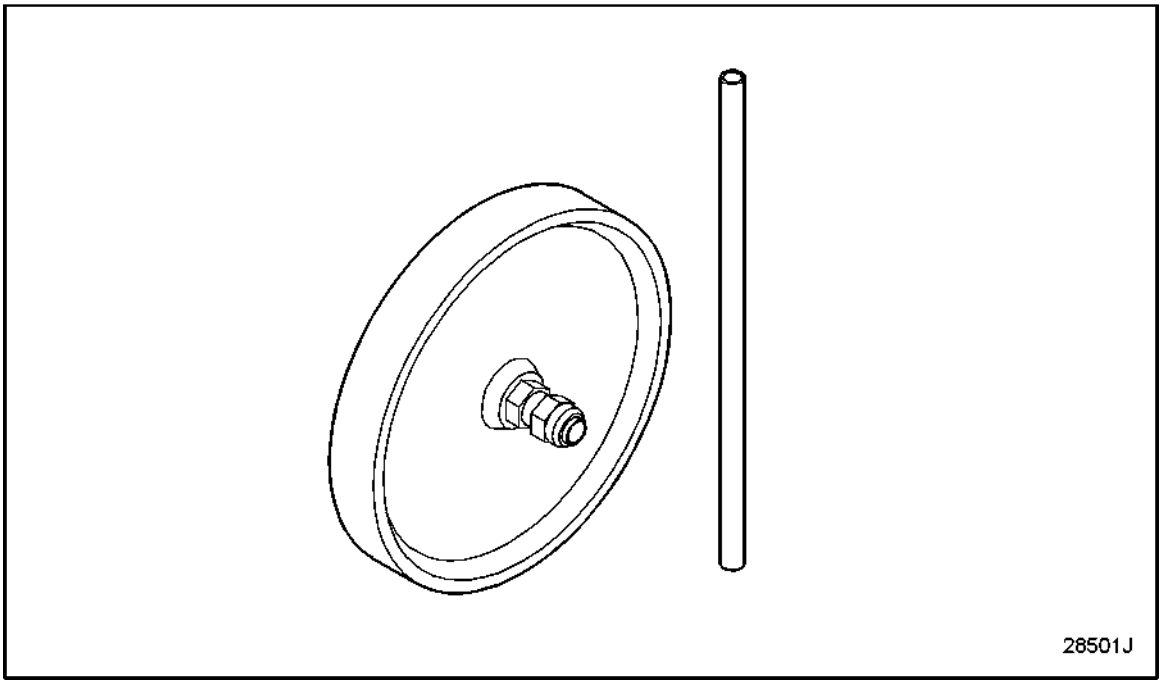


Figure 1351 Front Crankshaft Cup Plug Tester, J 34728

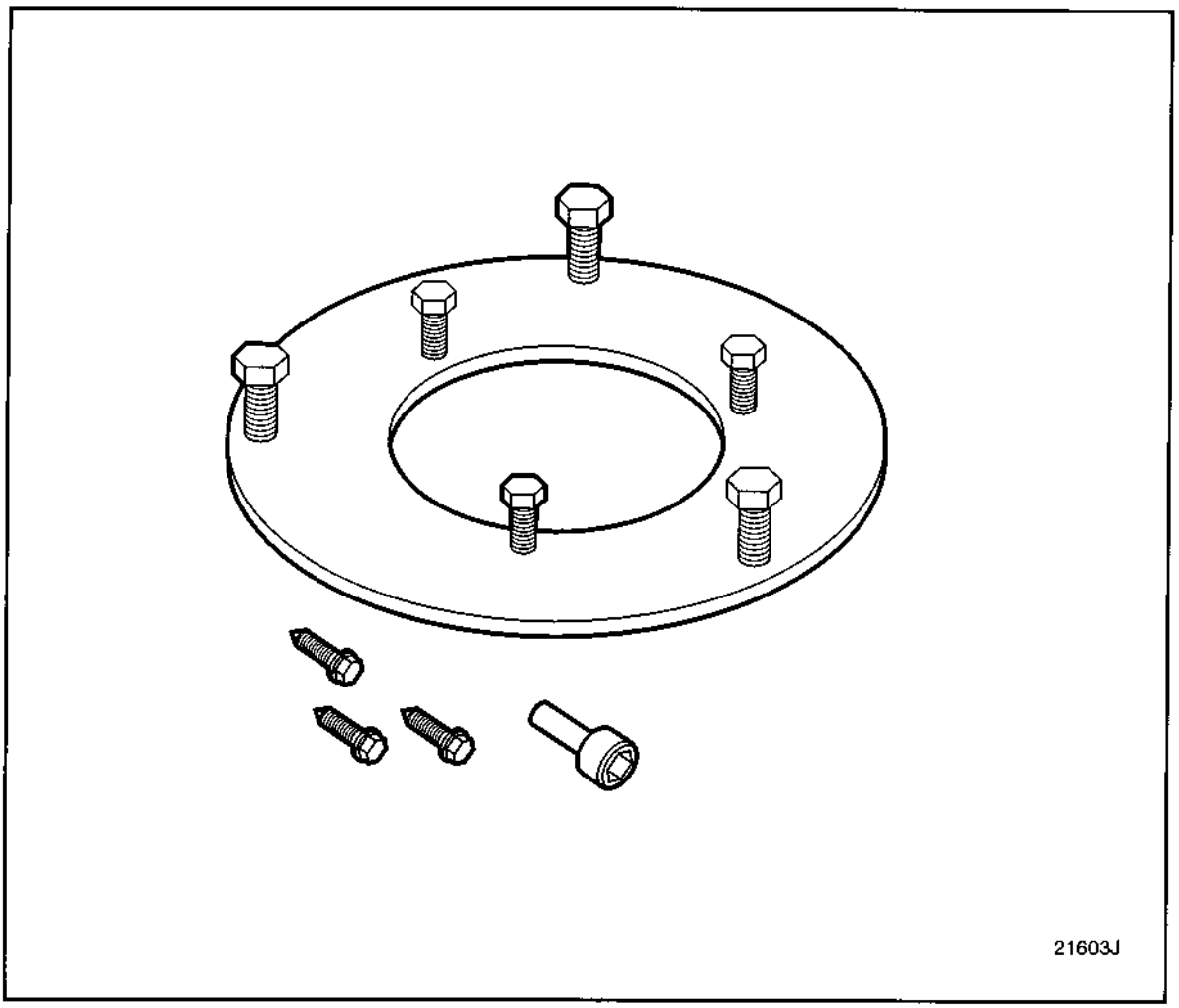


Figure 1352 Crankshaft Oil Seal Remover,J 35993

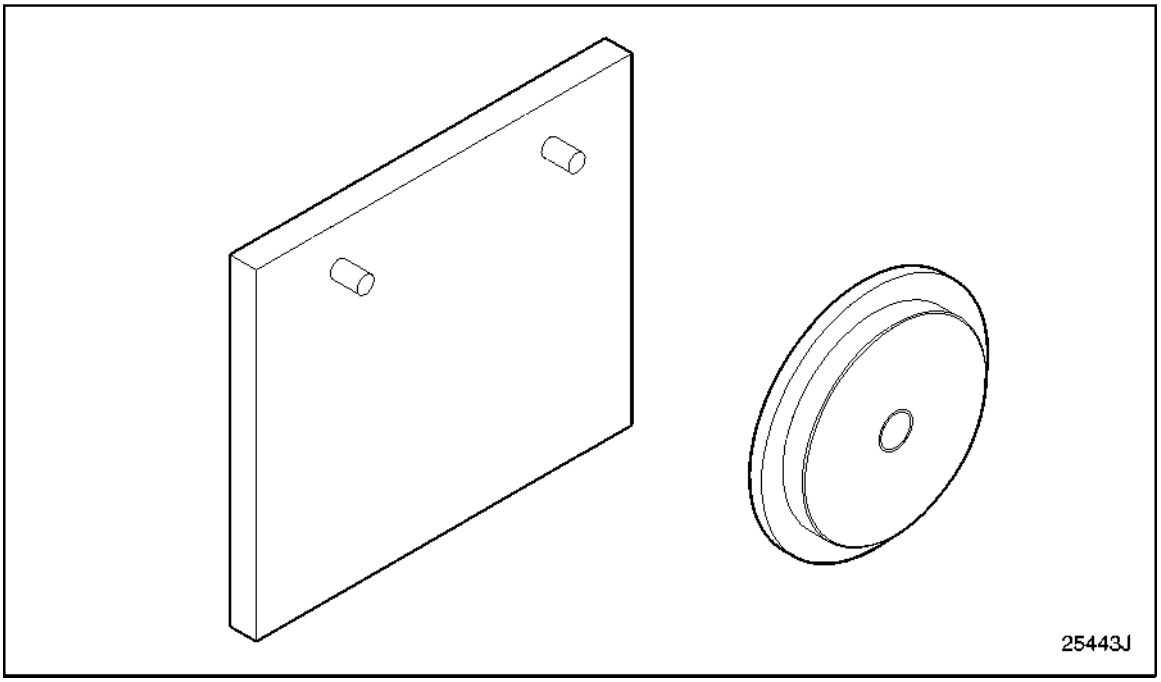


Figure 1353 Front Crankshaft Seal REM/INST,J 41599

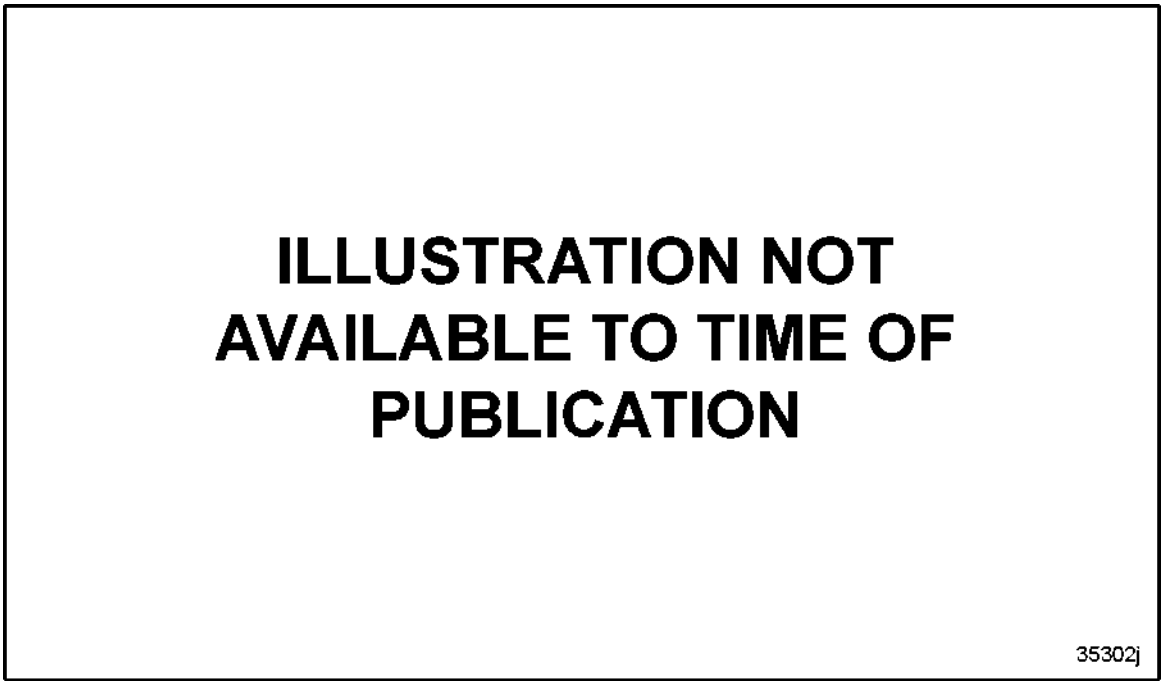


Figure 1354 Front Seal Expander (STD) 6V-53,J 7454

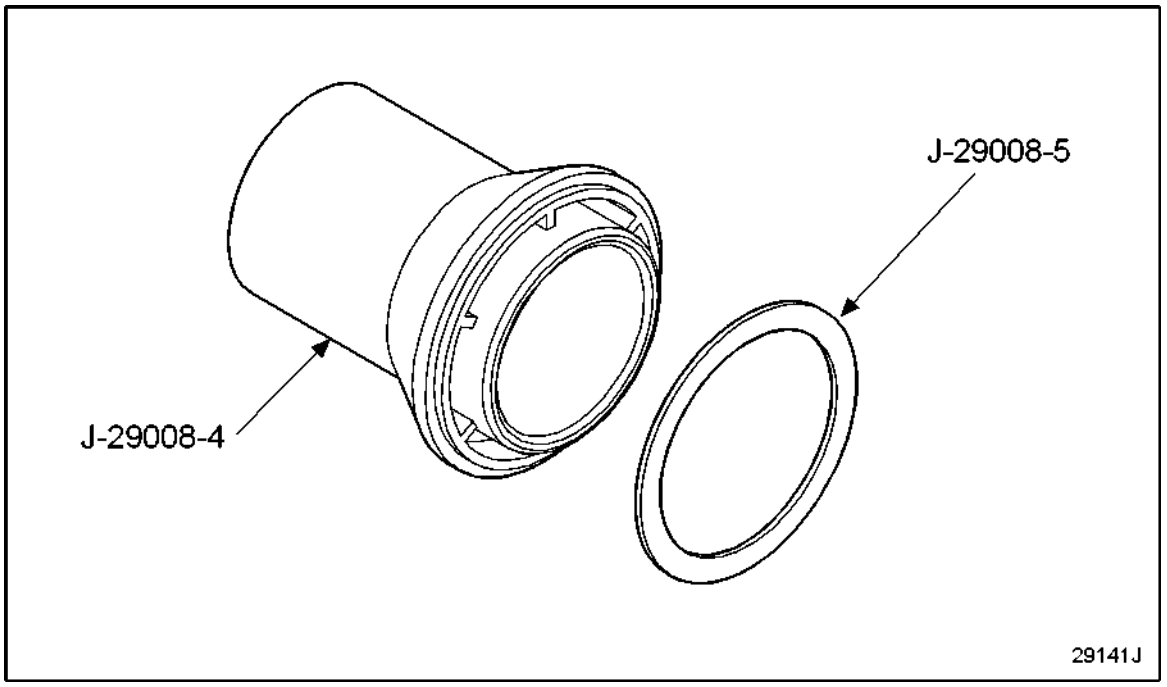


Figure 1355 Front Seal Installer (STD Seal), J 29008–B

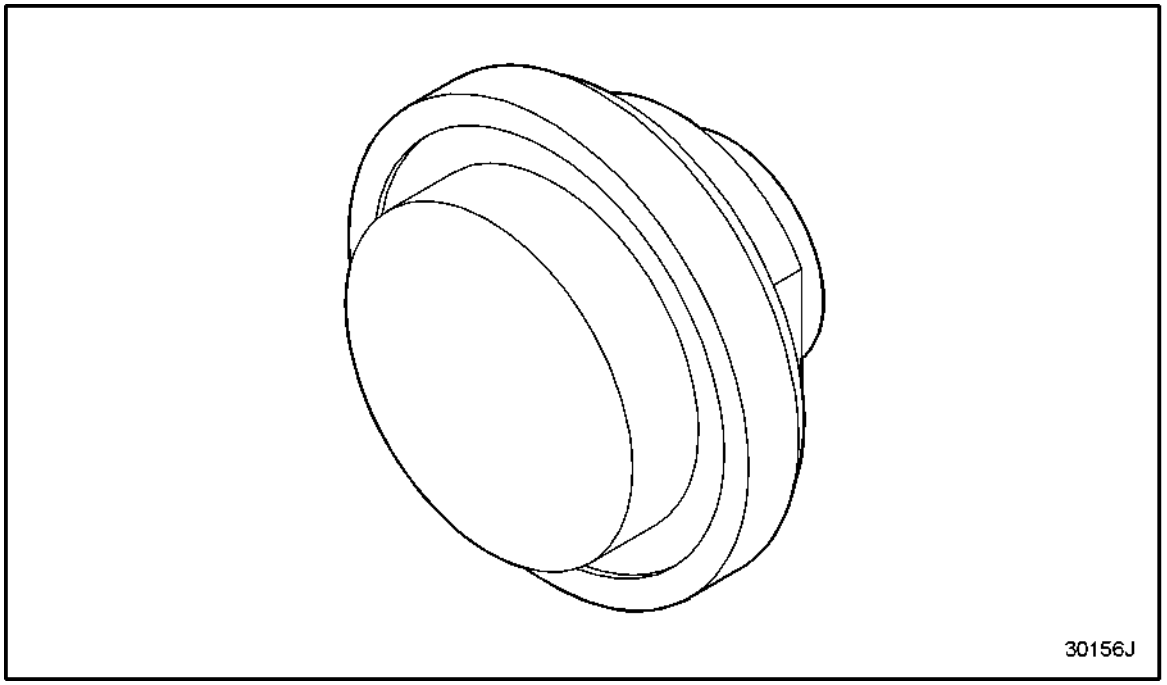


Figure 1356 Front Seal Installer (STD Seal) , J 9783

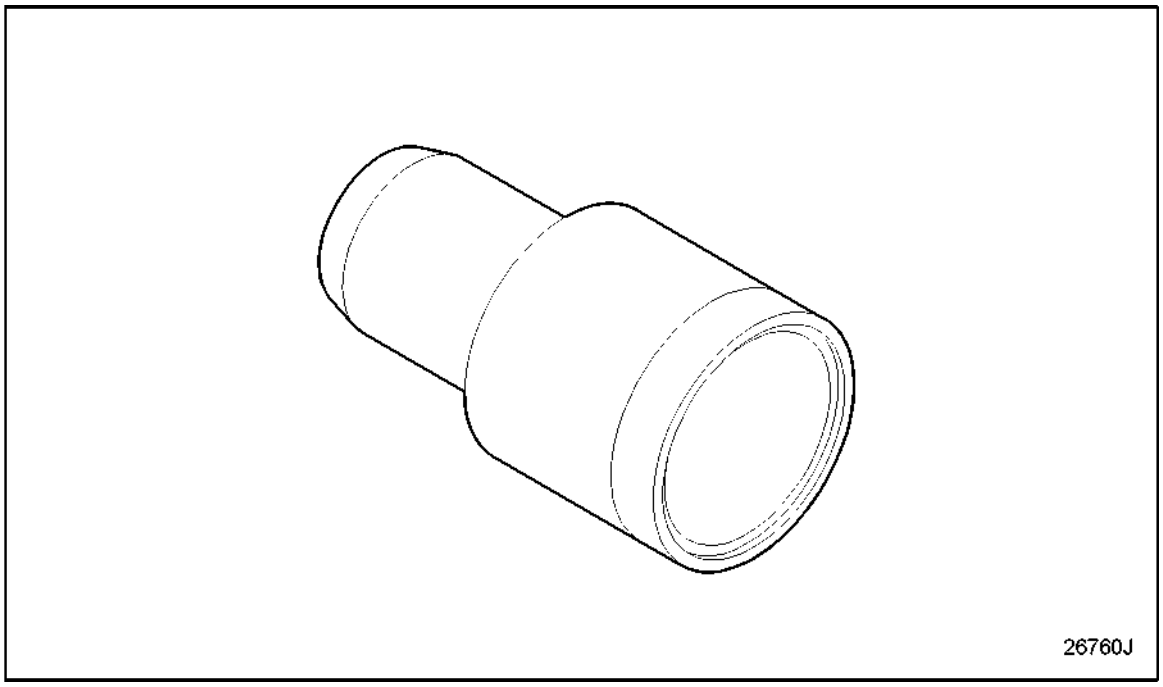


Figure 1357 Front Seal Installer (STD) 8V-53,J 22153

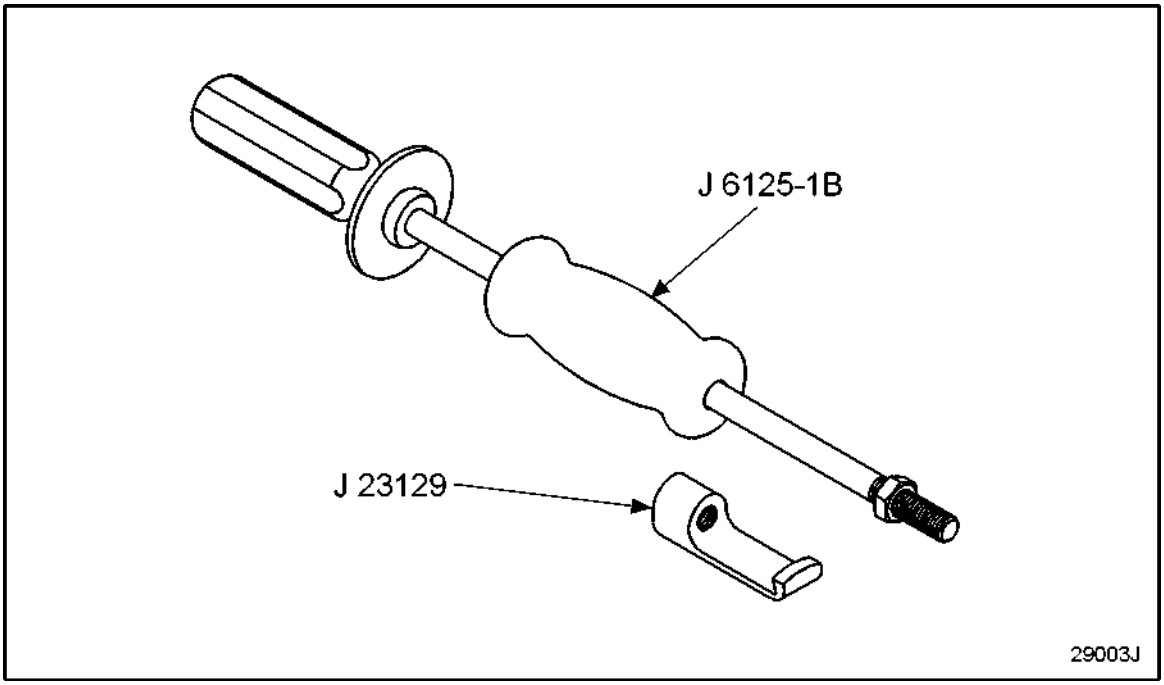


Figure 1358 Front Seal Remover,J 29007–A

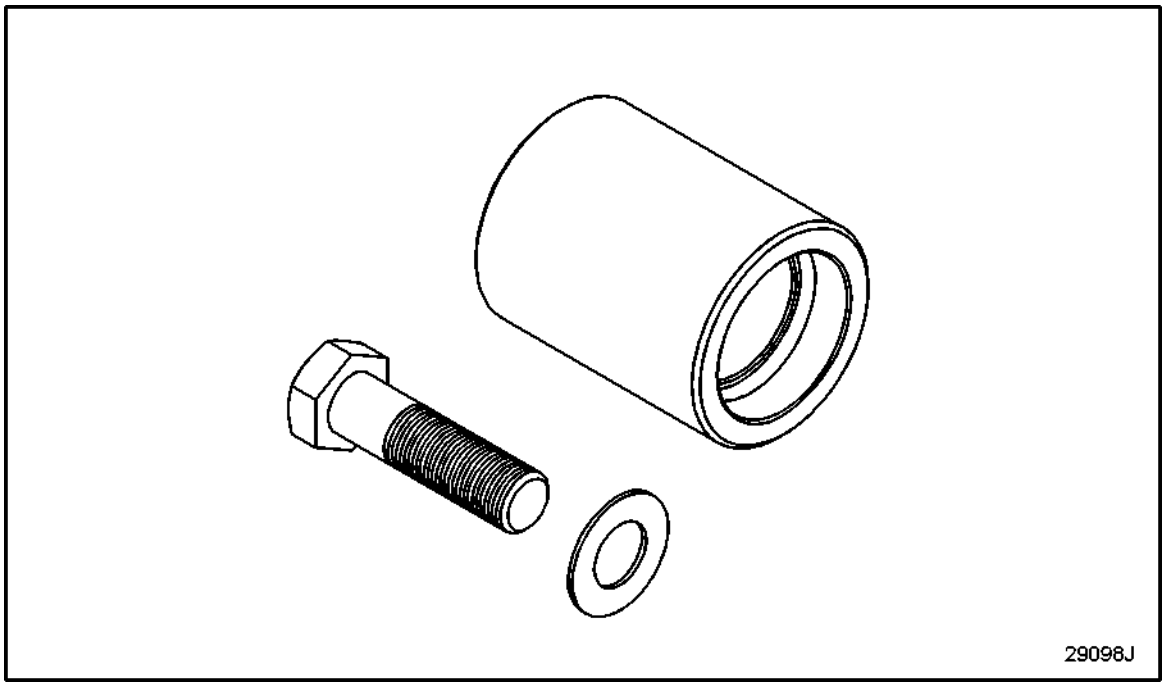


Figure 1359 Front Seal Sleeve Installer (6V-53),J 22524

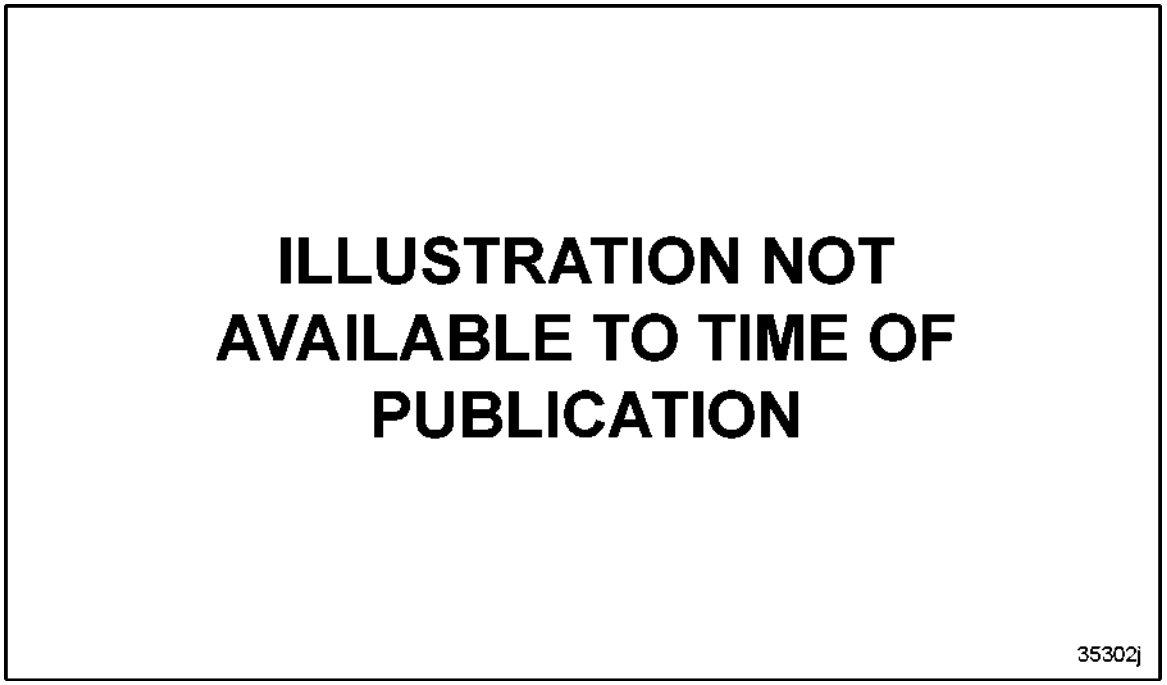


Figure 1360 Front Seal/Bearing Installer (STD),J 22518

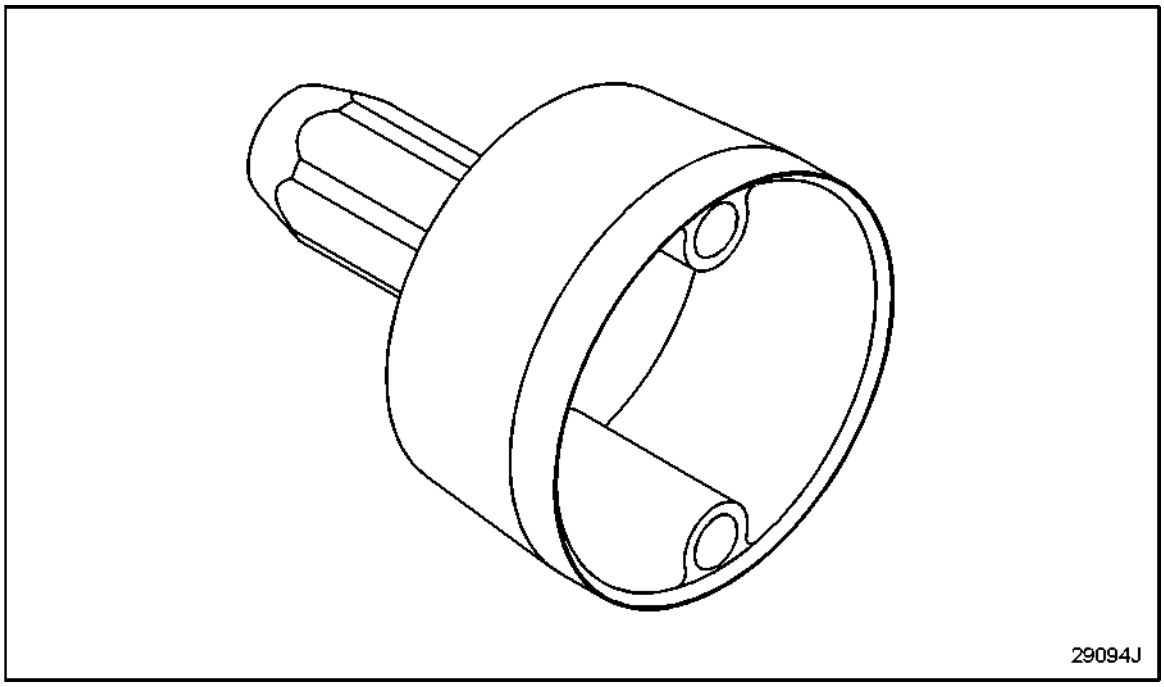


Figure 1361 Front/Rear Seal Expander,J 22425–B

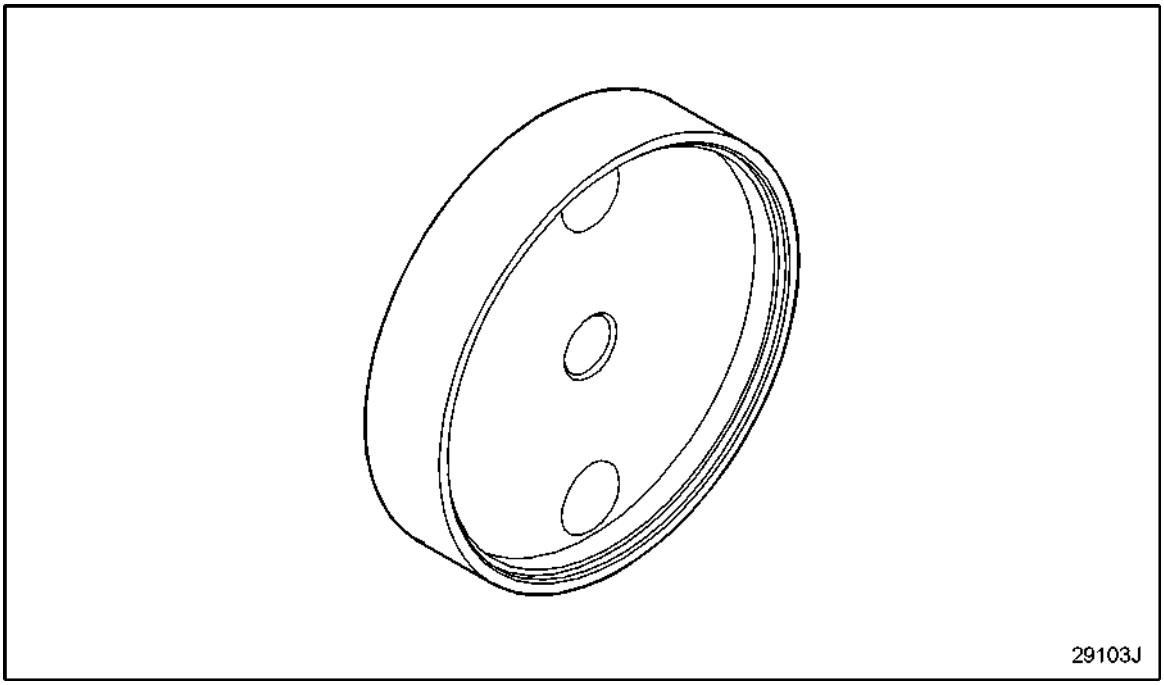


Figure 1362 Front/Rear Seal Installer,J 4194–01

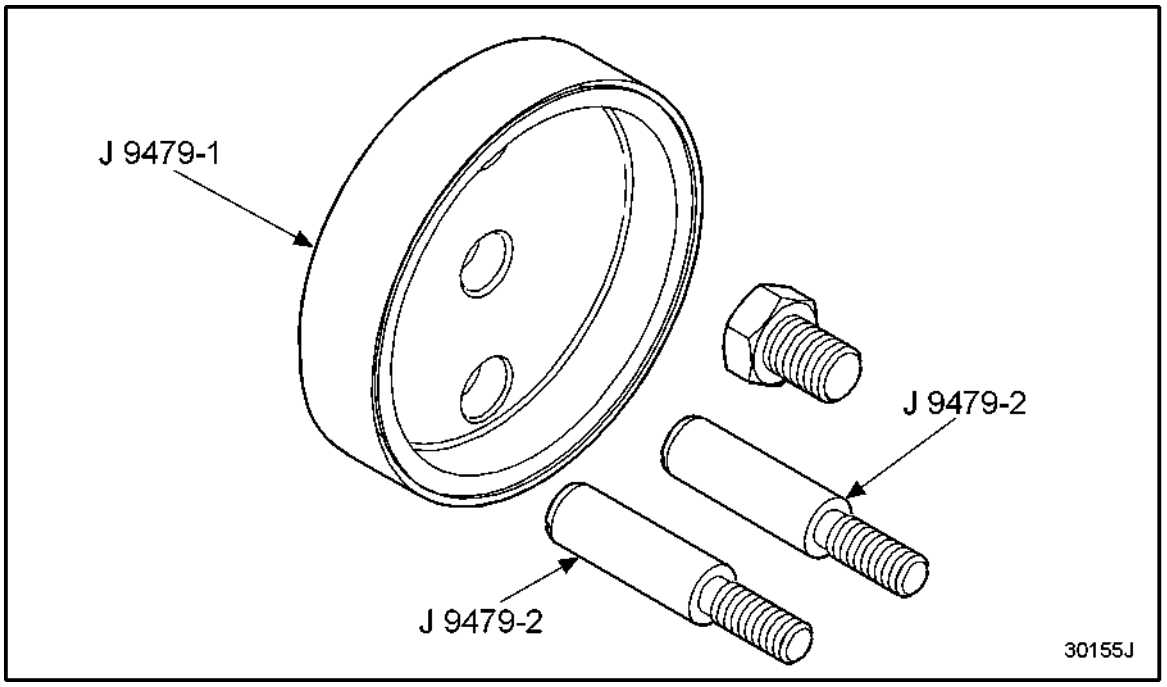


Figure 1363 Front/Rear Seal Installer, J 9727–A

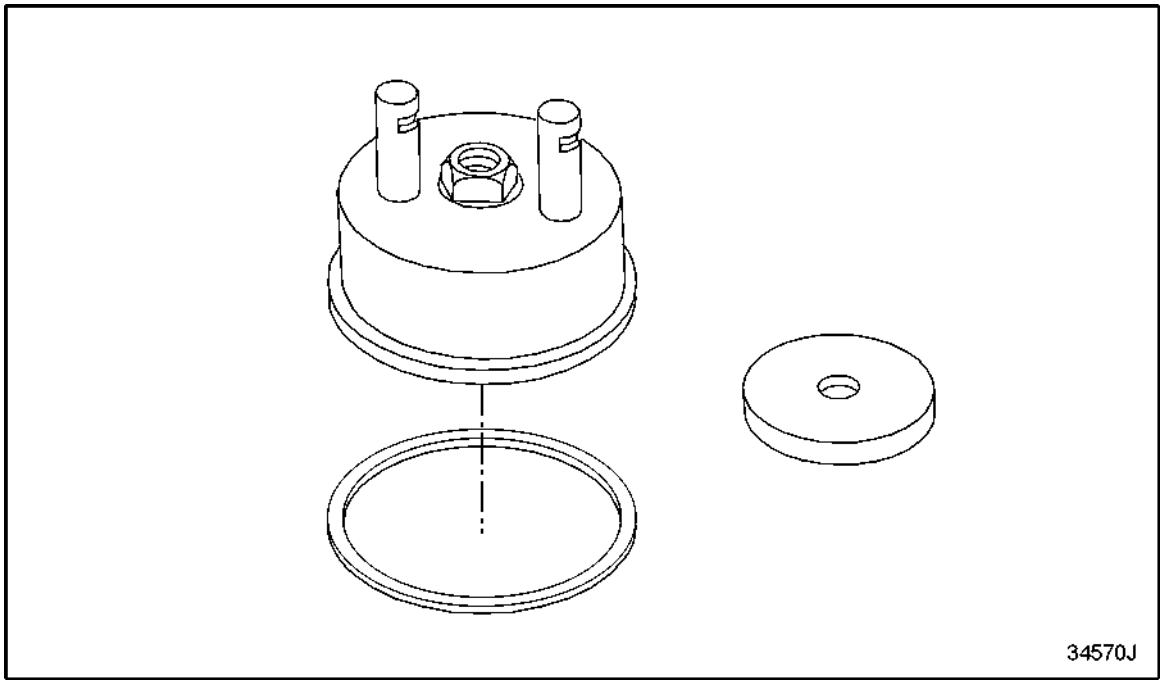


Figure 1364 Front/Rear Seal/Wear Sleeve Install , J 35686–A

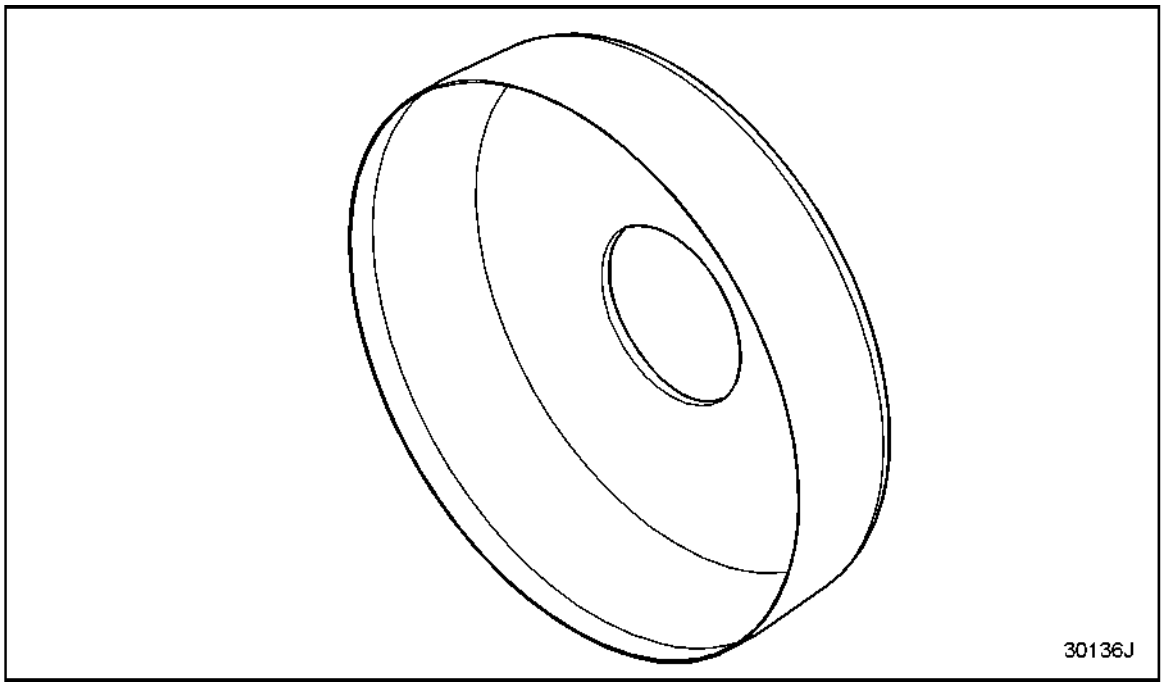


Figure 1365 FRT/RR Seal Expander (Oversize), J 4195–01

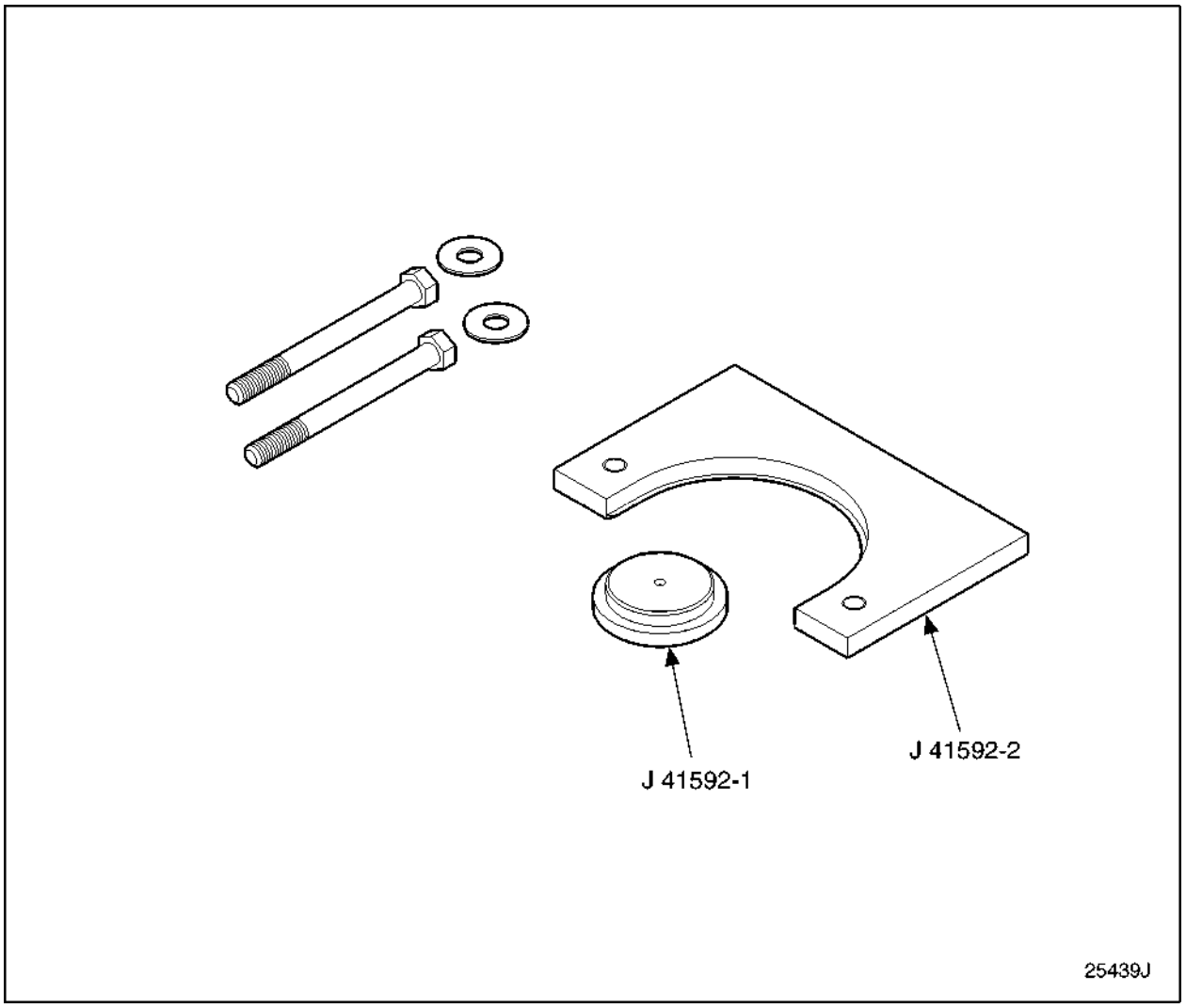


Figure 1366 Rear Crank Wear Sleeve Remover, J 41592

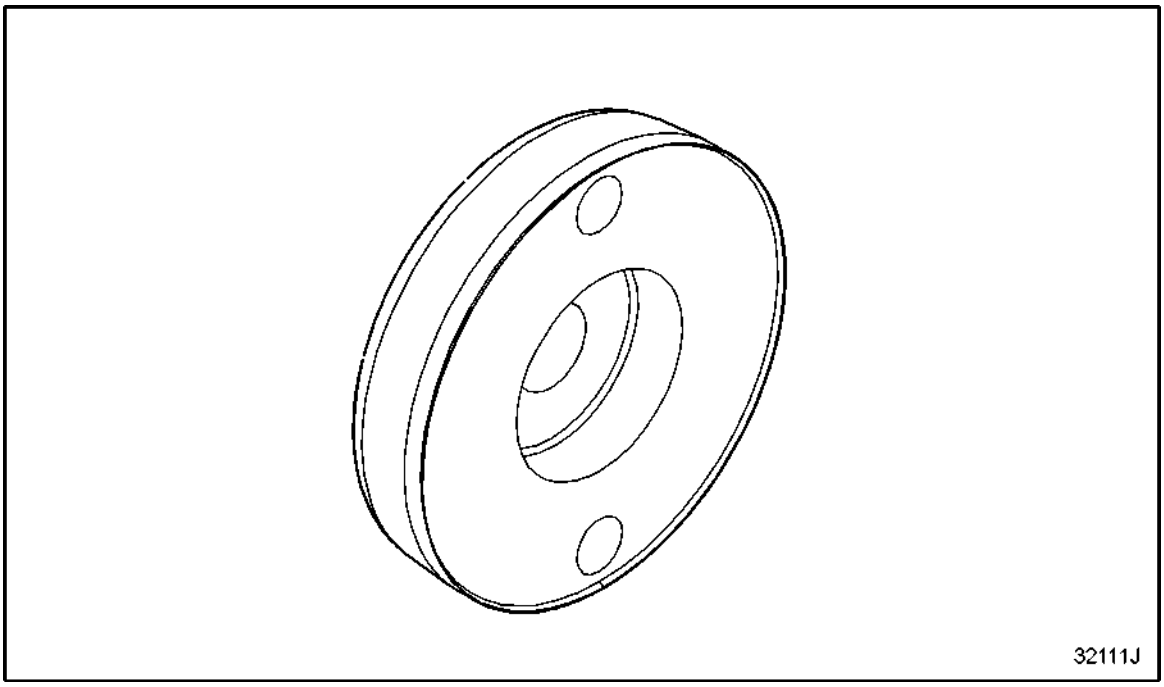


Figure 1367 Rear Seal Expander,J 4239

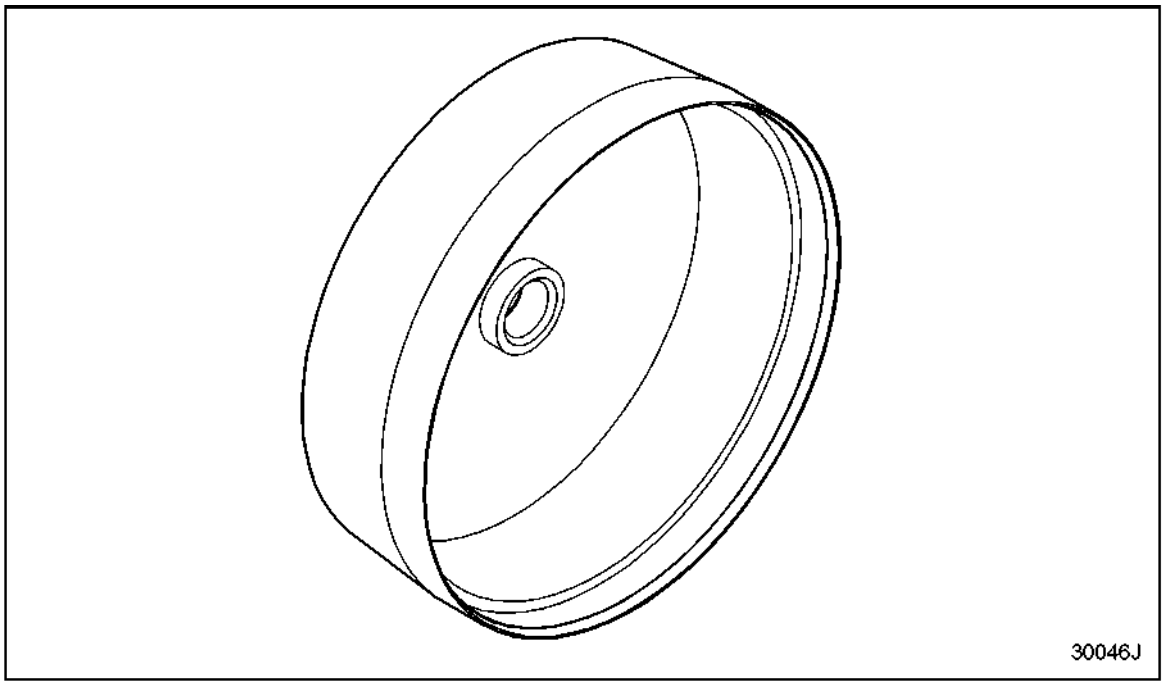


Figure 1368 Rear Seal Expander (Oversize Seal),J 22766

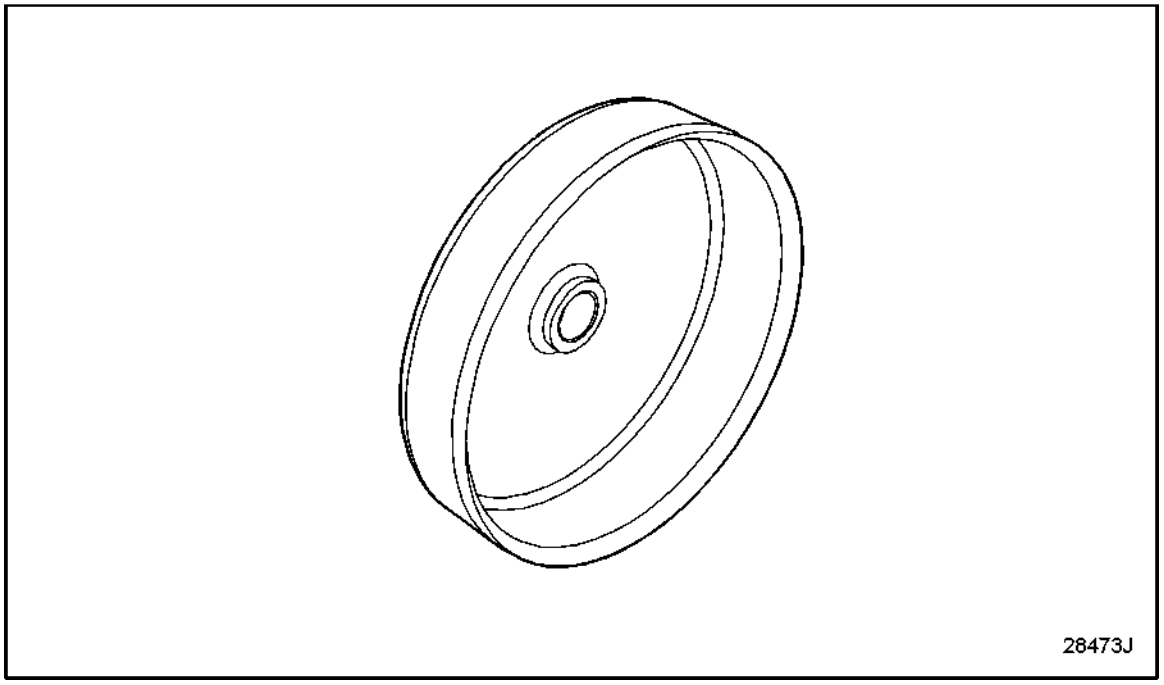


Figure 1369 Rear Seal Expander (Standard Seal), J 22605

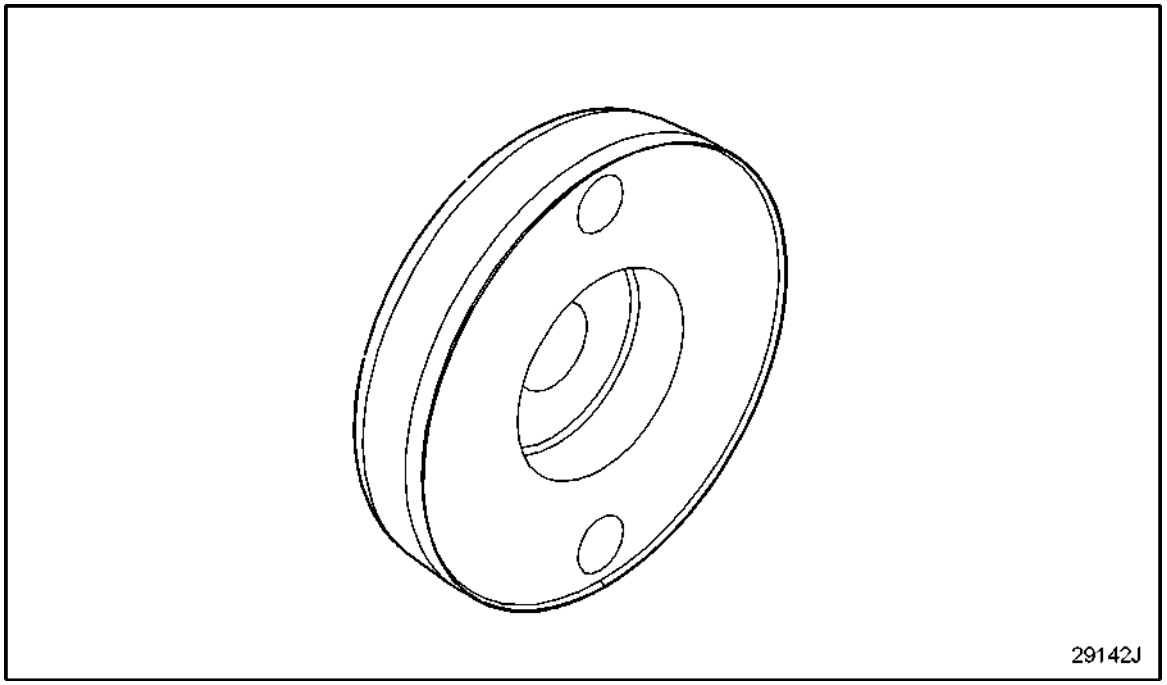


Figure 1370 Rear Seal Expander (STD Seal), J 29009–A

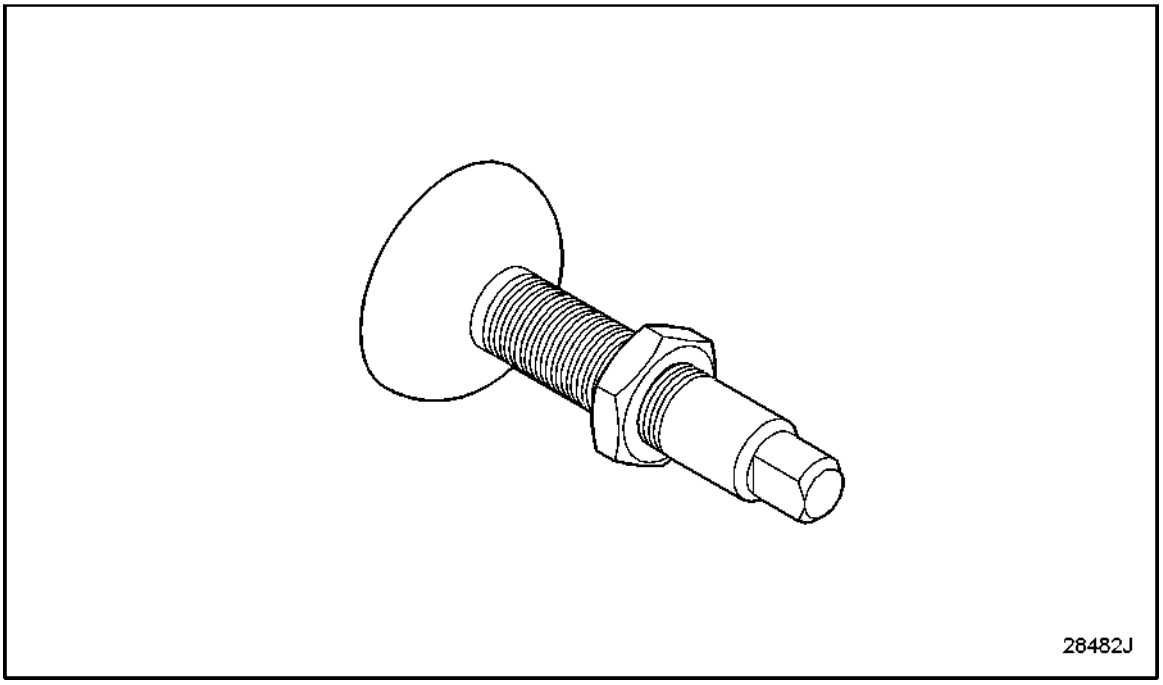


Figure 1371 Rear Seal Expander Adapter, J 23341

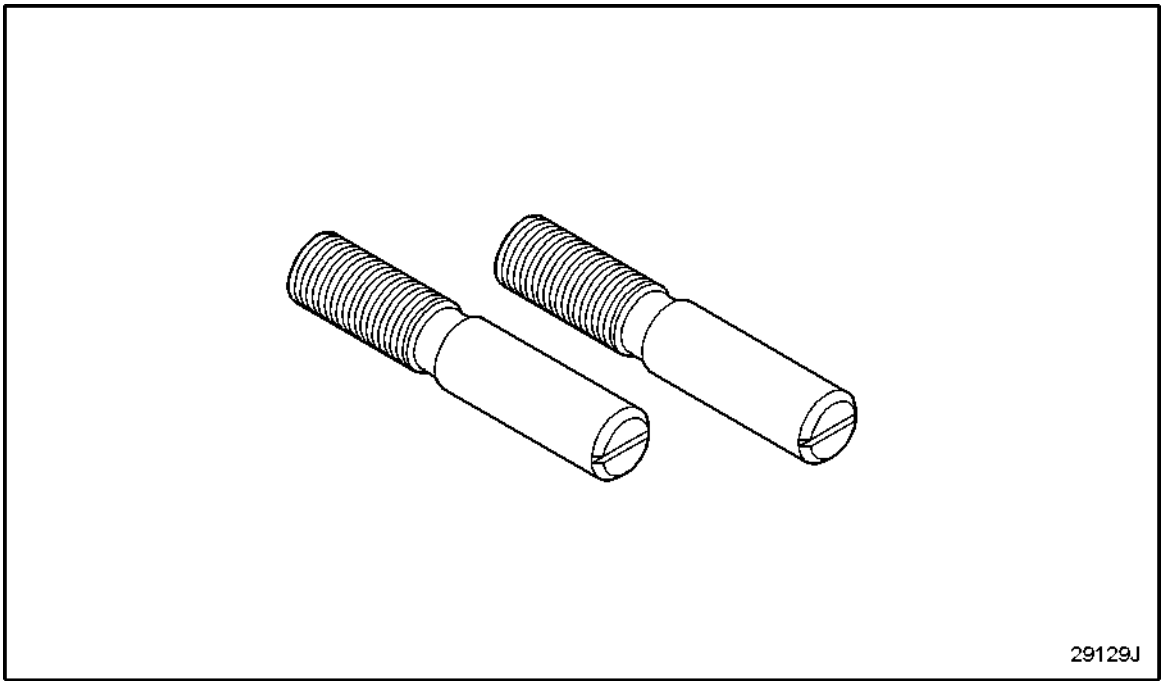


Figure 1372 Rear Seal Expander Guide Studs, J 25002

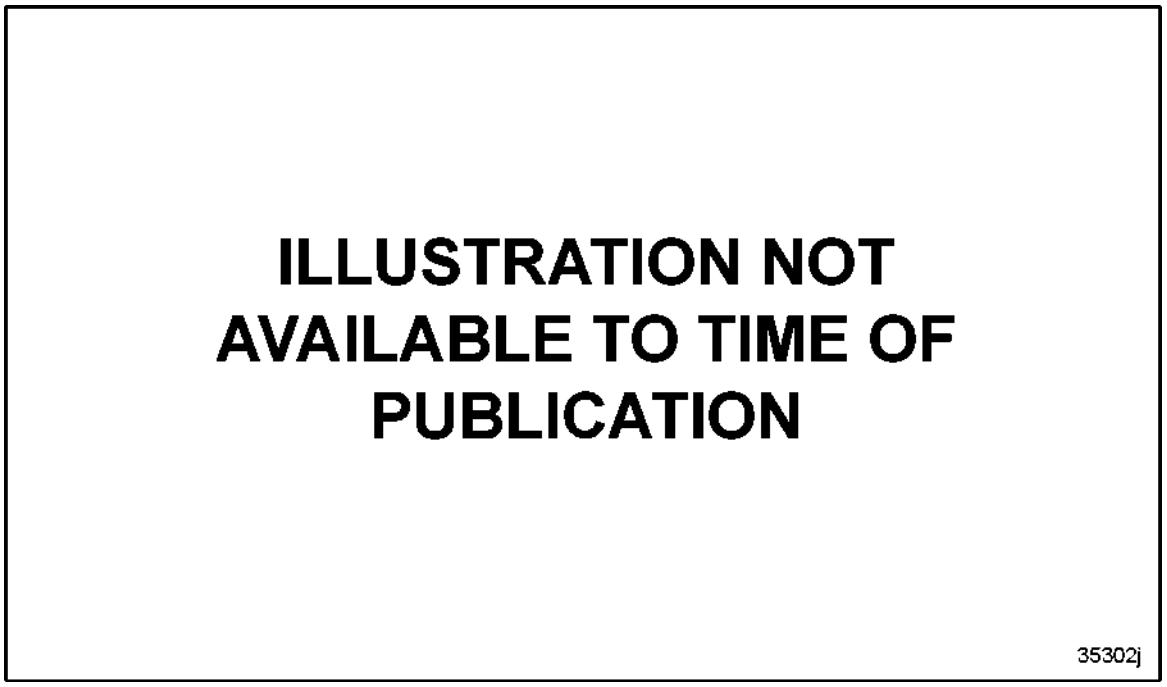


Figure 1373 Rear Seal Expander (STD Seal 536V-53), J 9769

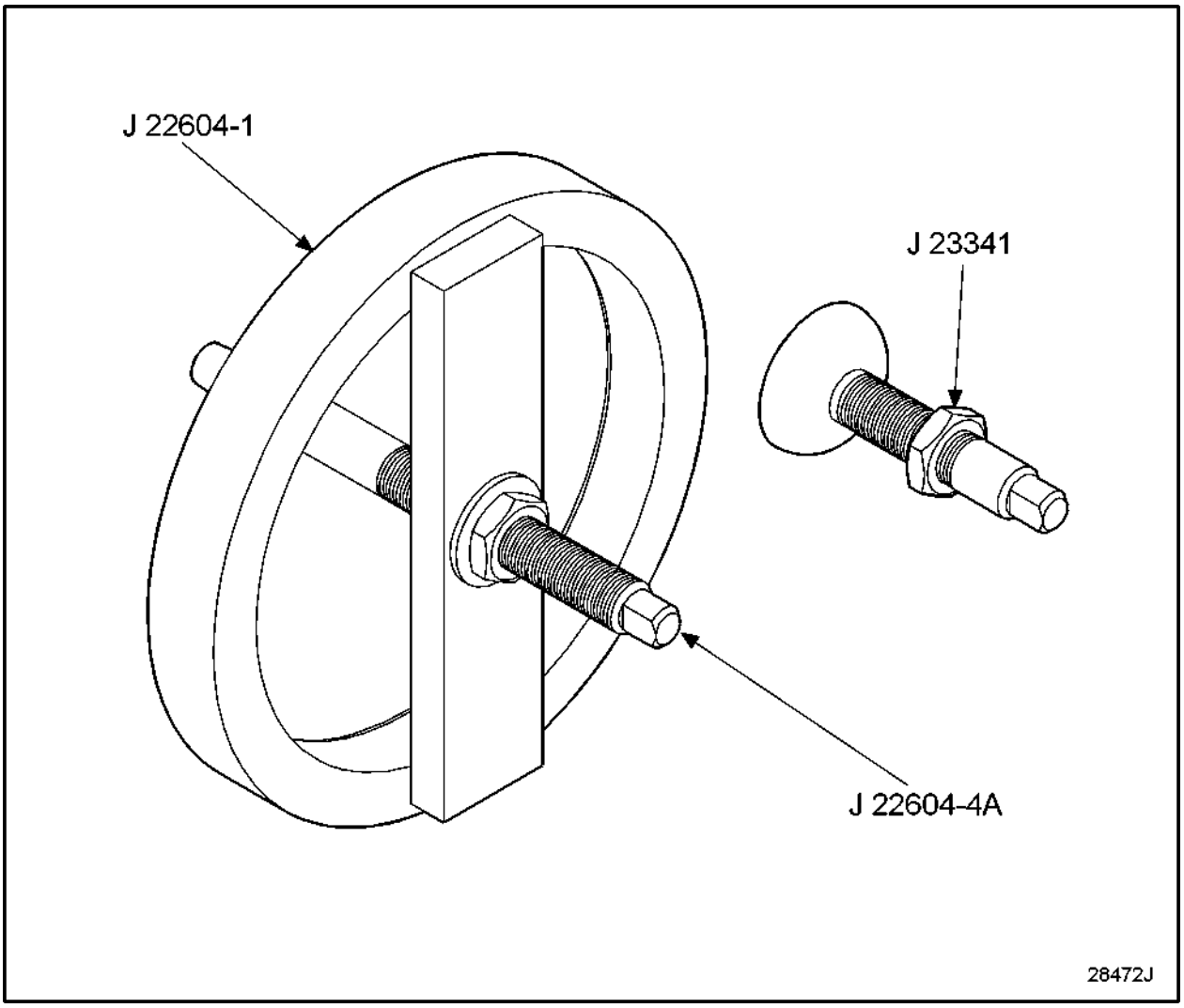


Figure 1374 Rear Seal Insert (STD SL) Cup PLG REM, J 22604–B

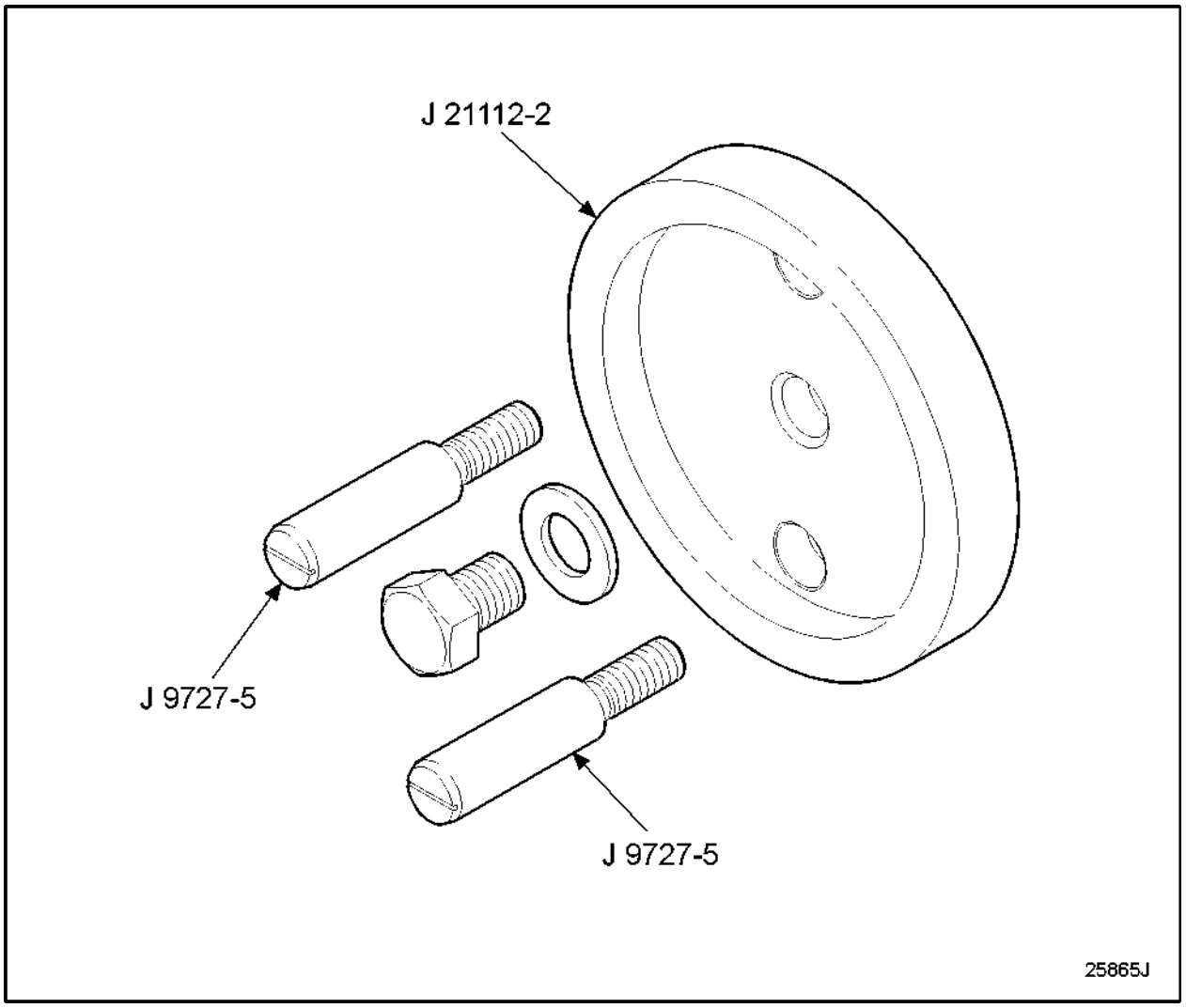


Figure 1375 Rear Seal Instal (Except 6,8,12V71),J 21112–B

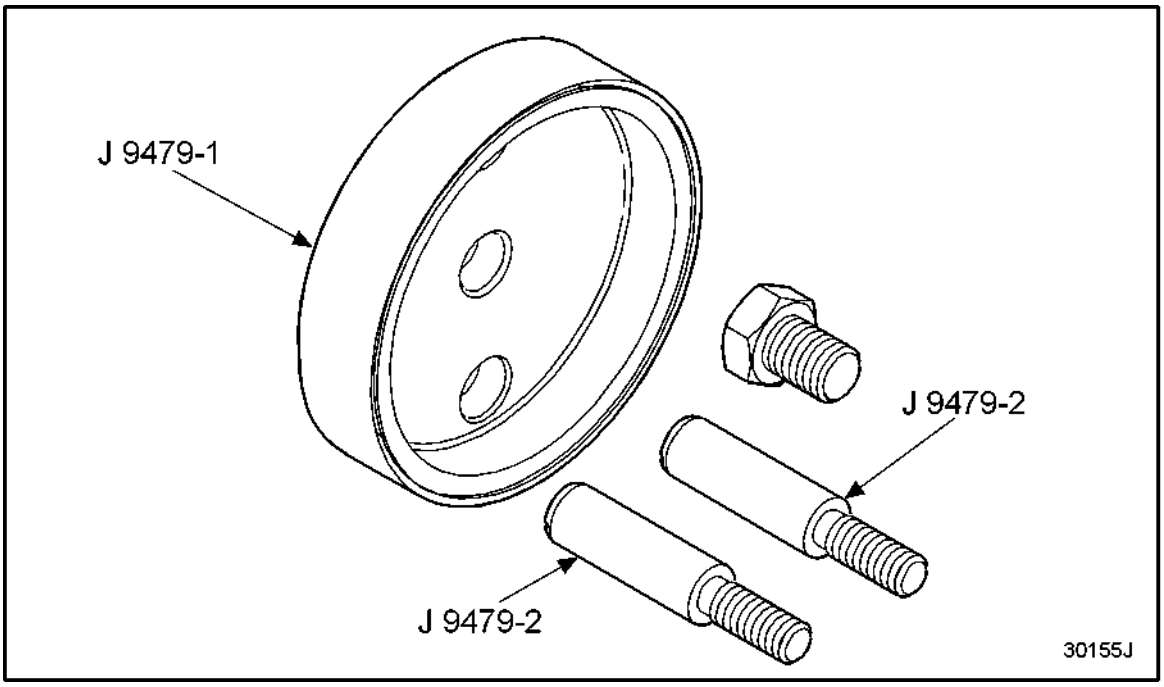


Figure 1376 Rear Seal Install (STD Seal 53,6V-53),J 9479

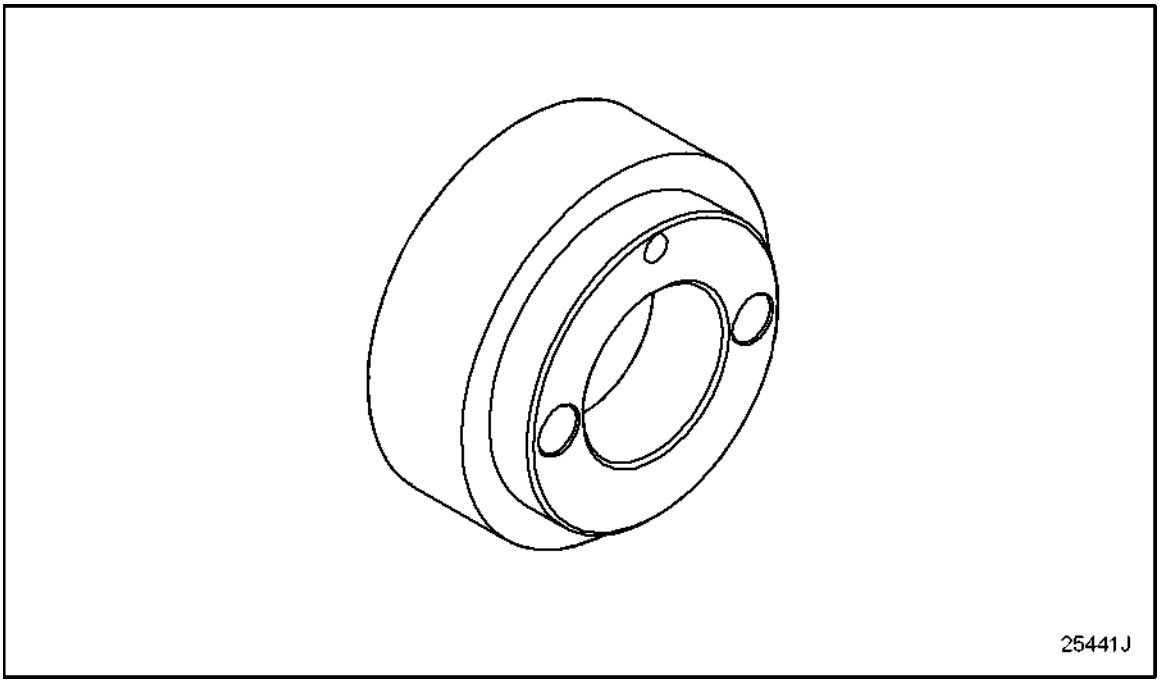


Figure 1377 Rear Seal Installer,J 41596

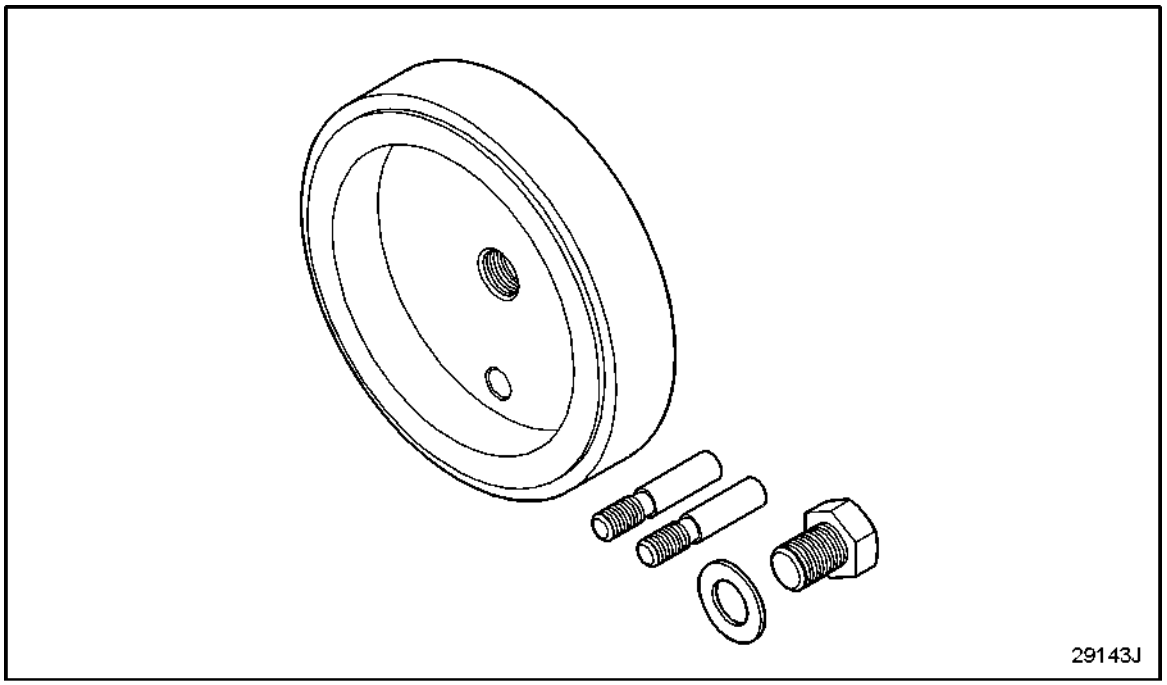


Figure 1378 Rear Seal Installer (STD Seal), J 29010–B

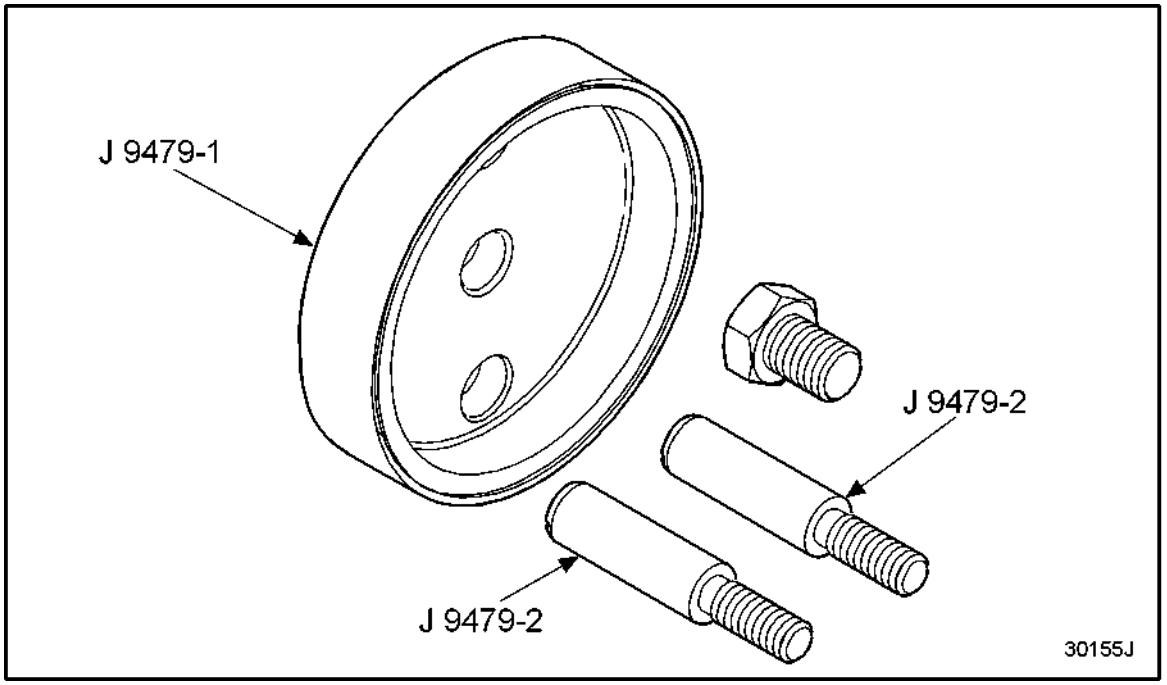


Figure 1379 Rear Seal Installer Guide Studs, J 9727–2

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Figure 1380 Rear Seal Installer Guide Studs,J 9727–5

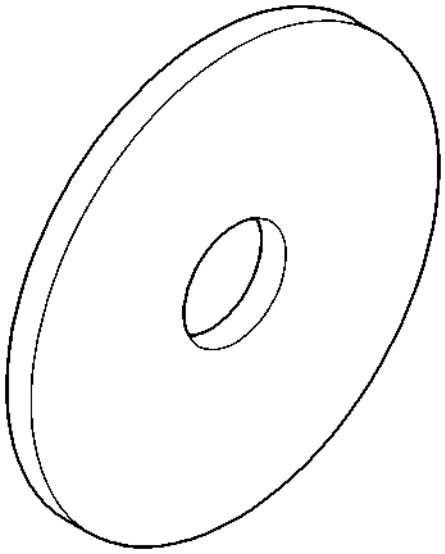

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Figure 1381 Rear Seal Installer & Remover Set,J 3154–04

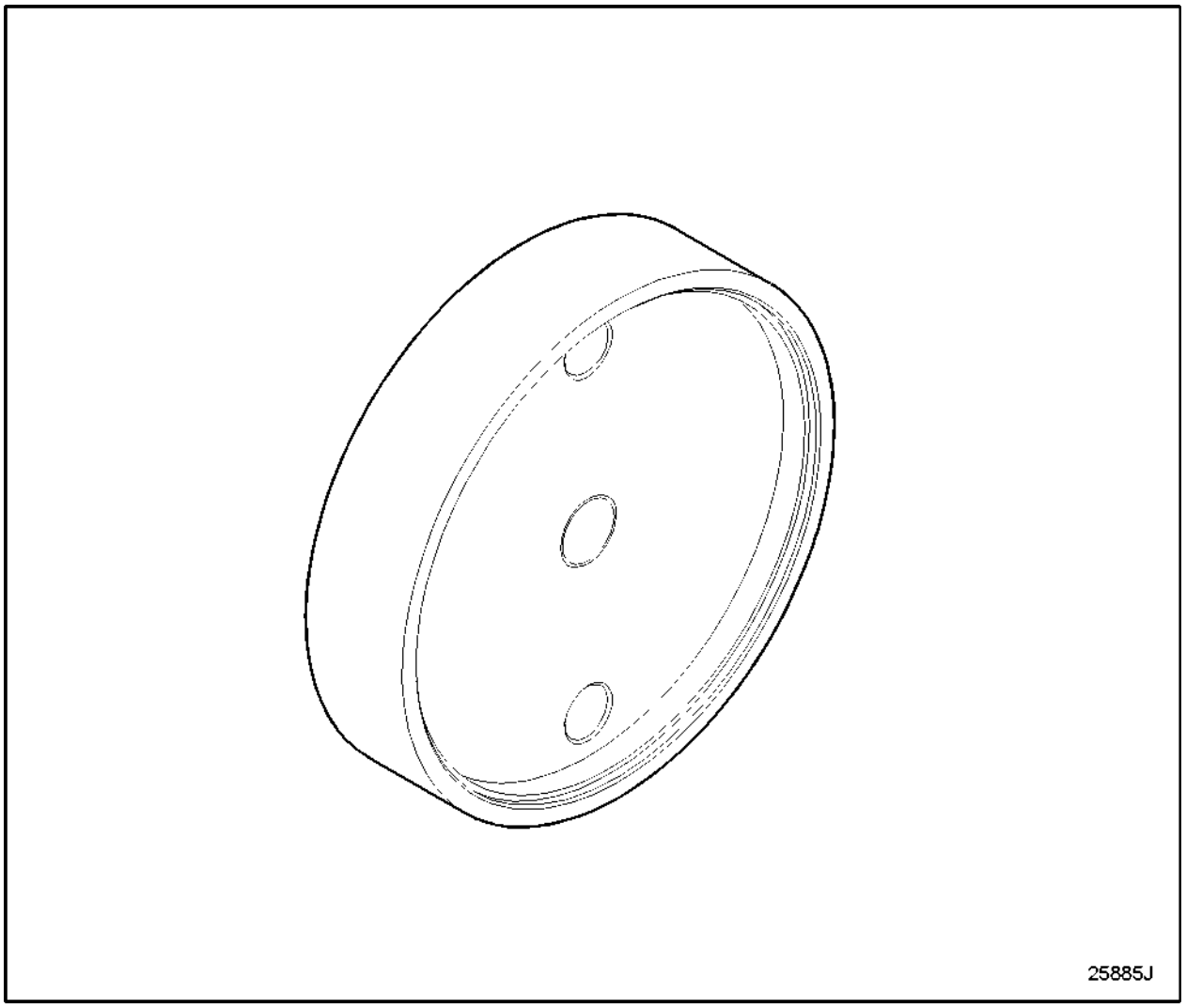

Figure 1382 Rear Seal Sleeve Installer,J 21983

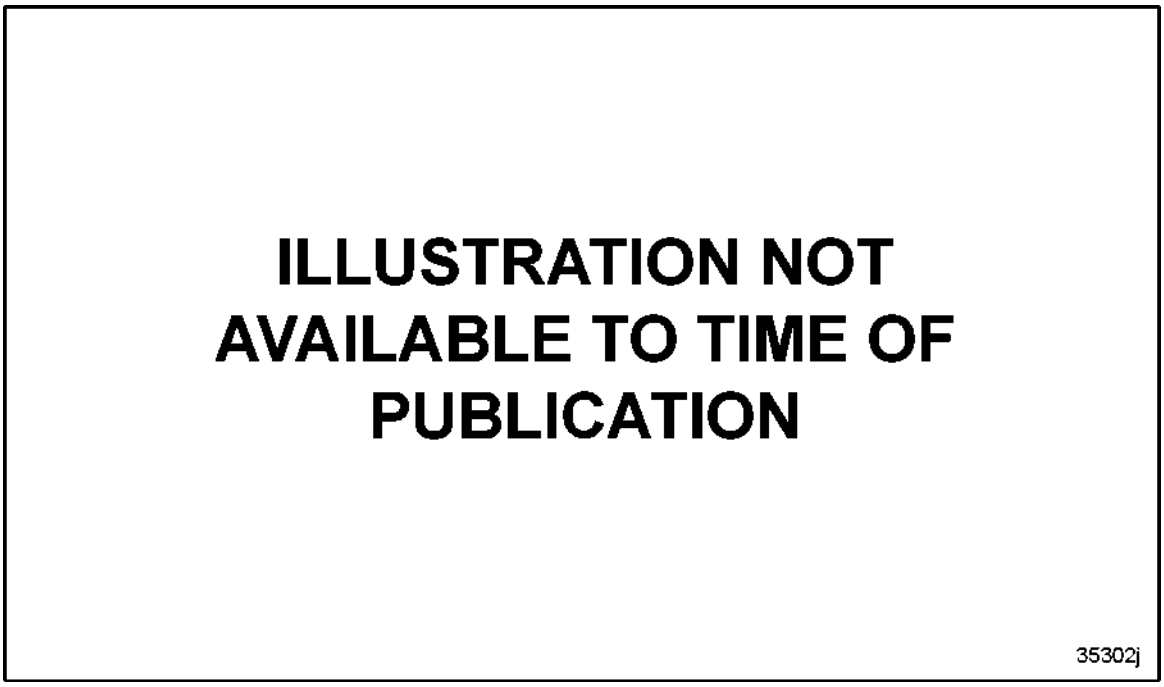

Figure 1383 Rear Seal Sleeve Installer, J 22676

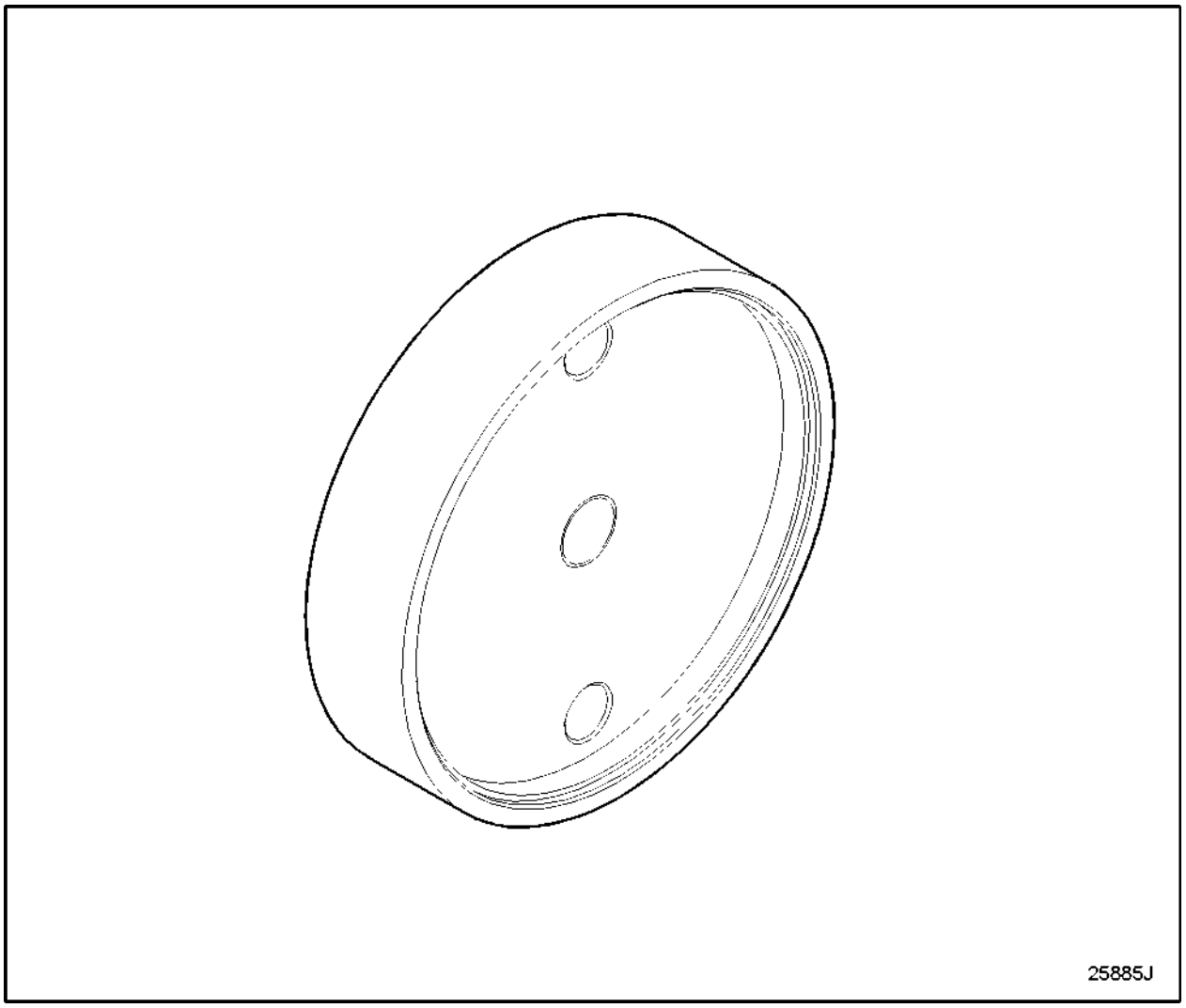

Figure 1384 Rear Seal Sleeve Installer,J 33426

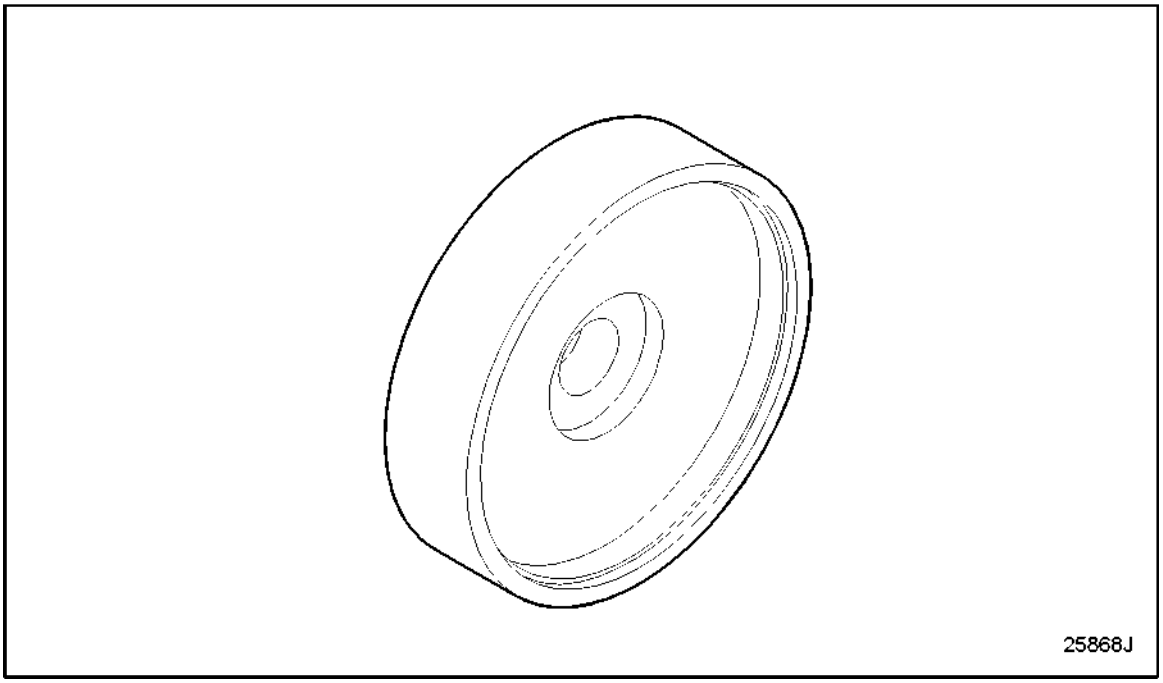

Figure 1385 Rear Seal Sleeve Installer (6V53), J 21277

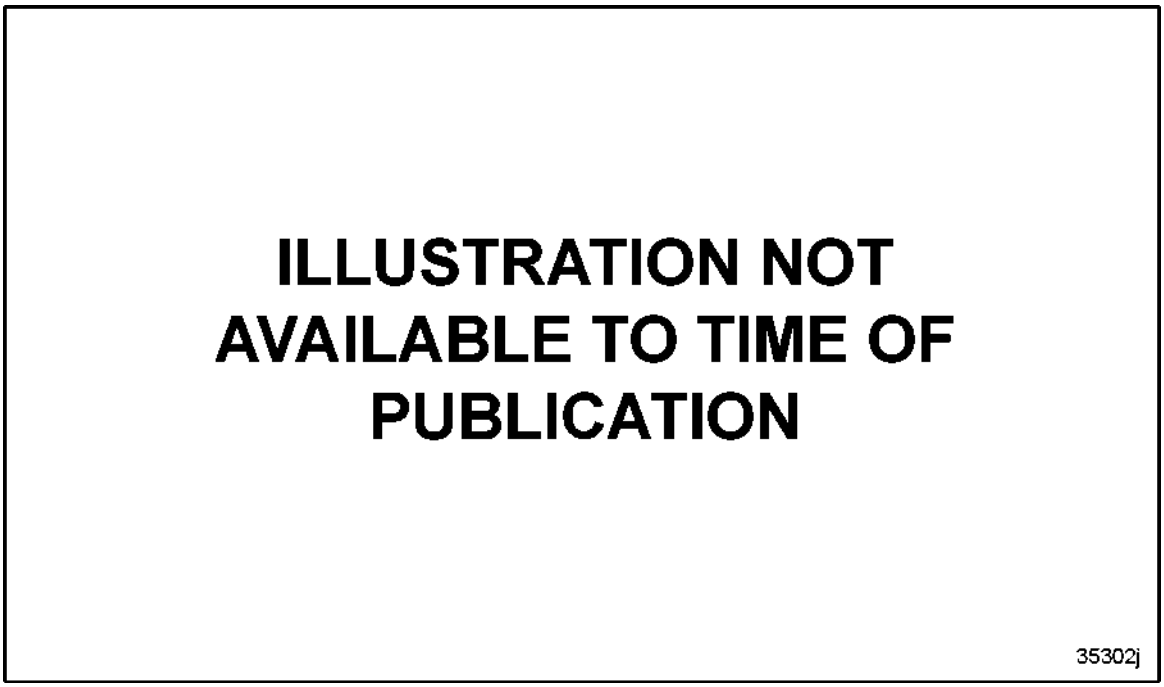

Figure 1386 Rear Seal /Sleeve Installer, J 41163

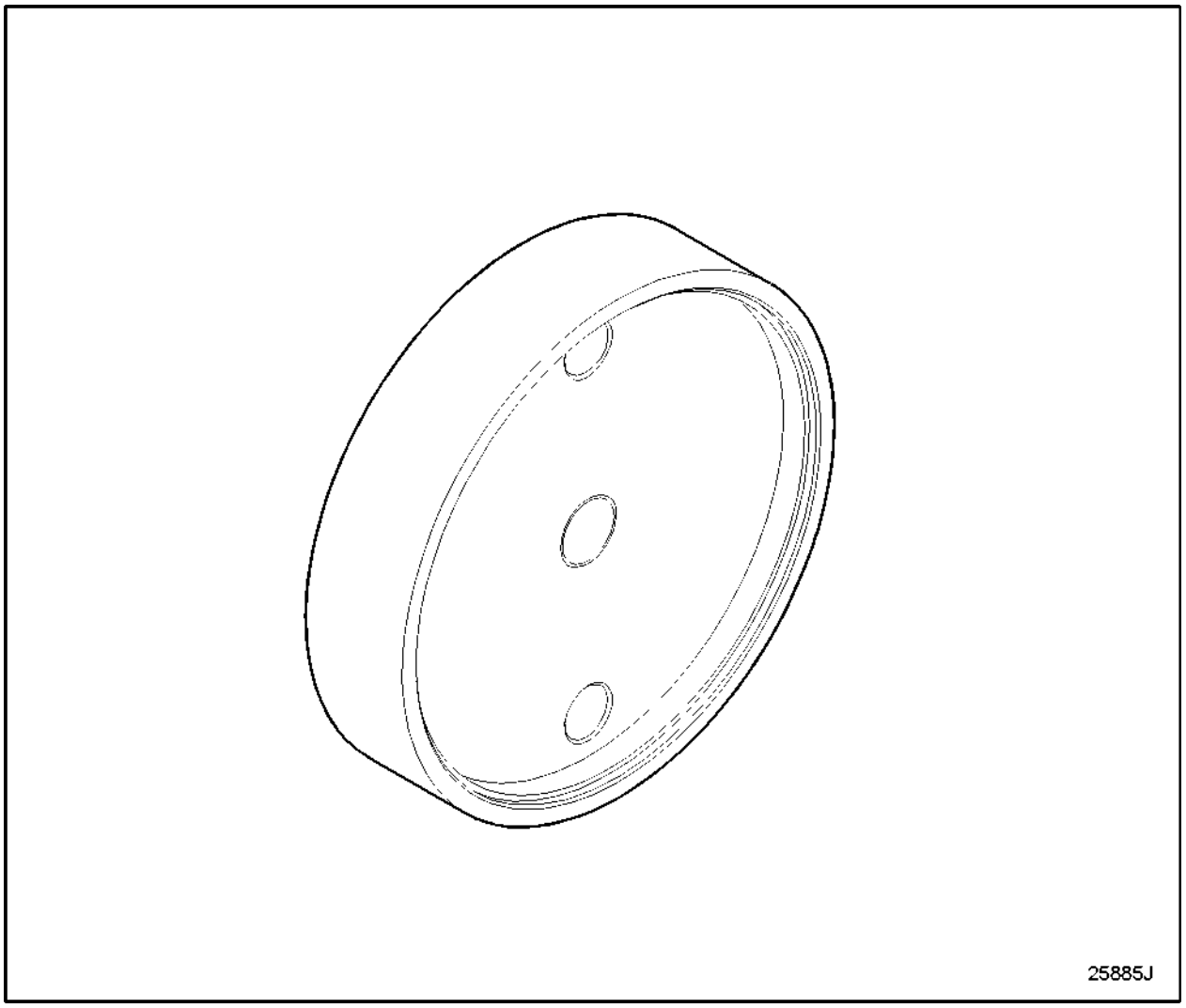

Figure 1387 Seal Expander (Oversize Seal), J 33873

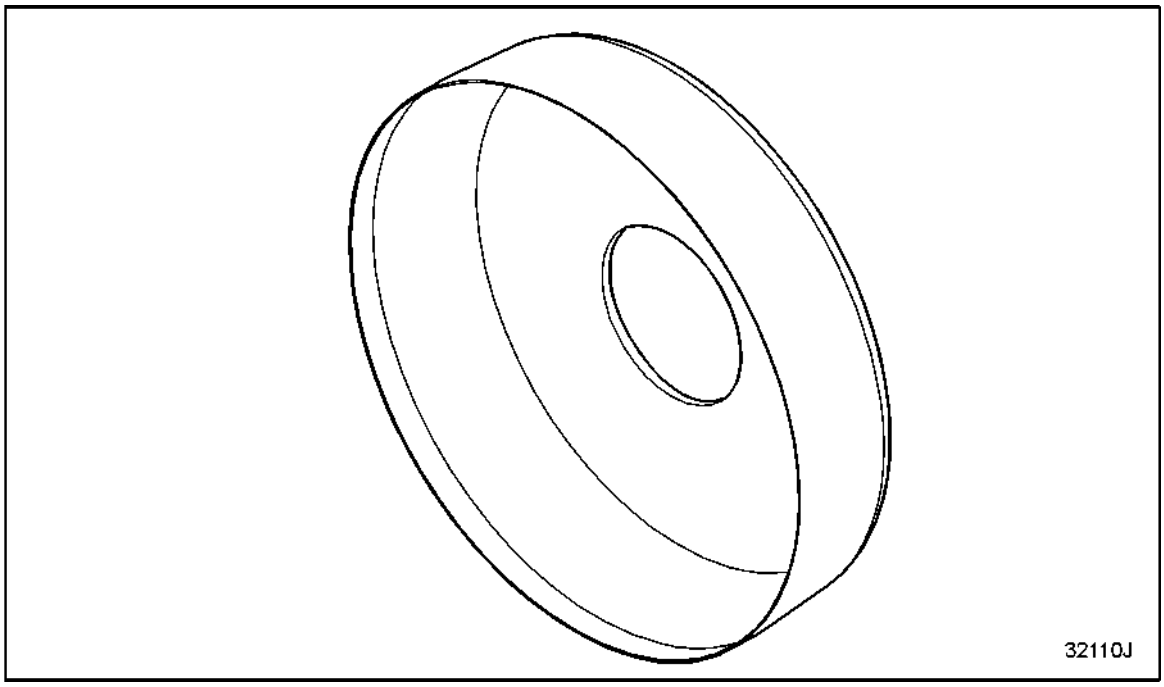

Figure 1388 Seal Expander O S (EX 6,8,12V71), J 8682

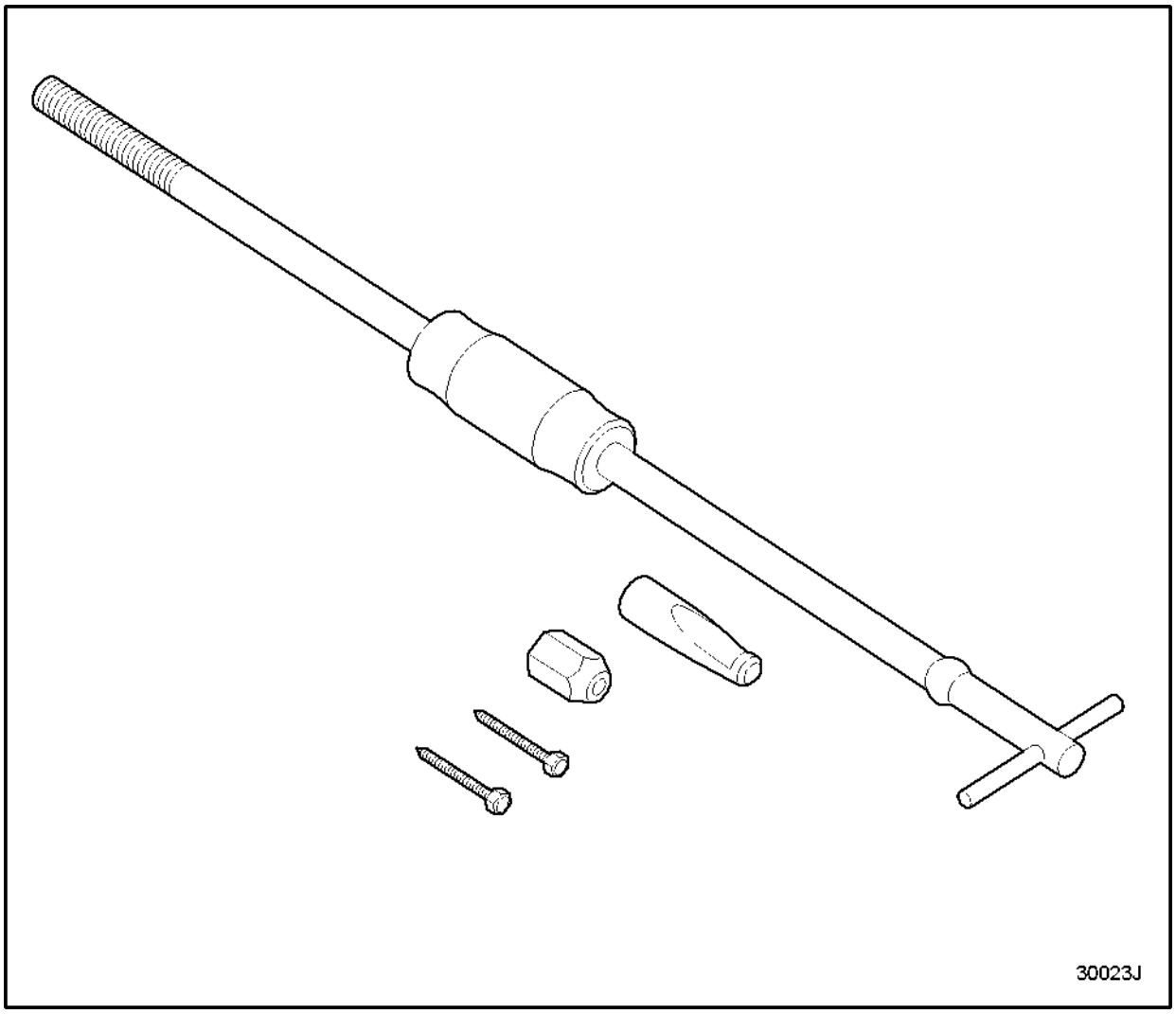

Figure 1389 Seal Remover,J 24171–A

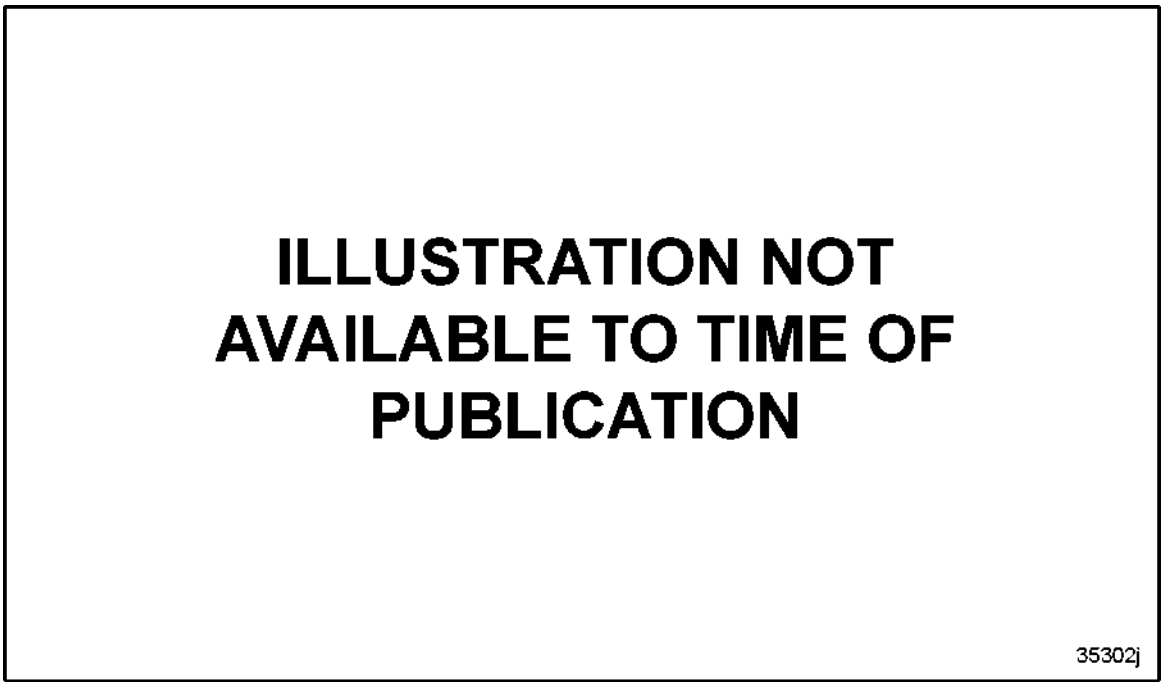

Figure 1390 Seal/Wear Sleeve Installer,J 39184

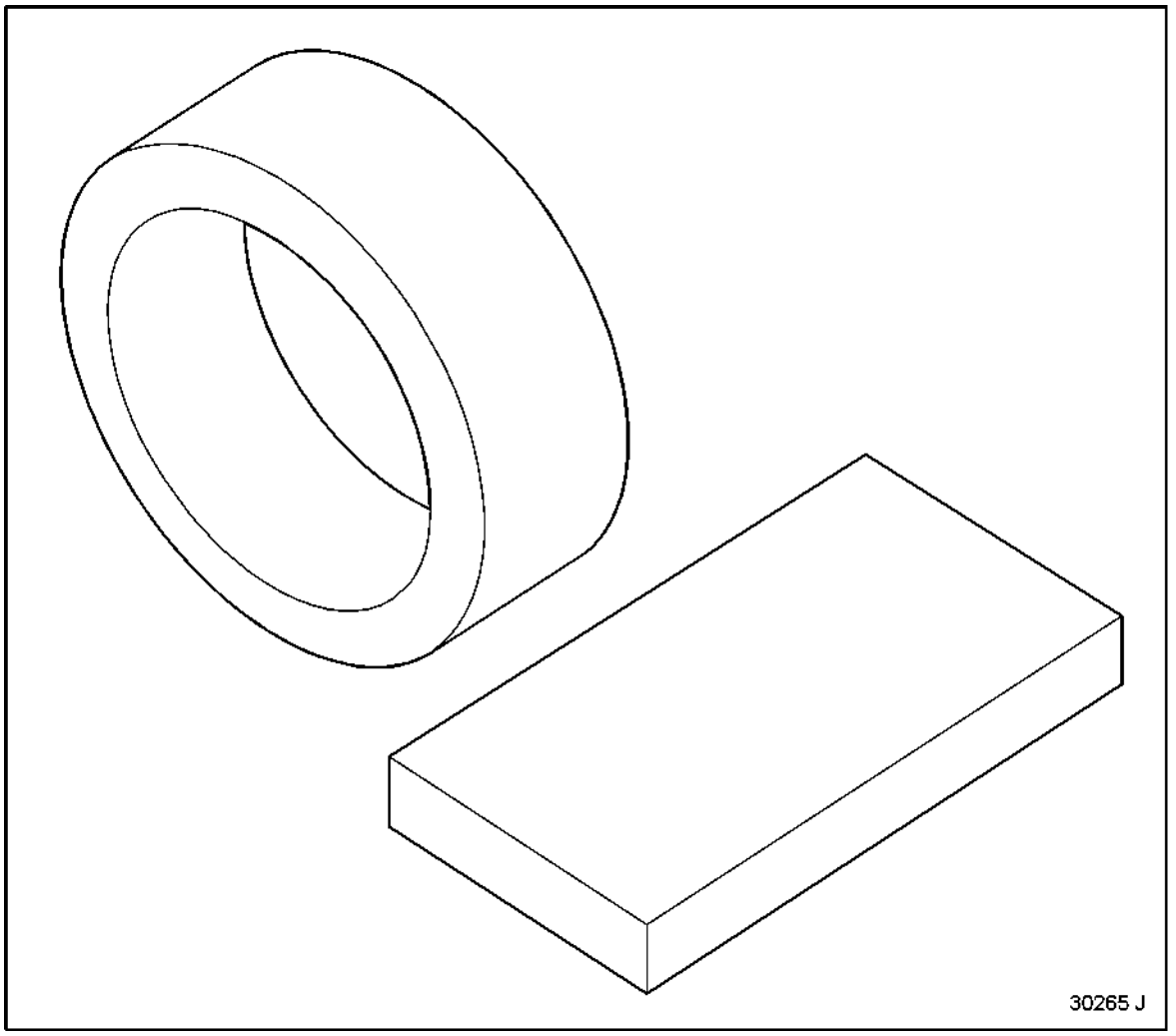

Figure 1391 Wear Sleeve Installer,J 39266

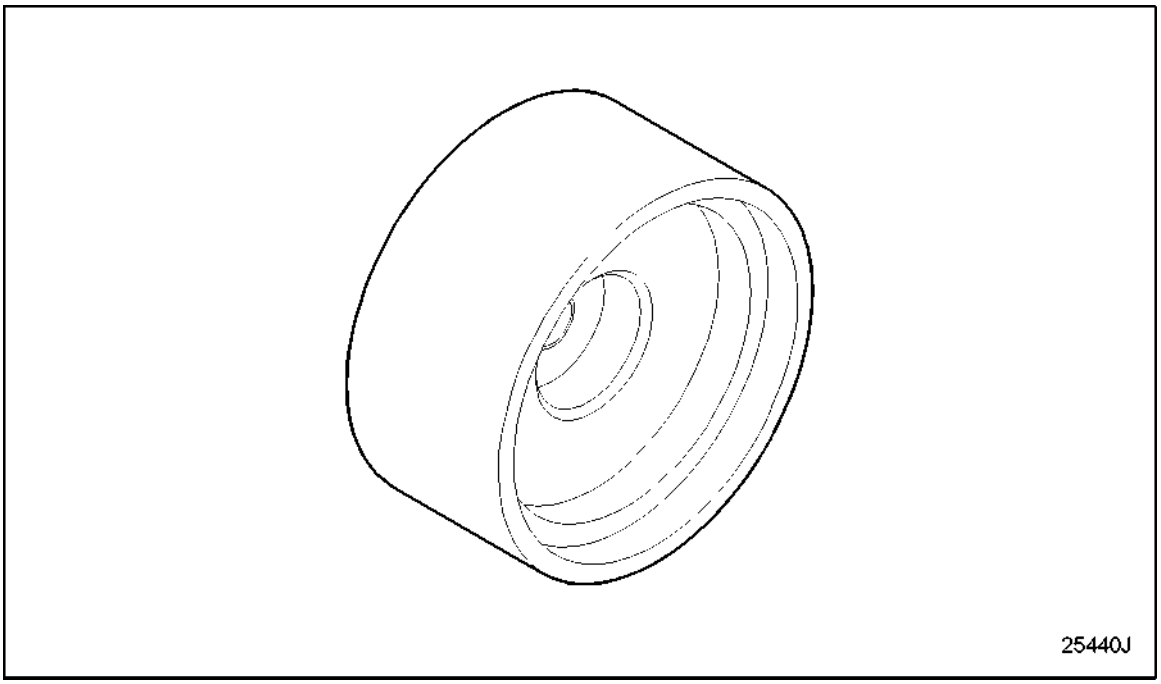

Figure 1392 Wear Sleeve Installer-FRT/RR Crank,J 41593

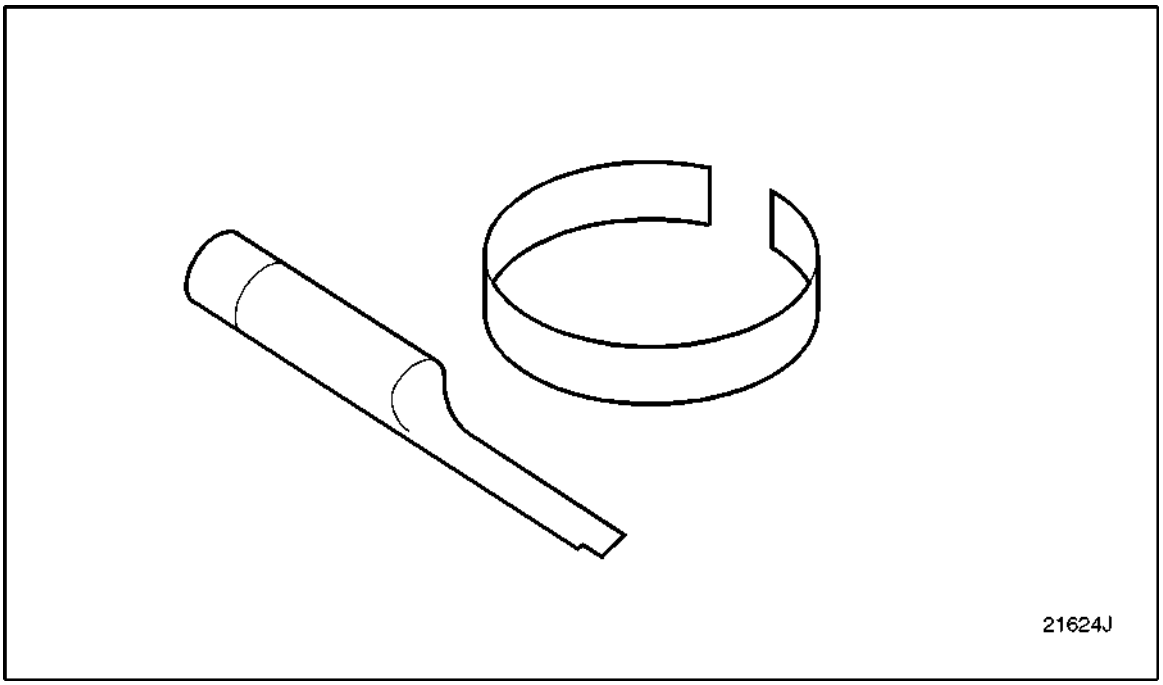

Figure 1393 Wear Sleeve Remover,J 37075–A

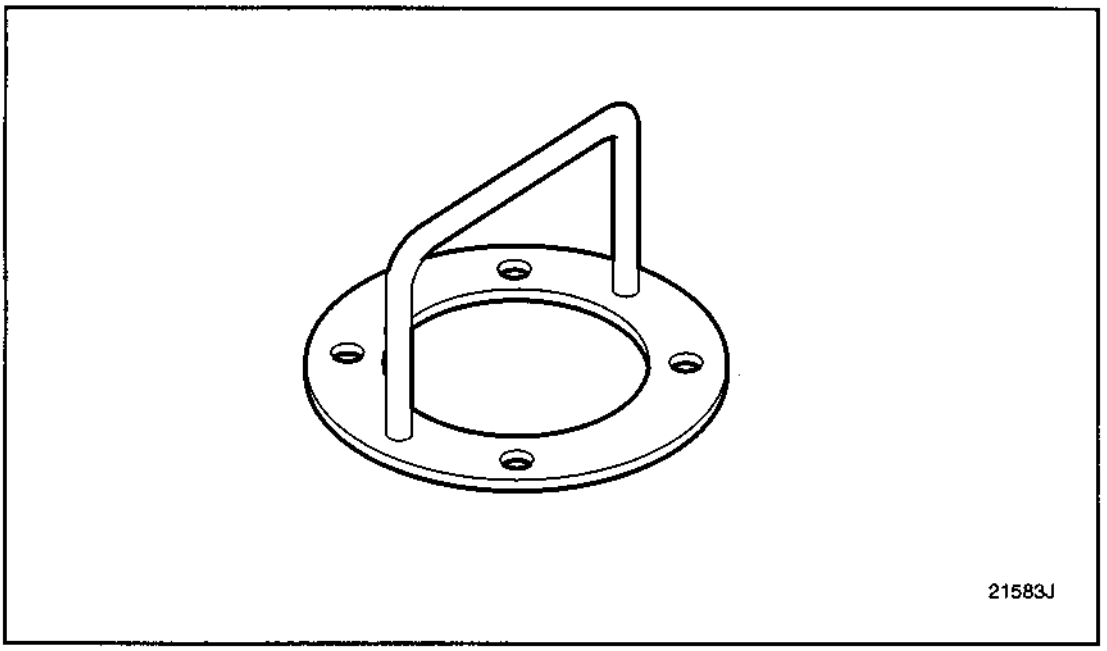

Figure 1394 Gear Case To Block Alignment Tool,J 35651

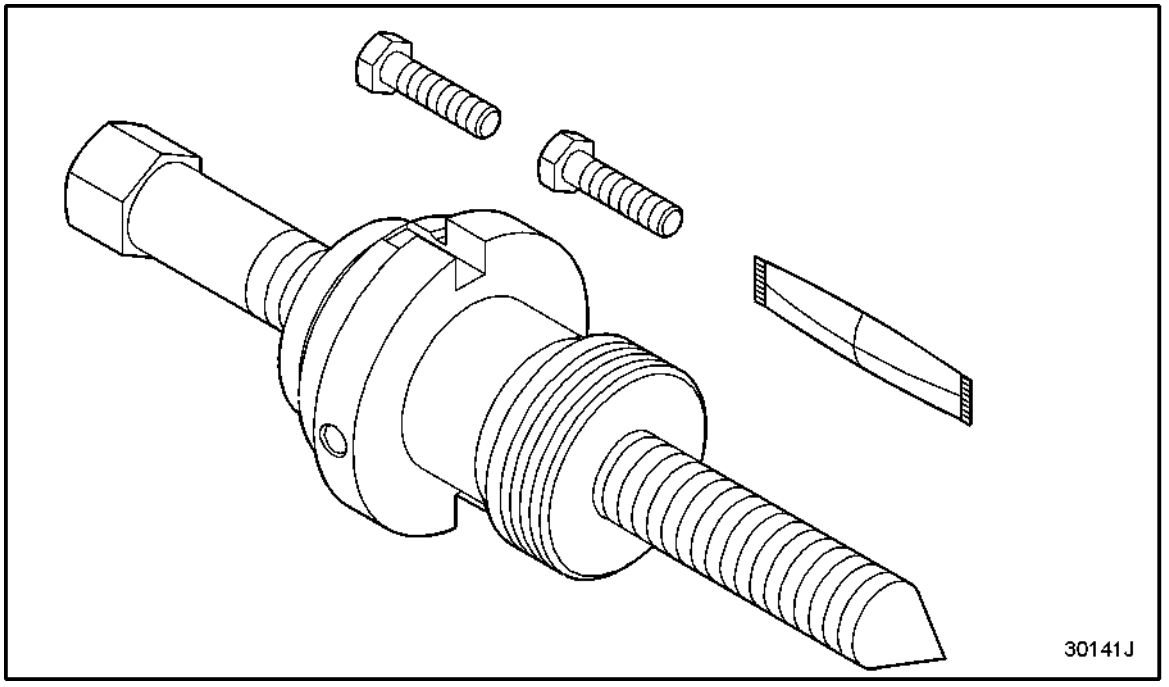

Figure 1395 Puller Remover (Rubber Bushed),J 5356

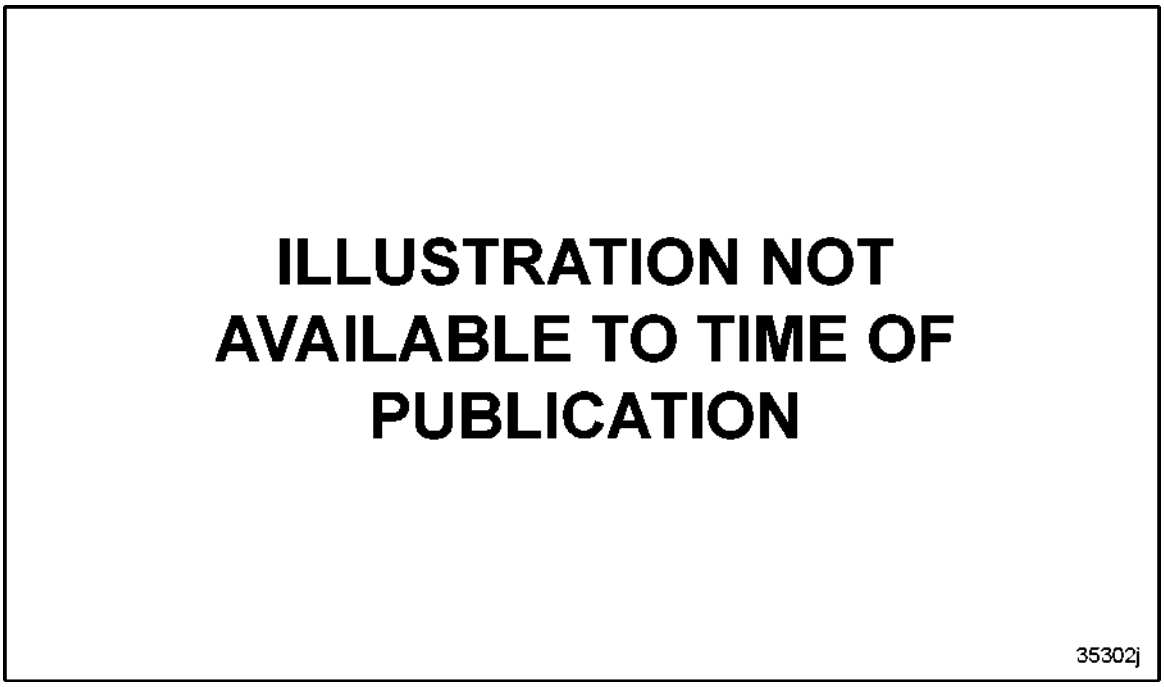

Figure 1396 Pulley & Gear Remover/Installer Set,J 29025–A

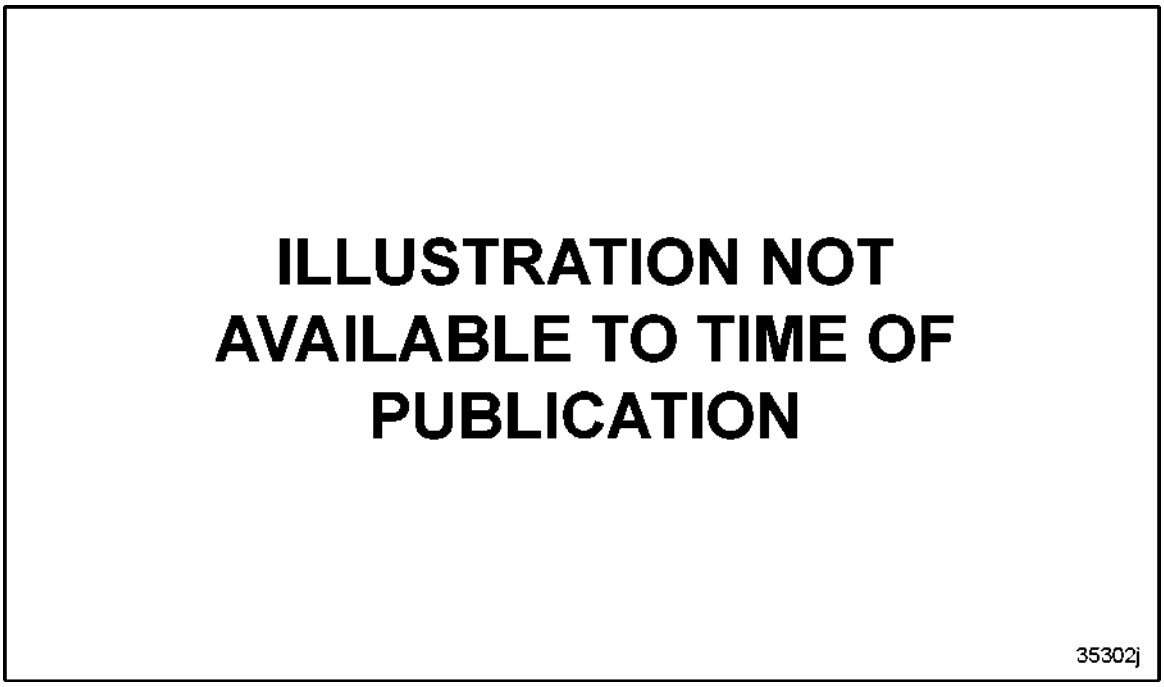

Figure 1397 Pulley Installer Set,J 7773

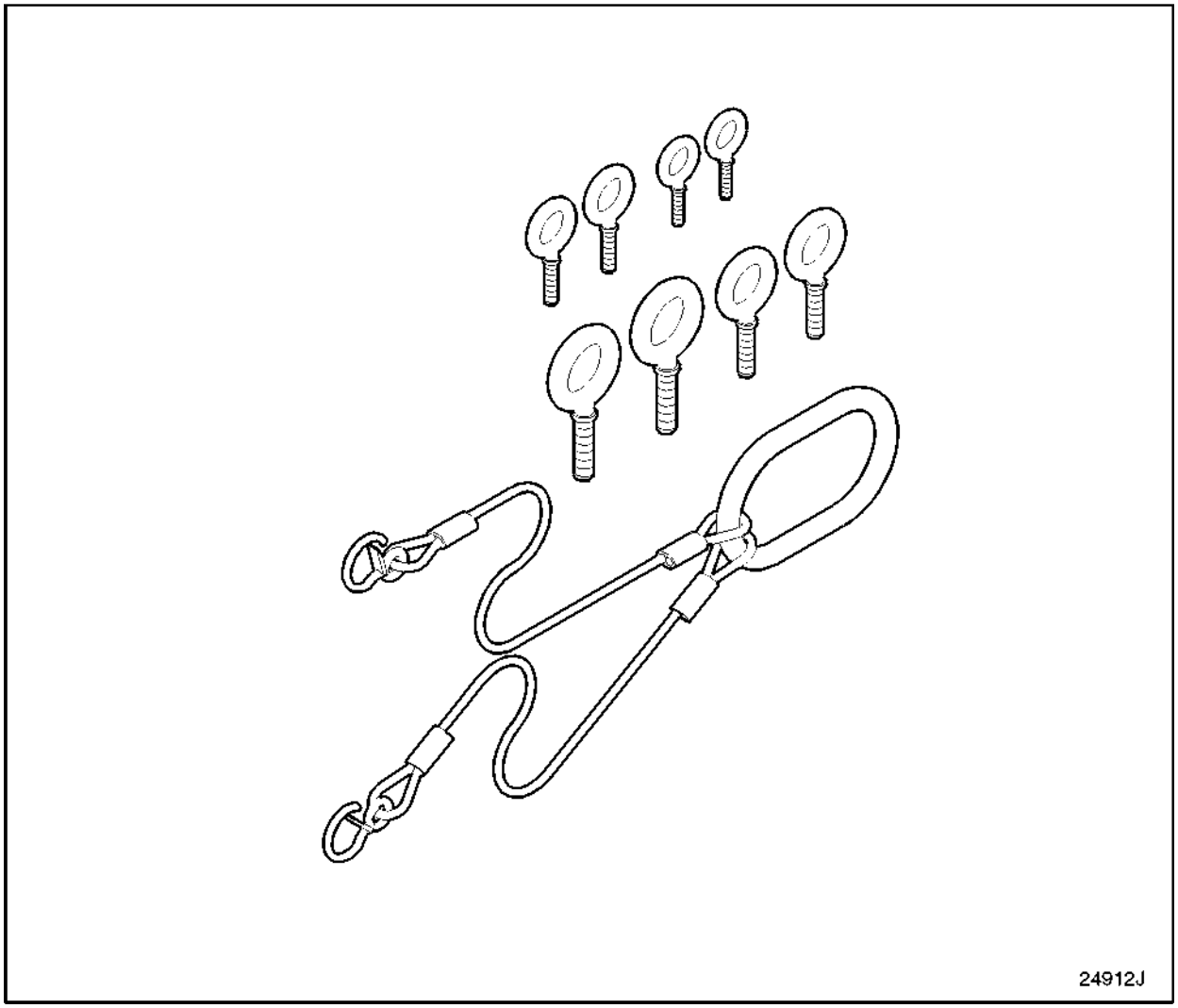

Figure 1398 Eye Bolts (2 Pcs), J 25026–2

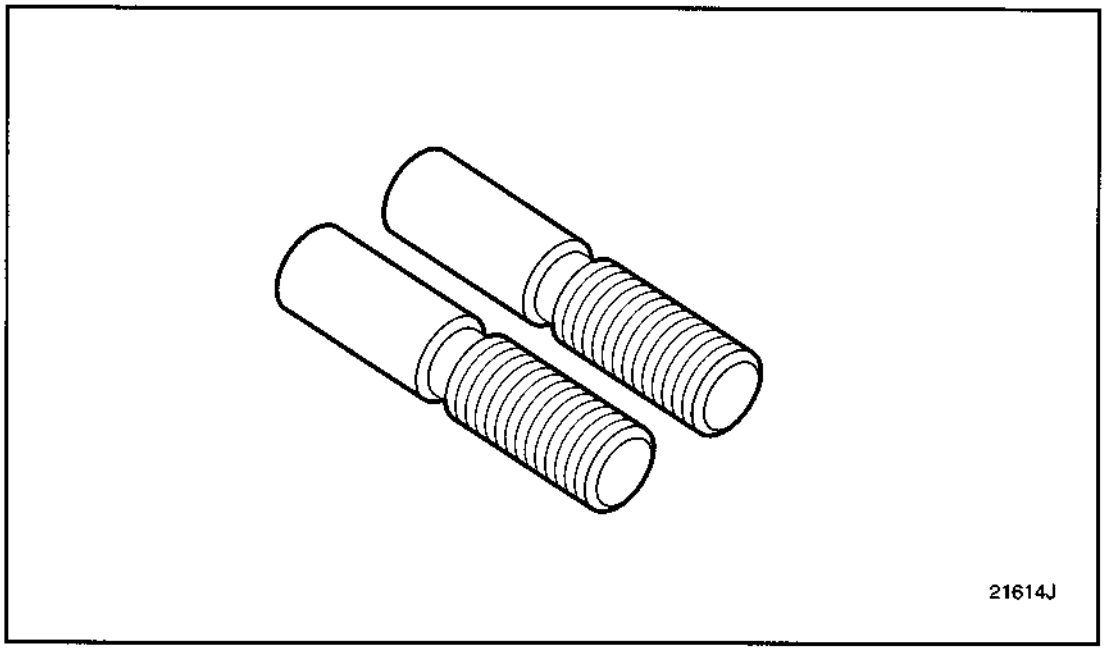

Figure 1399 Flywheel Guide Studs,J 36235

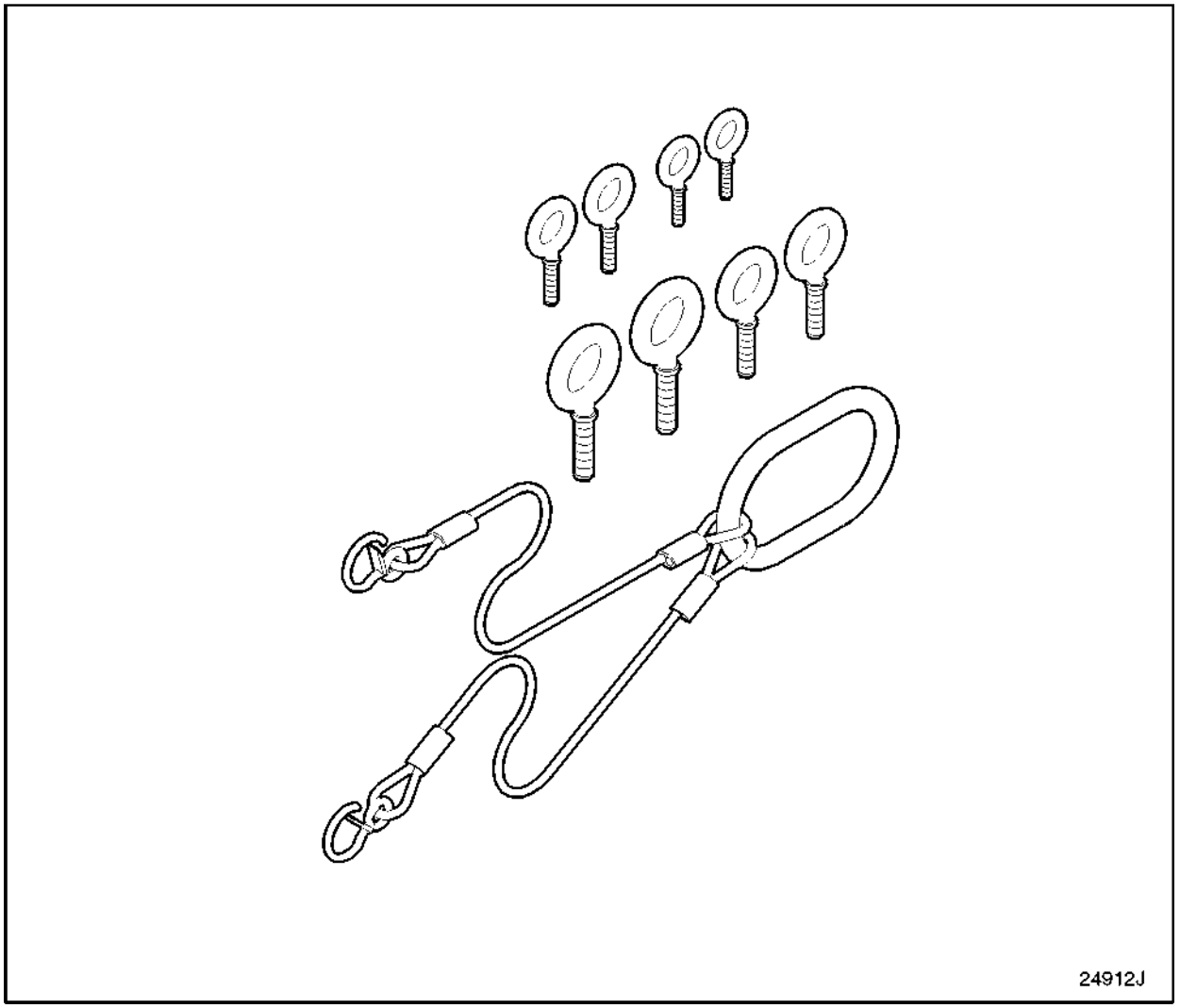

Figure 1400 Flywheel Lifting Fixture,J 25026–A

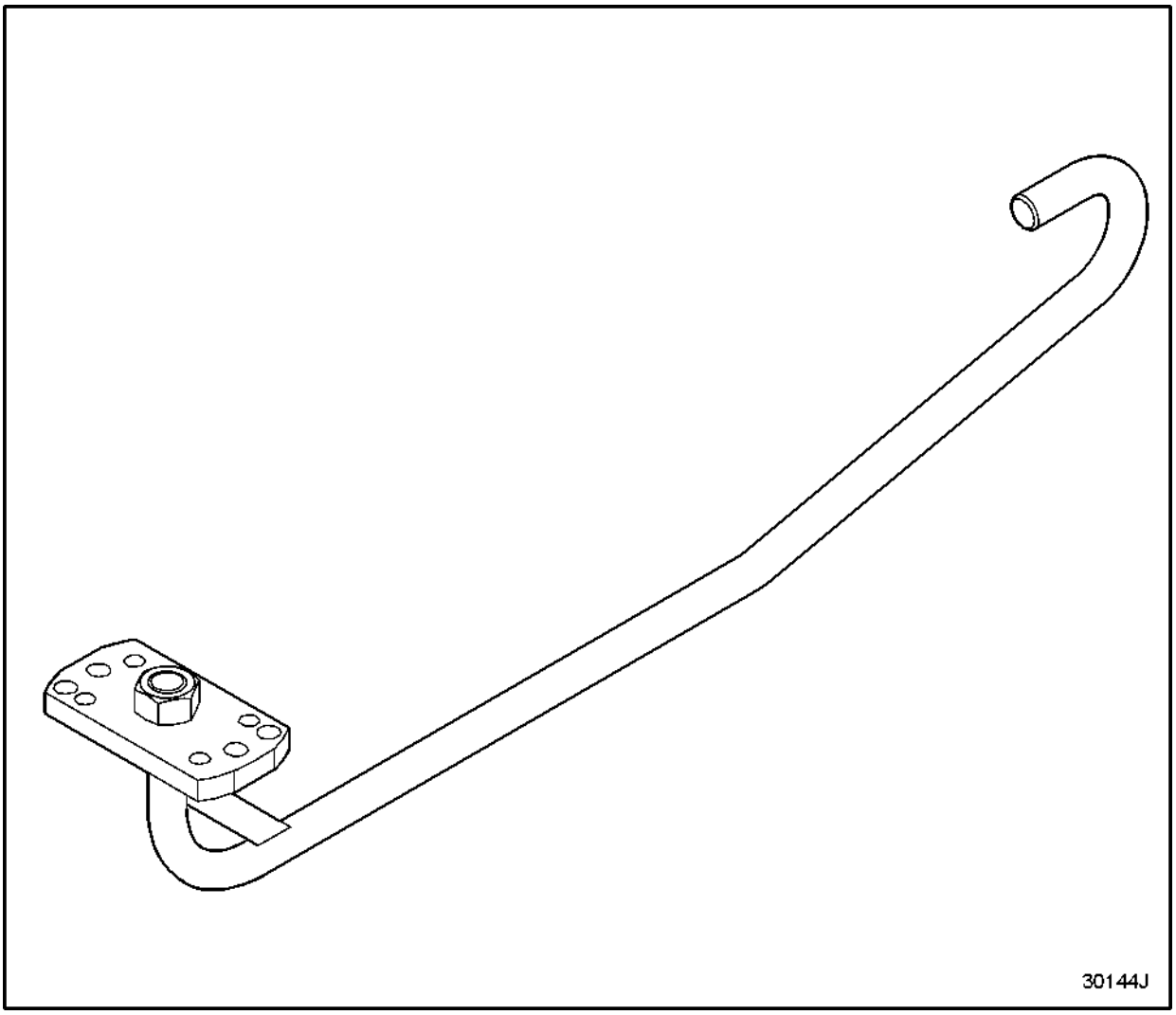

Figure 1401 Flywheel Lifting Tool,J 6361–01

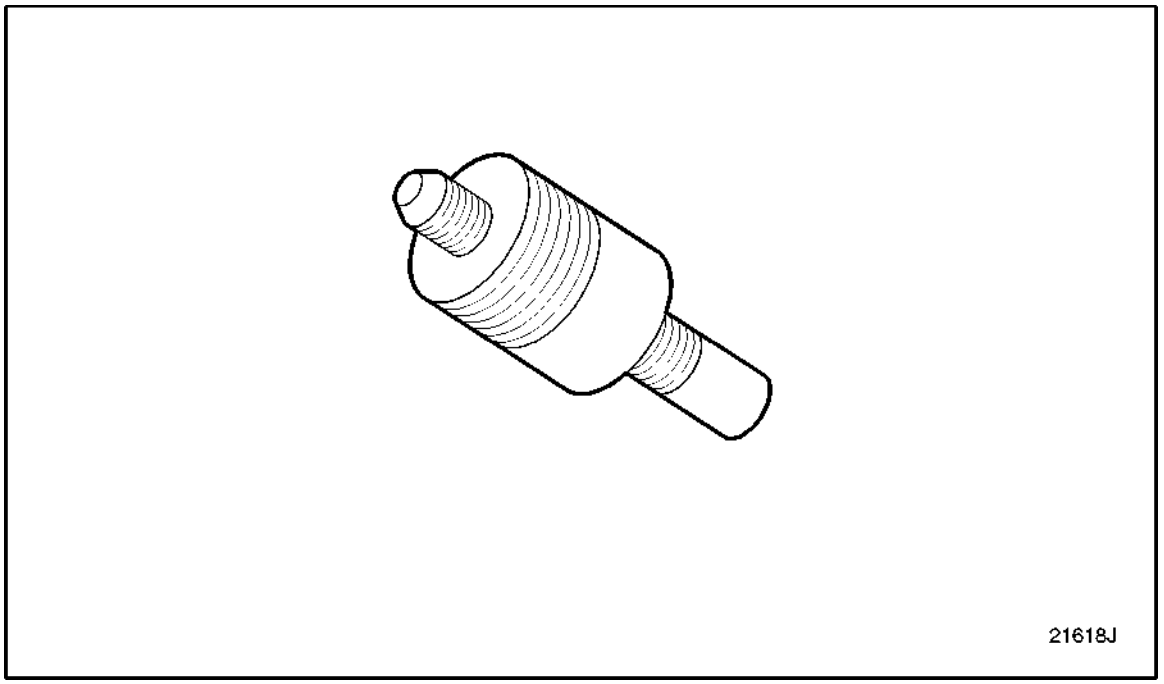

Figure 1402 Flywheel Lock,J 36375–A

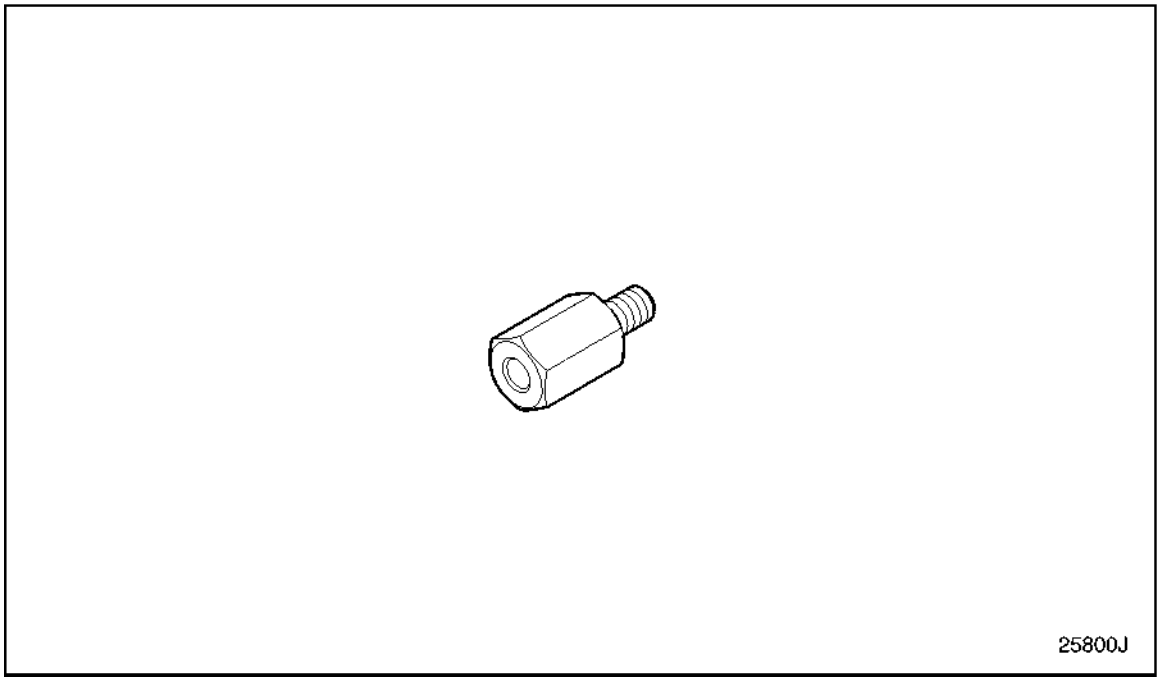

Figure 1403 Flywheel Runout Gauge Adapter,J 9737–11

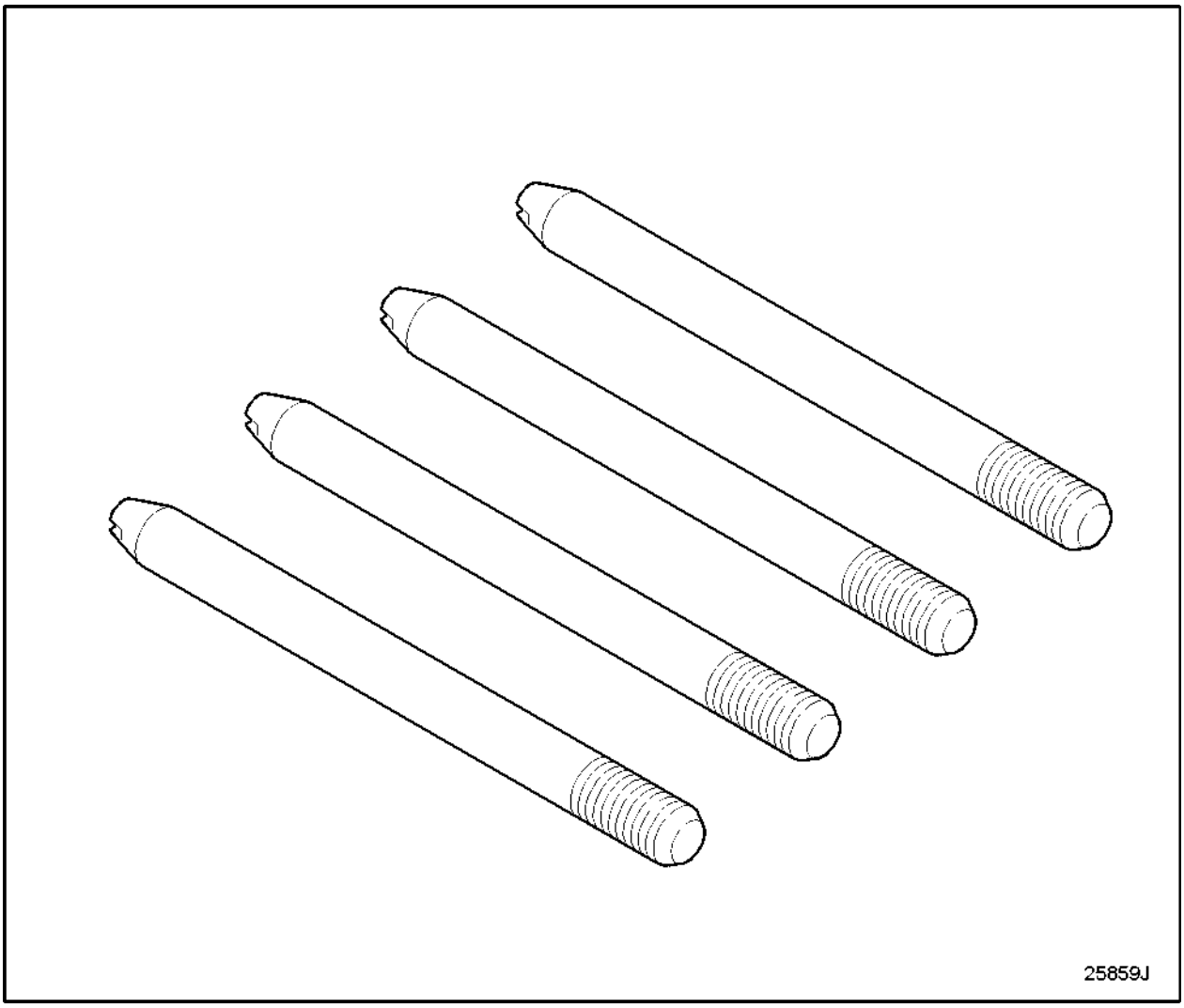

Figure 1404 Flywheel Housing Alignment Stud Set, J 1927–01

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Figure 1405 Flywheel Housing Alignment Stud ST,J 7540

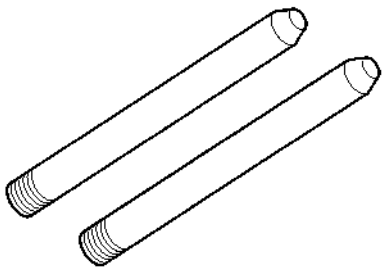

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Figure 1406 Flywheel Housing Guide Studs,J 34691

