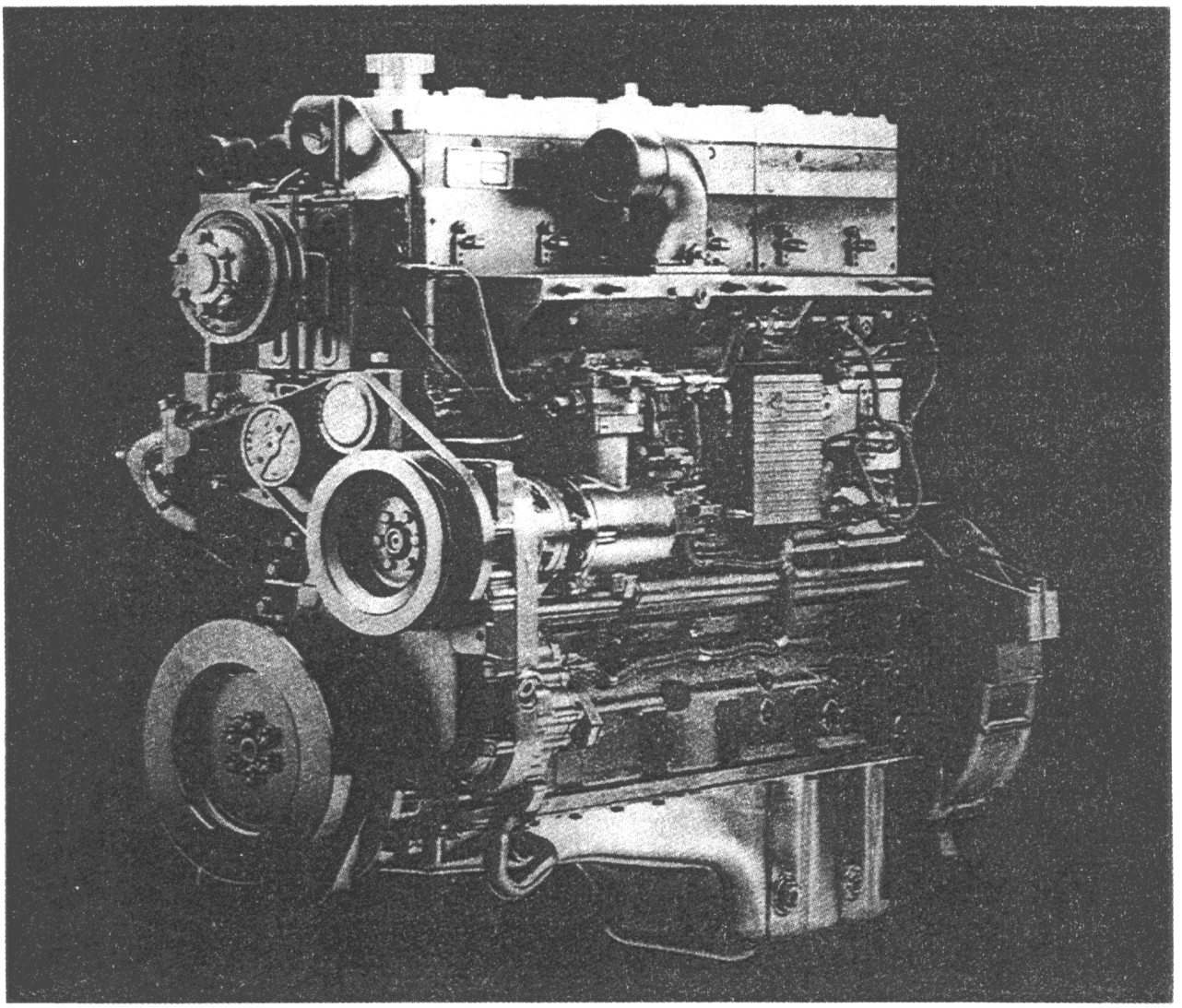
Shop Manual
N14 Engines



Bulletin No. 3810487
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Foreword

This manual contains complete rebuild specifications and information for the N14 model engines, and all associated components manufactured by Cummins Engine Company, Inc. A listing of accessory and component suppliers' addresses and telephone numbers is located in Section C. Suppliers can be contacted directly for any information **not** covered in this manual.

The repair procedures in this manual are based on the engine being installed on an approved engine stand. Some rebuild procedures require the use of special service tools. Make sure the correct tools are used as described in the procedures.

When a specific brand name, number, or special tool is referenced in this manual, an equivalent product can be used in place of the recommended item.

A series of specific service manuals (Troubleshooting and Repair, Specifications, Alternative Repair, and so on.) are available and can be ordered by filling out and mailing the Literature Order Form located in the Service Literature Section L.

Reporting of errors, omissions, and recommendations for improving this publication by the user is encouraged. Please use the postage paid, self-addressed Literature Survey Form in the back of this manual for communicating your comments.

The specifications and rebuild information in this manual is based on the information in effect at the time of printing. Cummins Engine Company, Inc. reserves the right to make any changes at any time without obligation. If differences are found between your engine and the information in this manual, contact a Cummins Authorized Repair Location, a Cummins Division Office, or the factory.

The latest technology and the highest quality components are used to manufacture Cummins engines. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts. These parts can be identified by the following trademarks:

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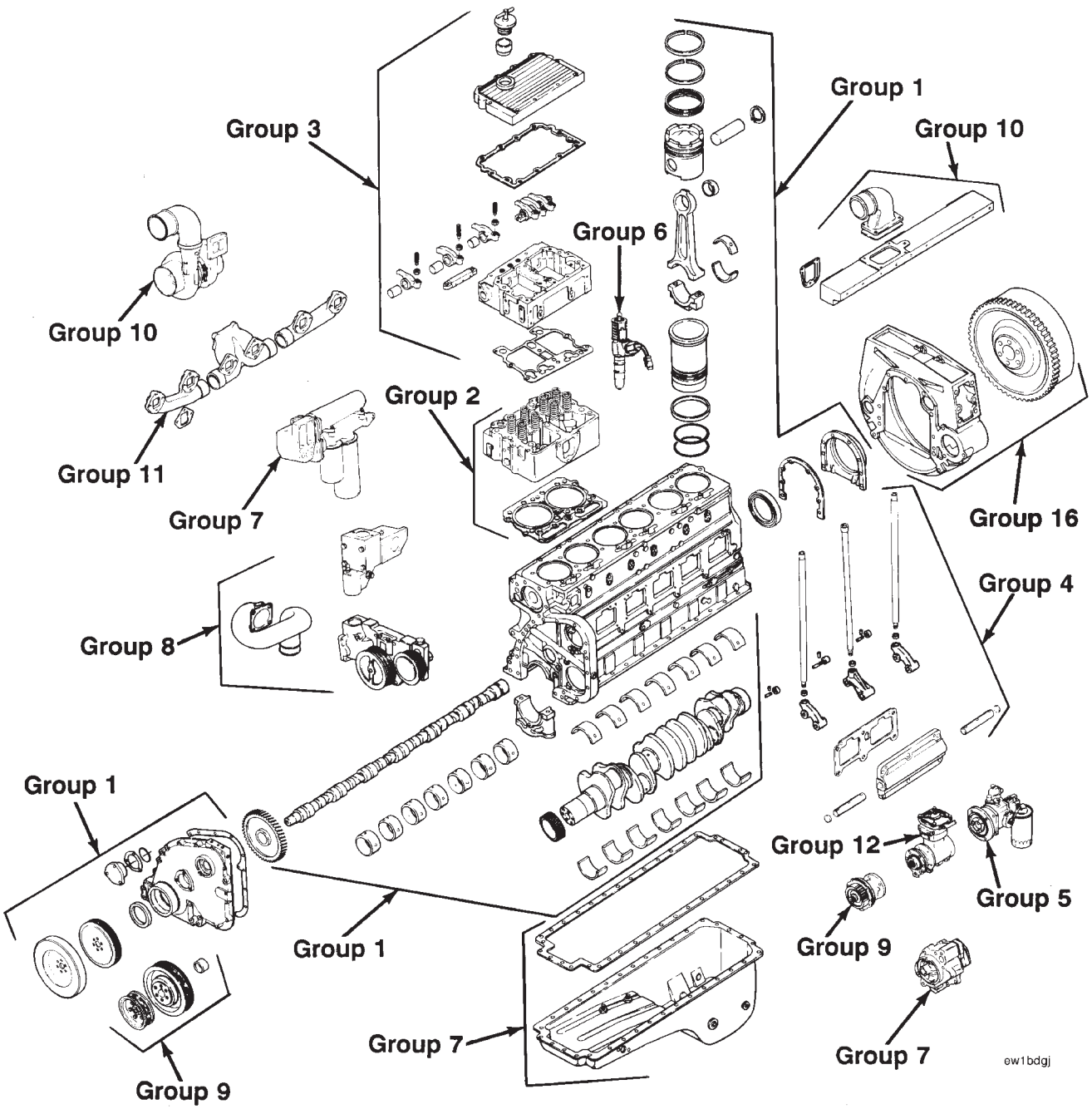
Cummins 22-Group System Exploded Diagram



Section I - Introduction

Section Contents

Manual Organization

All references to engine components in this manual are divided into 22 specific groups. The organization is consistent with the service bulletins, service parts topics, and the parts catalogs for your convenience in updating your copy of the shop manual.

Table of Contents

The Table of Contents in the front of the manual contains a quick page reference for each group number.

Group Contents

Each group contains the following information:

- A ''Section Contents'' page at the beginning of each group to quickly aid in locating the information desired.
- A Service Tools list with recommended tools needed to rebuild the components.
- General information to aid in rebuilding the component and an explanation of design change differences.
- Step-by-step rebuild instructions for disassembly, cleaning, inspection, and assembly of the component.
- Symbols which represent the action outlined in the instructions. The definitions of the symbols, listed in four languages (English, Spanish, French, and German), appear on pages i-5 through i-8.

Index

An alphabetical index is in the back of the manual to aid in locating specific information.

Metric Information

Both metric and U.S. customary values are used in this manual. The metric value is listed first, followed by the U.S. customary in brackets. An example is 60°C [140°F].

General Repair Instructions

This engine incorporates the latest diesel technology; yet, it is designed to be repaired using normal repair practices performed to quality standards.

- **Cummins Engine Company, Inc. does not recommend or authorize any modifications or repairs to engines or components except for those detailed in Cummins Service Information. In particular, unauthorized repair to safety-related components can cause personal injury. Below is a partial listing of components classified as safety-related:**

  Air Compressor
  Air Controls
  Air Shutoff Assemblies
  Balance Weights
  Cooling Fan
  Fan Hub Assembly
  Fan Mounting Bracket(s)
  Fan Mounting Capscrews
  Fan Hub Spindle
  Flywheel
  Flywheel Crankshaft Adapter
  Flywheel Mounting Capscrews
  Fuel Shutoff Assemblies
  Fuel Supply Tubes
  Lifting Brackets
  Throttle Controls
  Turbocharger Compressor Casing
  Turbocharger Oil Drain Line(s)
  Turbocharger Oil Supply Line(s)
  Turbocharger Turbine Casing
  Vibration Damper Mounting Capscrews

- **Follow All Safety Instructions Noted in the Procedures.**
  - Follow the manufacturer's recommendations for cleaning solvents and other substances used during the repair of the engine. **Always** use good safety practices with tools and equipment.
- **Provide A Clean Environment and Follow the Cleaning Instructions Specified in the Procedures**
  - The engine and its components **must** be kept clean during any repair. Contamination of the engine and components will cause premature wear.
- **Perform the Inspections Specified in the Procedures.**
  - The inspections will result in a minimal number of parts requiring replacement. The cost of the rebuild will be reduced more than the cost of the additional inspection time.
- **Replace all Components or Assemblies Which are Damaged or Worn Beyond the Specifications**
- **Use Genuine Cummins New or ReCon® Service Parts and Assemblies**
  - The assembly instructions have been written to reuse as many components and assemblies as possible. When it is necessary to replace a component or assembly, the procedure is based on the use of new Cummins or Cummins ReCon® components. All of the repair services described in this manual are available from all Cummins Distributors and most Dealer locations.
- **Follow The Specified Disassembly and Assembly Procedures to Avoid Damage to the Components.**

Complete troubleshooting and repair instructions are available in the Troubleshooting and Repair Manual which can be ordered or purchased from a Cummins Authorized Repair Location. Refer to Section L, Literature, for ordering instructions.

General Safety Instructions

Important Safety Notice

WARNING

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that **must** be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Make sure the work area surrounding the product is safe. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a ″Do **Not** Operate″ tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the engine by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before you slowly loosen the filler cap and relieve the pressure from the cooling system.
- Do **not** work on anything that is supported ONLY by lifting jacks or a hoist. **Always** use blocks or proper stands to support the product before performing any service work.
- Relieve all pressure in the air, oil, and the cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To prevent suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (freon) lines in a well ventilated area.
- To avoid personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Cooling System corrosion inhibitor contains alkali. Do **not** get the substance in your eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To avoid burns, be alert for hot parts on products that have just been turned OFF, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use them before performing any service work. Use ONLY genuine Cummins or Cummins Recon® replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do **not** use a fastener of lessor quality if replacements are necessary.

Symbols Used in this Manual

The following group of symbols has been used in this manual to help communicate the intent of the instructions.

When one of the symbols appears, it conveys the meaning defined below.

WARNING - Serious personal injury or extensive property damage can result if the warning instructions are not followed.

CAUTION - Minor personal injury can result or a part, an assembly or the engine can be damaged if the caution instructions are not followed.

Indicates a **REMOVAL or DISASSEMBLY** step.

Indicates an **INSTALLATION or ASSEMBLY** step.

INSPECTION is required.

CLEAN the part or assembly.

PERFORM a mechanical or time **MEASUREMENT**.

LUBRICATE the part or assembly.

Indicates that a **WRENCH or TOOL SIZE** will be given.

TIGHTEN to a specific torque.

PERFORM an electrical **MEASUREMENT**.

Refer to another location in this manual or another publication for additional information.

The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

Simbolos Usados En Este Manual

Los símbolos siguientes son usados en este manual para clarificar el proceso de las instrucciones. Cuando aparece uno de estos símbolos, su significado se especifica en la parte inferior.

ADVERTENCIA - Serios daños personales o daño a la propiedad puede resultar si las instrucciones de Advertencia **no** se consideran.

PRECAUCION - Daños menores pueden resultar, o de piezas del conjunto o el motor puede averiarse si las instrucciones de Precaución **no** se siguen.

Indica un paso de **REMOCION** o **DESMONTAJE.**

Indica un paso de **INSTALACION** o **MONTAJE.**

Se requiere **INSPECCION.**

LIMPIESE la pieza o el montaje.

EJECUTESE una **MEDICION** mecánica o del tiempo.

LUBRIQUESE la pieza o el montaje.

Indica que se dará una **LLAVE DE TUERCAS** o el **TAMAÑO DE HERRAMIENTA.**

APRIETESE hasta un par torsor específico.

EJECUTESE una **MEDICION** eléctrica.

Para información adicional refiérase a otro emplazamiento de este manual o a otra publicación anterior.

El componente pesa 23 kg [50 lb] o mas. Para evitar dano corporal empleen una cabria u obtengan ayuda para elevar el componente.

Symboles Utilises Dans Ce Manuel

Les symboles suivants sont utilisés dans ce manuel pour aider à communiquer le but des instructions. Quand l'un de ces symboles apparaît, il évoque le sens défini ci-dessous:

AVERTISSEMENT - De graves lésions corporelles ou des dommages matériels considérables peuvent survenir si les instructions données sous les rubriques ″Avertissement″ **ne** sont **pas** suivies.

ATTENTION - De petites lésions corporelles peuvent survenir, ou bien une pièce, un ensemble ou le moteur peuvent être endommagés si les instructions données sous les rubriques ″Attention″ **ne** sont **pas** suivies.

Indique une opération de **DEPOSE.**

Indique une opération de **MONTAGE.**

L'INSPECTION est nécessaire.

NETTOYER la pièce ou l'ensemble.

EFFECTUER une **MESURE** mécanique ou de temps.

GRAISSER la pièce ou l'ensemble.

Indique qu'une **DIMENSION DE CLE** ou **D'OUTIL** sera donnée.

SERRER à un couple spécifique.

EFFECTUER une **MESURE** électrique.

Se reporter à un autre endroit dans ce manuel ou à une autre publication pour obtenir des informations plus complètes.

Le composant pese 23 kg [50 lb] ou davantage. Pour eviter toute blessure, employer un appariel de levage ou demander de l'aide pour le soulever.

Symbole

In diesem Handbuch werden die folgenden Symbole verwendet, die wesentliche Funktionen hervorheben. Die Symbole haben folgende Bedeutung:

WARNUNG - Wird die Warnung **nicht** beachtet, dann besteht erhöhte Unfall- und Beschädigungsgefahr.

VORSICHT - Werden die Vorsichtsmassnahmen **nicht** beachtet, dann besteht Unfall- und Beschädigungsgefahr.

AUSBAU bzw. **ZERLEGEN.**

EINBAU bzw. **ZUSAMMENBAU.**

INSPEKTION erforderlich.

Teil oder Baugruppe **REINIGEN.**

DIMENSION - oder **ZEITMESSUNG.**

Teil oder Baugruppe **ÖLEN.**

WERKZEUGGRÖSSE wird angegeben.

ANZUG auf vorgeschriebenes Drehmoment erforderlich.

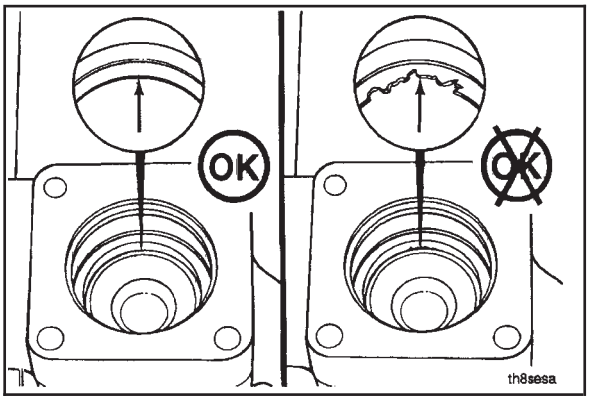
Elektrische **MESSUNG DURCHFÜHREN.**

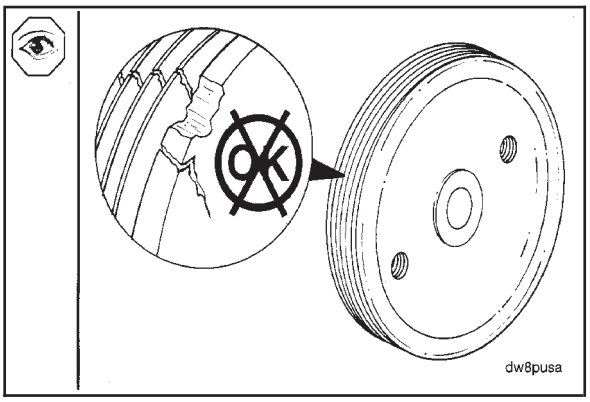
Weitere Informationen an anderer Stelle bzw. in anderen Handbüchern.

Das teil weigt 23 kg [50 lb] oder mehr. Zur vermeidung von koerperverletzung winde benutzen oder hilfe beim heben des teils in anspruch nehmen.

Illustrations

The illustrations used in this manual are intended to give an example of how to perform the action or the repair being described. Many of the illustrations are common and will **not** look exactly like the engine or the parts used in your application. Most of the illustrations contain symbols to indicate an action required or to indicate an **acceptable (OK)** or **unacceptable (not OK)** condition.

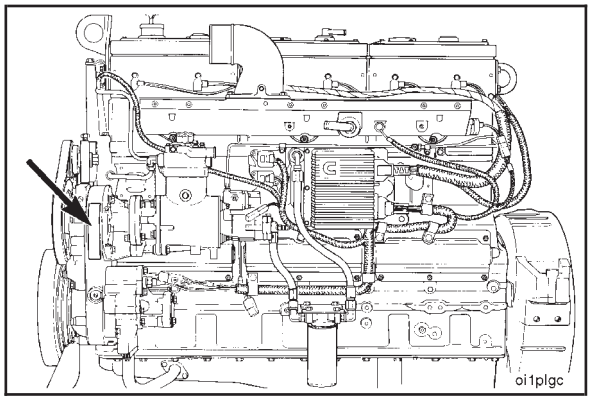




Glossary Of Terms

AFC:	Air Fuel Control; a device in the PT fuel pump that limits the fuel delivery until there is sufficient intake manifold pressure to allow for complete combustion.
ATDC:	After Top Dead Center; refers to the position of the piston or the crankshaft rod journal. The piston is moving downward on the power stroke and intake stroke.
BDC:	Bottom Dead Center; refers to the position of the piston or the crankshaft rod journal. The piston is at its lowest position in the cylinder.
BTDC:	Before Top Dead Center; refers to the position of the piston or the crankshaft rod journal. The piston is moving upward on the compression stroke and exhaust stroke.
Circumferential Direction:	In the direction of a circle in respect to the centerline of a round part or a bore.
Concentricity:	A measurement of the **difference** between the centers of **either** two or more parts **or** the bores in one part.
CPL:	Control Parts List; this listing identifies the specific parts that **must** be installed on the engine to meet agency certification.
Cummins Sealant:	This is a one part Room Temperature Vulcanizing (RTV) silicone rubber, adhesive and sealant material having **high** heat and oil resistance, and **low** compression set. Some of the equivalent products are Marston Lubricants, Hylosil, Dow Corning, Silastic 732, Loctite Superflex, General Electric 1473, and General Electric 1470.
D.C.:	Direct Current
Dye Penetrant Method:	A method used to check for cracks in a part by using a dye penetrant and a developer. Use crack detection kit, Part No. 3375432, or its equivalent.
End Clearance:	The clearance in an assembly determined by pushing the shaft in an axial direction **one way** and then pushing the shaft the **other way.**
E.S.N.:	Engine Serial Number
Hammer:	A hand tool consisting of a hard steel head on a handle.
I.D.:	Inside Diameter
Loctite 290:	A single component, anaerobic, polyester resin, liquid sealant compound that hardens between closely fitted metal surfaces producing a tough, hard bond with good characteristics. An equivalent product is Perma-Lok HL 126.
Loctite 609:	A single component anaerobic, liquid adhesive that meets or exceeds the requirements of MIL-R-46082A (MR) TYPE 1. Some of the equivalent products are Loctite 601 and Permabond HL 138.
Lubriplate 105:	A mineral oil base grease with calcium soap (2 percent to 6 percent), and zinc oxide (2 percent to 4 percent) additives.

Magnetic Particle Inspection:	A method of checking for cracks in **either** steel **or** iron parts. This method requires a Magnaflux machine, or an equivalent machine that imparts a magnetic field on the part being checked.
Mallet:	A hand tool consisting of a soft head, **either** wood, plastic, lead, brass, **or** rawhide, on a handle.
MAX:	Maximum allowed
MIN:	Minimum allowed
No.:	Number
O.D.:	Outside Diameter
OS:	Oversize
Protrusion:	The **difference** in the height between two parts in the assembled state.
STD:	Standard
TDC:	Top Dead Center; refers to the position of the piston or the crankshaft rod journal. The piston is at its highest position in the cylinder. The rod journal is pointing straight up toward the piston.
T.I.R.:	Total Indicator Runout; used when measuring the concentricity or the runout. The T.I.R. refers to the total movement of the needle on a dial indicator, from the most **negative** reading to the most **positive** reading.
Water Pump Grease:	A premium high temperature grease that will lubricate antifriction bearings continually from **minus** 40°C [**minus** 40°F] to **plus** 150°C [**plus** 350°F]. Some of the greases meeting this requirement are Aeroshell No. 5, Chevron SRI, Amoco Rykon Premium No. 2, Texaco Premium RB, and Shell Dolium R. Aeroshell No. 5 is **not** compatible with the other greases and **must not** be mixed. Cummins Engine Company, Inc., uses Aeroshell No. 5 on new engines and components.



ap8plgi

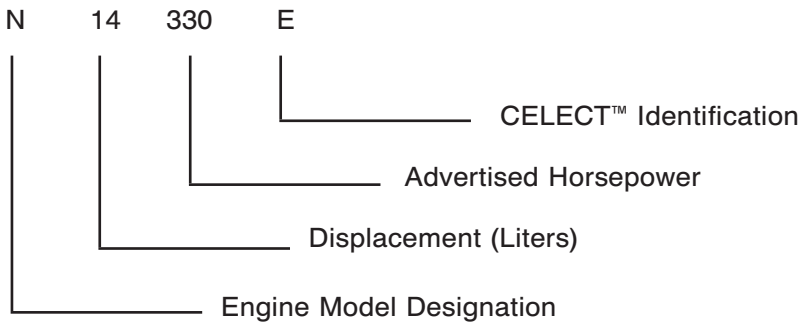
Engine Identification

The engine dataplate provides the model identification and other important information about the engine.

Have the following engine data available when communicating with a Cummins Authorized Repair Location. The information on the dataplate is **mandatory** when sourcing service parts:

1. Engine Serial Number (E.S.N.)
2. Control Parts List (CPL)
3. Model
4. Advertised Horsepower and RPM

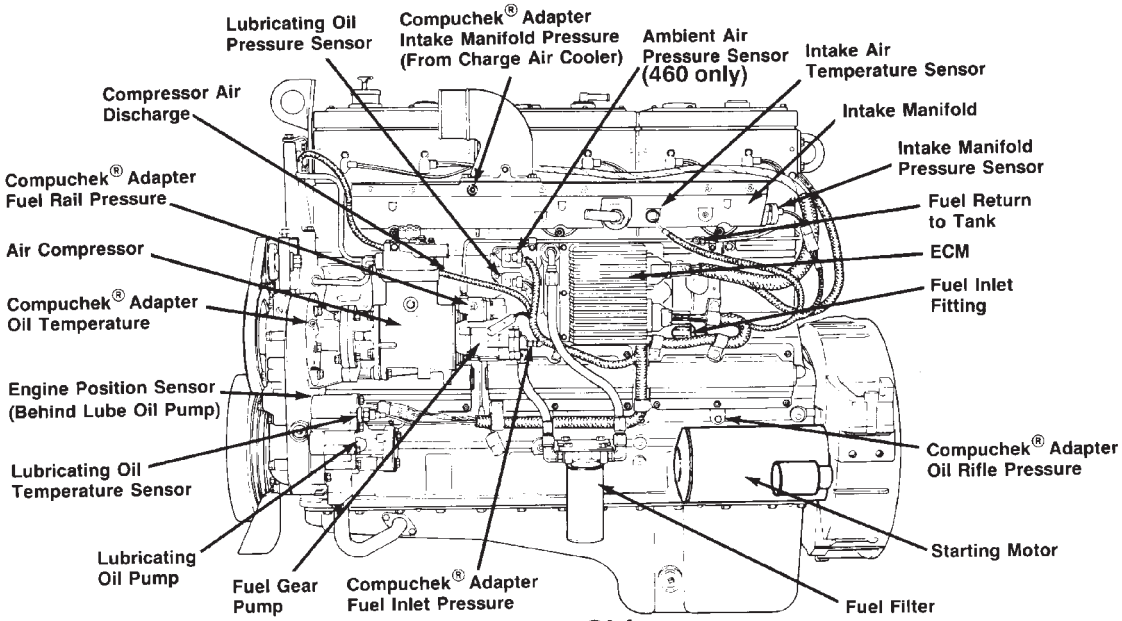
The model name provides the following engine data:

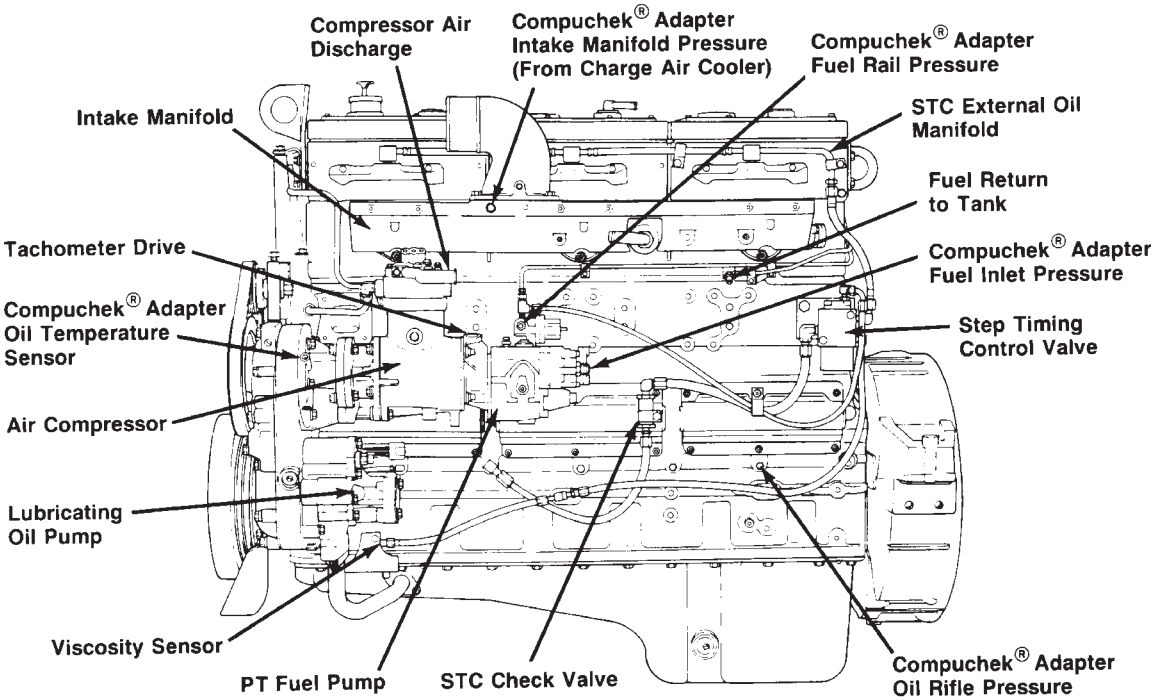


Engine Diagrams

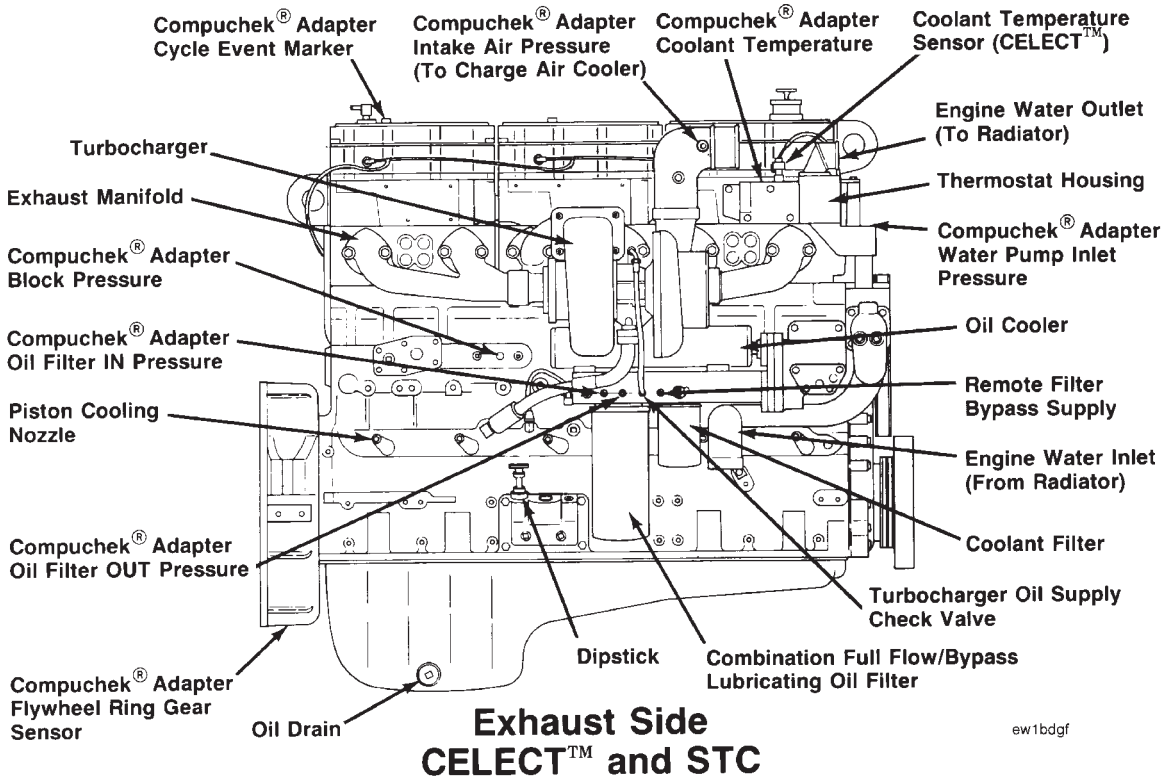
The following drawings contain information about engine components, filter locations, drain points, and access locations for instrumentation and engine controls.

The information and configuration of components shown in these drawings are of a general nature. Some component locations will vary depending on applications and installations.





Intake Side
STC



Exhaust Side
CELECT™ and STC

General Cleaning Instructions

Solvent and Acid Cleaning

Several solvent and acid-type cleaners can be used to clean the engine parts. **Cummins Engine Company, Inc. does not recommend any specific cleaners. Always** follow the cleaner manufacturer's instructions.

Experience has shown that the best results can be obtained using a cleaner that can be heated to 90 to 95 degrees Celsius [180 to 200 degrees Fahrenheit]. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results.

Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful **not** to damage any gasket surfaces. When possible, steam clean the parts before putting them in the cleaning tank.

Warning: The use of acid can be extremely dangerous to personnel, and can damage the machinery. Always provide a tank of strong soda water as a neutralizing agent.

Rinse all of the parts in hot water after cleaning. Dry completely with compressed air. Blow the rinse water from all of the capscrew holes and the oil drillings.

If the parts are **not** to be used immediately after cleaning, dip them in a suitable rustproofing compound. The rustproofing compound **must** be removed from the parts before installation on the engine.

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is the recommended way to clean the oil drillings.

Warning: Wear protective clothing to prevent personal injury from the high pressure and extreme heat.

Do **not** steam clean the following parts:

1. Electrical Components
2. Wiring
3. Injectors
4. Fuel Pump
5. Belts and Hoses
6. Bearings

Glass or Plastic Bead Cleaning

Glass or plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the size of the glass or plastic beads, the operating pressure, and the cleaning time.

Caution: Do not use glass or plastic bead cleaning on aluminum piston skirts. Do not use glass bead cleaning on aluminum ring grooves. Small particles of glass or plastic will embed in the aluminum and result in premature wear. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

NOTE: Plastic bead blasting media, Part No. 3822735, can be used to clean aluminum ring grooves. Do **not** use any bead blasting media on pin bores or aluminum skirts.

Follow the equipment manufacturer's cleaning instructions. The following guidelines can be used to adapt to manufacturer's instructions:

1. Bead size:
   - Use U.S. size No. 16-20 for piston cleaning with plastic bead media, Part No. 3822735.
   - Use U.S. size No. 70 for piston domes with glass media.
   - Use U.S. size No. 60 for general purpose cleaning with glass media.
2. Operating Pressure:
   - Glass: Use 620 kPa [90 psi] for general purpose cleaning.
   - Plastic: Use 270 kPa [40 psi] for piston cleaning.
3. Steam clean or wash the parts with solvent to remove all of the foreign material and glass or plastic beads after cleaning. Rinse with hot water. Dry with compressed air.
4. Do **not** contaminate the wash tanks with glass or plastic beads.

Section 0 - Engine Disassembly and Assembly - Group 00

Section Contents

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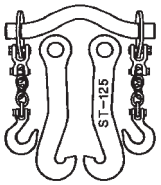
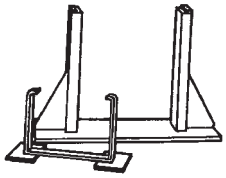
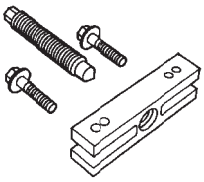
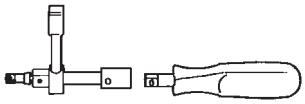
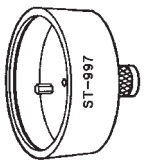
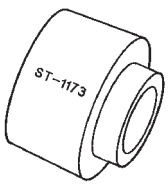
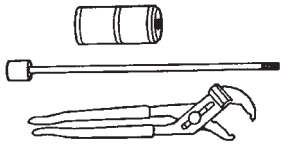
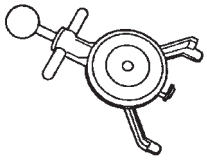
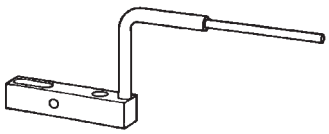
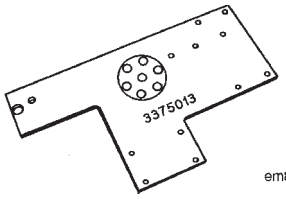
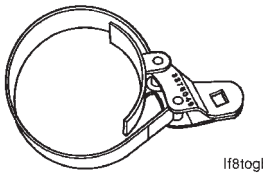
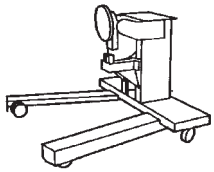
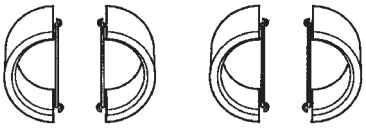
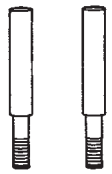
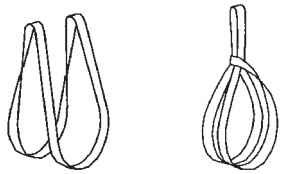
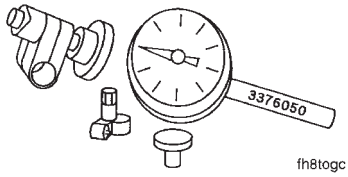
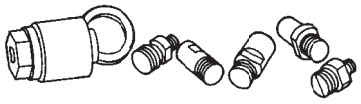
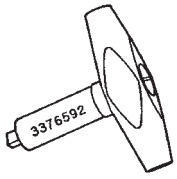
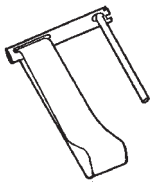
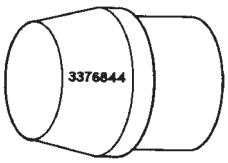
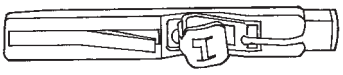
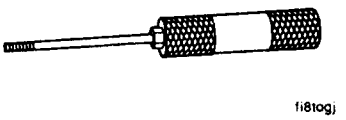
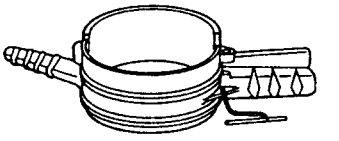
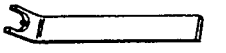
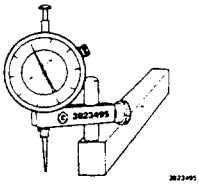
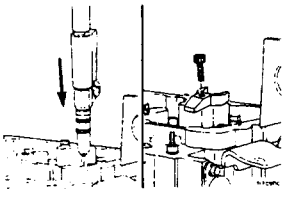
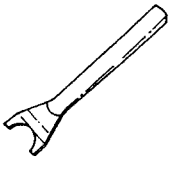
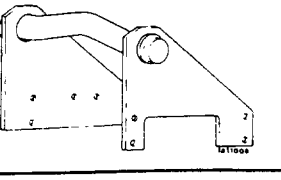
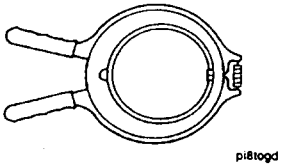
Engine Disassembly and Assembly - Service Tools

The following special tools are recommended to perform procedures in section 1. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-125 or 3822512	**Lifting Fixture** Designed to lift all H/NH engines **except** 5 1/8-inch bore with a top mounted turbocharger.	 em8togc
ST-163	**Engine Support Stand** Support engine when not in-chassis or on the engine rebuild stand.	 em8togc
ST-647	**Standard Puller** Use to remove drive pulleys, impellers, etc.	 ad8toga
ST-669	**Torque Wrench Adapter** Tighten crosshead and rocker lever adjusting screws.	 rh8togb
ST-997	**Crankshaft Oil Seal Installer** Use to drive the crankshaft oil seal into the rear cover. This tool also aligns the rear cover to the crankshaft.	 ks8togh
ST-1173	**Fuel Pump Drive Oil Seal Mandrel** Use to drive the accessory drive oil seal into the gear cover while mounted.	 ad8togd

Tool No.	Tool Description	Tool Illustration
ST-1178	**Main Bearing Cap Puller** Remove main bearings caps.	 mb8toga
ST-1259-1	**Top Plate** Included in oil seal puller/installer, Part No. ST-1259. Use to pull or install the front crankshaft oil seal.	 ks8togi
ST-1293	**Belt Tension Gauge** Measure drive belt tension.	 fa8togc
ST-1325	**Dial Gauge Attachment** Attaches to crankshaft to provide measuring of flywheel housing runout with a dial indicator.	 fh8togb
3375013	**Adapter Plate** Use the adapter plate to mount the engine to engine rebuild stand, Part No. 3375194.	 em8togf
3375049	**Oil Filter Wrench** Use to remove or tighten spin-on lubricating oil filters.	 lf8togb
3375194	**Engine Rebuild Stand** Support cylinder block during engine rebuild. Use with adapter plate, Part No. 3375013.	 em8togb
3375268	**Camshaft Installation Pilots** Use to guide the camshaft though the block camshaft bushings. Four are required per operation.	 cg8togc

Tool No.	Tool Description	Tool Illustration
3375601	**Connecting Rod Guide Pins** Guide connecting rods over crankshaft during removal or installation of connecting rods.	 cx8togg
3375957	**Nylon Lifting Sling** Aid in removal and installation of crankshaft, flywheel, and other heavy components.	 ks8toge
3376050	**Dial Indicator and Sleeve Assembly** Use with dial gauge attachment, Part No. ST-1325, to measure flywheel and flywheel housing runout.	 fh8togc
3376326	**Pulley Installation Tool** Install drive pulleys.	 ad8togb
3376592	**Inch Pound Torque Wrench** Required to make consistent settings of the top stop injectors. Screwdriver socket, Part No. ST-669-13, **must** be used with this tool.	 fi8togi
3376807	**Water and Fuel Filter Wrench** Use to remove the coolant filter and the fuel filter.	 wf8togc
3376844	**Lubrication Suction Tube O-ring Expander** Use to install the lubricating oil transfer tube.	 lp8toga
3822524	**Belt Tension Gauge** Use to check the belt tension on 3/8-inch to 1/2-inch top width belts.	 fa8togd

Tool No.	Tool Description	Tool Illustration
3822697	**STC Injector Puller** Use to remove step timing control (STC) injectors.	
3822736	**Piston Ring Compressor** Use to compress the piston rings when installing the pistons in the cylinder liner.	
3823348	**STC Tappet Adjusting Tool** Used to lock and retain the STC tappet on STC top stop injectors.	
3823495	**Depth Gauge** Use to measure counterbore ledge.	
3823579	**Injector Puller (CELECT™)** Use to remove and install injectors on CELECT™ engines.	
3823819	**Water Manifold Tube and Plug Removal Tool** Use to remove the water manifold tube and plug.	
3823835	**Rear Engine Service Lifting Bracket** Used with a hoist to lift the engine.	
3823871	**Piston Ring Expander** Remove and install piston rings on pistons	

Engine Disassembly and Assembly - General information

These procedures apply to all N14 engines. The differences between engine models due to the application, the optional equipment on an engine, and the year an engine was built are included in the instructions. Omit the steps that do **not** apply to the engine being rebuilt.

1. A **warning** statement is included for any component or assembly that weighs more than 23 kg [50 lb]. To avoid personal injury, use a hoist or get assistance from more than one person when **removing** or **installing** these parts.
2. All capscrews used on the N14 engine are U.S. customary.

Disassembly

The instructions in this procedure are organized in a logical sequence to **disassemble** an engine. This is **not** the **only** sequence to **disassemble** an engine. Certain parts **must** be removed in the sequence indicated. Use this sequence until you become familiar with the engine.

Discard all gaskets (**except** rocker housing cover gaskets which are reusable), seals, hoses, filters, and o-rings. Keep these parts if they are needed for a failure analysis.

Label, tag, or mark the parts for location as the parts are removed in order to easily find all of the parts that can be involved in a failure and to simplify the **assembly** procedure.

Label, tag, mark or photograph all special equipment prior to the removal from an engine. This engine **assembly** procedure does **not** include the installation of special optional equipment.

Force **must** be used to remove certain parts. A mallet **must** be used when force is required. All of the fasteners **must** be removed before using force.

Avoid as much dirt as possible during **disassembly.** The accumulation of additional dirt will make it more difficult to clean the components.

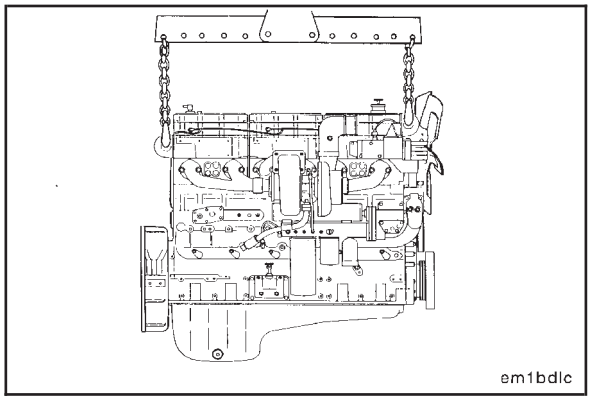
Assembly

Make sure all the components and assemblies have been cleaned, replaced or rebuilt, and are ready to be installed on the engine before beginning the assembly process.

Torque values are listed in each step. If a torque value is **not** specified, use the chart listed in Specifications, Group 18, to determine the correct torque value.

Many of the gaskets and the o-rings are manufactured from a material designed to absorb oil. These gaskets will enlarge and provide a tight seal after coming in contact with oil. Use **ONLY** a recommended contact adhesive or a vegetable-based oil to install these parts.

Always use a capscrew of the same system (metric or U.S. customary), the same dimension, and the same grade as the capscrew removed. The use of a longer, shorter, different grade, or wrong thread capscrew than the capscrew that is listed can result in damage to the engine.



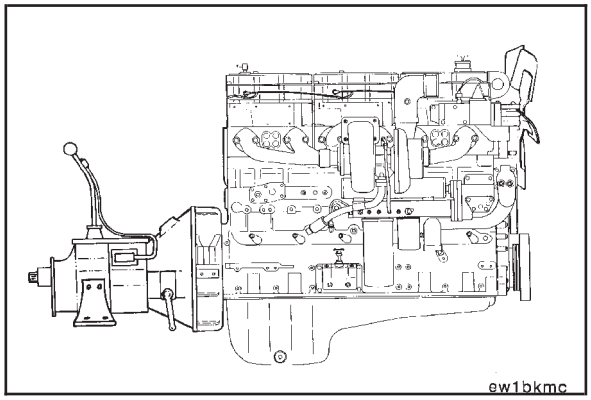
Engine Disassembly (00-01)

Engine - Preparation for Cleaning

Warning: The engine lifting equipment must be designed to safely lift the engine and the transmission as an assembly. The dry weight of the standard engine with accessories is 1256 kg [2770 lbs]. Refer to the equipment manufacturer's specifications for the transmission weight.

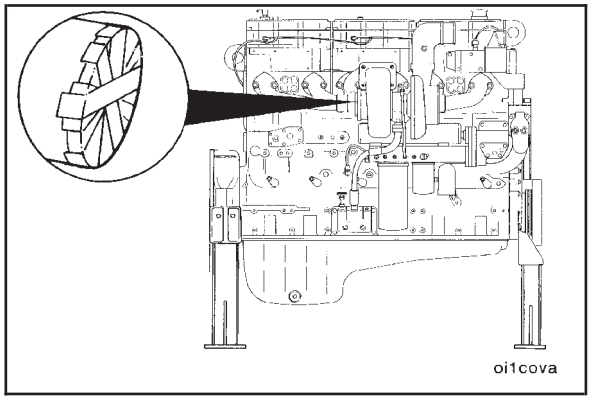
Use a correctly rated hoist, and attach engine lifting fixture, Part No. ST-125 or Part No. 3822512, to the engine mounted lifting brackets to remove the engine.

NOTE: If the transmission is **not** removed, place a support under the transmission to prevent it from falling.



Installations such as short and medium nose conventional chassis, the factory installed rear engine lifting brackets are usually removed due to space constraints. In this case, the service rear engine lifting bracket, Part No. 3823835, will be required to remove the engine from the chassis.

Refer to the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456, Section 9, for further information.

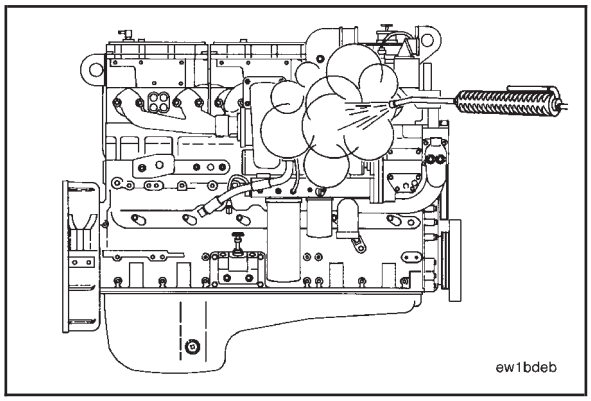


Install the engine on two engine support stands, Part No. ST-163.

Label and remove all electrical wiring and controls.

Install caps or tape on the following openings to prevent moisture and dirt from entering the engine:

1. Both sides of the turbocharger.
2. All oil, air, water, and fuel openings.



Engine - Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use steam to clean the engine, and dry with compressed air.

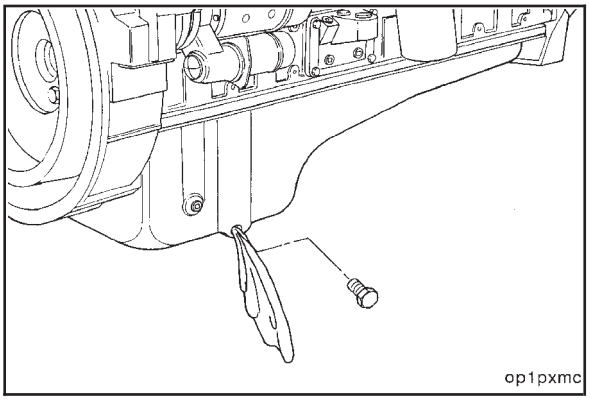
NOTE: The maximum oil pan capacity is 34 liters [9.0 U.S. gallons].

Remove the drain plug and the copper washer. Check the copper washer for wear.

Drain the oil.

If the drain plug is installed again, tighten the plug to the specified torque.

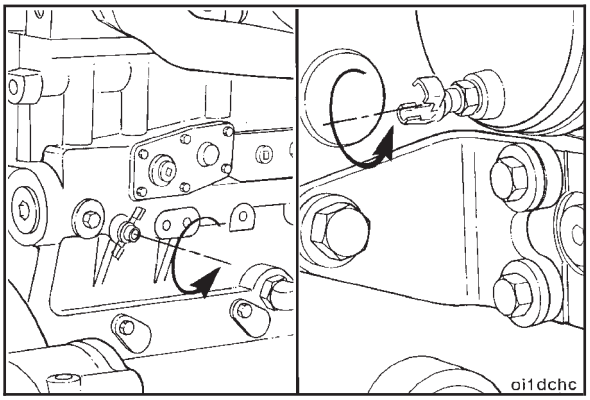
Torque Value: 136 N•m [100 ft-lb]



Coolant - Drainage

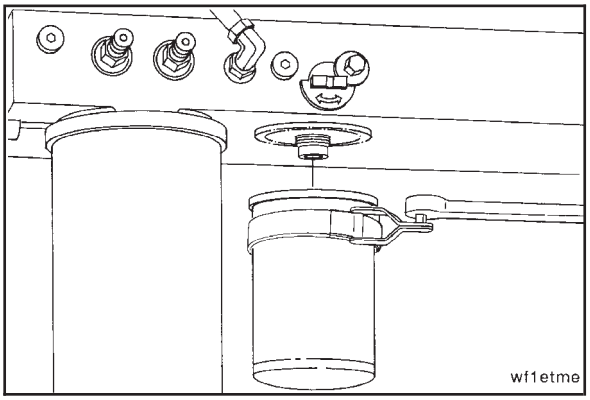
Remove the plugs from the engine and open the cylinder block draincock and the oil cooler draincock.

Use a suitable container to catch the coolant as it is drained.



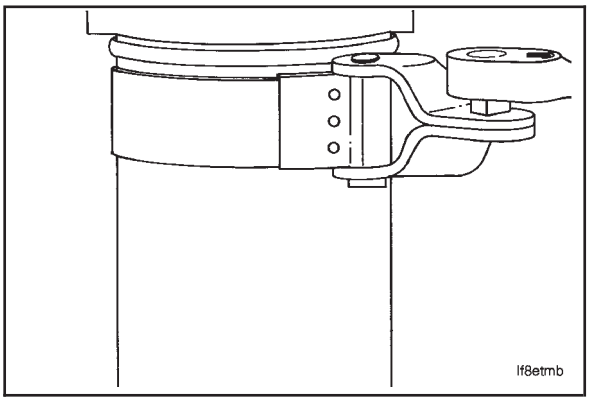
Coolant Filter - Removal

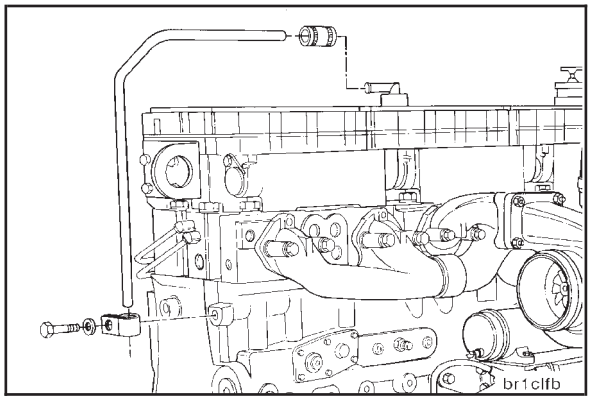
Use a water and fuel filter wrench, Part No. 3376807, to remove the coolant filter.



Lubricating Oil Filter - Removal

Use an oil filter wrench, Part No. 3375049, to remove the lubricating oil filter.



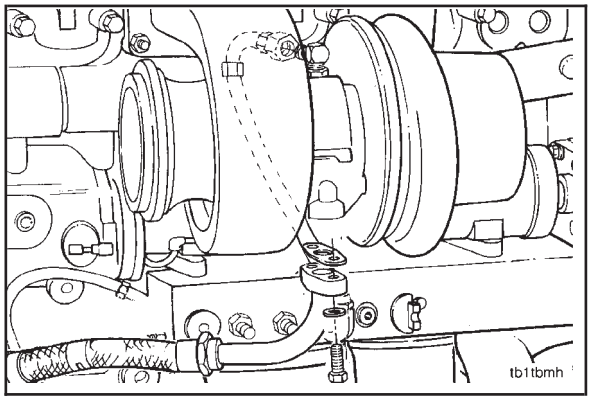


Crankcase Breather - Removal

Loosen the hose clamp at the breather vent tube.

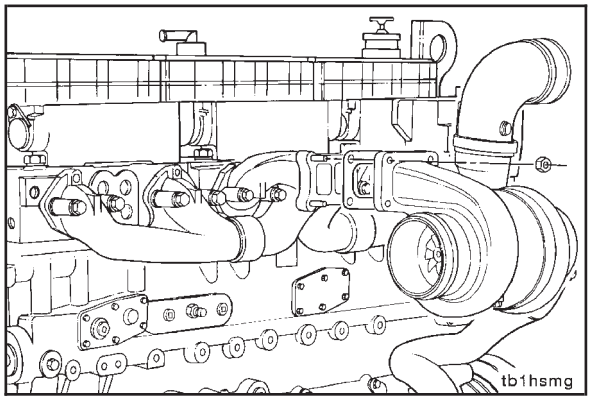
Remove the tube support bracket capscrew and the bracket.

Remove the tube and the hose from the engine.



Turbocharger - Removal

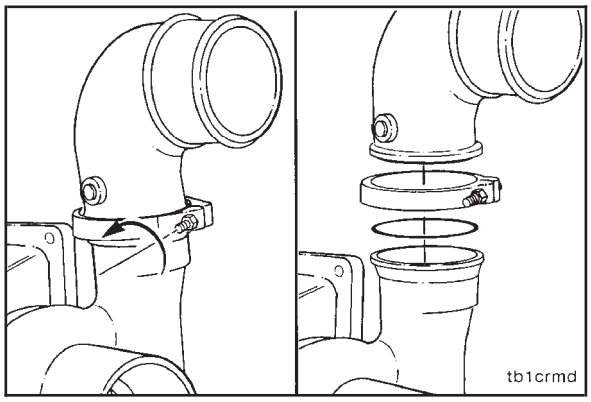
Remove the oil supply and the oil drain tubes from the turbocharger.



Remove the four turbocharger mounting nuts.

Remove the turbocharger and discard the gasket.

NOTE: If the turbocharger mounting nuts do **not** loosen freely, split the nuts to avoid breaking a mounting stud.



Loosen the clamp on the discharge elbow.

Remove the elbow and discard the o-ring.

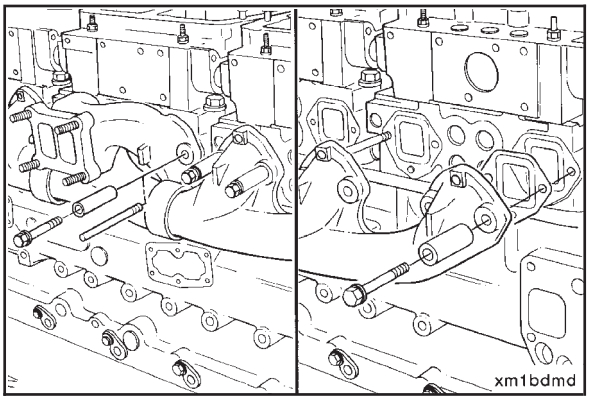
Exhaust Manifold - Removal

NOTE: Two dowels are used in each cylinder head to align the exhaust manifold assembly.

Remove two capscrews, and install two guide studs.

Warning: Because this assembly weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the exhaust manifold assembly to avoid personal injury.

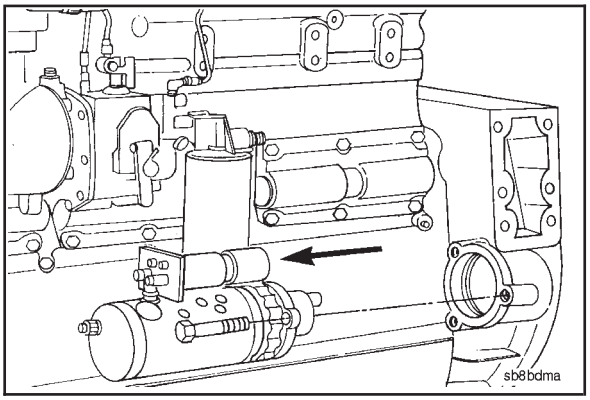
Remove the remaining ten capscrews, the exhaust manifold assembly, and the manifold gaskets.



Starting Motor - Removal

Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the starting motor to avoid personal injury.

Remove the three starting motor capscrews, the starting motor, and the spacer (if used).

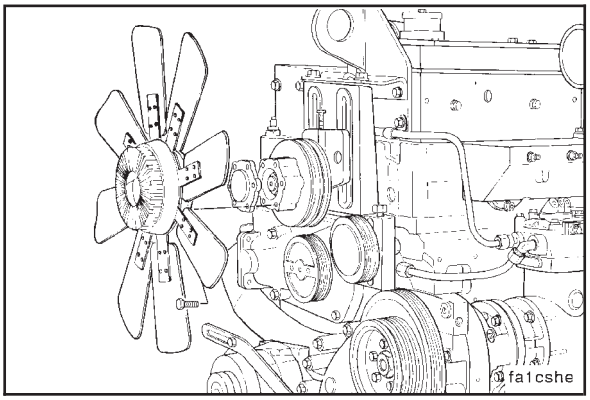


Fan and Fan Spacer - Removal

Caution: A fan hub spacer can be behind the fan. It will drop as the fan is removed. Make sure to remove the fan and the fan hub spacer together.

Remove the six capscrews and the fan.

NOTE: Do **not** discard the fan spacers. The spacers provide the thickness needed to install the fan in the correct position.

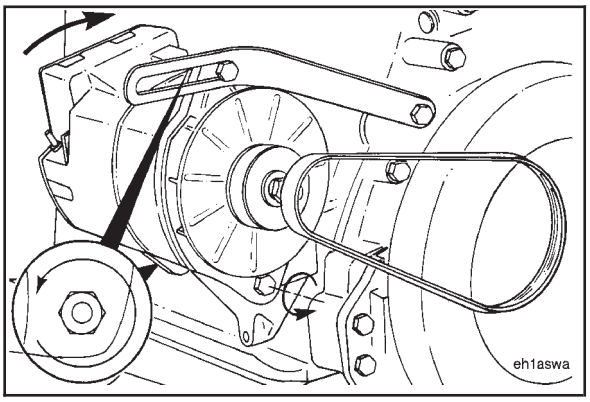


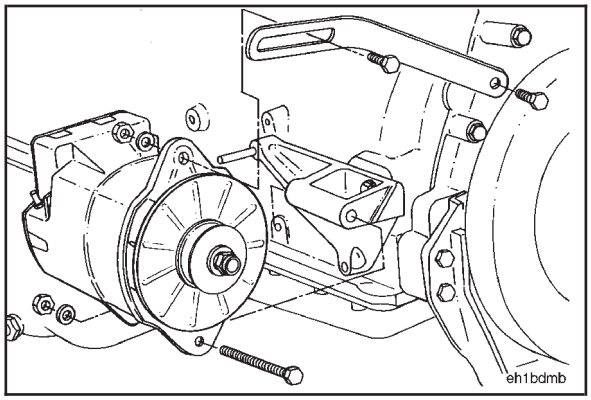
Alternator Belts - Removal

Loosen the alternator to alternator support nut and capscrew.

Loosen the adjusting link capscrew and tensioning bolt, if applicable.

Push the alternator toward the engine to release tension on the alternator belt, and remove the belt(s).

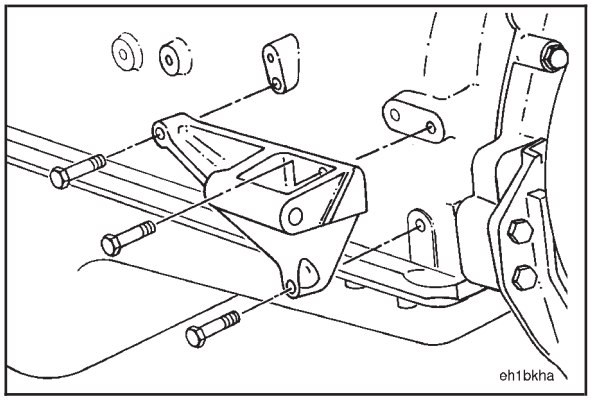




Alternator - Removal

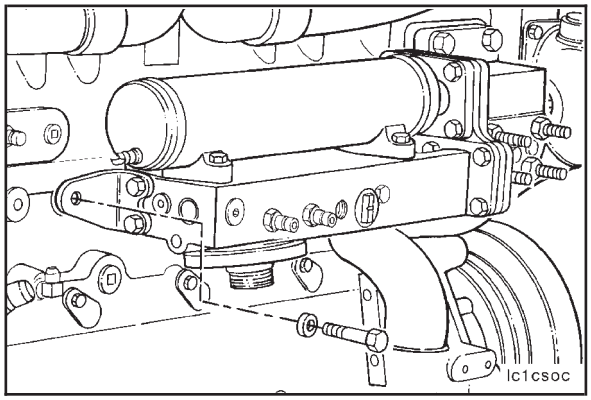
Remove the adjusting link capscrew and the adjusting link.

Remove the alternator to alternator support bracket, nut, washer, capscrew, and the alternator.



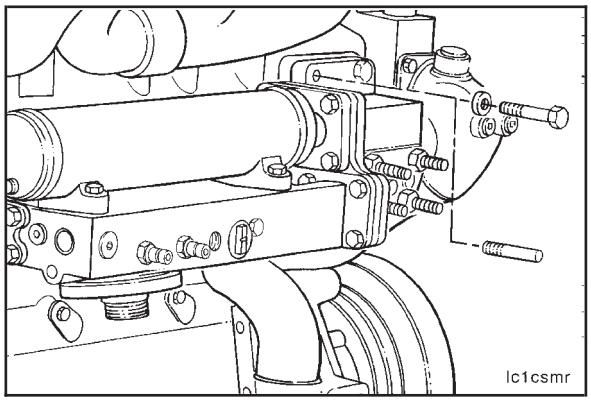
Alternator Mounting Bracket - Removal

Remove the three alternator mounting bracket capscrews and the mounting bracket.



Lubricating Oil Cooler Assembly - Removal

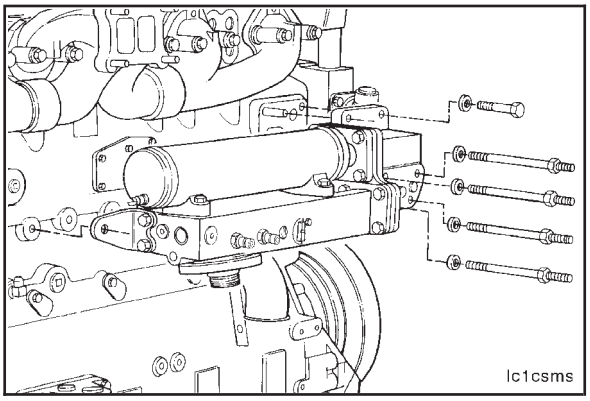
Remove the capscrew which holds the oil cooler support bracket to the cylinder block at the rear of the oil cooler.



Remove one of the capscrews which holds the oil cooler support to the cylinder block. Install a guide stud in the hole.

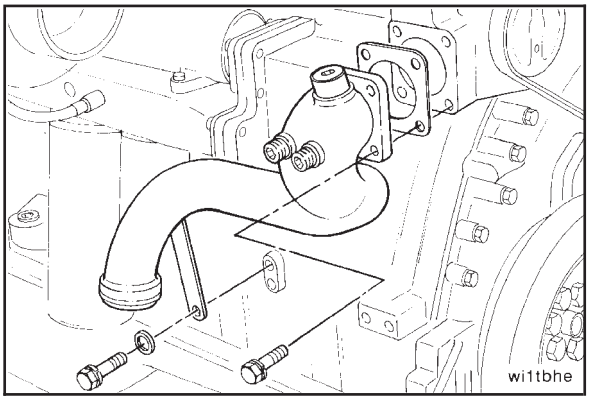
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the oil cooler assembly to avoid personal injury.

Remove the remaining five capscrews from the oil cooler support, and remove the cooler assembly.



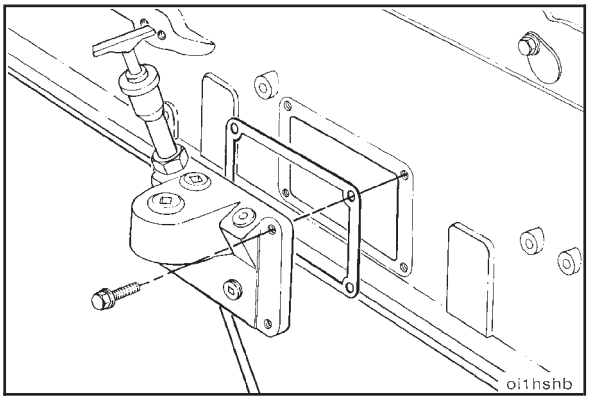
Coolant Inlet Transfer Connection - Removal

Loosen four mounting capscrews, and remove the coolant inlet transfer connection from the water pump.



Dipstick Tube and Housing - Removal

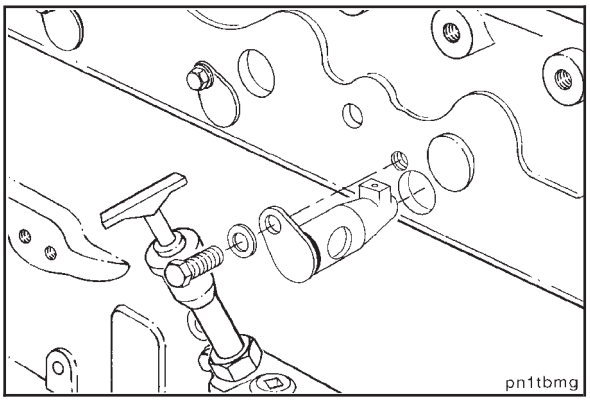
Remove the four capscrews and the housing.

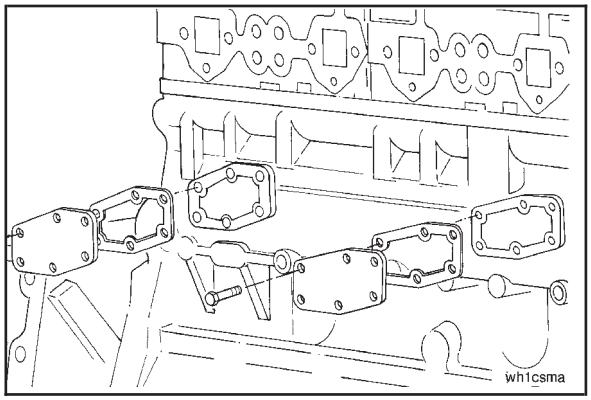


Piston Cooling Nozzles - Removal

Remove the piston cooling nozzles. Locking pliers clamped to the piston cooling nozzle flange may be needed to prevent nozzle damage during removal.

Remove and discard the o-rings.

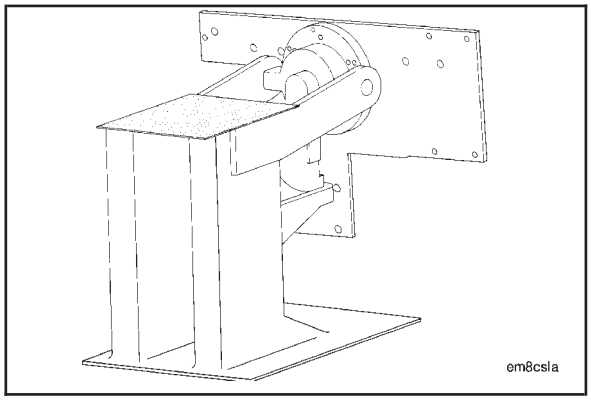




Water Header Covers - Removal

Remove the six capscrews from each of the two water header covers.

Remove the covers, and discard the gaskets.

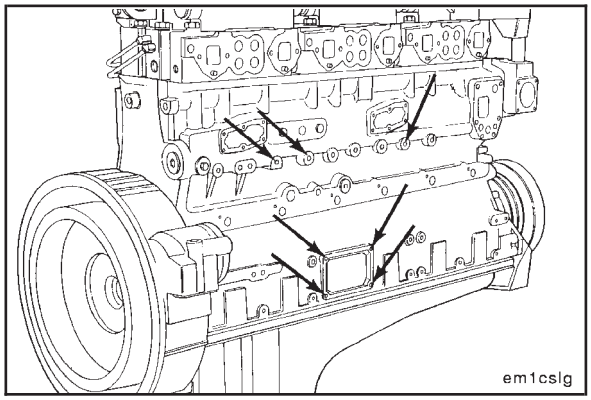


Engine - Installation on the Rebuild Stand

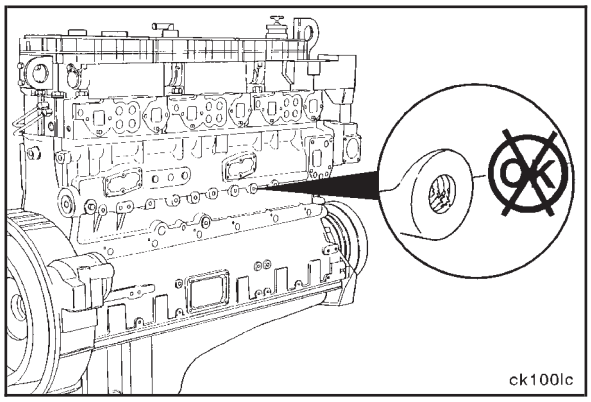
NOTE: Use engine rebuild stand, Part No. 3375194, and the adapter plate, Part No. 3375013.

Use six 5/8-11 X 1 3/4-inch grade 5 capscrews to install the adapter plate to the rebuild stand.

Torque Value: 102 N•m [75 ft-lb]



The engine stand adapter plate attaches to the cylinder block at the capscrew locations shown.



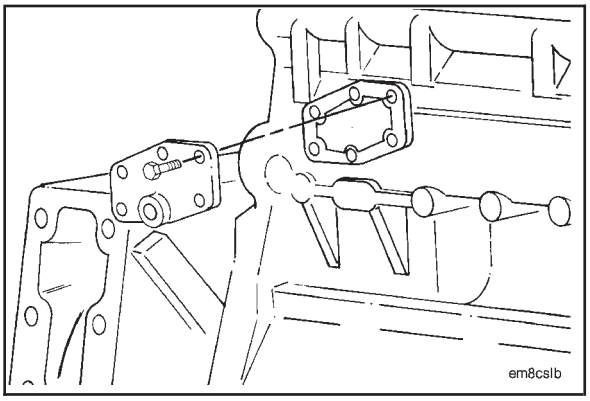
Check the condition of the threads in the cylinder block before attempting to mount the engine on the engine stand.

Clean the threads in the cylinder block, and repair any damaged threads.

Install the mounting plate adapter on the rear water header.

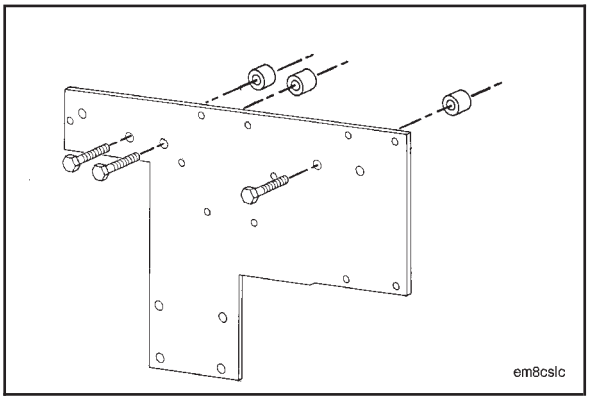
Use five 1/4-20 X 1 1/4-inch capscrews to mount the adapter. Tighten the capscrews.

Torque Value: 10 N•m [7 ft-lb]



Install three 1/2-13 X 3 3/8-inch capscrews through the adapter plate as shown.

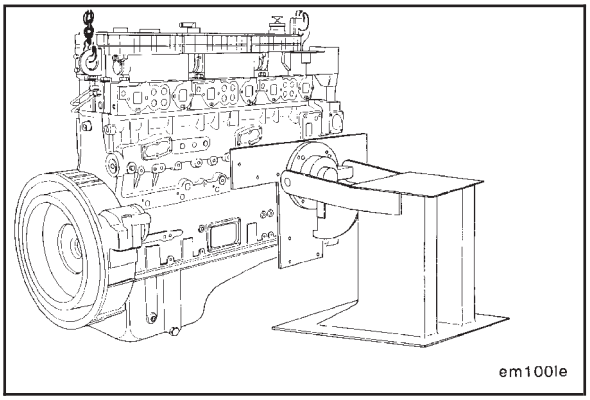
Install the three adapter plate spacers over the capscrews.



Use a lifting fixture, Part No. ST-125 or 3822512, to lift the engine.

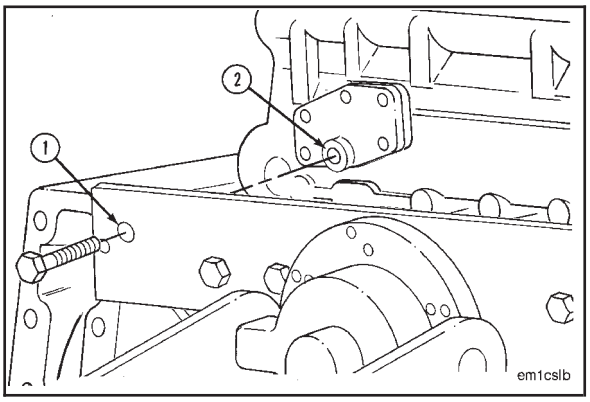
Align the exhaust side of the engine to the adapter plate of the rebuild stand.

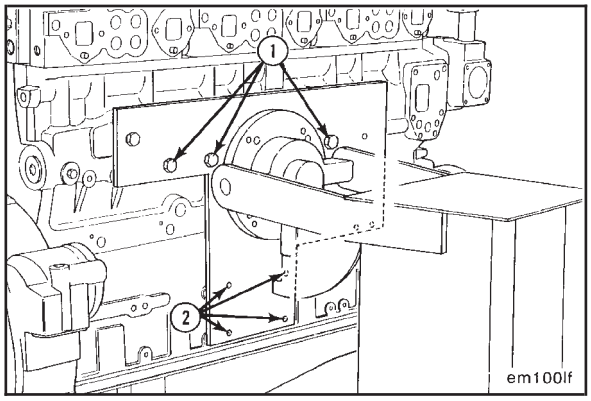
Installation such as short and medium nose conventional chassis, the factory installed rear engine lifting brackets are usually removed due to space contraints. In this case, the portable rear engine lifting bracket, Part No. 3823835, will be required to install the engine onto the rebuild stand.



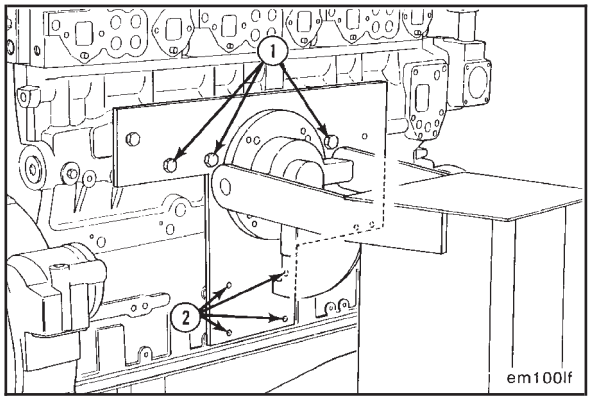
Align the mounting hole in the adapter plate (1) with the capscrew hole (2) in the mounting plate adapter.

Use a 5/8-11 X 1 3/4-inch grade 5 capscrew to mount the adapter plate to the mounting plate adapter. Use your fingers to tighten the capscrew.



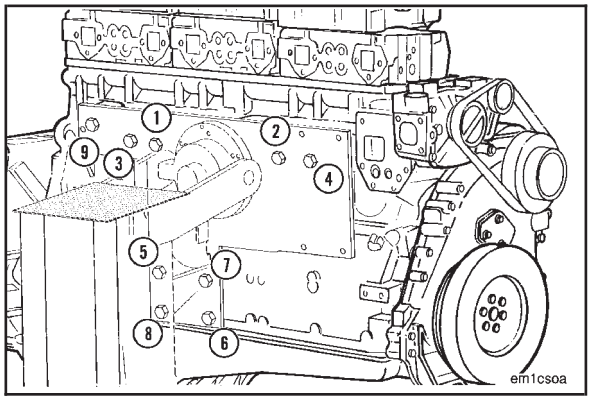


Adjust the position of the engine so that the remaining mounting holes in the adapter plate (1) and (2) align with the capscrew holes in the cylinder block.



Use your fingers to tighten the three 1/2-13 X 3 3/8-inch capscrews (1).

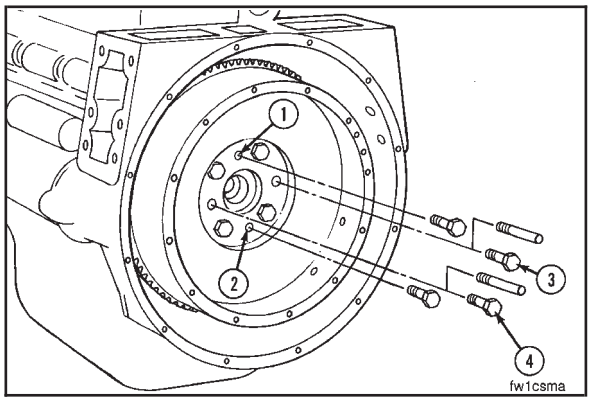
Install four 3/8-16 X 3 3/8-inch capscrews in the location shown (2). Use your fingers to tighten the capscrews.



Tighten all the adapter plate mounting capscrews in the sequence shown.

Torque Values:

3/8-inch	41 N•m [30 ft-lb]
1/2-inch	102 N•m [75 ft-lb]
5/8-inch	102 N•m [75 ft-lb]



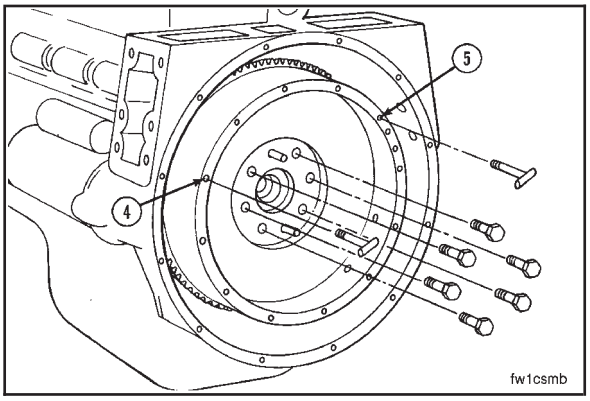
Flywheel - Removal

Install two 1/2 - 13 X 1 1/2 puller capscrews which have a minimum of 1 1/4-inch threaded area at points (1) and (2).

Remove capscrews (3) and (4), and install two 5/8 - 18 X 6-inch guide studs.

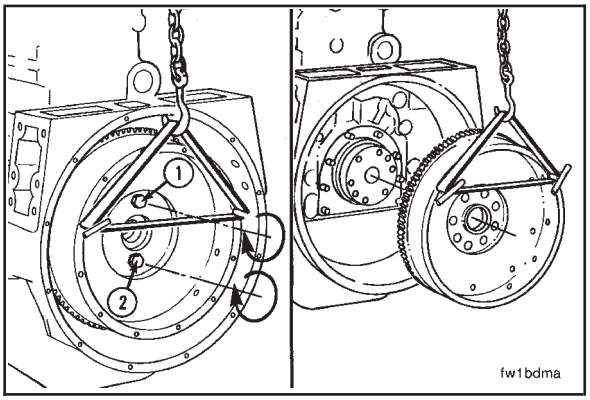
Determine the capscrew thread size, and install two ‘‘T-handles’’ in the flywheel at points (4) and (5).

Remove the remaining four flywheel mounting capscrews.



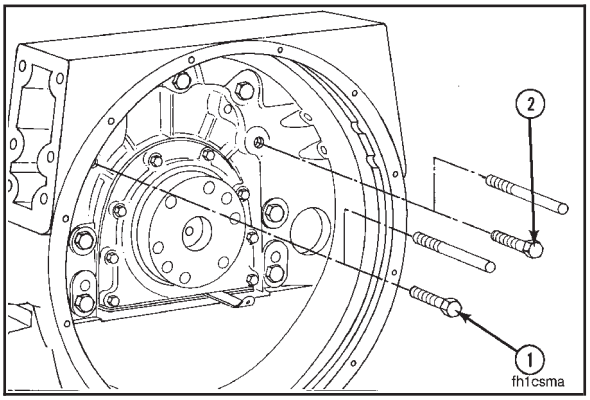
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the flywheel to avoid personal injury.

Tighten capscrews (1) and (2) in alternating sequence to loosen the flywheel.



Flywheel Housing - Removal

Remove capscrews (1) and (2), and install two 5/8 - 18 X 4-inch guide studs.

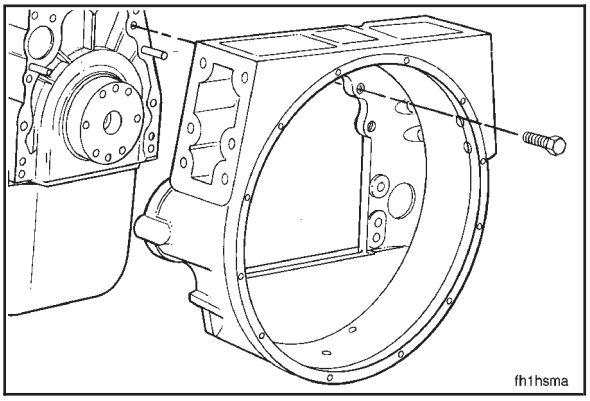


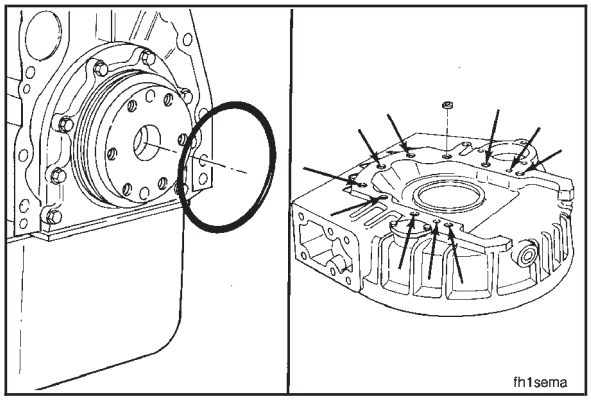
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the flywheel housing to avoid personal injury.

Remove the remaining capscrews and the flywheel housing.

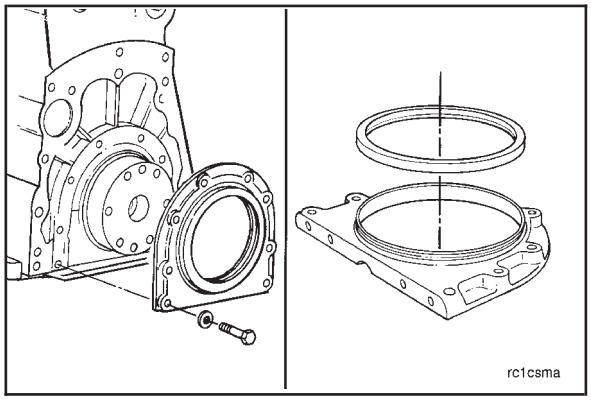
NOTE: Use a mallet to loosen the housing from the dowels in the cylinder block if necessary.

Remove the guide studs.





On wet-type flywheel housings, remove the o-ring from the rear cover and the 11 rectangular sealing rings from the flywheel housing.

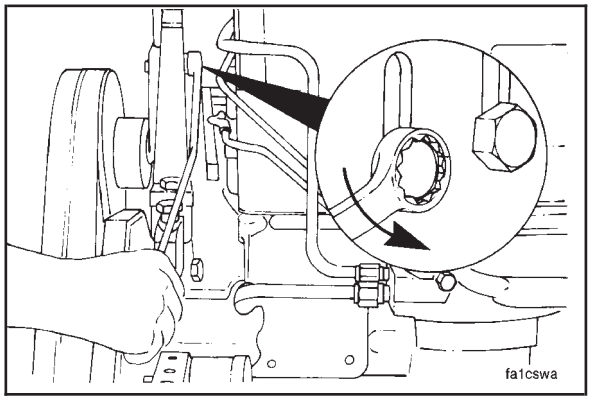


Rear Cover - Removal

Remove the capscrews from the rear cover, and remove the cover from the crankshaft flange.

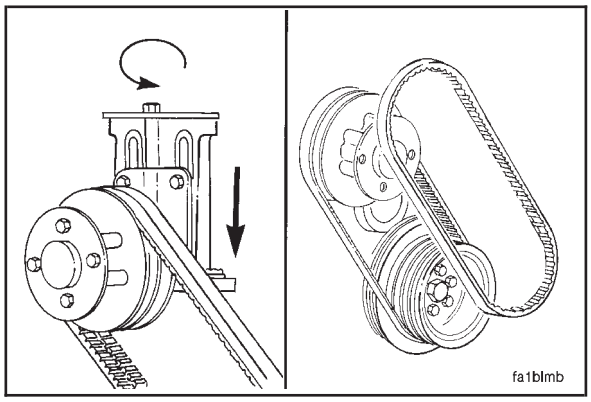
Crankshaft Seal, Rear - Removal

Remove the seal from the rear cover.



Fan Belts - Removal

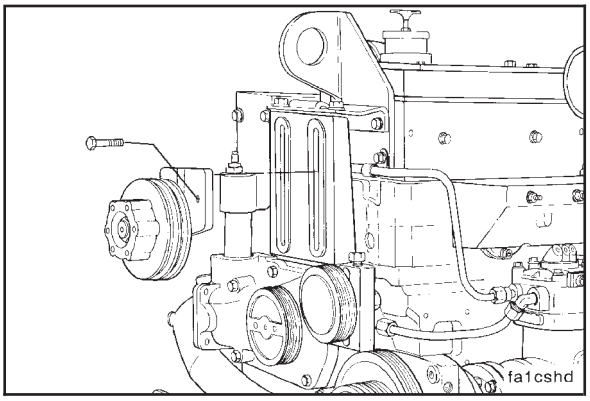
Loosen the four capscrews which secure the fan hub to the bracket.



Turn the adjusting screw **counterclockwise** to release tension, and remove the belts.

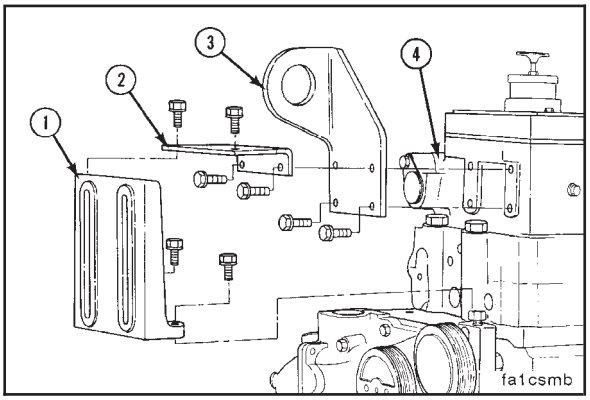
Fan Hub and Fan Hub Support Bracket - Removal

Remove the four capscrews that attach the fan hub to the support bracket, and remove the fan hub assembly.



Remove the four capscrews that attach the fan hub support (1) bracket to the cylinder block and the brace (2), and remove the fan hub support bracket.

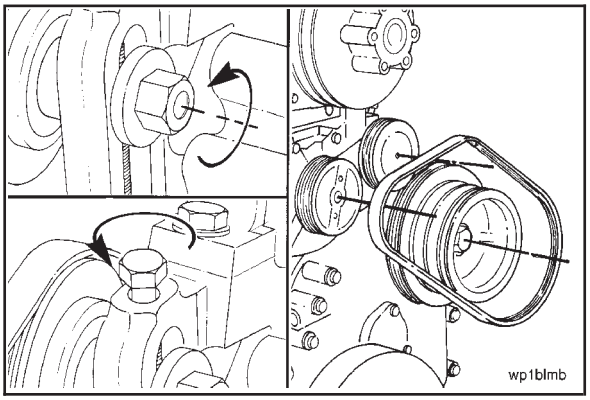
Remove the four capscrews that attach the front lifting bracket (3) to the rocker housing (4), and remove the brace (2) and the lifting bracket (3).



Water Pump Belt - Removal

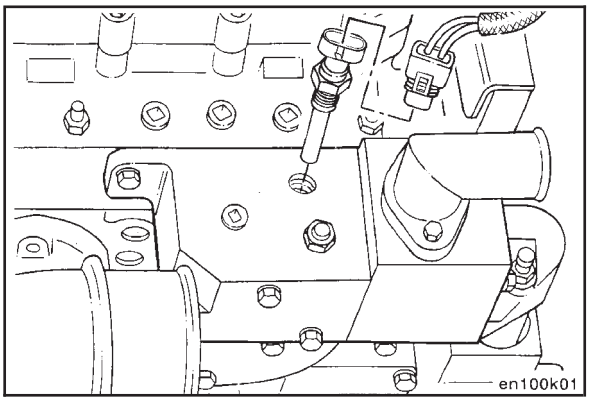
Loosen the idler pulley shaft lock nut.

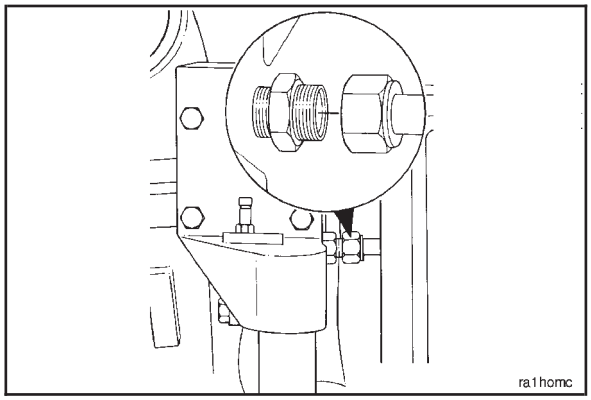
Turn the adjusting screw **counterclockwise** to release tension, and remove the water pump belt.



CELECT™ Coolant Temperature Sensor - Removal

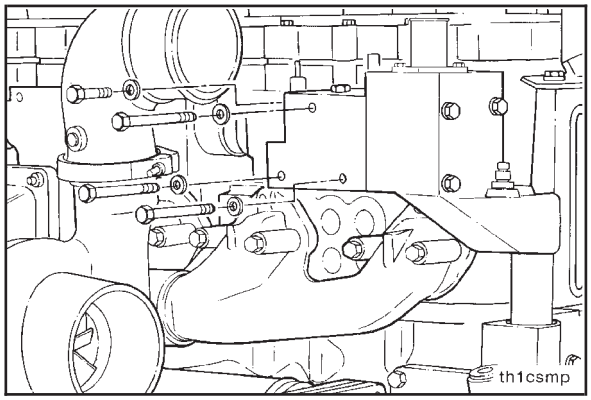
Remove the coolant temperature sensor from the thermostat housing.



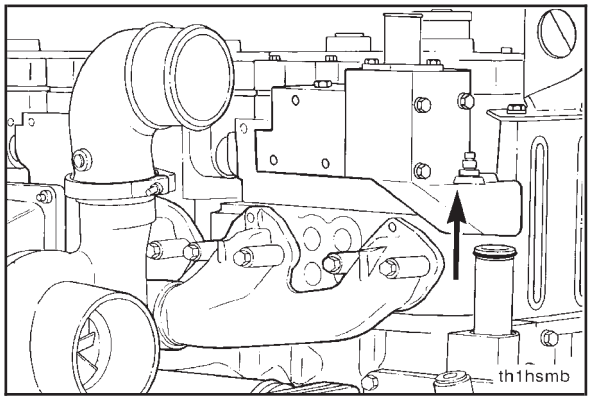


Thermostat Housing - Removal

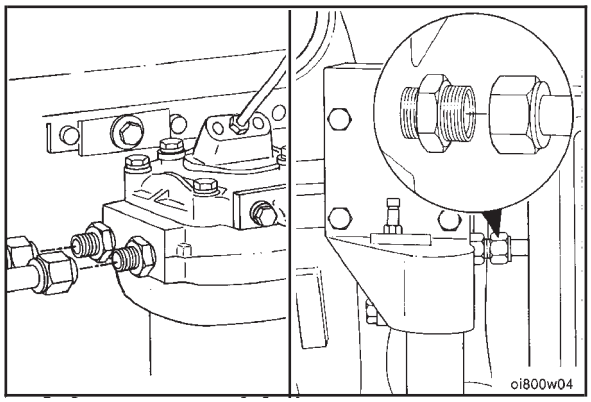
Disconnect the air compressor coolant return line from the thermostat housing.



Remove the four capscrews that attach the thermostat housing to the rocker housing.



Remove the thermostat housing from the water transfer tube.



Air Compressor Coolant Inlet and Outlet Tubes - Removal

Remove the coolant tubes to the air compressor, the cylinder block, and the water pump.

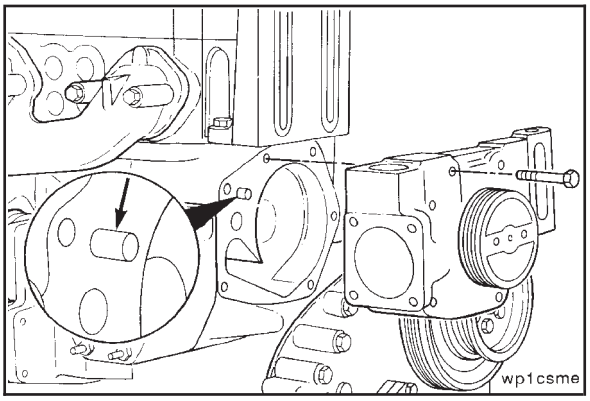
Water Pump - Removal

Remove the six mounting capscrews from the water pump.

NOTE: The water pump **must** be removed carefully to prevent damage to the impeller.

Remove the water pump from the engine.

Remove the water pump out and in a downward direction to clear the dowel pin. This dowel pin, used only on N14 cylinder blocks, prevents the installation of earlier model water pumps which do **not** incorporate an internal oil cooler coolant return passage.

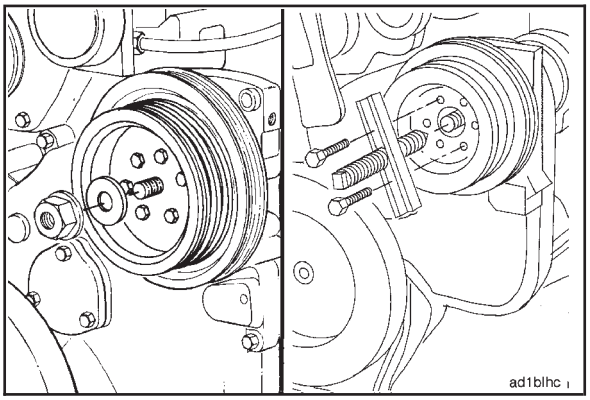


Accessory Drive Pulley - Removal

Remove the pulley retaining nut.

Caution: The gear cover will be damaged if the puller capscrews extend beyond the rear face of the accessory drive pulley.

Use a standard puller, Part No. ST-647, to remove the pulley.

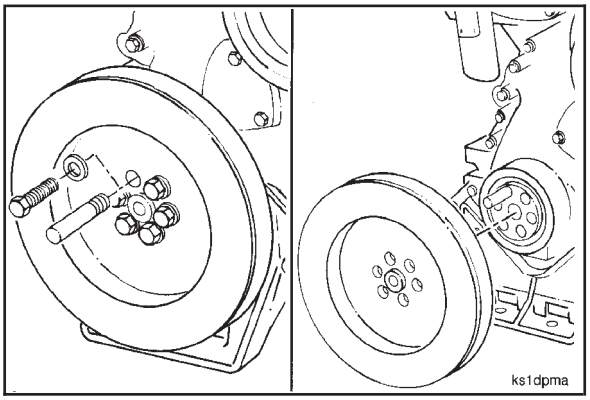


Vibration Damper - Removal

Caution: Do not use a hammer or a screwdriver to remove a viscous damper. These tools can damage the viscous damper.

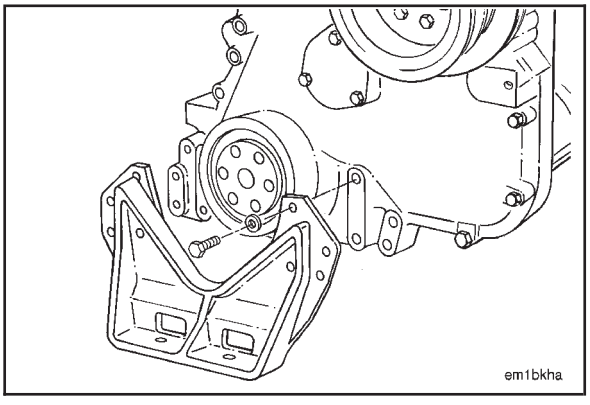
Remove one of the capscrews which holds the vibration damper and the pulley to the crankshaft, and install a guide stud in the hole.

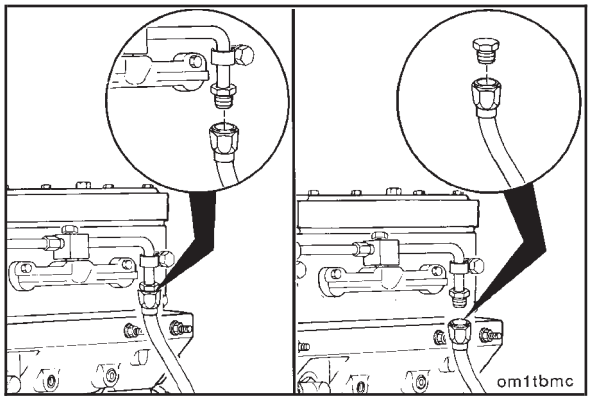
Remove the remaining five capscrews, the damper, and the pulley.



Engine Support Bracket, Front - Removal

Remove the eight mounting capscrews and the front engine support bracket from the gear cover.



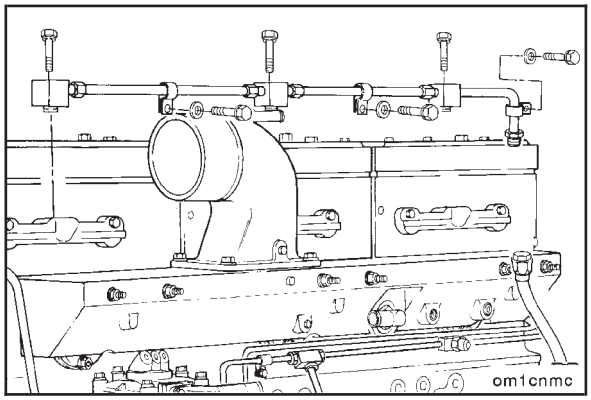


STC External Oil Plumbing - Removal

Disconnect the external oil manifold supply line from the rear of the external oil manifold.

Plug the supply line to avoid dirt contamination.

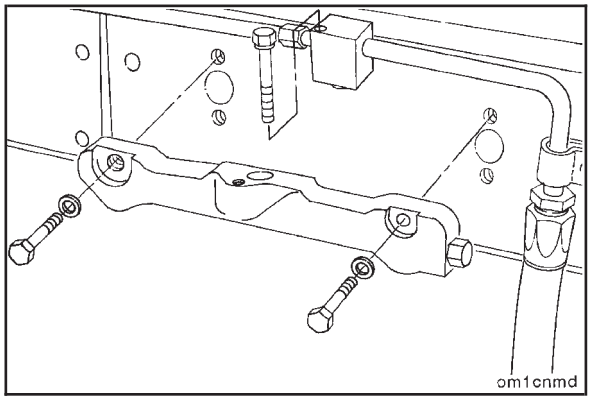
Caution: Hold the oil manifold fitting hex with a backup wrench while removing the supply line to avoid damaging the manifold.



Remove the three external oil manifold hold down capscrews.

Remove the three mounting clips, capscrews, and spacers.

Remove the external oil manifold from the connector.



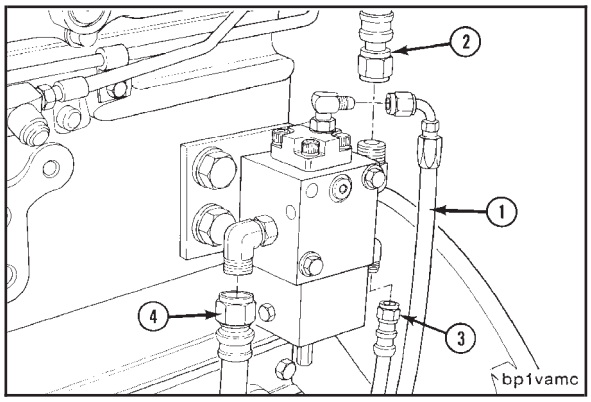
Remove the two oil manifold connector mounting capscrews.

Remove the oil manifold connector from the rocker lever housing.

NOTE: Use a wide, flat pry bar to pry at the center of the oil manifold connector. Remove the connector evenly from both pass through ports simultaneously to prevent damage to the connector or the rocker lever housing.

NOTE: If necessary, remove the intake air tube and elbow from the intake prior to removing the oil manifold connector.

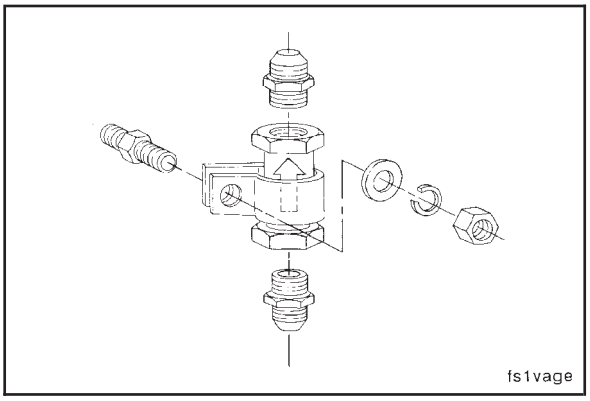
Repeat this procedure for each rocker housing.



Remove the following hoses from the STC oil control valve and the engine:

1. Fuel Rail Pressure Signal Hose
2. Oil Supply Hose to Tappets
3. Crankcase Vent Hose
4. Oil Supply Hose from Oil Rifle

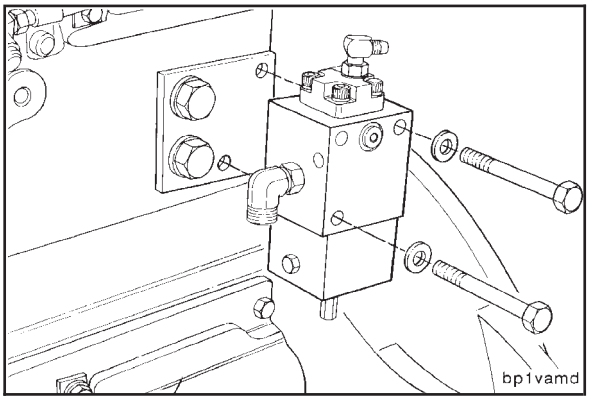
Remove the clamp, check valve, and oil supply hose from the engine.



STC Oil Control Valve - Removal

Remove the two capscrews attaching the STC oil control valve to the mounting plate. Remove the valve.

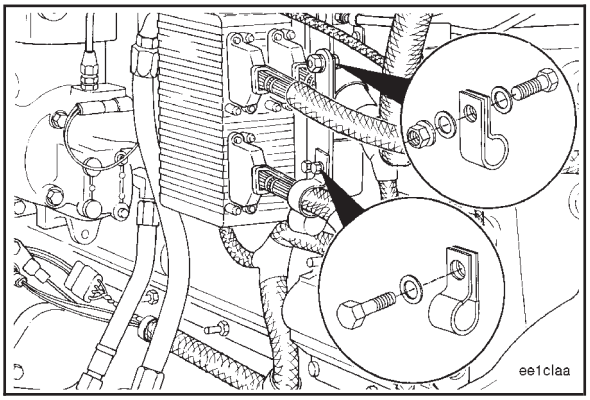
Remove the two capscrews attaching the mounting plate to the cylinder block and remove the mounting plate.



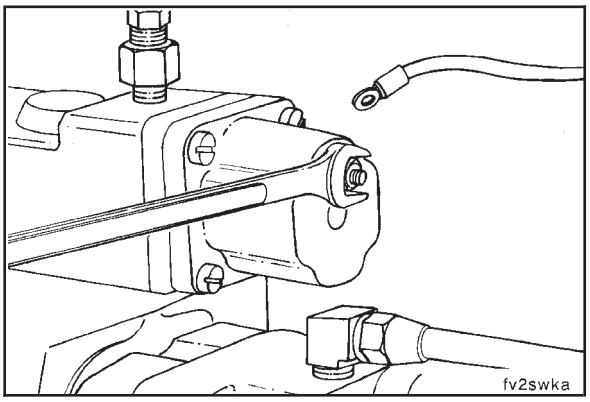
CELECT™ Actuator Harness - Removal

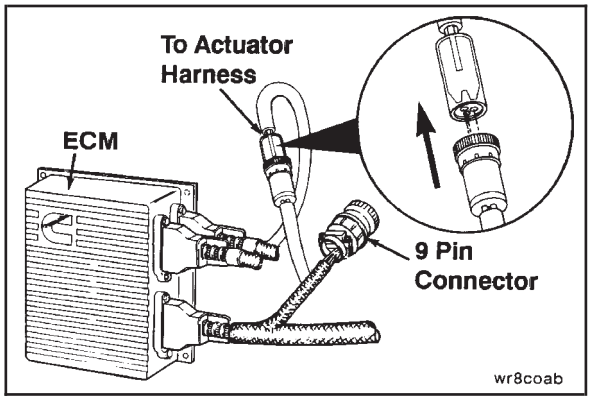
Remove the actuator harness clamps from the support bracket.

Although the OEM harness is shown, this will be disconnected when the engine is out of chassis.

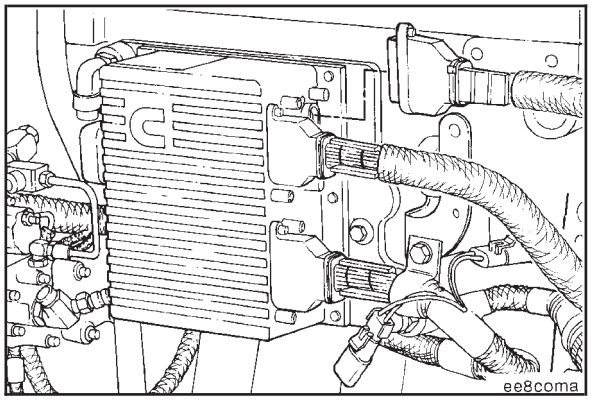


Disconnect the fuel shutoff valve control wire from the fuel shutoff solenoid valve.

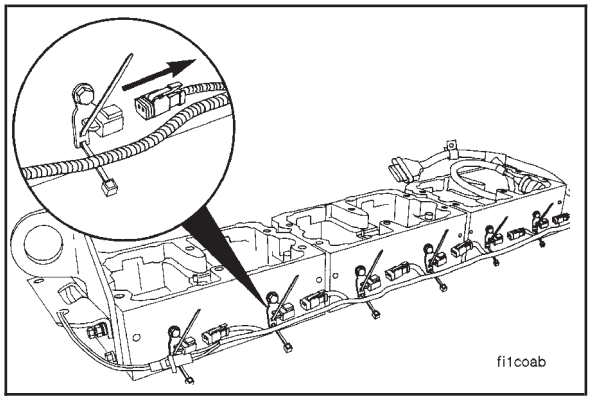




Disconnect the Deutsch three pin connector that contains the vehicle key switch, fan clutch, and engine brake control wires from the three pin connector which is wired directly into the Deutsch nine pin connector on the sensor harness.

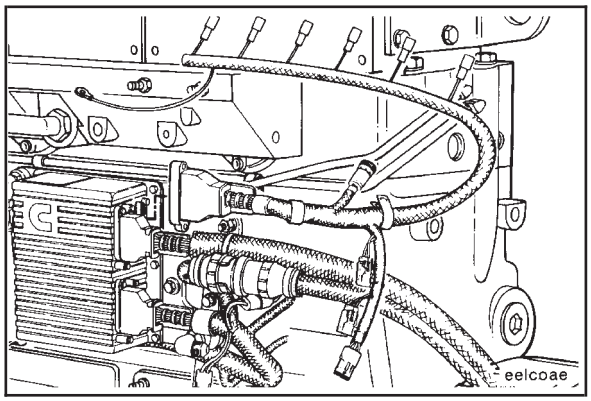


Remove the actuator harness amp connector from the electronic control module (ECM).



Disconnect the actuator harness from each of the pass through connectors along the side of the rocker box housing. Cut and remove the plastic wire ties that hold the actuator harness to each of the pass through connectors.

Remove the clamp capscrew on the rear of No. 3 rocker housing.

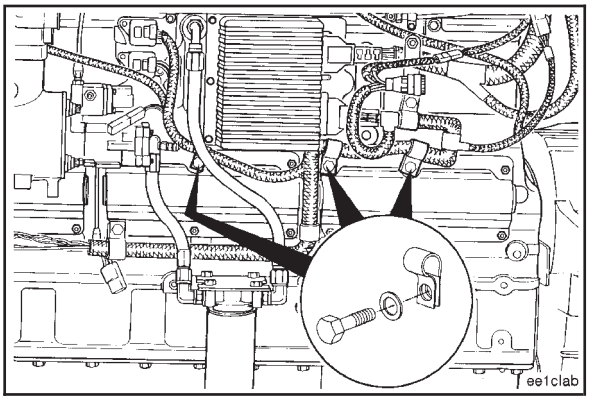


Remove the actuator harness from the engine.

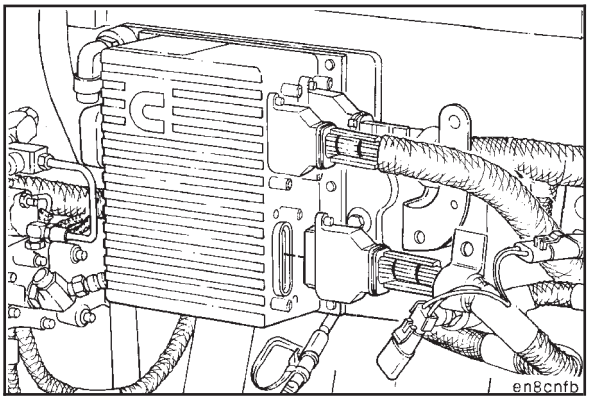
CELECT™ Sensor Harness - Removal

Remove the retaining clamps for the sensor harness from the support bracket and the engine block.

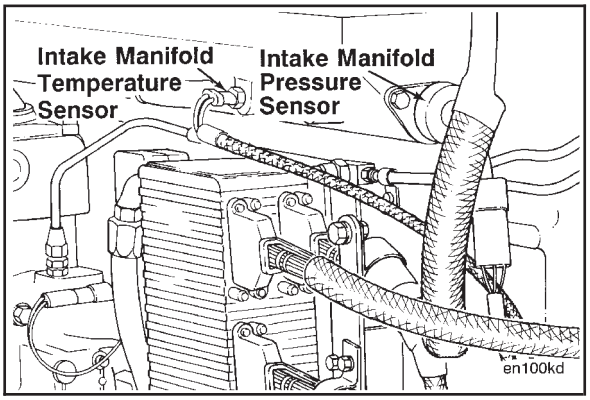
Although the OEM harness is shown, this will be disconnected when the engine is out of chassis.



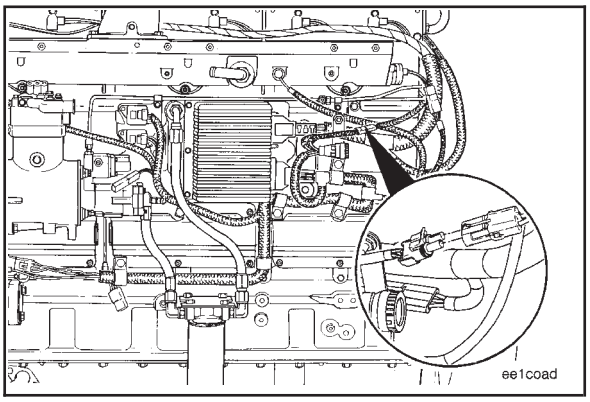
Disconnect the sensor harness amp connector from the ECM.

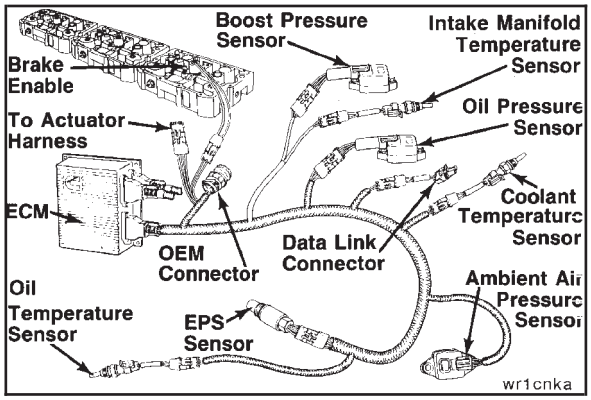


Remove the retaining clamp of the sensor harness from the rear of the engine block. Disconnect the sensor harness from the intake air temperature sensor and the intake manifold pressure sensor.



On engines equipped with engine brakes, disconnect the engine brake harness from the sensor wiring harness.





Remove the harness retaining capscrews and disconnect the harness from the following sensors:

Oil pressure sensor

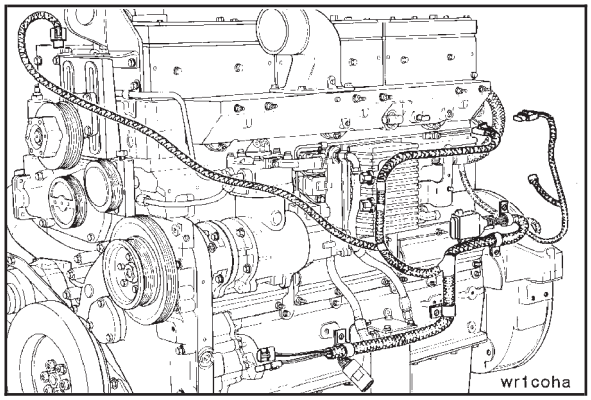
Oil temperature sensor

Ambient air pressure*

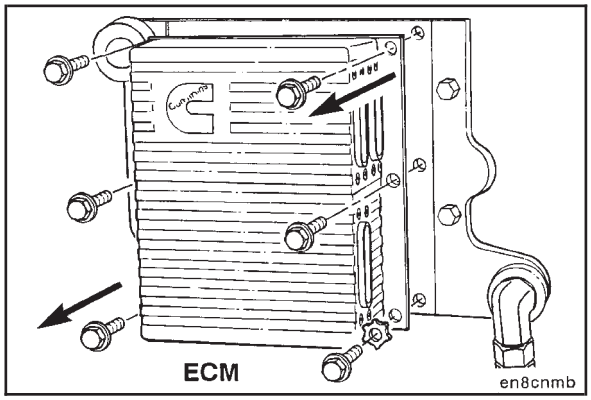
Engine position sensor

Engine coolant temperature sensor

*Not used on all ratings.

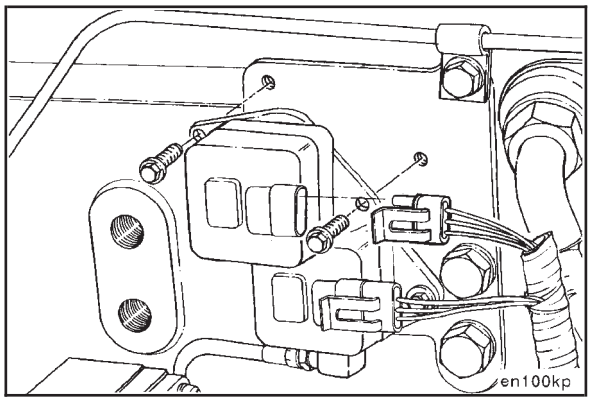


Remove the sensor harness from the engine.



CELECT™ Electronic Control Module (ECM) - Removal

Remove the six capscrews which hold the ECM to the cooling plate. These capscrews are metric. Remove the ECM from the cooling plate.

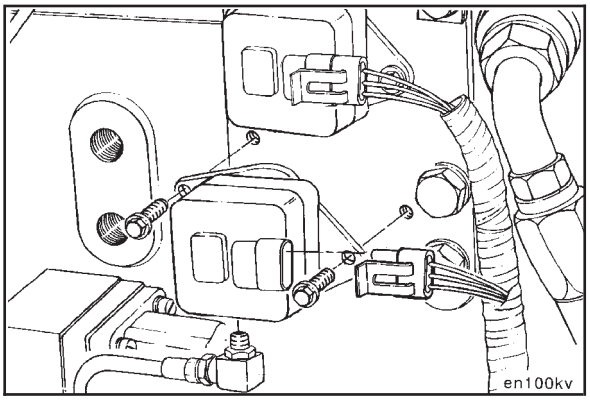


CELECT™ Ambient Air Pressure Sensor - Removal

Remove the sensor mounting capscrews. Remove the sensor from the engine.

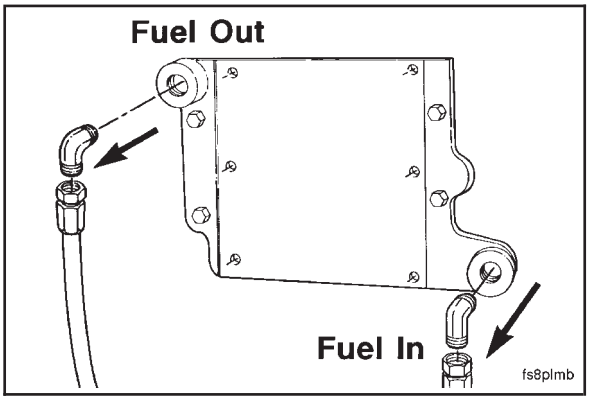
CELECT™ Lubricating Oil Pressure Sensor - Removal

Remove the oil pressure signal line. Remove the sensor mounting capscrews. Remove the sensor from the engine.

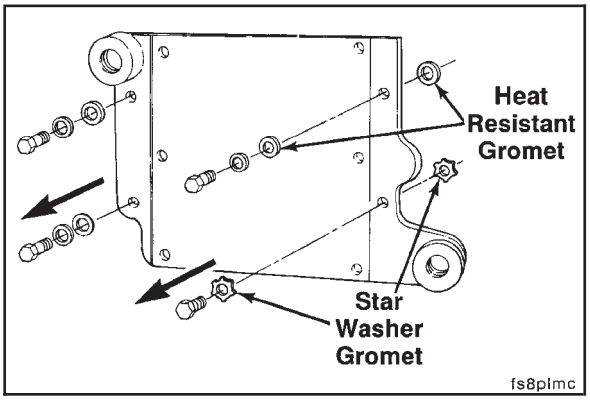


CELECT™ ECM Cooling Plate - Removal

Remove the inlet and the outlet fuel hoses from the cooling plate.



Remove the four cooling plate mounting capscrews. Do **not** lose any of the heat resistant grommets. The heat resistant grommets are on both sides of the cooling plate. One of the mounting locations has heat resistant star washer grommets on both sides of the cooling plate. Remove the cooling plate.



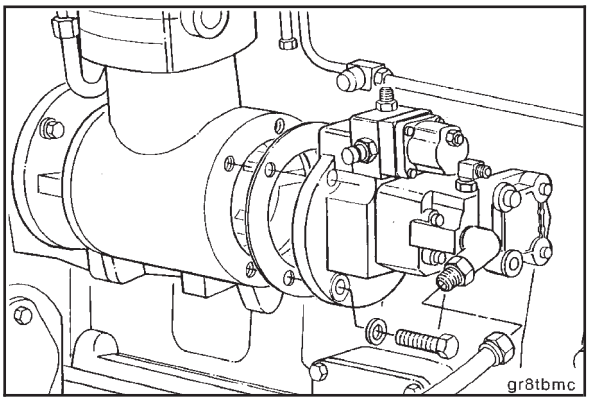
Fuel Pump - Removal

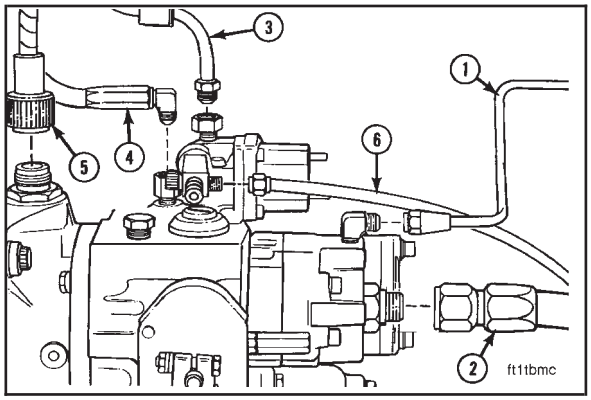
CELECT™ Engines

Remove the fuel plumbing.

Remove the four capscrews and remove the fuel pump.

Remove the spider coupling.





STC Engines

Remove the fuel tubing and AFC air signal line:

Gear pump cooling drain (1)

Fuel supply line (2)

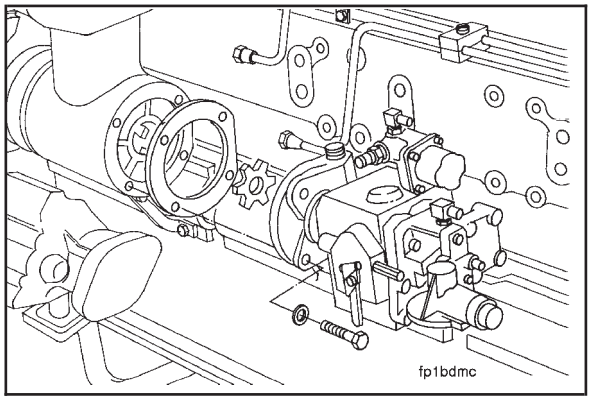
Fuel rail pressure line (3)

AFC air signal line (4)

Tachometer cable (if equipped) (5)

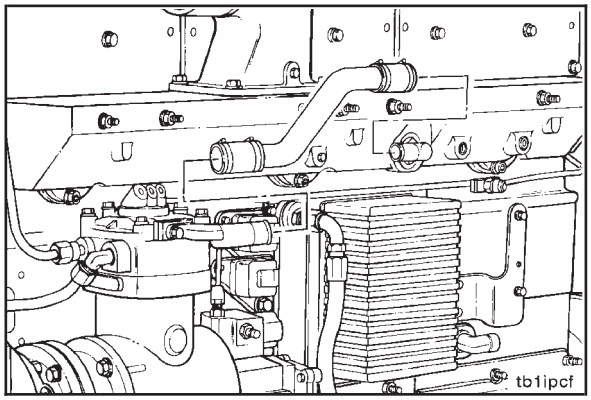
Fuel pressure sensing line (to STC valve) (6)

Throttle switch (if equipped) (not shown)



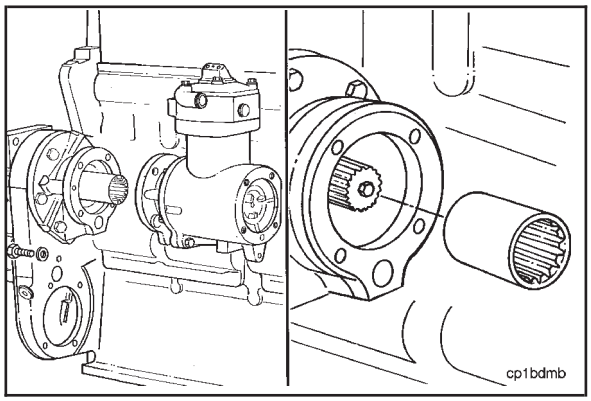
Remove the four capscrews and the fuel pump.

Remove the spider coupling.



Air Compressor - Removal

Disconnect the air supply line from the air compressor to the intake manifold.

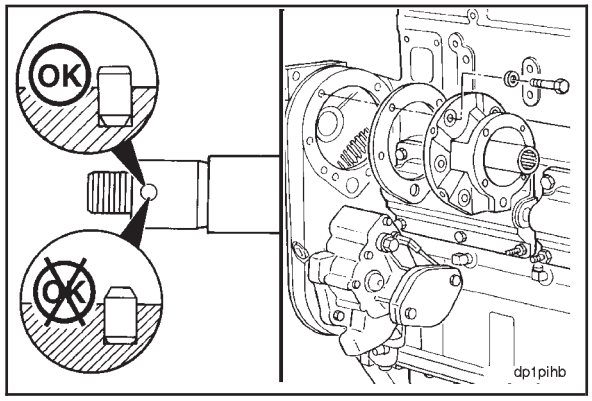


Remove the four capscrews, the air compressor, and the splined coupling.

Accessory Drive - Removal

Caution: If the accessory drive dowel pin has been incorrectly installed in the accessory drive shaft, the dowel pin must be removed before attempting to remove the accessory drive to prevent damage to the accessory drive bushing.

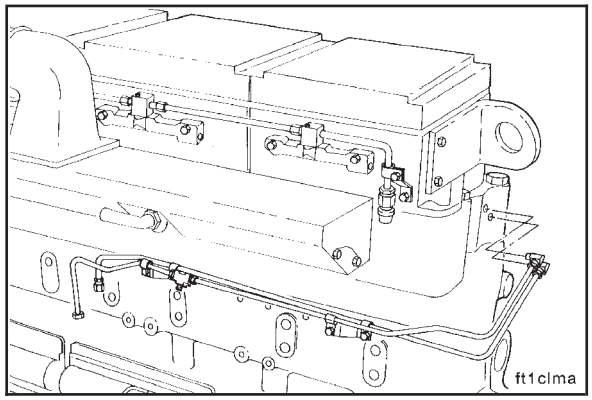
Remove the five capscrews and the accessory drive assembly.



Fuel Tubing - Removal

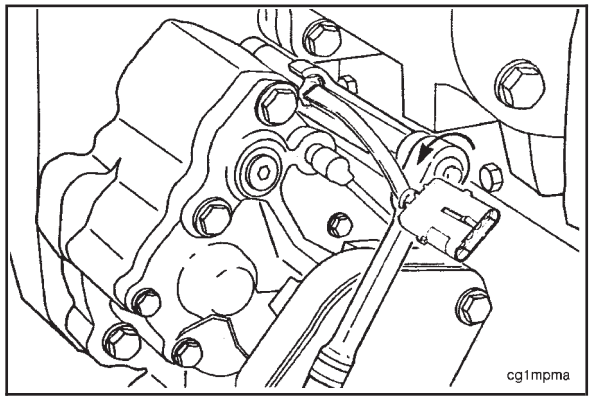
Remove the retaining clamps and the fuel rail supply tube from the engine. Remove the fuel return tube from the engine.

Remove the fuel fittings from the rear of the cylinder head.



CELECT™ Engine Position Sensor (EPS) - Removal

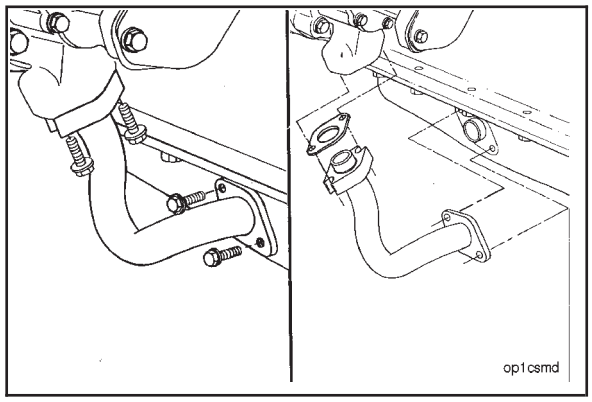
Disconnect the sensor from the sensor harness. Turn the EPS out of the cylinder block. Use service tool, Part No. 3822747.

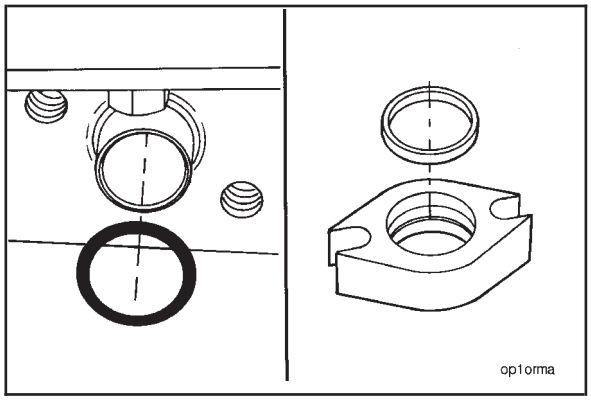


Lubricating Oil Transfer Tube - Removal

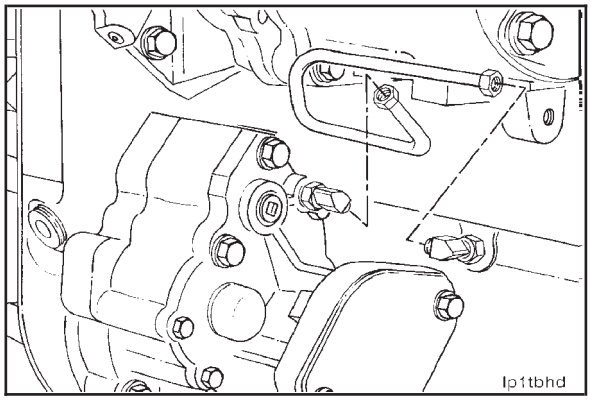
Remove the two capscrews from the flange at the oil pan and also the two capscrews from the flange at the lubricating oil pump.

Remove the lubricating oil transfer tube.





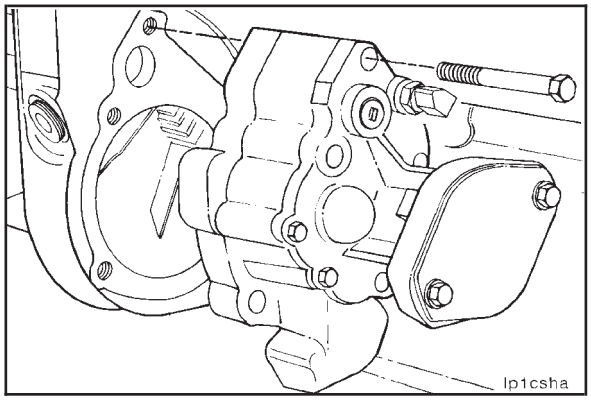
Remove and discard the o-ring from the oil pan flange tube and the rectangular sealing ring from the lubricating oil pump mounting flange.



Lubricating Oil Pump Signal Line - Removal

Remove the demand flow and cooling (DFC) signal line between the cylinder block main oil rifle and the lubricating oil pump.

On STC engines, remove the DFC signal line between the viscosity sensor and the lubricating oil pump.

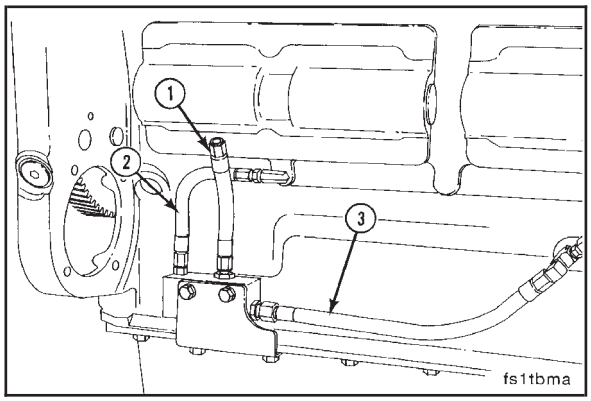


Lubricating Oil Pump - Removal

Remove the five capscrews which hold the lubricating oil pump to the cylinder block.

Caution: Do not pry on the lubricating oil pump mounting flange.

Remove the lubricating oil pump from the cylinder block gear flange. Discard the gasket.

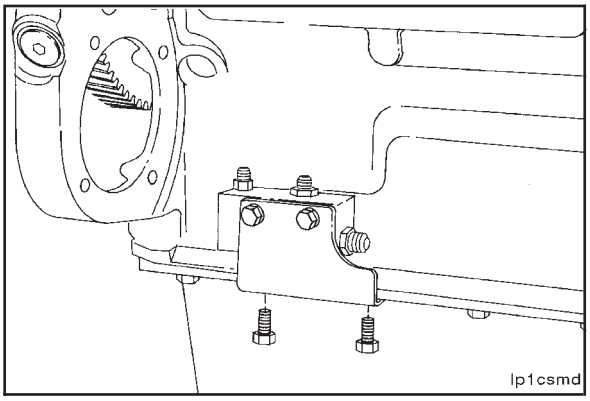


Viscosity Sensor - Removal

Remove the pressure signal line (1), the oil supply line (2), and drain line (3) from the viscosity sensor.

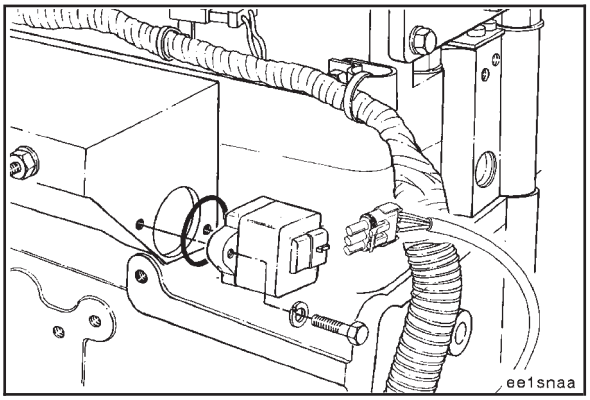
Remove the two mounting bracket capscrews from the pan rail.

Remove the entire assembly from the engine.



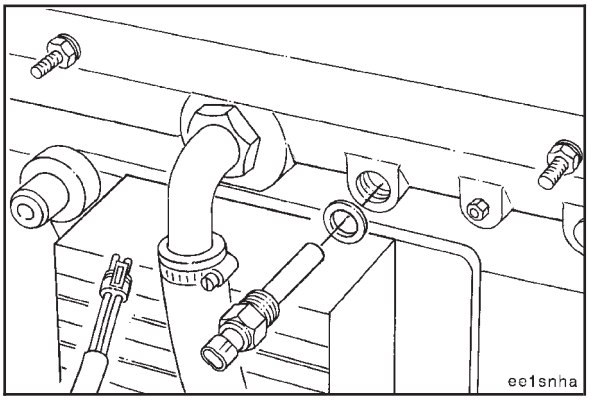
CELECT™ Boost Pressure Sensor - Removal

Remove the sensor mounting capscrews. Remove the sensor from the engine.



CELECT™ Intake Air Temperature Sensor - Removal

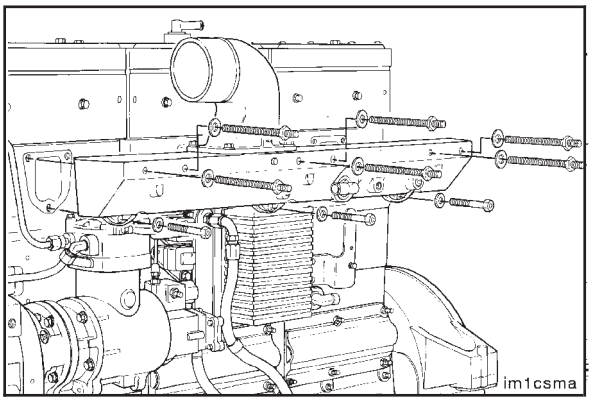
Remove the sensor from the engine.

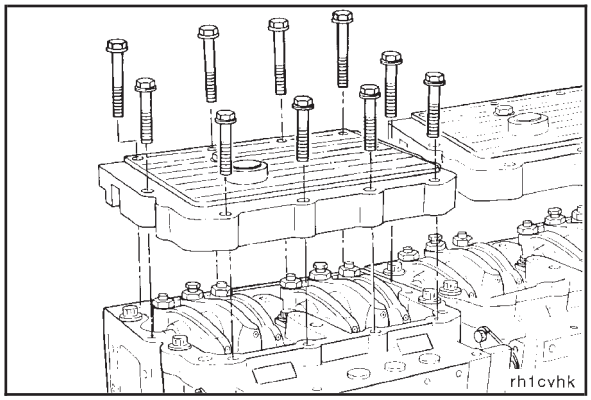


Intake Manifold - Removal

Remove the four capscrews that attach the intake air connector to the intake manifold.

Remove the nine capscrews, and remove the intake manifold.



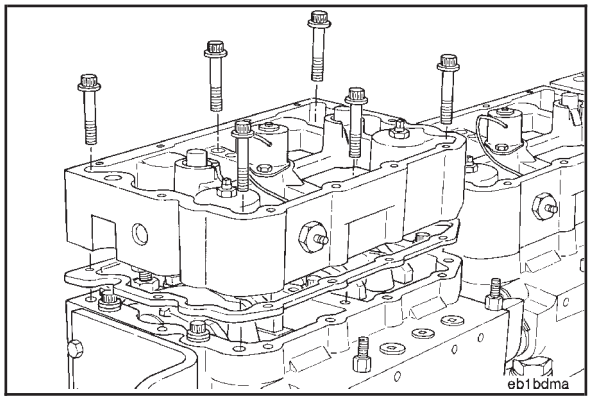


Rocker Housing Covers - Removal

Remove the ten capscrews from each rocker lever cover.

Remove the rocker lever covers. The rocker housing cover gaskets can be used again if they are **not** damaged.

Caution: Do not clean reusable gaskets with any solvent or steam. Solvent and steam will damage the gasket material. Clean only with soap and water.



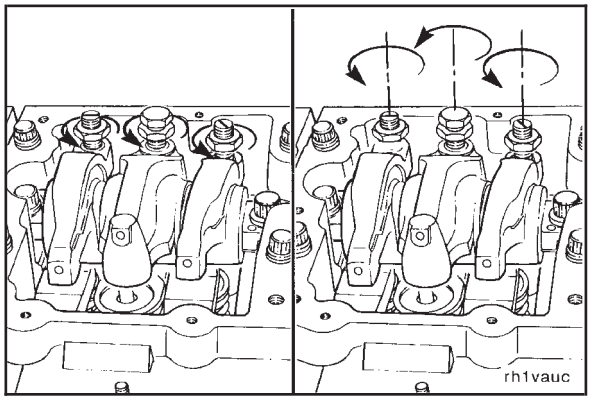
Engine Brakes - Removal

Disconnect the C-Brake harness wire from the electrical connector on each C-Brake housing.

Remove the capscrews from each C-Brake housing.

Remove the C-Brake housing.

Remove the C-Brake housing gasket.

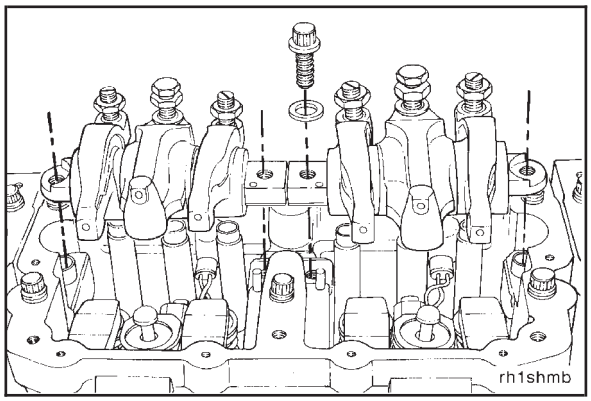


Rocker Lever Shaft Assemblies - Removal

Loosen the valve and injector adjusting screw lock nuts on each rocker lever.

Turn the adjusting screws **counterclockwise** until the rocker levers are loose.

Caution: Do not attempt to remove or install the rocker lever shaft assemblies without first loosening the levers.



Remove the rocker lever shaft capscrews and the rocker lever shaft assemblies.

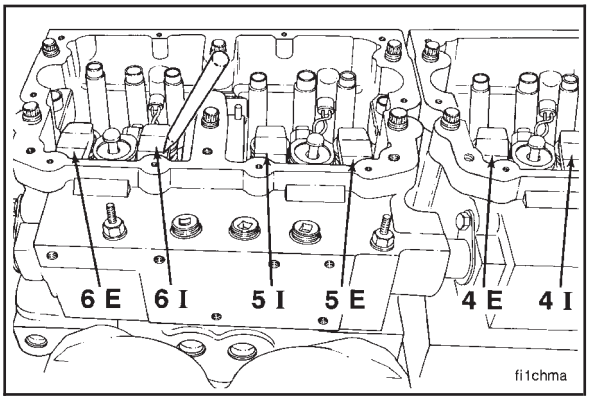
NOTE: To prevent increased wear, mark each rocker lever as it is removed so it can be installed back in its original location.

NOTE: Hold the shaft at both ends so that the rocker levers do **not** slide off.

Valve Crossheads - Removal

Remove the crossheads. Be sure to mark them appropriately so they can be installed in the same location and orientation during the installation procedure.

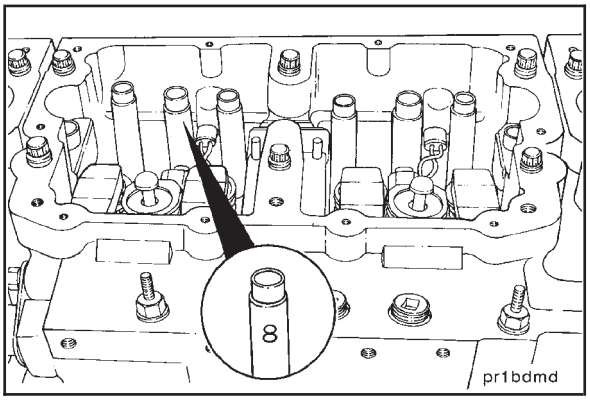
NOTE: Excessive crosshead wear can result if the crossheads are **not** installed in their original locations. The larger hole on the underside of the crosshead **must** be oriented toward the exhaust side of the engine.



Push Tubes - Removal

Remove the push tubes.

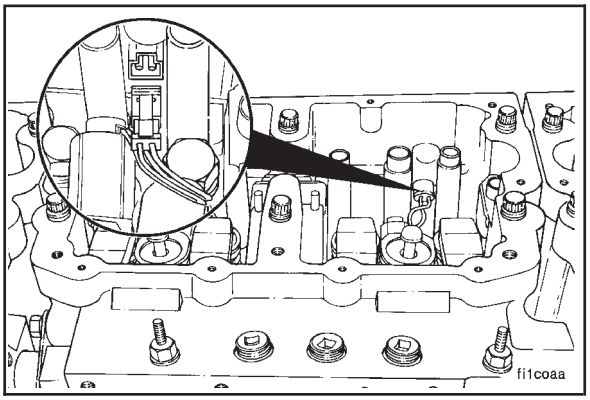
NOTE: To prevent increased wear, mark each push tube as it is removed so it can be installed back in its original location.



Injectors - Removal

CELECT™ Engines

Disconnect the injector solenoid leads from the pass through connector in the rocker housing.

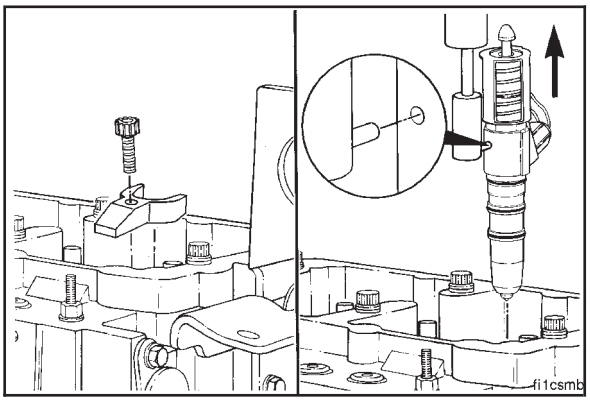


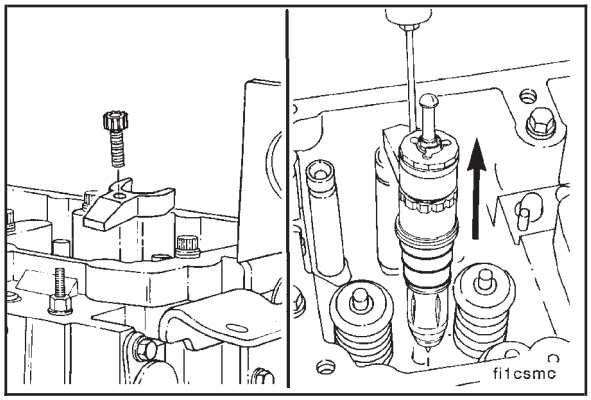
Remove the injector hold down clamp capscrew.

Remove the injector and the hold down clamp.

Use injector puller, Part No. 3823579, to remove CELECT™ injectors. Insert the pin of the tool into the hole provided in the body of the injector. The hole faces the exhaust side of the engine.

Caution: Do not catch the injector puller into the top stop spring cage. Damage to the injector will occur.



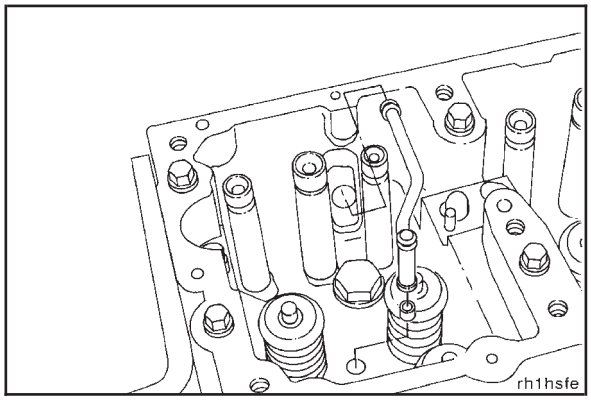


STC Engines

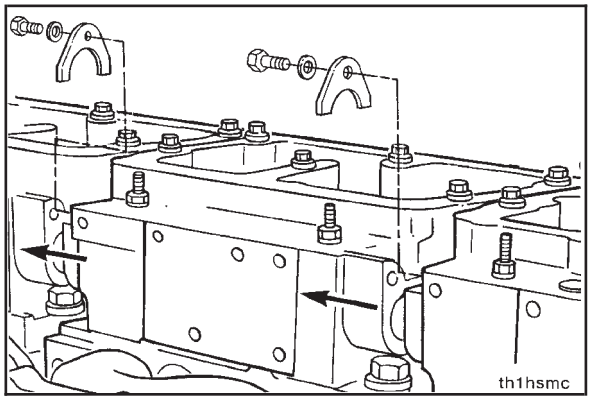
Remove the injector hold down clamp capscrew and the clamp.

Use injector puller, Part No. 3822697, to remove the STC injectors.

Insert the threaded end of the puller into the tapped hole in the STC oil feed lock nut.



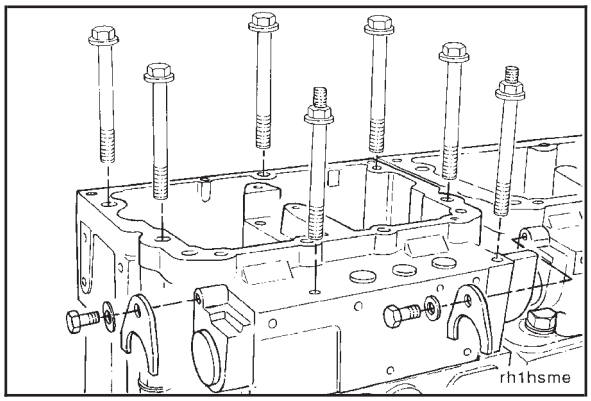
Remove the internal oil tube and the rubber grommet which is located in the cylinder head.



Rocker Lever Housing - Removal

Remove the water manifold tube clamps. Use service tool, Part No. 3823819, to push or pry the adjacent water tubes into the rocker housing cavity.

For example, the tube between housing No. 1 and No. 2 **must** be pushed into housing No. 2. The tube between housing No. 2 and No. 3 **must** be pushed into housing No. 3.



Remove the rocker housing mounting capscrews.

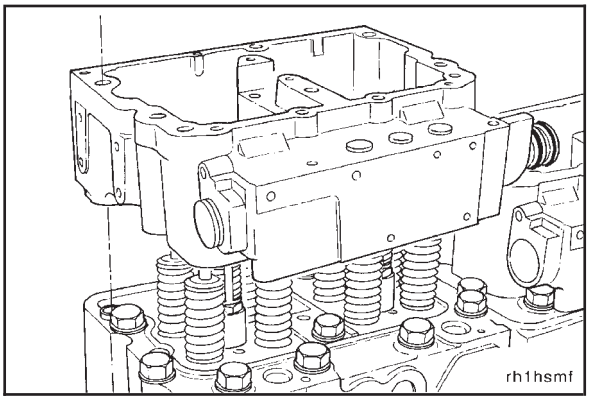
NOTE: To prevent increased wear, mark each rocker lever housing as it is removed so it can be installed back in its original location.

If the rocker housing assemblies are to be installed after rebuild with their original parts, mark each rocker lever housing as it is removed so it can be installed back in its original location thus taking advantage of worn-in mating parts.

Remove the rocker lever housings.

Remove the gaskets.

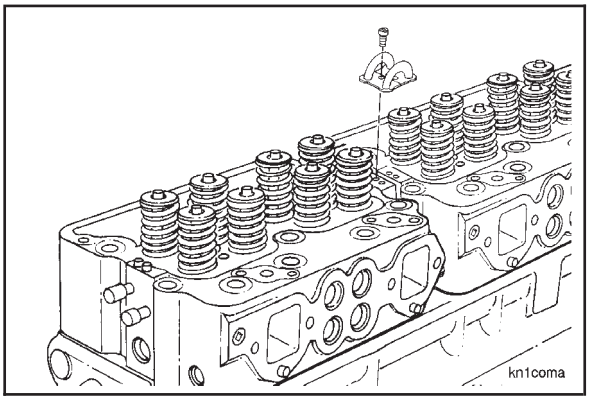
NOTE: On CELECT™ engines while handling the rocker lever housings, protect the wiring harness pass through connectors. Do **not** subject the pass through connectors to impact forces and do **not** rest the housing on the face with the pass through connectors.



Fuel Crossovers - Removal

Remove the four capscrews from each of the two fuel crossovers, and remove the fuel crossovers.

Remove and discard the four o-rings.

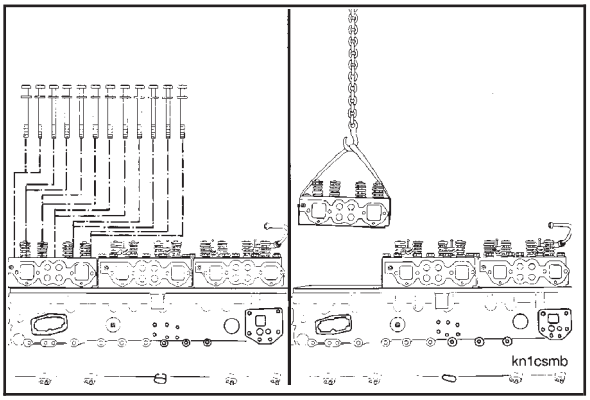


Cylinder Heads - Removal

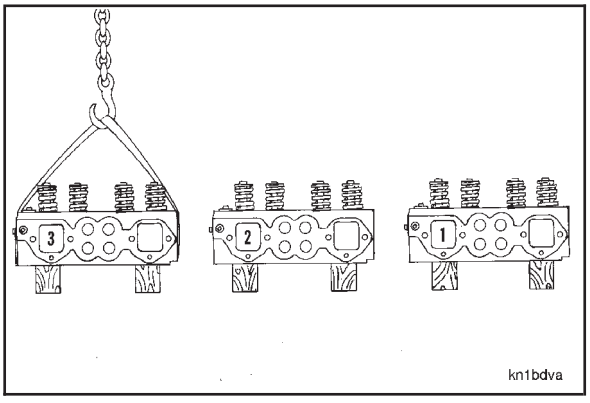
Remove the 12 capscrews and washers from each cylinder head.

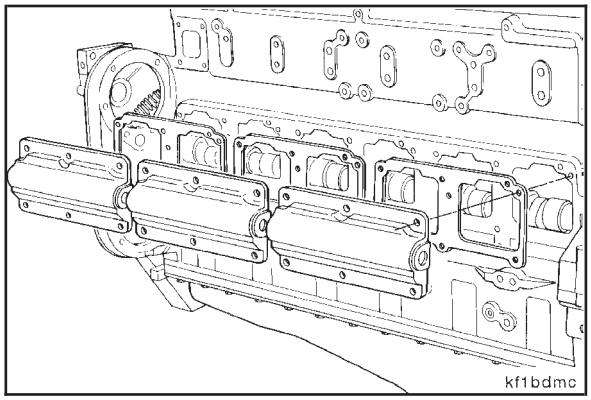
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the cylinder heads to avoid personal injury.

Lift the cylinder heads from the block, and remove the cylinder head gaskets.



Caution: To prevent damage to the head gasket surface, put the cylinder heads on wooden blocks when they are removed.





Cam Follower Assemblies - Removal

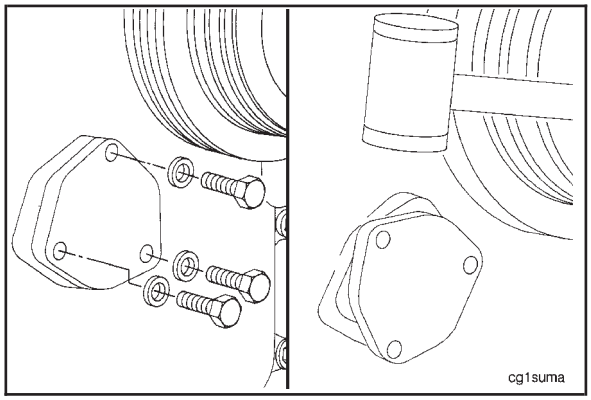
Remove the cam follower housing assemblies as follows:

1. Remove the six capscrews and studs from each cam follower housing.

NOTE: Record the position of the studs prior to removal.

2. Remove the cam follower housings and gaskets.

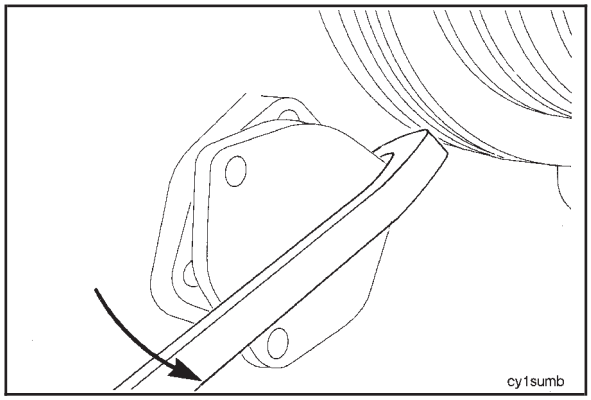
NOTE: To prevent increased wear, mark the cam follower housing assemblies as they are removed so they can be installed back in their original location on the block.



Camshaft Bearing Support - Removal

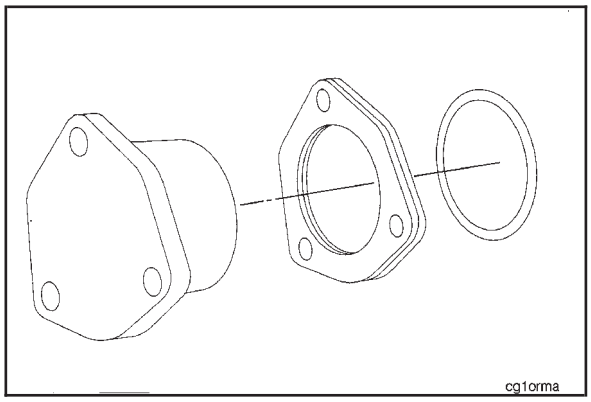
Remove the three capscrews from the support.

Use a rubber or plastic mallet to rotate the bearing support approximately 60 degrees.



Use a suitable pry bar to remove the bearing support from the gear cover.

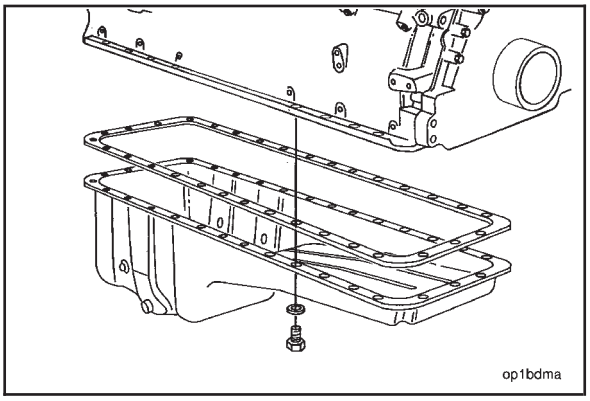
NOTE: Be careful **not** to damage the bearing support surfaces.



Remove the o-ring and the shims from the bearing support. Do **not** dispose of the shims.

Lubricating Oil Pan - Removal

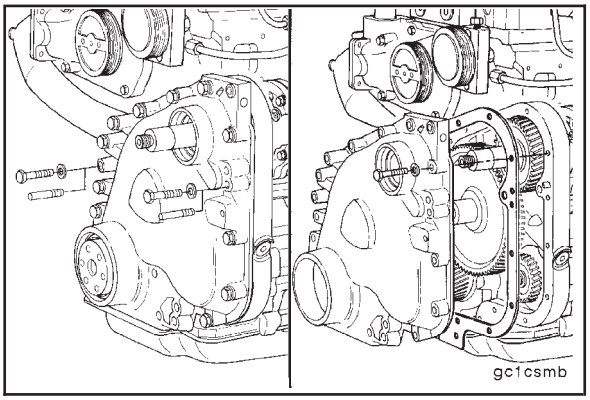
Remove the oil pan mounting capscrews and the oil pan.



Gear Cover - Removal

Remove one capscrew on each side of the gear cover, and install a 7/16 - 20 X 4-inch guide stud in each location to support the cover during removal.

Remove the remaining gear cover capscrews, and remove the gear cover.

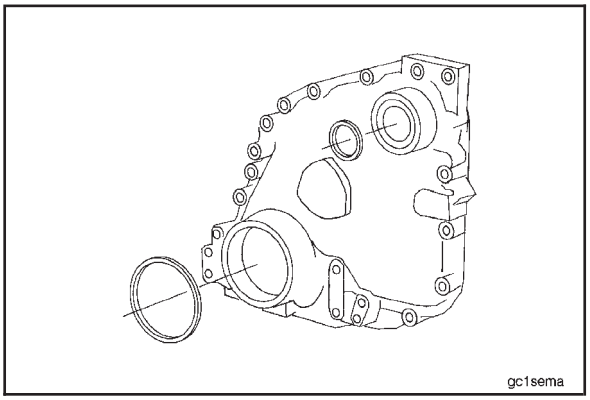


Crankshaft Seal, Front - Removal

Remove the front crankshaft seal.

Accessory Drive Seal - Removal

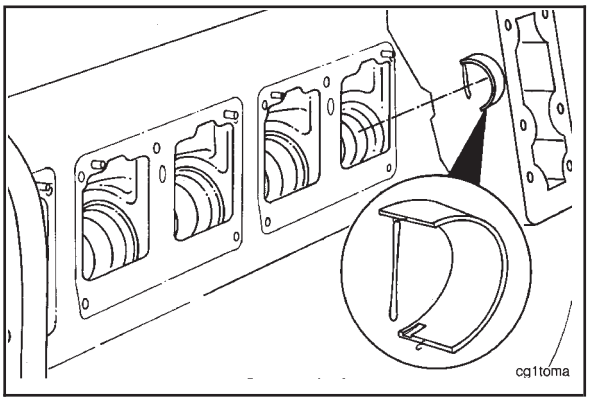
Remove the accessory drive seal. Refer to the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456, Section 7.

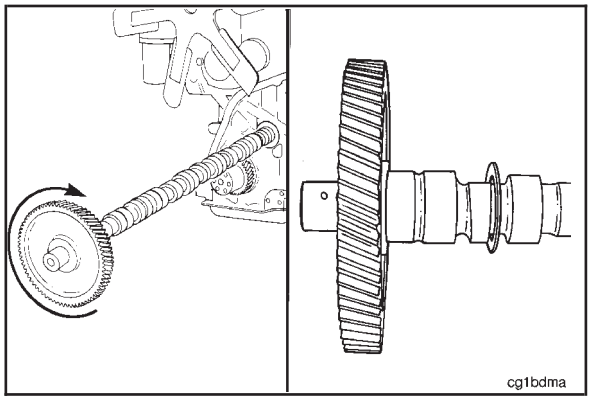


Camshaft - Removal

Install four camshaft pilots, Part No. 3375268, over the outer base circle of the valve lobes between the camshaft journals.

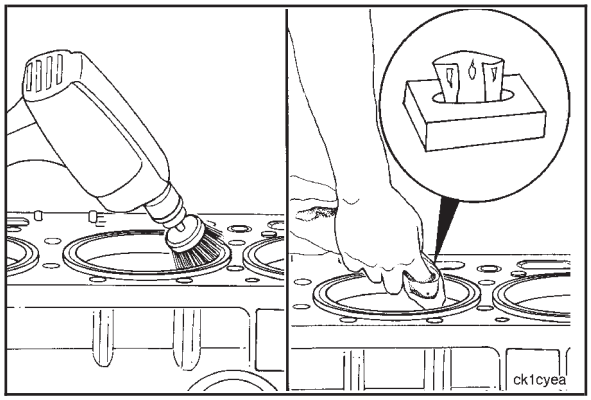
Use a rubber band to hold the installation pilots in place. The rubber band **must** straddle the valve lobe.





Use one hand to slowly rotate and pull the camshaft from the cylinder block and the other hand to balance the camshaft as it is removed.

Remove the camshaft thrust washer from the camshaft.

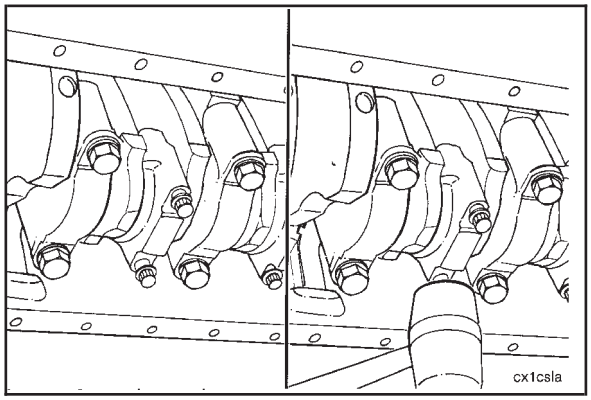


Piston and Connecting Rod Assemblies - Removal

Caution: Piston cooling nozzles must be removed prior to the removal of the piston and connecting rod assemblies.

Plug the overhead oil rifle, push tube cavities, and coolant passages in the block; and use a rotary wire brush to remove the carbon ring from the top of the cylinder liner. Use a scraper that has an aluminum blade if a rotary wire brush is not available.

Use lint-free paper to remove all the broken wire bristles and loose carbon from the cylinders.

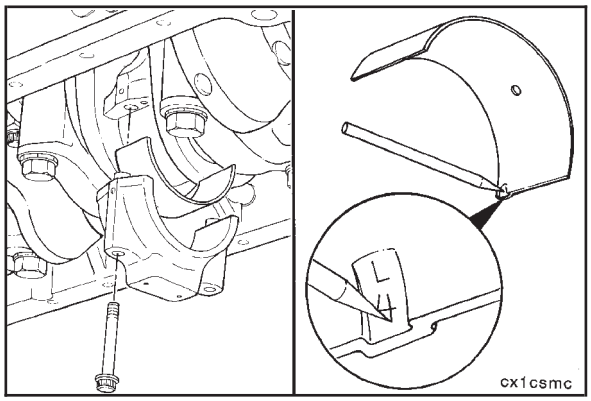


Rotate the crankshaft to position two of the connecting rods at bottom dead center (BDC).

Loosen the connecting rod capscrews.

NOTE: Do **not** remove the capscrews.

Hit the connecting rod capscrews with a rubber hammer to loosen the rod caps from the dowels.



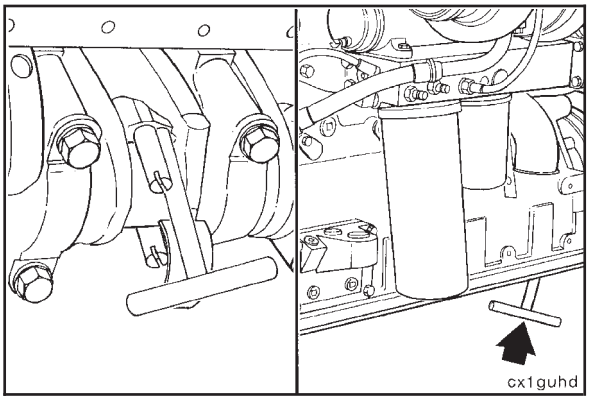
Remove the connecting rod capscrews and the rod caps.

Remove the bearing shell from the rod cap, and mark the cylinder number and the letter ‘‘L’’ in the flat surface of the bearing tang.

Install two connecting rod guide pins, Part No. 3375601.

Use a ''T-handle'' piston pusher to push the rod away from the crankshaft.

NOTE: Push the rod away from the crankshaft, over the crankshaft rod journal, and push the rod until the piston rings are outside of the top of the cylinder liner.

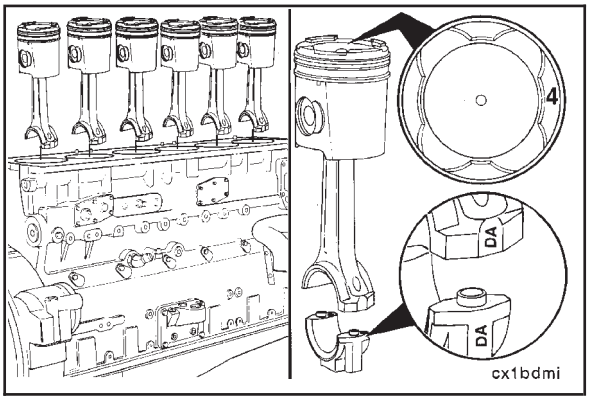


Remove the piston and rod assembly.

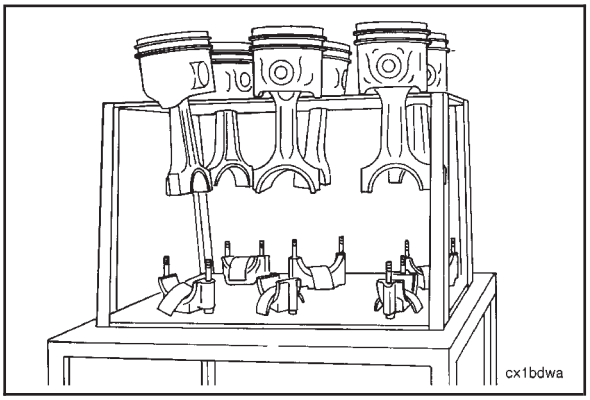
NOTE: The piston and connecting rod assemblies **must** be installed in the same cylinder number from which they were removed to make sure correct fit of worn mating surfaces if parts are to be used again.

Use a tag to mark the cylinder number from which each piston and rod assembly was removed.

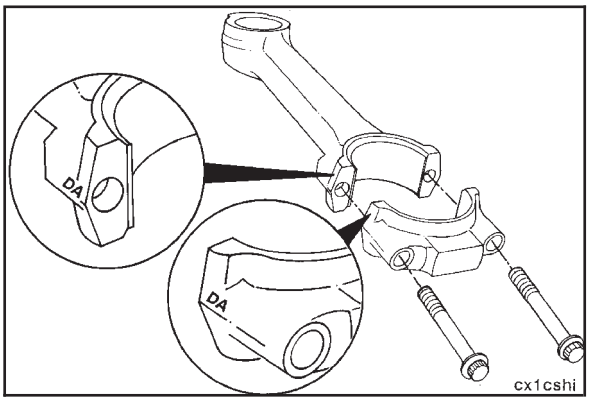
NOTE: The pistons **must** have the cylinder numbers stamped on the piston top toward the camshaft side of the engine.

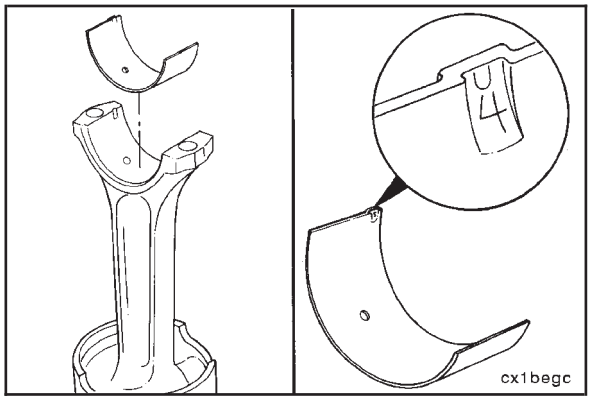


Put the rod and piston assemblies in a stand to protect them from damage.



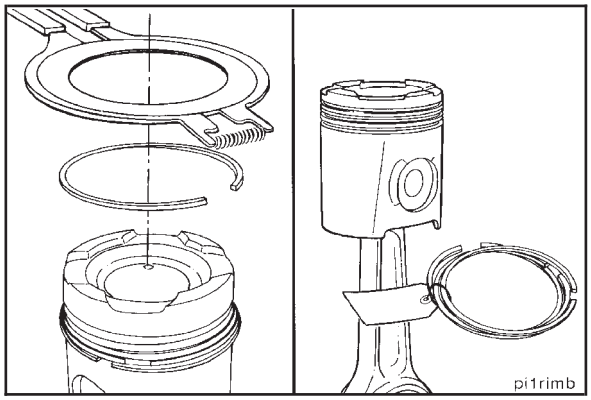
Caution: The rod cap alpha-numeric characters must match the alpha-numeric characters on the connecting rod and must be installed with the characters aligned to prevent damage to the connecting rods and the crankshaft.





Remove the upper rod bearing.

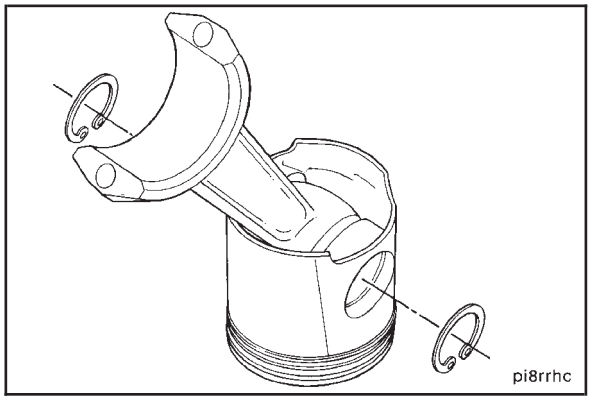
Mark the cylinder number and the letter ''U'' in the flat surface of the bearing tang.



Caution: Do not over expand the piston rings. Maximum gap at assembly is 1.63 inches.

Use the piston ring expander, Part No. 3823871, to remove the piston rings.

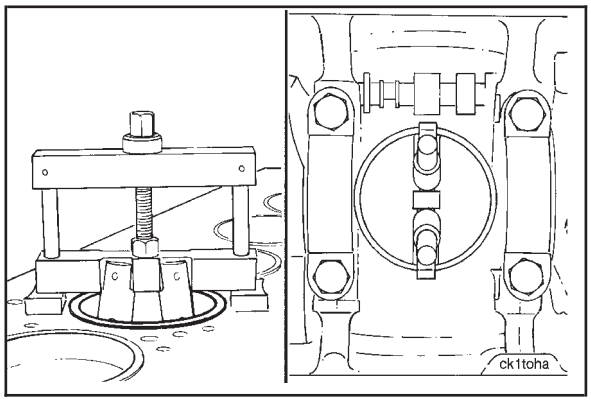
Put a tag on the rings, and record the cylinder number of the piston on the tag for future reference (if required).



Use internal snap ring pliers to remove the snap rings from both sides of the piston.

Caution: Do not use a hammer to remove the piston pins. The piston can distort and cause the piston to seize in the liner.

Use a blunt tool to push the piston pin from the piston and rod assembly.



Cylinder Liners - Removal

Caution: The liner puller must be installed and used as described to avoid damage to the cylinder block.

When using cylinder liner puller, Part No. 3376015, insert the liner puller in the top of the cylinder block.

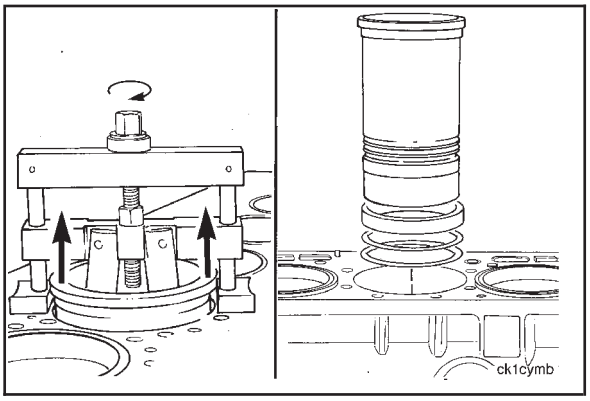
NOTE: The liner puller **must** be centered on the top of the cylinder block. The feet on the extension arms **must** be extended below the bottom of the liner.

Turn the puller jackscrew **clockwise**.

Use both hands to remove the liners.

Remove and discard the o-rings and the crevice seals.

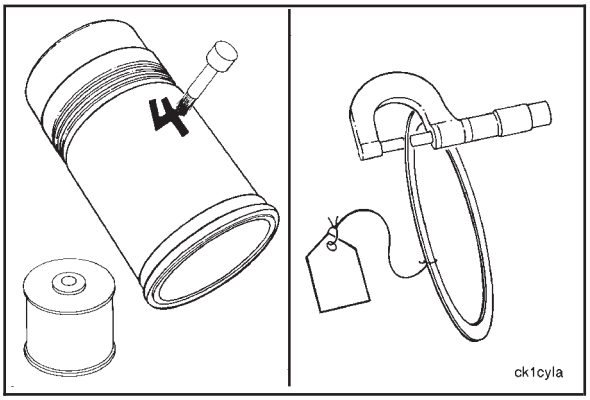
NOTE: Do **not** discard the sealing rings which are located under the cylinder liner flange. Sealing rings can be used again.



Use a liquid metal marker to mark the cylinder number on each liner.

If the sealing rings were removed, do the following:

1. Use a tag to mark the cylinder number.
2. Measure in several places and record the thickness of the sealing rings used in each cylinder. The thickness of the sealing ring is one factor in determining liner protrusion. This information **must** be known when the liners are installed in the engine.



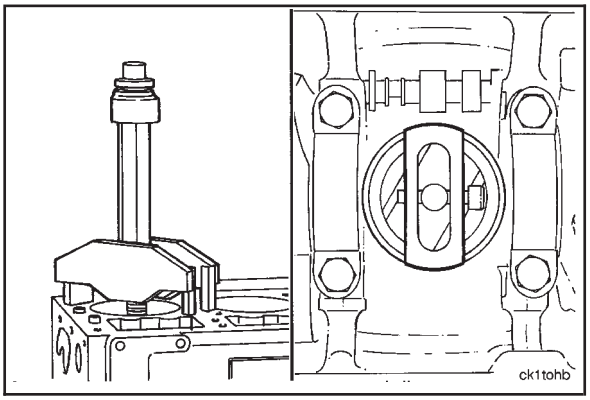
Caution: The liner puller must be installed and used as described to avoid damage to the cylinder block.

When using cylinder liner puller, Part No. 3375629, insert the liner puller in the top of the cylinder block.

NOTE: The liner puller **must** be centered on the top of the cylinder block.

Caution: The puller plate must not overlap the liner outside diameter.

NOTE: The puller plate **must** be parallel to the main bearing saddles.

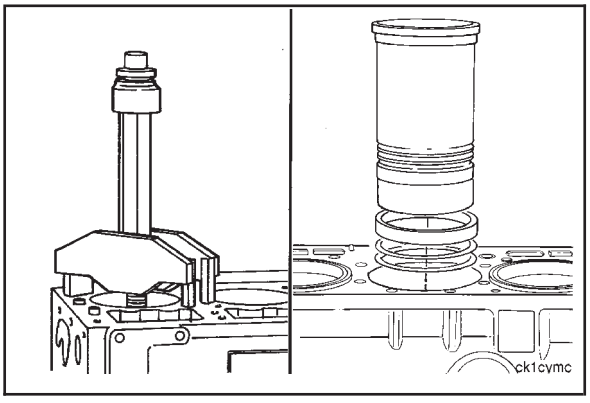


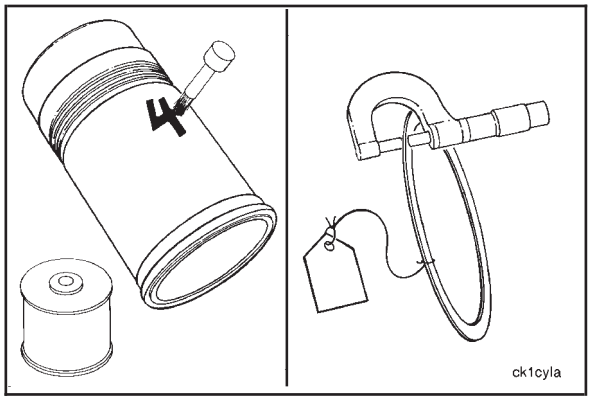
Turn the puller jackscrew **clockwise**.

Use both hands to remove the liner.

Remove and discard the crevice seals and the o-rings.

NOTE: Do **not** discard the sealing rings which are located under the liner flange. Sealing rings can be used again.

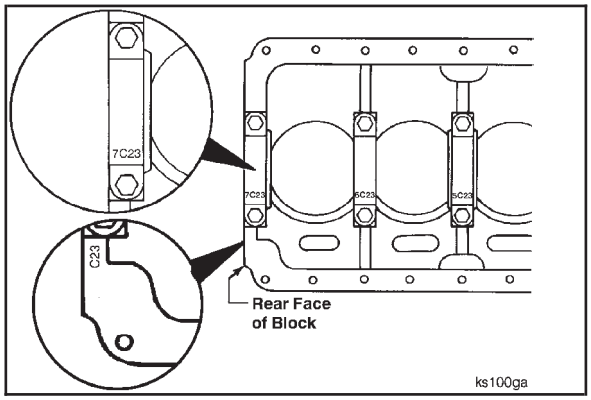




Use a liquid metal marker to mark the cylinder number on each liner.

If the sealing rings were removed, do the following:

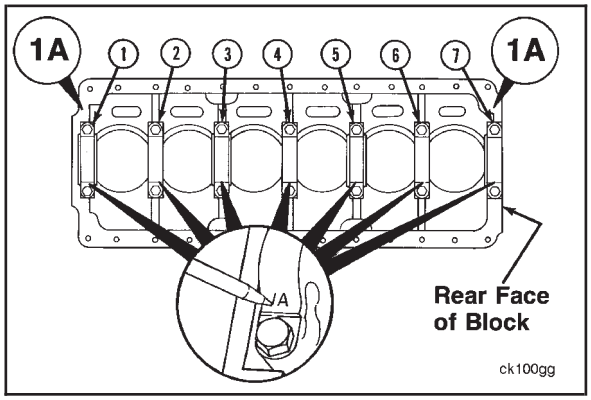
1. Use a tag to mark the cylinder number.
2. Measure in several places and record the thickness of the sealing rings used in each cylinder. The thickness of the sealing ring is one factor in determining liner protrusion. This information **must** be known when the liners are installed in the engine.



Crankshaft - Removal

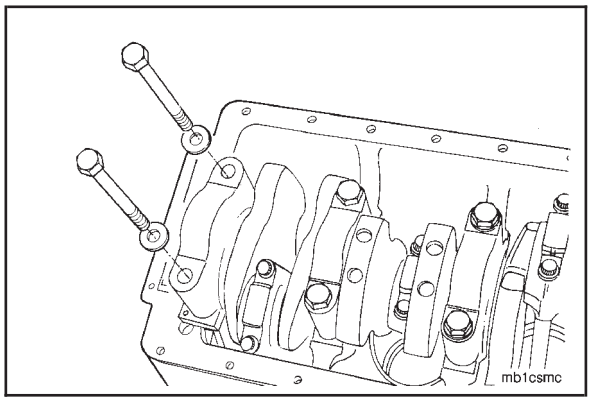
Caution: The main bearing caps must be marked for position and cylinder block identification.

The position number (1) of the cap is stamped on the camshaft side and the block identification number (2) is stamped on the exhaust side of the cap.



The cylinder block identification number is stamped on the front and the rear of the oil pan flange on the camshaft side of the engine.

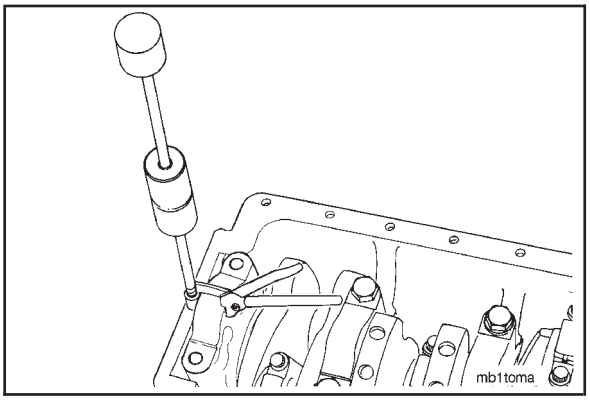
Check and mark all caps that are **not** marked before removing them from the cylinder block.



NOTE: The No. 7 main bearing cap has thrust bearings and dowel pins.

Remove the main bearing capscrews and the washers.

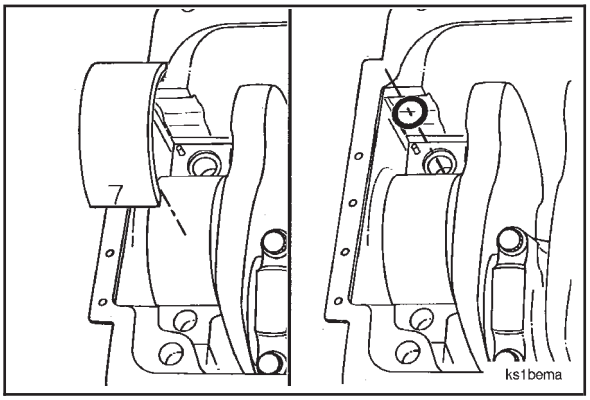
Use main bearing cap puller, Part No. ST-1178, to remove the caps. The service tool **must** be centered on the main bearing cap.



NOTE: Use a pencil or scribe to mark the bearing shells with the journal number from which they were removed if they are to be used again or if failure analysis is required. Mark the bearing on the back side or in the locating tang.

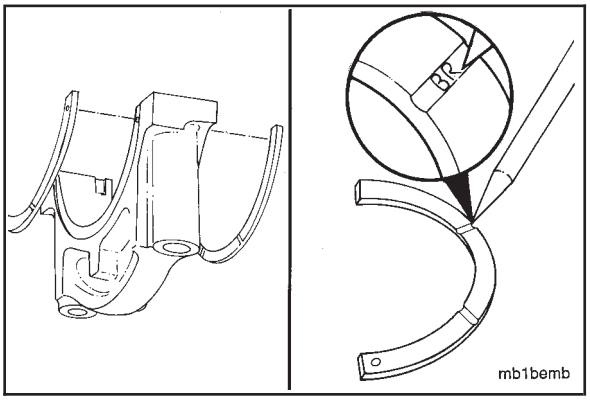
Remove the lower main bearing shell from the crankshaft journal.

Remove the dowel ring.



Remove the thrust bearings from the No. 7 cap.

Mark these bearings as the front and the rear thrust bearings.

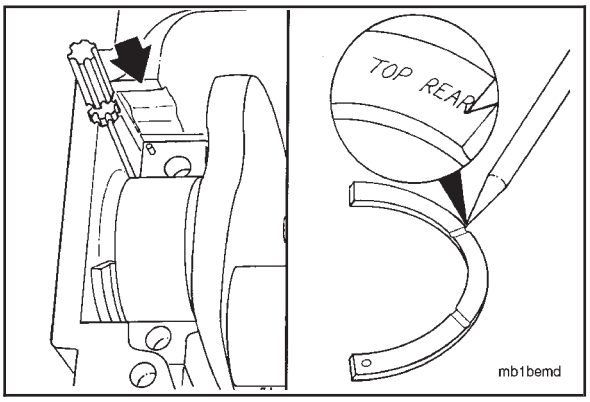


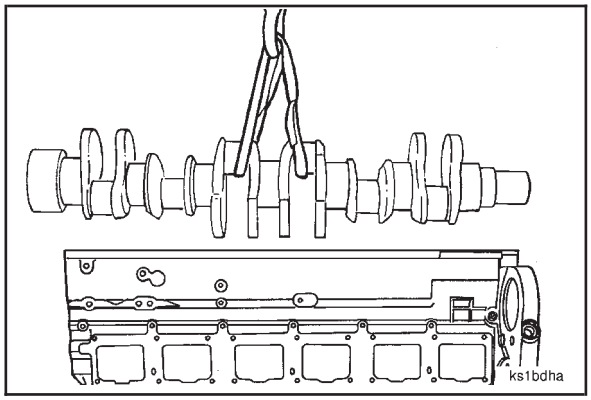
Caution: Do not damage the crankshaft when removing the thrust bearings.

Use a blunt tool to remove the upper thrust bearings.

Mark these bearings in the notched area as the front and the rear thrust bearings.

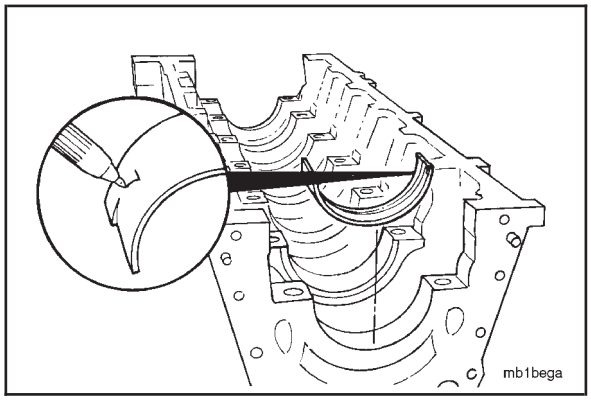
NOTE: If necessary, slide the crankshaft to the front or to the rear to allow the thrust bearings to be removed.





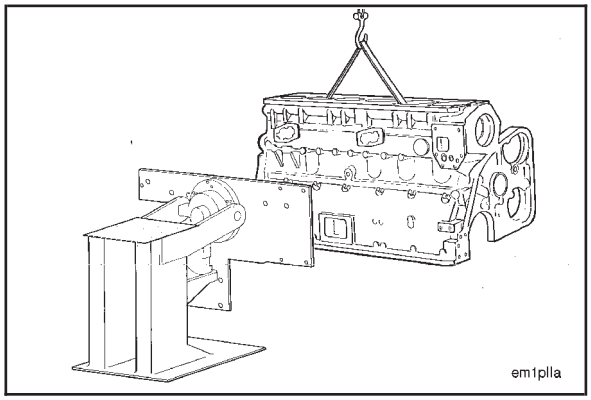
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the crankshaft to avoid personal injury.

Use a hoist and a lifting sling to remove the crankshaft.



Push the upper main bearing on the end that does **not** have the dowel ring groove.

NOTE: Mark the bearing shells with the journal number from which they were removed if they are to be used again or if failure analysis is required.

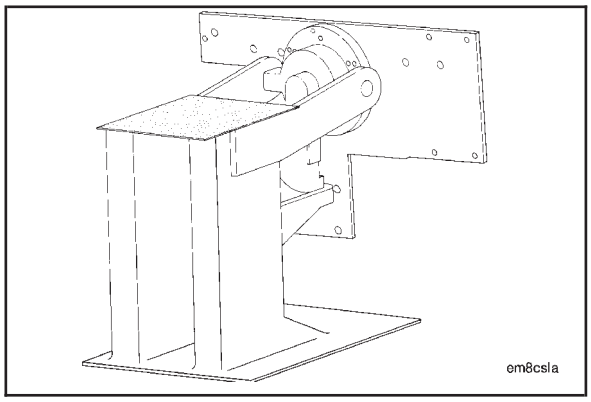


Cylinder Block - Removal from the Rebuild Stand

Use a nylon lifting sling, Part No. 3375957 (with a leather sleeve), to lift the cylinder block.

Remove the capscrews and the cylinder block from the rebuild stand.

Refer to Cylinder Block, Group 01, for cleaning and inspection purposes.



Engine Assembly (00-02)

Cylinder Block - Installation on the Rebuild Stand

NOTE: Use the engine rebuild stand, Part No. 3375194, and the adapter plate, Part No. 3375013.

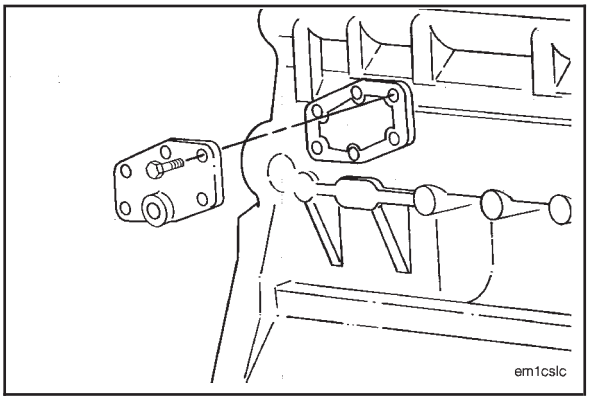
Use six 5/8 - 11 X 1 3/4-inch grade 5 capscrews to install the adapter plate to the rebuild stand.

Torque Value: 102 N•m [75 ft-lb]

Install the mounting plate adapter on the rear water header if removed during the cleaning or inspection procedure.

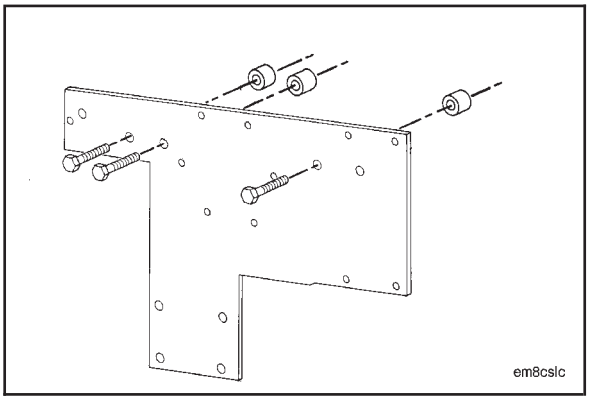
Use five 1/4-20 X 1 1/4-inch capscrews to mount the adapter.

Torque Value: 10 N•m [7 ft-lb]



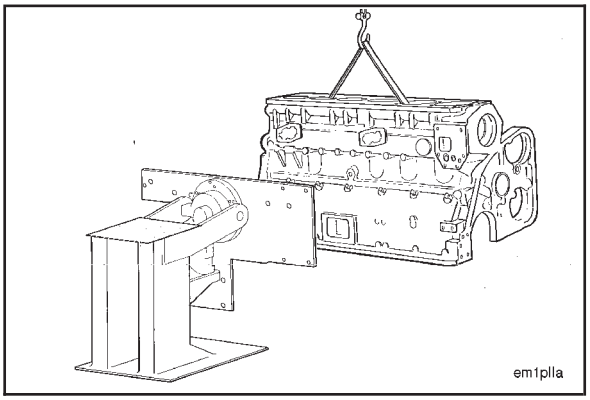
Install three 1/2-13 X 3 3/8-inch capscrews through the adapter plate as shown.

Install the three adapter plate spacers over the capscrews.



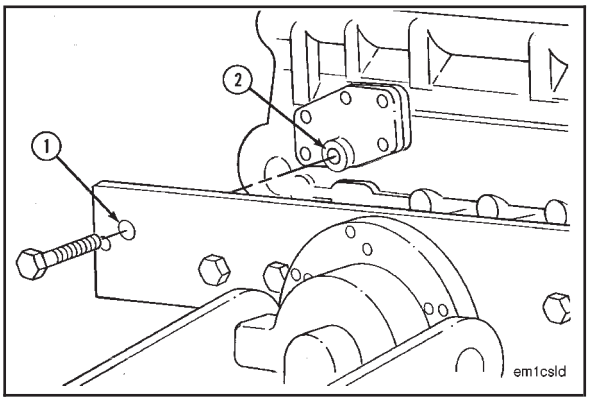
Use a nylon lifting sling, Part No. 3375957, (with a leather sleeve), to lift the cylinder block.

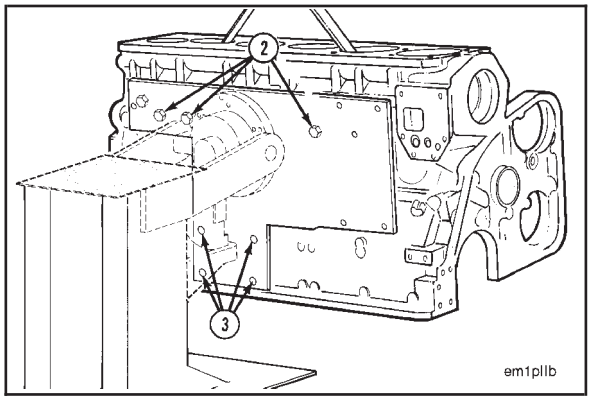
Put the oil cooler side of the cylinder block to the adapter plate of the rebuild stand.



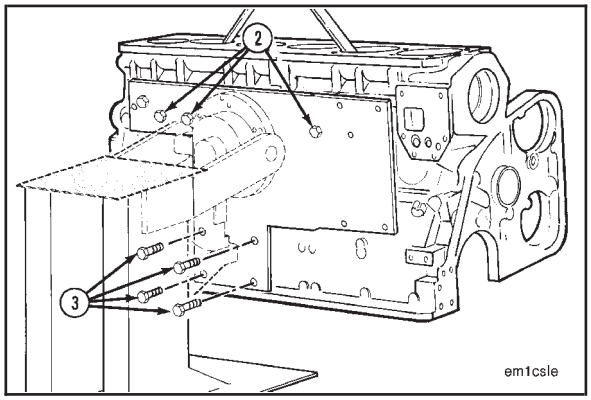
Align the mounting hole in the adapter plate (1) with the capscrew hole (2) in the mounting plate adapter.

Use one 5/8-11 X 1 3/4-inch grade 5 capscrew to mount the adapter plate to the mounting plate adapter. Use your fingers to tighten the capscrew.



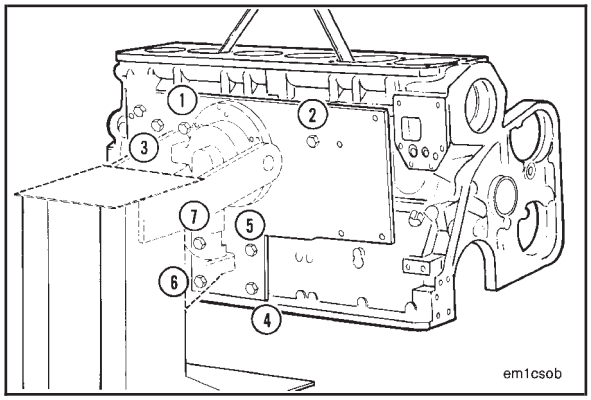


Adjust the position of the cylinder block so that the remaining mounting holes in the adapter plate (2) and (3) align with the capscrew holes in the cylinder block.



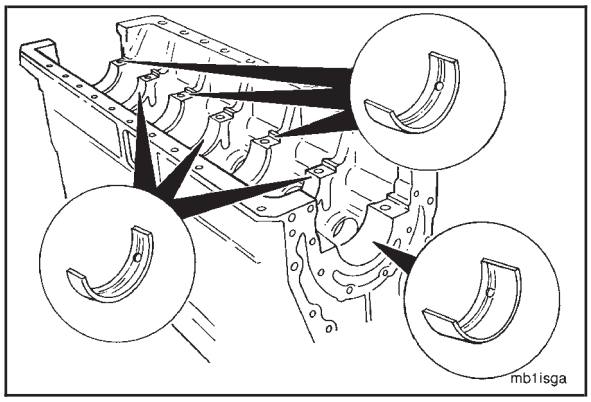
Use your fingers to tighten the three 1/2-13 X 3 3/8-inch capscrews (2).

Install four 3/8-16 X 3 3/8-inch capscrews in the location shown (3). Use your fingers to tighten the capscrews.



Tighten all of the adapter plate mounting capscrews in the sequence shown.

Torque Value: 3/8-inch 41 N•m [30 ft-lb]
1/2-inch 102 N•m [75 ft-lb]
5/8-inch 102 N•m [75 ft-lb]

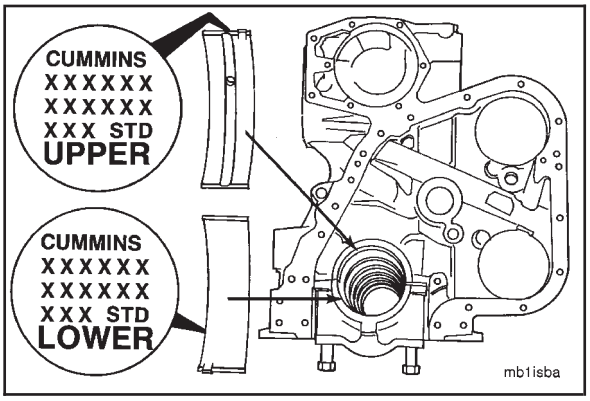


Crankshaft - Installation

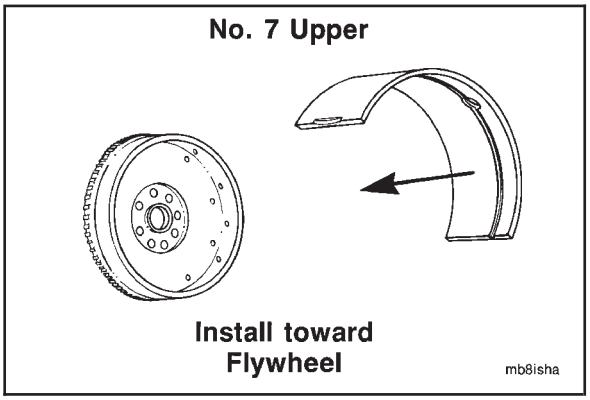
The main bearing shells are three different widths. The narrow main bearing shells fit locations Nos. 2, 4, and 6. The wide main bearing shells fit locations Nos. 1, 3, and 5.

The widest main bearing shell fits the No. 7 location.

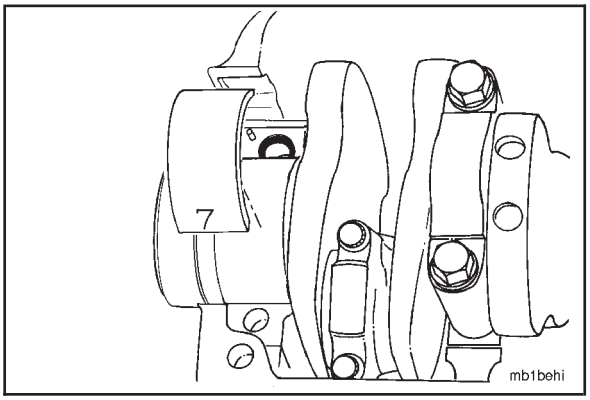
Caution: The upper main bearing shells have a groove and an oil hole to provide crankshaft lubrication. The lower main bearing shells do not. Both bearings are marked on the back to indicate the location and either standard (std.) or oversize (OS). The amount of OS is stamped on the back in U.S. customary inches.



The groove for the No. 7 shell is **not** in the center of the shell. The wider part of the No. 7 shell **must** be installed toward the flywheel end of the cylinder block.

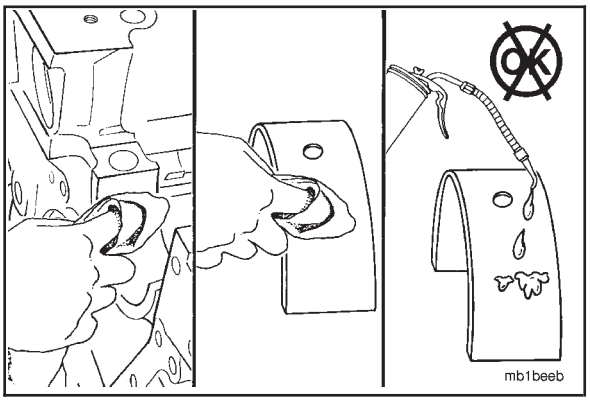


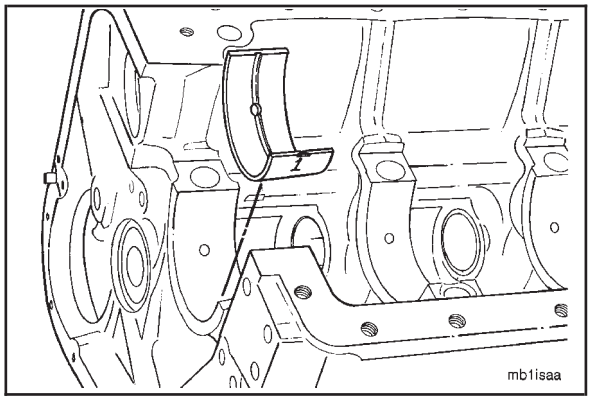
NOTE: If used bearing shells are to be installed, each **must** be installed in its original location in the engine. The bearing journal numbers **must** have been marked on the bearing during disassembly.



Caution: Do not lubricate the back of the bearing.

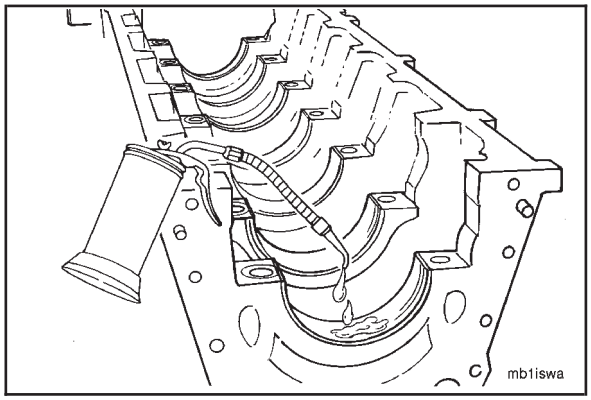
Use a lint free cloth to clean the bearing and the mounting surface.





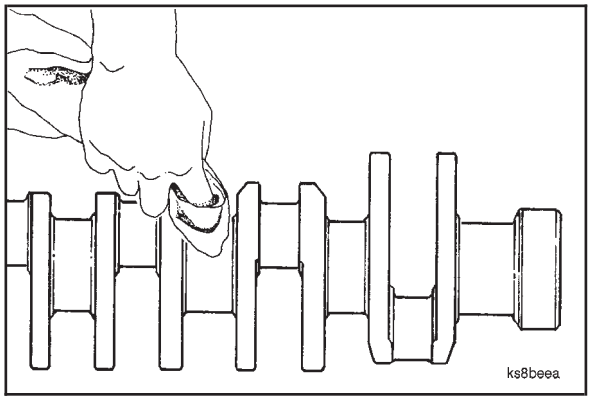
Align the ring dowel groove in the bearings with the counterbore in the cylinder block, and install the bearings.

Both ends of the bearing will be approximately 1.50 mm [0.060-inch] below the main bearing cap mounting surface when installed correctly.

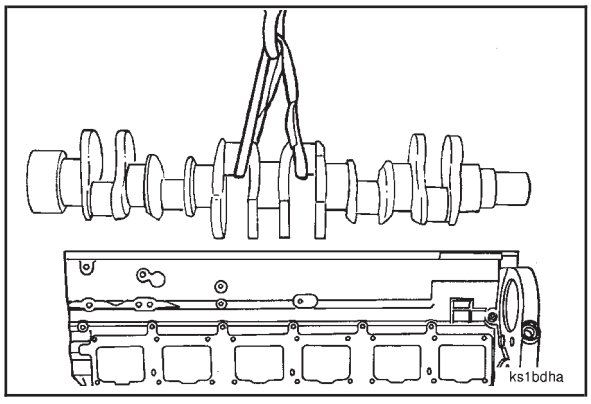


Caution: Prevent dirt from mixing with the lubricant. Dirty lubricant will cause low mileage failures.

Use clean Lubriplate® 105 or its equivalent to lubricate the upper bearing shells.



Use a lint free cloth to clean the crankshaft bearing journals.

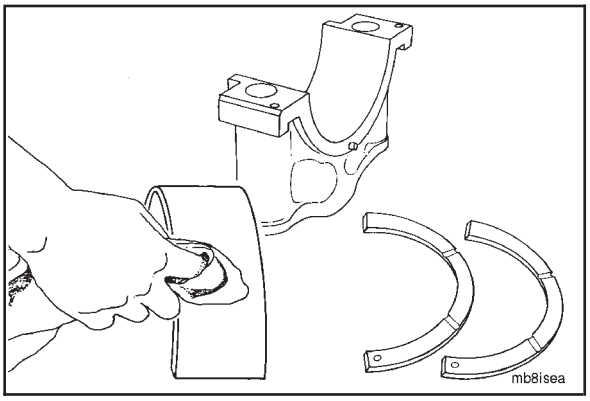


Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the part to avoid personal injury.

Caution: Use a lifting strap that will not damage the crankshaft. Do not drop the crankshaft on the bearings.

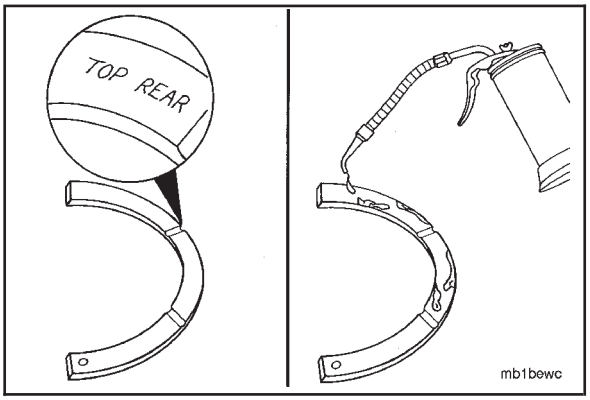
The end of the crankshaft with the smallest diameter **must** point toward the front of the block. Install the crankshaft.

Use a lint free cloth to clean the thrust bearings, the main bearing shells, and the main bearing caps.



NOTE: If used thrust bearings are to be installed, each **must** be installed in its original location in the engine. The bearing journal numbers **must** have been marked on the bearing during disassembly.

Use clean Lubriplate® 105 or its equivalent to lubricate the upper thrust bearings.

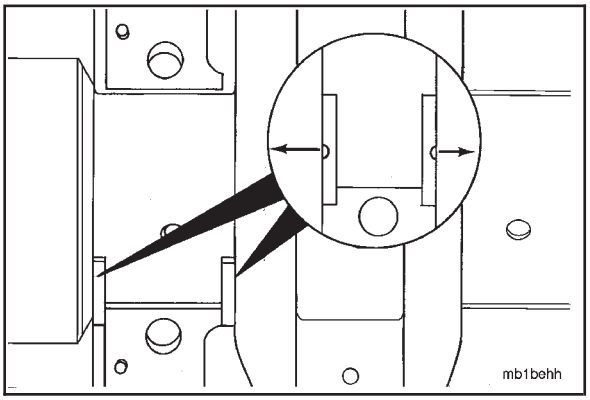


Caution: The grooves must be toward the crankshaft.

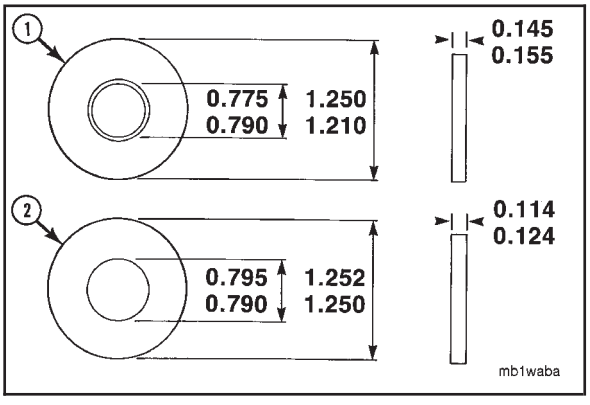
Install the upper thrust bearings in the No. 7 main bearing saddle.

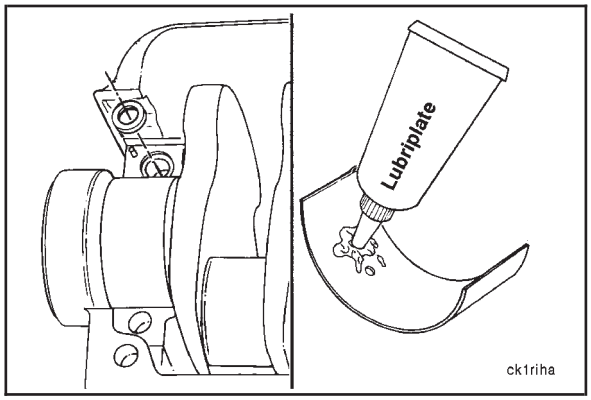
NOTE: Push the crankshaft toward the front of the engine to install the front bearing and to the rear of the engine to install the rear bearing.

The end of the thrust bearings **must** be even with the main bearing cap mounting surface.



Caution: Do not intermix the main bearing dowel ring and the main bearing capscrew washers. The hardened main bearing capscrew washer (1) is approximately 0.76 mm [0.030-inch] thicker than the soft main bearing dowel ring (2). Intermixing the capscrew washers and dowel rings will result in main bearing failure.

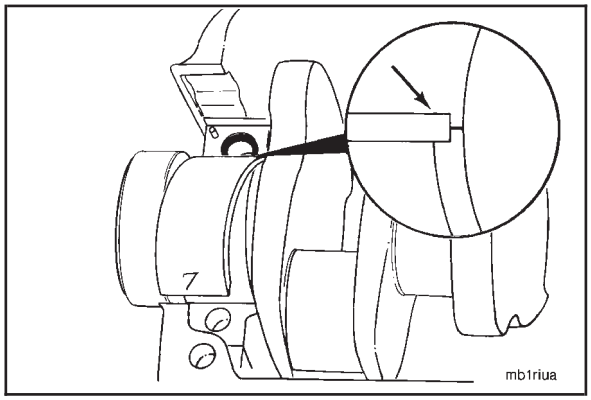




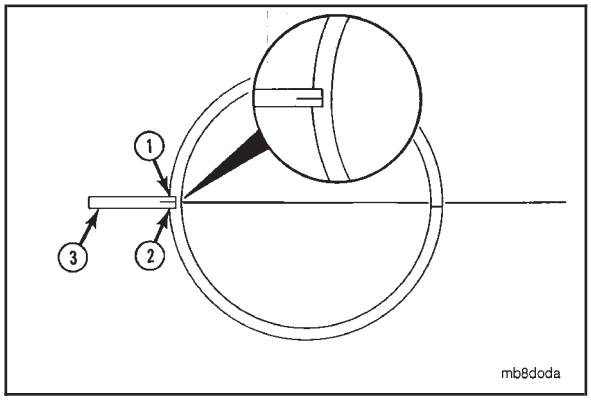
Install the dowel ring in the dowel ring counterbore of the cylinder block.

Install the lower main bearing shells as follows:

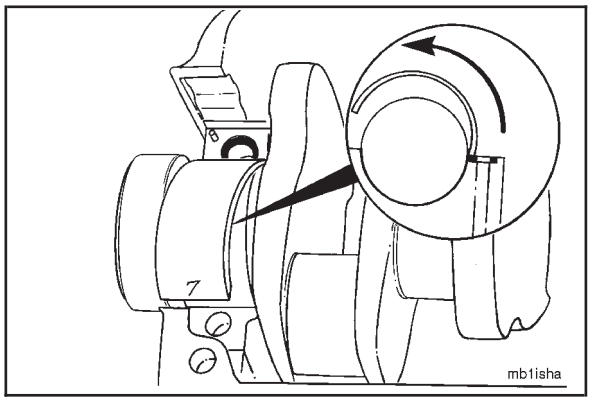
Use clean Lubriplate® 105 or its equivalent to lubricate the bearing shell to the crankshaft journal mating surface.



Align the dowel ring groove in the bearing with the dowel ring.



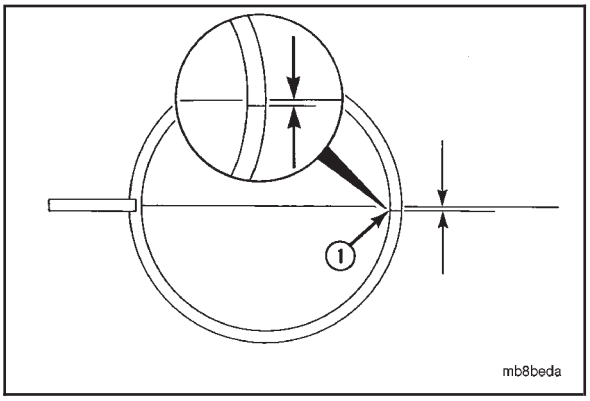
The dowel ring grooves (1) and (2) in the bearings **must** be engaged with the dowel ring (3).



Push on the side of the bearing shell **opposite** the dowel ring to install the bearing shell.

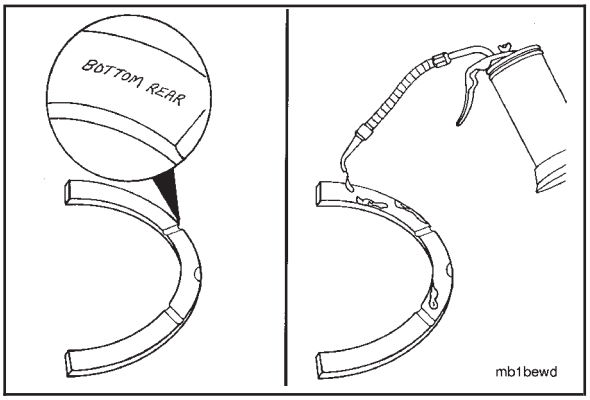
The end of the lower main bearing shell **opposite** the dowel ring **must** be engaged between the crankshaft and the cylinder block and be seated against the end of the upper bearing shell.

NOTE: If installed correctly, the ends of the bearing shells (1) will meet approximately 1.50 mm [0.060-inch] below the cylinder block main bearing mounting surface.



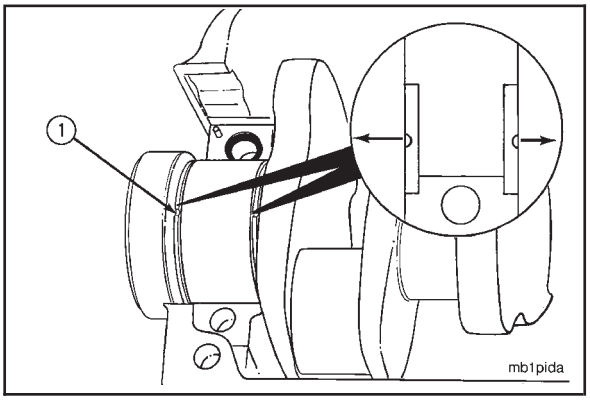
NOTE: If used thrust bearings are to be installed, each **must** be installed in its original location in the engine. The bearing journal numbers **must** have been marked on the bearing during disassembly.

Use clean Lubriplate® 105 or its equivalent to lubricate the lower thrust bearings.



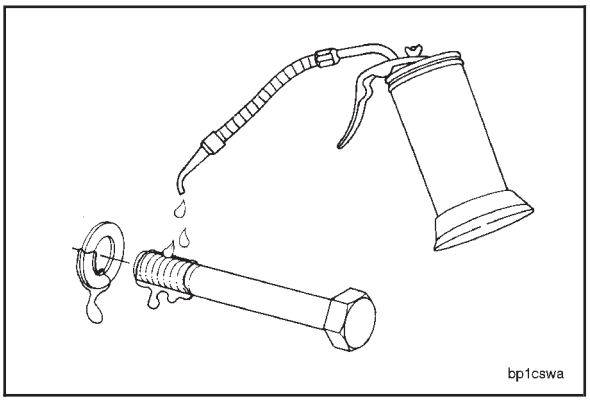
Put the lower thrust bearings around the No. 7 main journal with the grooves facing the thrust surfaces on the crankshaft.

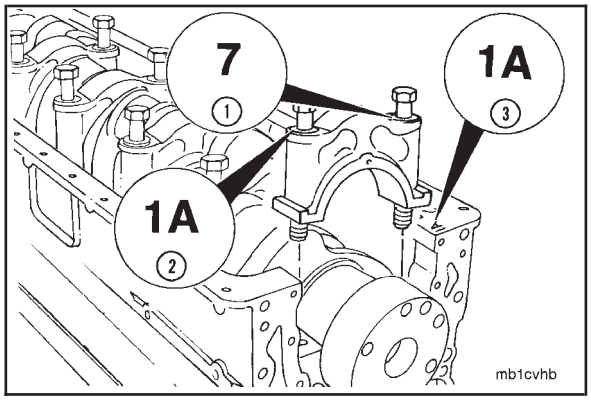
NOTE: The notch (1) on the outside diameter of the lower thrust bearings **must** align with the locating pins in the No. 7 main bearing cap.



Use clean 15W-40 oil to lubricate the capscrew threads and the flat washers.

Caution: Drain the excess oil from the capscrews before installing them in the cylinder block to prevent hydraulic lock and possible damage to the cylinder block during the capscrew torquing operation.

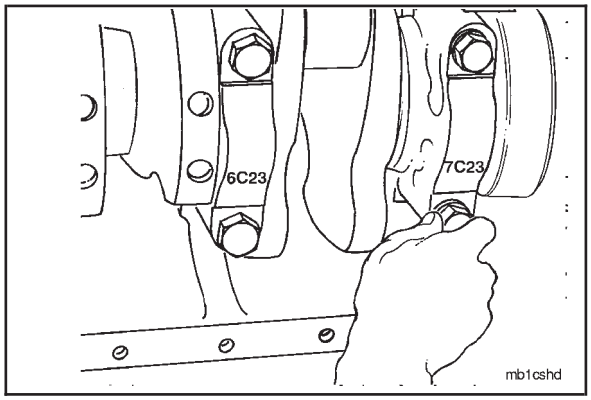




Caution: The main bearing caps are marked for position (1) on the camshaft side and the cylinder block identification (2) on the exhaust side. The cylinder block identification number (3) is stamped on the pan rail on the camshaft side of the block. Install the caps in the correct position with the position number to the camshaft side and its part number toward the rear of the engine.

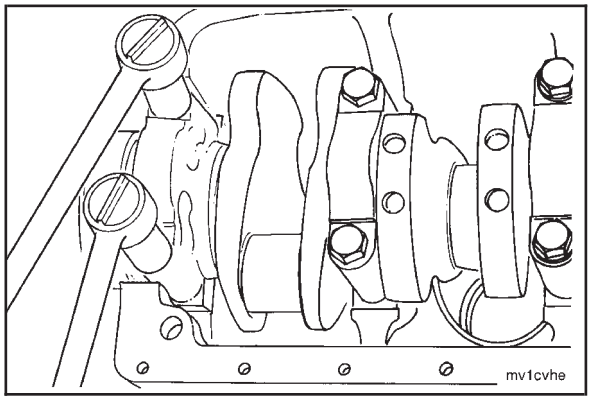
Install the main bearing caps.

Align the capscrew holes in the cap with the holes in the cylinder block. Make sure the dowel ring and the lower bearing shell are in position.



Install the capscrews and the washers through the cap and into the cylinder block.

Use your hand to tighten the capscrews two to three threads.

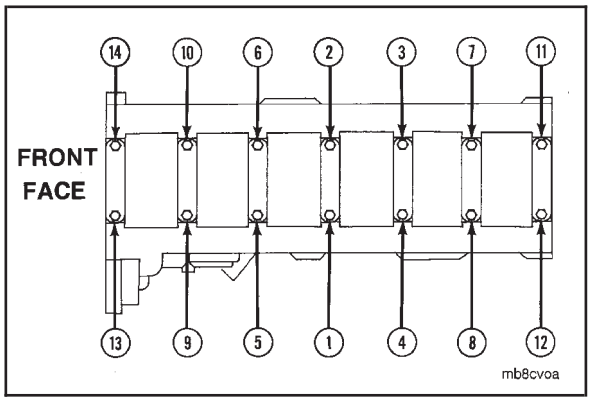


Caution: Do not use impact wrenches. The main bearing shells can become mislocated.

Use both of the capscrews to pull the main bearing cap into position.

Use two wrenches. Tighten both of the capscrews at the same time.

Make sure the cap is touching the block. If it is **not** , check for a bearing out of location.

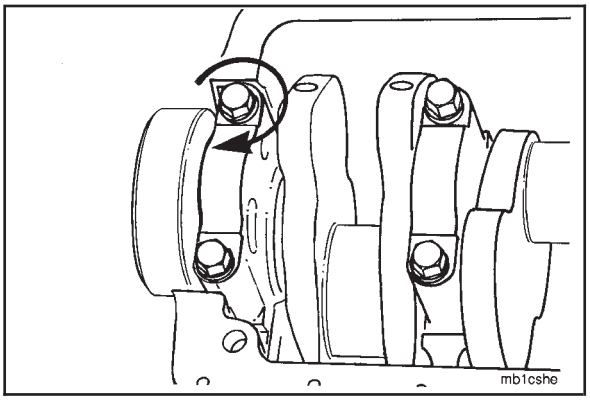


Caution: Do not rotate the crankshaft until the main bearing capscrews are tightened. This will keep the bearings in place.