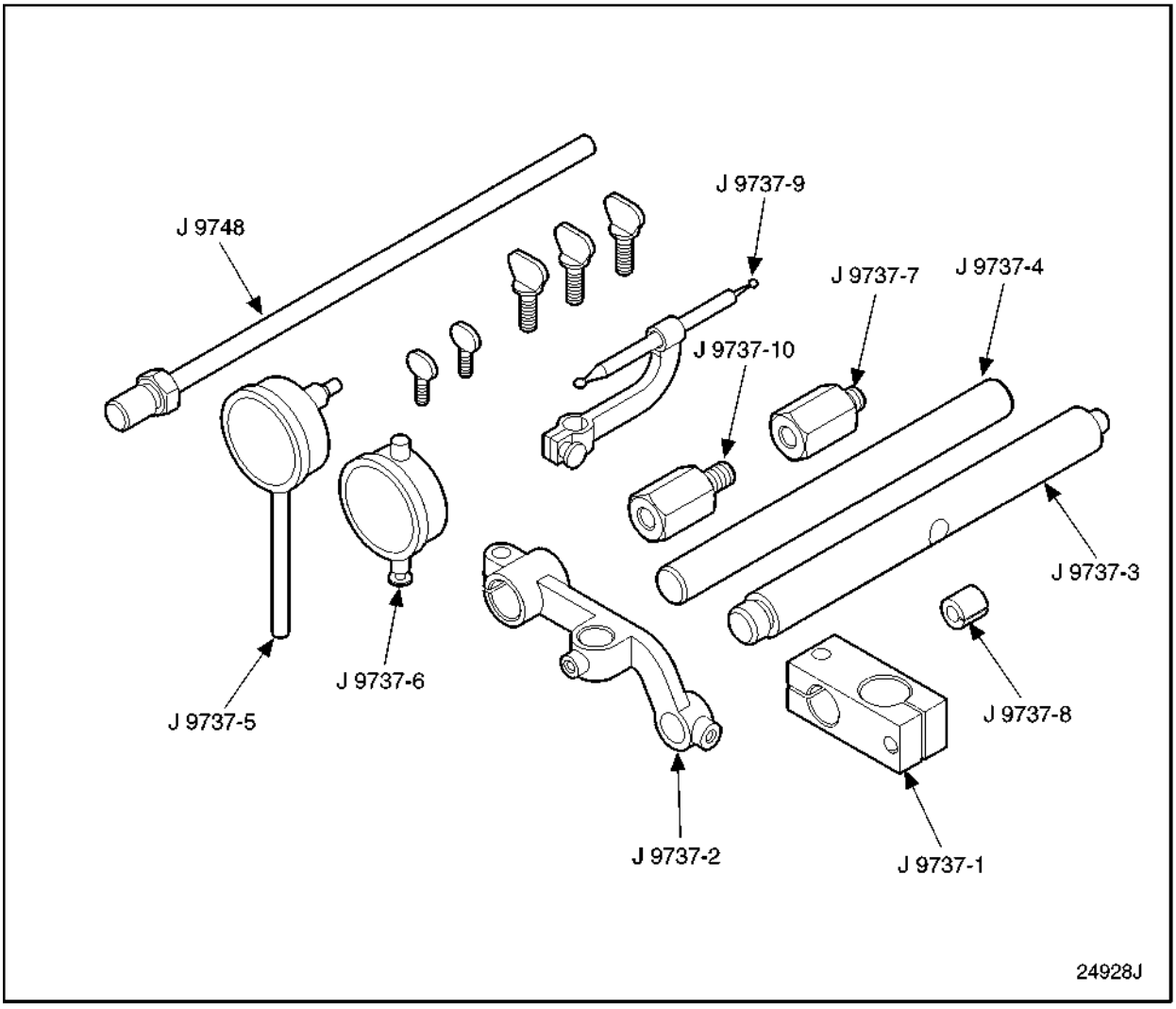

Figure 1407 Flywheel Housing Runout Gauge Set,J 9737–D

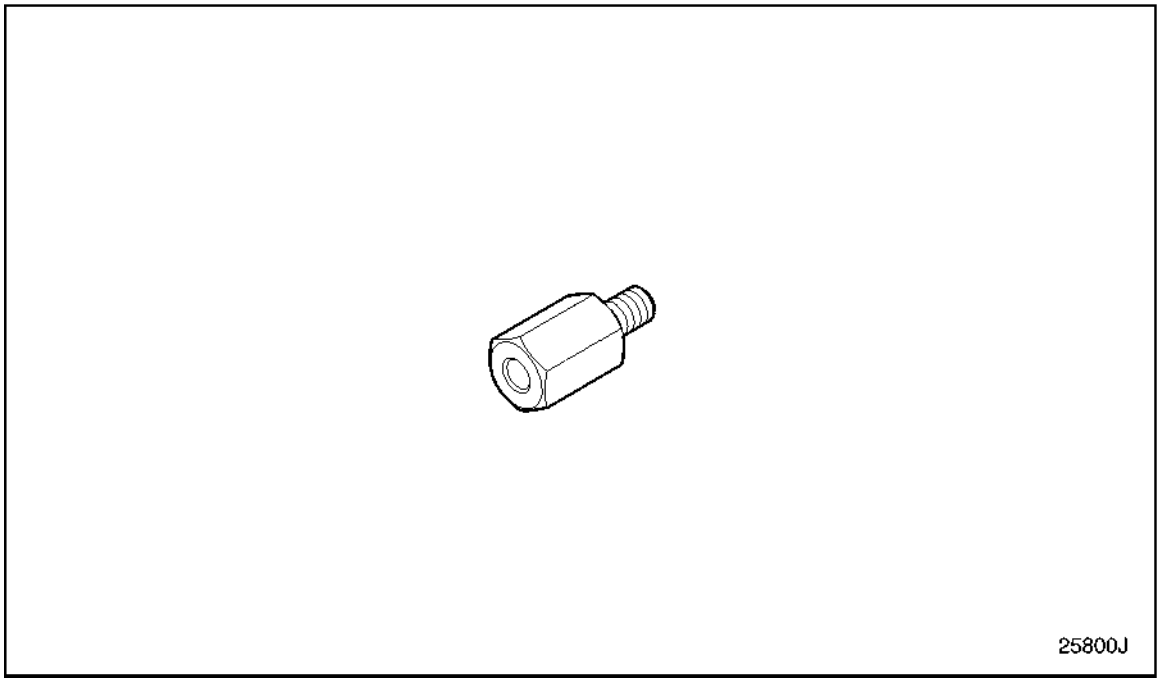

Figure 1408 Flywheel Runout Gauge Adapter,J 9737–11

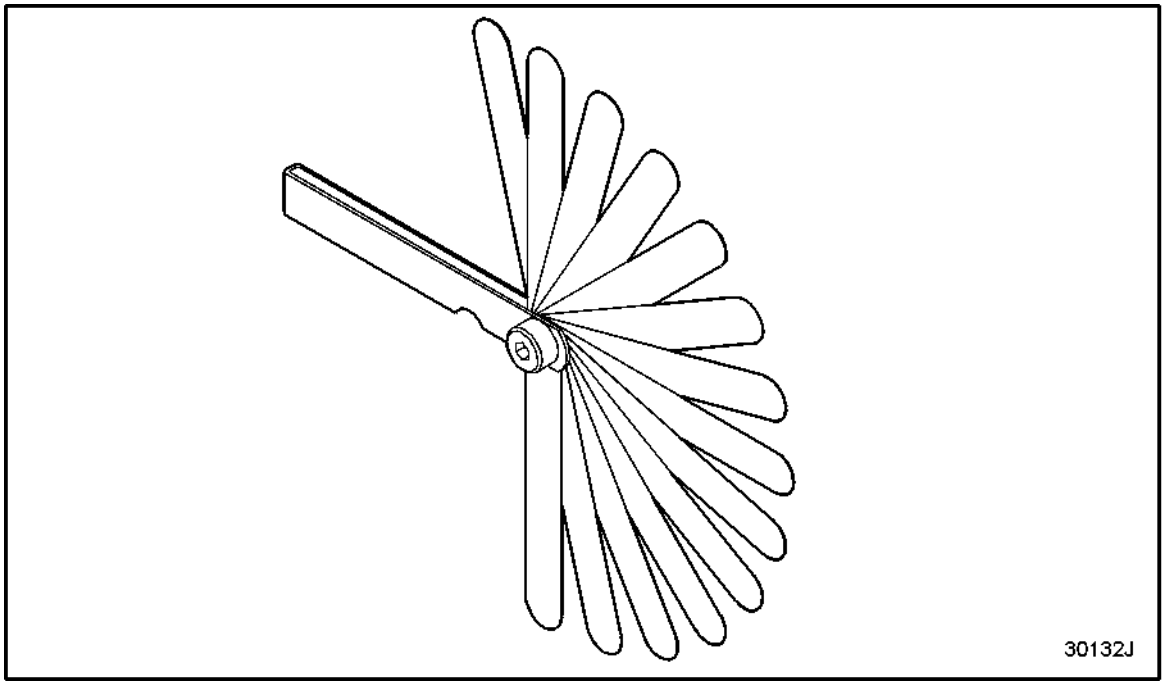

Figure 1409 Feeler Gauge Set,J 3172

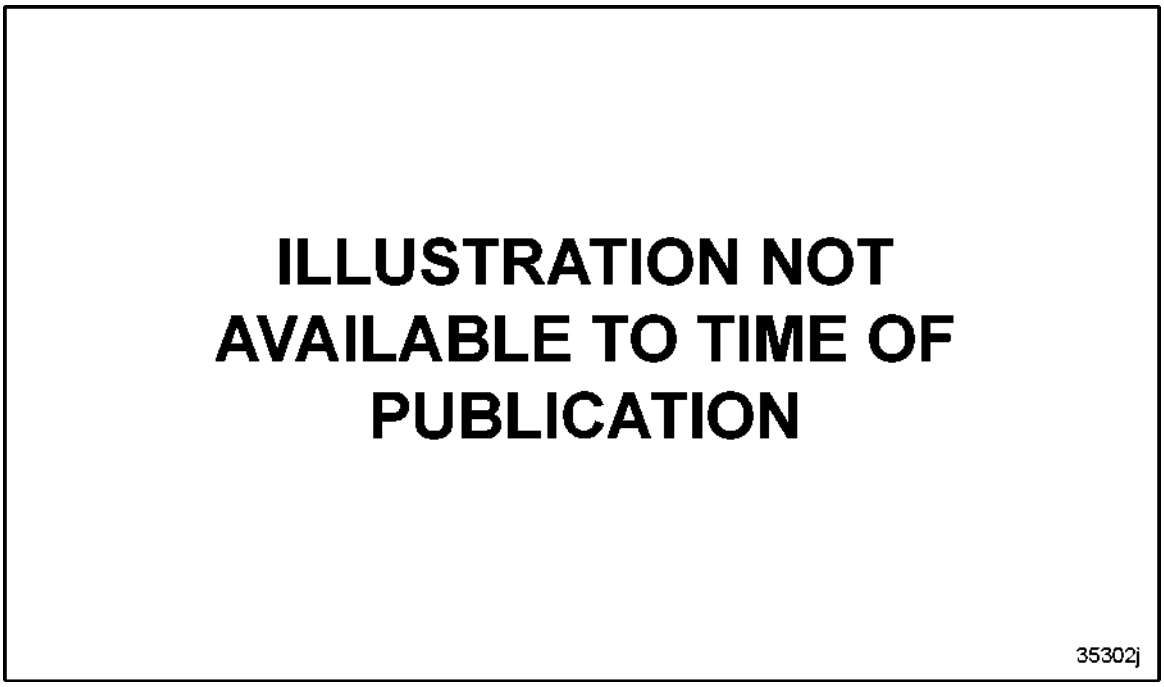

Figure 1410 Pin Retainer Installer,J 38088

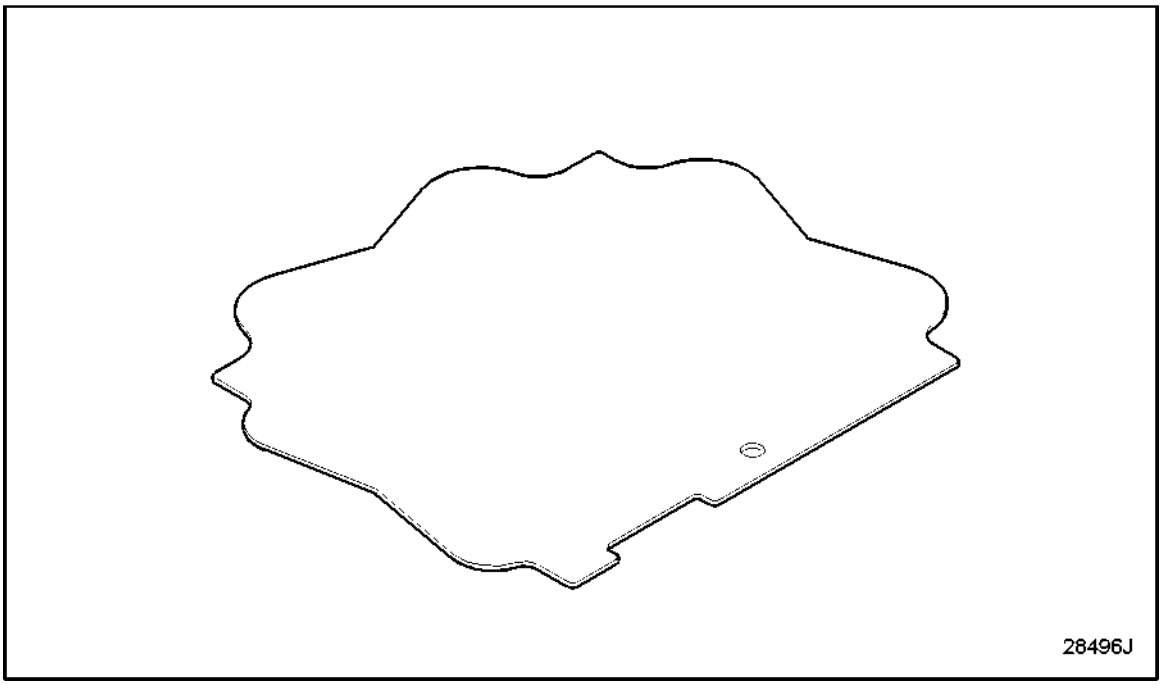

Figure 1411 Piston Crown I.D. Gage,J 25397–B

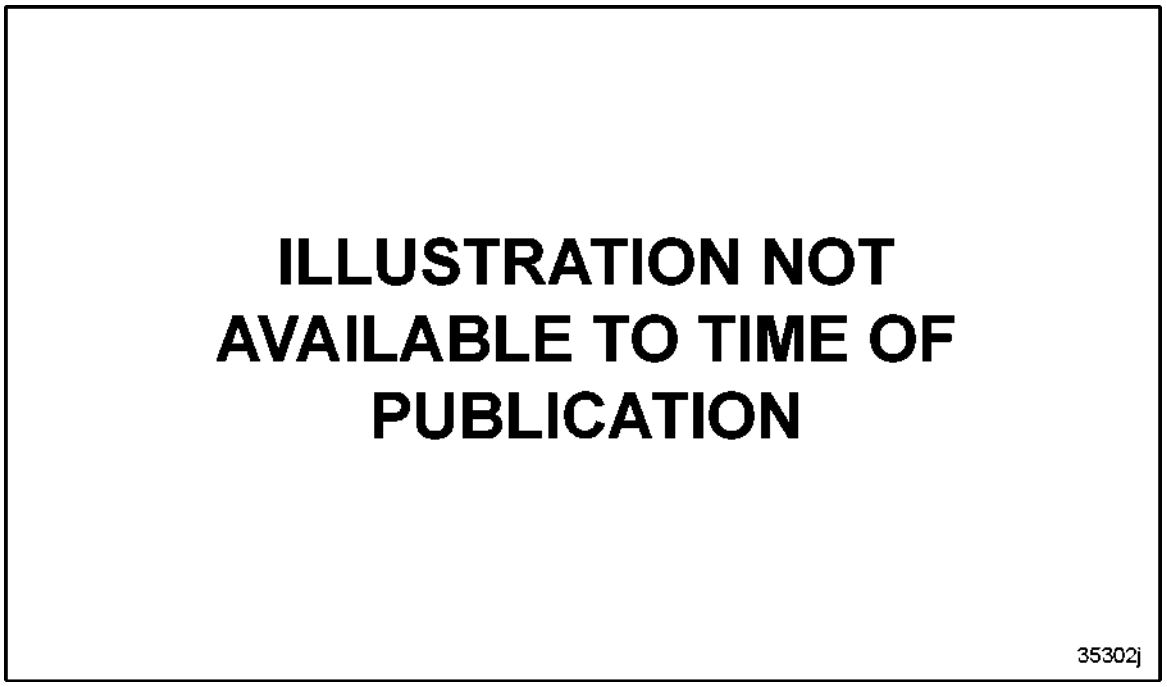

Figure 1412 Piston Crown I.D. Gage,J 41971

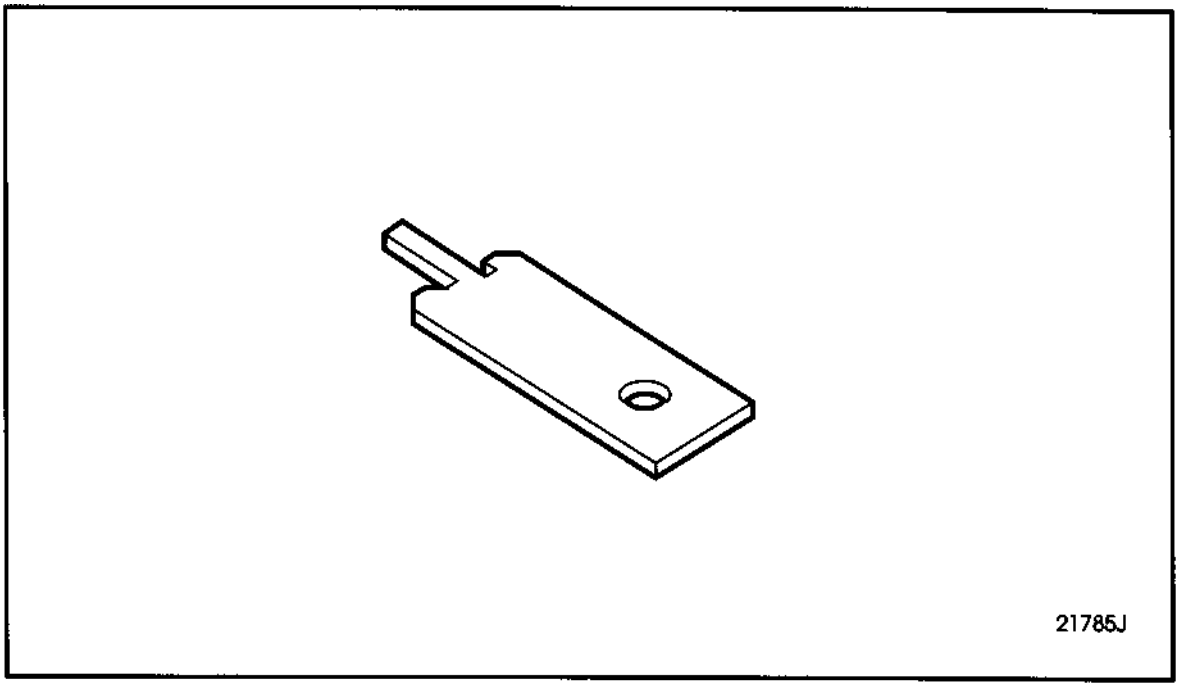

Figure 1413 Piston Crown I.D. Gage (3.5MM Fire),J 38609–A

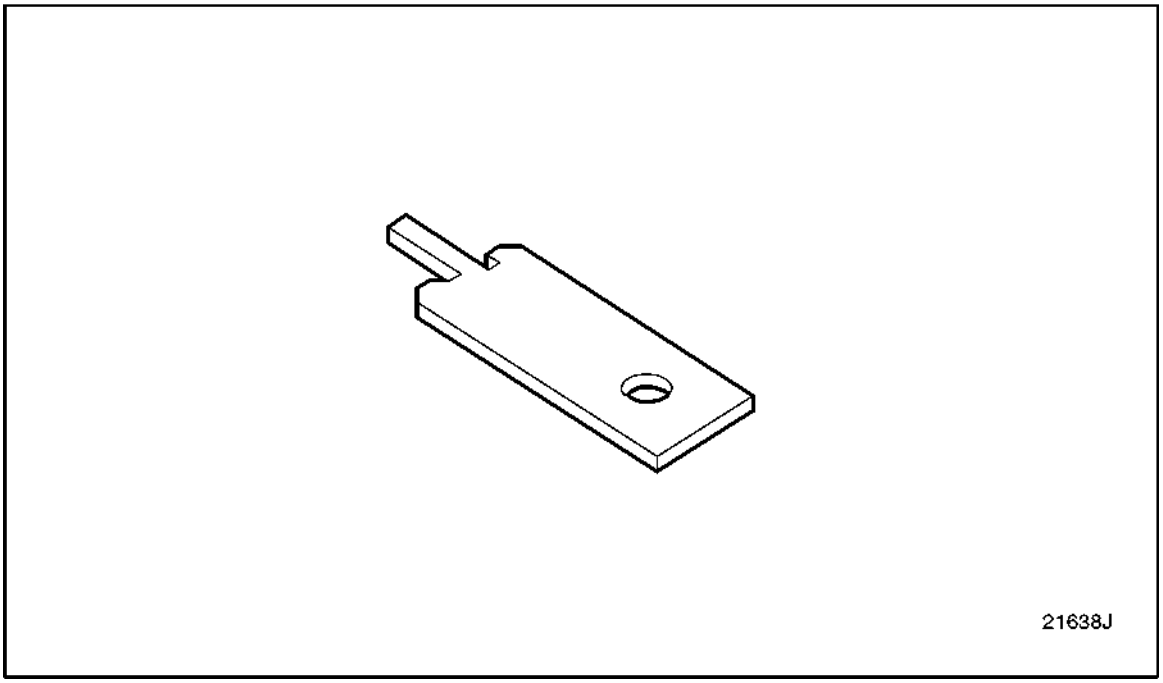

Figure 1414 Piston Groove Gage (Compression), J 38689–A

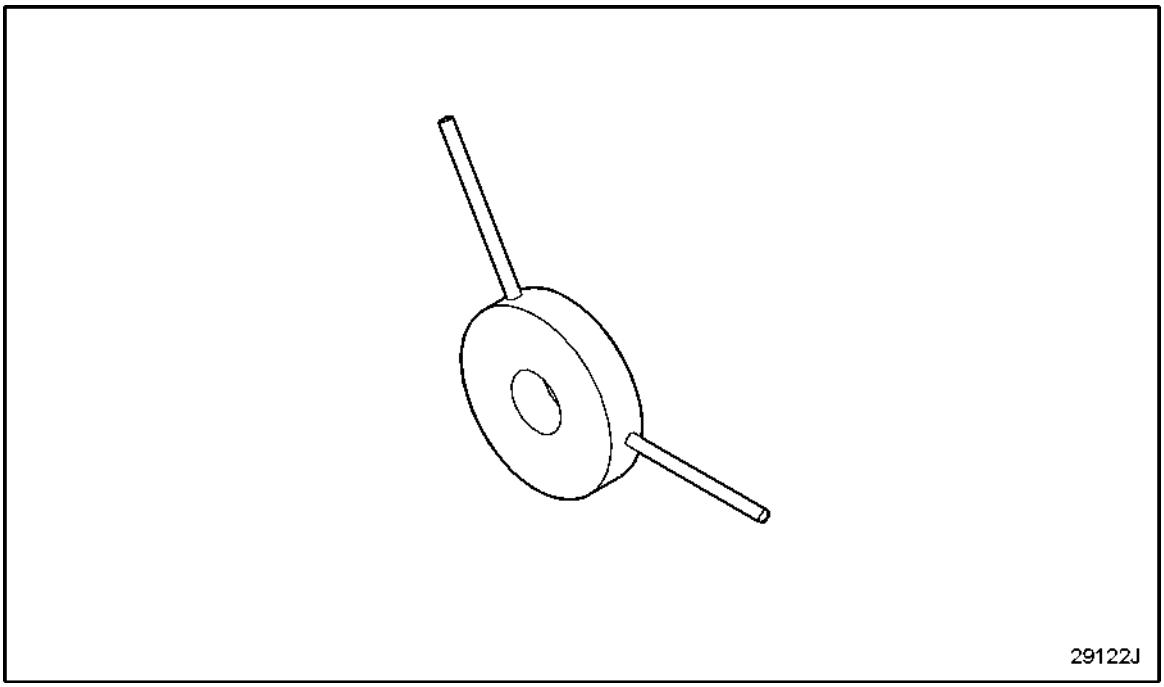

Figure 1415 Piston Groove Gage (Fire Ring), J 24599

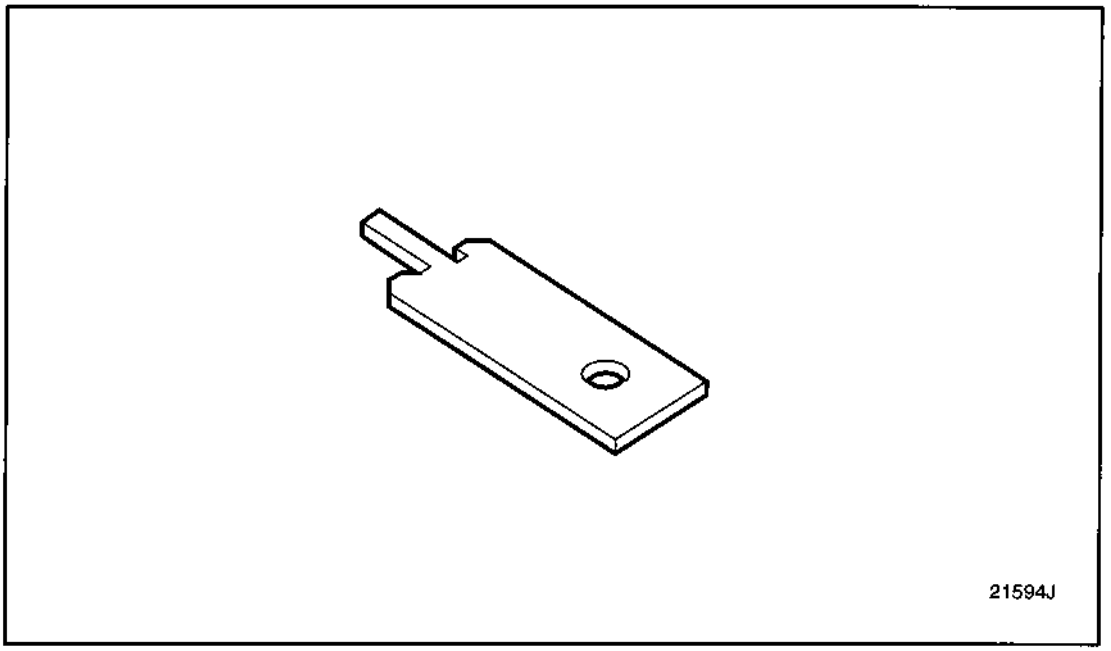

Figure 1416 Piston Groove Gage (Fire Ring), J 35884–A

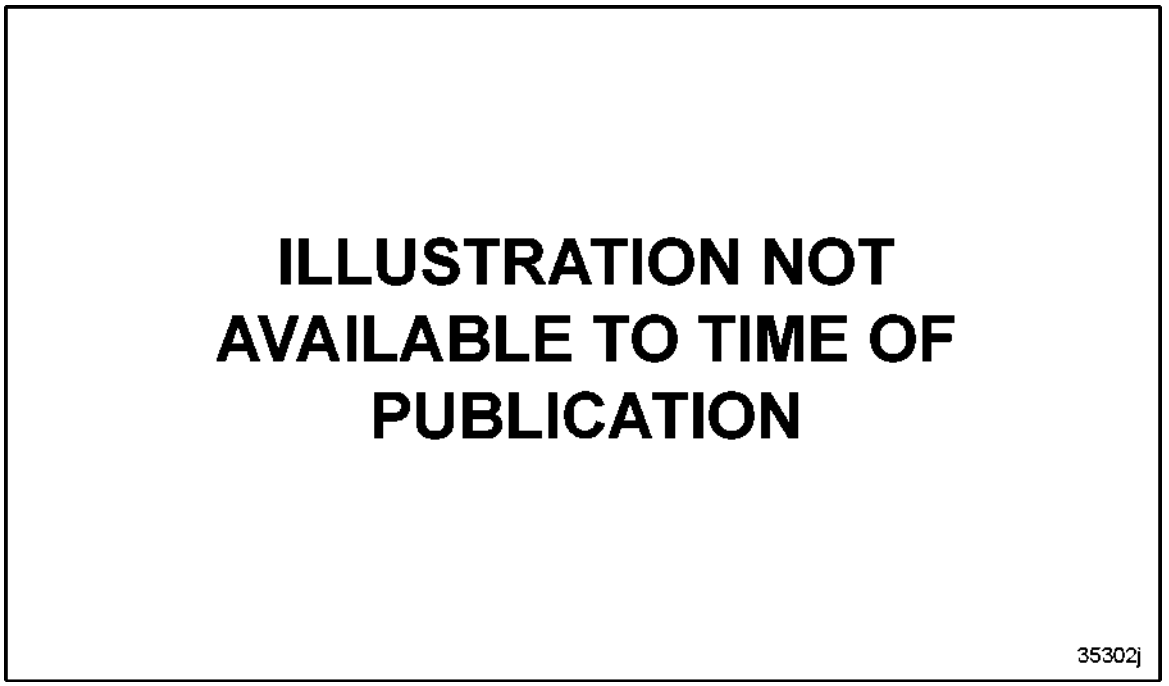

Figure 1417 Piston Pin Alignment Tool, J 38390

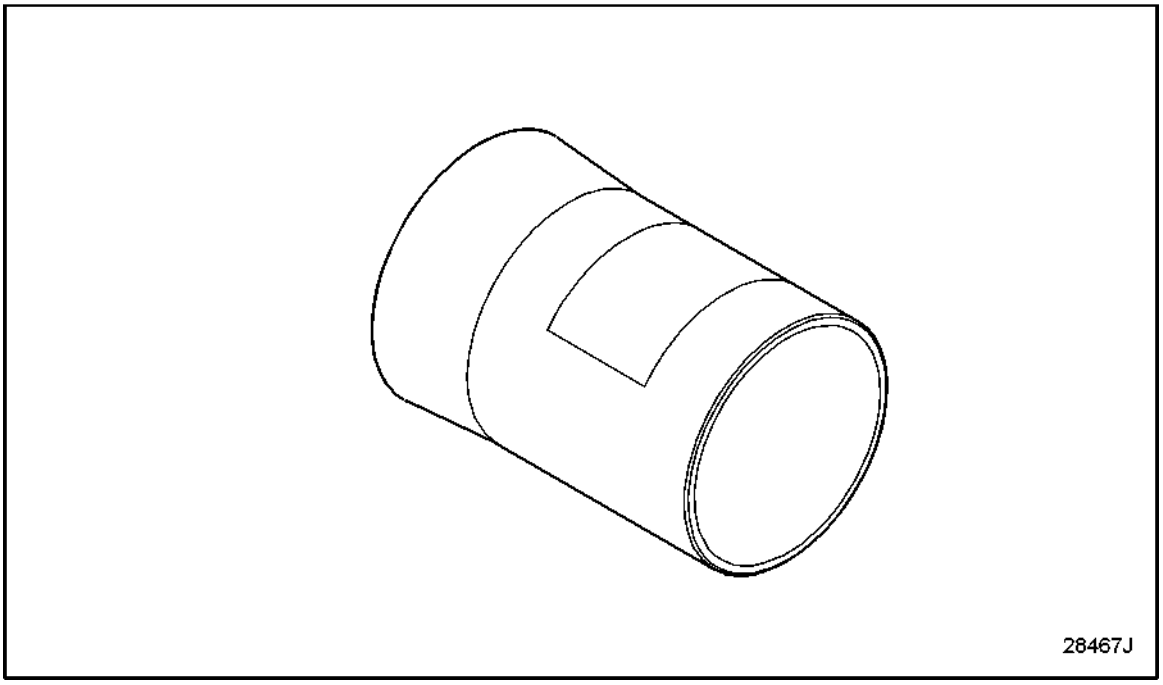

Figure 1418 Piston Ring Compressor ,J 22387

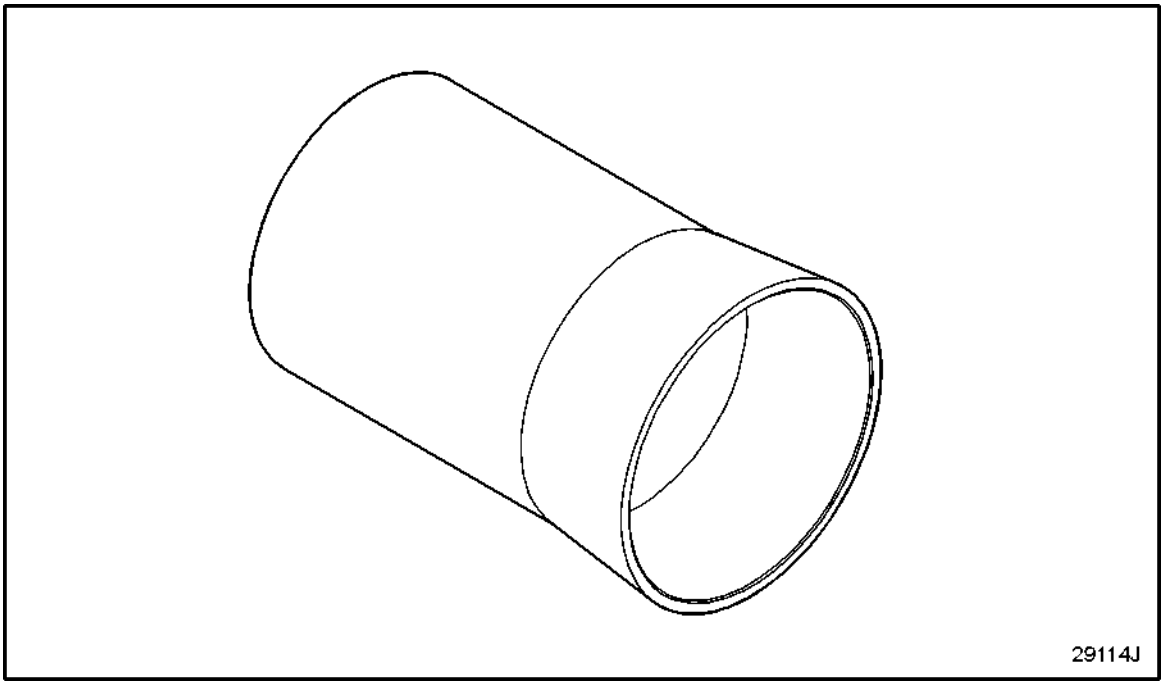

Figure 1419 Piston Ring Compressor,J 24227–B

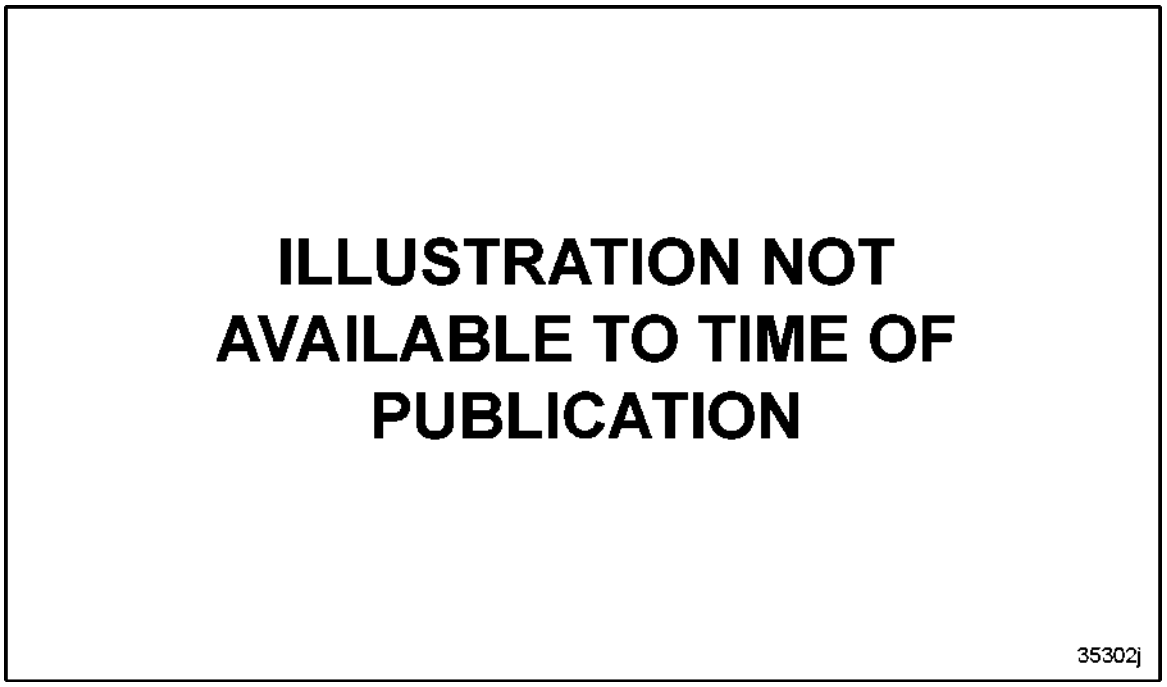

Figure 1420 Piston Ring Compressor,J 29614–A

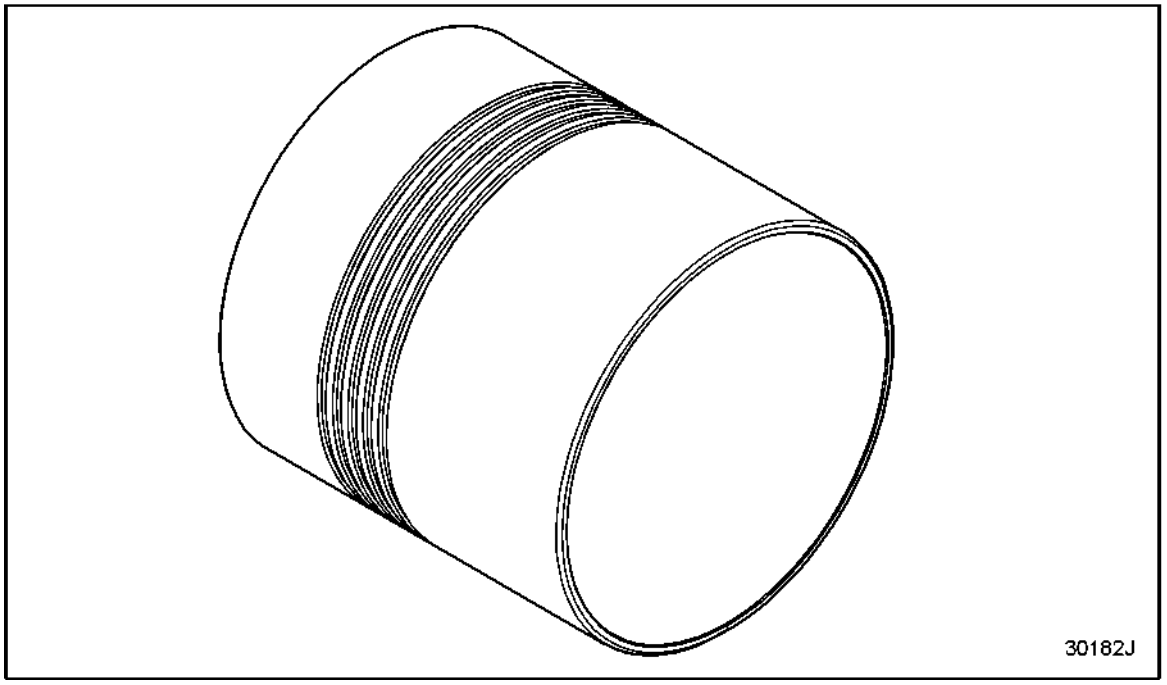

Figure 1421 Piston Ring Compressor,J 3272–03

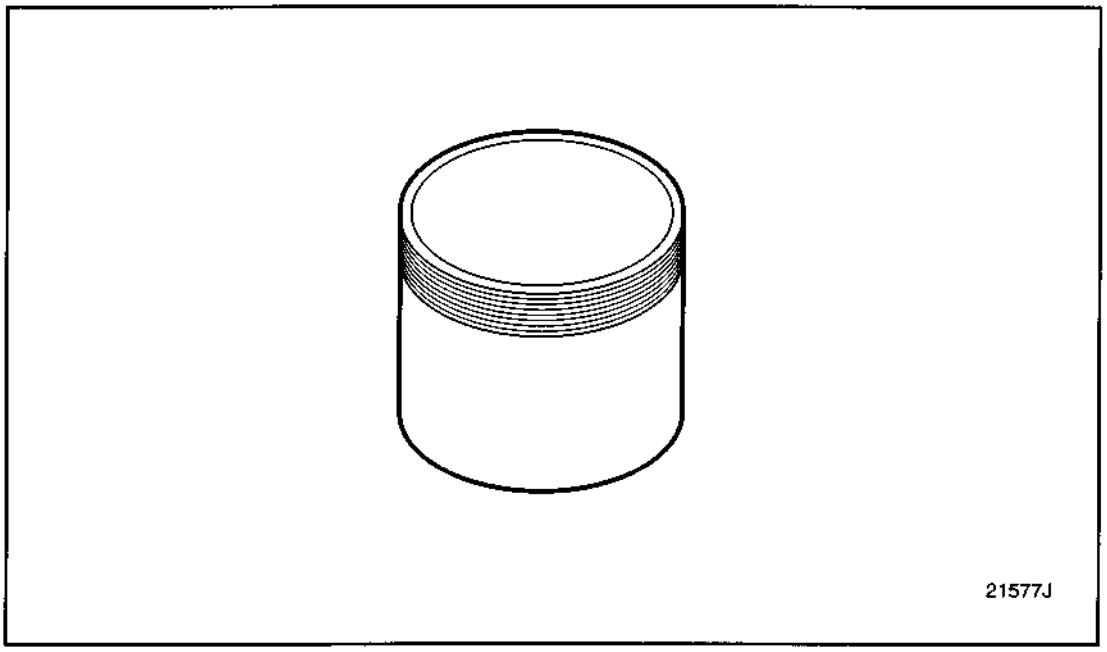

Figure 1422 Piston Ring Compressor,J 35598–A

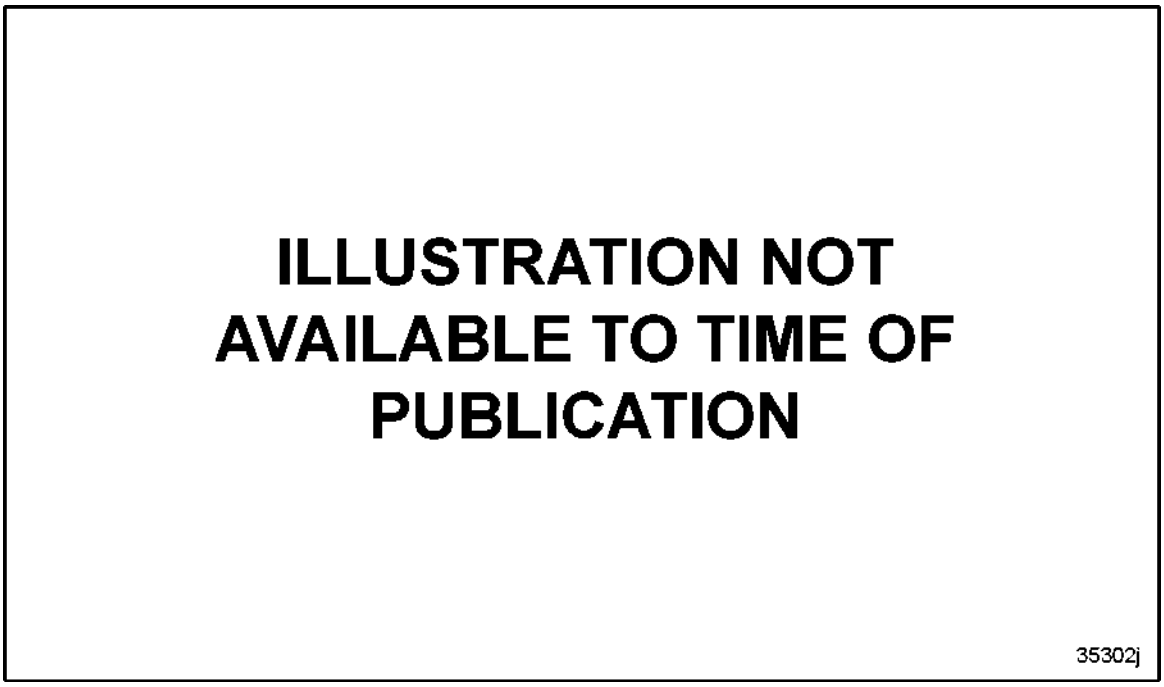

Figure 1423 Piston Ring Compressor,J 6883–A

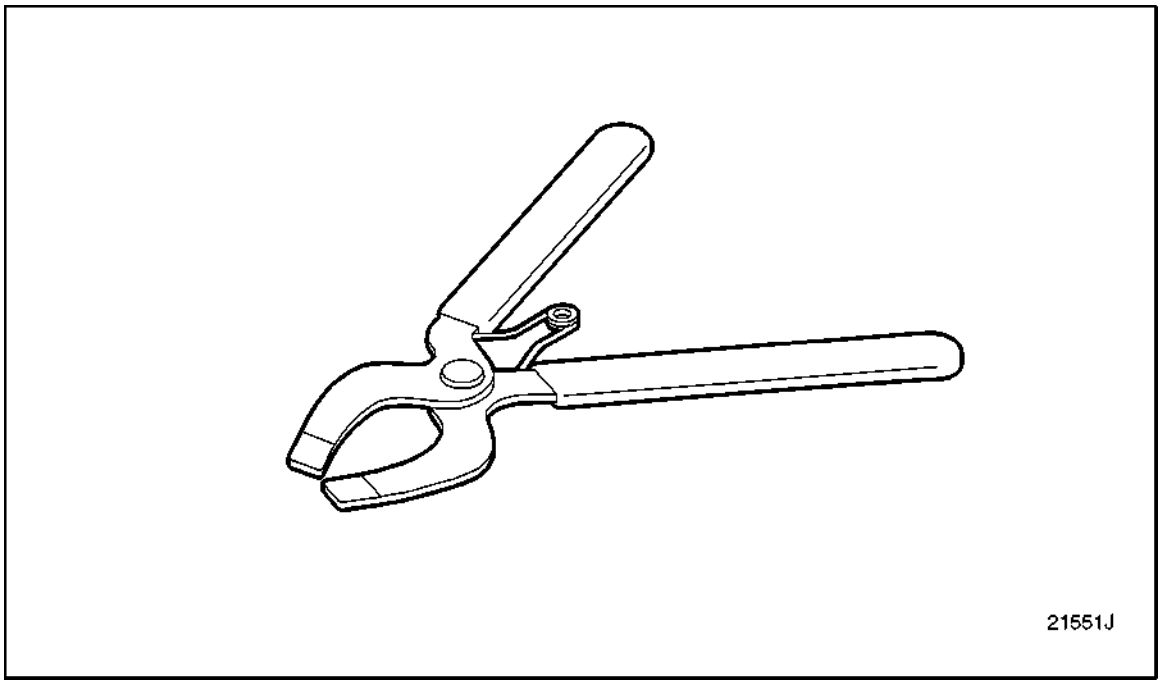

Figure 1424 Piston Ring Expander Pliers, J 22405–02

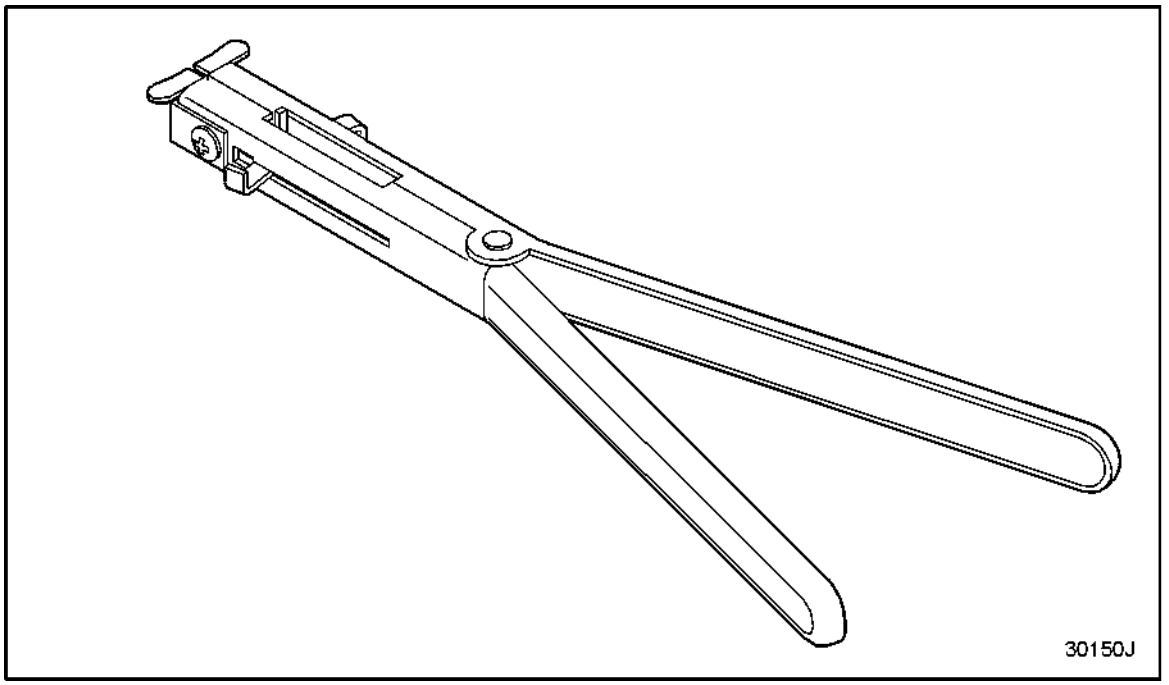

Figure 1425 Piston Ring Expander Pliers, J 8128

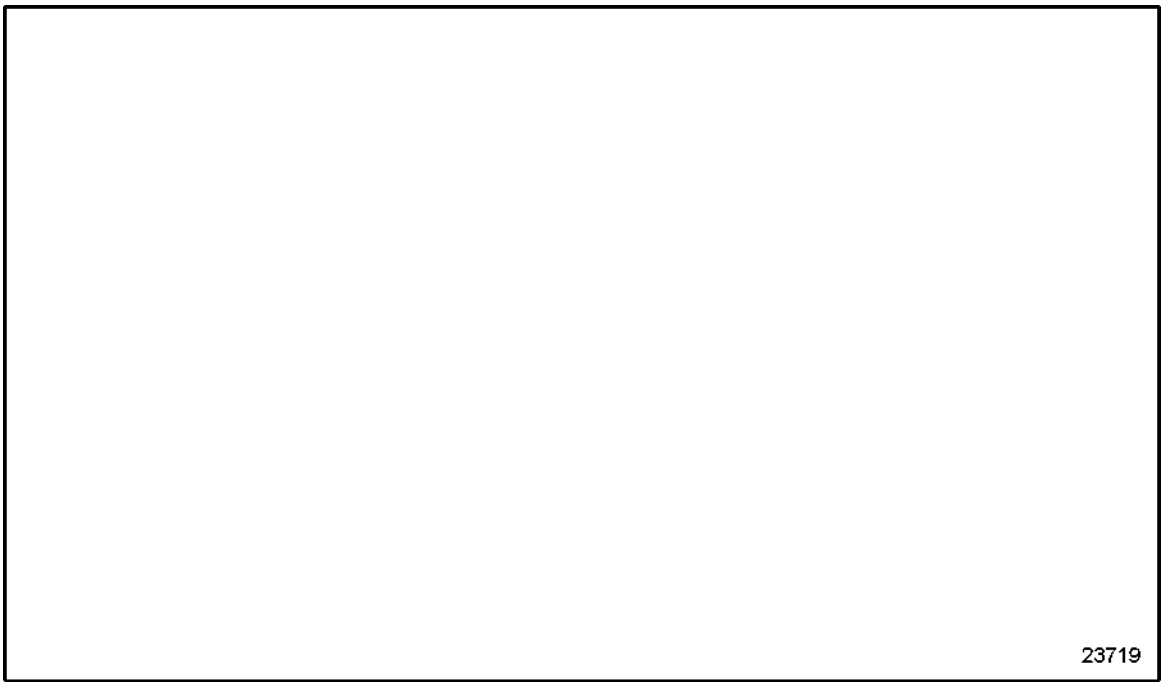

Figure 1426 Piston Ring Groove Gage Set,J 29511

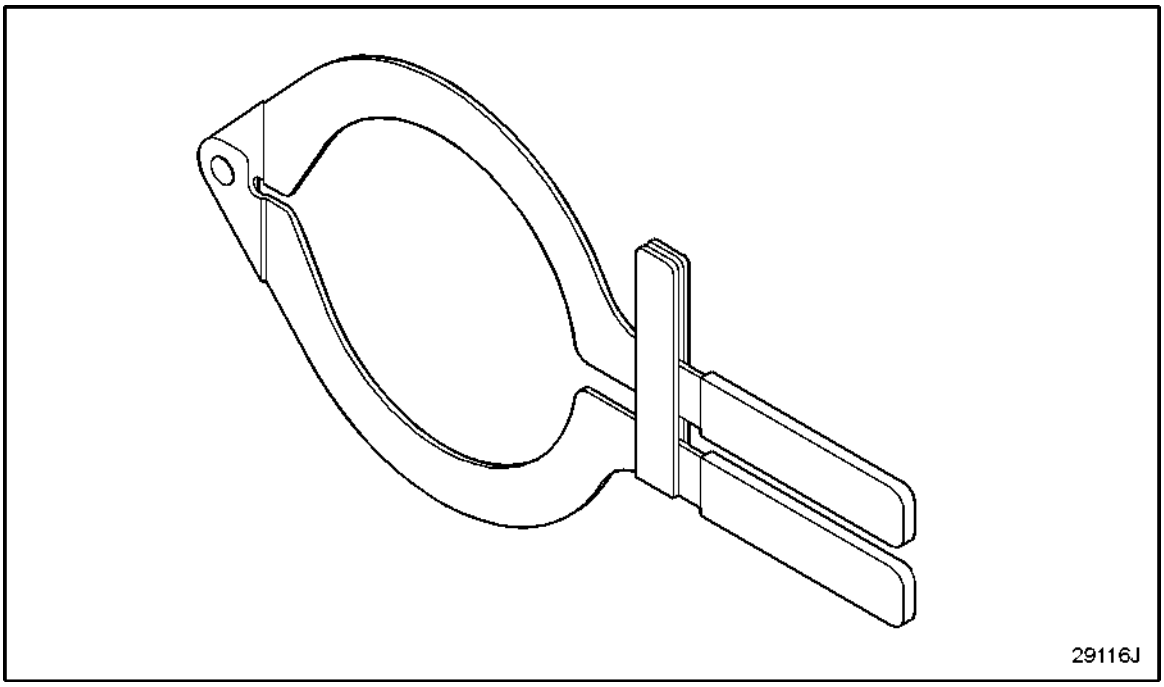

Figure 1427 Piston Seal Ring Compressor,J 24421

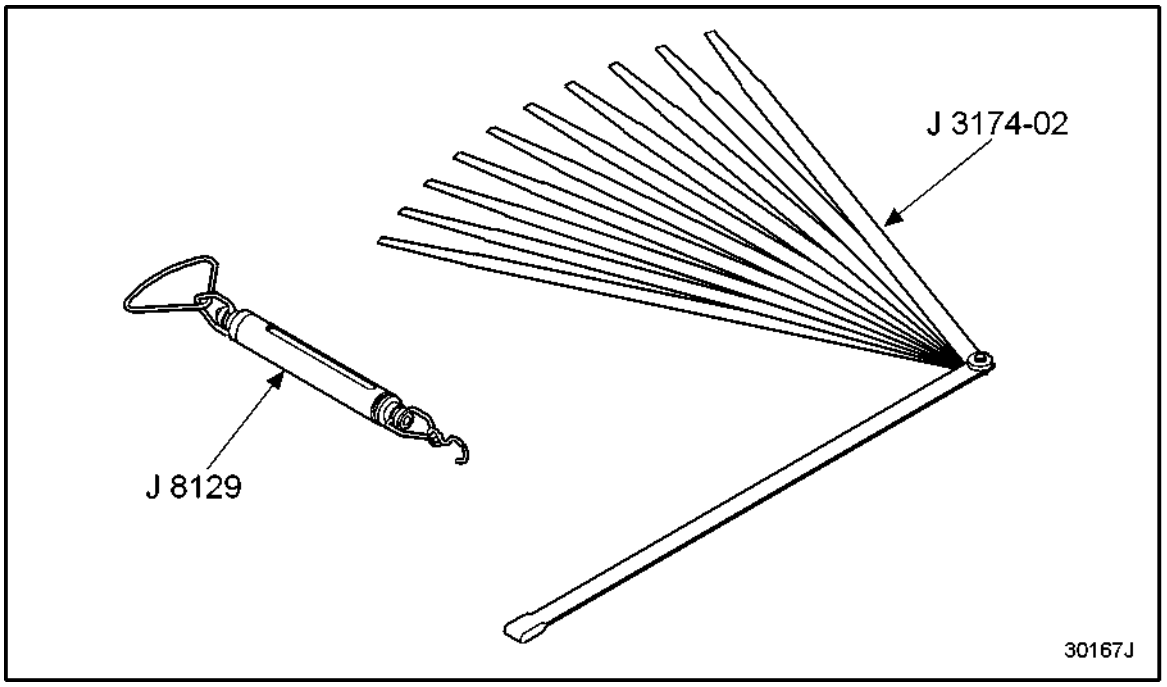

Figure 1428 Piston To Liner Feeler Gage Set,J 5438–01

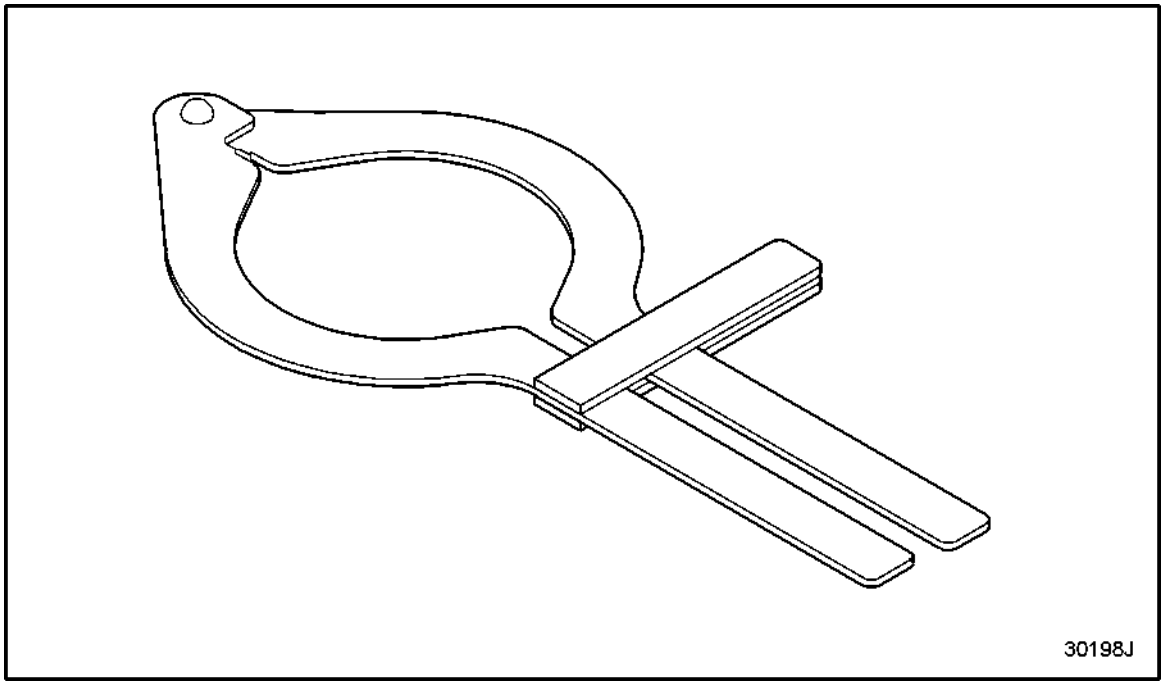

Figure 1429 Seal Ring Compressor (Croshd Piston),J 23453

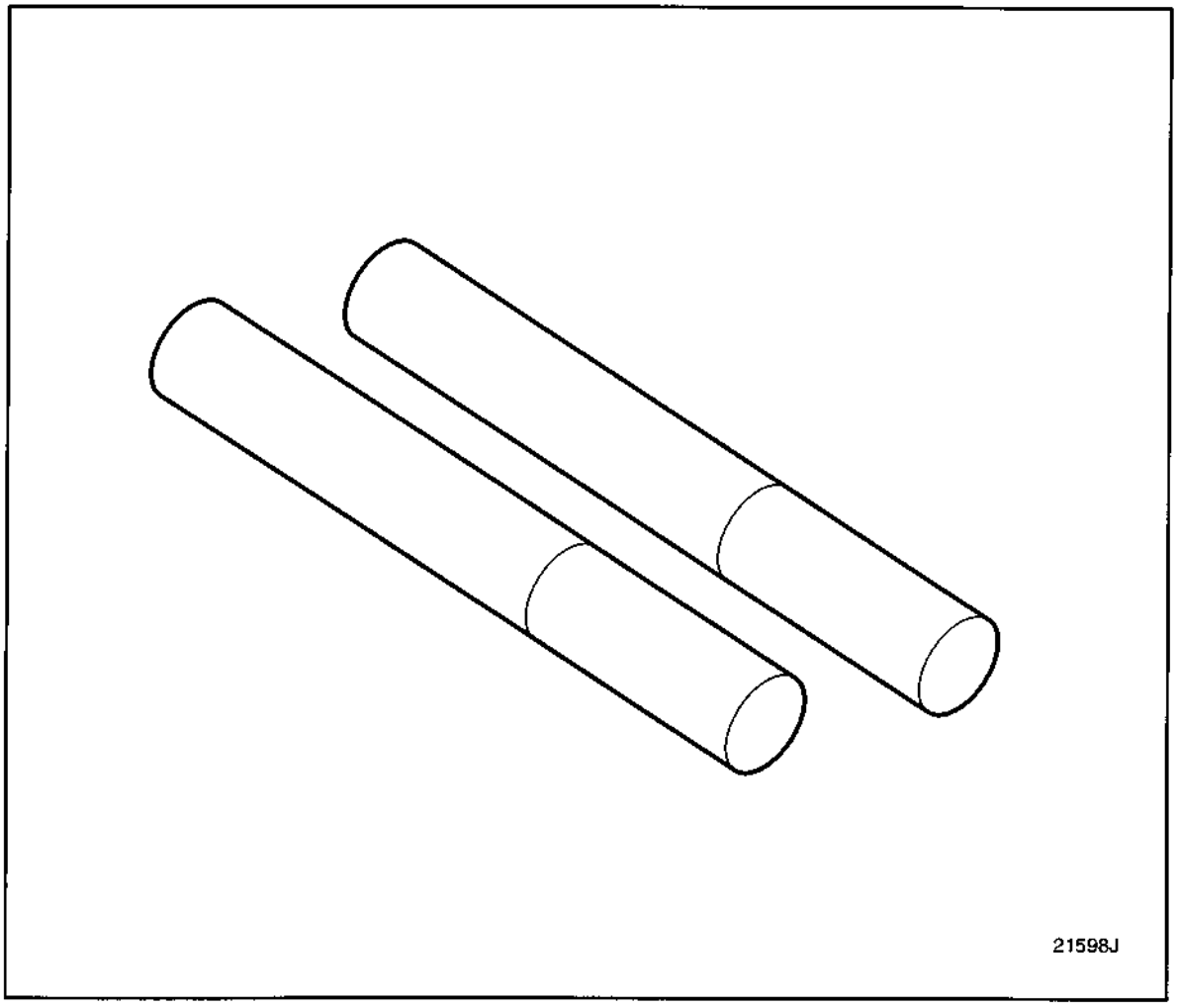

Figure 1430 Connecting Rod Installation Guides, J 35945

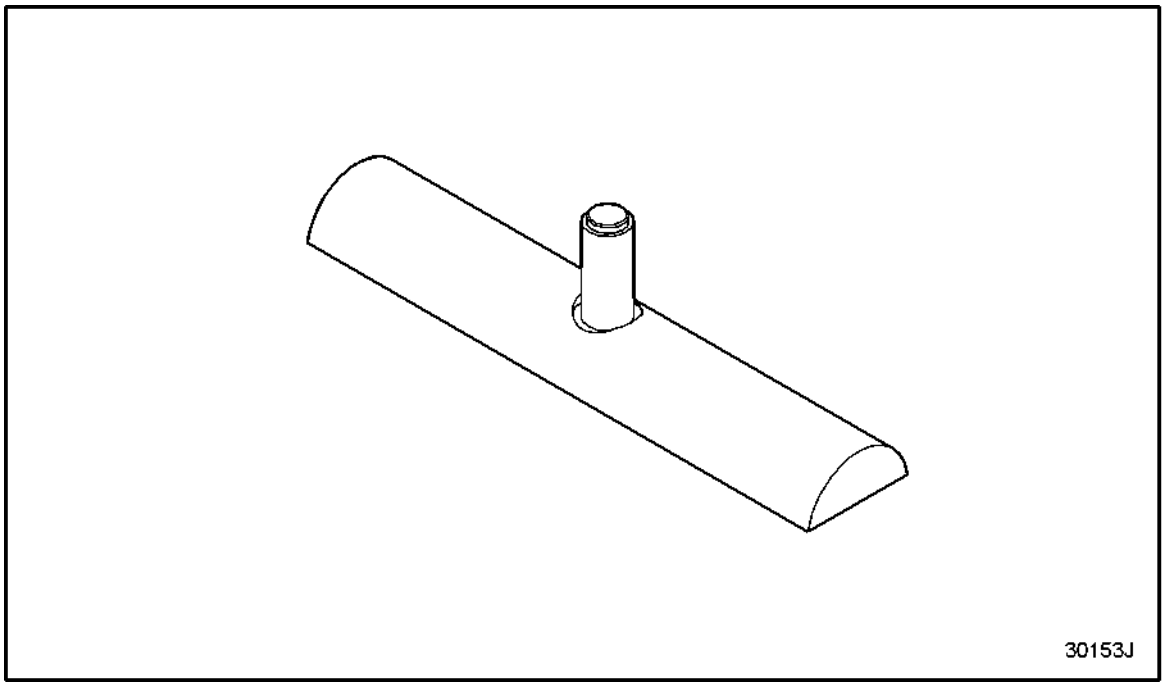

Figure 1431 Connecting Rod Nozzle Remover,J 8995

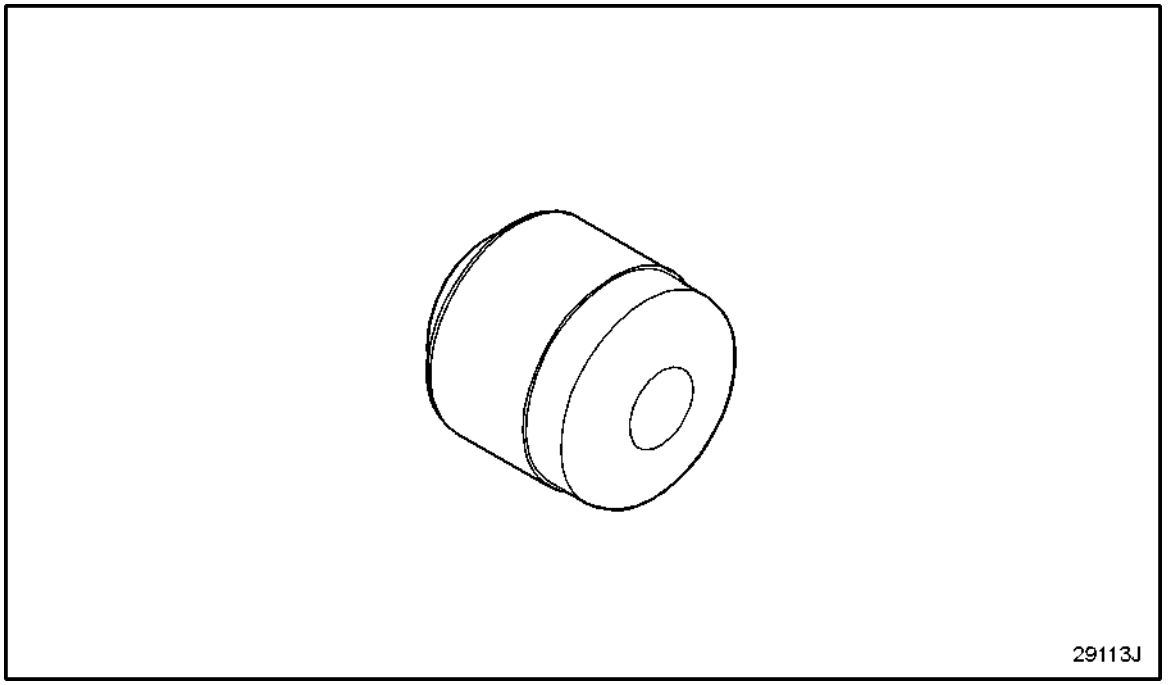

Figure 1432 Pin Retainer Instal (71 TRK TY PST),J 24107–01

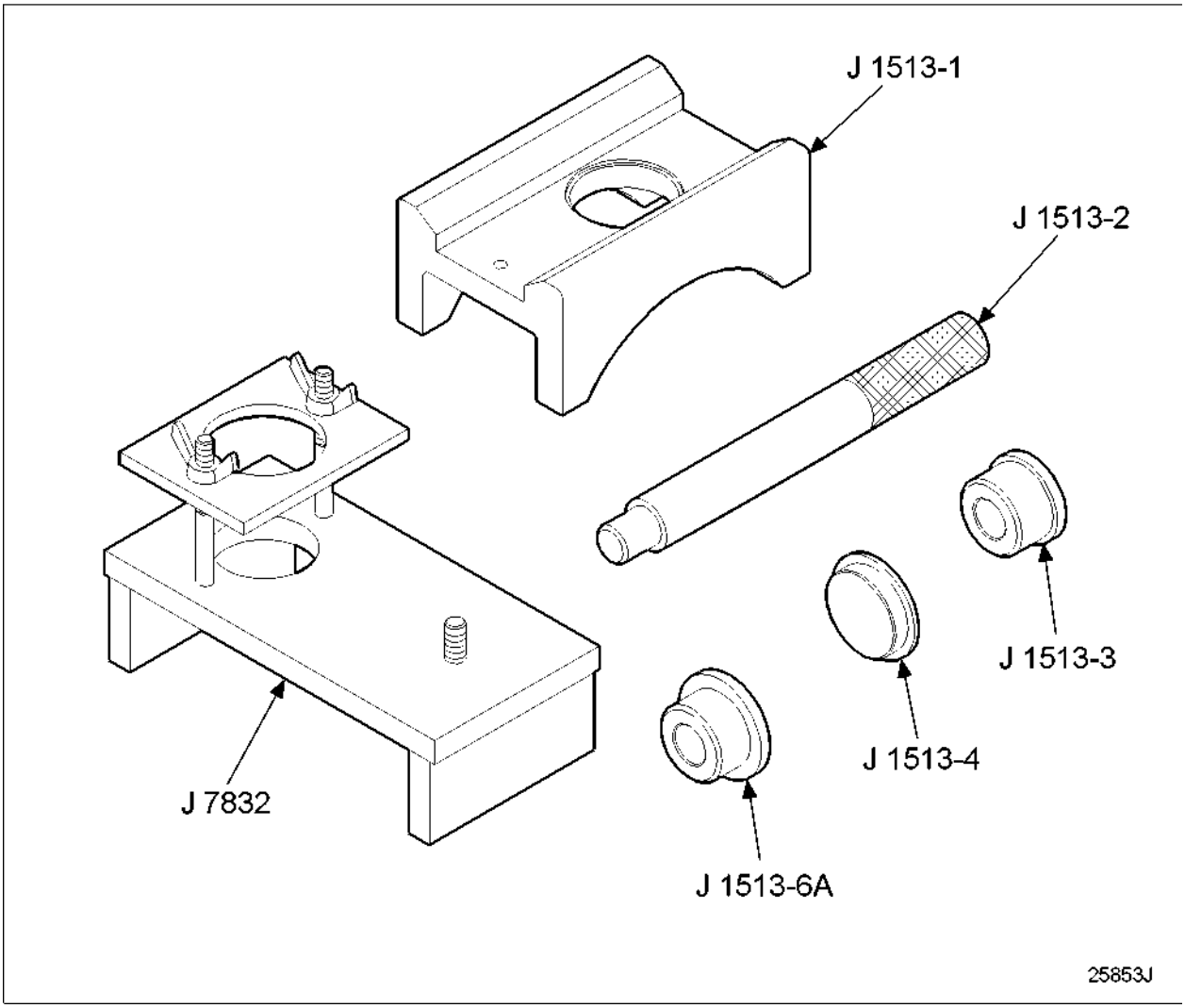

Figure 1433 Piston & Rod Bushing REM/INST SET,J 1513–02

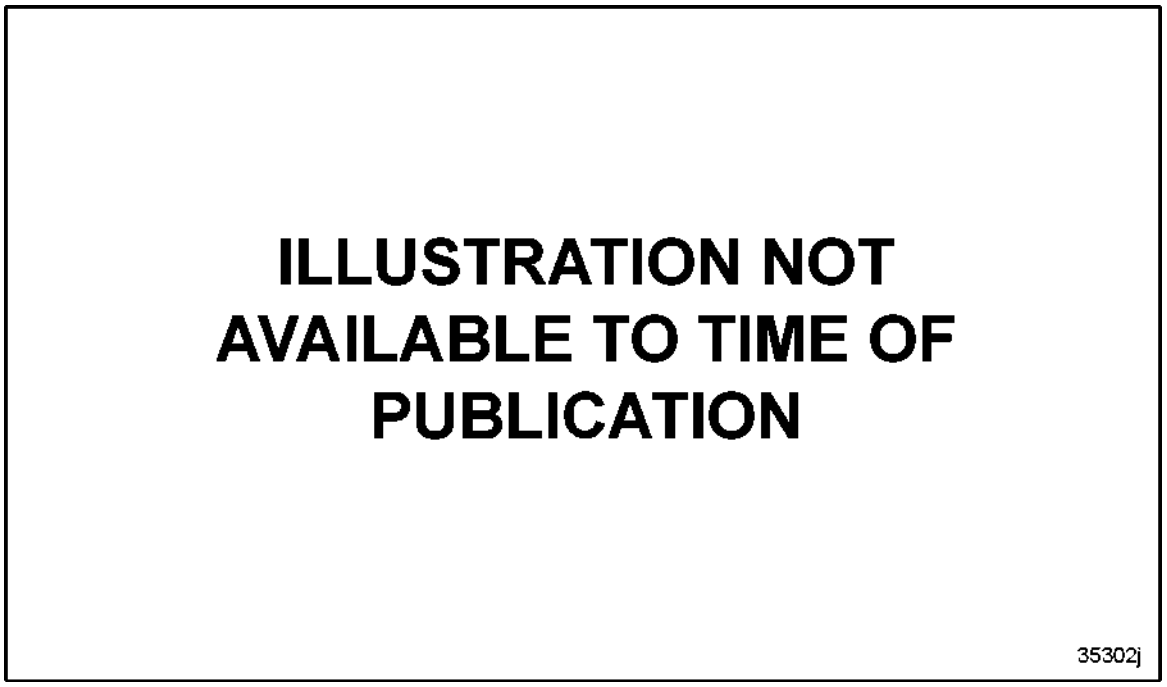

Figure 1434 Piston & Rod Bushing REM/INST SET,J 7587

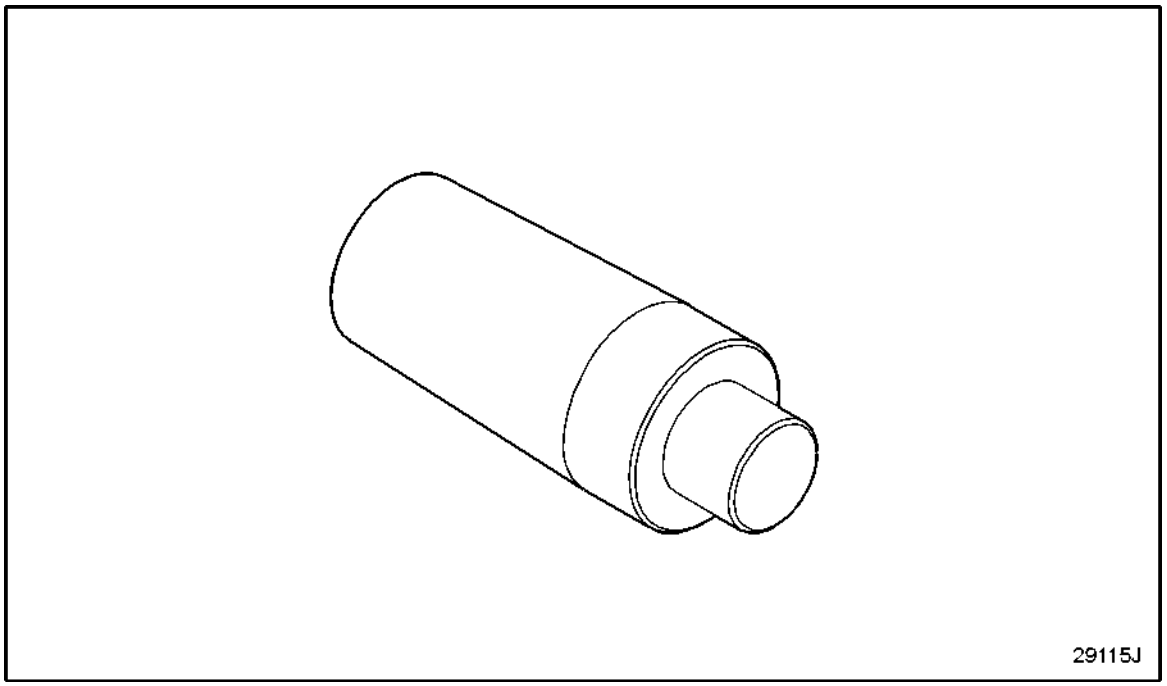

Figure 1435 Piston Pin Alignment Tool,J 24285

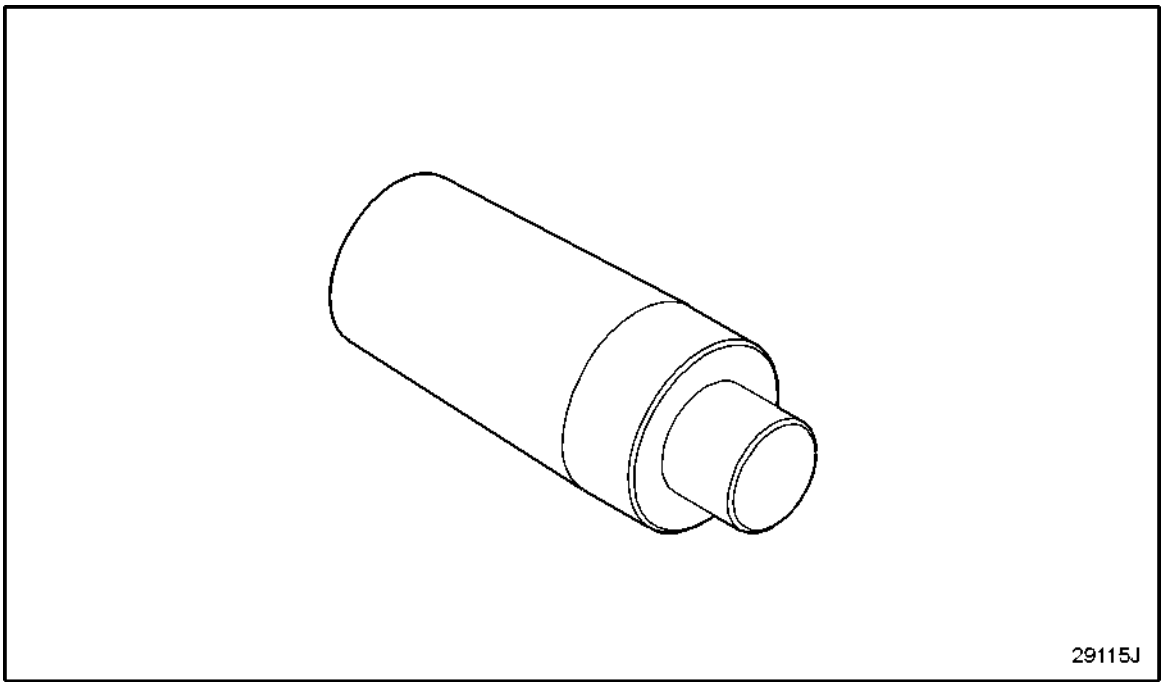

Figure 1436 Piston Pin Alignment Tool,J 35619

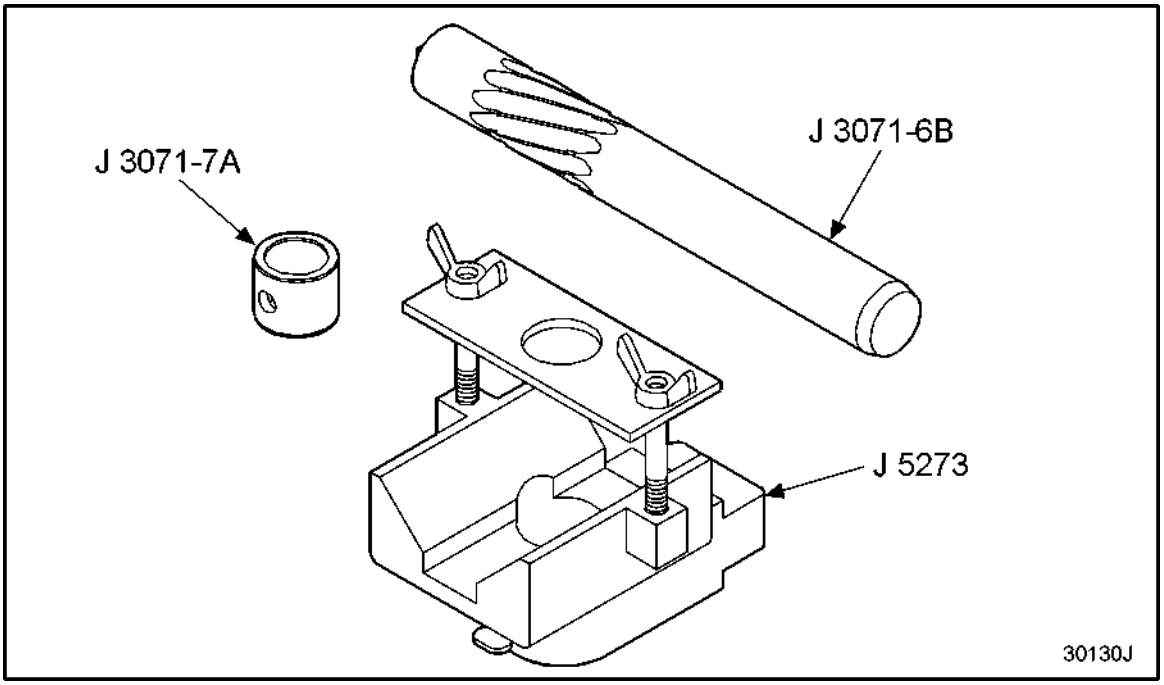

Figure 1437 Piston Pin Bushing Reamer Kit,J 3071–B

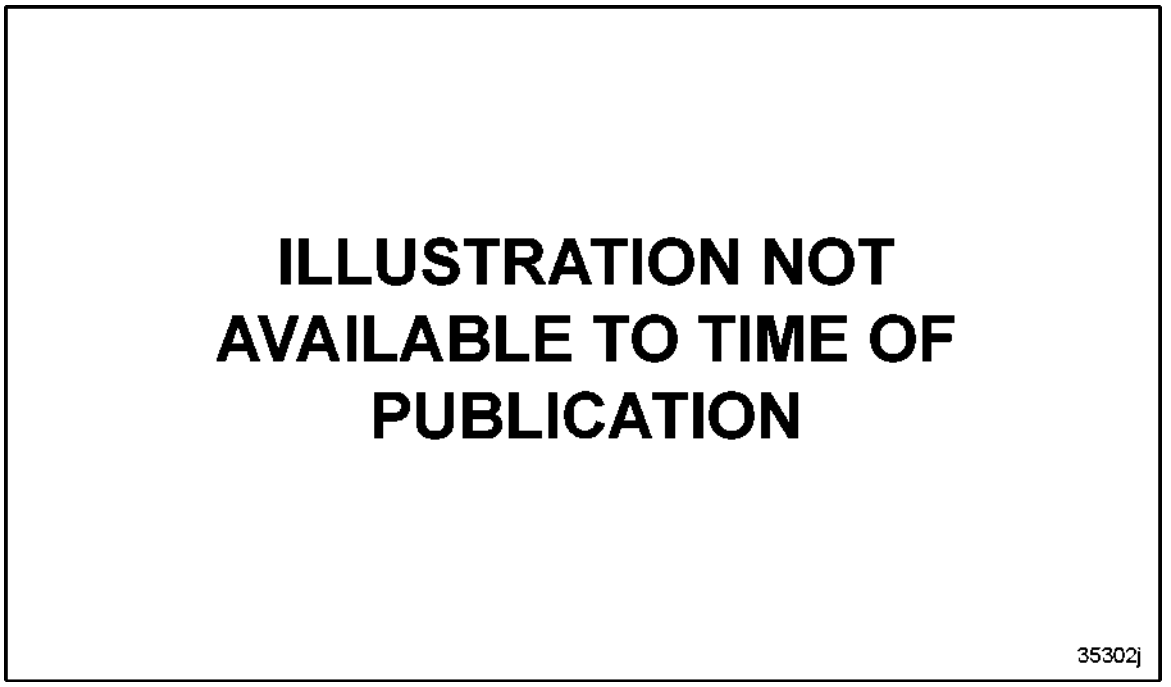

Figure 1438 Piston Pin Bushing Reamer Kit ,J 4970–02

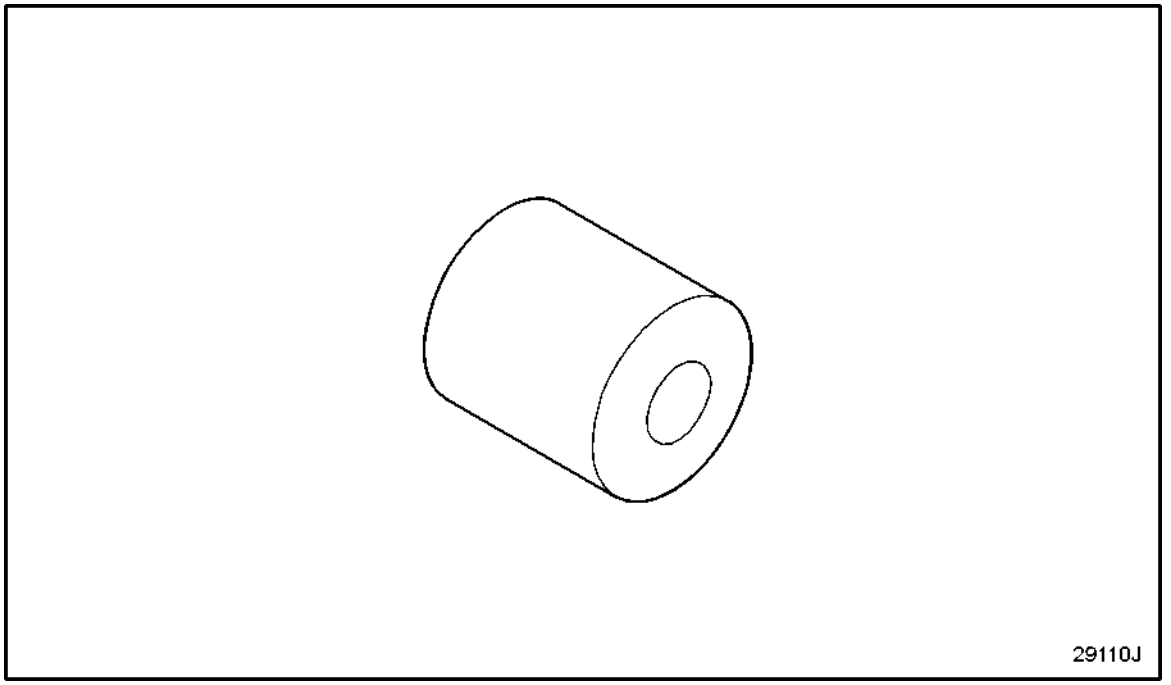

Figure 1439 Piston Pin Retainer Installer,J 23762–A

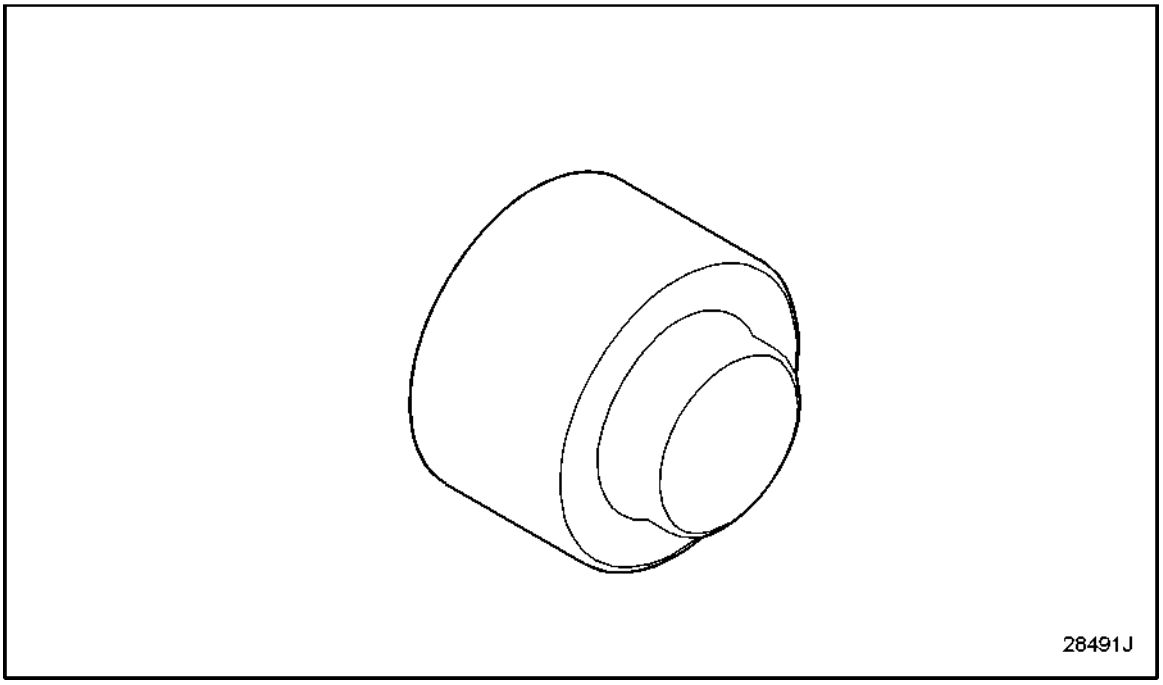

Figure 1440 Piston Pin Retainer Installer,J 24274–B

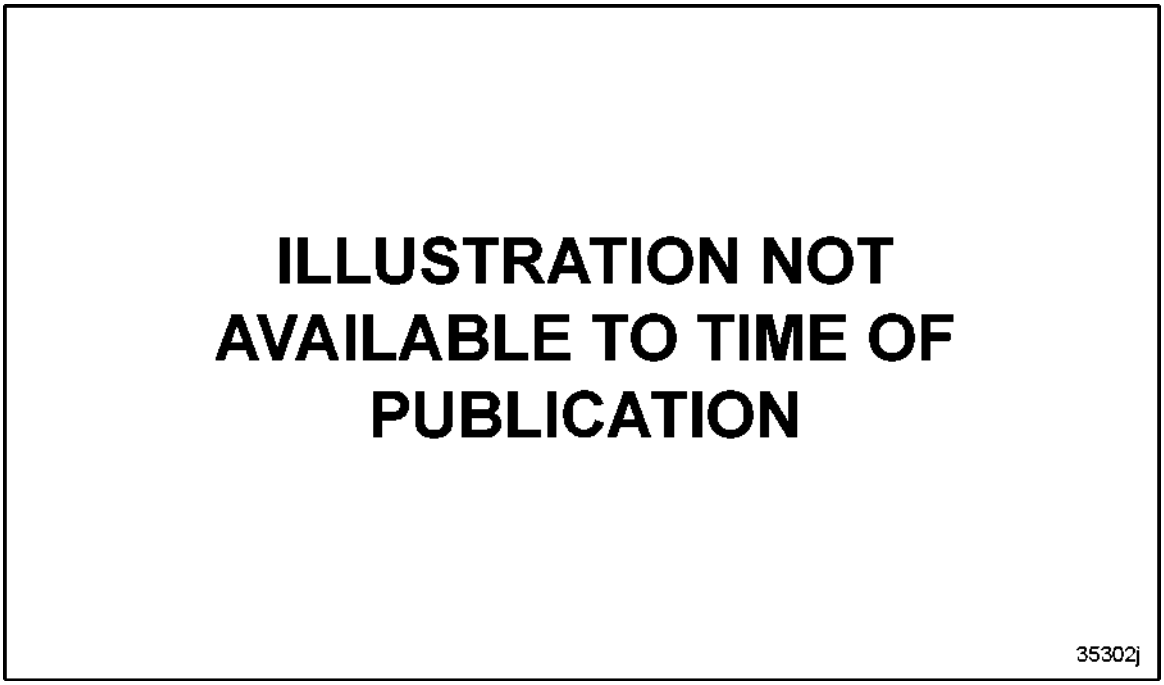

Figure 1441 Piston Pin Retainer Installer,J 35572

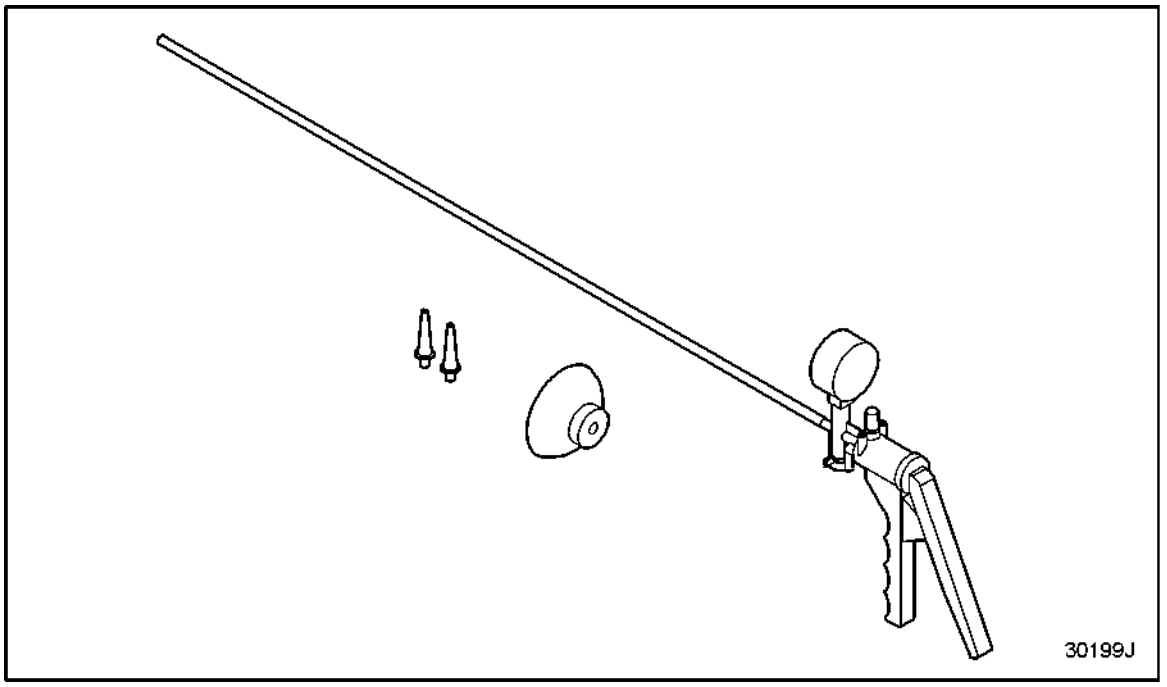

Figure 1442 Piston Pin Retainer Leak Detector, J 23987–B

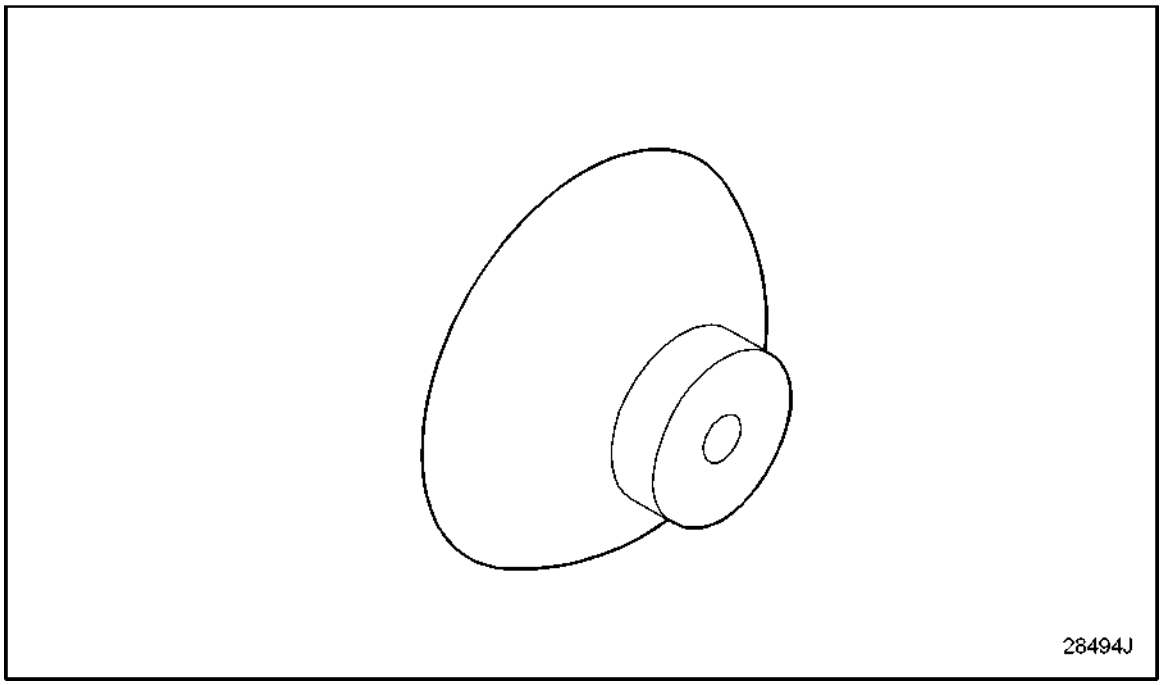

Figure 1443 Piston Pin Retainer Leak Test Cup, J 24629

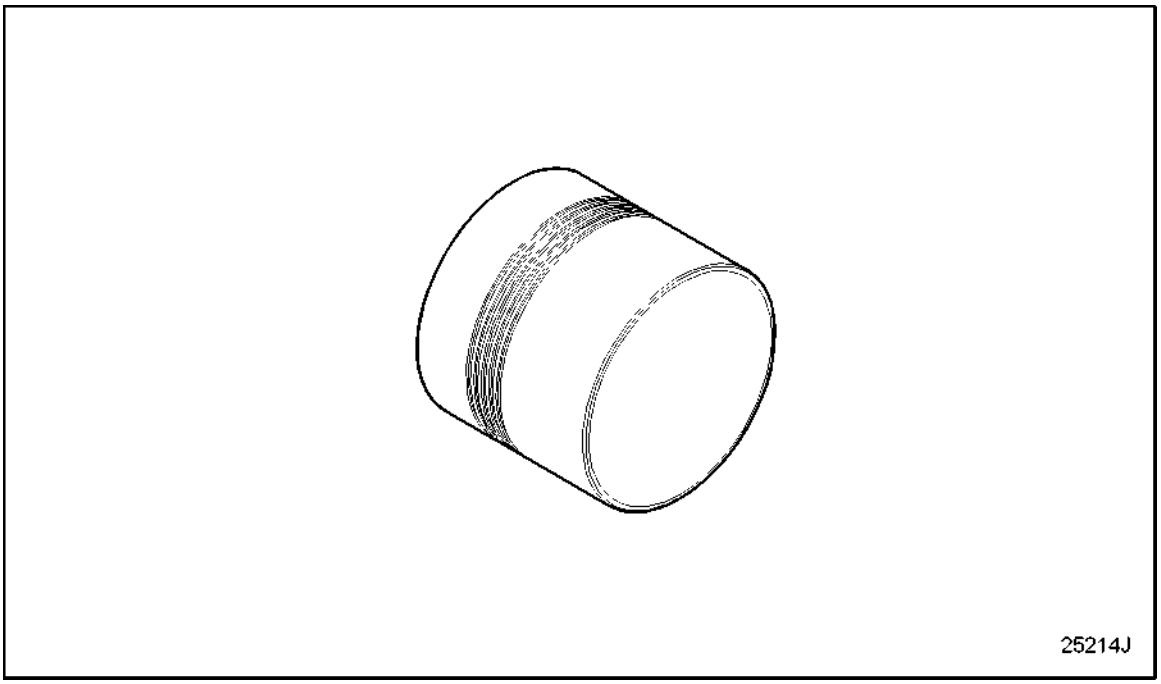

Figure 1444 Piston Ring Compressor, J 41328

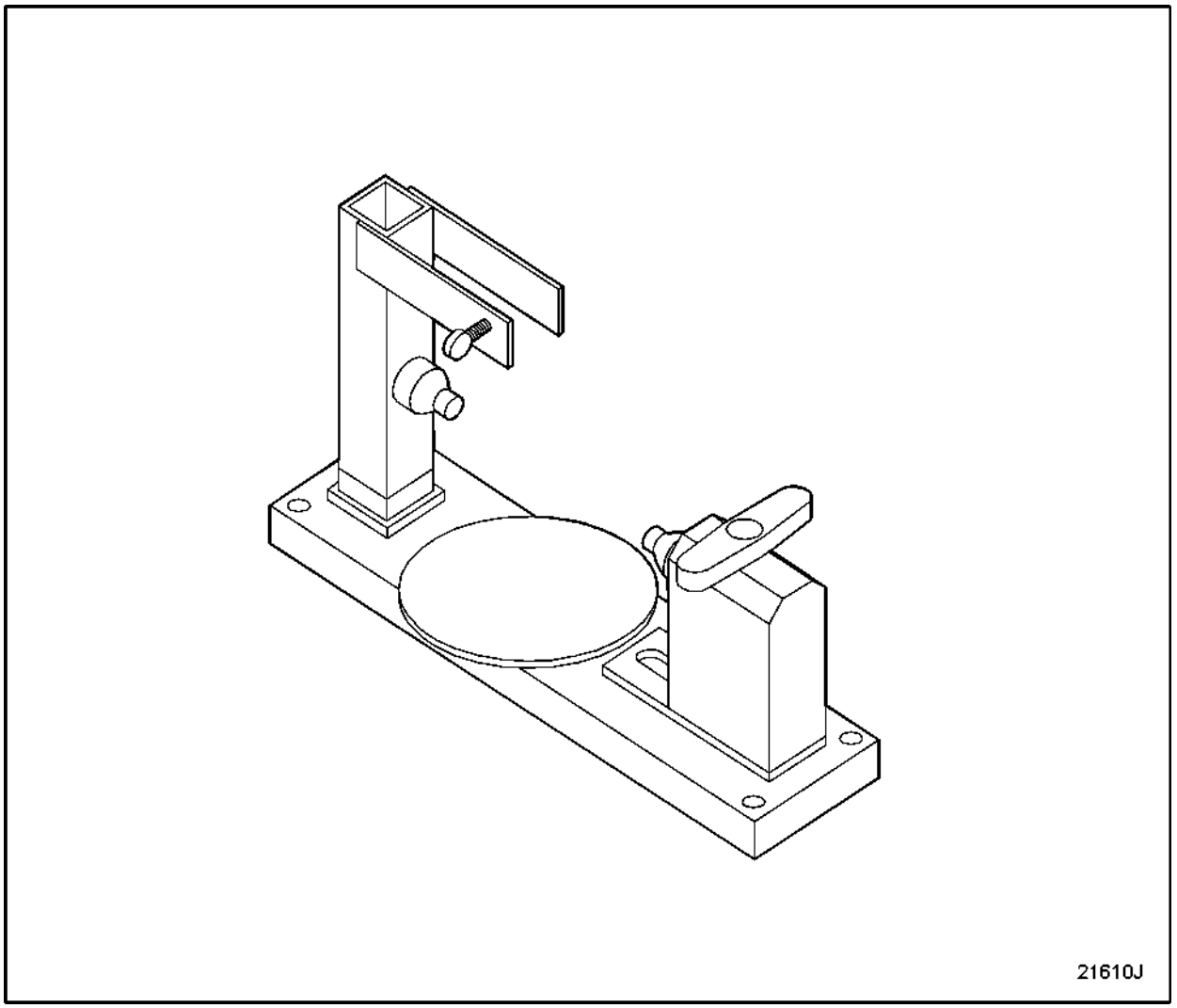

Figure 1445 Piston/Conn Rod Holding Fixture,J 36211

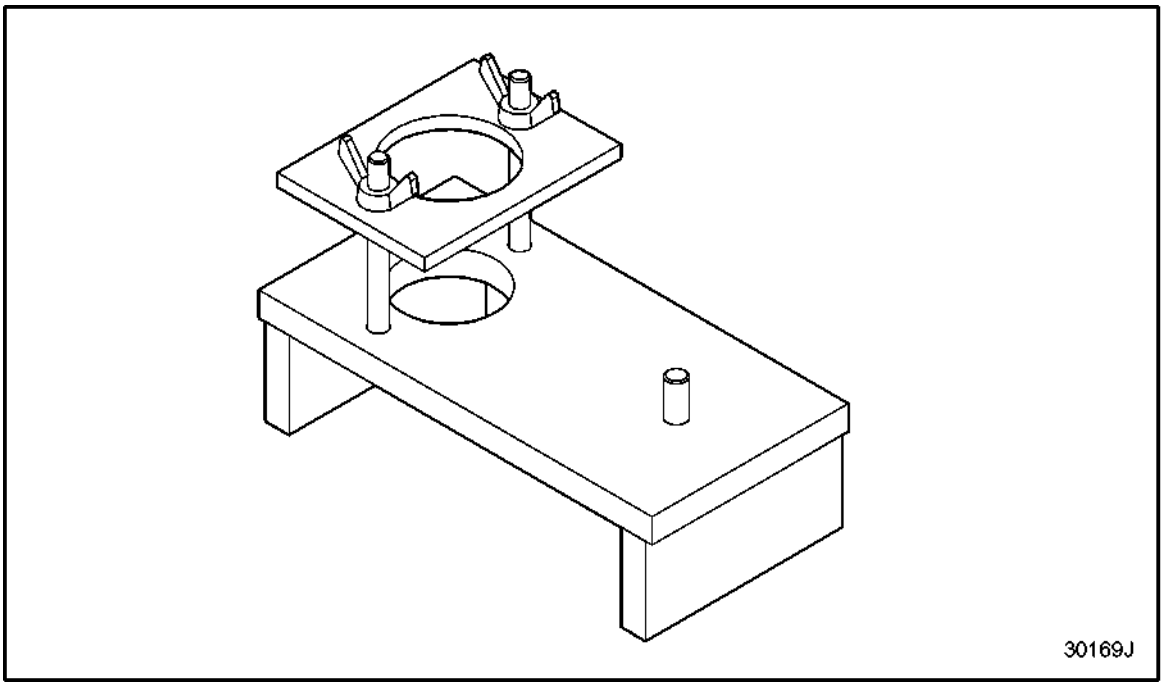

Figure 1446 Rod Holder,J 7632

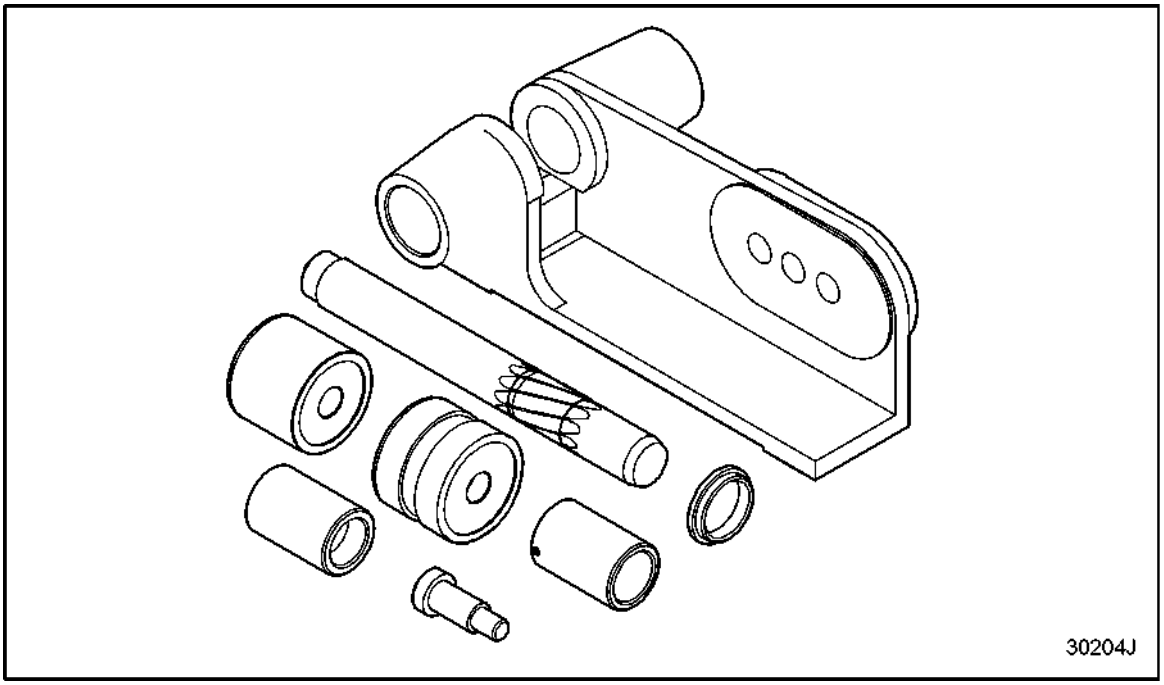

Figure 1447 Connecting Rod Bushing Reaming Set,J 29588–53

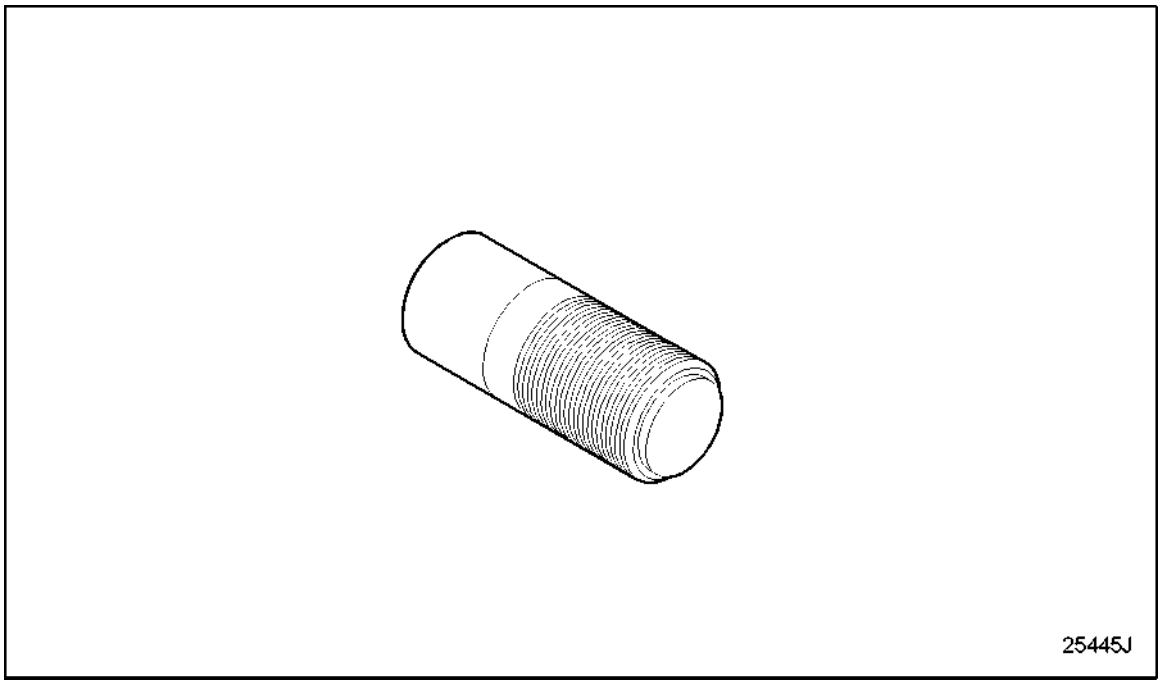

Figure 1448 Flywheel Lock-Timing,J 41786

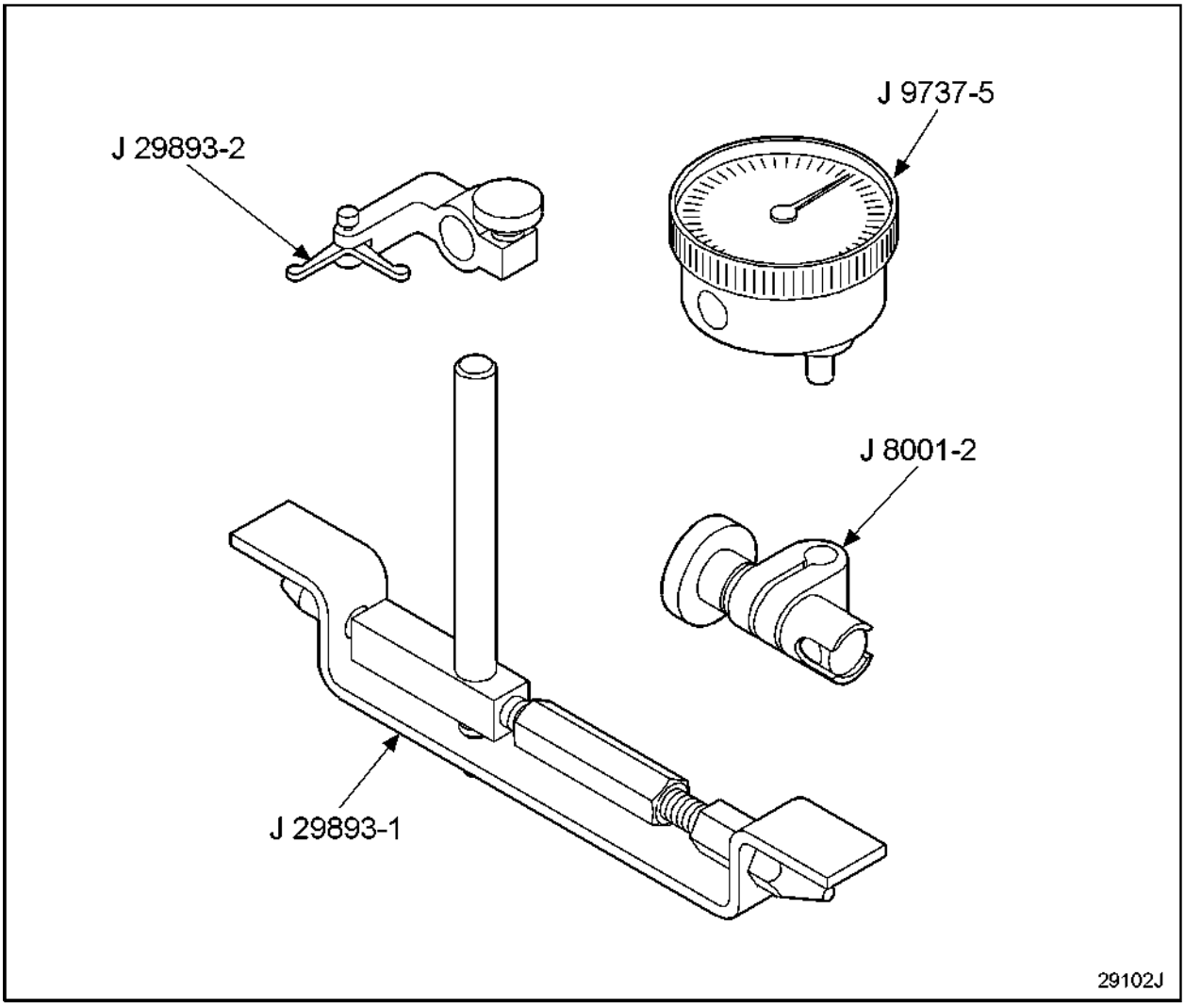

Figure 1449 Generator Gear Dial Indicator, J 29893

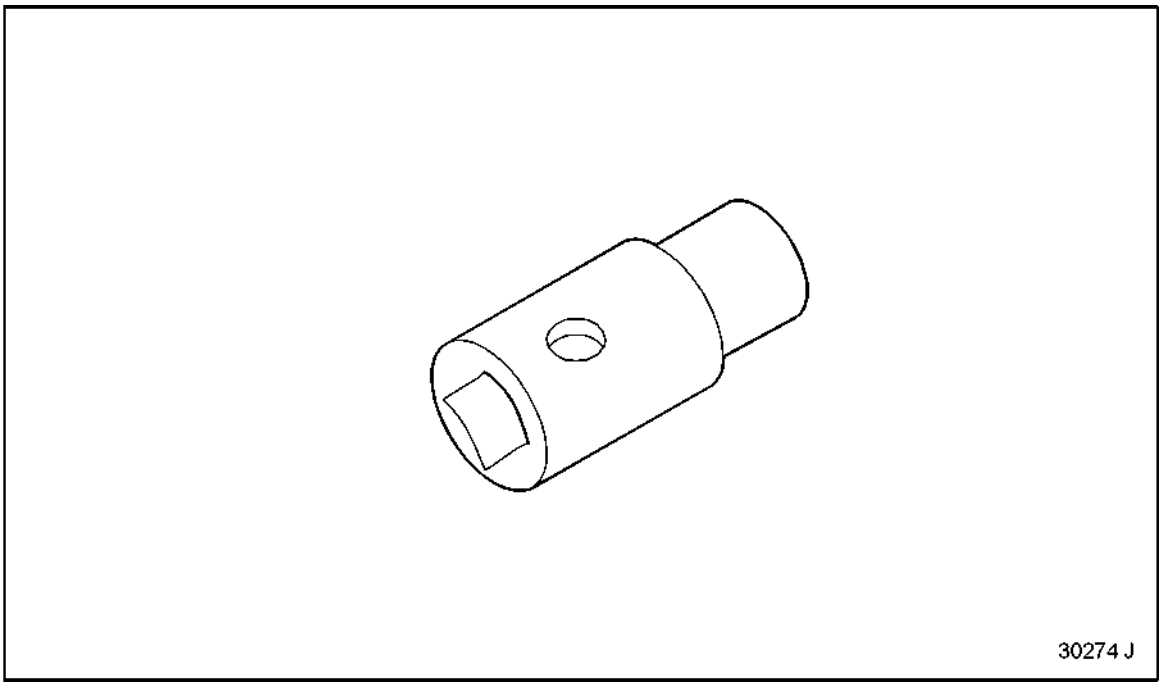

Figure 1450 Lower Idler Gear Socket,J 41167

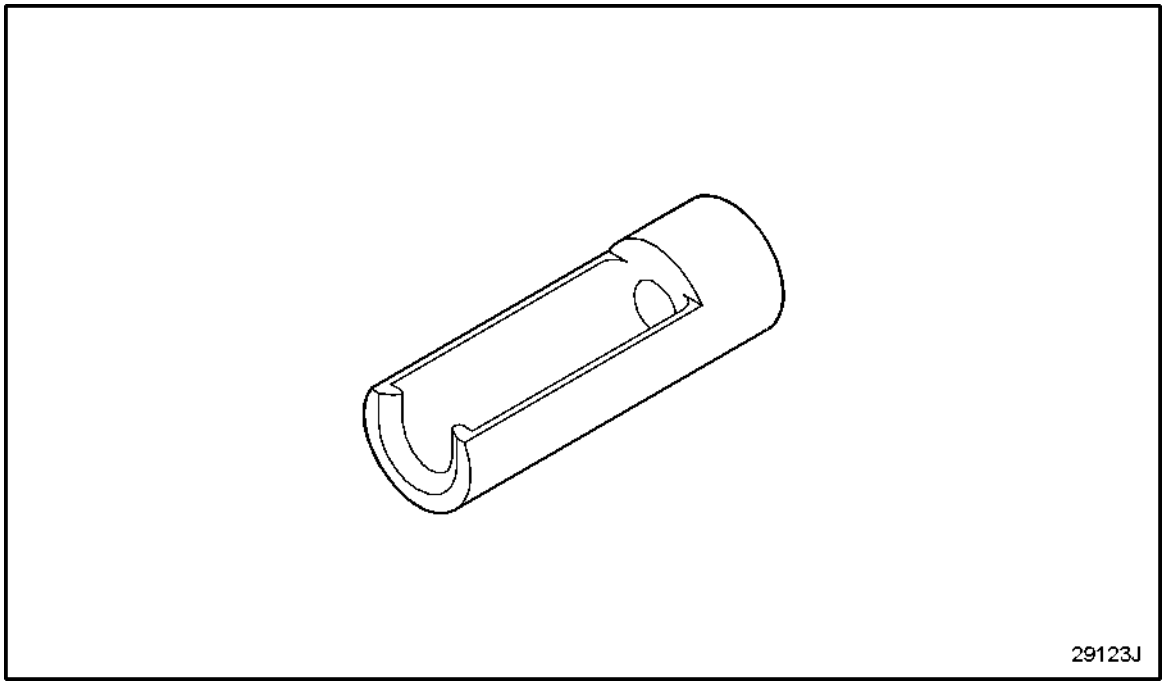

Figure 1451 Puller Adapter (Pressed Tach DRVS),J 24730

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Figure 1452 Tach Drive Alignment Tool Set,J 23068

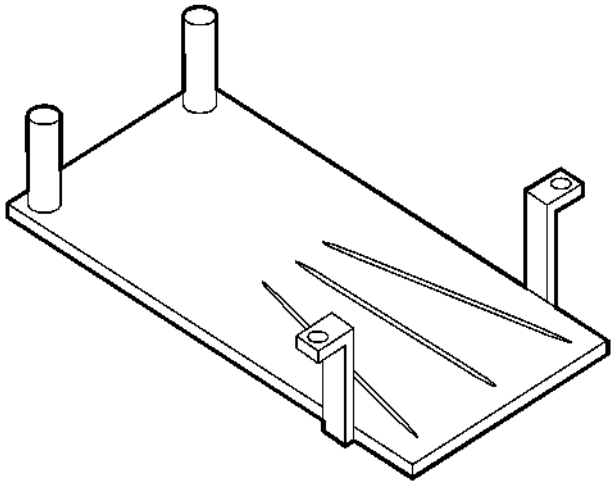

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Figure 1453 Balance Shaft Assembly Support,J 39814–A

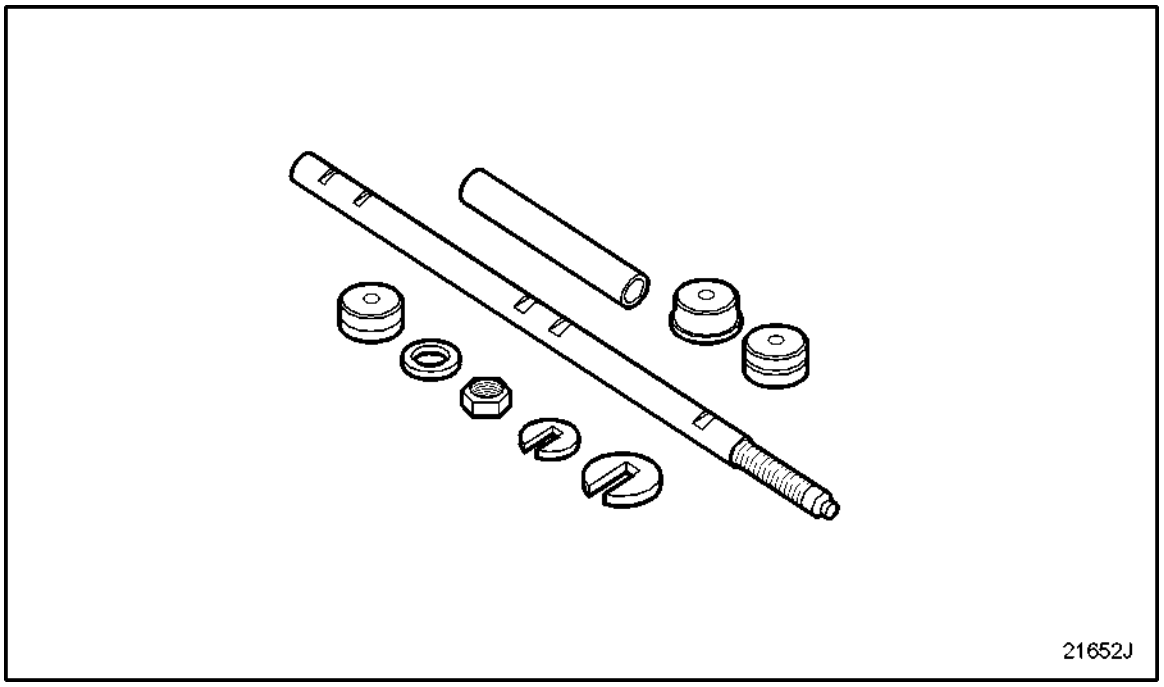

Figure 1454 Balance Shaft Bushing Inst & Remvr,J 39819

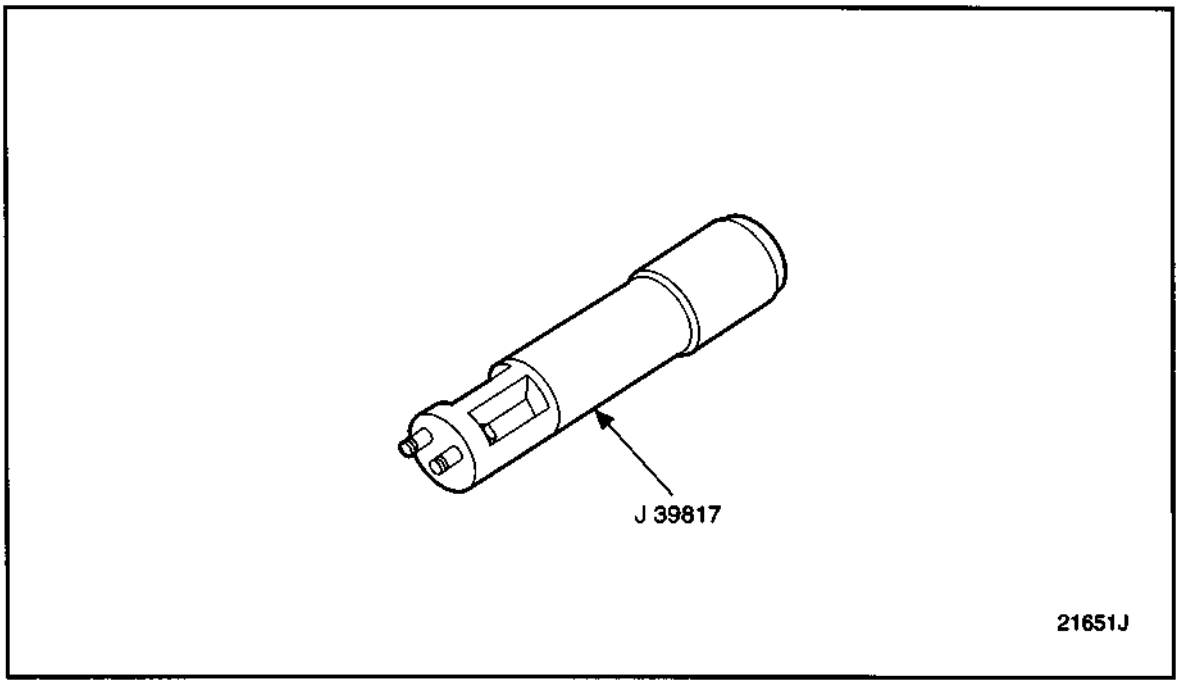

Figure 1455 Balance Shaft Installation Pilot,J 39817

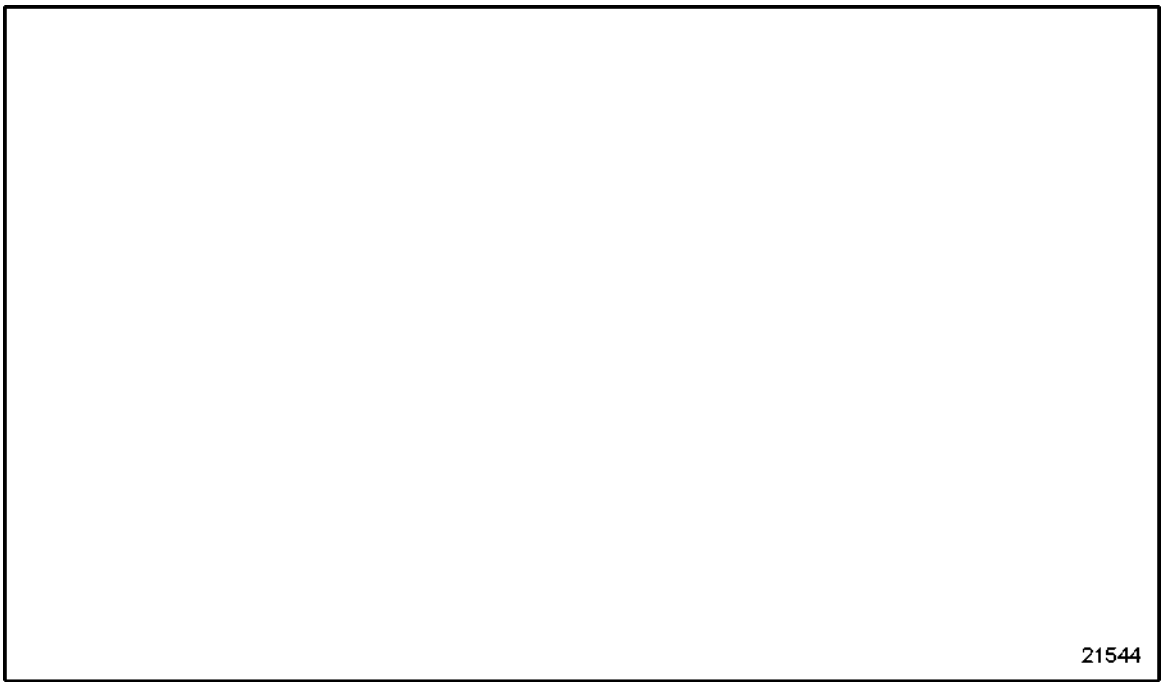

Figure 1456 Balance WT Cam Coupling Torque Wrench Adapter,J 9791

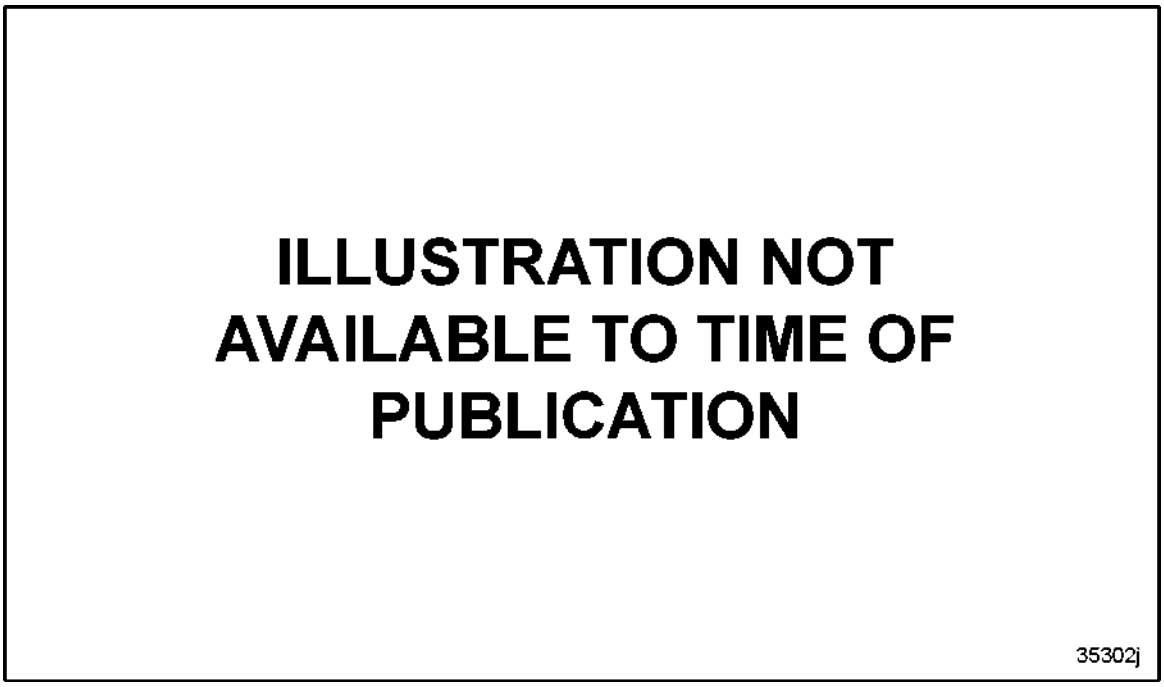

Figure 1457 Cam & Bal Shaft Bushg Rem/Install,J 7593–03

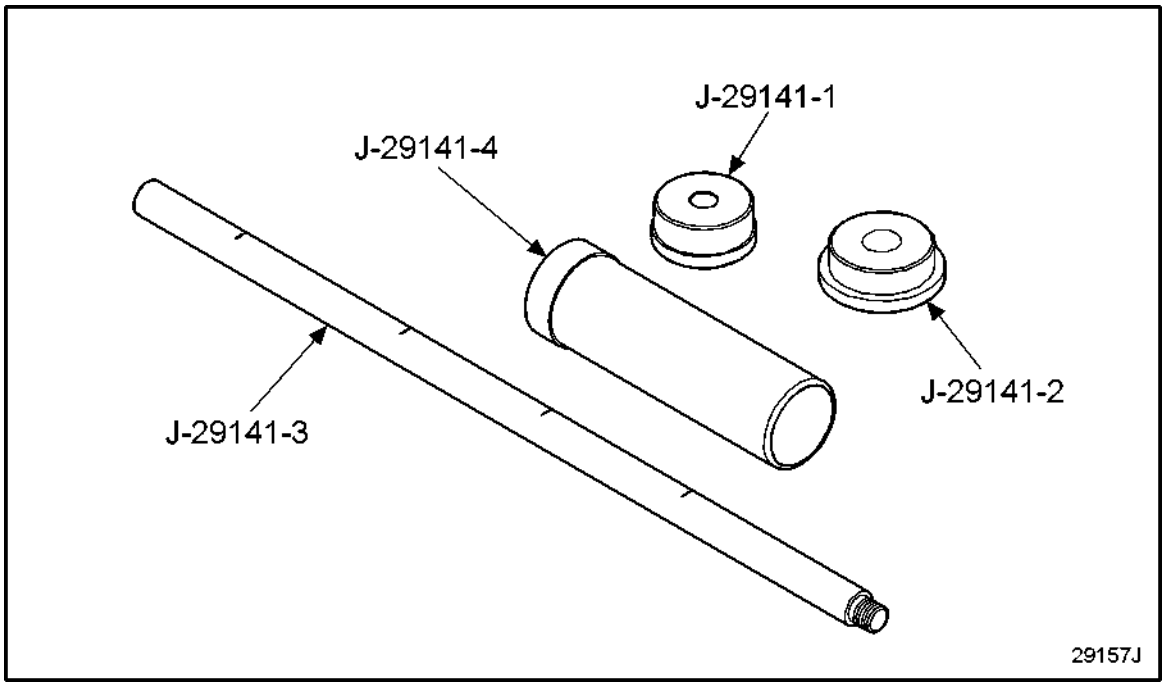

Figure 1458 Cam Bushing Remover & Installer,J 29141–A

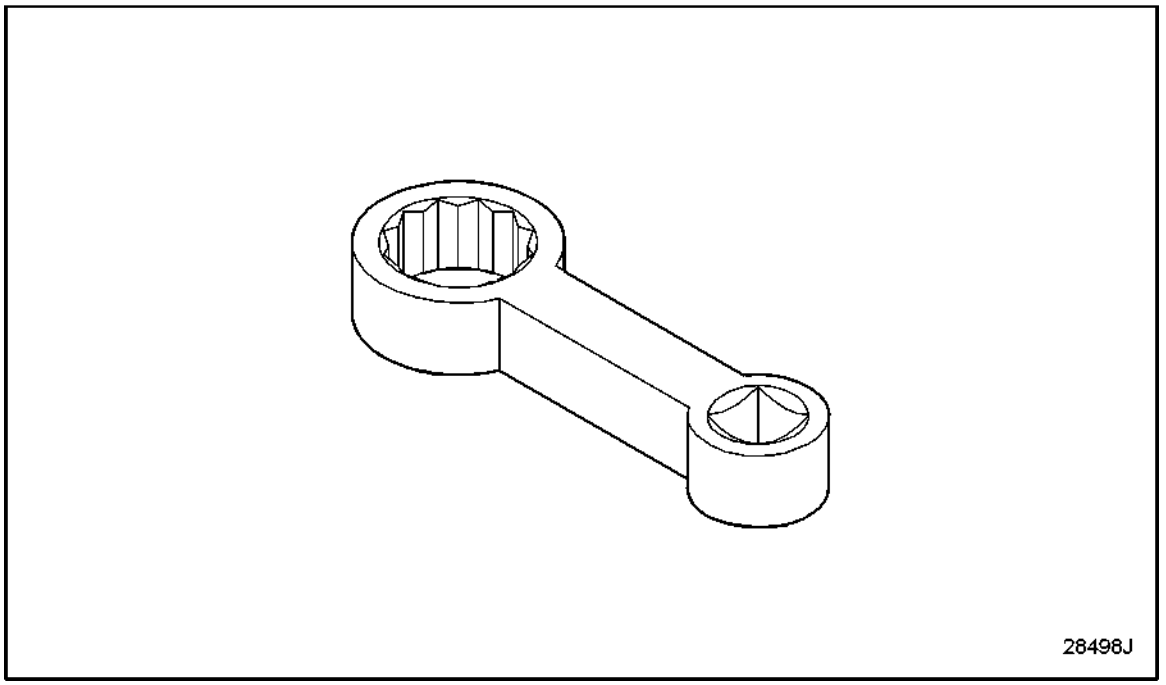

Figure 1459 Cam Coupling Torque Wrench Adapter,J 28462

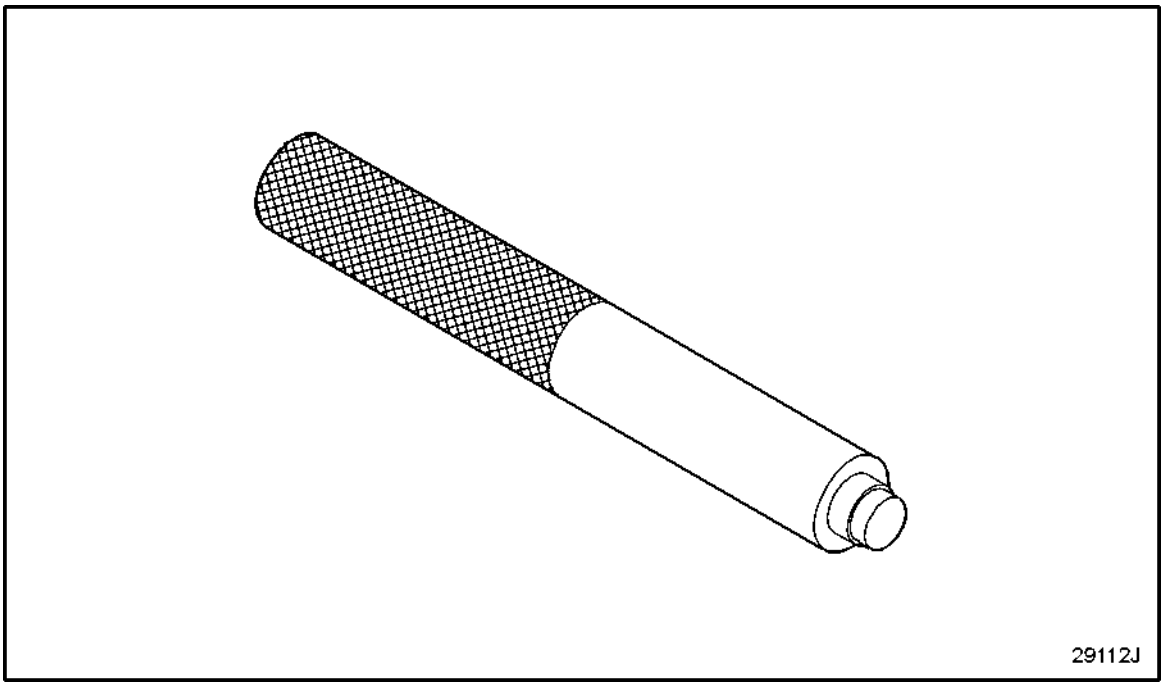

Figure 1460 Cam Cup Plug Installer,J 24094

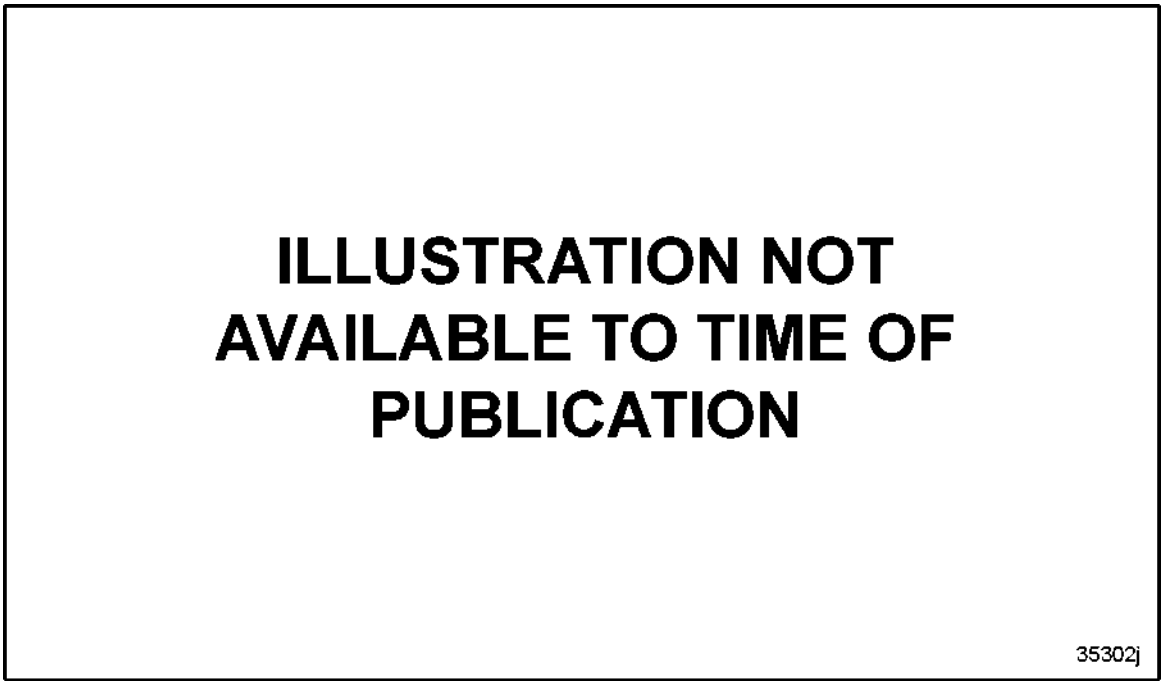

Figure 1461 Cam Installation Pilot,J 34033

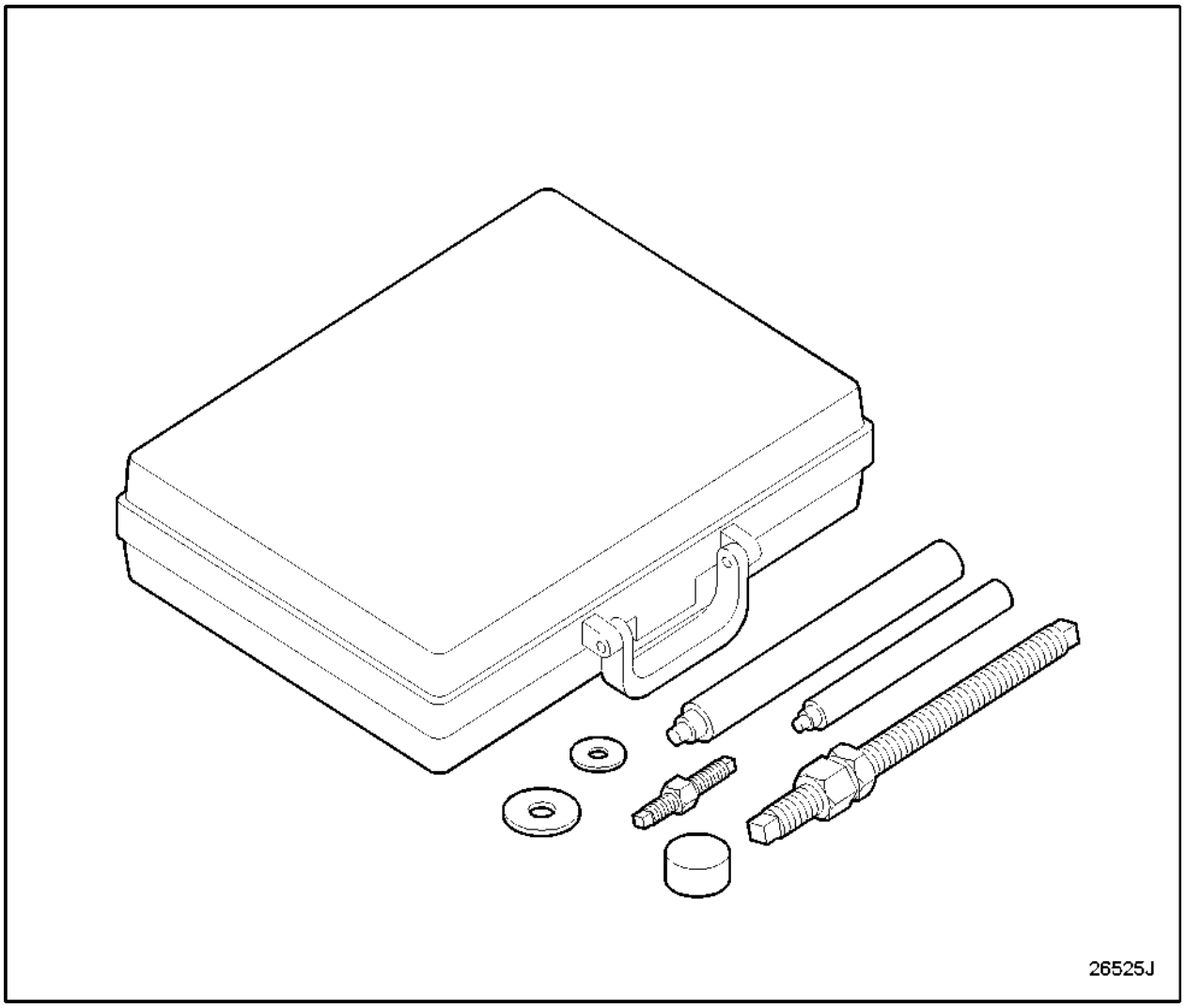

Figure 1462 Cam Shaft Bushing R & I,J 39537

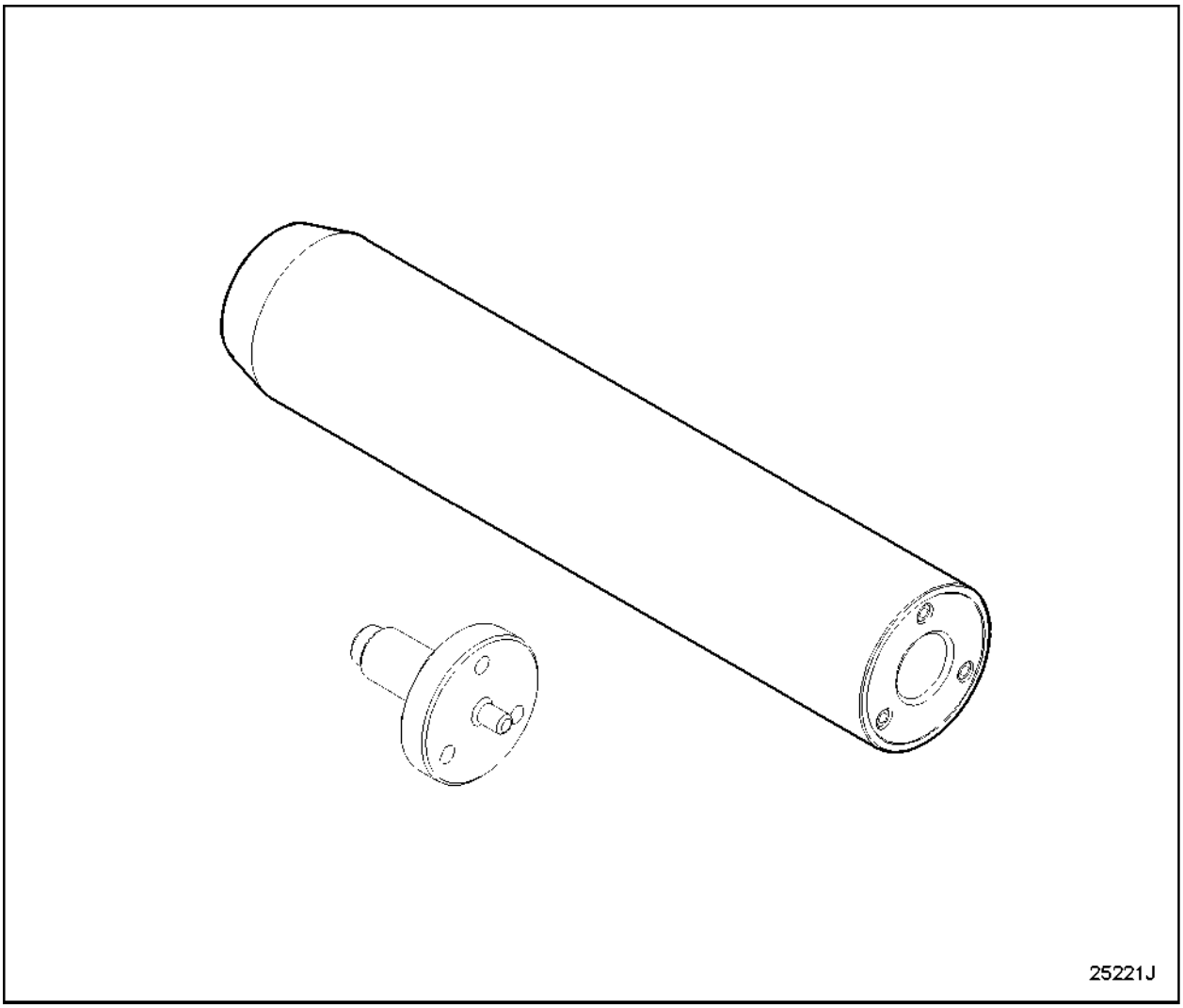

Figure 1463 Camshaft Pilot,J 41580

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Figure 1464 Gear/Cam Pulley Remover Adapter, J 7932

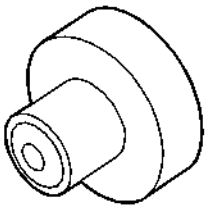

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Figure 1465 Upper Front Cover Seal Installer, J 9790

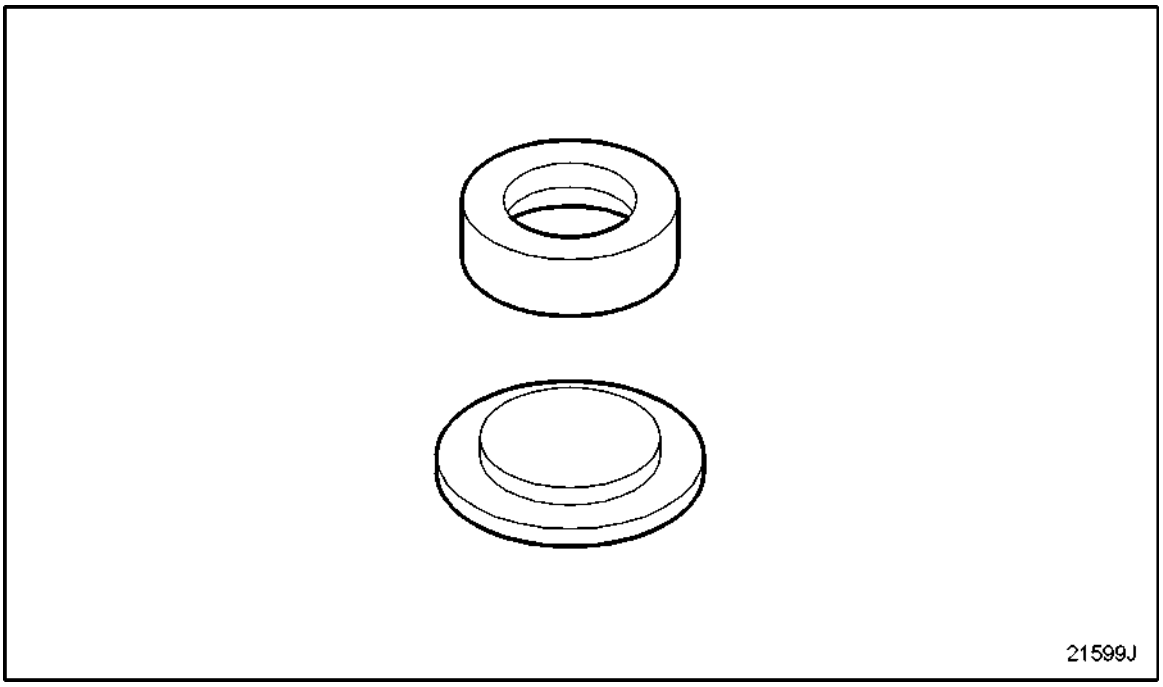

Figure 1466 Cam Gear Assembly Fixture,J 35949

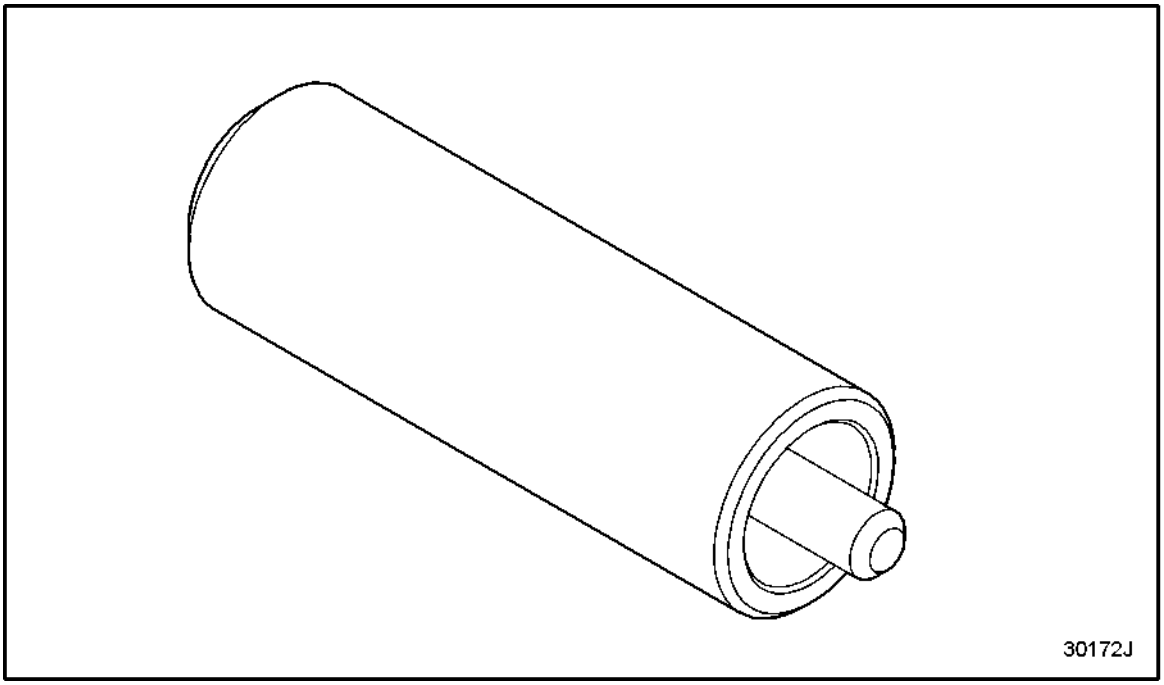

Figure 1467 Cam Gear Installer,J 1903

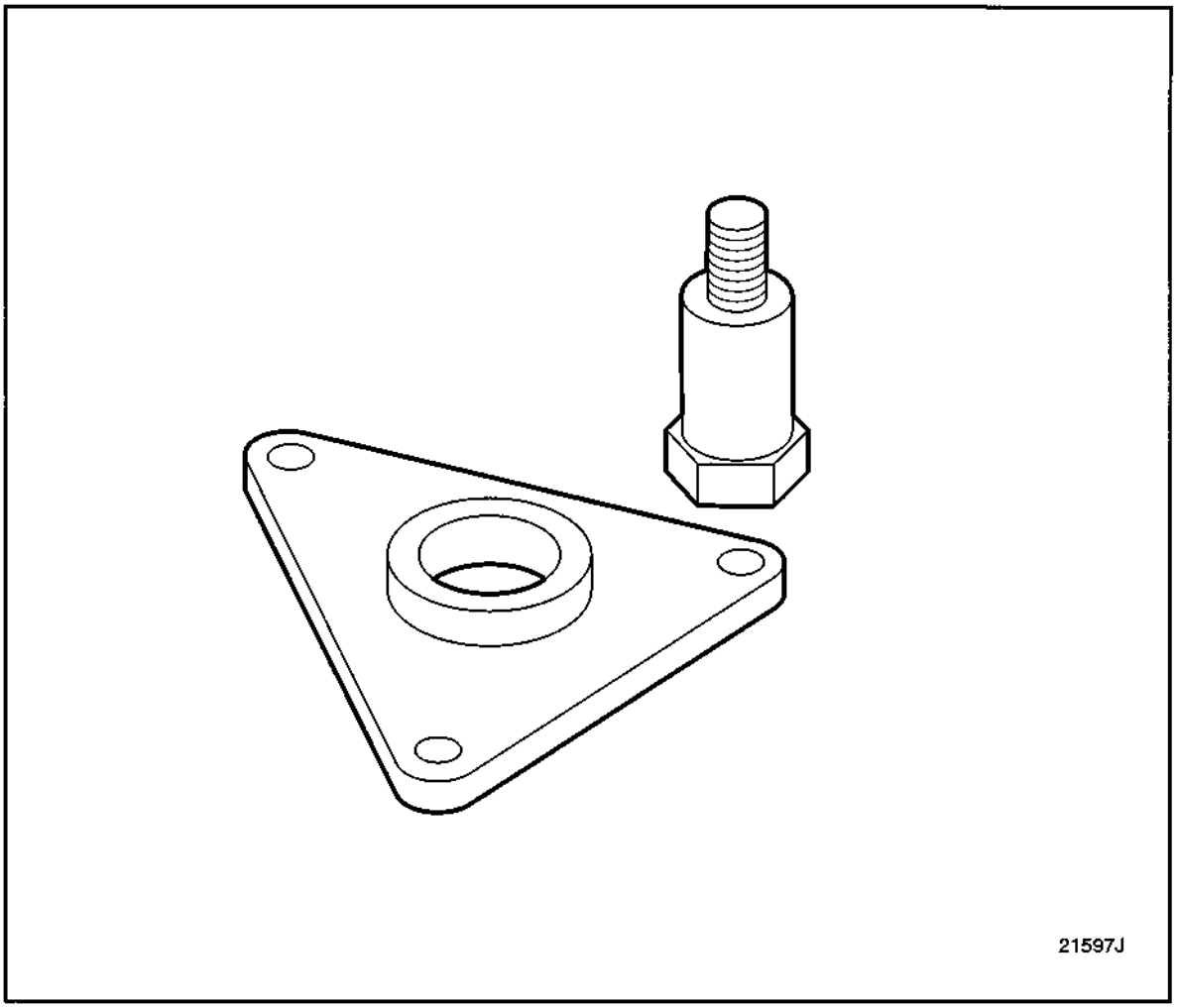

Figure 1468 Cam Gear Pilot,J 35906

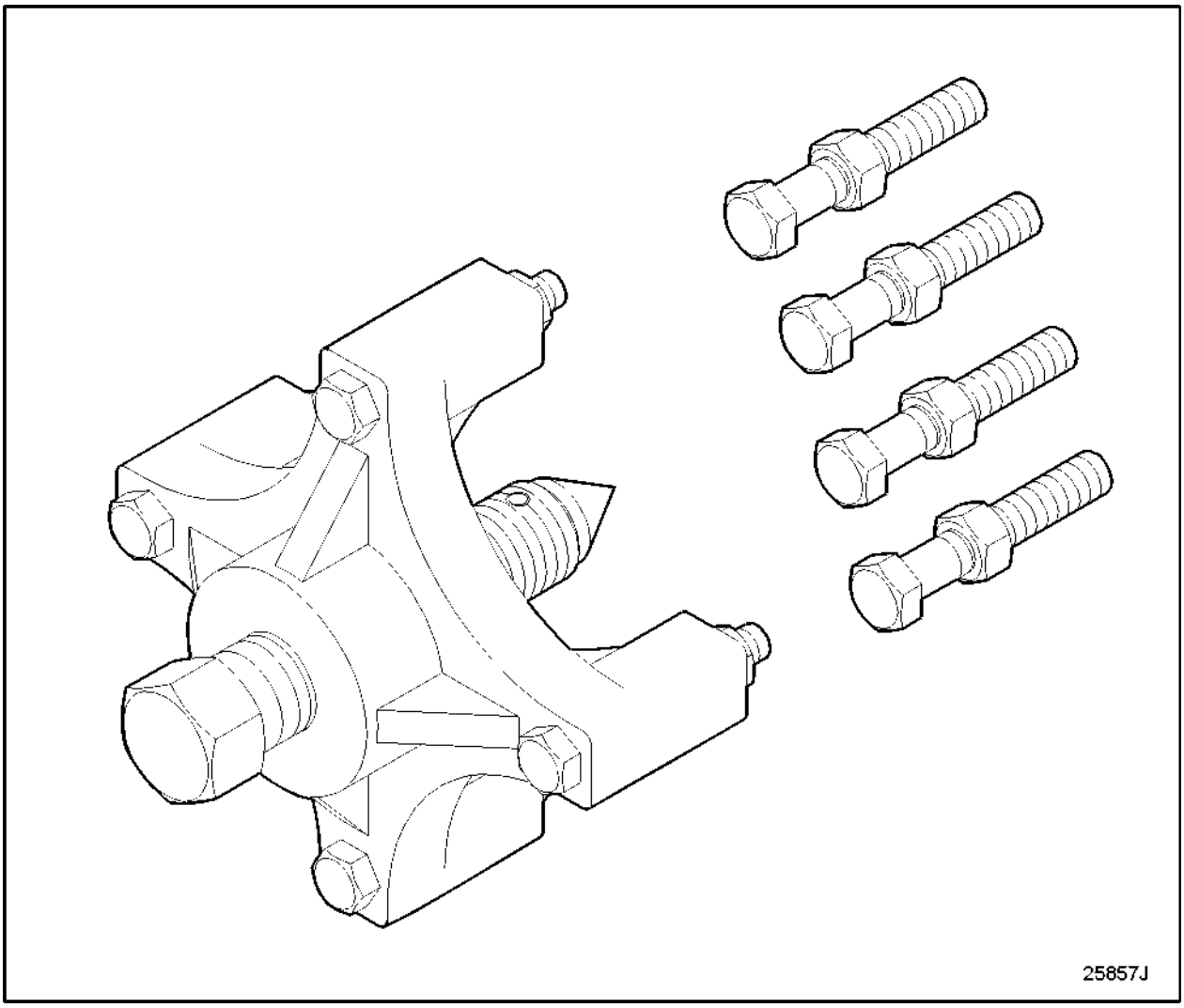

Figure 1469 Cam Gear Puller,J 1902–B

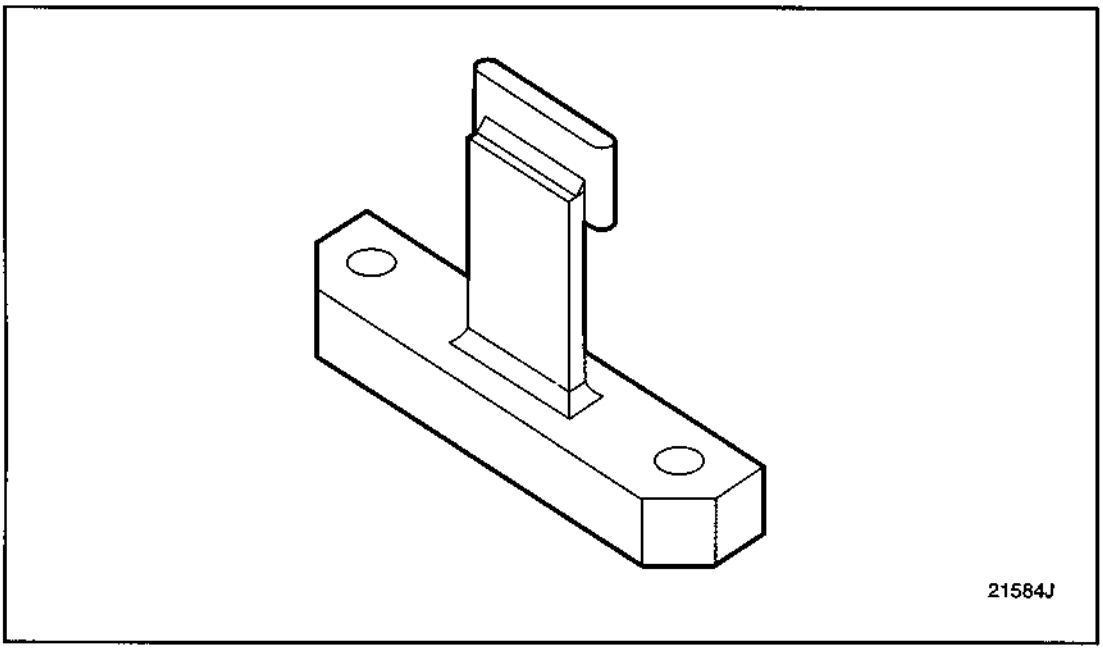

Figure 1470 Cam Gear Retaining Tool,J 35652

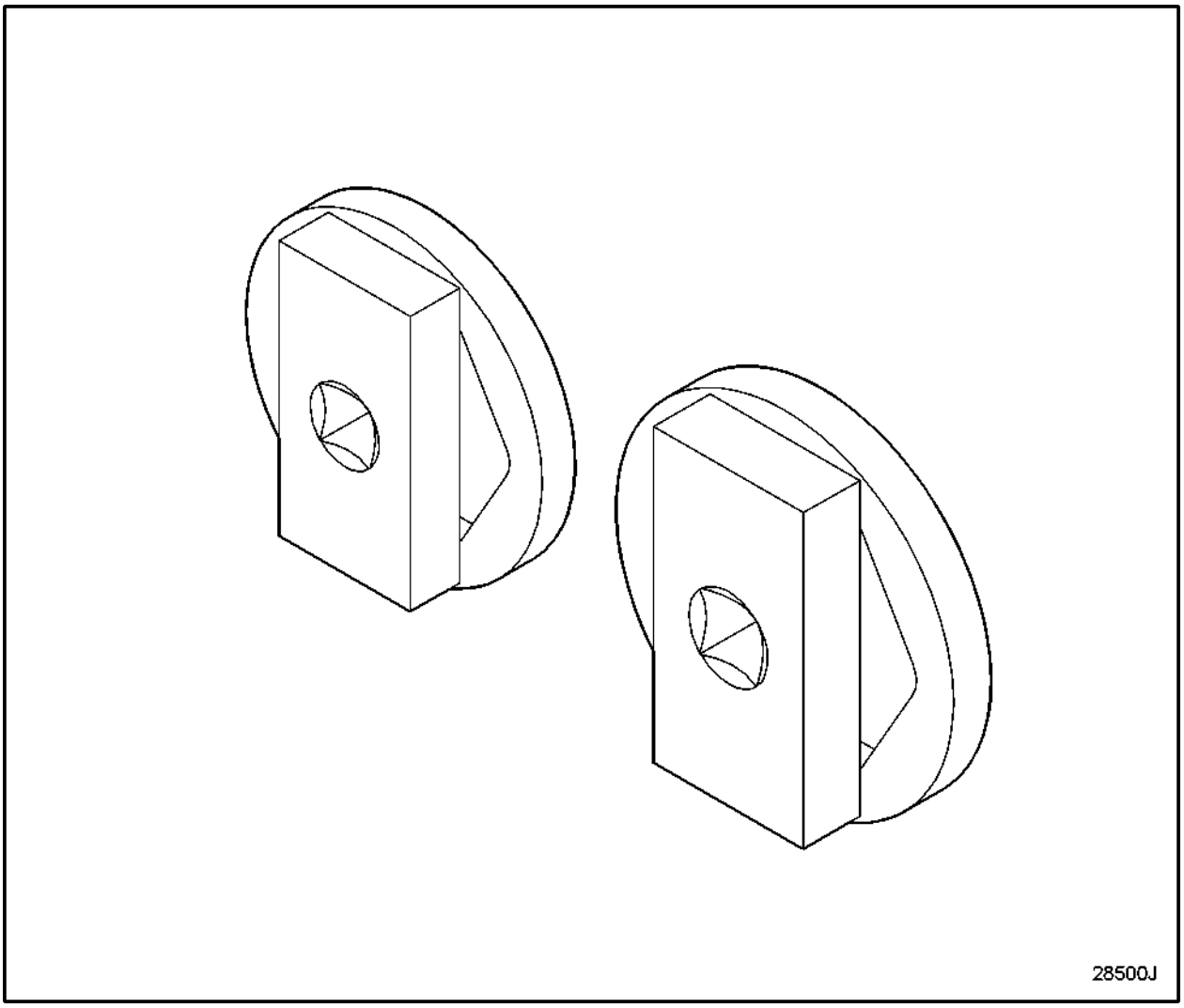

Figure 1471 Cam Idler Gear Nut Socket Set, J 29744

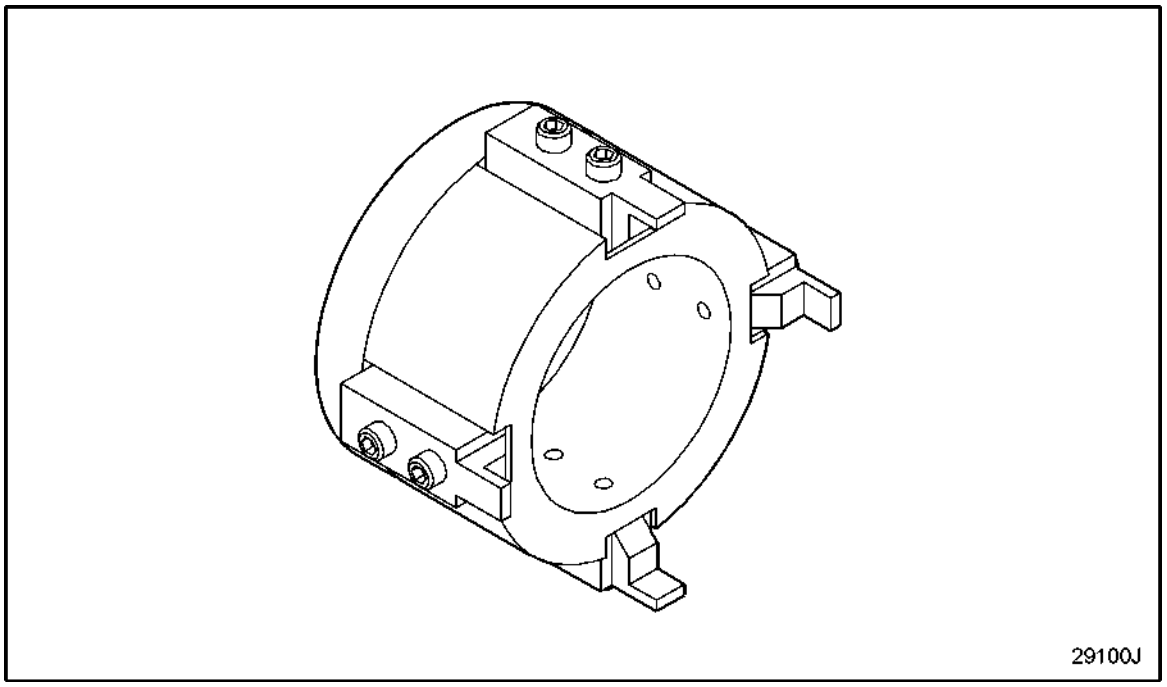

Figure 1472 Poly Vee Pulley Hub Nut Finger Set, J 22556–6

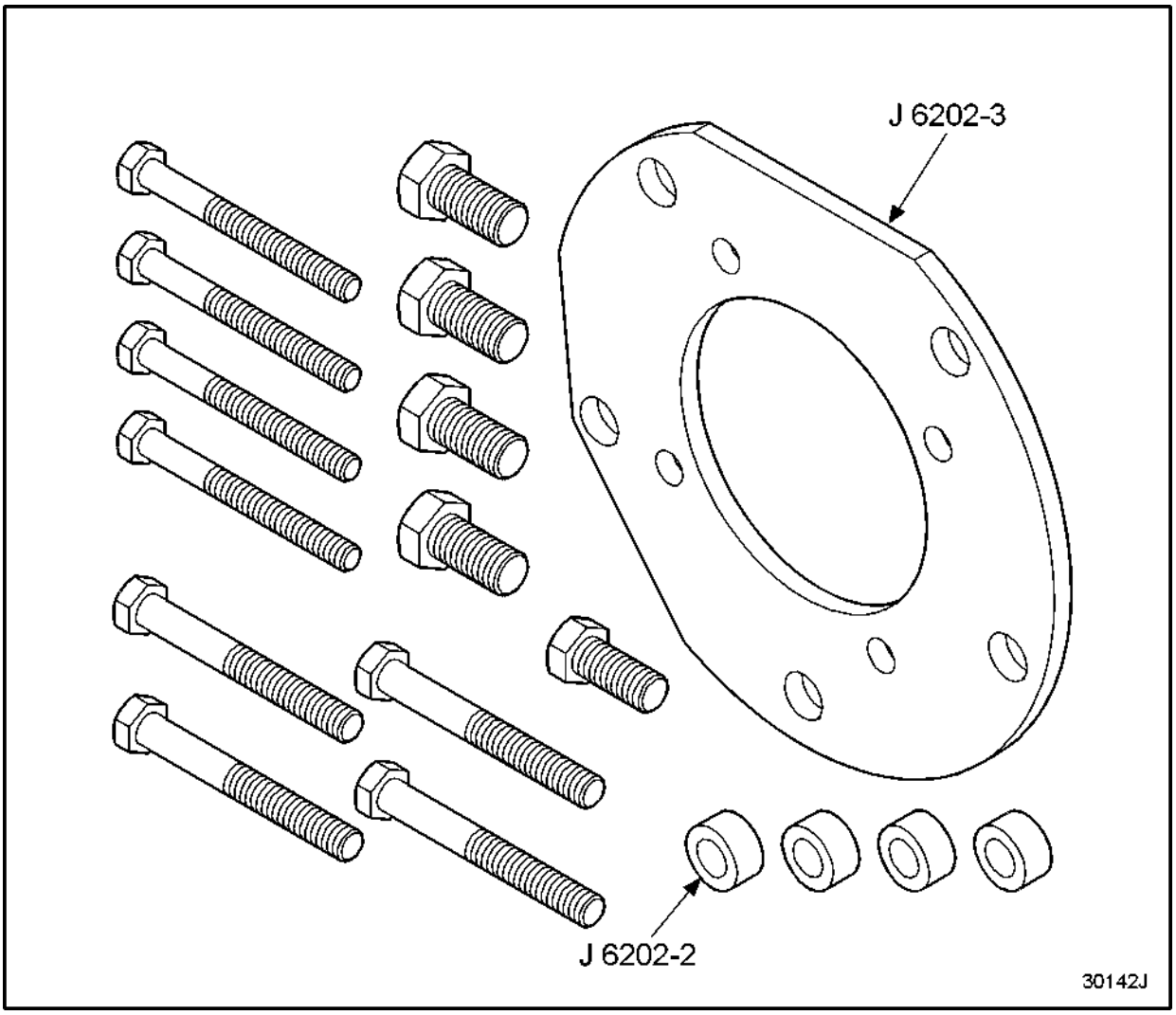

Figure 1473 RR Cam Gear Puller Adapt In Chassis,J 6202–01

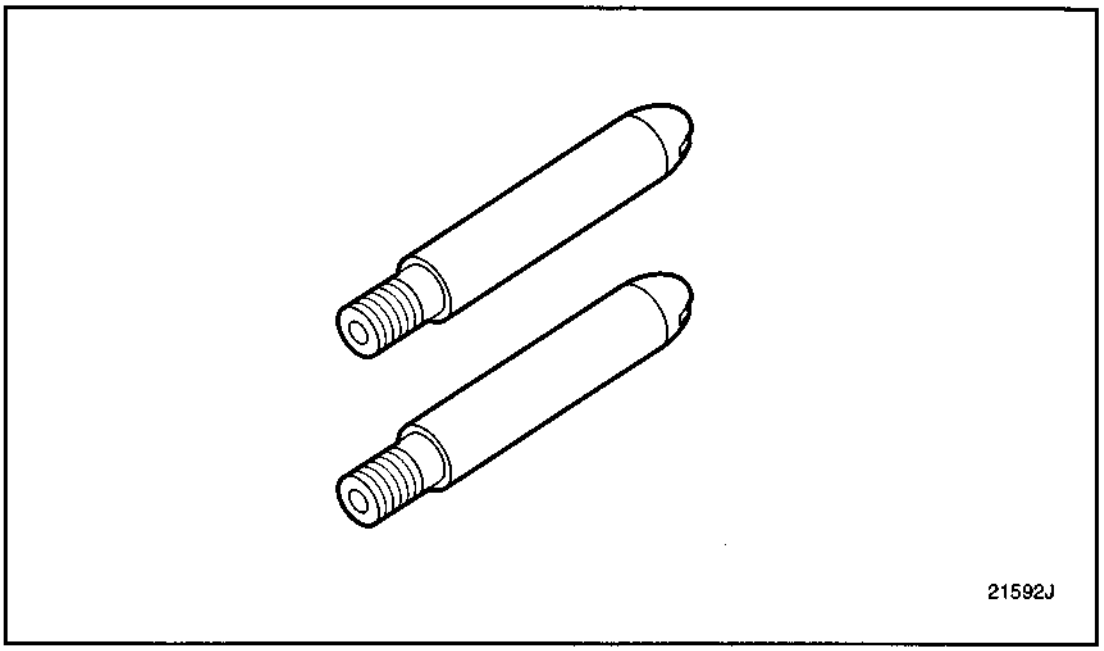

Figure 1474 Bull/Cam Idler Gear Guide Studs, J 35785

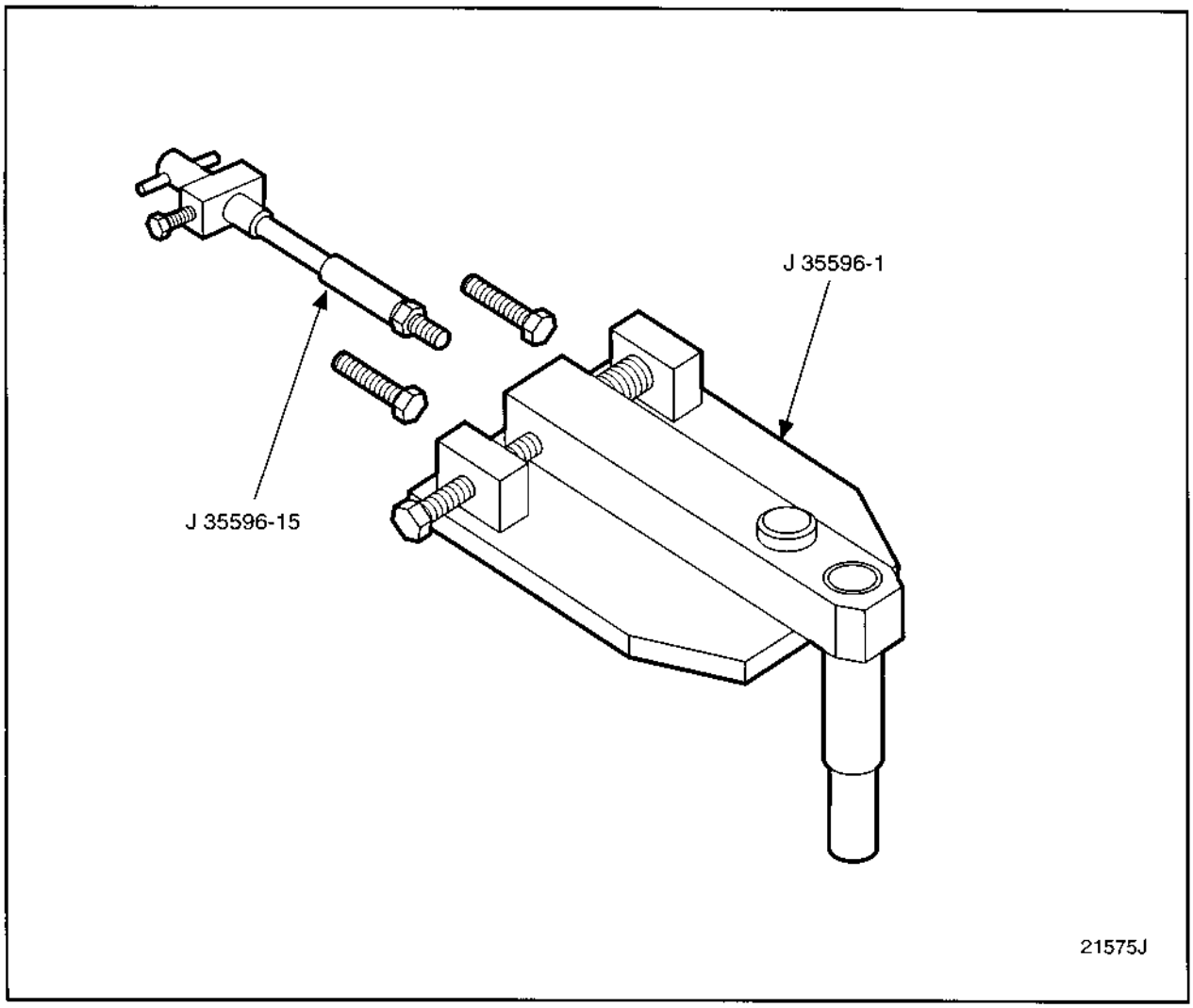

Figure 1475 Cam & Idler Gear Lash Adapter ,J 35596

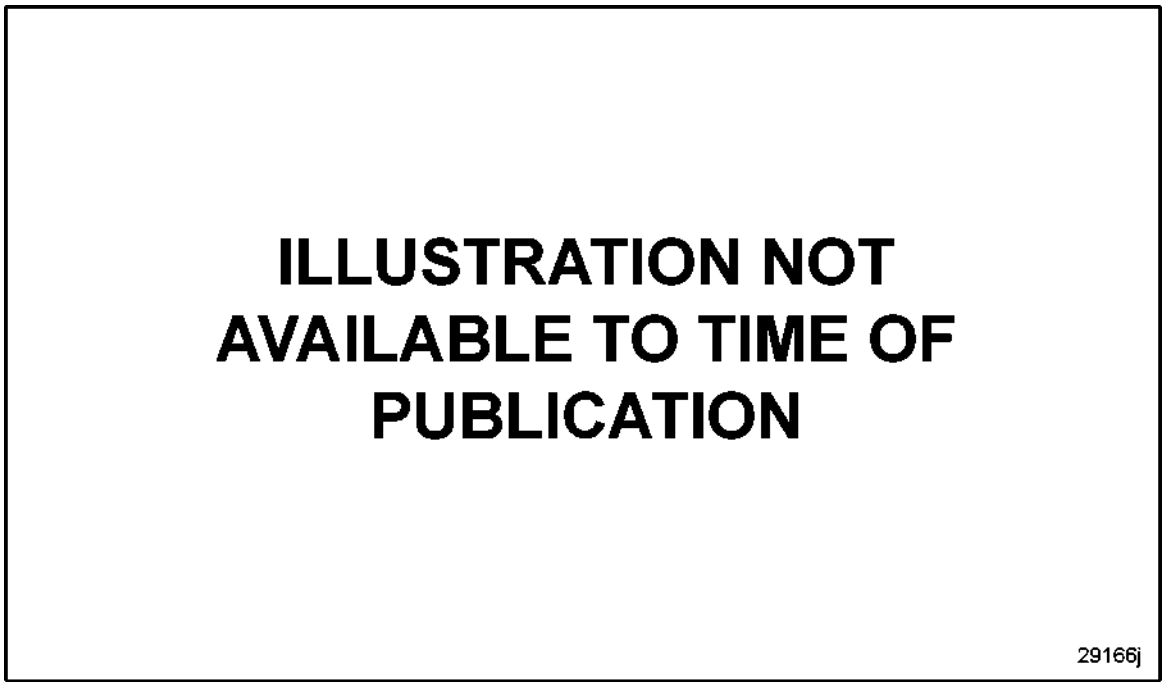

Figure 1476 Cam/Idler Gear Nut Spanner Wrench,J 22556

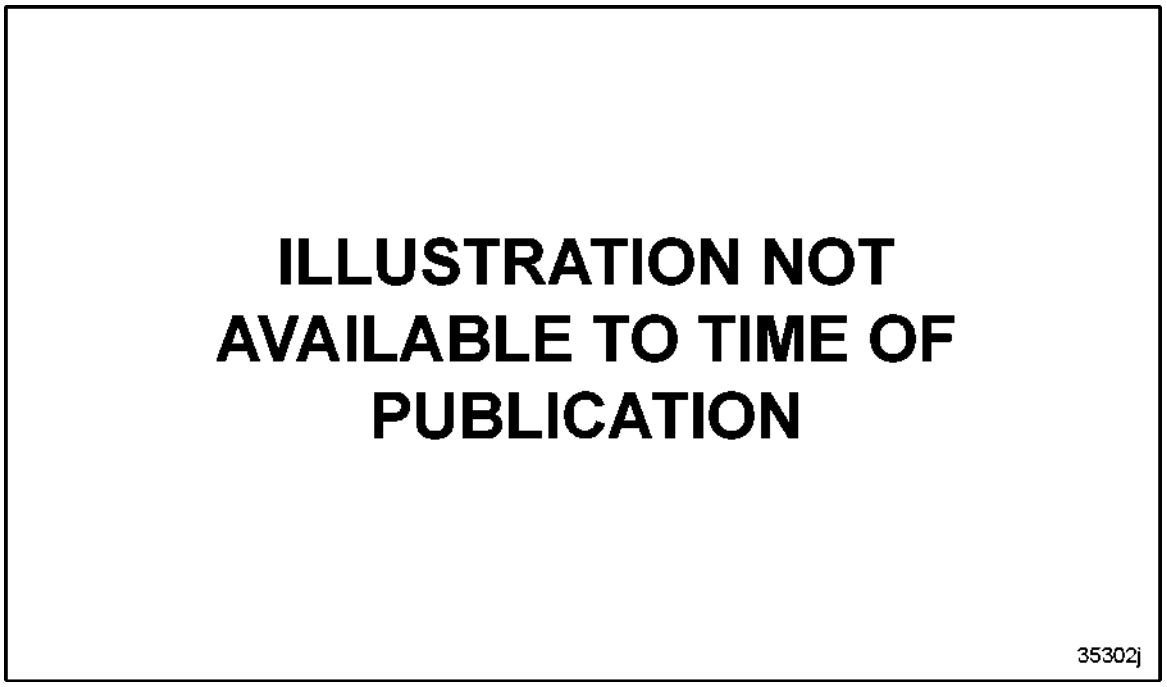

Figure 1477 Timing Gear Installer,J 7557

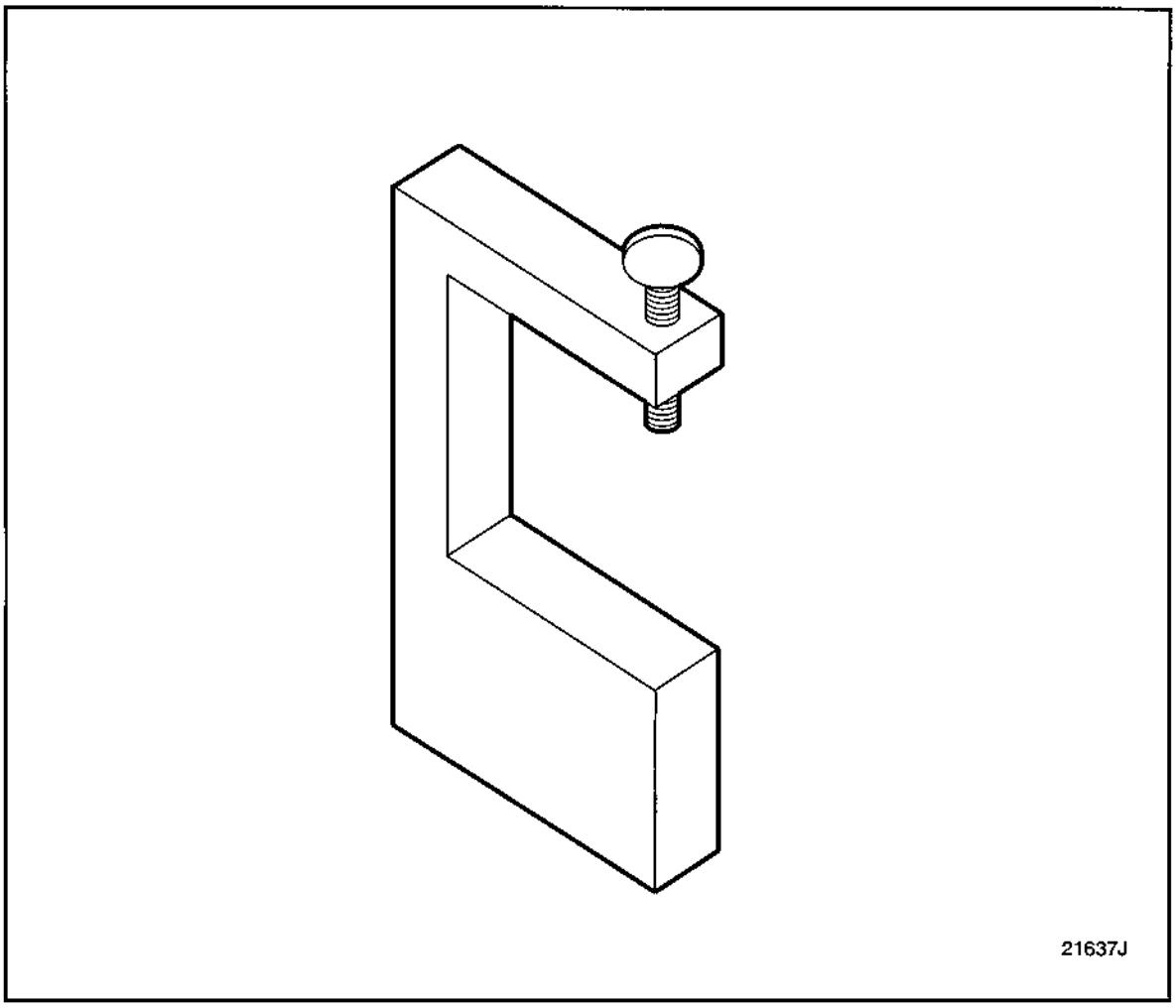

Figure 1478 Accessory Drive,J 38662

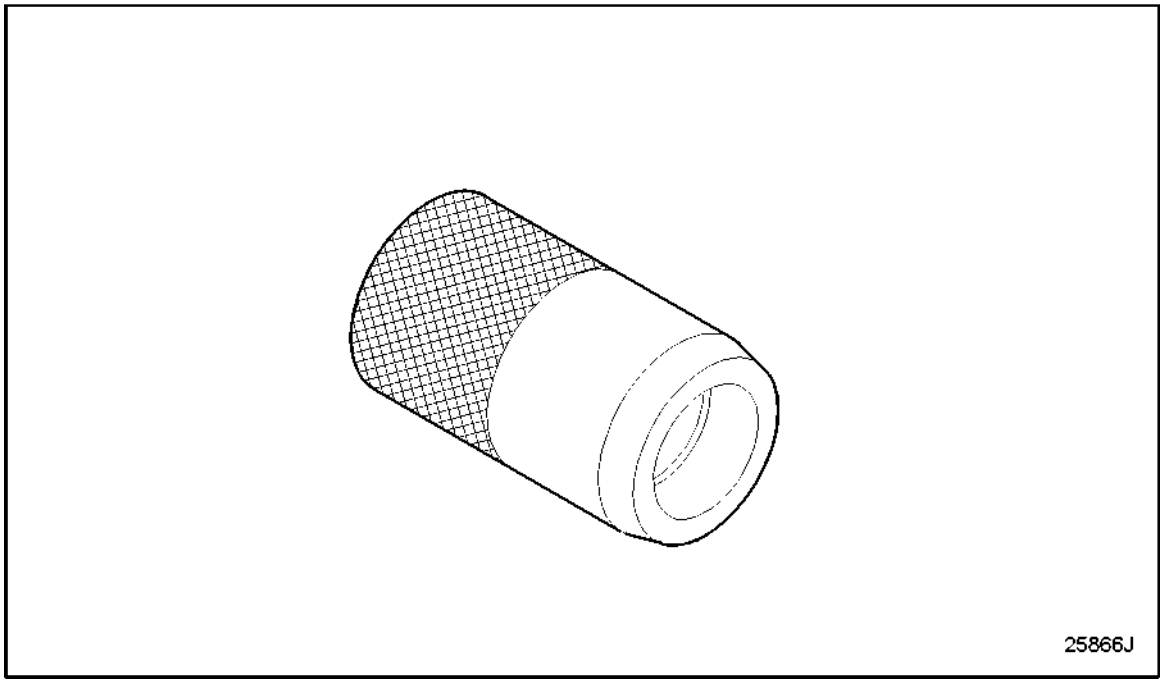

Figure 1479 Accessory Drive Seal Alignment Tool,J 21166

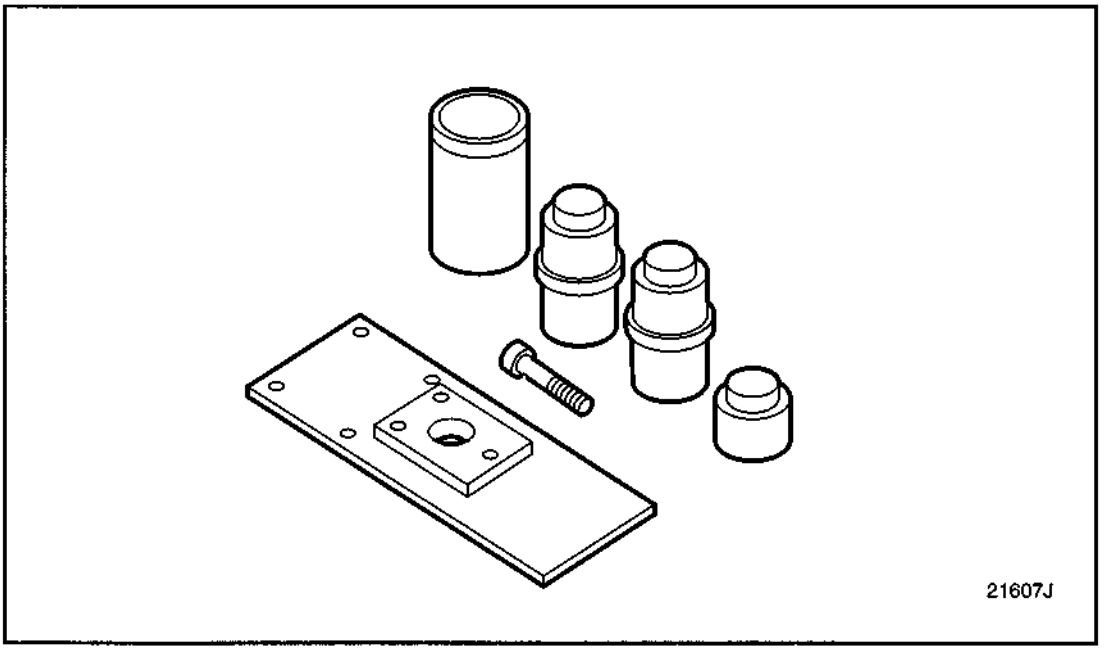

Figure 1480 Accessory Drive Service Set,J 36024–C

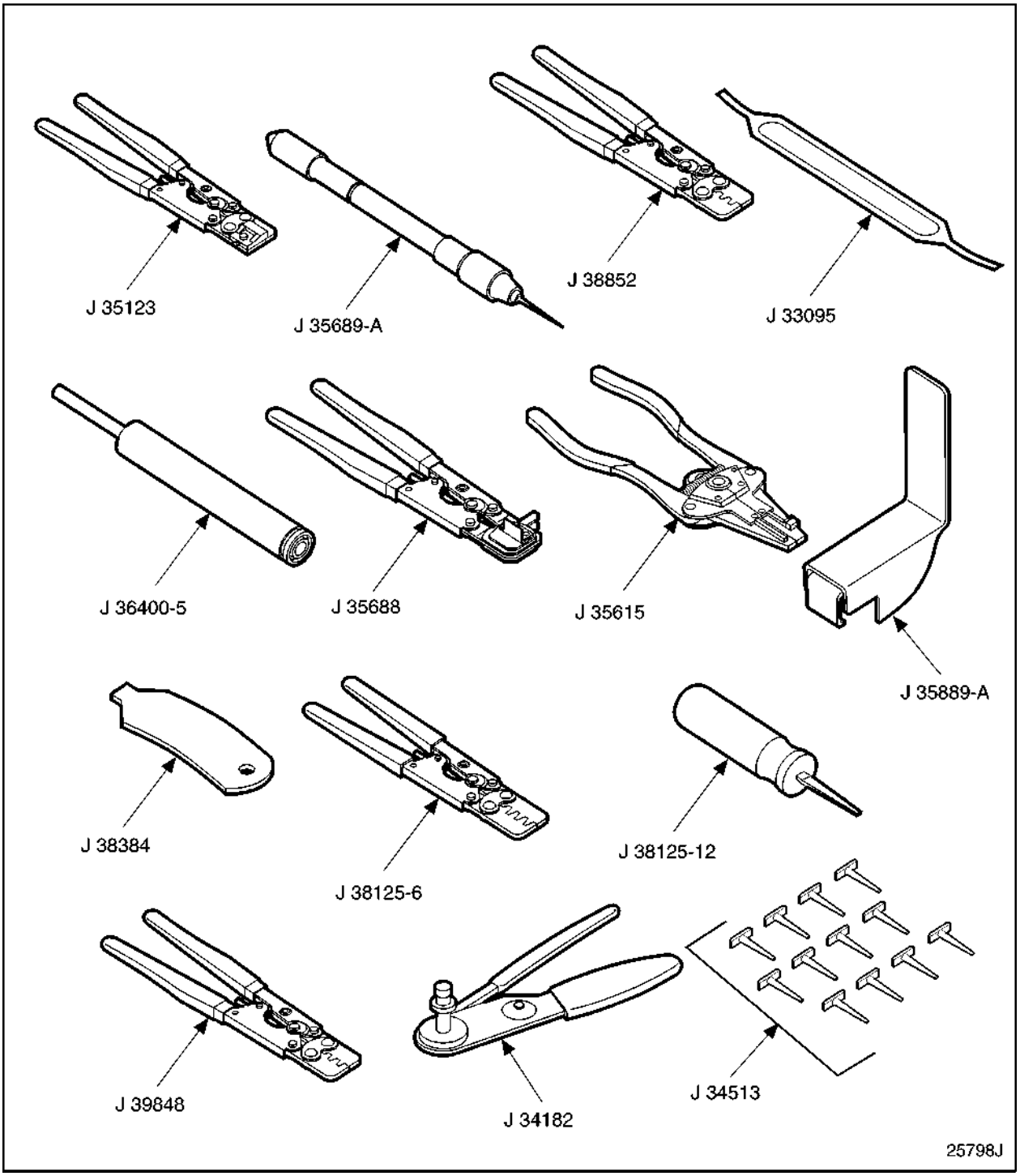

Figure 1481 DDEC Repair Kit,J 35888–60A

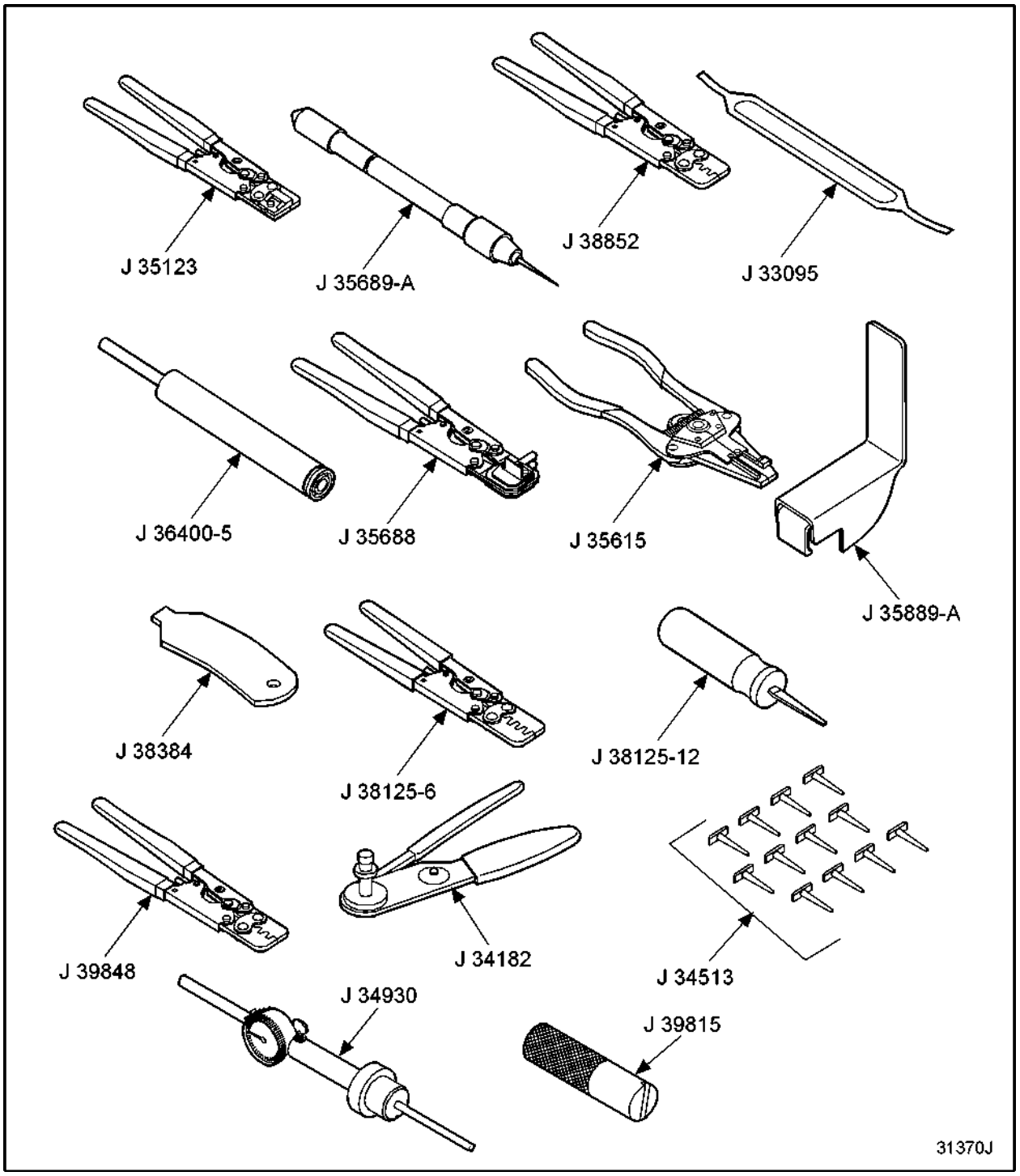

Figure 1482 DDEC Repair Kit,J 35888–A

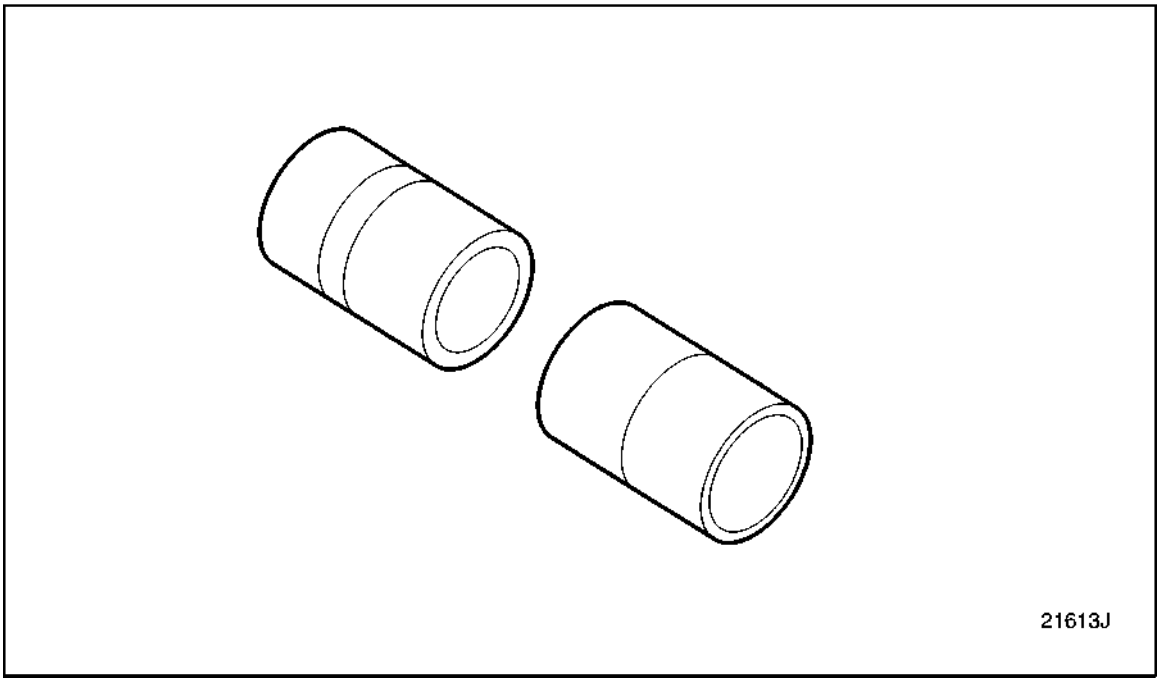

Figure 1483 Diagnostic Reader CBL ADPT (AMP),J 38500–152

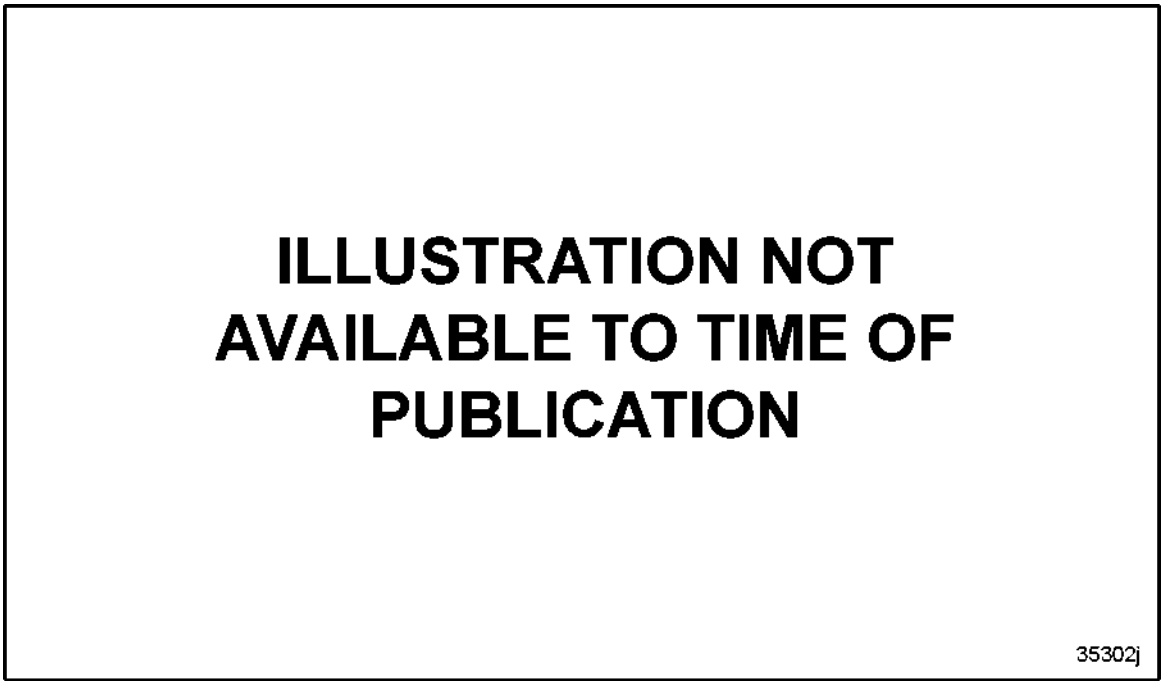

Figure 1484 Diagnostic Reader CBL ADPT (Deutsch),J 38500–60A

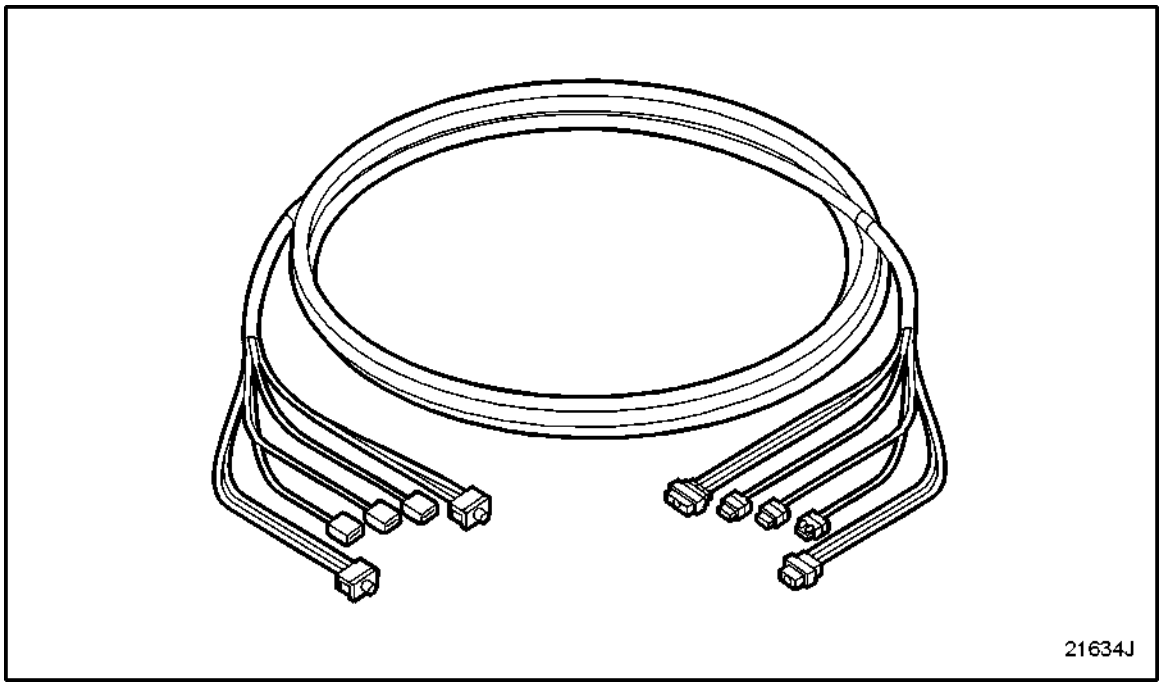

Figure 1485 ECM Test Harness, J 38596–A

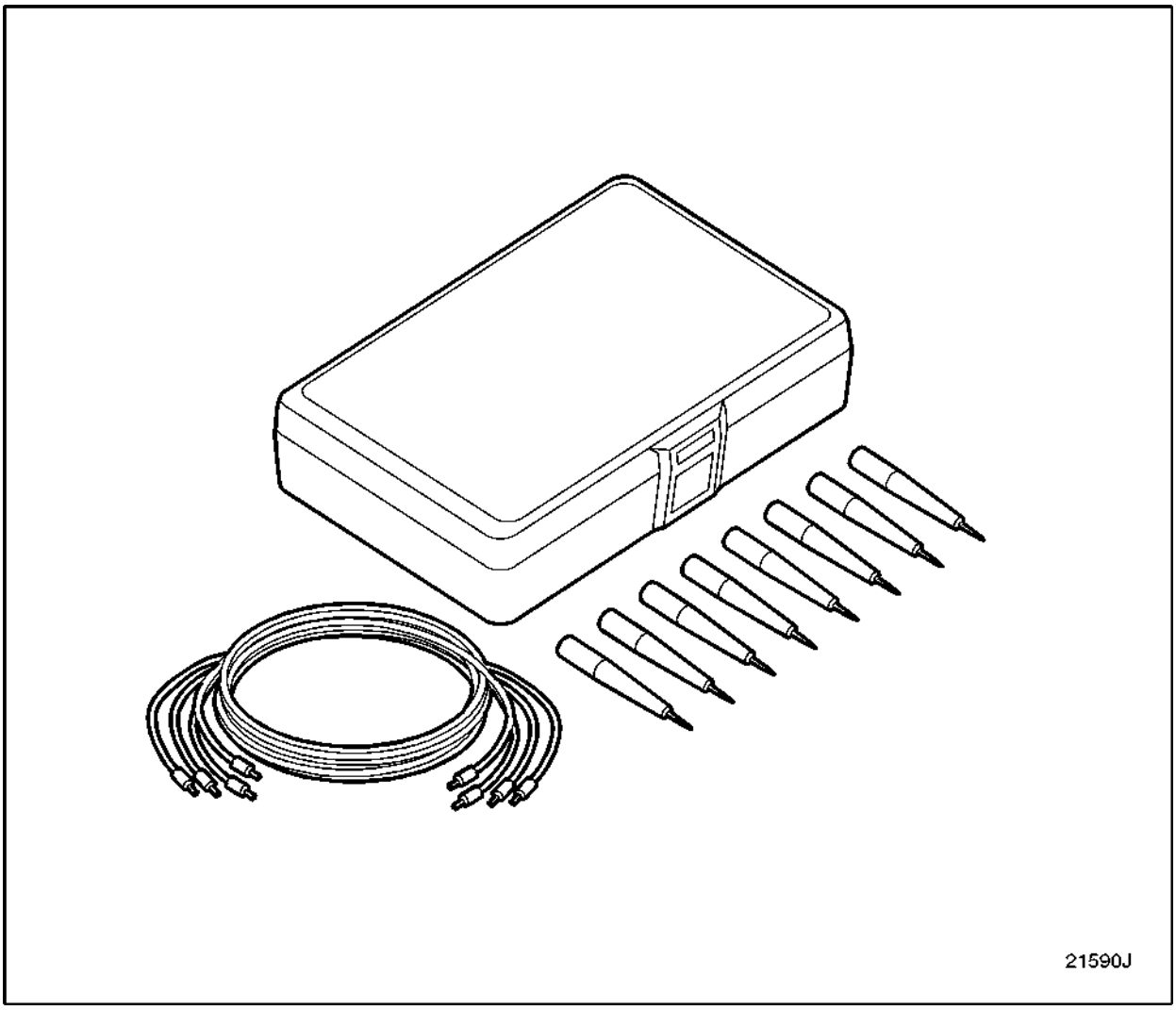

Figure 1486 Jumper Wire Set,J 35751

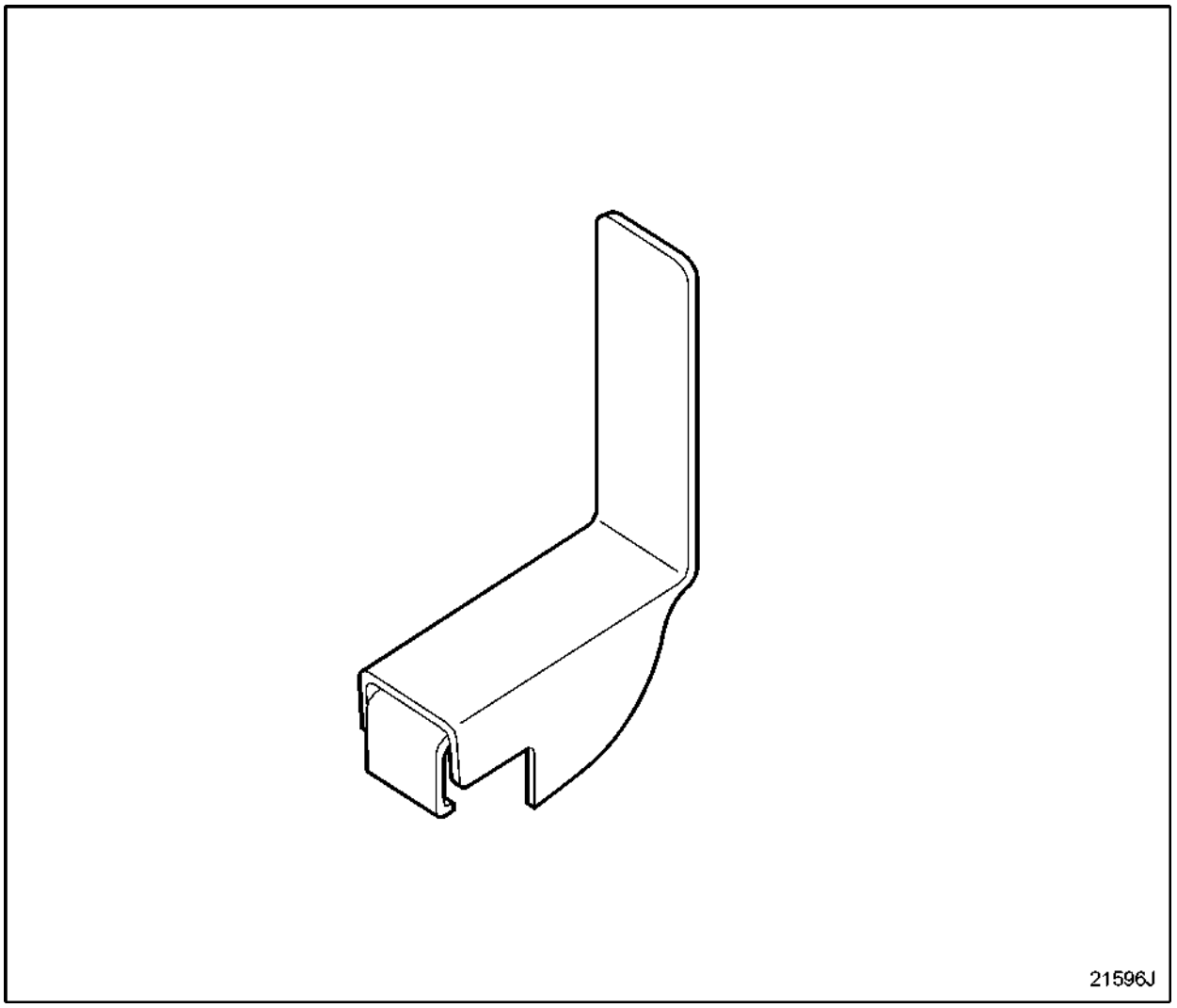

Figure 1487 Prom Remover Tool,J 35889–A

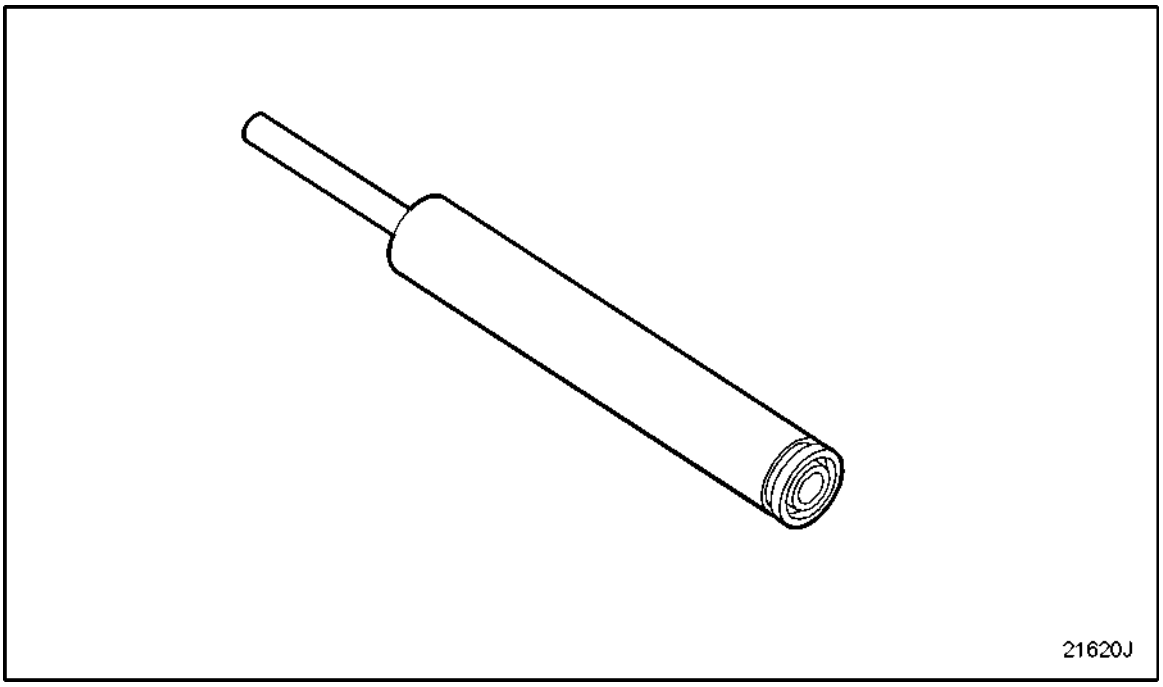

Figure 1488 Push Terminal Release Tool,J 36400–5

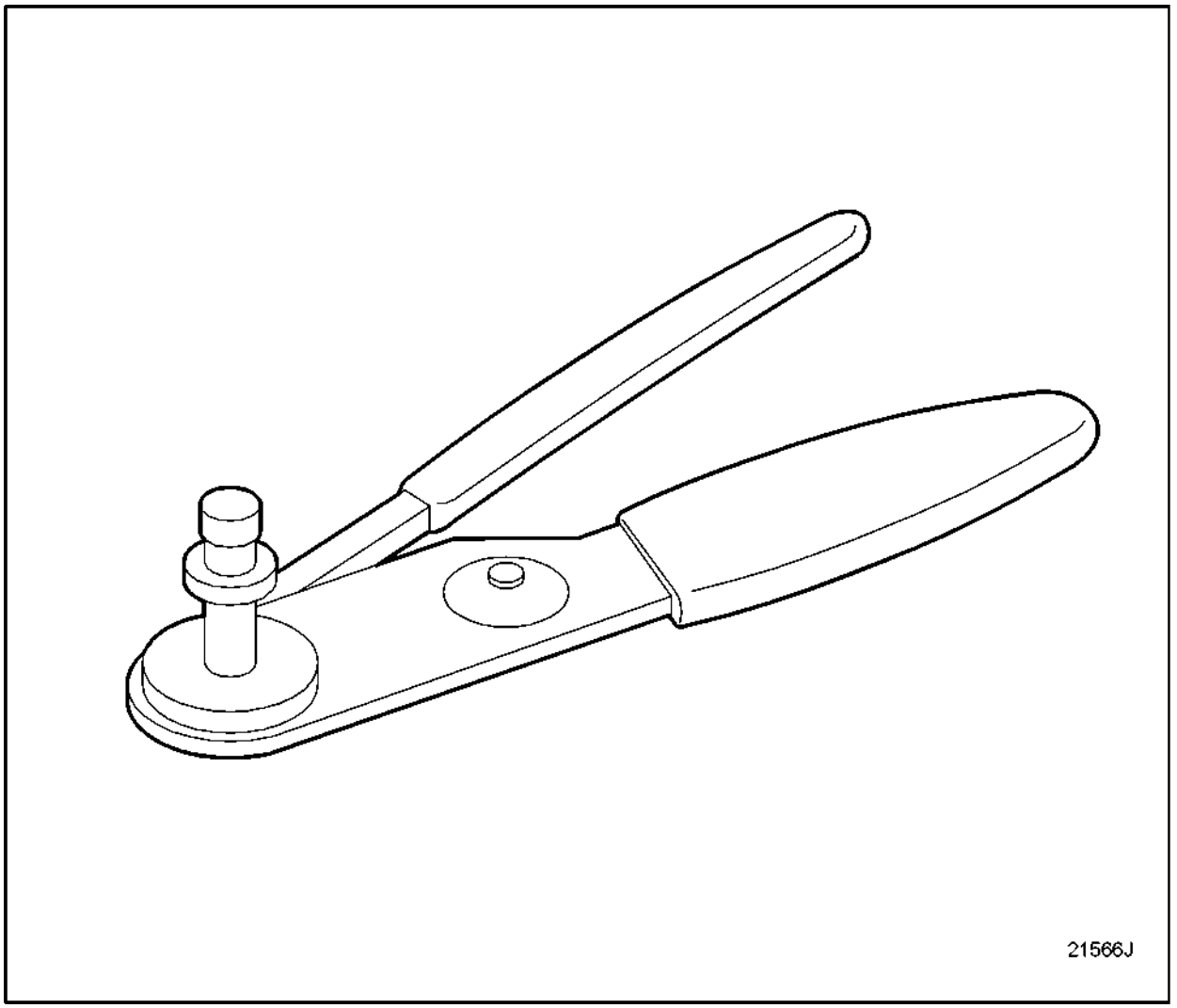

Figure 1489 Terminal Crimper (Deutsch), J 34182

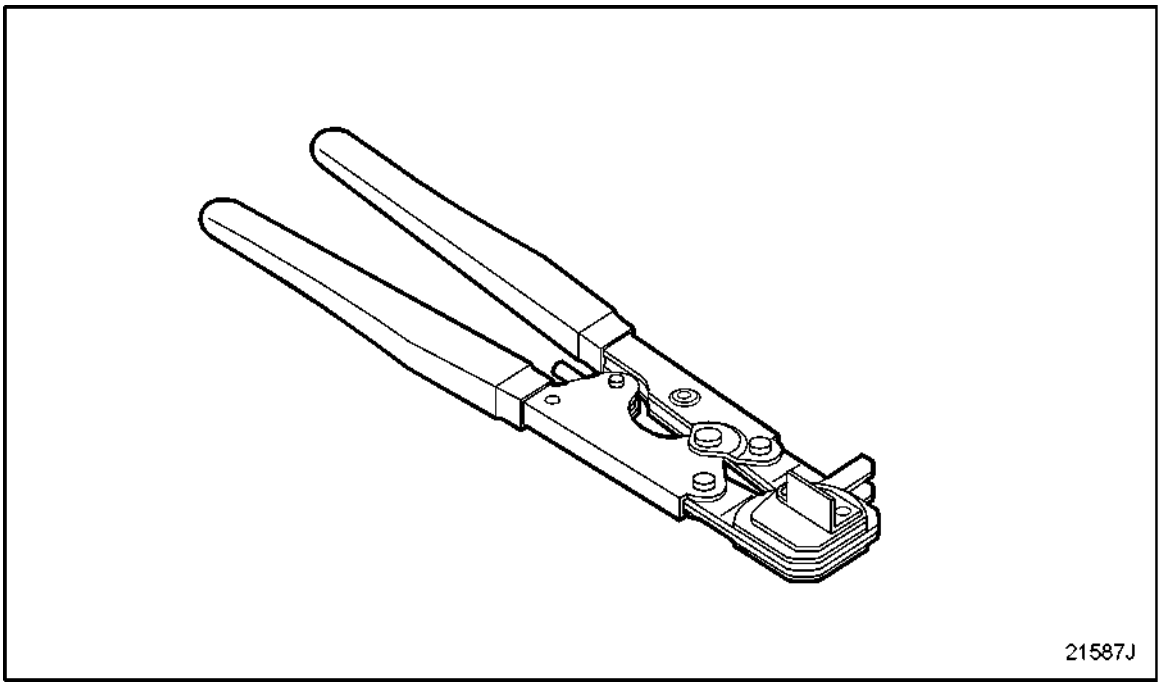

Figure 1490 Terminal Crimper (Group III),J 35688

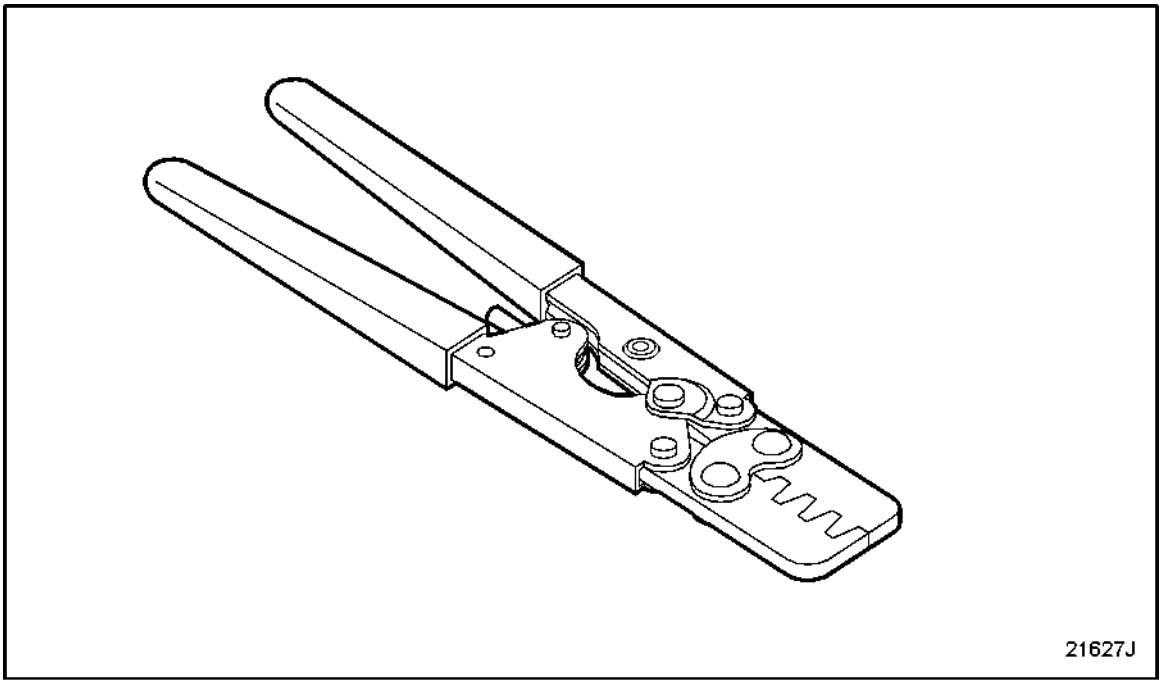

Figure 1491 Terminal Crimper (Metri-Pack),J 38125–6

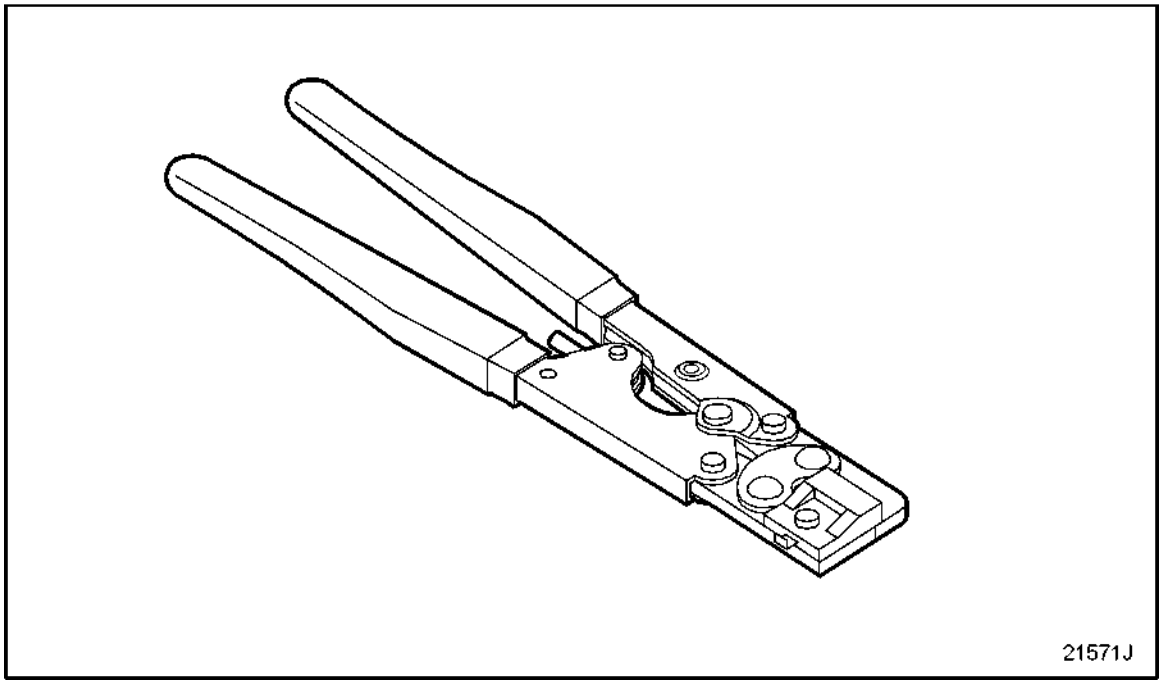

Figure 1492 Terminal Crimper (Group 1-Metri-PK), J 35123

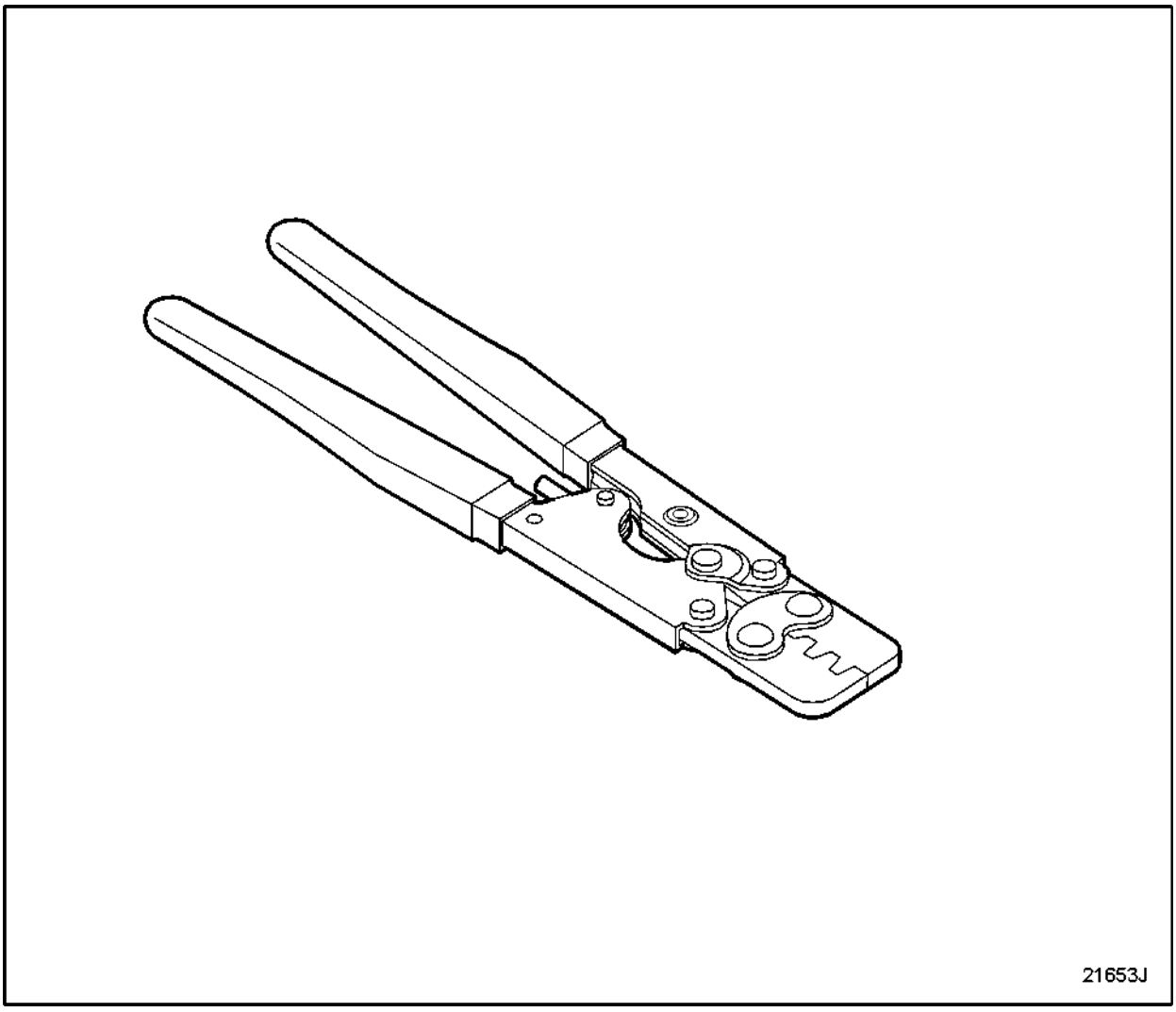

Figure 1493 Terminal Crimper (Metri-Pack 280), J 39848

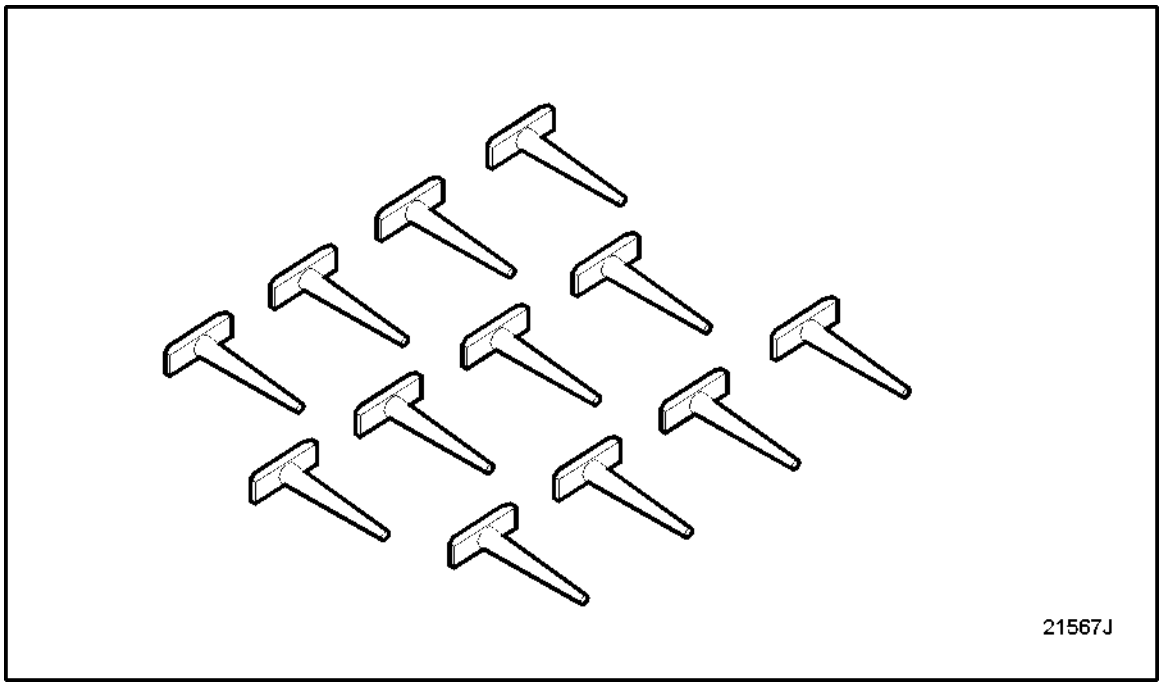

Figure 1494 Terminal Remover (Deutsch),J 34513

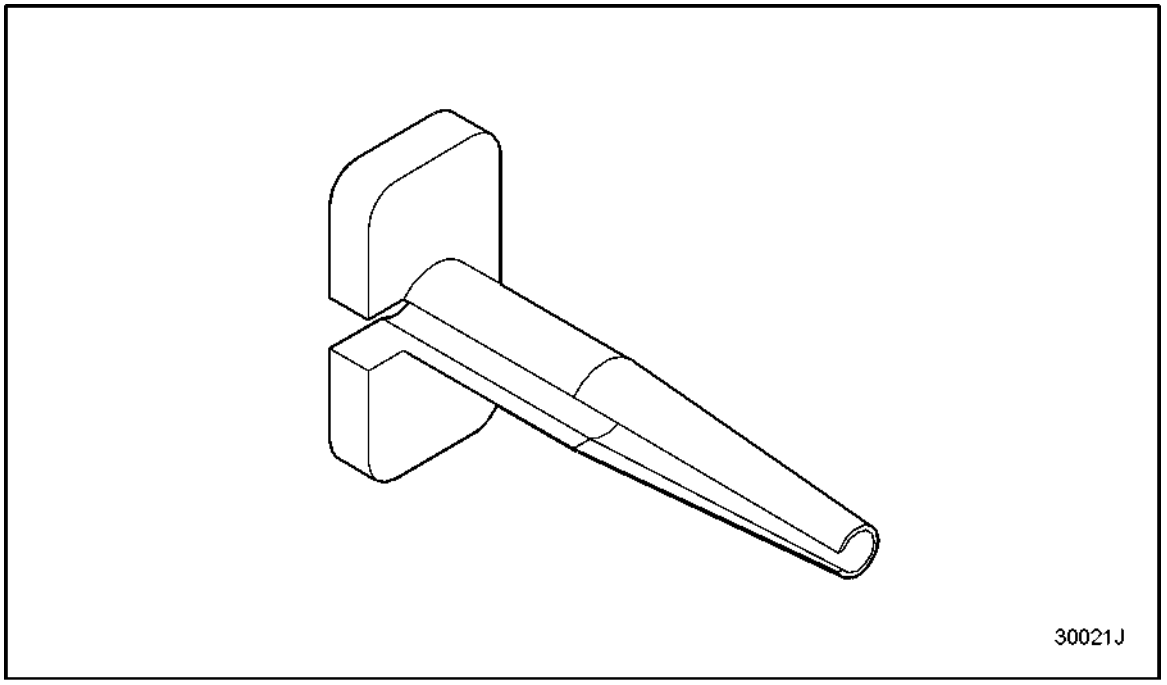

Figure 1495 Terminal Remover (Deutsch),J 38582–3

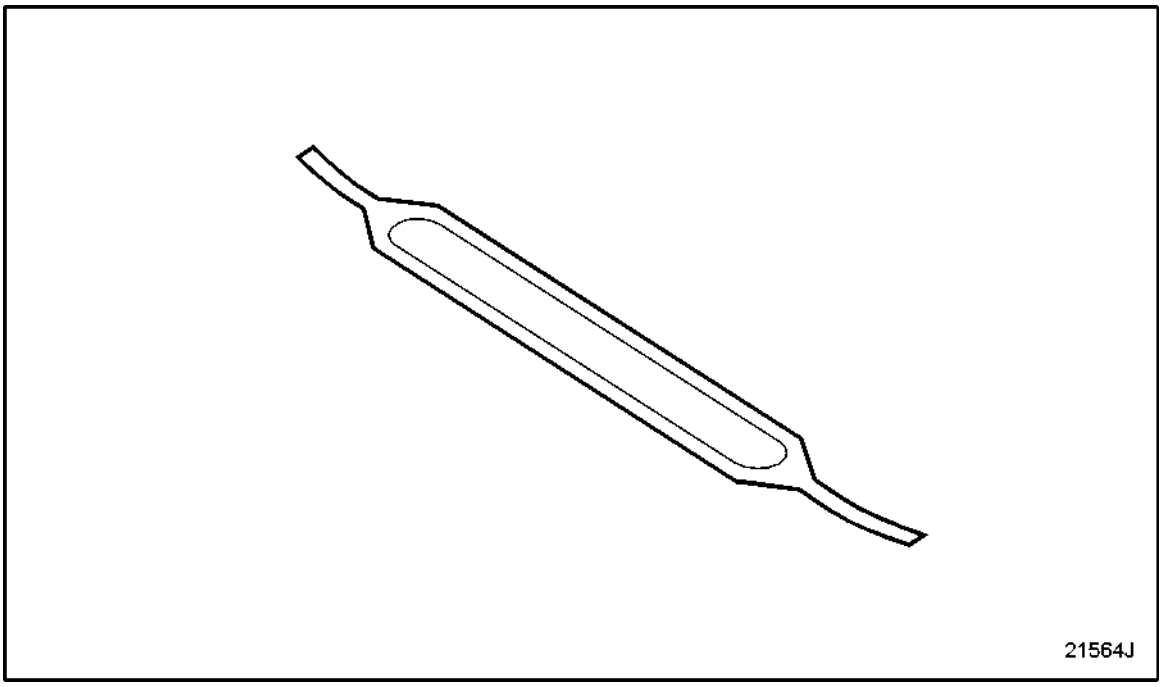

Figure 1496 Terminal Remover (Micro-Pack 280),J 33095

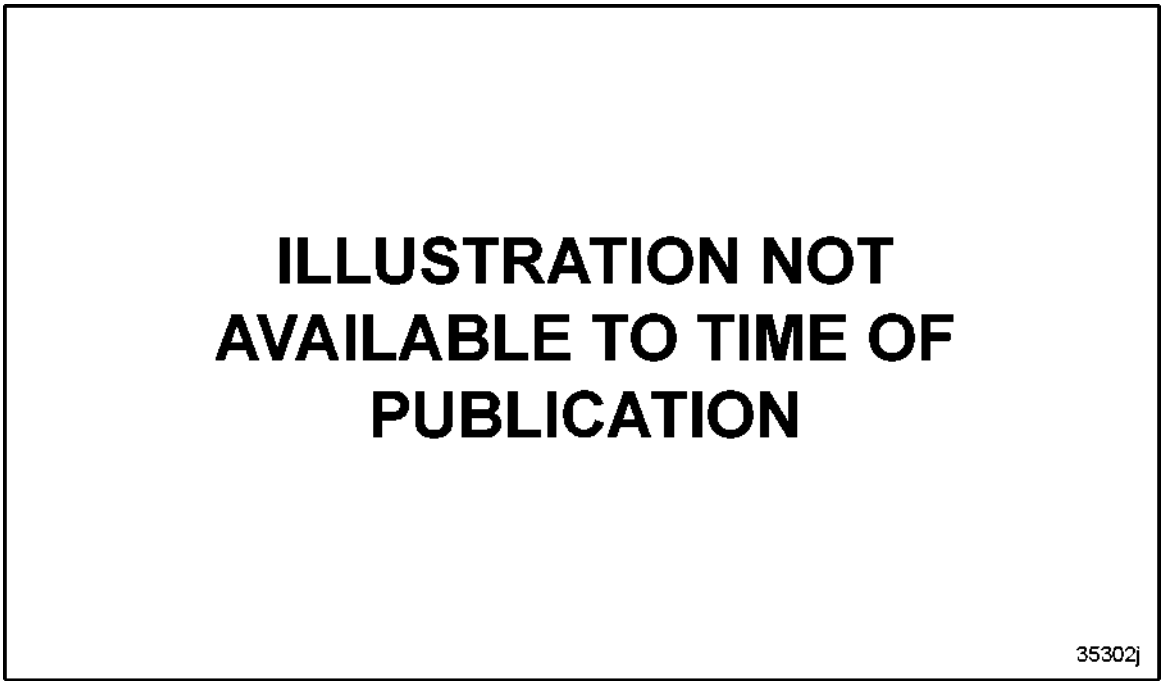

Figure 1497 Terminal Remover (Metri-Pack),J 39125–12A

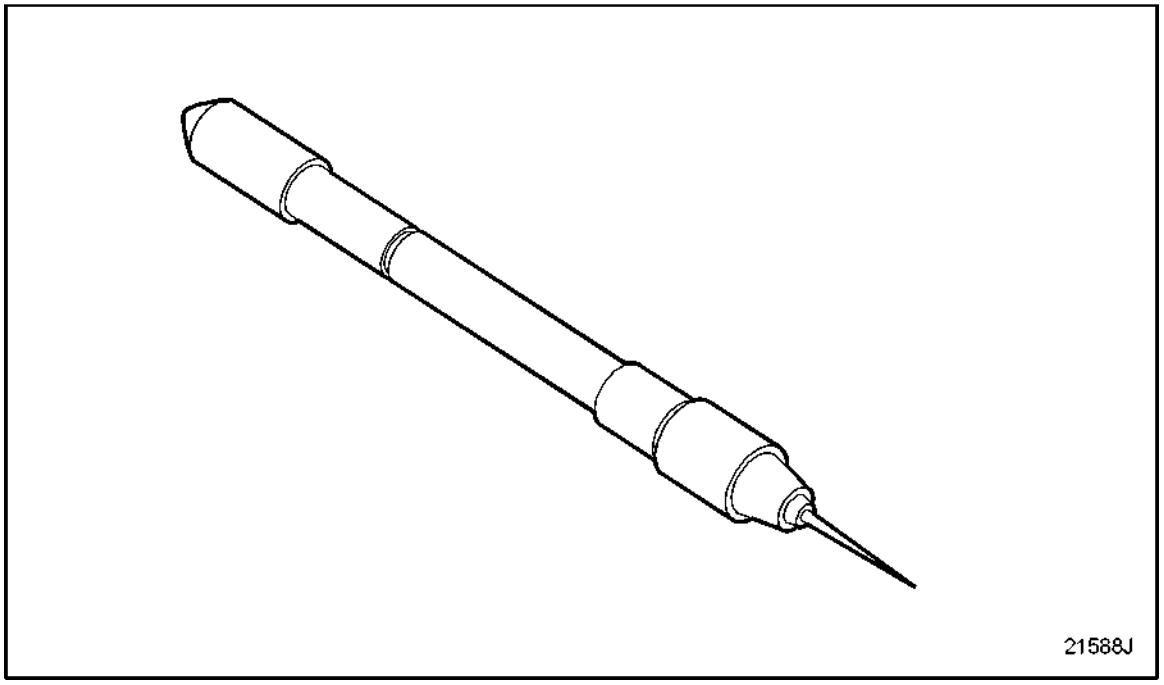

Figure 1498 Terminal REMV (GRP 1-1Metri Pack 150),J 35689–A

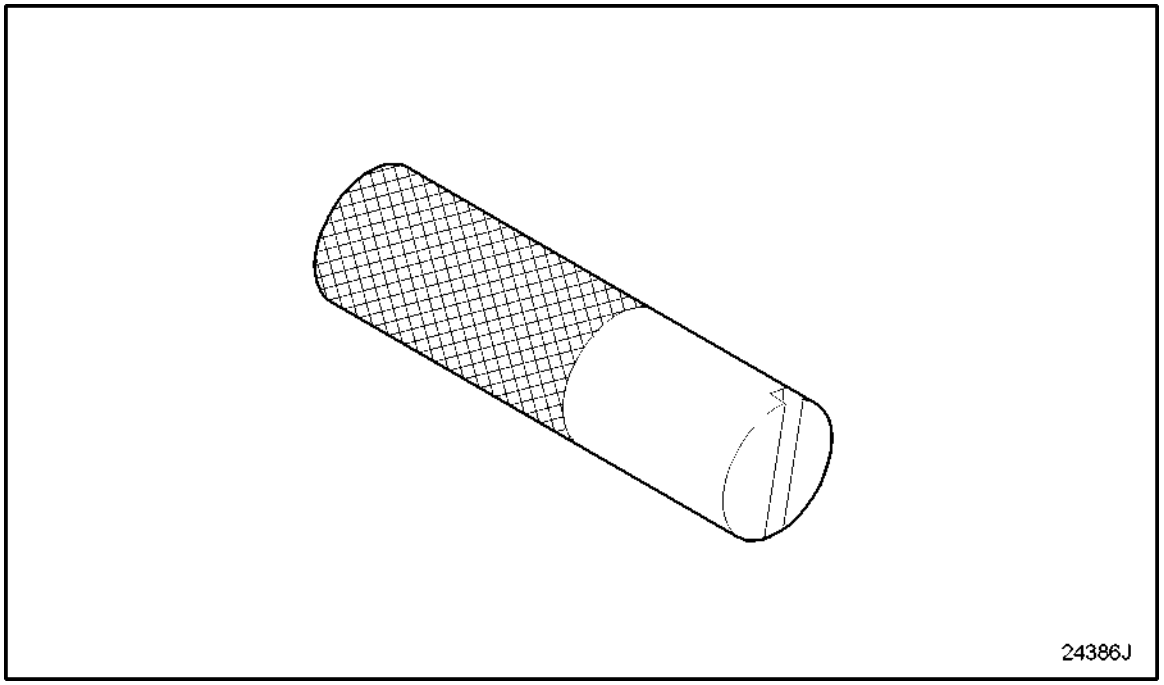

Figure 1499 TRS Alignment Tool,J 39815

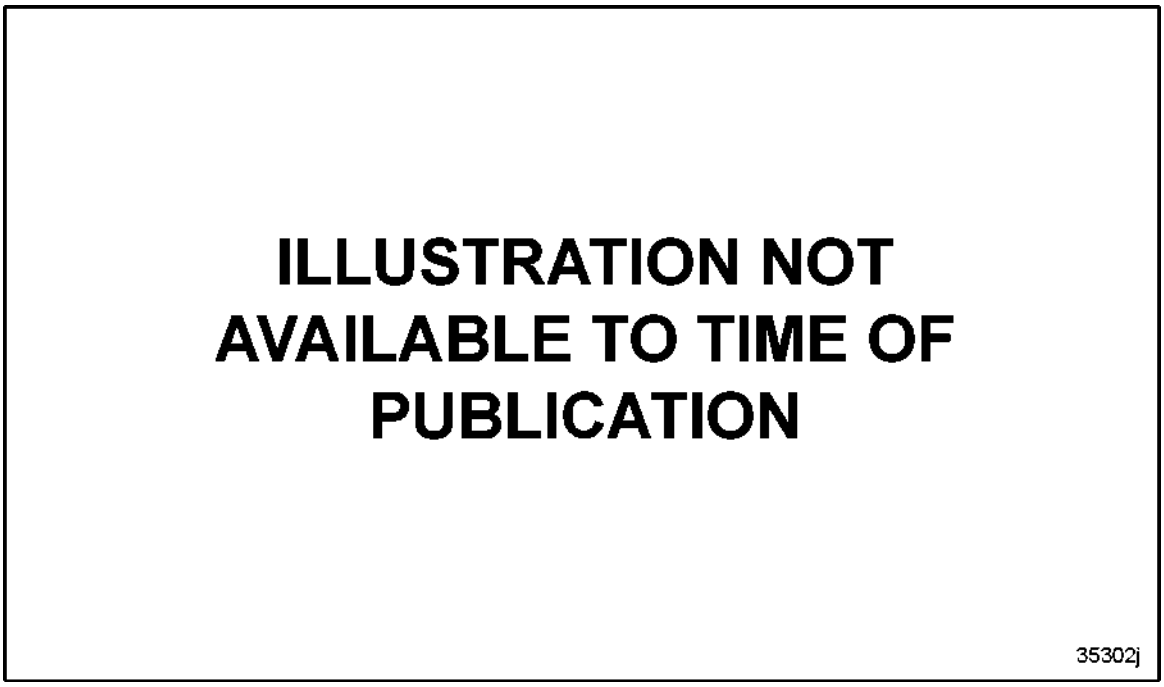

Figure 1500 V.I.M. Adapter Kit,J 41005–149

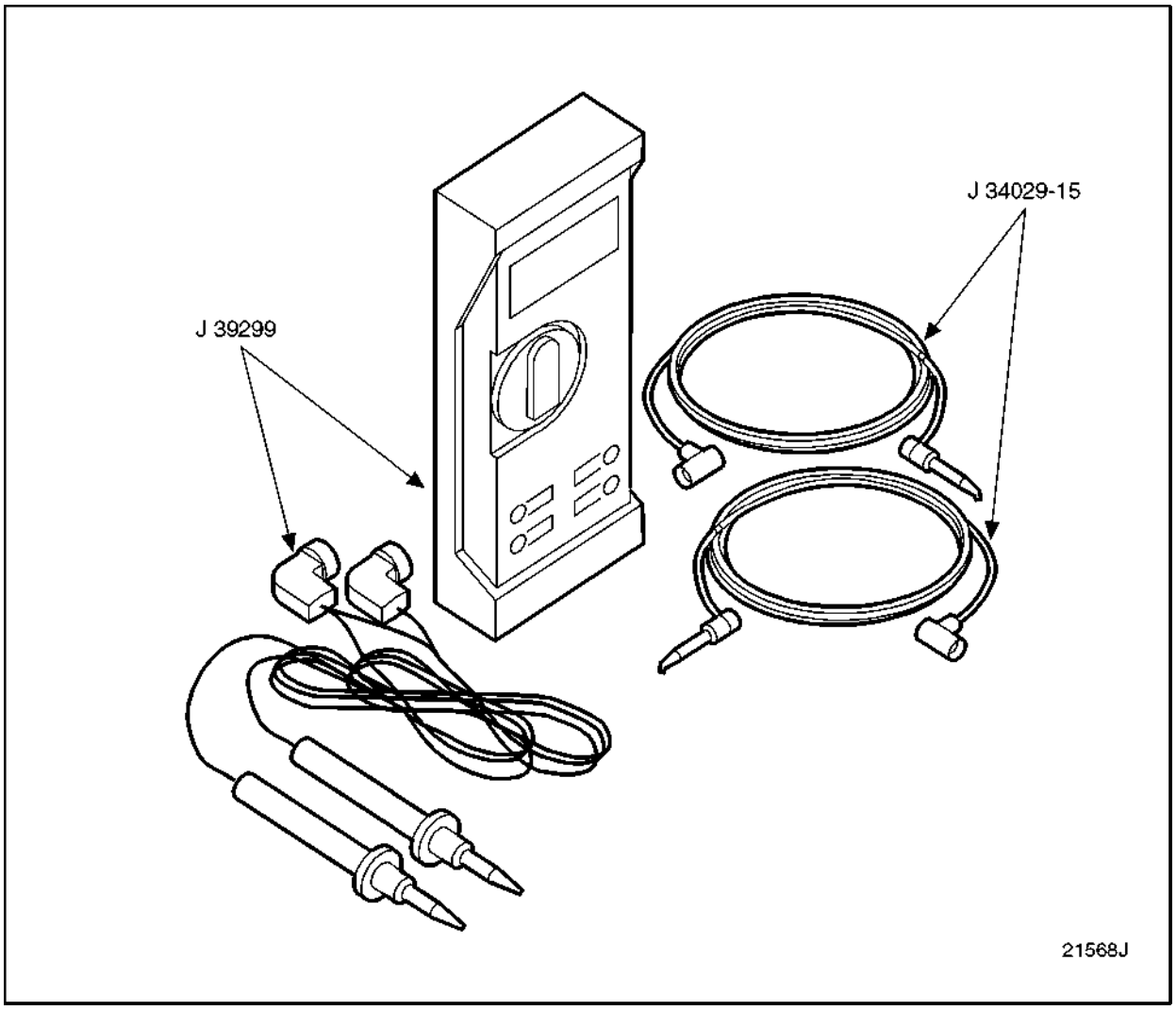

Figure 1501 Volt/Ohm Meter Kit,J 34520–A

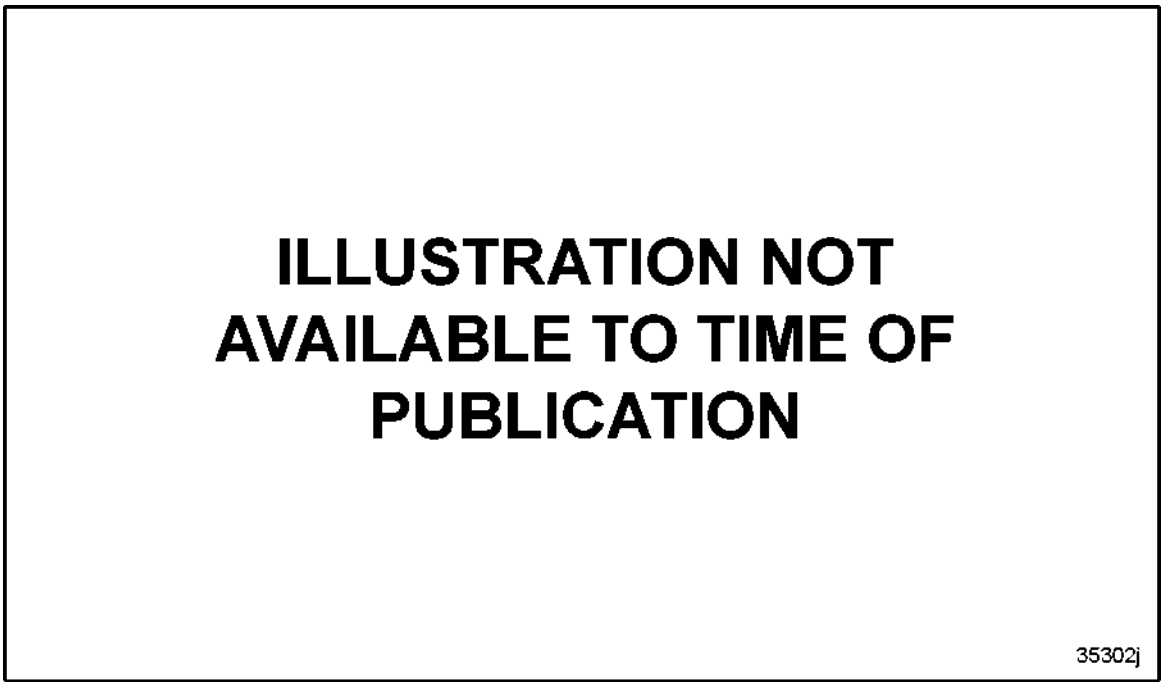

Figure 1502 DDEC II & DDEC III Cartridge Version 5.0,J 38500–750

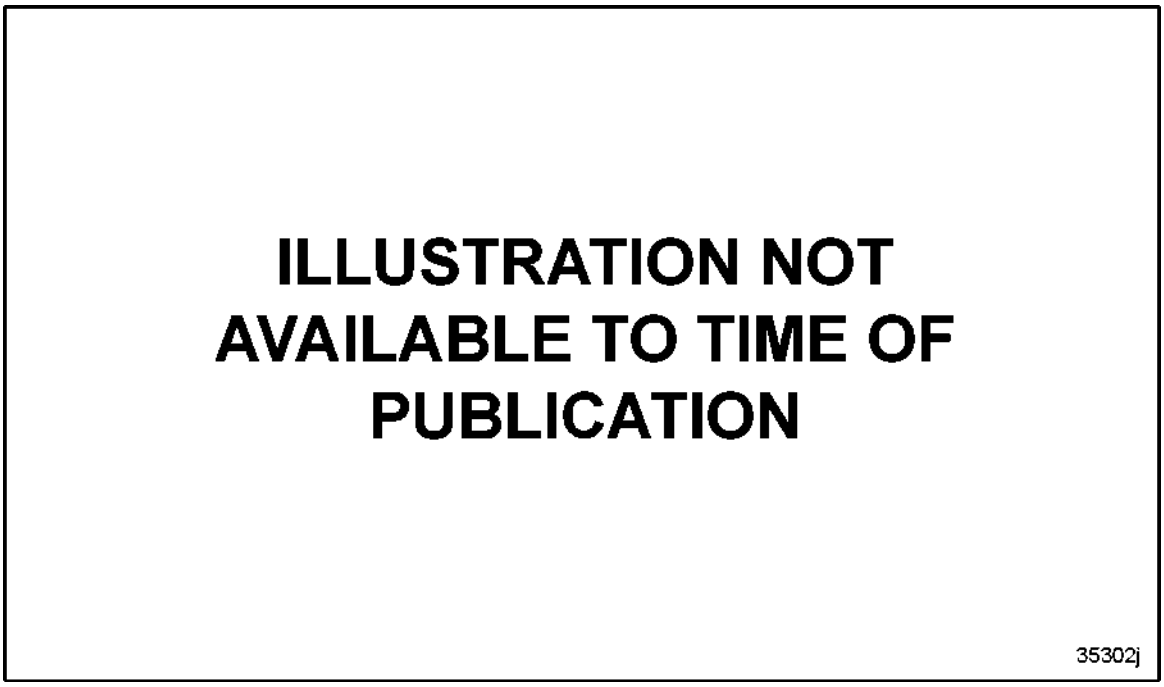

Figure 1503 Diagnostic Reader CBL ADPT (Packard) T,J 34812–1

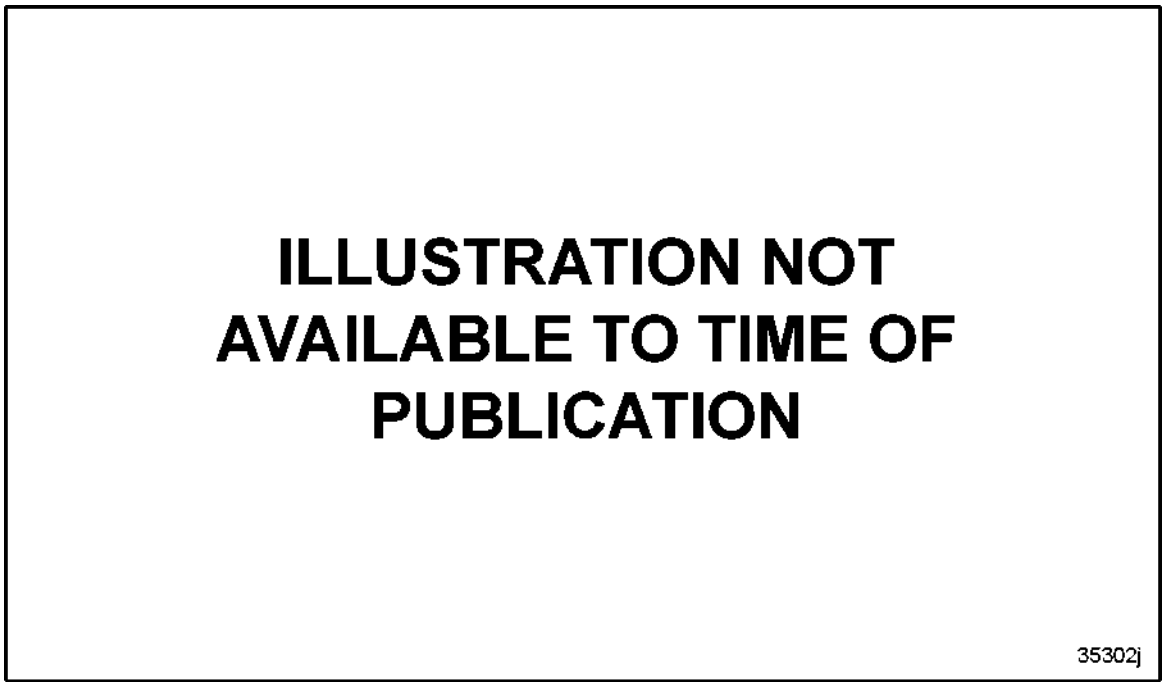

Figure 1504 TRS Alignment Tool,J 39298–2

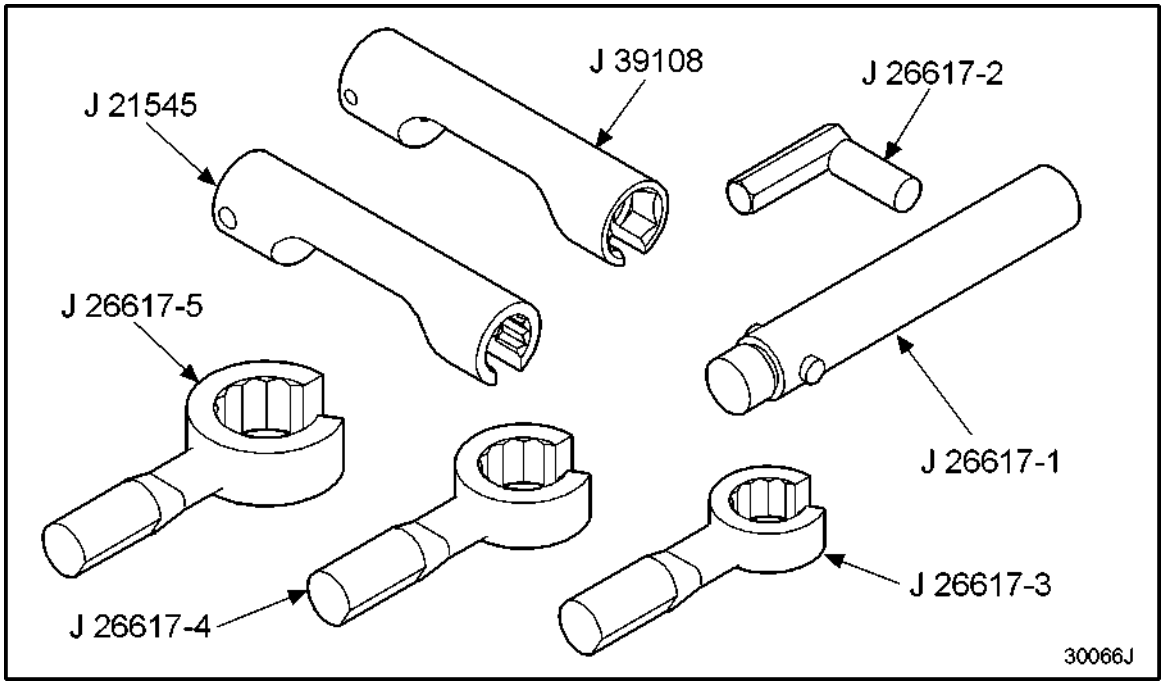

Figure 1505 Fuel Line Wrench Set,J 26617

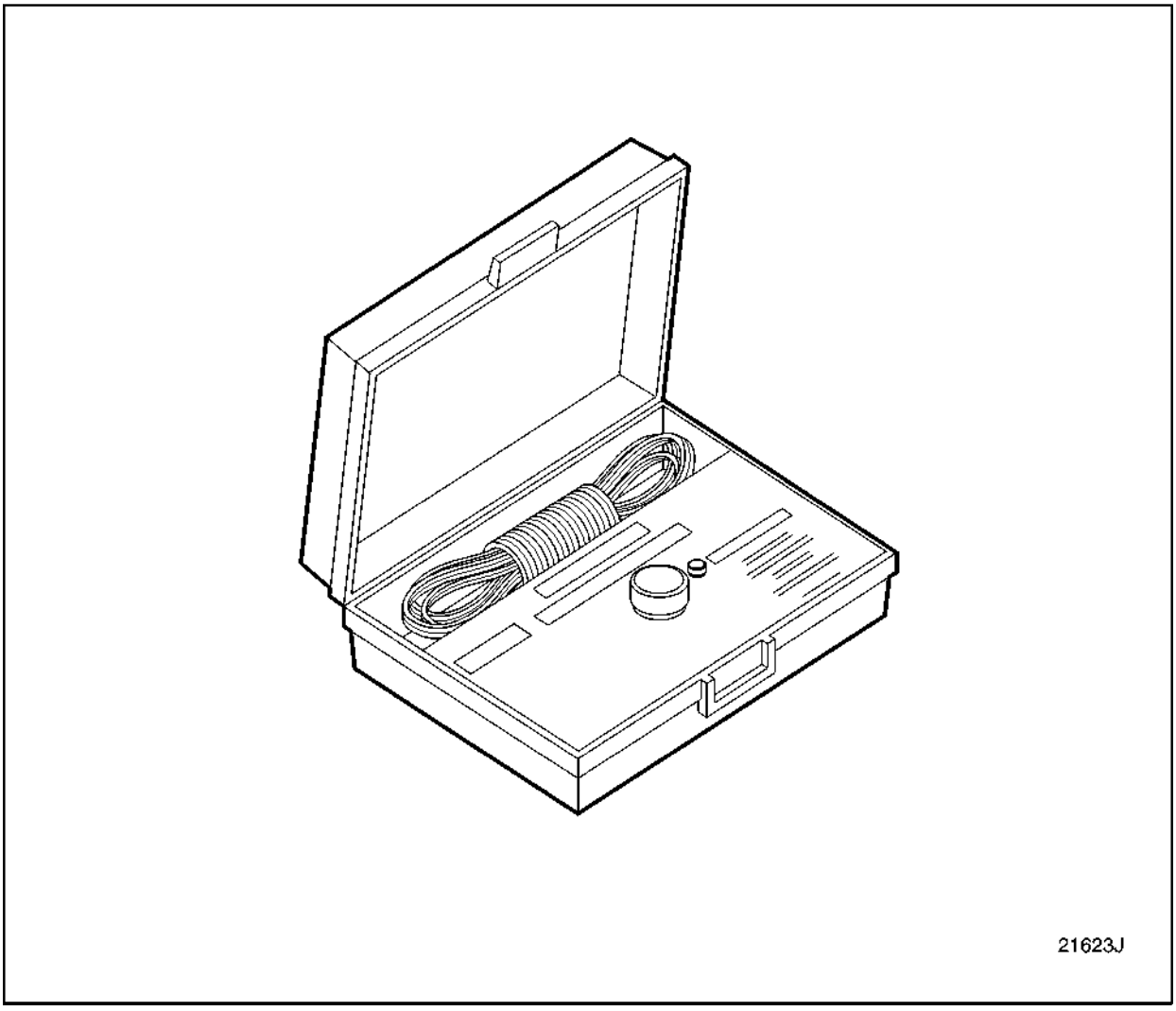

Figure 1506 Electronic Unit Injector Tester,J 37050–A

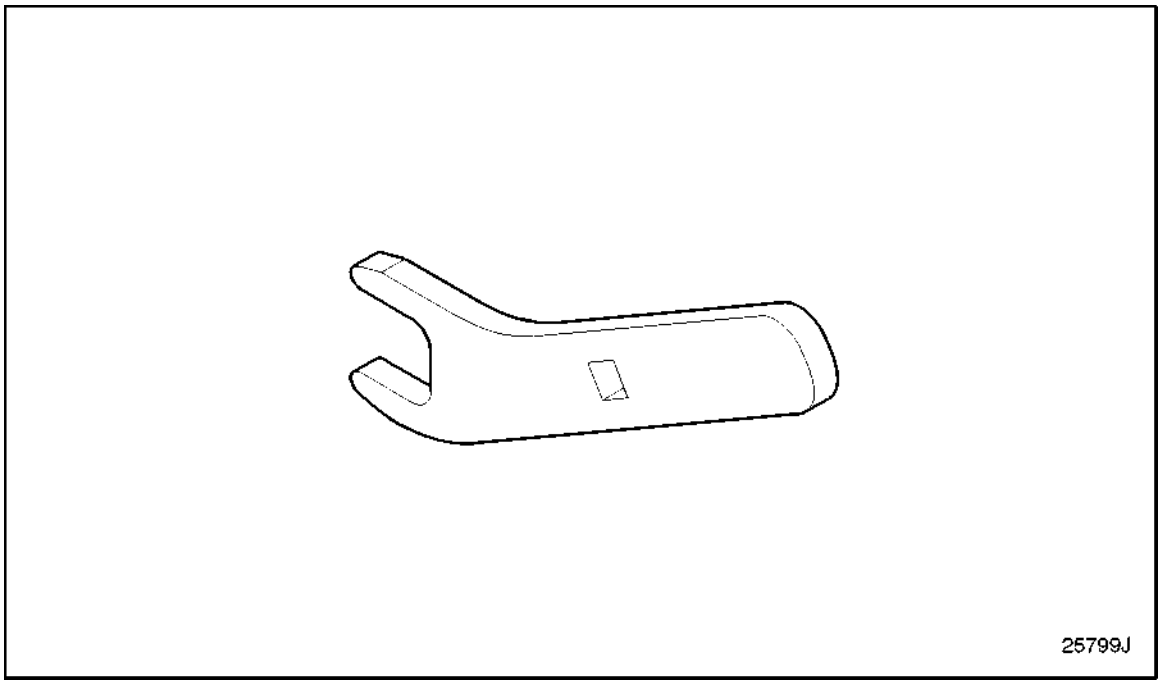

Figure 1507 Fuel Line Nut Wrench-Internal,J 41424

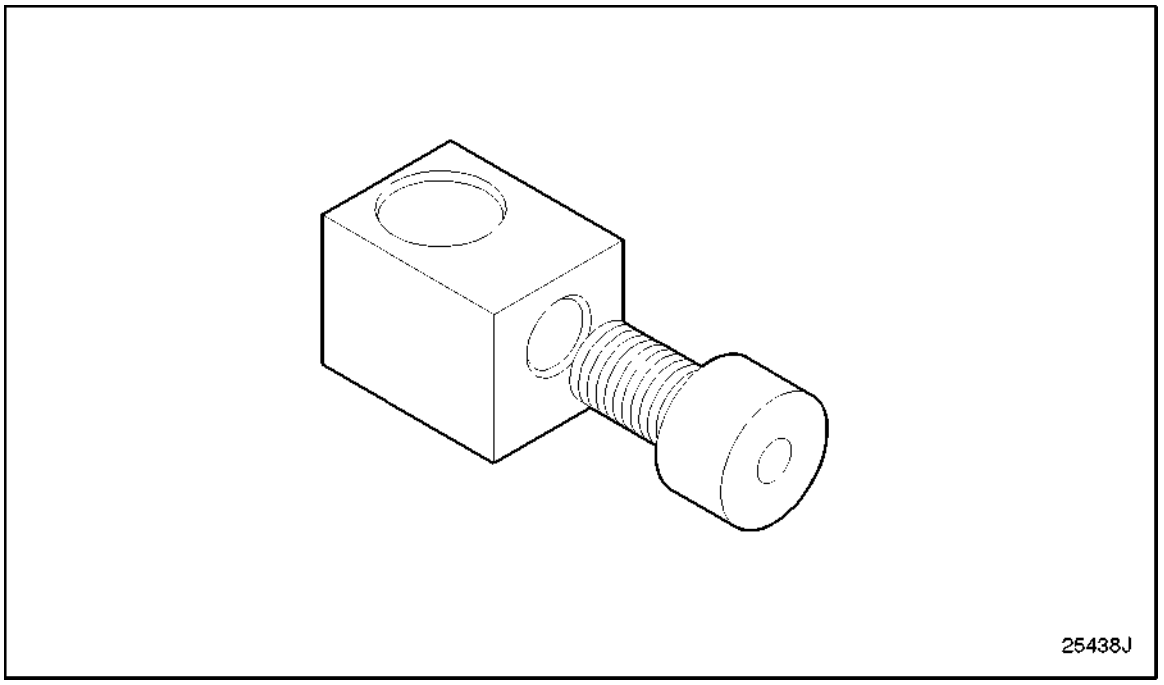

Figure 1508 Fuel Nozzle Test Adapter,J 41568

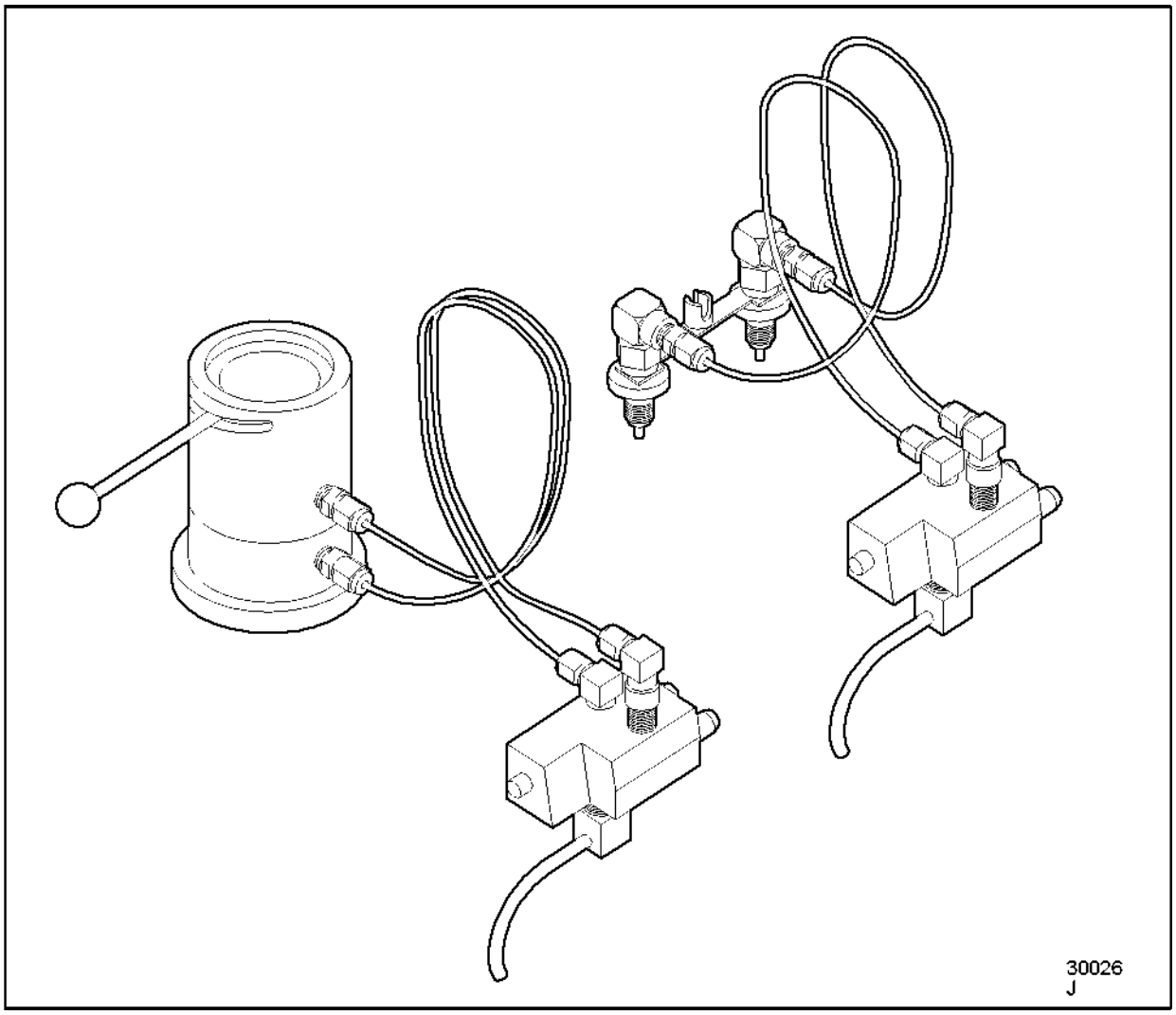

Figure 1509 Injector Pop Fixture ADP-Electronic,J 34760–147A

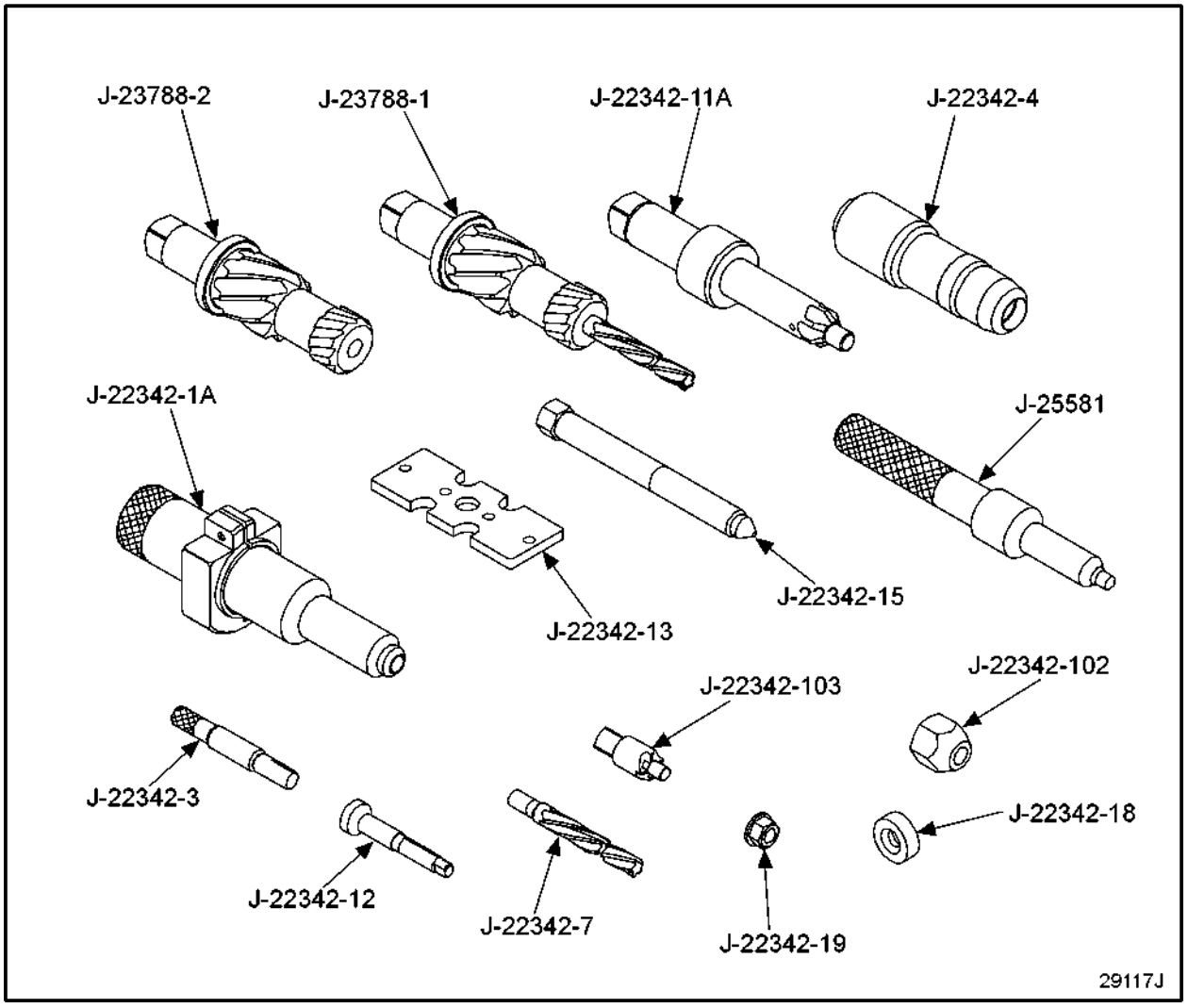

Figure 1510 Injector Tube Reconditioning Set,J 24517–B

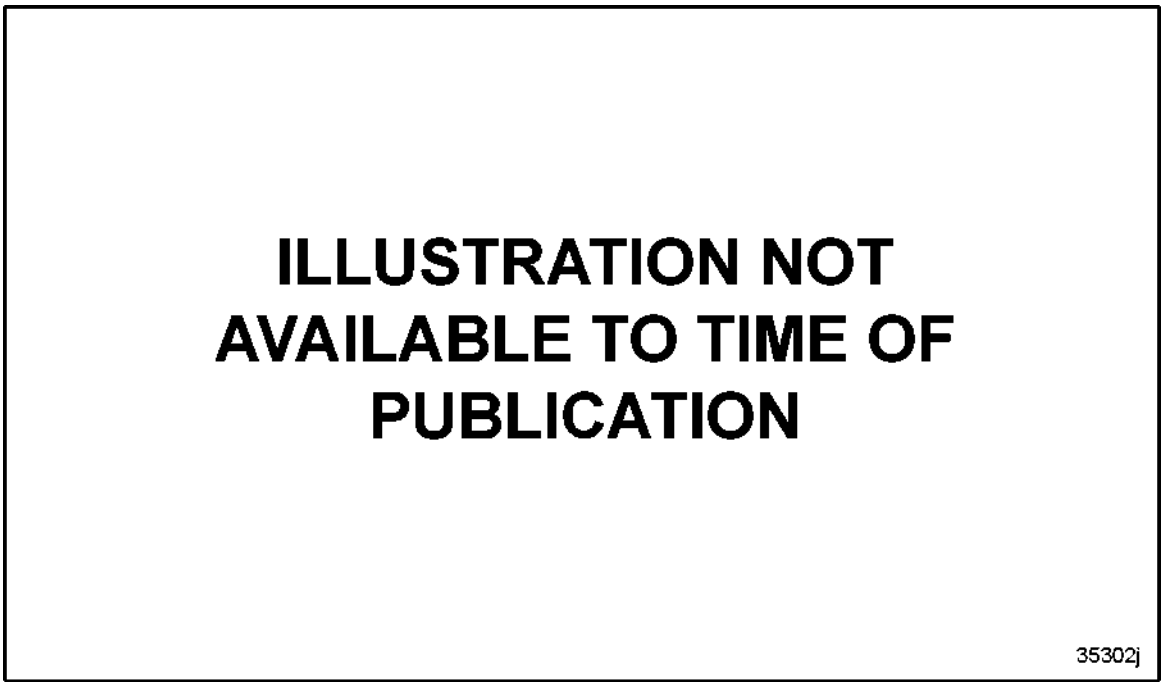

Figure 1511 Fuel Pressure Gauge (0-100 PSI), J 6355

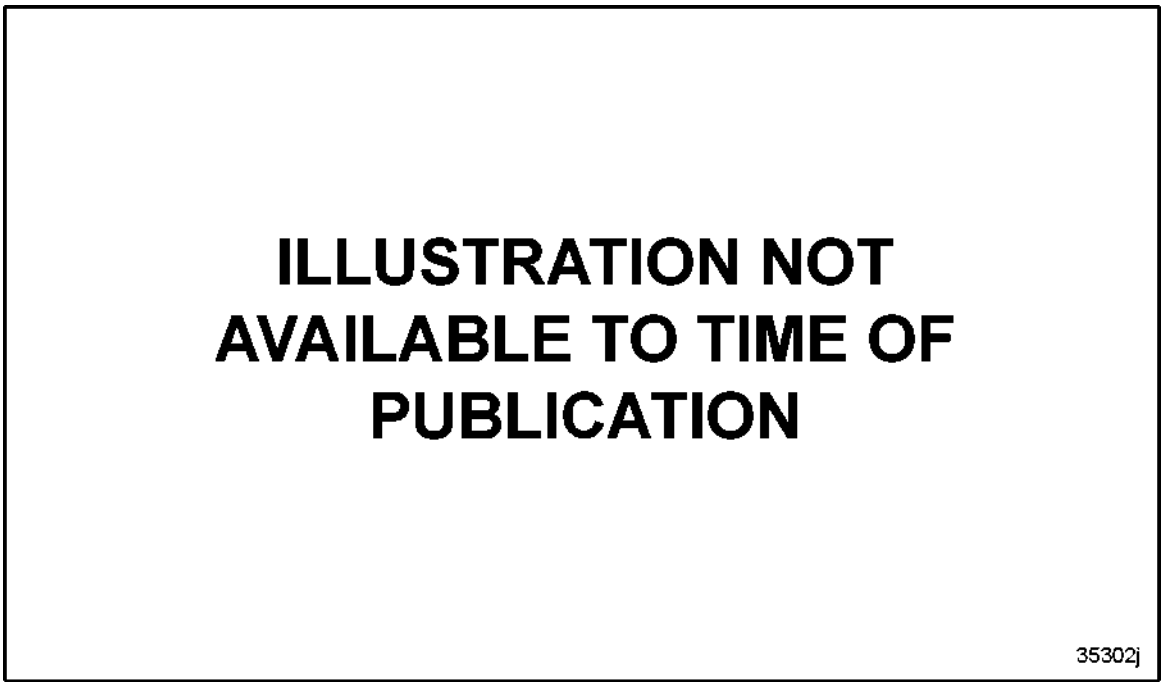

Figure 1512 Fuel Pressure Gauge (100PSI), J 8151

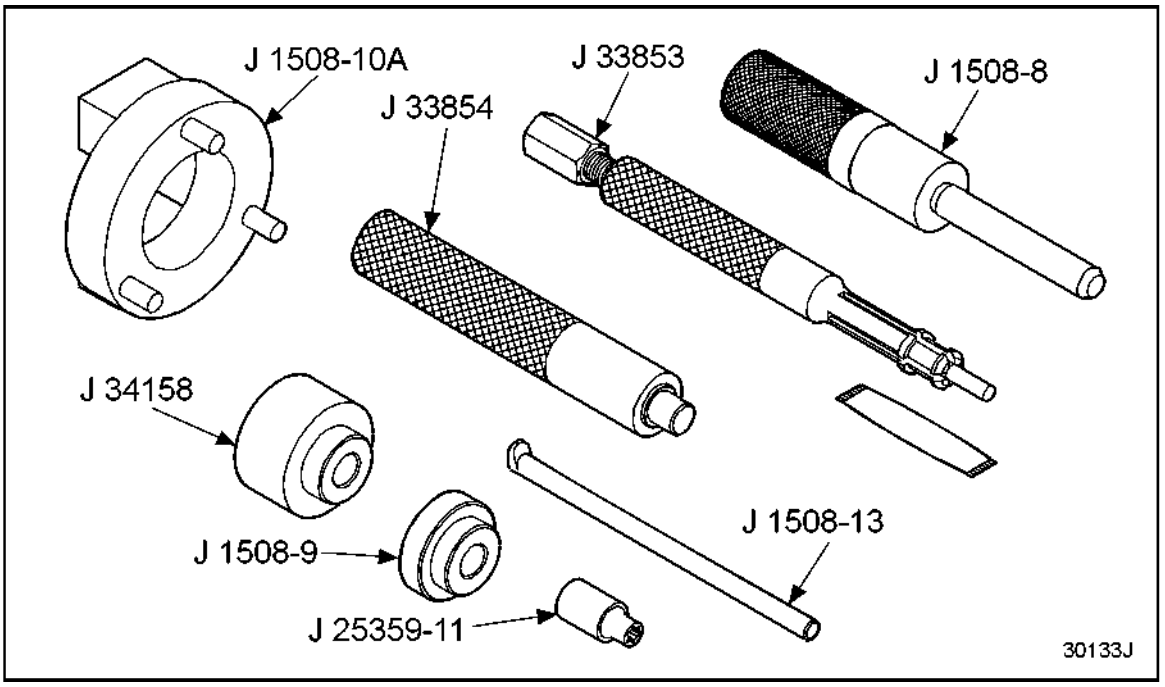

Figure 1513 Fuel Pump Repair Kit,J 34607–A

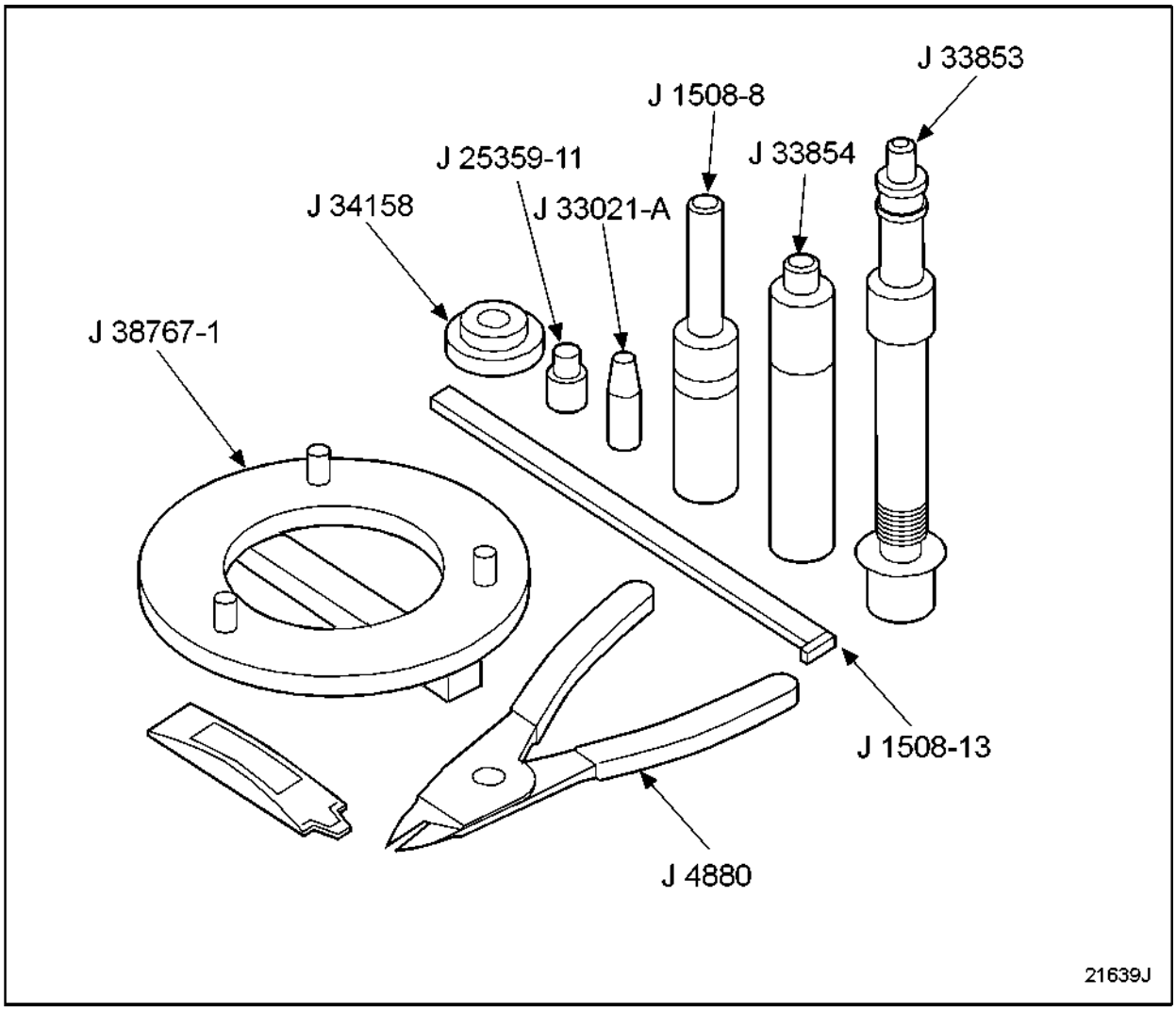

Figure 1514 Fuel Pump Repair Kit,J 38767

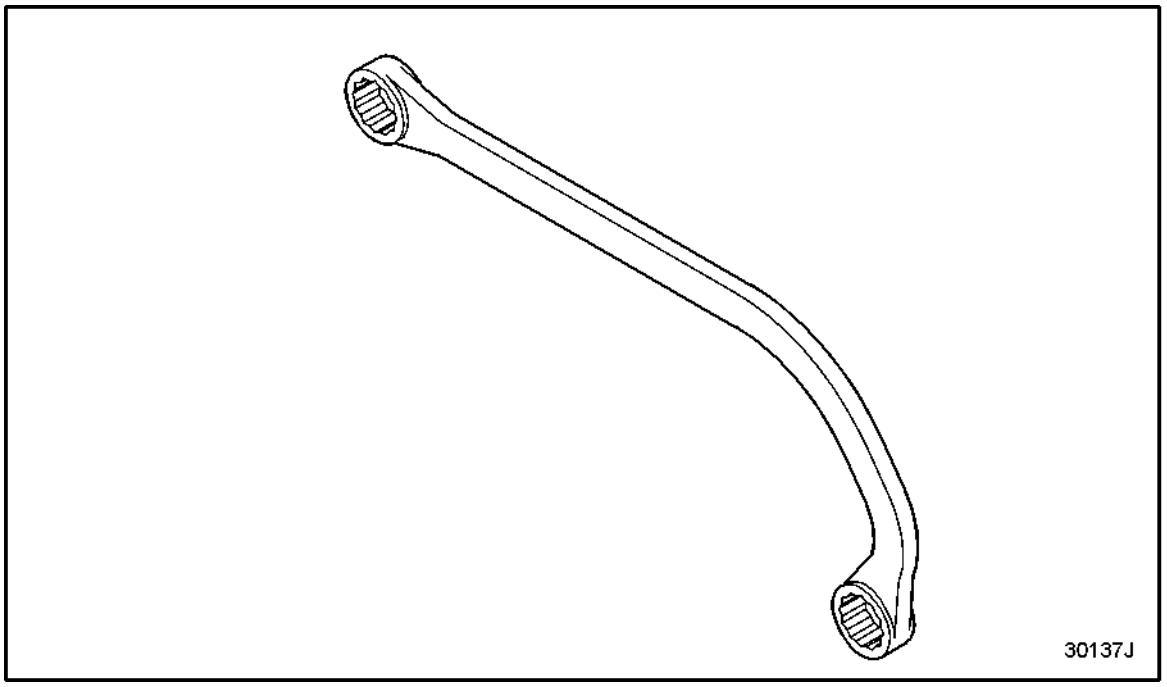

Figure 1515 Fuel Pump Wrench,J 4242

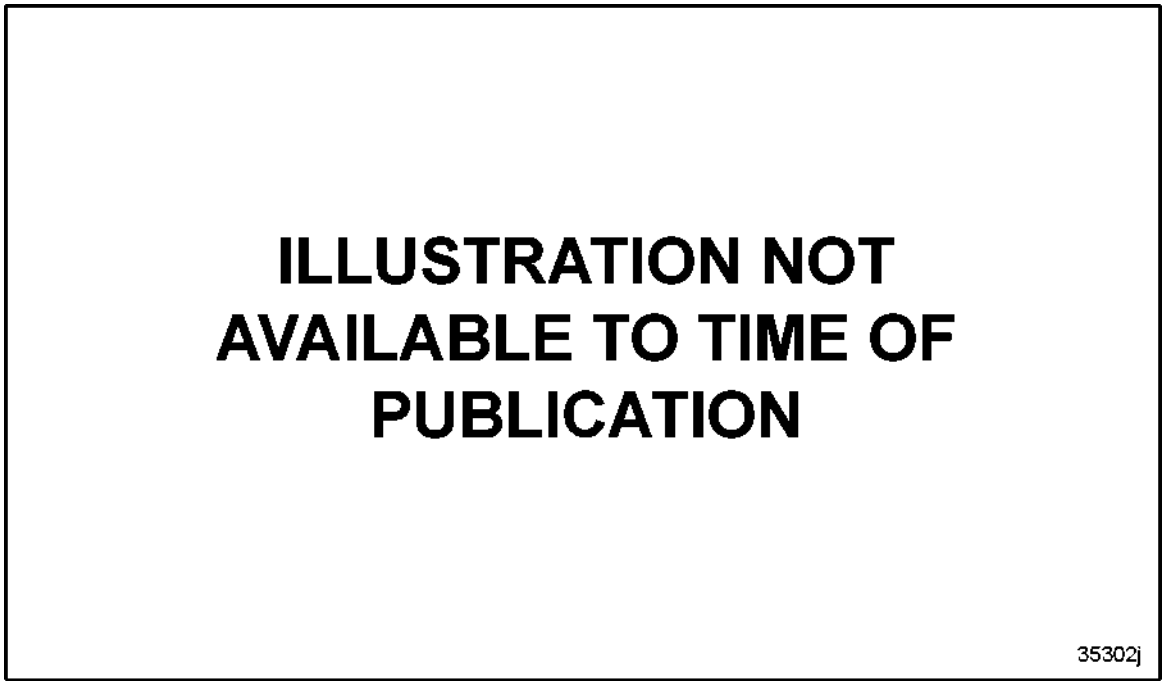

Figure 1516 GFI Diagnostic Cable,J 41518

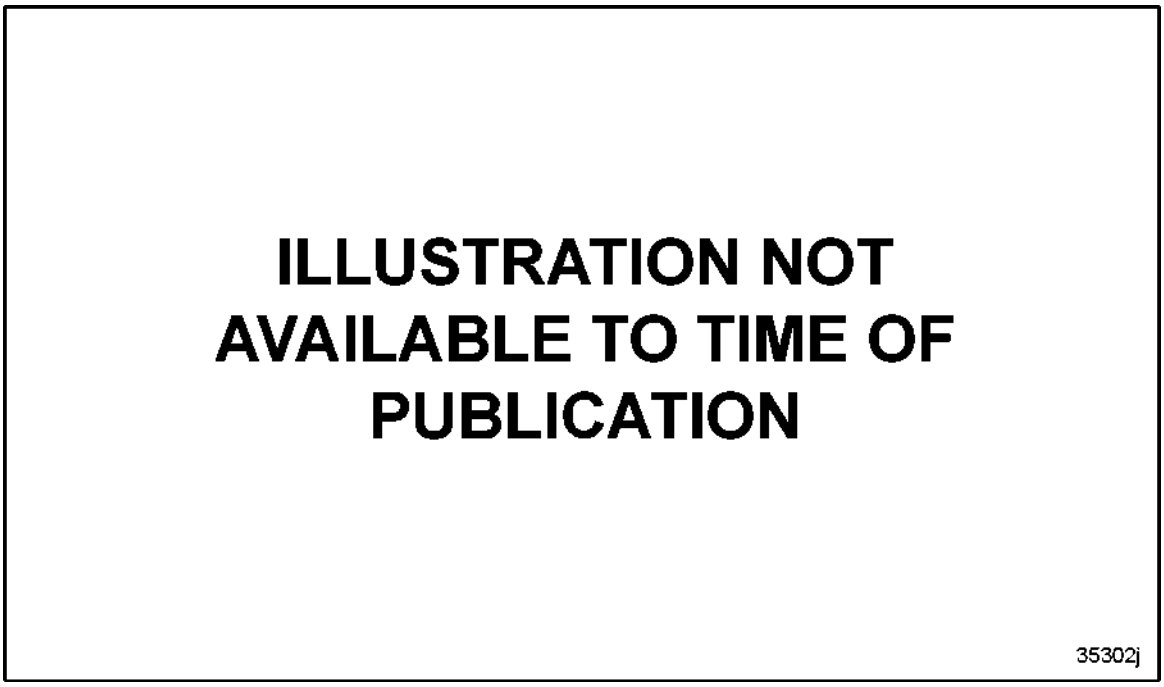

Figure 1517 Needle Bearing Instlr (Barnes Pump), J 33854

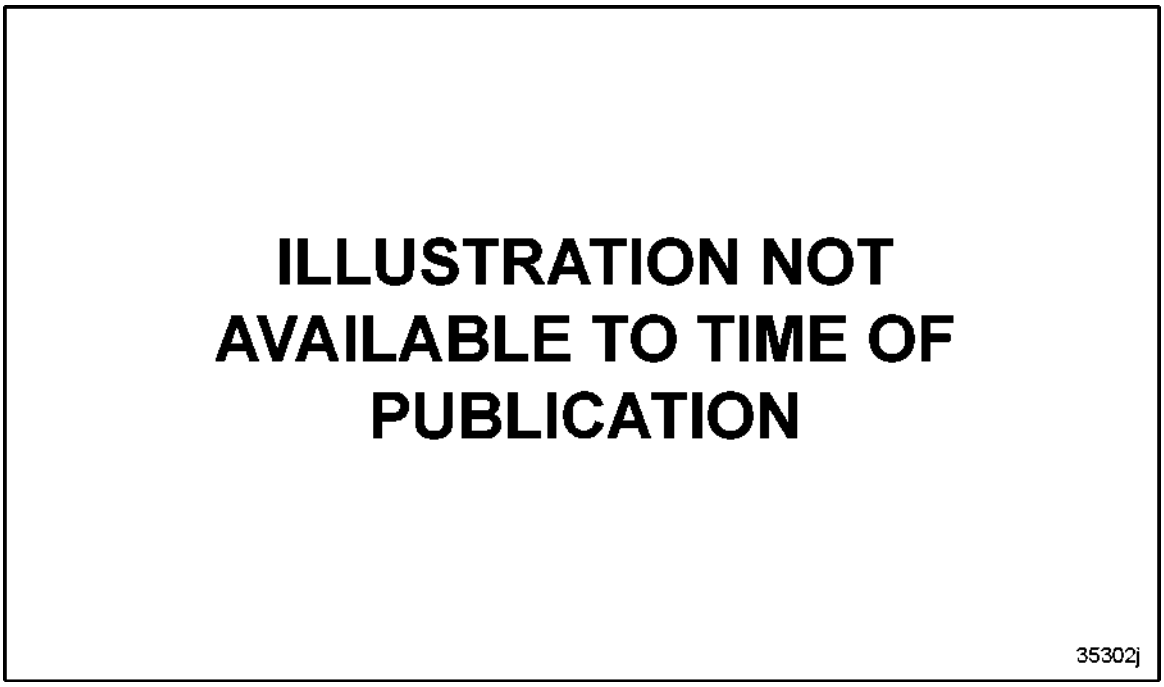

Figure 1518 Needle Bearing Remvr (Barnes Cup), J 33853

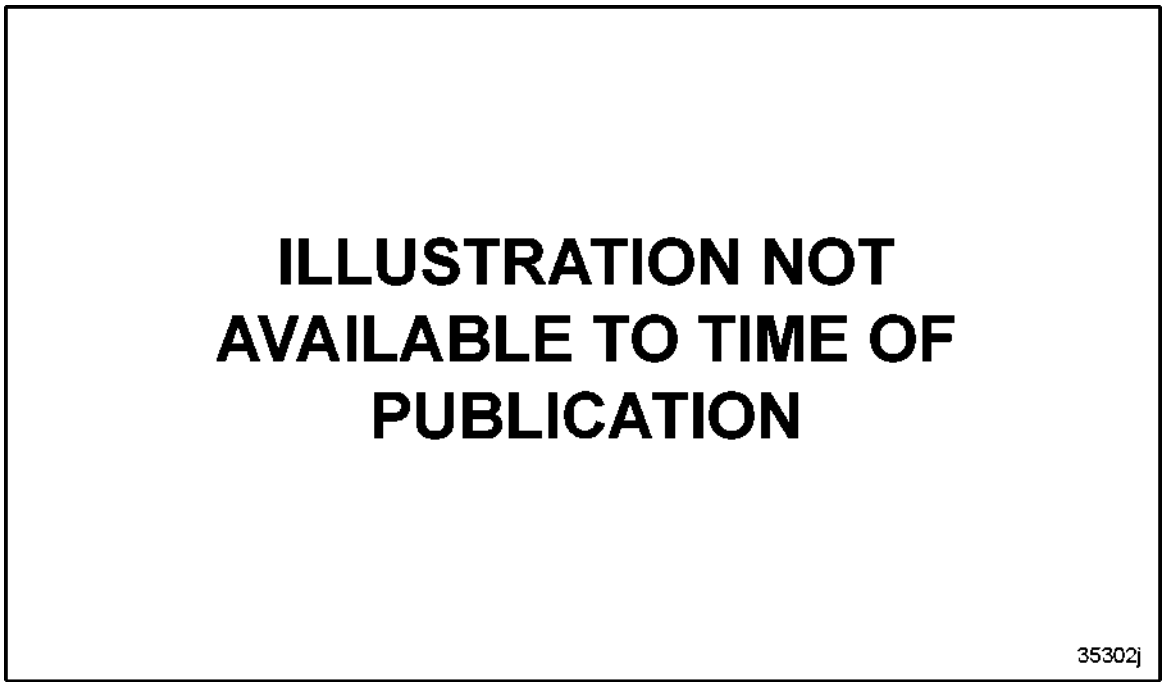

Figure 1519 Seal Installer (Barnes Cup),J 34158

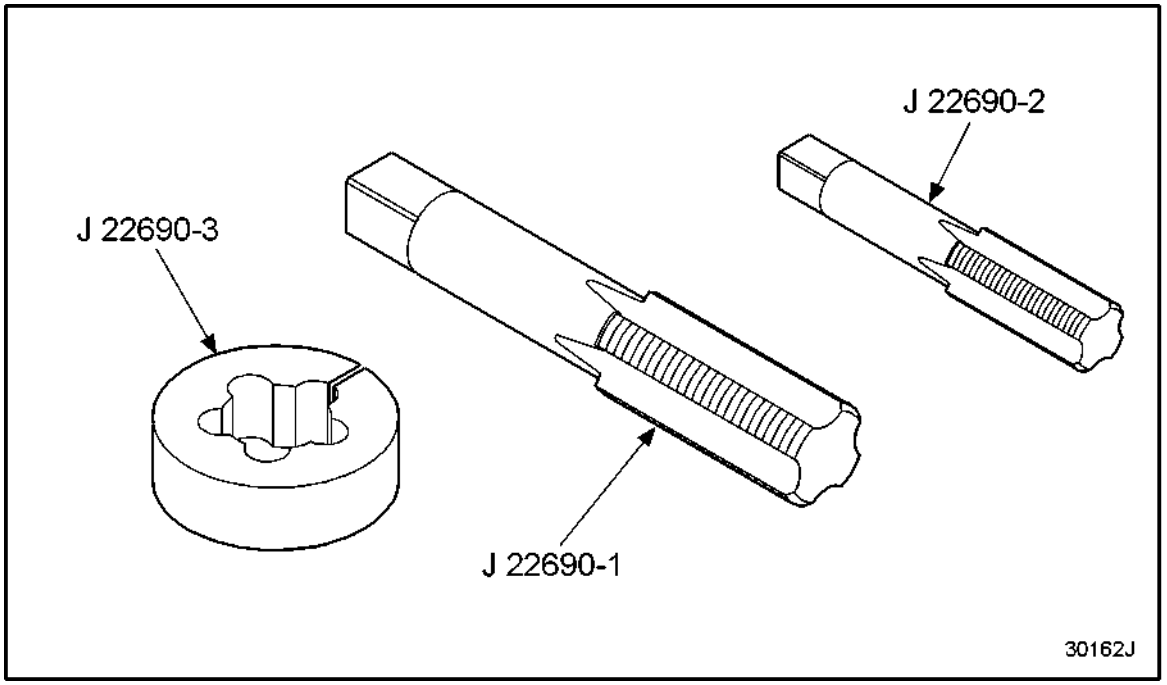

Figure 1520 Body & Nut Thread Recon System,J 22690

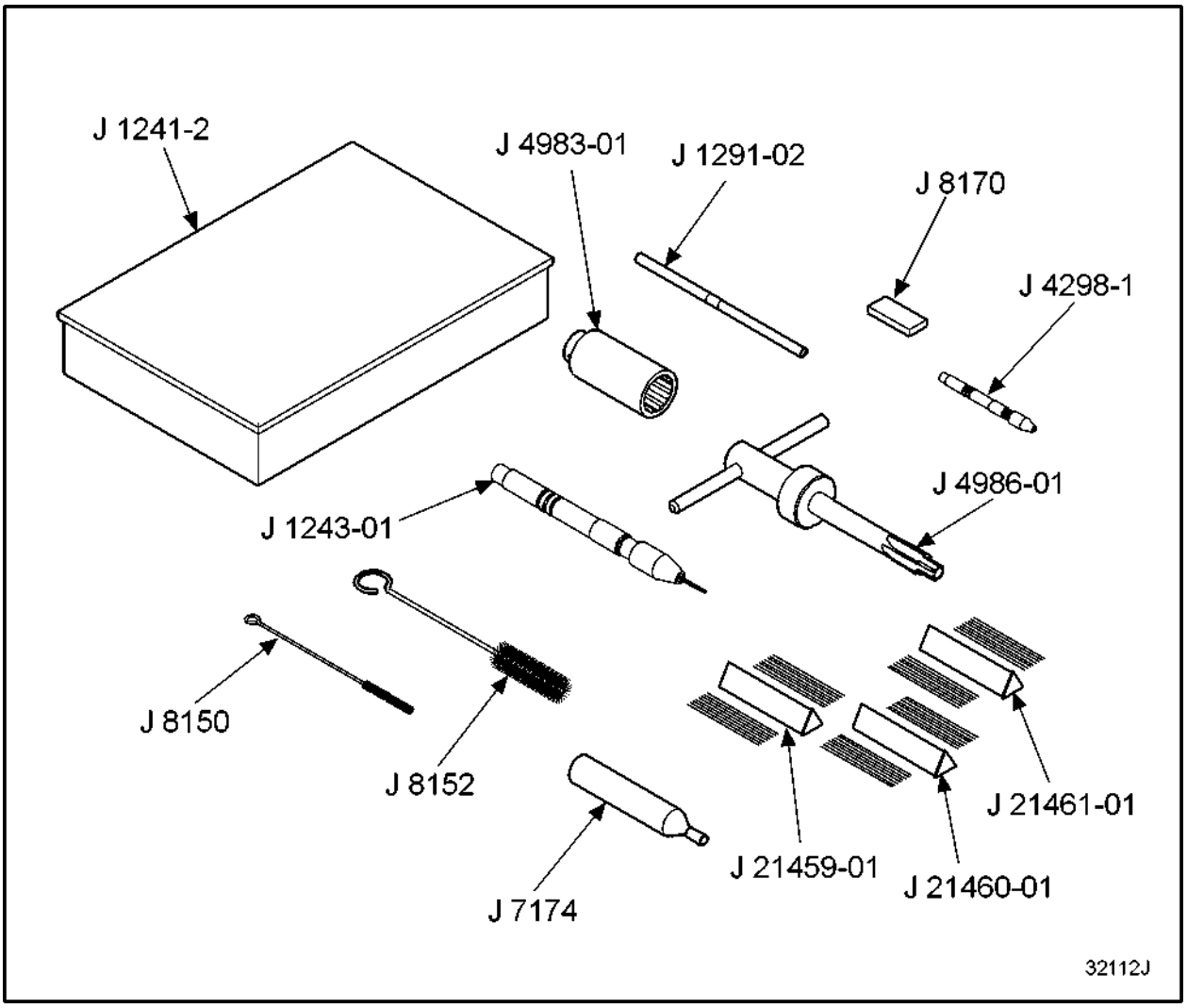

Figure 1521 Injector Service Set,J 1241–07

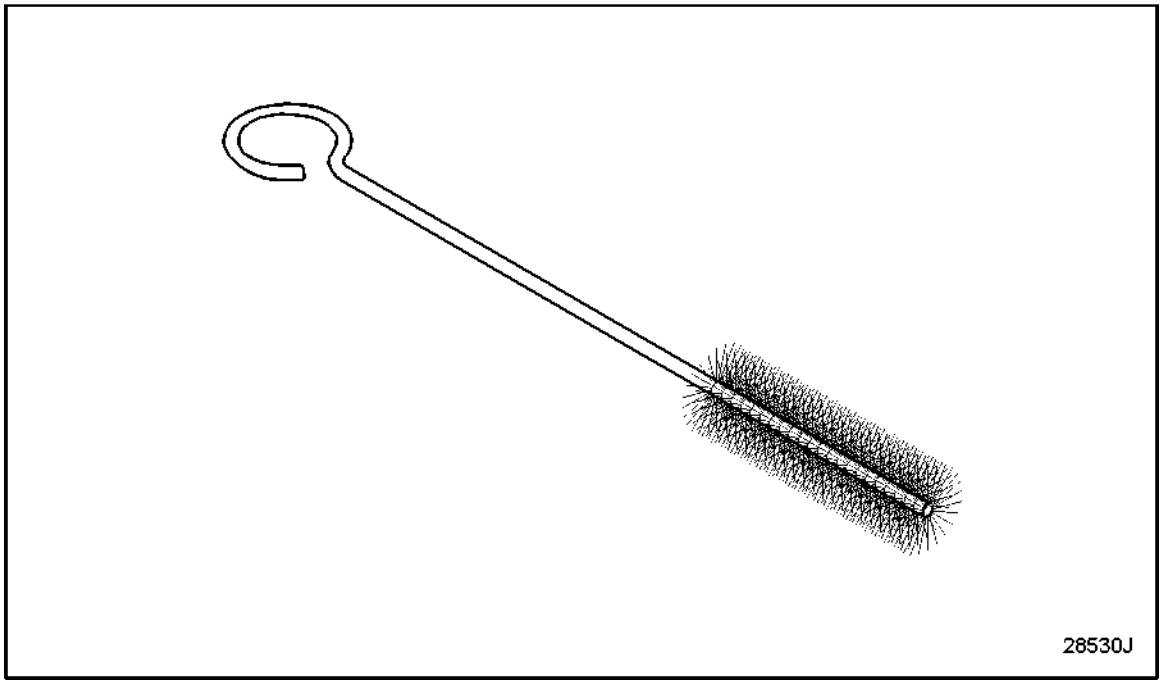

Figure 1522 Injector Fuel Hole Brush J 8152

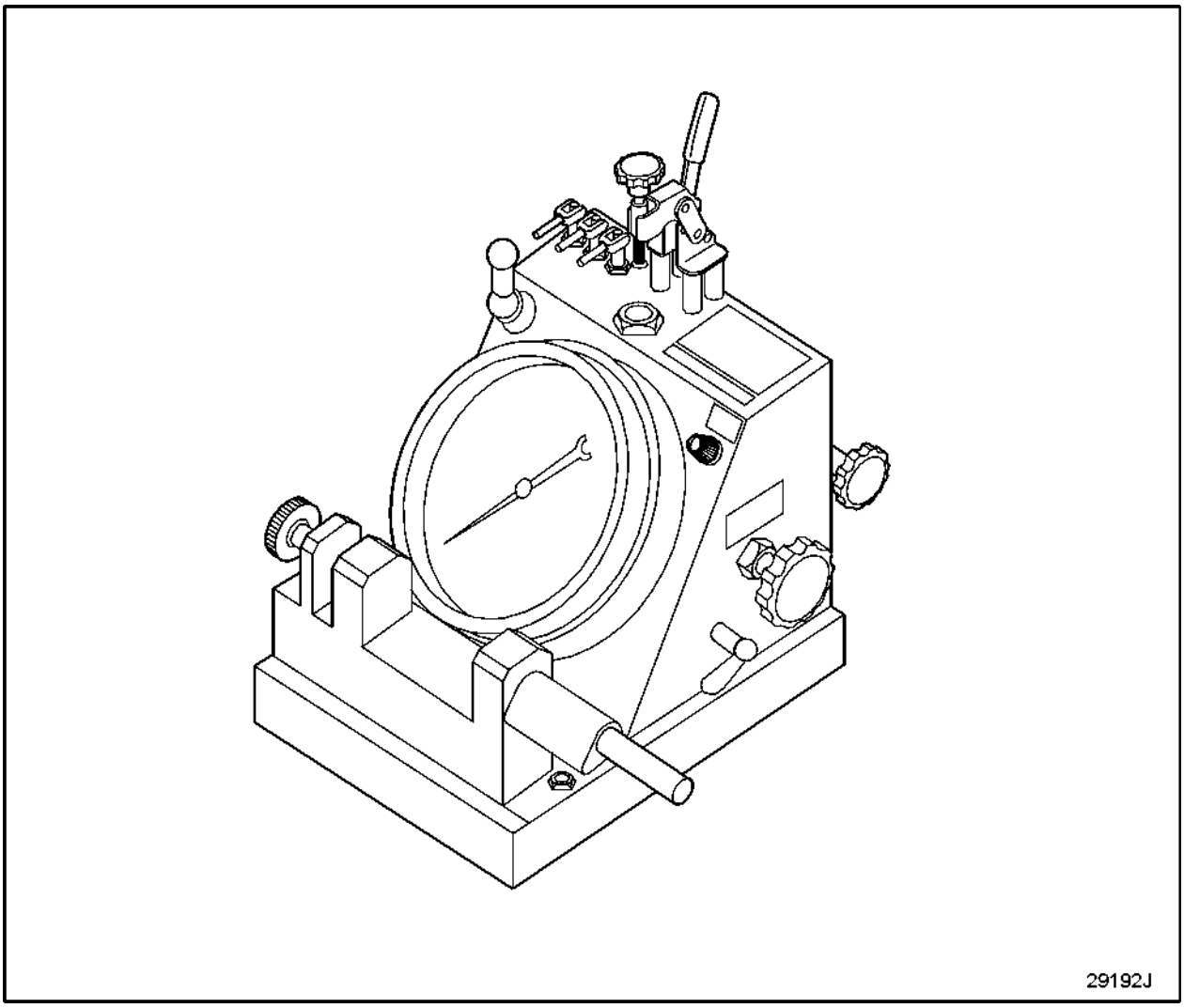

Figure 1523 Injector Spray Tip & P/B Flow Gauge, J 25600–B

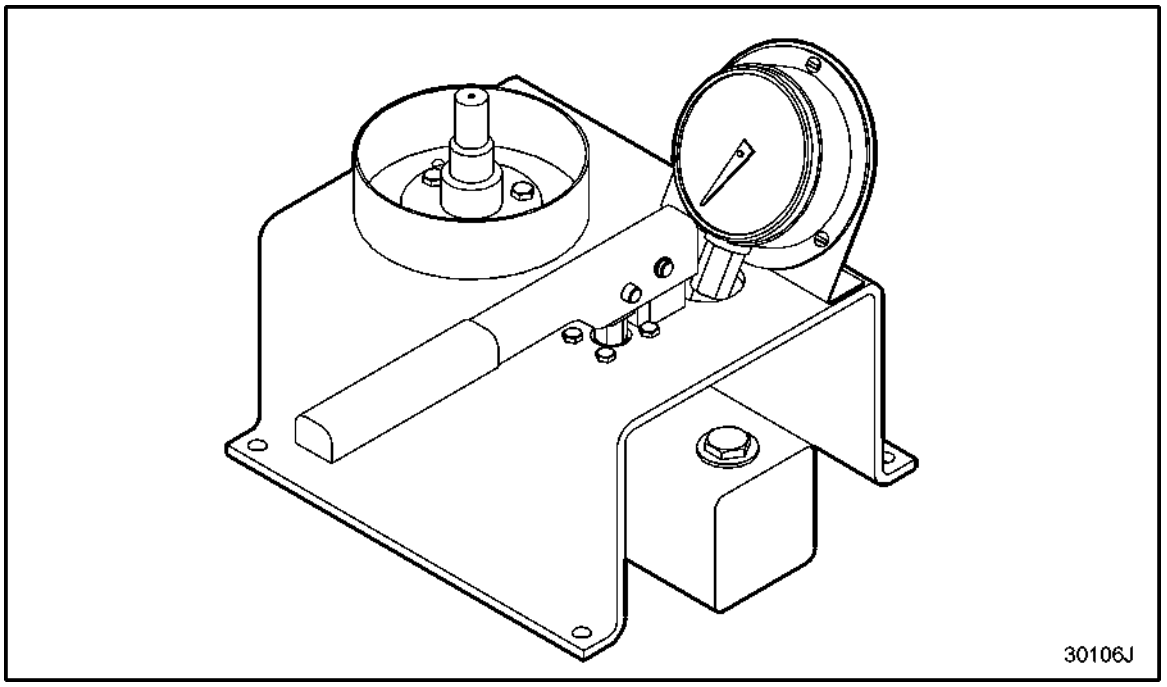

Figure 1524 Injector Tip Assembly Tester,J 22640–A

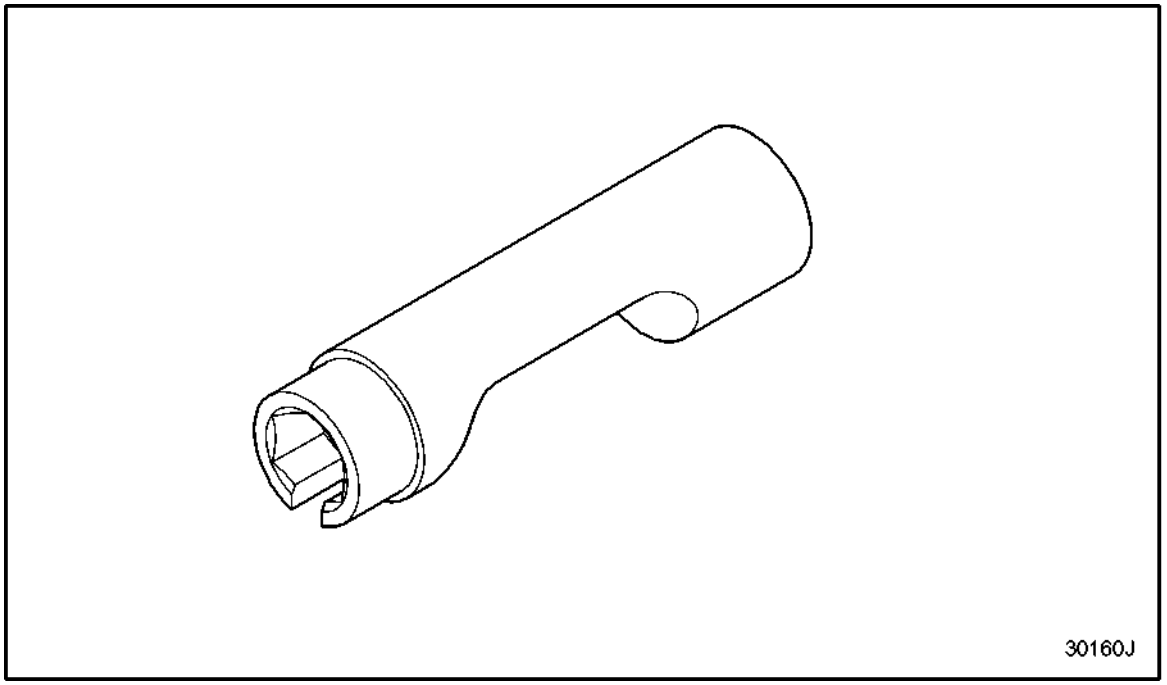

Figure 1525 Fuel Line Nut Wrench ,J 8932–B

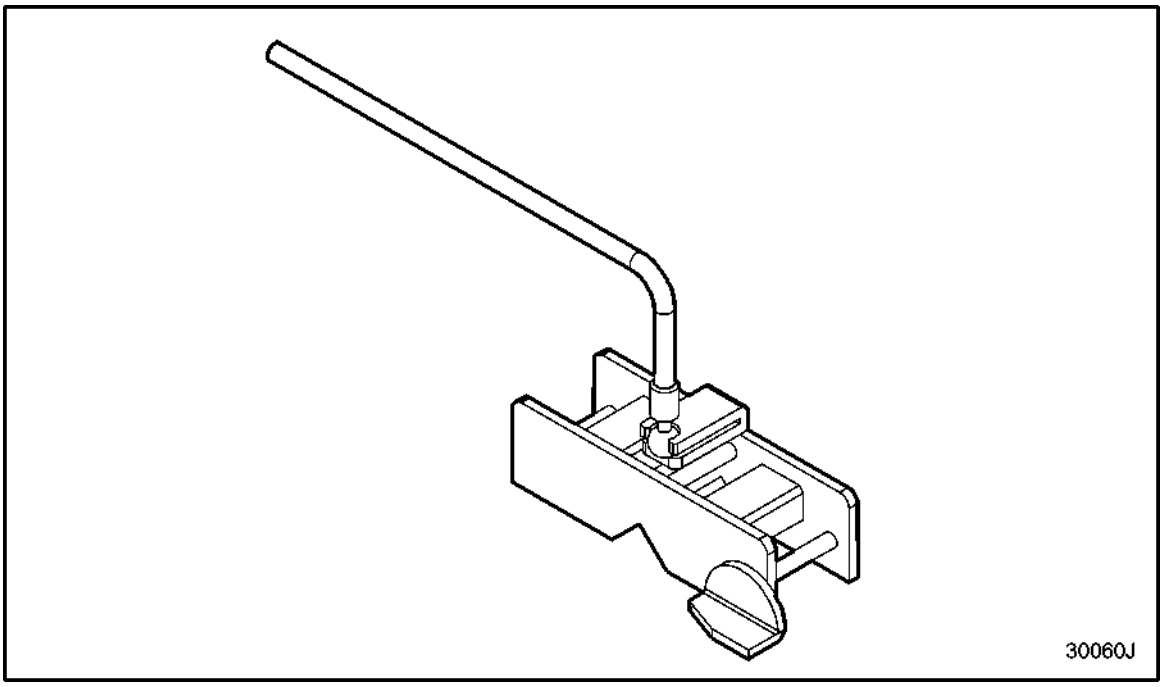

Figure 1526 Fuel Line Wrench Set,J 26617–A

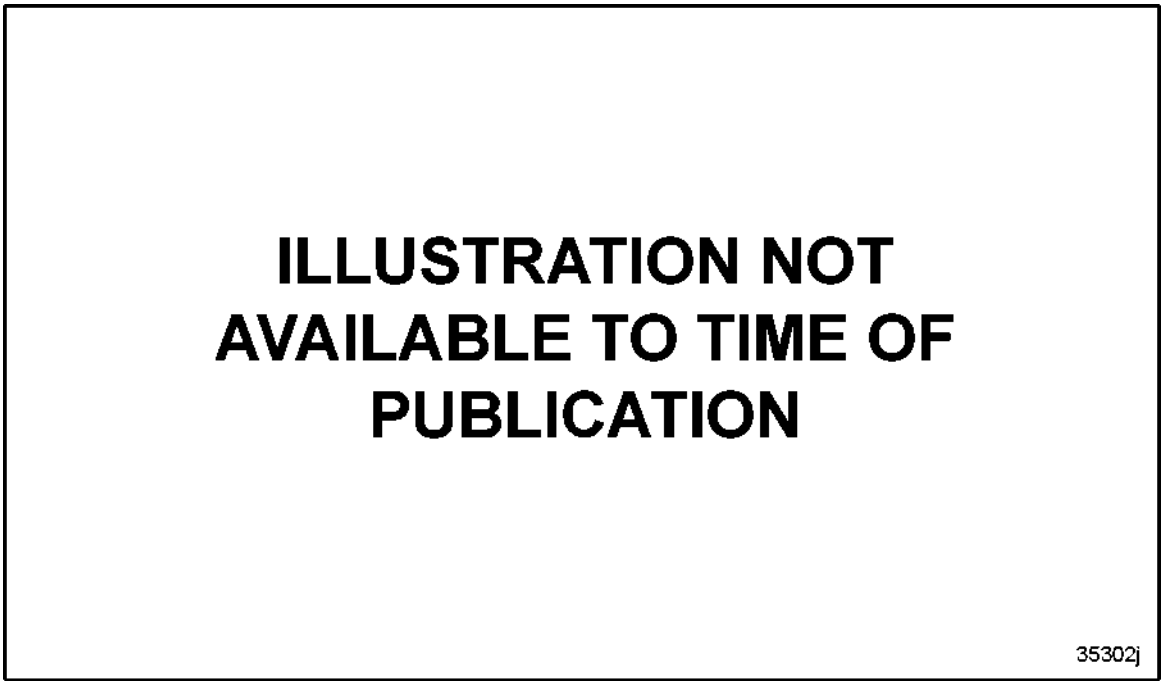

Figure 1527 Torque Wrench Adapter,J 41787

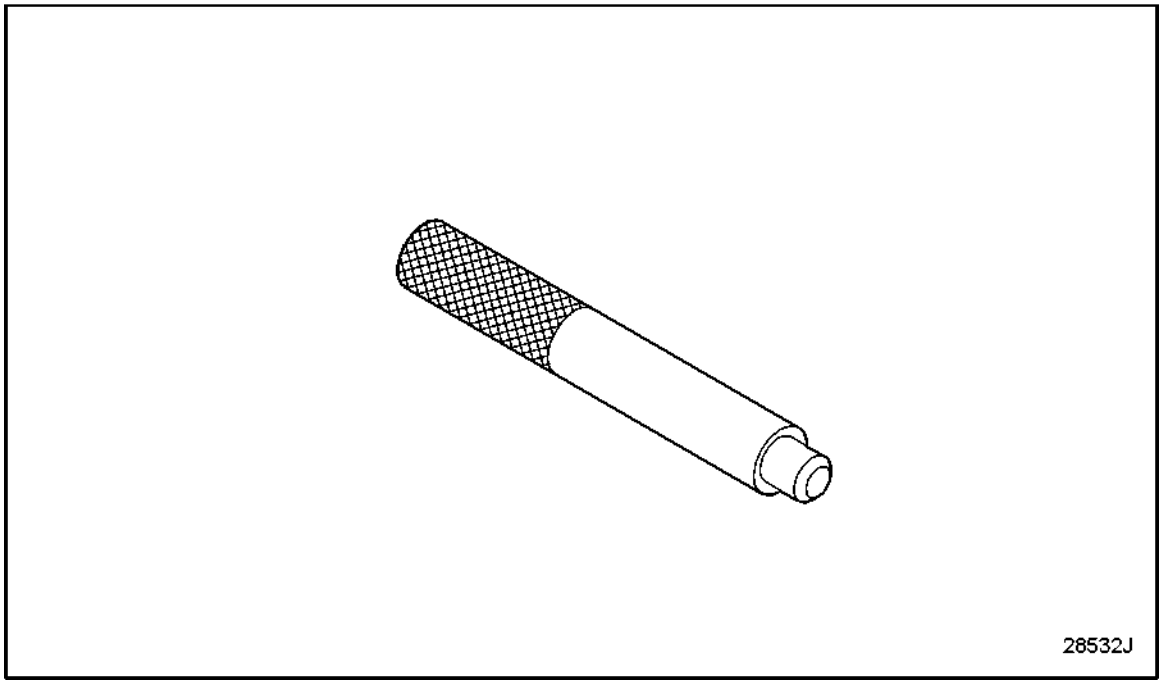

Figure 1528 Contrl Link BRG Remov/Install,J 8985

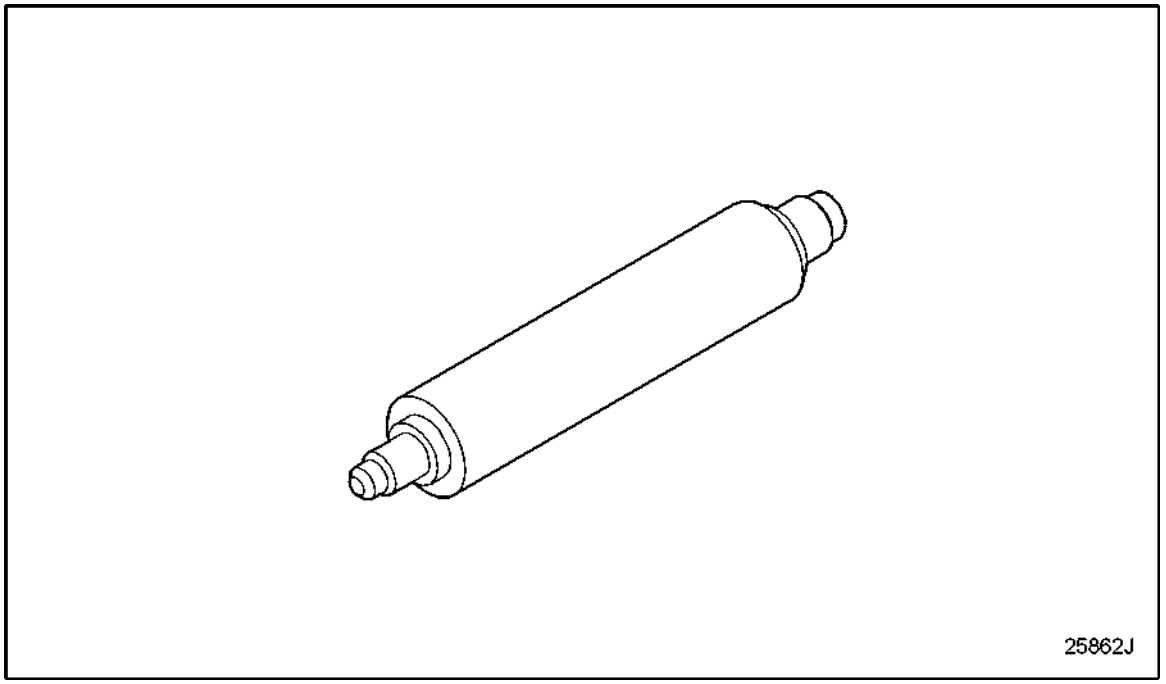

Figure 1529 Cover & Spring Housing Remover,J 21068

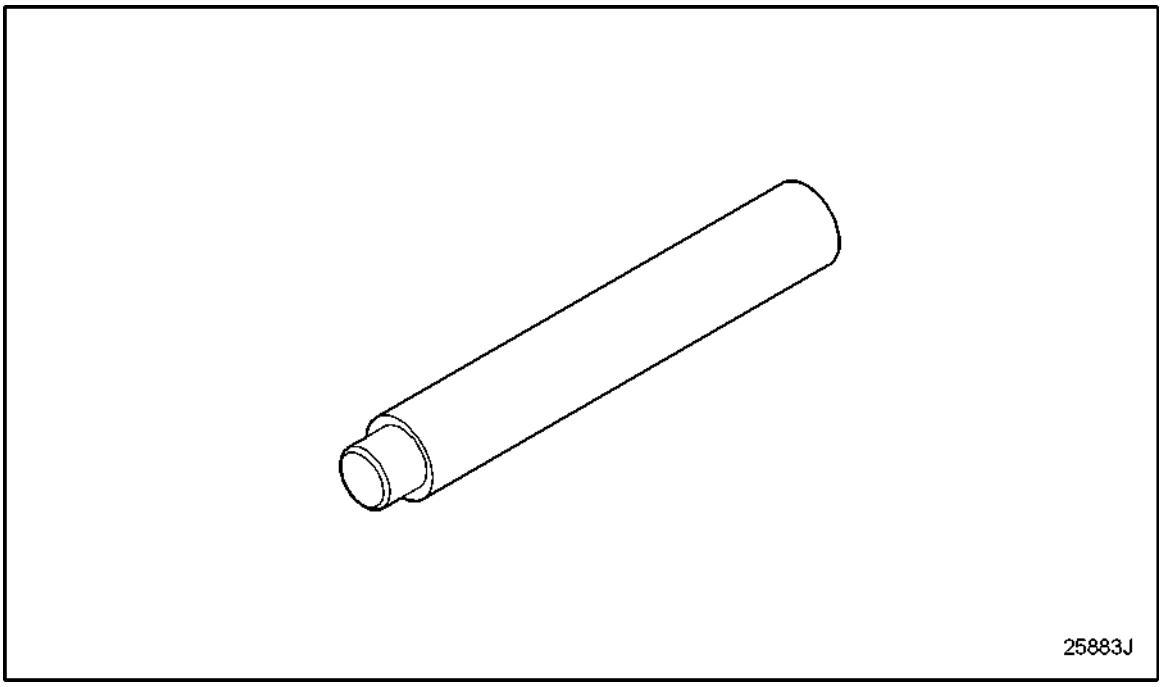

Figure 1530 Gov Weight Shaft Ret Ring Installer,J 21967–01

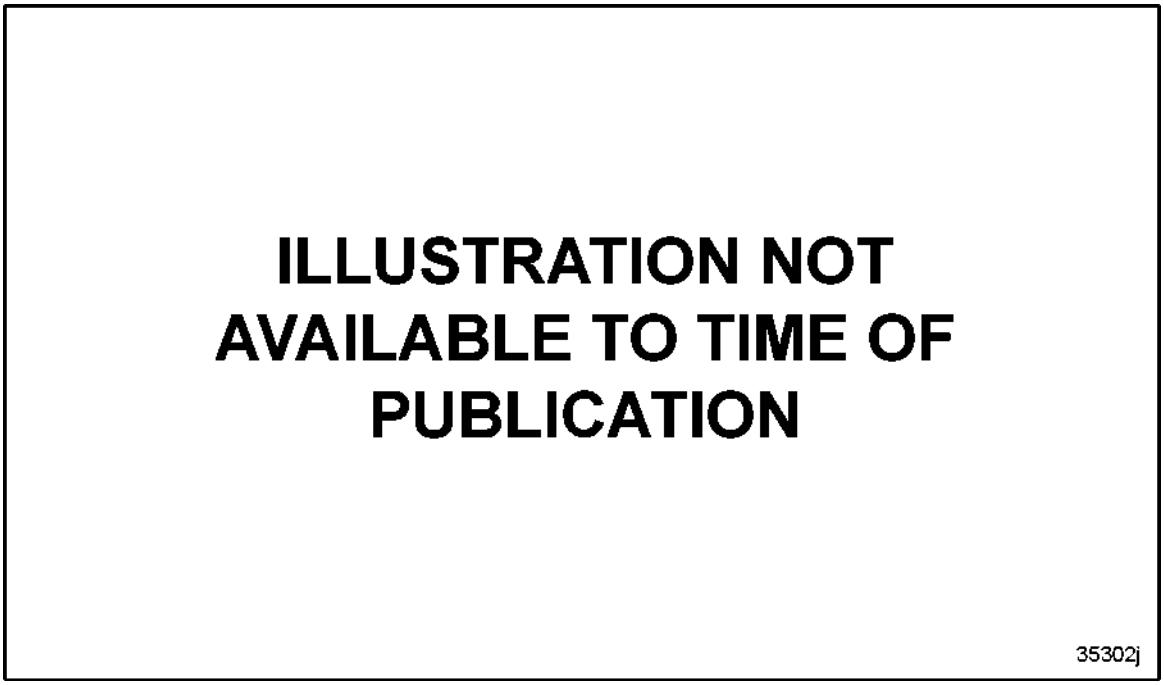

Figure 1531 Gov Weight Wedge- Static Gap Setting,J 36840

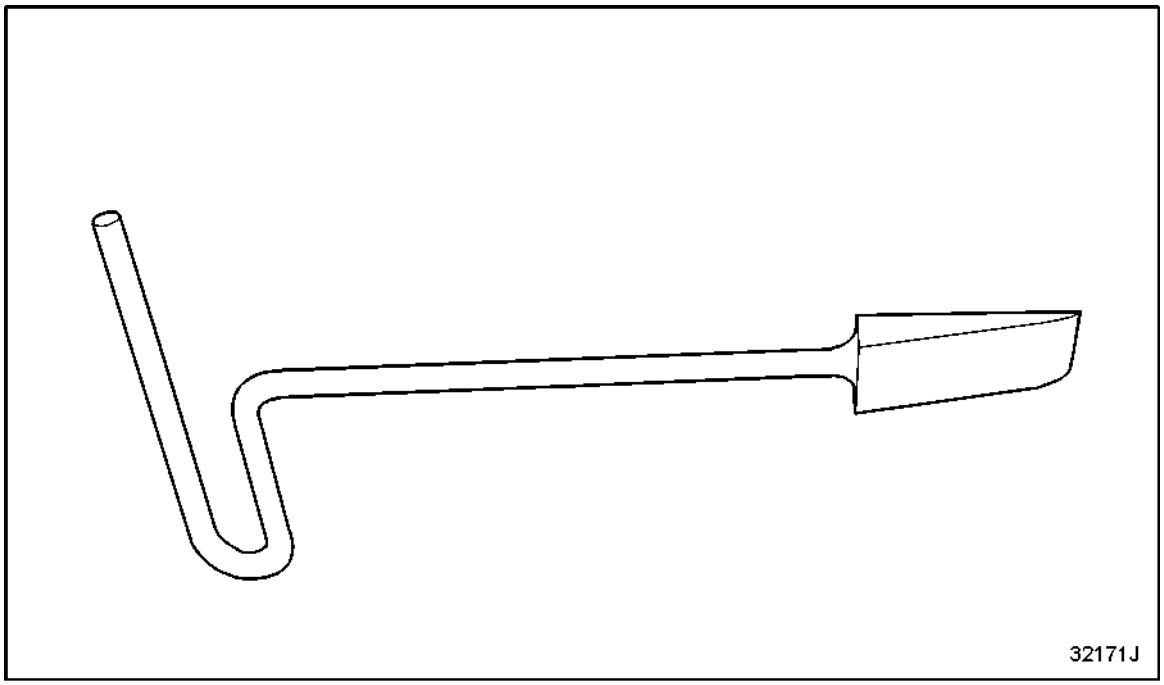

Figure 1532 Governor Housing Repair Kit,J 35516

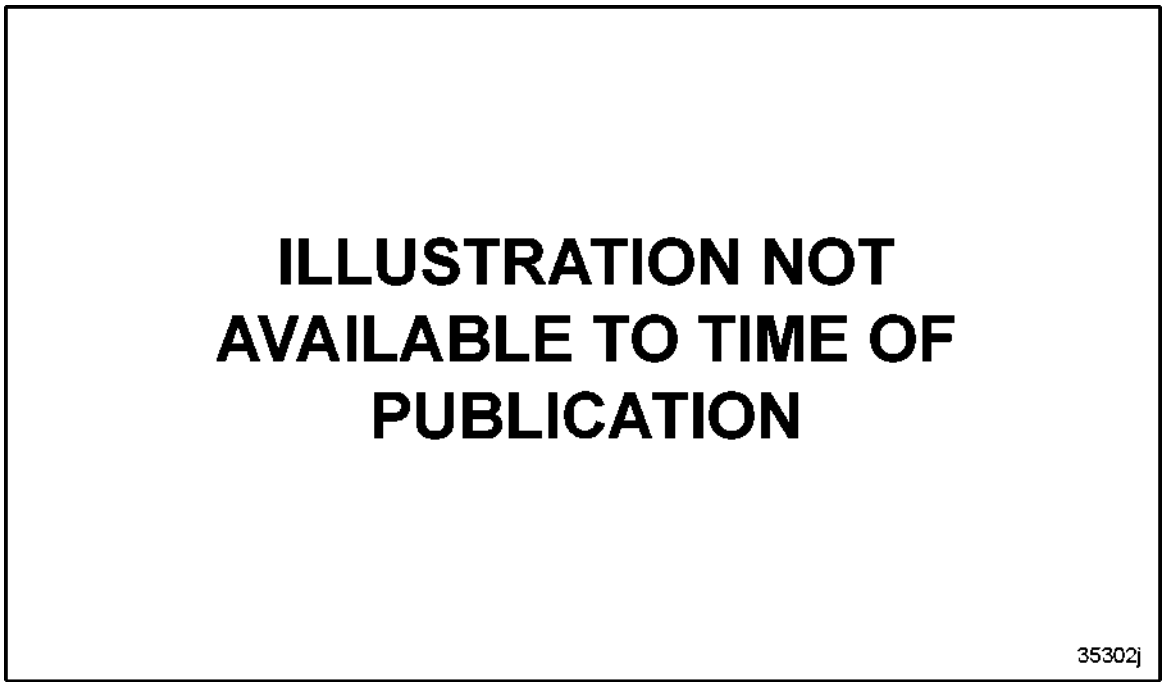

Figure 1533 Governor Housing Repair Kit,PT-7150–A

ILLUSTRATION NOT AVAILABLE TO TIME OF PUBLICATION

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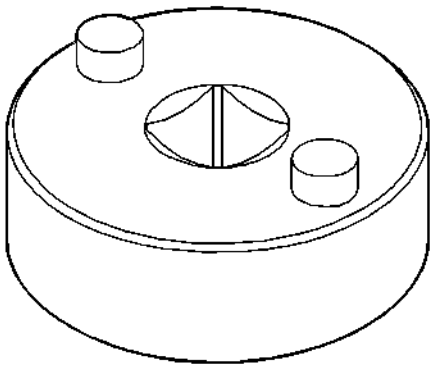
Figure 1534 Linkage Gage (Electronic),J 35618



26480J

Figure 1535 Weight Housing Plug Rem & Replacer,J 23176

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Figure 1536 Weight Spacer (6V-53), J 8984

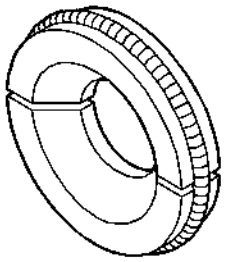

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Figure 1537 Drive Ring Remover, J 4685

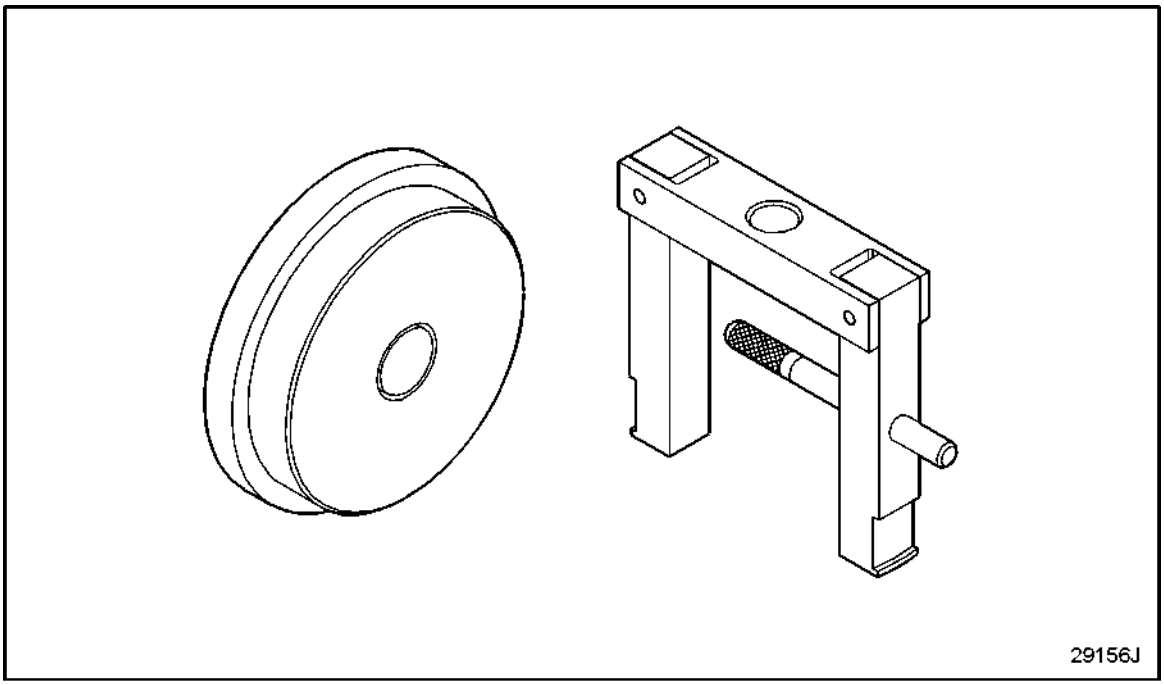


Figure 1538 Bushing - Remover & Installer Set,J 29140

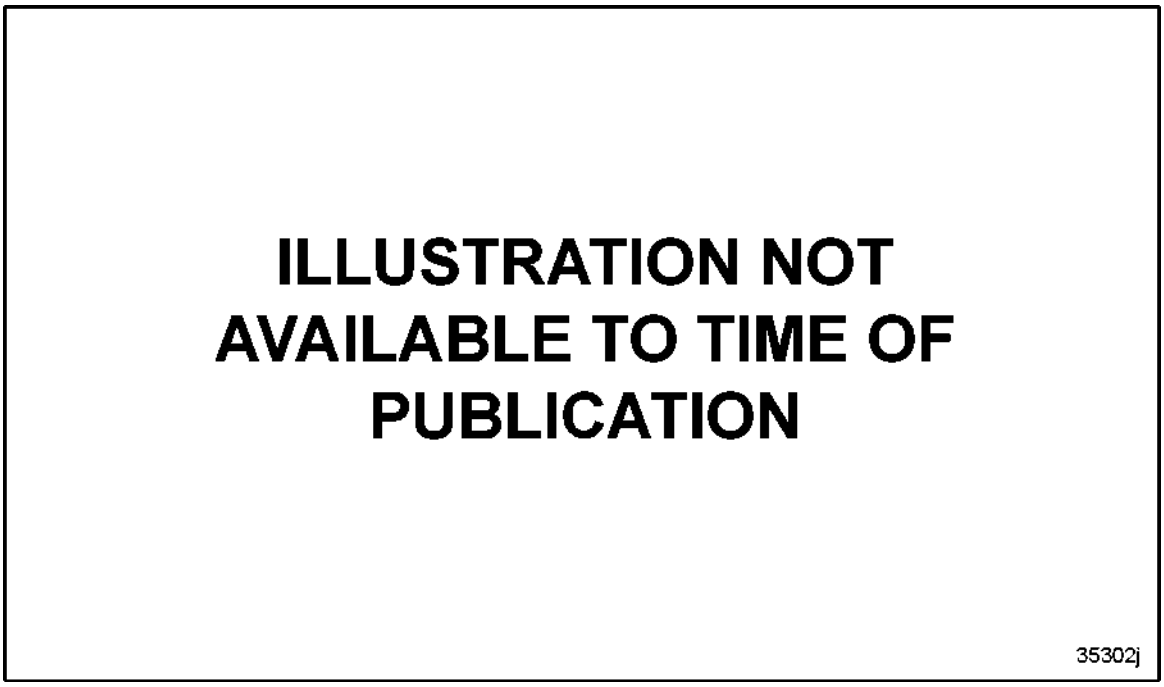


Figure 1539 Drive Gear Installer,J 8968–01

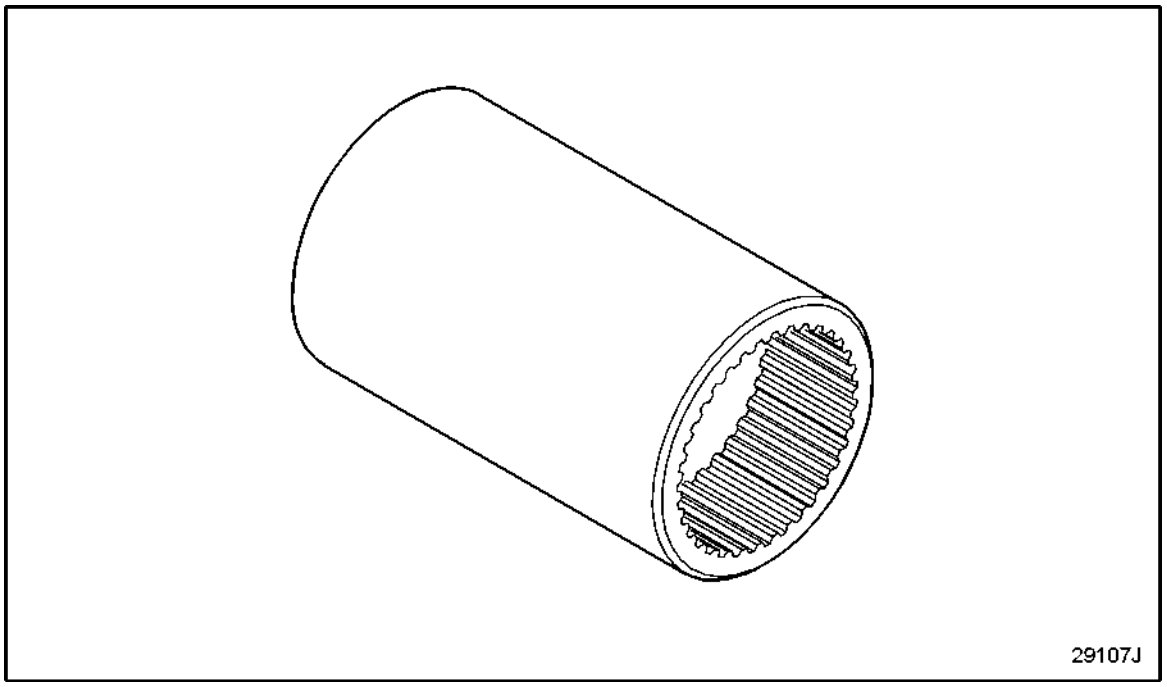


Figure 1540 Drive Gear Sip TST (TRQ WR ADPT),J 23126

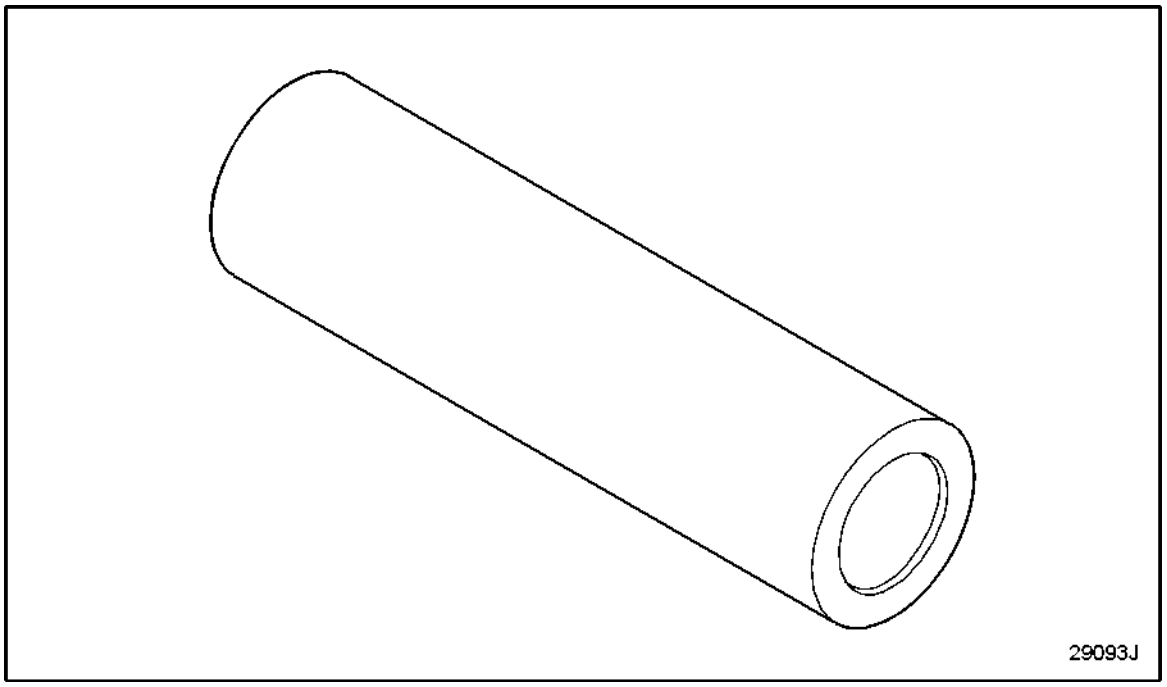


Figure 1541 Drive Shaft Dear INST (6.01") (6/8V),J 22398

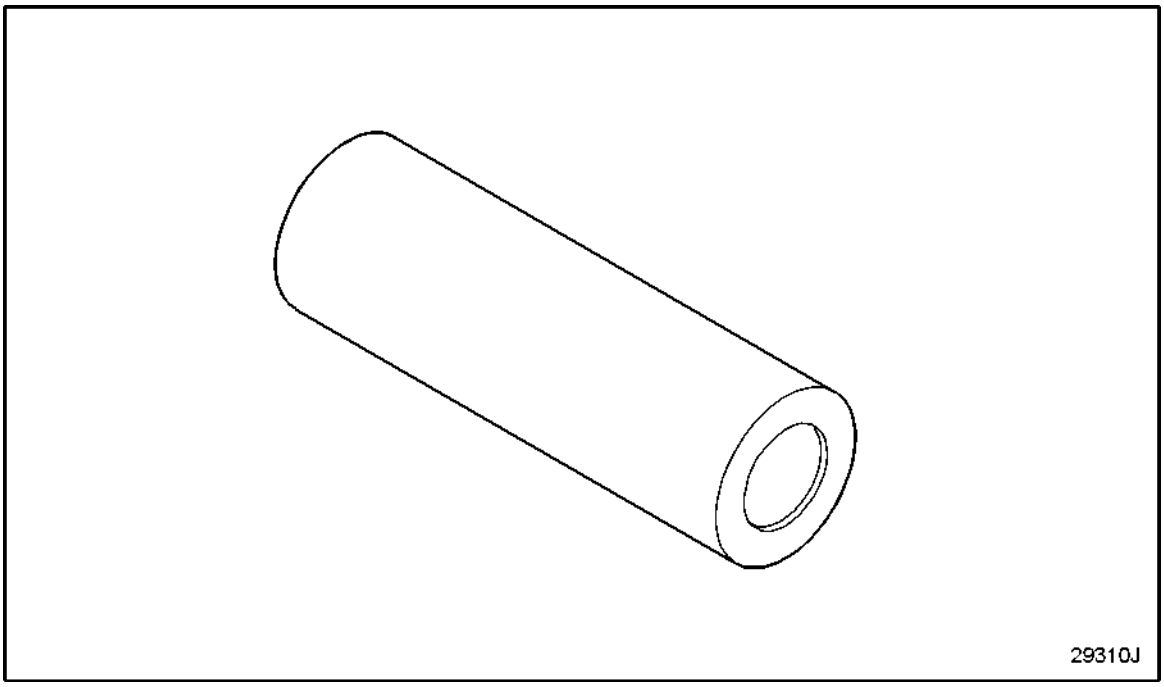


Figure 1542 Gear Instal 5.500" 16V-71/12V-16V92,J 9380

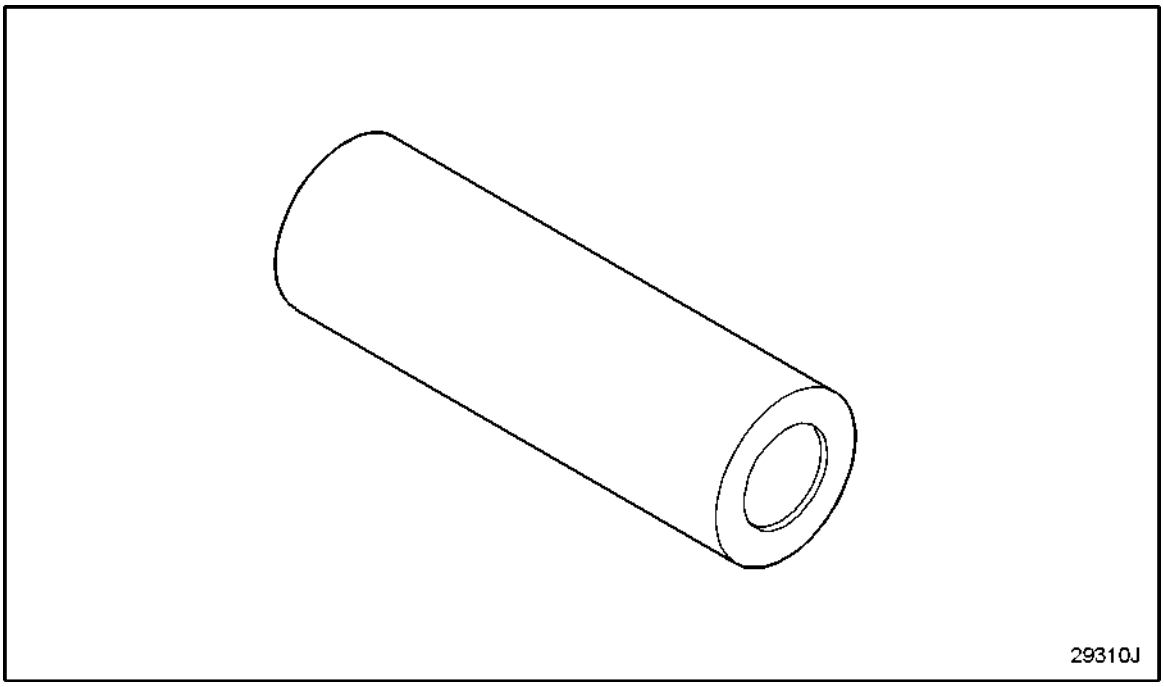


Figure 1543 Gear Installer,J 9381

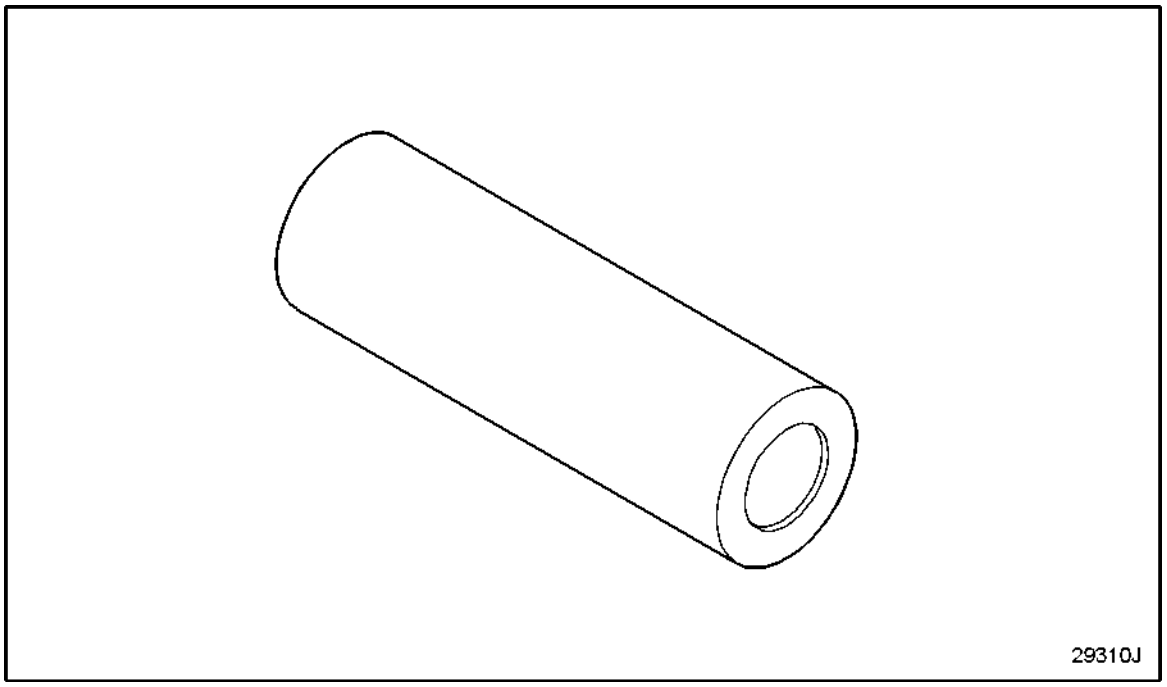


Figure 1544 Gear Installer (8.060") (16V),J 9382

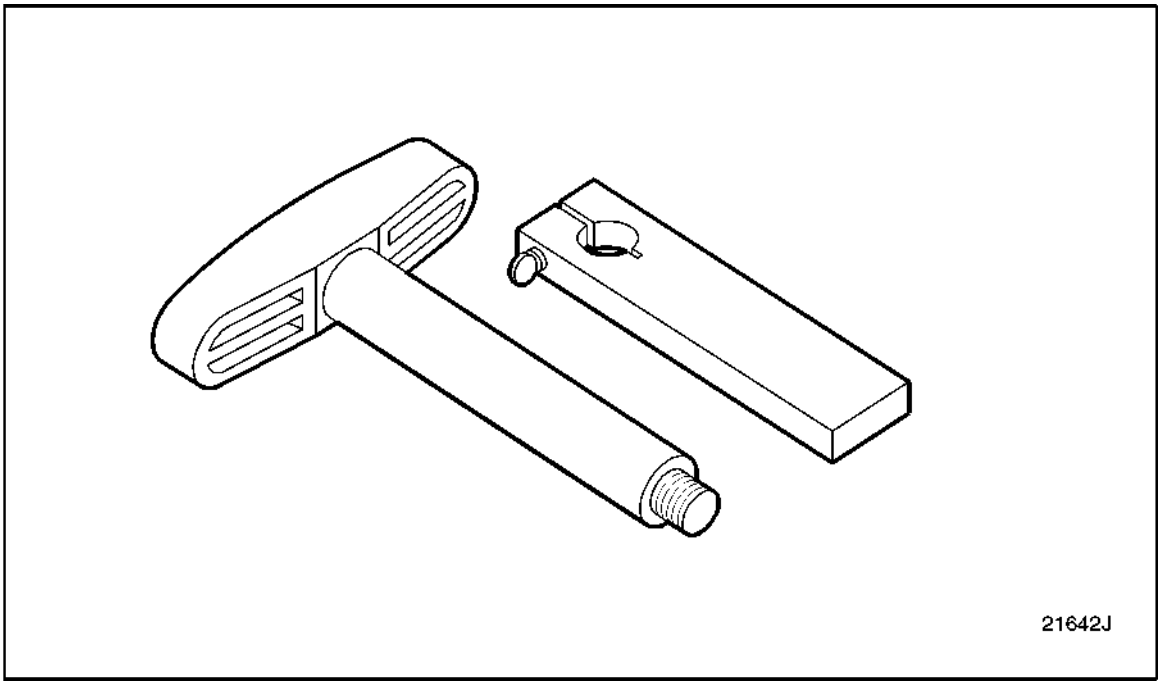


Figure 1545 Idler Shaft Wrench,J 39769

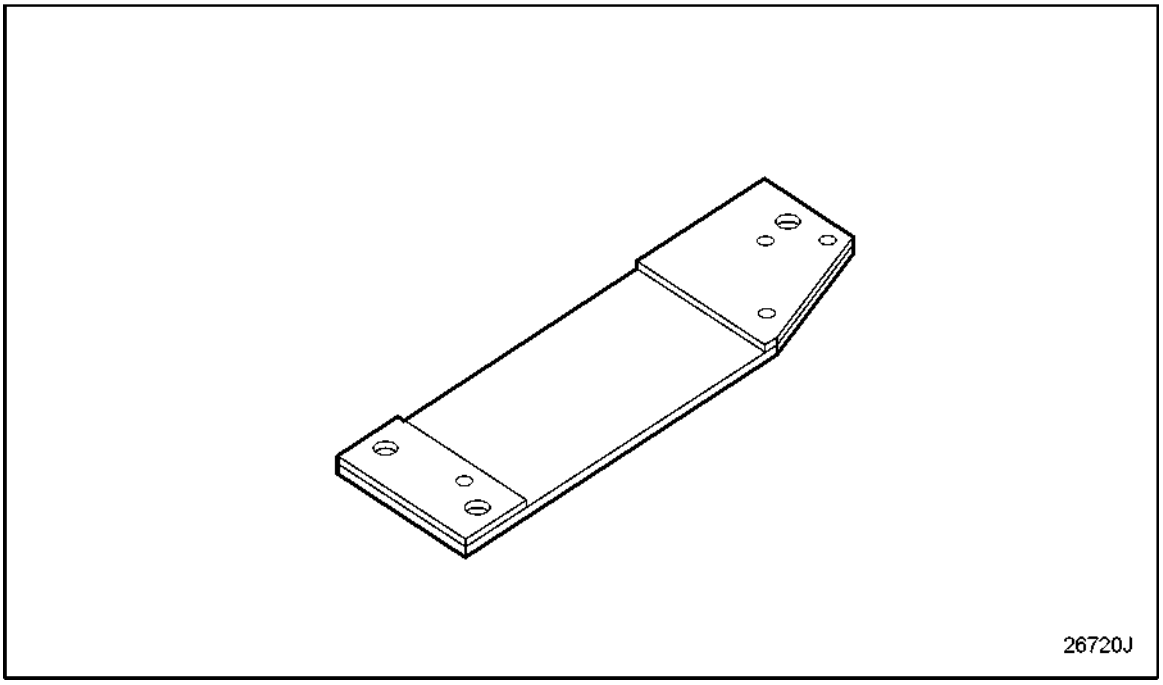


Figure 1546 Oil Cooler Test Plate,J 41975

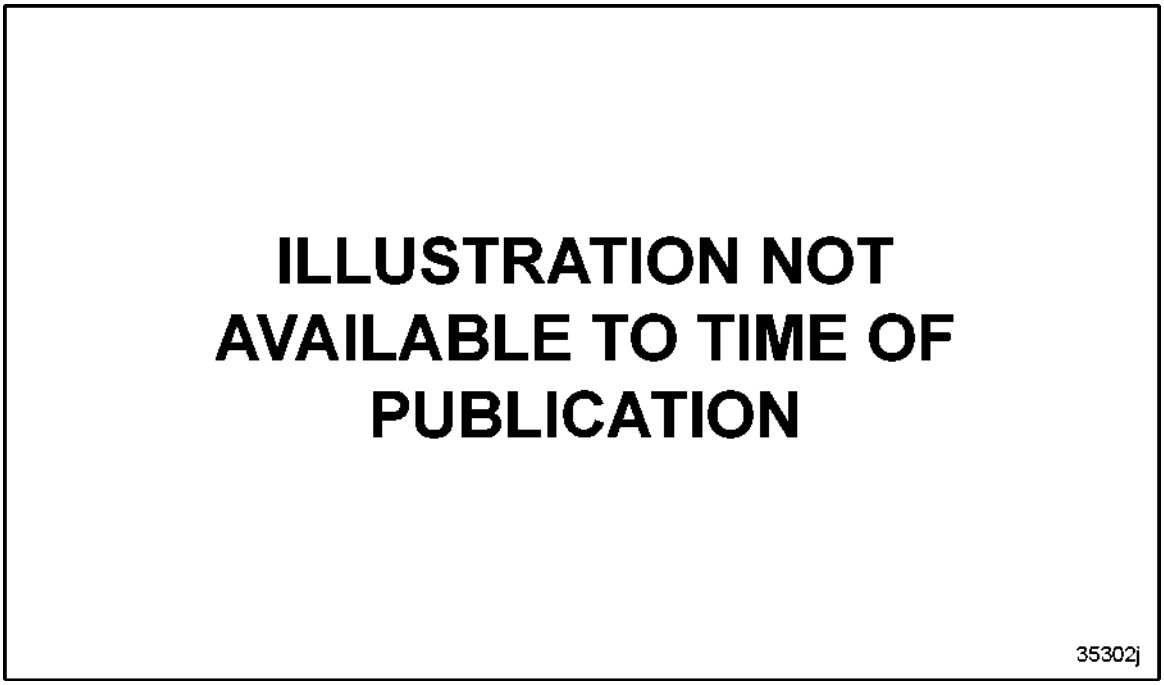


Figure 1547 Oil Cooling Plate,J 43075

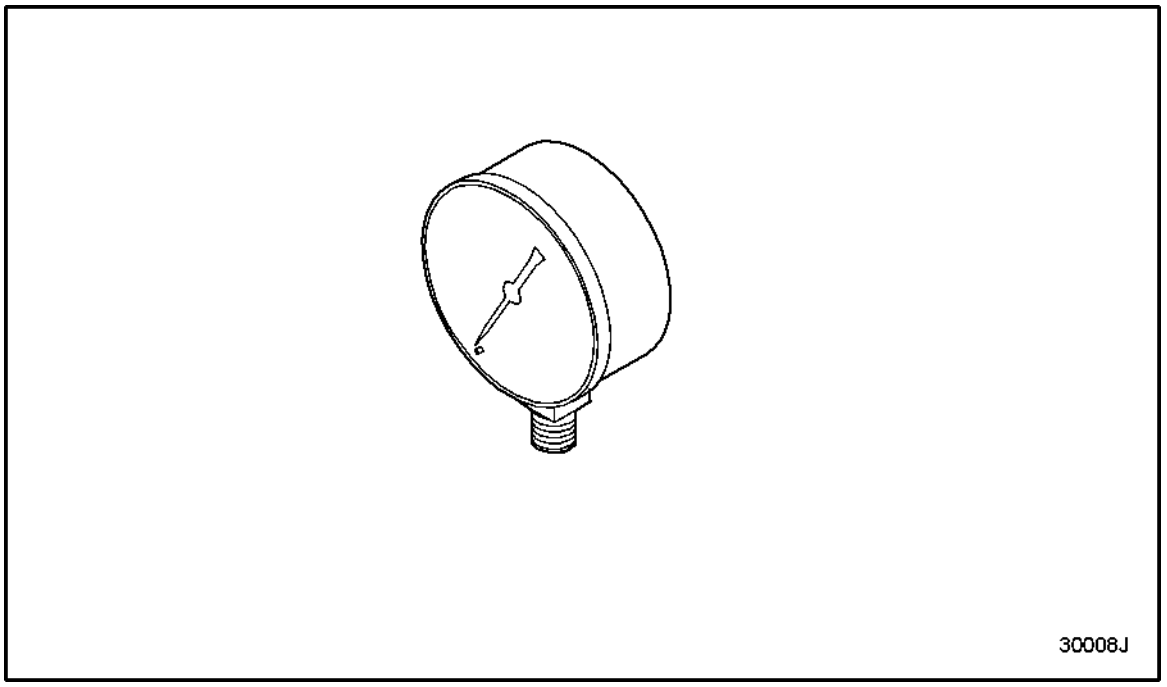


Figure 1548 Oil Pressure Gauge (0-160 PSI),J 29325–4

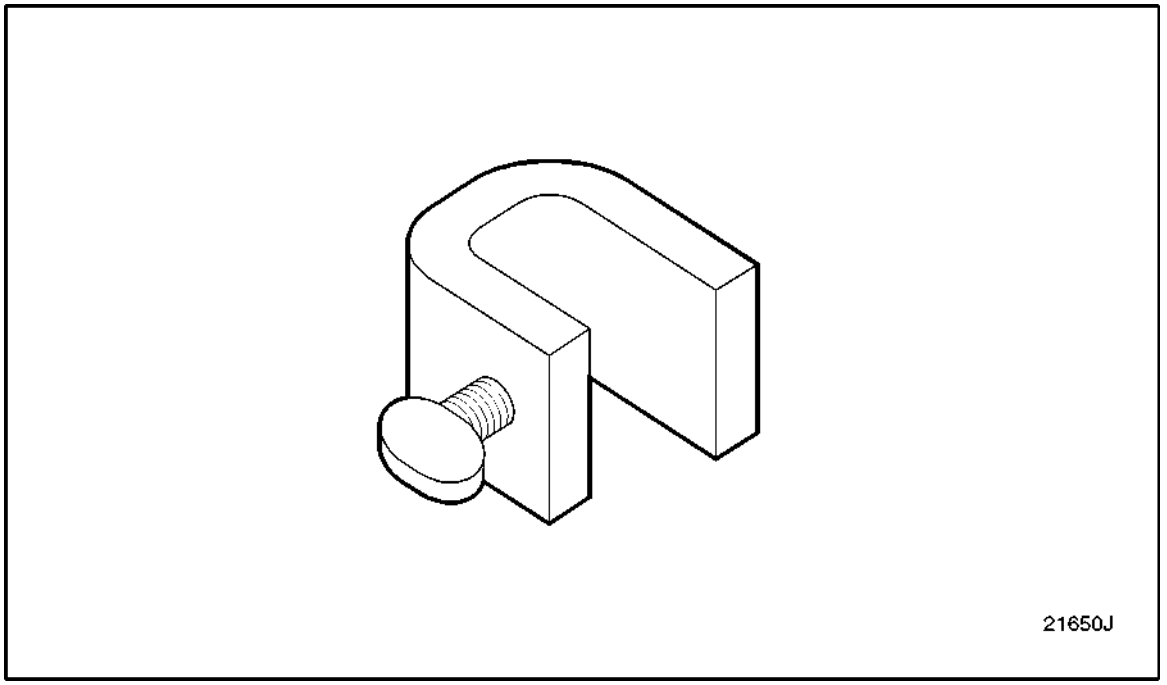


Figure 1549 Oil Pump Gear Holder,J 39816

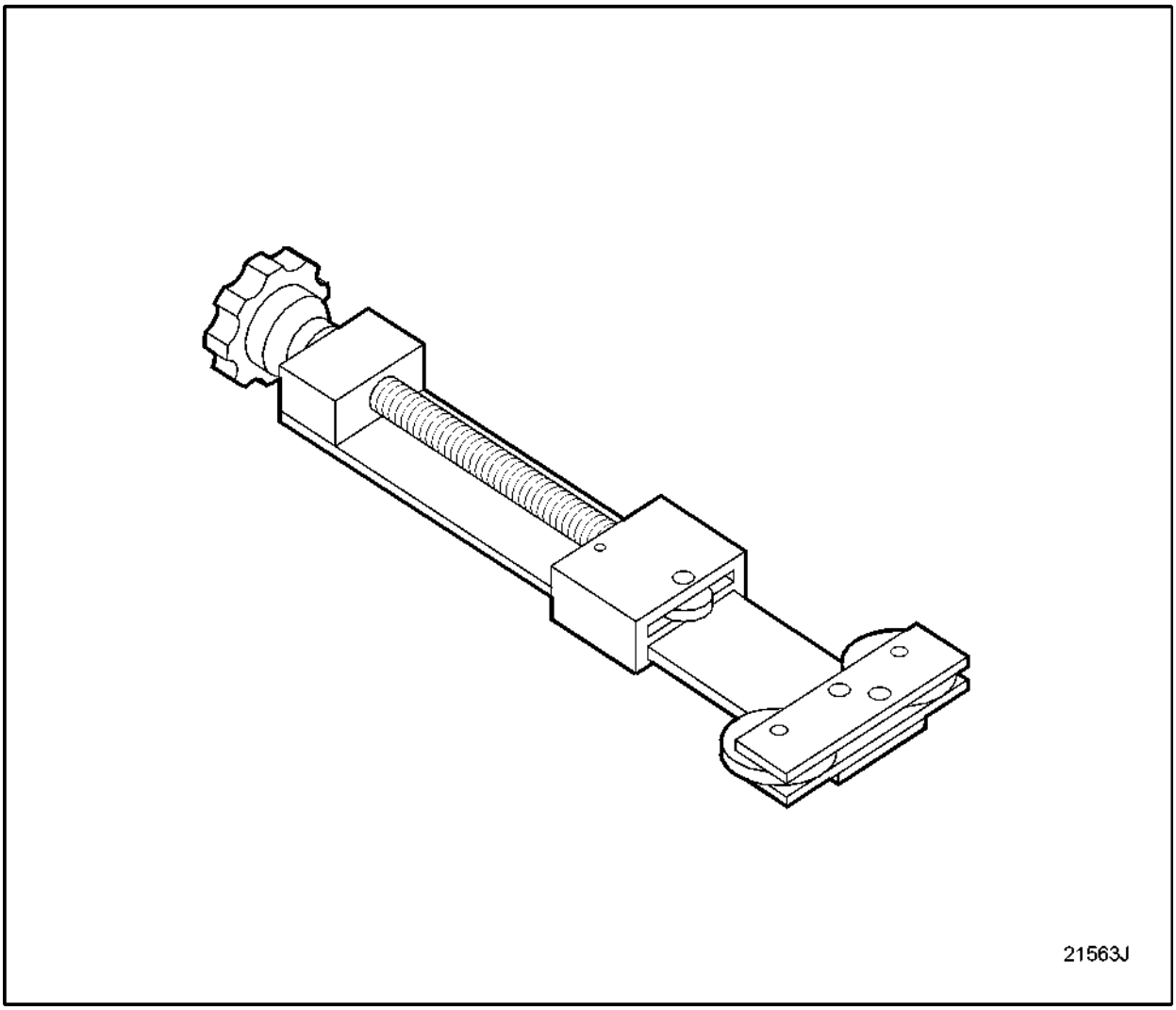


Figure 1550 Filter Cutter (Fuel and Lube),J 29925

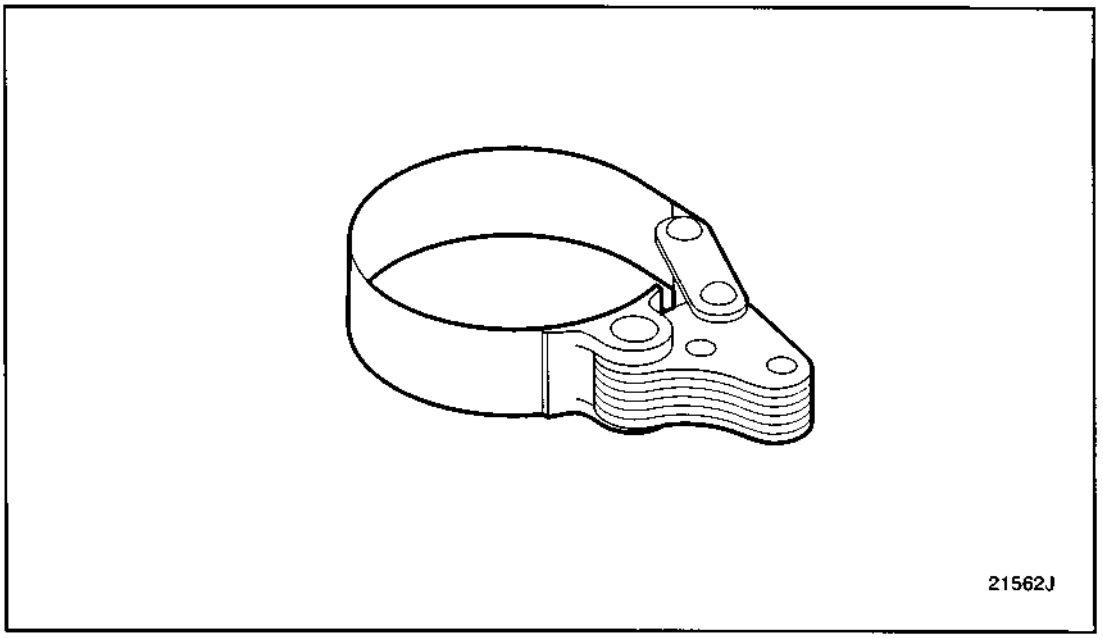


Figure 1551 Lube Oil Filter (Spin-on) Wrench, J 29917

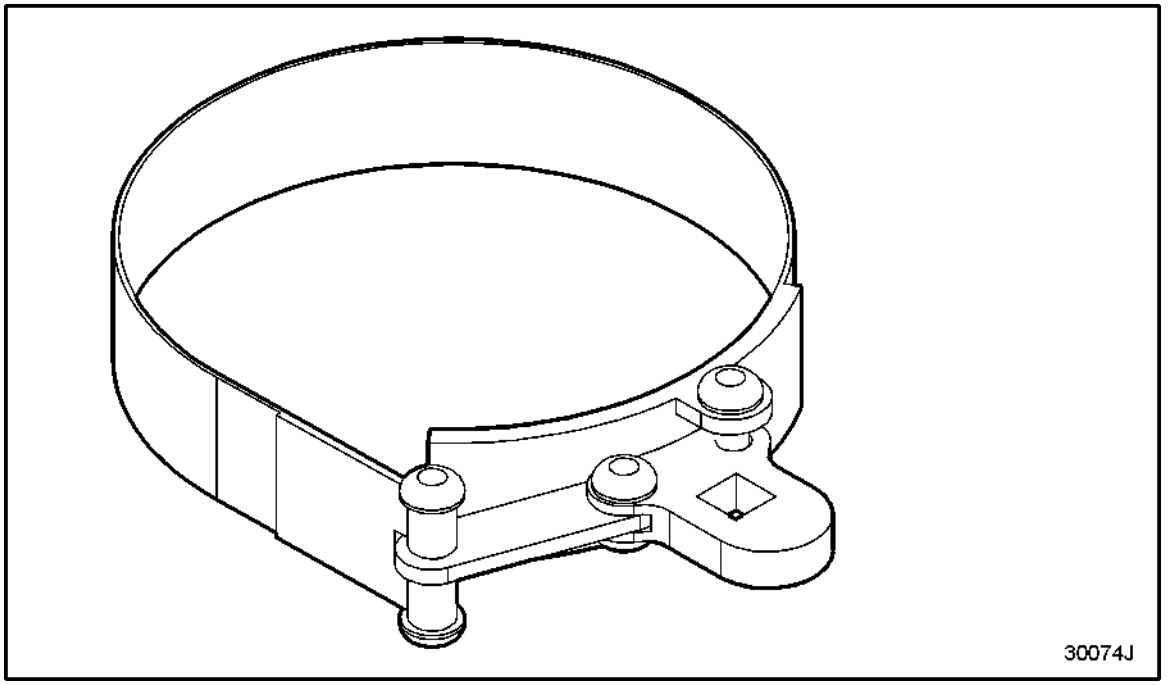
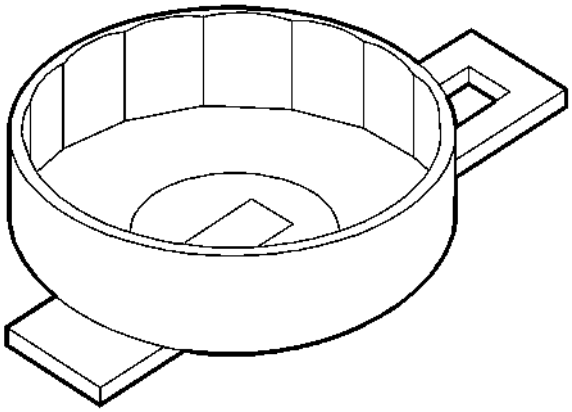