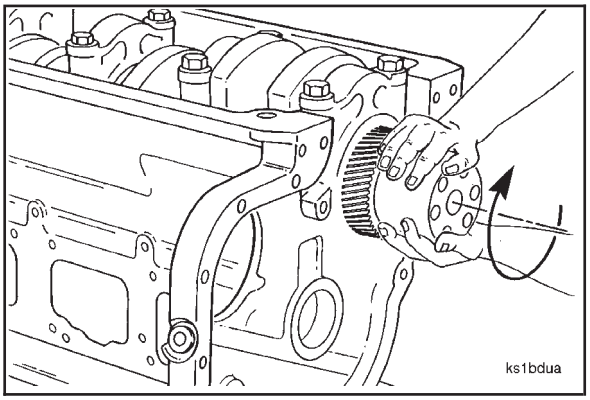
Tighten the main bearing capscrews in the sequence shown to the torque values listed in the two following steps:

Tighten the main bearing capscrews to the following torque values:

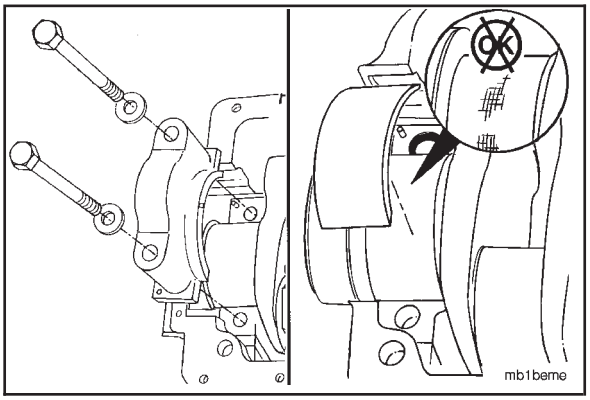
1. Tighten to 122 N•m [90 ft-lb].
2. Tighten to 230 N•m [170 ft-lb].
3. Tighten to 346 N•m [255 ft-lb].
4. Loosen completely.
5. Repeat steps 1 through 3.



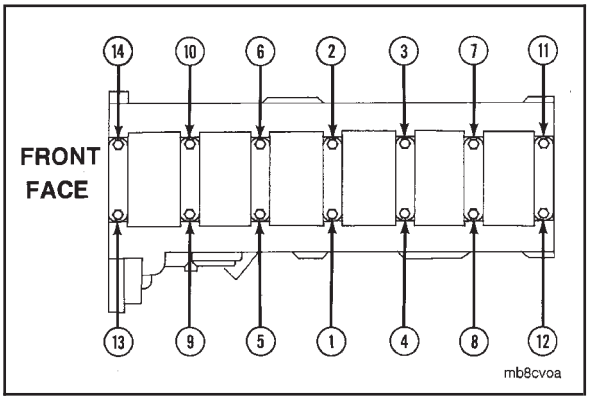
After tightening all the main bearing capscrews, use your hands to turn the crankshaft. If it does **not** turn freely, loosen the main bearing capscrews one cap at a time. This will help locate the bearing that is too tight.

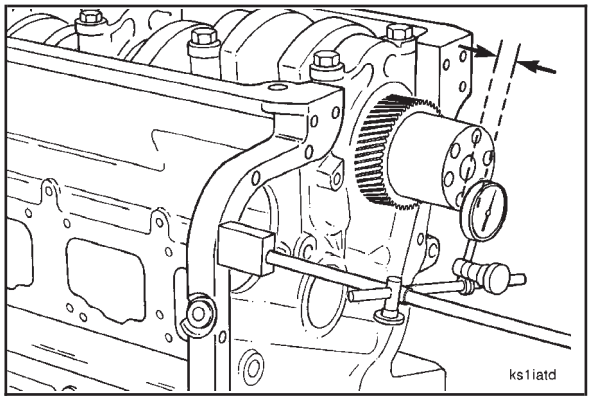


Remove the main bearing cap and the bearing. Check for an incorrect or mislocated bearing or main bearing cap, an incorrect oversize bearing, or debris between the main bearing and the cap.



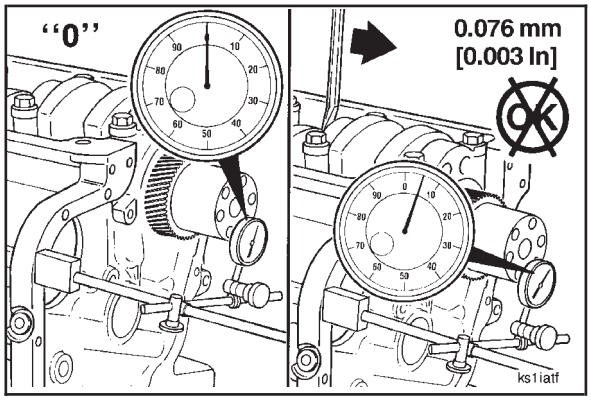
Tighten the main bearing capscrews in the sequence shown to the torque values listed previously in this procedure.



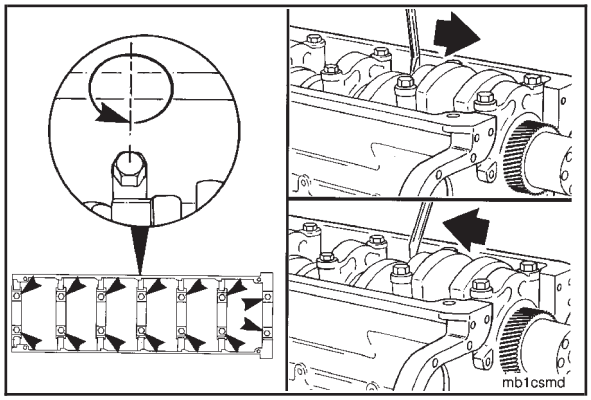


Measure the end clearance of the crankshaft.

Install a dial indicator to the rear face of the cylinder block. Put the tip of the gauge against the end of the crankshaft. Push the crankshaft toward the rear of the cylinder block.

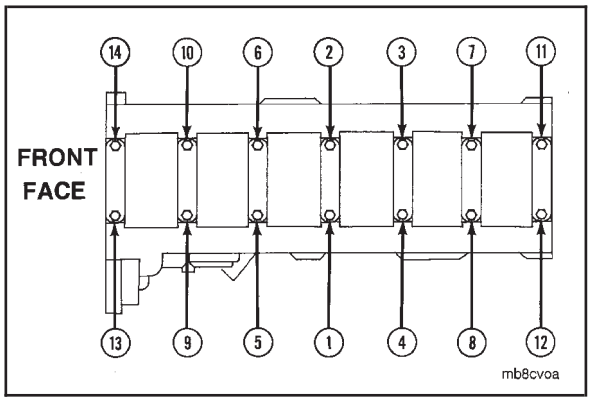


Set the dial indicator to ''0.'' Push the crankshaft toward the front of the cylinder block. If the end clearance is less than 0.10 mm [0.004-inch], do the following:



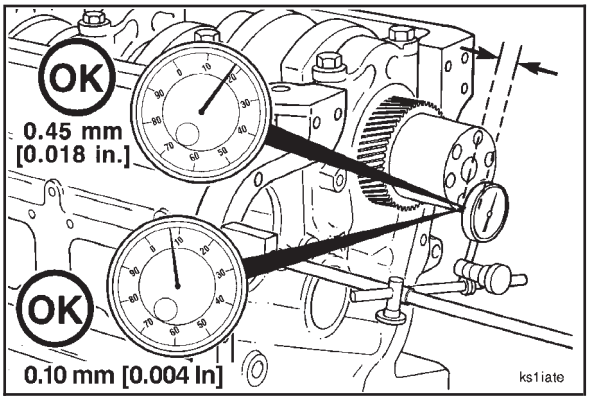
Loosen the main bearing capscrews one turn.

Push the crankshaft toward the front and then toward the rear of the cylinder block.



Tighten the main bearing capscrews in the sequence shown to the torque values listed previously in this procedure.

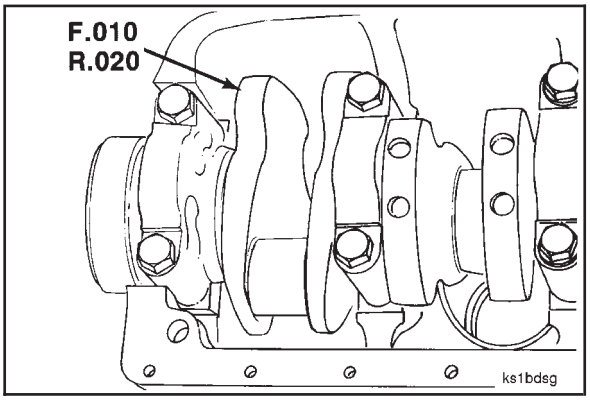
Measure the crankshaft end clearance. The end clearance specification for a new or reground crankshaft with new thrust bearings is 0.10 mm [0.004-inch] to 0.45 mm [0.018-inch].



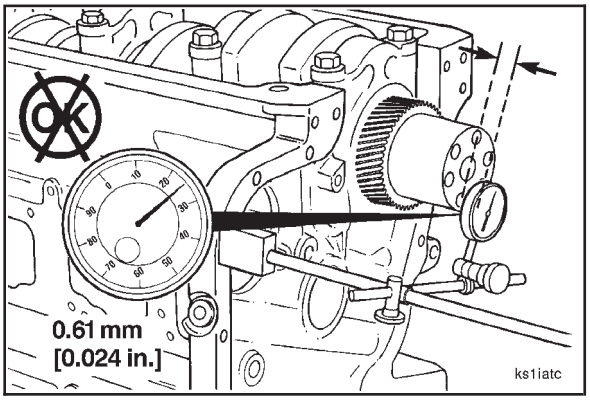
NOTE: Crankshafts that have been reground on the thrust bearing surfaces are marked for oversize thrust bearings on the rear crankshaft counterweight. If the crankshaft counterweight is marked, check the thrust ring part number to make sure the correct thrust ring size is used.

Example: F-.010 - Front 0.25 mm [0.010-inch]

Example: R-.020 - Rear 0.51 mm [0.020-inch]



If the crankshaft end clearance is more than 0.58 mm [0.023-inch], use oversize thrust bearings to adjust the end clearance to the correct specification.

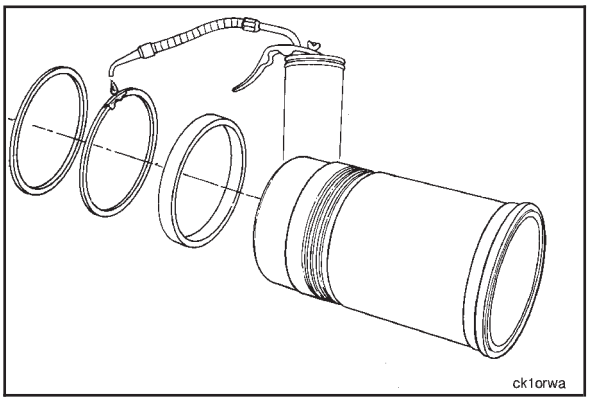


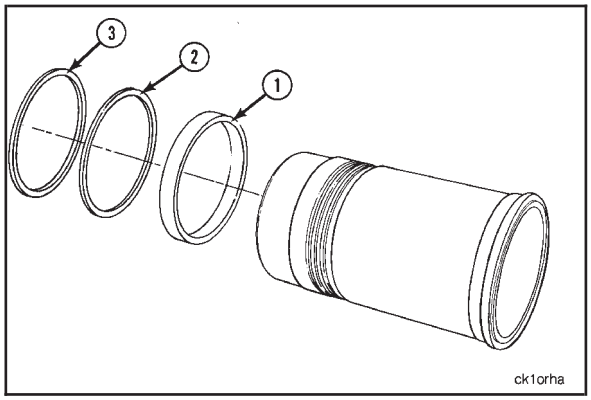
Cylinder Liners - Installation

NOTE: Make sure the cylinder block and all parts are clean before assembly. If used liners are being installed again, any sealing rings removed **must** be installed with the same liner in the same cylinder.

Use vegetable oil to lubricate the new liner o-rings and the crevice seals.

NOTE: Use vegetable oil to lubricate the o-rings. Do **not** use lubricating oil on the o-rings. The o-rings will increase in size after they have been lubricated with oil.

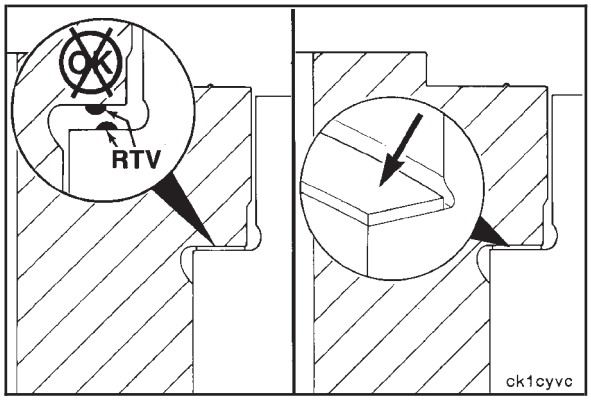




Install the o-rings and the crevice seals as follows:

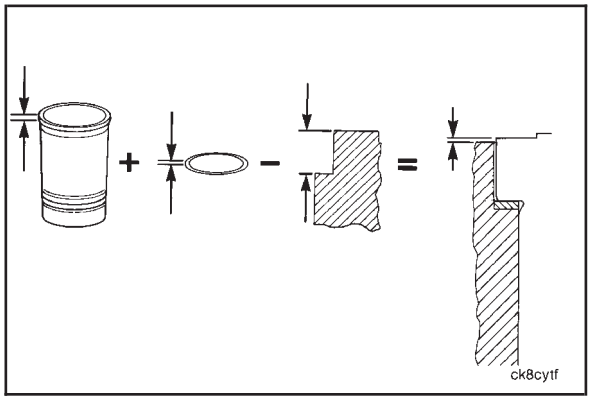
1. Install the crevice seal (1) in the top groove.
2. Install the black o-rings (2 and 3) in the center and the bottom grooves.

Caution: Make sure that the o-rings (2 and 3) are not twisted. Twisted o-rings will not seal and will impact liner protrusion.



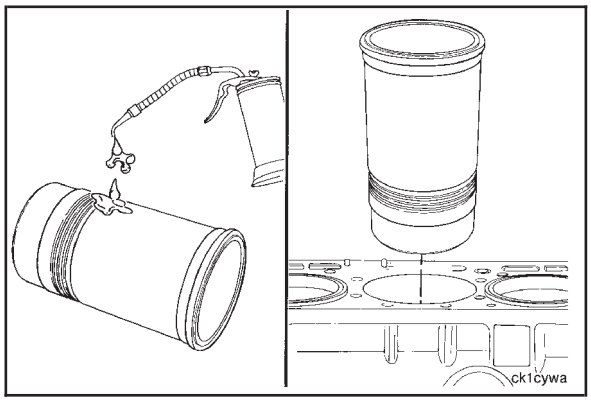
Caution: Lower press fit (LPF) liners must not have sealant applied to the counterbore. False liner protrusion and liner damage will occur.

Counterbore sealing is accomplished with brass seal rings. Seal rings are available in several thicknesses. The correct thickness **must** be chosen to meet cylinder liner protrusion specifications.



The desired protrusion is the total sum of the thickness of the liner flange and the seal rings minus the counterbore depth.

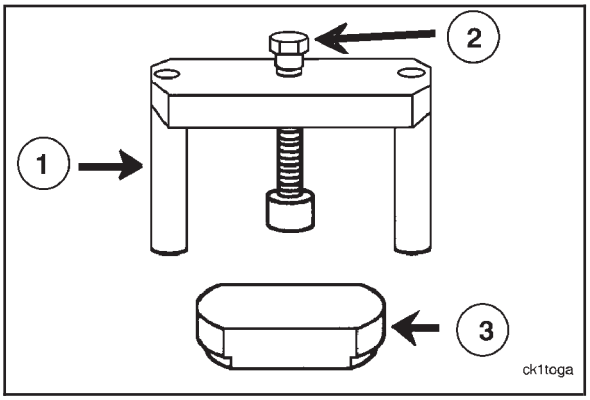
Cylinder Liner Protrusion		
mm		**in**
0.10	MIN	0.004
0.18	MAX	0.007



Lubricate the crevice seal and the o-rings with vegetable oil.

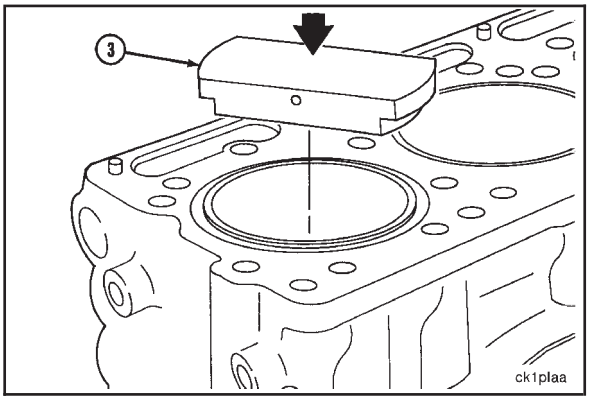
NOTE: Make sure the oil does **not** touch the counterbore or the liner flange and that the o-rings do **not** move from the grooves.

Liner installation tool, Part No. 3822953, is used to press the cylinder liner into the cylinder block. Protrusion can be checked while the liner is held down by the installation tool.

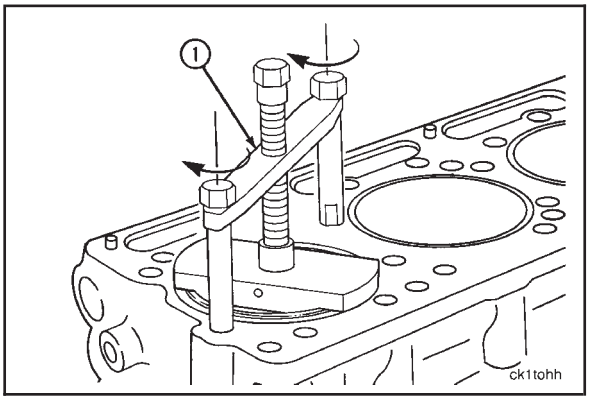


Put a sealing ring into position on the counterbore ledge.

Install the liner into the cylinder bore, slip through the sealing ring, and push down until it stops. Put the force plate (3) across the top of the liner with the step in the liner bore. Tap the top of the force plate with a soft hammer to square up and start the liner into the press fit bore.



Put the installation tool bridge (1) across the liner and install the two cylinder head capscrews finger tight to hold the bridge down. Rotate the force plate until the areas where the protrusion measurements will be taken are exposed.

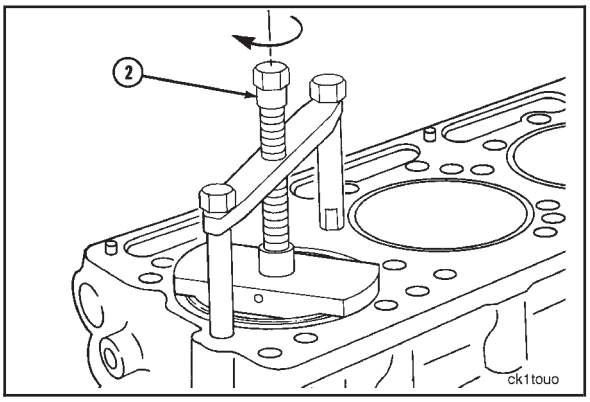


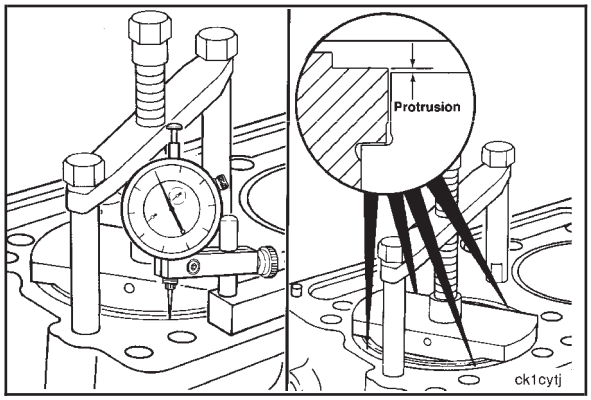
Caution: Do not use an impact wrench to tighten the liner force plate screw.

Tighten the forcing screw (2).

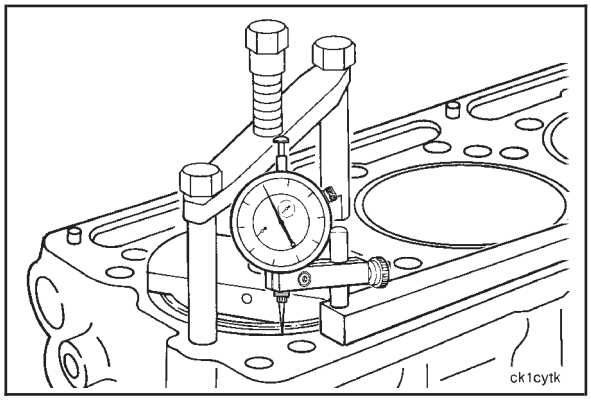
Torque Value: 136 N•m [100 ft-lb]

Check for correct protrusion.

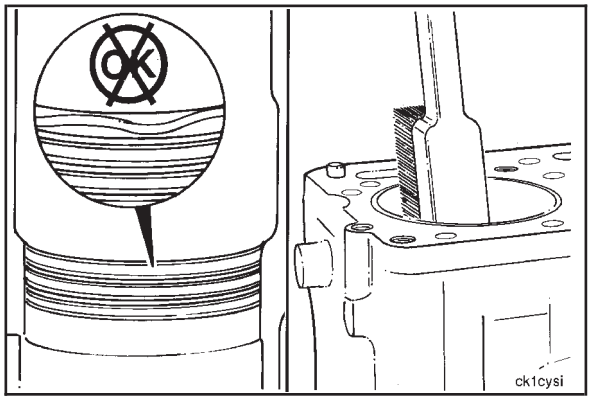




Use a depth gauge, Part No. 3823495, to measure the liner protrusion at four points 90 degrees apart. The protrusion **must** be from 0.10 mm to 0.18 mm [0.004-inch to 0.007-inch].



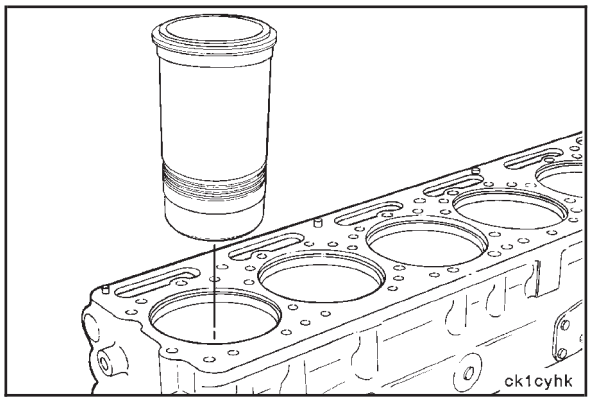
If correct liner protrusion is **not** attained, remove the liner from the cylinder block.



Check the following for causes of incorrect liner protrusion:

1. Check for twisted liner o-rings.
2. Incorrect liner sealing ring thickness.
3. Clean the liner flange and the cylinder block liner counterbore.
4. Inspect the liner flange for burrs.
5. Inspect the cylinder block liner counterbore for burrs.

Remove the burrs, or replace the damaged parts.

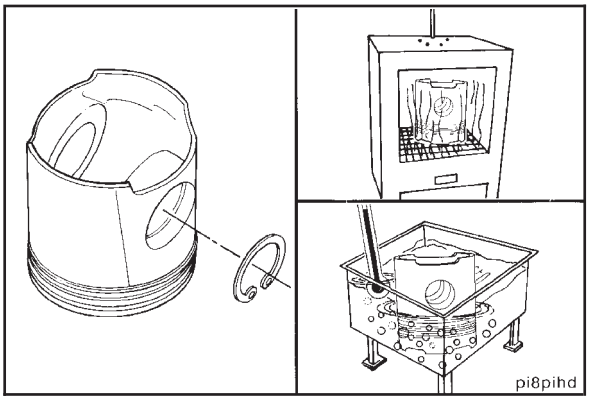


Install the liner again. Check the liner protrusion again. If protrusion is still **not** correct, refer to the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456, Section 7, ‘‘Counterbore Ledge Measurement and Machining.’’

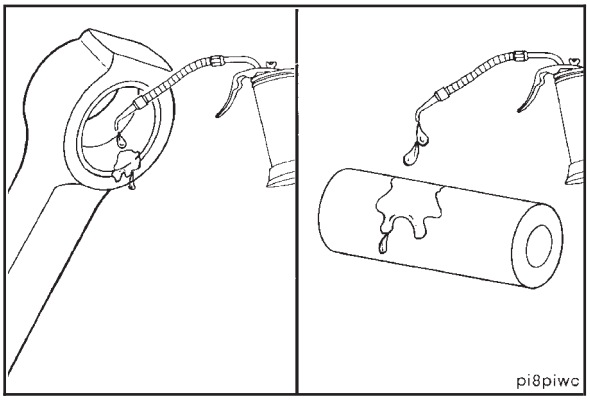
Piston and Connecting Rod Assemblies - Assembly and Installation

Install a new snap ring in one of the snap ring grooves of the piston pin bore on each piston.

Heat the pistons in boiling water for 15 minutes or in an oven for 30 minutes at 100° C [212° F].



Use clean 15W-40 oil to lubricate the connecting rod piston pin bore and the piston pin.

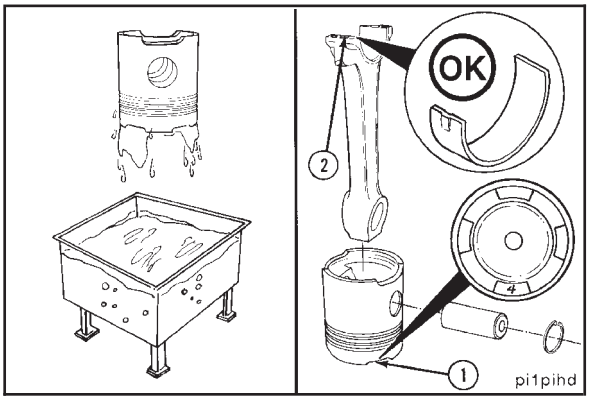


Caution: Use insulated gloves to prevent injury from the boiling water or the heated piston.

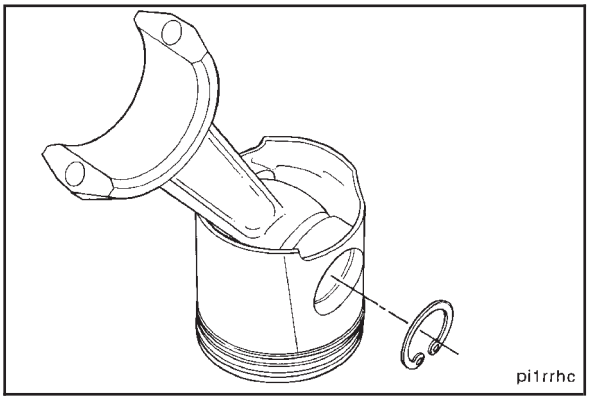
Remove the piston from the water or the oven.

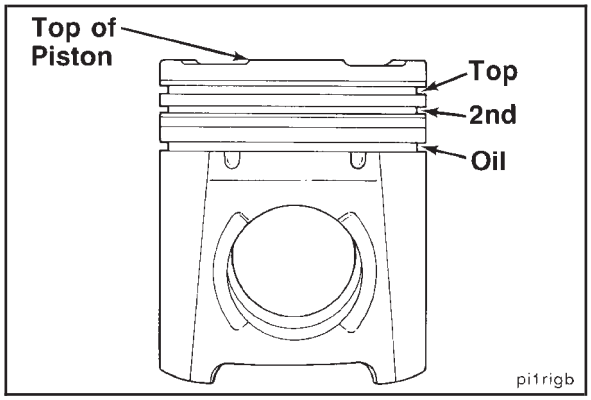
Align the pin bore of the rod with the pin bore of the piston, and install the piston pin. Do **not** use a hammer to install the piston pin. The piston will be damaged.

NOTE: The cylinder number of the piston top (1) **must** be toward the bearing tang (2) side of the rod.



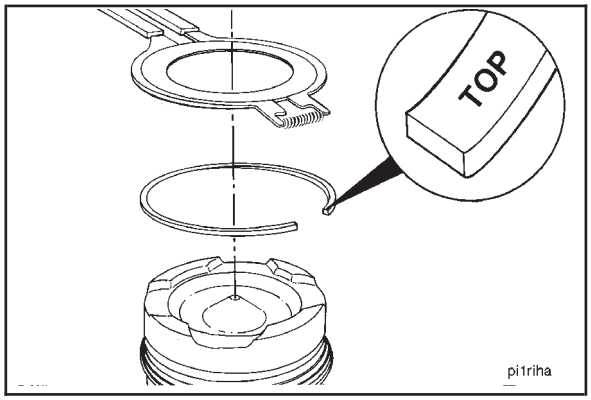
Install a new snap ring in the second piston pin bore snap ring groove. The snap ring **must** be seated completely in the snap ring groove.





The piston ring shipping package identifies the location of each piston ring by the part number. Install the rings in the sequence shown and in the proper orientation. The first and second rings have the word ''TOP'' stamped on the ring side facing the piston crown. The oil ring is **not** marked.

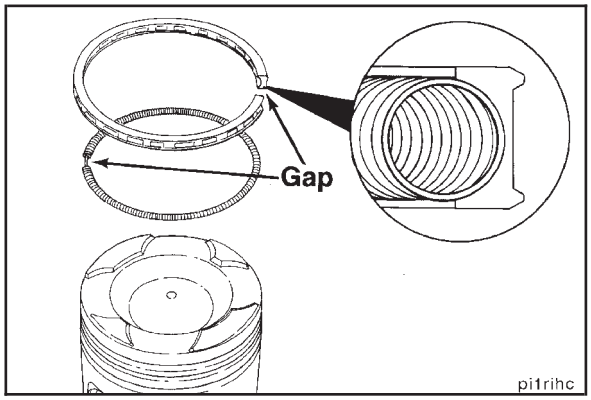
NOTE: The oil control ring is symmetrical and can be installed in either orientation.



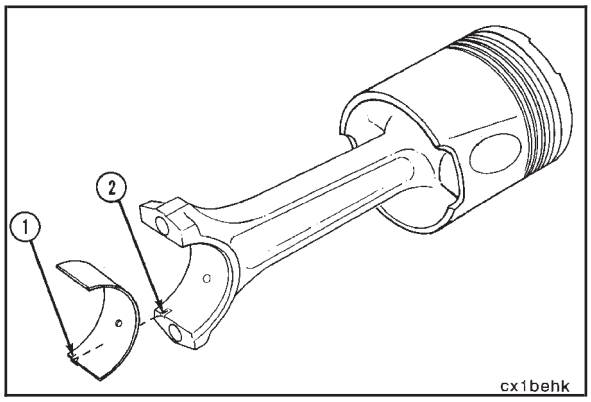
Caution: Do not over expand the piston rings. Maximum gap at assembly is 1.63 inches.

Use piston ring expander, Part No. 3823871, to install the piston rings with the part number, mark, or the word ''TOP'' toward the top of the piston.

NOTE: The oil control ring is symmetrical and can be installed in either orientation.



A cross-sectioned view of an oil control ring is shown. The two-piece oil control ring **must** be installed with the expander ring gap 180 degrees from the gap of the oil ring.

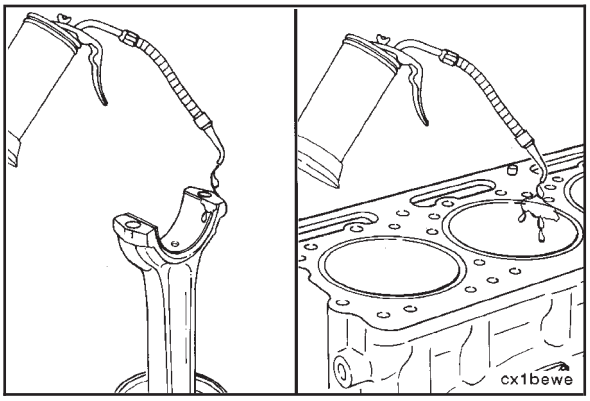


Install the upper bearing shell in the connecting rod. If used bearing shells are to be installed, each bearing shell **must** be installed in its original location.

NOTE: The tang (1) of the bearing shell **must** be in the slot (2) of the rod.

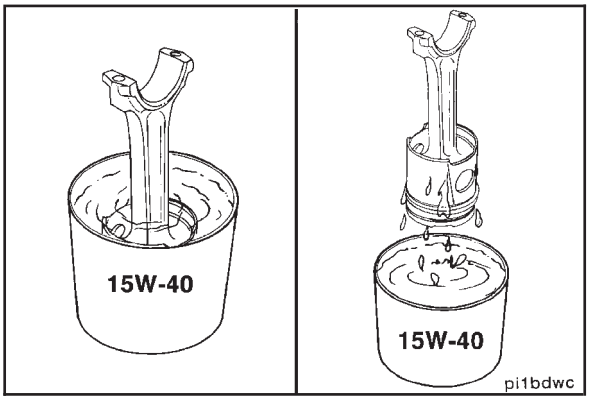
Use clean Lubriplate® 105 or its equivalent to lubricate the bearing shell.

Apply a heavy film of clean 15W-40 oil to the liner.



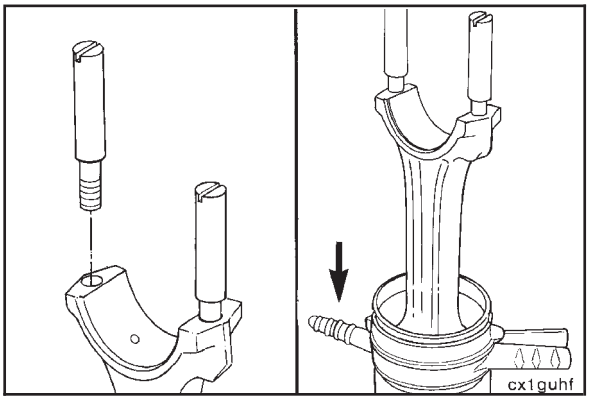
Put the piston and the ring assembly in a container of clean 15W-40 oil.

Remove the piston and the ring assembly from the container. Allow the excess oil to drain from the piston.



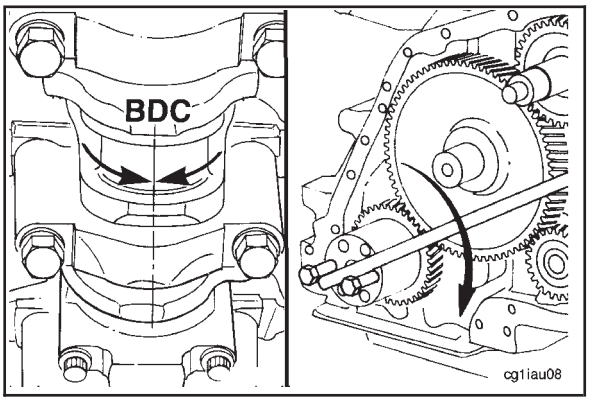
Install connecting rod guide pins, Part No. 3375601.

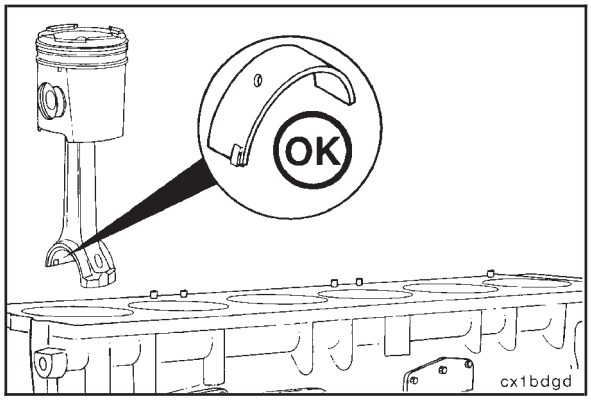
Use piston ring compressor, Part No. 3822736, to compress the rings.



Rotate the crankshaft to position the journal for the connecting rod at bottom dead center (BDC).

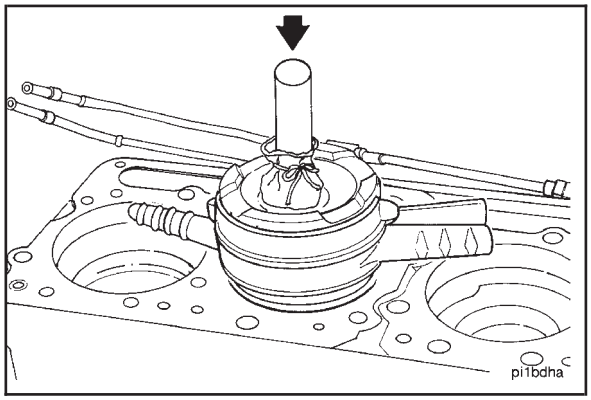
NOTE: Use the barring tool and two capscrews to rotate the crankshaft.





Caution: To avoid piston damage, do not use a metal object to push the piston in the liner.

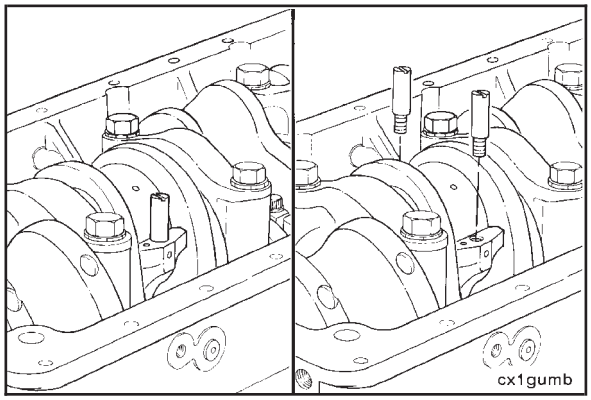
NOTE: The tang of the connecting rod **must** be toward the camshaft side of the cylinder block. The piston cooling nozzles **must** be removed prior to installation of the piston and connecting rod assemblies.



Caution: Do not use a hammer or equivalent to install the piston in the cylinder liner. The piston rings can be damaged.

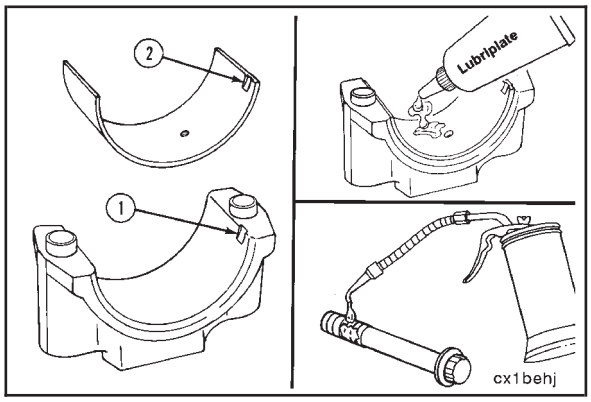
Install the connecting rod in the cylinder liner, and push the piston down. If the piston does **not** move freely, remove the piston. Inspect for broken or damaged rings.

When installing the connecting rod, pay close attention to make sure the rod is aligned with the rod journal. If the rod is misaligned, it can bind or scrape the crankshaft connecting rod journal side walls.



Use the guide pins to pull the connecting rod against the crankshaft.

Remove the guide pins.



Install the bearing in the connecting rod cap.

NOTE: The tang (2) of the bearing **must** be in the slot (1) of the cap.

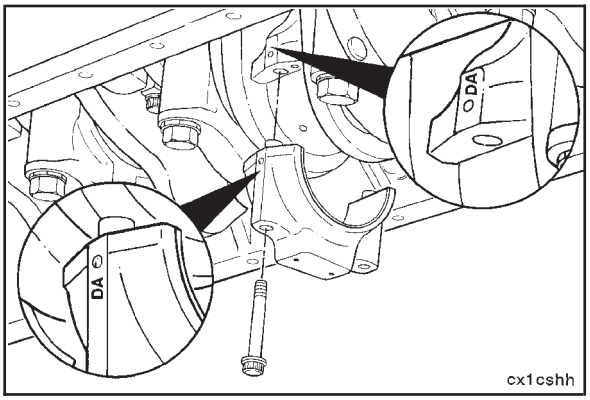
Lubricate the bearing shell with Lubriplate® 105 or its equivalent. Lubricate the connecting rod capscrew threads and the washer face with 140W oil.

Caution: The rod cap alpha-numeric characters must match the alpha-numeric characters on the connecting rod and must be installed with the characters aligned to prevent damage to the connecting rods and the crankshaft. The locking tang of the connecting rod cap must be toward the camshaft side of the cylinder block.

Install the connecting rod caps and the capscrews.

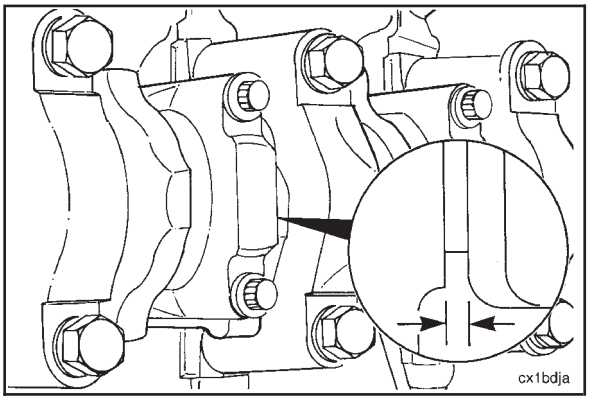
Tighten the rod capscrews in alternating sequence to the following torque values:

- Tighten to 102 N•m [75 ft-lb].
- Tighten to 264 N•m [195 ft-lb].



Measure the connecting rod side clearance. The side clearance **must** be between 0.114 mm [0.0045-inch] and 0.51 mm [0.020-inch].

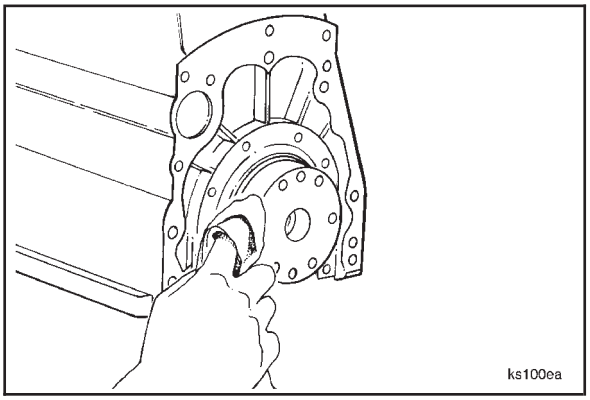
NOTE: The connecting rod **must** move freely from side to side on the crankshaft journal. If the rod does **not** move freely, remove the rod cap and make sure the bearing shells are the correct size. Check for dirt or damage on the crankshaft and the bearing shells.



Rear Cover - Installation

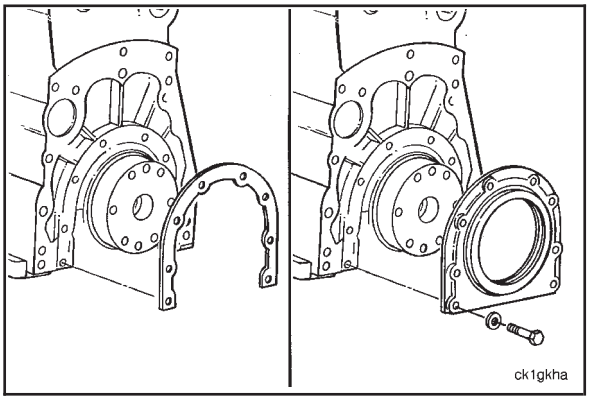
Use a clean cloth to clean the crankshaft flange.

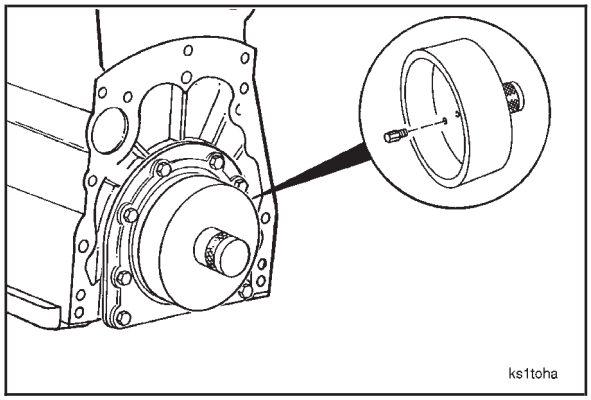
NOTE: Do **not** use lubricant to install the seal. The oil seal **must** be installed with the lip of the seal and the crankshaft clean and dry to provide a correct oil sealing surface and to provide maximum engine life.



Install a new gasket on the cylinder block.

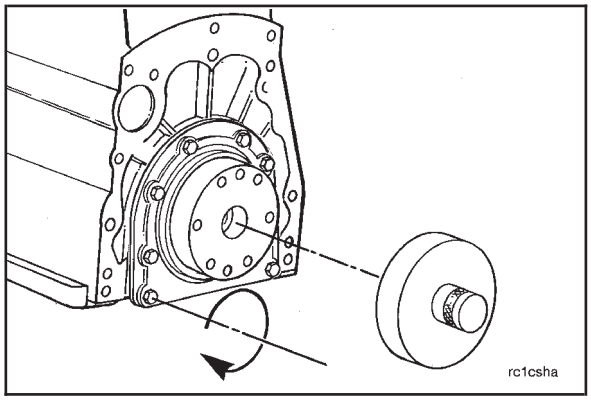
Install the rear cover and the eight capscrews and washers. Tighten the capscrews just enough to hold the rear cover in position.





Remove the pins from the crankshaft oil seal driver, Part No. ST-997; and use the driver to align the rear cover with the crankshaft.

Install the seal drive in the crankshaft flange and in the bore of the rear cover.

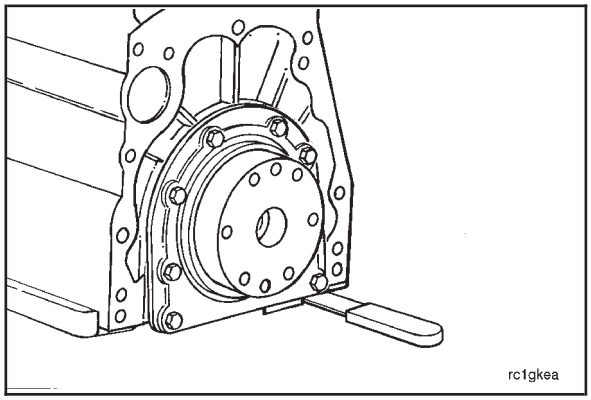


Tighten the rear cover mounting capscrews.

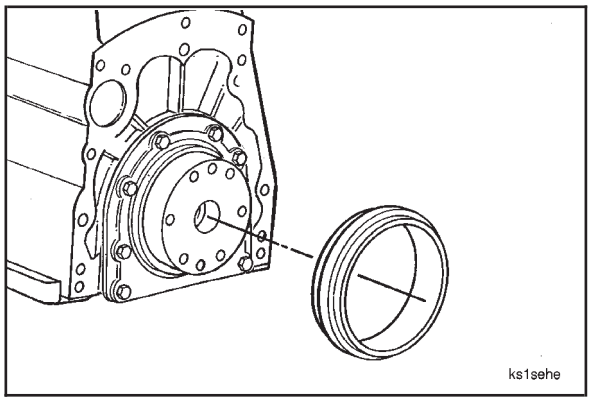
Torque Value: 47 N•m [35 ft-lb]

Remove the crankshaft oil seal driver, Part No. ST-997.

Use a gauge block, Part No. 3823495, to make sure the rear cover is within 0.10 mm [0.004-inch] of being parallel with the oil pan flange of the cylinder block.



Trim the excess gasket material from the ends of the rear cover gasket so the gasket is even or does **not** extend more than 0.25 mm [0.010-inch] beyond the pan flange.



Crankshaft Seal, Rear - Installation

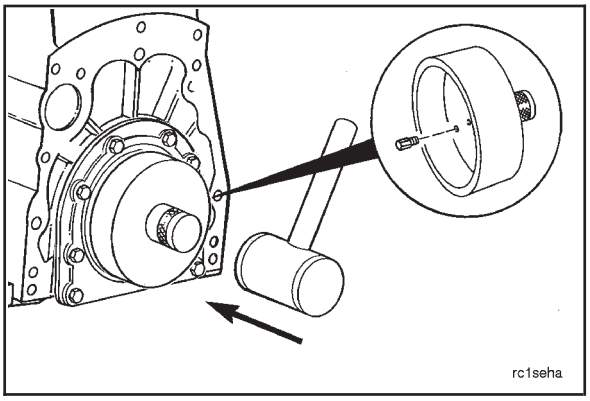
Use the installation sleeve provided with the seal to install the seal on the crankshaft.

NOTE: ''LDL TFE'' (Lay-down Lip, Teflon) oil seals for service replacement have an assembly tool which protects the seal lip during shipment and installation. The ''LDL TFE'' oil seal **must** be installed with the lip of the seal and the crankshaft clean and dry. Do **not** use any kind of lubricant. The use of lubricant will result in oil leakage at the seal.

Push the oil seal over the installation sleeve onto the crankshaft, and remove the sleeve.

Install the pins in crankshaft oil seal driver, Part No. ST-997.

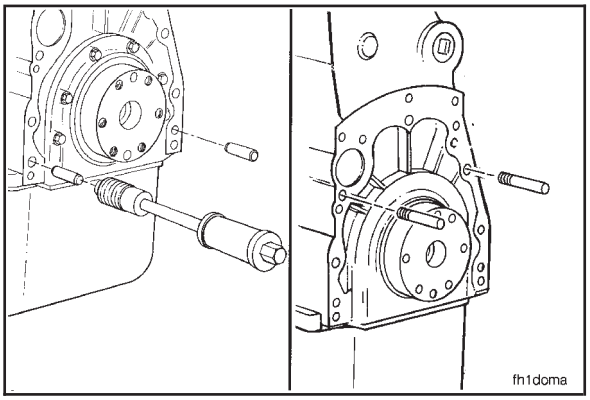
Use crankshaft oil seal driver, Part No. ST-997, to install the oil seal in the rear cover.



Flywheel Housing - Installation

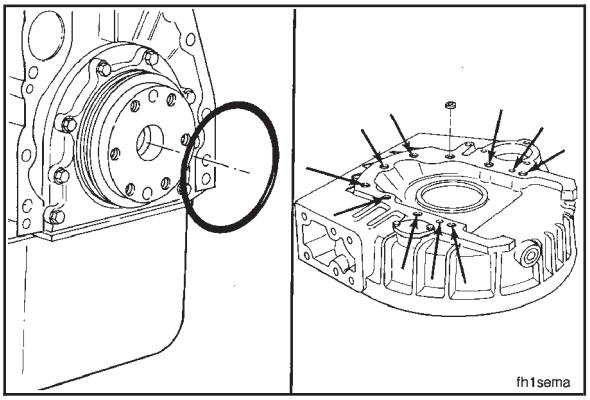
Caution: If a new flywheel housing is being installed, the dowels must be removed from the cylinder block prior to installing the housing to prevent damage to the housing. The housing must be doweled with an oversize dowel after it has been aligned. Refer to Flywheel Housing - Redowel to Cylinder Block (16-04).

Install two 5/8-18 x 4-inch guide studs in the cylinder block to help support and align the housing during installation.



If a wet-type flywheel housing is being installed, do the following:

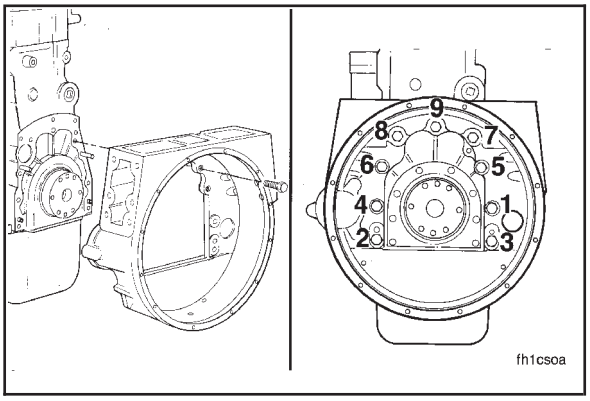
1. Install a new o-ring on the rear cover. Use vegetable oil to lubricate the o-ring.
2. Install 11 rectangular sealing rings in the capscrew dowel pin counterbores in the flywheel housing. Use gasket adhesive to fasten the sealing rings to the housing.

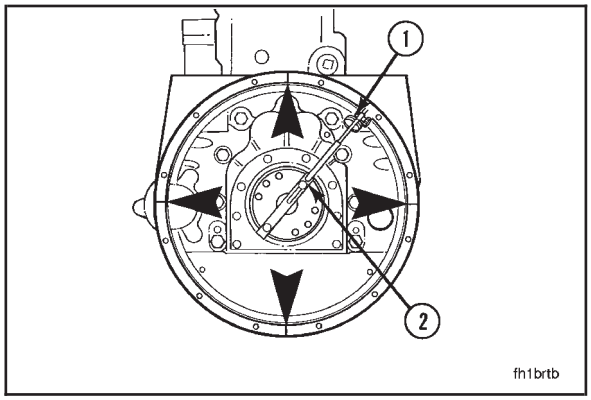


Install the flywheel housing over the guide studs.

Install the capscrews, and tighten in the sequence shown.

Torque Value: 203 N•m [150 ft-lb]



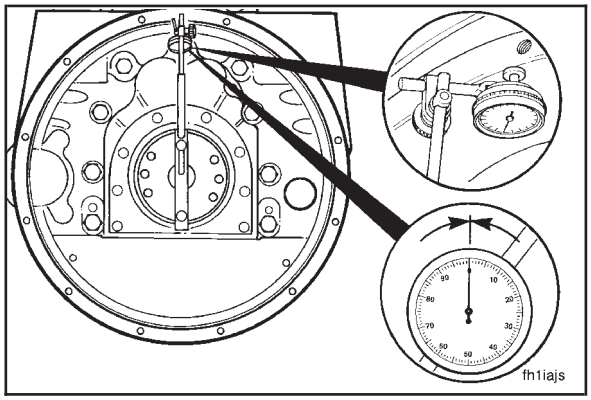


Bore Alignment - Measurement

Caution: The flywheel housing bore and the surface must be in alignment with the crankshaft to prevent possible damage to the engine, the clutch, or the transmission.

Use chalk to mark the housing at the 12:00 o'clock, 3:00 o'clock, 6:00 o'clock, and 9:00 o'clock positions.

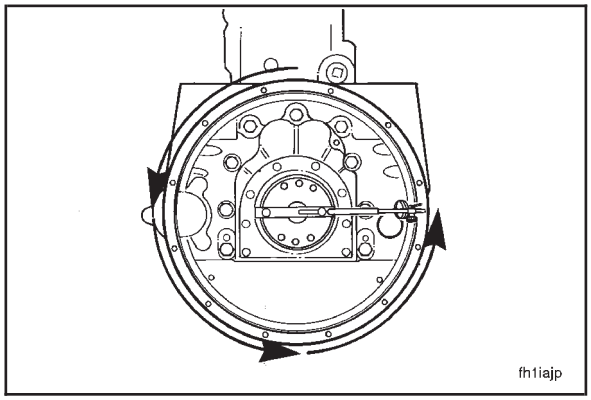
Use dial gauge indicator (1), Part No. 3376050, and dial gauge attachment (2), Part No. ST-1325, to measure the bore alignment.



Attach a dial indicator to the crankshaft as shown.

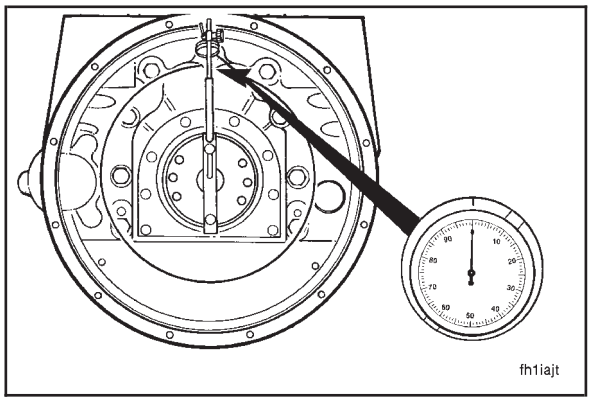
NOTE: The indicator arm **must** be rigid for an accurate reading. It **must not** sag.

Put the indicator at the 12:00 o'clock position. Adjust the dial indicator until the needle points to ''0.''



Rotate the crankshaft one complete revolution in a **clockwise** direction (viewed from the front of the engine).

Record the indicator reading at three different positions: 3:00 o'clock, 6:00 o'clock, and 9:00 o'clock.

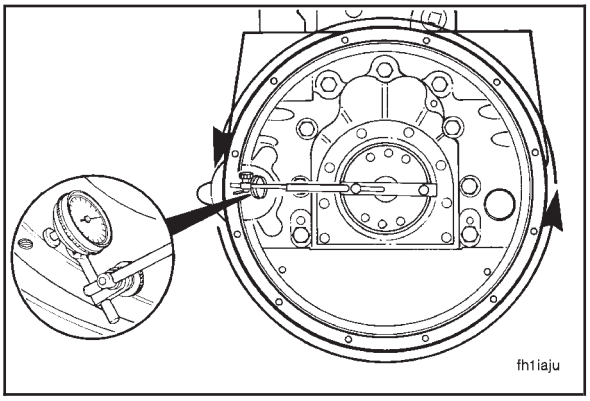


Continue rotating the crankshaft until the dial indicator is at the 12:00 o'clock position.

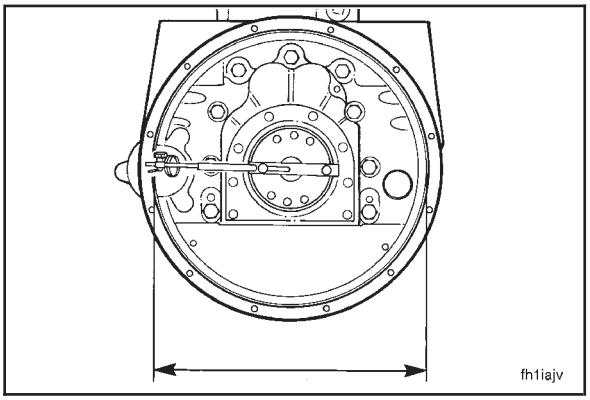
Check the dial indicator to make sure the needle still points to ''0.''

Determine the total indicator runout (T.I.R.) as follows:

Example:	mm	in
12 o'clock	0.00	0.000
3 o'clock	+ 0.08	+ 0.003
6 o'clock	- 0.05	- 0.002
9 o'clock	+ 0.08	+ 0.003
Equals T.I.R.	0.13	0.005

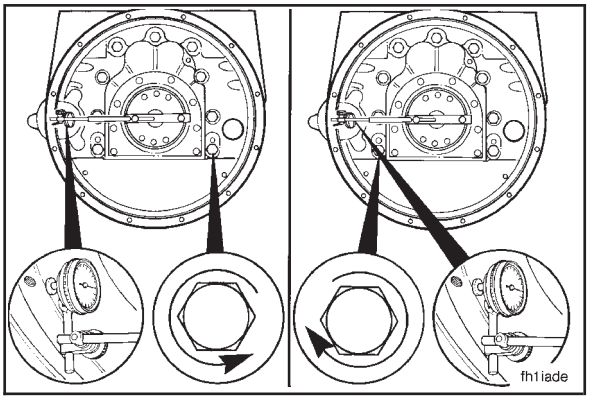


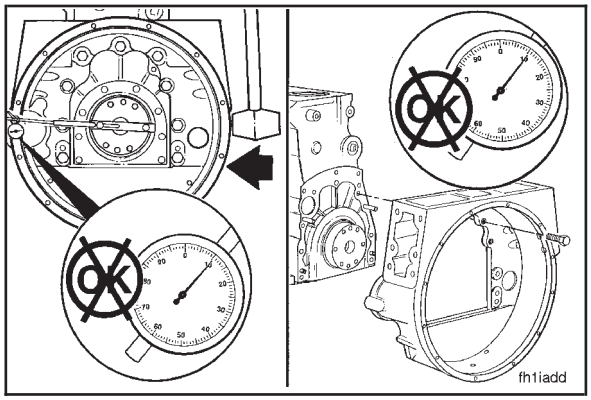
The maximum allowable total indicator runout (T.I.R.) depends on the diameter of the housing bore. See the following chart:



SAE No.	Bore Diameter		Bore Location Tolerance	
	mm	in	mm	in
00	787.40 to 787.65	31.000 to 31.010	0.30	0.012 T.I.R.
0	647.70 to 647.95	25.500 to 25.510	0.25	0.010 T.I.R.
1/2	584.20 to 584.40	23.000 to 23.008	0.25	0.010 T.I.R.
1	511.18 to 511.30	20.125 to 20.130	0.20	0.008 T.I.R.
2	447.68 to 447.80	17.625 to 17.630	0.20	0.008 T.I.R.
3	409.58 to 409.70	16.125 to 16.130	0.20	0.008 T.I.R.

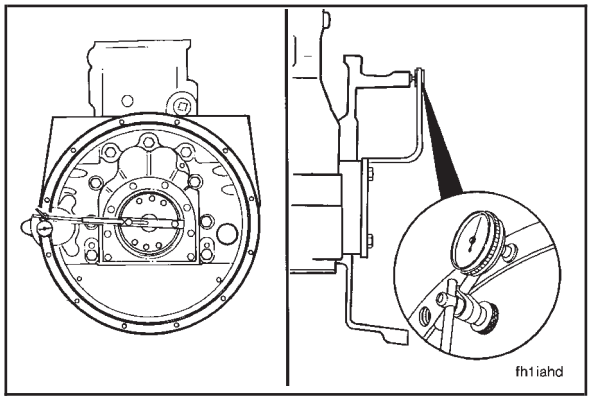
If the bore alignment does **not** meet the specifications, loosen the housing capscrews. Tighten the capscrews again, and measure the bore alignment again.





If the alignment is **not** within specifications and the bore is round, the housing can be shifted. Refer to Section 16.

If the alignment is **not** within specifications and the bore is **not** round, the housing **must** be replaced.

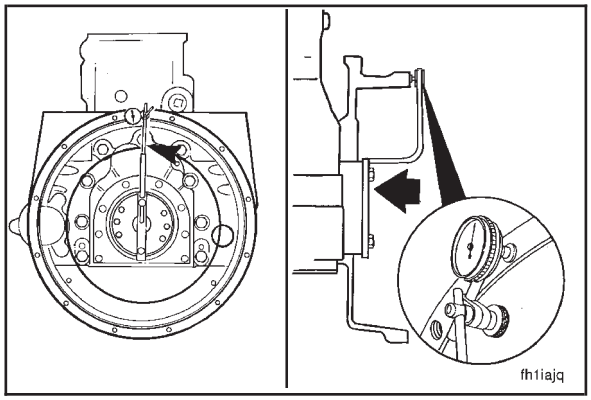


Face Alignment - Measurement

Install the dial indicator as shown.

Caution: The tip of the gauge must not enter the cap-screw holes or the gauge will be damaged.

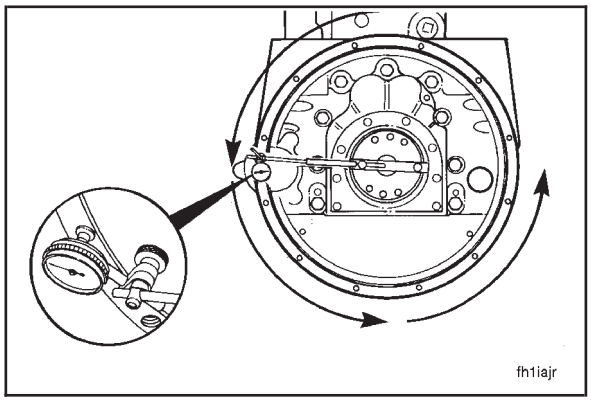
Put the tip of the dial indicator gauge against the flywheel housing surface.



Rotate the crankshaft until the dial indicator is at the 12:00 o'clock position.

Push the crankshaft toward the front of the engine. Adjust the dial on the indicator until the needle points to ''0.''

NOTE: The crankshaft **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

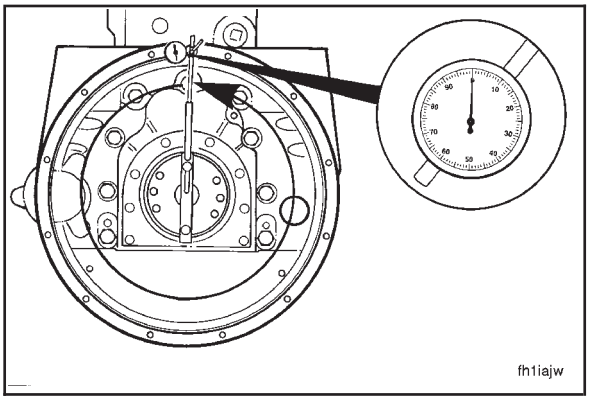


Rotate the crankshaft in a **clockwise** direction (viewed from the front of the engine).

Record the indicator reading at three different positions: 3:00 o'clock, 6:00 o'clock, and 9:00 o'clock.

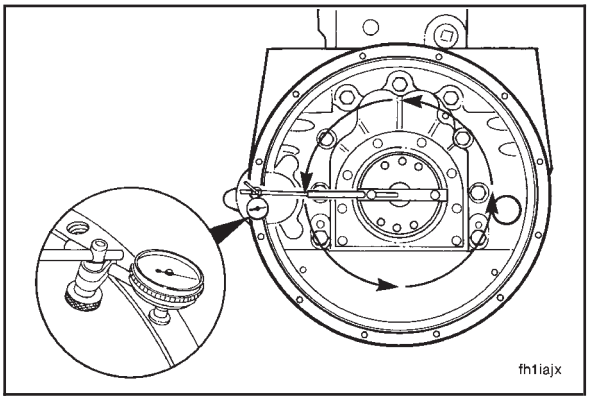
Continue rotating the crankshaft until the dial indicator is at the 12:00 o'clock position.

Check the dial indicator to make sure the needle still points to ''0.''

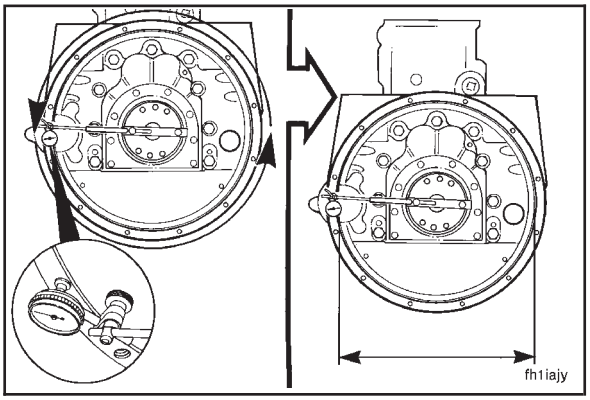


Determine the total indicator runout (T.I.R.) as follows:

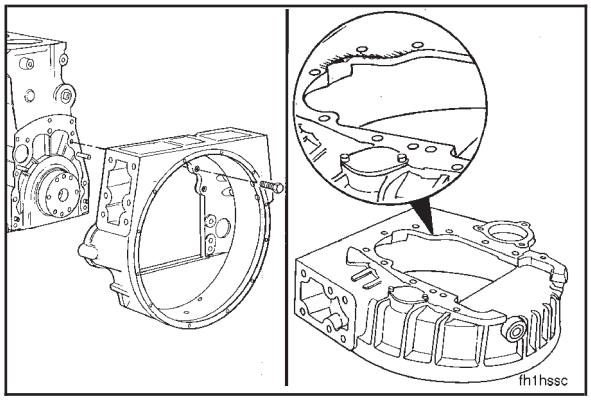
Example:	mm	in
12 o'clock	0.00	0.000
3 o'clock	+ 0.08	+ 0.003
6 o'clock	- 0.05	- 0.002
9 o'clock	+ 0.08	+ 0.003
Equals T.I.R.	0.13	0.005



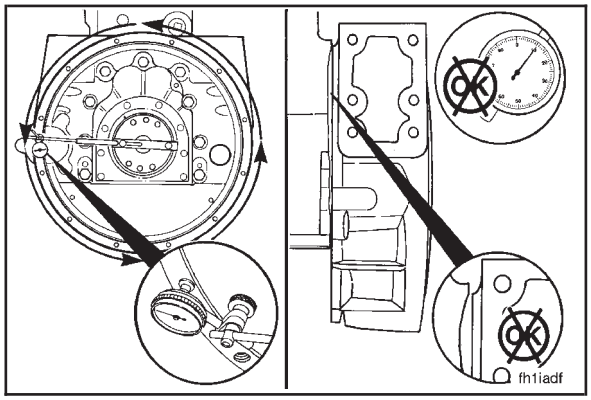
The maximum allowable total indicator runout (T.I.R.) depends on the diameter of the housing bore. See the following chart:



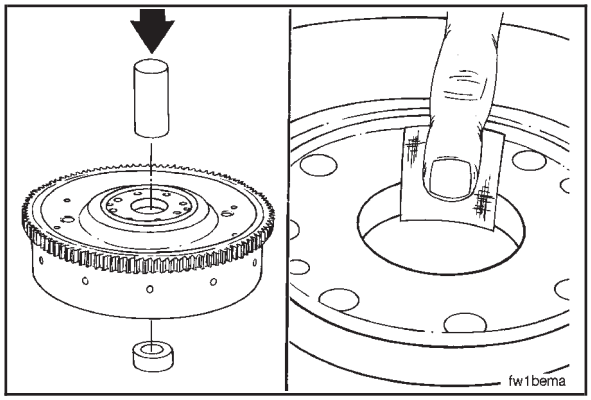
SAE	Bore Diameter		Face Alignment Tolerance	
No.	mm	in	mm	in
00	787.40 to 787.65	31.000 to 31.010	0.30	0.012 T.I.R.
0	647.70 to 647.95	25.500 to 25.510	0.25	0.010 T.I.R.
1/2	584.20 to 584.40	23.000 to 23.008	0.25	0.010 T.I.R.
1	511.18 to 511.30	20.125 to 20.130	0.20	0.008 T.I.R.
2	447.68 to 447.80	17.625 to 17.630	0.20	0.008 T.I.R.
3	409.58 to 409.70	16.125 to 16.130	0.20	0.008 T.I.R.



If the alignment is **not** within specifications, remove the housing. Check for nicks, burrs, or foreign material between the block and the housing.



Check the alignment again. If the alignment is **not** within specifications, the block or the housing is **not** machined correctly.

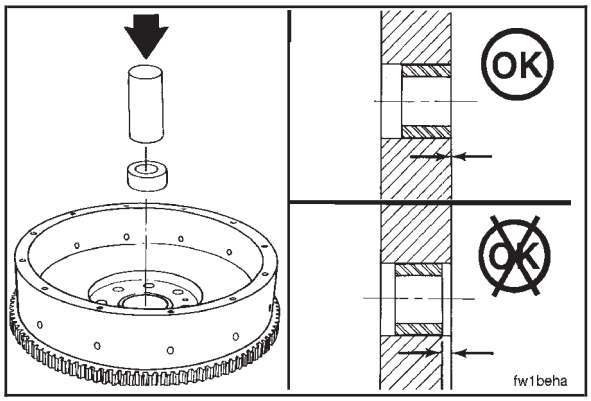


Flywheel - Installation

NOTE: Use a new pilot bearing when installing a new or rebuilt clutch.

Use a mandrel and a hammer to remove the pilot bearing.

Use Scotch-Brite® 7448, Part No. 3823258, to clean the pilot bore.



Use a mandrel and a hammer to install the pilot bearing.

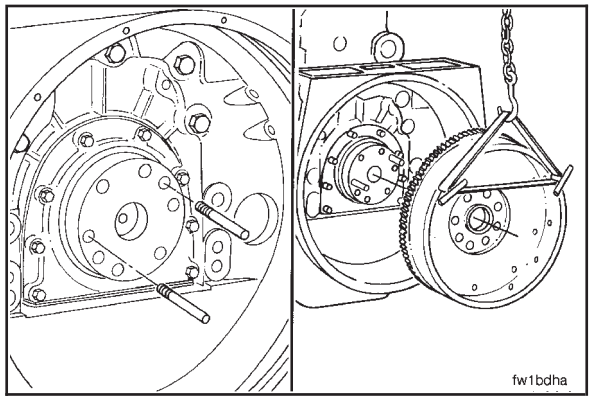
NOTE: The pilot bearing **must** be installed flush with the pilot bore surface.

Install two t-bolts into the flywheel clutch mounting surface.

Install two 5/8 - 18 x 6-inch guide studs in the crankshaft flange.

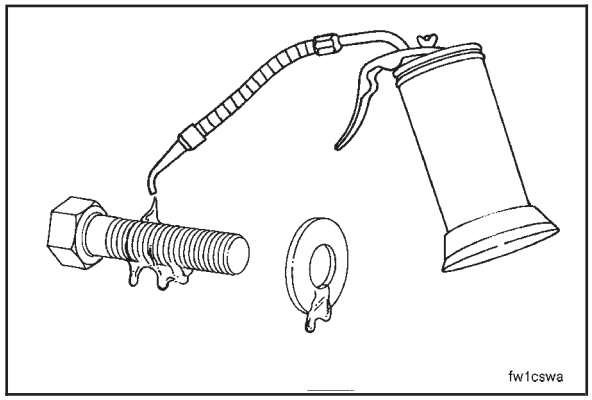
Warning: Because this part weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the part to avoid personal injury.

Install the flywheel on the guide stud.



Caution: Do not use an anti-seize compound, penetrating oil, or oil containing a friction modifier to lubricate the capscrews. This will result in incorrect capscrew torque and possible capscrew failure.

Lubricate the threads of the capscrews and the surface of the washers with 15W-40 lubricating oil.



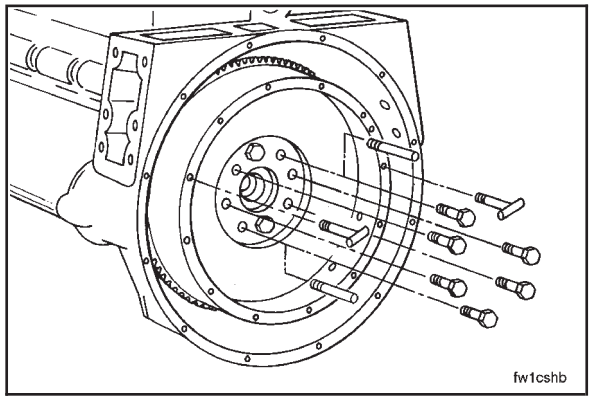
Install the four capscrews.

Remove the t-bolts and the guide studs.

Install the remaining two capscrews in the holes from which the guide studs were removed.

Tighten the capscrews in a star pattern.

Torque Value: 271 N•m [200 ft-lb]



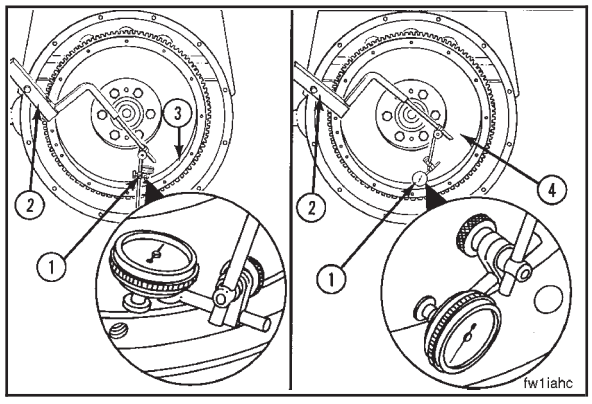
Bore Alignment - Measurement

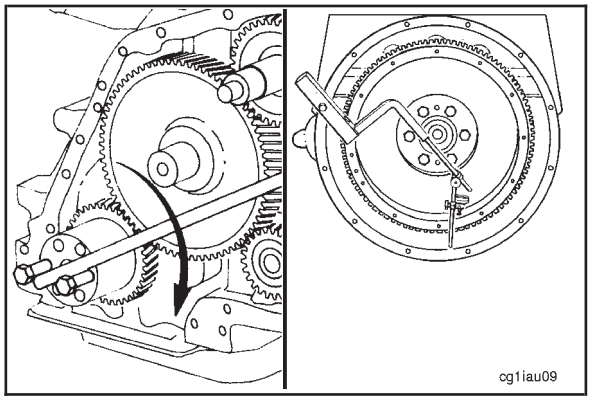
Use dial indicator gauge (1), Part No. 3376050, or its equivalent and dial gauge attachment (2), Part No. ST-1325, to inspect the flywheel bore (3) and the surface (4) runout.

Install the attachment to the flywheel housing.

Install the gauge on the attachment.

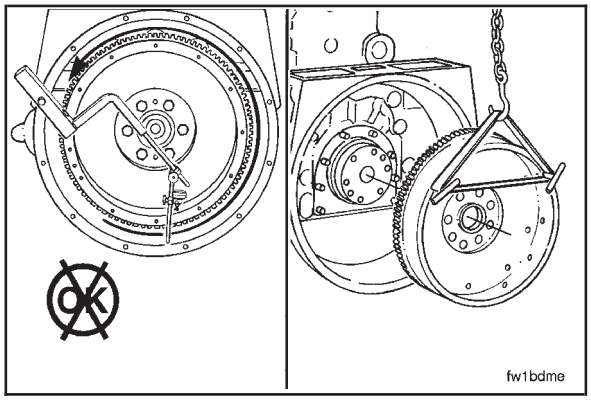
Install the contact tip of the indicator against the inside diameter of the flywheel bore, and set the dial indicator to ''0.''



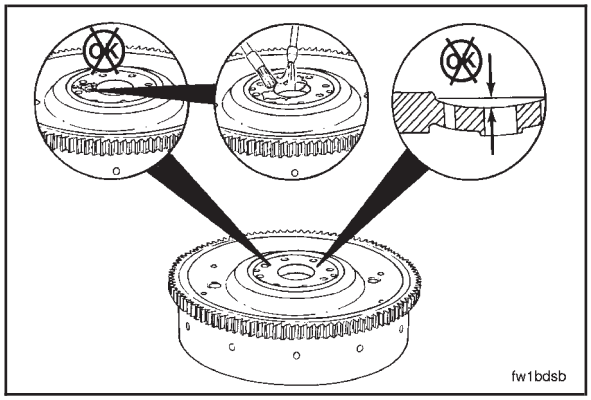


Rotate the crankshaft one complete revolution.

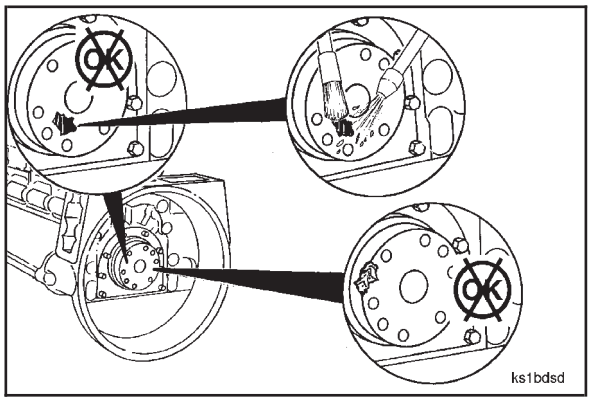
NOTE: The total indicator runout (T.I.R.) **must not** exceed 0.127 mm [0.0050-inch].



If the T.I.R. is greater than the specification, remove the flywheel.

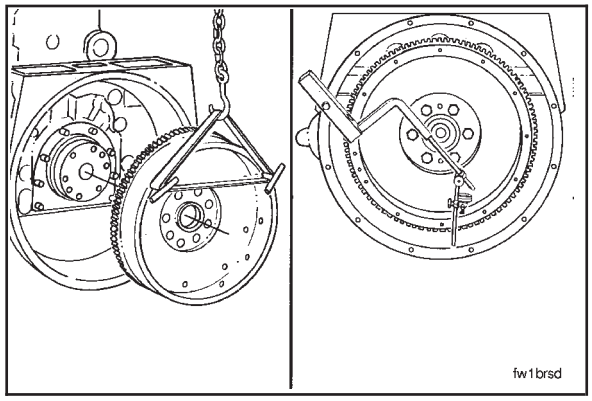


Inspect the flywheel mounting surface for dirt or damage.

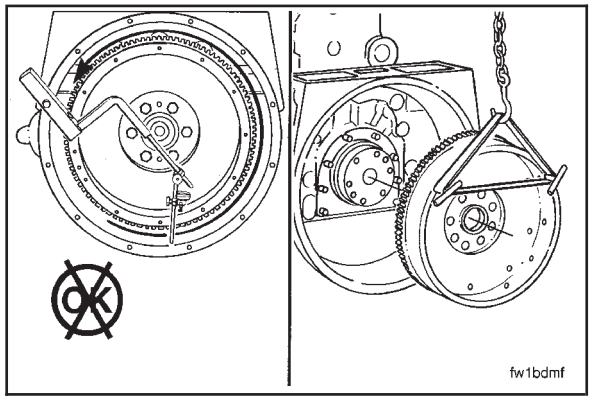


Inspect the crankshaft for dirt or damage. Replace the crankshaft if necessary.

Install the flywheel, and inspect the bore runout again.



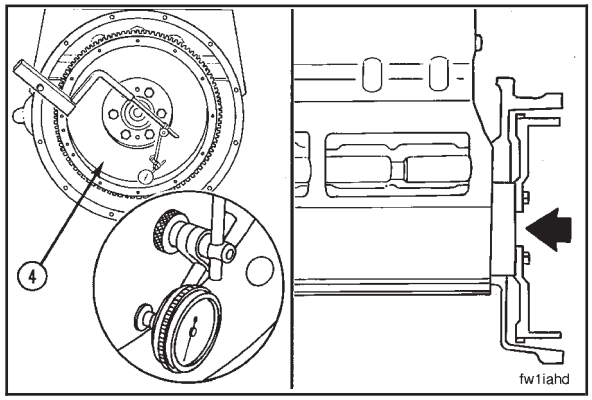
Replace the flywheel if the runout does **not** meet specifications.



Face Alignment - Measurement

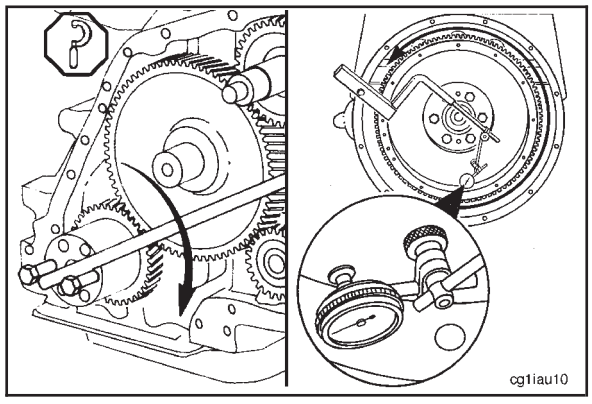
Install the contact tip of the indicator against the flywheel face, as close to the outside diameter as possible, to inspect the face (4) runout.

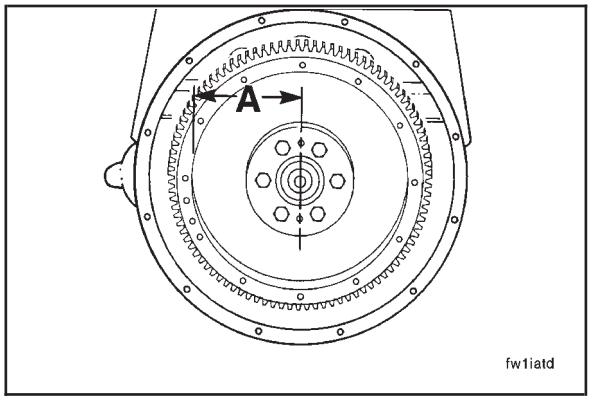
Push the flywheel forward to remove the crankshaft end clearance. Adjust the dial on the indicator until the needle points to ‘‘0.’’



Rotate the crankshaft one complete revolution. Measure the flywheel runout at four equal points on the flywheel.

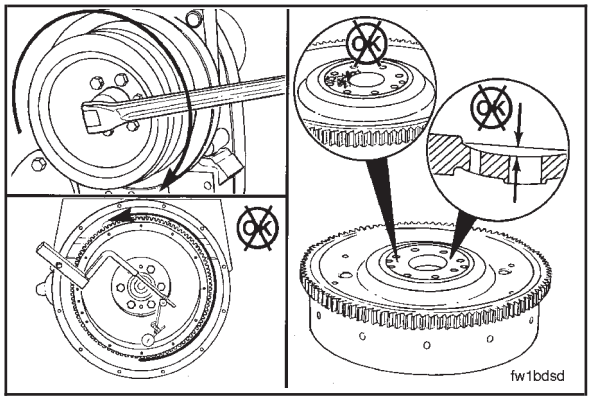
NOTE: The flywheel **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.



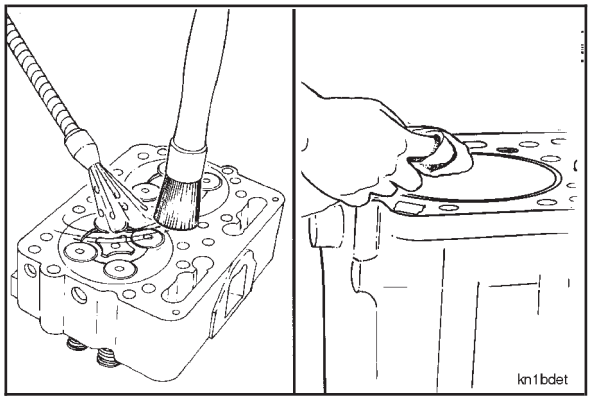


The total indicator runout (T.I.R.) **must not** exceed the following specifications:

Flywheel Radius (A)		Maximum (T.I.R.) of Flywheel Face	
mm	in	mm	in
203	8	0.203	0.008
254	10	0.254	0.010
305	12	0.305	0.012
356	14	0.356	0.014
406	16	0.406	0.016



If the flywheel face runout is **not** within specification, remove the flywheel. Check for nicks, burrs, or foreign material between the flywheel mounting surface and the crankshaft flange.

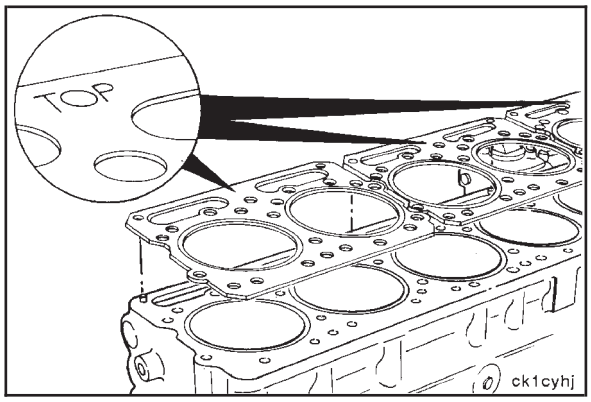


Cylinder Heads - Installation

Warning: Naptha and methyl ethyl ketone are flammable materials. Use caution to prevent personal injury. Follow the manufacturer's instructions. Do not use starting fluid.

Use a non-petroleum-based cleaner such as Part No. 3823717.

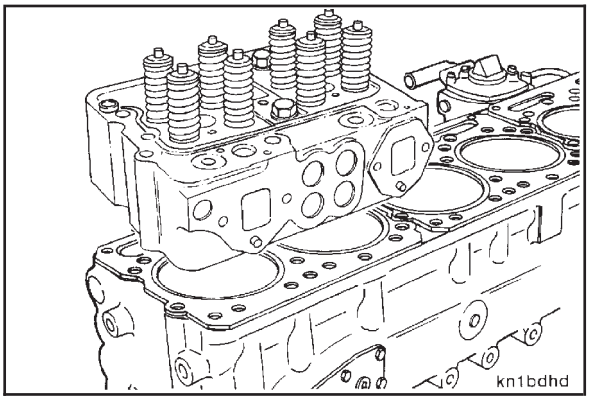
Clean the cylinder head and the cylinder block head gasket contact surface.



Install new gaskets on the dowel pins in the cylinder block.

NOTE: Make sure the side of the gasket marked ''TOP'' is up.

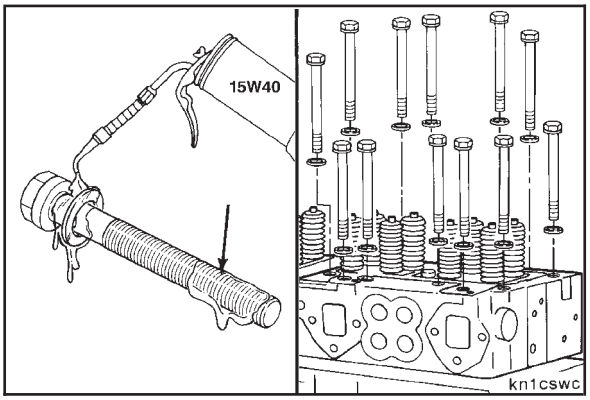
Install the cylinder heads over the dowel pins. If reusing original cylinder heads, install them in their original position.



Use clean 15W-40 oil to lubricate the cylinder head capscrews and both sides of the flat washers.

Allow the excess oil to drain from the threads.

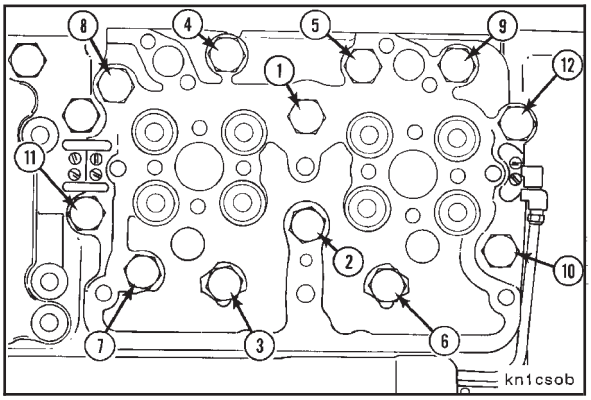
Install 12 capscrews and washers in each cylinder head.



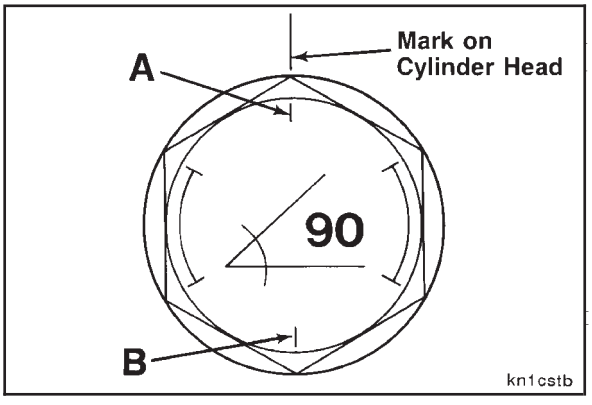
Complete the following steps to tighten the capscrews to the specified torque values in the sequence shown:

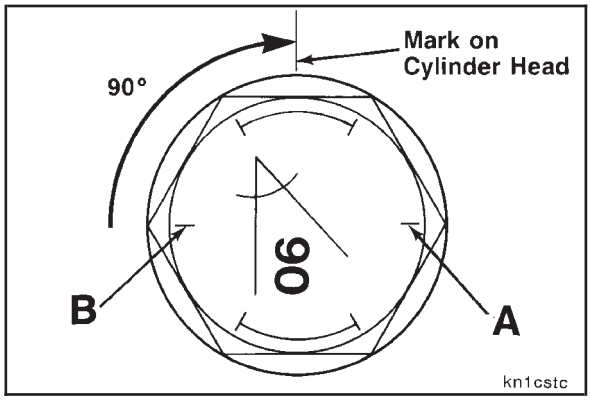
- Tighten to 136 N•m [100 ft-lb].
- Tighten to 298 N•m [220 ft-lb].
- Rotate 90 degrees, **not** less than one flat, and **not** more than two flats.

Repeat the tightening sequence to install each cylinder head.



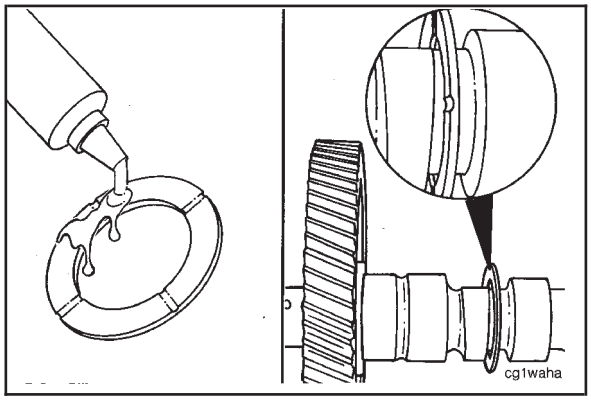
The markings on the head of the flange head capscrews serve as an aid during installation. After torquing the capscrew 298 N•m [220 ft-lb], mark the cylinder head adjacent to one of the two single marks ''A'' or ''B'' on the capscrew head.





After all 12 capscrews on one head have been torqued to 298 N•m [220 ft-lb], they **must** be rotated in the tightening direction an additional 90 degrees. Rotate the capscrew until the mark on the cylinder head is between the next two marks joined by an arc (more than one flat and less than two flats).

NOTE: When using torque plus angle, the tolerance on the 90 degree angle of rotation is one to two flats (90° plus or minus 30°). If the capscrew is rotated beyond two flats, do **not** loosen the capscrew. The clamp load is still acceptable; however, rotating the capscrew beyond two flats causes additional stretch and reduces the number of reuses. With proper torquing, the capscrew can typically be reused for the life of the engine.

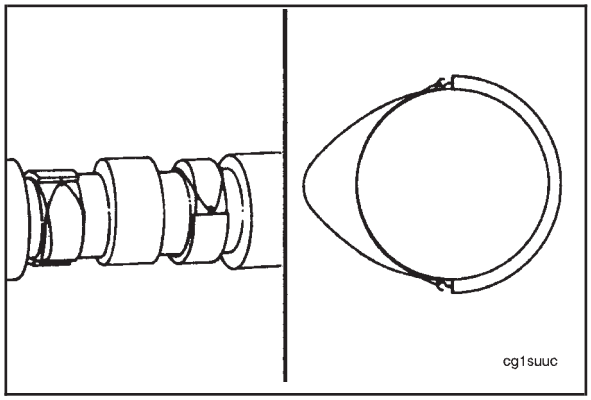


Camshaft - Installation

Apply a film of Lubriplate® 105 or its equivalent to both sides of the camshaft thrust washer.

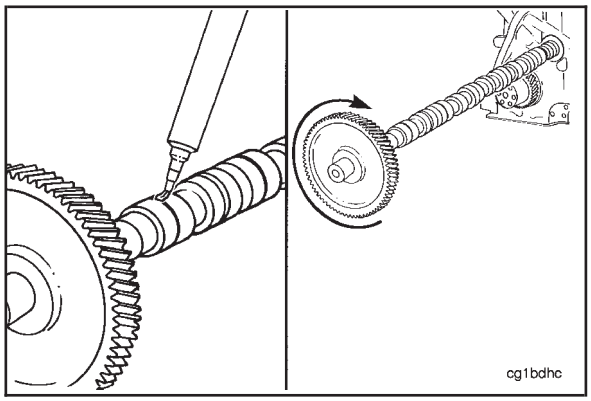
Caution: The oil grooves on the thrust washer must be toward the camshaft gear to prevent thrust washer failure.

Install the thrust washer on the camshaft.



Install four camshaft pilots, Part No. 3375268, over the base circle of the valve lobes between the camshaft journals.

Use a rubber band to hold the installation pilots in place. The rubber band **must** straddle the valve lobes.

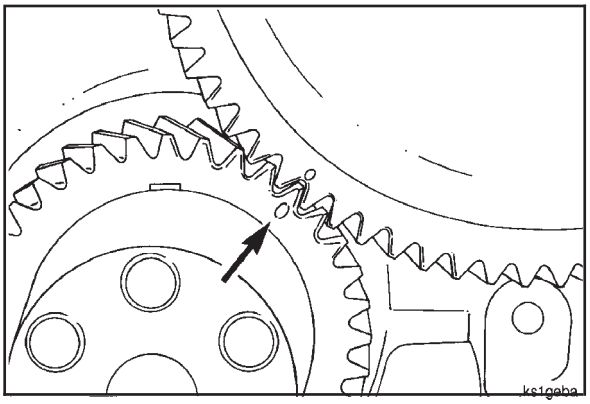


Apply a film of Lubriplate® 105 or its equivalent to the camshaft journals and the camshaft bushings.

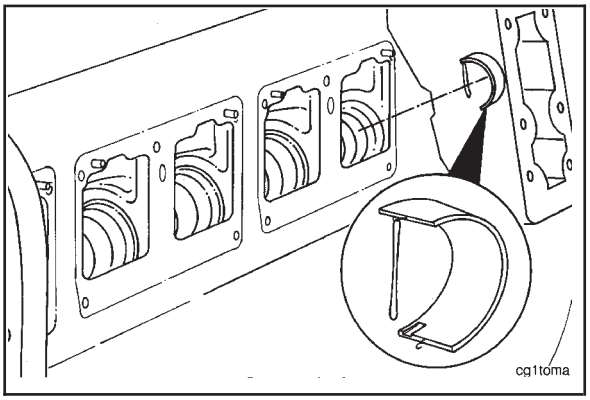
Rotate the camshaft slowly as it is being installed in the cylinder block.

Align the ‘‘O’’ mark on the camshaft gear with the ‘‘O’’ mark on the crankshaft gear.

After aligning the ‘‘O’’ marks, push the camshaft in the bore until the thrust washer fits against the cylinder block.

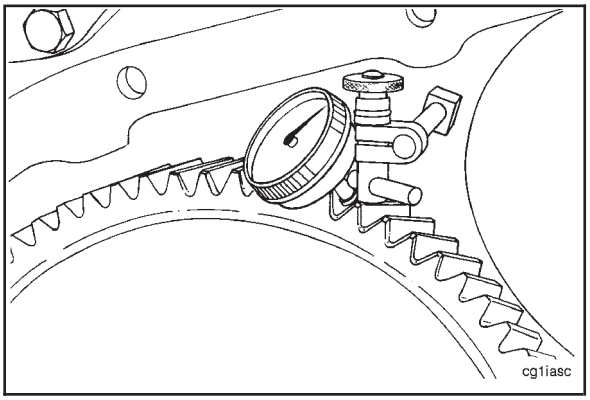


Remove the camshaft installation pilots. Do **not** allow the rubber bands to fall into the camshaft cavity of the cylinder block when removing the installation pilots.

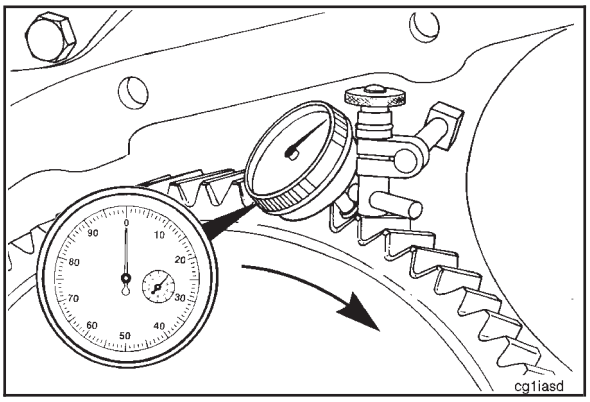


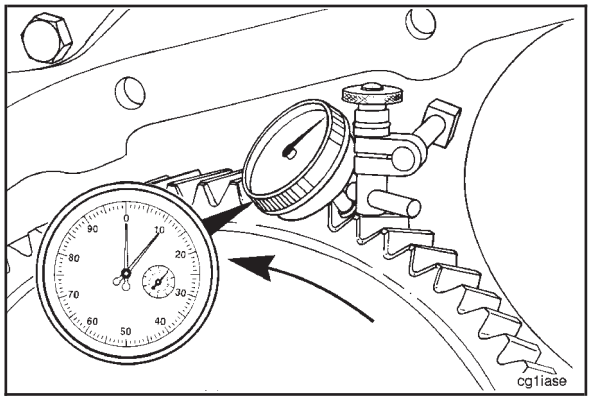
Use a dial indicator to check the backlash between the camshaft gear and the crankshaft gear.

Put the tip of the dial indicator against a tooth on the camshaft gear.



Turn the camshaft gear by hand as far as it will freely move, and set the dial indicator at ‘‘0’’ (zero).



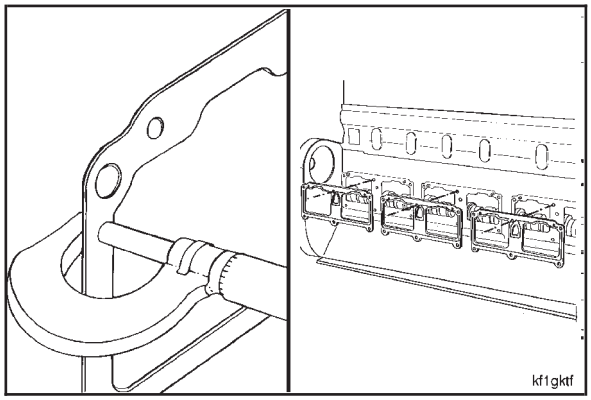


Turn the camshaft gear by hand in the **opposite** direction as far as it will freely move, and read the dial indicator.

Backlash Between the Camshaft and the Crankshaft Gears

mm		in
0.05	MIN	0.002
0.50	MAX	0.020

If the backlash is excessive, inspect the camshaft and crankshaft gears for tooth wear and replace if necessary. If the backlash is tight, inspect for debris or damage to the gear teeth and check again.



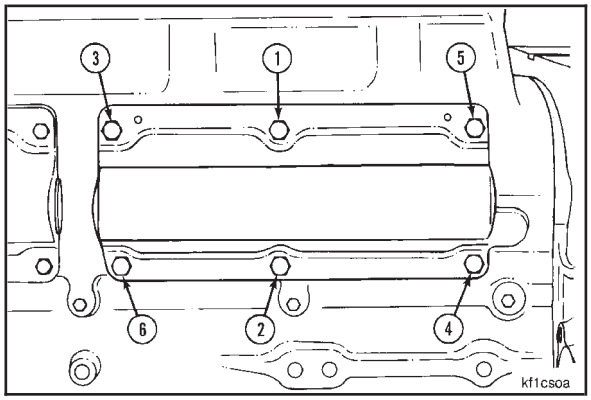
Cam Follower Assemblies - Installation

Install the new cam follower gaskets to the block as follows:

- Obtain a gasket with the same thickness as the gaskets removed.
- Install the gaskets over the dowel pins in the block.

NOTE: If the thickness of the original gaskets is unknown, install a gasket combination of 0.99 mm [0.039-inch] as a reference point.

NOTE: The Print-O-Seal gasket **must** be against the cylinder block with the sealing bead toward the cam follower housing.

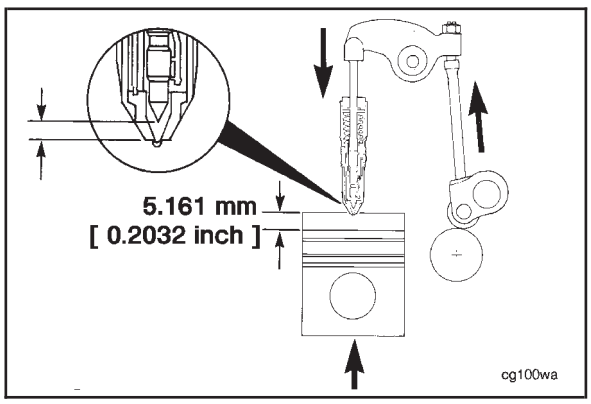


Use clean 15W-40 oil to lubricate the camshaft lobes.

Install a new gasket on the guide studs and the dowels for the No. 1 cam follower housing.

Install the cam follower assembly as follows:

- Install the capscrews and the studs in the same position from where they were removed. Tighten the capscrews in the alternating sequence shown to the following torque values:
  - — Tighten to 20 N•m [15 ft-lb].
  - — Tighten to 47 N•m [35 ft-lb].



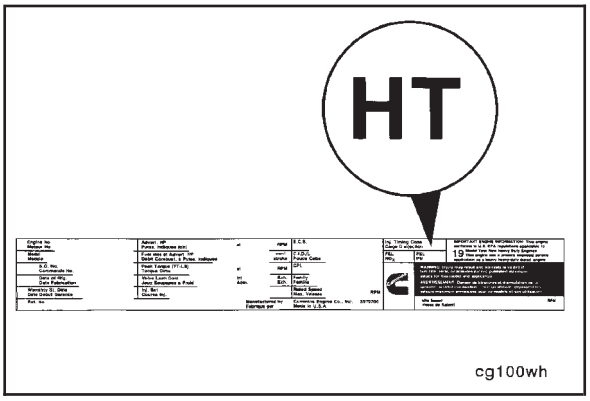
Injection Timing - General Information

The injection timing is the relative measurement of the distance remaining between the injector plunger and the injector cup when the piston is 5.161 mm [0.2032-inch], or 19 degrees before top dead center (TDC) on the compression stroke.

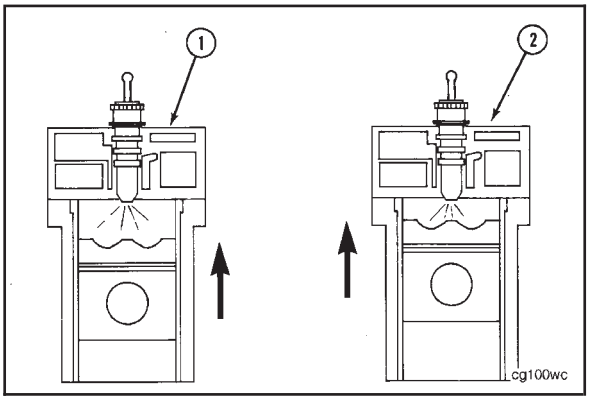
Injector timing is expressed by the amount of push tube travel remaining.

The injection timing code appears on the engine dataplate. Codes are alphabetic letters that relate to a numerical specification.

Specifications can be found in the Control Parts List (CPL) Manual, Bulletin No. 3379133.



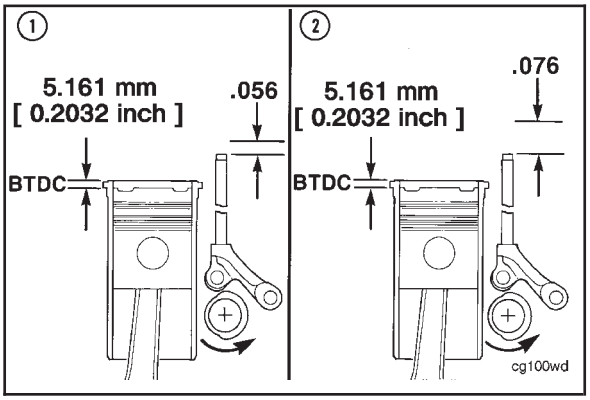
Advanced timing (1) means the fuel is injected earlier into the cylinder during the compression stroke. **Retarded** timing (2) means the fuel injection occurs closer to TDC in the cylinder.



The amount of push rod travel determines the time of fuel injection in relation to the piston position.

A **low** numerical value of the push rod travel remaining indicates a greater degree of advanced (1) or fast timing.

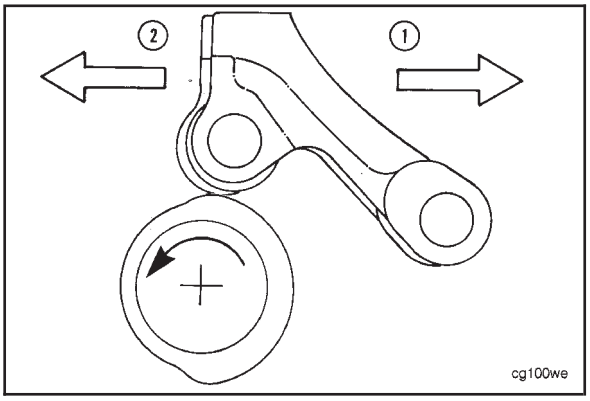
A **high** numerical value of the push rod travel remaining indicates a greater degree of retarded (2) or slow timing.

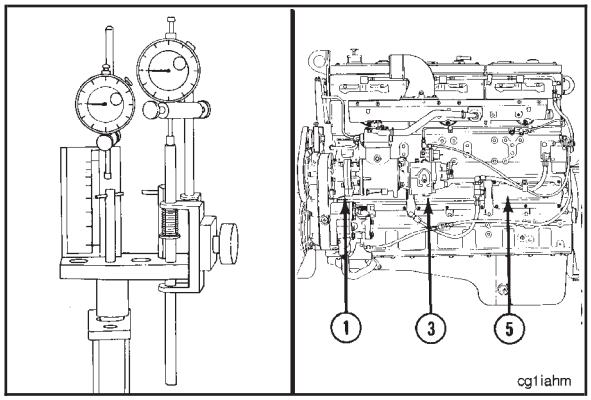


Injection timing changes are accomplished by **advancing** (1) or **retarding** (2) the cam follower action in relation to the piston position.

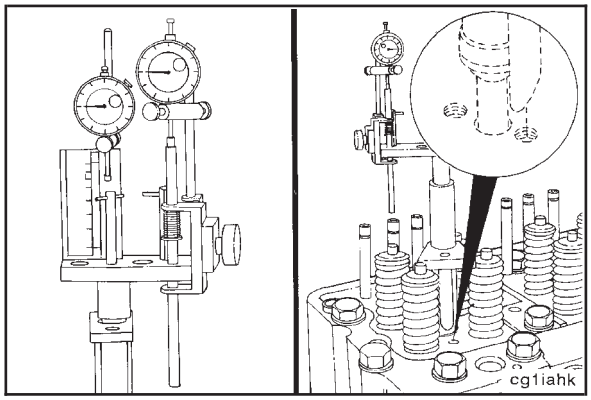
This is accomplished by changing the orientation of the camshaft lobe to the cam follower using different cam follower gasket thicknesses or offset camshaft gear keys.

NOTE: Gear train timing (index mark alignment) **always** remains the same.





NOTE: The injection timing check is a measurement which determines the injector push rod travel in relation to the piston travel. Due to normal parts tolerances, it is necessary to check one cylinder for each cam follower housing.

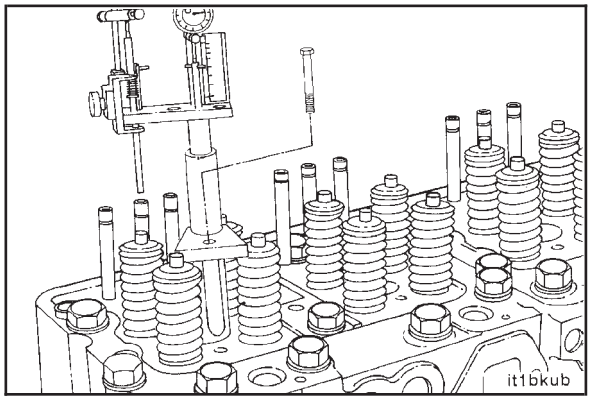


Timing Tool Installation

Caution: Pivot the dial indicator stems away from their respective plunger rods before installing the timing fixture to prevent damage to the indicators.

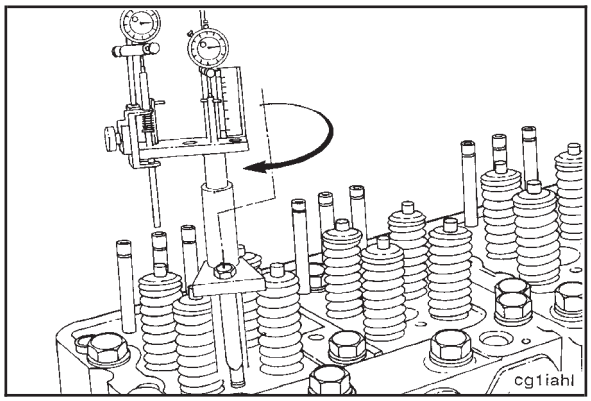
Install the piston plunger rod in the injector bore of the No. 1 cylinder.

NOTE: Make sure the plunger is centered and on top of the piston.



Align the swivel bracket with the injector clamp capscrew hole. Install the 6-inch swivel bracket capscrew. Tighten the capscrew finger tight.

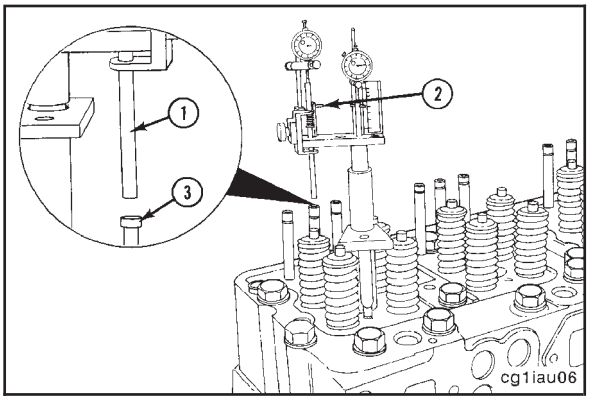
Position the push rod plunger rod near the push rod.



Tighten the swivel bracket capscrew enough to hold the timing tool rigid. Make sure the piston plunger post is clamped squarely to the cylinder head.

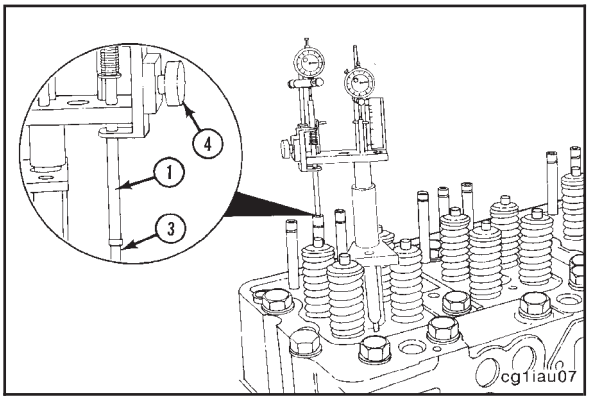
Align the plunger rod (1) and the injector push rod (3) with each other, and parallel to the plunger rod.

NOTE: Tighten the clamp handle (2) after the plunger rod is aligned with the injector push rod.

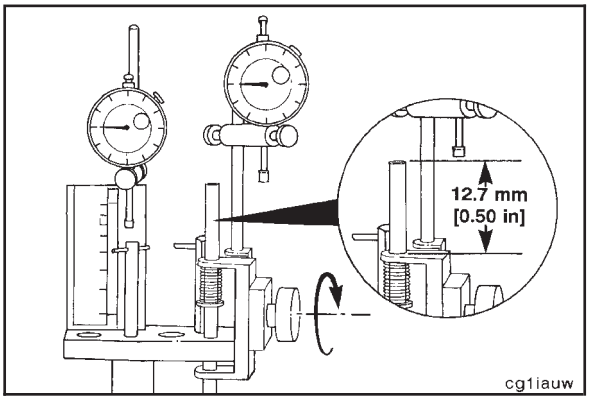


Loosen the support bracket (4) and slide the bracket down until the plunger rod (1) engages the injector push rod (3).

NOTE: The support bracket **must** be aligned with the vertical line on the clamp handle bracket. The push rod (3) **must** be vertically aligned with the plunger rod (1).

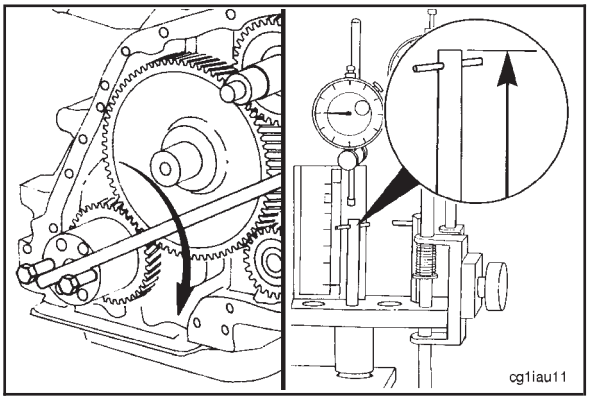


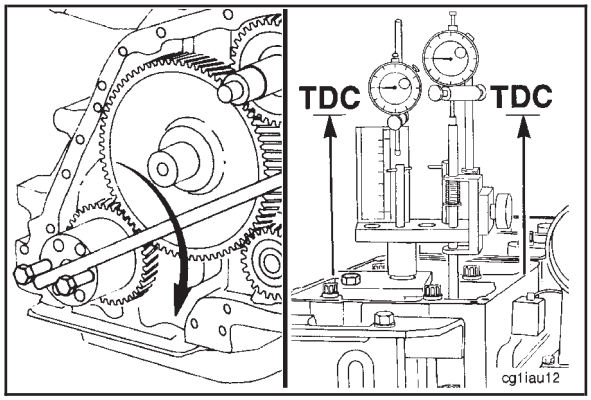
Compress the plunger rod tension spring approximately 12.7 mm [0.50-inch], and tighten the support bracket.



Determine the piston top dead center (TDC) on the compression stroke by rotating the crankshaft in the direction of engine rotation (**clockwise**) until the piston plunger reaches its uppermost position.

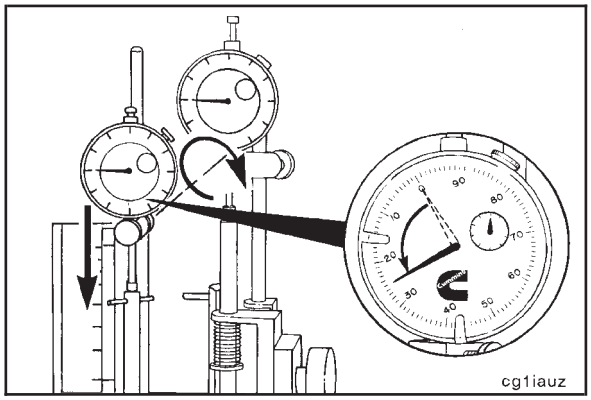
NOTE: Use **only** the crankshaft to rotate the engine. The use of the gears will result in false measurements. Gear lash **must** be closed up in the direction of normal rotation (crankshaft **clockwise**).





NOTE: The timing tool indicator needles will both start to move in the same direction of rotation as the piston approaches TDC if the cylinder is on the compression stroke. If both needles do **not** move in the same direction, rotate the engine one complete revolution in the same direction of rotation.

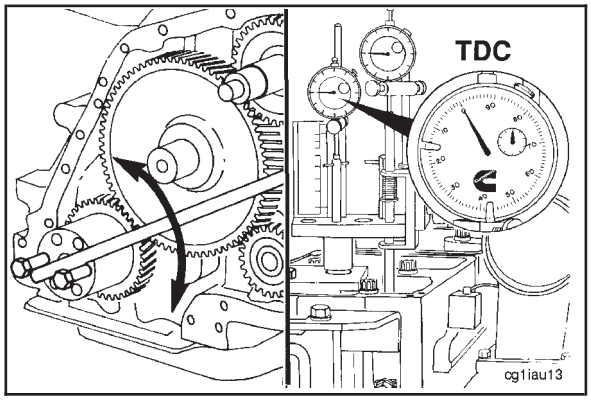
The next frames explain proper orientation and measurement with the dial indicators.



Caution: Both indicators must have a travel range of at least 6.35 mm [0.250-inch] or the indicators will be damaged.

Put the piston travel dial indicator over the plunger rod with the contact tip in the center of the piston plunger rod. Lower the indicator to within 0.63 mm [0.025-inch] of the fully compressed position.

Tighten the thumbscrew to hold the gauge in position.

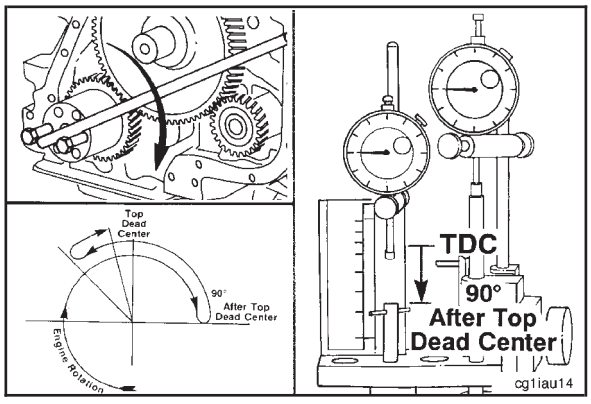


Rotate the crankshaft back and forth to make sure the piston is precisely at top dead center (TDC) on the compression stroke.

NOTE: Always set the dial indicator at ‘‘0’’ (zero) at TDC with the crankshaft having just been rotated in the direction of normal rotation (**clockwise**) to reduce the timing errors due to gear backlash.

NOTE: TDC is indicated by the maximum **clockwise** position of the piston travel indicator pointer.

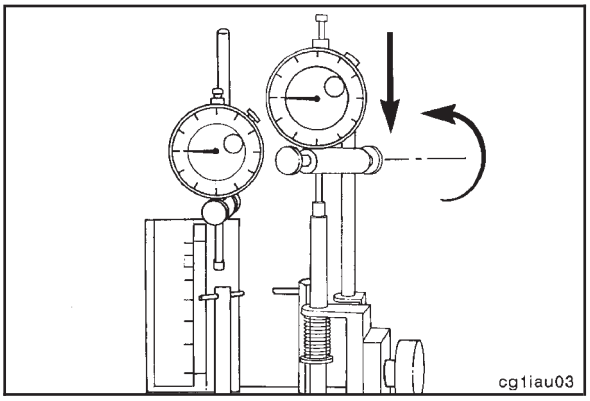
Set the dial indicator at ‘‘0’’ (zero). Lock the indicator face with the thumbscrew.



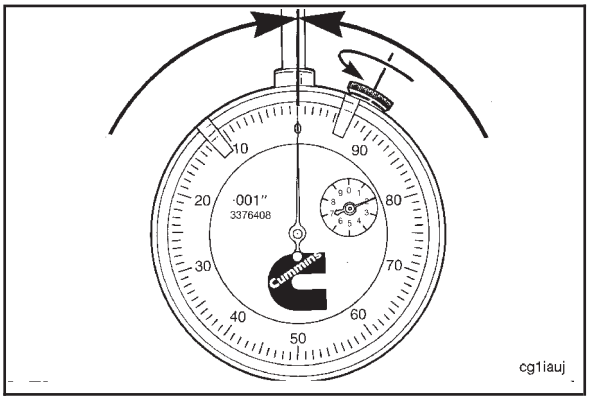
Rotate the crankshaft in the direction of engine rotation (**clockwise**) to 90 degrees after top dead center (ATDC).

NOTE: The piston travel plunger will be at the ‘‘NH/NT 90-degree’’ mark on the timing tool.

Put the push rod travel dial indicator in the center of the injector push rod plunger. Lower the indicator to within 0.63 mm [0.025-inch] of fully compressed position, and tighten the thumbscrew to hold the indicator in position.



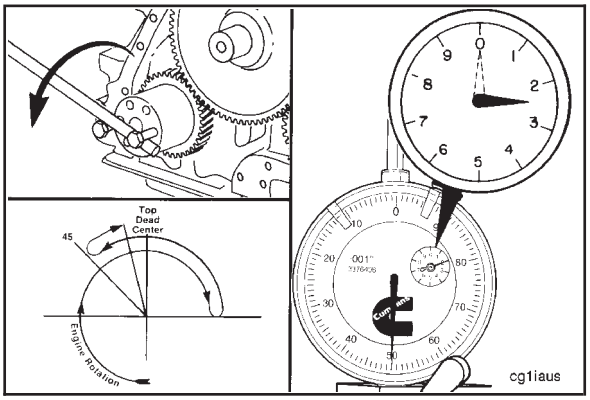
Set the dial indicator at ''0'' (zero). Lock the indicator face with the thumbscrew.



Rotate the crankshaft in the **opposite** direction of engine rotation (**counterclockwise**) through TDC to 45 degrees before top dead center (BTDC).

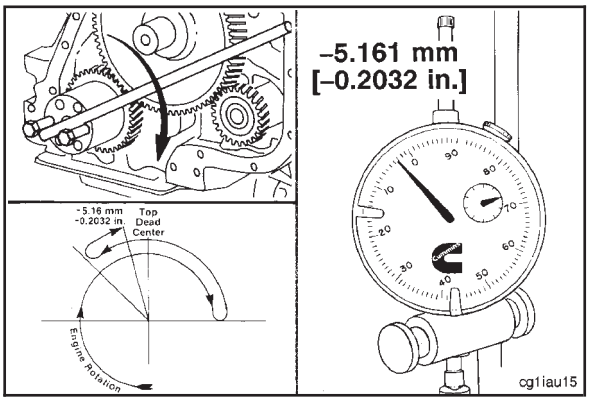
NOTE: This step is necessary to remove the gear train lash and to provide more accurate indicator readings.

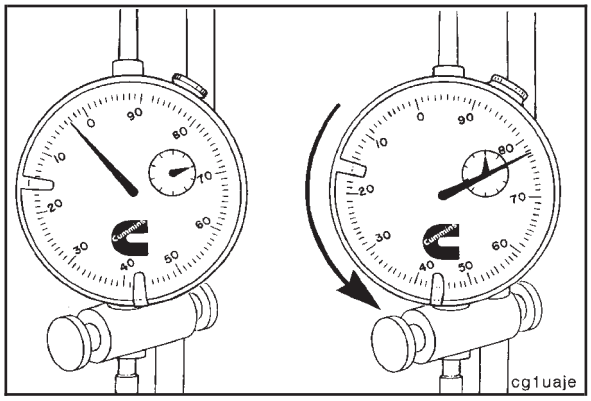
Observe the dial indicator readings prior to crankshaft rotation to assist in later determining BTDC piston setting and timing reading.



NOTE: If the crankshaft is rotated beyond the -5.161 mm [-0.2032-inch] position, the crankshaft **must** be rotated **counterclockwise** back to 45 degrees BTDC. Repeat the following step.

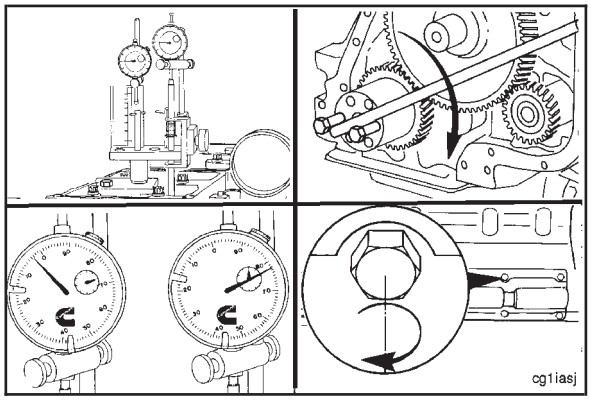
Rotate the crankshaft slowly in the direction of engine rotation (**clockwise**) until a reading of -5.161 mm [-0.2032-inch] BTDC is reached on the piston travel dial indicator.





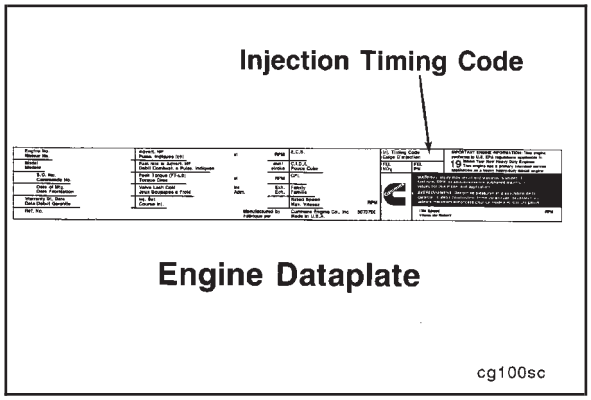
Compare the reading of the injector push rod travel indicator to the specification listed for the timing code.

NOTE: The push rod travel indicator is read in a **counterclockwise** direction from ''0'' (zero). The total amount of travel represents the injection timing value.

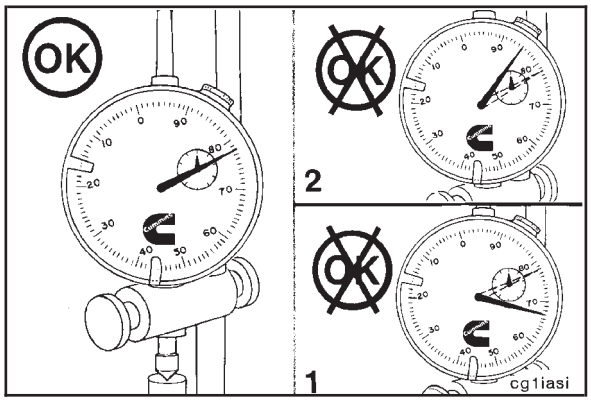


If the injection timing is **not** within the specified limits, check the following:

1. Is the timing tool correctly installed?
2. Are the dial indicators correctly adjusted?
3. Has the crankshaft been rotated in the correct direction and timing sequence?
4. Are the cam follower housing capscrews correctly tightened?
5. Are the crankshaft and camshaft gears in proper alignment?



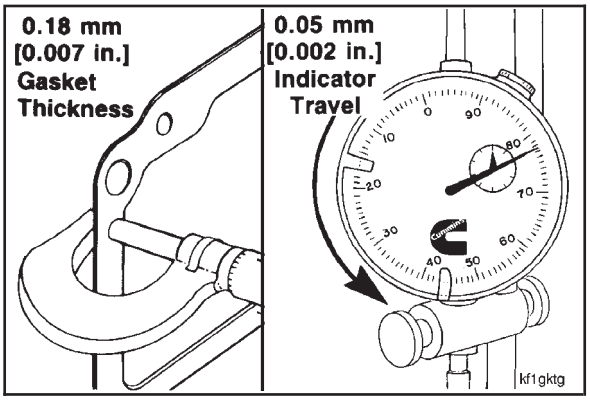
NOTE: To verify the correct injection timing for a particular engine, check the injection timing code on the engine dataplate. To acquire the timing specifications, refer to the Control Parts List (CPL) Manual, Bulletin No. 3379133.



If the indicator reading is higher than the specification, the timing is retarded (2).

If the indicator reading is lower than the specification, the timing is advanced (1).

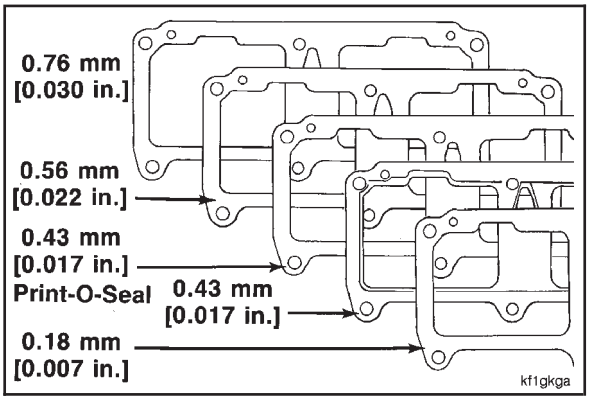
NOTE: The injection timing can be changed by removing the cam follower housing and by increasing or decreasing the gasket thickness. Each 0.18 mm [0.007-inch] of gasket thickness affects injection timing by approximately 0.05 mm [0.002-inch] indicator travel.



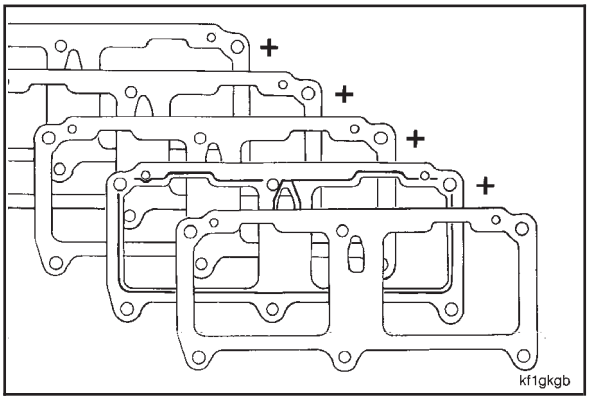
NOTE: Gaskets are available in the following nominal thicknesses:

1. 0.18 mm [0.007-inch].
2. 0.43 mm [0.017-inch].
3. 0.43 mm [0.017-inch] (Print-O-Seal*).
4. 0.56 mm [0.022-inch].
5. 0.76 mm [0.030-inch].

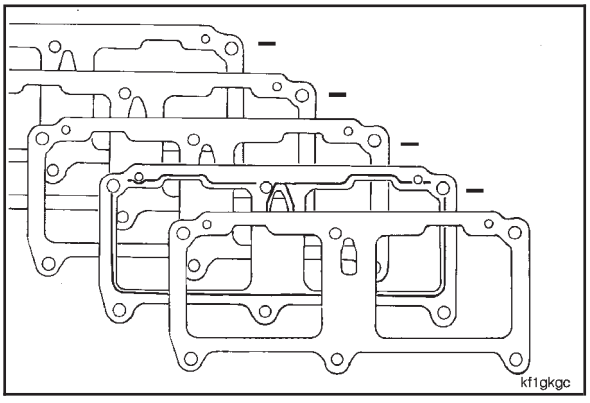
*One Print-O-Seal gasket **must** be used for each cam follower housing.



Increase the gasket thickness to **advance** the injection timing (Add = Advance).

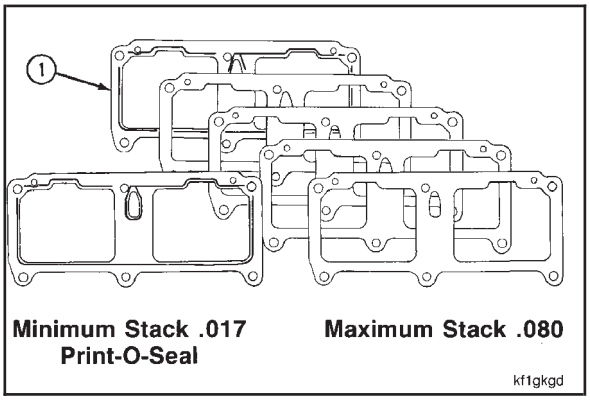


Decrease the gasket thickness to **retard** the injection timing (Remove = Retard).

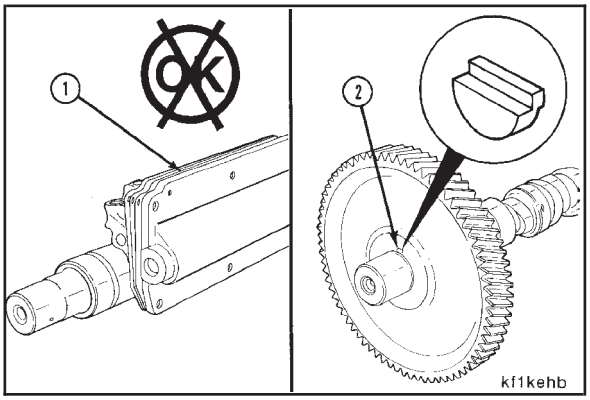


Cam Follower Housing Gaskets		
Gasket Part No.	Thickness [mm] Inch	Change in Push Rod Travel At 19° BTDC [mm] Inch
3020000 (Print-O-Seal)	0.36 to 0.51 [0.014 to 0.020]	0.09 to 0.13 [0.0035 to 0.005]
3020001	0.15 to 0.20 [0.006 to 0.008]	0.04 to 0.05 [0.0015 to 0.002]
3020002	0.36 to 0.51 [0.014 to 0.020]	0.09 to 0.13 [0.0035 to 0.005]
3020003	0.51 to 0.61 [0.020 to 0.024]	0.13 to 0.15 [0.005 to 0.006]
3020004	0.69 to 0.84 [0.027 to 0.033]	0.18 to 0.20 [0.007 to 0.008]

The accompanying chart lists the different cam follower housing gaskets, the gasket thickness, and approximate change in push rod travel at 19 degrees BTDC 0.2032-inch piston travel.

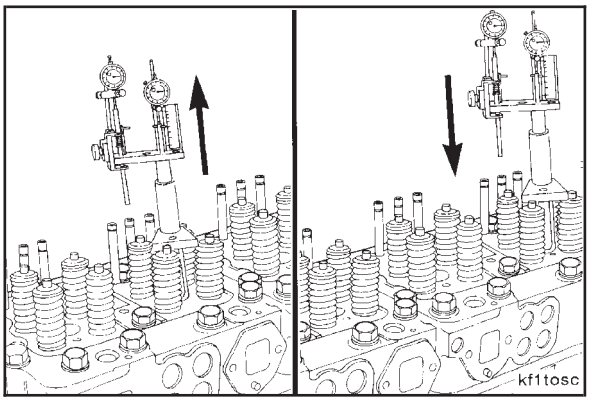


NOTE: The Print-O-Seal gasket (1) **must** be against the cylinder block with the sealing bead toward the cam follower housing. The minimum amount of gasket stack-up thickness which can be used is 0.43 mm [0.017-inch] (one Print-O-Seal gasket). The maximum gasket stack-up thickness allowed is 2.03 mm [0.080-inch].



If you can **not** correct the injection timing by increasing or decreasing the thickness of the cam follower housing gaskets (1), an offset camshaft key (2) **must** be installed.

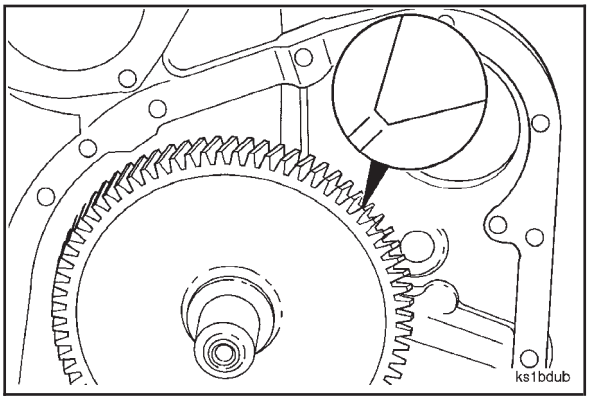
The timing code specifies the required camshaft key. An offset key can be required initially.



After completing the injection timing check on cylinder No. 1, check the injection timing on cylinders No. 5 and No. 3.

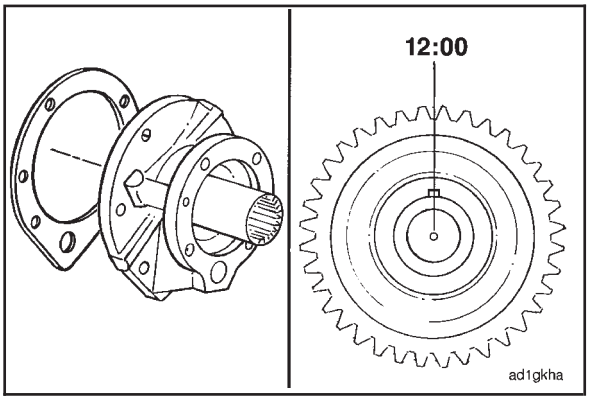
Accessory Drive - Installation

Rotate the crankshaft until the accessory drive timing marks on the camshaft gear are at approximately the 1:00 o'clock position.



Install a new gasket on the accessory drive assembly.

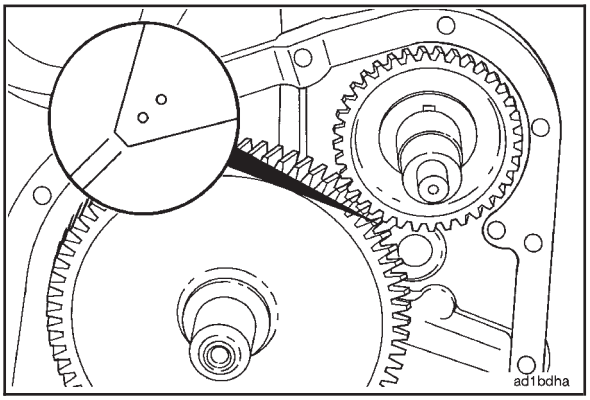
Put the accessory drive shaft dowel pin at approximately the 11:30 o'clock position when facing the shaft from the pulley end.



Install the accessory drive assembly in the gear housing accessory drive mounting hole.

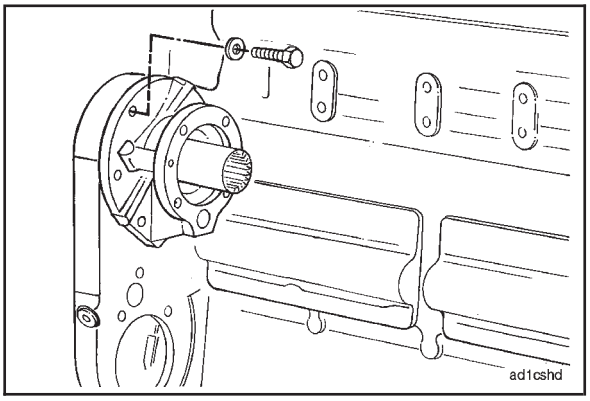
Check the alignment of the camshaft gear and the accessory drive gear timing marks.

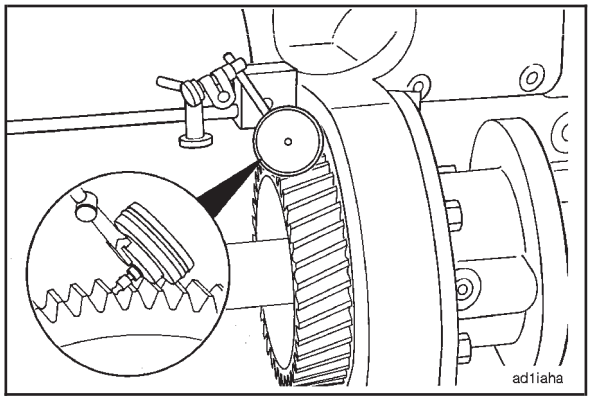
NOTE: The accessory drive shaft dowel pin will be at the 12:00 o'clock position after the accessory drive is installed.



Install and tighten the five accessory drive mounting capscrews.

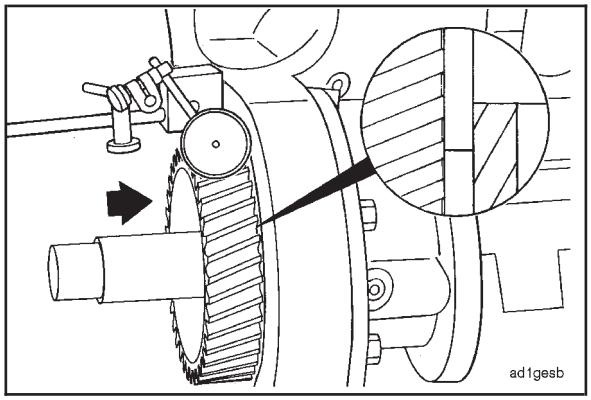
Torque Value: 61 N•m [45 ft-lb]





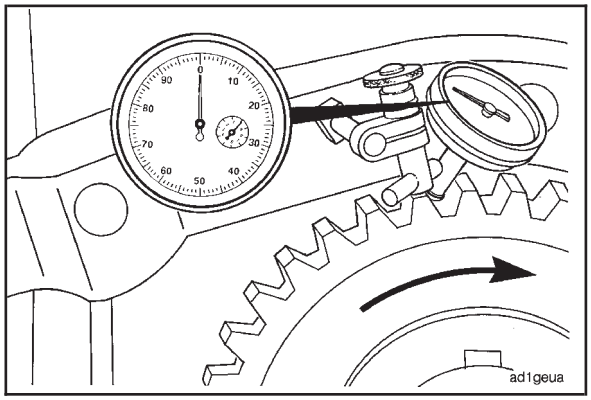
Use a dial indicator to check the backlash between the accessory drive gear and the camshaft gear.

Install the tip of the dial indicator against a tooth on the accessory drive gear as shown.

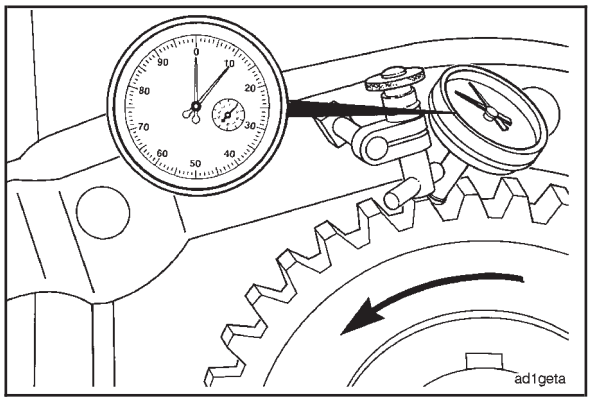


Push the accessory drive gear against the accessory drive thrust washer or thrust face.

Hold the gear against the thrust washer or thrust face when checking the backlash.



Turn the accessory drive gear by hand as far as it will freely move, and set the dial indicator to ‘‘0’’ (zero).



Turn the accessory drive gear by hand in the **opposite** direction as far as it will freely move, and read the dial indicator.

Backlash Between the Accessory Drive and the Camshaft Gear

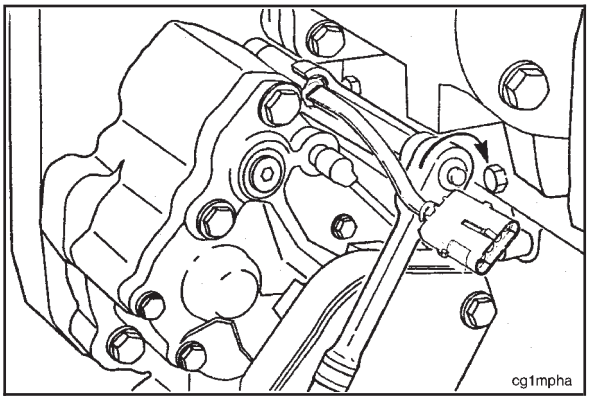
mm		in
0.05	MIN	0.002
0.50	MAX	0.020

If the backlash is **not** within specifications, the gear **must** be replaced.

CELECT™ Engine Position Sensor (EPS) - Installation

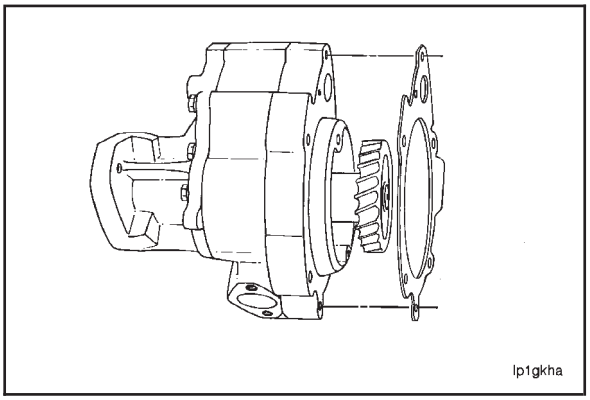
Install a new EPS in the mounting hole in the block. Make sure a new o-ring is present and in place. Use service tool, Part No. 3822747. Tighten the EPS.

Torque Value: 34 N•m [25 ft-lb]



Lubricating Oil Pump - Installation

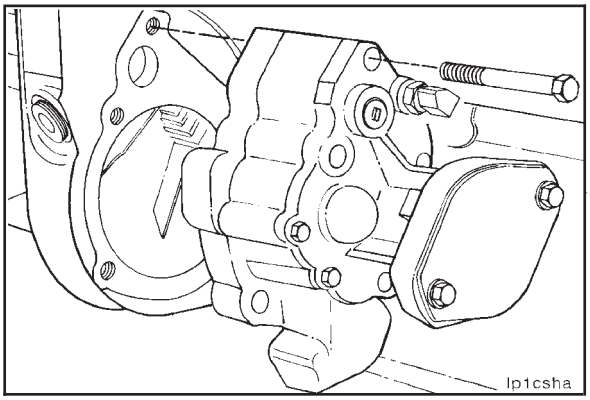
Install a new gasket on the mounting trunion of the lubricating oil pump.



Install the lubricating oil pump in the mounting hole in the cylinder block gear flange.

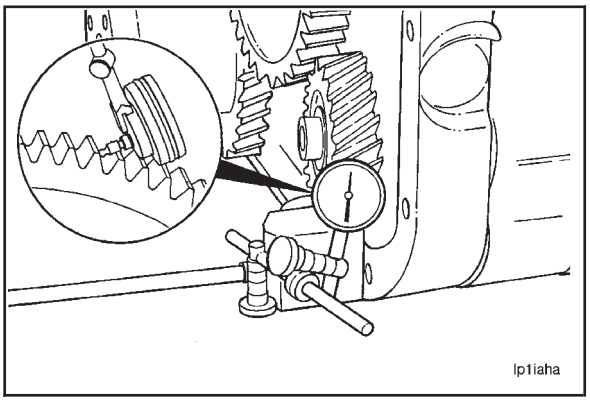
Install and tighten the five mounting capscrews.

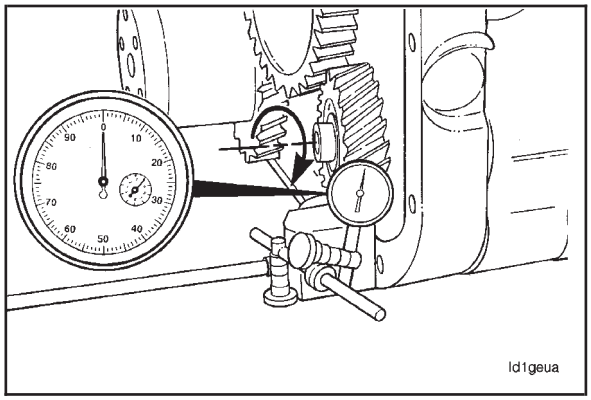
Torque Value: 54 N•m [40 ft-lb]



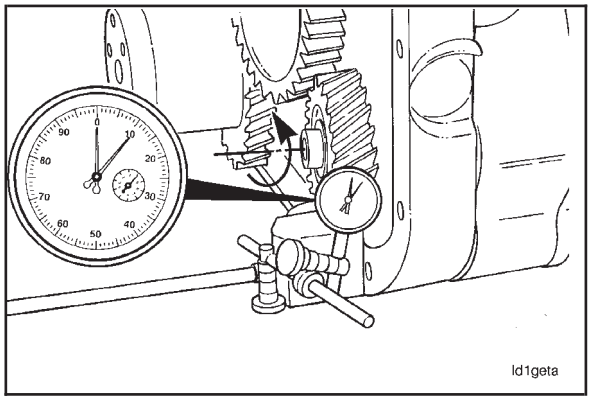
Use a dial indicator to check the backlash between the lubricating oil pump and the camshaft gear.

Install the tip of the dial indicator against a tooth on the lubricating oil pump drive gear as shown.





Turn the lubricating oil pump drive gear by hand as far as it will freely move, and set the dial indicator to ''0'' (zero).

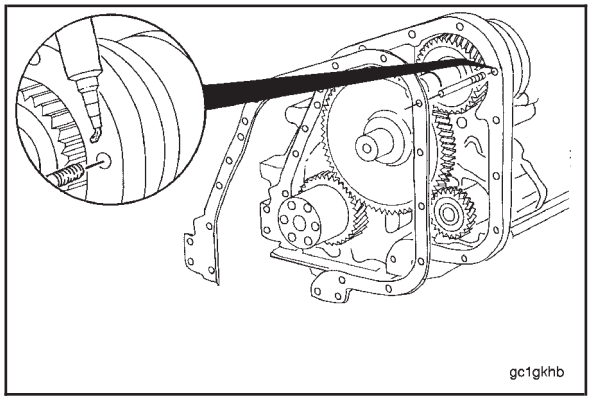


Turn the lubricating oil pump drive gear by hand in the **opposite** direction as far as it will freely move, and read the dial indicator.

Backlash Between the Lubricating Oil Pump Drive Gear and the Camshaft Gear

mm		in
0.05	MIN	0.002
0.50	MAX	0.020

If the backlash is **not** within specifications, the lubricating oil pump drive gear **must** be replaced.

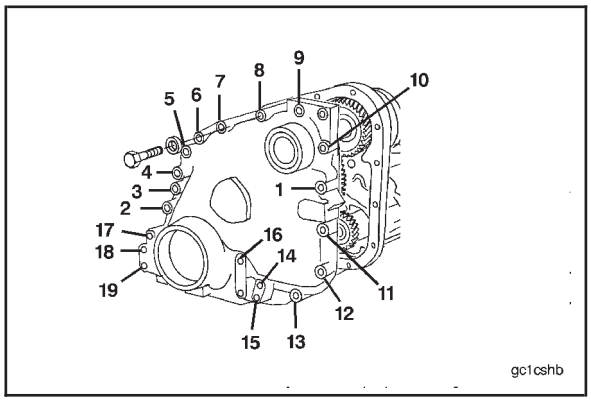


Gear Cover - Installation

Install one 7/16-20 X 4-inch guide stud in each side of the gear cover mounting flange to align the cover.

Install the gear cover gasket over the guide studs and the dowel pins.

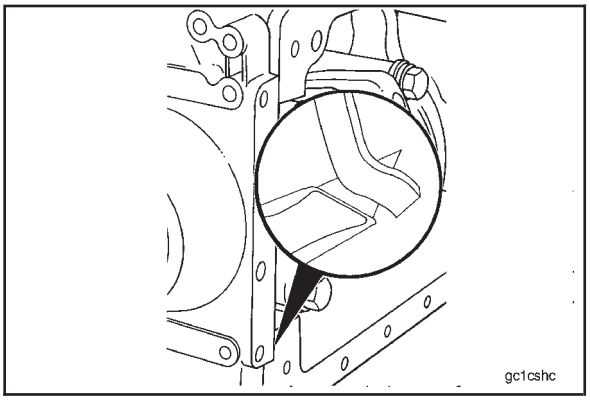
NOTE: Use a film of Lubriplate® 105 or its equivalent or grease to hold the gear cover gasket in place, if necessary.



Install the gear cover. Install and tighten the mounting capscrews in the sequence shown.

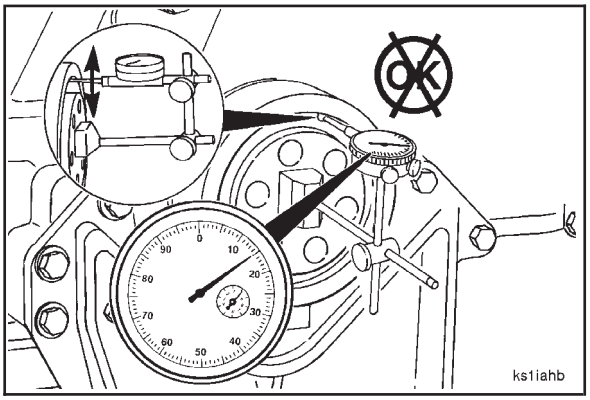
Torque Value: 68 N•m [50 ft-lb]

Cut off the ends of the gasket even with the cylinder block oil pan mounting flange.



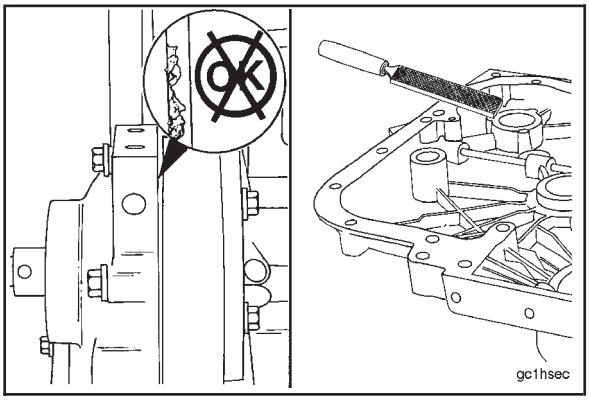
Mount a dial indicator on the front face of the crankshaft. Put the indicator plunger against the oil seal bore, and set the dial indicator to ''0'' (zero).

Rotate the crankshaft one complete revolution while monitoring the indicator. The total indicator reading **must not** exceed 0.38 mm [0.015-inch].

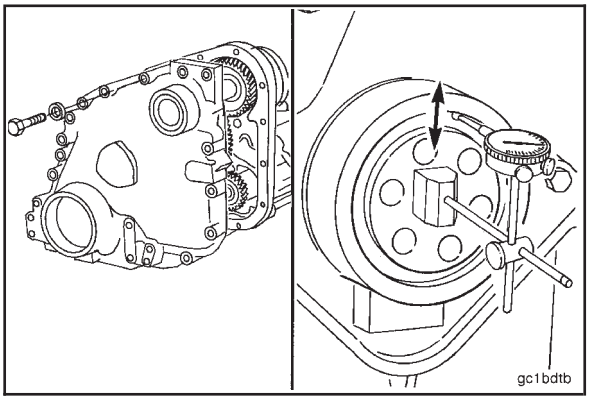


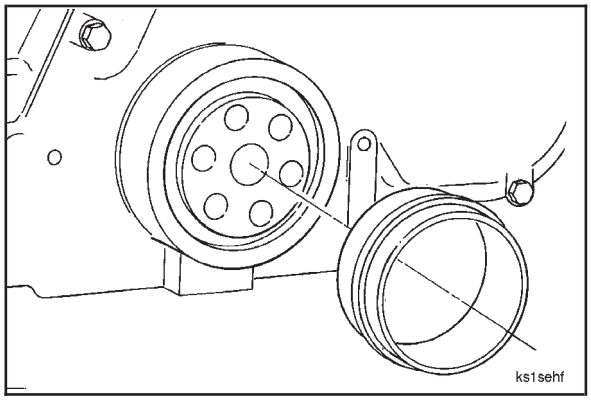
If the total indicator runout exceeds 0.38 mm [0.015-inch], remove the gear cover. Check the cover and the housing for nicks or burrs.

Clean the gear cover and the housing surfaces thoroughly.



Repeat the gear cover installation procedure, and check the total indicator runout again. If the total indicator readout is **not** within specifications, the gear cover **must** be replaced.

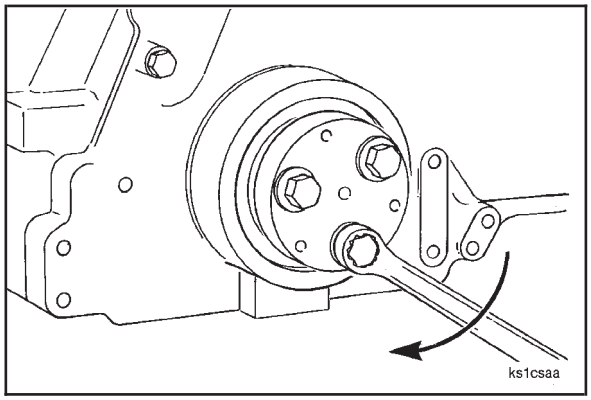




Crankshaft Seal, Front - Installation

NOTE: ''LDL TFE'' (Lay-down Lip, Teflon) oil seals for service replacement have an assembly tool which protects the seal lip during shipment and installation. The ''LDL TFE'' oil seal **must** be installed with the lip of the seal and the crankshaft clean and dry. Do **not** use any kind of lubricant. The use of lubricant will result in oil leakage at the seal.

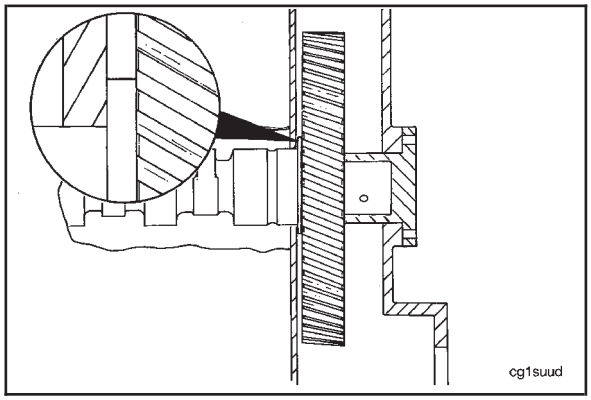
Use hand pressure to push the oil seal from the assembly tool onto the crankshaft as far as possible. Remove the assembly tool.



Install top plate, Part No. ST-1259-1, (from oil seal puller/installer, Part No. ST-1259) on the crankshaft; and use three vibration damper mounting capscrews and flat washers.

Tighten the three capscrews alternately in 1/2 turn increments until top plate, Part No. ST-1259-1, seats against the crankshaft nose.

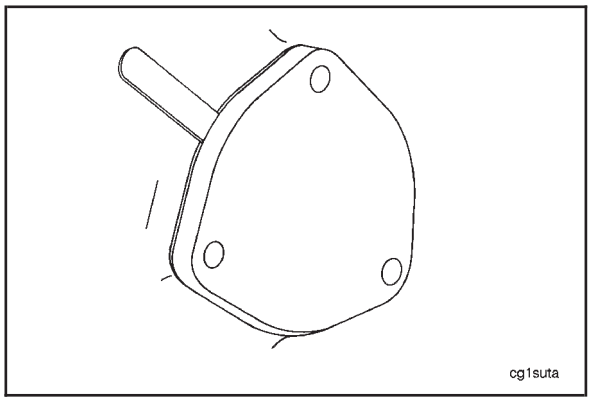
Remove the oil seal puller/installer, Part No. ST-1259.



Camshaft Bearing Support - Installation

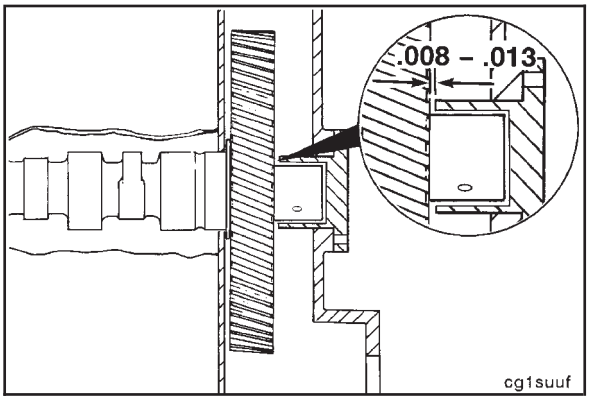
Install the support bearing in the bore of the gear cover. Do **not** install the o-ring on the support at this time.

Push the support against the camshaft so the camshaft gear rests against the camshaft thrust washer.

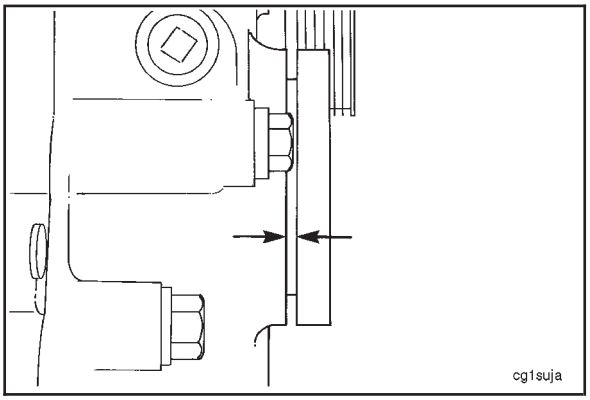


Hold the support against the camshaft, and use a feeler gauge to measure the space between the gear cover flange and the support bearing.

The clearance between the bearing support thrust face and the camshaft gear **must** be 0.20 mm to 0.33 mm [0.008- to 0.013-inch].

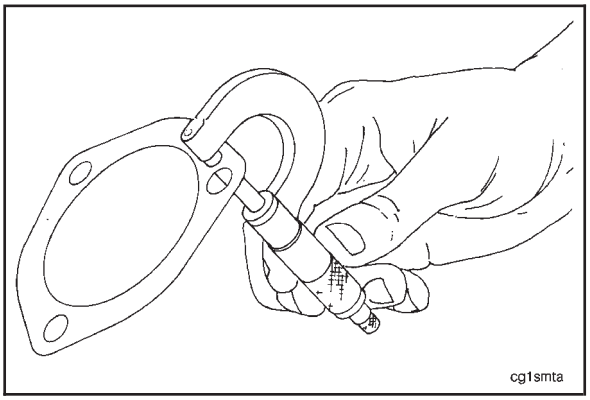


After measuring the space between the bearing support and the gear cover flange, add an additional 0.20 mm to 0.33 mm [0.008-inch to 0.013-inch] to that number to determine the thickness of the shims required. Example: Space of 1.52 mm [0.060-inch], measured with a feeler gauge, plus 0.25 mm [0.010-inch] for clearance would require 1.77 mm [0.070-inch] shims.

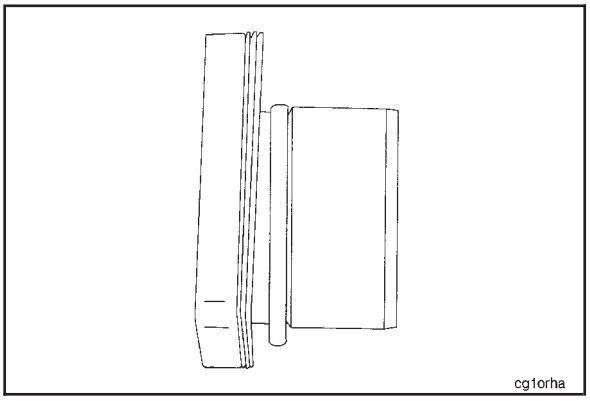


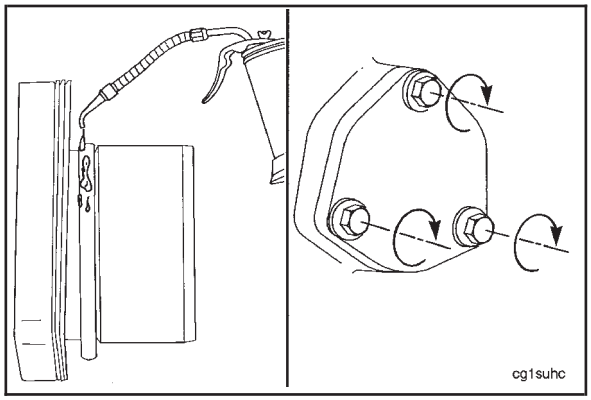
Use a micrometer to measure the shims removed from the support at the time of disassembly. Add or remove shims as required to obtain the correct clearance between the bearing support and the camshaft gear. Shims are available in the following thicknesses:

Shim Thickness	
mm	**in**
0.05	0.002
0.13	0.005
0.25	0.010
0.63	0.025



Install the required number of shims and a new o-ring on the support bearing.

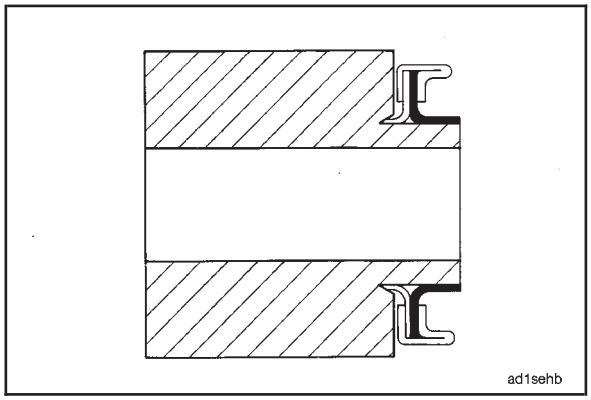




Caution: Do not use lubricating oil on the o-ring. The o-ring will increase in size when in contact with lubricating oil. Use vegetable oil to lubricate the o-ring.

Lubricate the o-ring with vegetable oil, and install the support bearing into the gear cover. Tighten the capscrews.

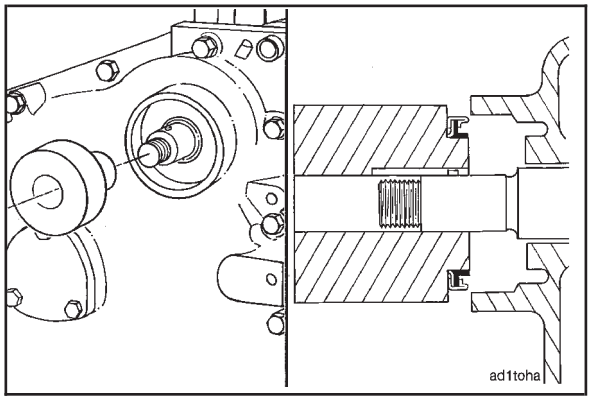
Torque Value: 27 N•m [20 ft-lb]



Accessory Drive Seal - Installation

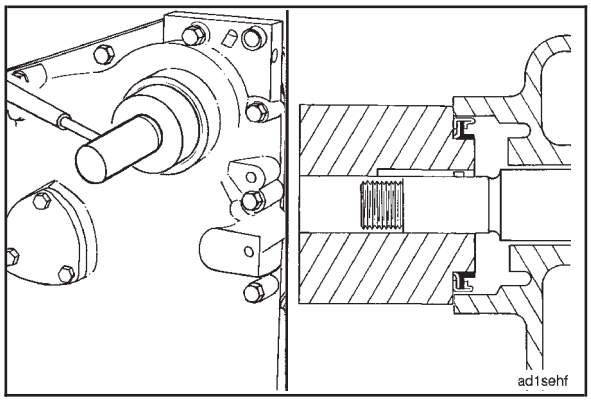
Install the oil seal on the fuel pump drive oil seal mandrel, Part No. ST-1173, with the closed or part number side facing the driver.

NOTE: Do **not** use any kind of lubricant to install the seal. The oil seal **must** be installed with the lip of the seal and the seal wear area of the accessory drive pulley clean and dry. Use of lubricant will result in oil leakage at the seal.



Put the fuel pump drive oil seal mandrel, Part No. ST-1173, over the accessory drive shaft.

Align the keyway in the driver with the groove pin in the accessory drive shaft.



Push the seal into the seal bore until the seal driver contacts the gear cover.

Accessory Drive Pulley - Installation

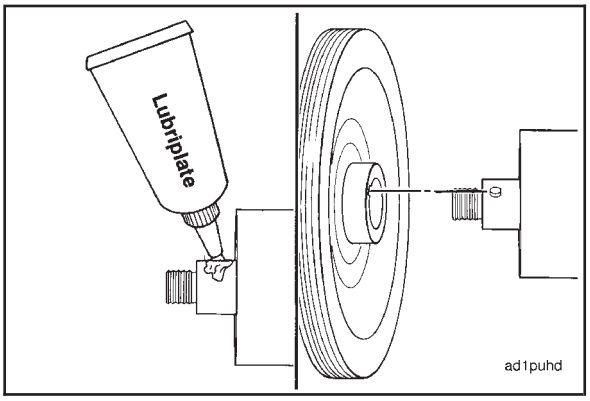
NOTE: Make sure the pipe plug behind the pulley is installed and tightened before pulley installation.

Apply a film of Lubriplate® 105 or its equivalent to the accessory drive shaft.

NOTE: Do **not** lubricate the seal or wear sleeve surfaces. This will prevent the seal from proper seat-in and cause the seal to leak.

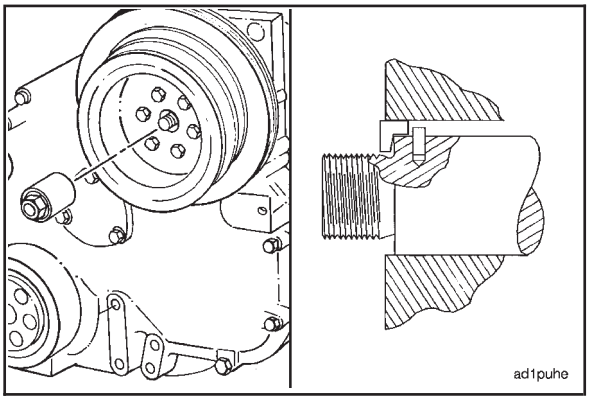
Align the keyway in the pulley with the dowel pin in the shaft.

Use your hand to partially push the pulley onto the shaft.



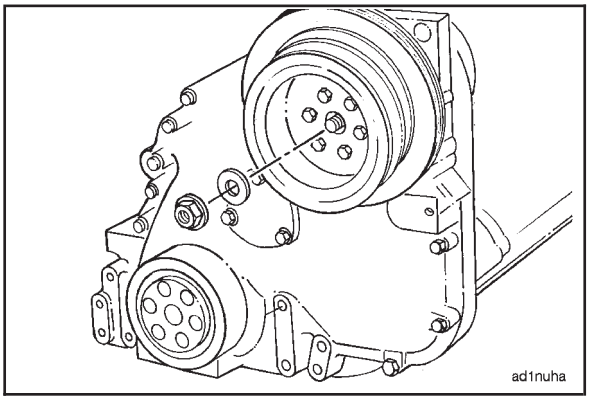
Install pulley installation tool, Part No. 3376326, on the accessory drive shaft; and press the pulley on the shaft until it fits against the shaft flange.

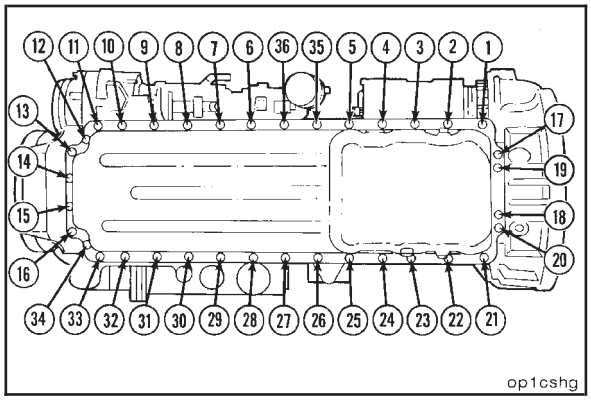
Install the keyway seal in the pulley keyway with one end of the seal pointing toward the center line of the shaft.



Install the washer and the flange retaining nut on the accessory drive shaft. Keep the crankshaft from rotating and tighten the nut.

Torque Value: 421 N•m [310 ft-lb]





Lubricating Oil Pan - Installation

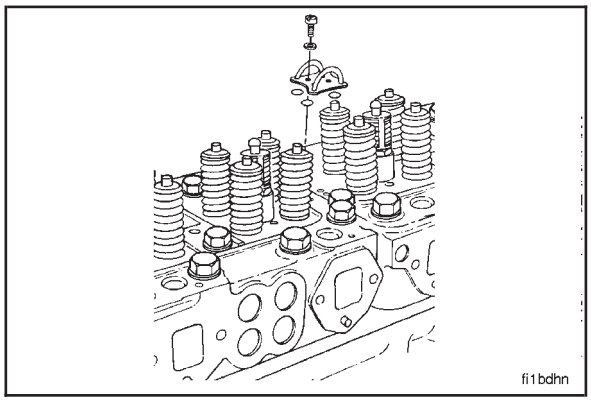
Install the oil pan gasket and the oil pan on the cylinder block. Use your fingers to install and tighten one of the 7/16-inch oil pan mounting capscrews on each side of the oil pan, halfway between the front and the rear of the oil pan. Use your fingers to install and tighten all the mounting capscrews.

Tighten the four 5/16-inch capscrews in the rear of the oil pan in the sequence shown.

Torque Value: 27 N•m [20 ft-lb]

Tighten the thirty-two (32) 7/16-inch capscrews in the sequence shown.

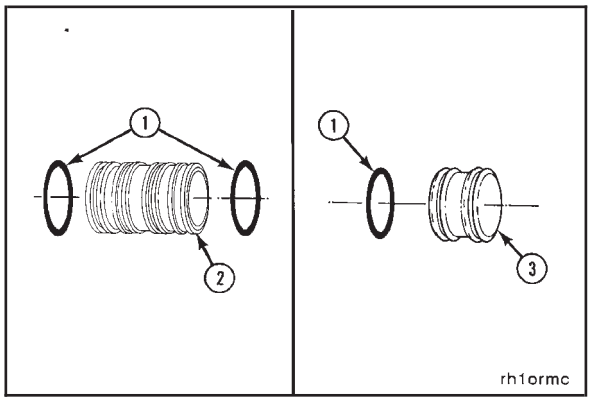
Torque Value: 68 N•m [50 ft-lb]



Fuel Crossovers - Installation

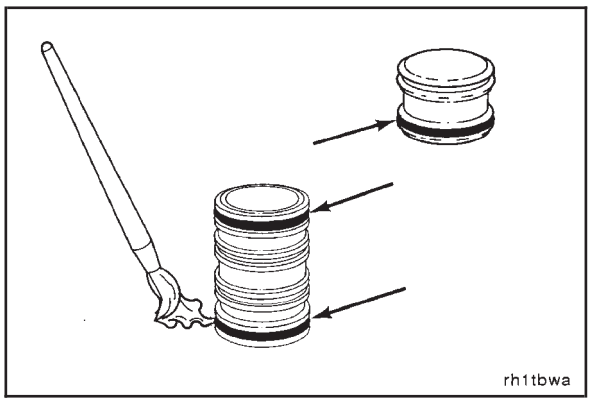
Use new o-rings, and install the two fuel crossover connections and the two cover plates. Tighten the capscrews.

Torque Value: 4.0 N•m [35 in-lb]



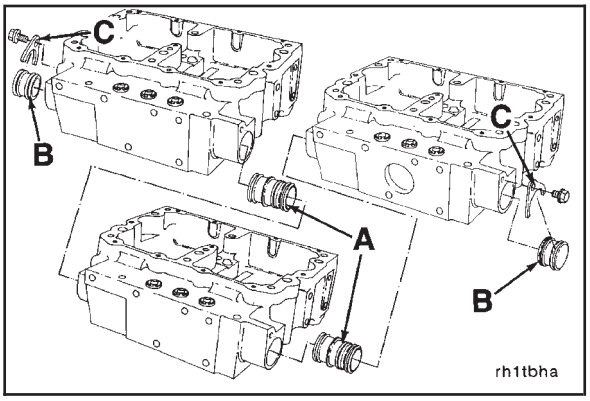
Rocker Lever Housing - Installation

Install two o-rings (1) on each of the two water tubes (2). Install one o-ring (1) on each of the two water plugs (3).

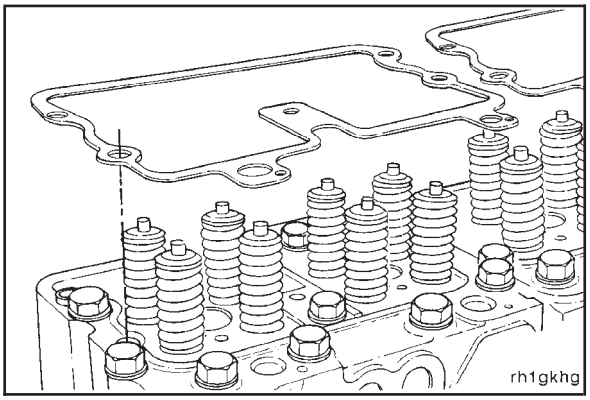


Apply a non-petroleum based lubricant such as soap or vegetable oil to the o-rings on the tubes and the plugs and to the bores in the rocker housing.

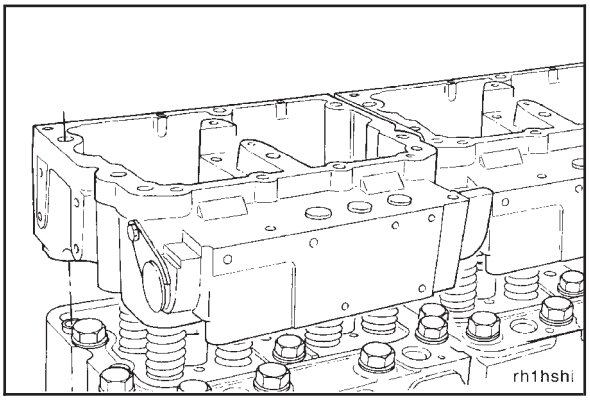
Install the water tubes (A) in the front of the No. 2 and No. 3 rocker lever housings. Install the plugs (B) in the front of the No. 1 rocker lever housing and in the rear of the No. 3 rocker lever housing.



Install new rocker lever housing gaskets on the cylinder heads.



Install the rocker lever housings.

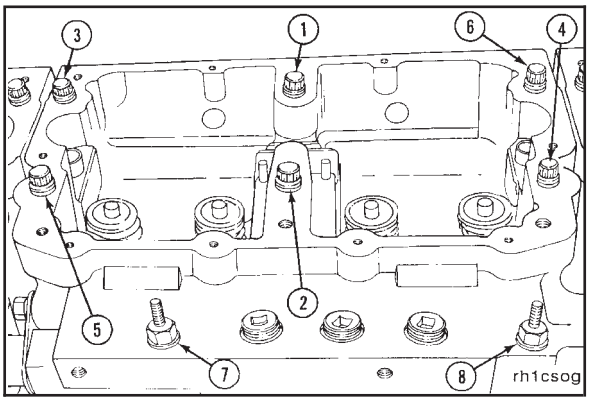


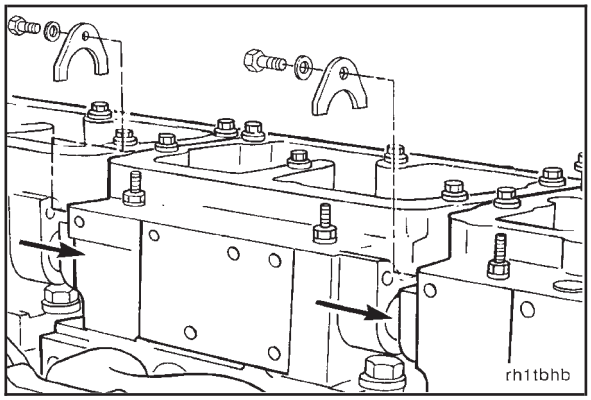
Tighten the rocker lever housing capscrews in the sequence shown (1 through 6).

Torque Value: 115 N•m [85 ft-lb]

Tighten the rocker lever housing capscrews in the sequence shown (7 and 8).

Torque Value: 47 N•m [35 ft-lb]



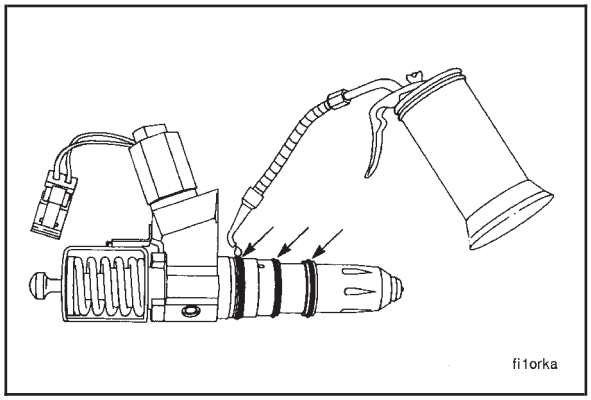


Use service tool, Part No. 3823819, to slide the two water tubes into the adjacent water manifold.

Install the two water tube retainer clamps.

Install and tighten the retainer clamp capscrews.

Torque Value: 45 N•m [33 ft-lb]



Injectors - Installation

CELECT™ Engines

NOTE: When installing injectors for reuse, new o-rings **must** be installed on the injector.

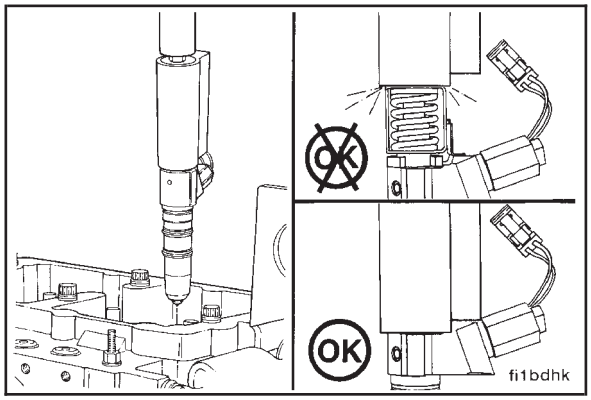
NOTE: The CELECT™ injectors require three different injector o-rings. The o-rings are color coded as follows:

Top o-ring - Black

Center o-ring - Brown

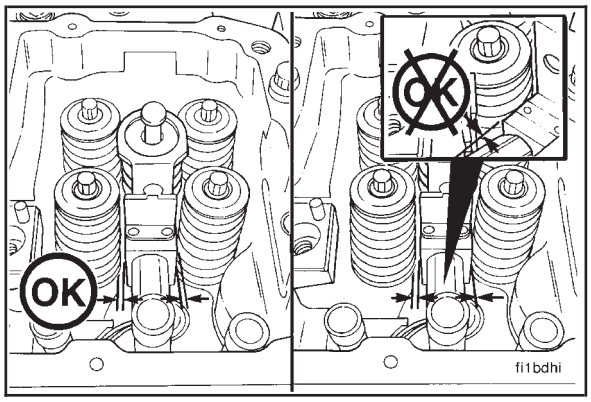
Bottom o-ring - Black with a white identification dot.

Lubricate the o-rings with lubricating oil just before installation.



Caution: Do not strike the top stop spring cage when installing CELECT™ injectors.

Using the CELECT™ injector puller/installer, Part No. 3823579, install the injector into the cylinder head injector bore with the injector solenoid valve facing the intake side of the engine.

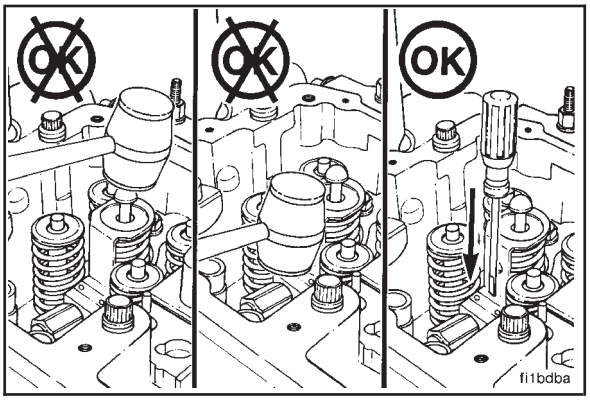


After partial installation of the injector, take precautions to center the solenoid valve between the valve springs. Avoid contact with the spring coils. If the injector is contacting a valve spring, use a screwdriver to position the injector again.

Warning: Do not strike or pry on the solenoid. Otherwise, injector damage will occur.

Continue driving the injector into the bore using the puller/installer, Part No. 3283579.

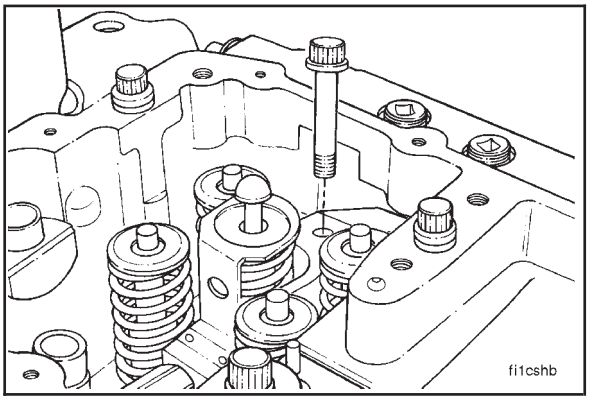
If injector puller, Part No. 3823579, is **not** available, a screwdriver can be used to install the injector by putting the screwdriver on the injector body at the base of the injector solenoid and striking the screwdriver with a soft mallet. Do **not** strike on the injector solenoid or on the top stop spring cage.



Warning: The injector must be fully seated before installing the hold down clamp. The hold down clamp can not pull the injector into the bore. Engine damage can occur if the injector is not fully seated.

Install the hold down clamp capscrew.

Torque Value: 54 N•m [40 ft-lb]

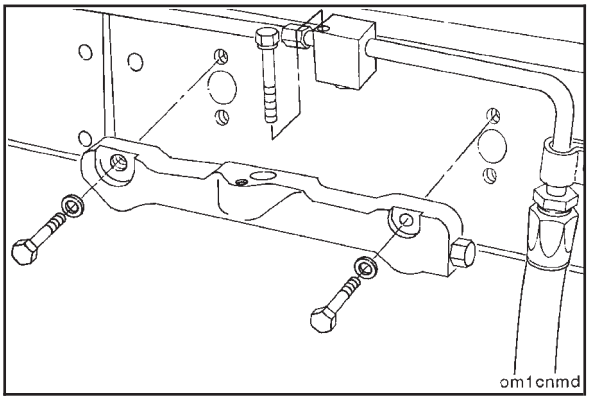


STC Engines

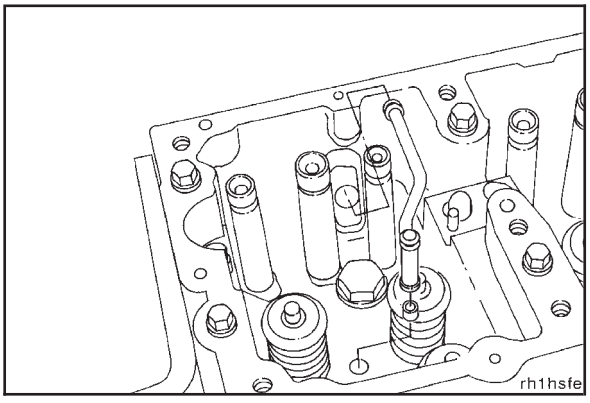
Install the oil manifold connector using new o-rings. Lubricate the o-rings and the rocker housing bores with vegetable oil. Also lubricate the internal jumper tube and o-ring and carefully align them with the external manifold connector during assembly. A snap will be felt as the oil manifold connector seats into the rocker lever housing.

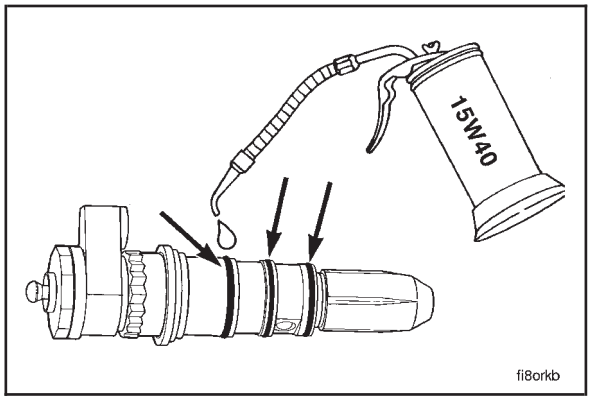
Install the two mounting capscrews and tighten.

Torque Value: 24 N•m [18 ft-lb]



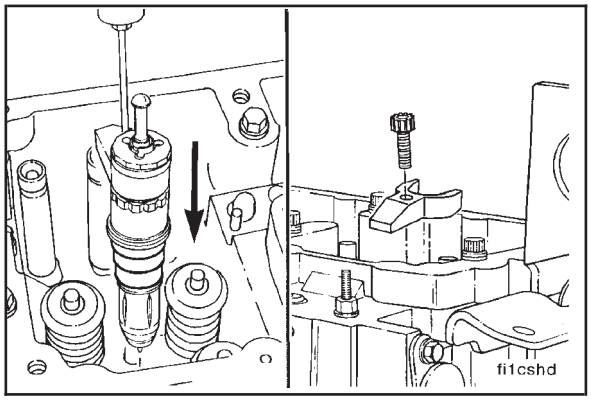
Install the internal oil tube using a new grommet seal and new o-rings. Lubricate the o-rings with vegetable oil.





NOTE: When installing injectors for reuse, new o-rings **must** be installed on the injector.

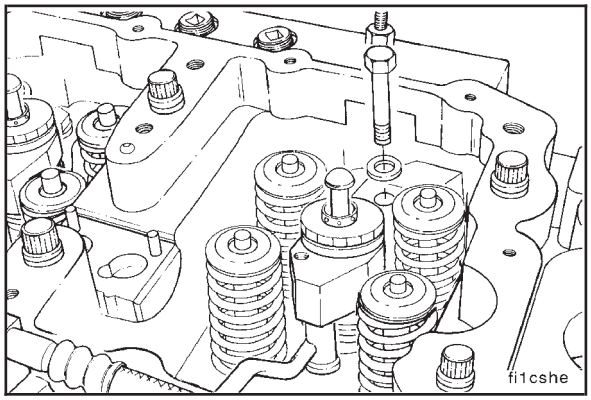
Lubricate the o-rings with lubricating oil just before installation.



Install the injector and hold down clamp.

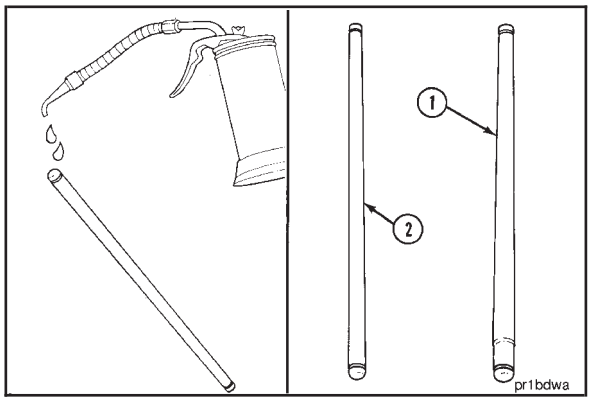
Use injector puller, Part No. 3822697, to install STC injectors.

Make sure the injector oil feed is aligned over the oil transfer tube.



Install the hold down clamp capscrew.

Torque Value: 54 N•m [40 ft-lb]

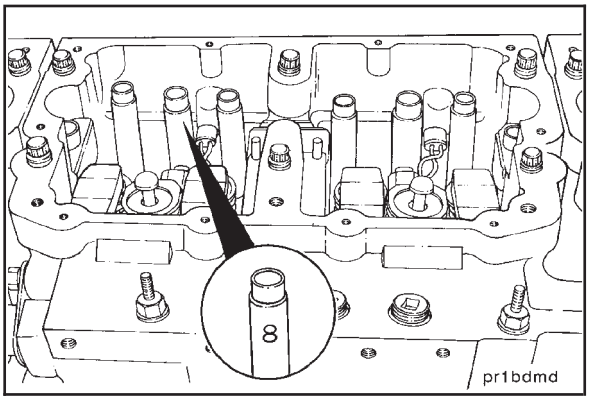


Push Tubes - Installation

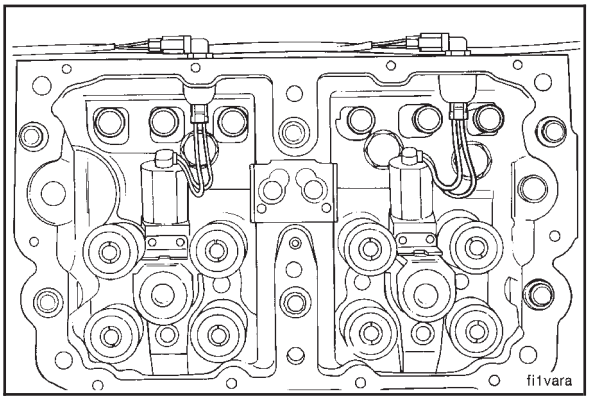
Use clean 15W-40 oil to lubricate the ball end of the push tubes.

NOTE: The injector push tubes (1) are larger in diameter than the valve push tubes (2).

Install the push tubes in the corresponding numbered location.

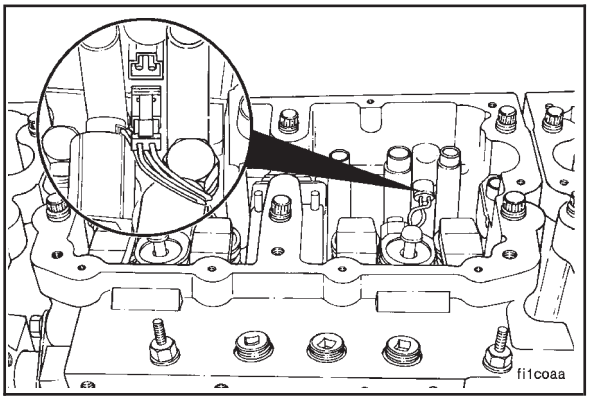


On CELECT™ engines, take care to route the injector solenoid leads to avoid contact with the valve and injector push tubes.



Twist the injector connector three turns to twist the lead wires.

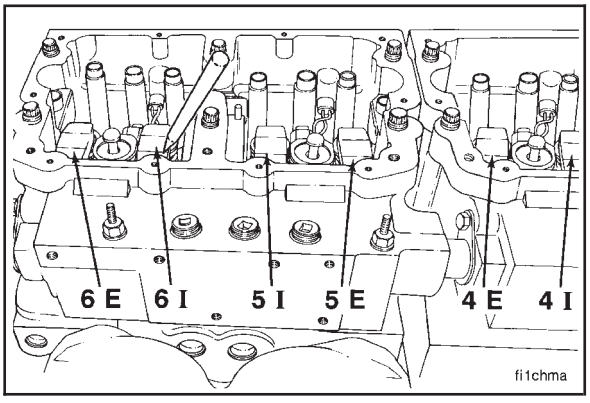
Connect the injector solenoid connector lead to the pass through connector in the rocker housing. Push the connector lead into the connector until the retainer seats.

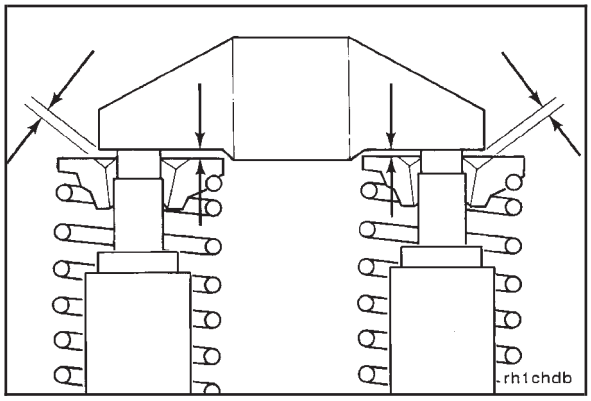


Valve Crossheads - Installation

Install the valve crossheads in their original location and orientation.

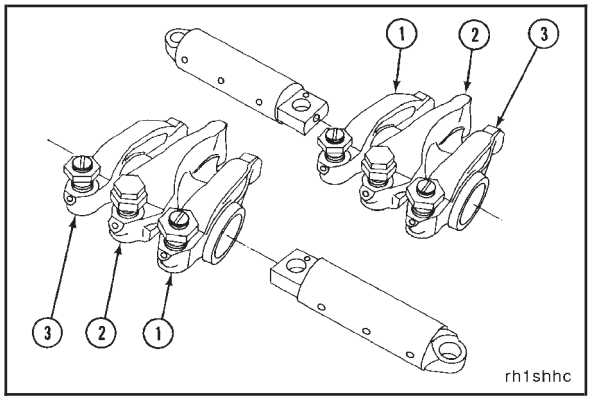
Lubricate the valve stems with clean 15W-40 oil.





Use a wire gauge to check the clearance between the crosshead and the valve spring retainer. The clearance **must** be a minimum of 0.51 mm [0.020-inch].

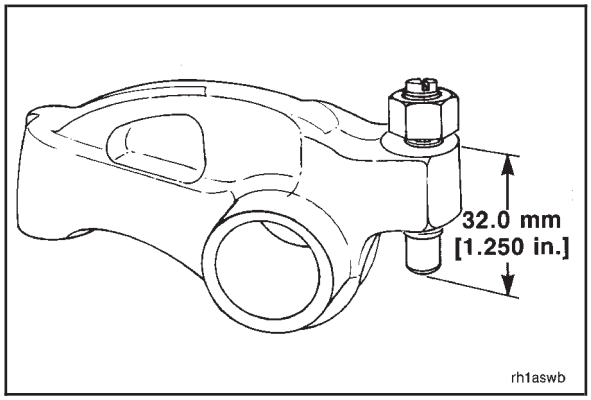
NOTE: The large pocket goes toward the exhaust side.



Rocker Lever Shaft Assemblies - Installation

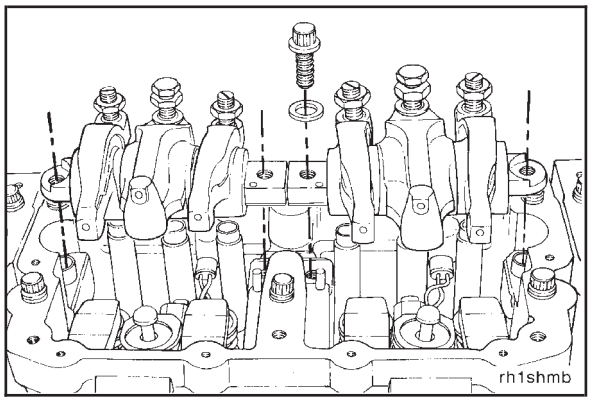
Install the exhaust (1), injector (2), and intake (3) rocker levers onto the shaft.

The two levers closest to the center of the rocker housing are the intake valve rocker levers. The levers closest to the end of the rocker housing are the exhaust valve rocker levers.



Caution: If the adjusting screws protrude beyond the maximum listed below, the push rods can be damaged when the rocker lever shaft capscrews are tightened. Do not attempt to install the rocker lever shaft assemblies without resetting the lash.

Loosen the rocker lever adjusting screws so there is a maximum of 32 mm [1.250 inches] from the top surface of the lever and the ball end of the adjusting screw.

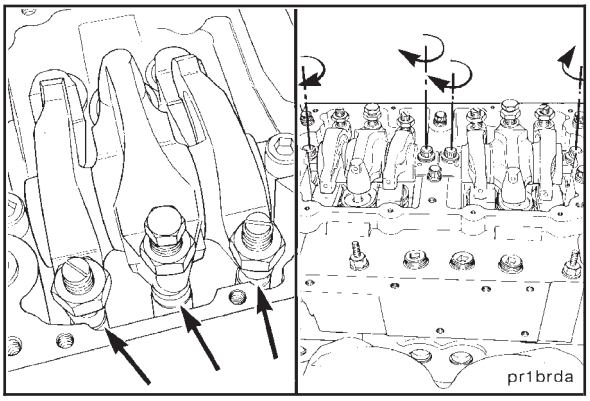


Put the rocker lever assembly over the dowel pin and dowel ring located in the rocker housing.

NOTE: Do **not** damage the dowel pin and ring located in the rocker housing.

Make sure the push rods are in the cam follower sockets, and align the push rods with the injector and valve rocker lever adjusting screws.

Alternately tighten the rocker shaft capscrews in 54 N•m [40 ft-lb] increments to 156 N•m [115 ft-lb].



Injector and Valve Adjustment

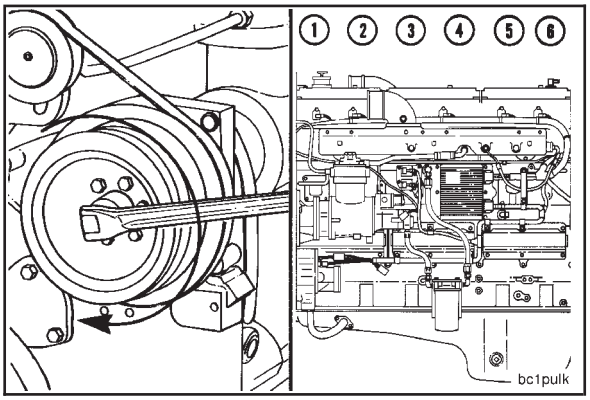
CELECT™ Engines

The valve set marks are located on the accessory drive pulley. The marks align with a pointer on the gear cover. Use the accessory drive shaft to rotate the crankshaft.

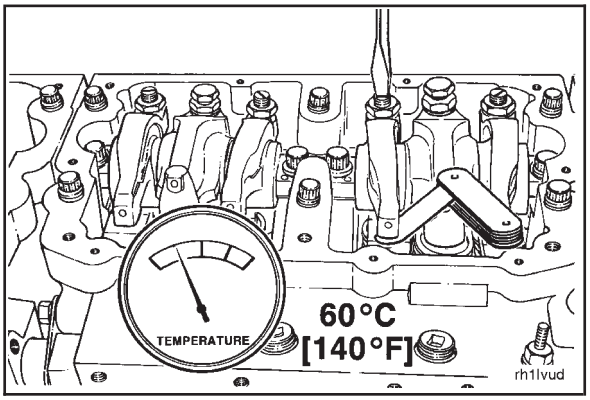
The crankshaft rotation is **clockwise** when viewed from the front of the engine.

The cylinders are numbered from the front end of the engine.

The engine firing order is 1-5-3-6-2-4.



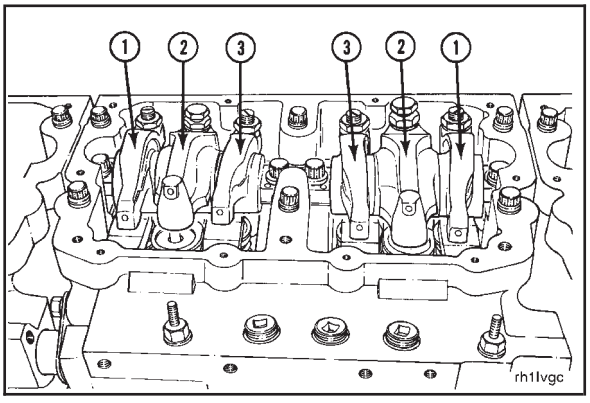
All overhead (valve and injector) adjustments **must** be made when the engine is cold (any stabilized coolant temperature at 60°C [140°F] or below).



Each cylinder has three rocker levers. The rocker lever nearest to the center of the housing is the intake lever.

- The exhaust rocker lever (1).
- The injector rocker lever (2).
- The intake rocker lever (3).

The two levers closest to the center of each rocker housing are the intake rocker levers. The two levers closest to the ends of the rocker housing are the exhaust levers.

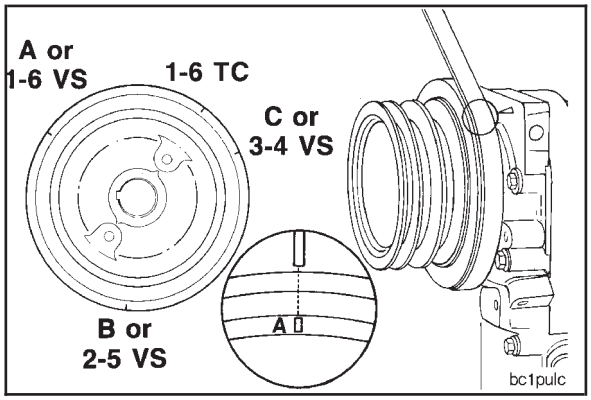


CELECT™ Engine Injector and Valve Adjustment Sequence			
Bar Engine in Direction of Rotation	**Pulley Position**	**Set Cylinder**	
		Injector	**Valve**
Start	A	1	1
Advance to	B	5	5
Advance to	C	3	3
Advance to	A	6	6
Advance to	B	2	2
Advance to	C	4	4
Firing Order: 1-5-3-6-2-4			

The valves and the injectors on the same cylinder are adjusted at the same index mark on the accessory drive pulley.

One pair of valves and one injector are adjusted at each pulley index mark **before** rotating the accessory drive to the next index mark.

Two crankshaft revolutions are required to adjust all the valves and the injectors.



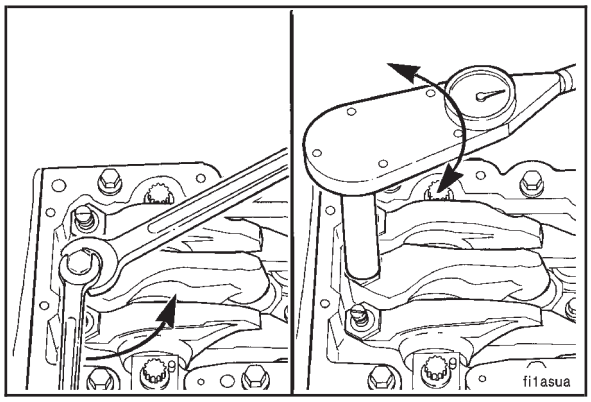
Rotate the accessory drive in the direction of engine rotation. The accessory drive will rotate **clockwise** on a right hand engine, when looking at the front of the engine. Align the ''A'' mark on the accessory drive pulley with the pointer on the gear cover.

CELECT™ Engine Injector and Valve Adjustment Sequence			
Bar Engine in Direction of Rotation	**Pulley Position**	**Set Cylinder**	
		Injector	**Valve**
Start	A	1	1
Advance to	B	5	5
Advance to	C	3	3
Advance to	A	6	6
Advance to	B	2	2
Advance to	C	4	4
Firing Order: 1-5-3-6-2-4			

Check the valve rocker levers on cylinder No. 1 to see if both valves are closed.

NOTE: Both valves are closed when both rocker levers are loose and can be moved from side to side. If both valves are **not** closed, rotate the accessory drive one complete revolution; and align the ''A'' mark with the pointer again.

If the valve rocker lever adjusting screws have been loosened and **not** yet adjusted, watch the valve push tubes as the engine rolls upon the ''A'' mark. Both valve push tubes will have moved to the downward (valve closed) position if the engine is on the correct stroke.

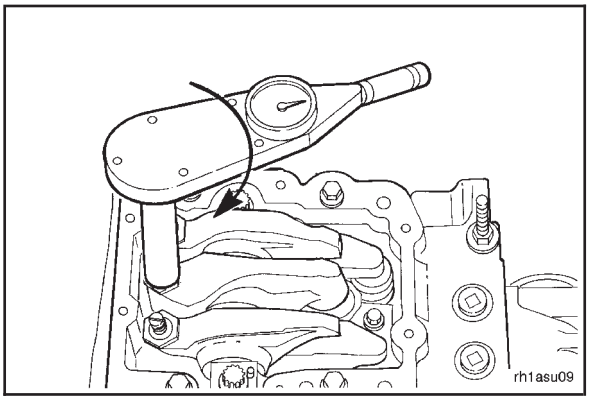


Loosen the injector adjusting screw lock nut on cylinder No. 1. Bottom the injector plunger by tightening and loosening the adjusting screw 2.8 N•m [25 in-lb] three or four times to remove the fuel.

NOTE: Do **not** bottom the plunger any tighter than 2.8 N•m [25 in-lb] when removing the excess fuel.

Tighten the adjusting screw on the injector rocker lever.

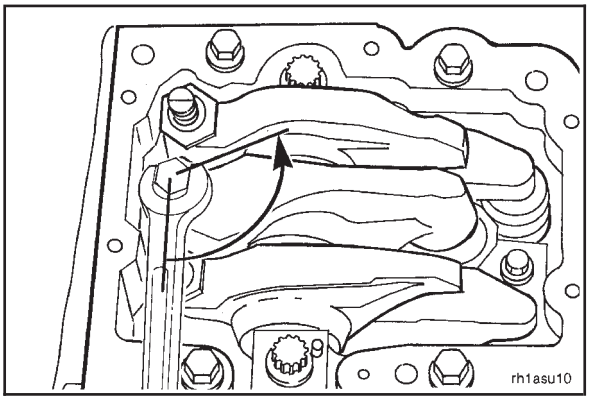
Torque Value: 2.8 N•m [25 in-lb]



Caution: After preloading the CELECT™ injector to 2.8 N•m [25 in-lb], make sure to back out the adjusting screw two flats (120 degrees) or damage to the injector will result.

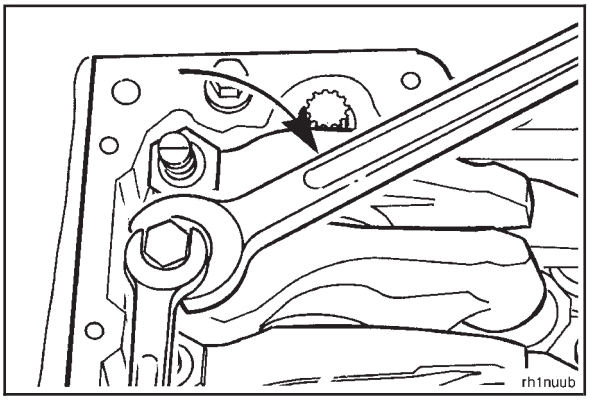
Back out the adjusting screw on the injector rocker lever two flats (120 degrees).

NOTE: Two flats will provide 0.63 mm [0.025 inch] lash. The specification is 0.50 to 0.74 mm [0.020 to 0.029 inch] lash.



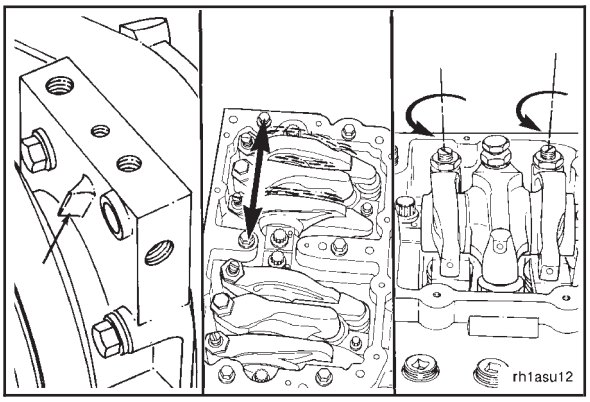
Hold the adjusting screw and tighten the lock nut.

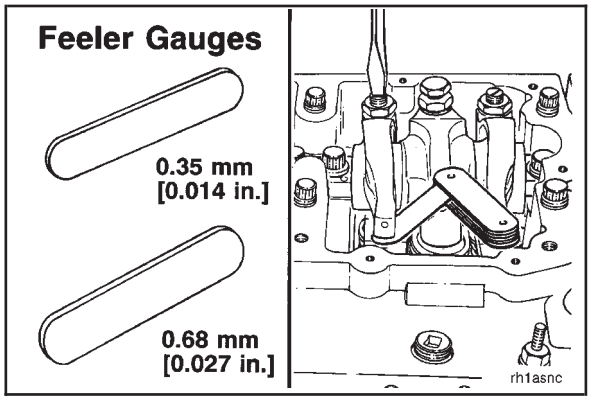
Torque Value: 68 N•m [50 ft-lb]



After setting the injector on a given cylinder, set the valves on the same cylinder.

With the ''A'' set mark aligned with the pointer on the gear cover and both valves closed on cylinder No. 1, loosen the lock nuts on the intake and the exhaust valve adjusting screws.

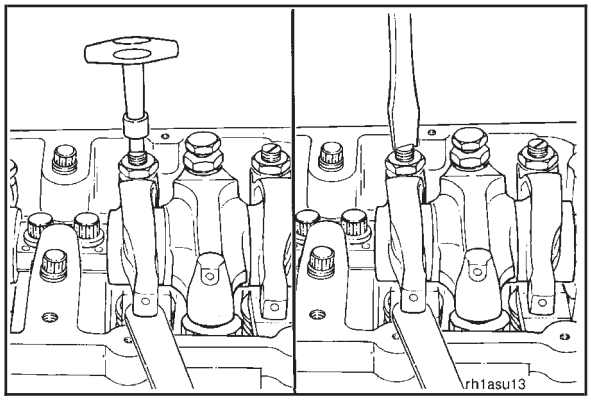




Select a feeler gauge for the correct valve lash specification.

Valve Lash Specifications	
Intake	**Exhaust**
0.35 mm [0.014-inch]	0.68 mm [0.027-inch]

Insert the feeler gauge between the top of the crosshead and the rocker lever pad.

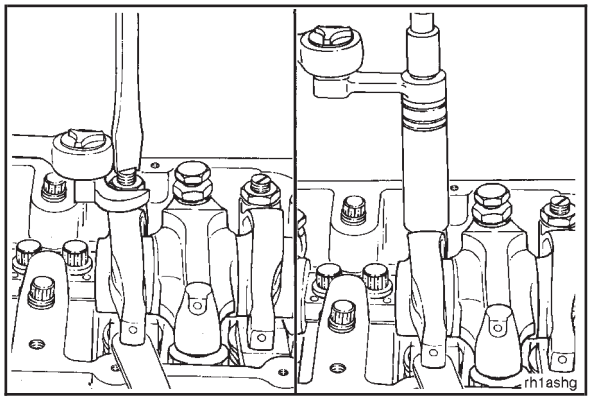


Two different methods for establishing valve lash clearance are described below. Either method can be used; however, the torque wrench method has proven to be the most consistent.

- **Torque Wrench Method:** Use the inch pound torque wrench, part No. 3376592, (normally used to set preload on STC injectors), and tighten the adjusting screw.

Torque Value: 0.6 to 0.7 N•m [5 to 6 in-lb]

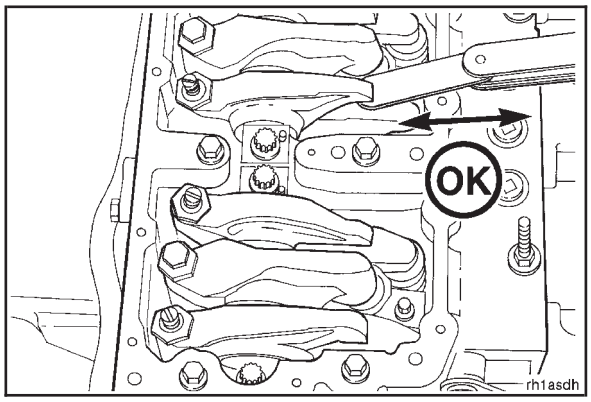
- **Feel Method:** Tighten the adjusting screw until a slight drag is felt on the feeler gauge.



Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened.

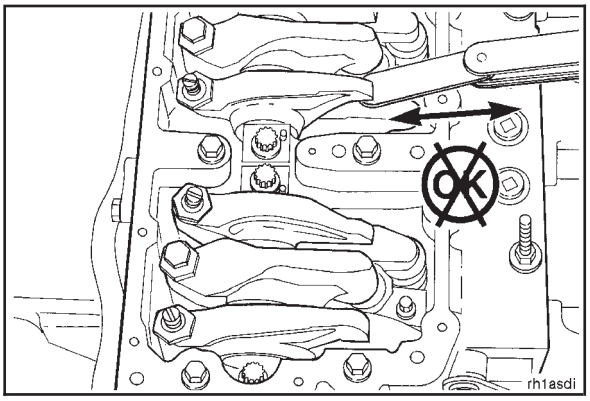
Torque Values:

With torque wrench adapter, Part No. ST-669	54 N•m [40 ft-lb]
Without adapter	68 N•m [50 ft-lb]

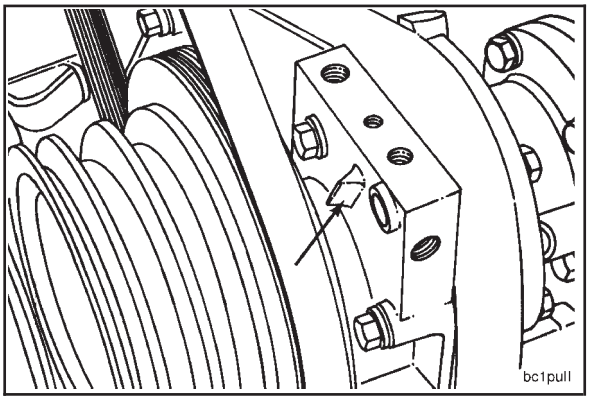


After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the crosshead and the rocker lever with only a slight drag.

If using the feel method, attempt to insert a feeler gauge that is 0.03 mm [0.001-inch] thicker between the cross-head and the rocker lever pad. The valve lash is **not** correct when a thicker feeler gauge will fit.



After adjusting the injector on cylinder No. 1 and the valves on cylinder No. 1, rotate the accessory drive; and align the next valve set mark with the pointer.



Adjust the appropriate injector and valves following the Injector and Valve Adjustment Sequence Chart.

Repeat the process to adjust all injectors and valves correctly.

Install the engine brakes again, if equipped. Refer to Engine Brake - Installation in this Section.

CELECT™ Engine
Injector and Valve Adjustment Sequence

Bar Engine in Direction of Rotation	Pulley Position	Set Cylinder	
		Injector	Valve
Start	A	1	1
Advance to	B	5	5
Advance to	C	3	3
Advance to	A	6	6
Advance to	B	2	2
Advance to	C	4	4

Firing Order: 1-5-3-6-2-4

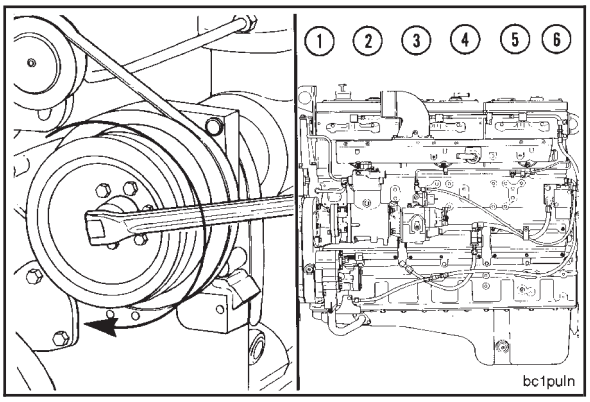
STC Engines

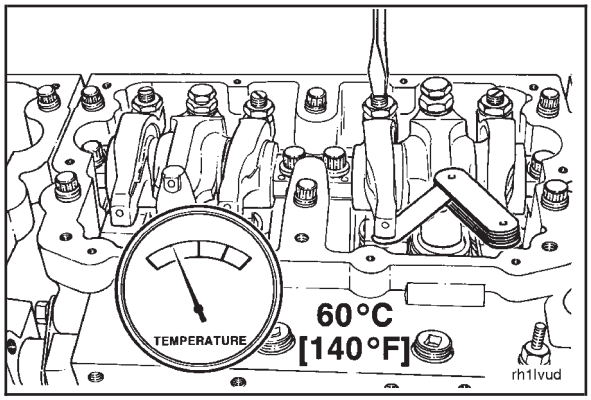
The valve set marks are located on the accessory drive pulley. The marks align with a pointer on the gear cover. Use the accessory drive shaft to rotate the crankshaft.

The crankshaft rotation is **clockwise** when viewed from the front of the engine.

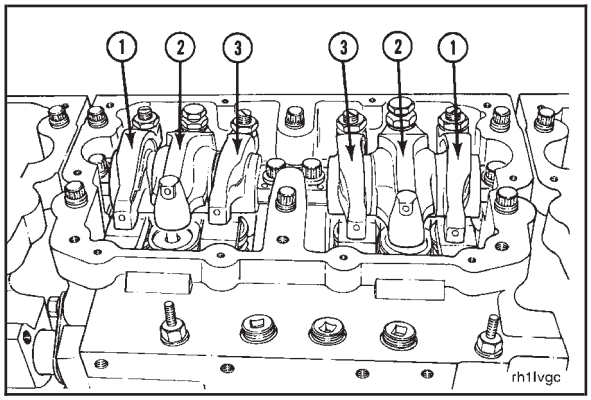
The cylinders are numbered from the front end of the engine.

The engine firing order is 1-5-3-6-2-4.





All overhead (valve and injector) adjustments **must** be made when the engine is cold (any stabilized coolant temperature at 60°C [140°F] or below).



Each cylinder has three rocker levers:

- The exhaust rocker lever (1).
- The injector rocker lever (2).
- The intake rocker lever (3).

The two levers closest to the center of each rocker housing are the intake rocker levers. The two levers closest to the ends of the rocker housing are the exhaust rocker levers.

STC Engine
Injector and Valve Adjustment Sequence

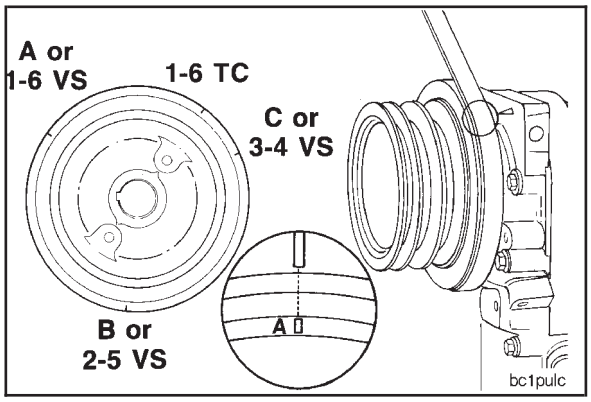
Bar Engine in Direction of Rotation	Pulley Position	Set Cylinder Injector	Set Cylinder Valve
Start	A	3	5
Advance to	B	6	3
Advance to	C	2	6
Advance to	A	4	2
Advance to	B	1	4
Advance to	C	5	1

Firing Order: 1-5-3-6-2-4

The valves and the injectors on the same cylinder are **not** adjusted at the same index mark on the accessory drive pulley.

One pair of valves and one injector are adjusted at each pulley index mark **before** rotating the accessory drive to the next index mark.

Two crankshaft revolutions are required to adjust all the valves and the injectors.