Figure 1552 Lube Oil Filter (Spin-on) Wrench, J 24783

ILLUSTRATION NOT AVAILABLE TO TIME OF PUBLICATION

35302j

Figure 1553 Oil Filter Cooler Base Tool,J 42513



21552J

Figure 1554 Oil Filter Wrench AC Large Filters,J 22775

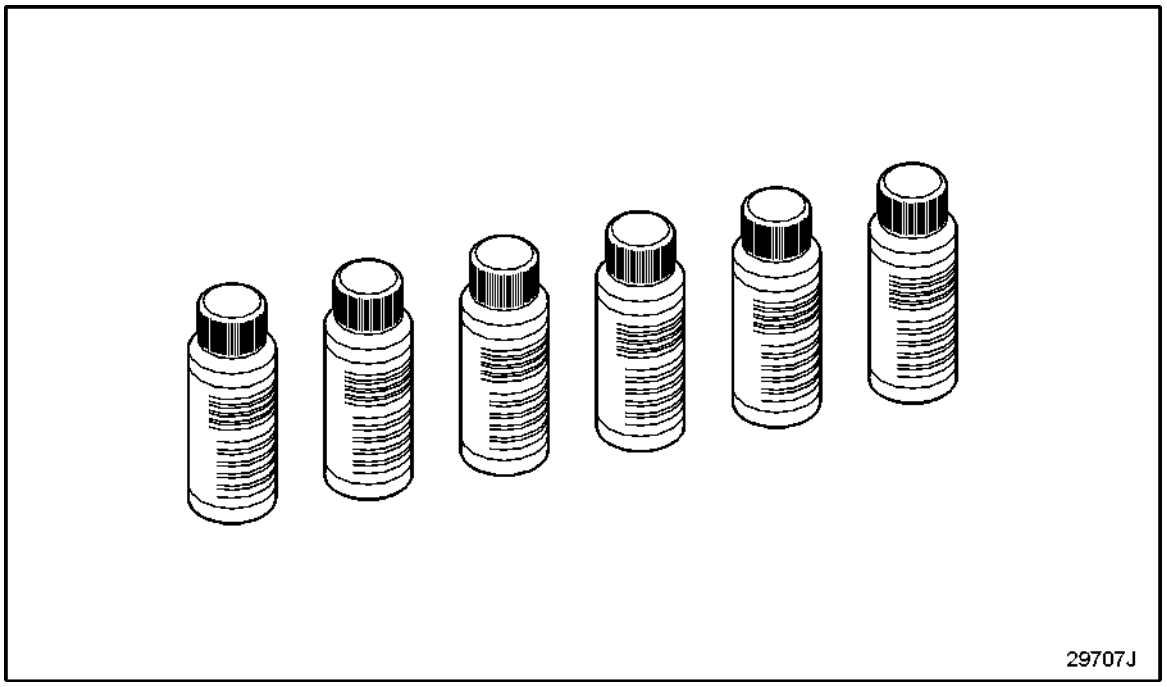


Figure 1555 Fluorescent Oil Additives (1OZ),J 28431–6

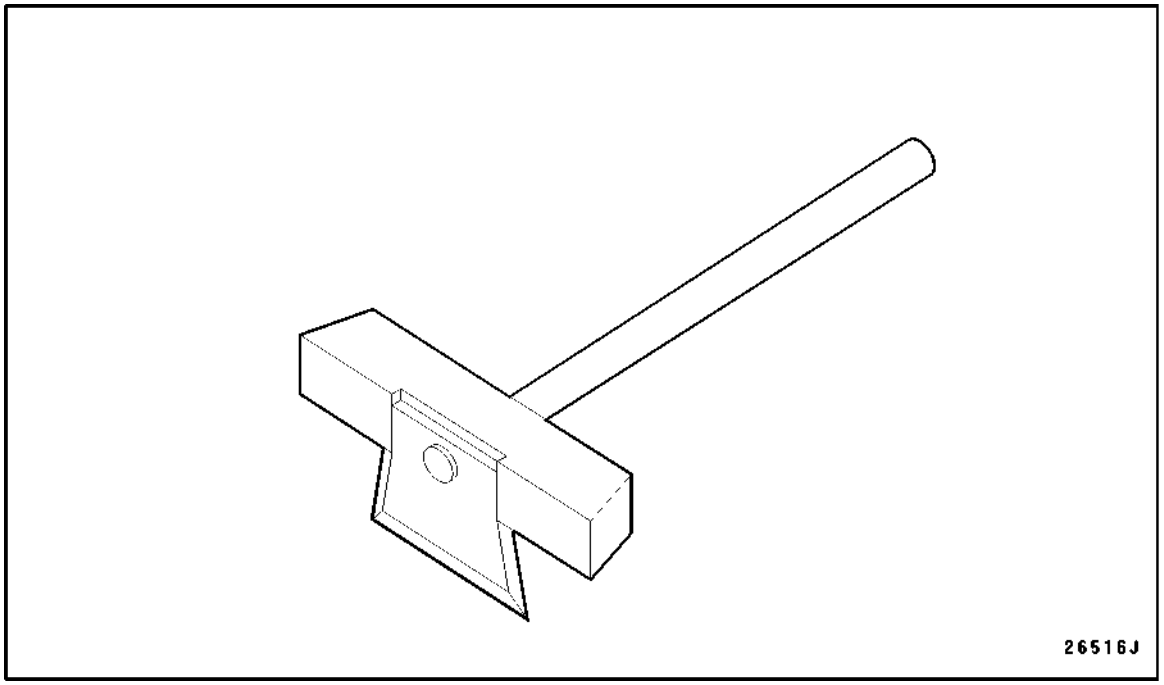


Figure 1556 Oil Pan Removal Tool,J 41423

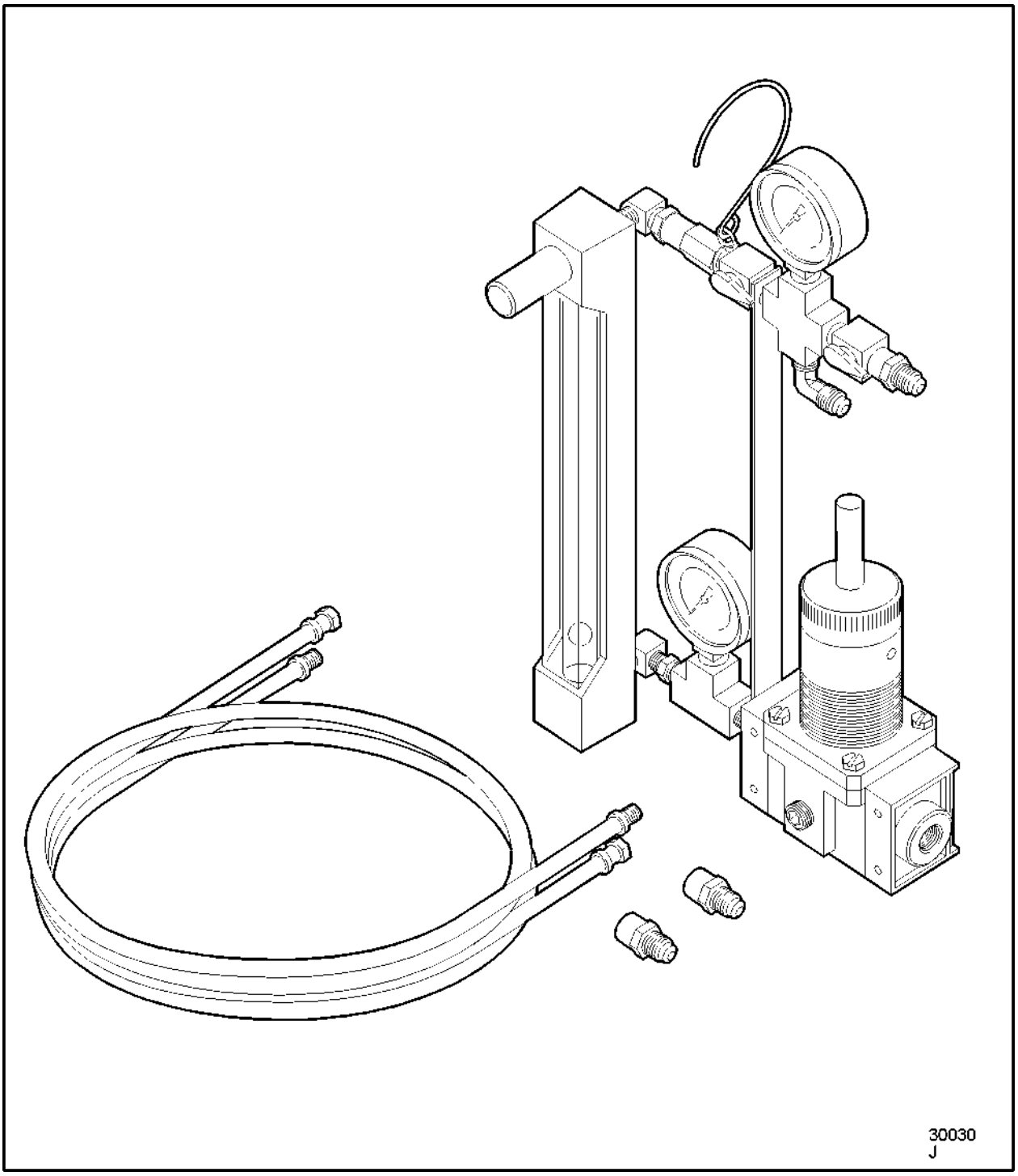


Figure 1557 Coolant Flow Checker, Air Injection, J 39944

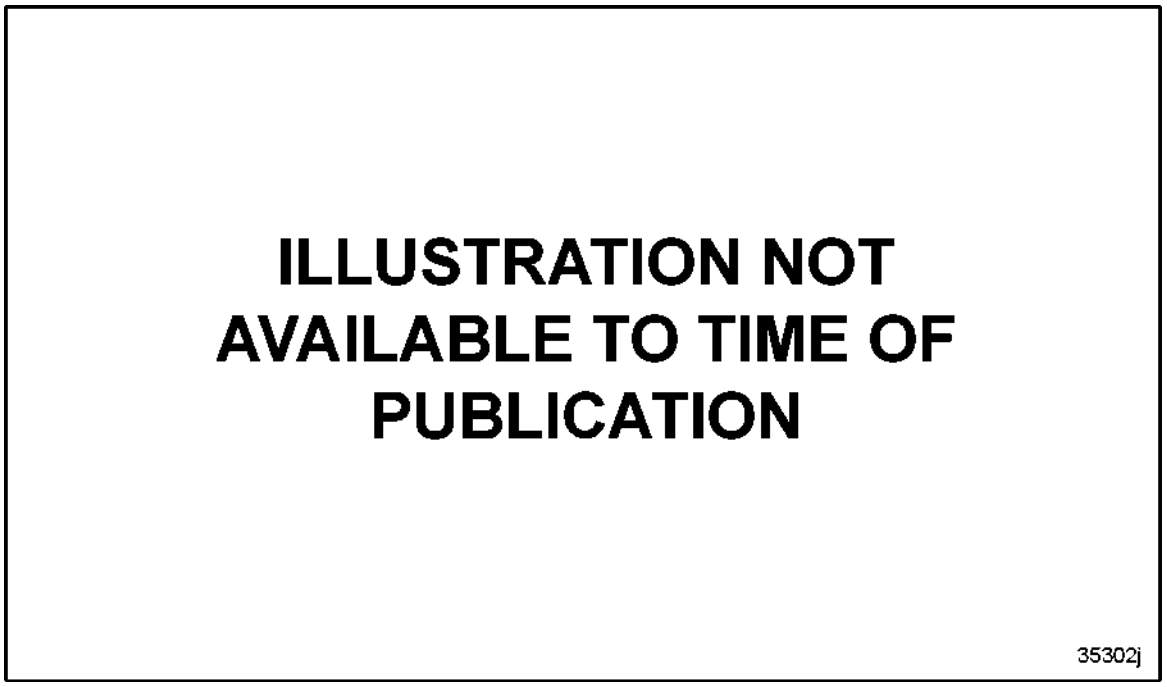


Figure 1558 Impeller Remover & Installer,J 29190–B

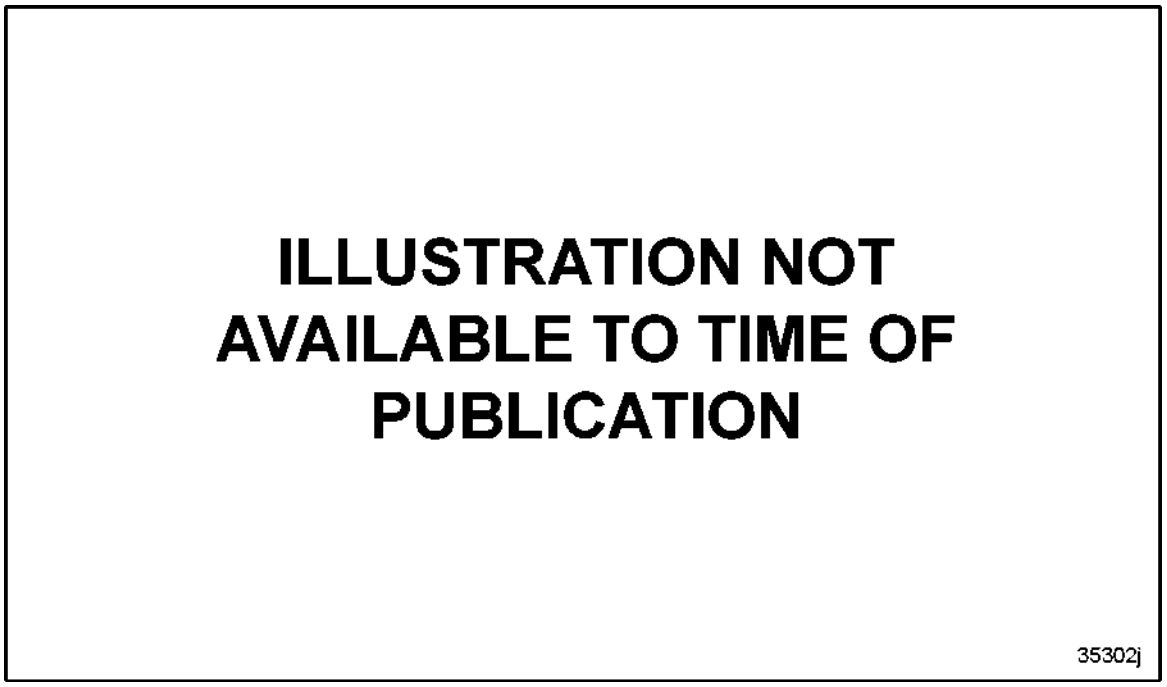


Figure 1559 Seal Installer (Unitized),J 35517–1

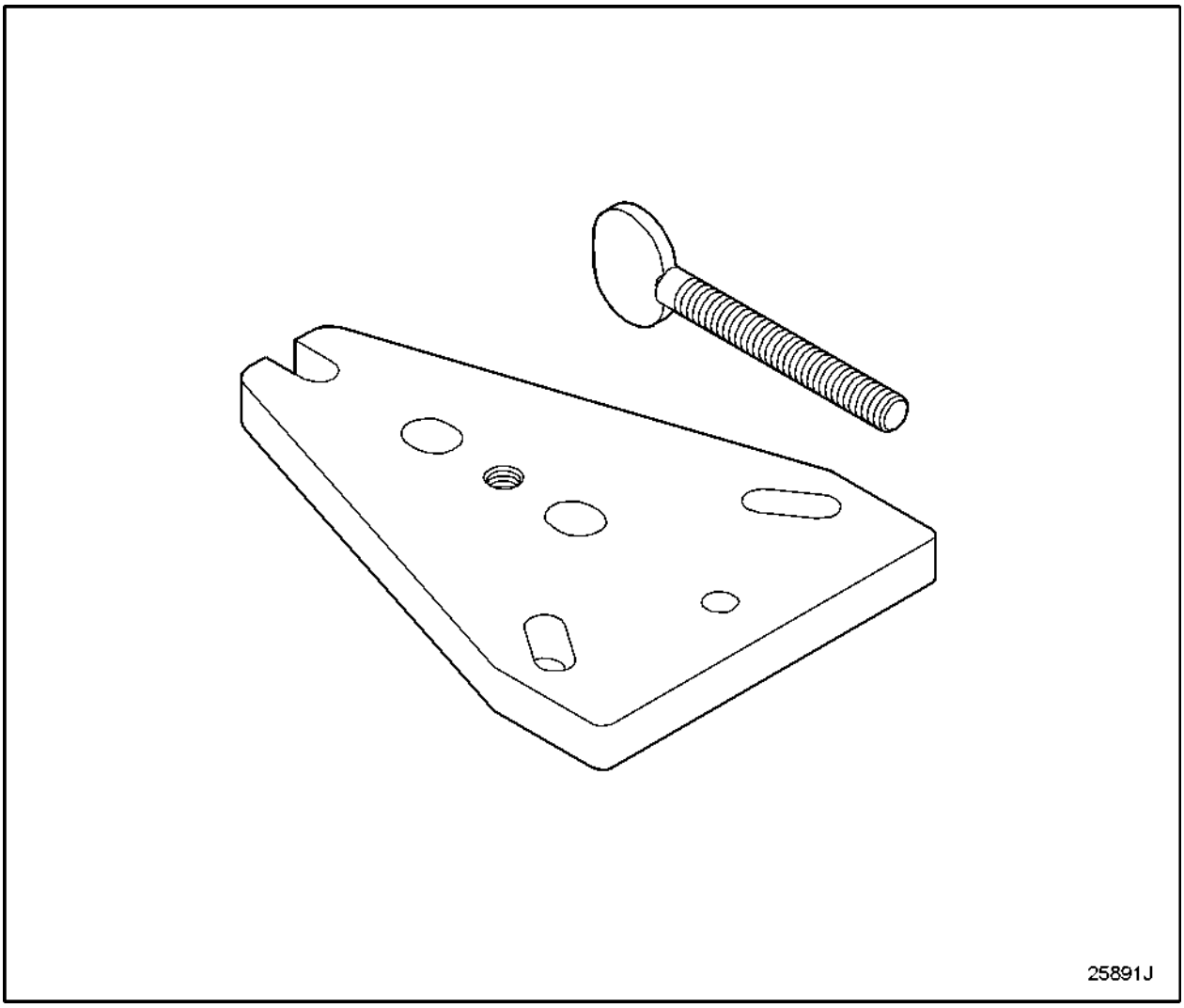


Figure 1560 Water Pump Impeller Remover,J 22143

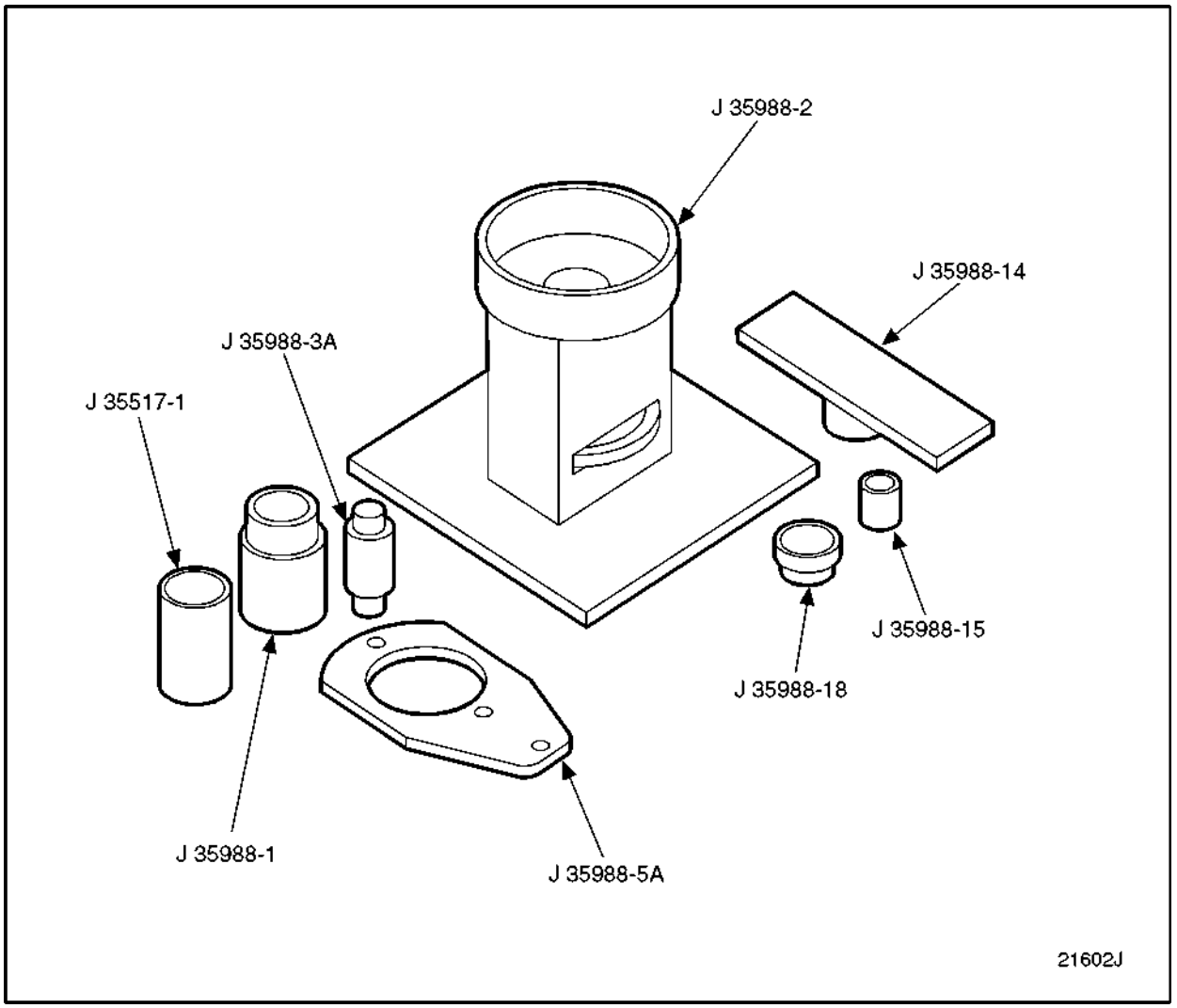


Figure 1561 Water Pump Service Set,J 35988–B

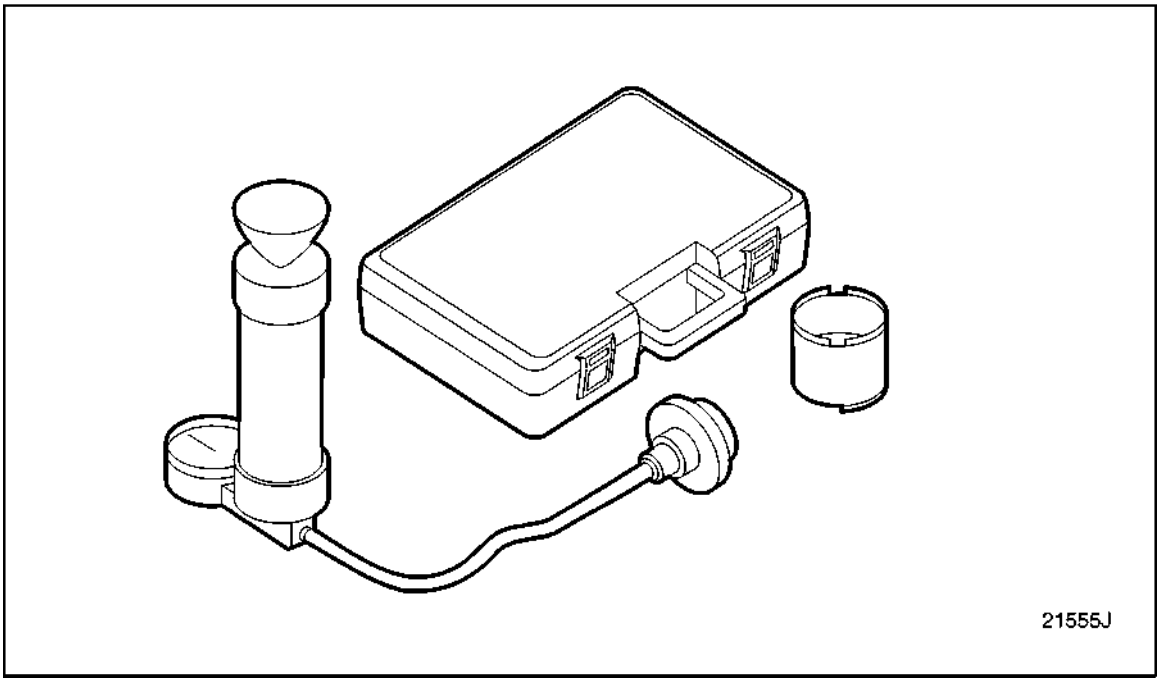


Figure 1562 Cooling System Pressure Tester,J 24460–01

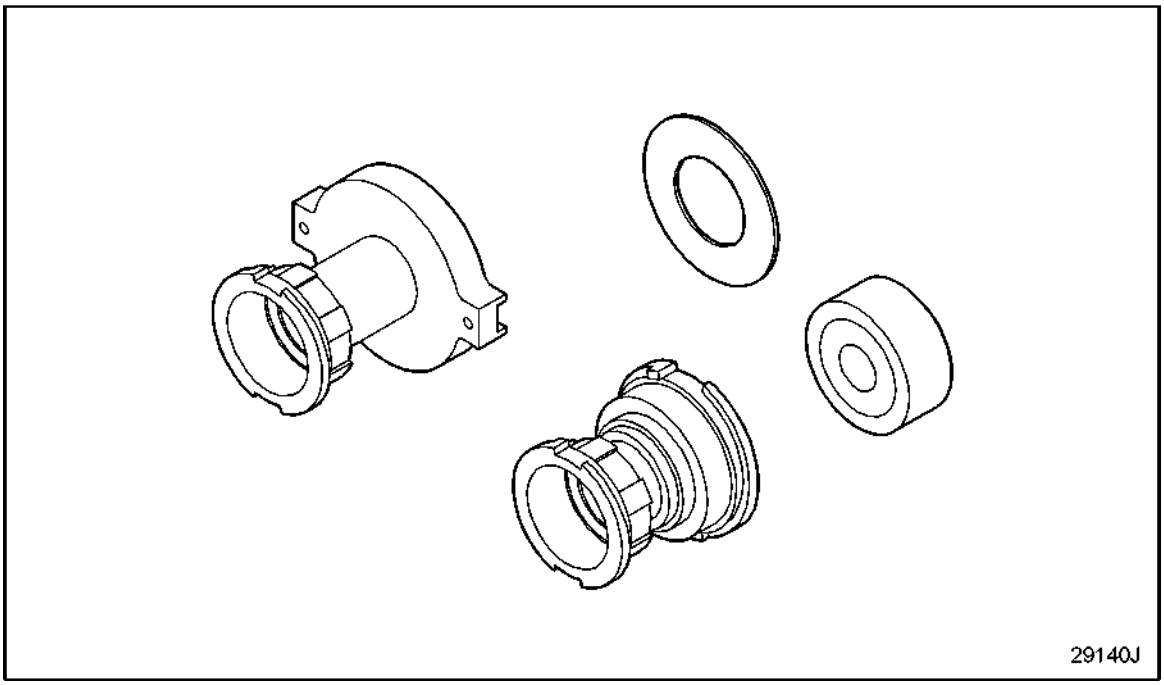


Figure 1563 Radiator Pressure Tester ADPT,J 29003–A

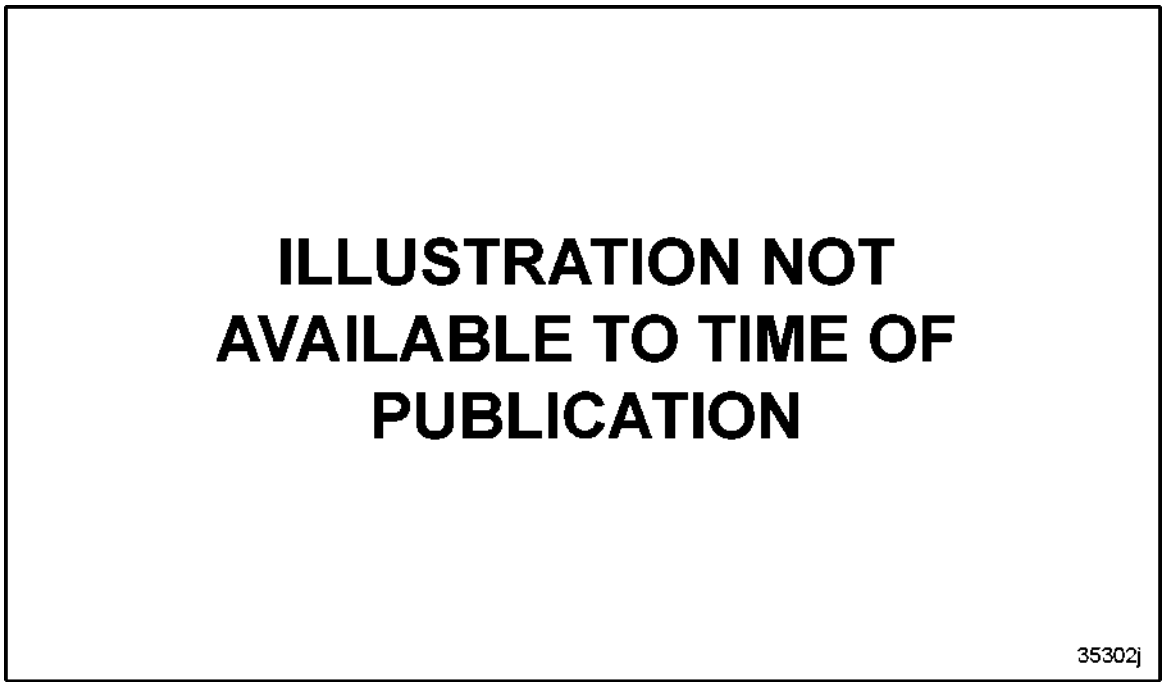


Figure 1564 Diesel Fuel Hydrometer,J 34352

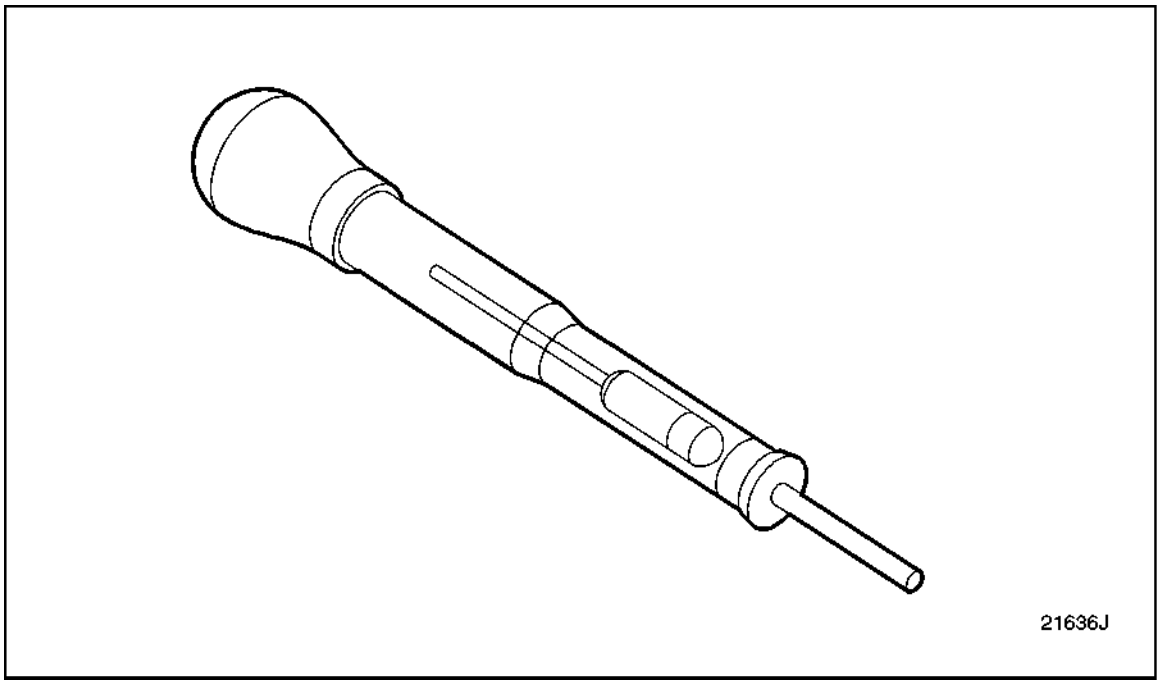


Figure 1565 Diesel Fuel Quality TSTR-Hydrometer,J 38641–A

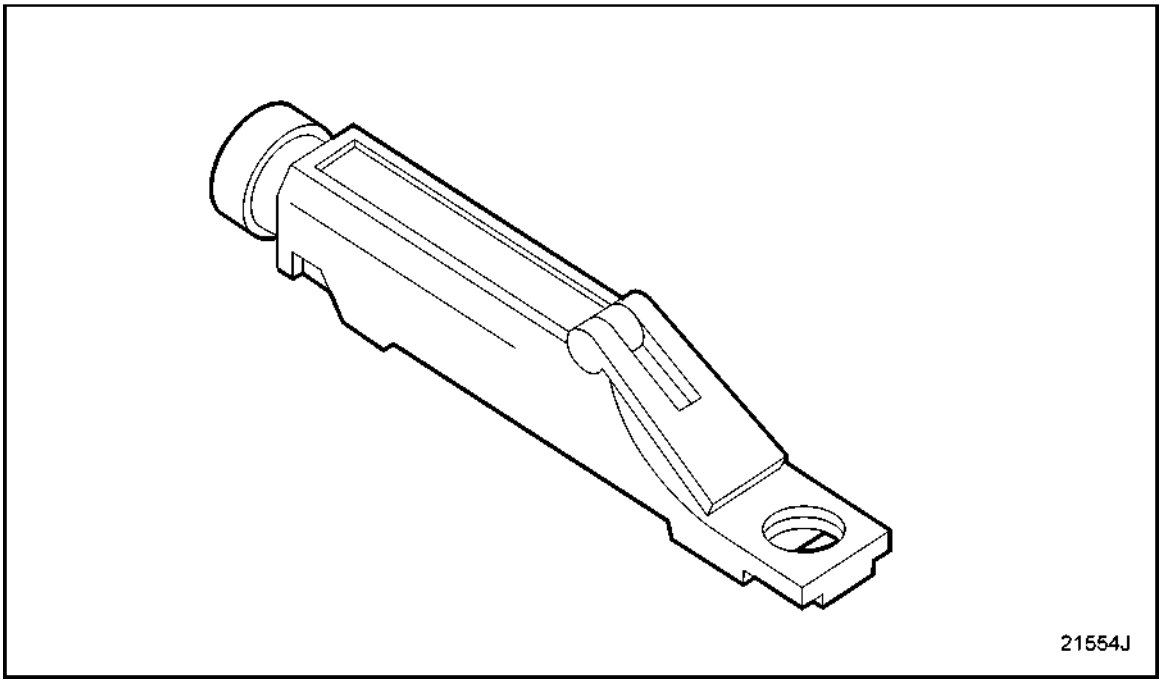


Figure 1566 Eng Coolant & Batt Fluid Tester,J 23688

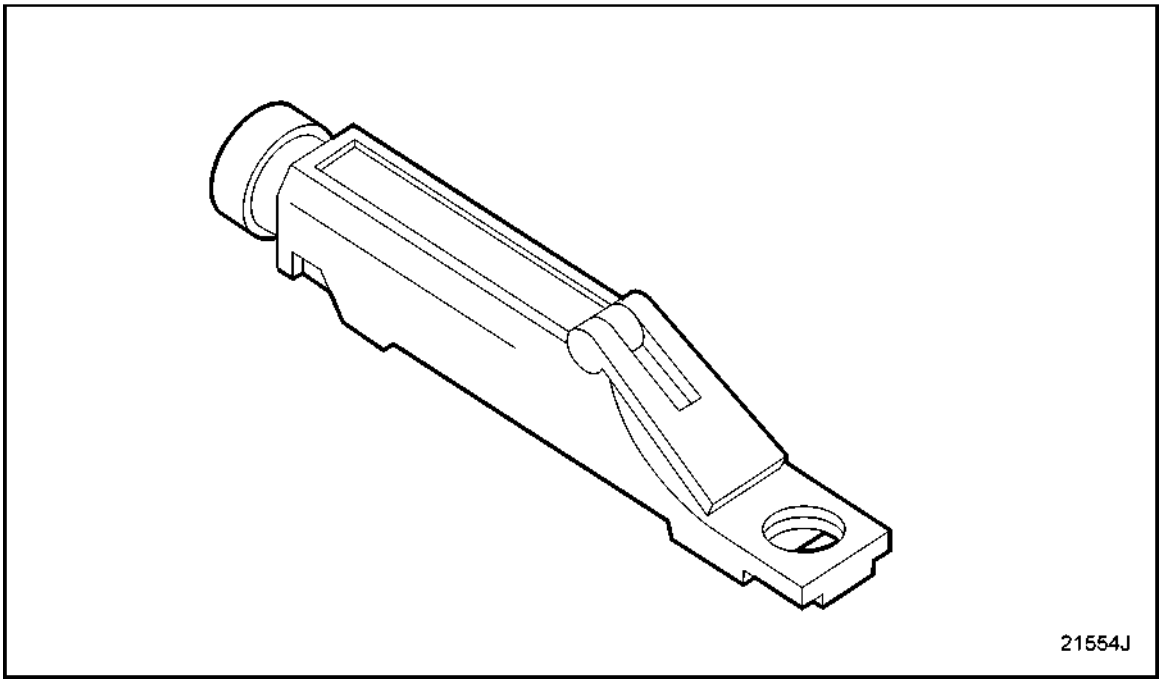


Figure 1567 Eng Coolant & Batt Fluid Tester,J 26568

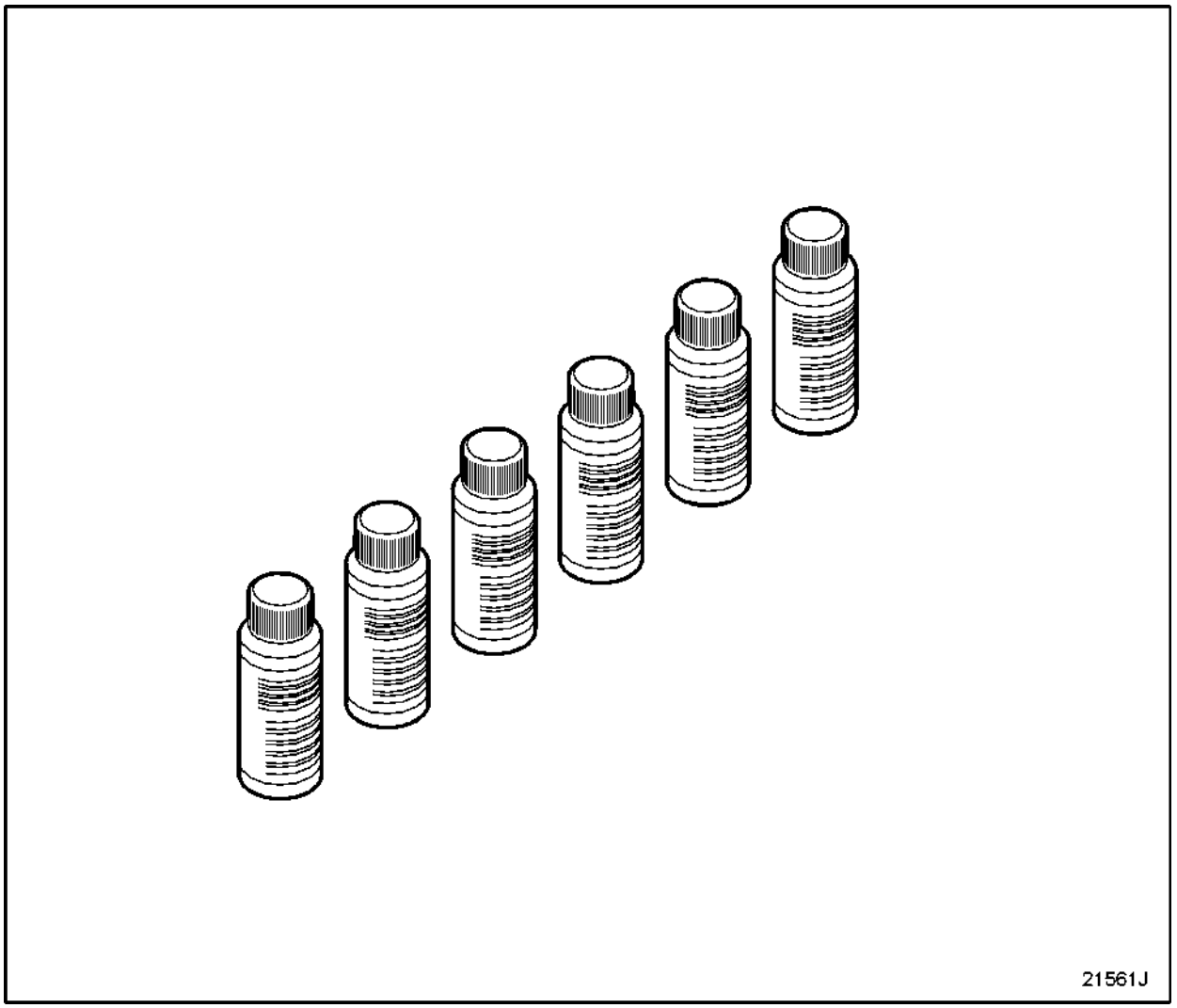


Figure 1568 Fluorescent Coolant Dye 24-1OZ,J 29545

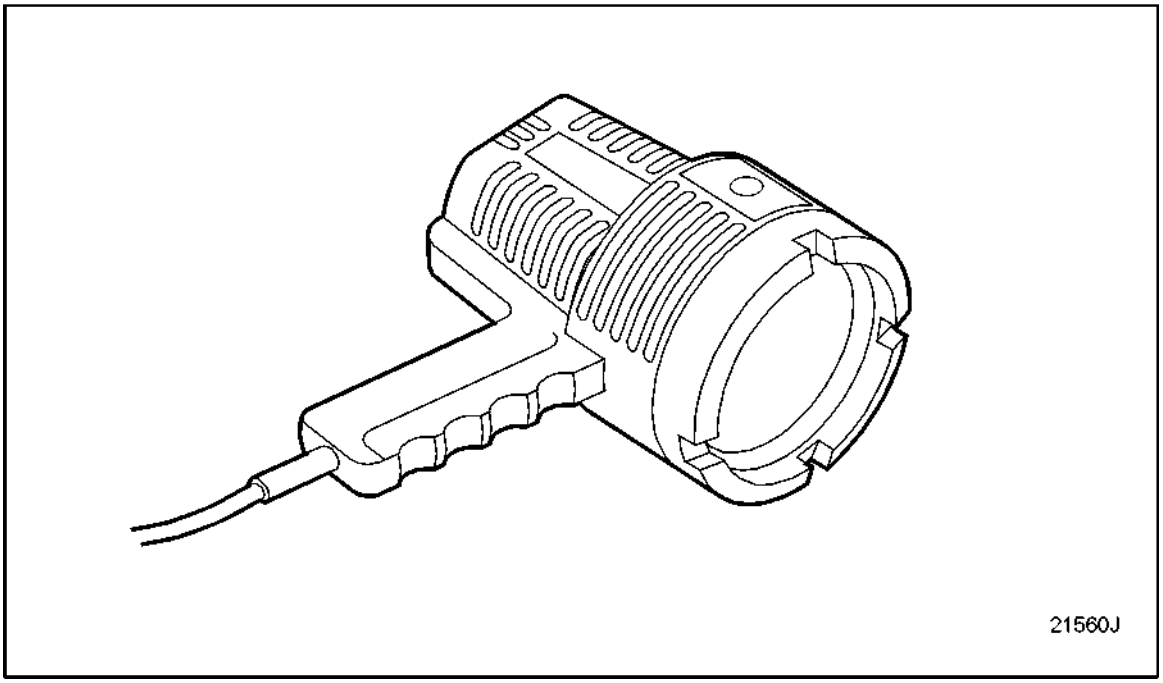


Figure 1569 High Intensity Black Light Kit,J 28428–E

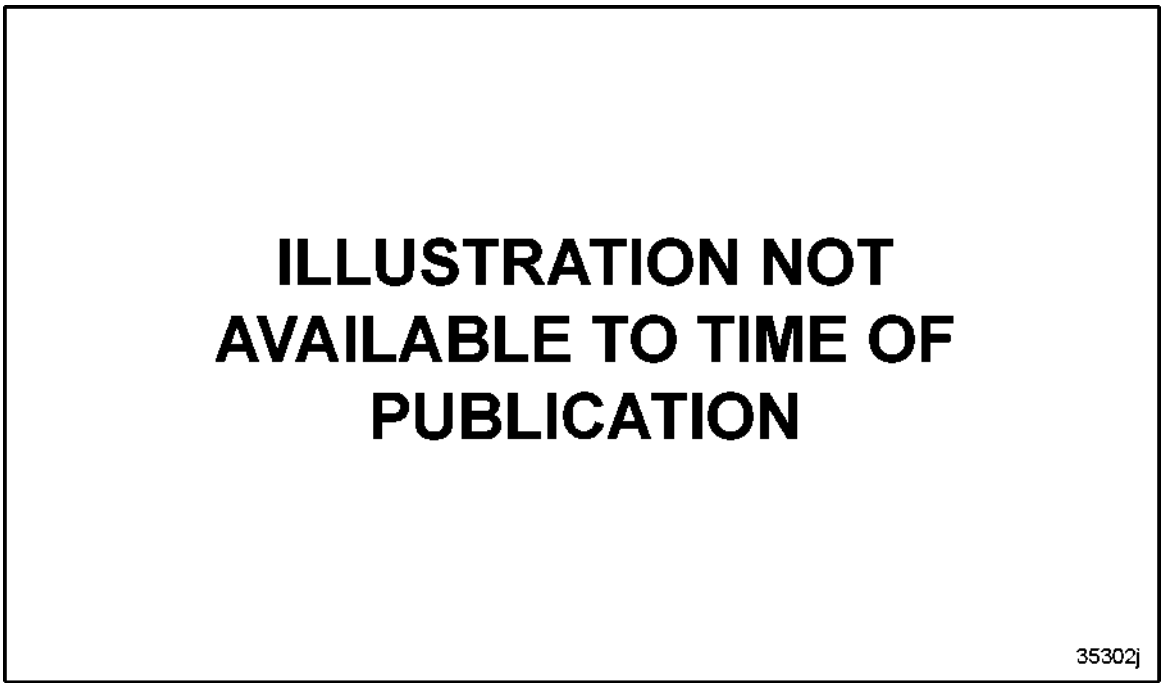


Figure 1570 Engine Pre-Luber,J 39258

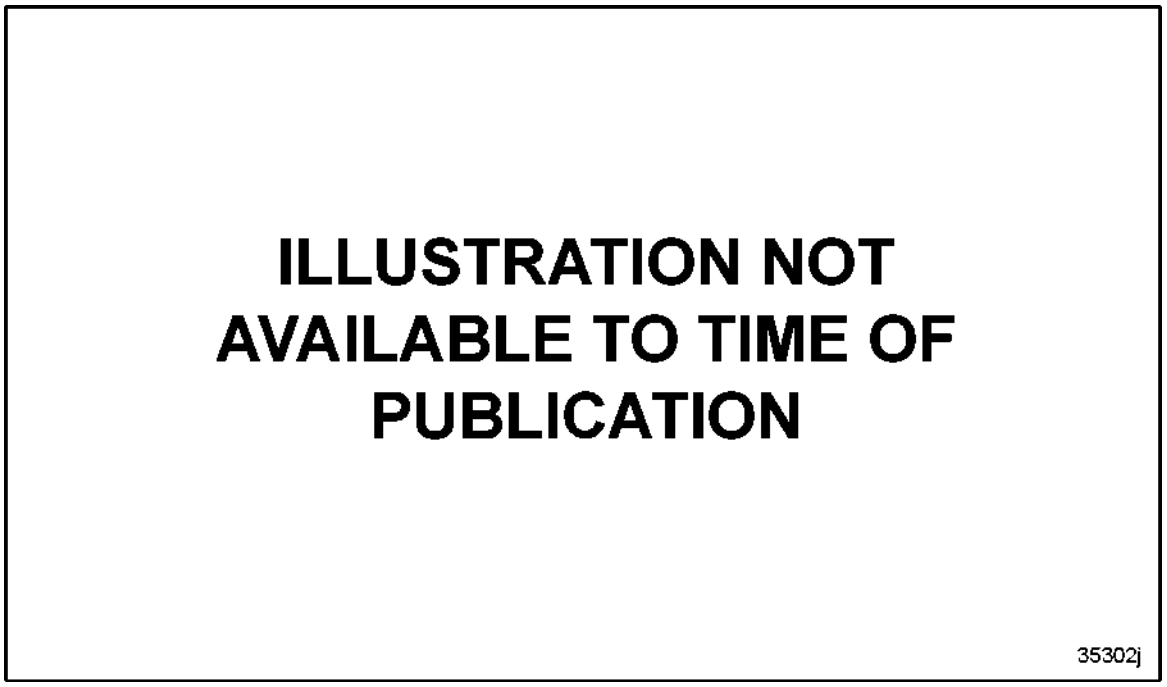


Figure 1571 Fluorescent Oil Dye 24-1OZ,J 28431–B

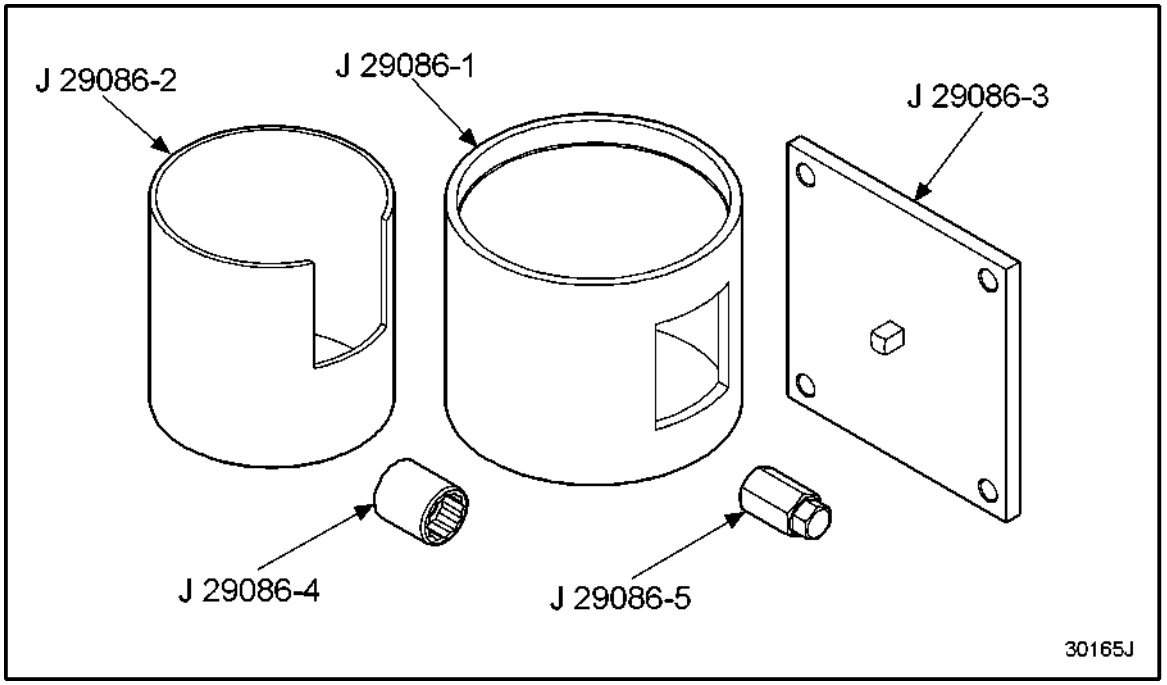


Figure 1572 Support Fixture,J 29086

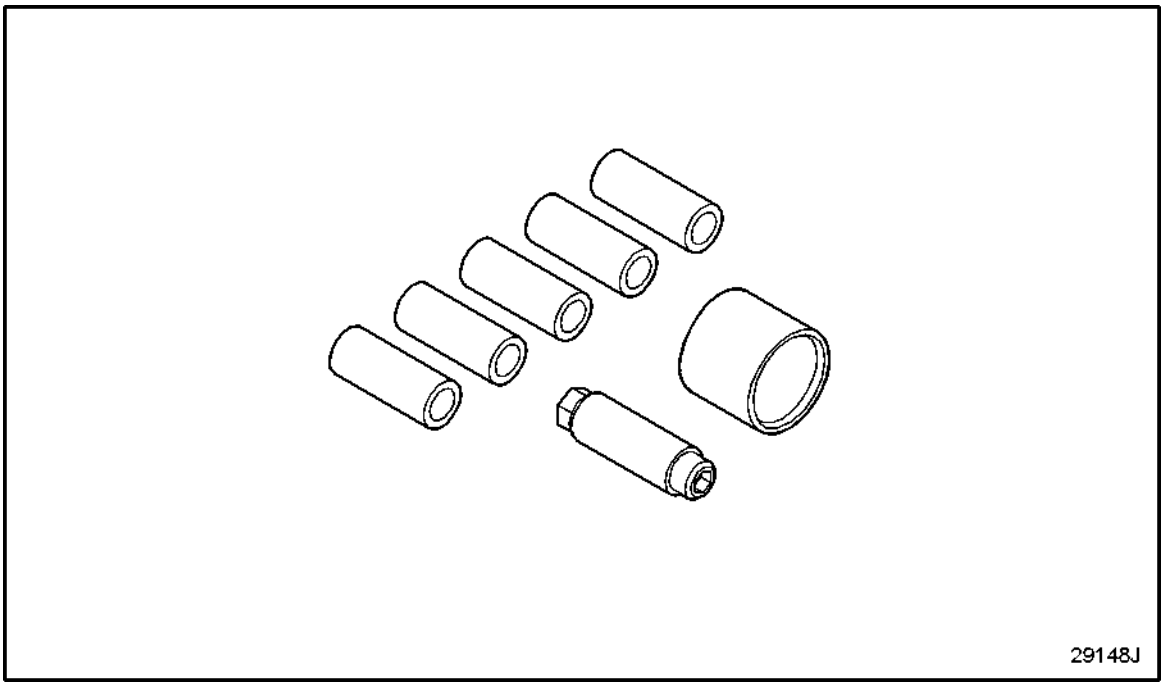


Figure 1573 Thrust Spacer Plug & Sleeve INSTJ 29090

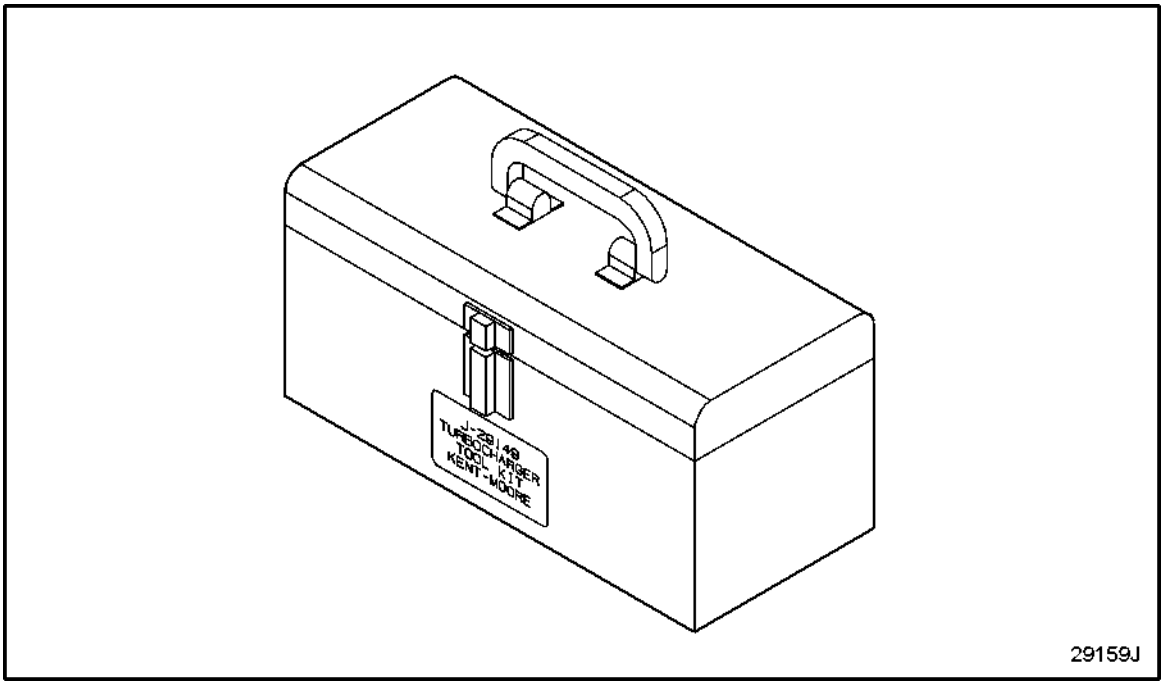


Figure 1574 Tool Box,J 29149–1

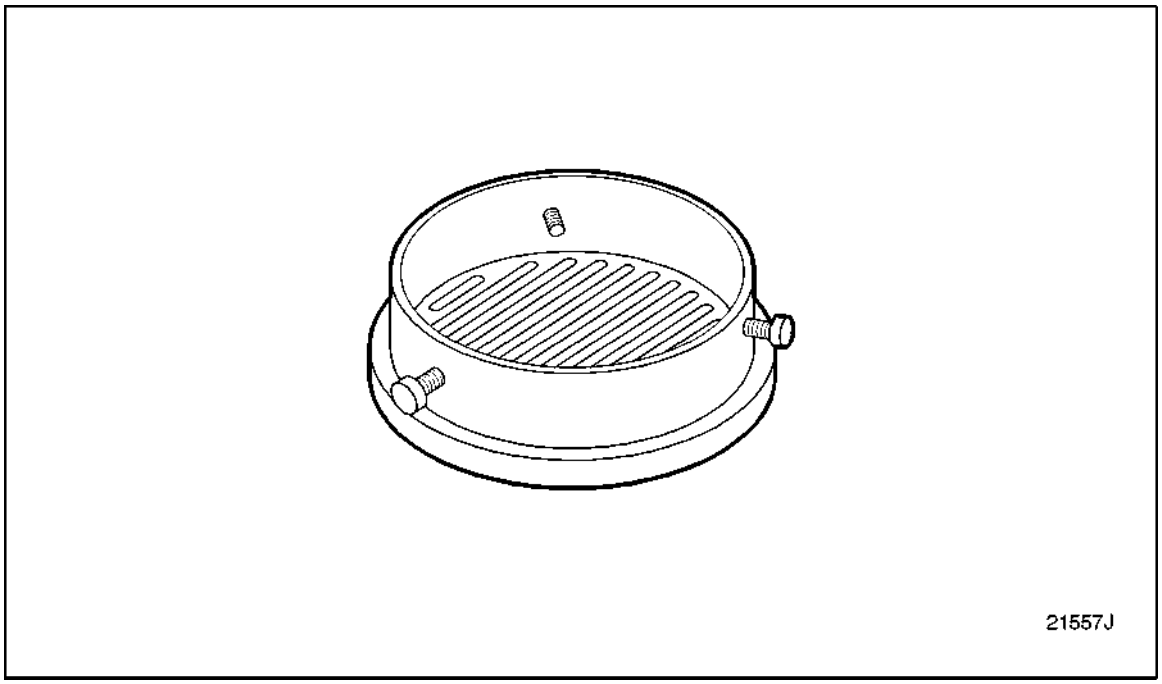


Figure 1575 Turbo Inlet (Compress) Shield, J 26554–A

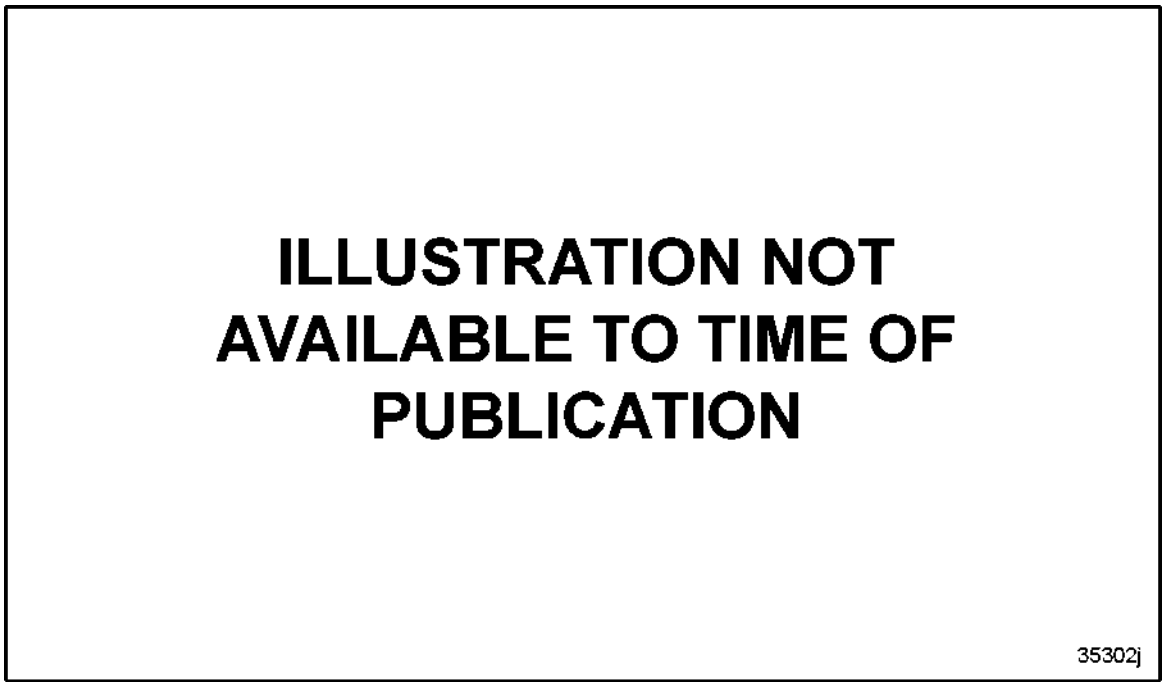


Figure 1576 Turbo Shaft Check, J 29089–A

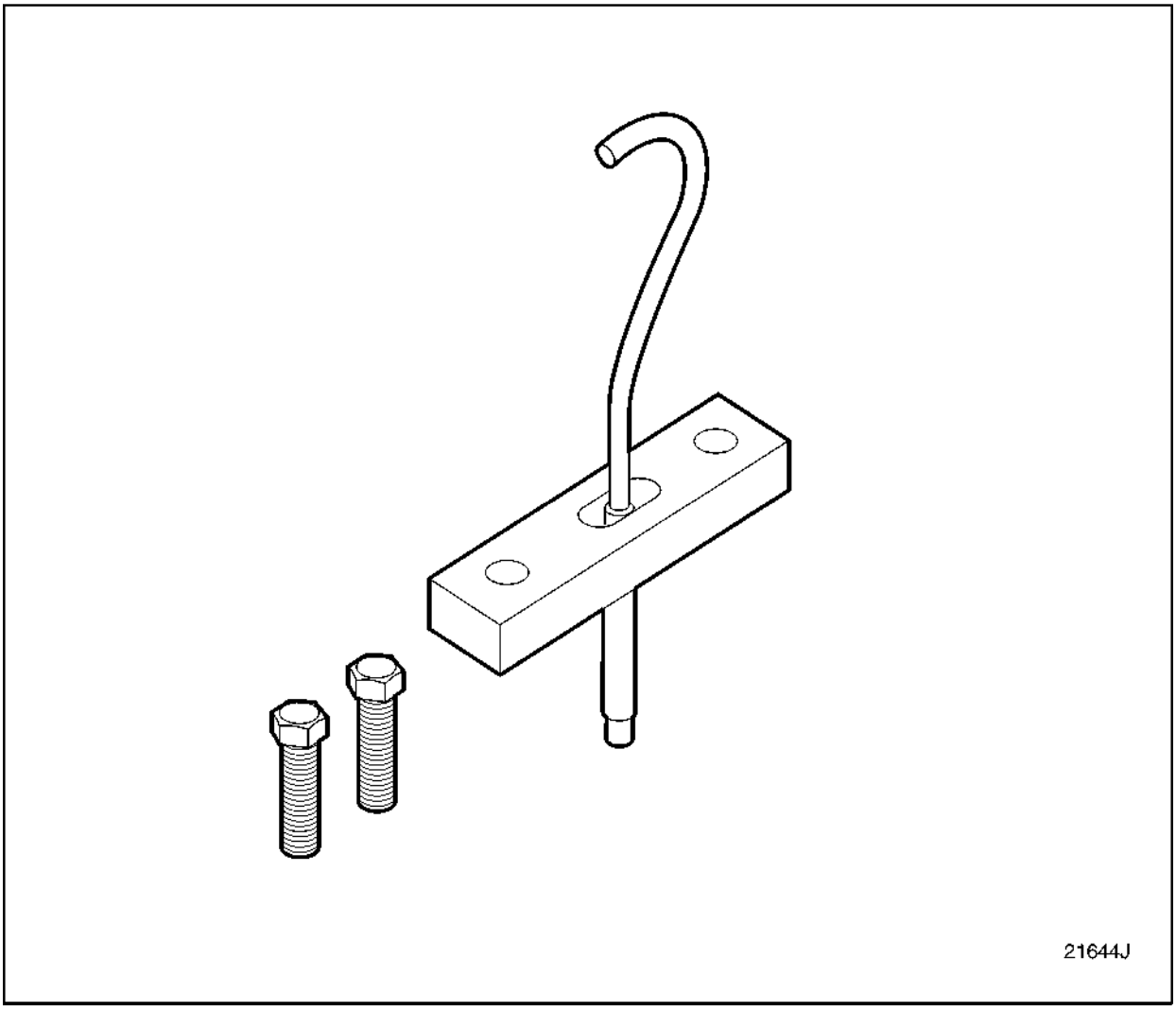


Figure 1577 Turbo Shaft Checker ,J 39164

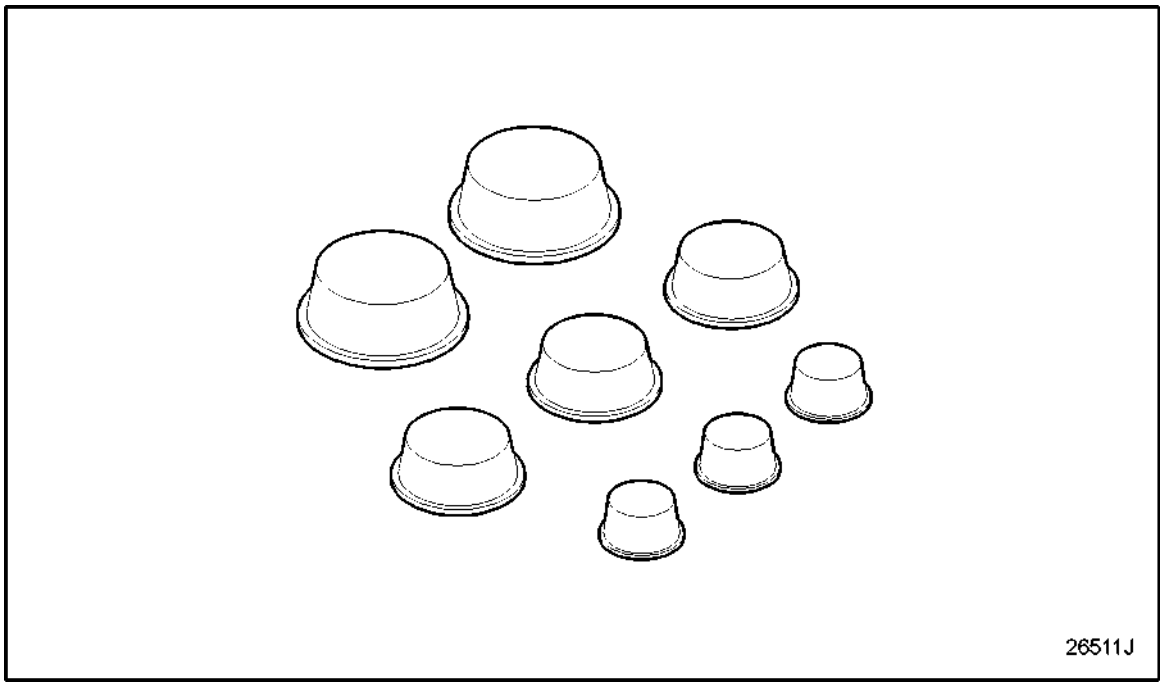


Figure 1578 Turbocharger Inlet Cap, J 41813

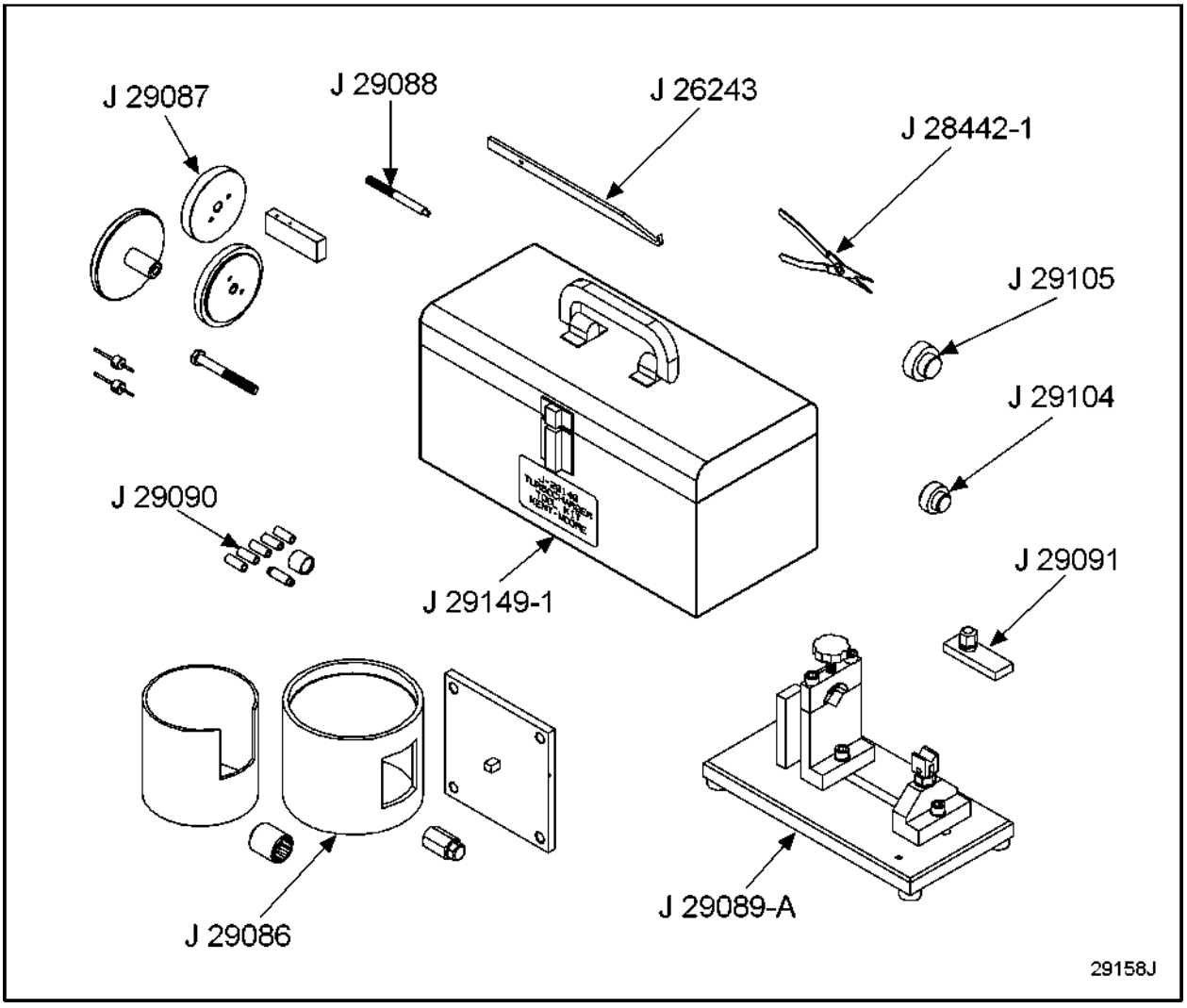


Figure 1579 Turbocharger Tool Kit,J 29149

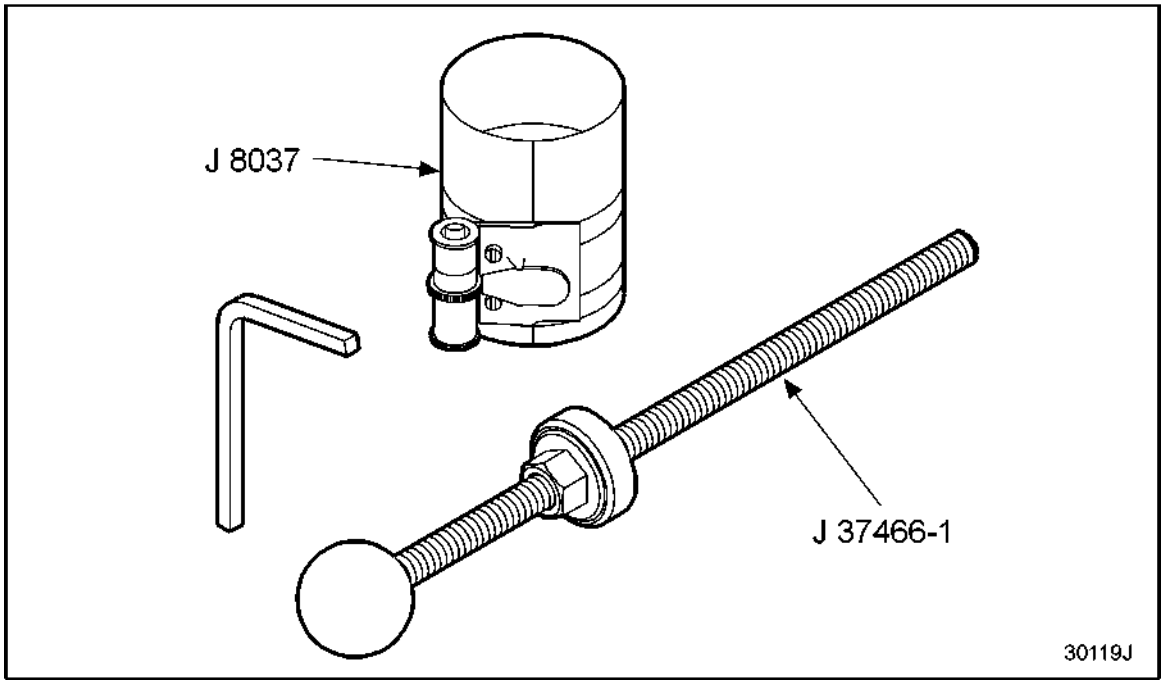


Figure 1580 By-Pass Valve Service Kit ,J 37466

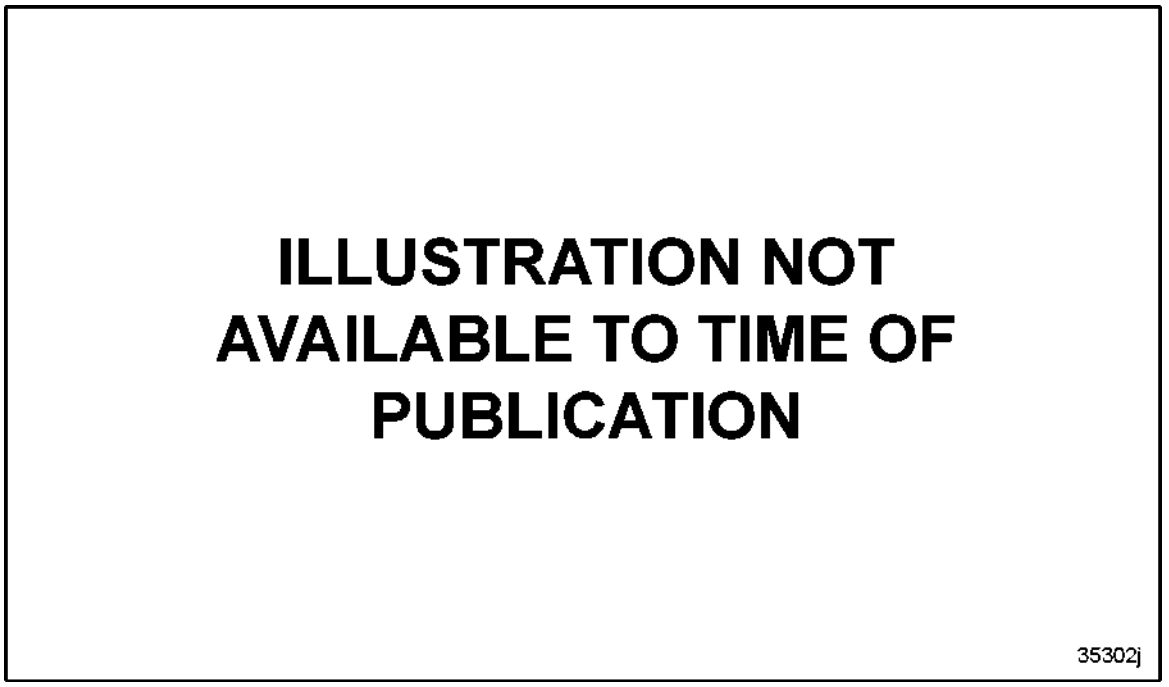


Figure 1581 Charged Air Cooler Tester,J 41473

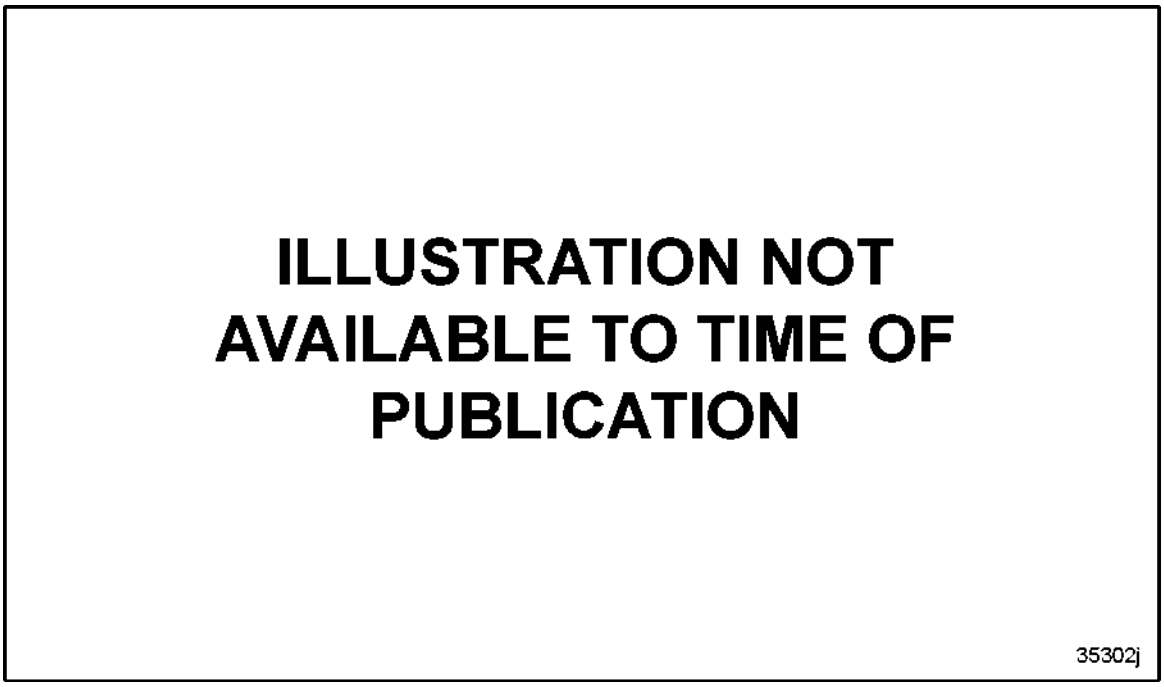


Figure 1582 Double Lip Seal (OS) & Wear Instal, J 35787–A

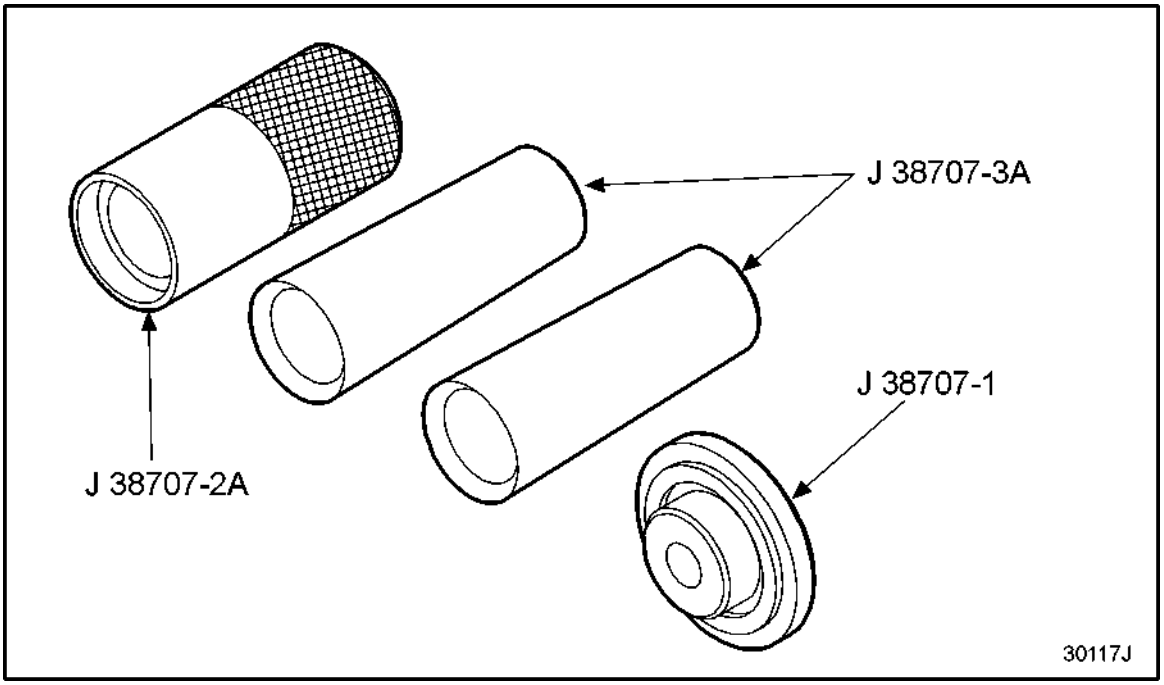


Figure 1583 Double Lip Seal (OS) & Wear SL, Instal J 38707–A

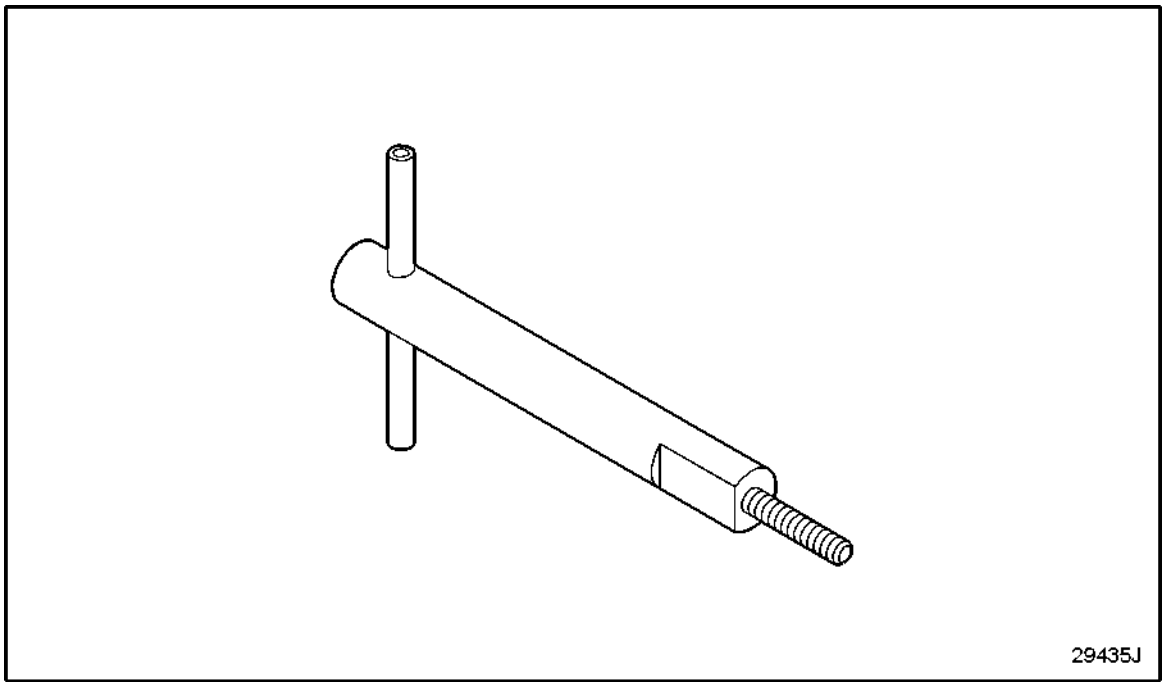


Figure 1584 Drive Shaft Alignment Tool,J 33001

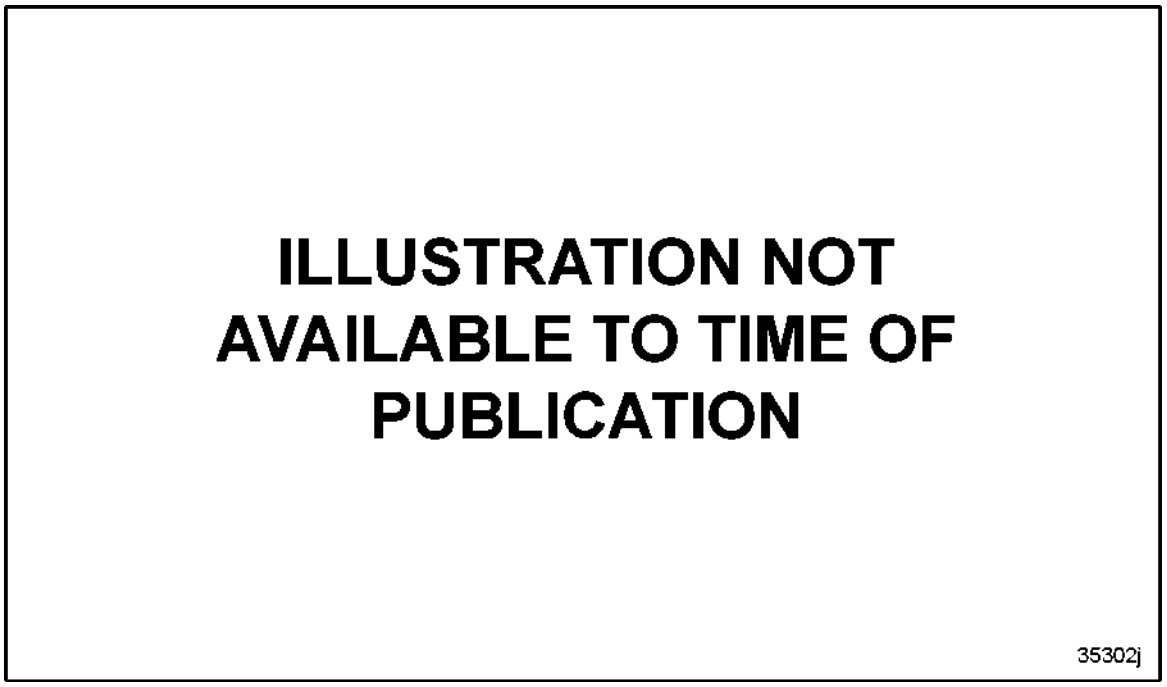


Figure 1585 Drive Alignment Set,J 21843–01

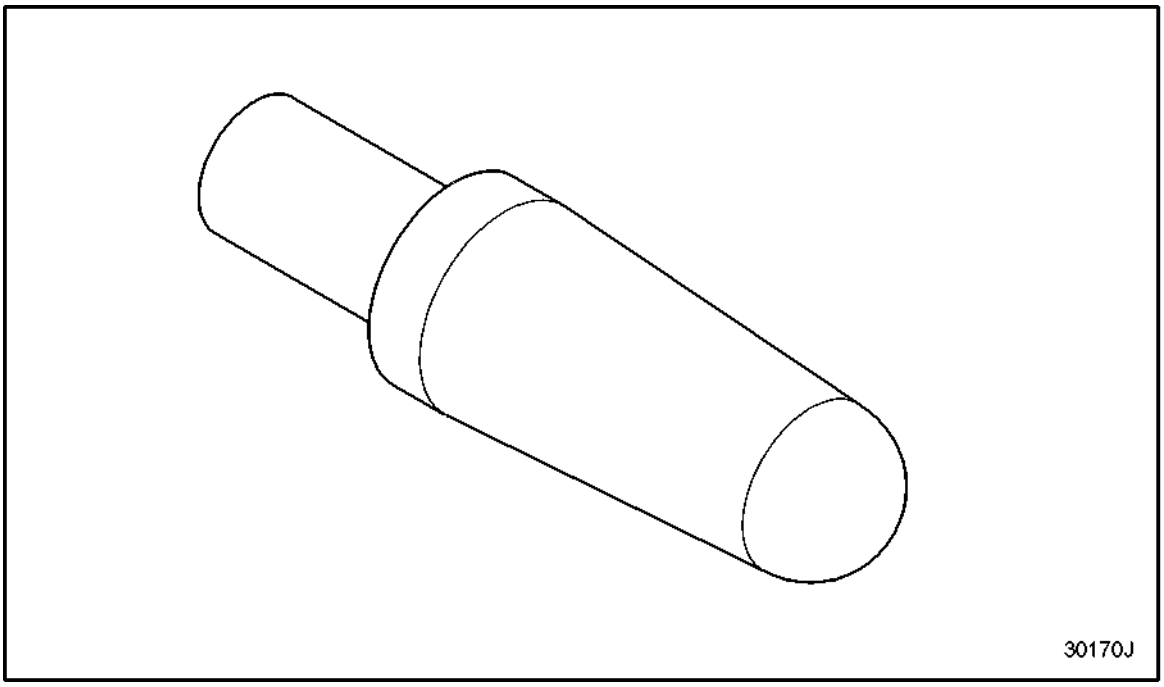


Figure 1586 Drive Cam Installer,J 1471

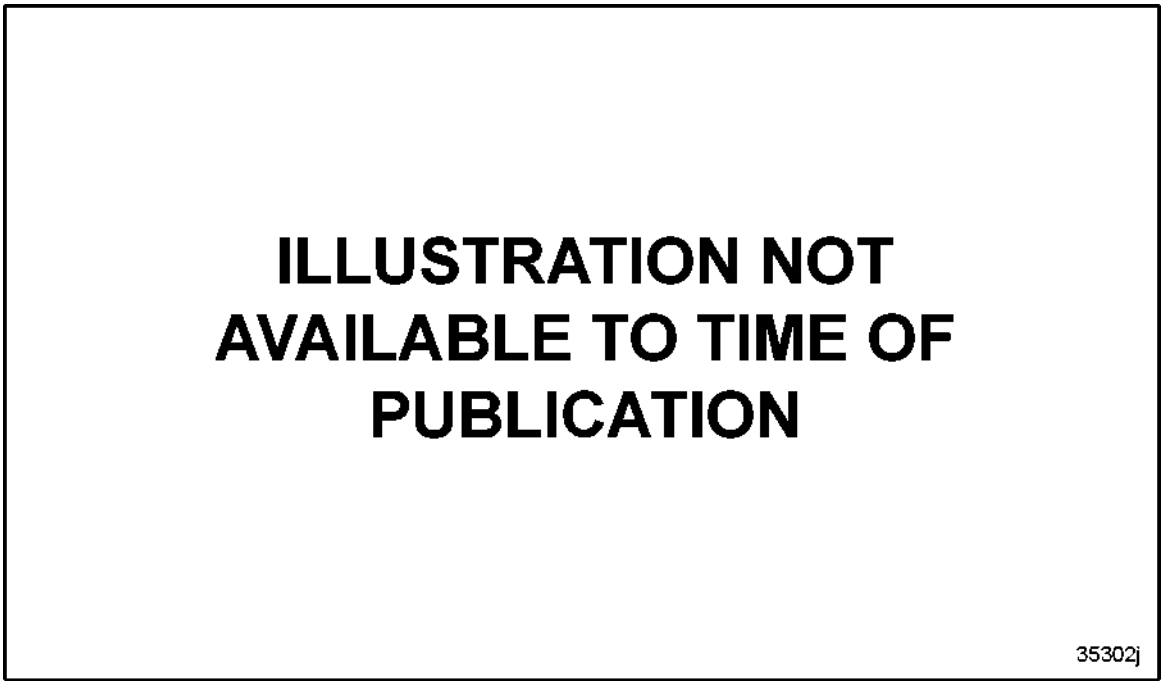


Figure 1587 Drive Cam Installer,J 5209

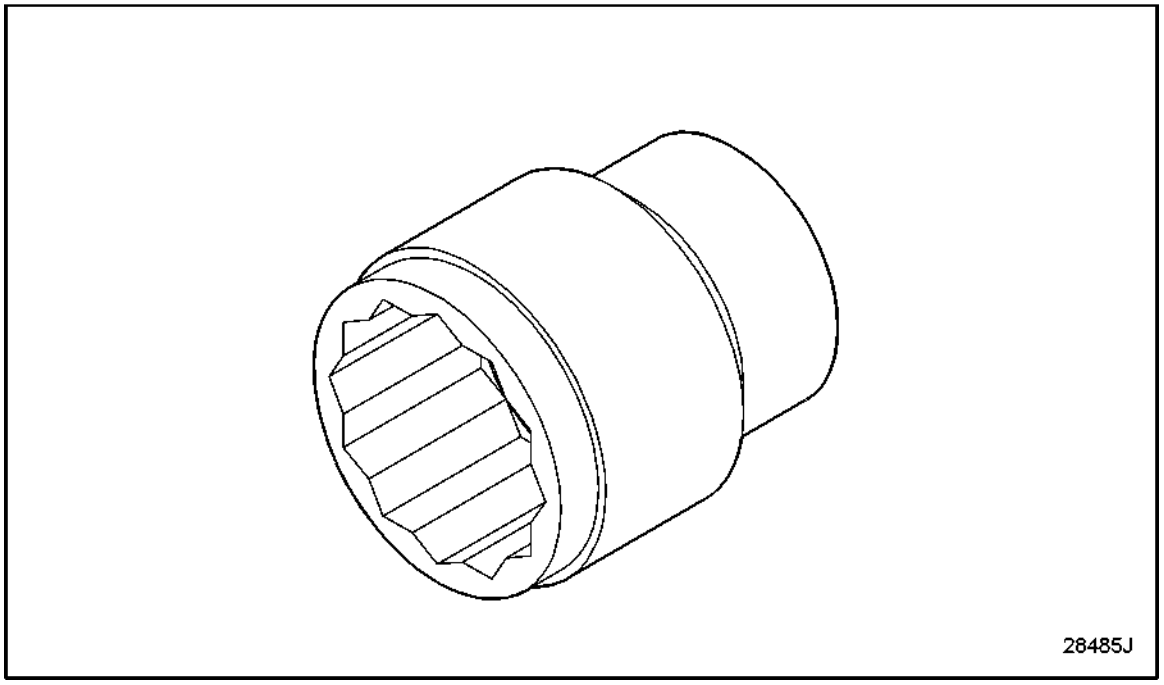


Figure 1588 Drive Gear Hub Socket,J 23641

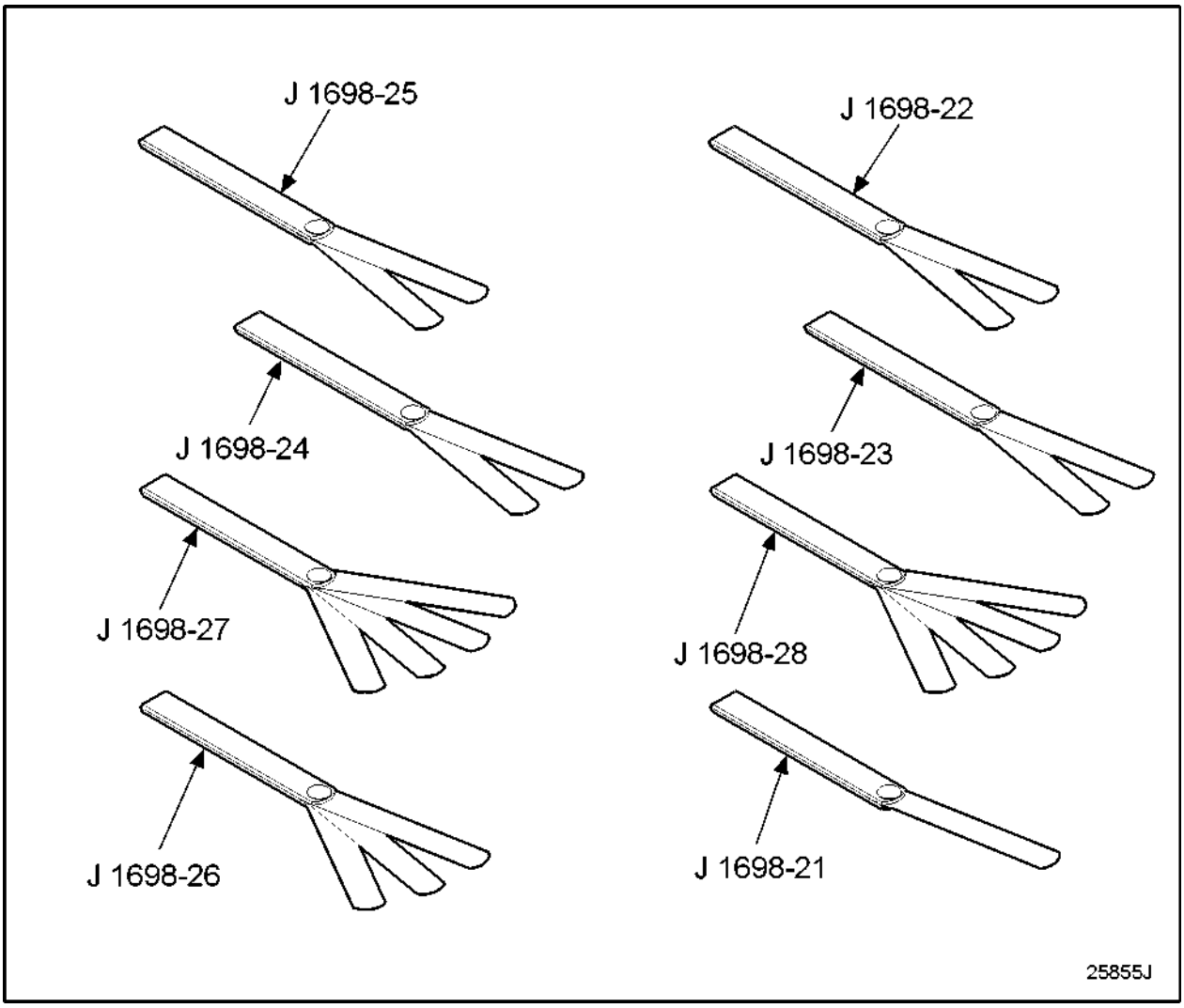


Figure 1589 Rotor Clearance Feeler Gage Set,J 1698–02

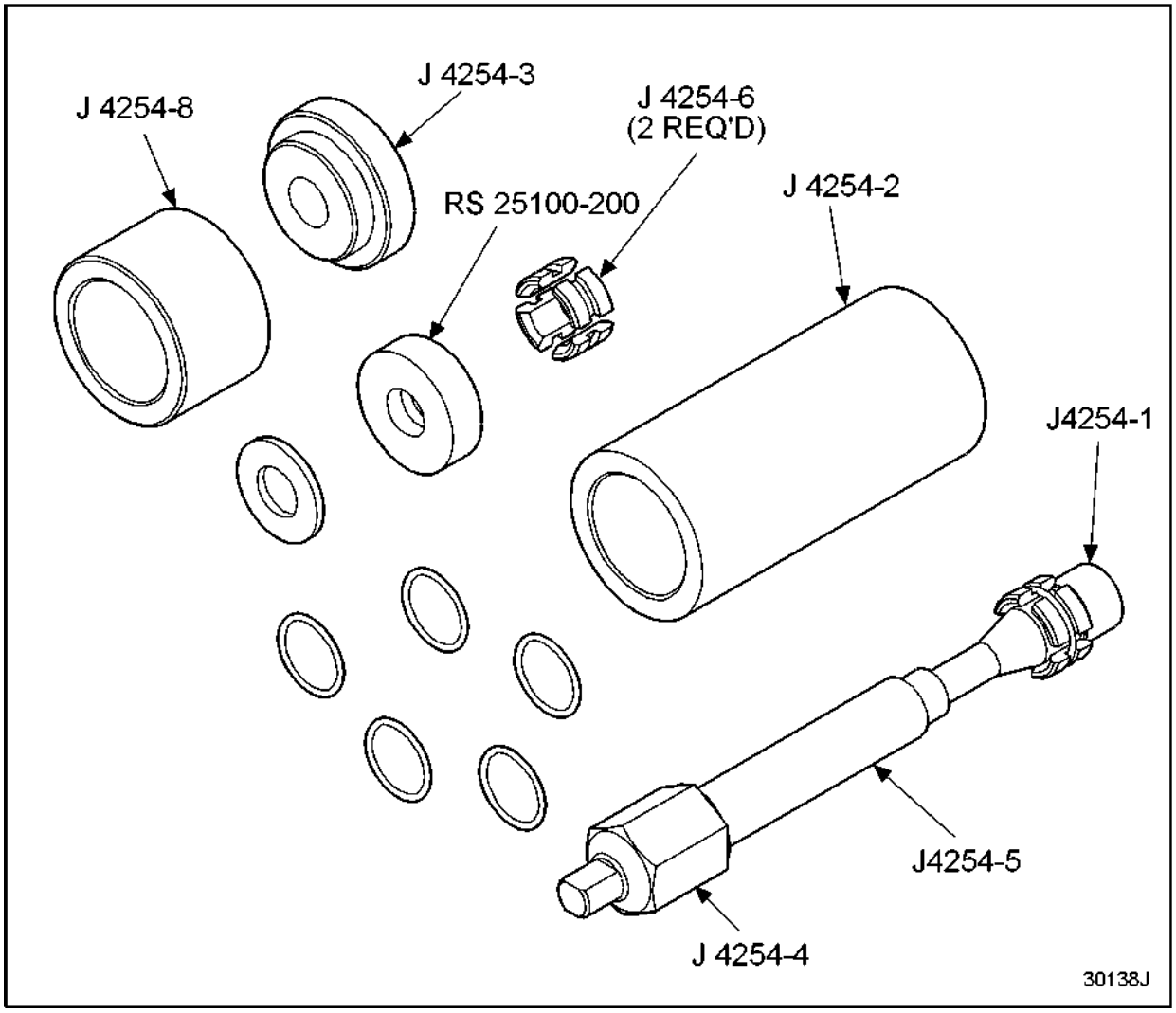


Figure 1590 Rotor SHFT REM/INST Set (3,4,6-71)J 4254

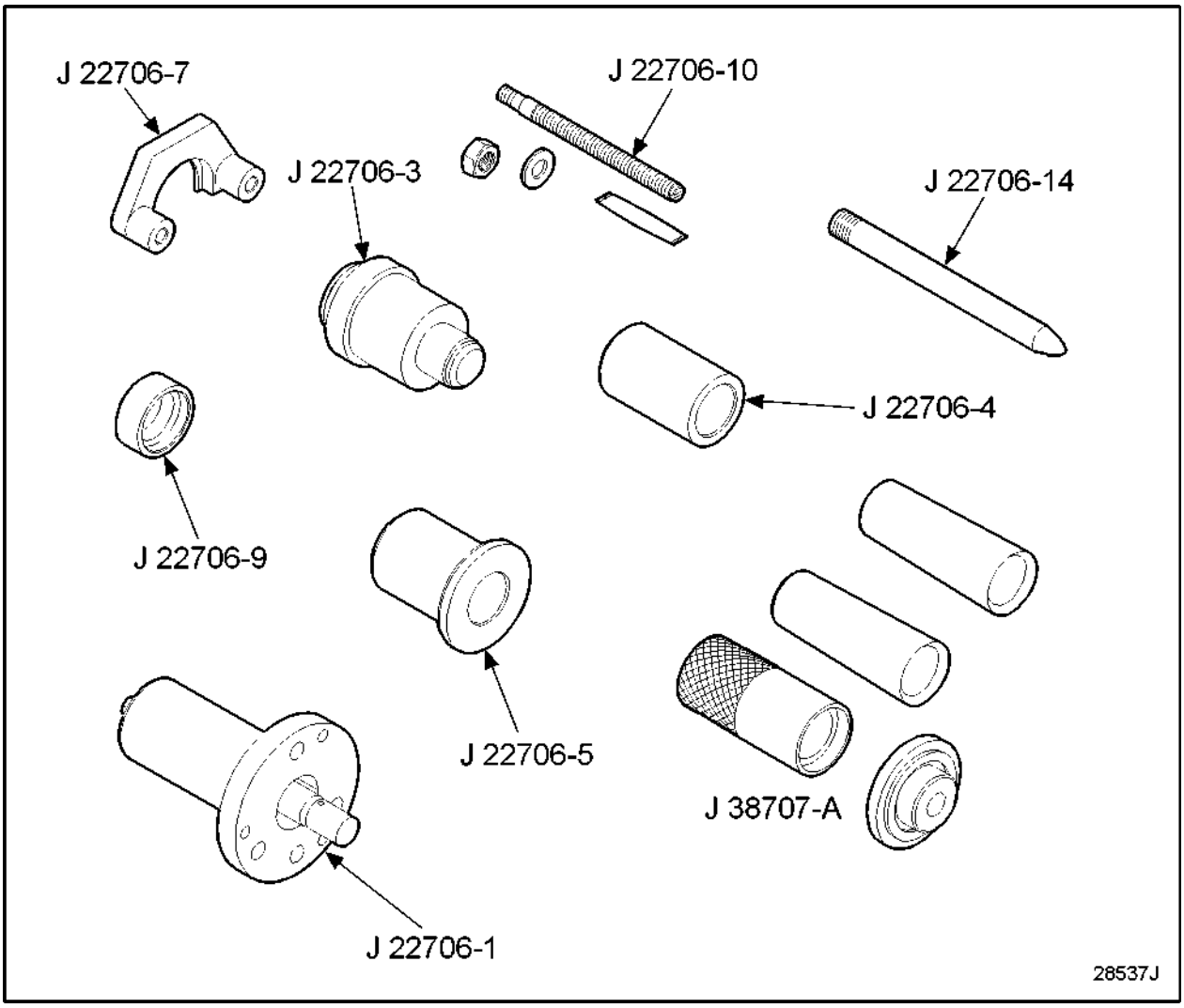


Figure 1591 Service Tool Set,J 22706–C

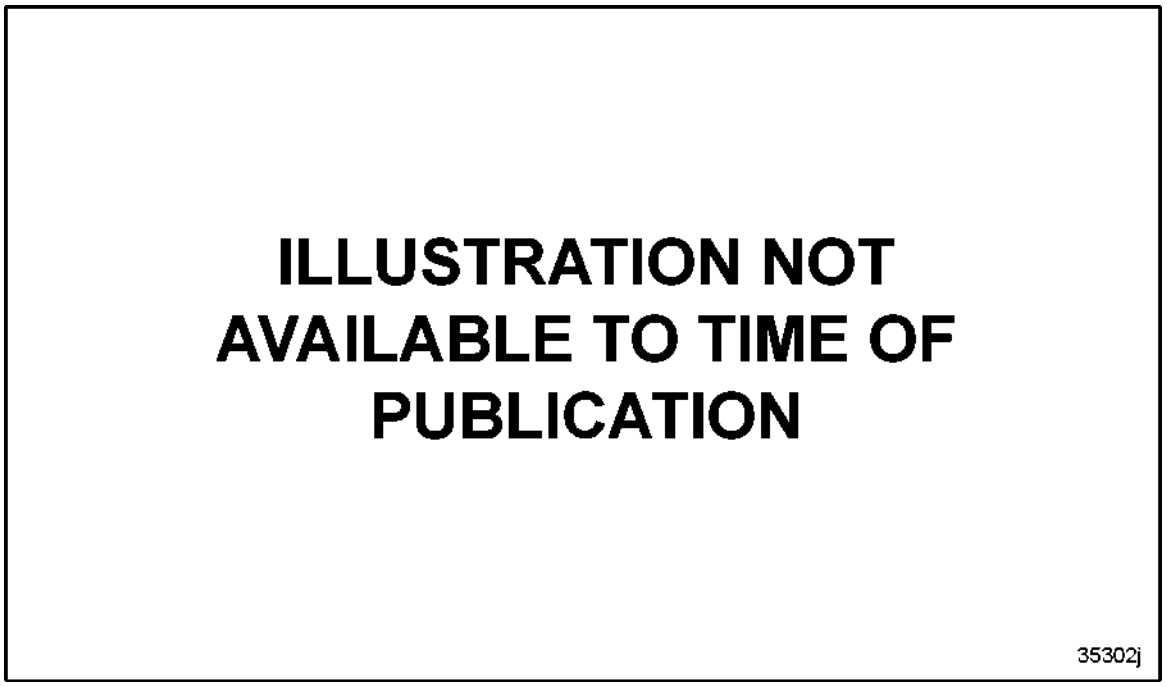


Figure 1592 Service Tool Set (2-71),J 8147

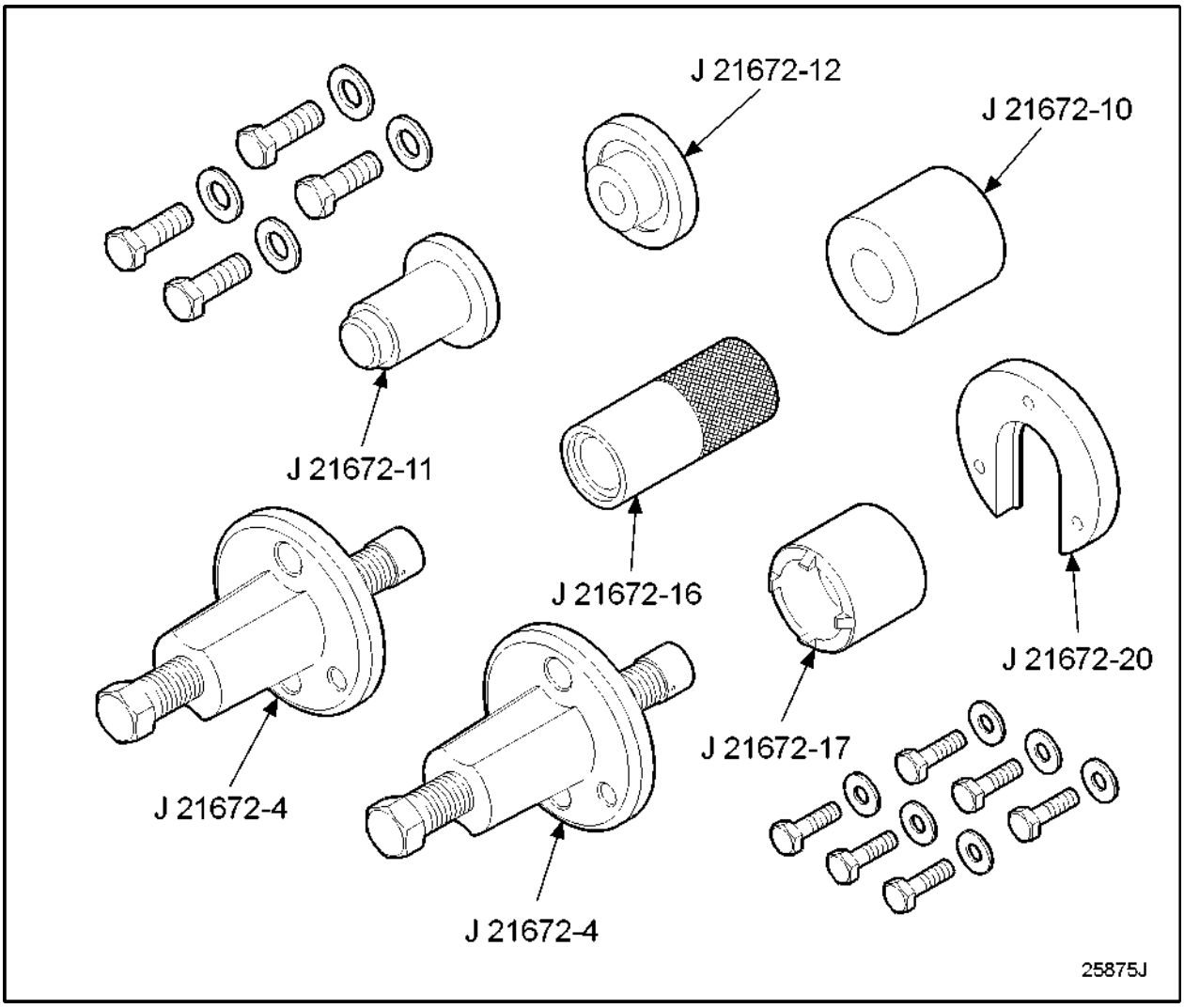


Figure 1593 Service Tool Set (8V-53),J 21672

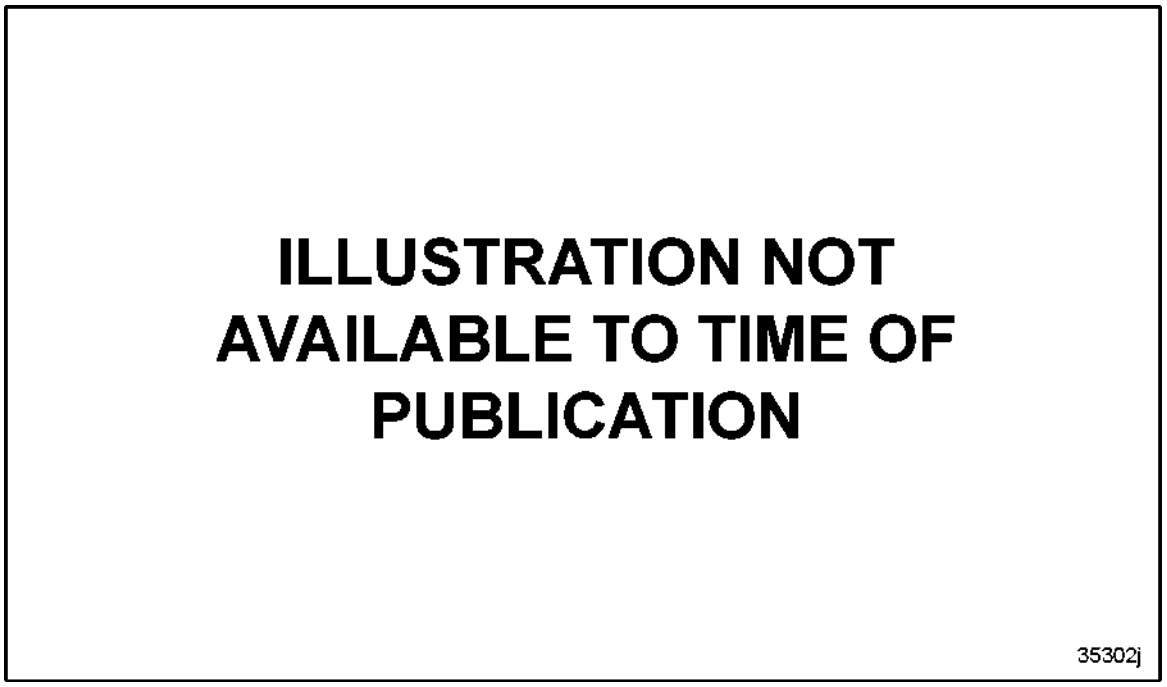


Figure 1594 Service Tool Set (EXCEPT 8V-53), J 23679–A

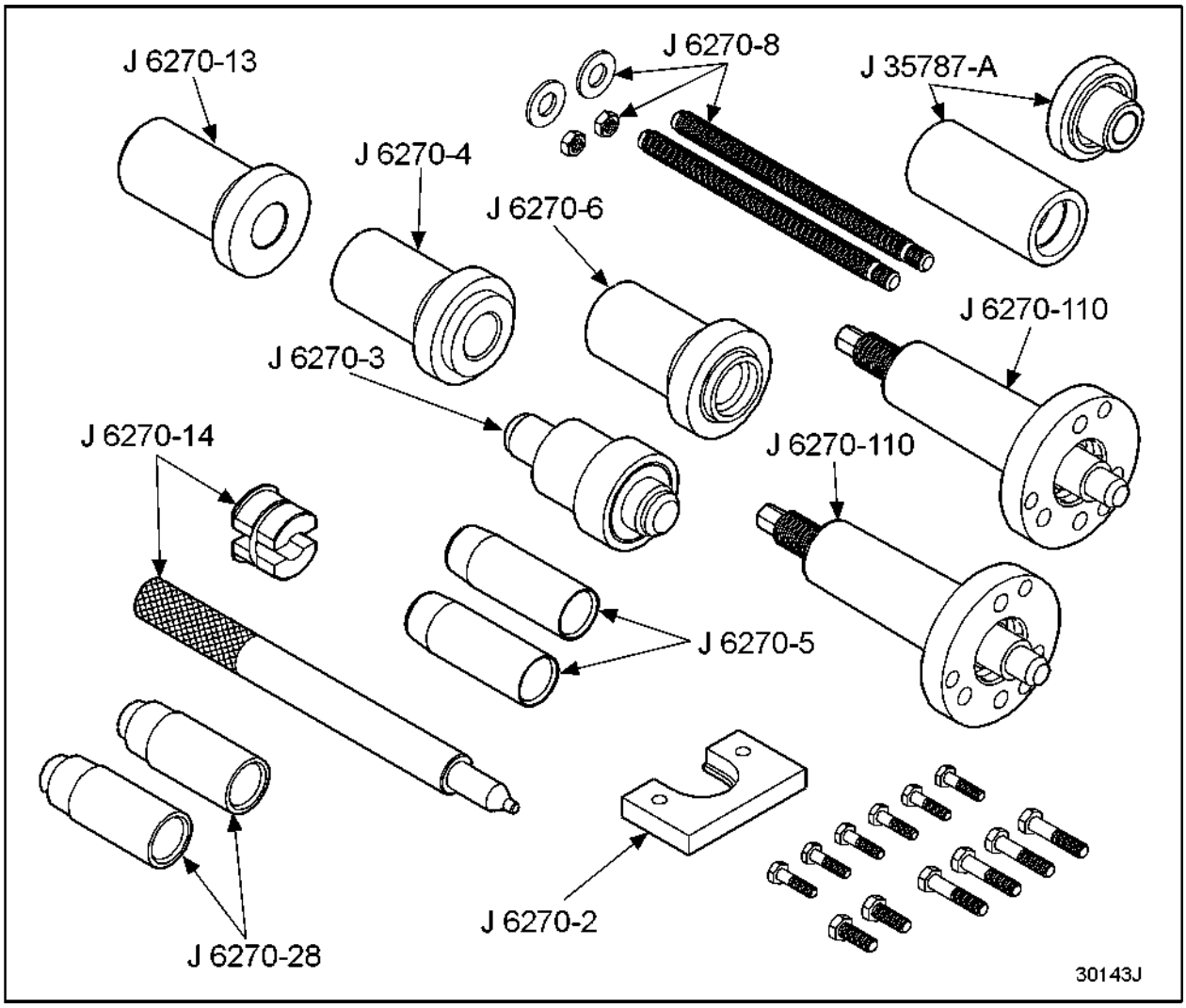


Figure 1595 Service Tool Set (Except 2-71),J 6270–G

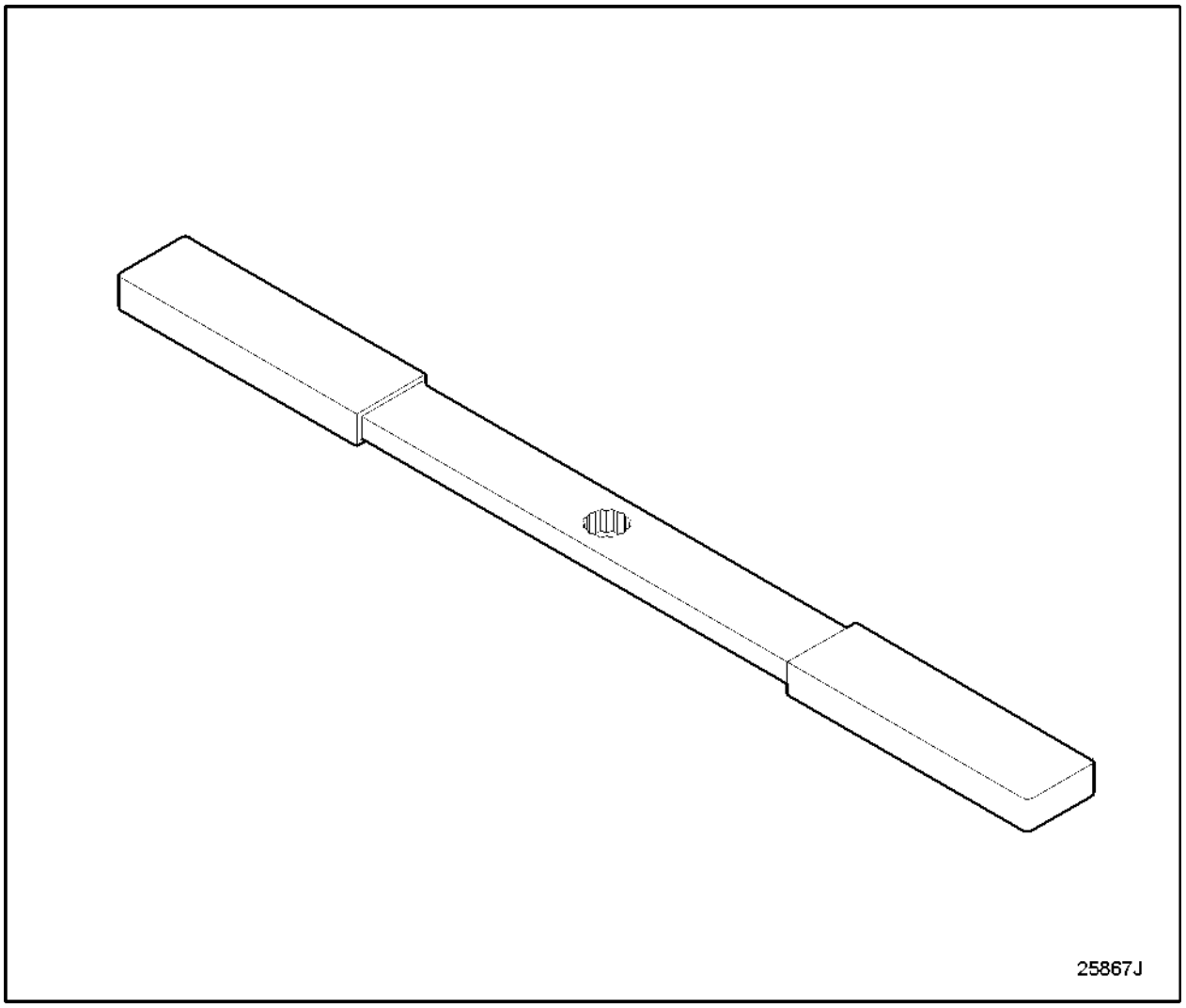


Figure 1596 Compressor Impeller Nut Wrench,J 21223–02

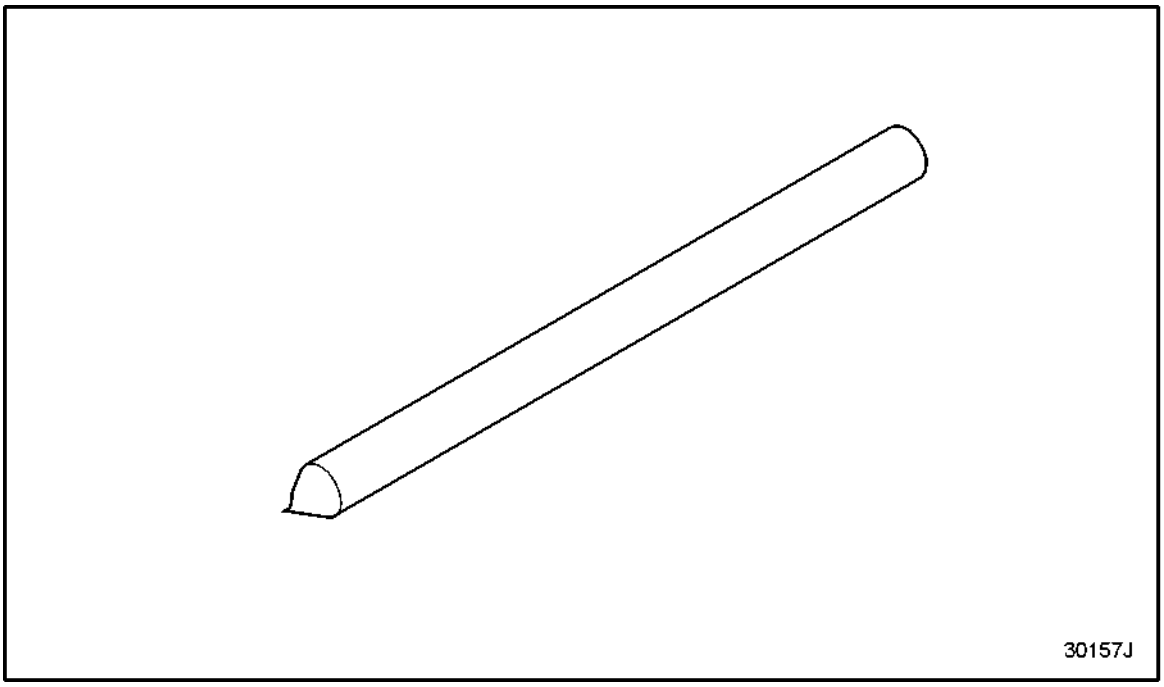


Figure 1597 Compressor Impeller Remover ,J 9496

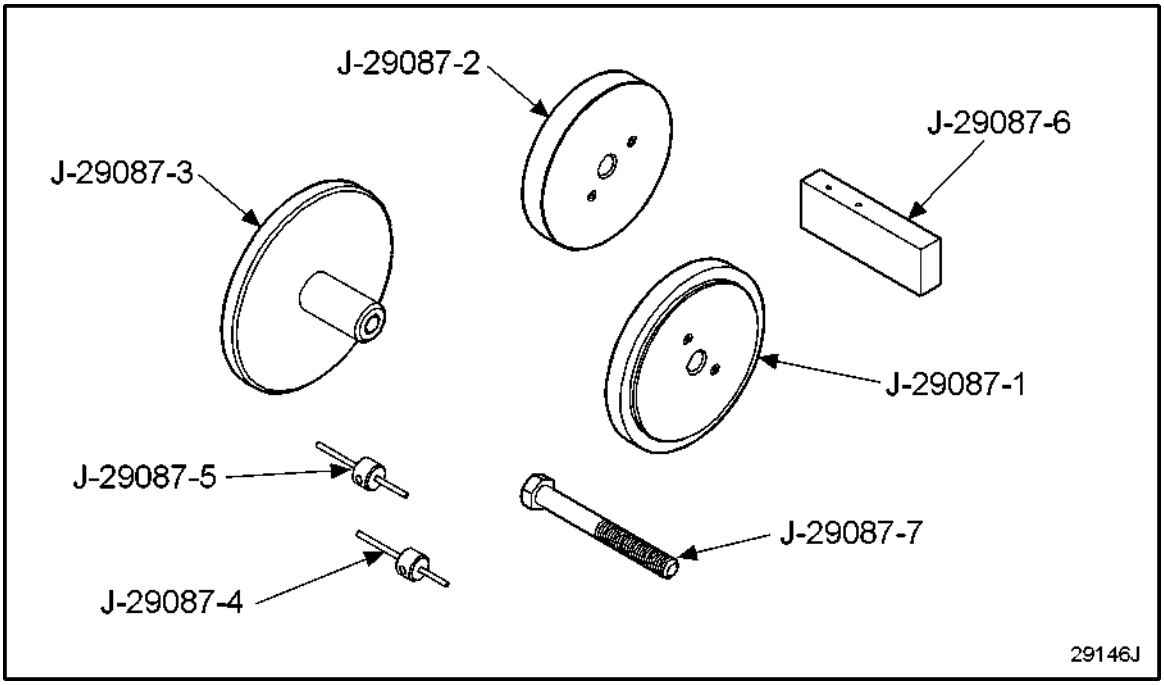


Figure 1598 Drill Fixture,J 29087

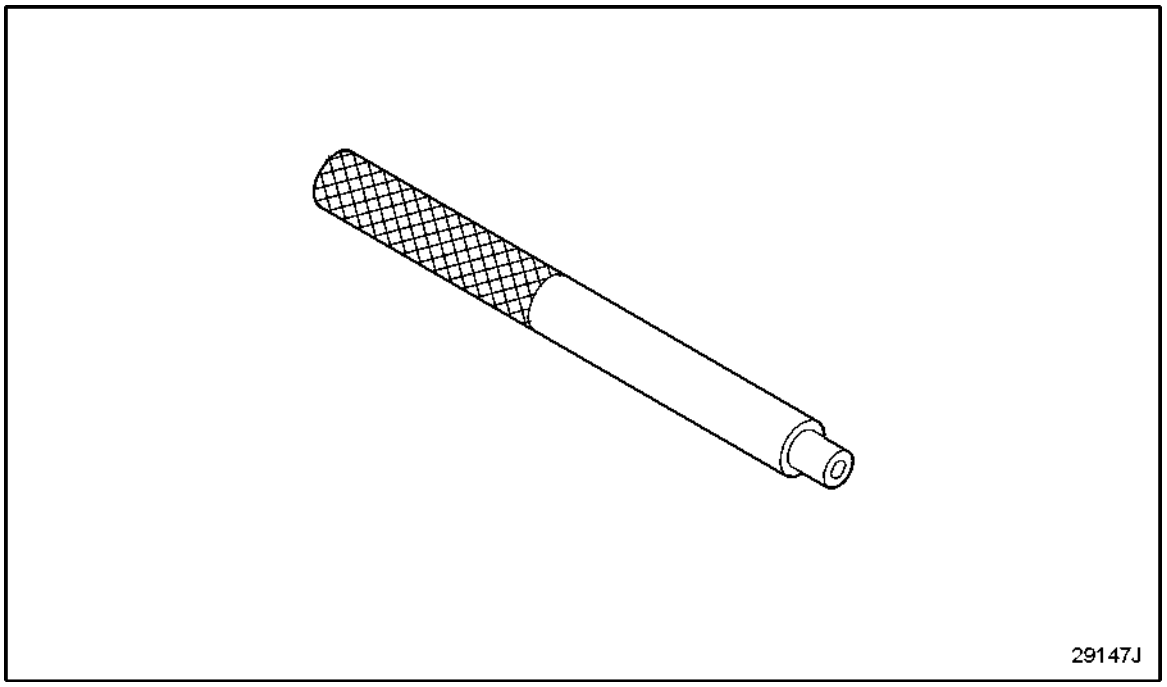


Figure 1599 Groove Pin Installer,J 29088

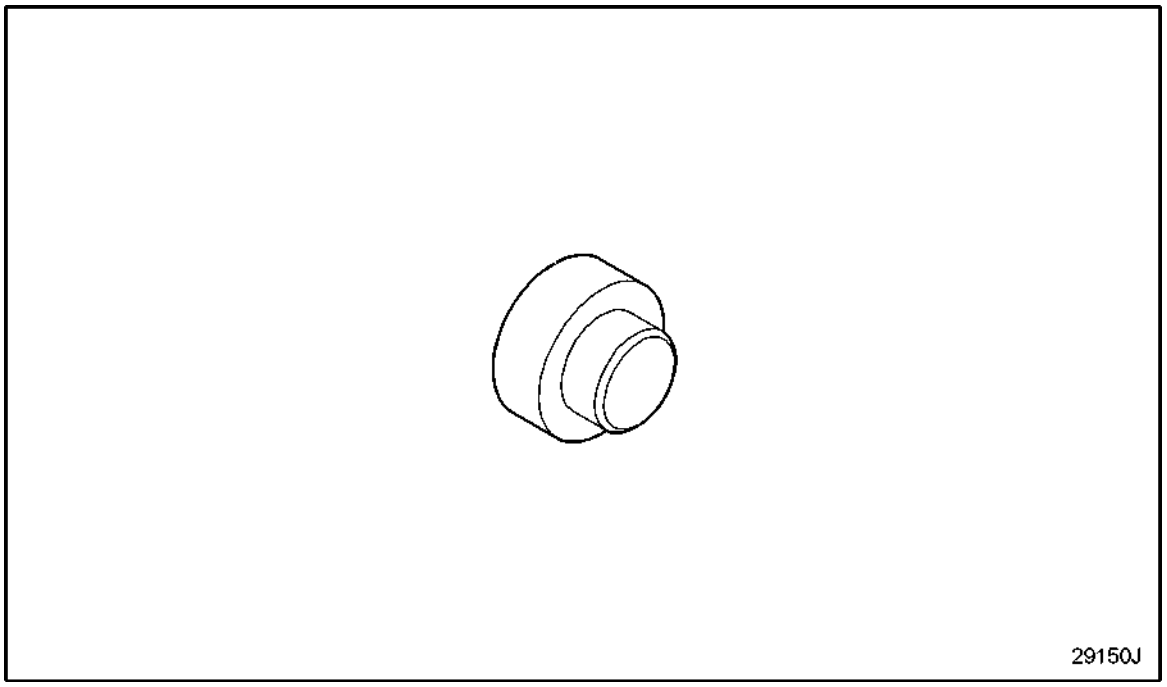


Figure 1600 Seal Ring Installer,J 29104

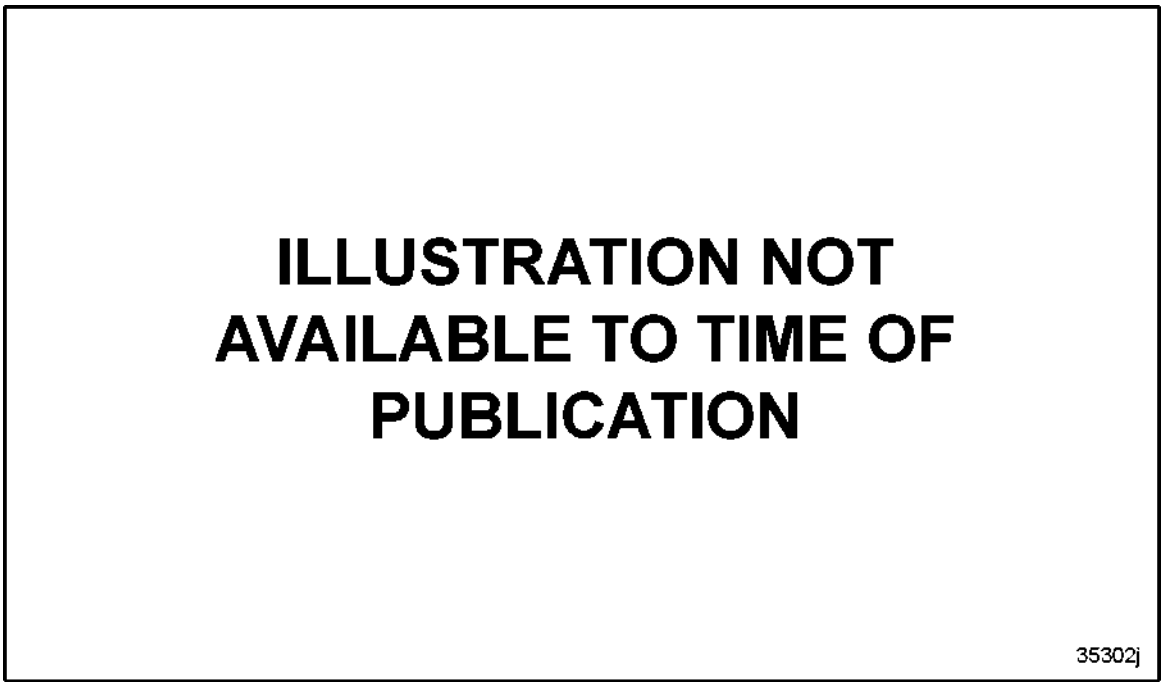


Figure 1601 Seal Ring Installer,J 29105

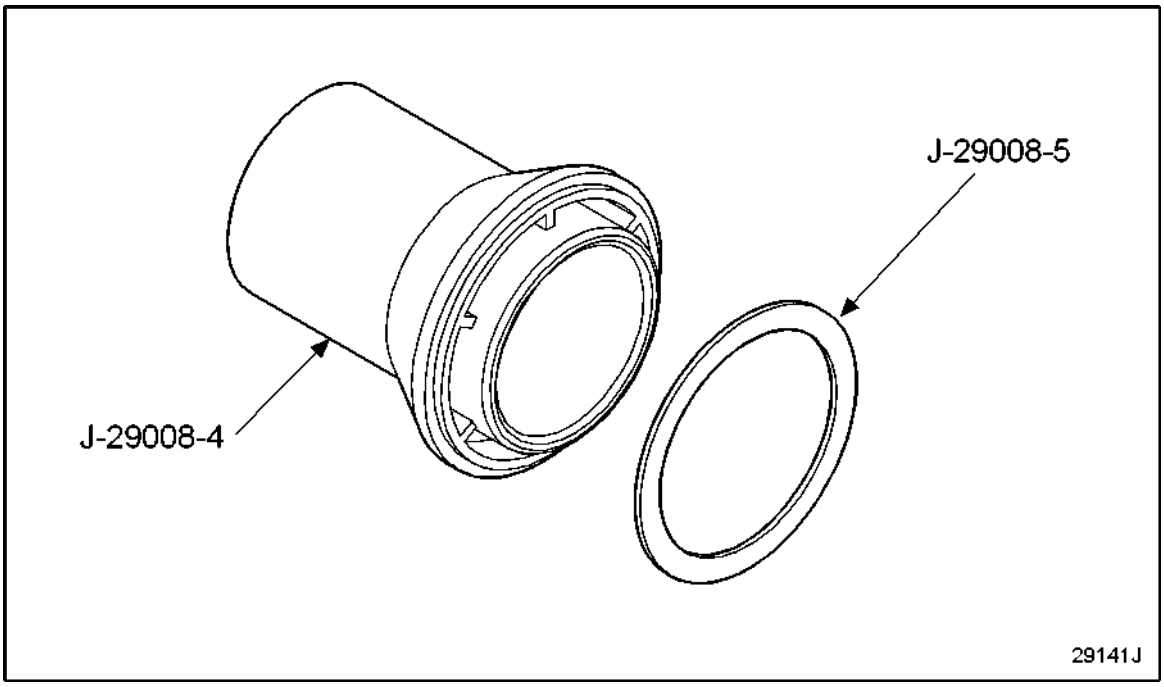


Figure 1602 Sled Gage Base,J 29091

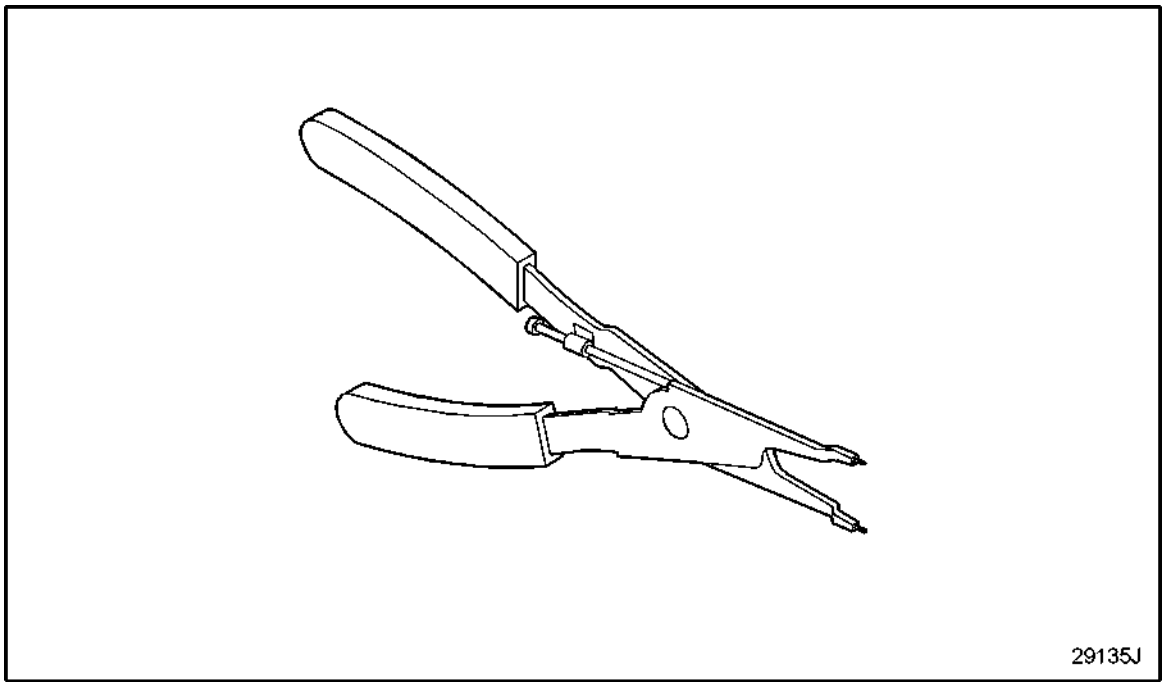


Figure 1603 Snap Ring Pliers (Internal), J 28507

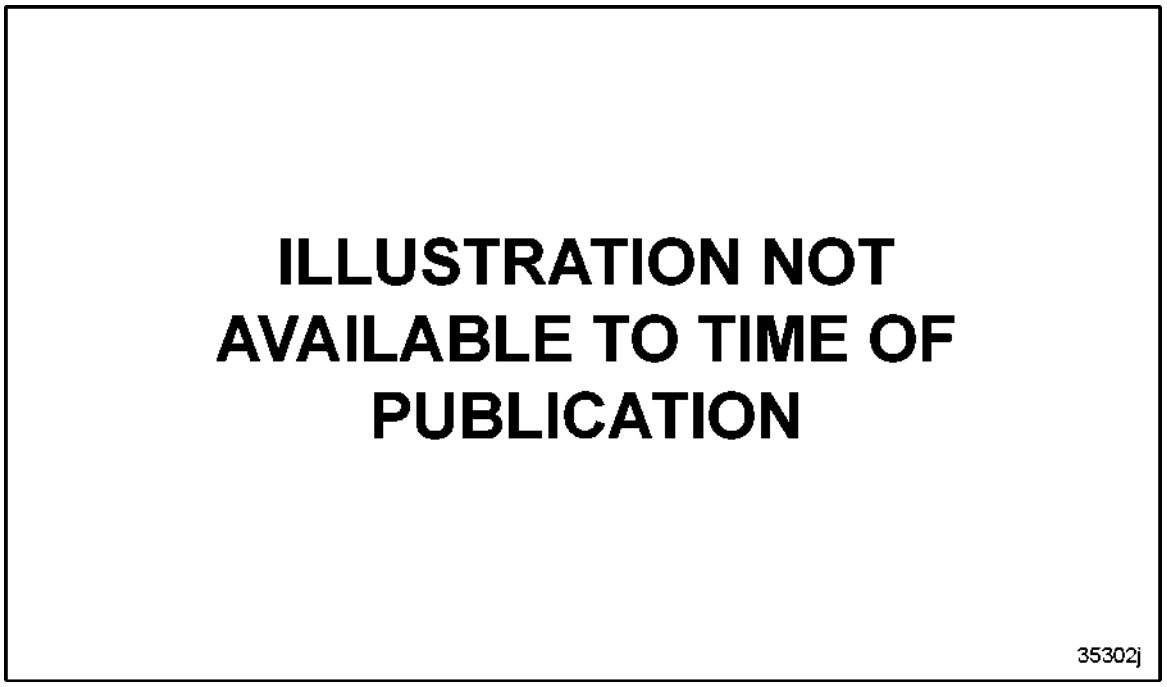


Figure 1604 Alternator Pulley Holder, J 41732

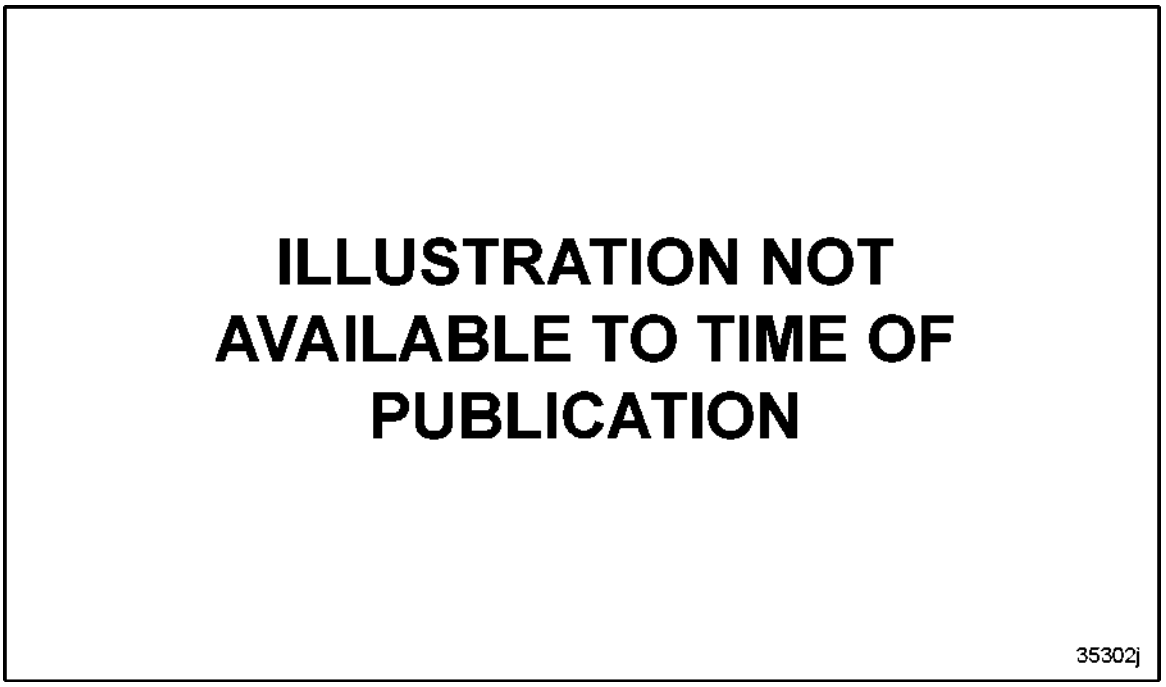


Figure 1605 Test Light Self Powered,J 21008–A

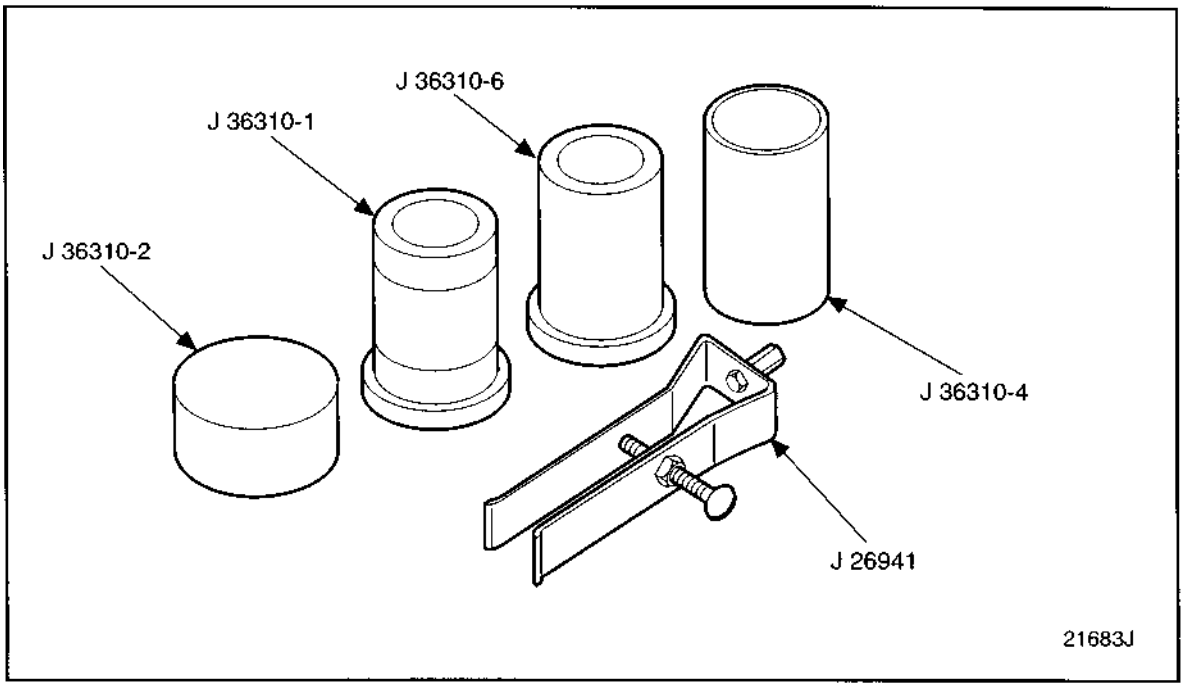


Figure 1606 Compressor Drive Service Set,J 36310–A

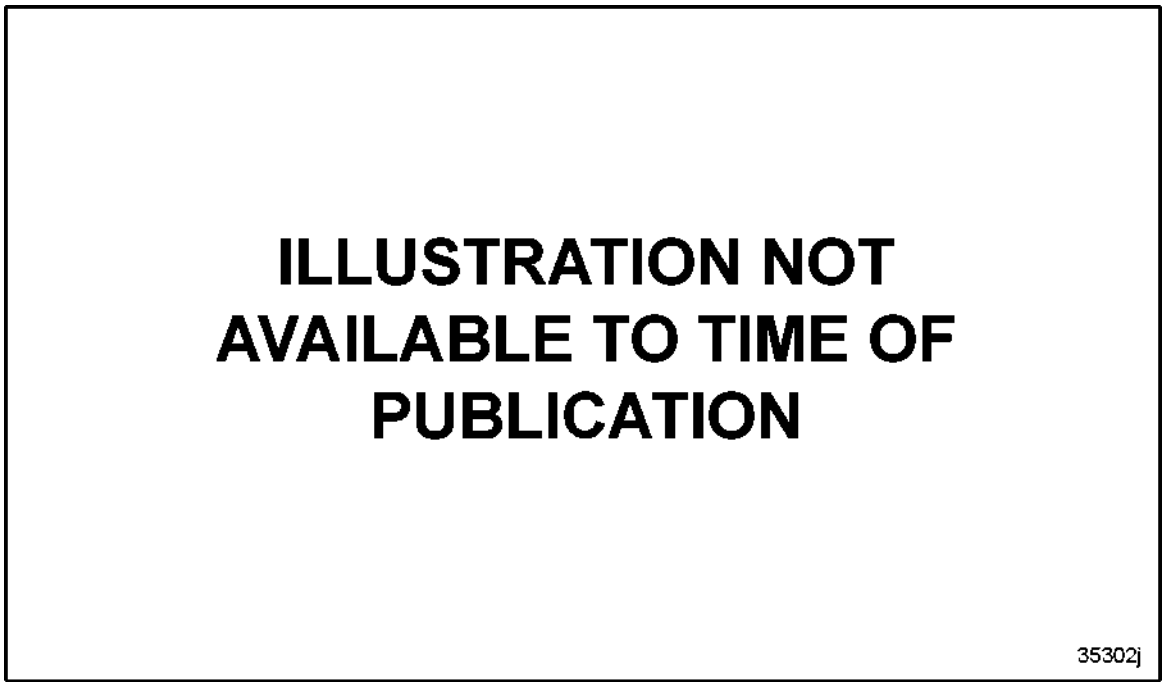


Figure 1607 **Freon Leak Detect,**J 29547–A

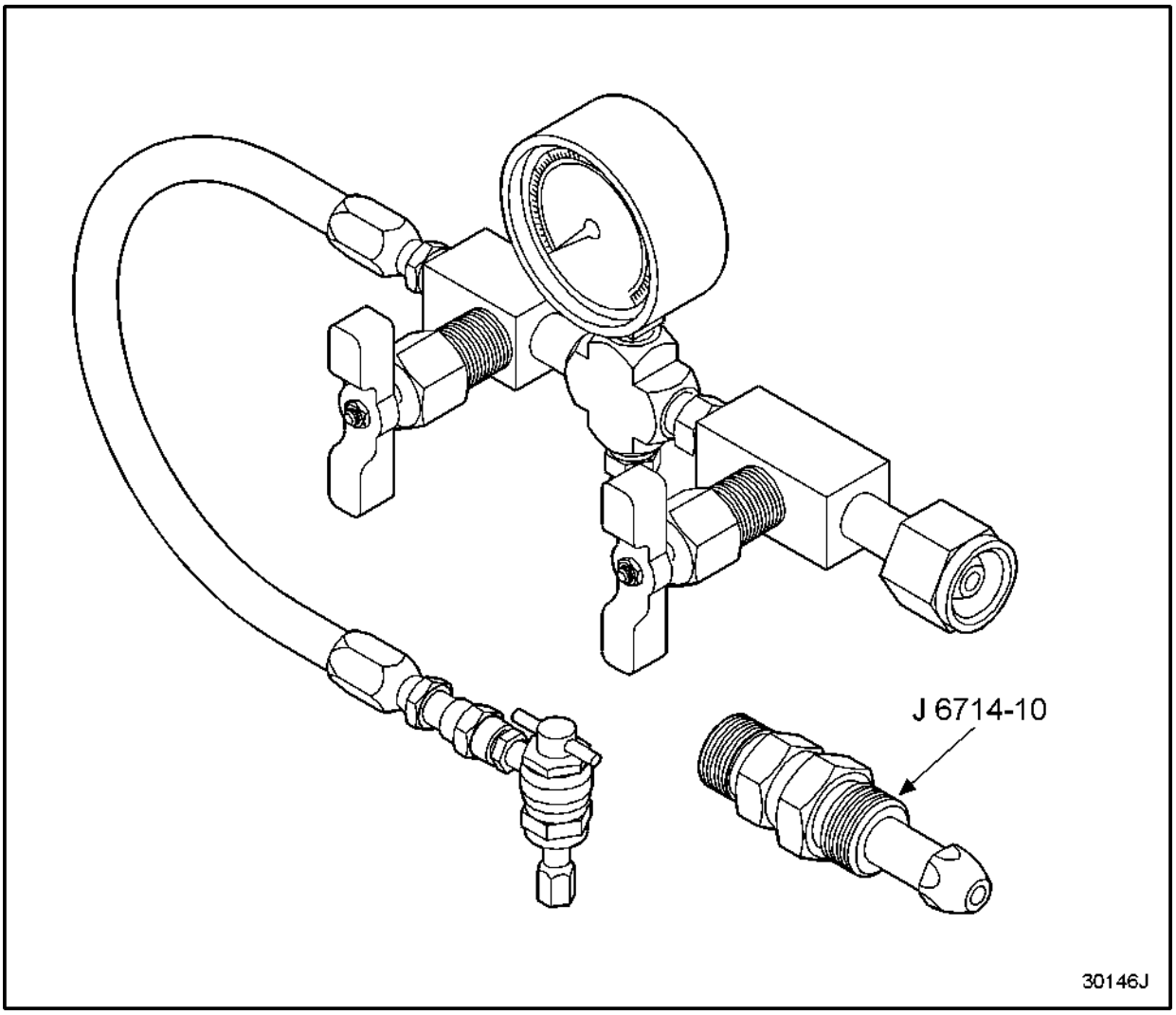


Figure 1608 Hysrostarter Accumulator Charge Kit,J 6714–D

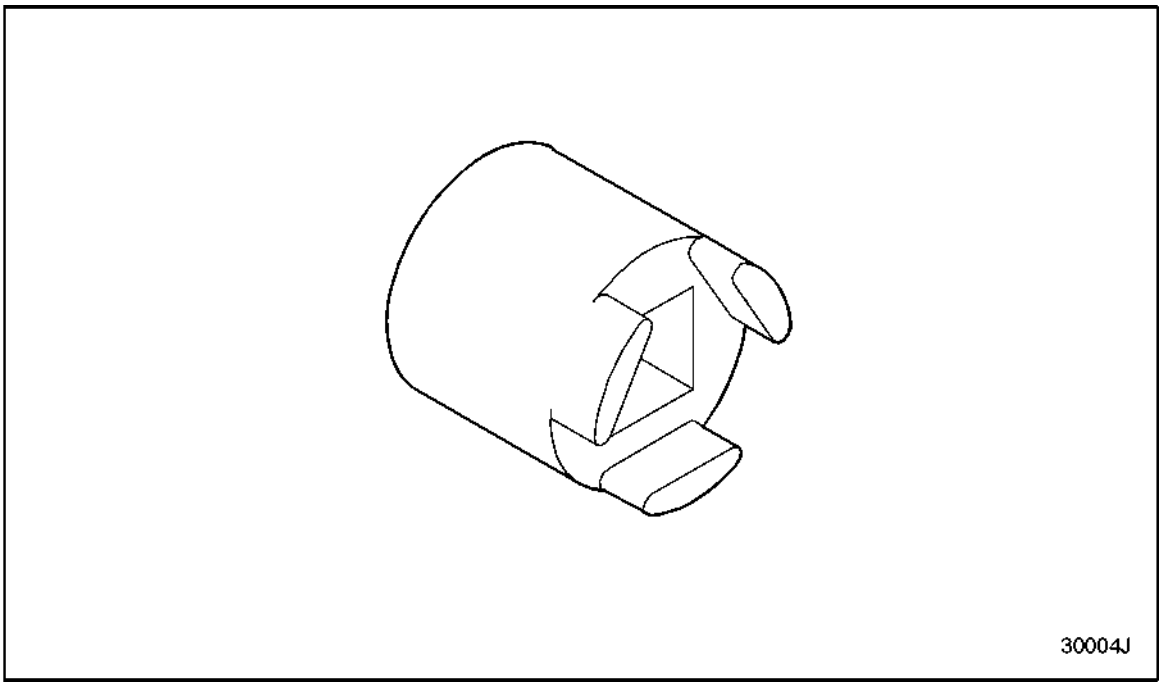


Figure 1609 Inlet Valve Stop Remover,J 25447–B

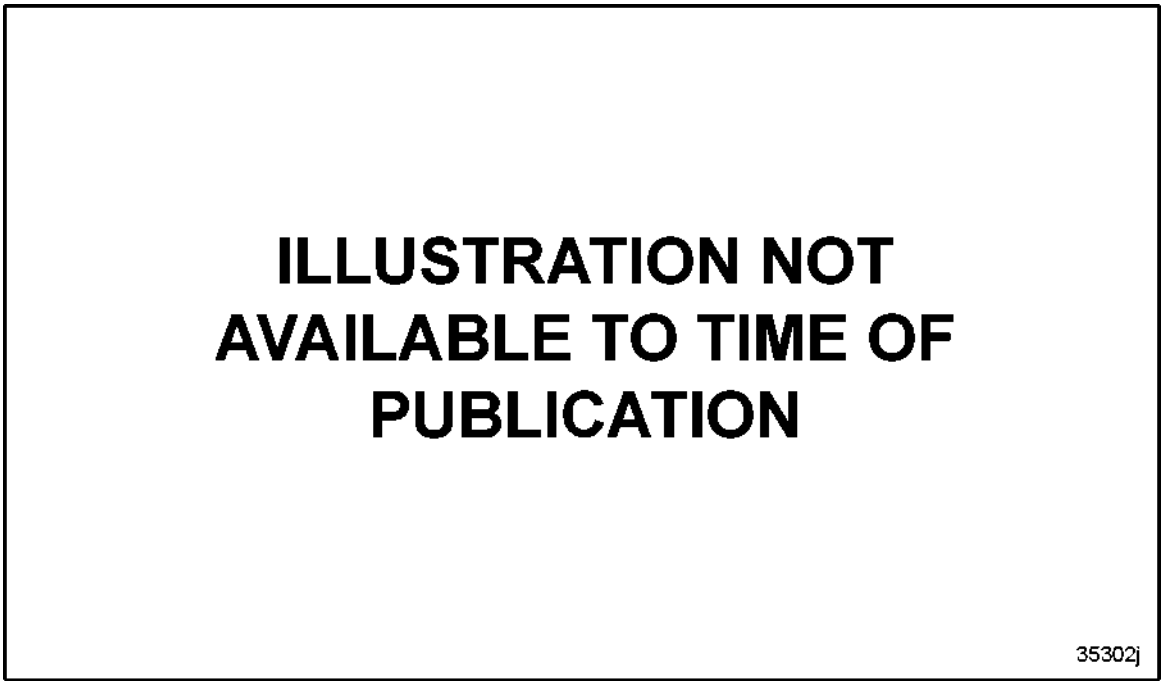


Figure 1610 Hub Installer,J 36311

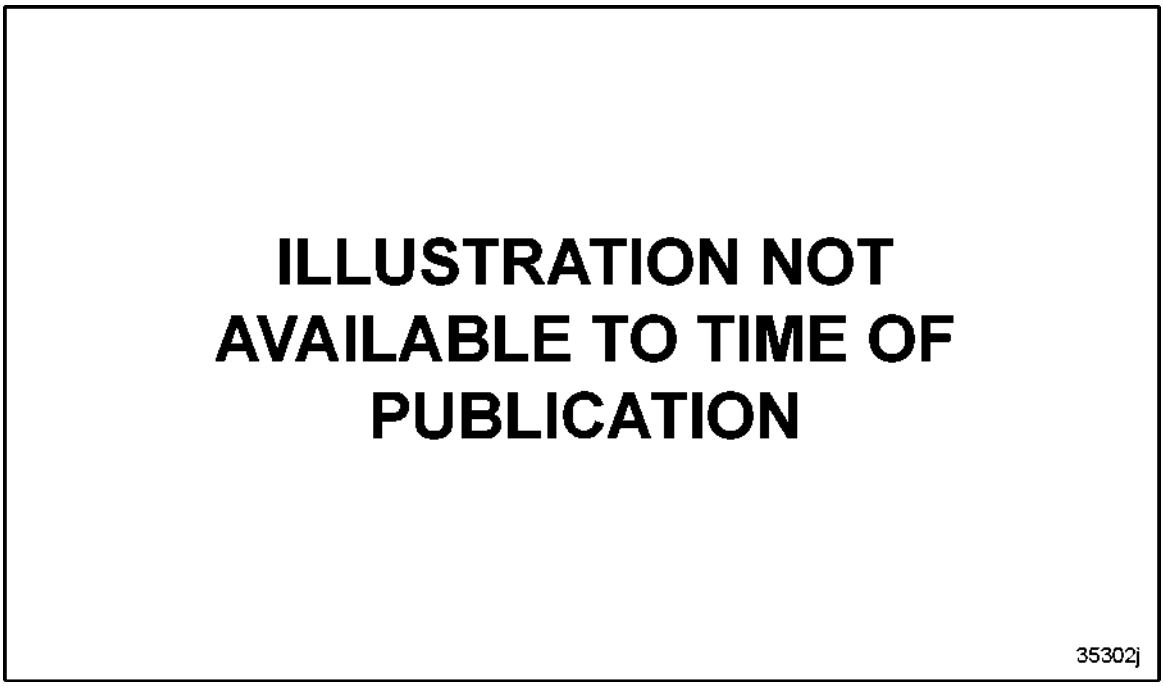


Figure 1611 Hub Remover,J 36309

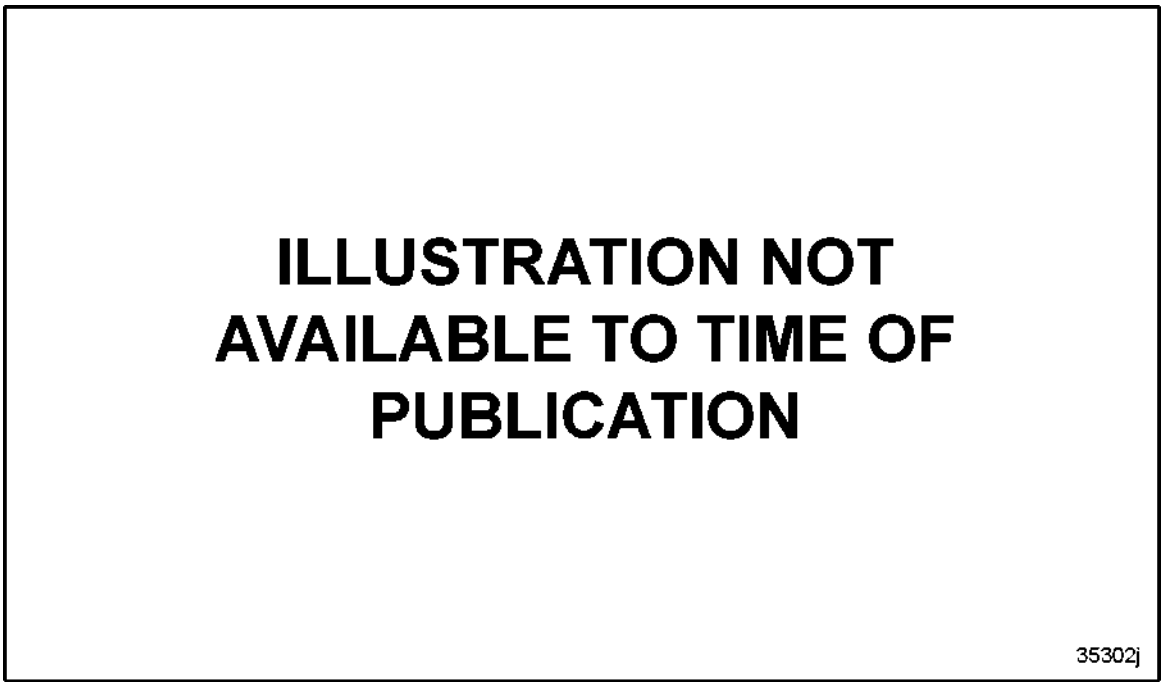


Figure 1612 Comp Gauge Pack,J 7334–E

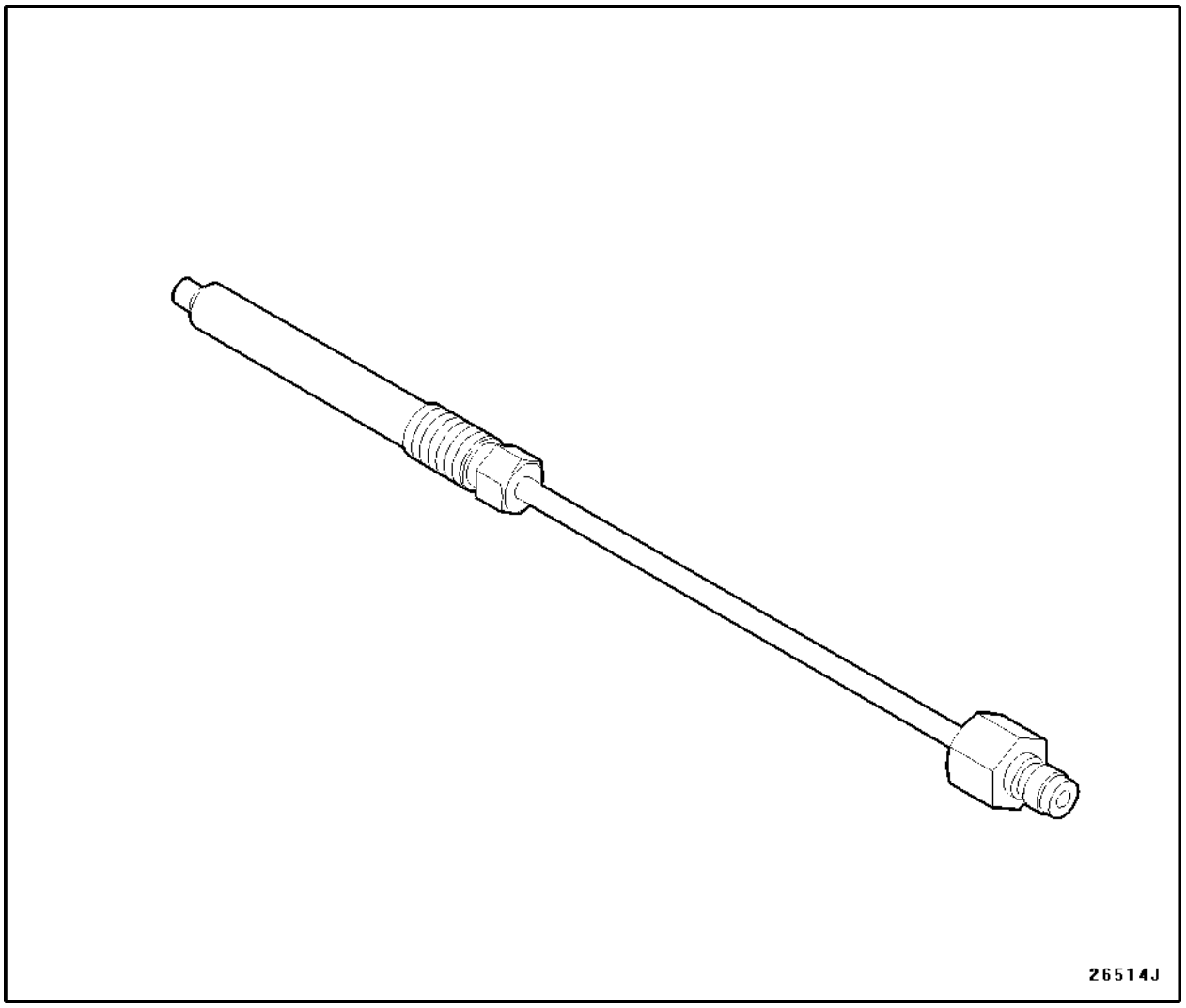


Figure 1613 Compression Gauge Adapter,J 41960

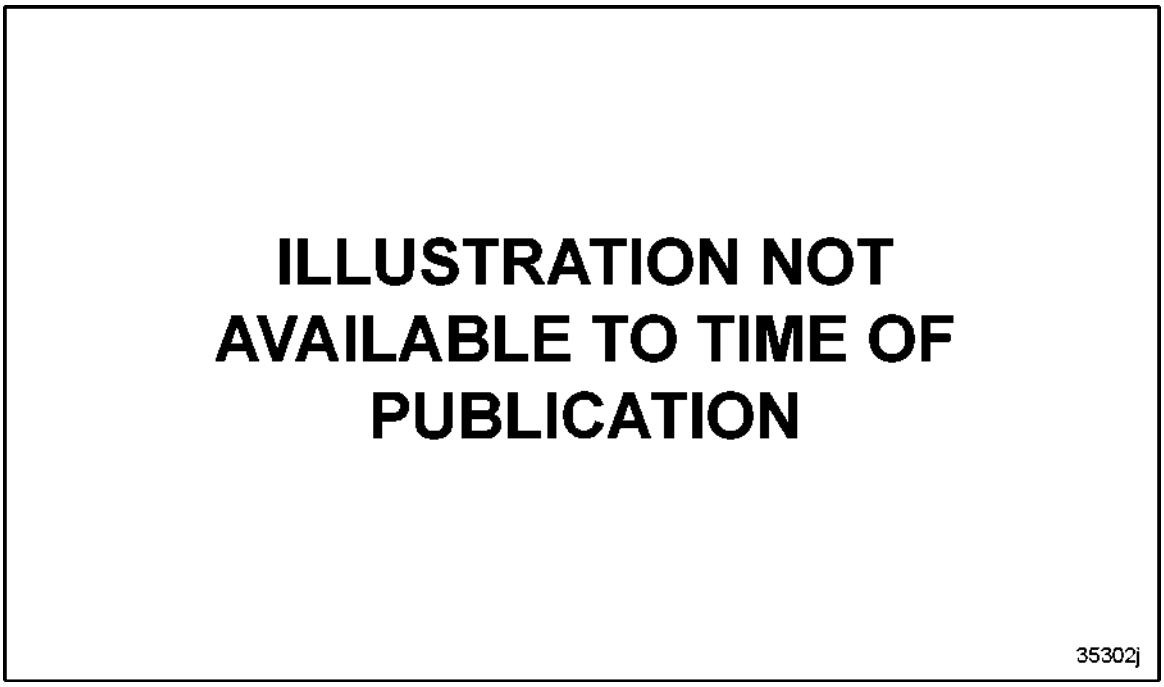


Figure 1614 Printer Paper (5 Roll Pack),J 38450–5

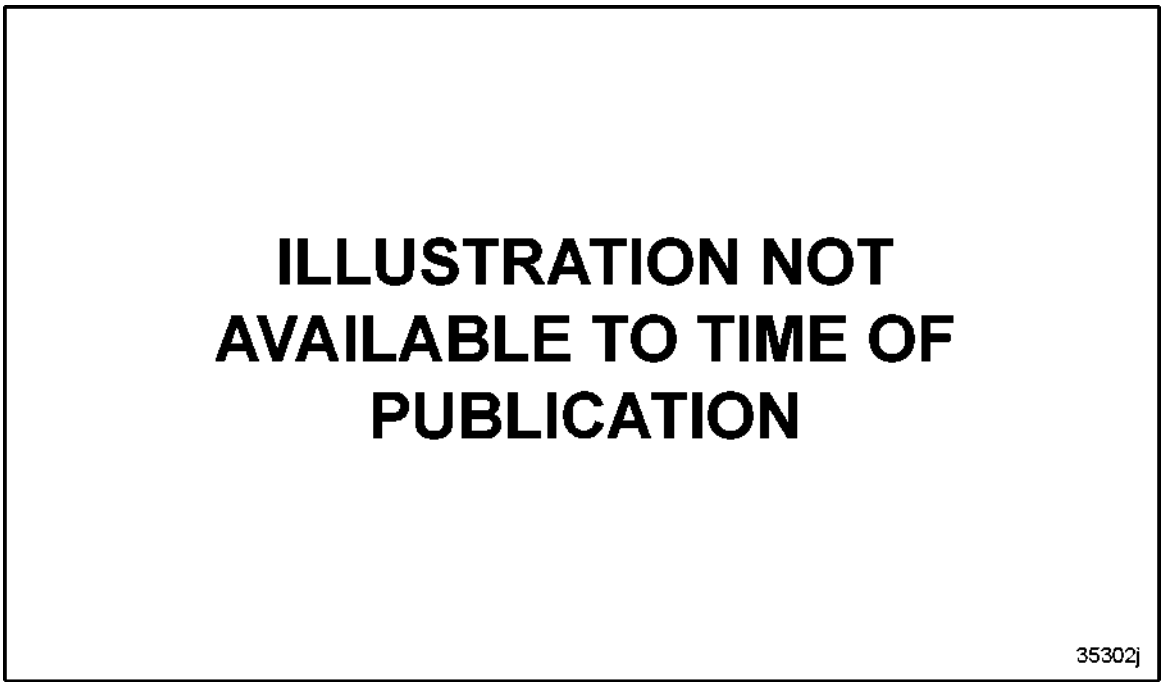


Figure 1615 Printer (Portable) 110V Recharger,J 39480

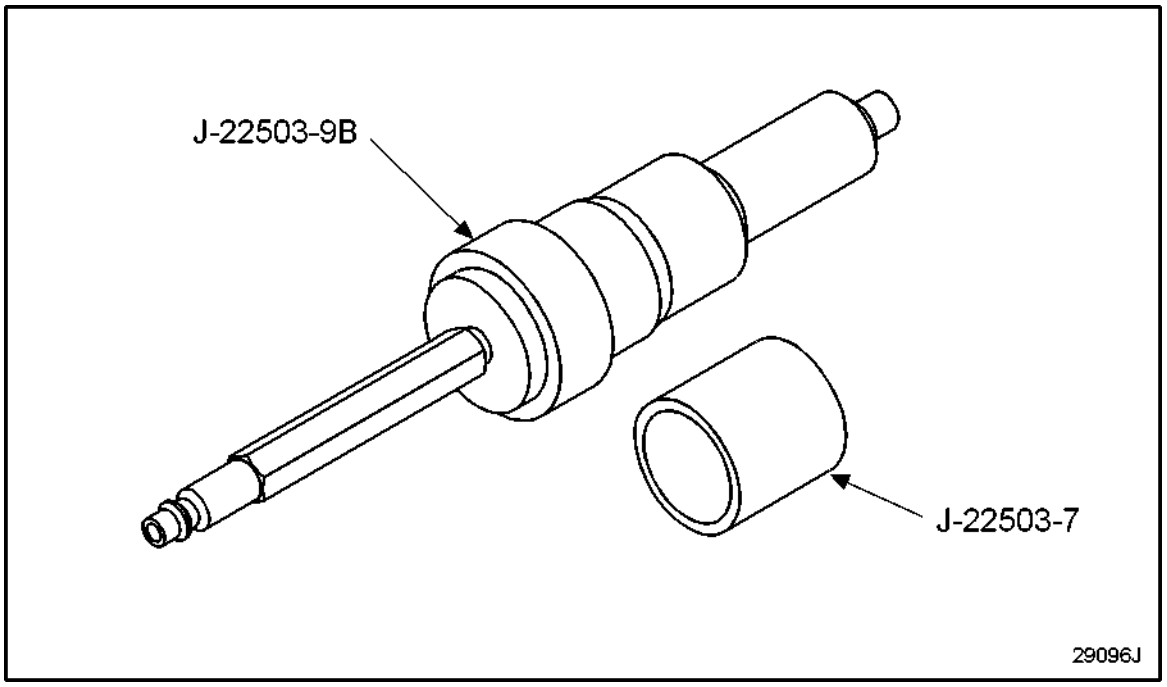


Figure 1616 Compression Gauge Adapter,J 22503–C

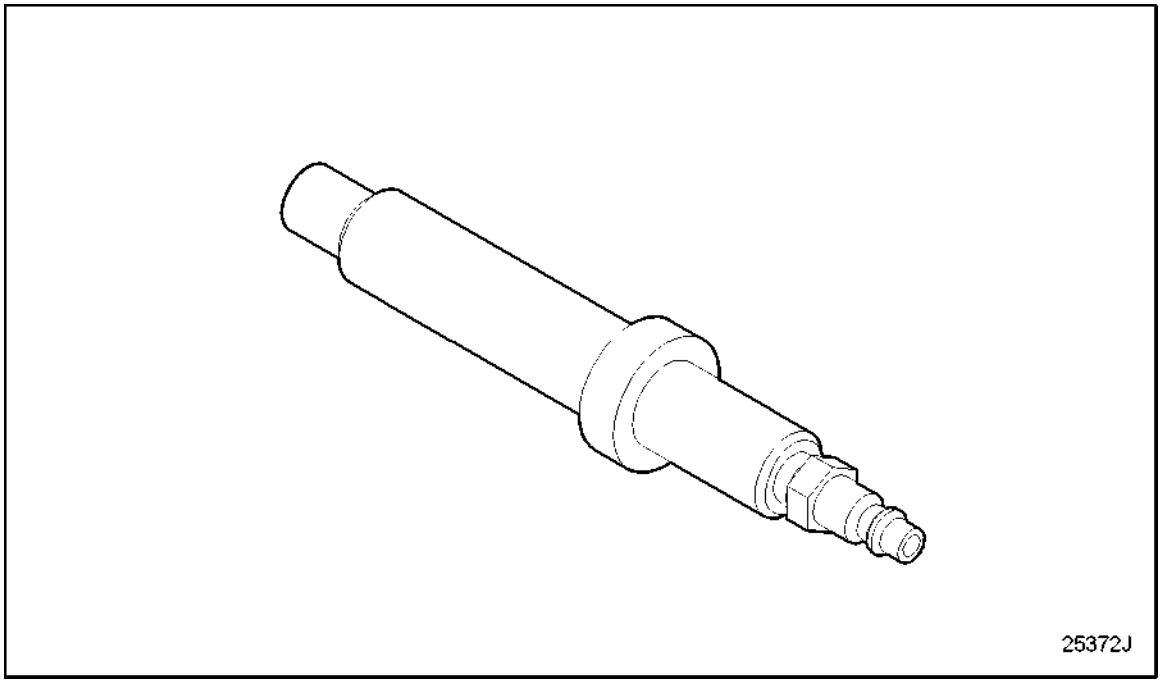


Figure 1617 Compression Gauge Adapter,J 41541

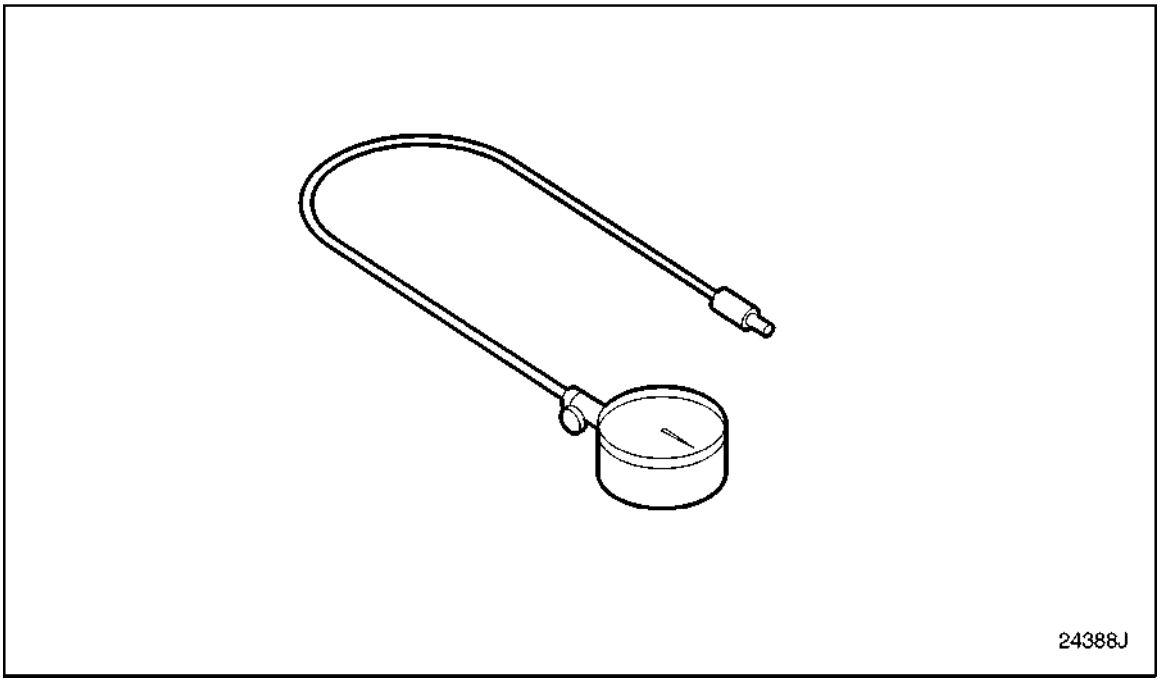


Figure 1618 Compression Pres GA & Hose Assy,J 6692–B

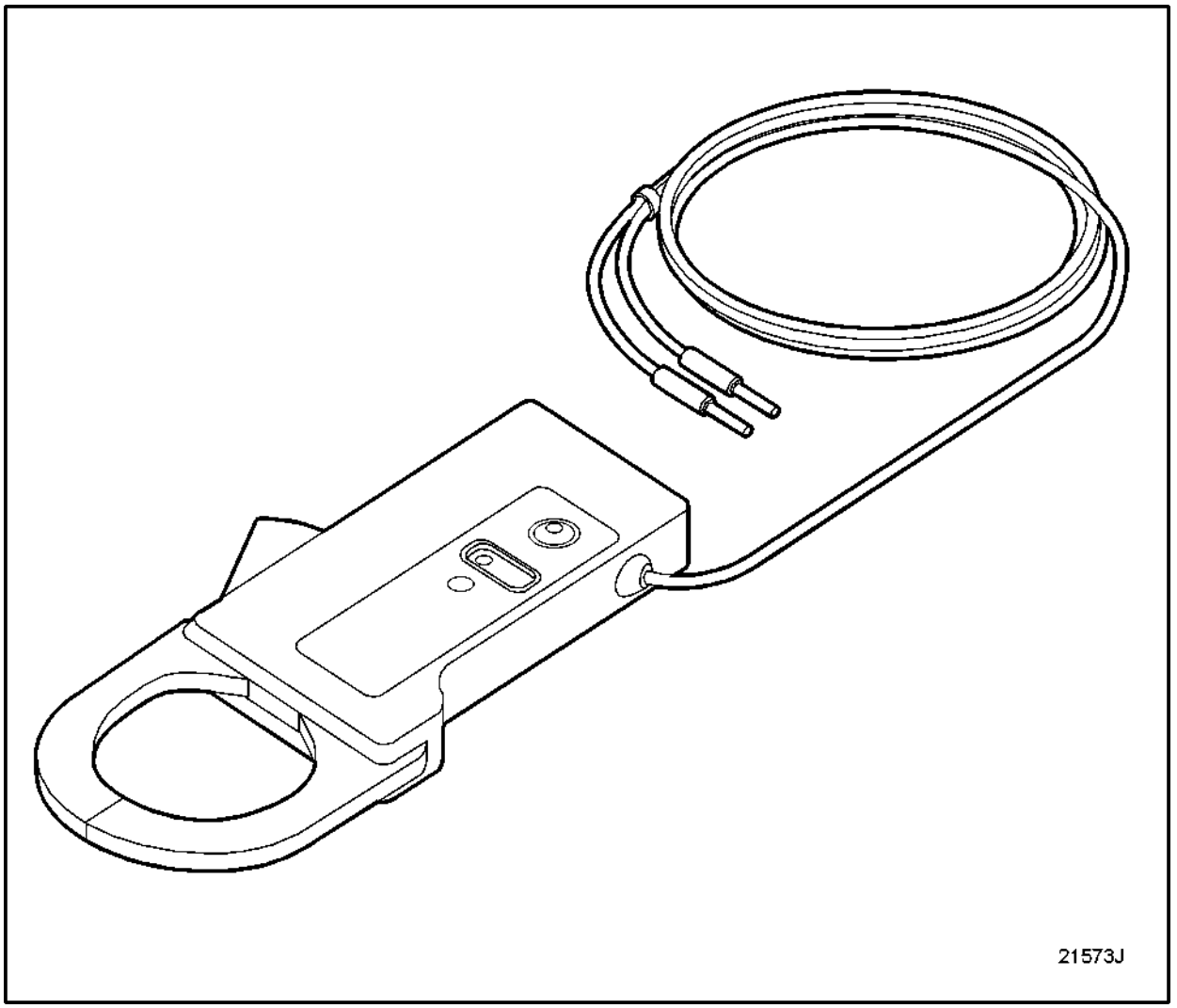


Figure 1619 Current Clamp (0-600 AMPS),J 35590

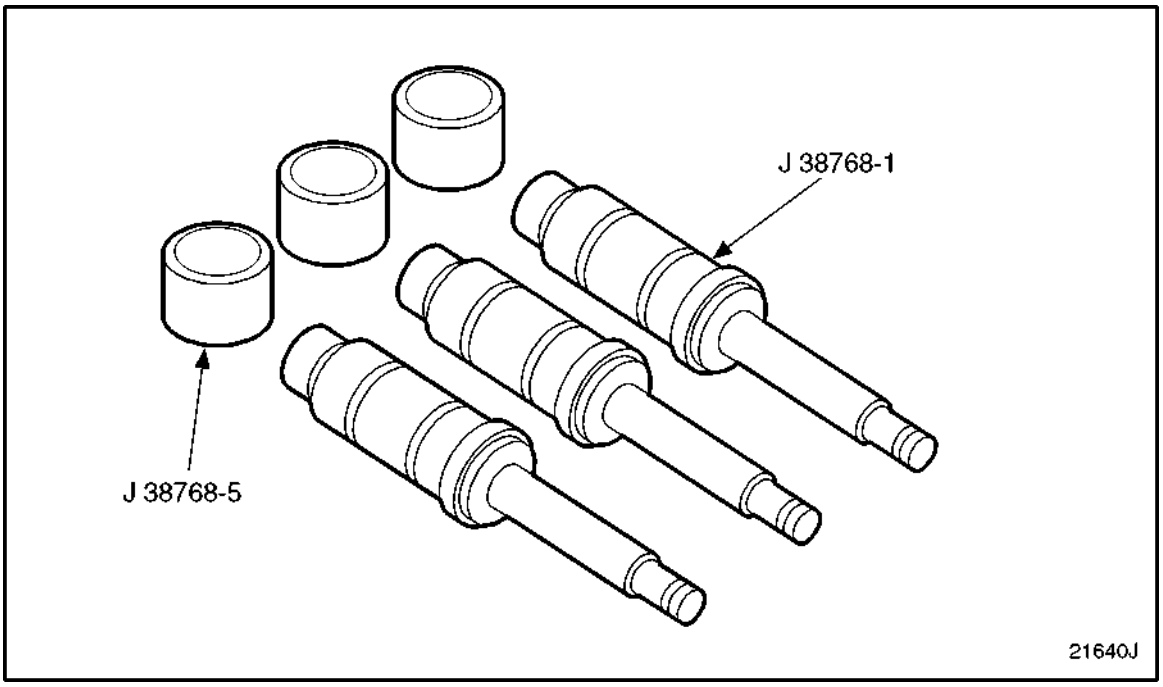


Figure 1620 Cylinder Compression Test ADPT Set,J 38767–A

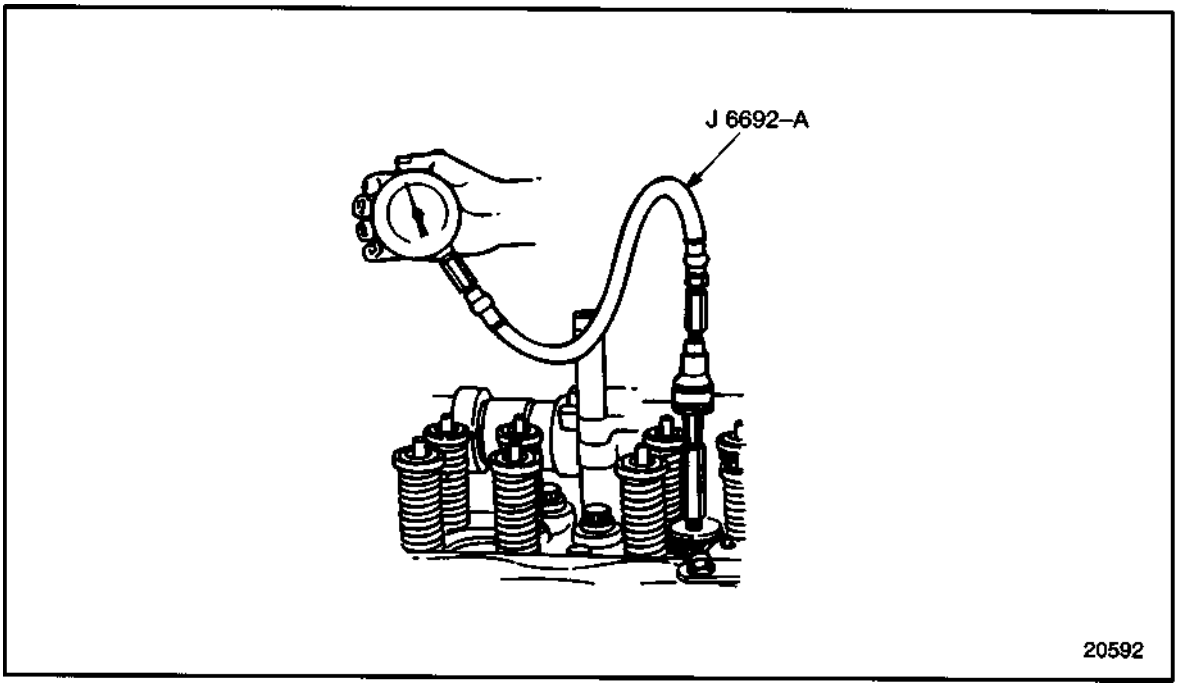


Figure 1621 Cylinder Leak Down Tester,J 29006

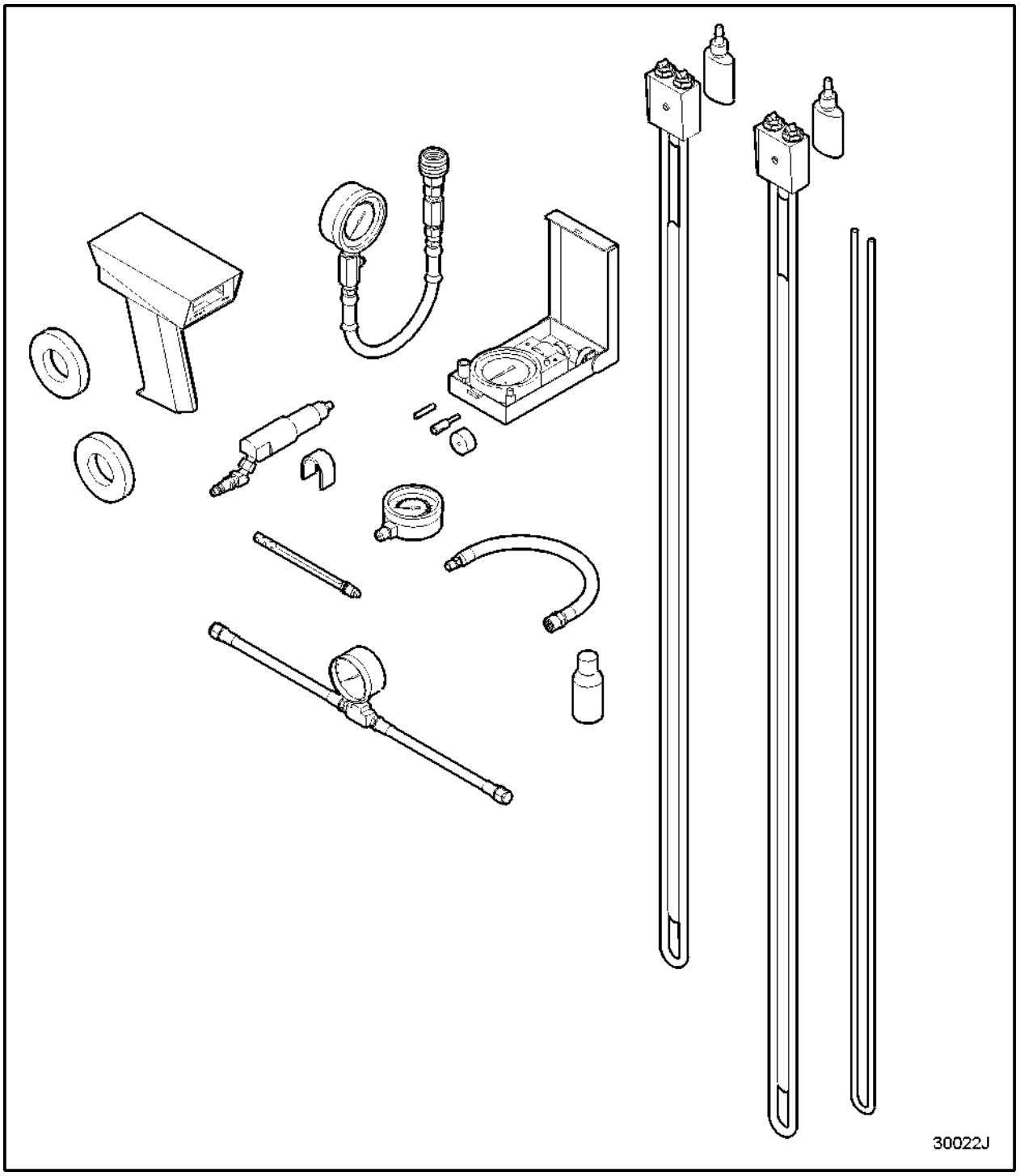


Figure 1622 Diagnosis Test Kit,J 22506

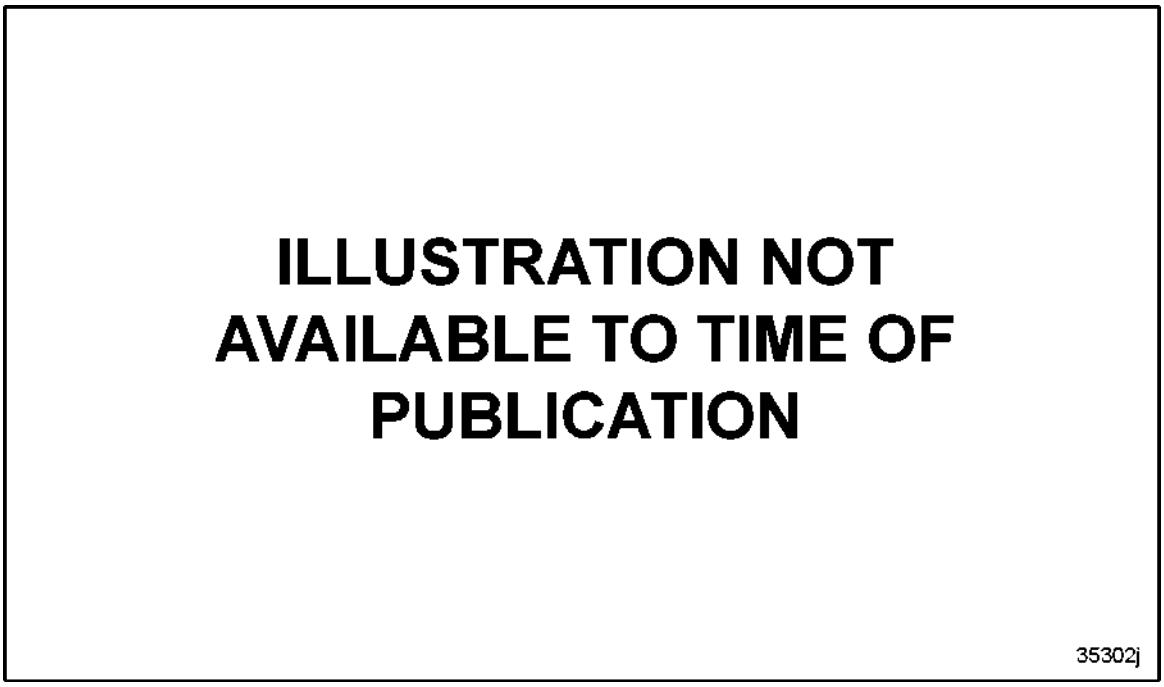


Figure 1623 Diagnostic Test Kit,J 9531–C

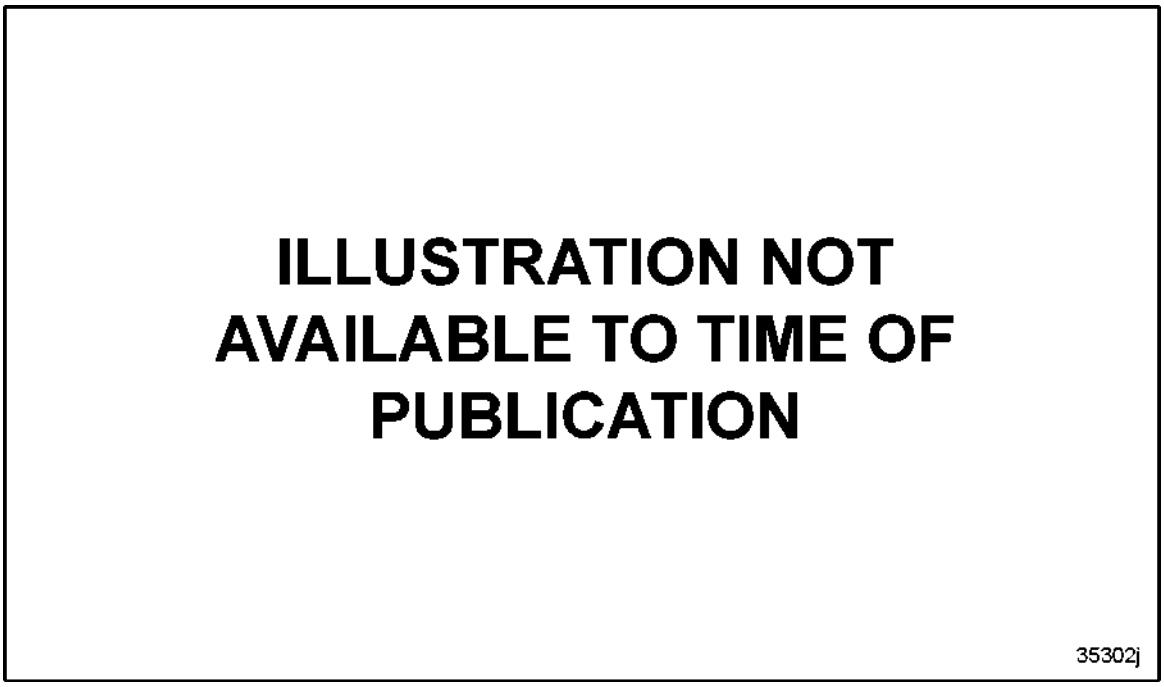


Figure 1624 Diagnostic Test Kit,J 34680–A

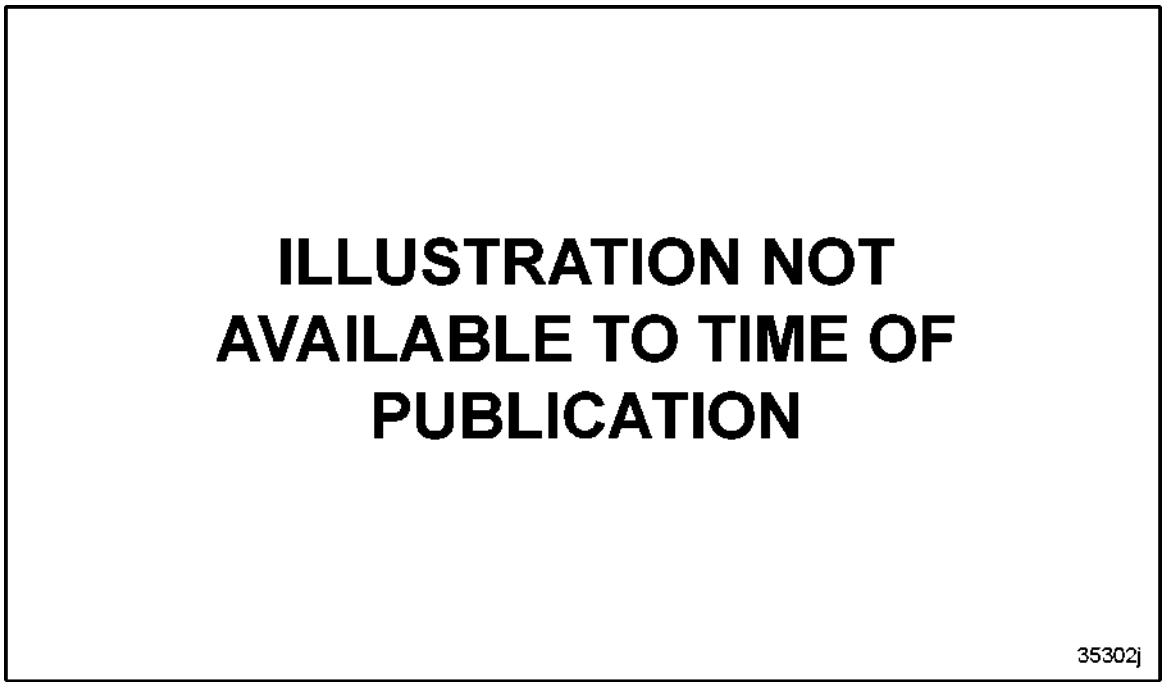


Figure 1625 Digital Photo Tach,J 28838–B

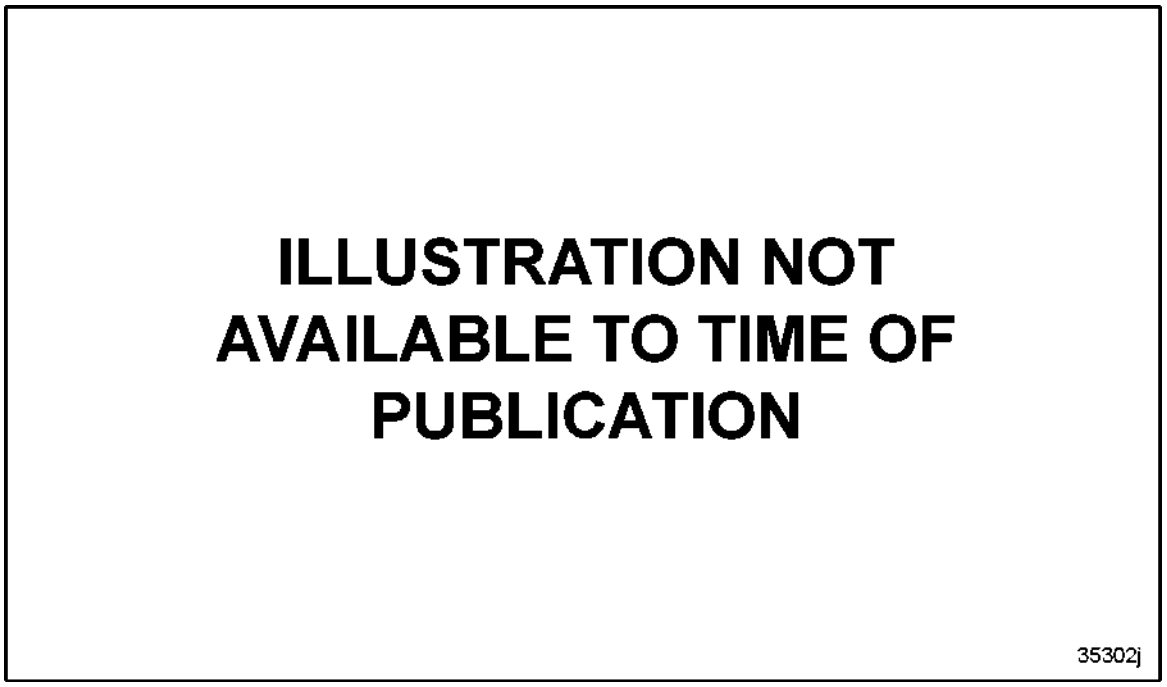


Figure 1626 Digital Pyrometer (-30 to 1800 D F),J 39422

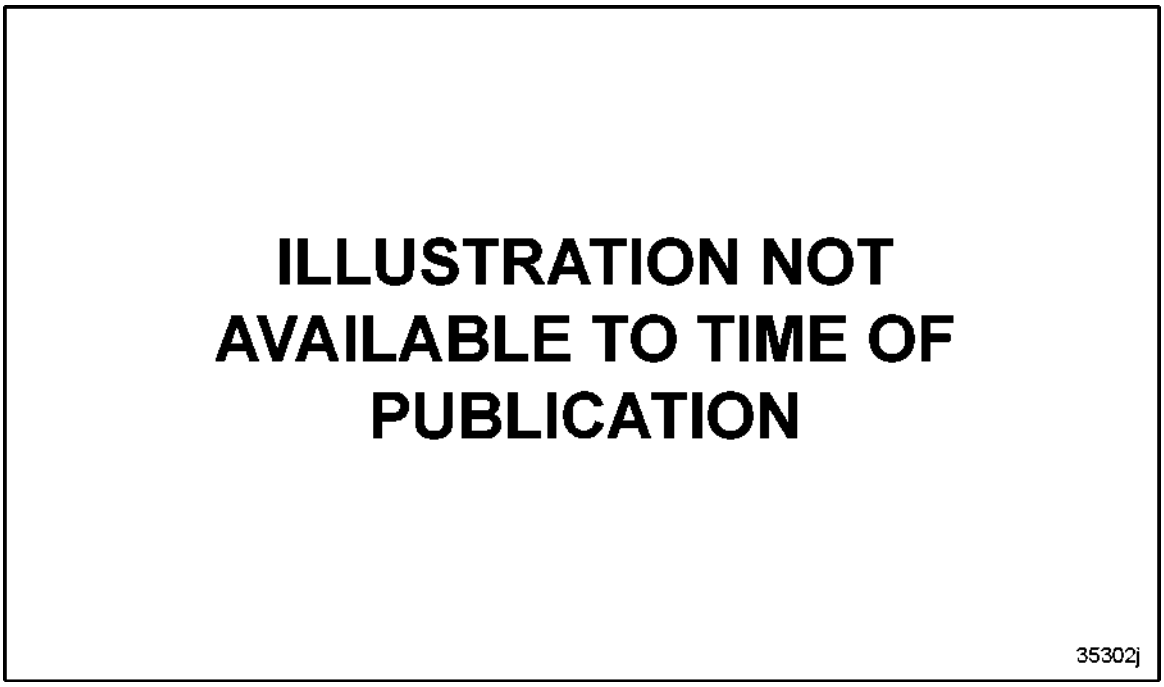


Figure 1627 Dry Air Cleaner Gage, J 8397

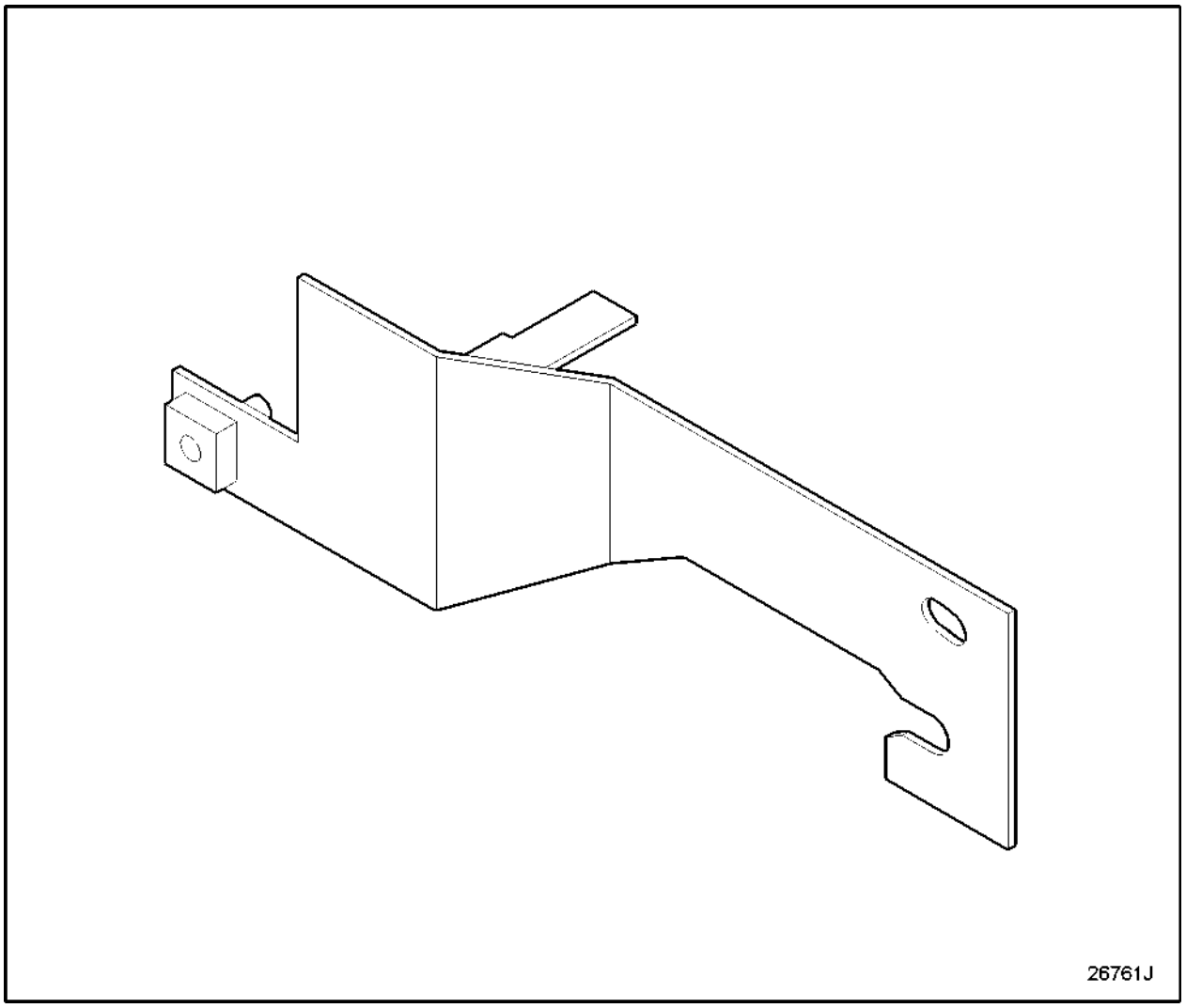


Figure 1628 Elec Gov Link Setting,J 22195

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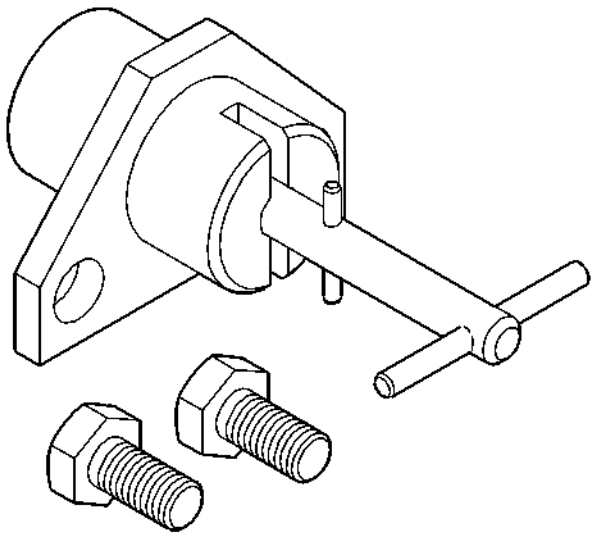
Figure 1629 Engine Diagnosis Kit,J 29534–B



29155J

Figure 1630 Flywheel Timing Pin & Adapter,J 29139

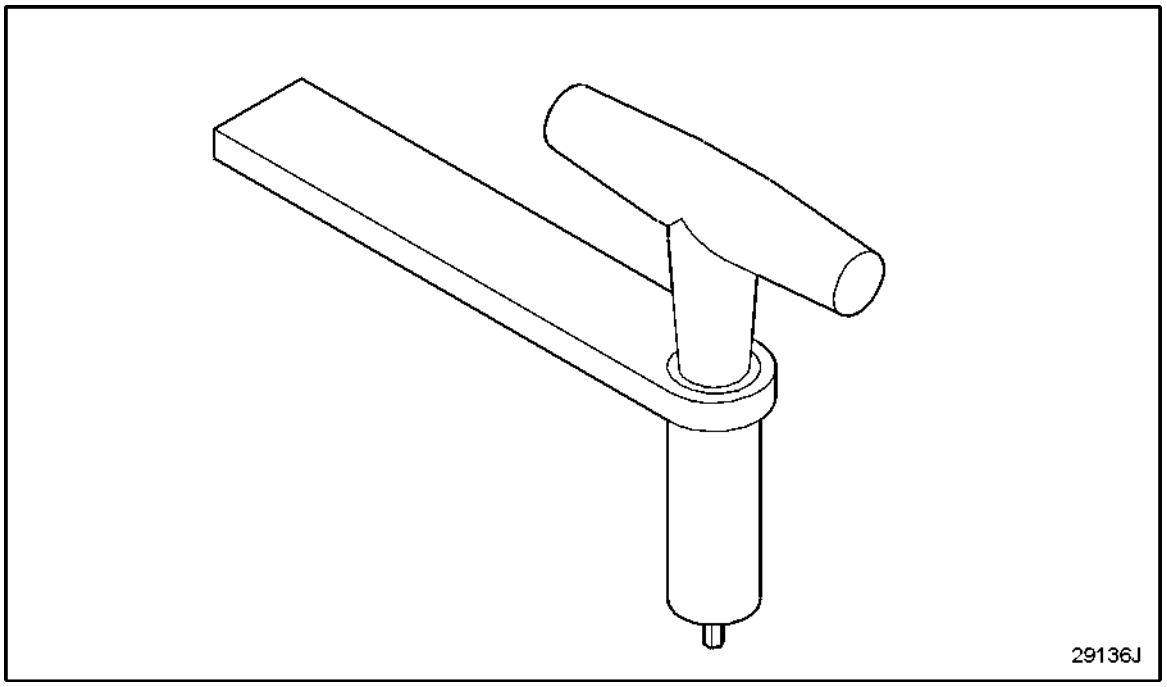


Figure 1631 Governor Adjusting Tool (VHSLS),J 28598–B

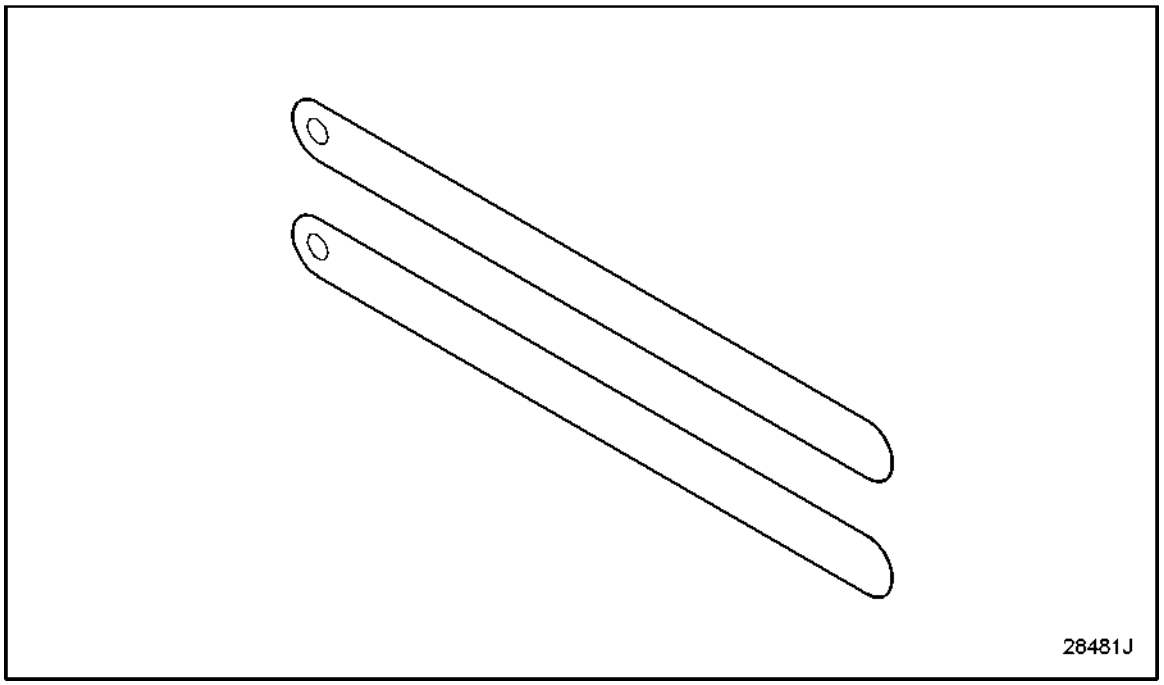


Figure 1632 Governor Gap GA Limiting Speed Gov,J 23185

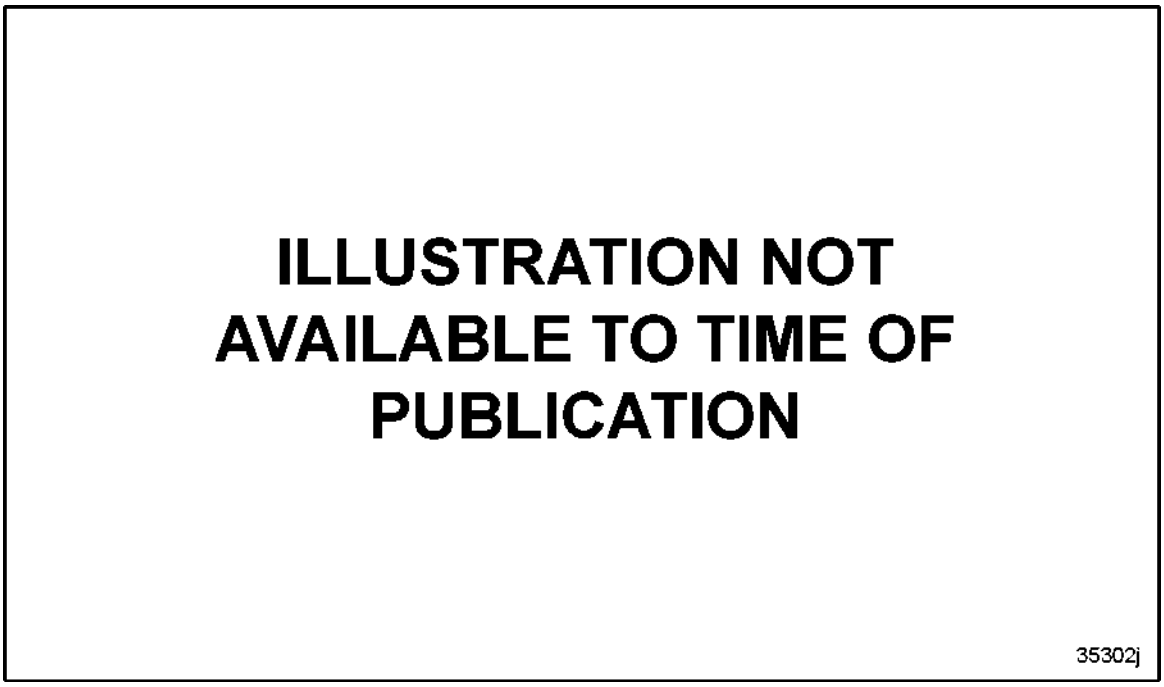


Figure 1633 Governor Gap Gage (.170"), J 5407

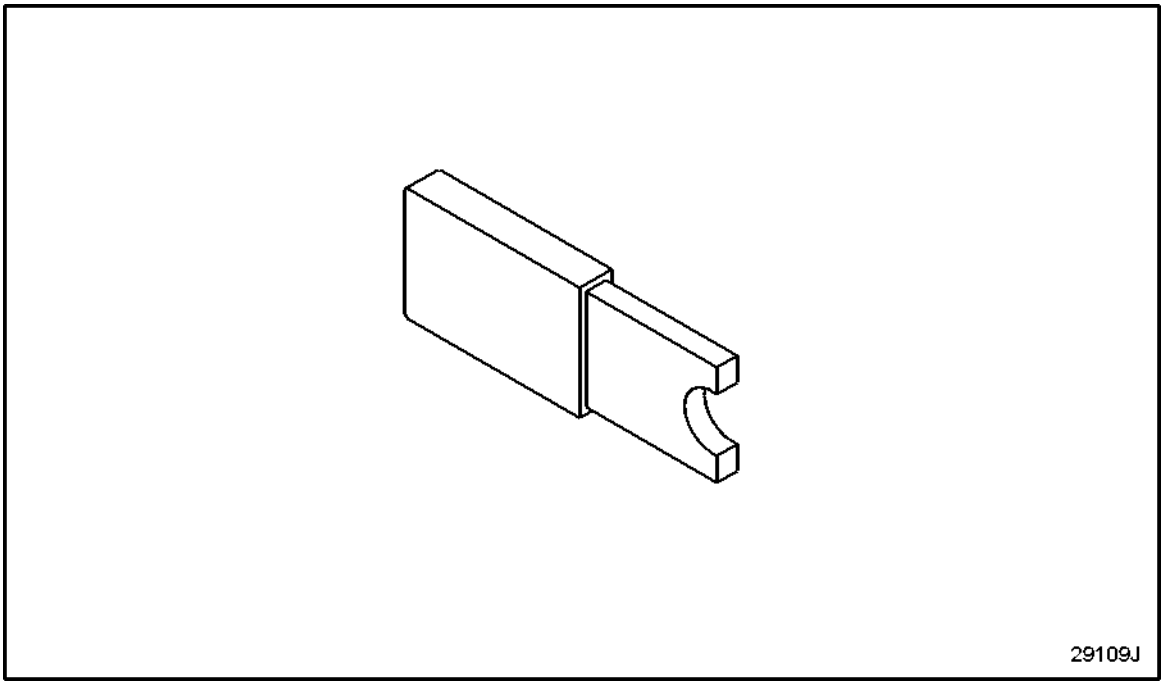


Figure 1634 Governor Gap Gage (.200"), J 23478

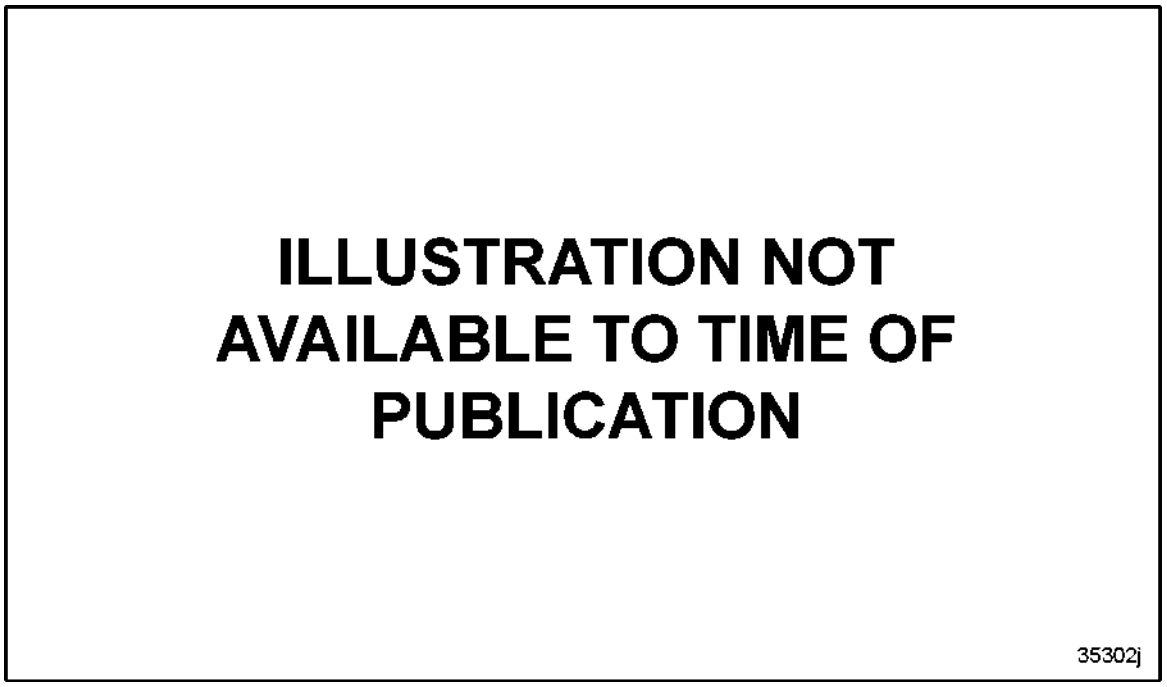


Figure 1635 Governor Gap Gage (.216"),J 29646–A

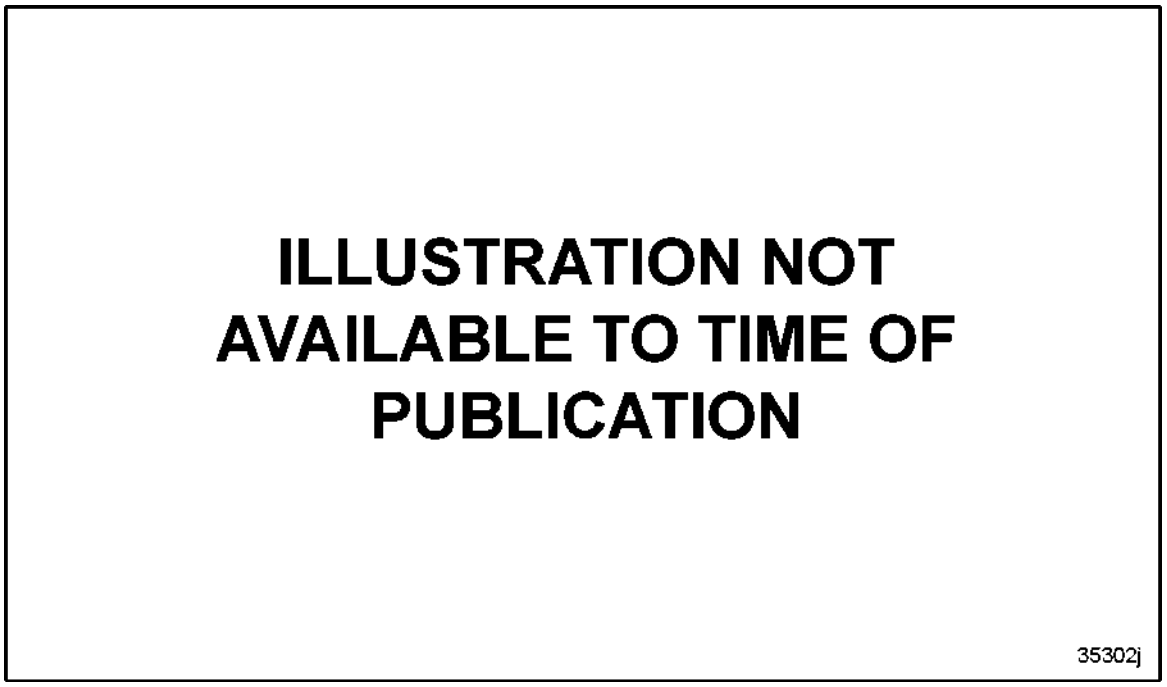


Figure 1636 Governor Link Dial Indicator,J 34184

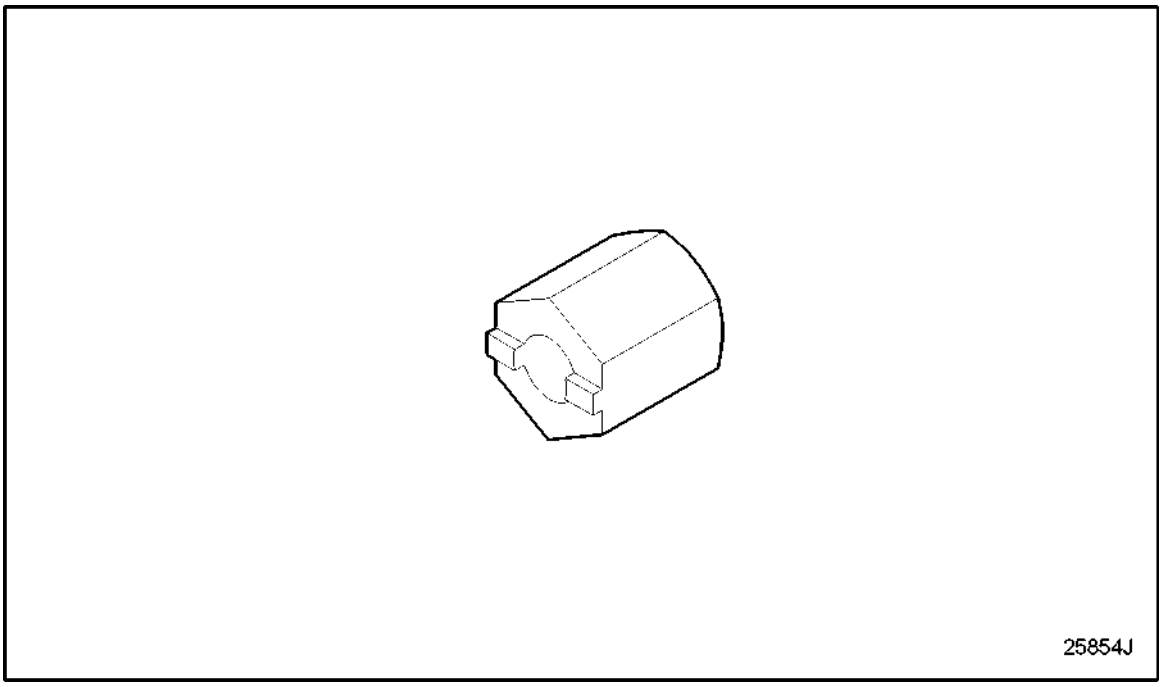


Figure 1637 Governor Nut Wrench,J 1652–01

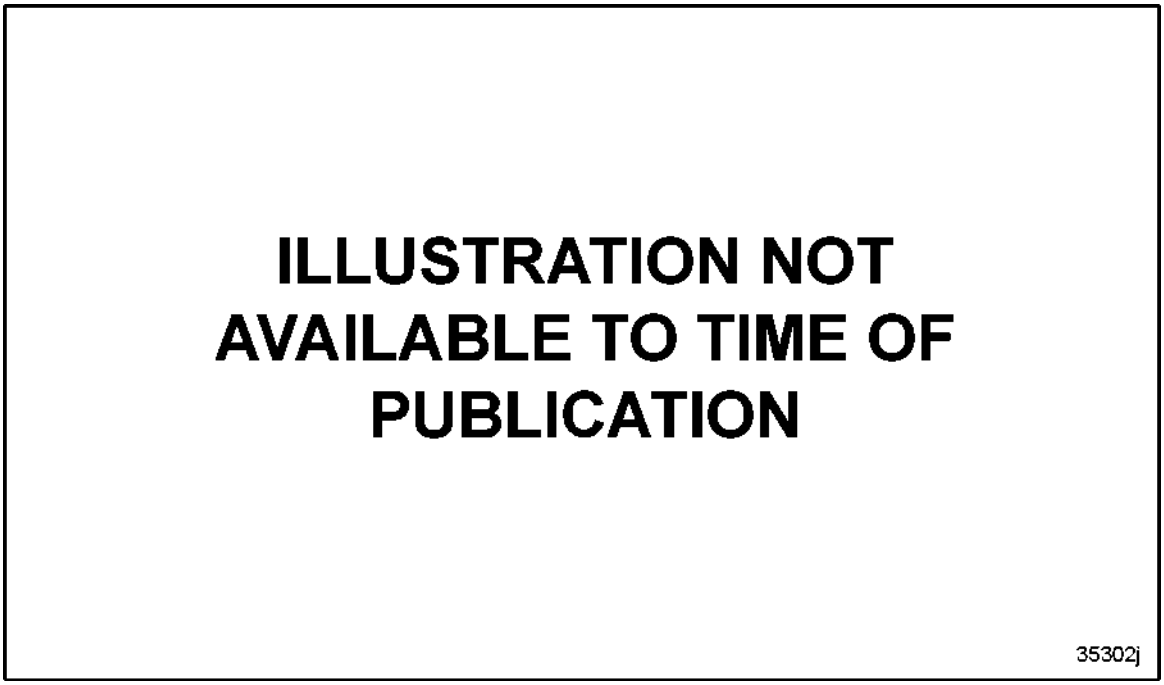


Figure 1638 Governor Retainer Nut SPNR Wrench,J 5895

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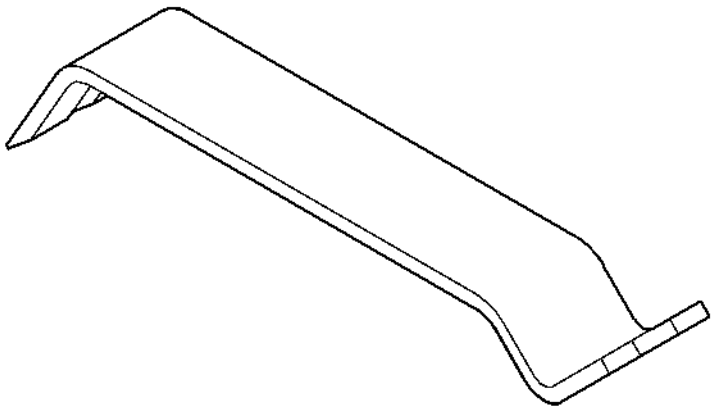
Figure 1639 Governor Setting Kit,J 5345–E



30139J

Figure 1640 Governor Speed Spring Wrench (PSG),J 4873–01

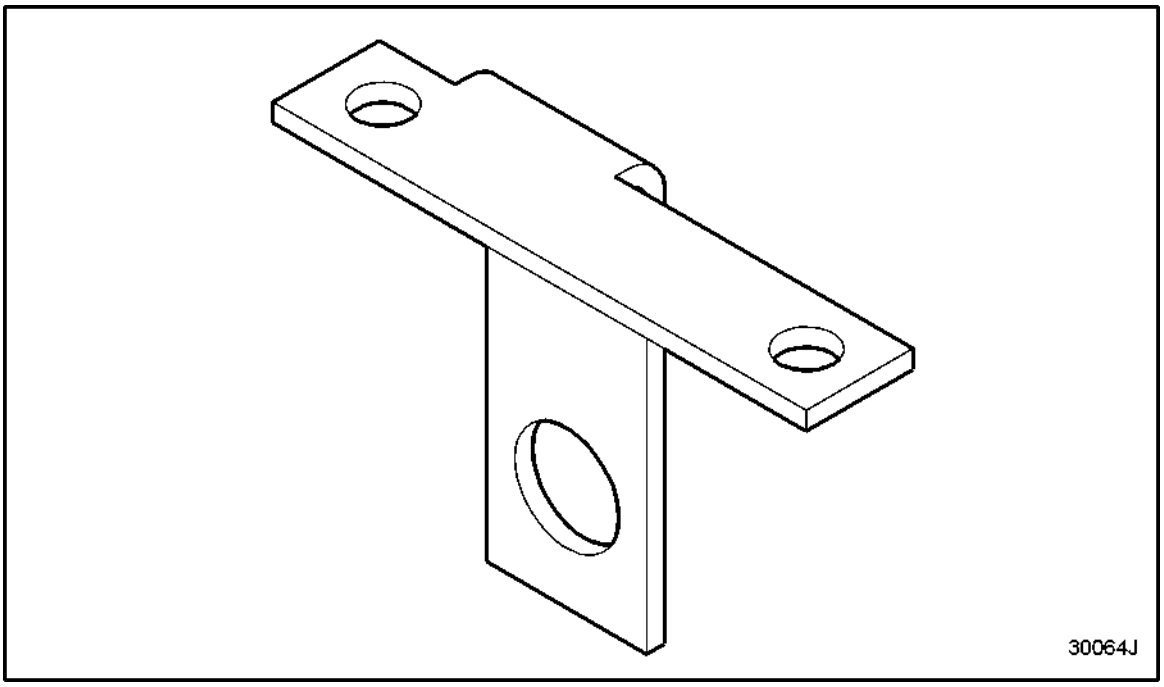


Figure 1641 Hydraulic Governor Linkage GA,J 23475–01

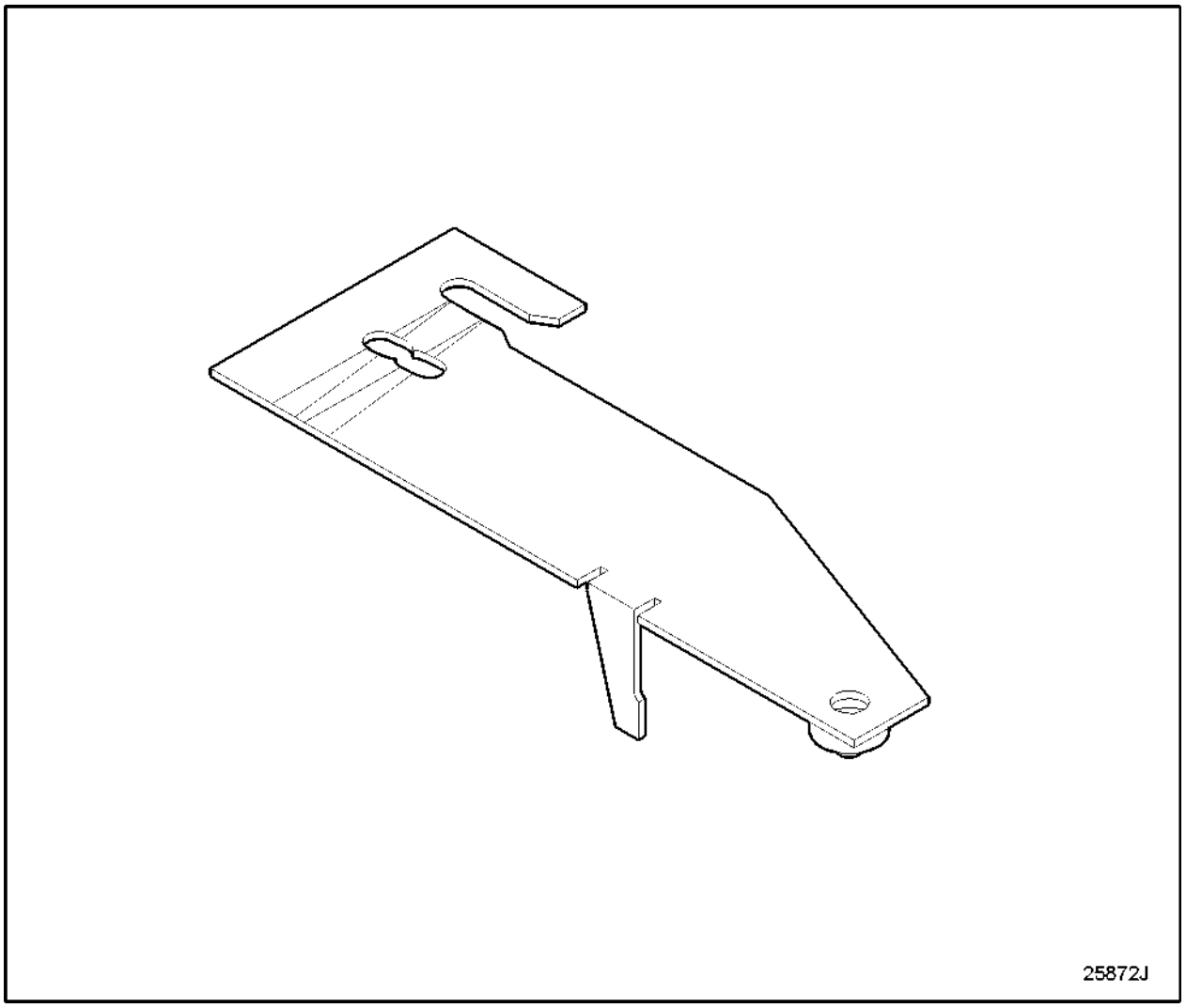


Figure 1642 Hydraulic Governor Linkage Gauge,J 21304

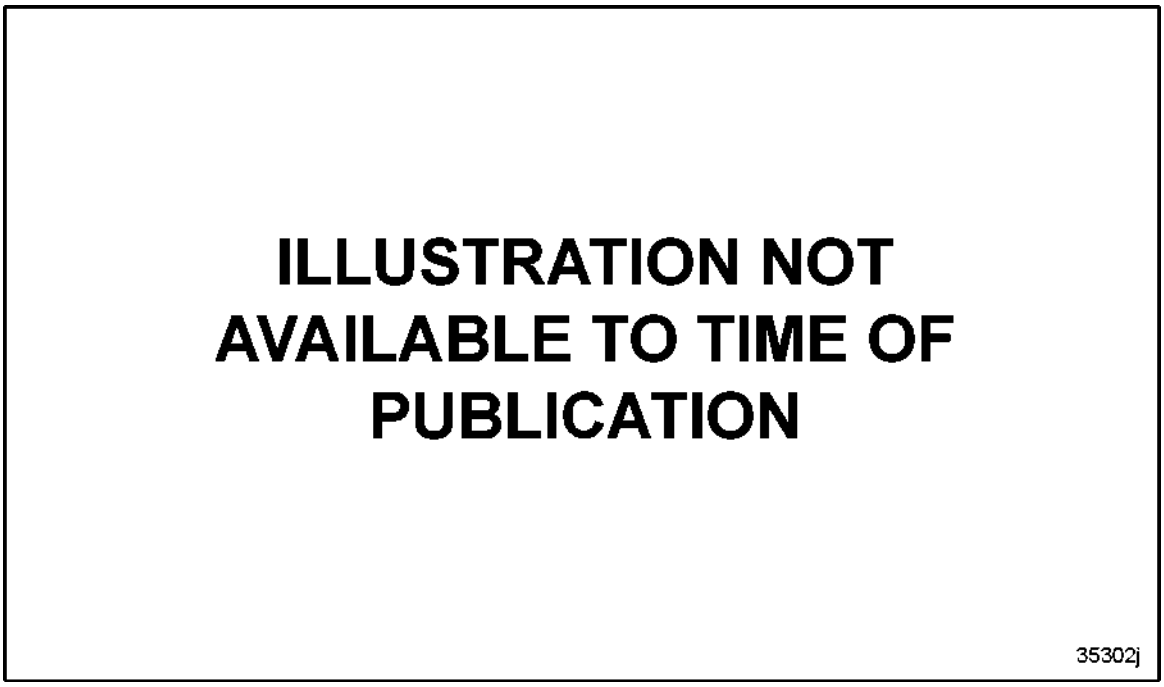


Figure 1643 Injection Pump Plunger Pin,J 41162

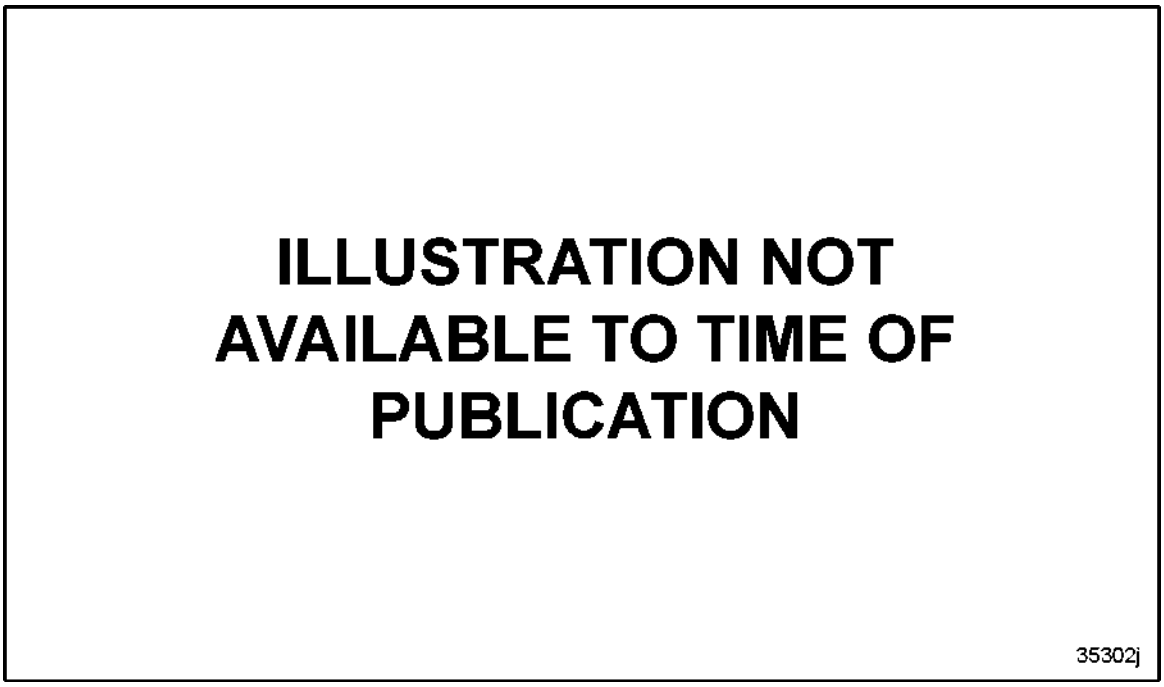


Figure 1644 Injection Pump Timing Pin,J 41161

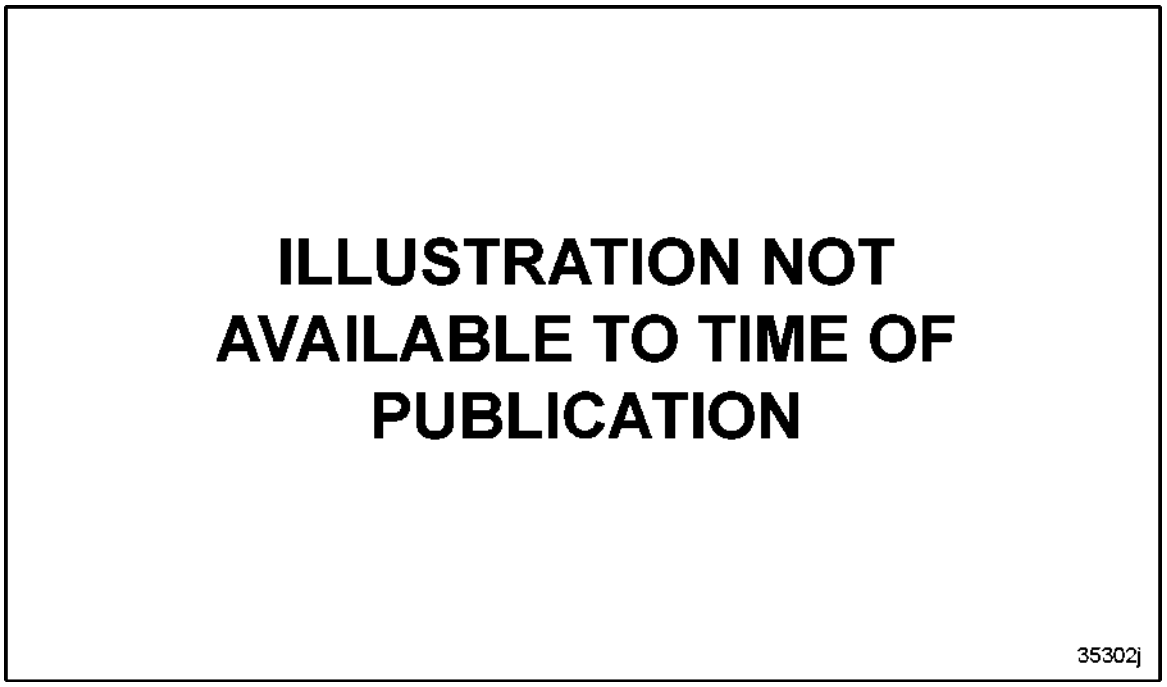


Figure 1645 Injector Flooding Bar,J 29522

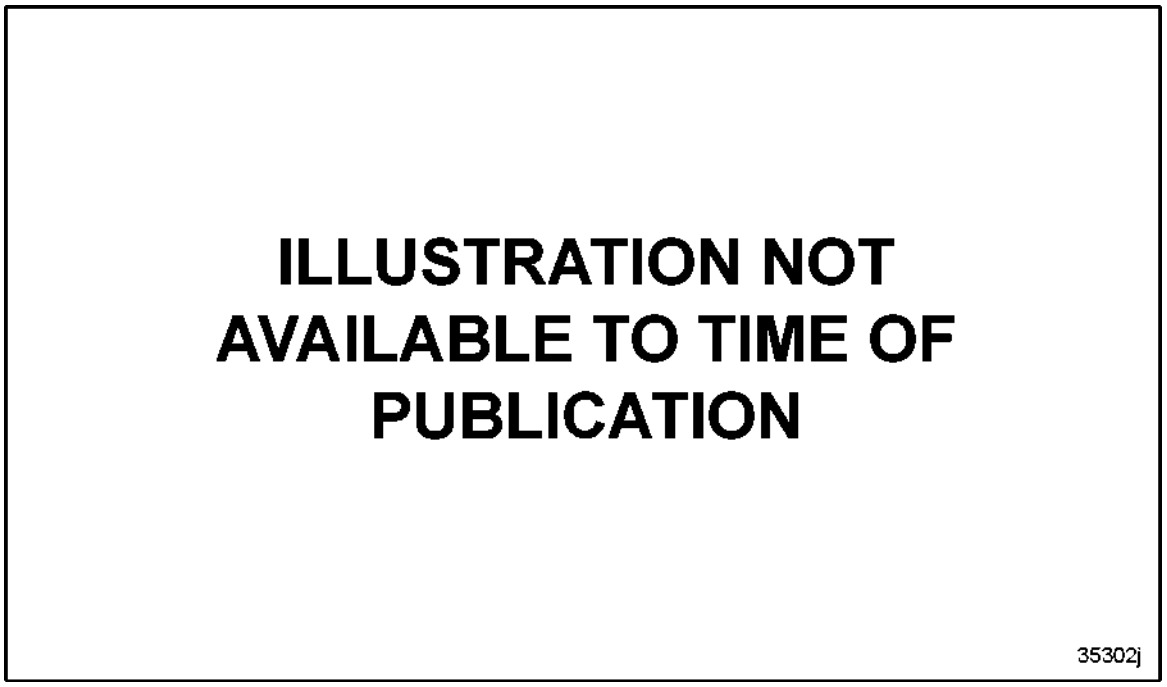


Figure 1646 Injector Timing Gage (2.710),J 7186–A

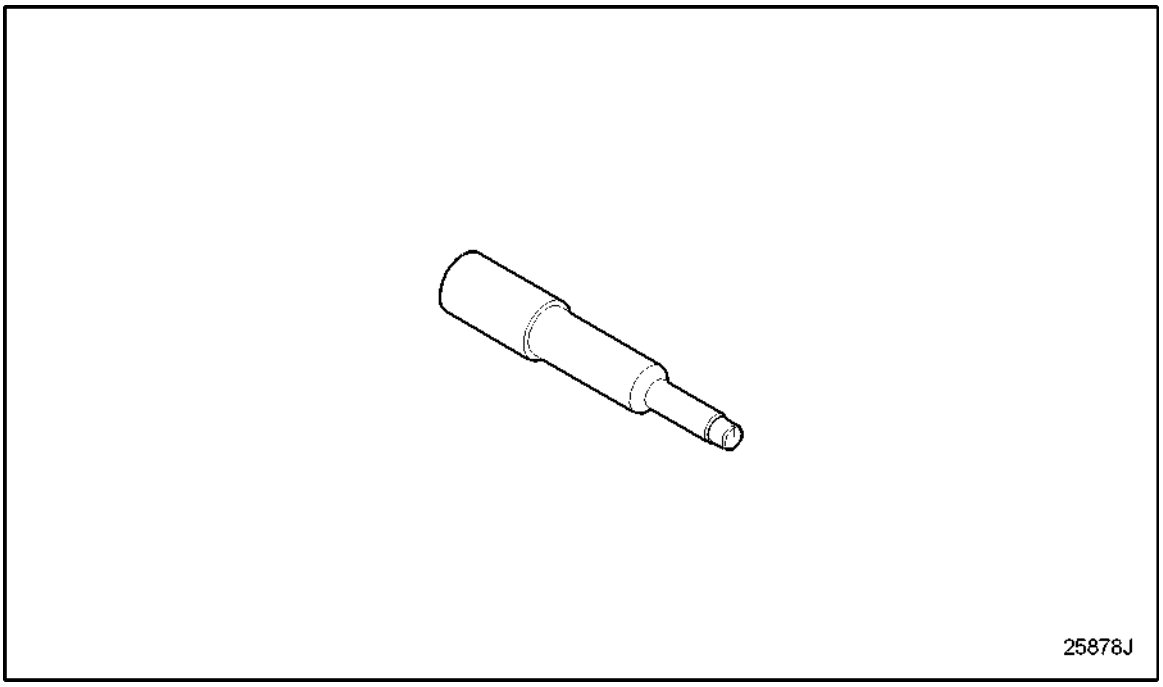


Figure 1647 Lever Positioning Pin (16V71 & 92),J 21779

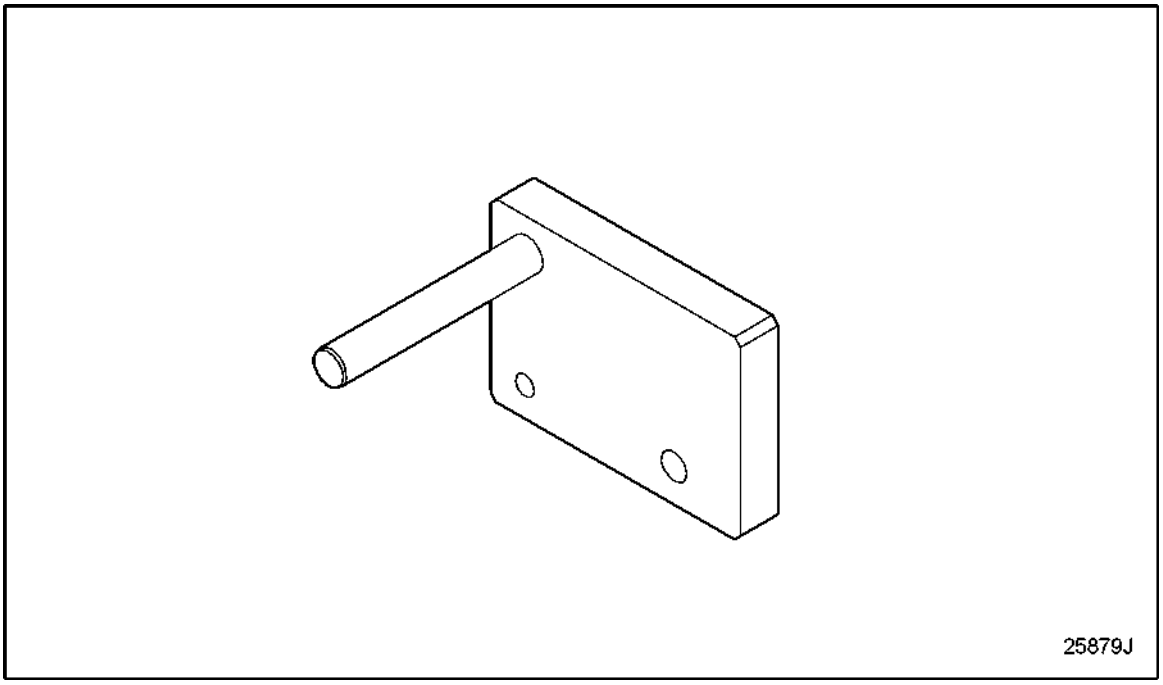


Figure 1648 Limiting Speed Mech Linkage Gov GAJ 21780

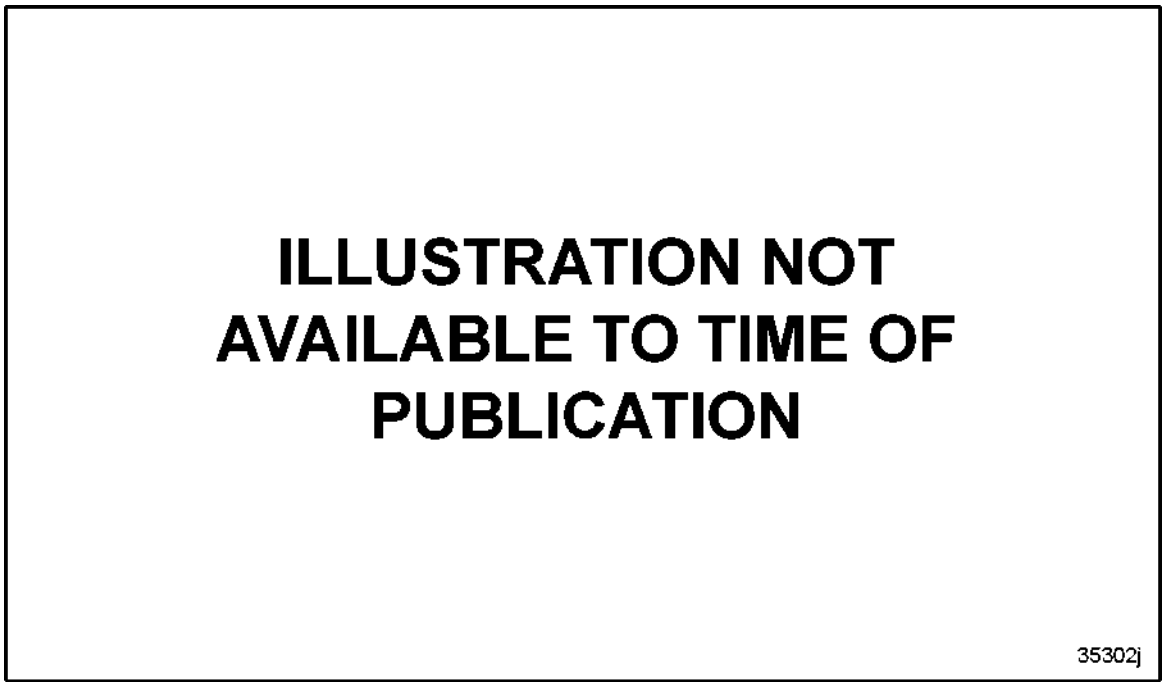


Figure 1649 Monometer (12"-0-12"),J 7333–6

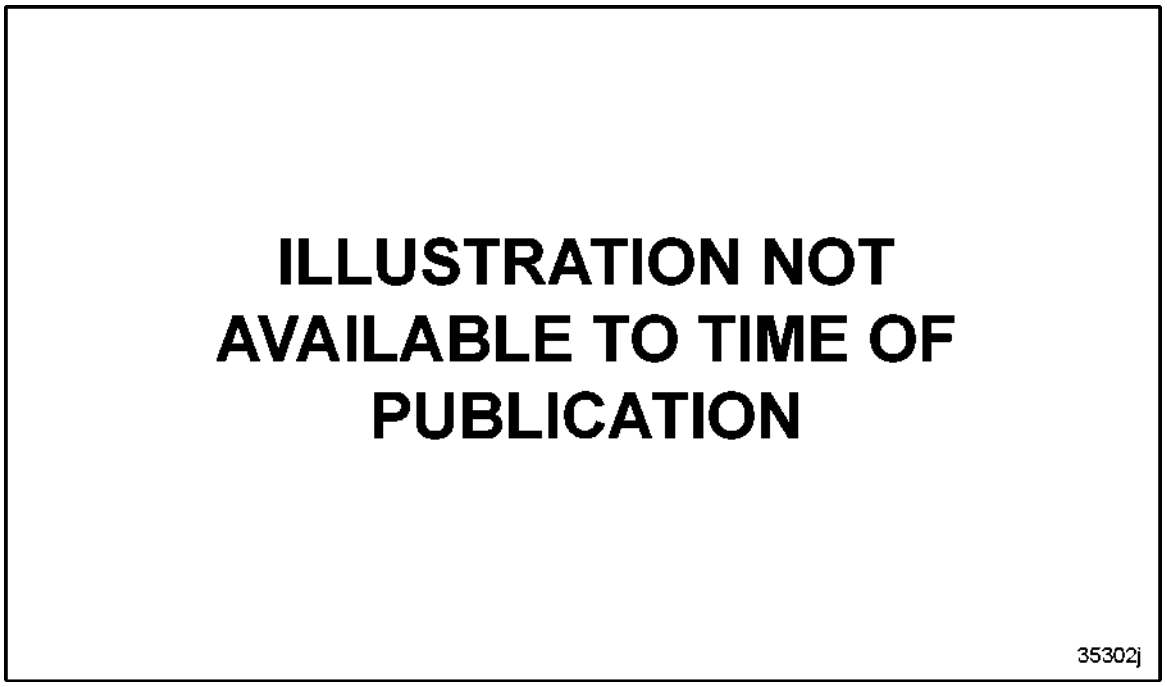


Figure 1650 Manometer (18"-0-18"),J 8639–01

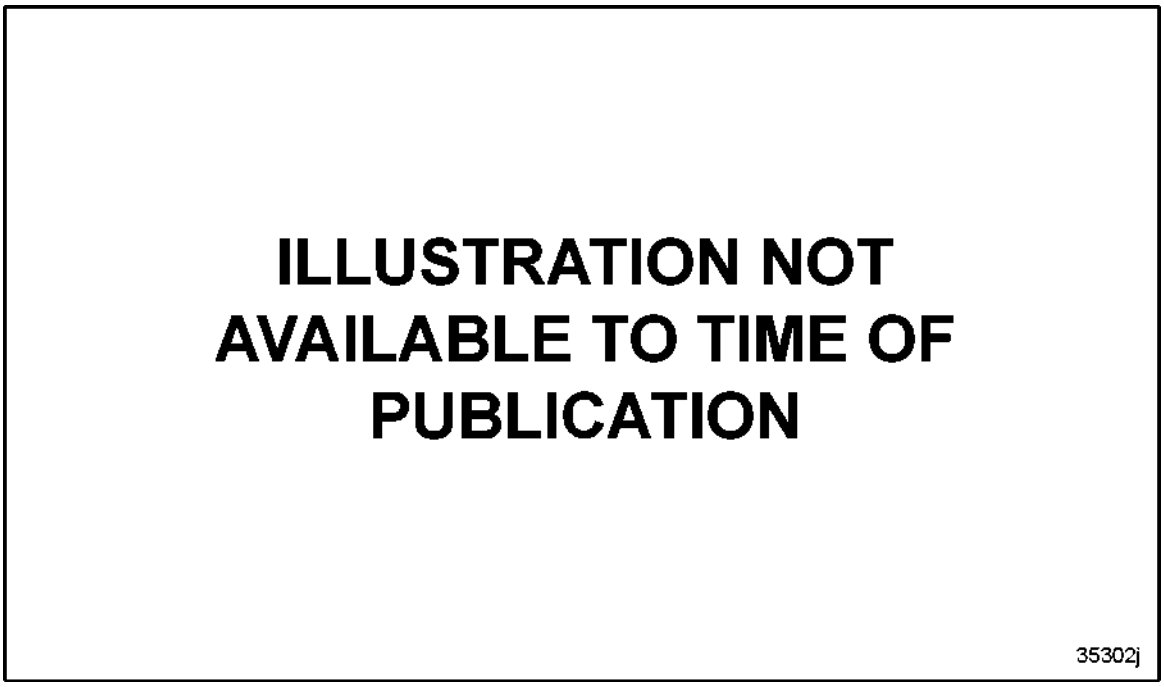


Figure 1651 Manometer (2-1/2"- 0 -2-1/2"), J 9531–23

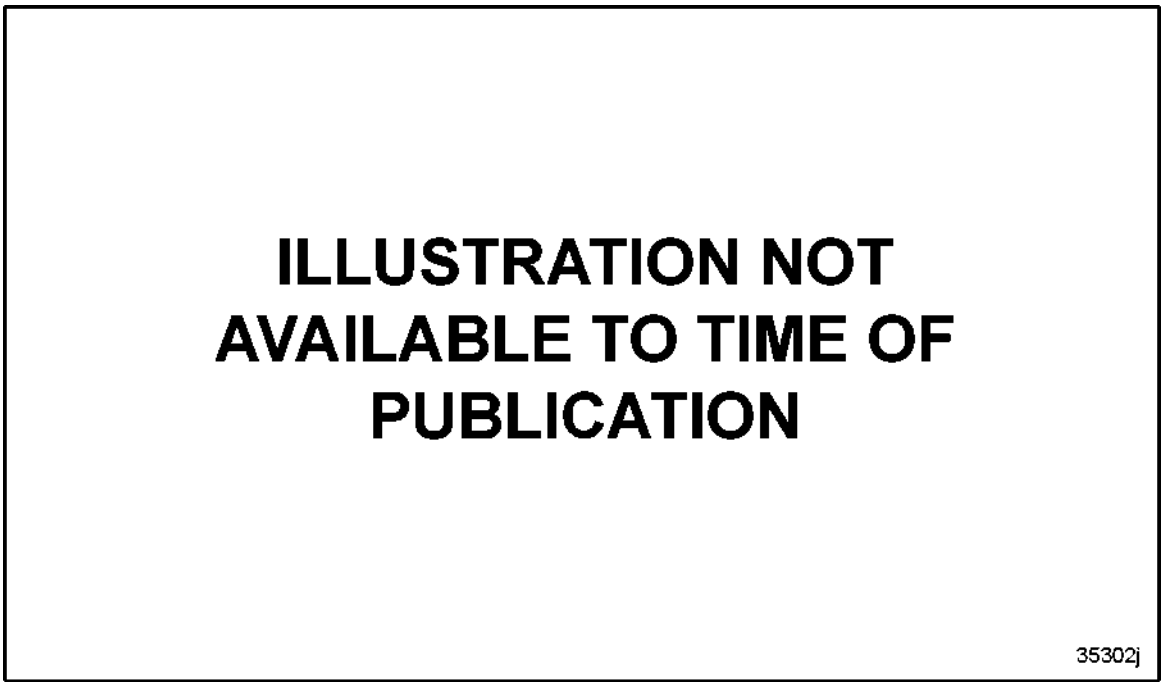


Figure 1652 Manometer (24"-0-24"), J 29021

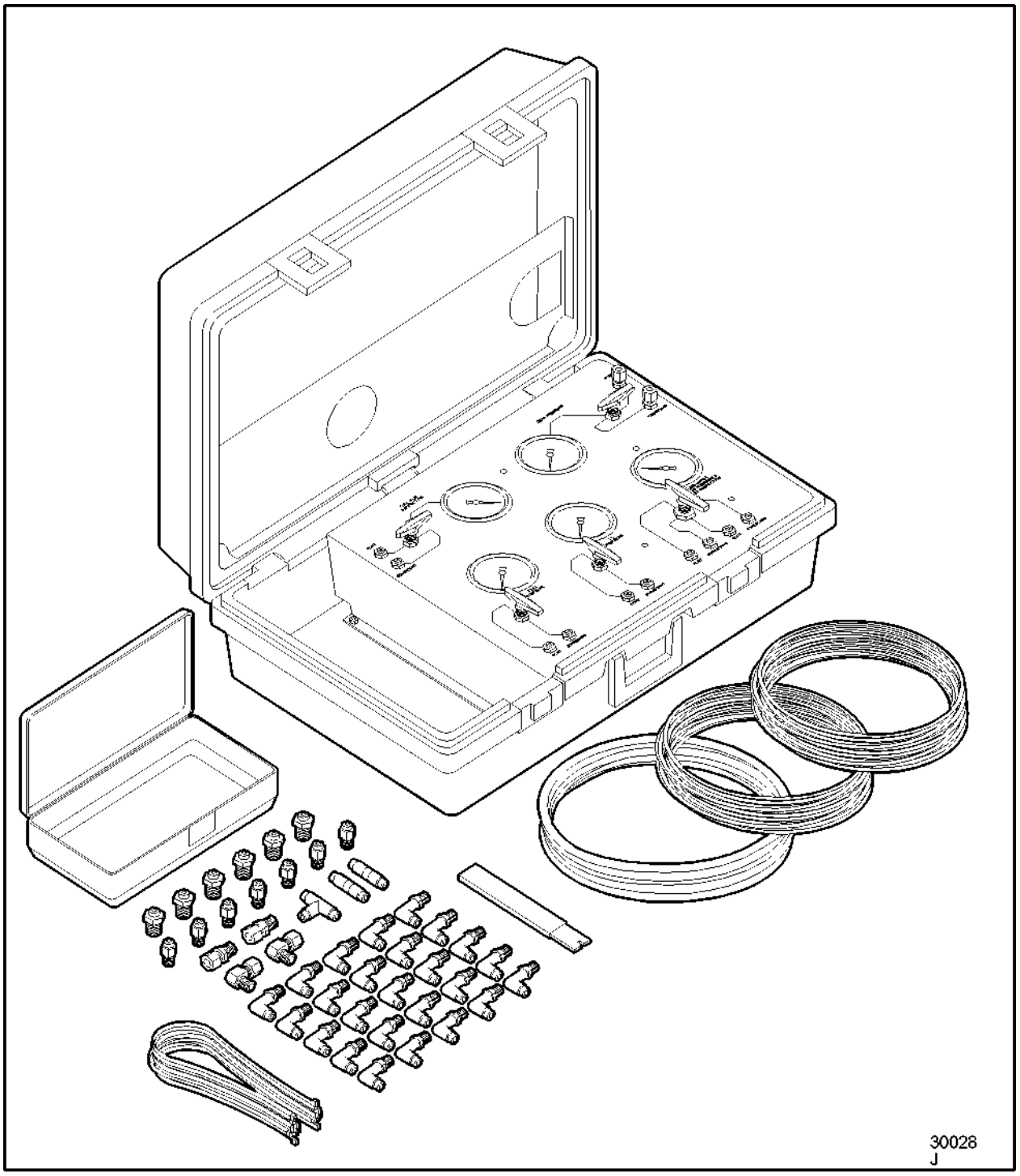


Figure 1653 Marine Engine Diagnostic Kit, J 38477–A

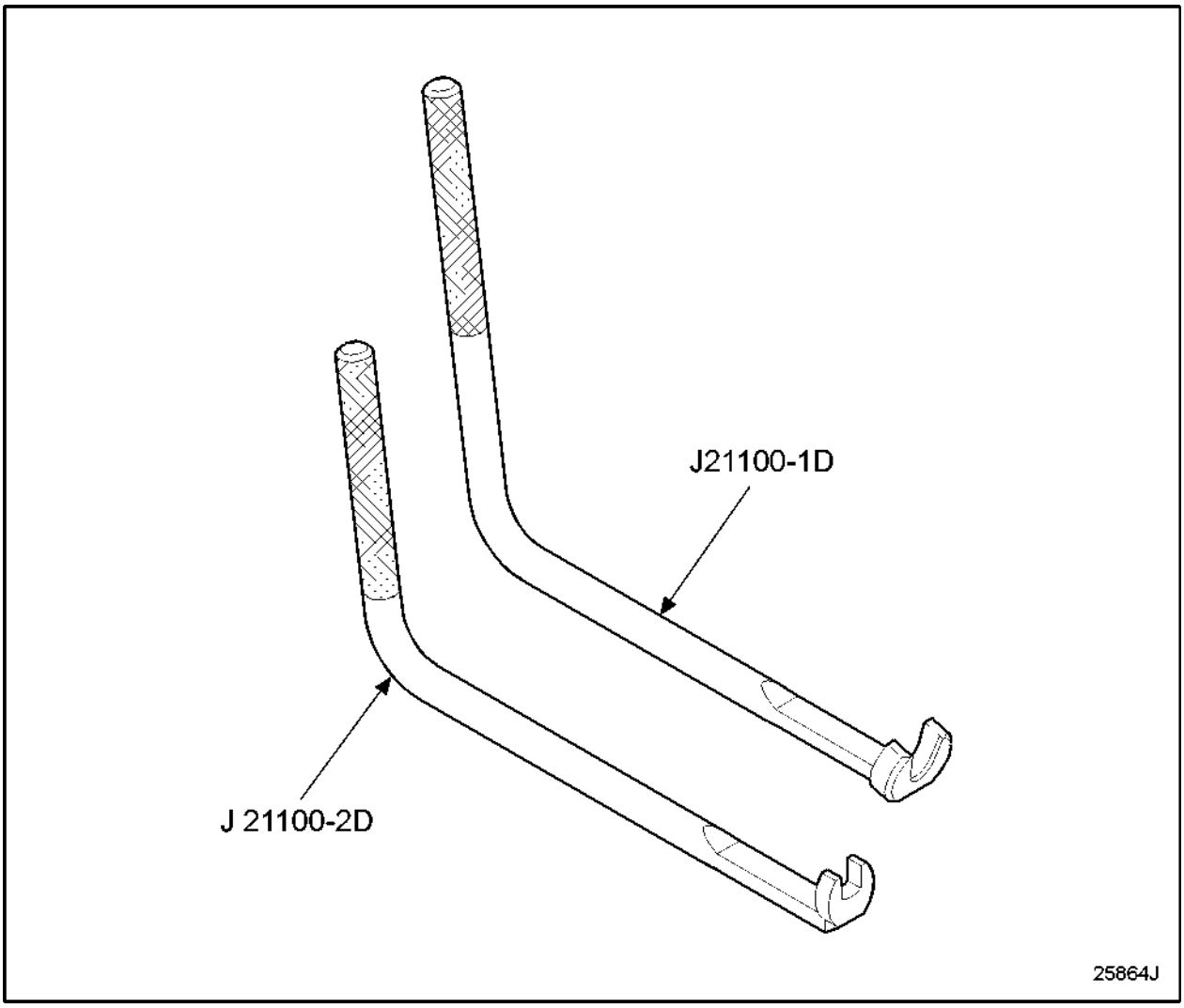


Figure 1654 Push Rod Adjusting Wrench Set, J 21100–E

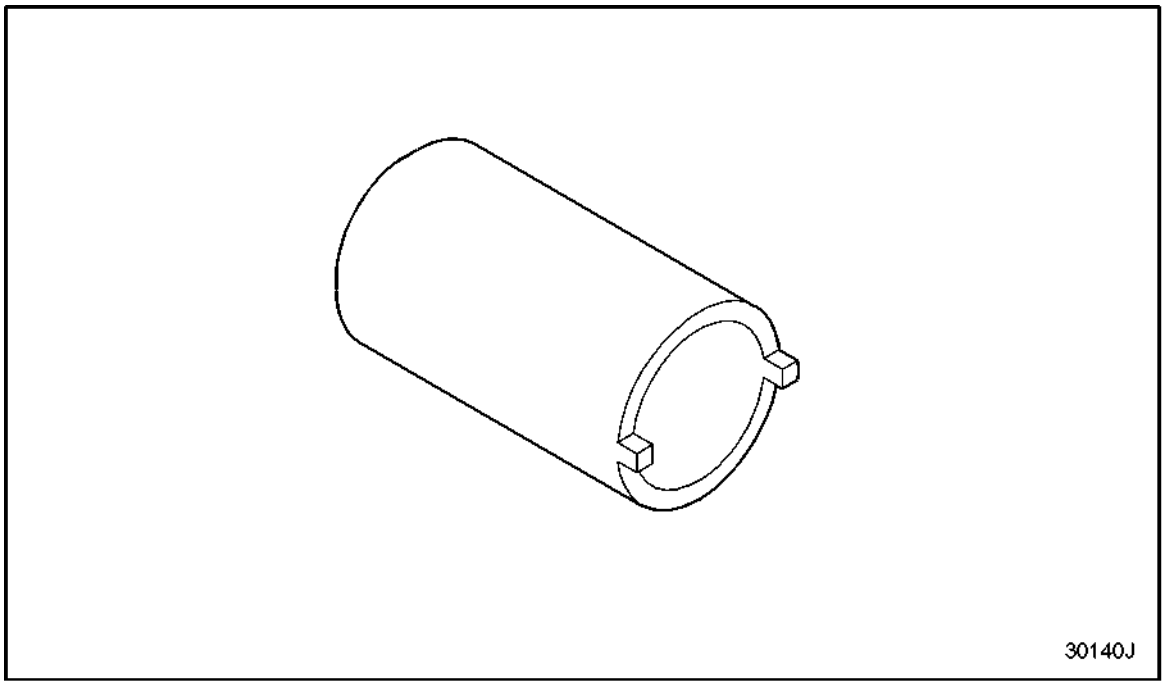


Figure 1655 **Spanner Nut Socket Hi Speed Spring,** J 5345–12 (old number J 5345–5)