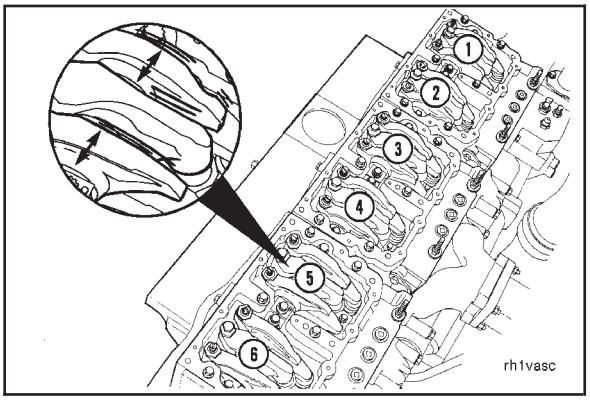


Rotate the accessory drive in the direction of engine rotation. The accessory drive will rotate **clockwise**, on a right hand engine, when looking at the front of the engine. Align the ''A'' mark on the accessory drive pulley with the pointer on the gear cover.

Check the valve rocker levers on cylinder No. 5 to see if both the intake and exhaust valves are closed.

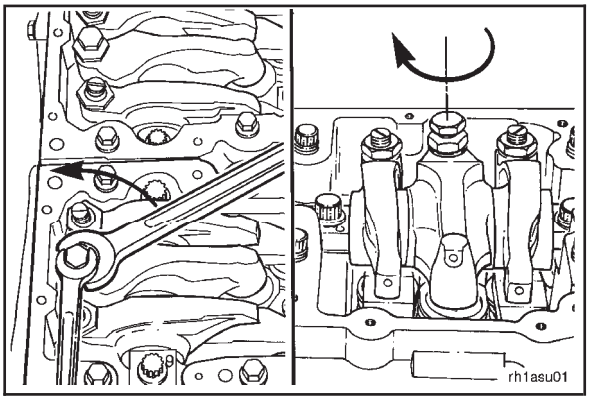
NOTE: Both the intake and exhaust valves are closed when both rocker levers are loose and can be moved from side to side. If both valves are **not** closed, rotate the accessory drive one complete revolution; and align the ''A'' mark with the pointer again.

If the valve rocker lever adjusting screws have been loosened and **not** yet adjusted, watch the valve push tubes as the engine rolls upon the ''A'' mark. Both valve push tubes will have moved to the downward (valve closed) position if the engine is on the correct stroke.

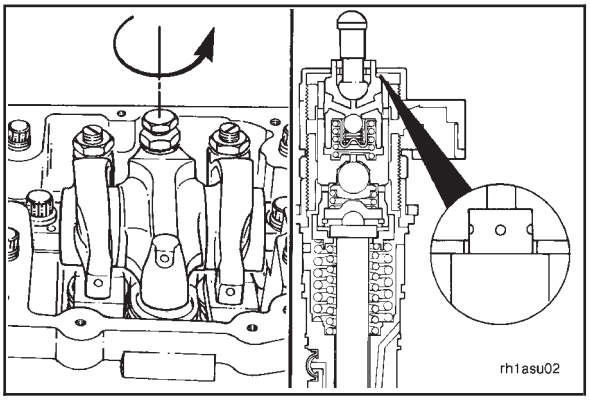


Loosen the lock nut on the injector adjusting screw on cylinder No. 3. Tighten the adjusting screw until all the clearance is removed from the injector train.

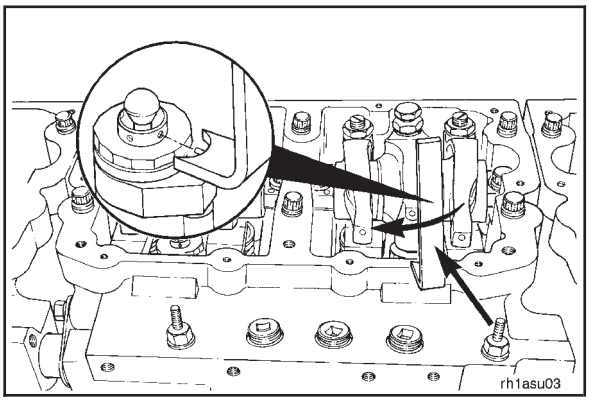
Tighten the adjusting screw one additional turn to correctly seat the link.

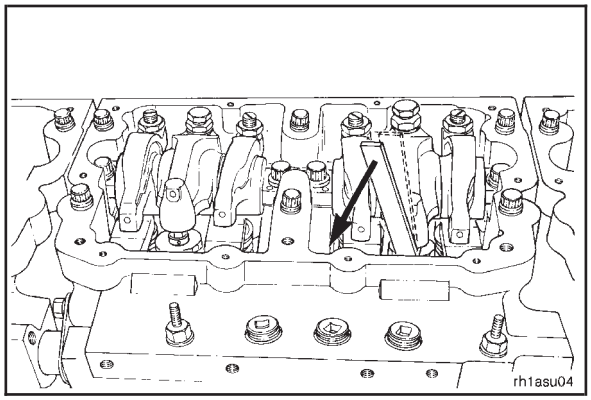


Loosen the injector adjusting screw until the injector rocker lever is loose or has a small amount of lash. When the rocker lever is loose, the STC injector tappet is touching the top of the injector.

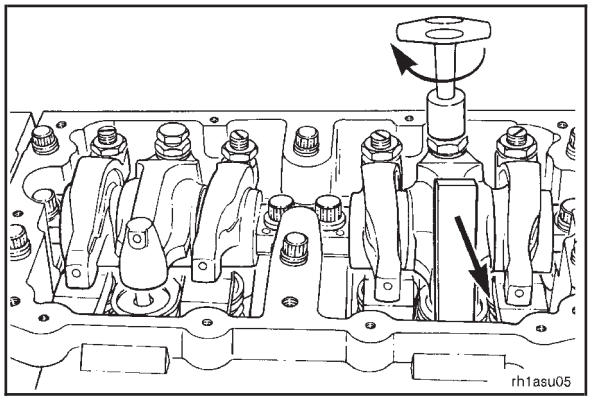


Place STC tappet adjusting tool, Part No. 3823348, on the upper surface of the STC injector top-cap. Rotate the tool around the tappet until the tool's locating pin is inserted into one of the four holes in the top of the tappet.





Apply thumb pressure to the tool handle to hold the tappet in the maximum upward position.

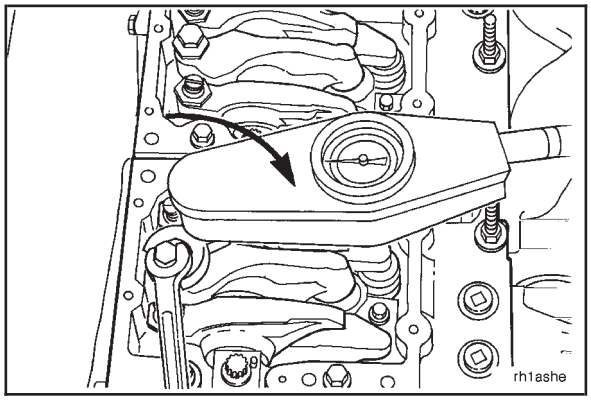


Caution: An overtightened setting on the injector adjusting screw will produce increased stress on the injector train and the camshaft injector lobe which can result in engine damage.

NOTE: Apply enough pressure on the tool handle so that the tappet does **not** move downward when the 0.56 to 0.68 N•m [5 to 6 in-lb] torque is applied.

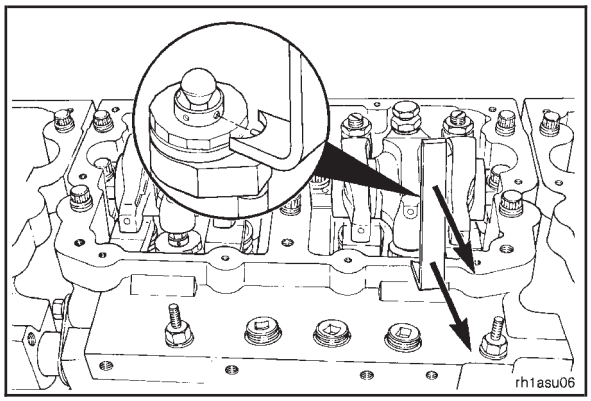
While holding the tappet up with the tool, use a torque wrench, Part No. 3376592, to tighten the adjusting screw.

Torque Value: 0.56 to 0.68 N•m [5 to 6 in-lb]



Hold the adjusting screw in this position. The adjusting screws **must not** turn when the lock nut is tightened. Tighten the lock nut.

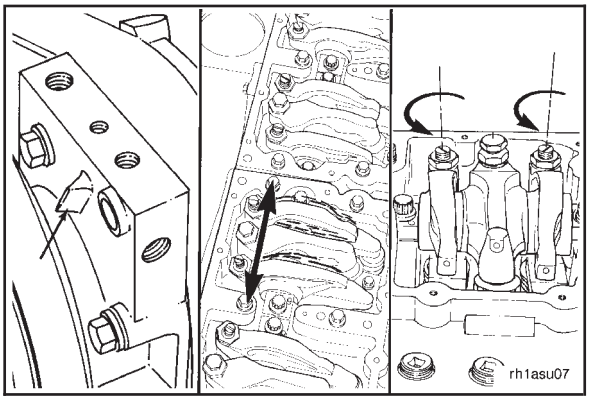
Torque Value: 68 N•m [50 ft-lb]



Caution: The tappet tool must be removed before rotating the crankshaft to prevent damage to the tappet and/or tool.

Remove the tappet adjusting tool.

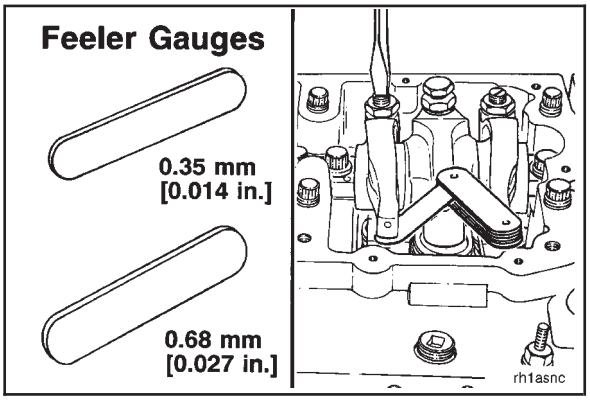
With the ''A'' set mark aligned with the pointer on the gear cover and both valves closed on cylinder No. 5, loosen the lock nuts on the intake and the exhaust valve adjusting screws.



Select a feeler gauge for the correct valve lash specification.

Valve Lash Specifications	
Intake	**Exhaust**
0.35 mm [0.014-inch]	0.68 mm [0.027-inch]

Insert the feeler gauge between the top of the crosshead and the rocker lever nose.

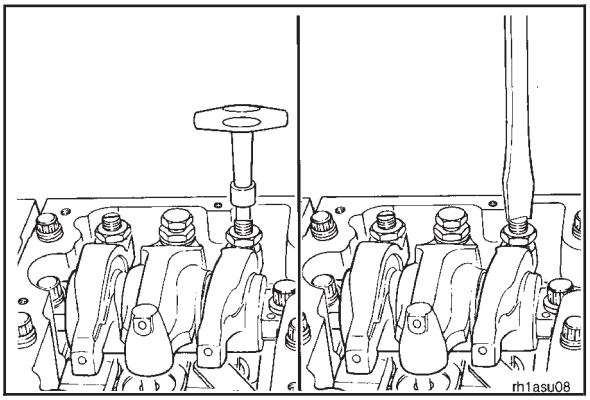


Two different methods for establishing valve lash clearance are described below. Either method can be used; however, the torque wrench method has proven to be the most consistent.

- **Torque Wrench Method:** Use the inch pound torque wrench, Part No. 3376592, (normally used to set preload on STC injectors), and tighten the adjusting screw.

Torque Value: 0.56 to 0.68 N•m [5 to 6 in-lb]

- **Feel Method:** Tighten the adjusting screw until a slight drag is felt on the feeler gauge.



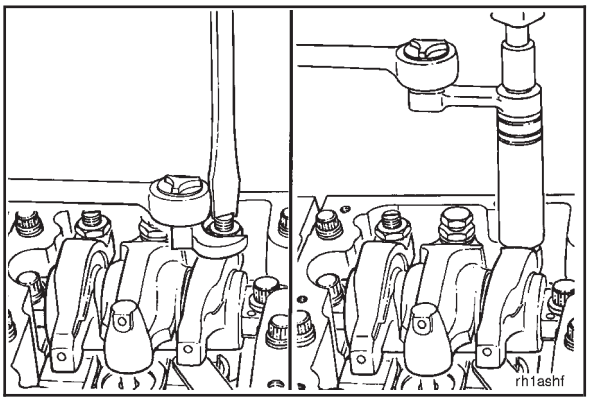
Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened.

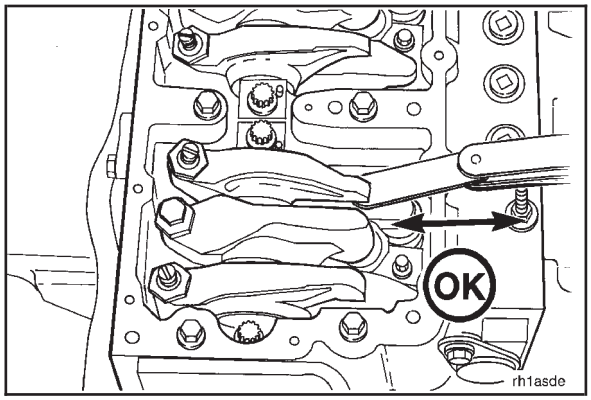
Tighten the lock nut.

Torque Values:

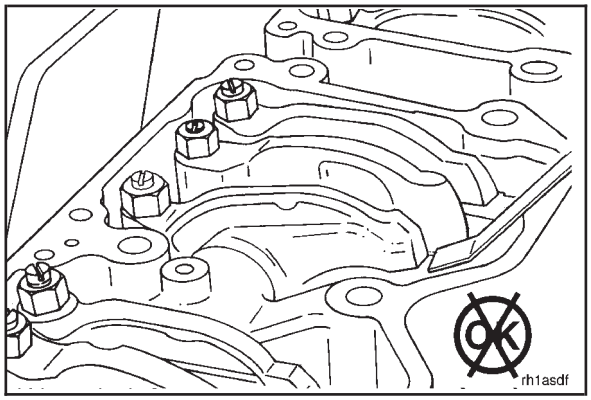
With torque wrench adapter, Part No. ST-669 — 54 N•m [40 ft-lb]

Without adapter — 68 N•m [50 ft-lb]

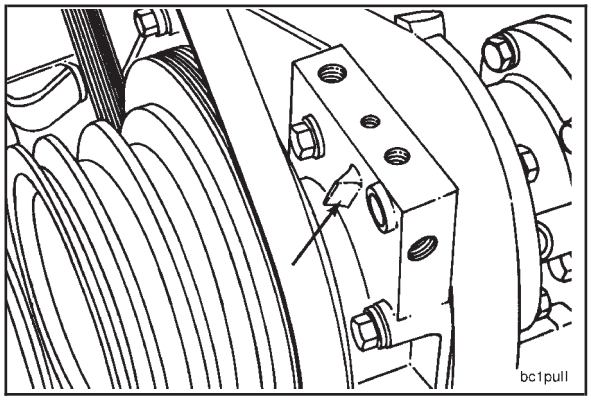




After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the crossheads and the rocker lever with only a slight drag.



If using the feel method, attempt to insert a feeler gauge that is 0.03 mm [0.001-inch] thicker between the crosshead and the rocker lever pad. The valve lash is **not** correct when a thicker feeler gauge will fit.



After adjusting the injector on cylinder No. 3 and the valves on cylinder No. 5, rotate the accessory drive; and align the next valve set mark with the pointer.

STC Engine Injector and Valve Adjustment Sequence			
Bar Engine in Direction of Rotation	**Pulley Position**	**Set Cylinder**	
		Injector	**Valve**
Start	A	3	5
Advance to	B	6	3
Advance to	C	2	6
Advance to	A	4	2
Advance to	B	1	4
Advance to	C	5	1
Firing Order: 1-5-3-6-2-4			

Adjust the appropriate injector and valves following the Injector and Valve Adjustment Sequence Chart.

Repeat the process to adjust all injectors and valves correctly.

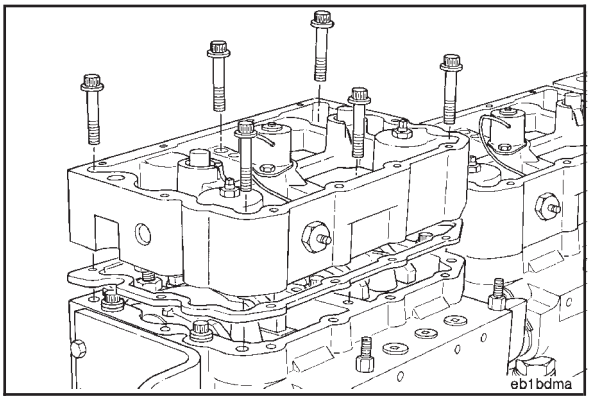
Install the C-Brakes again, if equipped. Refer to the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456.

Engine Brake - Installation

Install two guide pins into each rocker lever housing.

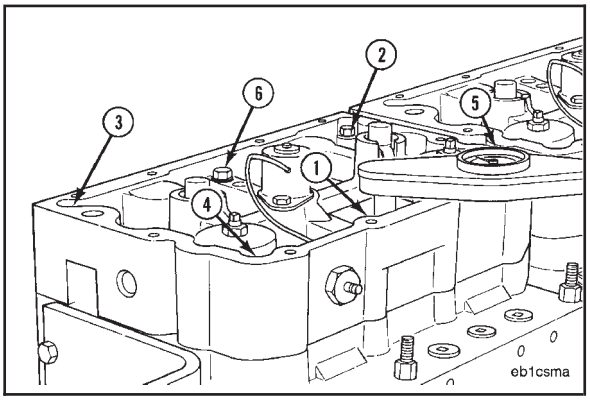
Install new C-Brake housing gaskets and the C-Brakes.

Remove the guide pins.



Install the C-Brake capscrews. Tighten the capscrews in the sequence shown to the torque value listed below.

Torque Value: 102 N•m [75 ft-lb]



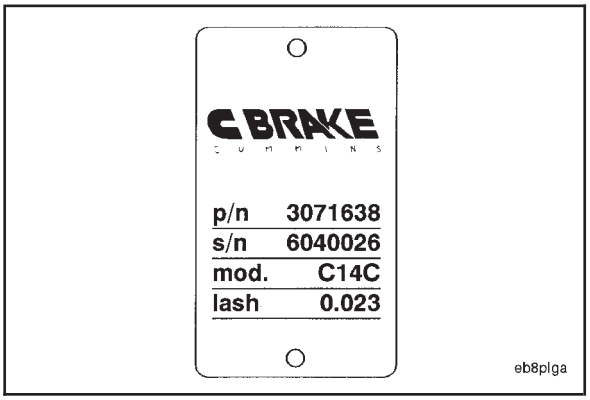
Engine Brake - Adjustment

C-Brake

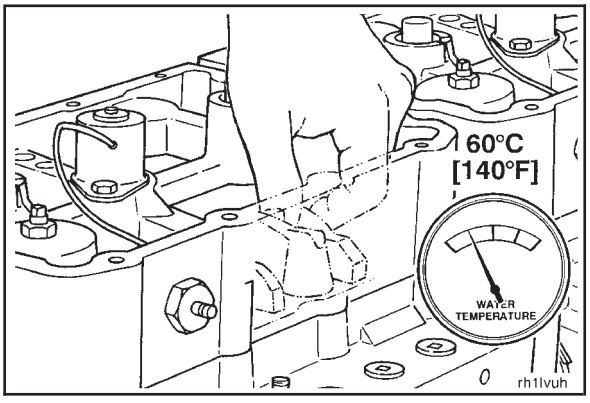
Caution: To get maximum brake operating efficiency and to prevent engine damage, it is important to follow the instructions on the following pages.

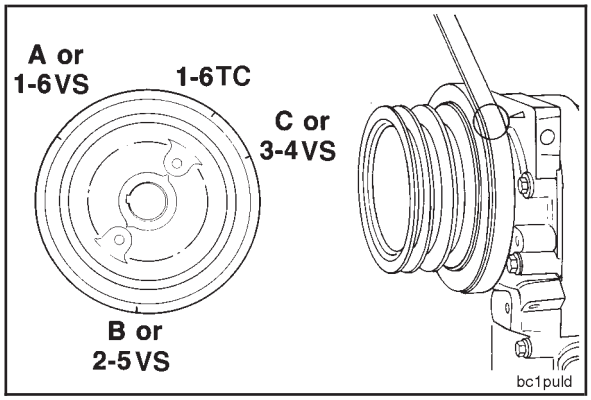
If the engine is equipped with a C-Brake, use the following adjustment procedure.

NOTE: C-Brake adjustment specifications are found on the C-Brake dataplate located on the exhaust side of the C-Brake housing.

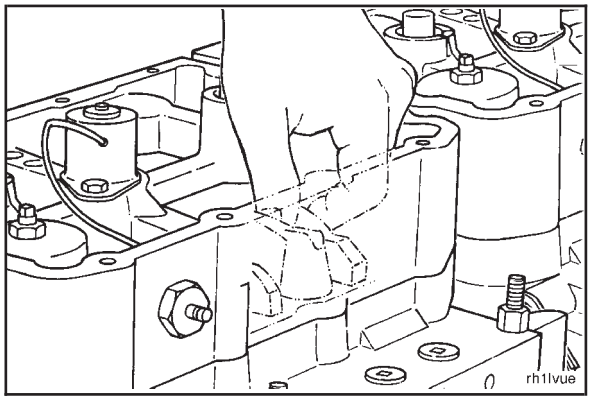


Slave piston adjustment **must** be made with the engine stopped and cold (stabilized water temperature or 60°C [140°F] or below). The exhaust valves on the cylinder which are to be adjusted **must** be in the closed position.





Rotate the crankshaft in the direction of engine rotation. Align the ''A'' mark on the accessory drive pulley with the pointer on the gear cover.



When the ''A'' mark is aligned, the intake and exhaust valves rocker levers **must** be loose for cylinder No. 5.

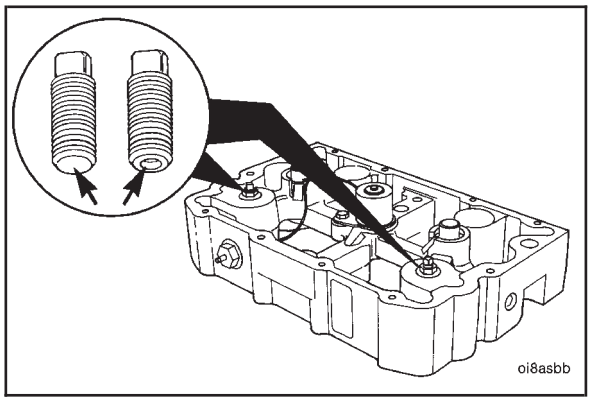
NOTE: Both the intake and exhaust valves are closed when both rocker levers are loose and can be moved from side to side. If both valves are **not** closed, rotate the accessory drive one complete revolution; and align the ''A'' mark with the pointer again.

The instructions using the ''A'' mark to begin the adjustments are for illustration purposes. Adjustments can start at any of the cylinders as shown.

C-Brake Set Position - STC and CELECT™

Bar In Direction	Pulley Position	Set Brake
Start	A	5
Advance to	B	3
Advance to	C	6
Advance to	A	2
Advance to	B	4
Advance to	C	1

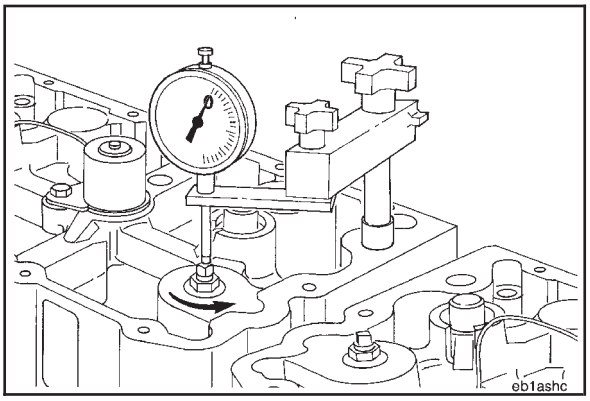
Firing Order: 1-5-3-6-2-4 Right Hand Rotation



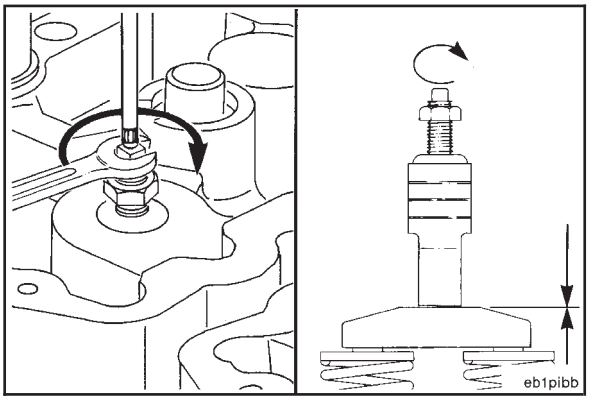
Caution: Use of the wrong adjusting screw can result in severe engine damage. See the latest N14 parts publication information.

Loosen the lock nut for the No. 5 slave piston adjusting screw.

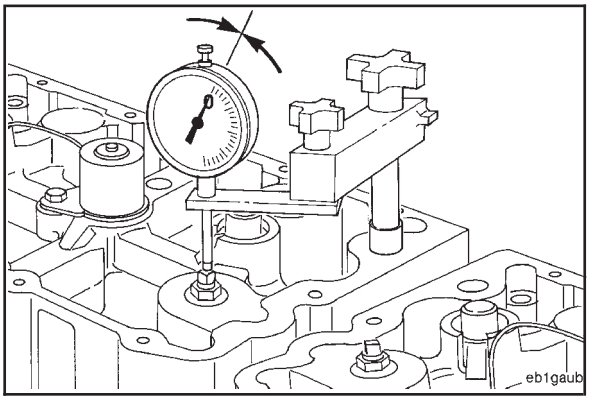
Install a dial indicator, Part No. 3375006, over the No. 5 slave piston adjusting screw. Use the adapter, Part No. 3823826, to mount the dial indicator fixture to the C-Brake.



Tighten the adjusting screw until the slave piston contacts the crosshead.

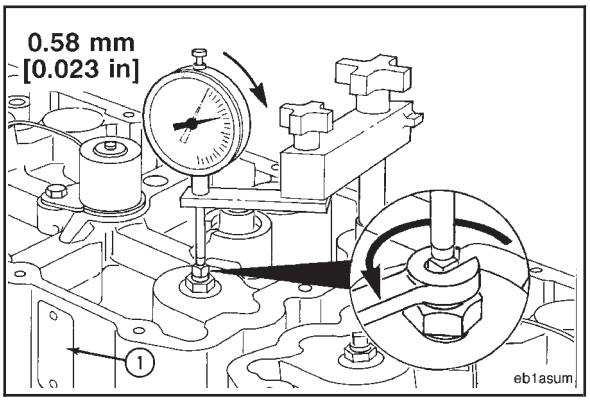


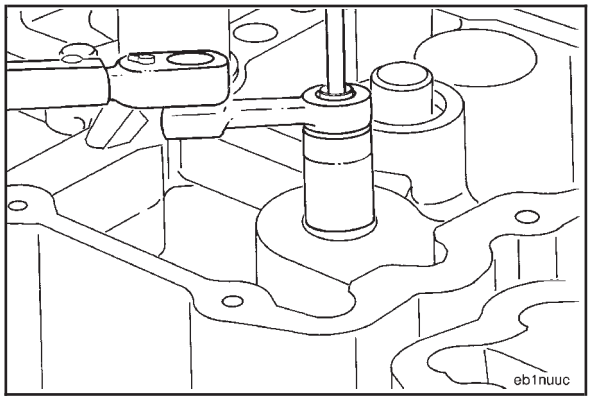
Zero the gauge with the dial indicator stem resting on the adjusting screw.



Loosen the adjusting screw until the indicator needle shows 0.58 mm [0.023-inch].

NOTE: C-Brake adjustment specifications are found on the C-Brake dataplate located on the exhaust side of the C-Brake housing.



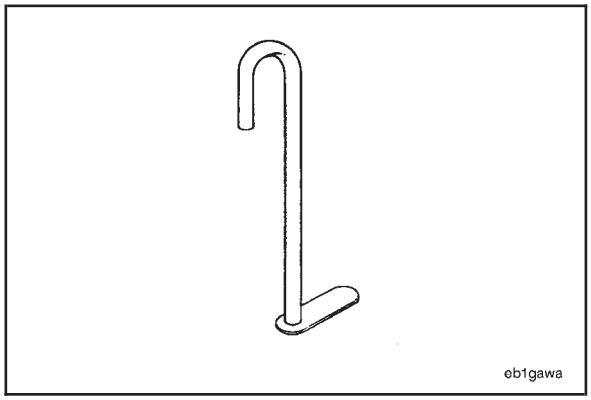


Use the torque wrench adapter, Part No. ST-669, and a 1/4-inch eight point socket to tighten the lock nut.

Torque Value: 24 N•m [18 ft-lb]

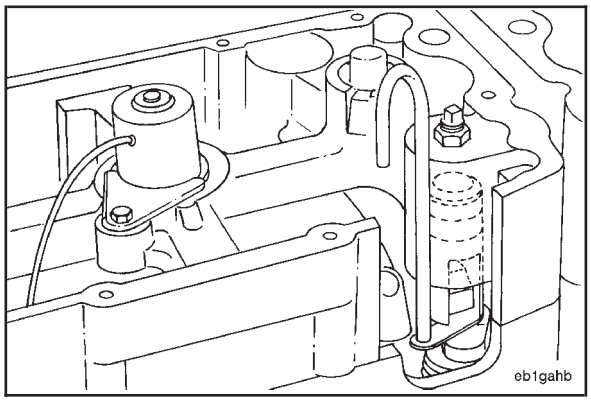
Repeat this procedure to adjust the remaining slave pistons.

C-Brake Set Position - STC and CELECT™		
Bar In Direction	**Pulley Position**	**Set Brake**
Start	A or 1-6VS	5
Advance to	B or 2-5VS	3
Advance to	C or 3-4VS	6
Advance to	A or 1-6VS	2
Advance to	B or 2-5VS	4
Advance to	C or 3-4VS	1
Firing Order: 1-5-3-6-2-4 Right Hand Rotation		



C-Brake - Alternate Method

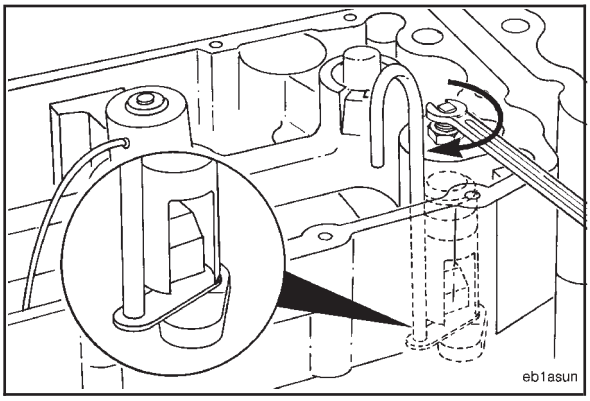
A feeler gauge, Part No. 3823802, can be used in place of the dial indicator in applications that do **not** have adequate clearance for the indicator to be installed.



Insert the feeler gauge blade between the crosshead and both contact surfaces of the slave piston.

NOTE: An accurate C-Brake setting can **only** be obtained if the feeler gauge is below **both** contact surfaces of the slave piston.

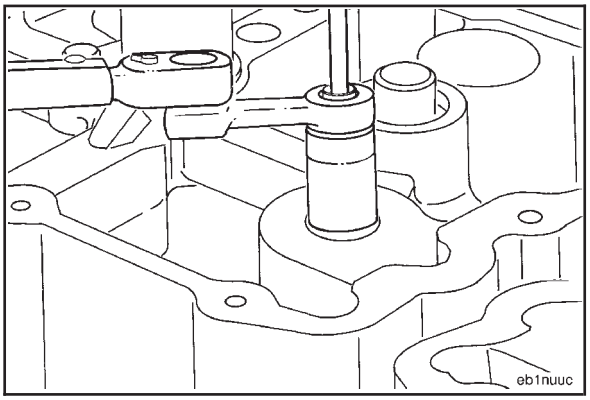
Tighten the slave piston adjusting screw until the slave piston contacts the feeler gauge and creates a slight drag.



Use the torque wrench adapter, Part No. ST-669, to tighten the lock nut.

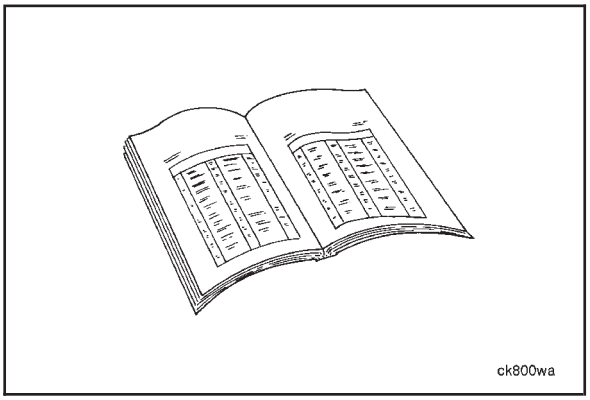
Torque Value: 24 N•m [18 ft-lb]

Repeat this procedure to adjust the remaining slave pistons.



Jacobs Brake

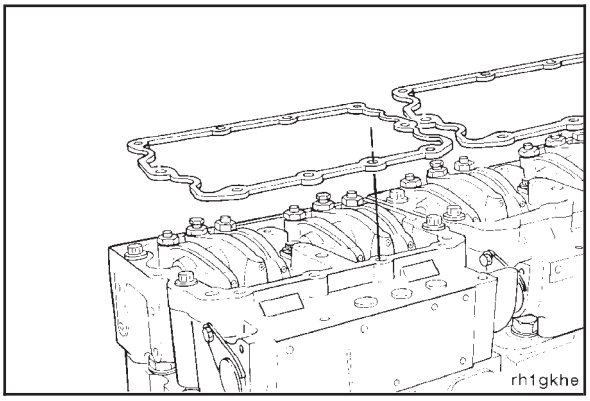
For details on how to adjust Jacobs Brakes, refer to the Jacobs Manufacturing Company, 22 East Dudley Town Road, Bloomfield, CT 06002, for service manual instructions.

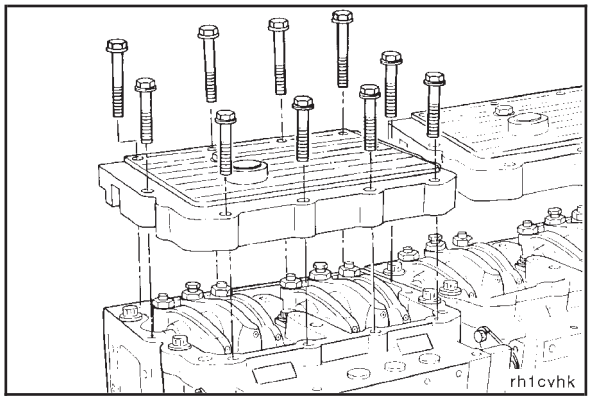


Rocker Housing Covers - Installation

Install the gasket on each rocker lever housing.

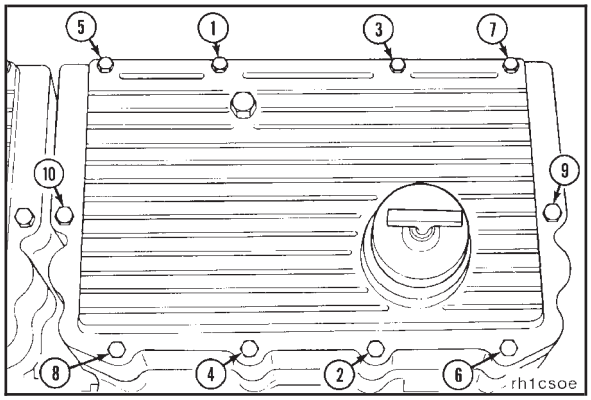
NOTE: The valve cover gaskets are reusable. Do **not** replace the gaskets unless they are damaged.





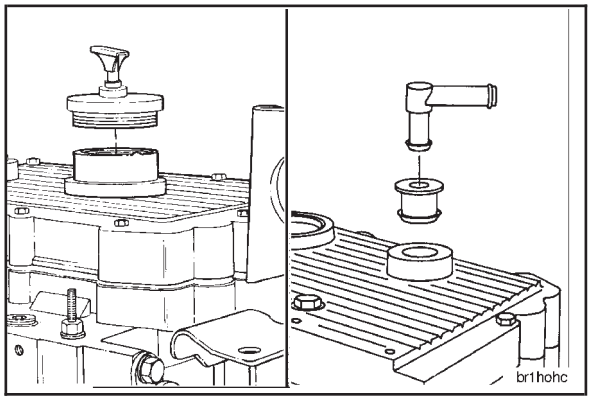
Install the covers on the rocker lever housing.

Install the ten capscrews and washers in each cover.

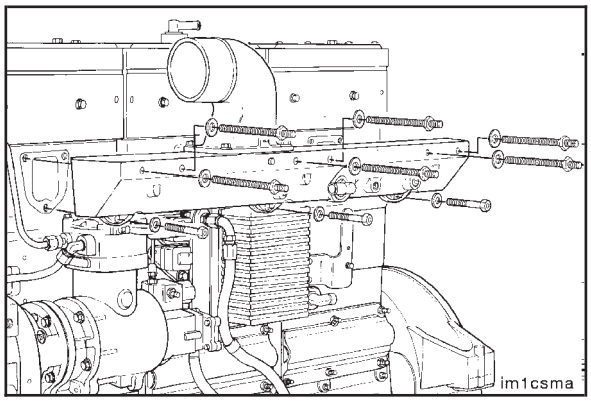


Tighten the capscrews in each cover in the sequence shown.

Torque Value: 12 N•m [105 in-lb]



Install the rubber grommet, breather tube, and oil filler cap into the rocker housing covers, if applicable.



Intake Manifold - Installation

Install the intake air connection to the intake manifold. Make sure the gasket is seating in its groove.

Install and tighten the four capscrews.

Torque Value: 34 N•m [25 ft-lb]

Using new gaskets, install the intake manifold onto the cylinder head mounting surfaces.

Install and tighten the nine capscrews.

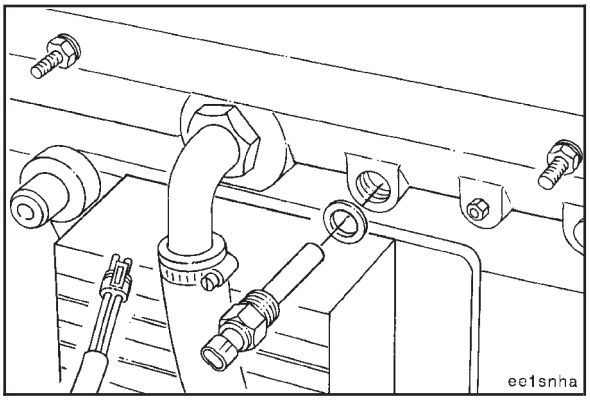
Torque Value: 47 N•m [35 ft-lb]

CELECT™ Intake Air Temperature Sensor - Installation

Install the sensor in the engine. Tighten the sensor.

Torque Value: 35 N•m [25 ft-lb]

Make sure the sensor is installed with a new o-ring.

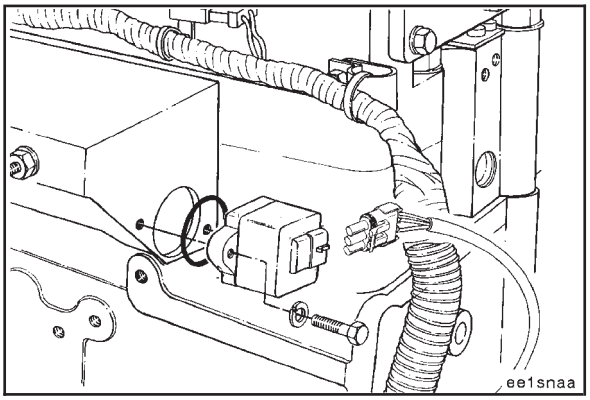


CELECT™ Boost Pressure Sensor - Installation

Install the sensor on the engine. Tighten the capscrews.

Torque Value: 30 N•m [22 ft-lb]

Make sure the sensor has a sealing ring on the bottom side of the sensor.



Viscosity Sensor - Installation

On STC engines install the bracket to the viscosity sensor. Install the two bracket capscrews and tighten.

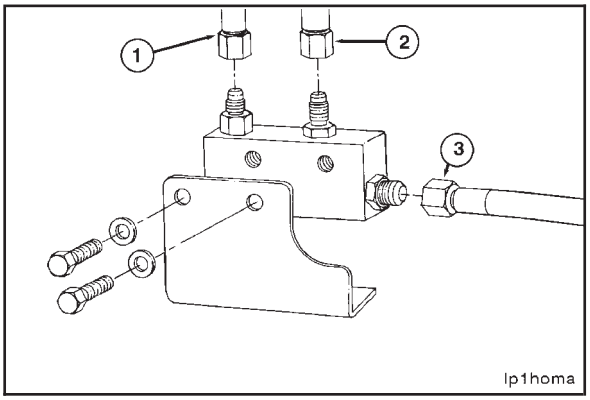
Torque Value: 27 N•m [20 ft-lb]

Connect the flexible hoses to the viscosity sensor fittings.

Torque Value:

1. 11 N•m [95 in-lb]
2. 20 N•m [15 ft-lb]
3. 27 N•m [20 ft-lb]

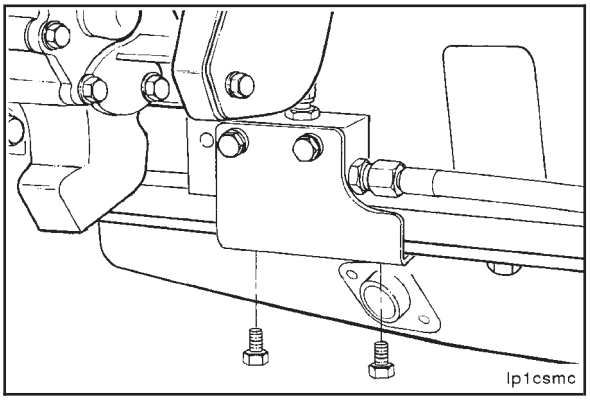
NOTE: Do **not** allow dirt or debris to enter the oil lines.

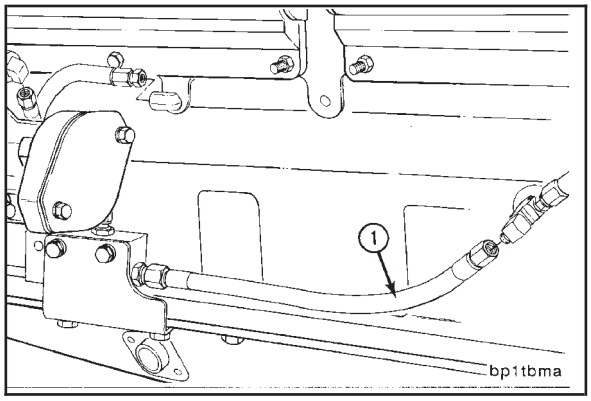


Install the entire assembly with flex hoses attached to the cylinder block pan rail.

Install the two capscrews and tighten.

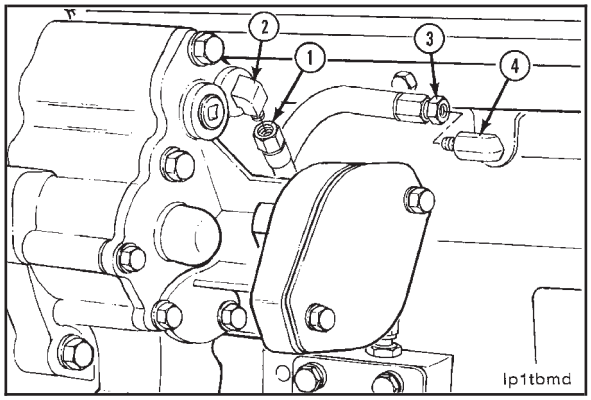
Torque Value: 68 N•m [50 ft-lb]





Connect the sensor drain line (1) to the tee fitting on the cylinder block.

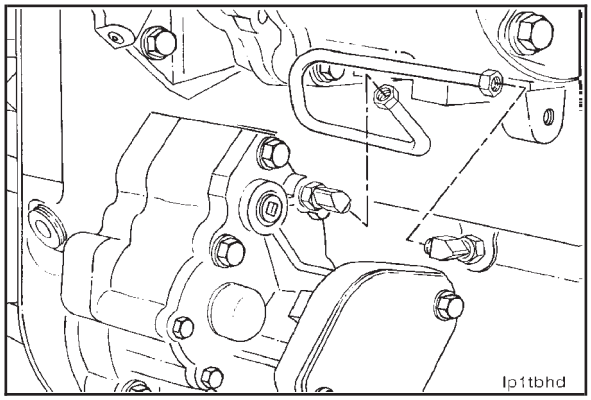
Torque Value: 27 N•m [20 ft-lb]



Connect the pressure signal line (1) to the lubricating pump fitting (2) and the rifle pressure supply line (3) to the oil rifle fitting (4).

Torque Values:

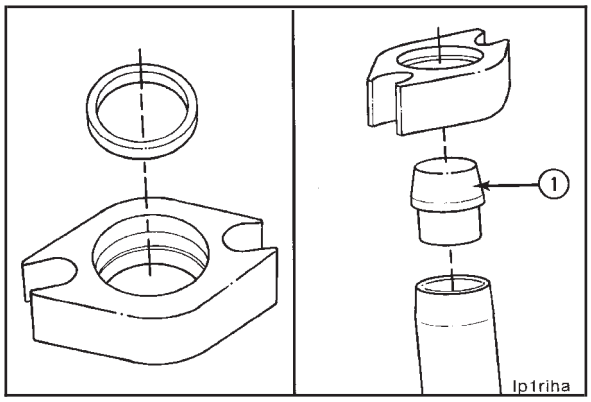
1. 10 N•m [89 in-lb]
3. 10 N•m [89 in-lb]



Lubricating Oil Pump Signal Line - Installation

On CELECT™ engines, install the DFC signal line. Tighten the signal line tube nuts.

Torque Value: 14 N•m [120 in-lb]



Lubricating Oil Transfer Tube - Installation

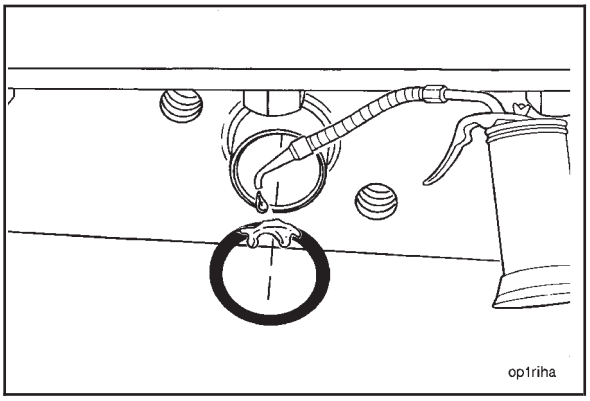
Install a new rectangular sealing ring in the lubricating oil pump mounting flange.

Use clean vegetable oil to lubricate the seal.

Install the sealing ring expander (1), Part No. 3376844, into the end of the lubricating oil transfer tube, and push the tube through the flange. Remove the sealing ring expander from the suction tube.

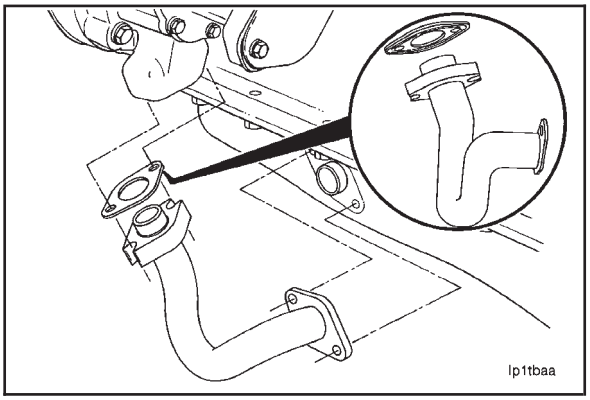
Install a new o-ring on the oil pan lubricating oil suction tube.

Use clean vegetable oil to lubricate the o-ring.



Loosely install the lubricating oil transfer tube assembly with the lubricating oil pump mounting flange, new sealing ring, new gasket, and the mounting capscrews to the oil pan and lubricating oil pump.

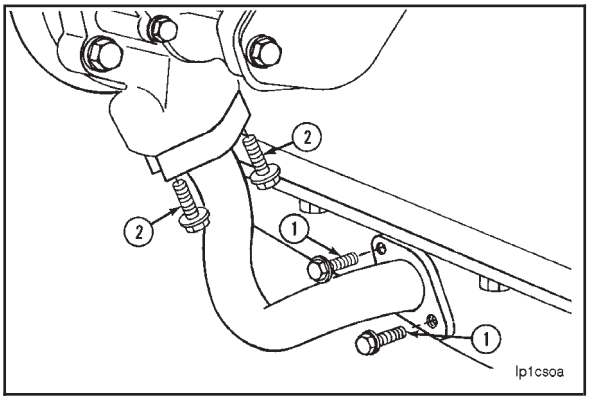
NOTE: The printed side of the mounting flange gasket on the oil transfer tube **must** be toward the flange.



Tighten the capscrews in the following sequence:

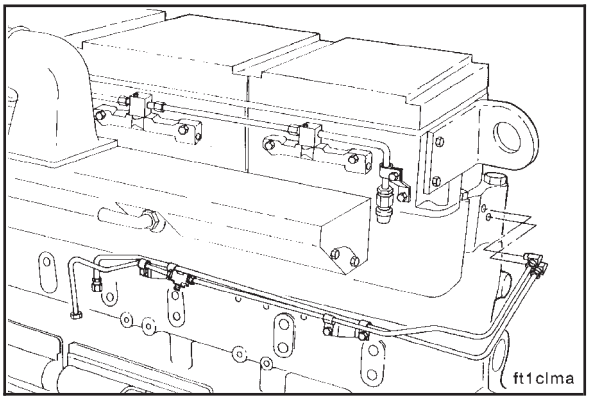
- First, tighten the two capscrews (1) at the oil pan.
- Second, tighten the capscrews (2) at the lubricating oil pump.

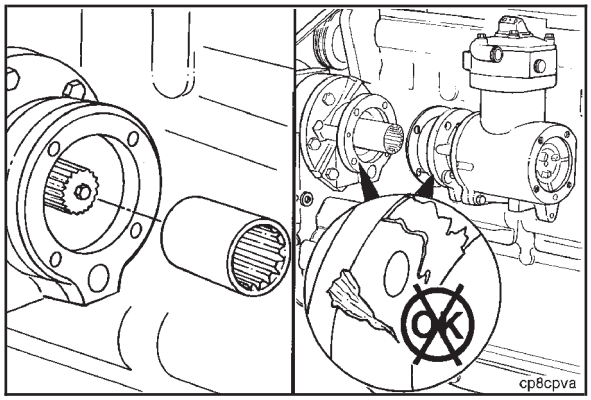
Torque Value: 47 N•m [35 ft-lb]



Fuel Tubing - Installation

Install fuel supply tube and fuel return tube to the engine. Tighten the tube nuts to the torque value specified for the size of the tube. Refer to the chart in Section 18. Secure the tubing with the required clamps. Tighten the mounting capscrews to the torque value specified for the size of the capscrew. Refer to the chart in Section 18.



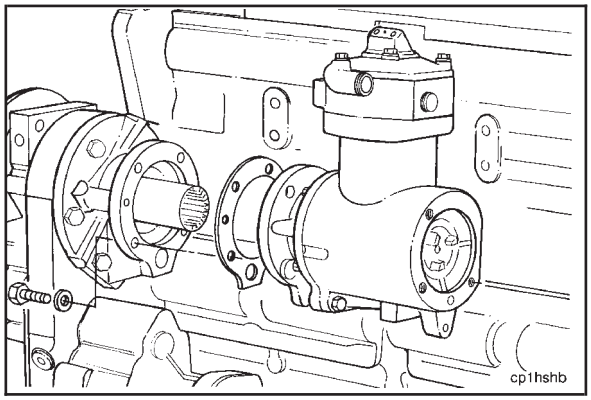


Air Compressor - Installation

Install the splined coupling on the accessory drive.

Make sure the gasket surfaces of the accessory drive and the air compressor are clean and **not** damaged.

It is **not** necessary to time the air compressor on the NT engine. Although the Big Cam III through 88 NT publications have specified air compressor timing, this is **not** required on any NT engine.



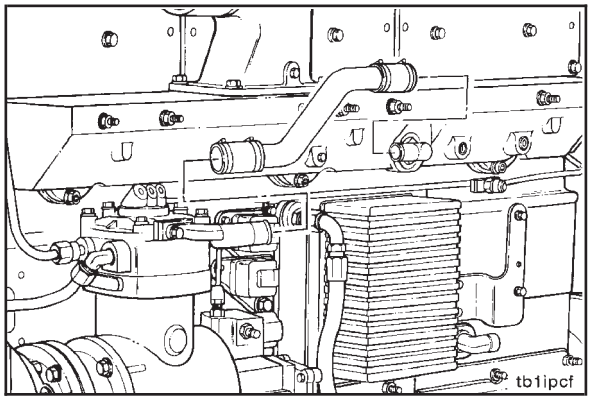
Use a new gasket when installing the air compressor. Install and tighten the four capscrews to the accessory drive.

Torque Value: 68 N•m [50 ft-lb]

Install the air compressor support bracket.

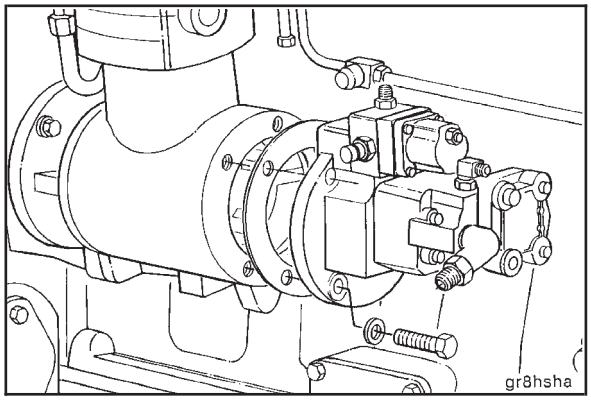
Torque Value: 47 N•m [35 ft-lb]

The air compressor support bracket is required to support the air compressor and provide acceptable compressor and accessory drive support gasket performance.



Install the supply air return line from the air compressor to the intake manifold.

Coolant tubes will be installed after water pump installation.



Fuel Pump - Installation

CELECT™ Engines

Install the spider coupling, the mounting gasket, and the fuel pump. Tighten the pump mounting capscrews.

Torque Value: 47 N•m [35 ft-lb]

Connect the fuel supply hose, the fuel rail supply tube, and the gear pump drain tube.

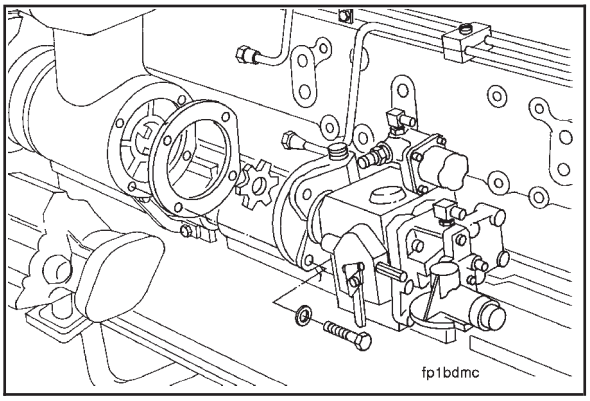
STC Engines

Install the fuel pump drive spider coupling.

Use a new gasket to install the fuel pump.

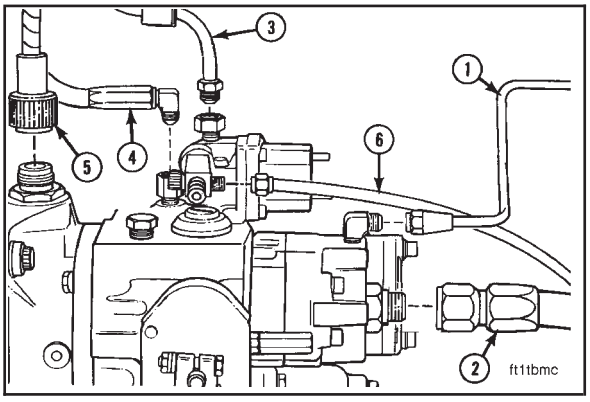
Install the four fuel pump mounting capscrews.

Torque Value: 47 N•m [35 ft-lb]



Install the AFC air signal line and fuel tubing:

- Gear pump cooling drain (1)
- Fuel inlet supply (2)
- Fuel rail pressure line (3)
- AFC air signal line (4)
- Tachometer cable (5)
- Fuel pressure sensing line (to STC valve) (6)

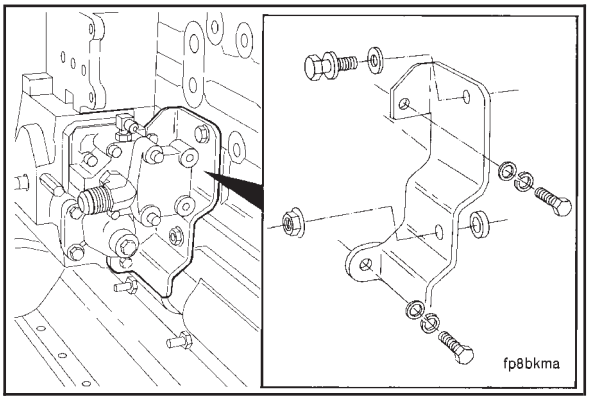


Engines using PT PACER require a mounting support bracket on the fuel pump and engine block due to the added weight of the PT PACER pump.

The PT PACER pump support bracket is required to provide acceptable fuel pump mounting gasket performance.

Install the bracket and tighten the capscrews alternately and evenly to both the fuel pump and engine block.

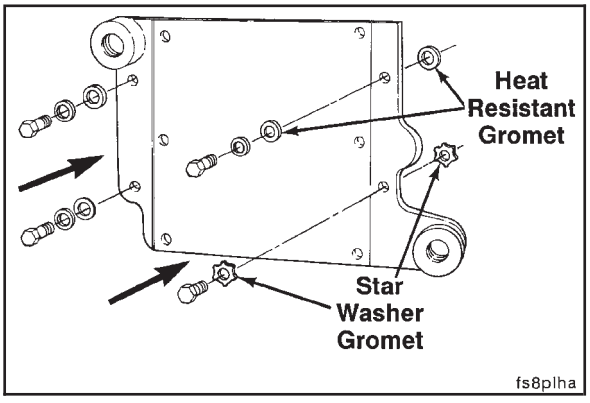
Torque Value: 47 N•m [35 ft-lb]

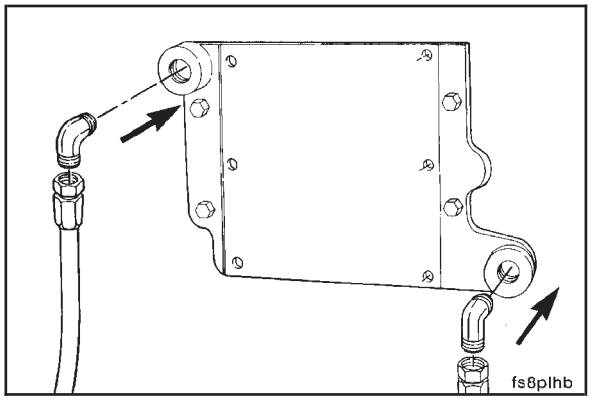


CELECT™ ECM Cooling Plate - Installation

Install the cooling plate. Install the heat resistant grommets on both sides of the cooling plate. Install the two heat resistant star washer grommets at the same mounting location. Tighten the four capscrews.

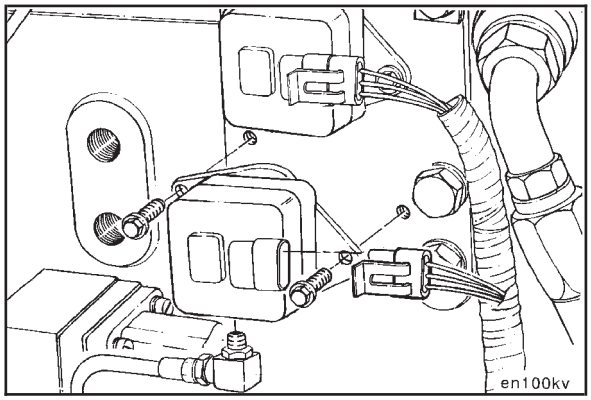
Torque Value: 41 N•m [30 ft-lb]





Connect and tighten the inlet and outlet fuel hoses to the cooling plate.

Inspect for paint or grease on the cooling plate.



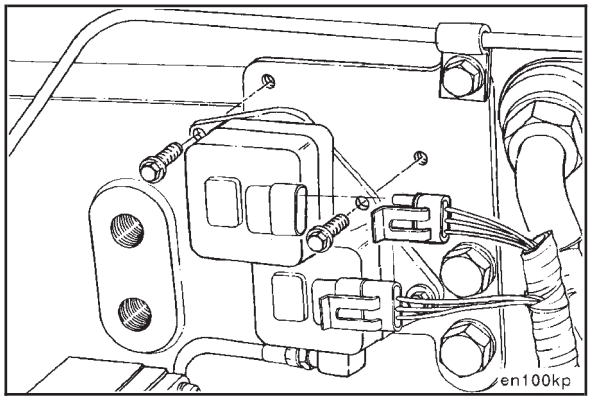
CELECT™ Lubricating Oil Pressure Sensor - Installation

Install the sensor on the engine. Tighten the capscrews.

Torque Value: 30 N•m [22 ft-lb]

Install the oil pressure signal line.

Push the connectors until they lock.

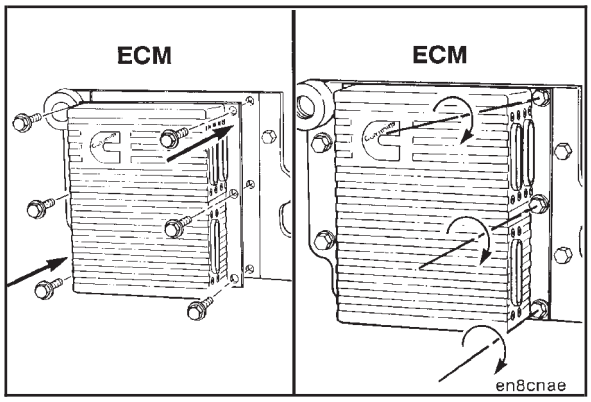


CELECT™ Ambient Air Pressure Sensor - Installation

Install the sensor on the engine. Tighten the capscrews.

Torque Value: 30 N•m [22 ft-lb]

Push the connectors together until they lock.



CELECT™ Electronic Control Module (ECM) - Installation

Install the ECM to the cooling plate. Tighten the six metric capscrews.

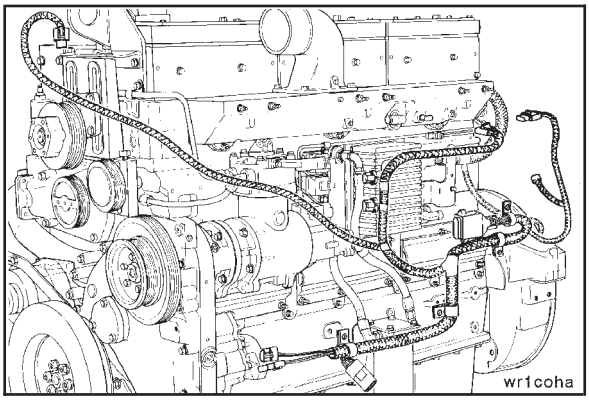
Torque Value: 7.3 N•m [65 in-lb]

Make sure the star washer is installed under one of the capscrews.

Caution: Do not paint the back side of the ECM. Make sure there is no grease or dirt between the ECM and the cooling plate.

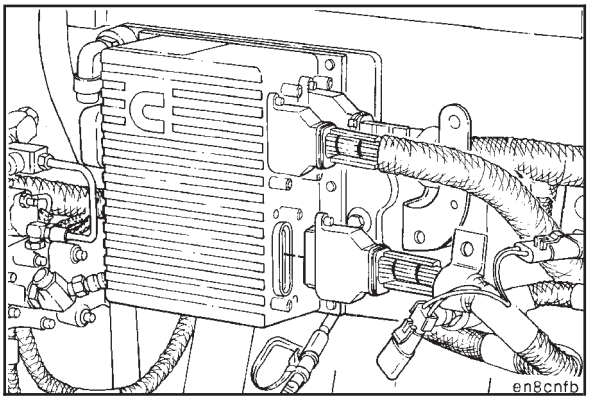
CELECT™ Sensor Harness - Installation

Install the sensor wiring harness on the engine.



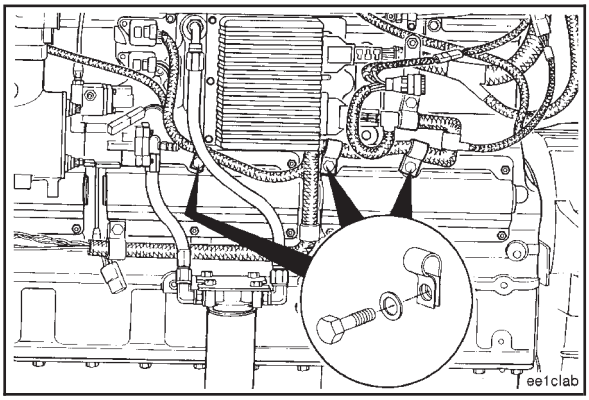
Install the sensor harness amp connector to the electronic control module (ECM). Tighten the connector capscrews to the ECM.

Torque Value: 2.0 N•m [18 in-lb]



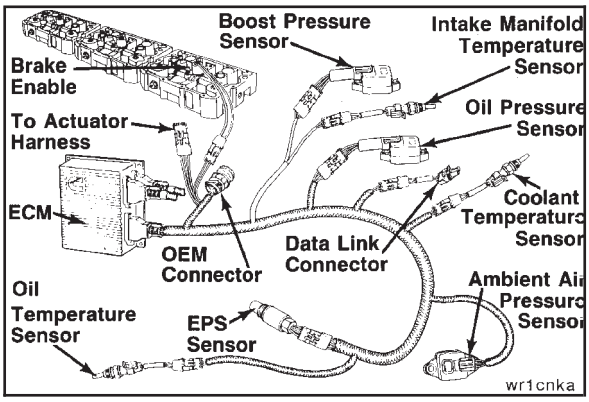
Install the sensor wiring harness retaining clamps to the support bracket and the engine block.

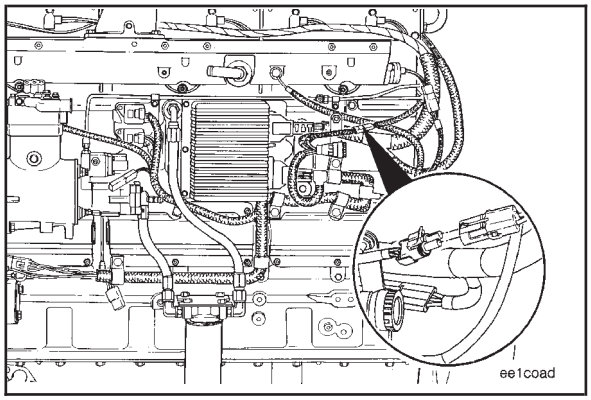
Torque Value: 20 N•m [15 ft-lb]



Install the mounting hardware and connect the following sensors to the sensor harness.

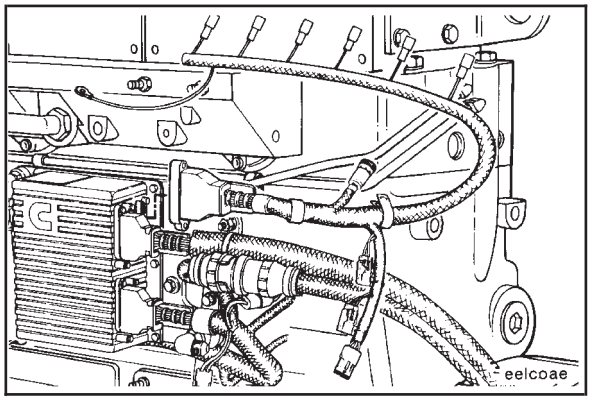
- Oil pressure sensor
- Oil temperature sensor
- Ambient air pressure sensor
- Fuel shutoff control wire
- Engine position sensor
- Coolant temperature sensor





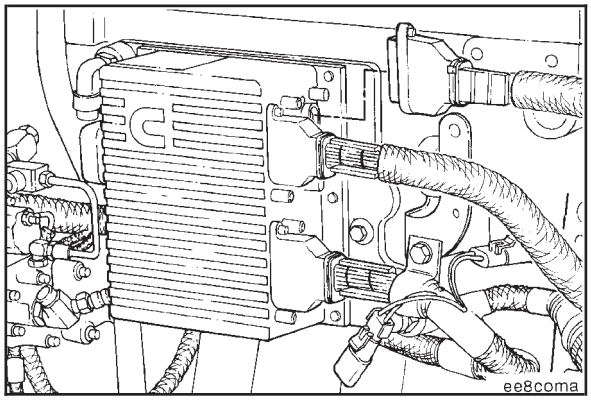
On engines equipped with engine brakes, connect the engine brake harness to the sensor harness.

Wire tie the harness to the fuel tubing at the rear of the engine.



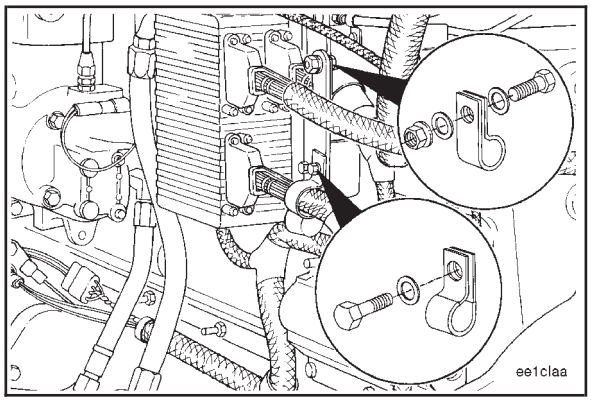
CELECT™ Actuator Harness - Installation

Install the actuator harness on the engine.



Install the actuator harness amp connector to the ECM. Tighten the two connector capscrews to the ECM.

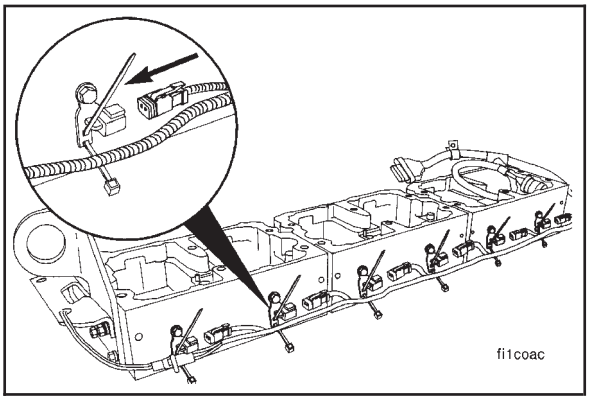
Torque Value: 2.0 N•m [18 in-lb]



Install the actuator harness retaining clamps to the support bracket and to the rear of the No. 3 rocker housing. Tighten the capscrews.

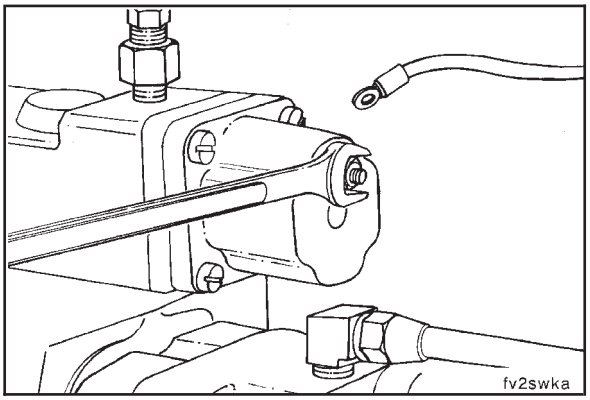
Torque Value: 20 N•m [15 ft-lb]

Connect the actuator harness to each of the pass through connectors along the side of the rocker lever housing. Make sure the connector clicks/snaps into place. Install a new plastic wire tie, Part No. 3062329, to each of the pass through connectors to hold the actuator harness to the pass through connectors.

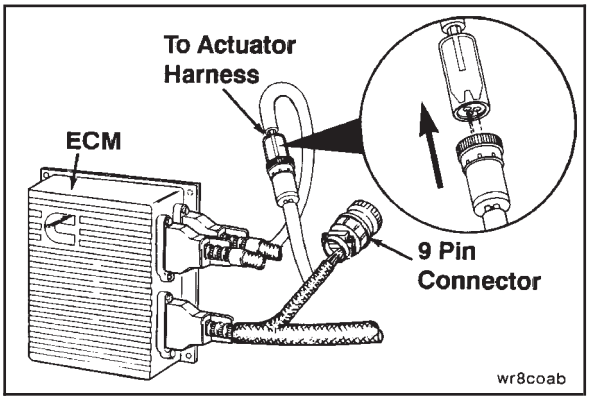


Connect the fuel shutoff control wire to the fuel shutoff solenoid. Tighten the retaining nut.

Torque Value: 2.8 N•m [25 in-lb]



Connect the Deutsch three pin connector that contains the vehicle key switch, fan clutch, and engine brake control wires to the three pin connector which is wired directly into the Deutsch nine pin connector on the sensor harness.



STC Oil Control Valve - Installation

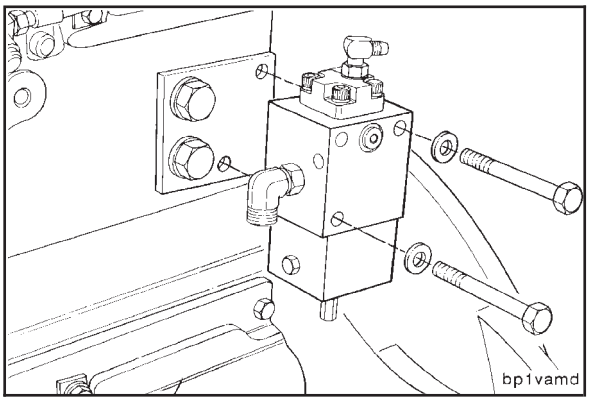
Install the mounting plate. Tighten the two capscrews.

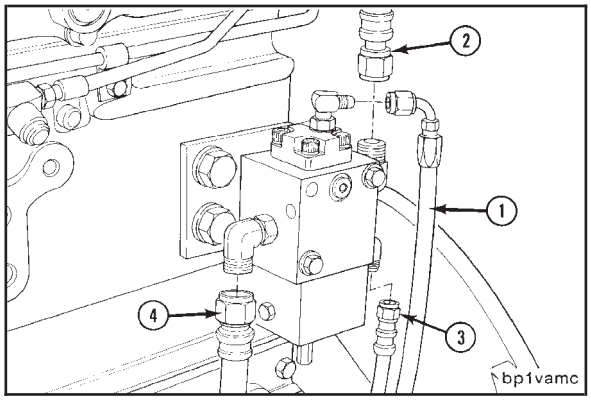
Torque Value: 68 N•m [50 ft-lb]

Install the STC oil control valve to the mounting plate with the two capscrews.

Tighten the capscrews.

Torque Value: 41 N•m [30 ft-lb]

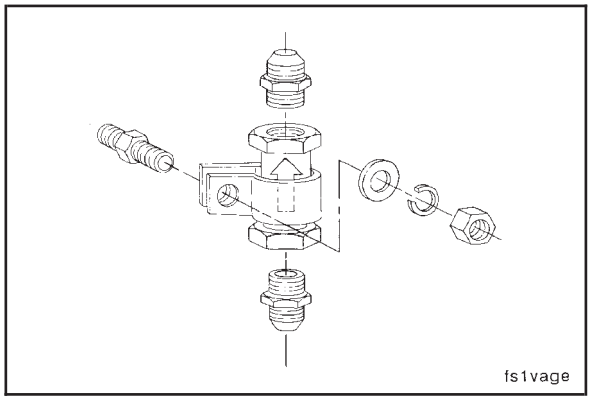




STC External Oil Plumbing - Installation

Connect the following lines to the STC oil control valve and tighten them to the specified torque:

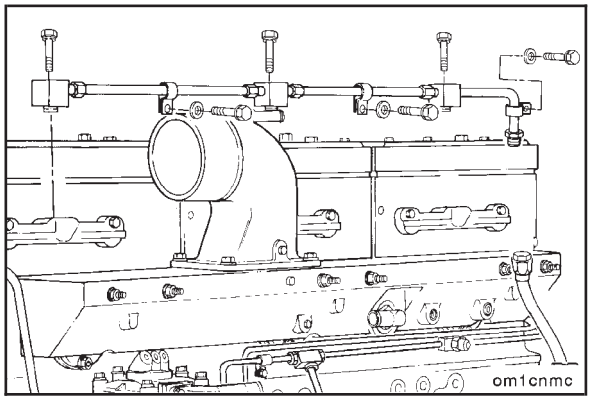
1. Fuel pressure sensing line - 9.5 N•m [84 in-lb]
2. Oil outlet line to tappets - 13.6 N•m [120 in-lb]
3. Oil vent line - 9.5 N•m [84 in-lb]
4. Oil supply line - 13.6 N•m [120 in-lb]



Install the check valve retaining clamp and check valve on the cam follower stud.

Torque Value: 47 N•m [35 ft-lb]

The check valve **must** be installed so the stamped arrow points in the direction of oil flow (from the oil rifle to the STC valve).



Install the external oil manifold using new o-rings. Lubricate the o-rings and the manifold connector bores with vegetable oil.

Install the external oil manifold hold down capscrews. Tighten the capscrews.

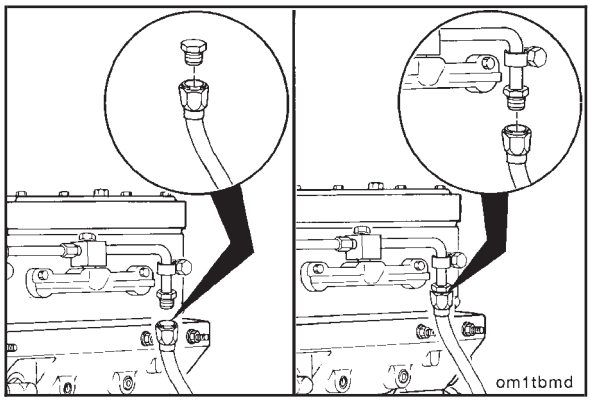
Torque Value: 12 N•m [105 in-lb]

Install the manifold clips, capscrews, and spacers. Tighten the capscrews.

Torque Value: 41 N•m [30 ft-lb]

Install the intake air tube and elbow if removed.

Torque Value: 34 N•m [25 ft-lb]



Remove the plug from the supply line and connect the supply line to the external oil manifold.

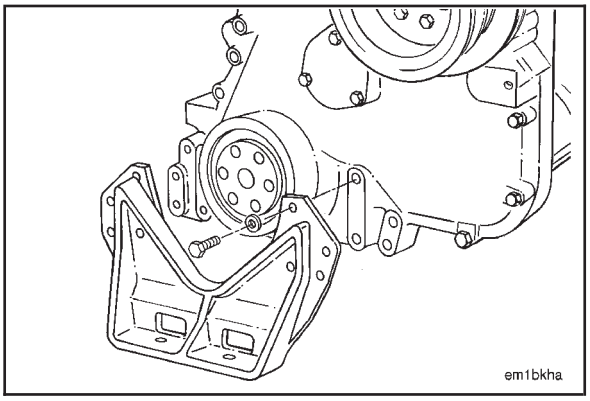
Caution: Hold the oil manifold fitting hex with a backup wrench while installing the supply line to avoid damaging the manifold.

Engine Support Bracket, Front - Installation

Install the engine support bracket and the eight mounting capscrews.

Tighten the capscrews.

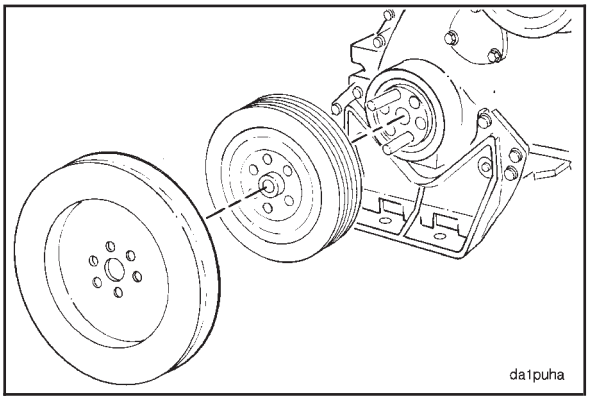
Torque Value: 68 N•m [50 ft-lb]



Vibration Damper - Installation

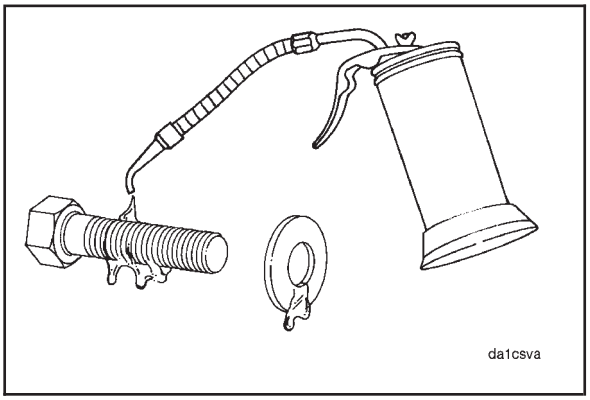
Install two guide pins into the end of the crankshaft. Install the pulley and the vibration damper.

NOTE: Make sure the mounting surfaces of the crankshaft nose, the vibration damper, and the pulley are clean, dry, and free of burrs.



Caution: Do not use an anti-seize compound, penetrating oil, or oil containing a friction modifier to lubricate the capscrews. This will result in incorrect capscrew torque and possible capscrew failure.

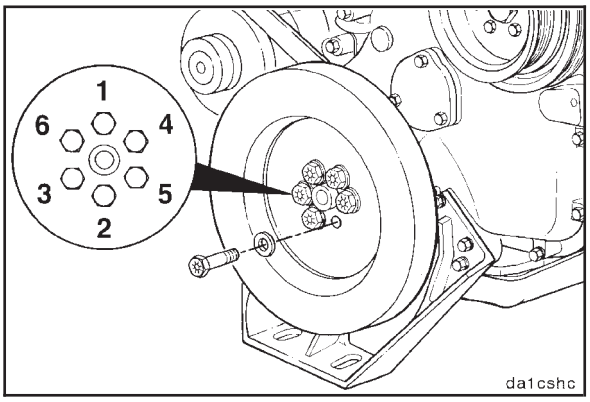
Lubricate the threads of the capscrews and the washer with a film of SAE 15W-40 oil.

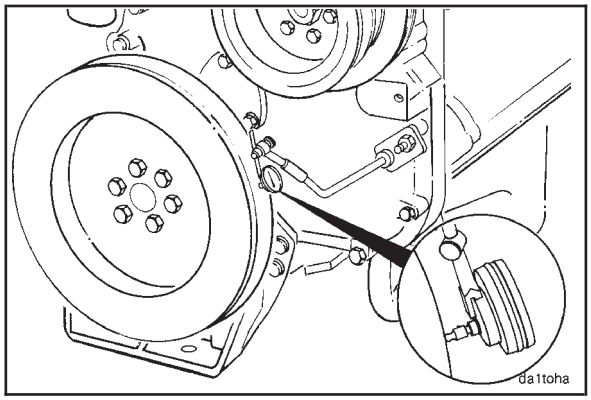


Install four of the six mounting capscrews. Remove the two guide studs, and install the remaining two capscrews.

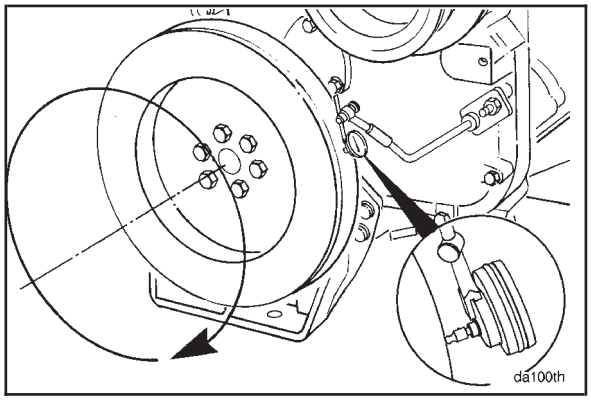
Install the washers and the capscrews. Keep the crankshaft from rotating, and tighten the capscrews to the following torque values, in the order shown:

Capscrew Size	SAE Grade No.	N•m [ft-lb]
5/8-inch	8	258 [190]

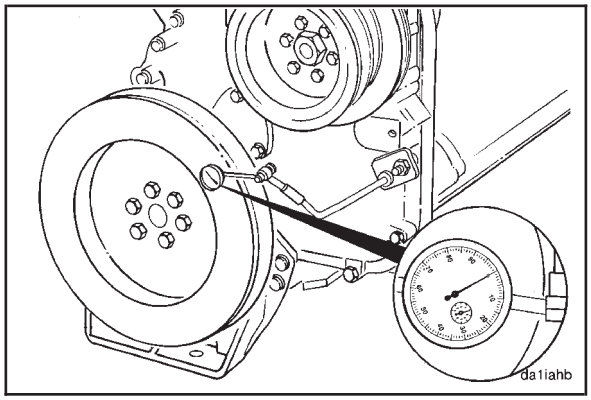




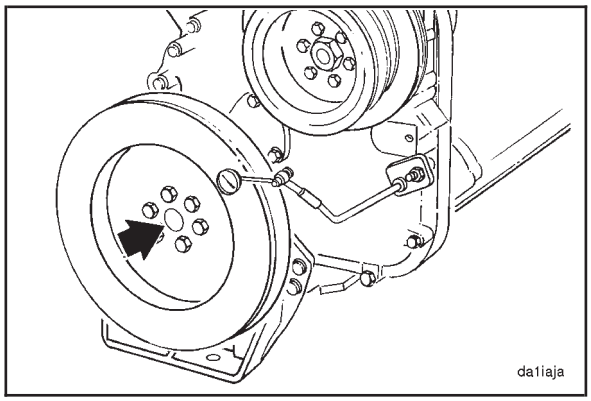
Install the dial indicator on the gear cover as indicated to measure damper eccentricity.



Rotate the crankshaft, and record the indicator movement. Replace the vibration damper if the eccentricity exceeds 0.10 mm [0.004-inch] per 25.4 mm [1.0 inch] of the damper diameter.



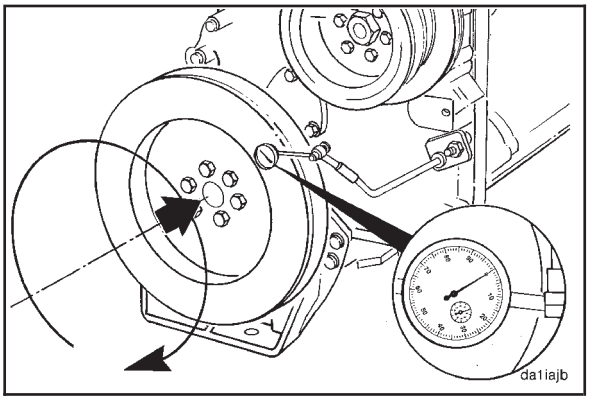
Install the dial indicator as indicated to measure wobble.



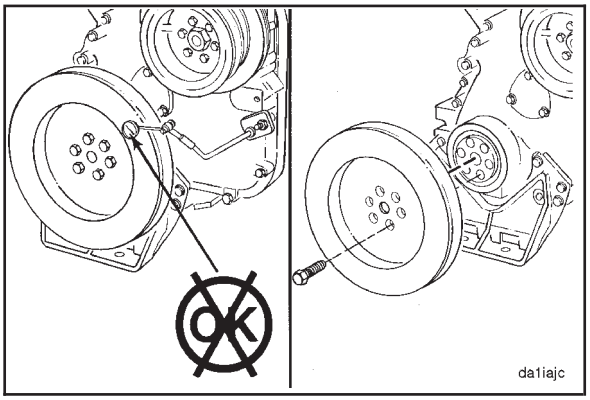
Push the crankshaft to the front or to the rear.

Rotate the crankshaft 360 degrees, maintaining the position of the crankshaft (either toward the front or the rear) in relation to the block.

Record the total indicator motion.

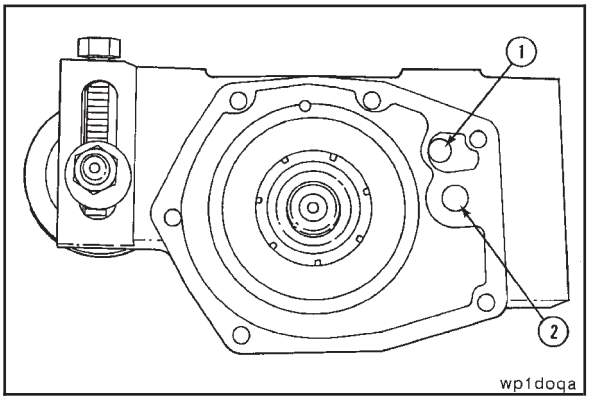


Replace the damper if wobble exceeds 0.18 mm [0.007-inch] per 25.4 mm [1.0 inch] of radius. This is the same as 0.09 mm [0.0035-inch] per 25.4 mm [1.0 inch] of damper diameter.



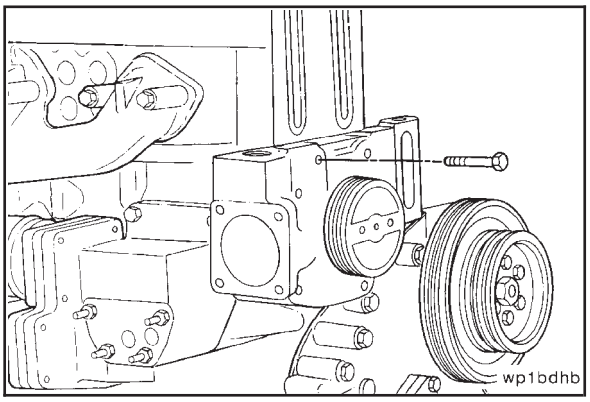
Water Pump - Installation

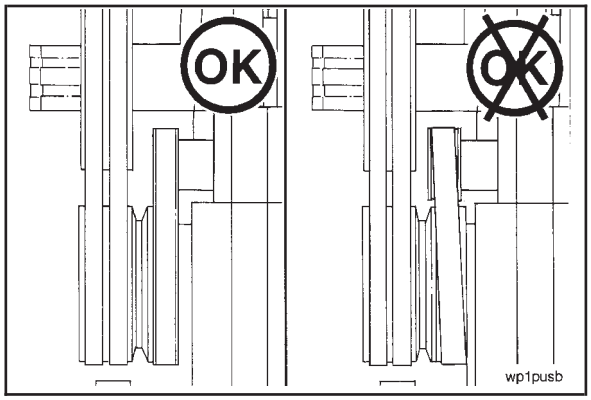
Caution: The water pump must have a dowel pin locating hole (1) and oil cooler return passage (2). Engine damage will occur due to lack of coolant flow through the oil cooler if the passage is not present.



Install the water pump with a new gasket to the block using the six mounting capscrews. Tighten the capscrews to the following torque values:

- Tighten to 15 N•m [10 ft-lb].
- Tighten to 30 N•m [20 ft-lb].
- Tighten to 47 N•m [35 ft-lb].

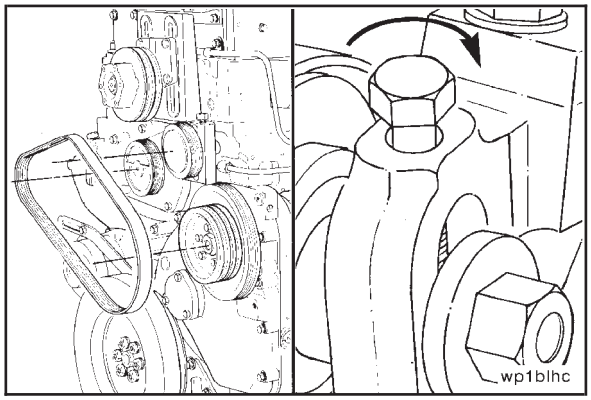




Water Pump Belt - Installation and Adjustment

Visually inspect the pulley alignment. Pulley misalignment **must not** exceed 0.5 mm per cm [1/16-inch per foot] of distance between the pulley centers.

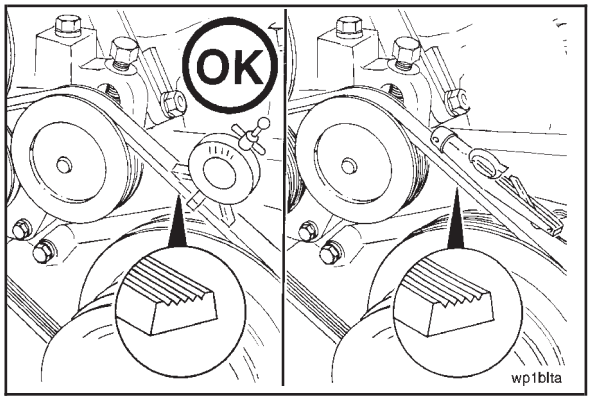
Inspect and repair or replace the idler pulley or water pump if pulley misalignment exceeds 0.5 mm per cm [1/16-inch per foot].



Install a new belt on the pulleys.

Turn the adjusting screw to adjust belt tension.

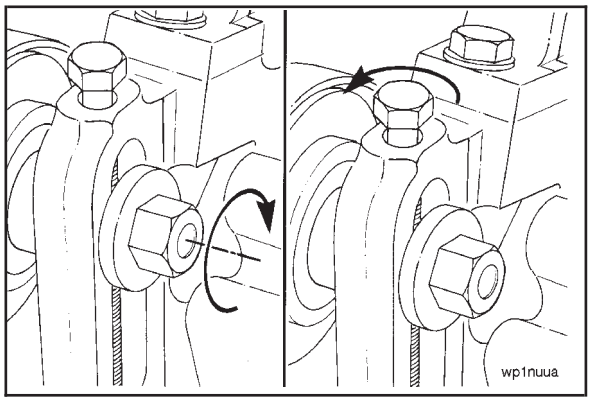
NOTE: Belt tension can increase when the lock nut is tightened. Do **not** adjust belt tension to full value with the adjusting screw.



Use Part No. ST-1293 (Borroughs) or 3822525 (Click-Type) Belt Tension Gauge to measure six-rib belt tension.

New Belt Tension	Used Belt Tension*
710 N [160 lb]	580 N [130 lb]

* A belt is considered used if it has been in operation for 10 minutes or longer.



Tighten the idler pulley shaft lock nut.

Torque Value: 68 N•m [50 ft-lb]

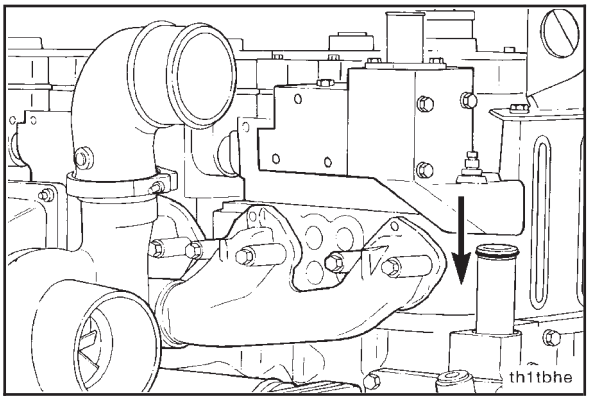
Loosen the adjusting screw 1/2-turn to prevent breakage.

Measure the belt tension again. Adjust if necessary.

Thermostat Housing - Installation

Install the water transfer tube with new o-rings into the water pump housing. Apply a non-petroleum based lubricant such as soap or vegetable oil to the o-rings on each end of the tube and to the bores in the water pump housing and the thermostat housing cover.

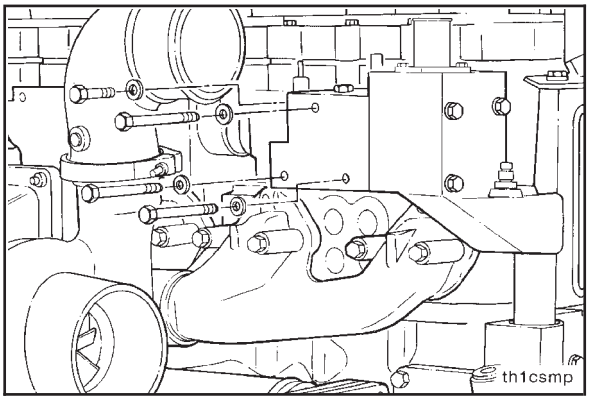
Install the thermostat housing assembly and mounting gasket on the rocker lever housing and onto the water transfer tube.



Install the four mounting capscrews and washers.

Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]

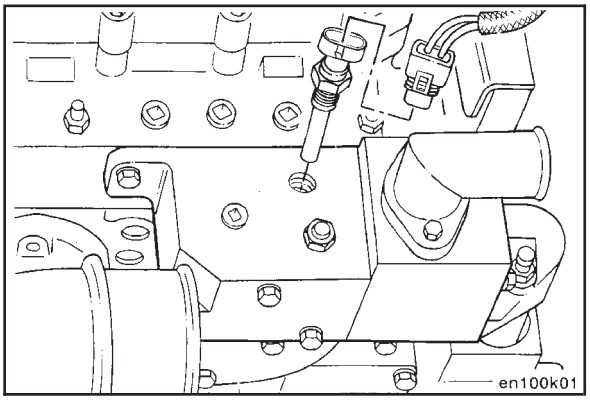


CELECT™ Coolant Temperature Sensor - Installation

Make sure the sensor has an o-ring. Install the sensor in the engine. Tighten the sensor.

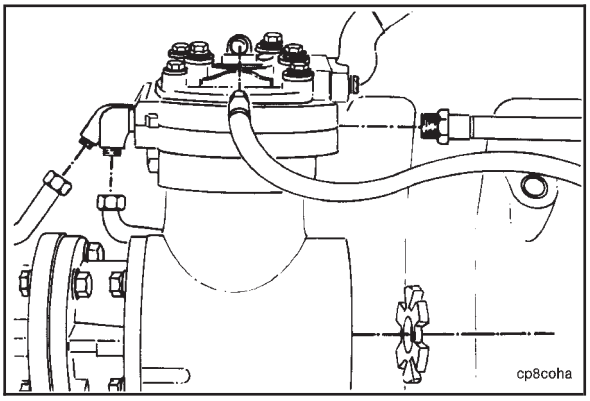
Torque Value: 34 N•m [25 ft-lb]

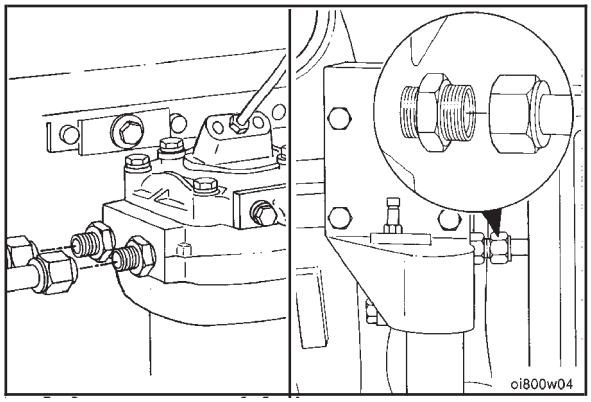
Push the electrical connector into the sensor until it locks in place.



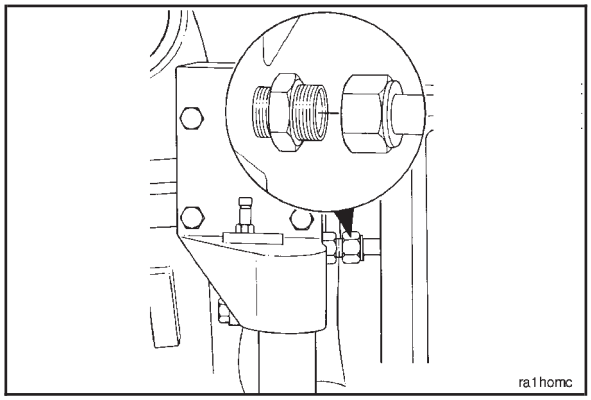
Air Compressor Coolant Inlet and Outlet Tubes - Installation

NOTE: If rubber grommets are used on the coolant lines, be sure they are installed carefully to prevent cuts or tears to the grommets which will cause coolant leaks. When flexible tubing is used, make sure that it does **not** rub any other surfaces.

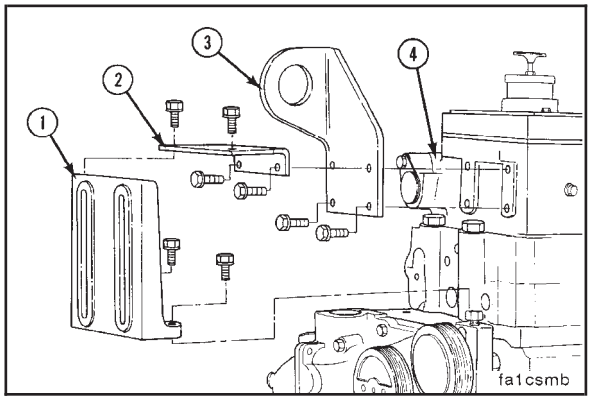




Install the coolant tubes to the air compressor and the water pump.



Install the coolant tube to the thermostat housing.

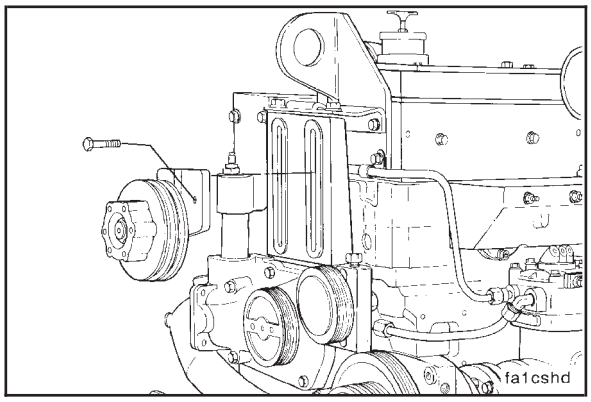


Fan Hub and Fan Hub Support Bracket - Installation

Install the following pieces on the engine and tighten the capscrews.

Torque Values:

- Fan Hub Bracket to Block - 100 N•m [75 ft-lb]
- Lifting Bracket and Brace to Block - 81 N•m [60 ft-lb]
- Brace to Fan Hub Bracket - 70 N•m [50 ft-lb]

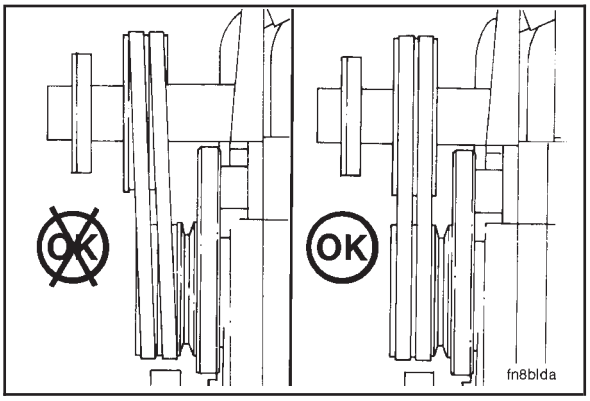


Install the new fan hub and the two capscrews.

Use your fingers to tighten the capscrews. Final tightening will occur after belt adjustment.

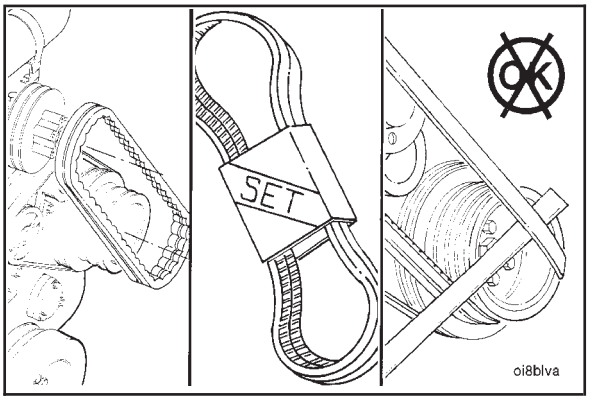
Fan Belts - Installation and Adjustment

Visually inspect the pulley alignment. Pulley misalignment **must not** exceed 0.5 mm per cm [1/16-inch per foot] of distance between the pulley centers. Inspect, repair, or replace the fan hub or the fan hub support bracket if pulley misalignment exceeds 0.5 mm per cm [1/16-inch per foot].



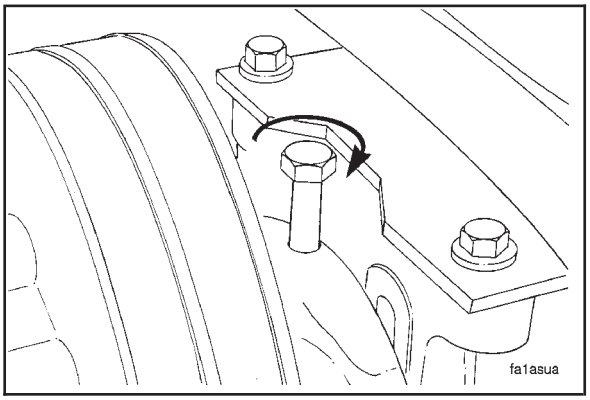
Install new belts on the pulley. When a drive pulley uses two or more belts, replace the belts as a complete set.

NOTE: To prevent damage, do **not** roll a belt over the pulley or pry it on with a tool.



Turn the adjusting screw to increase the belt tension.

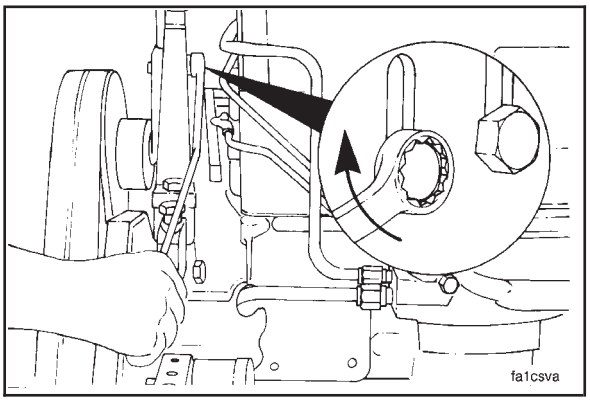
NOTE: Belt tension can increase when the fan hub mounting capscrews are tightened. Do **not** adjust the belt tension to full value with the adjusting screw.



Tighten the two capscrews until the fan hub is in correct alignment with the fan hub bracket.

NOTE: Do **not** tighten the capscrews to full torque value.

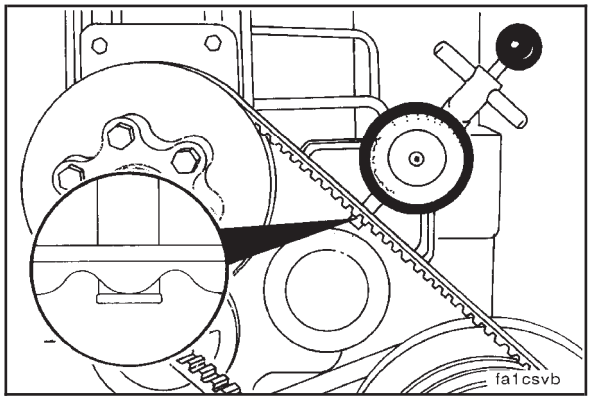
Measure the belt tension.



Belt Tension Specifications						
SAE Belt Size	Belt Tension Gauge Part No.		New Belt Installation Tension		Used Belt Tension Limits	
In.	Click-type	Burroughs	N	lbf	N min-max	lbf
.380	3822524	N/A	620	140	270-490	60-110
.440	3822524	N/A	620	140	270-490	60-110
1/2	3822524	ST-1138	620	140	270-490	60-110
11/16	3822524	ST-1138	620	140	270-490	60-110
3/4	3822524	ST-1138	620	140	270-490	60-110
7/8	3822524	ST-1138	620	140	270-490	60-110
4 Rib	3822524	ST-1138	620	140	270-490	60-110
5 Rib	3822524	ST-1138	670	150	270-530	60-120
6 Rib	3822525	ST-1293	710	160	290-580	65-130
8 Rib	3822525	ST-1293	890	200	360-710	80-160
10 Rib	3822525	3823138	1110	250	440-890	100-200
12 Rib	3822525	3823138	1330	300	530-1070	120-240

Refer to the Belt Tension Chart shown to select the correct gauge and tension values for the belt width.

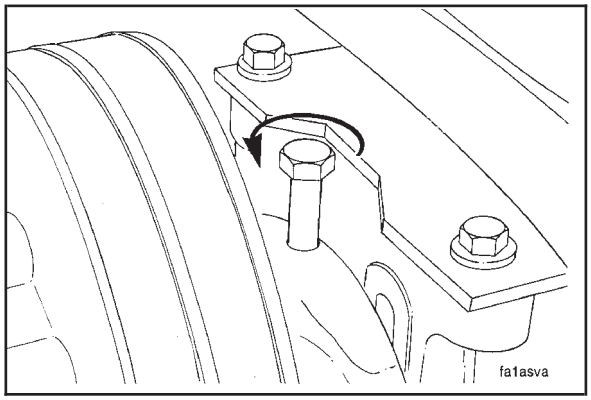
A belt is considered used if it has been in operation for at least 10 minutes.



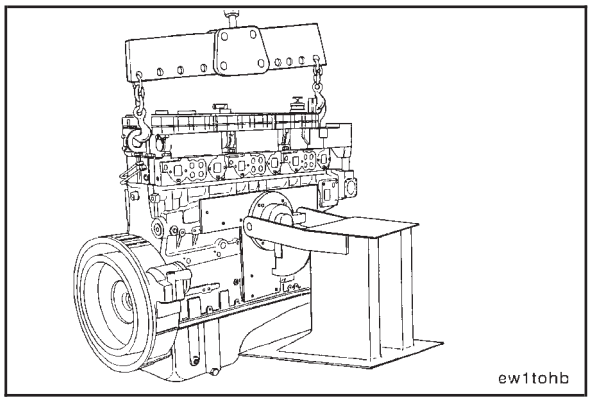
Tighten the two capscrews.

Torque Value: 108 N•m [80 ft-lb]

Measure the belt tension again using service tool, ST-1138. Adjust if necessary.



When satisfactory belt tension is obtained, loosen the adjusting screw 1/2-turn to prevent breakage.



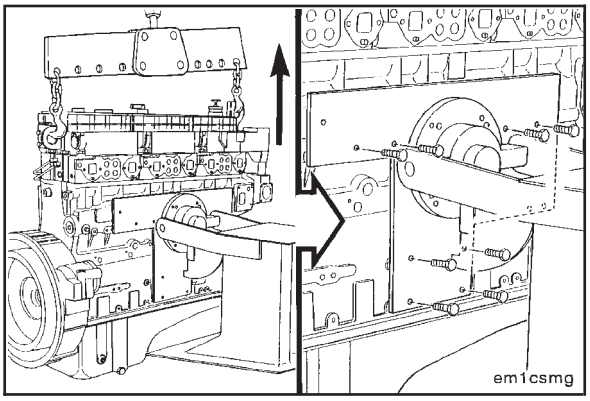
Engine - Removal From the Rebuild Stand

Use a lifting fixture, Part No. ST-125, and a hoist with a minimum lifting capacity of 4.5 M ton [5.0 tons] to lift the engine.

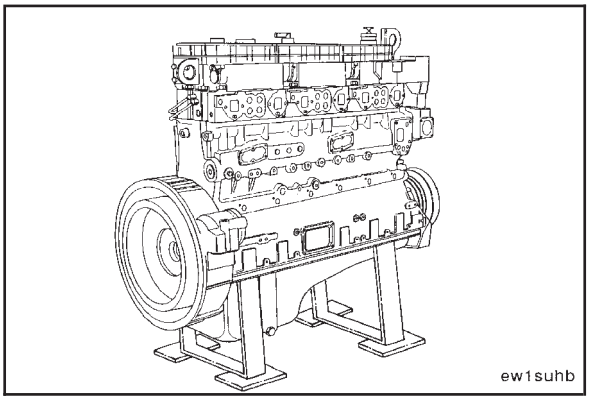
Attach the lifting fixture to the hoist and the lifting bracket as shown.

Use the hoist to move the weight of the engine off of the rebuild stand.

Remove the capscrews that hold the engine to the adapter plate.



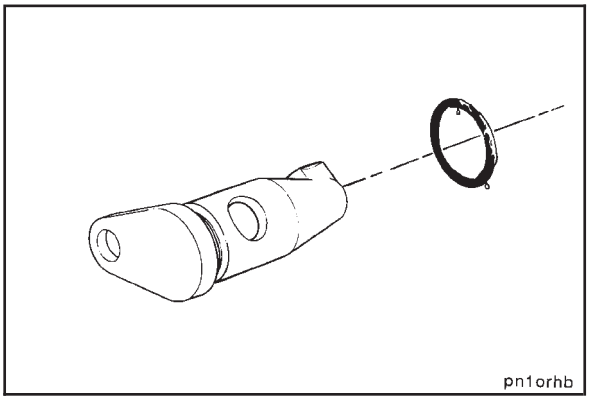
Install the engine on two engine support stands, Part No. ST-163.



Piston Cooling Nozzles - Installation

Use vegetable oil to lubricate the new o-rings. Do **not** soak the new o-rings in engine oil.

Install the o-rings in the groove of the piston cooling nozzle.



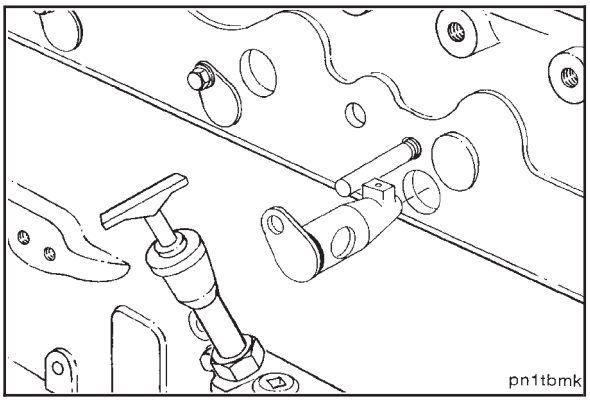
Install 4 inch X 3/8-16 guide studs in the capscrew holes.

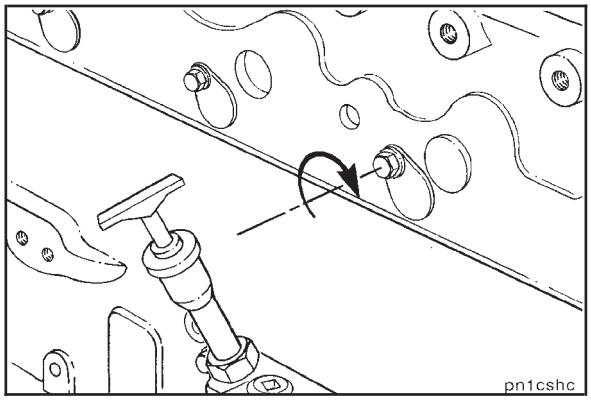
Install the nozzles in the cylinder block.

NOTE: Make sure the oil passage opening in the piston cooling nozzle is pointing up toward the piston.

Caution: Do not use the capscrew to pull the nozzle into the cylinder block. Nozzle and o-ring damage or external oil leaks can result.

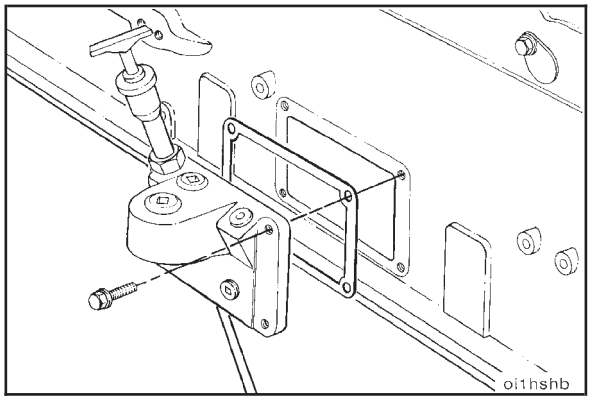
Remove the guide studs.





Install and tighten the capscrews.

Torque Value: 16 N•m [140 in-lb]



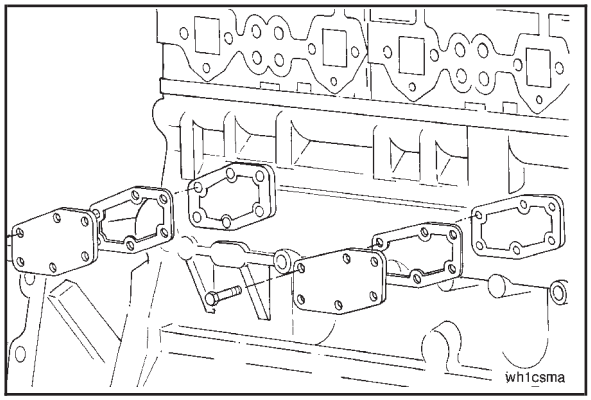
Dipstick Tube and Housing - Installation

Install the dipstick tube housing and a new gasket.

Install the four capscrews, and tighten.

Torque Value: 47 N•m [35 ft-lb]

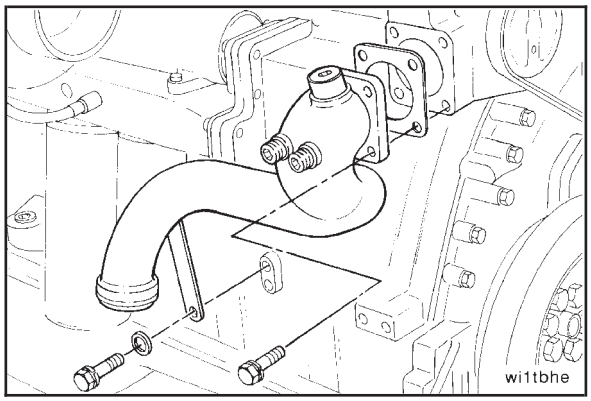
NOTE: Check the dipstick calibration after the engine is installed in the vehicle chassis. Refer to N14 Troubleshooting and Repair Manual, Bulletin No. 3810456.



Water Header Covers - Installation

Install new water header cover gaskets and the covers. Tighten the capscrews.

Torque Value: 12 N•m [110 in-lb]



Coolant Inlet Transfer Connection - Installation

Install the coolant inlet transfer connection and a new gasket on the water pump.

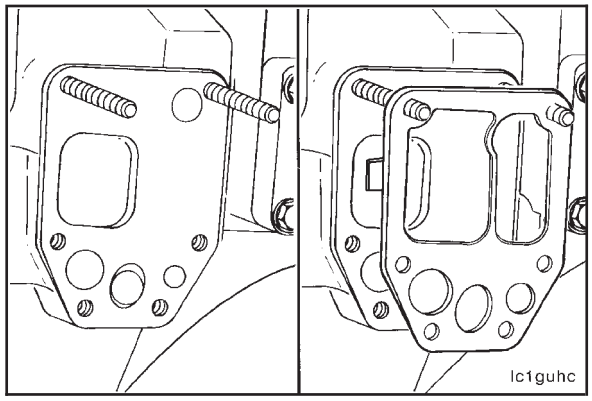
Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]

Lubricating Oil Cooler Assembly - Installation

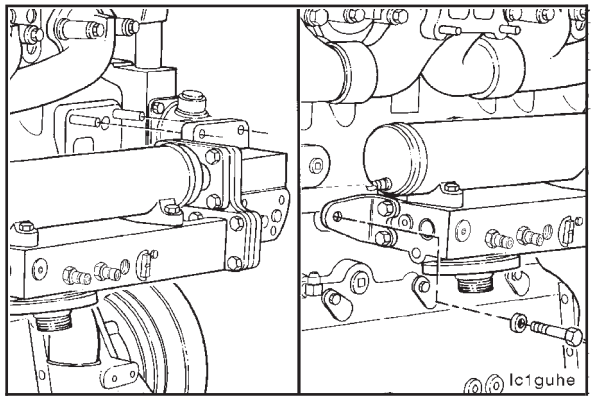
Install two guide studs in the oil cooler support mounting holes in the cylinder block.

Install a new oil cooler support gasket over the guide studs.



Install the oil cooler assembly over the guide studs, and push it against the cylinder block.

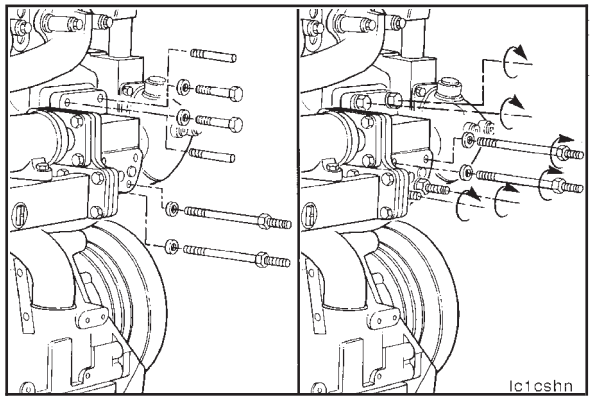
Install the oil cooler support bracket capscrew. Do **not** tighten at this time.



Install four of the support mounting capscrews, and remove the two guide studs.

Install the two remaining capscrews, and tighten all support capscrews.

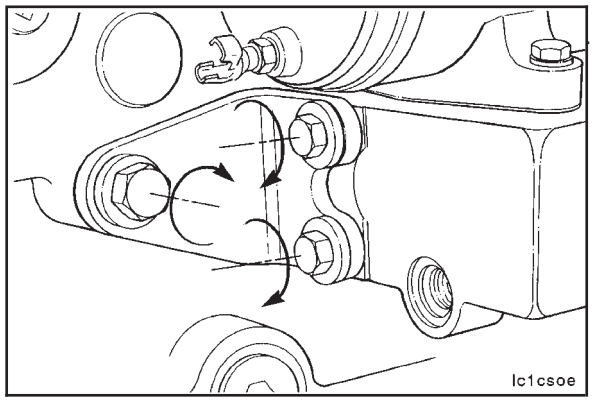
Torque Value: 47 N•m [35 ft-lb]

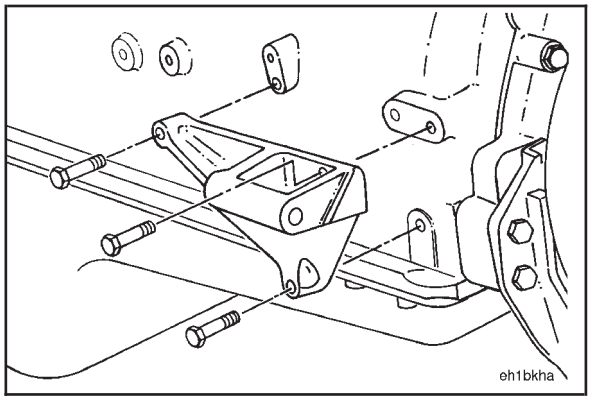


Finish mounting of the support bracket. First, loosen the two capscrews which hold the oil cooler support bracket to the rear of the oil cooler housing.

Then, alternately and evenly tighten the block mounting capscrew and the oil cooler housing capscrews. (Beginning with the block mounting capscrew.)

Torque Value: 47 N•m [35 ft-lb]

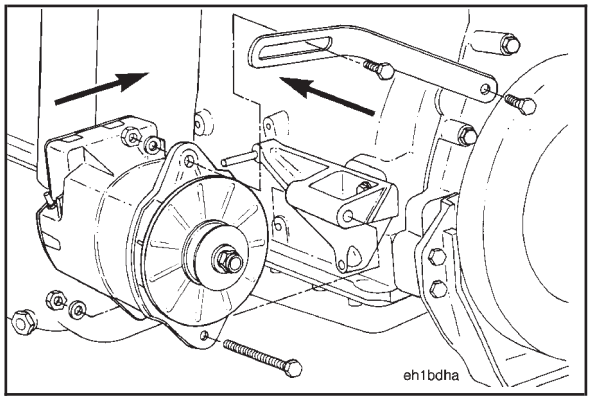




Alternator Mounting Bracket - Installation

Install the alternator mounting bracket. Tighten the mounting capscrews.

Torque Value: 47 N•m [35 ft-lb]

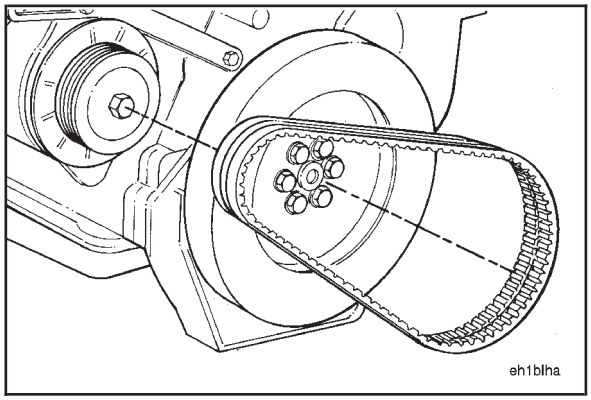


Alternator - Installation

Install the alternator, capscrew, washer, and nut to the alternator mounting bracket.

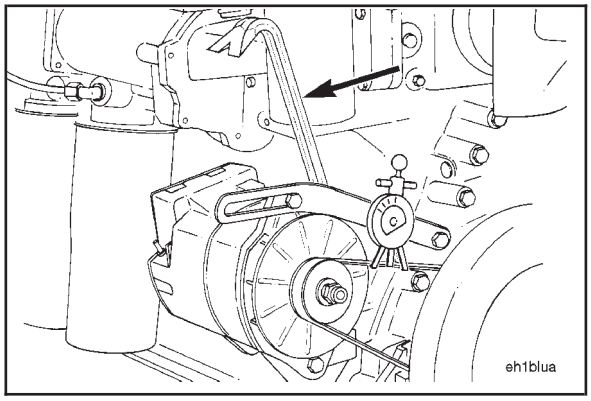
Install the adjusting link and the mounting capscrews.

NOTE: Do **not** tighten the alternator mounting and adjusting link capscrews and nuts until the alternator belt is installed and adjusted.



Alternator Belts - Installation and Adjustment

Install new alternator belts on the pulleys.



Use a pry bar between the engine and the alternator to tighten the alternator belt.

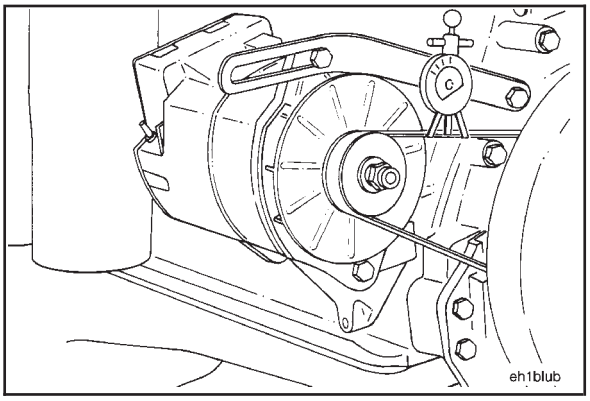
Use belt tension gauge, Part No. ST-1274, to measure the belt tension.

Adjust the belt tension to the following values:

New Belt Tension	Used Belt Tension
620 N [140 lbf]	490 N [110 lbf]

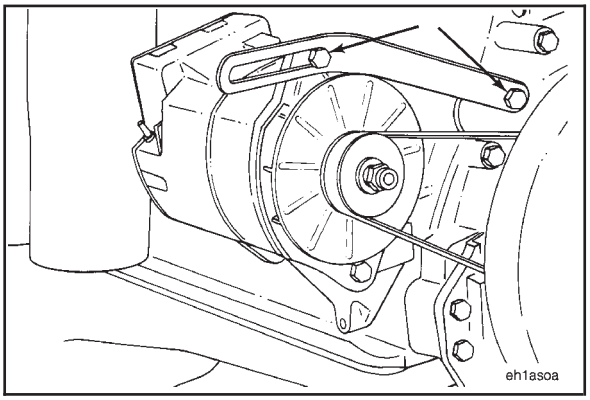
NOTE: A belt is considered used if it has been in operation for more than 10 minutes.

If the belt will **not** maintain the correct tension, it **must** be replaced.



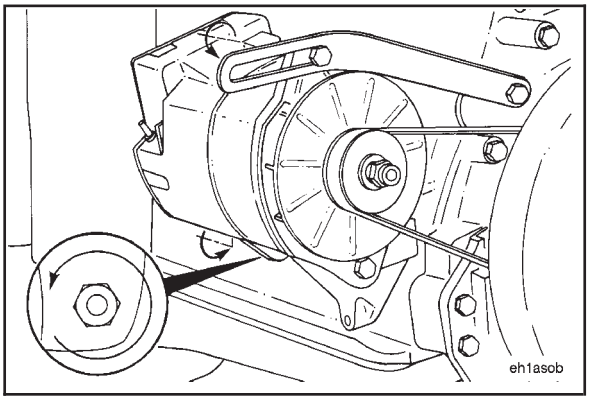
Tighten the adjusting link capscrews to the following torque values (Grade 5 or higher):

Bolt Size	Threads/ Inch	N•m	Ft-lb
5/16	18	20	[15]
7/16	14	34	[25]
1/2	13	68	[50]



Tighten the alternator to alternator support capscrew and nut to the following torque values (Grade 5 or higher):

Bolt Size	Threads/ Inch	N•m	Ft-lb
3/8	16	41	[30]
7/16	20	88	[65]
1/2	13	108	[80]

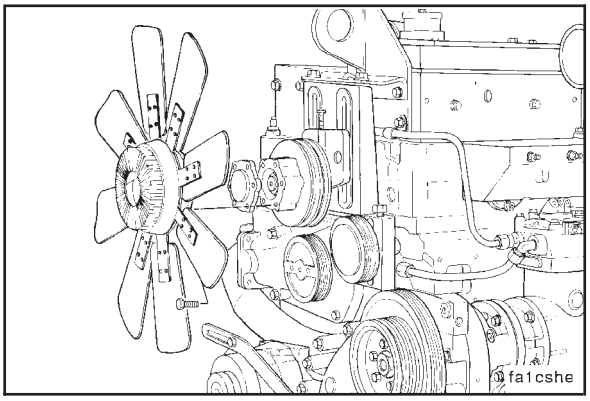


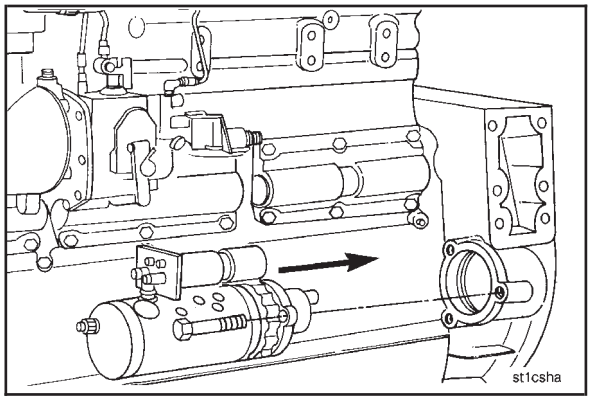
Fan and Fan Spacer - Installation

Install the same number and thickness of fan spacers as were removed during disassembly.

Install the fan. Tighten the 3/8-inch capscrews or hexagon nuts.

Torque Value: 47 N•m [35 ft-lb]





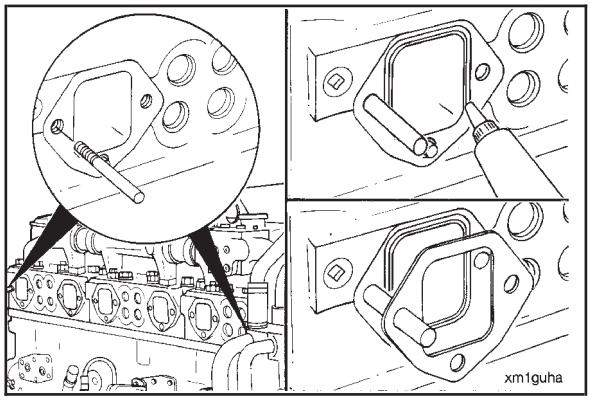
Starting Motor - Installation

Caution: Make sure to use the same thickness of starting motor spacer (if used) as the one removed to install the starting motor to prevent engine or starting motor damage.

Install the starting motor and the three capscrews.

Tighten the capscrews.

Torque Value: 176 N•m [130 ft-lb]

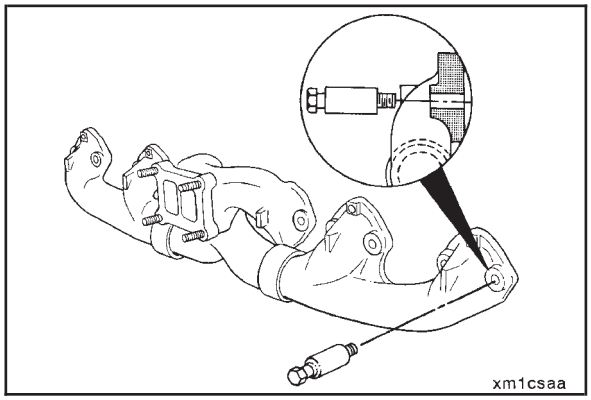


Exhaust Manifold - Installation

Install two guide studs.

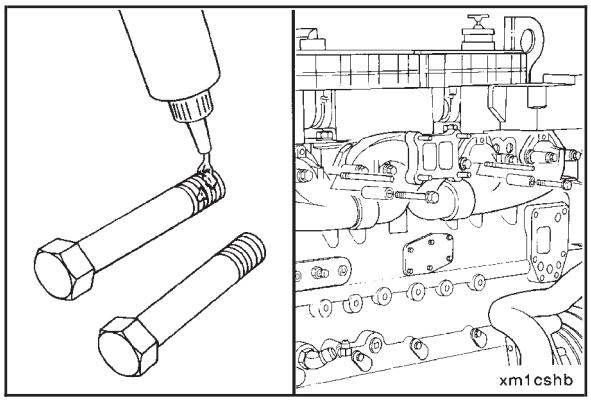
Use an adhesive or heavy grease to hold the gaskets in place on the cylinder head.

NOTE: The side of the gasket marked ''OUT'' **must** be away from the cylinder heads.



Special capscrews with spacers are required for the N14 exhaust manifold.

Do **not** use short capscrews.



Warning: Because this assembly weighs more than 23 kg [50 lbs], two people or a hoist will be required to lift the exhaust manifold assembly to avoid personal injury.

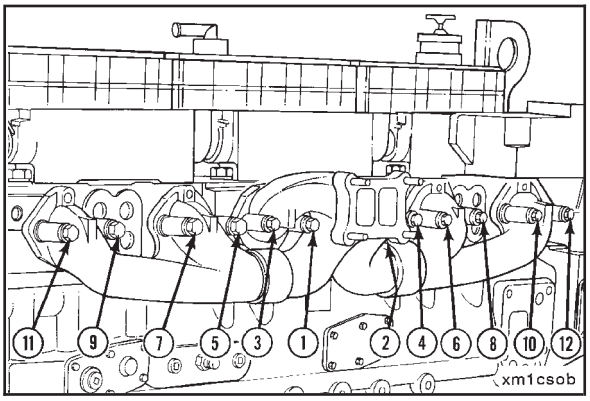
Install the exhaust manifold and ten capscrews.

Remove the guide studs, and install the remaining two capscrews.

NOTE: To aid in future capscrew removal, apply a film of high temperature anti-seize compound, Part No. 3823097, to the capscrew threads.

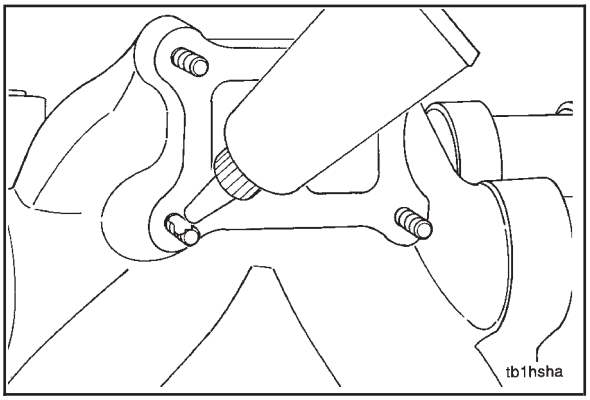
Tighten the capscrews in two steps in the sequence shown.

Torque Values: Step 1 47 N•m [35 ft-lb]
Step 2 81 N•m [60 ft-lb]



Turbocharger - Installation

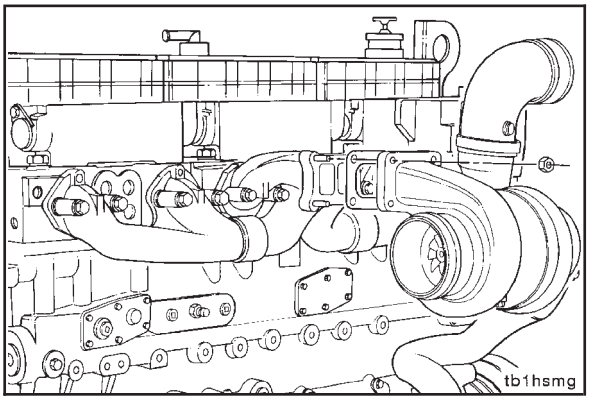
Apply a film of high temperature anti-seize compound, Part No. 3823097, to the turbocharger mounting studs.



Install a new mounting gasket, the turbocharger, and the four mounting nuts.

Tighten the mounting nuts.

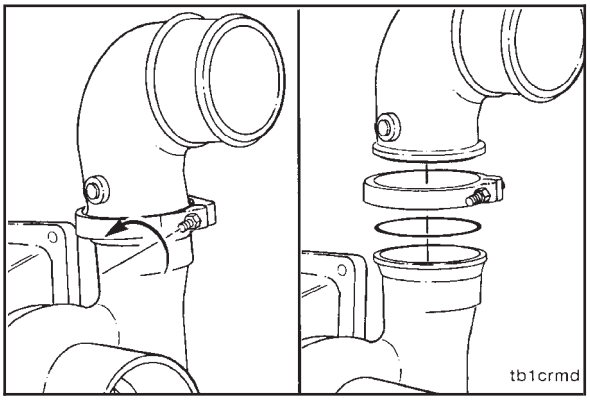
Torque Value: 68 N•m [50 ft-lb]

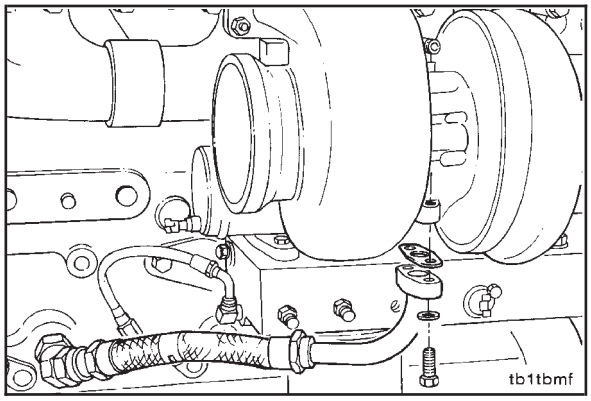


Install a new o-ring seal, the clamp, and the discharge elbow to the turbocharger.

Tighten the clamps.

Torque Value: 8.5 N•m [75 in-lb]

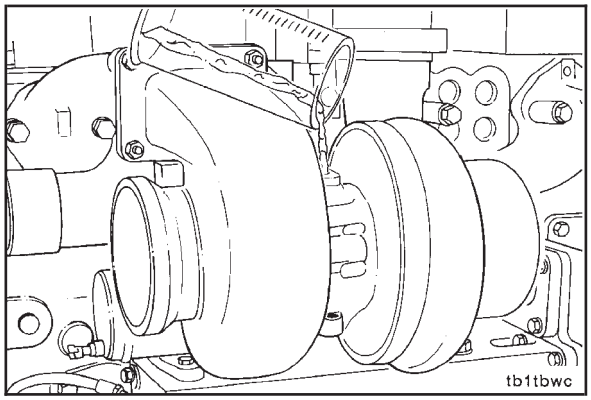




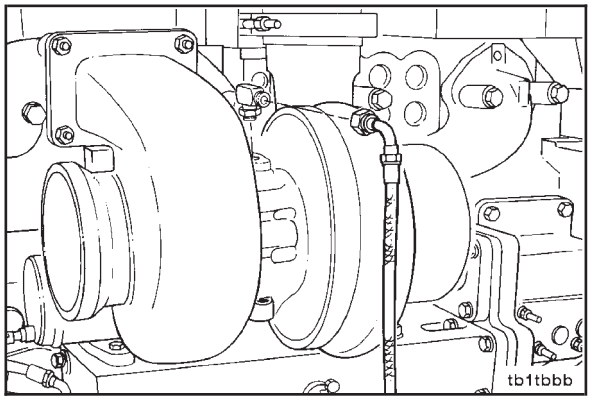
Install a new gasket, oil drain tube, and capscrews.

Tighten the capscrews.

Torque Value: 44 N•m [32 ft-lb]

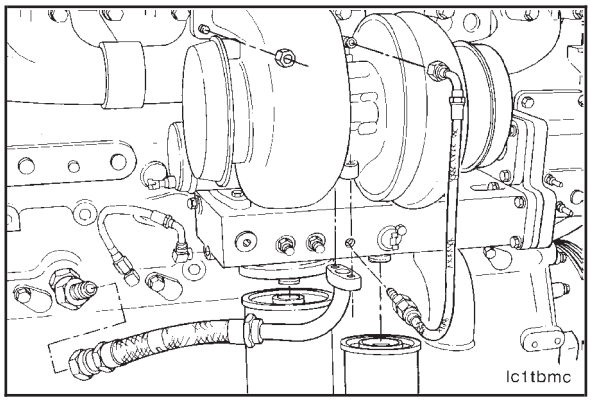


Pour 50 to 60 cc [2.0 to 3.0 ounces] of clean engine oil in the turbocharger oil supply opening.



If installing a new turbocharger, install the male union elbow.

Torque Value: 30 N•m [22 ft-lb]



Install the turbocharger oil supply tube.

Torque Value: 30 N•m [22 ft-lb]

Install the turbocharger drain tube to the turbocharger.

Torque Value: 44 N•m [32 ft-lb]

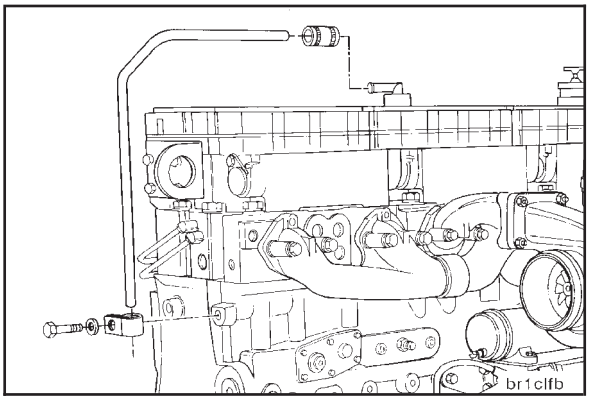
Crankcase Breather Tube - Installation

Install the breather vent tube on the breather tube, and tighten the hose clamps.

Torque Value: 4.5 N•m [40 in-lb]

Install and tighten the tube support brackets and cap-screws.

Torque Value: 47 N•m [35 ft-lb]

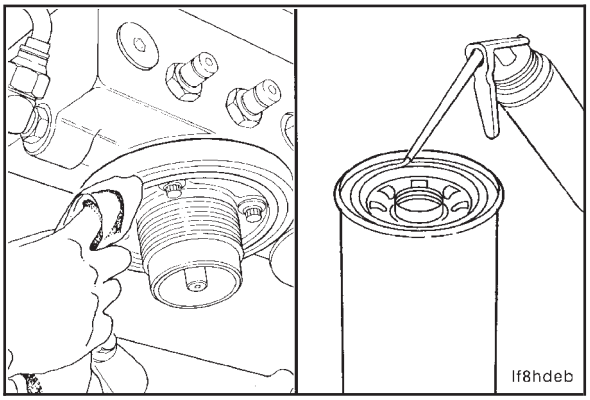


Lubricating Oil Filter - Installation

NOTE: The o-ring can stick on the filter head. Make sure it is removed before installing a new filter.

Clean the oil filter head surface.

Use clean vegetable oil to lubricate the gasket surface of the filter.

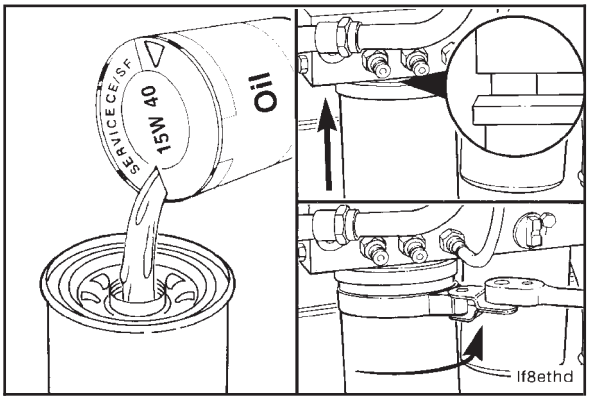


Fill the filter with clean 15W-40 oil.

Install the filter on the oil filter head. Tighten the filter until the gasket contacts the filter head surface.

Caution: Mechanical overtightening may distort the threads or damage the filter element seal.

Use oil filter wrench, Part No. 3375049, to tighten the filter an additional three-fourths to one (3/4 to 1) turn, or follow the instructions supplied with the filter.

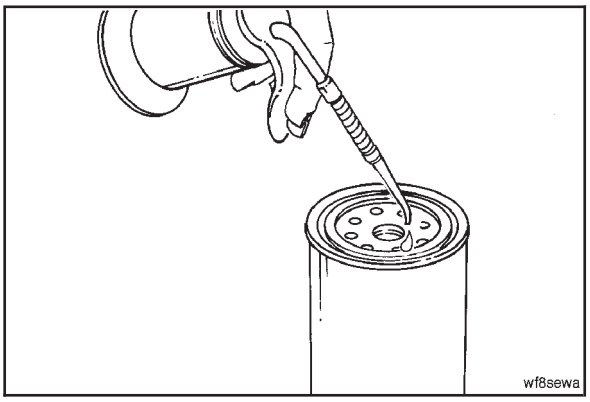


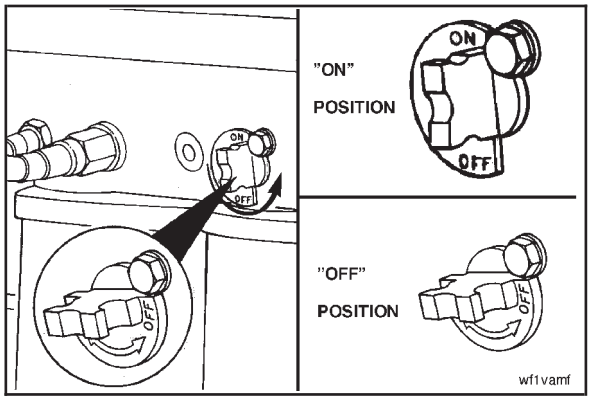
Coolant Filter - Installation

Apply a light film of clean 15W-40 oil to the coolant filter gasket sealing surface before installing the coolant filter.

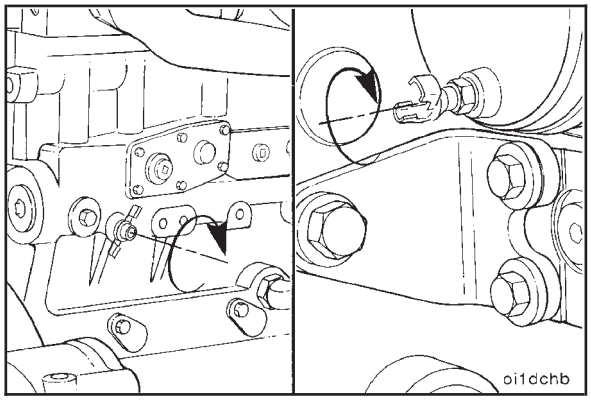
Install the filter as specified by the manufacturer.

NOTE: Mechanical overtightening can distort the threads or damage the filter head.

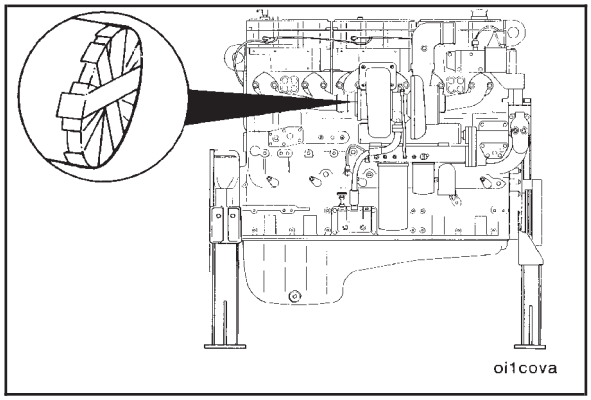




If the engine is to be run-in on an engine dynamometer, make sure the shutoff valve is closed. Open the valve after the run-in.



Be sure the engine draincock and oil cooler draincock are closed.



Engine - Covering All Openings

Cover all engine openings to prevent dirt and debris from entering the engine.

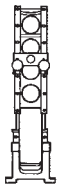
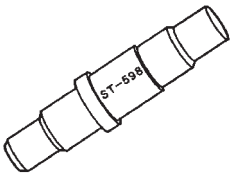
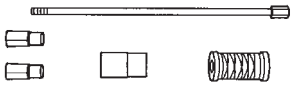
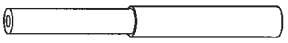
Section 1 - Cylinder Block - Group 01

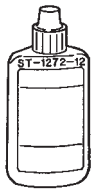
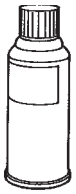
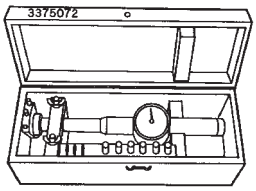
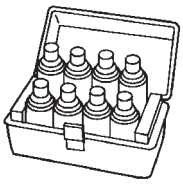
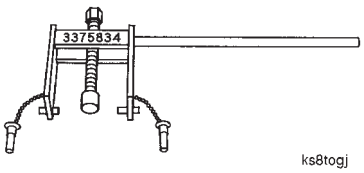
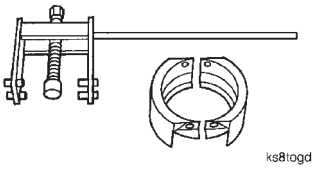
Section Contents

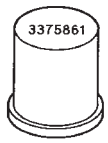
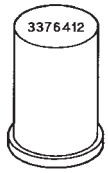
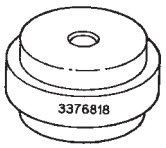
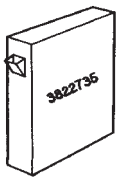
Page

Cylinder Block - Service Tools

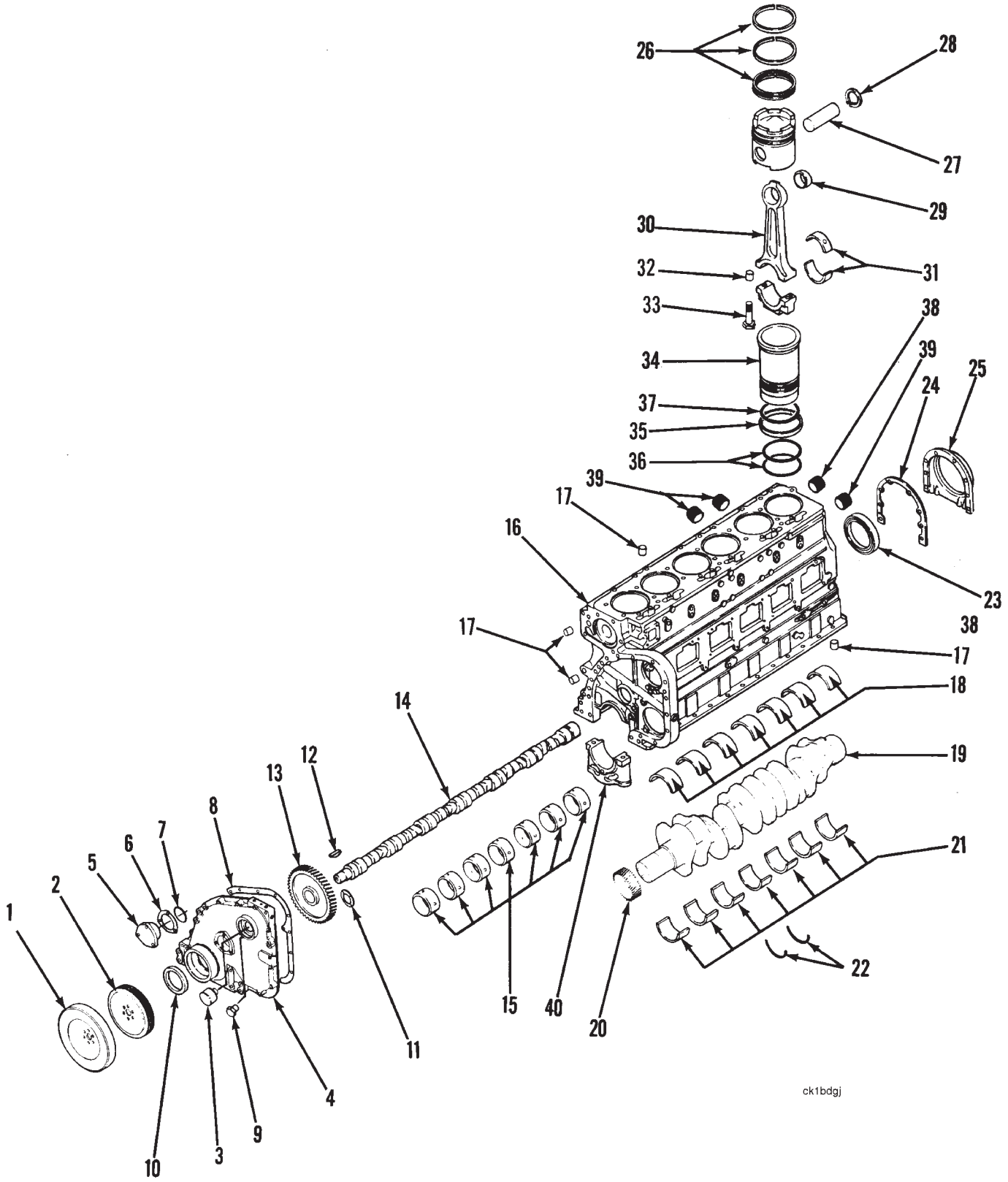
The following special tools are recommended to perform procedures in section 1. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-561	**Connecting Rod Checking Fixture** Measure connecting rod bend and twist.	 cx8toge
ST-598	**Gear Cover Bushing Mandrel** Designed to install and remove precision bushings in the gear cover accessory drive bore.	 gc8togd
ST-1134	**Dowel Pin Extractor** Used to pull dowel pins and crosshead guides.	 ck8toge
ST-1168-46	**Long Bushing Driver Shaft** Use to salvage cylinder blocks. (Included in cylinder liner counterbore tool kit, Part No. 3377356.)	 oi8togo
ST-1228	**Camshaft Bushing Driver Set** Replace cylinder block camshaft bushings.	 ck8togg
ST-1228-6	**Camshaft Bushing Guide** Use to install No. 7 bushing.	 cg8togd

Tool No.	Tool Description	Tool Illustration
ST-1272-12	**Loctite Compound** Use to install repair bushings.	 oi8togs
ST-1272-13	**Loctite Primer T** Use to clean the counterbore area and the outside diameter of the repair sleeve.	 oi8togt
3375066	**Pipe Sealant** Use when installing pipe plugs on engines to stop leaks.	 bp8togh
3375068	**Cup Plug Sealant** Use when installing cup plugs on engines to stop leaks.	 bp8togk
3375072	**Dial Bore Gauge Kit** Used to measure internal bore diameters.	 oi8togu
3375432	**Crack Detection Kit** Used to check or inspect components for cracks.	 bp8togj
3375834	**Gear Puller Assembly** Use to remove the crankshaft gear from the crankshaft.	 ks8togj
3375839	**Crankshaft Gear Puller Jaw** Used to remove the crankshaft gear.	 ks8togd

Tool No.	Tool Description	Tool Illustration
3375861	**Camshaft Bushing Driver** Use camshaft bushing driver set, Part No. 3376637, and driver, Part No. 3375861, to remove bushing No. 1 through No. 7.	 cg8toge
3376412	**Camshaft Bushing Driver** Use to install camshaft bushings No. 3 and No. 5.	 cg8togg
3376818	**Camshaft Bore Cup Plug Driver** Required to correctly position the rear camshaft bore cup plug in the cylinder block.	 cg8togh
3822735	**Plastic Bead Media** Use to clean the piston dome or crown and the ring grooves.	 bp8togp

Cylinder Block - Exploded View



Ref. No.	Description	Quantity
1	Damper, Vibration	1
2	Pulley, Crankshaft	1
3	Bushing, Gear Cover Accessory Drive	1
4	Cover, Gear	1
5	Support, Camshaft	1
6	Shim, Camshaft Support	--
7	Seal, O-ring	1
8	Gasket, Gear Cover	1
9	Plug, Inspection	1
10	Seal, Front Crankshaft	1
11	Bearing, Camshaft Thrust	1
12	Key, Woodruff	1
13	Gear, Camshaft	1
14	Camshaft	1
15	Bushing, Camshaft	7
16	Block, Cylinder	1
17	Pin, Dowel/Roll (not all shown)	19
18	Bearings, Upper Main	7
19	Crankshaft	1
20	Gear, Crankshaft	1
21	Bearings, Lower Main	7
22	Bearings, Crankshaft Thrust	2
23	Seal, Rear Crankshaft	1
24	Gasket, Rear Cover	1
25	Cover, Rear	1
26	Set, Piston Ring	6
27	Pin, Piston	6
28	Ring, Snap	12
29	Bushing, Piston Pin	6
30	Rod, Connecting	6
31	Bearings, Connecting Rod	12
32	Dowels, Ring	12
33	Bolts, Connecting Rod	12
34	Liner, Cylinder	6
35	Seal, Crevise	6
36	Seals, O-ring	12
37	Ring, Cylinder Liner Seal	6
38	Plugs, Expansion (not all shown)	3
39	Plugs, Straight Thread or Pipe (not all shown)	23
40	Caps, Main Bearings	7

Cylinder Block - General Information

1. A **WARNING** statement is included for any component or assembly that weighs more than 23 kg [50 lb]. To avoid personal injury, use a hoist or get assistance from more than one person when removing or installing these parts.
2. Most of the capscrews used on the N14 engine are U.S. Customary. All fasteners have right-hand threads unless a **CAUTION** states that a fastener has left-hand threads.

Discard all non-reusable gaskets, seals, and o-rings. Keep these parts if they are needed for a failure analysis.

Label, tag, or mark the parts for location as the parts are removed in order to simplify locating all parts that can be involved in a failure and to simplify the assembly procedure. Some parts can also be used again.

Force **must** be used to remove certain parts. A mallet **must** be used when force is required. All of the fasteners **must** be removed before using force.

Avoid as much dirt as possible during disassembly. The accumulation of dirt will make it more difficult to clean the components.

Torque values are listed in each assembly step. If a torque value is **not** specified, use the chart listed in the Specifications Section, Group 18, to determine the correct torque value.

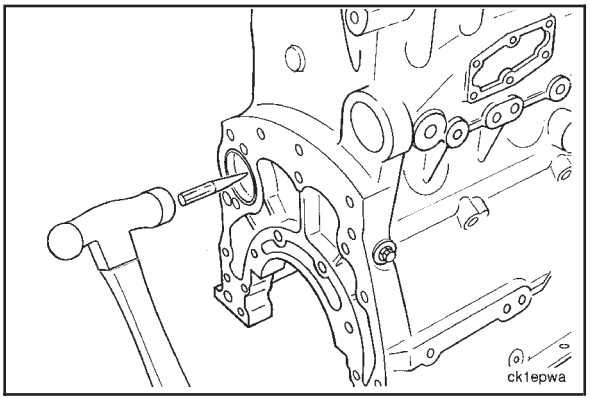
Many of the gaskets and o-rings are manufactured from a material designed to absorb oil. These gaskets will enlarge and provide a tight seal after coming in contact with oil. Use only a recommended contact adhesive or a vegetable-based oil to install these parts.

Always use a capscrew of the same system (metric or U.S. Customary), the same dimension, and the same grade as the capscrew removed. The use of a longer, shorter, different grade, or wrong thread capscrew than the capscrew that is listed can result in damage to the engine.

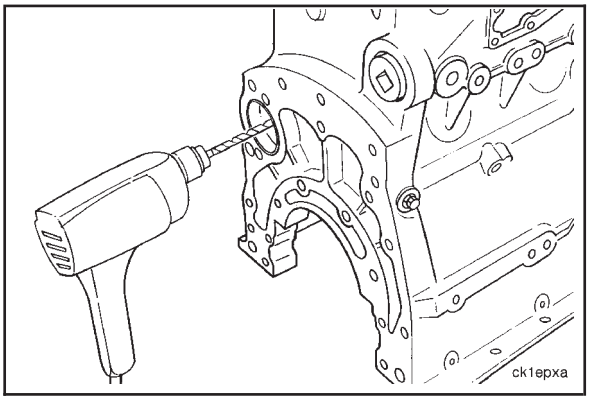
Cylinder Block - Disassembly (01-01)

Cam Bore Rear Cup Plug - Removal

To remove the cup plug from the camshaft bore, use a center punch to mark the cup plug for drilling.

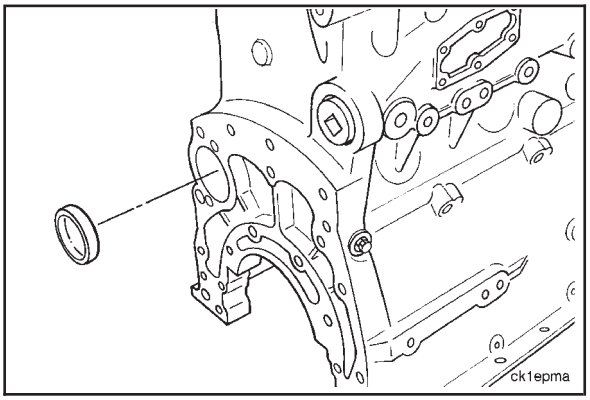


Drill a 3.18 mm [1/8-inch] hole in the cup plug.



Use an expansion plug removal tool, Part No. 3823159, to remove the cup plug.

NOTE: Discard all used cup plugs.

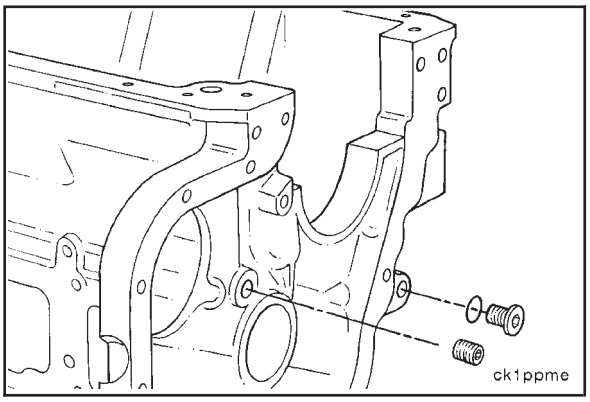


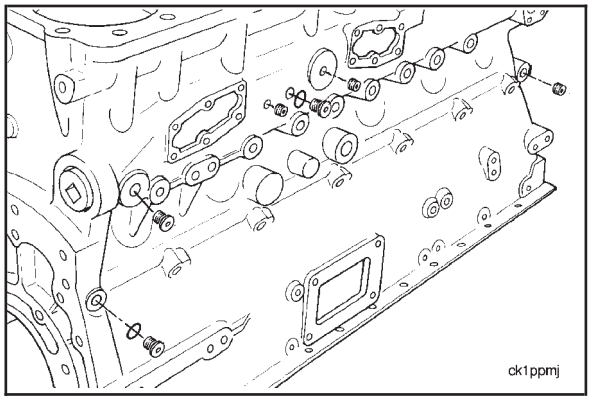
Straight Thread Plug and Pipe Plug - Removal

Remove the straight thread plugs and pipe plugs from all oil passages in the cylinder block.

Remove the straight thread plug from the piston cooling passage in the front of the cylinder block.

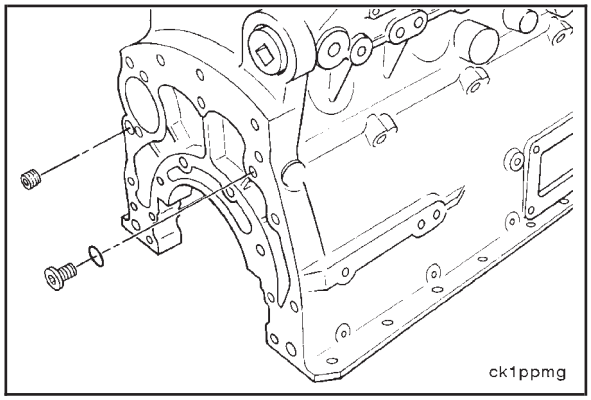
Remove the pipe plug from the main oil passage in the front of the cylinder block.





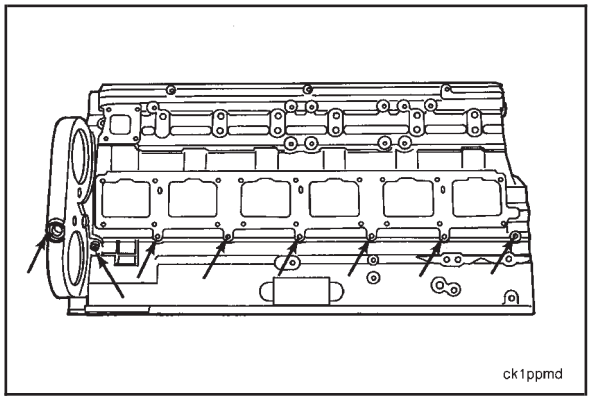
Remove the straight thread plug and pipe plug from the piston cooling oil passage on the exhaust side of the cylinder block.

Remove pipe plugs from the coolant passage on the exhaust side of the cylinder block.



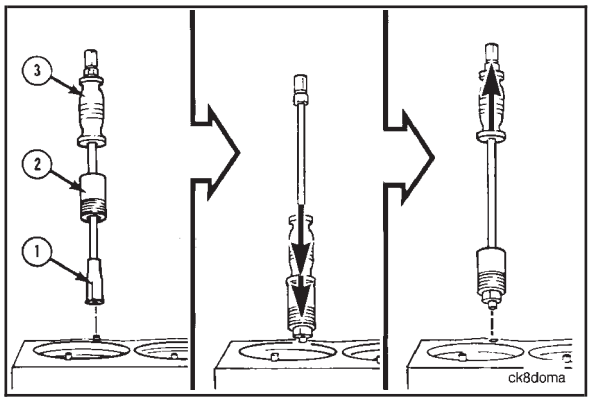
Remove the straight thread plug from the piston cooling passage at the rear of the cylinder block.

Remove the pipe plug from the main oil passage at the rear of the cylinder block.



Remove the six pipe plugs and one straight thread plug from the main oil passage on the intake side of the cylinder block.

Remove the straight threaded plug from the main oil transfer passage on the intake side of the cylinder block.



Dowel Pin - Removal

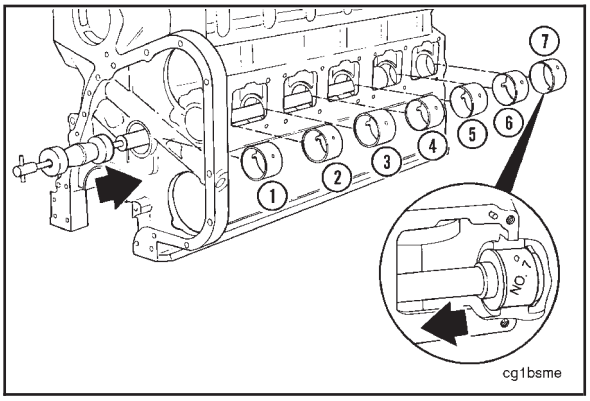
Use a dowel pin extractor, Part No. ST-1134, or its equivalent. Remove the six cylinder head groove pins, two front cover dowel pins, one water pump dowel pin, six cam follower housing dowel pins, and two flywheel housing dowel pins.

- Put the split collet (1) over the groove pin.
- Slide the extractor collar (2) over the split collet.
- Use the slide hammer (3) to push the extractor collar over the split collet tightly.
- Use the slide hammer to remove the groove pin.

Camshaft Bushings - Removal

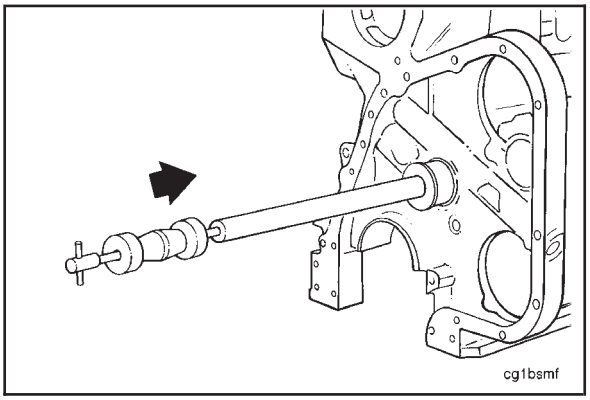
Use camshaft bushing driver set, Part No. 3376637, and driver, Part No. 3375861, to remove bushings No. 1 through No. 7.

Remove the No. 1 bushing first and then the remaining six (6) bushings in order from front to rear.

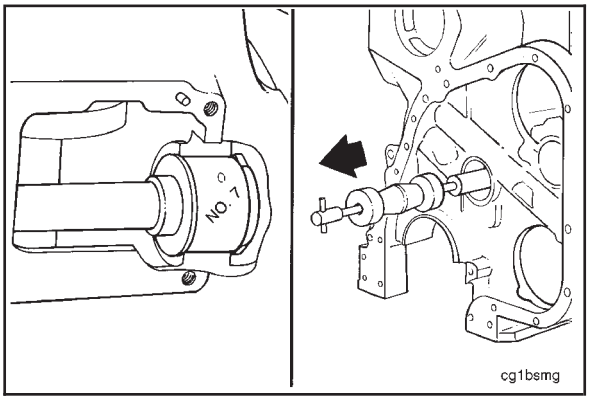


To remove bushings No. 1 through No. 7, insert the tool assembly through the camshaft bore until the driver is against the bushing.

Hit the slide hammer against the shaft assembly until the bushing is driven from the bore.



To remove the No. 7 bushing during in-chassis camshaft bushing removal, insert the tool assembly through the bore until the pins of the puller assembly are engaged behind the bushing.

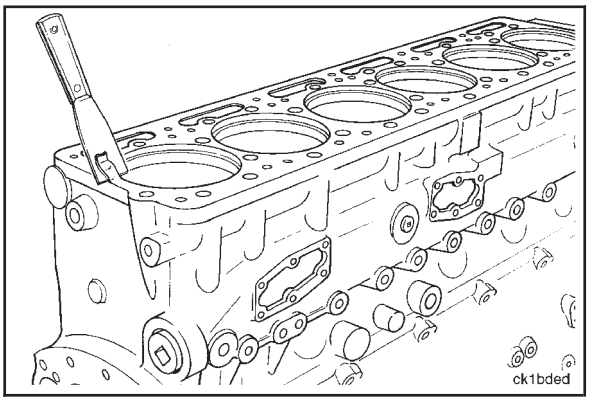


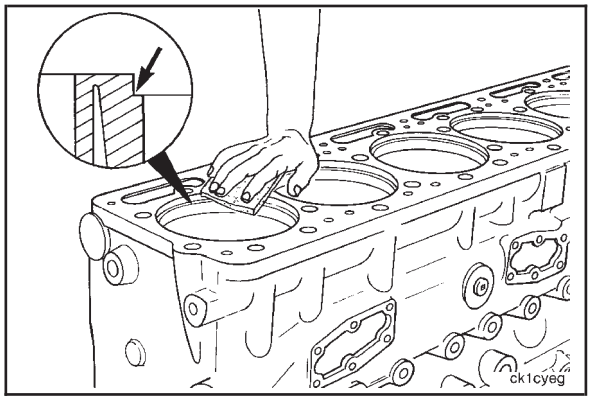
Cylinder Block - Cleaning and Inspection (01-02)

Cylinder Block - Cleaning

Caution: Do not damage the machined gasket surfaces or the camshaft bushings if the bushings have not been removed.

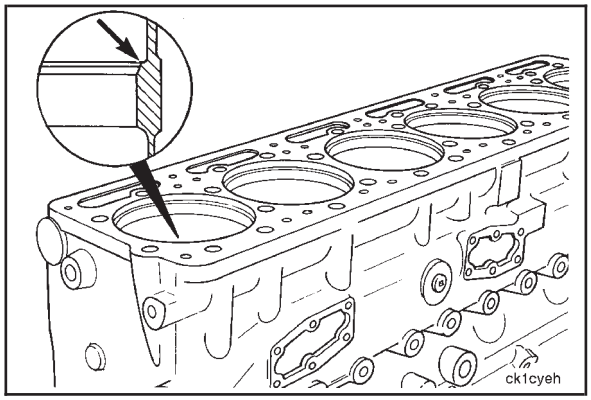
Use a gasket scraper, wire brush, or a fibrous abrasive pad such as Scotch-Brite® No. 7447, Part No. 3823258, or its equivalent to clean heavy deposits off the cylinder block.



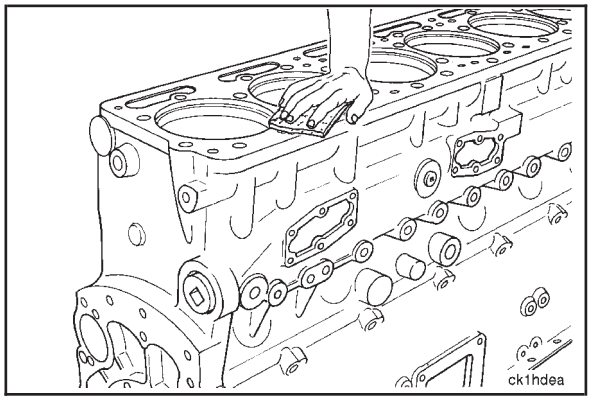


Clean the following cylinder block areas:

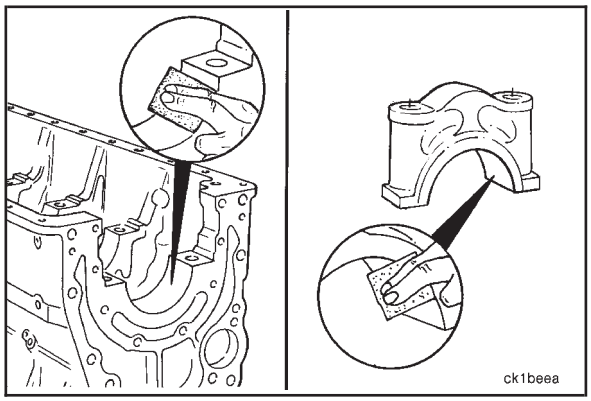
Cylinder liner counterbore ledge and press fit area.



Cylinder liner packing ring bore.

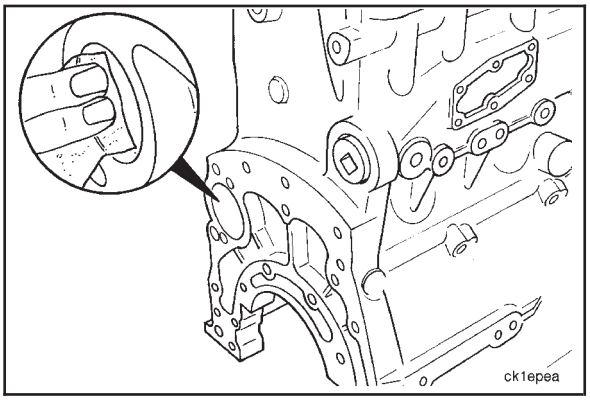


Cylinder head deck surface.

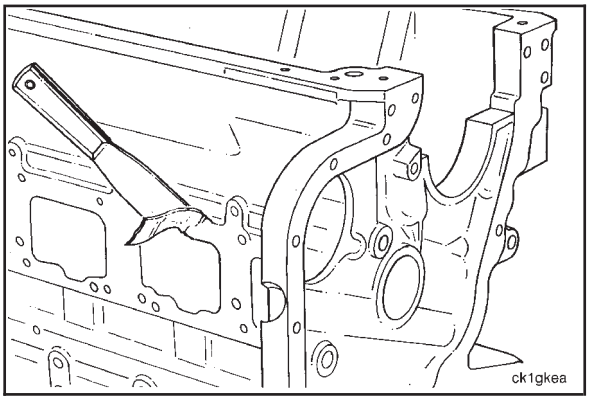


Main bearing saddles and caps.

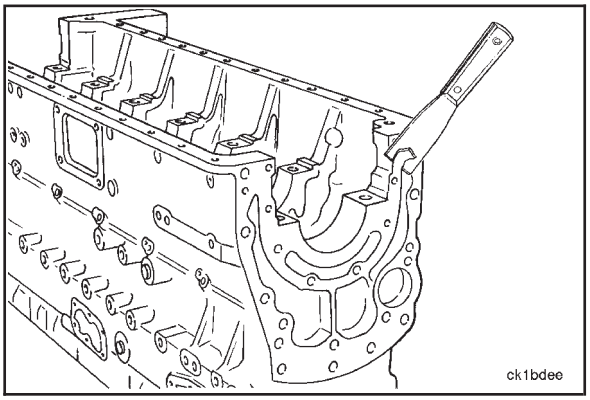
Camshaft bore cup plug area.



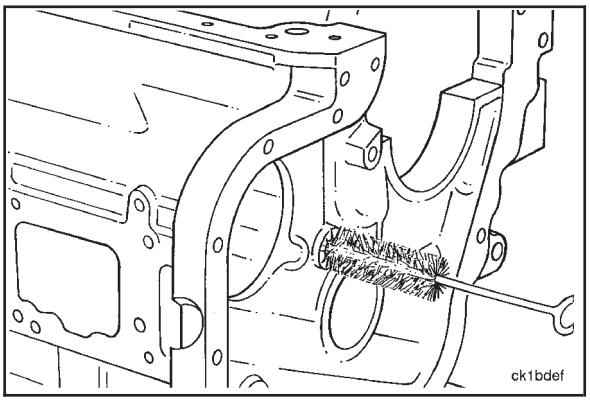
All gasket surfaces.

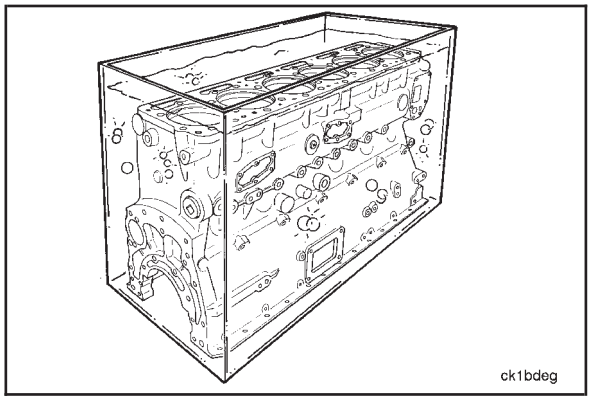


All component mounting surfaces.



Clean all oil passages. Use a bottle brush with a long handle.





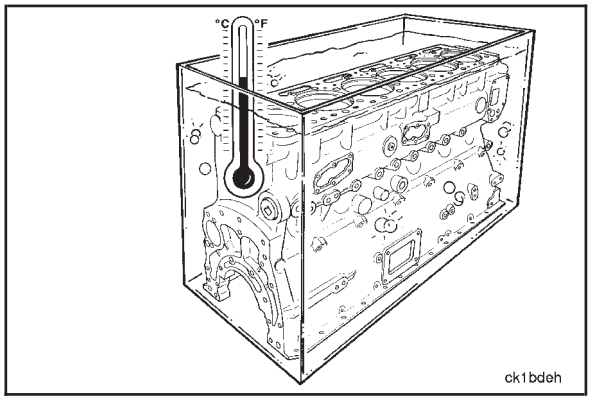
Warning: Use a face shield, rubber gloves, an apron, and boots and obey the warning label on the cleaning solution used to prevent personal injury.

Caution: Use a cleaning solution that will not damage the camshaft bushings if the bushings have not been removed.

Remove the block from the engine stand. Put the block in a cleaning tank.

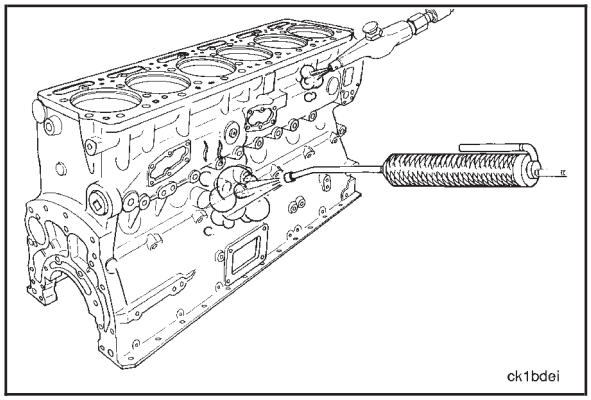
Follow the instructions of the manufacturer of the cleaning tank and the manufacturer of the cleaning solution.

NOTE: Cummins Engine Company, Inc., does **not** recommend any specific cleaning solution.



The best results can be obtained by using a cleaning solution that can be heated to 80° C to 95° C [180 ° F to 200° F].

Use a cleaning tank that will mix and filter the cleaning solution to get the best results.



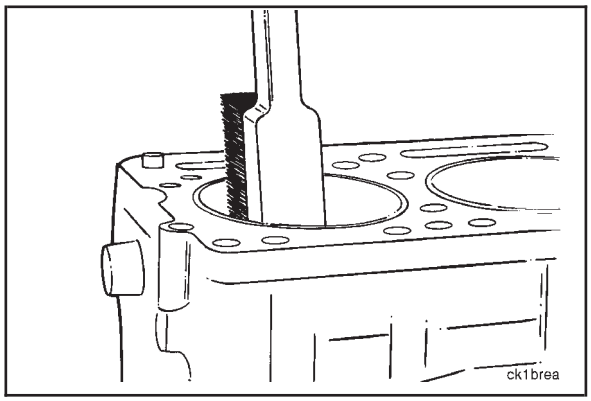
Warning: Use a face shield, rubber gloves, an apron, and boots and obey the warning label on the cleaning solution used to prevent personal injury.

Remove the block from the cleaning tank.

Clean all the oil passages using a steam cleaner.

Caution: Make sure all the water is removed from the capscrew holes and the oil passages to prevent rust formation in the cylinder block.

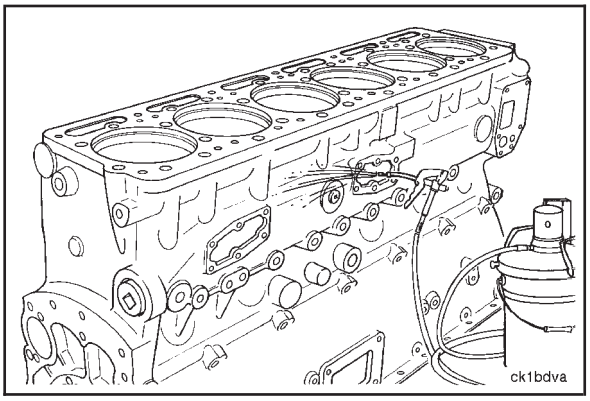
Use compressed air to dry the block.



Warning: Naptha and methyl ethyl ketone (MEK) are flammable materials and must be used with care. Do not use starting fluid as a cleaning agent. It can cause personal injury if ignited.

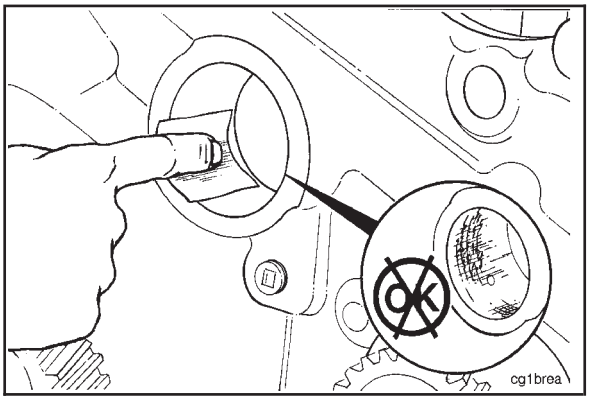
Clean the cylinder block counterbores with a suitable hydrocarbon solvent such as naptha, methyl ethyl ketone (MEK), or trichlorethane 1, 1, 1 (methyl chloroform).

NOTE: If the cylinder block is **not** going to be used immediately, apply a coating of preservative oil to prevent rust. Cover the block to prevent dirt from sticking to the oil.



Camshaft Bore - Cleaning

Use a fine emery cloth to remove burrs, and clean the bushing bores.

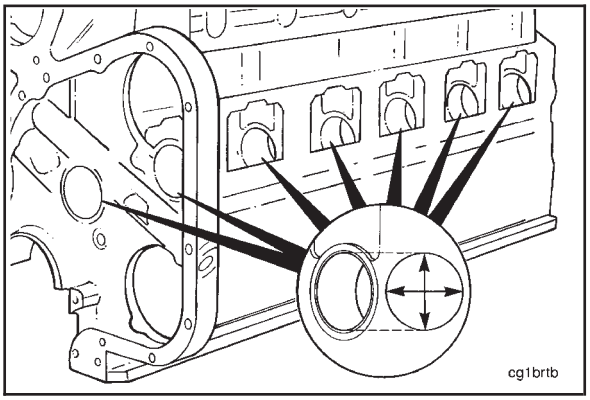


Camshaft Bore - Inspection

Measure the cylinder block camshaft bore inside diameter.

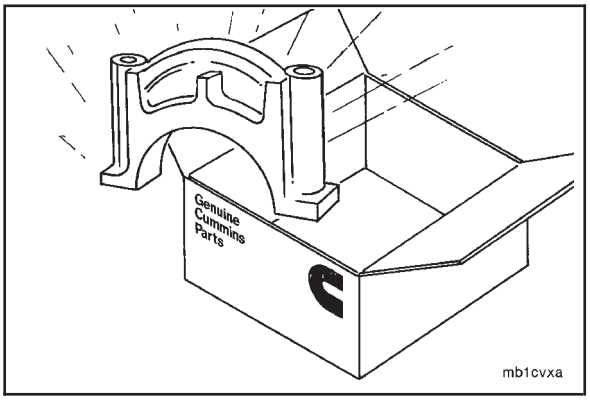
Camshaft Bore I.D.		
mm		in
68.237	MIN	2.6865
68.262	MAX	2.6875

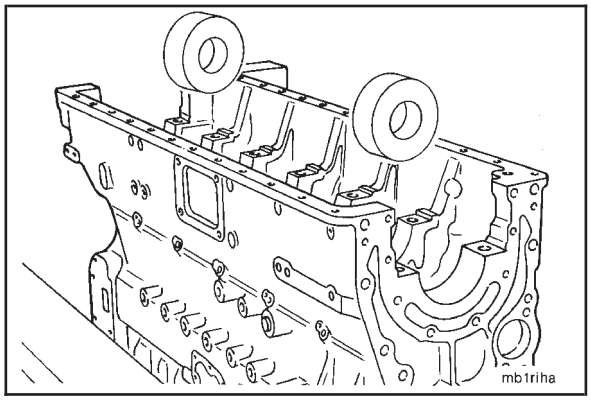
If the bore inside diameter is **not** within specifications, the bore **must** be repaired. Refer to the Alternate Repair Manual, Bulletin No. 3379035.



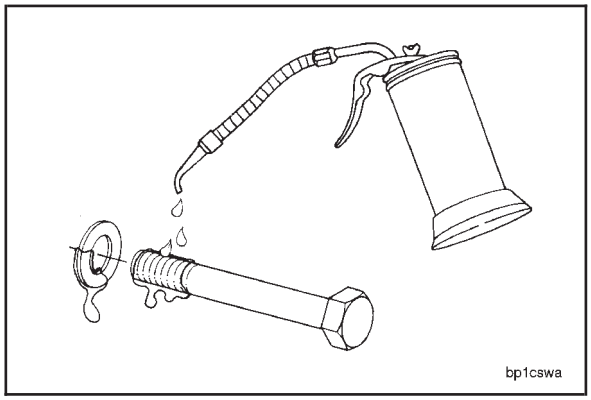
Main Bearing Bore Alignment - Measurement

NOTE: Service caps do **not** have the bore machined to a final specification. If the cap is replaced, the main bearing bore **must** be machined. Use the correct parts of the main bearing boring tool, Part No. ST-1177. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



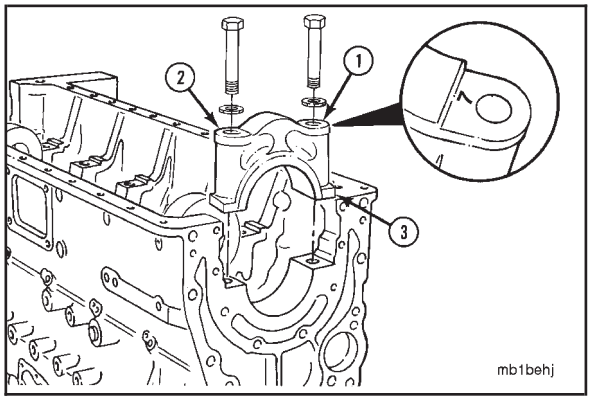


Use two centering rings, Part No. ST-1177-39 [4.750 inches diameter]. Put the rings in the No. 2 and the No. 6 main bearing locations.



Use clean 15W-40 oil to lubricate the main bearing capscrew threads and the flat washers.

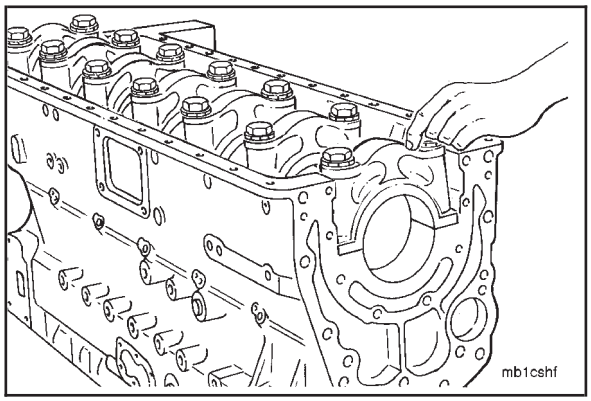
Drain the excess oil from the capscrews before installing them.



Caution: The main bearing caps are marked for position (1) on the camshaft side and the cylinder block identification (2) on the exhaust side. The cylinder block identification number (3) is stamped on the pan rail on the camshaft side of the block. Install the caps in the correct position with the position number to the camshaft side and its part number toward the rear of the engine.

Install the main bearing caps as follows:

1. Align the capscrew holes in the cap with the holes in the cylinder block.

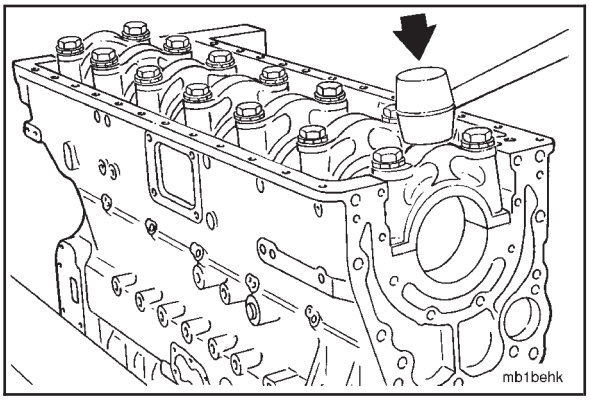


2. Install the capscrews and the washers through the cap and into the cylinder block.
3. Use your hand to tighten the capscrews two to three threads.

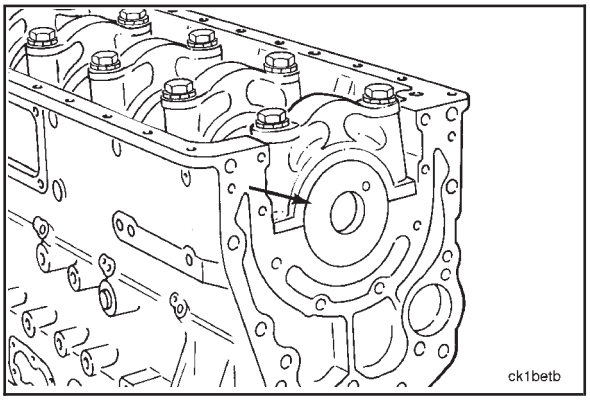
4. Hit the cap with a rubber mallet to push it into the correct position.

NOTE: The main bearing caps **must not** have any side clearance with the block.

Cylinder Block to Main Bearing Cap Press Fit		
mm		in
0.03	MIN	0.001
0.15	MAX	0.006

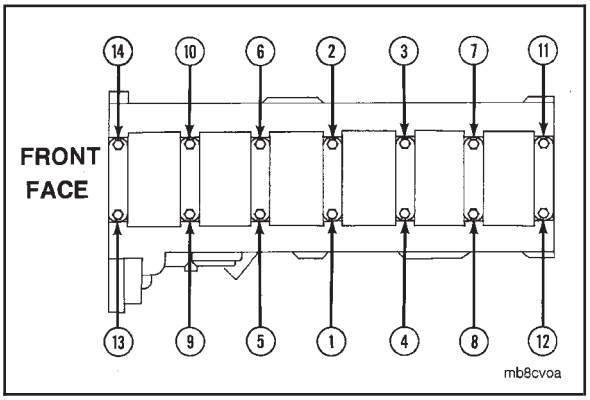


Put the checking ring into the cylinder block main bearing saddle. Put the main bearing cap over the checking ring.

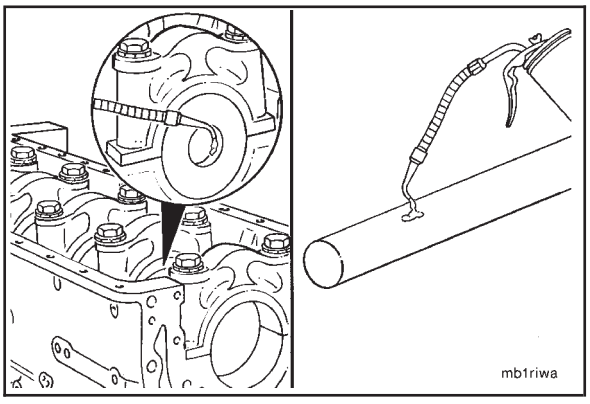


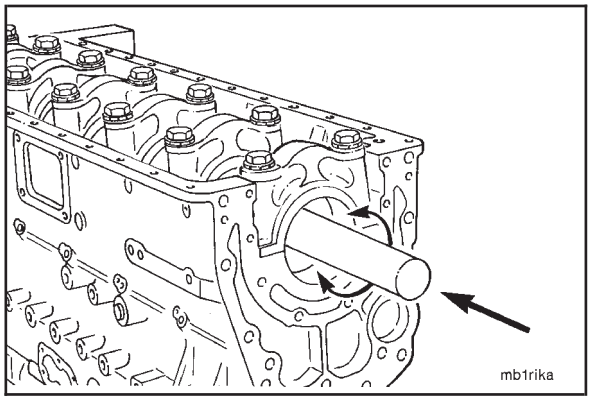
Tighten the main bearing cap capscrews to the following torque values in the sequence shown:

1. Tighten to 120 N•m [90 ft-lb].
2. Tighten to 230 N•m [170 ft-lb].
3. Tighten to 345 N•m [255 ft-lb].
4. Loosen completely.
5. Repeat steps No. 1 through No. 3.



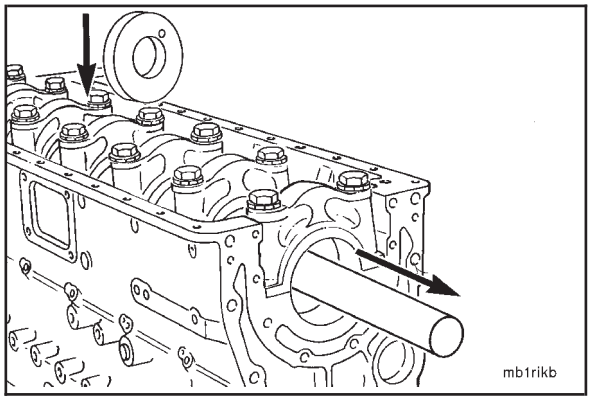
Use clean 15W-40 oil to lubricate the bores of the two centering rings, Part No. ST-1177-39, and the checking bar, Part No. ST-1177-16.



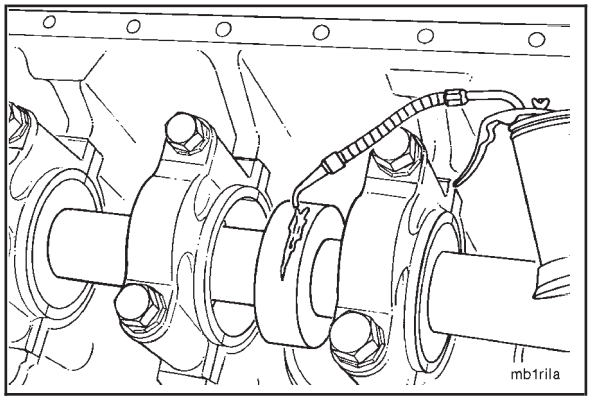


Insert the bar through the centering rings while slowly rotating the bar. The bar **must** turn easily.

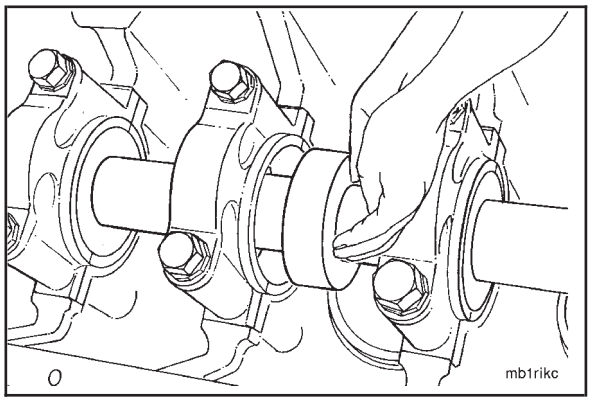
If the bar does **not** turn easily, check to make sure the main bearing caps are installed correctly. If they appear to be okay, move one of the centering rings to another bearing location.



Slide one end of the bar out of a centering ring. Slide the checking ring, Part No. ST-1177-13, onto the bar. Insert the bar into the centering ring.



Apply lubrication to the outside diameter of the checking ring.

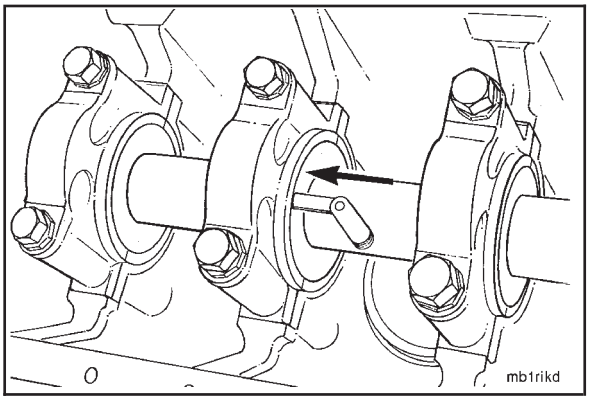


Use your hands to install the checking ring into the main bearing bore. If the ring will **not** slide through the bore, check the bore for burrs. If the ring will still **not** slide through the bore, the bore is undersize and **must** be repaired.

Refer to the Alternative Repair Manual, Bulletin No. 3379035, for repair procedures.

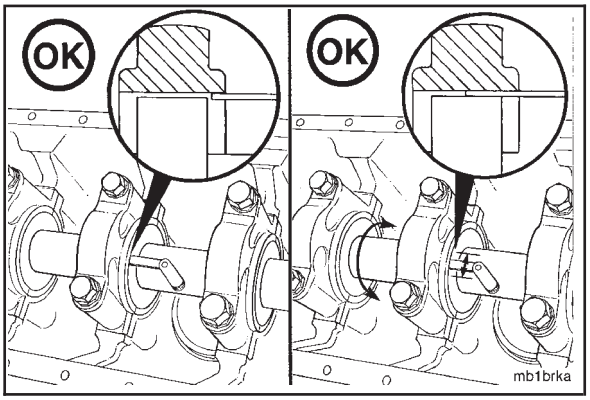
Use a 0.08 mm [0.003-inch] feeler gauge that is **not** more than 13 mm [0.5-inch] wide.

Center the checking ring in the bore. Try to put the feeler gauge between the checking ring and the bore. Rotate the gauge in the bore at both sides of the checking ring.



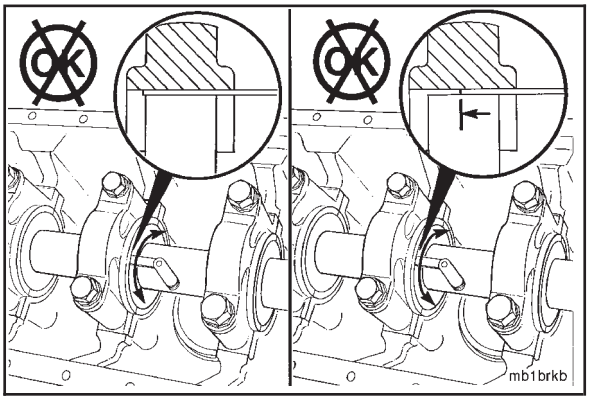
The bore alignment of the main bearing is okay if:

- the gauge does **not** enter at any point.
- the gauge will enter but will **not** slide through or around the bore and the alignment bar will rotate with the gauge inserted.



The bore alignment of the main bearing is **not** okay if:

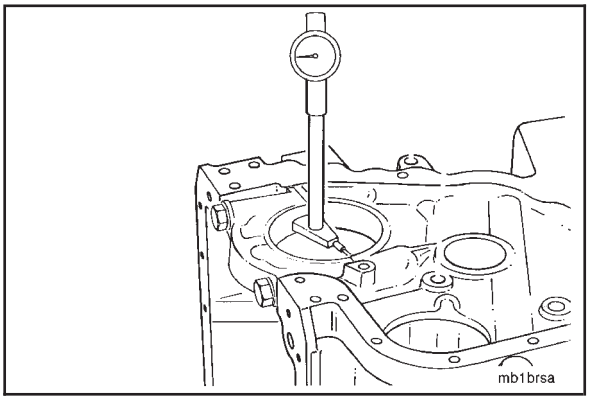
- the gauge enters and slides around the bore. This means that the bore is oversize and **must** be repaired.
- the gauge will enter on one side only but can slide around the bore. This means that the bore is tapered and **must** be repaired.

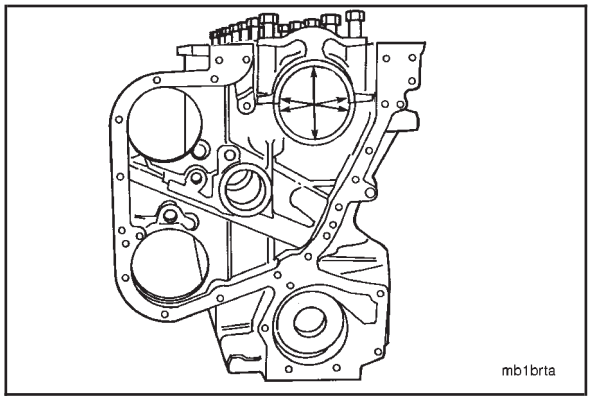


If the tools to check the main bearing bore alignment are **not** available, use a dial bore indicator to measure the main bearing bore inside diameters.

NOTE: This procedure does **not** check main bearing bore alignment but will identify bore diameters that do **not** meet specifications.

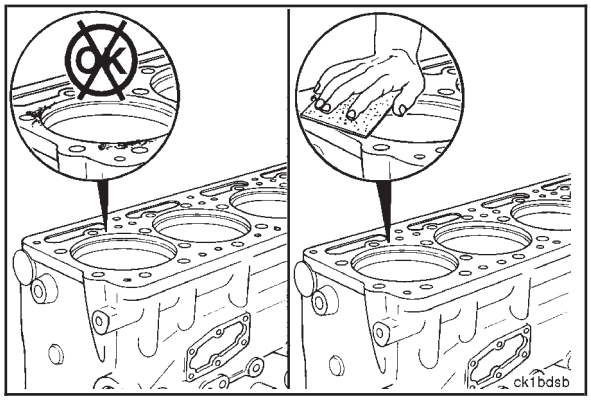
NOTE: Support the rear portion of the block on a flat surface to obtain the most accurate measurement of the inside diameter.





Measure the inside diameter in the three positions shown. The inside diameter **must** be completely round within 0.0190 mm [0.00075-inch].

Main Bearing Bore I.D. (Capscrews Torqued to Specification)		
mm		in
120.599	MIN	4.7480
120.637	MAX	4.7495



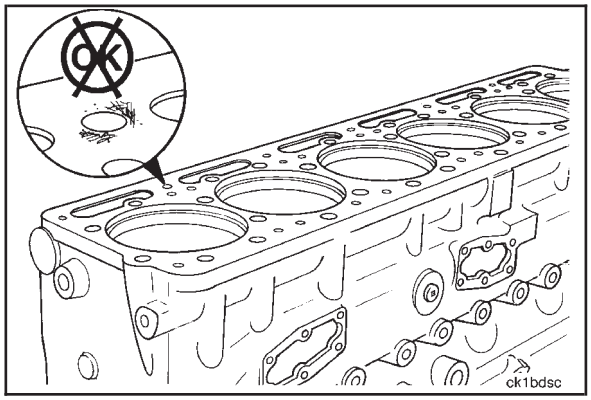
Cylinder Block - Inspection

Caution: All measurements of the cylinder block must be made when the block is positioned on a flat surface. If the block is mounted on the engine stand, the measurements can be wrong because of distortion.

Inspect the gasket surfaces.

Visually inspect for burrs or damage.

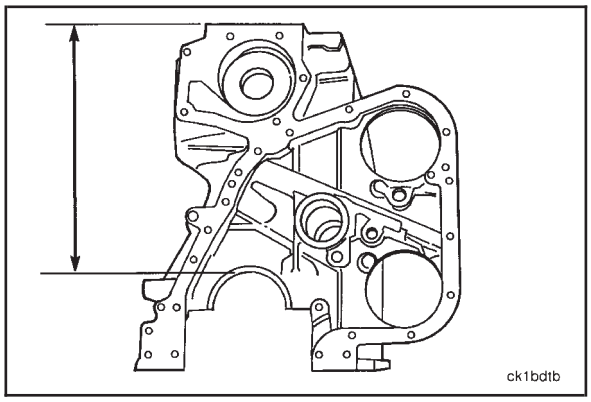
Use an Arkansas hone or a crocus cloth to remove the burrs.



Check the top surface of the block for wear. If fretting damage, scratches, cracks, or corrosion deeper than 0.08 mm [0.003-inch] are present in an area where a head gasket seal ring or a grommet makes contact, the surface **must** be repaired. There **must not** be any defect which extends more than 2.41 mm [0.095-inch] from the edge of the coolant passage.

Fretting damage in any other area is acceptable if it does **not** change the protrusion measurement of the counterbore or the cylinder liner.

Refer to the Alternative Repair Manual, Bulletin No. 3379035, for machining instructions.



Use a 610 mm [24 inches] caliper to measure the height of the cylinder block from the main bearing bore outside diameter to the cylinder head deck surface.

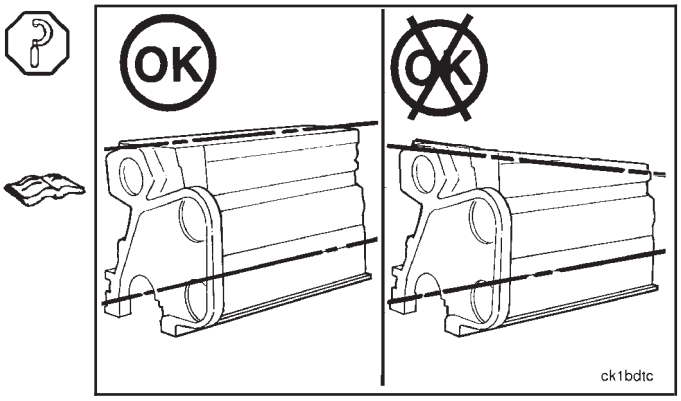
Cylinder Block Height		
mm		in
421.87	MIN	16.609
422.45	MAX	16.632

If the height of the block is less than 422.12 mm [16.619 inches], a 0.25 mm [0.010-inch] oversize head gasket **must** be used.

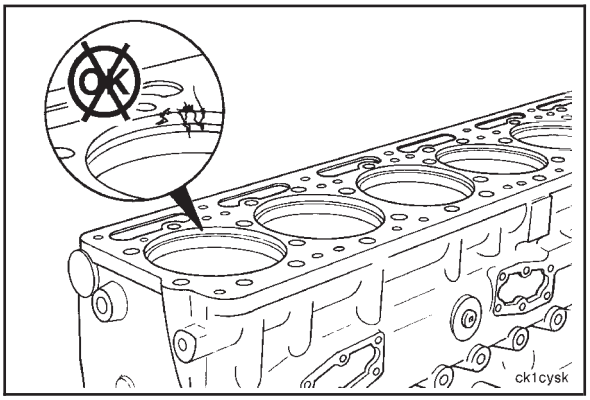
The height of the block **must not** vary more than 0.05 mm [0.002-inch] from end to end of the block. If the block height is **not** within specifications, the top surface of the block **must** be machined or the block **must** be replaced.

NOTE: If the top surface of the block is machined, the ledge depth of the cylinder liner counterbore **must** be machined.

Refer to the NH/NT Counterbore Troubleshooting and Repair Manual, Bulletin No. 3810450, or the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456, for detailed instructions.

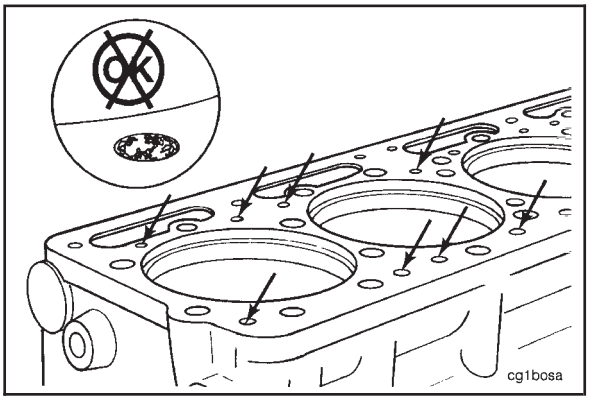


To inspect the cylinder liner counterbore, refer to the NH/NT Counterbore Troubleshooting and Repair Manual, Bulletin No. 3810450, or the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456, for complete instructions.



Coolant Passage - Inspection

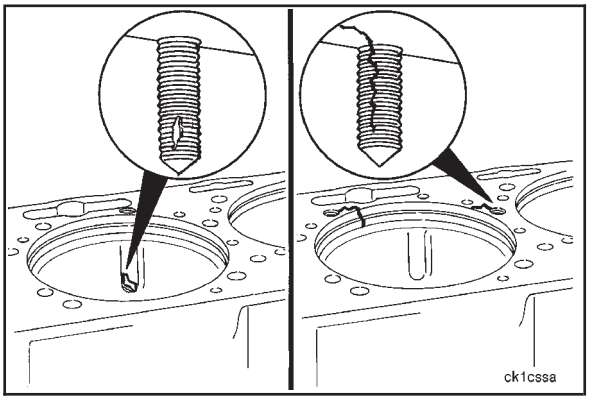
Check the water holes. If erosion or pitting is more than 0.08 mm [0.003-inch] deep or extends more than 2.41 mm [0.095-inch] from the edge of the hole, the water hole **must** be repaired. Refer to Cylinder Block Machining - Coolant Passage Repair later in this section for details.

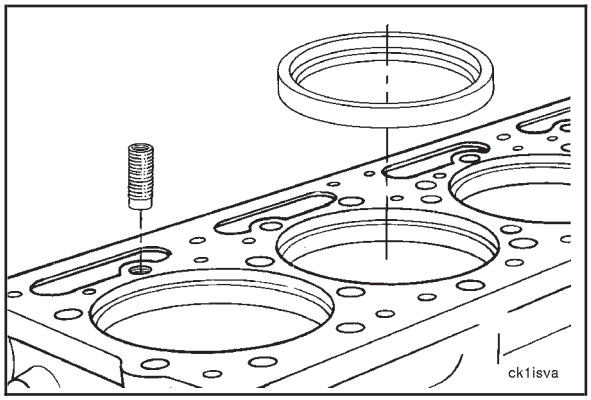


Cylinder Head Capscrew Holes - Inspection

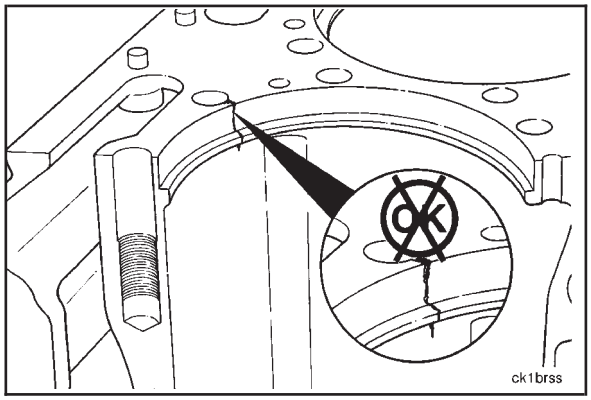
Inspect the capscrew bosses for cracks or porosity that extend into the coolant cavities or that have damaged threads.

Thread repair inserts can be used to fix most cases of thread damage and minor cracks. Refer to Cylinder Head Capscrew Hole Repair in Section 1-03.



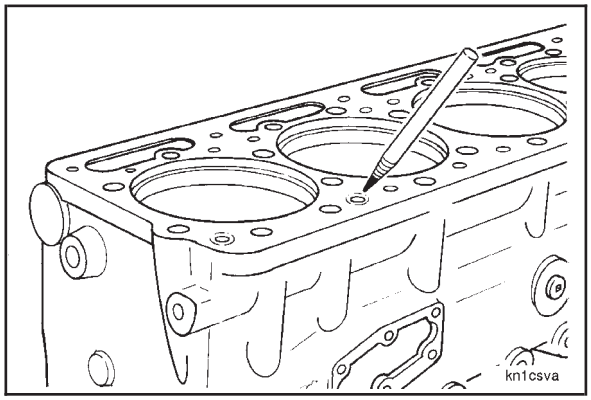


Closed end thread repair inserts can be used in conjunction with upper counterbore sleeves (0.020-inch oversize on the outside diameter or smaller), and coolant passage repair inserts.

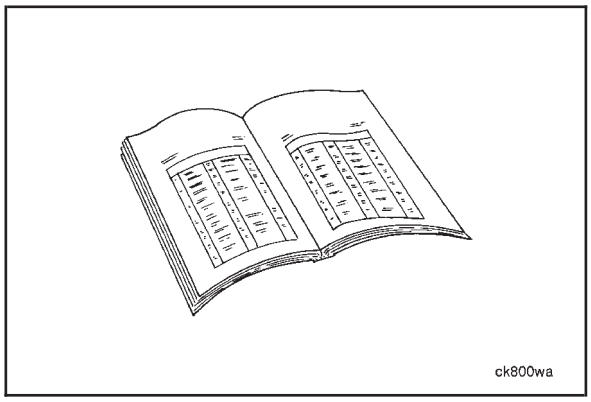


Cylinder blocks with vertical cracks that extend down over the counterbore ledge that can **not** be machined out using a 0.750-inch long sleeve can **not** be repaired.

In this case, the cylinder block **must** be replaced.



Mark all cylinder head capscrew holes that are to be repaired. Refer to Cylinder Block Machining - Cylinder Head Capscrew Hole Repair in Section 1-03.



Cylinder Block - Machining (01-03)

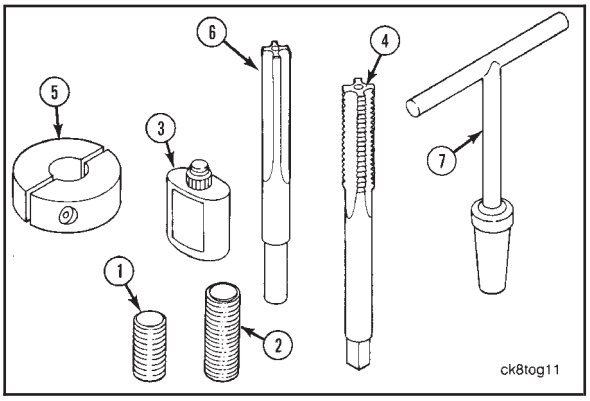
Cylinder Block - Deck Resurfacing

Refer to the Alternative Repair Manual, Bulletin No. 3379035.

Coolant Passage - Repairing

The coolant passage repair kit, Part No. 3823679, consists of the following components:

Ref. No.	Tool No.	Description	Qty.
1	3823680	Coolant Passage Repair Insert (3/4-inch Upper Deck - Short Cylinder Head Capscrews - not used on N14)	15
2	3823681	Coolant Passage Repair Insert (1 inch Upper Deck - Long Cylinder Head Capscrew - used on N14)	15
3	3823682	Sealing and Retaining Compound (50 ml)	1
4	3823683	1/2 x 20 Tap	1
5	3823684	Tap Stop	1
6	3823685	29/64-inch Reamer	1
7	3823686	Insert Installation Tool	1

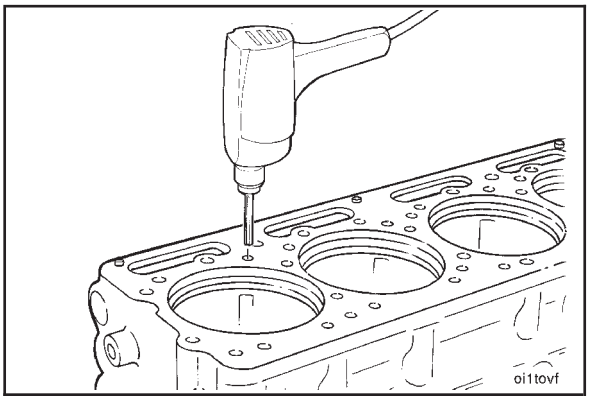


Sealing and retaining compound is also available in a 250 ml bottle, Part No. 3823689.

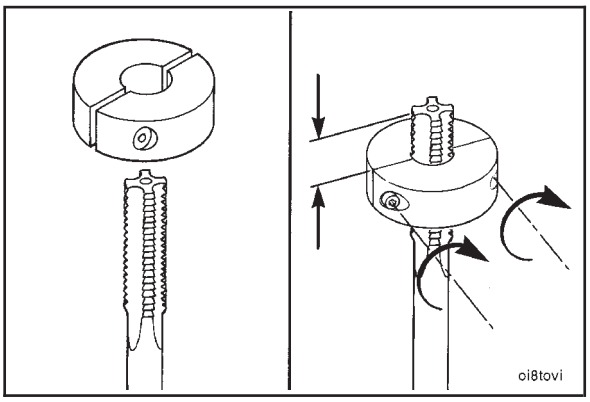
The coolant passage repair inserts for the N14 cylinder block are available in packages of 50, tool Part No. 3823688.

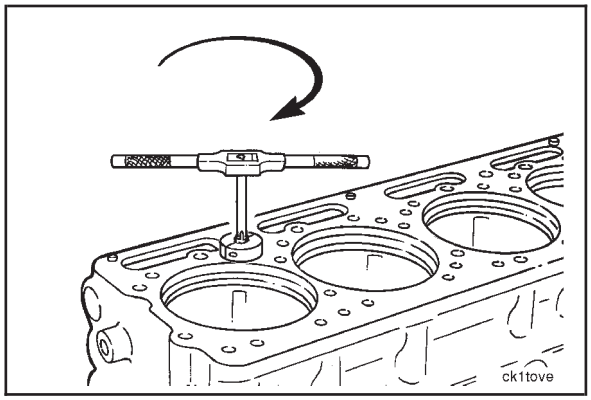
NOTE: If the reamer extends too far down in the hole, it will hit the radius of the coolant jacket and deflect the drill sideways, causing the hole to be out of round. Severely out of round holes will affect the performance of the insert.

Ream through with the 29/64-inch reamer.

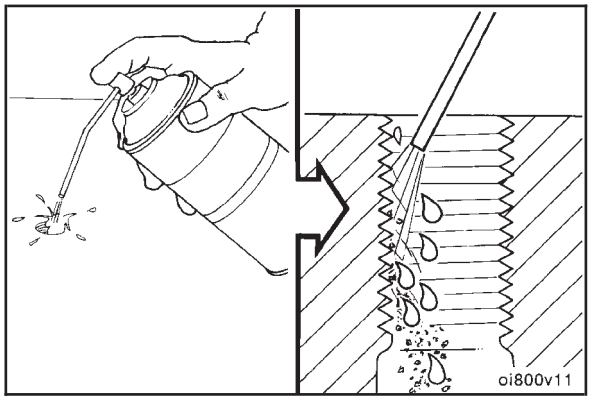


Set the tap depth with the tap stop to one inch.



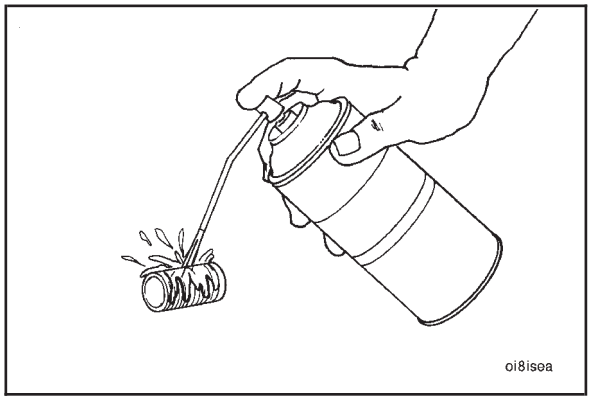


Tap until the stop contacts the cylinder block head deck surface.



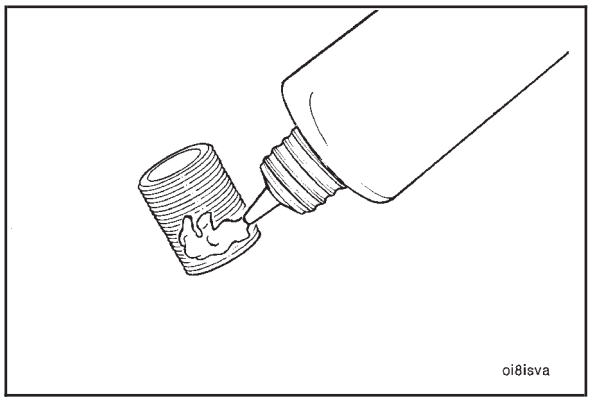
Clean the threads with safety solvent, Part No. 3823717.

Allow to dry.