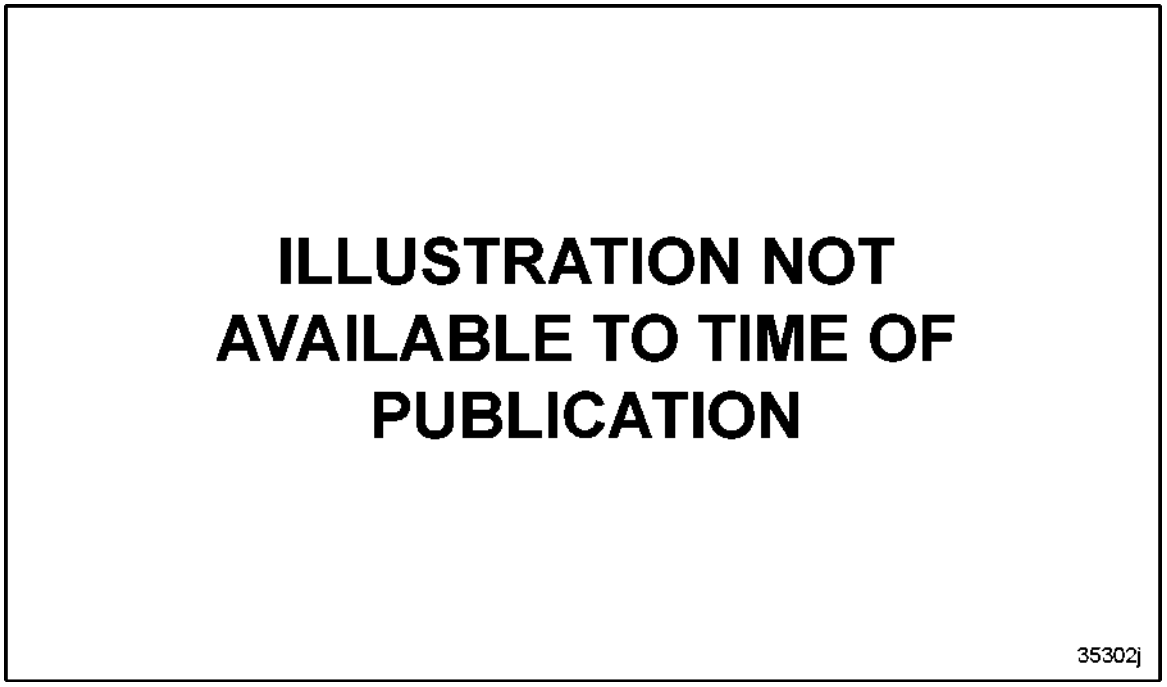


Figure 1656 **Thermometer (0-300deg F),** J 9531–17

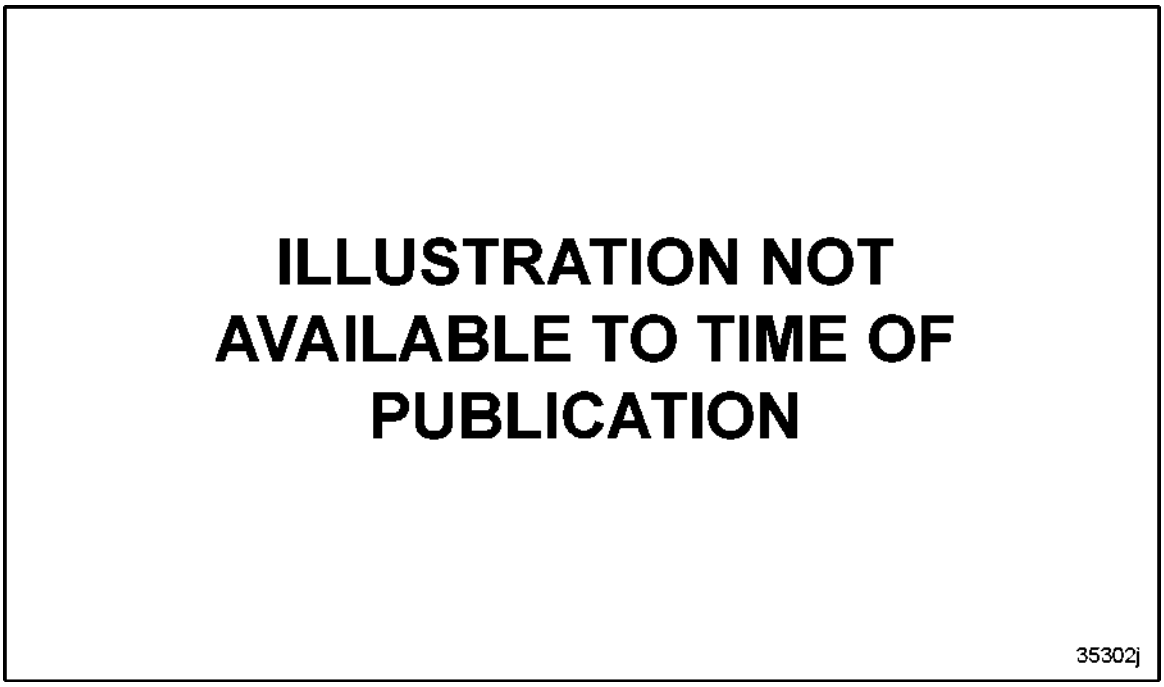


Figure 1657 Throttle Delay Pin GA, .690GO-.072NG,J 25558

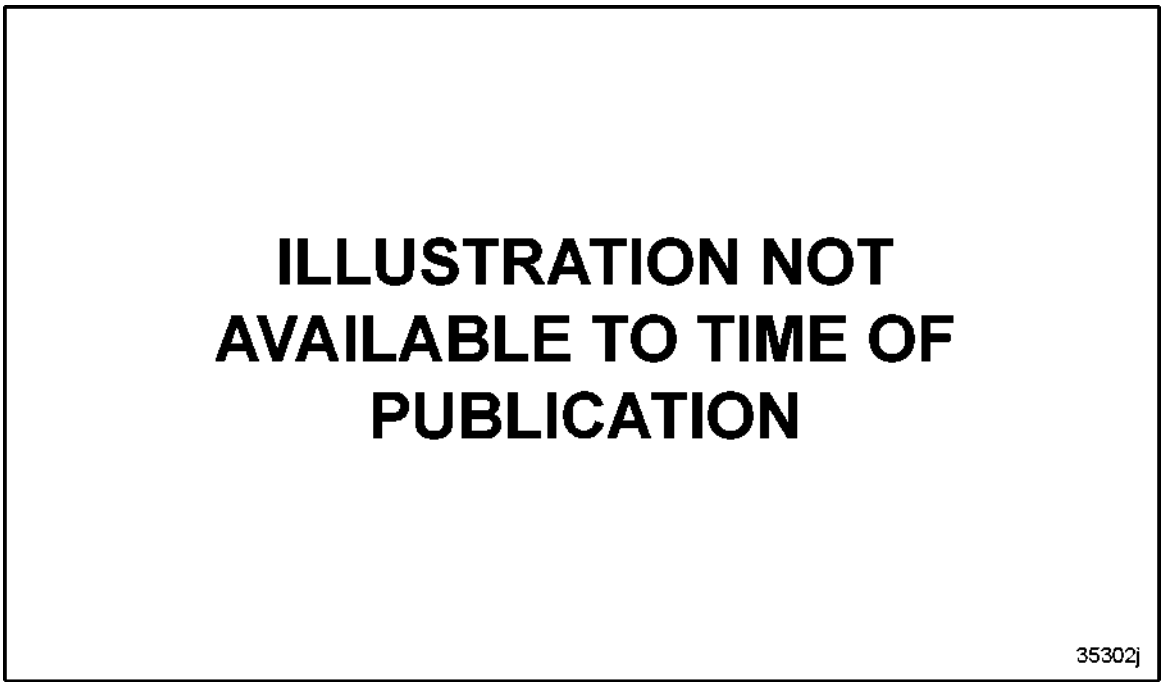


Figure 1658 Tune Up Kit,J 34651–A

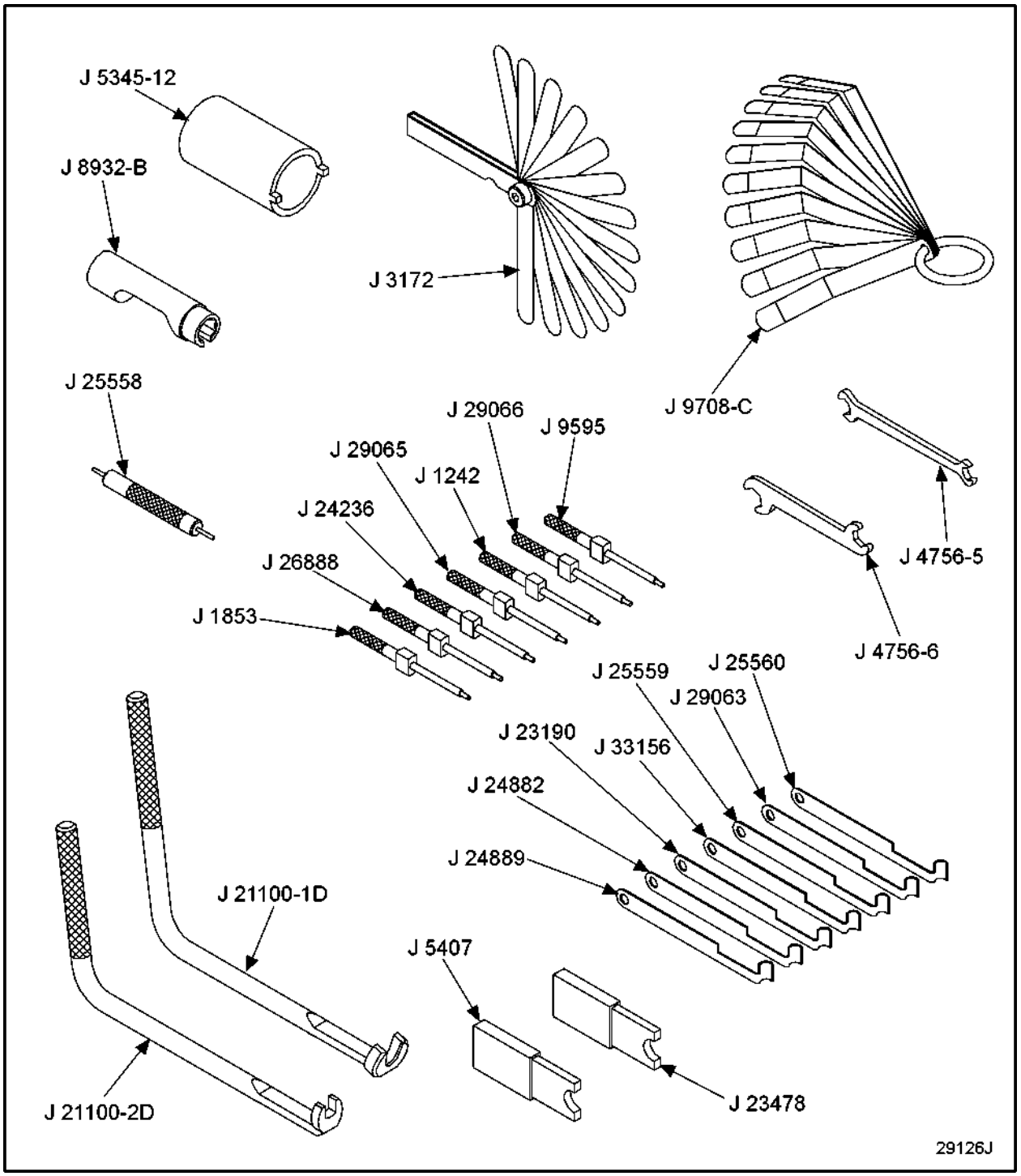


Figure 1659 Tune Up Kit,J 24790–D

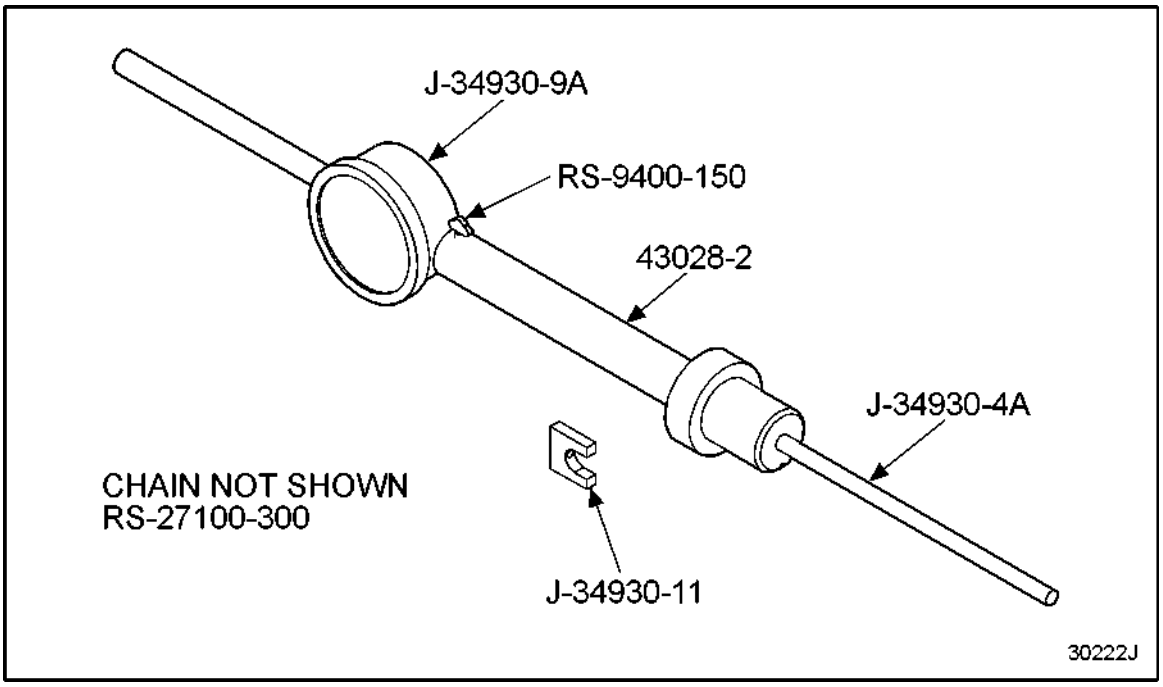


Figure 1660 Crankshaft Position Timing Tool,J 43028

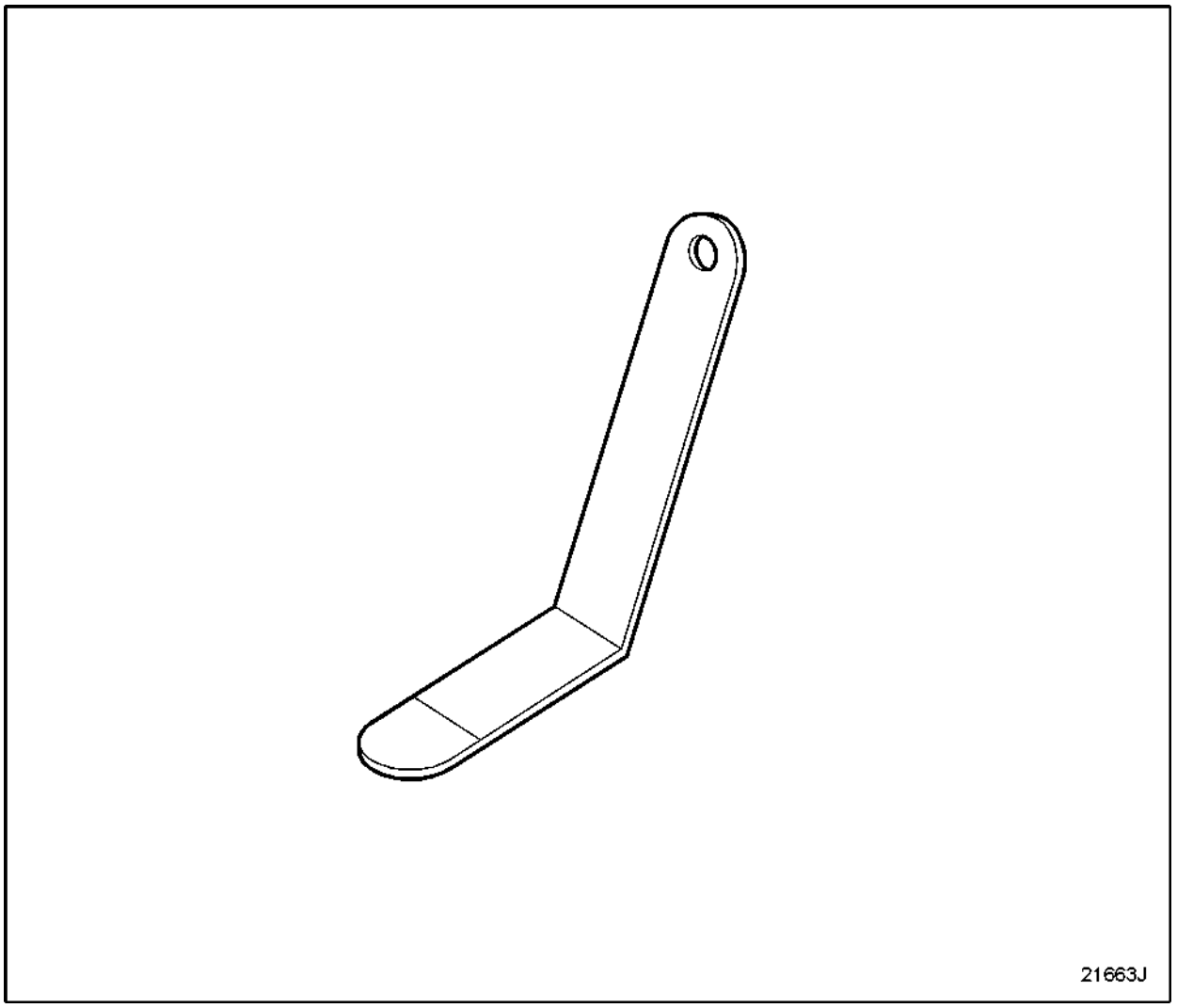


Figure 1661 Feeler GA (.20) Exhaust VLV Lash,J 9708–20

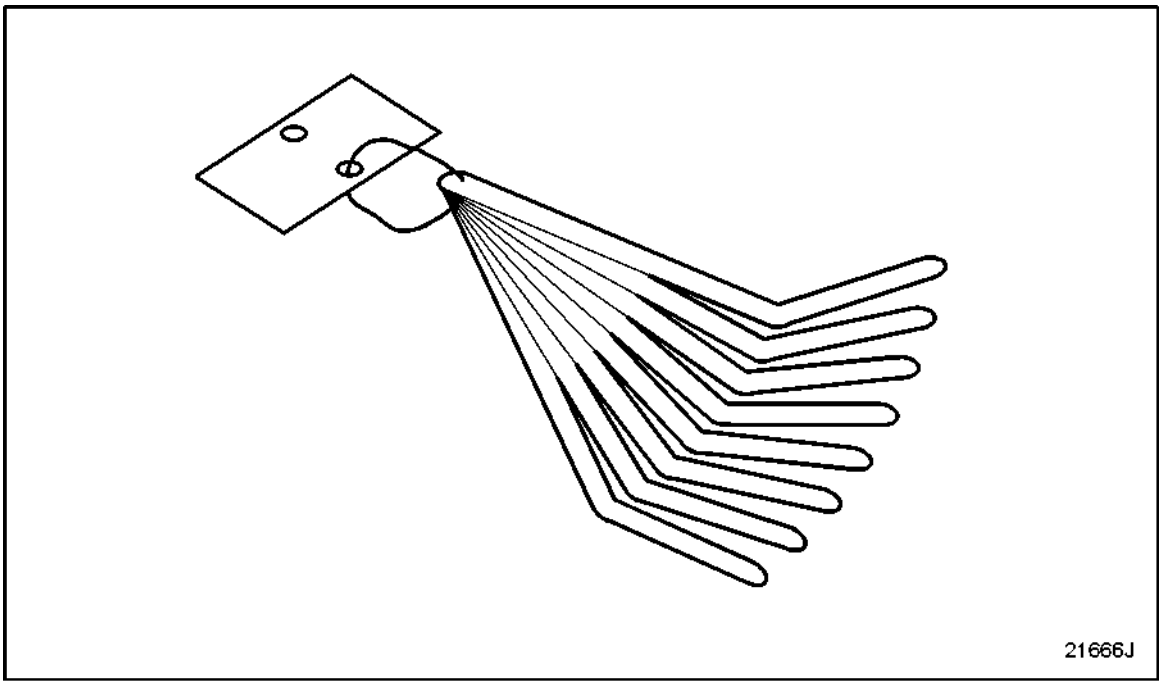


Figure 1662 Feeler GA Set,J 9708–C

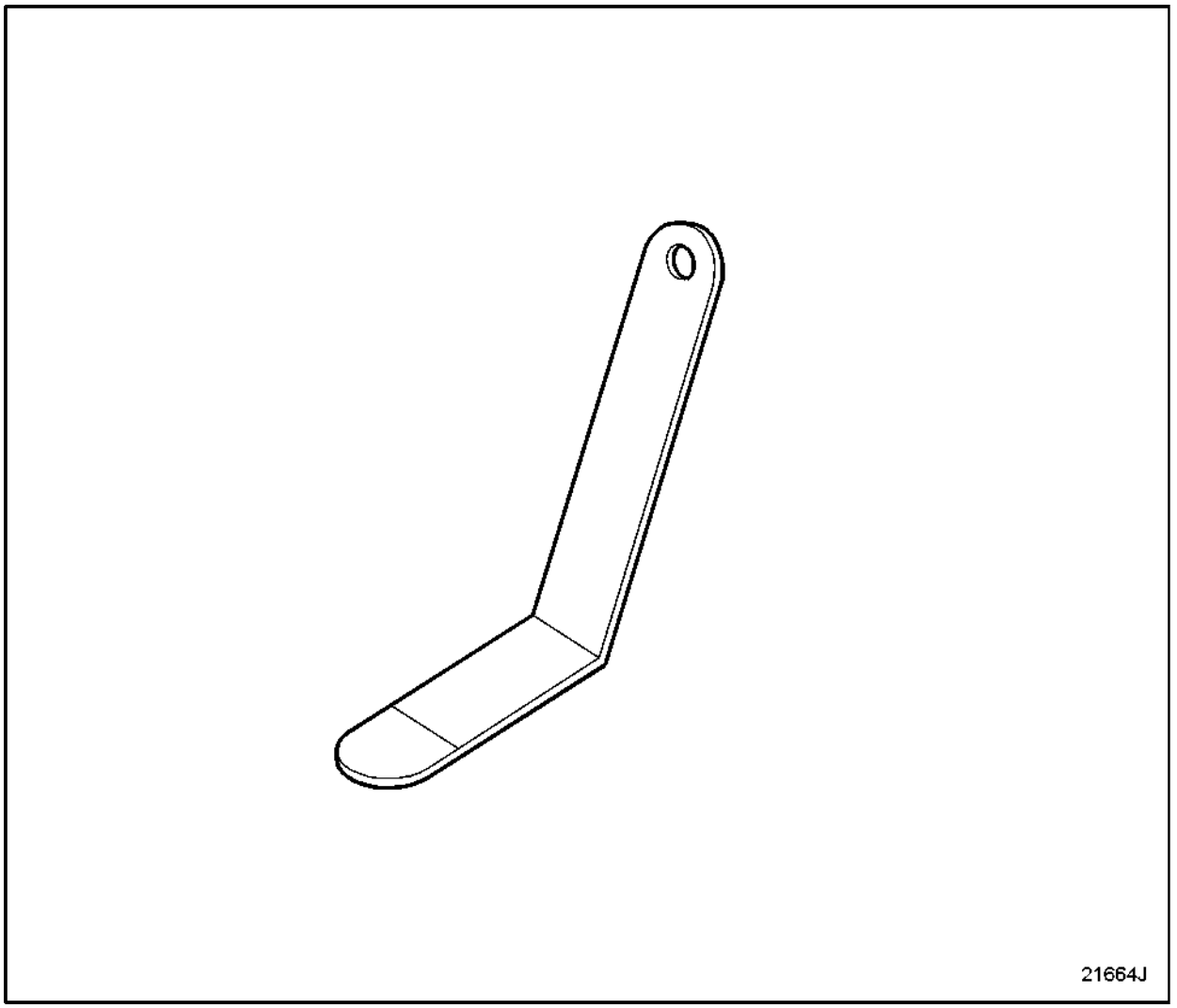


Figure 1663 Feeler Gage (.800) Intake VLV Lach,J 9708–21

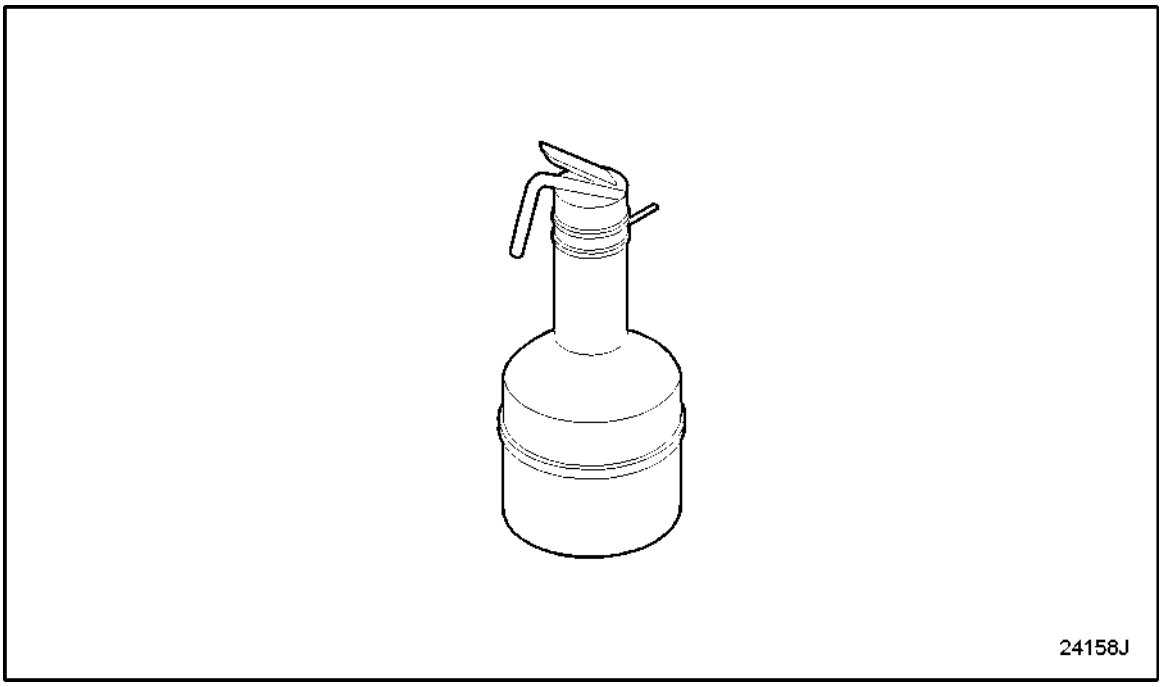


Figure 1664 Fuel System Primer,J 5956

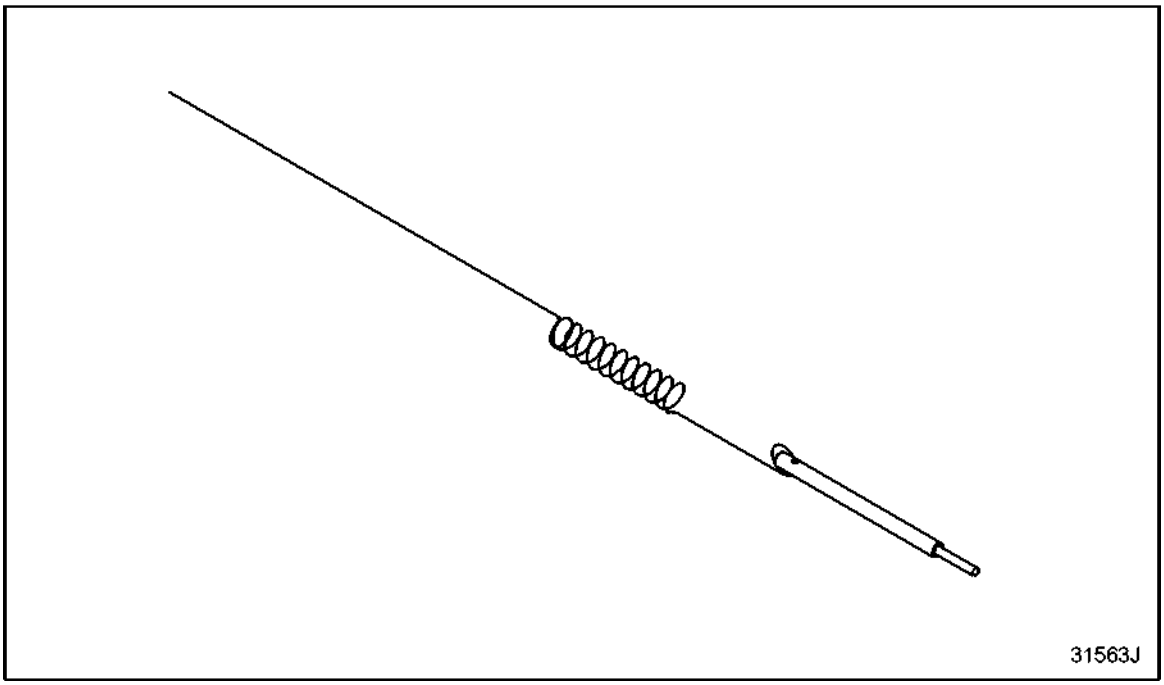


Figure 1665 Injector Control Rack pin,J 29523

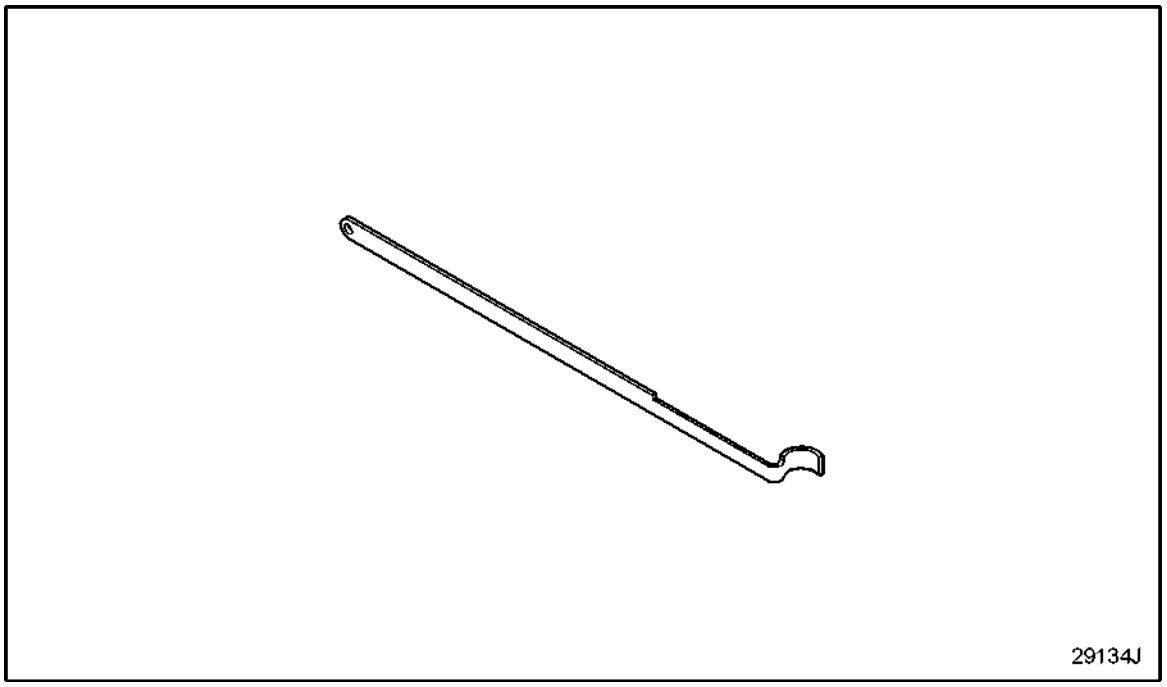


Figure 1666 Injector Control Rack Gage (.160),J 26645

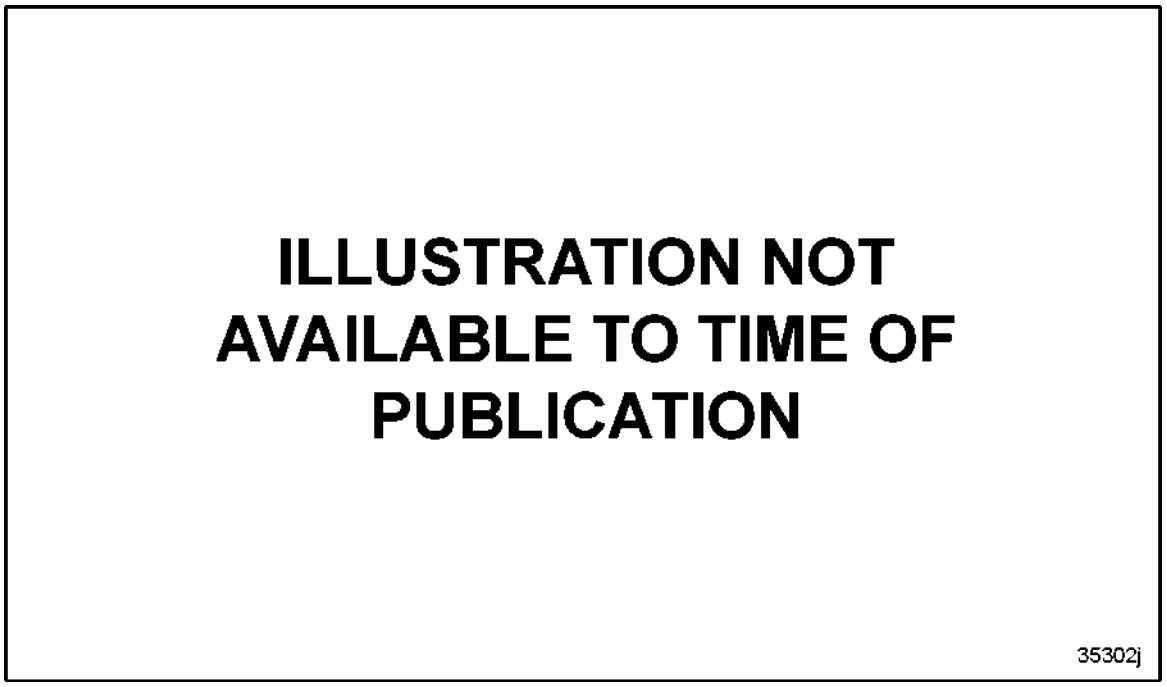


Figure 1667 Injector Rack Gage (.200),J 35586

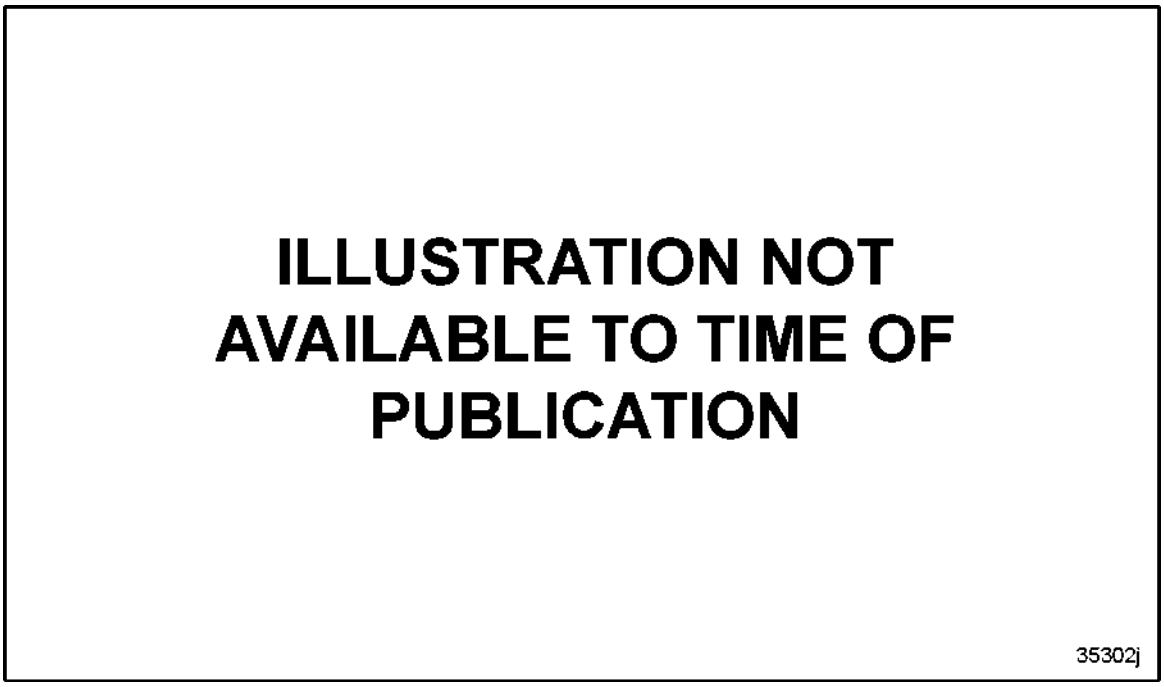


Figure 1668 Injector Rack Gage (.220),J 29285

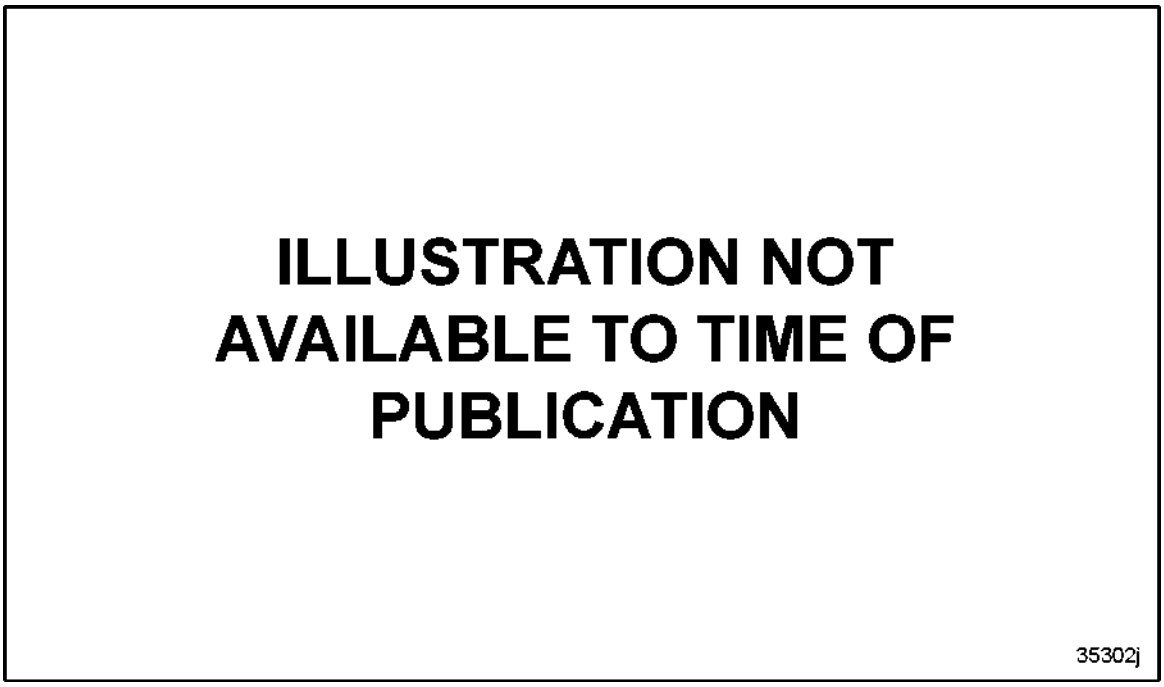


Figure 1669 Injector Rack Gage (.290),J 26646

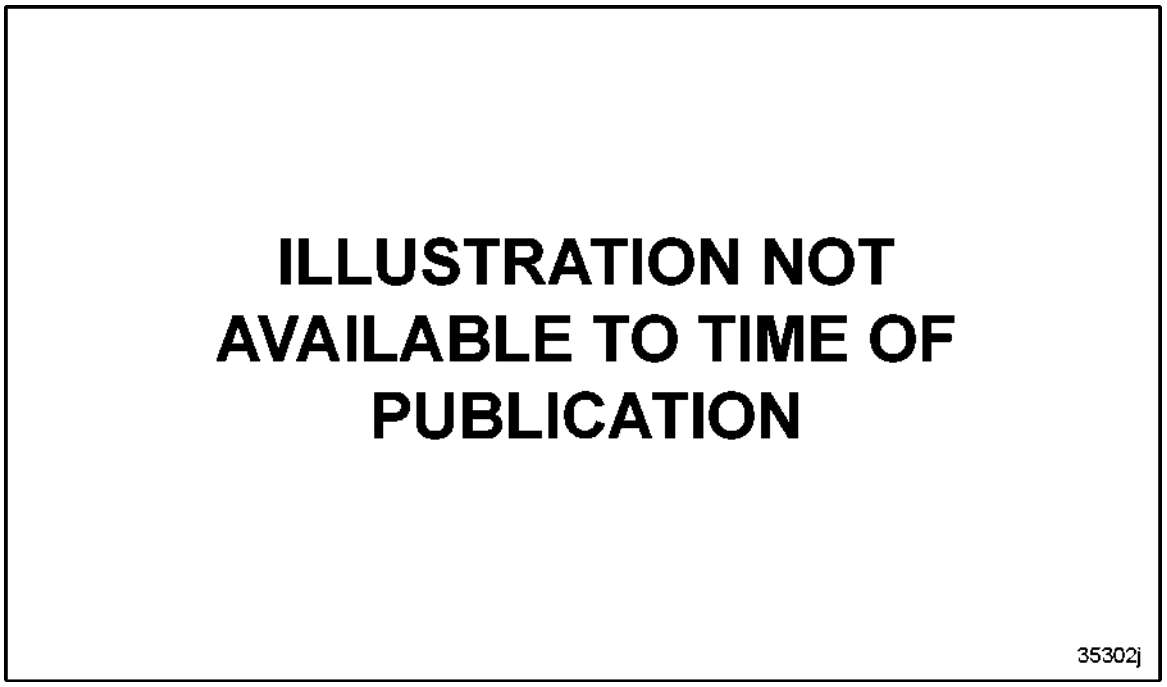


Figure 1670 Injector Rack Gage (.345),J 24889

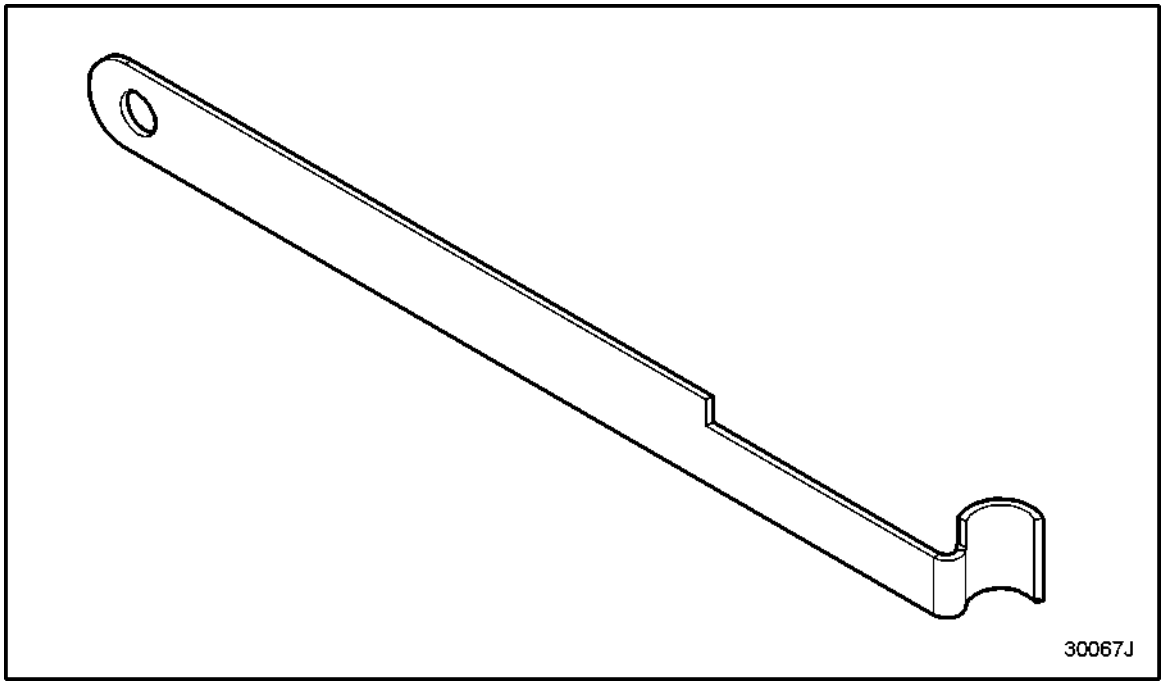


Figure 1671 Injector Rack Gage (.365),J 28779

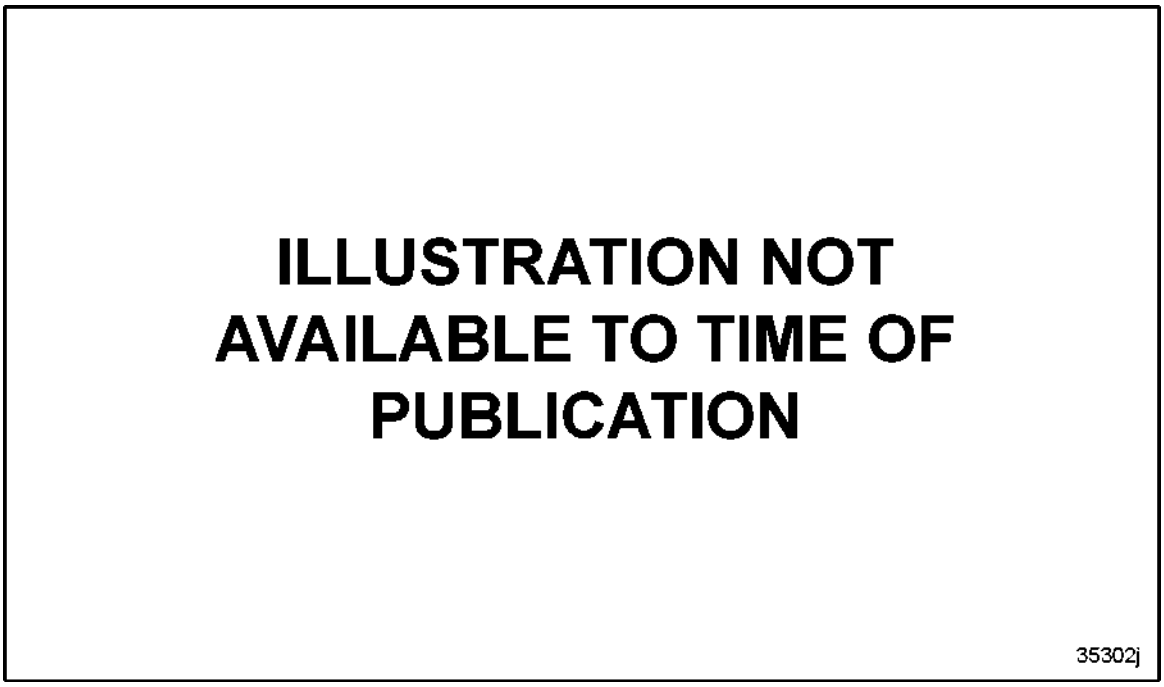


Figure 1672 Injector Rack Gage (.385), J 24882

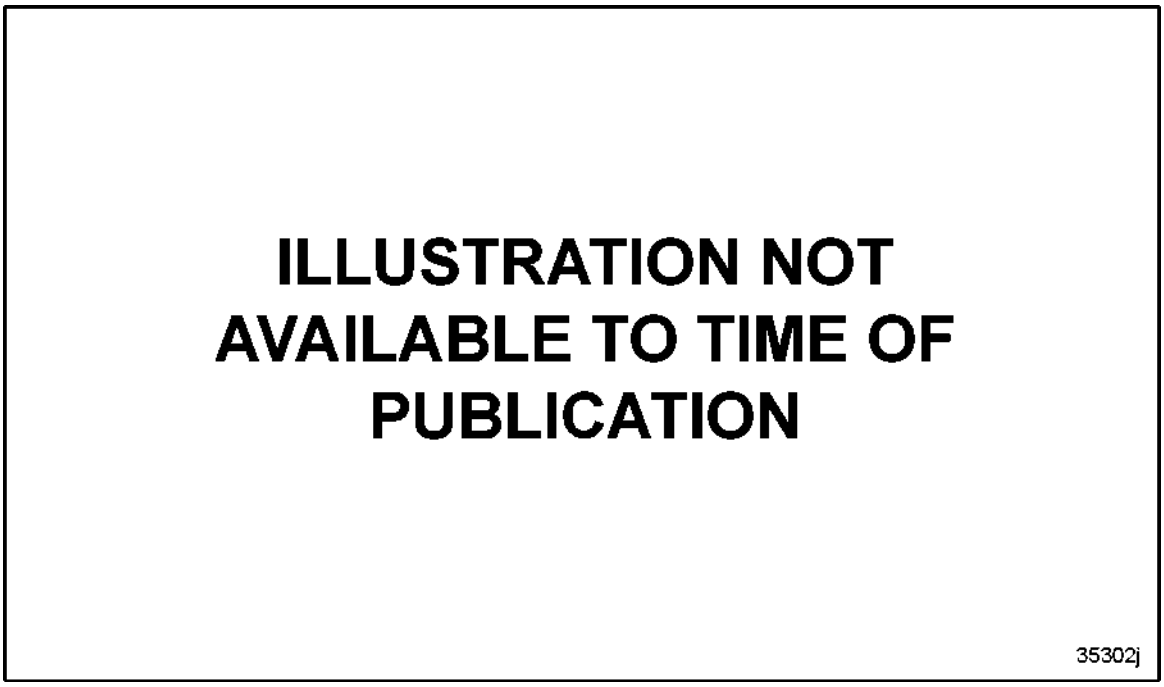


Figure 1673 Injector Rack Gage (.430), J 35735

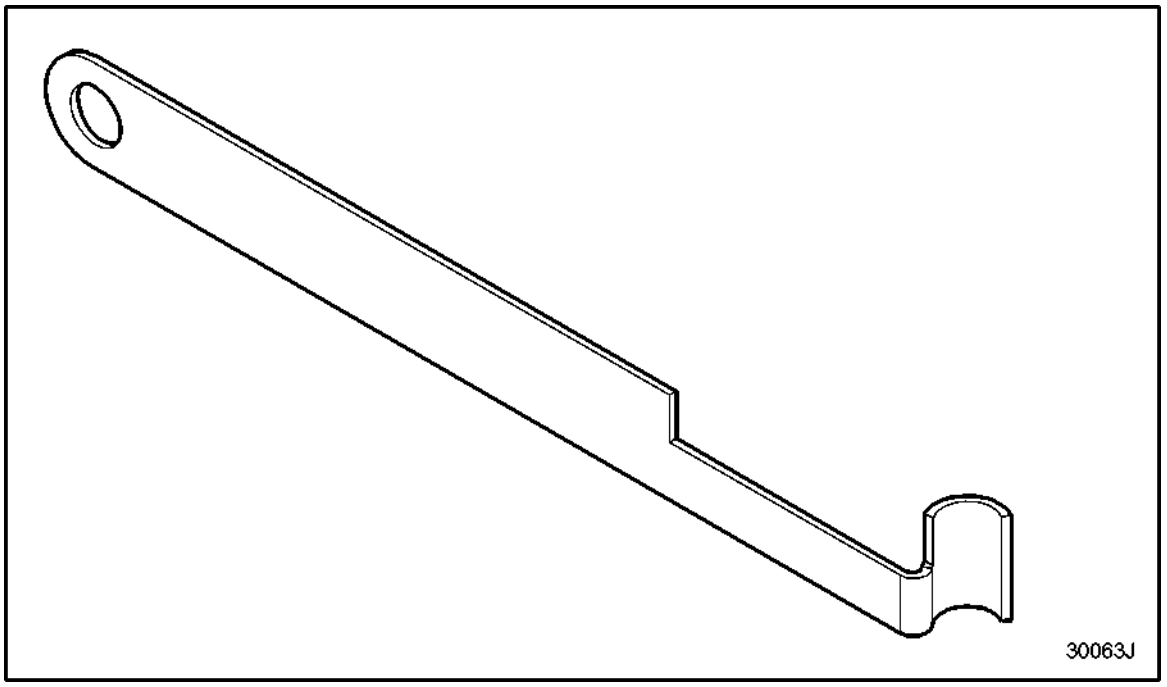


Figure 1674 Injector Rack Gage (.454),J 23190

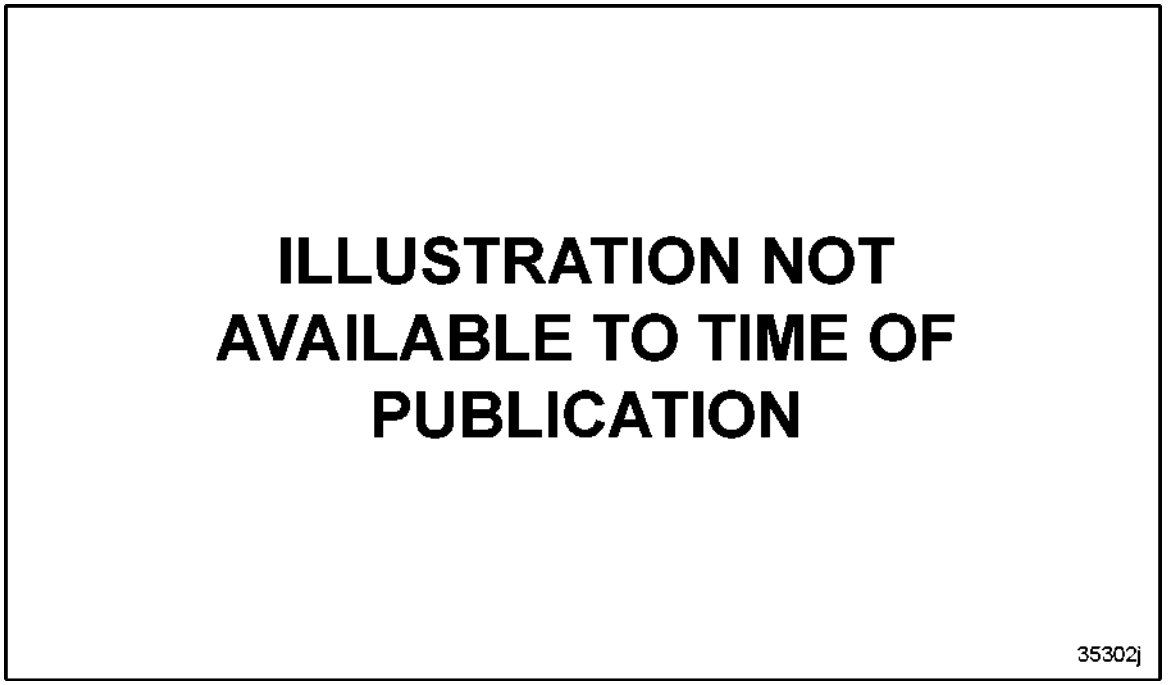


Figure 1675 Injector Rack Gage (.465),J 33156

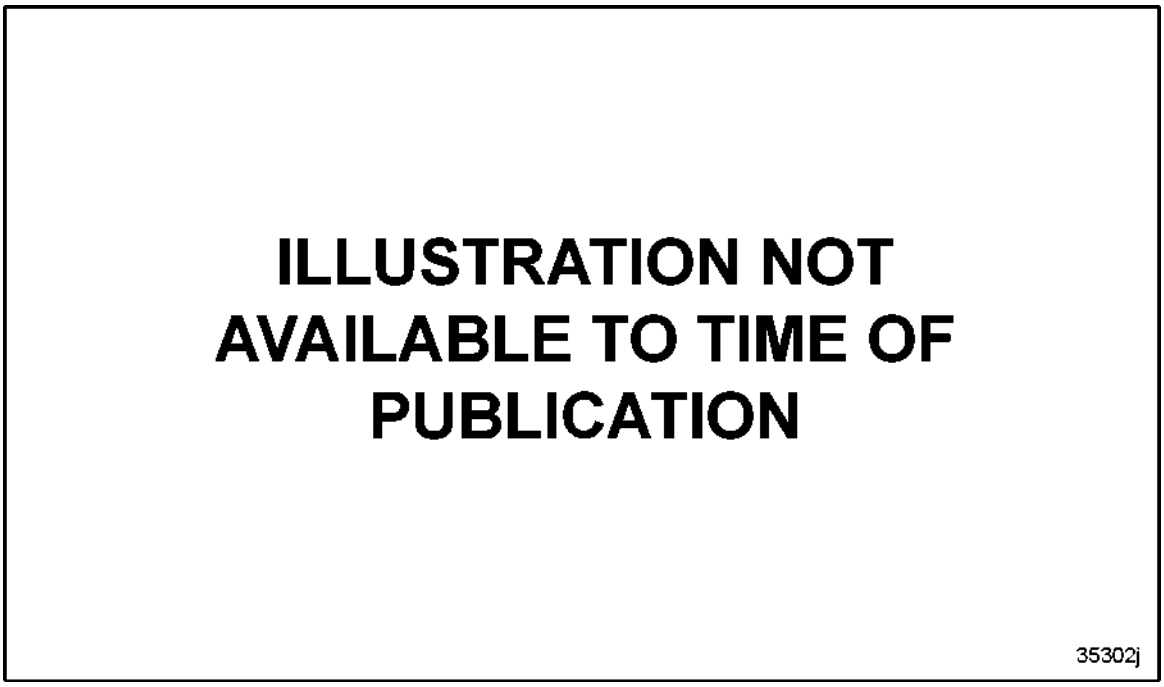


Figure 1676 Injector Rack Gage (.480),J 34080

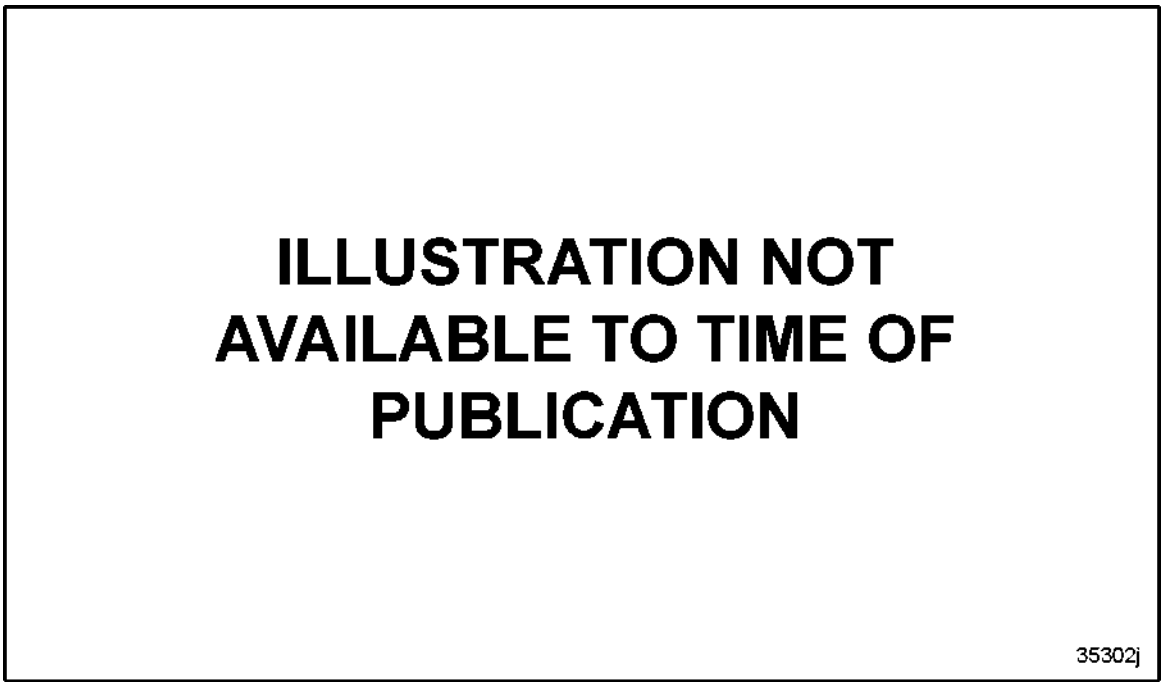


Figure 1677 Injector Rack Gage (.490),J 33157

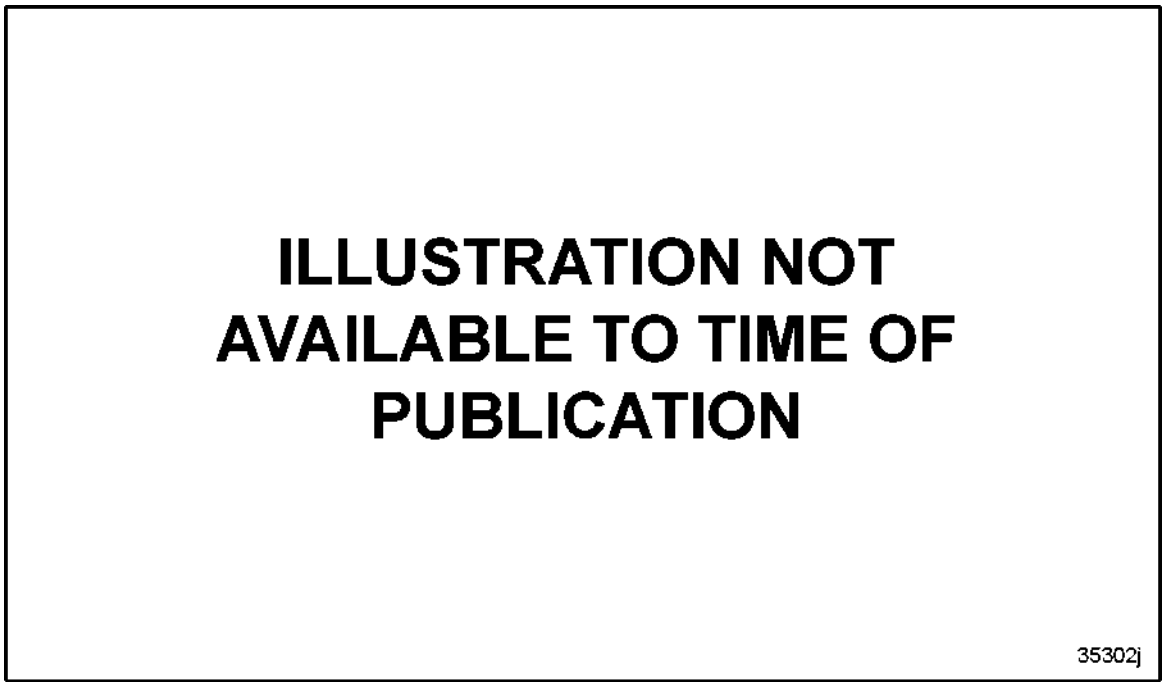


Figure 1678 Injector Rack Gage (.504),J 29062

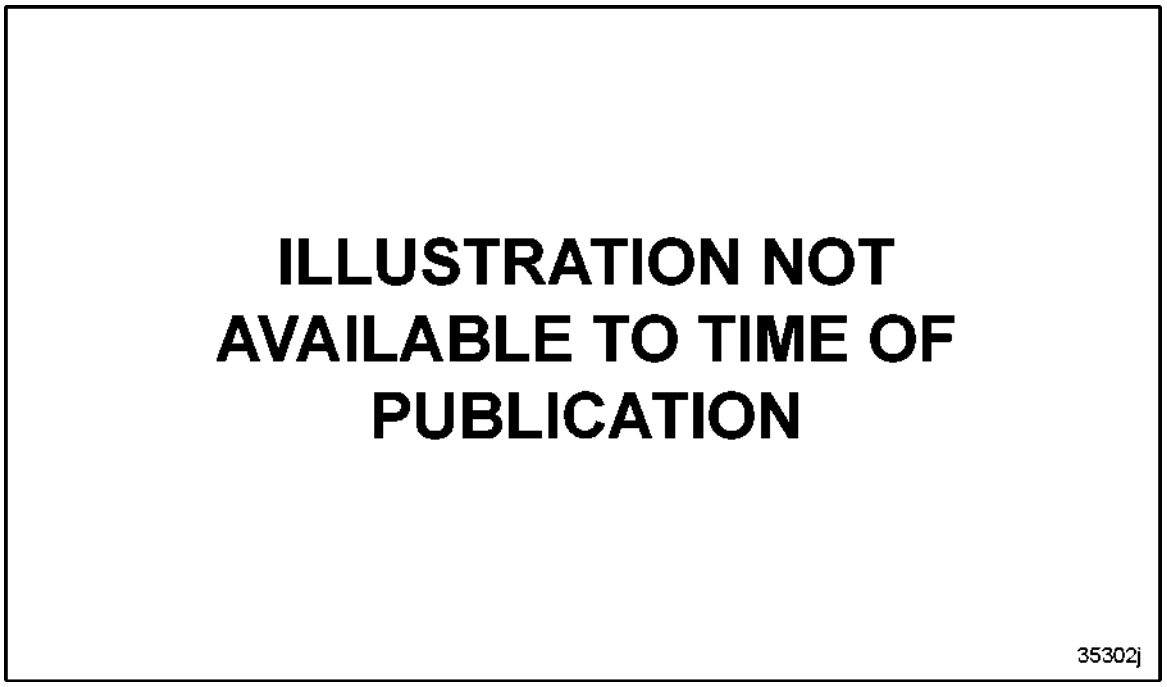


Figure 1679 Injector Rack Gage (.520),J 24872

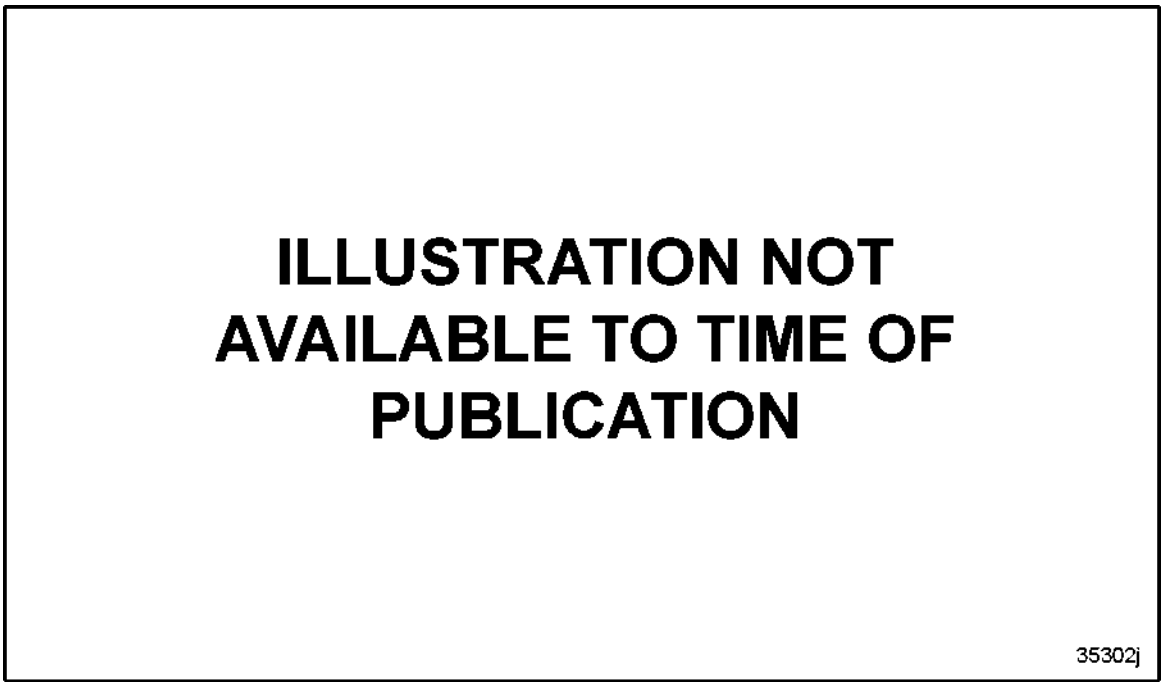


Figure 1680 Injector Rack Gage (.550),J 34609

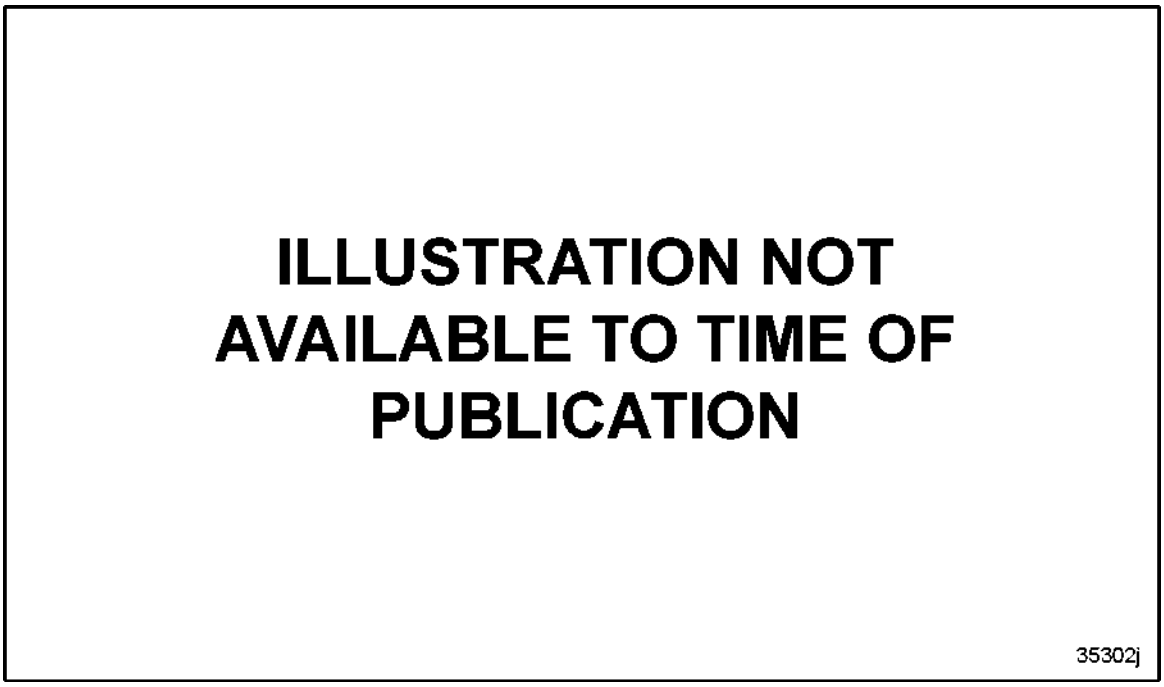


Figure 1681 Injector Rack Gage (.570),J 25559

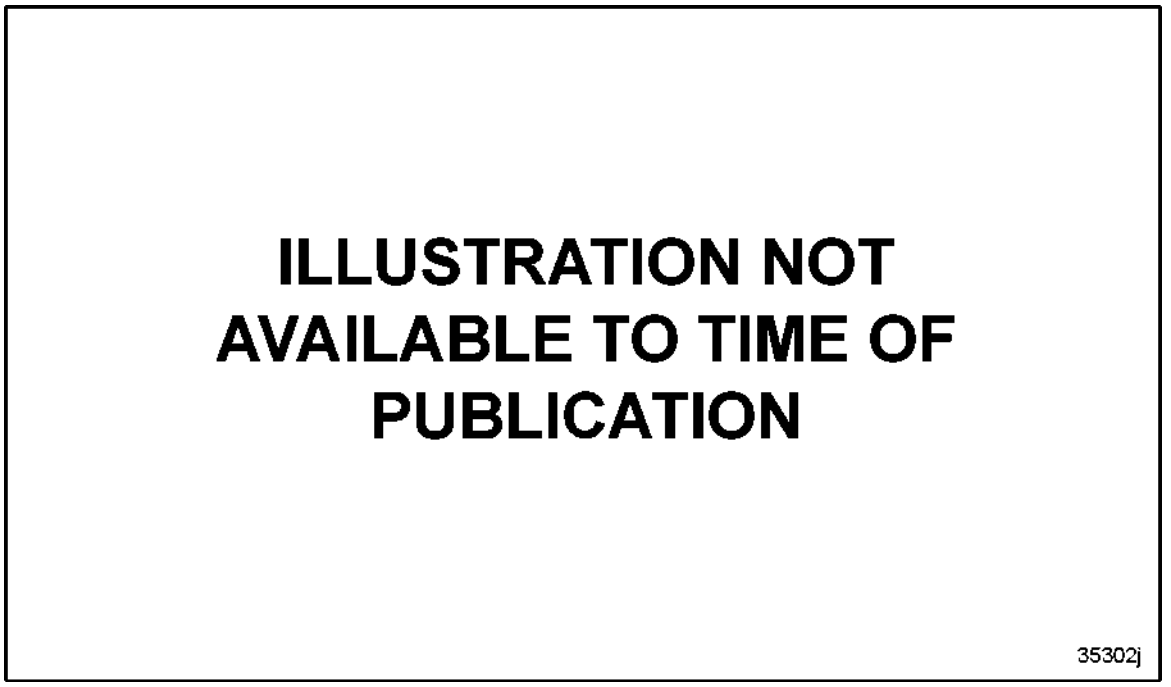


Figure 1682 Injector Rack Gage (.586 & .686),J 26927

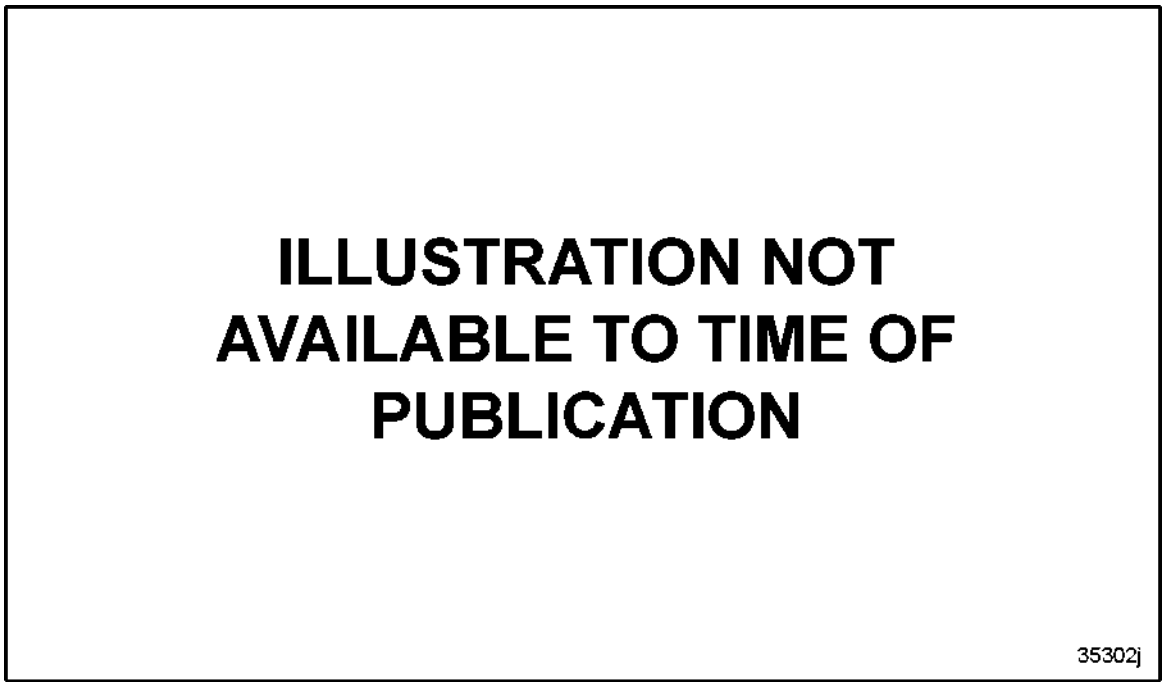


Figure 1683 Injector Rack Gage (.594),J 29063

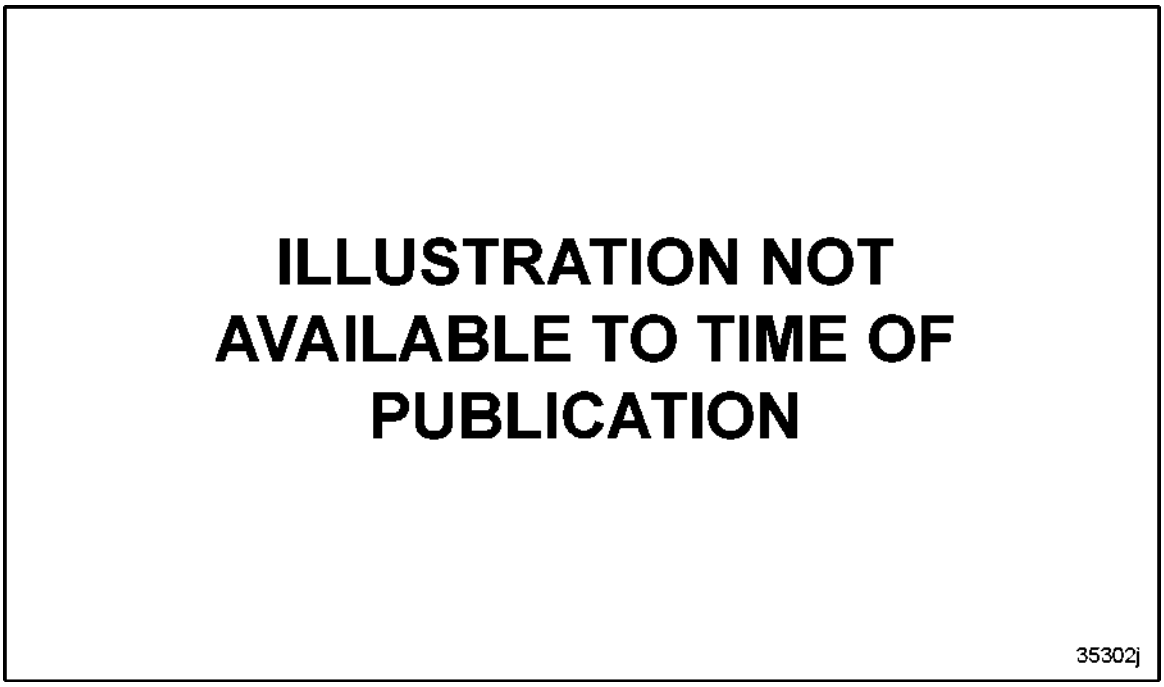


Figure 1684 Injector Rack Gage (.610),J 34079

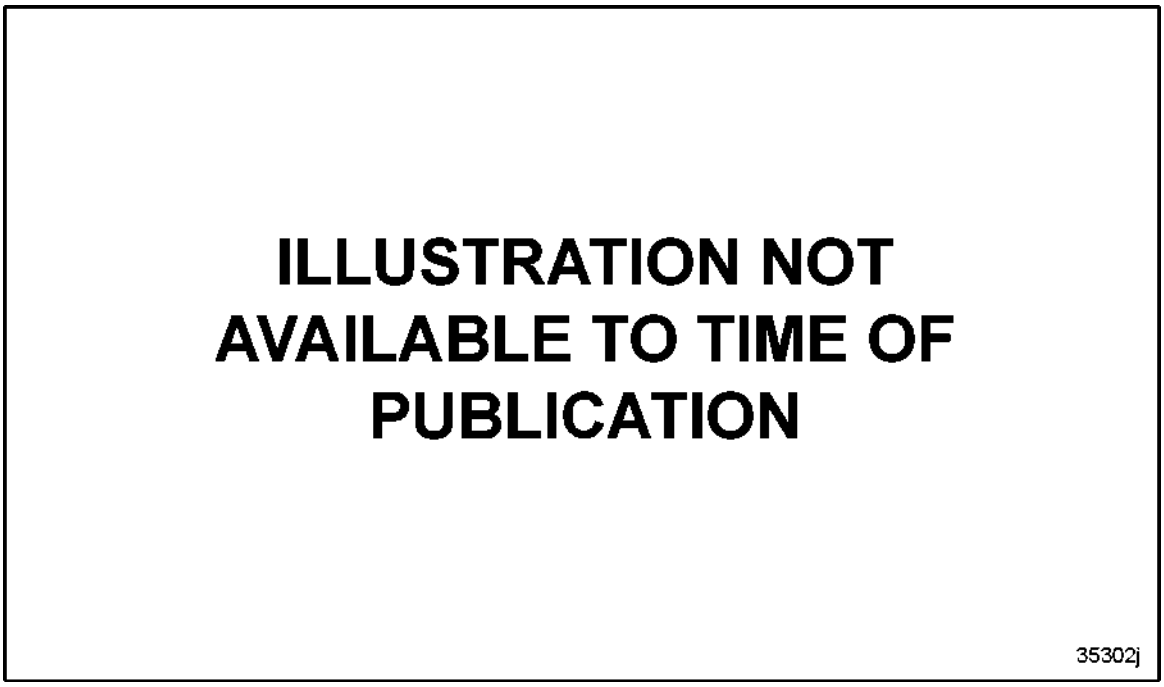


Figure 1685 Injector Rack Gage (.636),J 25560

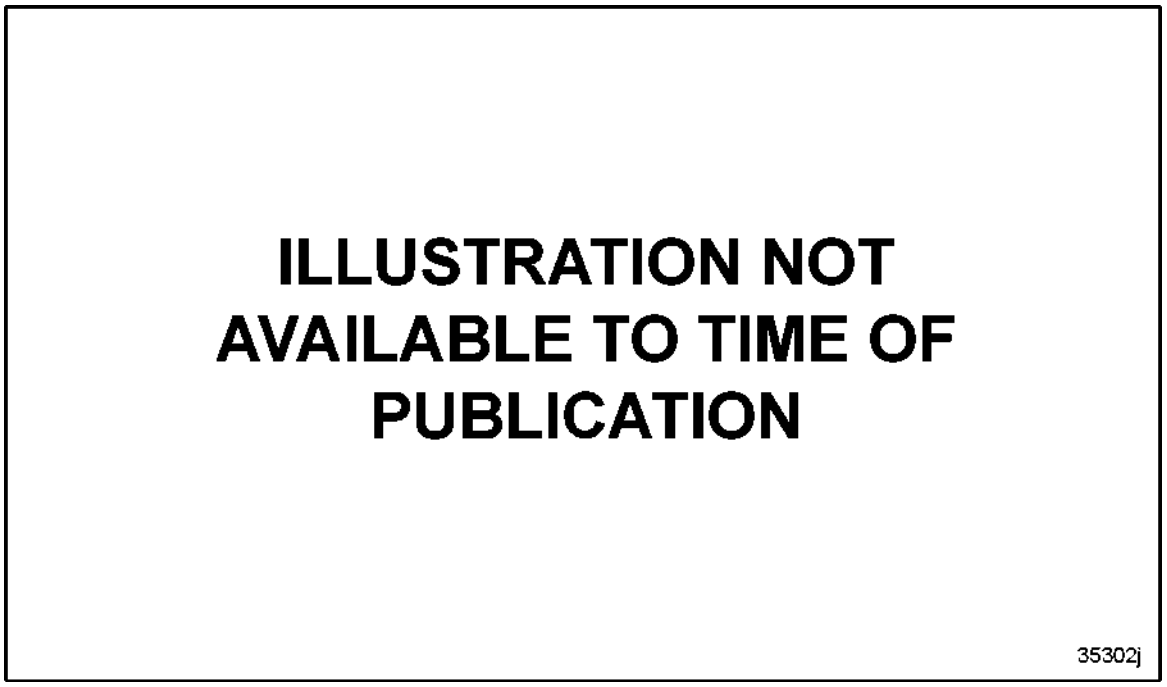


Figure 1686 Injector Rack Gage (.660),J 29064

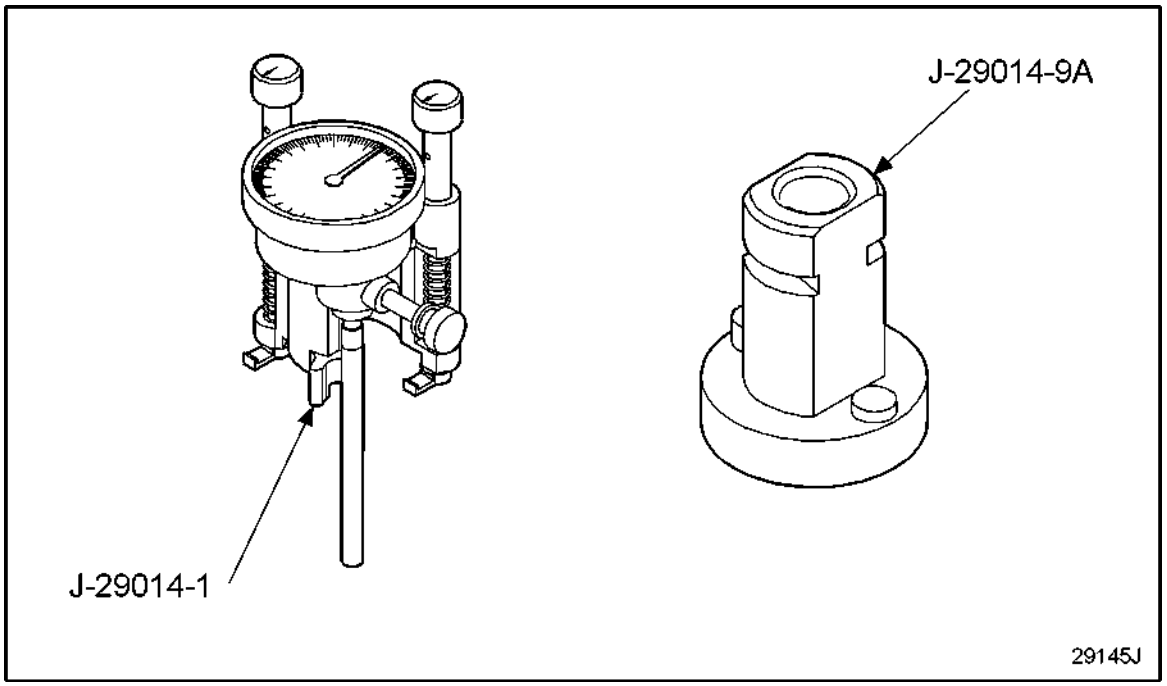


Figure 1687 Injector Timing Dial Indicator,J 29014–C

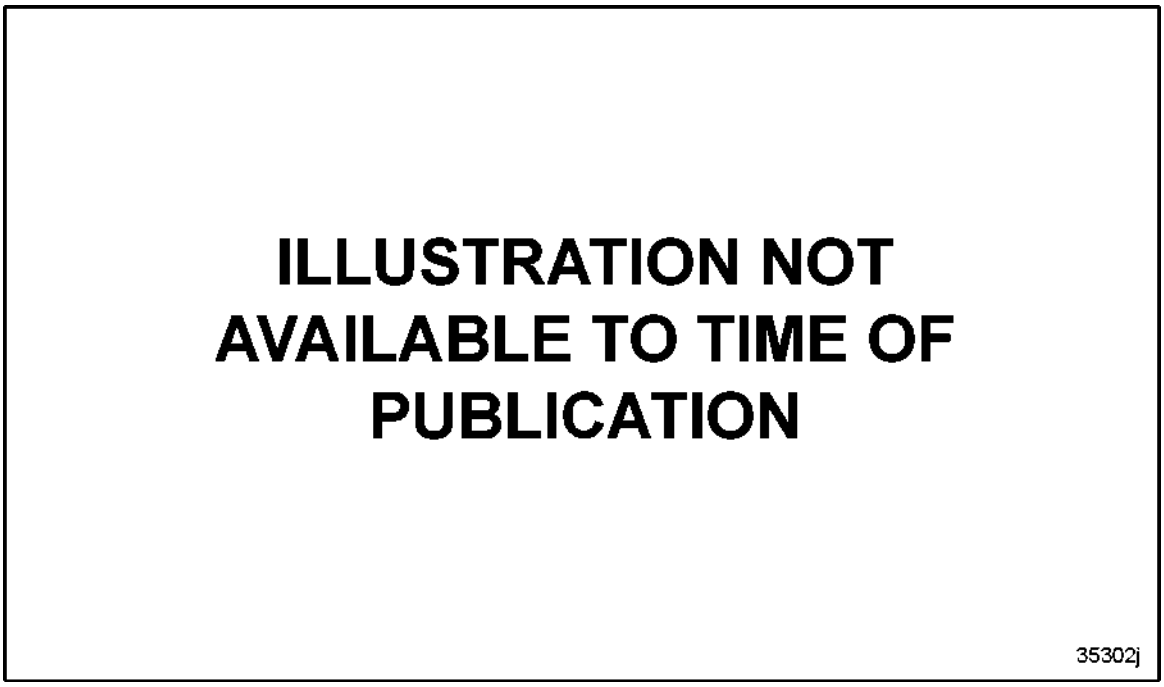


Figure 1688 Injector Timing Gage (1.458),J 34610

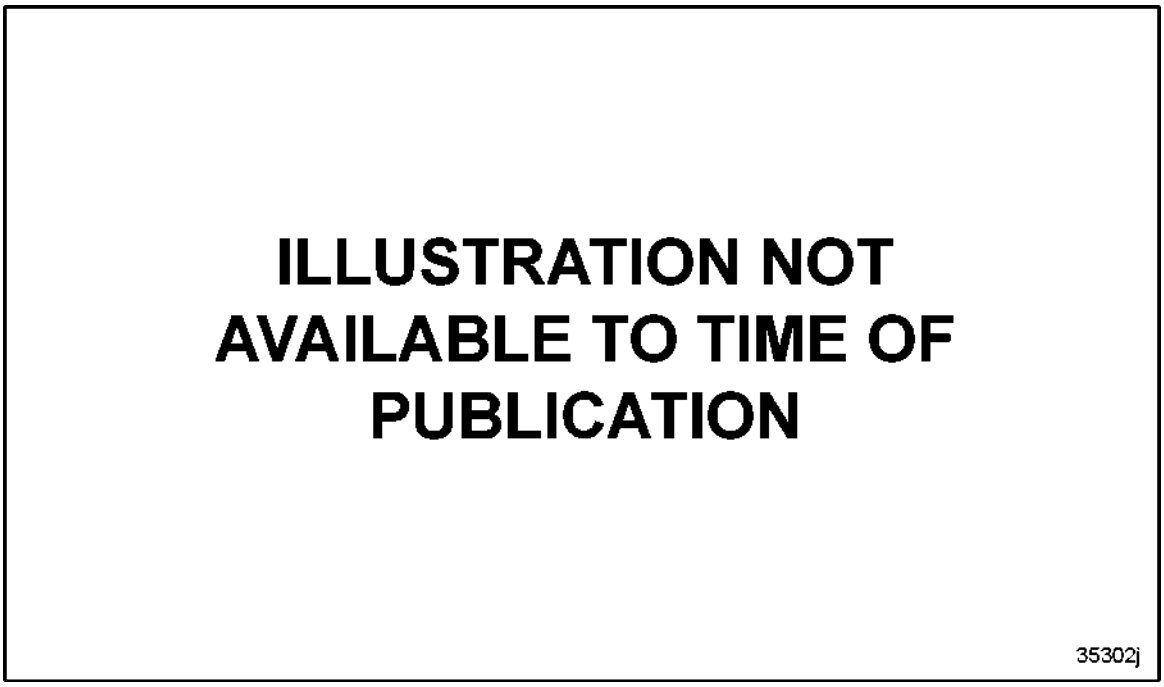


Figure 1689 Injector Timing Gage (1.460),J 1853

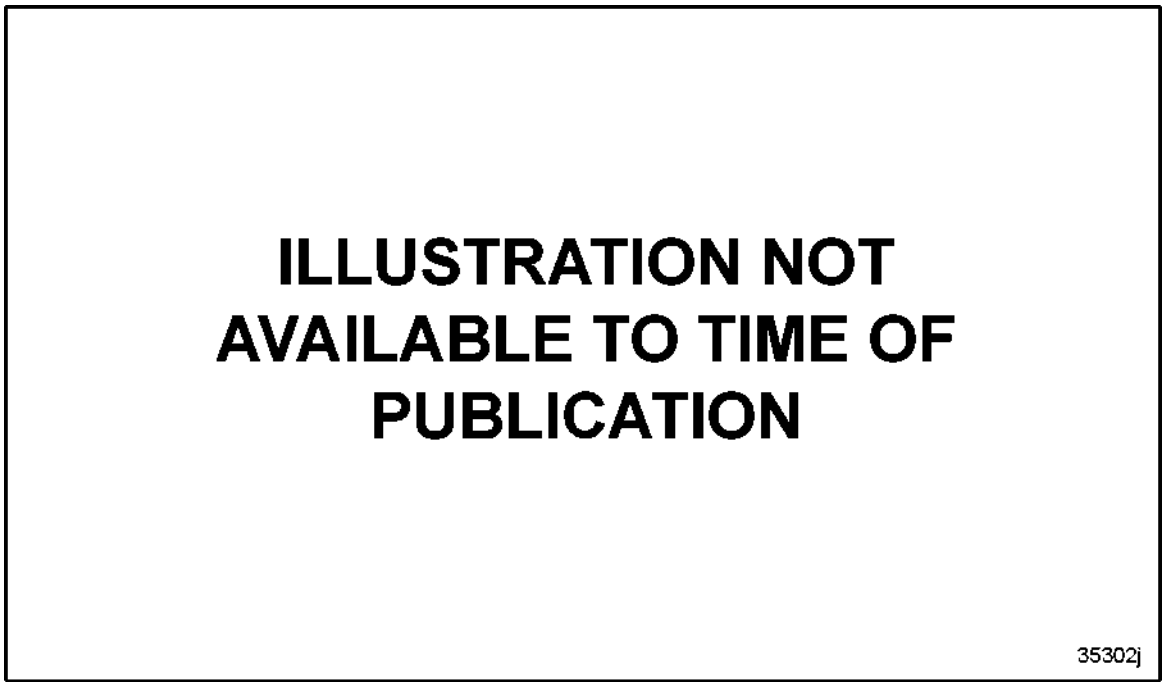


Figure 1690 Injector Timing Gage (1.464),J 34081

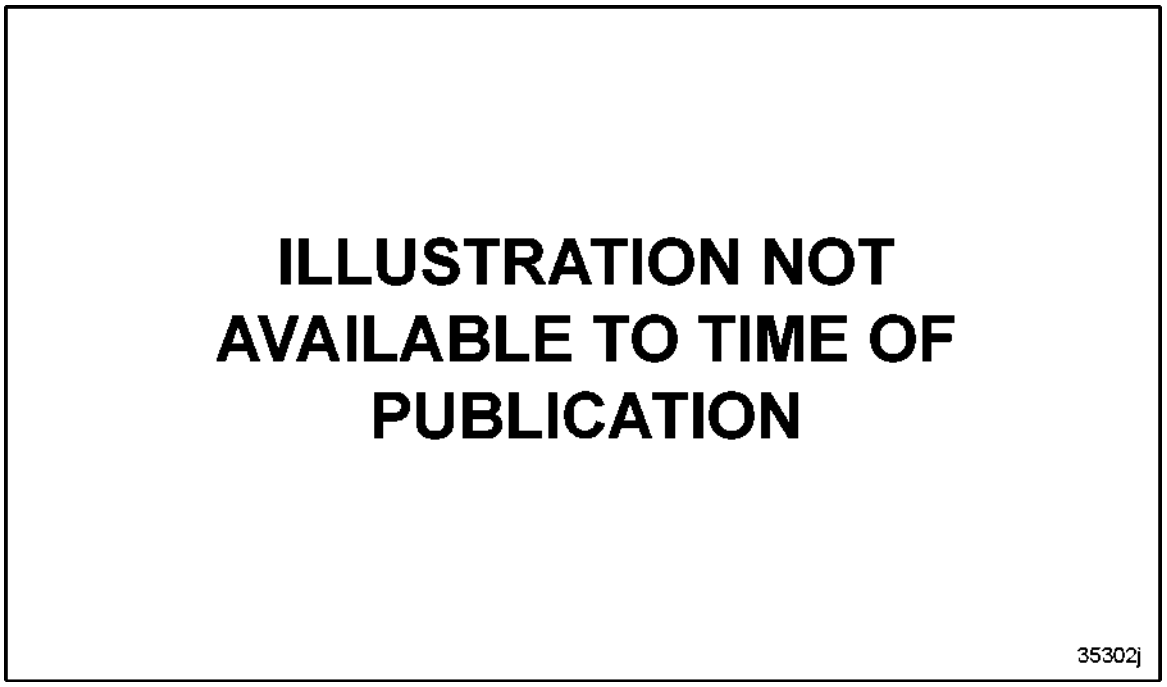


Figure 1691 Injector Timing Gage (1.466),J 26888

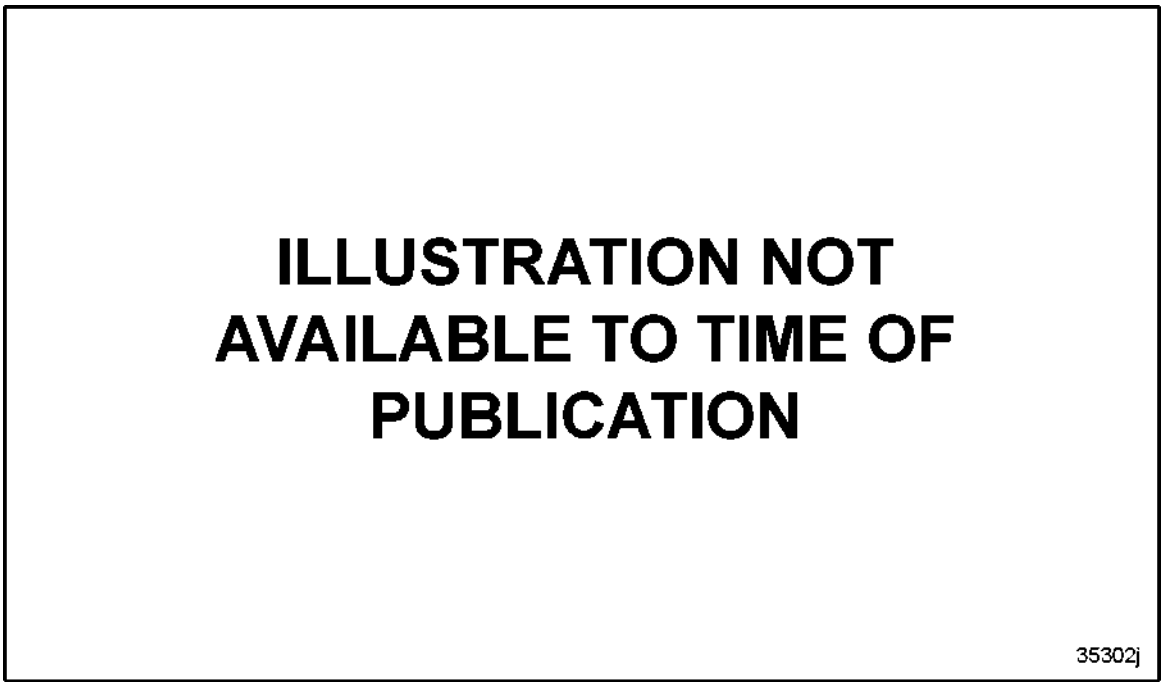


Figure 1692 Injector Timing Gage (1.470),J 24236

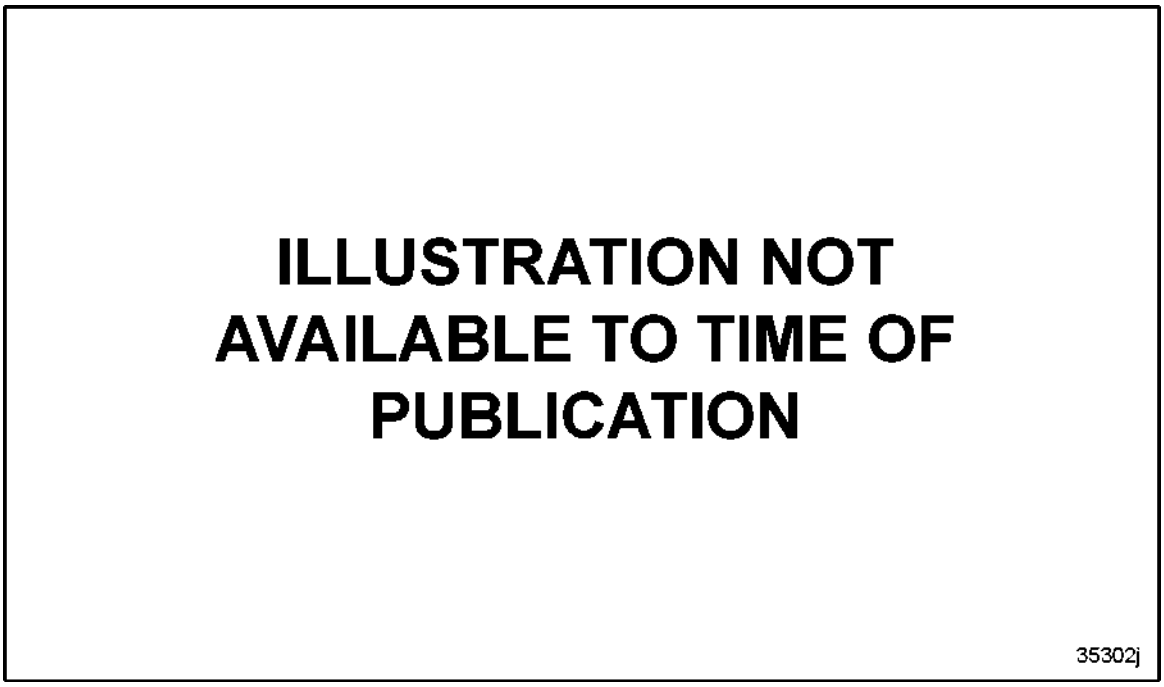


Figure 1693 Injector Timing Gage (1.475),J 34921

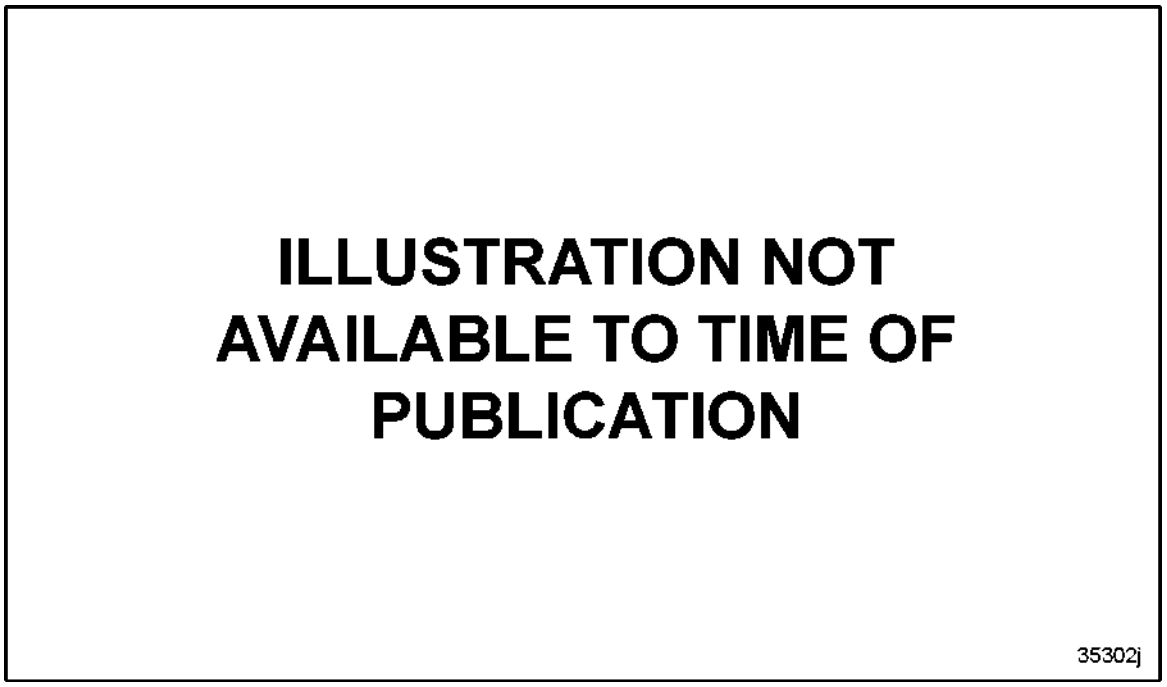


Figure 1694 Injector Timing Gage (1.480),J 29065

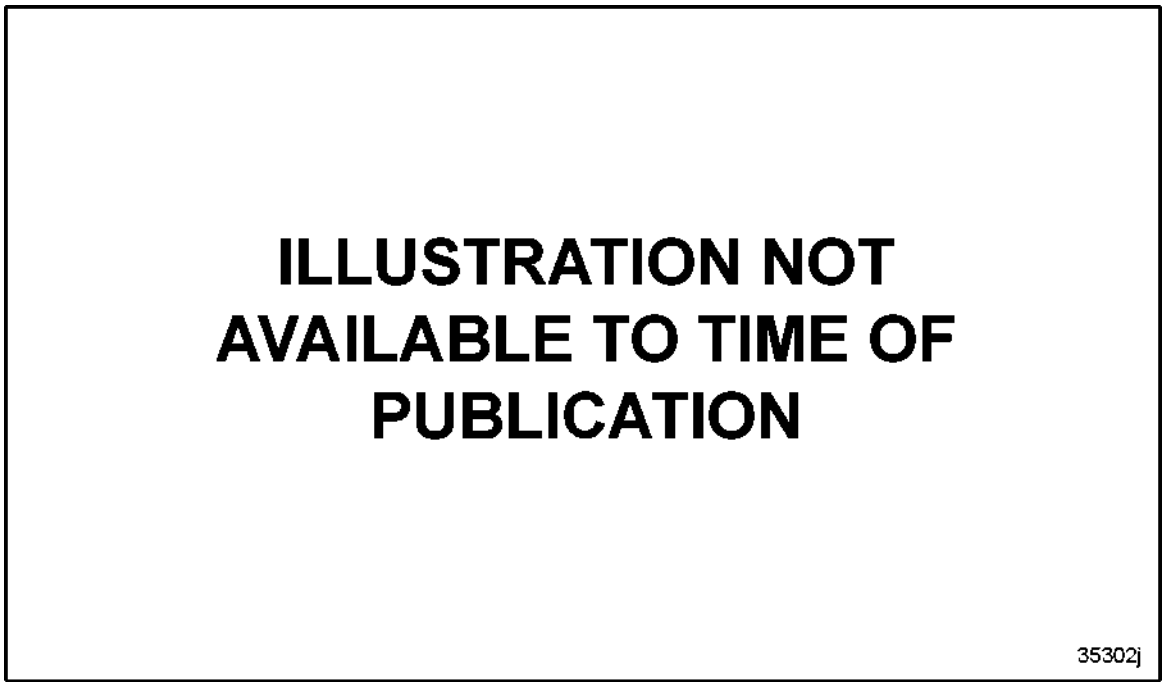


Figure 1695 Injector Timing Gage (1.484),J 1242

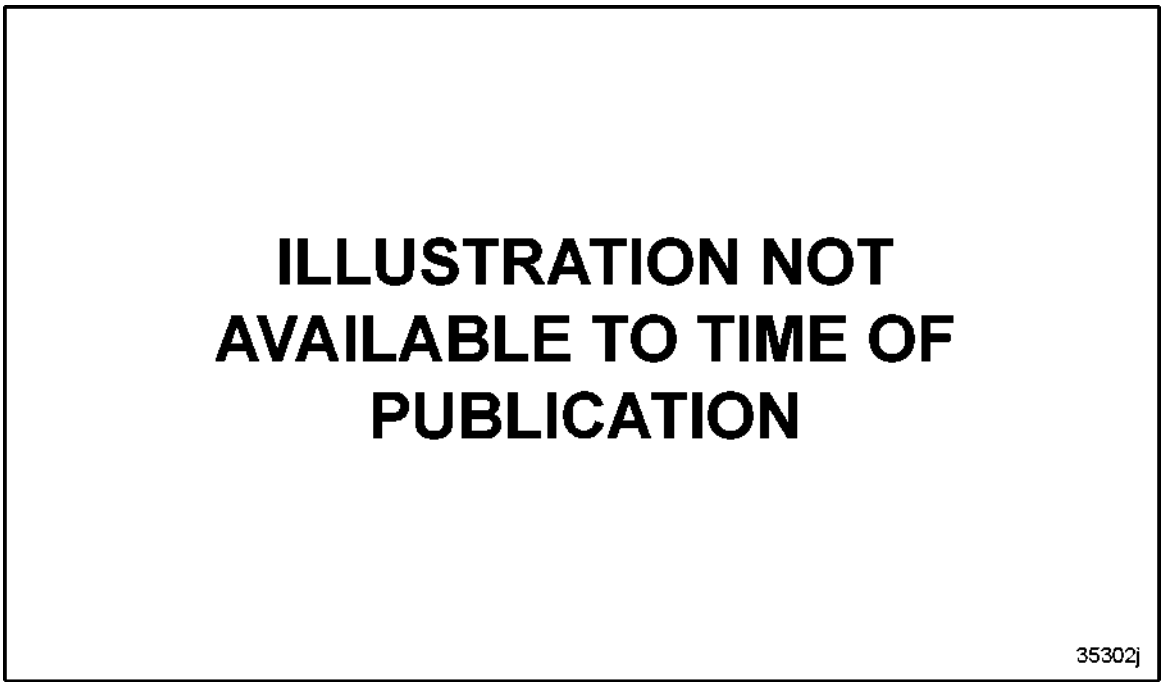


Figure 1696 Injector Timing Gage (1.490),J 29066

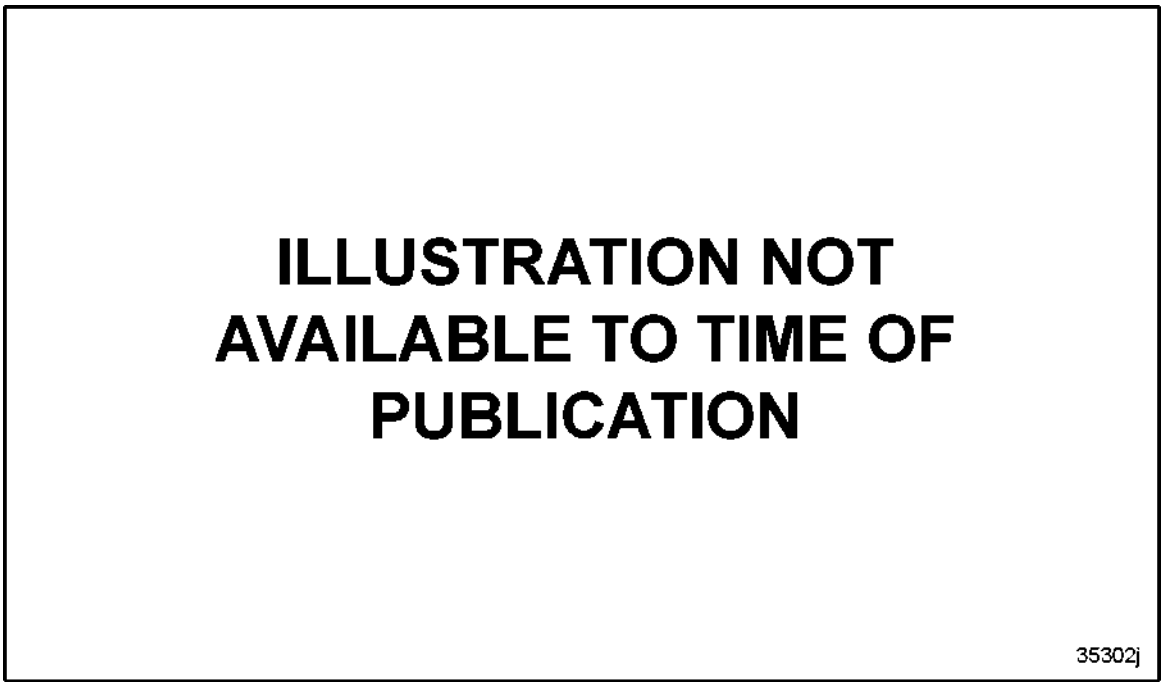


Figure 1697 Injector Timing Gage (1.496),J 9595

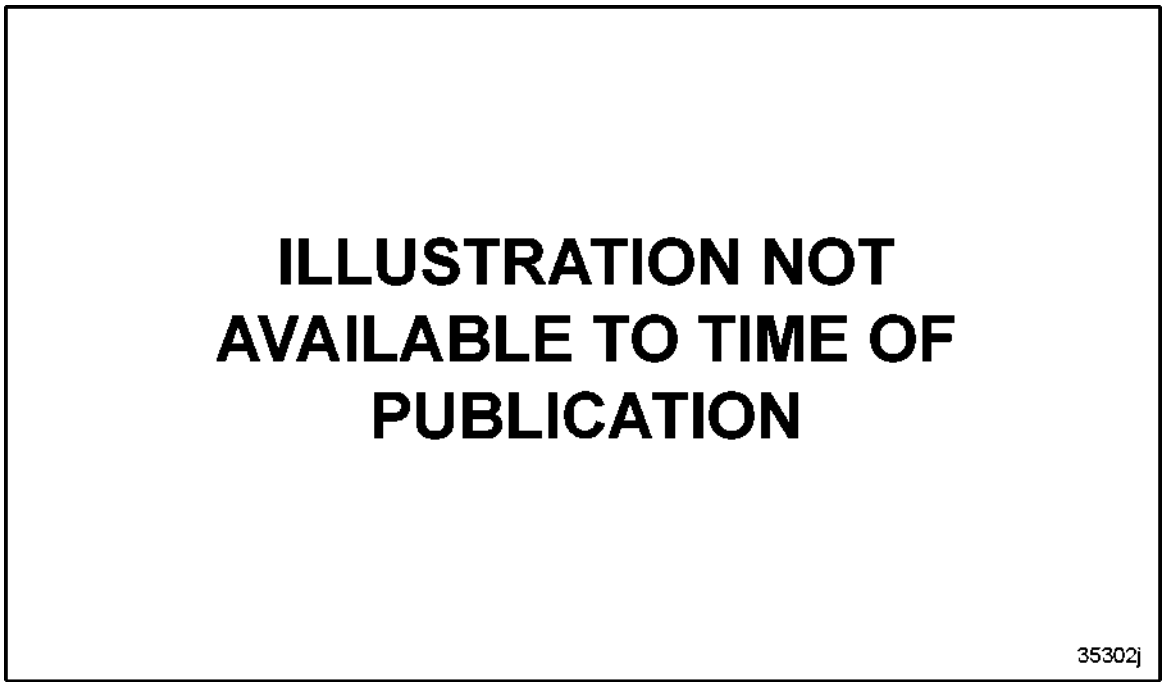


Figure 1698 Injector Timing Gage (1.500),J25454

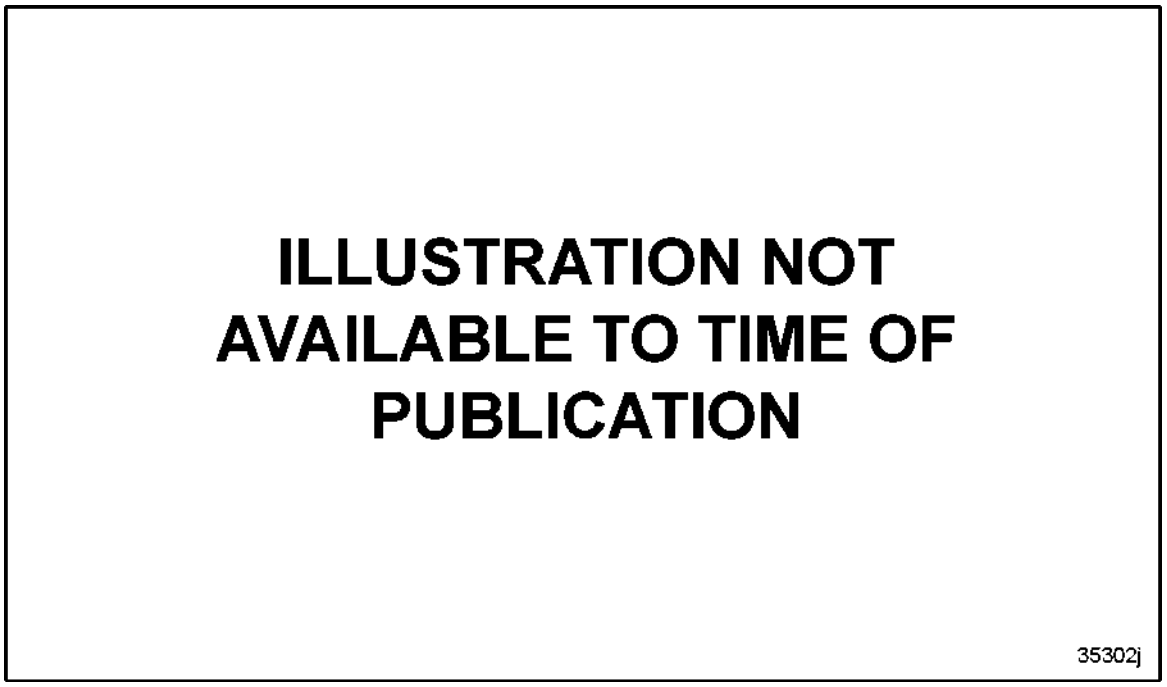


Figure 1699 Injector Timing Gage (1.508),J 8909

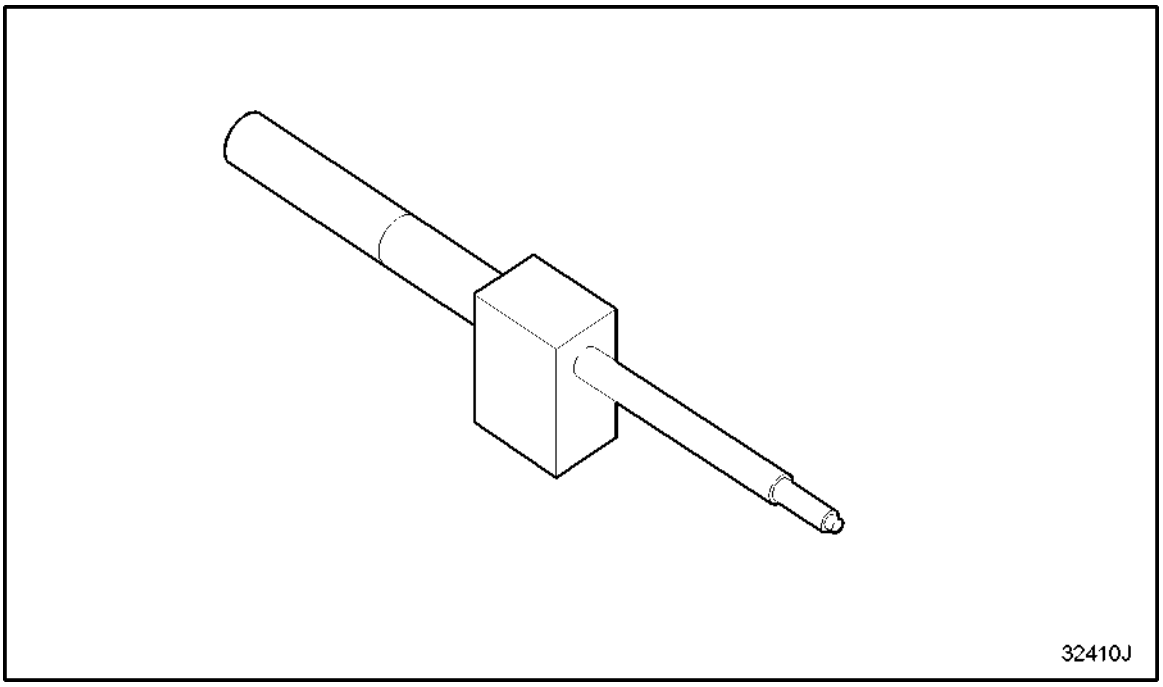


Figure 1700 Injector Timing Gage (1.515),J 34192

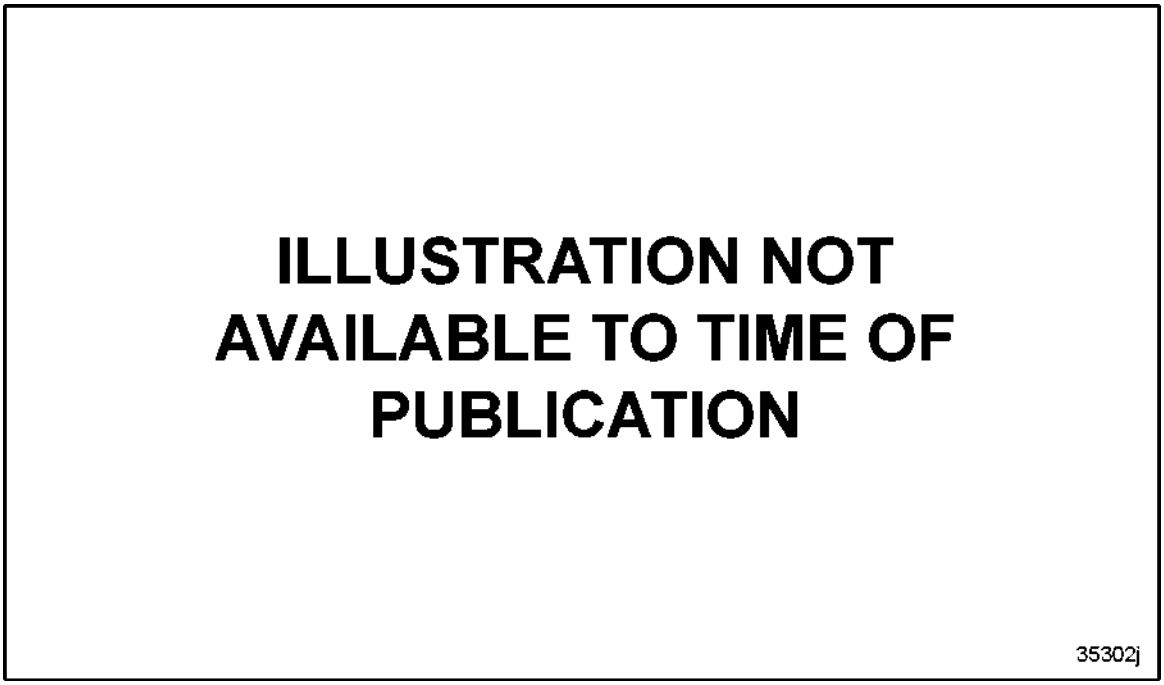


Figure 1701 Injector Timing Gage (1.520),J 25502

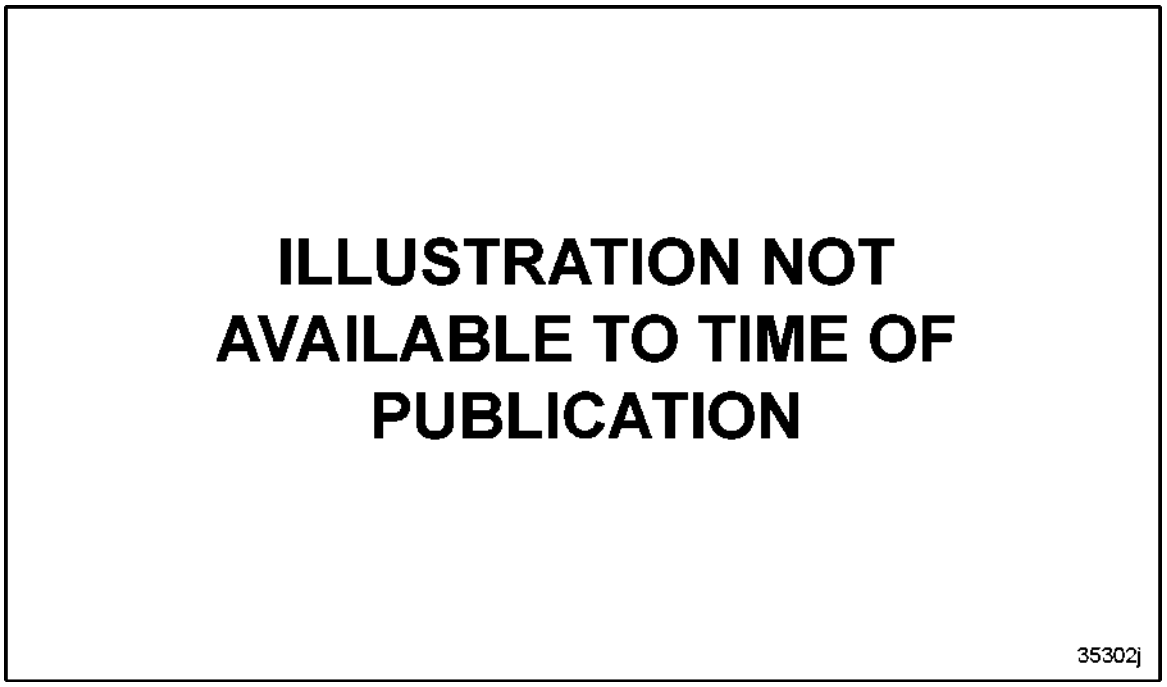


Figure 1702 Injector Timing Gage (2.170),J 36869

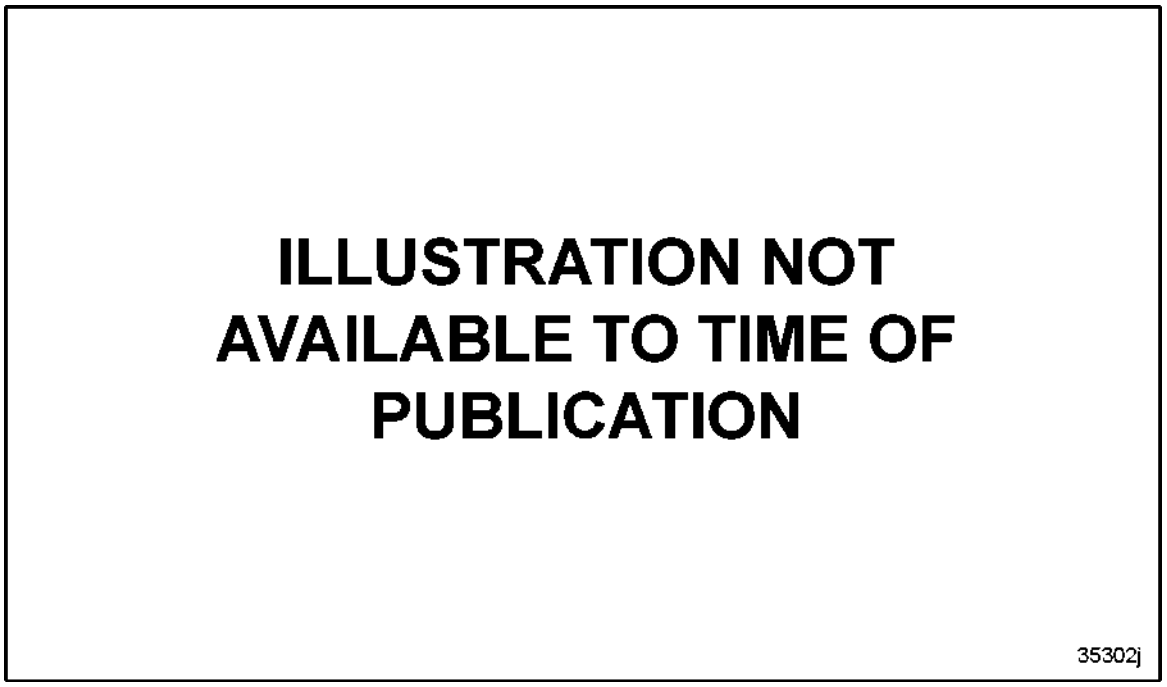


Figure 1703 Injector Timing Gage (2.175),J 22412–A

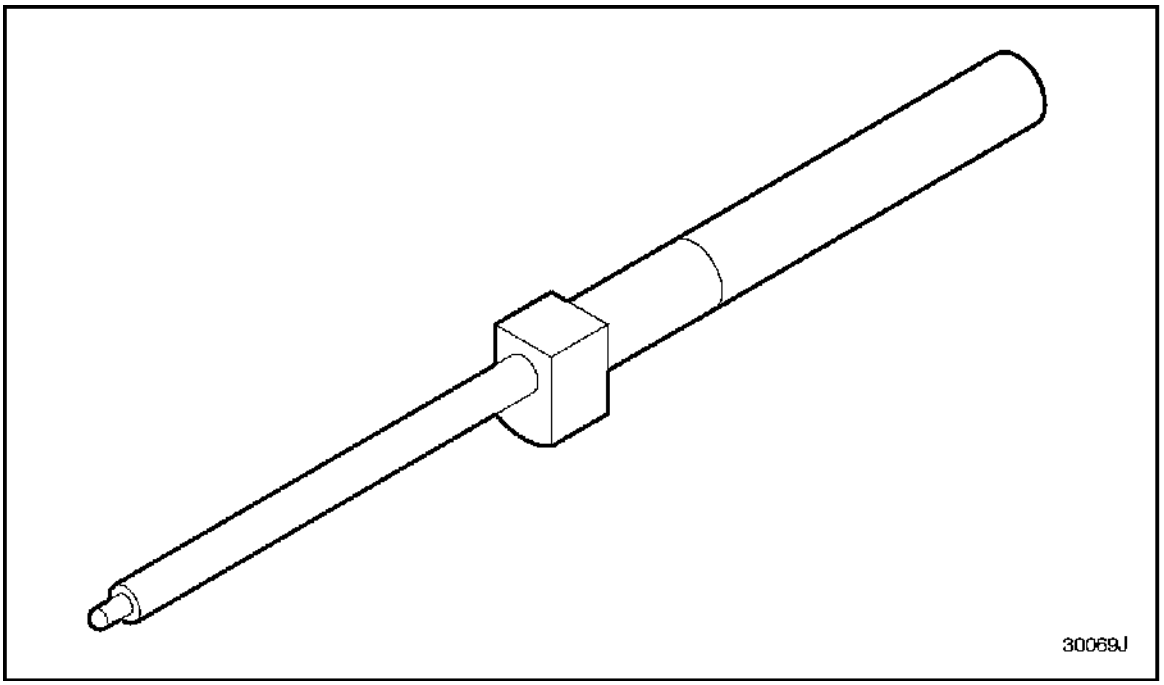


Figure 1704 Injector Timing Gage (2.185),J 29116–A

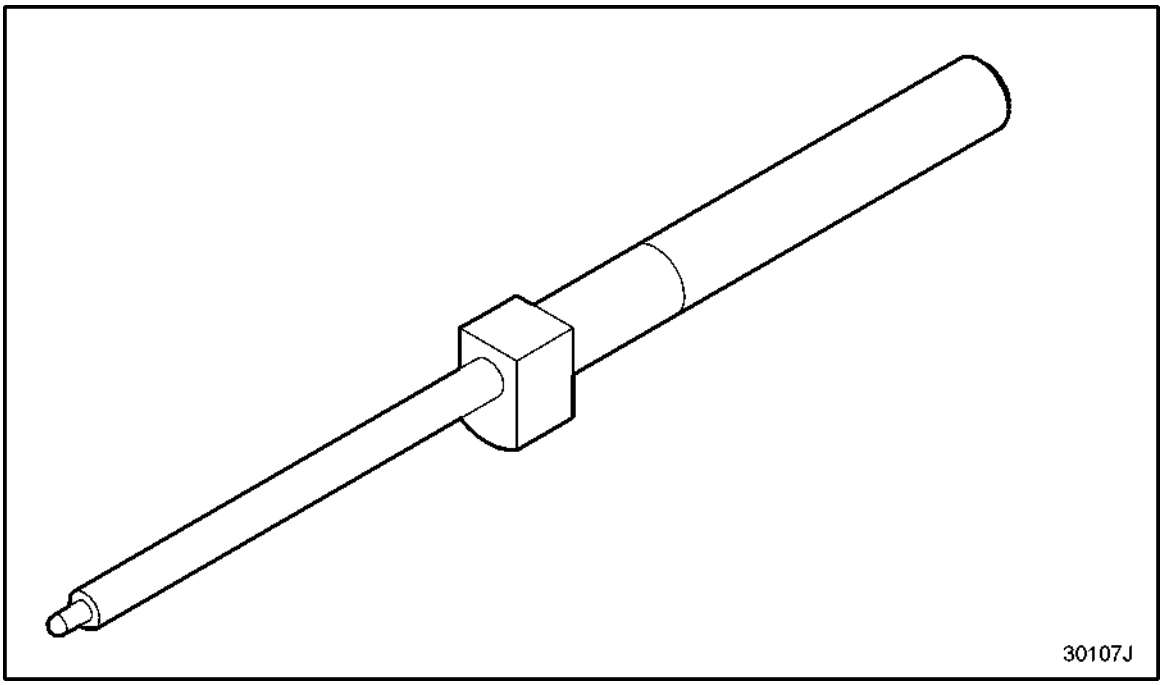


Figure 1705 Injector Timing Gage (2.205),J 24283–A

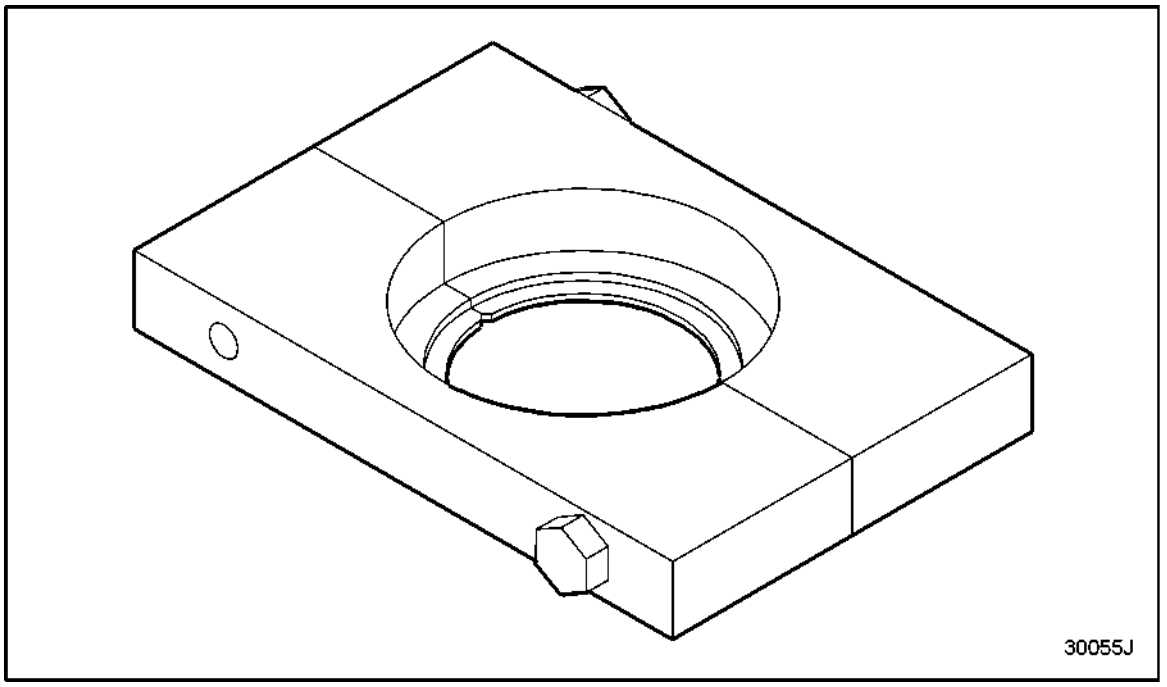


Figure 1706 Injector Timing Gage (2.590),J 39762

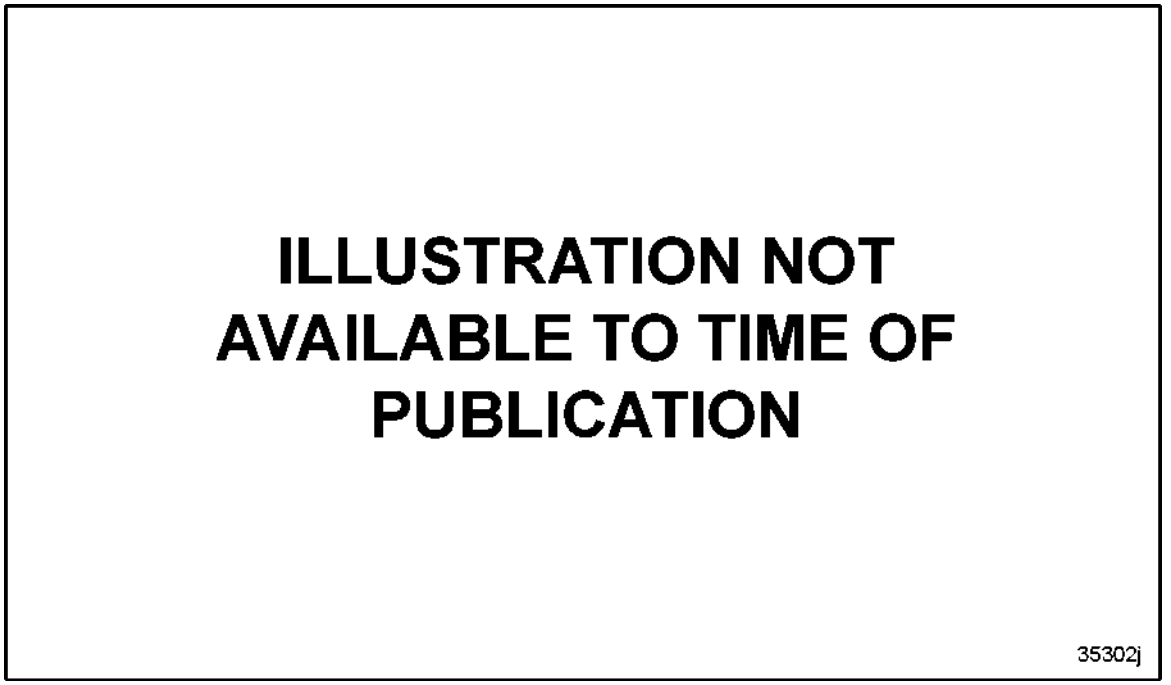


Figure 1707 Injector Timing Gage (64.1MM),J 38349

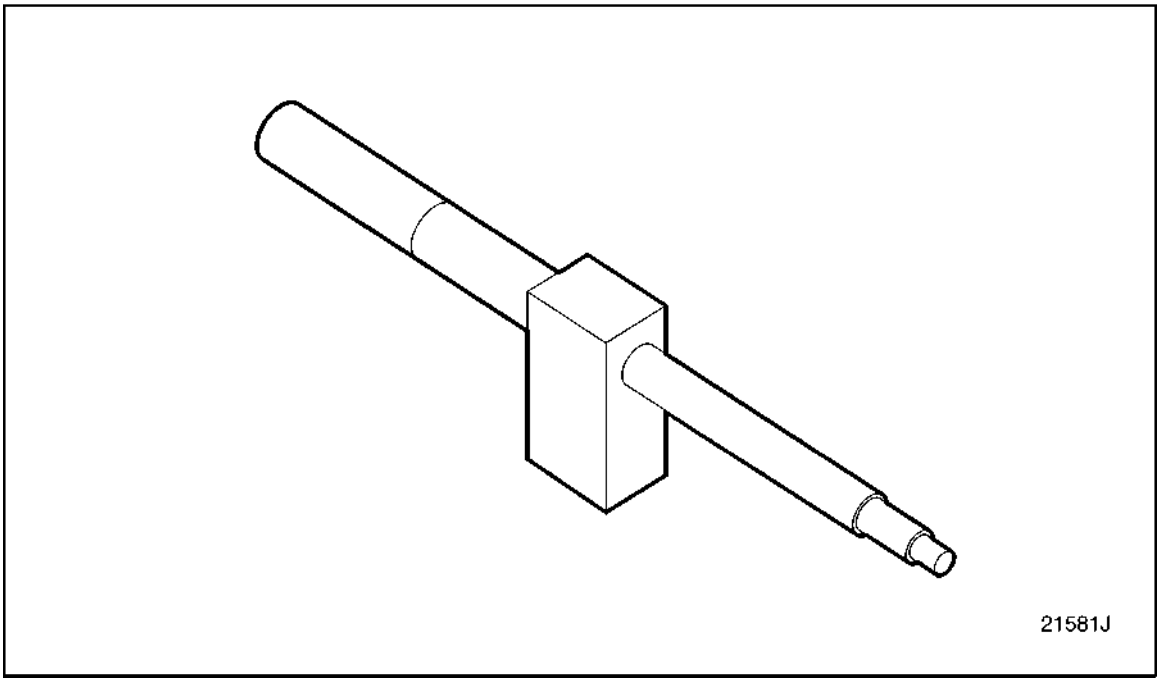


Figure 1708 Injector Timing Gage (78.2 MM),J 35637–A

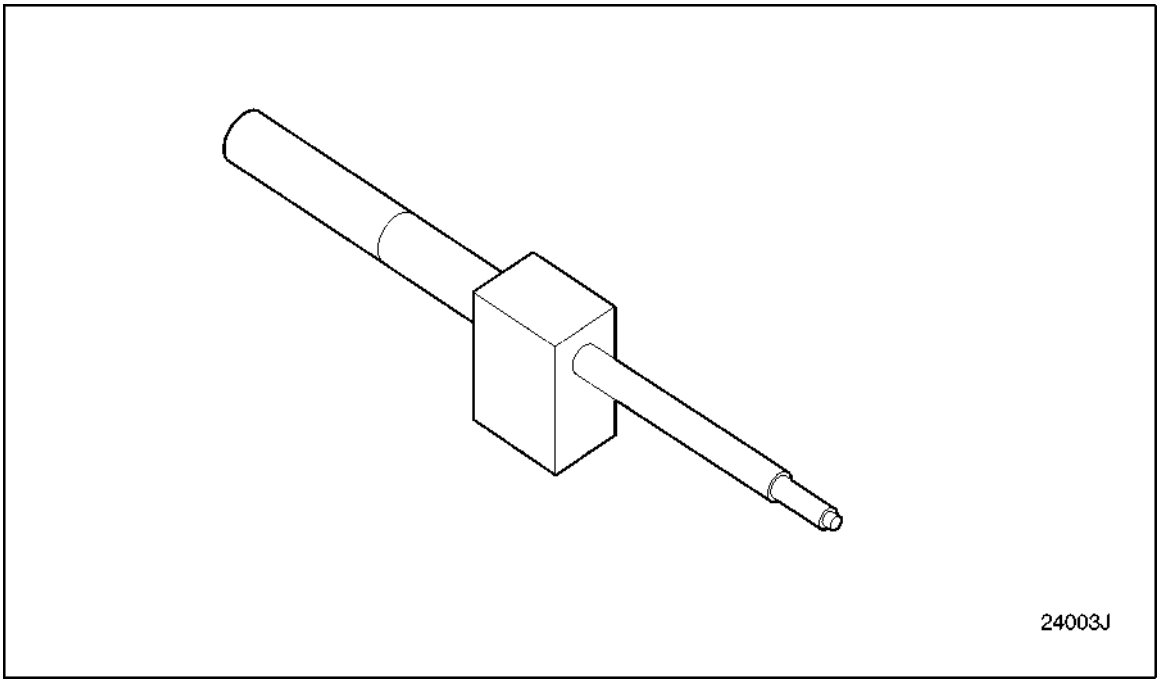


Figure 1709 Injector Timing Gage (78.8 MM),J 39697

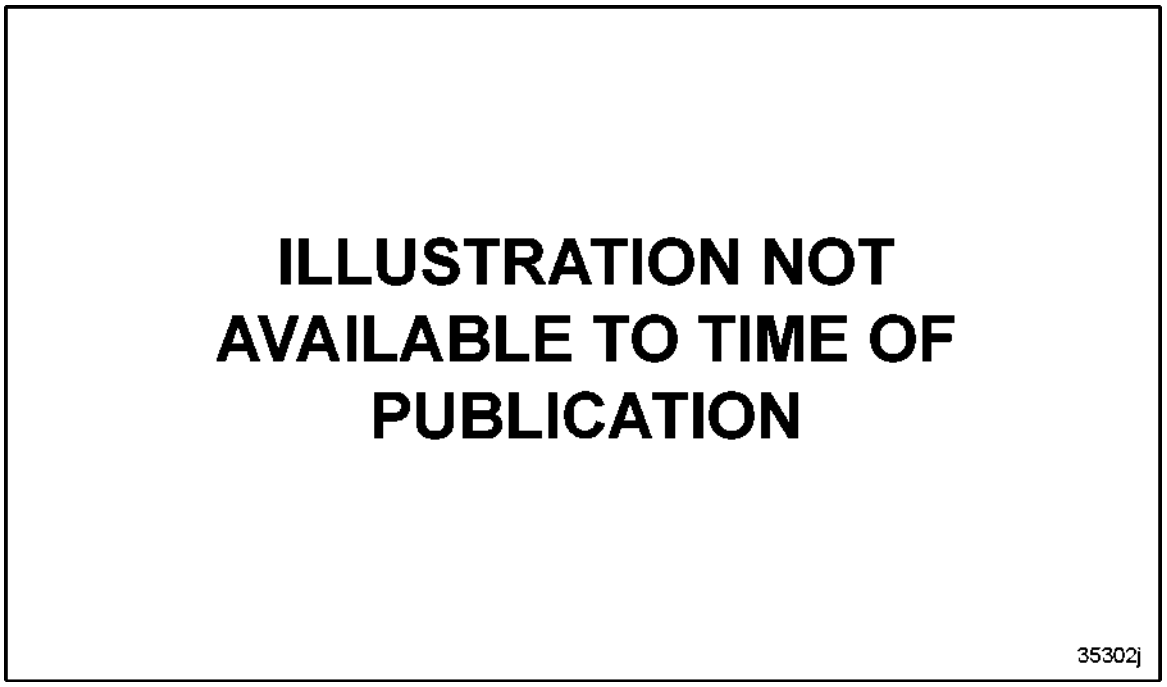


Figure 1710 Throttle Delay Gage (.404),J 9509–C

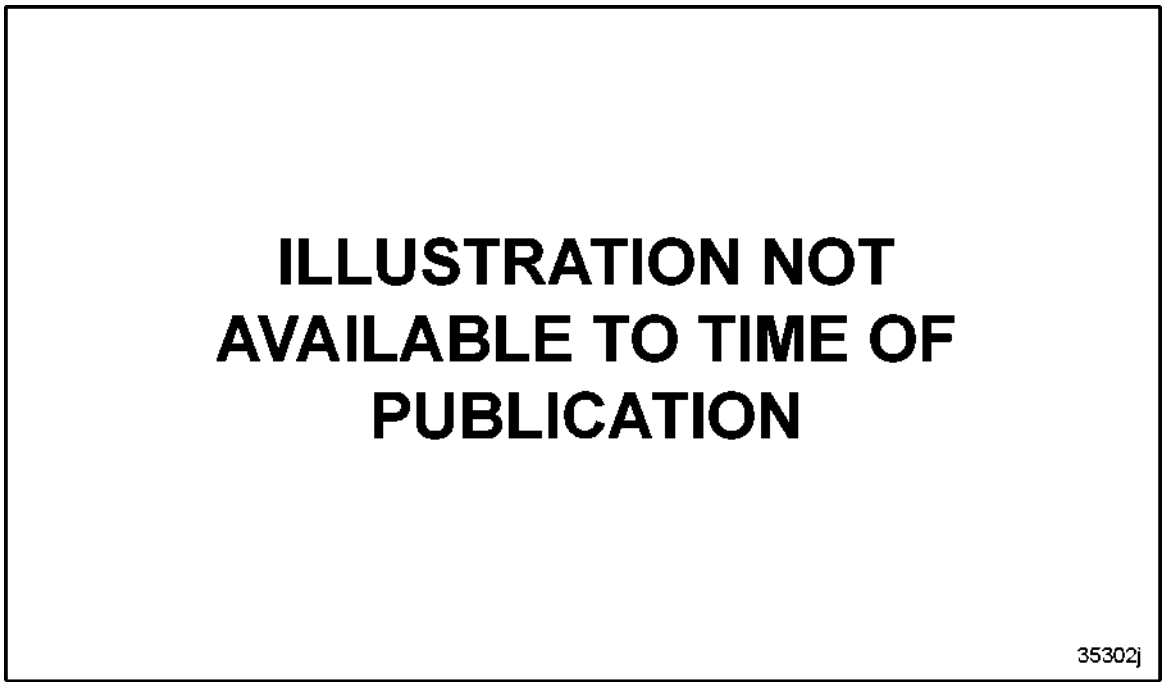


Figure 1711 Injector Rack Gage (.395),J 28479

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Figure 1712 0-30 Vacuum Gauge W/Protective Boot,J 9531–55

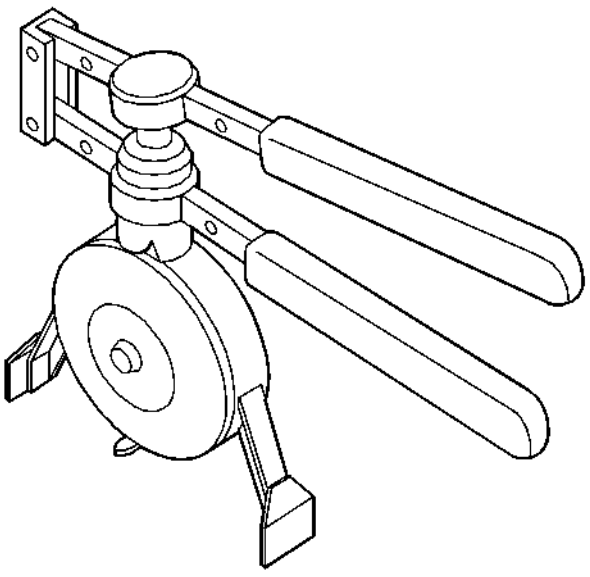

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Figure 1713 Belt Tension Gauge,J 33889–A

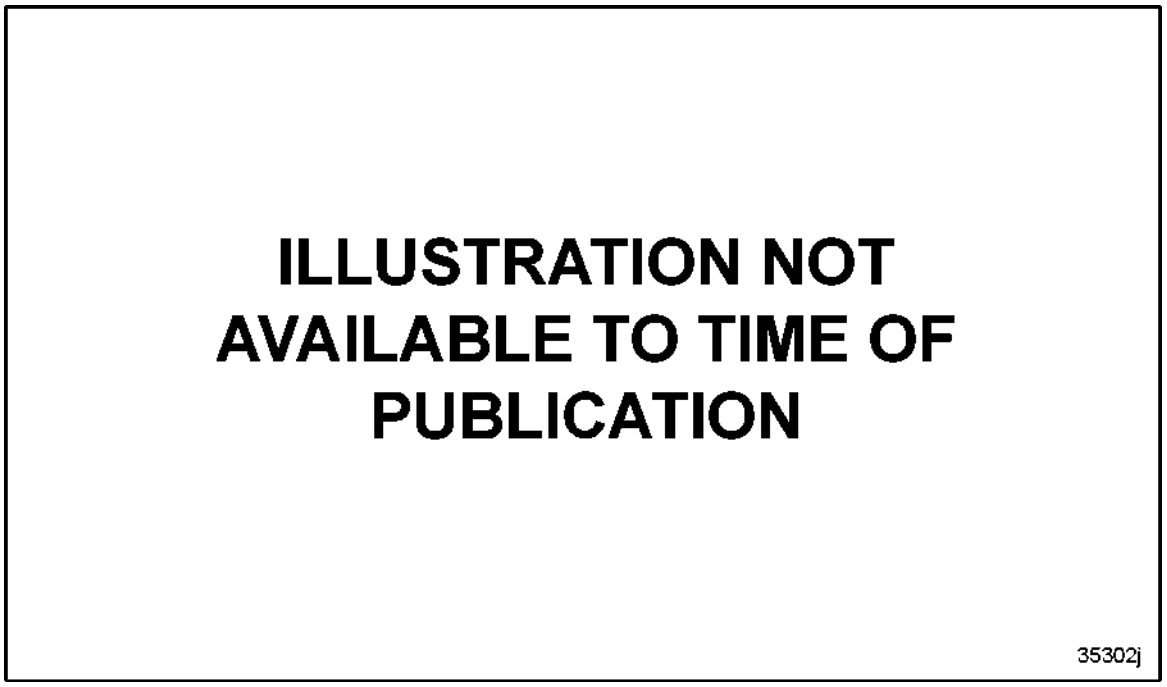

Figure 1714 Cylinder Compression Gauge Adapter, J 7915–E

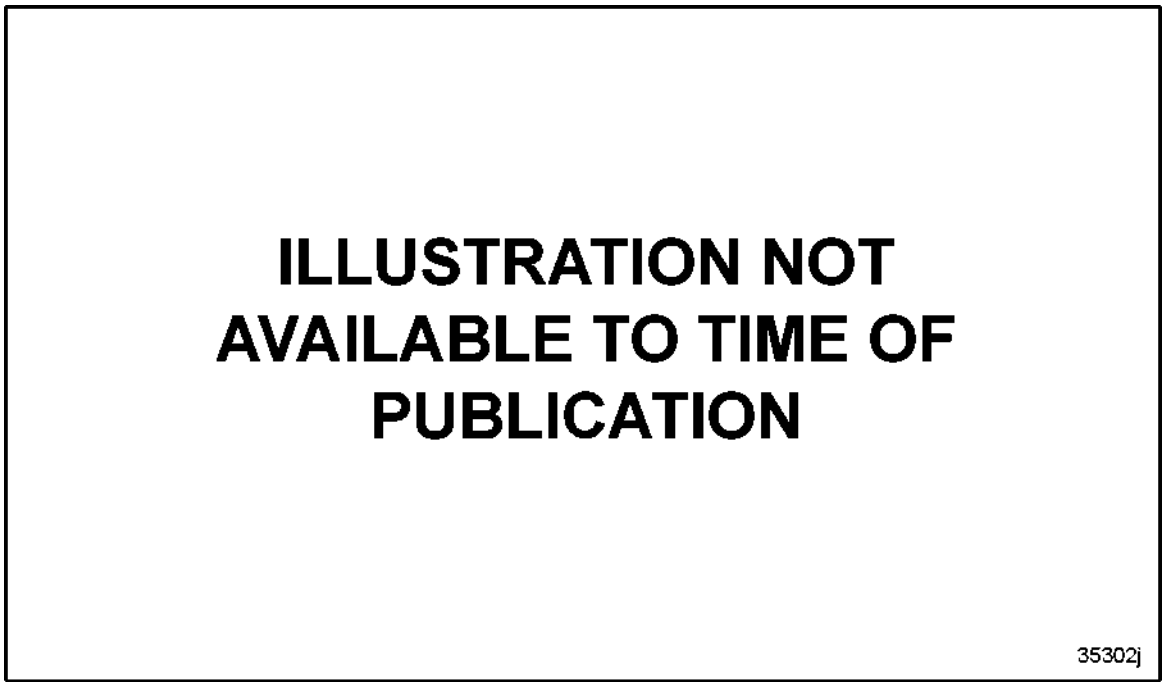

Figure 1715 DDC Diagnostic PC Cart, J 42868

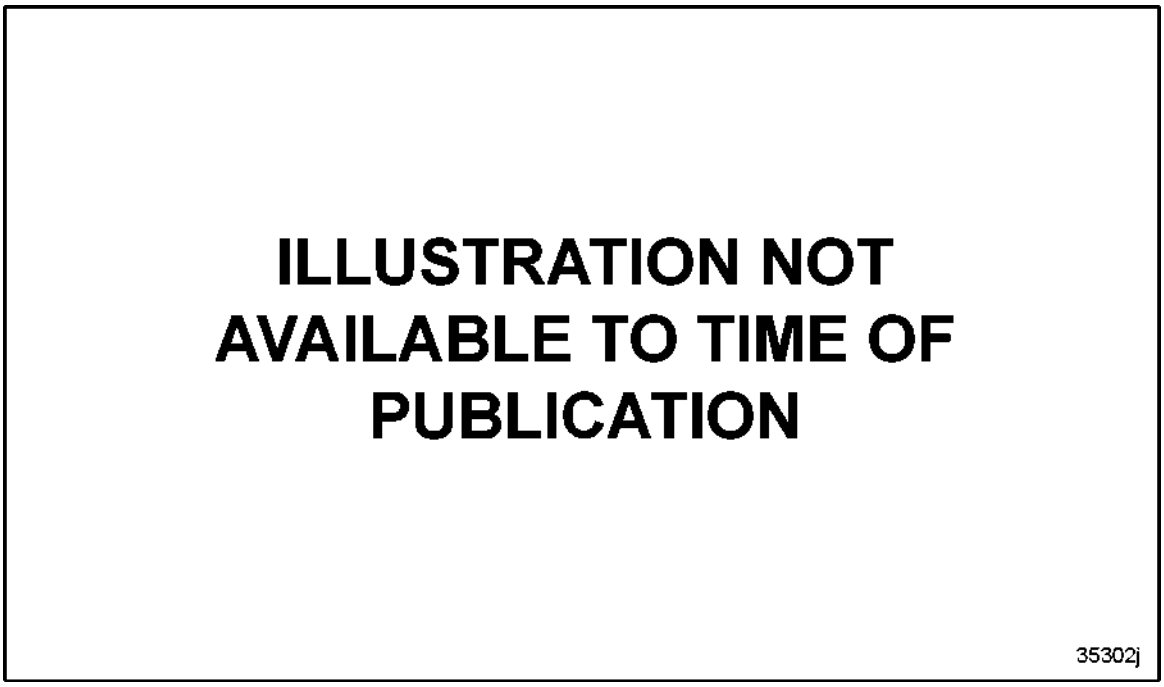

Figure 1716 Engine Field Test Kit,J 39257

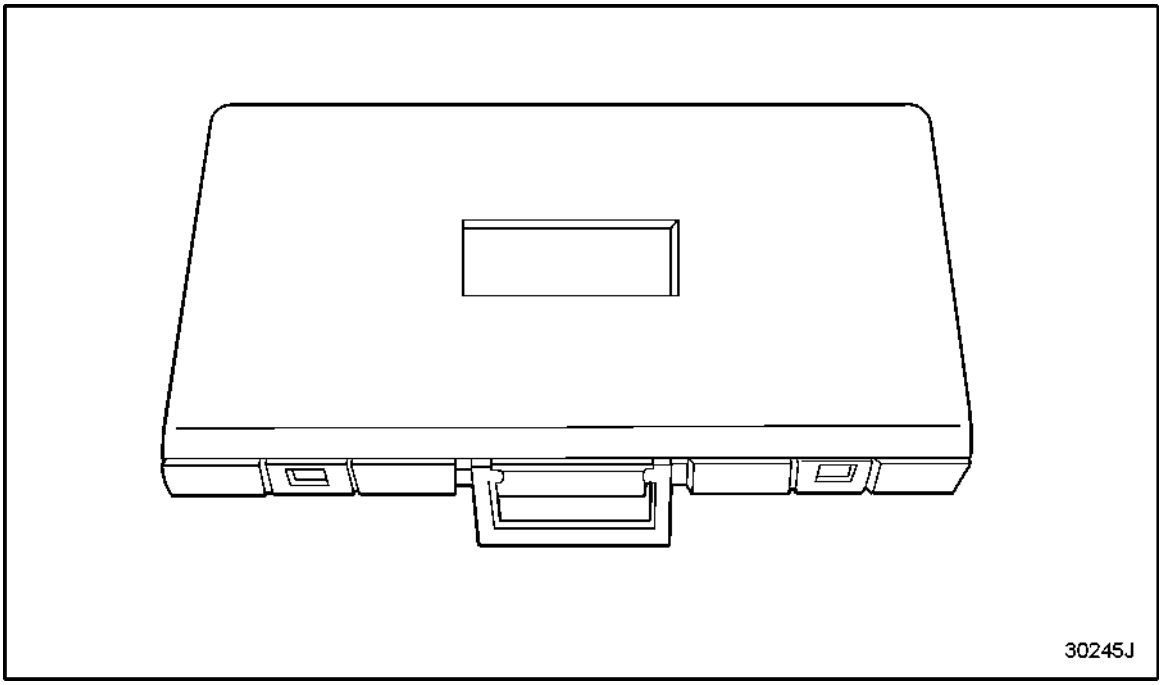

Figure 1717 Engine Harness Repair Kit,J 42948

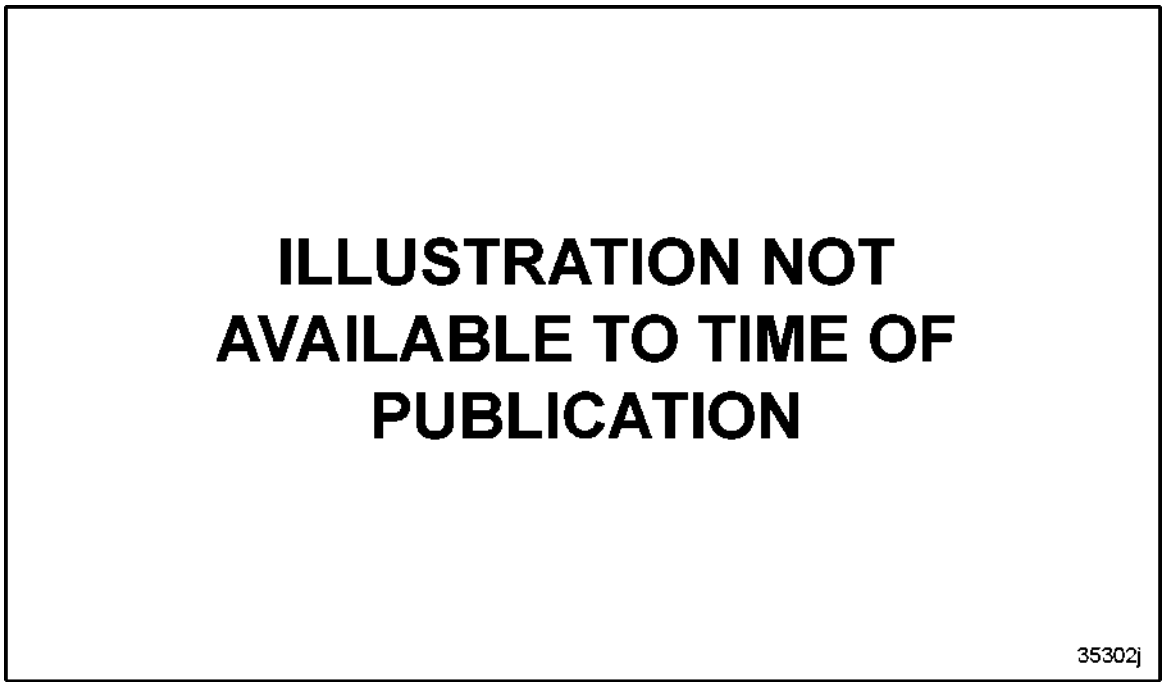

Figure 1718 Infrared Thermometer,PT-7144–A

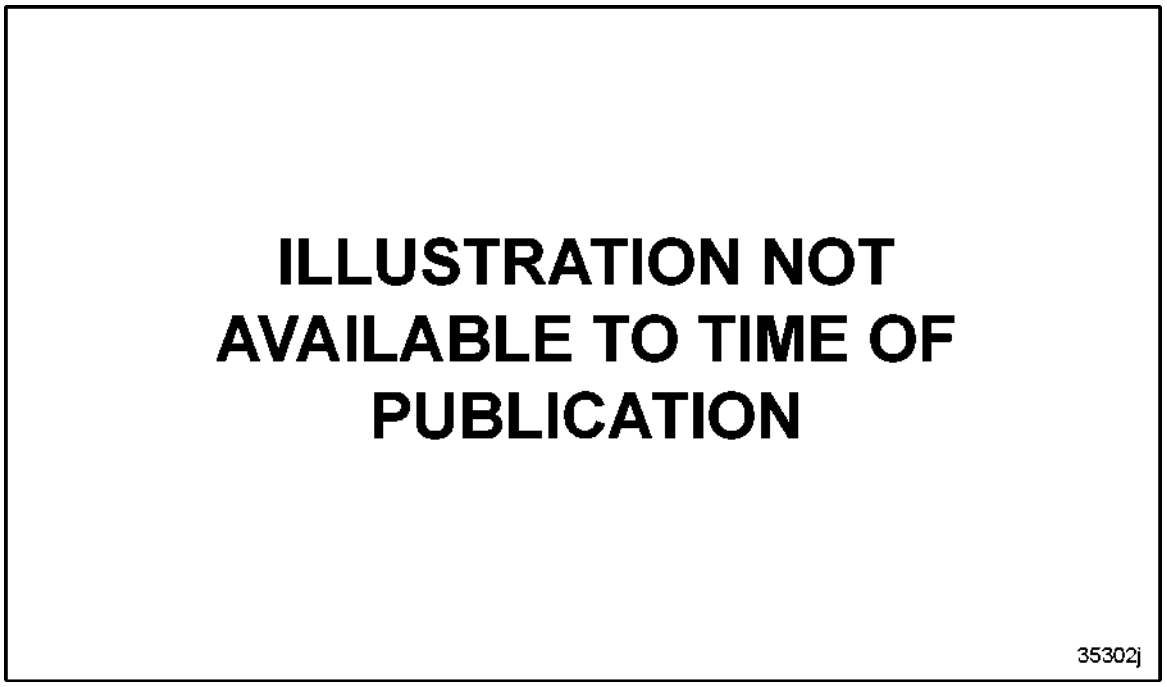

Figure 1719 Phasar Tach,J 35825

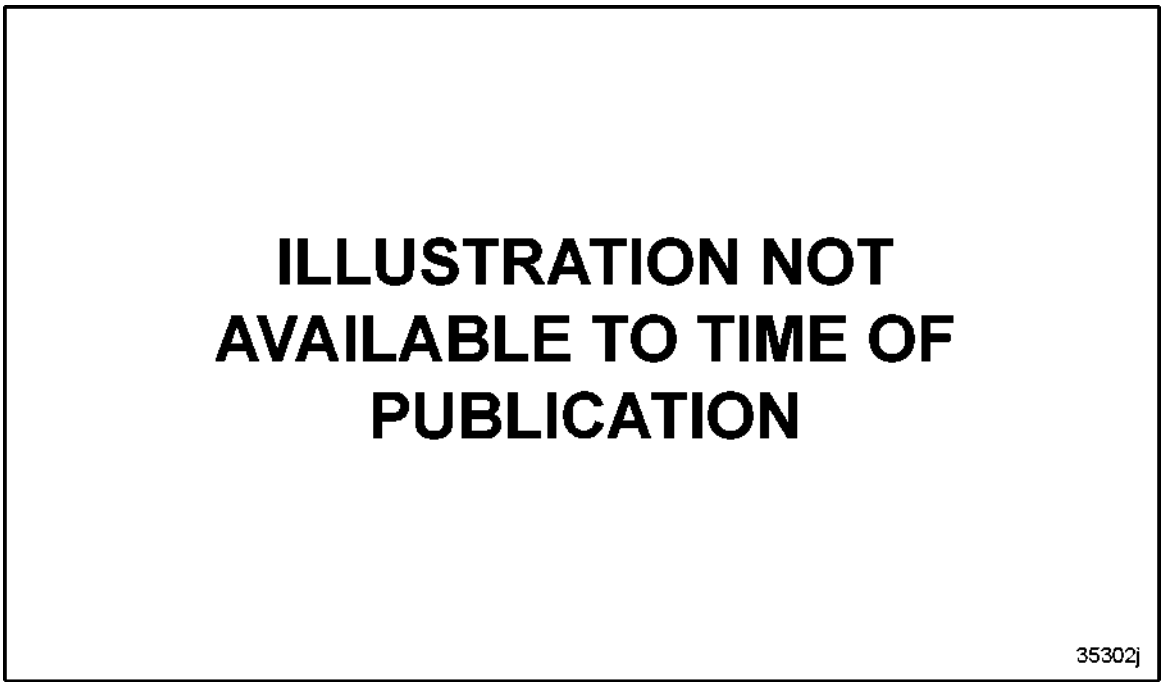

Figure 1720 Terminal Crimping Tool, J 35603

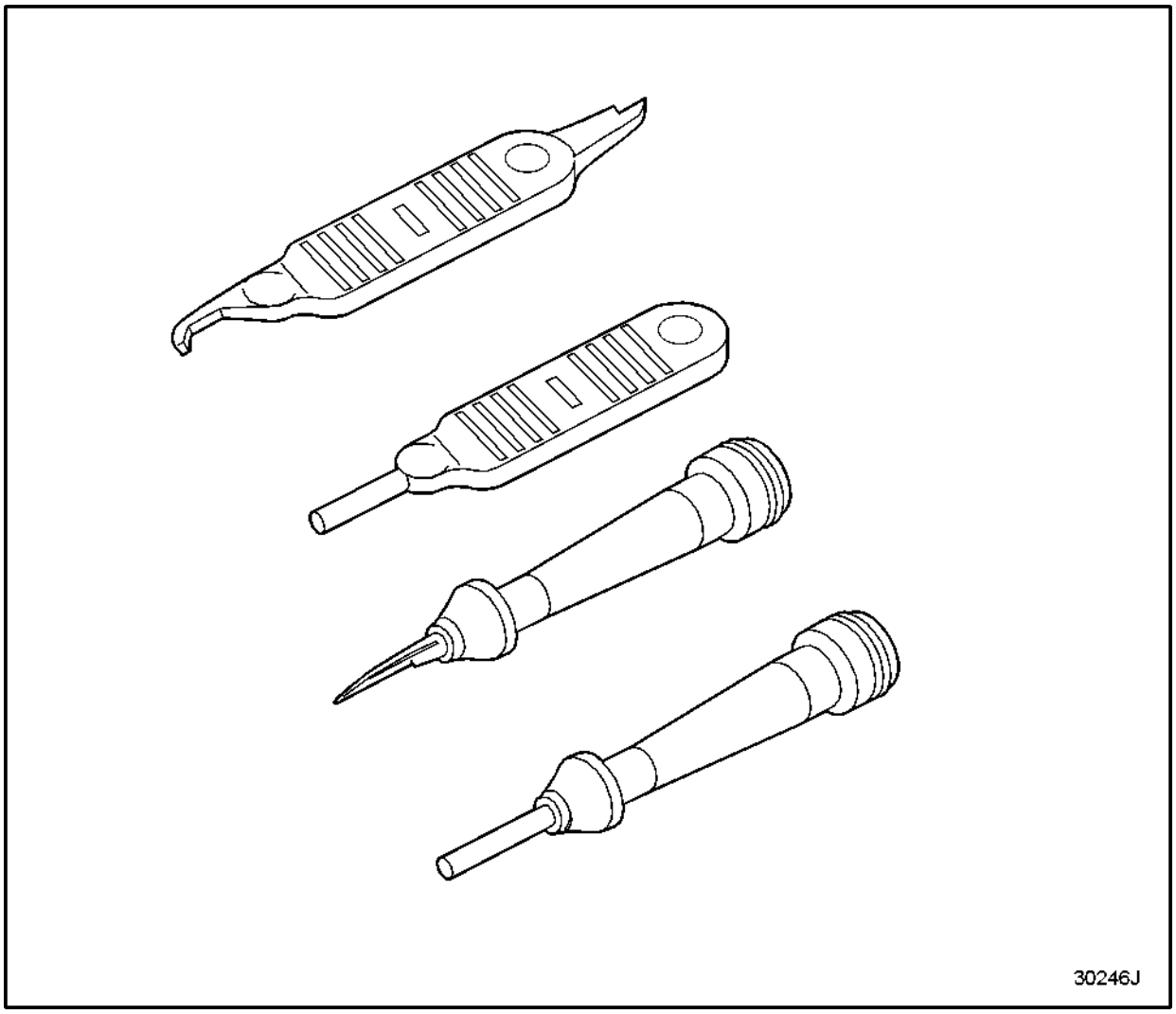

Figure 1721 Terminal Release Tool Kit,J 42949

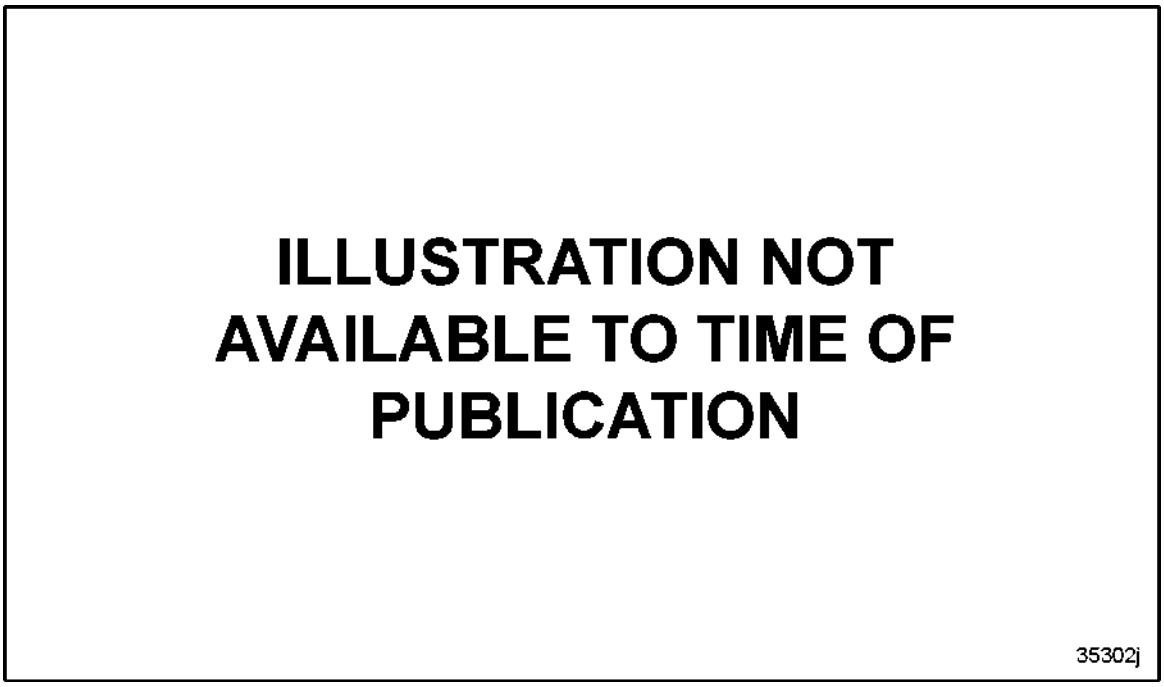

Figure 1722 Belt tension Gauge,J 25386–B

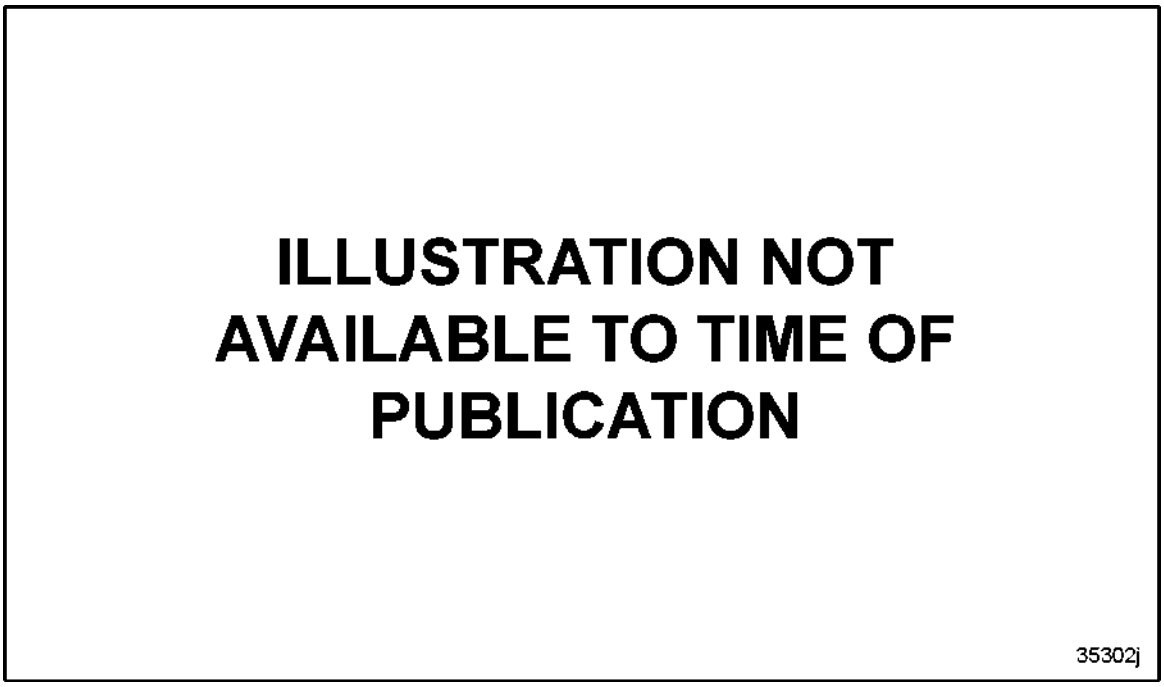

Figure 1723 Belt tension Gauge,BT-3372–DD

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Figure 1724 Belt tension Gauge,BT-3373–F

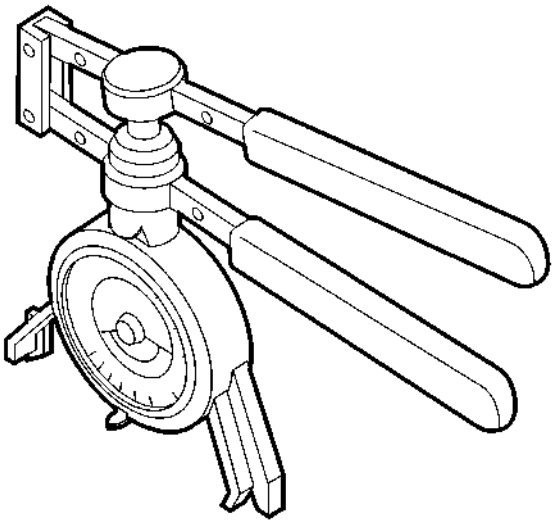

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Figure 1725 Belt Tension Gauge ,J 41251–B

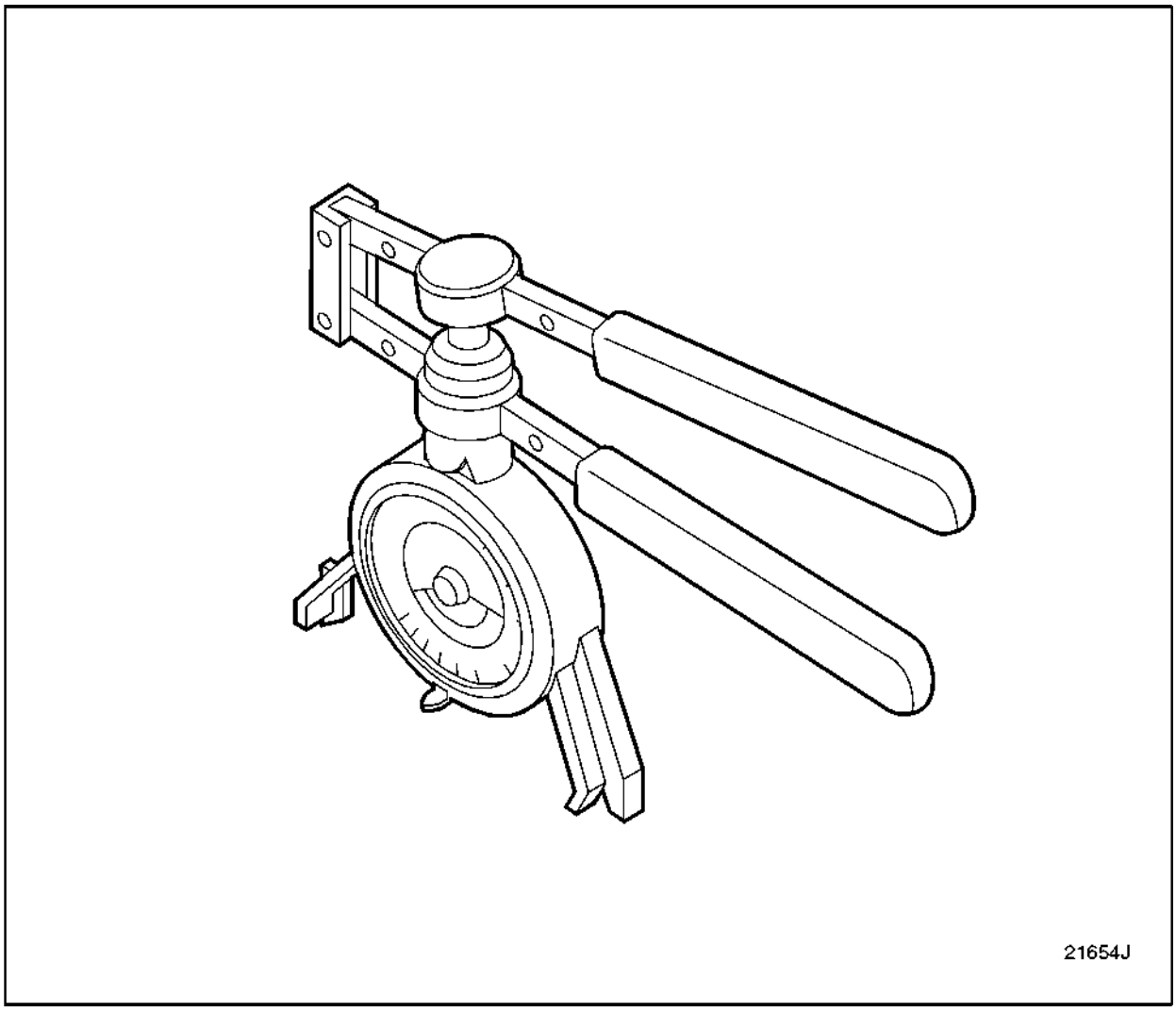

Figure 1726 Belt Tension Gauge (275-475 LBS), J 39966

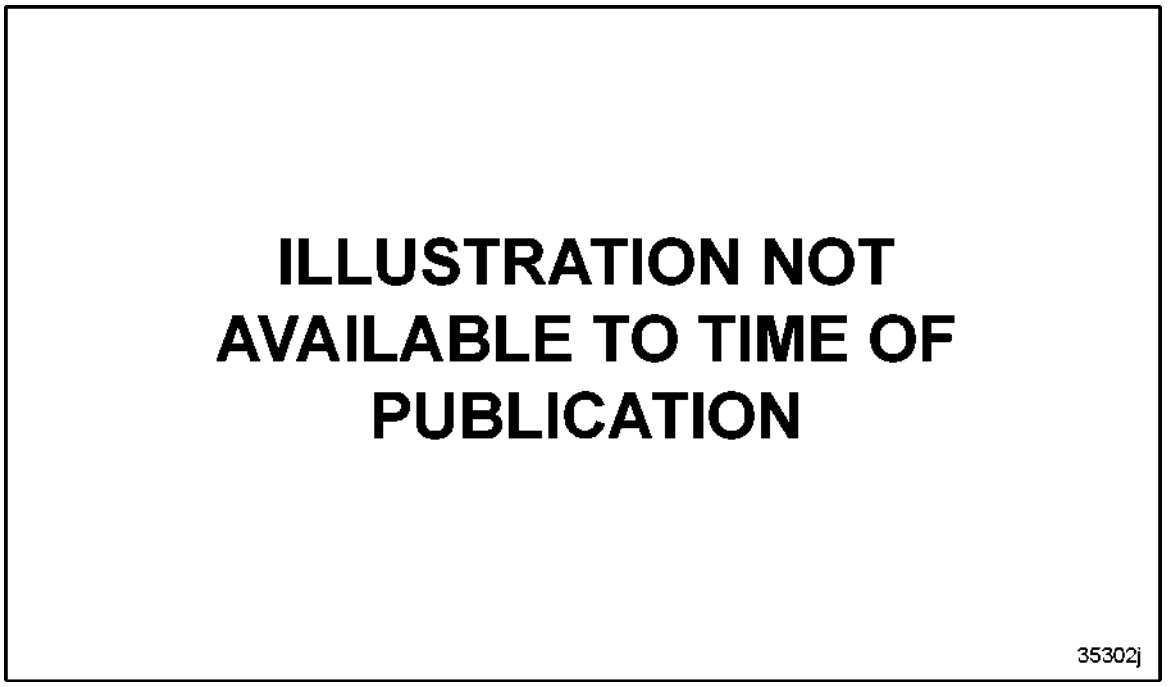

Figure 1727 Belt Tension Gauge (30-180LBS),BT-3373–F Old No. J 23600–B

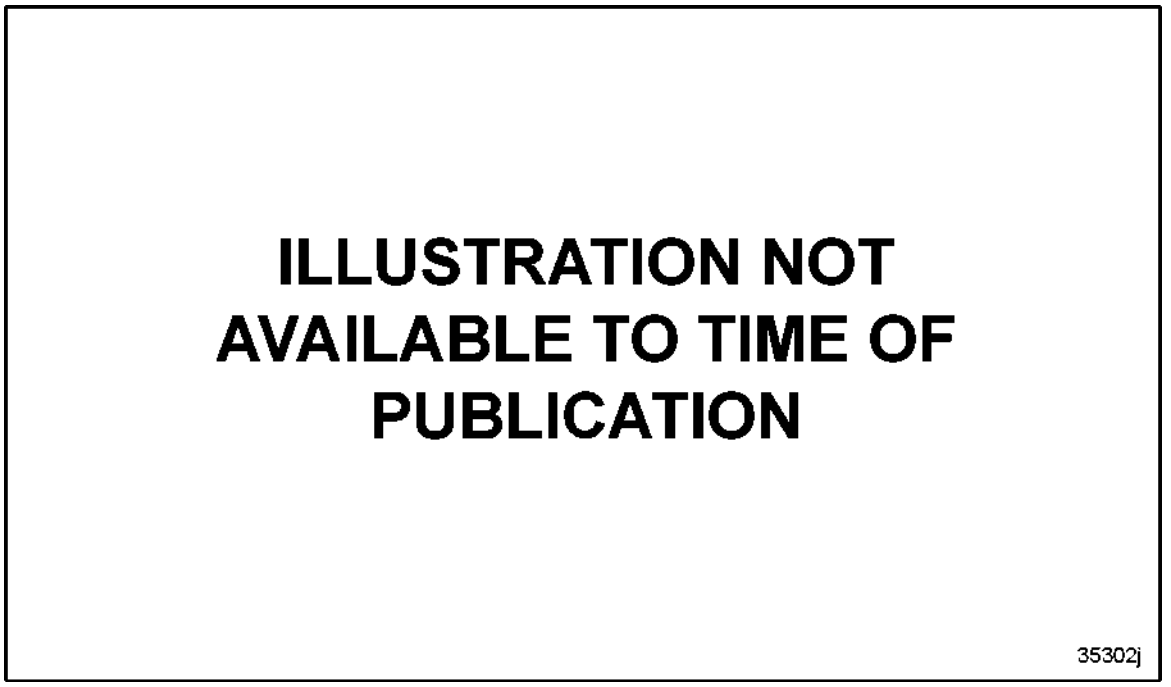

Figure 1728 Caliper (0-150 MM) Dial Type,J 26900–7

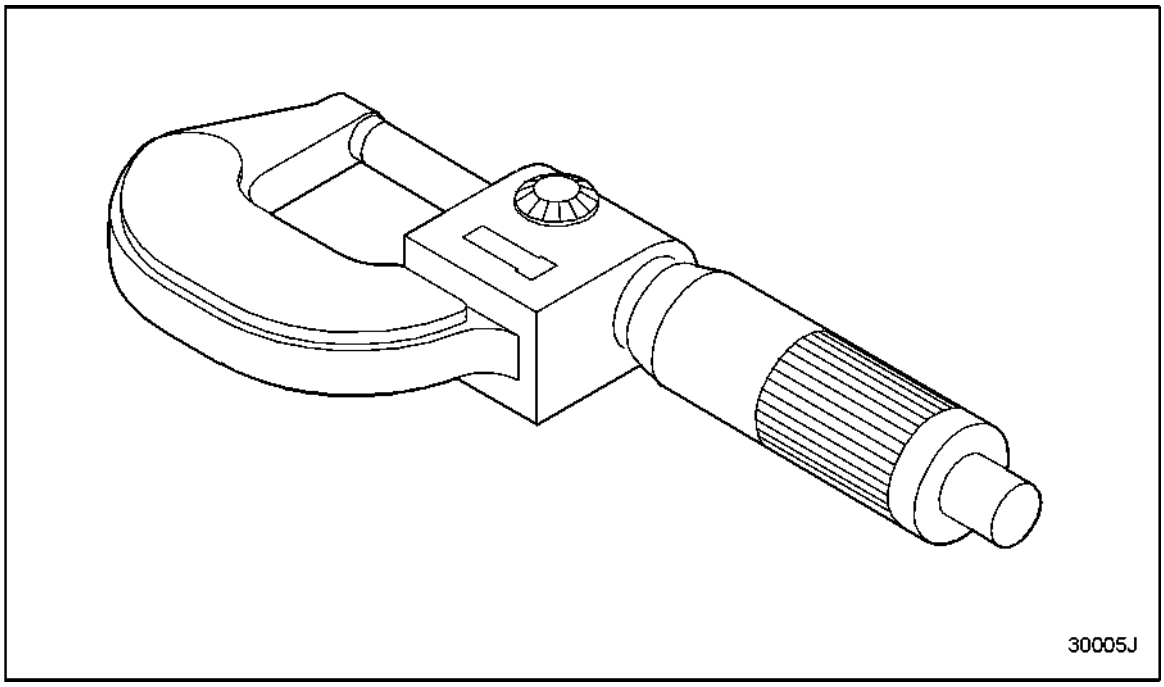

Figure 1729 Caliper (0-6" MM) Dial Type,J 26900–6

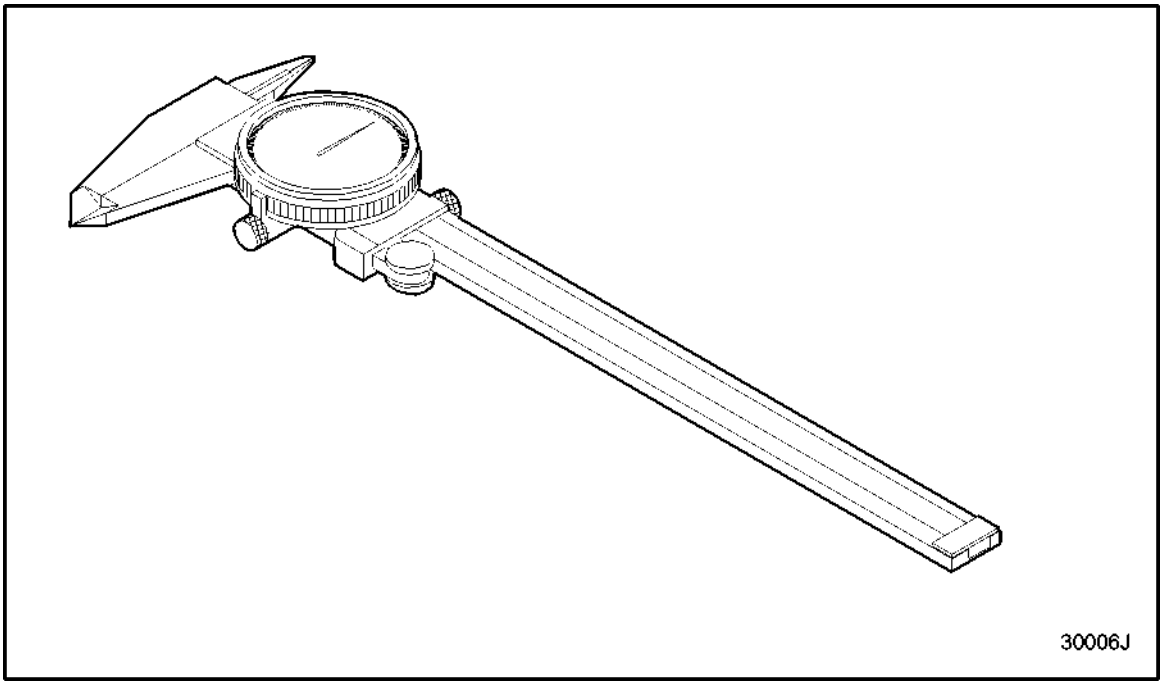

Figure 1730 Caliper (0-6" MM) Vernier Type,J 26900–5

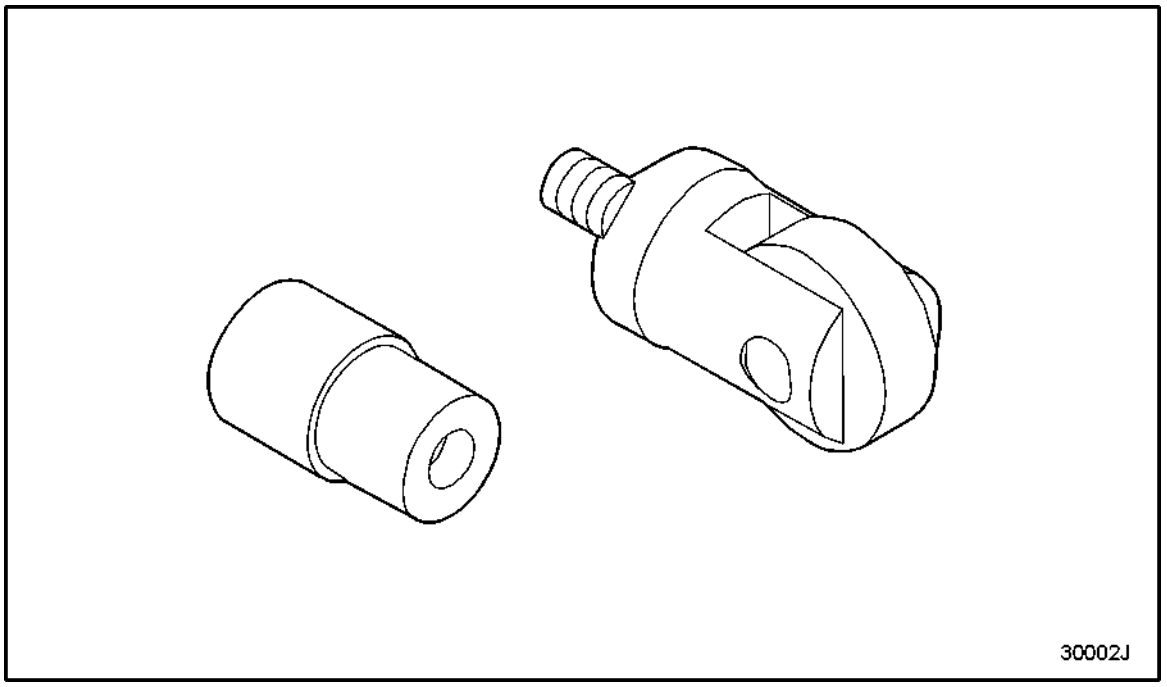

Figure 1731 Dial Indicator Roller ADPT,J 23672

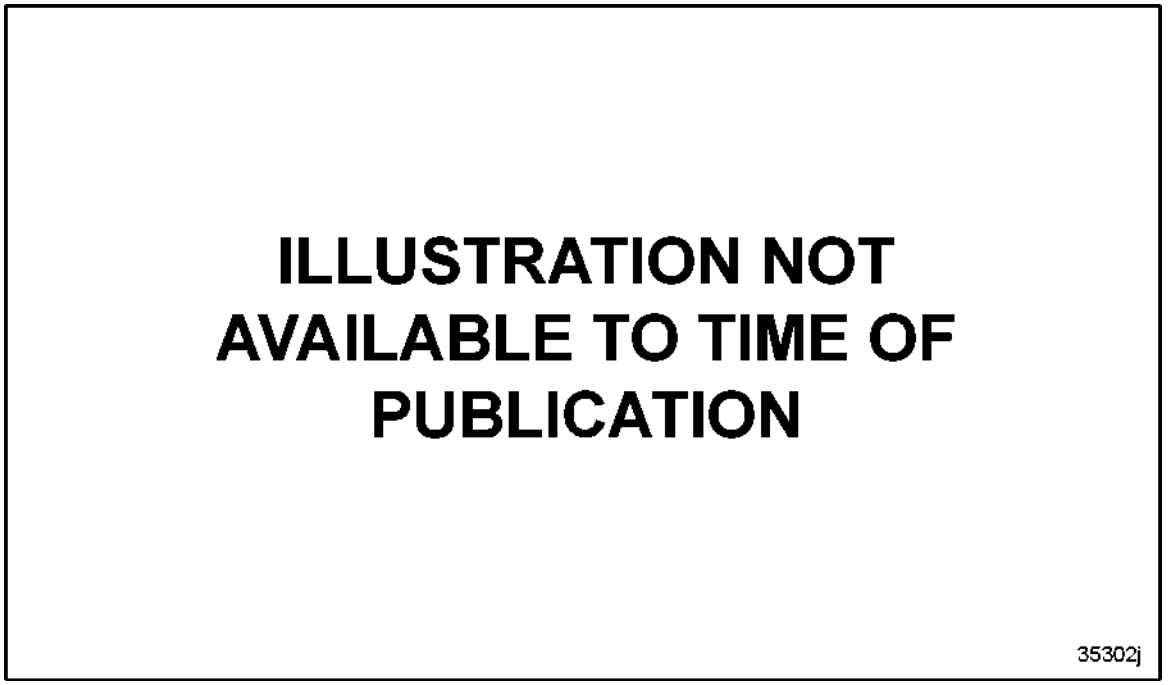

Figure 1732 Dial Indicator Set,J 8001

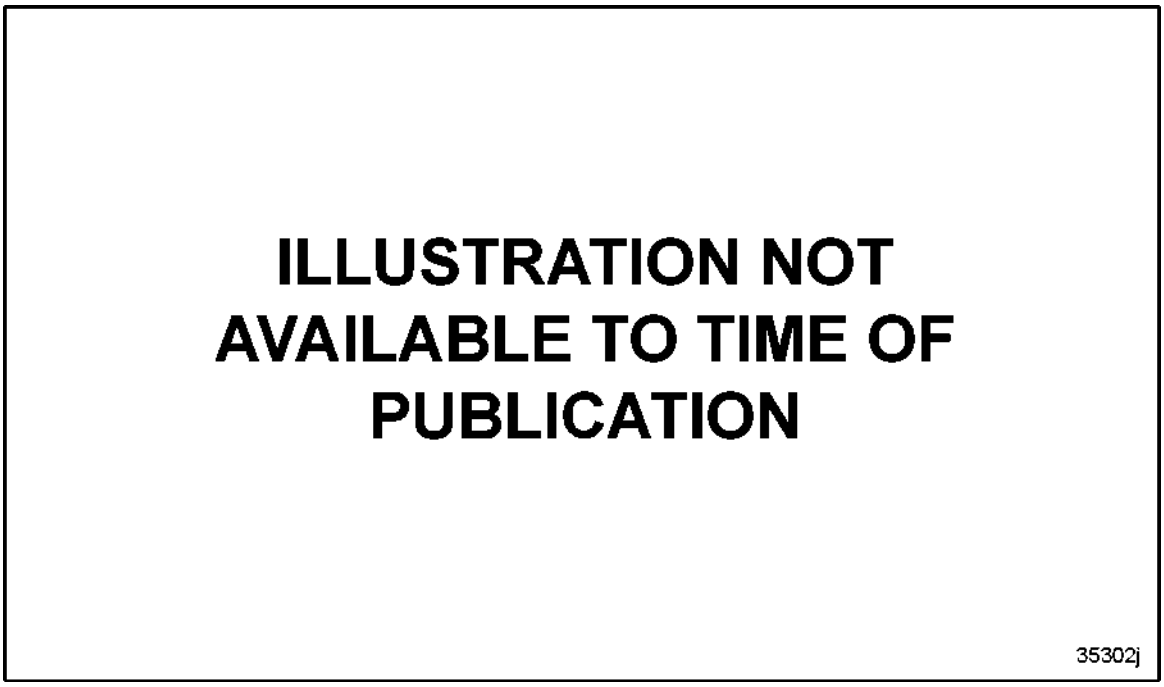

Figure 1733 Gauge 11/4-21/8 TE,J 26900–23

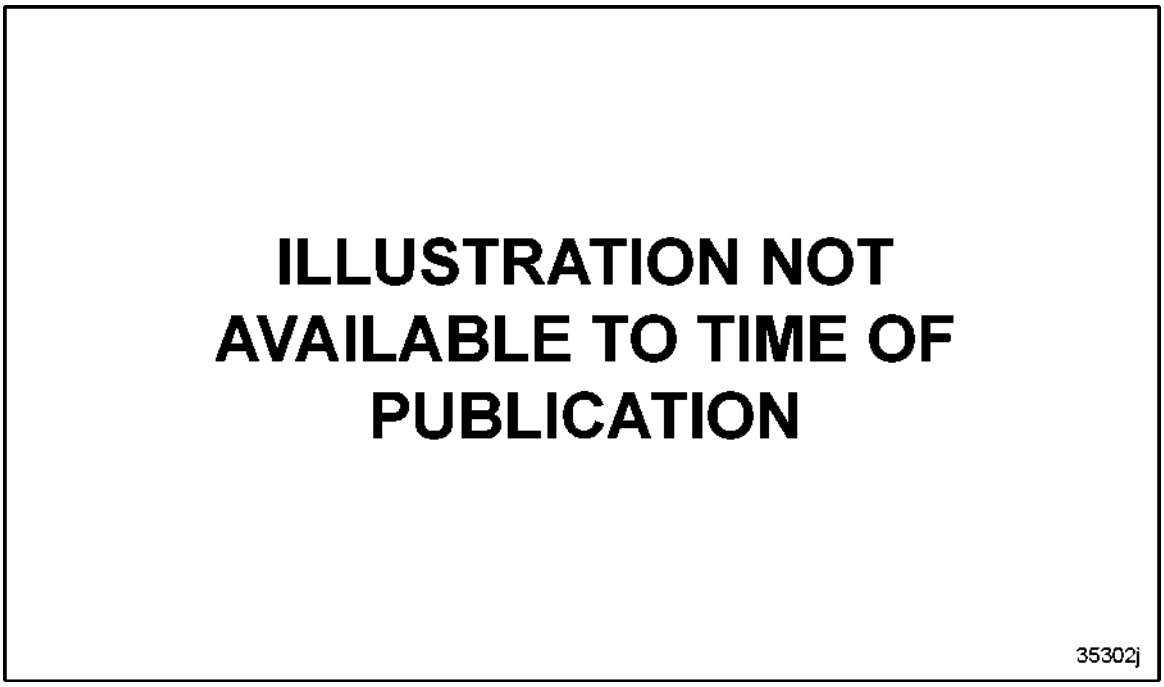

Figure 1734 Gauge Set 5/16-6",J 26900–33

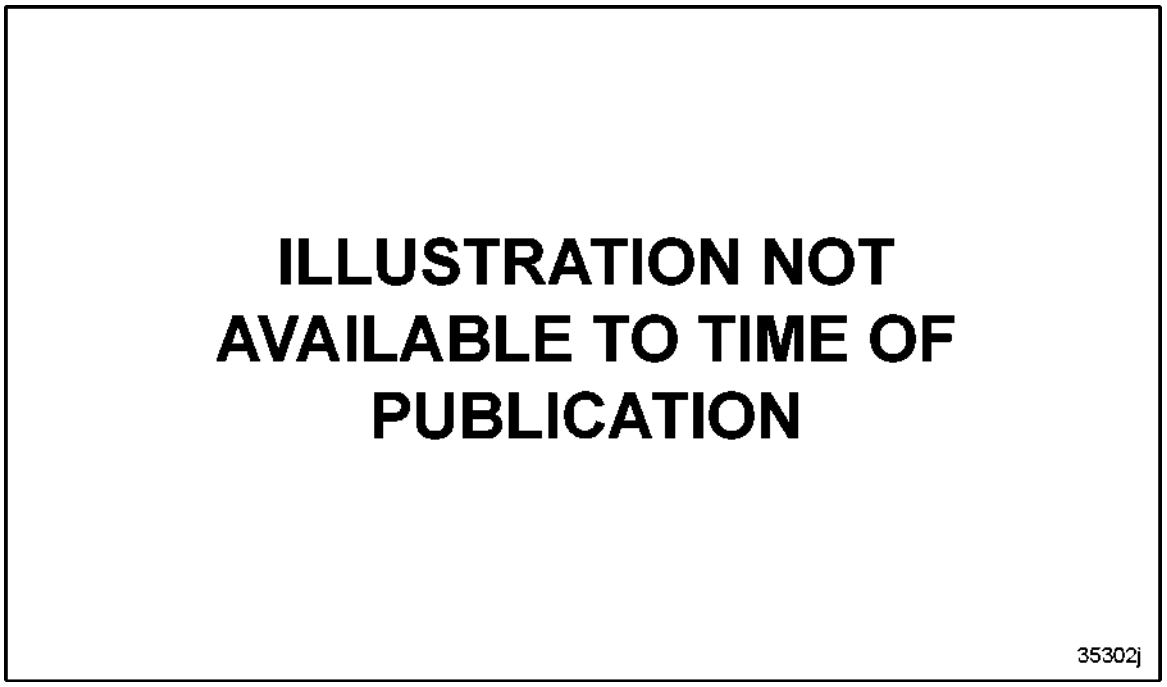

Figure 1735 **Holy Gauge Set ,125-.500,**J 26900–14

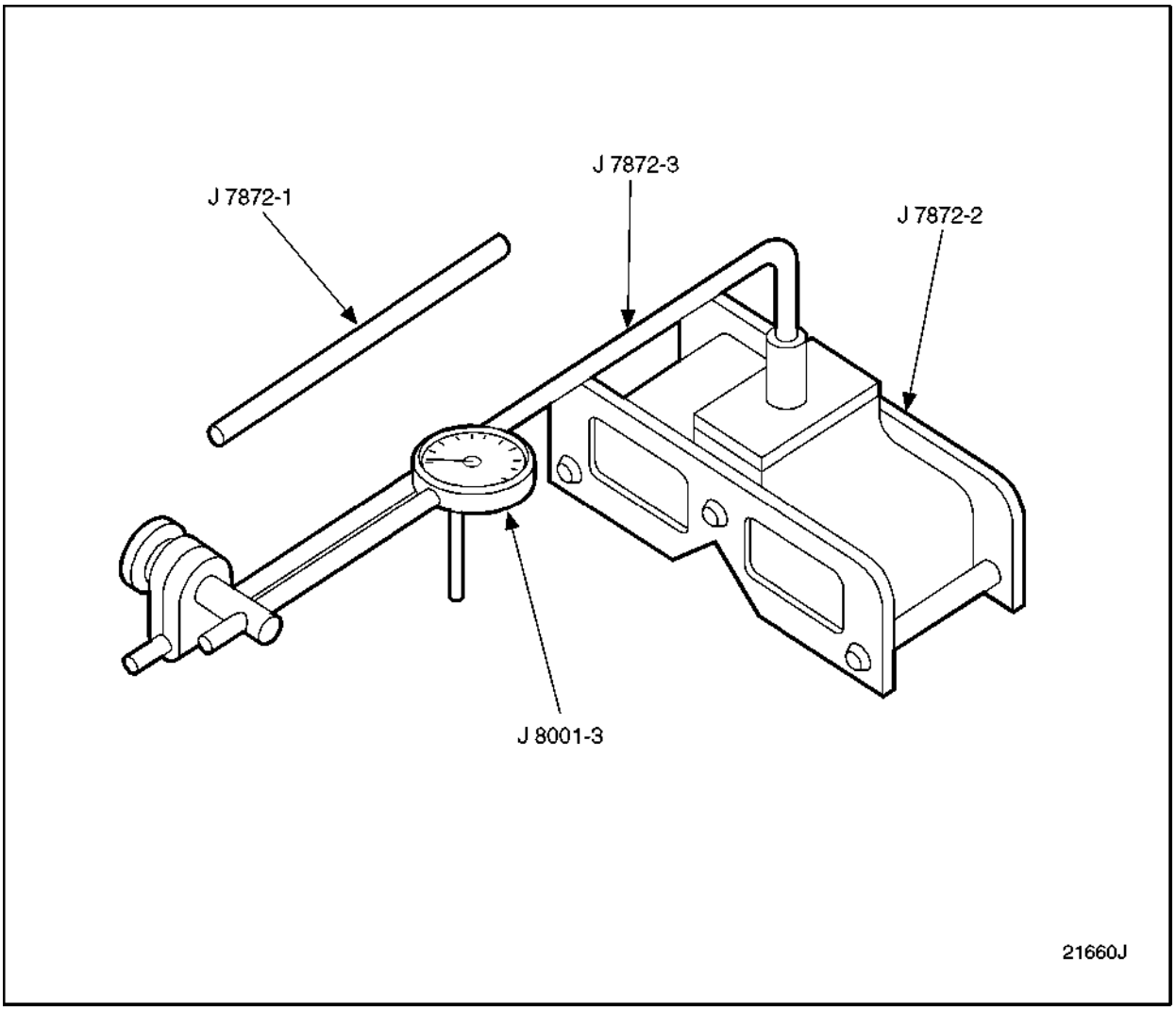

Figure 1736 Magnetic Base Dial Indicator, J 7872

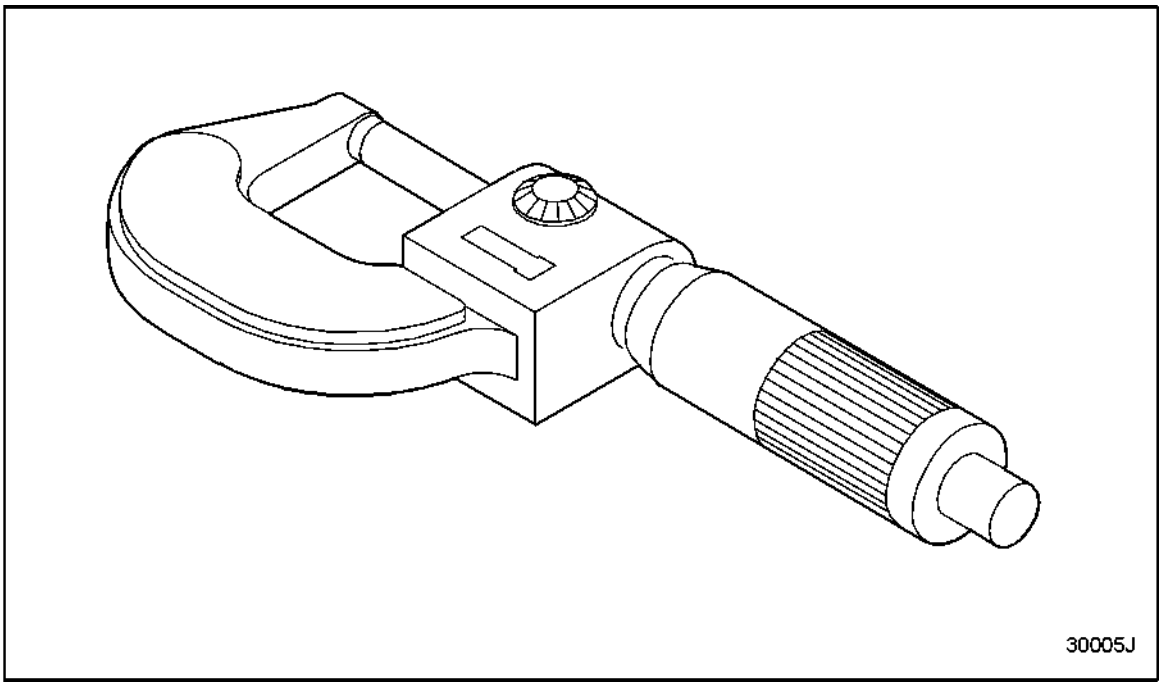

Figure 1737 Micrometer (Inch & MM) 0-1",J 26900–1

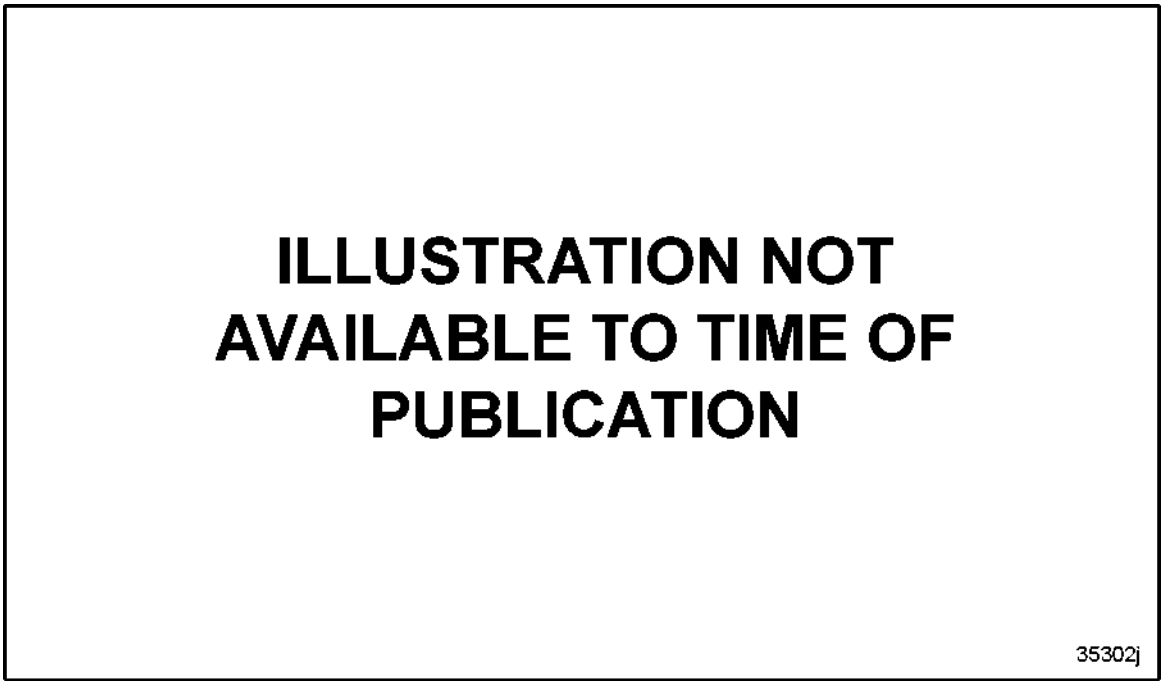

Figure 1738 Micrometer (Inch & MM) 1"-2",J 26900–2

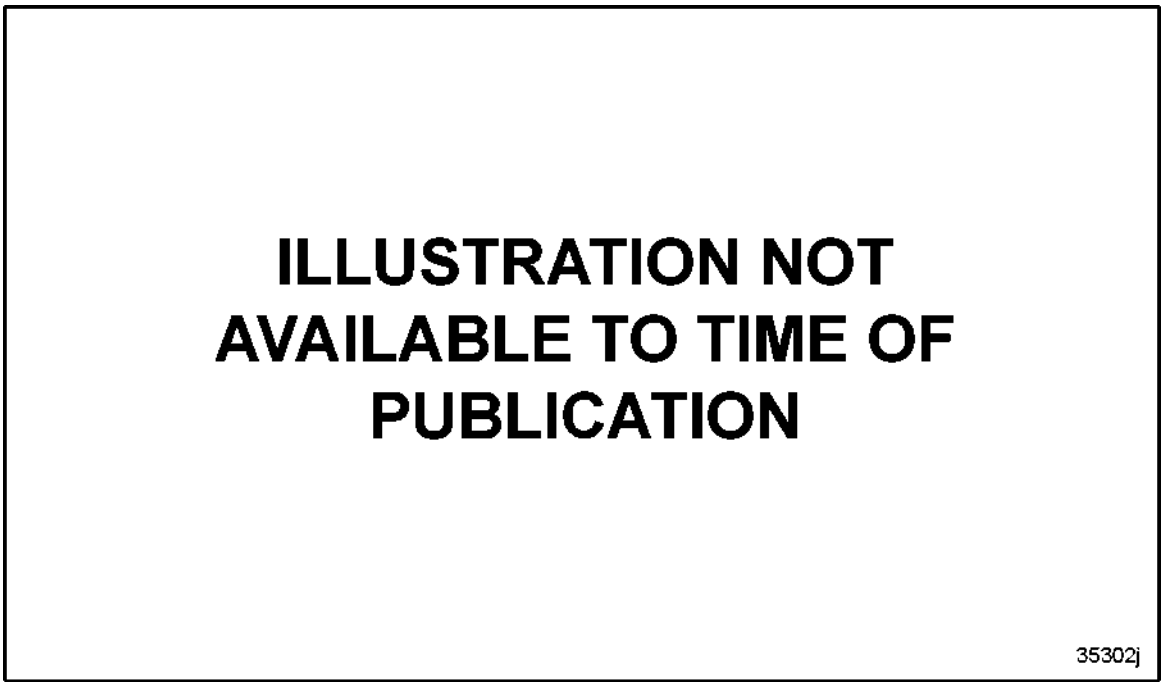

Figure 1739 Micrometer (Inch & MM) 2"-3",J 26900–3

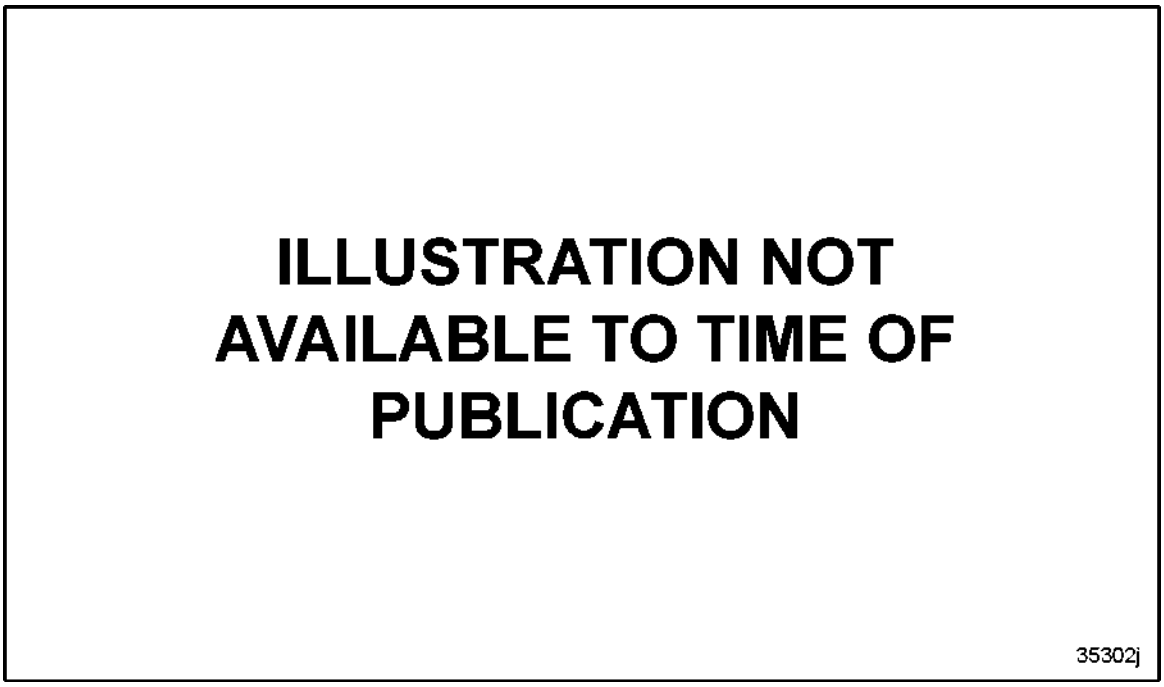

Figure 1740 Micrometer (Inch & MM) 3"-4",J 26900–4

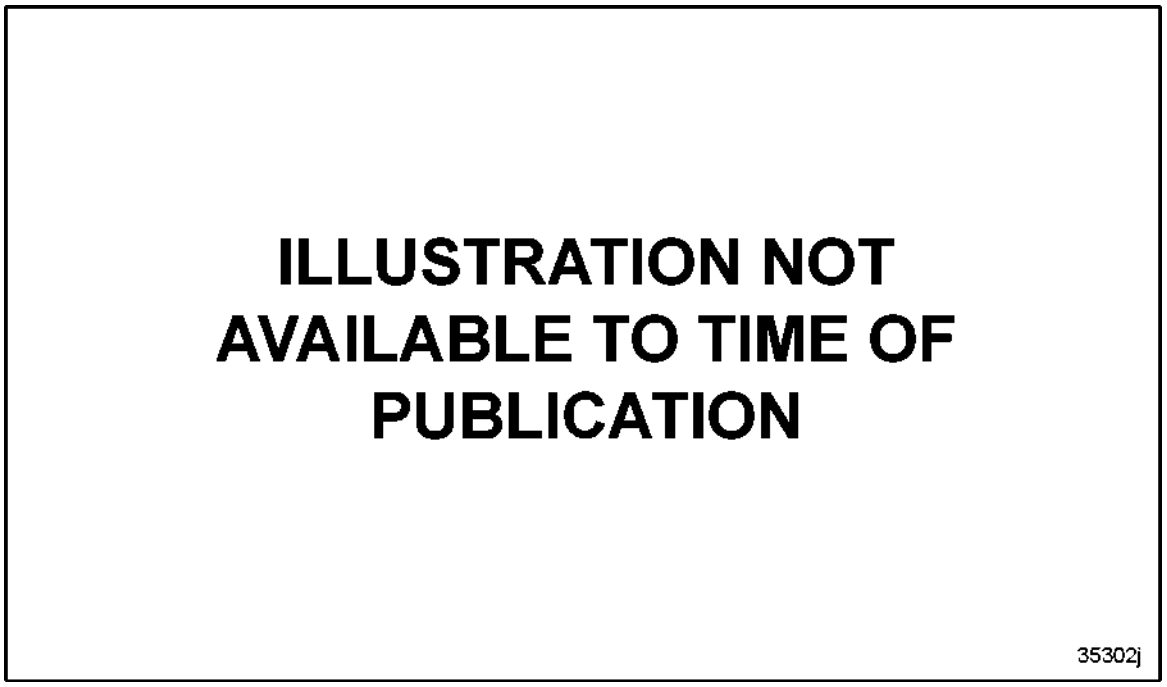

Figure 1741 **Micrometer (Inch & MM) 4"-5",**J 26900–30

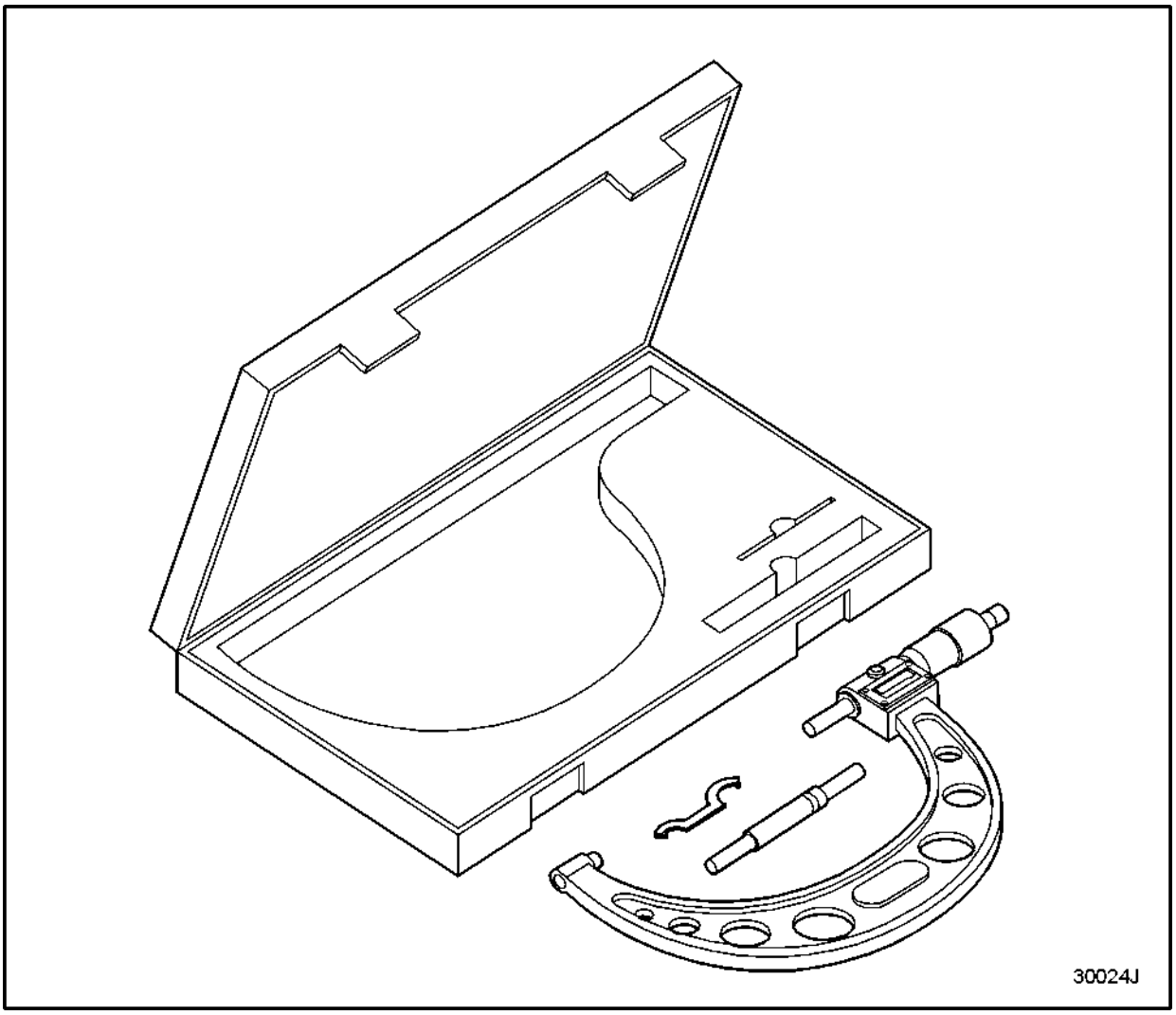

Figure 1742 Micrometer (Inch & MM)5"-6",J 26900–32

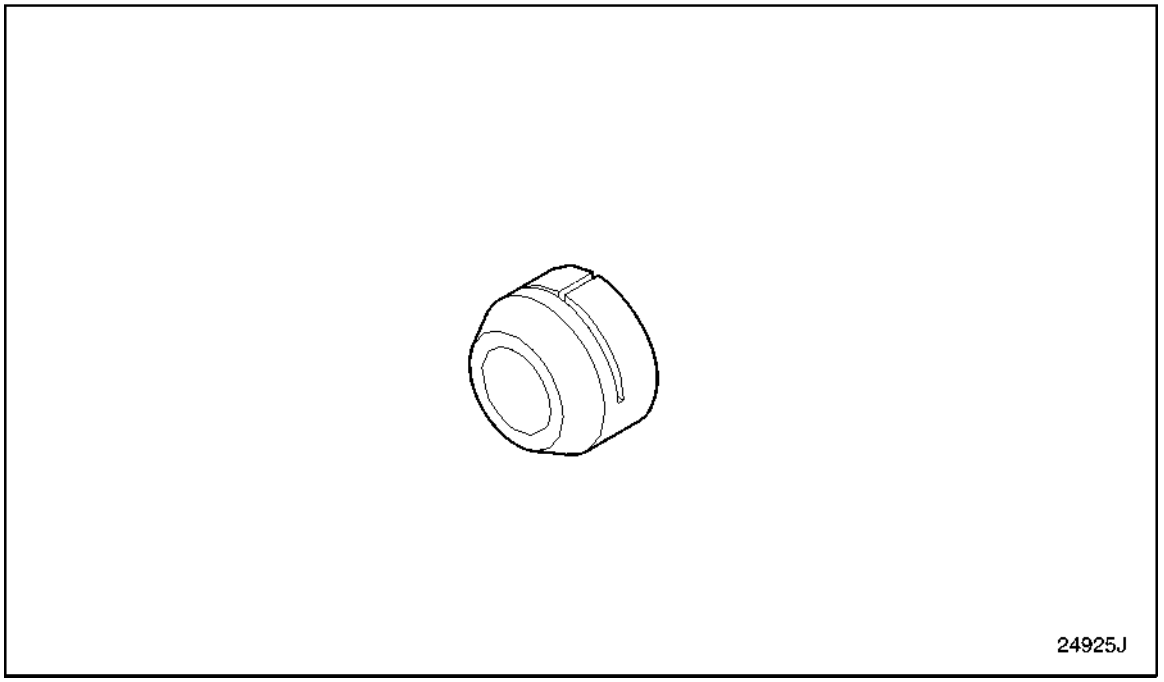

Figure 1743 Micrometer- Ball Attachment,J 4757

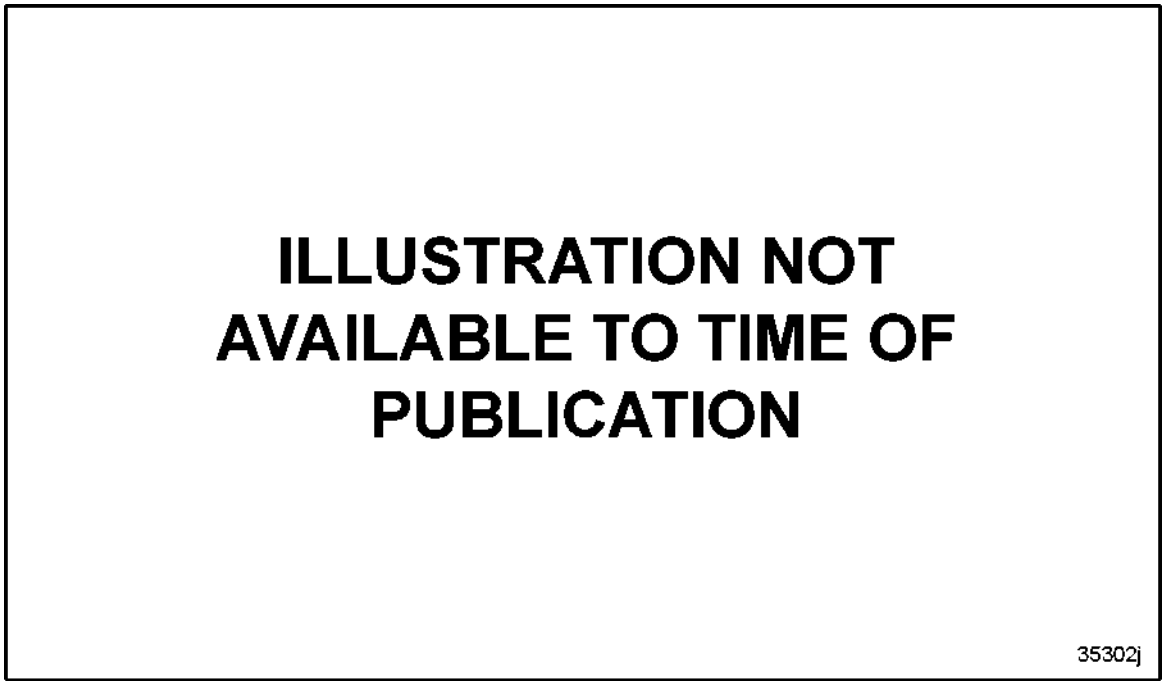

Figure 1744 Outside Micrm 3"-4",J 26900–37

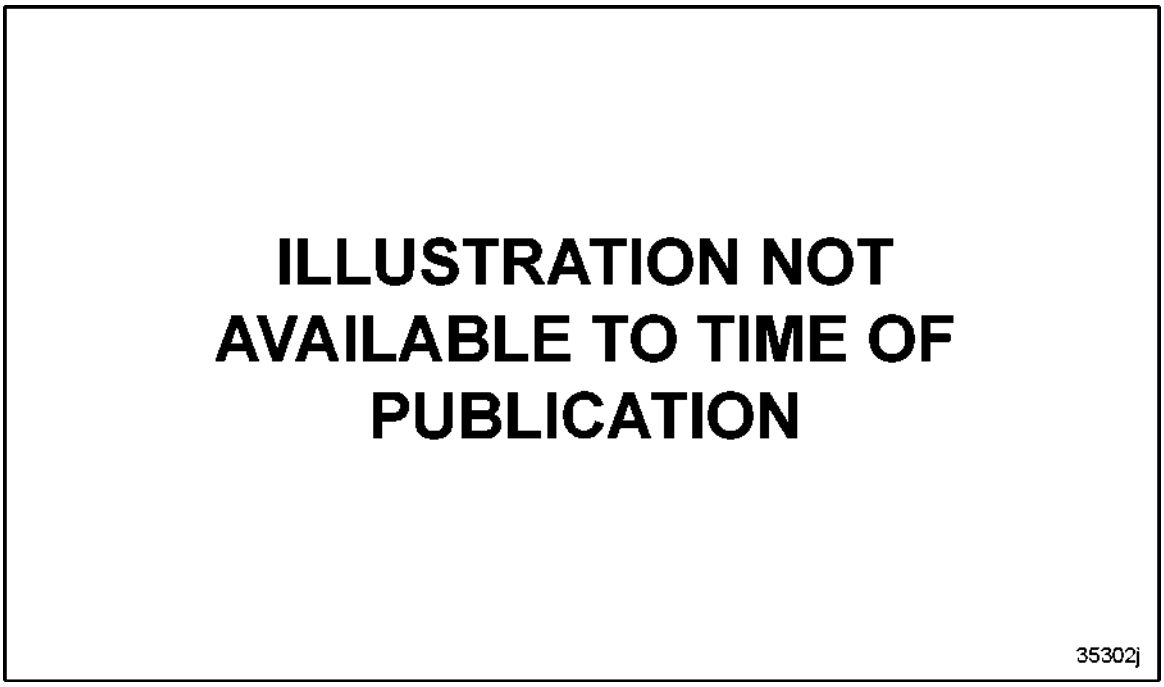

Figure 1745 Outside Micrm 5"-6",J 26900–39

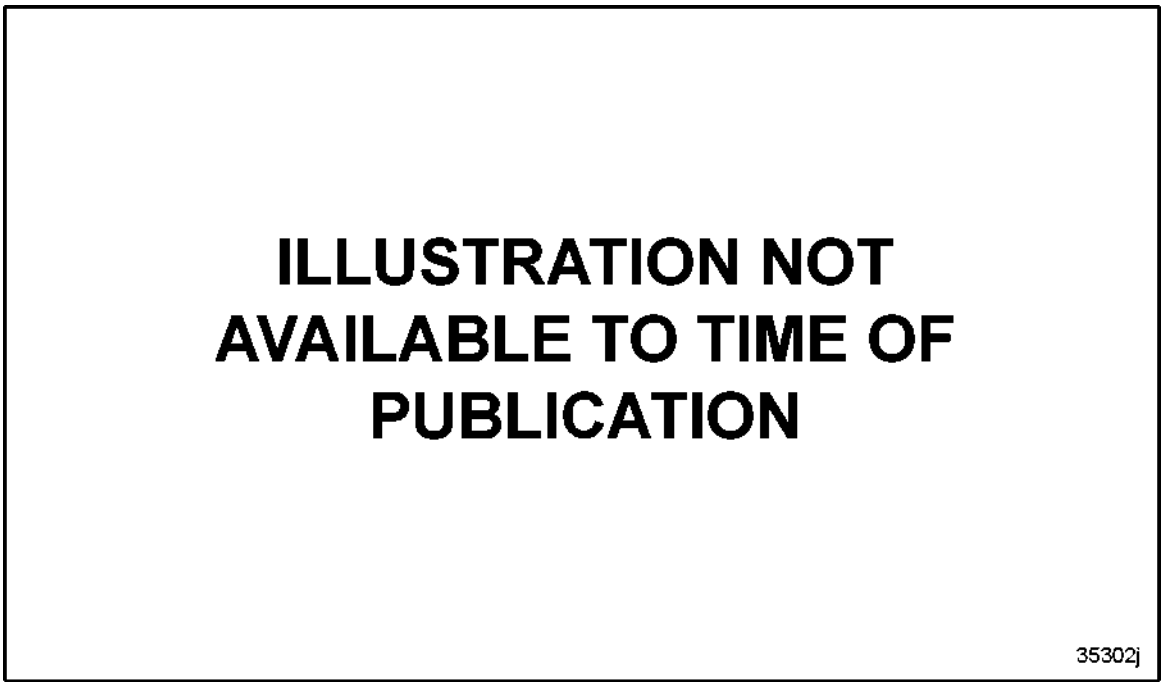

Figure 1746 Spring Tester (0-125 LBS),J 29296

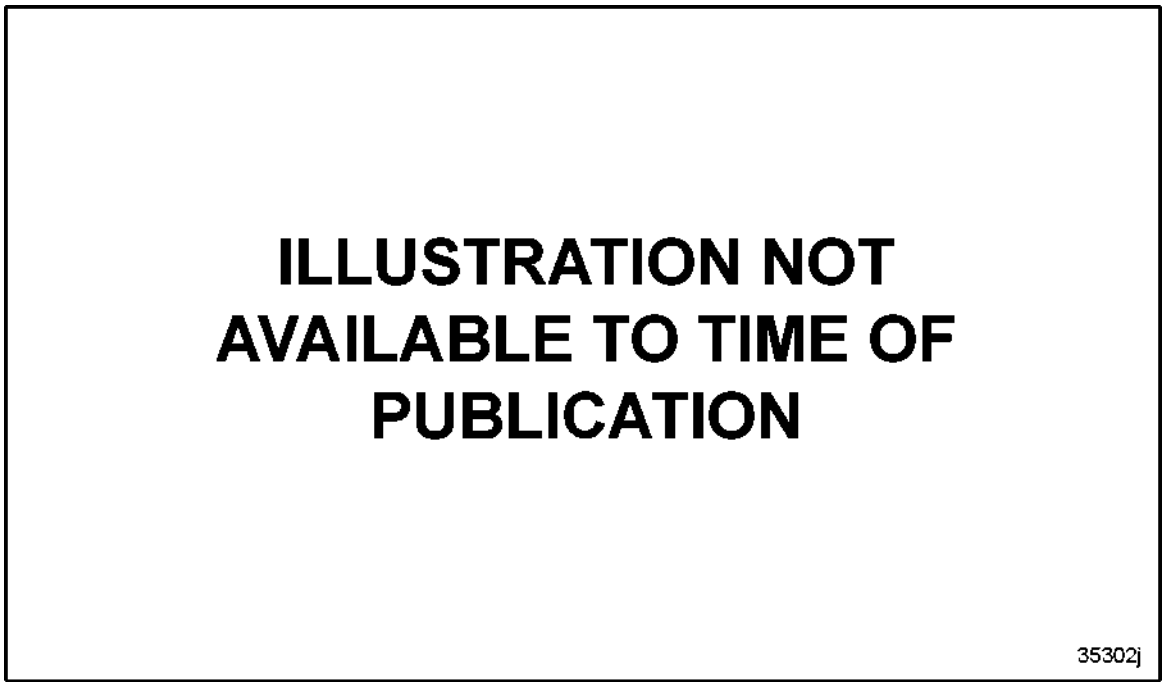

Figure 1747 **Tele GA .75-1.25",**J 26900–16

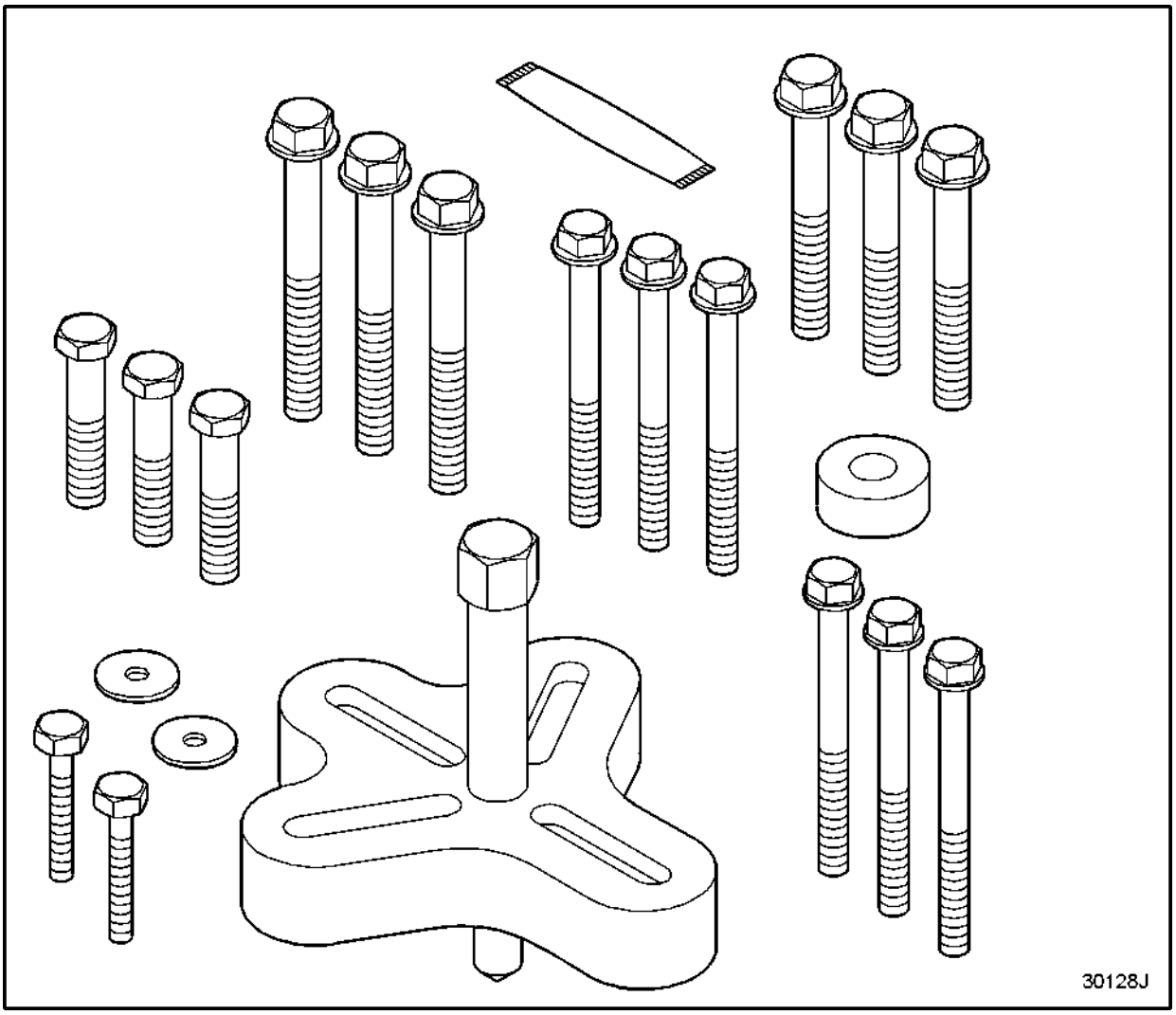

Figure 1748 Harmonic Balancer Hub Puller, J 24420–C

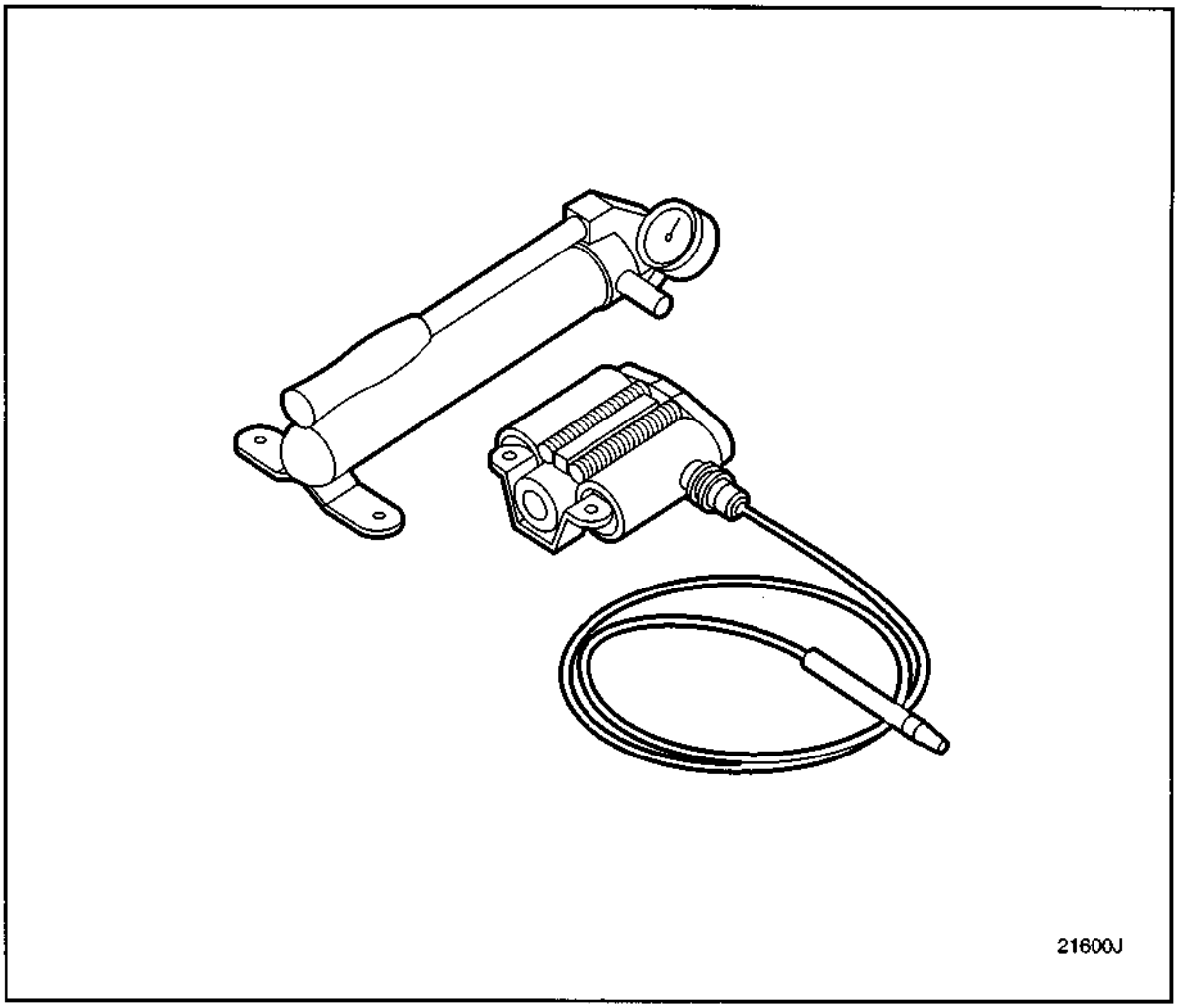

Figure 1749 Hydraulic Ram & Pump (17-1/2 Ton), J 35951–175

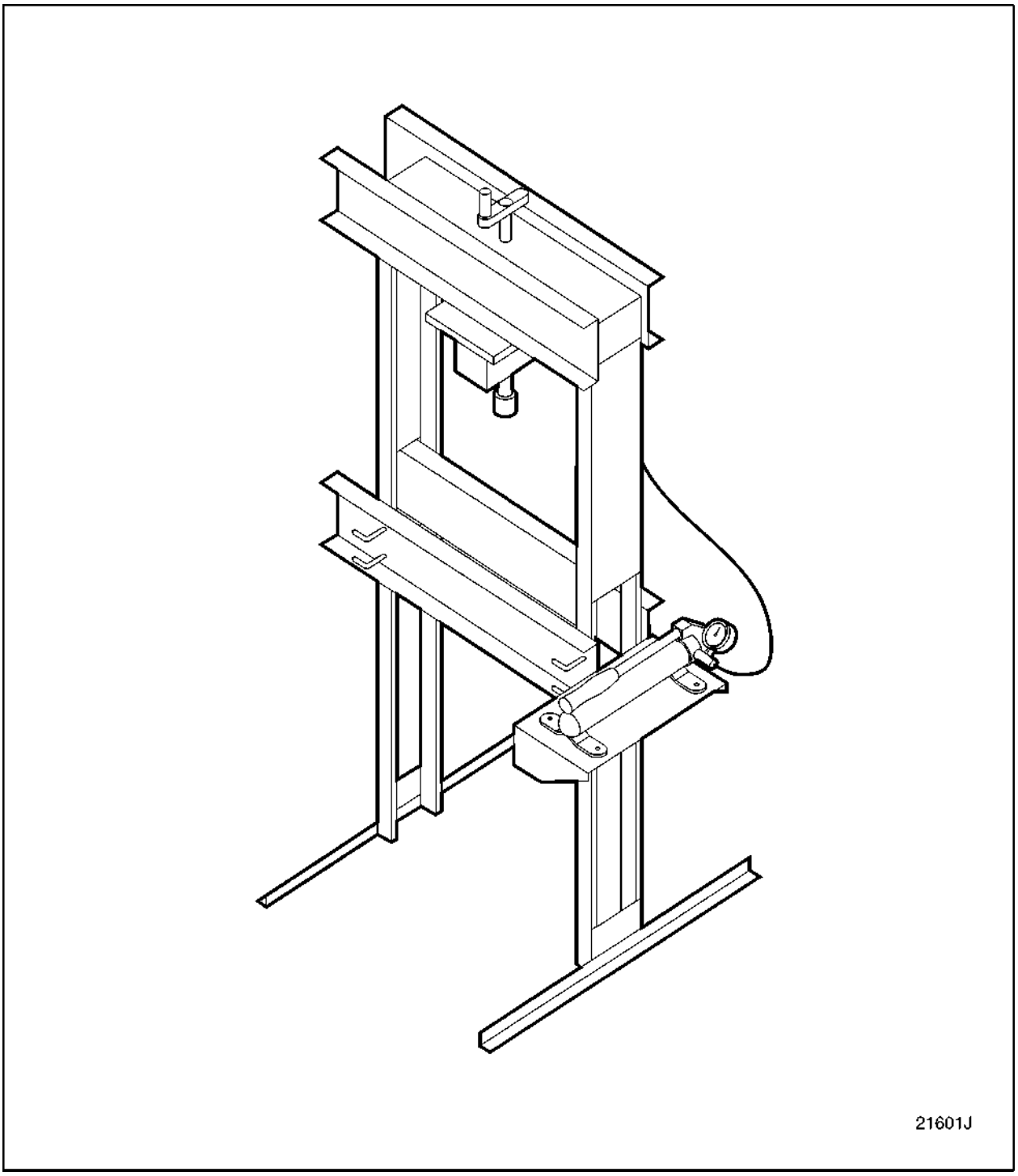

Figure 1750 Hydraulic Shop Press -17-1/2 Ton,J 35951

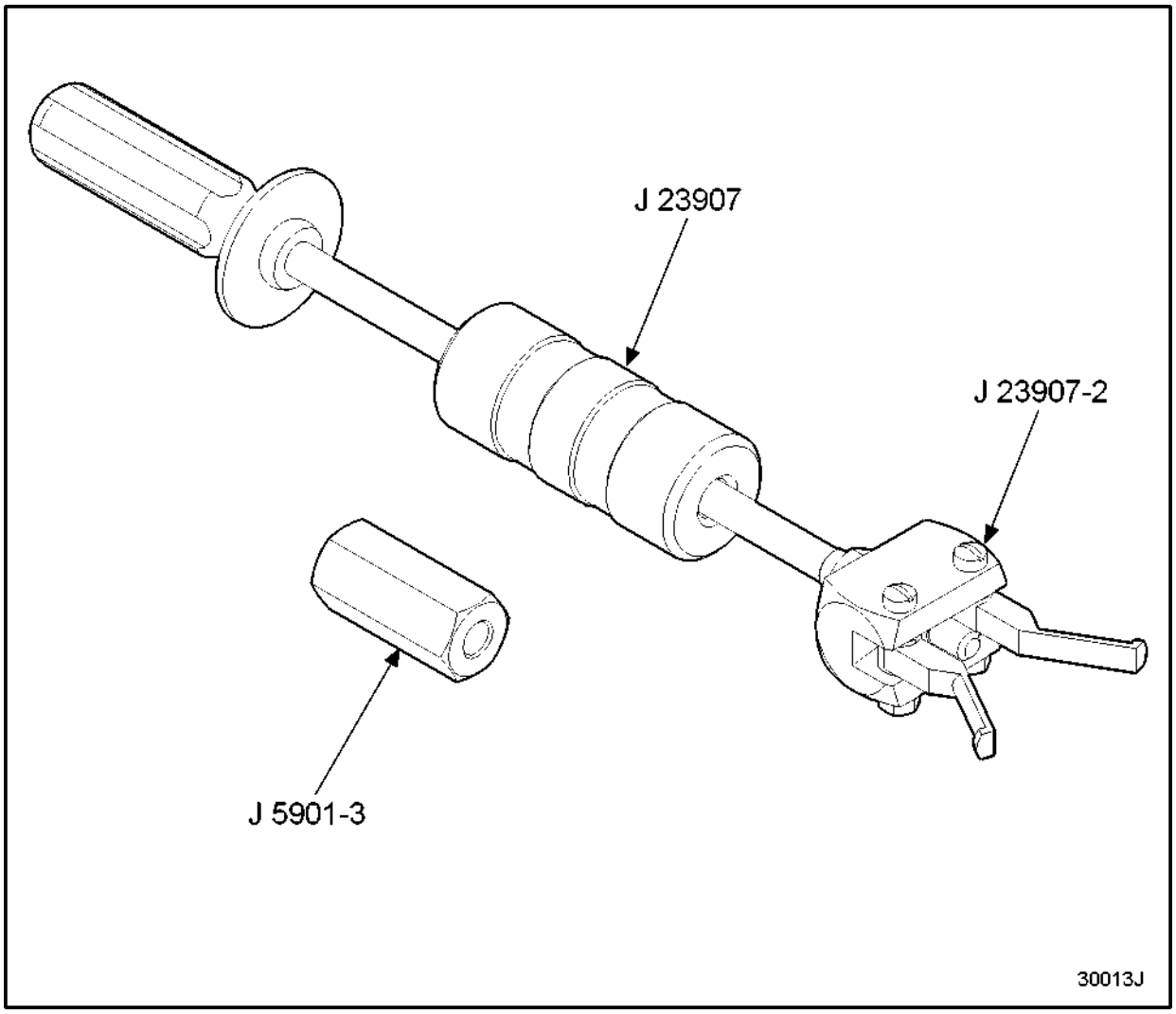

Figure 1751 Slide Hammer Puller Set,J 5901–01

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Figure 1752 Three Jaw Puller,J 25031–A

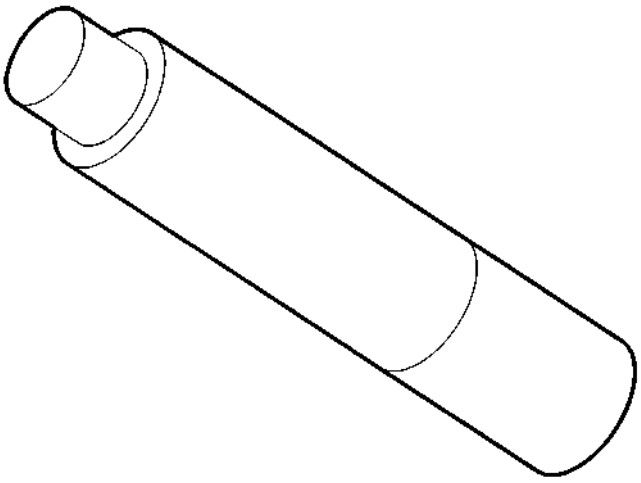

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Figure 1753 Universal Driver Handle (3/4"-10),J 8092