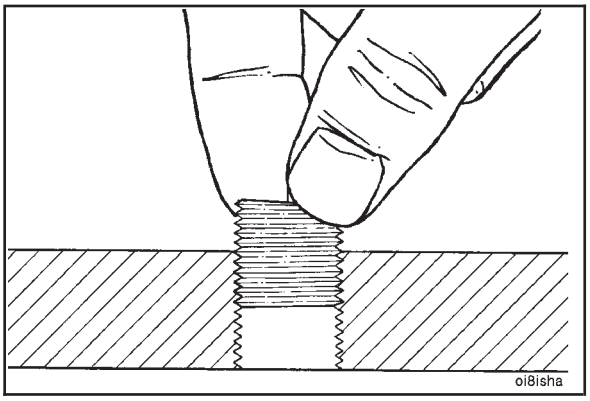
Clean the coolant passage insert with a safety solvent, Part No. 3823717.

Allow to dry.

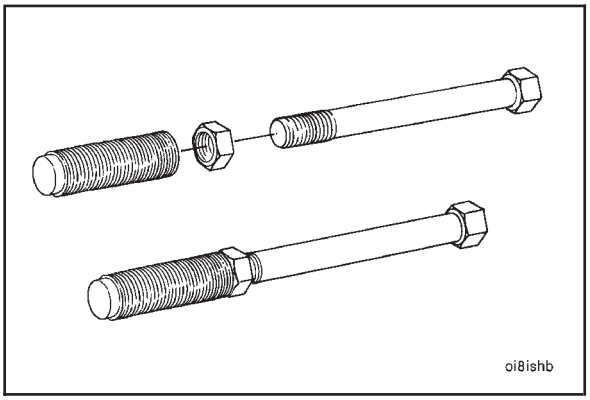


Liberally apply the sealing and retaining compound to the coolant passage insert threads.

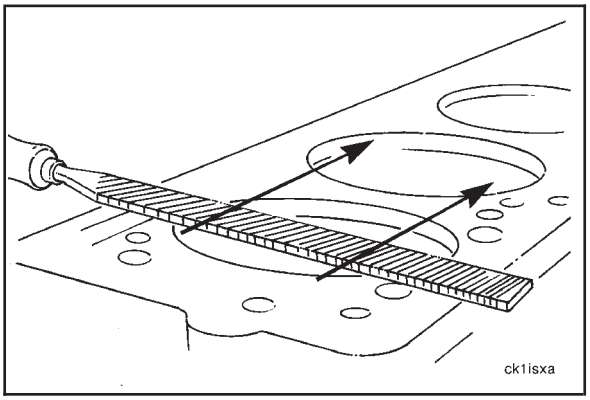
Start the insert with your fingers, and install it approximately half way.

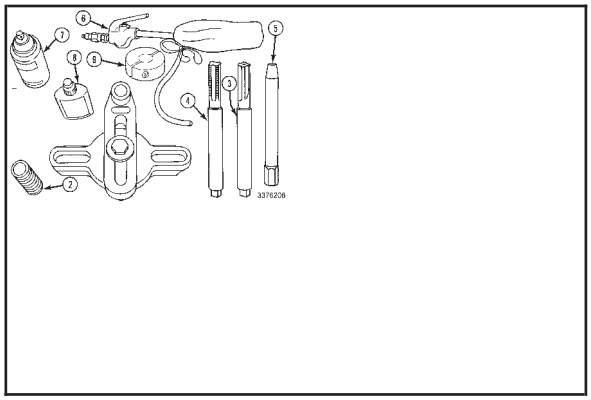


Liberally apply the sealing and retaining compound to the upper half of the thread, and finish installing with the installation tool.



Blend the top of the insert and the block with a file.

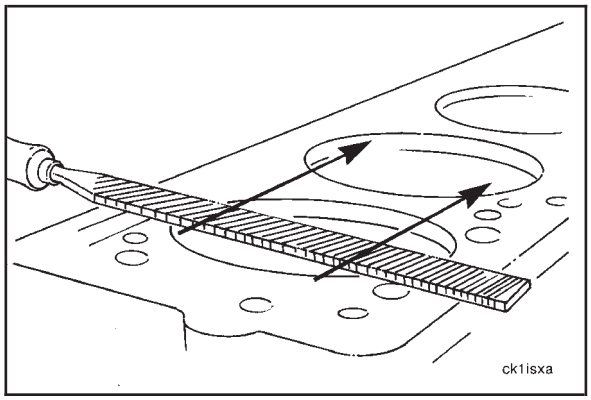




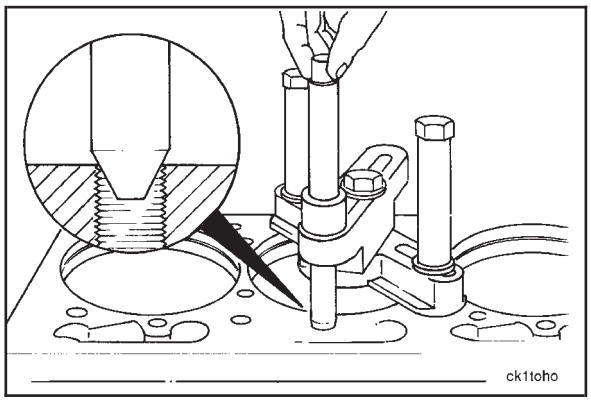
Cylinder Head Capscrew Holes - Repairing

Components included in the capscrew thread repair kit, Part No. 3376208, for the N14 block are as follows:

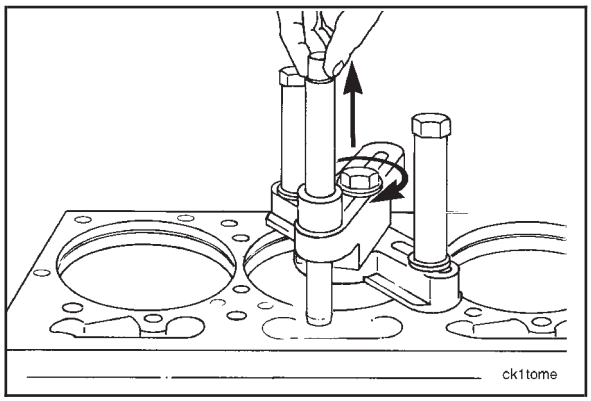
Ref. No.	Tool No.	Description
2	3376008	Insert
3	3376006	Reamer
4	3376007	Tap
5	ST-1272-5	Locator
6	ST-1272-11	Chip Removal Unit
7	ST-1272-13	Loctite® Primer-T
8	ST-1272-12 or 3823718	Retaining Compound
9	ST-1272-9	Stop Collar



Remove any burrs from the top deck surface of the cylinder block. A flat mill file is very effective for this process. Burr removal is necessary so that you can get an accurate fixture location.

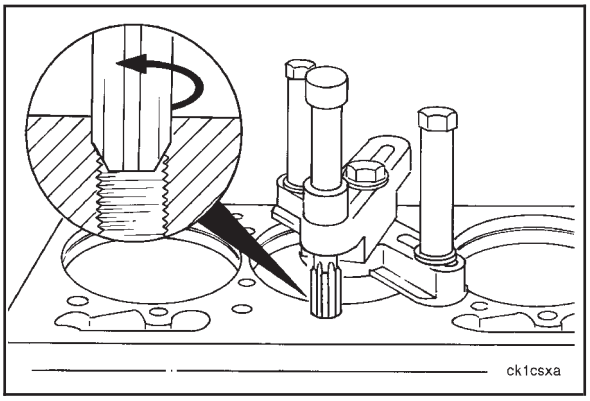


Align the fixture with the failed capscrew hole. Install the reamer base plate and the guide bar to the cylinder block. Position the guide bar over the capscrew hole to be repaired. Using a tapered locator, center the guide bar and the bushing over the capscrew hole.

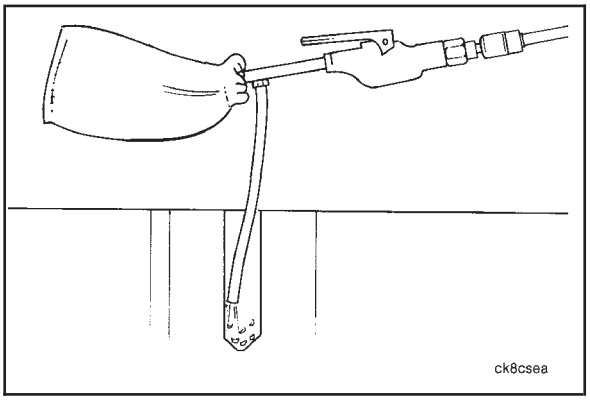


Tighten the guide bar and bushing assembly. Remove the tapered locator.

Ream the failed capscrew hole to the full depth of the hole.

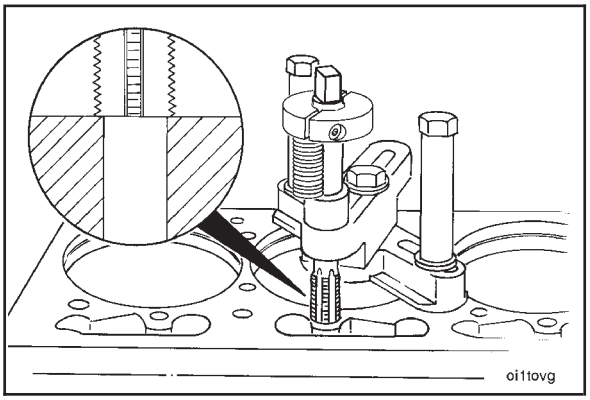


Use a chip removing unit to remove reamer chips from the capscrew hole.

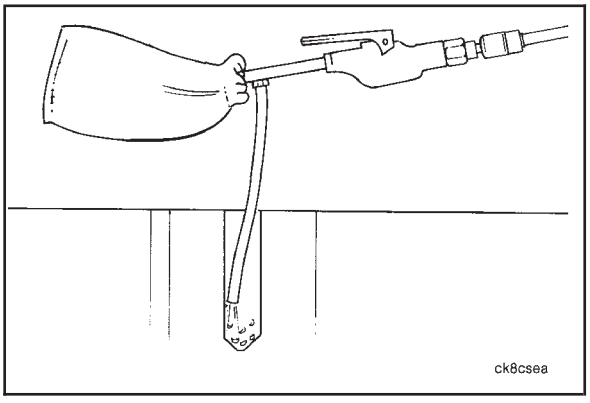


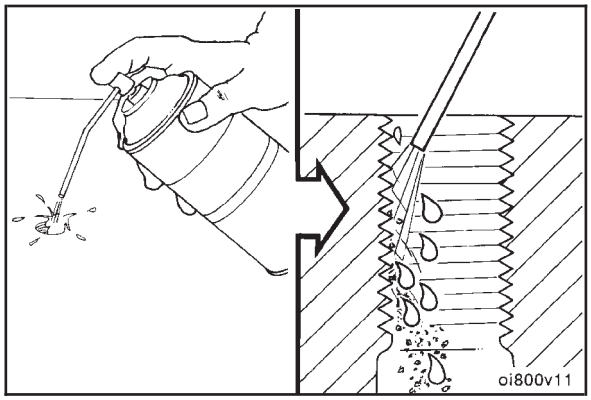
Set the tap stop collar to the correct height, using the insert to be installed. Tap the capscrew hole.

NOTE: It can be necessary to stop, remove the tap, and remove chips from the hole several times before achieving full depth.

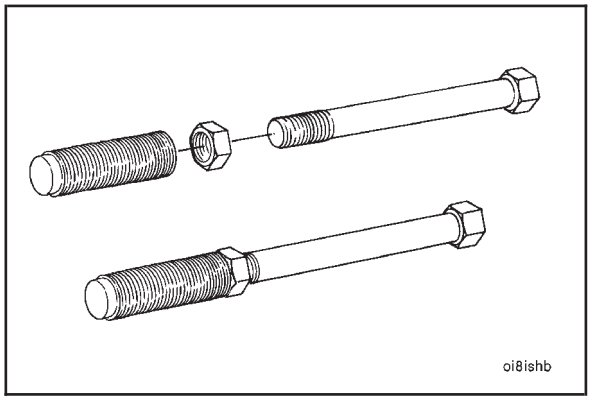


Use a chip removing unit to clean the capscrew hole of shavings and debris. Remove the tap.

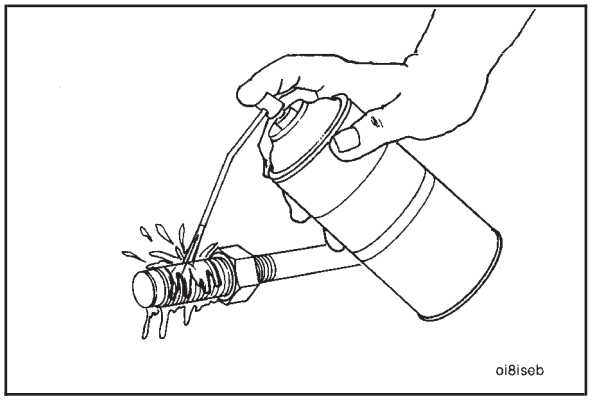




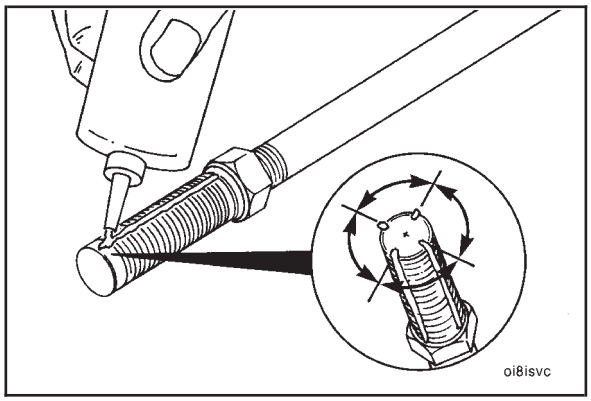
Clean and flush the newly cut threads with safety solvent, Part No. 3823717. Use a chip removing unit to clean the capscrew hole of shavings and debris, and allow to dry. Lightly spray the threads with Loctite® Primer-T, Part No. ST-1272-13, and allow to dry.



Prepare the thread insert for installation. Put the jam nut on a cylinder head capscrew. Install the repair insert on the capscrew until it contacts the jam nut.

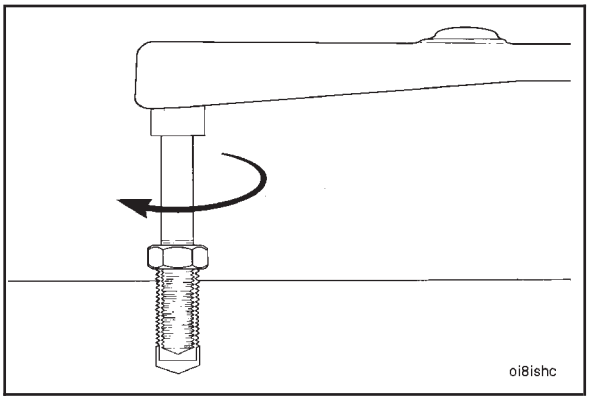


Clean and flush the outside diameter of the repair insert with safety solvent and allow to dry. Lightly spray with Loctite® Primer-T, Part No. ST-1272-13, and allow to dry.

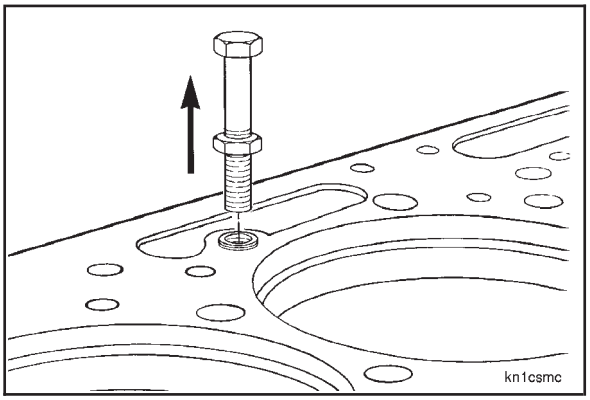


Apply four beads of sealant, Part No. 3823718, to the outside diameter of the closed end thread insert. The beads of sealant **must** be approximately 1/32-inch wide and 90 degrees apart. Each bead **must** be the full length of the external threaded portion of the insert.

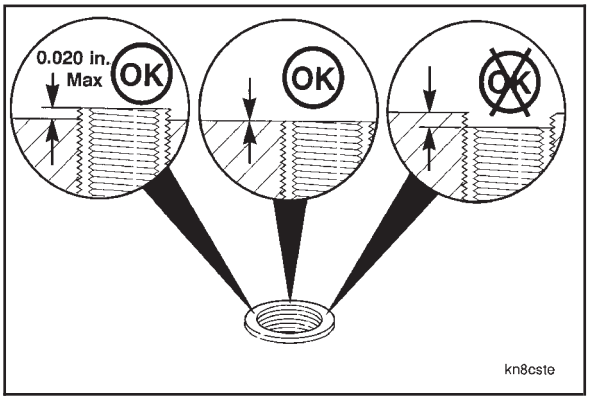
Install and tighten the repair insert.



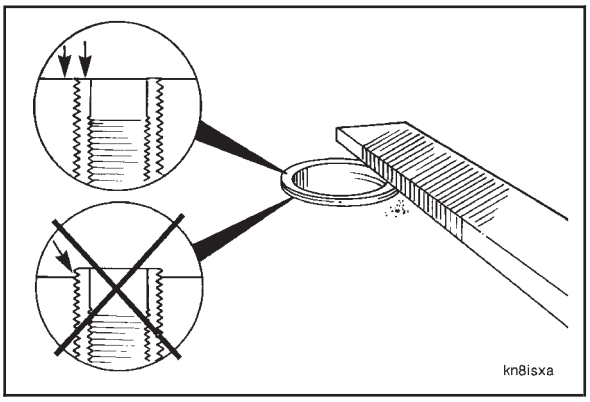
Loosen the jam nut. Remove the cylinder head capscrew and jam nut arrangement.

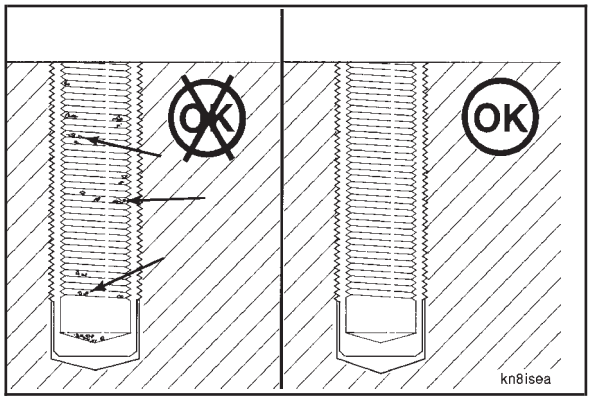


Correct installation will provide 0.00 mm to 0.50 mm [0.000-inch to 0.020-inch] protrusion above the cylinder block surface.

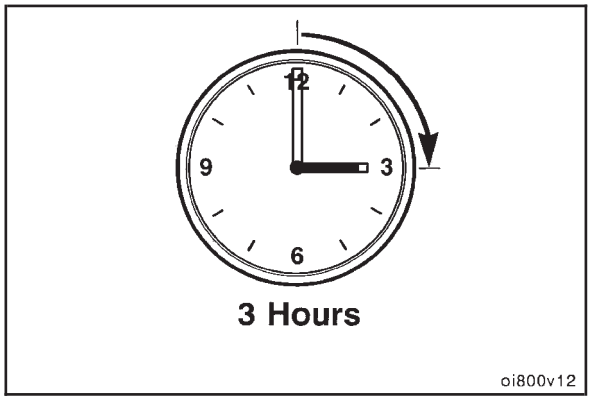


File the top of the thread repair insert even with the cylinder head mounting surface.

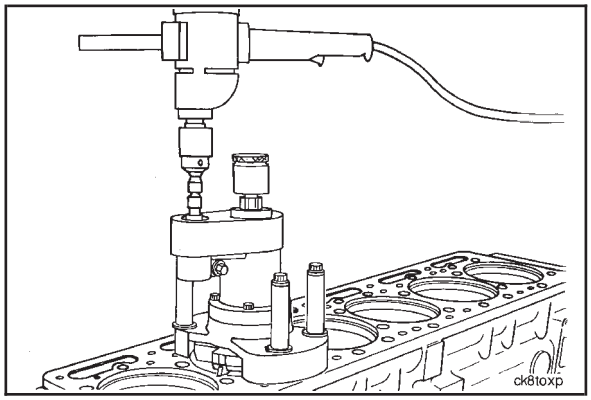




Make sure the inside portion of the repair insert is clean. Remove any file shavings or debris.

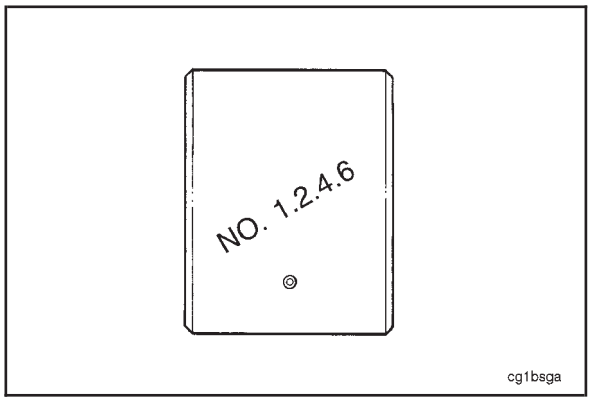


Before tightening the cylinder head capscrews, allow the sealant to cure for 3 hours.



Cylinder Block Counterbore - Inspection and Machining (1-04)

Due to the complex nature of troubleshooting procedures required for diagnosis and repair of counterbores, this information has been excluded from this manual. Complete counterbore repair guidelines can be found in the NH/NT Counterbore Troubleshooting and Repair Manual, Bulletin No. 3810450, and the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456.

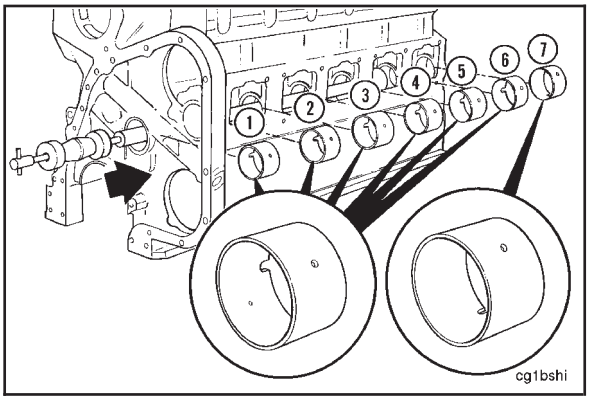


Cylinder Block - Assembly (01-05)

Camshaft Bushings - Installation

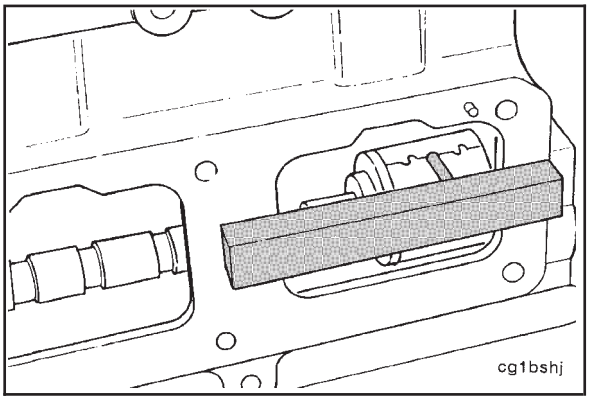
Caution: Incorrect installation will block oil flow to the rocker levers and the cam followers resulting in severe damage to the engine. Refer to the numbers stamped on the bushings to determine the correct cylinder block cam bore locations in which the bushings are to be installed.

Install the camshaft bushings in the following order: No. 7, No. 6, No. 5, No. 4, No. 3, No. 2, and No. 1.



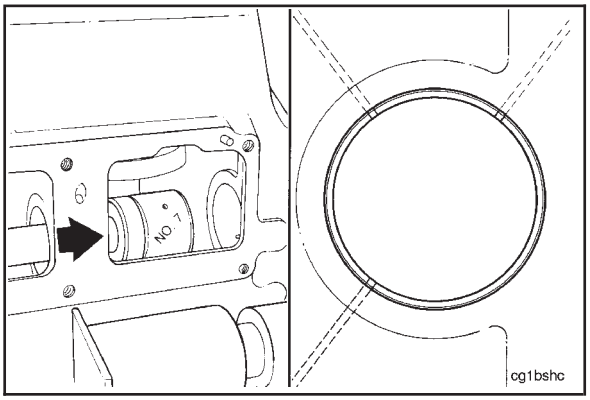
Bushing (No. 7) - Installation

An alignment pointer, Part No. 3823635, is used to align the cam bearing oil holes with the oil holes in the block. To use, mount the bearing on the driver. Place the alignment pointer against the machined side of the block at the cam follower holes with the end of the rod at the top of the bearing. Rotate the cam bearing until the seam of the bearing is at the end of the rod. Press the cam bearing in as described.



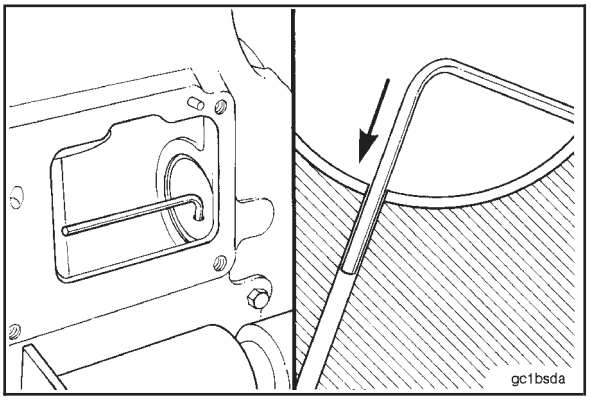
Install the bushing marked No. 7 on the driver with the location notch to the rear of the engine and at the 6:00 o'clock position.

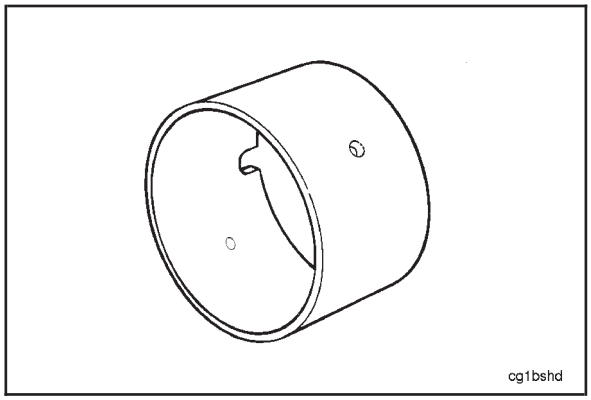
Push the bushing into the bore until the oil holes in the bushing are aligned with the drillings in the bore.



Use a 2.39 mm [0.094-inch] diameter rod or a 3/32-inch hexagon wrench to check the position and the location of the oil hole in the bushing and the cylinder block.

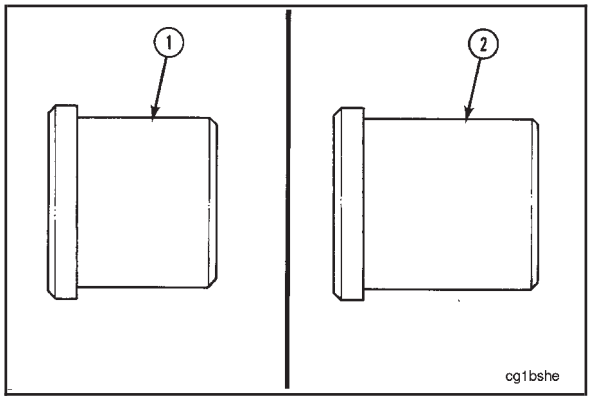
The rod **must** pass through the oil holes in the bushing and into the oil supply drillings in the cylinder block.





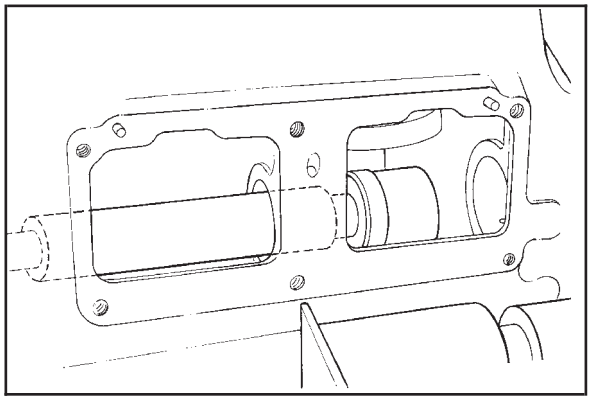
Bushings (No. 6 through No. 2) - Installation

An alignment pointer, Part No. 3823635, is used to align the cam bearing oil holes with the oil holes in the block. To use, mount the bearing on the driver. Place the alignment pointer against the machined side of the block at the cam follower holes with the end of the rod at the top of the bearing. Rotate the cam bearing until the seam of the bearing is at the end of the rod. Press the cam bearing in as described.



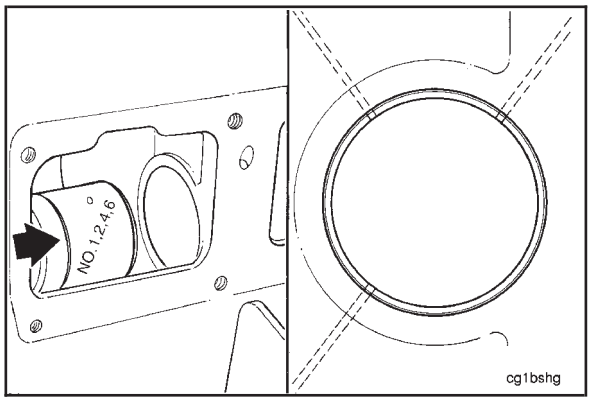
Use bushing driver (1), Part No. 3375861, to install bushings No. 1, No. 2, No. 4, and No. 6.

Use bushing driver (2), Part No. 3376412, to install bushings No. 3 and No. 5.



Install the tool assembly through the camshaft bore until the driver is in the cavity between the bores where the bushing is to be installed.

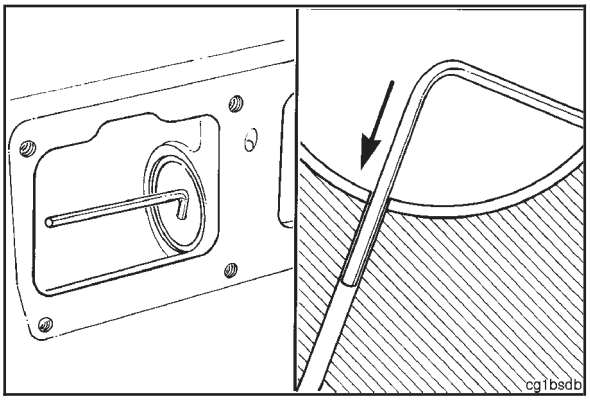
Install the bushing guide into the camshaft bore next to the bore where the bushing is to be installed.



An alignment pointer, Part No. 3823635, is used to align the cam bearing oil holes with the oil holes in the block. To use, mount the bearing on the driver. Place the alignment pointer against the machined side of the block at the cam follower holes with the end of the rod at the top of the bearing. Rotate the cam bearing until the seam of the bearing is at the end of the rod. Press the cam bearing in as described.

Use a 2.39 mm [0.094-inch] diameter rod or a 3/32-inch hexagon wrench to check the position and the location of the oil hole in the bushing and the cylinder block.

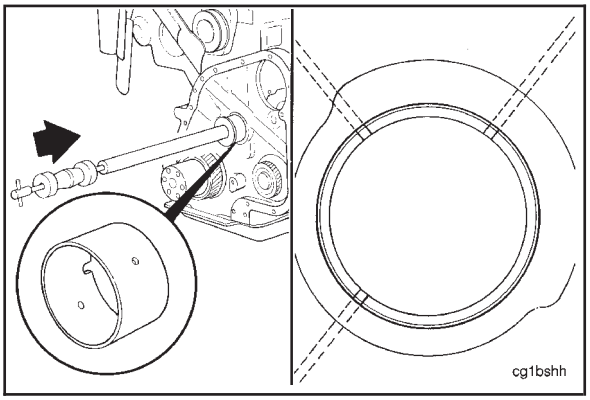
The rod **must** pass through the oil holes in the bushing and into the oil supply drillings in the cylinder block.



Bushing (No. 1) - Installation

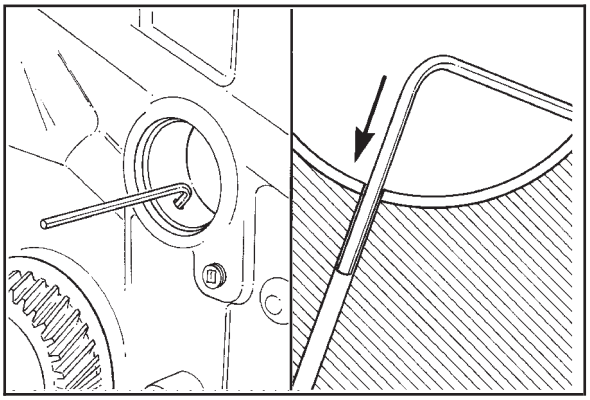
NOTE: Camshaft bushing guide, Part No. ST-1228-6, is **not** used to install the No. 1 bushing.

An alignment pointer, Part No. 3823635, is used to align the cam bearing oil holes with the oil holes in the block. To use, mount the bearing on the driver. Place the alignment pointer against the machined side of the block at the cam follower holes with the end of the rod at the top of the bearing. Rotate the cam bearing until the seam of the bearing is at the end of the rod. Press the cam bearing in as described.



Use a 2.39 mm [0.094-inch] diameter rod or a 3/32-inch hexagon wrench to check the position and the location of the oil holes in the bushing and the cylinder block.

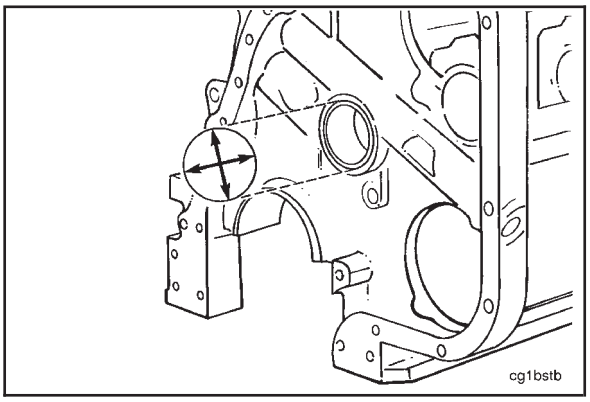
The rod **must** pass through the oil holes in the bushing and into the oil supply drillings in the cylinder block.

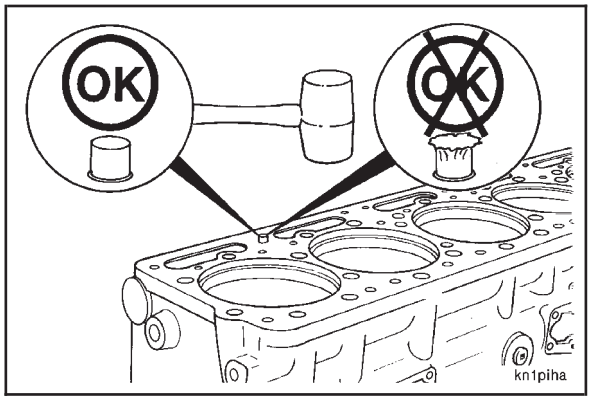


Measure the inside diameter of the installed camshaft bushings.

Camshaft Bushing I.D. Installed		
mm		**in**
63.457	MIN	2.4983
63.558	MAX	2.5023

NOTE: If any of the bushings is **not** within specification, the bushing **must** be replaced.



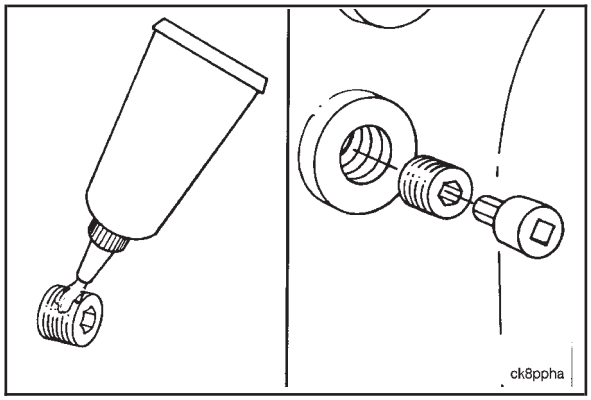


Dowel Pin - Installation

NOTE: Do **not** install the dowel pins in the block until the inspection and any necessary repair procedures are completed.

Caution: Do not use a hammer. Damage to the dowel pin will result.

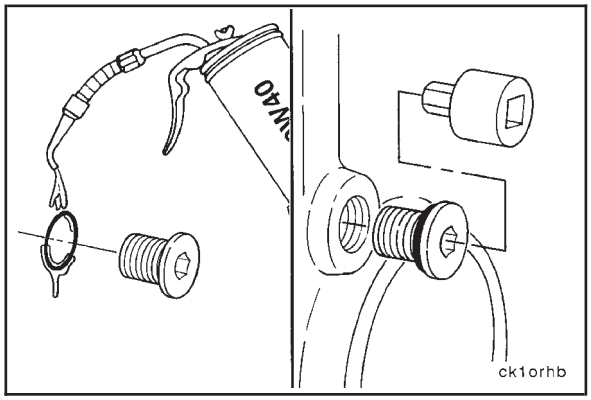
Use a plastic mallet. Install the six cylinder head groove pins, two front cover dowel pins, one water pump dowel pin, six cam follower housing dowel pins, and two flywheel housing dowel pins.



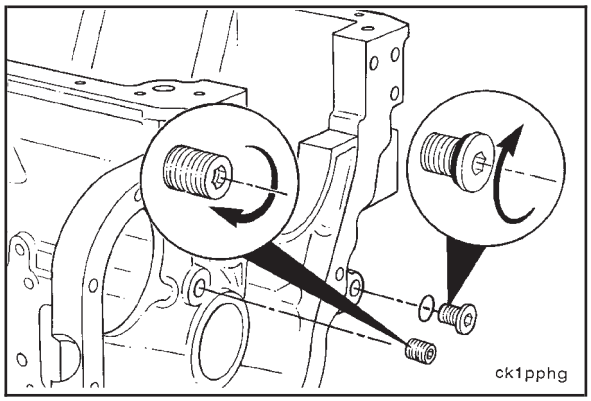
Straight Thread Plug and Pipe Plug - Installation

Caution: Do not install straight thread plugs or pipe plugs in the block until cleaning, inspection, and necessary repair procedures are completed. This will prevent dirt from being trapped in the engine.

Use pipe sealant, Part No. 3375066, to lubricate the pipe plug threads.



Install new o-rings on the straight thread plugs. The o-ring used by Cummins Engine Company, Inc., is the only one recommended by Cummins Engine Company. Lubricate the o-ring with clean 15W-40 oil.



Install a 3/4 - 16 straight thread plug in the piston cooling oil passage. Tighten the straight thread plug.

Torque Value: 75 N•m [55 ft-lb]

Install a 3/8-inch pipe plug in the main oil passage. Tighten the pipe plug.

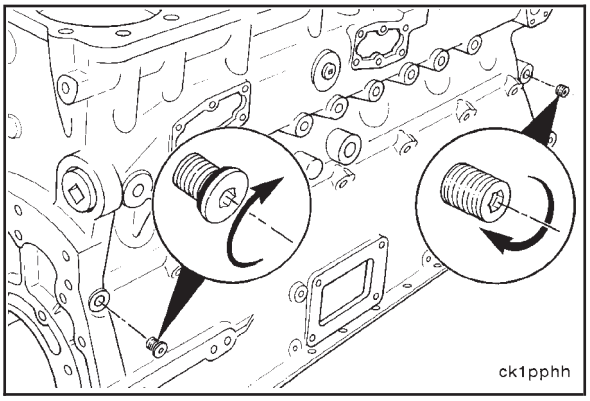
Torque Value: 27 N•m [20 ft-lb]

Install a 3/8-inch pipe plug in the piston cooling oil crossover passage at the front of the cylinder block. Tighten the pipe plug.

Torque Value: 27 N•m [20 ft-lb]

Install a 3/4 - 16 straight thread plug in the piston cooling oil passage at the rear of the cylinder block. Tighten the straight thread plug.

Torque Value: 75 N•m [55 ft-lb]



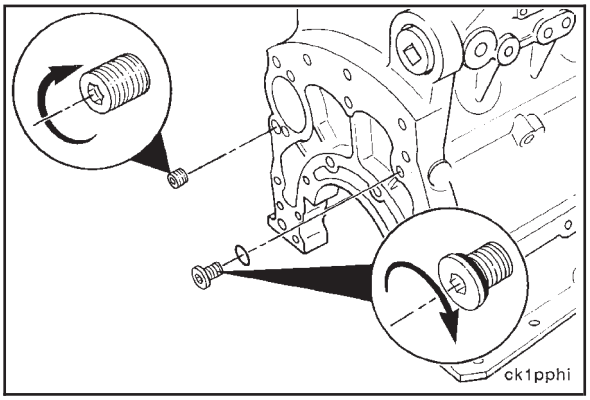
Install a 3/4 - 16 straight thread plug in the piston cooling oil passage. Tighten the straight thread plug.

Torque Value: 75 N•m [55 ft-lb]

Install a 3/8-inch pipe plug in the main oil passage. Tighten the pipe plug.

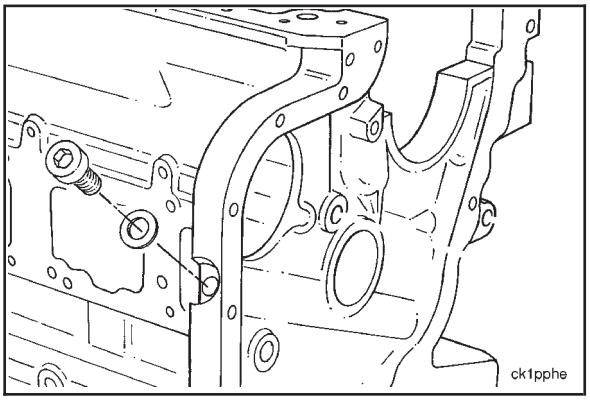
Torque Value: 27 N•m [20 ft-lb]

NOTE: These pipe plugs **must** be flush or below flush with the rear face of the cylinder block.



Install the copper washer and the 7/8 - 18 straight threaded plug in the main oil crossover passage in the front of the cylinder block. Tighten the straight thread plug.

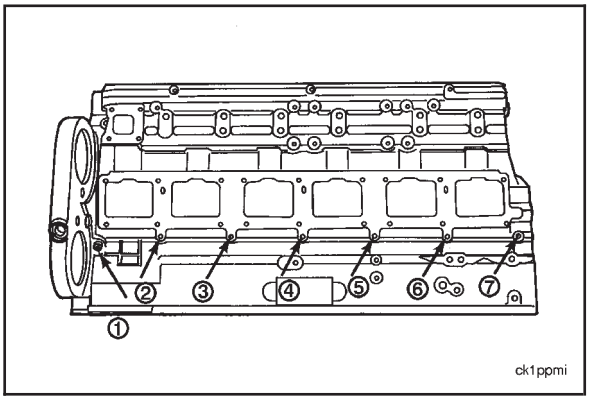
Torque Value: 88 N•m [65 ft-lb]

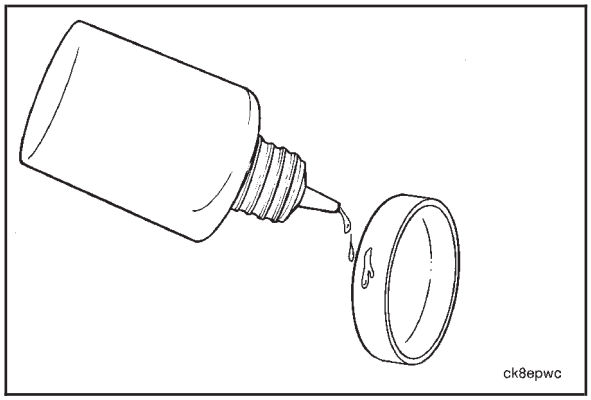


Install six pipe plugs and one straight thread plug from the main oil passage on the intake side of the cylinder block.

Install the straight threaded plug from the main oil transfer passage on the intake side of the cylinder block.

(1) Torque Value:	55 N•m [40 ft-lb]
(2) Torque Value:	7 N•m [5 ft-lb]
(3) Torque Value:	25 N•m [15 ft-lb]
(4 to 7) Torque Value:	15 N•m [10 ft-lb]

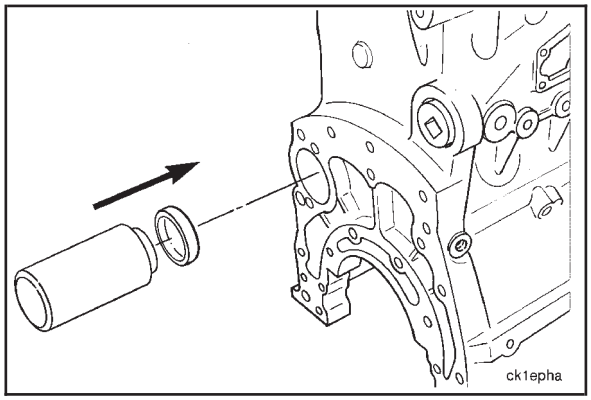




Cam Bore Rear Cup Plug - Installation

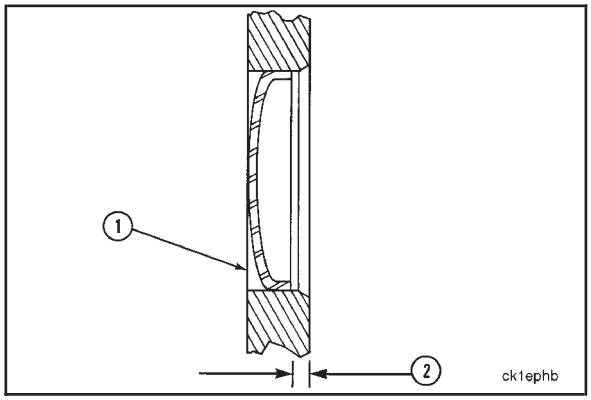
Caution: Do not install cup plugs in the block until the cleaning, inspection, and necessary repair procedures are completed. This will prevent dirt from being trapped in the engine.

Use cup plug sealant, Part No. 3375068, to seal the outside diameter of the cup plugs.

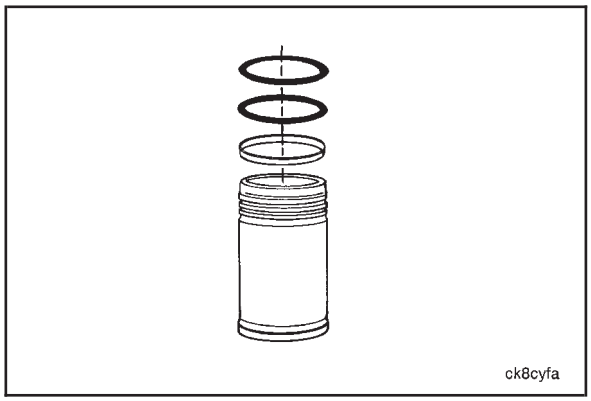


Use cup plug driver, Part No. 3376818, to install the cup plug.

A cup plug driver handle, Part No. 3376795, is required.



Caution: The cup plug must not be installed more than 2.03 mm [0.080-inch] below the surface of the cylinder block. The cup plug will interfere with the camshaft if installed deeper than the specification. If a service tool is not available, install the cup plug (1) flush to 2.03 mm [0.080-inch] (2) below the surface of the cylinder block.



Cylinder Liners - Cleaning and Inspection (01-06)

Cleaning

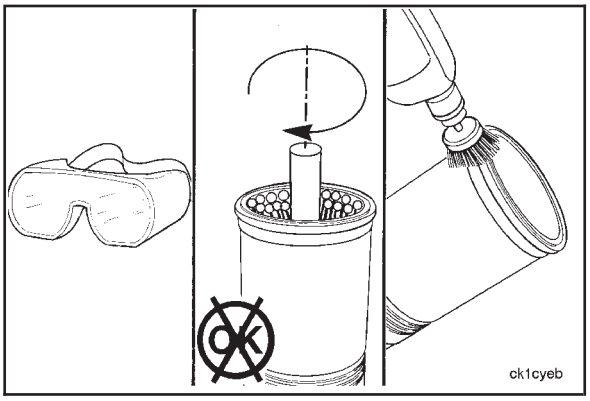
Remove the crevice seal. Remove the two o-rings.

Caution: Do not use a hone, deglazing, or prebrushing to clean the cylinder liners. Abrasives can damage the finish and the pattern and can contaminate the liner.

Warning: Wear eye protection. Make sure the wire brush is rated for the RPM being used if the brush is motor driven.

Use a high quality steel wire brush to clean the liner flange seating area.

Use a fine, fibrous abrasive pad such as Scotch-Brite® 7448, Part No. 3823258, or its equivalent to remove the remaining carbon.

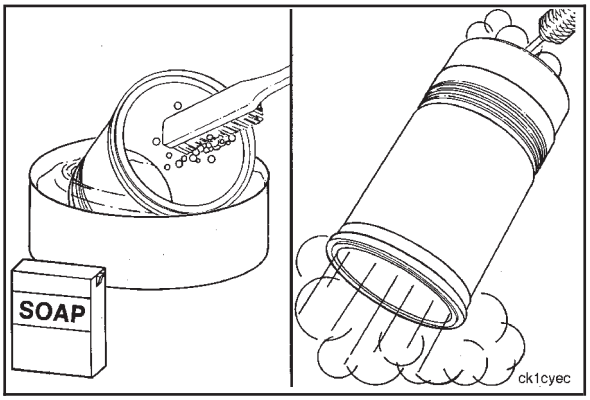


Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use a non-metallic bristle brush, detergent soap, and warm water to clean the inside diameter.

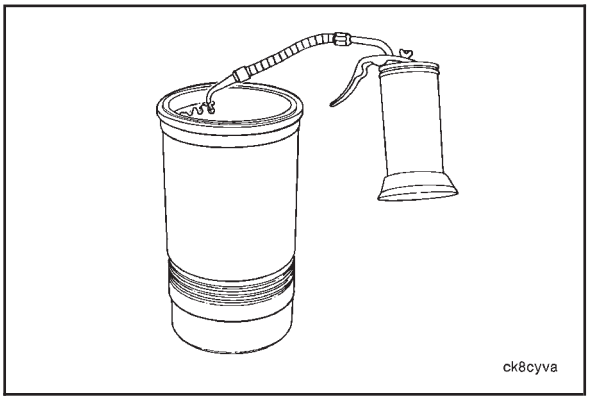
Use a steam cleaner or a solvent tank to clean the liners.

Dry with compressed air.



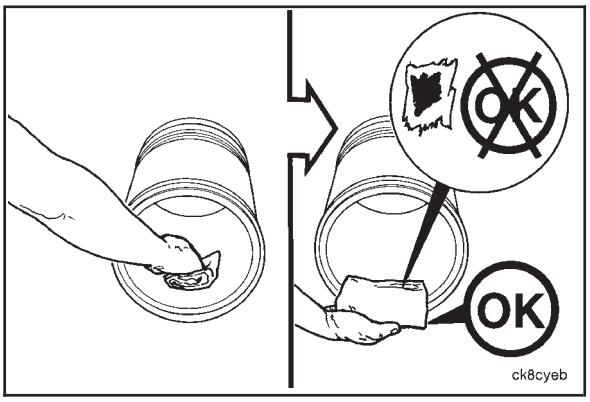
Use clean 15W-40 oil to lubricate the inside diameter of the liners.

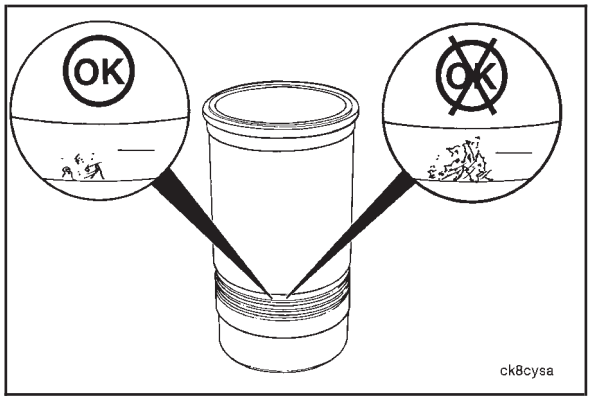
Allow the oil to soak in the liner for 5 to 10 minutes.



Continue to lubricate the inside of the liners and wipe clean until the paper towel shows no gray or black residue.

NOTE: Use lint-free paper towels to wipe the oil from the inside of the liners.

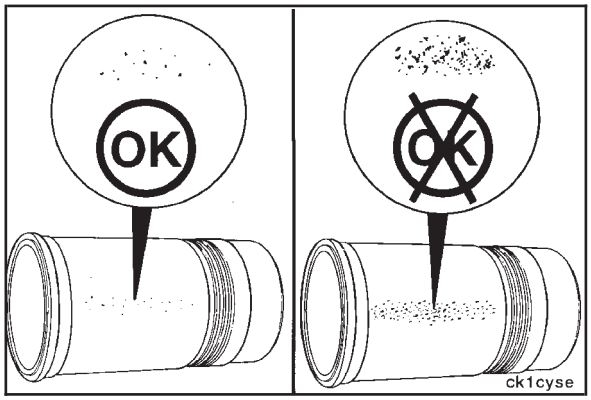




Inspection

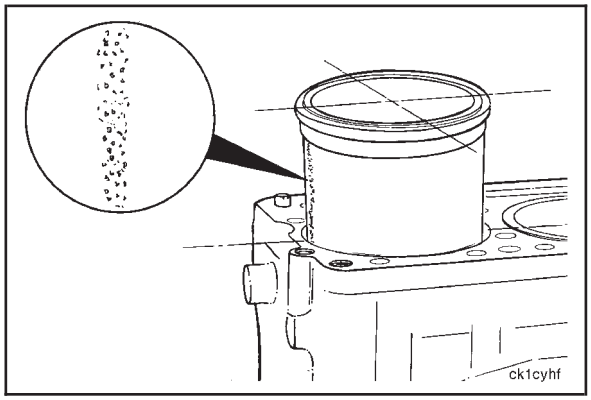
Visually inspect for pitting or erosion in the crevice seal groove.

Replace the liner if pitting or erosion is greater than one-half the width of the crevice seal groove.

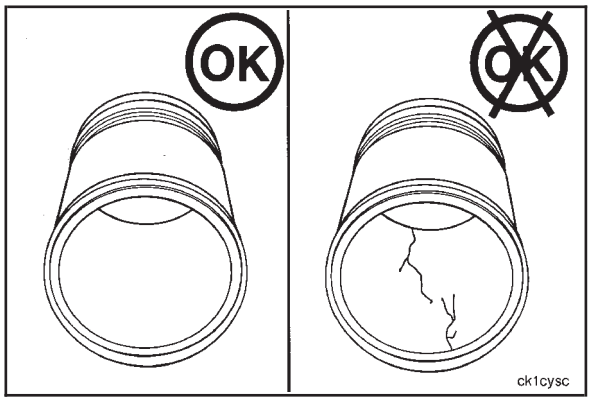


Visually inspect the outside diameter for excessive corrosion or pitting. Pits **must not** be more than 1.60 mm [0.063-inch] deep.

Replace the liner if the pits are too deep or if the corrosion can **not** be removed with a fine emery cloth.



Liners which have light pitting or erosion can be used again, but they **must** be installed with the pitting or erosion positioned in line with the crankshaft.



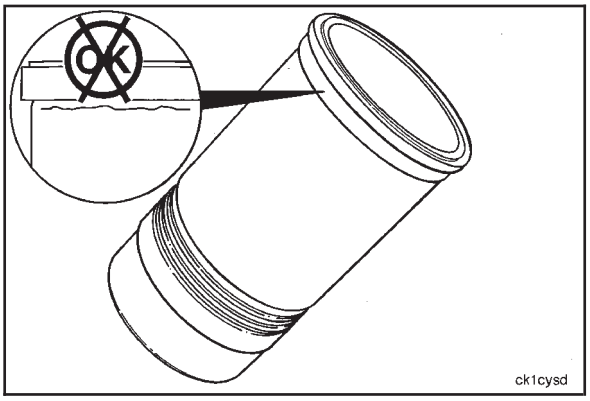
Visually inspect for cracks on the inside and the outside of the liner.

Replace the liner if cracks are found.

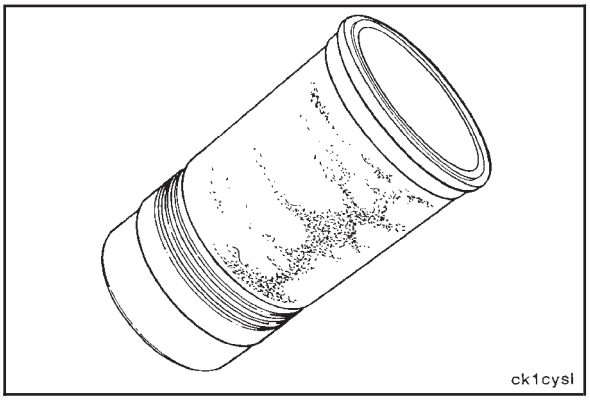
Inspect for cracks under the flange.

NOTE: Cracks can also be detected by using either magnetic inspection or the dye method.

Replace the liner if cracks are found in the flange area.



Visually inspect the exterior of the liners. The presence of any coating can indicate an inadequate concentration level of supplemental coolant additives (SCA). The proper concentration level of SCA will protect against the formation of scale or oil coatings. SCA's form a very hard film on the coolant side of the liner which resists damage from the implosion of air bubbles.The microscopic protective coating of ferrous oxide is invisible and will not be seen by the naked eye.

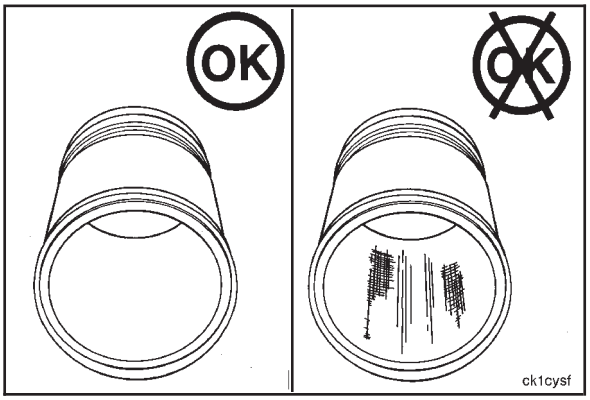


Inspect the inside diameters for vertical scratches deep enough to be felt with a fingernail.

NOTE: If a fingernail catches in the scratch, the liner **must** be replaced.

Visually inspect the inside diameter for scuffing or scoring.

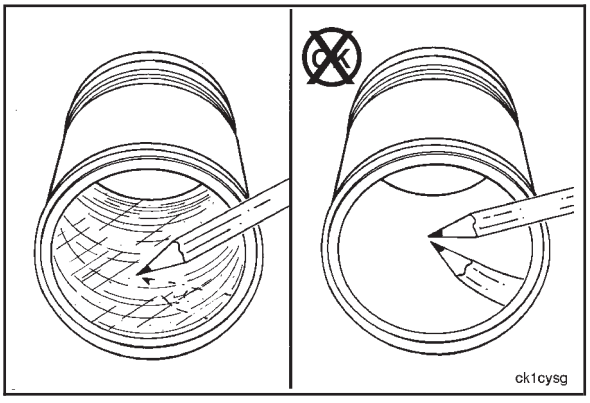
Replace the liner(s) if excessive scuffing or scoring is present. Refer to Parts Reuse Guidelines, Bulletin No. 3810303, for further information.

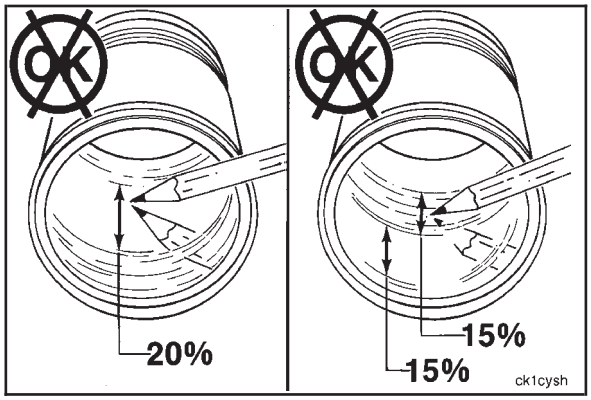


Visually inspect the inside diameter for liner bore polishing.

A **moderate polish** produces a bright mirror finish in the worn area with traces of the original hone marks or an indication of an etch pattern.

A **heavy polish** produces a bright mirror finish in the worn area with no traces of hone marks or an etch pattern.

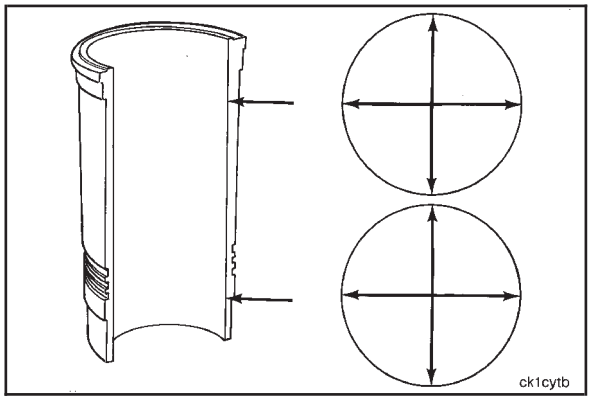




Replace the liner if:

1. a heavy polish is present over 20 percent of the piston ring travel area.
2. thirty percent (30%) of the piston ring travel area has both moderate and heavy polish, and one-half (15 percent) is heavy polish.

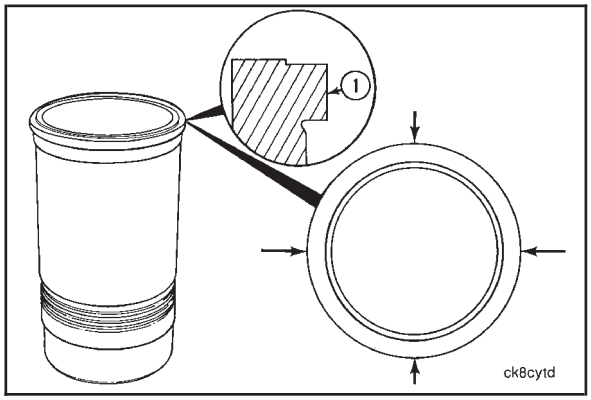
Refer to Parts Reuse Guidelines, Bulletin No. 3810303, for further information.



Use a dial bore gauge to measure the liner inside diameter in four places 90 degrees apart at the top and the bottom of the piston travel area.

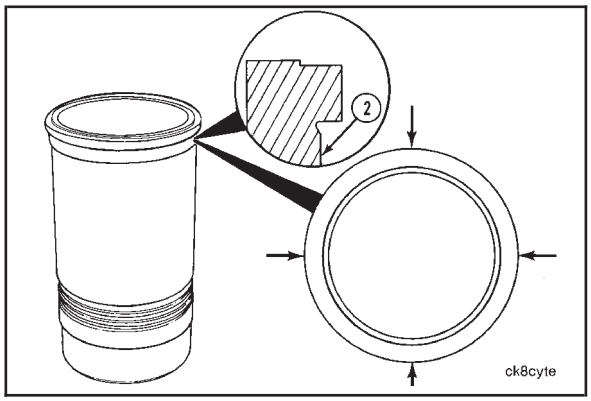
Cylinder Liner I.D.		
mm		in
139.696	MIN	5.4995
139.827	MAX	5.5050

Replace the liner if measured dimensions exceed limits given above in the table.



Measure the liner flange outside diameter.

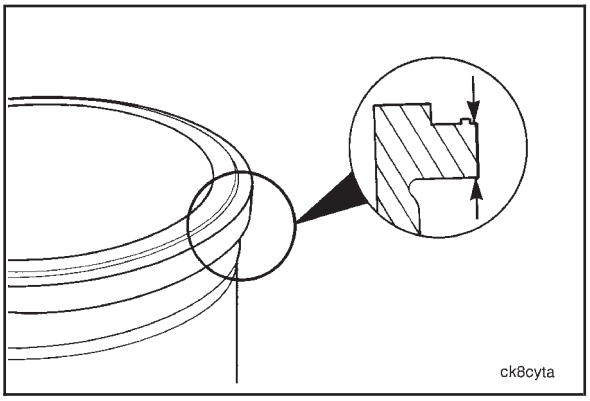
Liner O.D. (Upper Flange Area)			
	mm		in
Standard	166.72	MIN	6.564
	166.77	MAX	6.566
Oversize	167.23	MIN	6.584
	167.28	MAX	6.586



Measure the lower press fit area.

Liner O.D. (Lower Press Fit Area)			
	mm		in
Standard	159.91	MIN	6.296
	159.96	MAX	6.298
Oversize	160.93	MIN	6.336
	160.98	MAX	6.338

Cylinder Liner Flange Thickness			
	mm		in
Standard	9.01	MIN	0.355
	9.04	MAX	0.356
Oversize	9.52	MIN	0.375
	9.55	MAX	0.376



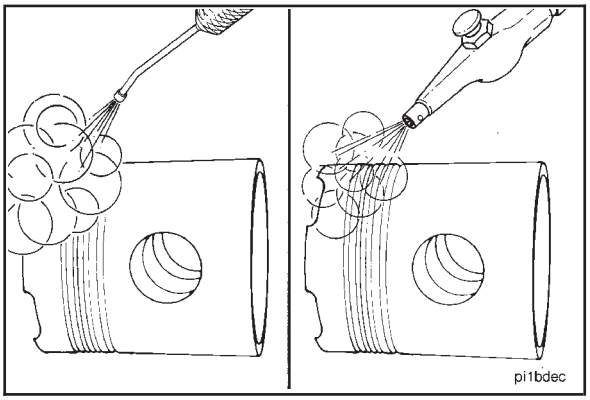
Pistons - Cleaning and Inspection (01-07)

Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Caution: Do not use the glass bead blast method to clean the pistons. The piston will be damaged by the blast material embedded in the aluminum.

Steam clean the carbon from the pistons.



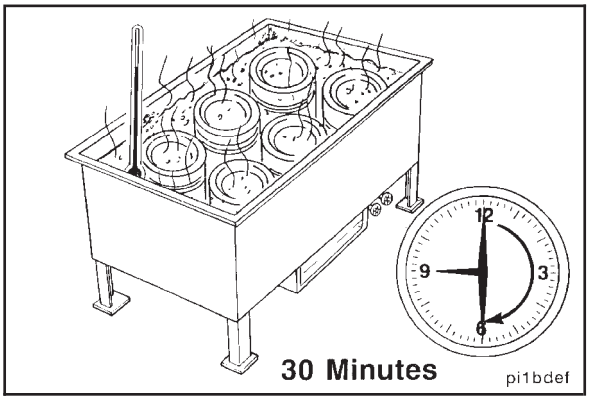
Caution: The cleaning solvent must be approved for aluminum to prevent damage to the pistons.

Use a kerosene emulsion-based solvent that can be heated to 95°C [200°F] and a cleaning tank that will constantly mix and filter the solvent.

NOTE: Do not use a solvent that has a pH higher than 9.5 or a solvent that contains chlorinated hydrocarbons with cresols, phenols, or cresylic components.

Put the pistons into the solvent and allow them to soak for a minimum of 30 minutes.

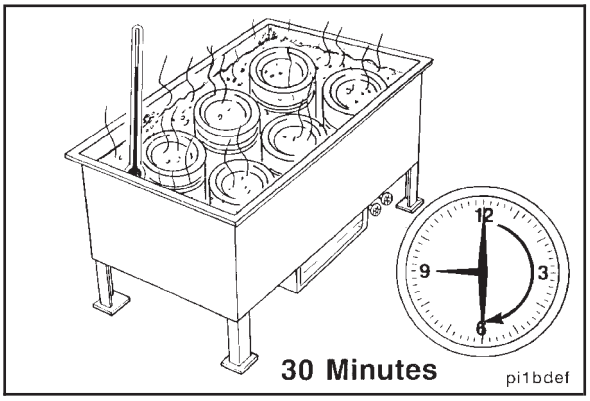
NOTE: Soak the pistons several hours or overnight for best results.

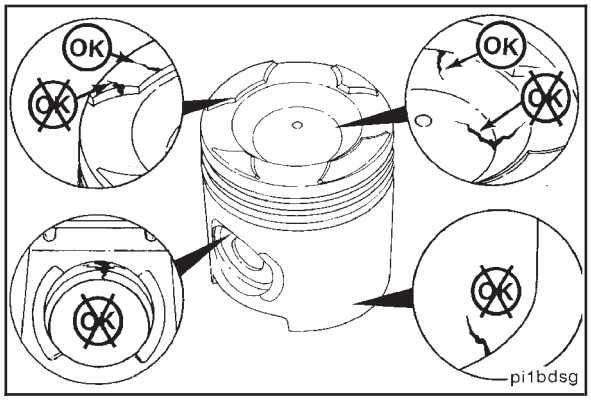


Caution: Do not use a metal brush to clean the pistons. The ring grooves will be damaged.

Use a non-metallic brush to clean the piston ring grooves.

Repeat the soaking and scrubbing process until the piston is cleaned thoroughly, and dry with compressed air.



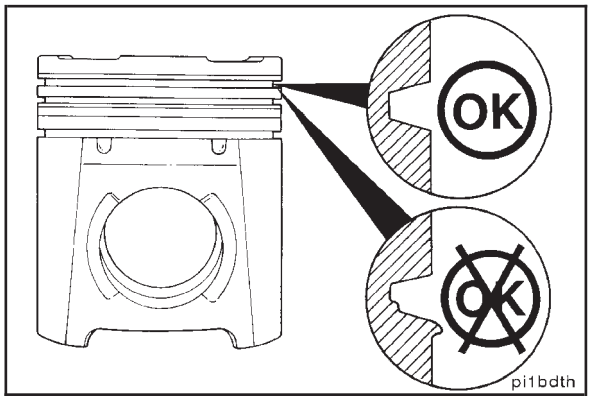


Inspection

Visually inspect the piston bowl, the pin bore, and the skirt for cracks or damage.

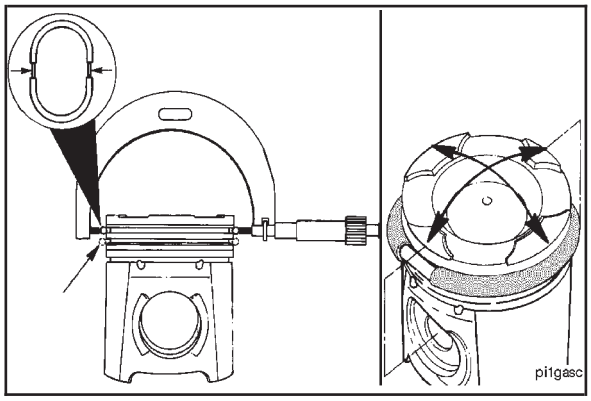
Use crack detection kit, Part No. 3375432, or equivalent to check for cracks on the top of the piston and in the piston pin bore.

NOTE: Do **not** use pistons with dome cracks larger than one-half (1/2) the rim width or with cracks which extend over the rim toward the ni-resist insert. Do **not** use pistons with dome cracks in the rim above the pin bore axis. Do **not** use pistons with cracks in the piston pin bore. Do **not** use pistons with scuff marks, visually unacceptable scratches or cracks in the skirt. If pistons are unacceptable for reuse, do **not** use the mating piston pins. Cummins recommends replacing pistons and pins in sets.



Visually inspect the piston ring lands and ring grooves for wear. A worn groove will have a detectable step at the back of the groove and a rolled edge at the surface of the piston or the ring groove outside diameter. Pistons exhibiting this wear are **not** acceptable for reuse.

Refer to the Parts Reuse Guidelines, Bulletin No. 3810303.



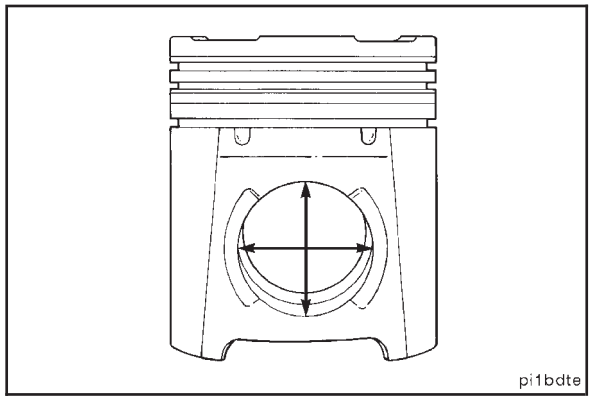
Use piston ring groove wear gauges, Part No. 3823870, 3823869, and a 5-6 inch micrometer, to inspect the top and second grooves (compression rings).

NOTE: The piston **must** be replaced if measured dimensions are less than those in the table below.

Measure each ring groove (diameter over pins) when the piston temperature is at 21°C [70°F] in two places 90 degrees apart as shown.

Ring Groove Wear Limits (Diameter Over Pins)			
	mm		in
Top Ring Groove:	140.2	MIN	5.515
2nd Ring Groove:	140.1	MIN	5.514

Measure the piston pin bore when the piston temperature is at 21°C [70°F] in two places 90 degrees apart.

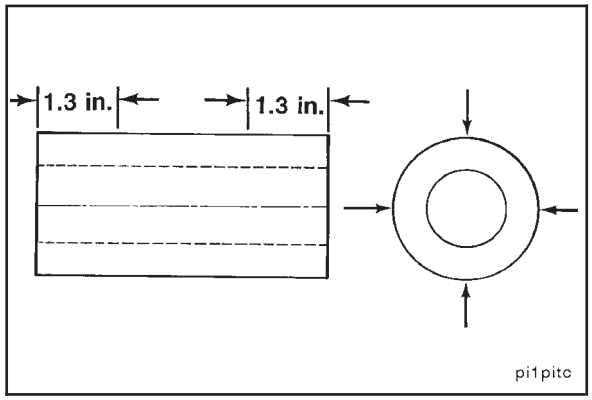


Piston Pin Bore		
mm		in
63.504	MIN	2.500
63.530	MAX	2.5012

NOTE: Add 0.013 mm [0.0005-inch] to the bore inside diameter per 5°C [10°F] temperature rise up to 32°C [90°F].

Visually inspect the piston pin for scratches, grooves, or other damage. Do **not** reuse if visually unacceptable.

Measure the piston pin outside diameter at both ends as shown in two places 90 degrees apart.



Piston Pin Outside Diameter		
mm		in
63.4848	MIN	2.4994
63.4997	MAX	2.4999

NOTE: Discard the piston pin if it is more than 0.03 mm [0.001-inch] out of round. If piston pin measurements exceed those in the table, do **not** reuse. If the piston pin is unacceptable for reuse, do **not** use the matching piston. Cummins recommends replacing pistons and pins in sets.

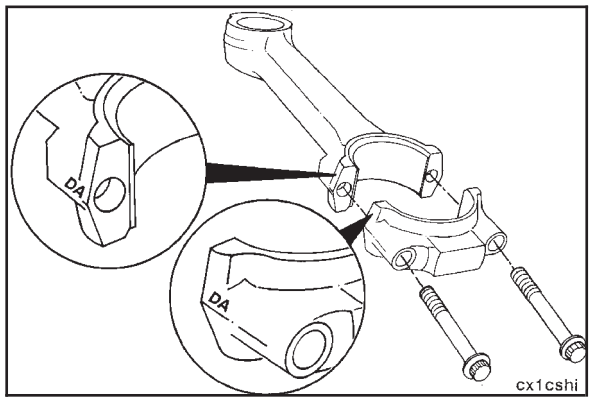
Connecting Rod Assemblies - Cleaning and Inspection (01-08)

Cleaning

NOTE: The alpha characters or numbers on the connecting rod cap **must** be the same as the alpha characters or numbers on the rod.

Do **not** assemble a new cap to a used rod or a used cap to a new rod.

Remove the capscrews and the caps from the rods.

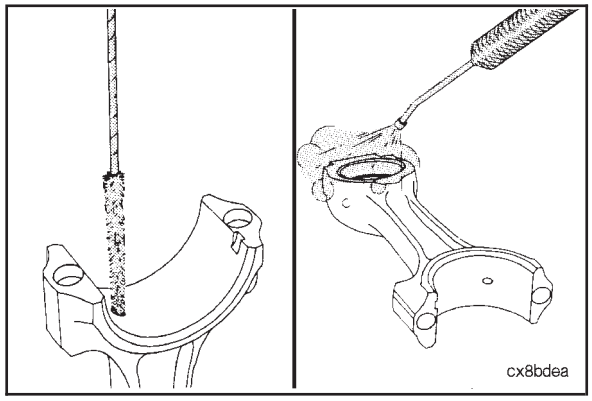


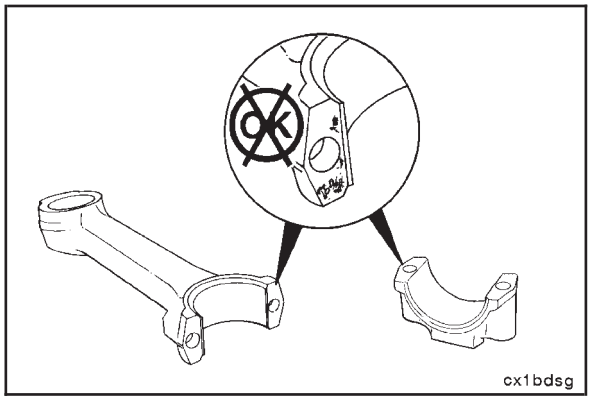
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use solvent or steam to clean the rods.

Use a soft bristle brush to clean the oil drilling.

Dry with compressed air.

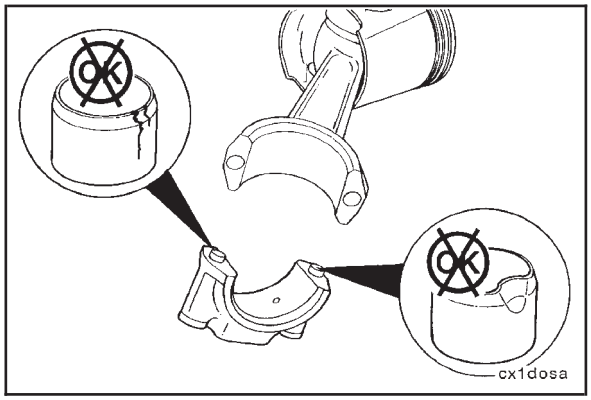




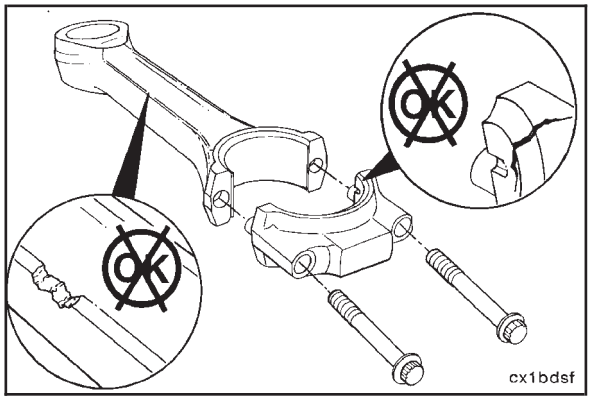
Inspection

Visually inspect the connecting rod and the cap for fretting damage on the mating surfaces.

The rod and the cap **must** be replaced as an assembly if any fretting damage is visible on either piece.

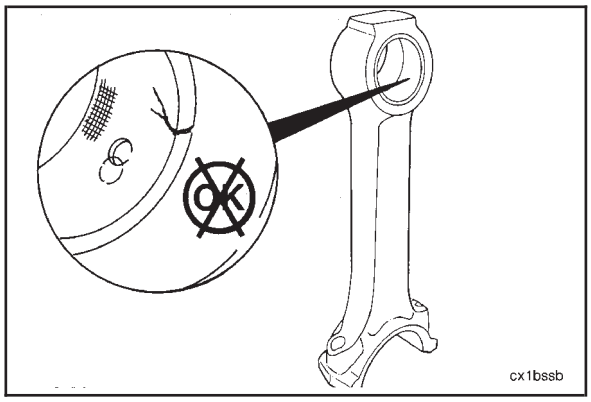


Visually inspect the ring dowels for cracks or damaged areas. Replace if necessary. Refer to Connecting Rod Ring Dowel - Removal later in this section.



Inspect the rods and the caps for damage.

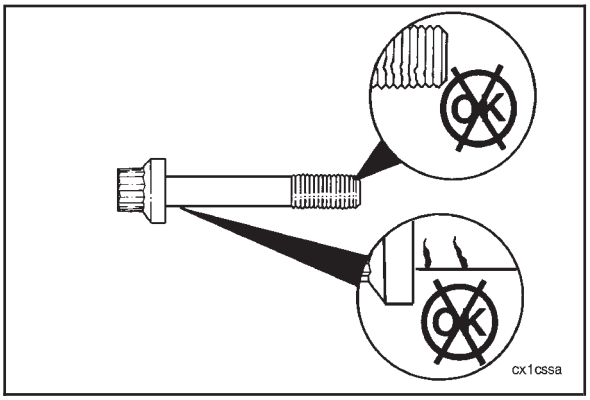
Replace the rod if the I-beam is nicked or damaged.



Visually inspect the rod pin bore bushing for damage or misalignment of the oil passage and the bushing.

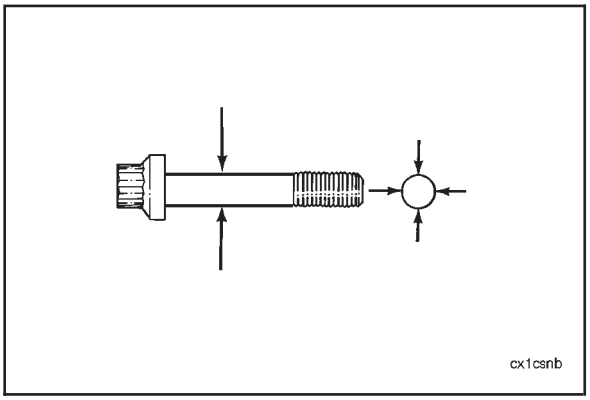
Visually inspect the capscrew threads for damage.

Visually inspect under the capscrew heads for cracks.



Measure the capscrew outside diameters.

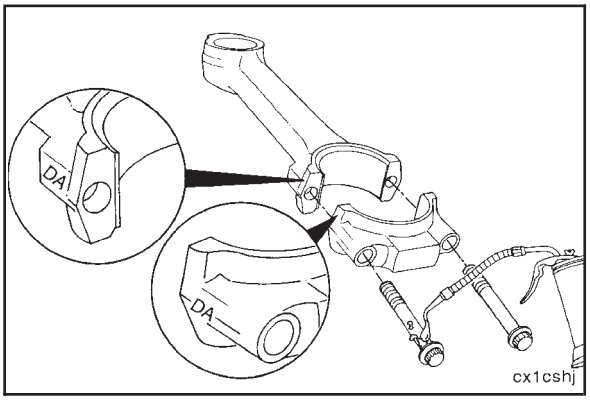
Connecting Rod Capscrew O.D.		
mm		in
14.50	MIN	0.571
14.99	MAX	0.590



Caution: The rod cap alpha-numeric characters must match the alpha-numeric characters on the connecting rod and must be installed with the characters aligned to prevent damage to the connecting rods and crankshaft.

Use clean 15W-40 oil to lubricate the connecting rod capscrews.

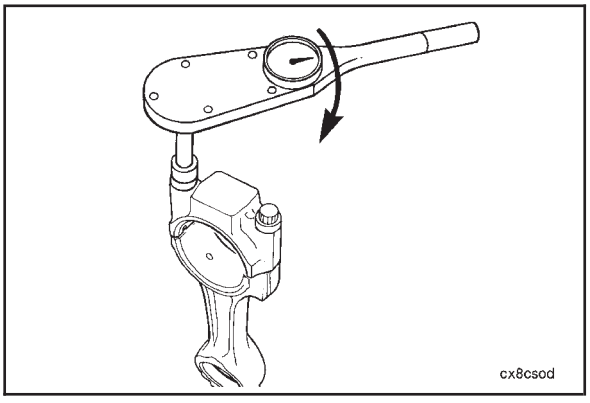
Assemble the rod, the cap, and the capscrews.

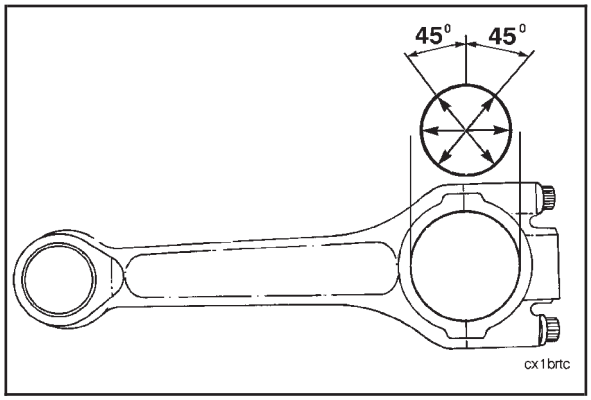


Caution: Use a vise with brass jaws to hold the rod. Notches, scratches, or dents in the I-beam will cause rod failure.

Tighten the capscrews in alternate sequence to the following torque values:

1. Tighten to 100 N•m [75 ft-lb].
2. Tighten to 264 N•m [195 ft-lb].

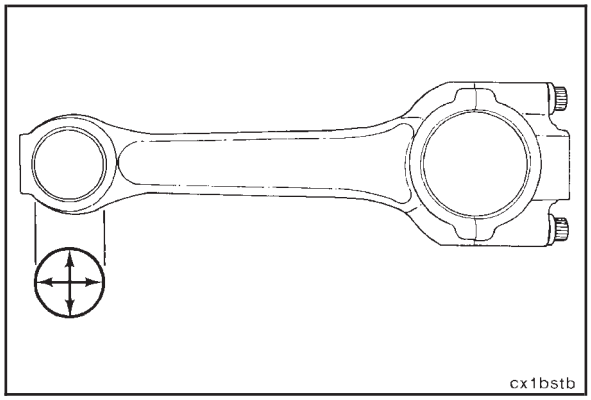




Measure the connecting rod bearing bore inside diameter.

Connecting Rod Crankshaft Bore I.D.		
mm		**in**
93.731	MIN	3.6902
93.769	MAX	3.6917

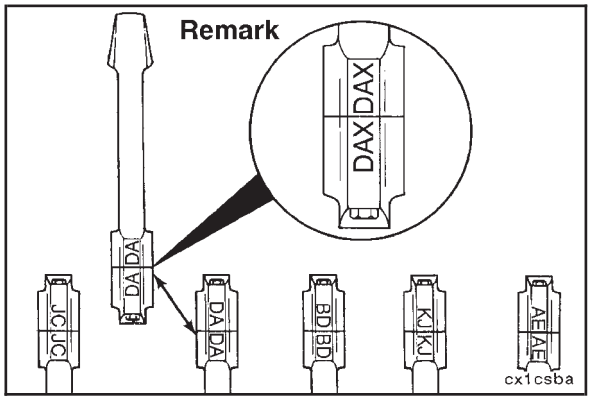
If any of the measurements are **not** within the specifications, the rod **must** be repaired or replaced.



Measure the piston pin bushing inside diameter.

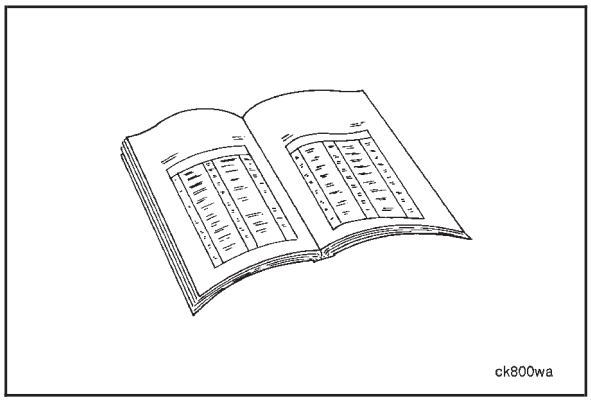
Piston Pin Bushing I.D.		
mm		**in**
63.525	MIN	2.5010
63.581	MAX	2.5032

If the bushing does **not** meet the specifications, the rod **must** be replaced.



Caution: The connecting rod must be assembled with the capscrews tightened to specifications before stamping identification numbers or alpha characters on the rod.

If a new connecting rod is installed, **always** check the rod and cap assemblies identification to make sure it does **not** match any of the other rod and cap assemblies in that engine. If it does, the rod and cap **must** be stamped so they can be differentiated from the other rod and cap assemblies.



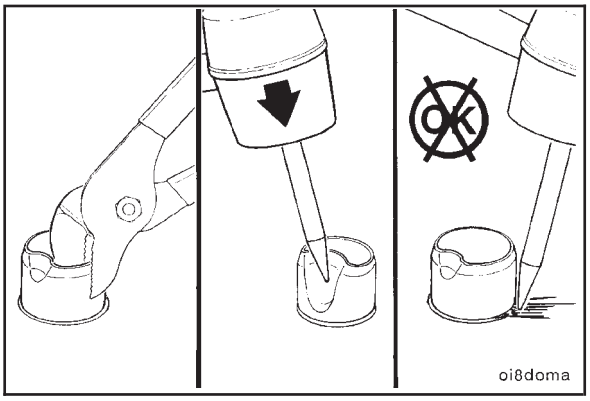
Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the connecting rods and capscrews.

Connecting Rod Ring Dowels - Removal

Caution: Do not damage the surface or the ring dowel hole during removal of the dowel.

Use pliers or locking pliers to remove the damaged ring dowels.

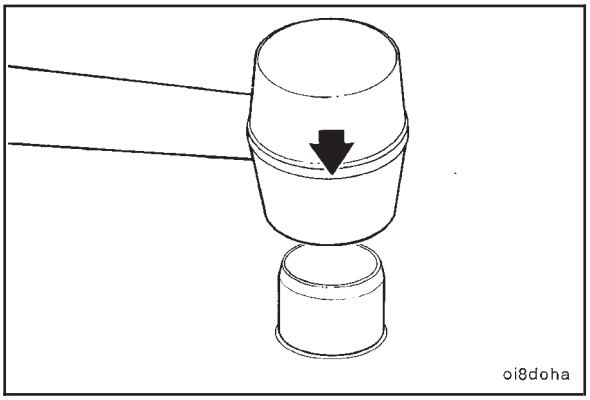
Use a blunt punch, if necessary, to bend the ring in for removal.



Connecting Rod Ring Dowels - Installation

Caution: Do not use a hammer or damage to the dowel will result.

Use a plastic mallet to install the ring dowel.



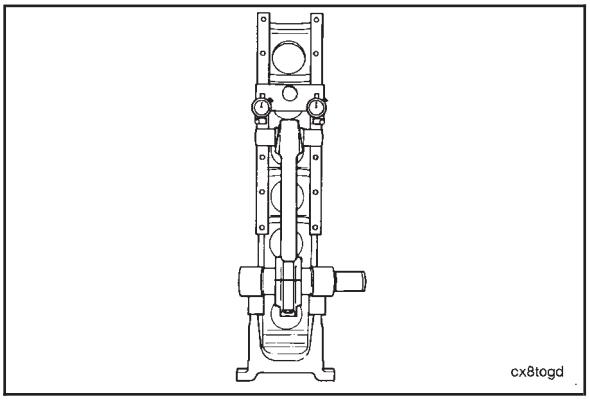
Connecting Rods - Bend and Twist Inspection (01-09)

Fixture Calibration

Use a connecting rod checking fixture, Part No. ST-561, and a connecting rod mandrel set, Part No. 3823785, to inspect the bend and the twist of the rods.

Calibrate the checking fixture with a new rod that has been measured for correct center to center length, 304.75 mm to 304.80 mm [11.998 inches to 12.000 inches].

NOTE: Assemble the connecting rod cap to the rod as described in Connecting Rods - Inspection.

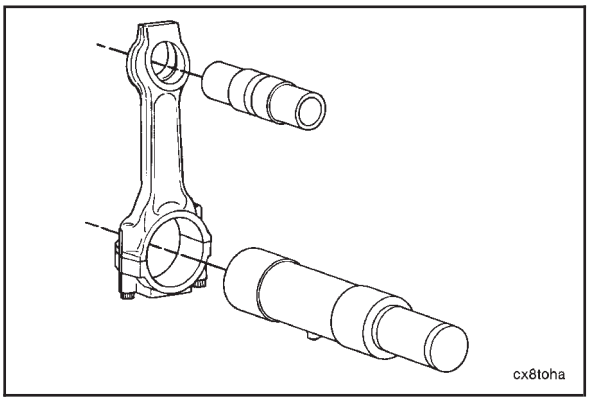


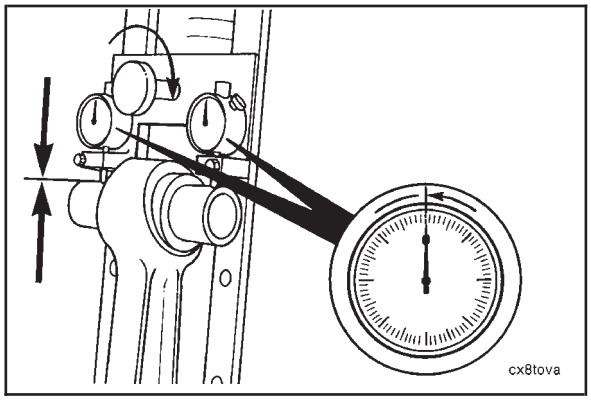
Install the piston pin mandrel from the connecting rod mandrel set, Part No. 3823785, into the piston pin bore.

NOTE: Use a mandrel, Part No. 3823787, if the piston pin bushing has been removed or the mandrel, Part No. 3823788, if the bushing is still in place.

Install the mandrel, Part No. 3823786, into the crankshaft bore and expand the mandrel.

NOTE: Make sure the pin on the mandrel is pointed down and locked in position in the center of the connecting rod.



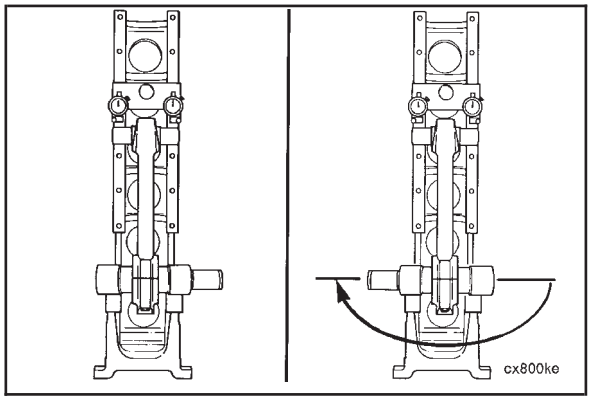


Install the connecting rod into the fixture.

Move the dial holder to position the contact points of the indicators on the mandrel in the piston pin bore.

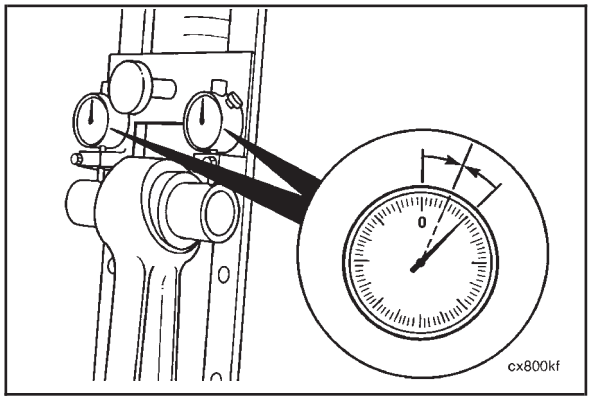
Tighten the bracket to hold the indicators in position.

Set the dial indicators to read ‘‘0.’’



Remove the connecting rod from the fixture.

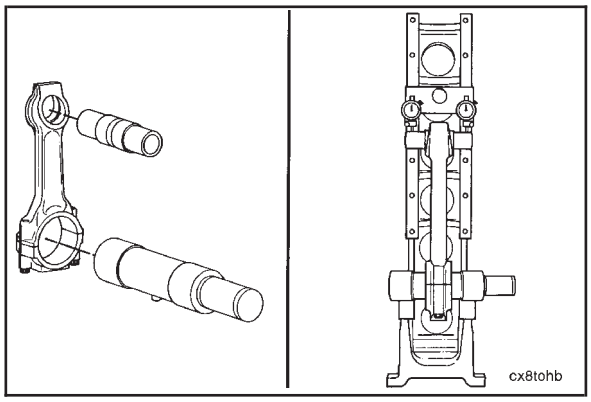
Turn the rod 180 degrees horizontally, and install the rod into the fixture again.



Check the dial indicators for the ‘‘0’’ position again.

If the dial indicators show any change from ‘‘0,’’ adjust the dials to half the indicated reading.

The fixture is now calibrated to allow the connecting rod to be installed into the fixture in either direction, and the dials will indicate an equal deflection on either side of ‘‘0.’’



Alignment - Inspection

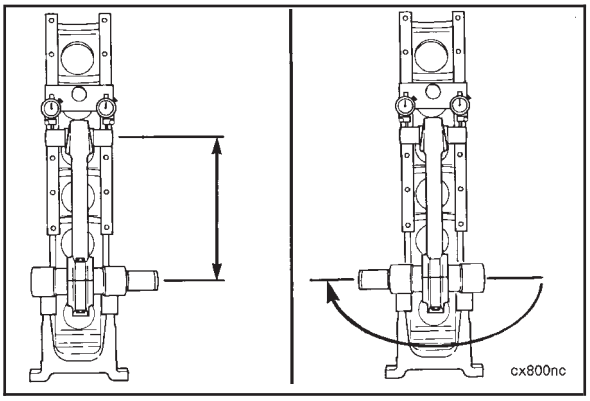
Install the mandrel and the arbor into the connecting rod to be inspected.

Install the connecting rod into the fixture.

Measure the rod length and bend (alignment).

Connecting Rod Length			
mm			in
304.75	MIN		11.998
304.80	MAX		12.000

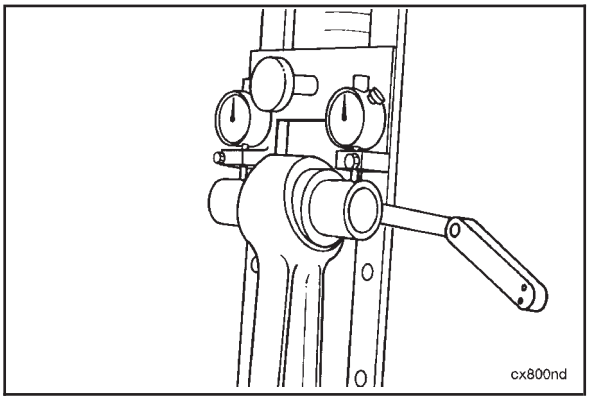
Connecting Rod Alignment			
	mm		in
Bushing Removed	0.25	MAX	0.010
Bushing Installed	0.10	MAX	0.004



Twist - Inspection

Using a feeler gauge, check the clearance between the mandrel and the dial indicator holding plate as shown.

Connecting Rod Twist			
	mm		in
Bushing Removed	0.50	MAX	0.020
Bushing Installed	0.25	MAX	0.010



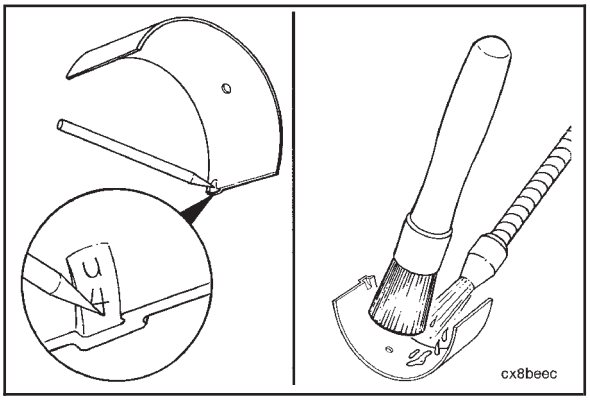
Connecting Rod Bearings - Cleaning and Inspection (01-10)

NOTE: The bearings **must** be marked for location as they are removed for future identification. Each bearing **must** be installed in its original location if the bearing is used again.

Cleaning

Caution: Do not use a scraper or a wire brush. The bearings can be damaged.

Use solvent and a soft bristle brush. Dry with compressed air.



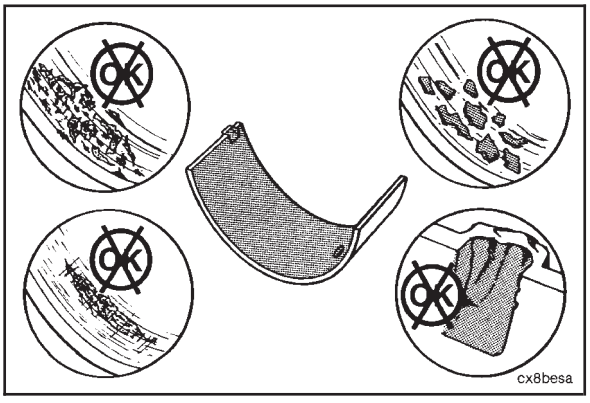
Inspection

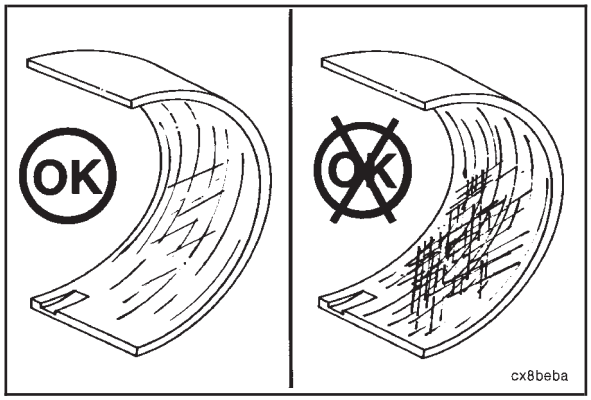
Visually inspect the bearings for damage.

Replace any bearings with the following damage:

- Pitting
- Flaking
- Corrosion
- Lock tang damage
- Scratches (deep enough to be felt with a fingernail)

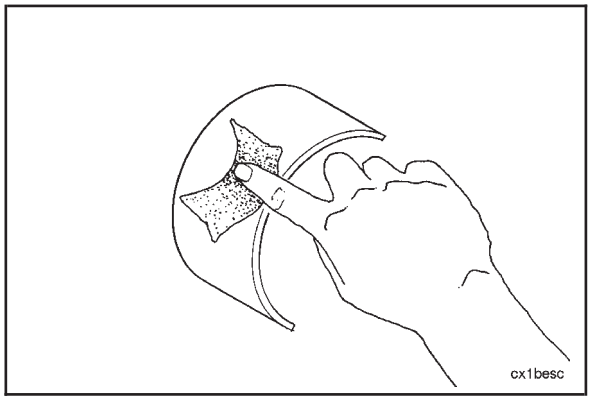
Refer to the Parts Reuse Guidelines, Bulletin No. 3810303, for further information.





NOTE: If large areas of copper lining are visible in the bearings before the engine has accumulated 241,000 kilometers [150,000 miles] or 3,750 hours, inspect the engine for contamination from fine dirt particles; and correct the problem to prevent further engine damage.

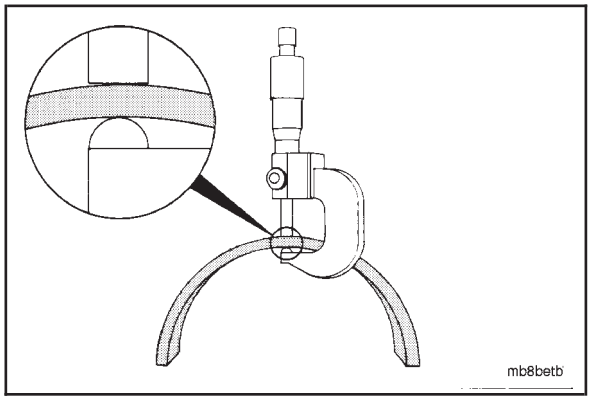
Normal bearing wear produces a smooth finish which will wear into the copper lining. Exposed copper does **not always** indicate worn bearings.



Visually inspect the bearing seating surface for nicks or burrs.

If burrs can **not** be removed with a fine crocus cloth, the bearings **must** be replaced.

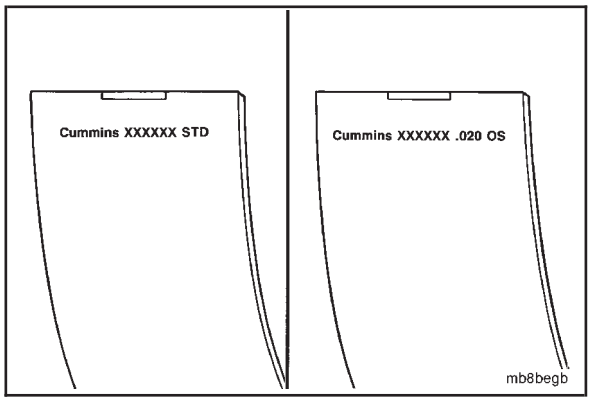
NOTE: For more detailed information of bearing damage, refer to Analysis and Prevention of Bearing Failures, Bulletin No. 3810387.



Measure the rod bearing shell thickness at the wear location with an outside micrometer that has a ball tip.

Connecting Rod Bearing Thickness (Standard)		
mm		in
2.362	MIN	0.0930
2.405	MAX	0.0947

Discard a bearing shell if its thickness is below the minimum specification.



NOTE: Oversize bearing shells are available for crankshafts which are 0.25 [0.010-inch], 0.51 mm [0.020-inch], 0.76 mm [0.030-inch], or 1.02 mm [0.040-inch] undersize.

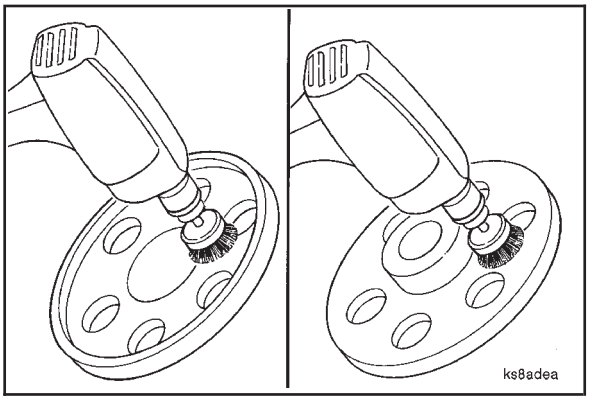
Bearing shells are identified by steel stamped characters on the back of the bearings to indicate either standard or the amount of oversize.

Crankshaft Adapter - Cleaning and Inspection (01-11)

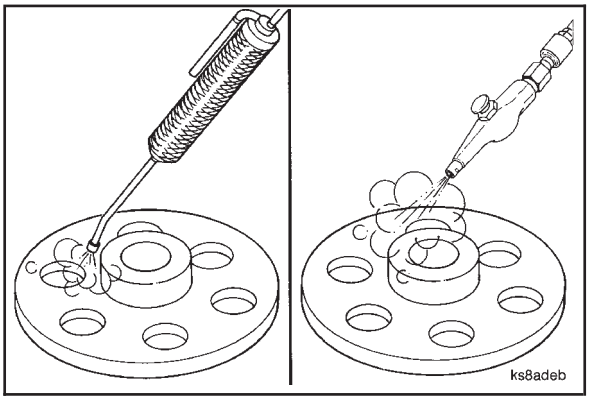
Cleaning

Warning: When performing the following procedures, wear eye protection. Also, the wire brush must be rated for the RPM being used if the brush is motor driven.

Use an emery cloth or a steel wire brush. Clean the inside and the outside diameters of the adapter.

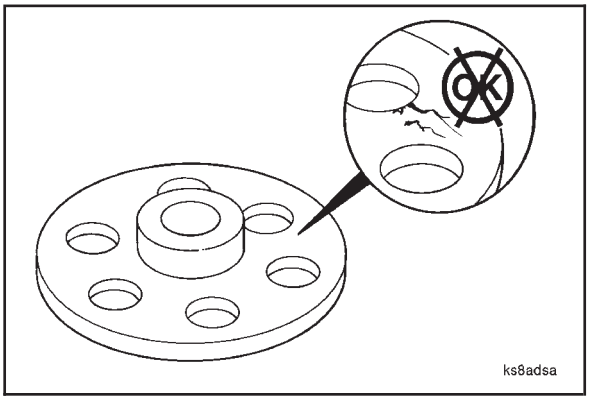


Use solvent to clean the adapter. Dry with compressed air.



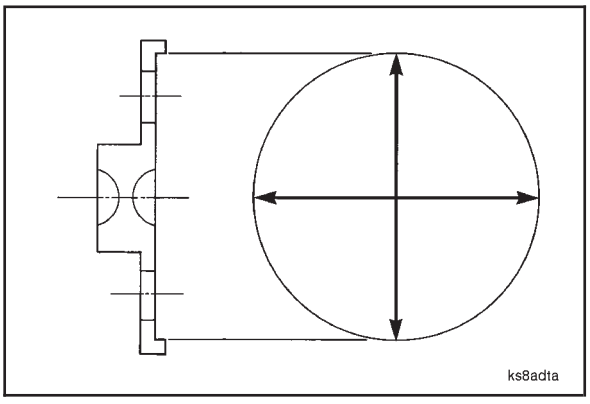
Inspection

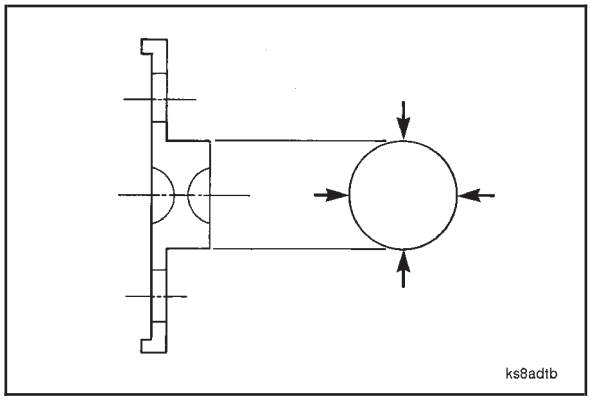
Visually inspect the adapter for cracks.



Measure the inside pilot diameter.

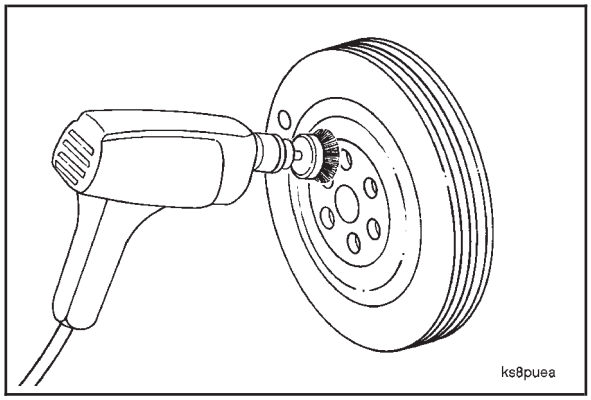
Inside Pilot Diameter		
mm		in
92.10	MIN	3.626
92.17	MAX	3.629





Measure the outside pilot diameter.

Outside Pilot Diameter		
mm		in
35.013	MIN	1.3785
35.052	MAX	1.3800

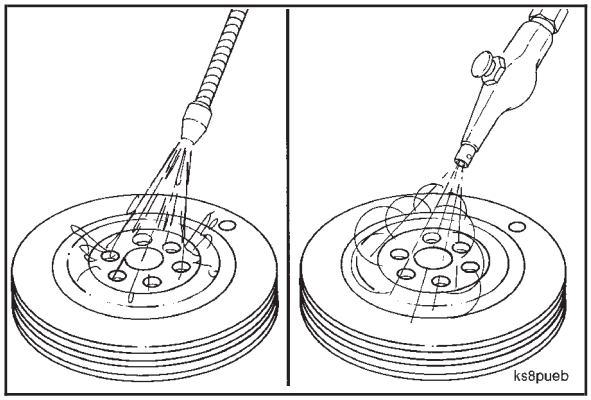


Crankshaft Pulley - Cleaning and Inspection (01-12)

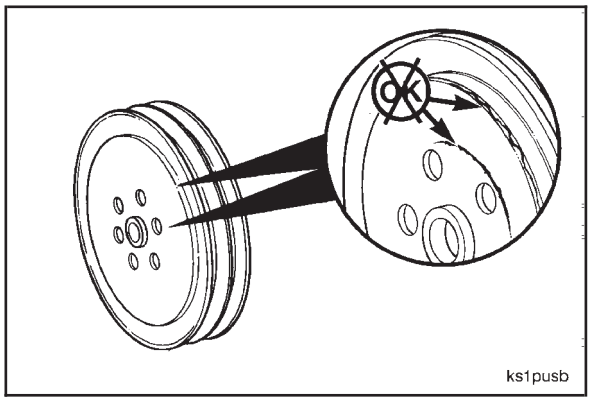
Cleaning

Warning: When performing the following procedures, wear eye protection. Also, the wire brush must be rated for the RPM being used if the brush is motor driven.

Use an emery cloth or a steel wire brush. Clean the pulley grooves and the inside and the outside mounting surfaces.



Use solvent to clean the pulley. Dry with compressed air.

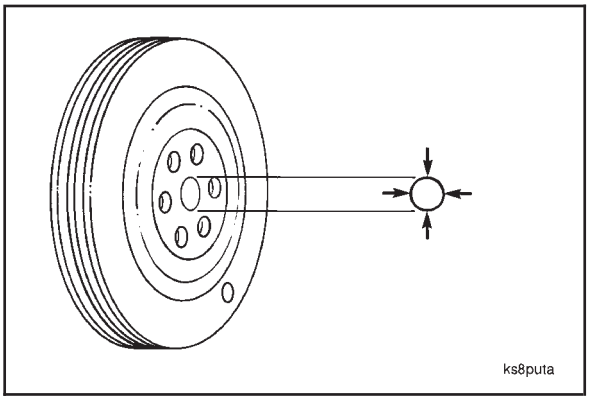


Inspection

Visually inspect the pulley for cracks in mounting web and near the belt grooves, belt groove wear, or other damage.

Measure the inside diameter.

Spun Steel Crankshaft Pulley I.D.		
mm		in
35.08	MIN	1.381
35.18	MAX	1.385

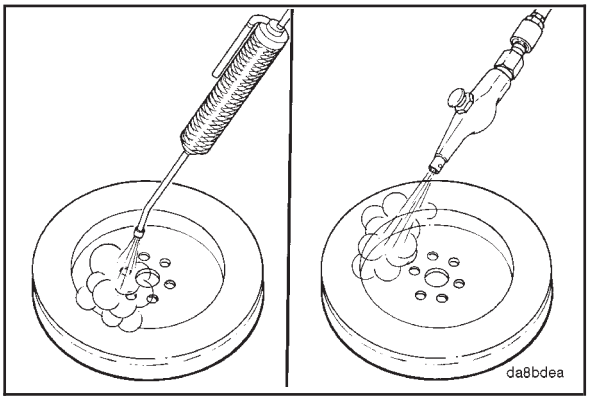


Vibration Damper - Cleaning and Inspection (01-13)

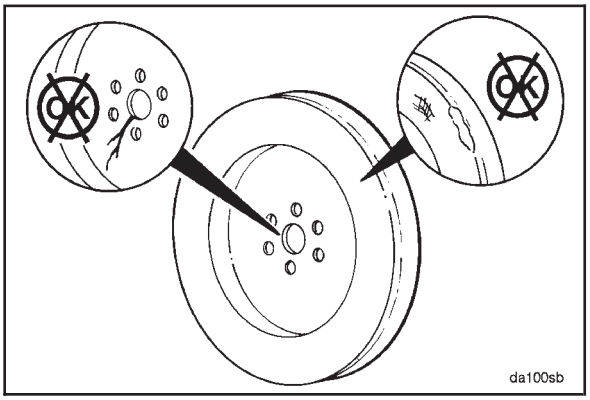
Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Steam clean and dry with compressed air.

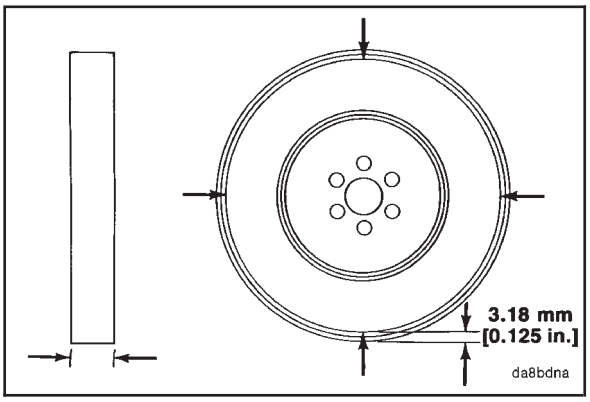


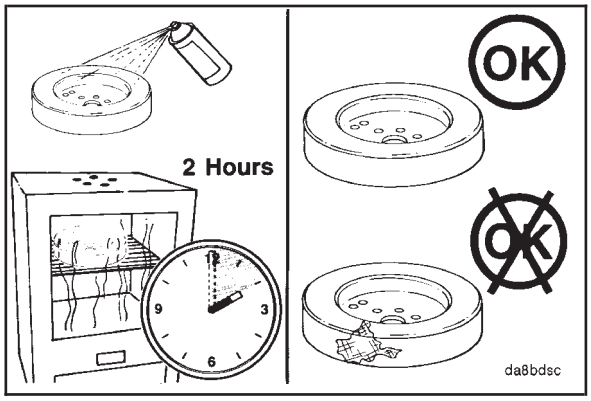
Check the mounting web for cracks. Check the housing for dents or raised surfaces. Replace the damper if any of these defects are identified.



Measure the thickness in four places 90 degrees apart approximately 3.18 mm [0.125-inch] from the outside diameter as shown.

The difference between any two of the four measurements **must not** exceed 0.25 mm [0.010-inch].





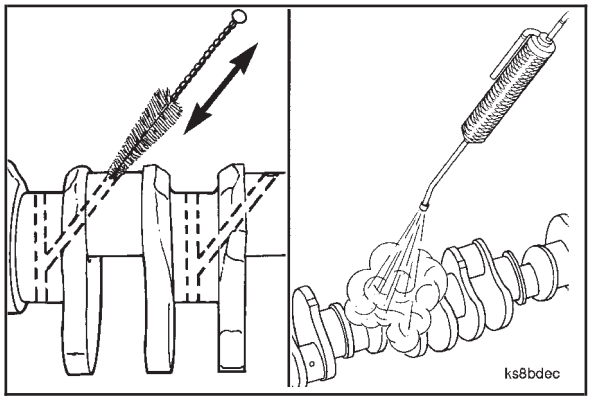
Inspection

Caution: Always wear protective gloves when handling heated parts. Personal injury can result.

Apply a spray of spot check developer, type SKD-NF®, or its equivalent, to the damper.

Put the damper (seam side down) into an oven heated to 93°C [200°F] for 2 hours.

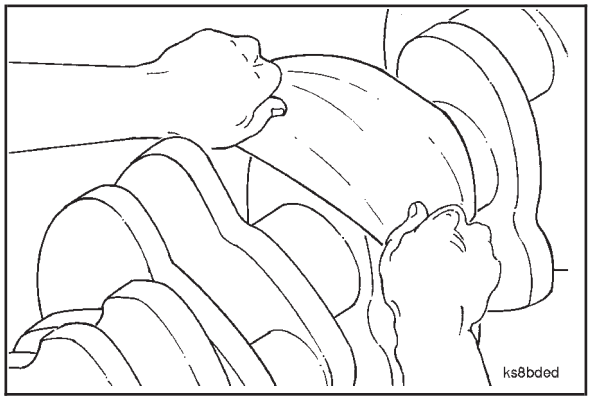
Remove the damper from the oven, and visually inspect for oil leaks.



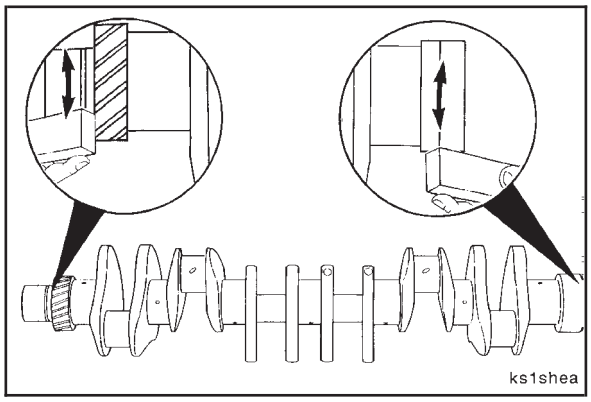
Crankshaft - Cleaning and Inspection (01-14)

Cleaning

NOTE: New crankshafts are coated with a heavy preservative. Use solvent to thoroughly remove the coating. Brush or flush the packing debris from the oil drillings before installing crankshaft in the engine. Use a light preservative to prevent rust during engine rebuild.

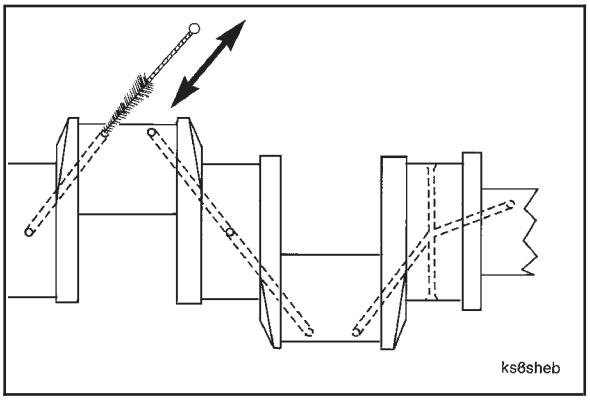


Use a fine crocus cloth or a 400 grit emery cloth to remove discoloration or light scratches from the machined surfaces.



Use a hone stone. Polish the outside diameter at the front and the rear oil seal locations, the flywheel mounting location, and the vibration damper location. Remove all the small scratches and the grooves.

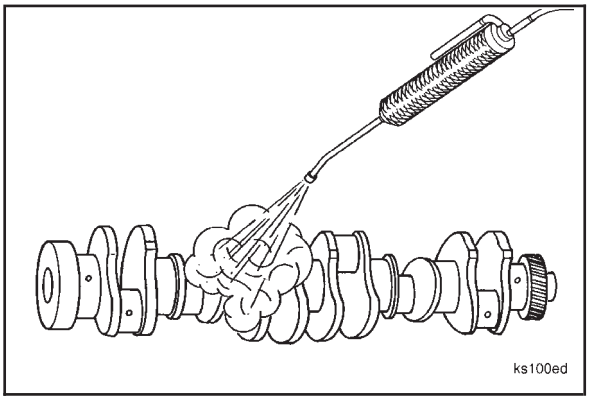
Use a bristle brush, Part No. ST-876, and solvent to clean all the oil drillings.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Steam clean the crankshaft and dry it with compressed air.

NOTE: Make sure to blow out the threaded holes on each end of the crankshaft and the oil drillings.

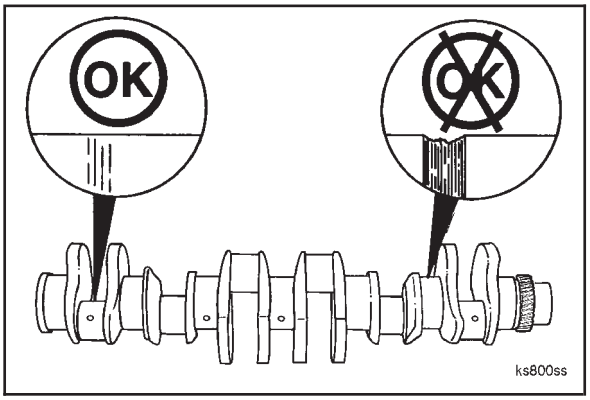


Inspection

Visually inspect the machined surfaces for scratches or nicks.

Use a fine crocus cloth to remove the nicks and scratches.

NOTE: If scratches or nicks can be felt with a fingernail after the crankshaft has been polished with a crocus cloth, the crankshaft **must** be replaced or reconditioned.

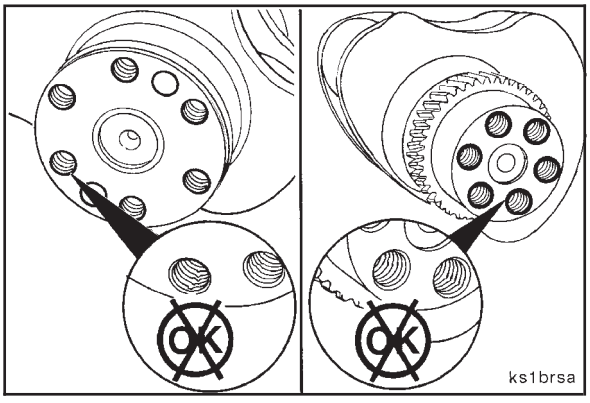


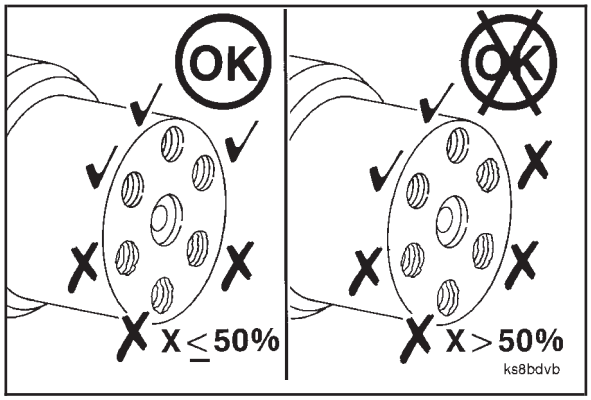
Visually inspect the threaded capscrew holes for damage.

Use one of the following methods to repair any threaded holes:

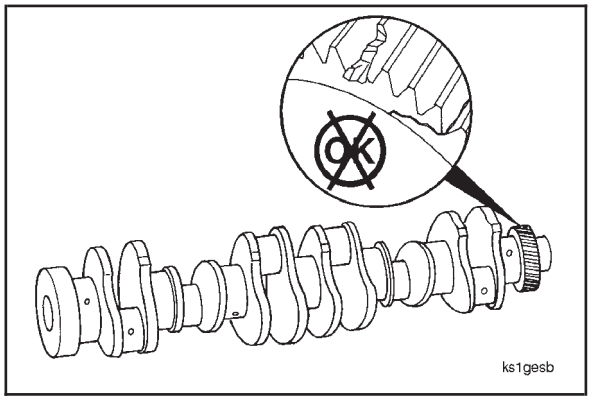
1. Use a tap to clean the burrs from the threads.
2. Use a thread repair insert.

If necessary, refer to the Alternative Repair Manual, Bulletin No. 3379035, for repair instructions.

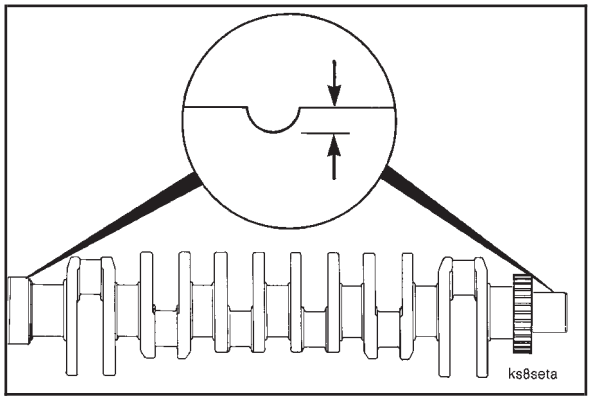




NOTE: A maximum of 50 percent of the threaded holes per crankshaft end can be repaired.

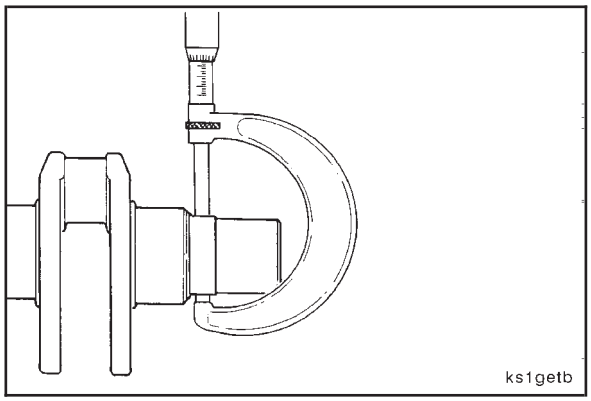


Visually inspect the crankshaft gear for cracks and broken or chipped teeth.



Where the front and the rear crankshaft seals contact the crankshaft, the maximum allowable wear is 0.13 mm [0.005 in].

Crankshaft Oil Seal Wear Groove		
mm		**in**
0.13	MAX	0.005

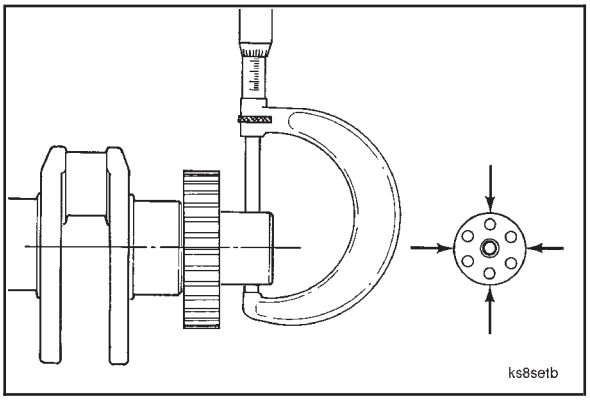


Measure the crankshaft gear fit area outside diameter (if the gear has been removed).

Crankshaft Gear Fit Area O.D.		
mm		**in**
95.501	MIN	3.7599
95.522	MAX	3.7607

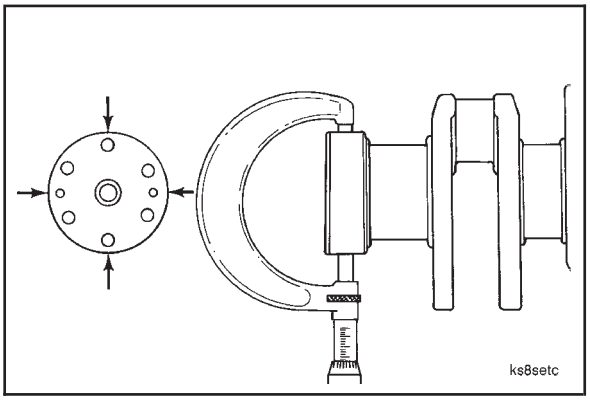
Measure the front oil seal area outside diameter.

Crankshaft Front Oil Seal Area O.D.		
mm		**in**
92.07	MIN	3.625
92.10	MAX	3.626



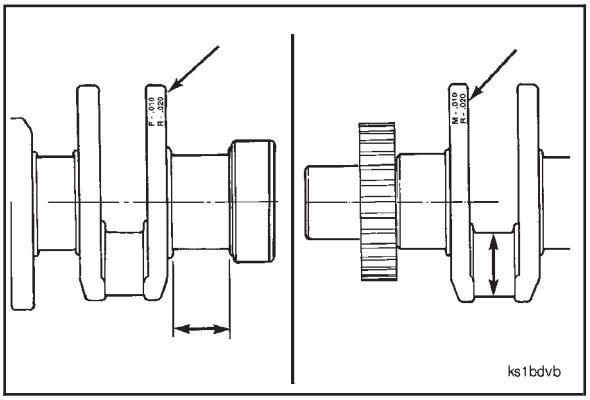
Measure the rear oil seal area outside diameter.

Crankshaft Rear Oil Seal Area O.D.		
mm		**in**
152.336	MIN	5.9975
152.40	MAX	6.000



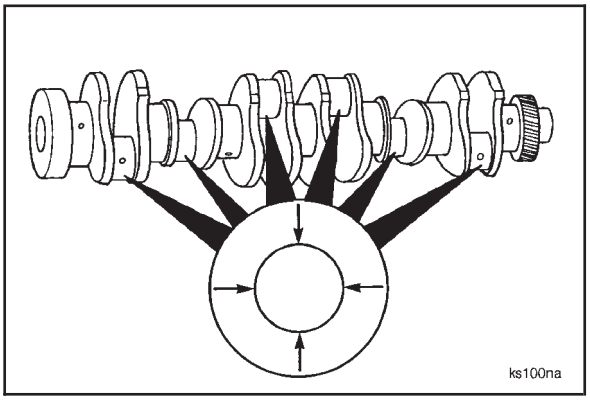
Crankshafts which are ground oversize in the thrust face width are normally marked on the rear counterweight.

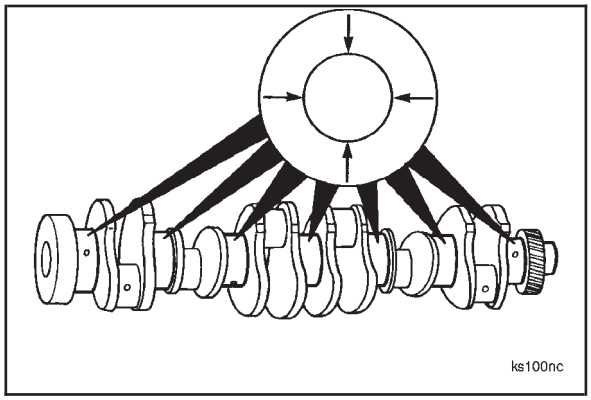
Crankshafts which are ground undersize in the connecting rod or the main bearing journals are normally marked on the front counterweight.



Measure the connecting rod journals outside diameters.

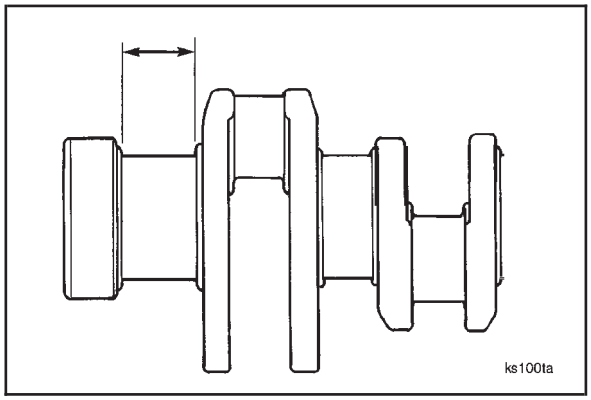
Crankshaft Connecting Rod Journal O.D.		
mm		**in**
88.824	MIN	3.4970
88.887	MAX	3.4995





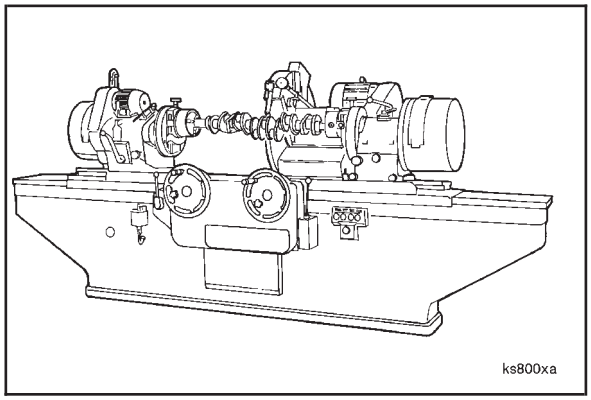
Measure the main bearing journals outside diameter.

Crankshaft Main Bearing Journal O.D.		
mm		**in**
114.236	MIN	4.4975
114.300	MAX	4.5000



Measure the thrust face width.

Crankshaft Thrust Face Width		
mm		**in**
76.23	MIN	3.001
76.35	MAX	3.006

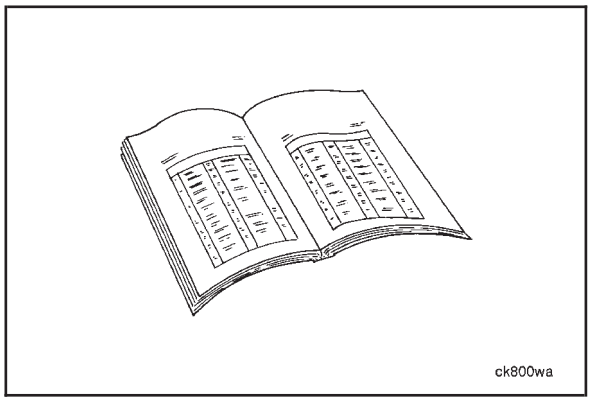


The crankshaft can be ground undersize if the bearing journals or the thrust distance is **not** within specifications.

Always grind all the journals when one is **not** within specifications.

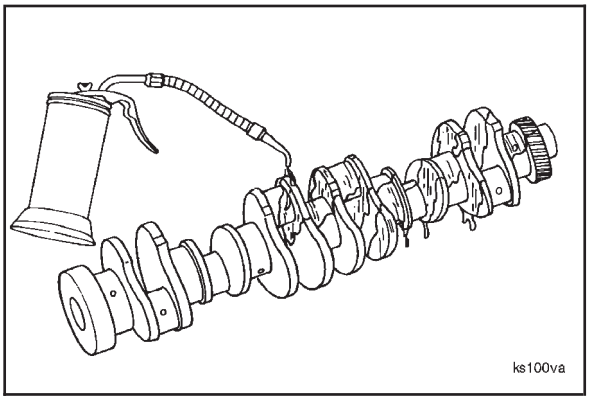
Oversize rod bearings, main bearings, and thrust bearings are available.

Refer to the Alternative Repair Manual, Bulletin No. 3379035, for grinding specifications and instructions.



Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the crankshaft and gear.

Use clean 15W-40 oil to lubricate the entire crankshaft to prevent rust.



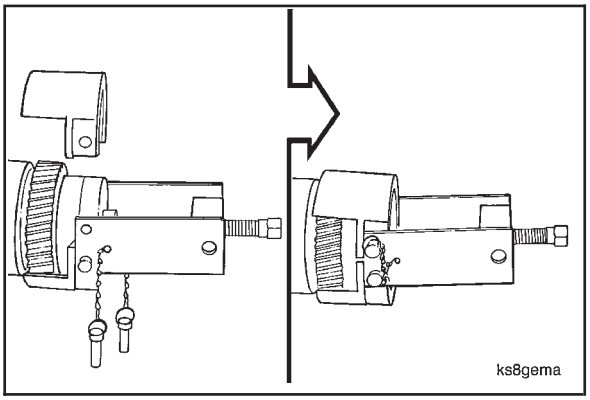
Crankshaft Gear - Replacement (01-15)

Removal

Only remove the gear when the crankshaft or the gear is damaged.

Use a puller jaw, Part No. 3375839, and gear puller assembly, Part No. 3375834.

NOTE: The crankshaft gear puller kit, Part No. 3375840, contains the gear puller jaw and the bridge assemblies required for all Cummins engine models.



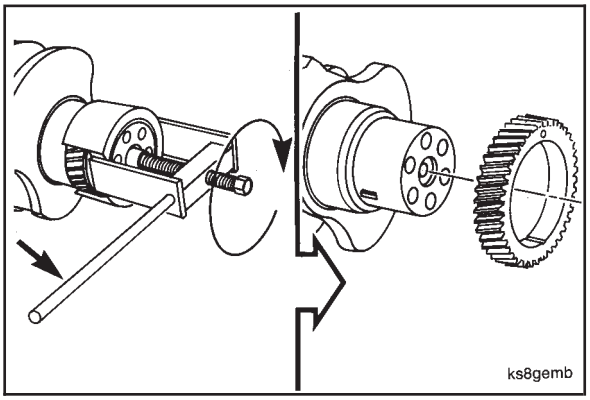
Install the puller jaw and the bridge assembly. Use engine oil to lubricate the puller jackscrew.

Caution: Do not exceed 475 N•m [350 ft-lb] of torque when turning the jackscrew on the puller jaw.

Hold the pry bar steady. Turn the jackscrew. Remove the gear.

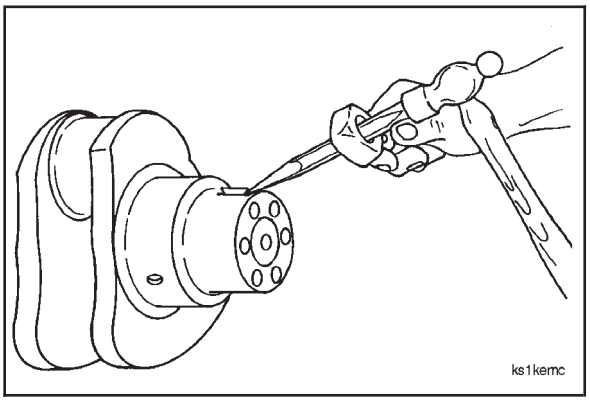
Caution: Do not use a cutting torch. High temperature will damage the gear.

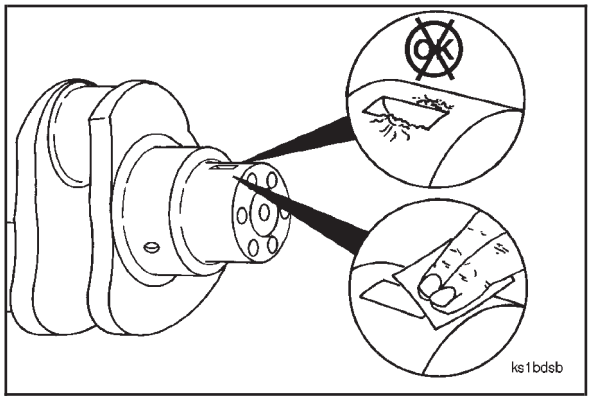
Heat can be applied with caution to help remove the gear.



Use a flat chisel and a hammer to remove the key.

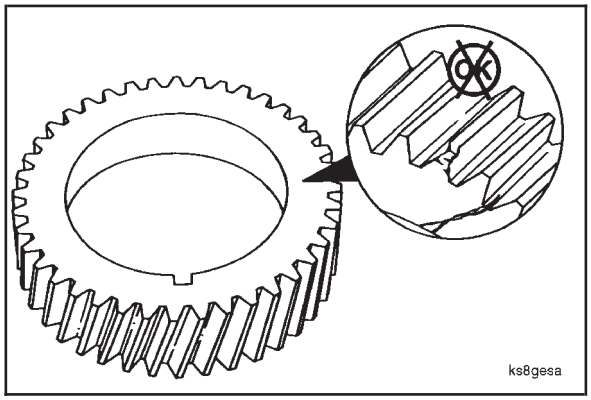
Use caution when removing the key to prevent crank damage.





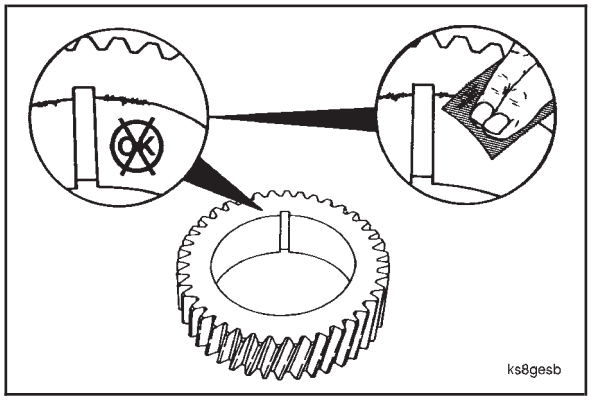
Visually inspect the crankshaft gear fit area for burrs or damage.

Use a fine crocus cloth to remove the burrs.



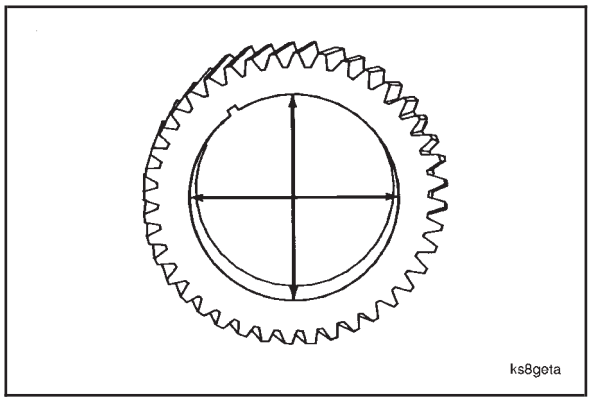
Inspection

Visually inspect the crankshaft gear for cracks and broken or chipped teeth.



Visually inspect the gear and the keyway for nicks or burrs.

Use a fine crocus cloth to remove any nicks and burrs.

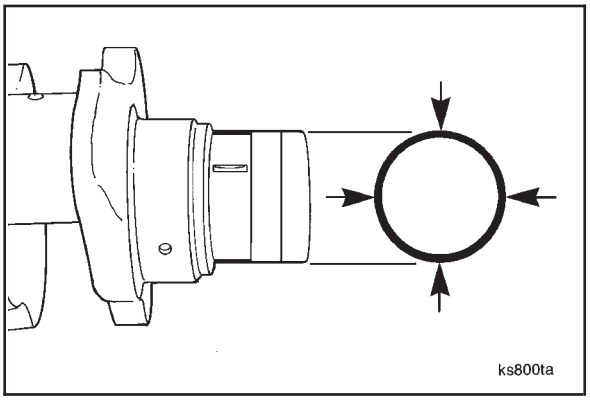


Measure the crankshaft gear bore.

Crankshaft Gear Bore I.D.		
mm		in
95.394	MIN	3.7557
95.415	MAX	3.7565

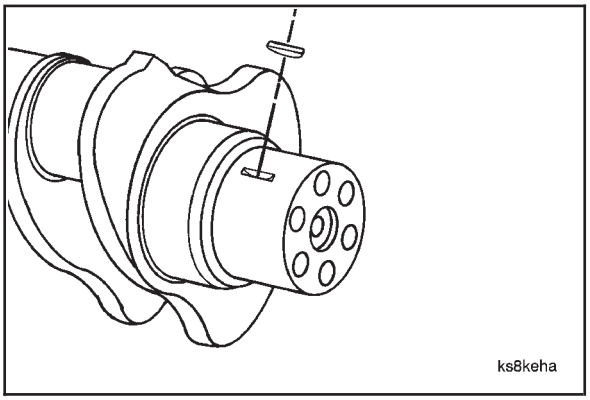
Measure the crankshaft gear fit area outside diameter.

Crankshaft Gear Fit Area O.D.		
mm		in
95.501	MIN	3.7599
95.522	MAX	3.7607

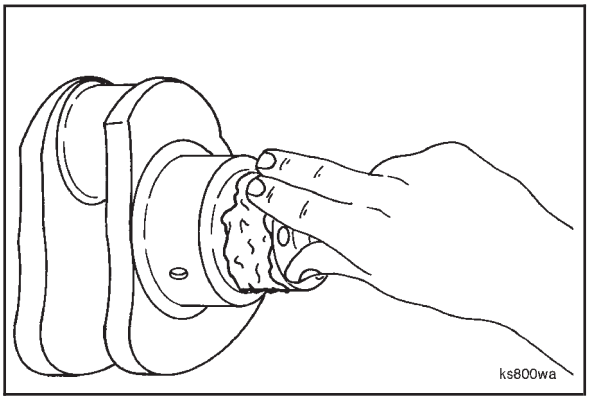


Installation

Use a plastic mallet to install a new key in the crankshaft keyway.

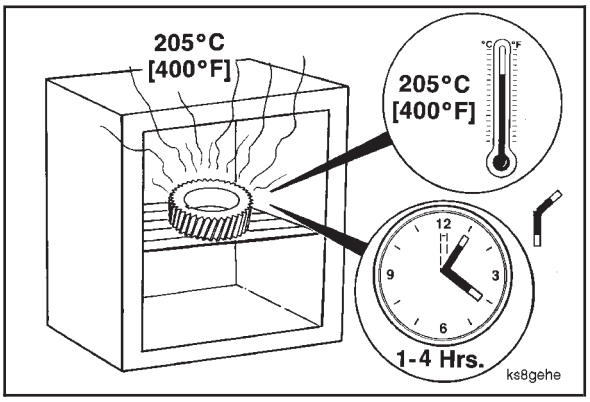


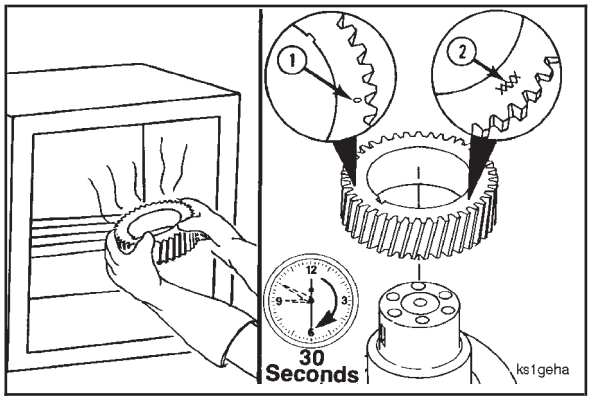
Use Lubriplate® No. 105 or its equivalent to lubricate the outside diameter of the crankshaft gear journal.



Caution: Do not exceed the specified time or temperature. The crankshaft gear and the teeth can be damaged.

Put the gear in an oven heated to 205°C [400°F] for a minimum of 1 hour but no more than 4 hours.





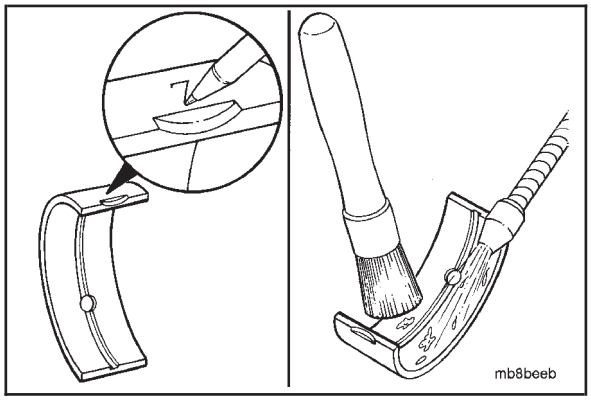
Caution: Always wear protective gloves when handling heated parts. Personal injury can result.

Caution: The timing mark (1) and the part number (2) on the gear must be facing away from the crankshaft after the gear is installed. Engine damage can result if the gear is installed backwards.

Remove the gear from the oven.

Align the keyway of the gear with the key in the crankshaft, and install the gear within 30 seconds.

Caution: Do not use water or oil to reduce the cooling time. The gear can crack. Allow the air to cool the gear.



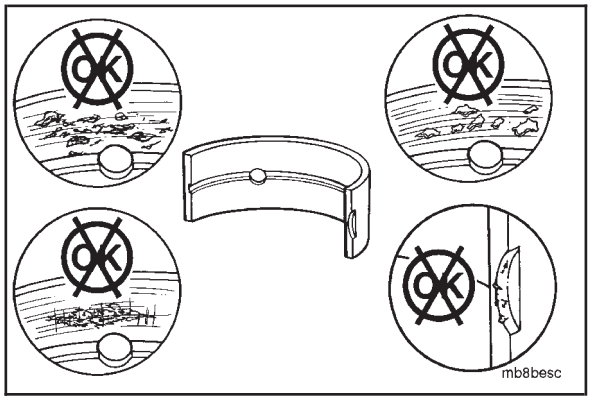
Crankshaft Bearings - Cleaning and Inspection (01-16)

NOTE: The bearings **must** be marked for location as they are removed for future identification. Each bearing **must** be installed in its original location if the bearing is used again.

Main Bearings - Cleaning

Caution: Do not use a scraper or a wire brush. The bearings can be damaged.

Use solvent and a soft bristle brush. Dry with compressed air.



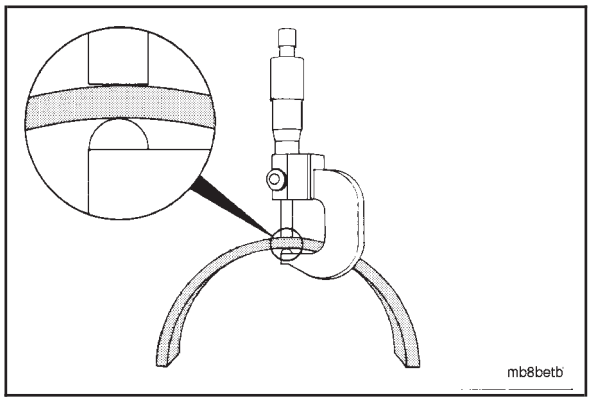
Main Bearings - Inspection

Visually inspect the bearings for damage.

Replace any bearings with the following damage:

- Pitting
- Flaking
- Corrosion
- Lock notch damage
- Scratches (deep enough to be felt with a fingernail)

Refer to the Parts Reuse Guidelines, Bulletin No. 3810303, for additional information.



Use an outside diameter ball tipped micrometer to measure the main bearing shell thickness at the wear location.

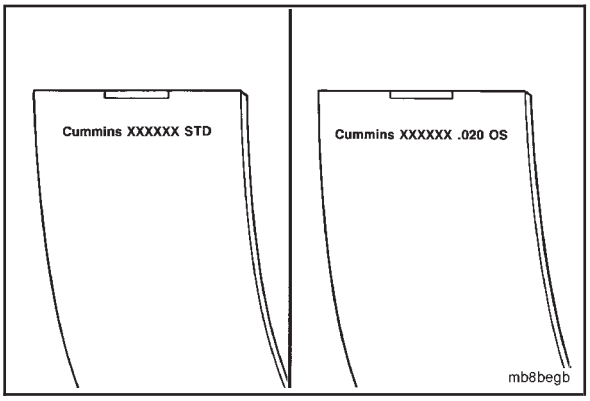
Main Bearing Shell Thickness (Standard)		
mm		in
3.086	MIN	0.1215
3.142	MAX	0.1237

Discard a main bearing shell if its thickness is below the minimum specification.

NOTE: For more detailed information of bearing damage, refer to Analysis and Prevention of Bearing Failures, Bulletin No. 3810387.

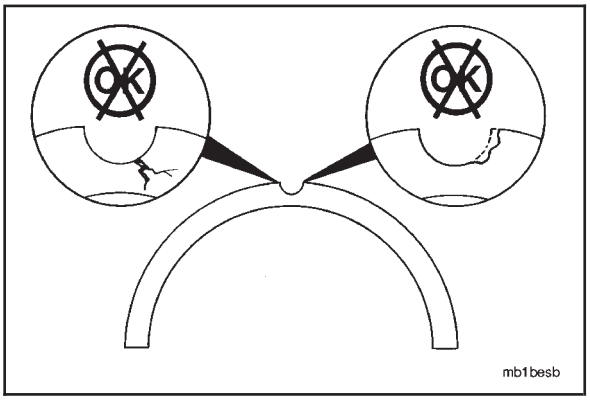
NOTE: Oversize bearing shells are available for crankshafts which are 0.25 mm [0.010-inch], 0.51 mm [0.020-inch], 0.76 mm [0.030-inch], or 1.02 mm [0.040-inch] undersize.

Bearing shells are identified by steel stamped characters on the back of the bearings to indicate either standard or the amount of oversize.



Thrust Bearings - Inspection

Visually inspect the thrust bearings for cracks or damage at the locating notch.

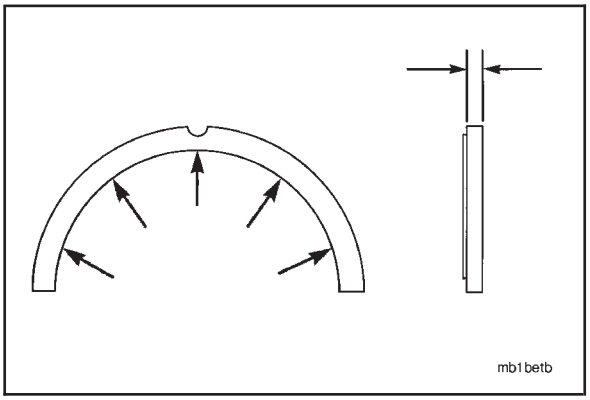


Measure the thrust bearing thickness. Measure the bearings in areas that show visible wear.

Thrust Bearing Thickness		
mm		in
6.185	MIN	0.2435
6.312	MAX	0.2485

NOTE: Thrust bearings are available in 0.25 mm [0.010-inch] and 0.51 mm [0.020-inch] oversize thicknesses.

In an assembled engine, the crankshaft end clearance **must** be 0.10 mm to 0.58 mm [0.004 inch to 0.023-inch]. Refer to Engine Assembly in Procedure 00-02.

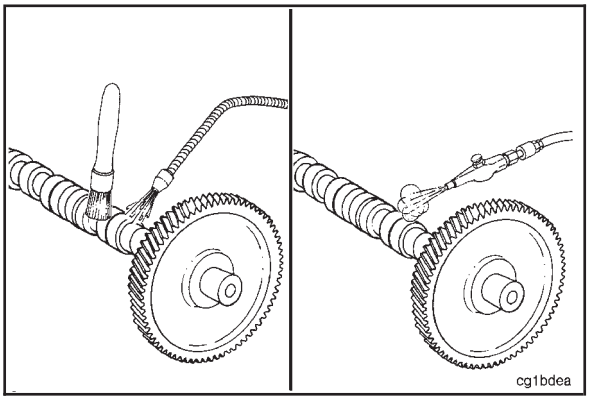


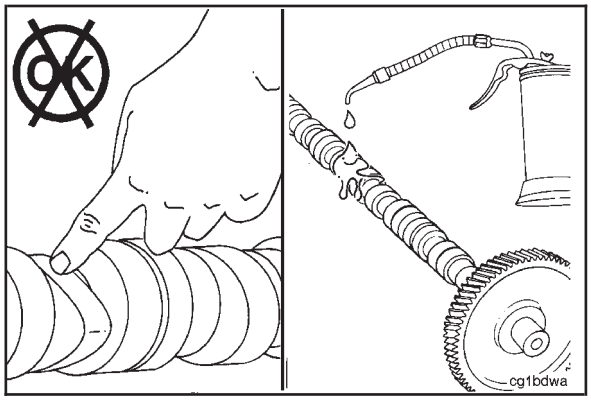
Camshaft - Cleaning and Inspection (01-17)

Cleaning

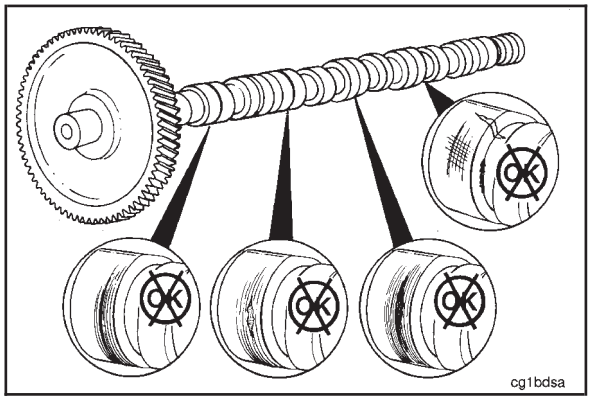
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Clean the camshaft with solvent or steam and dry it with compressed air.





NOTE: After the camshaft has been steam cleaned, do **not** touch the machined surfaces with bare hands. This will cause rust to form. Lubricate the camshaft with clean 15W-40 oil before handling.

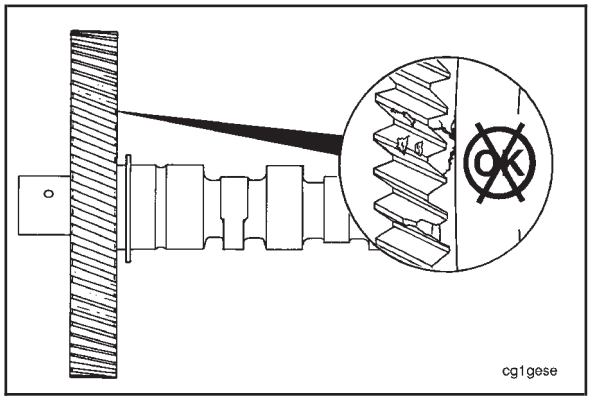


Inspection

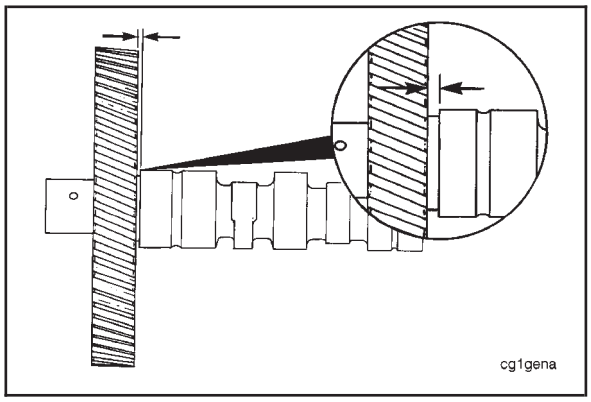
Visually inspect the valve and injector lobes for damage.

NOTE: Cummins Engine Company, Inc. does **not** recommend repairing camshafts by grinding the valve or injector lobes.

If the camshaft is damaged, it **must** be replaced.



Visually inspect the camshaft gear for cracks, chipped, or broken teeth.



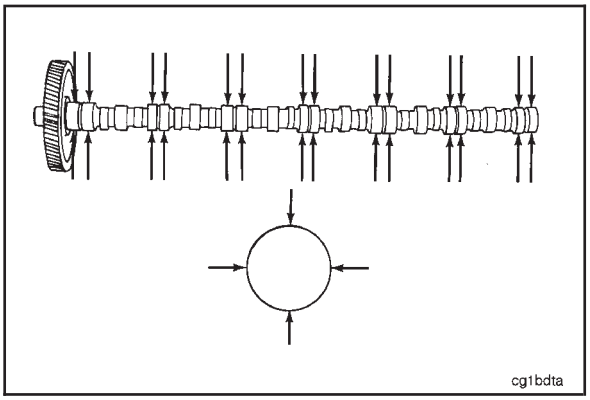
Use a feeler gauge to measure the clearance between the gear and the shoulder on the camshaft.

NOTE: The clearance **must not** exceed 0.13 mm [0.005-inch].

Measure the seven camshaft bushing journals.

Camshaft Bushing Journal O.D.		
mm		in
63.37	MIN	2.495
63.42	MAX	2.497

Replace the camshaft if the journal dimensions do **not** meet specifications.

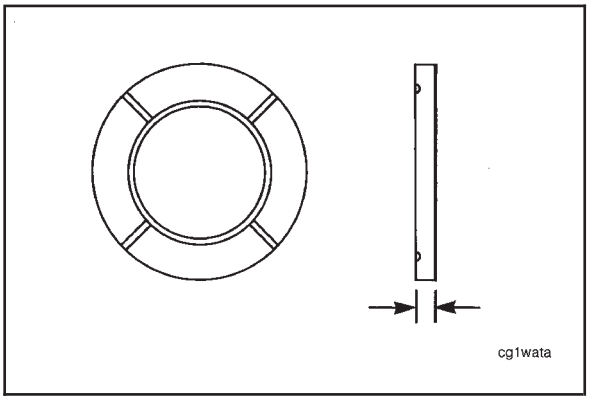


Measure the camshaft thrust washer.

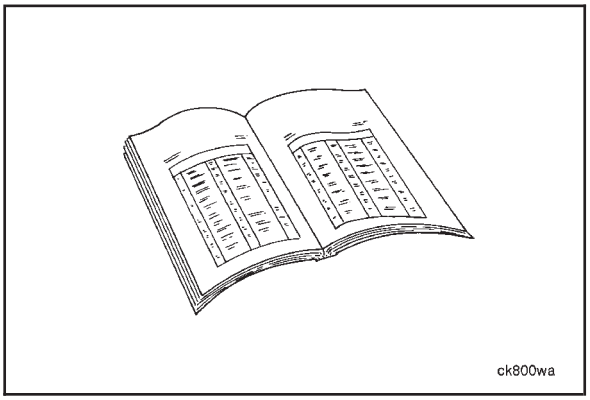
Camshaft Thrust Washer Thickness		
mm		in
2.29	MIN	0.090
2.49	MAX	0.098

Replace the thrust washer if it does **not** meet specifications.

In an assembled engine, the camshaft end clearance **must** be 0.20 mm to 0.33 mm [0.008-inch to 0.013-inch]. Refer to Engine Assembly in Procedure 00-02.



Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the camshaft and gear.

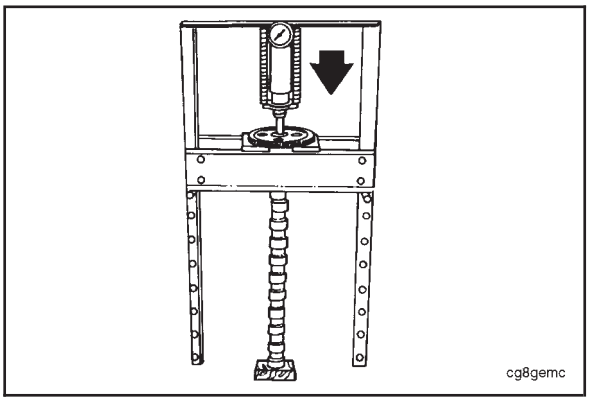


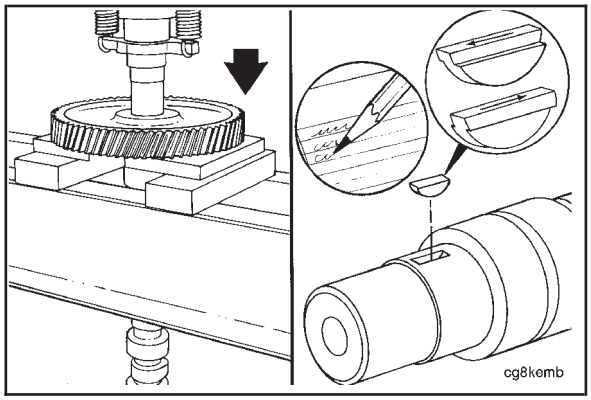
Camshaft Gear - Replacement (01-18)

Removal

Caution: Put a wooden block under the camshaft to avoid damage as the camshaft drops free from the cam gear.

Install the camshaft and gear assembly in a hydraulic press. Put v-blocks under the gear. Make sure the v-blocks support the hub area of the gear.





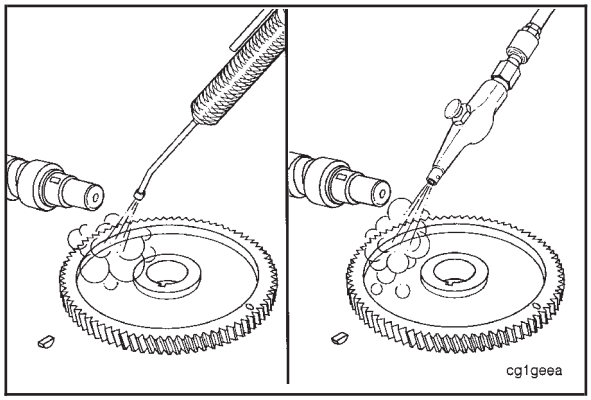
Caution: Do not use a heating torch to remove the gear. If you use a heating torch, a new gear must be installed.

Push the shaft from the gear.

NOTE: If the camshaft key is marked with an arrow, record the direction the arrow on the key is pointed (toward or away from the camshaft) for future reference.

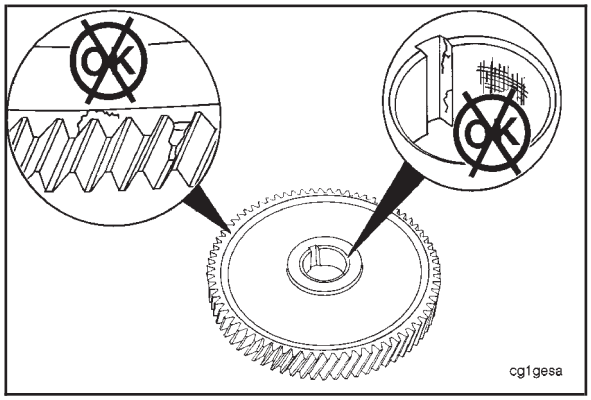
Use a flat chisel and a hammer to remove the camshaft key.

Record the size (amount of offset) and the part number of the key.



Cleaning

Use solvent to clean the parts. Dry them with compressed air.



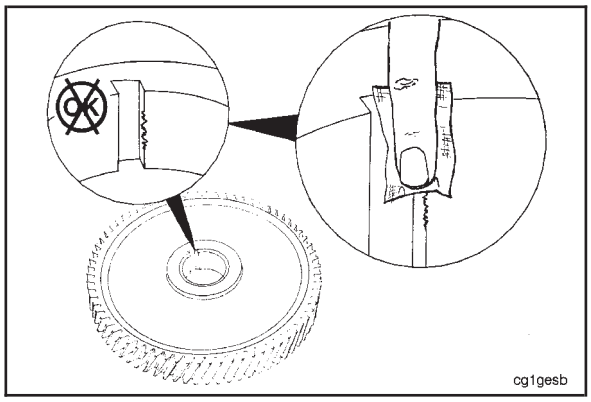
Inspection

Caution: If the inside diameter of the gear is damaged or has fretting in excess of a 3.175 mm [0.125-inch] wide band, do not use the gear. Fretting or damage can result in gear movement on the camshaft nose which can cause camshaft nose failure.

Visually inspect the camshaft gear for cracks, chipped, or broken teeth.

Inspect the bore of the gear for fretting or burrs.

NOTE: If the fretting, burrs, or raised material can **not** be removed with a fine crocus cloth, replace the gear.

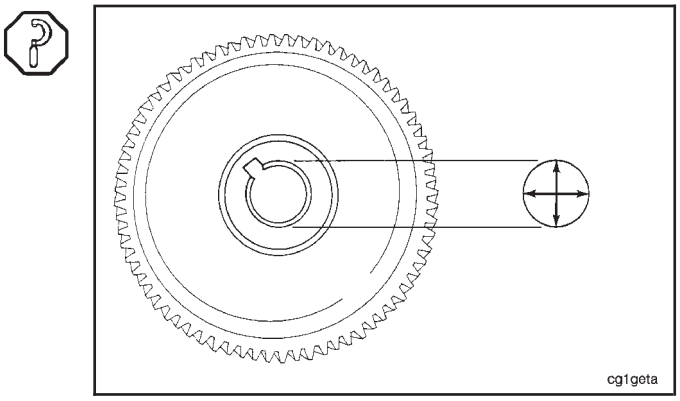


Inspect the gear keyway for burrs.

Remove burrs with a fine crocus cloth.

NOTE: If the keyway is damaged or the burrs can **not** be removed with a fine crocus cloth, the gear **must** be replaced.

Measure the gear bore.



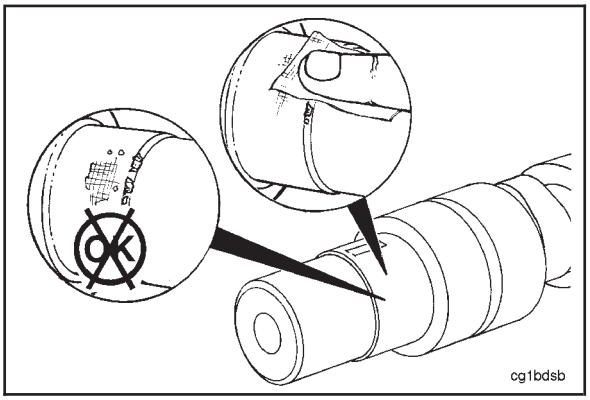
Camshaft Gear Bore I.D.			
	mm		in
Flangeless	45.662	MIN	1.7977
Camshaft	45.682	MAX	1.7985

Replace the camshaft gear if it does **not** meet specifications.

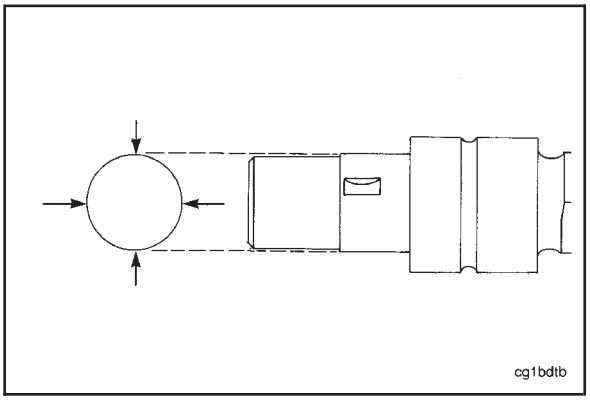
Caution: If the area of fretting is longer than a 3.175 mm [0.125-inch] wide longitudinal band, do not use the camshaft. Fretting or damage can result in gear movement on the camshaft nose and can cause camshaft nose failure.

Visually inspect the camshaft nose in the gear fit area for fretting or burrs.

NOTE: If fretting or burrs can **not** be removed with a fine crocus cloth, replace the camshaft.



Measure the camshaft nose in the gear press fit area.



Camshaft Gear Press Fit O.D.			
	mm		in
Flangeless	45.733	MIN	1.8005
Camshaft	45.745	MAX	1.8010

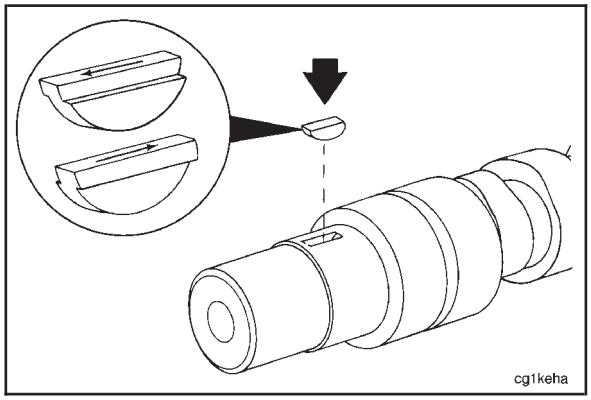
Replace the camshaft if it does **not** meet specification.

Camshaft Keys			
3/4 Inch Key Part No.	Offset mm [Inch]	Timing Change	Change in Push Rod Travel At 19°BTDC mm [Inch]
3021601	None	None	None
3021595	0.15 [0.0060]	Retard	0.07 [0.0030]
3021593	0.19 [0.0075]	Retard	0.09 [0.0037]
3021592	0.29 [0.0115]	Retard	0.14 [0.0057]
3021594	0.47 [0.0185]	Retard	0.23 [0.0092]
3021596	0.65 [0.0255]	Retard	0.32 [0.0127]
3021598	0.79 [0.0310]	Retard	0.39 [0.0155]
3021597	0.99 [0.0390]	Retard	0.49 [0.0195]
3021600	1.30 [0.0510]	Retard	0.65 [0.0255]
3021599	0.29 [0.0115]	Advance	0.14 [0.0057]
3024697*	0.65 [0.0255]	Advance	0.32 [0.0127]

* For CELECT™ Engines

Installation

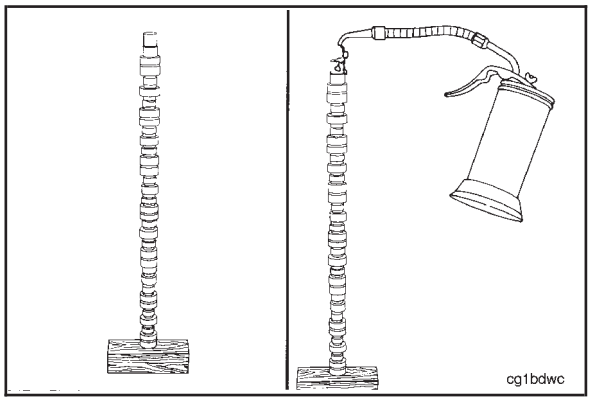
NOTE: The accompanying chart lists different camshaft key part numbers, the degree of offset, and the approximate injector timing change from nominal.



Use a plastic mallet to install the camshaft gear key.

NOTE: If the same camshaft and gear are used again, use the same part number key as the one that was removed. Make sure the arrow on the key is pointing in the same direction as when it was removed.

Refer to the engine dataplate and the Control Parts List Manual, Bulletin No. 3379133, for the correct key part number and key orientation.



Put the camshaft in a vertical position with the gear fit area (nose) pointing up.

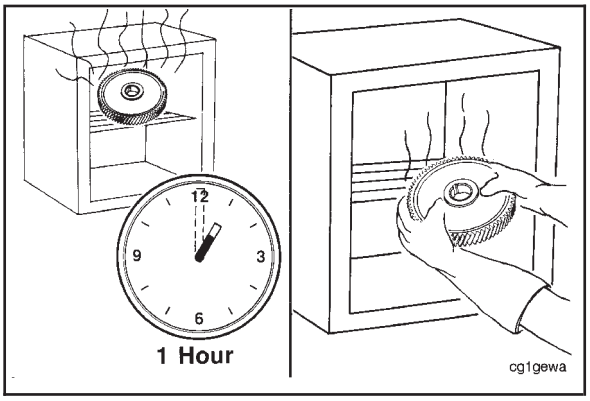
Apply Lubriplate® 105 or its equivalent to the camshaft gear fit area before installing the gear.

Caution: Wear protective gloves when handling parts that have been heated to prevent personal injury.

Heat the gear in an oven at 260°C [500°F] for a minimum of 1 hour.

Remove the gear from the oven.

NOTE: Install the gear on the camshaft within 30 seconds after it is removed from the oven.

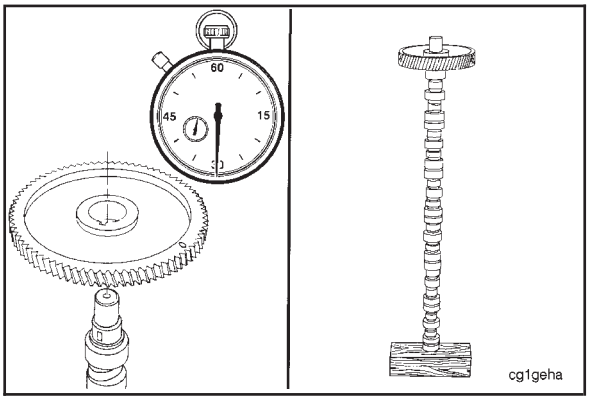


Caution: The timing marks and the part number on the gear must be facing away from the camshaft when the gear is installed to prevent engine damage.

Align the gear keyway with the key in the camshaft, and install the gear.

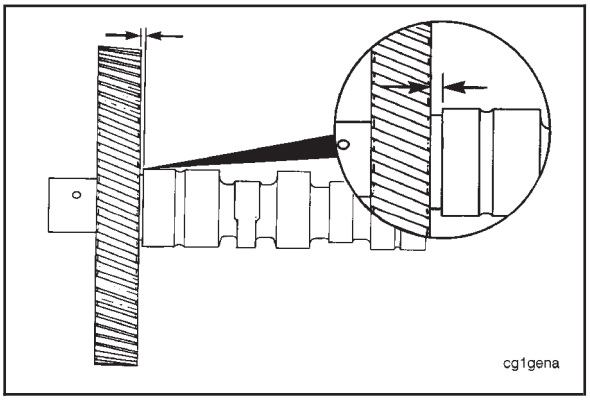
NOTE: Keep the camshaft in a vertical position with the gear up until the gear has cooled.

Caution: Do not use water or oil to reduce the cooling time. The gear can crack. Allow the air to cool the gear.



If the gear does **not** seat against the locating shoulder on the camshaft, remove the gear and install it again.

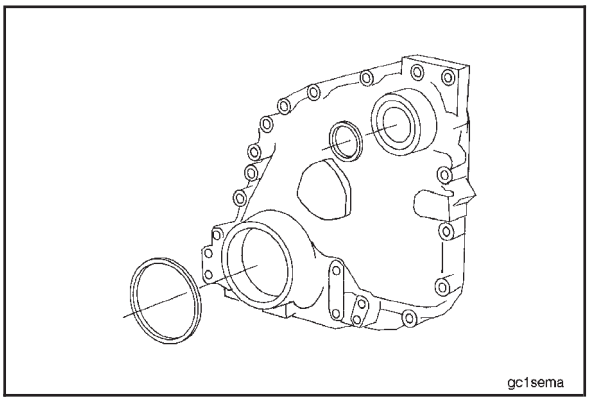
Use a feeler gauge to check the clearance between the camshaft gear and the shoulder. The clearance **must not** exceed 0.13 mm [0.005-inch].

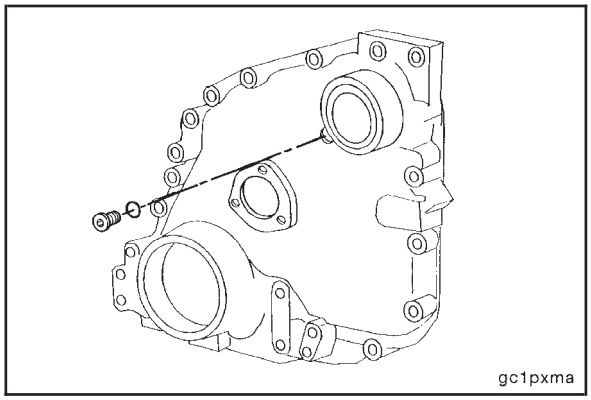


Gear Cover - Cleaning and Inspection (01-19)

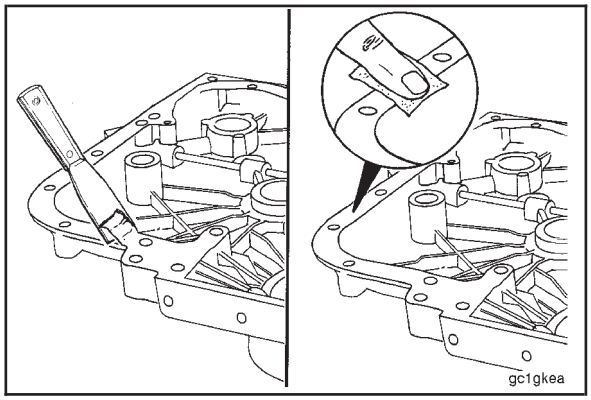
Cleaning

Use a mallet and a mandrel or a drift to remove the front crankshaft seal and the accessory drive seal.





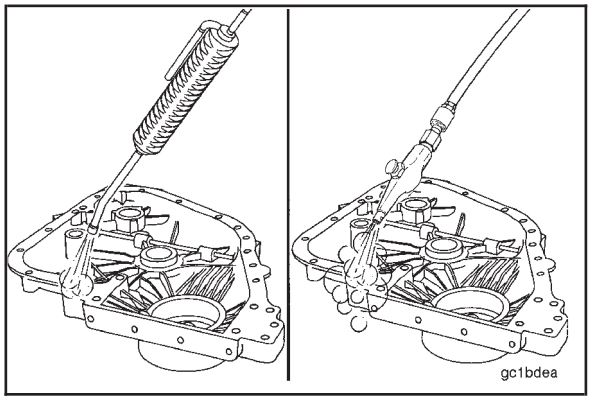
Remove the straight thread o-ring plug.



Caution: The aluminum gasket surface can be easily damaged if caution is not used when removing gasket material. An oil leak will result.

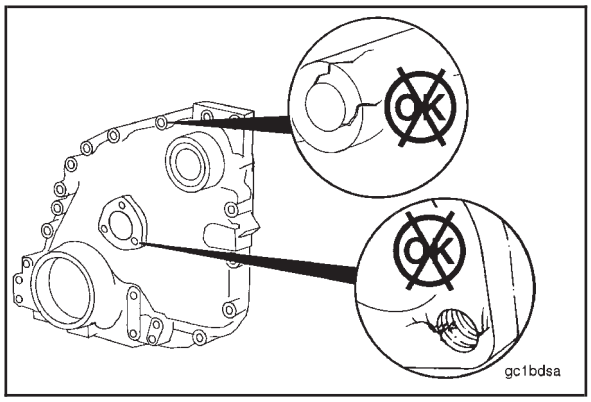
Use a gasket scraper to remove all gasket material.

Use a medium crocus cloth to remove burrs from the capscrew holes and the gasket surface.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot Steam can cause serious personal injury.

Steam clean the gear cover, and dry it with compressed air.



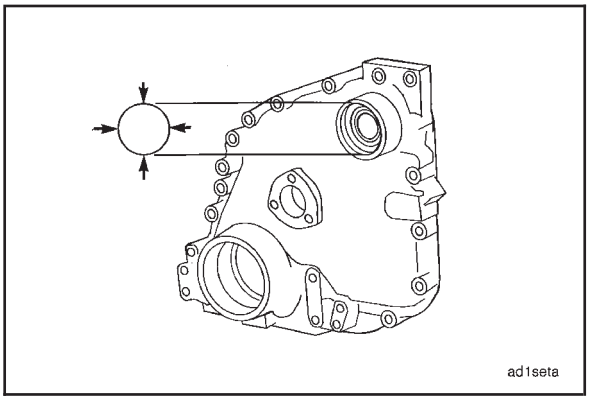
Inspection

Visually inspect the gear cover for cracks or damage.

Measure the accessory drive seal bore.

Accessory Drive Seal Bore I.D.		
mm		in
80.962	MIN	3.1875
81.038	MAX	3.1905

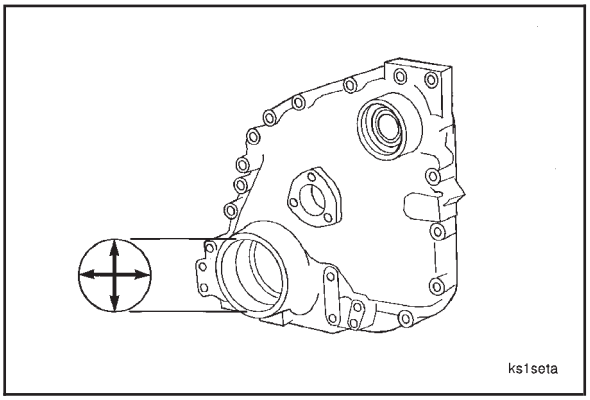
NOTE: Replace the gear cover if the accessory drive seal bore is **not** within specifications.



Measure the crankshaft seal bore.

Crankshaft Seal Bore I.D.		
mm		in
120.611	MIN	4.7485
120.688	MAX	4.7515

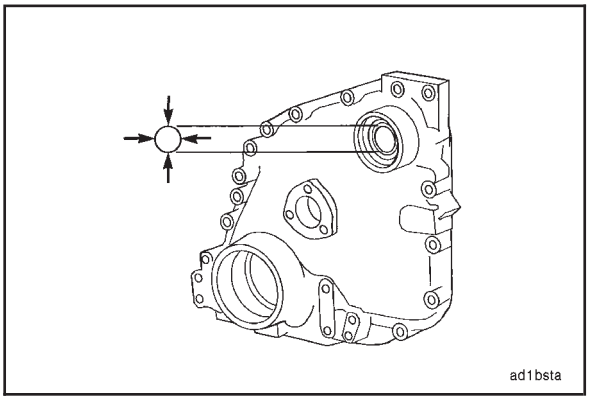
NOTE: Replace the gear cover if the crankshaft seal bore is **not** within specifications.



Measure the accessory drive bushing inside diameter.

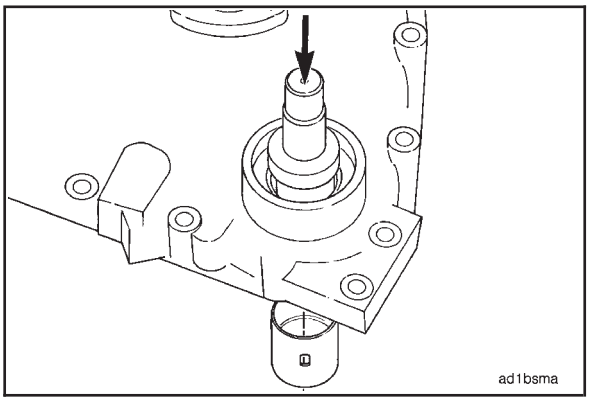
Accessory Drive Bushing I.D.		
mm		in
39.75	MIN	1.565
39.90	MAX	1.571

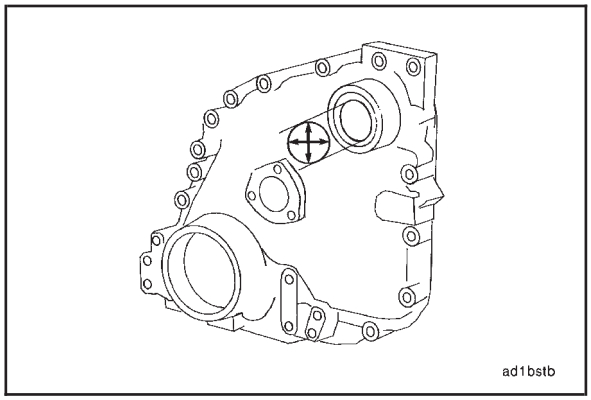
Replace the bushing if it is **not** within specifications.



Accessory Drive Bushing - Replacement

Use gear cover bushing mandrel, Part No. ST-598, to remove the accessory drive bushing. Support the opposite side of the cover.

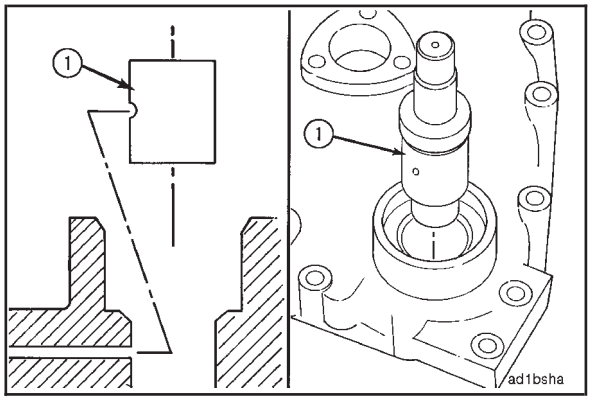




Measure the gear cover accessory drive bushing bore.

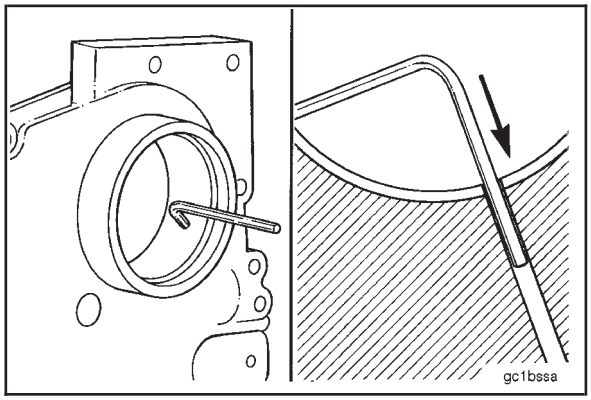
Accessory Drive Bushing Bore I.D.		
mm		in
43.07	MIN	1.696
43.10	MAX	1.697

NOTE: Replace the gear cover if the bore is **not** within specifications or if the bore is cracked or damaged.



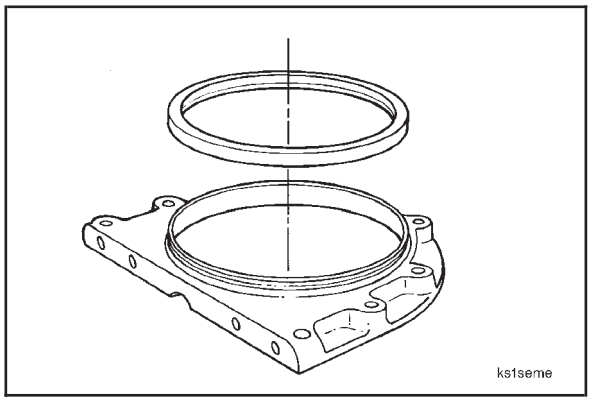
Use gear cover bushing mandrel, Part No. ST-598, to install a new accessory drive bushing.

Align the oil hole (1) in the bushing with the oil drilling in the front cover. Use a mallet or an arbor press to install the bushing. Support the opposite side of the cover.



Use a 3.17 mm [0.125-inch] diameter rod to check the position and the location of the oil hole in the bushing and the gear cover.

The rod **must** pass through the oil hole in the bushing and into the oil supply drilling in the gear cover.

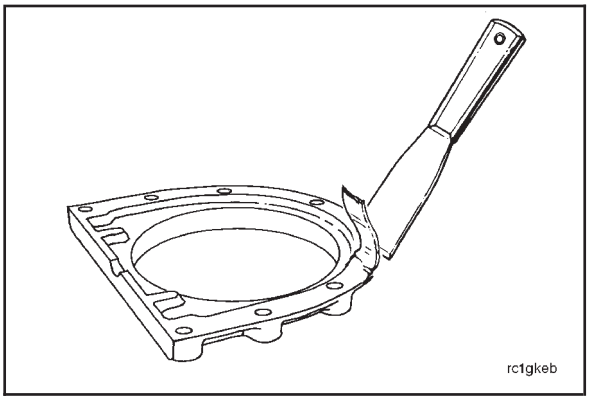


Rear Cover - Cleaning and Inspection (01-20)

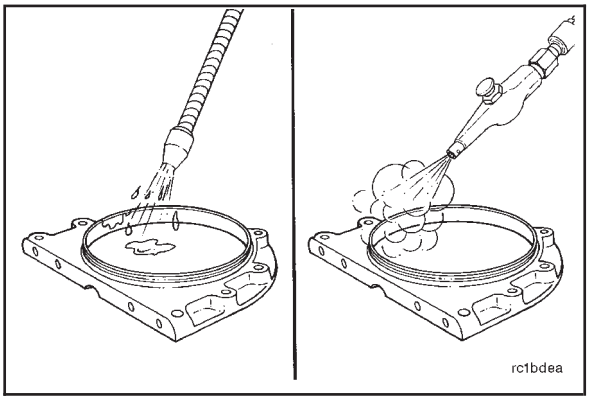
Use a mandrel or drift to remove the crankshaft oil seal.

Cleaning

Remove the gasket material from the rear cover gasket sealing surface.

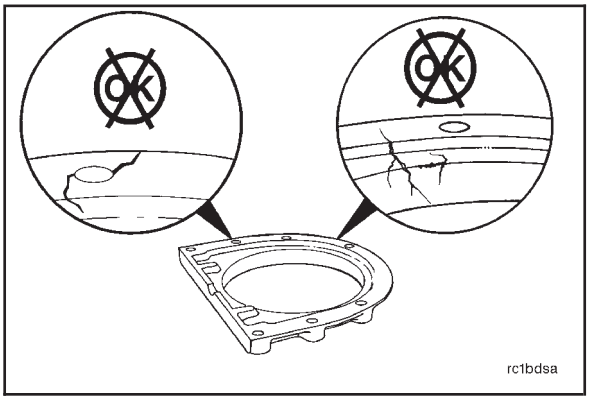


Use solvent to clean the rear cover. Dry with compressed air.



Inspection

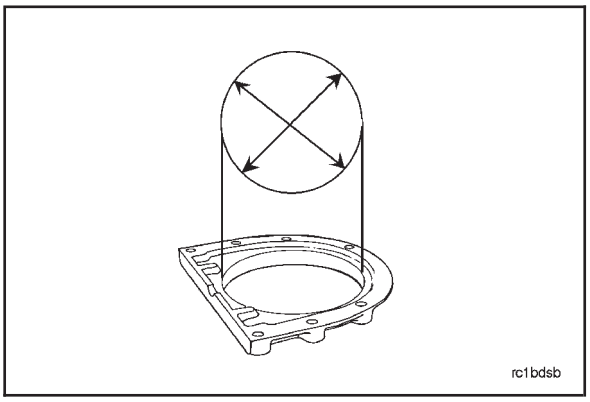
Inspect the rear cover for cracks or other damage.

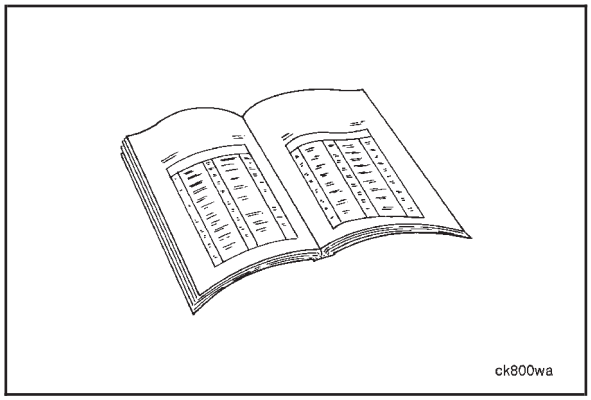


Measure the rear cover crankshaft seal bore.

Crankshaft Seal Bore I.D.		
mm		in
171.40	MIN	6.748
171.50	MAX	6.752

Replace the rear cover if the crankshaft seal bore is **not** within specifications.





Magnetic Crack Inspection (01-21)

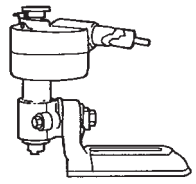
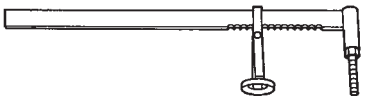
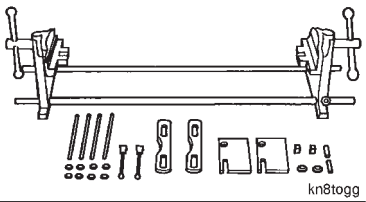
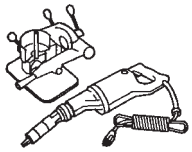
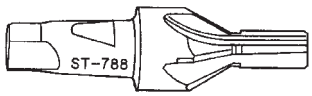
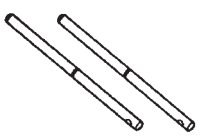
Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the crankshafts, camshafts, connecting rods, gears, and capscrews.

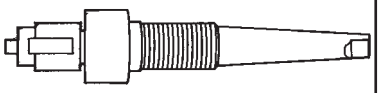
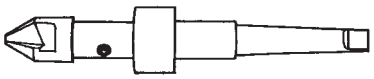
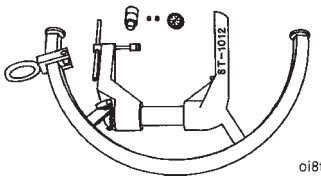
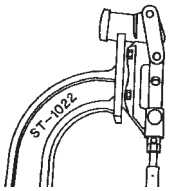
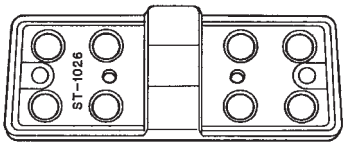
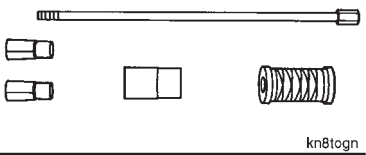
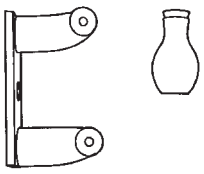
Section 2 - Cylinder Head - Group 02

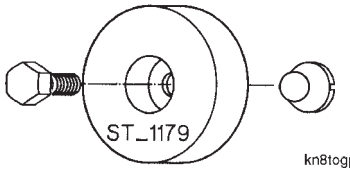
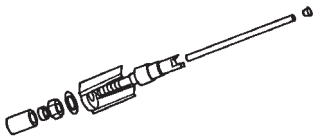
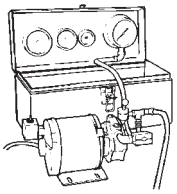
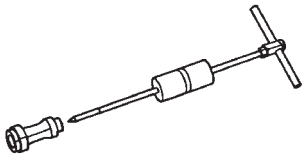
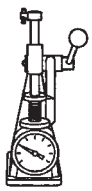
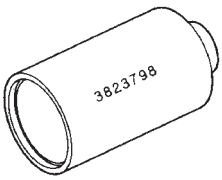
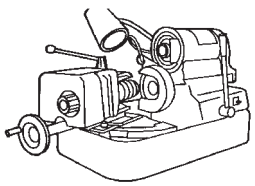
Section Contents

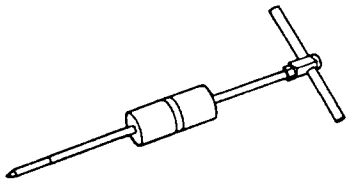
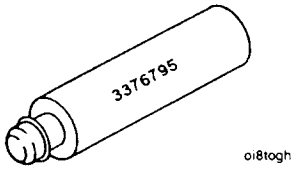
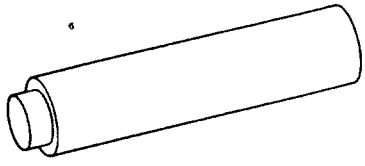
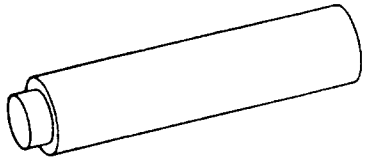
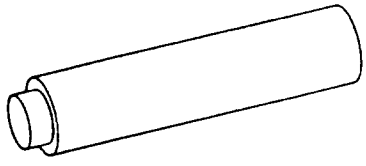
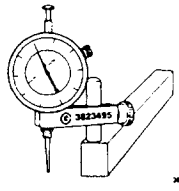
Cylinder Head - Service Tools

The following special tools are recommended to perform procedures in Group 02. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

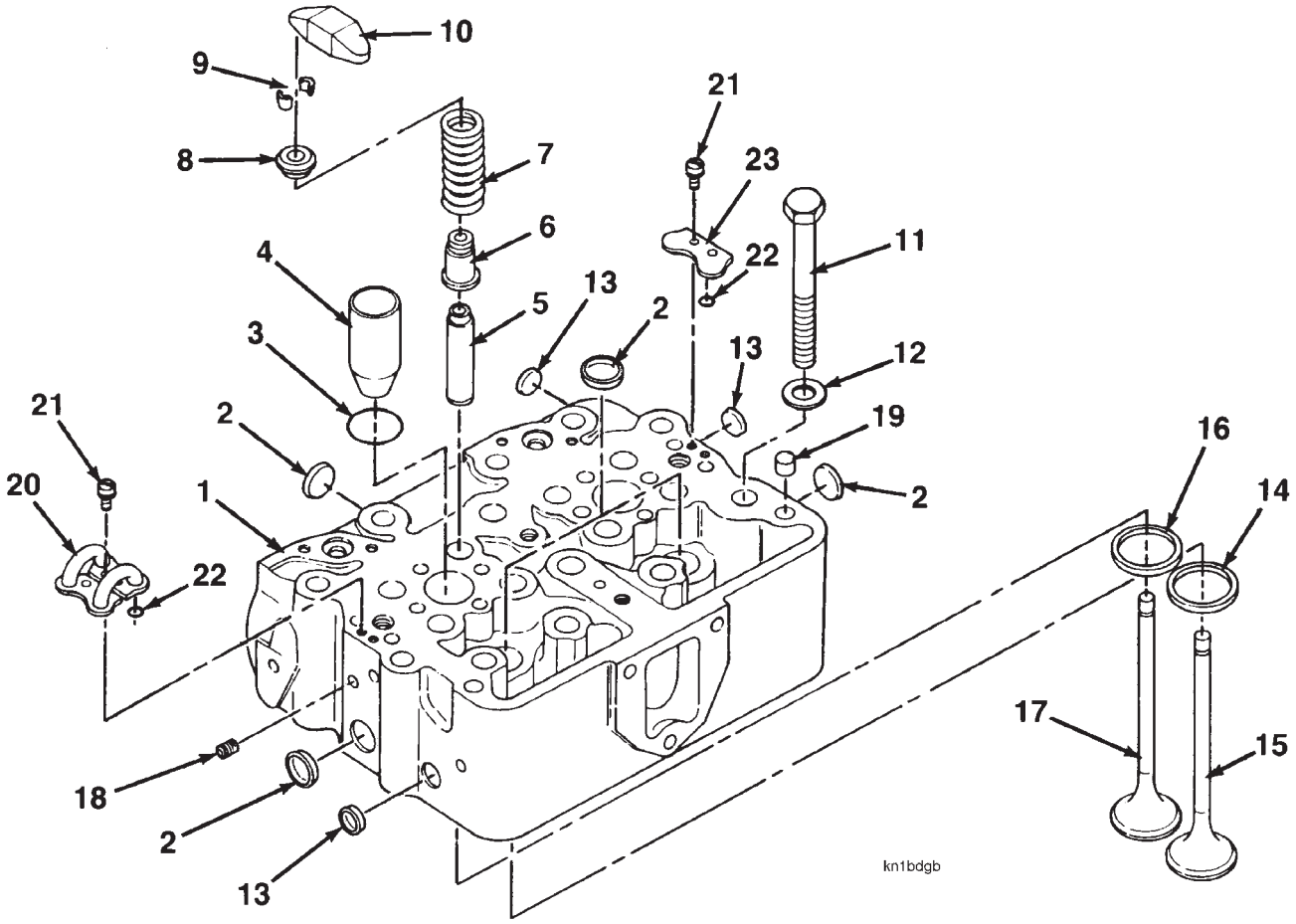
Tool No.	Tool Description	Tool Illustration
ST-257	**Valve Seat Insert Tool** Cut valve seat counterbores for oversize valve seat inserts.	 kn8toge
ST-448	**Valve Spring Compressor** Used to compress the valve spring while removing or installing the valve collets. **Note:** Single spring air-operated spring compressor, Part No. 3375960, (not shown) and multi-spring compressor, Part No. ST-1022, (not shown) used with Part No. ST-1026 (not shown) are also available.	 kn8togf
ST-583	**Head Holding Fixture** Hold and revolve the cylinder head during repair and assembly.	 kn8togg
ST-685	**Valve Seat Grinding Machine** Reface valve seats in the cylinder head.	 kn8togi
ST-788	**Bead Cutting Tool** Used to machine the beads in the lower injector sleeve seat area in the cylinder head.	 kn1togb
ST-804	**Valve Guide Arbor Set** Used with valve seat insert tool, Part No. ST-257, and valve seat grinding machine, Part No. ST-685	 kn8togj

Tool No.	Tool Description	Tool Illustration
ST-876	**Fuel Passage Cleaning Brush** Clean the internal fuel passages in the cylinder head.	 kn8togk
ST-880	**Injector Sleeve Expander** Roll and seal the upper portion of the injector sleeve in the cylinder head.	 kn8togl
ST-884	**Injector Seat Cutter** Used to machine the injector sleeve seat to the correct depth to allow the specified injector protrusion through the cylinder head.	 kn8togm
ST-1012	**Cylinder Head Water Test Fixture** Used with water tester adapter plate, Part No. ST-1013, to hydrostatic test for coolant leaks in the cylinder head. This fixture is designed for high volume usage. The test kit, Part No. 3377376, is available for low volume usage.	 oi8togd
ST-1022	**Valve Spring Compressor Stand** Use with compressor plate, Part No. ST-1026, to compress all valve springs on a cylinder head at the same time.	 oi1toga
ST-1026	**Valve Spring Compressor Plate** Use with valve spring compressor stand, Part No. ST-1022, to compress all valve springs on a cylinder head at the same time.	 oi1togb
ST-1134	**Dowel Pin Extractor** Pull the dowel pins and crosshead guides from the cylinder head.	 kn8togn
ST-1166	**Magnetic Crack Detector** Used to inspect cylinder heads and other ferrous castings that can **not** be magnafluxed for cracks. **Note:** Penetrant-type crack detection kit, Part No. 3375432, is also available. This kit can be used to detect cracks in both ferrous and non-ferrous materials.	 kn8togo

Tool No.	Tool Description	Tool Illustration
ST-1179	**Injector Sleeve Holding Tool** Hold the injector sleeve in place when rolling the upper portion of the sleeve and testing the cylinder head.	 kn8togp
ST-1227	**Injector Sleeve Driver** Drive the injector sleeve into the cylinder head.	 kn8togq
ST-1244	**Injector Sleeve Puller** Remove the injector sleeves from the cylinder head.	 kn8togv
ST-1257	**Valve Vacuum Tester** A vacuum test to determine if the valves are correctly seated in the cylinder head.	 kn8togr
ST-1279	**Valve Seat Extractor** Remove the valve seat inserts from the cylinder head.	 kn8togx
3375182	**Valve Spring Tester** Check the cylinder head valve spring tension.	 kn8togs
3823798	**Valve Head Checking Tool** This tool is used to visually check the valve head thickness after reconditioning for ‘‘accept’’ or ‘‘reject’’ purposes.	
3376256	**Valve Facing Machine** Face valves and valve stems.	 kn8togz

Tool No.	Tool Description	Tool Illustration
3376617	**Slide Hammer Assembly** Used with the valve seat extractor to remove the valve seat inserts from the cylinder head.	
3376795	**Cup Plug Driver Handle** Used with expansion plug drivers, Part Nos. 3376815, 3376816, and 3376817.	
3376815	**Expansion Plug Driver** Used to install the 3/4-inch expansion plugs in the cylinder head.	
3376816	**Expansion Plug Driver** Used to install the 1 inch expansion plugs in the cylinder head.	
3376817	**Expansion Plug Driver** Used to install the 1-1/4 inch expansion plugs in the cylinder head.	
3823495	**Depth Gauge** Use to measure the injector protrusion and valve recess in the cylinder head.	
3823909	**Valve Guide Driver** Install the valve guides to the correctly assembled height in the cylinder head.	

Cylinder Head - Exploded View



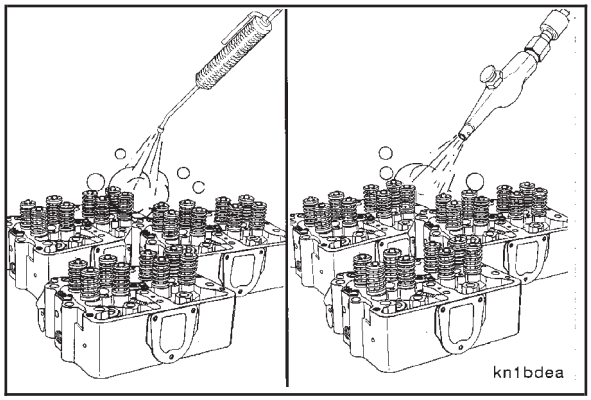
Reference No.	Description	Quantity
1	Head Cylinder	3
2	Plug, Expansion	24
3	Seal, O-ring	6
4	Sleeve, Injector	6
5	Guide, Valve Stem	24
6	Seal Stem	24
7	Spring, Valve	24
8	Retainer, Valve Spring	24
9	Collet, Valve Spring Retainer	48
10	Crosshead, Valve	12
11	Capscrew, Cylinder Head	36
12	Washer, Plain	36

Reference No.	Description	Quantity
13	Plug, Expansion	9
14	Insert, Intake Valve Seat	12
15	Valve, Intake	12
16	Insert, Exhaust Valve Seat	12
17	Valve, Exhaust	12
18	Plug, Pipe	10
19	Dowel, Ring	6
20	Connection, Fuel Crossover	2
21	Screw, Springtite	12
22	Seal, O-ring	12
23	Plate, Cover	1

Cylinder Head - General Information

The cylinder head group consists of the cylinder head, valves, valve guides, valve springs, stem seals, valve seat inserts, cylinder head capscrews, fuel crossover, collets, spring retainer, crossheads, and the injector sleeves. The exhaust valves are manufactured from a material that is capable of operating at a higher temperature than the intake valves. The exhaust valves can be installed in the intake valve location. Do **not** install the intake valves in the exhaust valve location. The valve seat inserts for the exhaust and the intake valves are also manufactured from different materials. The exhaust valve seat can be used for both intake and exhaust locations. Do **not** use the intake valve seat in the exhaust location.

Mark, label, or tag the cylinder head parts such as crossheads, valves, and valve springs with the cylinder number and location from which they were removed. This practice will prove to be a valuable aid in diagnosing any cylinder head or part failures and to make sure the reuseable parts are installed in their original locations.

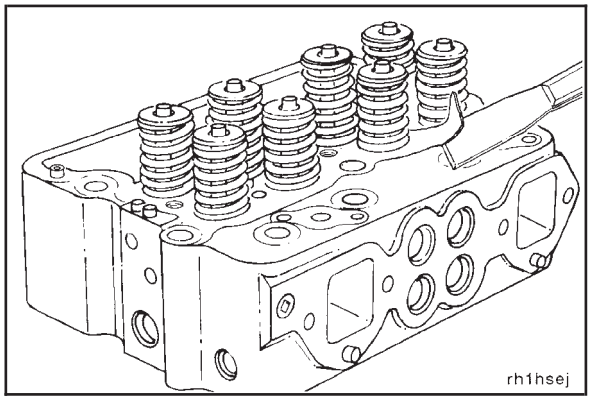


Cylinder Head - Cleaning and Inspection for Reuse (02-01)

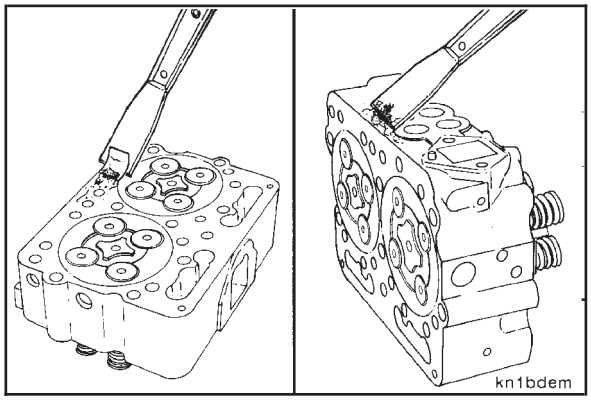
Cleaning

Steam clean the cylinder heads, and dry with compressed air.

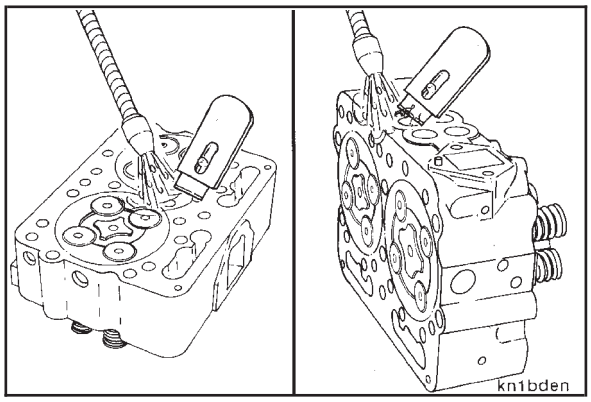
Blow out all capscrew holes, fuel passages, and oil passages.



Remove the gasket material from the rocker lever housing surface.

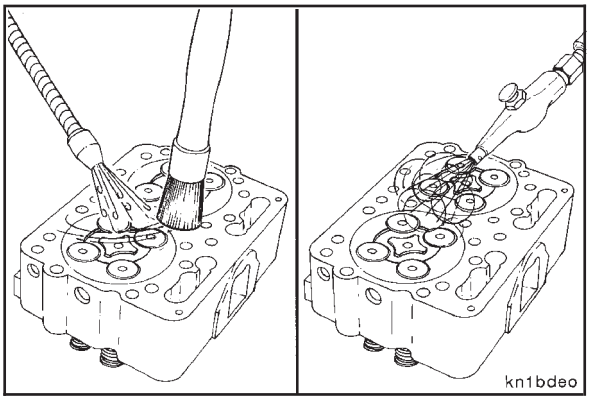


Use a gasket scraper to remove the heavy dirt and debris from the cylinder head gasket surface and the exhaust manifold gasket surface.



Use a razor blade scraper and solvent to remove any remaining material from the cylinder head gasket surface and the exhaust manifold gasket surface.

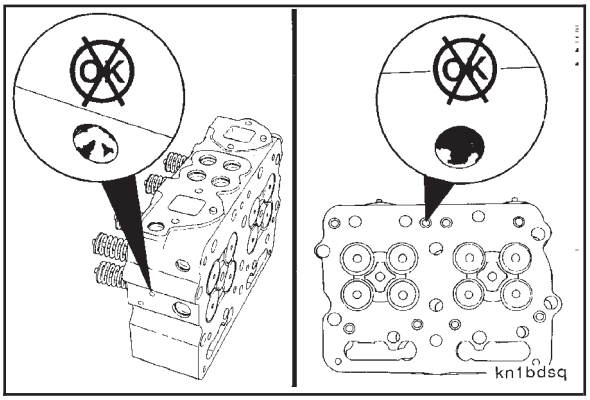
Clean with solvent, and dry with compressed air.



Inspection

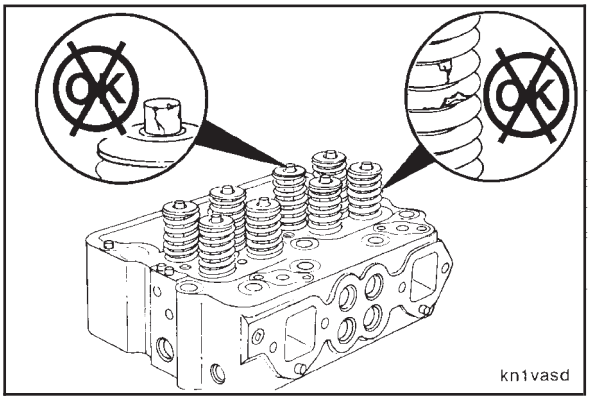
Visually inspect the fuel drillings and the water passages for restrictions or foreign material.

Remove any obstructions.

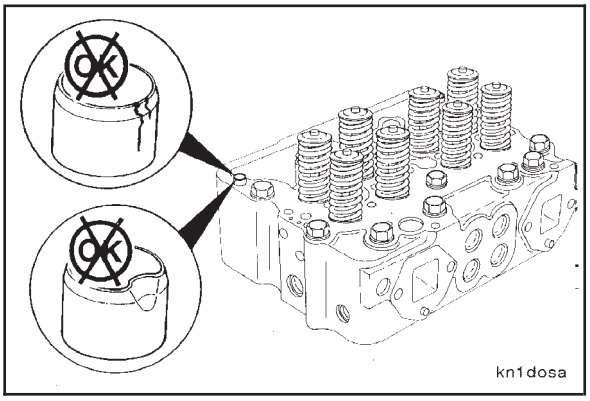


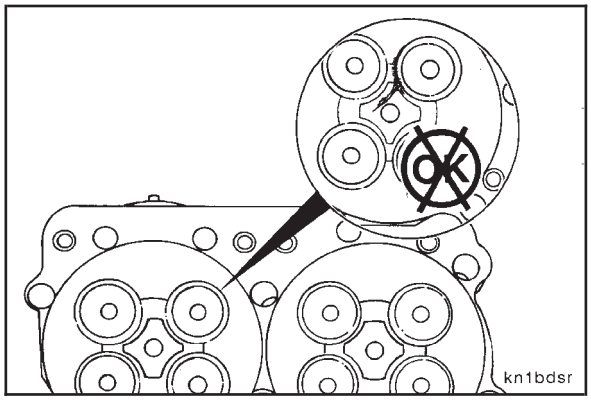
Visually inspect the valves and the valve springs for cracks, bent or broken valve stems, broken valve springs, or other damage.

NOTE: If cracked or damaged parts are found, the cylinder head **must** be rebuilt. Refer to Cylinder Head - Rebuild (02-02).



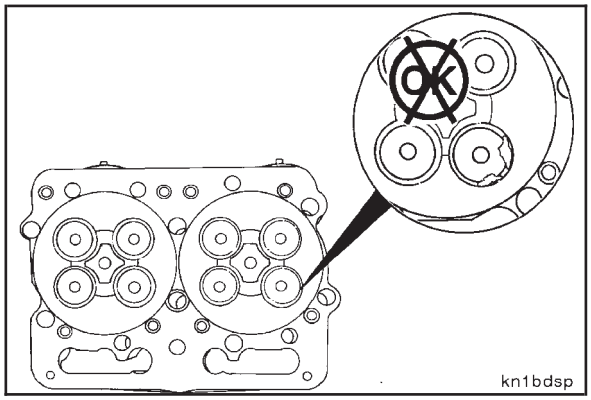
Visually inspect the ring dowels for cracks or damaged areas. Replace if necessary.



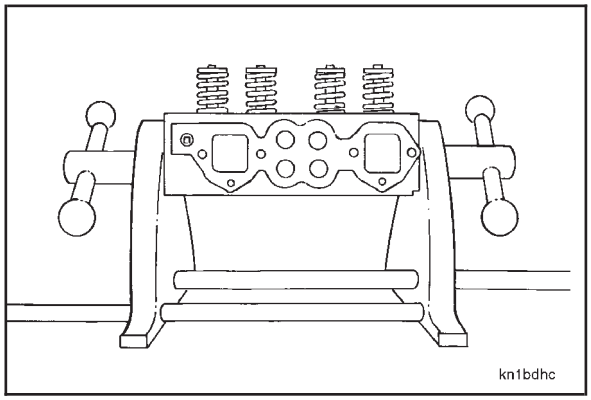


Visually inspect the cylinder head casting for cracks or damage.

NOTE: If cracks or leaks in the cylinder head are suspected, refer to Cylinder Head - Pressure Testing (02-08).



Visually inspect the valves for indications of leakage or burning. If indications of leakage or burning are found, the valves and the seats **must** be replaced or resurfaced. Refer to Cylinder Head - Rebuild (02-02).

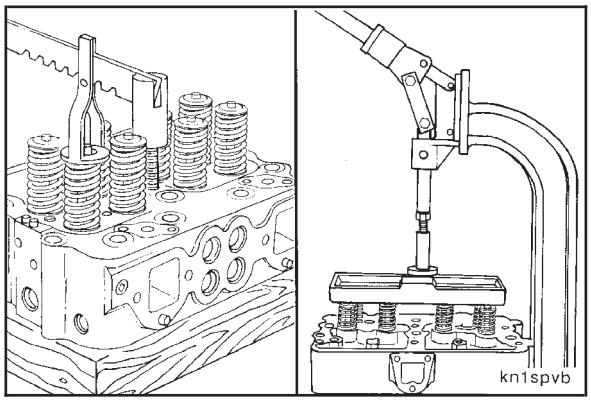


Cylinder Head - Rebuild (02-02)

Disassembly

Install the cylinder head in the head holding fixture, Part No. ST-583, as shown.

NOTE: Do **not** install the cylinder head in the holding fixture if a valve spring compressor, Part No. ST-1022, is used.



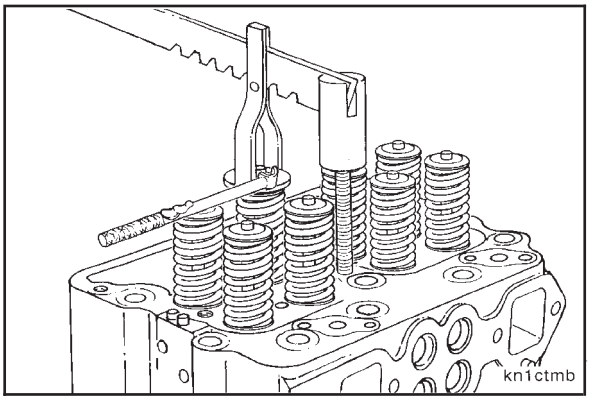
Use valve spring compressor, Part No. ST-448, or its equivalent (refer to the Service Tools list) to compress the valve springs.

NOTE: Install a wooden block between the valves and the head holding fixture to support the valves.

NOTE: Valve spring stand, Part No. ST-1022, and the compressor plate, Part No. ST-1026, can be used to compress all eight springs at the same time.

Use a pencil magnet to remove the valve collets. Discard the valve collets.

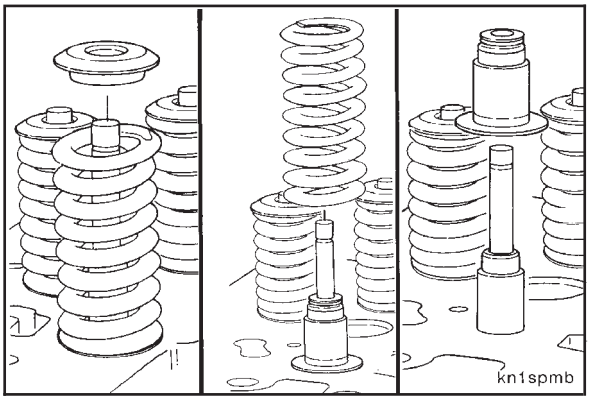
Slowly release the pressure on the valve spring.



Remove the valve spring retainer.

Remove the valve spring(s).