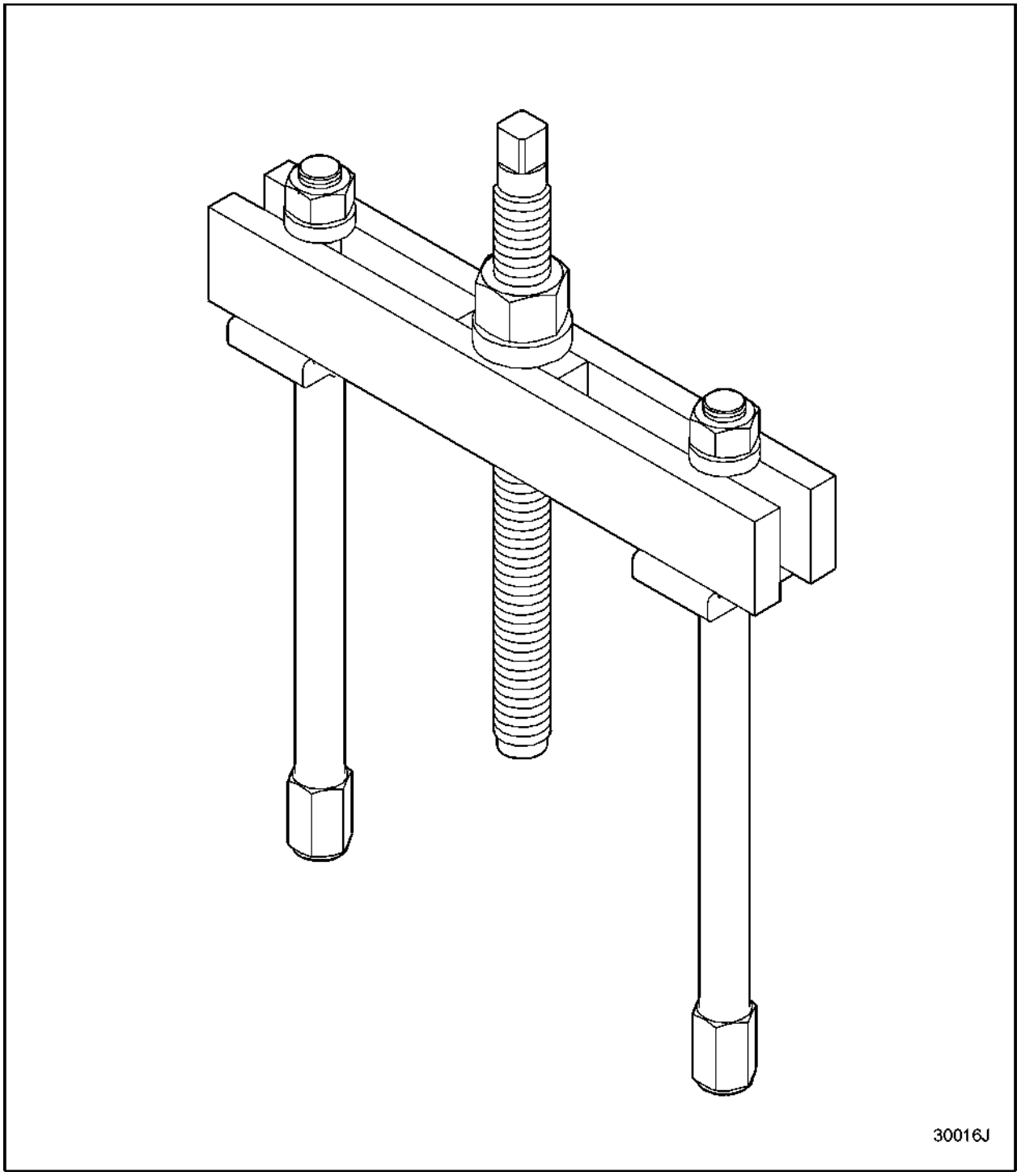

Figure 1754 Universal Puller (Range 13" Dia), J 8190

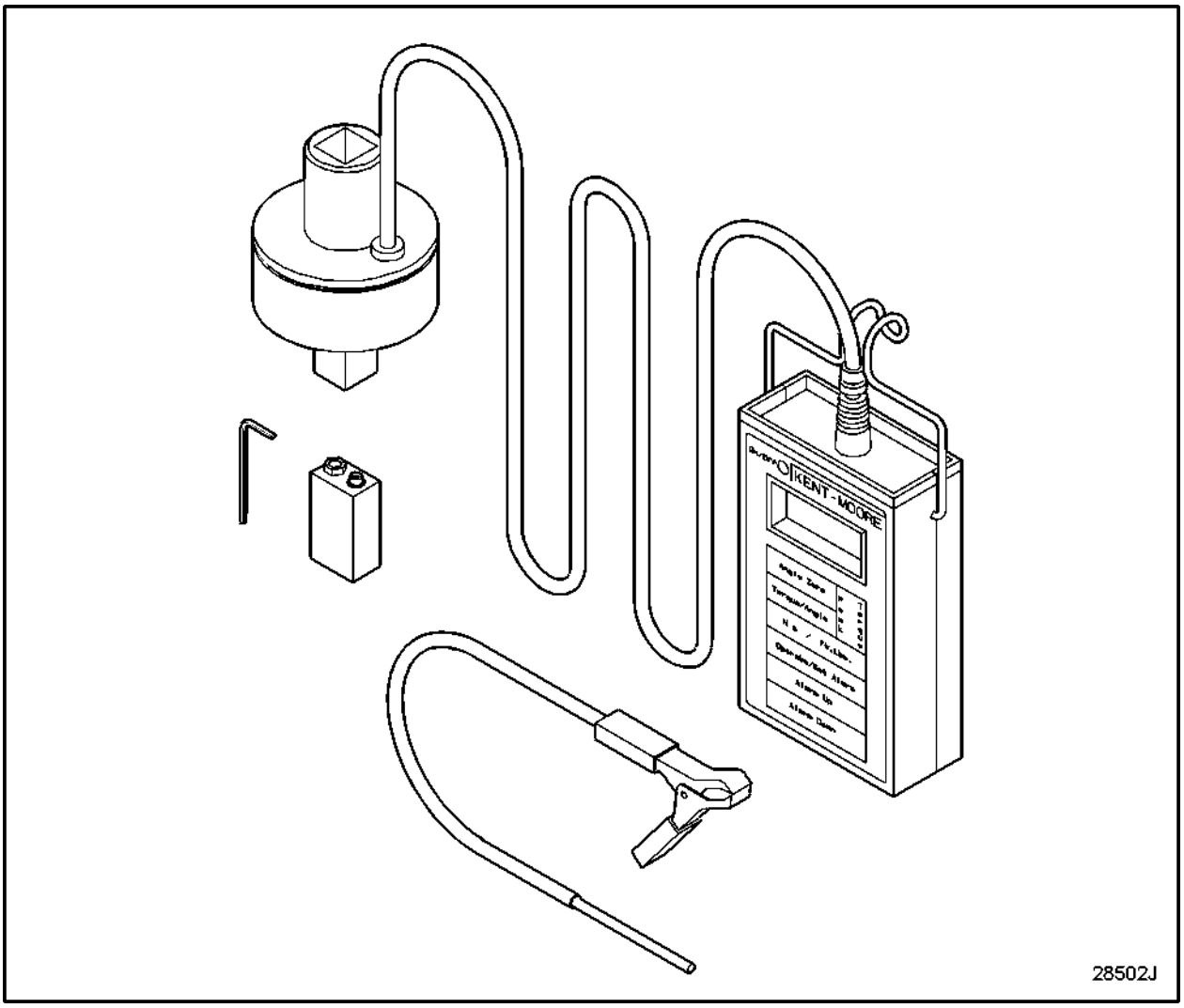

Figure 1755 Torque Angle Meter,J 37990

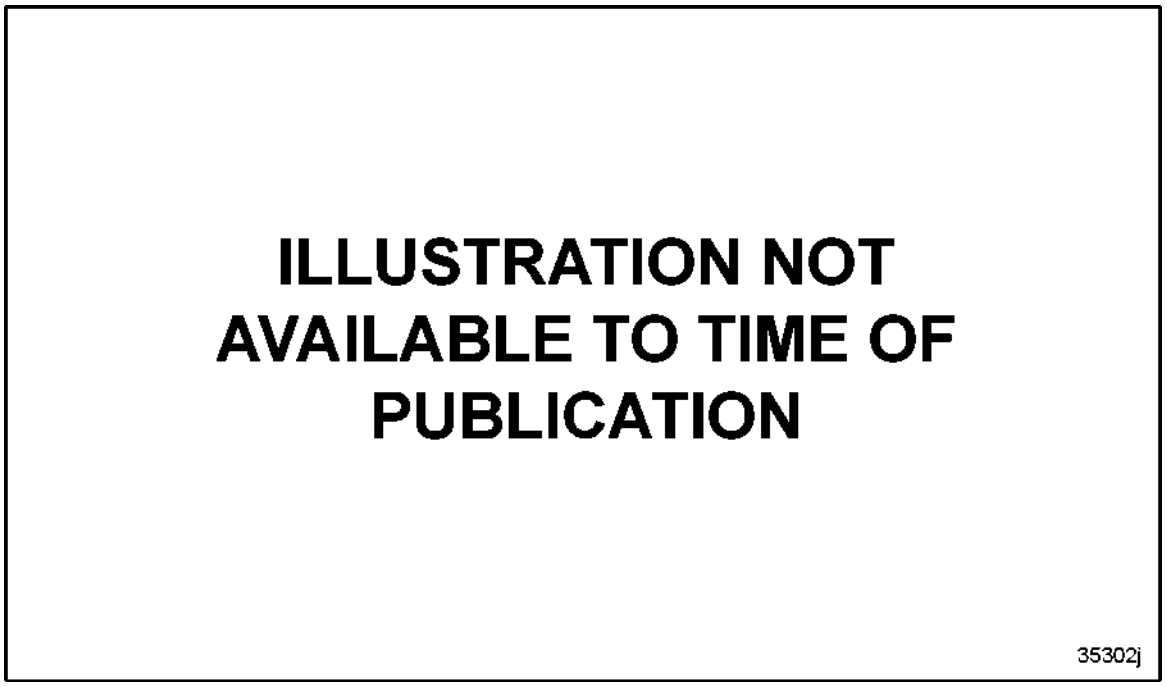

Figure 1756 Torque Bit & Socket Set, J 25359–C

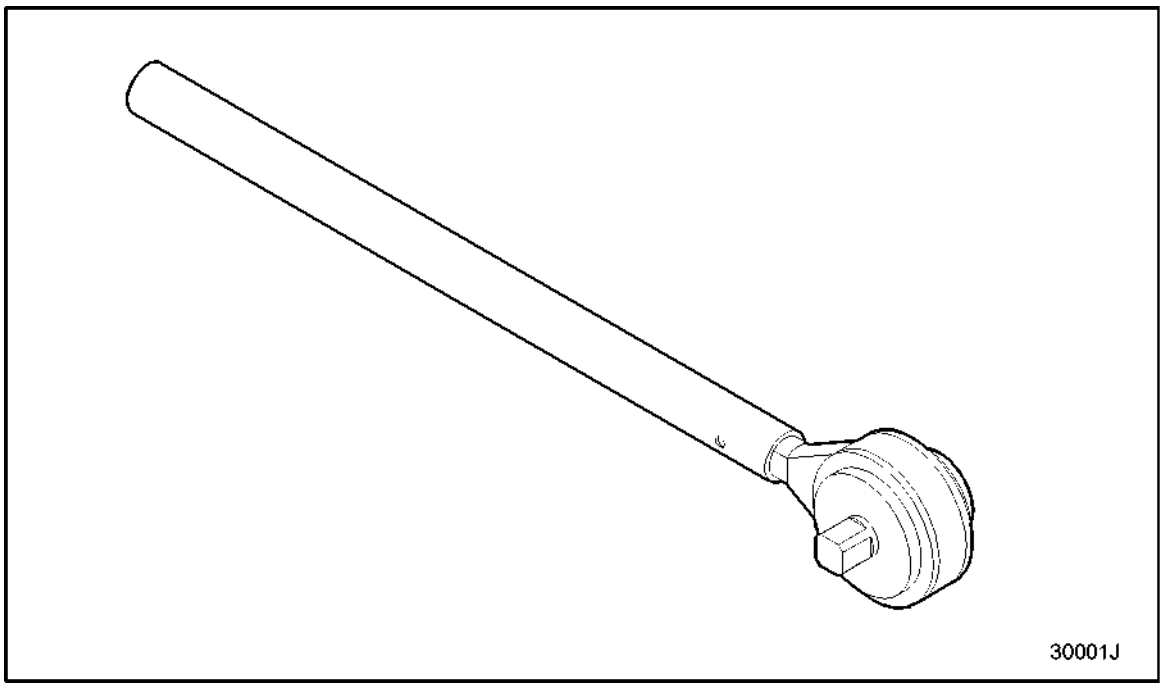

Figure 1757 Torque Multipier (1000LB), J 23410

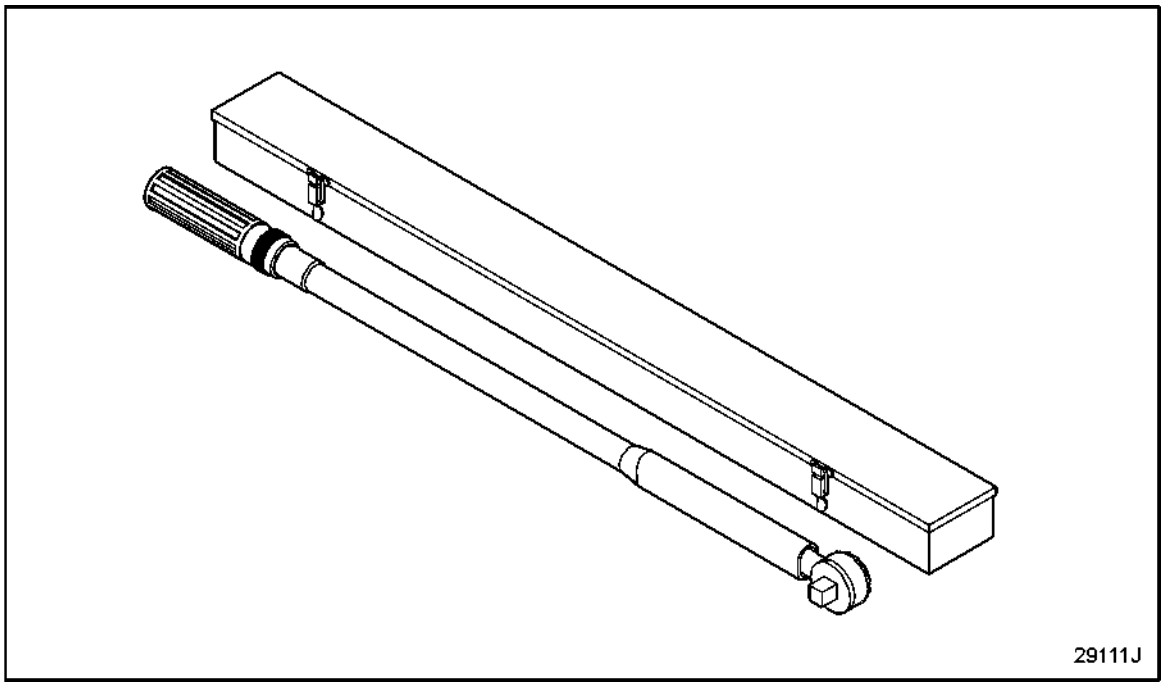

Figure 1758 Torque Wrench (100-600 FT LBS), J 23775–01

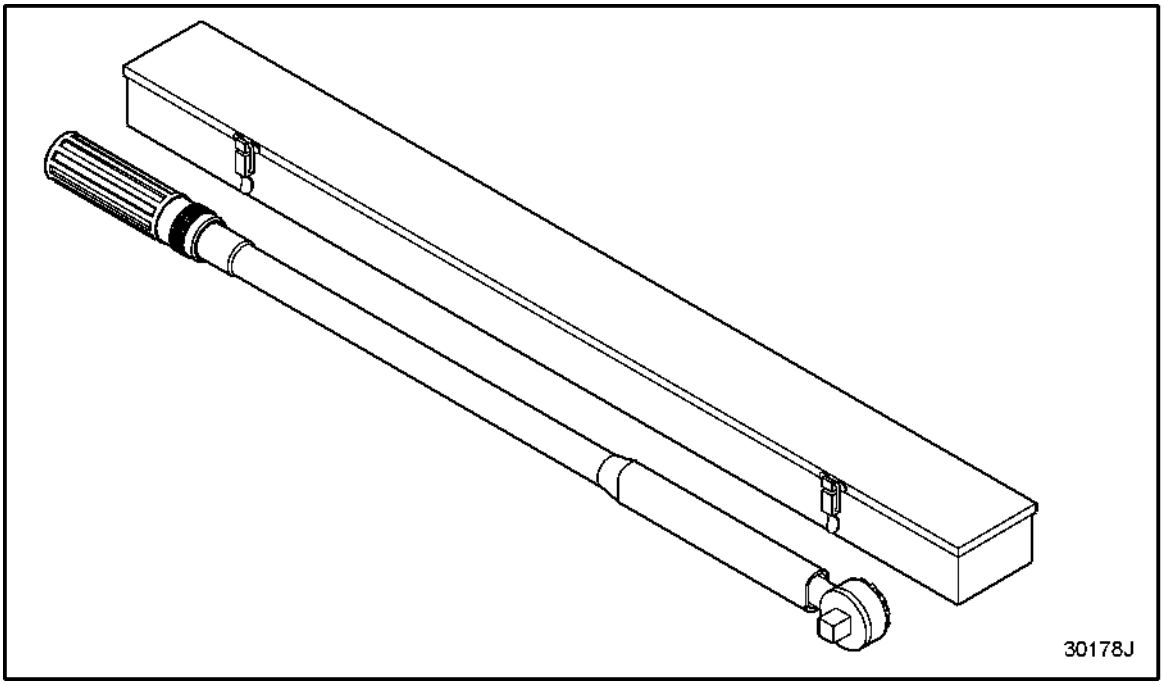

Figure 1759 Adjustable Torque Wrench 3/8 in. Drive (10-250 lbs), J 24405

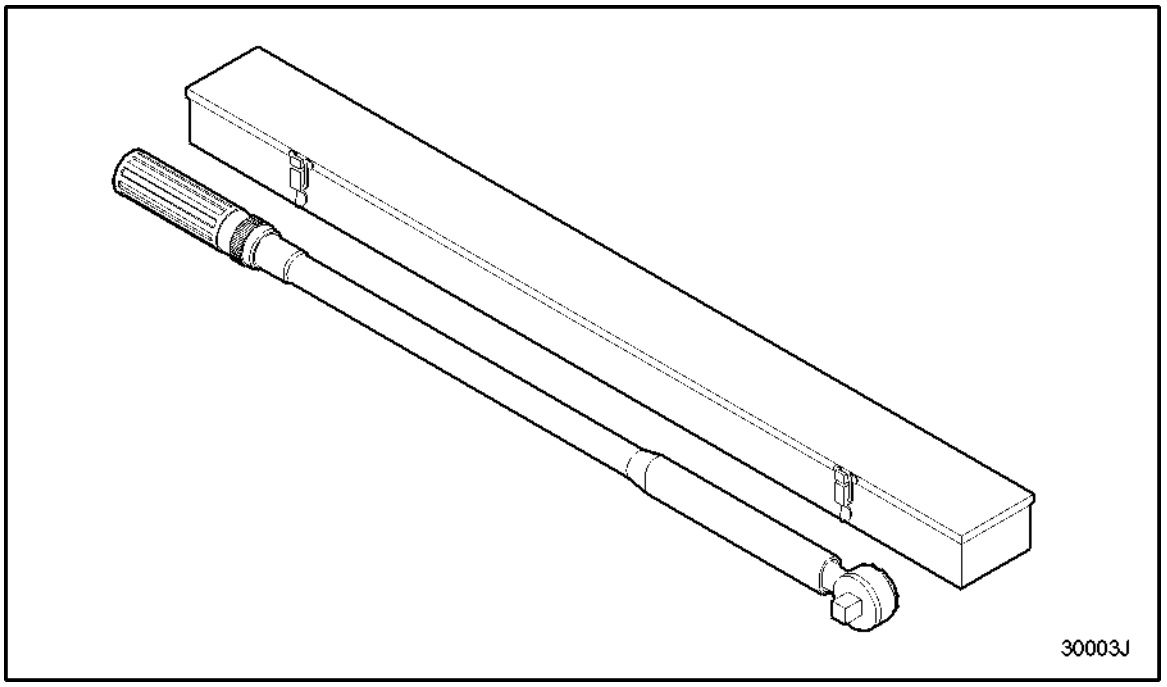

Figure 1760 Torque Wrench (15-100 lbs),J 24406

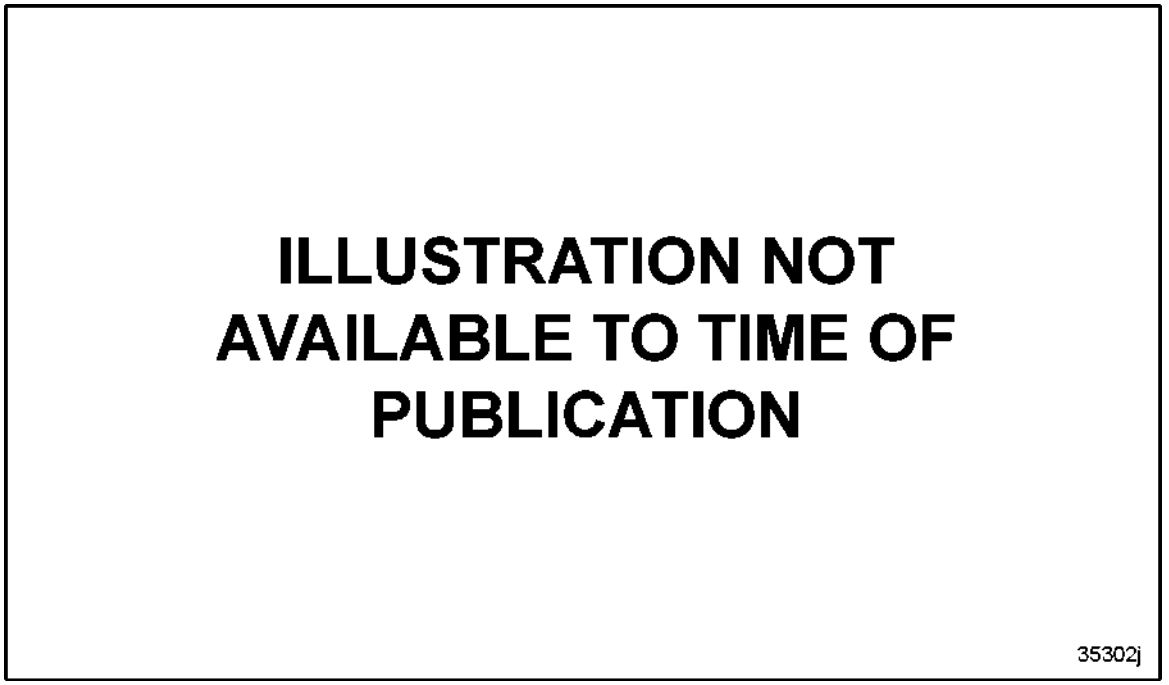

Figure 1761 Torque Wrench (30-250 FT LBS),J 24407

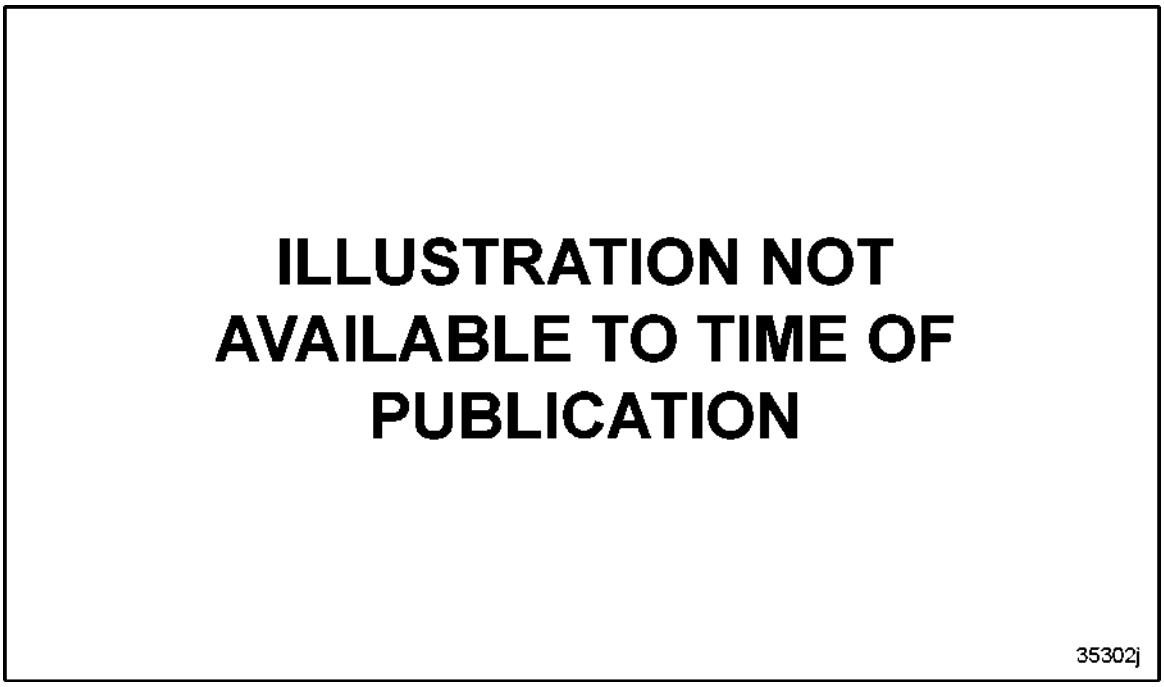

Figure 1762 Torque Wrench 1/2" 0-150 FT LBS),J 1313–B

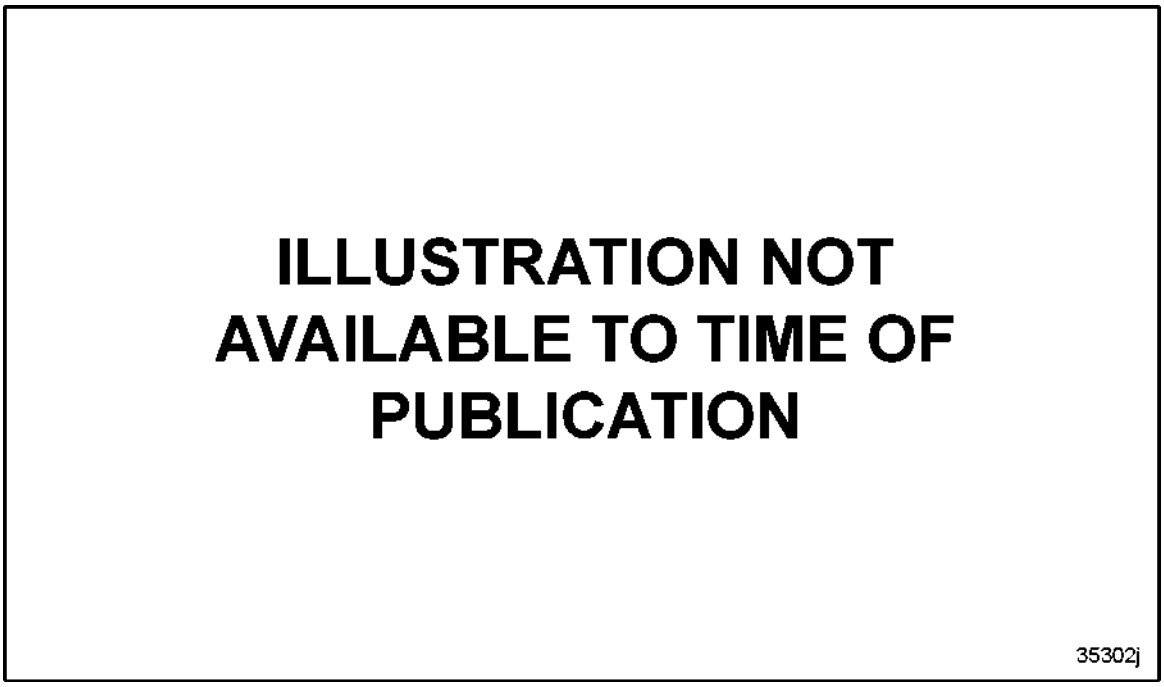

Figure 1763 Great Crate I & Rack System,J 34755

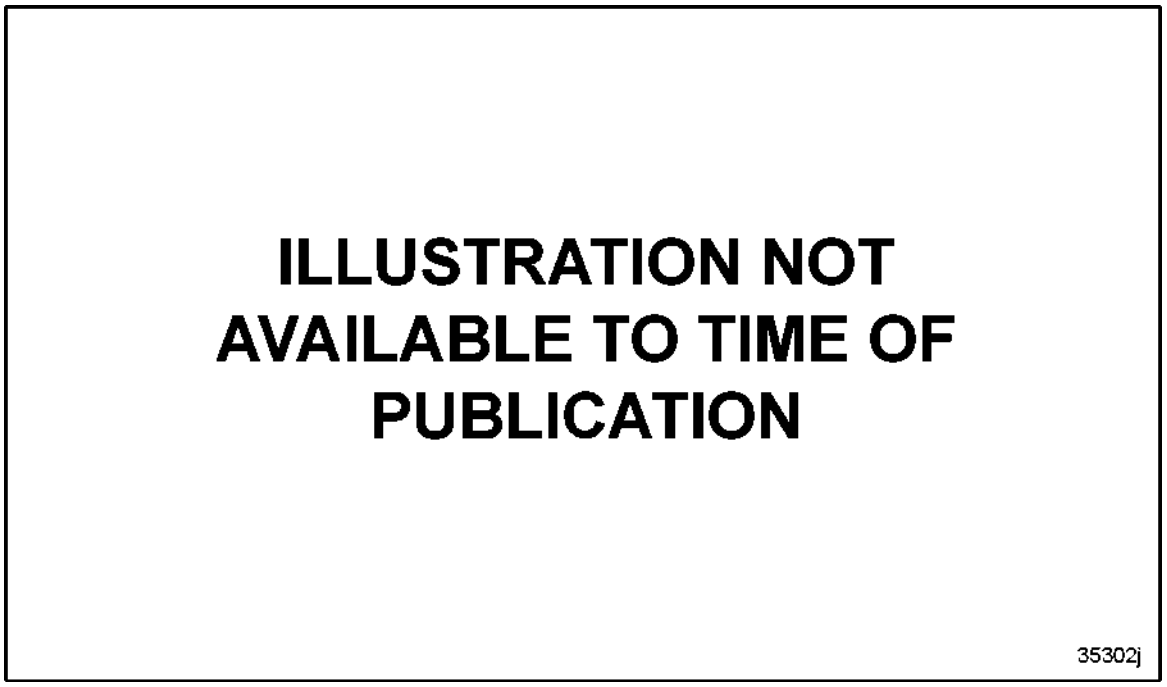

Figure 1764 Great Crate I Storage Box,J 34100

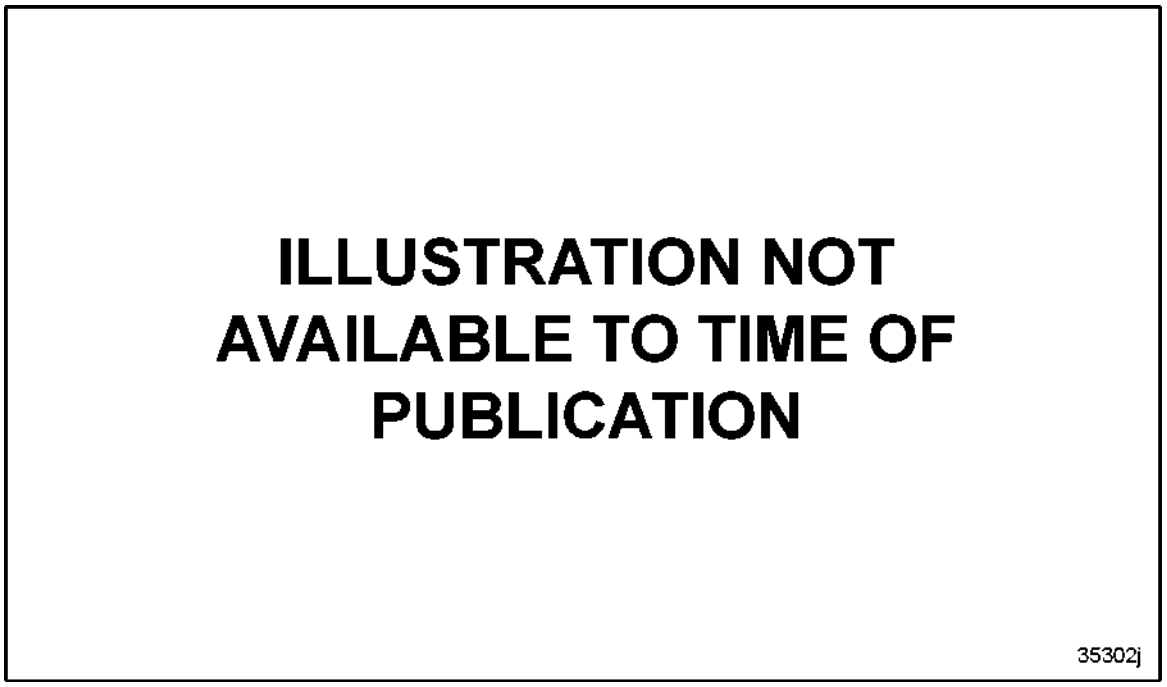

Figure 1765 Great Crate II & Rack System,J 35810

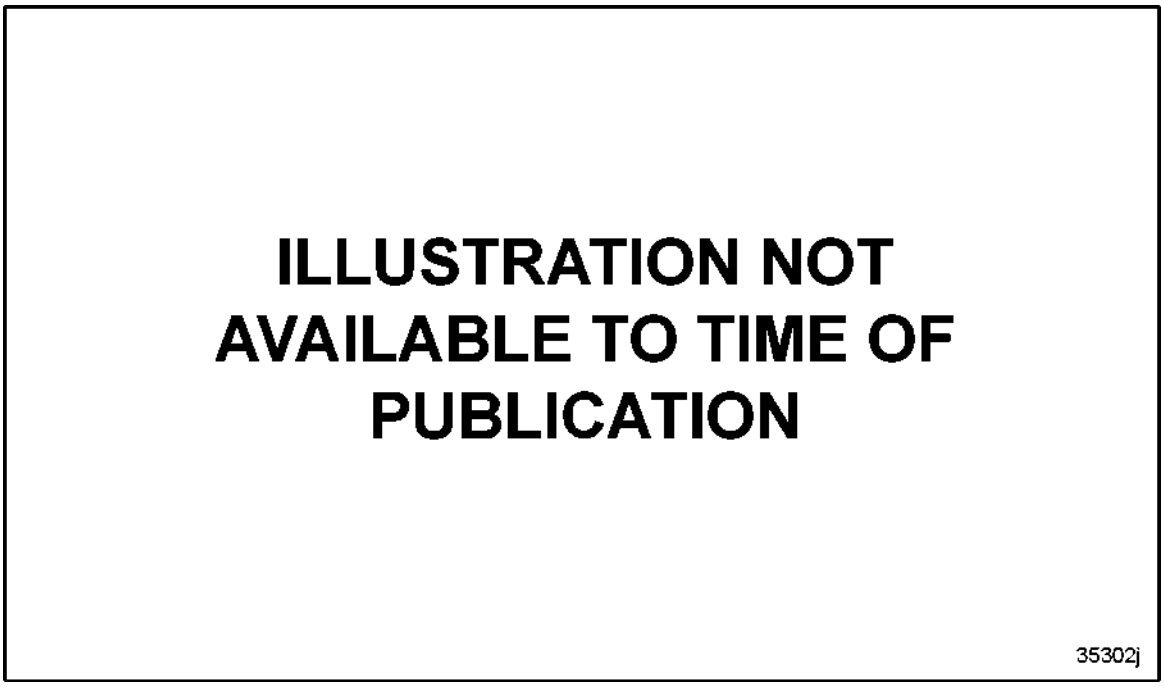

Figure 1766 Great Crate II Storage Box,J 35805

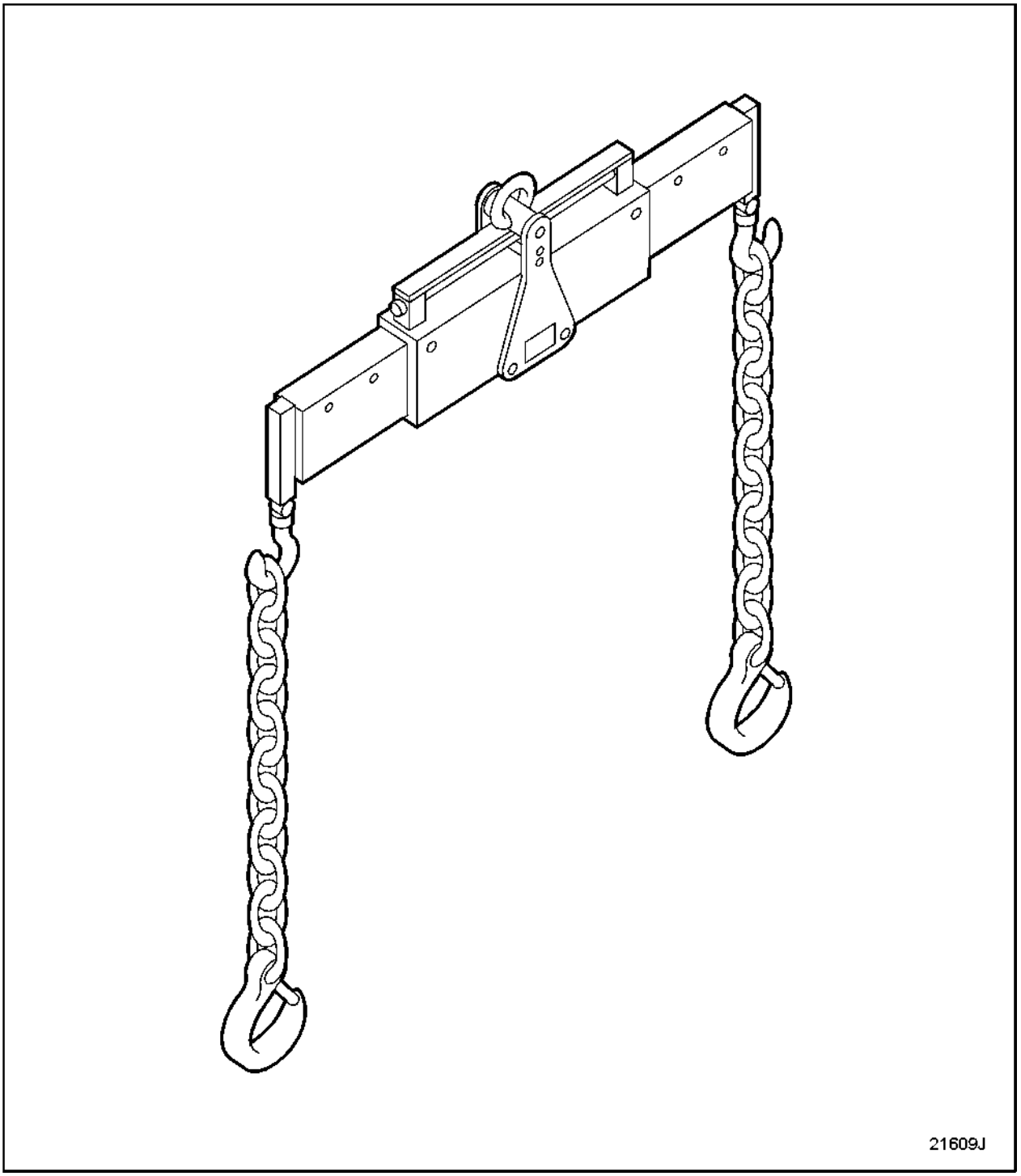

Figure 1767 Load-Rotor 4000 LB,J 36130–806

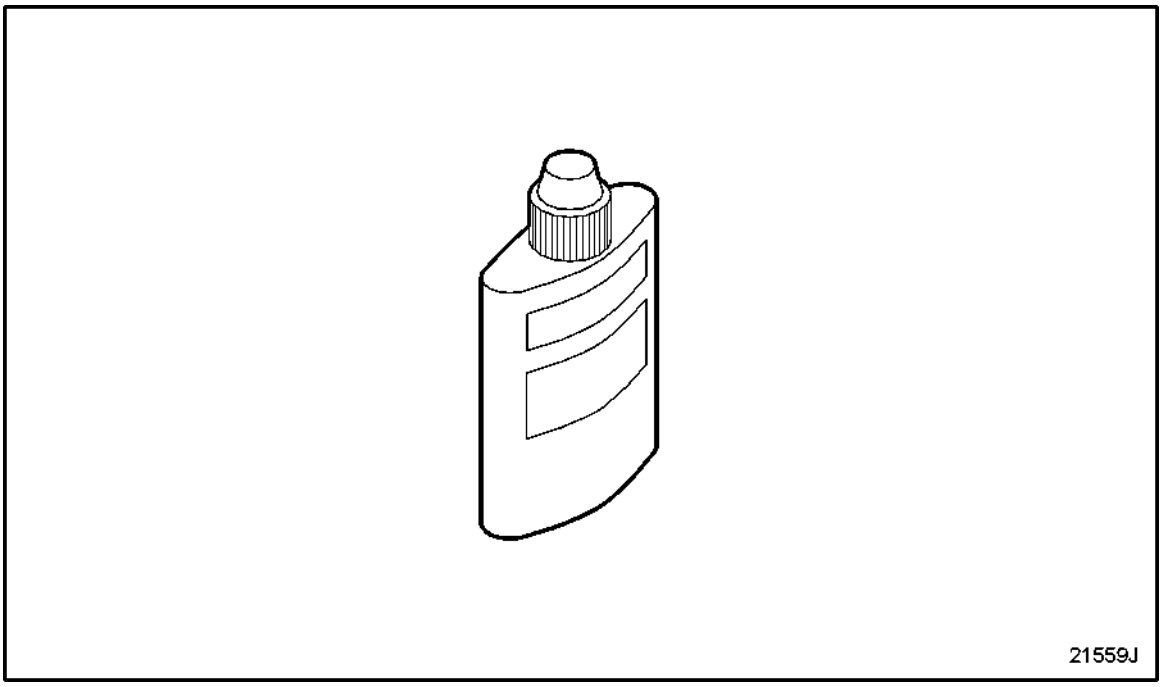

Figure 1768 **Lock-N-Seal,**PT-7272 (old number J 26558–242)

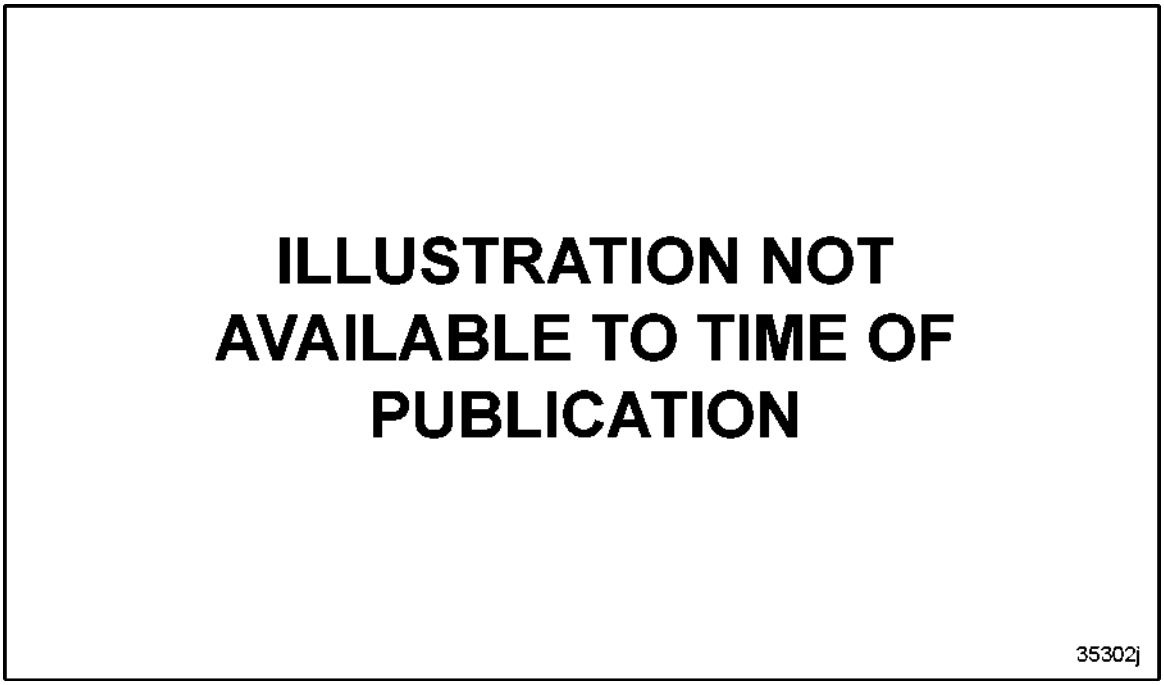

Figure 1769 **Loctite,**PT 7260

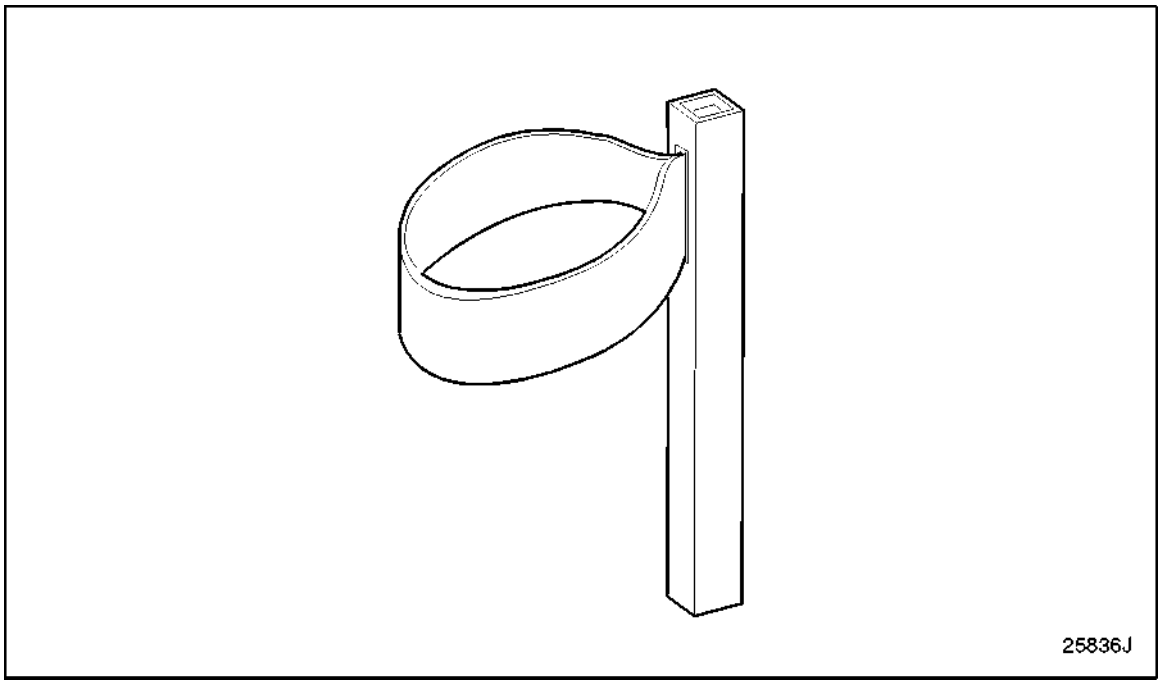

Figure 1770 Oil Filter Wrench,J 29927

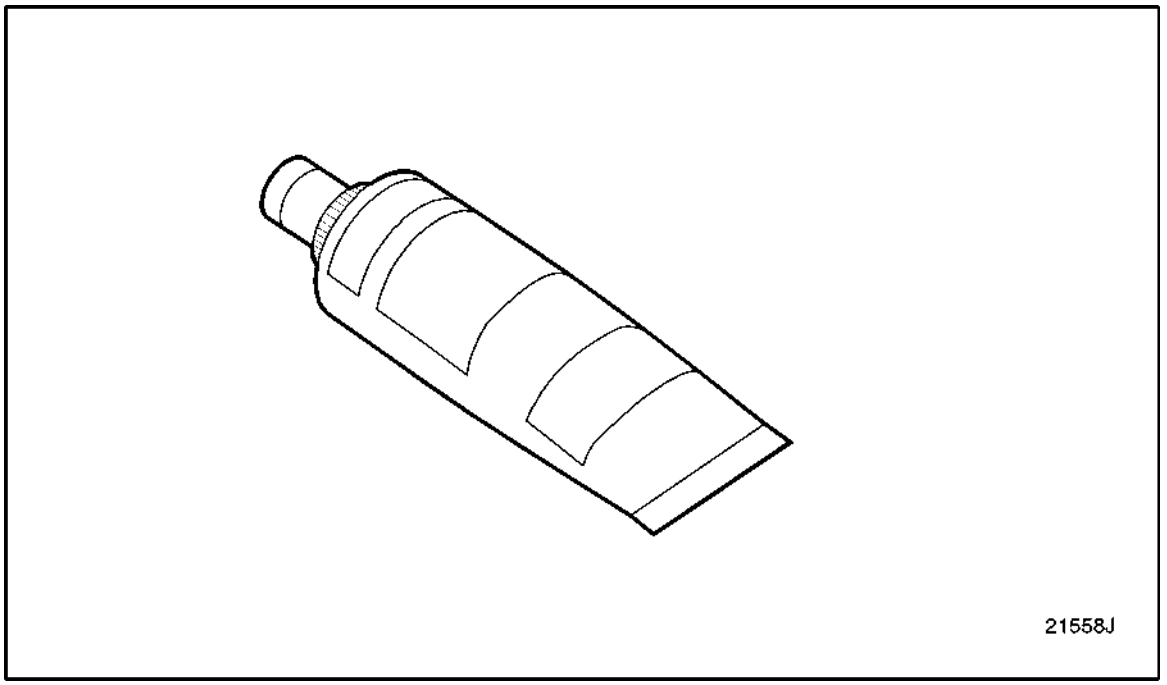

Figure 1771 Pipe Sealant,PT-7271 (old number J 26558–92)

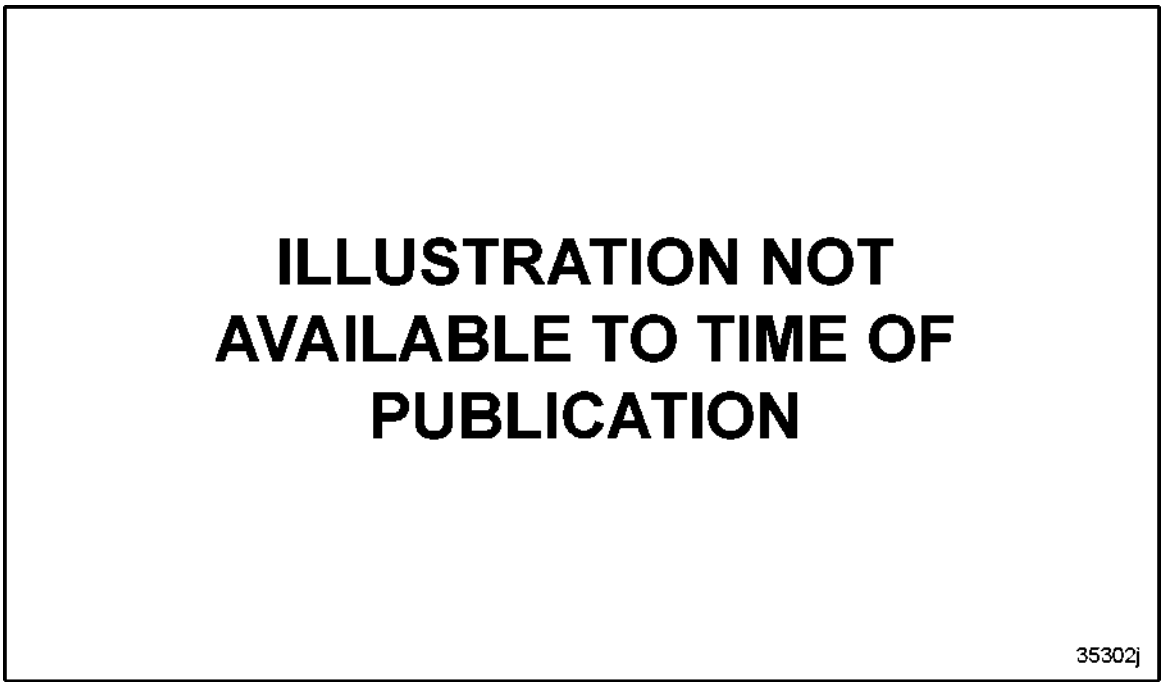

Figure 1772 Slide Hammer pair W/Adapters, J 6125–B

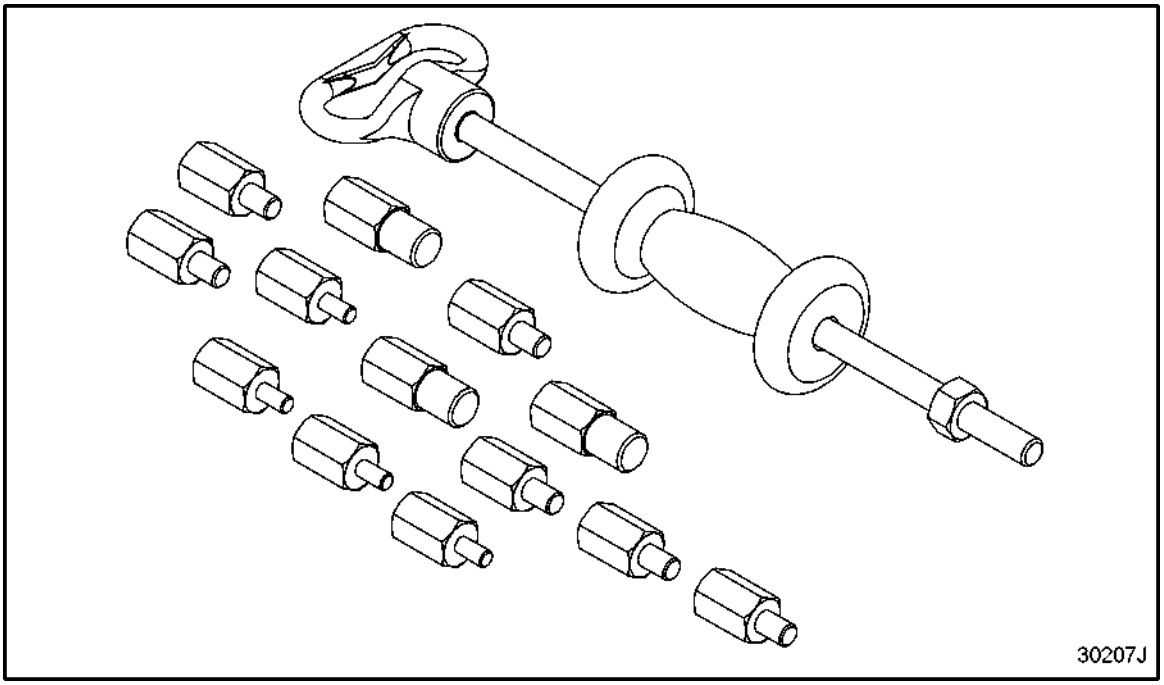

Figure 1773 Slide Hammer With Adapters, J 6471–02

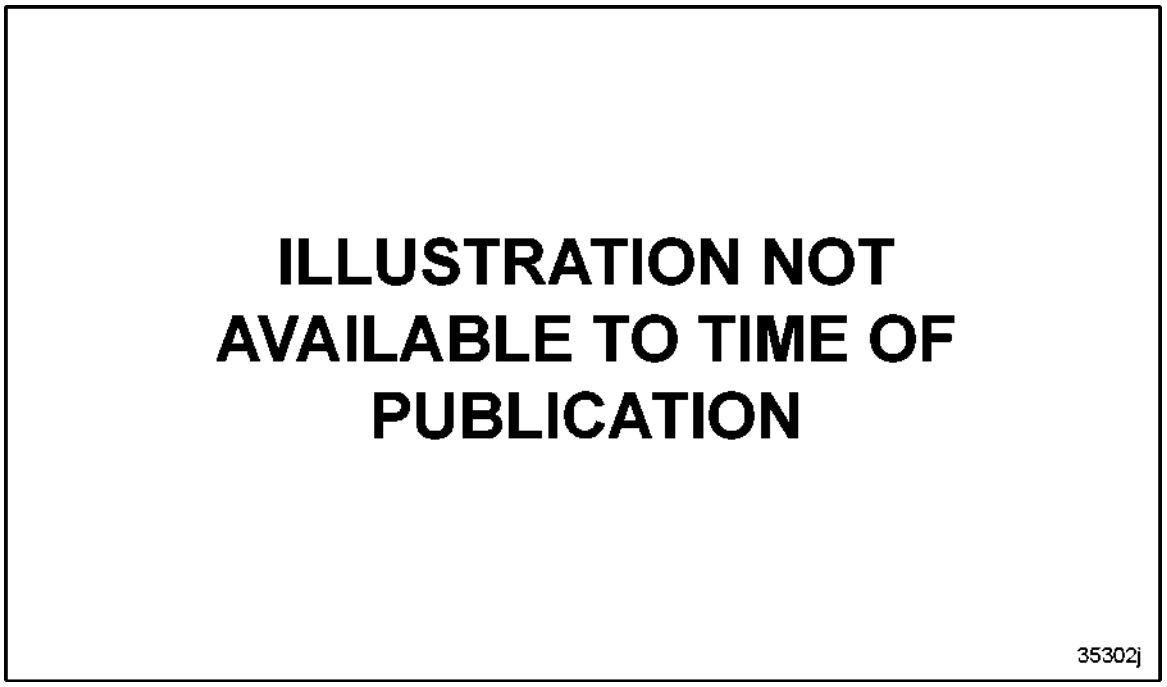

Figure 1774 **Snap Ring Pliers Vacuum Grip,** J 5586–A

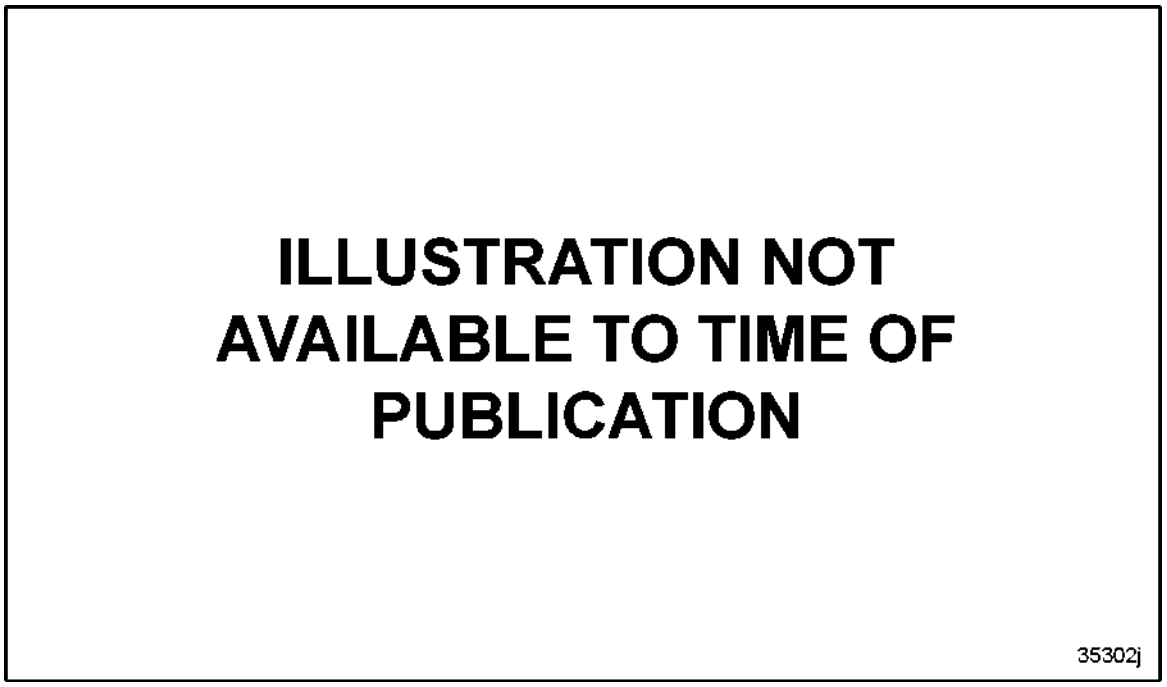

Figure 1775 **Storage Case Variety Set Of 3,** J 35550

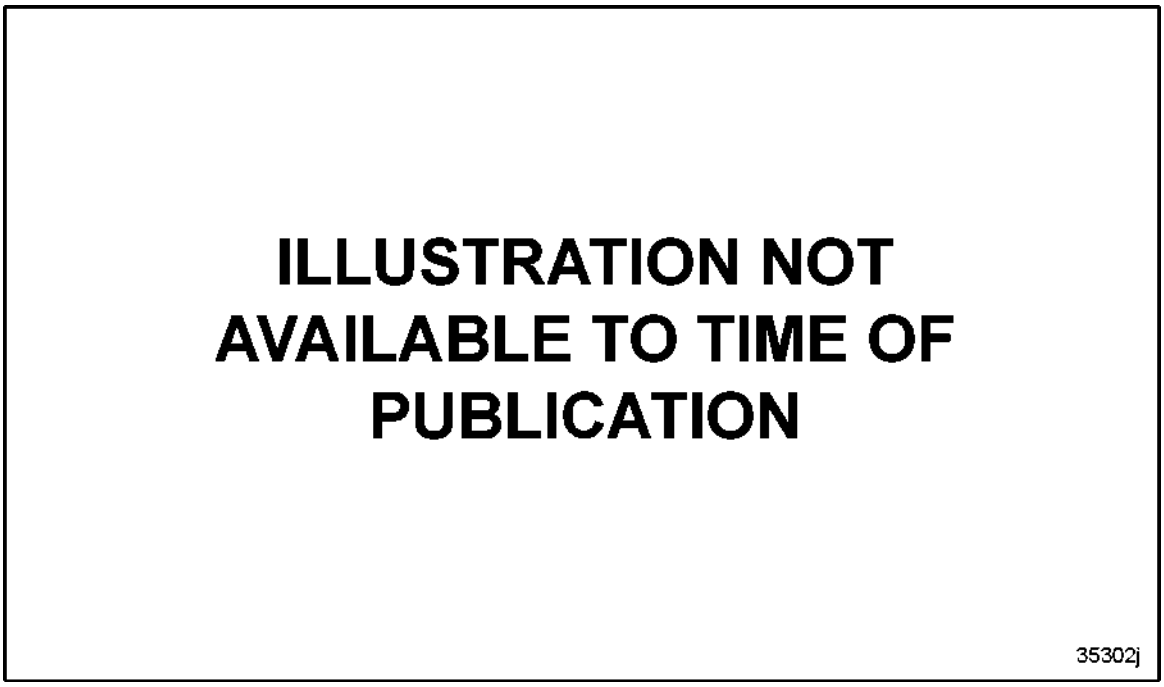

Figure 1776 Thread Repair Kit,J 26520

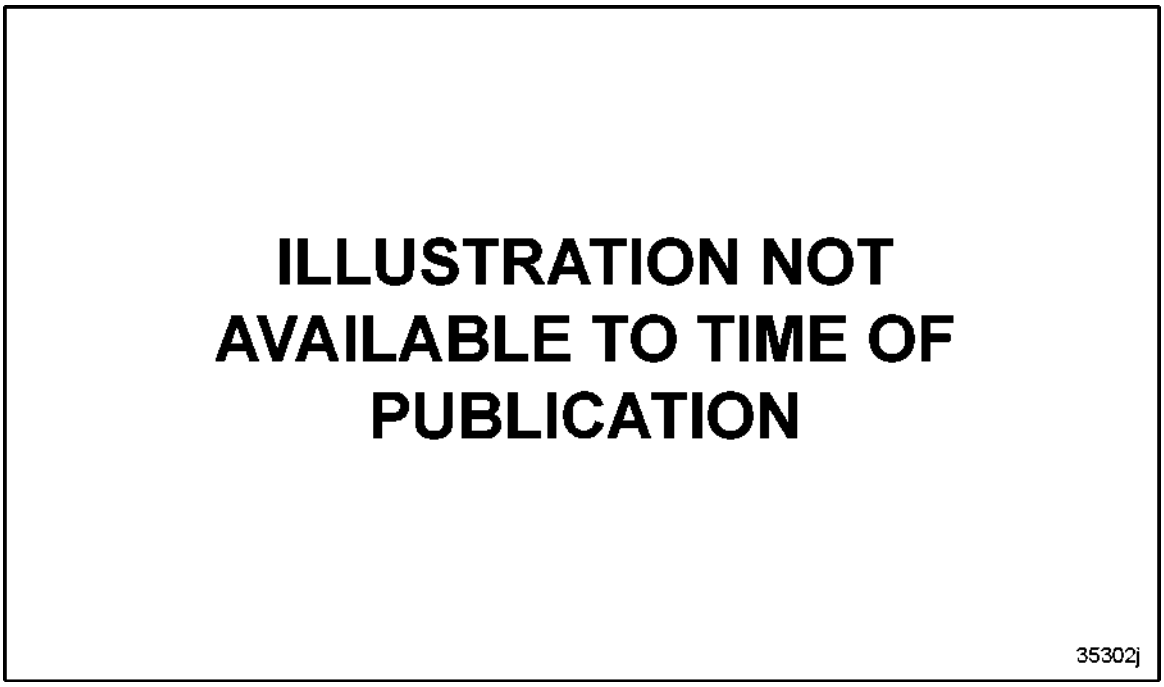

Figure 1777 Tube Flaring Set (45"),J 8051–01

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Figure 1778 Abrasive Pads (20), J 2901

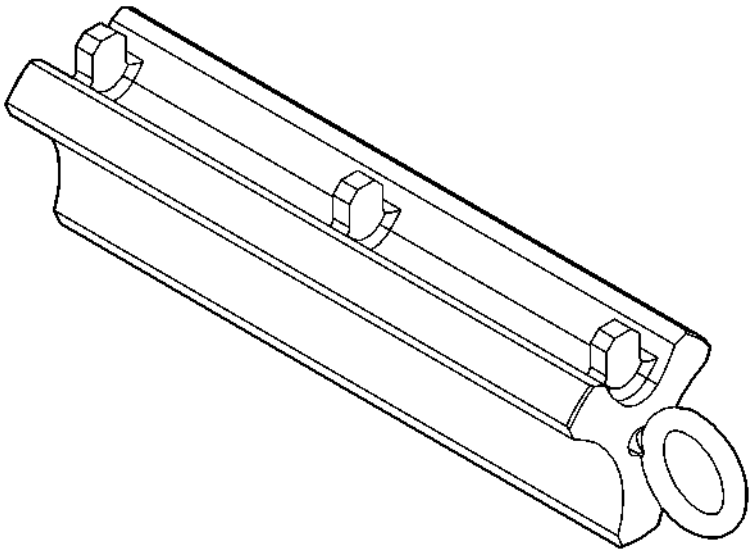

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Figure 1779 Block Align Tool (.020 OS,12 & 16V), J 24542

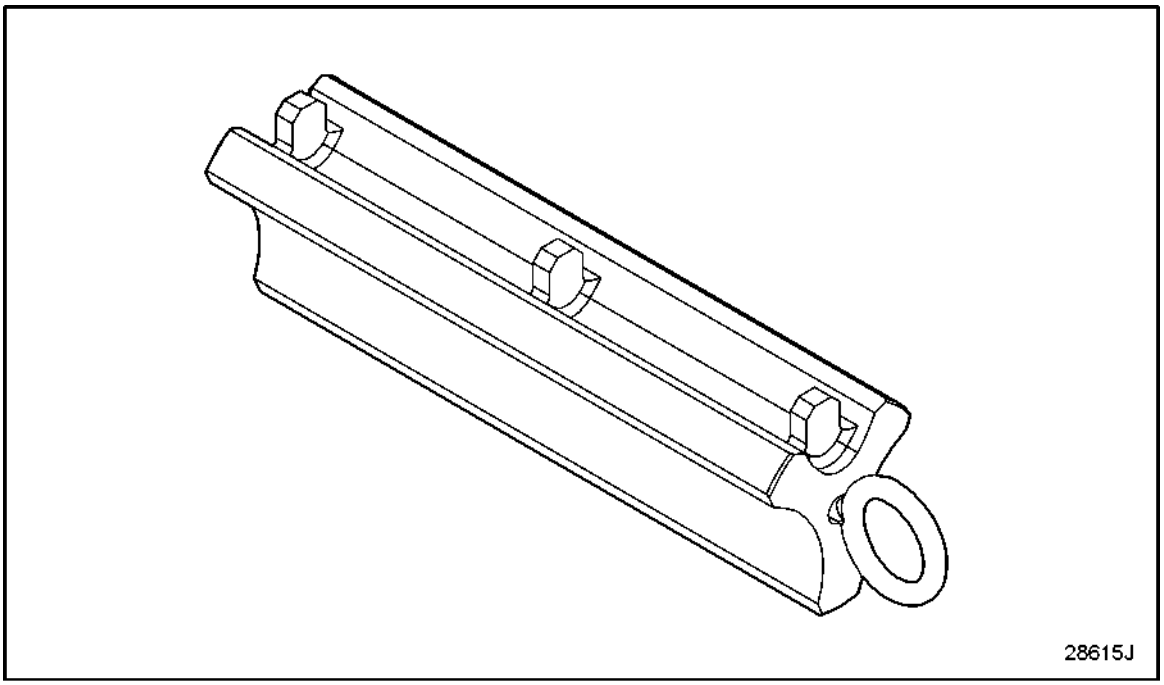

Figure 1780 Block Align Tool (.040 OS,12 & 16V),J 24543

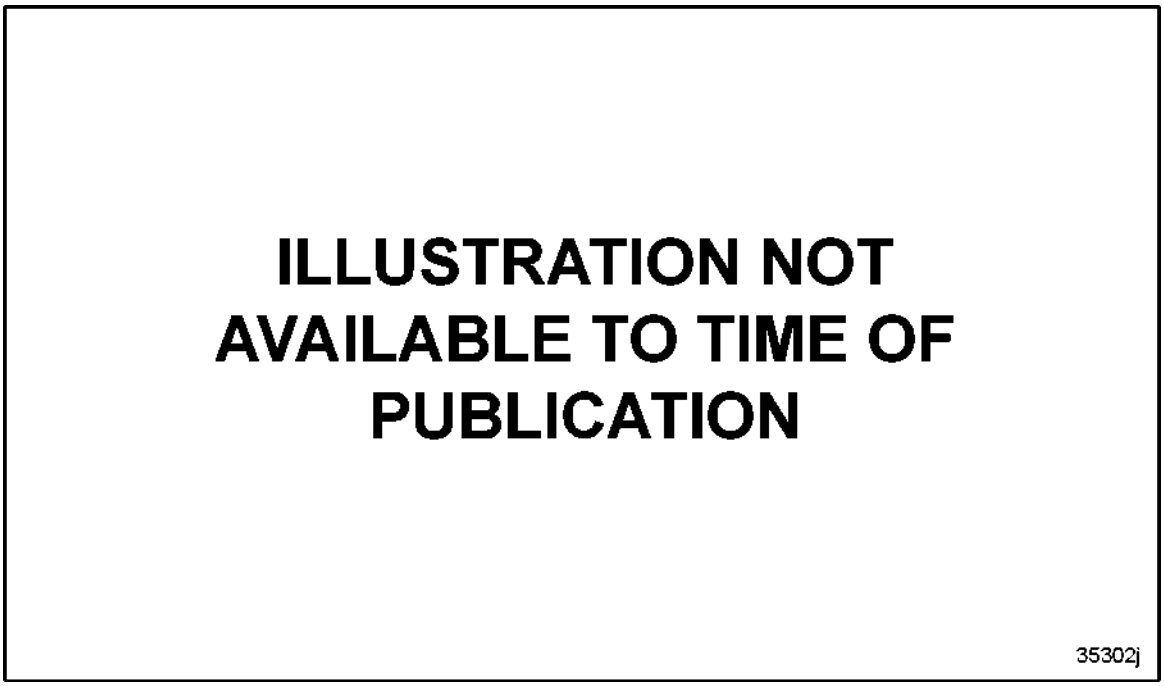

Figure 1781 Counterbore Cutter Tool Conv. Kit,J 41065

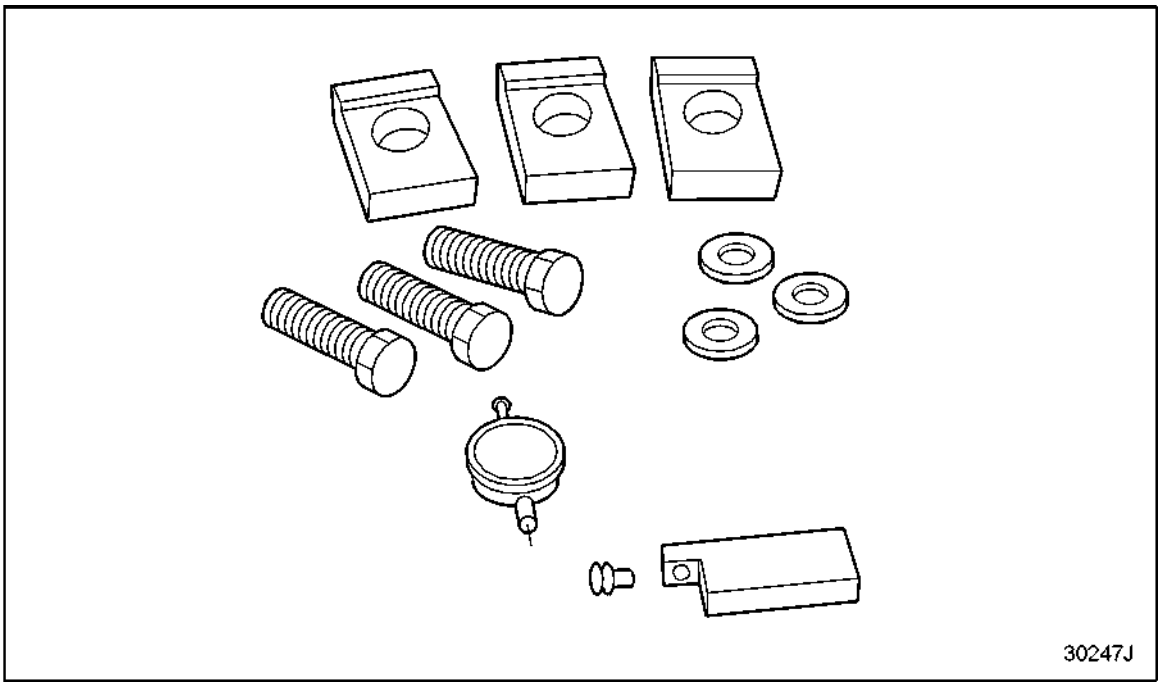

Figure 1782 Cylinder Sleeve Holding Adapters,J 43095

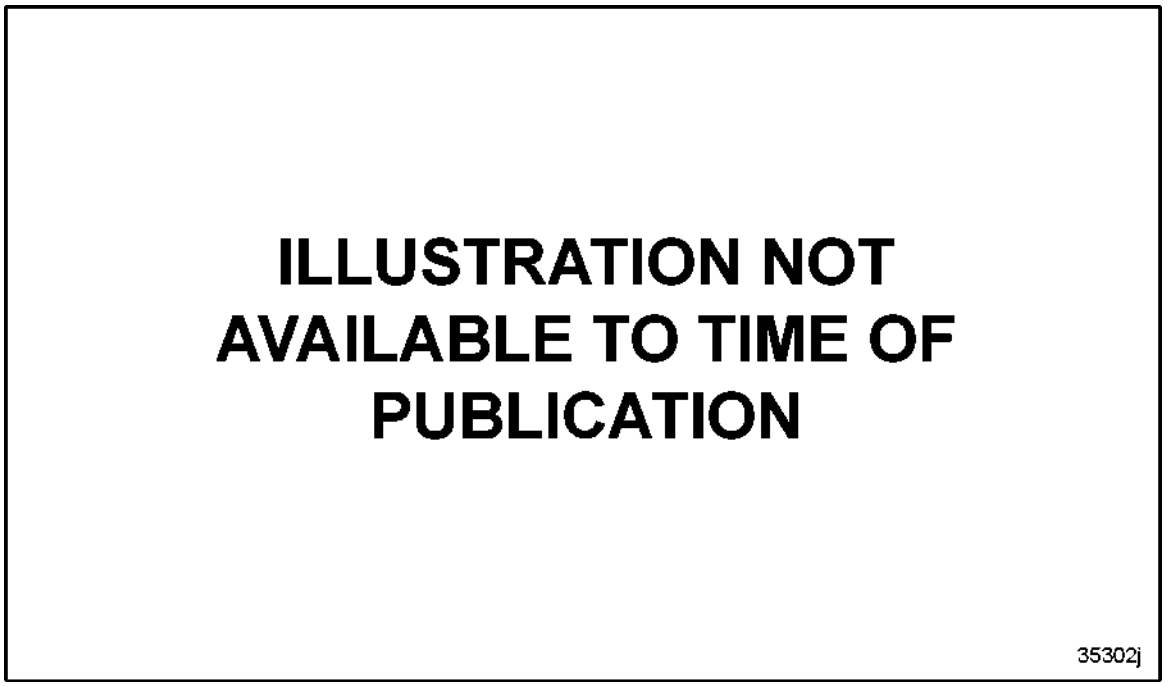

Figure 1783 Depth Collar,PT-2200–83

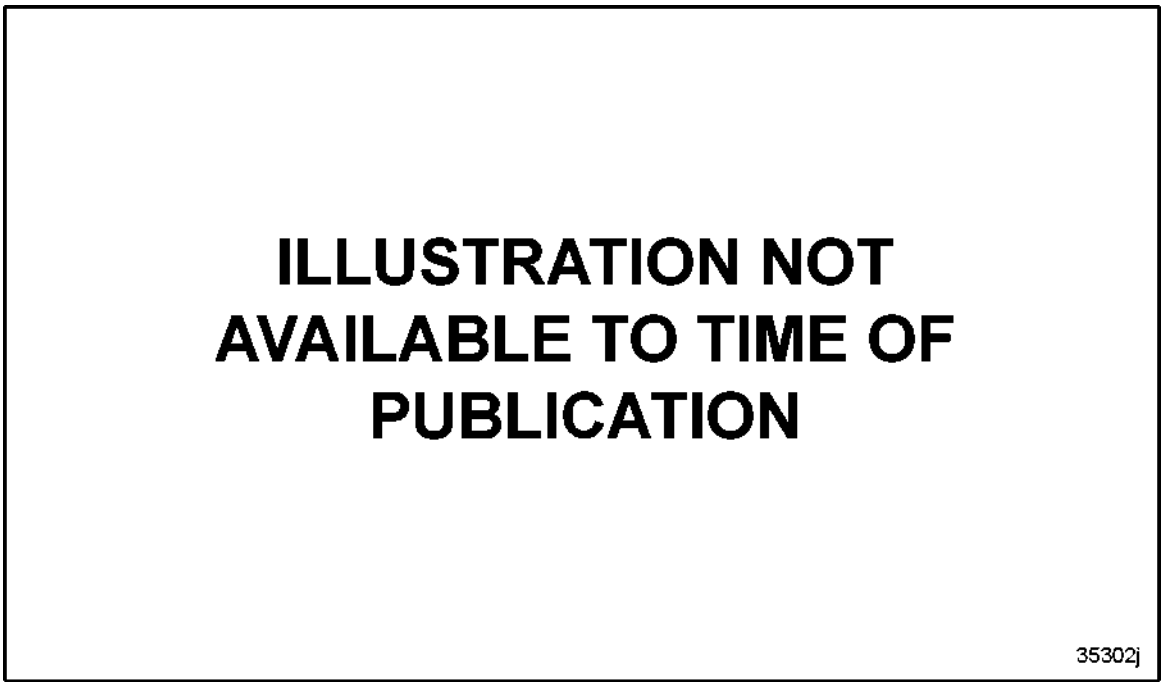

Figure 1784 Depth Set Collar,PT-2200–138

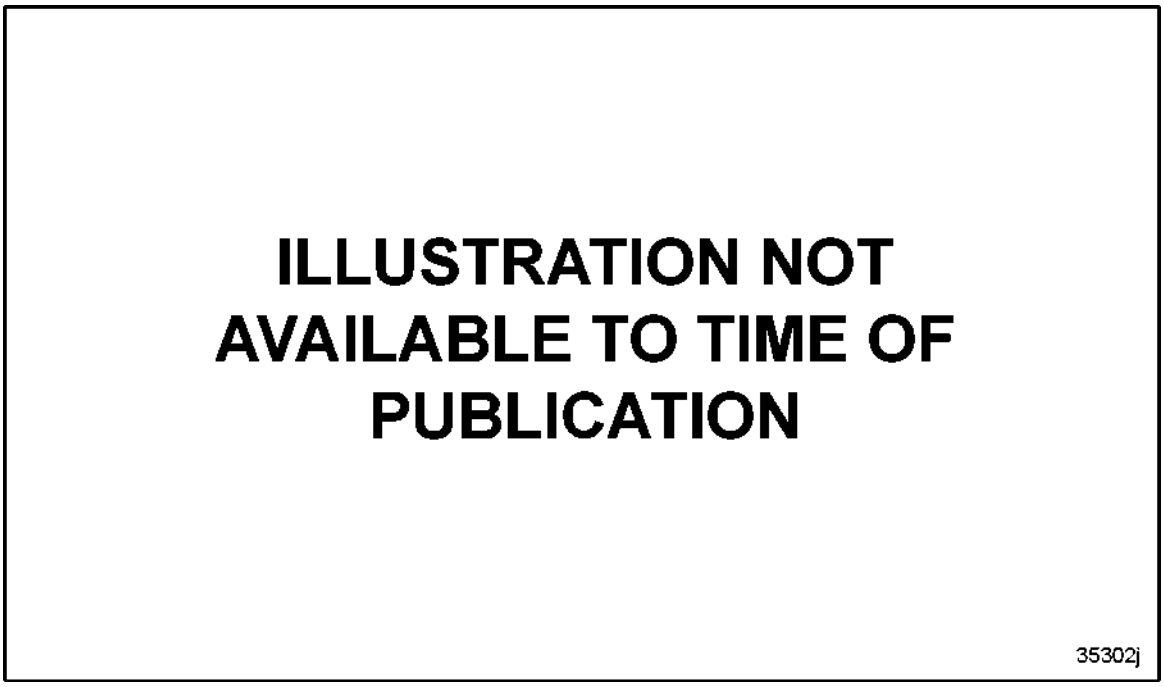

Figure 1785 Dial Depth Gauge,PT-5025

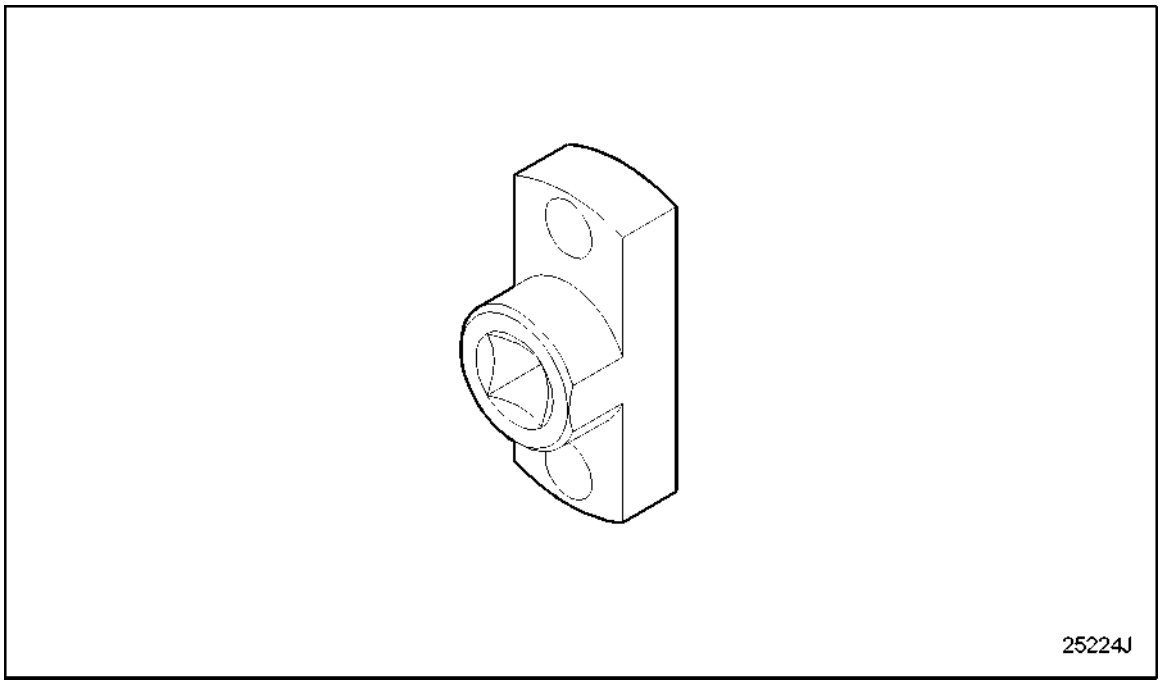

Figure 1786 Engine Barring Tool,J 41594

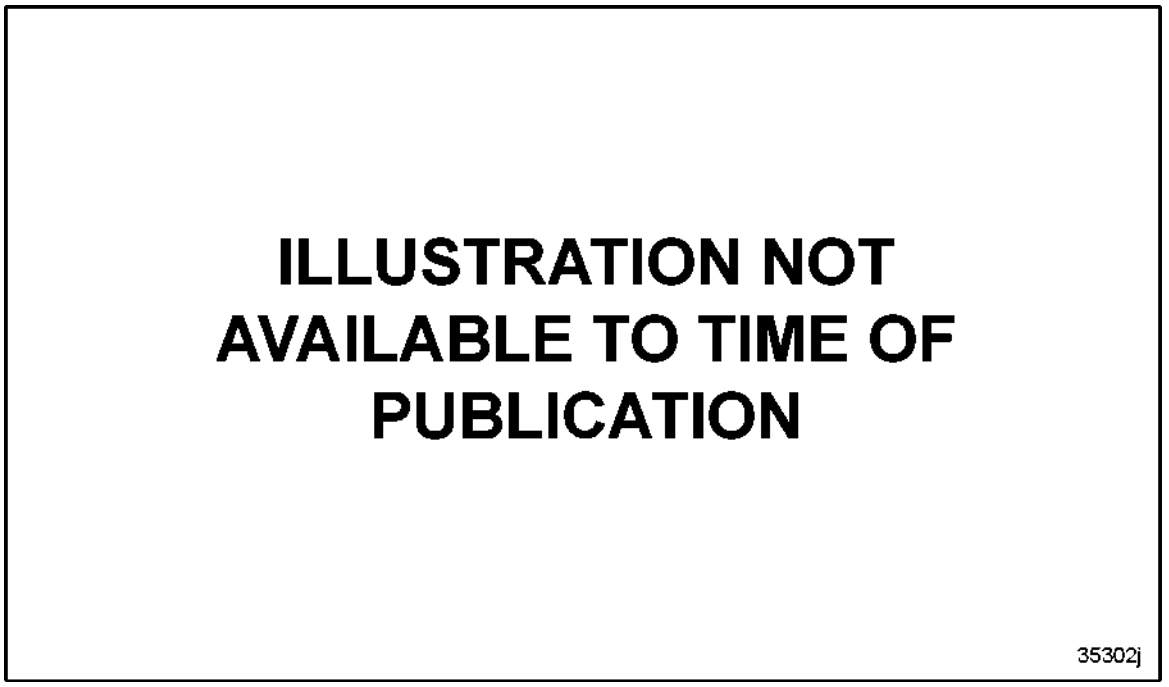

Figure 1787 Engine Barring Tool,J 41997

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Figure 1788 Extension Arm Kit,PT-5020–5SP

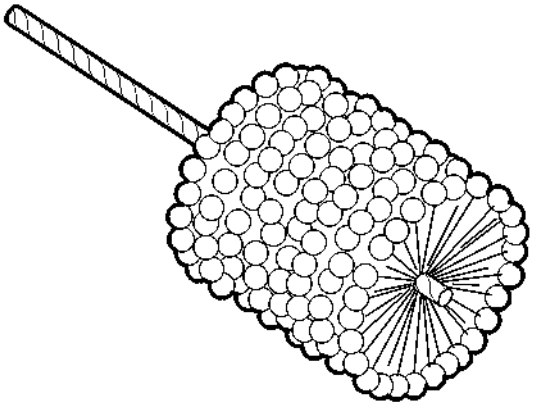

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Figure 1789 Flex Hone,J 41972

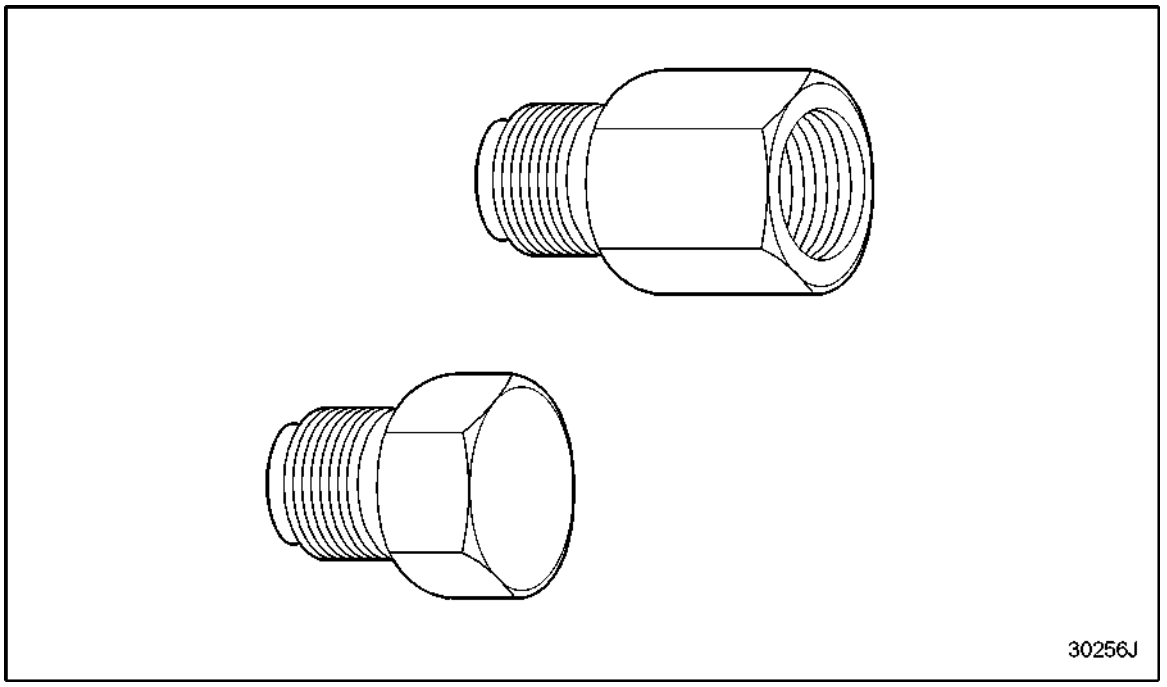

Figure 1790 ICP Adapter Plug Kit,J 43104

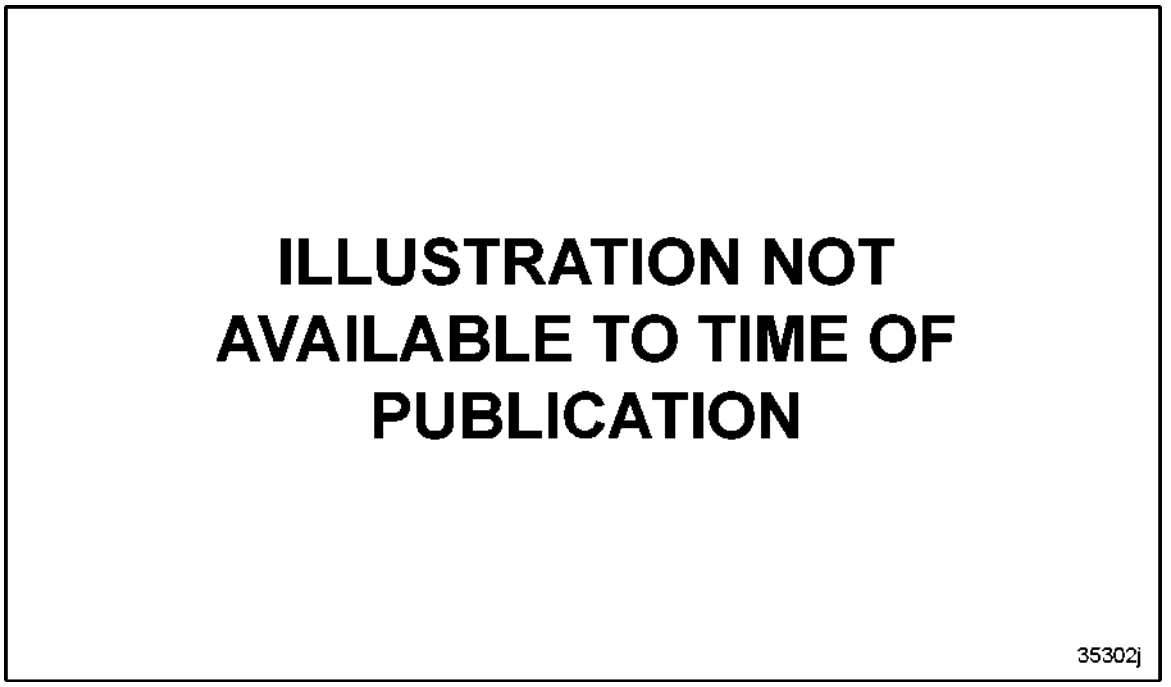

Figure 1791 Liner Puller,J 42779

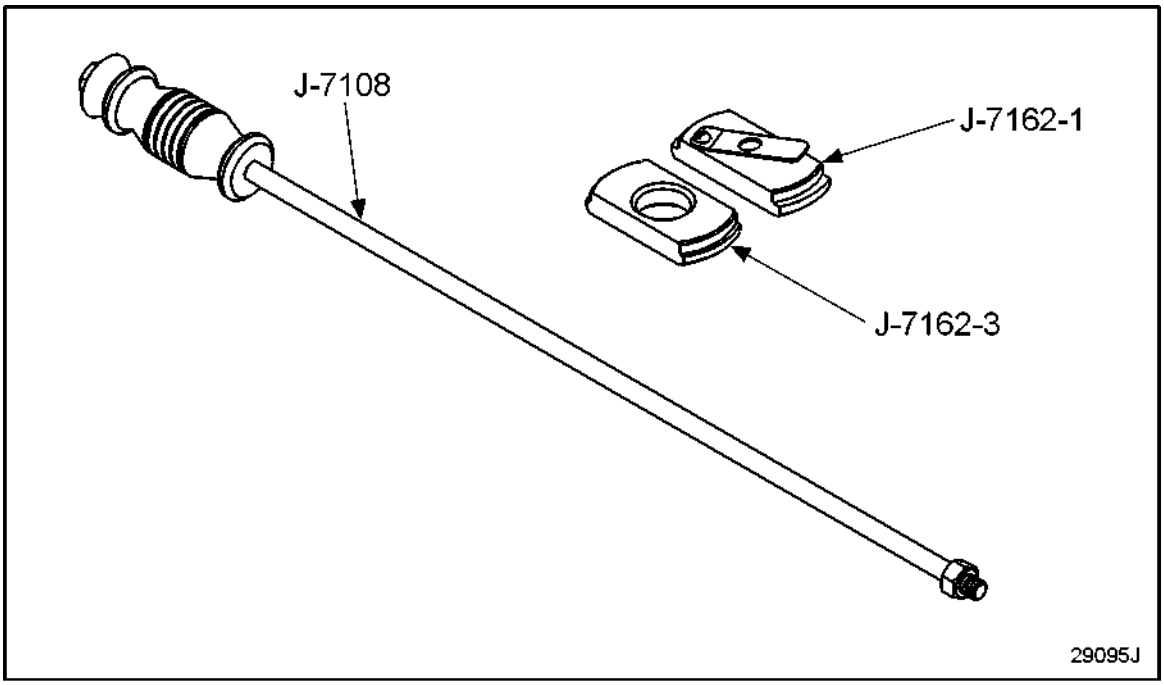

Figure 1792 Liner Remover,J 22490

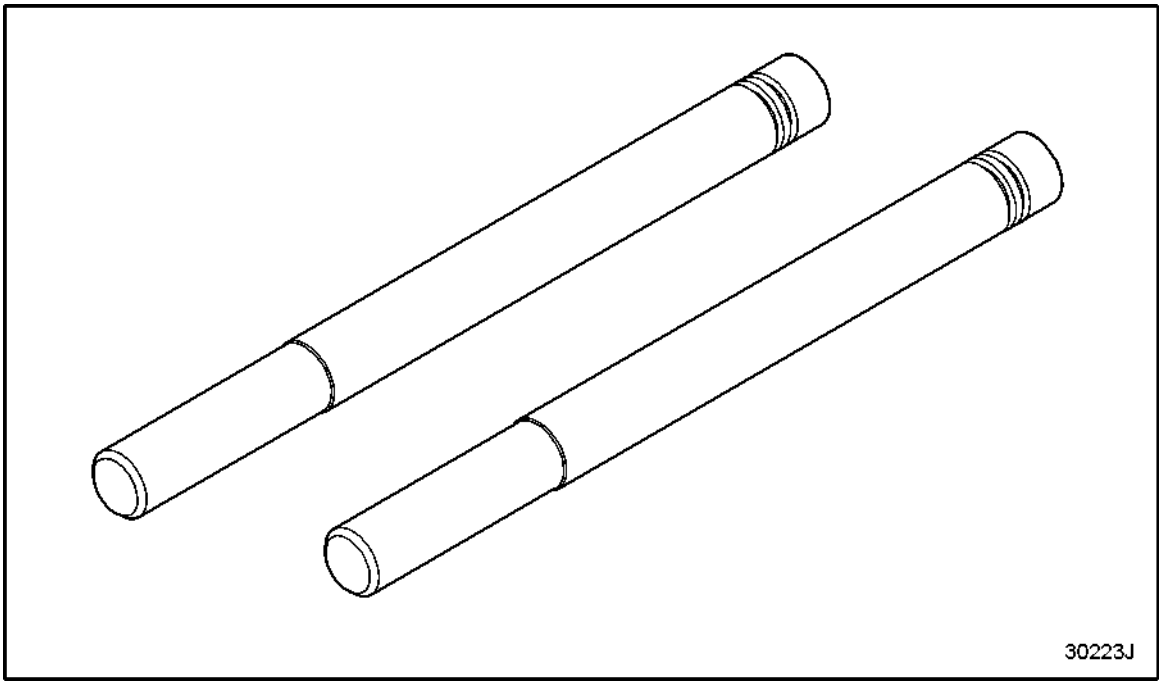

Figure 1793 Main Bearing Guide Studs,J 43048

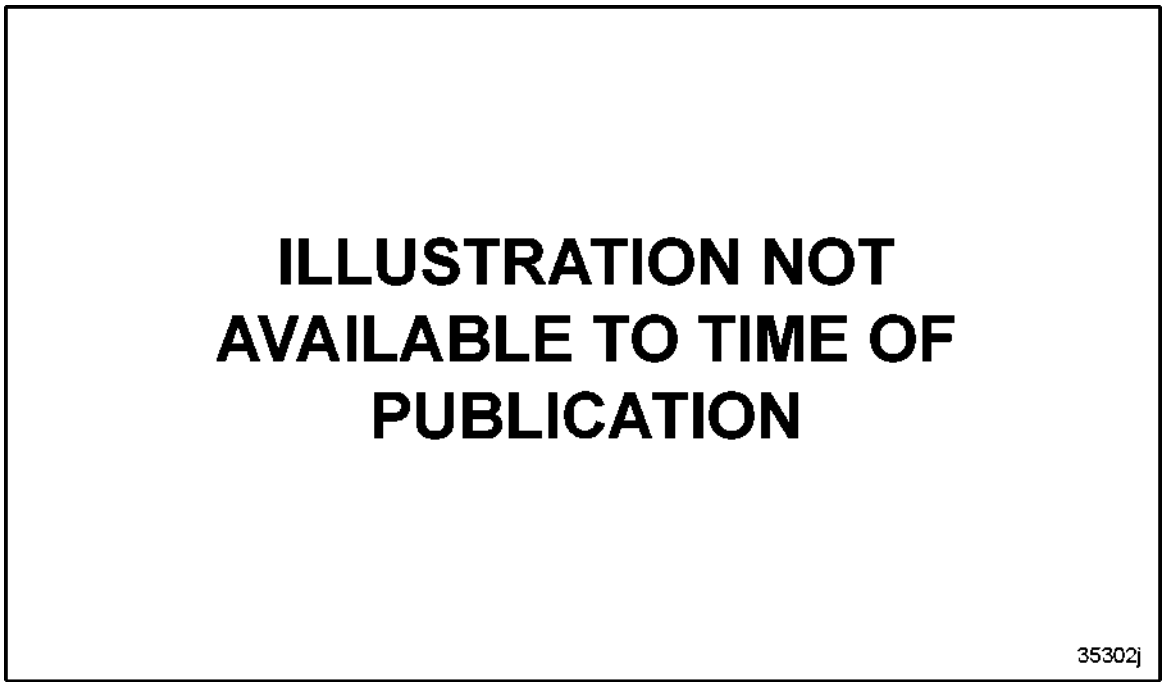

Figure 1794 Master Ring -Cylinder Block Bore,J 8386–01

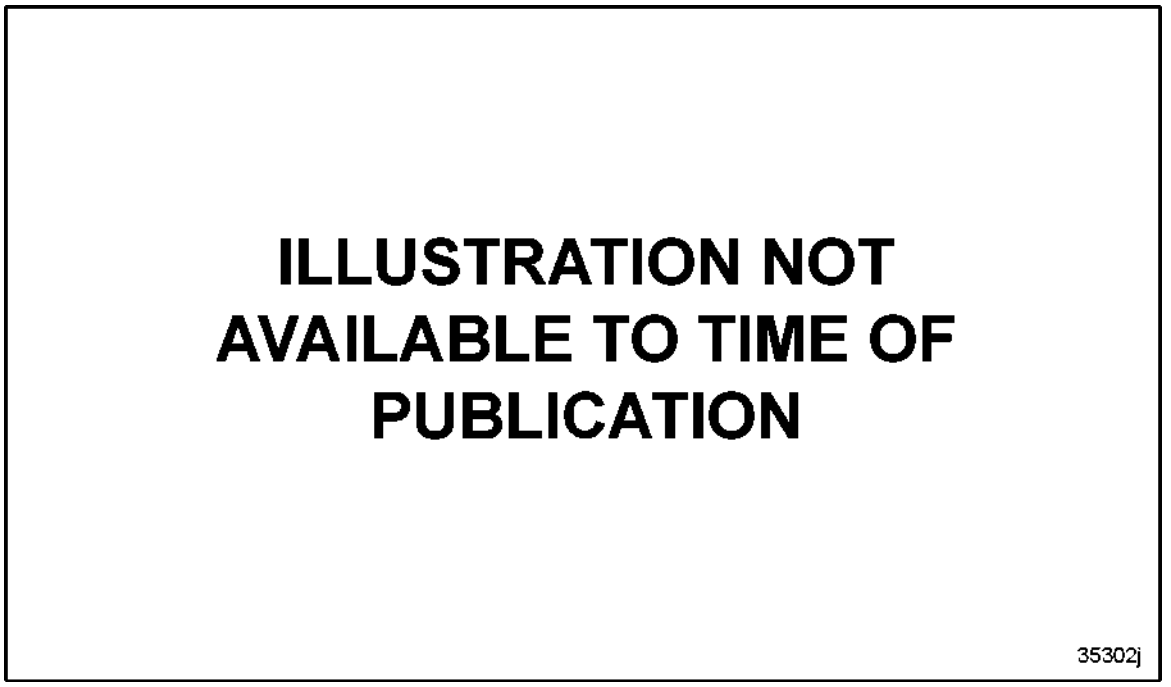

Figure 1795 Master Ring- Liner ID,J 8385–01

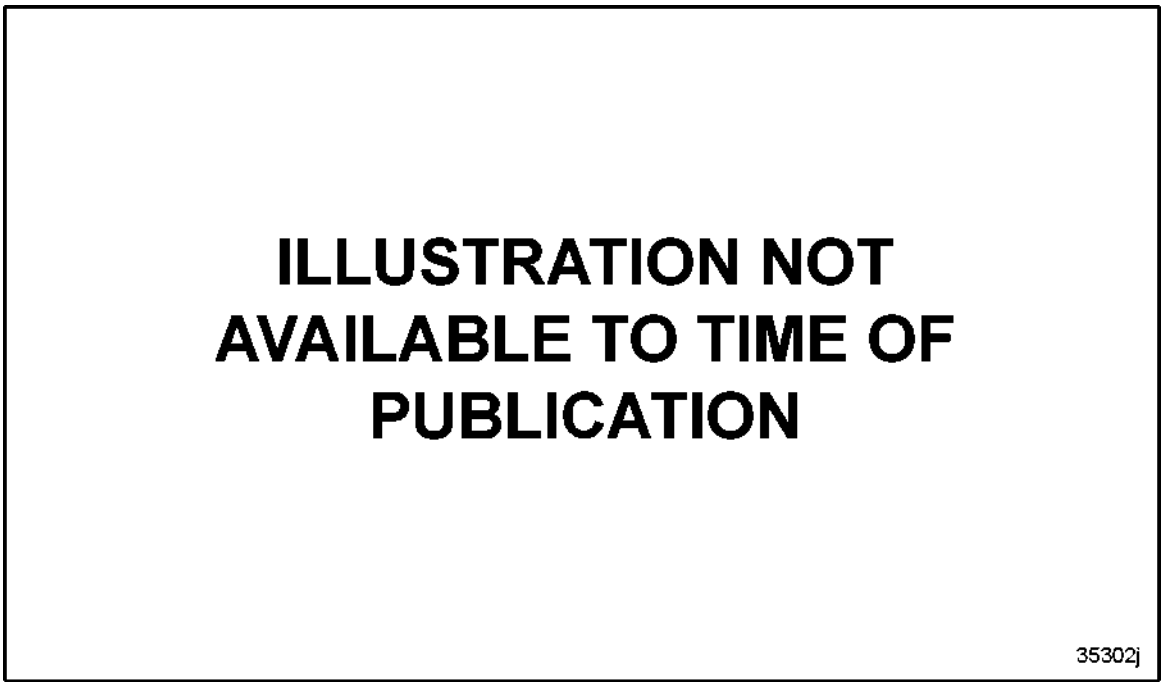

Figure 1796 Right Angle Drill,PT-7145–A

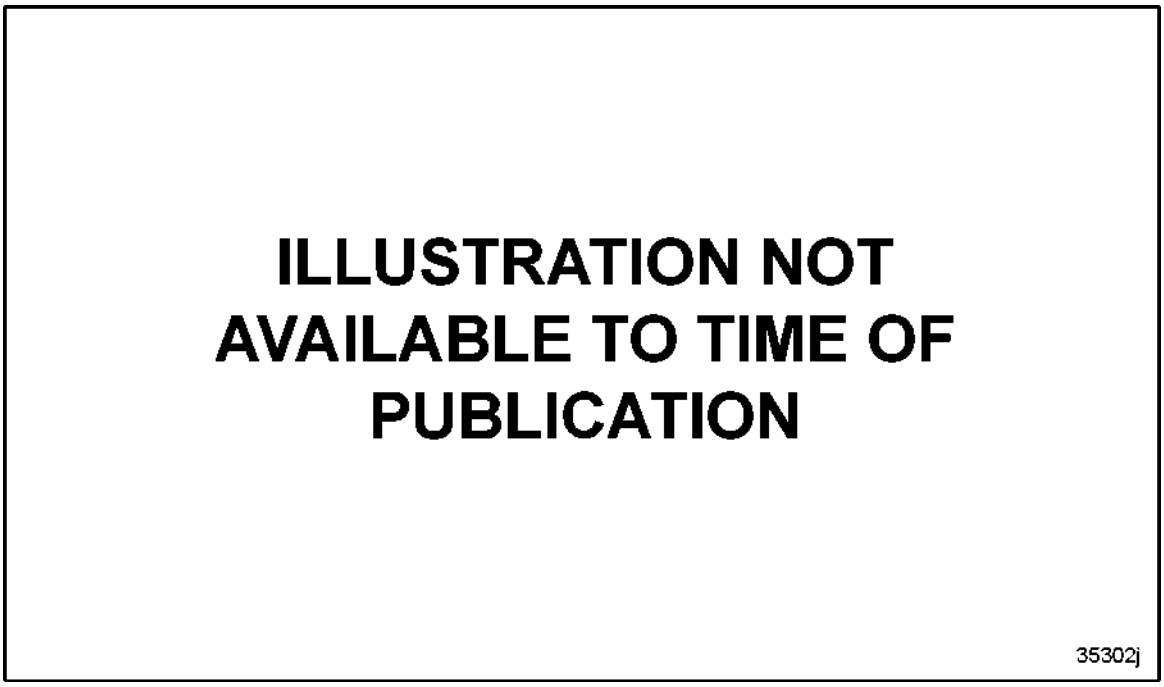

Figure 1797 Threaded Insert,J 38359

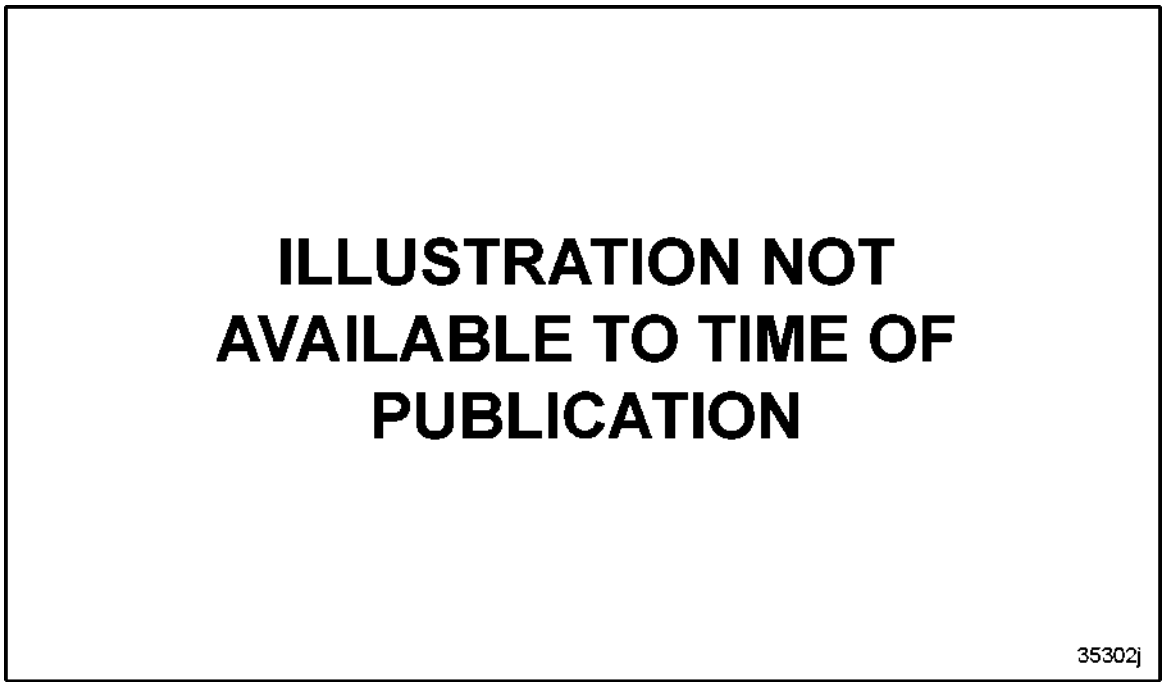

Figure 1798 X-Long Finish Line,PT-2000–400

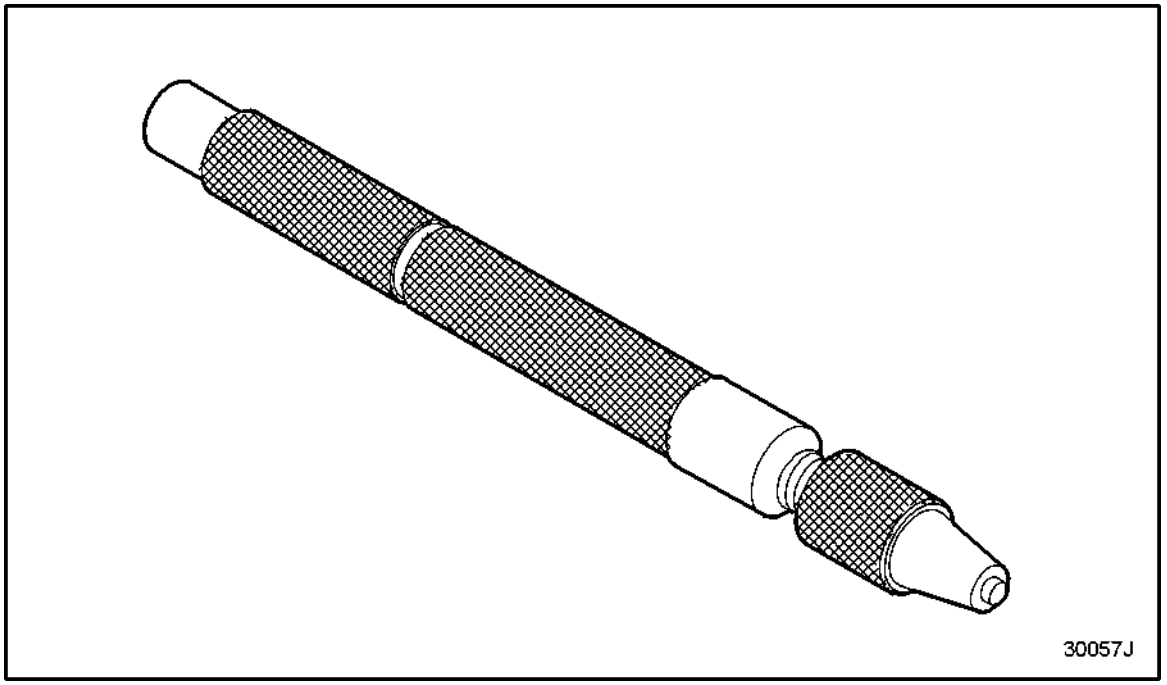

Figure 1799 Cylinder Head Alignment Bar,J 42955

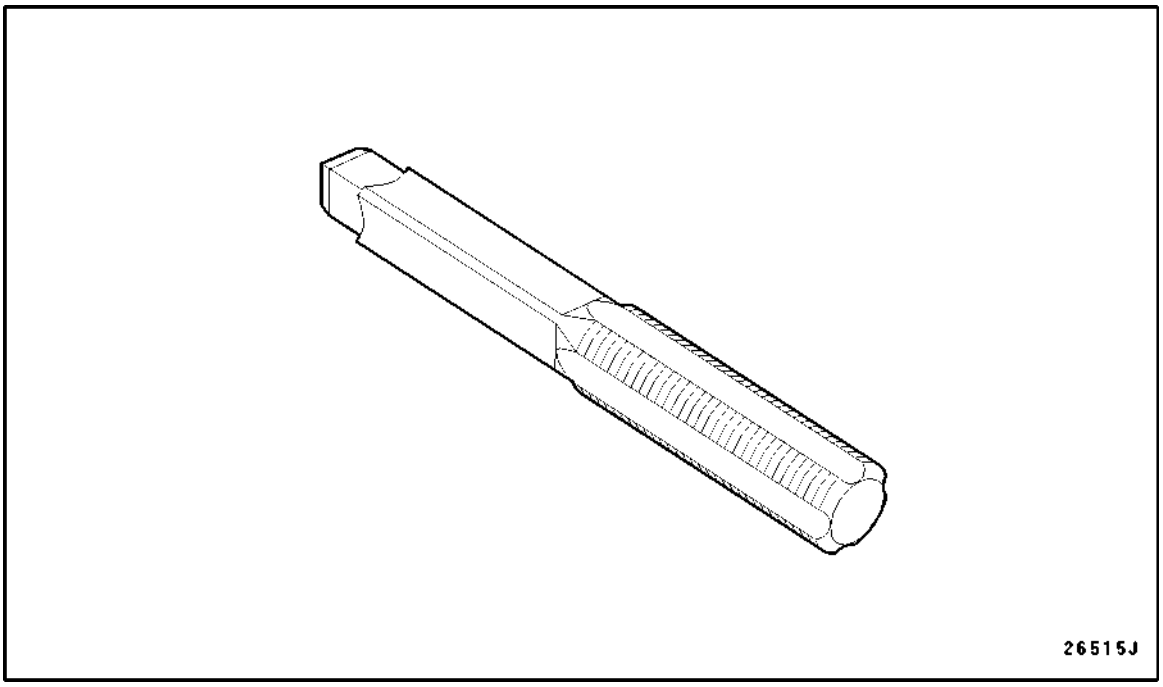

Figure 1800 Cylinder Head Bolt Bottom Tap, J 41962

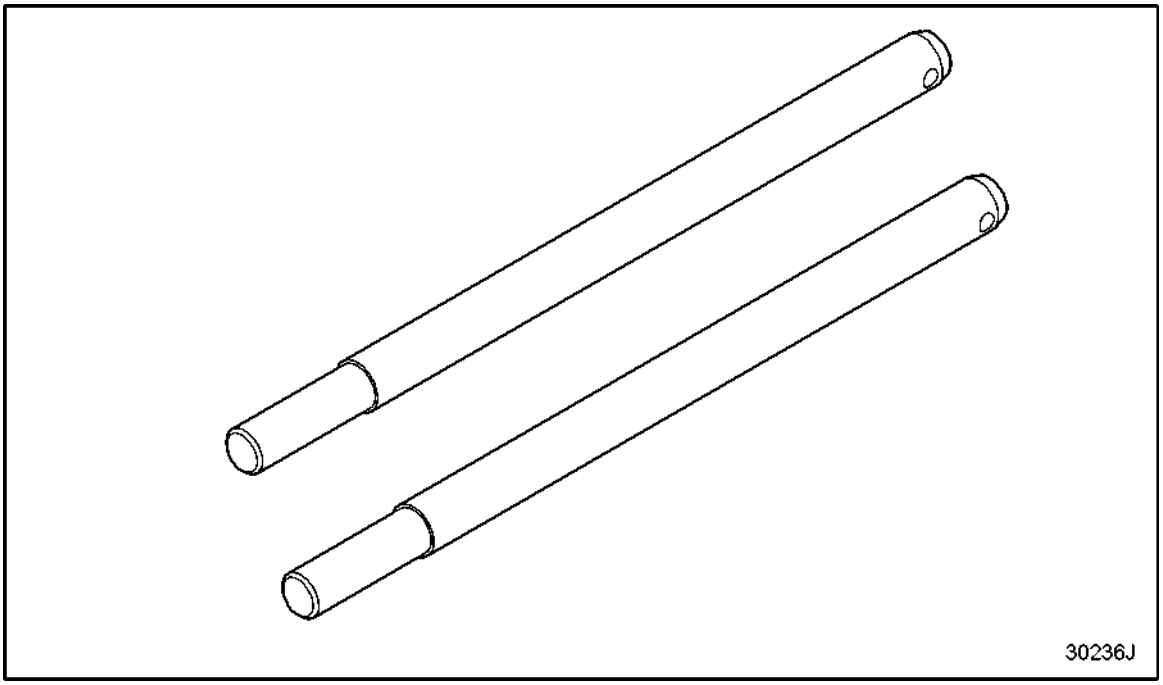

Figure 1801 Cylinder Head Guide Studs, J 42954

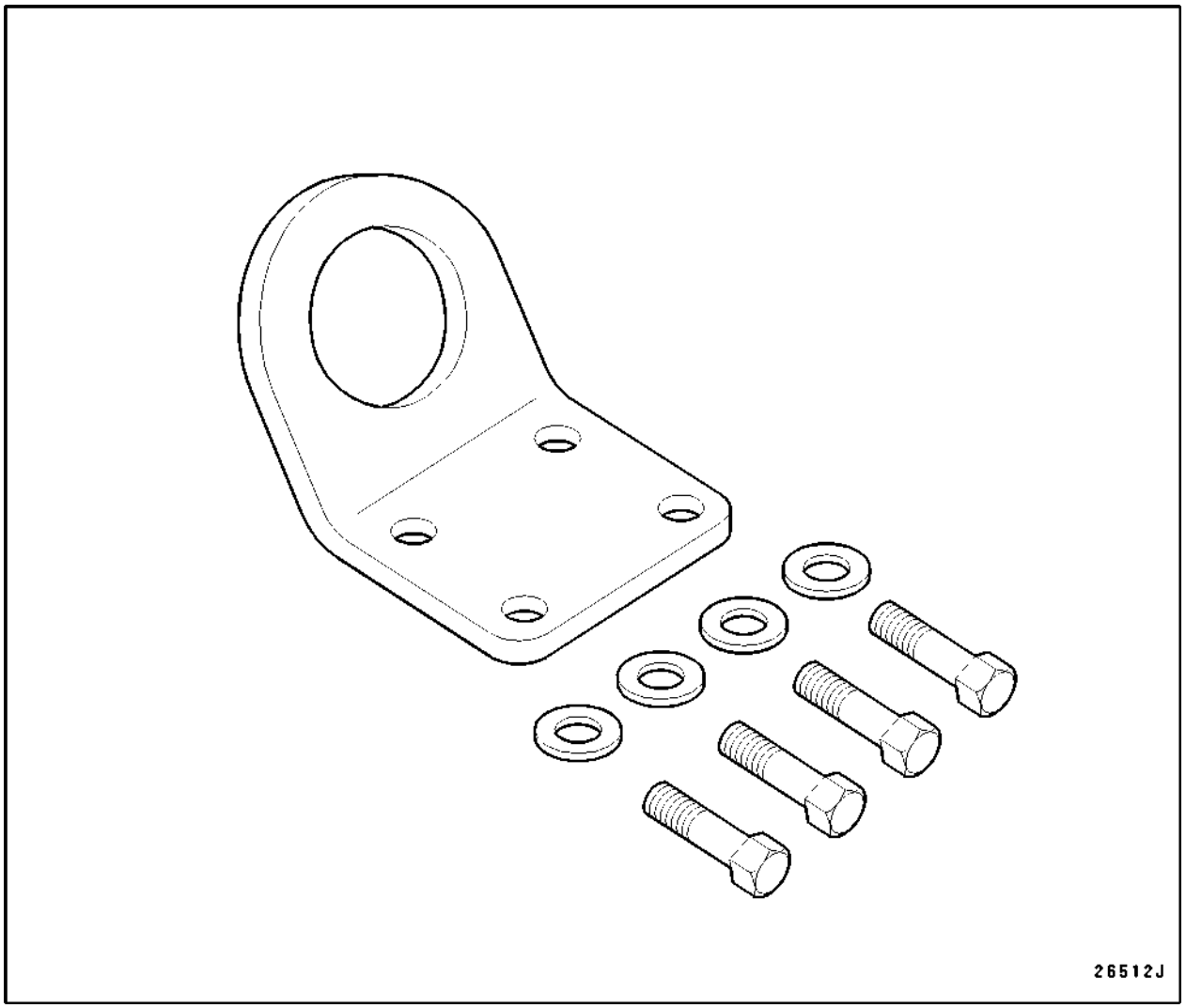

Figure 1802 Cylinder Head Lifter Bracket, J 41823

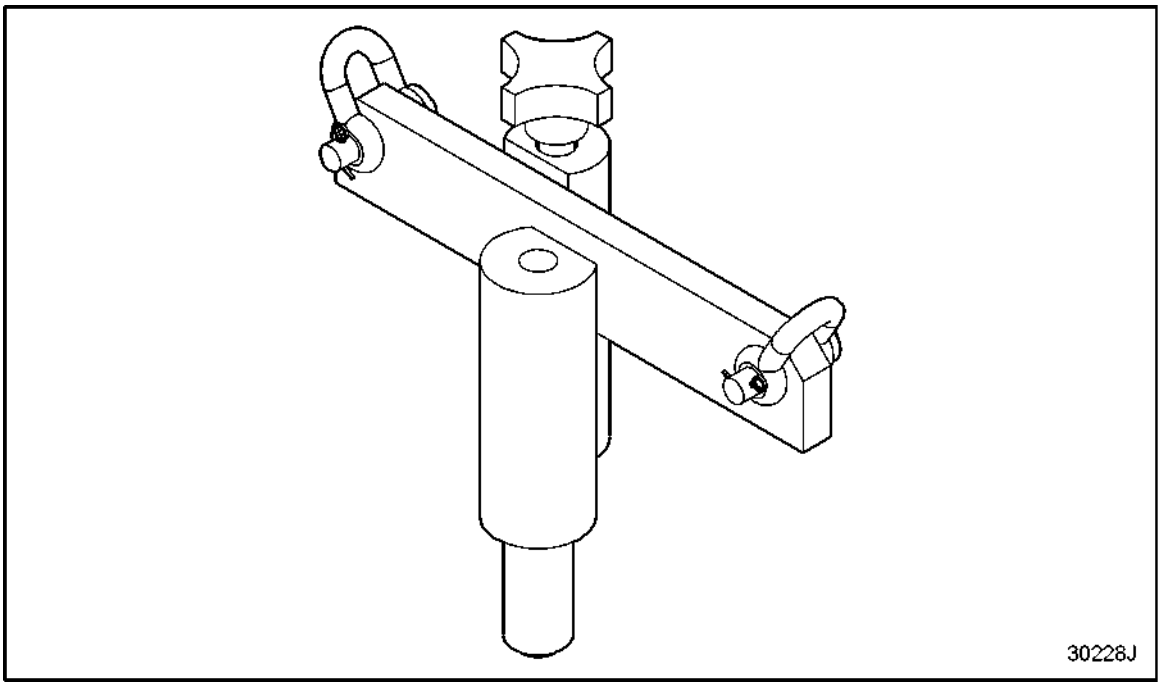

Figure 1803 Cylinder Head Lifting Fixture,J 42730

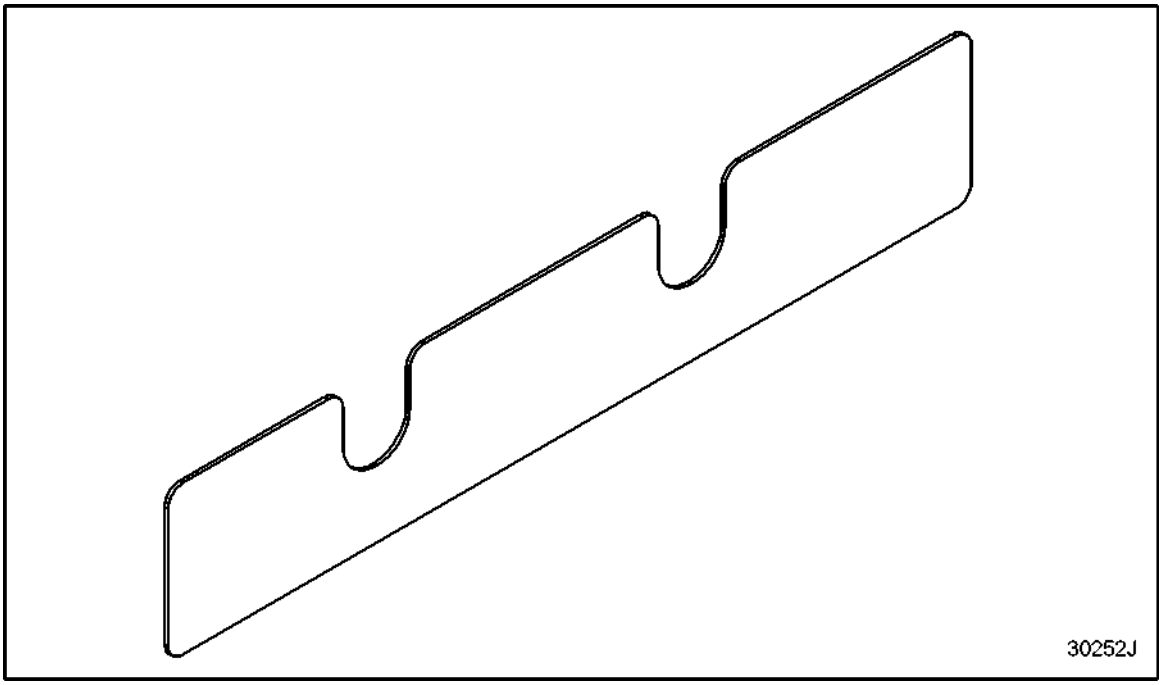

Figure 1804 Cylinder Head Magnet Intake Shield,J 43099

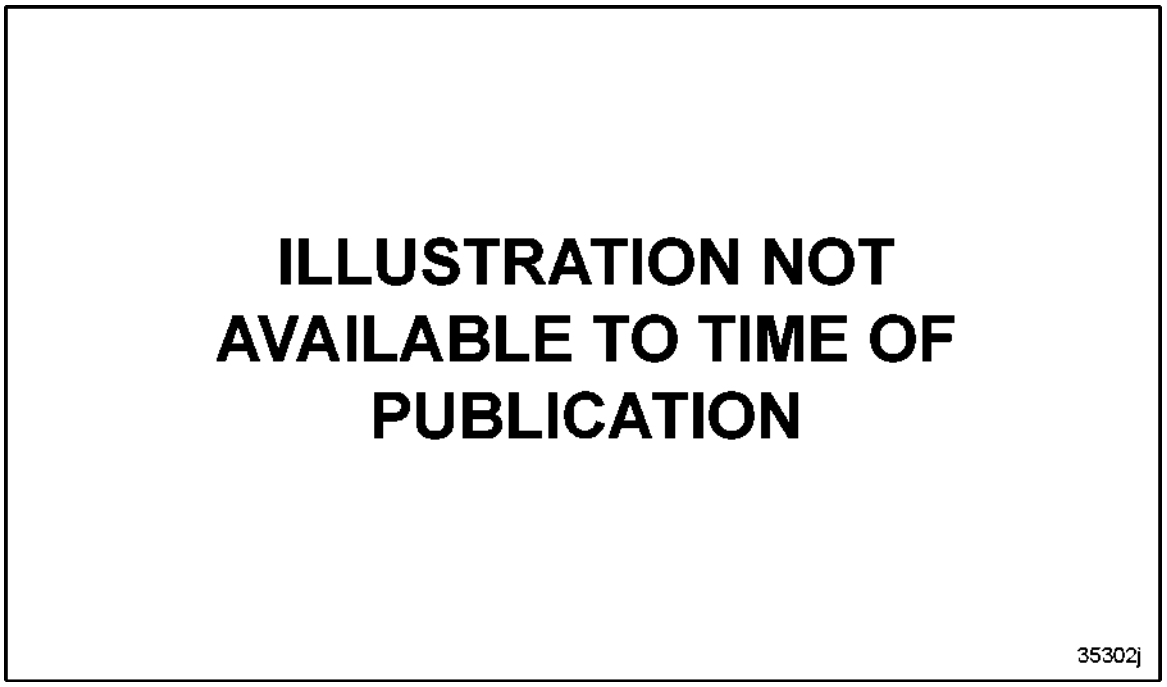

Figure 1805 Cylinder Headbolt Wrench M12,J 42514

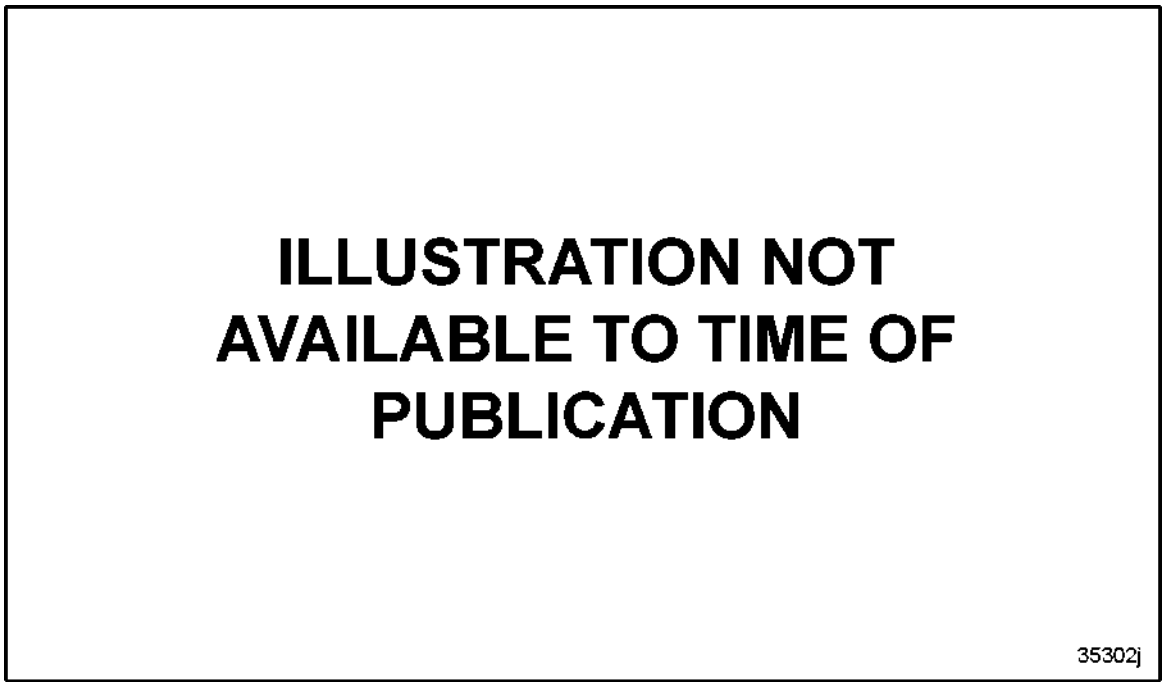

Figure 1806 Cylinder Headbolt Wrench M14,J 42637

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Figure 1807 Fuel Line Nut Wrench 11/16",J 39108

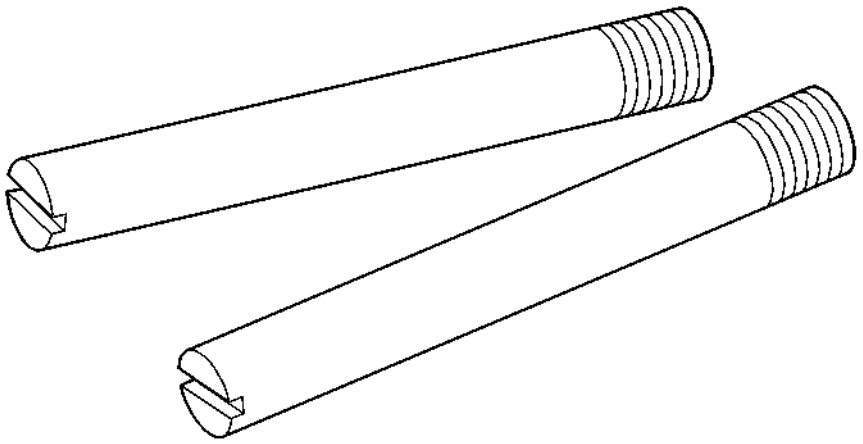

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Figure 1808 Guide Stud Set,J 43096

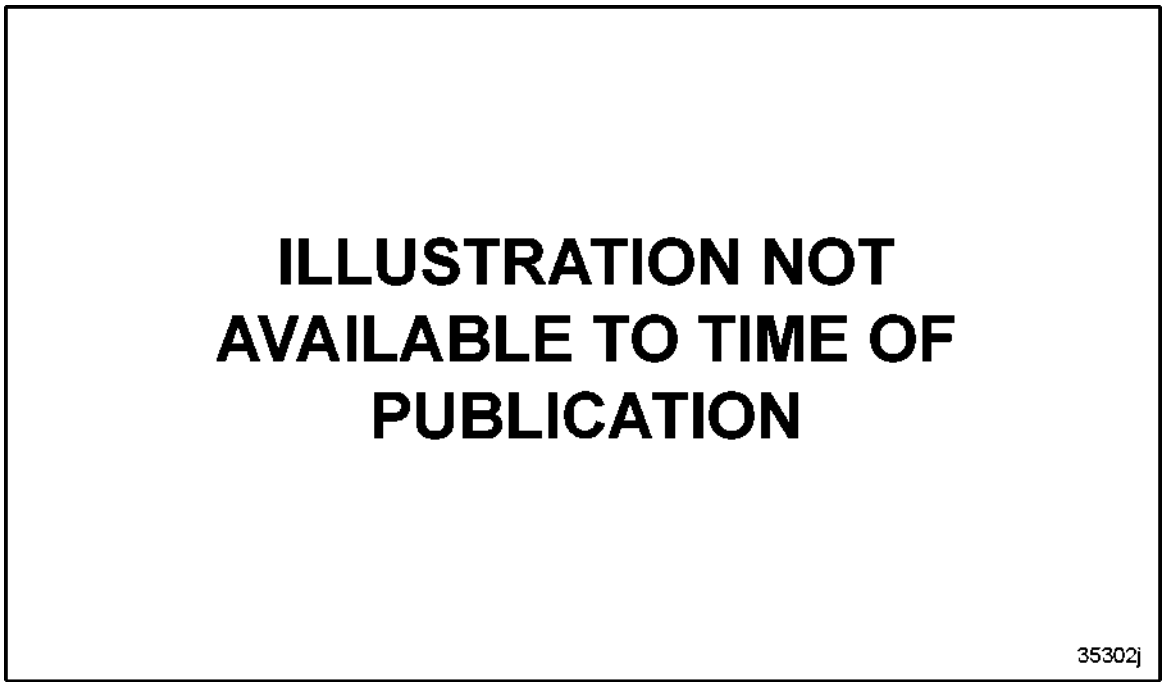

Figure 1809 Infrared Thermometer (0-1600 Deg F),PT-7149

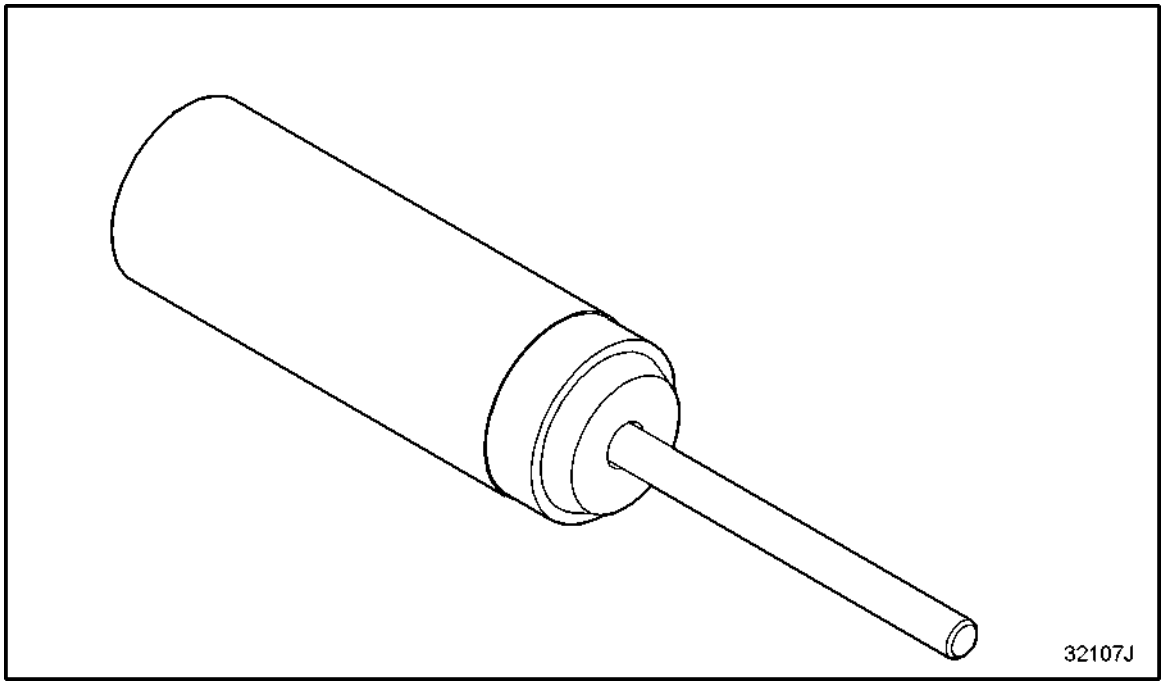

Figure 1810 Valve Seat Insert Installer,J 24357

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Figure 1811 Bridge Guide Installer,J 41574

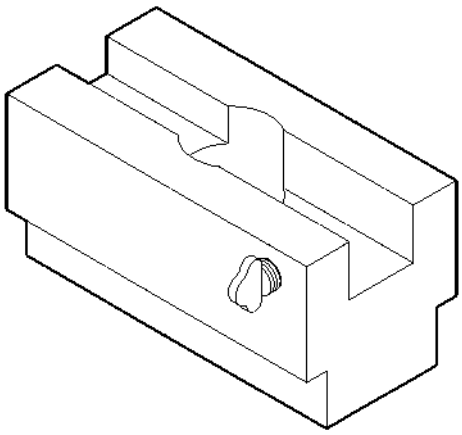

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Figure 1812 Bridge Holding Fixture,J 41569

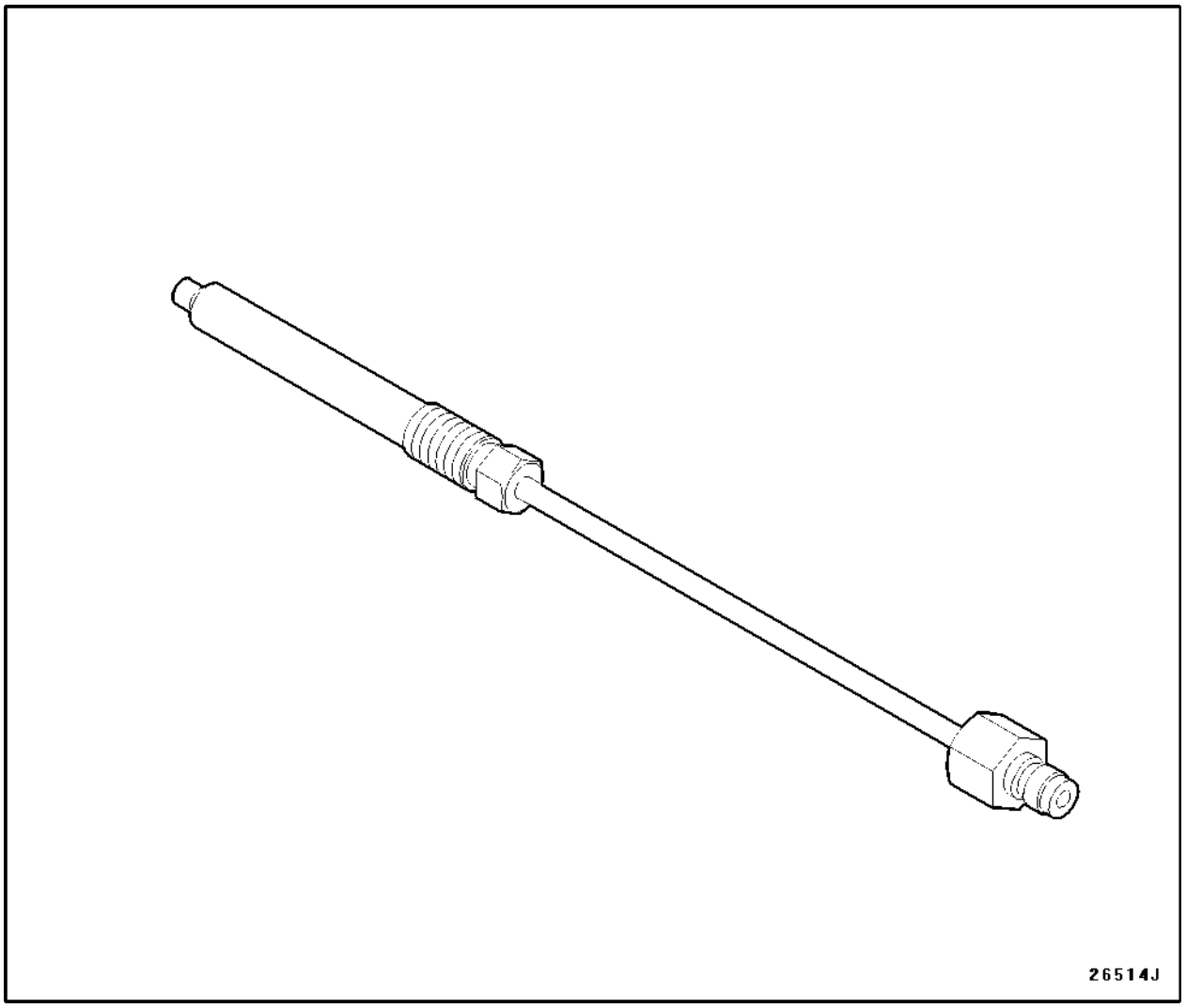

Figure 1813 Crankshaft Cup Plug Installer,J 41960

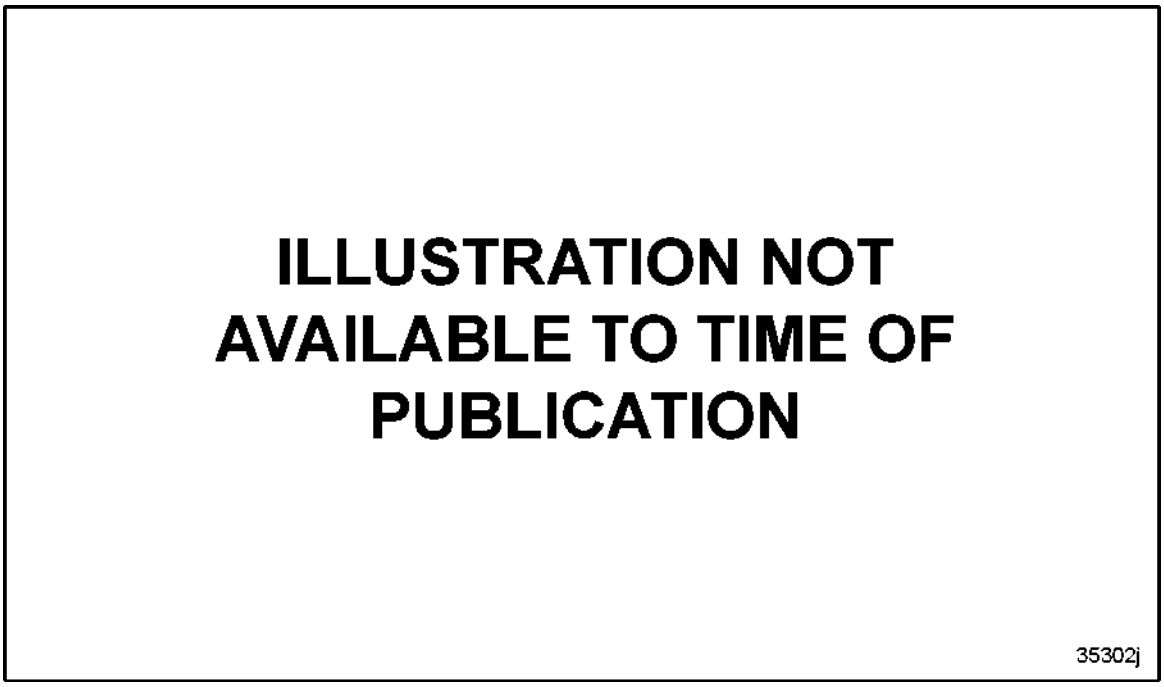

Figure 1814 Crankshaft Remover Protector,J 42778

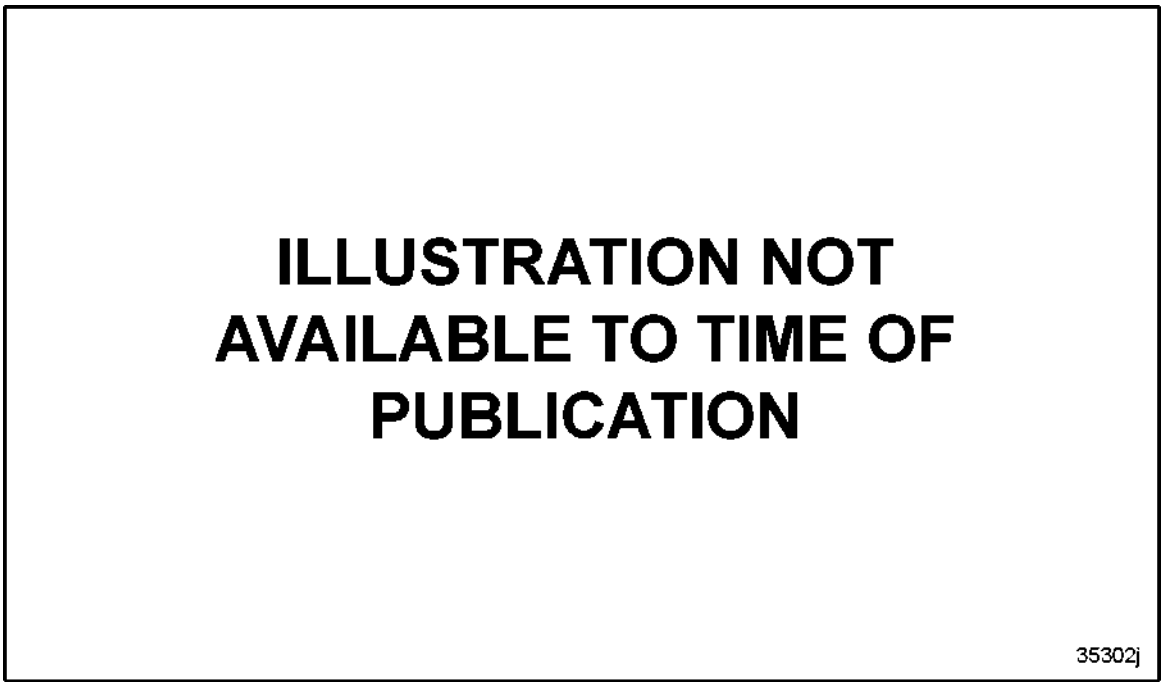

Figure 1815 Front Crankshaft Hub Installer,J 42196

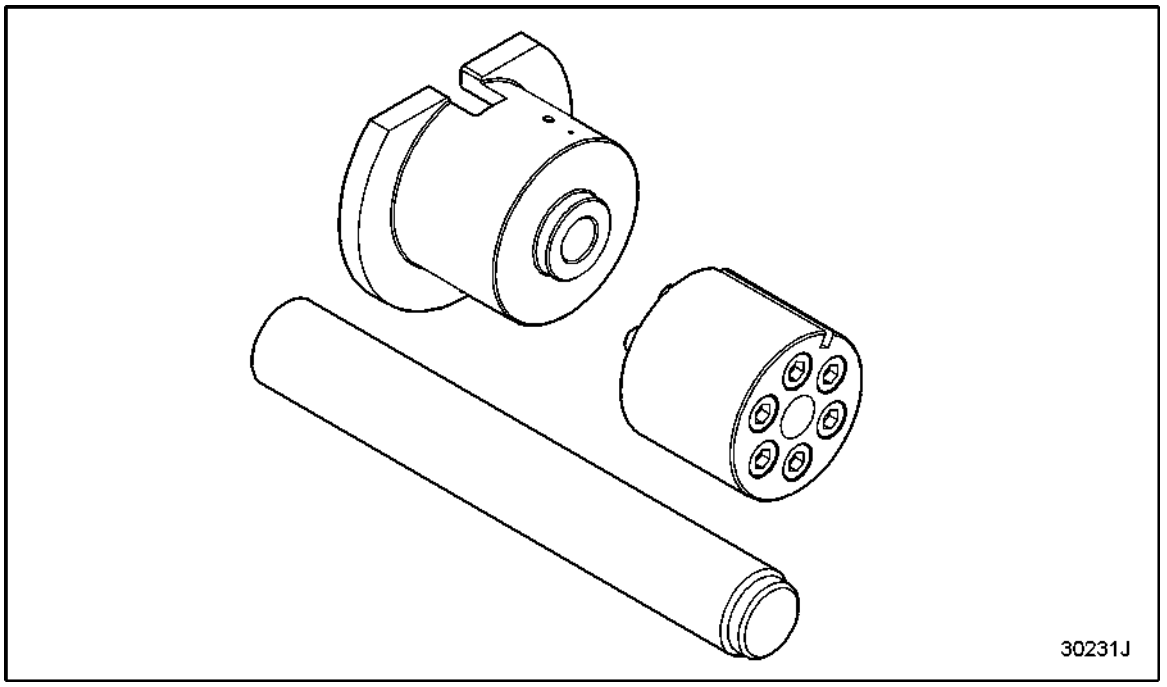

Figure 1816 Rear Crankshaft Flange Installer,J 42733

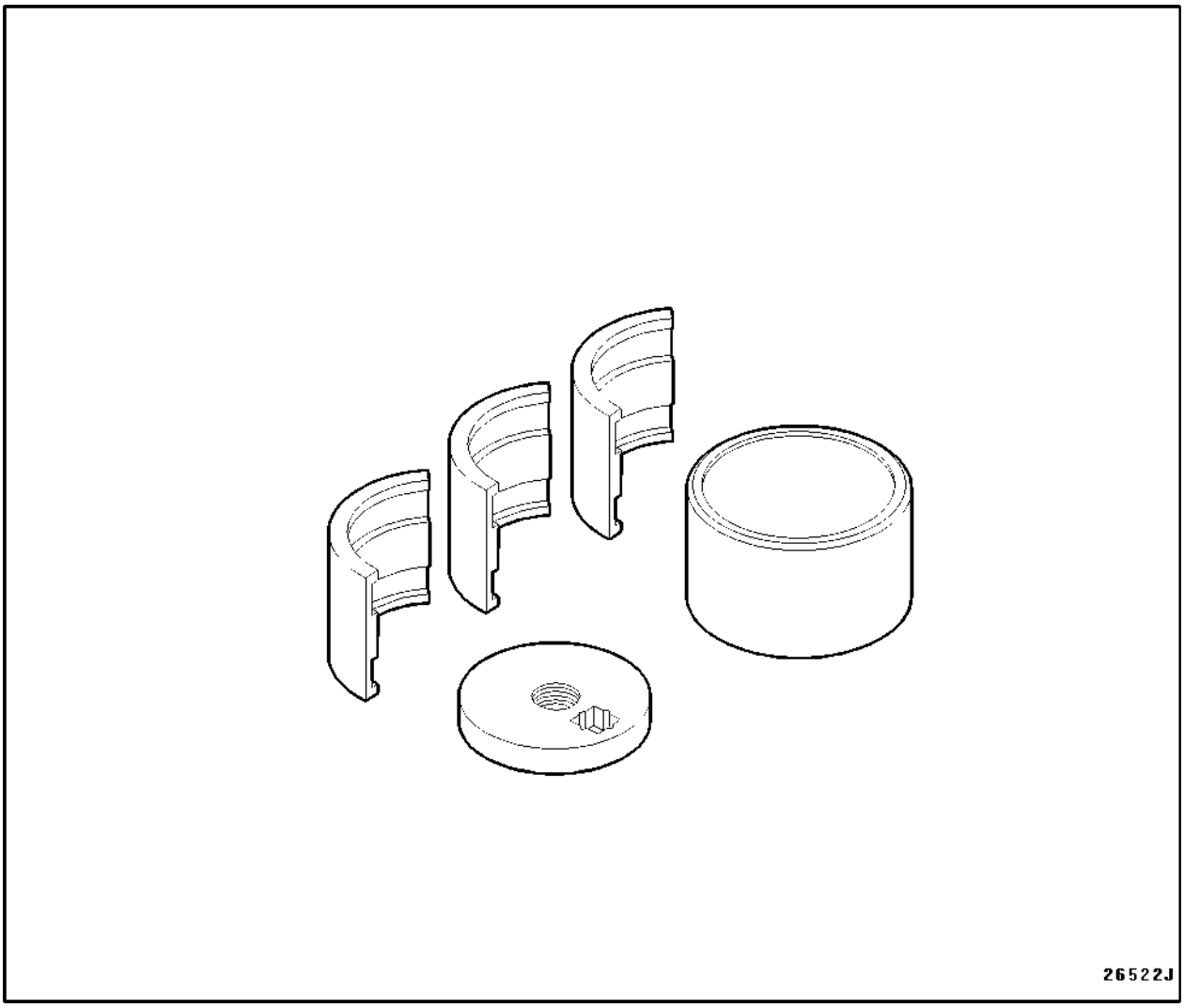

Figure 1817 Crank Wear Sleeve Remover, J 41968

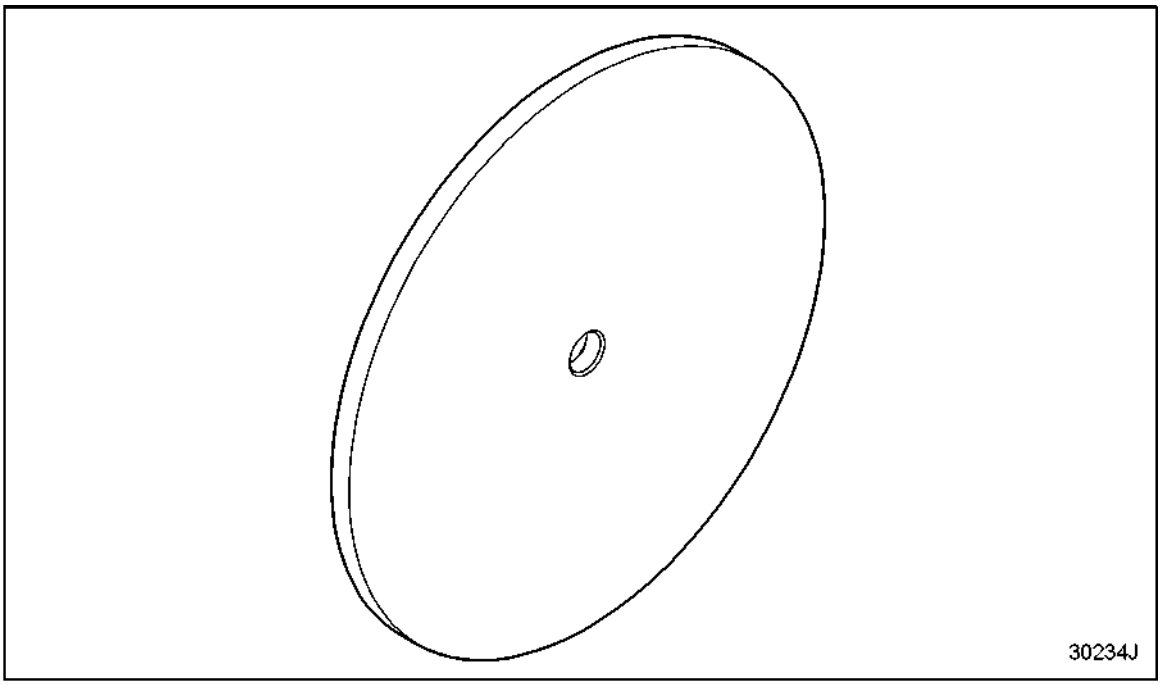

Figure 1818 Front Crankshaft Hub Seal Installer, J 42736

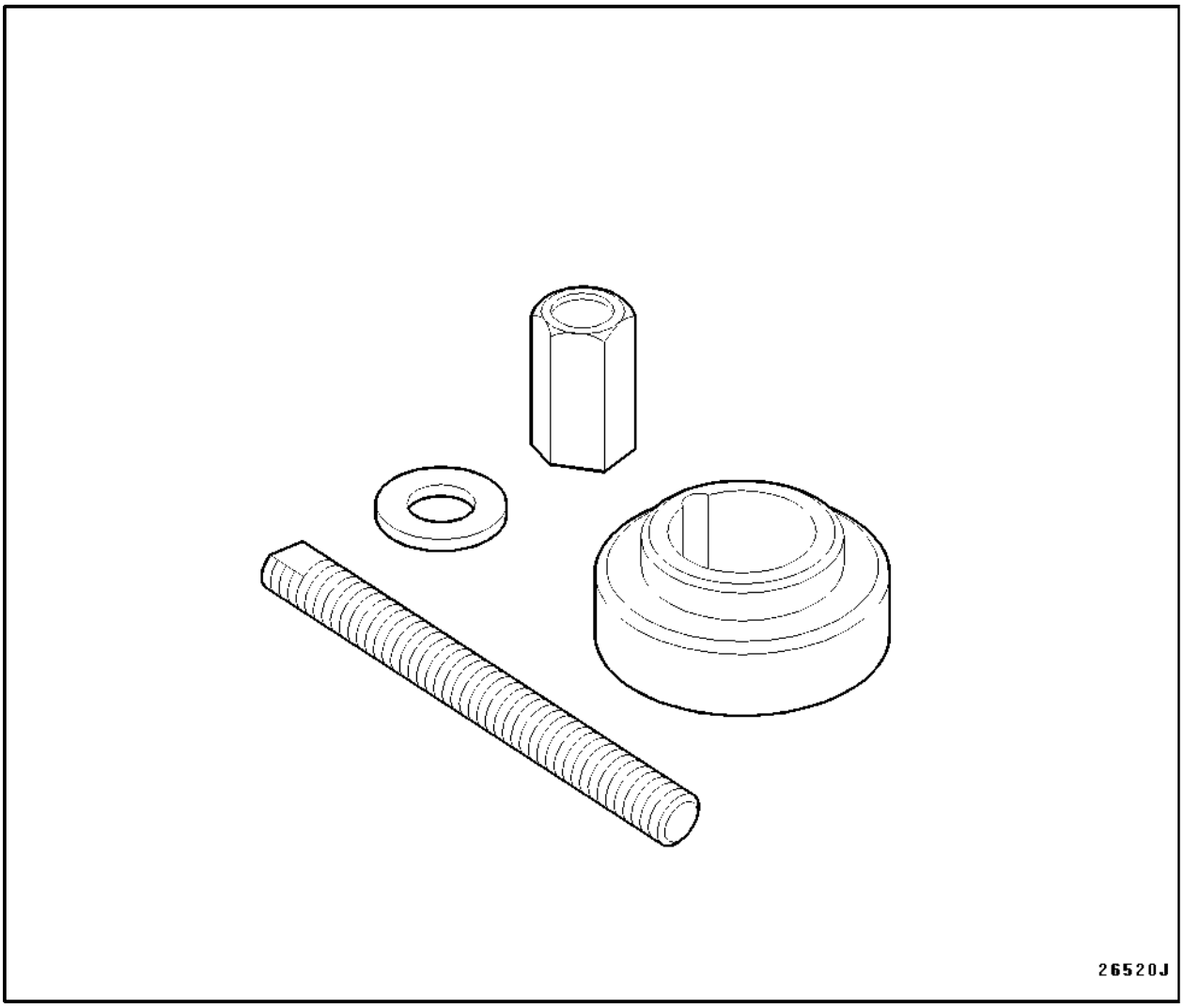

Figure 1819 Front Seal Installer,J 41966

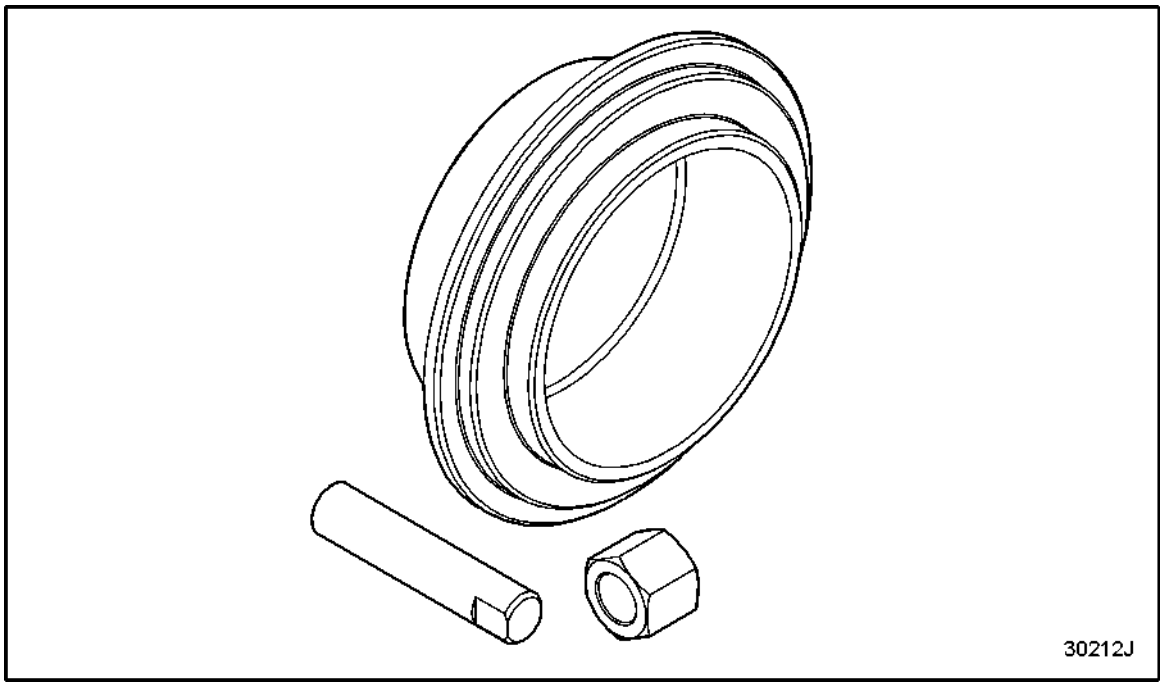

Figure 1820 Front Seal Installer,J 42261

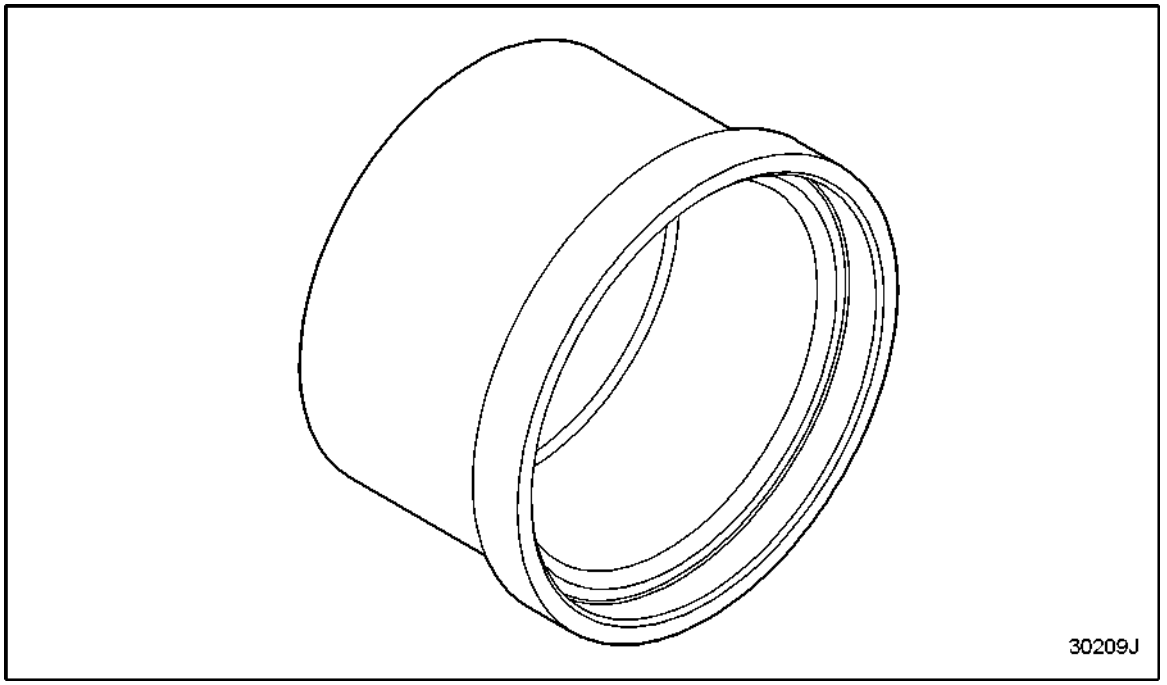

Figure 1821 Front Wear Sleeve Installer,J 42257

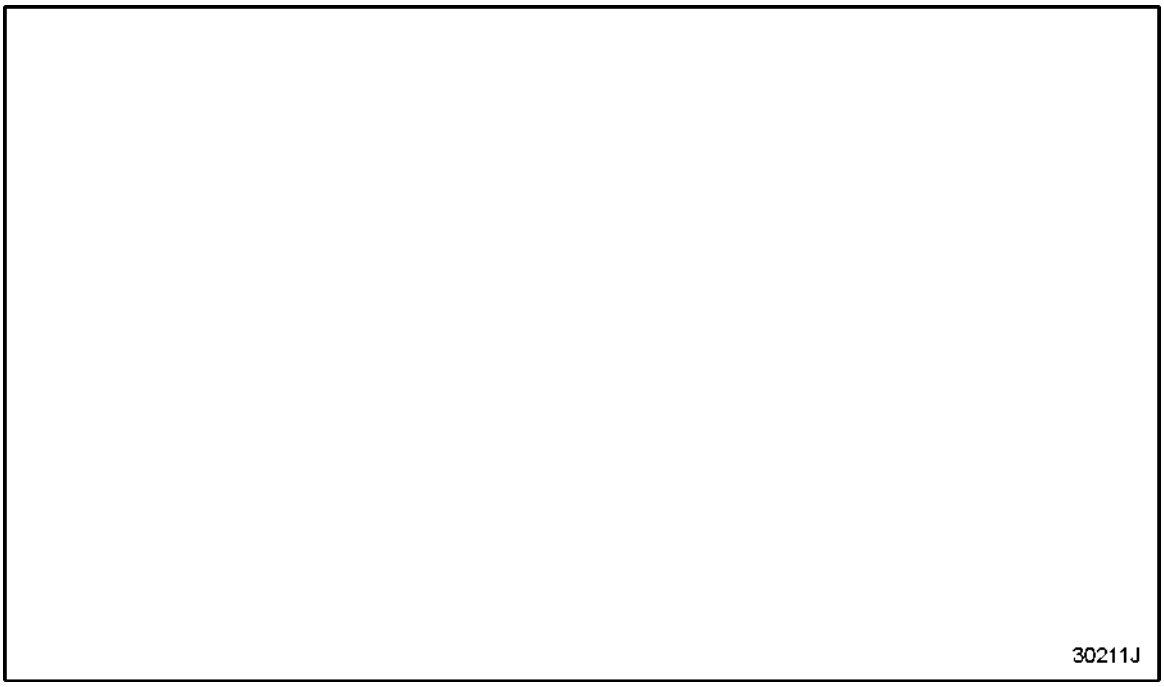

Figure 1822 Rear Crankshaft Seal Installer,J 42259

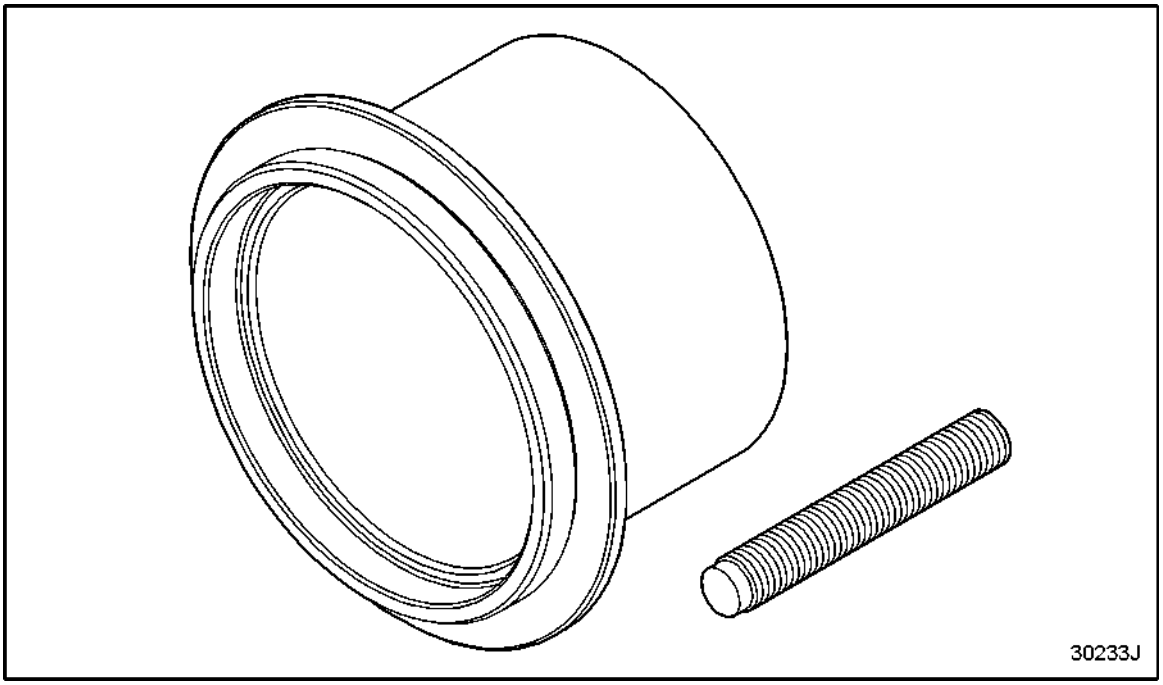

Figure 1823 Rear Crankshaft Seal Installer,J 42735

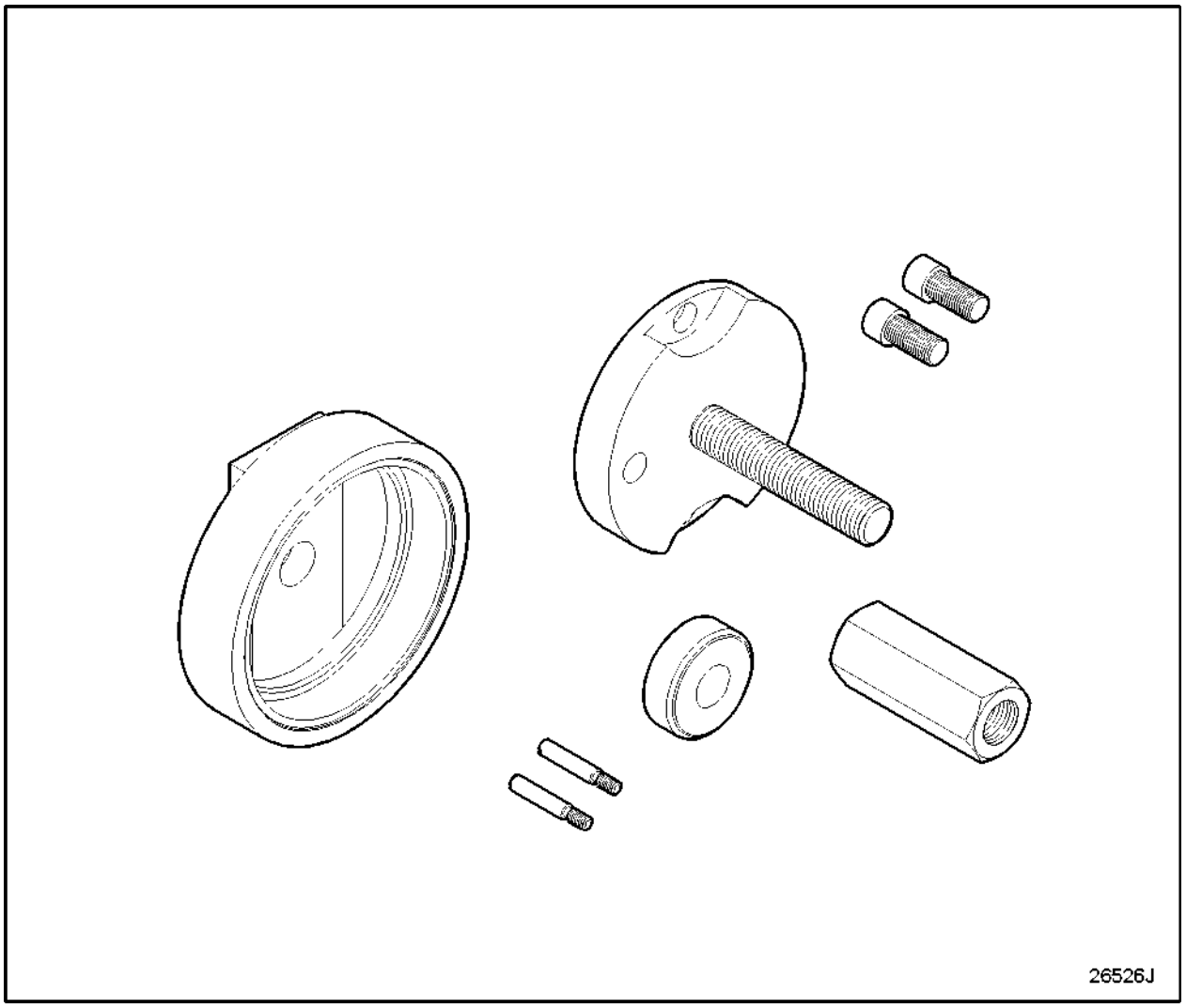

Figure 1824 Rear Seal Installer,J 41974

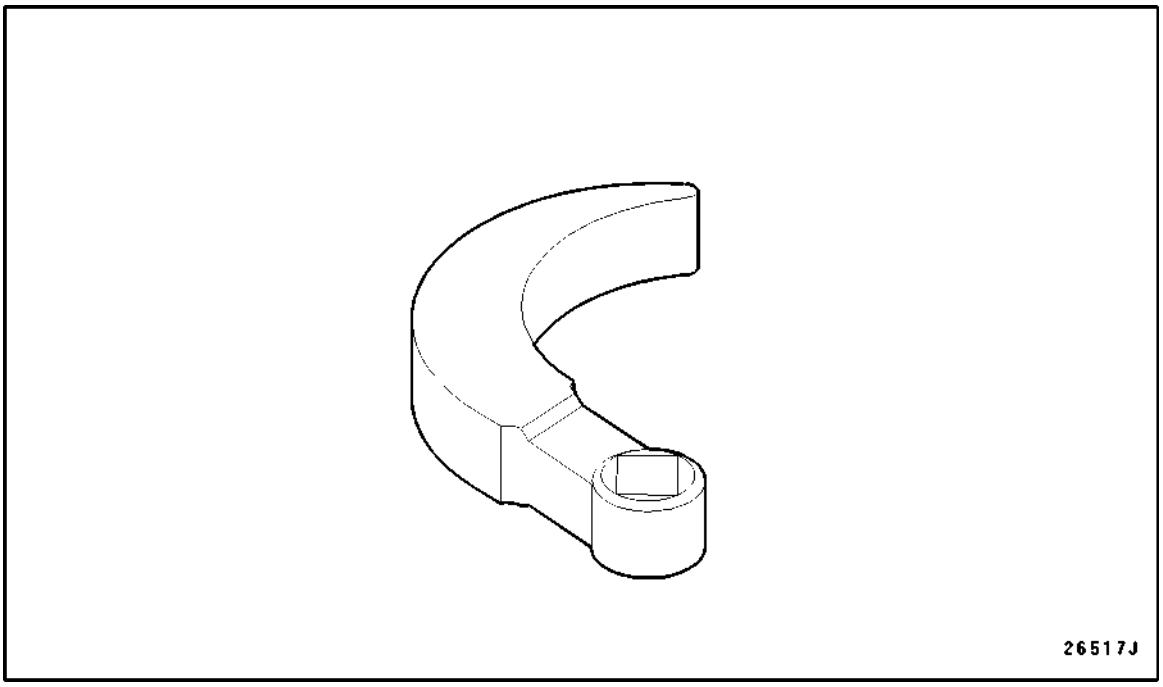

Figure 1825 Seal Remover,J 41963

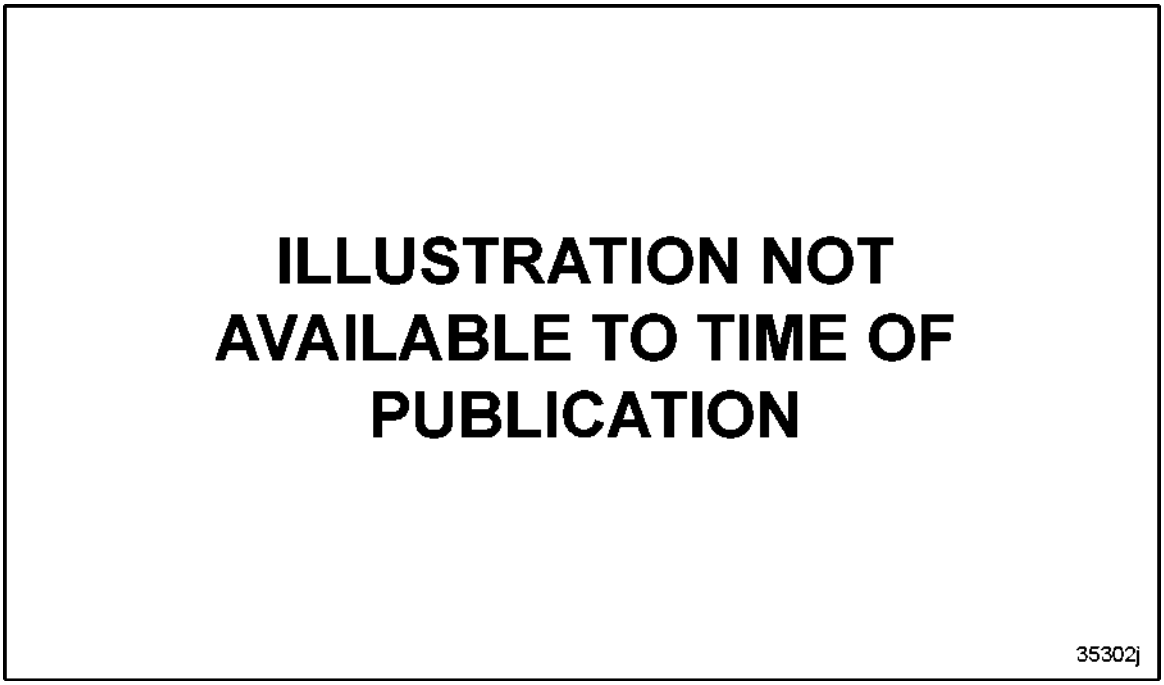

Figure 1826 Wear Ring Installer,J 39284

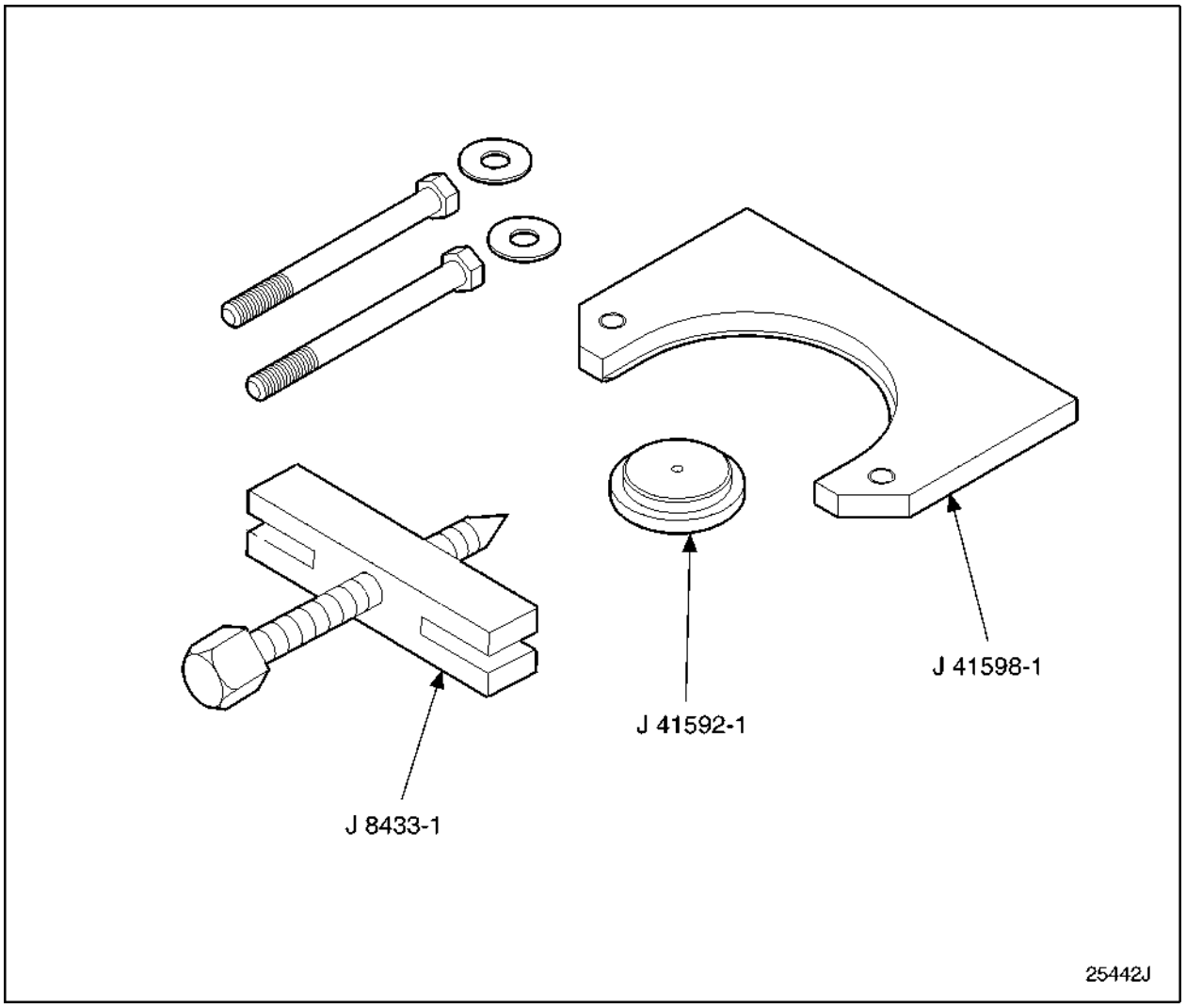

Figure 1827 Wear Sleeve Remover-Front,J 41598

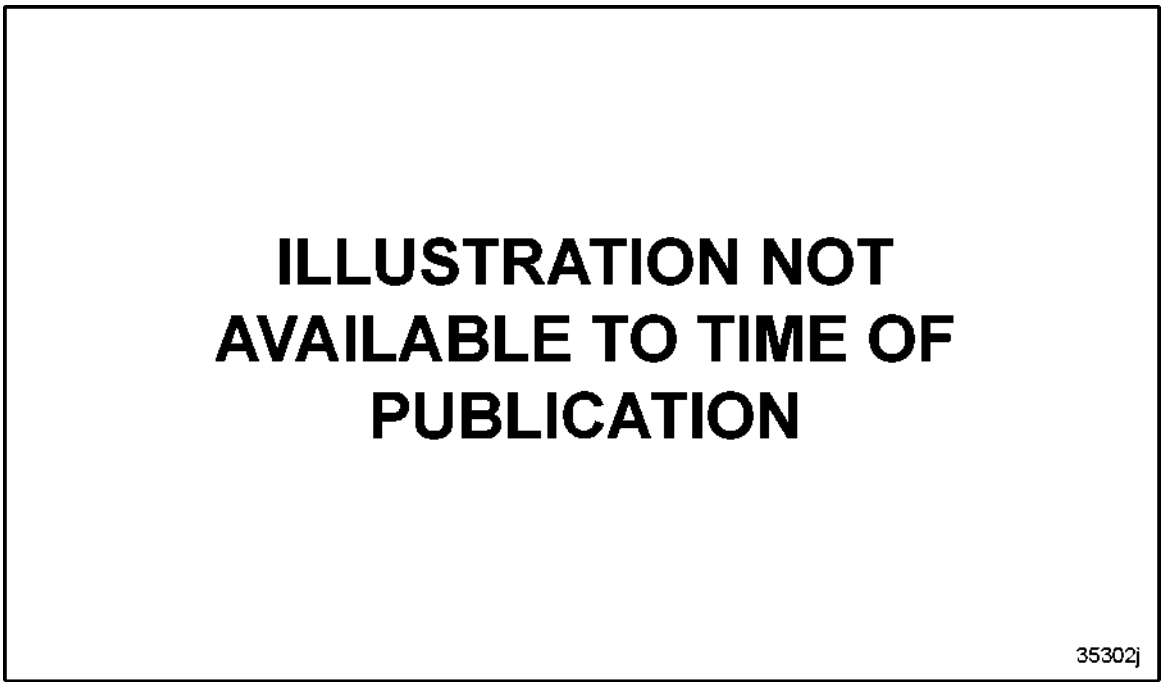

Figure 1828 Gear Case Bushing Kit (40),J 43030–40

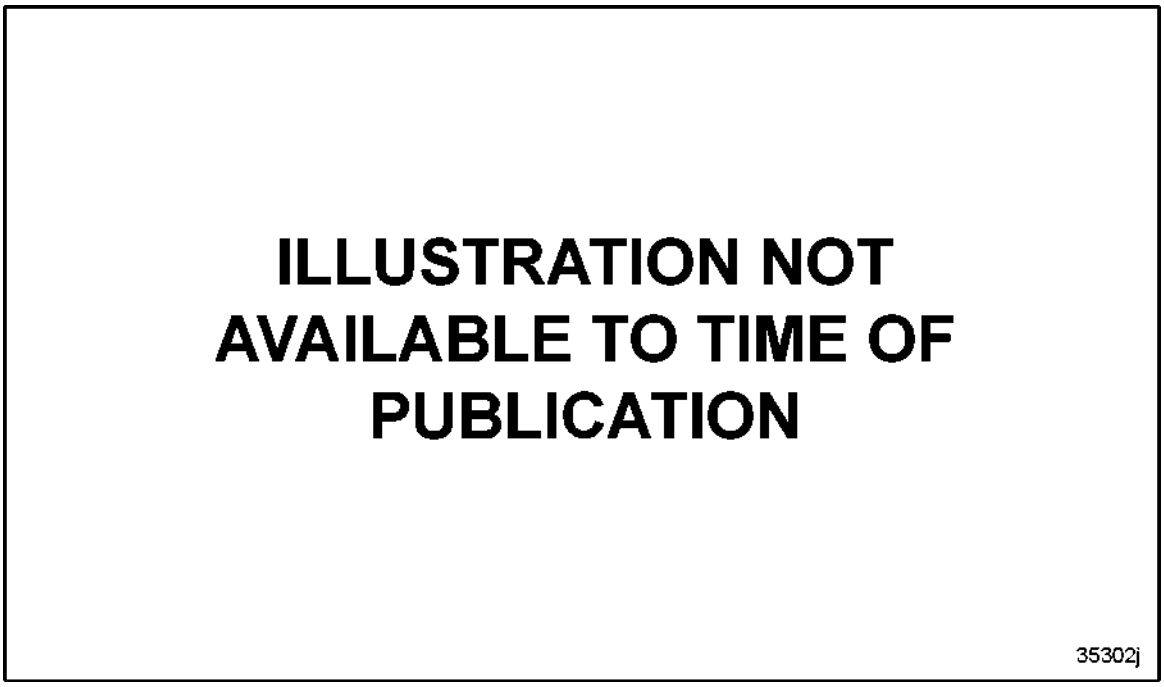

Figure 1829 Gearcase Reaming Fixture,J 43030

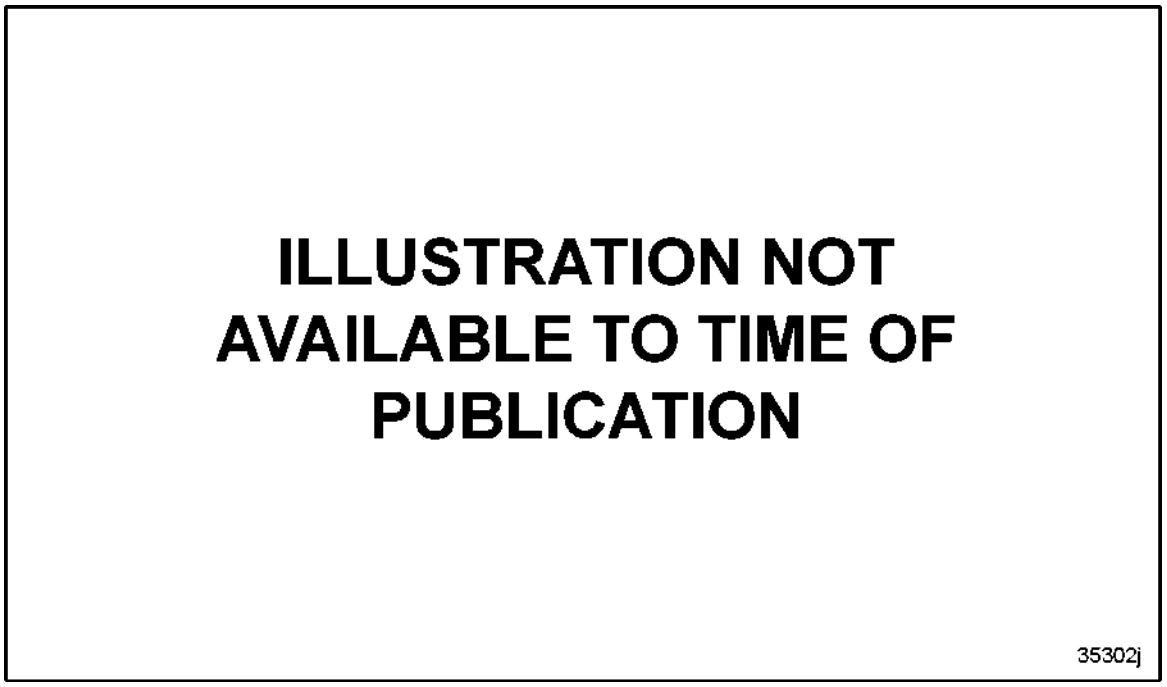

Figure 1830 Crankshaft Pulley & Gear Remover, J 42511

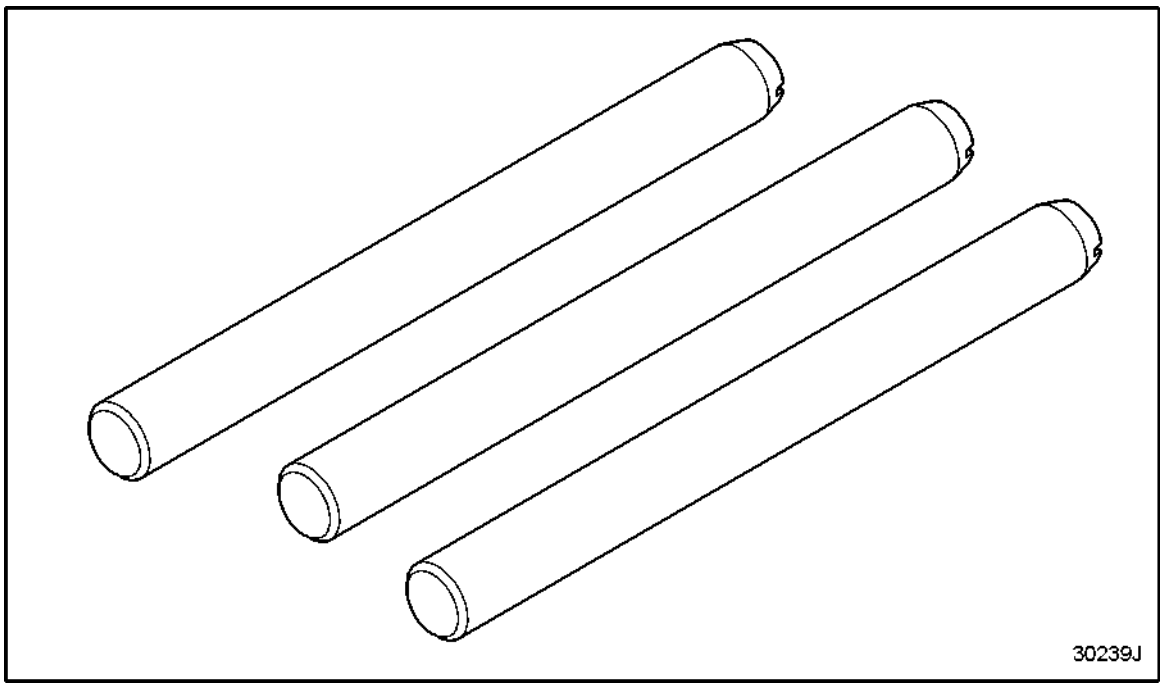

Figure 1831 Flywheel & Vib damper Guide Studs, J 42999

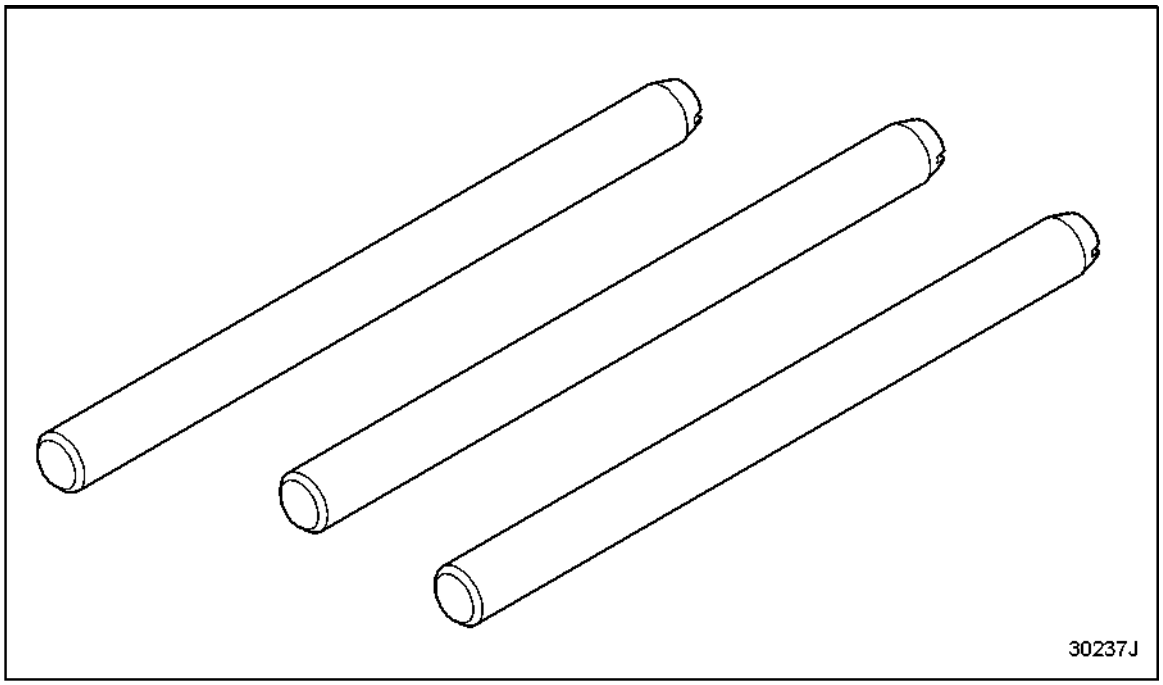

Figure 1832 Flywheel Guide Studs,J 42953

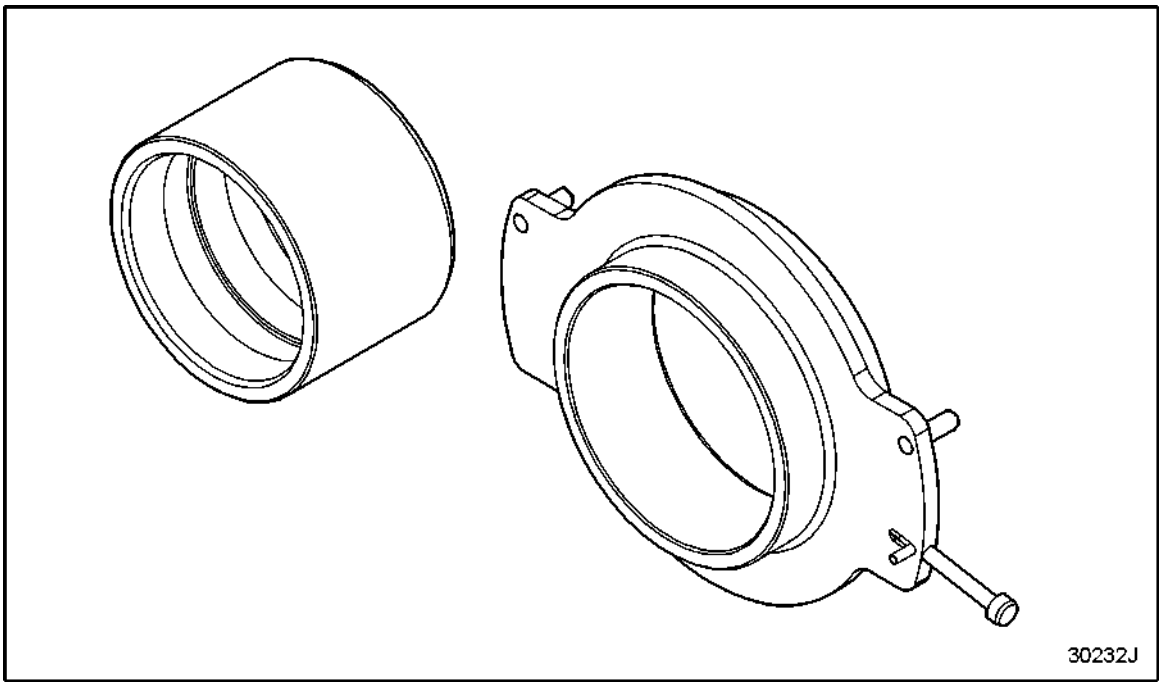

Figure 1833 Flywheel Housing Alignment Tool,J 42734

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Figure 1834 Piston Crown ID Gage,J 41733

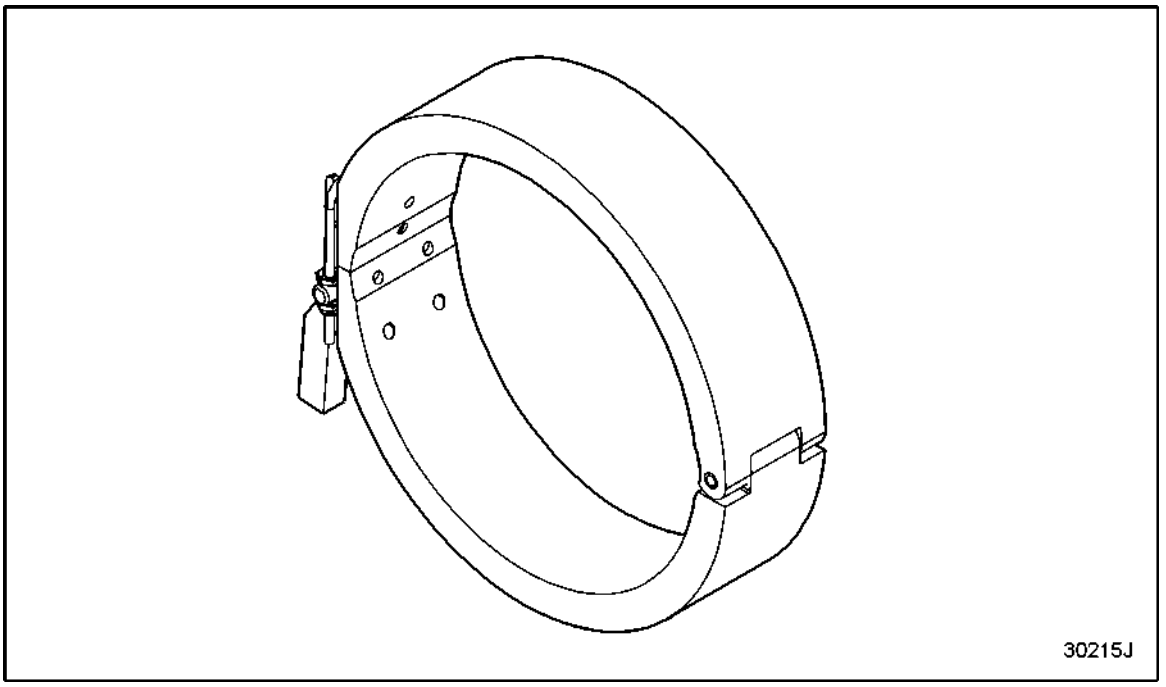

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Figure 1835 Piston Ring Compressor,J 42256