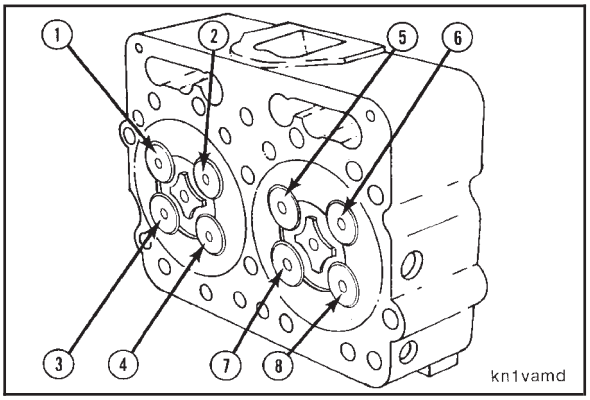
Remove the valve stem seal.



Remove the valves.

NOTE: Mark the location of the valves with an engraving tool as they are removed. The intake and exhaust valves are manufactured from different materials. The exhaust valves can be installed in the intake valve location. Do **not** install the intake valves in the exhaust location.

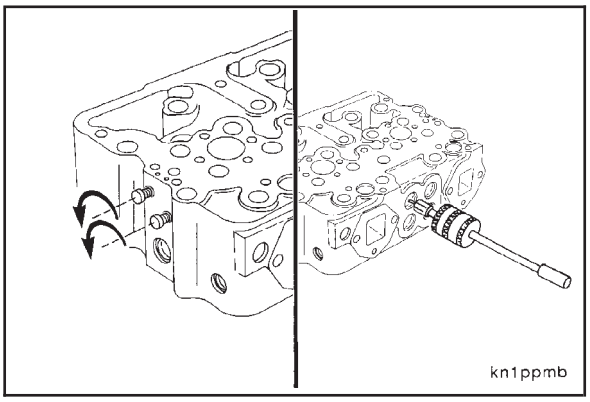
Repeat the procedure to remove the remaining valve collets, retainers, springs, stem seals, and valves.

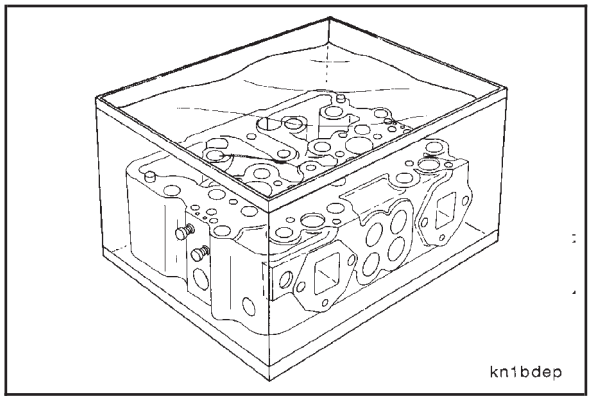


Remove the pipe plugs and the fuel fittings from the cylinder head.

Use an expansion plug removal tool, Part No. 3823159, to remove the expansion plugs.

NOTE: Expansion plugs **must** be removed from the head casting for cleaning purposes.



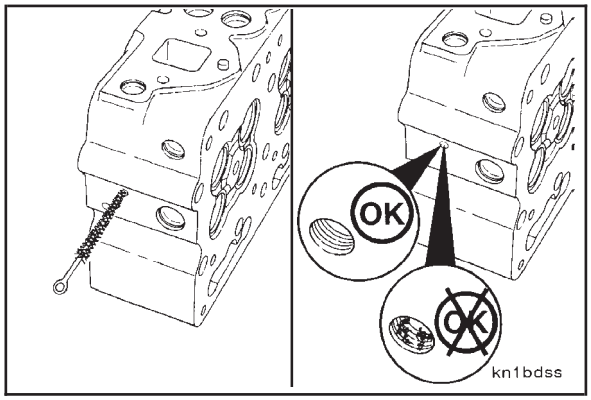


Cleaning

Warning: Use protective measures to prevent personal injury.

Install the cylinder head and the parts in a tank of cleaning solution.

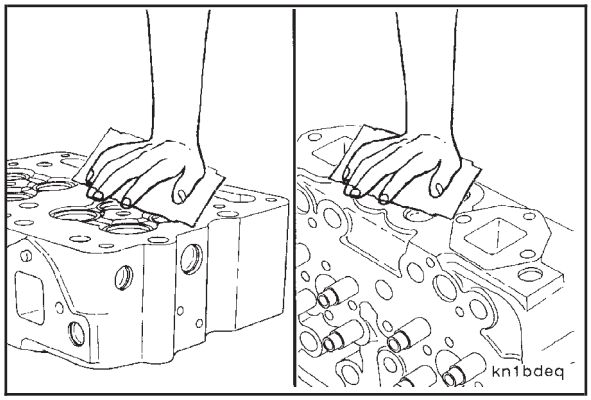
NOTE: Follow the cleaning solution manufacturer's instructions when cleaning the parts.



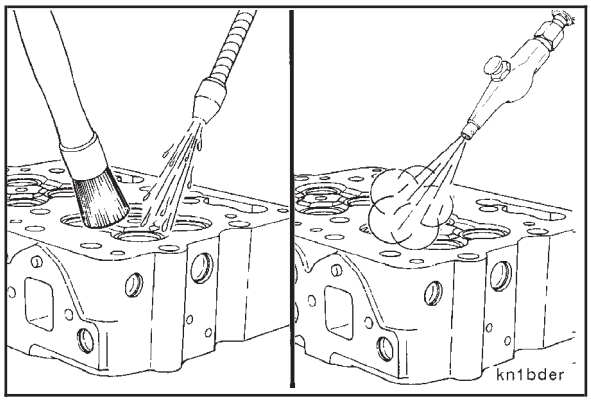
Remove the cylinder head and parts from the cleaning tank.

Use fuel passage cleaning brush, Part No. ST-876, to clean the fuel and the oil passages with solvent. Dry with compressed air.

Visually inspect the fuel and the oil passages to make sure they are clean.



Clean the combustion deck exhaust and the intake manifold gasket surfaces with a Scotch-Brite®, Part No. 3823258, or its equivalent and diesel fuel or solvent.



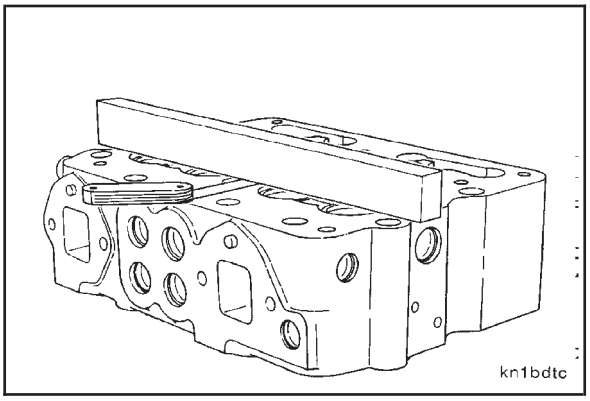
Clean with solvent. Dry with compressed air.

Use a straight edge and a 0.003-inch feeler gauge to measure the flatness of the cylinder head gasket surface.

Flatness Per 25.4 mm [1.00 in] of Length		
mm		**in**
0.020	MAX	0.0008

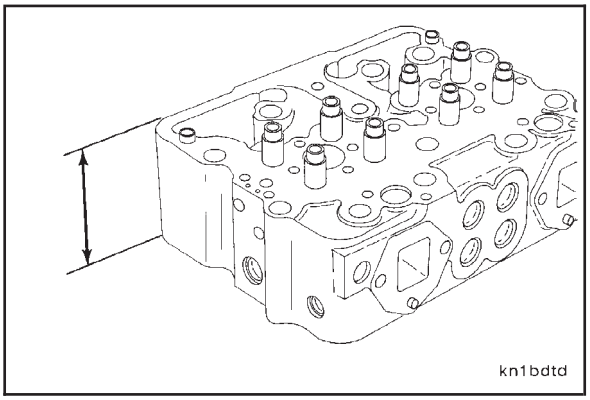
Flatness Per Total Overall Length		
mm		**in**
0.08	MAX	0.003

NOTE: If the cylinder head is worn more than the maximum specified above, the cylinder head **must** be resurfaced. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



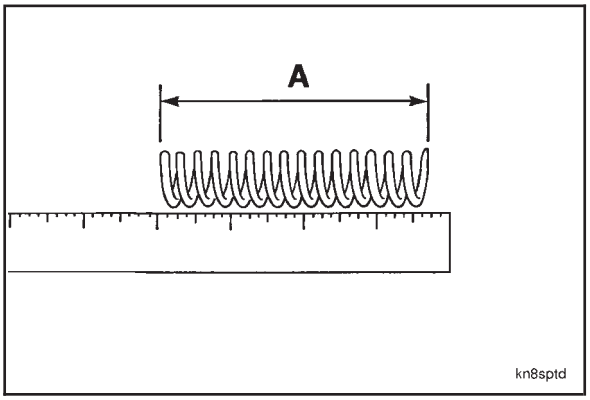
Measure the thickness of the cylinder head.

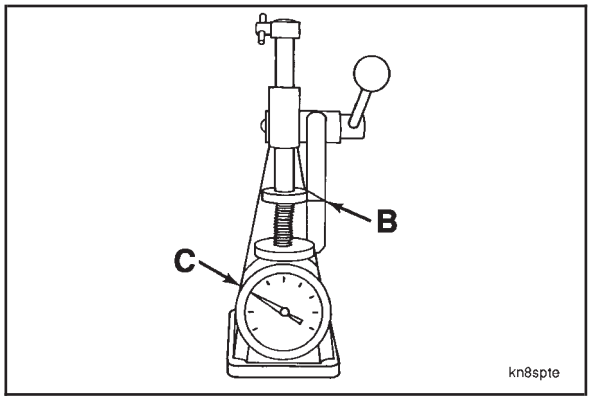
Cylinder Head Thickness		
mm		**in**
110.74	MIN	4.360
111.43	MAX	4.387



Measure the free height of the valve spring.

Free Height (A)			
Valve Spring Part No.	**mm**	**Limit**	**in.**
3070460	87.88	MAX	3.460



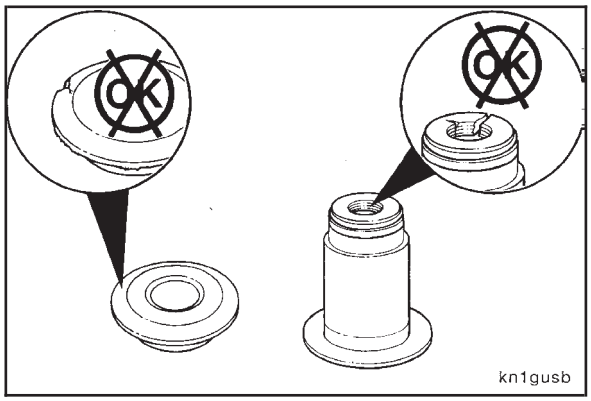


Use valve spring tester, Part No. 3375182, to measure the valve spring load at the valve spring working height.

Working Height (B)			
Valve Spring Part No.	mm	Limit	in.
3070460	56.89	Nominal	2.240

Load for Working Height (C)			
Valve Spring Part No.	N	Limit	lbf
3070460	1067	MIN	240
	1156	MAX	260

NOTE: If the valve spring load for the working height is less than the minimum specified, the valve spring(s) **must** be replaced.

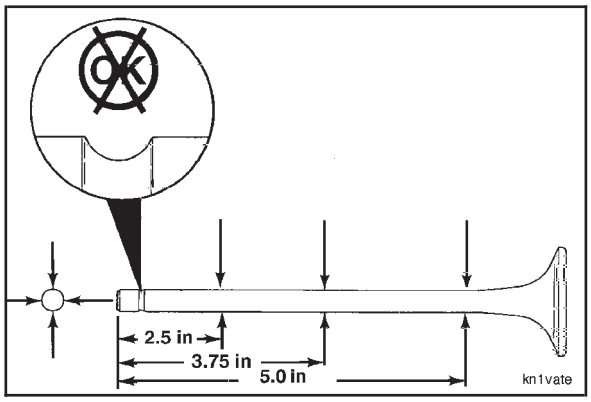


Inspection

Visually inspect the valve spring retainers and the valve stem seals for damaged or worn areas.

Remove the valve stem seals from the valve stem seal retainers, and visually inspect for damaged or worn areas.

Discard unserviceable parts.



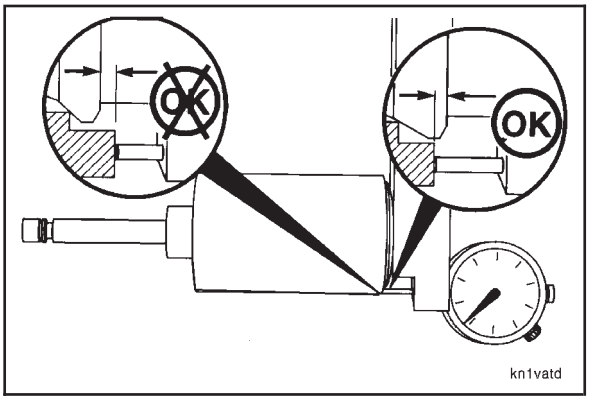
Visually inspect the valves for damage. Visually inspect the collet grooves for wear. Replace damaged valves or valves with worn collet grooves.

Measure the outside diameter of the valve stem.

Stem O.D.		
mm		in
9.59	MIN	0.3775
9.63	MAX	0.3793

Use the N14 valve head checking tool to measure the head thickness of the valves.

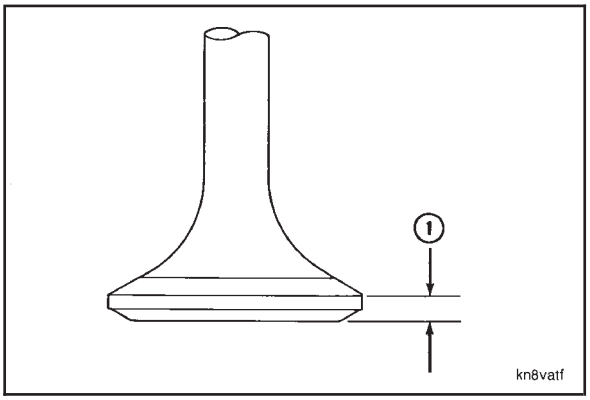
NOTE: Install the valve on the tool with the valve head contacting the tool as shown. If the valve head is even with, or extends beyond the end of the tool, the valve can be reground. If the valve head is below the end of the tool, the valve is **not** thick enough for regrinding.



If a valve head checking tool is **not** available after regrinding the valve seat surface, put the valve on a flat surface and measure the head thickness (1) at the outside diameter.

Valve Head Thickness (at O.D.)		
mm		**in**
2.90	MIN	0.114

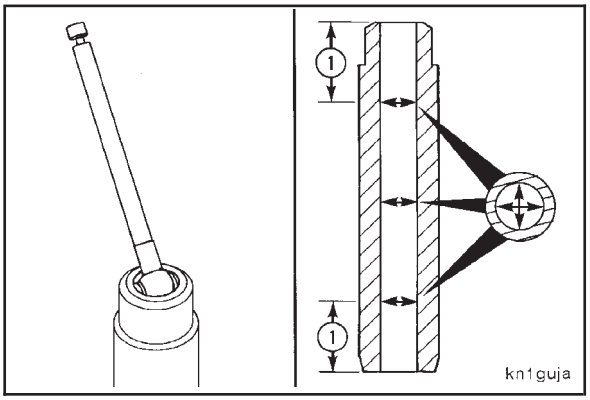
NOTE: If the valve head is thinner than the minimum specified, the valve **must** be replaced.



Visually inspect the valve guides for chips or cracks.

Measure the inside diameter of the valve guides 12.7 mm [0.50-inch] from each end (1) and at the center as shown.

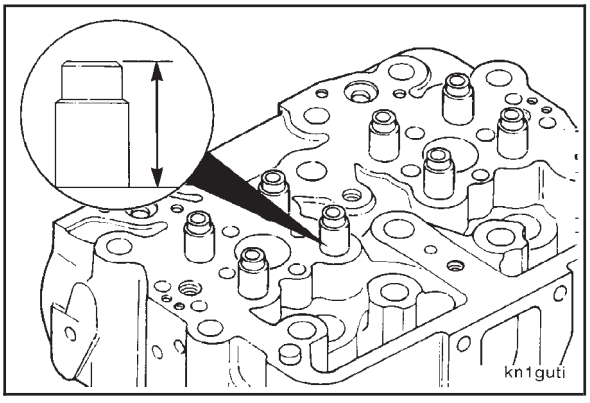
Valve Guide I.D. (Installed)		
mm		**in**
9.662	MIN	0.3804
9.738	MAX	0.3834

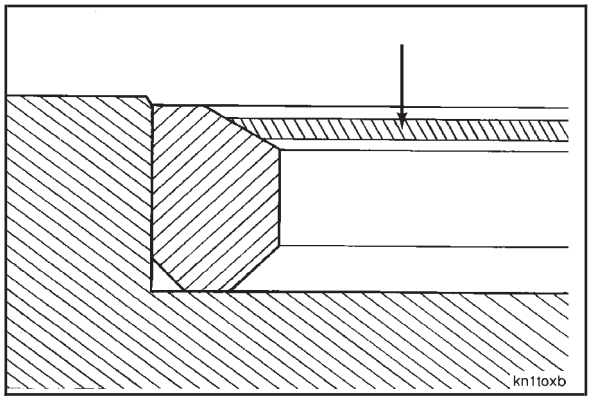


Measure the valve guide installed height.

Valve Guide Height (Installed)		
mm		**in**
31.75	MIN	1.250
32.76	MAX	1.290

NOTE: If damage is found or the valve guide(s) does **not** meet the limits specified, the valve guide(s) **must** be replaced. Refer to Cylinder Head - Replacing the Valve Guides (02-03).

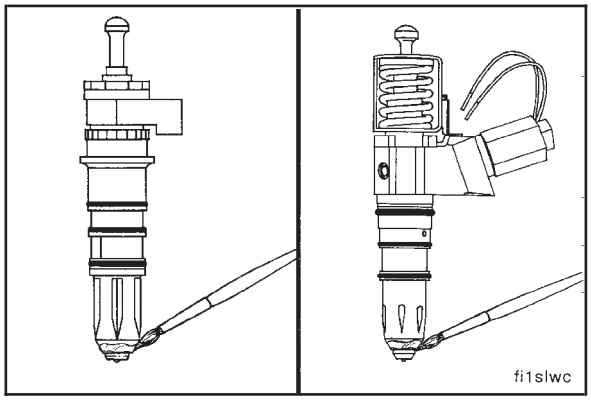




Measure the width of the valve seat area of the valve seat inserts.

Valve Seat Area (Width)		
mm		**in**
1.60	MIN	0.063
3.18	MAX	0.125

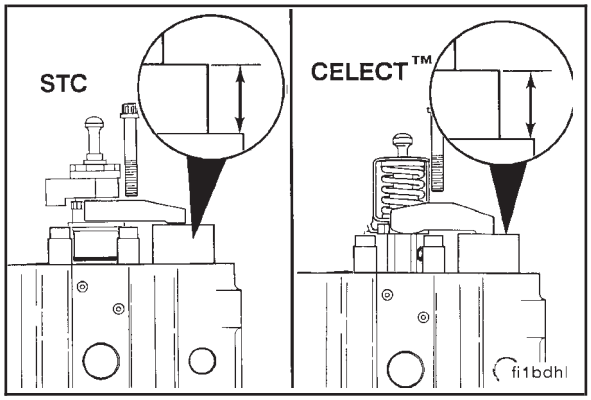
NOTE: If the valve seat area is worn wider than the maximum specified, refer to ''Grinding the Valve Seats'' later in this procedure or to Cylinder Head - Replacing the Valve Seat Inserts (02-05).



Perform the following steps to check the injector seating quality in the injector sleeve and to measure injector protrusion past the combustion face.

Caution: Support the cylinder head to prevent damage to the injector tip which protrudes from the combustion face.

Apply a very light film of blueing compound to the outside diameter of the injector at the injector seat area. Blueing compound can effectively be applied with your finger or with a brush.



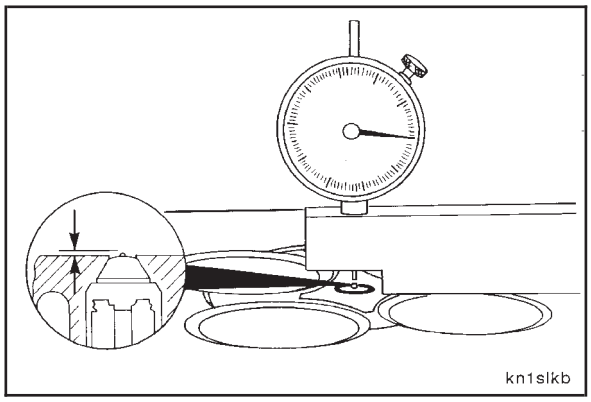
Caution: Support the cylinder head combustion face so that it clears the work surface to prevent damage to the injector tips during installation.

Install the injectors in the cylinder head without o-rings.

Place a 1.2-inch thick block under the injector hold down clamp. This represents the rocker housing.

Tighten the injector hold down capscrews.

Torque Value: 54 N•m [40 ft-lb]
(STC and CELECT™)

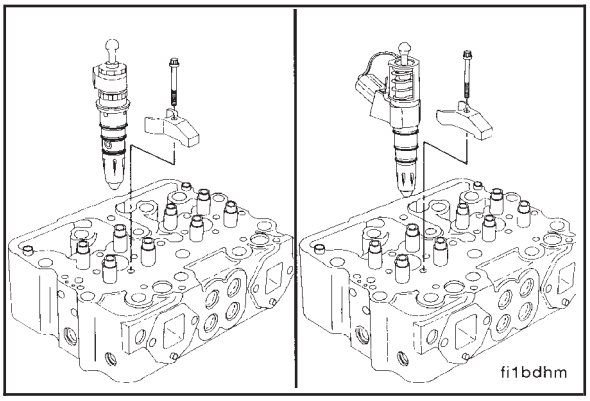


Turn the cylinder head over and use a depth gauge, Part No. 3823495, to measure the injector tip protrusion.

Injector Tip Protrusion		
mm		**in**
1.47	MIN	0.058
1.82	MAX	0.072

NOTE: If the injector tip protrusion does **not** meet the specifications given, the injector sleeve **must** be machined again.

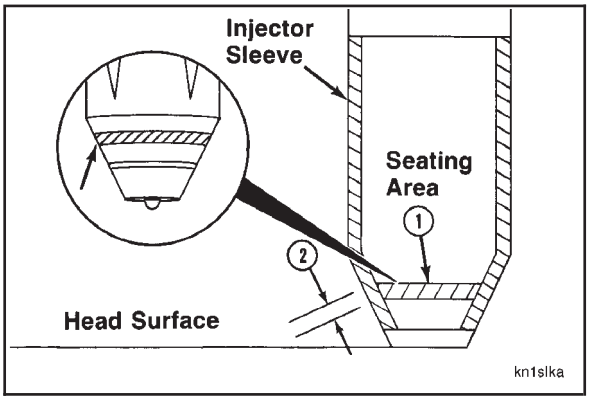
Remove the injectors from the cylinder head and check the pattern of the blueing compound in the injector sleeve.



The blueing pattern in the injector seating area (1) **must** be visible 360 degrees around the seating area.

The injector bore seating width (2) **must** be a minimum of 1.52 mm [0.060-inch].

NOTE: If the injector protrusion is more than the maximum specified or if the injector sleeve blueing pattern does **not** meet the specifications given, the injector sleeve(s) **must** be replaced. Refer to Cylinder Head - Replacing the Injector Sleeves (02-07).

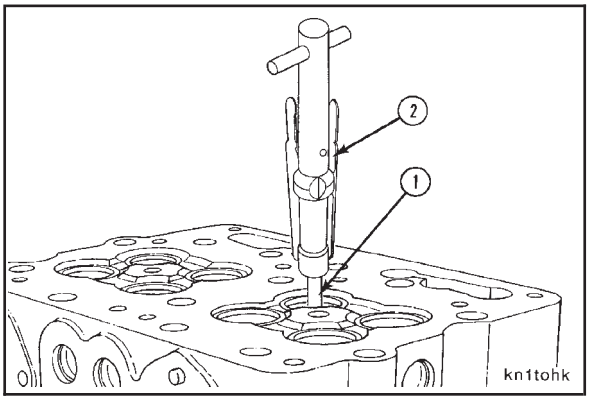


Grinding the Valve Seats

NOTE: If the valve guide inside diameter exceeds the maximum worn limit, replace the valve guide before grinding the valve seat.

Use a valve seat grinding machine, Part No. ST-685, and valve guide arbor set, Part No. ST-663, when grinding the valve seat inserts. Install the valve guide arbor (1) in the valve guide with the arbor puller (2).

NOTE: Rotate the arbor to make sure it is correctly installed.

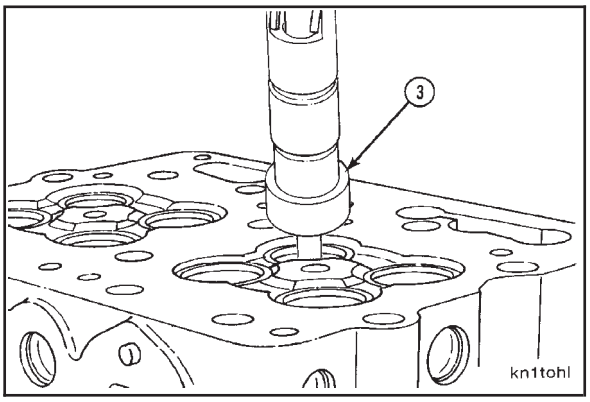


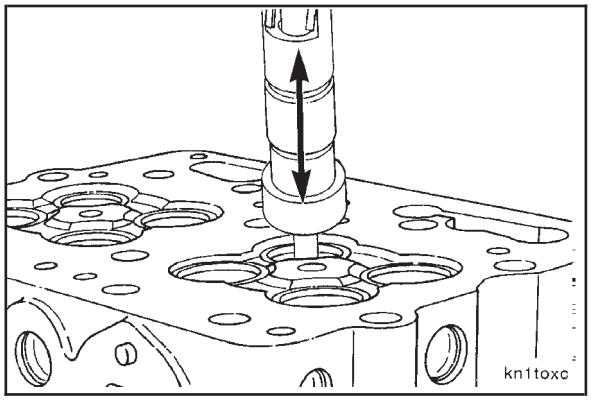
Install a valve seat grinding stone (3), Part No. ST-685-9, on the grinder unit.

NOTE: The grinding stone **must** be the correct size and have the correct angle (2 1/4-inch diameter X 30-degree grinding angle).

Install the grinder unit on the arbor.

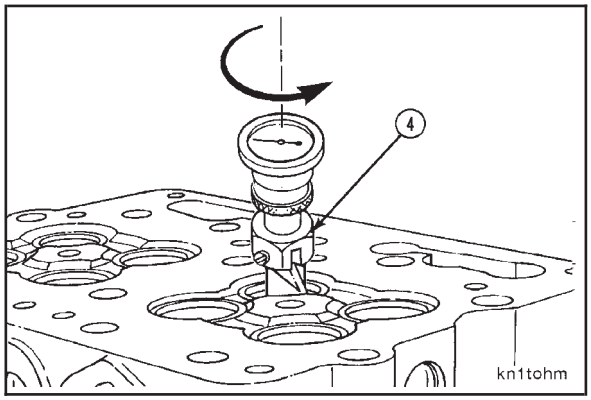
NOTE: The grinding stone (3) **must not** touch the valve seat insert when the drive unit motor is started.





Hold the drive unit in a vertical position, and use an up-and-down movement of 12.7 mm [0.50-inch] travel and light pressure to grind the insert.

Remove the grinder unit from the arbor.

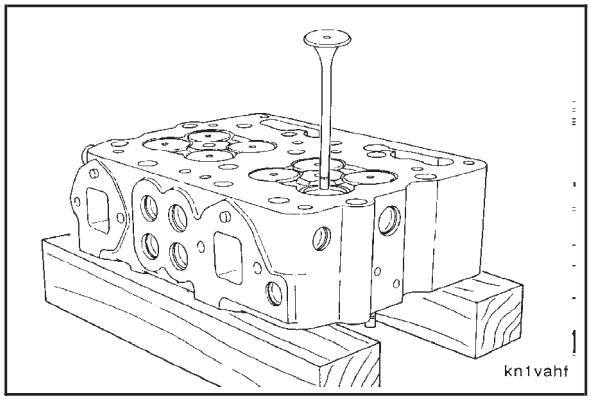


Install eccentrimeter gauge (4), Part No. ST-685-4, on the arbor.

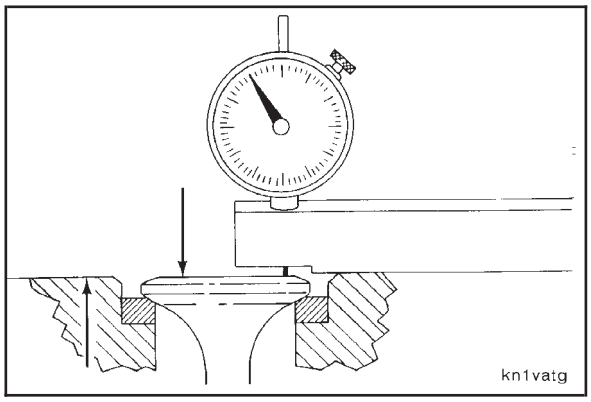
Measure the valve seat to valve guide concentricity.

Concentricity (Per 360 Degrees)		
mm		**in**
0.09	MAX	0.0035

NOTE: If the valve seat concentricity does **not** meet the specifications, grind the valve seat again. If the specifications can **not** be met, replace the valve seat insert. Refer to Cylinder Head - Replacing the Valve Seat Inserts (02-05).



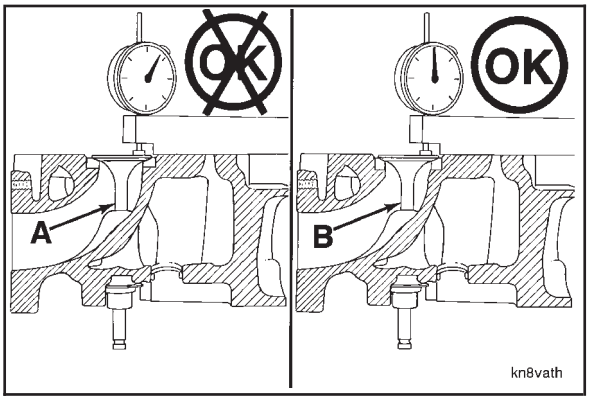
Install reconditioned valves in their respective bores. Hold the valve firmly against the valve seat insert.



Use a depth gauge, Part No. 3823495, to measure the valve protrusion.

Valve Protrusion		
mm		**in**
- 0.63	MIN	- 0.025
0.00	MAX	0.000

If the valve protrusion is out of limits, replace the old valve (A) with a new valve (B) **before** replacing the valve seat. If the protrusion is within limits with the new valve, proceed using the new valve with the old seat.



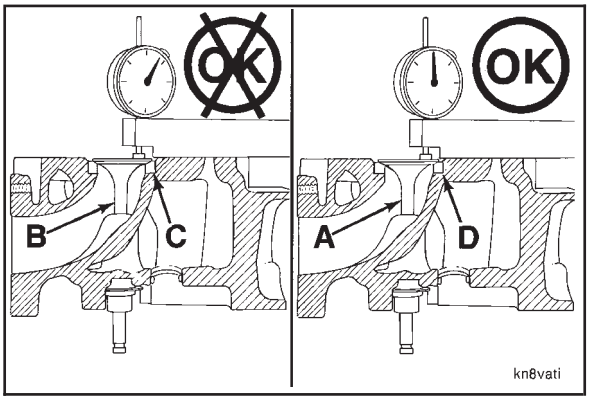
If the valve protrusion is still out of limits, even with the new valve (B), replace valve seat (C) with a new valve seat (D). After replacing the seat, check the valve protrusion again with the old valve (A) to determine if it can be reused. If **not**, proceed using new valve (B).

(A) = Old Valve

(B) = New Valve

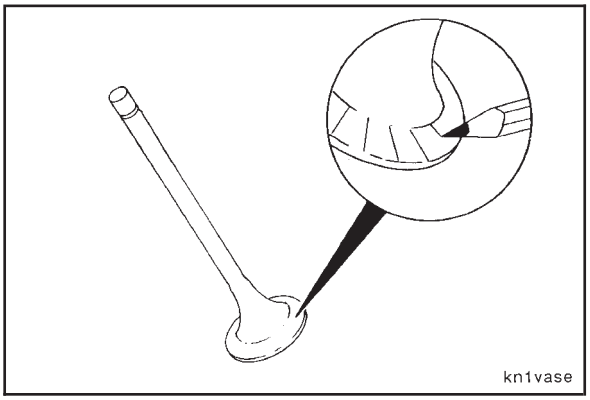
(C) = Old Valve Seat

(D) = New Valve Seat



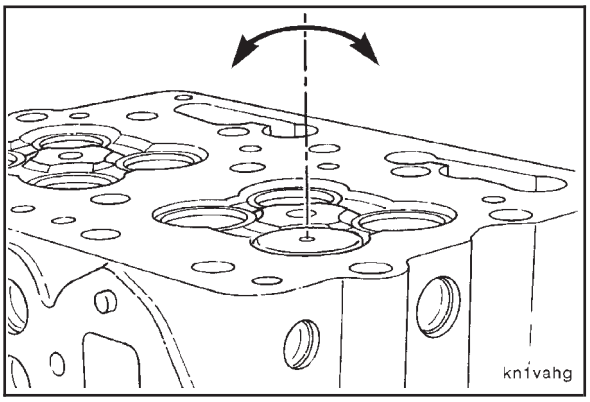
Check the valve seat contact area on the valve face to see if the valve seat contacts the center of the valve face.

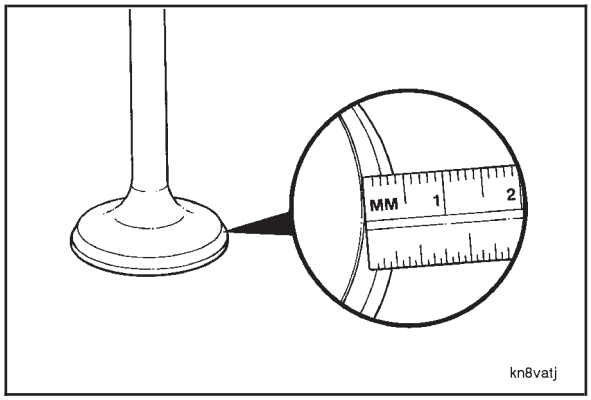
Use a pencil or Dykem® to put vertical marks on the face of the valve.



Install the valve in the valve guide. Hold the valve against the valve seat.

Rotate the valve backward and forward three or four times.

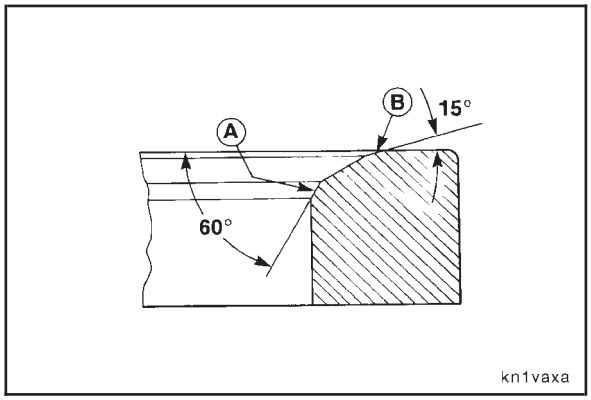




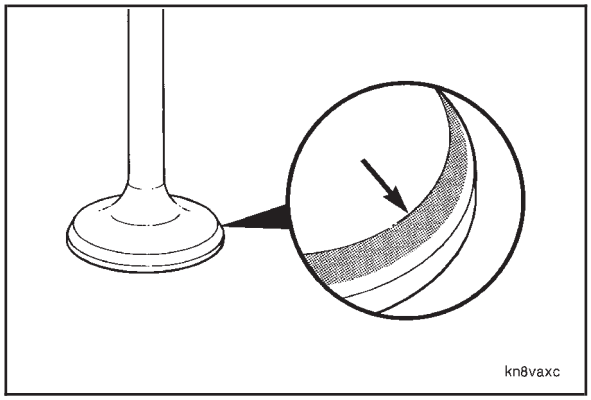
Remove the valve, and measure the valve seat width and the seat contact area as indicated by the broken lines.

The pencil or Dykem marks will be worn away where the valve contacted the seat.

Valve Seat Width Limit		
mm		**in**
1.60	MIN	0.063
3.18	MAX	0.125

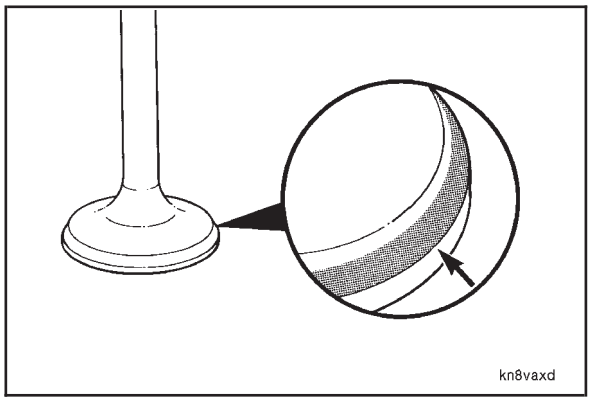


Grind area (A) with a 60-degree stone and area (B) with a 15-degree stone to center the seat on the valve face and to obtain the valve seat width limits.



The location of the broken lines on the valve face is the key to determining how much of each angle to grind.

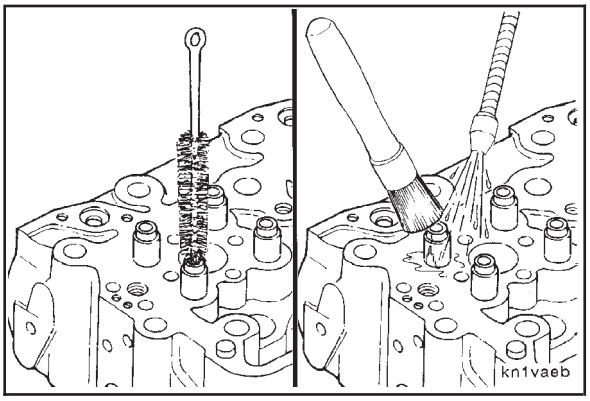
If the broken lines are at the bottom of the valve face, the seat will require more grinding with the 60-degree stone than with the 15-degree stone.



If the broken lines are at the top of the valve face, the seat will require more grinding with the 15-degree stone than with the 60-degree stone.

After grinding the valve seats, use a bristle brush to clean the inside diameter of the valve guides.

Use solvent to clean the cylinder head. Dry with compressed air.



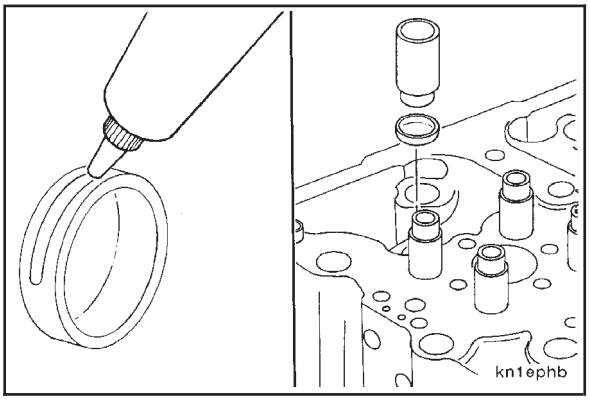
Assembly

Apply cup plug sealant, Part No. 3375068, to the outside diameter of the expansion plugs.

Use expansion plug drivers to install the expansion plugs in the cylinder head. Refer to the chart below.

Cup Plug Size	Driver Tool No.
3/4-inch	3376815
1 inch	3376816

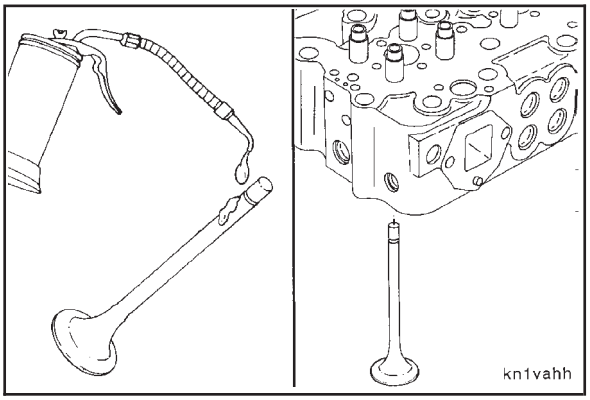
NOTE: Use the correct expansion plug driver to make sure the expansion plugs are installed to the correct depth in the cylinder head. Drive the plug until the shoulder of the driver contacts the cylinder head.



Use clean 15W-40 oil to prelubricate the valve stems.

Install the valves in their original position in the cylinder head.

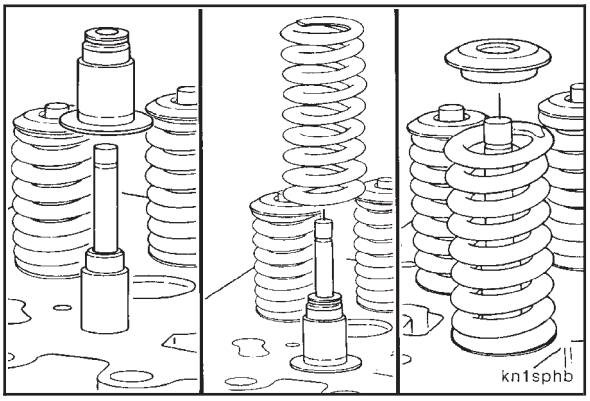
NOTE: After the valves are installed, put the cylinder head on a flat surface so the cylinder head surface will **not** be damaged.

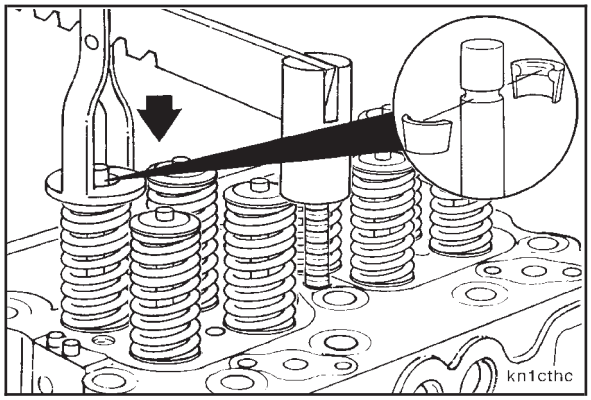


Install the valve stem seal.

Install the valve springs.

Install the valve spring retainers.

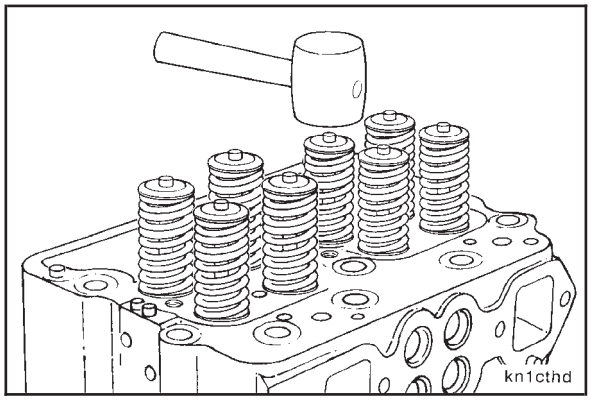




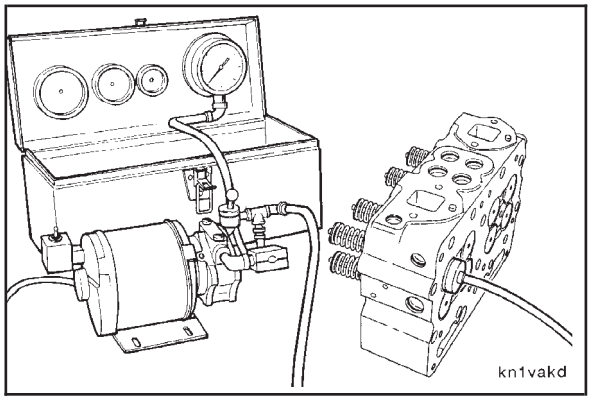
Use valve spring compressor, Part No. ST-448, or its equivalent (refer to the Service Tools list) to compress the valve springs.

Install the new valve spring retainer collets.

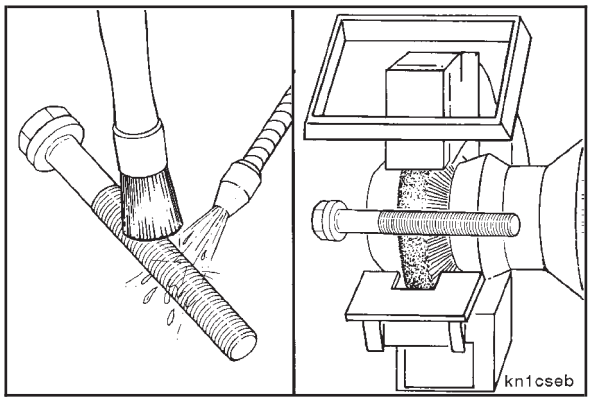
NOTE: Use new valve spring retainer collets when rebuilding the cylinder head.



Use a mallet to gently hit the valve stems to make sure the valve collets are correctly seated in the spring retainer.



Use valve vacuum tester, Part No. ST-1257, to vacuum test the valve seating. Refer to Cylinder Head - Vacuum Testing Valve Seating for Reuse (02-10).



Cylinder Head Capscrews

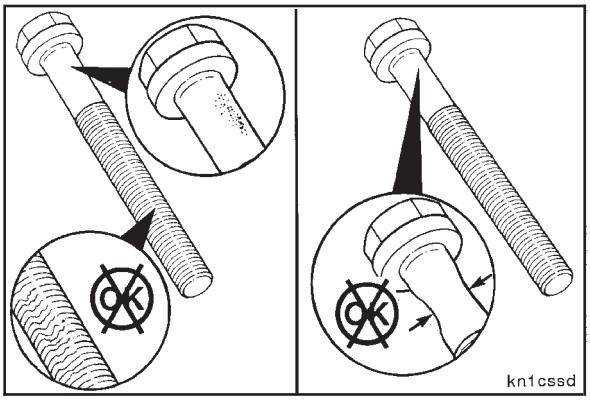
Caution: Do not use caustic or acid solutions to clean the cylinder head capscrews.

Use a petroleum-based solvent to clean the capscrews.

Clean the capscrews thoroughly with a wire brush, with a wire wheel (soft), or use a non-abrasive bead blast to remove deposits from the shank and the threads.

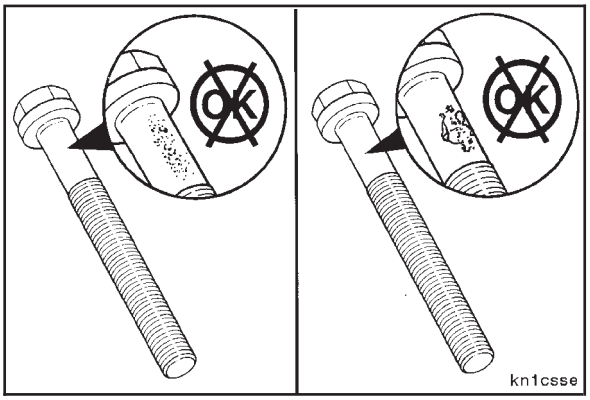
Visually inspect the cylinder head capscrews for damaged threads, corroded surfaces, or a reduced diameter (due to capscrew stretching).

NOTE: Do **not** reuse a capscrew that has damaged threads or a reduced diameter from having been stretched.

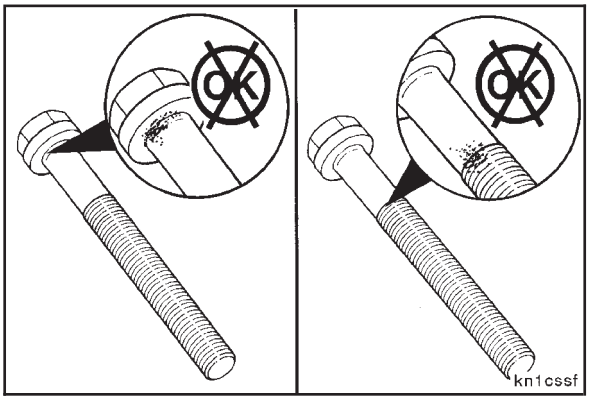


Do **not** reuse cylinder head capscrews under the following conditions:

- Visible corrosion or pitting exceeds 1 sqcm [0.155 sq. inch] in area. Example:
  - Acceptable 3/8-x3/8-inch
  - Unacceptable 1/2-x1/2-inch
- Visible corrosion or pitting exceeds 0.12 mm [0.005-inch] in depth.

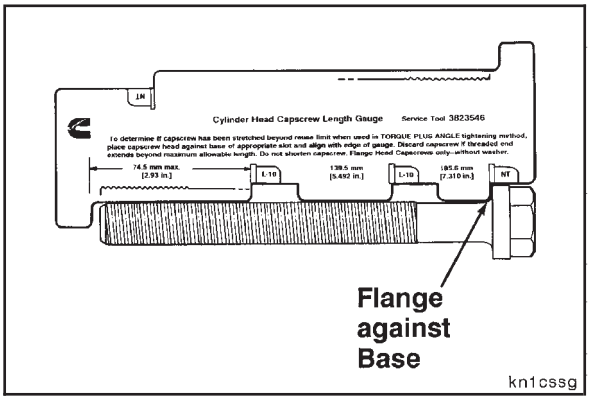


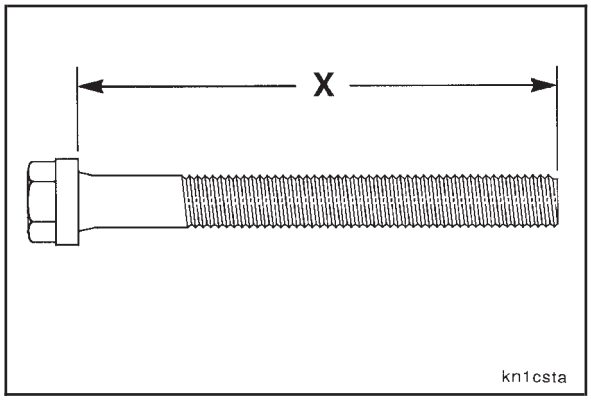
- Visible corrosion or pitting is located within 3.2 mm [1/8-inch] of the fillet.
- Visible corrosion or pitting is located within 3.2 mm [1/8-inch] of the threads.



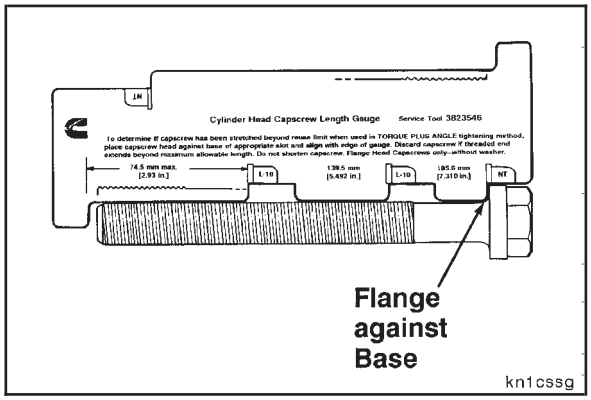
Using flange head capscrews with the torque plus angle method of installation places the capscrew beyond the yield point, and permanently stretches the capscrew at each use. These capscrews can be reused throughout the life of the engine unless the capscrew exceeds the specified free length. The capscrew free length **must** be checked to avoid bottoming out in the cylinder block during installation.

Use service tool, Part No. 3823546, to check capscrew free length.



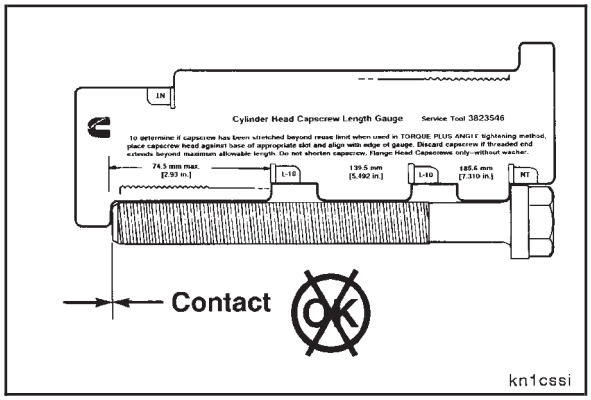


The capscrews can be checked using a set of calipers if service tool, Part No. 3823546, is **not** available. The maximum allowable free length (dimension 'X'), measured from the bottom of the flange to the end of the capscrew, is 185.6 mm [7.130 in].

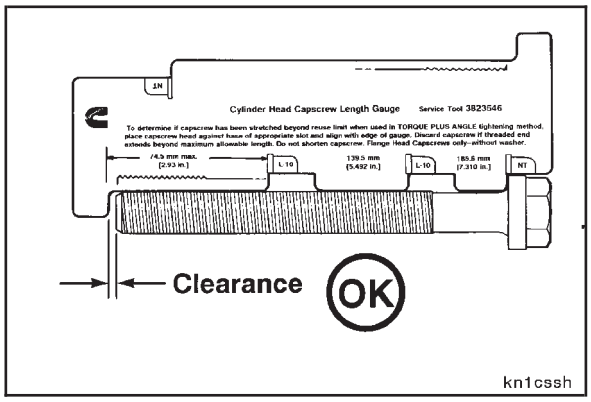


To check the capscrew free length, place the head of the capscrew in the appropriate slot with the flange against the base of the slot.

NOTE: Capscrew length **must** be checked without the hardened washer.

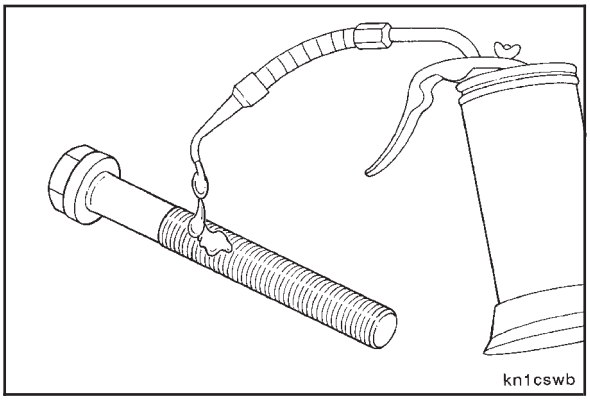


If the end of the capscrew touches the foot of the gauge, the capscrew is too long and **must** be discarded.



The capscrew can be used again if there is clearance between the end of the capscrew and the bottom base of the tool.

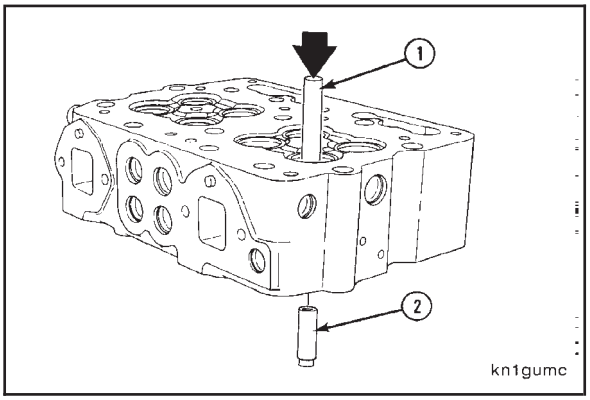
Immediately after cleaning and inspecting, apply a film of clean engine lubricating oil to capscrews that are to be used again.



Cylinder Head - Replacing the Valve Guides (02-03)

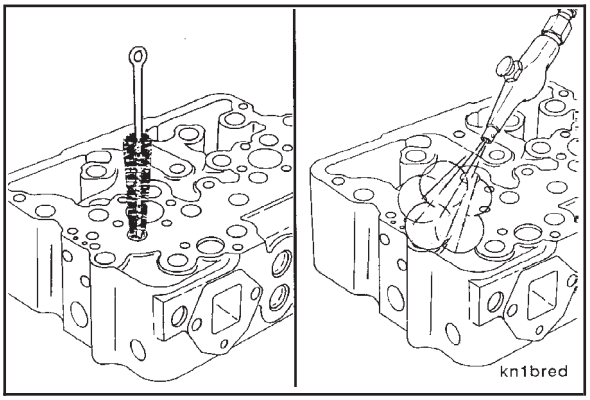
Disassembly

Use a valve guide driver, Part No. 3376398, (1) and an arbor press to remove the old valve guides (2).



Cleaning

Use a flexible brush and solvent to clean the valve guide bores in the cylinder head. Dry with compressed air.

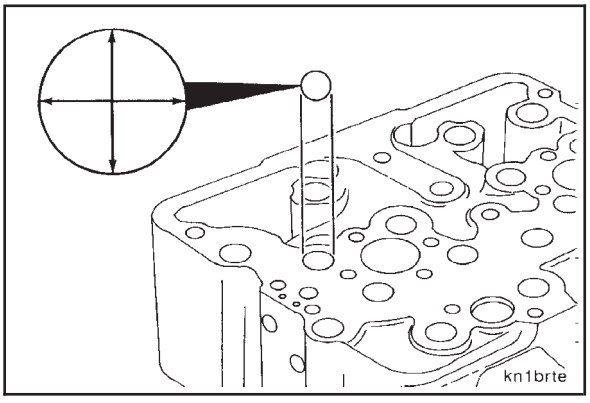


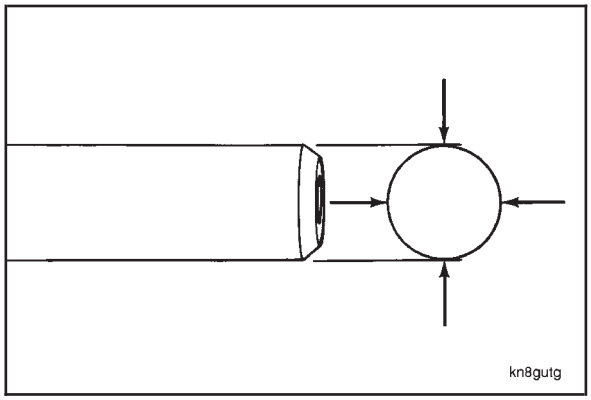
Inspection

Measure the inside diameter of the valve guide bore in the cylinder head.

Valve Guide Bore I.D.		
mm		in
19.05	MIN	0.750
19.07	MAX	0.751

NOTE: If the valve guide bore is worn larger than the maximum specified, the valve guide bore can be machined and 0.25 mm [0.010-inch] or 0.38 mm [0.015-inch] oversize valve guides installed. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



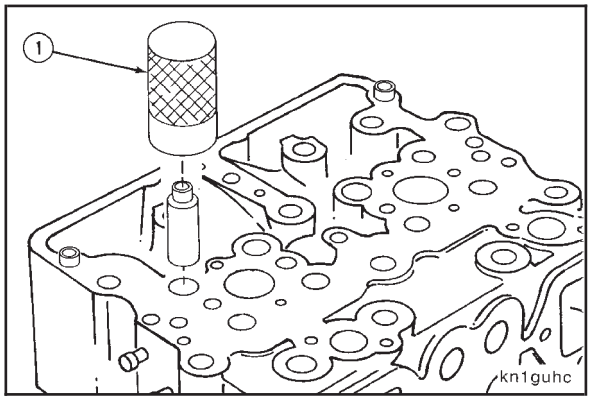


Assembly

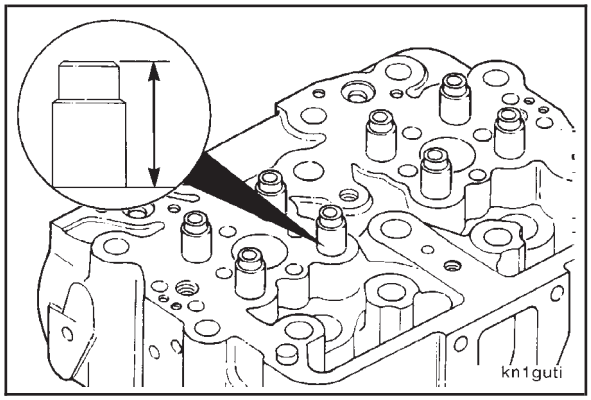
Measure the outside diameter of the new valve guides.

Valve Guide O.D.		
mm		in
19.088	MIN	0.7515
19.101	MAX	0.7520

NOTE: Oversize valve guides have identification grooves on the outside diameter of the guide. The 0.25 mm [0.010-inch] oversize guide has one groove. The 0.38 mm [0.015-inch] oversize guide has two grooves.

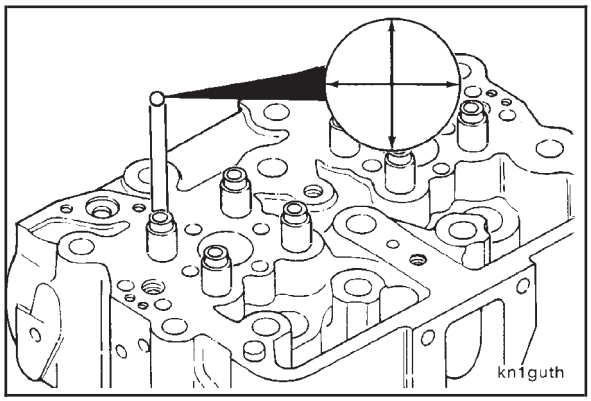


Use valve guide driver (1), Part No. 3823909, and an arbor press to install the new valve guides.



Measure the new valve guide installed height above the cylinder head top deck surface.

Valve Guide Height (Installed)		
mm		in
31.75	MIN	1.250
32.76	MAX	1.290



Measure the new valve guide inside diameter.

Valve Guide I.D. (Installed)		
mm		in
9.662	MIN	0.3804
9.713	MAX	0.3824

NOTE: If the valve guide is **not** within the specifications given, the valve guide **must** be removed and a new valve guide installed.

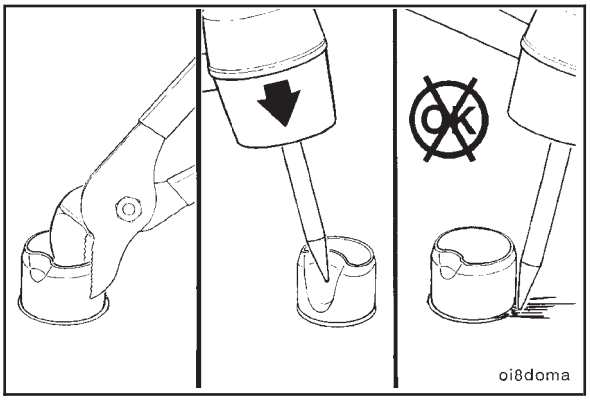
Cylinder Head - Ring Dowel Replacement (02-04)

Removal

Caution: Do not damage the surface or the ring dowel hole during removal of the dowel.

Use a pliers or a locking pliers to remove the damaged ring dowel.

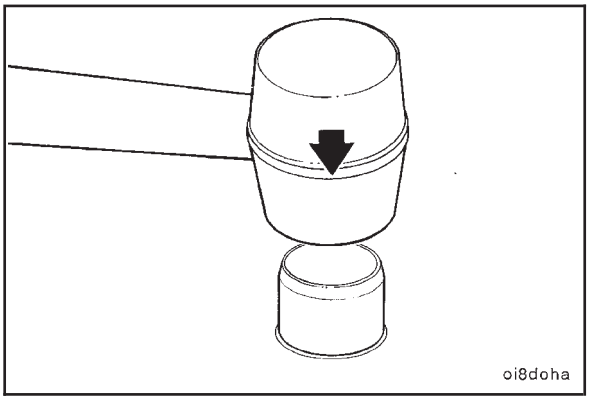
Use a blunt punch, if necessary, to bend the ring in for removal.



Installation

Caution: Do not use a hammer or damage to the dowel will result.

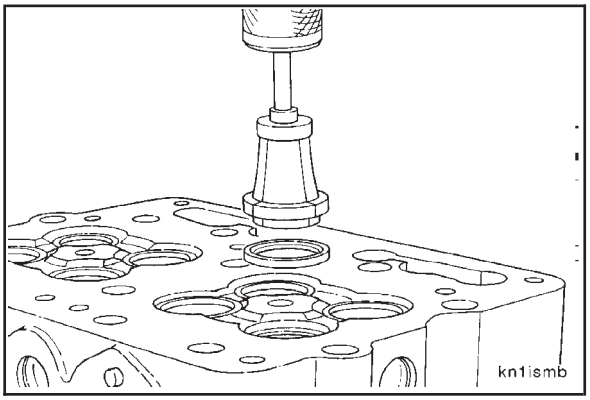
Use a plastic mallet to install the ring dowel.



Cylinder Head - Replacing the Valve Seat Inserts (02-05)

Disassembly

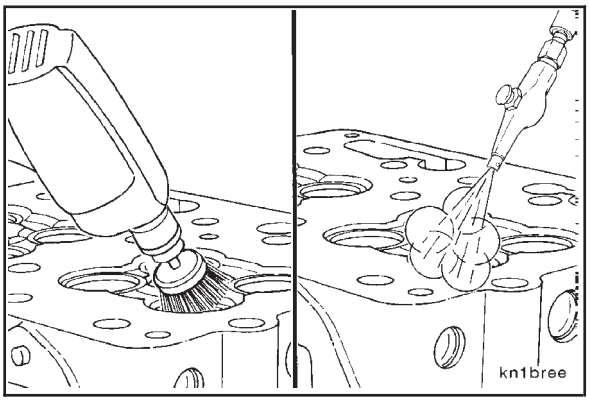
Use slide hammer assembly, Part No. 3376617, and valve seat extractor, Part No. ST-1279-1, to remove the valve seat inserts from the cylinder head.

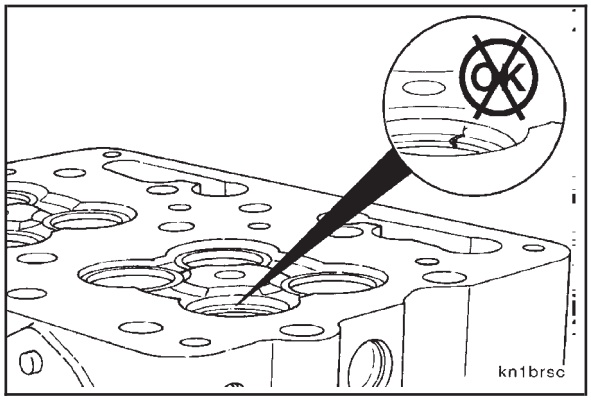


Cleaning

Use a wire brush and solvent to clean the deposits from the valve seat insert bores.

Use solvent to clean the cylinder head. Dry with compressed air.

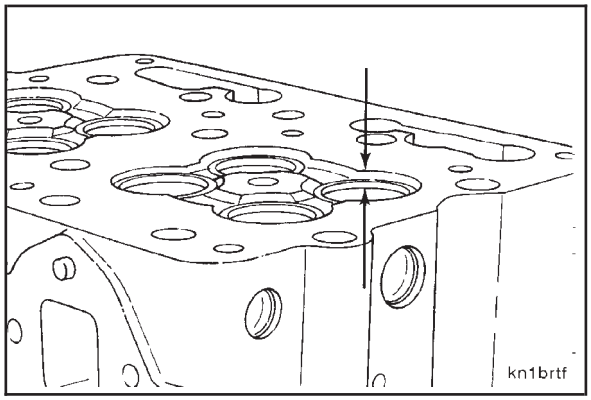




Inspection

Visually inspect the insert bore for cracks or damage.

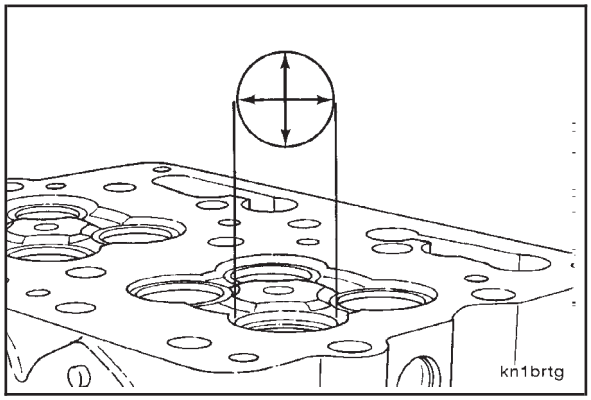
NOTE: If cracks or damage are found, it is possible to repair the cylinder head by machining the insert bore for oversize valve seat inserts. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



Measure the valve seat insert bore depth in the cylinder head.

Insert Bore Depth (Standard Insert)		
mm		in
9.39	MIN	0.370
9.52	MAX	0.375

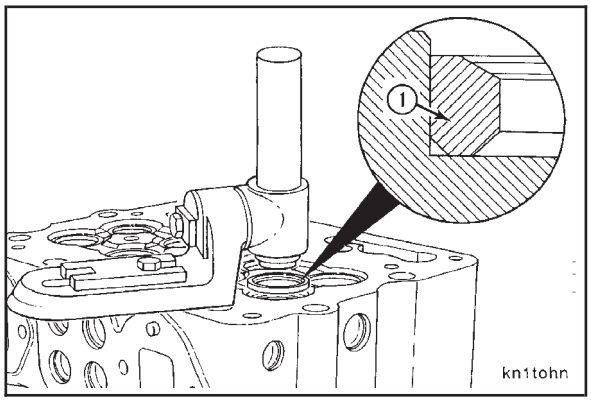
NOTE: If the valve seat insert bore depth does **not** meet the specifications given, it is possible to repair the cylinder head by machining the insert bore for oversize valve seat inserts. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



Measure the inside diameter of the valve seat insert bore in the cylinder head.

Insert Bore I.D. (Standard Insert)		
mm		in
50.787	MIN	1.9995
50.813	MAX	2.0005

NOTE: If the valve seat insert bore inside diameter does **not** meet the specifications given, it is possible to repair the cylinder head by machining the insert bore for oversize valve seat inserts. Refer to the Alternative Repair Manual, Bulletin No. 3379035.



Assembly

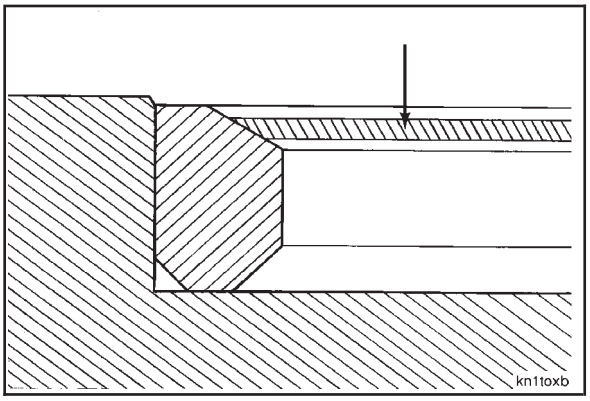
Install the base and swivel of valve seat insert tool, Part No. ST-257, on the cylinder head to guide the valve seat driver.

NOTE: The insert chamfer (1) **must** be installed toward the bottom of the counterbore.

Use the valve seat driver and an arbor press to push the valve seat insert into the counterbore.

NOTE: Make sure the insert is at the bottom of the counterbores.

Use valve seat grinding machine, Part No. ST-685, and valve guide arbor set, Part No. ST-663, to grind the new valve seat inserts. Refer to ‘‘Grinding the Valve Seats’’ under Cylinder Head - Rebuild (02-02).

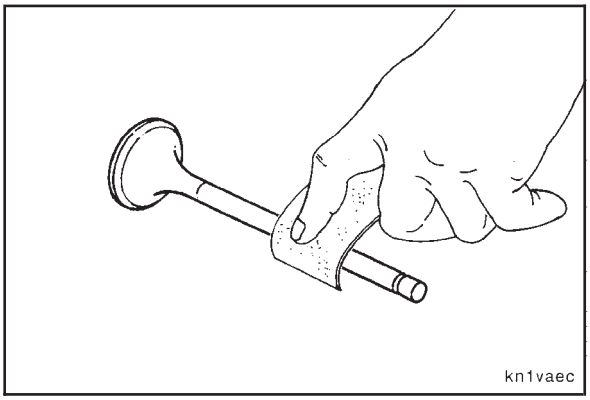


Cylinder Head - Grinding the Valves (02-06)

Cleaning

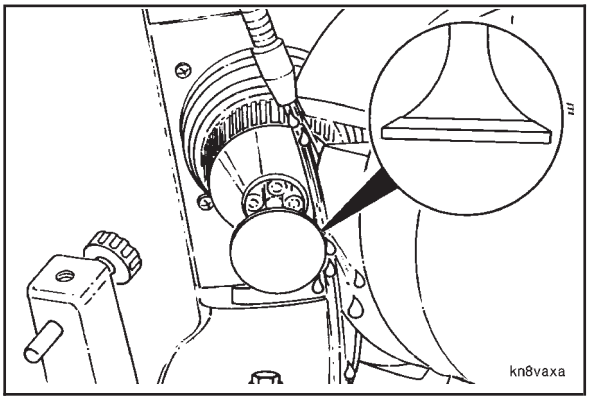
Use Scotch-Brite® 7448, Part No. 3823258, to clean the valve stems. Clean the carbon deposits from the valve face and the head.

NOTE: The valves **must** be clean and free of carbon deposits before they are ground. Valves can be cleaned by the bead blasting method in the head area only.



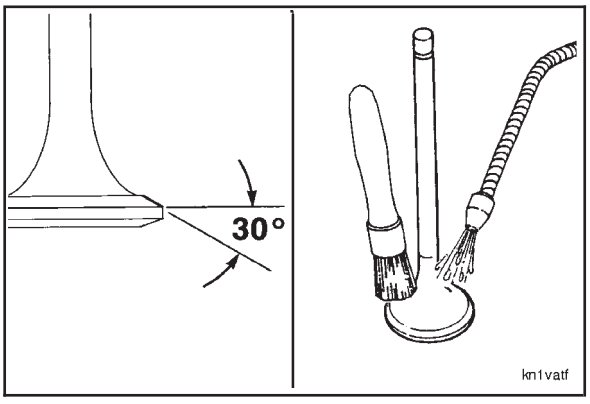
Use a valve facing machine, Part No. 3376256, to grind the face of the valve.

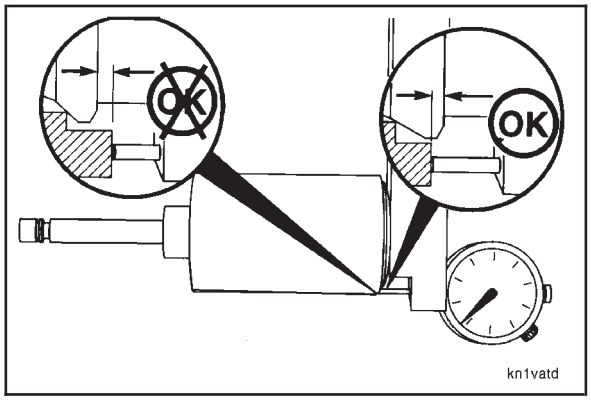
NOTE: Follow the instructions supplied with the valve facing machine for the correct setup before grinding the valves.



Grind the intake and the exhaust valves to the angle shown.

Use solvent to clean the metal particles from the valve. Dry with compressed air.

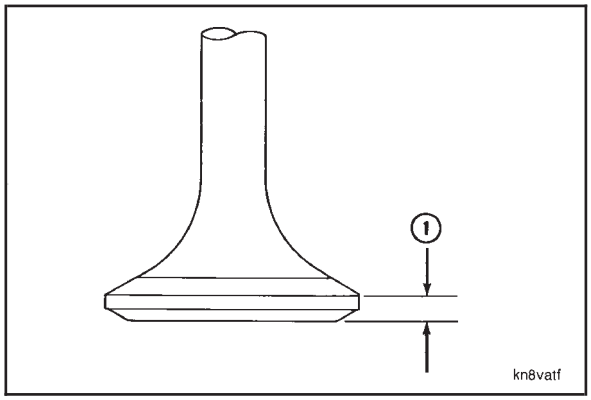




Inspection

Use the N14 valve head checking tool to measure the head thickness of the valve.

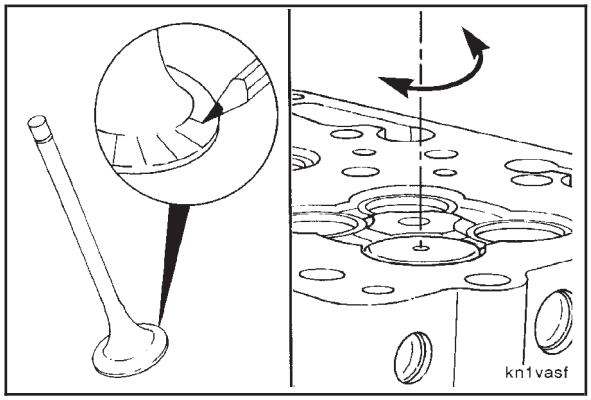
NOTE: If the valve head is below the end of the tool, the valve **must** be replaced.



If a valve checking tool is **not** available, put the valve on a flat surface and measure the head thickness (1) at the outside diameter.

Head Thickness (at O.D.)		
mm		**in**
2.90	MIN	0.114

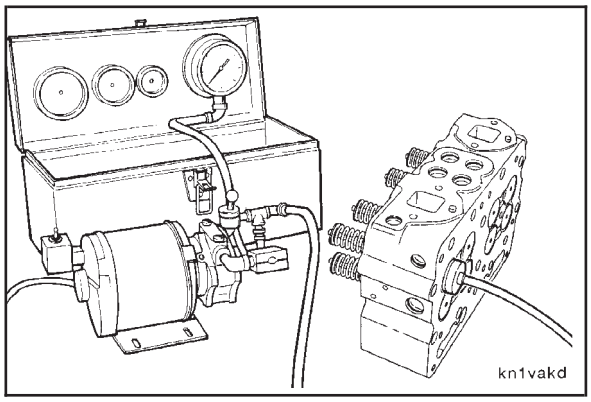
NOTE: If the valve head is worn thinner than the minimum specified, the valve(s) **must** be replaced.



Use a lead pencil or Dykem to mark across the valve face as shown. Install the valve in the valve guide.

Hold the valve against the valve seat, and rotate the valve backward and forward three or four times. Correct contact against the valve seat will break the marks on the valve face.

NOTE: Valves and valve seats that are correctly machined do **not** require the use of lapping compound to make an air tight seal. If lapping compound is required, inspect the adjustments of the facing machine and the condition of the grinding stone.



Install the valves in the cylinder head. Refer to ‘‘Assembly’’ under Cylinder Head - Rebuild (02-02).

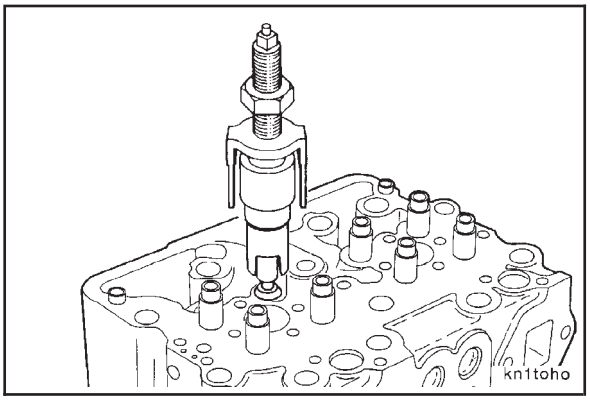
Use valve vacuum tester, Part No. ST-1257, to vacuum test the valve seating. Refer to Cylinder Head - Vacuum Testing Valve Seating for Reuse (02-10).

Cylinder Head - Replacing the Injector Sleeves (02-07)

Disassembly

Use an injector sleeve puller, Part No. ST-1244, to remove the injector sleeves from the cylinder head.

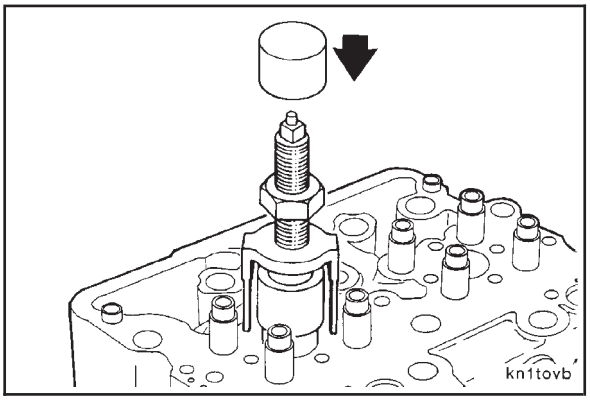
Install the puller in the injector sleeve with the legs of the bridge against the cylinder head.



Install the driver, Part No. ST-1244-8, against the large nut on the puller as shown.

Hit the driver with a mallet to push the forming collar into the injector sleeve.

Remove the driver from the puller.

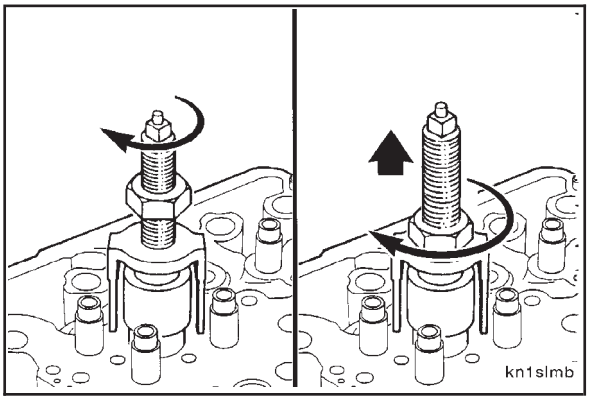


Tighten the small nut.

Torque Value: 65 N•m [50 ft-lb]

Turn the large nut **clockwise** to pull the injector sleeve from the cylinder head.

Loosen the nuts, and remove the old injector sleeve from the puller.

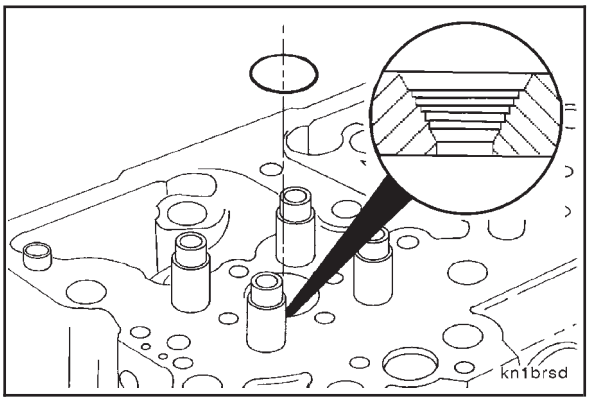


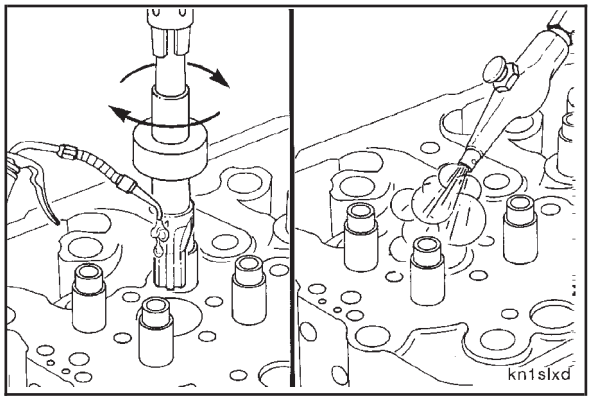
Cleaning and Inspection

Remove the injector sleeve o-ring from the injector bore in the cylinder head. Discard the o-ring.

Use solvent to clean the injector bore. Dry with compressed air.

Visually inspect the grooves (steps) in the bottom of the injector bore.





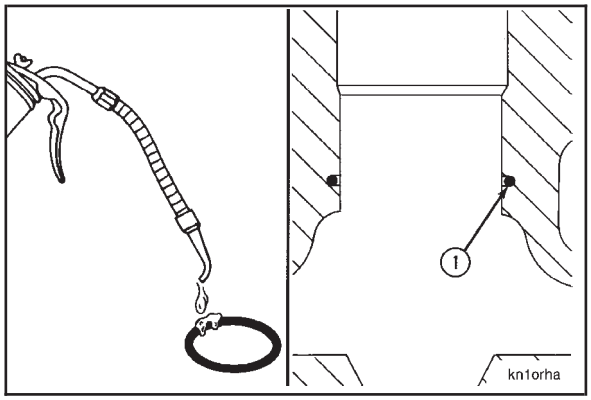
If the grooves (steps) are damaged or mutilated, use a pilot, Part No. ST-884-6; holder, Part No. ST-884-1; and cutting tool, Part No. ST-788, to machine the grooves (steps) in the bottom of the injector bore.

Install the bead cutting tool and the cylinder head in a drill press. Set drill press speed at **not** more than 75 RPM.

Use a cutting oil to lubricate the cutter head.

Carefully machine the bottom of the bore until the grooves (steps) are smooth.

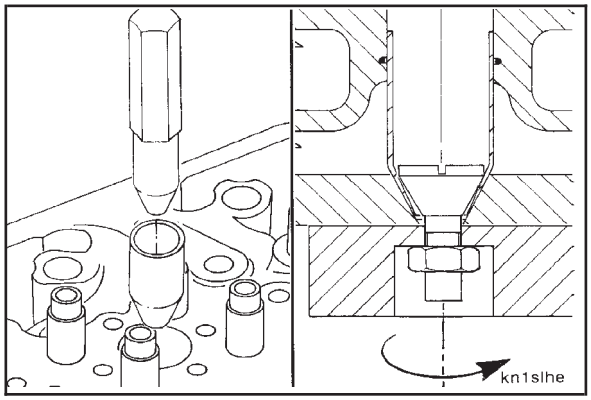
Clean the metal particles from the injector bore.



Assembly

Use vegetable oil to lubricate the injector sleeve o-rings.

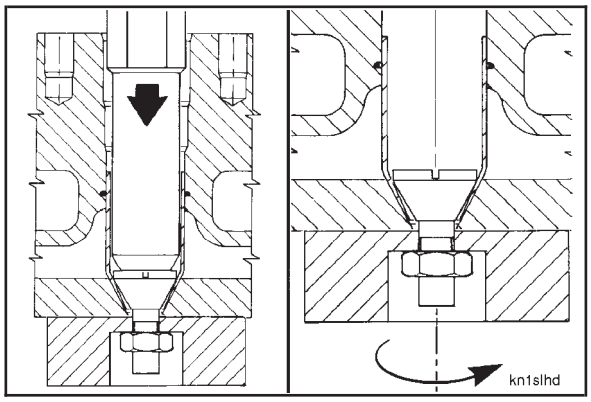
Install the o-ring (1) into the groove of the injector sleeve bore.



Use an injector sleeve driver, Part No. ST-1227, to push the injector sleeve into the cylinder head. Do **not** hit the driver with a hammer. Remove the sleeve driver.

Install an injector sleeve holding tool, Part No. ST-1179, into the injector sleeve and tighten the nut.

Torque Value: 60 N•m [45 ft-lb]



Install the injector sleeve driver against the holding tool mandrel. Hit the driver two moderate blows with a hammer to seat the sleeve in the bore.

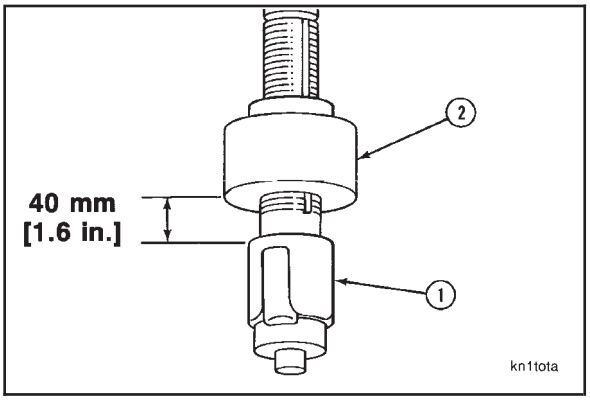
Remove the driver, and tighten the injector sleeve holding tool nut again.

Torque Value: 60 N•m [45 ft-lb]

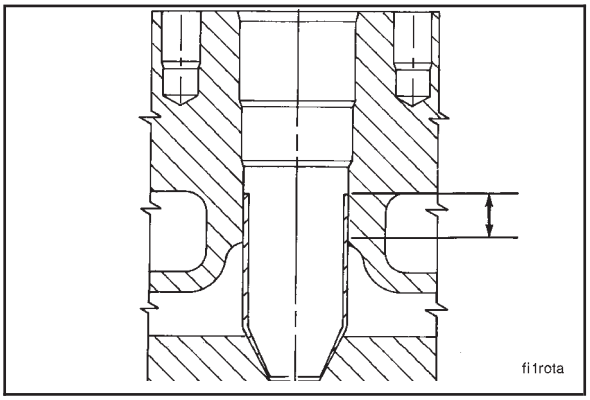
Use an injector sleeve expander, Part No. ST-880, to expand the upper section of the injector sleeve.

Adjust the expander roller edge (1) and the collar (2) to the clearance specified.

Clearance: 40 mm [1.6 inches]



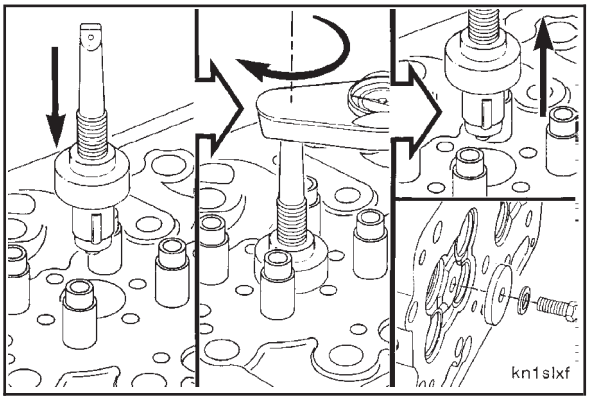
The rollers on the sleeve expander **must** extend 13 mm to 15 mm [0.5-inch to 0.6-inch] below the top of the injector sleeve. Do **not** extend the rollers more than 15 mm [0.6-inch] below the top of the sleeve.



Install the expander in the injector sleeve, and turn the mandrel with an inch pound torque wrench.

Torque Value: 8 N•m [75 in-lb]

Remove the expander and the holding tool from the injector sleeve.



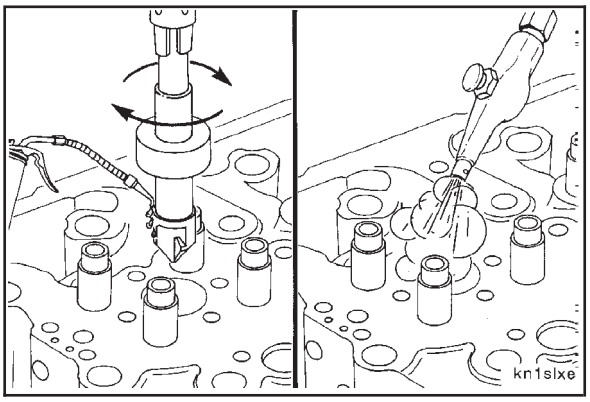
Use a pilot, Part No. ST-884-6; a holder, Part No. ST-884-1; and an injector seat cutter, Part No. ST-884-3, to cut the injector seat.

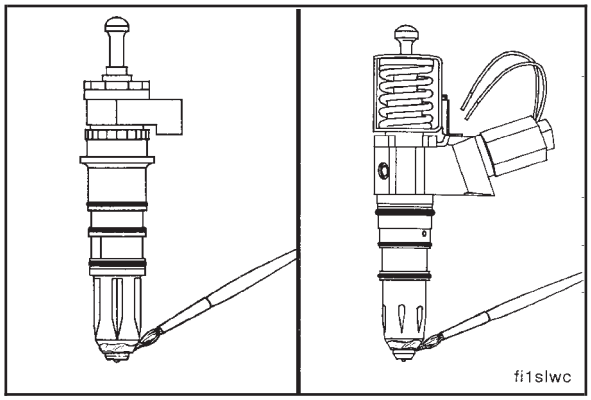
Install the injector sleeve cutter and the cylinder head in a drill press.

Use a generous amount of cutting oil to lubricate the cutter head during the machining operation to prevent galling of the injector sleeve.

Carefully machine the injector sleeve until the sealing area is smooth. Remove only the minimum amount of copper to obtain a smooth sealing area.

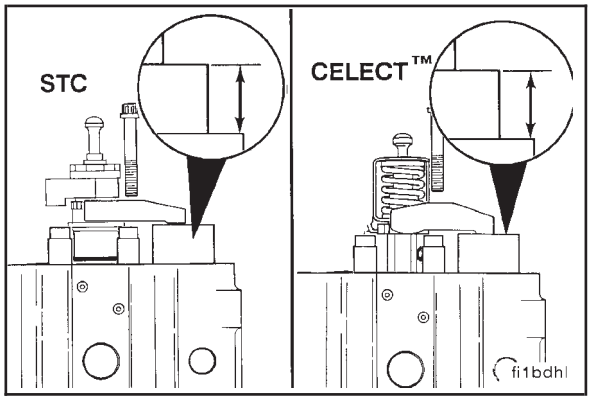
Clean the metal particles from the injector sleeve bore.





Caution: Support the cylinder head to prevent damage to the injector tip that protrudes from the combustion face.

Apply a very light film of blueing compound to the outside diameter of the injector at the injector seat area. Blueing compound can effectively be applied with your finger or with a brush.

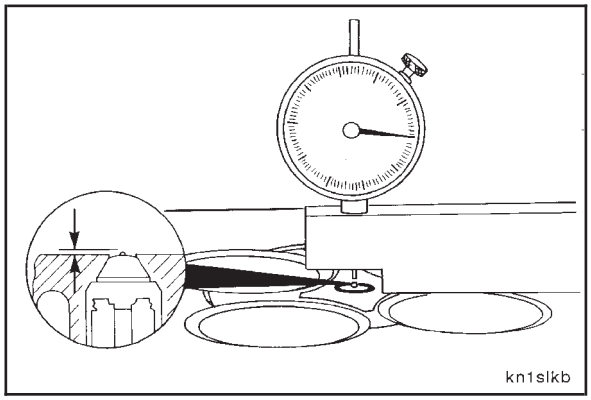


Install the injector in the cylinder head without o-rings.

Place a 1.2-inch thick block under the injector hold down clamp. This represents the rocker housing.

Tighten the injector hold down capscrews.

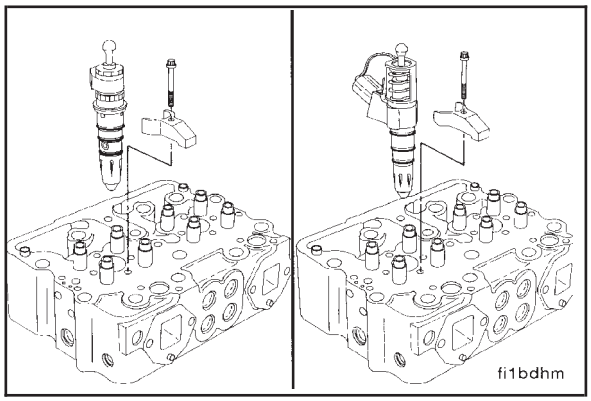
Torque Value: 54 N•m [40 ft-lb] STC and CELECT™



Turn the cylinder head over and use a depth gauge, Part No. 3823495, to measure the injector tip protrusion.

Injector Tip Protrusion		
mm		in
1.47	MIN	0.058
1.82	MAX	0.072

NOTE: If the injector tip protrusion does **not** meet the specifications given, the injector sleeve **must** be machined again.

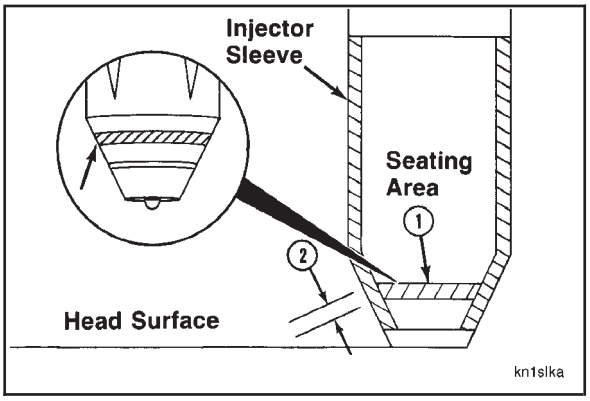


Remove the injectors from the cylinder head, and check the pattern of the blueing compound in the injector sleeve.

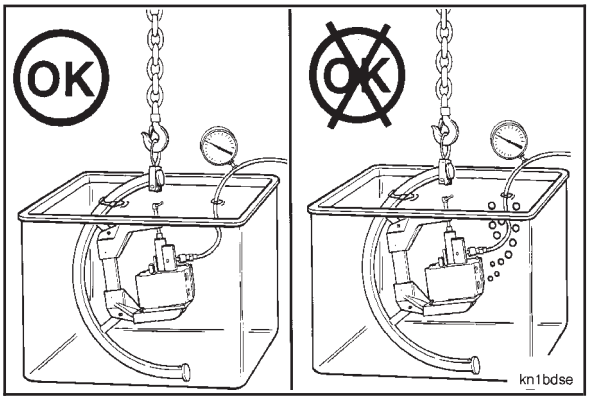
The blueing pattern in the injector seating area (1) **must** be visible 360 degrees around the seating area.

The injector bore seating width (2) **must** be a minimum of 1.52 mm [0.060-inch].

NOTE: If the injector protrusion is more than the maximum specified or if the injector sleeve blueing pattern does **not** meet the specifications given, the injector sleeve(s) **must** be replaced. Refer to Cylinder Head - Replacing the Injector Sleeves (02-07).



NOTE: Inspect the cylinder head for leaks after the new injector sleeves have been installed. Refer to Cylinder Head - Pressure Testing (02-08).

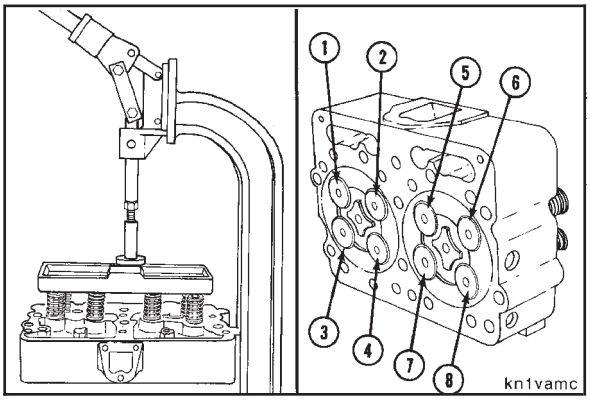


Cylinder Head - Pressure Testing (02-08)

Caution: Do not pressure test the cylinder head with the valves and the valve springs installed. If the cylinder head is assembled, the valve guides and the valve stems can be damaged because they cannot be dried thoroughly.

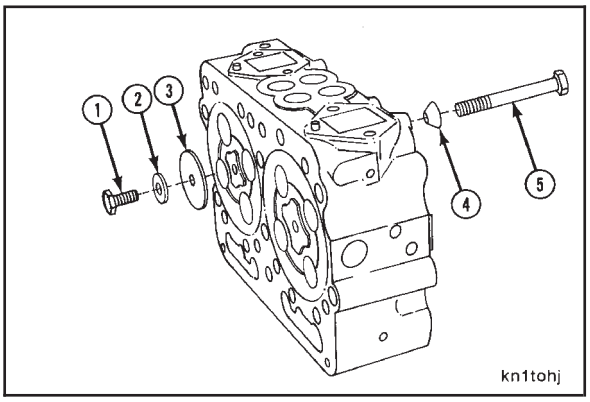
Remove the valves and the valve springs as follows:

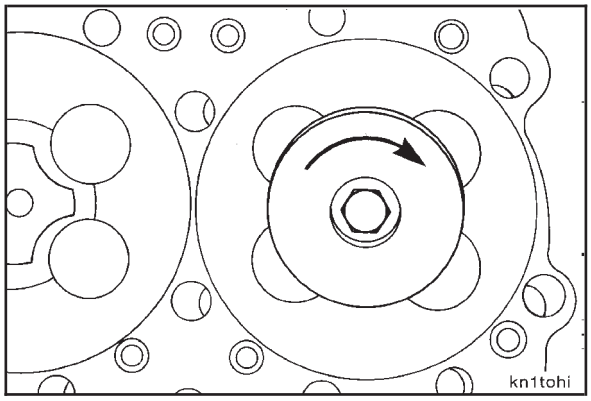
1. Use valve spring compressor stand, Part No. ST-1022, and valve spring compressor plate, Part No. ST-1026.
2. Mark each valve as it is removed to identify its location in the cylinder head.



Install two injector sleeve holding tools, Part No. ST-1179, in each cylinder head.

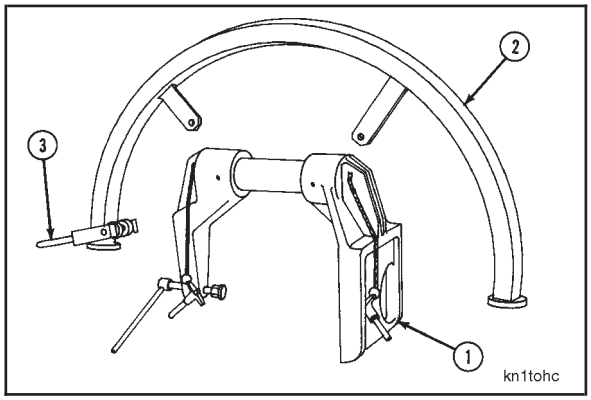
ST-1179 Injector Sleeve Holding Tool Description
(1) Hex Head Capscrew (1)
(2) Flat Washer (1)
(3) ST-1179-2 Anvil (1)
(4) 3377347 Nut and Plug Assembly (1)
(5) Hex Head Capscrew (1)



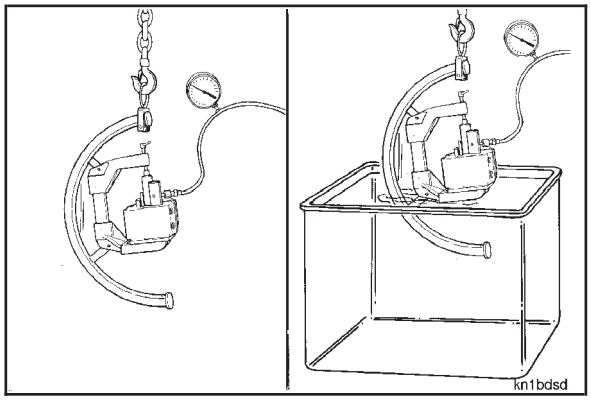


Tighten the injector sleeve holding tool capscrew.

Torque Value: 5 N•m [45 in-lb]
10 N•m [90 in-lb]
15 N•m [130 in-lb]



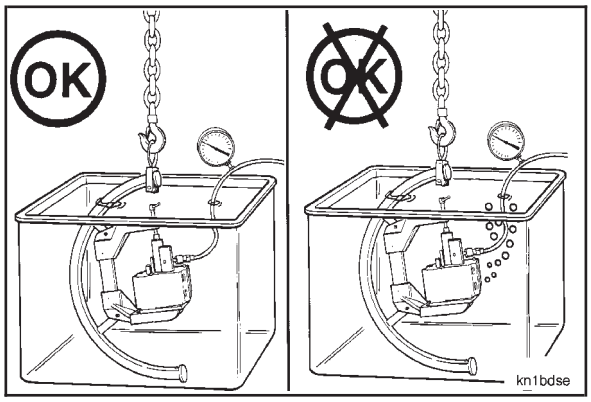
Install the cylinder head in a hydrostatic tester, Part No. ST-1012, and a hydrostatic tester adapter plate, Part No. ST-1013.



Connect a regulated air supply hose to the test fixture plate.

Apply 275 kPa [40 psi] air pressure.

Use a hoist to put the cylinder head in a tank of warm water heated to 60°C [140°F].



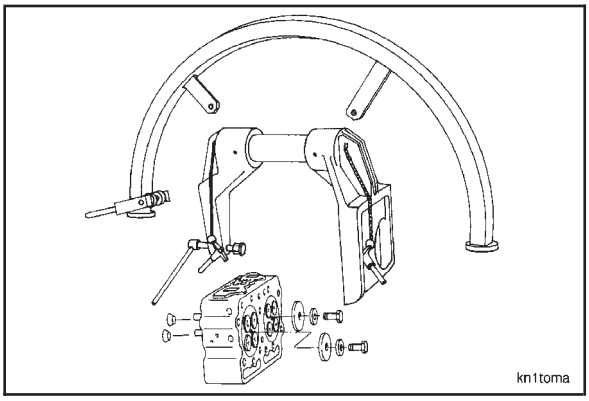
Completely submerge the cylinder head in the water.

Visually inspect for air bubbles rising from the water.

If air bubbles are seen, repair the leaking area.

Remove the test equipment.

Dry the cylinder head with compressed air.



Assemble the cylinder head. Refer to ‘‘Assembly’’ under Cylinder Head - Rebuild (02-02).

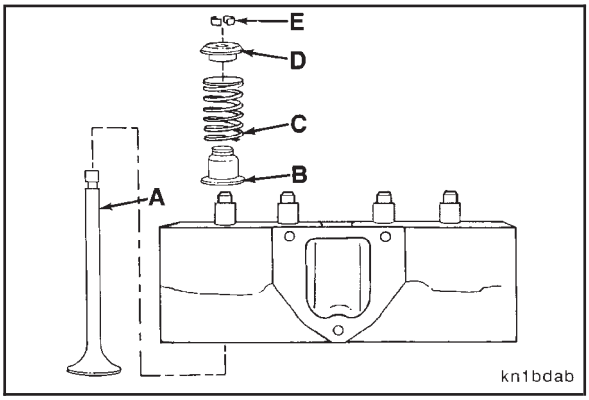
A. Valve

B. Valve Stem Seal

C. Valve Spring

D. Valve Spring Retainer

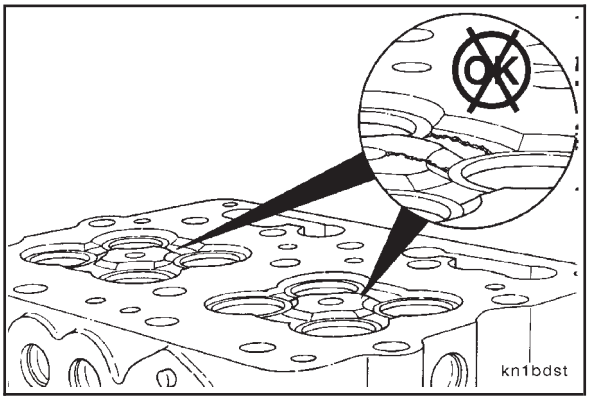
E. Collets



Cylinder Head - Magnetic Particle Checking (02-09)

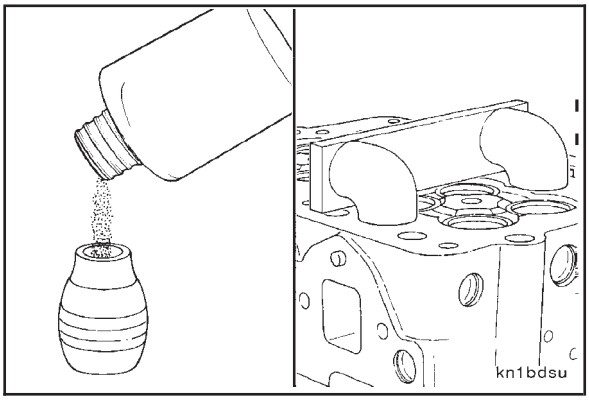
Caution: The cylinder head must be thoroughly cleaned after using the magnetic crack detector, Part No. ST-1166, so that all iron fragments are removed.

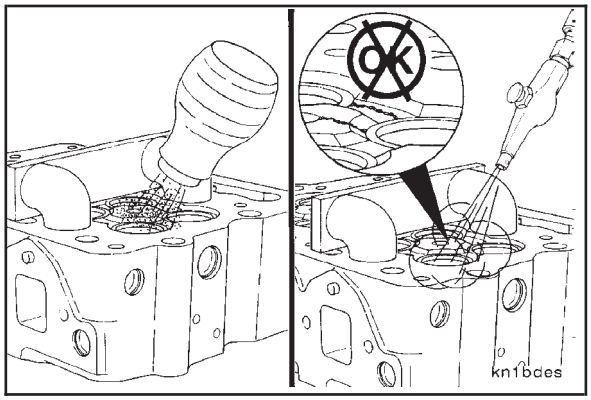
Use the magnetic crack detector, Part No. ST-1166, to find cracks in the areas around the valves and the injectors.



Fill the powder spray bulb one-third full of metal powder.

Put the magnetizing head on the cylinder head combustion surface as shown to check for cracks that run across the head.

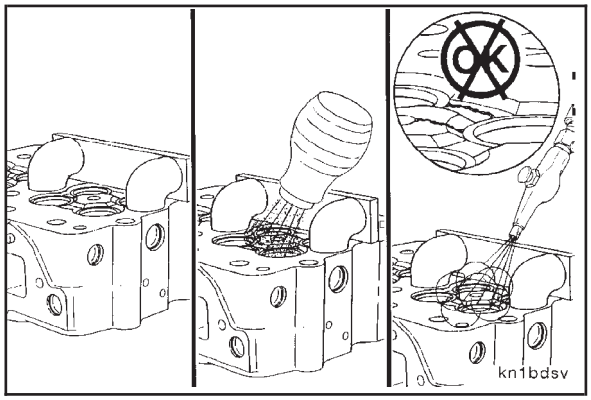




Lightly spray the metal powder onto the combustion surface.

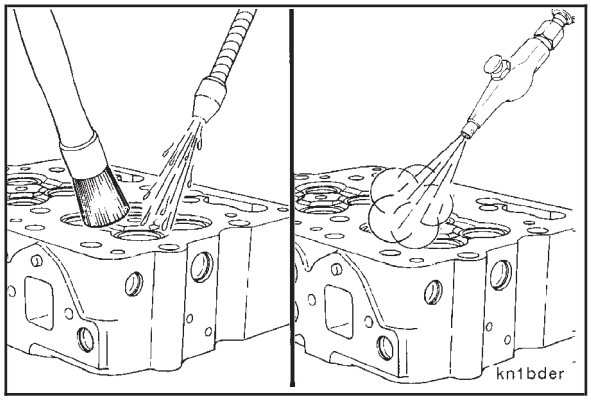
Use compressed air regulated to 205 kPa [30 psi] to remove excess powder from the area. The powder will remain if there are any cracks and will appear as a white line.

Visually inspect the cylinder head for cracks in the combustion face.

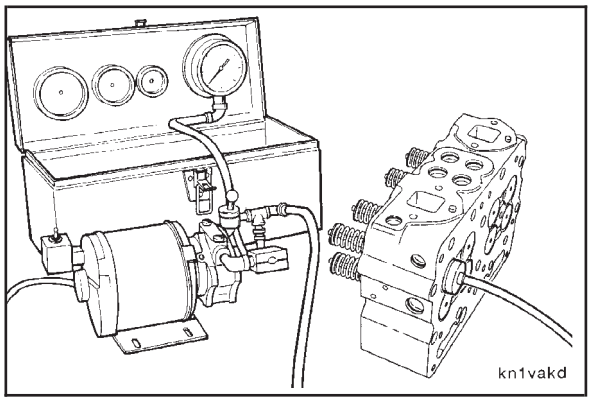


Put the magnetizing head on the combustion surface as shown to check for cracks that run lengthwise of the cylinder head.

Repeat the procedure as outlined above.



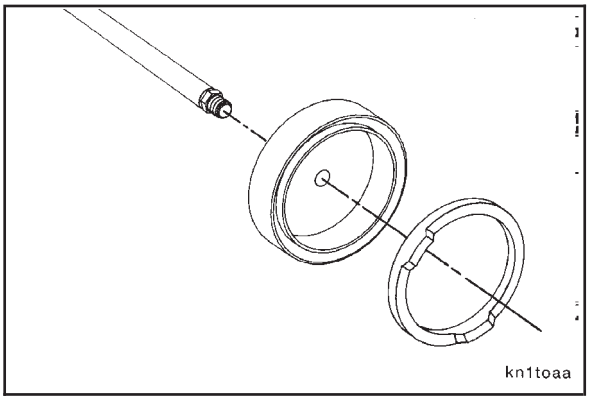
Clean with solvent. Dry with compressed air.



Cylinder Head - Vacuum Testing Valve Seating for Reuse (02-10)

Use valve vacuum tester, Part No. ST-1257, to inspect the seal between the valve and the valve seat.

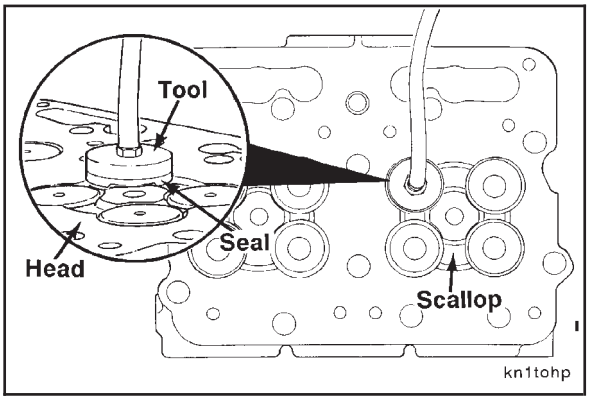
Install the seal ring, Part No. 3823848, and the vacuum cup, Part No. 3823847, to the vacuum hose.



NOTE: The valves and the valve seats **must** be clean and dry when vacuum testing.

Cover the valve with the cup and the seal.

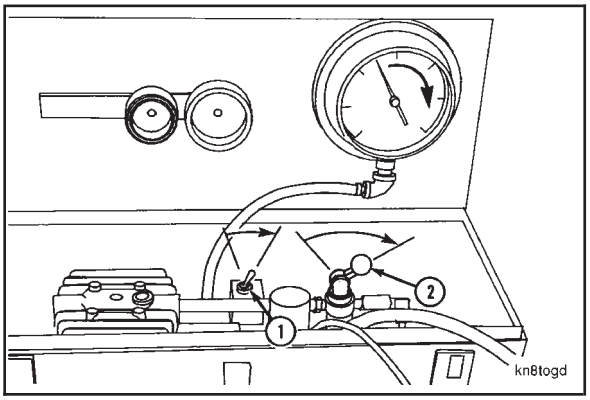
NOTE: The seal **must** make a tight contact on the cylinder head around the valve. The seal **must** completely fill the two milled areas between the valves.



Move the toggle switch (1) to the ''ON'' position.

Turn the vacuum control valve (2) to the ''OPEN'' position.

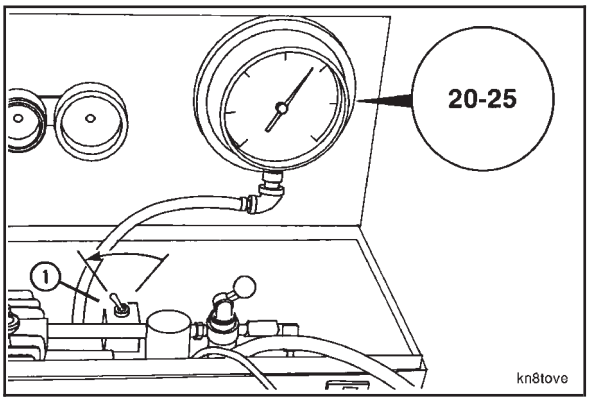
NOTE: The vacuum control valve is in the ''OPEN'' position if the vacuum gauge needle moves **clockwise**.

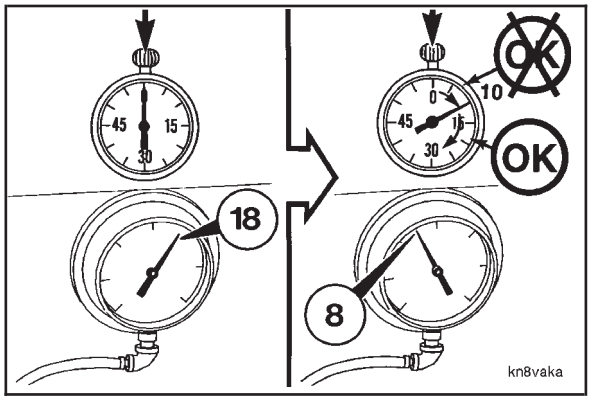


Operate the vacuum pump until the gauge indicates the specified vacuum.

Valve to Valve Seat Vacuum		
mm-Hg		in-Hg
5.08	MIN	20
6.35	MAX	25

Turn the toggle switch (1) to the ''OFF'' position.

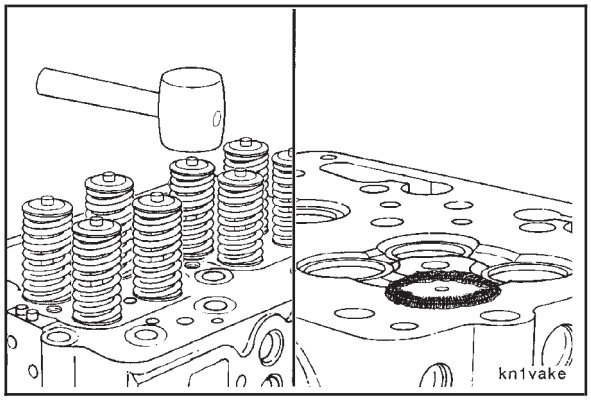




Use a stopwatch. Start timing when the needle on the gauge indicates 457 mm-Hg [18 in.Hg].

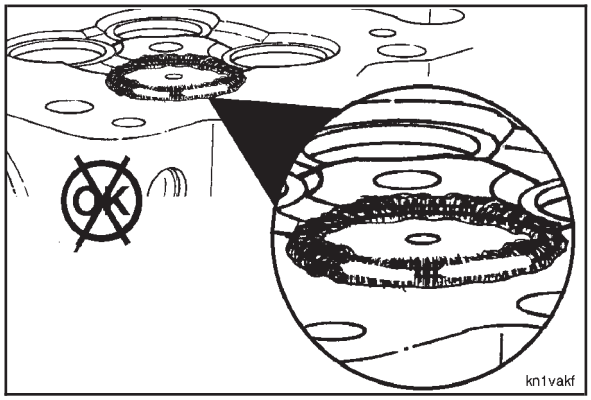
Stop timing when the needle on the gauge indicates 203 mm Hg [8 in.Hg].

The elapsed time for the needle to move between the specified gauge readings **must** be 10 seconds or more.

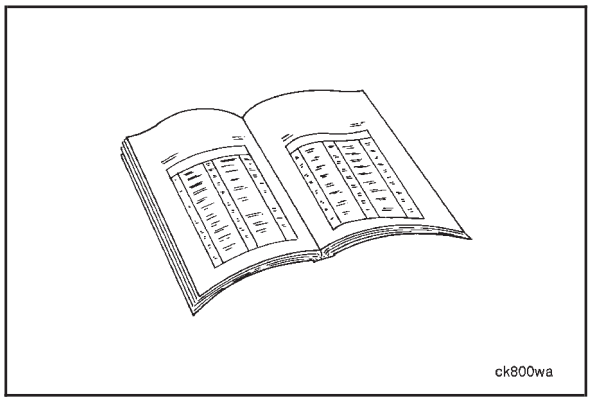


If the elapsed time is less than 10 seconds, perform the following checks:

- Repeat the test to make sure the equipment is operating correctly.
- Use a mallet to lightly hit the valve stem to make sure the valve is seated. Repeat the test.
- Apply a thin layer of grease on the outside diameters of the insert and the valve head. Repeat the test. The grease pattern will show the point of leakage.



NOTE: A break in the grease seal pattern will indicate leakage between the valves and the valve seat or the valve seat insert and the cylinder head. Refer to Cylinder Head - Rebuild (02-02).



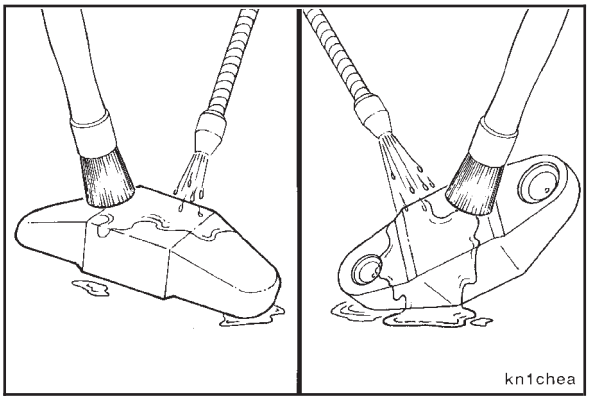
Cylinder Head - Valves - Magnetic Crack Inspection (02-11)

Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the intake and exhaust valves.

Valve Crosshead - Cleaning and Checking for Reuse (02-12)

Cleaning

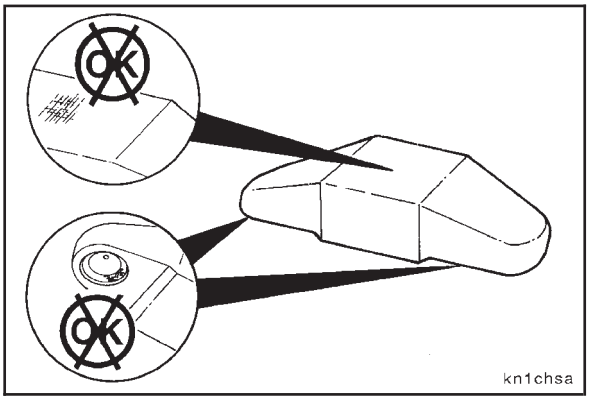
Use solvent to clean the crosshead. Dry with compressed air.



Inspection

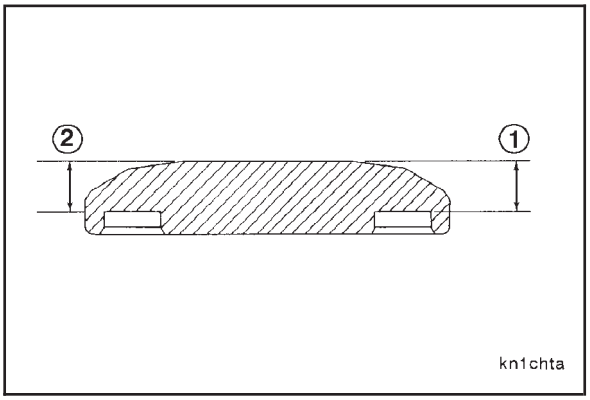
Visually inspect the rocker lever contact pad for wear, cracks, or damage.

Visually inspect the valve stem contact areas for damage.



Measure both valve stem pocket depths from the valve stem pocket to the rocker pad face (1).

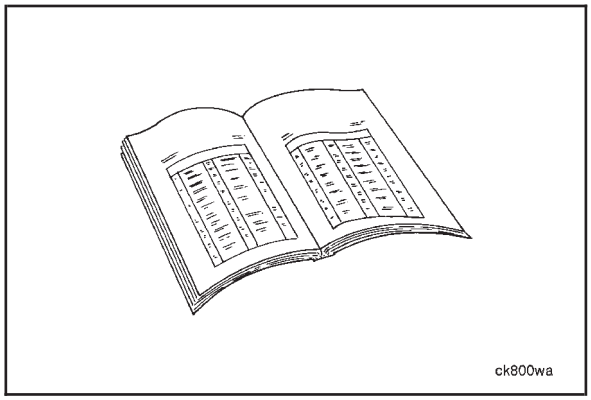
Stem Pocket to Pad Face		
mm		in
11.53	MIN	0.454
12.55	MAX	0.494



On a given crosshead, the stem pocket to pad bore dimension (1) on one end **must** fall to within 0.020 inch of the dimension (2) on the **opposite** end.

In a cylinder head assembly, the crosshead to valve spring retainer **must** be a minimum of 0.020 inch.

NOTE: If damaged parts are found or if the stem bore or pocket depth are **not** within the limits specified, the parts **must** be replaced. If cracks are suspected, refer to Valve Crosshead - Magnetic Crack Inspection (02-13).



Valve Crosshead - Magnetic Crack Inspection (02-13)

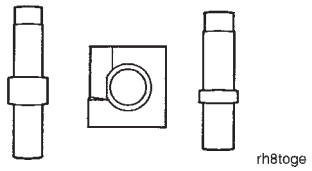
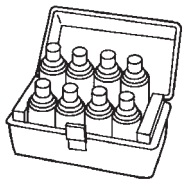
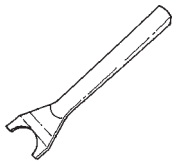
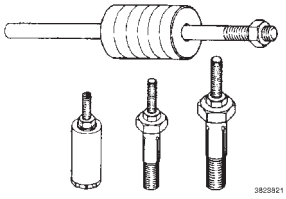
Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the valve crosshead.

Section 3 - Rocker Lever Housing Assembly - Group 03

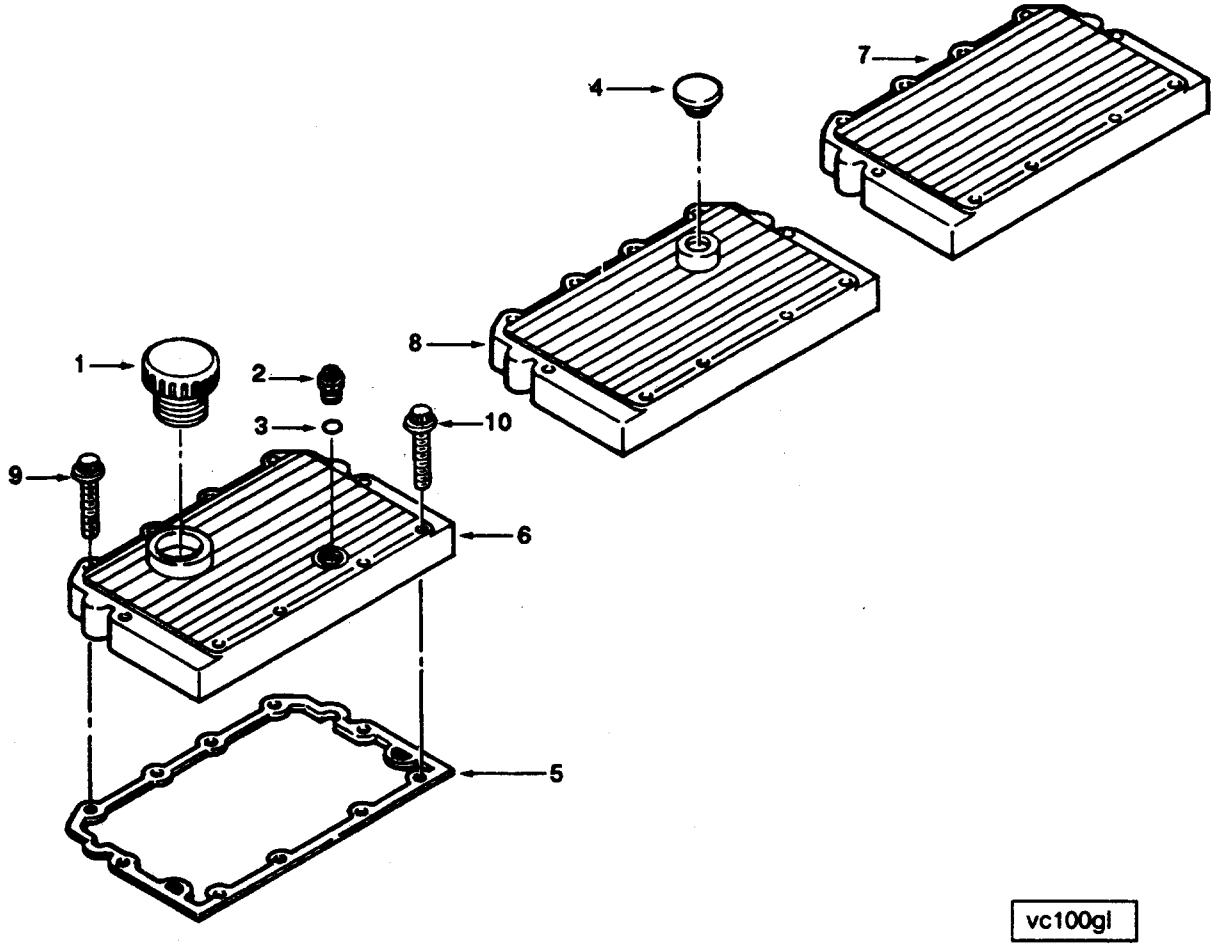
Section Contents

Rocker Lever Housing Assembly - Service Tools

The following special tools are recommended to perform procedures in section 3. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

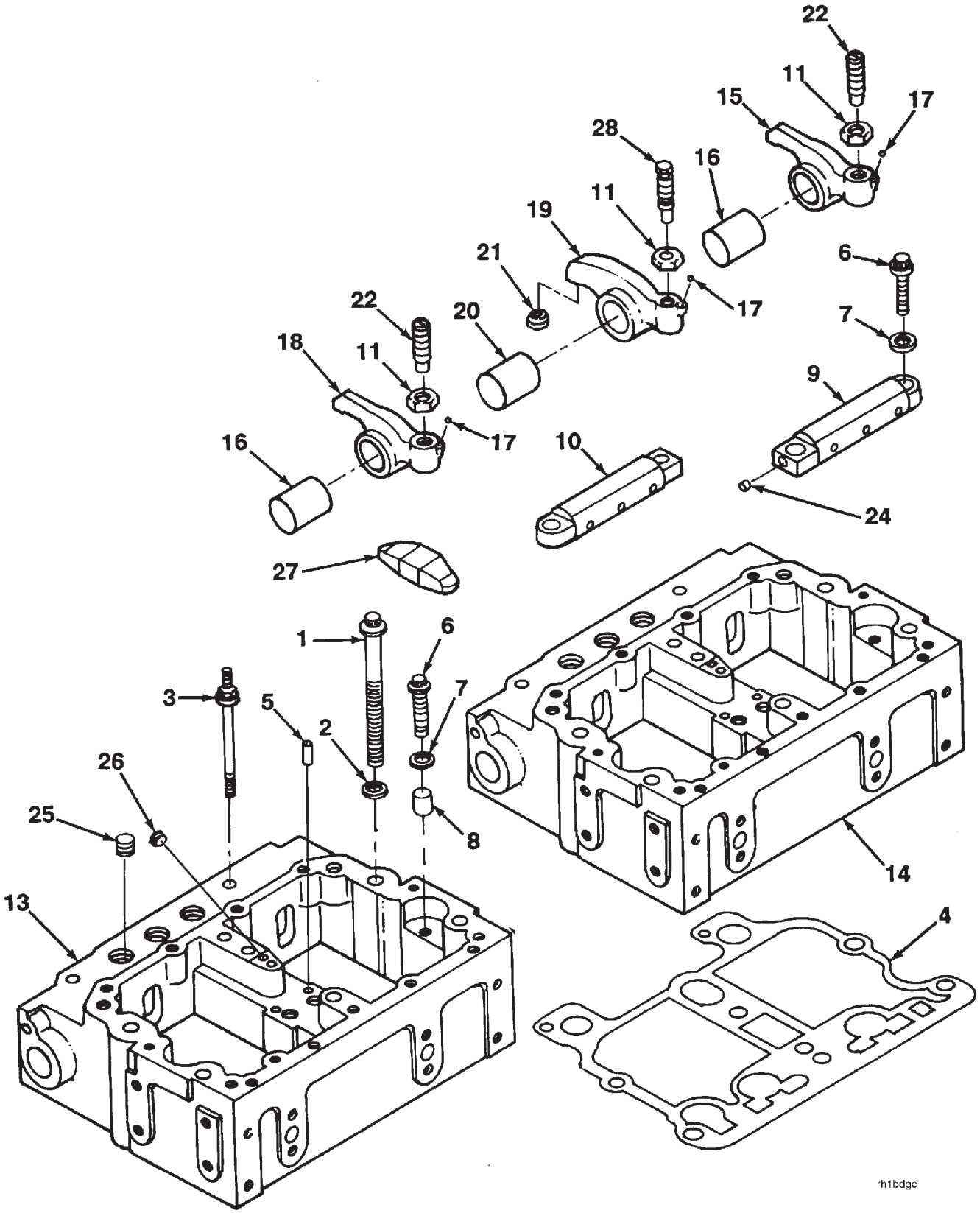
Tool No.	Tool Description	Tool Illustration
ST-691	**Rocker Lever Block and Mandrel Set** Used to remove and install precision steel bushings in the rocker levers.	 rh8toge
3375068	**Cup Plug Sealant** Used when installing pipe plugs, cup plugs, etc., on the engine to stop leaks.	 bp8togk
3375432	**Crack Detection Kit** Inspect components for cracks.	 bp8togj
3823819	**Water Manifold Tube and Plug Removal Tool** Used to remove the water manifold tube and plug.	 wm1toga
3823821	**Dowel Pin Extractor (or its equivalent)** Used to pull dowel pins and ring dowels from rocker housing assembly.	 3823821

Rocker Lever Housing Cover - Exploded View



Reference No.	Description	Qty.	Reference No.	Description	Qty.
1	Cap, Filler	1	6	Cover, Rocker Lever Housing	1
2	Plug, Threaded	1	7	Cover, Rocker Lever Housing	1
3	Seal, O-ring	1	8	Cover, Rocker Lever Housing	1
4	Seal, Grommet	1	9	Capscrew, Captive Washer	18
5	Gasket, Rocker Lever Housing Cover	3	10	Capscrew, Captive Washer	12

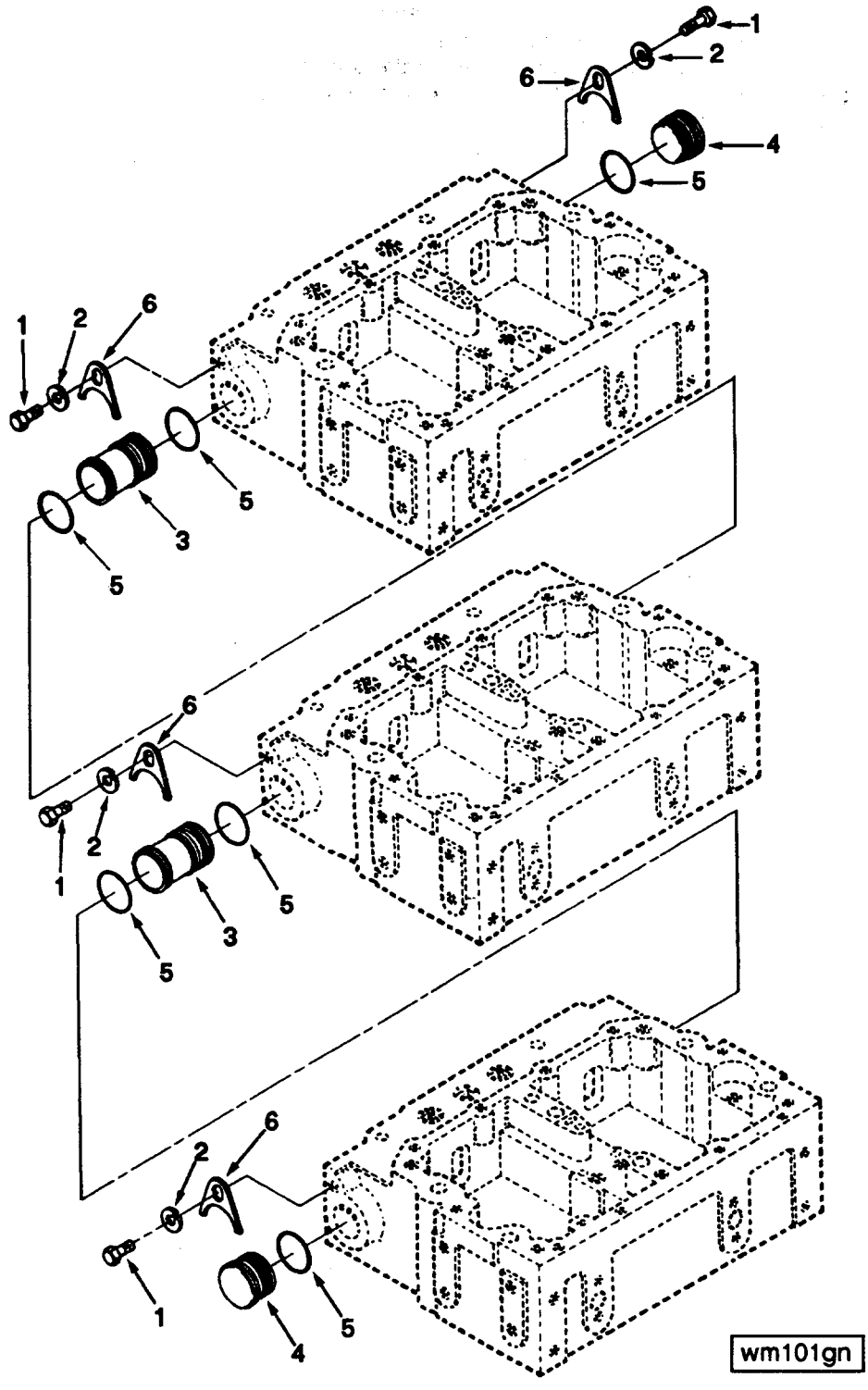
Rocker Lever Housing Assembly - Exploded View



Rocker Lever Housing Assembly - Exploded View

Reference No.	Description	Qty.
1	Capscrew, Twelve Point	18
2	Washer, Plain	18
3	Capscrew, Hexagon Head	6
4	Gasket, Rocker Lever Housing	3
5	Dowel, Pin	6
6	Capscrew, Twelve Point	12
7	Washer, Plain	12
8	Dowel, Ring	6
9	Shaft, Rocker Lever	3
10	Shaft, Rocker Lever	3
11	Nut, Regular Hexagon Jam	18
13	Housing, Rocker Lever	1
14	Housing, Rocker Lever	2
15	Lever, Rocker	6
16	Bushing	1
17	Plug, Ball	2
18	Lever, Rocker	6
16	Bushing	12
17	Plug, Ball	18
19	Lever, Rocker	6
20	Bushing	1
21	Socket, Tappet	1
17	Plug, Ball	2
22	Screw, Slotted Set	12
24	Plug, Expansion	6
25	Plug, Pipe	9
26	Plug, Pipe	3
27	Crosshead, Valve	12
28	Screw, Hexagon Head Set	6

Water Manifold Plumbing - Exploded View

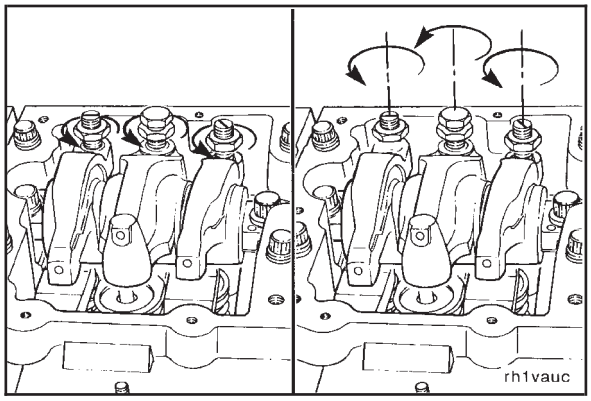


Reference No.	Description	Qty.
1	Capscrew, Hexagon Head	4
2	Washer, Lock	4
3	Tube, Water Transfer	2

Reference No.	Description	Qty.
4	Plug, O-ring	2
5	Seal, O-Ring	6
6	Retainer, Plug	4

Rocker Lever Housing Assembly - General Information

The rocker lever housing assembly group consists of the rocker lever assembly, the step timing control (STC) oil manifold connector, external oil manifold, internal oil tube, and the rocker housing cover. The rocker levers contain replaceable bushings. The intake, the exhaust, and the injector rocker levers contain ball plugs to plug the oil drilling holes in the levers. The rocker lever pad on the intake and the exhaust rocker levers is precision ground and **must not** be repaired. Oil flows through the rocker lever shaft to the rocker levers. The levers are push rod actuated and use an adjusting screw to control the clearance between the lever and the valve crosshead or injector link.



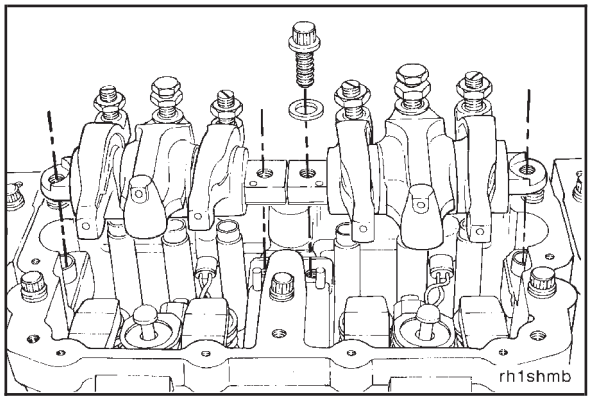
Rocker Lever - Cleaning and Inspection for Reuse (03-01)

Disassembly

Loosen the valve and injector adjusting screw lock nuts on each rocker lever.

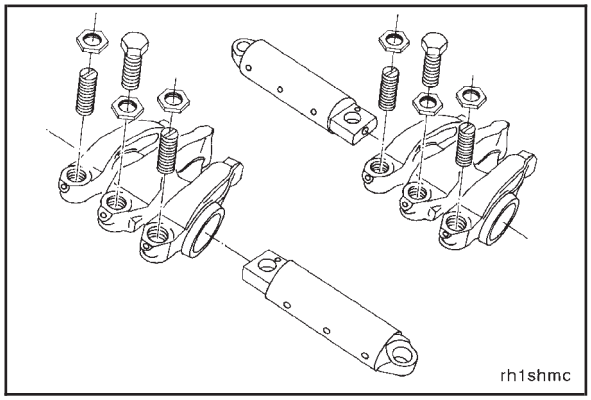
Turn the adjusting screws **counterclockwise** until the rocker levers are loose.

Caution: Do not attempt to remove or install the rocker lever shaft assemblies without backing out the adjusting screws. If not loosened, damage to the dowel pins and ring dowels can occur.



Remove the rocker lever shaft capscrews and the rocker lever shaft assemblies.

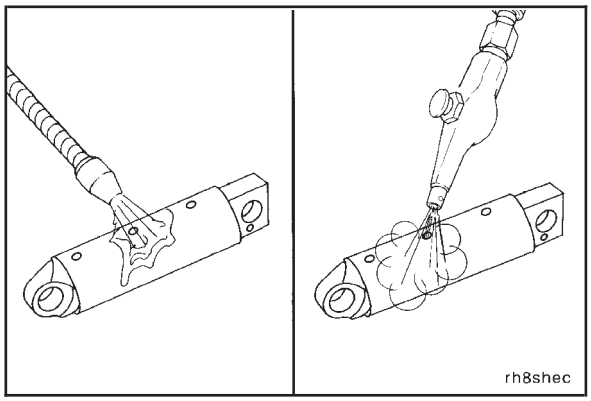
NOTE: To prevent increased wear, mark each rocker lever as it is removed so it can be installed back in its original location.



Remove the rocker levers from the shaft.

Remove the lock nuts and the adjusting screws from the rocker lever.

NOTE: To prevent increased wear, mark each adjusting screw as it is removed so it can be installed back in its original rocker lever.



Cleaning and Inspection

Use steam or solvent to clean the rocker lever shaft.

Dry with compressed air.

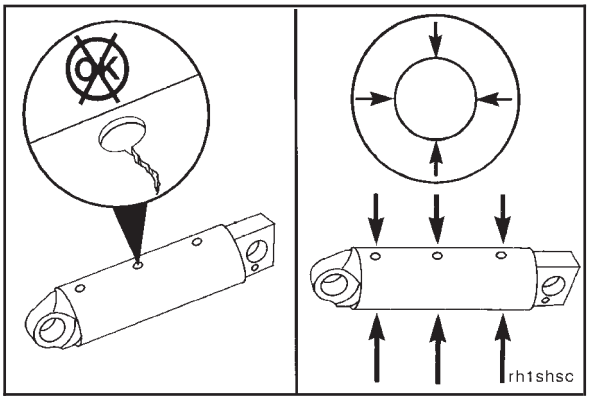
Visually inspect the shaft for cracks or damage.

Light fretting is typically found on the underside of the shaft and is **not** harmful, provided it meets the dimensional specifications.

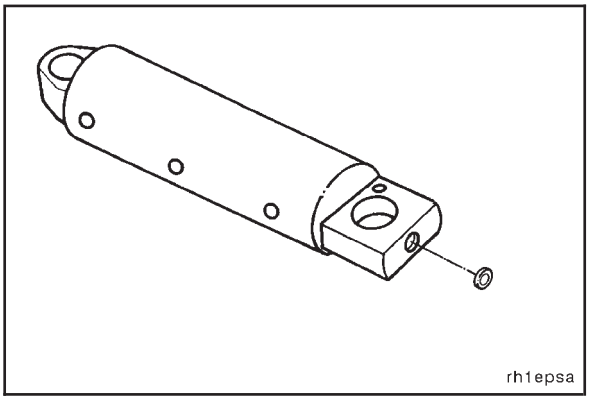
Measure the rocker lever shaft's outside diameter in the bushing wear area.

Rocker Lever Shaft O.D.		
mm		**in**
34.823	MIN	1.3710
34.862	MAX	1.3725

Replace the rocker lever shafts as necessary.

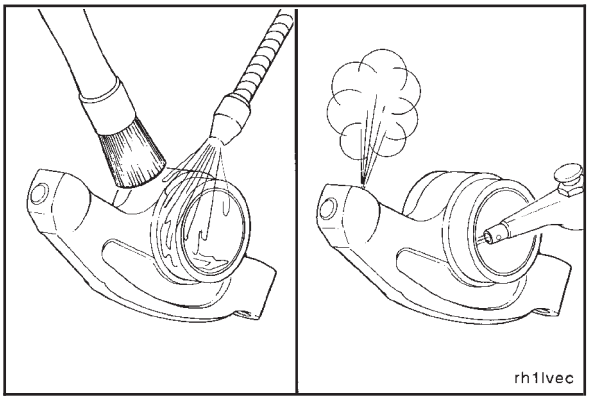


Visually inspect to see that the expansion plug is in place.

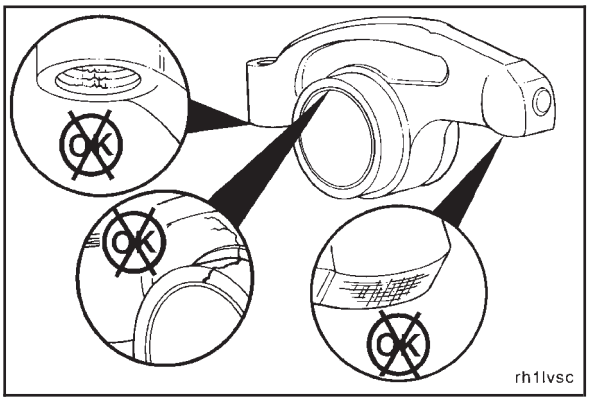


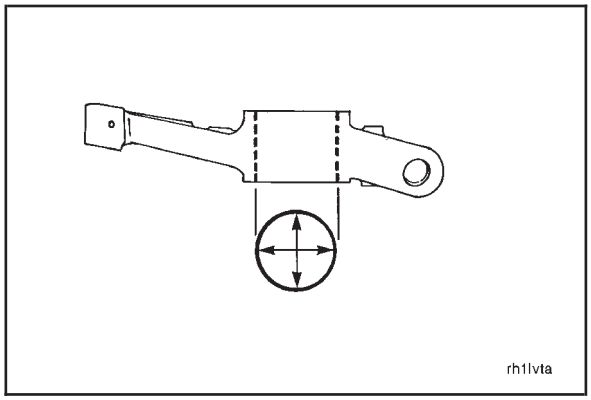
Use steam or solvent to clean the rocker levers, and dry with compressed air.

NOTE: Make sure to blow out the oil passages.



Visually inspect the rocker levers for cracks or unusual wear. Inspect the adjusting screw threads for damage.

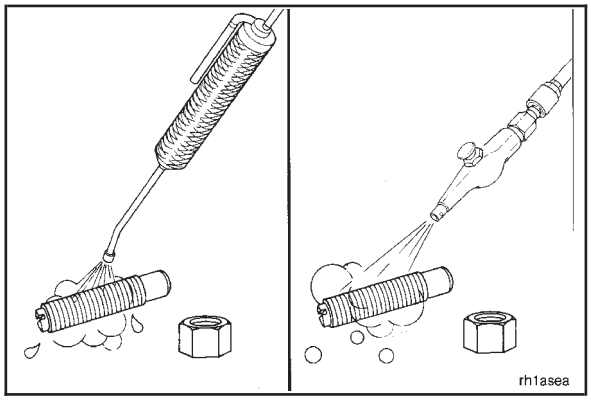




Measure the rocker lever bushing bore inside diameter.

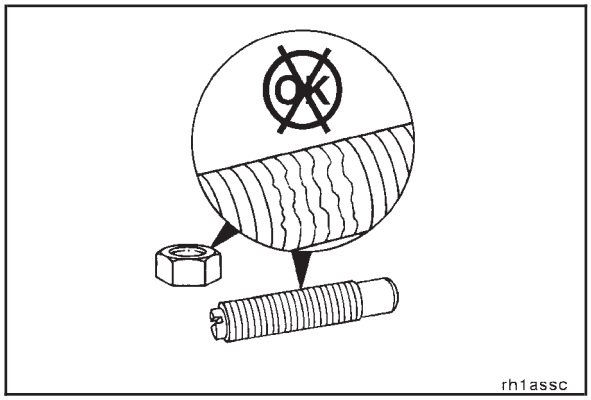
Rocker Lever Bushing I.D. (Installed)		
mm		**in**
34.89	MIN	1.3735
34.99	MAX	1.3775

NOTE: Replace the rocker lever bushings which are worn beyond the maximum limit. Refer to Rocker Lever Bushing - Replacement (03-02).

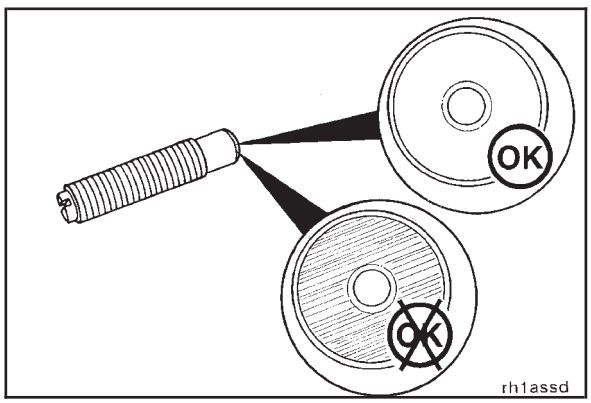


Use steam or solvent to clean the rocker lever adjusting screw and nuts.

Dry with compressed air.



Visually inspect the adjusting screws and the nuts for distorted threads.

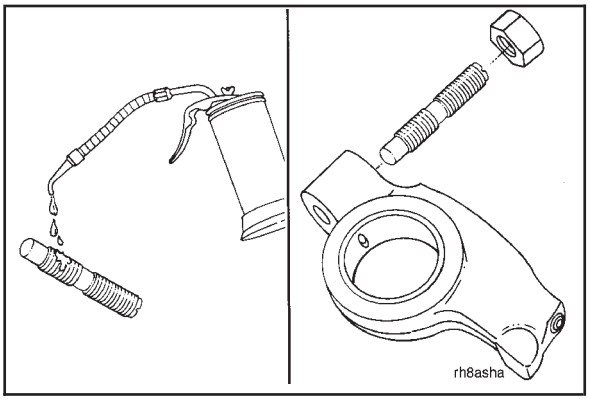


Visually inspect the adjusting screw. The contact area **must** be smooth with an even seating pattern.

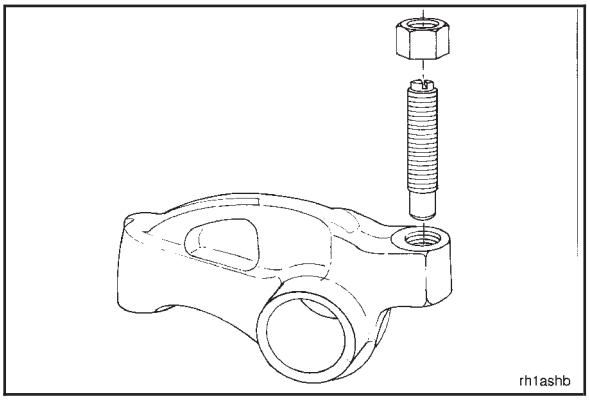
If parallel scratches are found in the contact area, the adjusting screw **must** be replaced. This condition is normally found with worn push rods that will also require replacement.

Assembly

Use clean 15W-40 oil to lubricate the threads of the adjusting screws.

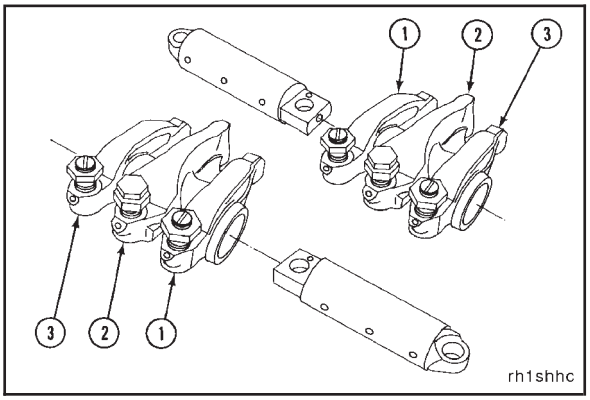


Install the adjusting screw and lock nut in each rocker lever. Do **not** tighten the lock nuts.



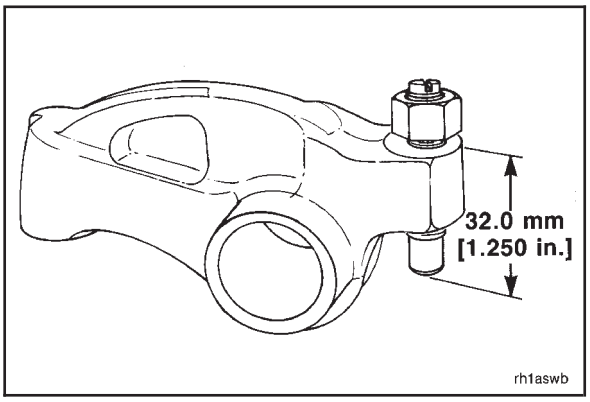
Install the exhaust (1), injector (2), and intake (3) rocker levers onto the shaft.

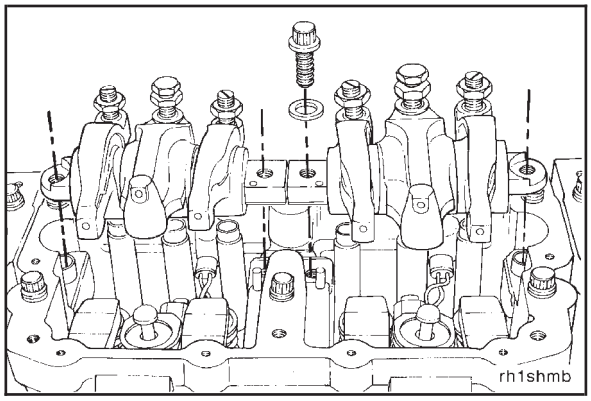
The two levers closest to the center of the rocker housing are the intake valve rocker levers. The levers closest to the end of the rocker housing are the exhaust valve rocker levers.



Caution: If the adjusting screws protrude beyond the maximum listed below, the push rods can be damaged when the housing capscrews are tightened. Do not attempt to install the rocker lever or shaft assemblies again without resetting the lash.

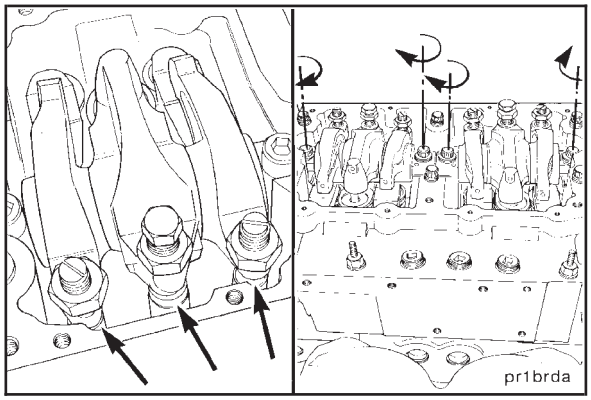
Loosen the rocker lever adjusting screws so there is a maximum of 32 mm [1.250 inches] from the top surface of the lever and the ball end of the adjusting screw.





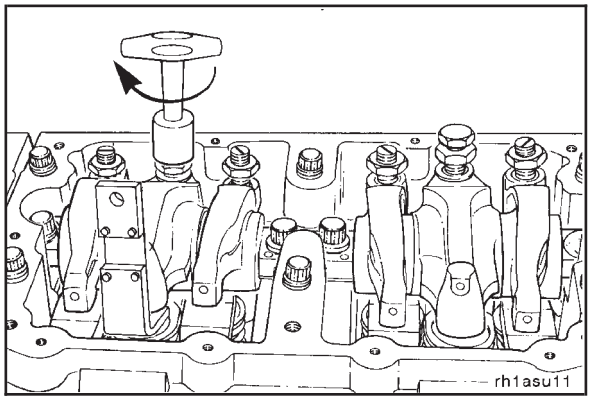
Place the rocker lever assembly over the dowel pin and dowel ring located in the rocker housing.

NOTE: Do **not** damage the dowel pin and dowel ring located in the rocker housing.

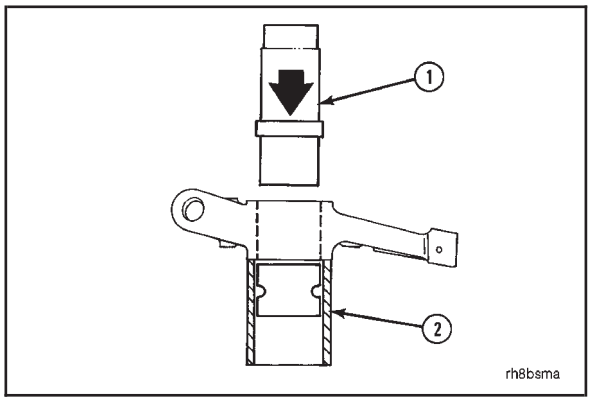


Make sure the push rods are in the cam follower sockets and align the push rods with the injector and valve rocker lever adjusting screws.

Alternately tighten the rocker shaft capscrews in 54 N•m [40 ft-lb] increments to 156 N•m [115 ft-lb].



Adjust the valves and injectors. Refer to Procedure 7-04 in the N14 Troubleshooting and Repair Manual, Bulletin No. 3810456.



Rocker Lever Bushing - Replacement (03-02)

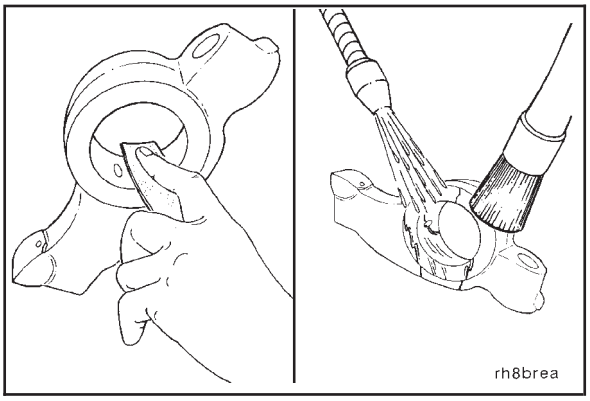
Disassembly

Install the rocker lever in an arbor press.

Use rocker lever block and mandrel set (1), Part No. ST-691, and a support (2) to push the bushing out of the rocker lever.

Use a 240 grit, or finer, emery cloth to remove any rough edges or burrs from the bore of the rocker lever.

Use solvent to clean the rocker levers. Dry with compressed air.



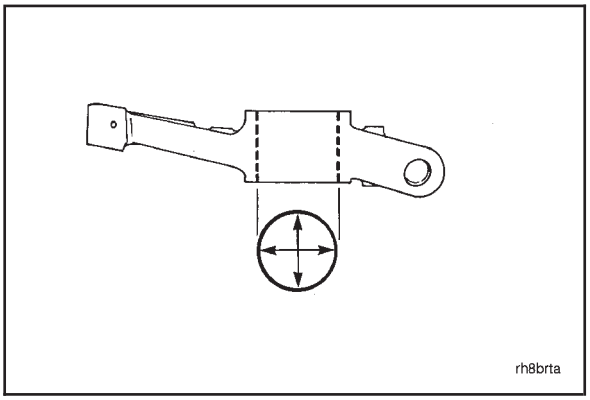
Inspection

NOTE: If cracks in the rocker lever are suspected, refer to Rocker Lever - Magnetic Crack Inspection (03-03).

Measure the inside diameter of the rocker lever bore.

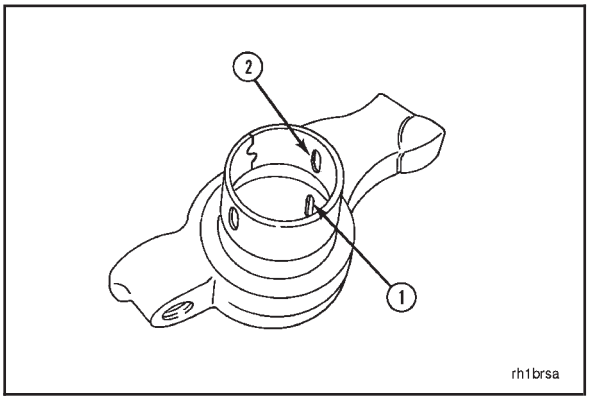
Rocker Lever Bore I.D.		
mm		**in**
36.474	MIN	1.436
36.500	MAX	1.437

NOTE: If the rocker lever bore is worn larger than the maximum specification, the rocker lever **must** be replaced.



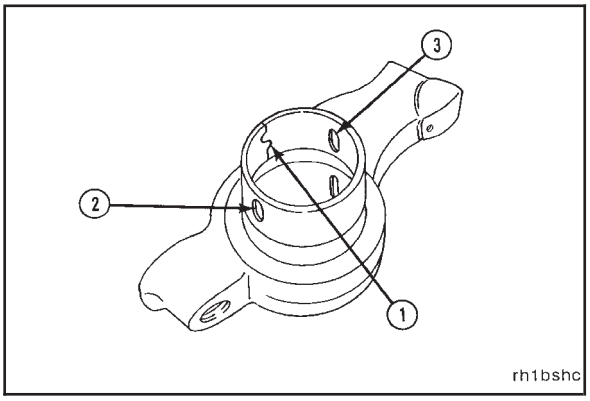
Assembly

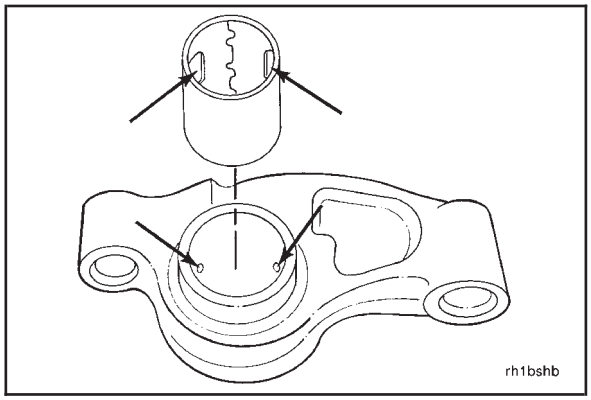
NOTE: The oil holes in the rocker lever bore (1) and the oil holes in the bushing (2) **must** be aligned correctly to supply oil to the adjusting screws, the crossheads, and the injector link.



Install the bushing in the valve rocker lever with the split clinch joint (1) toward the top of the lever.

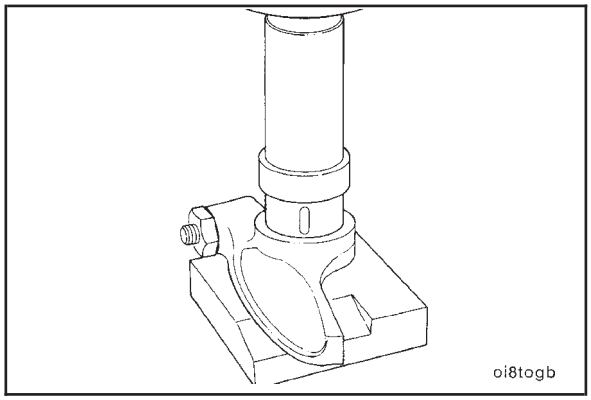
The short ‘‘slot hole’’ (2) **must** be aligned with the oil hole to the adjusting screw. The long ‘‘slot hole’’ (3) **must** be aligned with the oil hole to the lever pad.



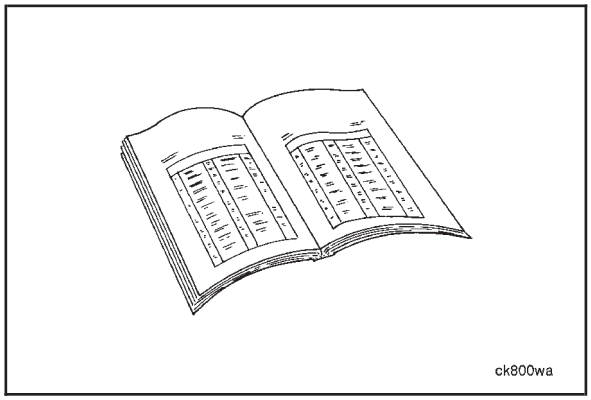


Install the bushing in the injector rocker lever with the split clinch joint toward the top of the lever.

The ''square hole'' **must** be aligned with the oil hole to the adjusting screw. The ''slot hole'' **must** be aligned with the oil hole to the injector link socket.

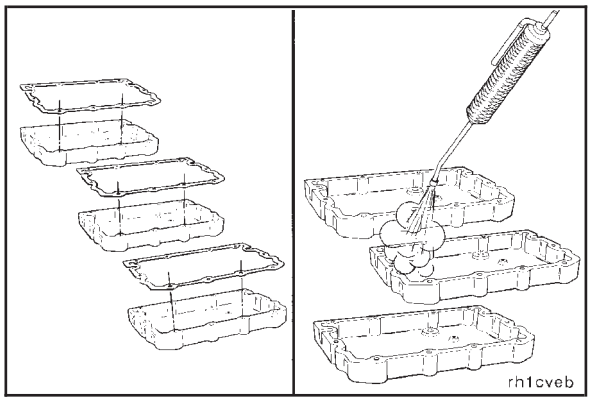


Use an arbor press and a rocker lever block and mandrel set, Part No. ST-691, to push the bushing into the rocker lever.



Rocker Lever - Magnetic Crack Inspection (03-03)

Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the rocker levers.



Rocker Housing Covers - Cleaning and Inspection for Reuse (03-04)

Cleaning

Remove the crankcase breather element, if used, and the oil filler cap. Refer to Procedure 2-05 in the Troubleshooting and Repair Manual N14 Engines, Bulletin No. 3810456.

Remove the gaskets.

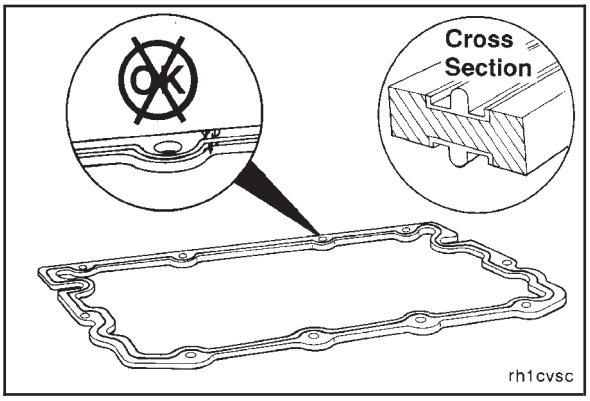
Steam clean the covers, and dry with compressed air.

NOTE: The valve cover gaskets are reuseable. Do **not** damage the gasket when removing or cleaning.

Steam clean the reusable gaskets. Dry with compressed air, and check for cuts or deformations in the silicone bead.

Replace the gasket if there are any cuts, abrasions, or deformations in the silicone bead. Check to see if the nylon carrier is cracked or broken; replace if necessary.

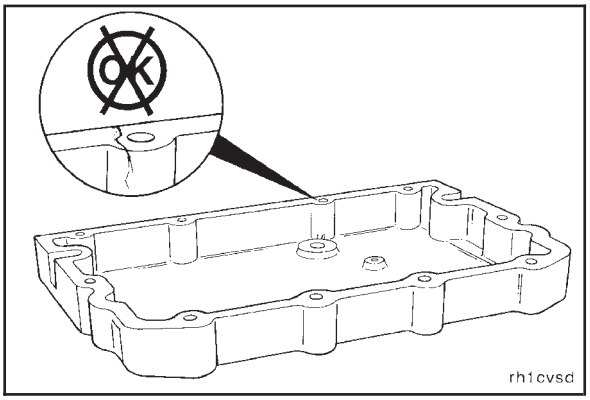
NOTE: The reusable gaskets **must not** be cleaned with solvent. Solvent will deteriorate and swell the silicone bead and destroy the gasket. The gaskets **must** be cleaned with soap and water.



Inspection

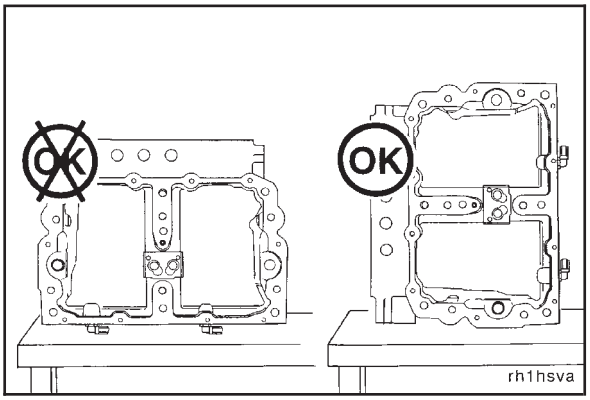
Inspect each cover for cracks or damage, and replace if necessary.

On the cover fitted with the crankcase breather tube, inspect the breather baffle for damage.



Rocker Lever Housing Assembly - Cleaning and Inspection for Reuse (03-05)

NOTE: On CELECT™ engines while handling the rocker lever housings, protect the wiring harness pass through connectors. Do **not** subject the pass through connectors to impact forces and do **not** rest the housing on the face with the pass through connectors.

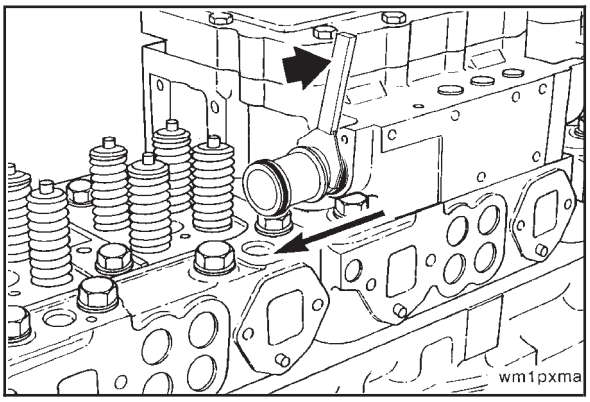


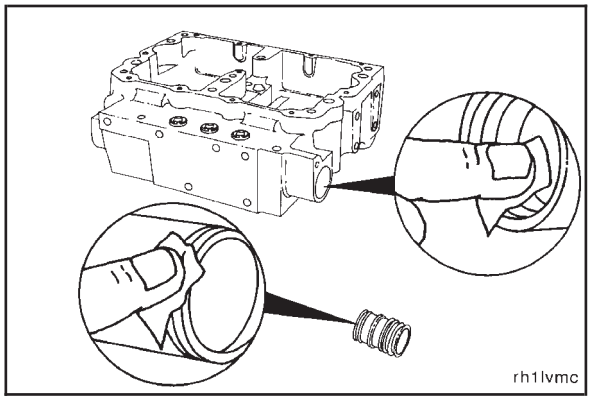
Water Manifold Tube - Removal

Remove the o-ring plug and water tube from the water manifold with service tool, Part No. 3823819.

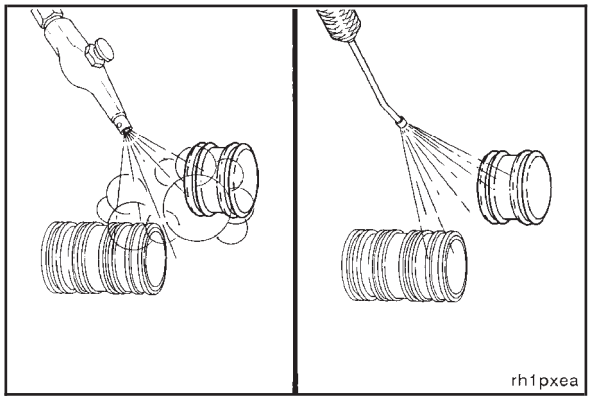
Insert the jumper tube removal tool into the retainer clamp slot. Use a pry bar and pry the jumper tube out of the water manifold.

Discard the o-rings.

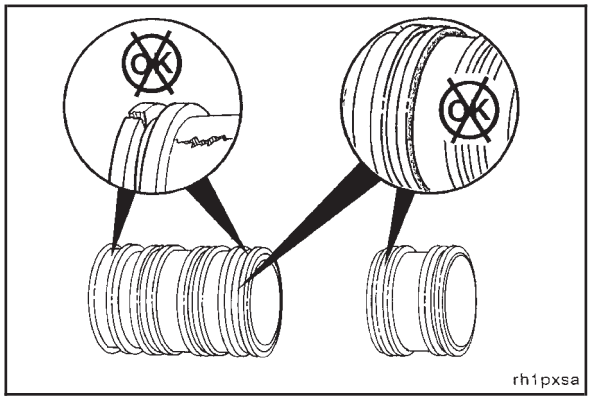




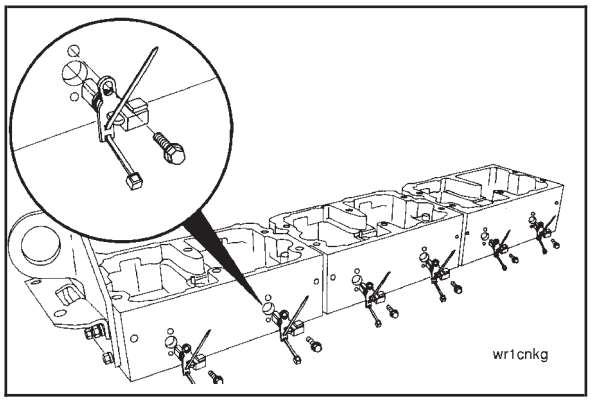
Use Scotch Brite 7448, Part No. 3823258, to clean the o-ring bores in the water manifold and the o-ring grooves in the o-ring plug and water tubes.



Steam clean the o-ring plugs and water tubes. Dry with compressed air.

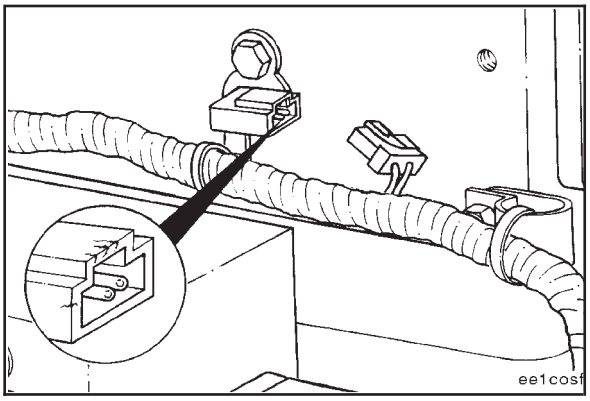


Visually inspect the o-ring plugs and water tubes for cracks, pitting, corrosion, or other damage. Replace if necessary.



On CELECT™ engines, remove the pass through connectors. Refer to the N14 Troubleshooting and Repair Manual CELECT™ System, Bulletin No. 3810469.

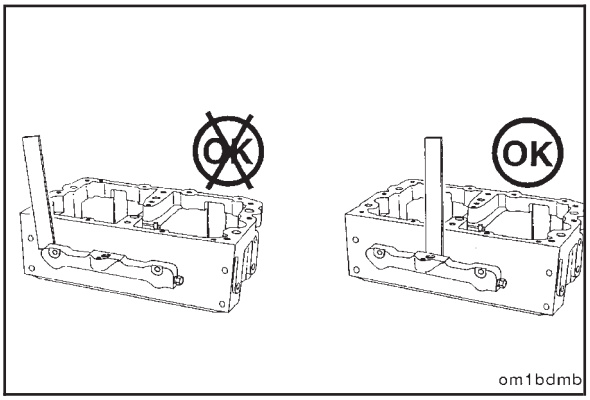
Visually inspect the pass through connectors for cracks, bent contacts, or other damage. Replace if necessary. Refer to the N14 Troubleshooting and Repair Manual CELECT™ System, Bulletin No. 3810469.



On STC engines, remove the oil manifold.

NOTE: When removing the oil manifold connector from the rocker lever housing, use a wide flat pry bar. Pry at the center of the oil manifold. Remove the connector evenly from both of the pass through ports to prevent damage to the connector and the rocker lever housing.

Clean and inspect the oil manifold. Refer to STC Oil Plumbing - Cleaning and Inspection for Reuse (03-06).



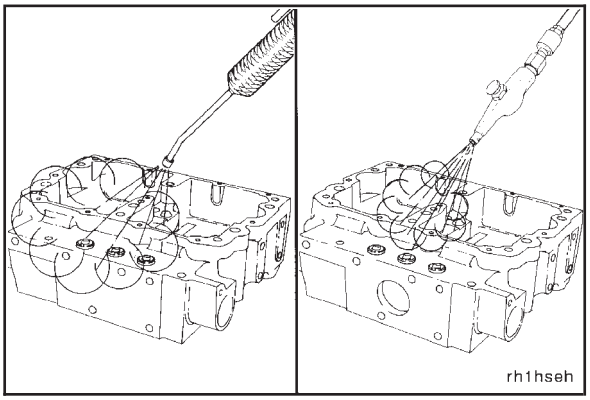
Cleaning

Steam clean the rocker lever housings.

Dry with compressed air.

NOTE: Make sure the oil supply hole is free of dirt or other deposits.

Do **not** remove the rocker shaft dowel pins, dowel rings, or brass cup plug for cleaning.

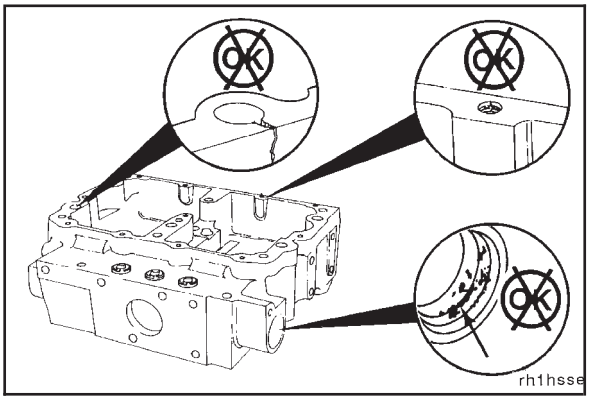


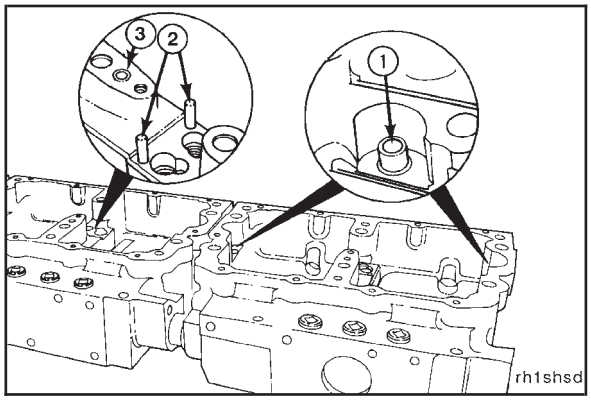
Inspection

Visually inspect the housings for cracks or damage, and replace if necessary.

Visually inspect the capscrew holes for damaged threads. If threads are damaged, refer to the Alternative Repair Manual, Bulletin No. 3379035.

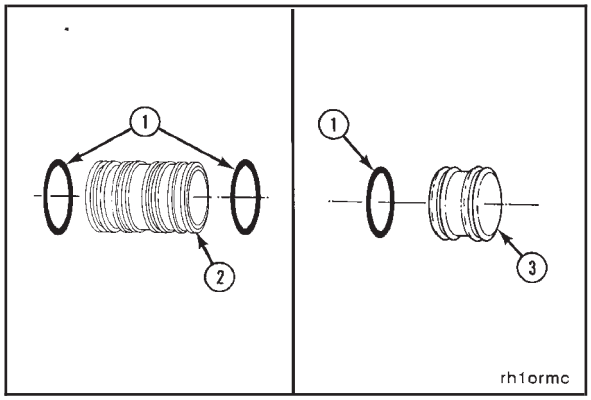
Visually inspect the water manifold sections for cracks, pitting, corrosion, or other damage.





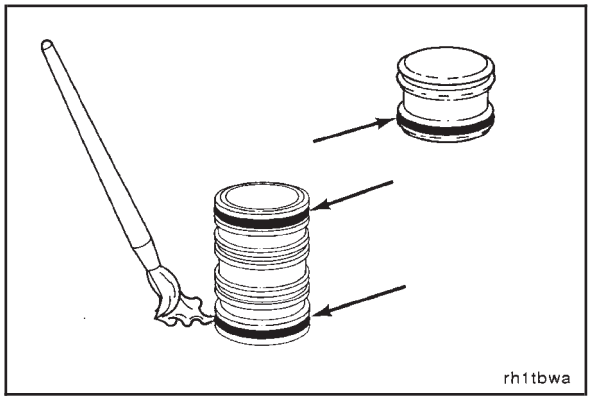
Visually inspect the rocker lever shaft dowel rings (1), the dowel pins (2), and the brass cup plug (3). Replace if necessary.

Use service tool, Part No. 3823821, to remove the dowel pins and dowel rings. Refer to Ring and Pin Dowel - Replacement (03-07).

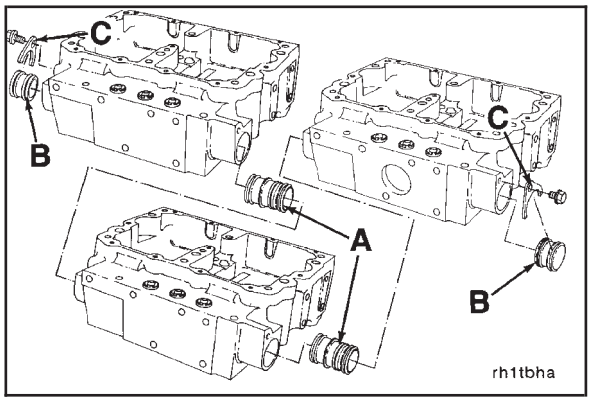


Installation

Install two o-rings (1) on each of the two water tubes (2). Install one o-ring (1) on each of the two water plugs (3).



Apply a non-petroleum based lubricant such as soap or vegetable oil to the o-rings on the tubes and plugs and to the bores in the rocker housings.

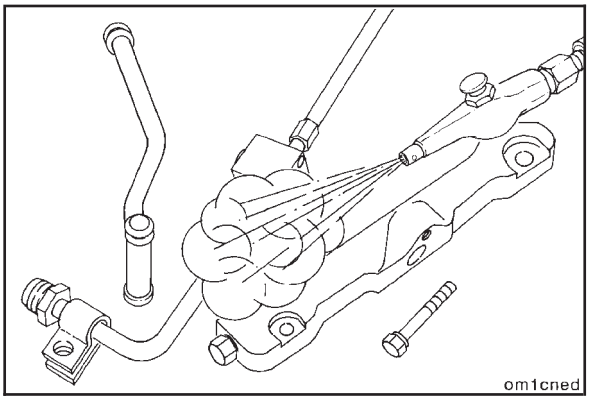


Install the water tubes (A) in the front of the No. 2 and No. 3 rocker lever housings. Install the plugs (B) in the front to the No. 1 rocker lever housing and in the rear of the No. 3 rocker lever housing.

STC Oil Plumbing - Cleaning and Inspection for Reuse (03-06)

Remove the o-rings and discard.

Clean the oil manifold connector, external oil manifold, and internal oil tube.

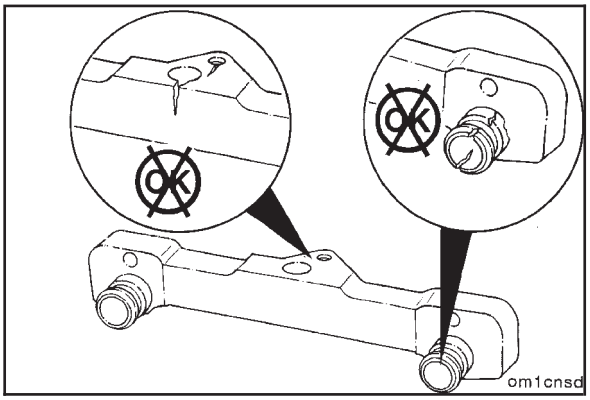


Inspect the oil manifold connector for cracks, damage, or restrictions.

Inspect the o-ring grooves on the connector for cracks or damage.

Inspect the rocker lever housing for damage.

Replace the oil manifold connector if necessary.

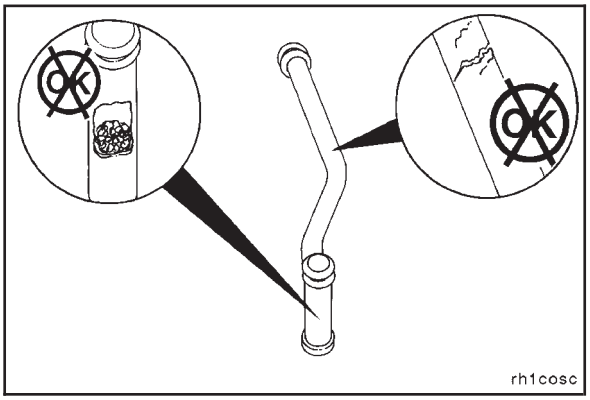


Inspect the internal oil tube for cracks, damage, or restrictions.

Inspect the o-ring grooves on the end of the tube for damage.

Inspect the oil manifold connector for damage.

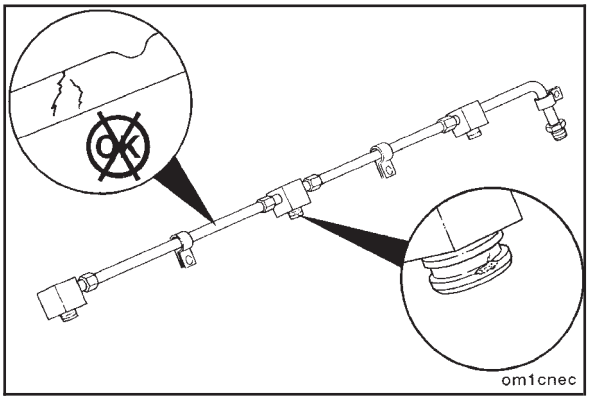
Replace the internal oil tube if necessary.

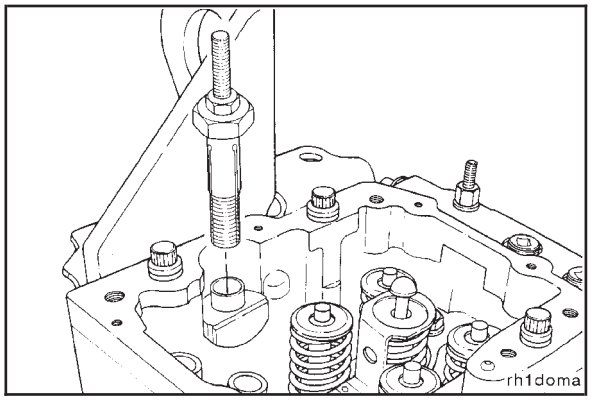


Inspect the external oil manifold for cracks, damage, or restrictions.

Inspect the oil manifold for damage in the o-ring grooves.

Replace the external oil manifold if necessary.

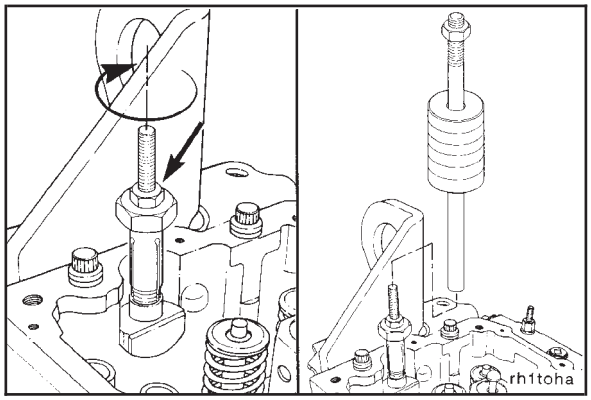




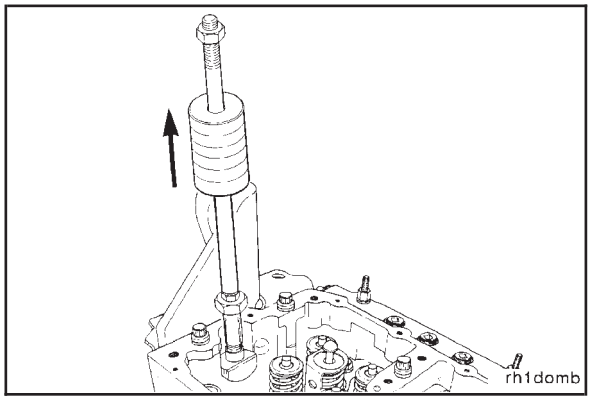
Ring and Pin Dowel - Replacement (03-07)

Removal

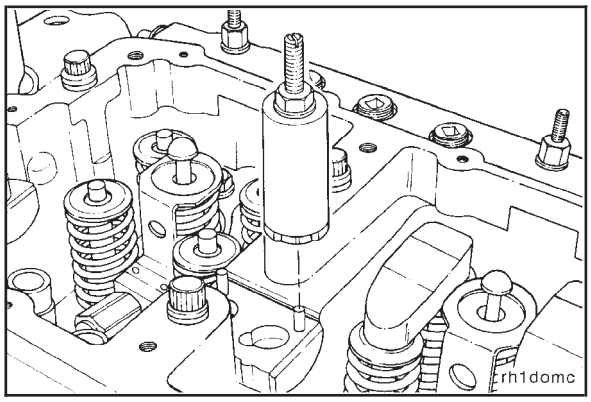
Select the proper size ring dowel remover and insert the threaded end into the ring dowel to be removed.



Tighten the hexagon nut until snug. Mount the slide hammer onto the dowel remover.

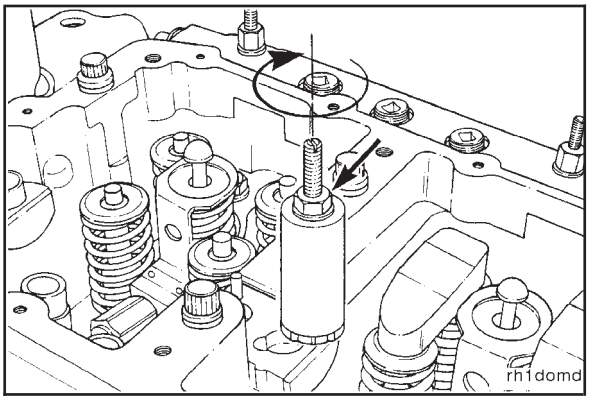


Use the slide hammer to remove the ring dowel.

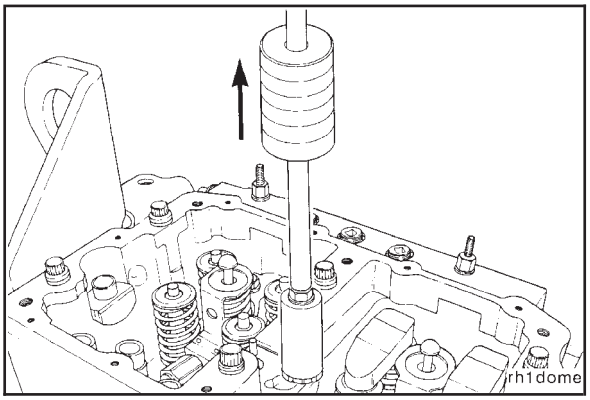


To remove a 1/4-inch straight dowel, place the 6.35 mm [1/4-inch] dowel remover on the dowel to be removed. It may be necessary to turn the dowel remover to clear unmachined casting.

Tighten the hexagon nut to grip the dowel.



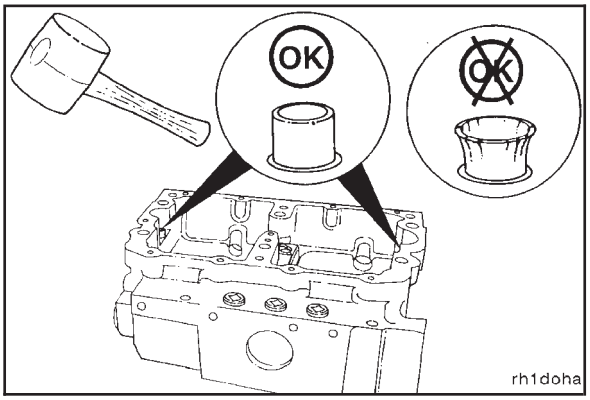
Mount the slide hammer on the 1/4-inch dowel remover and pull the dowel.



Installation

Caution: Do not use a hammer or damage to the dowel will result.

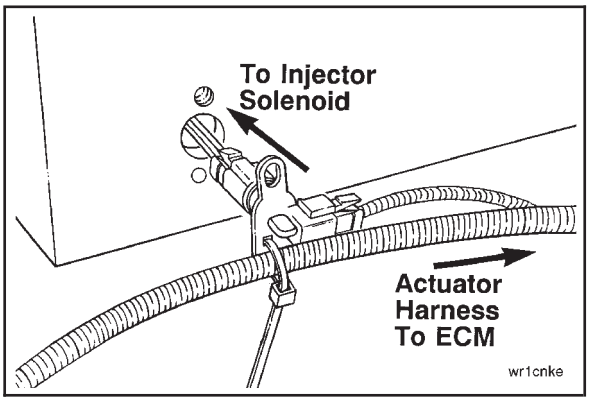
Use a mallet to install the ring dowels and pin dowels.

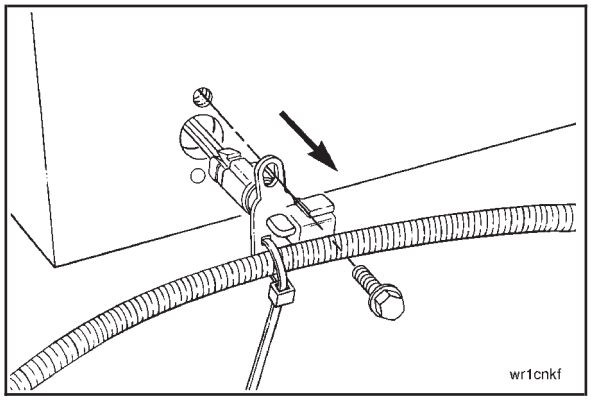


Metri-Pack Pass Through Connector - Replacement (03-08)

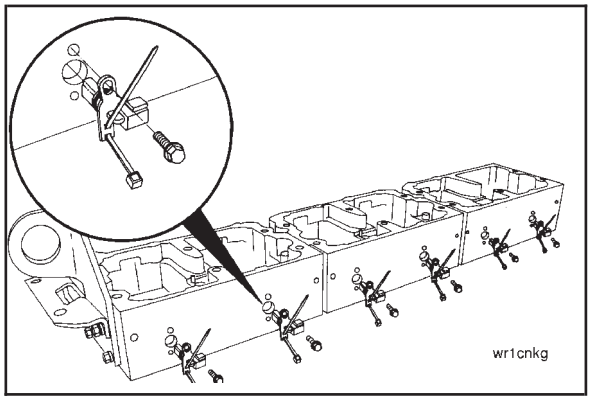
Removal

The Metri-Pack pass through connectors connect the actuator harness to each of the injector solenoid wires in the rocker lever housing.





Disconnect the actuator harness from the pass through connector. Remove the capscrew. Cut and remove the plastic wire tie that holds the actuator harness to the pass through connector. Pull the pass through from the rocker box housing. Disconnect the injector solenoid wires from the pass through connector.



Installation

Install the new pass through connector. Connect the pass through connector to the injector solenoid wires. Insert the pass through into the rocker lever housing. Tighten the capscrew.

Torque Value: 15 N•m [11 ft-lb]

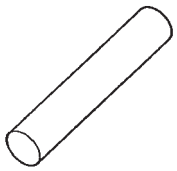
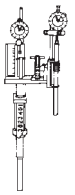
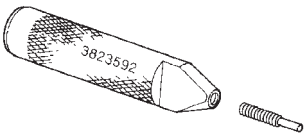
Connect the actuator harness to the pass through. Install a new plastic wire tie, Part No. 3062329.

Section 4 - Cam Follower Assembly - Group 04

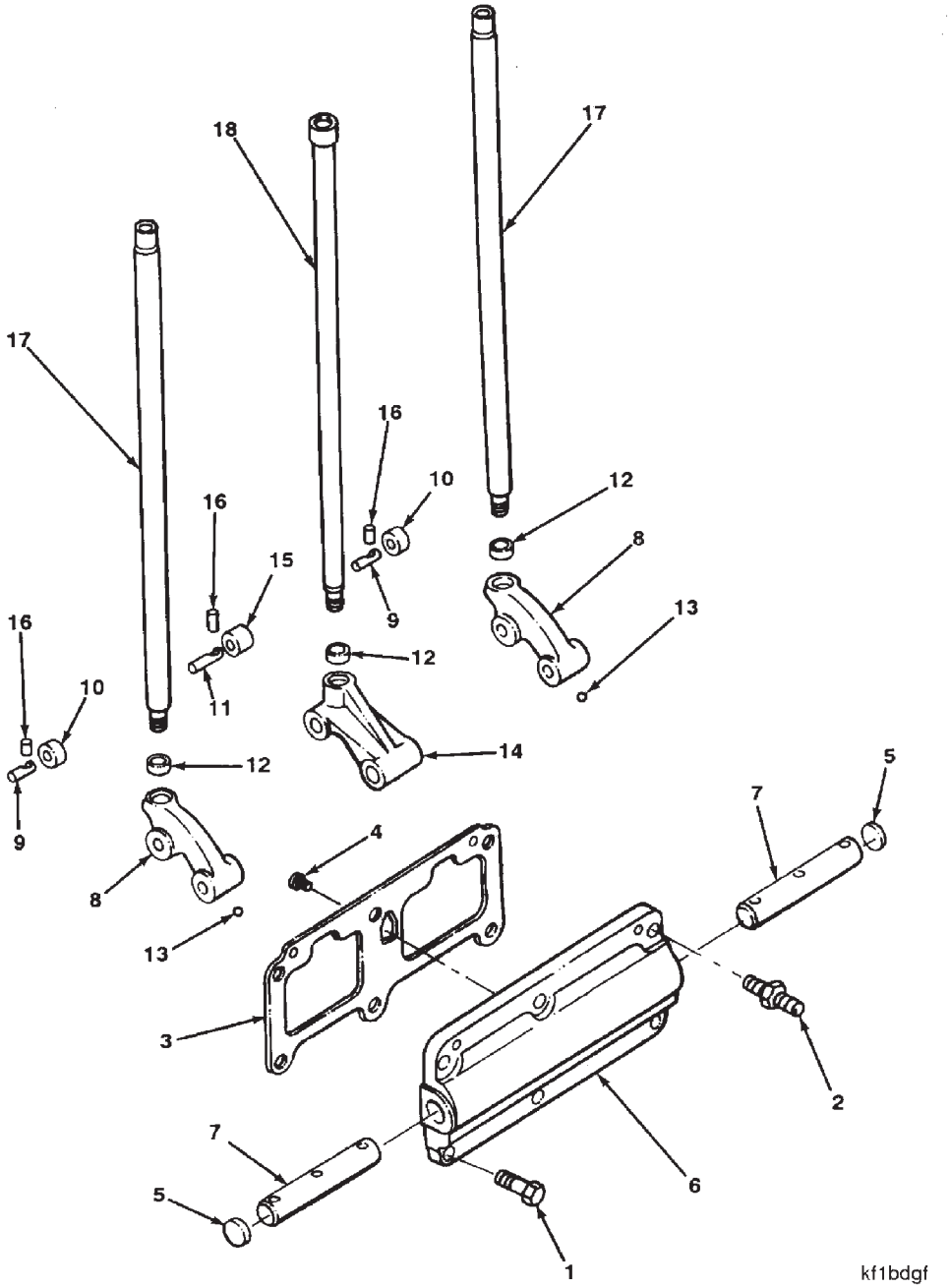
Section Contents

Cam Follower Assembly - Service Tools

The following special tools are recommended to perform procedures in section 4. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3375068	**Cup Plug Sealant** Use when installing cup plugs on engines to stop leaks.	 bp8togk
3376813	**Expansion Plug Driver** Use to drive the expansion plugs into the cam follower housing.	
3823451	**Injection Timing Fixture** Designed to determine the injector push tube travel in relation to the piston travel.	 3823451
3823592	**Cam Follower Pin Driver** Use to drive the roll pin out of the lever. This part number has a replaceable cam follower driver pin, Part No. 3823593.	 3823592

Cam Follower Assembly - Exploded View



Reference No.	Description	Qty.
1	Capscrew, Hexagon Head	7
2	Capscrew, Hexagon Head	11
3	Gasket, Cam Follower Housing	3
4	Screw, Lock	6
5	Plug, Expansion	6
6	Housing, Cam Follower	3
7	Shaft, Cam Follower	6
8	Lever, Cam Follower	12
9	Pin, Cam Follower Roller	12

Reference No.	Description	Qty.
10	Roller, Cam Follower	12
11	Pin, Cam Follower Roller	6
12	Socket, Cam Follower	18
13	Plug, Ball	12
14	Lever, Cam Follower	6
15	Roller, Cam Follower	6
16	Pin, Roll	18
17	Rod, Push Valve	12
18	Rod, Push Injector	6

Cam Follower Assembly - General Information

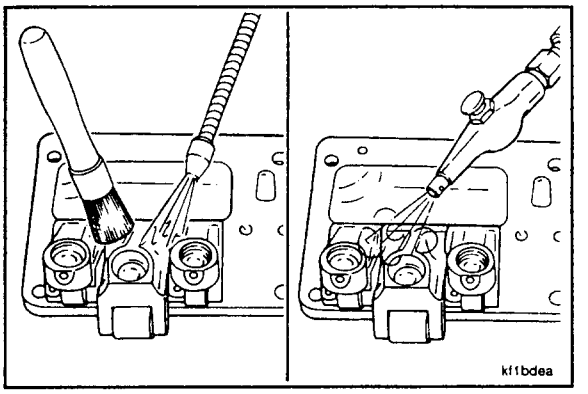
The cam follower group consists of the injector cam followers, valve cam followers, cam follower shafts, cam follower housing, and the valve and injector push rods. The N14 uses the crowned roller design cam follower. This design has been used since November, 1982.

NOTE: Label or tag all of the cam follower parts with the position of the housing on the engine and their relative position to the other parts as they are removed from the housing. Many of the cam follower parts are interchangeable; however, due to wear patterns, they **must** be installed in the same position from which they were removed.

Cam Follower Assembly - Cleaning and Inspection for Reuse (04-01)

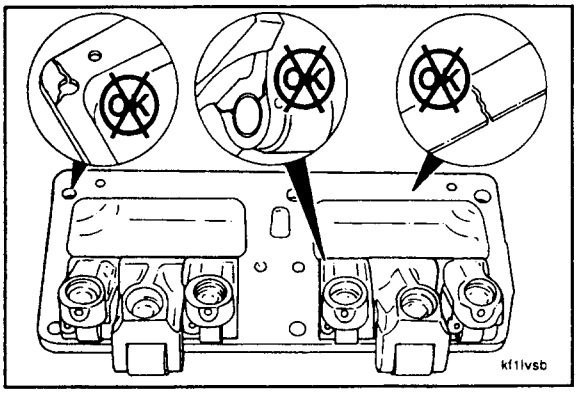
Cleaning

Clean the cam follower assemblies with solvent. Dry with compressed air.

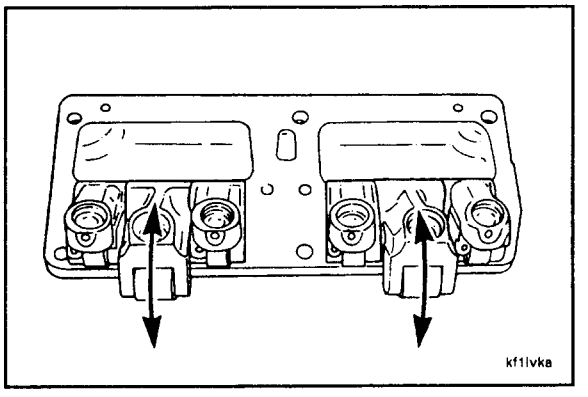


Inspection

Visually inspect the cam follower housings and the levers for cracks or damage. If cracks or damage are found, refer to Cam Follower Assembly - Rebuild (04-02).



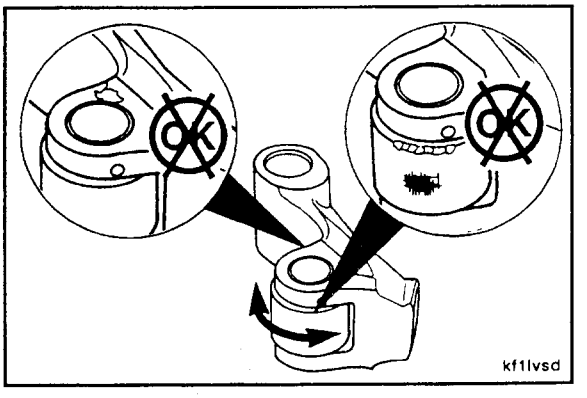
The levers **must** rotate freely on the shaft. If resistance is apparent, disassemble and check for burrs on the shaft. Refer to Cam Follower Assembly - Rebuild (04-02).

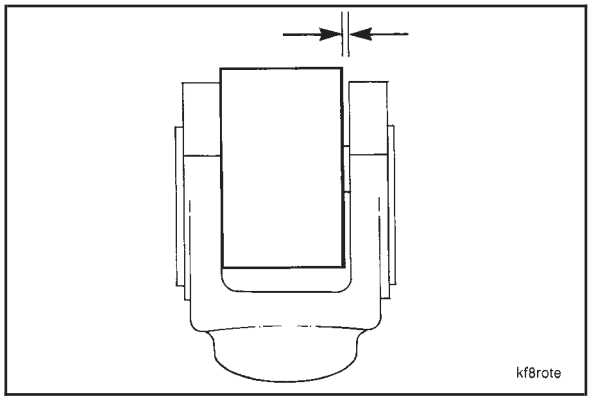


Visually inspect the cam follower rollers for flat spots, scuff marks, or other damage.

Turn the rollers by hand to make sure they rotate freely.

NOTE: If the cam follower rollers are damaged or do **not** rotate freely, the rollers **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).

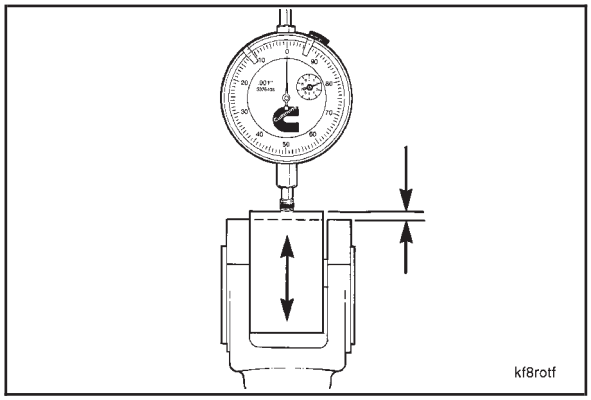




Measure the cam follower roller side clearance.

Roller Side Clearance		
mm		in
0.23	MIN	0.009
0.61	MAX	0.024

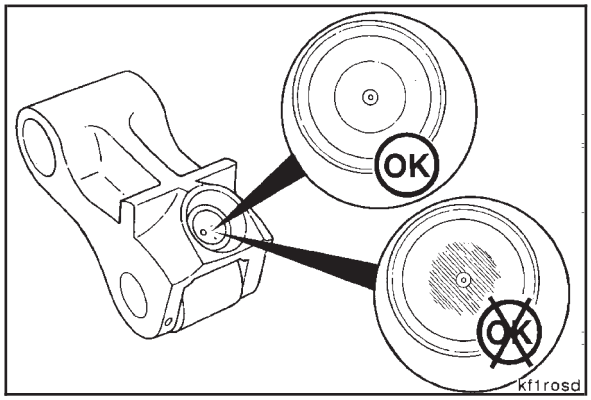
NOTE: If the roller side clearance is **not** within these specifications, the roller **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).



Use a dial indicator to measure the cam follower to roller pin clearance.

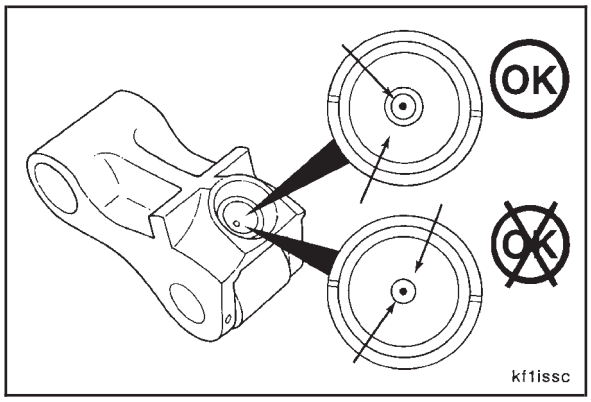
Roller to Pin Clearance		
mm		in
0.08	MIN	0.003
0.20	MAX	0.008

NOTE: If the roller to pin clearance is **not** within these specifications, the roller and the pin **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).



Visually inspect the sockets for excessive wear or damage.

A good even seating pattern **must** be seen when inspecting the cam follower socket.

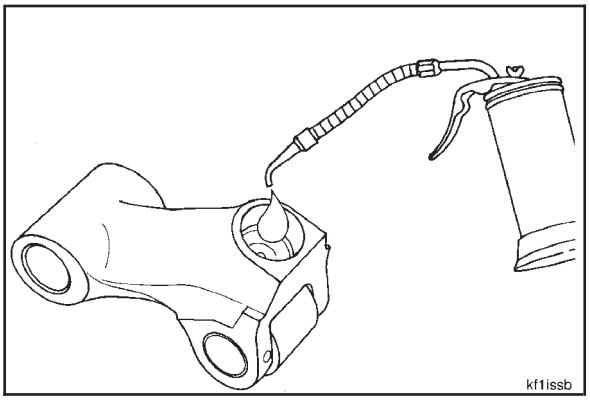


When parallel grooves and scratches are observed or the contact area extends into the oil hole chamfer of the socket, the worn socket **must** be replaced.

NOTE: If excessive wear or damage is found in the sockets, the sockets **must** be replaced. Refer to Cam Follower Socket - Replacement (04-04).

Do **not** use push rods with worn balls in cam followers with new sockets. Refer to Push Rod - Cleaning and Inspection for Reuse (04-05).

Use clean 15W-40 oil to check the oil flow through the cam followers.

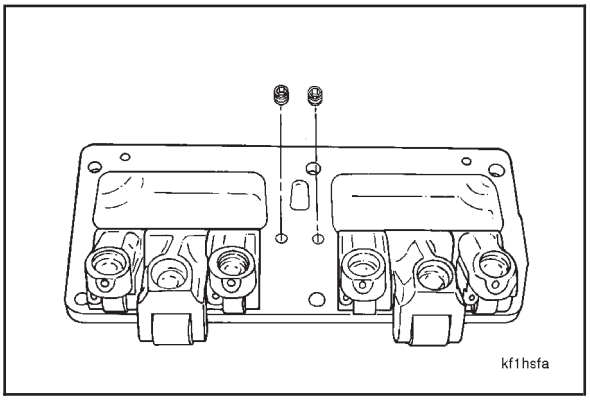


Cam Follower Assembly - Rebuild (04-02)

Disassembly

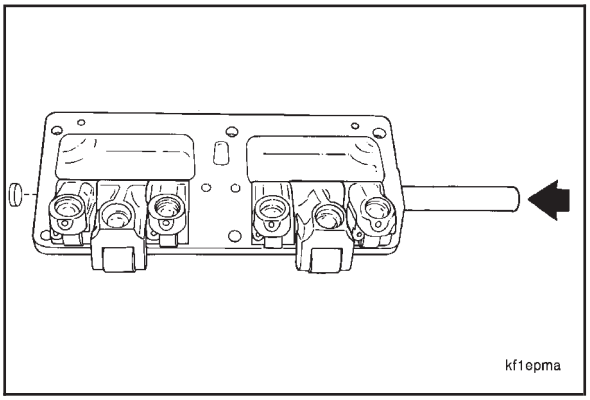
Remove the two locking screws.

NOTE: Each cam follower housing assembly consists of two shaft assemblies secured in a common center support with two locking screws.

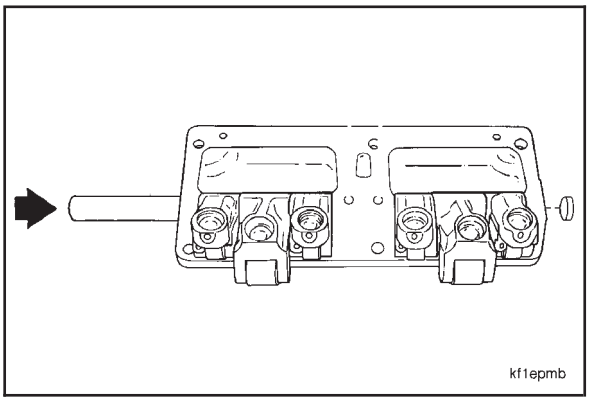


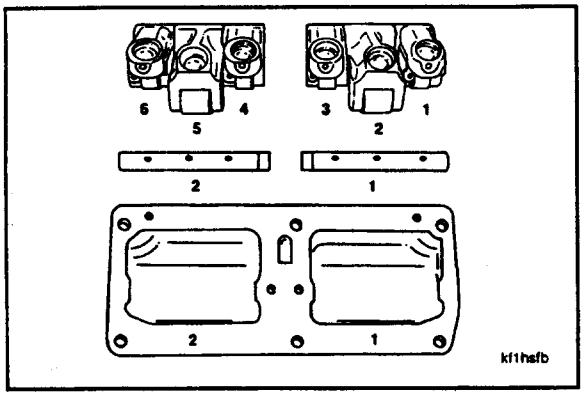
Caution: Do not push the cup plug through the cam follower lever shaft bores. The bores will be damaged.

Use expansion plug driver, Part No. 3376813, and a mallet to remove the cup plugs. Push the cup plug and the shafts through one end of the housing until the cup plug on the **opposite** end of the housing is pushed from the housing bore.



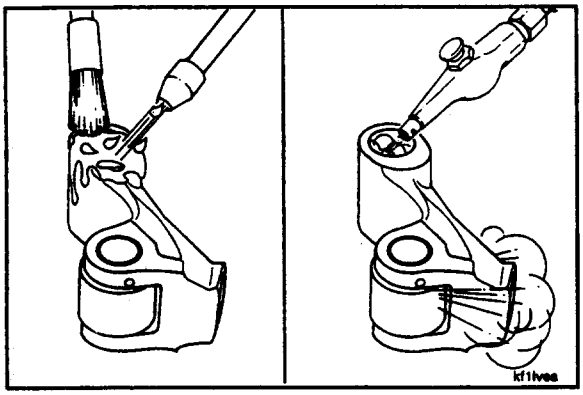
Push the shafts the **opposite** direction through the housing until the cup plug on the other end of the housing is pushed from the housing bore.





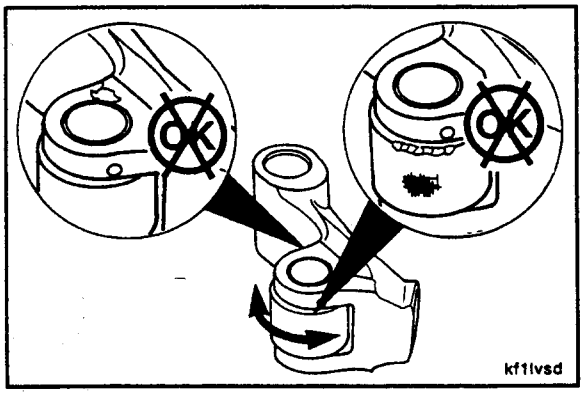
Remove the shafts and the cam follower levers from the housings.

NOTE: To prevent increased wear, mark the cam follower shafts and the levers as they are removed so they can be installed back in their original positions in the housing.



Cleaning

Clean the cam follower parts with solvent. Dry with compressed air.



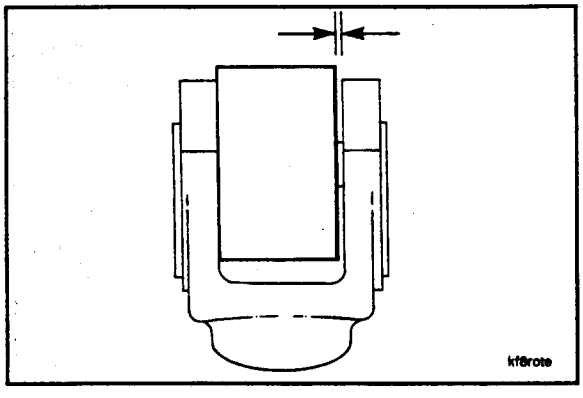
Inspection

Visually inspect the cam followers for cracks or other damage.

Visually inspect the cam follower rollers for flat spots, scuff marks, or other damage.

Turn the rollers by hand to make sure they rotate freely.

NOTE: If the cam follower rollers are damaged or do **not** rotate freely, the rollers **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).



Measure the cam follower roller side clearance.

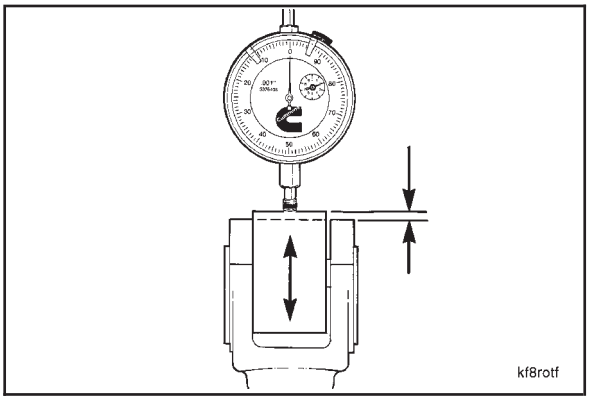
Roller Side Clearance		
mm		in
0.23	MIN	0.009
0.61	MAX	0.024

NOTE: If the roller side clearance is **not** within these specifications, the roller **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).

Use a dial indicator to measure the cam follower to roller pin clearance.

Roller to Pin Clearance		
mm		**in**
0.08	MIN	0.003
0.20	MAX	0.008

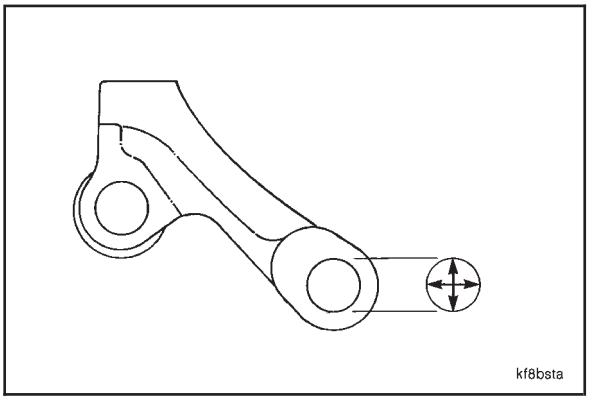
NOTE: If the roller to pin clearance is **not** within these specifications, the roller and the pin **must** be replaced. Refer to Cam Follower Lever - Roller Replacement (04-03).



Measure the cam follower lever shaft bore inside diameter.

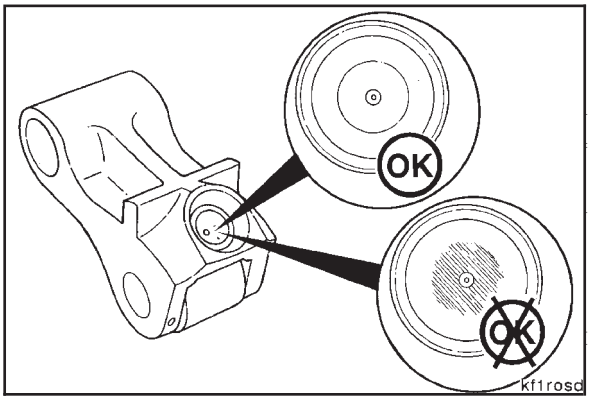
Lever Shaft Bore I.D.		
mm		**in**
22.228	MIN	0.8751
22.276	MAX	0.8770

NOTE: Valve and injector levers without bushings were introduced on January 1, 1987. If the shaft bore is worn beyond the maximum specification, the lever **must** be replaced.



Visually inspect the sockets for excessive wear or damage.

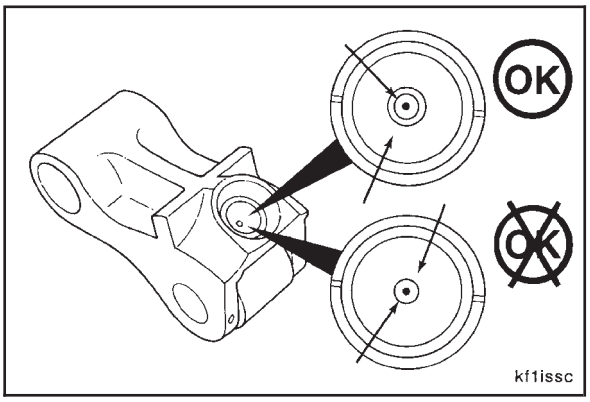
A good even seating pattern **must** be seen when inspecting the cam follower socket.

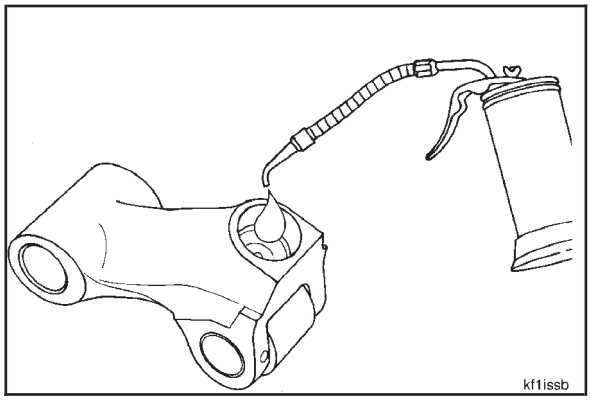


When parallel grooves and scratches are observed or the contact area extends into the oil hole chamfer of the socket, the worn socket **must** be replaced.

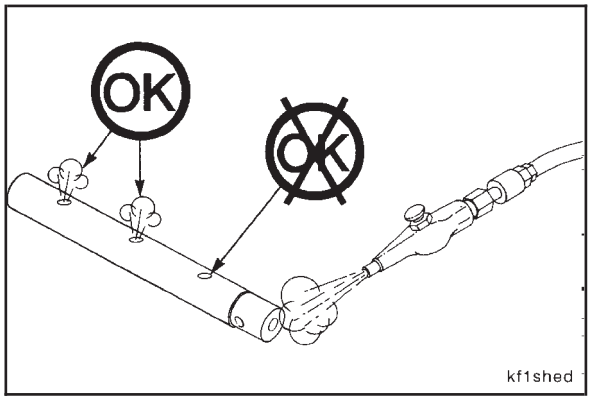
NOTE: If excessive wear or damage is found in the sockets, the sockets **must** be replaced. Refer to Cam Follower Socket - Replacement (04-04).

Do **not** use push rods with worn balls in cam followers with new sockets. Refer to Push Rod - Cleaning and Inspection for Reuse (04-05).