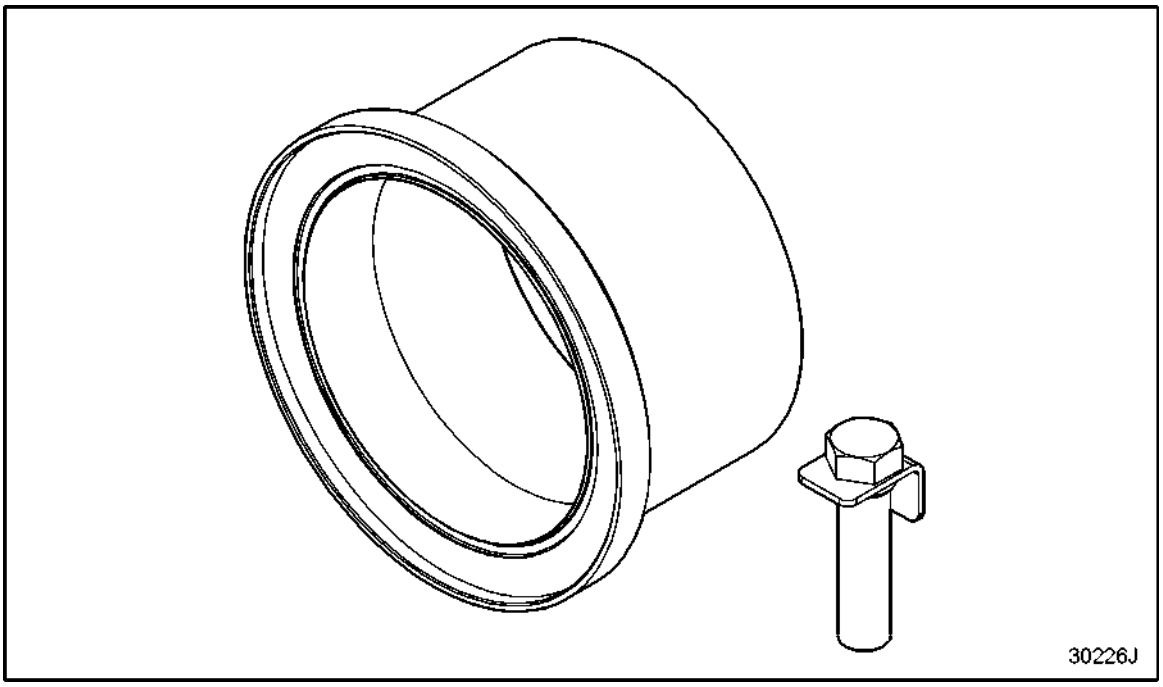

Figure 1836 Piston Ring Compressor,J 42727

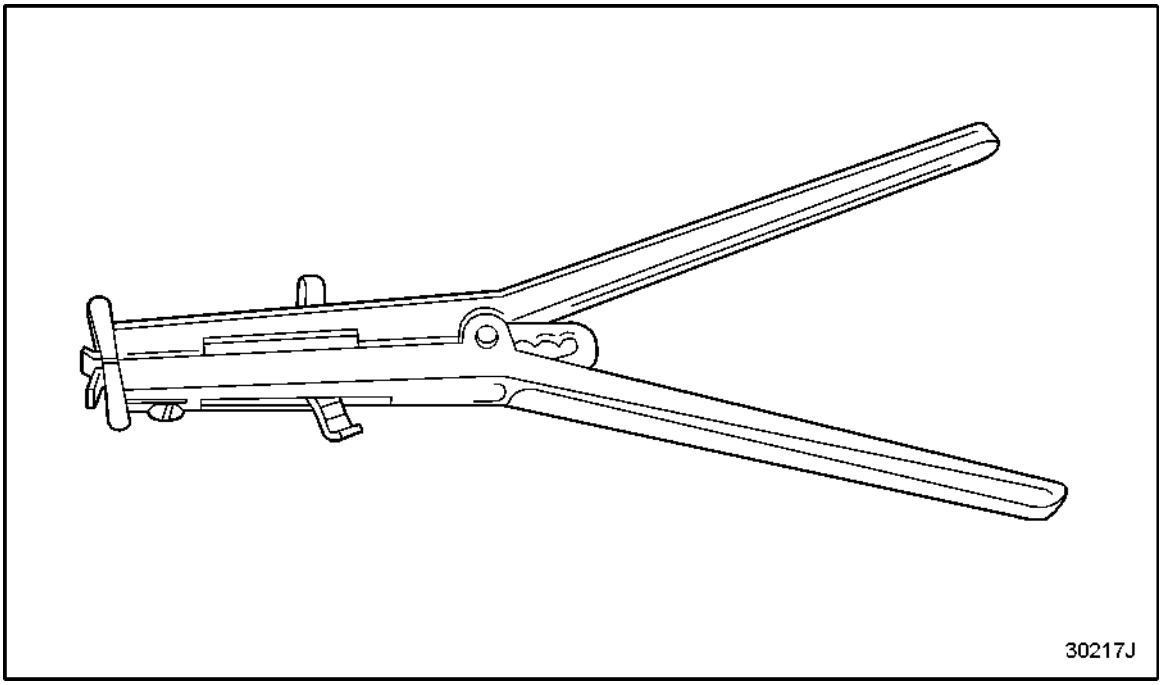

Figure 1837 Series 2000 Piston Ring Pliers,J 43011

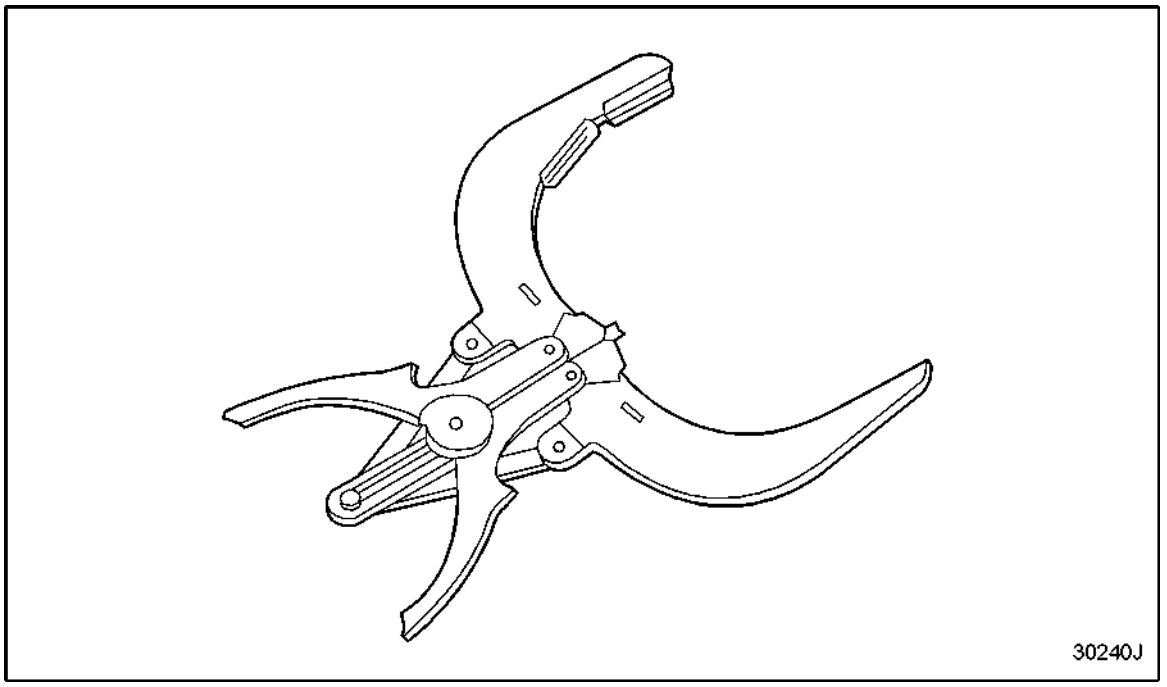

Figure 1838 Series 4000 Piston Ring Pliers,J 43012

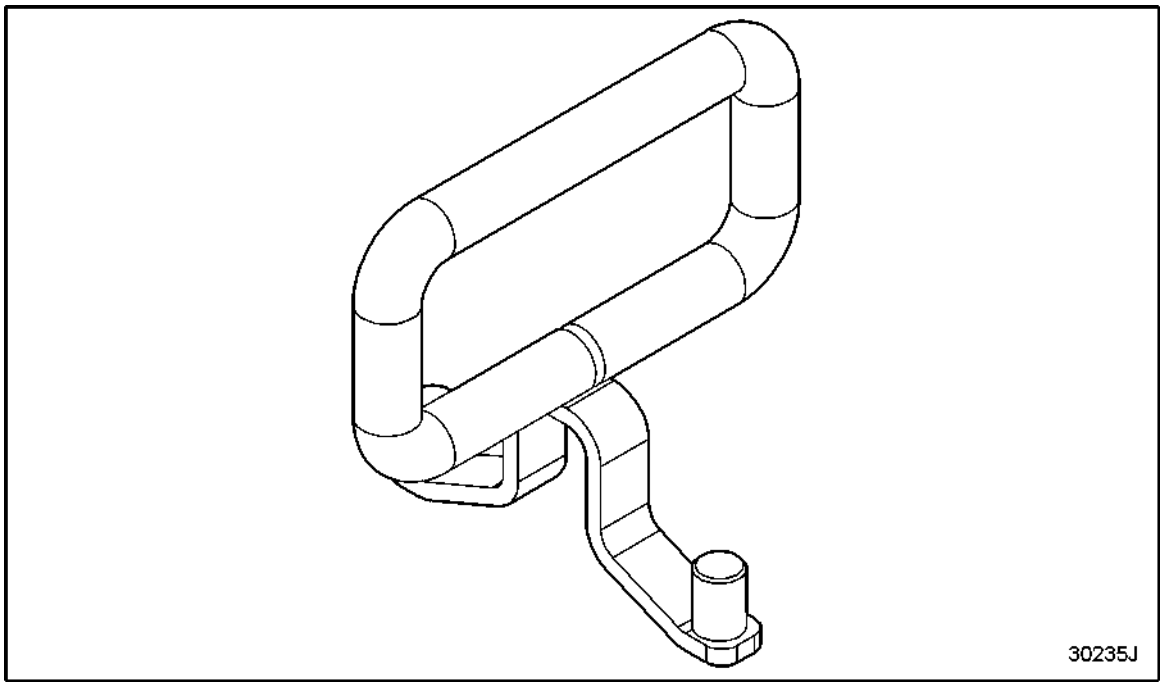

Figure 1839 Piston & Rod Lifting Tool,J 42781

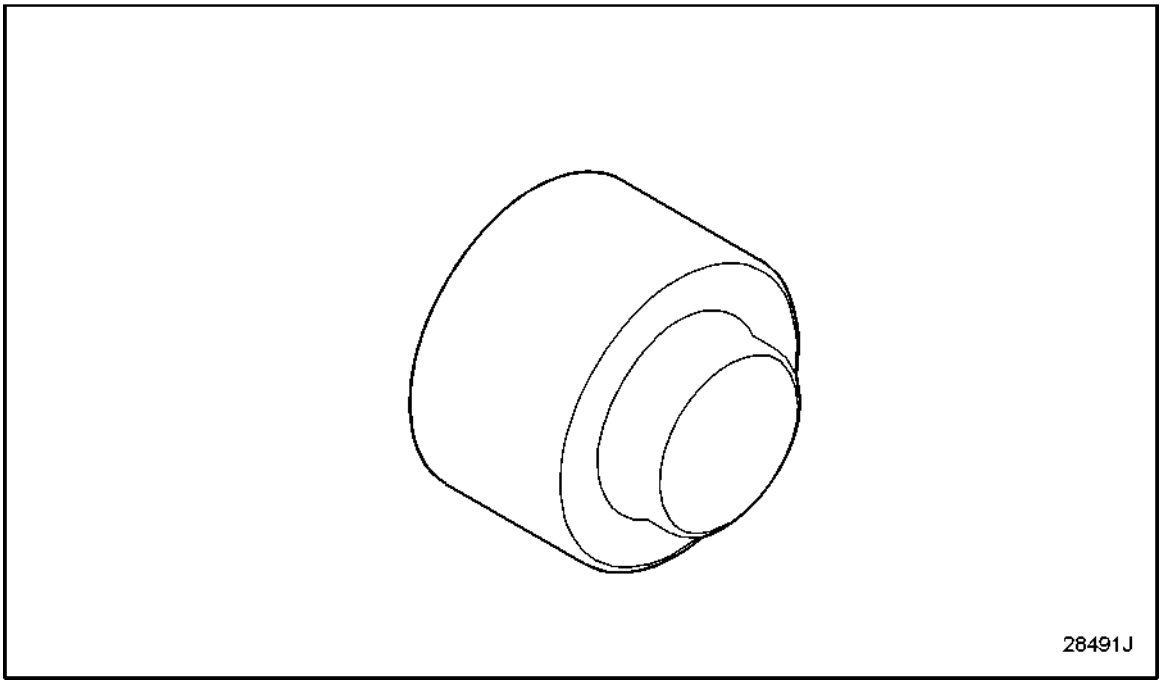

Figure 1840 Piston Pin Retainer Installer,J 24274–B

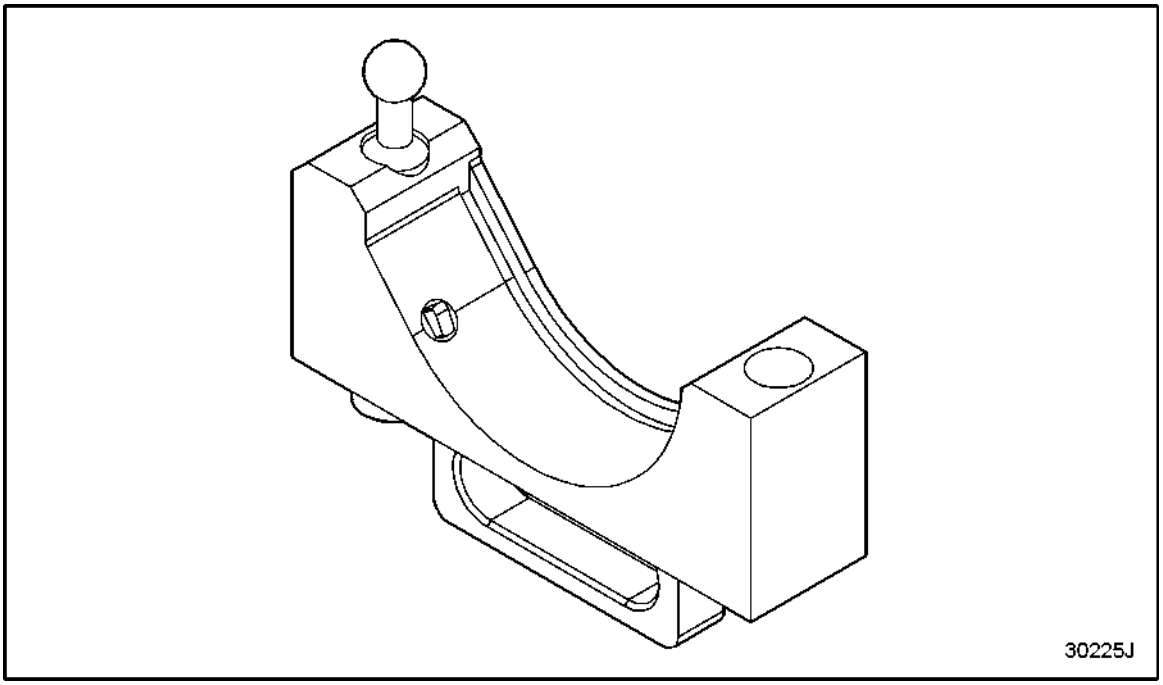

Figure 1841 Rod Bearing Adjusting Tool,J 42726

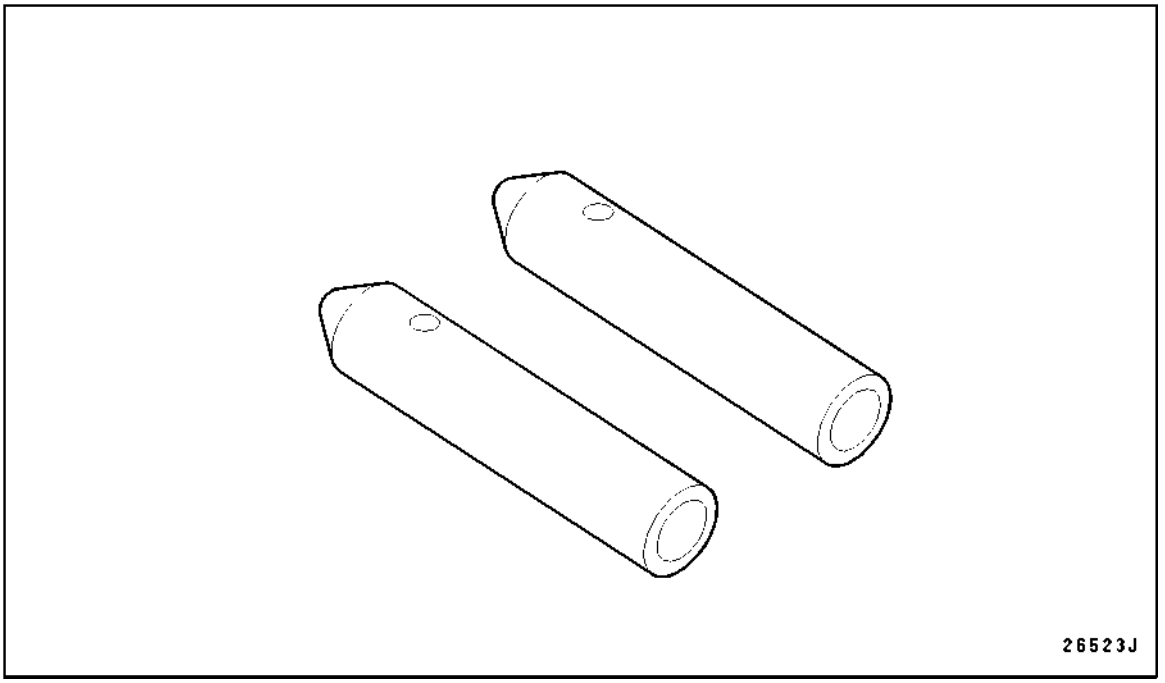

Figure 1842 Connecting Rod Guide Caps,J 41969

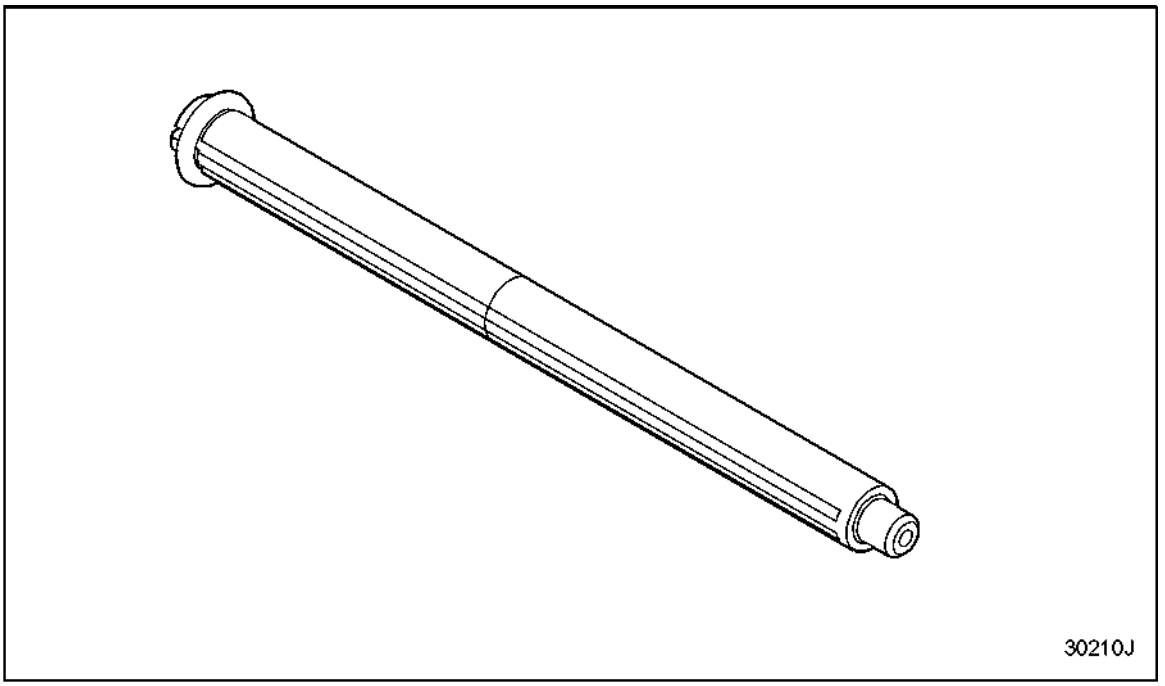

Figure 1843 Cam Follower remover/Installer,J 42258

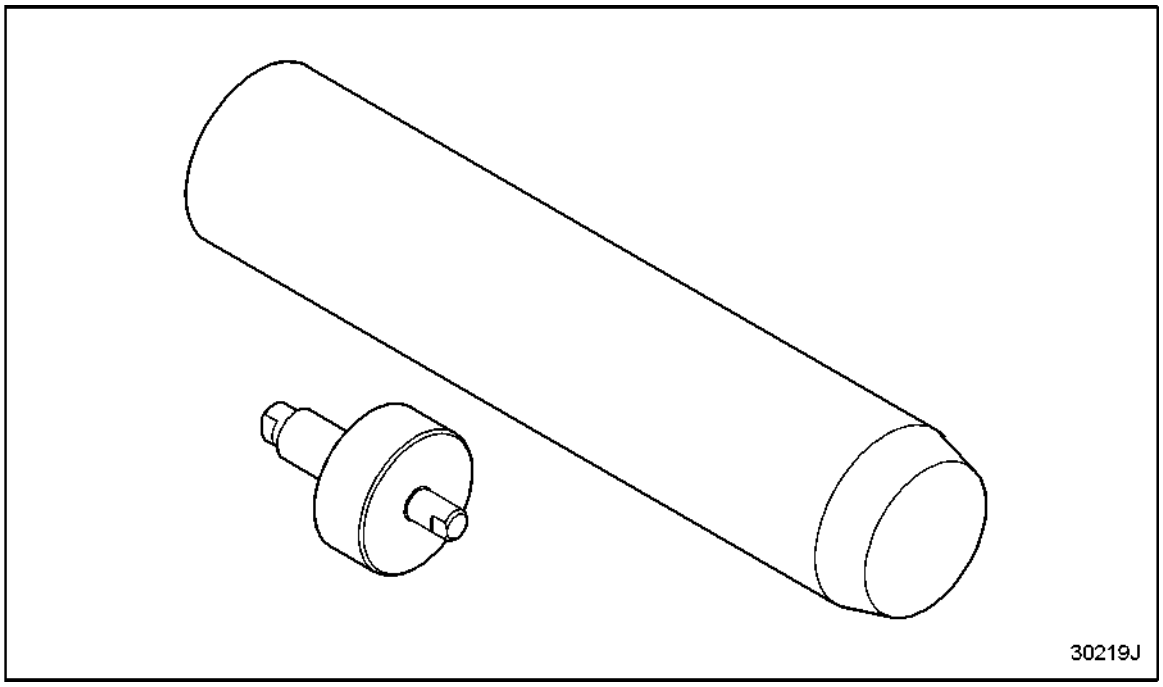

Figure 1844 Camshaft Pilot,J 42264

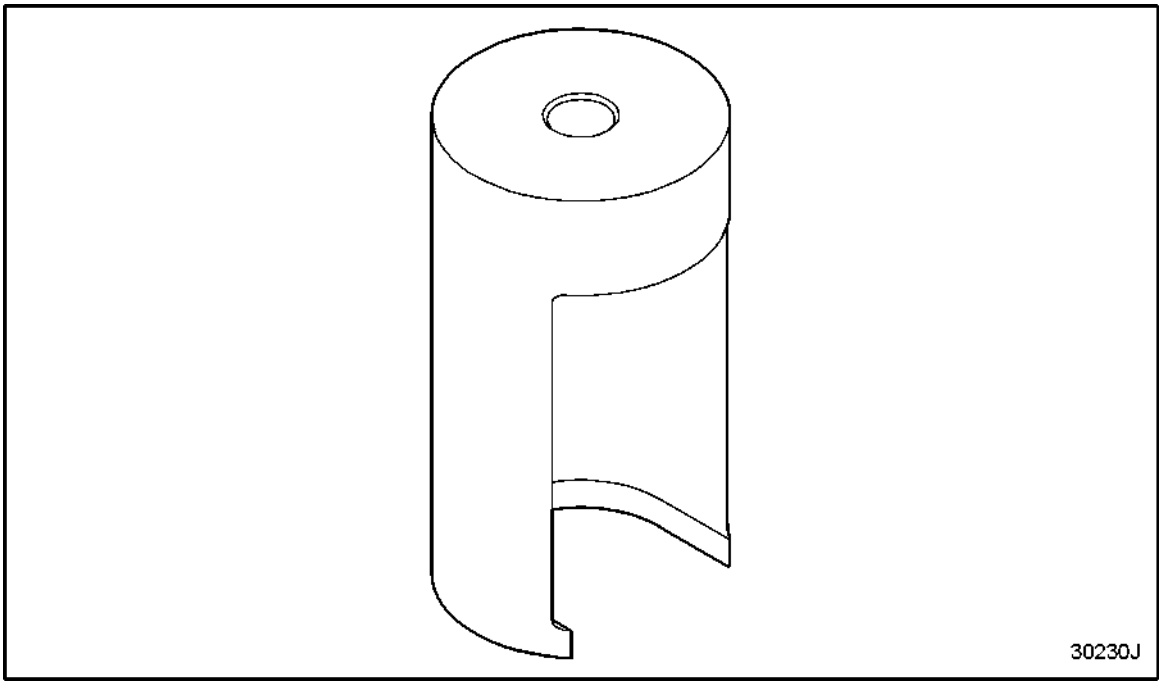

Figure 1845 Fuel Injector Puller,J 42732

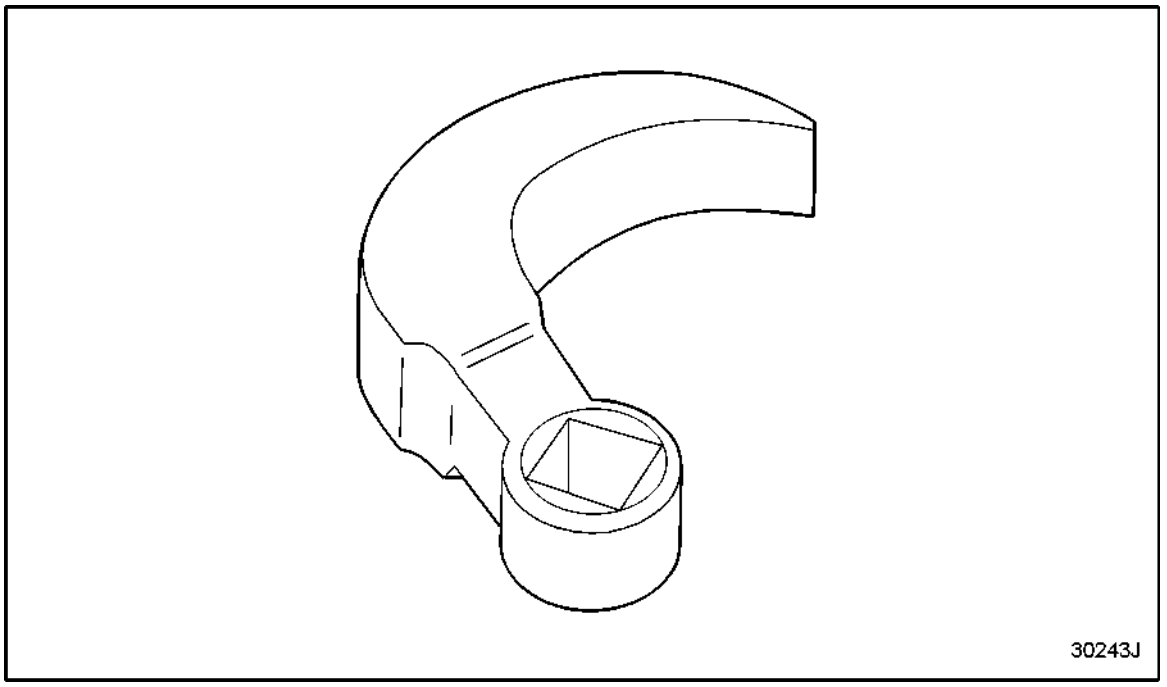

Figure 1846 Fuel Injector Remover Tool,J 42946

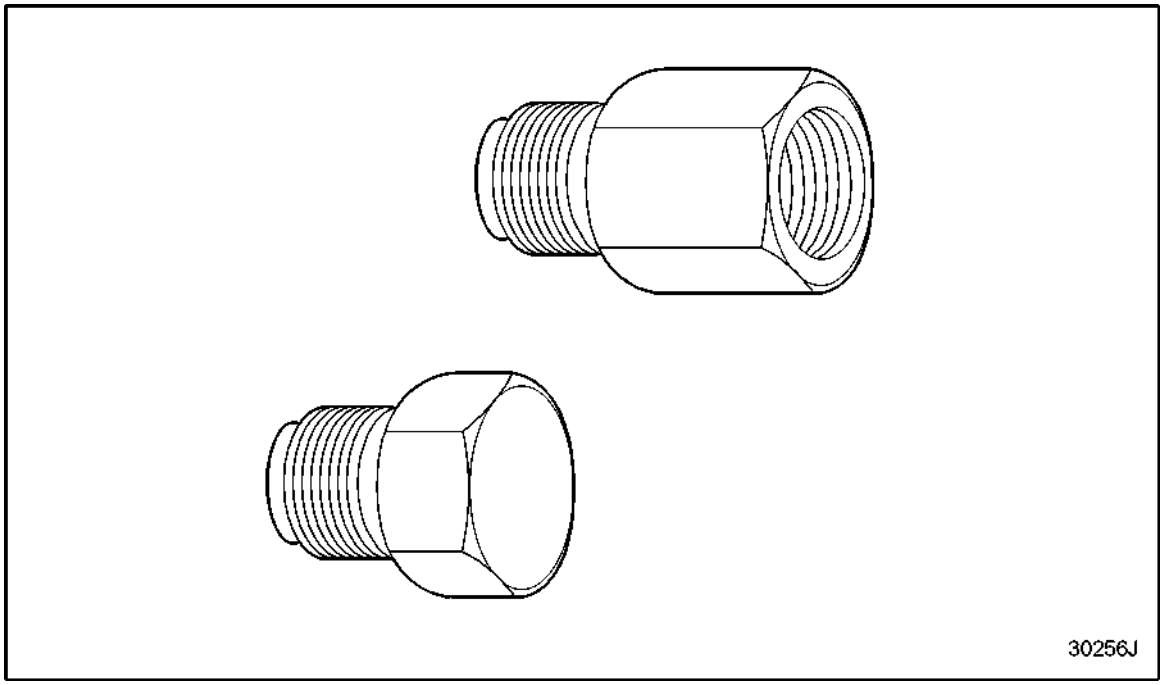

Figure 1847 ICP Breakout T Harness,J 43101

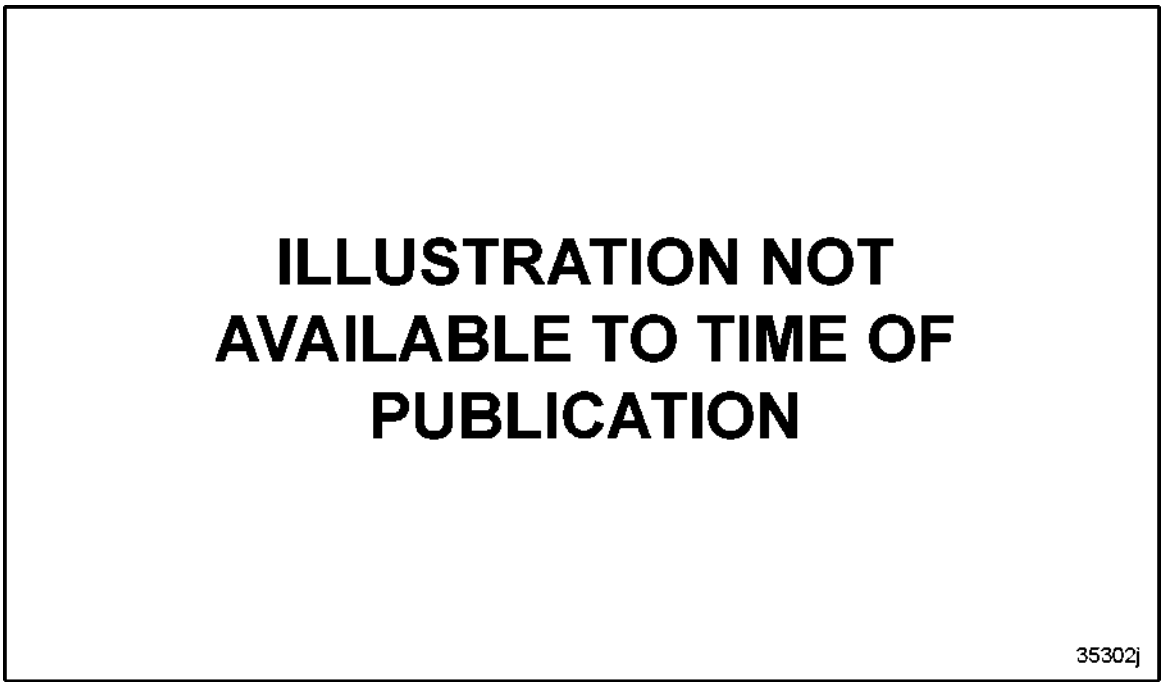

Figure 1848 Injector Remover/Replacer,J 42512

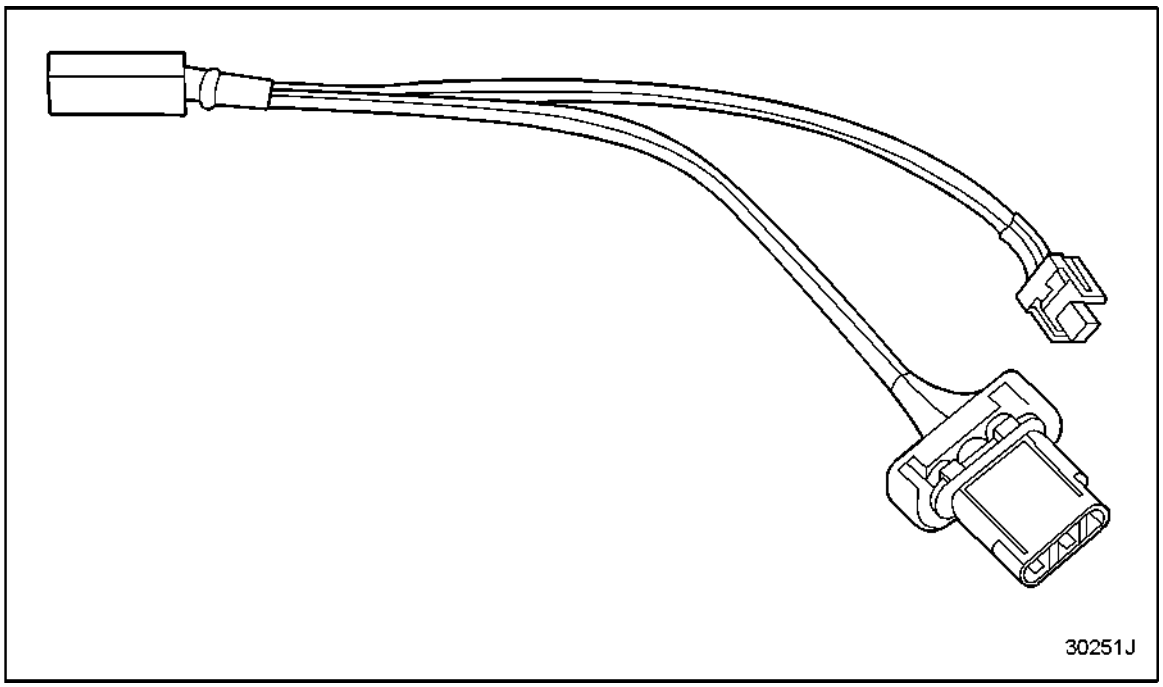

Figure 1849 Injector Test Harness,J 43098

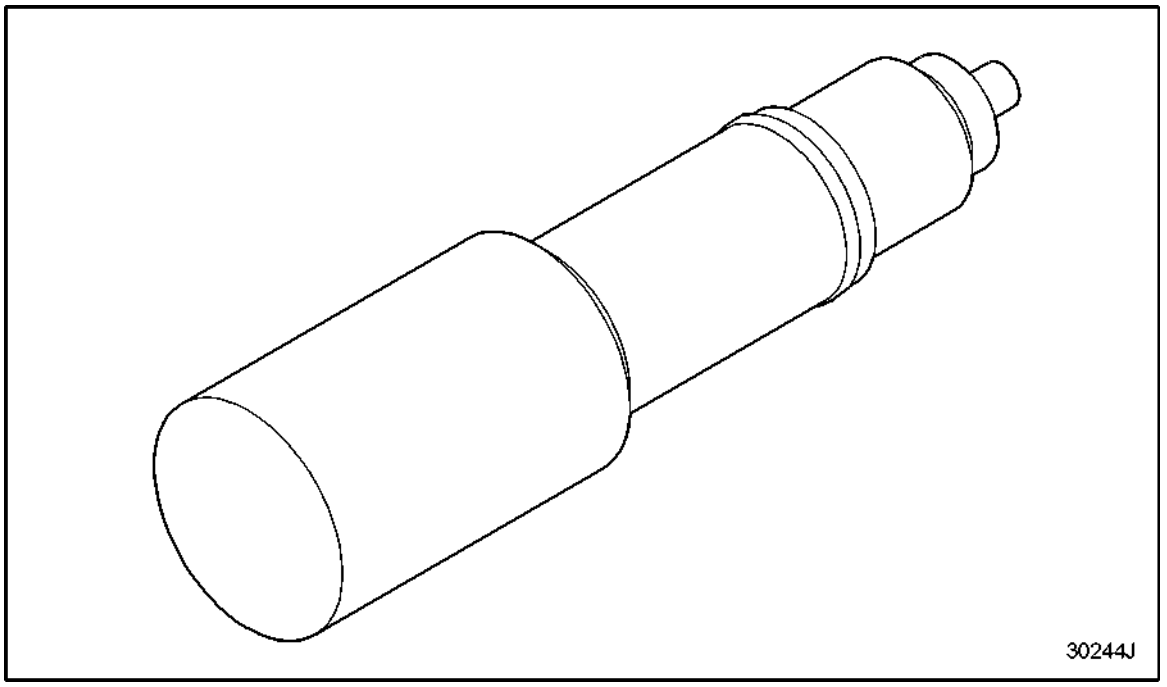

Figure 1850 Fuel Injector Sleeve Installer,J 42947

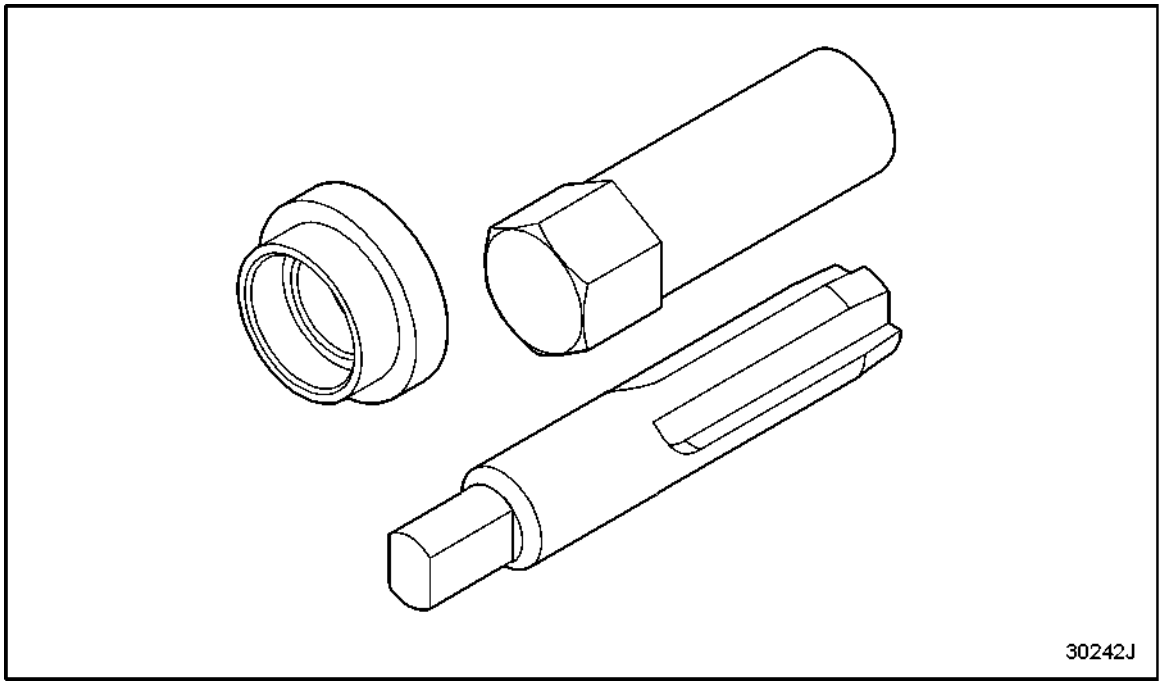

Figure 1851 Fuel Injector Sleeve Remover,J 42945

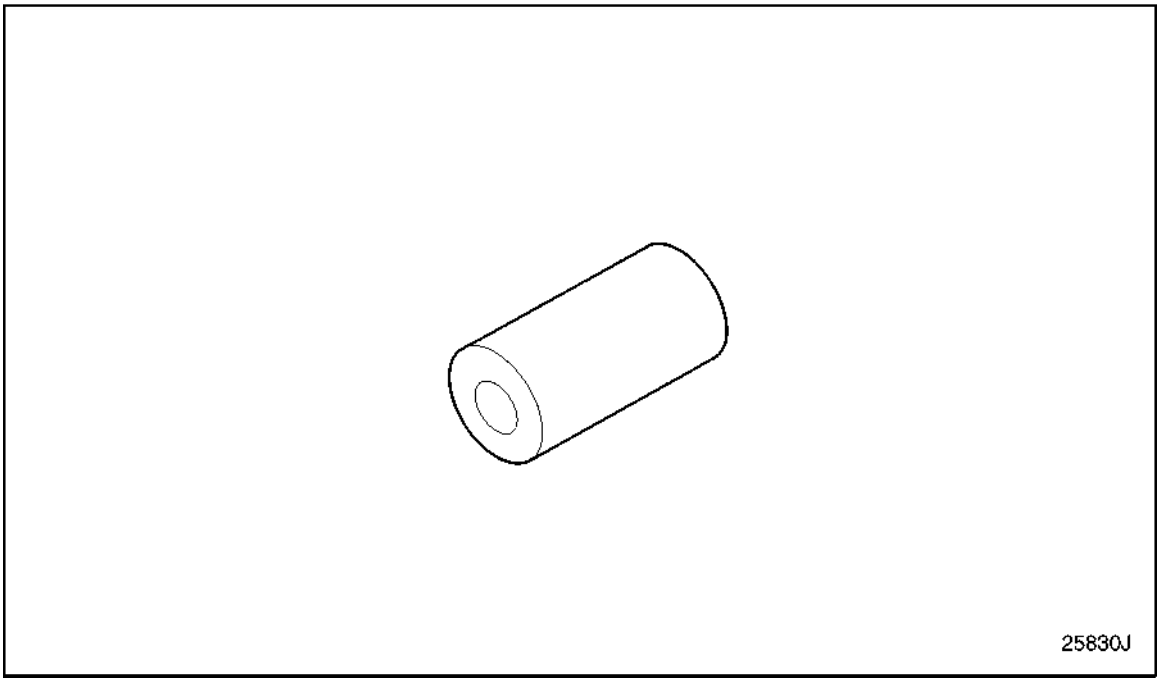

Figure 1852 Fuel Pump Drive Bearing Inst/Remv,J 41795

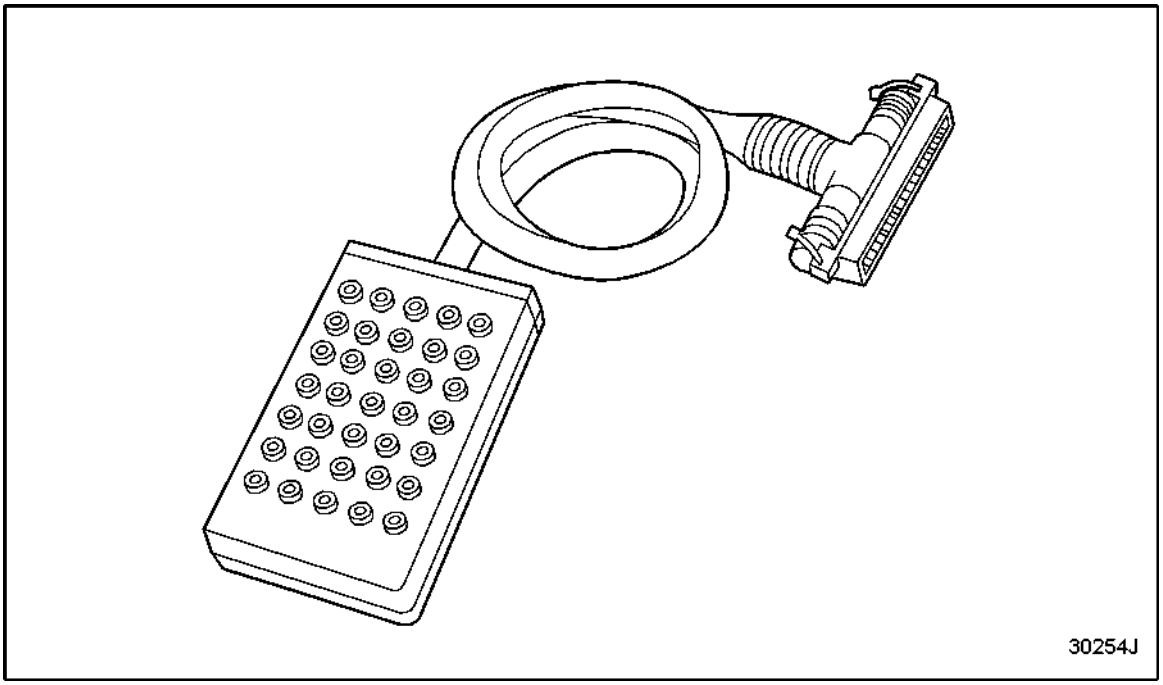

Figure 1853 CEC Breakout Box,J 43102

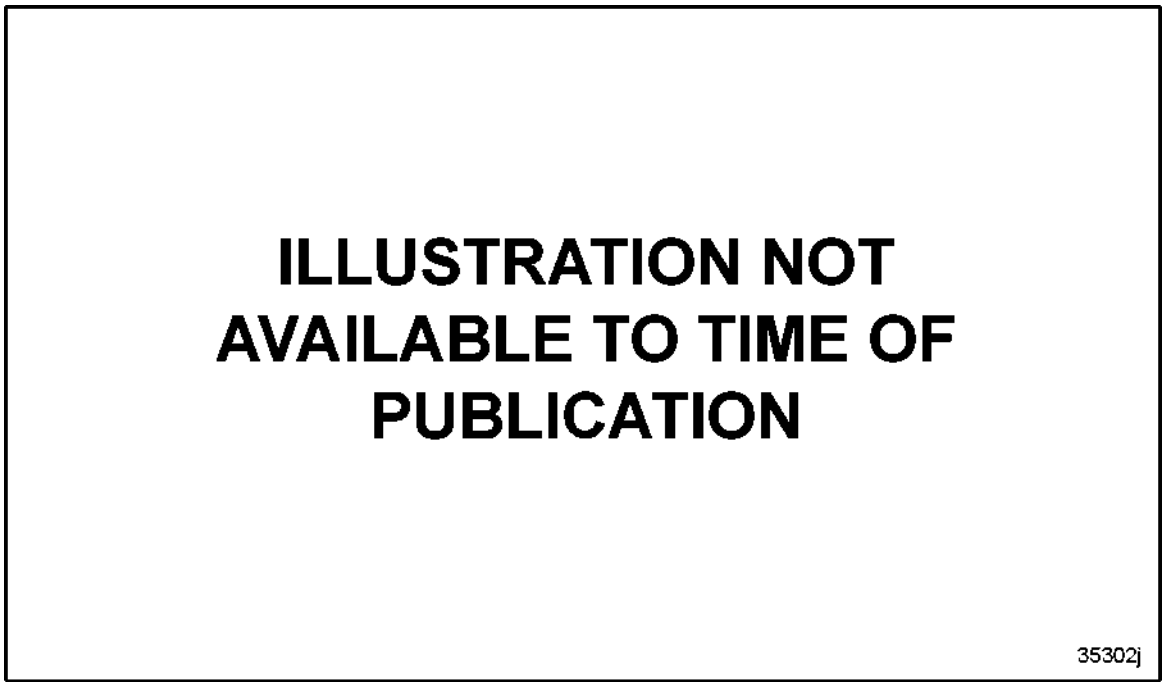

Figure 1854 **DDC DDEC III & IV PC Card,**J 38500–2300

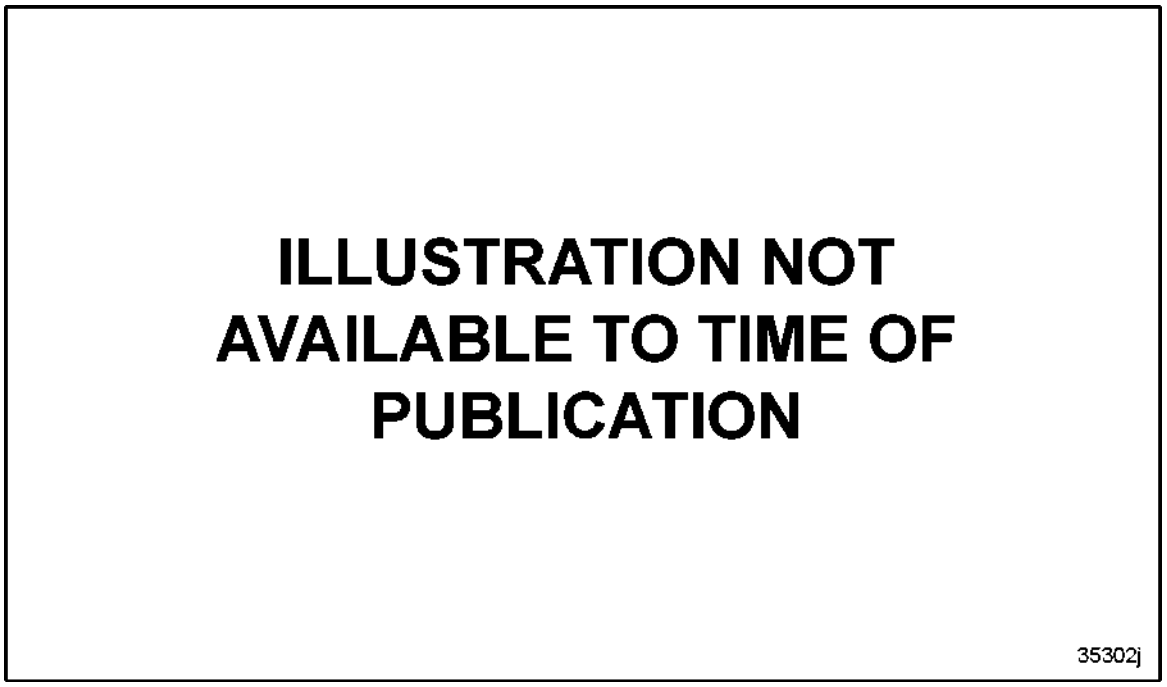

Figure 1855 **DDEC Diagnostic Kit,**J 35887–1

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Figure 1856 DDEC Marine Prolink Kit Vers 1.3,J 39110–A

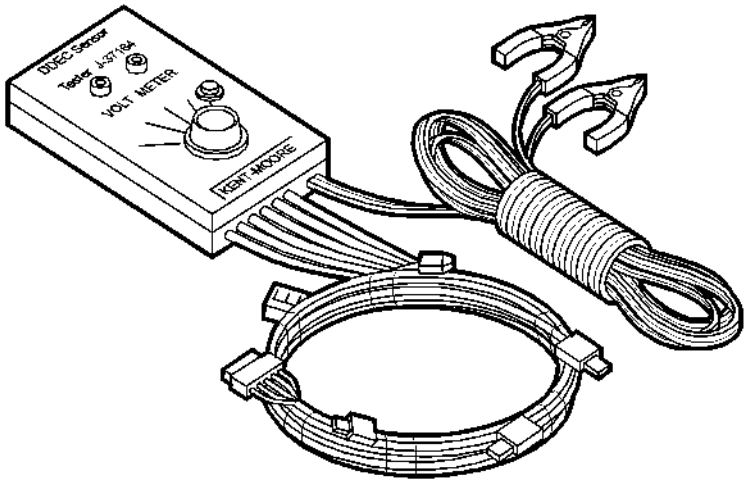

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Figure 1857 DDEC Sensor Tester,J 37164–B

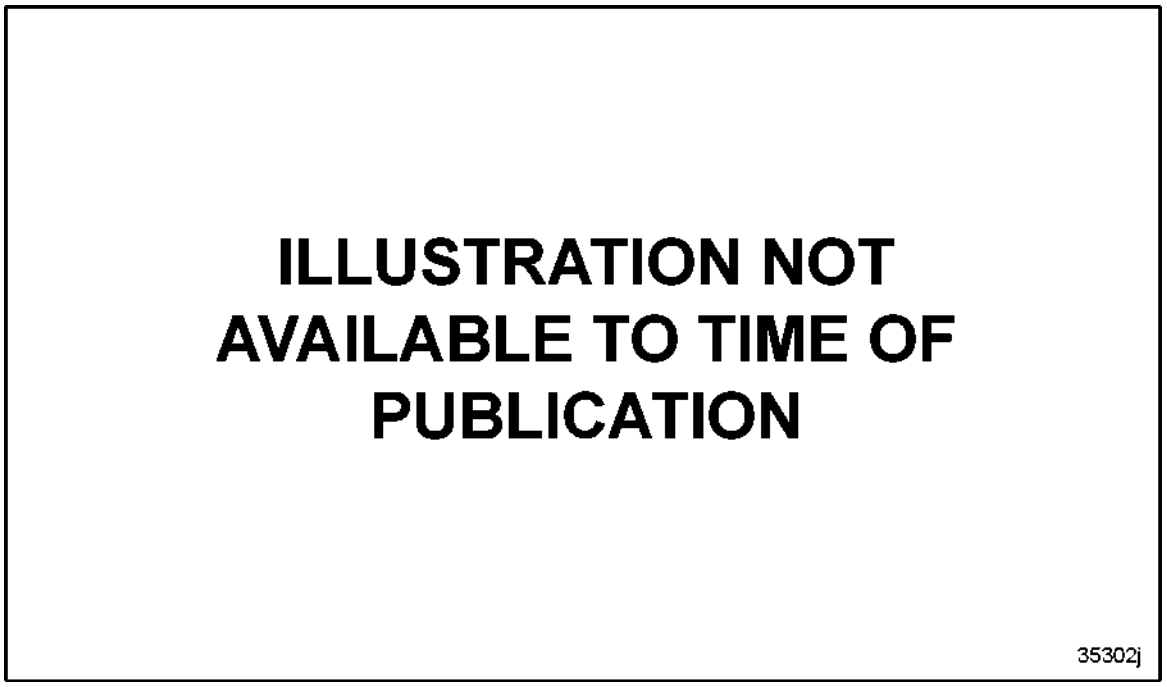

Figure 1858 Fluke 87 Digital Multimeter Kit ,J 39200

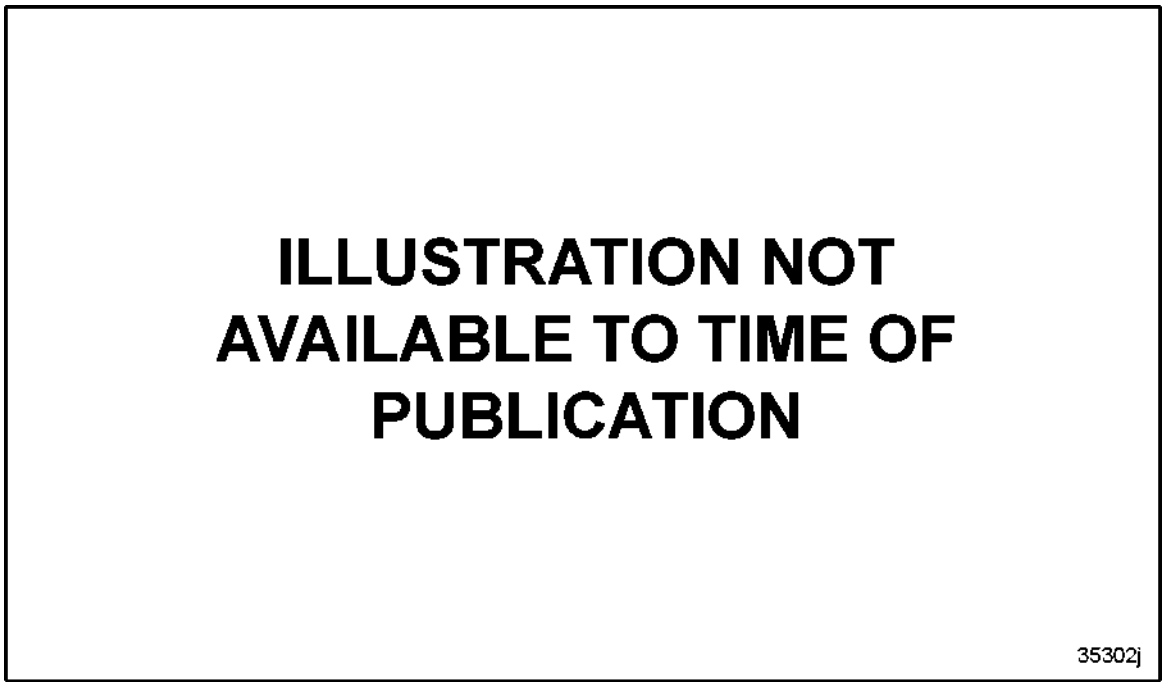

Figure 1859 Multi Protocol Cartridge V1.70/1.72,J 38500–1500

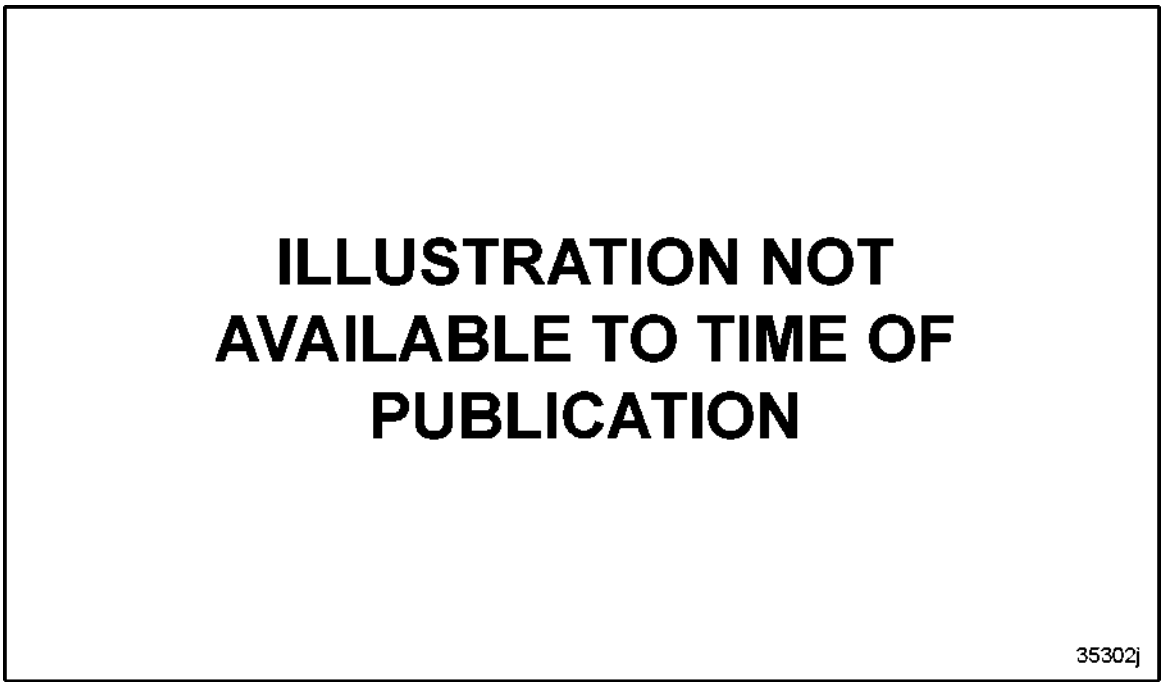

Figure 1860 Pro Link Diagnostic Reader,J 38500–1DD

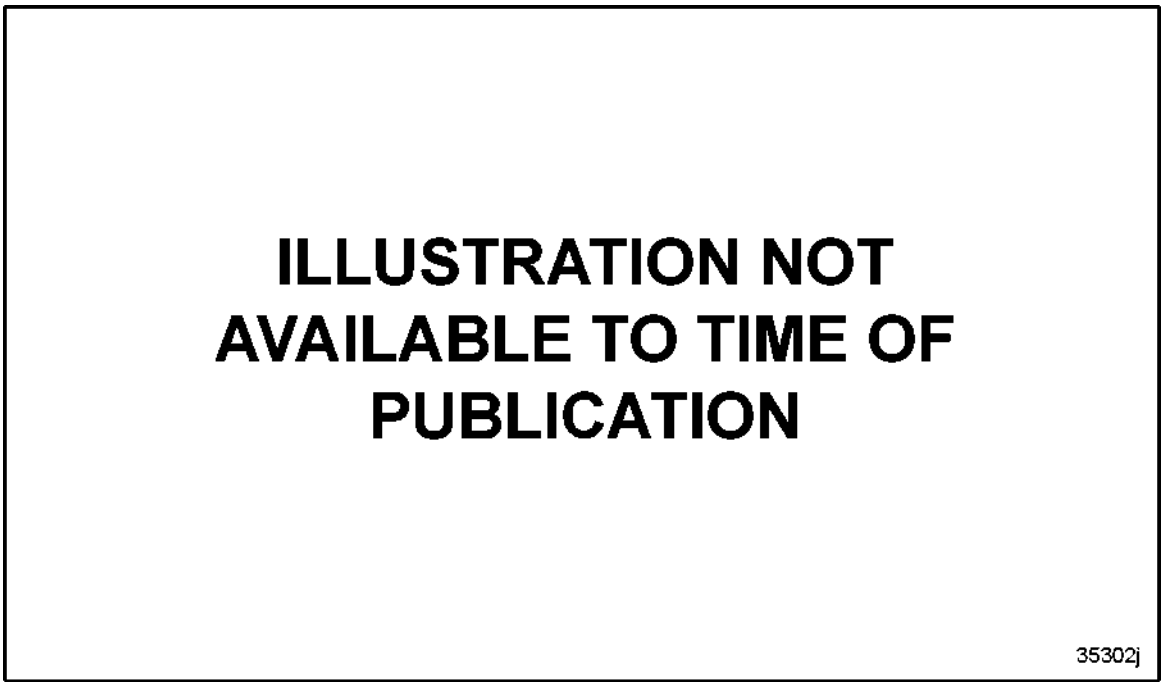

Figure 1861 Prolink Adapter-DDEC Marine,J 38500–155

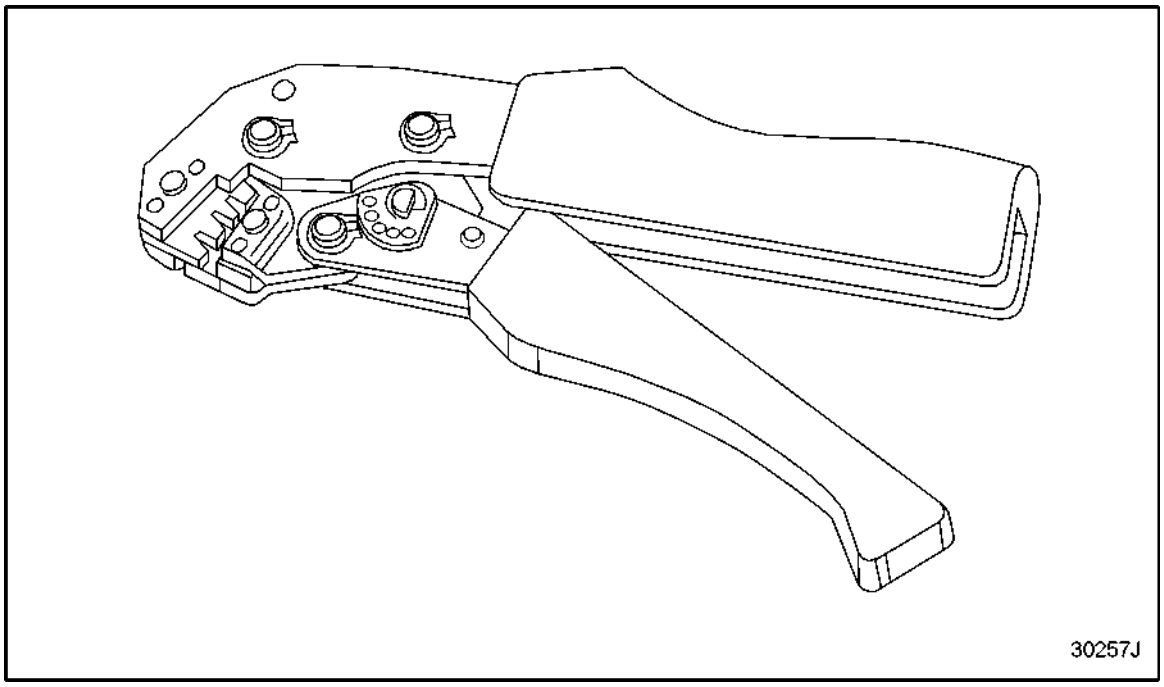

Figure 1862 Series 40E ECM Terminal Crimpers, J 42980

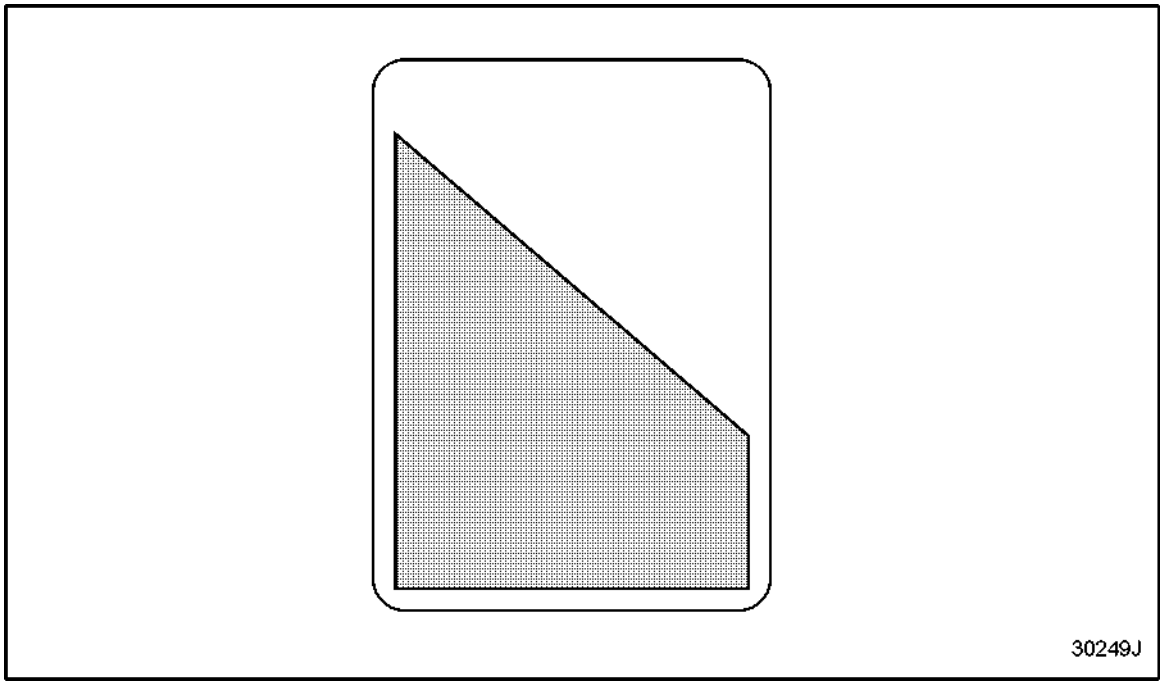

Figure 1863 Series 40E PCMCIA (Navistar), J 38500–2100

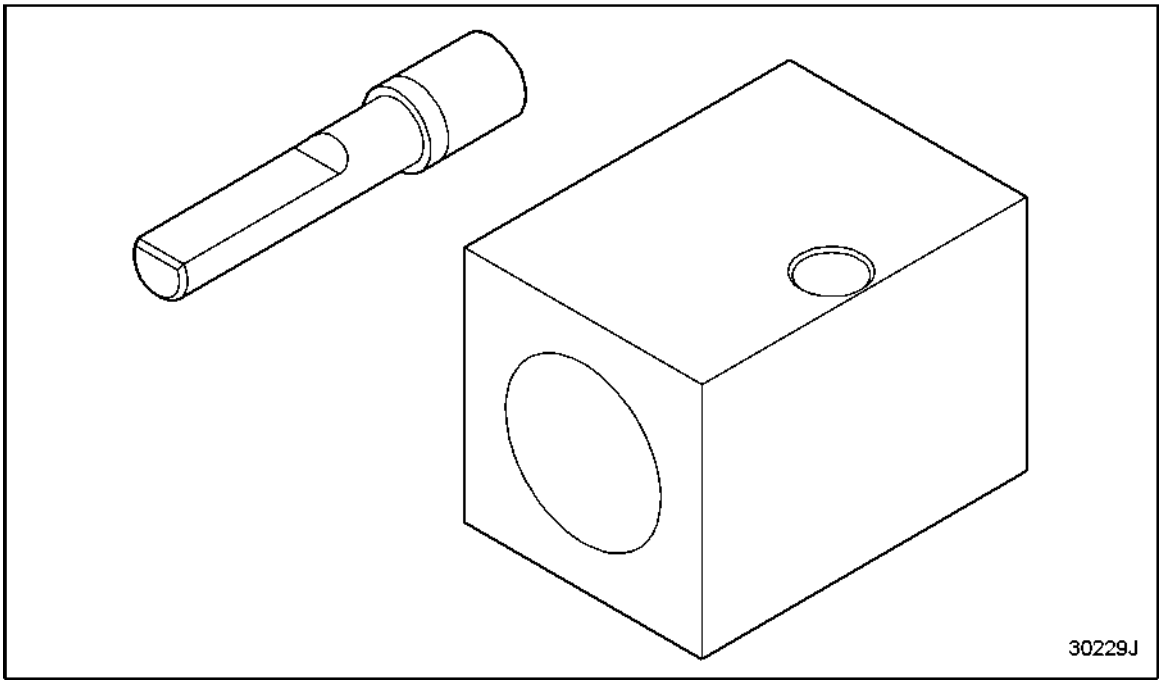

Figure 1864 Fuel Railing Engine Fixture,J 42731

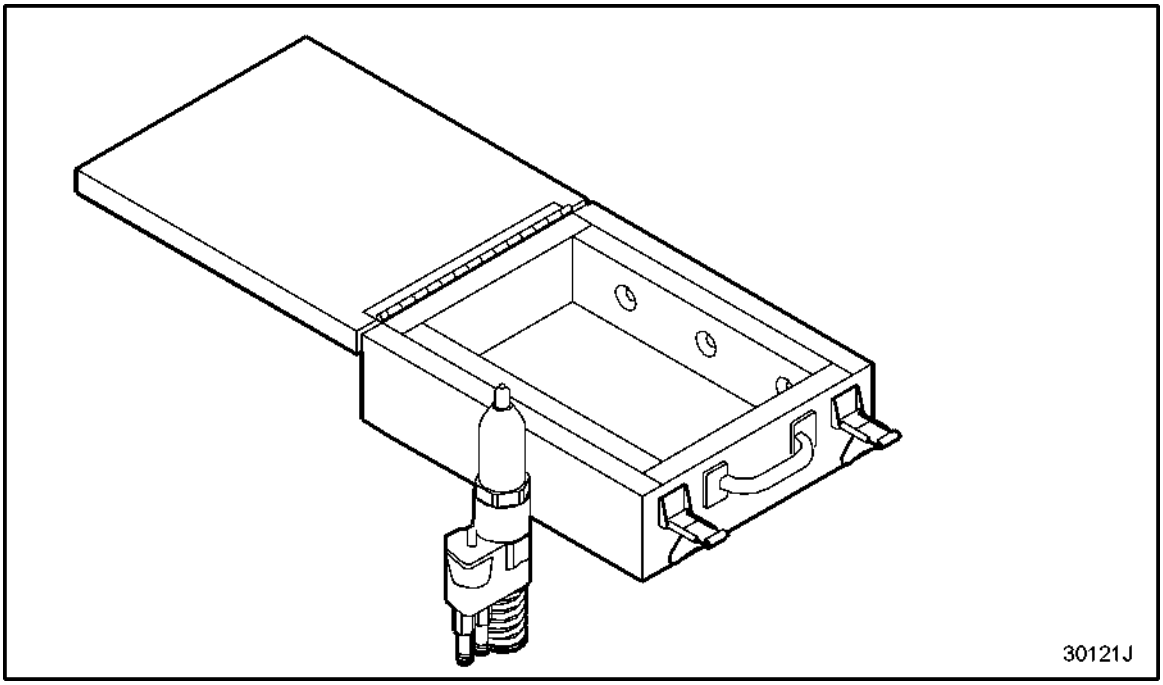

Figure 1865 Master Injector-149,J 34998

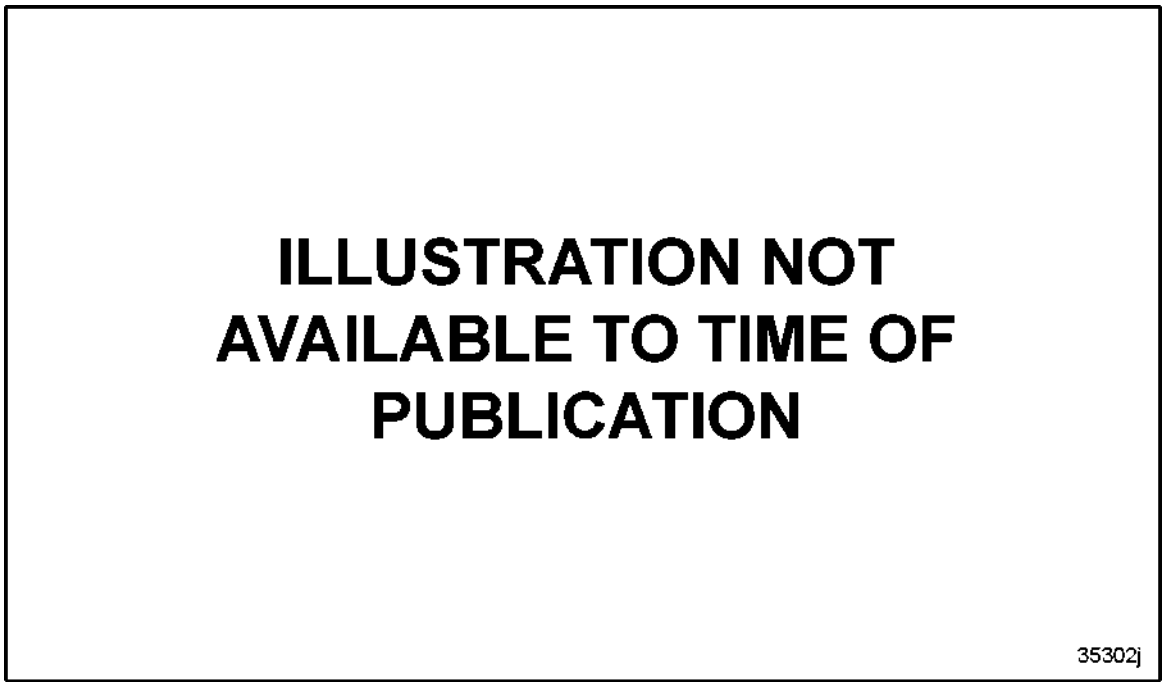

Figure 1866 **Nozzle Adapt Kit,**J 29097

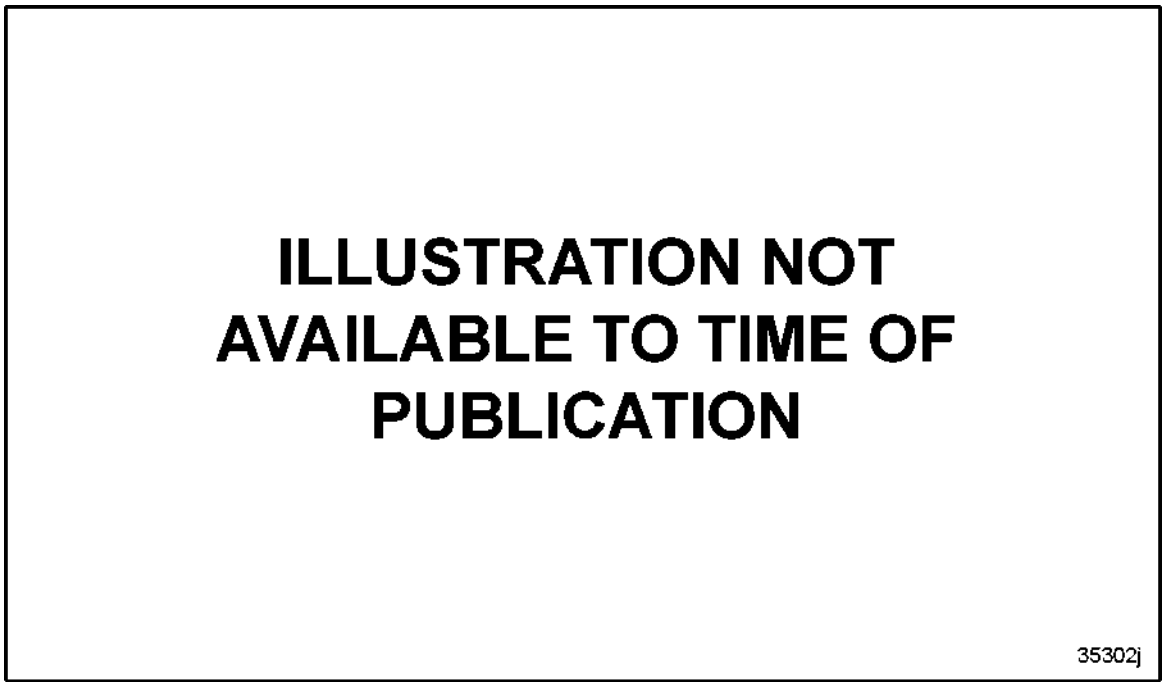

Figure 1867 **Nozzle Tester,**J 29075

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Figure 1868 Ultrasonic Nozzle Cleaner,J 29653

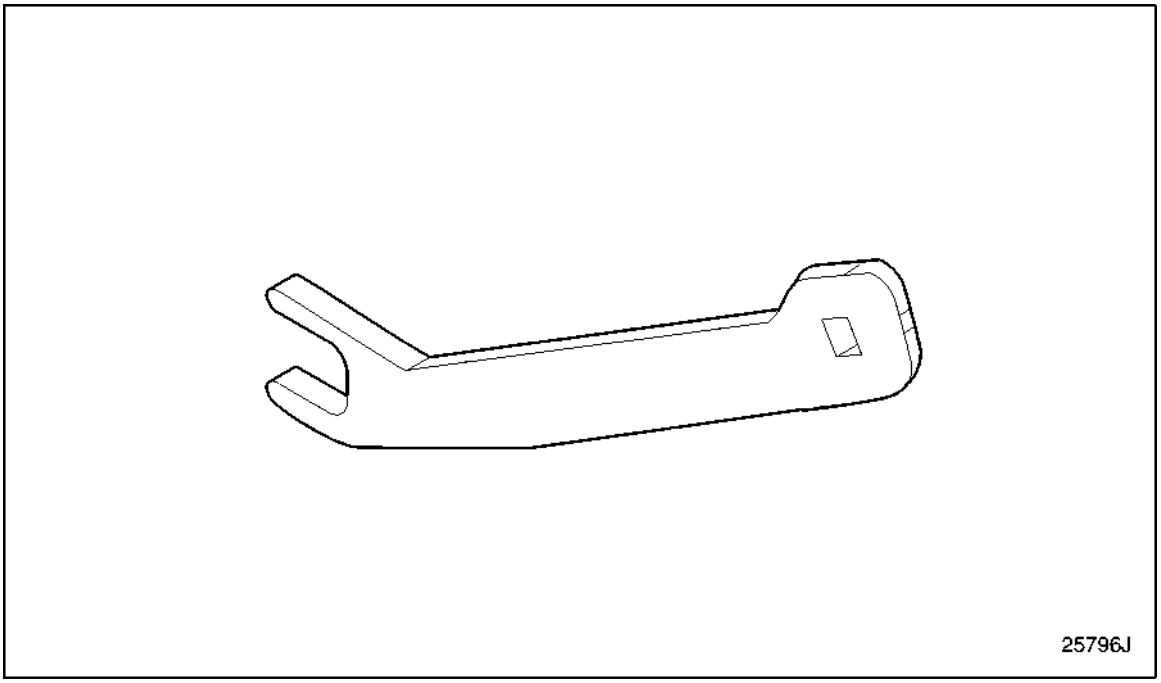

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Figure 1869 Fuel Line Nut Wrench-External,J 41994

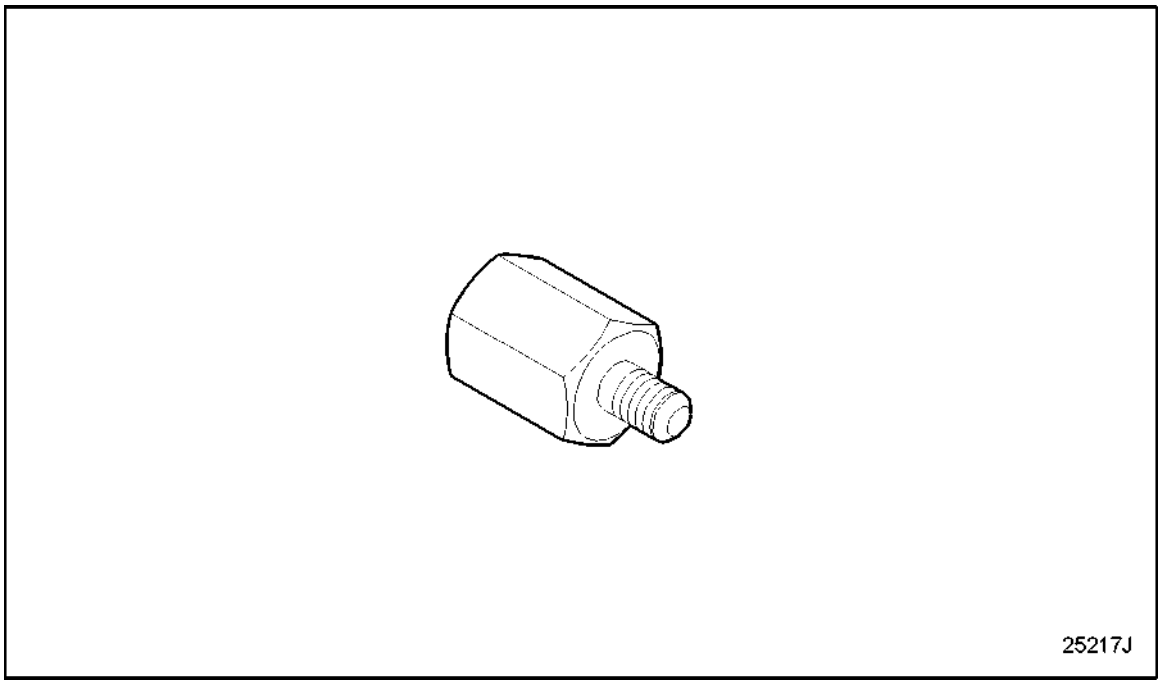

Figure 1870 Nozzle Puller Adapter J 41570

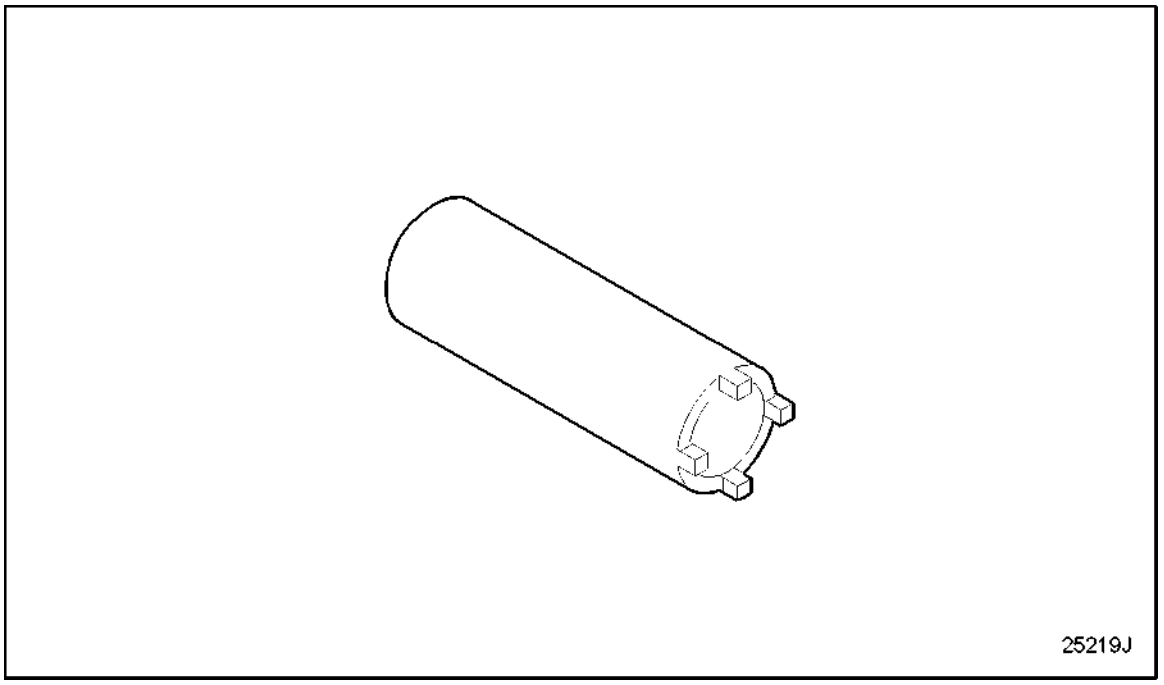

Figure 1871 Nozzle Tube Socket J 41575

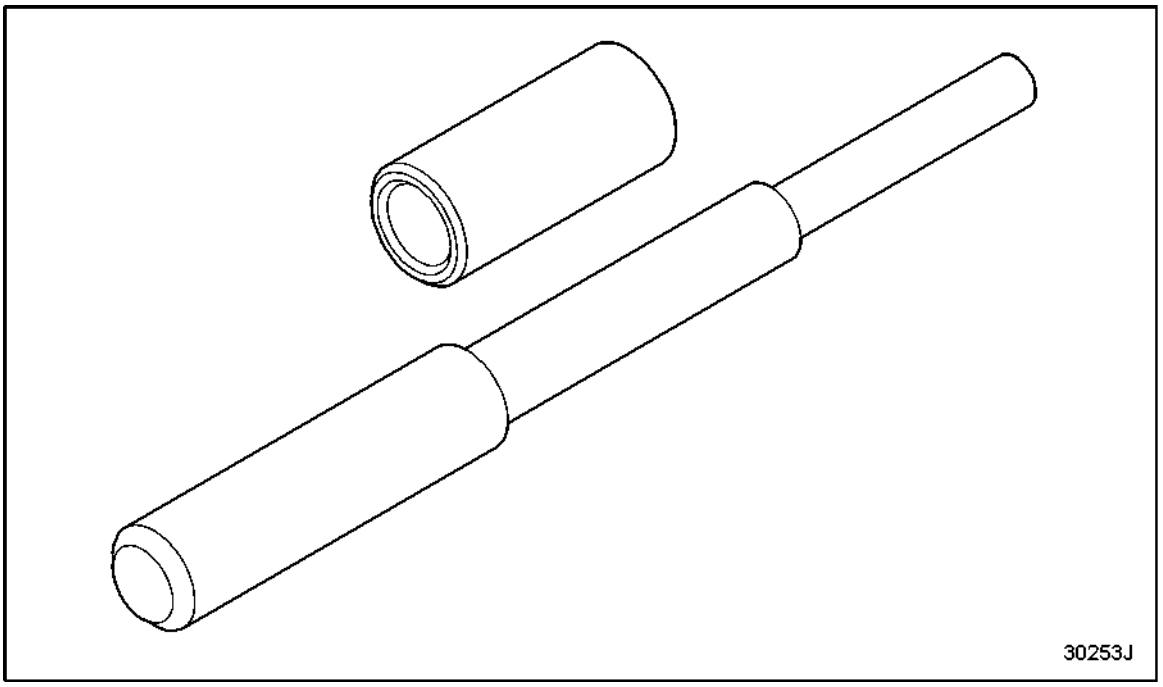

Figure 1872 Valve Guide Installer J 43100

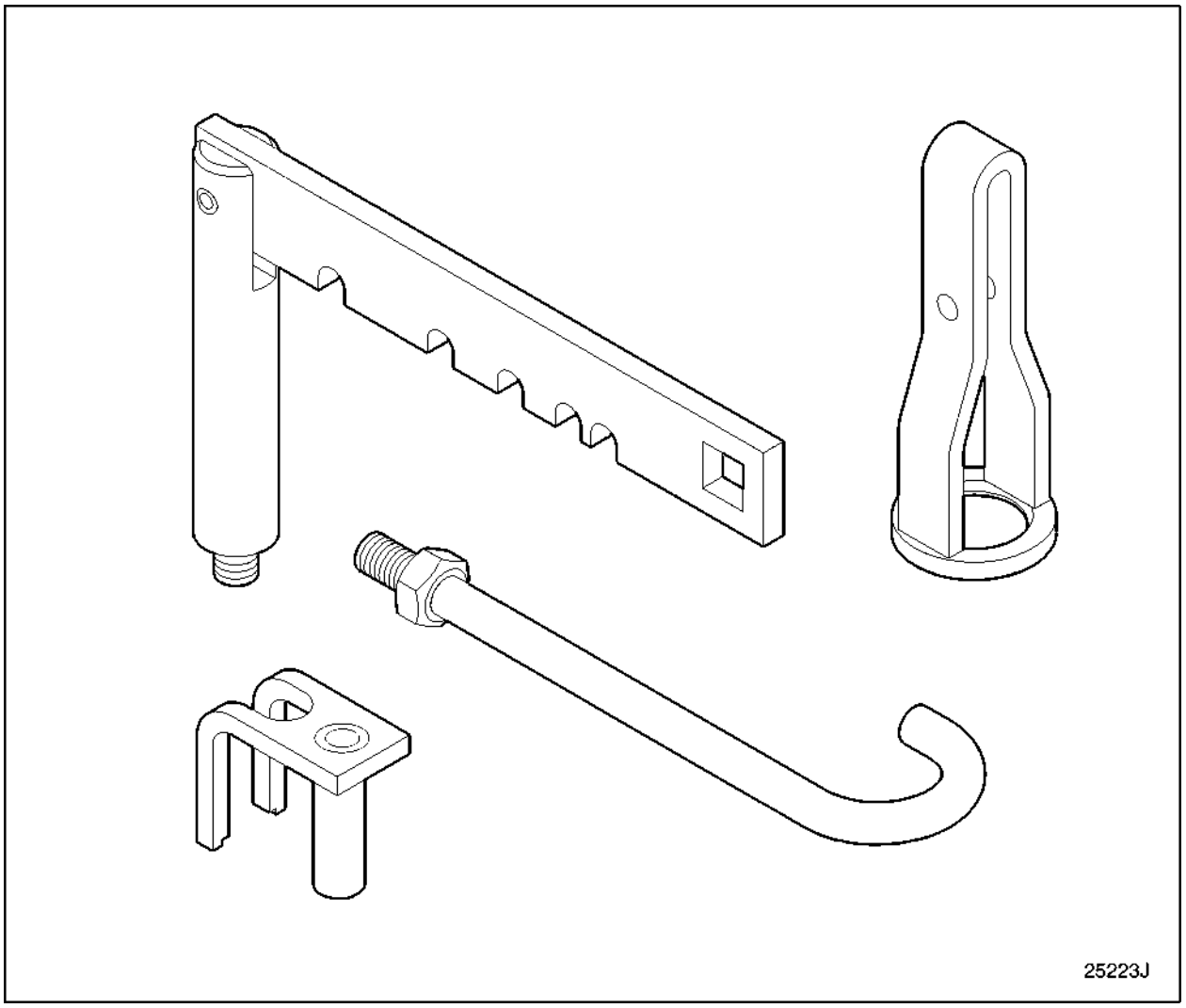

Figure 1873 Valve Spring Compressor J 41587

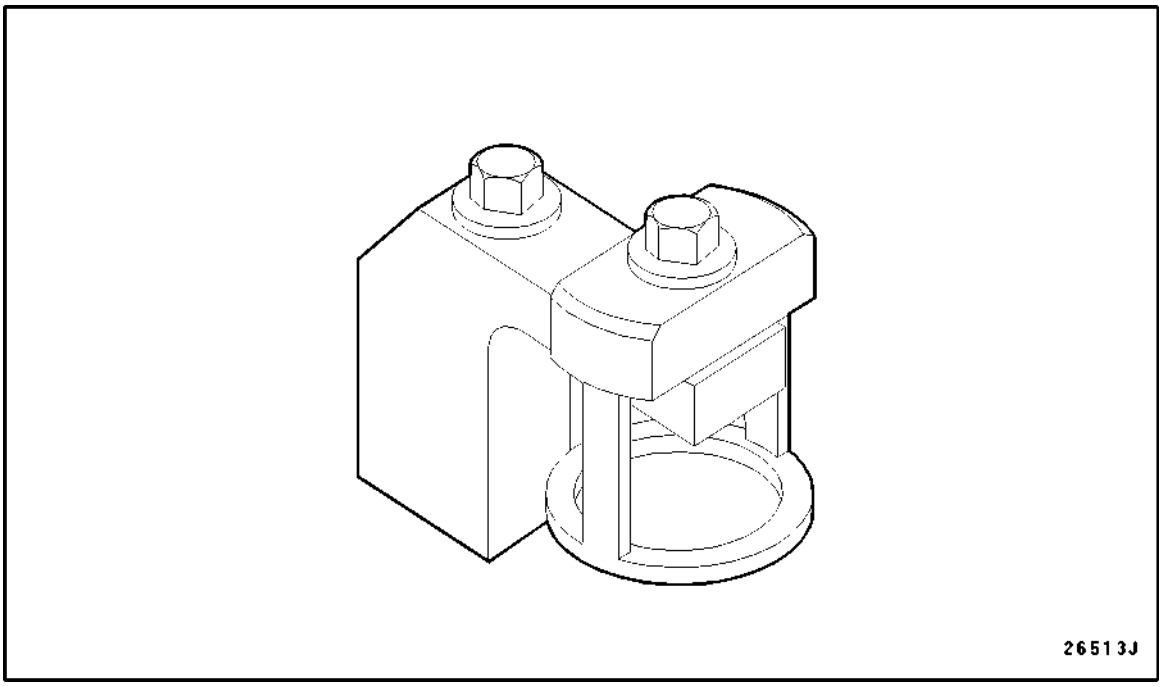

Figure 1874 Valve Spring Compressor J 41824

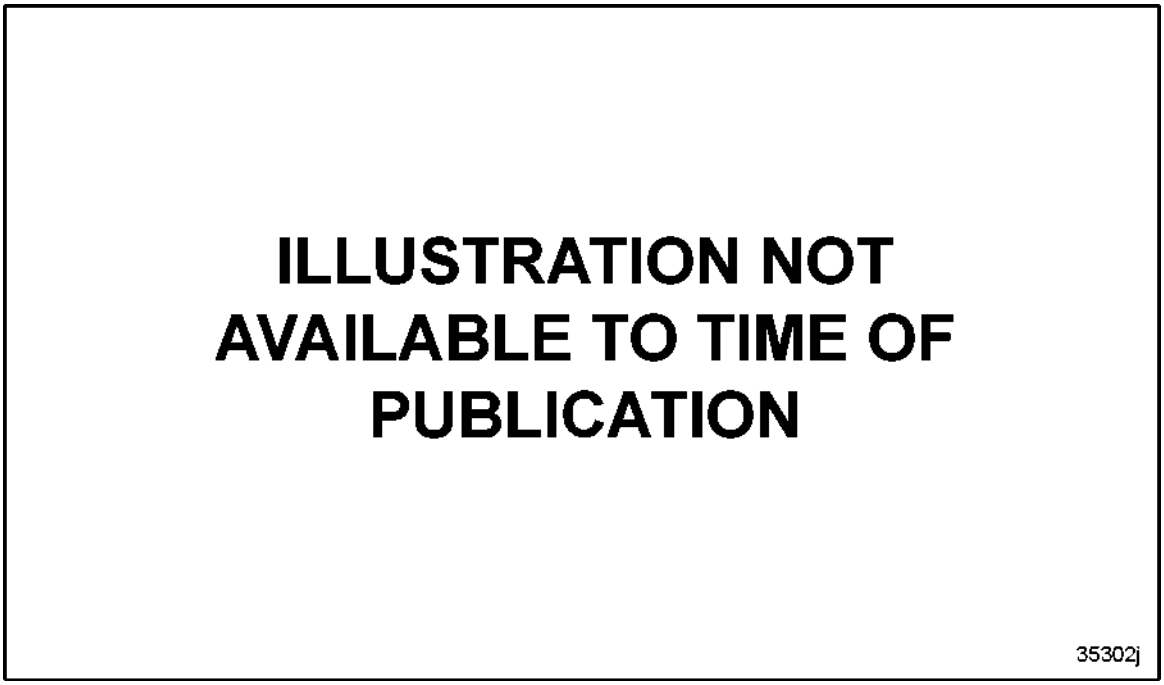

Figure 1875 Torque Wrench Adapter J 41787

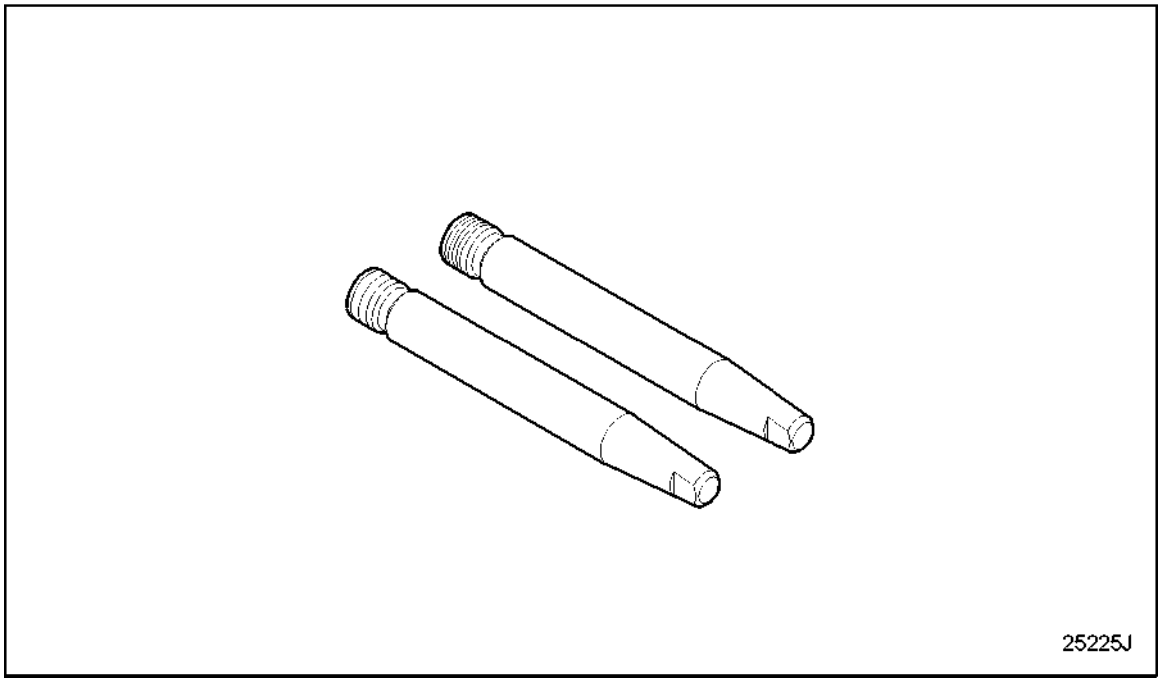

Figure 1876 Flywheel Guide Studs J 41595

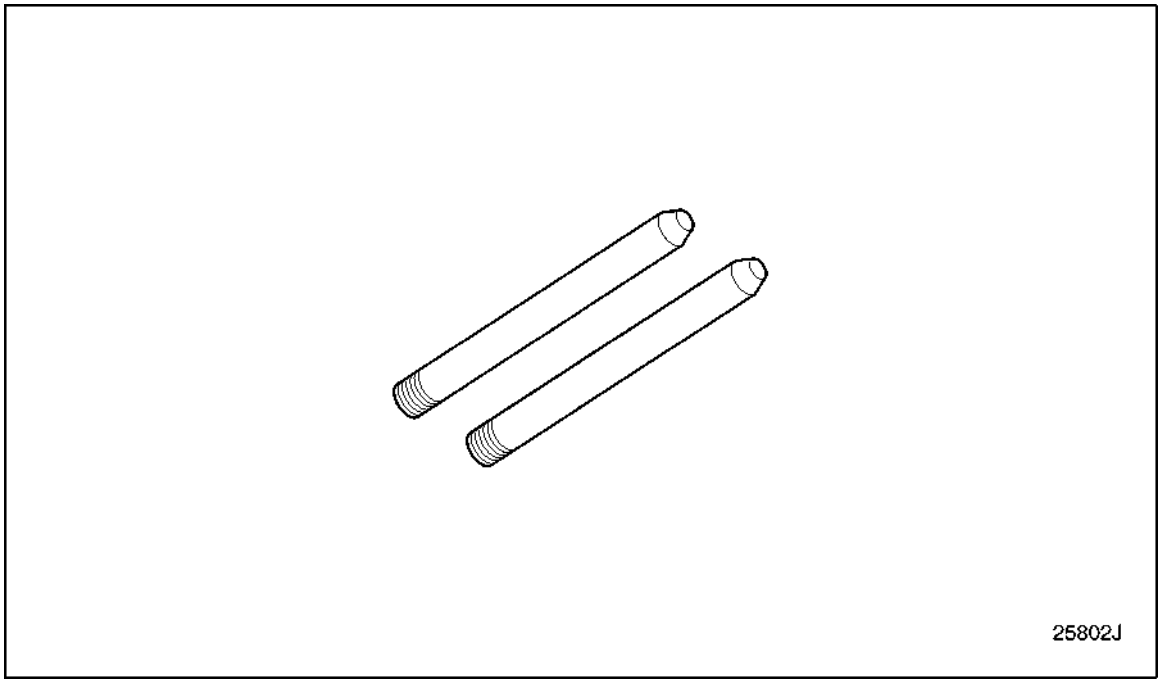

Figure 1877 Flywheel Housing Guide Studs J 34691-A

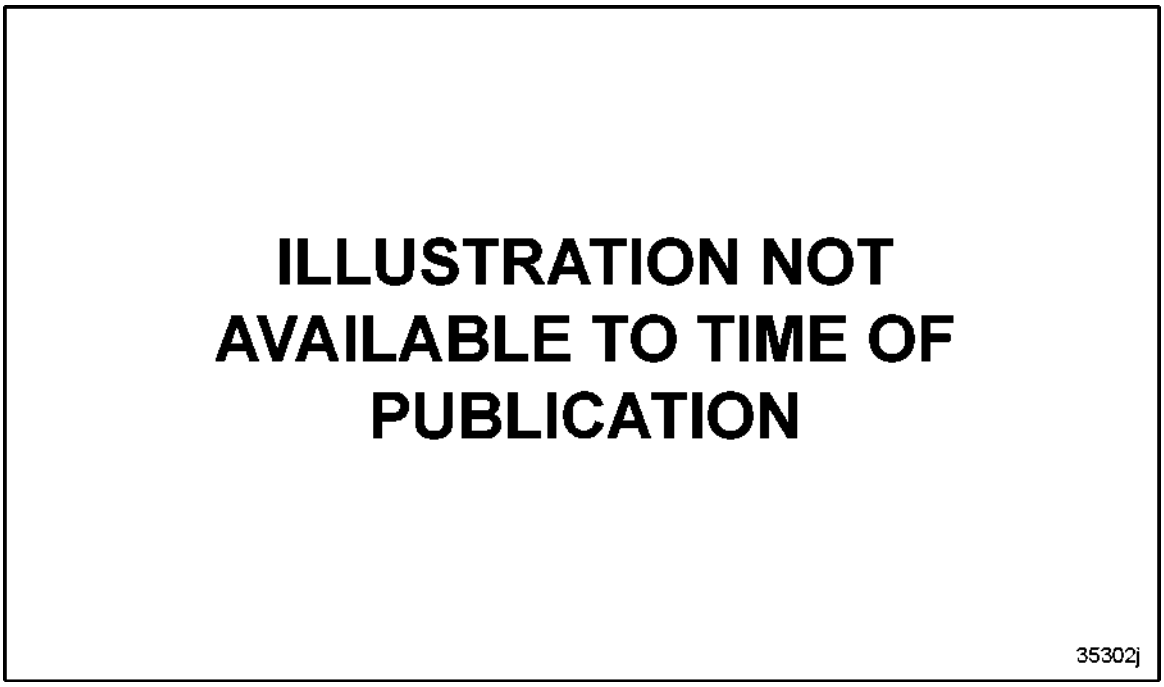

Figure 1878 EEC Variable Speed Cont (Gov.)J 36325

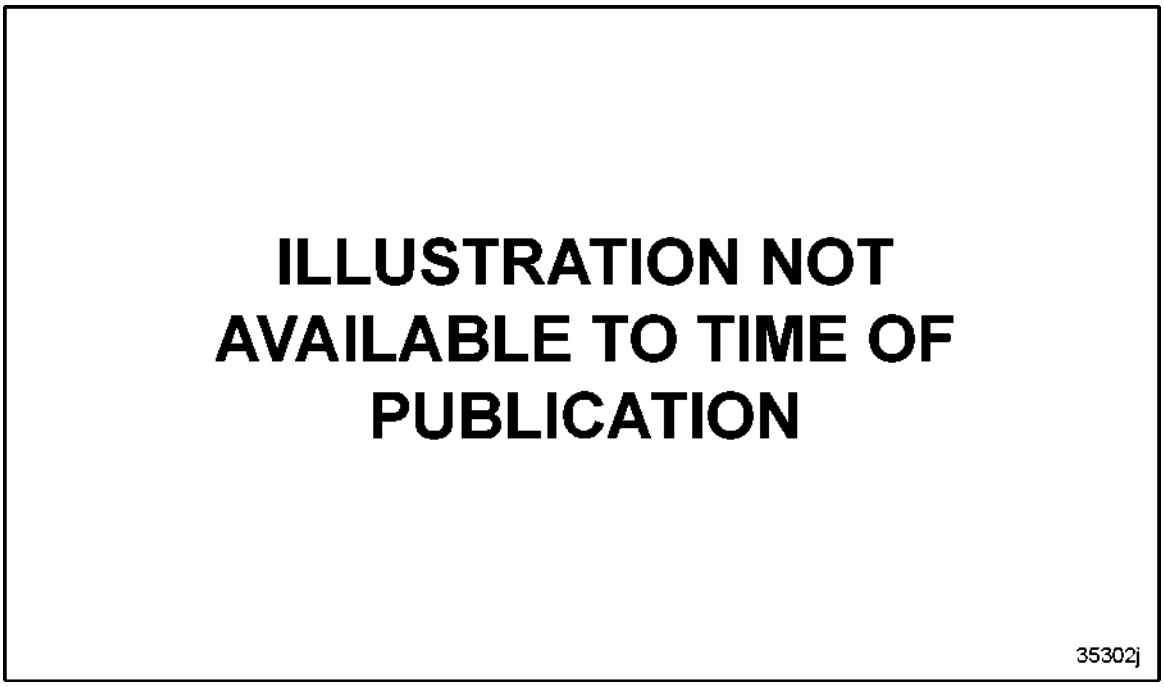

Figure 1879 Terminal CrimperJ 38706

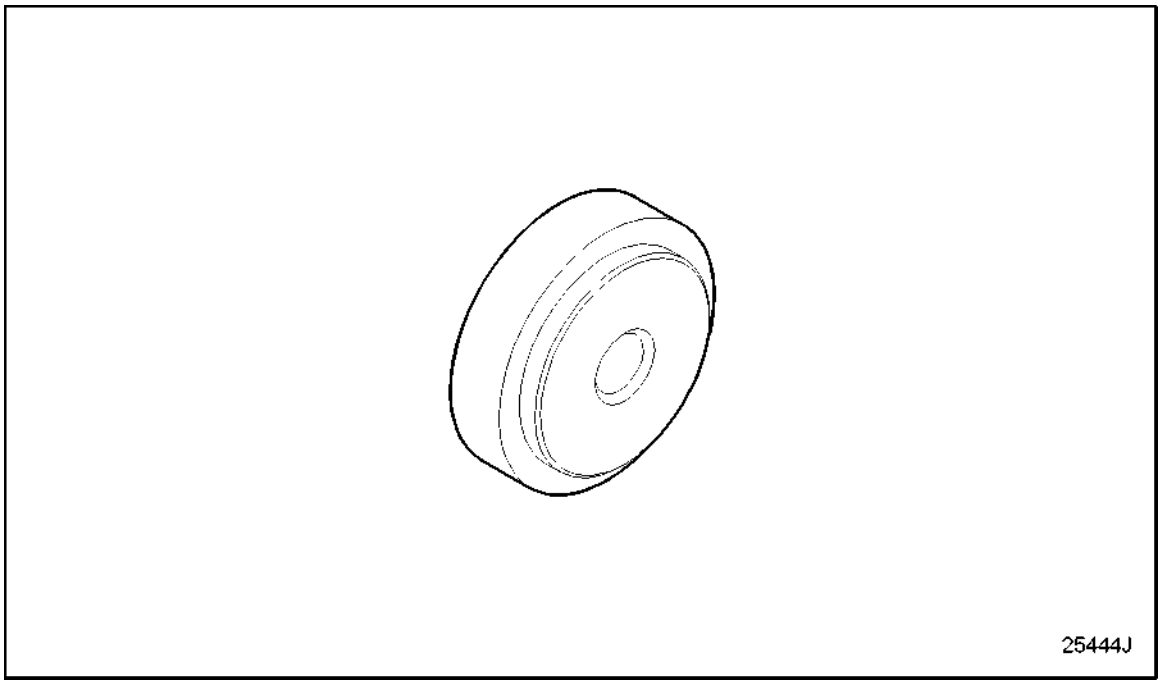

Figure 1880 Cup Plug Installer,J 41746

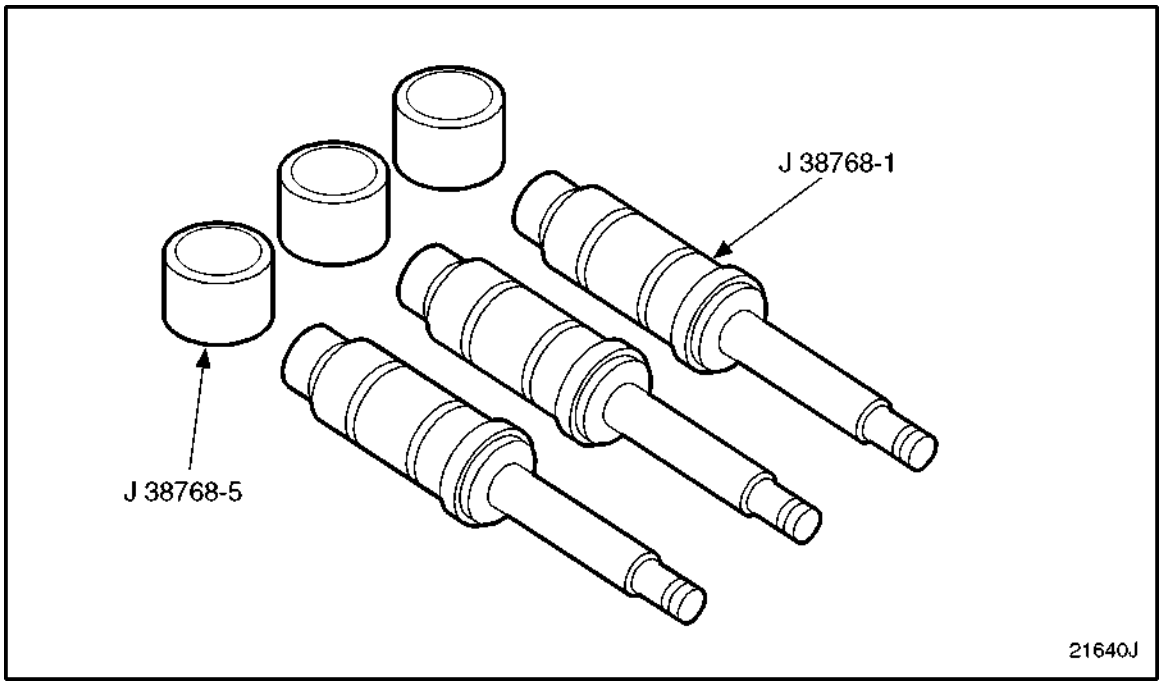

Figure 1881 Cylinder Compression Test Adaptor SetJ 38768

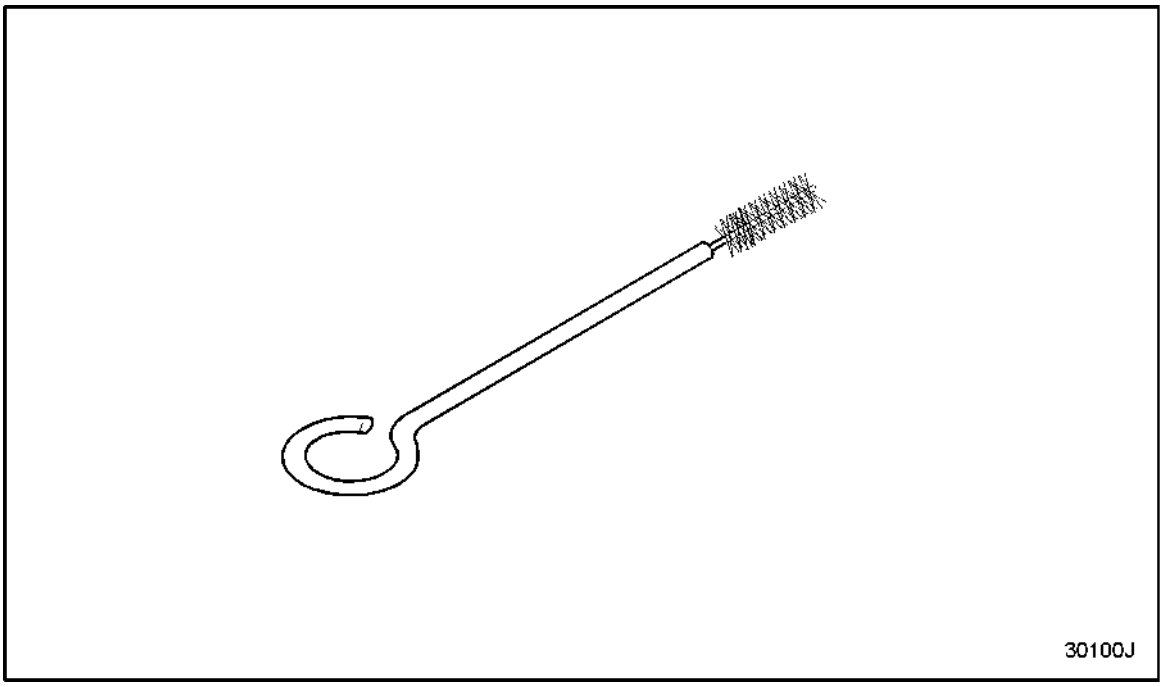

Figure 1882 Dial Bore Gage (3 3/32-8" Dia), J 5437–B

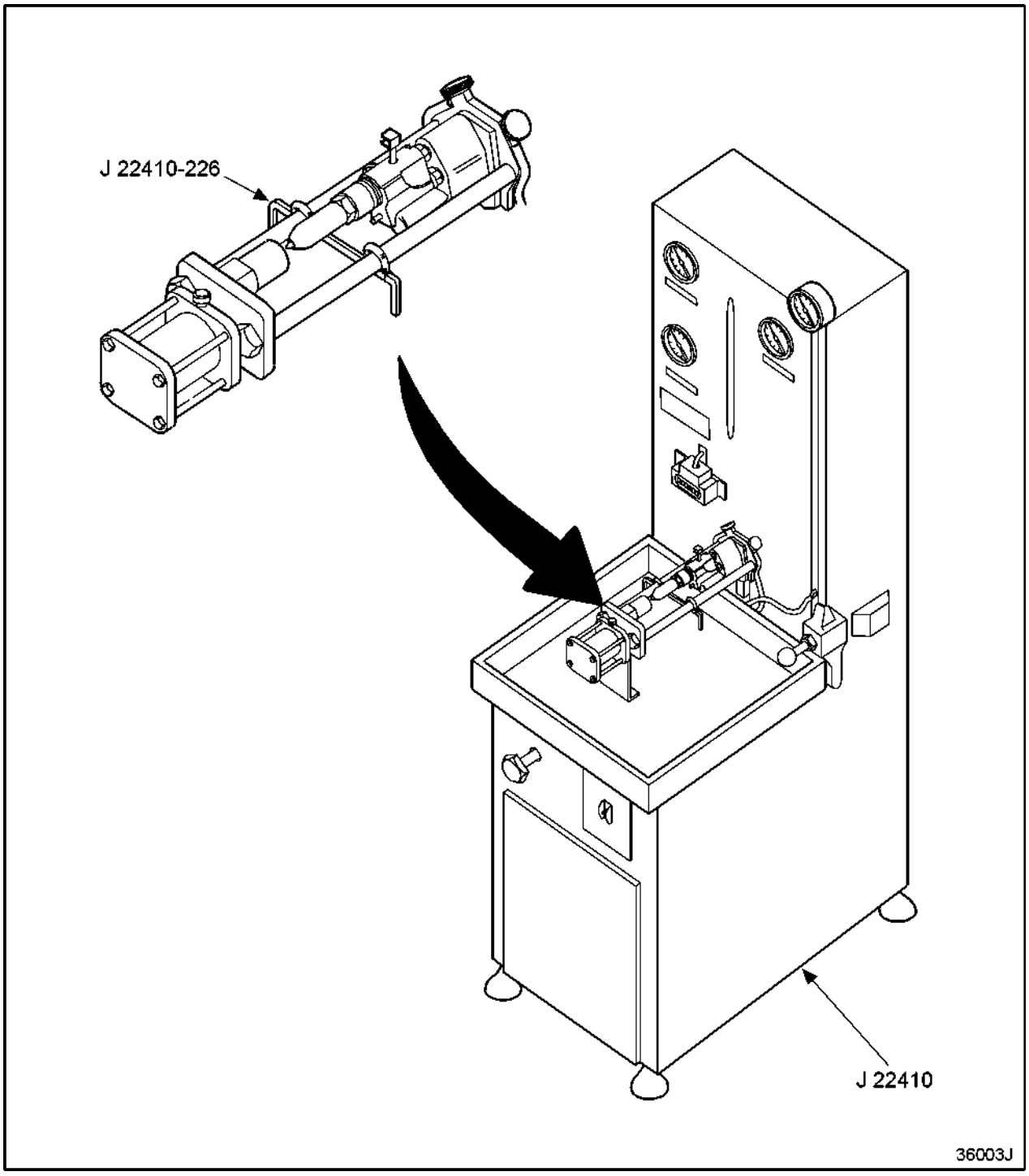

Figure 1883 Injector Seat, J 22410–226

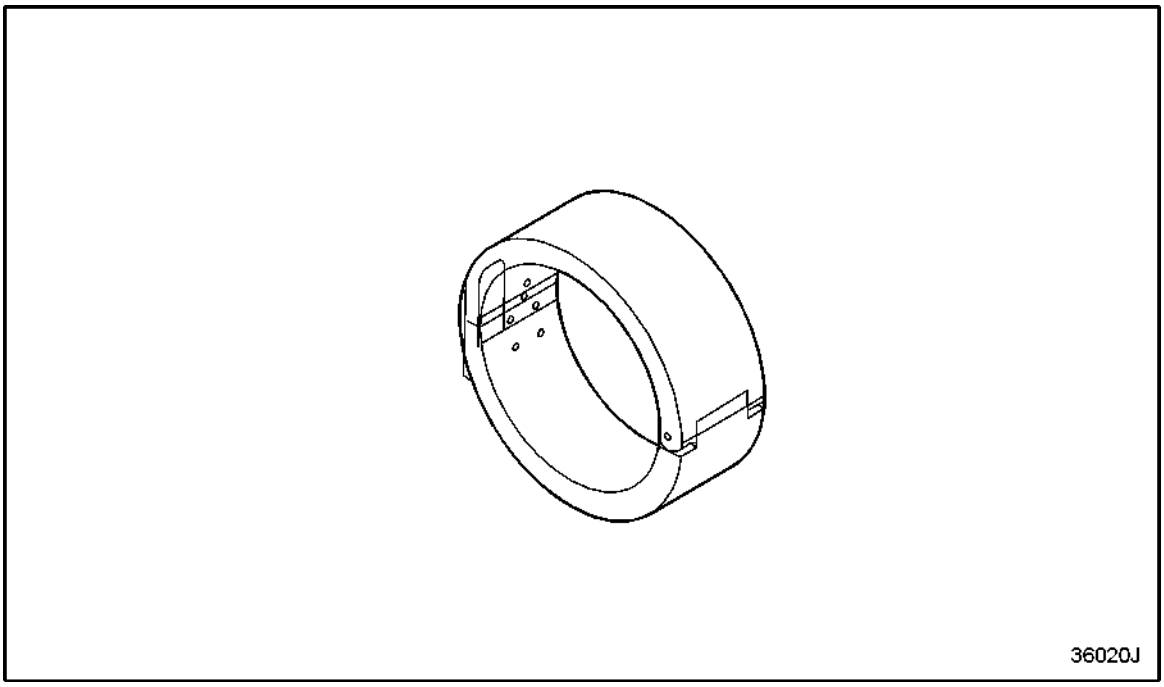

Figure 1884 Series 60 (14L) Piston Ring Compressor, J 43397

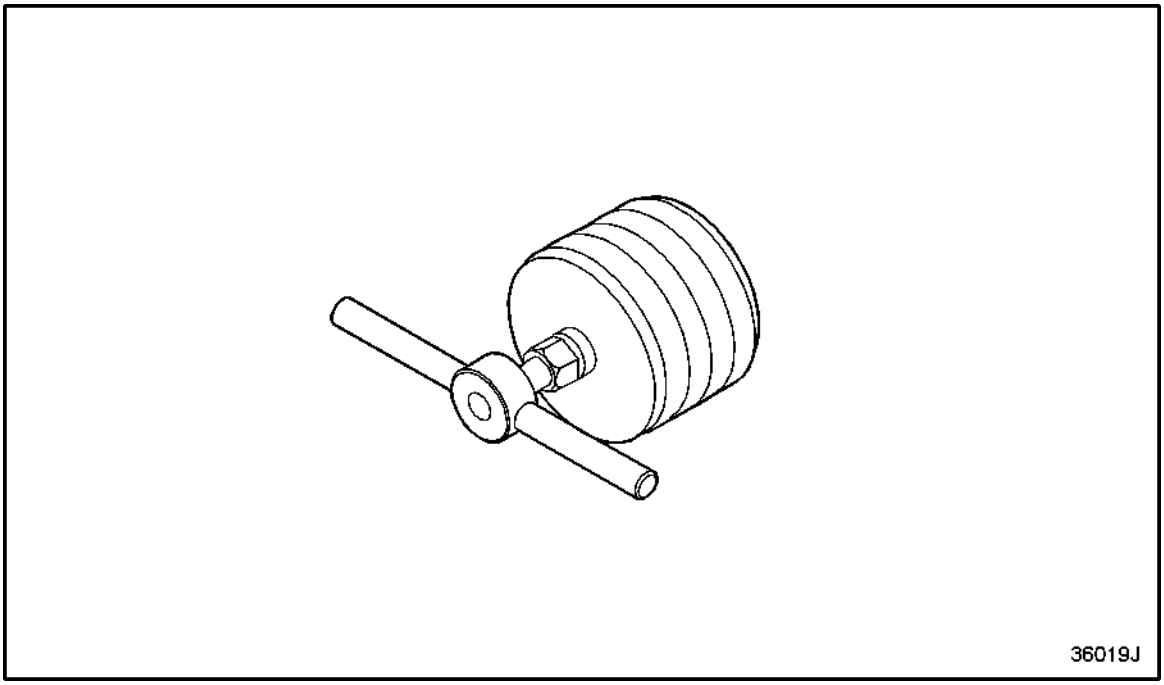

Figure 1885 Series 60 (14L) Cylinder Kit Puller, J 43396

ILLUSTRATION NOT AVAILABLE AT TIME OF PUBLICATION

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Figure 1886 Series 60 (14L) Rod Bolt Protector, J 34317

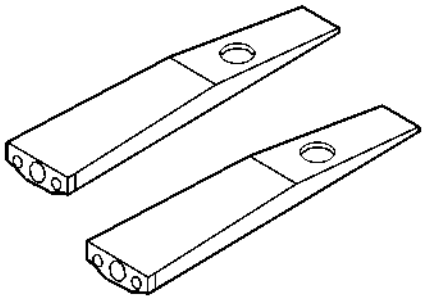

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Figure 1887 Series 60 (14L) Oil Nozzle Protector, J 43661

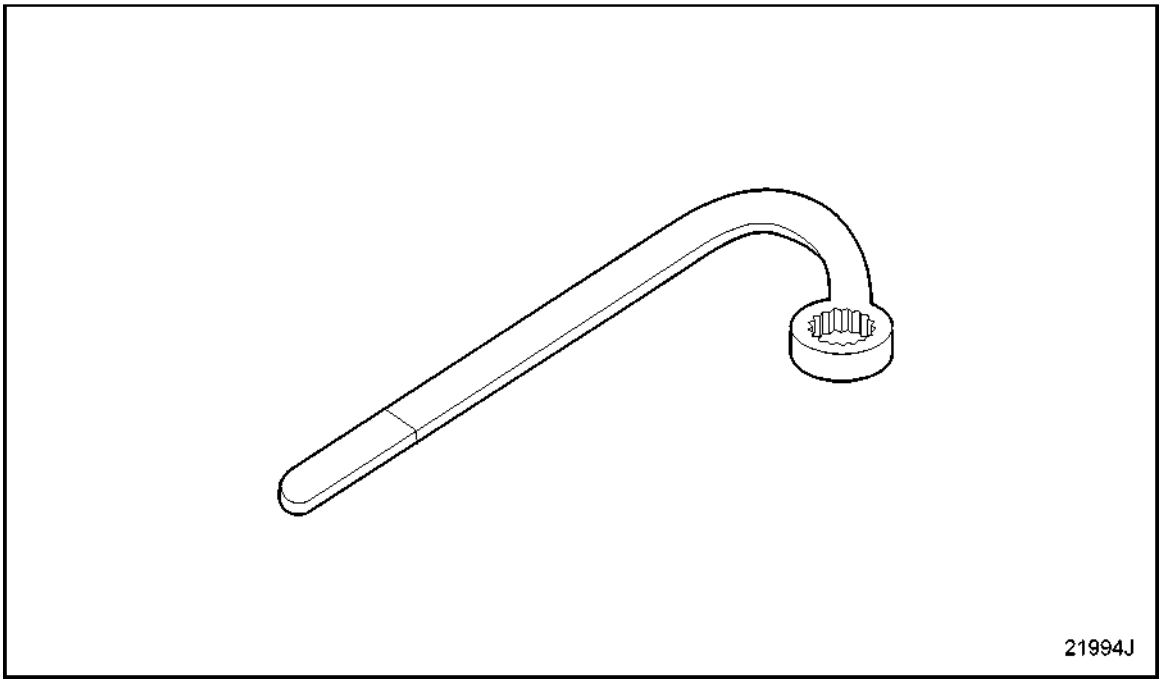


Figure 1888 Series 60 (14L) Air Compressor Wrench, J 35948

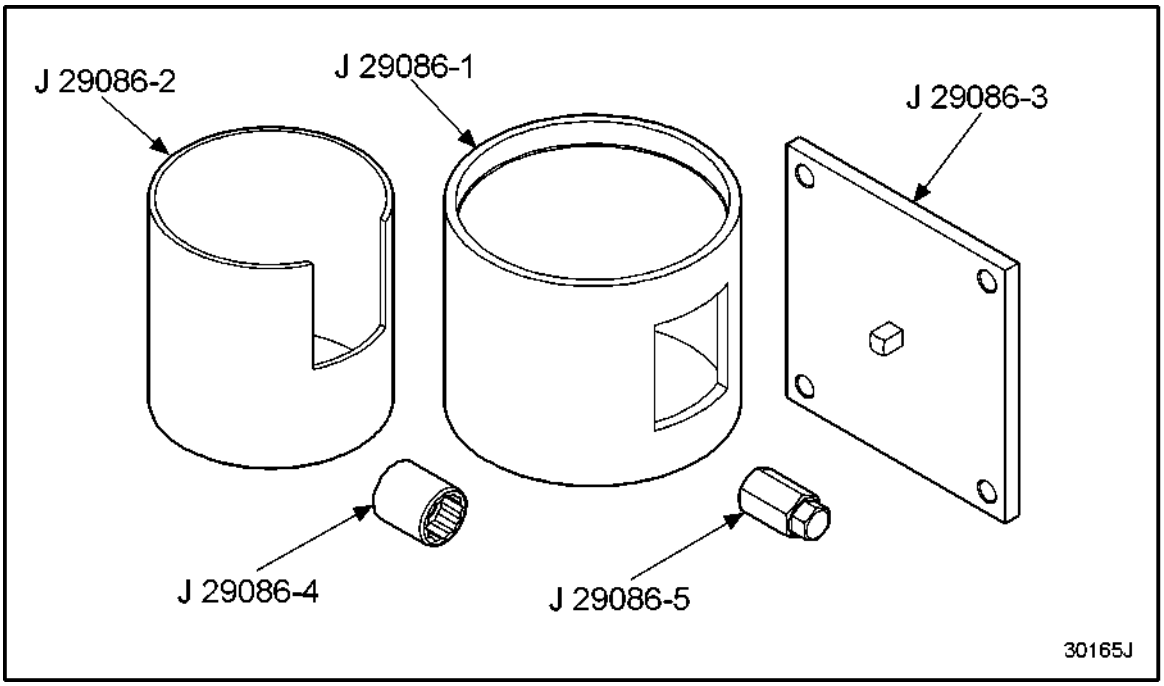


Figure 1889 Series 60 (14L) Turbocharger Support Fixture, J 29086

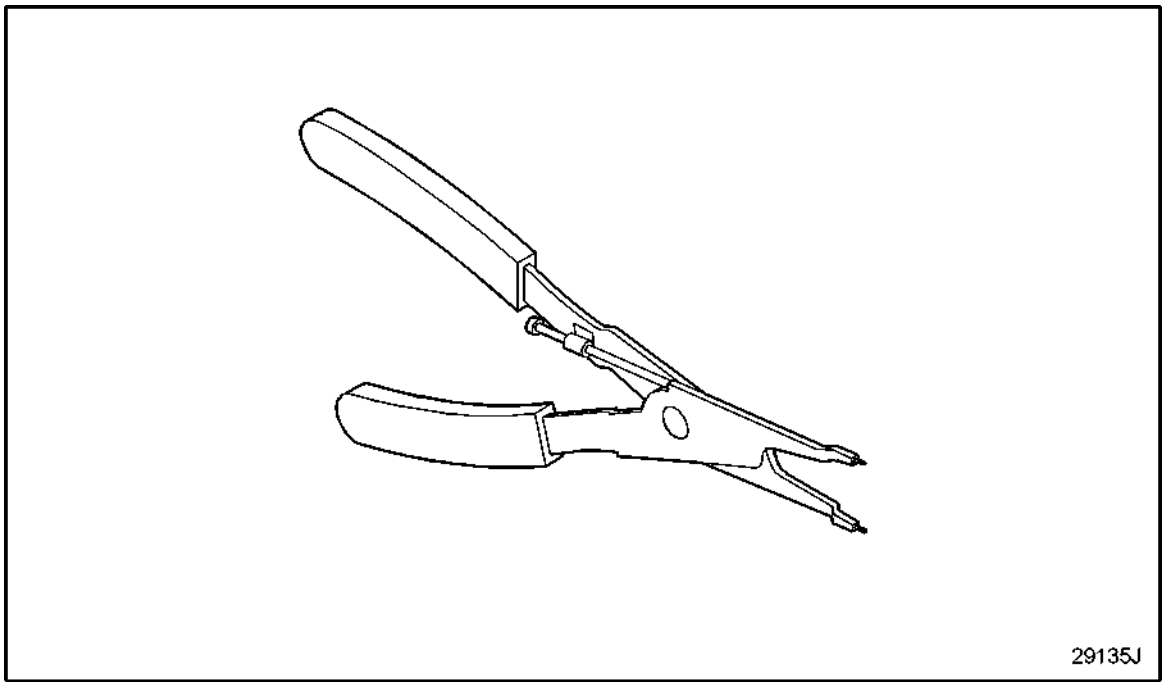


Figure 1890 Series 60 (14L) Snap Ring Pliers, J 28507

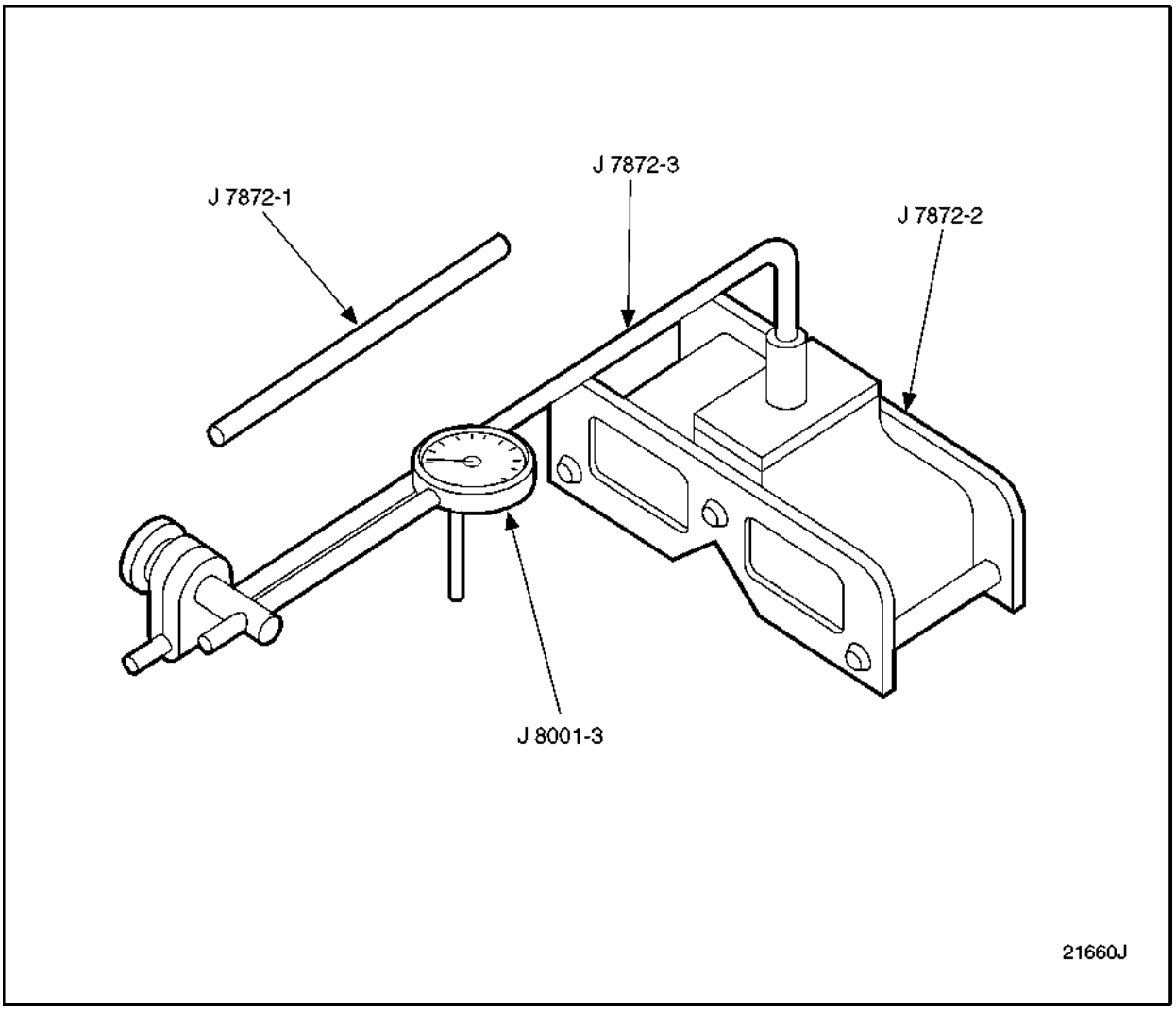


Figure 1891 Series 60 (14L) Magnetic Base, J 7872–2

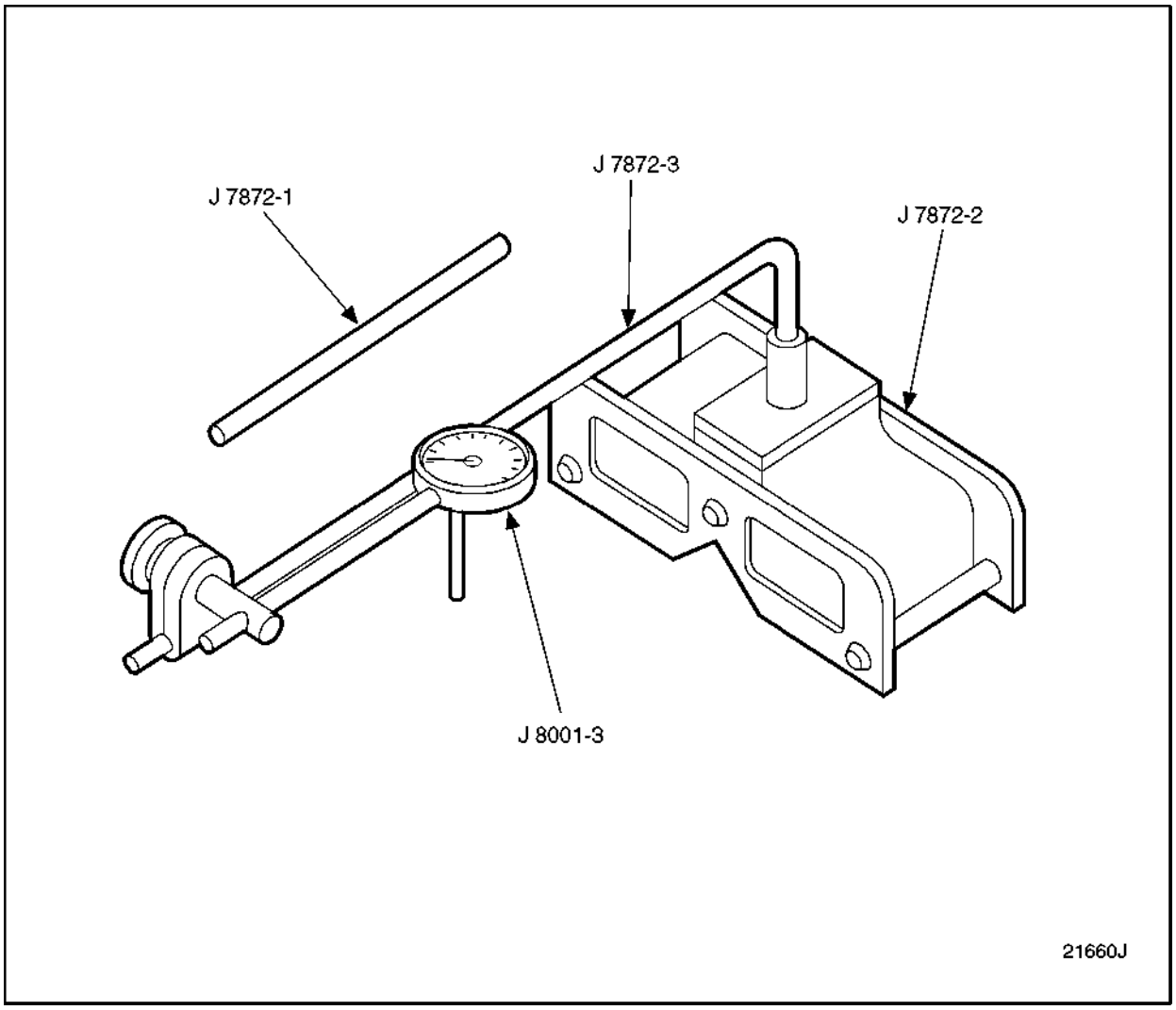


Figure 1892 Series 60 (14L) Extension Rod, J 7872–3

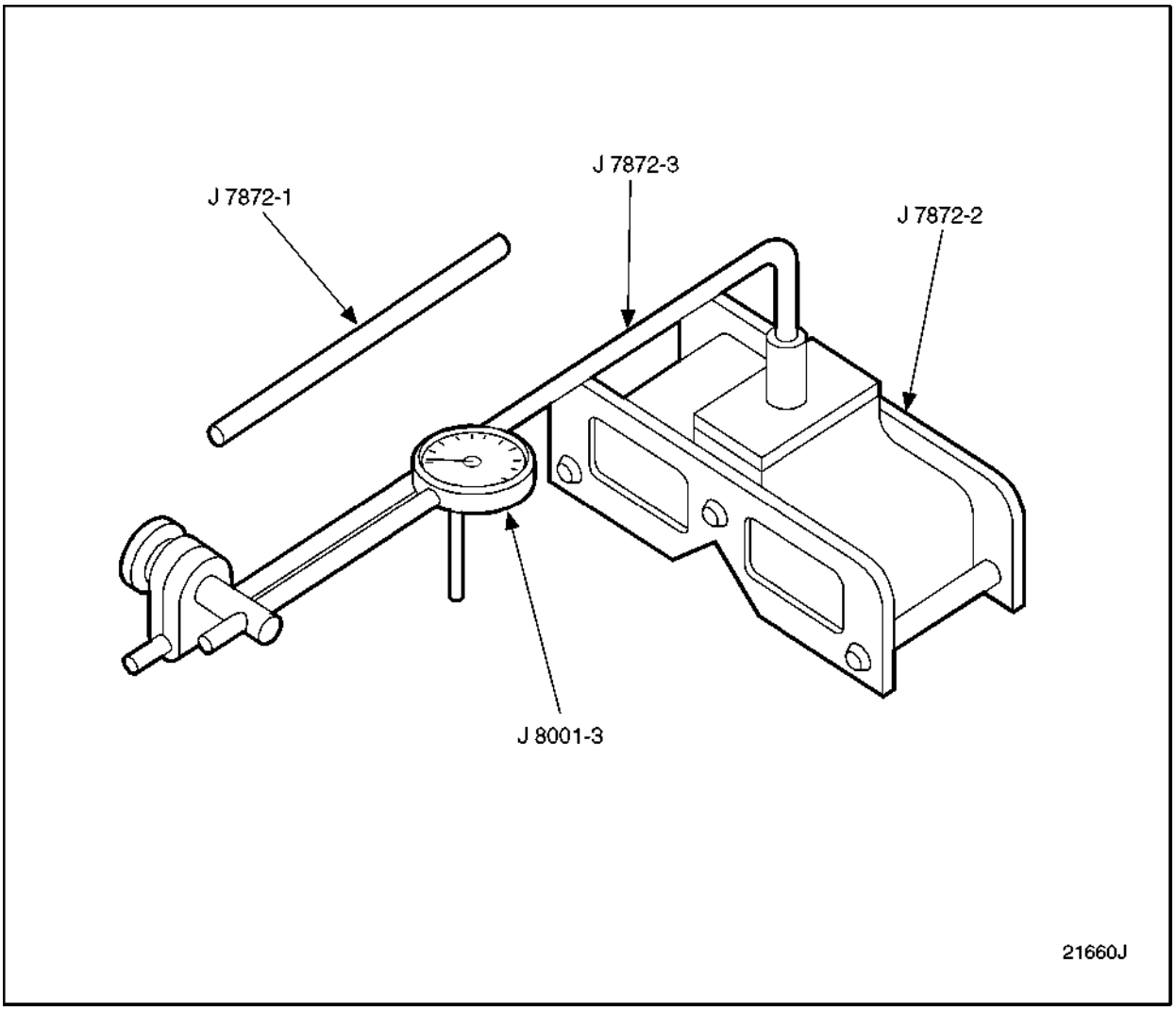


Figure 1893 Series 60 (14L) Extension Rod, J 7872–1

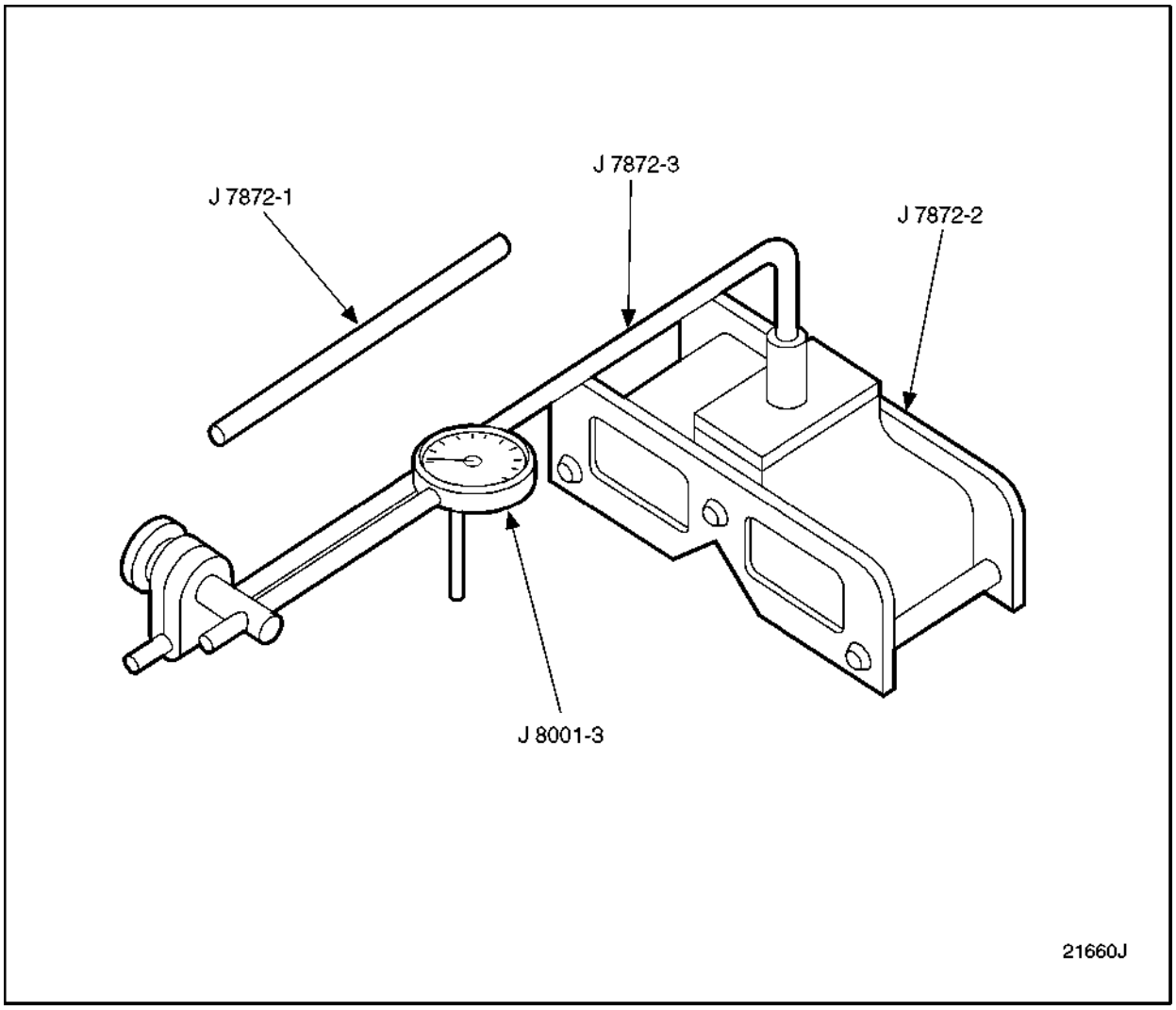


Figure 1894 Series 60 (14L) Dial Indicator, J 8001–3

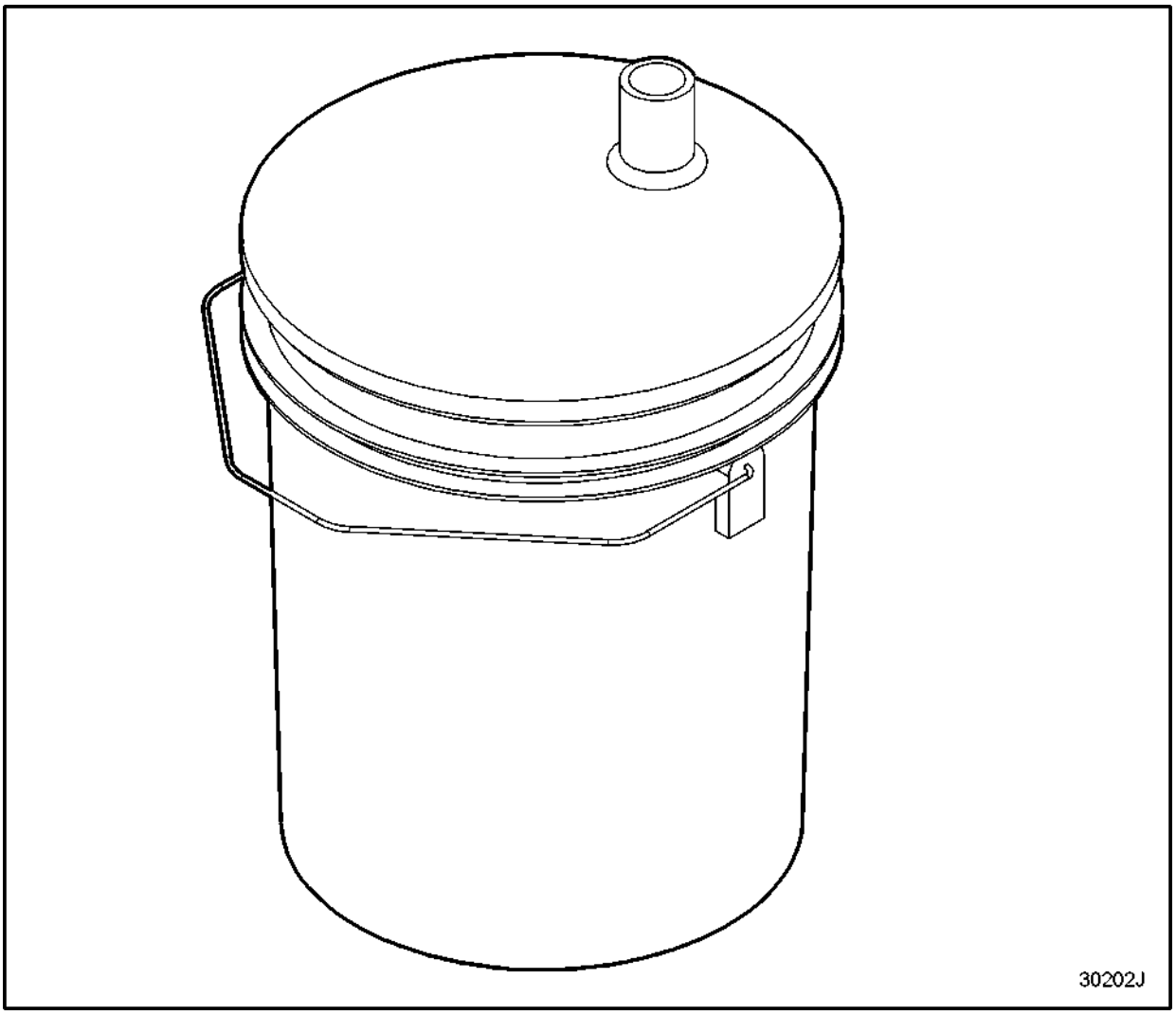


Figure 1895 **Injector Test Oil** J 26400-5B

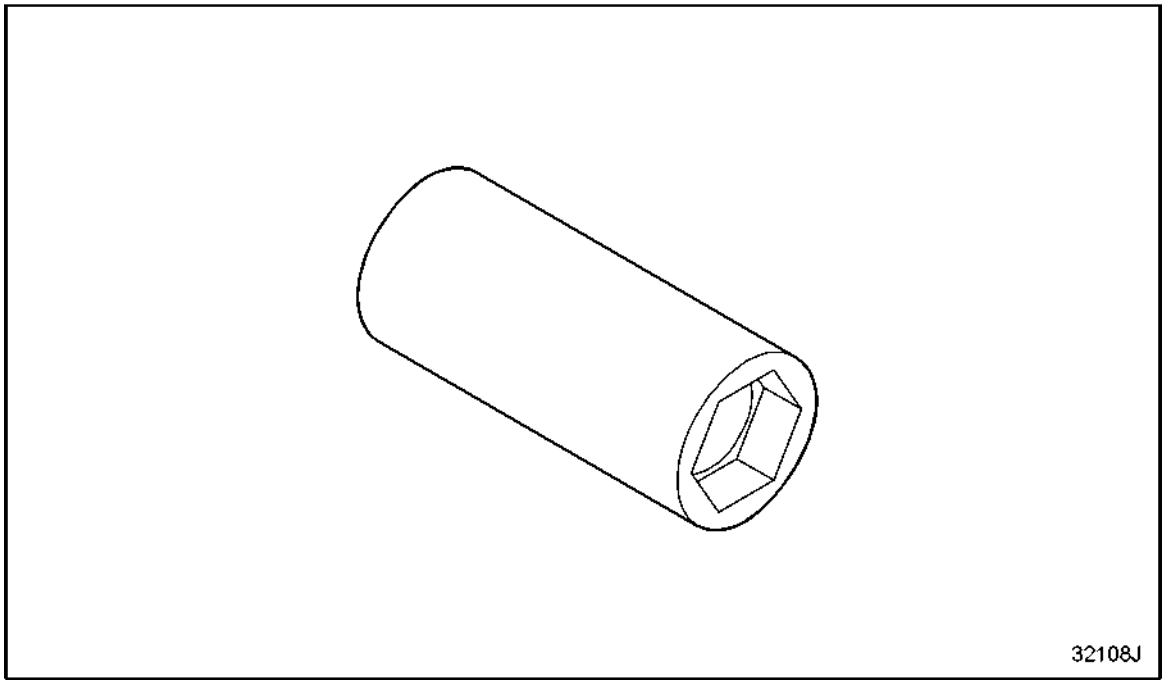


Figure 1896 Injector Nut Socket J 4983-01

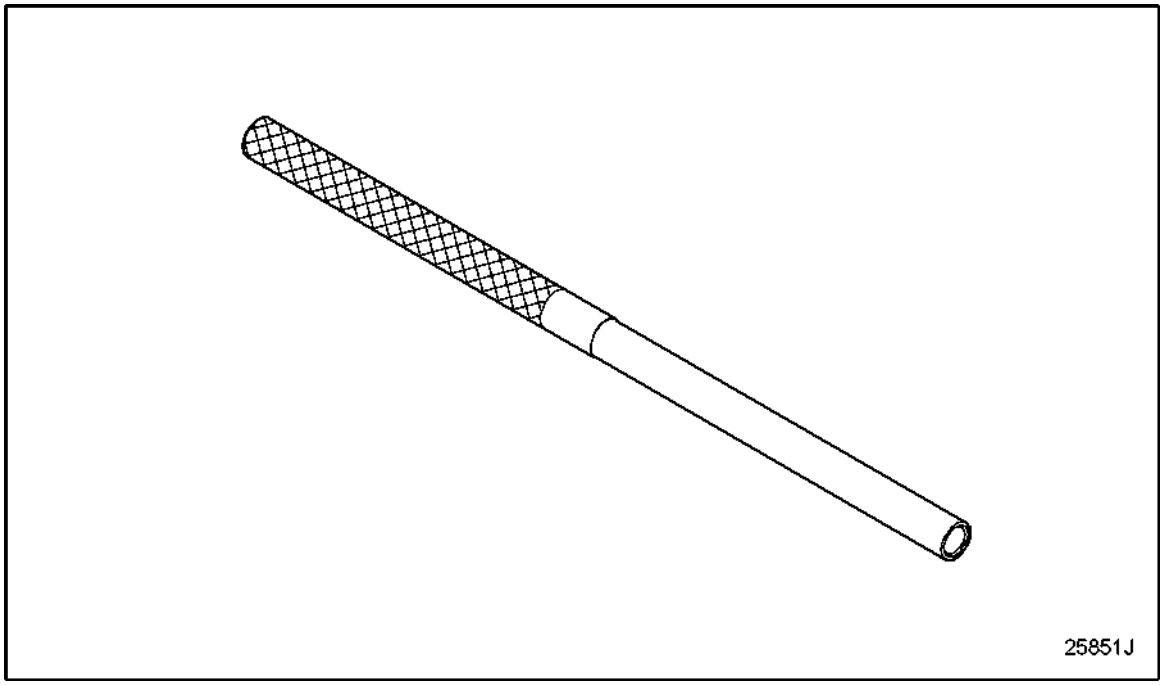


Figure 1897 Injector Spray Tip Driver J 1291-02

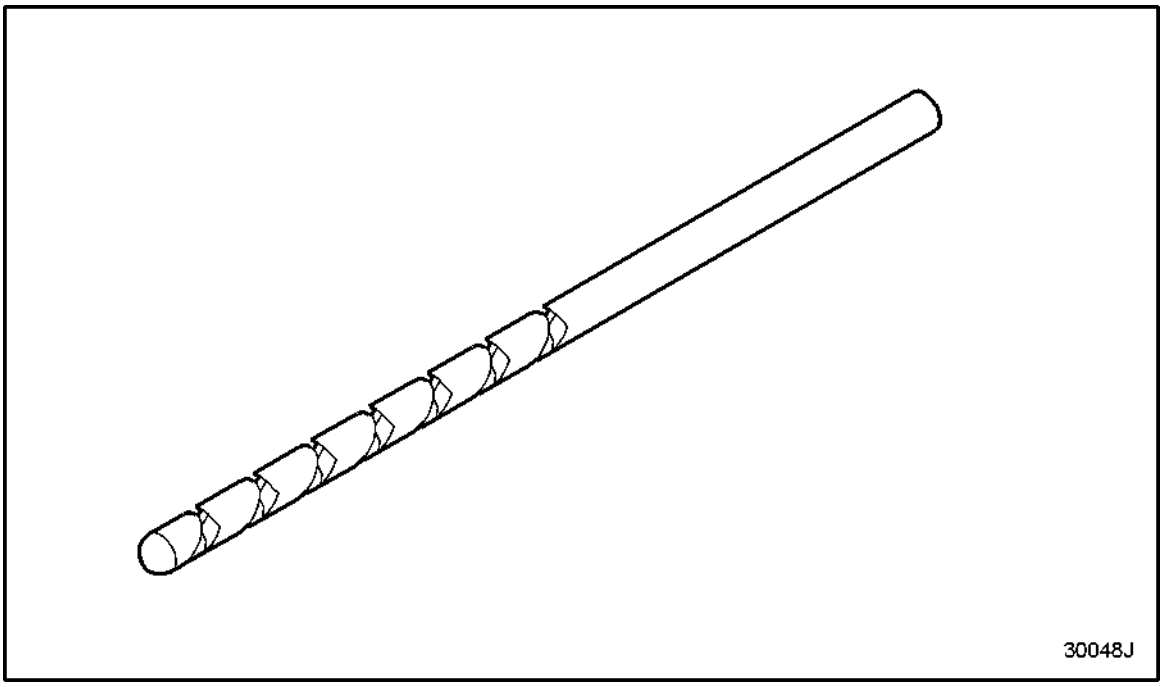


Figure 1898 Spray Tip Carbon Remover J 24838

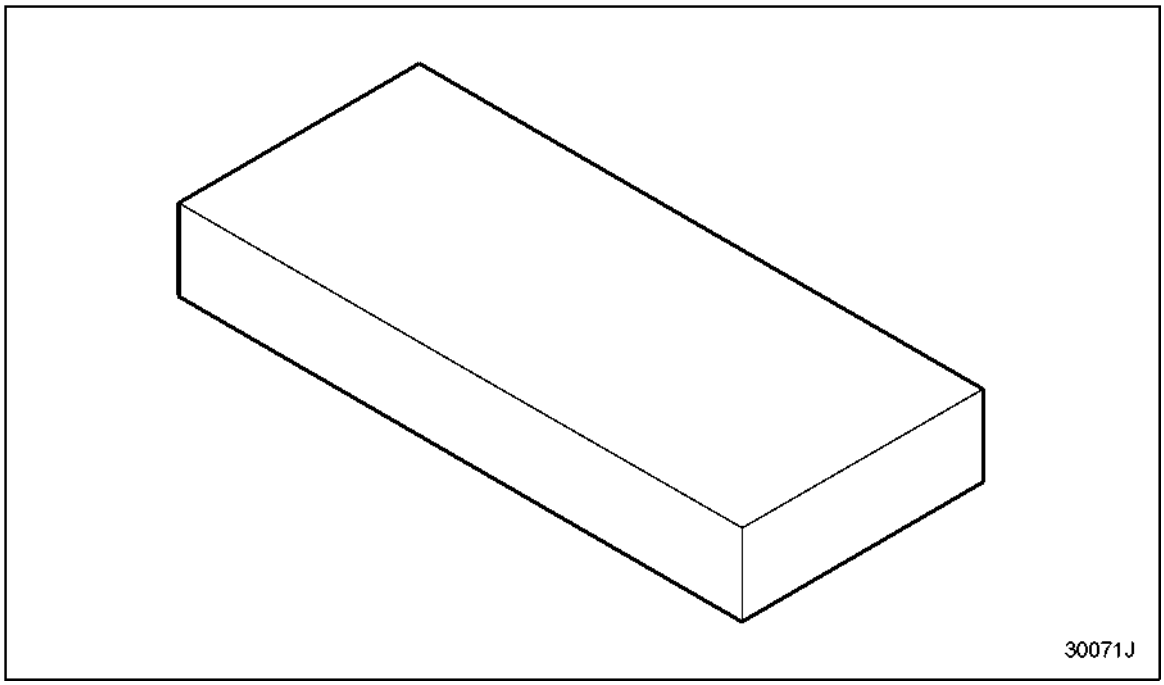


Figure 1899 Injector Wire Sharpening Stone J 8170

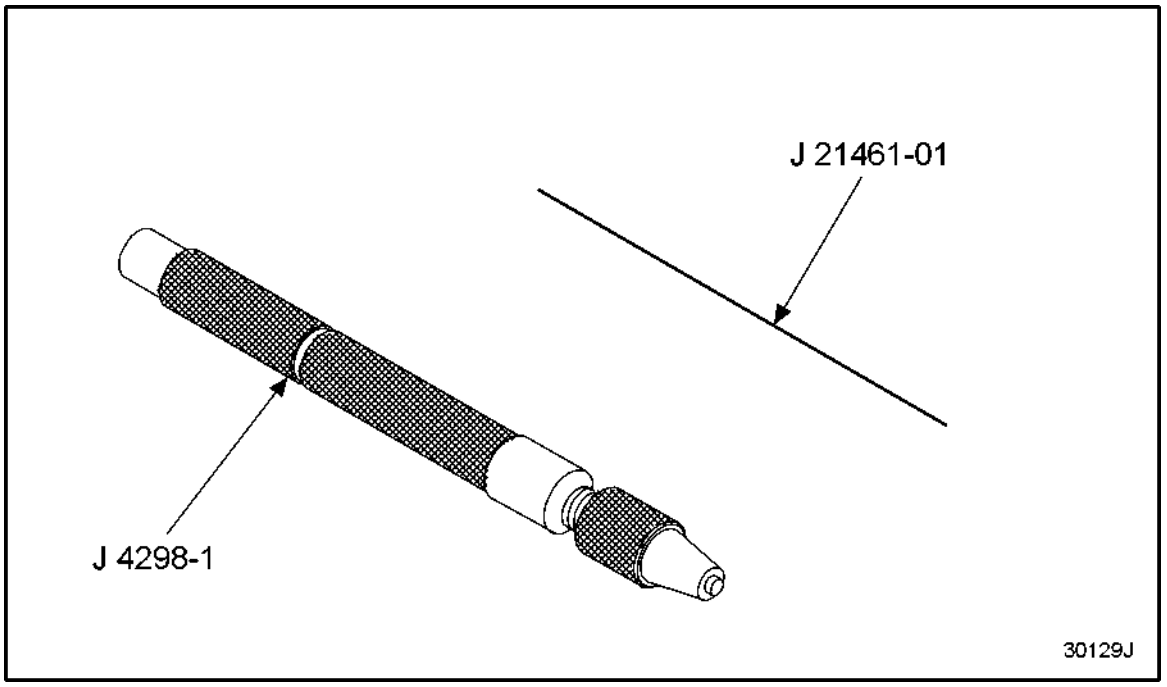


Figure 1900 Injector Spray Hole Cleaner J 8169-03

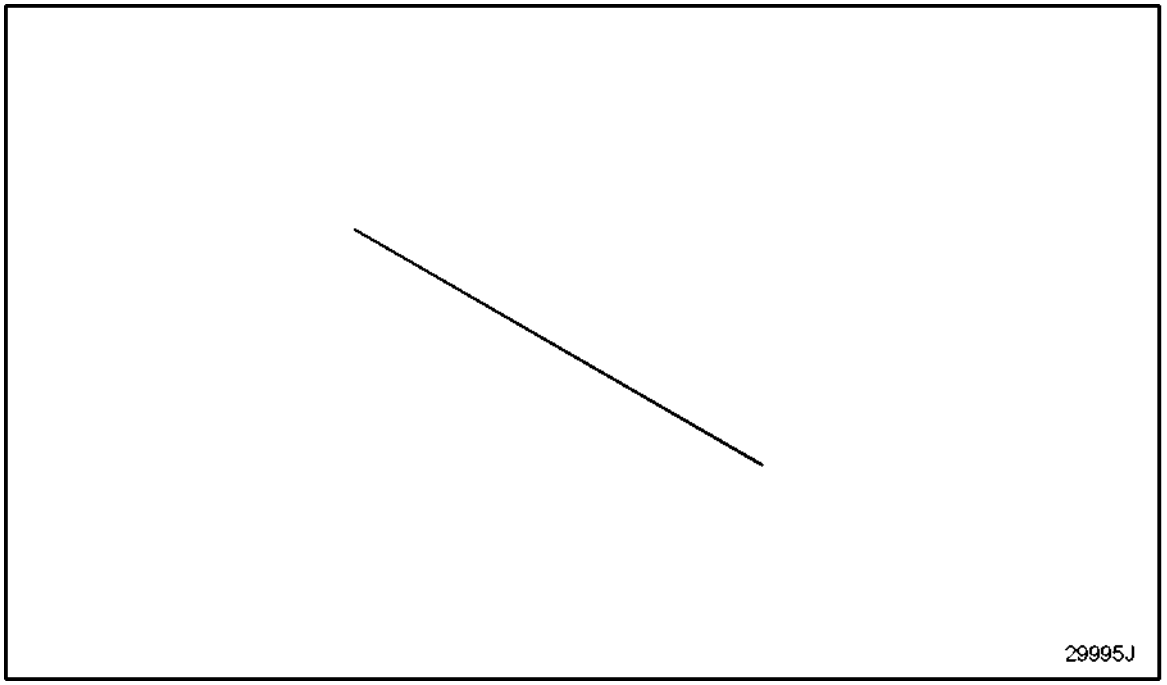


Figure 1901 Spray Hole Wire J 21460-01

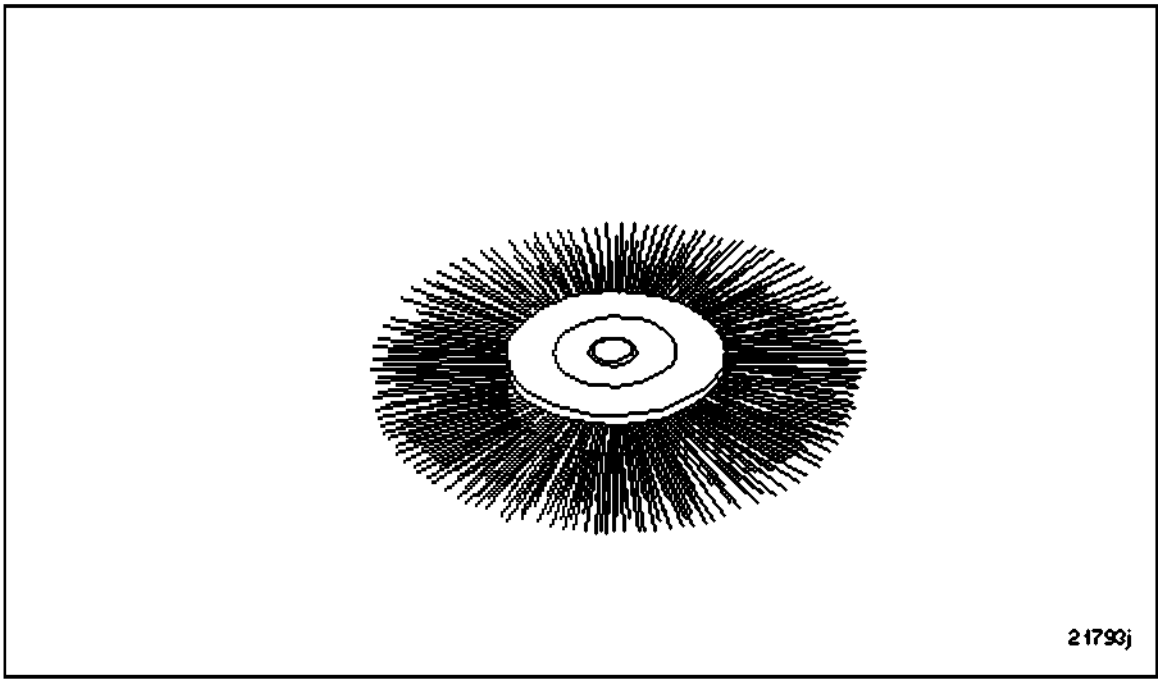


Figure 1902 Wire Brush (Brass) J 7944

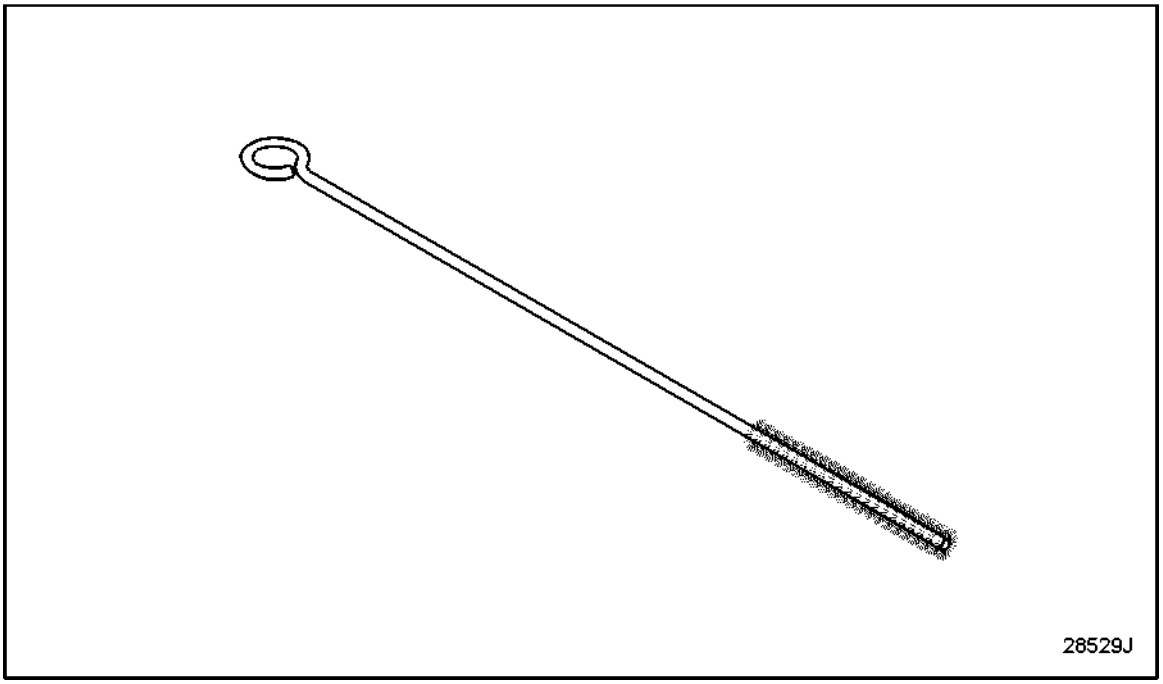


Figure 1903 Rack Hole Brush J 8150

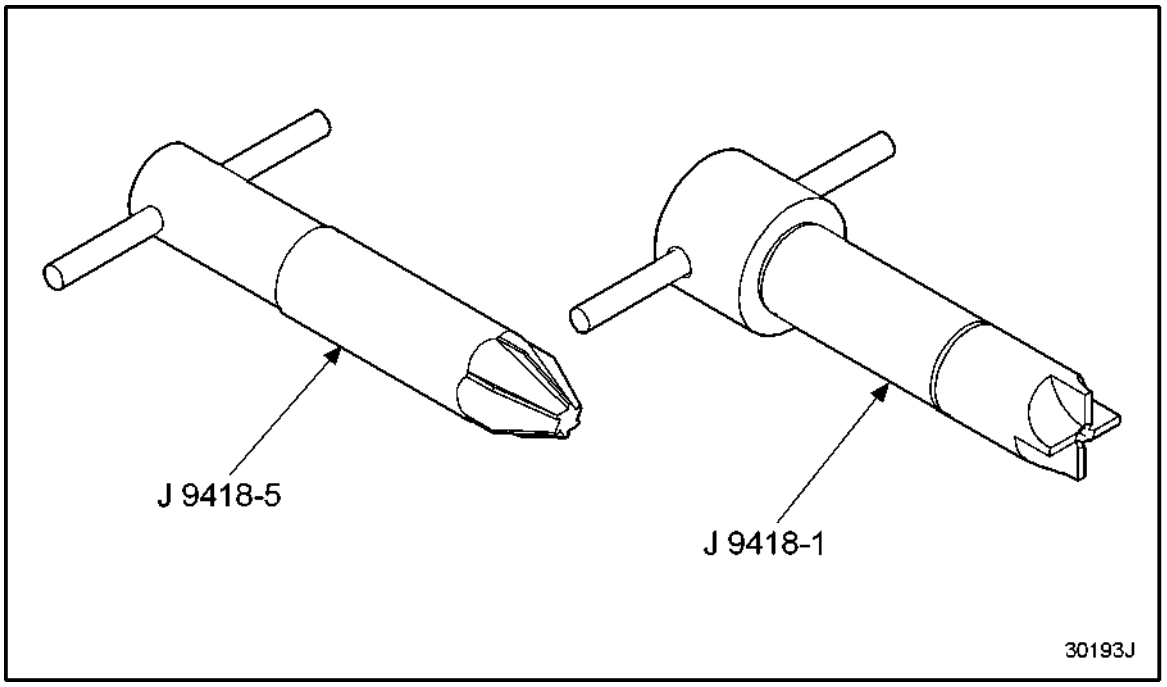


Figure 1904 Injector Nut Carbon Remover Set J 9418

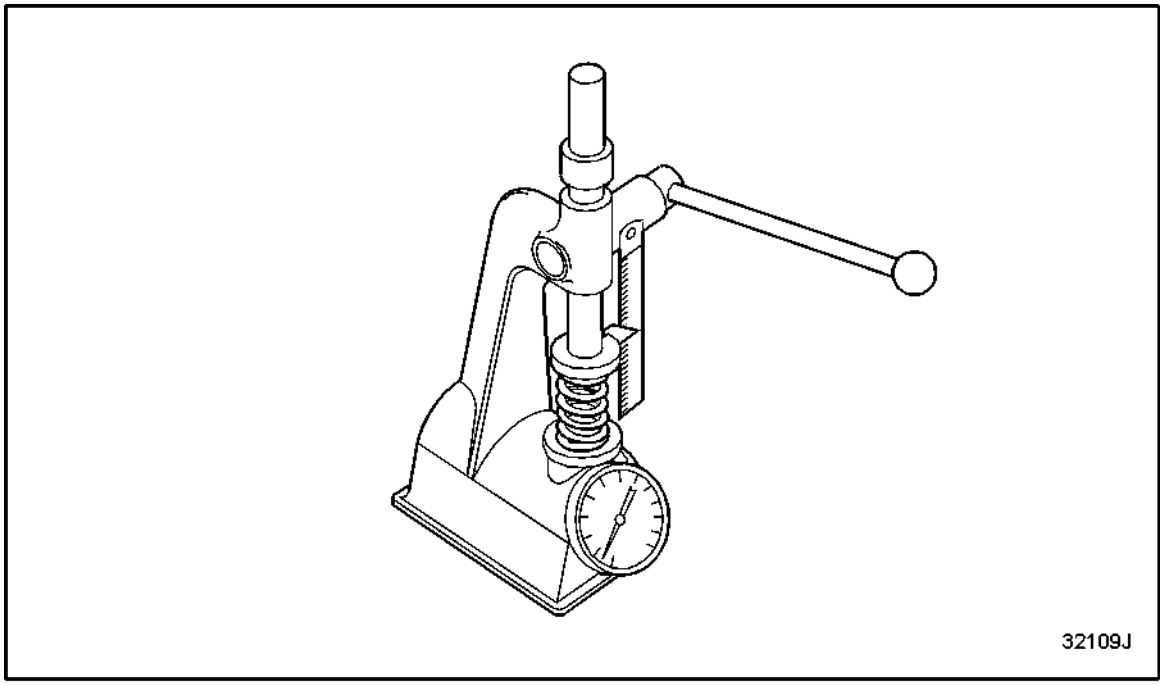


Figure 1905 Spring Tester (0-125 lbs.) J 29196

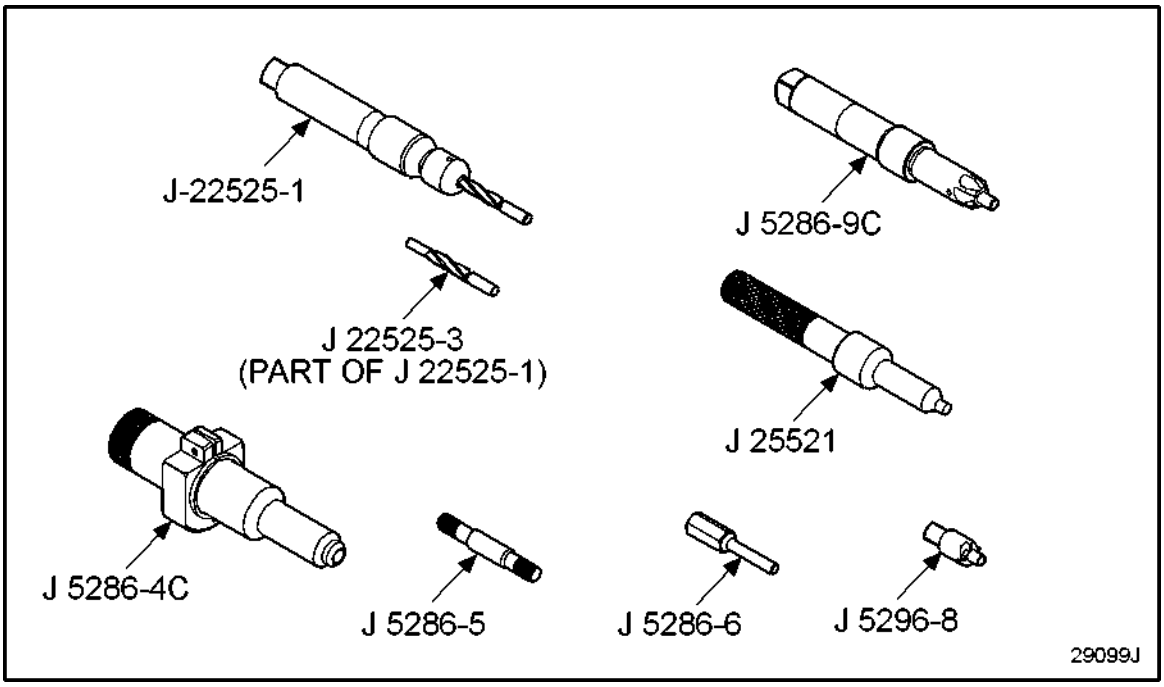


Figure 1906 Injector Tube Reconditioning Set J 22525-B

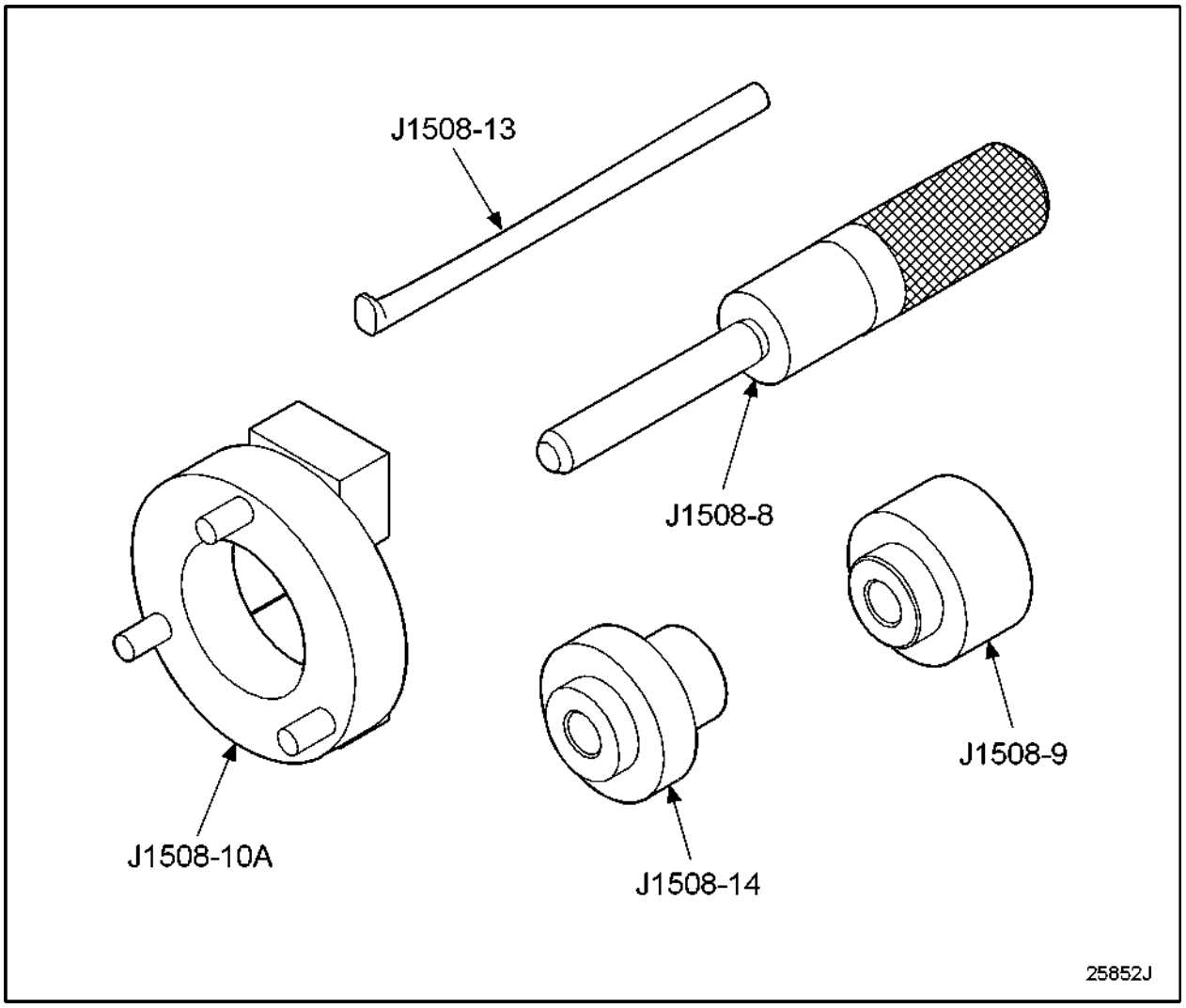


Figure 1907 Service Set (DDA Gear-G Rotor Type) J 1508-E

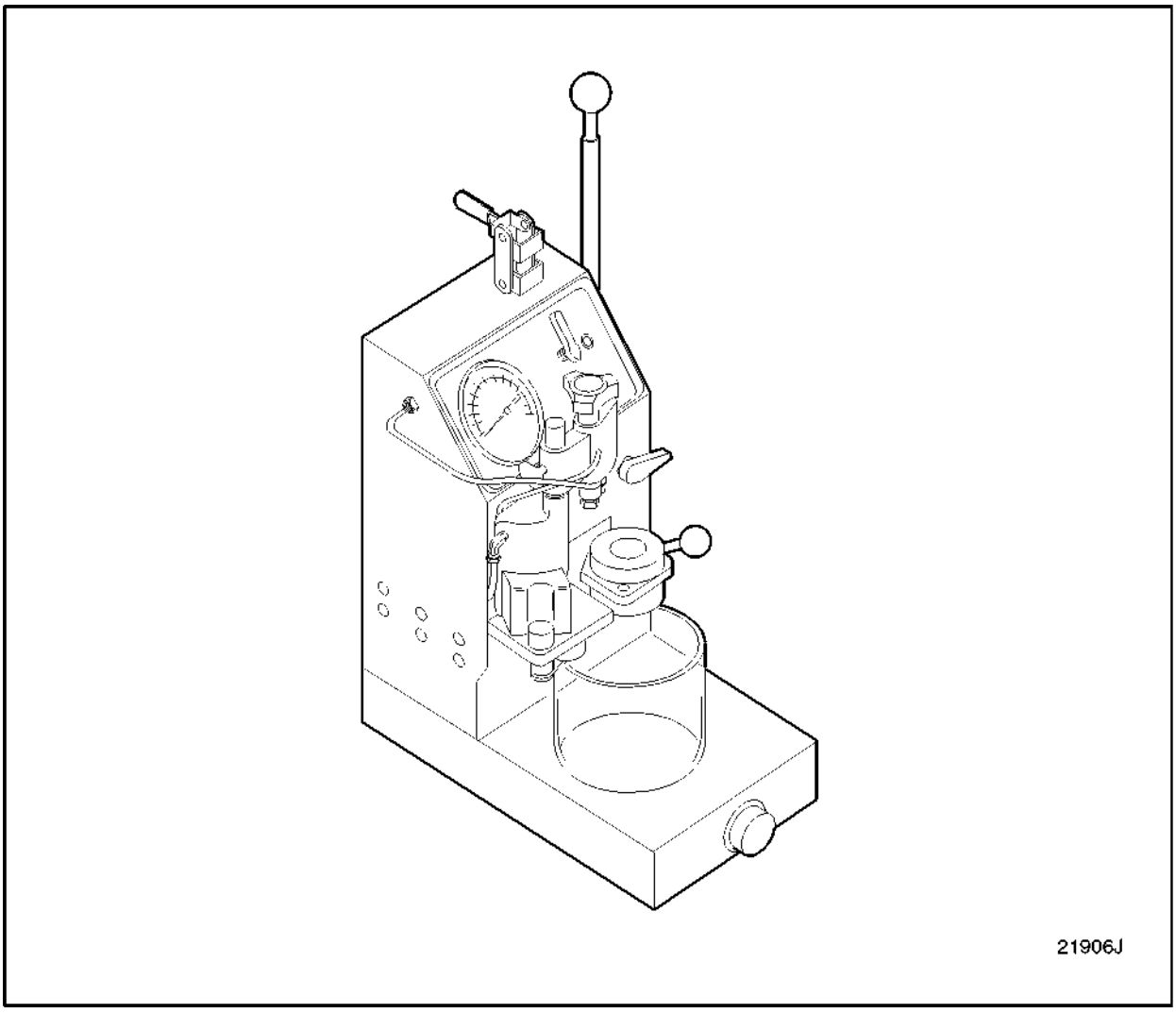


Figure 1908 **Injector Pop Fixture** J 34760-B **Includes: J 34760–147A and J 34760–150A**

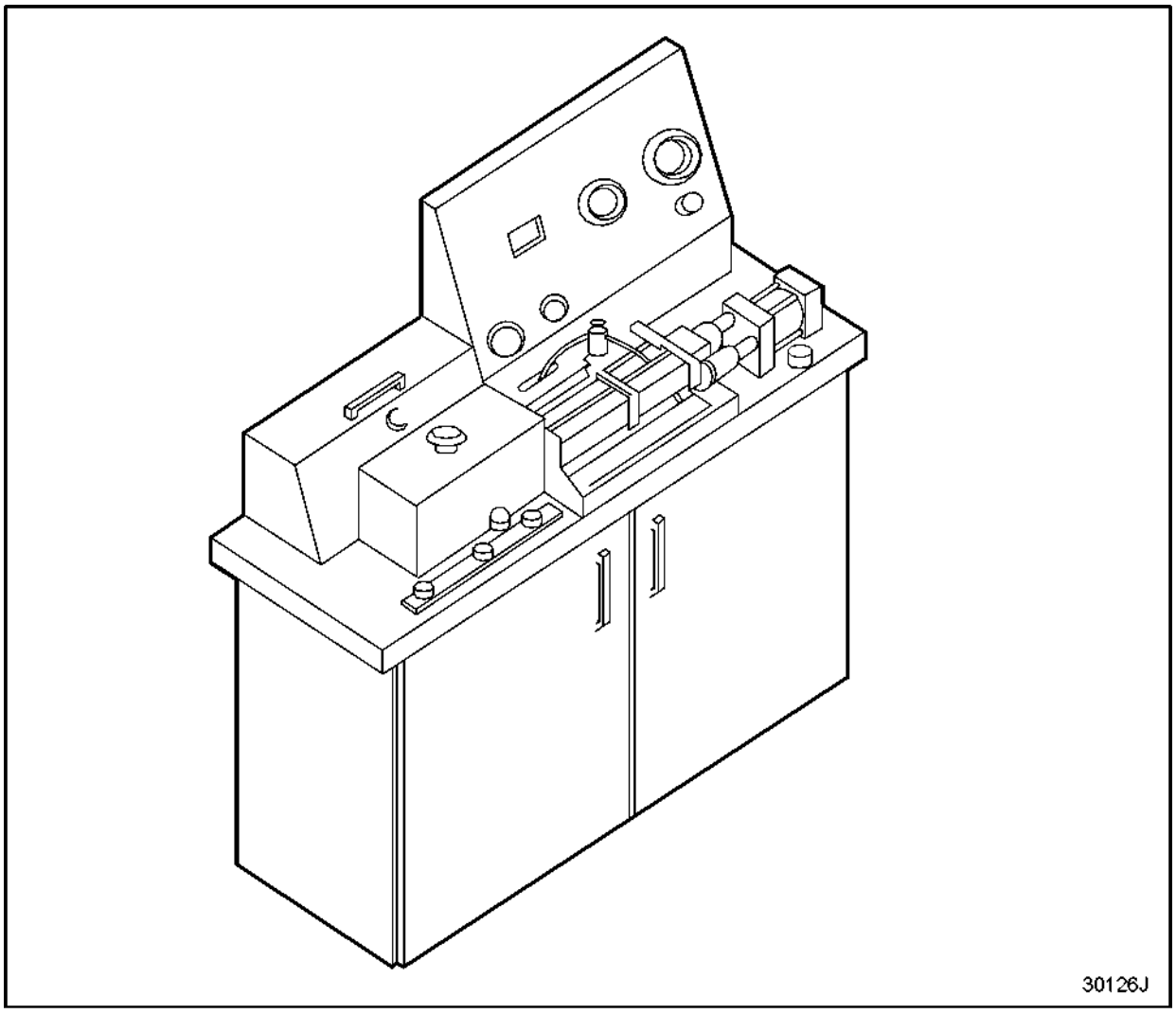


Figure 1909 **Calibrator** J 39300

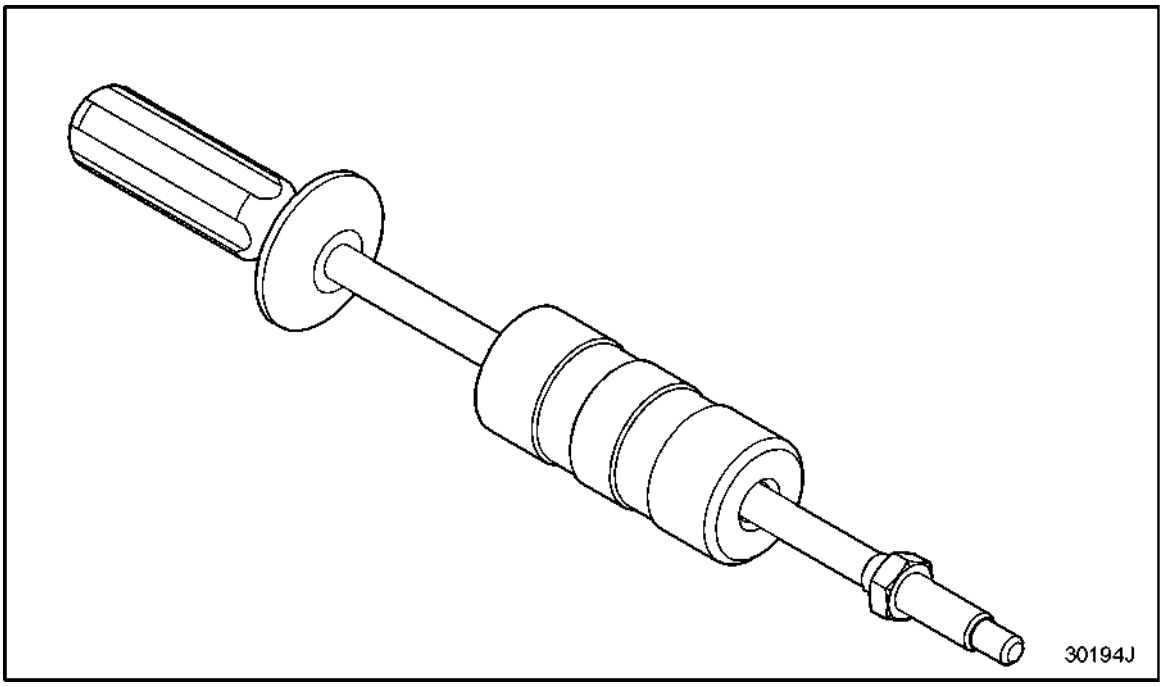


Figure 1910 Slide Hammer J 23907-1

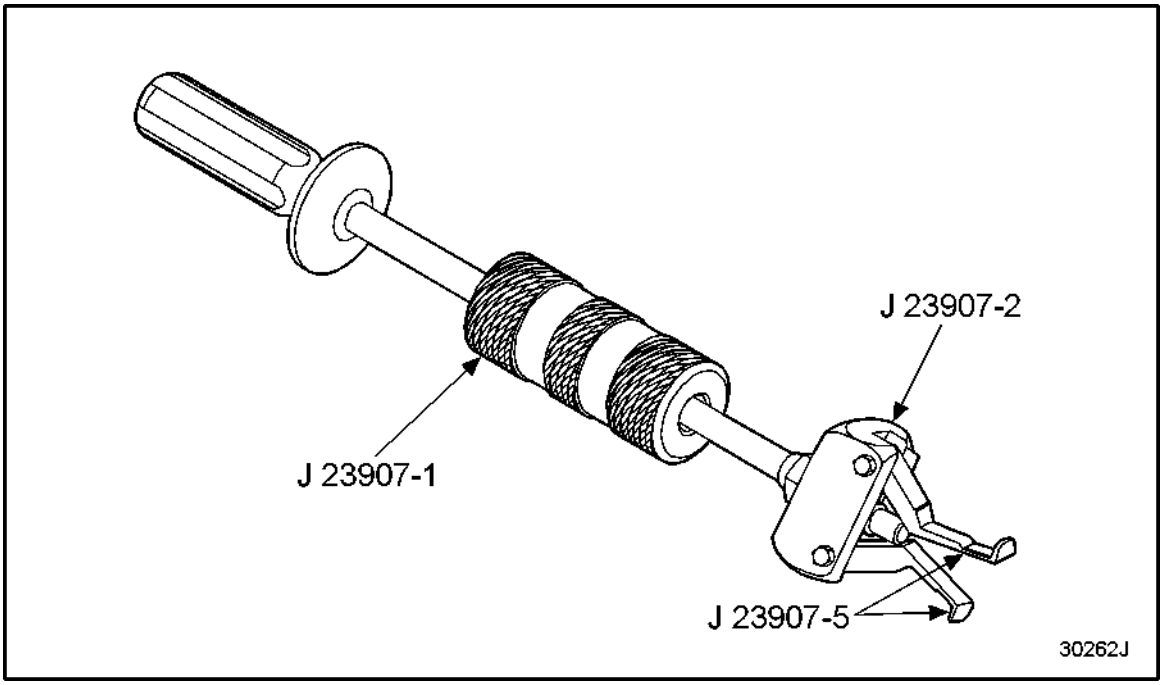


Figure 1911 Clutch Pilot Bearing Remover J 23907-2

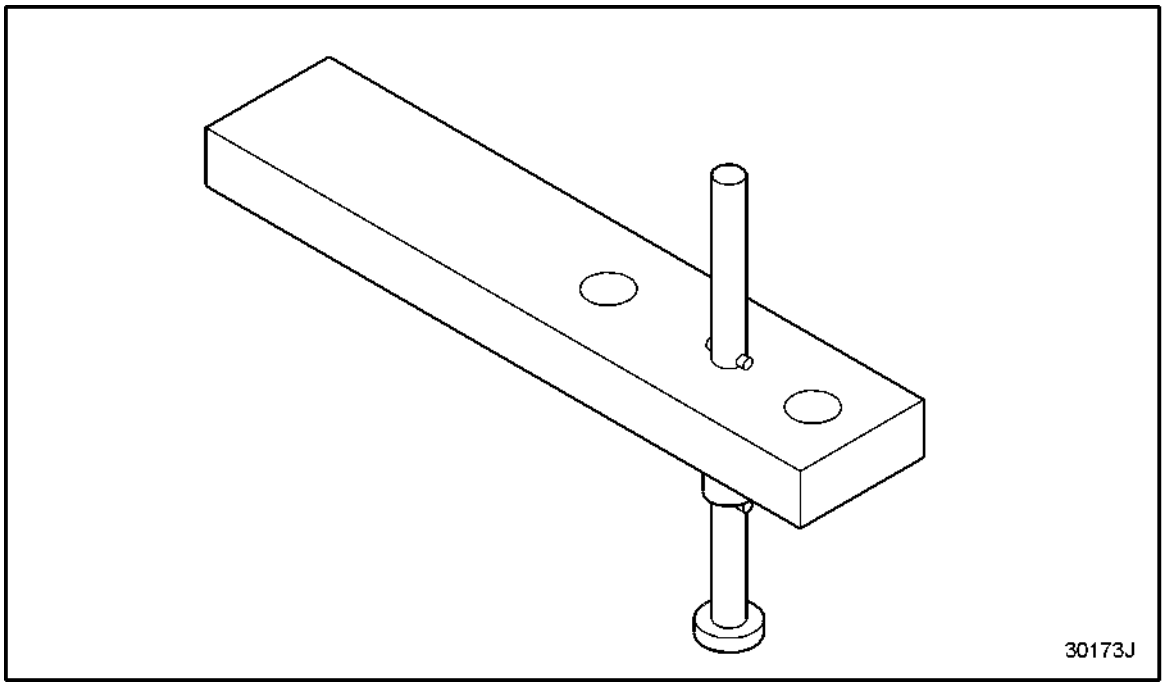


Figure 1912 Dial Indicator Adaptor J 21224

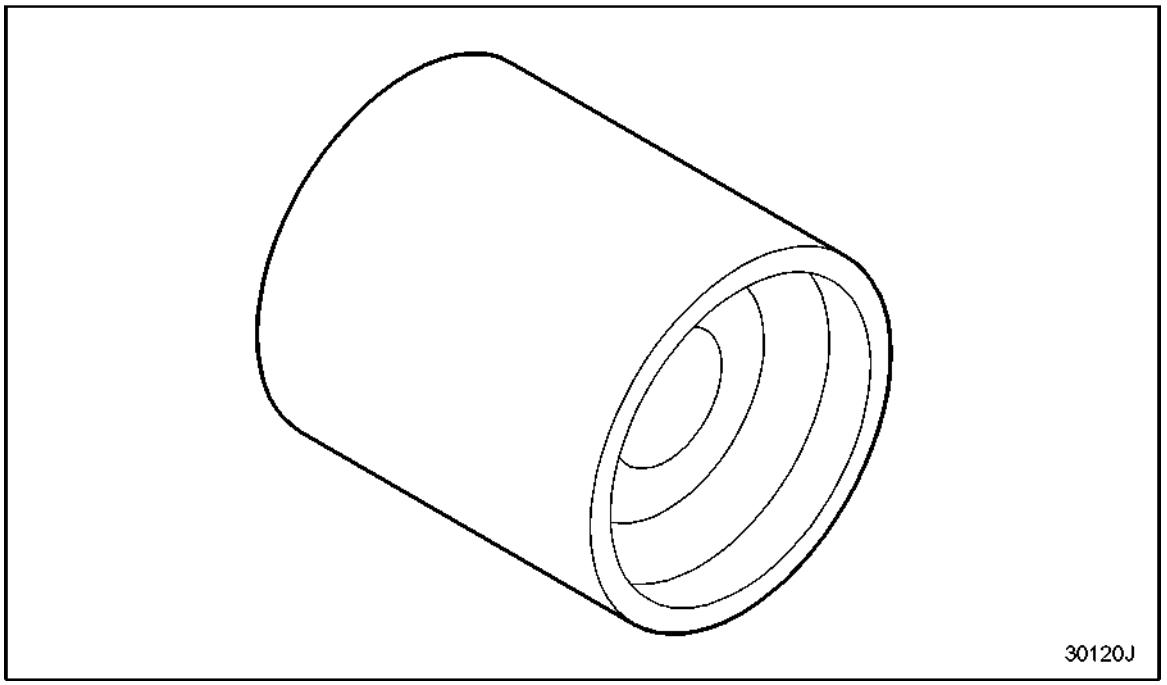


Figure 1913 Water Pump Seal Installer J 38858

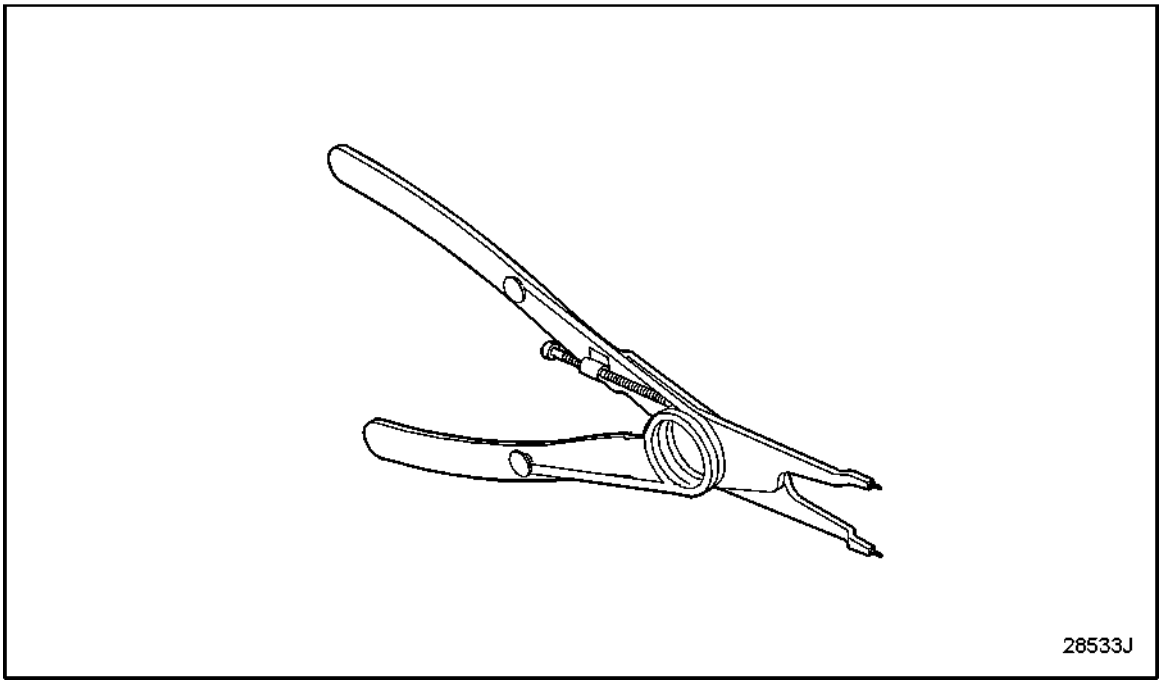


Figure 1914 Pliers (Tru-Arc) J 4646

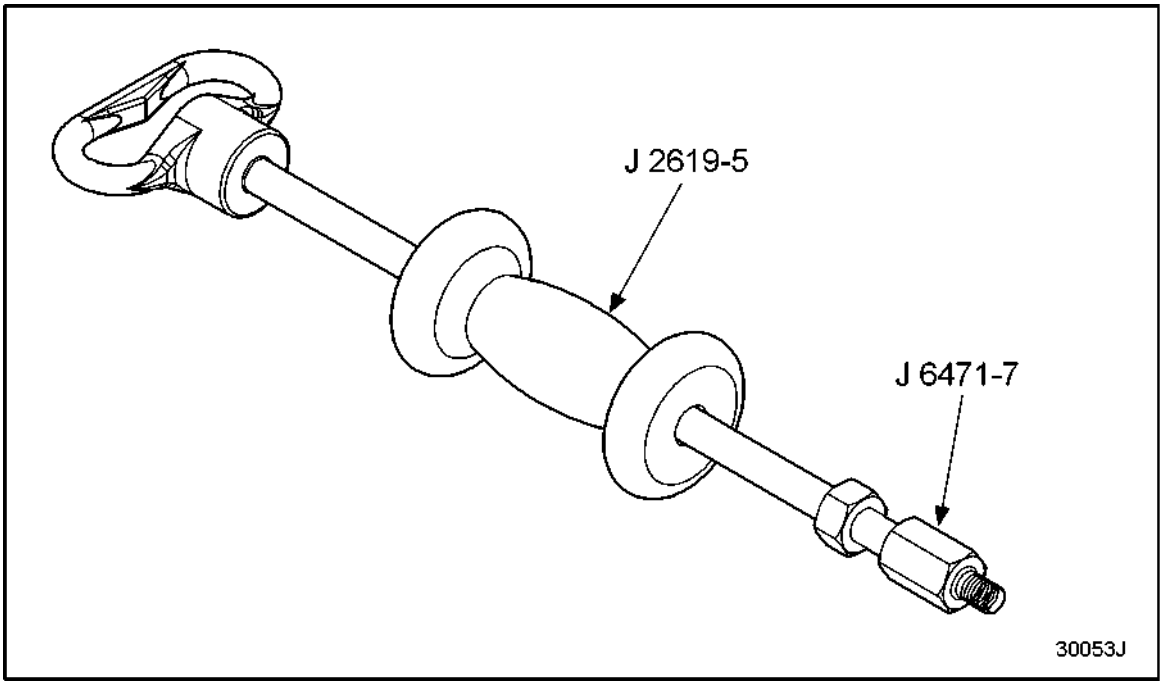


Figure 1915 Handle and Striker Assembly J 2619-5

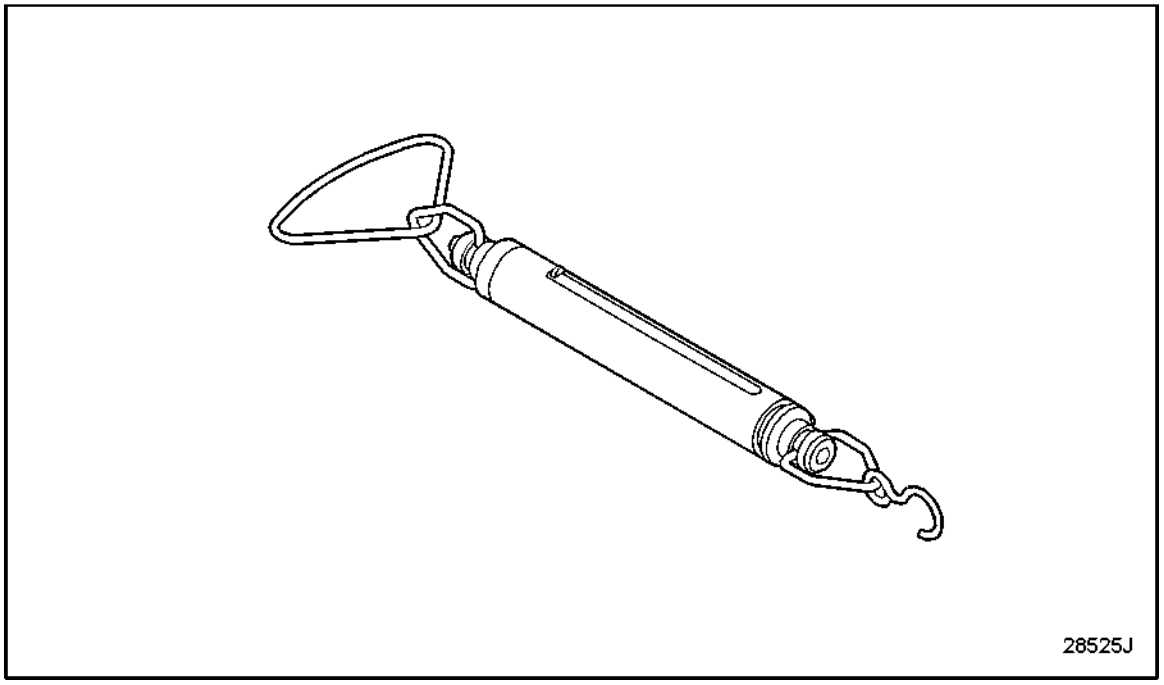


Figure 1916 Tension Scale J 8129

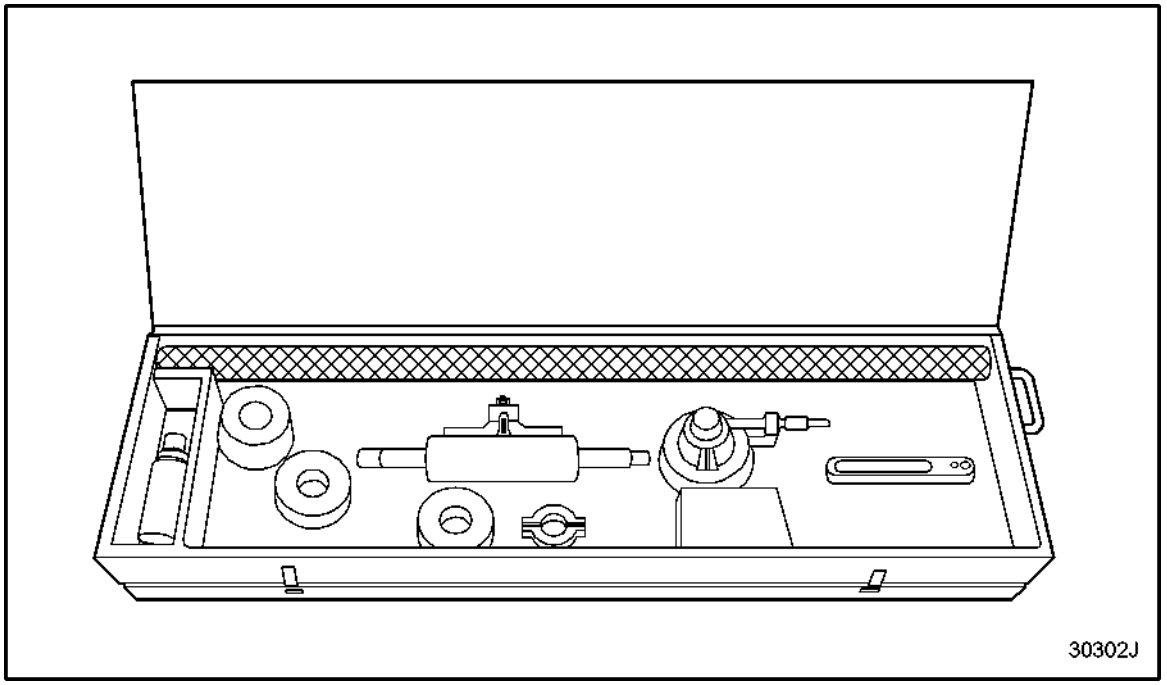


Figure 1917 Line Boring Complete Kit (main), J 29005

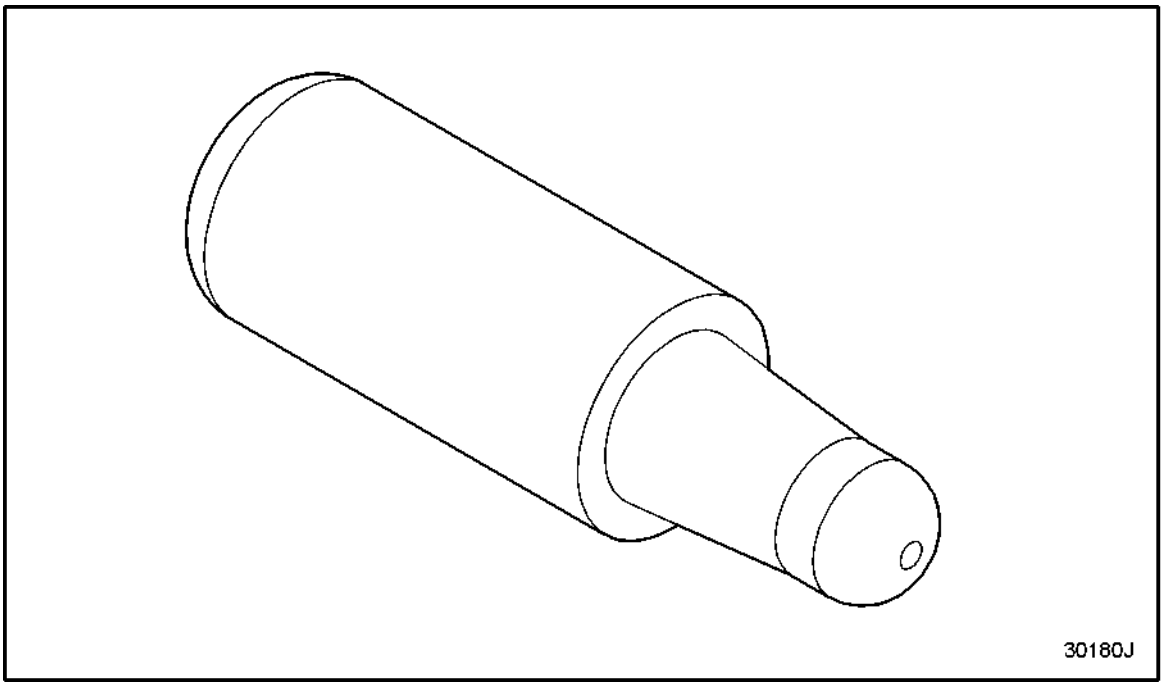


Figure 1918 Injector Tube Swagging Tool J 28611-A

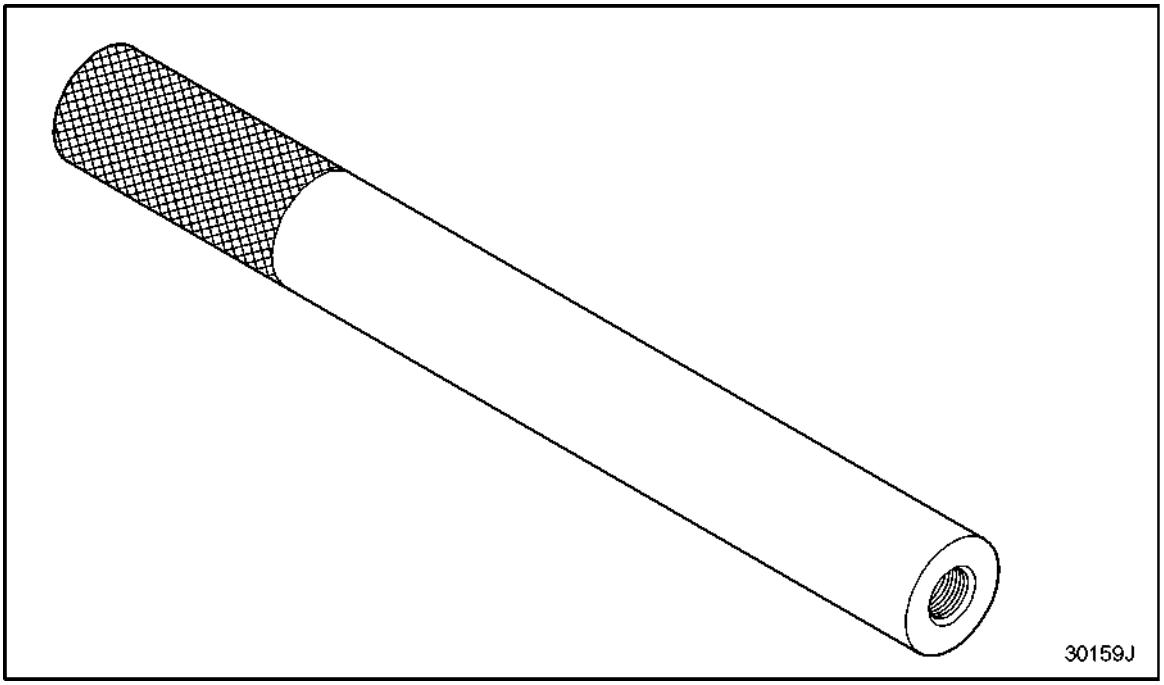


Figure 1919 Driver Handle J 3154-1A

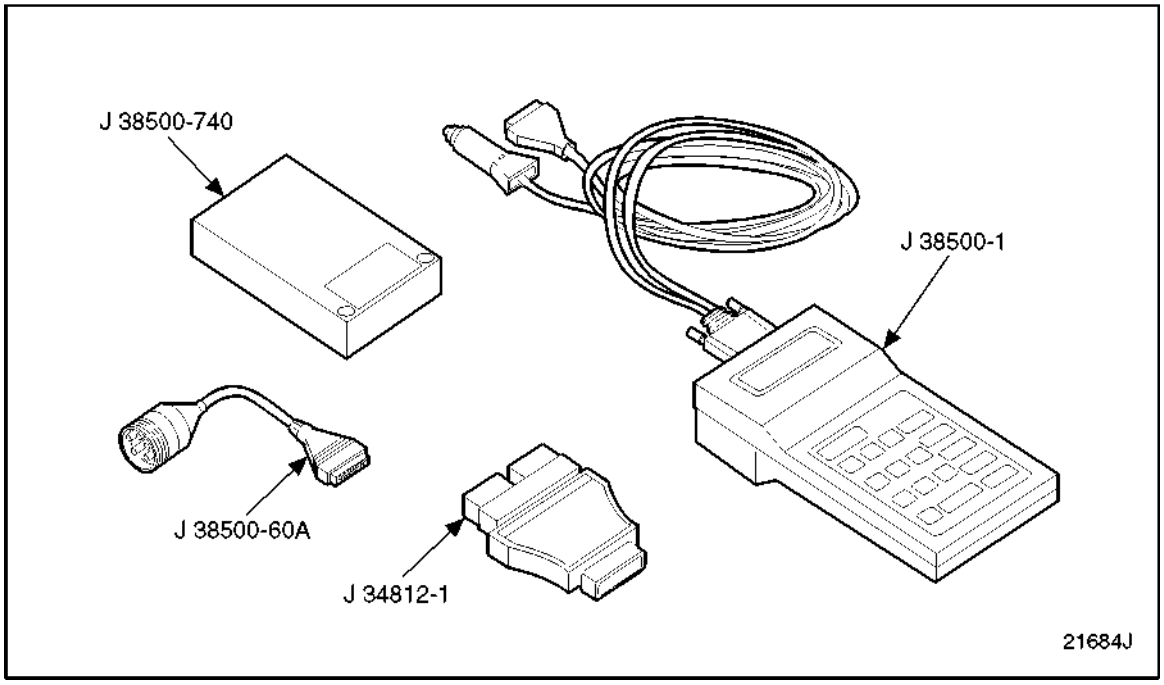


Figure 1920 Pro-Link for DDEC III and IV J 38500-H

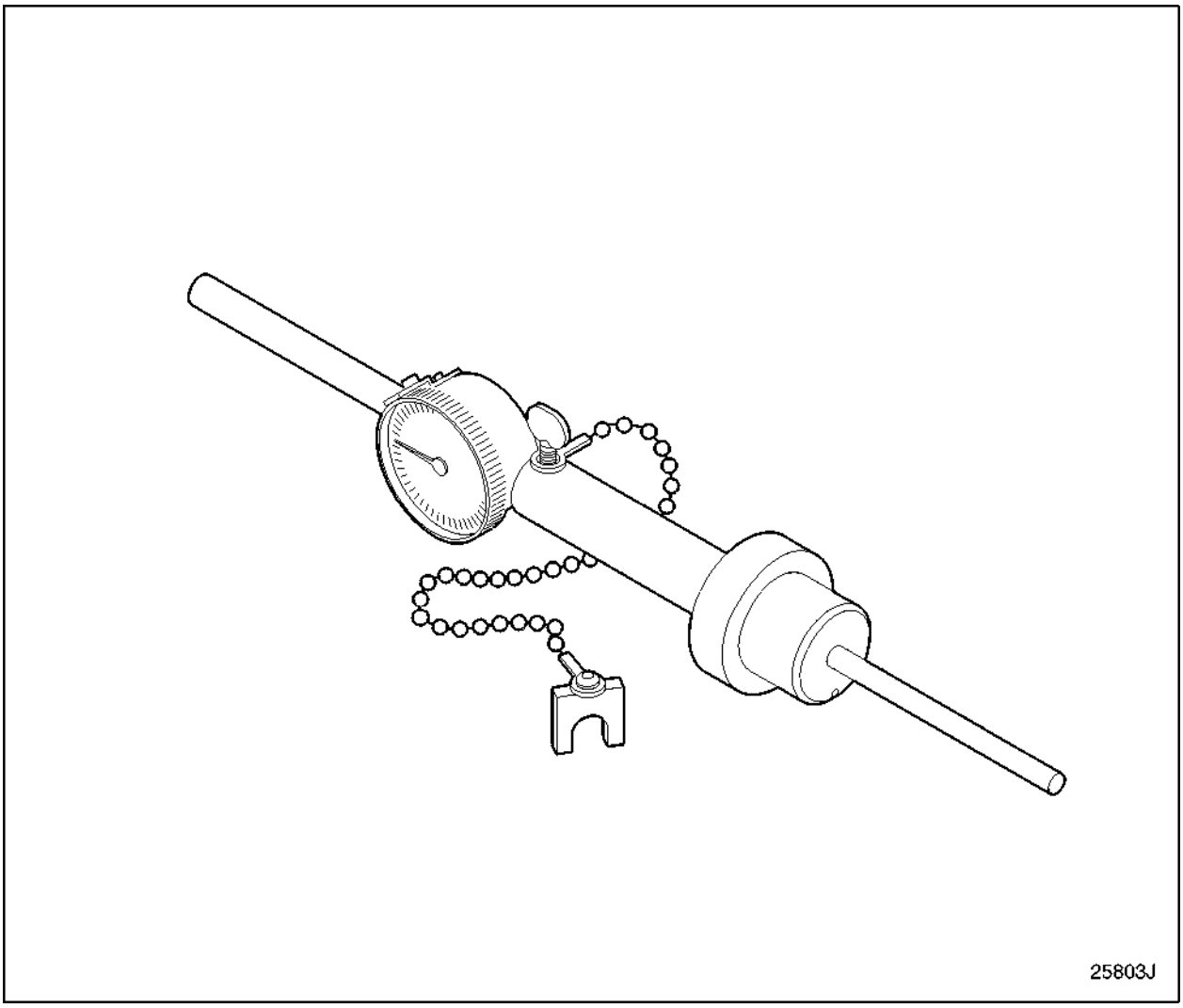


Figure 1921 Crankshaft Position Timing Tool J 34930-A

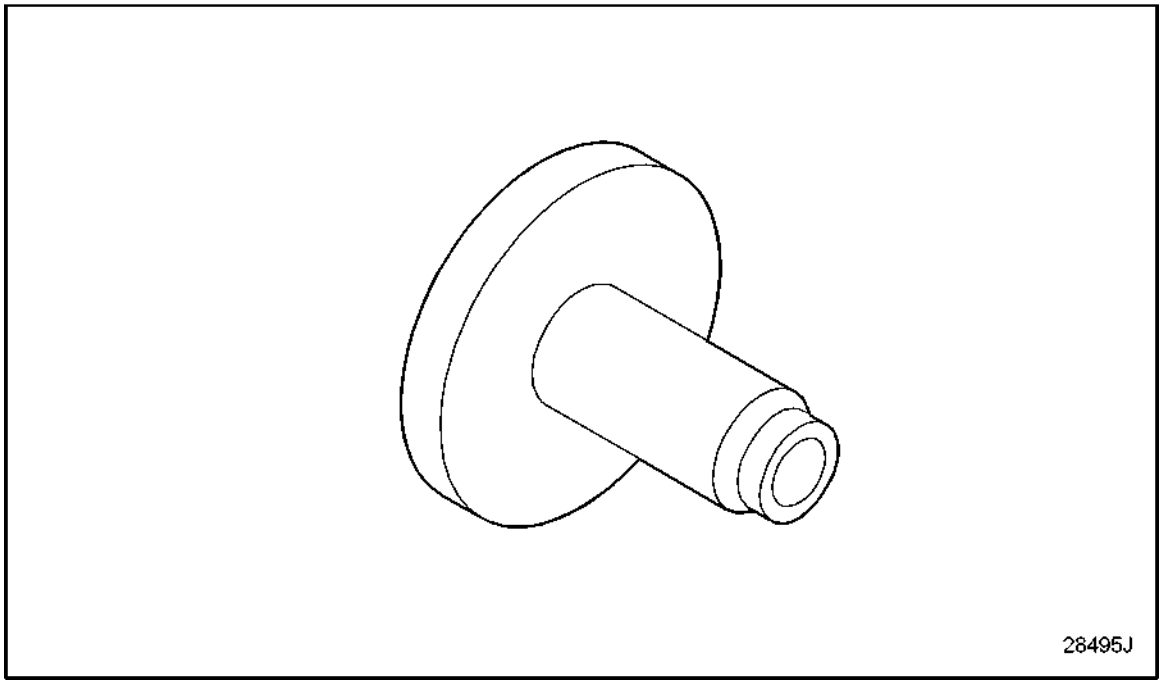


Figure 1922 Water Pump Drive Gear Installer J 25257

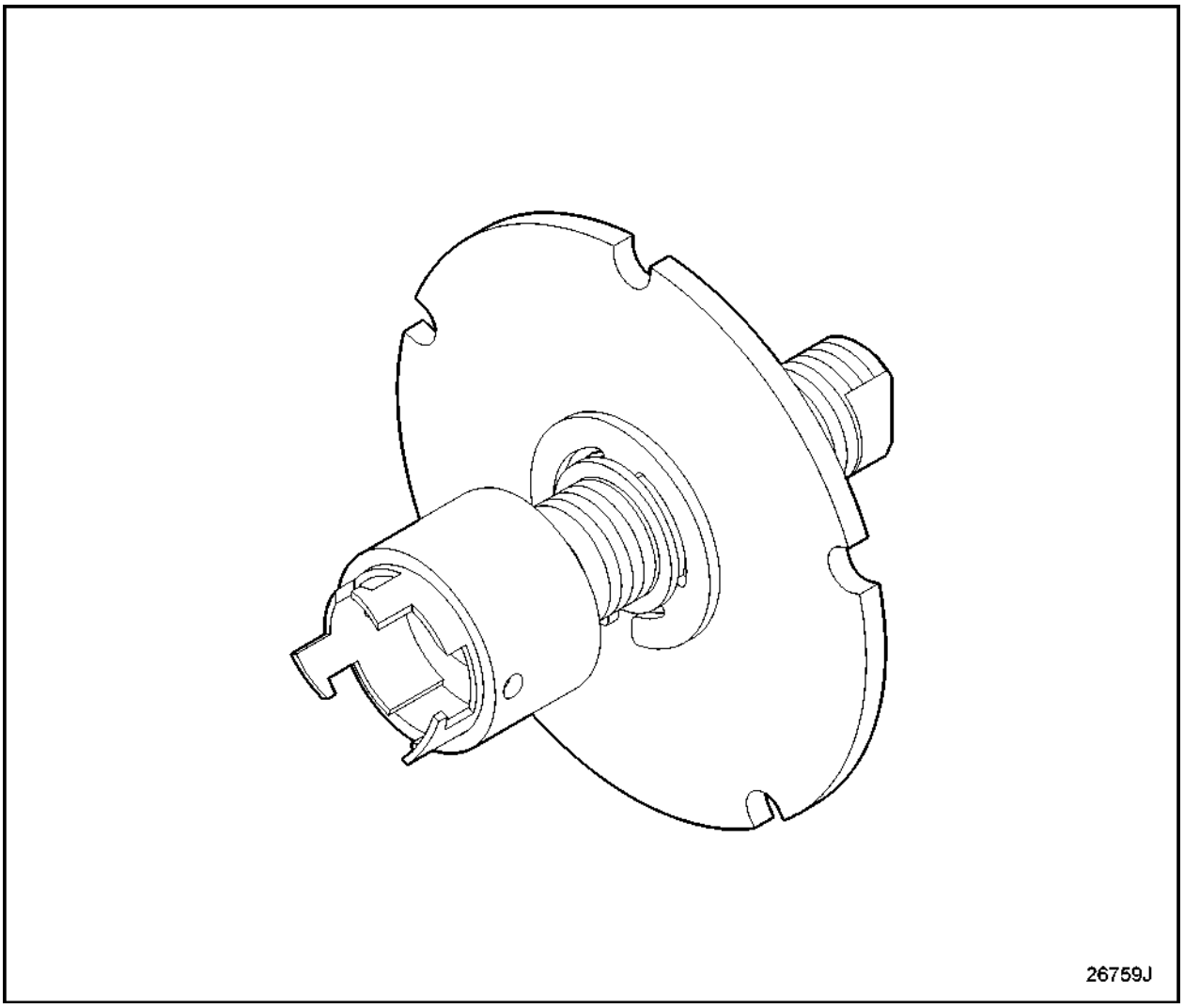


Figure 1923 Water Pump Seal Remover J 22150-B

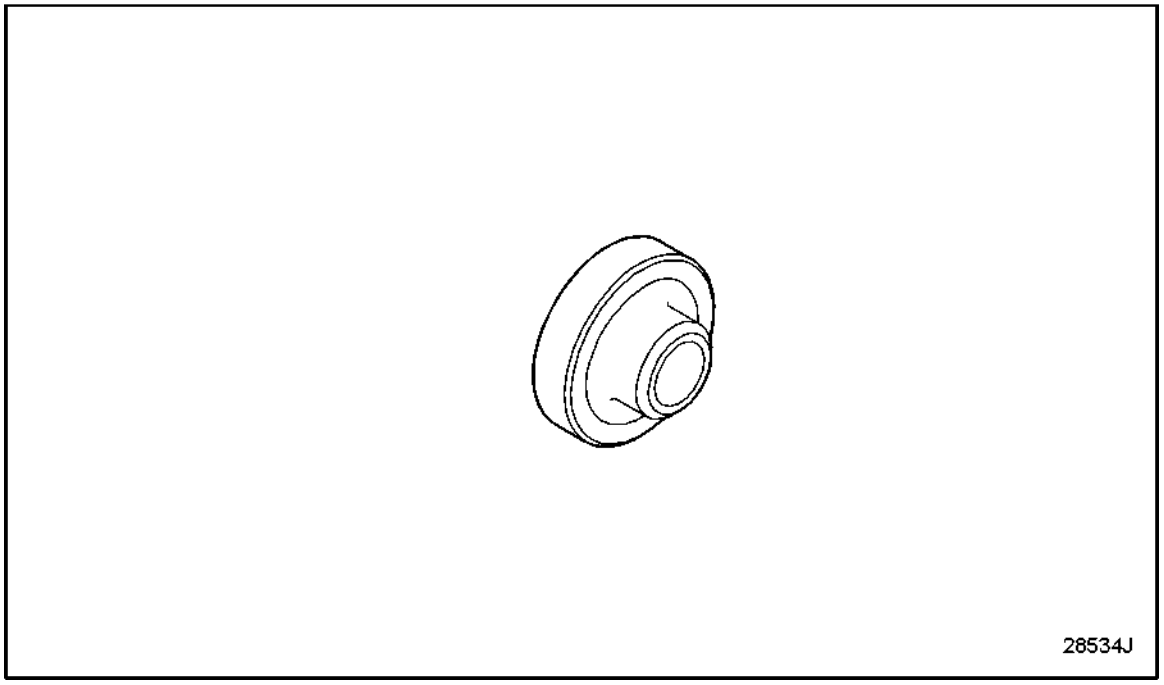


Figure 1924 Water Pump Seal Remover J 8501

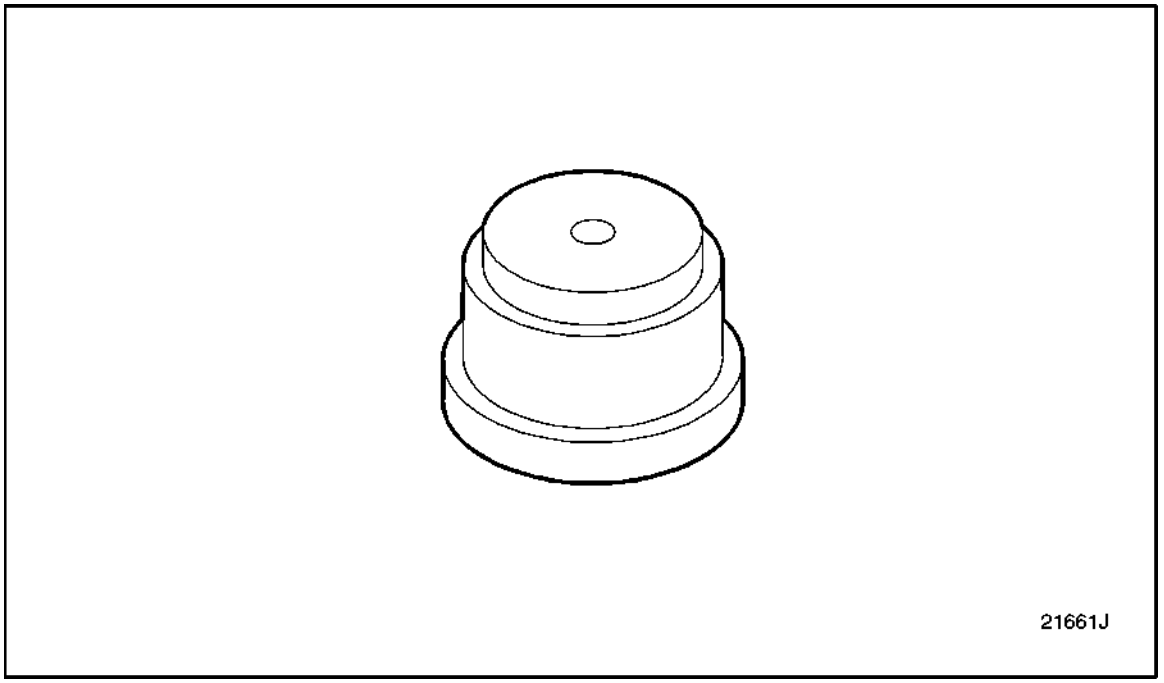


Figure 1925 Thermostat Seal Installer J 8550

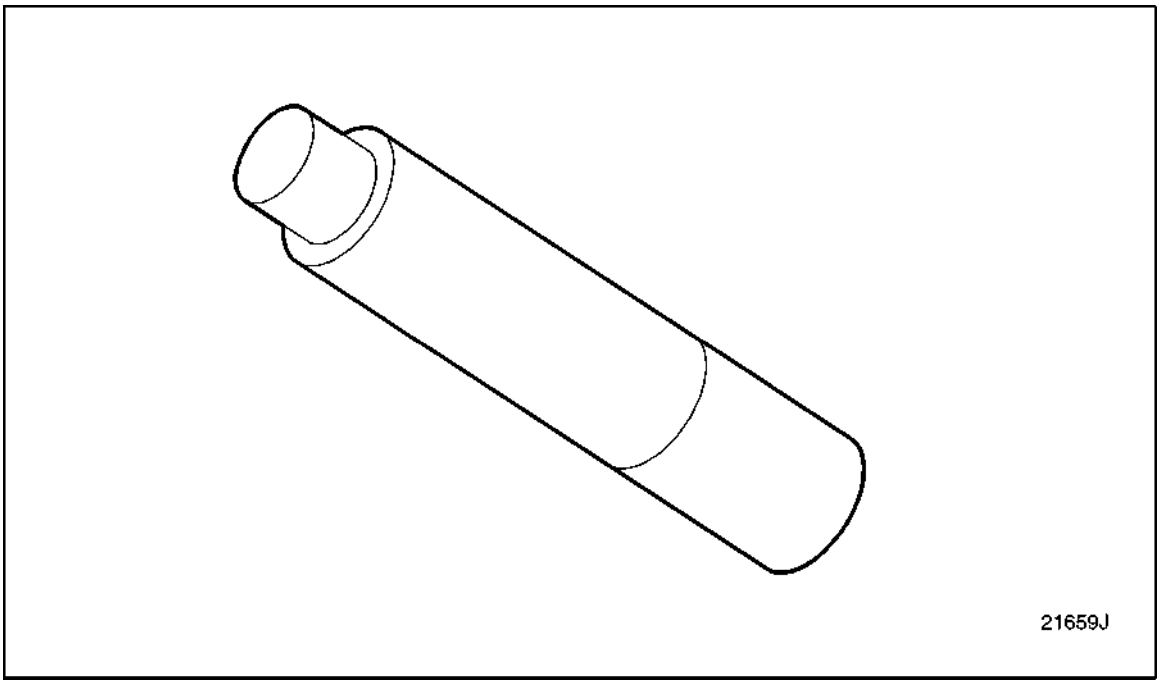


Figure 1926 Driver Handle J 7079-2

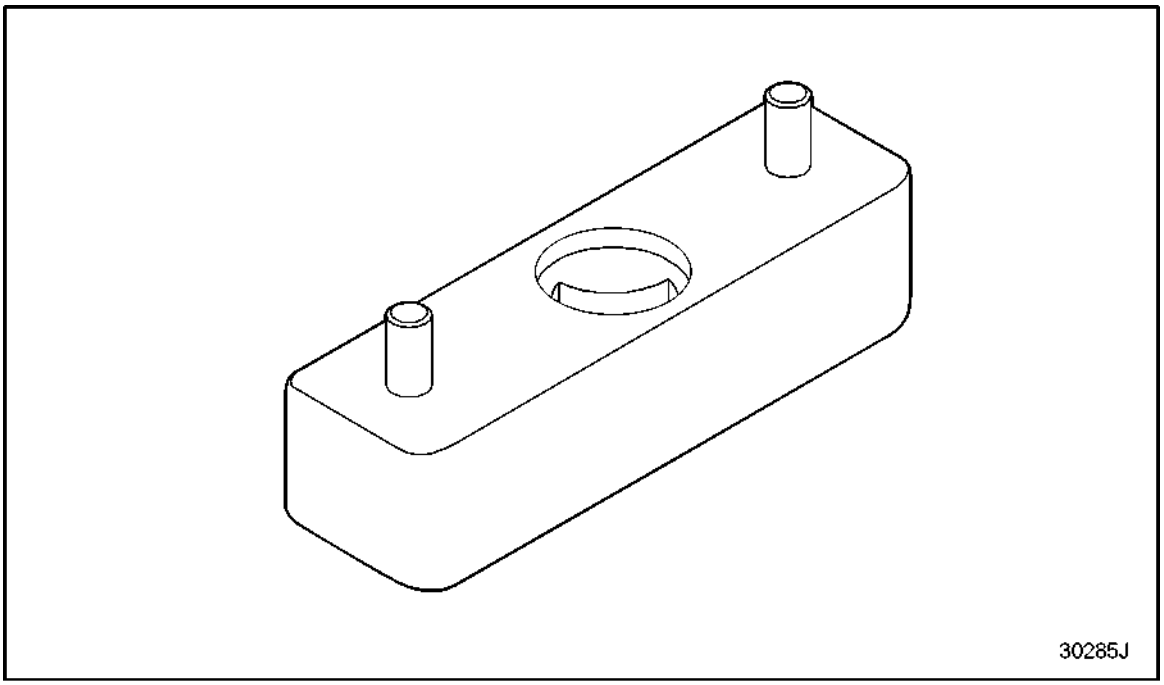


Figure 1927 Impeller Slip Test Adaptor J 33765

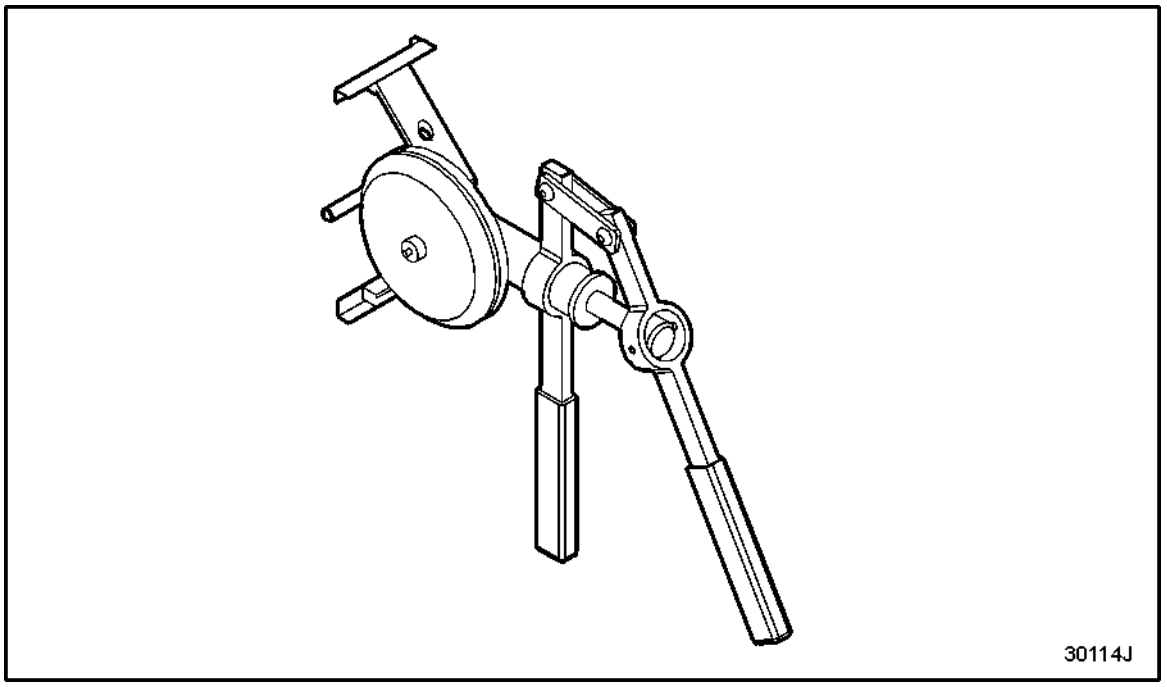


Figure 1928 Belt Tension Gage (Poly-Vee Belts) J 23586

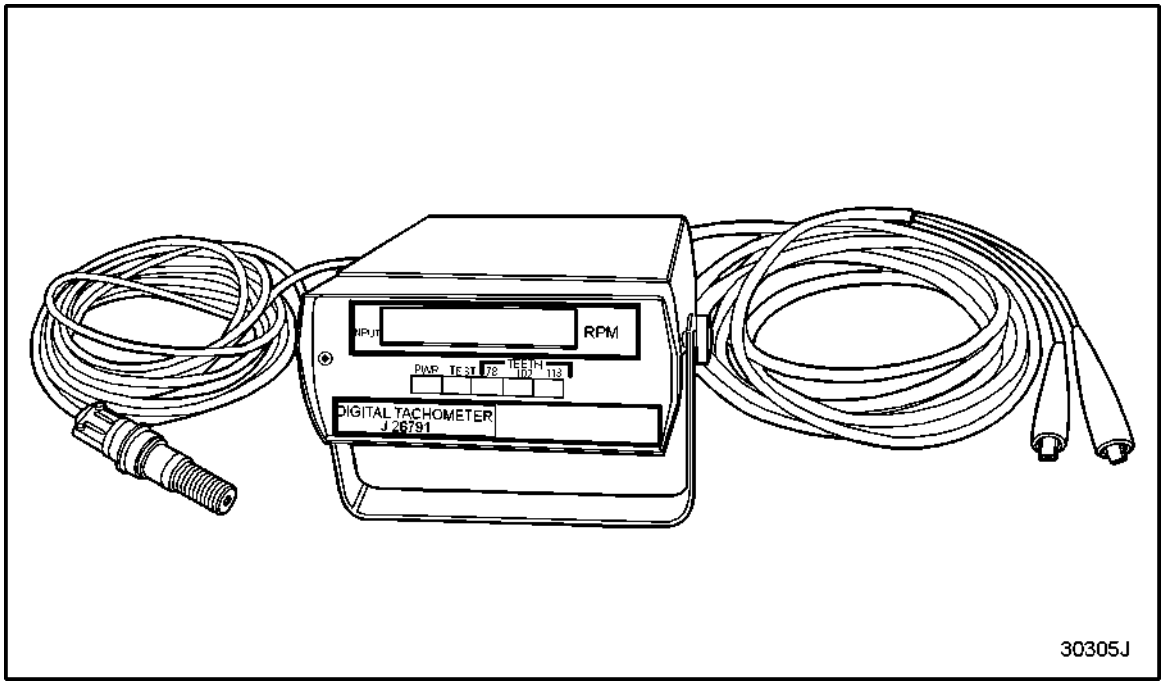


Figure 1929 Digital Tachometer J 26791

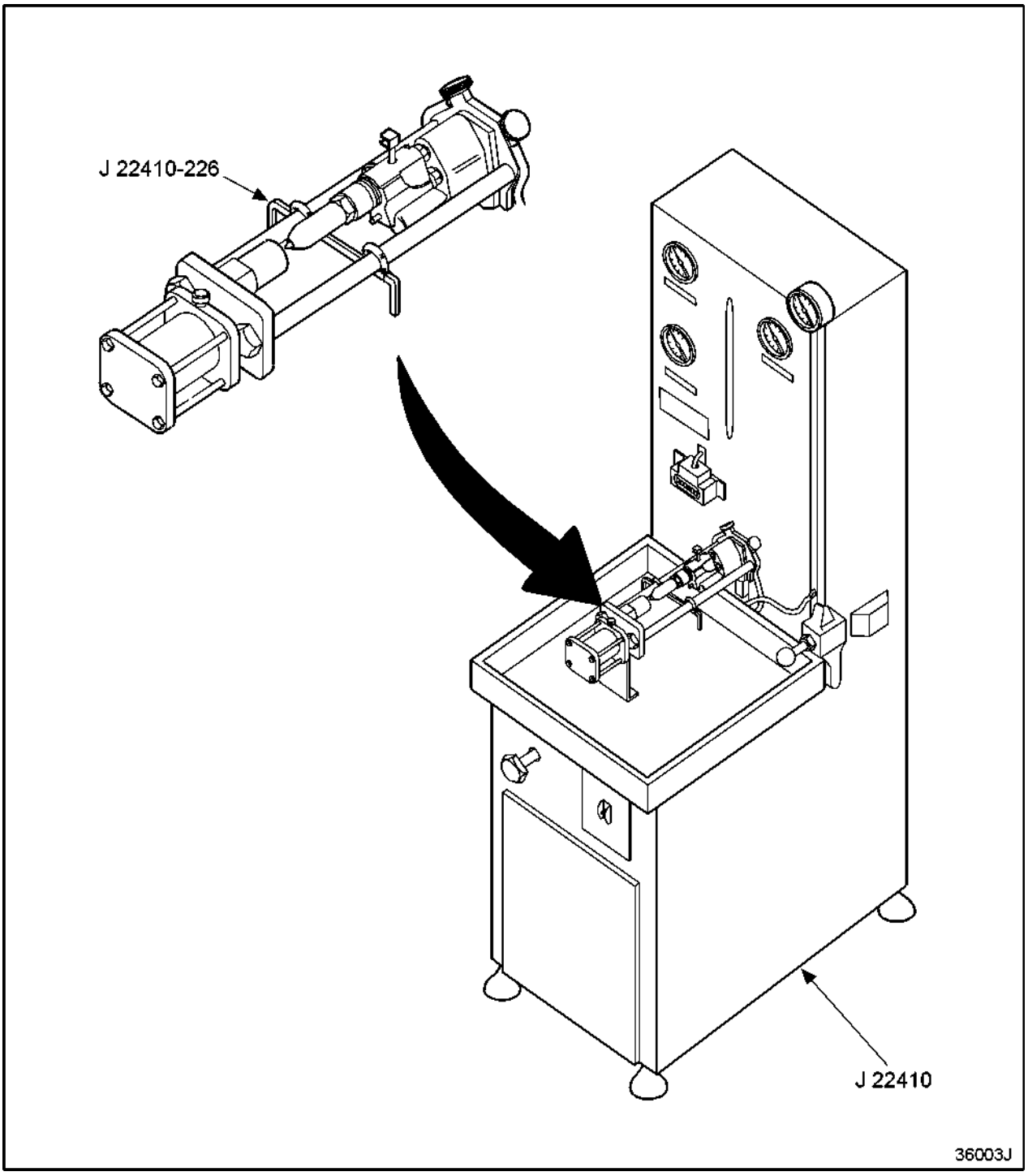


Figure 1930 Injector Calibrator and Injector Seat J 22410

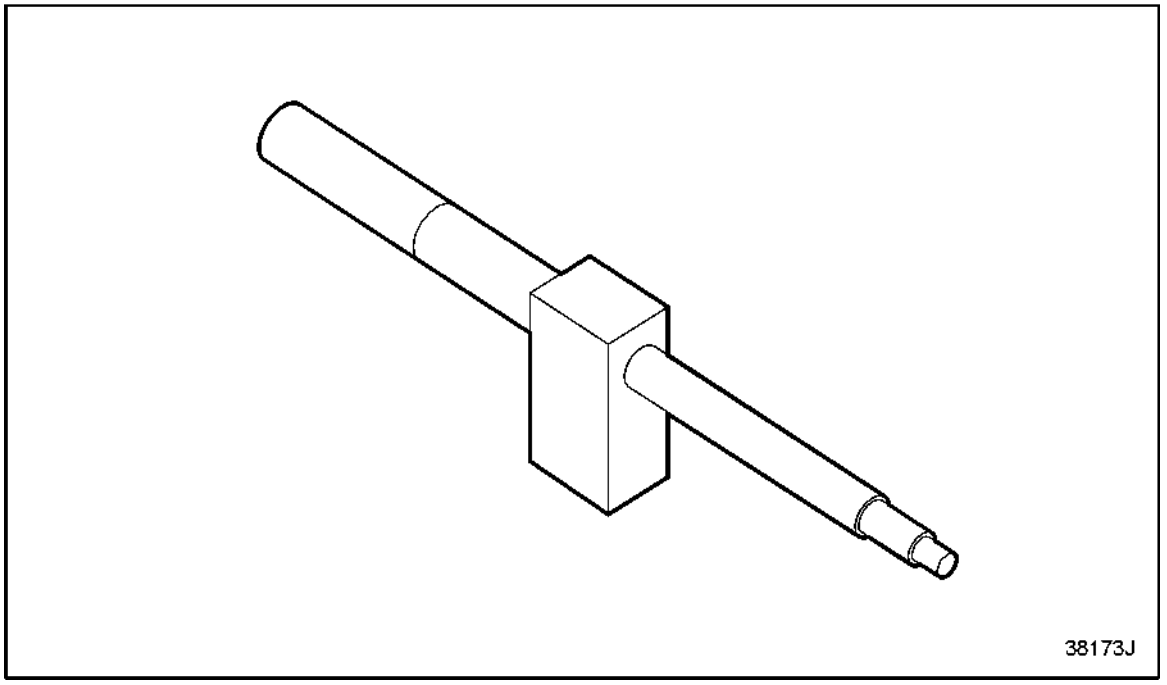


Figure 1931 Injector Timing Gage 1.540 J 44191

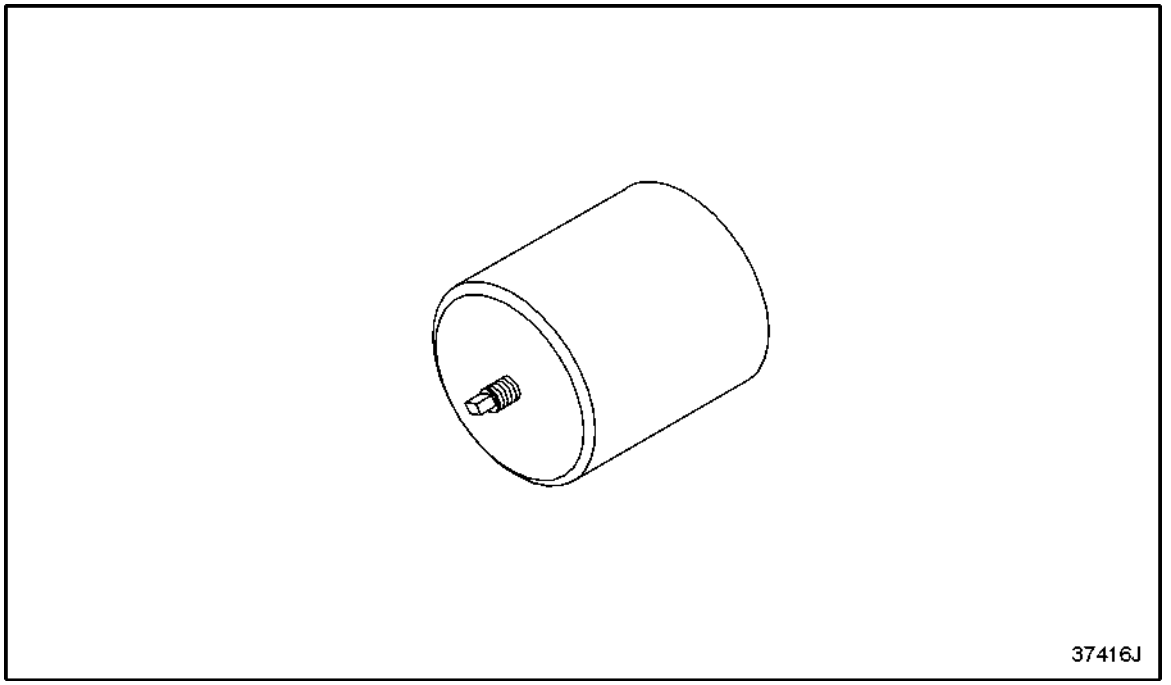


Figure 1932 Alignment Tool J 43394

D – TOLERANCE AND WEAR LIMITS

D 000 – GENERAL INFORMATION

Section **Page**

General Information

The tolerances and wear limits indicated in this publication are intended as a guide for the examination of engine components during inspection and repair. Listed in Table 1 and listed in Table 2 are the explanation of terms for dimensions of new components and reconditioning and operational limits.

Terms for Dimensions of New Components	Explanation
Tolerance size	Designed size followed by a letter or number symbol (e.g. 24^{H6}) or by the permissible dimensional deviation (e.g. $24^{+0.013}$)
Basic size	Designed size without fit symbol or quotation of dimensional deviation
Deviation	Permissible deviation from the basic or tolerance size, indicated by the upper and lower limits
Clearance	Difference between bore and shaft diameters when bore diameter is greater than shaft diameter
Interference	Difference between bore and shaft diameters when bore diameter is smaller than shaft diameter

Table 1 Explanation of Terms — Dimensions

Terms for Reconditioning and Operational Limits	Explanation
Wear Limit	The limit dimensions specified do not represent the absolute maximum values permissible for satisfactory engine operation. They indicate that the next basic overhaul can be reached safely. If a limit value is exceeded, the component must be replaced.
Reconditioning Instructions	If values exceed or drop below limit values, the components must be reconditioned in accordance with the relevant reconditioning instructions or replaced.

Table 2 Explanation of Terms — Reconditioning and Operational Limits

Deviations from roundness, cylindricity, parallelism and alignment must be within specified limit values, unless exceptions are specifically indicated.

All dimensions are given in mm (in.), unless alternative units of measurement are specifically indicated.

D 010 – CYLINDER LINER

Section **Page**

Cylinder Liner without Scraper Ring

See Figure 1067 for a general view and listed in Table 3 are the tolerance and wear limits for the cylinder liner without scraper ring.

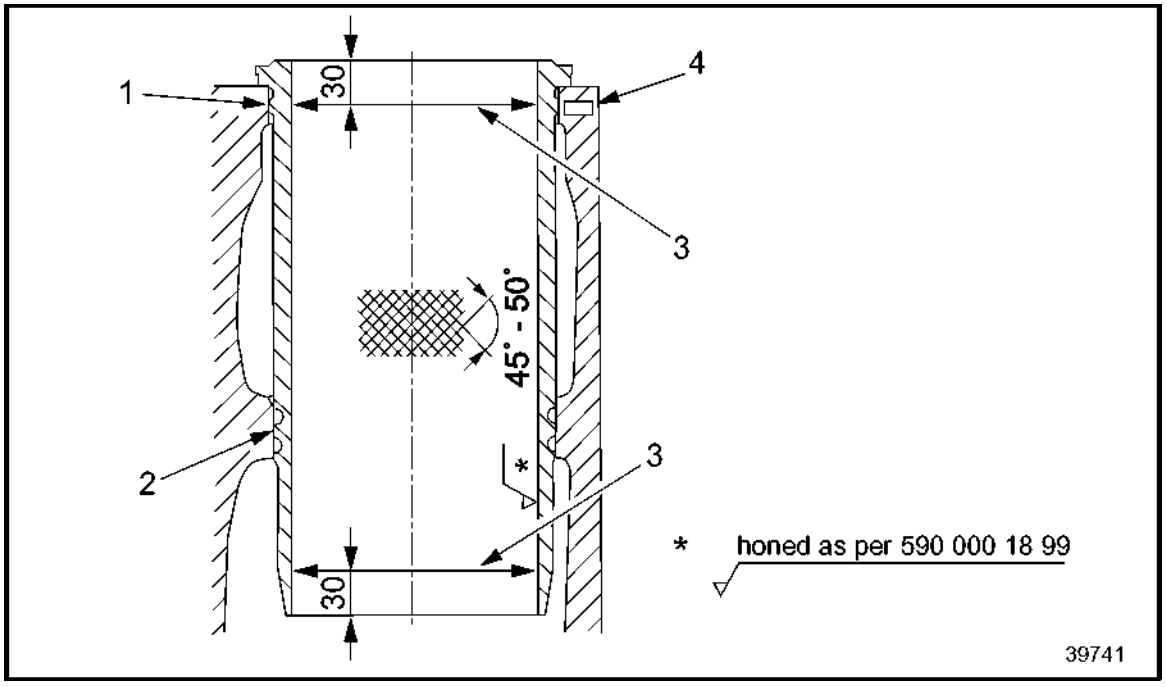


Figure 1067 Cylinder Liner

No.	Designation	Stage	Tol. Size	Deviation		Clearance		Interference	
				Lower	Upper	Min	Max	Min	Max
1	Housing bore - upper fit	0	193.0^{H7}	0	+ 0.046	-	0.059	-	0.016
		1	193.5^{H7}						
		2	194.0^{H7}						
	Cylinder liner - upper fit	0	193.0_{j6}	– 0.013	+ 0 .016				
		1	193.5_{j6}						
		2	194.0_{j6}						
2	Housing bore - lower fit	0	189.0^{H7}	0	+ 0.046	0.050	0.125	-	-
		1	189.5^{H7}						
		2	190.0^{H7}						
	Cylinder liner - lower fit	0	189.0_{f6}	– 0.079	– 0.050				
		1	189.5_{f6}						
		2	190.0_{s6}						
3	Bushing bore - installed	-	165.0^{H7}	0	+ 0.040	-		-	
4	Marking for stage								

Reconditioning Instructions

Re 1 and 2: In event of cavitation at upper and/or lower fit of cylinder block bore: introduce next repair stage and install cylinder liner of corresponding stage

Re 4: Marking with numeral punches 6mm (0.236 in.) high

— For Stage 1: 0.5

— For Stage 2: 1.0

Table 3 Cylinder Liner without Scraper Ring Tolerance Limits

Cylinder Liner with Scraper Ring

See Figure 1068 for a general view and listed in Table 4 are the tolerance specifications for the cylinder liner with scraper ring.

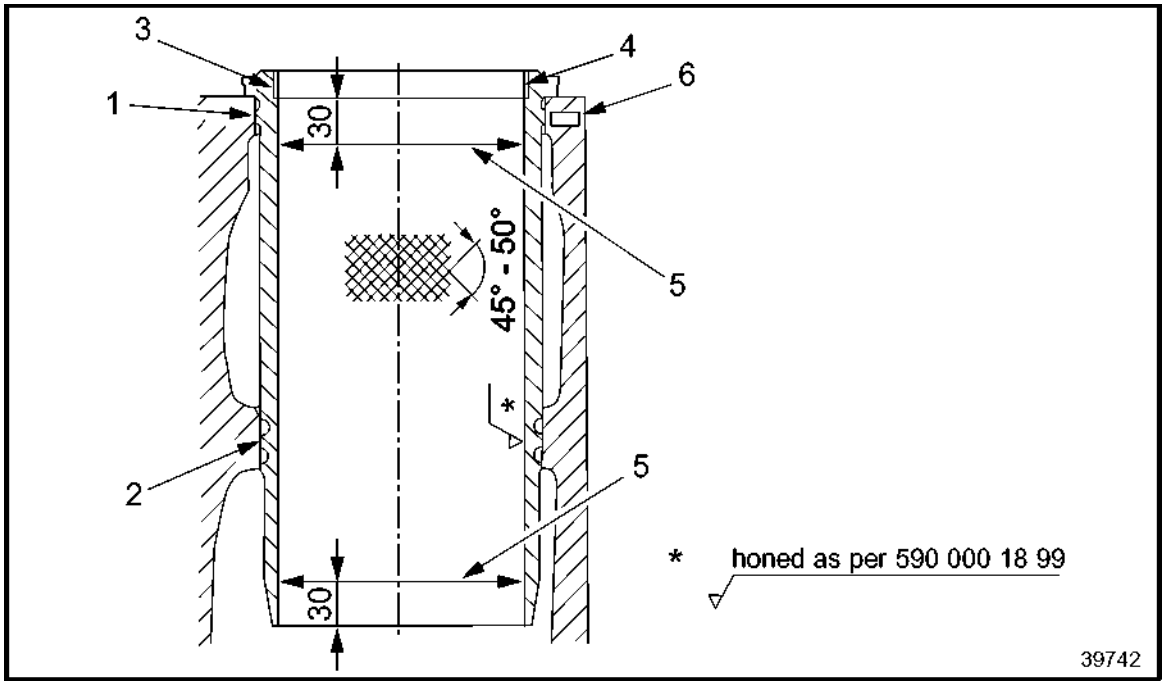


Figure 1068 Cylinder Liner with Scraper Ring

No.	Designation	Stage	Tol. Size	Deviation		Clearance		Interference	
				Lower	Upper	Min	Max	Min	Max
1	Housing bore - upper fit	0	196.0^{H7}	0	+ 0.046	-	0.059	-	0.016
		1	196.5^{H7}						
		2	197.0^{H7}						
	Cylinder liner - upper fit	0	196.0_{j6}	– 0.013	+ 0.016				
		1	196.5_{j6}						
		2	197.0_{j6}						
2	Housing bore - lower fit	0	189.0^{H7}	0	+ 0.046	0.050	0.125	-	-
		1	189.5^{H7}						
		2	190.0^{H7}						
	Cylinder liner - lower fit	0	189.0_{f6}	– 0.079	– 0.050				
		1	189.5_{f6}						
		2	190.0_{s6}						
3	Bushing bore	-	170.0^{H7}	0	+ 0.050	0.014	0.104	-	-
	Scraper ring OD	-	170.0_{g7}	– 0.054	– 0.014				
4	Scraper ring bore	-	164.0^{H8}	0	+ 0.063	-	-	-	-
5	Bushing bore installed	-	165.0^{H7}	0	+ 0.040	-	-	-	-
6	Marking for stage								

Reconditioning Instructions

Re 1 and 2: In event of cavitation at upper and/or lower fit of cylinder block bore: introduce next repair stage and install cylinder liner of corresponding stage

Re 3 and 4: Check scraper ring OD and ID when fitted

Re 6: Marking with numerical punches 6mm (0.236 in.) high

— For Stage 1: 0.5

— For Stage 2: 1.0

Table 4 Cylinder Liner with Scraper Ring Tolerance Limits

Main Bearing Cap

See Figure 1069 for a view of the main bearing cap and listed in Table 5 are the tolerance specifications for the main bearing cap.

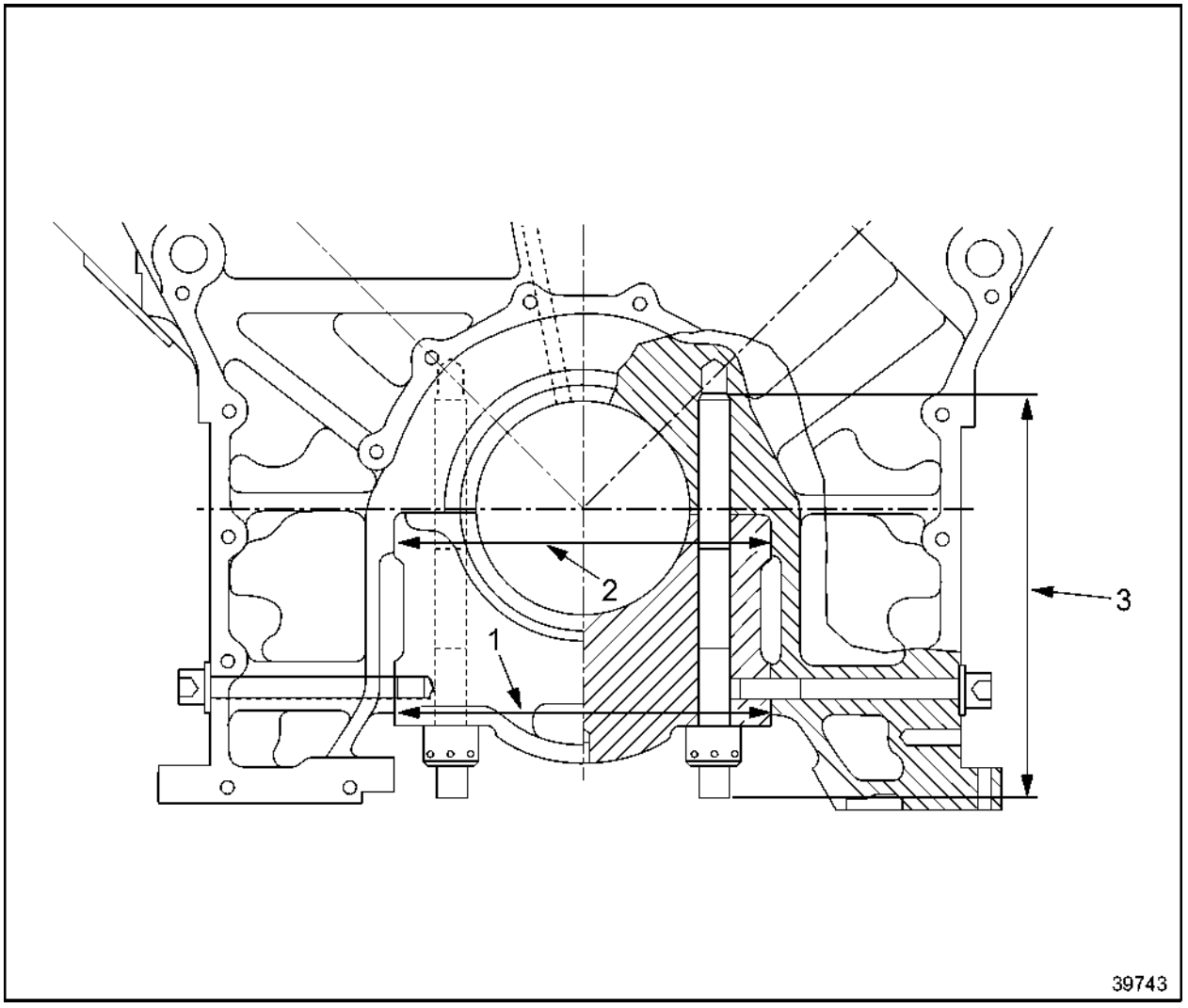


Figure 1069 Main Bearing Cap

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Bearing cap gap	298.0^{E9}	+ 0.110	+ 0.240	0.022	0.184	-	-
	Bearing cap width	298.0_{p6}	+ 0.056	+ 0.088				
2	Bearing cap gap	298.0^{H7}	0	+ 0.052	-	-	0.004	0.088
	Bearing cap width	298.0_{p6}	+ 0.056	+ 0.088				
3	Bolt length	348.0	– 0.500	+ 0.500	-	-	-	-

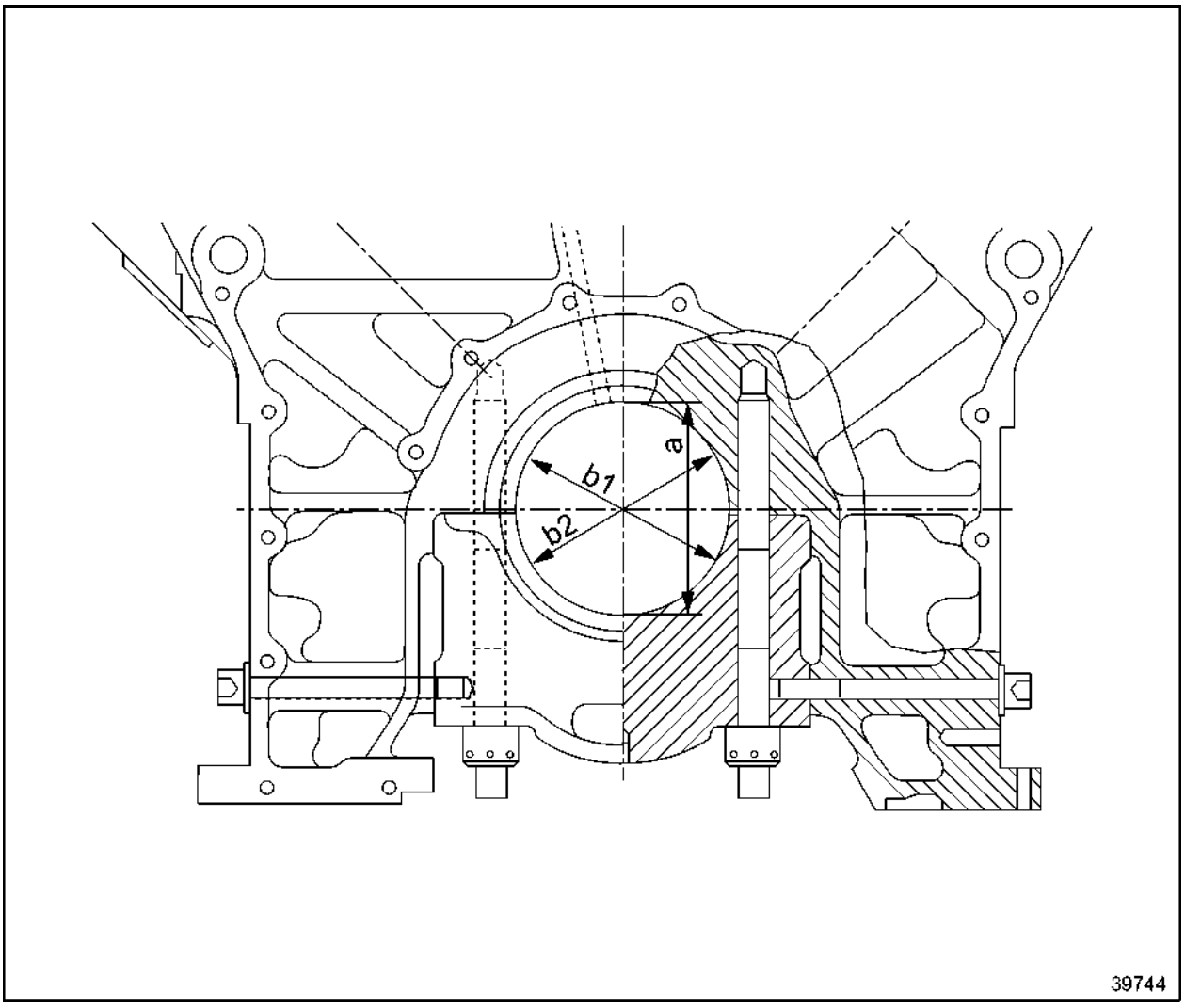
NOTE:

Re: Install bearing cap as specified and torque screws as per tightening specification; refer to section A 003 A 003

Table 5 Main Bearing Cap Tolerance Specifications

Main Bearing Bore

See Figure 1070 for a view of the main bearing bore.



Install crankshaft bearing cap in cylinder block (refer to section C 031.05.11 A 003) and torque bolts; refer to section A 003 C 031.05.11.

Measure main bearing bores:

- ☐ Determine diameters a, b1, and b2 each in 2 measuring planes and from the results determine the mean values of a, b1, and b2.

Check roundness of bores:

- ☐ Possible deviations from roundness result from the mean values of a, b1, and b2 in accordance with the equation 0.5 (b1 + b2) – a

Vertical ovality — a value greater than 0.5 (b1 + b2) is not permissible.

Figure 1070 Main Bearing Bore

Coaxial Tolerance of Cylinder Block Bores for Crankshaft Bearings

See Figure 1071 for a view of the coaxial tolerance points for the cylinder block bores and crankshaft bearings and listed in Table 6 are the maximum coaxial deviations.

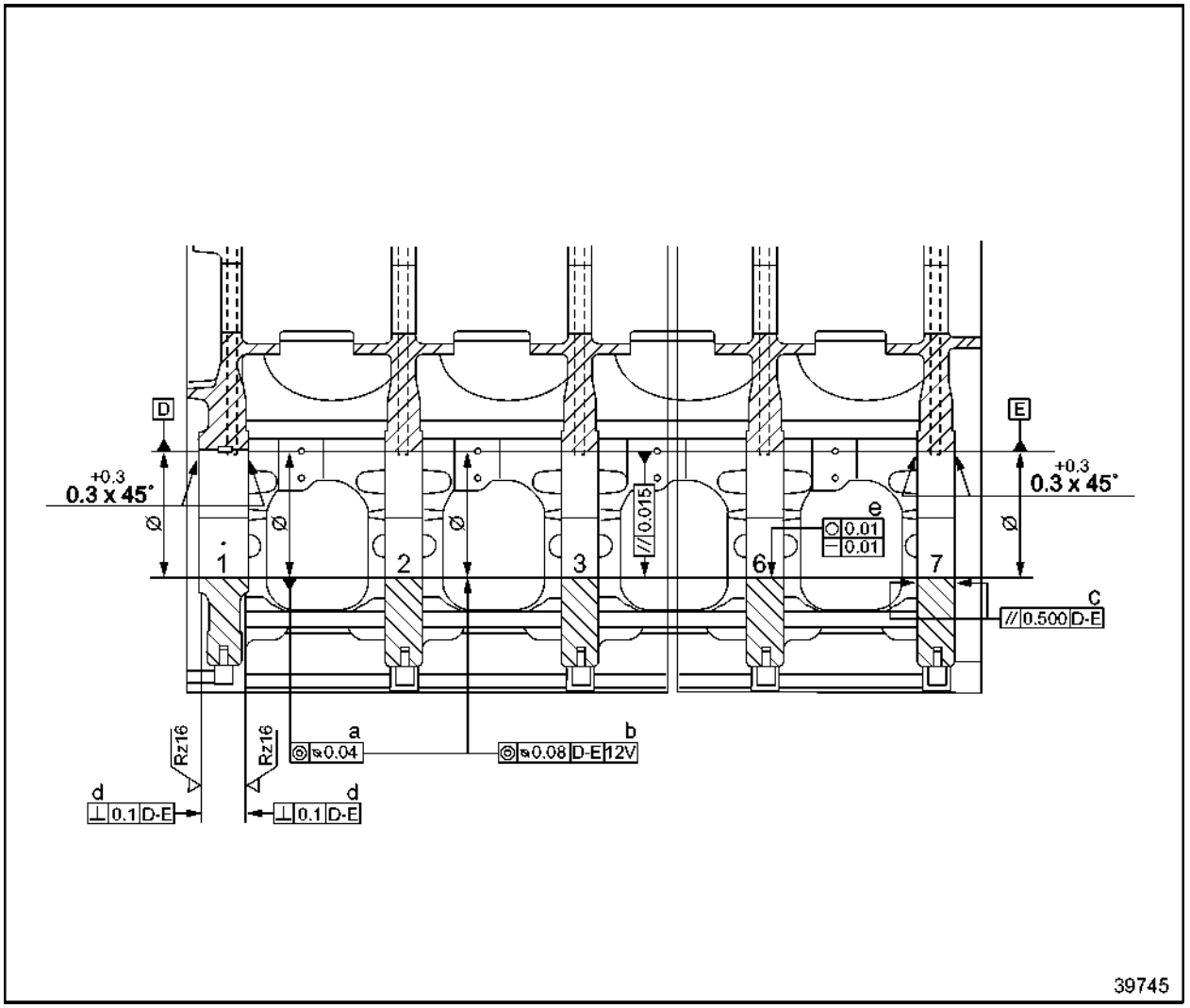


Figure 1071 **Coaxial Tolerance of Cylinder Block Bores for Crankshaft Bearings**

Maximum Permissible Coaxial Deviation	New Condition
a - with adjacent left and right bearings	Diameter 0.040
b - from main bearing 1 to 7	Diameter 0.080
c - applicable for all bearings	// 0.500
d - applicable for all bearings	⊥ 0.100
e - applicable for all bearings, not concave	O 0.010 _ 0.010
f - applicable for all bearings	// 0.015

Table 6 Maximum Permissible Coaxial Deviation

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.

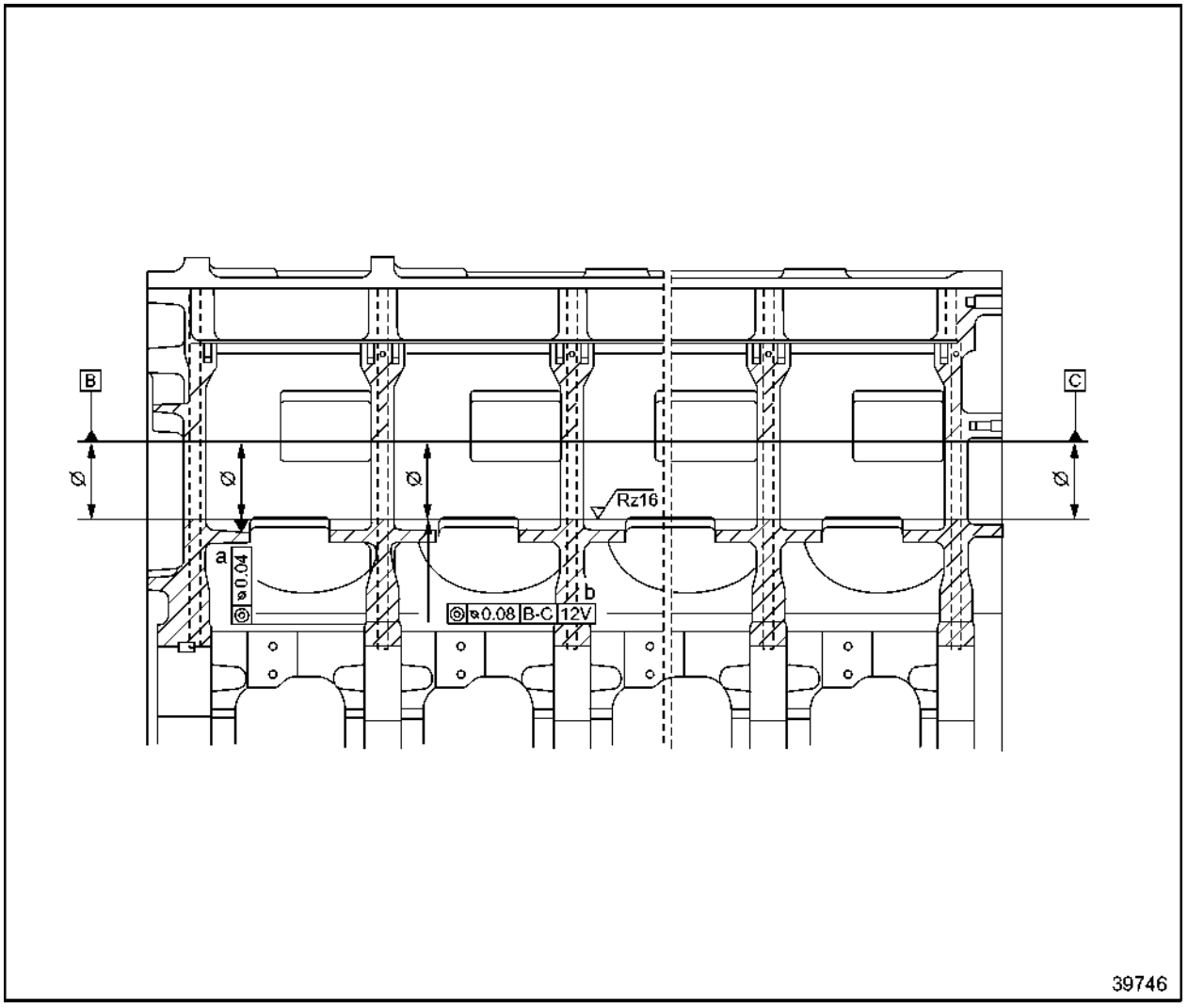


Figure 1072 Coaxial Tolerance Points of Cylinder Block Bores for Camshaft Bearings

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

Free End Idler Gear

See Figure 1073 for a view of the free end idler gear and listed in Table 8 are the free end idler gear tolerance specifications.

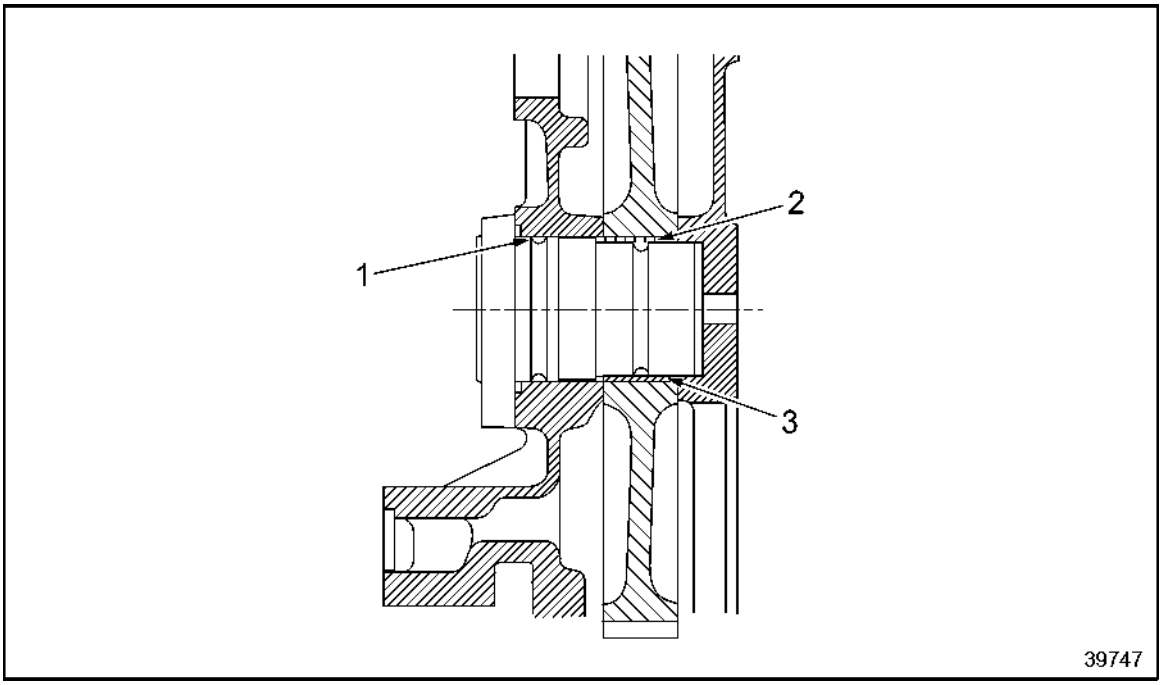


Figure 1073 Free End Idler Gear

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Equipment carrier bore	81.0^{H7}	0	+ 0.035	0	0.070	-	-
	Axle OD	81.0_{h7}	– 0.035	0				
2	Gear bore	80.0^{H7}	0	+ 0.030	-	-	0.029	0.078
	Bushing bore	80.0_{s6}	+ 0.059	+ 0.078				
3	Bushing bore	-						
	- Installed	75.0^{H8}	0	+ 0.046	0.060	0.136	-	-
	- Removed	75.0^{E6}	+ 0.060	+ 0.079				
	Axle OD	75.0_{e7}	– 0.090	– 0.060				

Table 8 Tolerance Specifications for the Free End Idler Gear

Free End Main Bearing Arrangement

See Figure 1074 for a free end main bearing arrangement view and listed in Table 9 are the tolerance specifications.

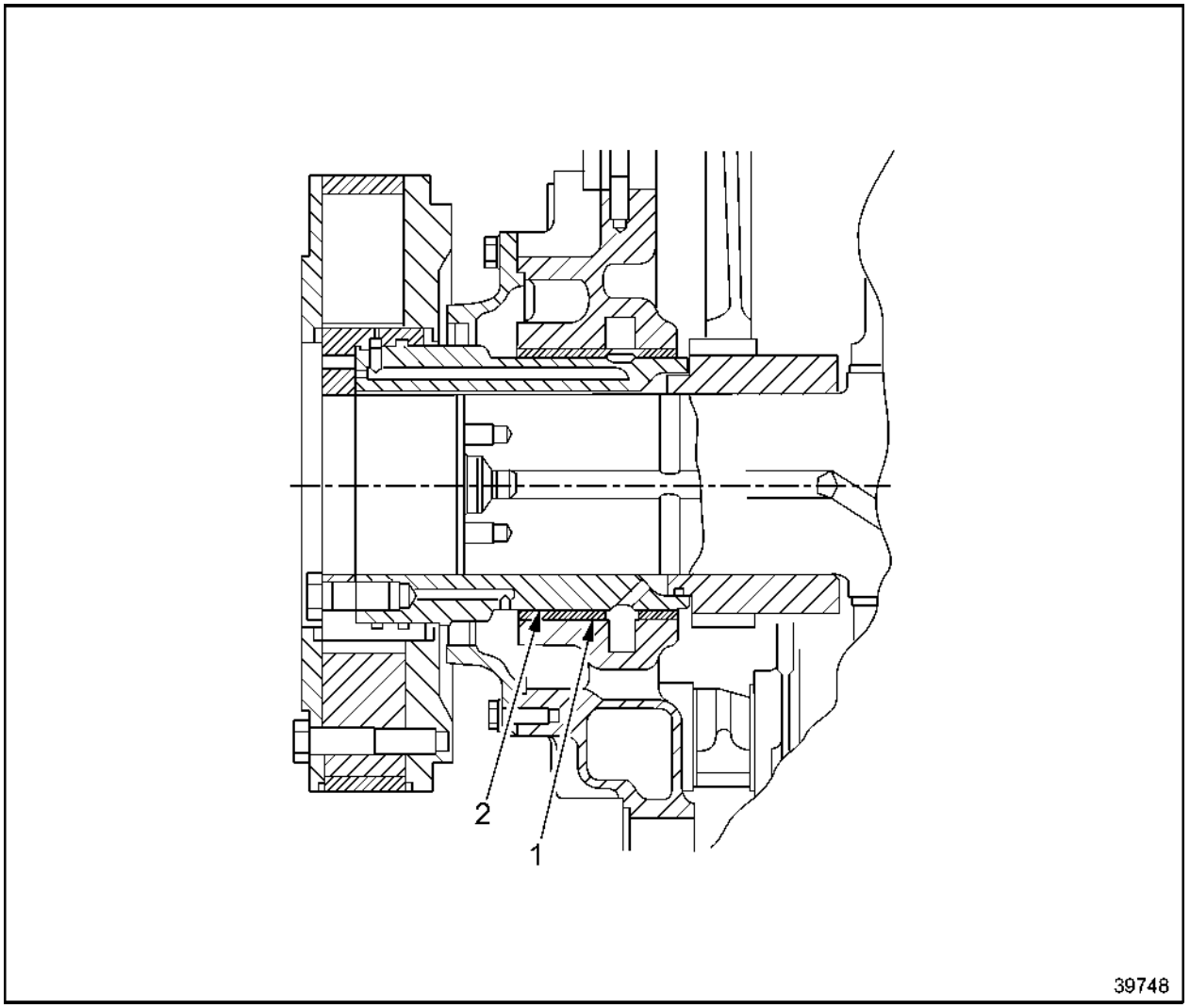


Figure 1074 Free End Main Bearing Arrangement

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Equipment carrier bore	193.000^{H6}	0	+ 0.029	-	-	0.175	0.233
	Bearing OD - removed	193.204	0	+ 0.029				
2	Bearing bushing bore - bearing fitted	180.121	0	+ 0.069	0.321	0.430	-	-
	Drive flange OD - not press-fitted	179.800_{h7}	−0.040	0				

Table 9 Main Bearing Tolerance Specifications

Free End Crankshaft Seal

See Figure 1075 for the free end crankshaft seal view and listed in Table 10 are the free end crankshaft seal tolerance specifications.

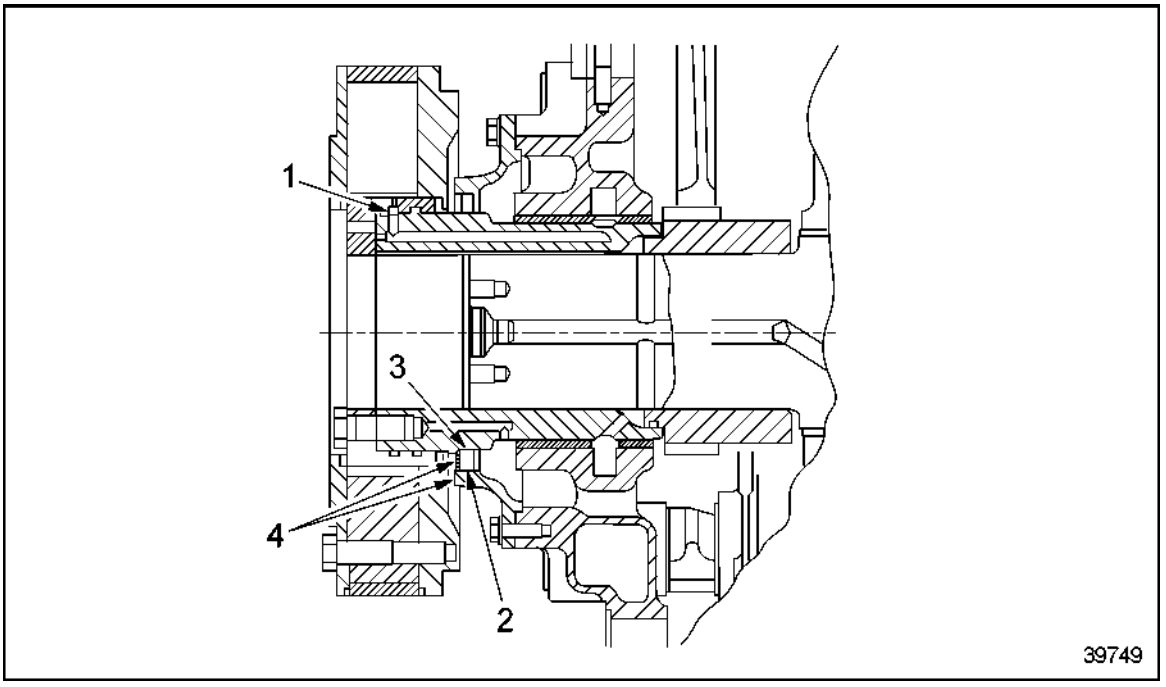


Figure 1075 Free End Crankshaft Seal

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Inner star bore	198.00 ^{H7}	0	+ 0.046	-	0.059	-	0.016
	Drive flange OD - not press fitted	198.00_{j6}	– 0.013	0.016				
2	Seal carrier bore	230.00^{H8}	0	+ 0.072	-	-	0.518	0.590
	Shaft seal OD	230.47	– 0.120	+ 0.120				
3	Running surface OD	198.80_{h8}	– 0.115	0	-	-	-	-
4	Radial-lip oil seal fitted flush							

Reconditioning Instructions

Re 3: Running surface worn: metal-spray running surface and grind using feed-in method.

Table 10 Free End Crankshaft Seal Tolerance Specifications

Main Bearing Alignment

See Figure 1076 for the main bearing alignment and listed in Table 11 are the main bearing alignment tolerance specifications.

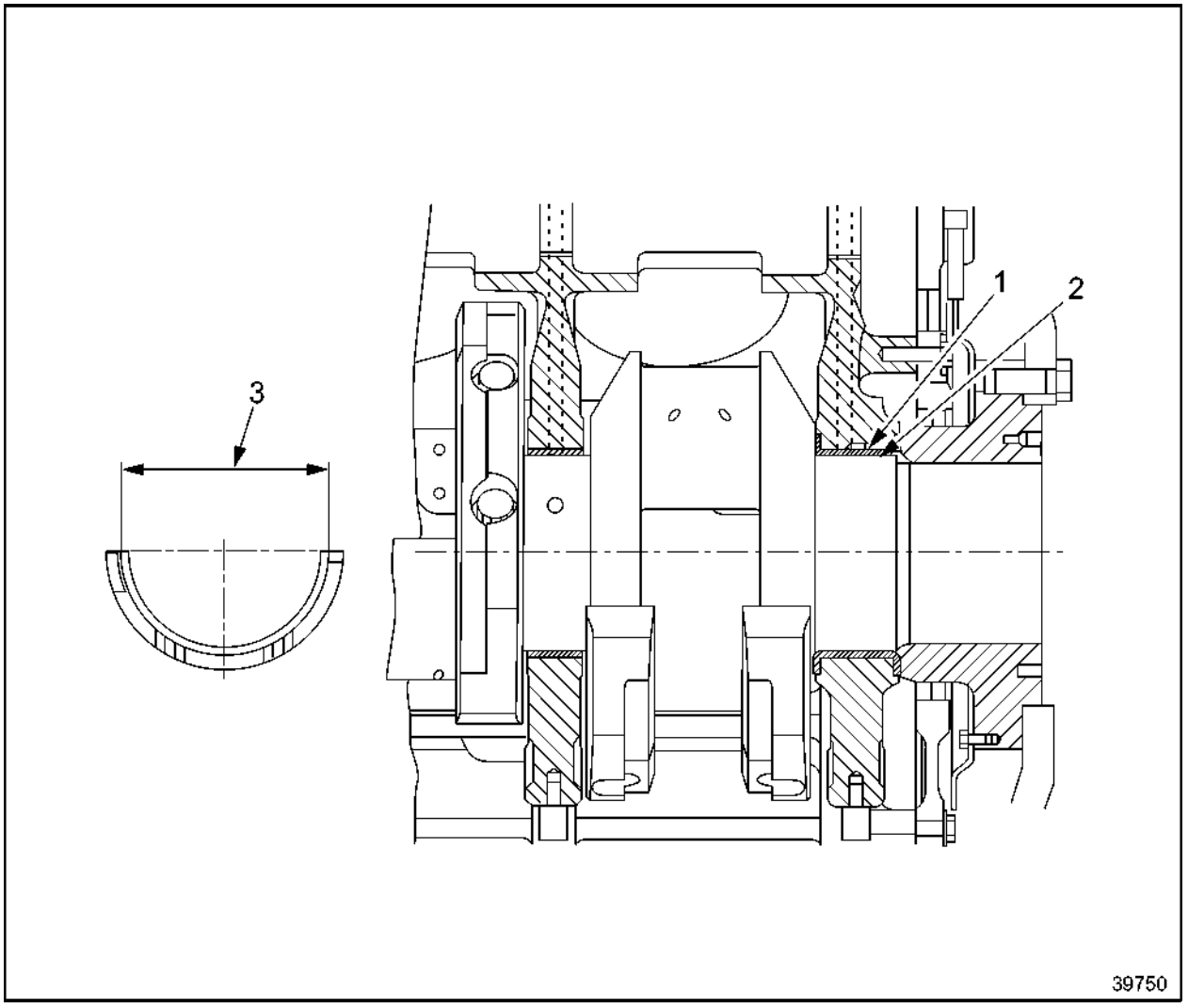


Figure 1076 Main Bearing Alignment

No.	Designation	Stage	Tol. Size	Deviation		Clearance	
				Lower	Upper	Min	Max
1	Housing bore	0-0	171.000^{H6}	0	+ 0.025	-	-
		0-1	171.000^{H6}				
		0-2	171.000^{H6}				
		0-3	171.000^{H6}				
		1-0	171.500^{H6}	0	+ 0.025		
		1-1	171.500^{H6}				
		1-2	171.500^{H6}				
		1-3	171.500^{H6}				
2	Alignment bearing diameter - installed	0-0	160.120	0	+ 0.054	0.120	0.199
		0-1	159.620				
		0-2	159.120				
		0-3	158.620				
		1-0	160.120	0	+ 0.054		
		1-1	159.620				
		1-2	159.120				
		1-3	158.620				
	Main bearing journal	0-0	160.000_{h6}	– 0.025	0		
		0-1	159.500_{h6}				
		0-2	159.000_{h6}				
		0-3	158.500_{h6}				
		1-0	160.000_{h6}	– 0.025	0		
		1-1	159.500_{h6}				
		1-2	159.000_{h6}				
		1-3	158.500_{h6}				
3	Spreading dimension, alignment bearing - Upper Half - Lower Half	0-0	171.200	0	+ 0.500	-	-
		0-1	171.200				
		0-2	171.200				
		0-3	171.200				
		1-0	171.700	0	+ 0.500		
		1-1	171.700				
		1-2	171.700				
		1-3	171.700				

Table 11 Main Bearing Alignment Tolerance Specifications

Main Bearing

See Figure 1077 for a view of the main bearing tolerance points and listed in Table 12 are the tolerance values for the main bearing.

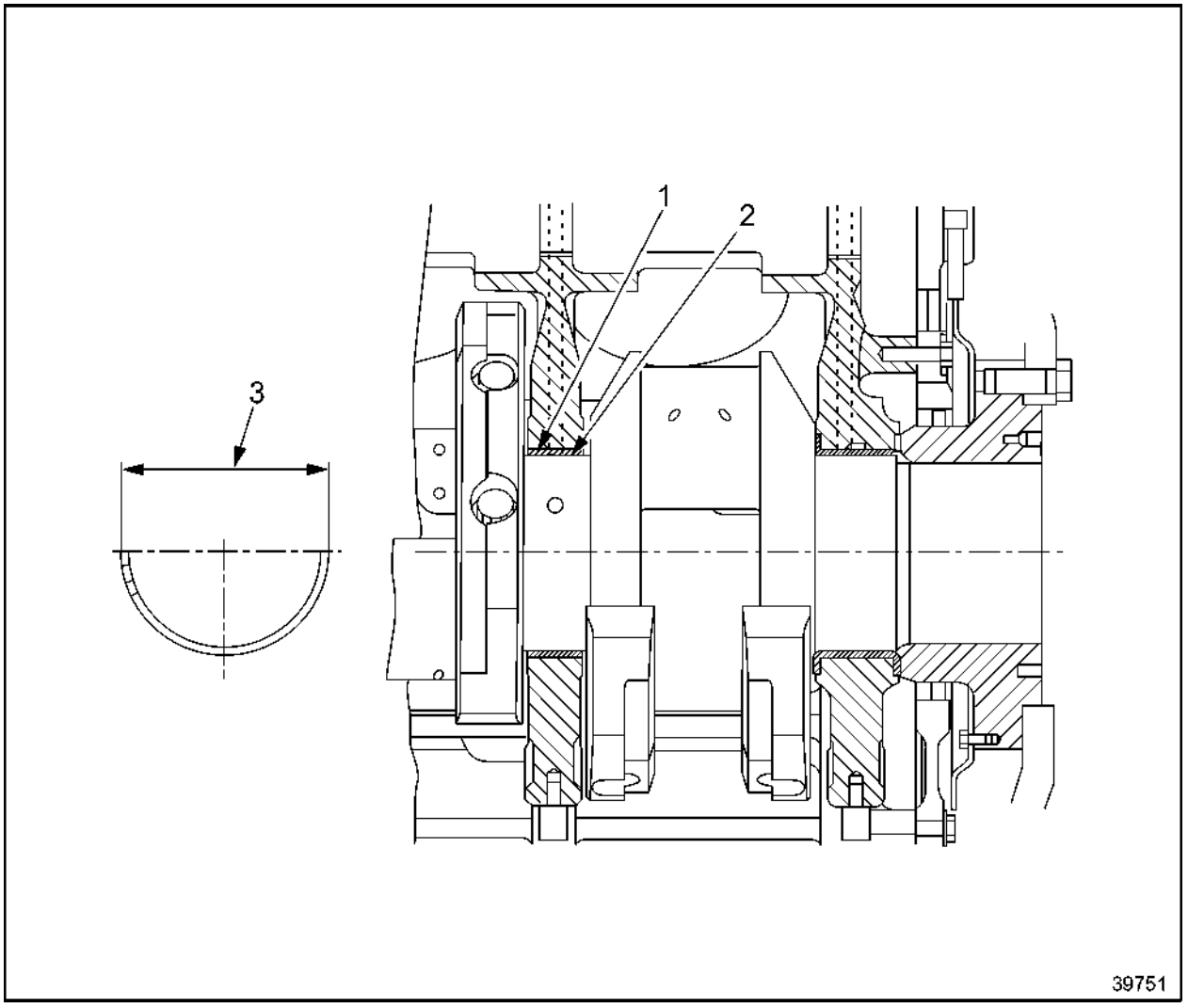


Figure 1077 Main Bearing

No.	Designation	Stage	Tol. Size	Deviation		Clearance	
				Lower	Upper	Min	Max
1	Housing bore	0-0	171.000^{H6}	0	+ 0.025	-	-
		0-1	171.000^{H6}				
		0-2	171.000^{H6}				
		0-3	171.000^{H6}				
		1-0	171.500^{H6}	0	+ 0.025		
		1-1	171.500^{H6}				
		1-2	171.500^{H6}				
		1-3	171.500^{H6}				
2	Alignment bearing diameter - Installed	0-0	160.120	0	+ 0.054	0.120	0.199
		0-1	159.620				
		0-2	159.120				
		0-3	158.620				
		1-0	160.120	0	+ 0.054		
		1-1	159.620				
		1-2	159.120				
		1-3	158.620				
	Main bearing journal	0-0	160.000_{h6}	– 0.025	0		
		0-1	159.500_{h6}				
		0-2	159.000_{h6}				
		0-3	158.500_{h6}				
		1-0	160.000_{h6}	– 0.025	0		
		1-1	159.500_{h6}				
		1-2	159.000_{h6}				
		1-3	158.500_{h6}				
3	Spreading dimension, alignment bearing - Upper half - Lower half	0-0	171.400	0	+ 1.000	-	-
		0-1	171.400				
		0-2	171.400				
		0-3	171.400				
		1-0	171.900	0	+ 1.000		
		1-1	171.900				
		1-2	171.900				
		1-3	171.900				

Table 12 Tolerance Values for Main Bearing

Crankshaft Axial Clearance

See Figure 1078 for a view of the crankshaft axial clearance points and listed in Table 13 are the crankshaft axial clearances.

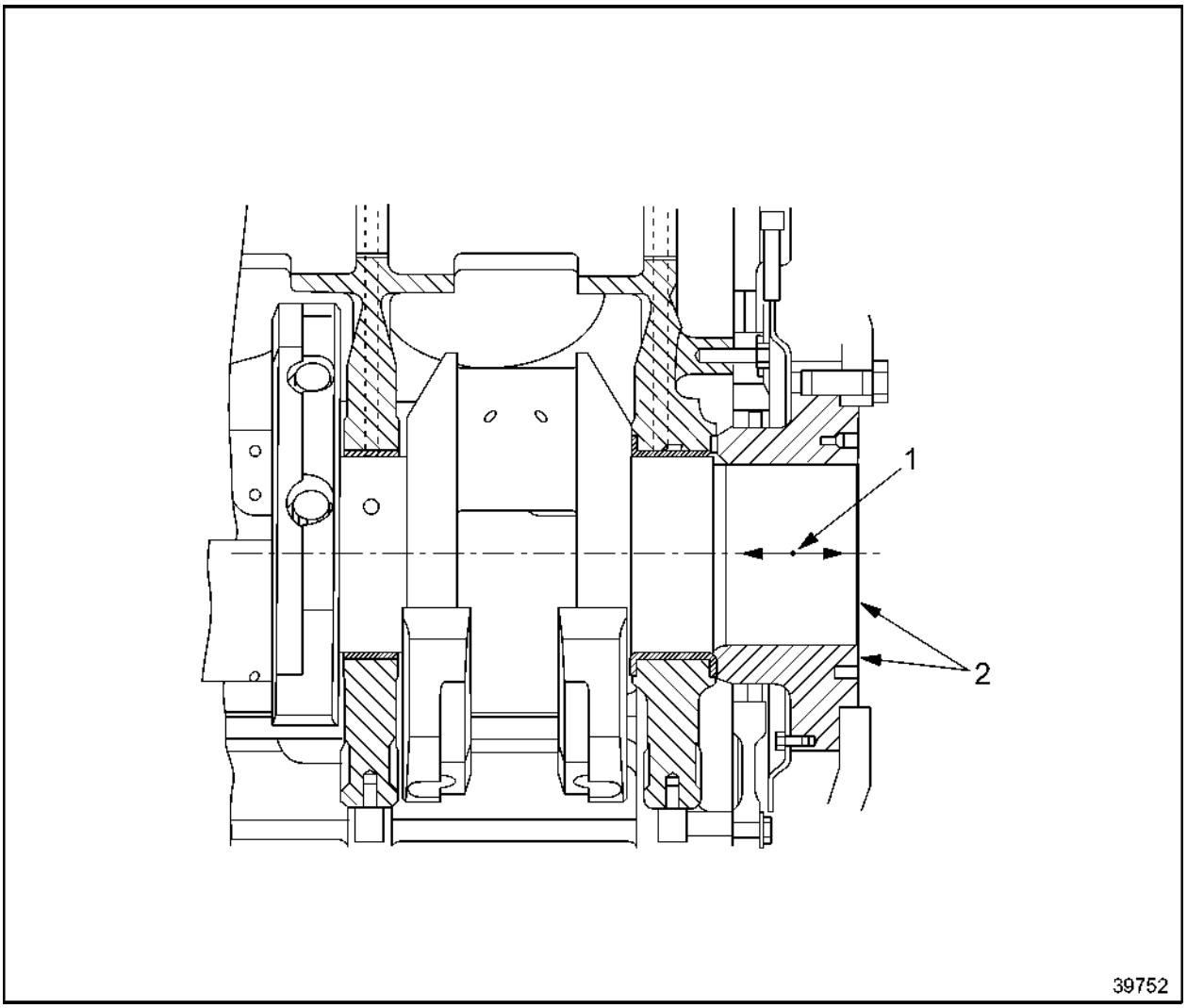


Figure 1078 Crankshaft Axial Clearance Points

No.	Designation	Clearance	
		Min	Max
1	Crankshaft axial play	0.200	0.600
2	PTO flange fitted flush		

Table 13 Crankshaft Axial Clearance

Driving End Crankshaft Seal

See Figure 1079 for a view of the driving end crankshaft seal tolerance points and listed in Table 14 are the driving end crankshaft seal tolerances.

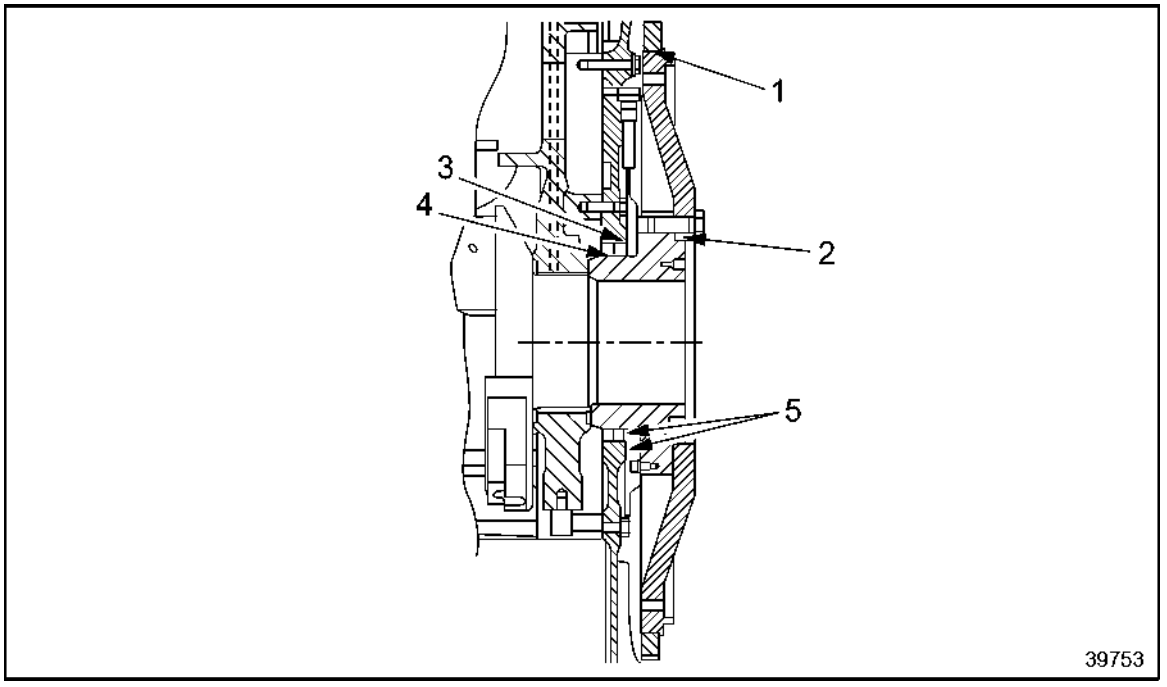


Figure 1079 Driving End Crankshaft Seal

No.	Designation	Deviation		Clearance		Interference	
		Lower	Upper	Min	Max	Min	Max
1	Ring gear bore	707.030	707.290	-	-	0.340	0.760
	Flywheel OD	707.630	707.790				
2	Flywheel bore	247.705	247.725	0.265	0.314	-	-
	Drive flange OD	247.411	247.440				
3	Flywheel housing bore	240.000	240.046	-	-	0.301	0.590
	Radial-lip shaft seal OD	240.350	240.590				
4	Running surface OD	209.585	209.700	-	-	-	-
5	Radial-lip shaft seal press-fitted flush						

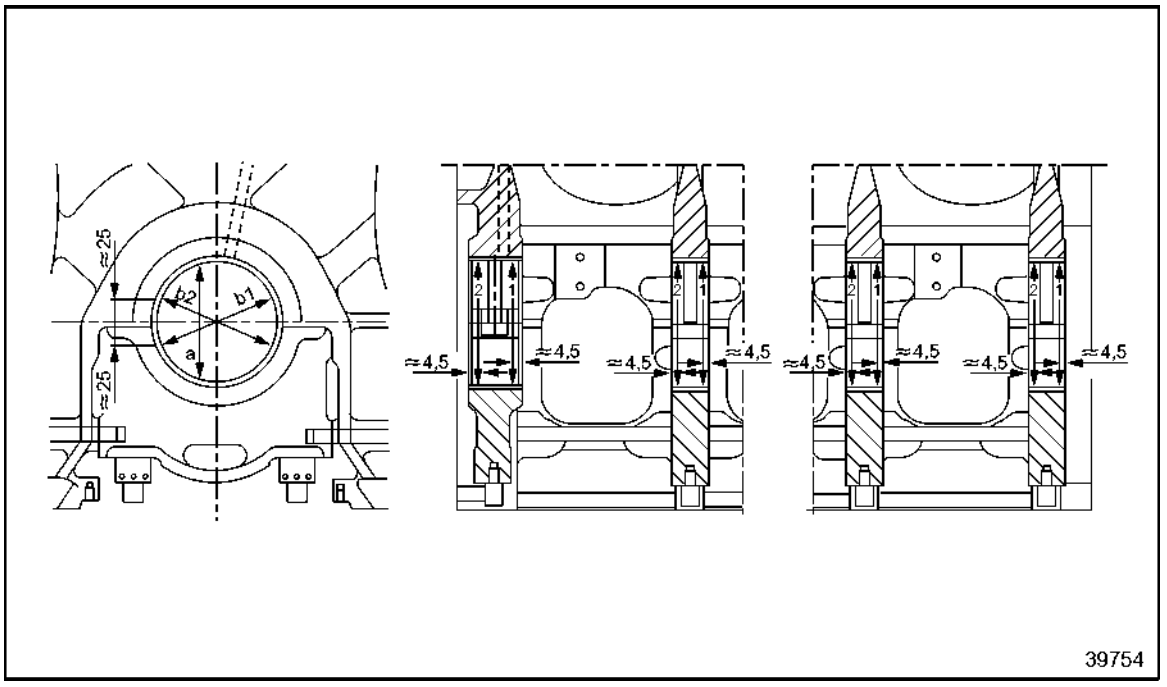
Reconditioning Instructions

Re 4: Running surface worn: Metal-spray running surface and grind using feed-in method.

Table 14 Driving End Crankshaft Seal Tolerances

Crankshaft Bearing Shells

See Figure 1080 for a view of the crankshaft bearing shells tolerance points.



1. Install bearing shells and torque bearing cap according to torque specifications.
2. Measure crankshaft bearing bores.
   [a] Determine diameters a, b1, and b2 in measuring planes 1 and 2 and in each case calculate mean values of a, b1, and b2.
3. Check roundness of bores.
   [a] Possible deviations from roundness result from the mean values of a, b1, and b2 in accordance with the equation 0.5 (b1+b2) —a
4. Replace bearing shells.
   [a] If deviation from roundness >0.040.
   [b] If b1 and b2 are > < 0.040.
   [c] With vertical ovality — a < 0.5 (b1+b2) — is not permissible.

Figure 1080 Crankshaft Bearing Shells

Counterweight Fixture

See Figure 1081 for the counterweight fixture tolerance point and listed in Table 15 are the counterweight fixture tolerance values.

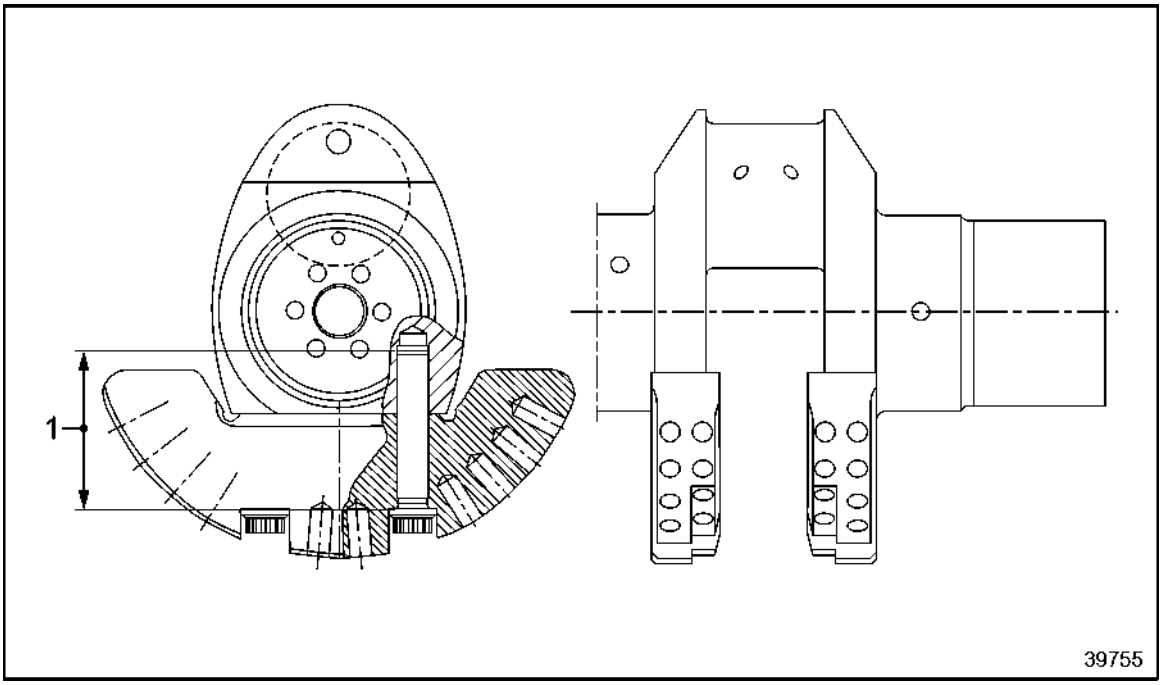


Figure 1081 Counterweight Fixture

No.	Designation	Tol. Size	Deviation		Wear Limit
			Lower	Upper	
1	Bolt length - removed	130.0	– 0.40	0	Max length 132.0

Reconditioning Instructions

Re 1: If the wear limit has been exceeded, replace counterweight bolt.

Table 15 Counterweight Fixture Tolerance Values

Free End Crankshaft Gear

See Figure 1082 for a view of the free end crankshaft gear and listed in Table 16 are the free end crankshaft gear tolerance values.

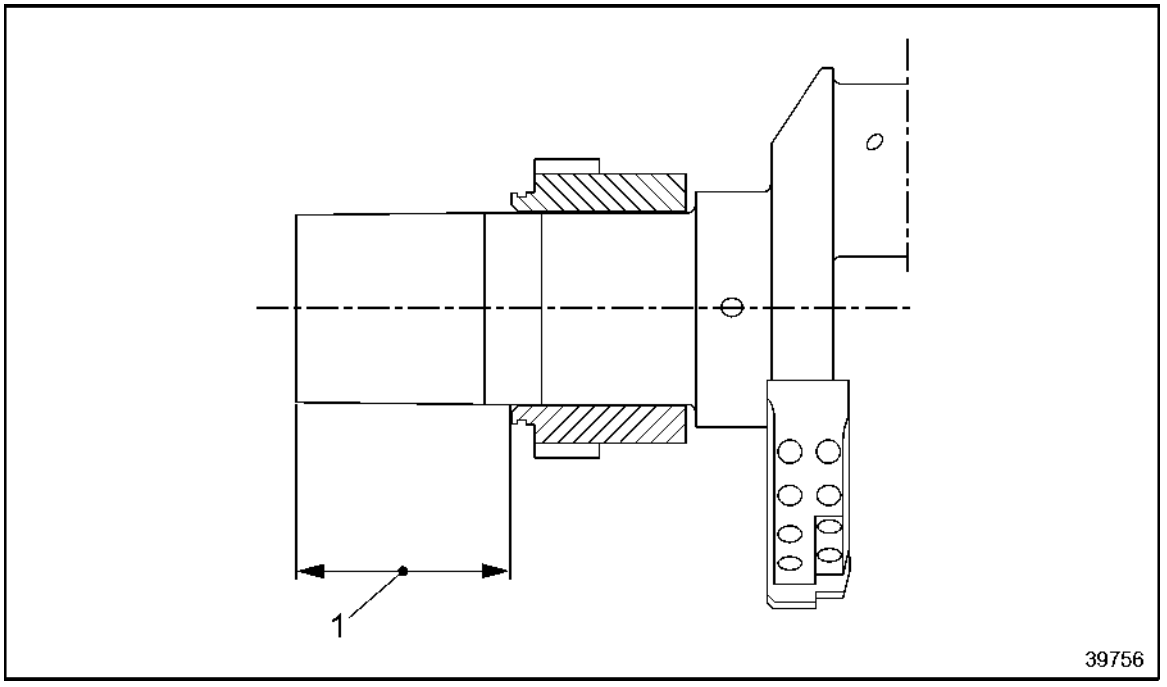


Figure 1082 Free End Crankshaft Gear

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Gear press-fitted - crankshaft end to gear face	145.50	– 0.30	+ 0.30

Table 16 Free End Crankshaft Gear Tolerances

Coaxial Tolerance of Crankshaft Main Bearing Journals

See Figure 1083 for a view of the crankshaft main bearing journals coaxial tolerances and listed in Table 17 are the crankshaft main bearing journals coaxial tolerances.

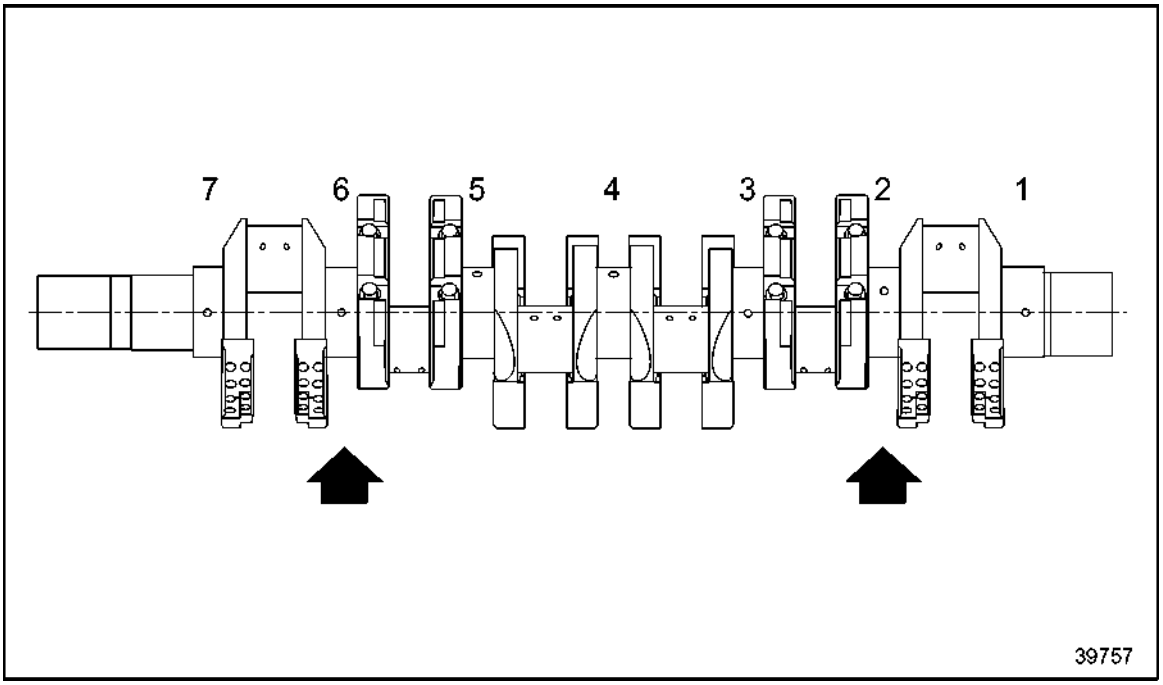


Figure 1083 Coaxial Tolerance of Crankshaft Main Bearing Journals

Maximum Permissible Coaxial Deviation	New Condition
From main bearing journal 1 to main bearing journal 7	0.100
From main bearing journal to main bearing journal	0.050

Table 17 Crankshaft Main Bearing Journals Coaxial Tolerances

Crankshaft Dynamic Balancing

See Figure 1084 for a view of the crankshaft dynamic balancing points and listed in Table 18 are the crankshaft dynamic balancing specifications.

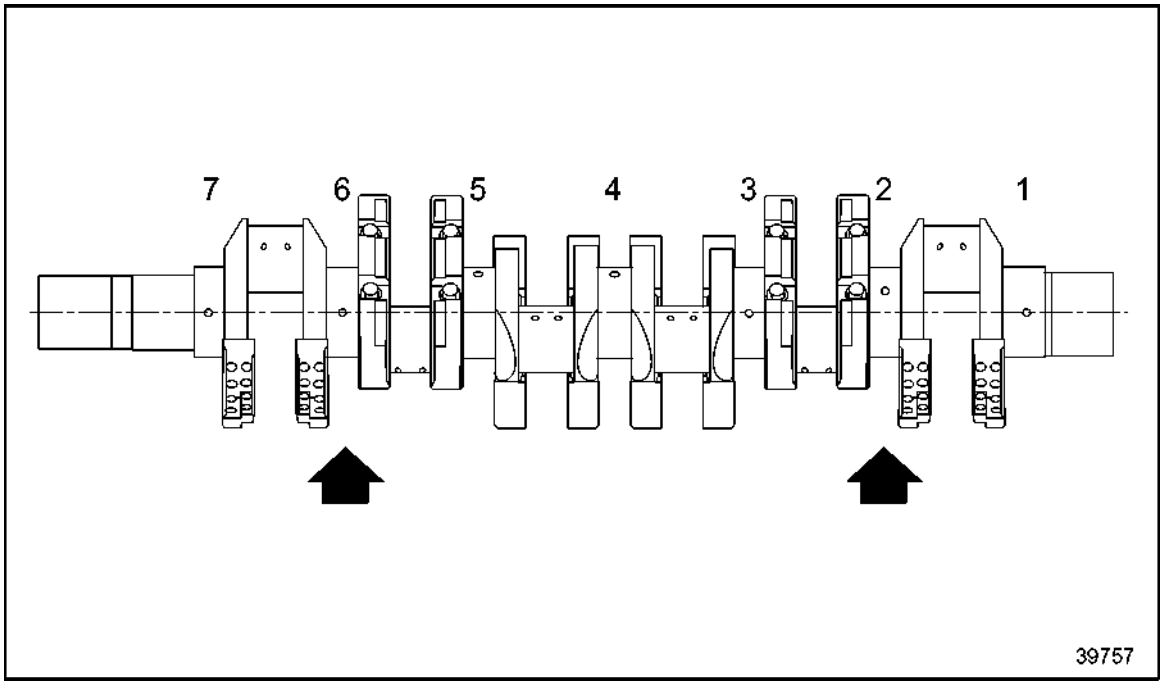


Figure 1084 Crankshaft Dynamic Balancing Points

Balancing Specification	New Condition
Maximum operating speed: 1900 1/min	-
Mass of balancing group: 525 kg	-
Support the crankshaft in main bearings 2 and 6	-
Balancing speed: 150 1/min	-
Permissible residual unbalance for each balancing plane during initial balancing:	160 gcm
Permissible residual imbalance for each balancing plane for comparable balancing in other clamping or balancing machinery	480 gcm

Reconditioning Instructions

It will only be necessary to rebalance the crankshaft if the counterweights have been replaced.

If a crankshaft has been reworked to the next repair stage, rebalancing will not be necessary provided that the counterweights have not been replaced.

Mark the counterweights and reassemble them according to marking.

Table 18 Crankshaft Dynamic Balancing Specifications

Connecting Rod Bearing

See Figure 1085 for a view of the connecting rod bearing tolerance points and listed in Table 19 are the connecting rod bearing tolerances.

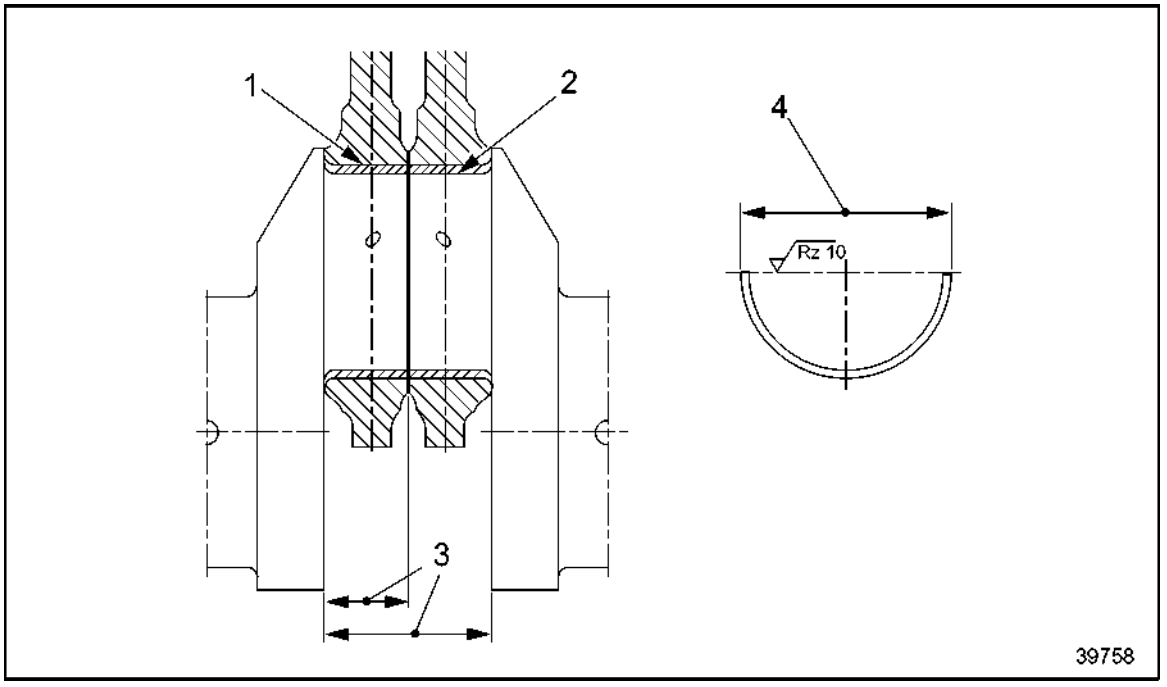


Figure 1085 Connecting Rod Bearing

No.	Designation	Stage	Tol. Size	Deviation		Clearance	
				Lower	Upper	Min	Max
1	Connecting rod bore	-	126.000^{H6}	0	+ 0.025	-	-
2	Connecting rod bearing bore - connecting rod bearing installed	0-0	117.082	0	+ 0.048	0.082	0.158
		0-1	116.882				
		0-2	116.682				
		0-3	116.482				
	-	0-0	117.000_{h6}	– 0.022	0		
		0-1	116.800_{h6}				
		0-2	116.600_{h6}				
		0-3	116.400_{h6}				
3	Crankpin length	-	97.500	– 0.100	+ 0.100	0.200	0.600
	Connecting rod width	-	48.600	– 0.100	0		
4	Spreading dimension, connecting rod bearing shell - Upper half - Lower half	0-0	126.400	0	+ 0.100	-	-
		0-1	126.400				
		0-2	126.400				
		0-3	126.400				

Table 19 Connecting Rod Bearing Tolerances

Connecting Rod Locating Pin

See Figure bush 1086 for a view of the connecting rod locating pin and listed in Table 20 are the connecting rod locating pin tolerances.

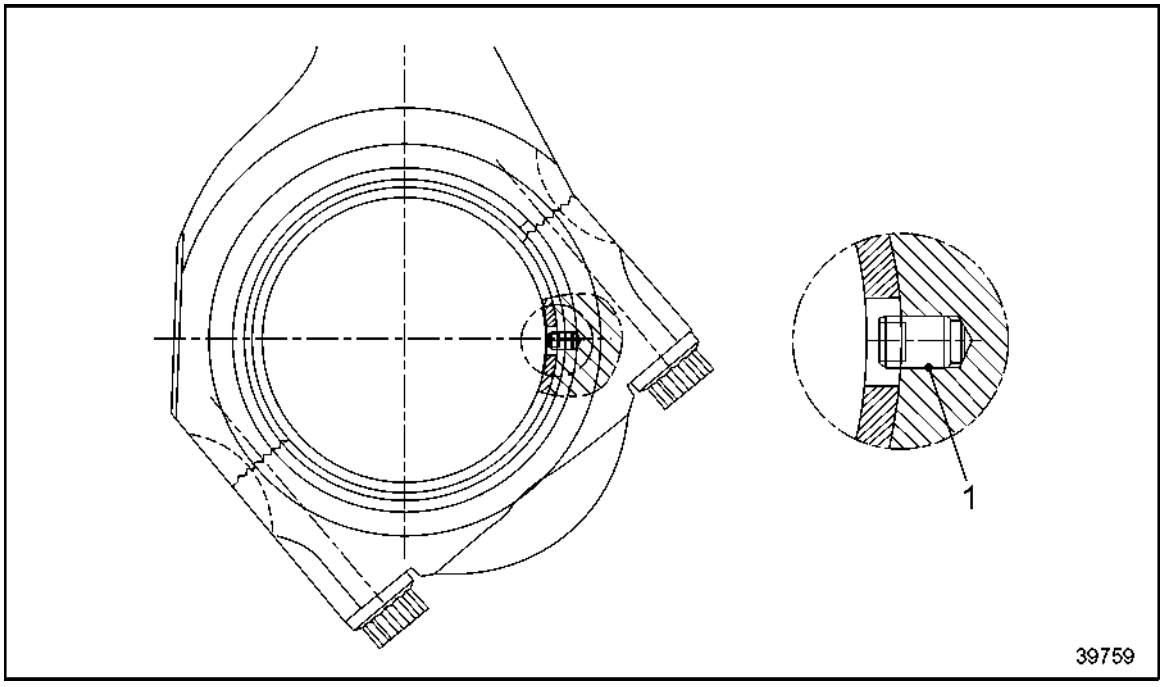


Figure 1086 Connecting Rod Locating Pin

No.	Designation	Stage	Tol. Size	Deviation		Interference	
				Lower	Upper	Min	Max
1	Locating pin bore	0	7.0^{H7}	0	+ 0.015	0.004	0.028
		1*	7.3^{H7}				
		2	7.6^{H7}				
	Locating pin OD	0	7.0_{r6}	+ 0.019	+ 0.028		
		1*	7.3_{r6}				
		2	7.6_{r6}				

* Also permitted for new engines.

Table 20 Connecting Rod Locating Pin Tolerances

Connecting Rod Bearing Bore

See Figure 1087 for a view of the connecting rod bearing bore tolerance points and listed in Table 21 are the connecting rod bearing bore tolerances.

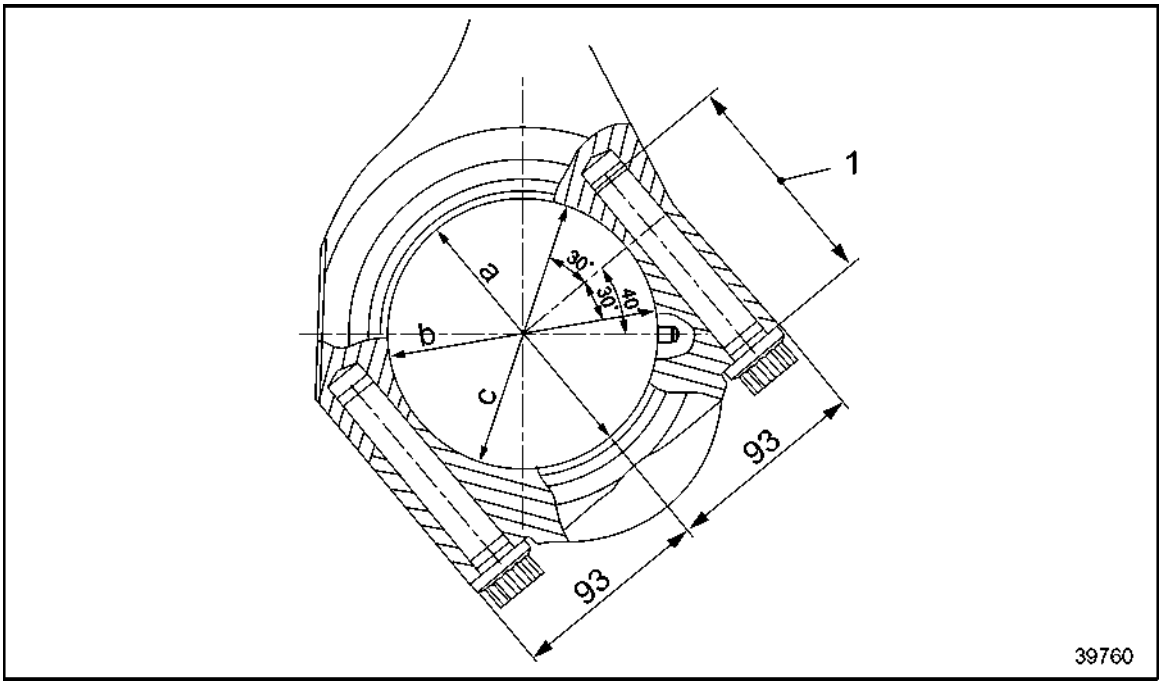


Figure 1087 Connecting Rod Bearing Bore

No.	Designation	Tol. Size	Deviation		Wear Limit
			Lower	Upper	
1	Bolt length - removed	103.00	– 0.40	+ 0.20	104.50

NOTE:

For connecting rod — connecting rod cap reassembly without bearing shells and bolts must be torqued to 10–20 N·m (7.38–14.75 lb·ft), and not to specified torque.

Connecting rod bearing — measure bearing bore in a, b, and c. Minimum dimension must be in direction a.

Table 21 Connecting Rod Bearing Bore Tolerances

Connecting Rod Shells

See Figure 1088 view of the connecting rod shells tolerance points listed in Table 22 are the connecting rod bearing shells tolerances.

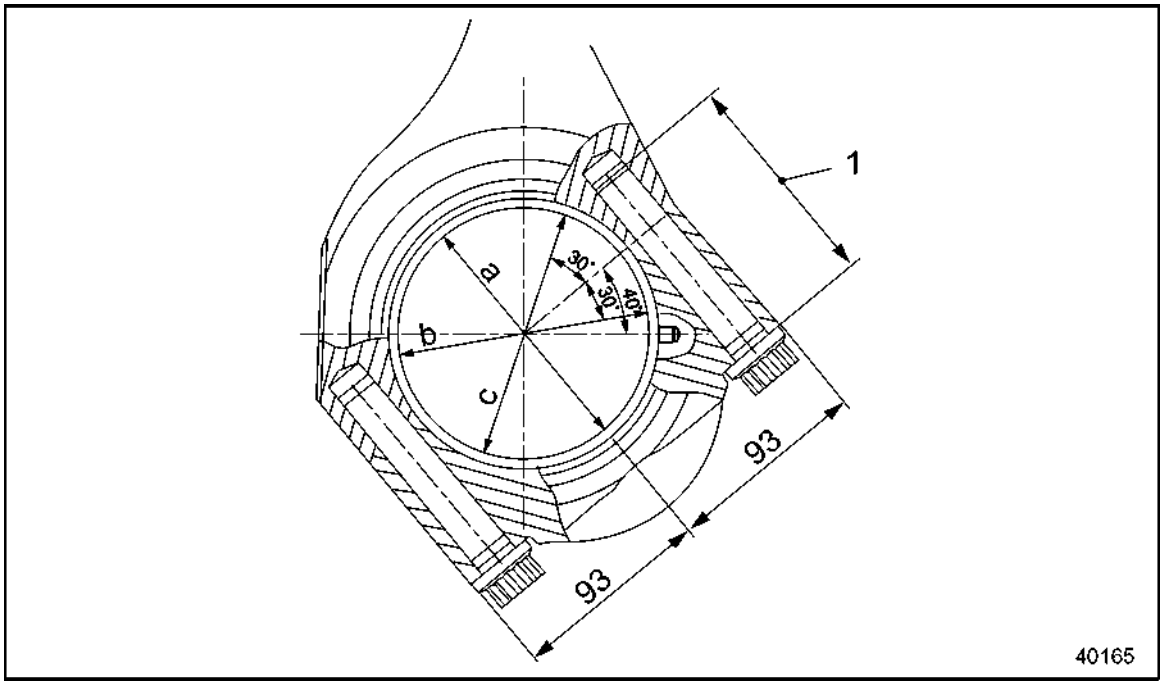


Figure 1088 Connecting Rod Bearing Shells

No.	Designation	Tol. Size	Deviation		Wear Limit
			Lower	Upper	
1	Bolt length - removed	103.00	– 0.40	+ 0.20	104.50

NOTE:

Torque connecting rod bearing, connecting rod, connecting rod cap; refer to section A 003 A 003.

Connecting rod bearing — measure bearing bore in a, b, and c. Minimum dimension must be in direction a.

Table 22 Connecting Rod Bearing Shells Tolerances

Connecting Rod Bores Parallelism

See Figure 1089 for a view to check the connecting rod bores parallelism and listed in Table 23 are the connecting rod bores parallelism tolerances.

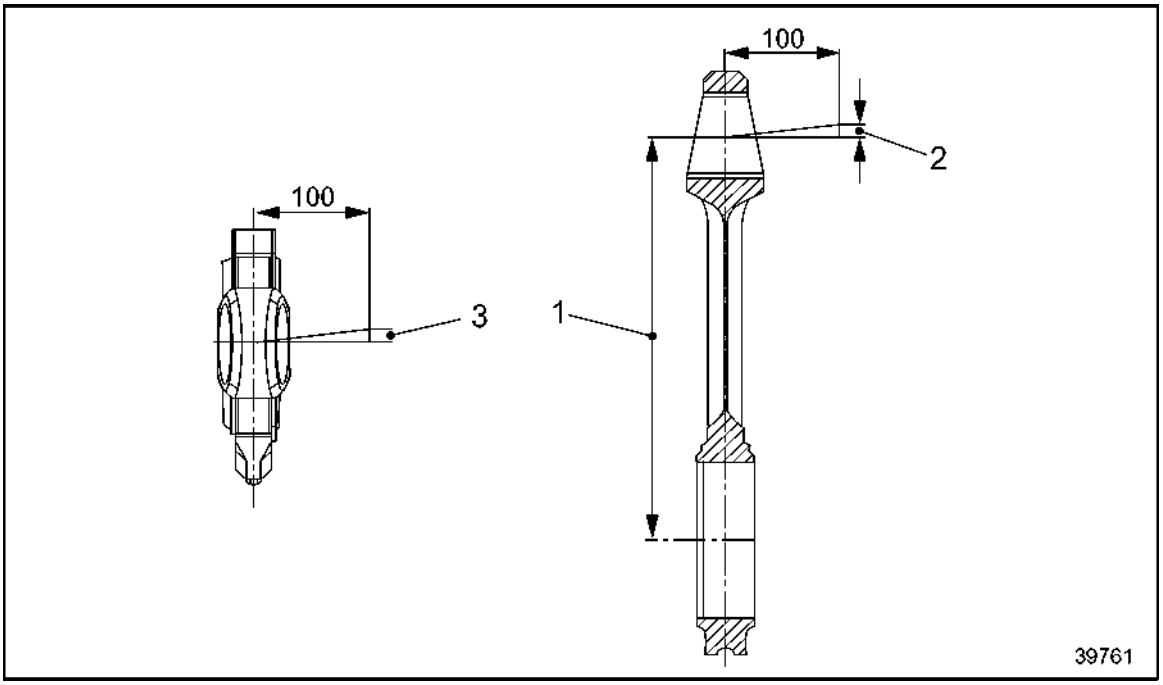


Figure 1089 Connecting Rod Bores Parallelism

No.	Designation	Tol. Size	Deviation		Wear Limit
			Lower	Upper	
1	Connecting rod length - with bushing but without bearing shells	354.000	– 0.100	+ 0.100	-
	Connecting rod length - without bushing and without bearing shells	354.000	– 0.100	+ 0.100	
2	Parallelism of axes - non-parallelism	0.070 measured at distance of 100 mm (3.94 in.)			Non-parallelism maximum 0.100
3	Parallelism of axes - twist	0.250 measured at distance of 100 mm (3.94 in.)			Twist maximum 0.350
	Connecting rod weight	9.530 kg	– 0.060 kg	+ 0.060 kg	-

Table 23 Connecting Rod Bores Parallelism Tolerances

Piston Bearing

See Figure 1090 for a view of the piston bearing tolerance points and listed in Table 24 are the piston bearing tolerances.

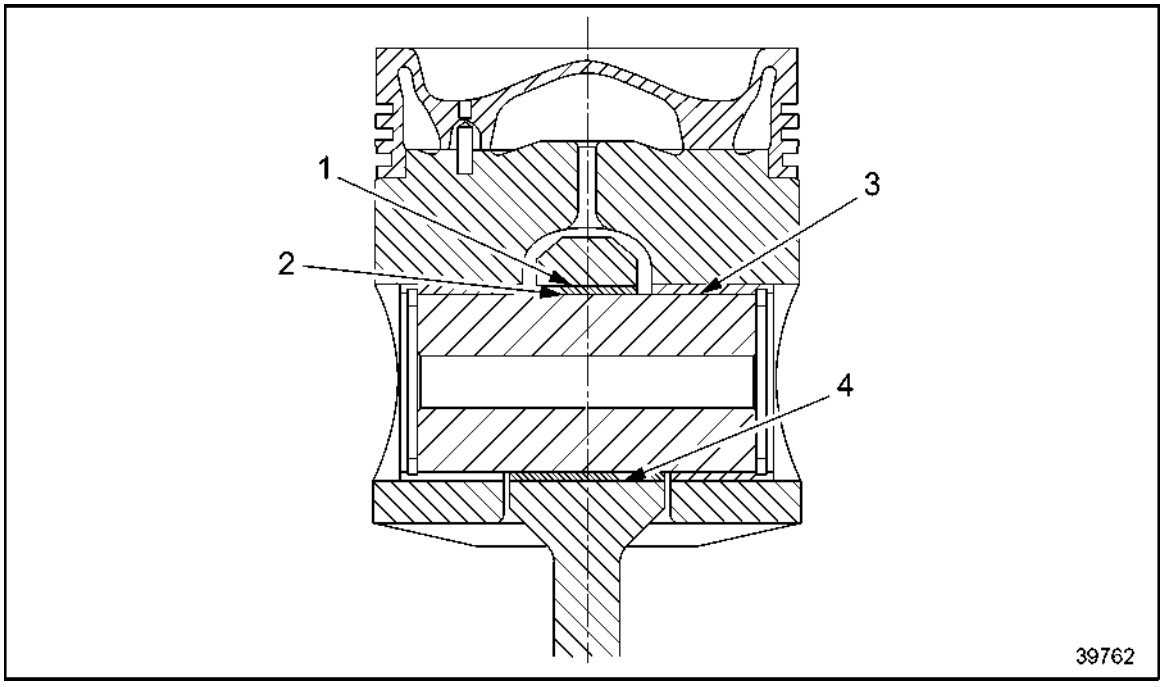


Figure 1090 Piston Bearing

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

Piston Rings

See Figure 1091 for a view of the piston rings tolerance points and listed in Table 25 are the tolerances for the piston rings.

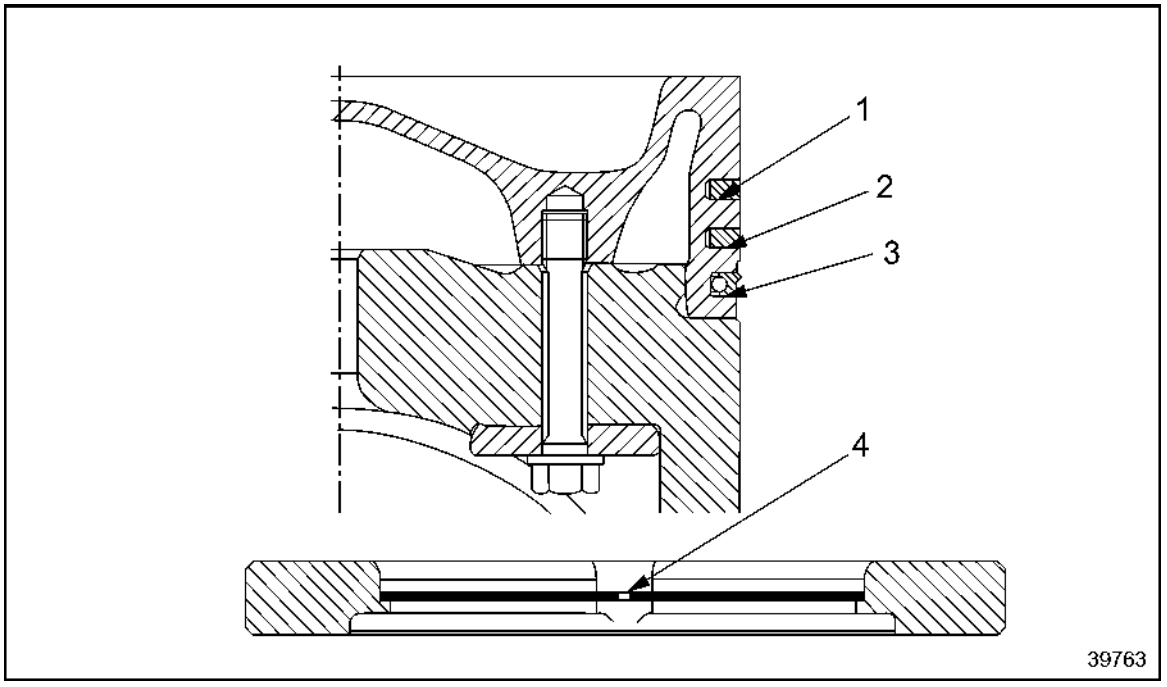


Figure 1091 Piston Rings

No.	Designation	Tol. Size	Deviation		Clearance	
			Lower	Upper	Min	Max
1	Groove width	4.000	+ 0.170	+ 0.190	0.170	0.540
	Rectangular-section ring	4.000	– 0.350	0		
2	Groove width	4.000	+ 0.080	+ 0.100	0.080	0.450
	Taper face compression ring	4.000	– 0.350	0		
3	Groove width	5.000	+ 0.080	+ 0.100	0.080	0.450
	Oil control ring	5.000	– 0.350	0		
4	Ring end clearance rectangular-section ring taper face compression ring oil control ring	-	-	-	0.400 1.000 0.450	0.700 1.300 0.800

NOTE:

Re 4: Measure ring end clearance in ring gage 165.0^{H4}

Table 25 Piston Ring Tolerances

Piston Clearance in Cylinder Liner, Without Scraper Ring

See Figure 1092 for a view of the piston clearance in cylinder liner, without a scraper ring. Listed in Table 26 are the tolerance values for the piston clearance in the cylinder liner without a scraper ring.

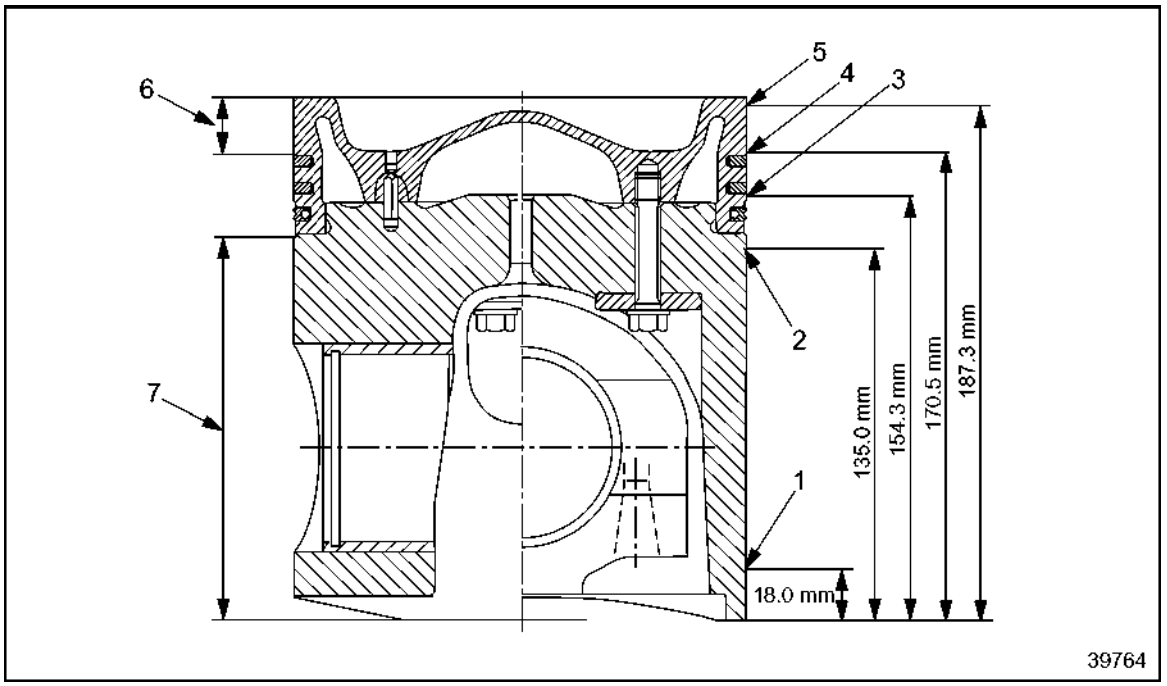


Figure 1092 Piston Clearance in Cylinder Liner, Without Scraper Ring

No.	Designation	Tol. Size	Deviation		Clearance	
			Lower	Upper	Min	Max
1	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.184	0.246
	Piston skirt diameter	164.805	– 0.011	+ 0.011		
2	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.270	0.330
	Piston skirt diameter	164.720	– 0.010	+ 0.010		
3	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.400	0.840
	Piston crown diameter	164.580	– 0.020	+ 0.020		
4	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.315	0.395
	Piston crown diameter	164.665	– 0.020	+ 0.020		
5	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.595	0.685
	Piston crown diameter	164.380	- 0.025	+ 0.025		
6	Piston crown, crowned-falling-oval					
7	Piston skirt, crowned-falling-oval					

Reconditioning Instructions

Re 1 to 5: Measure piston crown and piston skirt diameters at right angles to piston pin axis.

Table 26 Piston Clearance in Cylinder Liner Without Scraper Ring Tolerances

Piston Clearance in Cylinder Liner With Scraper Ring

See Figure 1093 for a view of the piston clearance in cylinder liner, with a scraper ring. Listed in Table 27 are the tolerance values for the piston clearance in cylinder liner with scraper ring.

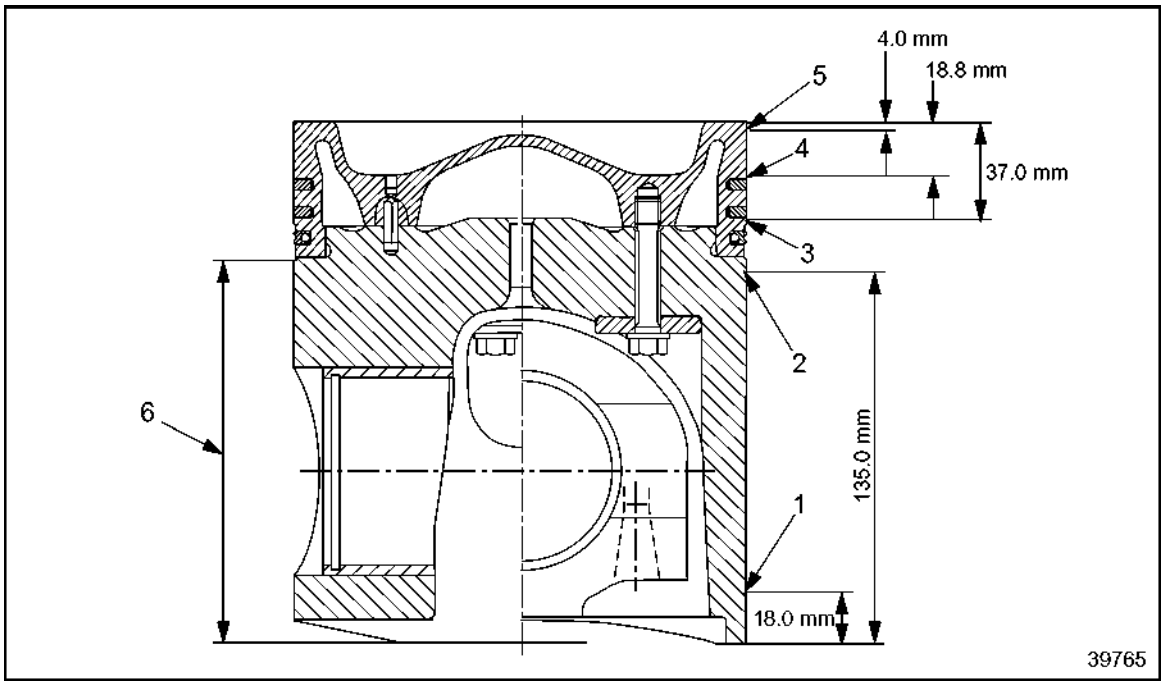


Figure 1093

No.	Designation	Tol. Size	Deviation		Clearance	
			Lower	Upper	Min	Max
1	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.184	0.246
	Piston skirt diameter	164.805	– 0.011	+ 0.011		
2	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.270	0.330
	Piston skirt diameter	164.720	– 0.010	+ 0.010		
3	Cylinder liner bore	165.000^{H7}	0	+ 0.040	0.400	0.840
	Piston crown diameter	164.580	– 0.020	+ 0.020		
4	Scraper ring bore	164.000^{H8}	0	+ 0.063	0.575	0.688
	Piston crown diameter	163.400	– 0.025	+ 0.025		
5	Scraper ring bore	164.000^{H8}	0	+ 0.063	0.715	0.833
	Piston crown diameter	163.255	– 0.025	+ 0.025		
6	Piston skirt, crowned-falling-oval					

Reconditioning Instructions

Re 1 to 5: Measure piston crown and piston skirt diameters at right angles to piston pin axis.

Table 27 Piston Clearance in Cylinder Liner With Scraper Ring Tolerances

Inlet and Exhaust Valve Guides

See Figure 1094 for a view of the inlet and exhaust value guides. Listed in Table 28 are the tolerances for the inlet and exhaust valve guides.

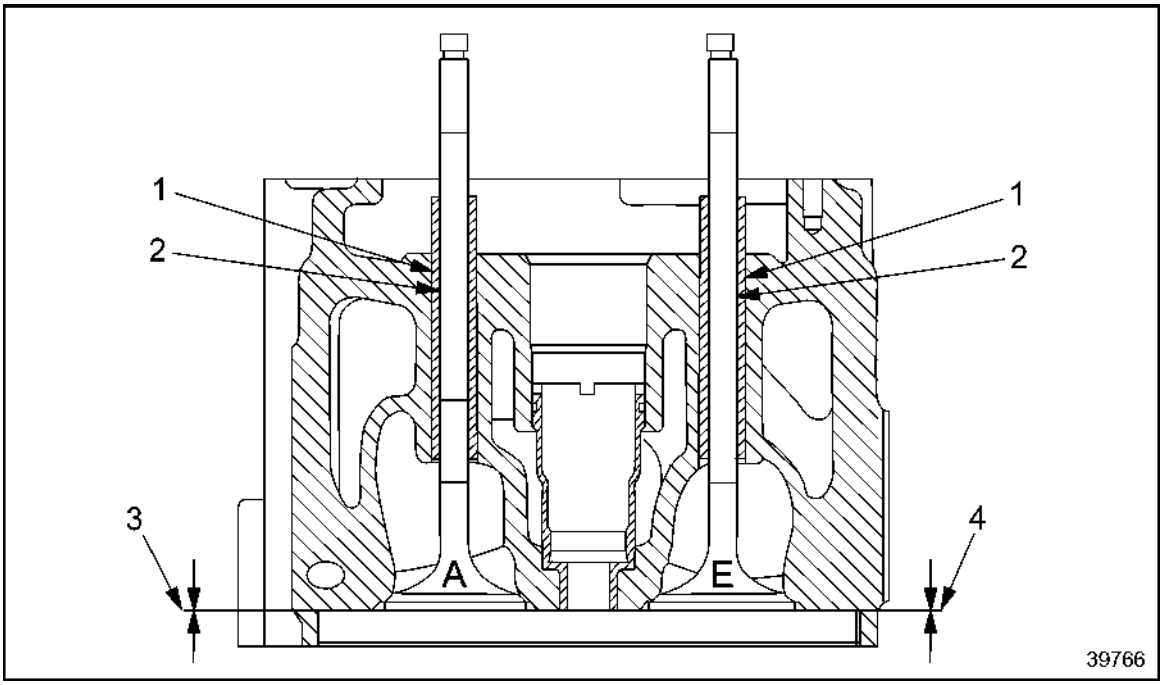


Figure 1094 Inlet and Exhaust Valve Guides

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Cylinder head bore	19.000^{H7}	0	+ 0.021	-	-	0.007	0.041
	Valve guide ODO	19.000_{k6}	+ 0.028	+ 0.041		-		
2	Valve guide bore - installed	11.000^{H7}	0	+ 0.018	0.055	0.093	-	-
	Valve stem diameter	10.935	– 0.010	+ 0.010				
3	Valve clearance - Exhaust	0.400	-	-	-	-	-	-
4	Valve clearance - Inlet	0.500	-	-	-	-	-	-

NOTE:

Re 2: Finish-machine valve guide bore after pressing into cylinder head.

It must be possible to insert the go-end plug gage by pushing gently onto the valve guide length.

No-go plug gage must not engage.

Table 28 Tolerances for Inlet and Exhaust Valve Guide

Inlet and Exhaust Valve Seats

See Figure 1095 for a view of the inlet and exhaust value seats. Listed in Table 29 are the tolerances for the inlet and exhaust valve seats.

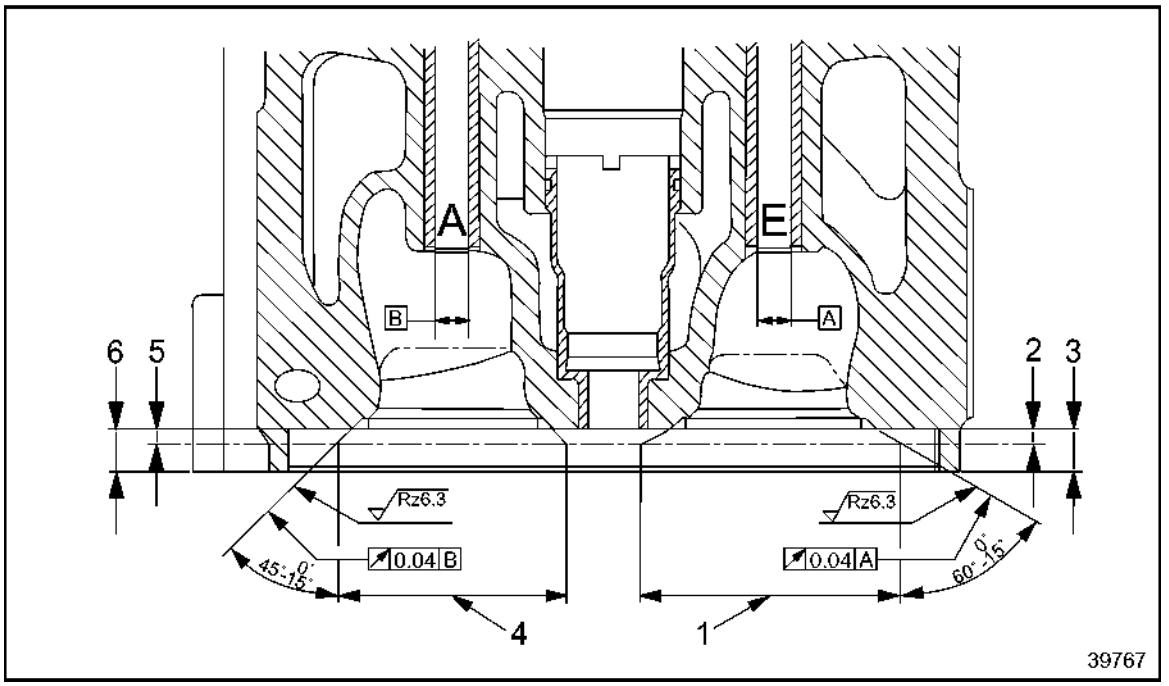


Figure 1095 Inlet and Exhaust Valve Seats

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Inlet Gage mandrel diameter	87.13	0	0
2	Inlet Reference dimension - plug gage	4.80	– 0.10	+ 0.10
3	Inlet Cylinder head bore depth	13.80	0	+ 0.10
4	Exhaust Gage mandrel diameter	73.20	0	0
5	Exhaust Reference dimension -plug gage	4.80	– 0.10	+ 0.10
6	Exhaust Cylinder head bore depth	13.80	0	+ 0.10

Table 29 Tolerances for Inlet and Exhaust Valve Seats

Inlet Valve

See Figure 1096 for a view of the inlet valve. Listed in Table 30 are the tolerances for the inlet valve.

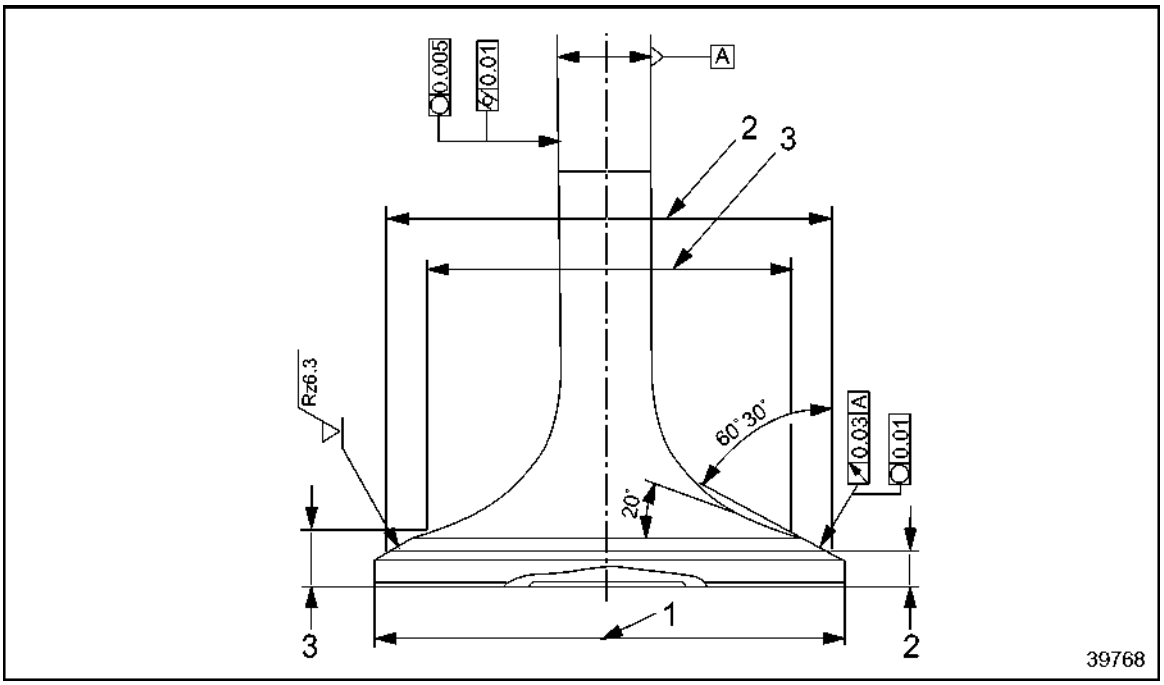


Figure 1096 Inlet Valve

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Valve head OD	57.00	– 0.20	+ 0.20
2	Reference dimension — Valve seat diameter	54.00	-	-
	— Valve seat width	4.05	– 0.20	+ 0.10
3	Reference dimension — Valve seat diameter	44.00	-	-
	— Valve seat width	6.59	– 0.20	0

Table 30 Inlet Valve Tolerances

Exhaust Valve

See Figure 1097 for a view of the exhaust valve. Listed in Table 31 are the tolerances for the exhaust valve.

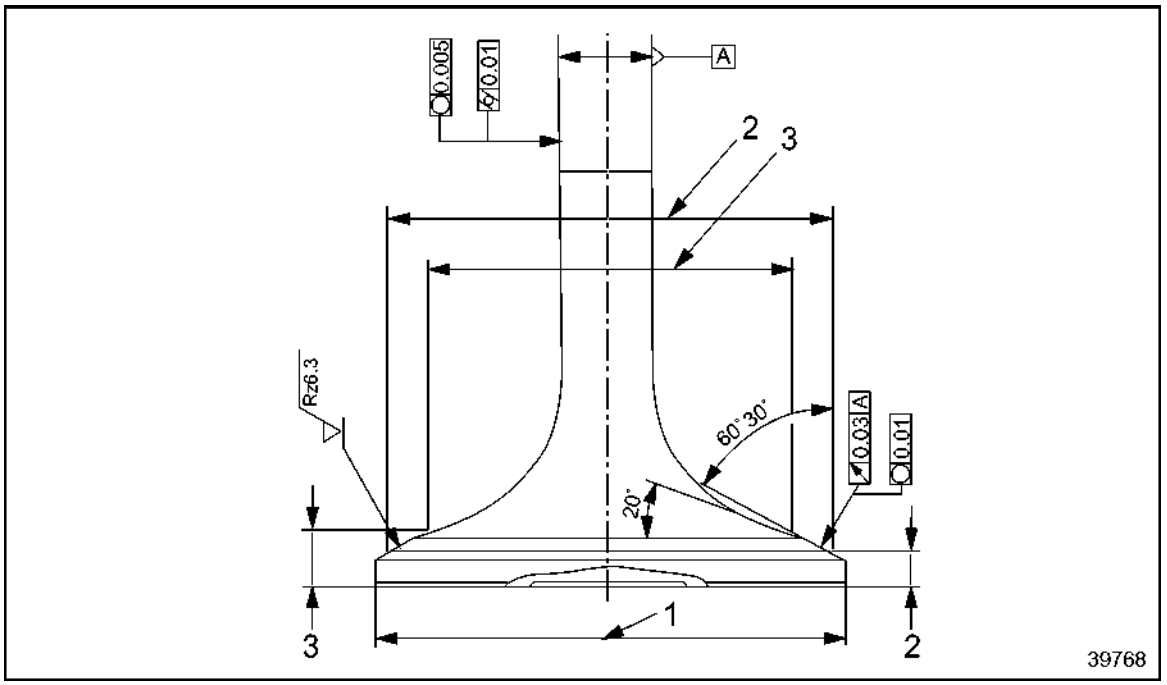


Figure 1097 Exhaust Valve

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Valve head OD	56.00	– 0.20	+ 0.20
2	Reference dimension — Valve seat diameter	54.00	-	-
	— Valve seat width	4.18	– 0.20	+ 0.10
3	Reference dimension — Valve seat diameter	44.00	-	-
	— Valve seat width	7.02	– 0.20	0

Table 31 Exhaust Valve Tolerances

Outer Valve Springs

See Figure 1098 for a view of the outer valve springs. Listed in Table 32 are the tolerances for the outer valve springs.

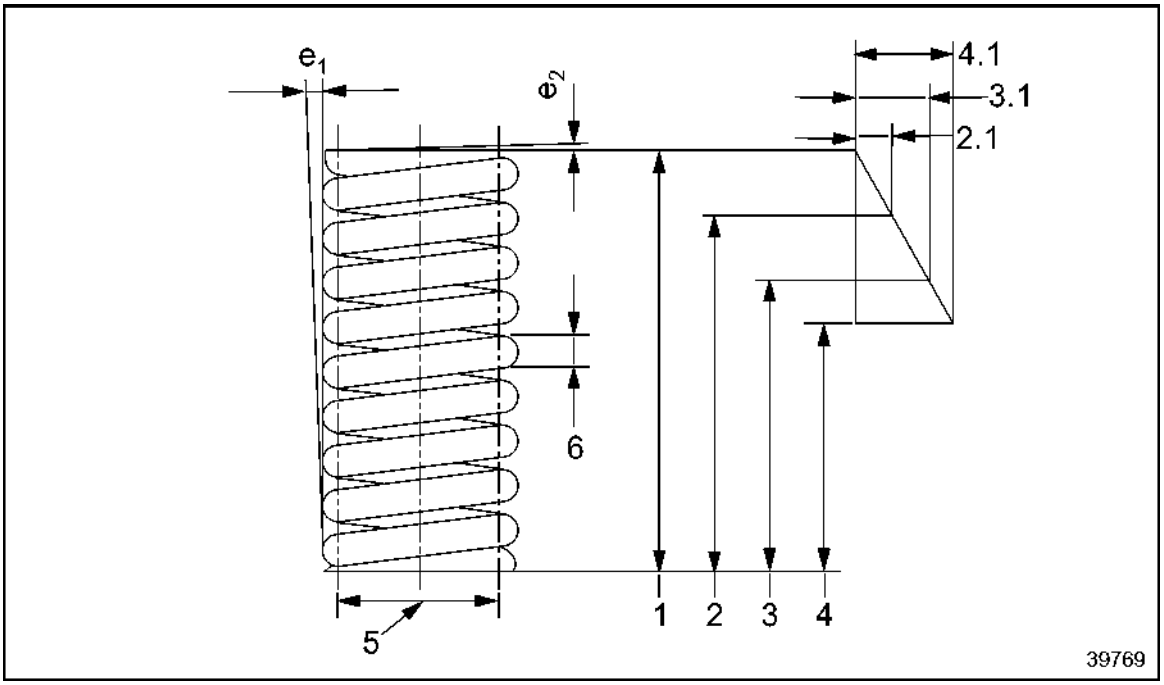


Figure 1098 Outer Valve Springs

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Spring length - unloaded	83.90		-
2	Spring length - loaded	66.00	-	-
2.1	Spring power at spring length 66.00	530.00 N	-	-
3	Spring length - loaded	51.75	-	-
3.1	Spring power at spring length 51.75	952.00 N	– 39 N	+ 39 N
4	Spring length - loaded	47.70	-	-
4.1	Spring power at spring length 47.70	1073.00 N	-	-
5	Coil diameter	34.40	-	-
6	Wire diameter	5.30	-	-
e1	Permissible deviation of surface line from vertical with unloaded spring max. 2.5 mm			
e2	Spring support permissible deviation from parallelism less than 0.6 mm			

Table 32 Outer Valve Springs Tolerances

Inner Valve Springs

See Figure 1099 for a view of the inner valve springs. Listed in Table 33 are the tolerances for the inner valve springs.

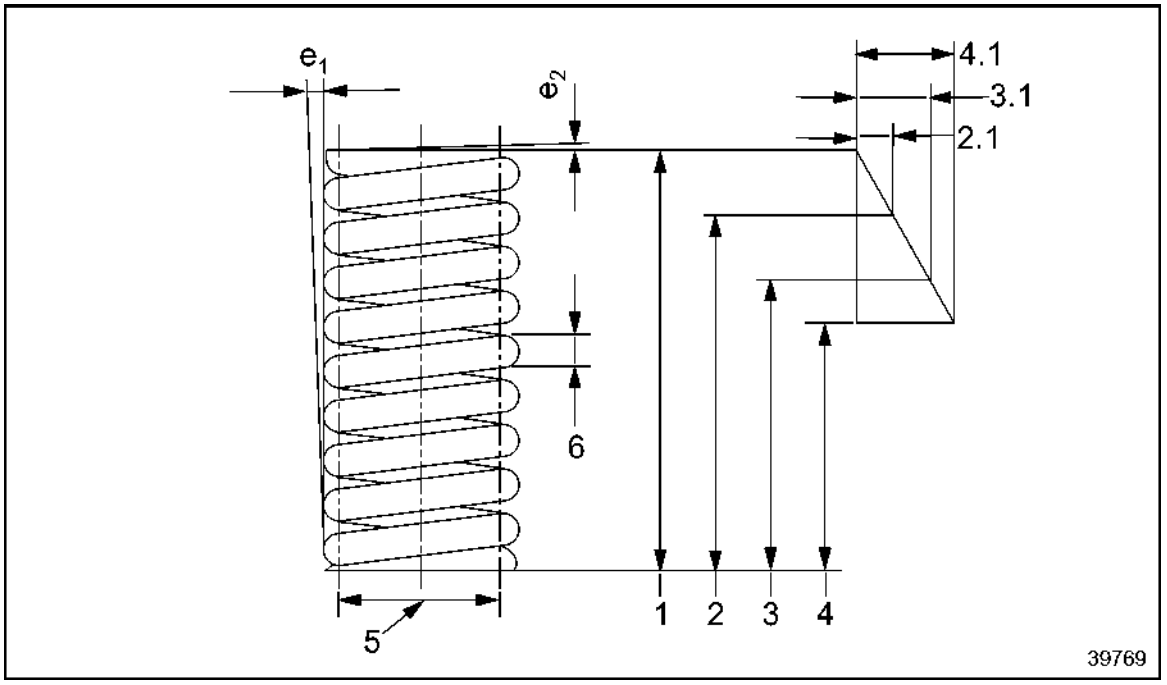


Figure 1099 Inner Valve Springs

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Spring length - unloaded	78.40	-	-
2	Spring length - loaded	61.00	-	-
2.1	Spring power at spring length 61.00	256.00 N	-	-
3	Spring length - loaded	46.75	-	-
3.1	Spring power at spring length 46.75	466.00 N	– 19 N	+ 19 N
4	Spring length - loaded	42.50	-	-
4.1	Spring power at spring length 42.50	529.00 N	-	-
5	Coil diameter	23.00	-	-
6	Wire diameter	3.60	-	-
e1	Permissible deviation of surface line from vertical with unloaded spring max. 2.3 mm			
e2	Spring support permissible deviation from parallelism less than 0.4 mm			

Table 33 Inner Valve Springs Tolerances

Cylinder Head — Mating Face — Protective Sleeve — Valve Bridge

See Figure 1100 for cylinder head, mating face, protective sleeve, and valve bridge.
Listed in Table 34 are the tolerances for cylinder head, mating face, protective sleeve, and valve bridge.

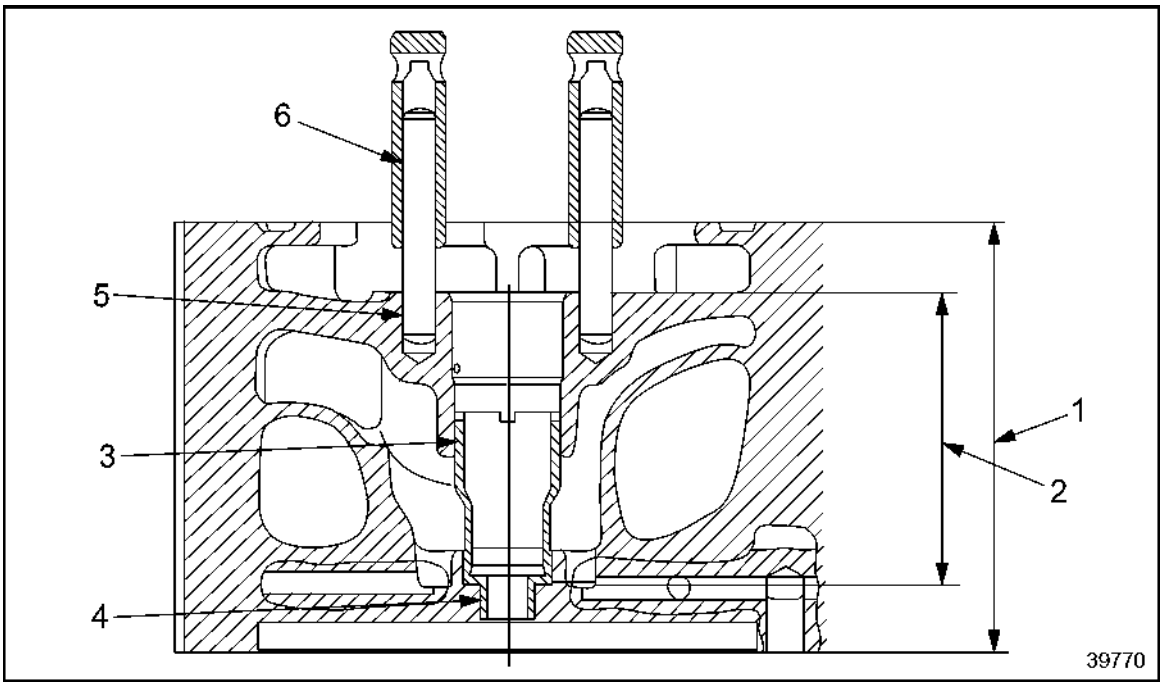


Figure 1100 Cylinder Head — Mating Face — Protective Sleeve — Valve Bridge

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Cylinder head height	184.00	– 0.100	+ 0.100	-	-	-	-
2	Protective sleeve support	124.00	0	+ 0.200	-	-	-	-
3	Protective sleeve bore	44.20	0	+ 0.100	0.200	0.300	-	-
	Protective sleeve OD	44.10	– 0.100	0				
4	Cylinder head thread	M24x1.5	-	-	-	-	-	-
	Protective sleeve thread	M24x1.5	-	-				
5	Cylinder head bore	14.00 ^{N7}	– 0.023	– 0.005	-	-	0.012	0.041
	Sliding pin diameter	14.00 $_{m6}$	+ 0.007	+ 0.018				
6	Valve bridge bore	14.00 ^{D7}	+ 0.050	+ 0.068	0.032	0.061	-	-
	Sliding pin diameter	14.00 $_{m6}$	+ 0.007	+ 0.018				

Table 34 Cylinder Head — Mating Face — Protective Sleeve — Valve Bridge Tolerances

Cylinder Head Screw Fixture

See Figure 1101 for the cylinder head screw fixture. Listed in Table 35 are the tolerances for the cylinder head screw fixture.

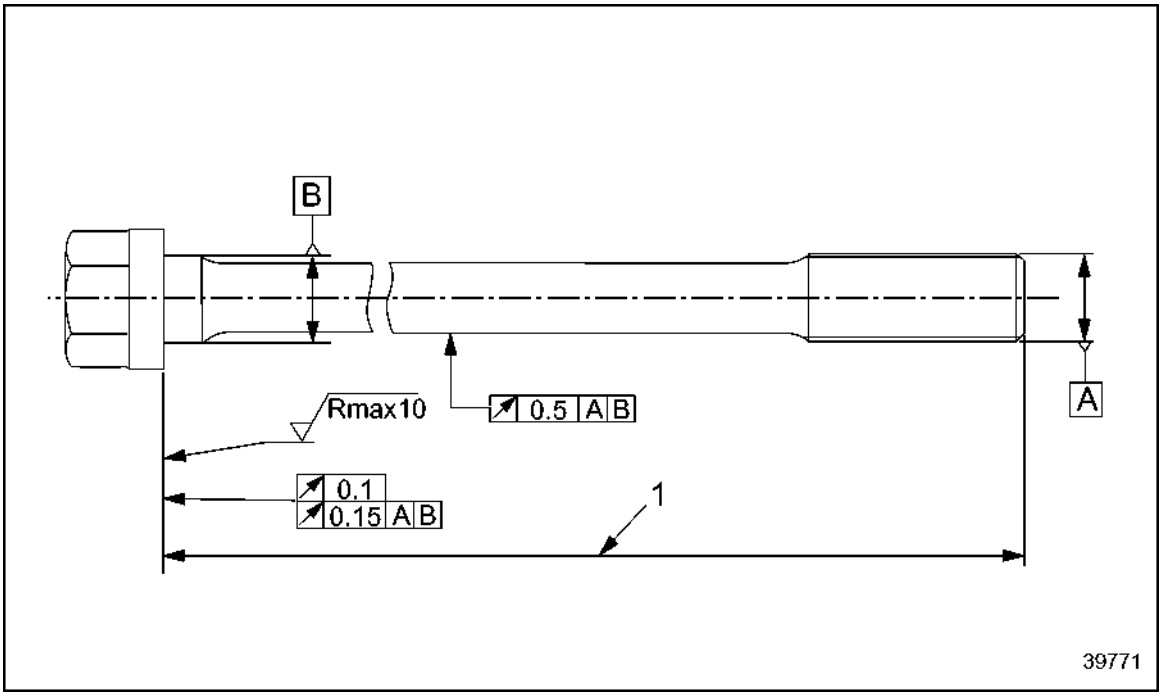


Figure 1101 Cylinder Head Screw Fixture

No.	Designation	Tol. Size	Deviation	
			Lower	Upper
1	Bolt - removed	283.00	– 0.30	+ 0.30

Table 35 Cylinder Head Screw Fixture Tolerances

Coaxial Tolerance of Camshaft Bearings

See Figure 1102 for coaxial tolerance of camshaft bearings. Listed in Table 36 are the coaxial tolerances of camshaft bearings.

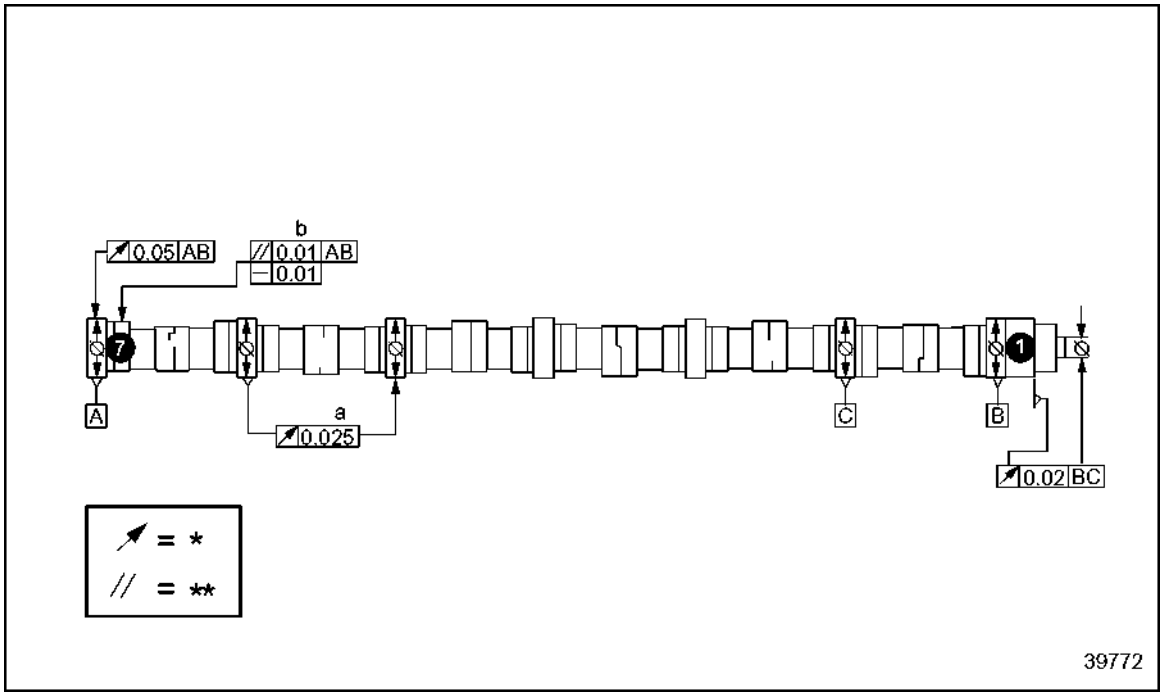


Figure 1102 Coaxial Tolerances of Camshaft Bearings

Maximum permissible deviation from coaxial tolerance	New condition
of bearing 1 to bearing 7	* 0.050 See Figure 1102
a of bearing to bearing	* 0.025 See Figure 1102
b all cams	** 0.010 See Figure 1102 _ 0.010 See Figure 1102

Table 36 Coaxial Tolerances of Camshaft Bearings

Camshaft Bearing

See Figure 1103 for a view of the camshaft bearing. Listed in Table 37 are the tolerances for the camshaft bearing.

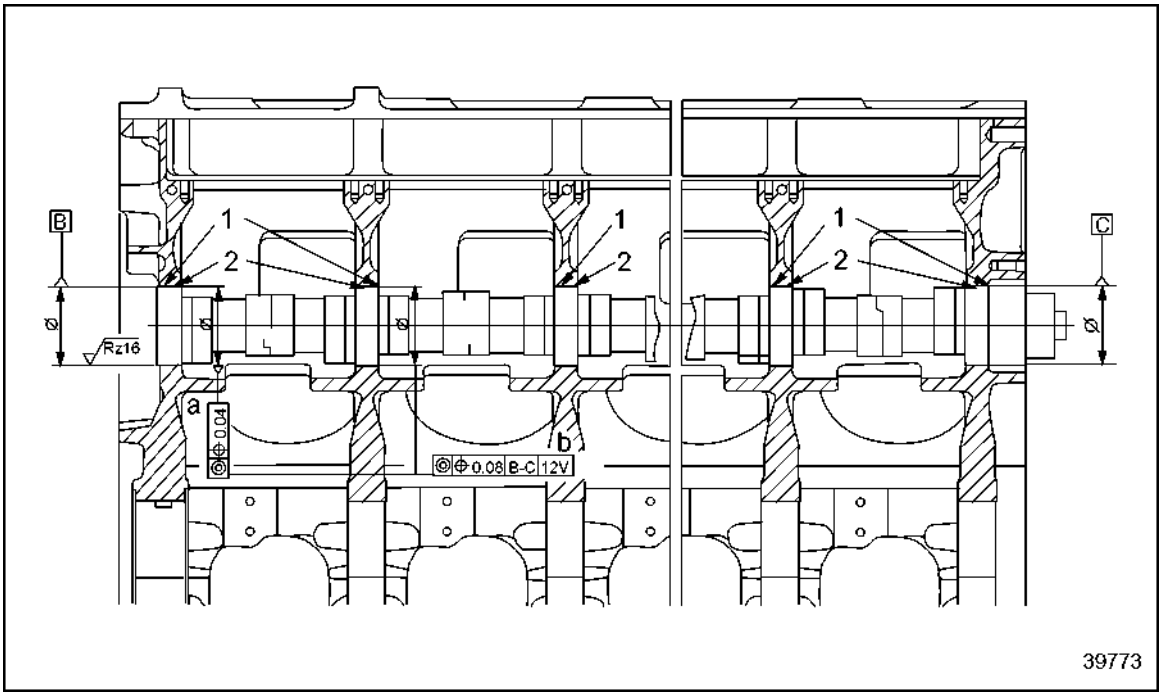


Figure 1103 Camshaft Bearing

No.	Designation	Stage	Tol. Size	Deviation		Clearance		Interference	
				Lower	Upper	Min	Max	Min	Max
1	Housing bore	0-0 1-0	97.000^{H6} 97.500^{H6}	0	+ 0.022	-	-	0.058	0.130
	Bushing OD - removed	0-0 1-0	97.080 97.580	0	+ 0.050	-	-		
2	Bushing bore - installed - removed		 92.012 93.900	 0 – 0.200	 + 0.052 + 0.200	- 0.084	- 0.171	-	-
	Camshaft OD		92.000_{e7}	– 0.107	– 0.072				
a	With adjacent left and right bearings								
b	From camshaft bearing 1 to 7								

Table 37 Camshaft Bearing Tolerances

Camshaft Axial Clearance

See Figure 1104 for camshaft axial clearance. Listed in Table 38 are the tolerances for camshaft axial clearance.

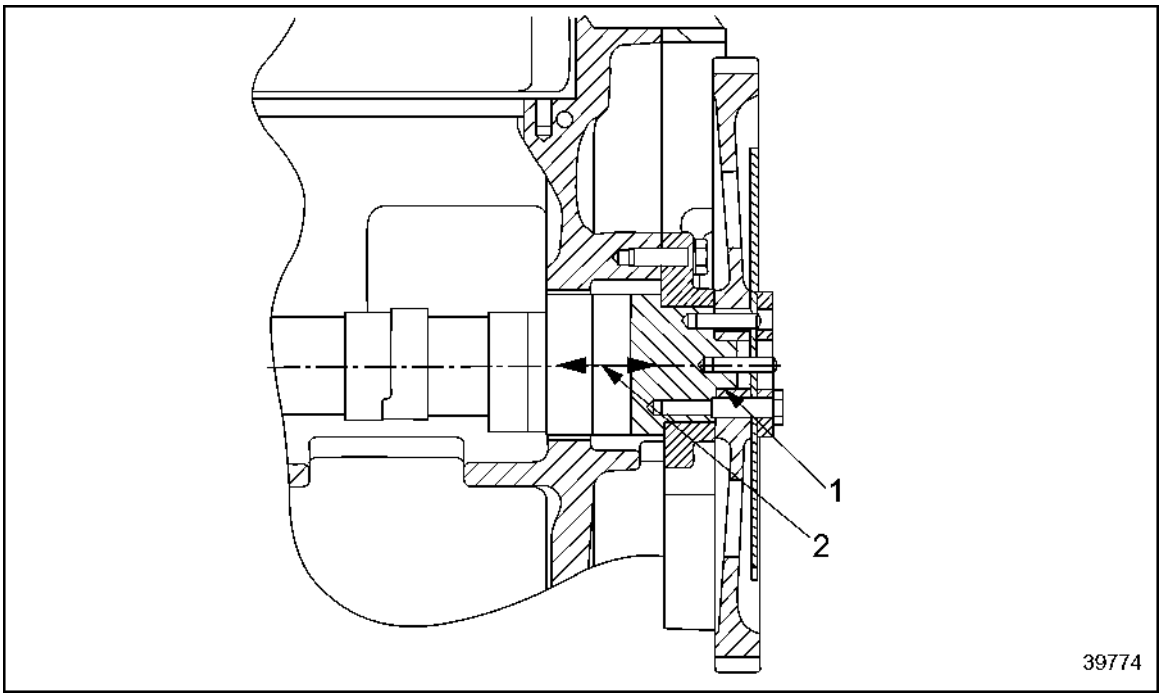


Figure 1104 Camshaft Axial Clearance

No.	Designation	Tol. Size	Deviation		Clearance	
			Lower	Upper	Min	Max
1	Gear bore	32.00^{H7}	0	+ 0.025	0	0.050
	Camshaft OD	32.00_{h7}	– 0.025	0		
2	Axial play - Camshaft	-	-	-	0.100	0.178

Table 38 Camshaft Axial Clearance Tolerances

Inlet and Exhaust Rocker Arm Bearing

See Figure 1105 for the inlet and exhaust rocker arm bearing. Listed in Table 39 are the tolerances for the inlet and exhaust rocker arm bearing.

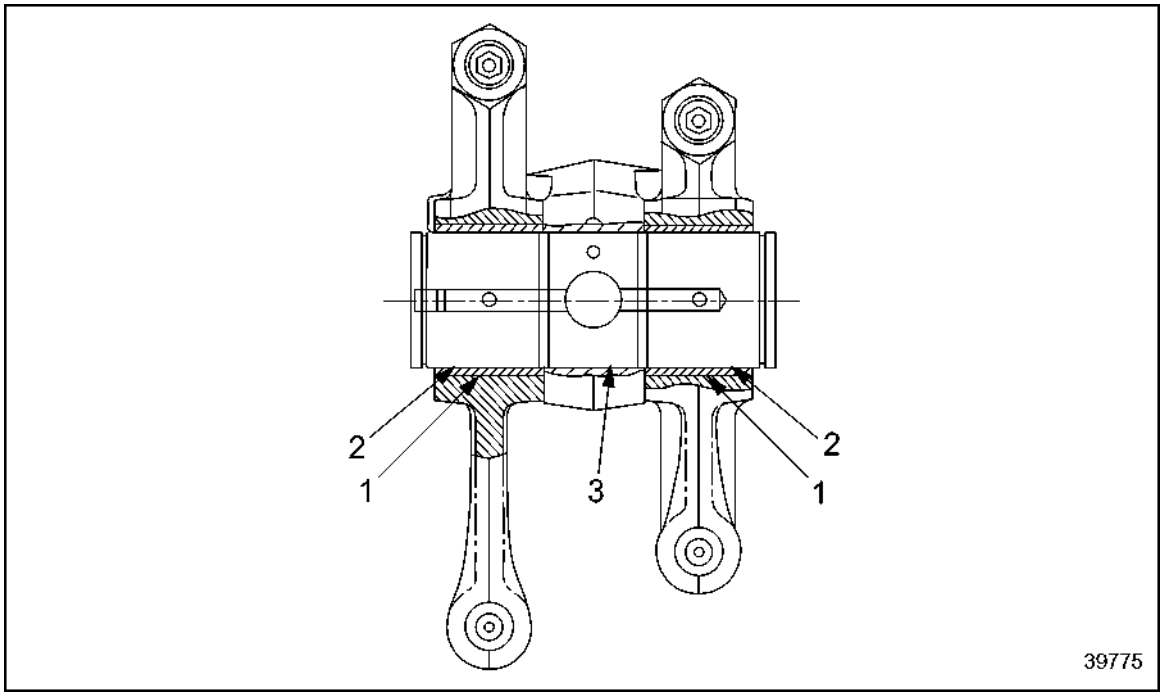


Figure 1105 Inlet and Exhaust Rocker Arm Bearing

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Rocker arm bore	50.00^{H7}	0	+ 0.025	-	-	0.018	0.059
	Bushing OD	50.00_{s6}	+ 0.043	+ 0.059				
2	Bushing bore	45.00^{E6}	+ 0.050	+ 0.066	0.075	0.107	-	-
	Rocker shaft OD	45.00_{f6}	– 0.041	– 0.025				
3	Bearing pedestal bore	45.00^{U7}	– 0.086	– 0.061	-	-	0.020	0.061
	Rocker shaft OD	45.00_{f6}	– 0.041	– 0.025				

Table 39 Inlet and Exhaust Rocker Arm Bearing Tolerances

Inlet and Exhaust Rocker Arm Bearing

See Figure 1106 for the inlet and exhaust rocker arm bearing. Listed in Table 40 are the tolerances for the inlet and exhaust rocker arm bearing.

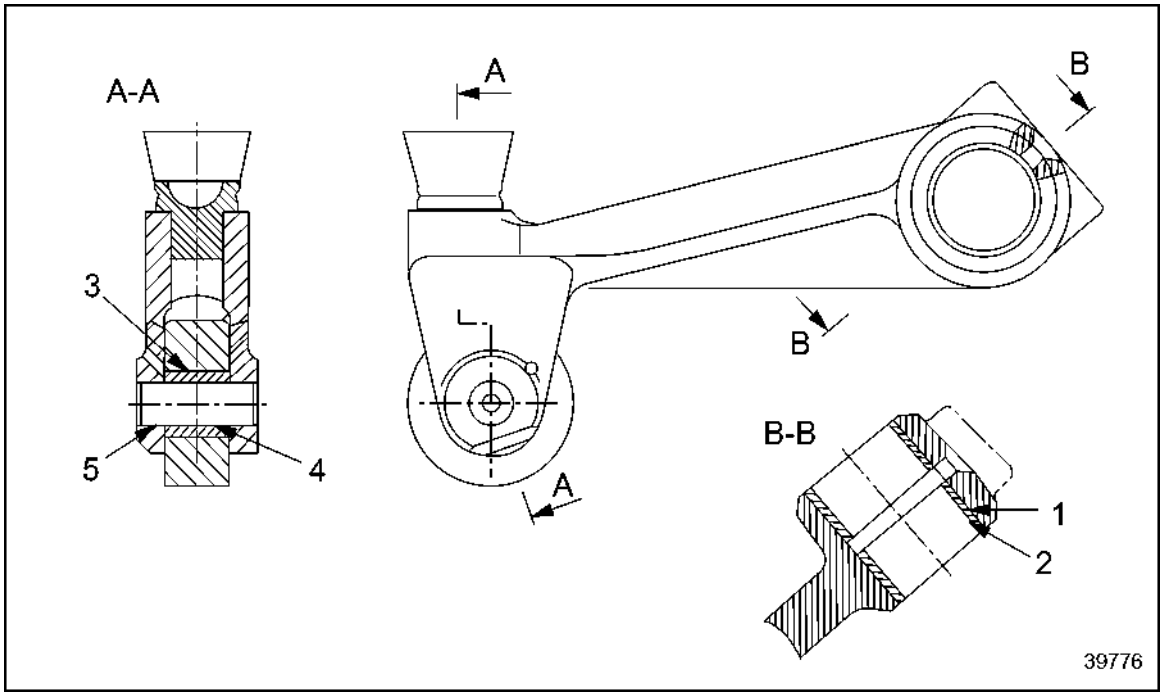


Figure 1106 Inlet and Exhaust Rocker Arm Bearing

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Rocker arm bore	36.00^{H7}	0	+ 0.025	-	-	0.009	0.050
	Bushing OD	36.00	+ 0.034	+ 0.050				
2	Bushing bore							
	- installed	32.00	0	+ 0.050	0.025	0.091	-	-
	- removed	32.00^{G7}	0.009	+ 0.034				
	Shaft OD	32.00 f6	- 0.041	- 0.025				
3	Roller bore	21.00^{E7}	+ 0.040	+ 0.061	0.40	0.082	-	-
	Bushing OD	21.00_{h7}	– 0.021	0				
4	Bushing bore	14.00^{E7}	+ 0.032	+ 0.061	0.032	0.053	-	-
	Pin OD	14.00_{h5}	– 0.008	0				
5	Rocker arm bore	14.00^{P6}	– 0.026	– 0.015	-	-	0.007	0.026
	Pin OD	14.00_{h5}	– 0.008	0				

Table 40 Inlet and Exhaust Rocker Arm Bearing Tolerances

Engine Coolant Pump for H.P. Temperature System

See Figure 1107 for the engine coolant pump for high pressure temperature system.
Listed in Table 41 are the tolerances for the engine coolant pump for high pressure temperature system.

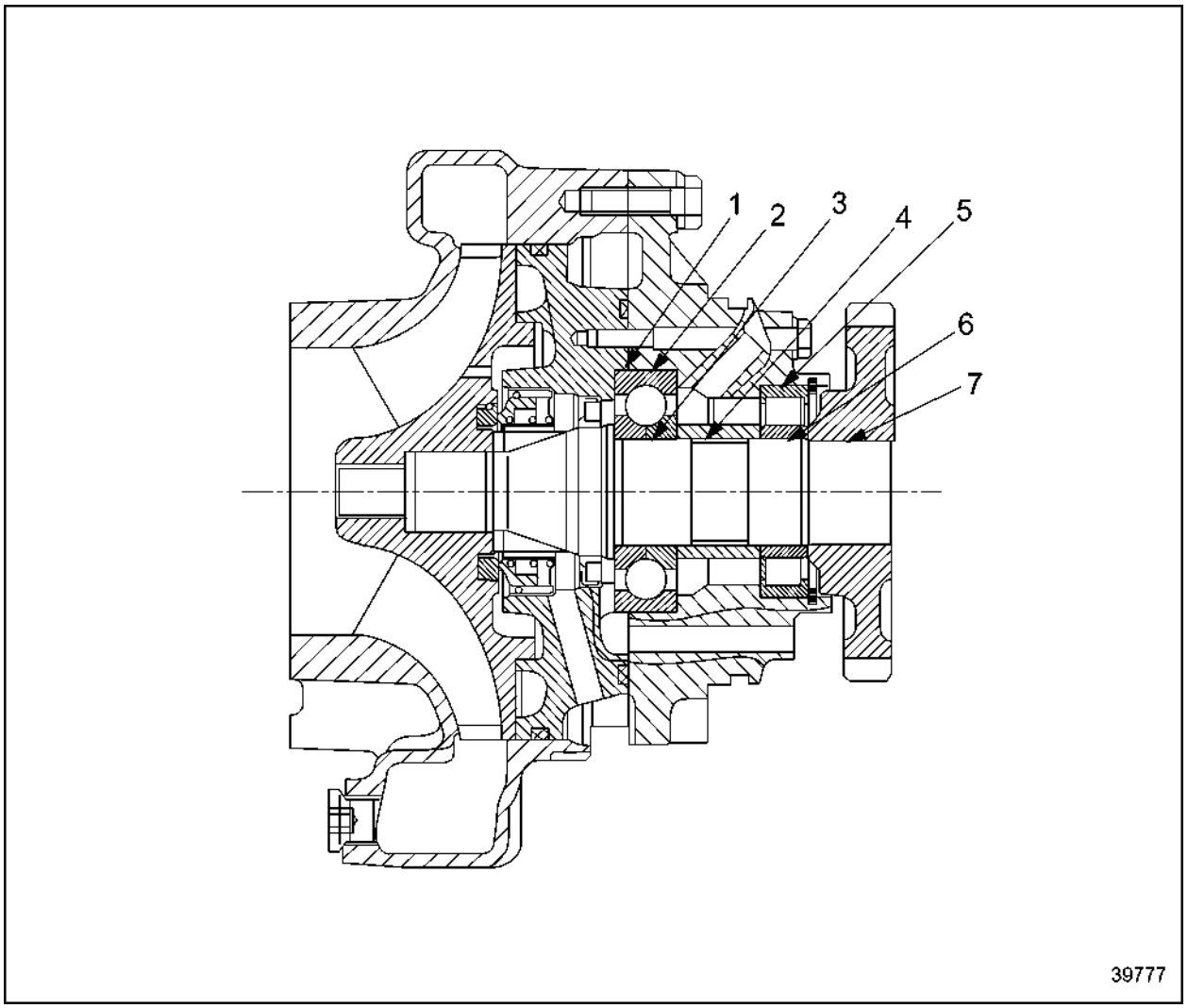


Figure 1107 Engine Coolant Pump for H.P. Temperature System

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Seal carrier bore	90.00^{K7}	– 0.025	+ 0.010	-	0.025	-	0.025
	Bearing OD	90.00	– 0.015	0				
2	Housing bore	90.00^{K7}	– 0.025	+ 0.010	-	0.025	-	0.025
	Bushing OD	90.00	– 0.015	0				
3	Bearing bore	40.00	– 0.012	0	-	-	0.002	0.025
	Shaft OD	40.00_{k5}	+ 0.002	+ 0.013				
4	Spacer sleeve bore	40.00^{N7}	– 0.033	– 0.008	-	-	0.010	0.045
	Shaft OD	40.00_{k5}	+ 0.002	+ 0.013				
5	Housing bore	80.00^{K7}	– 0.021	+ 0.009	-	0.024	-	0.024
	Bearing OD	80.00	– 0.015	0				
6	Bearing bore	40.00	– 0.012	0	-	-	0.002	0.025
	Shaft OD	40.00_{k5}	+ 0.002	+ 0.013				
7	Gear bore	39.00^{H7}	0	+ 0.025	-	-	0.018	0.059
	Shaft OD	30.00_{s6}	+ 0.043	+ 0.059				

Table 41 Engine Coolant Pump for H.P. Temperature System 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.

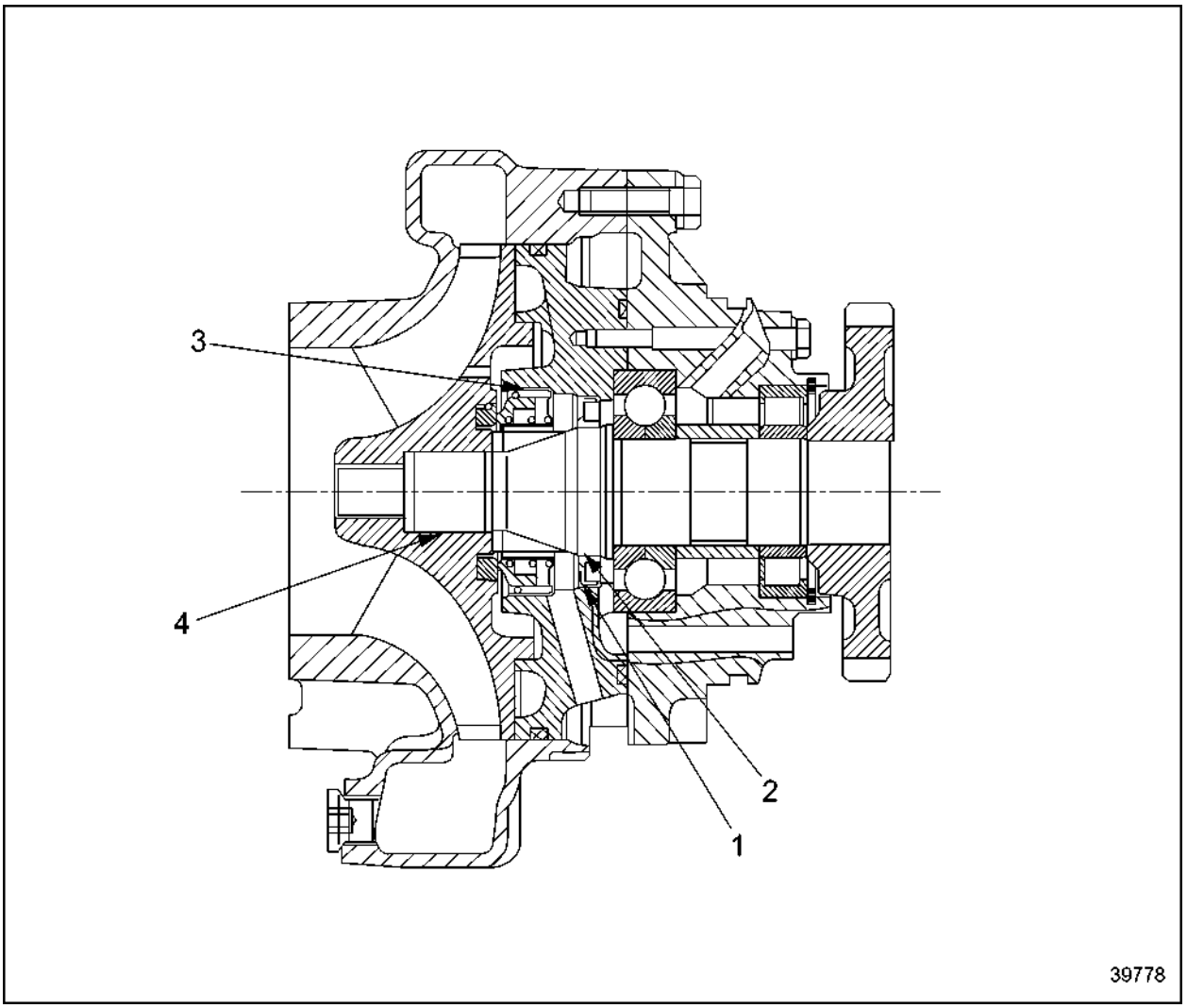


Figure 1108 Engine Coolant Pump for H.P. Temperature System

No.	Designation	Tol. Size	Deviation		Interference	
			Lower	Upper	Min	Max
1	Seal carrier bore	72.00^{H8}	0	+ 0.046	0.084	0.230
	Shaft seal OD	72.00	+ 0.130	+ 0.230		
2	Shaft OD	48.00	– 0.100	0	-	-
3	Seal carrier bore	78.10^{H7}	0	+ 0.030	0.067	0.100
	Rotary seal OD	78.20	– 0.003	0		
4	Impeller bore	30.00^{H5}	0	+ 0.009	0.032	0.050
	Shaft OD	30.00_{t5}	+ 0.041	+ 0.050		

Reconditioning Instructions

Re 2: Running surface worn: Metal-spray pump shaft and grind using feed-in method.

Table 42 Engine Coolant Pump for H.P. Temperature System Tolerances

Engine Coolant Pump for Low Pressure Temperature System

See Figure 1109 for the engine coolant pump for low pressure temperature system.
Listed in Table 43 are the tolerances for the engine coolant pump for low pressure temperature system.

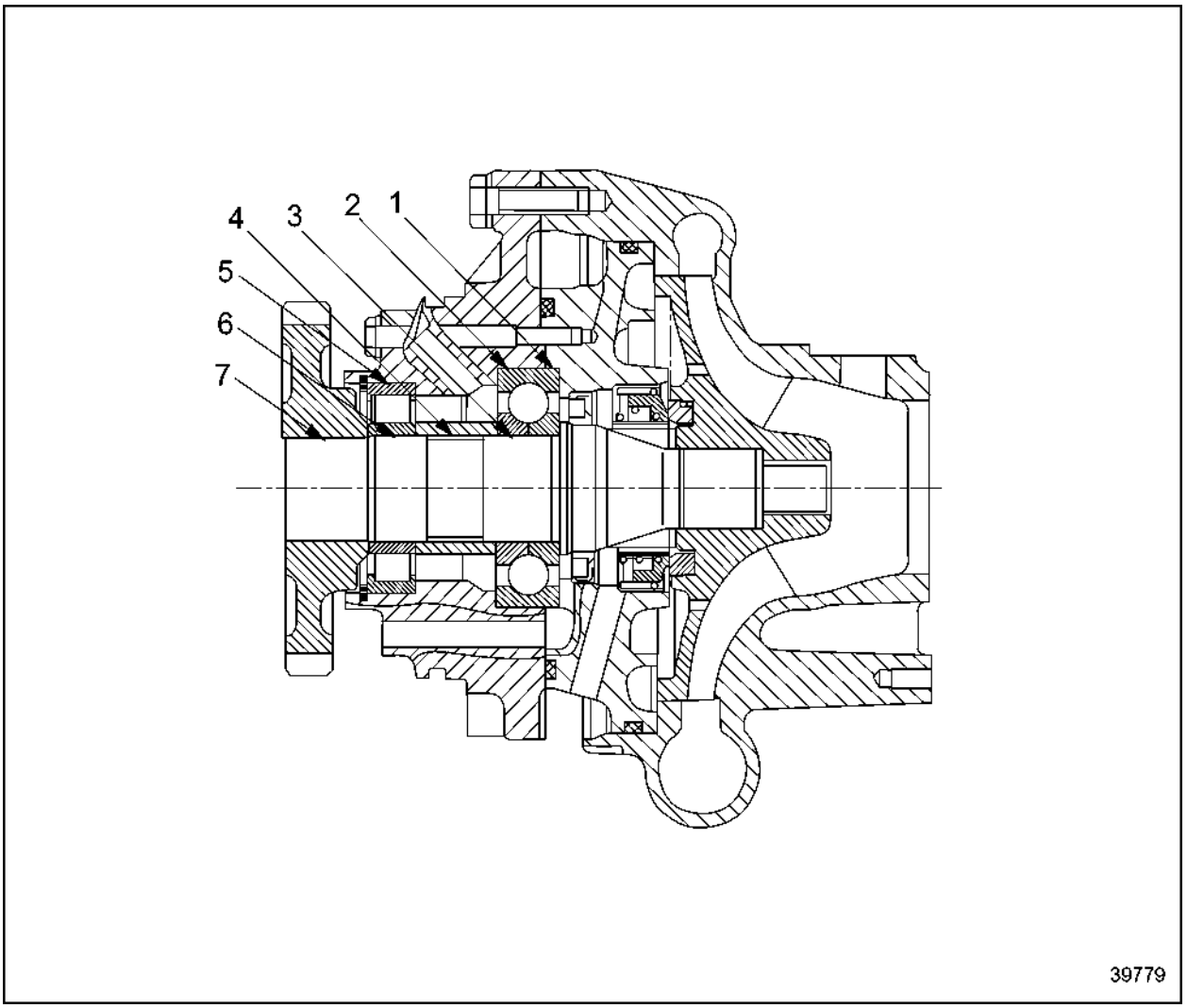


Figure 1109 Engine Coolant Pump for Low Pressure Temperature System

No.	Designation	Tol. Size	Deviation		Clearance		Interference	
			Lower	Upper	Min	Max	Min	Max
1	Seal carrier bore	90.00^{K7}	– 0.025	+ 0.010	-	0.025	-	0.025
	Bearing OD	90.00	– 0.015	0				
2	Housing bore	90.00^{K7}	– 0.025	+ 0.010	-	0.025	-	0.025
	Bushing OD	90.00	– 0.015	0				
3	Bearing bore	40.00	– 0.012	0	-	-	0.002	0.025
	Shaft OD	40.00_{k6}	+ 0.002	+ 0.013				
4	Spacer sleeve bore	40.00^{N7}	– 0.033	– 0.008	-	-	0.010	0.045
	Shaft OD	40.00_{k5}	+ 0.002	+ 0.013				
5	Housing bore	80.00^{K7}	– 0.021	+ 0.009	-	0.024	-	0.024
	Bearing OD	80.00	– 0.015	0				
6	Bearing bore	40.00	– 0.012	0	-	-	0.002	0.025
	Shaft OD	40.00_{k5}	+ 0.002	+ 0.013				
7	Gear bore	39.00^{H7}	0	+ 0.025	-	-	0.018	0.059
	Shaft OD	30.00_{s6}	+ 0.043	+ 0.059				

Table 43 Engine Coolant Pump for Low Pressure Temperature System Tolerances

Engine Coolant Pump for Low Pressure Temperature System

See Figure 1110 for the engine coolant pump for low pressure temperature system.
Listed in Table 44 are the tolerances for the engine coolant pump for low pressure temperature system.

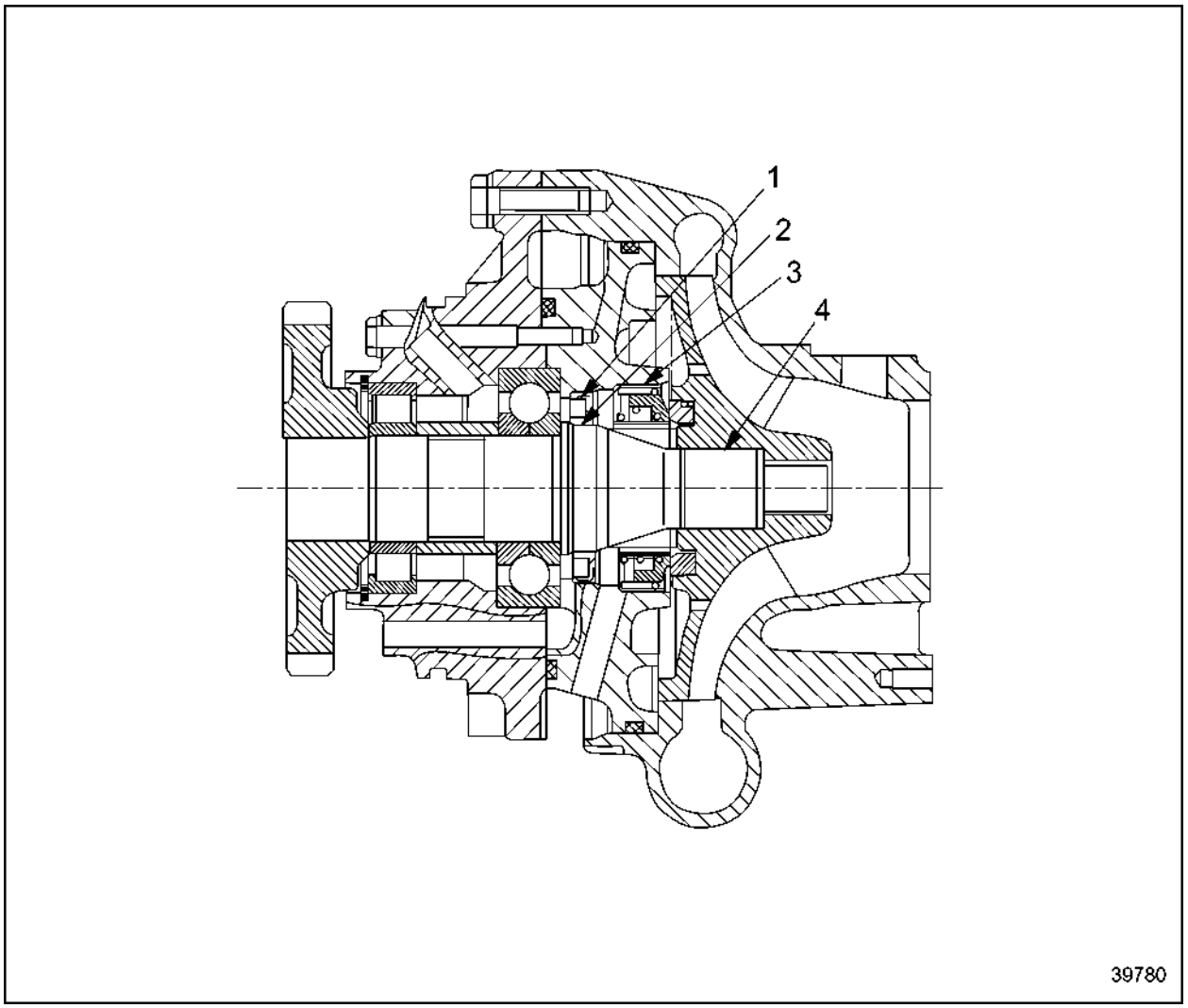


Figure 1110 Engine Coolant Pump for Low Pressure Temperature System

No.	Designation	Tol. Size	Deviation		Interference	
			Lower	Upper	Min	Max
1	Seal carrier bore	72.00^{H8}	0	+ 0.046	0.084	0.230
	Shaft seal OD	72.00	+ 0.130	+ 0.230		
2	Shaft OD	48.00	– 0.100	0	-	-
3	Seal carrier bore	78.10^{H7}	0	+ 0.030	0.067	0.100
	Rotary seal OD	78.20	– 0.003	0		
4	Impeller bore	30.00^{H5}	0	+ 0.009	0.032	0.050
	Shaft OD	30.00_{t5}	+ 0.041	+ 0.050		

Reconditioning Instructions

Re 2: — Running surface worn: Metal-spray pump shaft and grind using feed-in method.

Table 44 Engine Coolant Pump for Low Pressure Temperature System Tolerances

D 020 – ASSEMBLY SPECIFICATIONS

Section **Page**

Assembly Specifications

Listed in Table 45 are the assembly specification values for the Series 4000 engines used in Construction and Industrial, Generator Set, Hydrofrac, and marine applications.

Characteristic	Specification	
Lash	**Lower Limit (mm)**	**Upper Limit (mm)**
Camshaft to crankshaft gear	0.230	0.350
Crankshaft to idler gear (right)	0.083	0.400
Crankshaft to idler gear (left)	0.083	0.400
Idler to oil pump gear	0.127	0.346
Idler to hydraulic pump gear	0.127	0.346
Idler to mount 4 gear	0.056	0.247
Idler to mount 5 gear	0.136	0.266
Idler to mount 6 gear	0.136	0.266
Idler to mount 7 gear	0.056	0.247
Idler to mount 8 gear	0.136	0.266
End Play	-	
Crankshaft (pre-check)	0.250	0.500
Crankshaft	0.250	0.570
Camshaft	0.080	0.178
Timing	-	
Camshaft timing (see note 1)	8.43	8.73
Hub Press Depth	-	
Front	11.3	15.5
Rear (C & I)	13.7	17.0
Rear (Marine)	16.7	20.0
Cylinder Block to Filler Strip Plane Variance	-	
Flywheel housing mating surface (rear plane)	- 0.10	0.10
Oil pan mating surface (bottom plane)	- 0.10	0.10
SRS Sensor-to-Wheel Gap Clearance	-	
DDEC applications	1.02	2.03
MDEC applications	0.31	1.02
Pre-Production Test Leak Verification	**Allowable Leakage**	**Allowable Leakage**
Allowable leak limit HTC water system	N/A	250 cc
Allowable leak limit LTC water system	N/A	250 cc
Allowable leak limit fuel system	N/A	20 cc

Run-out	-	
See 70RU-9	-	-

NOTE:

1. Camshaft lift measured on the exhaust lobe in cylinder A1 with the engine at TDC.

Verify intake valve lash on all cylinders — reset as necessary (Use Go/No — Go feeler gage 0.007–0.009 in.)

Verify exhaust valve lash on all cylinders — reset as necessary (Use Go/No — Go feeler gage 0.019–0.021 in.)

Table 45 Engine Assembly Specifications

E – TROUBLESHOOTING

E 010 – MECHANICAL TROUBLESHOOTING

E 011 – FAN CLUTCH

E 011.01 – GENERAL MECHANICAL TROUBLESHOOTING INFORMATION

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan:

- **Never work in close proximity to the fan.**
- **Never try to keep the fan from rotating by holding the fan.**
- **Never tie down the fan with straps, chains, or other restraints.**
- **Never shut off the oil supply to the fan clutch.**

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan, remove loose items of clothing and jewelry; tie back or contain long hair that could be caught in any moving part causing injury. A hydraulic fan may start without warning.

Before investigating a complaint, it will be necessary to fully understand the operation of the fan clutch and the fan clutch controls. Refer to section C 222.05.01C 222.05.01 , for information on the description and operation of the fan clutch and the fan clutch controls. Refer to *DDEC III/IV Multi-ECM Troubleshooting Guide*, 6SE496 for information regarding the ECM (Electronic Control Module) system and DDEC controls.

E 011.02 – FAULT CONDITIONS

Engine Runs Hot and Fan Will Not Lock Up

Perform the following corrective actions to resolve engine runs hot and fan will not lock up:

1. Fan clutch will not lock up.

   Visually verify that the fan is not locked up. A locked-up fan running at high speed will create a significantly greater air flow (and noise level) than will a free-wheeling fan. The problem may be located in a component system other than the fan clutch.

   CAUTION:

   To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan:
   - ☐ **Never work in close proximity to the fan.**
   - ☐ **Never try to keep the fan from rotating by holding the fan.**
   - ☐ **Never tie down the fan with straps, chains, or other restraints.**
   - ☐ **Never shut off the oil supply to the fan clutch.**

   CAUTION:

   To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan, remove loose items of clothing and jewelry; tie back or contain long hair that could be caught in any moving part causing injury. A hydraulic fan may start without warning.

   Disconnect the solenoid wires at the harness connector to lock up the fan clutch. Check fan lockup with a strobotac. Match-mark the fan and fan clutch pulley. The two marks should rotate at exactly the same speed. If they do not, the fan clutch is not completely locked up. Go to step 2 for a further probable cause.

2. Coolant level may be low.

   Fill radiator to correct coolant level. Go to step 3 for a further probable cause.

3. Fan belt is slipping during engine operation.

   Properly tension a loose belt; refer to section C 221.05.11C 221.05.11 . Replace the belt if it is worn. Repair or replace belt tensioning mechanism if necessary. Check the pulley grooves to insure there is no excessive wear. Go to step 4 for a further probable cause.

4. There may be electrical wiring problems.

Ensure tight connections, good grounding points, and no bad wires. Check all electrical connectors to ensure none are broken, cracked, or damaged. Go to step 5 for a further probable cause.

5. Solenoid valve may not be working properly.

   Check for proper operation. Install a pressure gage in the "COM" or "CLUTCH" port.

   If the pressure gage readings are correct, bypass the solenoid valve to check fan clutch lockup. Remove the oil supply hose from the "NO" or "INLET" port on the solenoid valve, and reattach it directly to the "CONTROL PRESSURE" port in the fan clutch. Install a pressure gage in the line as close to the fan clutch as possible. Cap or plug all open connections.

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan:

- ☐ **Never work in close proximity to the fan.**
- ☐ **Never try to keep the fan from rotating by holding the fan.**
- ☐ **Never tie down the fan with straps, chains, or other restraints.**
- ☐ **Never shut off the oil supply to the fan clutch.**

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan, remove loose items of clothing and jewelry; tie back or contain long hair that could be caught in any moving part causing injury. A hydraulic fan may start without warning.

Start the engine. The fan clutch should be locked up, when a minimum of 40 psi. engine oil pressure is provided. (The clutch must be supplied with a minimum of 40 psi oil pressure applied to the "CONTROL PRESSURE" port.) Go to step 6 for a further probable cause.

6. Clutch plates worn out.

   If breakaway torque is below specifications, repair or replace the fan clutch; refer to section C 221.05.05C 221.05.05 .

Engine Runs Cold and Fan Runs Continuously At Maximum Speed

Perform the following corrective actions to resolve engine runs cold and fan runs continuously at maximum speed:

1. Fan clutch will not fully release.

   Visually verify that the fan is not releasing and rotating at an idle speed. A free-wheeling fan running at idle speed will create significantly less air flow (and noise level) than a locked-up fan running at high speed.

   CAUTION:

   To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan:
   - ☐ **Never work in close proximity to the fan.**
   - ☐ **Never try to keep the fan from rotating by holding the fan.**
   - ☐ **Never tie down the fan with straps, chains, or other restraints.**
   - ☐ **Never shut off the oil supply to the fan clutch.**

   CAUTION:

   To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan, remove loose items of clothing and jewelry; tie back or contain long hair that could be caught in any moving part causing injury. A hydraulic fan may start without warning.

   Check fan release with a strobotac. Match-mark the fan and fan clutch pulley. Start the engine. The two marks should not rotate at exactly the same speed. If they do, the fan clutch is not completely releasing. Fan speed should be at idle with a cool engine. Refer to section C 222.05.01C 222.05.01 .

   Next, shut off the engine. The fan should rotate freely without engine oil pressure to lock up the fan clutch. Go to step 2 for a further probable cause.

2. There may be electrical wiring problems.

   Ensure tight connections, good grounding points, and no bad wires. Check all electrical connectors to be sure none are broken, cracked, or damaged. Go to step 3 for a further probable cause.

3. Solenoid valve may not be working properly.

   Install a pressure gage in the "COM" or "CLUTCH" port. With a cool engine the solenoid valve should supply "0" oil pressure to the fan clutch, and the fan should free-wheel.

   If the pressure gage readings are correct, disconnect the oil supply hose from the fan clutch "OIL IN" port. The clutch should release fully, and the fan should free-wheel. Go to step 4 for a further probable cause.

4. Fan mounting bolts may be too long.

   If the fan mounting bolts extend through the fan mounting hub and contact the front of the front bearing retainer, the fan clutch may be mechanically locked up. Replace with bolts that fit full thread in fan mounting hub, but do not extend too far through. (Check to insure bearings in fan clutch have not been damaged.) Go to step 5 for a further probable cause.

NOTE:
SAE grade 8 bolts are recommended in mounting the fan to the fan mounting hub. If washers are used, they, too, should be hardened. Bolts holding the fan on the fan mounting hub must fully engage the threads, but must not extend too far through the fan mounting hub to contact the front of the bearing retainer or other components.

5. A manual override switch may be preventing the fan clutch from releasing.

   (Although not recommended by Rockford Powertrain, some vehicles are equipped with a manual override switch in the cab which overrides the control of the thermal sensor.) Turn switch to "Off" or replace a defective switch. Go to step 6 for a further probable cause.

6. Control pressure line is restricted, not allowing oil to exhaust from clutch.

   Relieve restriction. Go to step 7 for a further probable cause.

7. Compressor override system may not be operating properly.

   If vehicle is equipped with air conditioning and override, check components of the system to ensure false signal is not being sent to solenoid, causing fan clutch lockup.

Fan Clutch Cycles Off and On Continuously at an Abnormally High Rate

Perform the following corrective actions to resolve fan clutch cycles off and on continuously at an abnormally high rate:

1. Coolant level is low.

   Fill radiator to proper level. Go to step 2 for a further probable cause.

2. Heat range setting of thermostat and thermal sensor is not compatible.

   Replace either thermostat or thermal sensor with correct temperature setting to obtain proper sequence of operation.

Noisy Operation

Perform the following corrective actions to resolve noisy operation:

1. Noise originating elsewhere, but "telegraphing" to appear as though the fan or the fan clutch is noisy.

   On some engines, a severe noise originates in the air conditioner compressor and telegraphs through belts to be heard in the fan clutch. Go to step 2 for further checking. If no noise is present, fan clutch is OK.

2. Internal failure.

   Move fan blade in and out between engine and radiator. There should be no forward-rearward movement of the fan mounting hub. If movement exists, repair the fan clutch.

Fan Clutch Squeals as it Engages

Perform the following corrective actions to resolve fan clutch squeals as it engages:

1. Fan mounting bolts may be too long.

   If the fan mounting bolts extend through the fan mounting hub and contact the front of the front bearing retainer, the fan clutch may be mechanically locked up. Replace with bolts that fit full thread in fan mounting hub, but do not extend through too far. (Check to ensure bearings in the fan clutch have not been damaged.) Go to step 2 for a further probable cause.

2. The main bearings in the fan clutch may have failed.

   Check for forward-rearward axial movement of the fan. If movement exists, repair the fan clutch. Determine cause of oil starvation or bearing overload. Go to step 3 for a further probable cause.

3. Fan belt is slipping.

   Properly tension a loose belt. Replace the belt if it is worn. Repair or replace belt tensioning mechanism if necessary. Check the pulley grooves to ensure there is no excessive wear.

Oil Leaking From The Seals

Perform the following corrective actions to resolve oil leaking from the seals:

NOTE:
Leaking hose connections can often appear to be seal leaks. Check carefully. Always clean the oily area well, to verify the actual source of the leak.

NOTE:
Oil seal design requires that a small amount of oil must lubricate the seal lip. This oil often accumulates and eventually weeps from the seal area. A small amount of oil weep is to be considered normal if, after thoroughly cleaning the surface, the oil track does not reach the O.D. of the pulley within one hour of operation. Clean the wet area thoroughly. Continue to operate the fan clutch until a clear determination can be made that a normal weep is not being mistaken for an actual leak. If it is determined a leak is occurring, repair the fan clutch.

1. Oil drain line may be too small or restricted.

   Remove restriction. A restricted drain line can cause excessive pressure inside the fan clutch, causing seal leaks. Go to step 2 for a further probable cause.

2. Orifice may have been left out of the fan clutch.

   (Some fan clutches operate without an orifice or have the orifice designed into internal passageways of the fan clutch. Refer to a parts manual to determine if a separate orifice plug is used.) Install the correct orifice if the fan clutch does not have the correct one. When the proper orifice fitting is installed in the OIL IN port, the leak may cease. If the leak continues, repair the fan clutch. Go to step 3 for a further probable cause.

3. Front or rear oil seals may be damaged.

   Repair the fan clutch correctly, using tools and procedures as specified. Go to step 4 for a further probable cause.

4. Oil may be leaking under the wear sleeve.

   Repair the fan clutch correctly, using tools and procedures as specified. Go to step 5 for a further probable cause.

5. Belt tension may be excessive.

   Check to ensure belt tensioning mechanism is not bound up, misaligned, or creating excess tension. Adjust belt tension to proper engine or vehicle manufacturer’s specifications. If belt tension is correct and seals continue to leak, repair the fan clutch.

E 012 – ENGINE MECHANICAL TROUBLESHOOTING

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 .

E 012.05 B – ENGINE DOES NOT TURN

Start with the first probable cause for engine not turning when the starter switch/button is pushed, listed in Table 1. Perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete. If the problem still persists, call for technical assistance.

Probable Causes	Check	Remedial Action
Battery	Battery charge state Cable connections	Charge battery; replace if necessary Connect; replace if necessary
Starter	Starter / engine wiring	Connect; replace if necessary
	Start repeat relay	Replace
	Starter	Replace
	Ring gear	Replace
Vehicle Monitoring (DDEC)	Vehicle monitoring start release	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
Running gear blocked	Whether engine can be turned by hand	Repair running gear

Table 1 Engine Does Not Turn

E 012.05 C – ENGINE TURNS BUT DOES NOT FIRE

Start with the first probable cause for engine turns when operating the starter switch but does not fire or stops after a few revolutions, listed in Table 2. Perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant preheat temperature too low	Refer to section E 012.05 AE	Refer to section E 012.05 AE
Fuel H.P. too low, no start release	Refer to section E 012.05 H	Refer to section E 012.05 H
Engine receiving insufficient combustion air	Air filter contamination indicator Refer to G121.051.01Operator Guide	Air filter contamination indicator Refer to G121.051.01Operator Guide
	Air filter	Replace. Refer to G121.051.01Operator Guide
	Charge Air Cooler	Clean; replace if necessary
Compression pressure too low	Refer to E 012.05 G	Refer to E 012.05 G
Engine does not reach firing speed	Battery	Charge; replace if necessary
	Starter / engine wiring	Connect; replace
	Starter	Replace
Electronics wiring loose or faulty	Voltage supply	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
DDEC not working	Engine monitoring system	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
Engine speed sensor and camshaft sensor (faulty synchronization)	Installation depth Wiring, function with dialogue unit / data recorder	Install sensors correctly Repair; replace if necessary Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 2 Engine Turns but Does Not Fire

E 012.05 D – ENGINE FIRES ERRATICALLY AFTER START

Start with the first probable cause for engine fires erratically after start listed in Table 3, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant preheat temperature too low	Refer to section E 012.05 AE	Refer to section E 012.05 AE
Fuel system is aerated	Whether engine fires steadily after short period	Run for 5 minutes to de-aerate fuel
Fuel injection equipment faulty	Injector wiring, fault recorder, fault display	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 3 Probable Causes and Action for Engine Fires Erratically

E 012.05 E – ENGINE DOES NOT REACH FULL-LOAD SPEED

Start with the first probable cause for engine not reaching full-load speed listed in Table 4, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine receiving insufficient combustion air	Refer to section E 012.05 N	Refer to section E 012.05 N
Fuel injection equipment faulty	Injector wiring, fault recorder, fault display	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
H.P fuel pump generating insufficient pressure	Refer to section E 012.05 H	Refer to section E 012.05 H * If visual checks are OK, refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
Engine receiving insufficient fuel	Refer to section E 012.05 K	Refer to section E 012.05 K
Charge air temperature too high	Refer to section E 012.05 M	Refer to section E 012.05 M
PTO (Power take-off too high)	Auxiliary PTO capacity; data recorder	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 4 Engine Does not Reach Full-Load Speed

E 012.05 F – ENGINE SPEED NOT STEADY

Start with the first probable cause for engine speed not steady listed in Table 5, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Fuel injection equipment faulty	Injection timing	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
H.P. fuel pump suction valve sluggish	H.P. fuel pump with data recorder	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
	Check suction valve for ease of movement	Repair; replace if necessary
DDEC	Engine governor	Replace sensor; Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 5 Engine Speed Not Steady

E 012.05 G – COMPRESSION PRESSURE TOO LOW

Start with the first probable cause for compression pressure too low listed in Table 6, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Cylinder head gasket leaking	Cylinder head gasket	Replace
Valve seats in cylinder head worn	Cylinder head	Repair
Valves do not close	Valve clearances	Adjust. Refer to G055.050.01Operator Guide
	Valves	Recondition; replace if necessary
Piston rings worn	Piston rings	Replace

Table 6 Compression Pressure Too Low

E 012.05 H – HIGH PRESSURE FUEL PUMP PRESSURE TOO LOW

Start with the first probable cause for H.P. fuel pump pressure too low listed in Table 7, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Fuel sensor faulty	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)	Replace sensor
H.P. fuel pump of fuel quantity regulator / pressure regulator (actuating solenoid)	Suction valve	Repair; replace if necessary
Pressure relief valve leaking	Fuel return from pressure relief valve	Replace pressure relief valve
Fuel pressure less than 4 bars	Refer to section E 012.05 K	Seal pump; replace if necessary
High pressure fuel pump generating insufficient pressure	Fuel pressure with data recorder. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)	Replace high pressure pump

Table 7 Fuel Pump Pressure Too Low

E 012.05 I – FUEL PUMP PRESSURE TOO HIGH

Start with the first probable cause for fuel pump pressure too high listed in Table 8, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
H.P. fuel sensor not working.	Fuel pressure with dialogue unit/recorder or fault display via flashing light. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)	Replace sensor
H.P. fuel pump —quantity/pressure regulator (actuating solenoid)	Harsh engine running noise at idling connector and wiring. Suction valve	Repair; replace if necessary

Table 8 Fuel Pressure Too High

E 012.05 J – HIGH PRESSURE FUEL PUMP LEAKING

Start with the first probable cause for high pressure fuel pump leaking at the weep hole listed in Table 9, perform the check and take the suggested remedial action.

Probable Causes	Check	Remedial Action
H.P. fuel pump seals leaking	For engine oil or fuel discharge	Replace H.P. fuel pump

Table 9 High Pressure Fuel Pump Leaking

E 012.05 K – FUEL PUMP PRESSURE TOO LOW

Start with the first probable cause for fuel pressure too low listed in Table 10, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Fuel supply blocked	Shutoff valve in fuel system	Open
Fuel level too low	Fuel supply	Replenish
Fuel line leaking	Seals	Replace seal if necessary
Fuel filter contaminated	Fuel duplex filter	Replace filter. Refer to G083.051.03Operator Guide
Fuel delivery pump faulty	Fuel delivery pump and drive	Repair; replace if necessary

Table 10 Fuel Pressure Too Low

E 012.05 L – TURBOCHARGER - ABNORMAL RUNNING NOISES

Start with the first probable cause for exhaust turbocharger — abnormal running noises listed in Table 11, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Turbocharger dirty	Exhaust turbocharger	Clean
Turbocharger faulty	Turbocharger bearing	Replace
	Rotor assembly	Replace

Table 11 Abnormal Running Noises

E 012.05 M – CHARGE AIR TEMPERATURE TOO HIGH

Start with the first probable cause for charge air temperature too high listed in Table 12, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Charge air cooler dirty	Charge air cooler	Clean
Charge air coolant temperature too high	Coolant thermostat; Refer to section E 012.05 AF	Check; replace if necessary
Antifreeze concentration too high	Engine coolant Charge air coolant	Rectify concentration as per specifications
Incorrect corrosion inhibitor (deposits in (CAC) charge air cooler)	Charge air coolant Coolant inhibitor	Clean coolant system. Treat engine coolant (*Oil, Fuel, and Filter Requirements, DDC/MTU Series 2000, MTU/DDC Series 4000* 7SE273. Replace (CAC) charge air cooler if necessary.
Temperature transmitter on engine A or B side faulty	Temperature transmitter with dialogue unit/fault recorder or fault display via flashing light. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)	Replace

Table 12 Charge Air Temperature Too High

E 012.05 N – CHARGE AIR PRESSURE TOO LOW

Start with the first probable cause for charge air pressure too low listed in Table 13, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine receiving insufficient combustion air	Air filter	Replace
	Air filter contamination indicator	Replace; contact OEM
	Air supply pipework	Seal
	(CAC) charge air cooler	Clean; replace if necessary
	Exhaust turbocharger	Repair
	Charge air pressure	-
Pressure transmitter on engine A or B side faulty	Pressure transmitter with dialogue unit/fault recorder or fault display via flashing light	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 13 Charge Air Pressure Too Low

E 012.05 O – CHARGE AIR COOLER, COOLANT DISCHARGE AT WEEP HOLE

Start with the first probable cause for the charge air cooler, coolant discharge at the weep hole, listed in Table 14, perform the check and take the suggested remedial action. Refer to G111.051.01 Operator Guide.

Probable Causes	Check	Remedial Action
Charge air cooler leaking	Coolant discharge from intake manifold elbow weep holes	Replace charge air cooler

Table 14 Coolant Discharge at Intake Manifold Weep Holes

E 012.05 P – EXHAUST GASES BLACK

Start with the first probable cause for exhaust gases black listed in Table 15, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine receiving insufficient combustion air	Refer to section E 012.05 N	Refer to section E 012.05 N
Fuel injection equipment faulty	Refer to section E 012.05 D	Refer to section E 012.05 D
Too high resistance in exhaust system	Exhaust back pressure Exhaust system	Clean exhaust silencer
Engine overload; power take-off too high	Auxiliary PTO power (power consumption too high) dialogue unit/data recorder (speed-sensitive fuel limiter actual/specified torque)	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 15 Exhaust Gases Black

E 012.05 Q – EXHAUST GASES BLUE

Start with the first probable cause of exhaust gases blue listed in Table 16, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Too much oil in combustion chambers	Engine oil level	Correct oil level. Refer to G180.000.01 Operator Guide.
	Exhaust turbocharger	Repair
	Cylinder block ventilation	Replace
	Valve stem seals	Replace
	Piston rings	Replace
	Valve guides	Replace
	Cylinder liners	Replace
Compression pressure too low	Refer to section E 012.05 G	Refer to section E 012.05 G

Table 16 Exhaust Gases Blue

E 012.05 R – EXHAUST GASES WHITE

Start with the first probable cause of exhaust gases white listed in Table 17, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant preheat temperature too low	Refer to section E 012.05 AE	Refer to section E 012.05 AE
		Drain fuel prefilter
Engine cold	Engine coolant temperature	Refer to section E 012.05 Z
	Exhaust turbocharger	Repair
Coolant in combustion chambers	Charge air cooler	Replace
	Cylinder head gaskets	Replace
	Cylinder heads cracked	Replace
	Cylinder liners	Replace

Table 17 Exhaust Gases White

E 012.05 S – STARTER POWER SUPPLY FAULTY

Start with the first probable cause for starter power supply faulty listed in Table 18, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Battery not or insufficiently charged	Poly-vee belt	Adjust tension; replace if necessary
	Generator / alternator	Repair or replace
	Battery	Replace
Charge Indicator Lamp does not display charge with engine running	Connection cable to indicator lamp Fuses Charge indicator lamp Battery Generator voltage regulator	Secure Replace Replace Replace Replace
	Generator / alternator	Tighten cable fixtures Replace
	Connection cable on starter	Secure
DDEC	Engine monitoring system	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 18 Starter Power Supply Faulty

E 012.05 T – ENGINE OIL CONSUMPTION ABNORMALLY HIGH

Start with the first probable cause for engine oil consumption abnormally high listed in Table 19, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Cylinder block ventilation faulty	Cylinder block ventilation	Replace
Engine oil system leaking externally	External subassemblies	Seal pipework
	External pipework	Check connections; tighten if necessary
	Engine oil drains	Seal
	Shaft seals	Replace
	Oil pan	Seal pipework
	Cylinder block	Repair
Engine oil system leaking internally	Coolant quality Oil line connection to engine oil heat exchanger	Replace sealing rings
Exhaust turbocharger leaking	Exhaust turbocharger	Replace bearings
Engine wear	Valve stem seal	Replace
	Piston rings	Replace
	Valve guides	Replace
	Cylinder liners	Replace

Table 19 Engine Oil Consumption Abnormally High

E 012.05 U – ENGINE OIL LEVEL ABNORMALLY HIGH

Start with the first probable cause for engine oil level abnormally high listed in Table 20, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Fuel or engine coolant in engine oil	Engine oil quality	-
High pressure fuel system leaking	Injectors	Replace seals to cylinder head
	Weep hole	Replace pump if discharge present
Coolant in engine oil	Cylinder block	Repair
	Cylinder heads	Replace
	Cylinder liner seals	Replace
	Cylinder liners	Replace
	Coolant distribution housing	Replace

Table 20 Engine Oil Level Abnormally High

E 012.05 V – ENGINE OIL TEMPERATURE TOO HIGH

Start with the first probable cause of engine oil temperature too high, listed in Table 21, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine oil heat exchanger dirty	Engine oil heat exchanger	Clean; replace if necessary
Temperature transmitter faulty	Temperature transmitter with dialogue unit/fault recorder or fault display via flashing light	Repair or replace as necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 21 Engine Oil Temperature Too High

E 012.05 W – ENGINE OIL PRESSURE TOO HIGH

Start with the first probable cause for engine oil pressure too high listed in Table 22, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Oil viscosity too high	Engine oil viscosity	Change engine oil
Engine oil system	Engine oil pressure relief valve	Replace
Engine oil pressure sensor faulty	Pressure sensor with dialogue unit/fault recorder or fault display via flashing light	Replace. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 22 Engine Oil Pressure Too High

E 012.05 X – ENGINE OIL PRESSURE TOO LOW

Start with the first probable cause of engine oil pressure too low listed in Table 23, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine oil filter dirty	Engine oil filter	Replace filter
Engine oil level too low	Engine oil level	Replenish
Engine oil pressure sensor faulty	Pressure transmitter with dialogue unit/fault recorder or fault display via flashing light	Replace. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
After oil filter change, the pure oil or contaminated oil drain plugs on equipment carrier are still open	Drain plugs on equipment carrier	Close drain plugs
Engine oil system leaking externally	Refer to section E 012.05 T	Refer to section E 012.05 T
Fuel in engine oil	Engine oil quality	Refer to section E 012.05 U
Engine oil pressure relief valve	Opening pressure	Adjust or replace
Engine oil pump faulty	Engine oil pump	Repair; replace if necessary
Pressure loss in running gear	Running gear lubrication points	Replace bearings
Coolant in engine oil	Engine oil quality	Refer to section E 012.05 U

Table 23 Engine Oil Pressure Too Low

E 012.05 Y – ENGINE COOLANT TEMPERATURE TOO HIGH

Start with the first probable cause for engine coolant temperature too high listed in Table 24, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant level too low	Engine coolant level	Add engine coolant
Engine coolant system dirty	Engine coolant system	Clean
	Vent lines	Clean
	Engine coolant heat exchanger	Clean; replace if necessary
DDEC	Indicator lamp	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
Fan drive faulty	Refer to section E 012.05 AL	Refer to section E 012.05 AL
Engine coolant thermostat faulty	Engine coolant thermostat	Replace
Engine coolant pressure too low	Refer to section E 012.05 AA	Refer to section E 012.05 AA
Engine coolant temperature transmitter not working	Temperature transmitter and wiring with dialogue unit / fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 24 Engine Coolant Temperature Too High

E 012.05 Z – ENGINE COOLANT TEMPERATURE TOO LOW

Start with the first probable cause for engine coolant temperature too low listed in Table 25, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant thermostat faulty	Engine coolant thermostat	Replace
Engine coolant temperature transmitter not working Fan drive faulty, always on	Temperature transmitter and wiring with dialogue unit / fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 25 Engine Coolant Temperature Too Low

E 012.05 AA – ENGINE COOLANT PRESSURE TOO LOW

Start with the first probable cause for engine coolant pressure too low listed in Table 26, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Coolant system not sealed	Cover closed	Close cover
	Breather valve	Replace cover
Engine coolant system leaking externally	External pipework	Check connections; tighten if necessary
	External subassemblies	Check connections; tighten if necessary
	Coolant drain points	Seal
	Cylinder block	Check for leaks; replace if necessary
	Engine coolant heat exchanger	Repair
Engine coolant level too low	Engine coolant level	Add engine coolant
Engine coolant pump faulty	Engine coolant pump	Replace
Engine coolant system leaking internally	Oil quality	Change engine oil
	Cylinder heads	Replace
	Cylinder liner gaskets	Replace
Engine coolant pressure sensor faulty	Pressure transmitter with dialogue unit/fault recorder or fault display via flashing light	Replace; refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 26 Engine Coolant Pressure Too Low

E 012.05 AB – ENGINE COOLANT LOSS

Start with the first probable cause for engine coolant loss listed in Table 27, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine coolant system leaking externally	Refer to section E 012.05 AA	Refer to section E 012.05 AA
Engine coolant system leaking internally	Refer to section E 012.05 AA	Refer to section E 012.05 AA
Engine coolant pump leaking	Engine coolant pump	Repair
Display fault Engine coolant level transmitter	Transmitter wiring dialogue unit/fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 27 Engine Coolant Loss

E 012.05 AC – ENGINE COOLANT LEVEL RISING

Start with the first probable cause engine coolant level rising listed in Table 28, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Engine oil in engine coolant	Engine oil heat exchanger	Repair; replace if necessary
	Engine coolant quality	Refer to section E 012.05 AA
Air in engine coolant	Vent lines	Clean
	Compression pressures	Replace cylinder head gaskets

Table 28 Engine Coolant Level Rising

E 012.05 AD – ENGINE COOLANT PUMP LEAKING AT WEEP HOLE

Start with the first probable cause for engine coolant pump leaking at the weep hole listed in Table 29, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Radial lip oil seal leaking	For oil discharge	Replace sealing ring
Rotary seal leaking	Engine coolant discharge	Replace slip ring; replace engine coolant pump if necessary

Table 29 Engine Coolant Pump Leaking at Weep Hole

E 012.05 AE – PREHEAT TEMPERATURE TOO LOW

Start with the first probable cause for preheat temperature too low listed in Table 30, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Power supply for preheater	Power supply available	Provide power supply
Preheater not working	Preheater switch on	Check OEM instructions

Table 30 Preheat Temperature Too Low

E 012.05 AF – CHARGE AIR COOLANT TEMPERATURE TOO HIGH

Start with the first probable cause for charge air coolant temperature too high listed in Table 31, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Charge air coolant level too low	Charge air coolant level	Replenish charge air coolant
Charge air coolant system dirty	Charge air coolant system	Clean
	Vent lines	Clean
	Charge air coolant heat exchanger	Clean; replace if necessary
DDEC	Indicator lamp	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)
Fan drive faulty	Refer to section E 012.05 AL	Refer to section E 012.05 AL
Charge air coolant thermostat faulty	Charge air coolant thermostat	Replace
Charge air coolant too low	Refer to section E 012.05 AH	Refer to section E 012.05 AH
Charge air coolant temperature transmitter faulty	Temperature transmitter and wiring dialogue unit / fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 31 Charge Air Coolant Temperature Too High

E 012.05 AG – CHARGE AIR COOLANT TEMPERATURE TOO LOW

Start with the first probable cause for charge air coolant temperature too low listed in Table 32, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Charge air coolant thermostat faulty	Charge air coolant thermostat	Replace
Charge air coolant temperature transmitter not working	Temperature transmitter and wiring with dialogue unit / fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 32 Charge Air Coolant Temperature Too Low

E 012.05 AH – CHARGE AIR COOLANT PRESSURE TOO LOW

Start with the first probable cause for charge air coolant pressure too low listed in Table 33, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Charge air coolant system not sealed	Cover closed	Close cover
	Breather valve	Replace cover
Charge air coolant system leaking externally	External pipework	Check connections; tighten if necessary
	External subassemblies	Check connections; tighten if necessary
	Charge air coolant drain points	Seal
	Charge air cooler	Check for leaks; replace if necessary
	Charge air coolant heat exchanger	Repair
Charge air coolant level too low	Charge air coolant level	Add charge air coolant
Charge air coolant pump faulty	Charge air coolant pump	Replace
Charge air coolant system leaking internally	Oil quality	Refer to section E 012.05 O
Charge air coolant pressure sensor faulty	Pressure transmitter with dialogue unit/fault recorder or fault display via flashing light	Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 33 Charge Air Coolant Pressure Too Low

E 012.05 AI – CHARGE AIR COOLANT LOSS

Start with the first probable cause for charge air coolant loss listed in Table 34, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Charge air coolant system leaking externally	Refer to section E 012.05 AH	Refer to section E 012.05 AH
Charge air coolant pump leaking	Charge air coolant pump	Repair
Charge air coolant system leaking internally	Oil quality; Refer to section E 012.05 O	Refer to section E 012.05 O
Display fault Charge air coolant level transmitter	Transmitter, wiring dialogue unit/fault recorder or fault display via flashing light	Repair; replace if necessary. Refer to *DDEC III/IV Single ECM Troubleshooting* (6SE497) and/or *DDEC Multi-ECM Troubleshooting Guide* (6SE496)

Table 34 Charge Air Coolant Loss

E 012.05 AJ – CHARGE AIR COOLANT LEVEL RISING

Start with the first probable cause for charge air coolant level rising listed in Table 35, perform the check and take the suggested remedial action.

Probable Causes	Check	Remedial Action
Air in charge air coolant	Vent lines	Clean

Table 35 Charge Air Coolant Level Rising

E 012.05 AK – CHARGE AIR COOLANT PUMP LEAKING

Start with the first probable cause for charge air coolant pump leaking at the weep hole listed in Table 36, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Radial lip oil seal leaking	For oil discharge	Replace sealing ring
Rotary seal leaking	Engine coolant discharge	Replace slip ring; replace coolant pump if necessary

Table 36 Charge Air Coolant Pump Leaking at Weep Hole

E 012.05 AL – FAN DRIVE FAULTY

Start with the first probable cause for a faulty fan drive listed in Table 37, perform the check and take the suggested remedial action. If the problem persists, go to the next probable cause, perform the check, etc., until troubleshooting is complete.

Probable Causes	Check	Remedial Action
Vee-belt	Vee-belt tension	Set tension; replace if necessary. Refer to G221.051.03 Operator Guide
Control oil pressure	Oil supply; solenoid valve control	Clean; replace if necessary
Fan coupling faulty	Fan coupling	Replace

Table 37 Fan Drive Faulty

E 020 – TESTING

E 021 – SOLENOID VALVE TESTING

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E 021.01 – TESTING THE SOLENOID VALVE

Perform the following steps to test the solenoid valve:

NOTE:
Pressurized oil, 40 psi min - 100 psi max, must be applied to the solenoid.

1. Attach an accurate pressure gage and drain line to the solenoid. (Pressure from the solenoid must be measured.)
2. Unless this test is being conducted on the engine, attach line from external pressure source to the solenoid NO or INLET port. Heat the coolant gradually.

F – PREVENTIVE MAINTENANCE

F 010 – ROCKFORD FAN CLUTCH

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F 010.05 – ROCKFORD FAN CLUTCH

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F 010.05.08 – MAINTENANCE OF ROCKFORD FAN CLUTCH

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan:

- **Never work in close proximity to the fan.**
- **Never try to keep the fan from rotating by holding the fan.**
- **Never tie down the fan with straps, chains, or other restraints.**
- **Never shut off the oil supply to the fan clutch.**

CAUTION:

To avoid injury when working near or on an operating engine equipped with a hydraulic clutch fan, remove loose items of clothing and jewelry; tie back or contain long hair that could be caught in any moving part causing injury. A hydraulic fan may start without warning.

The fan drive system requires a minimum of maintenance. A few simple checks made periodically will ensure correct operation and a long life.

Fan Hub Assembly to Mounting Bracket Bolts

Check bolt torque after first week of operation and every 500 hours thereafter.

Fan-To-Fan Mounting Hub Bolts

Check torque of all bolts after first week of operation and every 500 hours thereafter.

Fan Belts

Maintain proper belt tension.

Hoses and Fittings

Check all hoses and fittings every 500 hours. Replace all soft, brittle, or frayed hoses. Tighten all loose or leaking fittings.

Electrical

All electrical connections should be checked for tightness after each 5,000 hours. All electrical lines should be checked for breaks and frays. Check to ensure all grounding points are intact.

Thermostat

The engine thermostat operation should be checked according to engine manufacturer's specifications and recommendations.

Fan Clutch

After each 1,000 hours, the fan clutch should be checked for signs of internal wear as follows:

1. Bearing wear: With the engine off and no oil supplied to the fan clutch, push the fan forward, then rearward. No end play should be found.

NOTE:
For the next tests, it is necessary to provide an external supply of oil pressure at 40 psi minimum, 100 psi maximum. The oil supply should be compatible with the oil being used in the engine.

2. Clutch Plate Drive Slot Wear: With the engine off and the clutch locked by means of the external oil supply, rotate the fan with a light force clockwise/counterclockwise. Movement at a point 30 in. from the center of the fan blade should not exceed 1.00 in. Excess movement indicates excessive wear at the drive tangs.
3. Clutch Plate Wear: With the engine off, apply 40 psi oil pressure to lock up the clutch. Using the pull-type scale connected to the fan blade 30 in. from the center of the fan, a pull of no less than 230-250 lbs should be required to rotate the blade independently of the pulley.

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