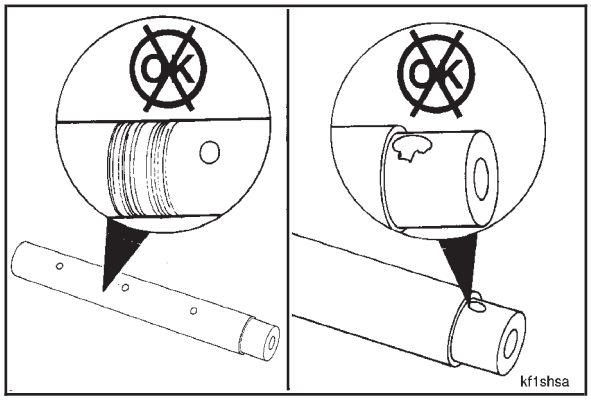


Use clean 15W-40 oil to check the oil flow through the cam followers.



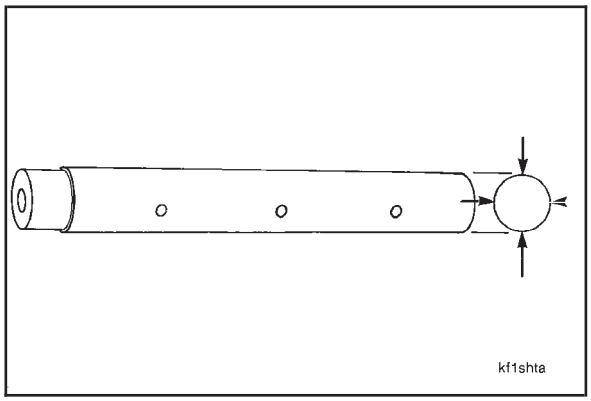
Clean the cam follower shafts with solvent. Dry with compressed air.

Make sure the oil drillings are **not** restricted or plugged.



Visually inspect the cam follower shafts for scoring or damage.

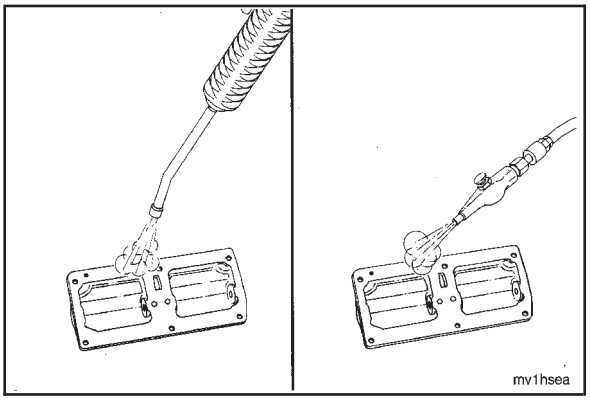
Visually inspect the locking screw holes in each shaft. The grooves **must** be clean and **not** damaged.



Measure the cam follower shaft outside diameter.

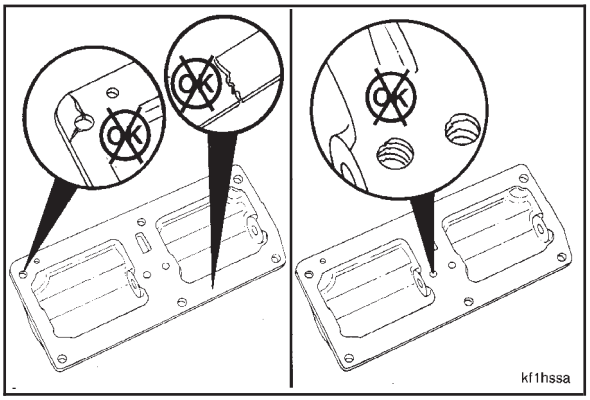
Cam Follower Shaft O.D.		
mm		in
22.156	MIN	0.8723
22.195	MAX	0.8738

Steam clean the cam follower housings. Dry with compressed air.



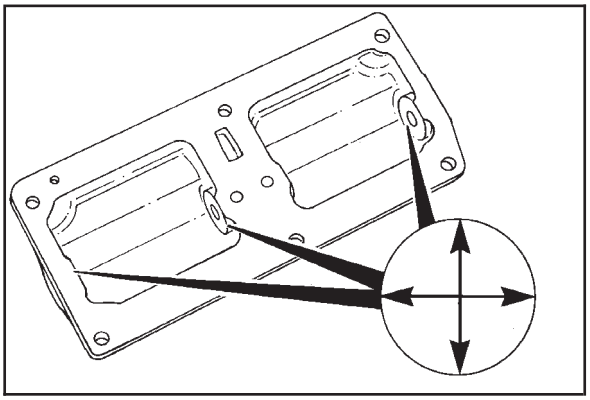
Visually inspect the cam follower housings for cracks or damage.

Visually inspect the locking screw holes for damaged or distorted threads.



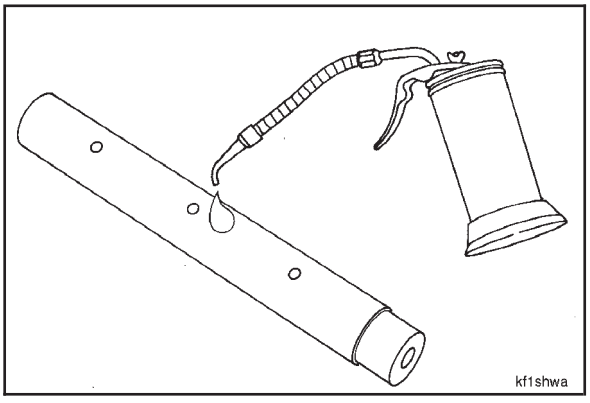
Measure the cam follower shaft bore inside diameter.

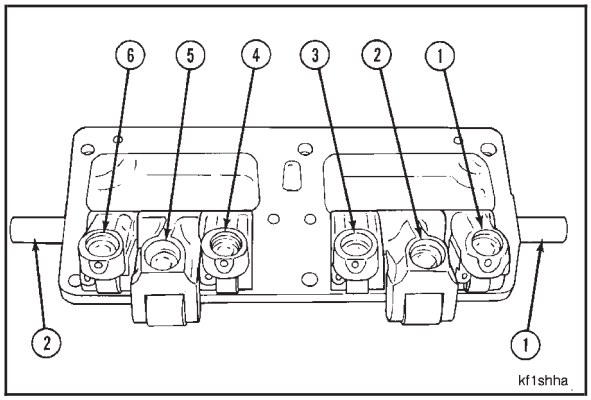
Cam Follower Shaft Bore I.D.		
mm		**in**
22.200	MIN	0.8740
22.225	MAX	0.8750



Assembly

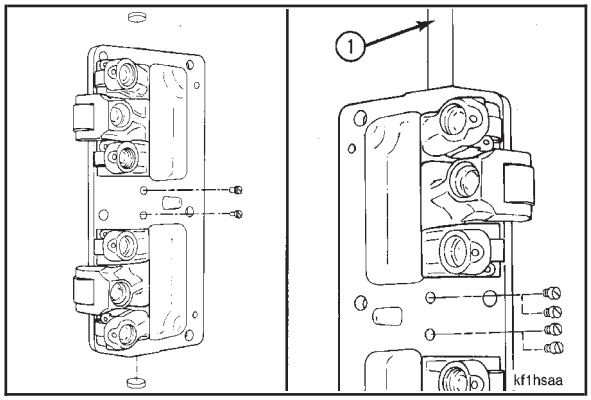
Use Lubriplate® 105 or its equivalent to lubricate the bushingless cam followers and cam follower shafts.





Install the levers and the shafts in the housings.

NOTE: To prevent increased wear, install the cam follower levers and the shafts back in their original location in the housing.

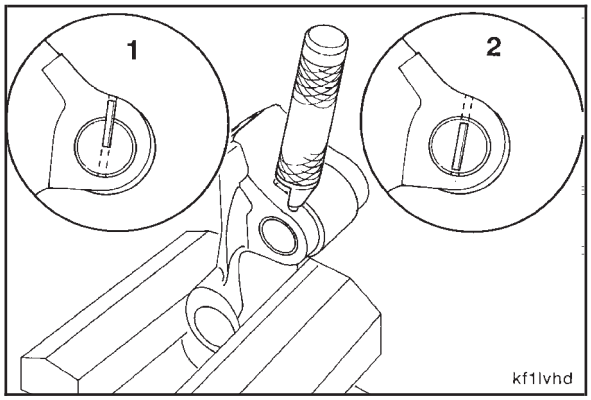


Install the cup plugs in the housings as follows:

1. Install two temporary capscrews in the shafts to prevent breaking the locking screws.
2. Put cup plug sealant, Part No. 3375068, on the cup plugs.
3. Use expansion plug driver (1), Part No. 3376813, to install the cup plugs. Install to a depth of 0.025 inch ± 0.010 inch below flush.
4. Remove the two temporary capscrews, and install the two locking screws in the shafts.

Torque Value: 2 N•m [15 in-lb]

NOTE: The heads of the locking screws **must** be flush or below flush with the gasket surface of the cam follower housing.



Cam Follower Lever - Roller Replacement (04-03)

Disassembly

Install the cam follower lever into a vise with brass jaws. The cam follower lever does **not** have a through hole in which to drive the roll pin for removal.

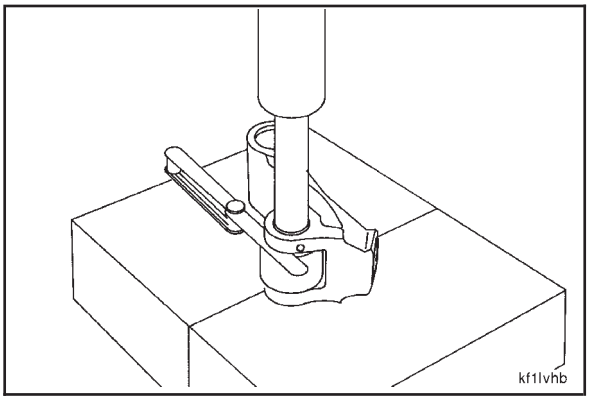
Use a hammer and cam follower pin driver, Part No. 3823592, or a suitable pin punch to drive the roll pin out of the lever (1) and into the roller pin (2).

Install the cam follower lever into an arbor press.

Caution: Use the largest feeler gauge that will fit between the roller and the lever to prevent leg deflection when removing the roller pin. This will reduce shaving of the bronze roller pin and prevent leg breakage.

Install a feeler gauge between the roller and the leg of the lever.

Push the roller pin from the cam follower lever. Discard the unacceptable rollers and all the roller pins.

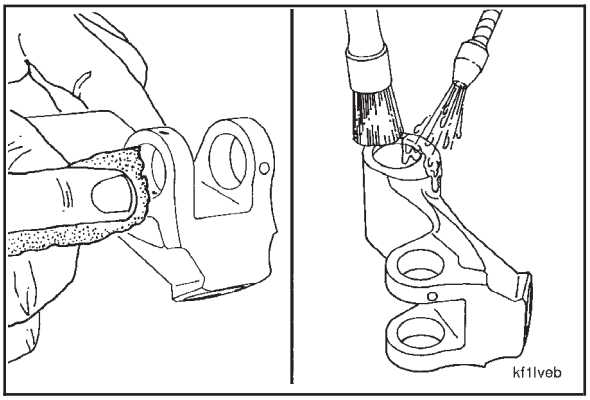


Cleaning

Use a 240 grit, or finer, emery cloth to remove any burrs from the edges of the pin bore holes.

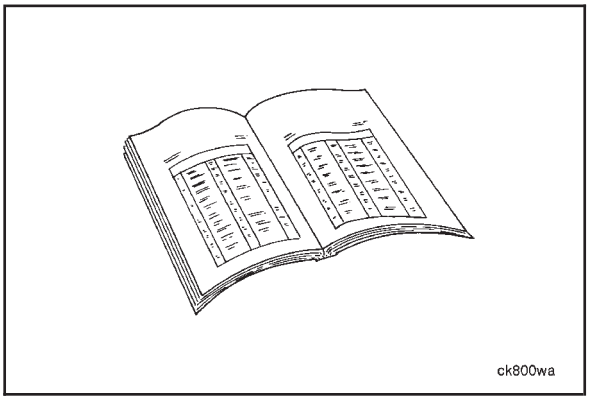
NOTE: Do **not** burnish the inside diameter of the pin bore holes.

Use solvent to clean the levers. Dry with compressed air.



Inspection - Magnetic Crack

Refer to the Alternate Repair Manual, Bulletin No. 3379035, for procedures to magnetically check for cracks in the cam follower levers.

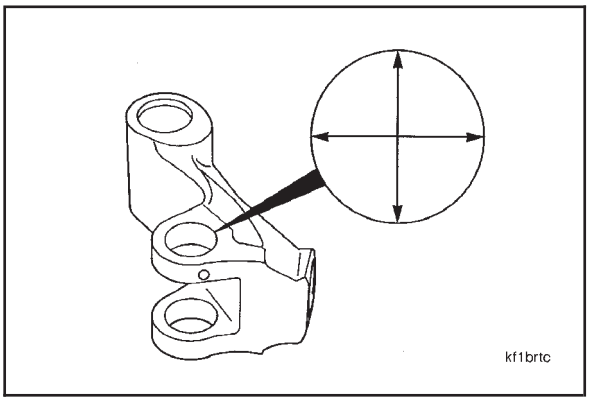


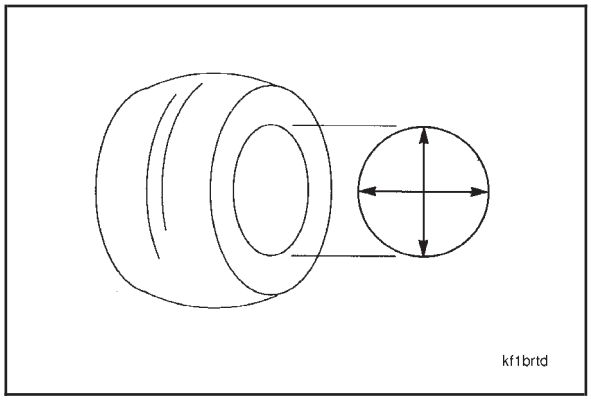
Inspection - Dimensional

Measure the inside diameter of the cam follower lever roller pin bore.

Valve Lever Roller Pin Bore I.D.		
mm		in
12.674	MIN	0.4990
12.687	MAX	0.4995

Injector Lever Roller Pin Bore I.D.		
mm		in
19.042	MIN	0.7497
19.055	MAX	0.7502

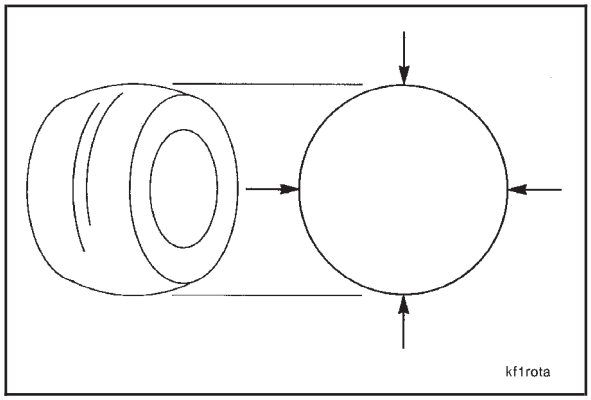




Measure the inside diameter of the new cam follower lever roller bore.

Valve Lever Roller Bore I.D.		
mm		**in**
12.776	MIN	0.5030
12.801	MAX	0.5040

Injector Lever Roller Bore I.D.		
mm		**in**
19.151	MIN	0.7540
19.177	MAX	0.7550

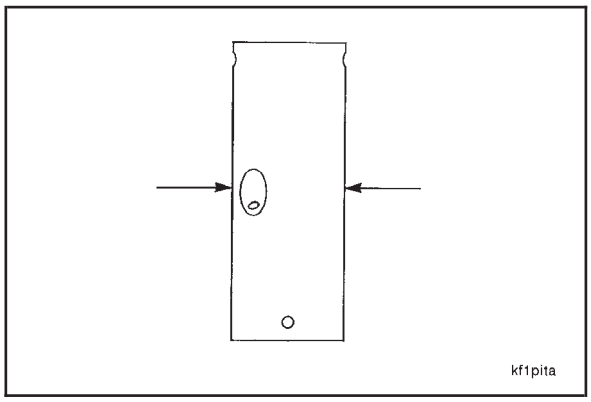


Measure the outside diameter of the new cam follower roller.

NOTE: The valve and the injector rollers are crowned. The crowned roller **must** be measured in the middle of the roller outside diameter.

Crowned Valve Roller O.D.		
mm		**in**
31.711	MIN	1.2485
31.762	MAX	1.2505

Crowned Injector Roller O.D.		
mm		**in**
41.237	MIN	1.6235
41.287	MAX	1.6255



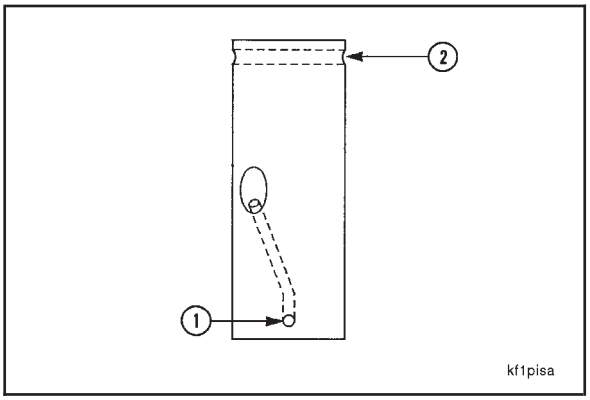
Measure the outside diameter of the new roller pin.

Valve Roller Pin O.D.		
mm		**in**
12.692	MIN	0.4997
12.700	MAX	0.5000

Injector Roller Pin O.D.		
mm		**in**
19.063	MIN	0.7505
19.070	MAX	0.7508

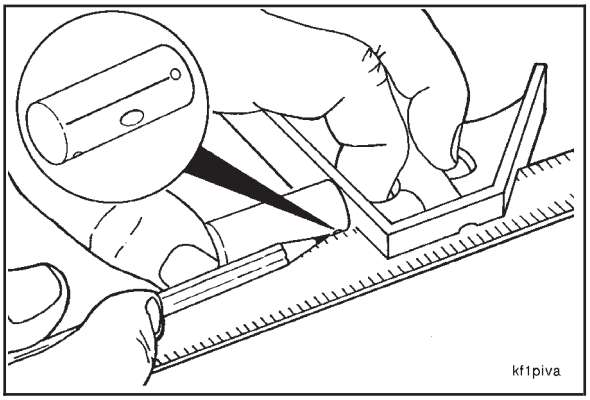
Assembly

NOTE: The roller pin **must** be installed correctly to make sure the cam follower roller and the roller pin are supplied with oil. Inspect the new roller pin as shown to determine the oil feed pass (1) and the alignment hole (2) locations. The oil feed passage is drilled approximately two-thirds of the way through the pin. The alignment hole is drilled completely through the pin.

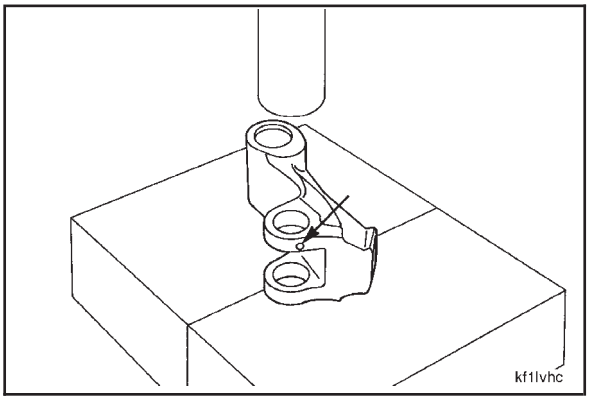


Use a grease pencil or a similar marker to draw a line on the side of the roller pin that is perpendicular to the alignment hole.

NOTE: The line will help align the roller pin correctly in the cam follower lever.



Install the cam follower lever in an arbor press with the leg with the alignment hole towards the top.

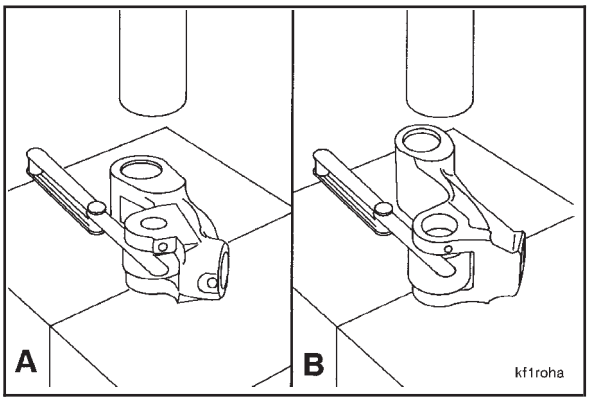


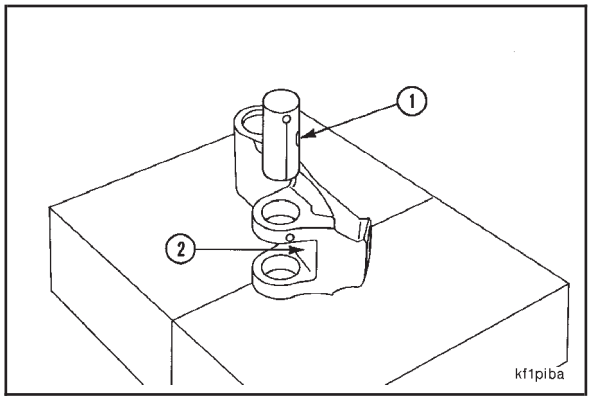
Install the roller into the cam follower lever.

Caution: Use the largest feeler gauge that will fit between the roller and the lever to prevent leg deflection when installing the roller pin. This will reduce shaving of the bronze roller pin and prevent leg breakage.

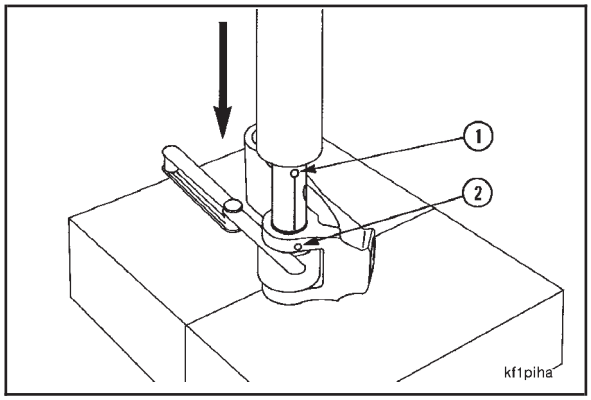
Install a feeler gauge between the roller and the leg of the lever.

- Valve cam follower lever (A)
- Injector cam follower lever (B)





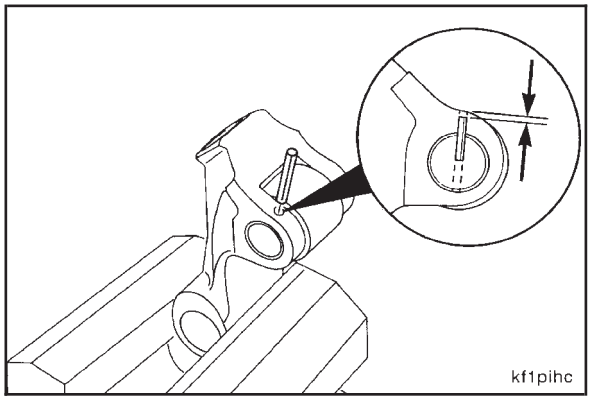
Caution: The cam follower roller pin must be installed with the oil feed hole (1) positioned towards the top of the cam follower lever (2).



NOTE: Freezing the roller pin will simplify its installation.

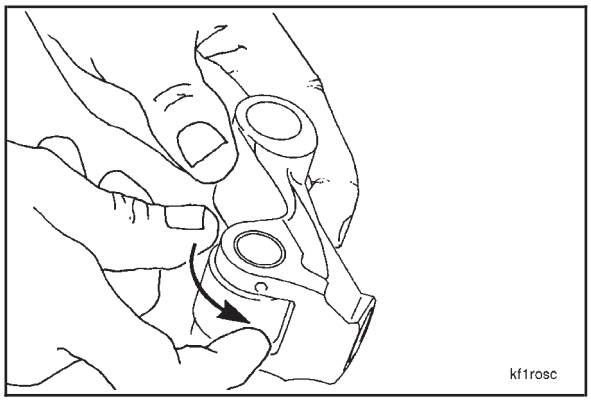
Use clean 15W-40 oil to lubricate the roller pin.

Install the roller pin. Make sure the pin alignment hole (1) is correctly aligned with the alignment hole (2) in the lever before pushing the roller pin into the cam follower lever.



Install a new roll pin into the cam follower lever.

Drive the roll pin in until it is approximately 1.5 mm [0.06-inch] below the surface of the cam follower lever.

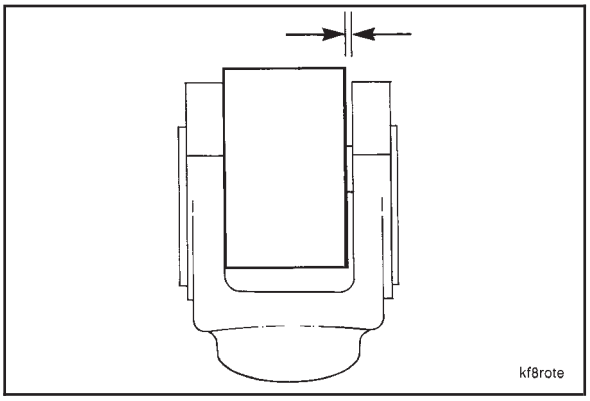


Turn the roller by hand to make sure it rotates freely.

Measure the cam follower roller side clearance.

Roller Side Clearance		
mm		in
0.23	MIN	0.009
0.61	MAX	0.024

NOTE: If the roller does **not** rotate freely or the clearance is **not** within specification, disassemble and check the roller pin and the lever for damage. The pin can **not** be used again.

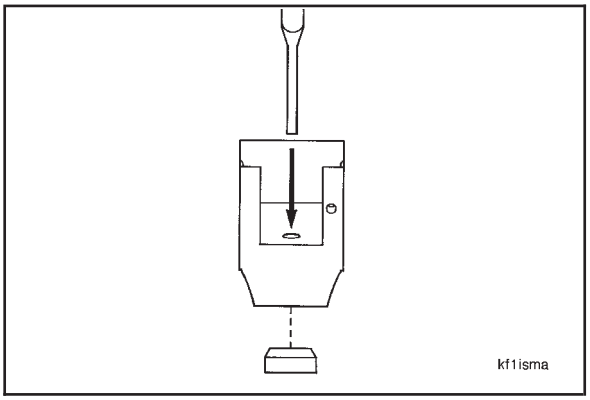


Cam Follower Socket - Replacement (04-04)

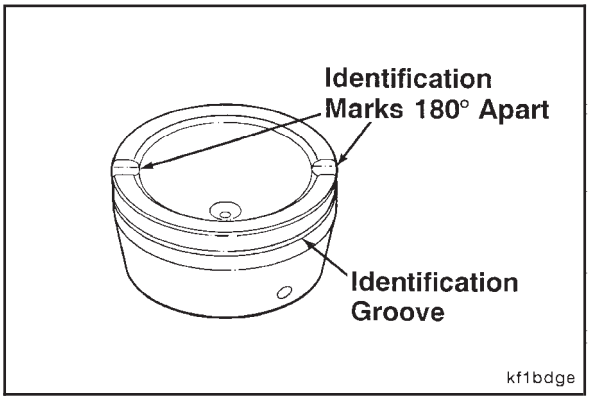
NOTE: This procedure assumes that the roller is removed.

Use a pin punch to remove the socket.

NOTE: The roller **must** be removed to allow access to the socket removal hole. Refer to Cam Follower Lever - Roller Replacement (04-03).



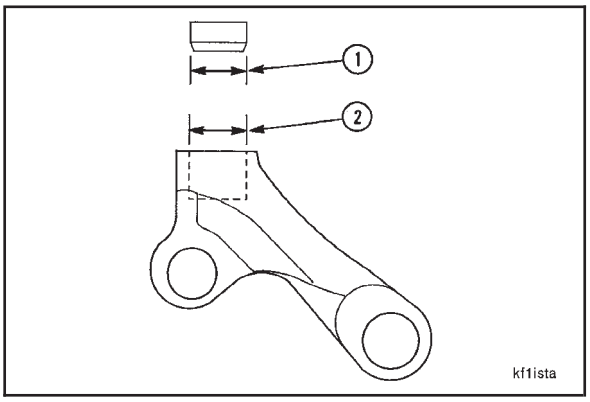
The N14 valve and injector cam follower socket has an identification groove around the outside diameter and two marks 180 degrees apart on top of the socket.

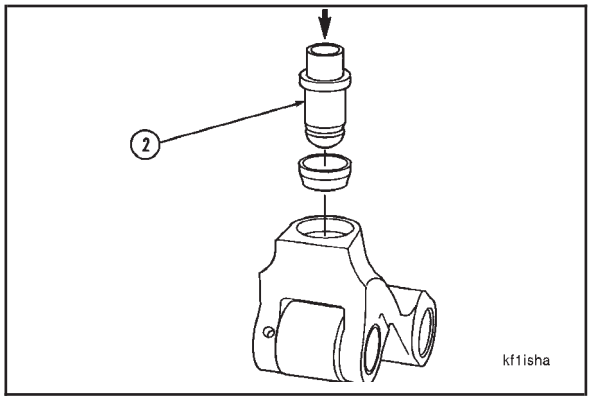


Measure the parts.

(1) Socket O.D.		
mm		in
19.062	MIN	0.7505
19.088	MAX	0.7515

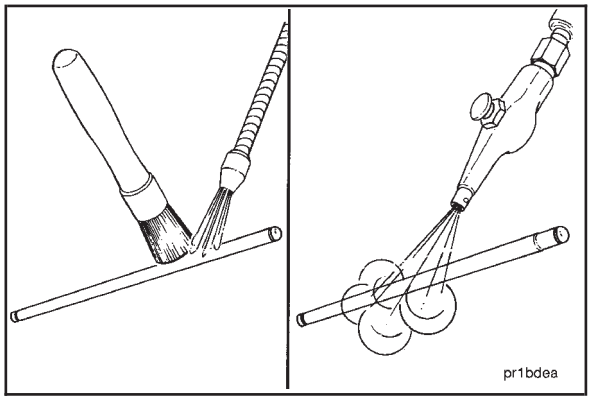
(2) Lever Bore I.D.		
mm		in
19.025	MIN	0.7490
19.050	MAX	0.7500





Caution: Support as shown to prevent cracks in the cam follower. An old roller can be used to support the lever.

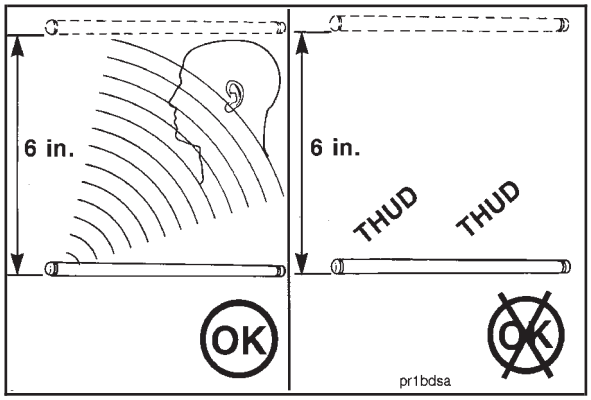
Use a brass drift or a used push rod end (2). Use an arbor press. Install the new socket. The socket **must** touch the bottom of the bore in the lever.



Push Rod - Cleaning and Inspection for Reuse (04-05)

Cleaning

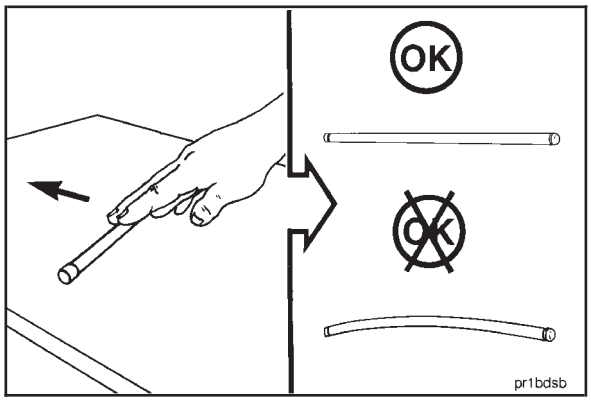
Use solvent to clean the push rods. Dry with compressed air.



Inspection

Inspect for engine oil in the push rods as follows:

1. Hold the push rod horizontally and drop it from a height of 6 inches onto a concrete floor or a metal surface.
2. The push rod can be used if a ringing sound is heard.
3. If a dull (or non-ringing) sound is heard, the push rod contains engine oil and **must** be discarded.

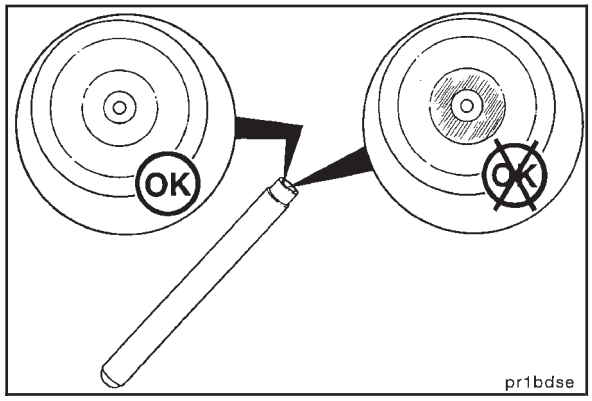


Inspect the straightness of the push rod by rolling it on a level bench. Replace the push rod if it is bent. Do **not** use a bent push rod.

Visually inspect the socket end of the push rod for uneven wear, scratches, or separation of the insert from the tube.

If a worn push rod is found, the mating adjusting screw **must** also be replaced.

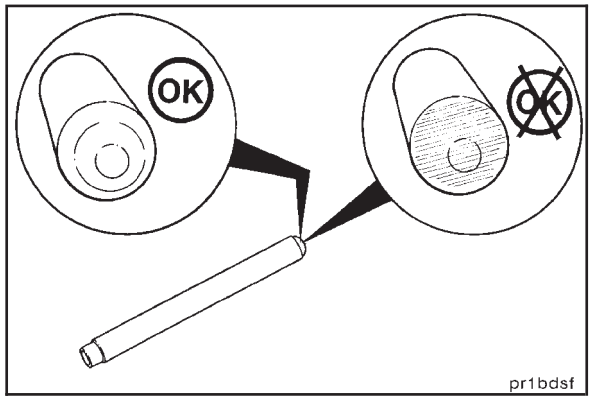
When parallel scratches are found in the contact area, the push rods **must** be replaced.



Visually inspect the ball end of the push rod.

The contact area **must** show a smooth seating pattern.

If the ball end of the push rod has parallel grooves and scratches with a nipple in the center, the push rod **must** be replaced. If a worn push rod is found, the mating cam follower socket **must** be replaced. Refer to Cam Follower Socket - Replacement (04-04).



Section 5 - Fuel System - Group 05

Section Contents

Fuel Pump - General Information

NOTE: Warranty repairs are **not** to be made to the fuel pump unless the work is performed in a shop meeting all requirements established by Cummins Engine Company, Inc. to accurately calibrate, test, and repair the fuel systems on Cummins engines.

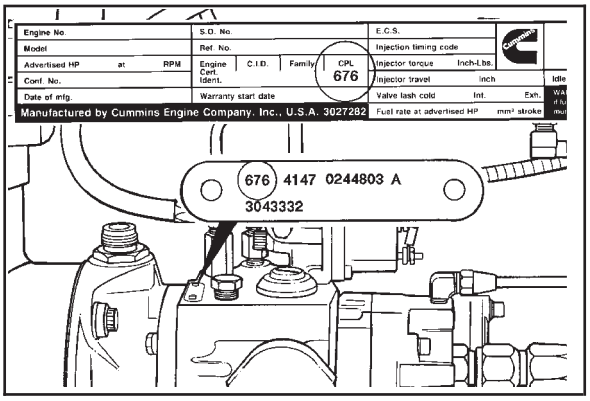
The fuel pump is calibrated for a specified performance and will vary between engine application and model. The performance of the engine is defined by the Control Parts List (CPL) and the fuel pump code.

The fuel pump calibration **must** be within the published specifications. Fuel pump calibration is certified by several emission agencies. Tampering with the fuel pump can be a violation of the law. Tampering with the fuel pump can also void the engine warranty and lower the performance of the engine.

Fuel Pump - Cleaning and Inspection for Reuse (05-01)

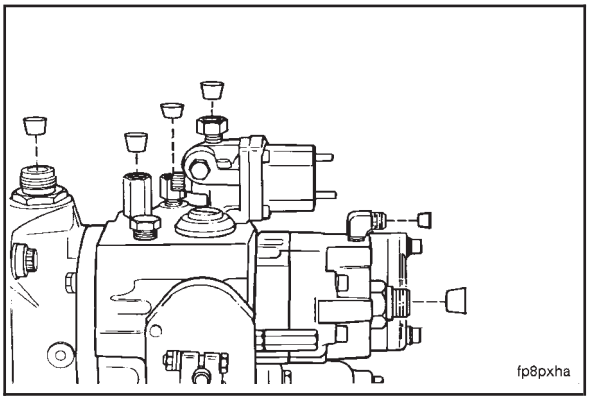
When removing the fuel pump from step timing control (STC) engines, check to make sure the same Control Parts List (CPL) number is on both the fuel pump dataplate and the engine dataplate.

If the CPL number on the fuel pump dataplate does **not** match the CPL number on the engine dataplate, the fuel pump **must** be calibrated again to the correct specification for the engine.

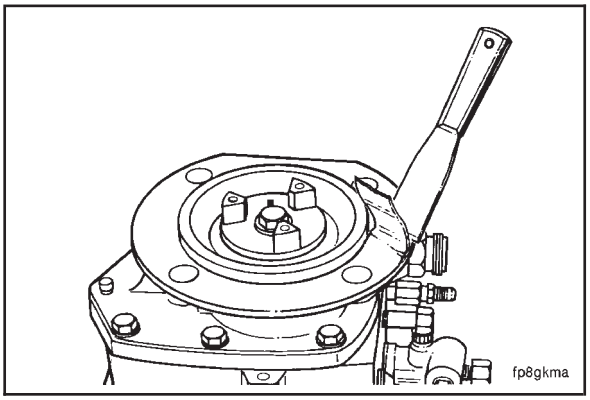


Cleaning - PT Fuel Pump

Install plastic cup plugs or tape on all openings of the fuel pump to prevent dirt or cleaning solvent from entering the pump.

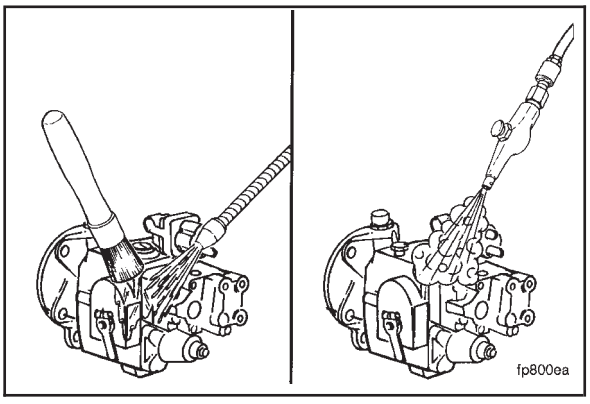


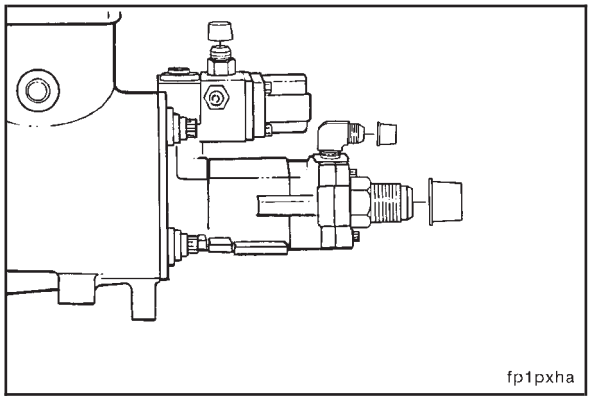
Remove the gasket material from the front cover gasket sealing surface.



Caution: Use a cleaning solvent approved for cleaning aluminum to prevent damage to the fuel pump.

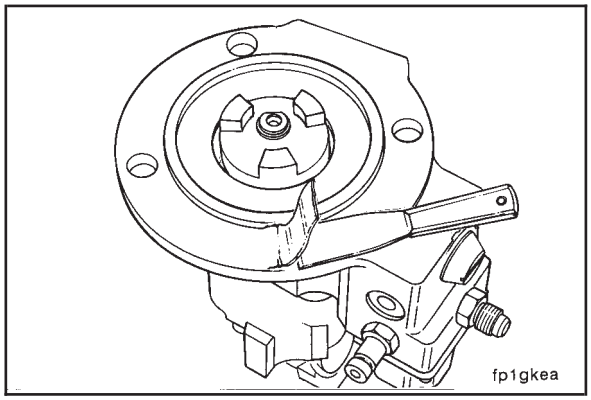
Use a brush and solvent to clean the fuel pump exterior. Dry with compressed air.



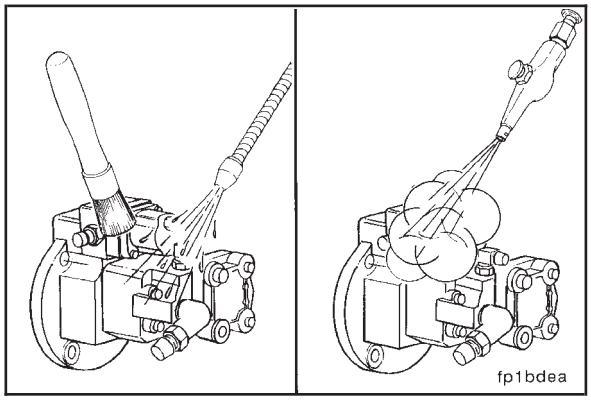


Cleaning - CELECT™ Fuel Pump

Install plastic cup plugs or tape on all openings of the fuel pump to prevent dirt or cleaning solvent from entering the pump.

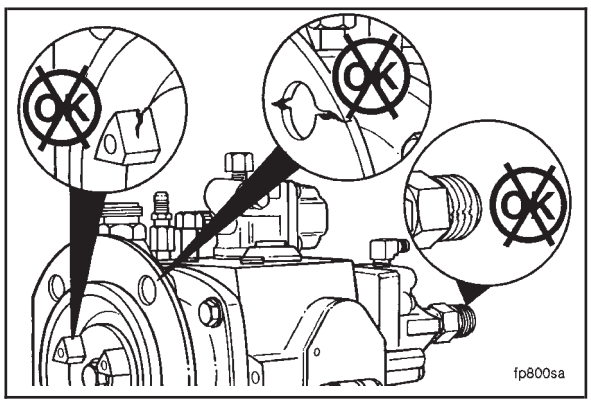


Remove the gasket material from the front cover gasket sealing surface.



Caution: Use a cleaning solvent approved for cleaning aluminum to prevent damage to the fuel pump.

Use a brush and solvent to clean the fuel pump exterior. Dry with compressed air.



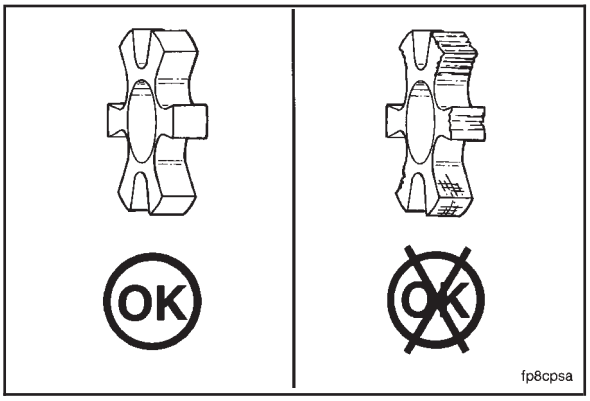
Inspection - PT Fuel Pump

Visually inspect the fuel pump body and front cover for cracks or other damage.

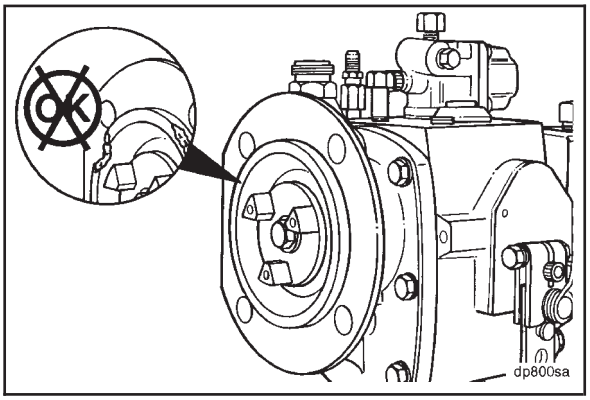
Visually inspect the fuel pump assembly for damaged capscrews and damaged or loose fuel fittings.

Visually inspect the drive coupling lugs for excessive wear or damage.

Visually inspect the drive coupling spider for cracks or other damage.



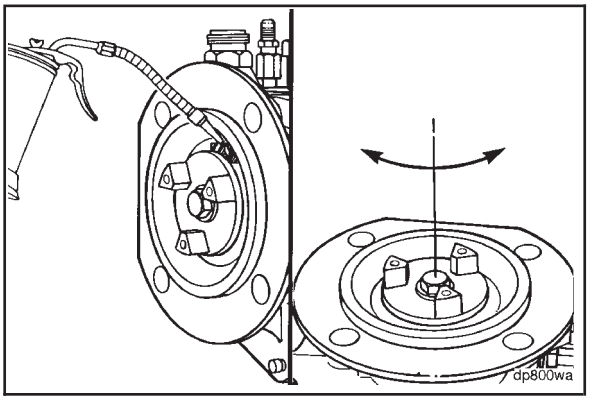
Visually inspect the front cover pilot to make sure the pilot is continuous without cracks or gaps.



Use clean 15W-40 oil to lubricate the tachometer drive gear.

Turn the fuel pump shaft by hand. The shaft **must** rotate freely.

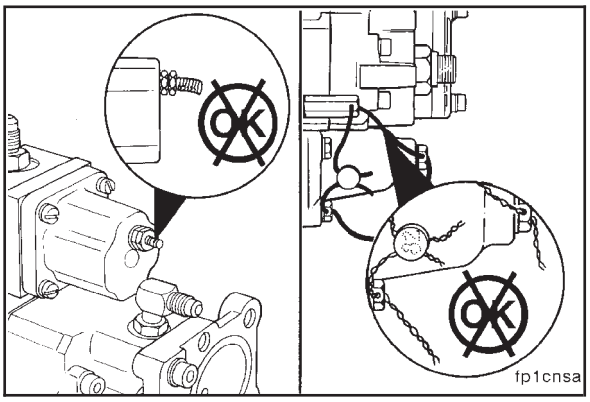
NOTE: If the shaft does **not** rotate freely, the pump **must** be disassembled for further inspection. Refer to Fuel Pump - Rebuild (05-02).

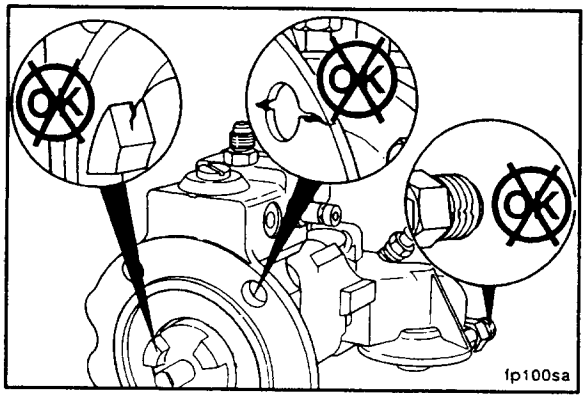


Visually inspect the fuel pump shutoff valve for loose or damaged electrical terminals.

Visually inspect the fuel pump tamper seals.

NOTE: If the tamper seals have been broken or are missing, the fuel pump **must** be checked to insure the calibration accuracy. Refer to Fuel Pump - Calibration (05-03).



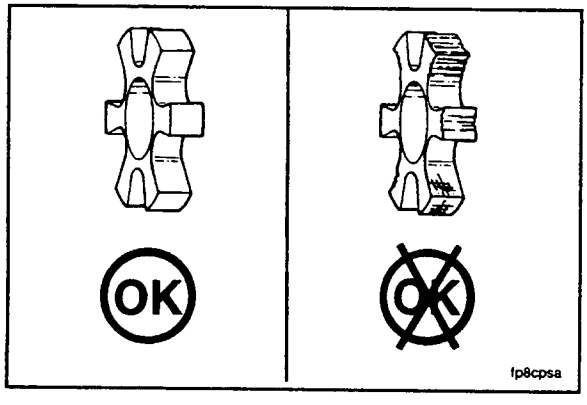


Inspection - CELECT™ Fuel Pump

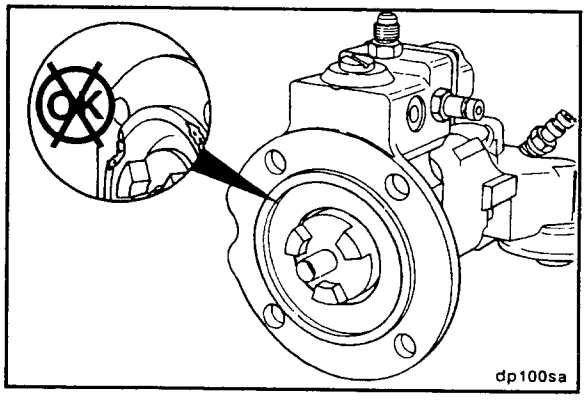
Visually inspect the fuel pump body and front support for cracks or other damage.

Visually inspect the fuel pump assembly for damaged capscrews and damaged or loose fuel fittings.

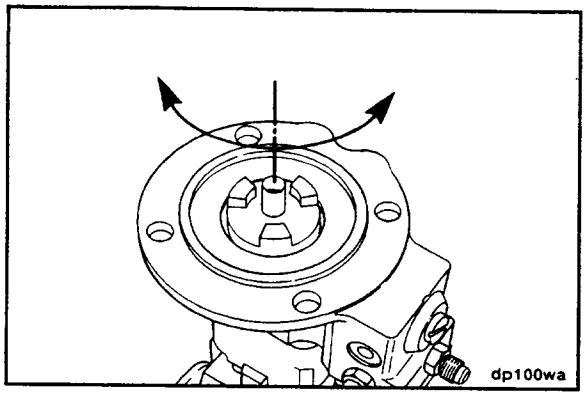
Visually inspect the drive coupling lugs for excessive wear or damage.



Visually inspect the drive coupling spider for cracks or other damage.



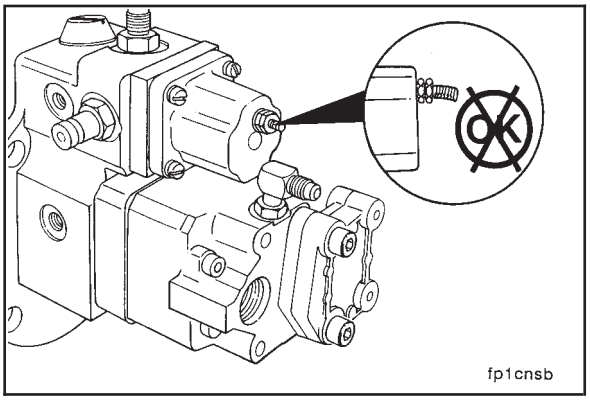
Visually inspect the front support pilot to make sure the pilot is continuous without cracks or gaps.



Turn the fuel pump shaft by hand. The shaft **must** rotate freely.

NOTE: If the shaft does **not** rotate freely, the pump **must** be disassembled for further inspection. Refer to Fuel Pump - Rebuild (05-02).

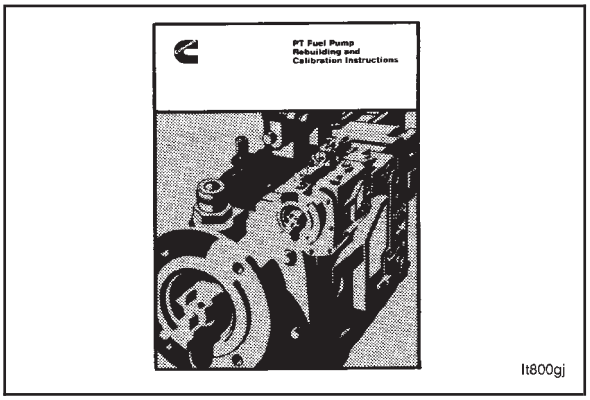
Visually inspect the fuel pump shutoff valve for loose or damaged electrical terminals.



Fuel Pump - Rebuild (05-02)

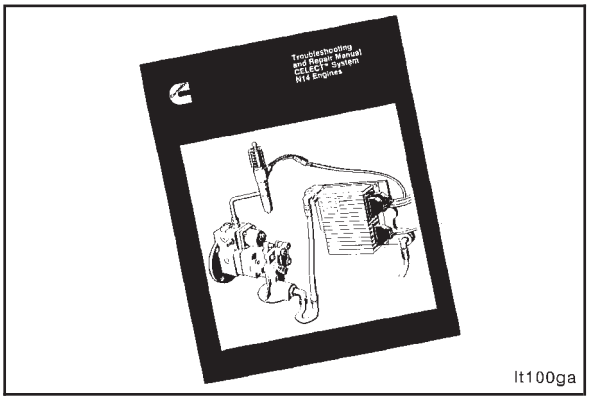
PT

The disassembly, inspection, repair, assembly, and calibration procedures for the PT fuel pump are covered in PT Fuel Pump Rebuilding and Calibration Instructions, Bulletin No. 3379084.



CELECT™

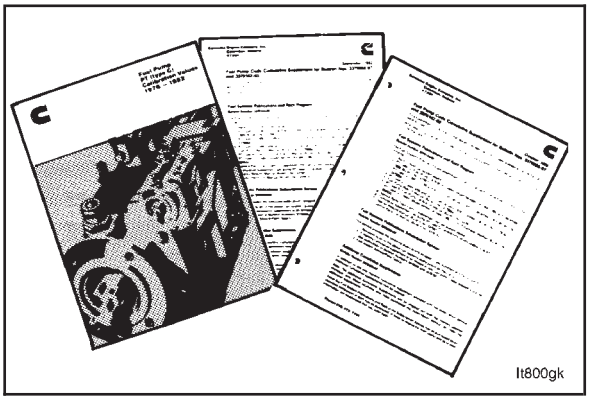
The disassembly, inspection, repair, assembly, and testing procedures for the CELECT™ fuel pump are covered in the Troubleshooting and Repair Manual - CELECT™ System N14 Engines, Bulletin No. 3810469.

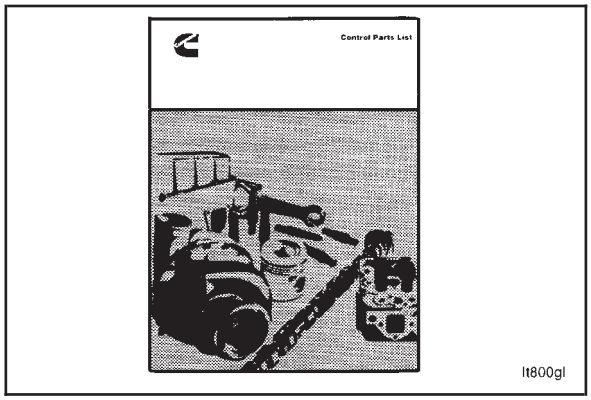


Fuel Pump - Calibration (05-03)

The fuel pump calibration instructions for the PT fuel pump are covered in the Fuel Pump Rebuild Manual, Bulletin No. 3379084. Calibration specifications for the fuel pump are provided in Fuel Pump, PT (type G) Calibration Values 1981 to present, Bulletin No. 3379352, and in monthly supplements available through the Fuel System Publications Subscription Service, Bulletin No. 3379209.

NOTE: CELECT™ fuel pumps do **not** require calibration.



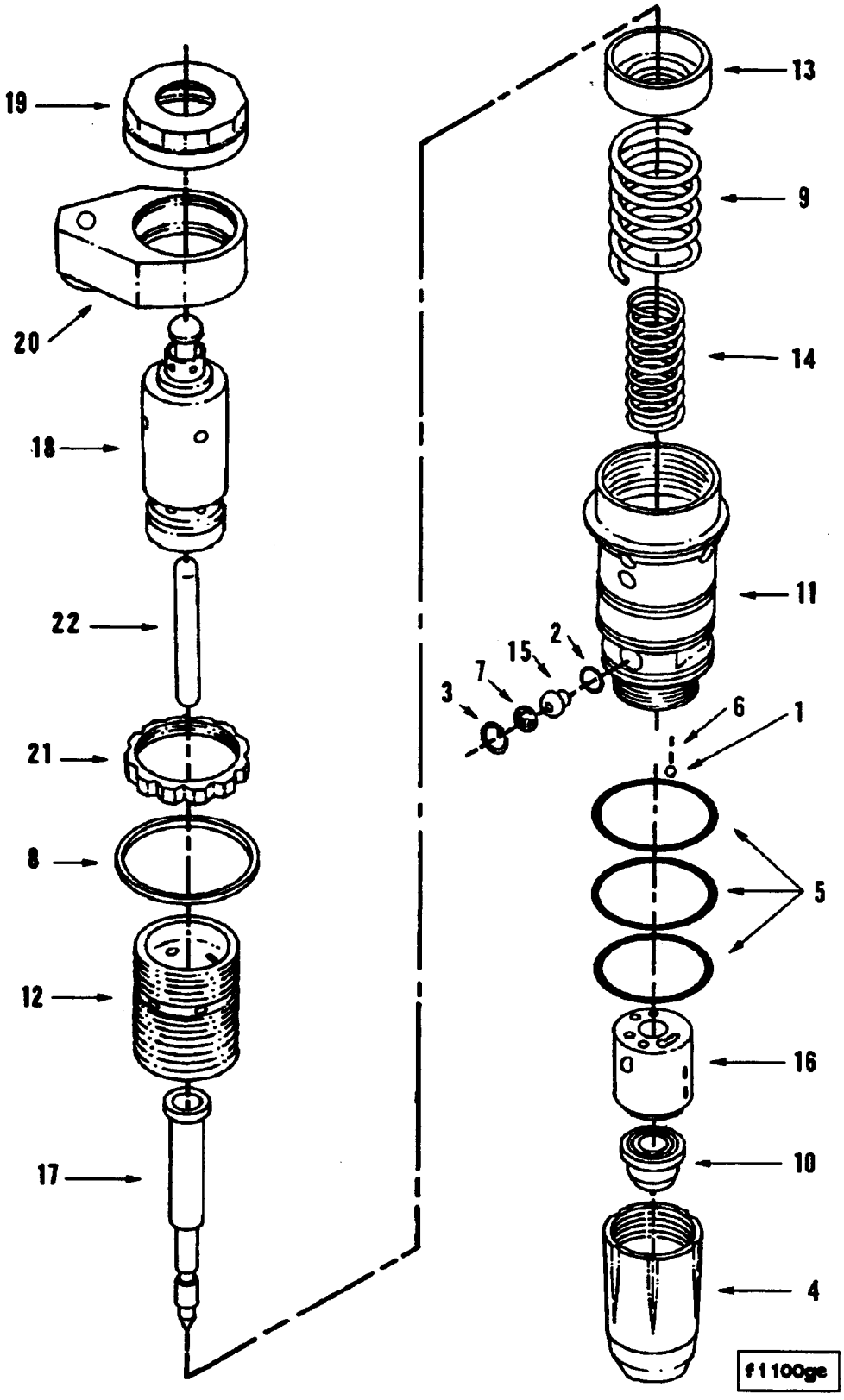


The Control Parts List (CPL) Manual, Bulletin No. 3379133, is a listing of basic engine parts and timing specifications which are necessary to produce a given engine performance. By using the CPL number stamped on the engine dataplate and this manual, parts within the engine can be identified. These parts then determine whether a fuel pump calibration is correct for that engine.

Section 6 - Injectors and Fuel Lines - Group 06

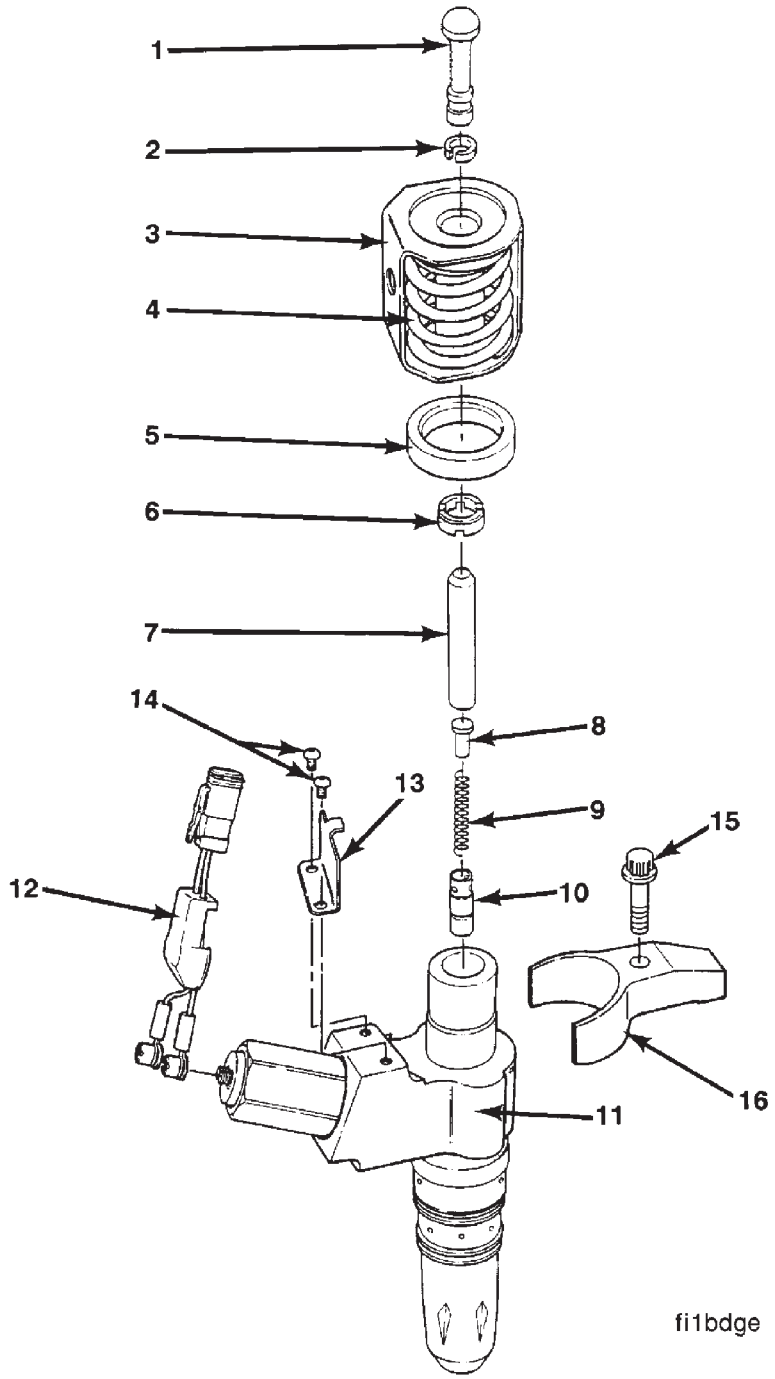
Section Contents

Injector - PT (type D) Step Timing Control - Exploded View



Reference No.	Description	Quantity
1	Ball, Check	1
2	Gasket, Injector	1
3	Retainer, Screen	1
4	Retainer, Cup	1
5	Seal, O-ring	3
6	Pin, Roll	2
7	Screen, Filter	1
8	Washer, Plain	1
9	Spring, Compression	1
10	Cup, Injector	1
11	Adapter, Injector	1
12	Screw, Stop	1
13	Retainer, Spring	1
14	Spring, Compression	1
15	Plug, Orifice	1
16	Barrel	1
17	Plunger	1
18	Tappet, STC	1
19	Cap, Tappet Top Stop	1
20	Nut, Tappet Top Stop Lock	1
21	Nut, Lock	1
22	Link, Injector (Internal)	1

Injector - CELECT™ - Exploded View



Reference No.	Description	Quantity
1	Link, Top	6
2	Retainer, Link	6
3	Retainer, Spring	6
4	Spring, Compression	6
5	Shim, Top Stop	6
6	Shim, Bottom Stop	6
7	Plunger, Timing	6
8	Guide, Spring	6
9	Spring, Bias	6

Reference No.	Description	Quantity
10	Plunger, Metering	6
11	Body, Injector	6
12	Harness, Wiring	6
13	Retainer, Top Stop Assembly	6
14	Screw, Socket	12
15	Capscrew, Hold Down	6
16	Clamp, Hold Down	6

Injectors - PT (type D) Step Timing Control (STC) - General Information

The step timing control (STC) system allows an engine to operate with advanced injection timing under light load conditions. STC allows the engine to operate with normal injection timing under heavy load conditions.

The injectors used in N14 engines equipped with STC are PT (type D) STC full top stop style injectors. The injector top stop plunger travel and total travel **must** be adjusted with a top stop injector setting fixture **before** installing them into an engine. To adjust the injector overhead setting on STC engines after injector installation, use the 0.6 to 0.7 N•m [5 to 6 in-lb] torque wrench method to preload the injector adjusting screw **while holding the STC tappet up with the STC tappet lifting tool.** It is **extremely** important to use the tappet lifting tool to hold the tappet up while applying the preload.

The STC tappet assembly contains a plunger and a sleeve that are machined to a very precise tolerance. The plunger and the sleeve are then match-fit. **Never** exchange or combine the plungers and the sleeves.

The tappet assembly and the injector are **not** match-fit. The tappet assembly can be used in any STC injector, provided the tappet part number is correct for the injector assembly part number. After the tappet is replaced or reinstalled, the top stop total travel **must** be reset on the top stop injector setting fixture before installing the injector into the engine.

Injectors - CELECT™ - General Information

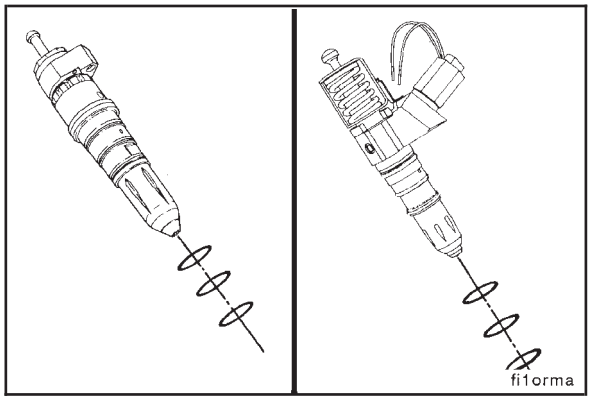
The CELECT™ system allows an engine to have variable timing, depending on load, engine temperature, environmental conditions, etc. The timing and fueling rate are controlled electronically.

The injectors used in CELECT™ engines are top stop, electronically controlled, closed nozzle unit injectors. The top stop plunger travel **must** be adjusted with a top stop setting fixture **before** installing them into an engine. To adjust the overhead setting on CELECT™ engines, preload the injector to 25 in-lb torque. Then, back out the adjusting screw two flats to establish the correct lash per the instructions in the Troubleshooting and Repair Manual - CELECT™ System N14 Engines, Bulletin No. 3810469.

Step Timing Control (STC) Oil Control Valve - General Information

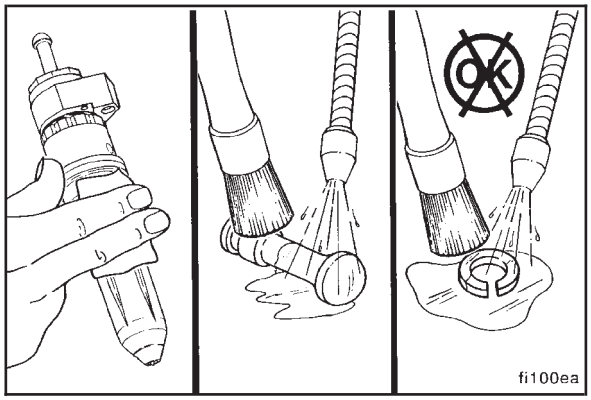
The STC oil control valve is calibrated to a specific flow and pressure, using a fuel pump test stand. Tampering with the valve or the plumbing will result in the loss of fuel economy and engine durability. Correct valve operation is necessary to maintain acceptable cylinder pressures and white smoke levels and to ensure optimum fuel economy.

For more information on the STC oil control valve, refer to the Step Timing Oil Control Valve Shop Manual, Bulletin No. 3810371, Troubleshooting and Repair Step Timing Control System Manual, Bulletin No. 3810385, and the Troubleshooting and Repair Manual STC/PT Fuel System - N14 Engines, Bulletin No. 3810481.



Injectors - Cleaning the Exterior and Inspection for Reuse (06-01)

Remove and discard the three injector o-rings.

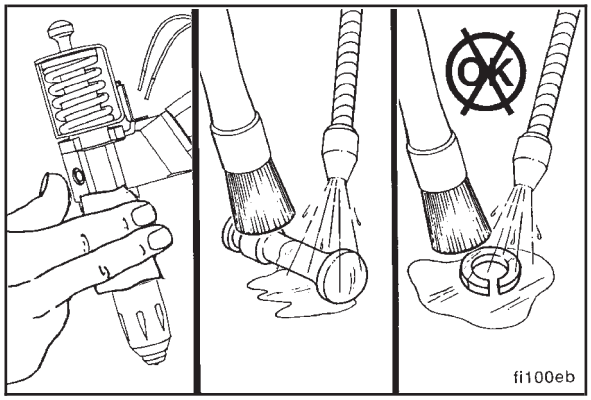


Cleaning - STC

Use a clean, lint-free cloth to clean the exterior of the injectors.

Use solvent to clean the injector plunger links.

NOTE: STC injectors contain a tappet stop link, which is held in place by a plastic retaining clip. Do **not** immerse or wash the plastic clip in a cleaning solvent because it can dissolve.

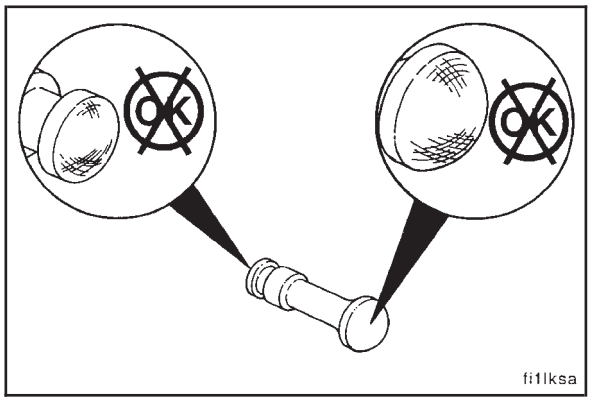


Cleaning - CELECT™

Use a clean, lint-free cloth to clean the exterior of the injectors.

Use solvent to clean the injector plunger links.

NOTE: CELECT™ injectors contain a top link which is held in place by a plastic retaining clip. Do **not** immerse or wash the plastic clip in a cleaning solvent because it can dissolve.



Inspection - STC

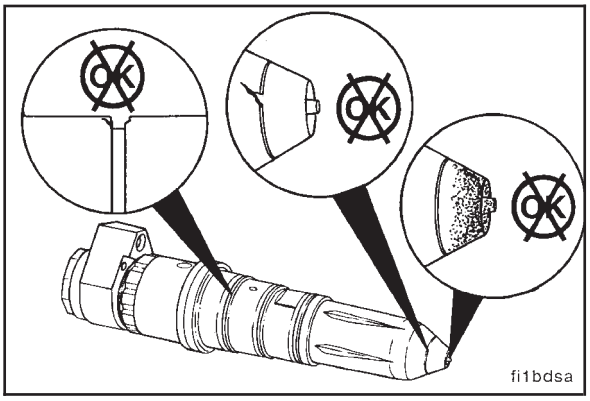
Visually inspect the injector plunger links for damage, excessive wear, and pitting or scoring on the ball ends.

NOTE: If the plunger link is damaged or the pitting or scoring can be seen or felt, the plunger links **must** be replaced.

Visually inspect the injector for carbon deposits on the injector cup and cup retainer.

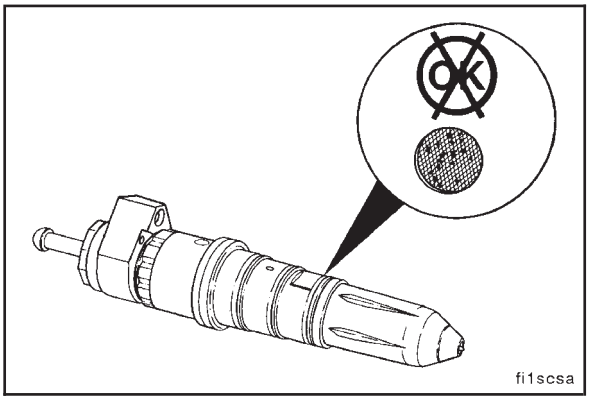
Visually inspect the o-ring grooves for damage.

Visually inspect the injector body and cup retainer for cracks or other damage.



Visually inspect the orifice screen for damage, contamination, or metal particles.

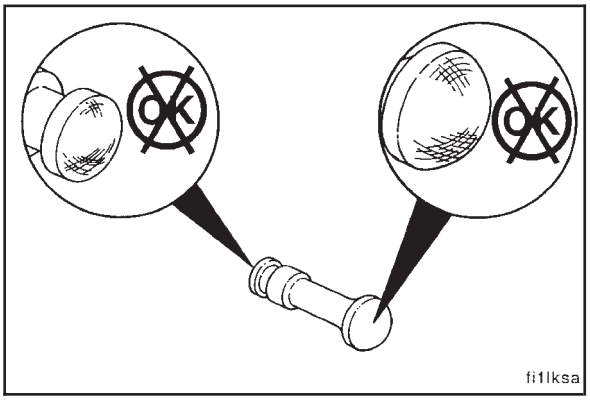
NOTE: If damaged or contaminated parts are found, the injectors **must** be replaced or rebuilt. Refer to Injector Rebuild and Calibration information (06-02 and 06-03), respectively.



Inspection - CELECT™

Visually inspect the injector plunger links for damage, excessive wear, and pitting or scoring on the ball ends.

NOTE: If the plunger link is damaged or the pitting or scoring can be seen or felt, the plunger links **must** be replaced.

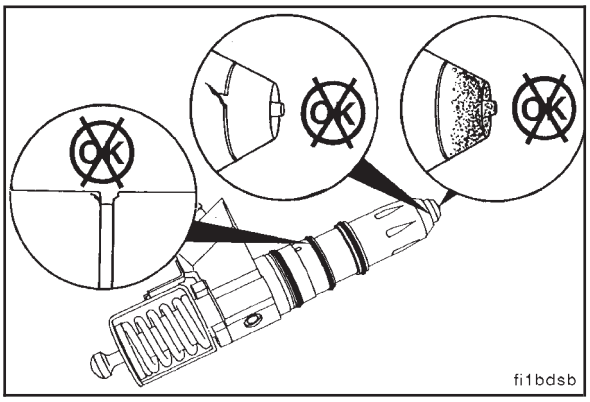


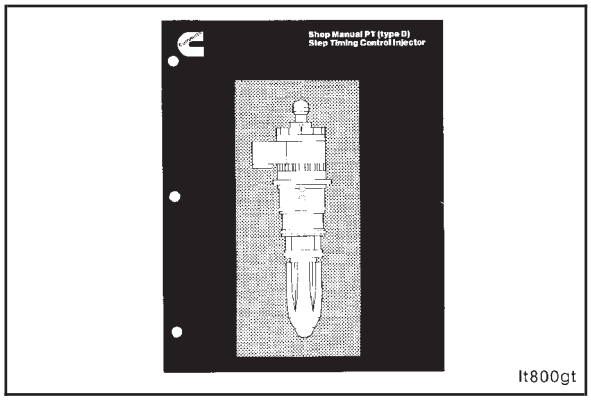
Visually inspect the injector for carbon deposits on the injector cup and cup retainer.

Visually inspect the o-ring grooves for damage.

Visually inspect the injector body and cup retainer for cracks or other damage.

Visually inspect the top stop spring cage and cage retainer for cracks or other damage.

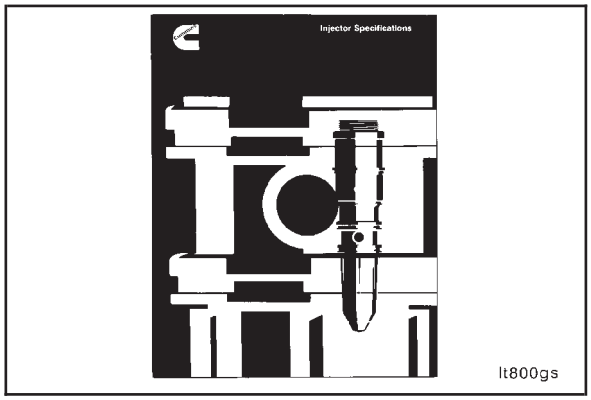




Injectors - Rebuild (06-02)

The disassembly, inspection, repair, and calibration procedure for STC injectors are covered in Shop Manual PT (type D) Step Timing Control Injector, Bulletin No. 3810313.

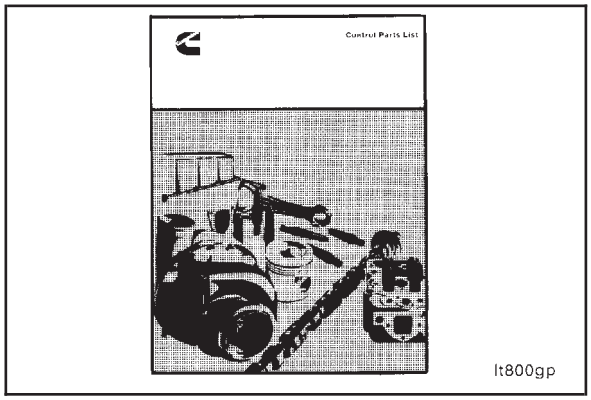
NOTE: CELECT™ injectors are presently **not** rebuildable in the field.



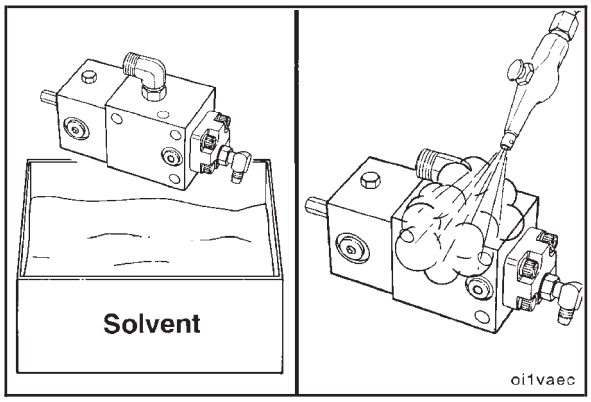
Injectors - Calibration (06-03)

The injector calibration specifications and parts information are provided in Injector Specifications, Bulletin No. 3379664.

NOTE: CELECT™ injectors do **not** require flow calibration.



The CPL (Control Parts List) Manual, Bulletin No. 3379133, is a listing of basic engine parts and timing specifications which are necessary to produce a given engine performance. The CPL number stamped on the engine dataplate is used to identify parts within the engine, including the injectors.



STC Oil Control Valve - Cleaning (06-04)

Warning: When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to avoid personal injury.

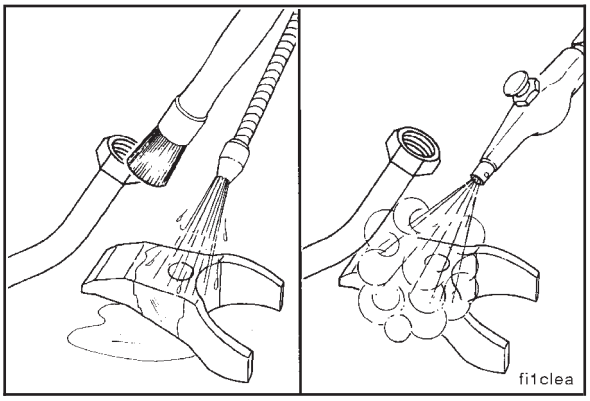
Plug all openings to prevent dirt from entering the valve.

Use a solvent to clean the outside of the valve. Dry with compressed air.

Fuel Tubes, Fittings, and Mounting Parts - Cleaning and Inspection for Reuse (06-05)

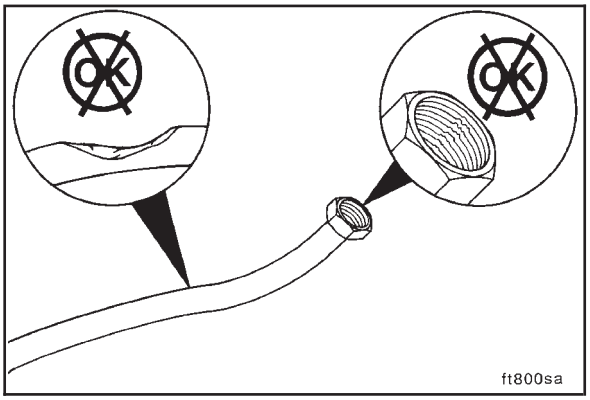
Cleaning

Use solvent to clean the fuel tubes, fittings, and parts. Dry with compressed air.



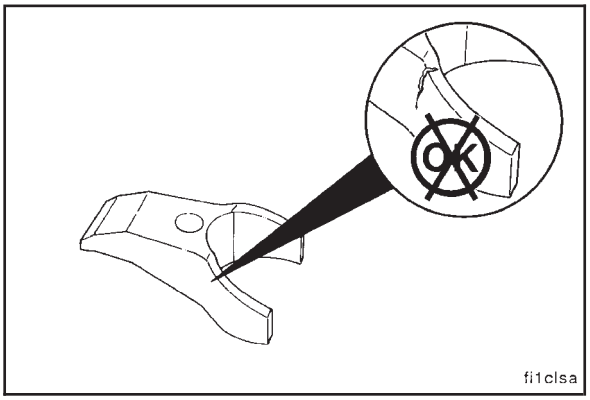
Inspection

Visually inspect the fuel tubes for cracks or locations where the tubing is crushed. Do **not** attempt to repair fuel tubing.



Visually inspect the injector hold down clamps for cracks or other damage.

NOTE: If cracked or damaged parts are found, the parts **must** be replaced.

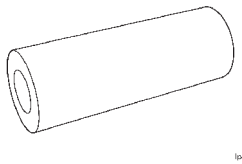
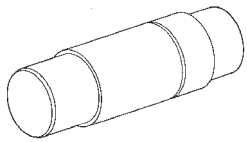
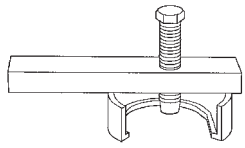
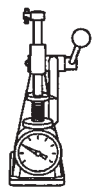
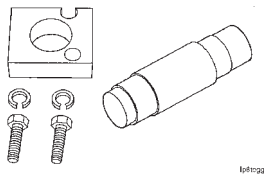


Section 7 - Lubricating Oil System - Group 07

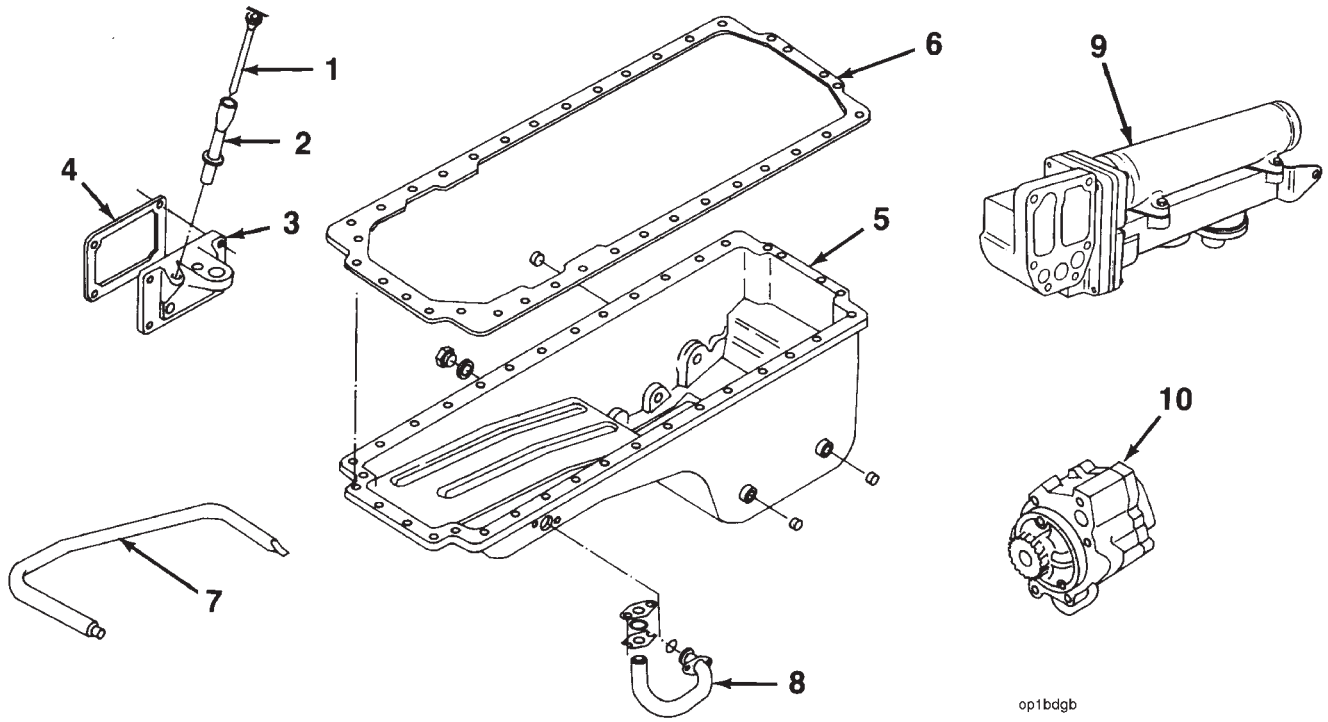
Section Contents

Lubricating Oil System - Service Tools

The following special tools are recommended to perform procedures in Group 07. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

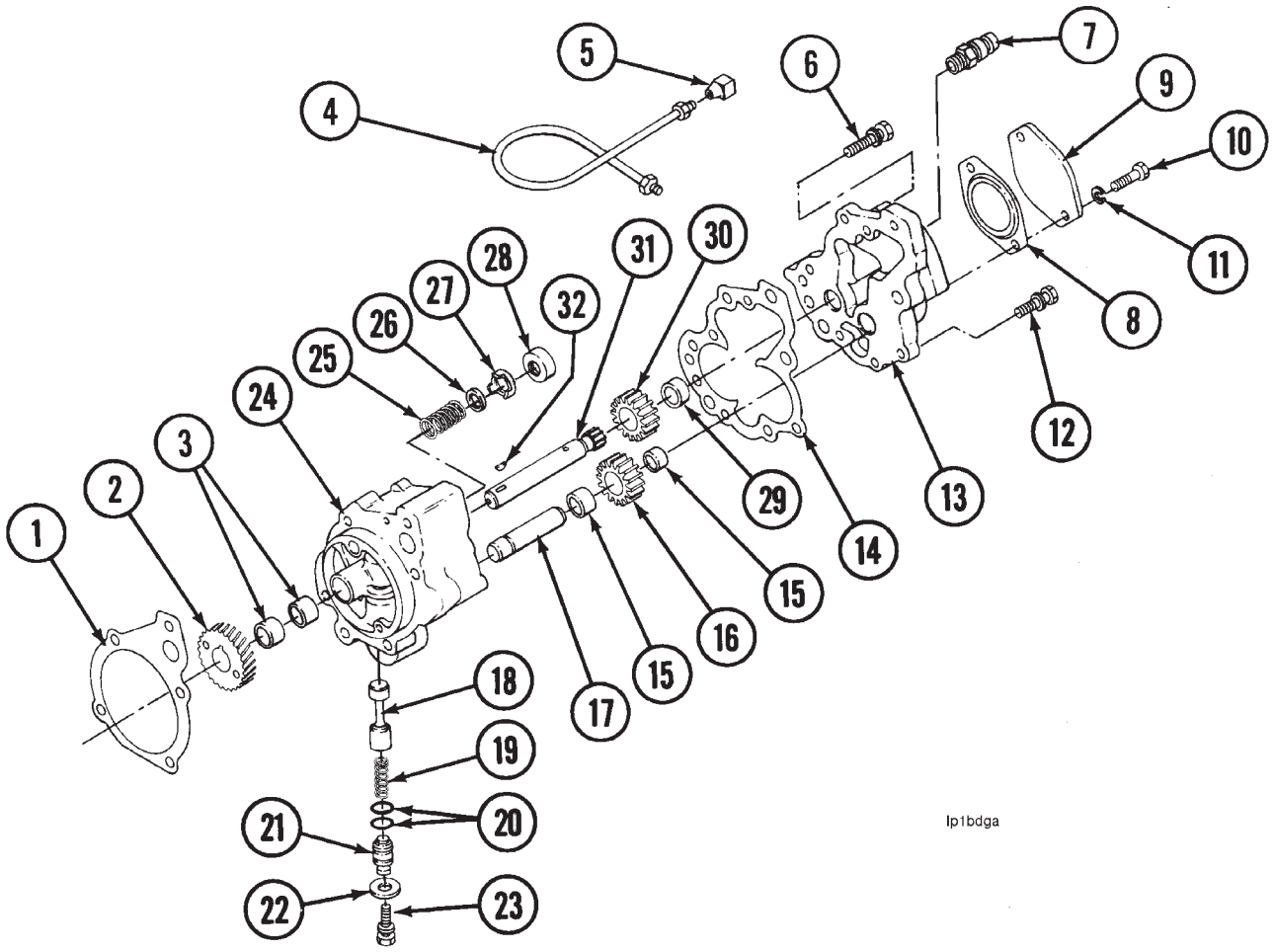
Tool No.	Tool Description	Tool Illustration
ST-1157	**Spacer Mandrel** Install the gear onto the lubricating oil pump shaft.	
ST-1158	**Bushing Mandrel** Remove and install the bushing from the single lubricating oil pump with double capacity.	
3375082	**Gear Puller** Remove the drive gear, Part No. 143190, from the drive shaft.	
3375182	**Valve Spring Fixture** Measures spring force at a given spring height.	 kn8togs
3376011	**DFC Pressure Valve Fixture** Install the high pressure limit valve assembly into the DFC lubricating oil pump.	

Lubricating Oil System - Exploded View



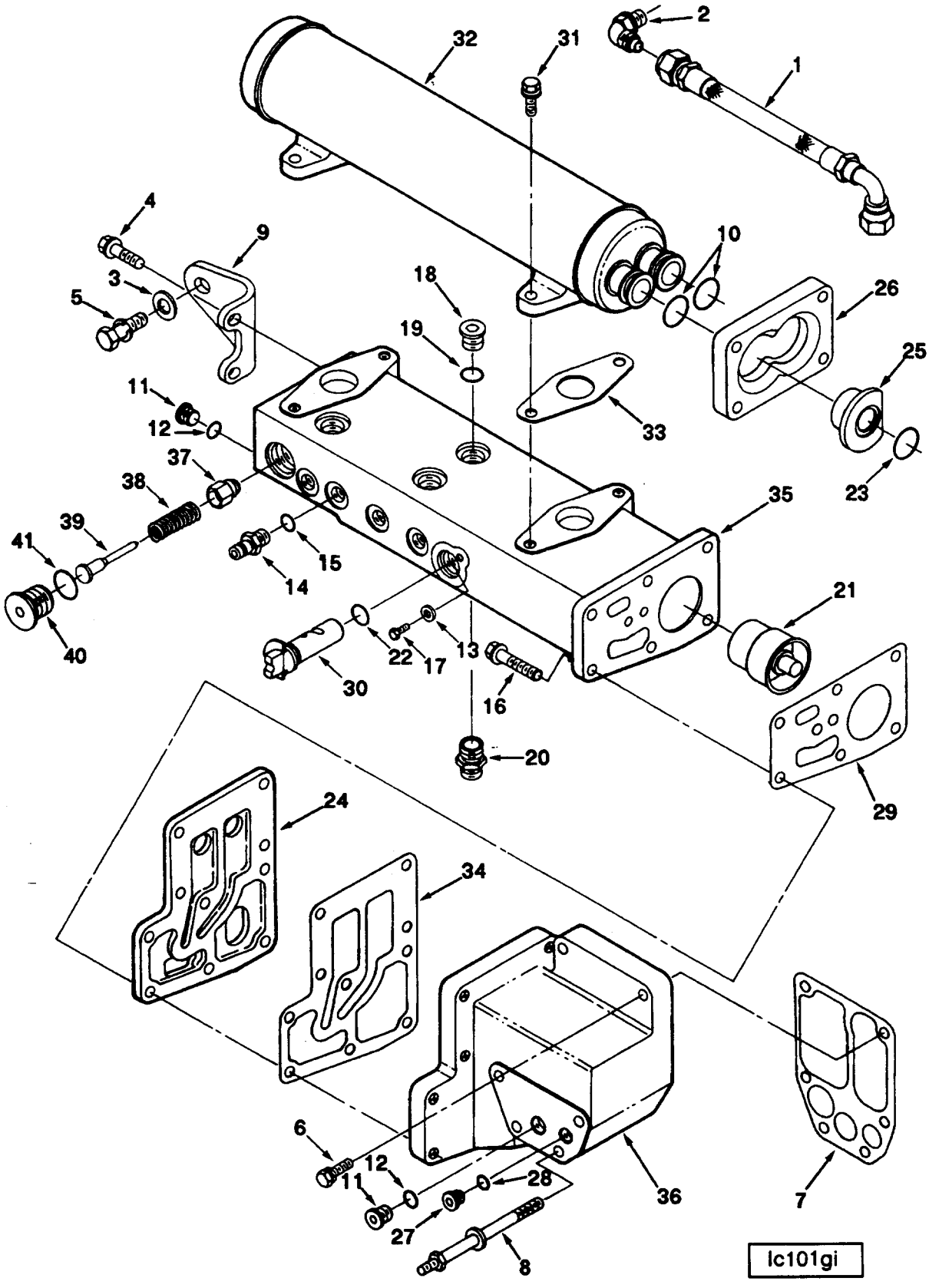
Reference No.	Description	Quantity
1	Dipstick	1
2	Tube, Oil Gauge	1
3	Cover, Hand Hole	1
4	Gasket, Hand Hole Cover	1
5	Pan, Oil	1
6	Gasket, Oil Pan	1
7	Tube, Oil Suction	1
8	Tube Assembly, Oil Transfer	1
9	Filter and Cooler, Lubricating Oil	1
10	Pump, Lubricating Oil	1

Lubricating Oil Pump Assembly - Exploded View



Reference No.	Description	Quantity	Reference No.	Description	Quantity
1	Gasket, Lubricating Oil Pump	1	18	Plunger, Pressure Regulator	1
2	Gear, Lubricating Oil Pump	1	19	Spring, Pressure Regulator	1
3	Bushing	2	20	Seal, O-ring	2
4	Tube, Pressure Sensing	1	21	Plug, Retainer	1
5	Elbow, Male Adapter	2	22	Washer, Plain	1
6	Capscrew, Captive (5/16 - 18 X 1)	7	23	Capscrew, Captive (5/16 - 18 X 5/8)	1
7	Nipple, Coupling	1	24	Body, Lubricating Oil Pump	1
8	Gasket, Hydraulic Pump	1	25	Spring, Bypass Valve	1
9	Plate, Cover	1	26	Washer, Plain	1
10	Capscrew (3/8 - 16 X 1)	2	27	Disc, Valve	1
11	Washer, Lock (3/8-inch)	2	28	Plug, Retainer	1
12	Capscrew, Captive	2	29	Bushing	1
13	Cover, Lubricating Oil Pump	1	30	Gear, Lubricating Oil Pump	1
14	Gasket, Cover	1	31	Shaft, Lubricating Oil Pump	1
15	Bushing	2	32	Key, Plain Woodruff	1
16	Gear, Lubricating Oil Pump	1			
17	Shaft, Idler	1			

Lubricating Oil Cooler - Exploded View



Ref. No.	Description	Quantity
1	Hose, Flexible	1
2	Elbow, Male Union	2
3	Washer, Plain	1
4	Screw, Captive Washer Cap	2
5	Screw, Captive Washer Cap	1
6	Screw, Captive Washer Cap	2
7	Gasket, Oil Cooler Support	1
8	Screw, Captive Washer Cap	4
9	Bracket, Oil Cooler	1
10	Seal, O-ring	2
11	Plug, Threaded	2
12	Seal, O-ring	2
13	Washer, Plain	1
14	Nipple, Coupling	2
15	Seal, O-ring	2
16	Screw, Captive Washer Cap	10
17	Screw, Hexagon Head Cap	1
18	Plug, Threaded	5
19	Seal, O-ring	5
20	Adapter, Filter Head	1
21	Thermostat	1
22	Seal, O-ring	1
23	Seal, O-ring	2
24	Spacer, Cooler Support	1
25	Adapter, O-ring	2
26	Retainer, Connection	1
27	Plug, Threaded	1
28	Seal, O-ring	1
29	Gasket, Oil Transfer Connection	1
30	Shaft, Shutoff Valve	1
31	Screw, Captive Washer Cap	4
32	Cooler, Oil	4
33	Gasket, Lub Oil Cooler Housing	2
34	Gasket, Oil Cooler Support	1
35	Connection, Oil Transfer	1
36	Support, Oil Cooler	1
37	Valve, Bypass	1
38	Spring, Compression	1
39	Plunger, Bypass Valve	1
40	Plug, Threaded	1
41	Seal, O-ring	1

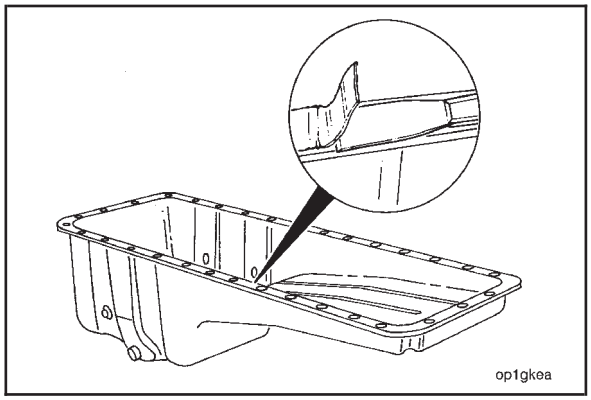
Lubricating Oil System - General Information

The lubricating oil system group consists of the oil pan, the oil suction tube, the oil transfer tube assembly, the oil dipstick and oil gauge tube, the oil filter and cooler assembly, and the lubricating oil pump.

Service replacement dipsticks do **not** have the high and low level marks indicated on the dipstick. The dipstick **must** be calibrated after the engine is installed in the chassis.

Instructions for pressure testing the lubricating oil cooler element are included in this manual.

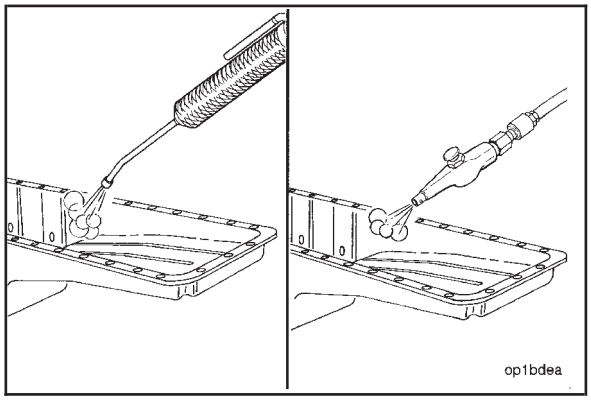
During disassembly, mark the parts such as the pressure regulator plunger, idler shaft, drive shaft, gears, and the capscrew length, size, and location as they are removed. Identify the parts as they are removed so they can be correctly assembled again.



Lubricating Oil Pan - Cleaning and Inspection for Reuse (07-01)

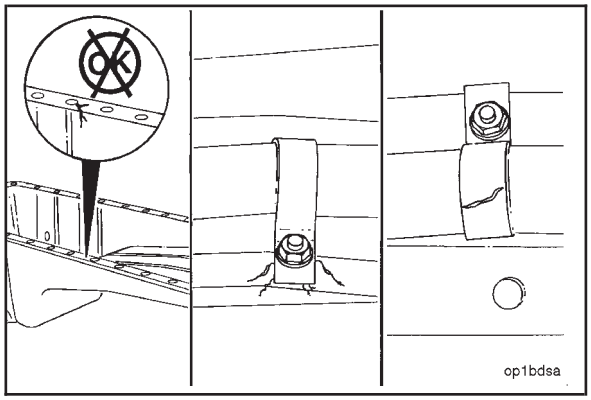
Cleaning

Remove all gasket material from the oil pan gasket sealing surface.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use steam to clean the oil pan. Dry with compressed air.



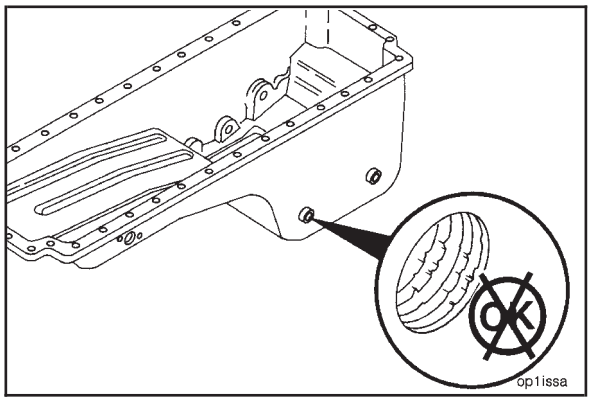
Inspection

Visually inspect the oil pan for cracks or damage.

Visually inspect the inside and the outside of the oil pan for cracks around the suction tube mounting studs.

Visually inspect for a cracked or broken suction tube mounting clip.

NOTE: A waterproof, rubberized foam coated oil pan has been developed for applications that are subjected to severe corrosive and abrasive environments. Refer to Service Parts Topics for more information.



Visually inspect the threaded holes or thread inserts for damage.

NOTE: If the oil pan is cracked or damaged or if the threaded holes are damaged, the oil pan **must** be replaced.

Lubricating Oil Transfer Tube - Cleaning and Inspection for Reuse (07-02)

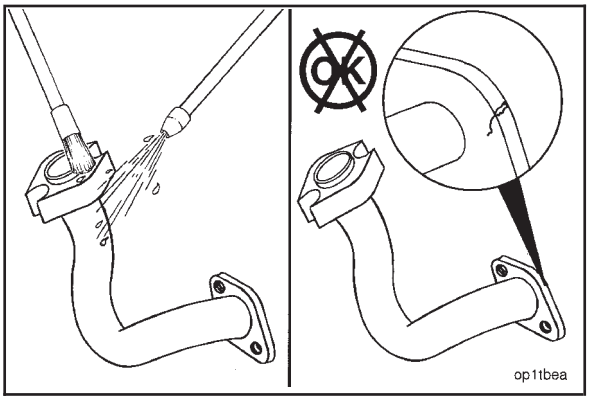
Cleaning

Use solvent to clean the lubricating oil transfer tube and the mounting flanges. Dry with compressed air.

Inspection

Visually inspect the tube and the flanges for cracks, corrosion, or other damage.

NOTE: If cracks or damage are found, the transfer tube **must** be replaced.

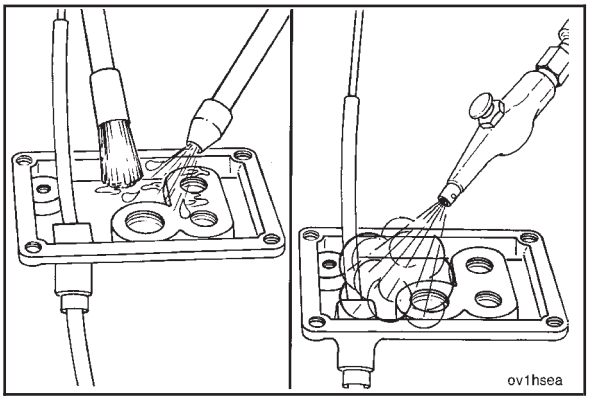


Lubricating Oil Dipstick and Dipstick Tube - Cleaning and Inspection for Reuse (07-03)

Cleaning

Remove all gasket material from the hand hole cover gasket sealing surface.

Use solvent to clean the dipstick, dipstick tube, and the hand hole cover. Dry with compressed air.

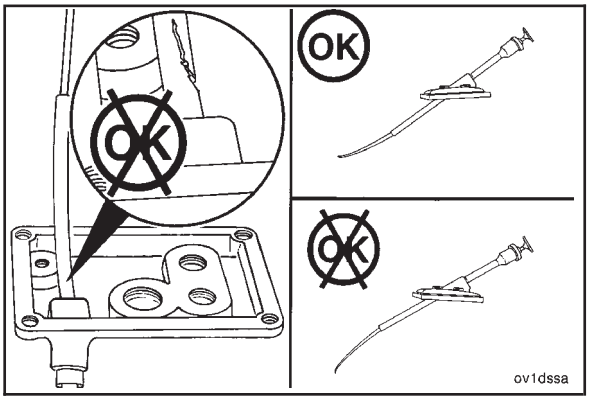


Inspection

Visually inspect the dipstick tube and the hand hole cover for cracks or damage.

Visually inspect the dipstick tube angle.

NOTE: If cracks or damage are found or if the dipstick tube does **not** angle down into the oil pan, the damaged parts or the dipstick tube **must** be replaced.

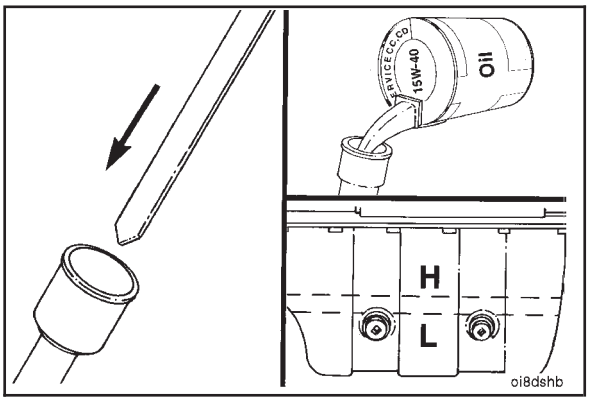


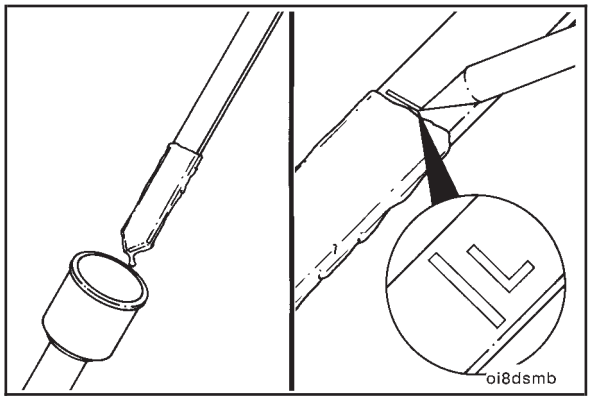
Lubricating Oil Dipstick - Calibration (07-04)

While the engine is installed in chassis, install the dipstick in the dipstick tube housing.

Use clean 15W-40 oil to fill the oil pan to the specified ''LOW'' oil pan capacity level.

Oil Pan Capacity		
Liters		U.S. Gallons
30	LOW	8.0
35	HIGH	9.5

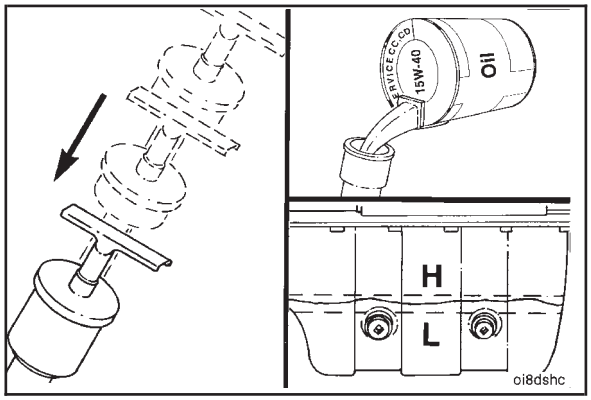




Remove the dipstick and scribe a mark across the dipstick. Mark the ''LOW'' level with an ''L.''

NOTE: The dipstick will break if the scribe mark is too deep.

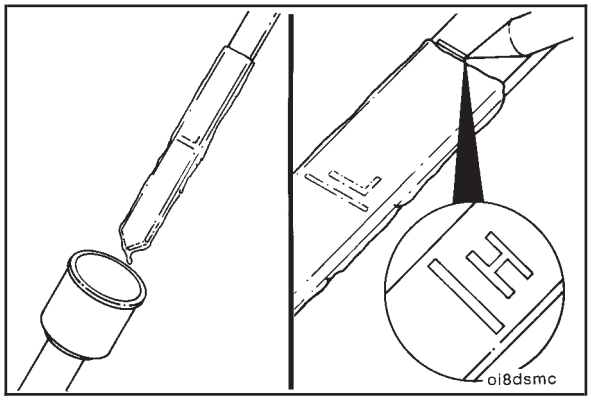
NOTE: Cut the new dipstick off approximately 38 mm [1.5 inches] below the ''LOW'' oil level mark.



Install the dipstick into the dipstick tube housing.

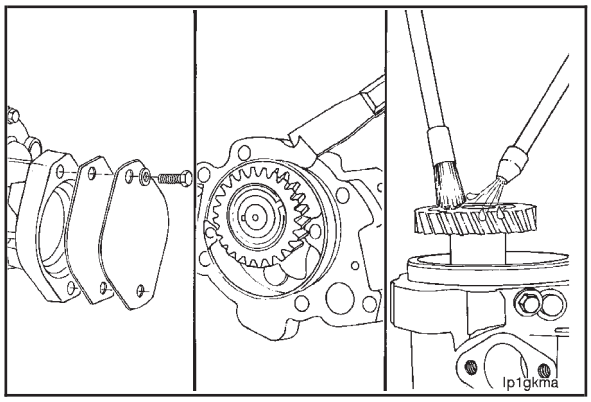
Use clean 15W-40 oil to fill the oil pan to the specified ''HIGH'' oil pan capacity level.

Refer to the preceding oil pan capacity table for the oil required.



Remove the dipstick and scribe a mark across the dipstick. Mark the ''HIGH'' oil level with an ''H.''

NOTE: The dipstick will break if the scribe mark is too deep.



Lubricating Oil Pump - Cleaning and Inspection for Reuse (07-05)

Cleaning

Remove the cover and the gasket from the power steering pump mounting flange.

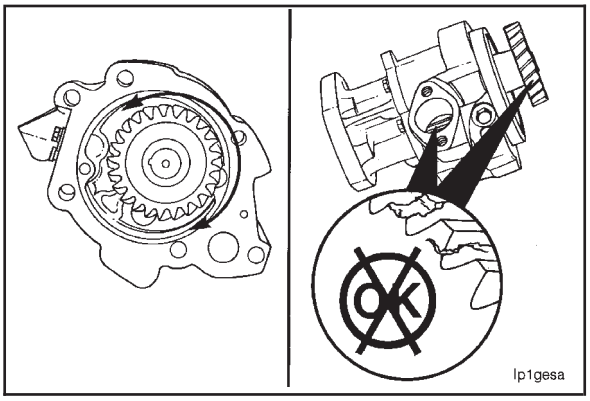
Use a gasket scraper to remove the gasket material from the gasket mating surfaces.

Use solvent to clean the lubricating oil pump. Dry with compressed air.

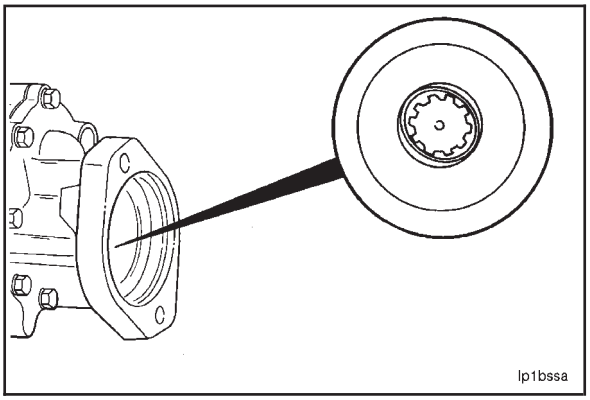
Inspection

Turn the main drive gear by hand to check the internal gears for freedom of rotation.

Visually inspect the gears for cracked or broken teeth.



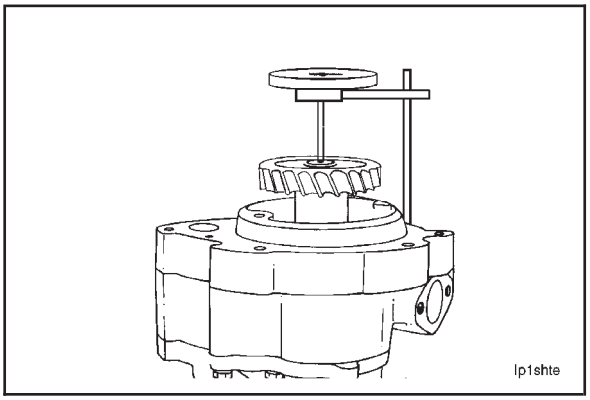
Visually inspect the bushings for excessive wear or discoloration due to overheating or seizure of the shafts.



Measure the drive shaft end clearance with a dial indicator located at the end of the lubricating oil pump drive shaft.

Drive Shaft End Clearance		
mm		in
0.10	MIN	0.004
0.28	MAX	0.011

NOTE: If the main drive gear does **not** turn freely by hand, cracked or broken teeth are found, or the shaft end clearance is **not** within the specifications given, the oil pump **must** be replaced or rebuilt. Refer to Lubricating Oil Pump - Rebuild (07-06).



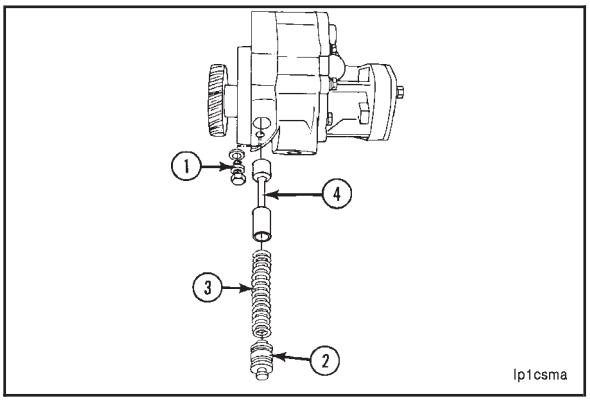
Lubricating Oil Pump - Rebuild (07-06)

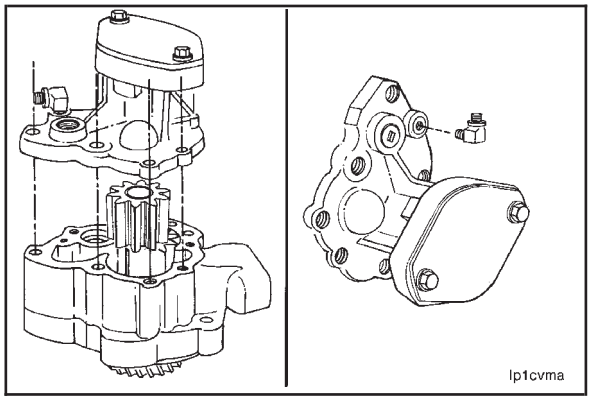
Disassembly

Remove the main oil pressure regulator as follows:

1. Remove the capscrew (1) and the retainer plug (2).
2. Remove the spring (3) and the regulator plunger (4).

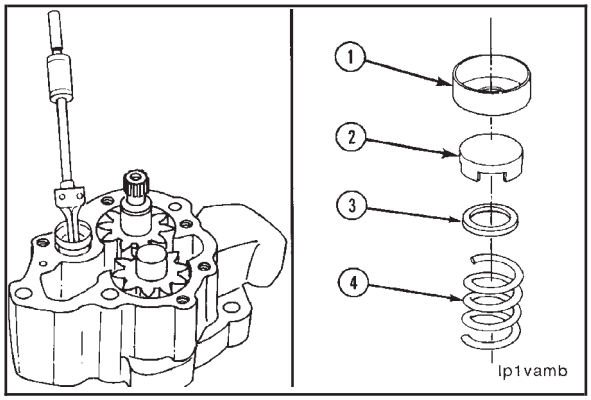
NOTE: Carefully remove the capscrew (1). The pressure regulator spring (3) is under compression.





Remove the oil pump cover. Remove and discard the cover gasket.

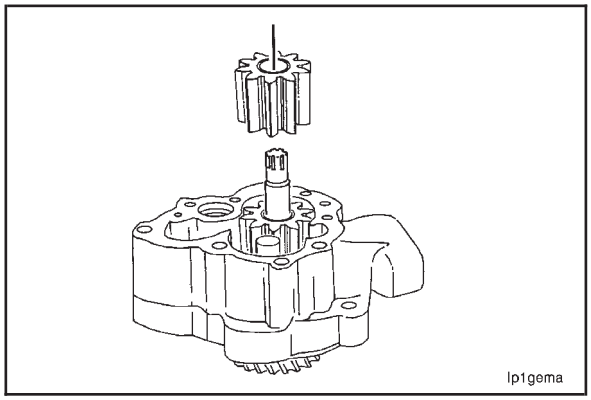
Remove the 7/16-20 straight thread o-ring adapter from the oil pump cover.



Remove the high oil pressure relief valve as follows:

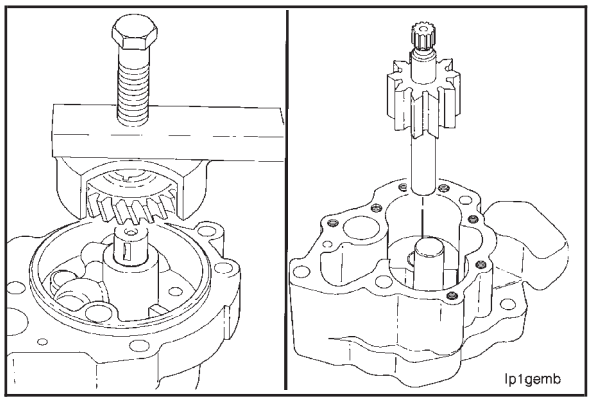
1. Use the light-duty puller kit, Part No. 3375784, or its equivalent to remove the retainer plug (1).
2. Remove the valve disc (2), the washer (3), and the pressure relief valve spring (4).

NOTE: Carefully remove the retainer plug (1). The pressure relief valve spring (4) is under compression.



Remove the driven gear from the shaft.

NOTE: Do **not** remove the driven gear shaft from the oil pump body. Refer to inspection procedures listed below.



Use lubricating oil pump gear puller, Part No. 3375082, to remove the oil pump main drive gear.

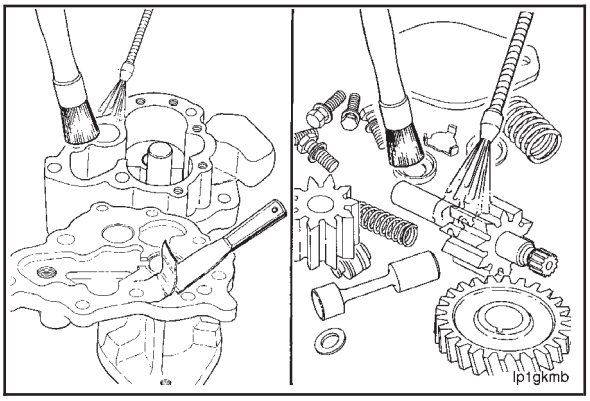
Remove the drive shaft and gear assembly from the oil pump body.

NOTE: Do **not** remove the drive gear from the shaft. Refer to the inspection procedures listed below.

Cleaning

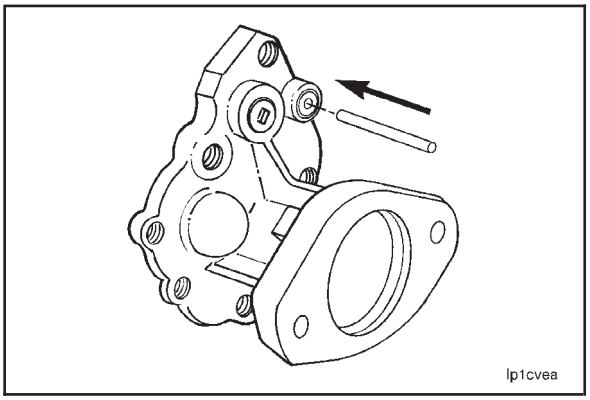
Clean the gasket material from the lubricating oil pump body and the cover.

Use solvent to clean the lubricating oil pump parts. Dry with compressed air.



Use an acetylene torch tip cleaner or its equivalent that is 1.02 mm [0.040-inch] or less in diameter to clean the orifice in the cover.

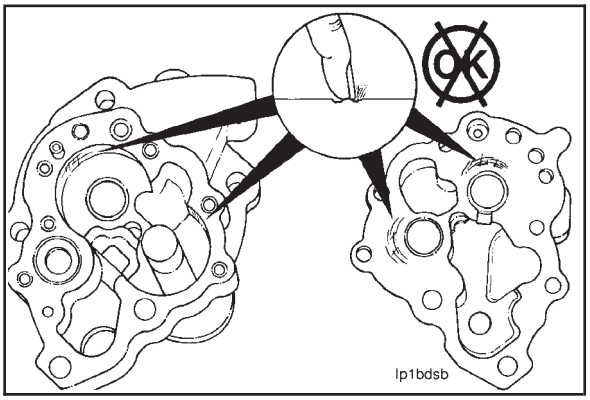
NOTE: The diameter of the orifice is 1.02 mm [0.040-inch]. Do **not** attempt to drill out the orifice or use a larger diameter wire to clean the orifice.



Inspection

Visually inspect the cover and gear pockets in the body for scratches or other damage.

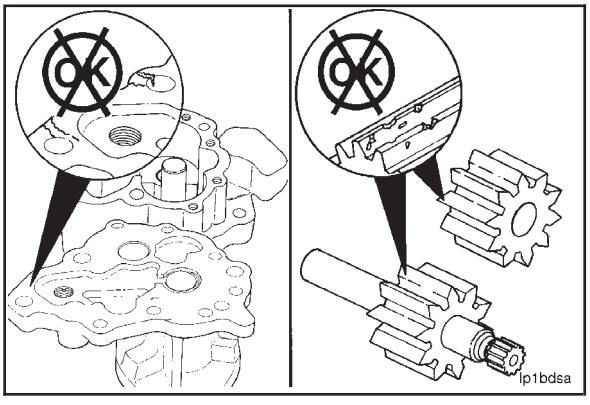
If the marks on the cover or in the body can be felt with your fingernail, the part **must** be replaced.

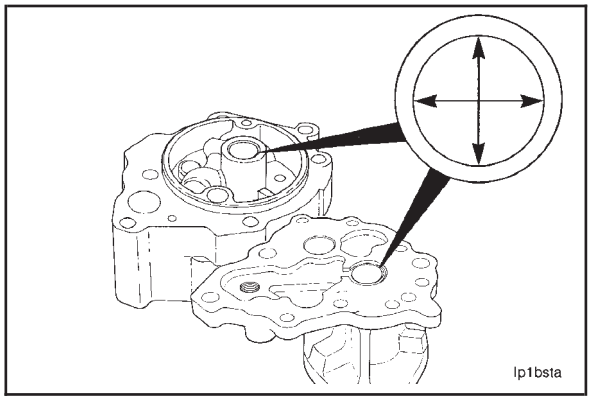


Visually inspect the oil pump body and cover for cracks or damage.

Visually inspect the oil pump gears for worn or damaged teeth.

NOTE: Cracked, worn, or damaged oil pump parts **must** be replaced.



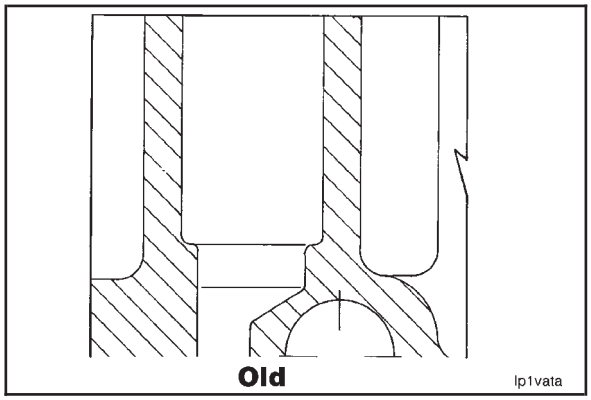


Visually inspect the bushings in the oil pump body and the cover for damage.

Measure the inside diameter of the bushings in the oil pump body and cover.

Bushing I.D.		
mm		**in**
22.263	MIN	0.8765
22.314	MAX	0.8785

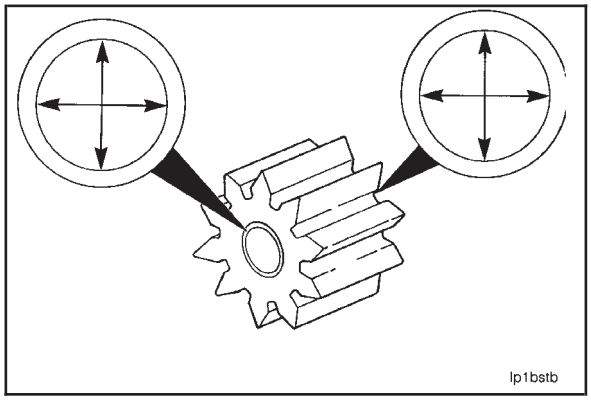
NOTE: If the bushings are worn larger than the maximum given, the bushings **must** be replaced.



Measure the high oil pressure relief valve seat depth in the oil pump body.

Valve Seat Depth		
mm		**in**
46.73	MAX	1.840

NOTE: If the valve seat depth is greater than the maximum specification given, the oil pump body **must** be replaced.

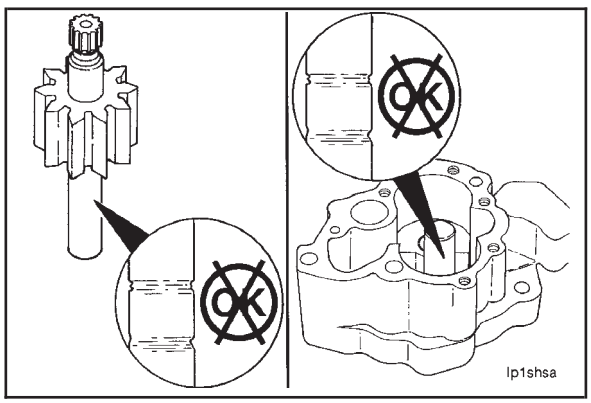


Visually inspect the bushings in the driven gear for damage.

Measure the inside diameter of the bushings in the oil pump driven gear.

Bushing I.D.		
mm		**in**
22.263	MIN	0.8765
22.314	MAX	0.8785

NOTE: If the bushings are worn larger than the maximum given, the bushings **must** be replaced.

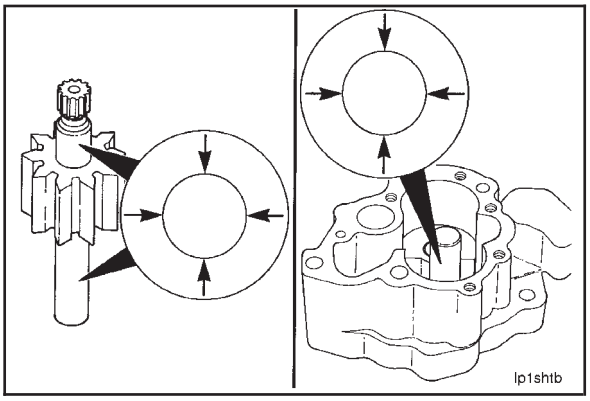


Visually inspect the drive shaft and the driven shaft for damage.

Measure the outside diameter of the drive and the driven shafts in the bushing contact area.

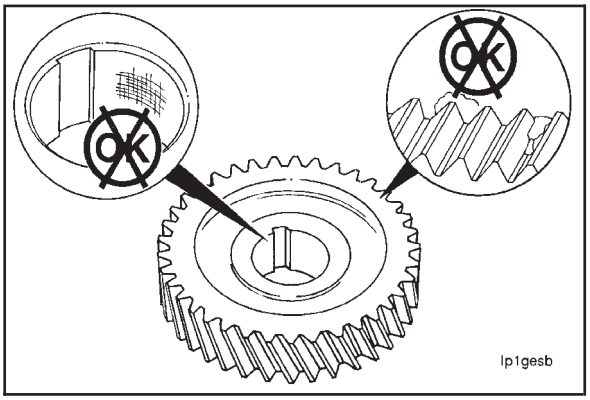
Shaft O.D.		
mm		**in**
22.20	MIN	0.8745
22.22	MAX	0.8750

NOTE: Shafts that are damaged or worn smaller than the minimum given **must** be replaced. Refer to Lubricating Oil Pump Drive Gear or Shaft - Replacement (07-09).



Visually inspect the main drive gear for cracks, chipped, or broken teeth.

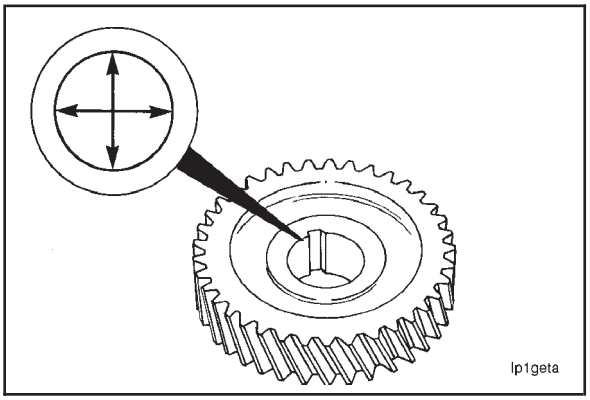
Inspect the bore of the gear for scoring or other damage.



Measure the inside diameter of the main drive gear bore.

Main Drive Gear Bore I.D.		
mm		**in**
22.161	MIN	0.8725
22.187	MAX	0.8735

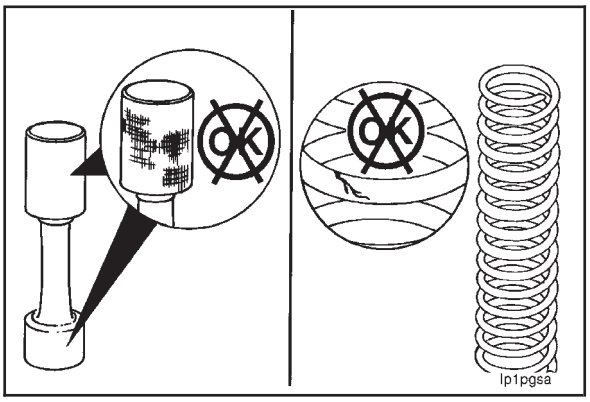
NOTE: If the main drive gear bore is worn beyond the maximum limit, the drive gear **must** be replaced.

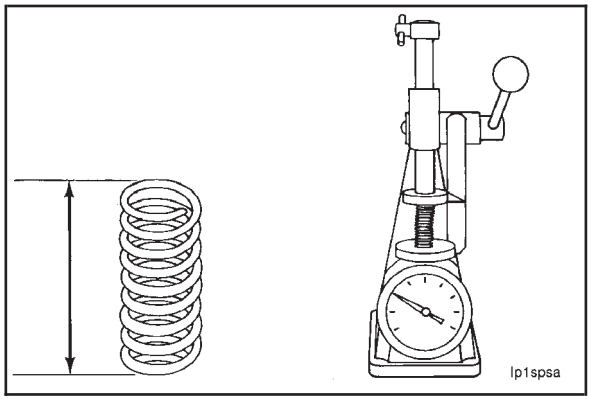


Visually inspect the main oil regulator plunger for scratches or scoring.

NOTE: If scratches are deep enough to be felt with a fingernail, the plunger **must** be replaced.

Visually inspect the spring for damaged or broken coils.



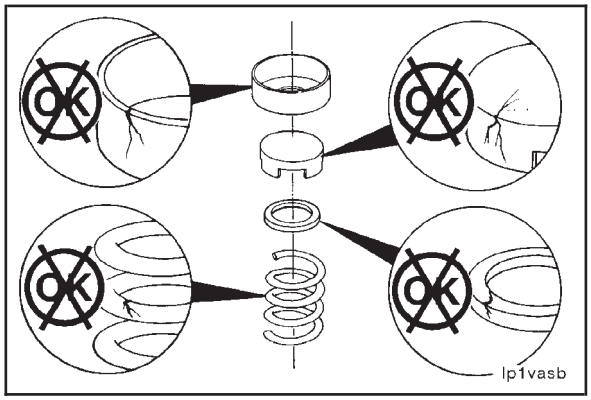


Use valve spring tester, Part No. 3375182, to determine if the spring is defective.

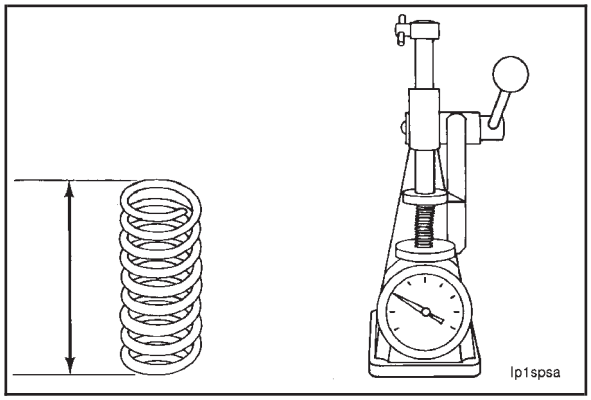
NOTE: Compress the spring to a height of 46.23 mm [1.820 inches]. The force required **must** be:

- Minimum: 98 Newtons [22 lbf]
- Maximum: 116 Newtons [26 lbf]

NOTE: If the force required to compress the spring is **not** within the specifications given, the spring **must** be replaced.



Visually inspect the high pressure relief valve retainer plug, the valve disc, the washer, and the valve spring for damage.

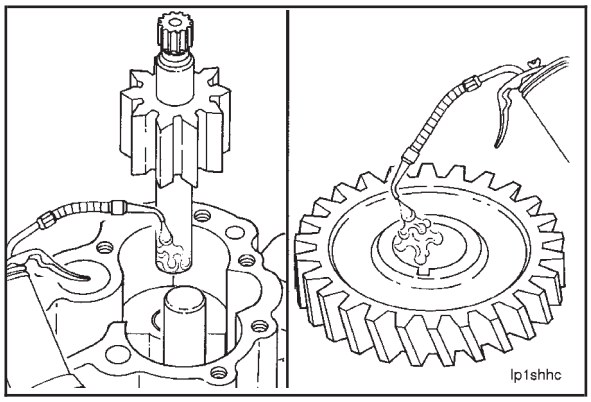


Use valve spring tester, Part No. 3375182, to measure the relief spring tension.

NOTE: Compress the spring to a height of 29.08 mm [1.145 inches]. The force required **must** be:

- Minimum: 262 Newtons [59 lbf]
- Maximum: 320 Newtons [72 lbf]

NOTE: If the force required to compress the spring is **not** within the specifications given, the spring **must** be replaced.



Assembly

Use clean 15W-40 oil to lubricate the drive shaft.

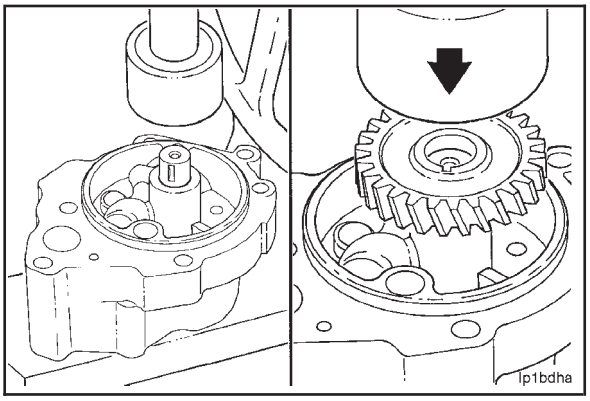
Install the drive shaft, from the gear pocket side of the oil pump body, into the drive shaft bore.

Use clean 15W-40 oil to lubricate the inside diameter of the oil pump main drive gear.

Install the oil pump body and the drive shaft assembly in an arbor press.

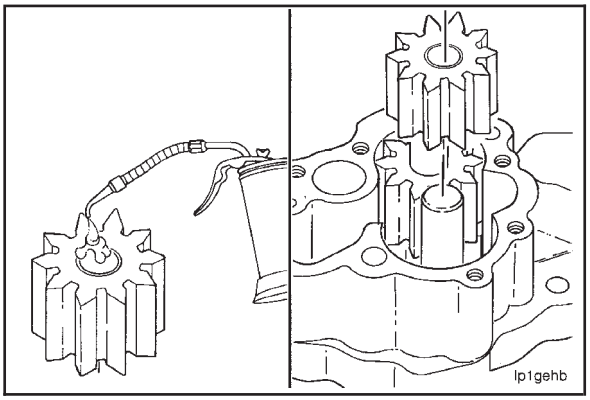
Support the end of the drive shaft, and press the main drive gear onto the shaft.

NOTE: At this stage of assembly, there **must not** be more than 0.30 mm [0.012-inch] end clearance between the main drive gear and the oil pump body. Use a dial indicator located on the end of the lubricating oil pump drive shaft to make this measurement.



Lubricate the inside diameter of the bushings in the driven gear with clean 15W-40 oil.

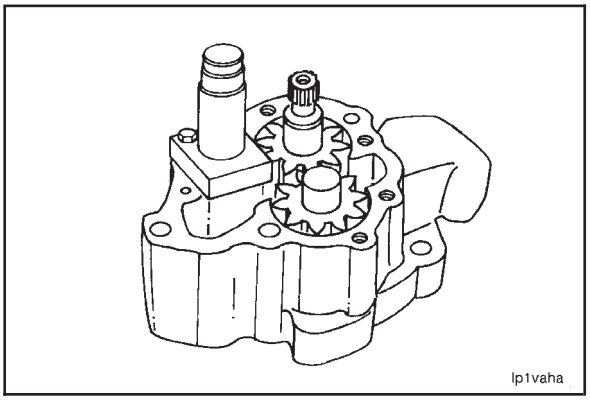
Install the driven gear on the shaft.



Install the high oil pressure relief valve as follows:

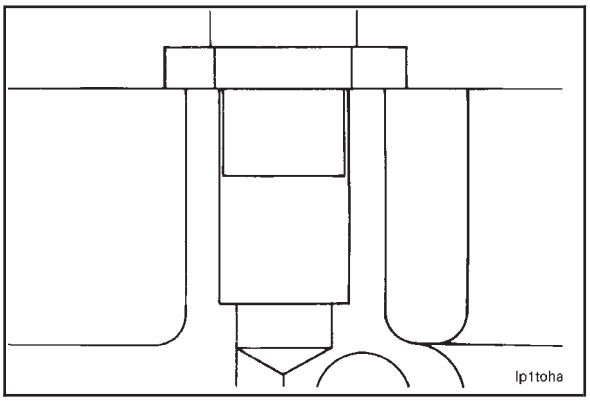
1. Install locating plate, Part No. 3376013 (in DFC pressure valve fixture, Part No. 3376011) on the oil pump body.

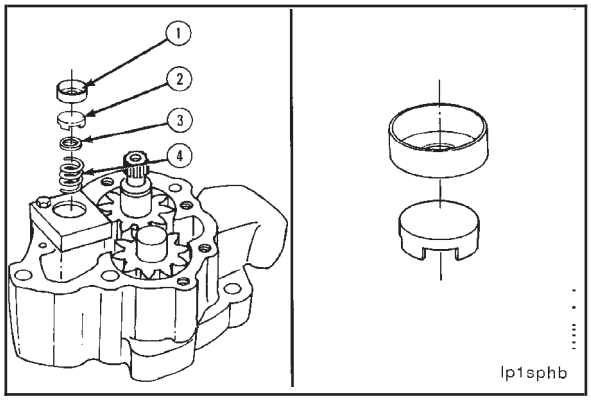
NOTE: Use two 5/16 - 18 X 1 1/4-inch capscrews. Do **not** tighten the capscrews at this time.



Install the large diameter of valve mandrel, Part No. 3376012, through the locating plate into the pressure limit valve bore in the oil pump body.

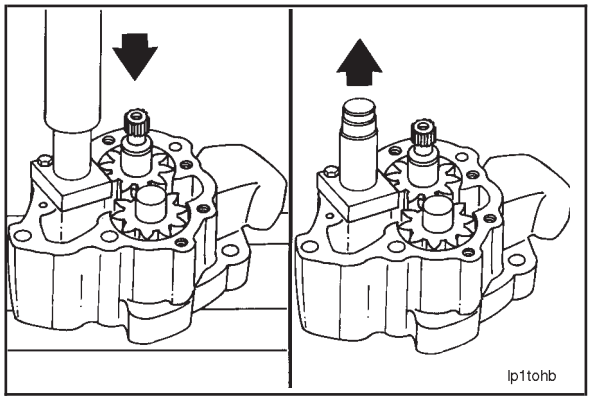
Tighten the capscrews, and remove the mandrel.





Install the spring (4), the washer (3), the valve disc (2), and the retainer plug (1) into the bore of the locating plate.

NOTE: Make sure the prongs on the disc are down (toward the washer) and that the cup side of the retainer plug is up (toward the mandrel).



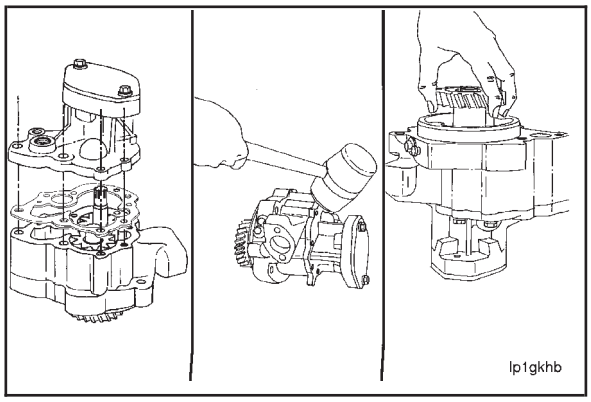
Install the small end of valve mandrel, Part No. 3376012, into the bore in the locating plate.

Install the assembly in an arbor press.

Press the mandrel until the large diameter of the mandrel is against the locating plate.

Remove the assembly from the arbor press.

Remove the mandrel and locating plate from the oil pump body.



Install a new gasket and the cover to the pump body.

NOTE: Tap the cover lightly with a rubber hammer to push the cover over the dowels.

Install the capscrews and the washers. Tighten the capscrews.

Torque Value: 25 N•m [20 ft-lb]

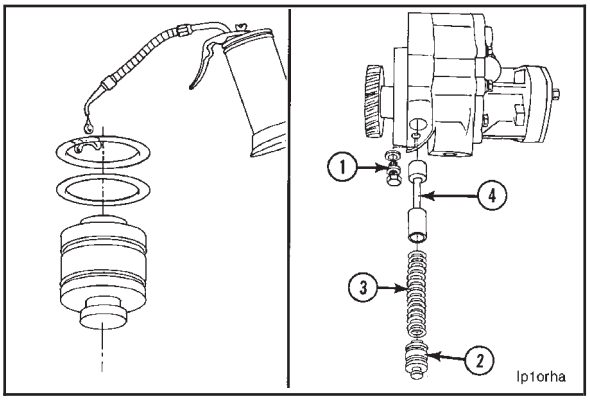
Turn the gears to make sure they rotate freely.

Install new o-rings on the main oil pressure regulator plunger retainer plug. Lubricate the o-rings with vegetable oil.

Install the plunger (4), the spring (3), the retainer plug (2), and the capscrew (1).

Tighten the retainer plug capscrew.

Torque Value: 25 N•m [20 ft-lb]

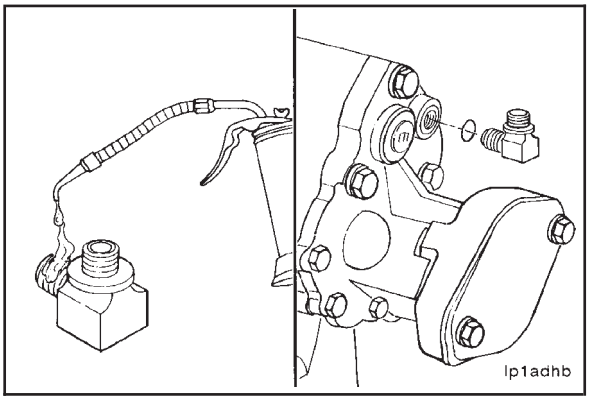


Install a new o-ring on the adapter elbow. Lubricate the o-ring with clean 15W-40 oil.

Install the adapter elbow into the lube pump cover. Tighten the adapter.

Torque Value: 7 N•m [60 in-lb]

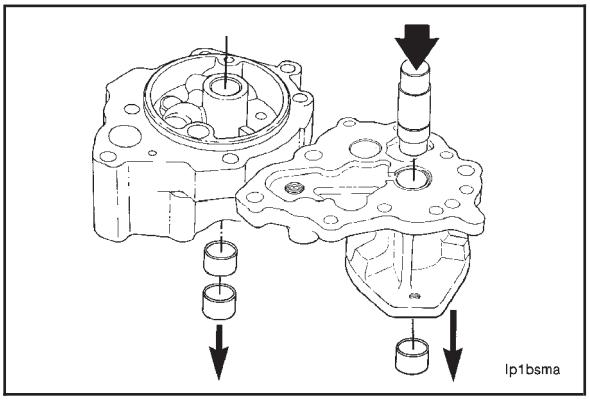
NOTE: The adapter must be positioned to align with the DFC signal line.



Lubricating Oil Pump Body and Cover Bushing - Replacement (07-07)

Disassembly

Use bushing mandrel, Part No. ST-1158, to remove the worn or damaged bushings from the oil pump body and the cover.

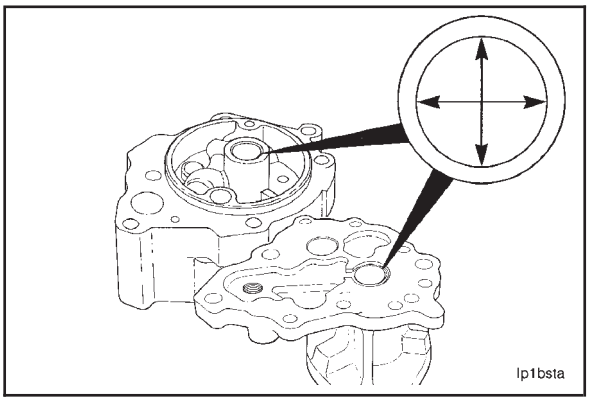


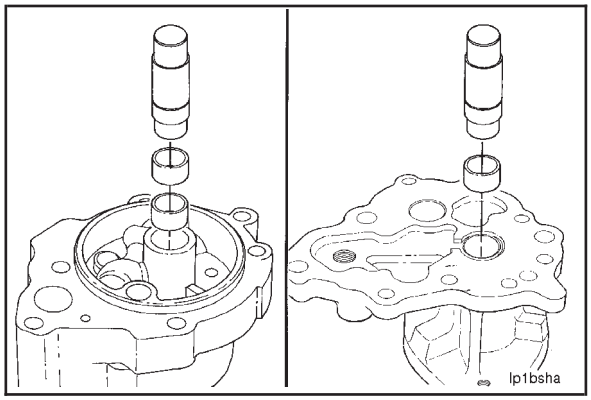
Inspection

Visually inspect the bushing bore in the oil pump body and the cover for damage.

Measure the inside diameter of the bushing bore in the oil pump body and cover.

Bushing Bore I.D.		
mm		in
25.387	MIN	0.9995
25.413	MAX	1.0005

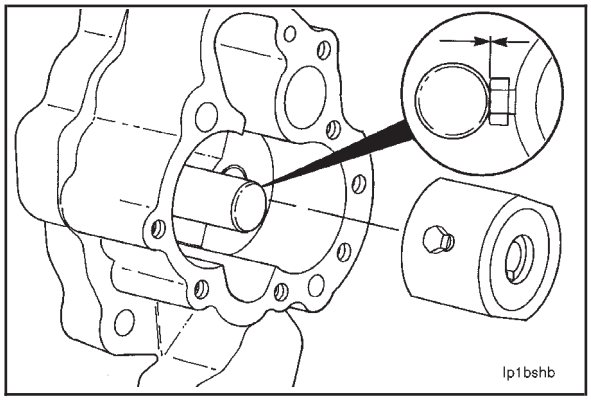




Assembly

Use bushing mandrel, Part No. ST-1158, to push the new bushings into the oil pump body and cover.

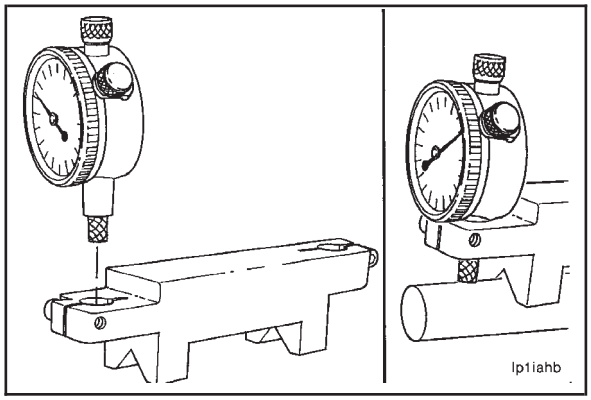
NOTE: The bushings **must** be installed level with or no more than 0.51 mm [0.020-inch] below the surface of the oil pump body or cover.



Use lubricating oil pump boring tool, Part No. 3375206, to cut the bore in the new bushings in the oil pump body and the cover.

Install the guide bushing into the gear pocket.

Tighten the capscrew against the side of the gear pocket to hold the guide bushing in position.



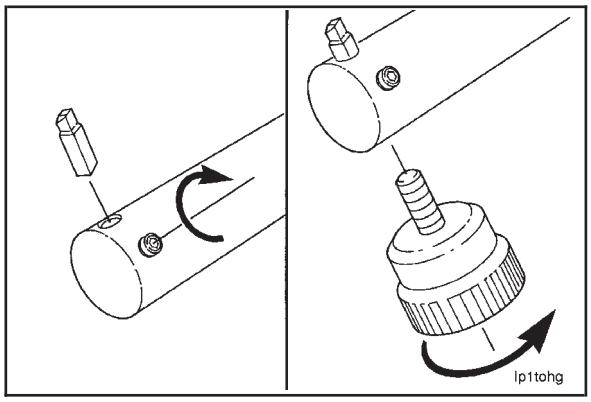
Install the dial indicator into the setting block.

Install the setting block on the setting standard.

Adjust the dial indicator.

NOTE: The indicator tip **must** be set on the diameter size of the new bushing bore to be cut.

Bushing I.D. (New)		
mm		in
22.28	MIN	0.877
22.30	MAX	0.878



Install the tool bit into the boring bar.

NOTE: Do **not** completely tighten the set screw.

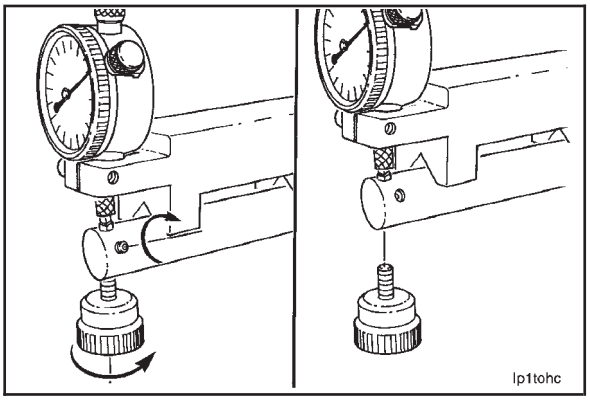
Install the tool bit adjusting knob into the boring bar.

NOTE: Hold the setting block and the indicator against the boring bar so the indicator tip will be over the tool kit.

Turn the adjusting knob **clockwise** to push the tool bit against the indicator tip.

NOTE: Adjust the tool bit until the indicator is set to the same size as the setting standard.

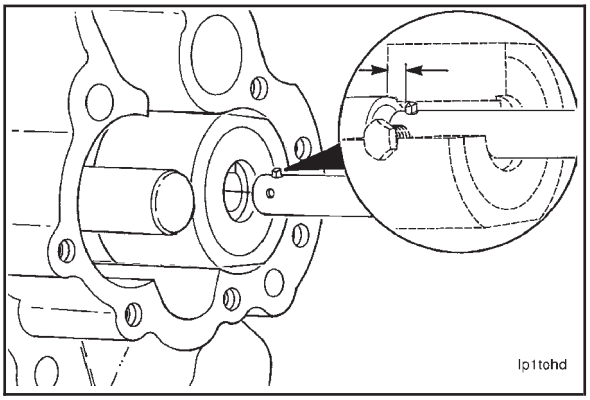
Tighten the set screw and remove the adjusting knob.



Install the boring tool into the guide bushing.

NOTE: The tool bit **must** go through the slot in the guide bushing. Do **not** allow the tool bit to hit against the guide bushing.

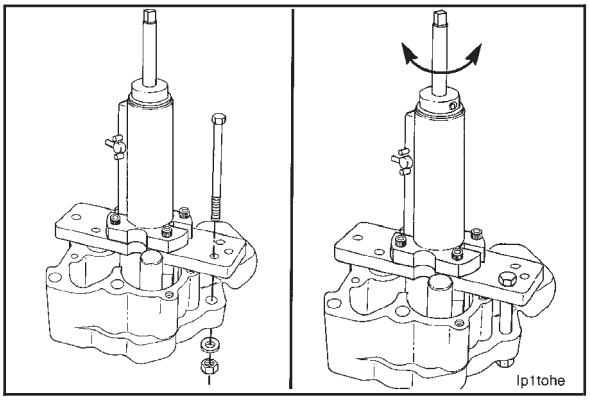
Adjust the travel of the boring bar so the tool bit will go through the guide bushing but does **not** touch the bushing in the oil pump body.



Use capscrews to fasten the boring tool to the oil pump body.

Rotate the boring tool shaft to make sure it will turn freely.

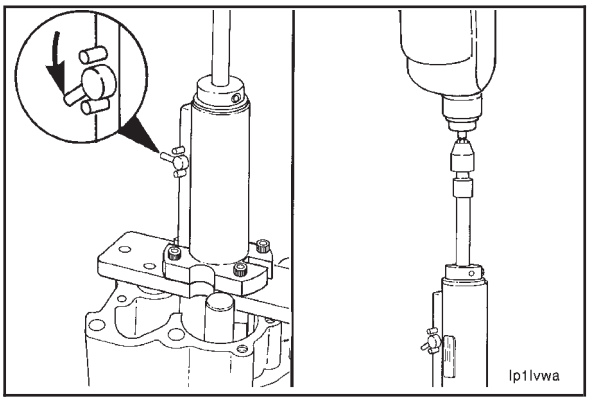
NOTE: The pump and the boring tool **must** be in a vertical position. Make sure the boring tool can cut completely through the bushings.

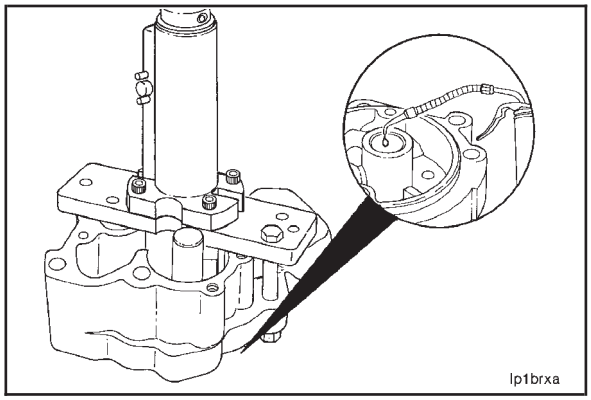


Move the feed control lever to the ‘‘ON’’ position.

NOTE: This will prevent the drive shaft from moving down.

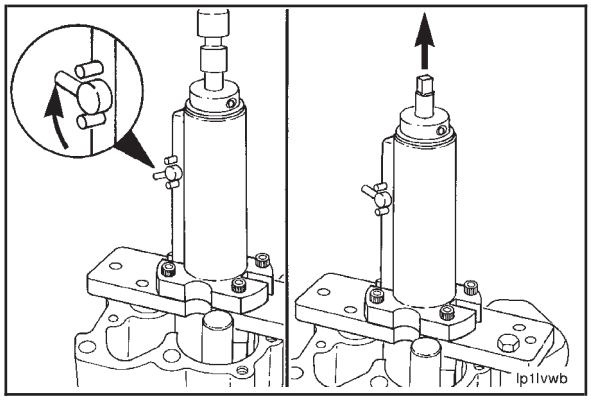
Install the drive adapter into a heavy duty 3/8-inch drill motor, and engage the adapter with the drive shaft of the boring tool.





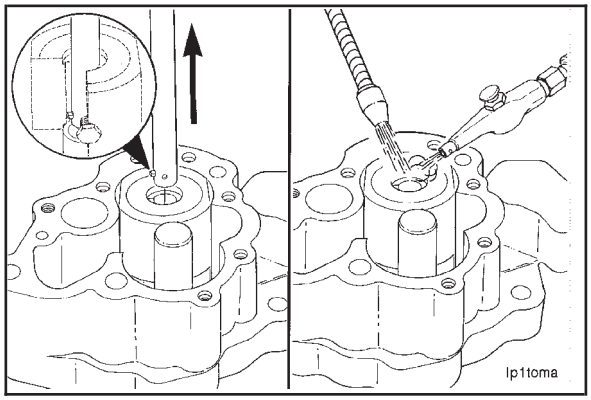
Use a cutting oil, and cut the bore in both bushings in the oil pump body.

NOTE: Do **not** push down on the drill motor. The feed mechanism in the boring tool will move the boring bar.



Stop the drill motor, and move the feed control lever to the ''OFF'' position.

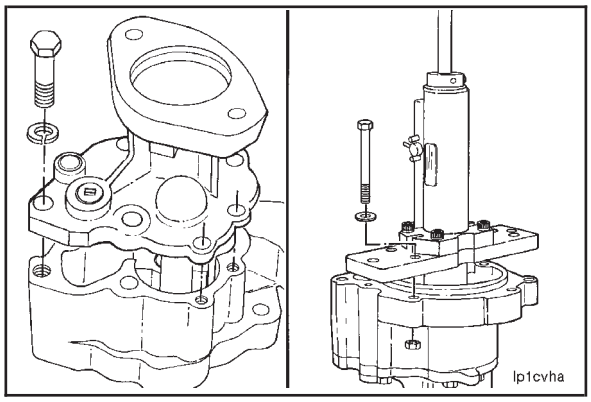
Pull up on the drive shaft to remove the tool bit from the bore.



Remove the boring tool from the oil pump body.

NOTE: The tool bit **must** move through the slot in the guide bushing. Do **not** allow the tool bit to hit against the guide bushing.

Clean the metal particles from the oil pump body.



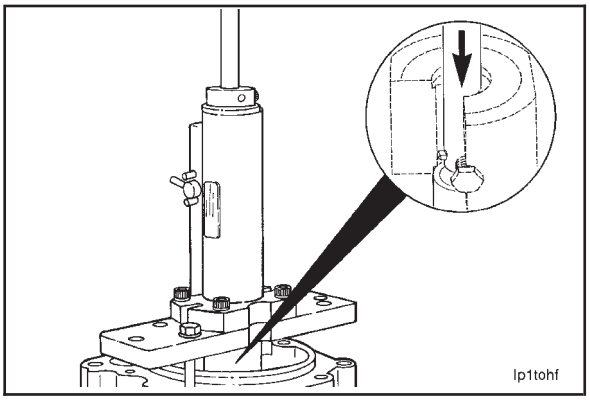
Install the cover on the oil pump body.

Install the boring tool to the pump body.

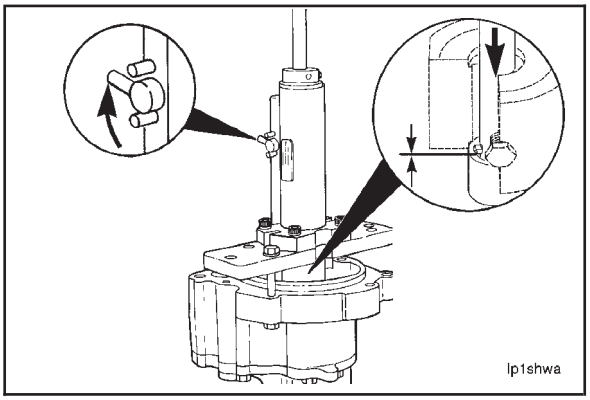
NOTE: Use the long capscrews and the nuts to fasten the tool to the oil pump body.

Install the boring bar through the guide bushing.

NOTE: The tool bit **must** go through the slot in the guide bushing. Do **not** allow the tool bit to hit against the guide bushing.

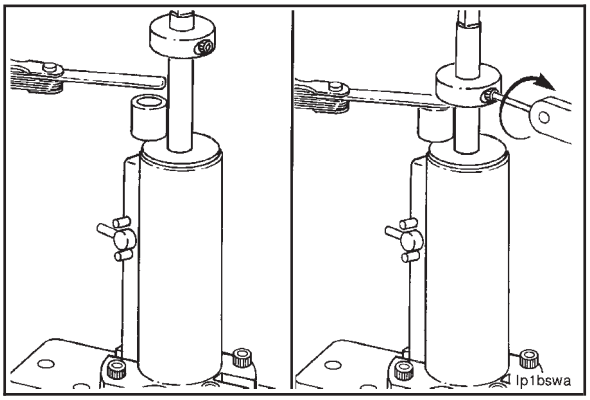


With the feed control level in the ''OFF'' position, move the drive shaft down until the tool bit touches the bushing in the cover.



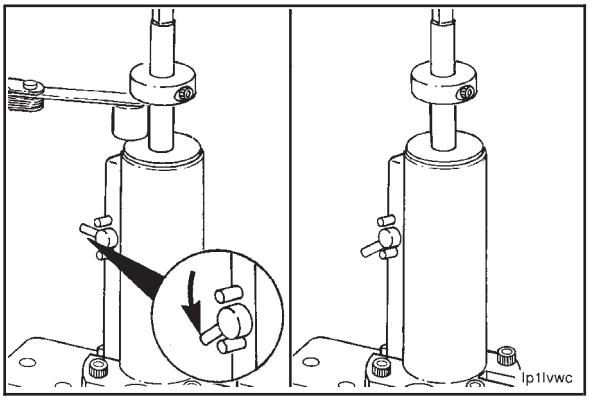
Hold a new bushing and a 1.57 mm [0.062-inch] feeler gauge against the drive shaft at the top of the boring tool body.

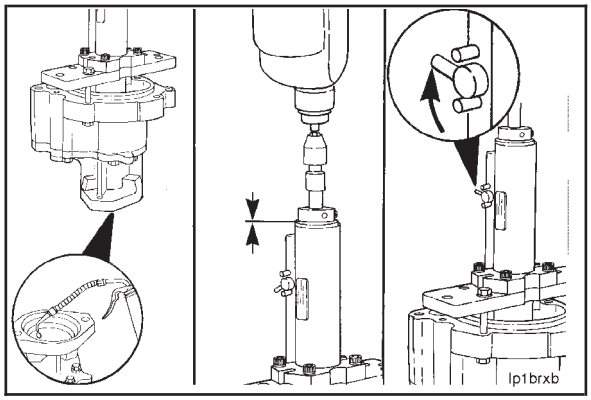
Move the stop collar down against the feeler gauge and tighten the set screw.



Move the feed lever to the ''ON'' position.

Remove the feeler gauge and the bushing.

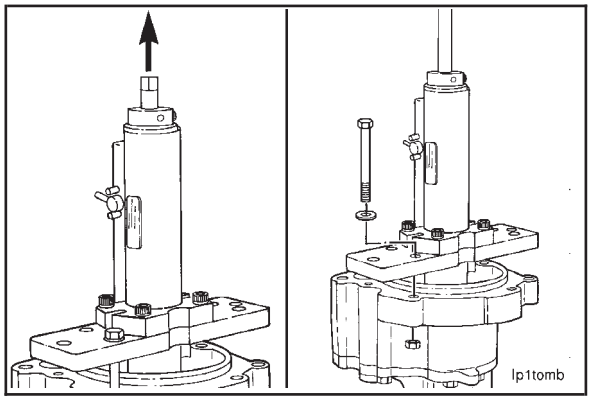




Use a cutting oil to lubricate and cool the bit while cutting the bore in the bushing.

Stop the drill motor when the stop collar on the drive shaft is against the body of the boring tool.

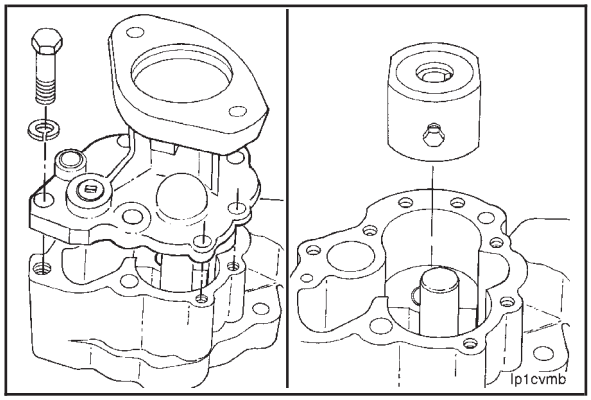
Move the feed control lever to the ‘‘OFF’’ position.



Pull the drive shaft up to remove the tool bit from the bushing.

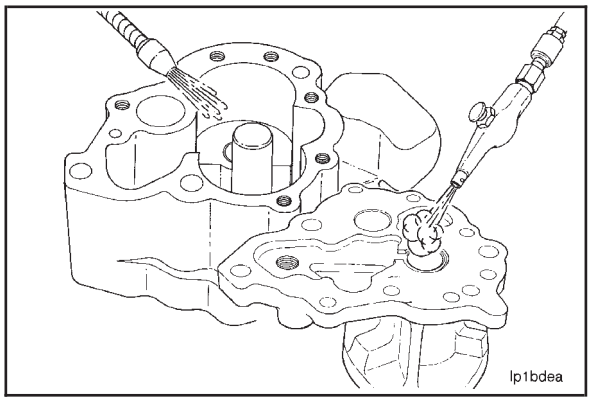
Remove the boring tool from the oil pump body.

NOTE: The tool bit **must** move through the slot in the guide bushing. Do **not** allow the tool bit to hit against the guide bushing.



Remove the cover from the oil pump body.

Remove the guide bushing from the oil pump body.



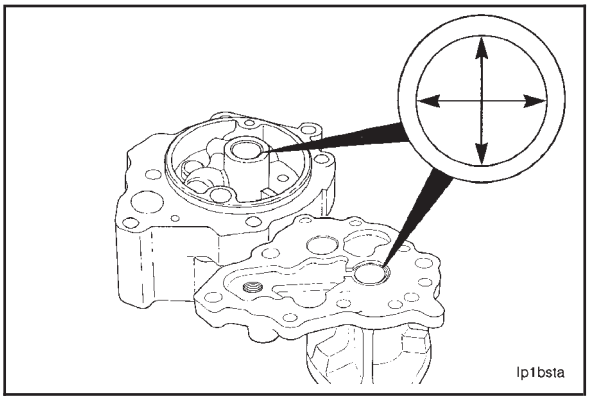
Use solvent to clean the oil pump body and the cover. Dry with compressed air.

NOTE: All metal particles **must** be cleaned from the oil pump body and the cover.

Measure the inside diameter of the bushings in the oil pump body and the cover.

Bushing I.D. (New)		
mm		in
22.28	MIN	0.877
22.30	MAX	0.878

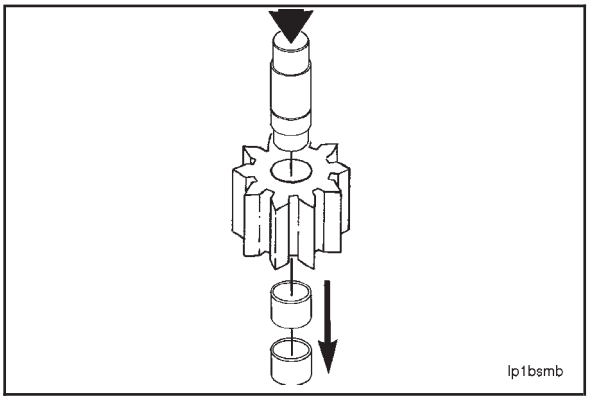
NOTE: Bushings that do **not** meet the specifications given **must** be replaced.



Lubricating Oil Pump Driven Gear Bushing - Replacement (07-08)

Disassembly

Use bushing mandrel, Part No. ST-1158, to remove the worn or damaged bushings from the driven gear.



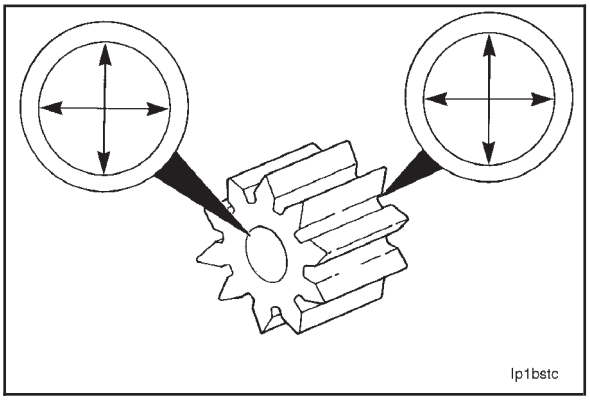
Inspection

Visually inspect the bushing bore in the driven gear for damage.

Measure the inside diameter of the bushing bore in the oil pump driven gear.

Bushing Bore I.D.		
mm		in
25.387	MIN	0.9995
25.413	MAX	1.0005

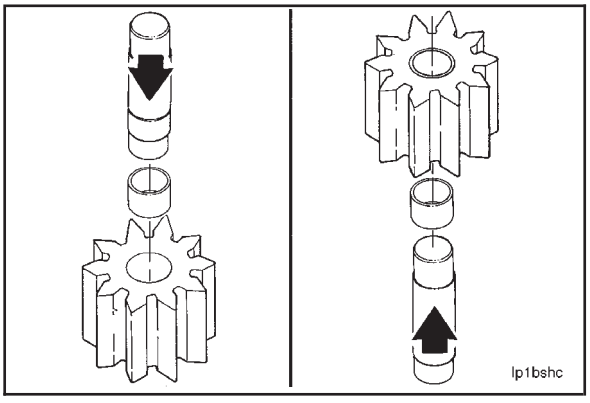
NOTE: If the bushing bore inside diameter is **not** within specifications, the gear **must** be replaced.

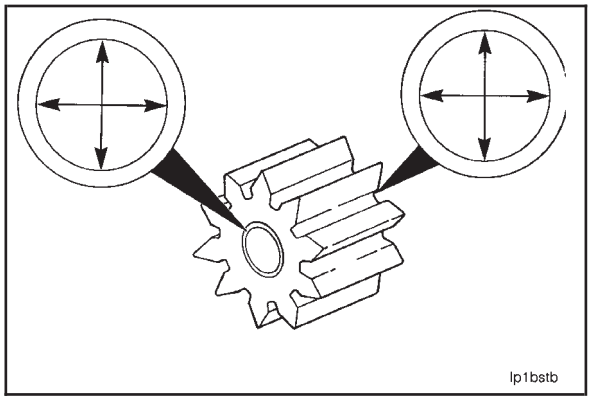


Assembly

Use bushing mandrel, Part No. ST-1158, to push the new bushings into the driven gear.

NOTE: The bushings **must** be installed level with or to a maximum of 0.51 mm [0.020-inch] below the surface of the driven gear.

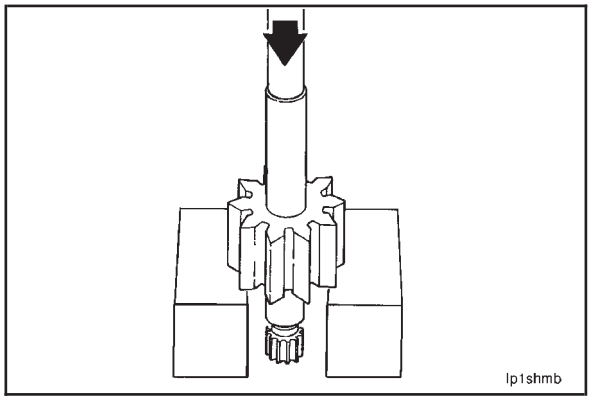




Measure the inside diameter of the new bushings in the driven gear.

Bushing I.D. (New)		
mm		in
22.28	MIN	0.877
22.30	MAX	0.878

NOTE: The bushings used in the driven gear are finished bushings and do **not** require cutting. If the bushing inside diameter is **not** within the specifications given after installation, the bushing **must** be replaced.

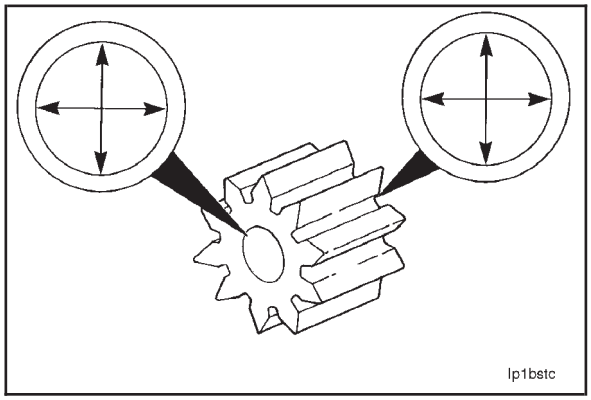


Lubricating Oil Pump Drive Gear or Shaft - Replacement (07-09)

Disassembly

To remove the drive shaft from the drive gear, do the following:

1. Install the shaft and the gear assembly in an arbor press.
2. Use a mandrel to push the shaft from the gear.



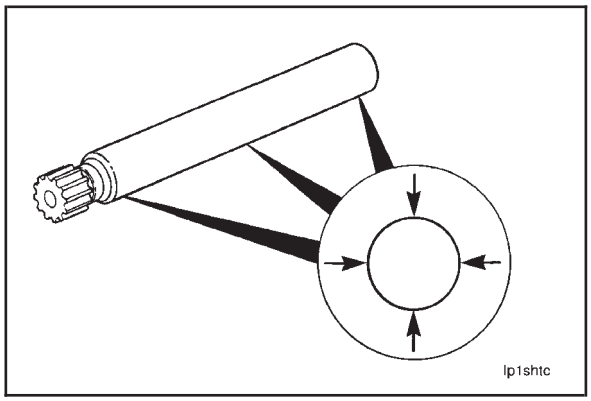
Inspection

Visually inspect the bore in the drive gear for damage.

Measure the inside diameter of the bore in the drive gear.

Drive Gear Bore I.D.		
mm		in
22.187	MIN	0.8735
22.200	MAX	0.8740

NOTE: If the bore inside diameter is **not** within specifications, the gear **must** be replaced.



Visually inspect the drive shaft for damage.

Measure the outside diameter of the drive shaft.

Drive Shaft O.D.		
mm		in
22.212	MIN	0.8745
22.225	MAX	0.8750

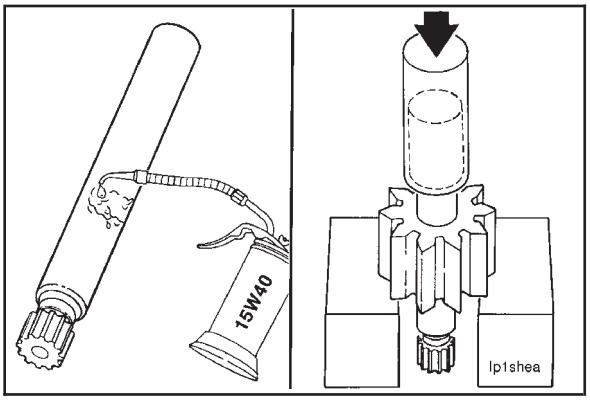
NOTE: Shafts that are damaged or worn smaller than the minimum given **must** be replaced.

Assembly

Use clean 15W-40 oil to lubricate the drive shaft.

Use spacer mandrel, Part No. ST-1157, and an arbor press to push the drive gear onto the drive shaft. If the spacer mandrel is **not** available, install the gear onto the shaft to the following dimension as measured from the end of the shaft.

Installed Depth		
mm		in
27.43	MIN	1.080
27.69	MAX	1.090

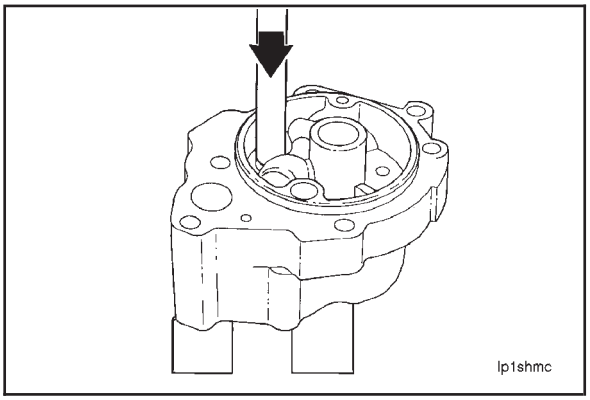


Lubricating Oil Pump Driven Shaft - Replacement (07-10)

Disassembly

Install the oil pump body in an arbor press with the cover mounting surface of the body facing down.

Use a mandrel to push the driven shaft from the lubricating oil pump body.



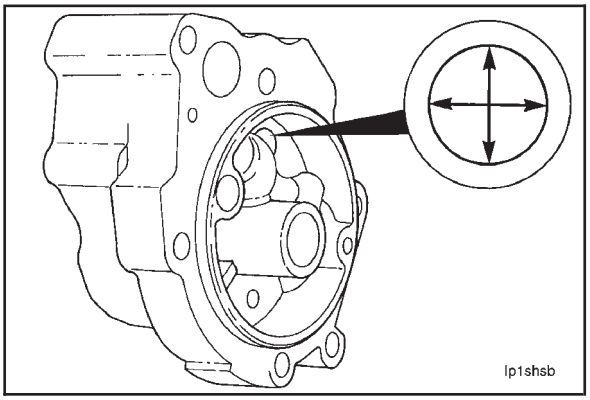
Inspection

Visually inspect the driven shaft bore in the lubricating oil pump body for damage.

Measure the inside diameter of the driven shaft bore.

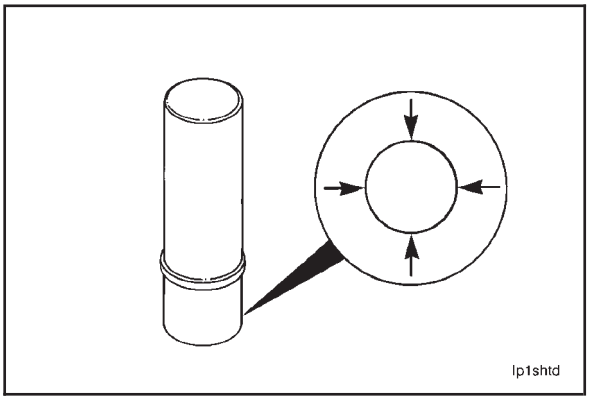
Driven Shaft Bore I.D.		
mm		in
22.263	MIN	0.8765
22.289	MAX	0.8775

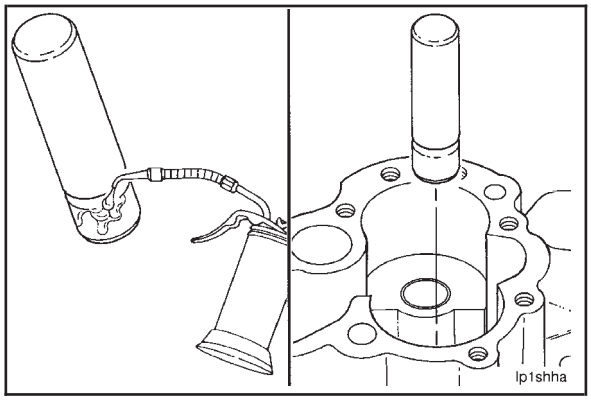
NOTE: If the shaft bore diameter is **not** within specifications, the pump body **must** be replaced.



Measure the driven shaft outside diameter in the press fit area.

Driven Shaft Press Fit Area O.D.		
mm		in
22.301	MIN	0.8780
22.314	MAX	0.8785

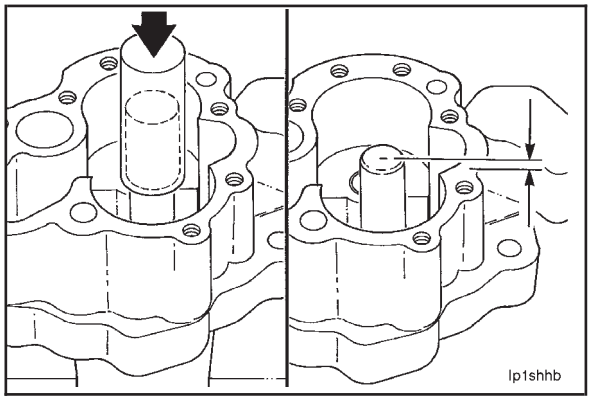




Assembly

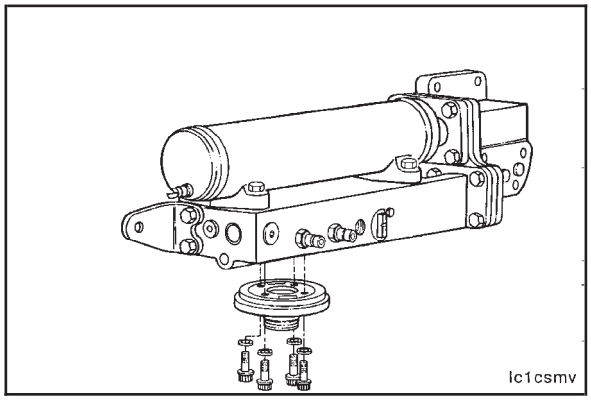
Use gear and spacer mandrel, Part No. ST-1157, to install the driven shaft into the oil pump body as follows:

1. Lubricate the large outside diameter of the driven shaft with clean 15W-40 oil.
2. Install the large outside diameter of the driven shaft into the bore in the oil pump body.



3. Use an arbor press and the gear and spacer mandrel to push the shaft into the bore.
4. Measure the amount of shaft protrusion above the oil pump cover mounting surface.

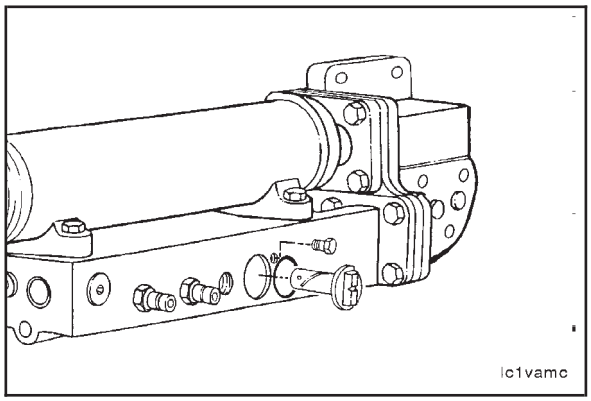
Driven Shaft Protrusion		
mm		in
17.90	MIN	0.705
18.67	MAX	0.735



Lubricating Oil Cooler Assembly - Rebuild (07-11)

Disassembly

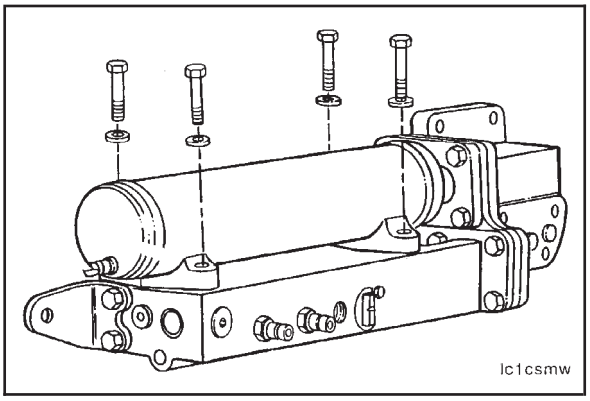
Remove the four filter head 12 point capscrews and the filter head.



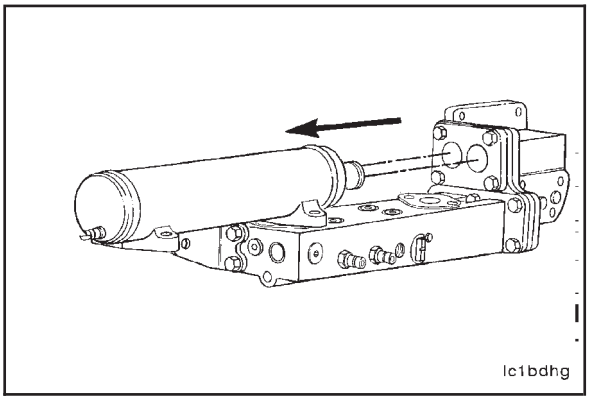
Remove the coolant filter shutoff valve retaining capscrew and washer.

Remove the shutoff valve and the o-ring.

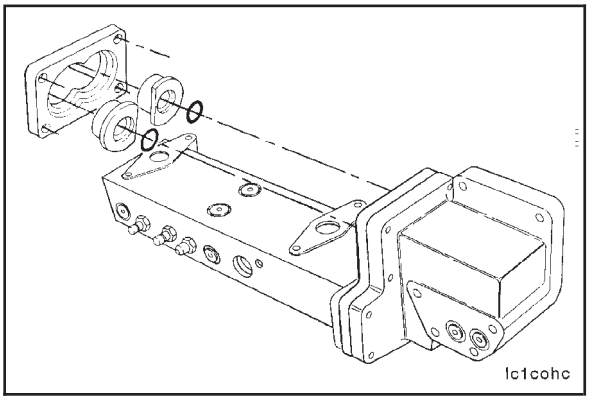
Remove the oil cooler core hold down capscrews.



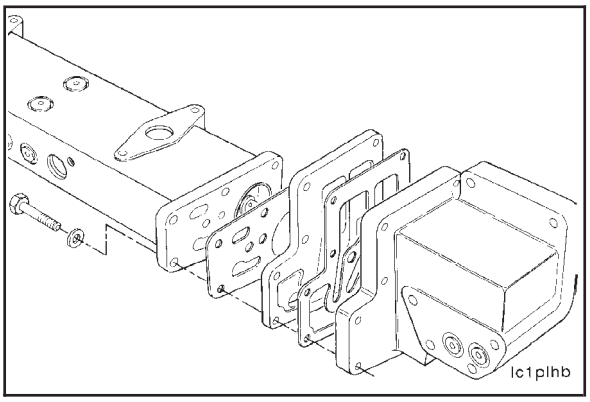
Remove the oil cooler core from the oil cooler transfer connection (housing) by pulling the oil cooler water transfer tubes out of the o-ring adapters.

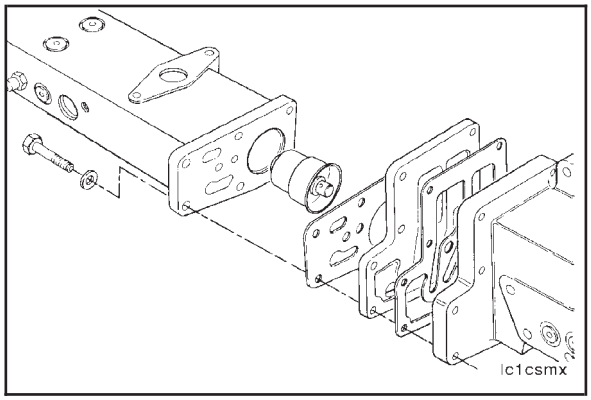


Remove the four adapter plate capscrews and the o-ring adapters.

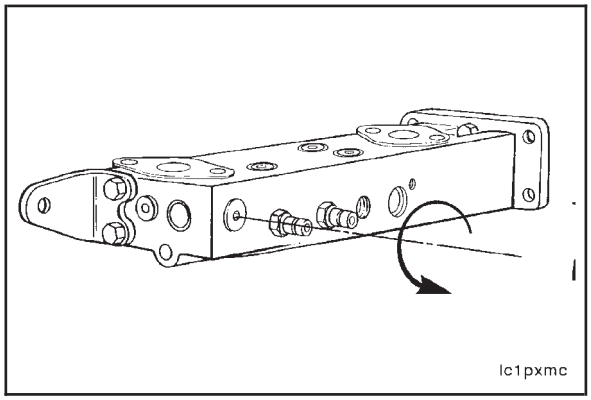


Remove the six capscrews which connect the oil cooler support to the oil cooler transfer housing.

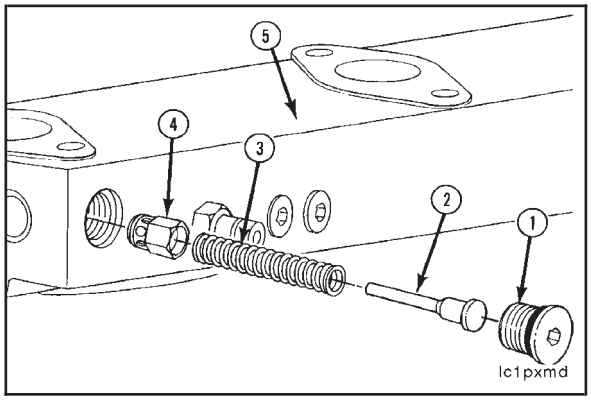




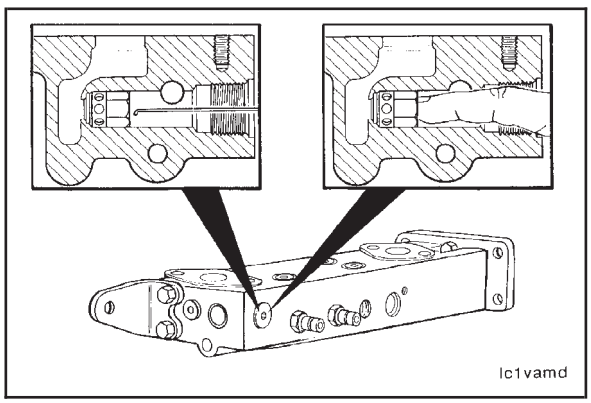
Remove the oil cooler bypass valve and the spacer plate.



Loosen the lubricating oil filter bypass valve retaining plug with a 5/16-inch hexagon allen wrench.



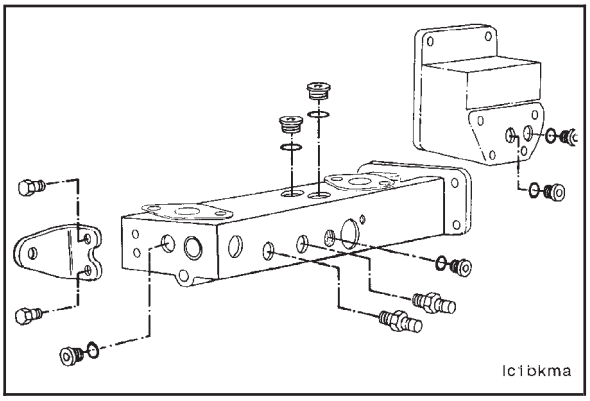
Remove the retaining plug (1), the plunger (2), spring (3), and the poppet valve (4) from the lubricating oil cooler transfer housing (5).



If the poppet valve sticks in the housing, it can be removed with the aid of a bent wire or by using your finger.

Remove Compuchek® fittings and straight thread o-ring plugs from the transfer housing and support.

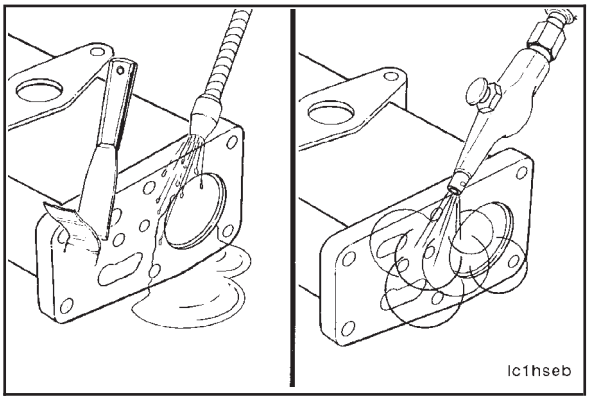
Remove the transfer housing support bracket.



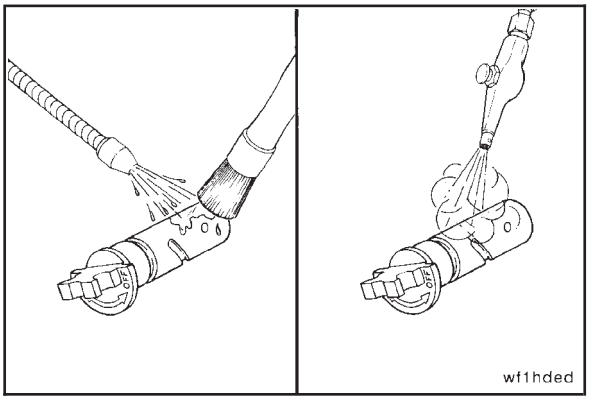
Cleaning

Clean the gasket material from the oil cooler core, transfer housing, support, spacer plate and filter head.

After removing the gasket material, clean with solvent; and dry with compressed air.

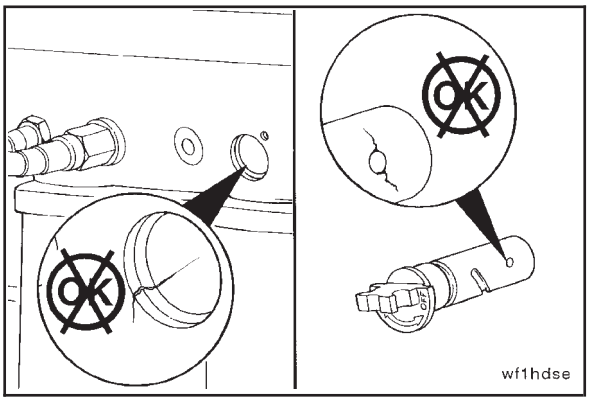


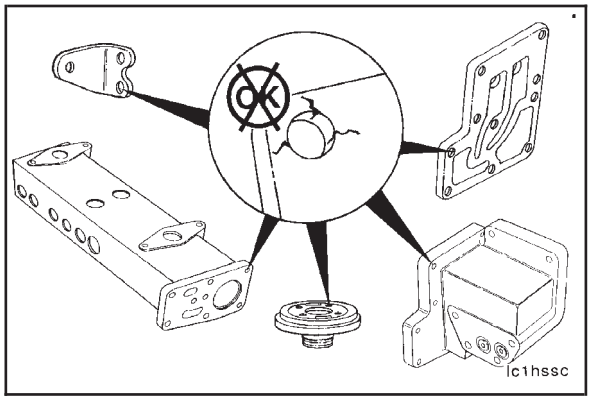
Clean the filter head and shutoff valve with solvent. Dry with compressed air.



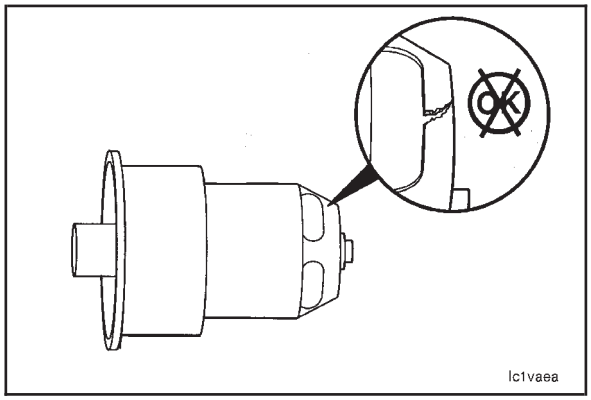
Inspection

Inspect the filter head and shutoff valve for cracks, pitting, corrosion, or other damage. Replace if damage is found.

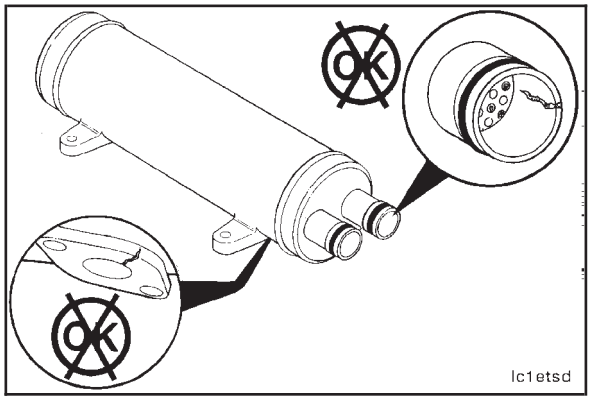




Visually inspect the oil cooler support, housing, spacer plate, filter head, and support bracket for cracks or damage.

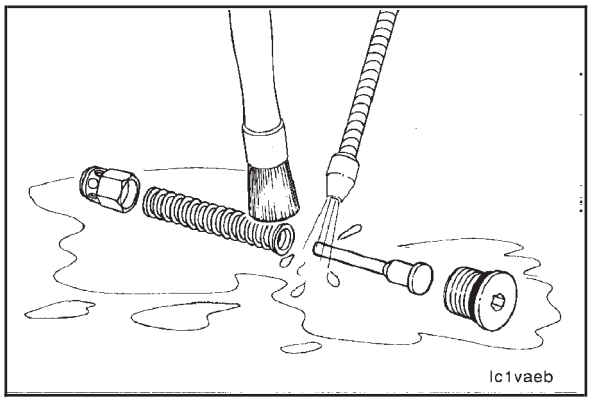


Visually inspect the oil cooler bypass valve for damage. Any damage to the front face of the valve will allow oil to bypass the oil cooler.



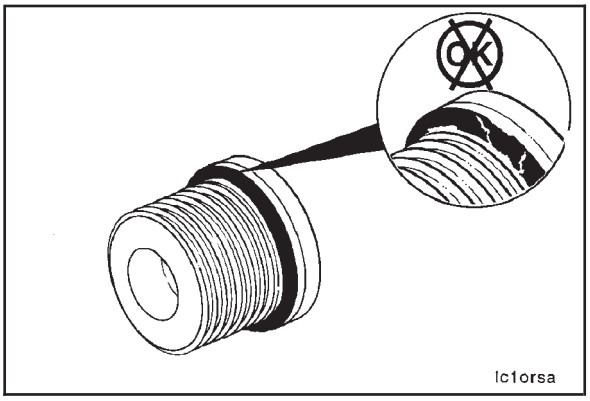
Visually inspect the oil cooler core for cracks or damage.

Caution: Do not attempt to repair a damaged oil cooler core; it must be replaced.

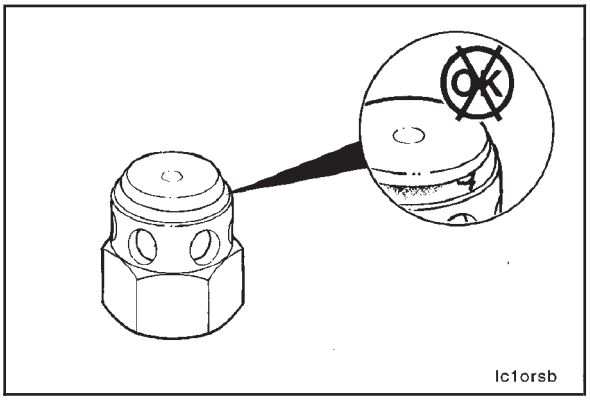


Clean the lubricating oil filter bypass poppet valve spring, plunger and retaining plug.

Inspect the o-ring on the retaining plug for cuts or tears. Replace the o-ring if damaged.



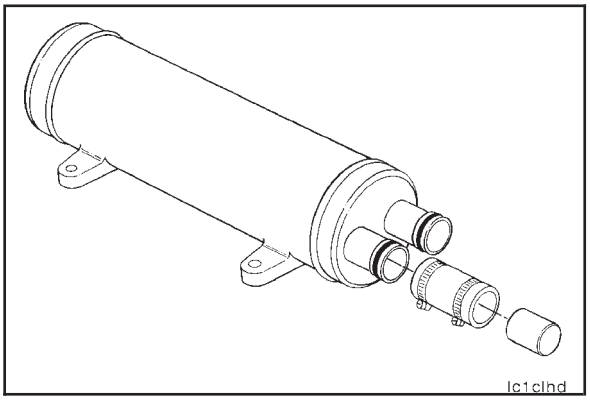
Inspect the teflon o-ring on the poppet valve for wear, cuts, or tears. Replace the complete poppet valve if there is any damage.

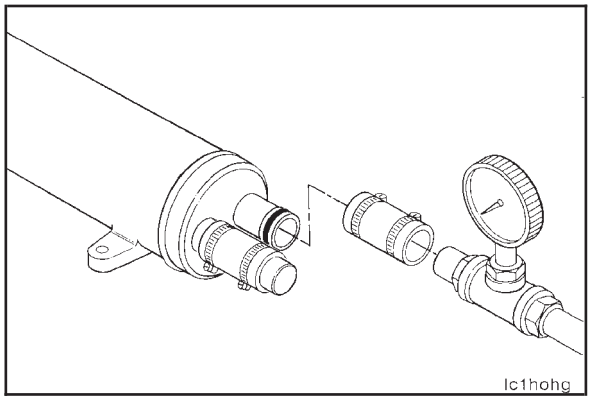


Testing - Oil Cooler Core

Caution: Do not reuse an oil cooler core after an engine failure since there is not a practical method to clean the cooler core. Metal particles which can circulate through the lubricating system can remain in the cooler core and can cause engine damage. Do not allow dirt or gasket material to enter the oil passages when cleaning the oil cooler and the cylinder block surface.

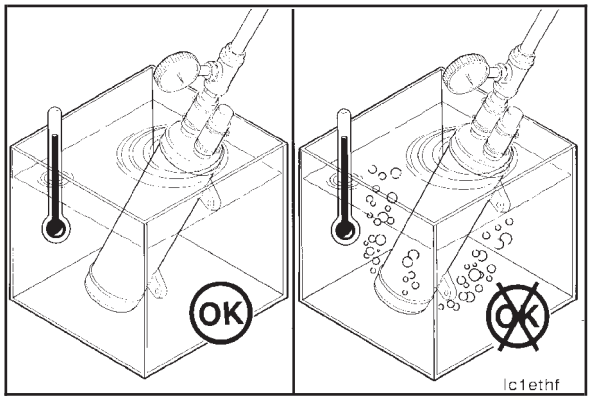
Install and clamp a short section of hose over either the inlet or outlet transfer tube of the oil cooler. Install a plug into the **opposite** end of the section of hose and install the clamp.





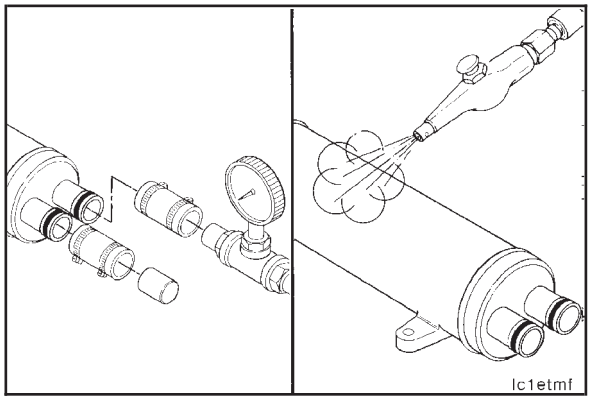
Attach a regulated air pressure hose to the other water transfer tube and apply 81 kPa [60 psi] air pressure.

Caution: Conduct this test with extreme caution. Pressurization of the oil cooler assembly while submerged in a hot water bath poses a condition where one must exercise care to avoid burns and water splash. Use heavy duty hoses and clamps for attachment of the air supply line and blanking plug to ensure against leaks and accidental blanking plug expulsion during pressurization.



Submerge the oil cooler in a tank of water heated to 82°C [180°F] for 3 to 5 minutes and inspect for leaks.

NOTE: If leaks are found, replace the oil cooler core.



Remove the oil cooler core from the water tank.

Remove the hoses and clamps from the oil cooler.

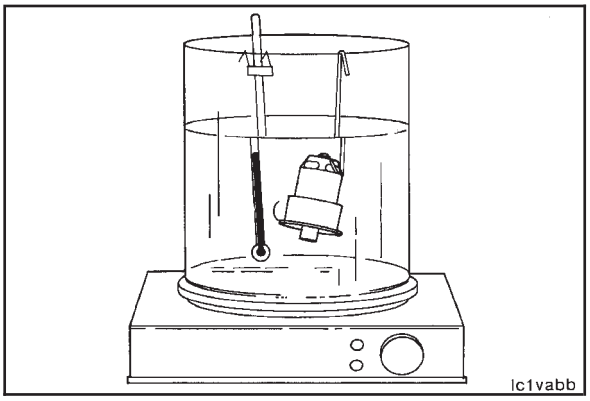
Remove all water from the oil side of the cooler. Dry the oil cooler with compressed air.

Testing - Oil Cooler Bypass Valve

Caution: The flash point of new lubricating oil is approximately 221°C [430°F]. Do not allow oil temperature in the container to exceed 149°C [300°F]. Do not allow water droplets to enter the container of hot oil. Water droplets will cause a violent reaction which can cause personal injury.

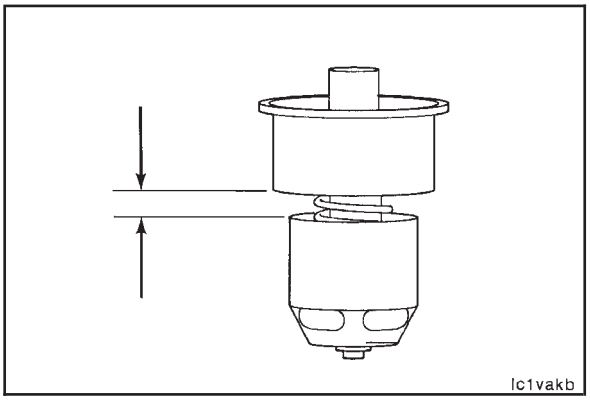
Suspend the valve and a 116°C [250°F] thermometer in a container of new lubricating oil. Do **not** allow the valve or the thermometer to touch the sides or bottom of the container.

Heat the lubricating oil.



NOTE: Record the temperature at which the valve is fully extended. The valve **must** be fully extended to at least 6 mm [0.250-inch] when the temperature reaches 116°C [240°F].

Replace the valve if it does **not** operate as described.

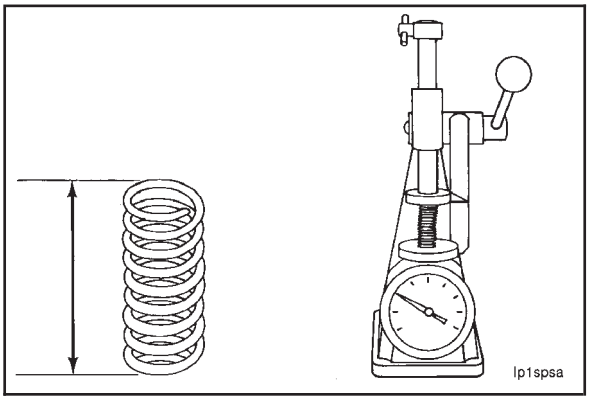


Testing - Lubricating Oil Filter Bypass Valve Poppet Valve Spring

Use the valve spring tester, Part No. 3375182, to measure the spring force.

Compress the spring to a height of 59.18 mm [2.330 inch]. The force required to compress the spring to the specified height **must** be:

MIN: 105.2 N [23.65 lbf]
MAX: 123.8 N [27.85 lbf]



Assembly

Install straight thread o-ring plugs.

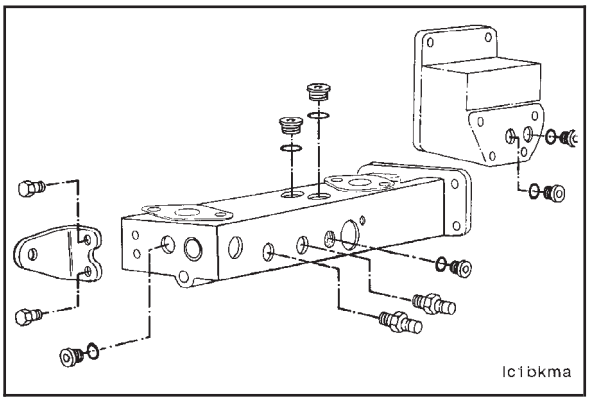
Torque Value: 35 N•m [25 ft-lb]

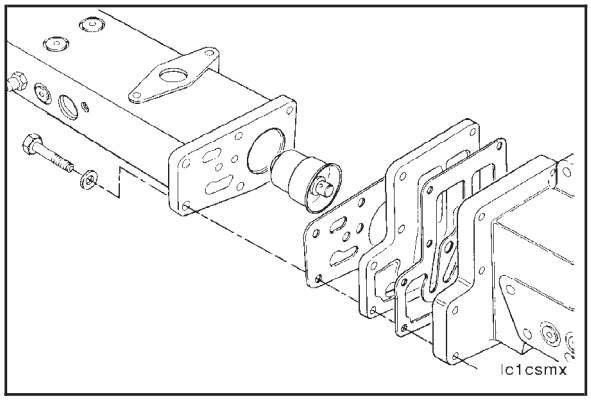
Install Compuchek® fittings.

Torque Value: 14 N•m [10 ft-lb]

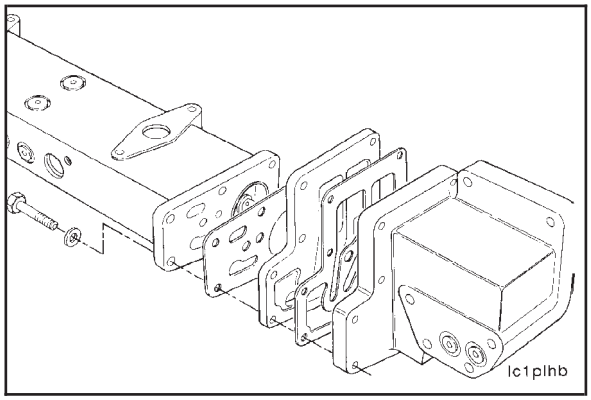
Install the transfer housing support bracket.

Torque Value: 45 N•m [35 ft-lb]





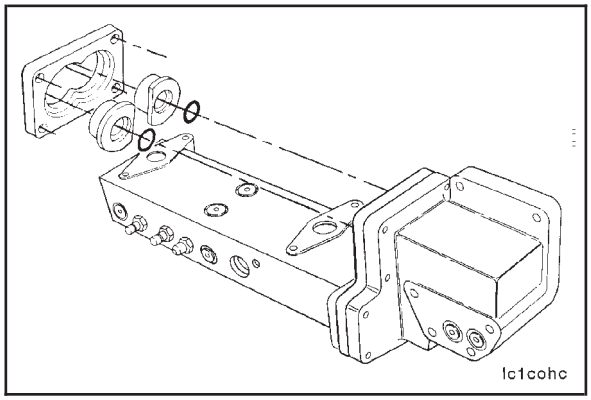
Install the oil cooler bypass valve into the transfer housing.



Place the spacer plate and a new spacer gasket on the oil cooler support. Use two of the connection retainer capscrews to keep the gasket and plate loosely aligned on the support.

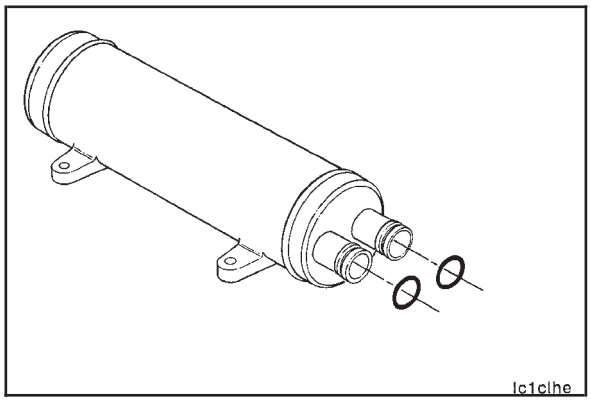
Install the transfer housing, a new transfer connection gasket, and the six capscrews that hold the oil cooler support to the oil cooler transfer housing. Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]



Install the connection retainer and o-ring adapters with new o-rings. Do **not** tighten the four retainer capscrews at this time. Adapters **must** be loose so they will align with the transfer tubes.

NOTE: Be careful to keep o-rings in place when installing the adapters and retainer.

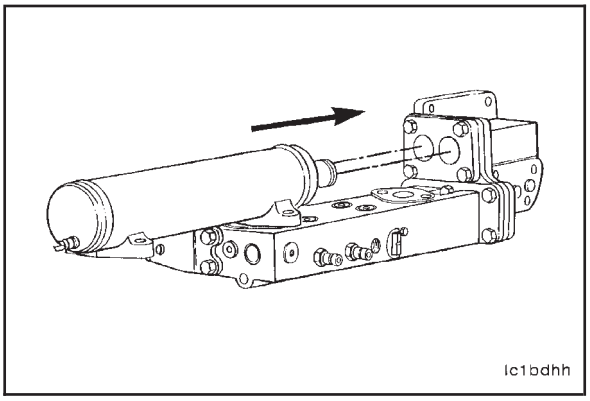


Installation - Oil Cooler Core

Lubricate new o-rings with vegetable oil, and install on the oil cooler core transfer tubes.

Install the oil cooler core on the oil cooler transfer connection (housing) by inserting the transfer tubes into the o-ring adapters.

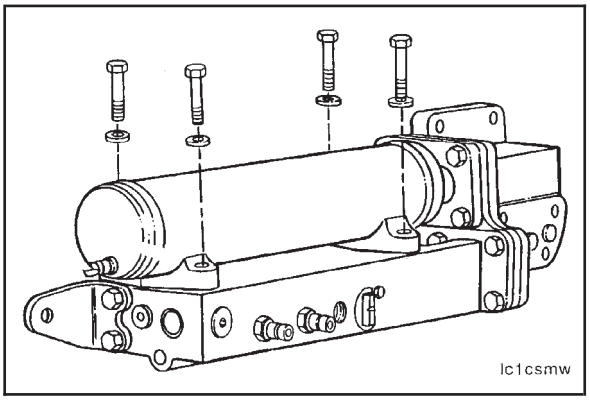
NOTE: Make sure the o-ring adapters move freely when the transfer tubes are inserted as this will allow tubes to be centered in the adapters.



Install the oil cooler core mounting gaskets and hold down capscrews.

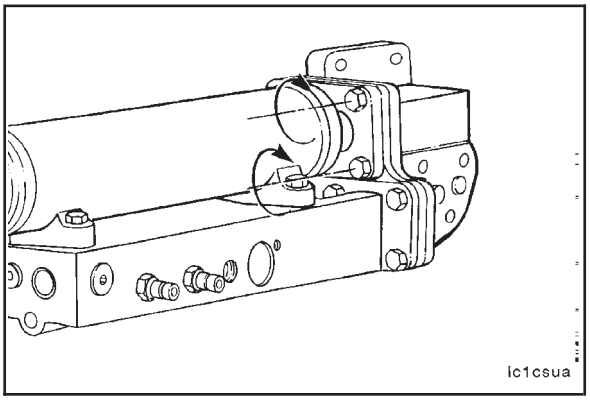
Tighten the hold down capscrews.

Torque Value: 27 N•m [20 ft-lb]

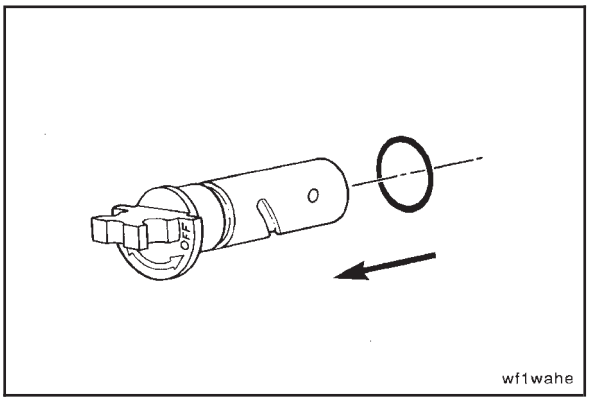


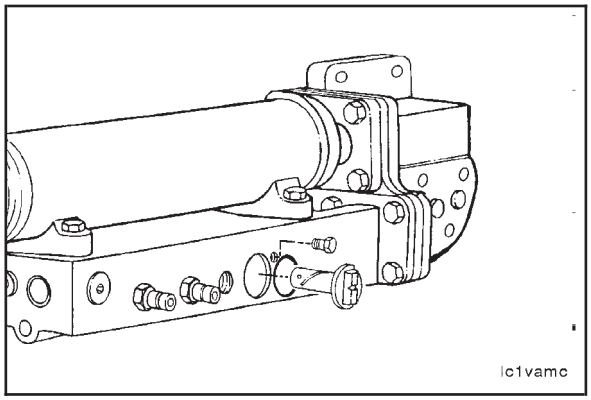
Alternately tighten the o-ring adapter retainer capscrews.

Torque Value: 47 N•m [35 ft-lb]



Install a new o-ring on the coolant filter shutoff valve.





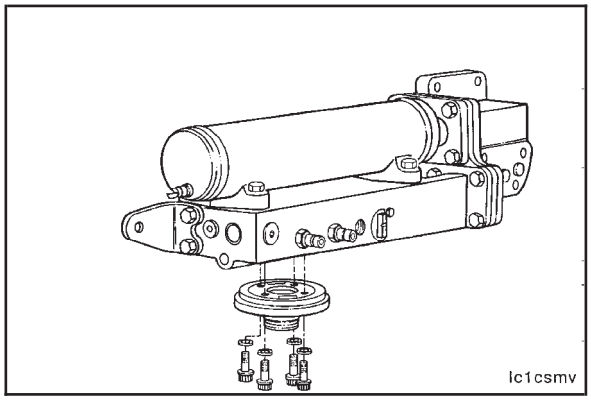
Lubricate the o-ring with Lubriplate® 105 or equivalent, and install the shutoff valve in the filter head.

Install the retaining capscrew and washer.

Torque Value: 20 N•m [15 ft-lb]

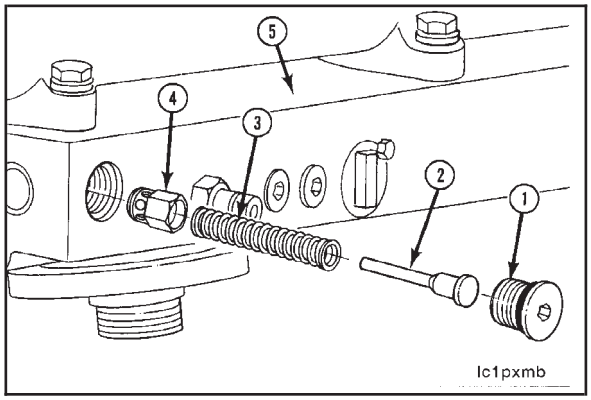
Turn the valve to the ‘‘ON’’ position.

The valve is in the ‘‘ON’’ position when the valve is in the vertical position.



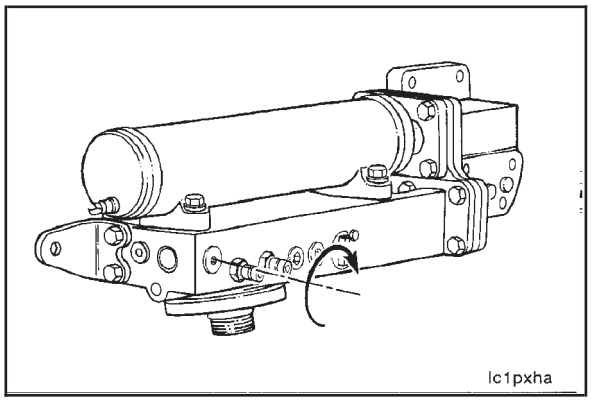
Install the oil cooler filter head, gasket, washers, and filter head 12 point capscrews.

Torque Value: 20 N•m [15 ft-lb]



Installation - Lubricating Oil Filter Bypass Valve

After lubricating all pieces and the o-ring seal, install the poppet valve (4), spring (3), the plunger (2), and retaining plug (1) into the lubricating oil cooler transfer housing (5).



Tighten the retaining plug.

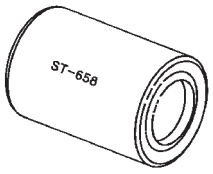
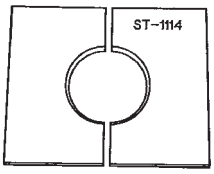
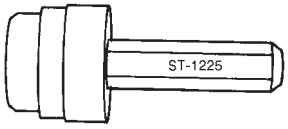
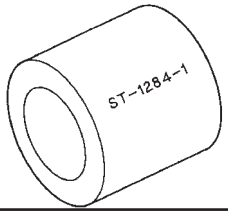
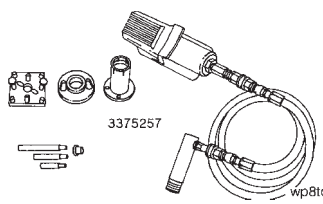
Torque Value: 34 N•m [25 ft-lb]

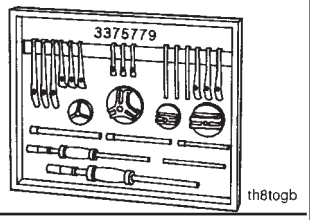
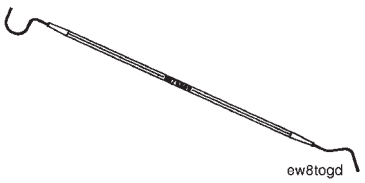
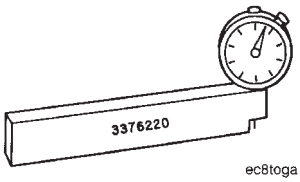
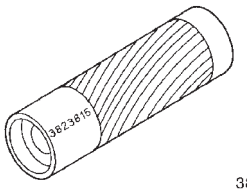
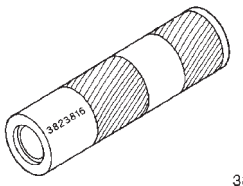
Section 8 - Cooling System - Group 08

Section Contents

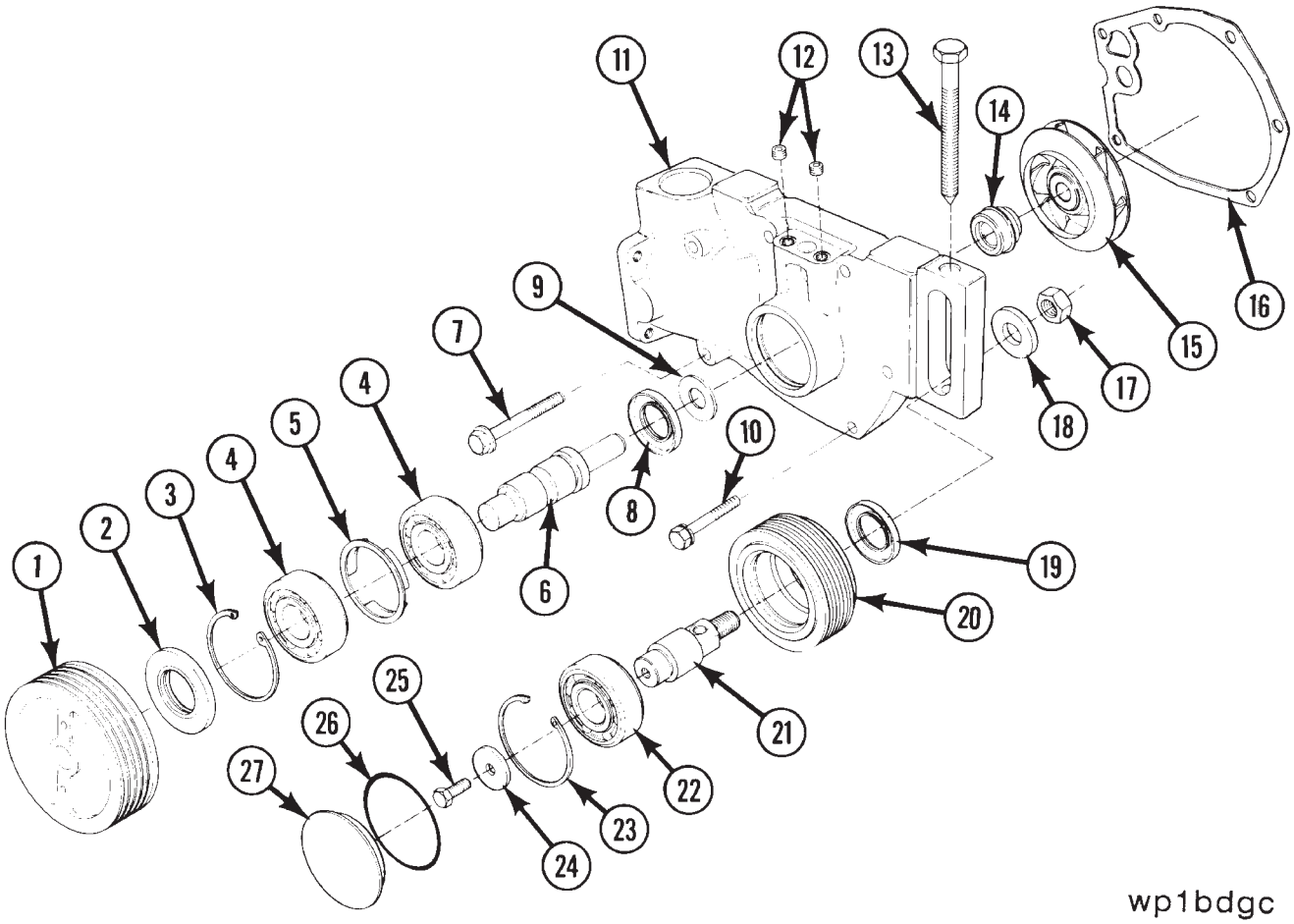
Cooling System - Service Tools

The following special tools are recommended to perform procedures in section 8. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-658	**Water Pump Bearing Mandrel** Use to press the water pump bearing on the shaft and to install the bearing and shaft assembly into the water pump body.	 wp8togf
ST-1114	**Bearing Disassembly Fixture** Use to hold the bearing spacer when removing the water pump bearings from the shaft.	 wp8togd
ST-1225	**Thermostat Seat Driver** Use to install the seat in the thermostat housing.	 th2togb
ST-1284-1	**Rocker Lever Bushing Mandrel** Use to press the bearing and spacer assembly into the pulley.	 rh8togg
3375066	**Pipe Sealant** Use when installing pipe plugs or cup plugs on the engine in order to prevent leaks.	 ew8togc
3375257	**Water Pump Pulley Impeller Puller** Use to remove the water pump pulley and impeller from the water pump drive shaft.	 wp8toge

Tool No.	Tool Description	Tool Illustration
3375779	**Medium Duty Puller Kit** Use to remove the radiator thermostat seat from the thermostat housing bore.	
3376399	**O-ring Pick** Use to install and remove o-rings.	
3823495	**Depth Gauge** Use to measure the bypass thermostat seat counterbore depth.	
3823815	**Water Pump Seal Driver** Use to pilot water pump grease seals onto the water pump drive shaft.	
3823816	**Water Pump Slinger Driver** Use to install the slinger onto the water pump drive shaft.	

N14 Water Pump and Idler Assembly - Exploded View



Reference No.	Description	Quantity
1	Pulley, Water Pump	1
2	Seal, Outer Oil	1
3	Ring, Retaining	1
4	Bearing, Ball	2
5	Spacer	1
6	Shaft, Water Pump	1
7	Capscrew, Long	2
8	Seal, Inner Oil	1
9	Slinger	1
10	Capscrew, Short	5
11	Body, Water Pump	1
12	Plug, Pipe	2
13	Screw, Adjusting	1
14	Assembly, Seal and Seat	1

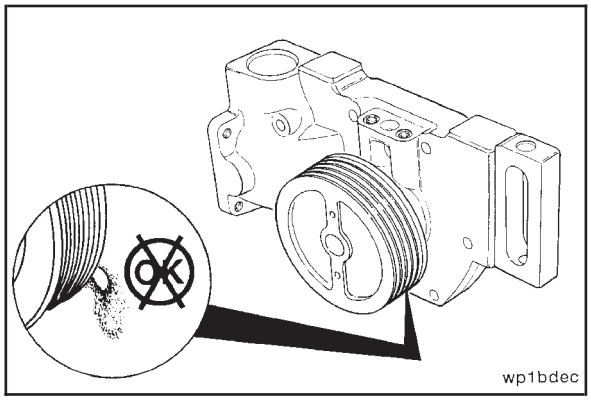
Reference No.	Description	Quantity
15	Impeller	1
16	Gasket	1
17	Nut	1
18	Washer	1
19	Seal, Oil	1
20	Pulley, Idler	1
21	Shaft, Idler	1
22	Bearing, Ball	1
23	Ring, Retaining	1
24	Washer	1
25	Capscrew	1
26	O-ring	1
27	Cover	1

Water Pump and Idler Assembly - General Informaton

The water pump for the N14 engines is a centrifugal-type vane pump with a stamped steel shrouded impeller. The shrouded impeller increases the pump's performance and reduces thrust loading. The water pump is belt driven from the accessory drive pulley. Belt tension is controlled by an adjustable idler pulley. The two non-sealed ball bearings are lubricated when assembled, with an adequate amount of grease for the entire service life of the pump. Grease is contained in the assembly by two oil seals **not** integrated to the bearings. A unitized water seal/seat is pressed into the pump body and onto the impeller shaft. It is a mechanical face shield which seals the coolant in the pump while allowing the shaft to rotate.

The water pump idler assembly mounts directly to the water pump and uses a non-sealed bearing and an oil seal. The bearing is greased during assembly and a press-on cover and o-ring are used to seal the unit from dirt.

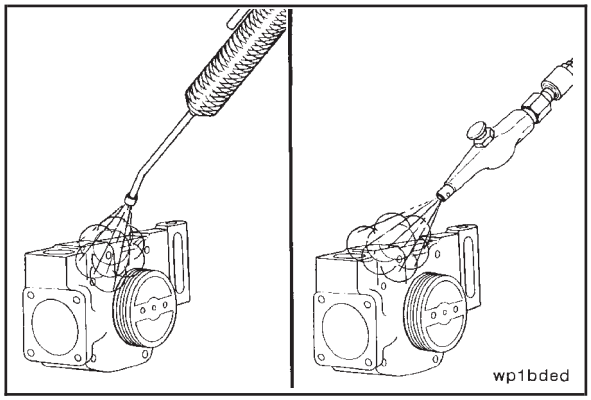
The N14 water pump is different from past NT engine water pumps in that it incorporates an internal coolant return passage from the oil cooler. It is important that only N14 water pumps are installed onto N14 engines. Installation of earlier model water pumps without this coolant return passage will damage the N14 engine.



Water Pump Assembly - Cleaning and Inspection (08-01)

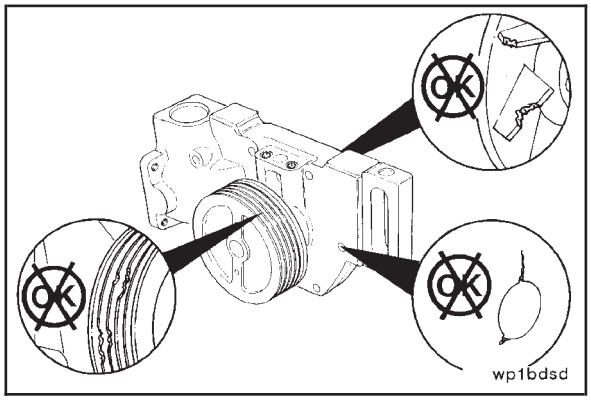
Cleaning

Before cleaning the water pump, inspect the weephole for large amounts of chemical fallout. A small amount is normal, but rebuild or replace the pump if a large amount is caked around the weephole.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use solvent or steam to clean the water pump exterior. Dry with compressed air.

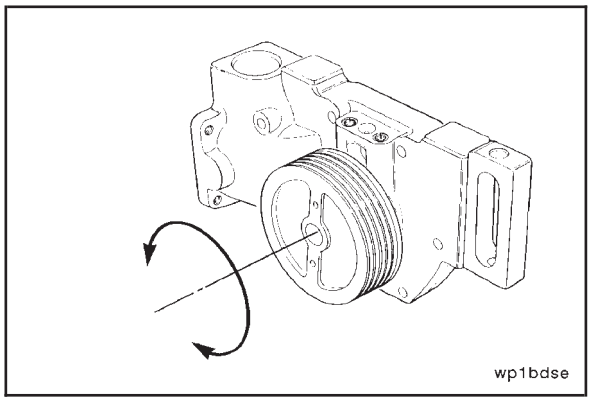


Inspection

Visually inspect the water pump body for cracks or damage.

Visually inspect the impeller for cracks, erosion, or damage.

Visually inspect the pulley for worn or damaged grooves.



Turn the water pump shaft by hand to inspect the bearings and the impeller for freedom of rotation

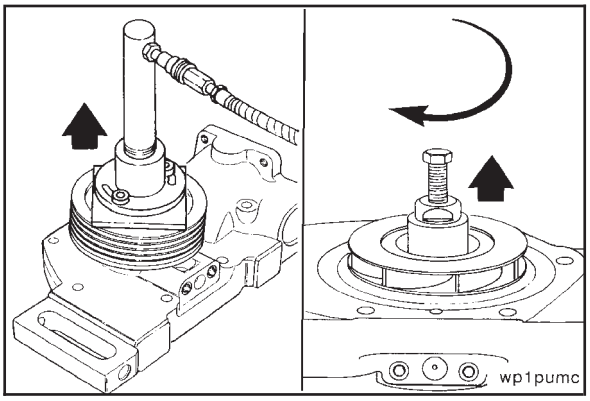
NOTE: If damaged parts are found or the shaft does **not** rotate freely in the water pump body, the water pump **must** be replaced or rebuilt. Refer to Water Pump - Rebuild (08-02).

Water Pump Assembly - Rebuild (08-02)

Disassembly

Remove the pulley with puller, Part No. 3375257.

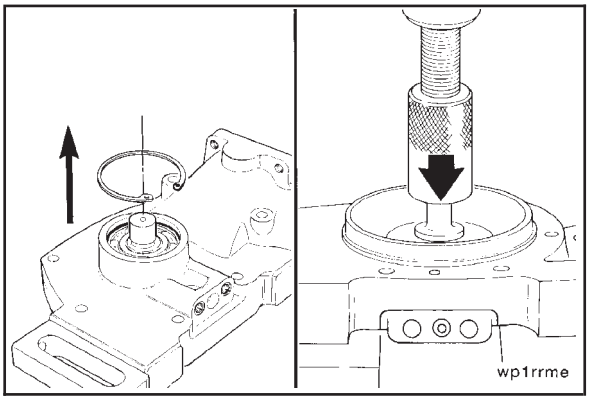
Remove the impeller with puller, Part No. 3823040.



Remove the retaining ring that holds the bearing assembly and shaft in the body.

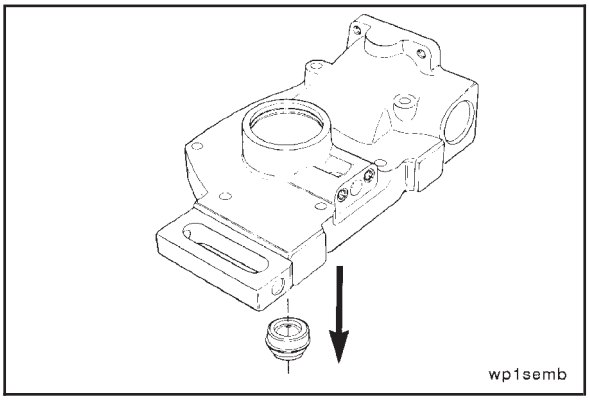
Support the pulley side of the body in an arbor press. Push the shaft from the impeller end to remove the outside oil seal, bearings, and the shaft from the body.

Use a punch and a hammer to remove the inner oil seal and the slinger from the shaft. Discard the inner oil seal and slinger.

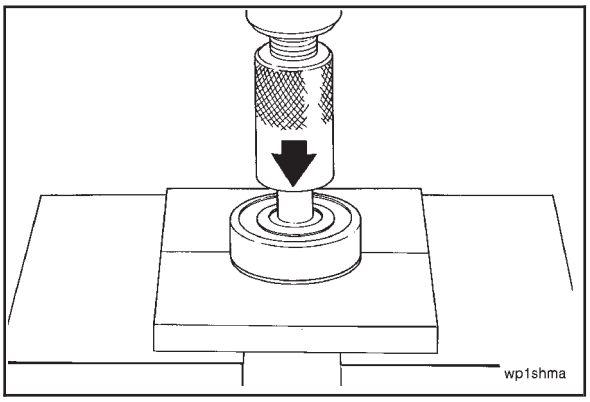


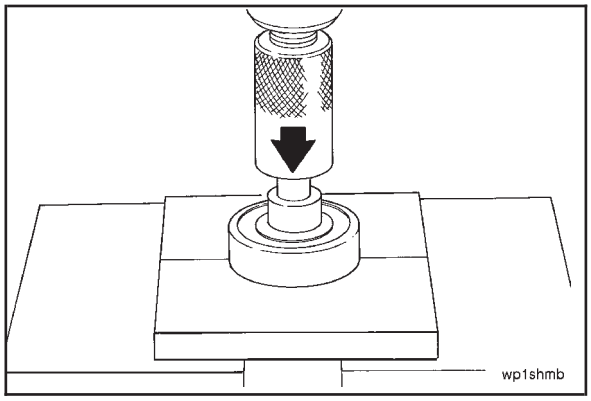
Support the impeller side of the body. Use a punch and a hammer to remove the water seal and seat assembly from the body.

Discard the seal and seat assembly.

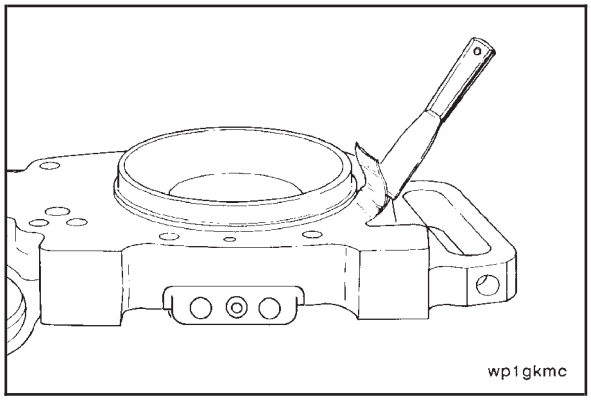


Use bearing disassembly fixture, Part No. ST-1114, to support the outer bearing and bearing spacer. Push the shaft from the bearing and the spacer. Discard the bearing.



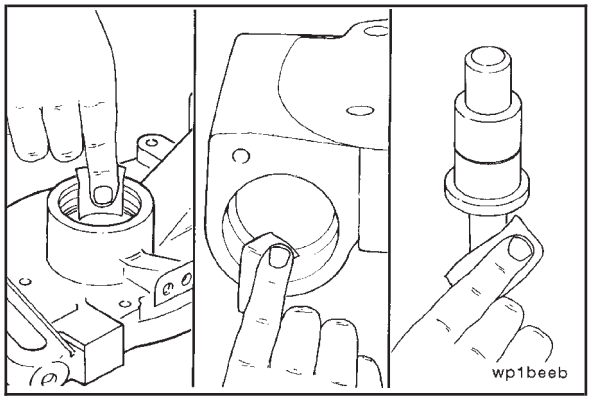


Use the disassembly fixture to support the inner bearing. Push the shaft from the bearing. Discard the bearing.



Cleaning

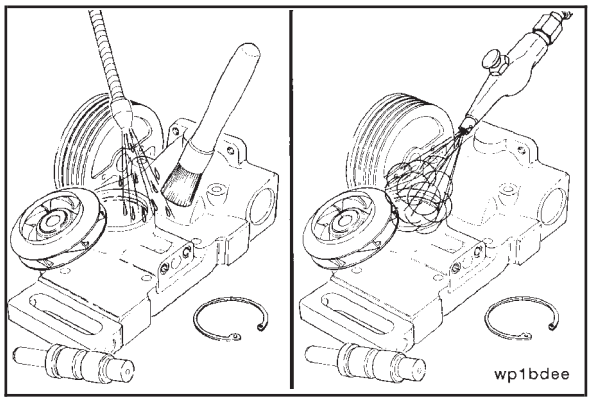
Use a gasket scraper to remove the gasket material from the gasket sealing surfaces.



Use Scotch-Brite® 7448, Part No. 3823258, to clean the bearing and the oil seal bores in the water pump body.

Use Scotch-Brite® 7448, Part No. 3823258, to clean the inside diameter of the coolant transfer tube bore in the water pump body.

Use Scotch-Brite® 7448, Part No. 3823258, to clean the water pump shaft.

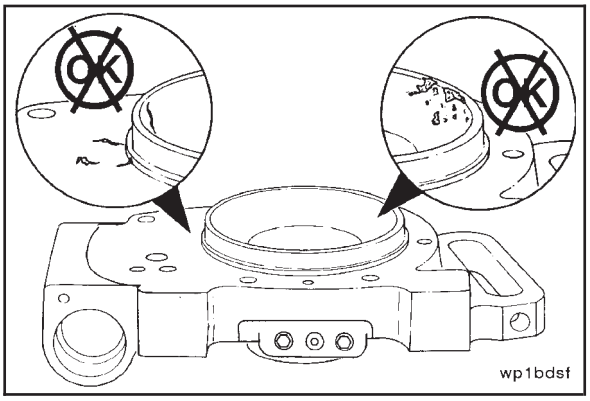


Use solvent to clean the water pump parts. Dry with compressed air.

Inspection

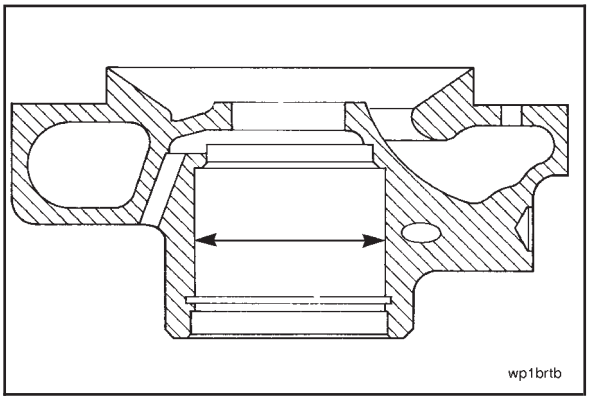
Visually inspect the water pump body for cracks, porosity, or excessive corrosion.

NOTE: If the part being inspected does **not** meet the specification given or if it is damaged or no alternative is given, the part **must** be replaced.



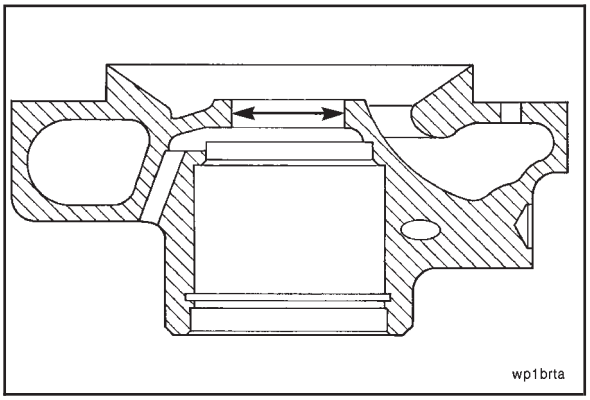
Measure the water pump body bearing bore inside diameter.

Water Pump Body Bearing Bore I.D.		
mm		in
61.988	MIN	2.4405
62.014	MAX	2.4415

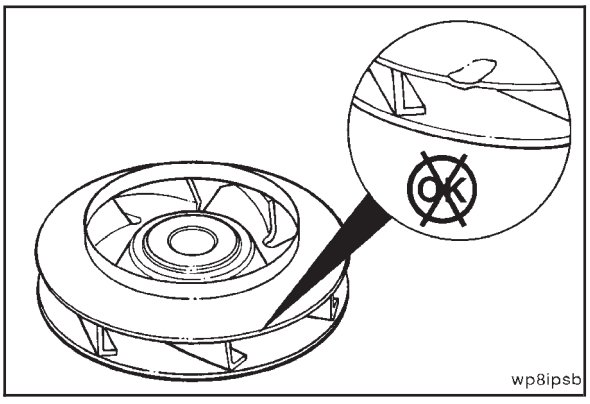


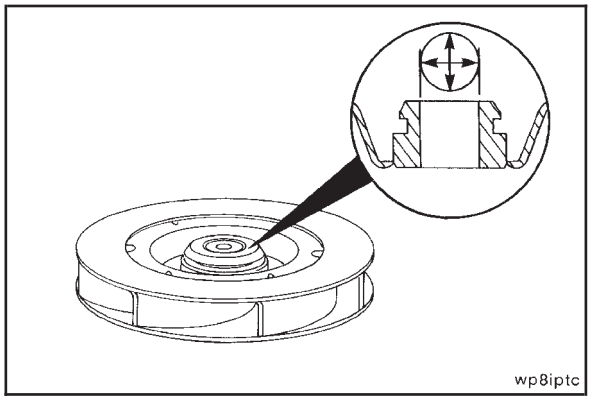
Measure the water pump body seal and seat assembly bore inside diameter.

Seal and Seat Assembly Bore I.D.		
mm		in
36.45	MIN	1.435
36.47	MAX	1.436



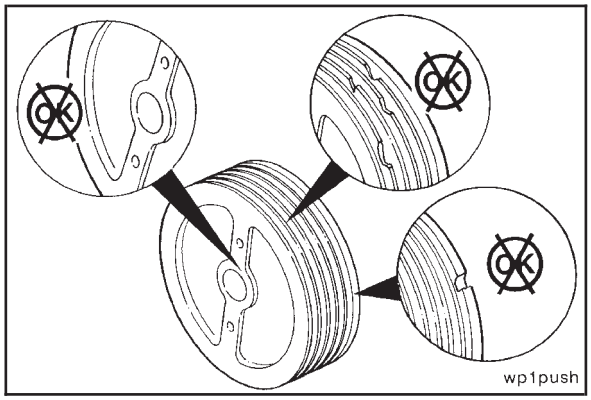
Visually inspect the water pump impeller for cracks or damage.





Measure the water pump impeller bore inside diameter.

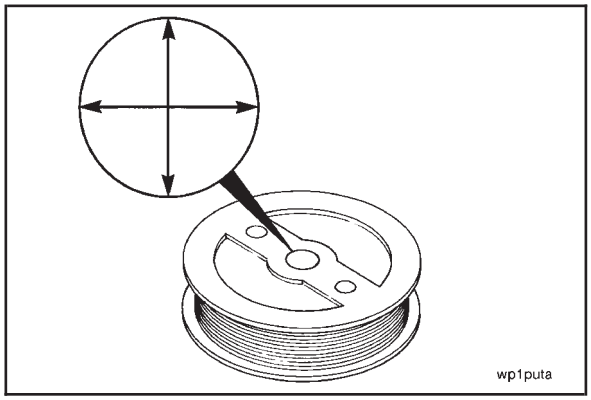
Impeller Bore I.D.		
mm		**in**
15.85	MIN	0.624
15.88	MAX	0.625



Visually inspect the water pump drive pulley for cracks or damage.

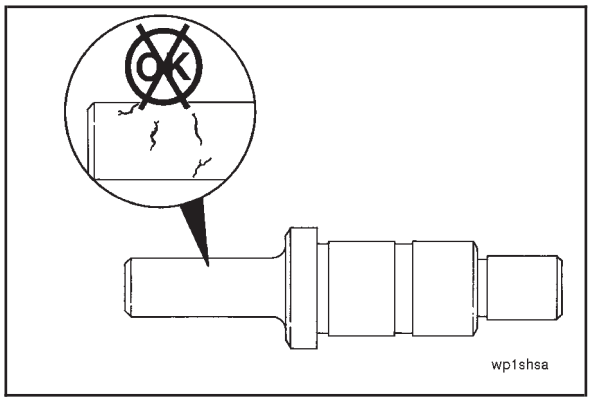
Visually inspect the pulley grooves and the oil seal wear sleeve for wear or damage.

Replace the wear sleeve if worn.



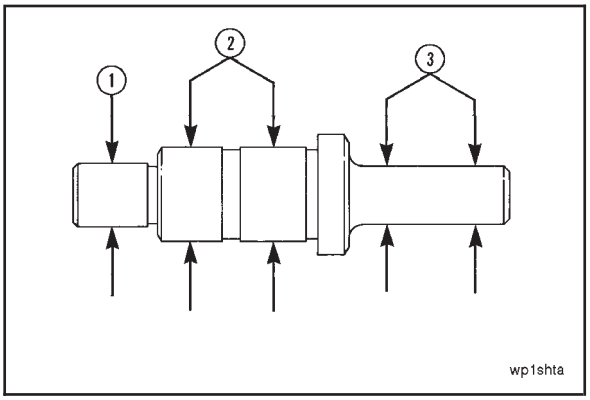
Measure the drive pulley bore inside diameter.

Drive Pulley Bore I.D.		
mm		**in**
19.037	MIN	0.7495
19.062	MAX	0.7505



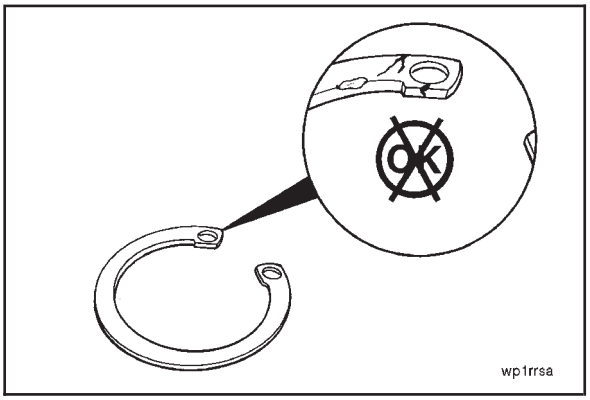
Visually inspect the water pump shaft for grooves, nicks, or damage.

Shaft Journal O.D.			
Point	mm		in
1	19.121	MIN	0.7528
	19.128	MAX	0.7531
2	25.011	MIN	0.9847
	25.022	MAX	0.9851
3	15.905	MIN	0.6262
	15.918	MAX	0.6267



Visually inspect the bearing retaining ring for nicks or cracks.

Discard damaged parts.

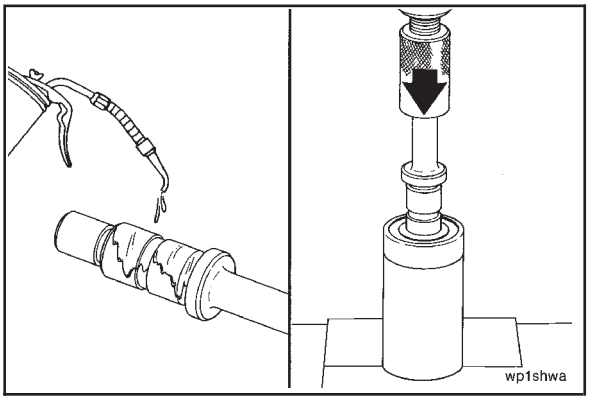


Assembly

Use clean 15W-40 oil to lubricate the water pump shaft.

Use water pump bearing mandrel, Part No. ST-658, to support a new inner bearing. Install the shaft into the bearing.

NOTE: Push the pulley end of the shaft through the bearing until the bearing is against the large diameter (shoulder) of the shaft.



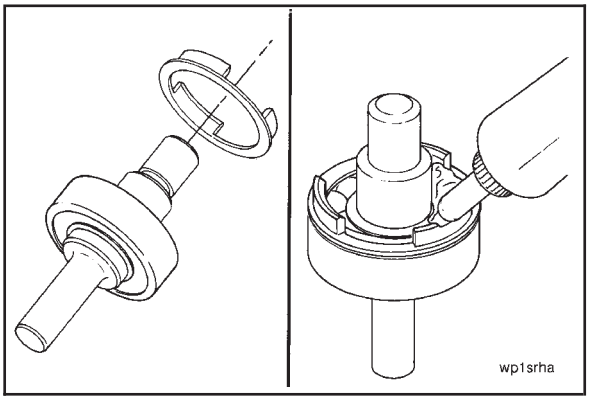
Visually inspect the bearing spacer for cracks or damage.

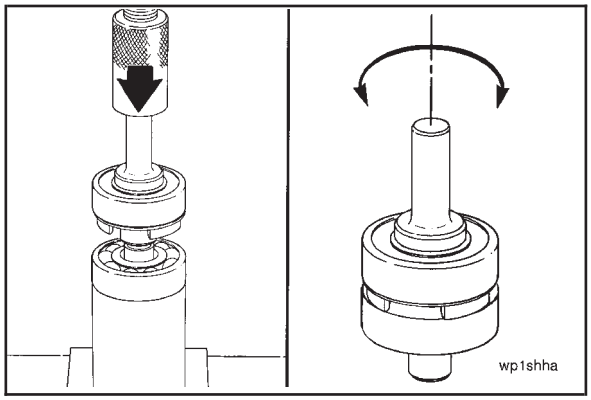
Check the thickness of the bearing spacer.

Bearing Spacer Thickness		
mm		in
7.97	MIN	0.314
8.18	MAX	0.322

Install the bearing spacer on the shaft.

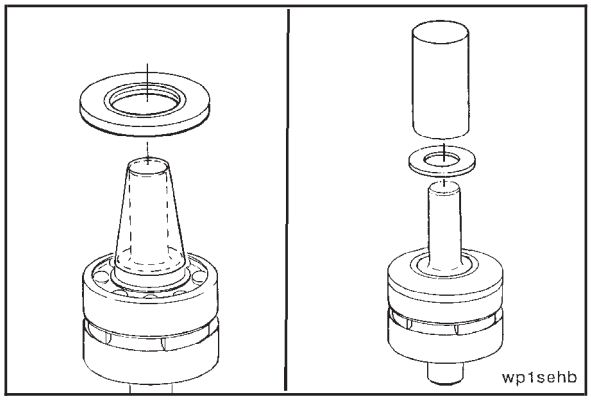
Fill both bearings and the cavity of the spacer between the water pump bearings with Chevron SRI grease or its equivalent.





Use water pump bearing mandrel, Part No. ST-658, to support a new outer bearing. Install the shaft and the spacer into the bearing.

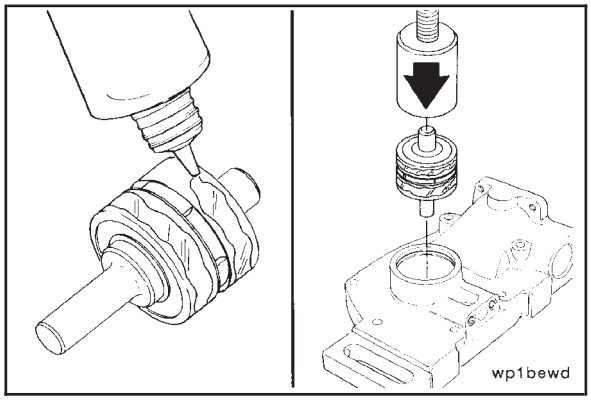
NOTE: Push the shaft through the bearing until the bearing is against the spacer. Make sure the inner race of the bearing is **not** overloaded from contact with the spacer. The bearings **must** rotate freely.



Install a new inner oil seal and a new slinger onto the shaft.

Use seal expander, Part No. 3823885, to install the seal.

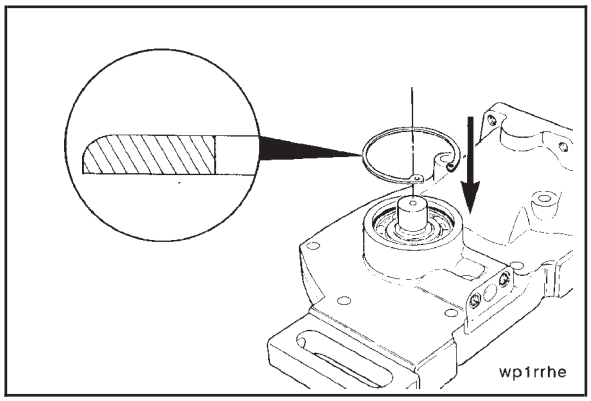
Use water pump slinger driver, Part No. 3823816, to press the slinger to the proper location.



Prepare the outside diameter surface of the bearing with Locktite® Primer T, Part No. ST-1272-13.

Apply a thin film of Locktite® 609, Part No. 3823718, to the outside diameter of the bearings.

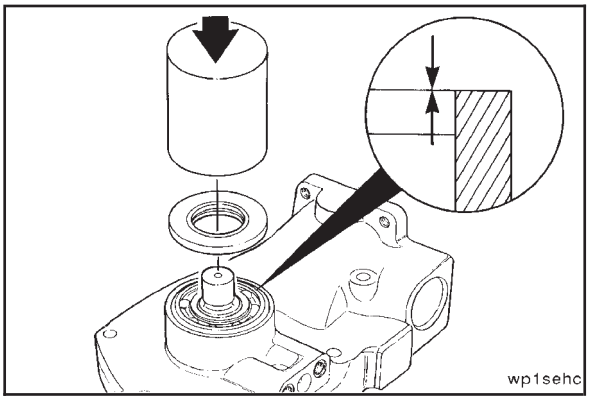
Support the impeller side of the water pump body in an arbor press. Use water pump mandrel, Part No. ST-658, to install the bearing and shaft assembly in the water pump body.



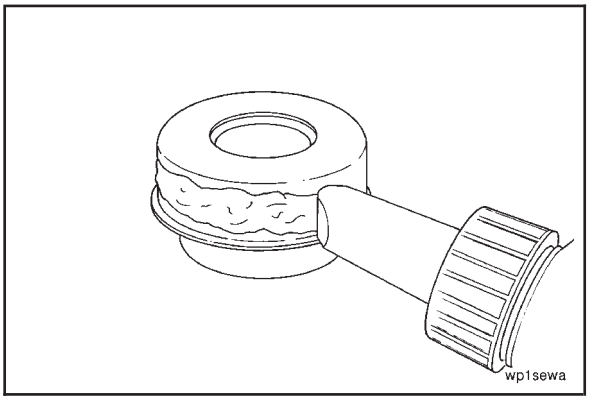
Install the retaining ring into the groove in the water pump body.

NOTE: The flat side of the bearing retaining ring **must** be installed toward the bearing.

Install a new outside oil seal, using a mandrel to press the seal in flush with the housing.



Apply a thin film of pipe sealant, Part No. 3375066, to the outside diameter of the new water pump seal.

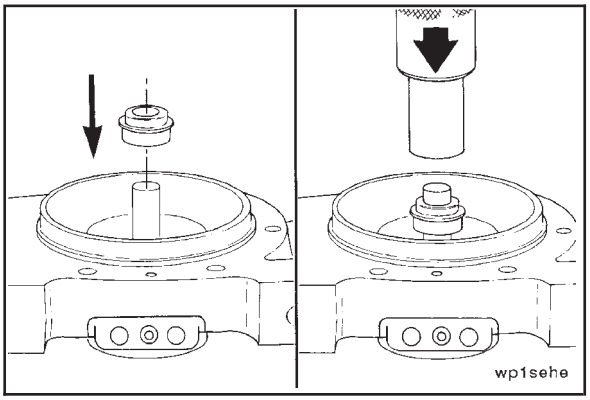


Support the pulley side of the water pump in an arbor press.

Install a new water pump seal over the shaft.

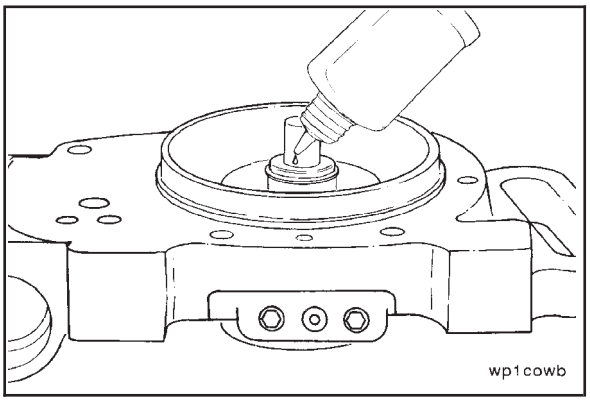
Use water pump seal mandrel, Part No. 3823815, to push the water pump seal into the water pump body.

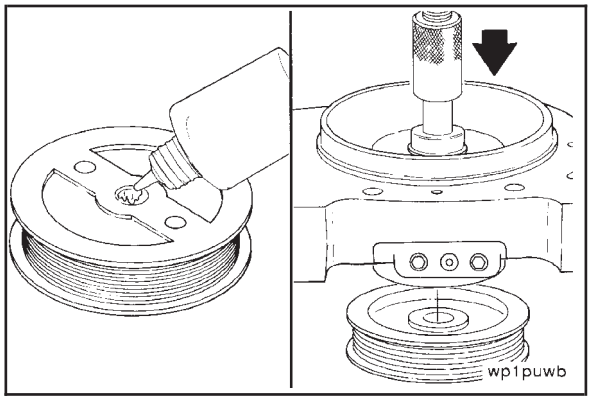
NOTE: The use of any tool other than Part No. 3823815 can result in seal damage.



Apply one drop of Locktite® 290, Part No. 3823682, or its equivalent to the joint between the water pump shaft and the water pump seal.

NOTE: Do **not** allow any Locktite® to contact the seal faces.

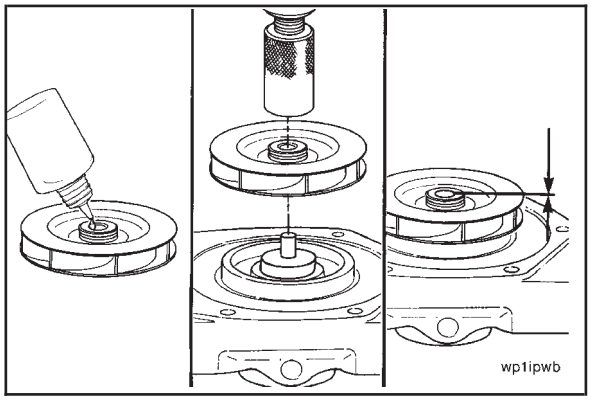




Prepare the drive pulley bore surface with Locktite® Primer T, Part No. ST-1272-13.

Apply a light film of Locktite® 609, Part No. 3823718, to the bore in the drive pulley.

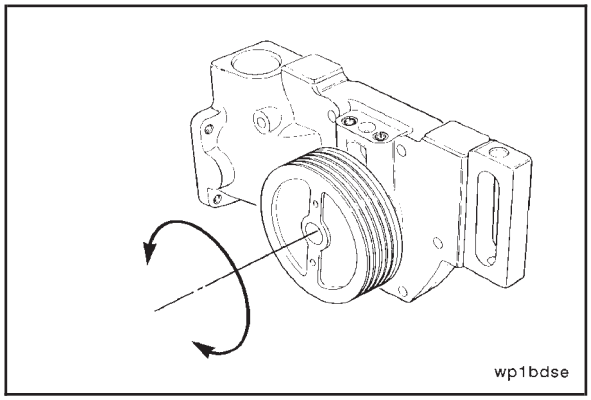
Support the water pump pulley in an arbor press. Push the water pump shaft into the pulley bore until the pulley is against the large diameter (shoulder) of the shaft.



Prepare the impeller bore surface with Locktite® Primer T, Part No. ST-1272-13.

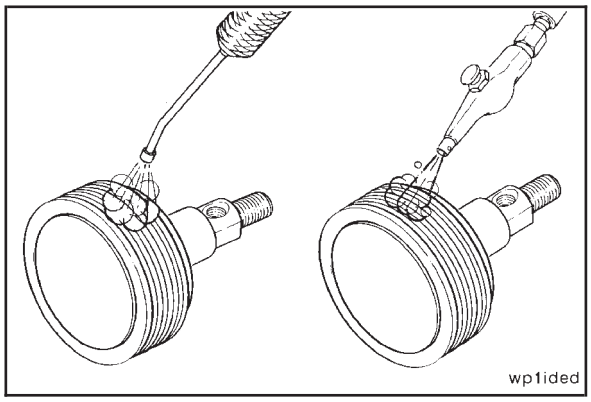
Apply a light film of Locktite® 609, Part No. 3823718, to the bore in the impeller.

Support the pulley end of the water pump shaft in an arbor press. Push the impeller onto the shaft until the end of the impeller hub is aligned with the end of the shaft.



As a final inspection, turn the water pump pulley by hand to inspect the bearings for freedom of rotation.

NOTE: If the water pump shaft does **not** rotate freely in the water pump body, the water pump **must** be disassembled, inspected, and assembled again.



Water Pump Idler Assembly - Cleaning and Inspection (08-03)

Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

NOTE: Do **not** apply steam directly to the face of the bearing seal.

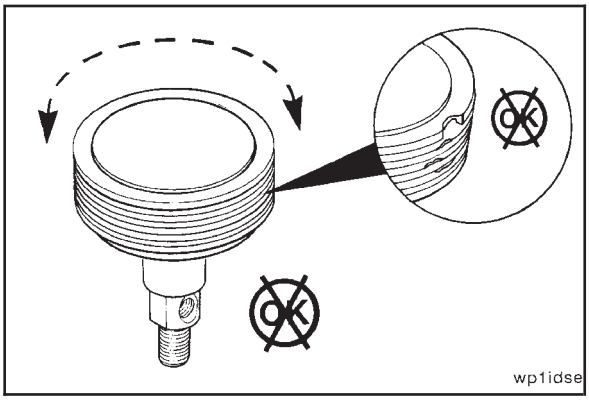
Use solvent or steam to clean the idler assembly exterior. Dry with compressed air.

Inspection

Visually inspect the idler assembly for cracked, chipped, or broken pulley grooves.

Turn the idler pulley by hand to inspect the shaft and the bearing for freedom of rotation.

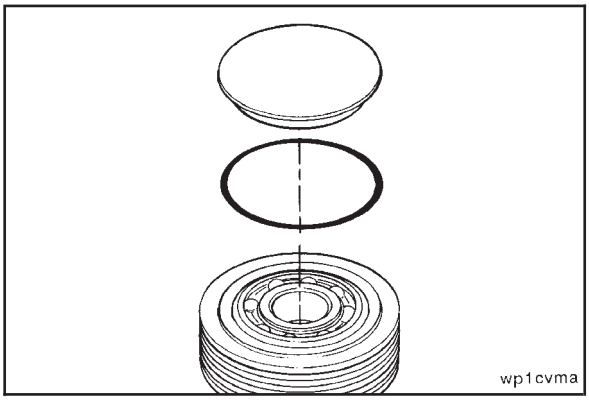
NOTE: If damaged parts are found or the idler assembly does **not** rotate freely, the idler assembly **must** be replaced or rebuilt. Refer to Water Pump Idler Assembly - Rebuild (08-04).



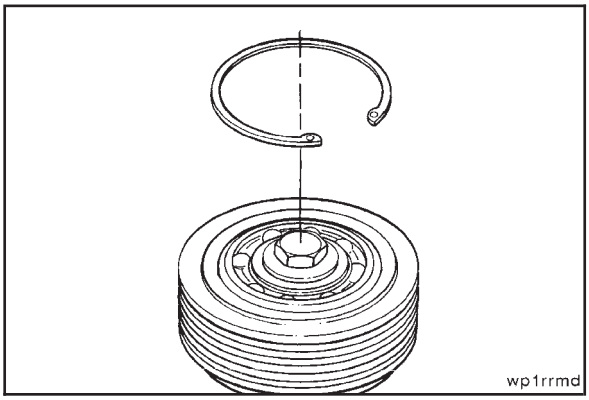
Water Pump Idler Assembly - Rebuild (08-04)

Disassembly

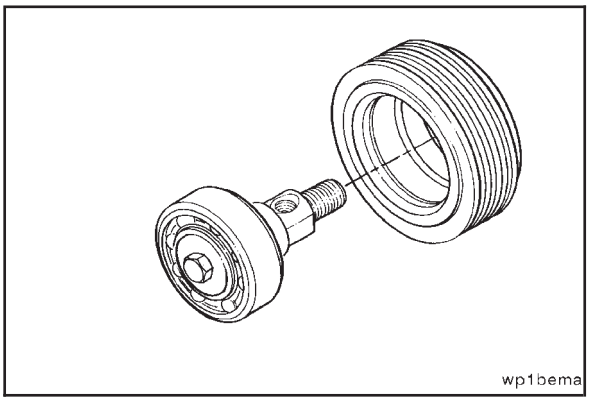
Carefully pry off the cover and the o-ring.

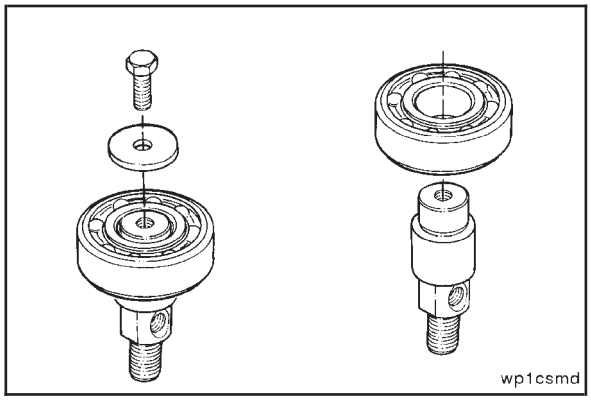


Remove the bearing retaining ring from the idler pulley.



Support the pulley evenly and push the bearing and the shaft out.

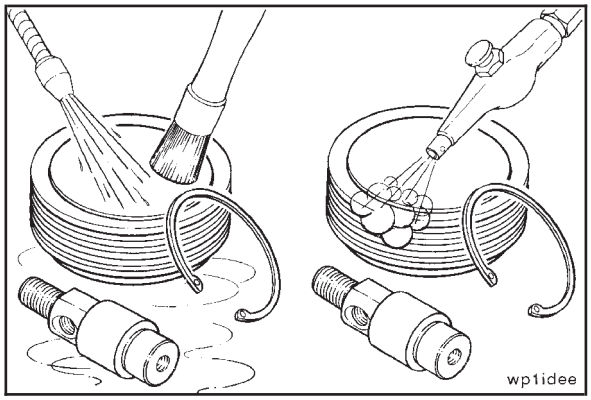




Remove the capscrew and the washer.

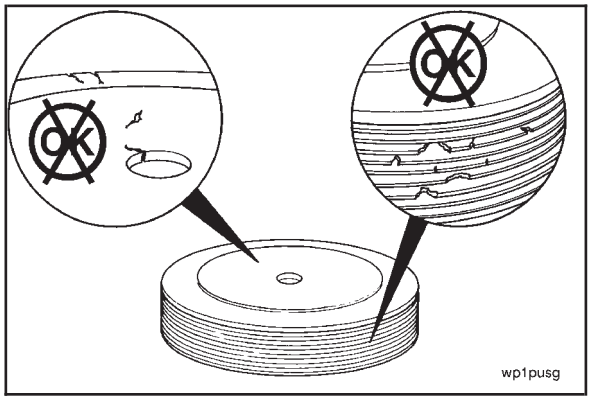
Press the shaft out of the bearing.

Discard the bearing.



Cleaning

Use solvent to clean the idler assembly parts. Dry with compressed air.

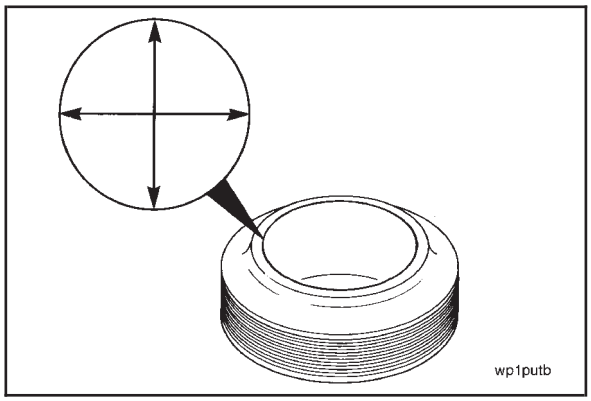


Inspection

Visually inspect the idler pulley for cracks or damage.

Visually inspect the pulley grooves for wear or damage.

NOTE: If the part being inspected does **not** meet the specifications given or if damaged or no alternative is given, the part **must** be replaced.

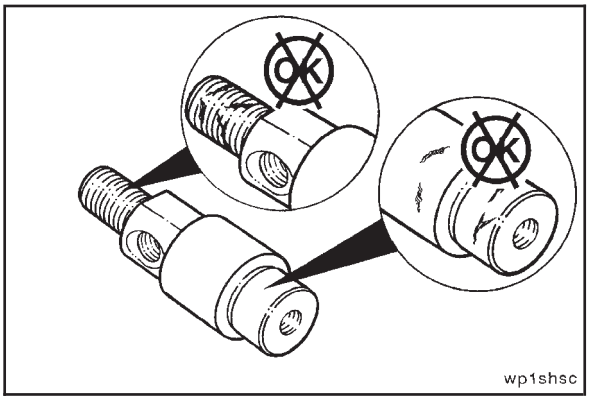


Measure the inside diameter of the idler pulley bearing bore.

Idler Pulley Bearing Bore I.D.		
mm		**in**
61.996	MIN	2.4408
62.012	MAX	2.4414

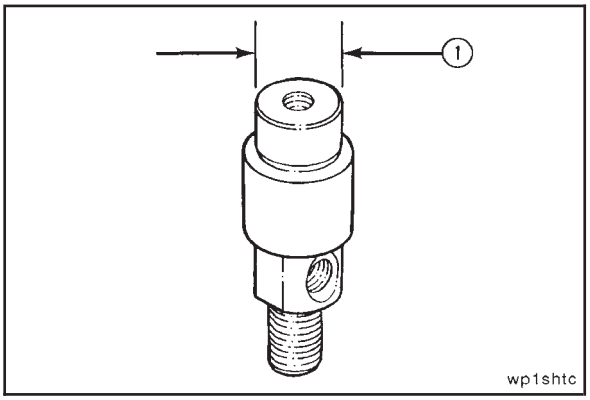
Visually inspect the idler shaft for grooves, nicks, or damage.

Inspect the adjusting screw and the mounting nut threads for wear or distortion.



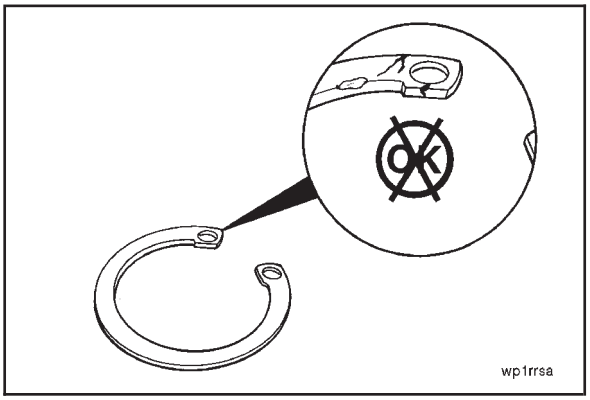
Measure the outside diameter (1) of the bearing press fit area of the idler shaft.

Idler Shaft O.D.		
mm		in
24.980	MIN	0.9835
24.993	MAX	0.9840



Visually inspect the bearing retaining ring, idler pulley cover, capscrew, and washer for cracks or damage.

Discard damaged parts.

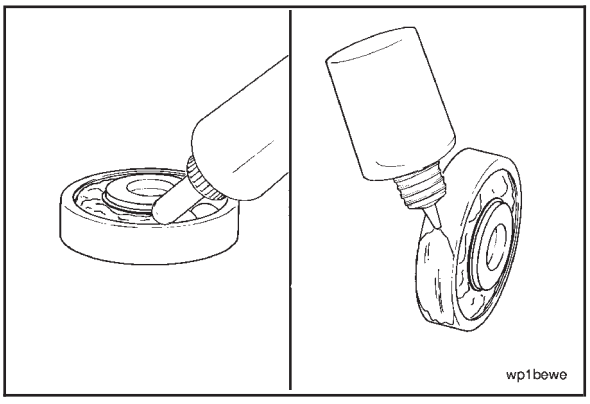


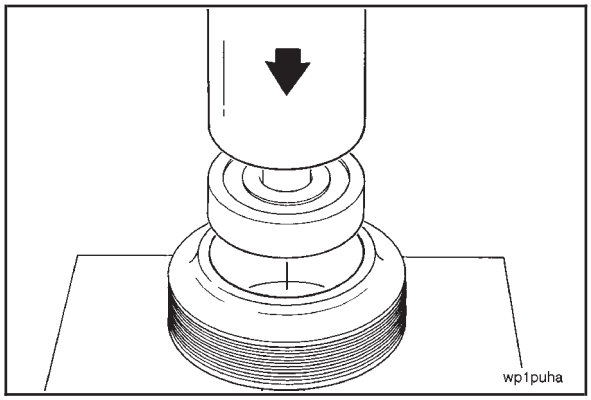
Assembly

Fill the space between the bearing races and the roller bearings with Chevron SRI grease or its equivalent.

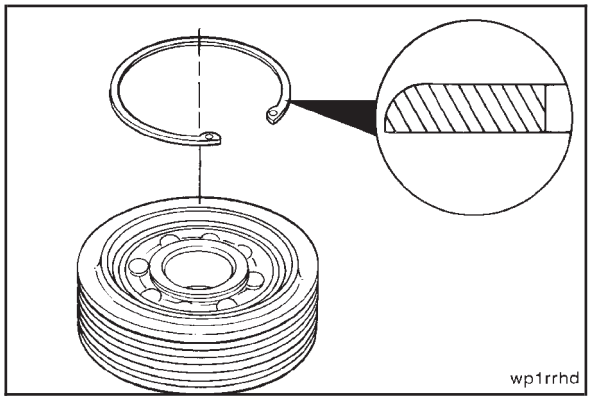
Prepare the outside diameter surface of the bearing with Locktite® Primer T, Part No. ST-1272-13.

Apply a thin film of Locktite® 609, Part No. 3823718, to the outside diameter of the bearing.



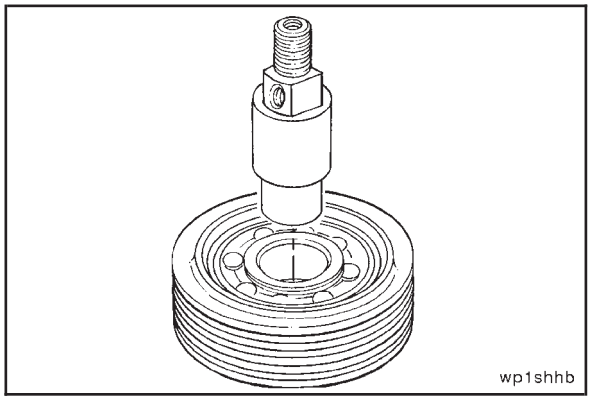


Support the idler pulley in an arbor press. Use bearing installation tool, Part No. ST-658, to press the bearing into the pulley until the bearing is against the bottom of the bearing bore.

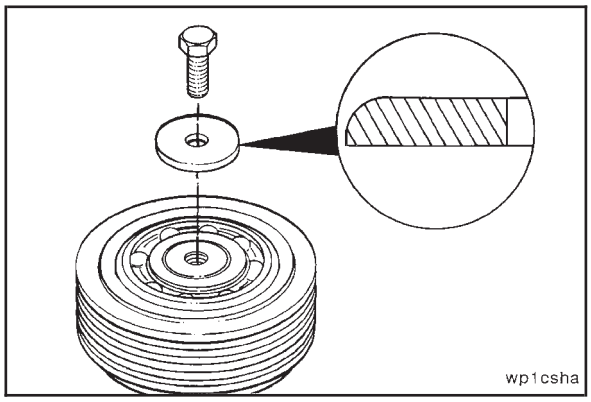


Install the retaining ring into the groove in the idler pulley.

NOTE: The flat side of the bearing retaining ring **must** be installed toward the bearing.



Push the shaft into the bearing by hand.



Install the flat washer and the capscrew.

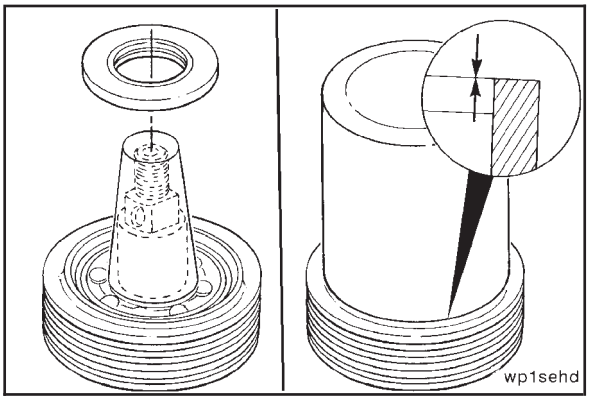
Make sure the flat side of the washer is against the bearing.

Torque Value: 27 N•m [20 ft-lb]

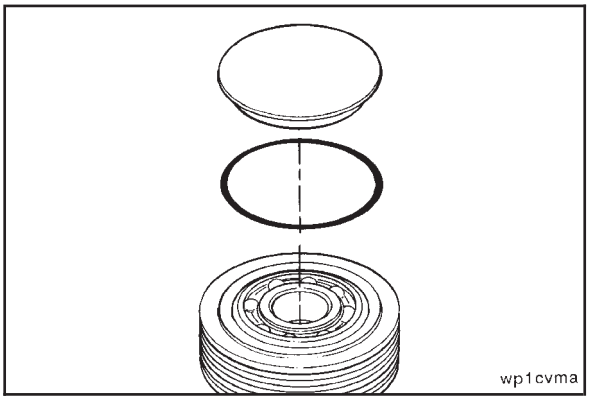
Install the oil seal with the lip toward the bearing.

Use seal expander, Part No. 3823885, to guide the seal onto the shaft.

Use a tube mandrel to press the seal in flush with the pulley.



Press the cover and a new o-ring into the pulley.

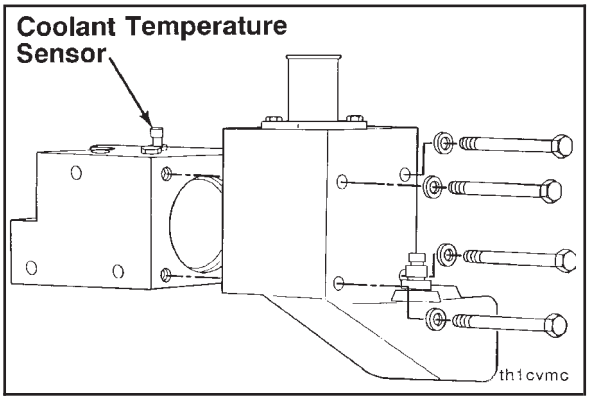


Thermostat Housing - Cleaning and Inspection (08-05)

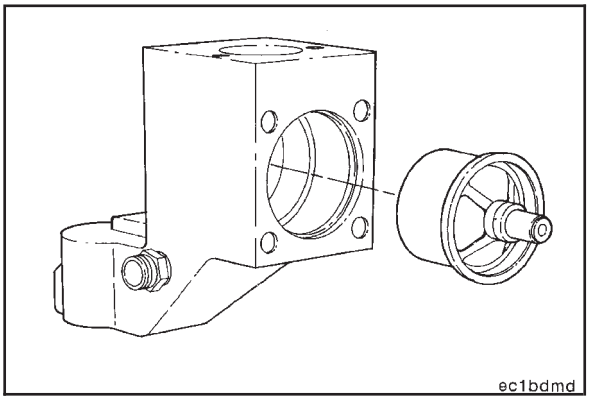
Disassembly

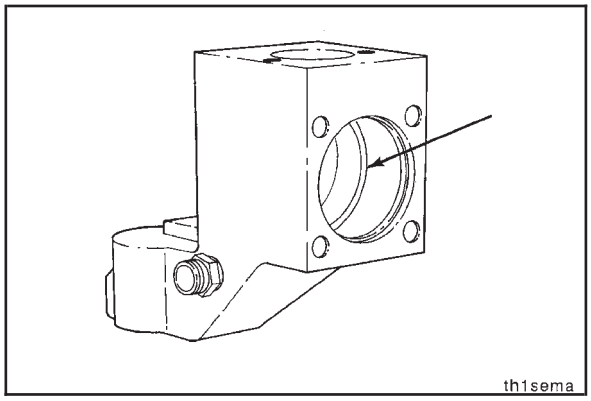
Remove the four thermostat cover capscrews and disassemble the thermostat housing.

If the thermostat housing assembly is being replaced, remove the CELECT™ coolant temperature sensor at this time from the thermostat housing.

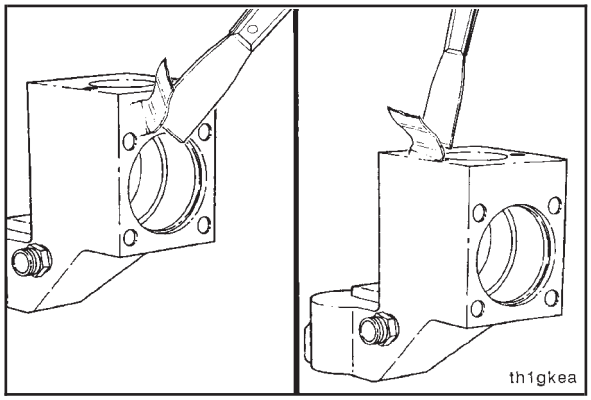


Remove the thermostat from the cover.



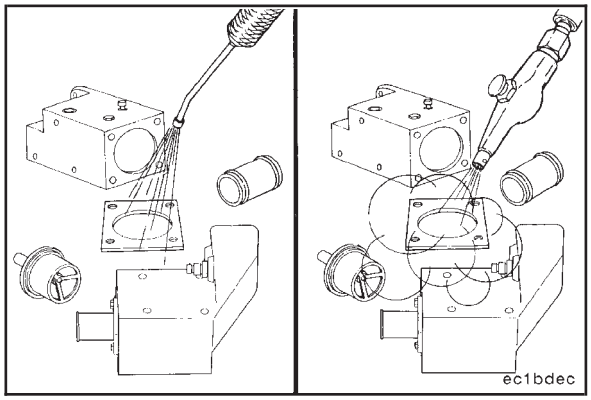


Carefully remove the thermostat seal to avoid damaging the thermostat cover.



Cleaning

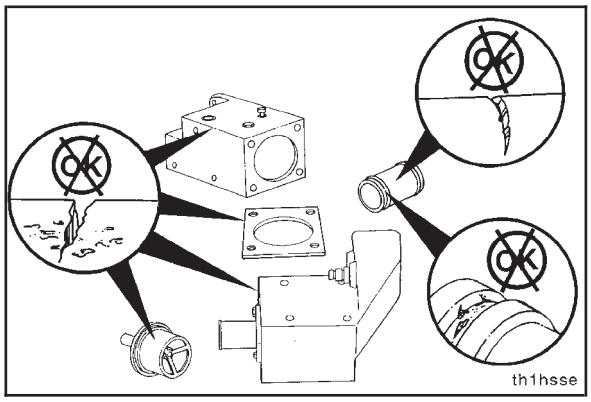
Use a gasket scraper to remove the gasket material from the mating surfaces of the housing and the cover.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use solvent or steam to clean the parts.

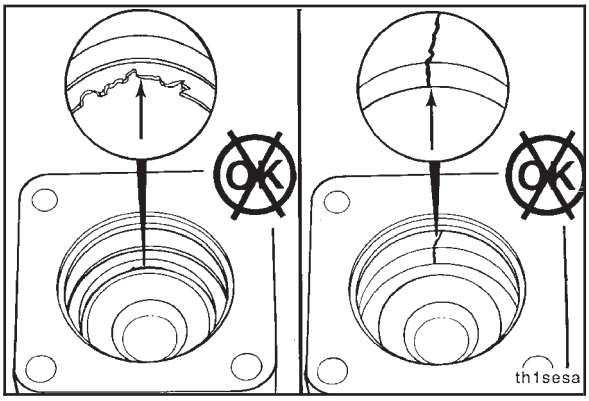
Dry with compressed air.



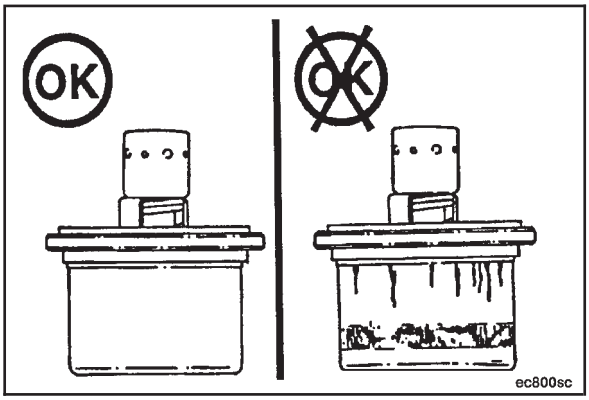
Inspection

Visually inspect the housing and the cover for cracks, corrosion, or damage. Replace the parts if necessary.

Inspect the thermostat seal and the thermostat cover gasket surface for cracks, corrosion, or damage. Replace the thermostat cover if necessary. The thermostat seal can **not** be reused. The seal **must** be replaced if it is removed from the cover.

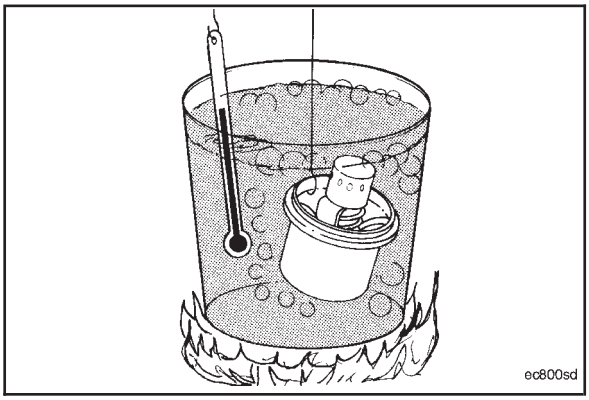


Inspect the thermostat for damage.



Suspend the thermostat and a 100° C [212° F] thermometer in a container of water. Do **not** allow the thermostat or the thermometer to touch the sides of the container. Heat the water.

NOTE: Record the temperatures at which the thermostat begins to open and when it is fully open. Allow several minutes for the thermostat to react to a stabilized water temperature.

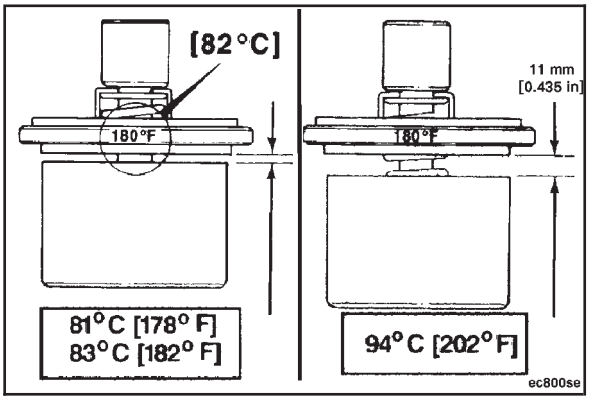


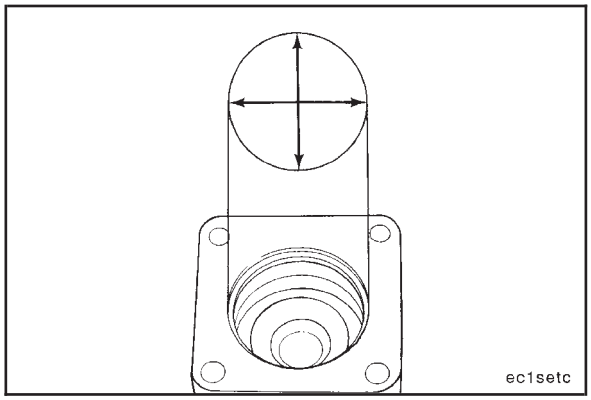
NOTE: The nominal operating temperature is stamped on the thermostat.

The thermostat **must** begin to open within 1° C [2° F] of nominal temperature.

The thermostat **must** be fully open to at least 9.5 mm [0.375-inch] within 12° C [22° F] above nominal temperature.

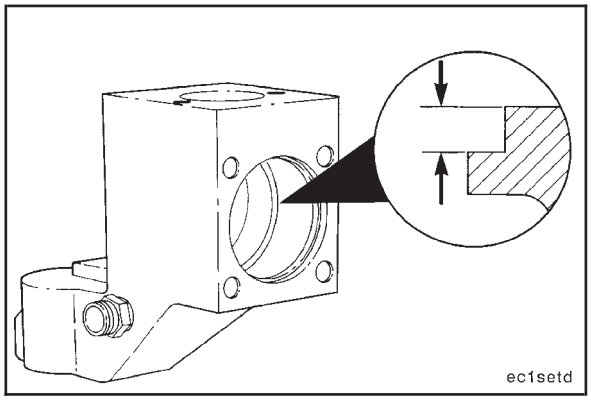
Replace the thermostat if it does **not** operate as described.





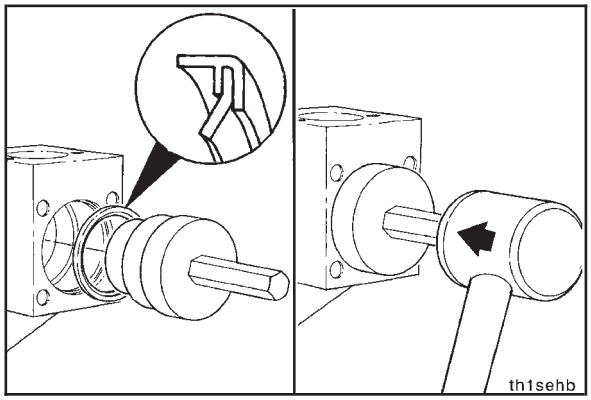
Measure the inside diameter of the thermostat seal counterbore in the thermostat housing.

Thermostat Seal Bore I.D.		
mm		**in**
67.39	MIN	2.653
67.46	MAX	2.656



Use a depth micrometer or a depth gauge, Part No. 3823495, to measure the depth of the seal counterbore in the thermostat housing.

Thermostat Seal Bore Depth		
mm		**in**
42.16	MIN	1.66
42.67	MAX	1.68

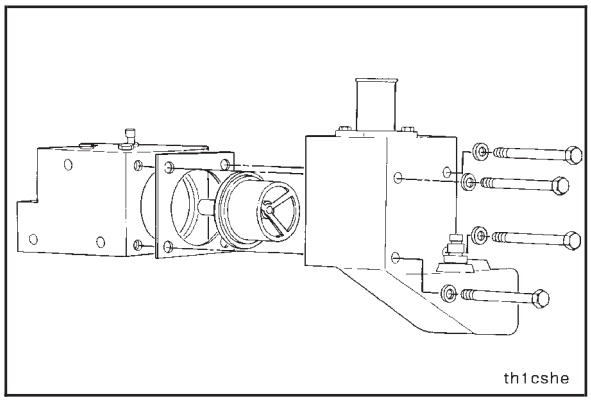


Assembly

Caution: When installing a new seal, the flat side of the seal must be toward the mandrel for correct installation.

Use thermostat seal mandrel, Part No. ST-1225, and a lead hammer to install the seal.

A counterbore in the housing bore locates the seal.



Install the thermostat in the cover.

Install a new gasket on the thermostat housing.

Install the thermostat cover and the four mounting capscrews.

Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]

Install the CELECT™ coolant temperature sensor into the thermostat housing.

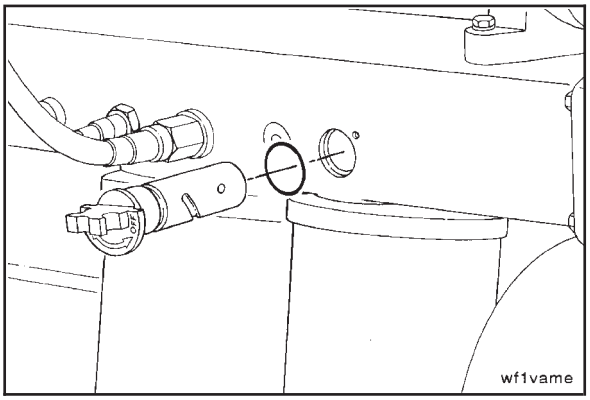
Torque Value: 34 N•m [25 ft-lb]

Coolant Filter Head Insert (08-06)

Refer to Lubricating Oil Cooler Assembly - Rebuild in Section 7 for removal, cleaning, inspection, and installation of the coolant filter head insert.

Coolant Filter Shutoff Valve (08-07)

Refer to Lubricating Oil Cooler Assembly - Rebuild in Section 7 for removal, inspection, and installation of the coolant filter shutoff valve.

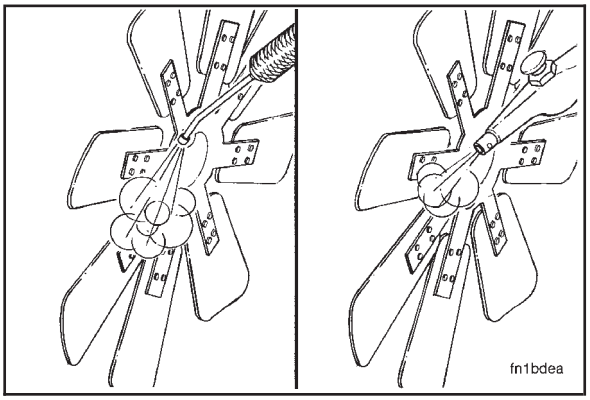


Fan - Cleaning and Inspection (08-08)

Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

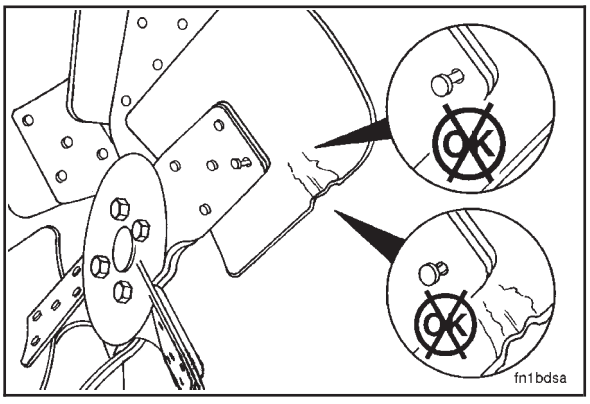
Use solvent or steam to clean the fan. Dry with compressed air.

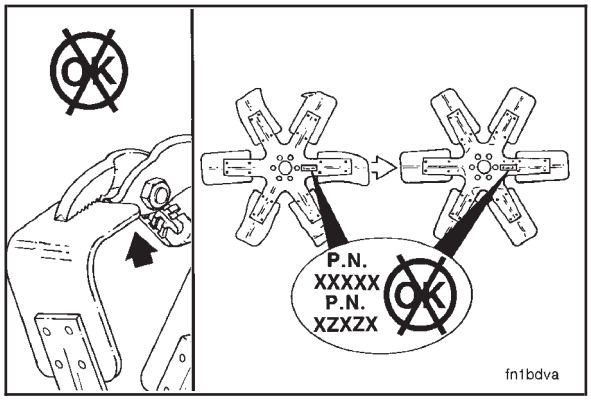


Inspection

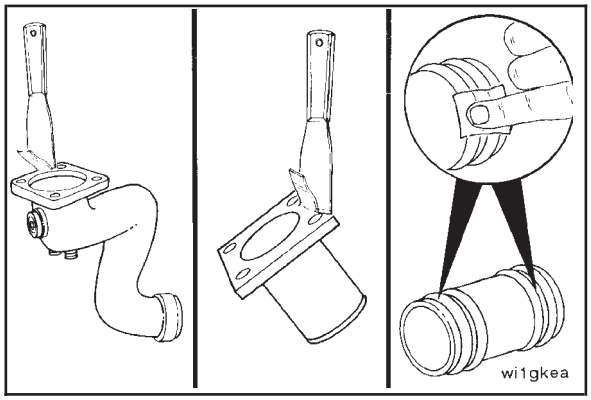
Warning: A bent or damaged fan blade can fail during operation and cause serious personal injury or property damage.

Visually inspect the fan for cracks, loose rivets, and bent or loose blades.





Warning: Do not straighten a bent fan blade or continue to use a damaged fan. Replace the original equipment fan with a fan of the identical part number. Cummins Engine Company, Inc. must approve any other fan changes.

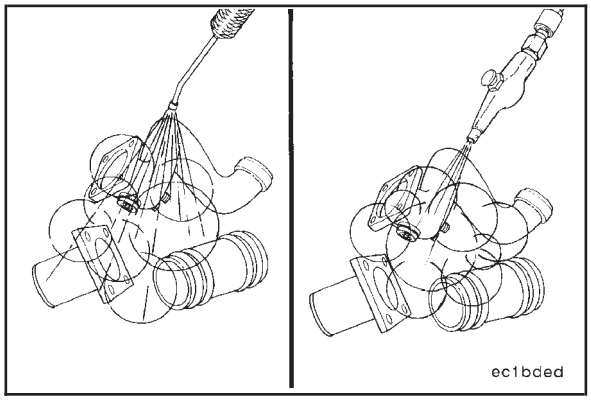


Water Transfer Tubes - Cleaning and Inspection (08-09)

Cleaning

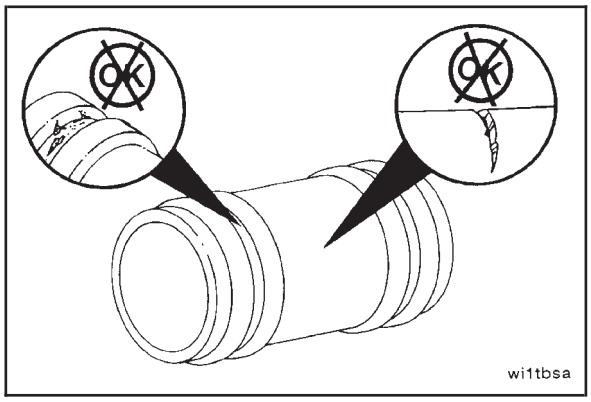
Use a gasket scraper to remove gasket material from the mating surfaces of the transfer tubes.

Use Scotch-Brite® 7448, Part No. 3823258, to clean the o-ring grooves on the thermostat housing to water pump water transfer tube.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use solvent or steam to clean the parts. Dry with compressed air.



Inspection

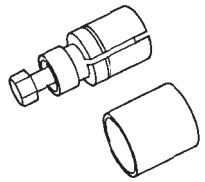
Inspect the transfer tubes for cracks, dents, and corrosion or pitting in the o-ring grooves.

Section 9 - Drive Units - Group 09

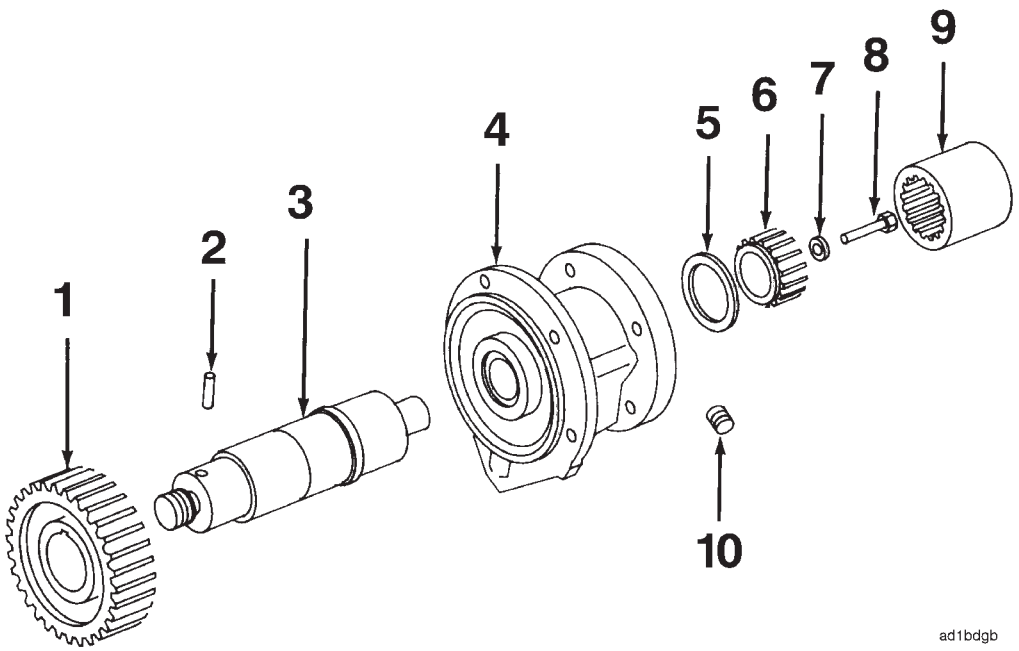
Section Contents

Drive Units - Service Tools

The following special tools are recommended to perform procedures in section 9. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3376663	**Coupling Puller** Remove the splined coupling gear from the compressor drive	 bp8togg

Accessory Drive - Exploded View



Reference No.	Description	Quantity
1	Gear, Accessory Drive	1
2	Pin, Groove	1
3	Shaft, Accessory Drive	1
4	Housing, Accessory Drive	1
5	Washer, Plain	1

Reference No.	Description	Quantity
6	Hub, Spline Coupling	1
7	Washer, Plain	1
8	Capscrew, Special	1
9	Sleeve, Spline Coupling	1
10	Plug, 5/16-inch Straight Thread O-Ring	2

Drive Units - General Information

Accessory Drive

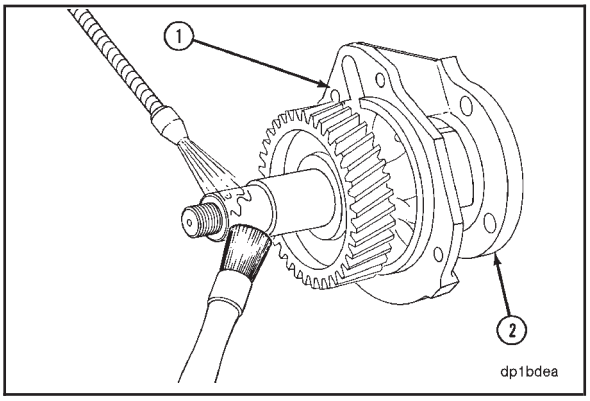
The accessory drive housings are available in two designs--with and without hardware for mounting an air compressor. The fuel pump drive assembly has hardware for a hub or spider-type coupling. The compressor drive assembly has hardware for a splined sleeve-type coupling. The rebuild procedures are the same for both designs.

Accessory Drive - Cleaning and Inspection for Reuse (09-01)

Cleaning

Remove all gasket material from surfaces (1) and (2).

Clean the exterior of the drive with solvent. Dry with compressed air.

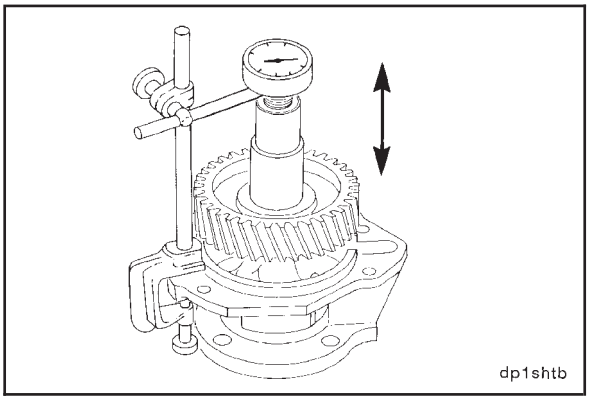


Inspection

Measure the drive shaft end clearance at the end of the shaft for accurate measurement.

Drive Shaft End Clearance		
mm		in
0.10	MIN	0.004
0.225	MAX	0.009

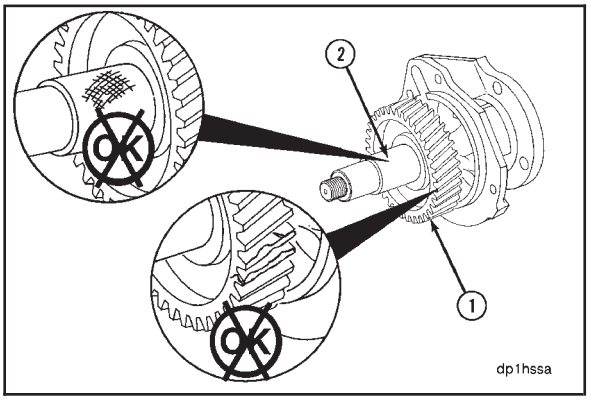
NOTE: If the shaft end clearance does **not** meet these specifications, rebuild or replace the drive unit. Refer to Accessory Drive - Rebuild (09-02).



Visually inspect the housing for cracks or damaged mounting holes.

Visually inspect the drive gear (1) for damaged teeth.

Visually inspect the shaft (2) for scratches, scoring, or other damage.

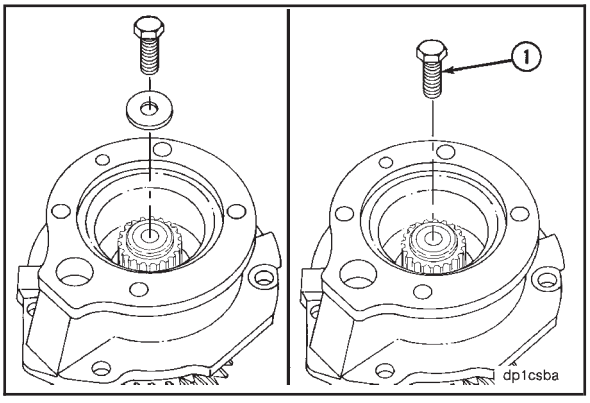


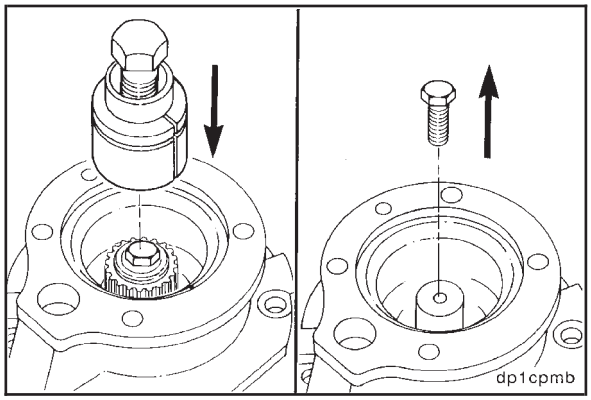
Accessory Drive - Rebuild (09-02)

Disassembly

Remove the special capscrew and washer.

Caution: Install a 3/8-16 X 3/4-inch capscrew (1) without the washer into the shaft to prevent damage to the shaft while the gear is being removed.

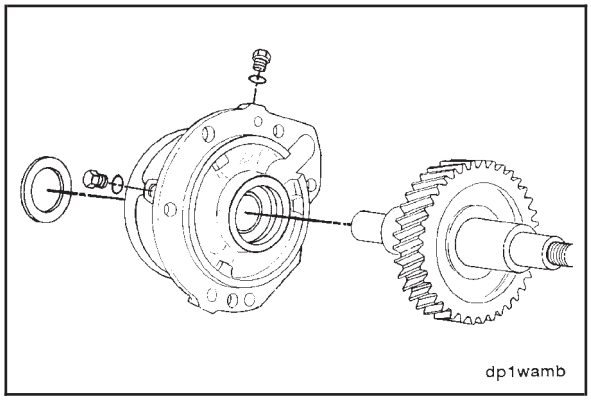




Use coupling puller, Part No. 3376663, to remove the splined coupling.

Use a three-jaw puller to remove the hub-type coupling.

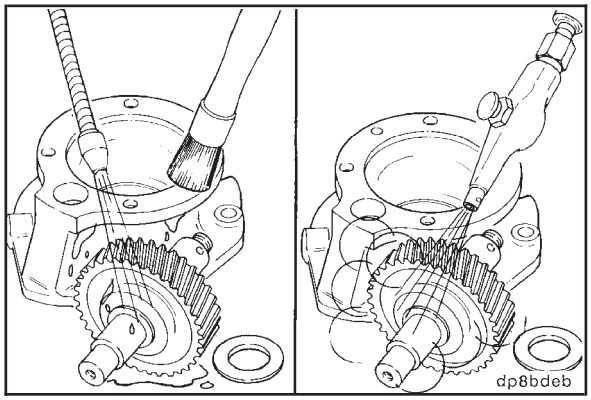
Remove the capscrew.



Remove the clamping washer.

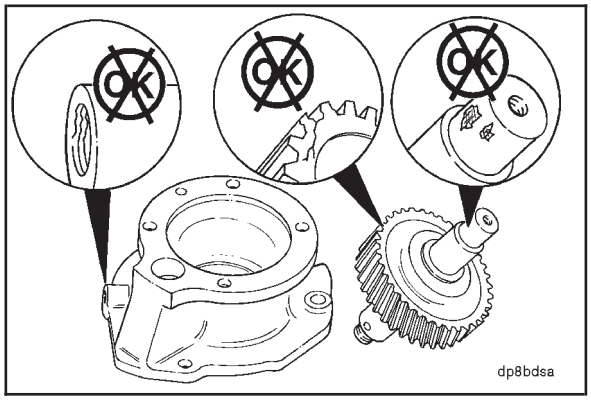
Remove the gear and shaft assembly.

Remove the straight thread o-ring plugs from the housing.



Cleaning

Clean the parts with solvent. Dry with compressed air.

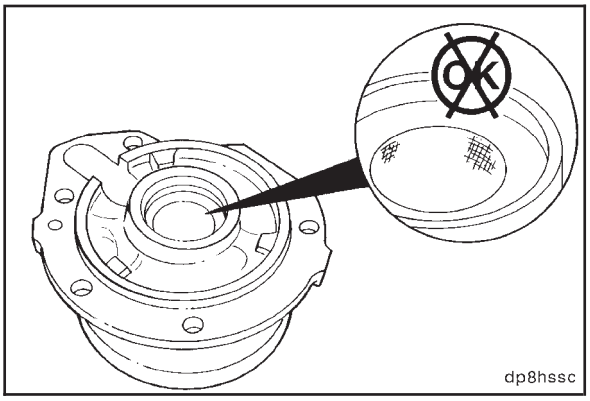


Inspection

Visually inspect the parts for damage.

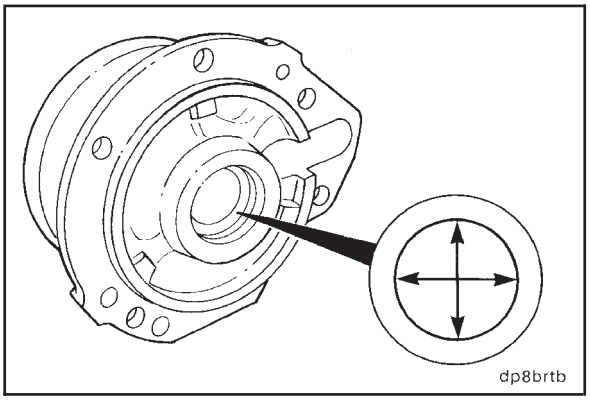
If the gear or the shaft **must** be replaced, refer to Accessory Drive Gear - Replacement (09-03).

Visually inspect the shaft bore in the housing for scoring or damage.



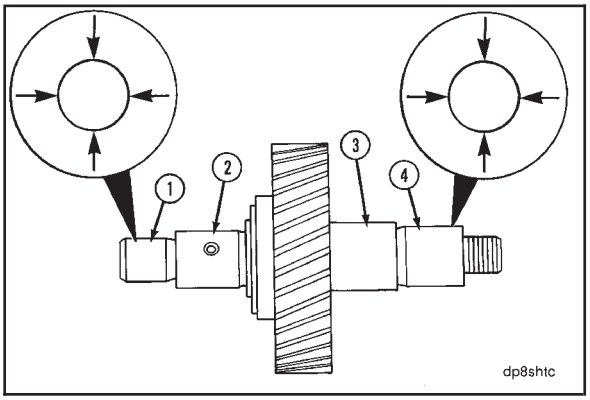
Measure the inside diameter of the shaft bore in the drive housing.

Drive Shaft Bore I.D.		
mm		**in**
33.426	MIN	1.3160
33.515	MAX	1.3195



Measure the drive shaft outside diameter.

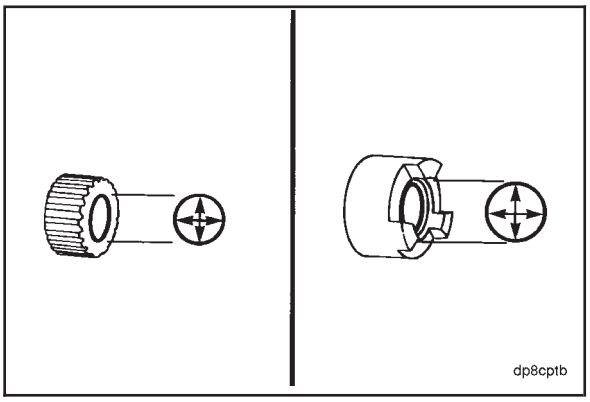
Drive Shaft Journal O.D.			
Point	**mm**		**in**
(1)	25.476	MIN	1.0030
	25.489	MAX	1.0035
(2)	33.274	MIN	1.3100
	33.325	MAX	1.3120
(3)	39.624	MIN	1.5600
	39.674	MAX	1.5620
(4)	34.963	MIN	1.3765
	34.976	MAX	1.3770

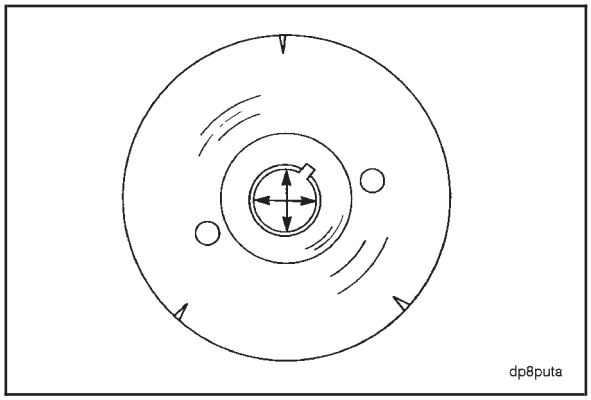


Measure the inside diameter of the splined coupling gear or the hub coupling.

Splined Coupling I.D.		
mm		**in**
25.400	MIN	1.0000
25.425	MAX	1.0010

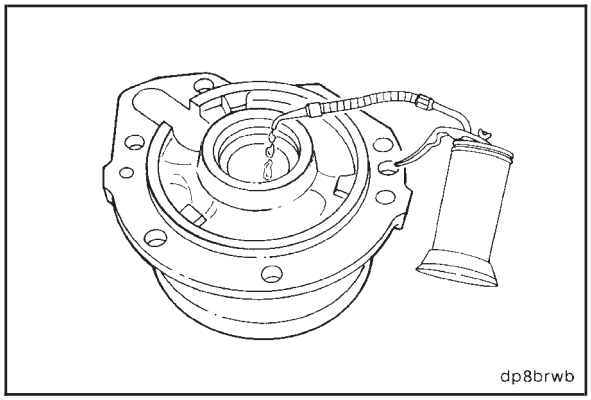
Hub Coupling I.D.		
mm		**in**
25.425	MIN	1.0010
25.438	MAX	1.0015





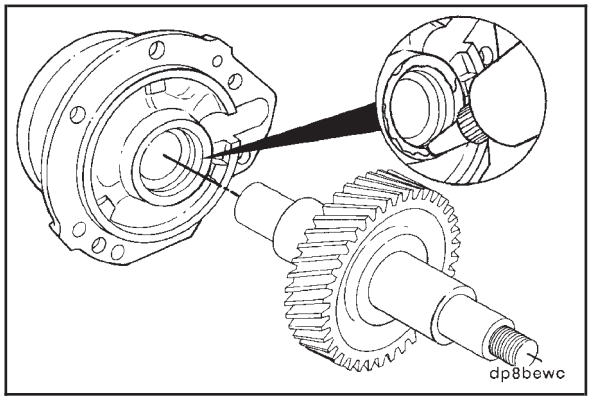
Measure the inside diameter of the drive pulley bore.

Drive Pulley Bore I.D.		
mm		**in**
34.930	MIN	1.3752
34.950	MAX	1.3760



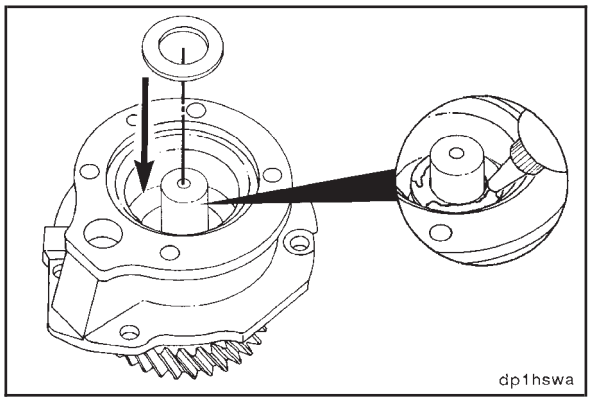
Assembly

Use clean 15W-40 oil to lubricate the housing shaft bore.



Use Lubriplate® 105 or its equivalent to lubricate the front thrust face on the housing.

Install the shaft and the gear.

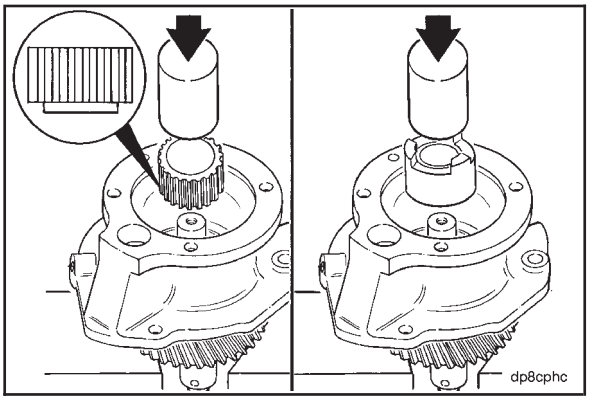


Use Lubriplate® 105 or its equivalent to lubricate the rear thrust face on the housing.

Install the clamping washer over the shaft.

With the gear/shaft assembly supported in an arbor press, use a mandrel to install the coupling. Push the coupling until it touches the clamping washer.

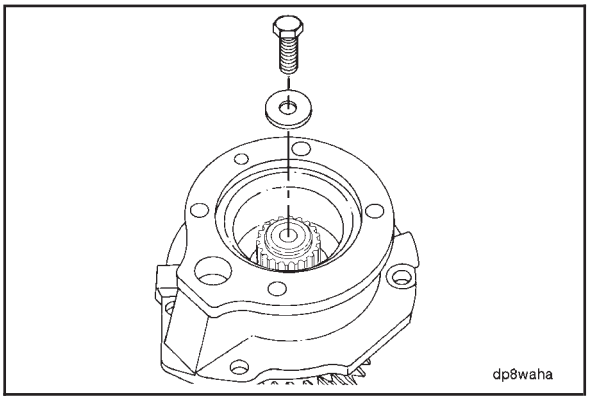
NOTE: The splined-type coupling **must** be installed with the relieved area facing the clamping washer. The hub-type coupling **must** be installed with the drive tangs facing away from the clamping washer.



Caution: The capscrew must contain an oil drilling if an air compressor is to be mounted on the engine.

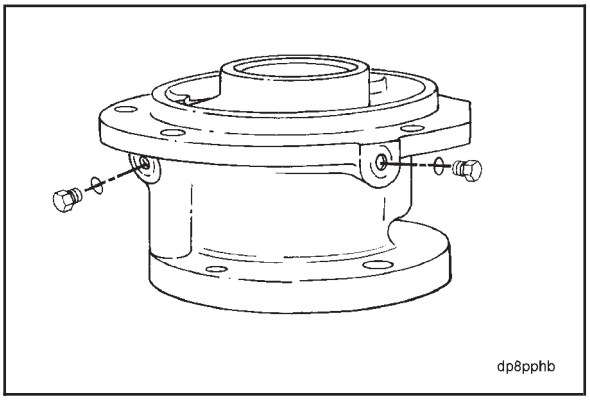
Install the washer and the capscrew.

Torque Value: 47 N•m [35 ft-lb]



Install the straight thread o-ring plugs in the housing.

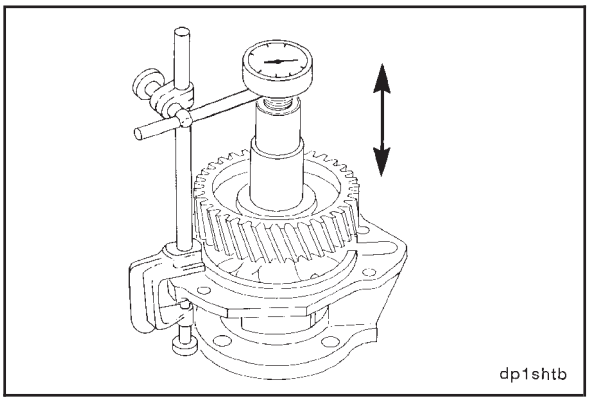
Torque Value: 5 N•m [47 in-lb]

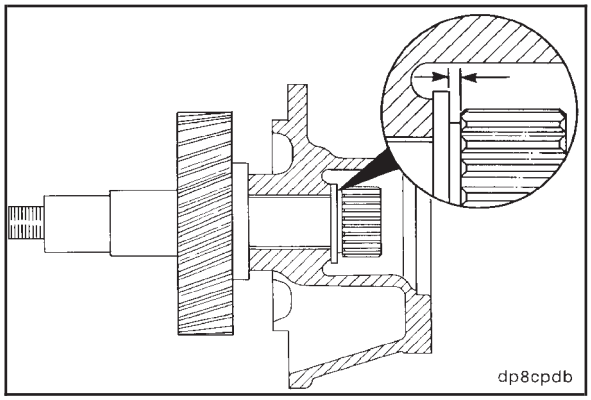


Rotate the shaft to check for correct assembly.

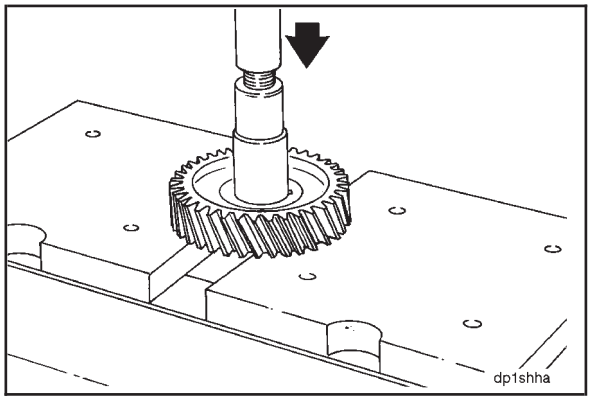
Measure the drive shaft end clearance at the end of the shaft for accurate measurement.

Drive Shaft End Clearance		
mm		in
0.10	MIN	0.004
0.225	MAX	0.009





If the end clearance is not within specifications, make sure the coupling is positioned tightly against the clamping washer.



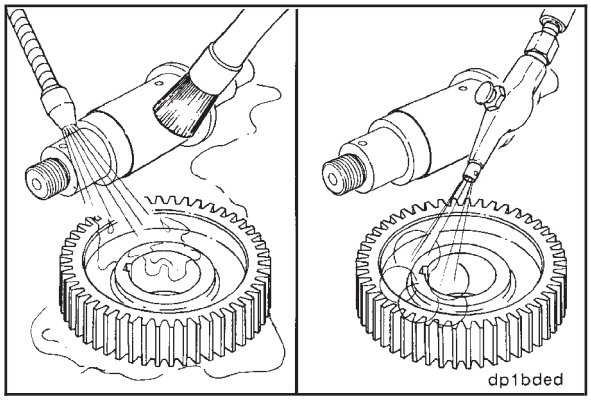
Accessory Drive Gear - Replacement (09-03)

Disassembly

Install the shaft and gear assembly in an arbor press with the part number side of the gear facing upwards.

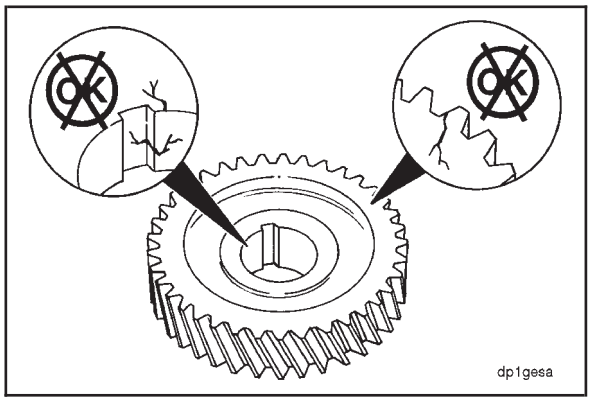
Caution: Do not let the shaft fall when removing it from the drive gear. Damage to the shaft or personal injury can occur.

Push the shaft from the gear.



Cleaning

Clean the parts with solvent. Dry with compressed air.



Inspection

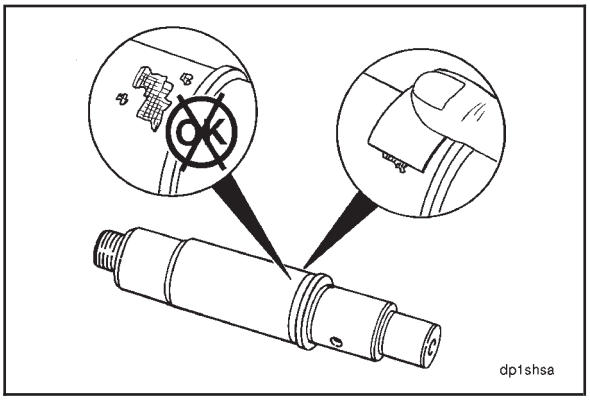
Visually inspect the gear for cracks, chipped, or broken teeth.

Inspect the bore of the gear for fretting or burrs.

NOTE: If the fretting, burrs, or raised material can **not** be removed with a fine crocus cloth, replace the gear.

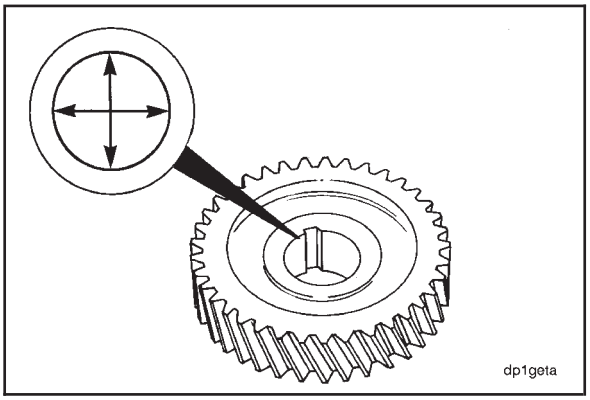
Visually inspect the shaft in the gear fit area for fretting or burrs.

NOTE: If fretting or burrs can **not** be removed with a fine crocus cloth, replace the shaft.



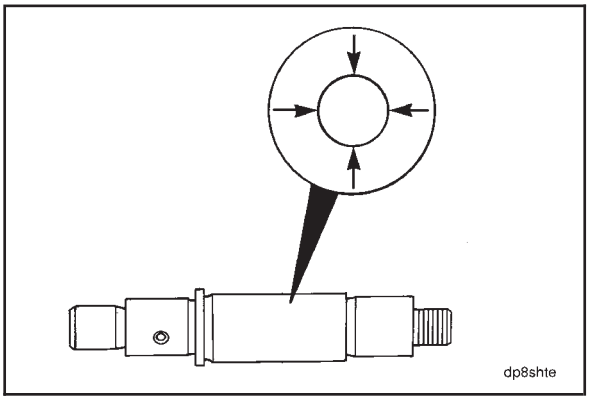
Measure the inside diameter of the drive gear.

Drive Gear Bore I.D.		
mm		in
39.730	MIN	1.5642
39.751	MAX	1.5650



Measure the drive shaft outside diameter at the gear fit location.

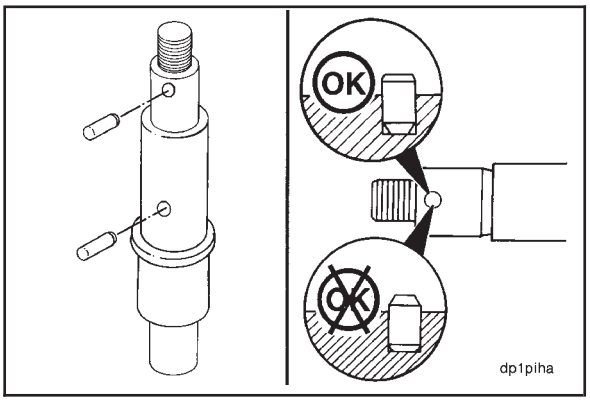
Drive Shaft Gear Fit Journal O.D.		
mm		in
39.789	MIN	1.5670
39.814	MAX	1.5675

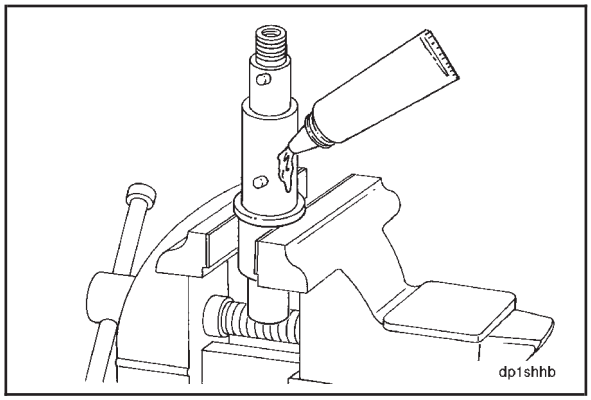


Assembly

Use a lead hammer to install the groove pin(s) in the shaft.

NOTE: If the groove pins have been removed, install the tapered end of the groove pin into the shaft. Incorrect installation will result in interference with the gear keyway or cause damage to the gear cover accessory drive bushing.

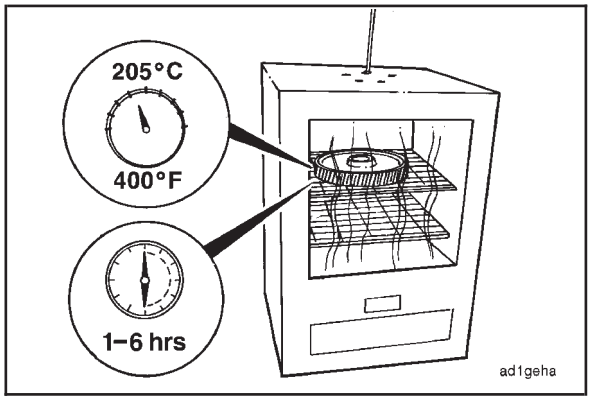




Caution: The jaws of the vise must have copper plates to prevent damage to the shaft.

Clamp the accessory drive shaft in a vise.

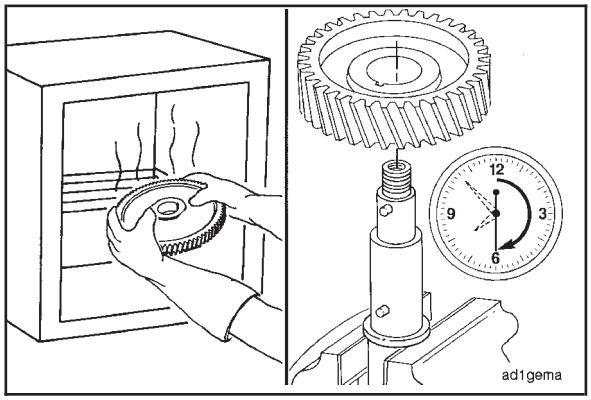
Apply Lubriplate® 105 or its equivalent to the gear fit area before installing the gear.



Place the accessory drive gear in an oven.

Caution: Do not exceed the temperature or time limits with the gear in the oven. The gear will be damaged.

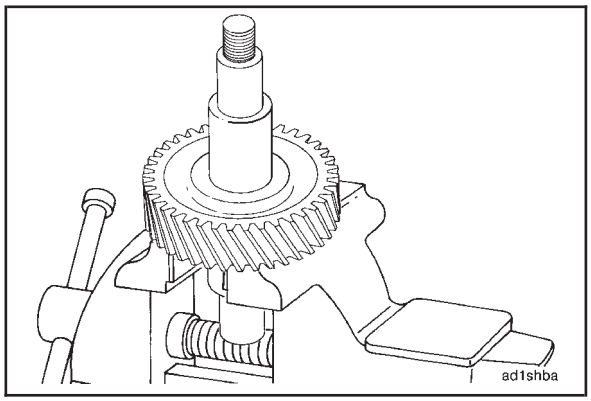
Heat the gear to 205° C [400° F] for a minimum of 1 hour but no longer than 6 hours.



Caution: Wear asbestos gloves when handling heated parts. Hot parts can cause serious personal injury.

Caution: The part number on the gear must be facing away from the flange on the accessory drive shaft when the gear is installed to prevent engine damage.

Remove the gear from the oven. Align the keyway in the gear with the groove pin in the accessory drive, and install the gear on the shaft within 30 seconds.

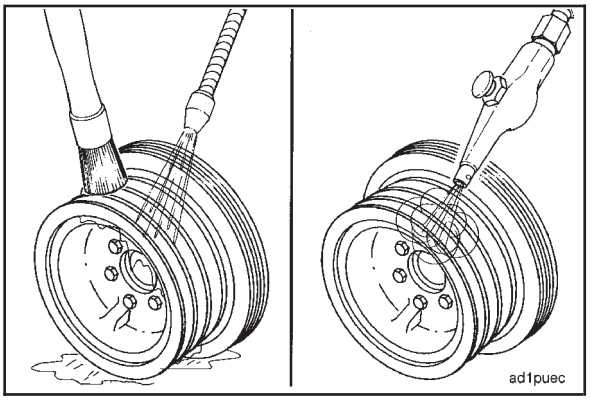


Caution: Keep the accessory drive shaft in a vertical position until the gear has cooled. Do not use water to reduce the cooling time; the gear will crack.

Accessory Drive Pulley - Cleaning and Inspection for Reuse (09-04)

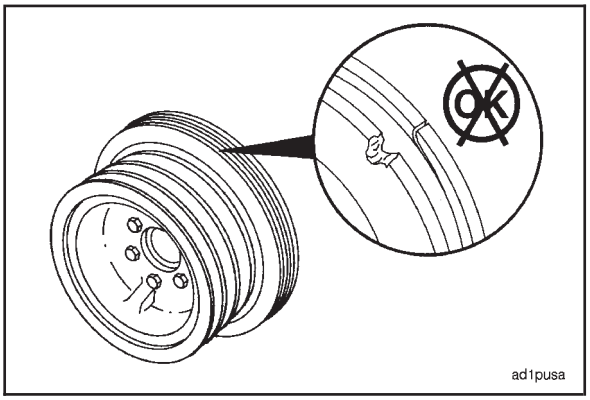
Cleaning

Clean the accessory drive pulley with solvent. Dry with compressed air.

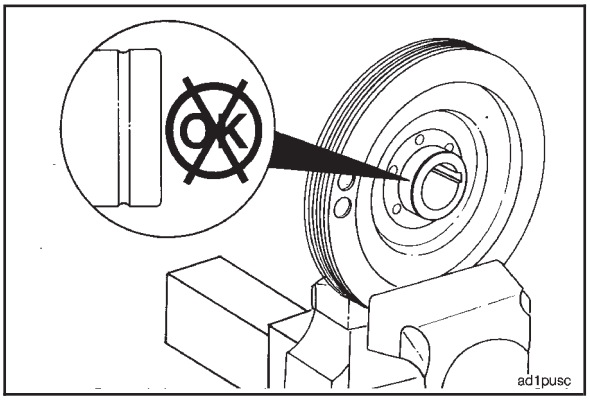


Inspection

Visually inspect the pulley for cracks, wear in the belt grooves, or other damage.



If the oil seal wear surface on the accessory drive pulley wear sleeve is mutilated or has a groove worn deep enough that it can be felt with a fingernail, the wear sleeve **must** be replaced. Refer to Accessory Drive Pulley Wear Sleeve - Replacement (09-05).

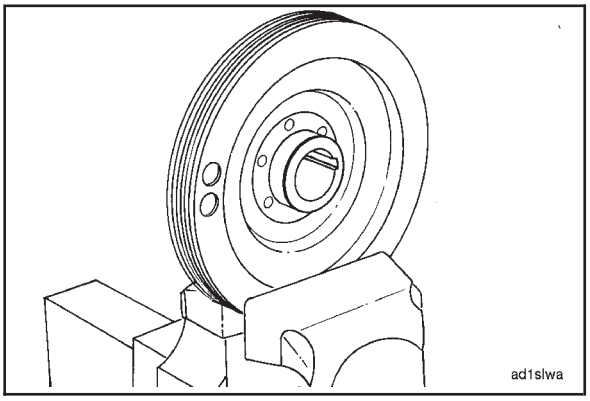


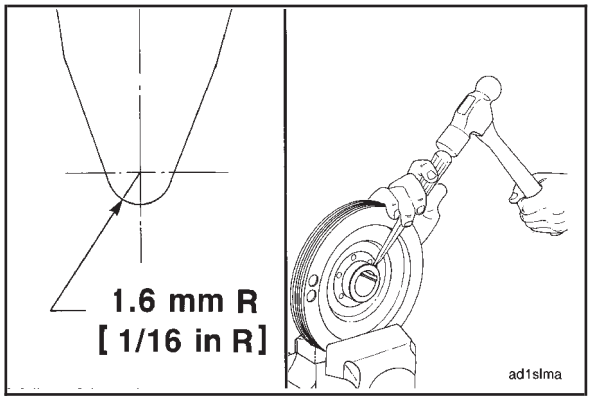
Accessory Drive Pulley Wear Sleeve - Replacement (09-05)

Removal

Caution: The jaws of the vise must have copper plates to prevent damage to the pulley.

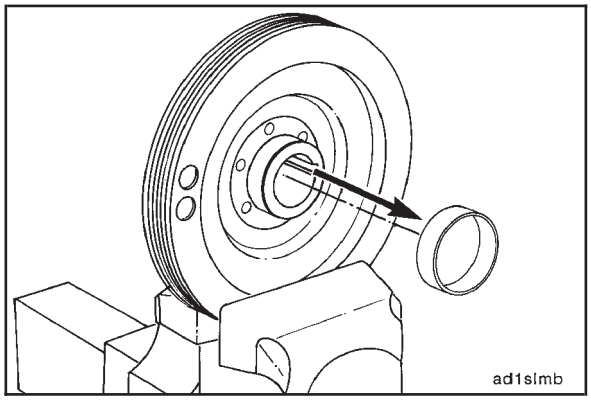
Clamp the accessory drive pulley in a vise.



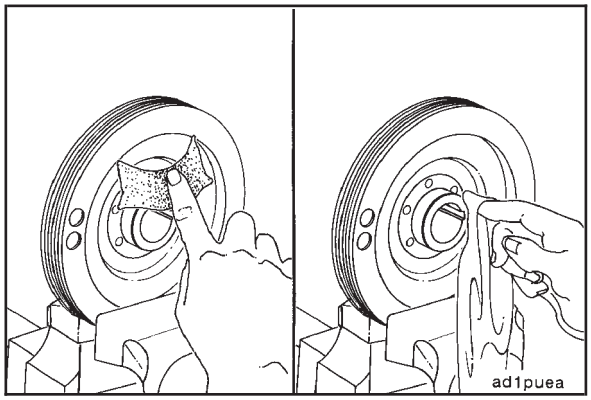


Grind a 1.57 mm [0.062-inch] radius on the cutting edge of a 19.05 mm [0.75-inch] chisel.

Place the chisel point against the wear sleeve. Use moderate blows with a hammer to strike the chisel at four points on the outside diameter of the wear sleeve to relieve the press fit.

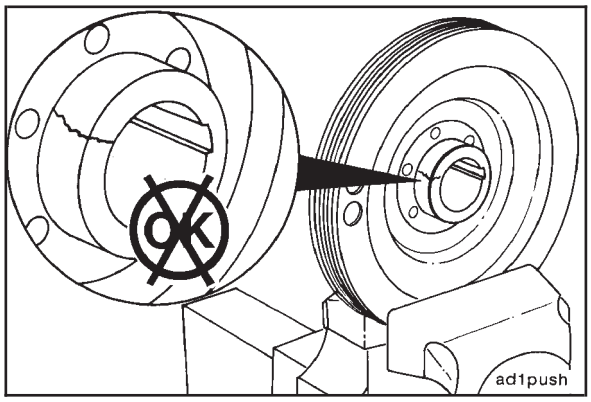


After the press fit has been relieved, remove the wear sleeve by hand.



Cleaning and Inspection

Use a crocus cloth to remove any deposits from the pulley wear sleeve mounting boss.

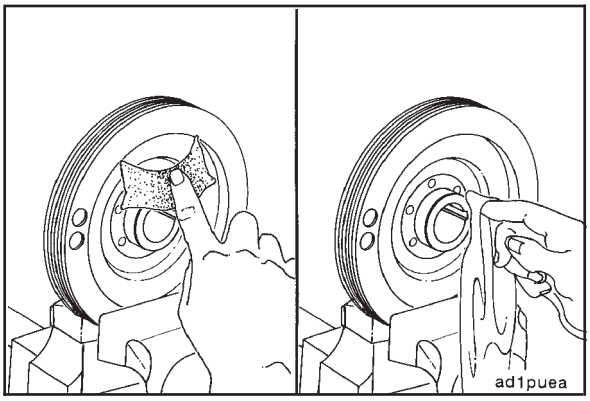


Inspect the pulley wear sleeve mounting boss for minor nicks, scratches, sharp edges, or other damage.

Use a fine grit emergy cloth dipped in clean lubricating oil to remove minor defects.

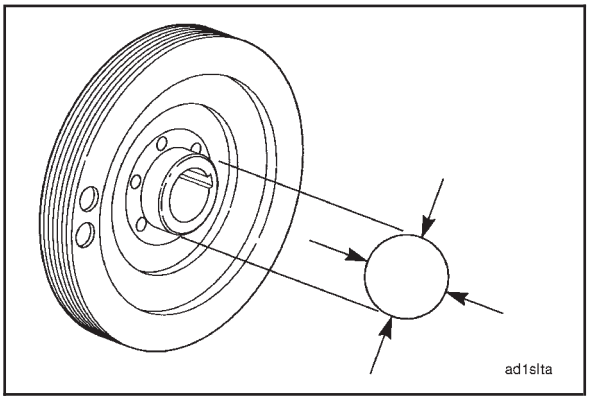
Use a crocus cloth for final polishing operation and to remove any remaining deposits on the pulley wear sleeve mounting boss.

Clean the wear sleeve mounting boss with a clean cloth.



Measure the pulley wear sleeve mounting boss outside diameter.

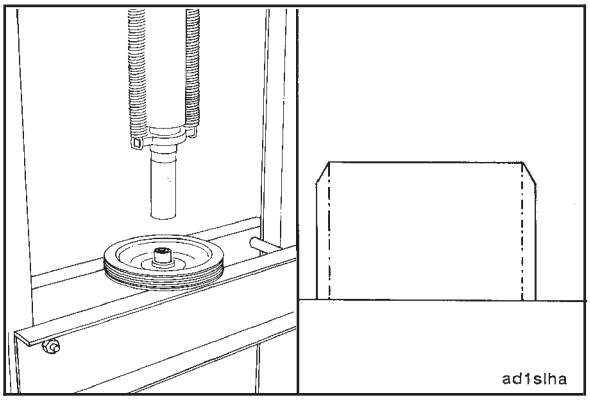
Wear Sleeve Fit Area O.D.		
mm		in
50.77	MIN	1.999
50.82	MAX	2.001



Installation

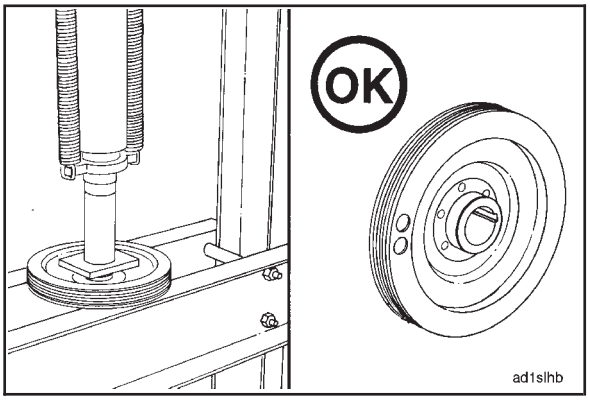
Support the accessory drive pulley in an arbor press.

Install the wear sleeve on the pulley seal wear surface with the chamfer on the outside diameter of the wear sleeve facing up (away from the pulley).



Place a flat steel plate on top of the wear sleeve. Press the sleeve on the pulley until the steel plate contacts the pulley.

Inspect the wear sleeve for damage or burrs.

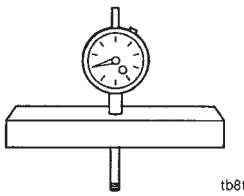


Section 10 - Intake Air System - Group 10

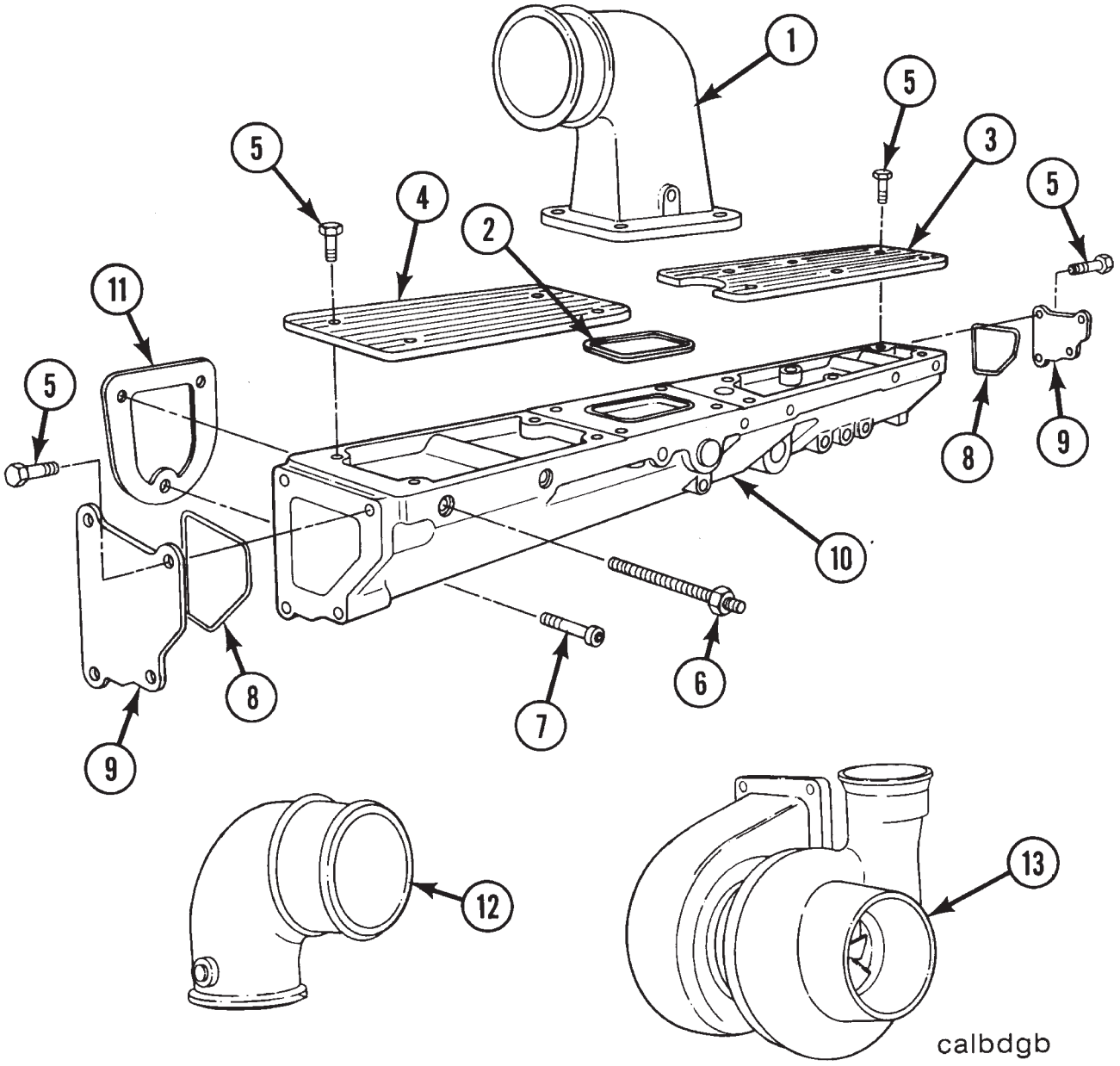
Section Contents

Intake Air System - Service Tools

The following special tools are recommended to perform procedures in section 10. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

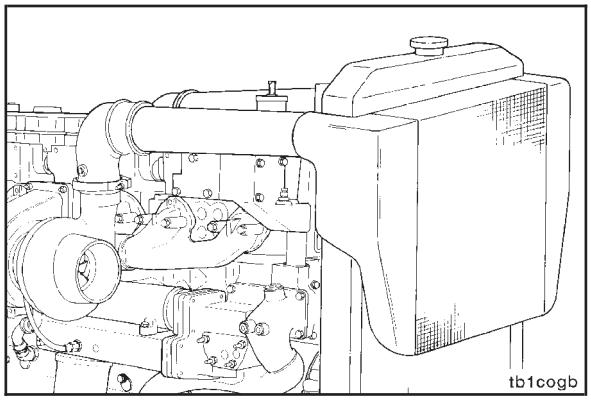
Tool No.	Tool Description	Tool Illustration
ST-537	**Dial Depth Gauge** Measure turbocharger axial motion.	 tb8togf

Intake Air System - Exploded View



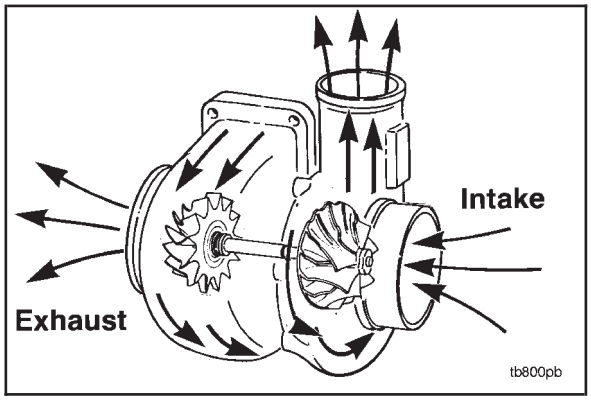
Ref. No.	Description	Qty.
1	Connection, Intake Manifold	1
2	Seal, Rectangular Ring	1
3	Cover	1
4	Cover	1
5	Screw, Self-Tapping	18
6	Capscrew	6
7	Capscrew	3

Ref. No.	Description	Qty.
8	Seal, O-ring	2
9	Plate	2
10	Manifold, Intake	1
11	Gasket, Intake Manifold	3
12	Elbow	1
13	Turbocharger	1



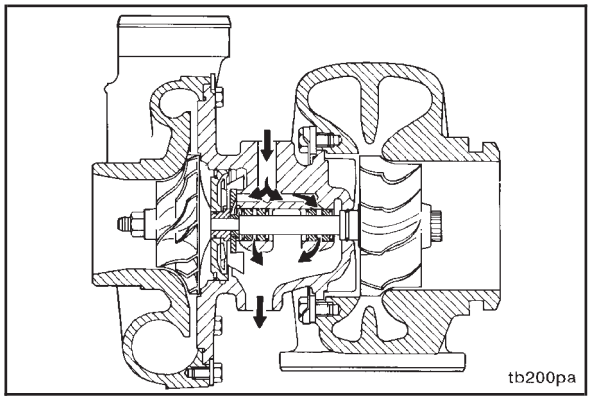
Intake Air System - General Information

The intake air system consists of intake air piping, turbocharger, charge air cooler (CAC) piping, and CAC.



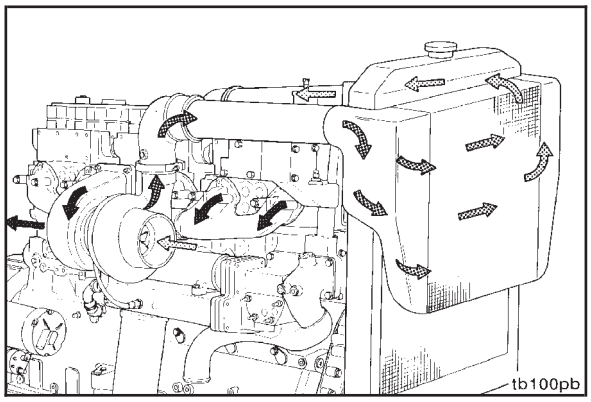
The turbocharger uses exhaust gas energy to turn the turbine wheel. The turbine wheel drives the compressor impeller which provides pressurized air to the engine for combustion. The additional air provided by the turbocharger allows more fuel to be injected to increase the power output from the engine.

NOTE: The correct turbocharger **must** be used. Providing too much additional air will increase the cylinder pressures and shorten the life of the engine.



The turbine and compressor wheels and the shaft are supported by two rotating bearings in the bearing housing. Passages in the bearing housing direct filtered, pressurized engine oil to the shaft bearings and thrust bearings. The oil is used to lubricate and cool the rotating components to provide for smooth operation. The oil then drains from the bearing housing to the engine sump through the oil drain line.

NOTE: An adequate supply of good, filtered oil is very important to the life of the turbocharger.



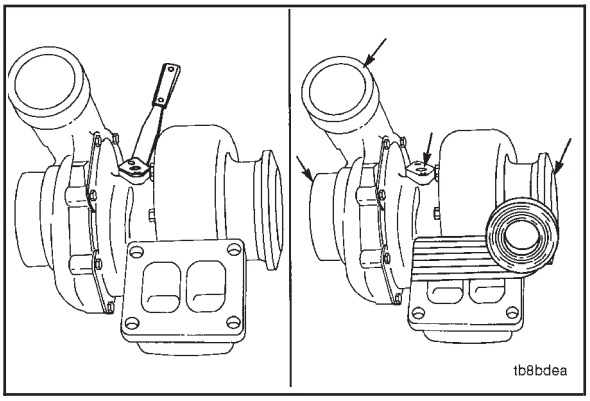
As the intake air is compressed by the turbocharger, the air is heated. This heated air is then passed through the charge air cooler which cools the air. Because cool air is more dense than warm air, more air can be compressed into the cylinder, yielding a much greater combustion efficiency.

Turbocharger - Cleaning and Inspection (10-01)

Cleaning

Remove all carbon deposits and gasket material from the gasket mating surfaces.

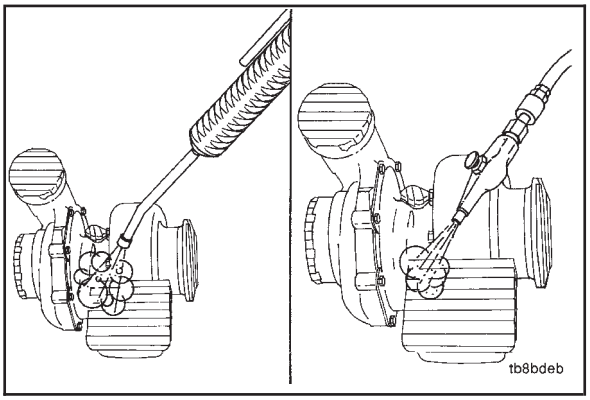
NOTE: Tape or plug all openings to prevent solvent or steam from entering the oil cavities in the turbocharger.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use solvent or steam to clean the exterior of the turbocharger. Dry with compressed air.

Remove the tape and the plugs.



Inspection

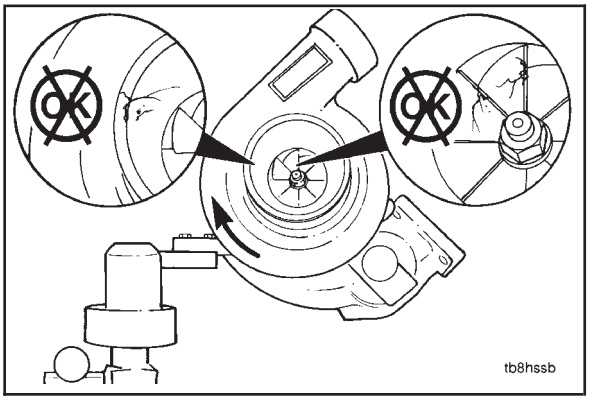
Visually inspect the turbocharger housing for damage. Replace if through cracks are found.

Visually inspect the turbine wheel and the compressor impeller for fretting, cracked, or broken vanes. Replace damaged parts.

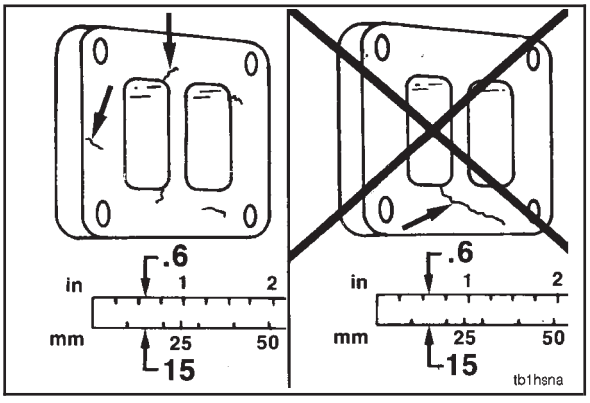
Turn the compressor impeller in the direction shown to inspect the turbine shaft for freedom of rotation

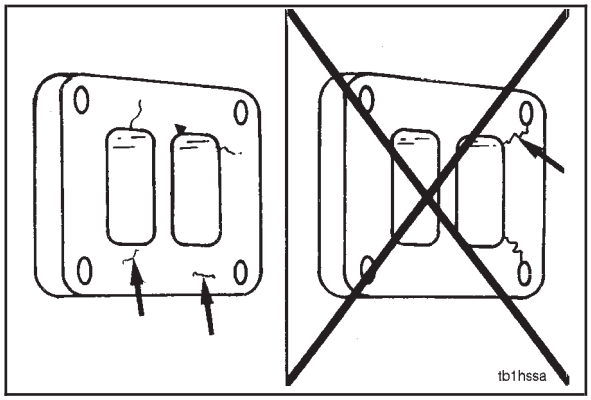
NOTE: The shaft **must** rotate freely. Replace damaged parts.

Refer to BHT3C Turbocharger Shop Manual, Bulletin No. 3810230.

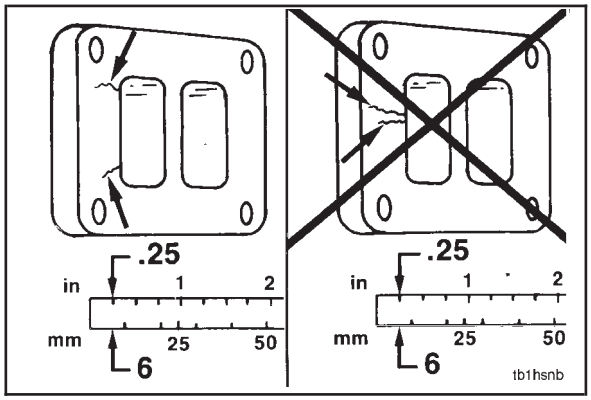


Cracks on the turbocharger mounting flange longer than 15 mm [0.6-inch] are **not** acceptable.

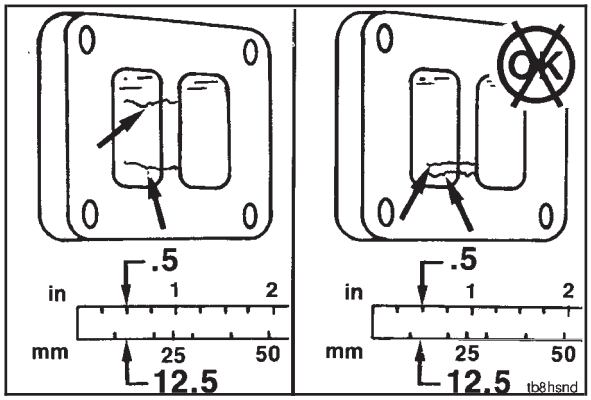




Cracks on the turbocharger mounting flange **must not** reach the mounting holes.



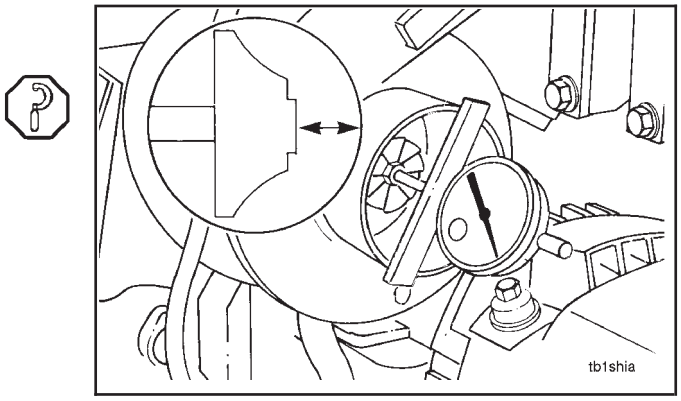
Two cracks on the turbocharger mounting flange **must** be separated by 6.4 mm [0.25-inch].



Through cracks at the dividing wall are acceptable and can be any length.

They **must** be separated by at least 12.5 mm [0.5-inch].

Turbocharger Shaft Axial Clearance - Checking (10-02)



Measure the axial clearance (end to end), using dial depth gauge, Part No. ST-537.

Push the rotor assembly away from the gauge.

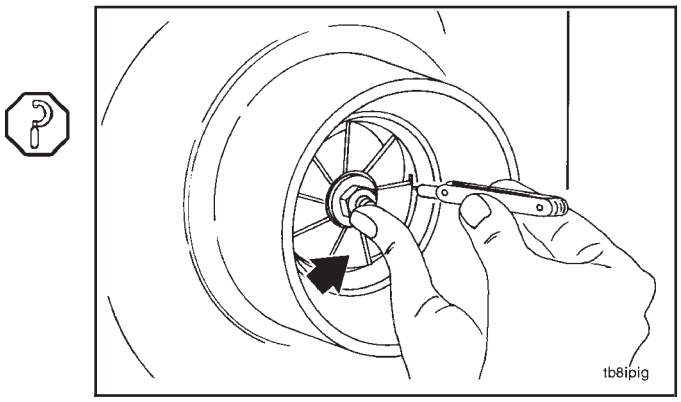
Set the gauge on zero (0).

Push the rotor assembly toward the gauge and record the clearance.

Axial Clearance			
Model No.	**mm**		**in**
BHT3C	0.03	MIN	0.001
	0.10	MAX	0.004

Replace the turbocharger if the axial clearance does **not** meet the specifications.

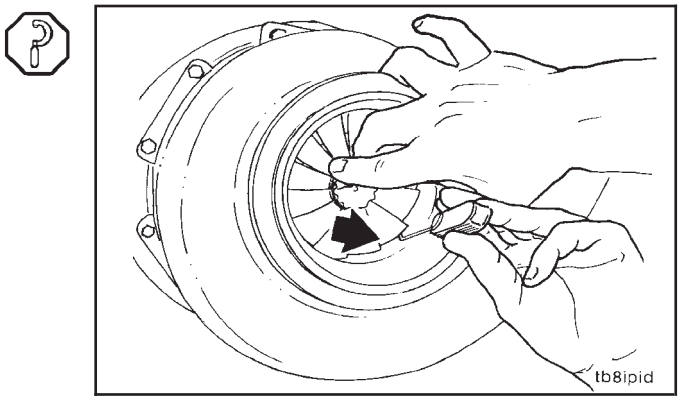
Turbocharger Bearing Radial Clearance - Checking (10-03)



Measure the compressor impeller radial clearance.

NOTE: Hold the impeller toward the housing. Install a wire feeler gauge or a flat feeler gauge with a maximum width of 1/4-inch at the minimum clearance point between the impeller and the housing.

Compressor Impeller Radial Clearance			
Model No.	**mm**		**in**
BHT3C	0.15	MIN	0.006
	0.457	MAX	0.018

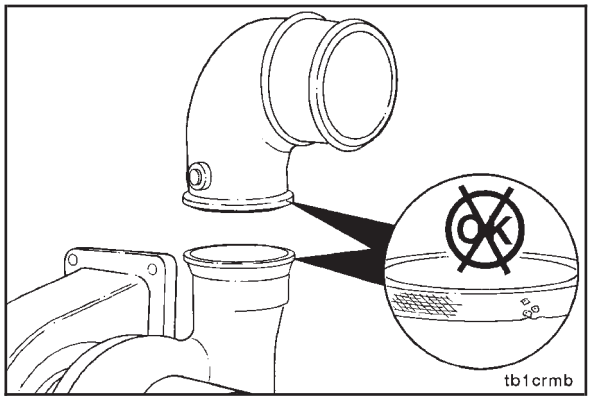


Measure the turbine wheel radial clearance.

NOTE: Hold the turbine wheel toward the housing. Install a wire feeler gauge at the minimum clearance point between the wheel and the housing.

Turbine Wheel Radial Clearance			
Model No.	**mm**		**in**
BHT3C	0.20	MIN	0.008
	0.533	MAX	0.021

NOTE: If the compressor impeller or the turbine wheel to housing radial clearance does **not** meet the specifications listed, the turbocharger **must** be rebuilt. Refer to the Component Shop Manuals, Bulletin Nos. 3810230 or 3810241, for Holset turbochargers.

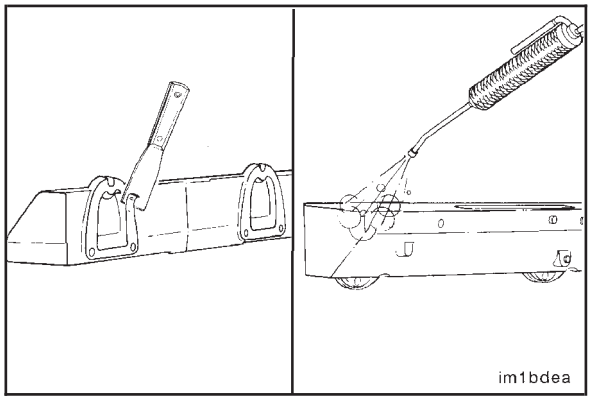


Intake Air Piping - Elbows (10-04)

Inspection

Visually inspect the turbocharger compressor V-band outlet and the discharge elbow V-band connection for dents or fretting.

Replace the turbocharger compressor housing or discharge elbow if damaged so that the compressed air will **not** leak.



Intake Manifold - Cleaning and Inspection (10-05)

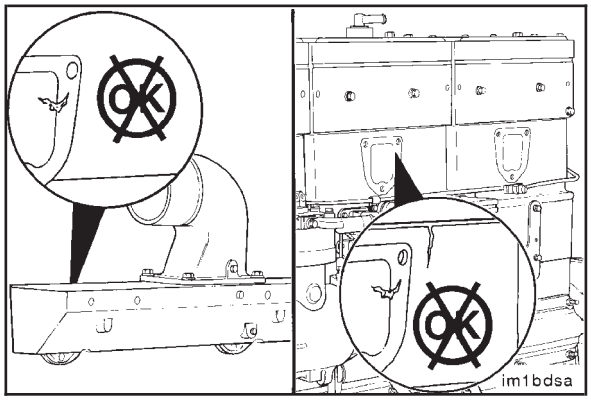
Cleaning

Remove all gasket material from the gasket mating surfaces.

Use solvent or steam to clean the intake manifold.

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Dry with compressed air.



Inspection

Visually inspect the intake manifold for cracks, fretting, or other damage.

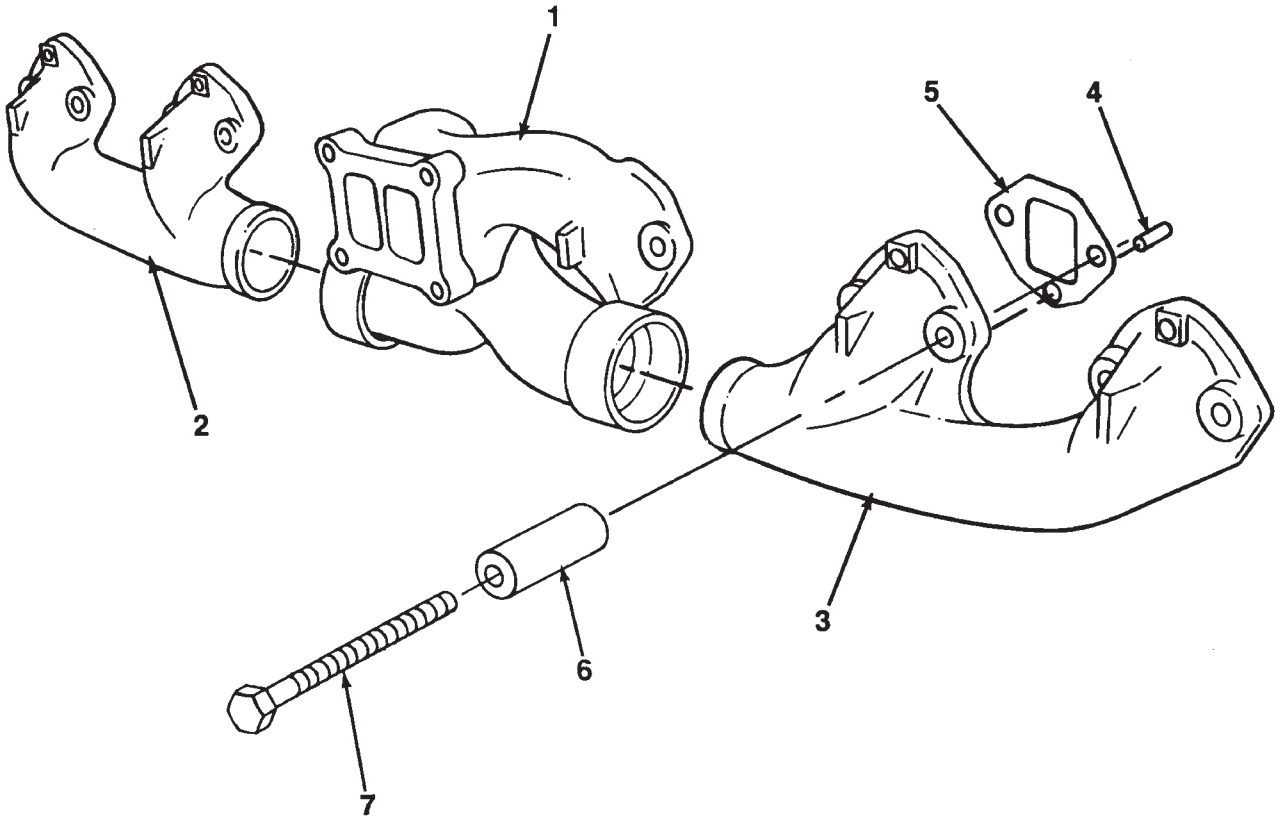
Clean and visually inspect mating surfaces on the cylinder head for cracks and fretting.

Replace the manifold if cracks or other damage are found.

Section 11 - Exhaust System - Group 11

Section Contents

Exhaust System - Exploded View



xm1bdgb

Reference No.	Description	Quantity
1	Manifold, Exhaust (Center)	1
2	Manifold, Exhaust (End)	1
3	Manifold, Exhaust (End)	1
4	Pin, Groove	6
5	Gasket, Exhaust Manifold	6
6	Spacer	12
7	Capscrew	12

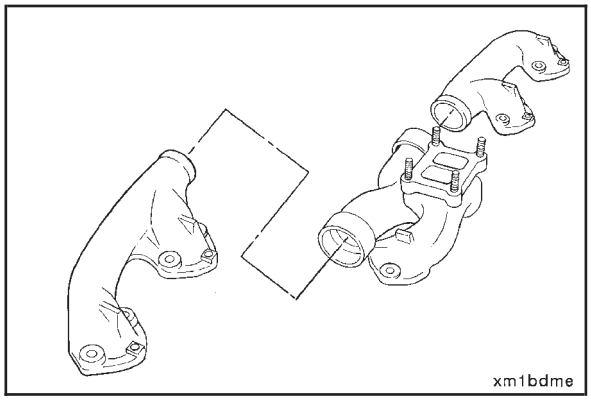
Exhaust System - General Information

The exhaust manifold group consists of the exhaust manifolds and the turbocharger mounting studs.

The exhaust manifold utilizes a wear coating on the sealing surfaces of the manifold sections for improved sealing characteristics and greater reliability.

As a running change on the 88NT model engines, the N14 will also incorporate the towerless capscrew mounting boss design exhaust manifolds. The capscrew mounting boss ‘‘towers’’ have been removed from the manifold castings and replaced with spacers. The spacers insulate the capscrews from the extreme hot temperatures which results in more consistent and better controlled clamp loads at the manifold-to-cylinder head interface.

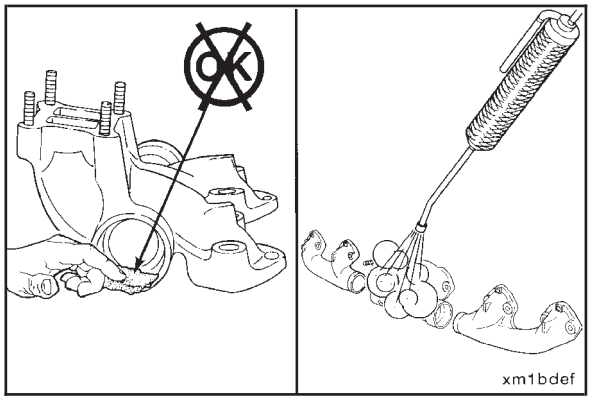
Caution: Special high temperature resistant exhaust manifold mounting capscrews are required to mount the exhaust manifold. Use only the special capscrews, Part No. 3067930, to fasten the exhaust manifold assembly to the cylinder head.



Exhaust Manifold - Cleaning and Inspection for Reuse (11-01)

Disassembly

Use a mallet to remove the exhaust manifold sections.



Cleaning

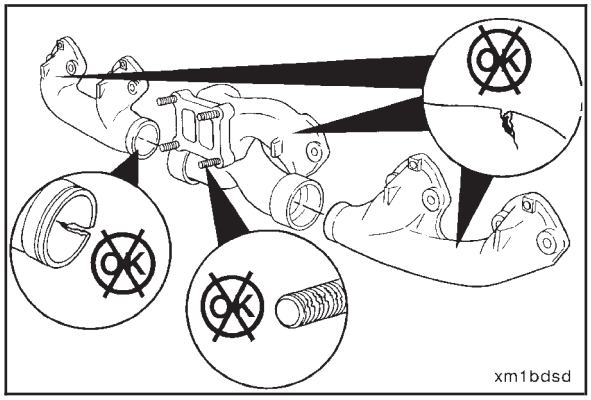
Use a wire brush to remove carbon from the gasket sealing surfaces.

Use penetrating oil and wipe the wear coated slip joints clean of carbon.

NOTE: Do **not** use abrasive materials to clean the wear coated slip joints on the manifold sections. Abrasives will damage the wear coating.

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Use steam to clean the manifold sections. Dry with compressed air.



Inspection

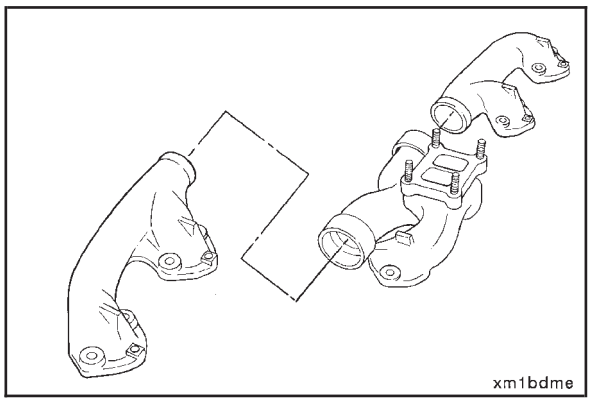
Visually inspect the manifold sections for cracks or damage.

Visually inspect the sealing connection surfaces for damage.

Visually inspect the center section for damaged turbocharger mounting stud threads.

Replace damaged parts. Refer to Exhaust Manifold Turbocharger Mounting Stud - Replacement (11-02).

Check spacers and mounting flange for fretting, etc.



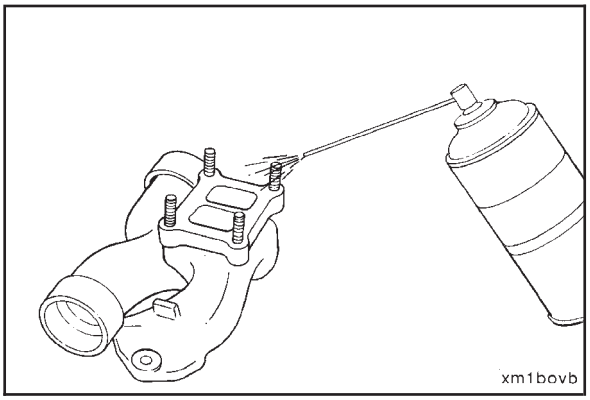
Assembly

NOTE: The exhaust manifold sections **must** be assembled on a flat surface for proper alignment.

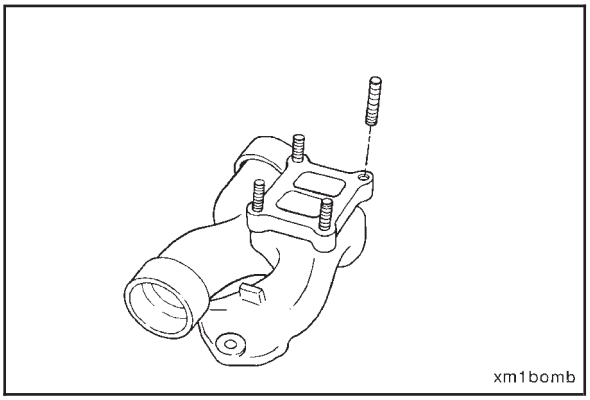
Install the exhaust manifold end sections to the center section.

Exhaust Manifold Turbocharger Mounting Stud - Replacement (11-02)

Apply penetrating oil to the base of the turbocharger mounting stud to be removed.



Use a standard stud extractor to remove the turbocharger mounting stud(s) from the center section.

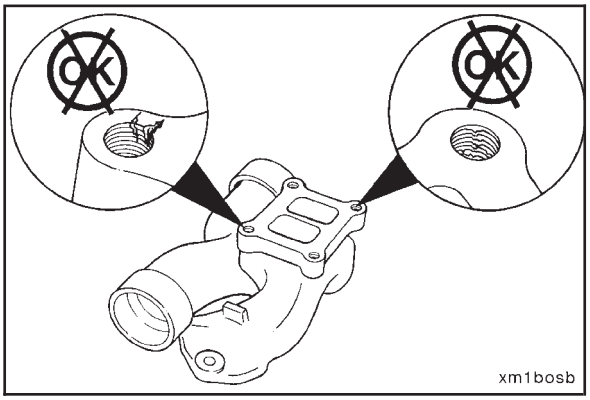


Mounting Hole Threads - Inspection

Visually inspect for damaged threads in the turbocharger mounting stud holes.

If threads are damaged (cross-threaded, etc.), chase the threads with a 3/8-16 N.C.-38 tap.

Visually inspect the manifold sections for cracks or damage.



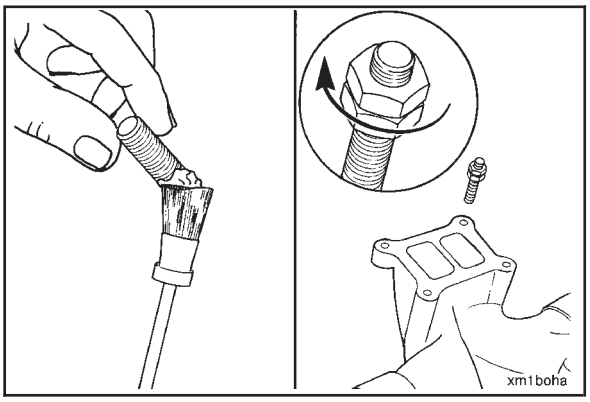
NOTE: Install the shorter threaded end of the turbocharger mounting stud in the exhaust manifold flange.

Apply a coat of anti-seize compound to the threads.

Install the studs in the mounting flange.

Use two mounting nuts locked together to tighten the studs.

Torque Value: 40 N•m [30 ft-lb]



Section 12 - Air Equipment - Group 12

Section Contents

Air Equipment - General Information

Air Compressor

The air equipment group consists of Cummins single and two-cylinder air compressors, compressor check valves, and air and coolant piping. It also includes air activated cranking motors.

The air compressor is lubricated by engine lubricating oil which enters the compressor through a drilling in the support. The oil lubricates the connecting rod bearings and the crankshaft. The oil then flows to the air compressor crankcase and returns to the engine through a drain passage located in the support.

The air compressor is cooled by the engine coolant. Only the cylinder head is cooled on the single cylinder air compressor. Both the cylinder head and cylinders are cooled on the two-cylinder air compressor.

Service information, specifications, and repair of Cummins air compressors are contained in the following publications:

- Single cylinder air compressor - Air Equipment Rebuild Manual, Bulletin No. 3810242
- Two-cylinder air compressor - Air Equipment Rebuild Manual, Bulletin No. 3810257

Instructions for testing and repairing air cranking motors and air compressors **not** manufactured by Cummins can be obtained from the original equipment manufacturers.

The following list contains the addresses of suppliers of air equipment for use on Cummins engines:

U.S.A.

Bendix H.V.S.G.
901 Cleveland St.
Elyria, OH 44036
Attention: Technical Services Dept.

Engine Starting Systems
Allen and Martinsville Rd.
P.O. Box 1776
Liberty Corner, NJ 07938

Midland Brake, Inc.
490 South Chestnut St.
Owosso, MI 48867

Canada

Bendix H.V.S.G.
P.O. Box 5712
1005 Wilton Grove Rd.
London Ontario, Canada N6A4S8
Attention: Technical Services Dept.

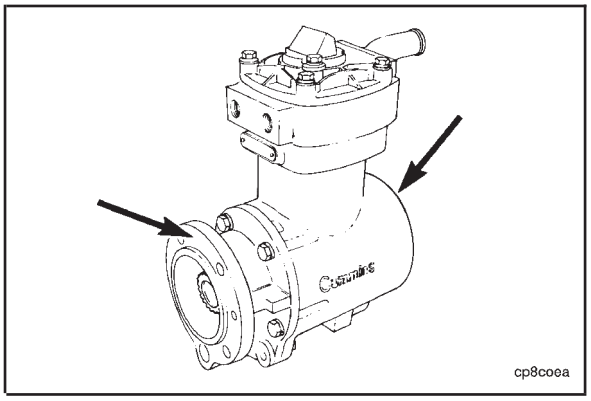
International

Bendix H.V.S.G. Europe Ltd.
66 Grosvenor St.
London, England W1X90B
Attention: Technical Services Dept.

Air Compressor - Cleaning and Inspection for Reuse (12-01)

Cleaning

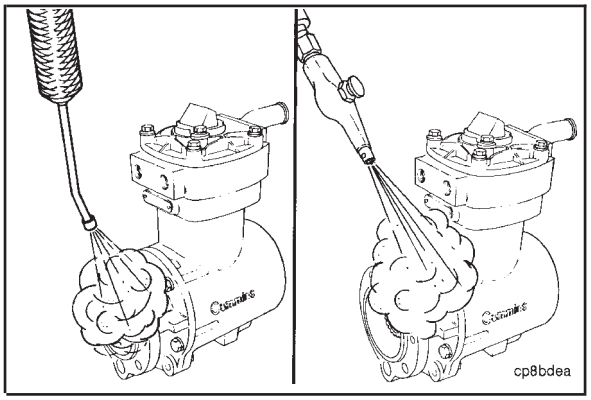
Remove all gasket material from the sealing surfaces.



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Caution: Seal all openings with tape to prevent future damage from solvent or steam entering the oil passages in the air compressor.

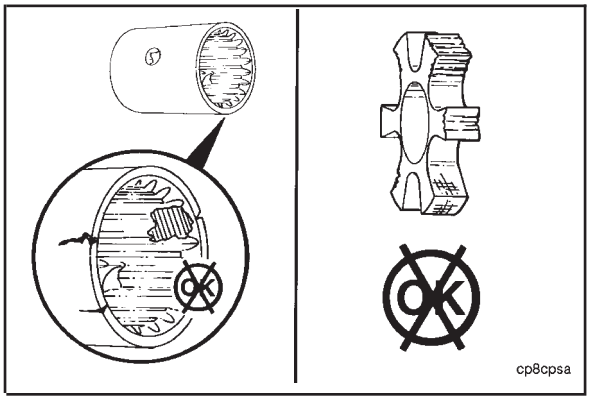
Use solvent or steam to clean the air compressor. Dry with compressed air.



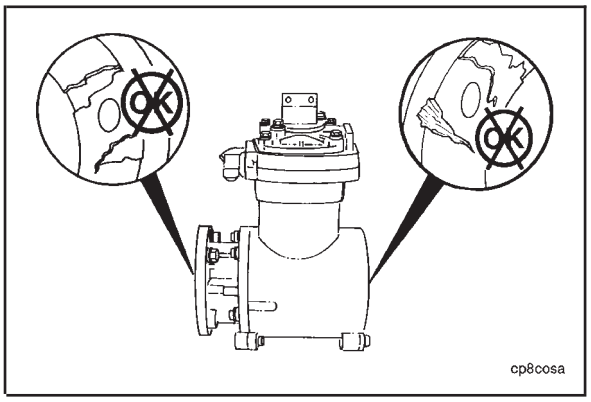
Inspection

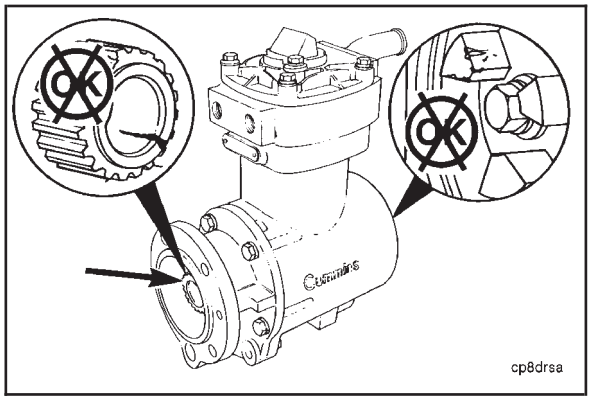
Visually inspect the compressor drive splined coupling for cracks or broken splines.

Visually inspect the fuel pump drive hub or spider coupling for wear or damage.

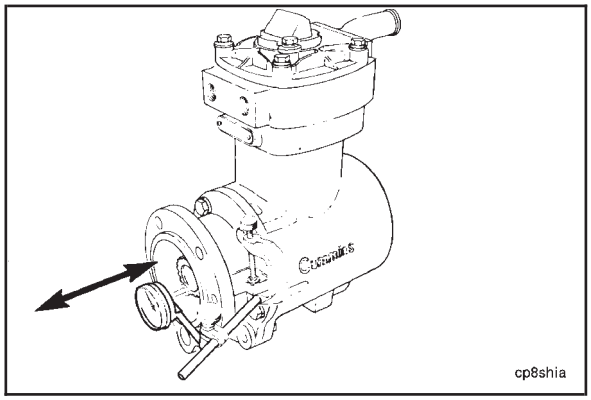


Visually inspect the compressor housing for cracks or damage.



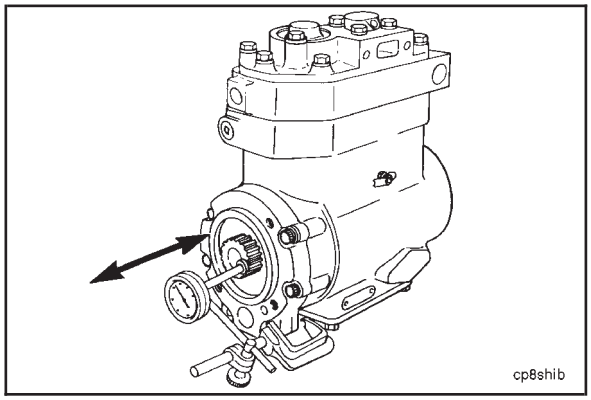


Visually inspect the compressor drive gear and the fuel pump hub-type drive coupling for wear or damage.



Measure the single cylinder air compressor crankshaft end clearance.

Crankshaft End Clearance		
mm		**in.**
0.06	MIN	0.002
0.69	MAX	0.027



Measure the two-cylinder air compressor crankshaft end clearance.

Crankshaft End Clearance		
mm		**in.**
0.05	MIN	0.002
0.28	MAX	0.011

NOTE: If cracked or damaged parts are found or the end clearance exceeds the limits specified, the air compressor **must** be rebuilt or replaced. Refer to Air Equipment Rebuild Manual, Bulletin No. 3810242, for single cylinder, or Bulletin No. 3810257, for two-cylinder air compressor rebuild instructions.

Section 13 - Electrical Equipment - Group 13

Section Contents

Electrical Equipment - General Information

The electrical equipment used on the N14 engine is **not** manufactured by Cummins Engine Company, Inc.Complete instructions for adjusting, testing, and repairing the electrical equipment **can** be obtained from the equipment manufacturer. The following list contains the suppliers of the electrical equipment used on Cummins engines:

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 0895-833633

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
U.S.A.
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st St.
Cleveland, OH 44013
U.S.A.
Telephone: (216) 431-0740

Air Starting Motors*

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand
Engine Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
U.S.A.
Telephone: (312) 530-3800

Start Master
Air Starting Systems
A Division of Sycon Corporation
P.O. Box 491
Marion, OH 43302
U.S.A.
Telephone: (614) 382-5771

Electric Starting Motors

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

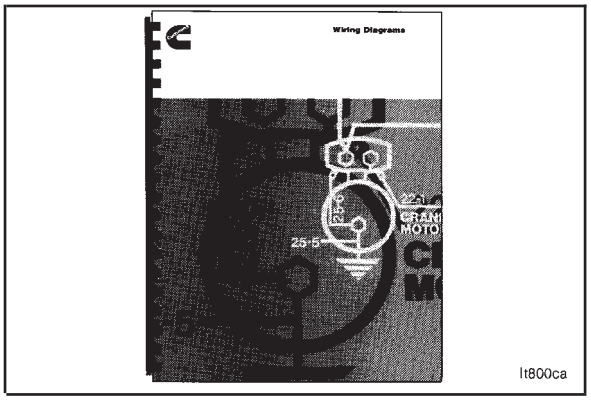
Delco-Remy
P.O. Box 2439
Anderson, IN 46018
U.S.A.
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st Street
Cleveland, OH 44013
U.S.A.
Telephone: (216) 431-0740

* Non-Electrical Equipment Suppliers

Wiring Diagrams

A complete collection of electrical wiring diagrams, as applied to all Cummins engines, is contained in Wiring Diagrams, Bulletin No. 3379099.



Alternator Bracket - Cleaning and Inspection for Reuse (13-01)

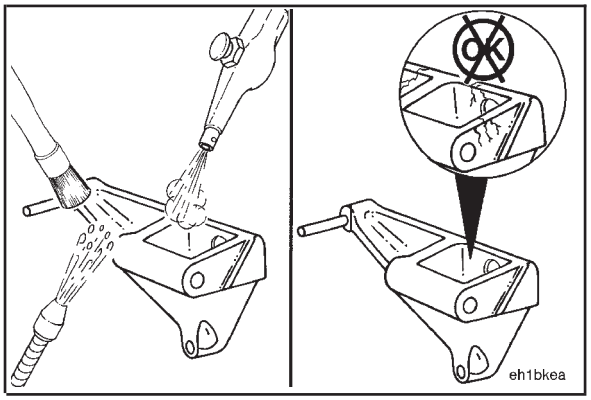
Cleaning

Use solvent to clean the bracket. Dry with compressed air.

Inspection

Visually inspect the bracket for cracks and other damage. Discard damaged parts.

NOTE: The cylinder block mounting surface **must** be clean and free of paint to provide a proper electrical ground for the alternator.



Alternator Adjusting Link - Cleaning and Inspection for Reuse (13-02)

Cleaning

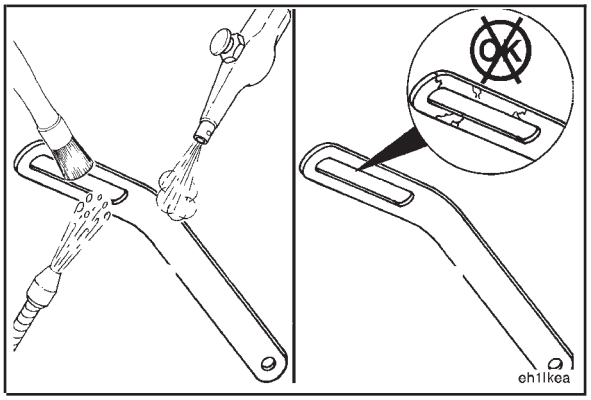
Use solvent to clean the adjusting link. Dry with compressed air.

Inspection

NOTE: Some parts can vary in design.

Visually inspect the adjusting link for cracks or damage.

Discard damaged parts.

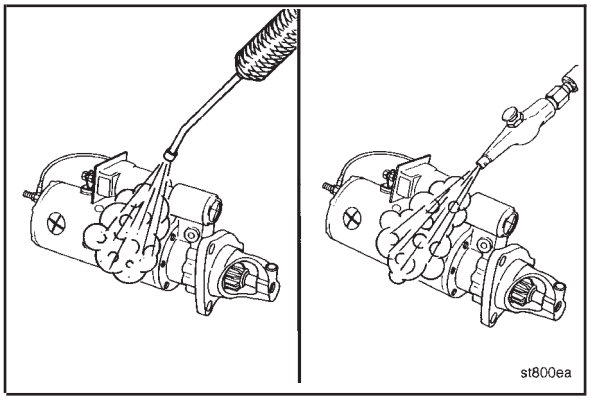


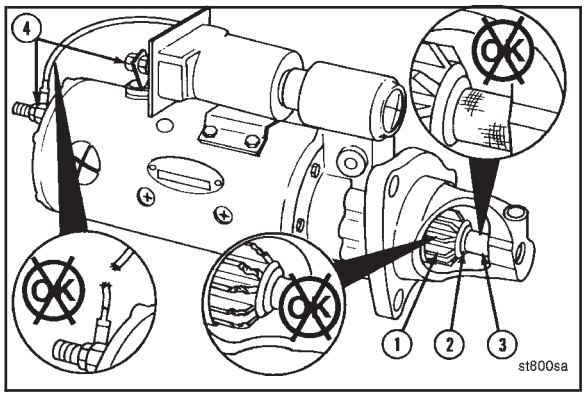
Starting Motor - Cleaning and Inspection for Reuse (13-03)

Cleaning

Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam can cause serious personal injury.

Use steam to clean the starting motor. Dry with compressed air.





Inspection

Visually inspect the gear (1) for cracked or broken teeth.

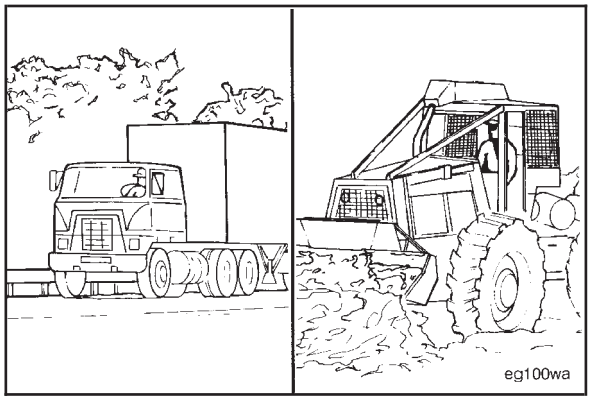
Visually inspect the drive bushing (2) and the gear shaft (3) for excessive wear or damage.

Visually inspect the terminal posts (4) for loose or broken connections.

NOTE: If the starting motor parts are damaged or the posts are loose or damaged, the starting motor **must** be repaired or rebuilt. Refer to the electrical equipment manufacturer's specifications to rebuild the starting motor.

Section 14 - Engine Testing - Group 14

Section Contents



General Information

This section outlines engine testing and engine run-in recommendations for N14 engines. All engines **must** be run-in after a rebuild or a repair involving the replacement of one or more piston ring sets, cylinder liners or cylinder kits.

Incorrect or insufficient break-in of the piston rings will lead to early oil consumption or high blowby complaints. Adherence to these run-in guidelines will allow the full durability of new rings to be realized.

Before running the engine, make sure the engine is filled with the proper coolant. Also, be sure the lubricating oil system is filled and primed.

In-Chassis Run-In

The majority of heavy duty diesel applications will provide sufficient run-in under normal **loaded** operations. However, light load/high rpm operation **must** be avoided during the run-in period. The following in-chassis run-in guidelines are recommended for N14 engines after a repair involving replacement of one or more of the piston ring sets, cylinder liners or cylinder kits where engine or chassis dynamometer or load bank run-in can **not** be performed.

SRT 14-704, Engine - Run-In and Test (In-chassis) provides time for in-chassis run-in when there is no other way to perform the run-in (chassis dynamometer, load bank or portable dynamometer) and the engine will be applied in high speed/low load operation immediately after engine is returned to service.

Engine Dynamometer Run-In

This is the preferred method of run-in for engines that have been rebuilt **Out-Of-Chassis.** It is **not** practical, nor recommended that an engine be removed from the application to conduct the run-in after a rebuild or cylinder repair has been performed in-chassis. SRT 14-701, Engine - Run-In and Test (Engine Dynamometer) provides the time for this work. There is no requirement, nor is it recommended for an engine that has been run-in and tested on an engine dynamometer to be run-in again after it has been reinstalled in the vehicle or equipment.

Chassis Dynamometer, Portable Dynamometer or Load Bank Run-In

When it is **not** possible to load an engine immediately after rebuild or repair, (example: on-highway tractor that **must** be ''bobtailed'' for delivery, a stand-by generator or fire pump that can **not** be operated because of customer restrictions, a fire truck that can **not** be loaded with the water pump, etc.), the engine **must** be run-in on a chassis dynamometer, portable dynamometer or load bank following the recommendations outlined in the attached procedures. SRT 14-702, Engine - Run-In and Test (Chassis Dynamometer), or SRT 14-703, Engine - Run-In and Test (Load Bank or Portable Dynamometer), provide time for this work.

Definition of Terms On Engine Performance Curve

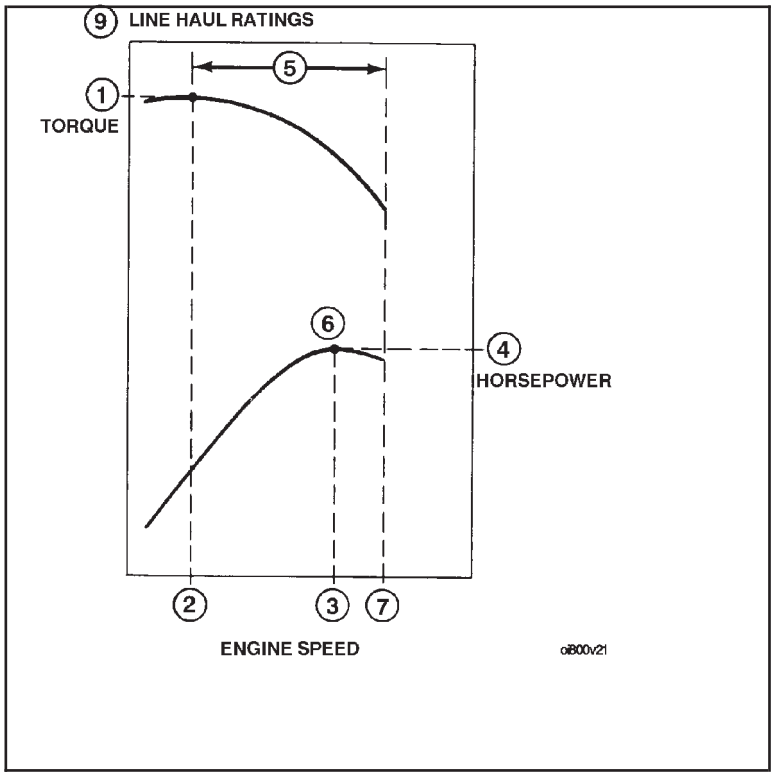


Fig. 1

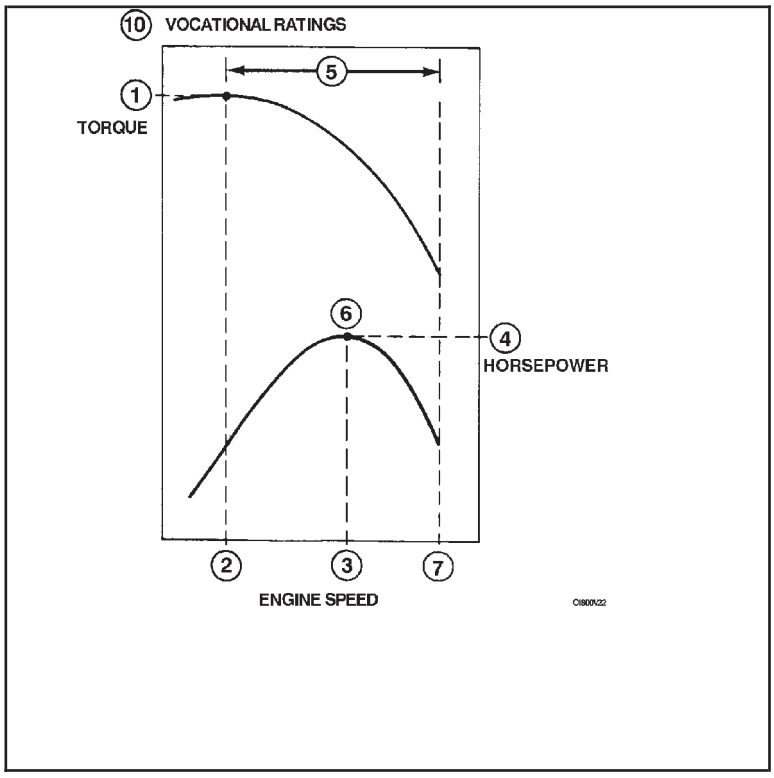


Fig. 2

Cummins 1991 N14 Heavy Duty Engine Operating Curve Definitions:

1. **Peak Torque (N•m [ft-lb])** - Maximum torque that the engine will produce. Also, sometimes referred to as COMMAND TORQUE. This is listed on the engine data plate.

2. **Peak Torque RPM (RPM)** - Engine speed at which peak torque is generated. This is listed on the engine data plate.

3. **Maximum HP RPM (RPM)** - Engine speed at which maximum power is developed. This is listed with Advertised Horsepower on the engine data plate.

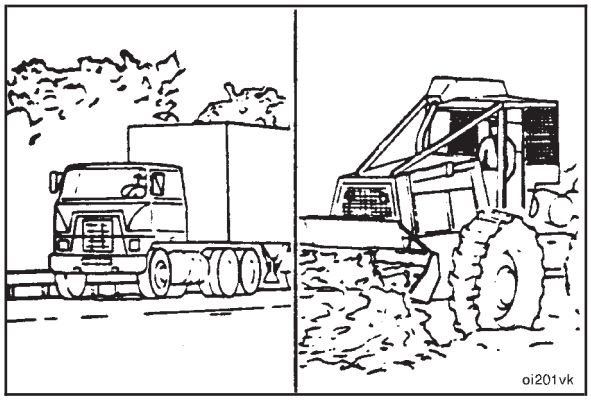
4. **Advertised Horsepower (HP)** - Maximum power that the engine will develop. This is provided on the engine data plate with its corresponding engine speed.

5. **Command Range (RPM)** - The engine's operating range from COMMAND TORQUE or Peak Torque up to the engine's governed speed.

6. **COMMAND Point** - The point on the performance curve where maximum horsepower and optimum fuel economy come together. This is the point where Advertised Horsepower occurs.

7. **Full Load Governed Speed (RPM)** - Defined as the upper end of the engine's full load operating range. This is listed on the engine data plate.

8. **No-Load Governed Speed (RPM)** - (not shown) Maximum unloaded engine speed. This value is listed on the engine data sheet and in the FPEPS publications.



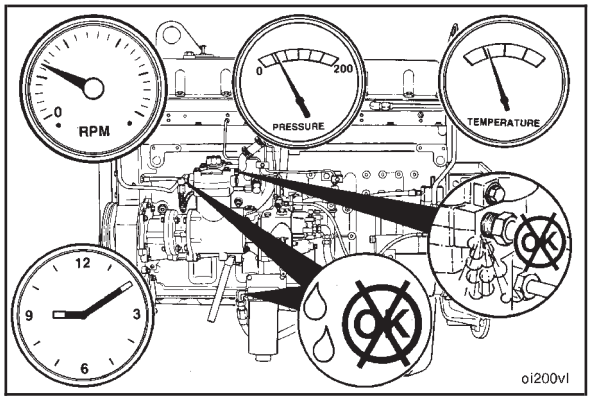
General Run-In Procedures

Caution: Refer to General Engine Test Specifications before operating the engine to avoid internal component damage.

Caution: The lubricating oil system must be pressurized before operating the engine to avoid internal component damage.

NOTE: The amount of time specified for the following engine run-in phases are minimums.

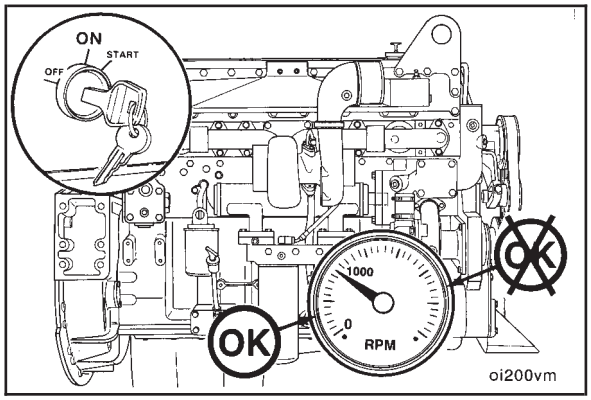
The engine can be operated for longer periods of time at each operating range or phase with the exception of engine idling which **must** be kept to 10 minutes or less.



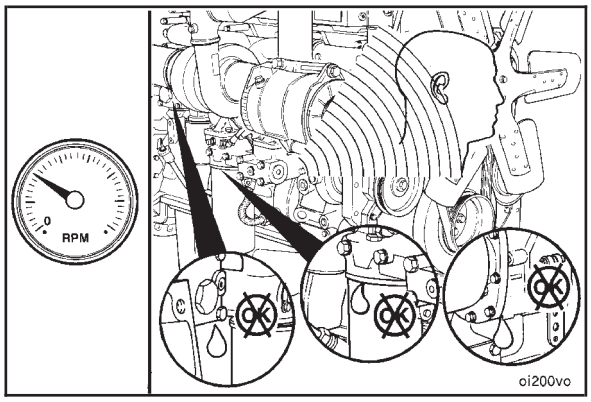
Start the engine and idle for initial check.

NOTE: Avoid long idle periods. Operate the engine at low idle only long enough (10 minutes maximum) to check for correct oil pressure and any fuel, oil, water, or air leaks.

NOTE: Do **not** operate the engine at idle speed longer than specified during engine run-in. Excessive carbon formation will occur and cause damage to the engine.



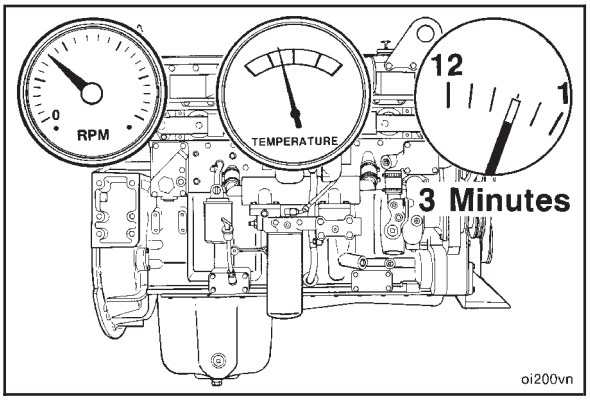
NOTE: To avoid internal component damage, do **not** allow the engine speed to exceed 1,000 RPM before run-in.



While the engine is idling, listen for unusual noises; watch for coolant, fuel, and lubricating oil leaks; and check for correct engine operation in general.

NOTE: Repair all leaks or component problems before continuing the engine run-in.

Caution: Do not shut off the engine immediately after the run-in is completed. Allow the engine to cool by operating at low idle for a minimum of 3 minutes to avoid internal component damage.



General Engine Test/Run-In Specifications

Maintain the following limits during the engine test/run-in procedures:

Due to variations in ratings of different engine models, refer to the specific ''Engine Data Sheet'' for the particular engine model being tested.

Charge Air Cooler Restriction (Maximum) ..... 102 mm Hg [4.0 in. Hg]
14 kPa [2.0 psi]

Intake Restriction (Maximum at Advertised Horsepower)

- Clean Air Filter ..... 38.0cm H_20 [15.0 in. H_20]
- Dirty Air Filter ..... 63.5cm H_20 [25.0 in. H_20]

Exhaust Back Pressure (Maximum at Advertised Horsepower) ..... 7.5cm Hg [3.0 in. Hg]

Blowby* (Maximum at Advertised Horsepower)

- New or rebuilt engines
  (maximum) (less than 160,000 km [100,000 miles] or 3600 hours) ..... 30.5 cm H_20 [12.0 in. H_20]
- Used Engines
  (maximum) (over 160,000 km [100,000 miles] or 3600 hours) ..... 46.0 cm H_20 [18.0 in. H_20]

Oil Pressure

- Low Idle (minimum allowable) ..... 70 kPa [10.0 psi]
- At 1200 RPM or Torque Peak (minimum allowable) ..... 205 kPa [30 psi]
- At Advertised RPM ..... 241 to 310 kPa [35 to 45 psi]

Fuel Inlet Restriction measured at fuel pump inlet (Maximum at Advertised Horsepower)

- Clean Fuel Filter (STC Engine) ..... 102 mm [4.0 in. Hg]
- Dirty Fuel Filter (STC Engine) ..... 203 mm [8.0 in. Hg]
- Clean Fuel Filter (CELECT™ Engine) ..... 127 mm [5.0 in Hg]
- Dirty Fuel Filter (CELECT™ Engine) ..... 228 mm [9.0 in Hg]

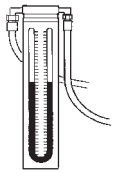
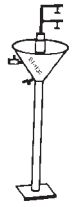
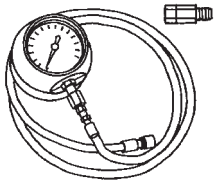
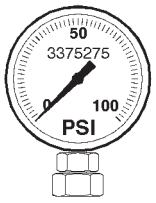
Fuel Drain Line Restriction (Maximum at Advertised Horsepower)

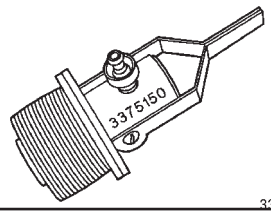
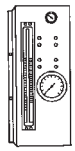
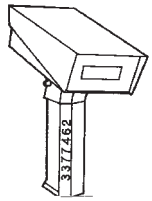
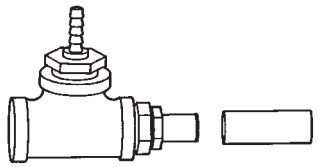
- With Check Valves ..... 16.5 cm Hg [6.5 in Hg]
- Without Check Valves ..... 6.5 cm Hg [2.5 in Hg]

* Blowby checking tool, Part No. 3375150 and Part No. 3822566, have a special 7.67 mm [0.302-inch] orifice that **must** be used to be certain an accurate reading is obtained.

Engine Testing - Service Tools

The following special tools are recommended to perform procedures in Section 14. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-434	**Vacuum Gauge** Used to check fuel filter or intake air restriction.	 eg8togc
ST-435-6	**Pressure Gauge** Included in snap rail pressure gauge, Part No. 3375932. Used to measure fuel pressure.	 eg8togh
ST-1111-3	**Manometer** Used with tool, Part No. 3375150, for measuring blowby.	 eg100ja
ST-1135	**Lubricating Oil Sampling Filter** Used to monitor oil contamination.	 st-1135
ST-1273	**Pressure Gauge** Used to measure intake manifold pressure.	 eg8togi
3375275	**Pressure Gauge (0-160 psi)** Used to measure lubricating oil pressure.	 3375275

Tool No.	Tool Description	Tool Illustration
3375150	**Blowby Checking Tool** Used with manometer, Part No. ST-1111-3, to measure the engine crankcase pressure.	 3375150
3375932	**Pressure Gauge (0-300 psi)** Used to measure fuel pressure. Includes necessary hoses and hardware to attach to a fuel pump. Part No. ST-435-1 is the hose and Part No. ST-435-6 is the pressure gauge.	 eg8togh
3376375	**Fuel Measuring Device** Measure the rate of fuel consumption of a Cummins diesel engine.	 eg8togf
3377462	**Digital Optical Tachometer** Used to measure engine speed (RPM).	 3377462
3822566	**Blowby Check Tool** Used with manometer, Part No. ST-1111-3, to measure the engine crankcase pressure.	 eg8toge

Engine Dynamometer - Install Engine (14-01)

NOTE: Be sure the dynamometer capacity is sufficient to permit testing at 100 percent of the engine rated horsepower. If the capacity is **not** enough, the testing procedure **must** be modified to the restrictions of the dynamometer.

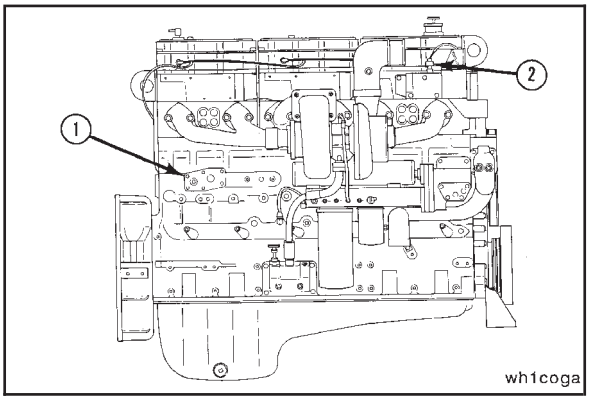
Use engine lifting fixture, Part No. 3822512, to install the engine to the test stand. Align and connect the dynamometer. Refer to the manufacturer's instructions for aligning and testing the engine.

Refer to Service Bulletin No. 3666005, Dynamometer and Road Engine Testing, for detailed instructions on auxiliary aftercooling system attachment.

NOTE: Some engines are equipped with fittings used for Compuchek® testing sensors. The sensor probes used for Compuchek® and dynamometer testing are **not** compatible. If the same location is used, remove the Compuchek® fitting and install adapters for the dynamometer sensor.

Install the coolant pressure sensor (1).

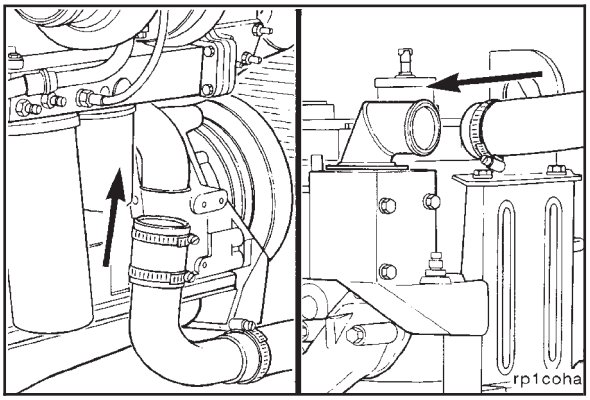
Install the coolant temperature sensor (2).



Connect the coolant supply to the water inlet connection.

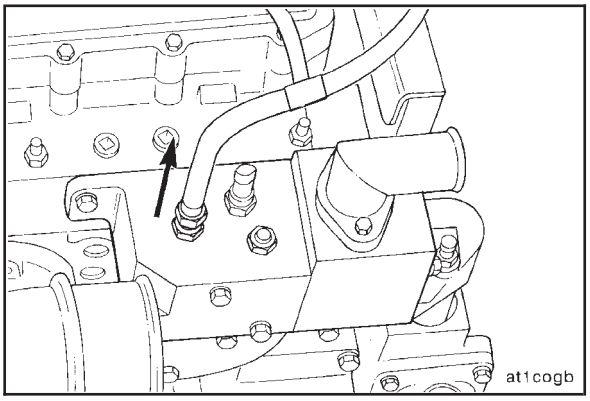
Connect the coolant return to the water outlet connection.

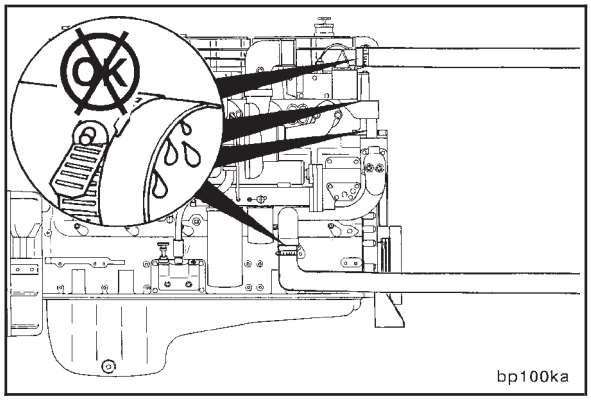
Install the drain plugs and close all of the water drain cocks.



Loosen the cooling system vent line.

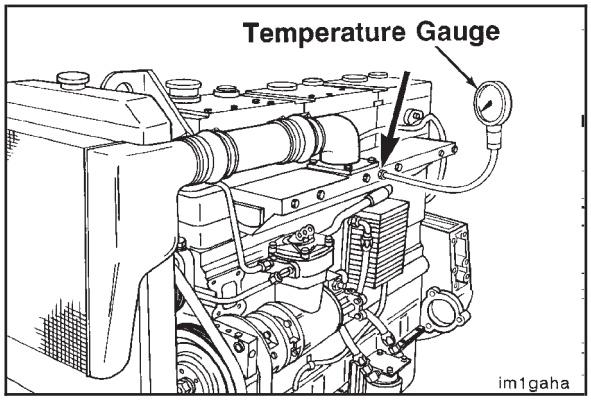
Fill the system with coolant until it flows from the vent. Tighten the vent line and finish filling the system.





Visually inspect the engine for coolant leaks.

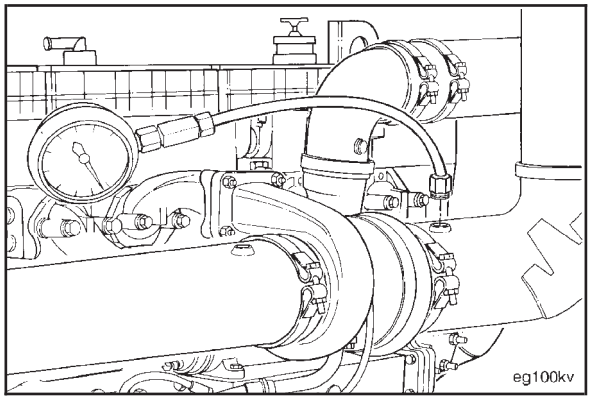
Repair all leaks found.



The intake air piping **must** be plumbed through an aftercooler to control the temperature of the intake air during the run-in procedure. Rig an aftercooler beside the engine, and plumb the intake pipes from the turbocharger, through the aftercooler and back to the intake manifold.

Use a temperature gauge to measure the intake manifold temperature.

NOTE: Maintain the intake manifold air temperature at 66°C [150°F] or below during the dynamometer testing or run-in; if manifold temperature exceeds this limit, terminate the test and idle the engine to let it cool down. Do **not** idle more than 10 minutes. Testing can resume when the intake air temperature can be maintained below 66°C [150°F]. Under no circumstances is the intake manifold air temperature allowed to exceed 77°C [170°F].

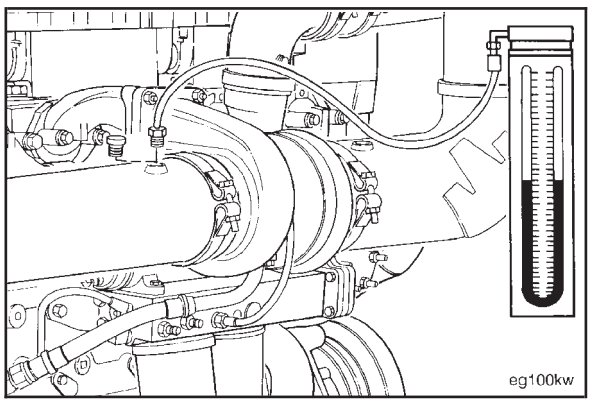


Install a water manometer to the air inlet pipe of the turbocharger to measure inlet restriction.

NOTE: The manometer adapter **must** be installed at a 90 degree angle to the air flow in a straight section of pipe, one pipe diameter before the turbocharger.

NOTE: A vacuum gauge **can** be used to record the intake air restriction.

Minimum Gauge Capacity: 760 mm H_20 [30 inches H_20].



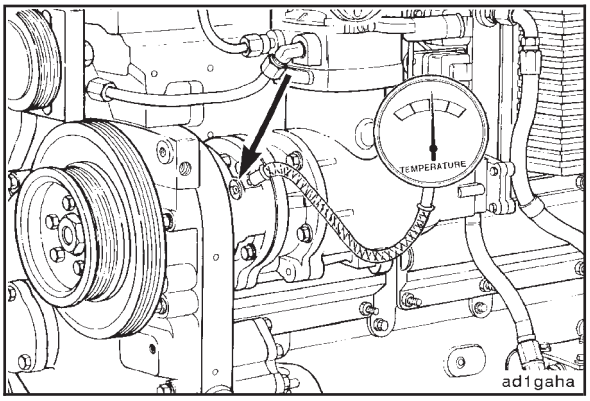
Install a mercury manometer to a straight section of the exhaust piping near the turbocharger outlet to measure exhaust restriction.

NOTE: The manometer **must** be scaled to record exhaust back pressure in excess of 75 mm [3.0 inches] of mercury.

NOTE: A pressure gauge **can** be used to record the exhaust back pressure.

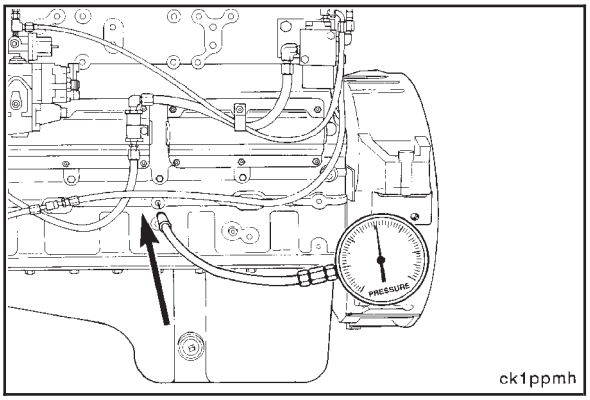
Minimum Gauge Capacity: 254 mm Hg [10 inches Hg].

Remove the straight thread fitting in the accessory drive and install the lubricating oil temperature sensor.

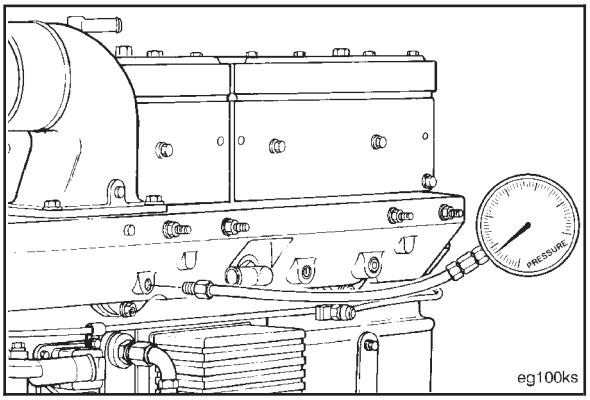


Remove the pipe plug from the main oil rifle drilling in the cylinder block.

Install the lubricating oil pressure sensor.



Remove the pipe plug in the intake manifold just below the inlet air connection and install the intake manifold pressure gauge.



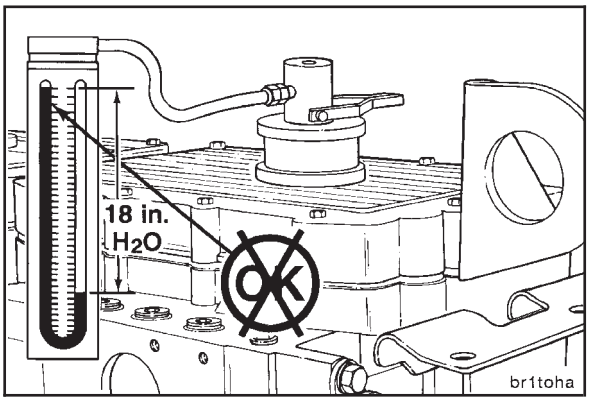
Install the Part No. 3375150, Engine Blowby Tool, to the breather on the rocker lever cover to measure engine crankcase pressure.

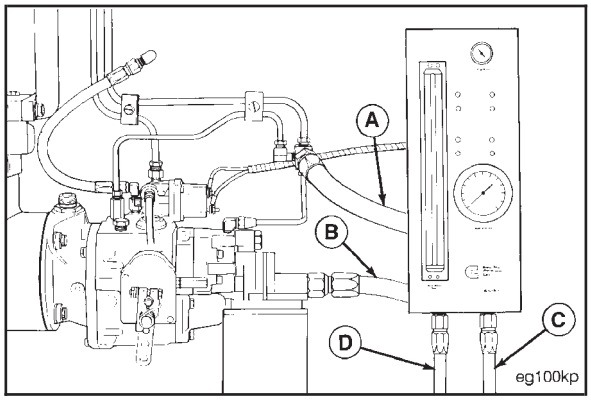
Install a water manometer, Part No. ST-1111-3, to the engine blowby tool.

Install a plug in the crankcase breather vent tube.

NOTE: A pressure gauge can be used to record the engine blowby.

Minimum Gauge Capacity: 1270 mm H_20 [50 inches H_20].





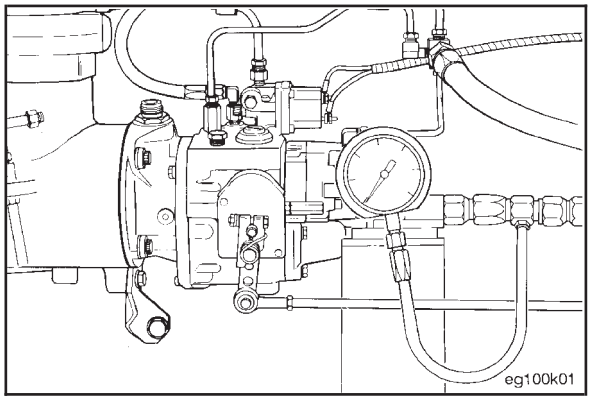
Fuel Rate

The Part No. 3376375, Fuel Measuring instrument, is used during the performance check to measure fuel consumption.

Install the fuel measuring device as follows:

- The fuel return hose from the engine to the fuel measuring device (A).
- The fuel inlet hose to the fuel filter inlet (B).
- The return hose from the device (C) to the fuel tank.
- The fuel inlet hose to the device from the fuel tank suction line (D).

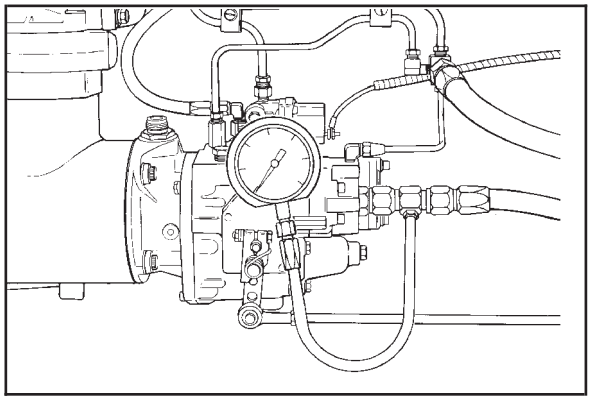
NOTE: Adjust fuel rate to compensate for temperature variation if required.



Fuel Inlet Restriction

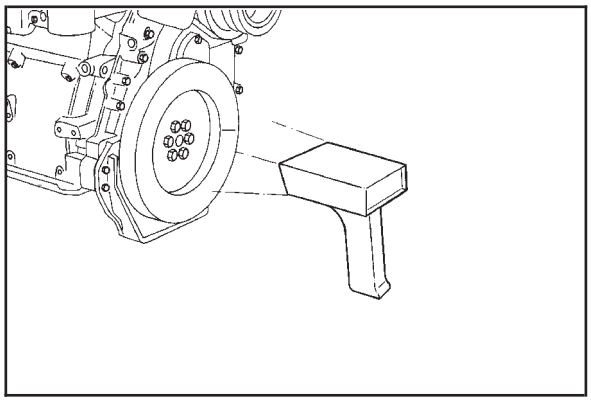
Measure the fuel inlet restriction. Install a vacuum gauge, Part No. ST-434, between the fuel pump inlet and the gear pump inlet.

NOTE: Do **not** measure fuel inlet restriction with the fuel measuring device installed. This will **not** measure the inlet restriction of the vehicle's supply plumbing.



Hold the gauge at the same level as the gear pump.

NOTE: The gauge will **not** measure the correct vacuum if the gauge is **not** held at the same level as the gear pump.



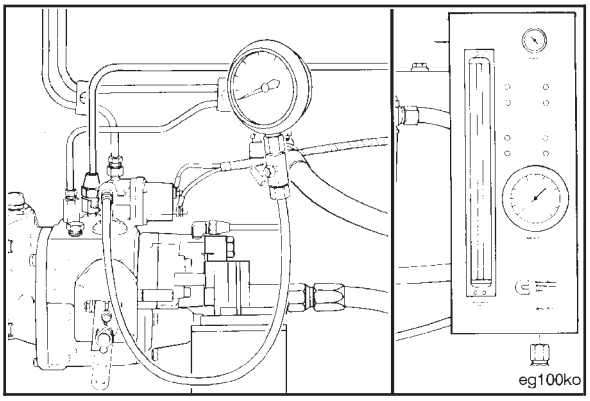
Engine Speed (RPM) With a Verified Tachometer

Use digital optical tachometer, Part No. 3377462, to check and verify engine speed.

Fuel Pressure

Measure the fuel pressure. Install the pressure gauge, Part No. ST-435-6, or the pressure gauge in the fuel measuring device, Part No. 3376375, to the Compucheck® fitting on the fuel shutoff valve.

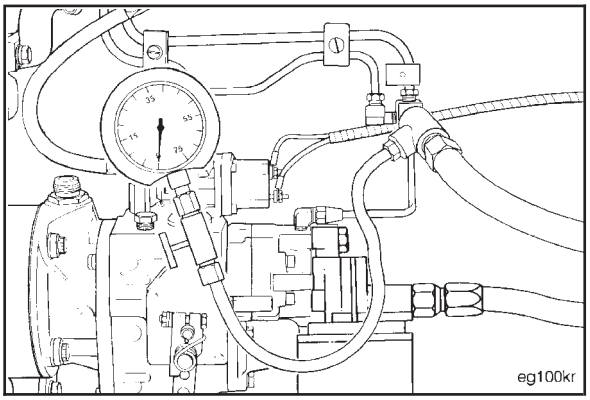
NOTE: Pressure gauge, Part No. ST-435-6, is included with snap rail pressure gauge, Part No. 3375932.



Fuel Drain Line Restriction

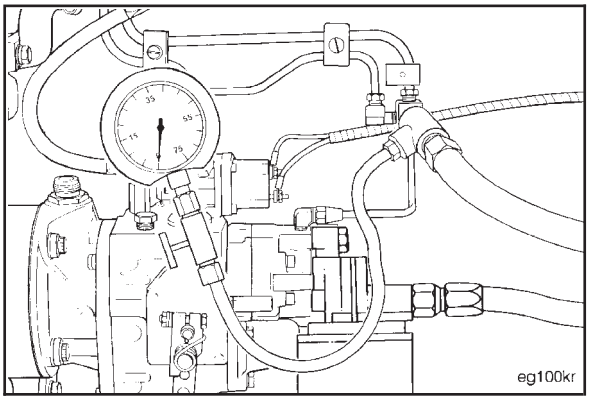
Use pressure gauge, Part No. ST-1273, to measure fuel drain line restriction.

NOTE: Do **not** measure fuel drain line restriction with the fuel measuring device installed. This will **not** measure the drain line restriction of the vehicle's return plumbing.



Hold the gauge at the same level as the connection.

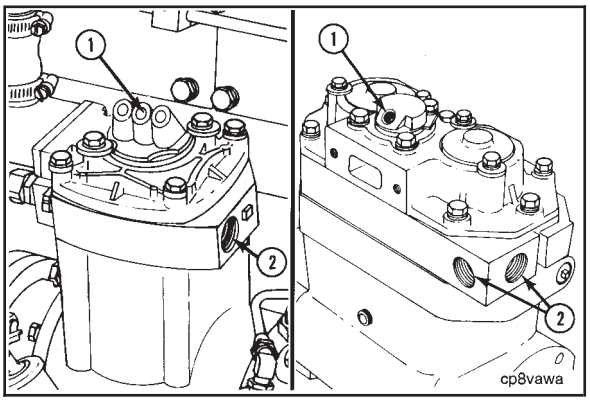
NOTE: The gauge will **not** measure the correct pressure if the gauge is **not** held at the same level as the connection.

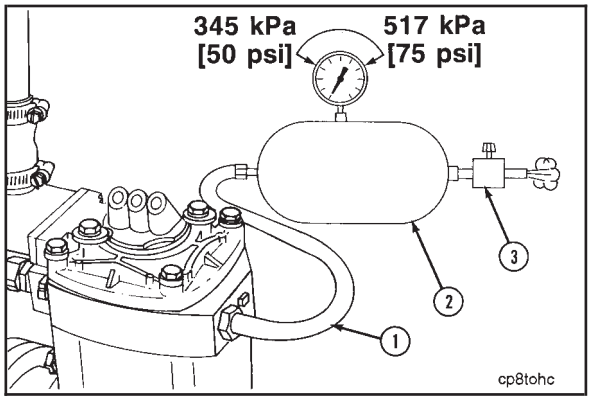


NOTE: All air compressors manufactured by Cummins Engine Company, Inc. **must** be operating during the engine run-in. During the performance check, all air compressors **must** be in the unload or non-operating mode.

Connect a source of compressed air capable of producing 665 kPa [95 psi] to the air compressor unloader (1). This air line **must** contain a valve between the source and the unloader.

NOTE: The compressed air load in the accompanying illustration **must** be attached to the air compressor outlet (2).



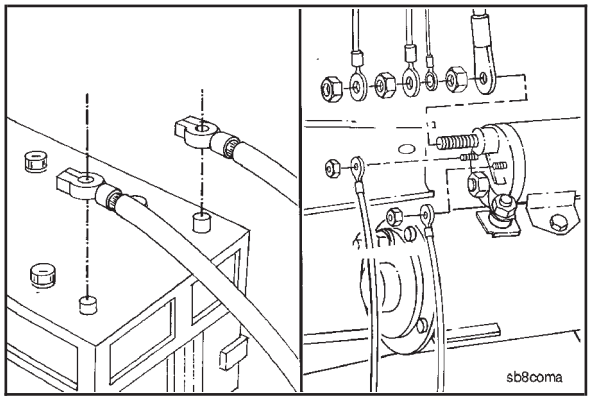


Use an air tank (2). Install an air regulator (3) capable of maintaining 345 to 517 kPa [50 to 75 psi] air pressure at both minimum and maximum engine RPM.

Install a steel tube or high temperature hose (1).

Hose Temperature (Minimum): 235°C [500°F].

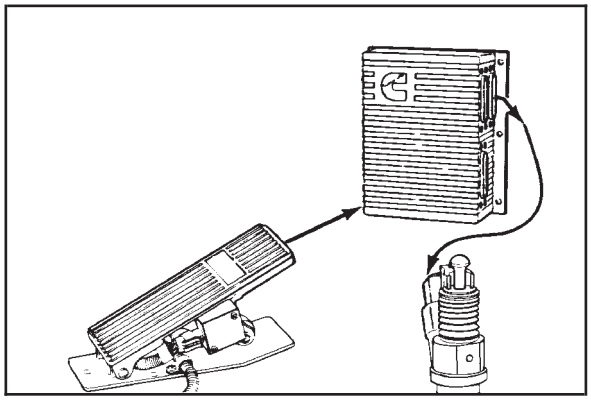
Connect the tube or hose (1) to the air compressor outlet.



NOTE: Inspect the voltage rating on the starting motor before installing the electrical wiring.

Install the electrical wiring to the starting motor and batteries, if used.

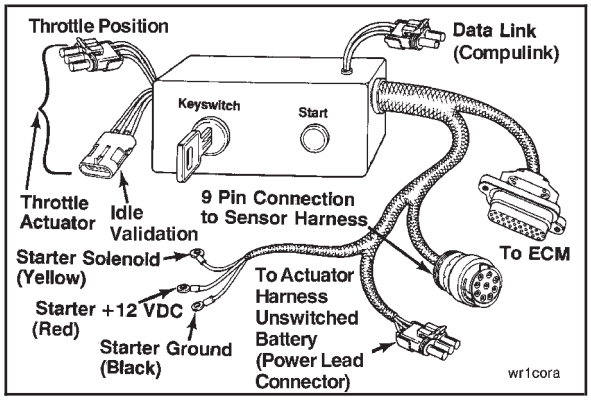
NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.



Electronic Hookup - CELECT™ Engines Only

When testing a CELECT™ engine on an engine dynamometer, it is necessary to attach a throttle input control, and a 12 volt power supply to the ECM.

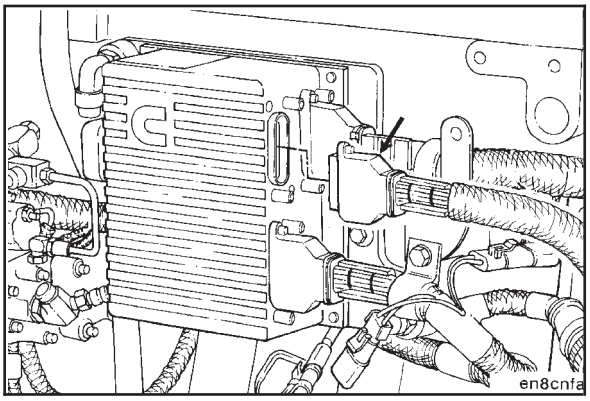
A Compulink™ **must** also be used to bypass certain features and programmed parameters associated with the CELECT™ ECM while the engine run-in or performance test is in process.



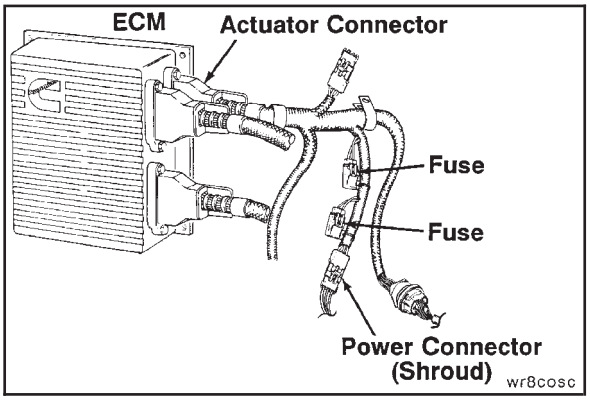
The engine dynamometer OEM harness for both the N14 and L10 engines are the same. The CELECT™ dynamometer test OEM wiring harness, Service Tool Part No. 3823948, is available through Cummins. The harness is supplied with all necessary connections and switches. Items not supplied are the remote throttle actuator and the 12 volt battery.

Connect the dynamometer test OEM wiring harness AMP connector to the ECM. Tighten the connector capscrews to the ECM.

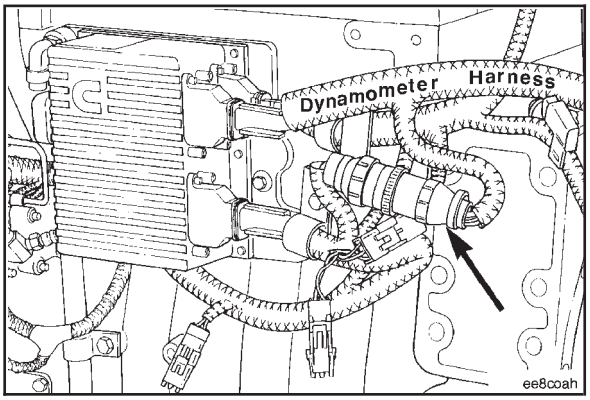
Torque Value: 2.0 N•m [18 in-lb]



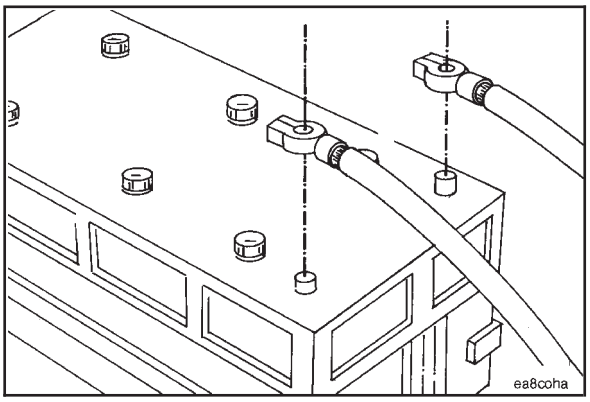
Connect the dynamometer test OEM wiring harness 3-pin connector to the actuator harness power connector (shroud).

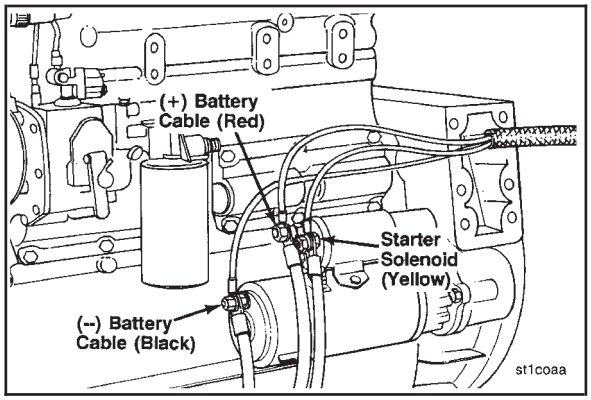


Connect the dynamometer test OEM wiring harness 9-pin connector to the sensor harness 9-pin connector.

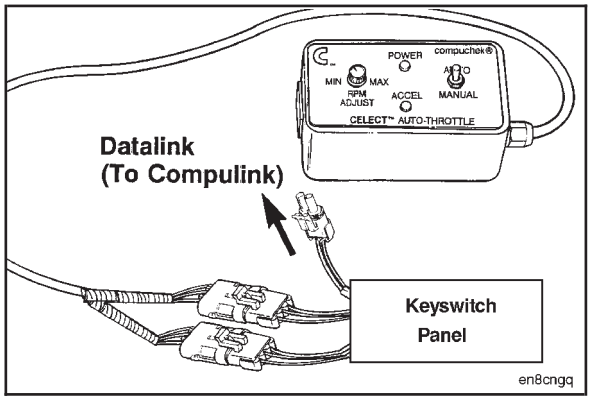


Connect the battery power to the starting motor.



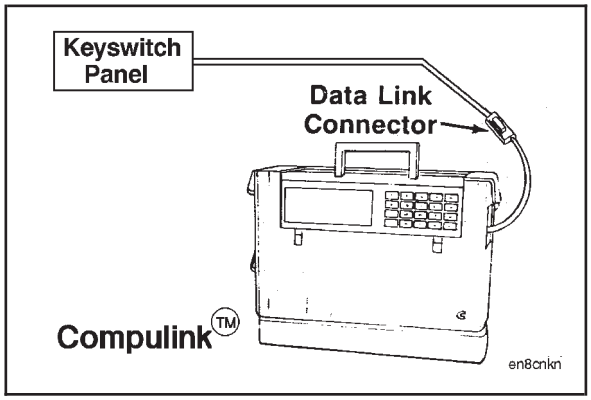


Connect the dynamometer test OEM wiring harness starting motor solenoid lead (yellow) to the starting motor solenoid. Connect the ground lead (black) to the starting motor or battery negative or ground side. Connect the + 12 volt DC power lead (red) to either the starting motor or battery positive (+ 12 volt DC) side.



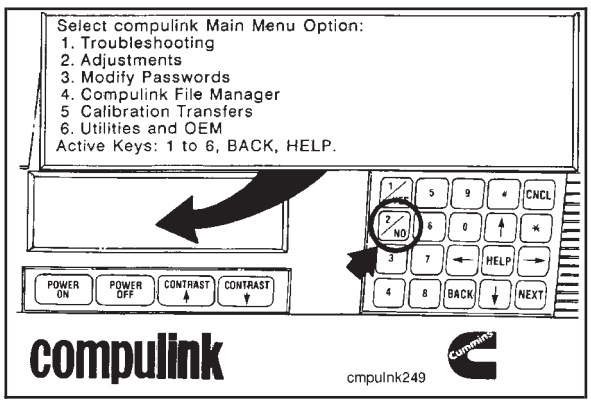
To control throttle input and engine speed, connect the auto/manual throttle control, Service Tool Part No. 3823828, to the throttle control leads at the keyswitch panel on the dynamometer test OEM wiring harness.

Place the ''Auto-Manual'' switch in the ''Manual'' position to enable use of the ''Min-Max RPM Adjust'' control.



Connect the keyswitch panel datalink cable to the Compulink™.

Depress the ''POWER ON'' button on the Compulink™.

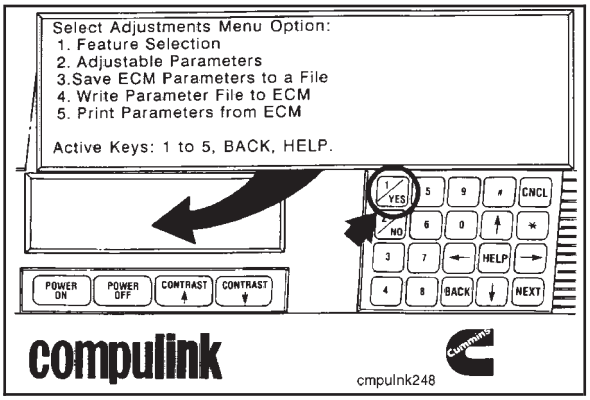


If the ''Progressive Shift Feature'' is turned ''ON'', it **must** be turned ''OFF'' during the engine test to allow the engine to accelerate through its RPM range.

Select the ''Adjustments'' option from the main menu screen by depressing the number ''2'' on the Compulink™ keypad.

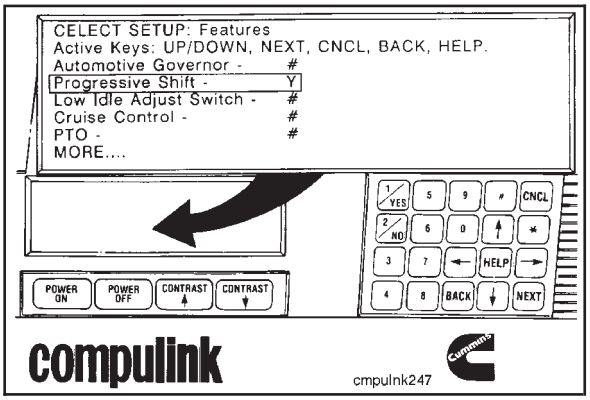
Select the ''Feature Selection'' from the menu options by depressing the number ''1'' on the keypad.

The next screen will show if the ''Progressive Shift Feature'' is turned ''ON'' or ''OFF''.

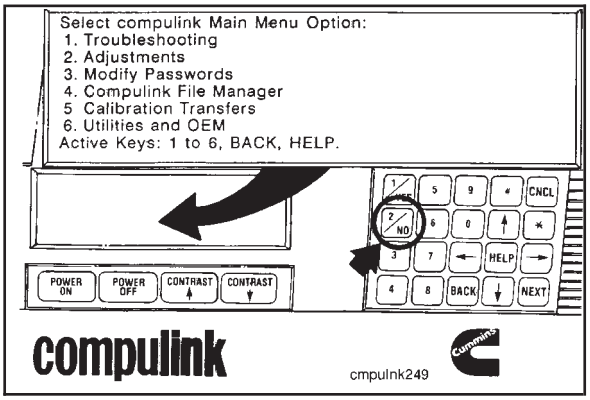


Check the ''Progressive Shift Feature''. If ''Y'' is displayed, depress the number ''2'' key on the keypad to display ''N'' and turn ''OFF'' the ''Progressive Shift''.

NOTE: Turn the ''Progressive Shift Feature'' back ''ON'' when the test is completed.



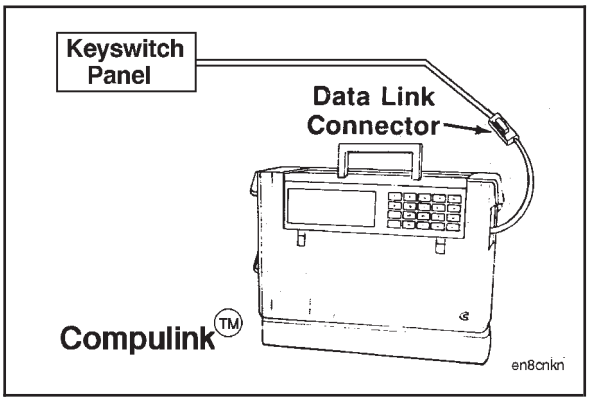
Depress the active key to cancel or back up to the screen showing the ''Main Menu Option''.

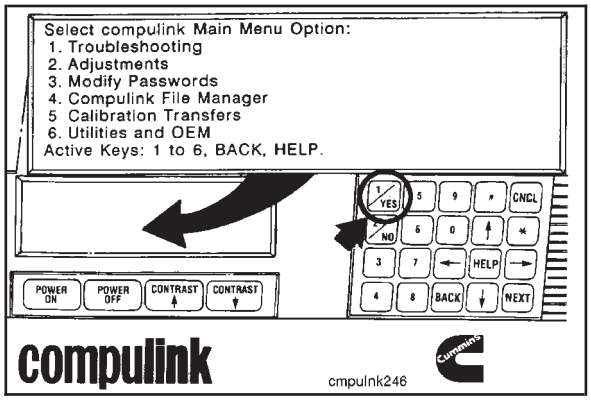


The ECM is equipped with a tamperproof system that limits engine speed when the vehicle speed signal is lost. This parameter **must** be bypassed with the Compulink™ in the Compuchek® mode or if the Compulink™ is needed to monitor engine data, the adjustable parameters **must** be adjusted outside the engine operating range.

To save, adjust, and write parameters to and from the ECM, refer to the CELECT™ Compulink™ Cartridge Manual, Bulletin No. 3810472.

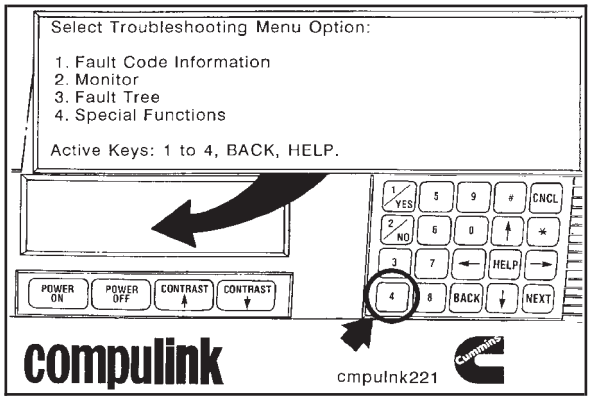
NOTE: Parameters **must** be returned to their original value when the test or run-in is completed.



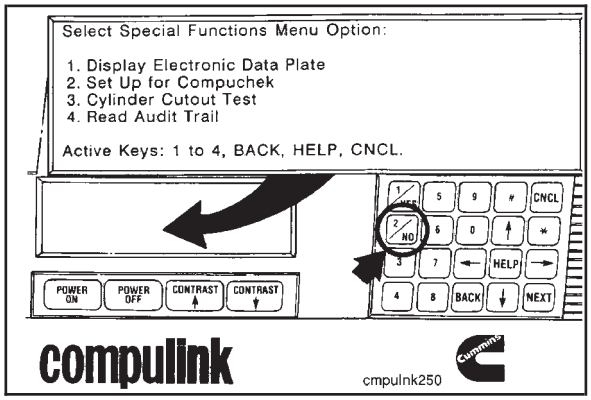


If the parameter is to be bypassed with the Compulink™, refer to the following instructions.

Select ''Troubleshooting'', key (1), from the ''Main Menu Option'' screen.



Select ''Special Functions'', key (4), from the ''Troubleshooting Menu''.

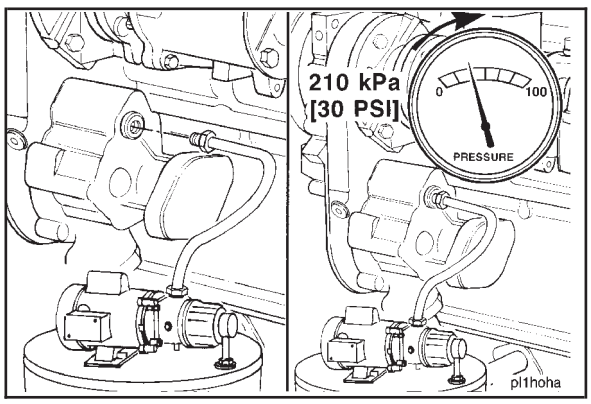


Select ''Set Up for Compuchek'' from the ''Special Functions Menu''. The Compulink™ **must** be left in this mode throughout the test.

The setup is now completed, and the auto/manual throttle control can be used to control engine speed.

NOTE: The throttle control **must** be used in the manual position.

Use the active keys to cancel or back up the Compulink™ when the test is complete.



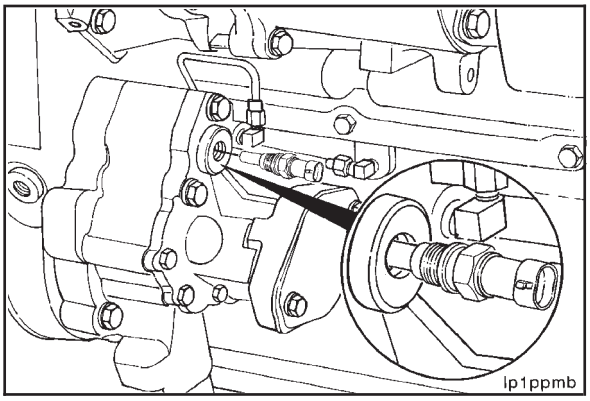
Priming the Lubricating Oil and Fuel Systems (14-02)

Lubricating Oil System Priming

△ **Caution: The lubricating oil system must be primed before operating the engine after any internal engine repairs or extended engine storage (beyond 6 months) to avoid internal component damage. Do not prime the system from the bypass filter; the filter will be damaged.**

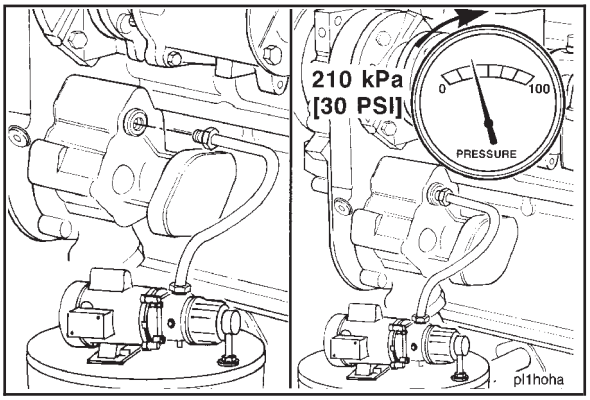
On CELECT™ engines, remove the lubricating oil temperature sensor from the lubricating oil pump cover.

Lubricating oil pumps on N14 STC engines are equipped with a 9/16-18 UNF Compuchek® coupling nipple. Use the coupler, Part No. 3376859, to connect the priming pump to the coupling.



Install the priming pump oil supply hose to the lubricating oil pump coupling. Use clean 15W-40 lubricating oil from a drum or a container. Supply oil to the lubricating oil pump and engine.

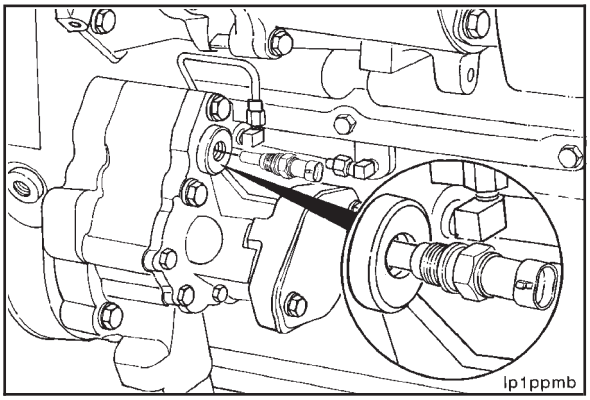
Allow the oil to flow until the oil pressure gauge indicates a maximum pressure of 210 kPa [30 psi] at the main oil rifle to prime the lubricating oil system.



Remove the priming pump oil supply hose and install the lubricating oil temperature sensor (CELECT™ engines), or 9/16-18 UNF Compuchek® coupling nipple (STC engines).

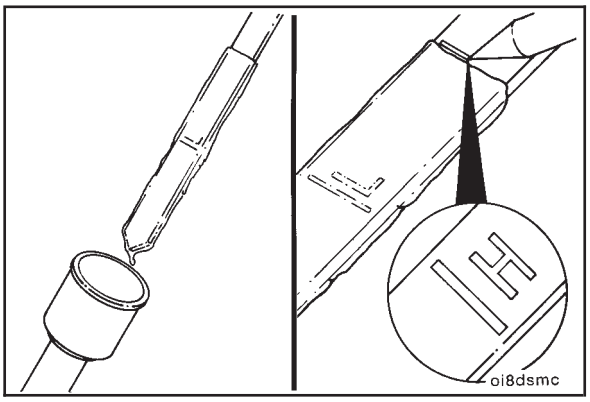
Torque Value:

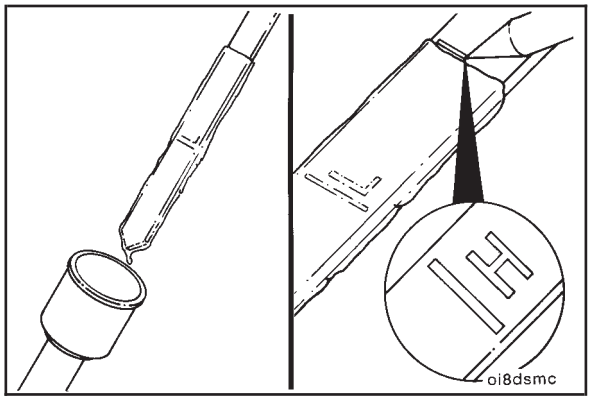
Plug	34 N•m [25 ft-lb]
Sensor	34 N•m [25 ft-lb]



Wait 10 minutes to be sure the lubricating oil has drained into the oil pan. Use the dipstick to measure the oil level.

Fill the oil pan to the specified ‘‘high’’ level.

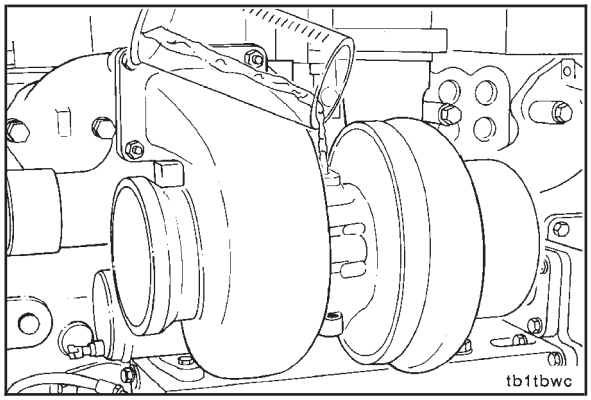




NOTE: If an external pressure pump is **not** available, prime the lubricating system as follows:

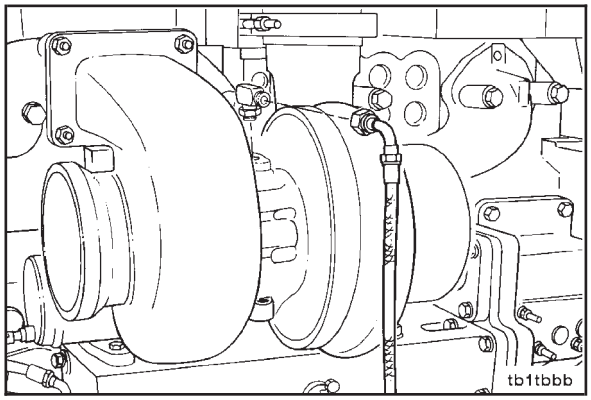
Use the dipstick to measure the lubricating oil level.

Fill the oil pan to the ‘‘high’’ level mark on the dipstick.



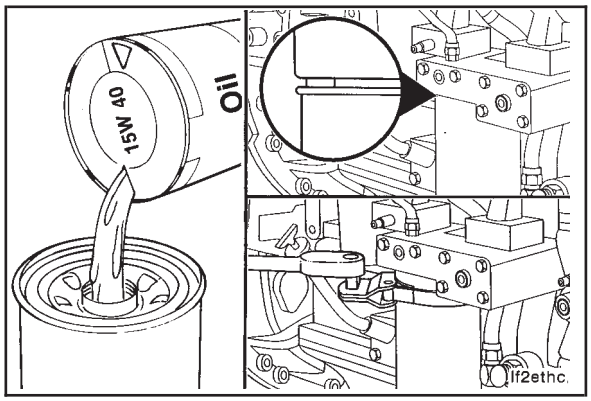
Disconnect the turbocharger lubricating oil supply line.

Pour 50 to 60 cc [2.0 to 3.0 fl oz] of clean 15W-40 oil in the turbocharger oil supply line fitting.



Install the turbocharger oil supply line.

Torque Value: 30 N•m [22 ft-lb]



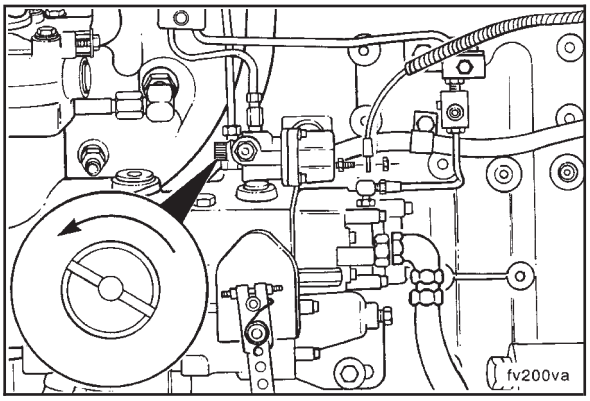
Use clean 15W-40 oil to fill the lubricating oil filter.

Tighten the filter until the gasket contacts the filter head surface.

Tighten the filter an additional three-fourths to one (3/4 to 1) turn.

Disconnect the electrical wire that supplies power to the fuel pump solenoid.

NOTE: The manual override screw **must** be turned **counterclockwise** until it stops.

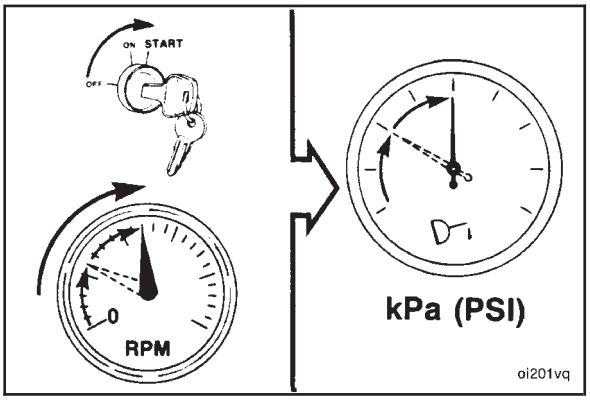


Caution: Do not crank the starting motor for more than 30 seconds. Excessive heat will damage the starting motor.

Crank the engine until the oil pressure gauge indicates a positive pressure.

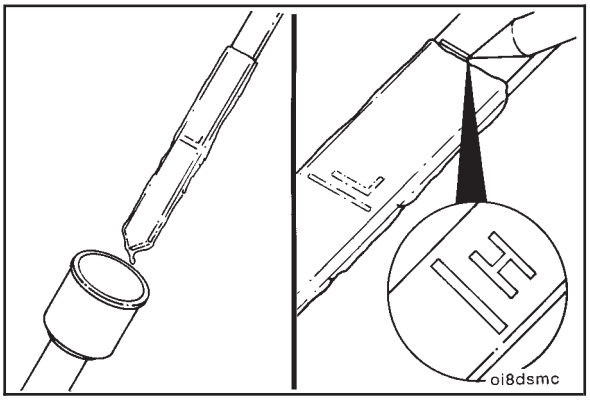
NOTE: If a positive pressure is **not** indicated within 30 seconds, stop cranking the engine and allow 2 minutes for the starting motor to cool before cranking the engine again.

NOTE: If a positive oil pressure is still **not** indicated, find and correct the problem before continuing.



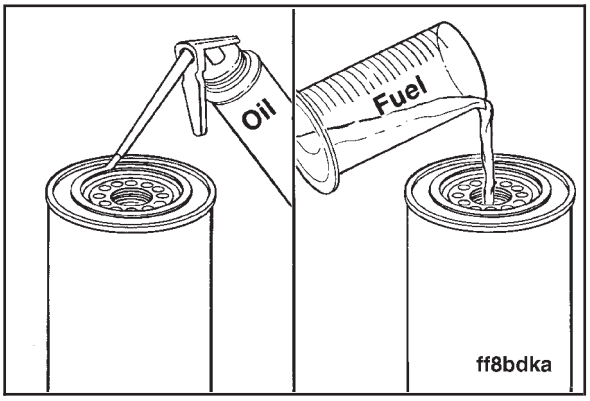
Wait 10 minutes to be sure the lubricating oil has drained into the oil pan. Use the dipstick to measure the oil level.

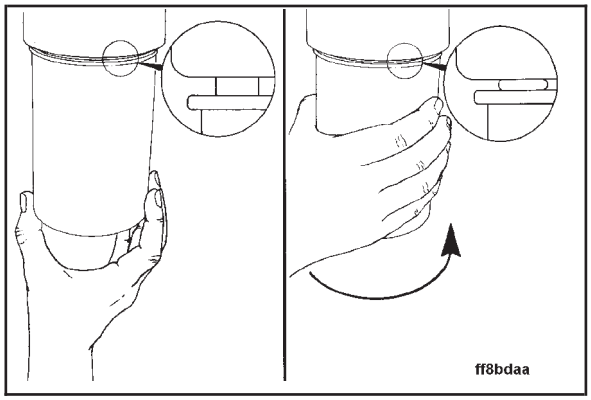
Fill the oil pan to the specified ‘‘high’’ level.



Use clean 15W-40 oil to lubricate the fuel filter gasket.

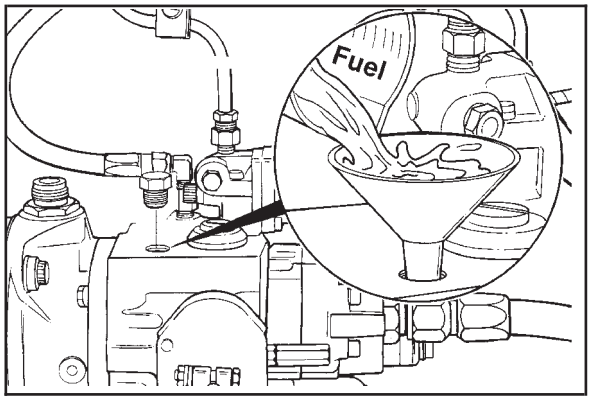
Fill the filter with clean fuel.





Install the filter on the filter head and tighten the filter until the gasket contacts the filter head surface.

Tighten the filter an additional one-half to three-fourths (1/2 to 3/4) turn.



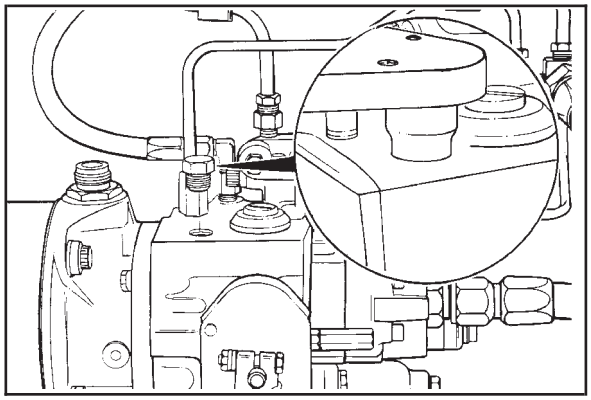
Fuel System Priming - PT System

To reduce engine cranking time, prime the fuel pump.

NOTE: If the fuel pump is dirty, clean the outside of the pump near the filter screeen cap.

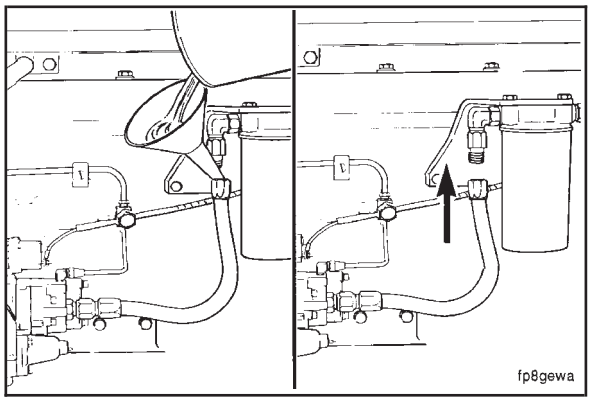
Remove the plug from the top of the fuel pump housing.

Fill the housing with clean fuel.



Install the plug in the fuel pump housing.

Torque Value: 27 N•m [20 ft-lb]



NOTE: If the priming plug is difficult to remove or the fuel pump is a VS type, use clean fuel to fill the gear pump.

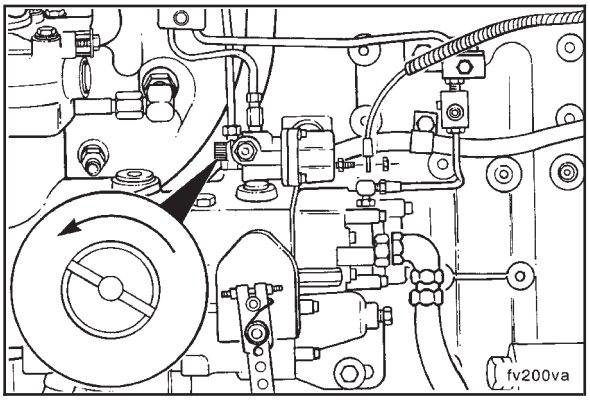
Remove the fuel supply hose at the fuel filter or the flow meter and fill the hose with clean fuel.

Install the fuel supply hose to the filter head or flow meter.

Install the electrical wire that supplies power to the solenoid.

NOTE: The manual override screw on the solenoid **must** be turned **counterclockwise** until it stops to allow the solenoid to open and close.

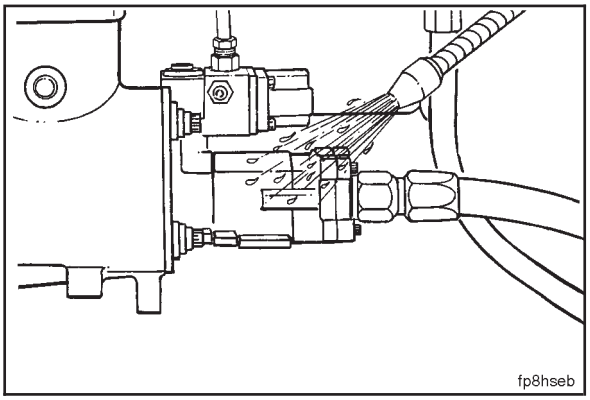
Install the throttle control device to the throttle arm on the fuel pump.



Fuel System Priming - CELECT™ System

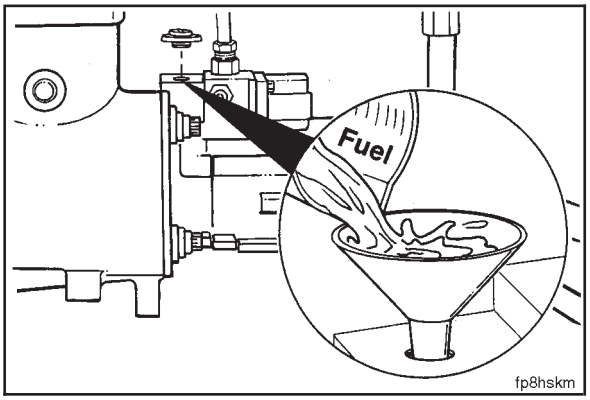
To reduce engine cranking time, prime the fuel supply pump.

NOTE: If the fuel supply pump is dirty, clean the outside of the pump near the filter screen cap.



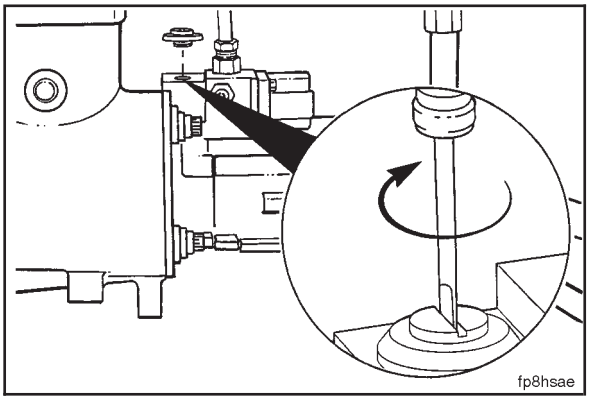
Remove the filter cap from the top of the front support.

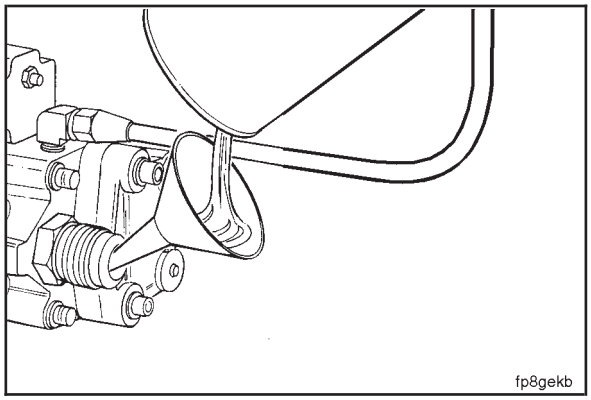
Fill the pump with clean fuel oil.



Install and tighten the filter cap.

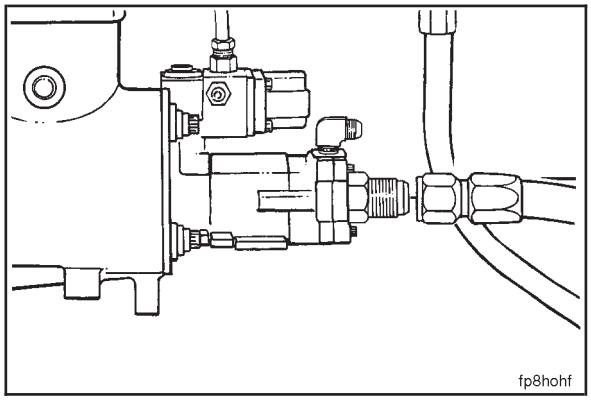
Torque Value: 18 N•m [13 ft-lb]



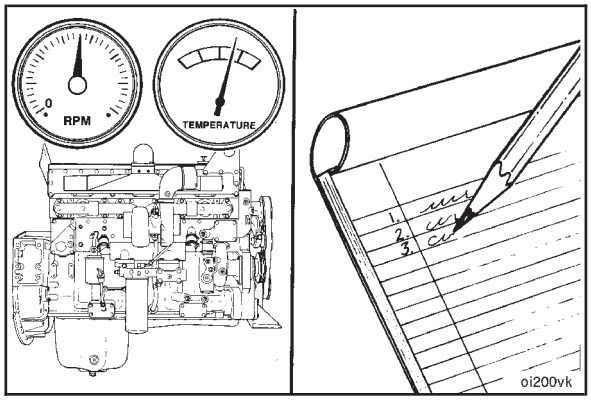


If the filter cap opening can **not** be used, remove the fuel supply hose to the gear pump.

Lubricate the gear pump gears with clean engine lubricating oil.



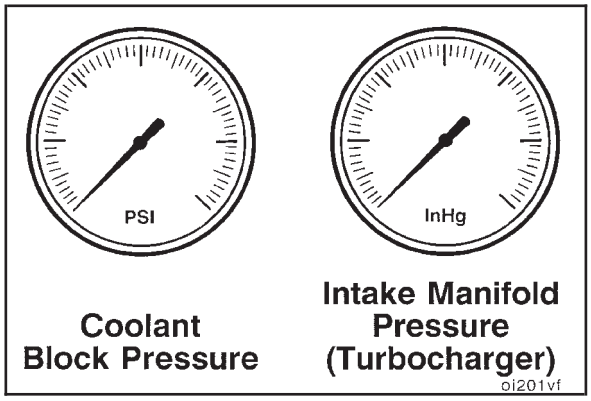
Install the fuel supply hose to the gear pump.



Engine Run-In Procedure - Engine Dynamometer (14-03)

Measurements from these indicators and gauges **must** be observed closely during all phases of the engine run-in period. Engine measurements taken are:

- Engine speed
- Engine torque
- Lube oil pressure
- Coolant out temperature
- Fuel pressure
- Crankcase blowby
- Fuel rate (using Part No. 3376375)



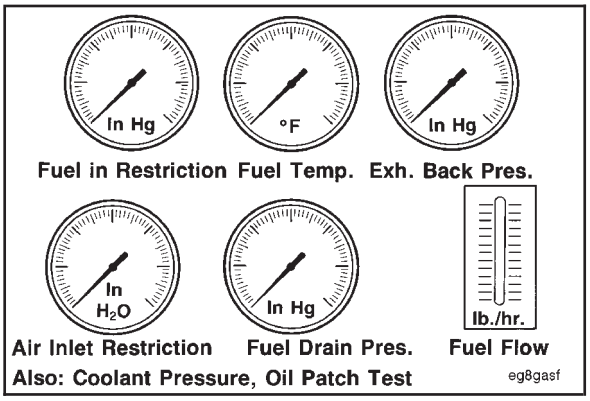
To correctly evaluate the engine performance, this additional measurement, intake manifold pressure (turbocharger boost), **must** be observed during engine run-in phases.

Refer to the Engine Dynamometer worksheet on the last page of this procedure.

NOTE: It is recommended to monitor block coolant pressure during run-in to aid in early indication of a cooling system problem.

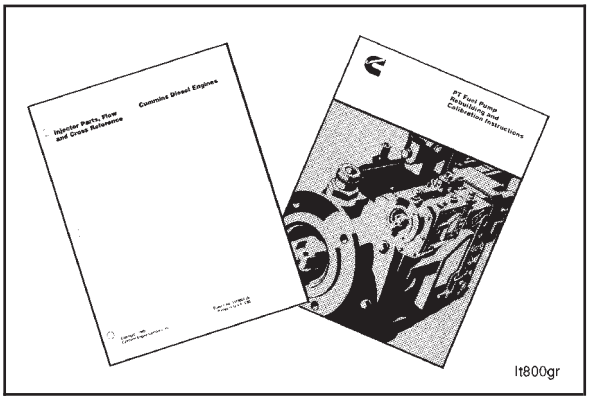
It is a good practice to observe these measurements even if engine performance meets specifications. If engine performance does **not** meet specifications, these measurements can indicate possible reasons for underperformance. The measurements taken are:

- Fuel inlet restriction at fuel pump inlet
- Fuel temperature
- Exhaust system back pressure
- Air inlet restriction pressure
- Fuel drain pressure
- Coolant pressure
- Oil patch test
- Compulink™ for CELECT™ equipped engines



Obtain the CPL number from the engine data plate and the fuel pump code from the fuel pump data plate. Engine performance specifications and fuel system calibration values for specific engine CPL and fuel pump codes are listed in the following publications:

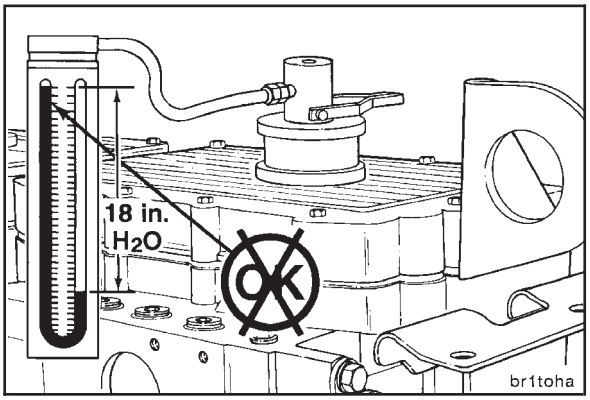
1. Fuel Pump Calibration Values, Bulletin No. 3379352.
2. Injector Parts Flow and Cross Reference, Bulletin No. 3379664.
3. Engine Data Sheets.
4. N14 Troubleshooting and Repair Manual, Bulletin No. 3810456.



If a sudden increase in blowby occurs, or if blowby exceeds the maximum allowable limit during any run-in step, return to the previous step and continue the run-in. If blowby does **not** reach an acceptable level during the next step, discontinue the run-in and determine the cause.

Do **not** proceed to the next step until a steady blowby reading is obtained.

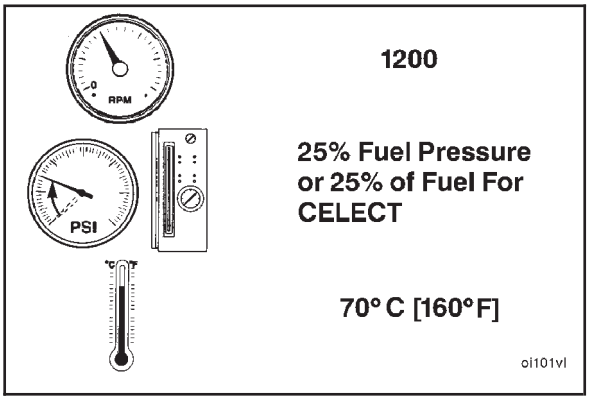
NOTE: Blowby **must** be measured by using Service Tool, Part No. 3375150 or 3822566, with manometer, Part No. ST-1111-3, or equivalent. Service Tool, Part No. 3375150, as shown, utilizes a chamfered 7.67 mm [0.302 in] orifice.

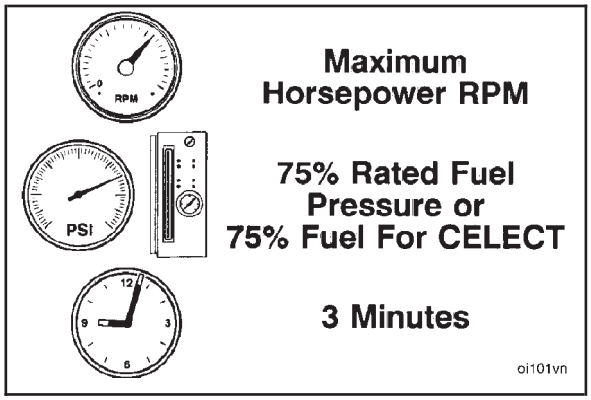


Start the engine.

Move the throttle to obtain 1200 RPM engine speed, and apply a test load sufficient to develop 25 percent rated fuel pressure or 25 percent fuel rate on CELECT™ engines.

Operate the engine at this speed and load level until the coolant temperature is 70°C [160°F]. Check all gauges and record the data.

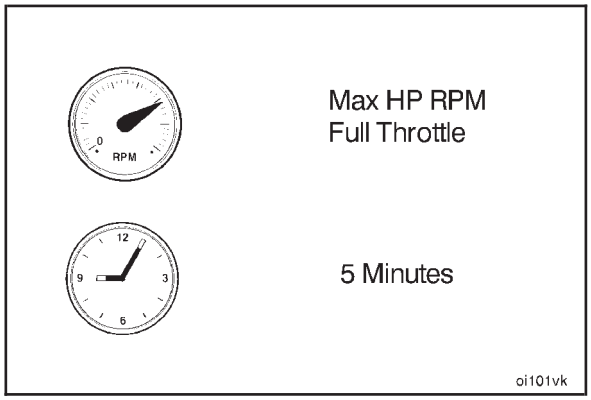




Open the throttle to obtain speed at which maximum horsepower is developed and adjust the dynamometer load to achieve 75 percent of rated fuel pressure or 75 percent fuel rate on CELECT™ engines. Operate the engine at this speed and load level for 3 minutes.

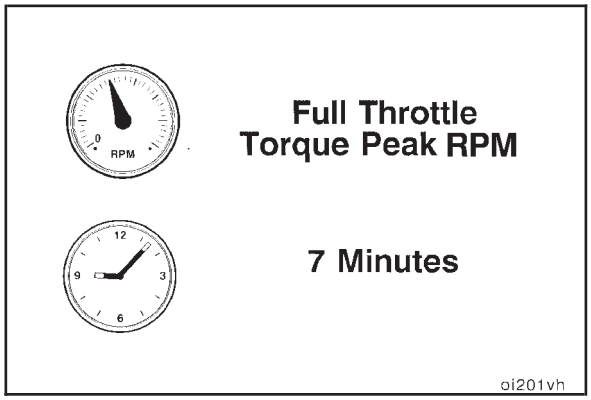
Check all gauges and record the data.

NOTE: Do **not** proceed to the next step until blowby is stable within specifications.



Maintain maximum horsepower RPM and advertised horsepower, and increase the dynamometer load until 100 percent rated fuel pressure or 100 percent fuel flow is developed. Operate the engine at this speed and load level for 5 minutes or until the blowby becomes stable within specifications.

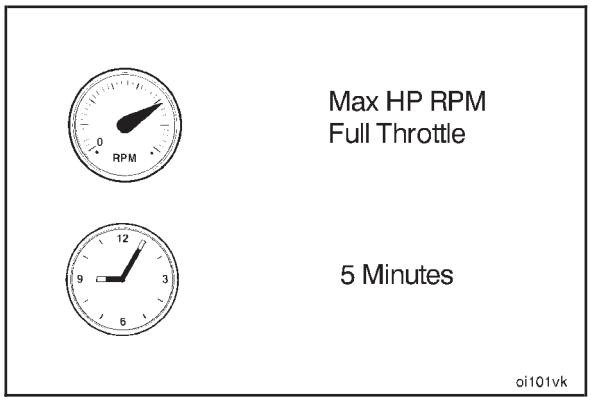
Check all gauges and record the data.



Increase the dynamometer load until the engine speed reduces to the engine's torque peak RPM.

Operate the engine at torque peak RPM for 7 minutes.

Check all gauges and record the data.



Reduce the dynamometer load until the engine speed increases to the engine's maximum horsepower RPM.

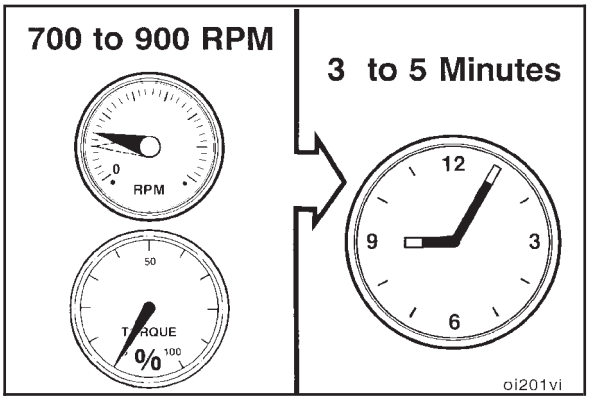
Operate the engine at maximum horsepower RPM for 5 minutes.

Check all gauges and record the data.

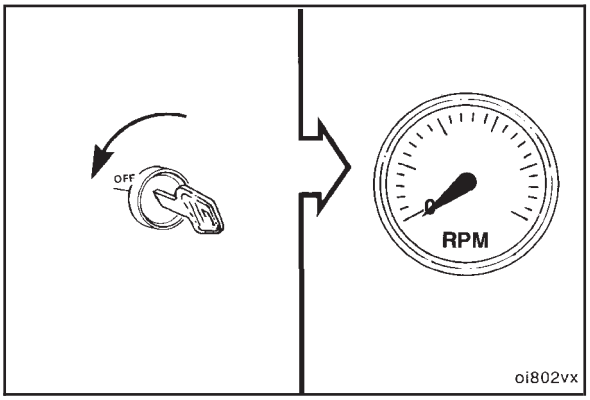
Compare the readings to the specifications listed in the previously mentioned publications.

Caution: Shutting off the engine immediately after operating at full load will damage the turbocharger and internal components. Always allow the engine to cool before shutting it off.

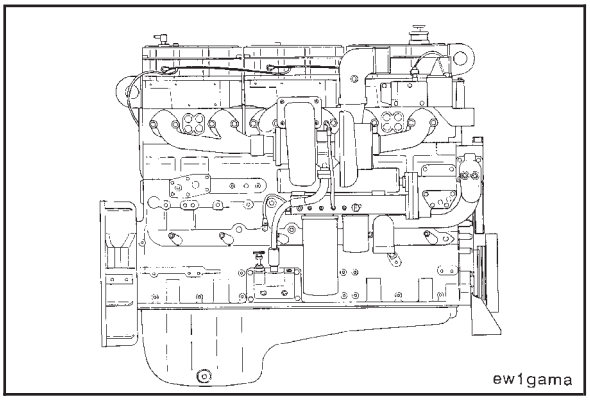
Remove the dynamometer load completely, and operate the engine at 700 to 900 RPM for 3 to 5 minutes. This period will allow the turbocharger and other components to cool.



Shut off the engine.



Make sure all instrumentation is removed before removing the engine from the engine dynamometer.



Dynamometer Worksheet

Date _____ Repair Order No. _____ Operator_____

ESN _____ CPL _____ Fuel Pump Code_____

Complaint_____ SC Code (CELECT™)_____

PARAMETER	CODE SPECIFICATIONS	ACTUAL READING
Fuel Pressure (psi @ RPM)		
Fuel Rate (pph)		
Check Point 1 (psi @ RPM)	(Reference Only)	
Intake Mfd. Pressure (in.Hg)		
Governor Break RPM		
No-Air Setting (psi @ RPM)		
*Intake Air Restriction	25 in. H_20, Maximum	
Intake Manifold Temperature for CAC Engines	150°F or Below (Target Range) 170°F Maximum	
*Exhaust Air Restriction	3 in. Hg, Maximum	
*Fuel Inlet Restriction	8 in. Hg (Dirty Filter), Maximum	
*Fuel Drain Line Restriction	2.5 in. Hg with Check Valves, Max. 6.5 in. Hg without Check Valves, Max.	
Engine Blowby	12 in. H_20 New Engines, Max. 18 in. H_20 Used Engines, Max.	

*Recorded at Advertised Horsepower (Maximum Power)

Road Speed Limit _____ **Engine High Speed Limit**_____

Check Oil Level ____ Low ____ High ____ OK **Fuel Quality** ____ **OK** ____ **Not OK**

ENGINE SPEED (RPM)	*FUEL RATED (pph)	FUEL PRESSURE (psi)	INTAKE MANIFOLD PRESSURE (in. Hg)	INTAKE MANIFOLD TEMP. (°F]	† ENGINE BLOWBY (in.H_20)	LUBRICATING OIL PRESSURE (psi)	HORSEPOWER OR TORQUE

* Be Sure That the Fuel Rate is Corrected for Temperature.

Fuel Temperature	Correction for Flow Rate
Less than 7°C[45°F]	Flow meter **not** accurate
7 to 13°C[45 to 55°F]	Subtract 2% from flow rate reading
13.0 to 20.0°C[55 to 68°F]	Subtract 1% from flow rate reading
20.0 to 29°C[68 to 85°F]	No Correction
29 to 42°C[85 to 108°F]	Add 1% to flow rate reading
42 to 56°C[108 to 132°F]	Add 2% to flow rate reading
56°C above [132°F]	Flow meter **not** accurate.

Pressure Conversions
1 in. H_20 = 0.074 in. Hg = 0.036 psi 1 in. Hg = 13.514 in. H_20 = 0.491 psi 1 psi = 2.036 in. Hg = 27.7 in. H_20

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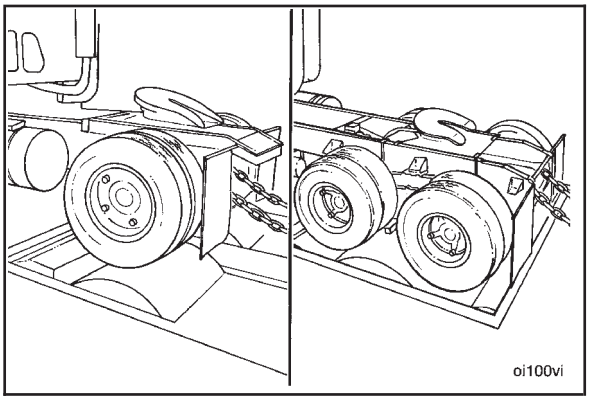
Chassis Dynamometer Operation (14-04)



The performance of an engine installed in ‘‘on-highway’’ vehicles can be tested on a chassis dynamometer.

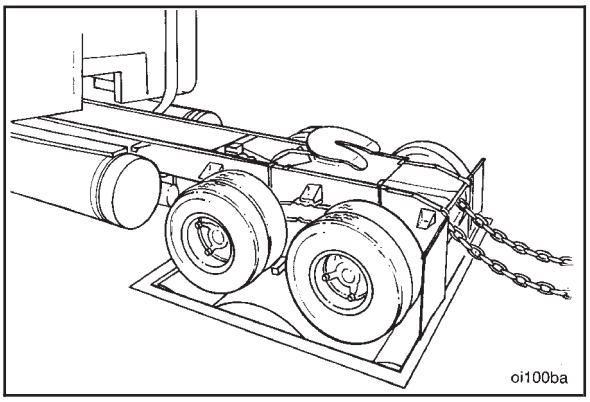
NOTE: Due to driveline inefficiencies and engine-driven accessories, the rated horsepower will be reduced by approximately:

- 20 percent for single axle vehicles
- 25 percent for tandem axle vehicles

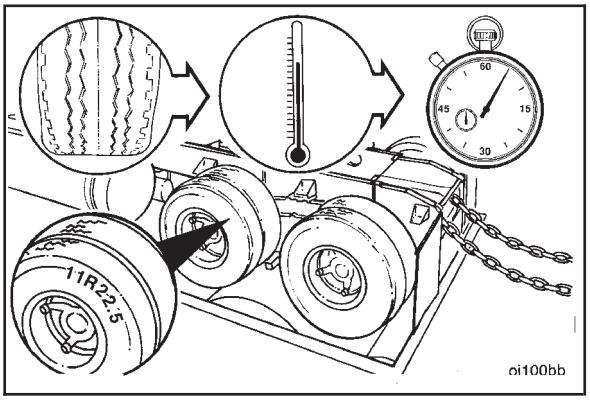
The net horsepower available is called wheel horsepower (WHP).

NOTE: These percentages are used for engine run-in only and are **not** to be used as absolute figures.

Caution: Before installing or operating a vehicle on a chassis dynamometer, follow all the vehicle manufacturer’s safety precautions.

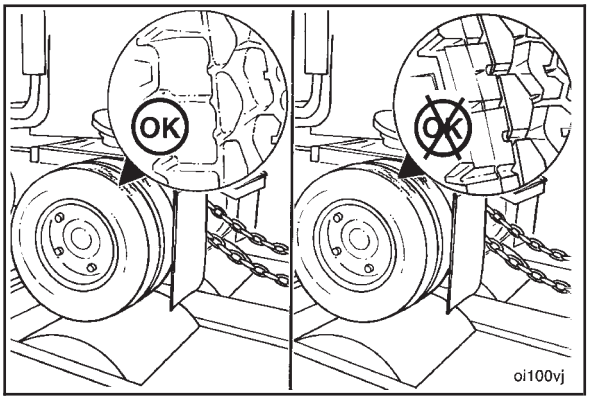


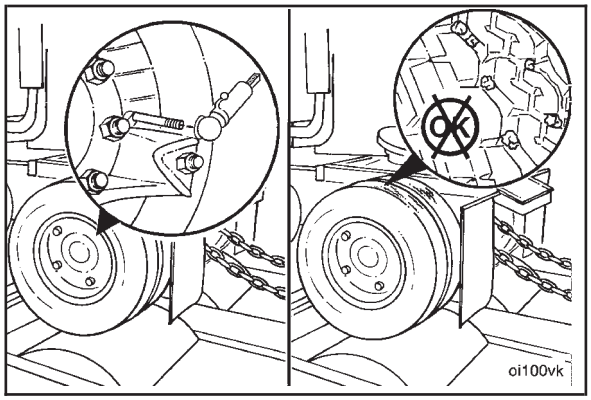
Caution: Low profile radial tires are more sensitive to heat than bias ply tires. Excessive operating time at full load can damage tires due to overheating. Check the tire manufacturer’s recommendations for the maximum allowable chassis dynamometer operating time.



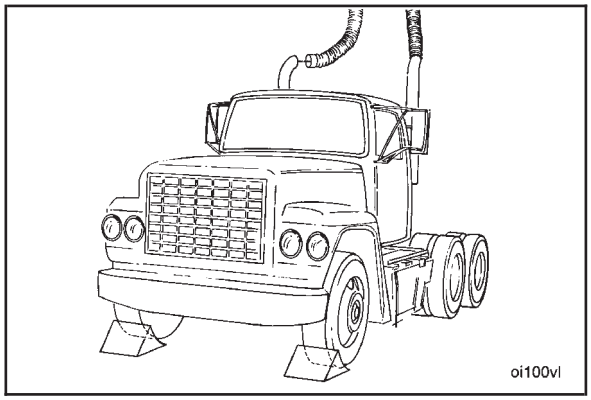
The following are general safety precautions to be observed while operating the chassis dynamometer.

- Use tires that have more than 160 kilometers [100 miles] on them. Do **not** use new tires.
- Do **not** use recapped tires or tires of different sizes or designs.

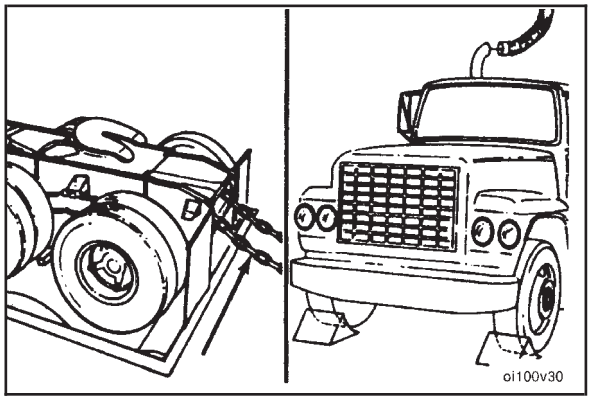




- Make sure the tires are inflated to the manufacturer's specifications.
- Remove all rocks or other material from the tread of all tires that will be rotating on the dynamometer rollers.

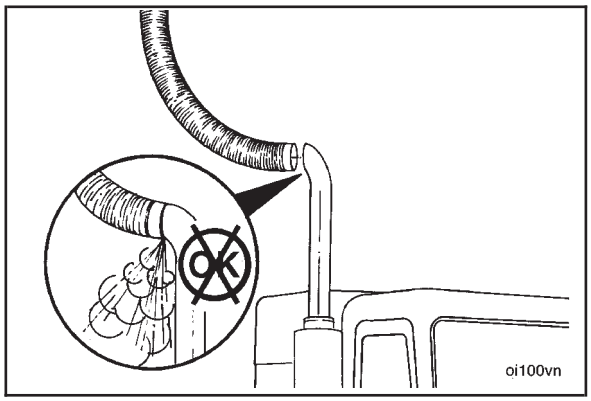


- Make sure there is correct overhead clearance for exhaust stacks, air deflectors, or other attachments above the cab.



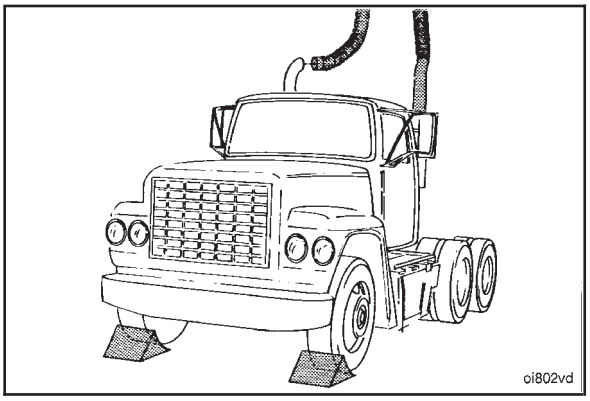
Caution: The ''tie down'' chains must have slack in their tension to prevent damage to the chassis dynamometer.

- Carefully position the vehicle on the rollers.
- Attach the ''tie down'' chains to the rear of the vehicle, and put wheel chocks in front of the front wheels.



- Adjust the vehicle and dynamometer room exhaust system to make sure all exhaust gases are removed from the room.
- Refer to the chassis dynamometer and vehicle manufacturer's recommendations and specifications for testing procedures.

- Make sure there is proper overhead clearance for exhaust stacks, air deflectors, or other attachments above the cab.

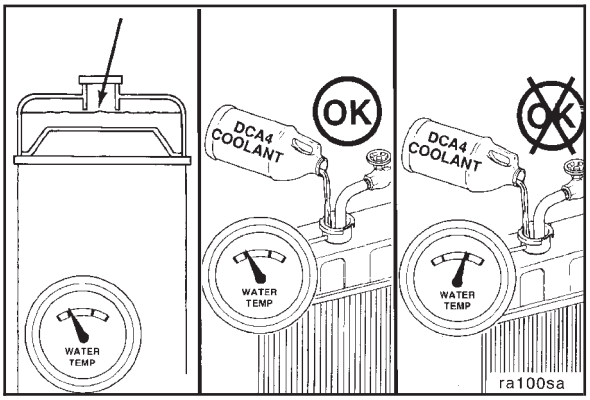


General Test Procedure - Chassis Dynamometer (14-05)

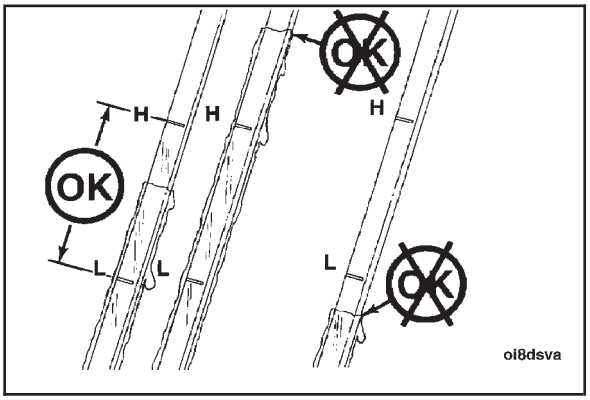
Check the engine coolant level to be sure it is filled to the proper level.

Warning: Check the coolant level only when the engine is stopped. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Failure to do so can cause personal injury from heated coolant spray.

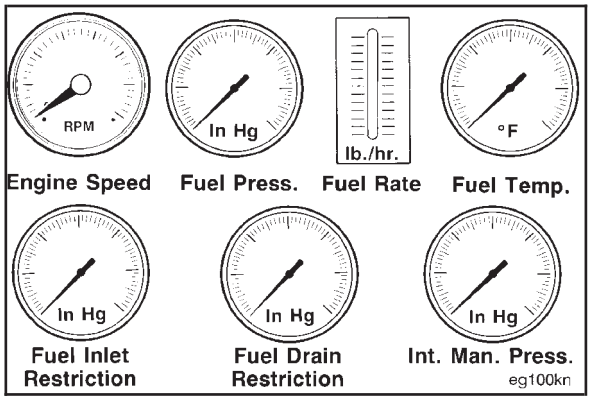
Caution: Do not add cold coolant to a hot engine. This can cause engine casting damage. Allow the engine to cool to below 50°C [120°F] before adding coolant.



Check the engine lubricating oil level to be sure it is filled to the proper level.

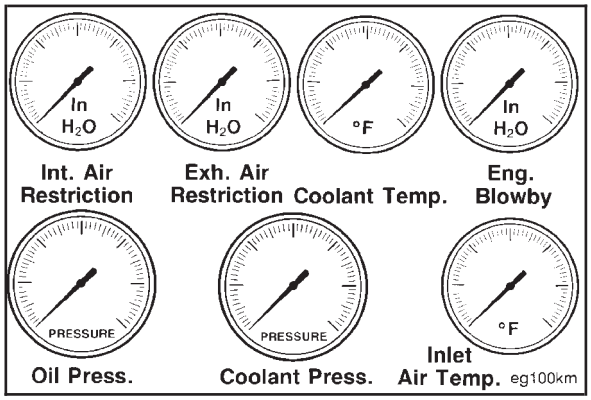


NOTE: Use a known source of ‘‘good’’ quality No. 2 diesel fuel. This is very important since No. 1 diesel fuels, along with most other alternate fuels, are lighter (lower specific gravity, higher API gravity) than No. 2 diesel fuel. The lighter the fuel, the lower the energy content (BTU) per gallon (liter, etc).

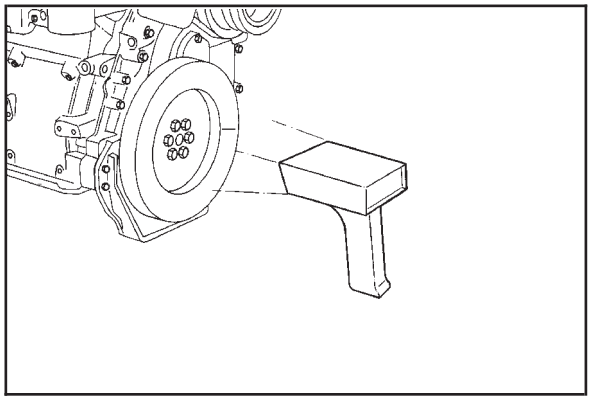


To properly monitor engine performance, record the following parameters. To limit dynamometer operating time, instrument the engine to make as many checks as possible.

- Engine speed rpm with a verified tachometer
- Fuel pressure
- Fuel rate
- Fuel temperature (if needed to correct fuel rate)
- Fuel inlet restriction
- Fuel drain line restriction
- Intake manifold pressure

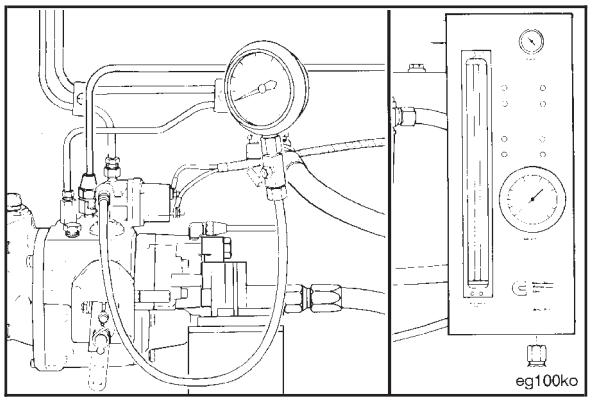


- Intake air restriction
- Exhaust air restriction
- Coolant temperature
- Engine blowby
- Lubricating oil pressure
- Coolant pressure
- Inlet air temperature



Engine Speed (RPM) With a Verified Tachometer

Use digital optical tachometer, Part No. 3377462, to check and verify engine speed.



Fuel Pressure (STC Engines Only)

Measure the fuel pressure on STC engines. Install the pressure gauge, Part No. ST-435-6, or the pressure gauge in the fuel measuring device, Part No. 3376375, to the Compuchek® fitting on the fuel shut-off valve.

NOTE: Pressure gauge, Part No. ST-435-6, is included with snap rail pressure gauge, Part No. 3375932.

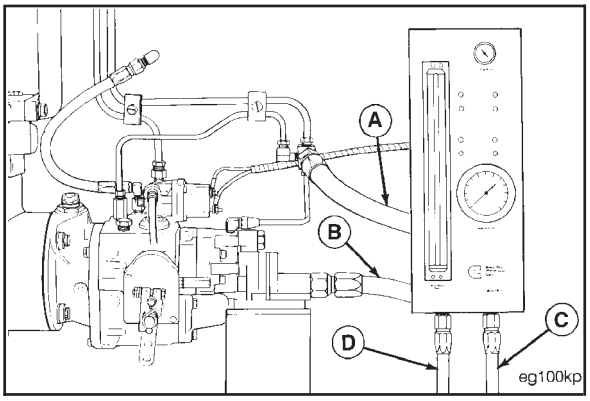
Fuel Rate

Use fuel measuring device, Part No. 3376375, to measure the rate of fuel consumption.

Install the fuel measuring device as follows:

- The fuel return hose from the engine to the fuel measuring device (A).
- The fuel inlet hose to the fuel filter inlet (B).
- The return hose from the device (C) to the fuel tank.
- The fuel inlet hose to the device from the fuel tank suction line (D).

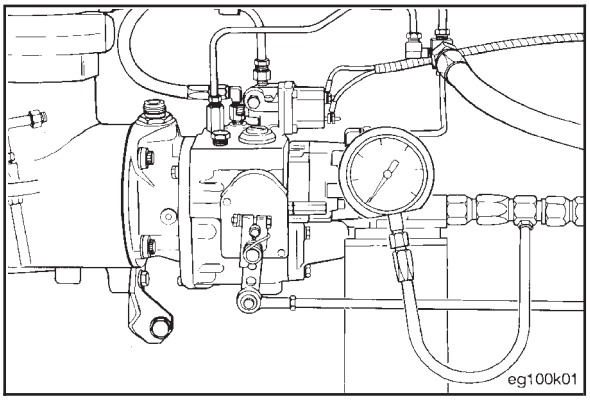
NOTE: Adjust the fuel rate to compensate for temperature variation if required.



Fuel Inlet Restriction

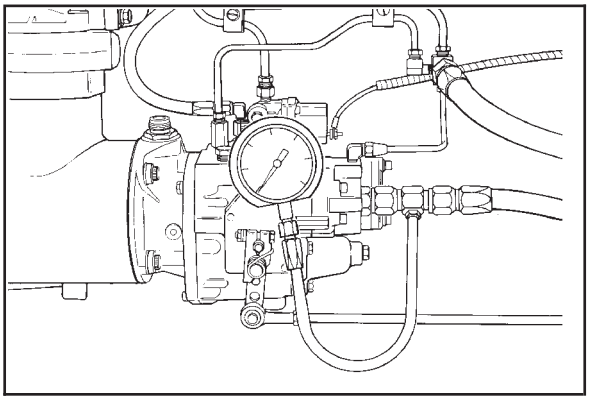
Measure the fuel inlet restriction. Install a vacuum gauge, Part No. ST-434, between the fuel pump inlet and the gear pump inlet.

NOTE: Do **not** measure fuel inlet restriction with the fuel measuring device installed. This will **not** measure the inlet restriction of the vehicle's supply plumbing.



Hold the gauge at the same level as the gear pump.

NOTE: The gauge will **not** measure the correct vacuum if the gauge is **not** held at the same level as the gear pump.



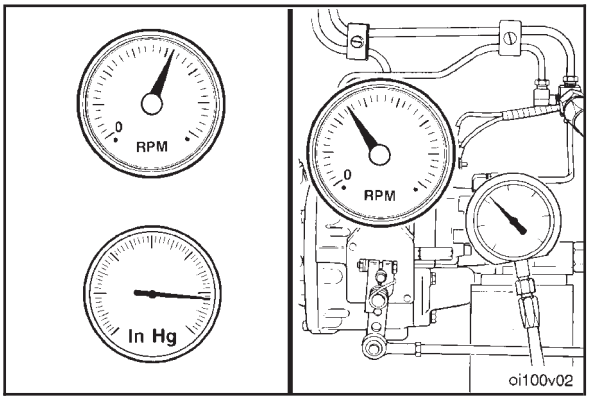
Operate the engine at maximum horsepower RPM and Advertised Horsepower.

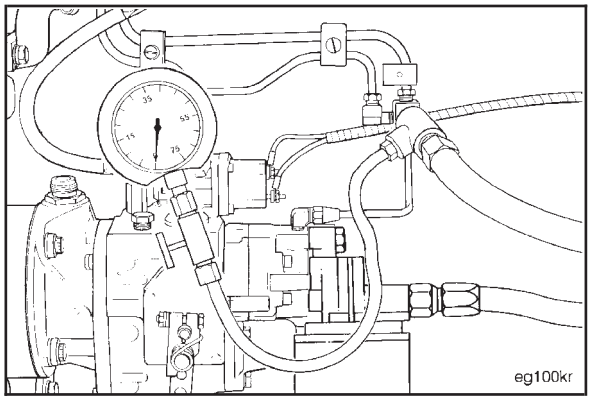
Observe the reading on the gauge.

NOTE: The maximum fuel inlet restriction is as follows:

	STC	CELECT™ (plus ECM Cooling Plate)
Clean fuel filter:	102 mm Hg [4 in Hg]	127 mm Hg [5 in Hg]
Dirty fuel filter:	203 mm Hg [8 in Hg]	228 mm Hg [9 in Hg]

Correct the restriction or replace the fuel filter.

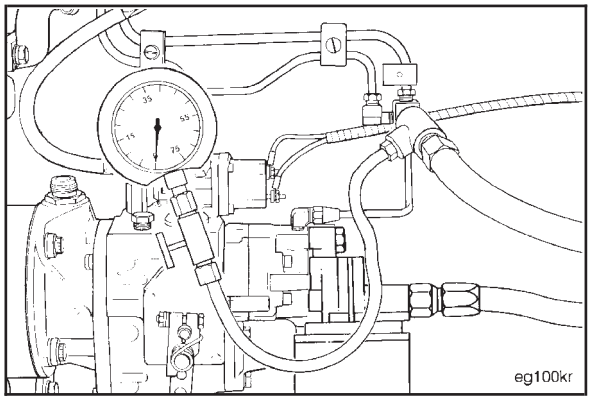




Fuel Drain Line Restriction

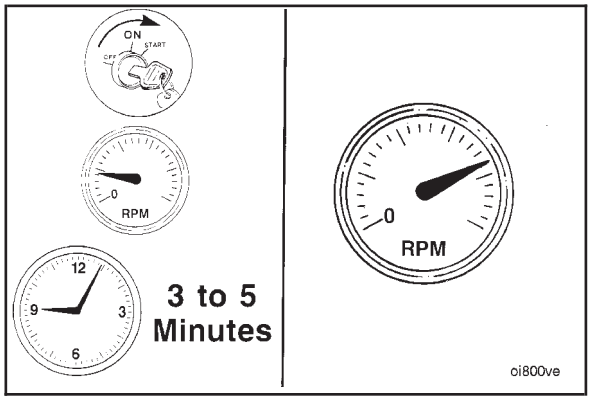
Use Pressure Gauge, Part No. ST-1273, to measure fuel drain line restriction.

NOTE: Do **not** measure fuel drain line restriction with the fuel measuring device installed. This will **not** measure the drain line restriction of the vehicle's return plumbing.



Hold the gauge at the same level as the connection.

NOTE: The gauge will **not** measure the correct pressure if the gauge is **not** held at the same level as the connection.



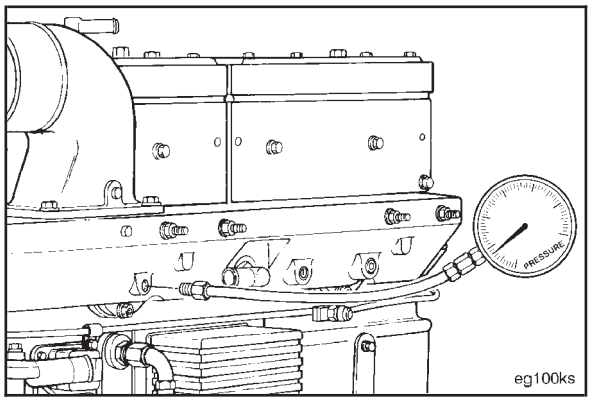
Operate the engine at maximum horsepower RPM and Advertised Horsepower.

Observe the reading on the gauge.

NOTE: The maximum fuel drain line restriction for STC and CELECT™ is as follows:

With Check Valves: 165 mm Hg [6.5 in Hg]

Without Check Valves: 65 mm Hg [2.5 in Hg]



Intake Manifold Pressure

Measure the intake manifold pressure (turbocharger boost). Install pressure gauge, Part No. ST-1273, in the intake manifold as shown.

Observe the reading on the pressure gauge.

Charge Air Cooler Restriction

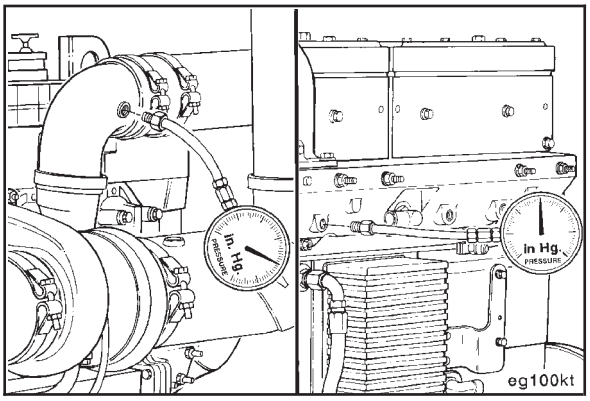
Measure the intake pressure drop across the charge air cooler.

This test can be done with a mercury manometer or two separate gauges, Part No. ST-1273. If two gauges are being used, calibrate both gauges on a common pressure source at 206 kPa [30 PSI] to ensure consistency.

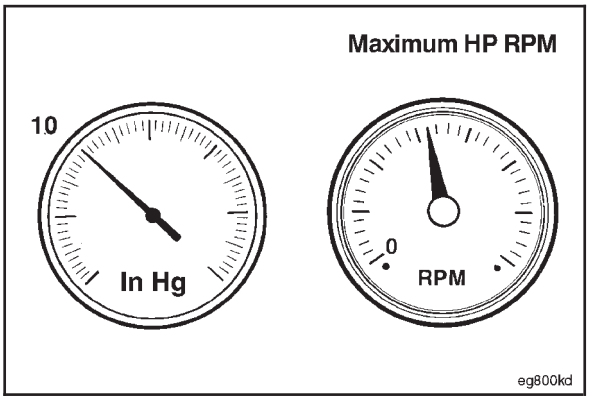
Install one pressure gauge, Part No. ST-1273, in the fitting in the turbocharger compressor outlet elbow. Install the other pressure gauge in the fitting in the intake manifold.

Observe the reading on the gauges. Pressure drop **must not** be greater than:

102 mm Hg [4.0 in. Hg]
14 kPa [2.0 psi]



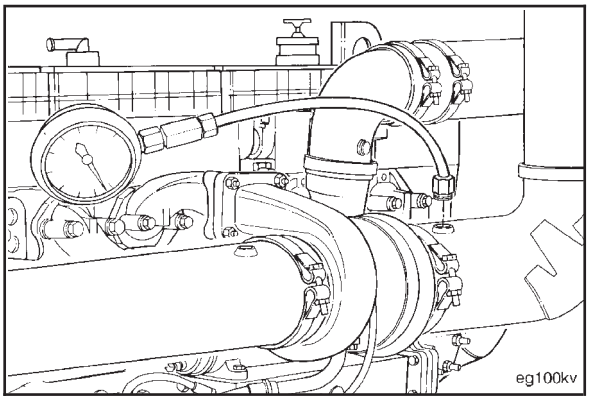
NOTE: When measuring the pressure drop, operate a dynamometer at the rpm that delivers the maximum horsepower of engine tested. Engine speed will be 1600-1700 rpm on most engines.

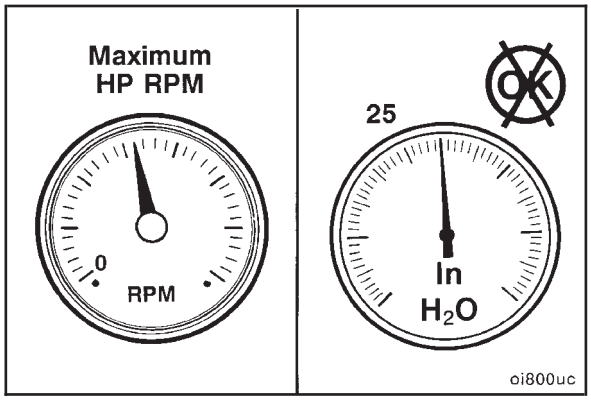


Intake Air Restriction

Measure the inlet air restriction. Install the vacuum gauge, Part No. ST-434, or a manometer in the intake air piping.

NOTE: The gauge adapter **must** be installed at a 90 degree angle to the air flow in a straight section of pipe at a minimum of one pipe diameter before the turbocharger.

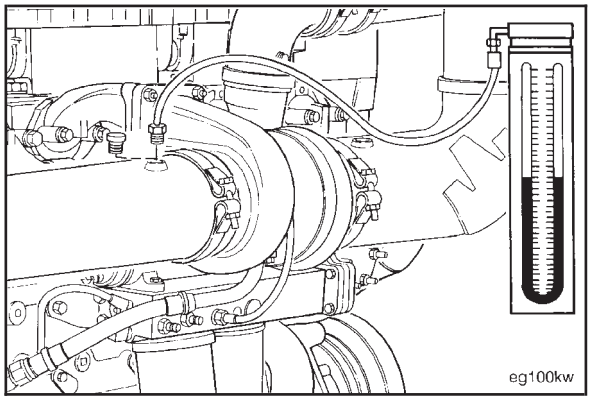




Operate the engine at maximum horsepower RPM and Advertised Horsepower.

Observe the reading on the gauge or manometer.

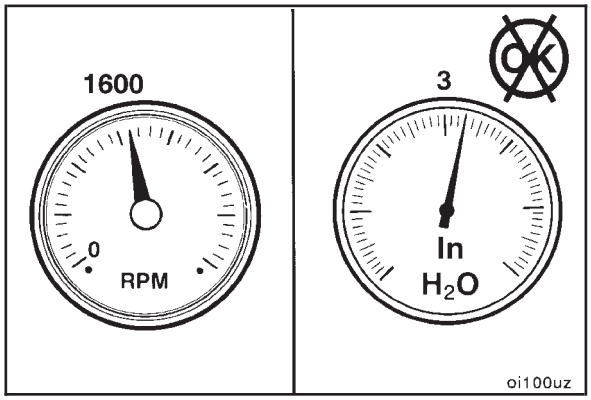
NOTE: Restriction **must not** exceed 635 mm H_20 [25 inches H_20].



Exhaust Air Restriction

Measure the exhaust air restriction. Install the vacuum gauge, Part No. ST-1273, or a manometer in the exhaust air piping.

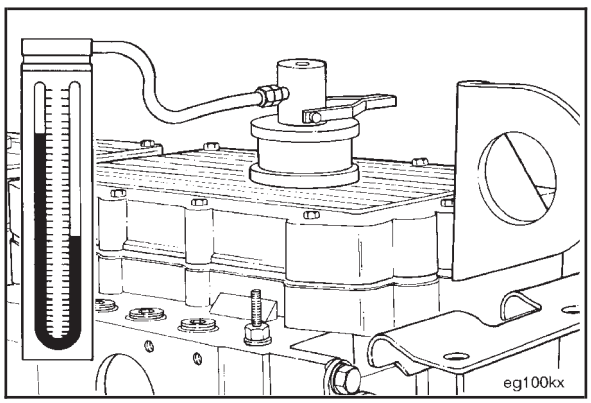
NOTE: The gauge adapter **must** be installed near the turbocharger in a straight section of pipe at the turbine outlet.



Operate the engine at maximum horsepower RPM and advertised horsepower.

Observe the gauge or manometer.

NOTE: Pressure **must not** exceed 75 mm Hg [3.0 inches Hg].



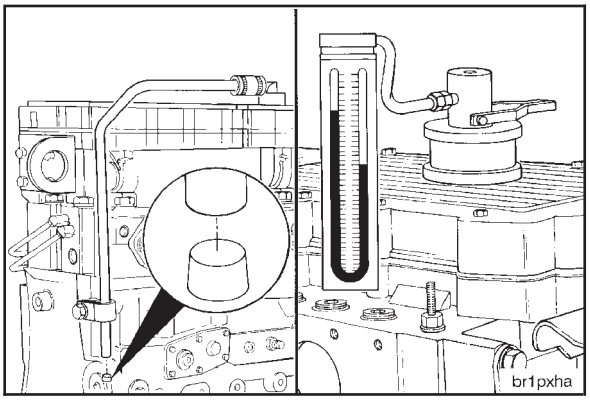
Engine Blowby

Measure the engine crankcase pressure.

Use blowby checking tool, Part No. 3375150, and water manometer, Part No. ST-1111-3.

Install a plug in the crankcase breather vent tube.

Remove the ''bottle stopper'' oil filler cap and install the blowby checking tool, Part No. 3375150.

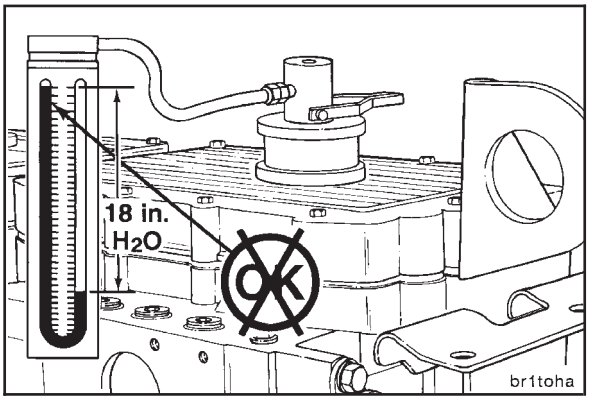


Install the water manometer to the blowby checking tool. Observe the engine blowby.

Engine blowby **must not** exceed the following specifications:

Blowby Specifications	
New, Rebuilt Engines*	30.5 cm H_20 [12.0 in H_20]
Used Engines**	46.0 cm H_20 [18.0 in H_20]

*Less than 160,000 km [100,000 miles] or 3600 hours.
**Over 160,000 km [100,000 miles] or 3600 hours.



Lubricating Oil Pressure

Use Pressure Gauge, Part No. 3375275, to measure lubricating oil pressure.

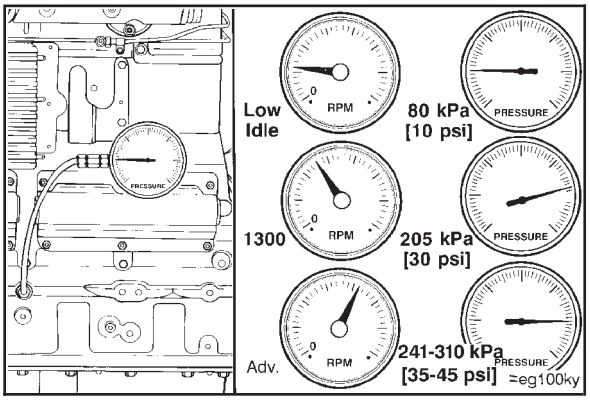
Install the pressure gauge to the main oil rifle and observe the oil pressure.

Low Idle (minimum allowable) 80 kPa [10 psi]

At 1300 RPM (minimum allowable) 205 kPa [30 psi]

At 2100 RPM 310 to 375 kPa [45 to 55 psi]

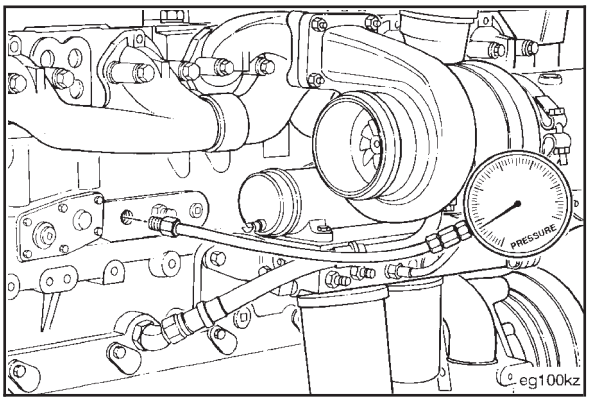
NOTE: On STC equipped engines, oil pressure will appear higher (approximately 620 to 690 kPa [90 to 100 psi]) when the oil temperature is cold due to the viscosity sensor.

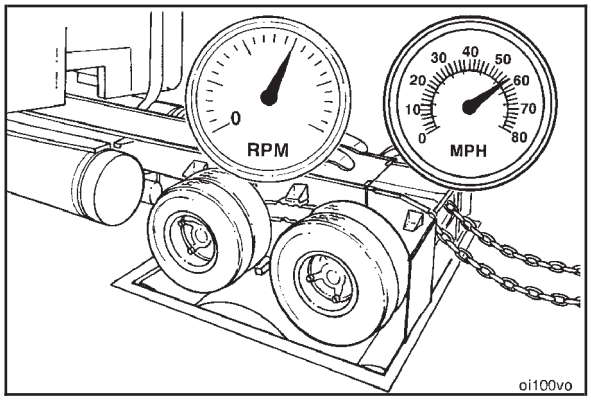


Coolant Pressure

Use coolant pressure/temperature/flow analyzer kit, Part No. 3822994, to measure engine coolant pressure.

Maximum coolant pressure (pressure cap removed) with closed thermostat is 317 kPa [46 psi].

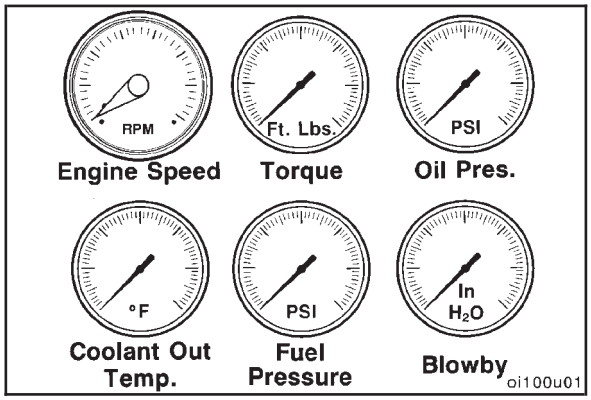




Engine Run-In Procedure - Chassis Dynamometer (14-06)

NOTE: Refer to Chassis Dynamometer Operation, Procedure 14-04, for general operating procedures and safety precautions.

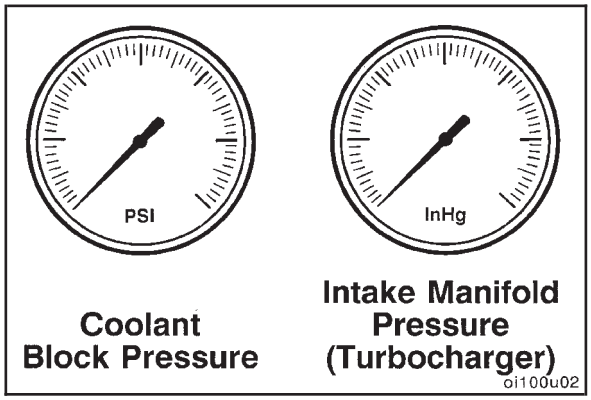
NOTE: Operate the vehicle in a gear that produces a road speed of 90 to 100 km/h [55 to 60 mph] at maximum horsepower RPM.



Monitor and record the following measurements during run-in:

- Compulink (install on CELECT™ engines)
- Lubricating oil pressure
- Coolant temperature
- Fuel pressure
- Torque
- Blowby
- Engine speed (RPM)
- Fuel flow (use service tool, Part No. 3376375)

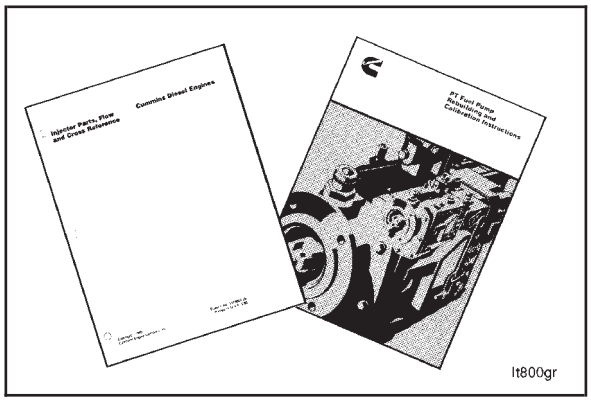
Refer to the Chassis Dynamometer worksheet on the last page of this procedure.



To correctly evaluate the engine performance, this additional measurement, intake manifold pressure (Turbocharger boost), **must** be observed during engine run-in phases.

Refer to the Engine Dynamometer worksheet on the last page of this procedure.

NOTE: It is recommended to monitor block coolant pressure during run-in to aid in early indication of a cooling system problem.



Obtain CPL number from the engine data plate and the fuel pump code from the fuel pump data plate.

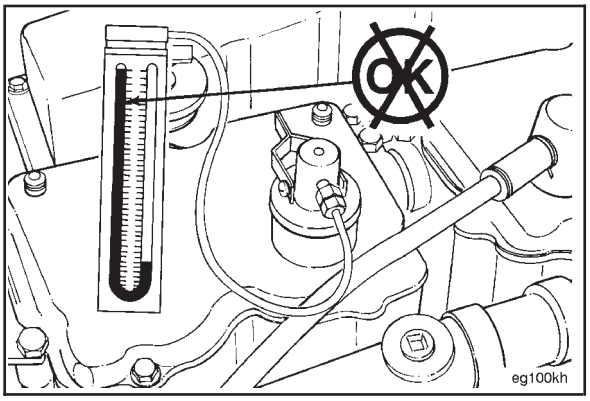
Engine performance specifications and fuel system calibration values are listed for specific engine CPL and fuel pump codes in the following publications:

1. Fuel Pump Calibration Values, Bulletin No. 3379352.
2. Injector Parts Flow and Cross Reference, Bulletin No. 3379664.
3. Engine Data Sheets
4. N14 Troubleshooting and Repair Manual, Bulletin No. 3810456

If a sudden increase in blowby occurs, or if blowby exceeds the maximum allowable limit during any run-in, return to the previous step and continue the run-in. If blowby does **not** reach an acceptable level during the next step, discontinue the run-in and determine the cause.

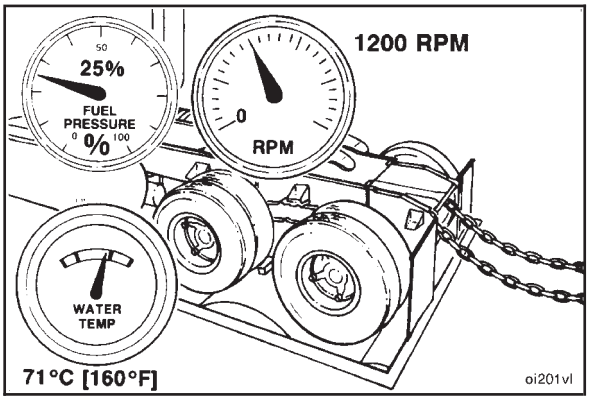
Do **not** proceed to the next step until a steady, acceptable blowby reading is obtained.

NOTE: Blowby **must** be measured by using Service Tool, Part No. 3375150 or 3822566 with manometer, Part No. ST-1111-3, or equivalent. Service Tool, Part No. 3375150, as shown, utilizes a chamfered 7.67 mm [0.302 in] orifice.



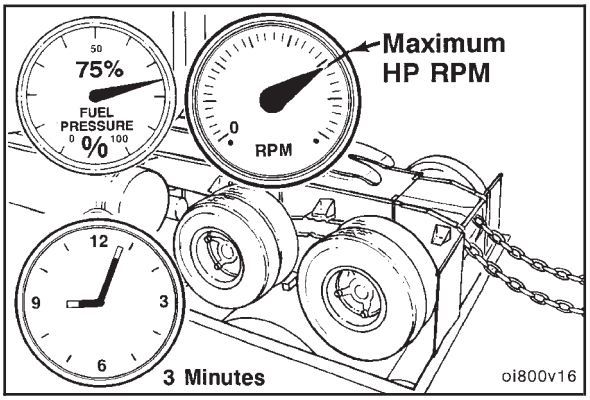
Move the throttle to obtain 1200 RPM engine speed, and apply a test load sufficient to develop 25 percent rated fuel pressure or 25 percent fuel rate on CELECT™ engines.

Operate the engine at this speed and load level until the coolant temperature reaches 71°C [160°F].

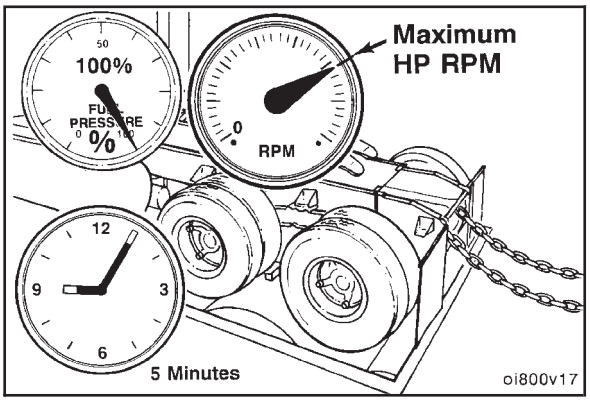


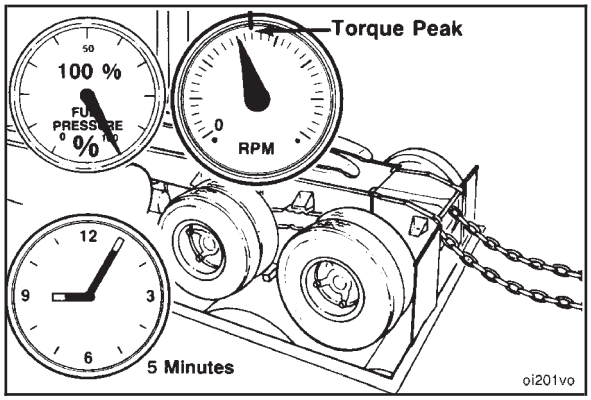
Operate the engine at maximum horsepower RPM and 75 percent of rated fuel pressure or 75 percent fuel rate on CELECT™ engines for 3 minutes. Check the gauges, and record the readings.

NOTE: Do **not** proceed to the next step until a steady, acceptable blowby reading is obtained.



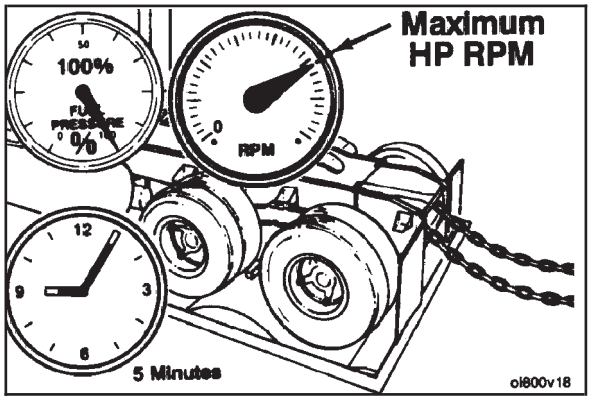
Operate the engine at maximum horsepower RPM and Advertised Horsepower with a wide open throttle, for 5 minutes. Check the gauges, and record the readings.





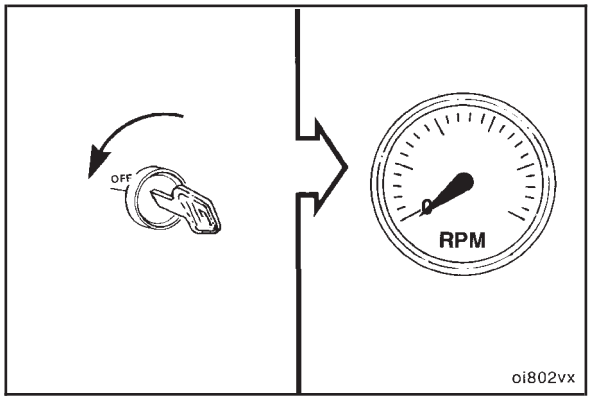
Operate the engine at nominal torque peak RPM, full load, wide open throttle, for 5 minutes. Check the gauges, and record the readings.

NOTE: Refer to the engine ''Data Sheet'' for the torque peak RPM of the engine model being tested.

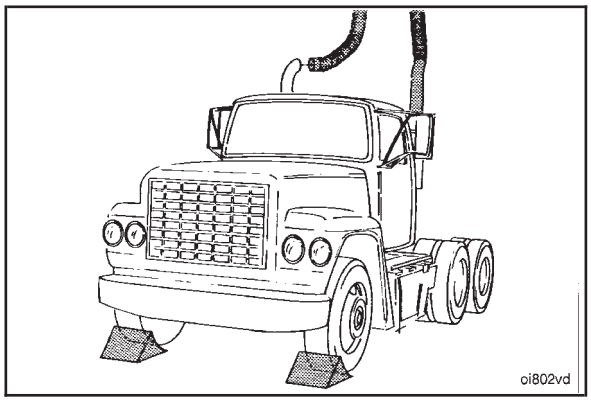


Operate the engine at maximum horsepower RPM and Advertised Horsepower with a wide open throttle for 5 minutes. Check the gauges, and record the readings. Compare the readings to those published on the appropriate engine ''Data Sheet''.

Caution: Do not shut off the engine immediately after the run-in is completed. Allow the engine to cool by operating it at 700 to 900 RPM for a minimum of 3 to 5 minutes to avoid internal component damages. This allows the turbocharger and other components to cool.



Shut off the engine.



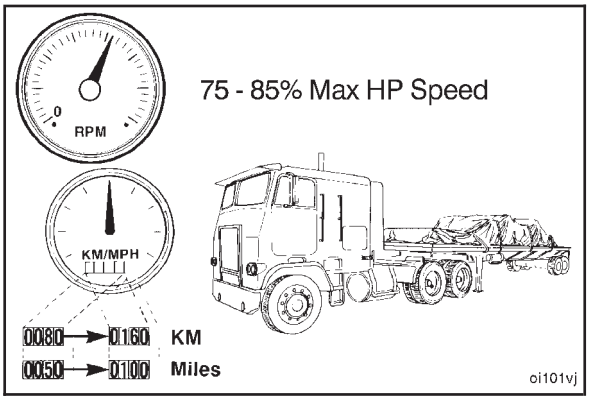
Make sure all instrumentation is removed before removing the vehicle from the chassis dynamometer.

Engine Run-In Procedure Without Dynamometer (14-07)

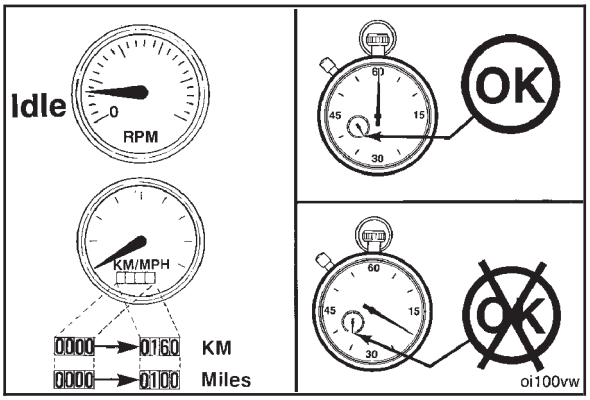
On-Highway

Caution: Refer to General Information and General Engine Test Specifications and Procedures before operating the engine to avoid internal component damage.

Operate the vehicle pulling heaviest available trailer allowed for the first 80 to 160 km [50 to 100 miles] after rebuild. Operate vehicle in highest gear possible within the normal operating RPM range of the engine. It is necessary to operate the engine at or near full throttle at 75 percent to 85 percent of maximum horsepower RPM indicated on the data tag.



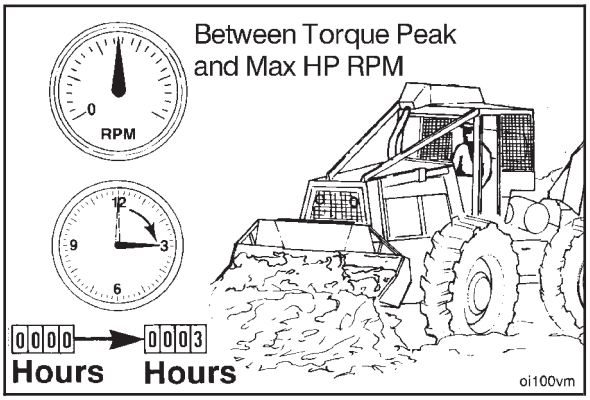
NOTE: Do **not** idle the engine for more than 5 minutes at any one time during the first 160 km [100 miles] of operation.



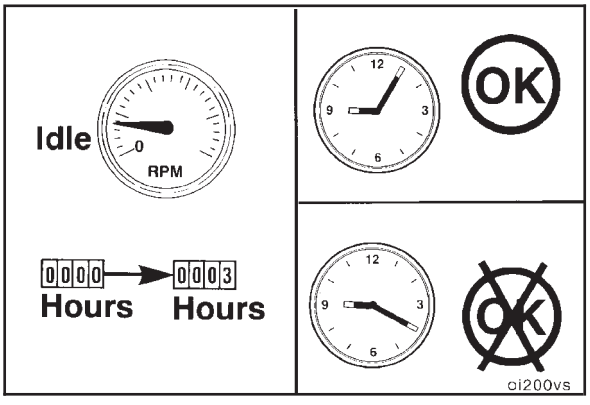
Off-Highway

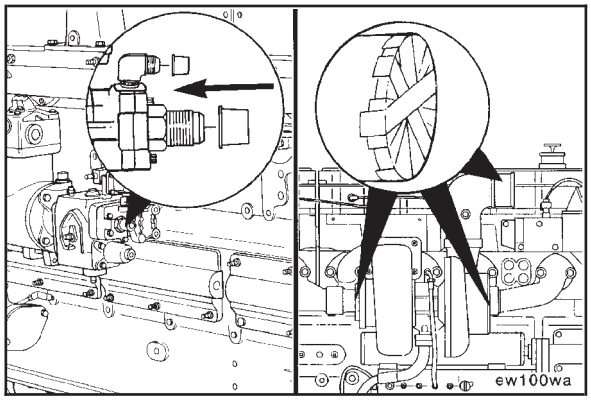
Caution: Refer to General Information and General Engine Test Specifications and Procedures before operating the engine to avoid internal component damage.

Operate the engine under the highest load possible at full throttle within the normal operating RPM range of the engine for the first 3 hours of operation after rebuild.



NOTE: Do **not** idle the engine for more than 5 minutes at any one time during the first 3 hours of operation after rebuild.

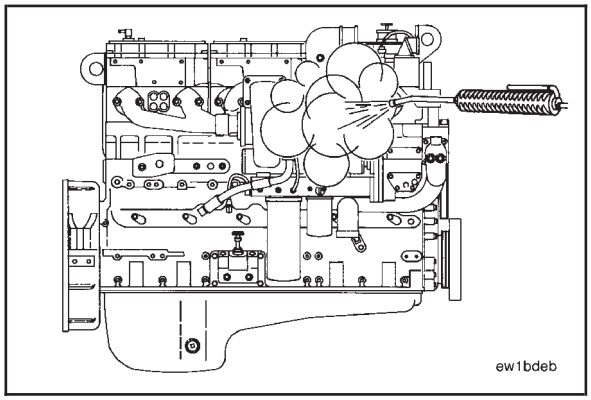




Engine Painting (14-08)

Cover the following:

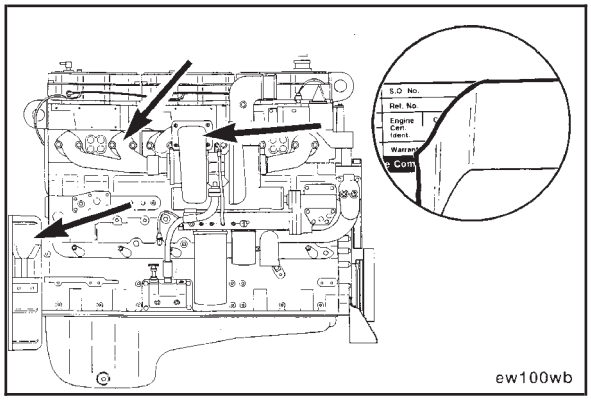
- Exhaust and Intake Openings
- Electrical Components
- Fuel Inlet and Drain Connections
- Any Exposed Fittings, Threads and Electrical Wire Terminals



Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

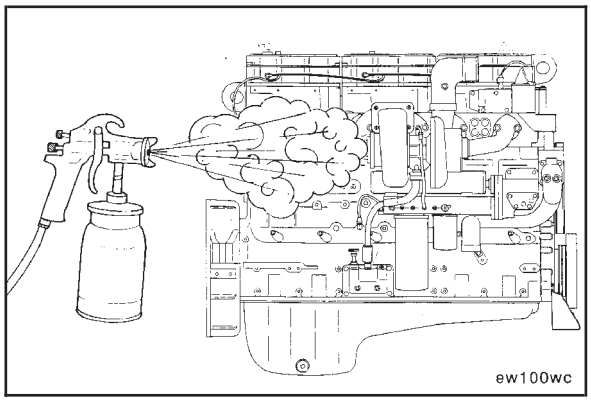
Use steam to clean the engine. Dry with compressed air.

NOTE: Make sure **all** engine surfaces are clean and dry before painting the engine.



Cover the following:

- All Dataplates
- Valve and Injector Set Marks
- Exhaust Manifold
- Turbocharger Turbine Housing
- Flywheel
- Flywheel Housing Transmission Mounting Surface



Paint the engine.

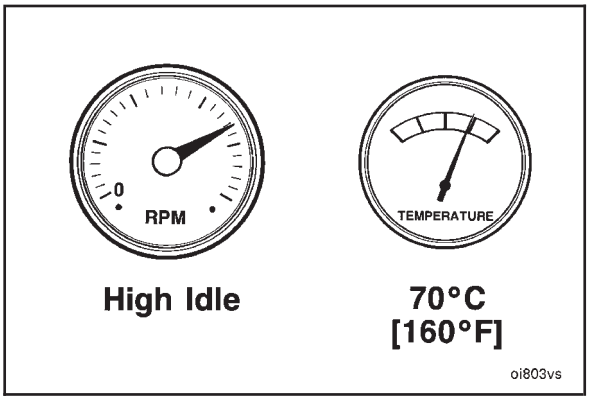
Engine Storage - Short Term (14-09)

NOTE: This procedure describes the proper method to prepare an engine for short term storage (1 to 6 months).

Operate the engine at ''High Idle'' speed until the coolant temperature indicator reaches:

Temperature: 70°C [160°F]

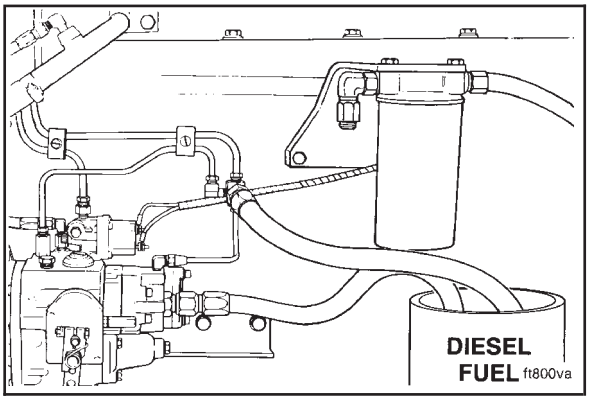
Shut off the engine.



Remove the fuel lines to the engine fuel filter and the injector return line.

NOTE: Use Daubert Chemical NoxRust No. 518 Preservative Oil, or equivalent. The oil **must** meet Military Specification MIL-L-644 Type P-9.

Fill two containers, one with diesel fuel, the second with preservative oil. Install both fuel lines in the container of diesel fuel.

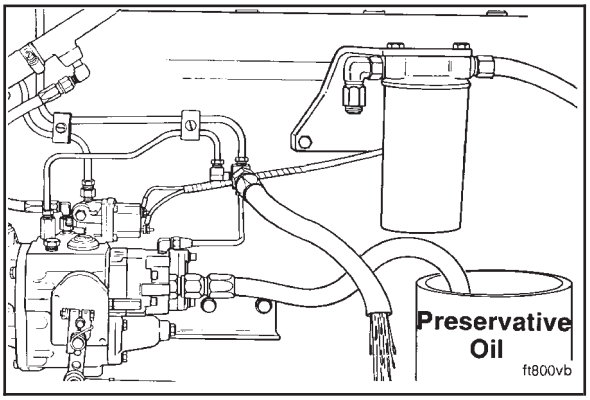


Start the engine.

After the engine is operating smoothly, transfer the fuel supply line to the container of preservative oil. Operate the engine until the preservative oil is coming out of the injector return line.

Shut off the engine.

Install the fuel lines to the fuel filter and the injector return line fitting.

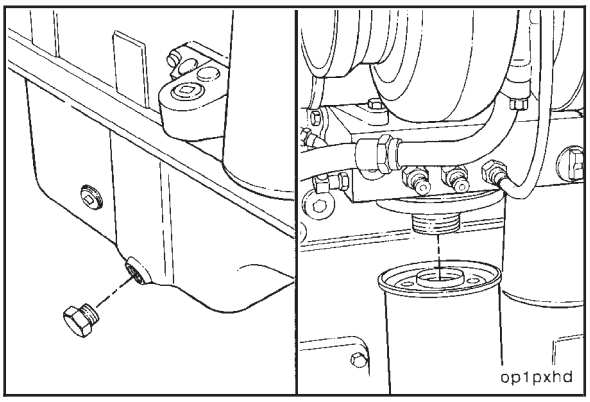


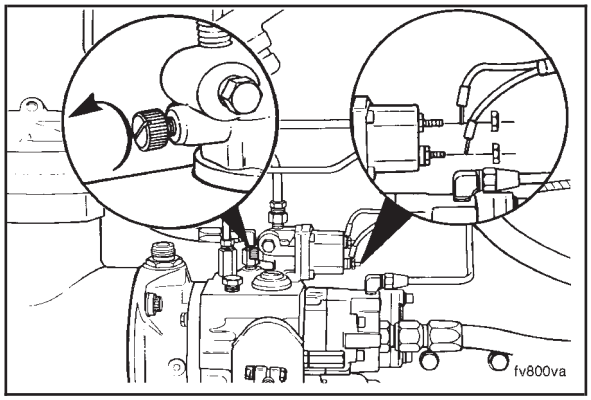
Drain the lubricating oil pan, the oil filters, and the fuel filter.

Install the drain plug in the oil pan.

Torque Value: 136 N•m [100 ft-lb]

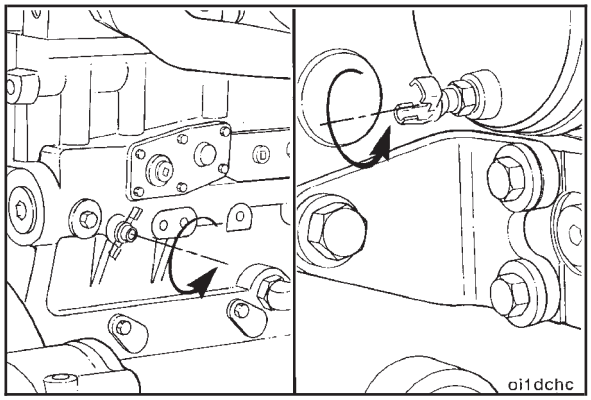
NOTE: Place appropriate brightly colored tag on the engine, stating that the engine oil has been drained.





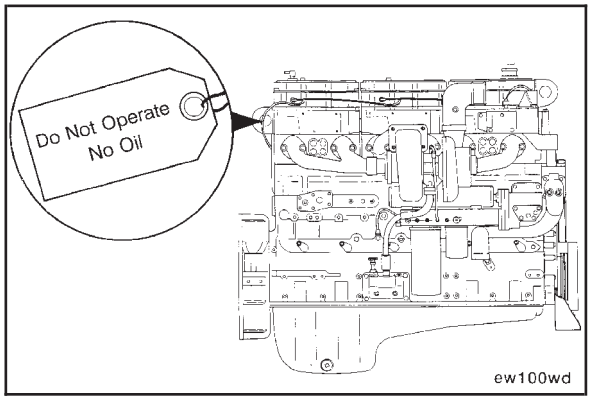
Turn the fuel pump manual shutoff valve **counterclockwise** until it stops.

Remove the electrical wiring from the fuel pump solenoid.



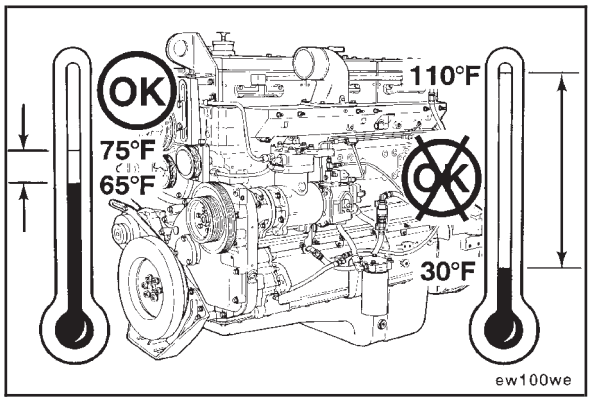
Drain the cooling system.

NOTE: It is **not** necessary to drain the coolant if it is a permanent type antifreeze with a rust inhibitor. Do **not** drain the coolant if the engine is installed in a vehicle.



Cover **all** openings with tape to prevent dirt and moisture from entering the engine.

Install a warning tag on the engine. The tag **must** indicate that the engine does **not** contain oil and **must not** be operated.



Store the engine in an area that is dry and has a constant temperature.

Use the accessory drive shaft to rotate the crankshaft two to three revolutions every 3 to 4 weeks.

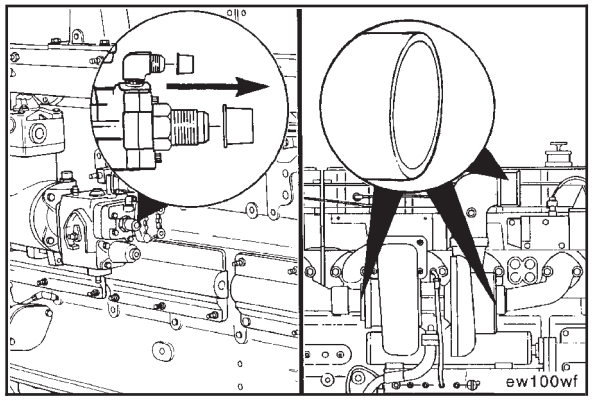
Remove the Engine From Short Term Storage

Remove the tape from the openings. Remove the warning tag.

Replace the oil, water, and fuel filters.

Prime the lubricating oil system. Refer to Priming the Lubricating Oil System (14-02).

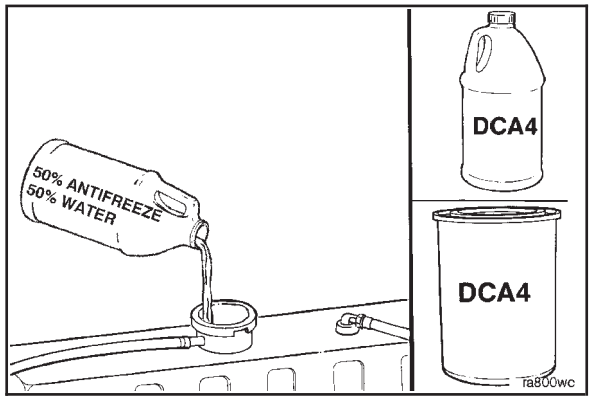
Use clean diesel fuel to flush the preservative oil from the fuel system.



Fill the cooling system (if necessary).

Adjust the injector and valve clearance. Refer to Engine Assembly (00-02).

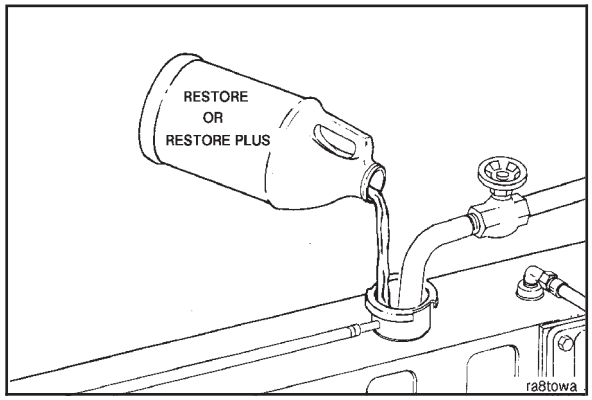
Adjust the belt tension. Refer to Engine Assembly (00-02).



Engine Storage - Long Term (14-10)

This procedure describes the proper method to prepare an engine for long term storage (6 to 24 months).

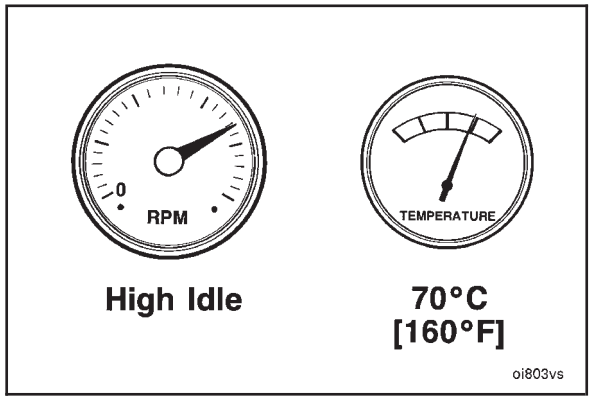
NOTE: After 24 months in storage, the engine cooling system **must** be flushed with a suitable solvent or a light, hot oil. This procedure **must** then be repeated.

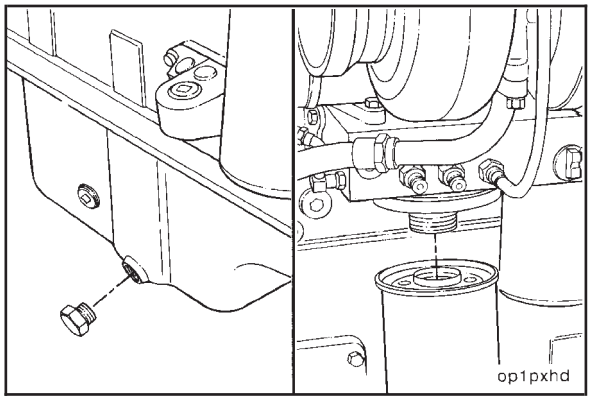


Operate the engine at ''High Idle'' speed until the coolant temperature indicator reaches:

Temperature: 70°C [160°F]

Shut off the engine.



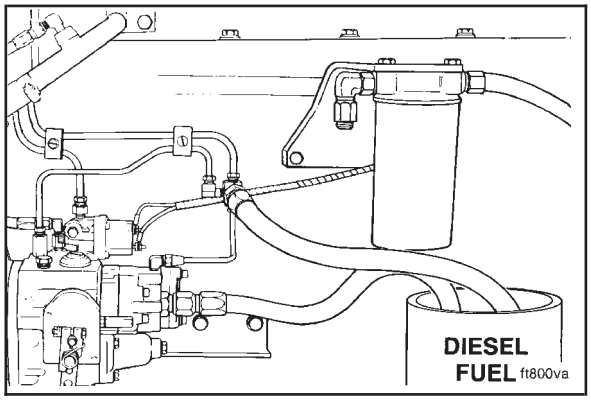


Drain the lubricating oil pan. Install the drain plug.

Torque Value: 136 N•m [100 ft-lb]

Fill the oil pan to the ''High'' level mark with preservative oil.

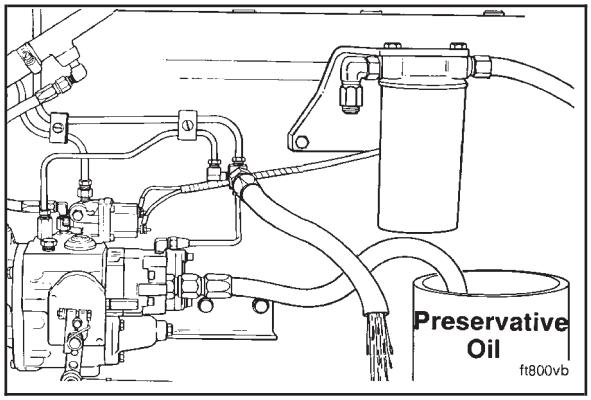
NOTE: Use Shell 66202, or an equivalent preservative oil. The oil **must** meet Military Specification MIL-L-21260 Type R10 Grade 2 SAE 30.



Remove the fuel lines to the engine fuel filter and the injector return line.

NOTE: Use Daubert Chemical NoxRust No. 518 Preservative Oil, or equivalent. The oil **must** meet Military Specification MIL-L-644 Type P-9.

Fill two containers, one with diesel fuel, the second with preservative oil. Install both fuel lines in the container of diesel fuel.

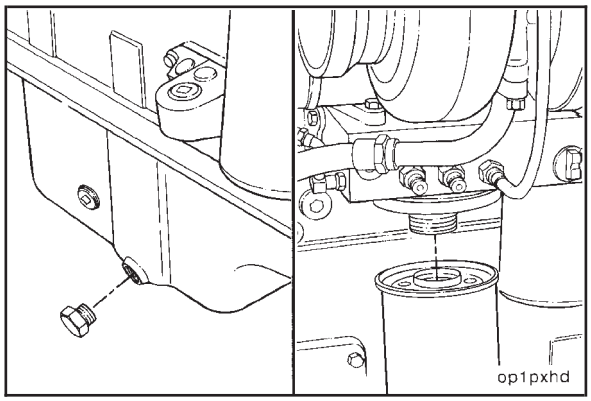


Start the engine.

After the engine is operating smoothly, transfer the fuel supply line to the container of preservative oil. Operate the engine until the preservative oil is coming out of the injector return line.

Shut off the engine.

Install the fuel lines to the fuel filter and the injector return line fitting.



Drain the preservative oil from the lubricating oil pan and the oil filters.

Install the drain plug.

Torque Value: 136 N•m [100 ft-lb]

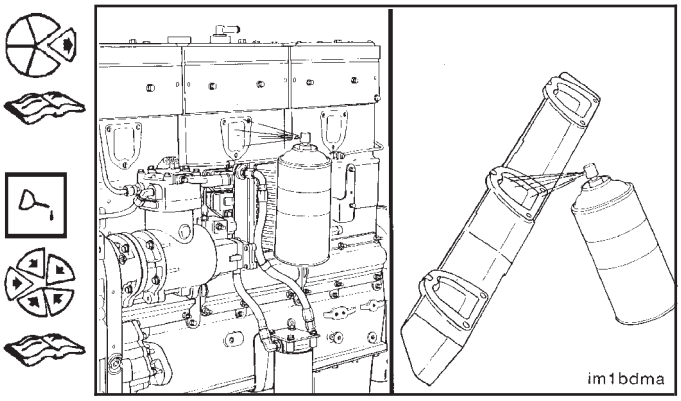
Drain and flush the cooling system.

NOTE: Use a rust inhibitor that will mix with water.

Remove the intake manifold. Remove the exhaust manifold. Refer to Engine Disassembly (00-01).

Spray preservative oil into the intake and exhaust ports in the cylinder head and into the exhaust manifolds.

Install the intake manifold. Install the exhaust manifold. Refer to Engine Assembly (00-02).



Remove the rocker housing cover. Refer to Engine Disassembly (00-01).

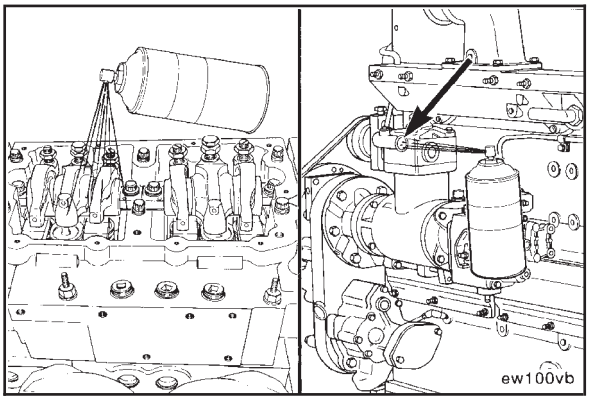
Spray the rocker levers, crossheads, valve springs, valve stems, valve guides, and the push rods with preservative oil.

Install the rocker housing cover. Refer to Engine Assembly (00-02).

Spray preservative oil into the intake port on the air compressor.

Brush or spray preservative compound on all of the exposed surfaces that are not painted.

NOTE: Use a rust preservative compound that meets Military Specification MIL-C-16137C Type P-2 Grade 1 or 2.

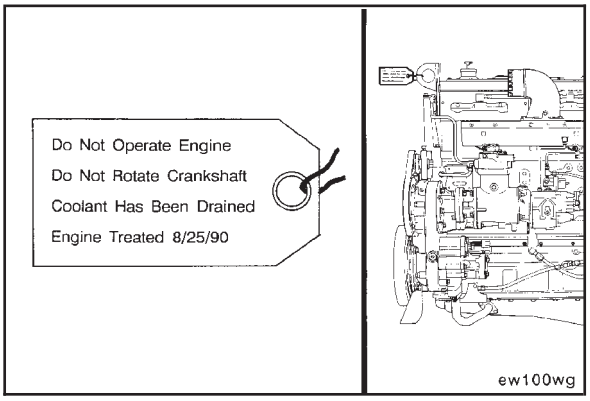


Cover **all** of the openings with heavy paper and tape to prevent dirt and moisture from entering the engine.

Install a warning tag on the engine. The tag **must** indicate:

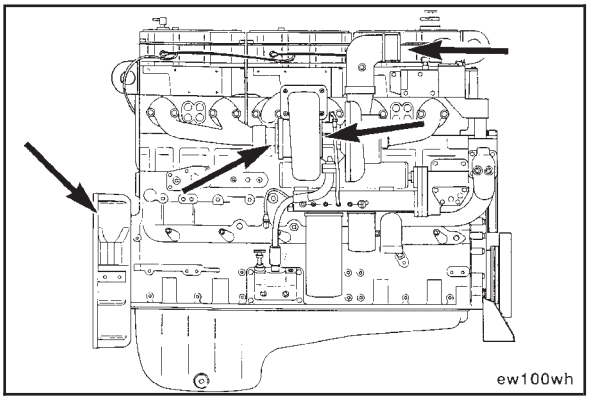
- The date the engine was treated with preservatives.
- Do **not** rotate the crankshaft.
- The coolant has been drained.
- Do **not** operate the engine.

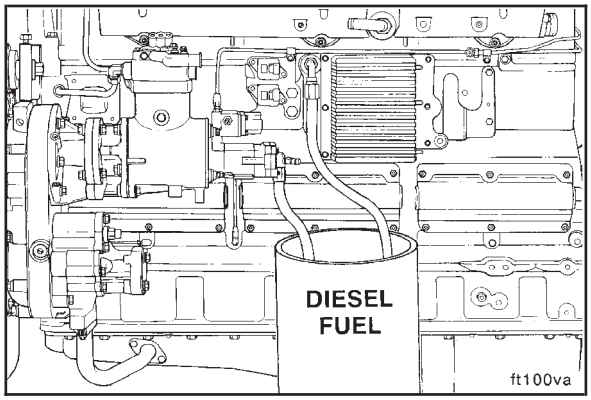
Store the engine in an area that is dry and has a constant temperature.



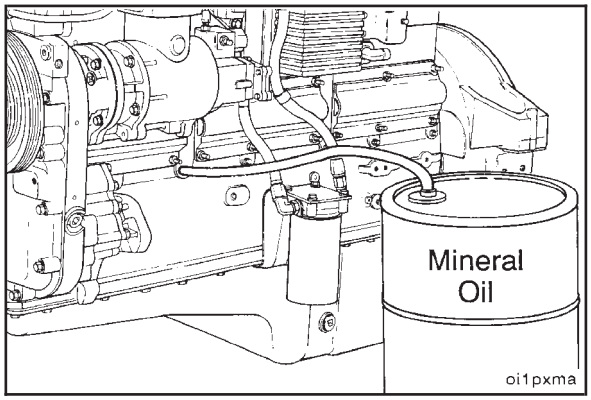
Remove the Engine from Long Term Storage

Remove the heavy paper and tape from the openings. Remove the warning tag.





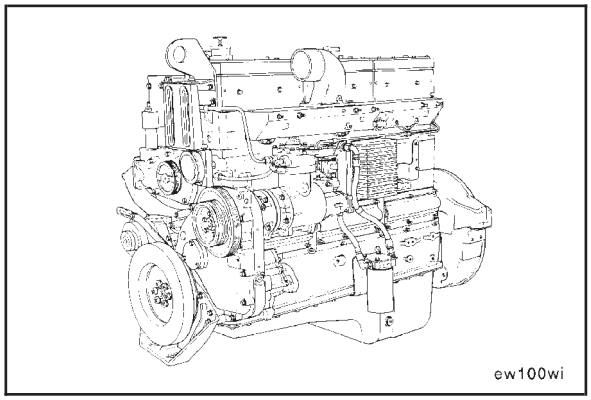
Use clean diesel fuel to flush the preservative oil from the fuel system.



Remove a plug from the main oil rifle drilling. Use a light mineral oil to flush the preservative oil from the engine.

NOTE: Use the accessory drive shaft to rotate the crankshaft three to four revolutions during the flushing procedure.

Drain and flush the cooling system.



Replace the oil, water, and fuel filters.

Fill the cooling system with coolant.

Prime the lubricating oil system. Refer to Priming the Lubricating Oil System (14-02).

Adjust the injector and valve clearance. Refer to Engine Assembly (00-02).

Adjust the belt tension. Refer to Engine Assembly (00-02).

Tighten the intake manifold cover capscrews. Tighten the exhaust manifold capscrews. Refer to Engine Assembly (00-02).

Section 15 - Instruments and Controls - Group 15

Section Contents

Instruments and Controls - General Information

The instruments and controls group consists of the gauges, speed switches, safety controls, cold weather operating aids, etc. used on Cummins engines.

Gauges that indicate the coolant temperature, oil pressure, and oil temperature will provide the operator information on the condition of the engine. Overheating and low or high oil pressure indicate a malfunction that requires mechanical correction.

Cold weather operating aids provide cold weather protection and better starting conditions for the engine.

The instruments and controls used on the N14 engine are **not** manufactured by Cummins Engine Company, Inc. The following list contains the suppliers of the instrumentation used on Cummins engines:

Air Heaters

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

Coolant Heaters

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Service Products Company, Inc.
635 S. Mapleton Street
Columbus, IN 47201
Telephone: (812) 377-8178

Engine Protection Controls

Teddington Industrial Equipment
Windmill Road
Sunburn on Thames
Middlesex
TW16 7HF
England
Telephone: 09327-85500

The Nason Company
10388 Enterprise Drive
Davisburg, MI 48019
Telephone: (313) 625-5381

Fuel Warmers

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Service Products Company, Inc.
635 S. Mapleton Street
Columbus, IN 47201
Telephone: (812) 377-8178

Gauges

A.I.S.
Dyffon Industrial Estate
Ystrad Mynach
Hengoed
Mid Glamorgan
CF8 7XD
England
Telephone: 0443-812791

Grasslin U.K. Ltd.
Vale Rise
Tonbridge
Kent
TN9 1TB
England
Telephone: 0732-359888

Icknield Instruments Ltd.
Jubilee Road
Letchworth
Herts
England
Telephone: 04626-5551

Superb Tool and
Gauge Co.
21 Princip Street
Birmingham
B4 61E
England
Telephone: 021-359-4876

Kabi Electrical and Plastics
Cranborne Road
Potters Bar
Herts
EN6 3JP
England
Telephone: 0707-53444

Datcon Instrument Co.
P.O. Box 128
East Petersburg, PA 17520
Telephone: (717) 569-5713

Rochester Gauge of Texas
11637 Denton Drive
Dallas, TX 75229
Telephone: (214) 241-2161

Instruments and Controls - General Information (Cont'd)

Oil Heaters

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

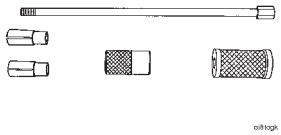
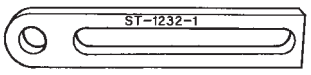
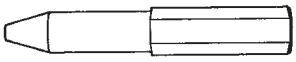
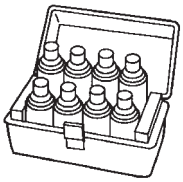
Service Products Company, Inc.
635 S. Mapleton Street
Columbus, IN 47201
Telephone: (812) 377-8178

Section 16 - Mounting Adaptations - Group 16

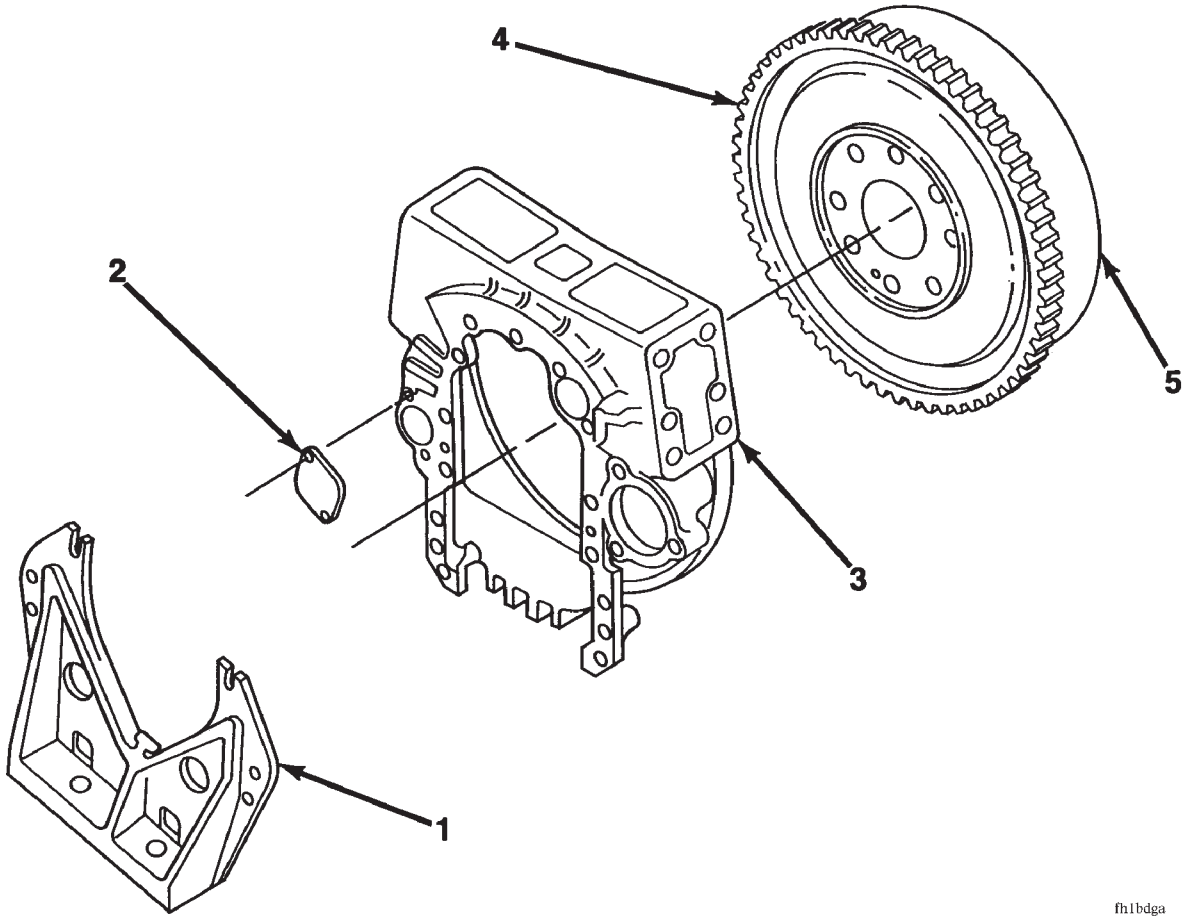
Section Contents

Mounting Adaptations - Service Tools

The following special tools are recommended to perform procedures in Group 16. The use of these tools is shown in the appropriate procedure. These tools can be purchased from your local Cummins Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-1134	**Dowel Pin Extractor** Use to pull dowel pins and crosshead guides.	
ST-1232-1 (in Part No. ST-1232)	**Plate** Use in conjunction with drill and ream bushing sets to accurately drill and ream holes in flywheel housings for the installation of standard oversize dowel pins.	 fh8toge
ST-1232-2 (in Part No. ST-1232)	**Spacer Washer** Use in conjunction with drill and ream bushing sets to accurately drill and ream holes in flywheel housings for the installation of standard oversize dowel pins.	 fh8togf
3375052 (in Part No. ST-1232)	**Locator Pin** Use in conjunction with drill and ream bushing sets to accurately drill and ream holes in flywheel housings for the installation of standard oversize dowel pins.	 fh8togg
3375432	**Crack Detection Kit** This kit provides a convenient way to detect cracks in any engine component.	 bp8togj
3376495	**Drill/Ream Bushing Set** Use to drill and ream holes in flywheel housing for the installation of dowel pins.	

Mounting Adaptations - Exploded View



Reference No.	Description	Quantity
1	Support, Front Engine	1
2	Cover, Access Hole	1
3	Housing, Flywheel	1
4	Gear, Ring	1
5	Flywheel	1

Mounting Adaptations - General Information

The mounting adaptations group consists of the flywheel housing, flywheel, flywheel ring gear, pilot bearing, and the front engine support.

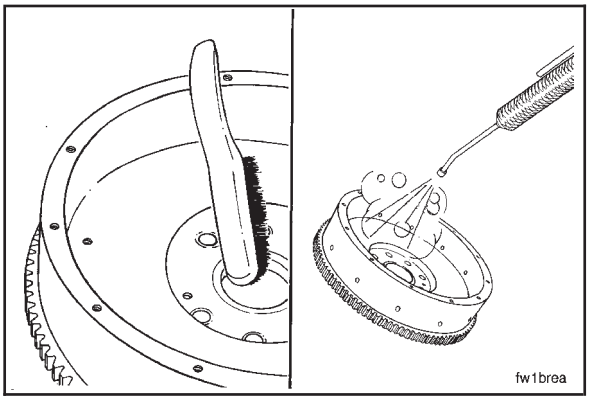
The flywheel is available **only** as an assembly with the ring gear installed; however, the ring gear is available for service replacement.

Flywheel - Cleaning and Inspection for Reuse (16-01)

Cleaning

Use a wire brush to clean the crankshaft pilot bore.

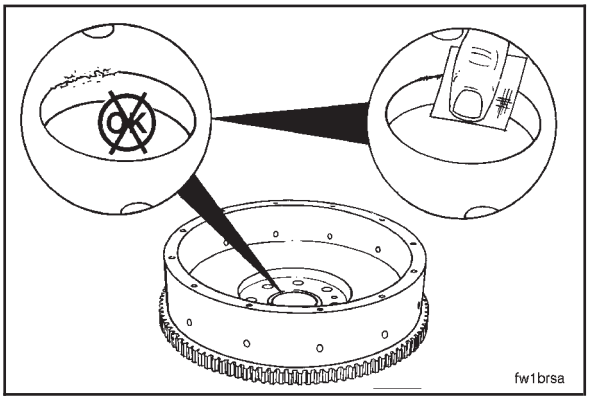
Steam clean or use a solvent, and dry with compressed air.



Inspection

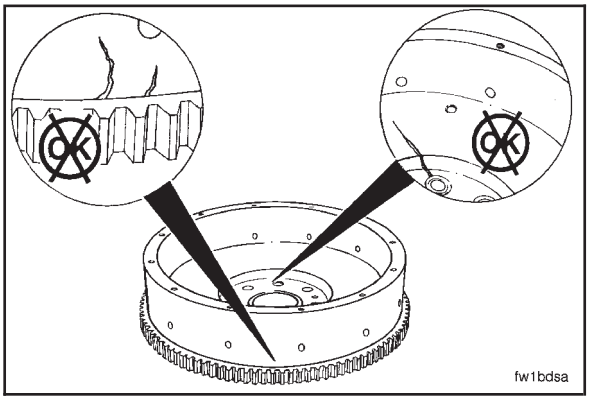
Visually inspect for nicks or burrs.

Use a fine crocus cloth to remove small nicks and burrs.



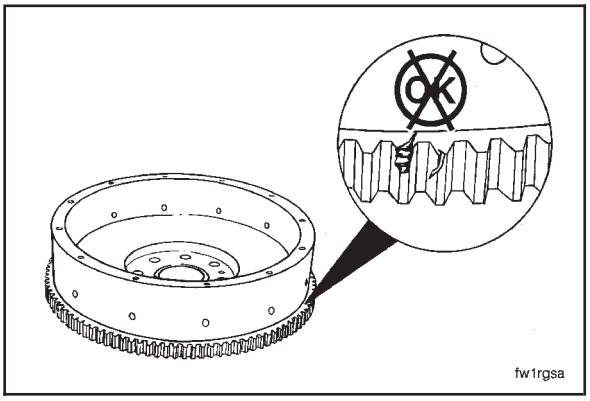
Warning: Do not use a cracked or resurfaced flywheel. These can break, causing serious personal injury or property damage.

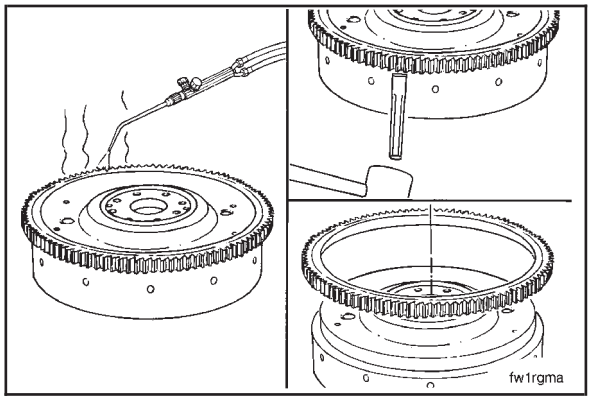
Use crack detection kit, Part No. 3375432, to check for cracks in the flywheel. Follow the instructions provided with the kit.



Inspect the flywheel ring gear teeth for cracks and chips.

NOTE: If the ring gear teeth are cracked or broken, the ring gear **must** be replaced.



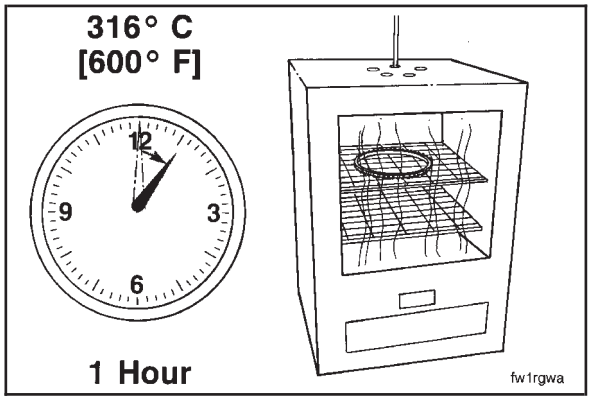


Flywheel Ring Gear - Replacement (16-02)

Caution: Do not use a cutting torch to heat the ring gear. The flywheel can be damaged.

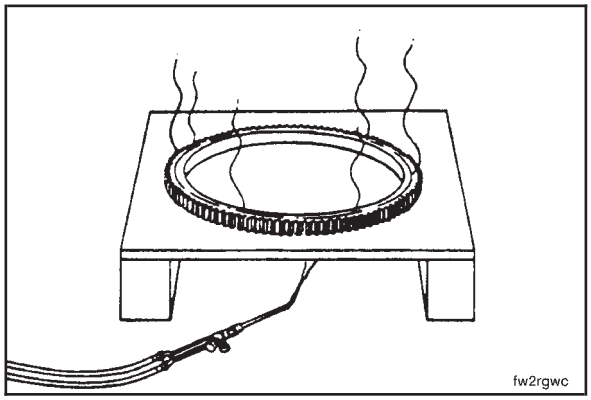
Heat the outside diameter of the ring gear with a heating torch.

Use a blunt chisel and a hammer to remove the gear from the flywheel.



Caution: Do not overheat the ring gear. The metal hardness will be changed.

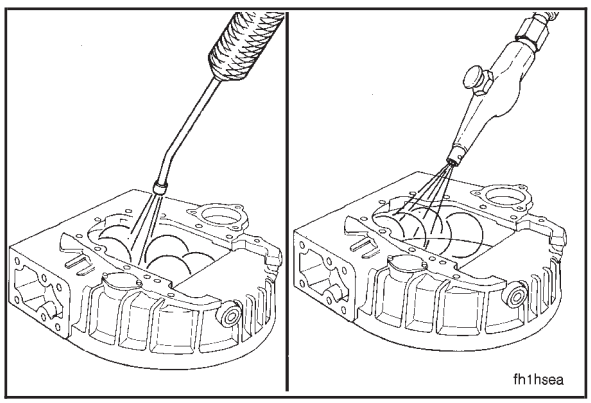
Heat the new ring gear in an oven heated to 316°C [600°F] for a minimum of 1 hour.



Caution: Wear protective gloves when handling parts that have been heated to prevent personal injury.

Remove the gear from the oven, and install it on the flywheel before it cools.

NOTE: If an oven is **not** available, use a heating torch to heat the inside diameter of the new ring gear to 316°C [600°F]. Use a Tempilstik® crayon or its equivalent to check the gear temperature before installing it on the flywheel. A more even temperature can be obtained by placing the ring gear on a metal plate, then heating the bottom side of the plate with a heating torch. Do **not** exceed the specified temperature.



Flywheel Housing - Cleaning and Inspection for Reuse (16-03)

Cleaning

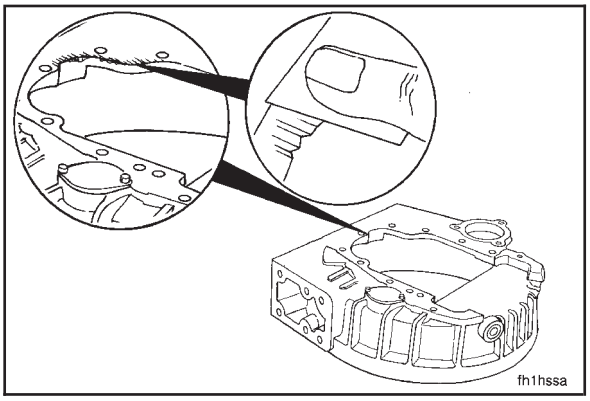
Steam clean or use solvent to clean the housing.

Dry with compressed air.

Inspection

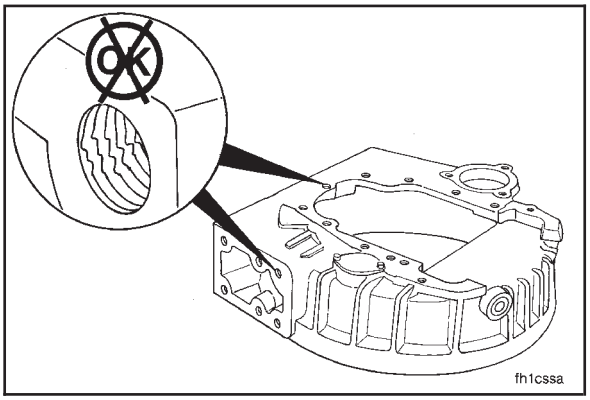
Visually inspect all surfaces for nicks, burrs, or cracks.

Use a fine crocus cloth to remove small nicks and burrs.



Inspect all threaded capscrew holes for damage.

Repair or replace the housing if the capscrew holes are damaged.

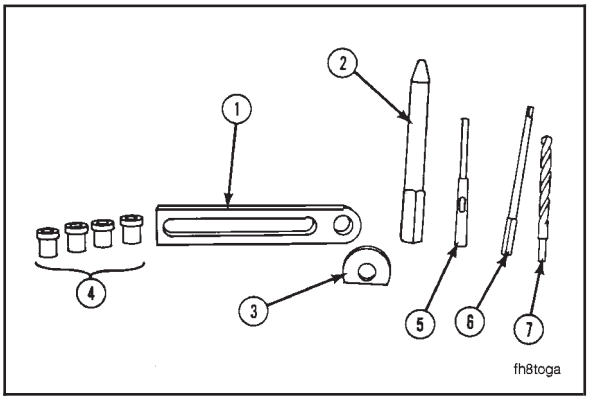


Flywheel Housing - Redowel to Cylinder Block (16-04)

The following tools are needed to perform this procedure:

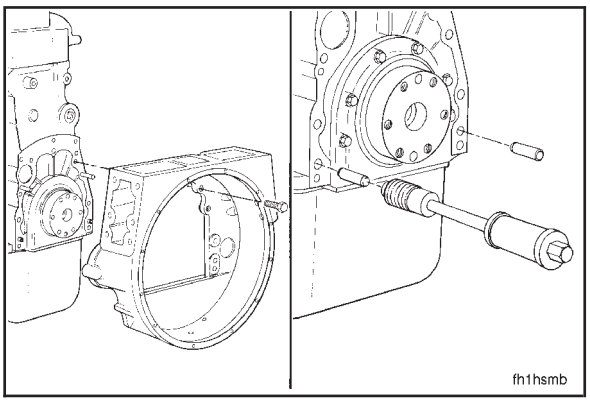
- Drill ream fixture, Part No. ST-1232, which contains:

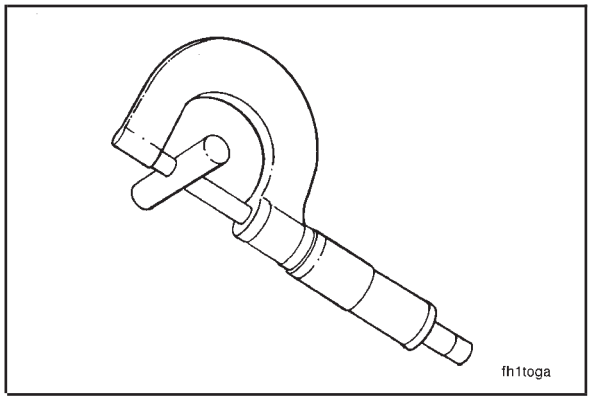
(1)	Plate, Part No. ST-1232-1
(2)	Locator pin, Part No. 3375052
(3)	Spacer washer, Part No. ST-1232-2
(4) Drill/ream Bushing set	Actual sizes depend on the dowel size Part No. 3376495
(5) Drill adapter	Locally obtained; use to adapt open-shank reamers to drill-chuck
(6) Reamer	Locally obtained
(7) Drill bit	Locally obtained



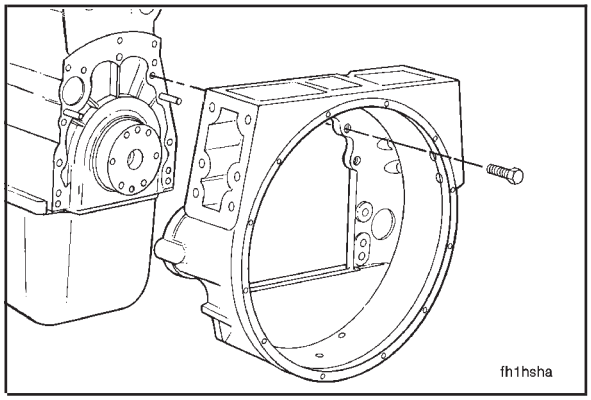
Remove the flywheel housing. If necessary, refer to Engine Disassembly, Group 00-01.

Use dowel pin extractor, Part No. ST-1134, or its equivalent to remove the two dowel pins from the cylinder block.





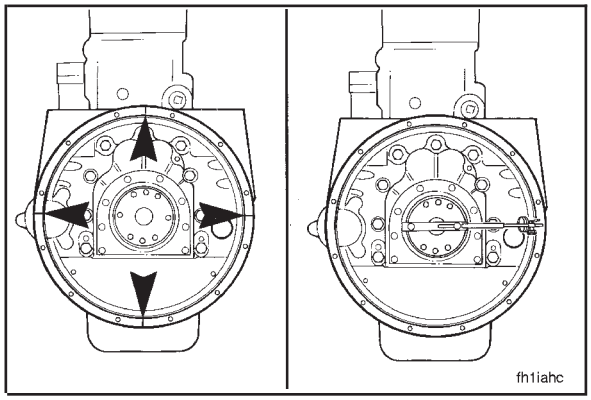
Measure and record the diameter of one of the dowel pins which was removed to determine the next oversize dowel to be installed after the housing is aligned.



Install the flywheel housing without the dowel pins. Tighten the capscrews.

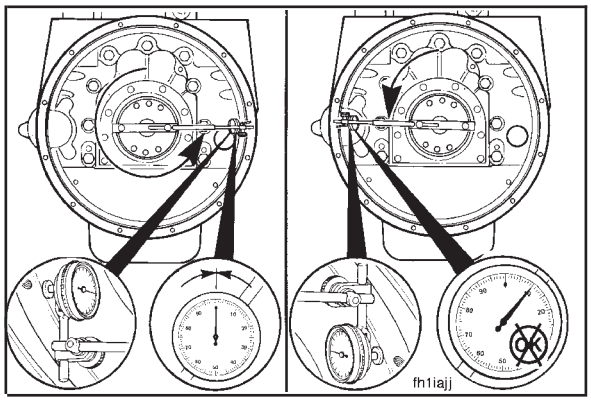
Torque Value: 7 N•m [5 ft-lb]

NOTE: Do **not** tighten the capscrews to the final torque value until the flywheel housing is aligned.



Use chalk to mark the housing at the 12:00 o'clock, 3:00 o'clock, 6:00 o'clock, and 9:00 o'clock positions.

Attach the dial indicator to the crankshaft as shown.

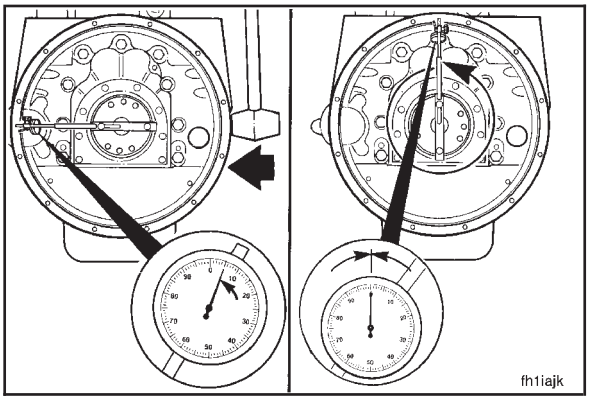


Use the accessory drive to rotate the crankshaft until the dial indicator is at the 3:00 o'clock position. Adjust the dial indicator until the needle points to ″0.″

Rotate the crankshaft until the indicator is at the 9:00 o'clock position. Check the total indicator reading.

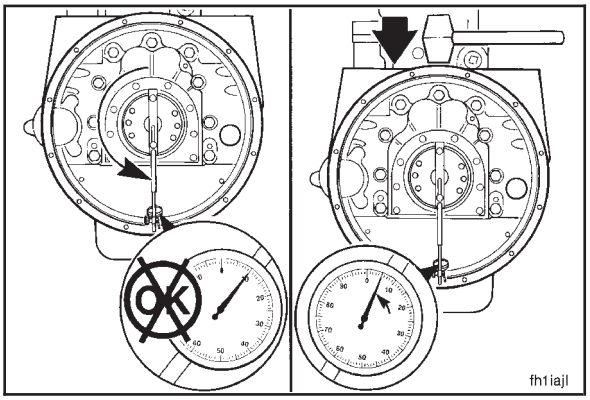
If the total indicator reading exceeds the limits listed in Section 00-02 ‘‘Flywheel Housing Installation,’’ use a mallet to horizontally move the housing one-half the distance of the total indicator reading.

Rotate the crankshaft until the indicator is at the 12:00 o’clock position. Adjust the dial until the needle points to ‘‘0.’’



Rotate the crankshaft until the indicator is at the 6:00 o’clock position. Check the total indicator reading.

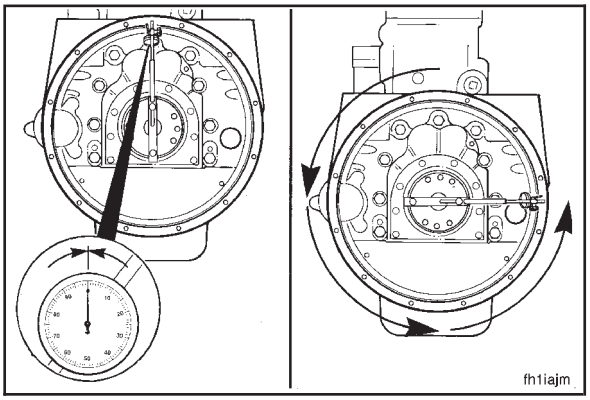
If the total indicator reading exceeds the limits listed in Section 00-02 ‘‘Flywheel Housing Installation,’’ use a mallet to vertically move the housing one-half the distance of the total indicator reading.



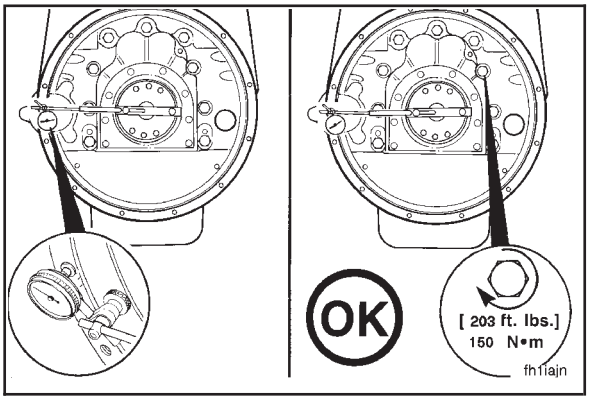
Rotate the crankshaft until the indicator is at the 12:00 o’clock position. Adjust the dial until the needle points to ″0.″

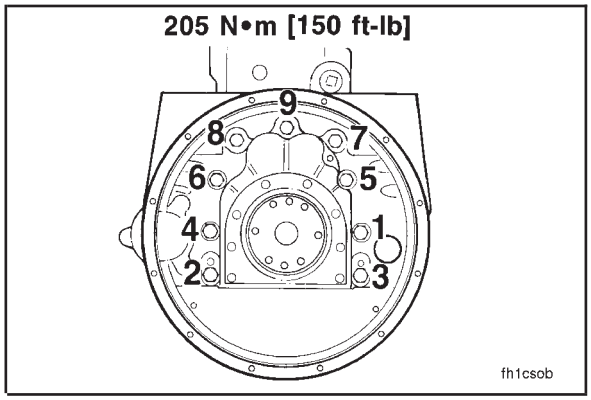
Rotate the crankshaft, and record the indicator reading at the 3:00 o’clock, 6:00 o’clock, and 9:00 o’clock positions.

If the total indicator reading exceeds the limits listed in Section 00-02 ‘‘Flywheel Housing Installation,’’ repeat the previous steps.



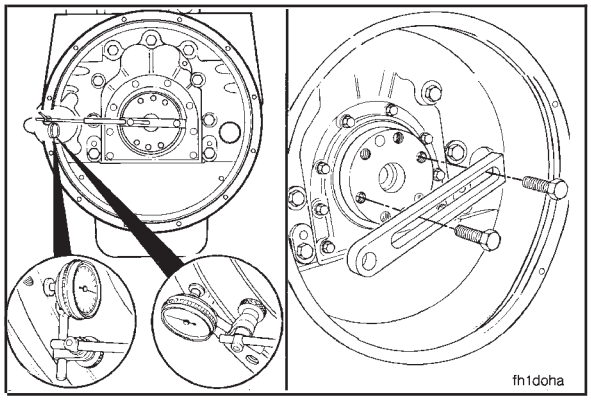
After the housing bore is aligned, check to make sure the surface of the housing is in alignment. Refer to Section 00-02 ‘‘Flywheel Housing Installation - Face Alignment.’’





Tighten the mounting capscrews in the sequence shown.

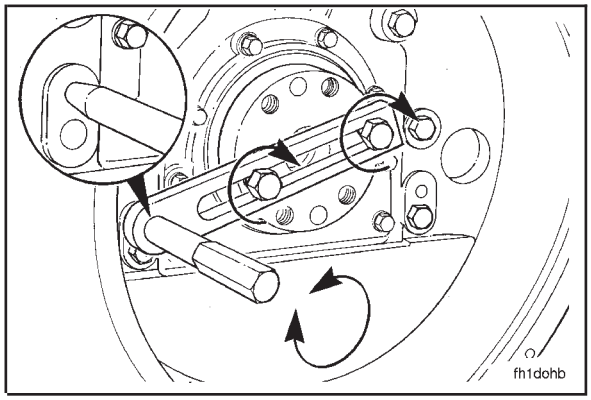
Torque Value: 203 N•m [150 ft-lb]



After the capscrews are torqued, check the housing bore and the surface alignment again before doweling the housing.

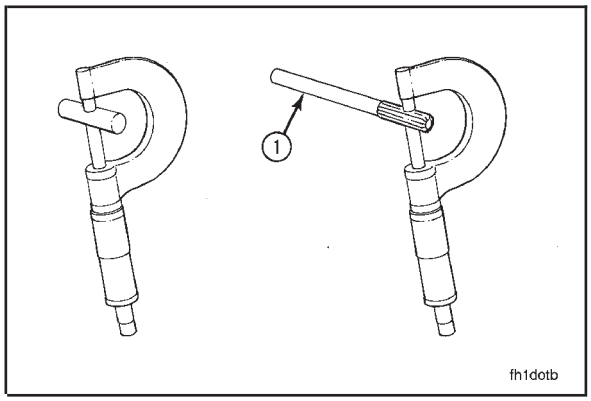
Use the appropriate size capscrews. Attach a plate, Part No. ST-1232-1, which is contained in drill ream fixture, Part No. ST-1232.

NOTE: Do **not** tighten the capscrews so tightly that the plate will **not** move.



Use the locator pin to align the plate with the hole for the dowel pin. Tighten the capscrews. The taper on the pin **must** engage the dowel pin hole.

The locator pin **must** rotate easily after the capscrews are tightened.



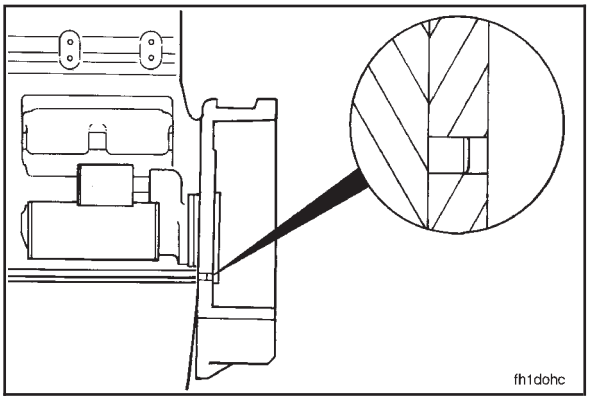
Measure the dowel pins which are to be installed.

Obtain a reamer (1) that is 0.013 mm to 0.02 mm [0.0005-inch to 0.001-inch] smaller than the dowel.

The dowel **must** be long enough to protrude from the block one-half of the flywheel housing wall thickness but **must not** protrude past the housing wall.

NOTE: There are three oversize dowel pins available:

Oversize Dowel Pin O.D.			
Overall Dimension		**Amount Oversize**	
mm	**in**	**mm**	**in**
13.08	[0.515]	0.38	[0.015]
13.46	[0.530]	0.76	[0.030]
13.84	[0.545]	1.14	[0.045]

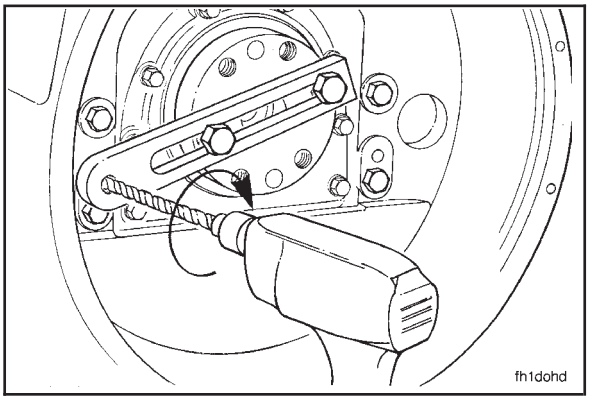


Install the appropriate drill bushings. The Table shows the bushings available in Part No. 3376495.

The drill bushing used **must** be the same size as the reamer (or the drill) which is used.

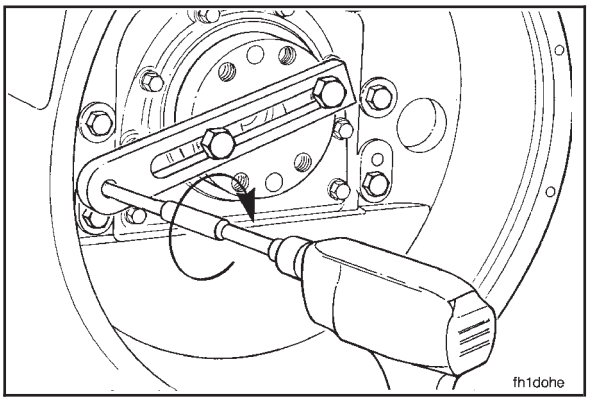
Drill/Ream Bushing Set 25.4 mm [1 inch] O.D.				
	Oversize mm	**Oversize [inch]**	**Bushing Size mm**	**Bushing Size [inch]**
3376495		Special	12.304	[0.4844]
		Standard	12.700	[0.5000]
	0.38	[0.015]	13.096	[0.5156]
	0.76	[0.030]	13.494	[0.5312]
	1.14	[0.045]	13.879	[0.5464]

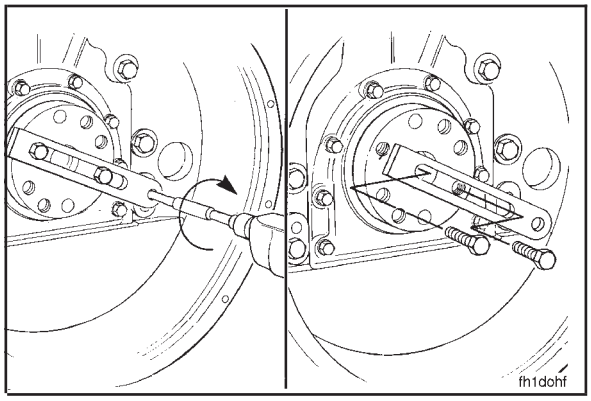
If the new dowel pins are more than 0.38 mm [0.015-inch] larger than the old dowels, drill the hole to a size that is slightly smaller than the reamer. Then the reamer will **not** have to remove an excessive amount of material.



Caution: Do not allow metal chips to enter the engine. Damage to the engine will result.

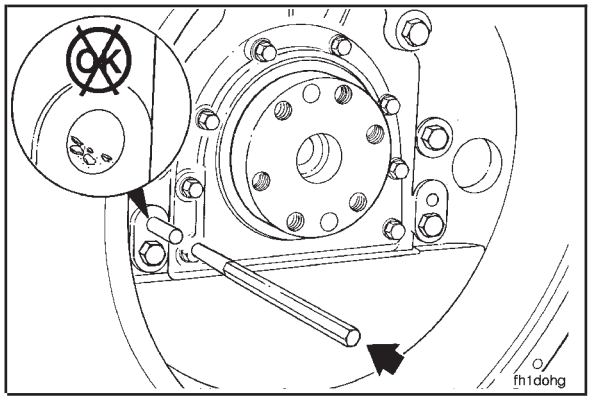
Ream the hole until the reamer touches the bottom of the hole in the block.





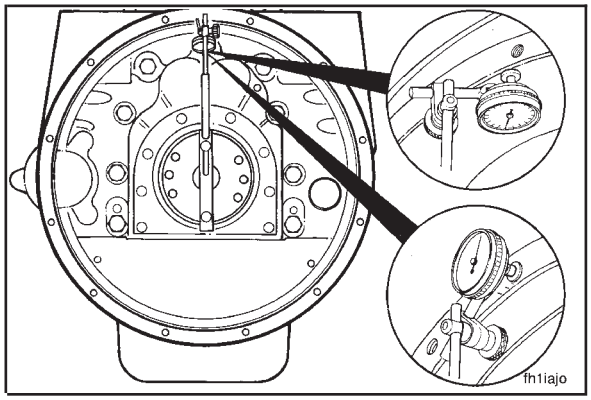
After reaming one hole, turn the plate and align it with the second dowel hole. Repeat the procedure in the second hole.

Remove the plate from the crankshaft.

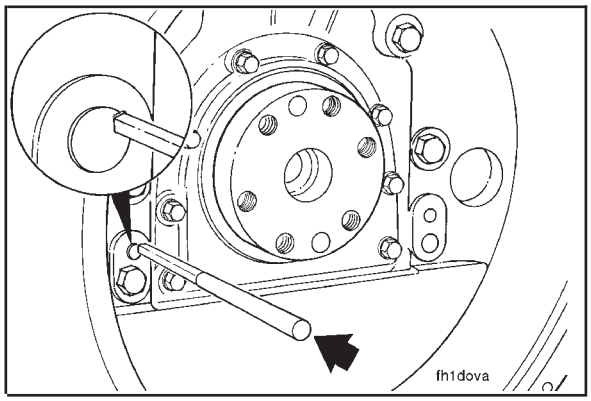


Caution: To avoid possible engine damage, make sure the dowel hole does not contain any metal chips.

Use a square nose drift. Drive each dowel in until it touches the bottom of the hole in the block.



After the dowels are installed, measure the bore and the surface alignment again.



Use a square nose drift. Stake the dowel holes to prevent the dowels from coming out.

Front Engine Support Bracket - Cleaning and Inspection for Reuse (16-05)

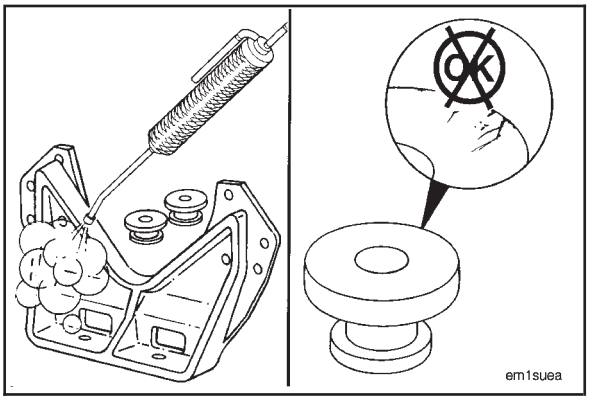
Warning: When using a steam cleaner, wear protective clothing and safety glasses or a face shield. Hot steam will cause serious personal injury.

Cleaning

Steam clean or use solvent, and dry the parts with compressed air.

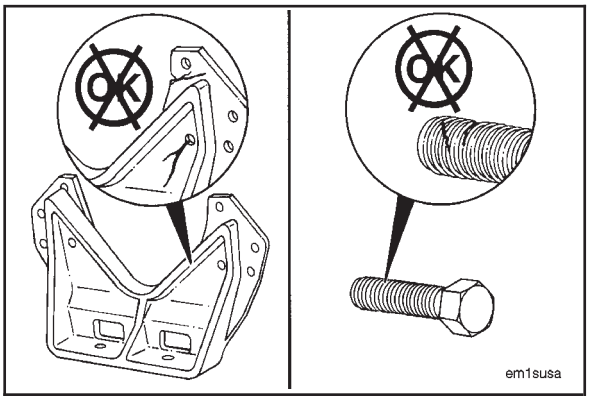
Inspection

Visually inspect the engine mounts for cracks or deterioration. If cracks or deterioration are found, the engine mounts **must** be replaced.



Visually inspect the engine support bracket for cracks or damage. If cracks or damage are found, the support bracket **must** be replaced.

Inspect the capscrew threads and replace if damaged.



Specifications - Group 18

Group Index

Page

General Engine Specifications

General Engine Data — Metric [U.S. Customary]

Horsepower (Refer to the engine dataplate)

Engine speed @ Maximum Output:

- Standard Rating (RPM) 2100
- Formula Rating (RPM) ..... 1800 or 1900

Bore & Stroke ..... 140 mm [5.5 in.] X 152 mm [6.0 in.]

Displacement ..... 14.0 liters [855 C.I.D.]

Compression Ratio ..... 14.0 to 16.7:1

Firing Order 1-5-3-6-2-4

Engine Weight (With Standard Accessories):

- Dry Weight ..... 1153 to 1194 kg [2540 to 2630 lb.]
- Wet Weight ..... 1208 to 1249 kg [2660 to 2750 lb.]

Intake System

Maximum Allowable Intake Restriction with Clean Air Filter Element:

- Normal Duty Dry Type Cleaner ..... 25 cm H_20 [10 in. H_20]
- Medium Duty Dry Type Cleaner ..... 30 cm H_20 [12 in. H_20]
- Heavy Duty Dry Type Cleaner ..... 38 cm H_20 [15 in. H_20]

Maximum Allowable Intake Restriction with Dirty Air Filter Element ..... 64 cm H_20 [25 in. H_20]

Lubrication System

Oil Pressure - Low Idle (Minimum Allowable) ..... 70 kPa [10 psi]

At No Load Governed Speed:

- Automotive ..... 240 to 310 kPa [35 to 45 psi]

Oil Capacity of Standard Engine:

- Bypass Filter ..... 2.8 liters [0.75 U.S. Gal.]
- Full Flow Filter Capacity ..... 3.5 liters [0.93 U.S. Gal.]
- Oil Pan Capacity (high-low) ..... 35 to 30 liters [9.5 to 8.0 U.S. Gal.]

Total System Capacity Including Bypass Filter ..... 42 liters [11 U.S. Gal.]

General Engine Specifications (Continued)

Cooling System — Metric [U.S. Customary]

Coolant Capacity (engine only) ..... 21 liters [22 U.S. qt.]

Standard Modulating Thermostat Range:

- Conventional Aftercooling ..... 82 to 93°C [180 to 200°F]
- Optimized Aftercooling ..... 79 to 91°C [175 to 195°F]

Maximum Coolant Cylinder Block Pressure (Pressure Cap Removed)

Closed Thermostat ..... 350 kPa [50 psi]

Maximum Allowable Top Tank Temperature ..... 100°C [212°F]

Minimum Recommended Top Tank Temperature ..... 70°C [158°F]

Minimum Recommended Pressure Cap ..... 50 kPa [7 psi]

Exhaust System

Maximum Allowable Back Pressure Created by Piping and Silencer:

- Hg ..... 75 mm [3 in.]
- H_20 ..... 1000 mm [40 in.]

Exhaust Pipe Size (Normally Acceptable Inside Diameter) ..... 127 mm [5 in.]

Fuel System

Note: For performance and fuel rate values, refer to the engine data sheet or the fuel pump code for the particular model involved.

Maximum Allowable Restriction to Pump:

- With Clean Filter ..... 100 mm Hg [4 in. Hg]
- With Dirty Filter ..... 200 mm Hg [8 in. Hg]

Maximum Allowable Return Line Restriction without Check Valves ..... 64 mm Hg [2.5 in. Hg]

Maximum Allowable Return Line Restriction with Check Valves and/or Overhead Tanks . 165 mm Hg [6.5 in. Hg]

Electrical System

Minimum Recommended Battery Capacity

Battery Size	Ambient Temperatures			
	-18°C (0°F)		0°C (32°F)	
	Cold Cranking Amperes	Reserve Capacity * Amperes	Cold Cranking Amperes	Reserve Capacity Amperes
12 Volt	1800	640	1280	480
24 Volt **	900	320	640	240

* The number of plates within a given battery size determines reserve capacity. Reserve capacity determines the length of time sustained cranking can occur.

** CCA ratings are based on two 12-volt batteries in series.

Capscrew Markings and Torque Values

Caution: When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using incorrect capscrews can result in engine damage.

SAE capscrews are graded according to the strength of the capscrew. They are marked on the head so the correct strength and torque value are known.

The table below lists the capscrew markings and the correct value for the capscrew. SAE capscrews are identified by:

U.S. Customary (5/16 X 18 X 1 1/2)		
5/16	**18**	**1 1/2**
Major Thread Diameter in Inches	Number Threads per Inch	Length in Inches

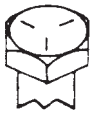
Notes:

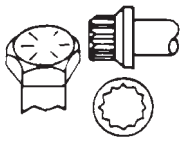
1. **Always** use the torque values listed in the following table when specific torque values are **not** available.
2. Do **not** use the torque values in place of those specified in other sections of this manual. It is important to use the correct torque values for SAE grade 5 and 8 capscrews.
3. The torque values in the table are based on the use of lubricated threads.

Capscrew Markings and Torque Values - U.S. Customary

SAE Grade Number 5 8

Capscrew Head Markings
These are all SAE Grade 5 (3) line





	Capscrew Torque - Grade 5 Capscrew				Capscrew Torque - Grade 8 Capscrew			
Capscrew Body Size	**Cast Iron**		**Aluminum**		**Cast Iron**		**Aluminum**	
(Inches) - (Thread)	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
1/4 - 20	9	7	8	6	15	11	12	9
- 28	12	9	9	7	18	13	14	10
5/16 - 18	20	15	16	12	30	22	24	18
- 24	23	17	19	14	33	24	25	19
3/8 - 16	40	30	25	20	55	40	40	30
- 24	40	30	35	25	60	45	45	35
7/16 - 14	60	45	45	35	90	65	65	50
- 20	65	50	55	40	95	70	75	55
1/2 - 13	95	70	75	55	130	95	100	75
- 20	100	75	80	60	150	110	120	90
9/16 - 12	135	100	110	80	190	140	150	110
- 18	150	110	115	85	210	155	170	125
5/8 - 11	180	135	150	110	255	190	205	150
- 18	210	155	160	120	290	215	230	170
3/4 - 10	325	240	255	190	460	340	365	270
- 16	365	270	285	210	515	380	410	300
7/8 - 9	490	360	380	280	745	550	600	440
- 14	530	390	420	310	825	610	660	490
1 - 8	720	530	570	420	1100	820	890	660
- 14	800	590	650	480	1200	890	960	710

Refer to the notes above.

Pipe Plug Torque Values

Size			Torque		Torque	
Thread	Actual Thread O.D.		In Aluminum Components		In Cast Iron or Steel Components	
in	mm	in	N•m	ft-lb	N•m	ft-lb
1/16	8.1	0.32	5	45 in-lb	15	10
1/8	10.4	0.41	15	10	20	15
1/4	13.7	0.54	20	15	25	20
3/8	17.3	0.68	25	20	35	25
1/2	21.6	0.85	35	25	55	40
3/4	26.7	1.05	45	35	75	55
1	33.5	1.32	60	45	95	70
1-1/4	42.2	1.66	75	55	115	85
1-1/2	48.3	1.90	85	65	135	100

Decimal and Metric Equivalents

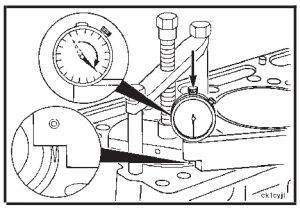
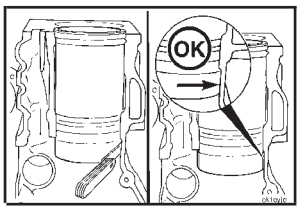
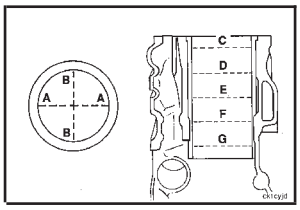
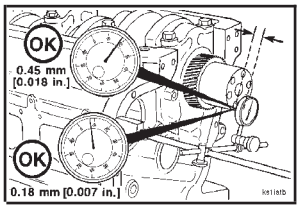
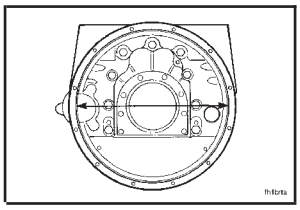
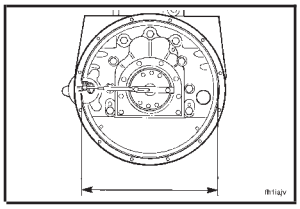
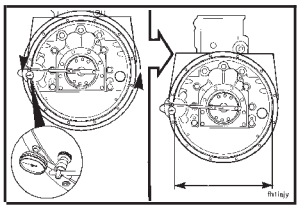
Metric mm	Decimal in.	Fractions	Metric mm	Decimal in.	Fractions
0.39688	0.015625	1/64	13.09687	0.515625	33/64
0.79375	0.03125	1/32	13.49375	0.53125	17/32
1.19062	0.046875	3/64	13.89062	0.546875	35/64
1.58750	0.0625	1/16	14.28750	0.5625	9/16
1.98437	0.078125	5/64	14.68437	0.578125	37/64
2.38125	0.09375	3/32	15.08125	0.59375	19/32
2.77812	0.109375	7/64	15.47812	0.609375	39/64
3.1750	0.125	1/8	15.87500	0.625	5/8
3.57187	0.140625	9/64	16.27187	0.640625	41/64
3.96875	0.15625	5/32	16.66875	0.65625	21/32
4.36562	0.171875	11/64	17.06562	0.671875	43/64
4.76250	0.1875	3/16	17.46250	0.6875	11/16
5.15937	0.203125	13/64	17.85937	0.703125	45/64
5.55625	0.21875	7/32	18.25625	0.71875	23/32
5.95312	0.234375	15/64	18.65312	0.734375	47/64
6.35000	0.250	1/4	19.05000	0.750	3/4
6.74687	0.265625	17/64	19.44687	0.765625	49/64
7.14375	0.28125	9/32	19.84375	0.78125	25/32
7.54062	0.296875	19/64	20.24062	0.796875	51/64
7.93750	0.3125	5/16	20.63750	0.8125	13/16
8.33437	0.328125	21/64	21.03437	0.828125	53/64
8.73125	0.34375	11/32	21.43125	0.84375	27/32
9.12812	0.359375	23/64	21.82812	0.859375	55/64
9.52500	0.375	3/8	22.22500	0.875	7/8
9.92187	0.390625	25/64	22.62187	0.890625	57/64
10.31875	0.40625	13/32	23.01875	0.90625	29/32
10.71562	0.421875	27/64	23.41562	0.921875	59/64
11.11250	0.4375	7/16	23.81250	0.9375	15/16
11.50937	0.453125	29/64	24.20937	0.953125	61/64
11.90625	0.46875	15/32	24.60625	0.96875	31/32
12.30312	0.484375	31/64	25.00312	0.984375	63/64
12.70000	0.500	1/2	25.40000	1.00	1

Specifications - General Information

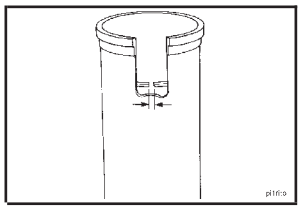
The specifications in this section are organized in the same sequence used in each group of this manual. The minimum and maximum tolerance limit specifications are listed in both metric and U.S. Customary dimensions. The assembly and rebuild specifications and torque values are provided to make sure the parts are correctly assembled, fit correctly, and are secured with the correct torque value.

Capscrew torque values are listed in newton meters and foot pounds, unless otherwise specified. If a torque value is **not** listed, use the standard torque value for the capscrew. Refer to Capscrew Markings and Torque Values on page 18-5.

Engine Assembly - Specifications

Part or Assembly	Ref. Point	mm		in	
Cylinder Liner Protrusion		0.10 0.18	MIN MAX	0.004 0.007	
Cylinder Liner to Lower Cylinder Liner Bore Clearance		0.05 0.15	MIN MAX	0.002 0.006	
Cylinder Liner Out of Round		0.05	MAX	0.002	
Crankshaft End Clearance		0.18 0.45	MIN MAX	0.007 0.018	
Flywheel Housing Bore I.D.	SAE No. 00 0 1/2 1 2 3	 787.7 648.0 584.4 511.3 447.8 409.7	 MAX MAX MAX MAX MAX MAX	 31.01 25.51 23.01 20.13 17.63 16.13	
Flywheel Housing Bore Alignment T.I.R.	SAE No. 00 0 1/2 1 2 3	 0.30 0.25 0.25 0.20 0.20 0.20	 MAX MAX MAX MAX MAX MAX	 0.012 0.010 0.010 0.008 0.008 0.008	
Flywheel Housing Face Alignment T.I.R.	SAE No. 00 0 1/2 1 2 3	 0.30 0.25 0.25 0.20 0.20 0.20	 MAX MAX MAX MAX MAX MAX	 0.012 0.010 0.010 0.008 0.008 0.008	

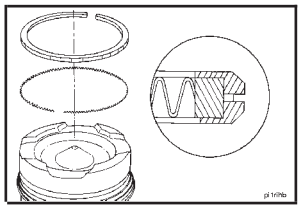
Part or Assembly	Ref. Point	mm		in



Piston Ring Gap

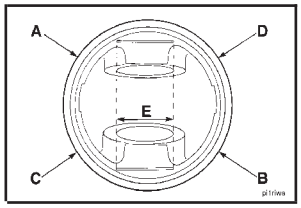
Piston			
• Top	0.43	MIN	0.017
	0.68	MAX	0.027
• Second	0.51	MIN	0.020
	0.76	MAX	0.030
• Third	0.48	MIN	0.019
	0.74	MAX	0.029
• Oil	0.25	MIN	0.010
	0.64	MAX	0.025

Note: Add 0.08 mm [0.003-inch] to the maximum limit for each 0.03 mm [0.001-inch] wear in the cylinder liner wall.



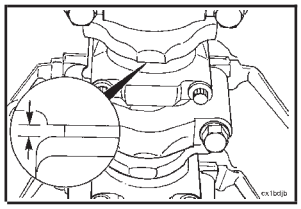
Oil Control Ring End Gap

The two-piece oil ring **must** be installed with the expander gap 180 degrees from the oil ring gap.



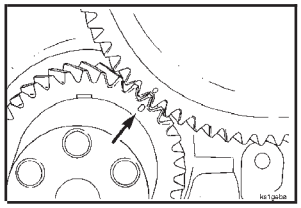
Piston Ring End Gap

The ring gaps **must not** be aligned with the piston pin bore. Rotate the rings to position the gaps as shown.



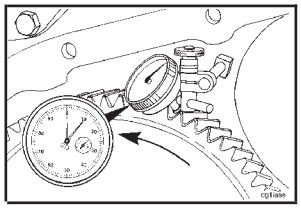
Connecting Rod Side Clearance	0.114	MIN	0.0045
	0.33	MAX	0.13

Note: The rod **must** move freely from side-to-side.

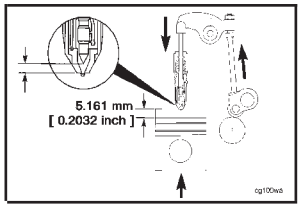


Engine Timing

Note: The timing marks on the camshaft gear **must** align with the timing marks on the crankshaft gear to make sure the engine timing is set correctly.



Backlash Between the Camshaft and the Crankshaft Gear	0.05	MIN	0.002
	0.50	MAX	0.020

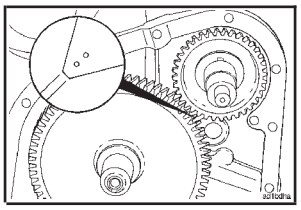


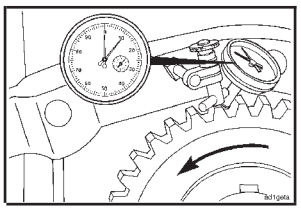
Injection Timing

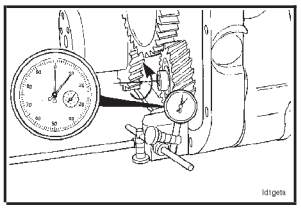
To verify the correct injection timing for a particular engine refer to the engine dataplate.

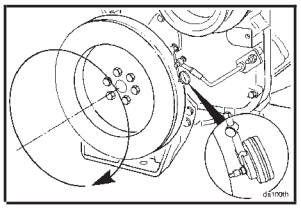
Refer to Group 00, Engine Assembly, Injection Timing, Page 0-89, for complete instructions.

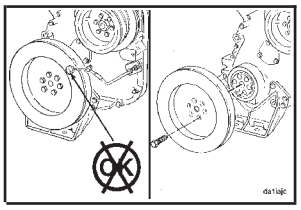
Part or Assembly	Ref. Point	mm		in
Accessory Drive Assembly Timing Position the accessory drive shaft dowel pin at the 12:00 o'clock position. Align the timing mark on the accessory drive gear with the timing mark on the camshaft gear.				
Backlash Between the Accessory Drive and the Camshaft Gear **Note:** If the backlash is **not** within specifications, the gear **must** be replaced.		0.05 0.50	MIN MAX	0.002 0.020
Backlash Between the Lubricating Oil Pump Drive Gear and the Camshaft Gear **Note:** If the backlash is **not** within specifications, the lubricating oil pump drive gear **must** be replaced.		0.05 0.50	MIN MAX	0.002 0.020
Vibration Damper Eccentricity T.I.R.		0.10	MAX	0.004
Vibration Damper Face Alignment (''Wobble'') T.I.R.		0.18	MAX	0.007
Flywheel Bore Runout T.I.R.		0.127	MAX	0.0050
Flywheel Face Runout T.I.R.	Radius (A) mm in 203 8 254 10 305 12 356 14 406 16	 0.203 0.254 0.305 0.356 0.406	 MAX MAX MAX MAX MAX	 0.008 0.010 0.012 0.014 0.016

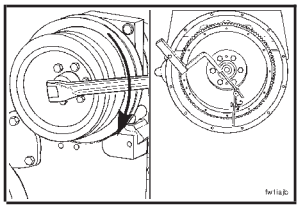


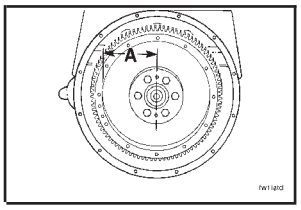




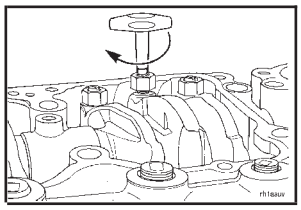






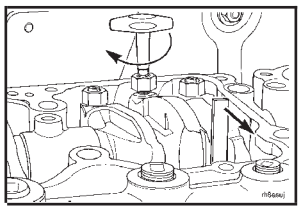


Part or Assembly	Ref. Point	mm	in



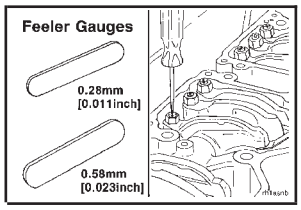
PTD Top-Stop Injector Adjustment

Refer to Engine Assembly, Group 00, PTD Top-Stop Injector Adjustment, Page 0-129.

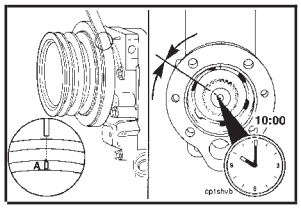


PTD STC Injector Adjustment

Refer to Engine Assembly, Group 00, PTD STC Injector Adjustment, Page 0-133.



Intake Valve Lash Specifications	0.28	MIN	0.011
Exhaust Valve Lash Specifications	0.58	MIN	0.023



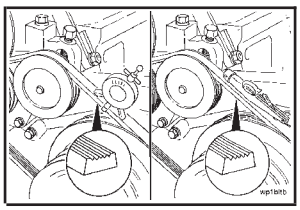
Air Compressor to Accessory Drive Timing

Position the air compressor crankshaft timing mark at the 10:00 o'clock position.

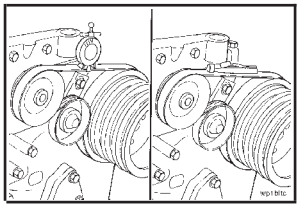
Align the (A) valve set mark on the accessory drive pulley with the pointer on the gear cover.

Part or Assembly	Ref. Point	mm	in

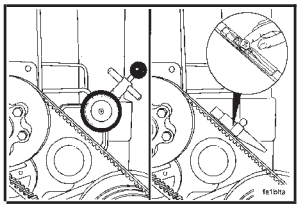
Belt Tension	Ref. Point	Newtons	Pounds Force
Water Pump Belt (Big Cam IV and New Big Cam IV)			
• New Belt Tension		710	160
• Used Belt Tension		290-580	65-130



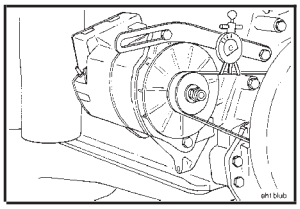
Belt Tension	Ref. Point	Newtons	Pounds Force
Water Pump Belt (88 Big Cam IV)			
• New Belt Tension		620	140
• Used Belt Tension		270-490	60-110



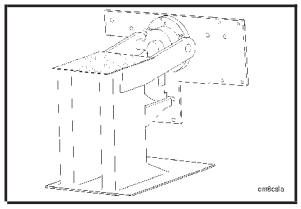
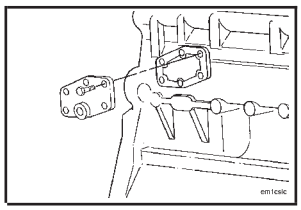
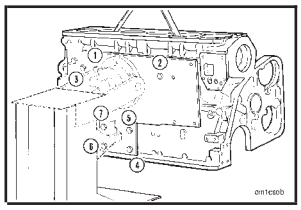
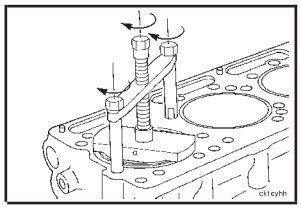
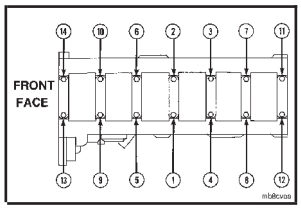
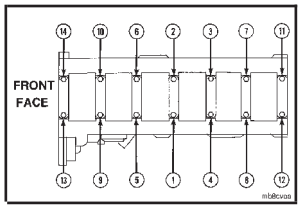
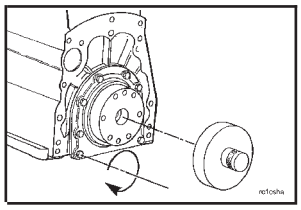
Belt Tension	Ref. Point	Newtons	Pounds Force
Fan Belts			
• New Belt Tension		620	140
• Used Belt Tension		270-490	60-110

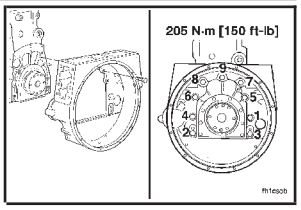
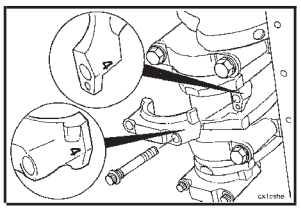
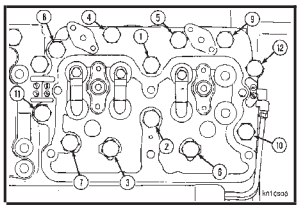
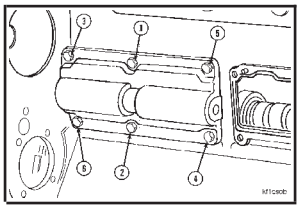
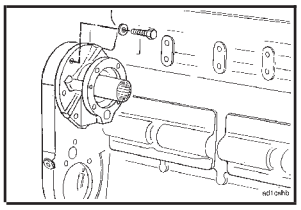
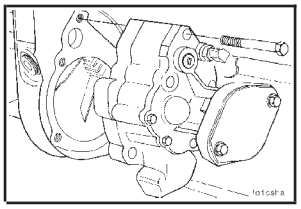
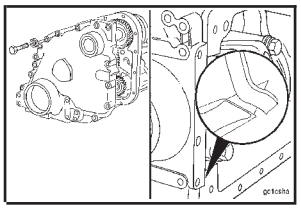


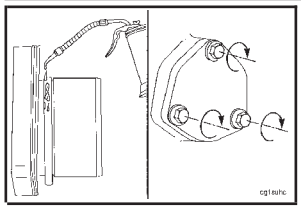
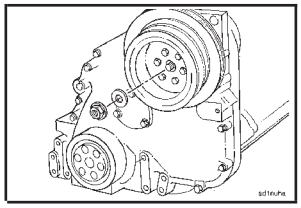
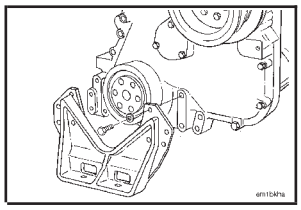
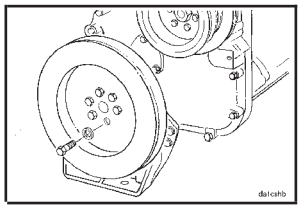
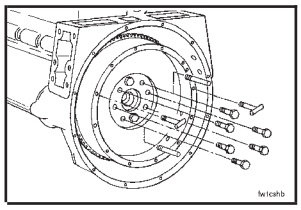
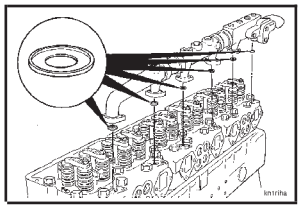
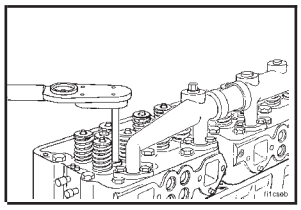
Belt Tension	Ref. Point	Newtons	Pounds Force
Alternator Belts			
• New Belt Tension		620	140
• Used Belt Tension		270-490	60-110

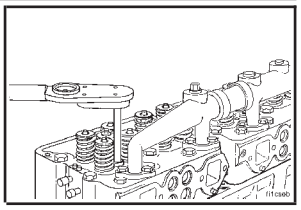
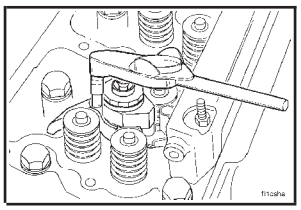
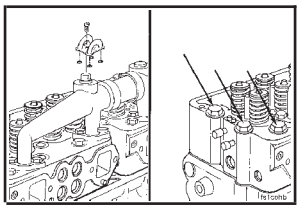
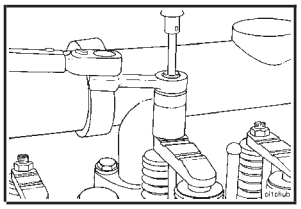
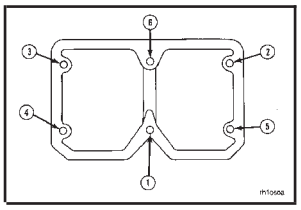
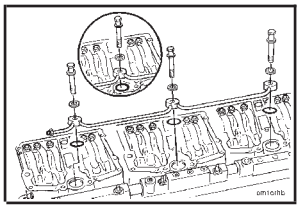
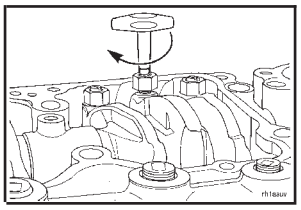


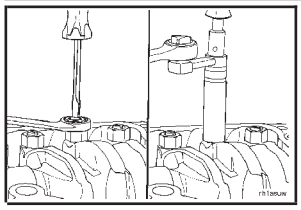
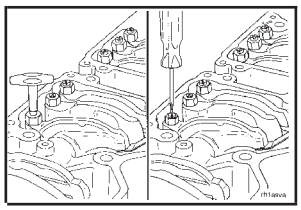
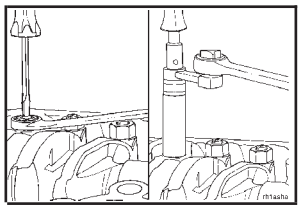
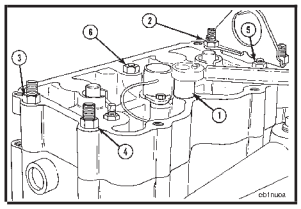
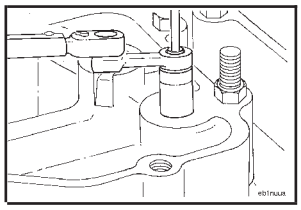
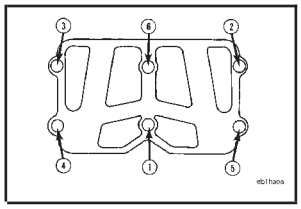
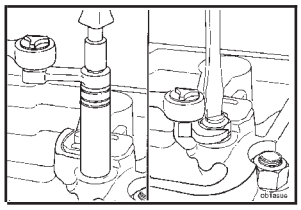
Engine Assembly - Capscrew Torque Values

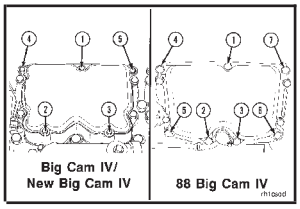
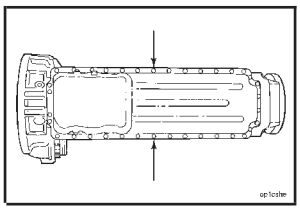
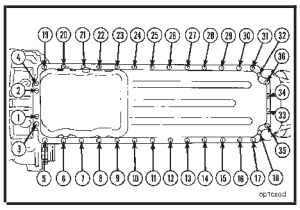
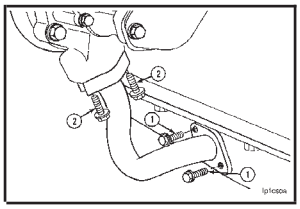
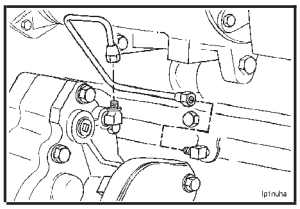
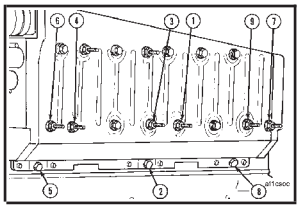
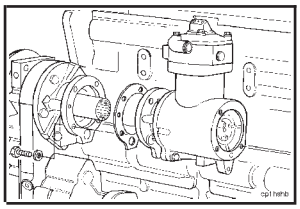
	Part or Assembly	Step	Torque Values N•m	ft-lb
	**Adapter Plate to Rebuild Stand**		100	75
	**Mounting Plate Adapter to Rear Water Header, if Removed**		9	7
	**Adapter Plate Mounting Capscrews** • 3/8-inch • 1/2-inch • 5/8-inch **Note:** Tighten all the adapter plate mounting capscrews in the sequence shown.		 40 100 100	 30 75 75
	**Liner Force Plate Screw**		136	100
	**Main Bearing Capscrews (1 inch diameter capscrews)** **Note:** Tighten in the sequence shown.	1 2 3 4 5 6 7	150 285 415 Loosen all 150 285 415	110 210 305 110 210 305
	**Main Bearing Capscrews (3/4-inch Diameter Capscrews)** **Note:** Tighten in the sequence shown.	1 2 3 4 5 6 7	120 230 345 Loosen all 120 230 345	90 170 255 90 170 255
	**Rear Cover Mounting Capscrews**		45	35

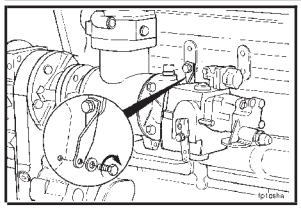
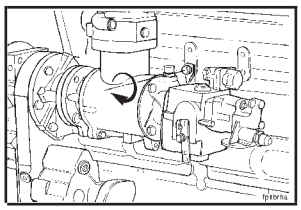
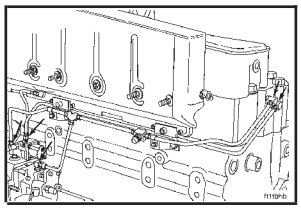
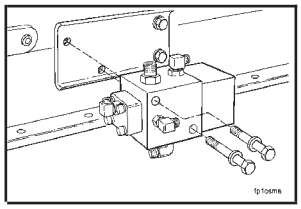
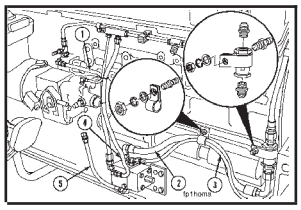
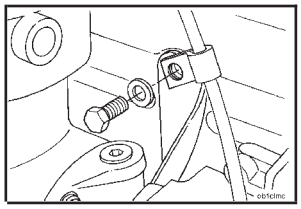
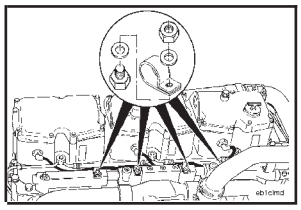
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Flywheel Housing **Note:** Tighten in the sequence shown.		205	150	
Connecting Rod Capscrews **Note:** Tighten the connecting rod capscrews in alternating sequence.		100 230	75 170	
Cylinder Head **Note:** Tighten in the sequence shown. Repeat steps 1, 2, and 3 to install each cylinder head.	1 2 3	35 135 385	25 100 285	
Cam Follower Housing (Without Mechanical Variable Timing) **Note:** Tighten in the alternating sequence shown.		20 45	15 35	
Note: With mechanical variable timing, the three housings of the MVT cam followers **must** be installed to the engine as an assembly. Tighten the center cam follower housing first.				
Accessory Drive Mounting Capscrews		60	45	
Lubricating Oil Pump		55	40	
Gear Cover		70	50	

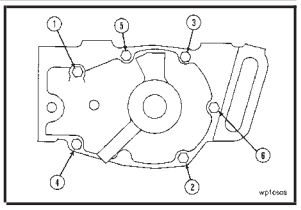
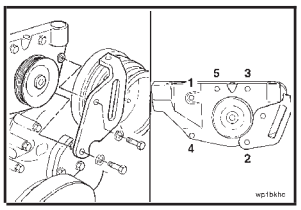
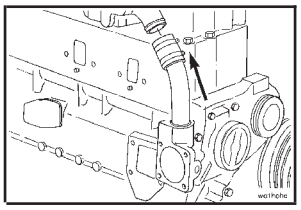
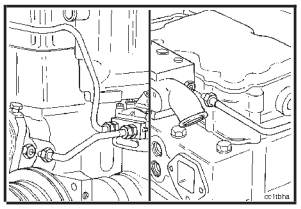
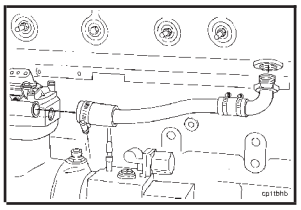
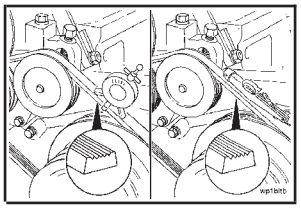
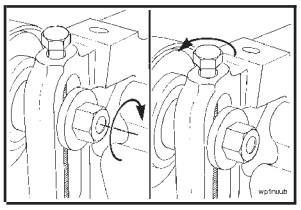
	Part or Assembly	Step	Torque Values N•m	ft-lb
	**Camshaft Bearing Support**		25	20
	**Accessory Drive Pulley**		420	310
	**Front Engine Support Bracket**		70	50
	**Vibration Damper** Capscrew Size: 5/8-inch; SAE grade No. 8		260	190
	**Flywheel** **Note:** Tighten the capscrews in a star pattern.		270	200
	**Water Manifold Assembly**		45	35
	**Injectors (PTD-Top Stop)** • Big Cam IV engines **Note:** For Big Cam IV engines (5/16-inch - 18 capscrews), tighten the capscrews alternately and evenly, 6 N•m [48 in-lb] torque one at a time, to a final torque of 18 N•m [156 in-lb].		18	156 in-lb

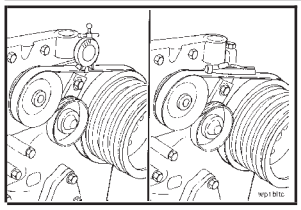
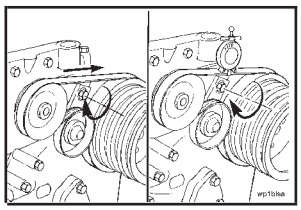
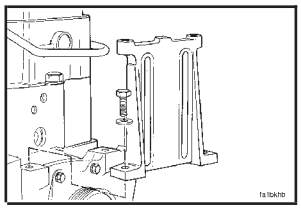
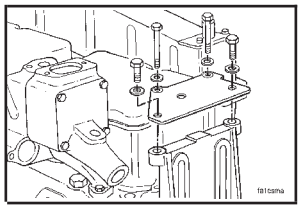
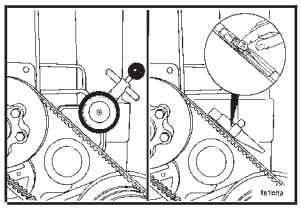
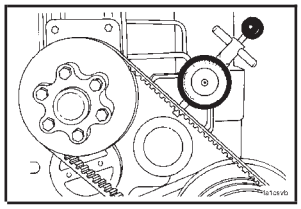
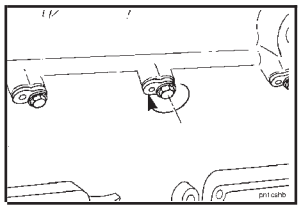
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Injectors (PTD-Top Stop)				
• New Big Cam IV and 88 Big Cam IV		34	25	
Note: For New Big Cam IV and 88 Big Cam IV engines (3/8-inch - 16 capscrews), tighten the capscrews alternately and evenly, 11 N•m [8 ft-lb] torque one at a time to a final torque of 34 N•m [25 ft-lb].				
Injectors (PTD-STC)		54	40	
Fuel Crossovers		4	35 in-lb	
Crossheads - Lock Nut				
• Less Jacobs® Brake:				
.. With adapter, Part No. ST-669		35	25	
.. Less adapter		40	30	
• With Jacobs® Brake Model 401 adjusting screw (exhaust crosshead only)				
.. With adapter, Part No. ST-669		30	22	
.. Less adapter		35	25	
Rocker Housing Mounting Capscrews		80	60	
Engine Brake Mounting Capscrews		95	70	
Note: Tighten the capscrews in the sequence shown.				
STC External Oil Manifold		11	95 in-lb	
Injector Adjusting Screw		0.56-0.68	5-6 in-lb	

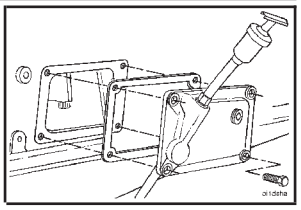
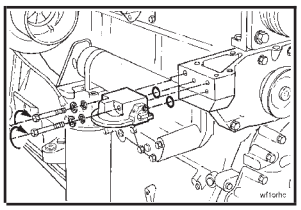
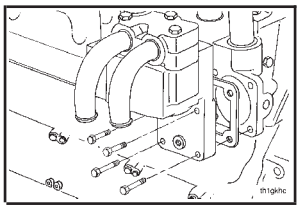
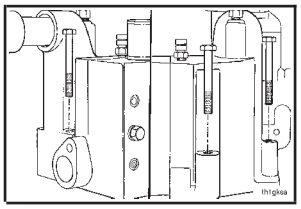
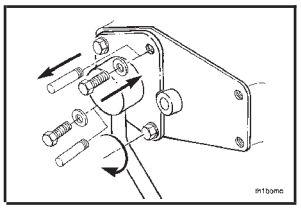
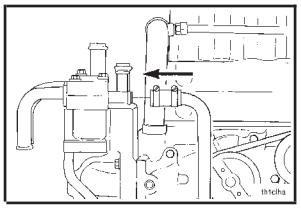
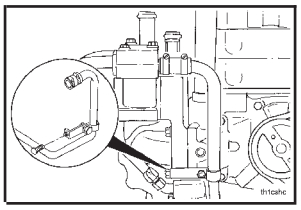
	Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
	**Injector Lock Nut**			
	• With torque wrench adapter, Part No. ST-669		45	35
	• Without adapter		60	45
	**Valve Lash Clearance (Torque Wrench Method Using Specified Feeler Gauge)**		0.68	6 in-lb
	**Valve Lock Nut**			
	• With torque wrench adapter, Part No. ST-669		45	35
	• Without adapter		60	45
	**Cummins C Brake Nuts**		90	65
	Note: Tighten the C Brake nuts in the sequence shown.			
	**Cummins C Brake Lock Nut**		24	18
	**Jacobs® Hold Down Nuts**		90	65
	Note: Tighten the nuts in the sequence shown.			
	**Jacobs® Lock Nut**			
	• With torque wrench adapter, Part No. 669		30	22
	• Without adapter		35	25

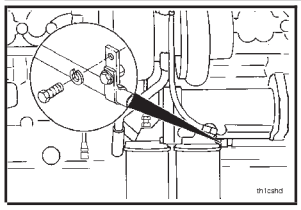
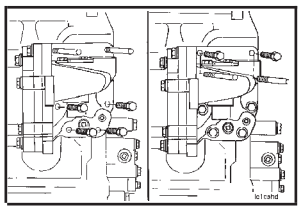
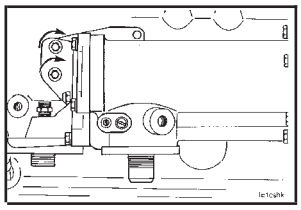
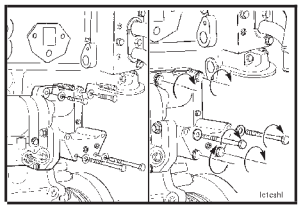
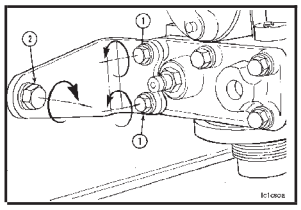
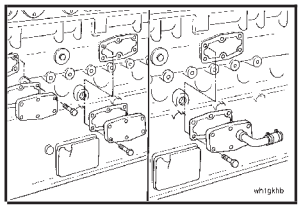
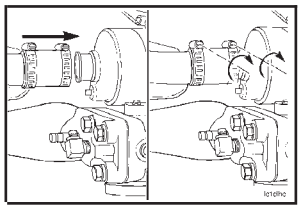
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Rocker Housing Covers				
• Big Cam IV/New Big Cam IV		20	15	
• 88 Big Cam IV		16	12	
Note: Tighten in the sequence shown.				
Oil Pan (7/16-inch Mounting Capscrews)		20	15	
Note: Tighten one of the 7/16-inch oil pan mounting capscrews on each side of the oil pan, halfway between the front and the rear of the oil pan.				
Oil Pan				
• Four 5/16-inch capscrews in rear of the oil pan.		25	20	
• Thirty-two 7/16-inch capscrews		70	50	
Note: Tighten in the sequence shown.				
Lubricating Oil Transfer Tube				
• First, tighten the two capscrews (1) at the oil pan.		45	35	
• Second, tighten the capscrews (2) at the lubricating oil pump.		45	35	
DFC Signal Line Tube Nuts		15	120 in-lb	
Aftercooler				
• Big Cam IV Unitized Aftercooler		70	50	
Note: Tighten the nine capscrews in the sequence shown. Use only grade 8 capscrews.				
Air Compressor		65	50	

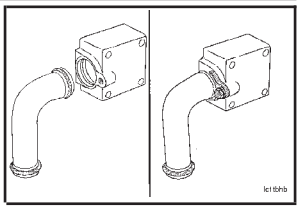
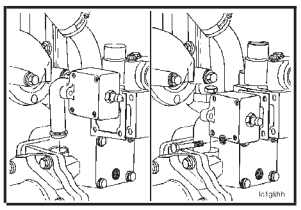
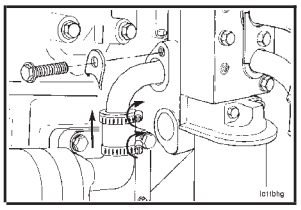
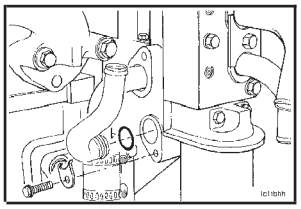
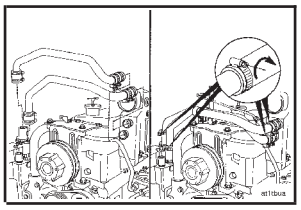
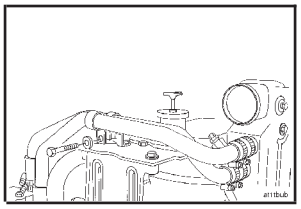
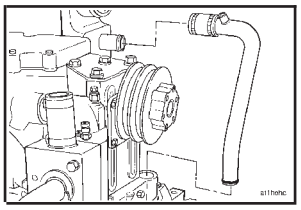
	Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
	**Fuel Pump**		45	35
	**Support Bracket to Cylinder Block Mounting Capscrews**		45	35
	**Fuel Tubing** Tube Size			
	1/4-inch		15-20	10-15
	5/16-inch		20-25	15-20
	3/8-inch		25-35	20-25
	1/2-inch		35-40	25-30
	**STC Oil Control Valve**		25	20
	**STC Oil Control Valve Hoses** Hose Size			
	No. 4		14-16	120-140 in-lb
	No. 6		20-35	15-25
	No. 8		40-55	30-40
	**Wiring Harness Mounting Clip to Cylinder Block**		45	35
	**Wiring Harness Mounting Clips to Water Manifold Mounting Studs** • Mounting Nuts		20	15

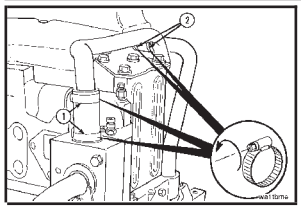
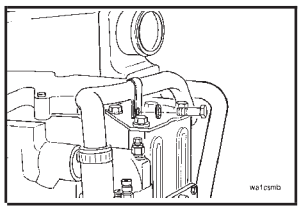
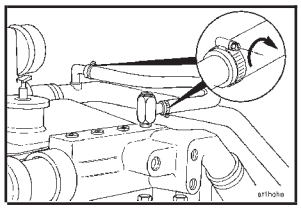
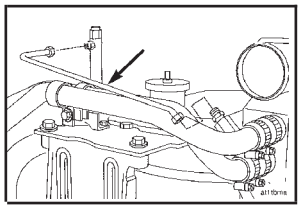
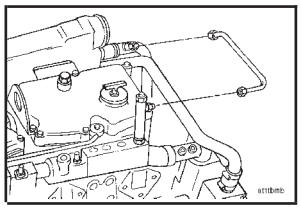
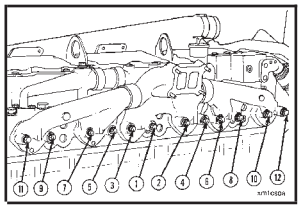
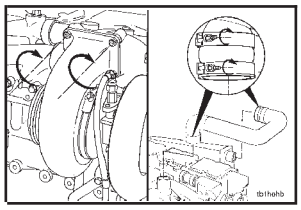
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Water Pump (Big Cam IV and New Big Cam IV)		15 30 45	10 20 35	
Note: Tighten the capscrews in the sequence shown.				
Water Pump (88 Big Cam IV) Idler Pulley Support Bracket		15 30 45	10 20 35	
Note: The two capscrews which mount the idler pulley support bracket are longer than the other four water pump capscrews.				
Coolant Transfer Tube Hose Clamp (Big Cam IV and New Big Cam IV Only)		5	40 in-lb	
Air Compressor Coolant Tubes Tube Nuts (Big Cam IV and New Big Cam IV)		20	15	
Air Compressor Air Inlet Fitting Into the Aftercooler		15	10	
Air Compressor Air Inlet Tube Hose Clamps (88 Big Cam IV)		5	40 in-lb	
Water Pump Belt (Big Cam IV and New Big Cam IV)				
• New Belt Tension		710 N	160 lbf	
• Used Belt Tension		290-580 N	65-130 lbf	
Note: A belt is considered used it if has been in operation for more than 10 minutes. If used belt tension is below the minimum, tighten to the maximum value.				
Idler Pulley Shaft Lock Nut (Big Cam IV and New Big Cam IV)		70	50	

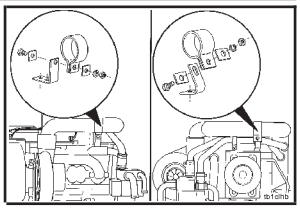
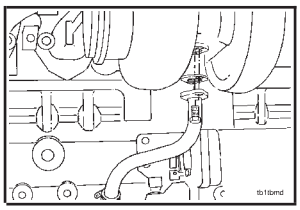
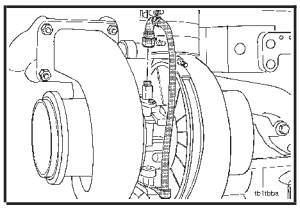
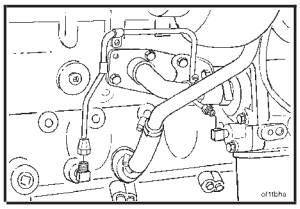
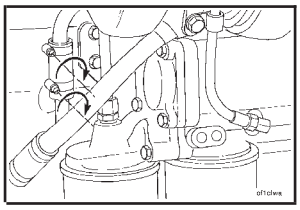
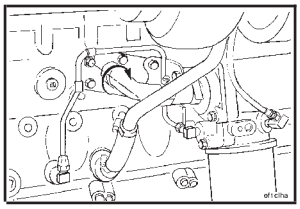
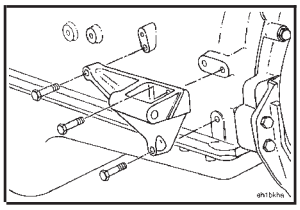
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
 **Water Pump Belt (88 Big Cam IV)**			
• New Belt Tension		620 N	140 lbf
• Used Belt Tension		270-490 N	60-110 lbf
Note: A belt is considered used if it has been in operation for more than 10 minutes. If used belt tension is below the minimum, tighten to the maximum value.			
 **Idler Pulley (88 Big Cam IV)**		45	35
 **Fan Hub Support Bracket**		100	75
 **Brace to Fan Hub Bracket**		70	50
Brace to Rocker Housing		80	60
 **Fan Drive Belts**			
• New Belt Tension		620 N	140 lbf
• Used Belt Tension		270-490 N	60-110 lbf
Note: A belt is considered used if it has been in operation for more than 10 minutes. If the belt tension is below the minimum, tighten to the maximum value.			
 **Fan Hub**		110	80
 **Piston Cooling Nozzles**			
• Hexagon Head		15	140 in-lb
• Slotted Head		10	95 in-lb

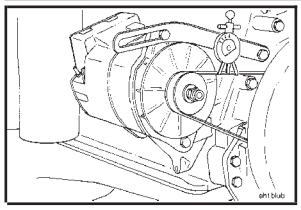
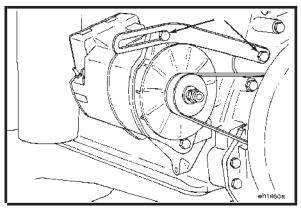
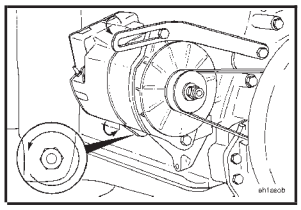
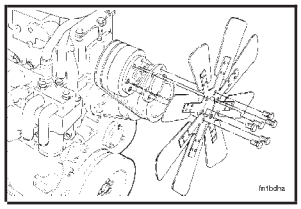
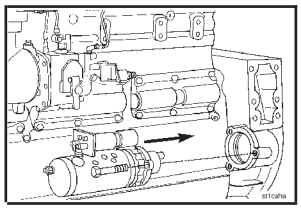
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Hand Hole Cover		45	35	
Coolant Filter Head (88 Big Cam IV)		45	35	
Thermostat Housing (Big Cam IV and New Big Cam IV)		45	35	
Thermostat Housing (88 Big Cam IV)		45	35	
Thermostat (Reserve Flow Cooling) Big Cam IV, New Big Cam IV, and NTC-444 Only		12	110 in-lb	
Thermostat (Reserve Flow Cooling) Big Cam IV, New Big Cam IV, and NTC-444 Clamps		5	40 in-lb	
Thermostat (Reserve Flow Cooling) Front Hold Down Strap Capscrew		45	35	

	Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
	**Thermostat (Reserve Flow Cooling)** Rear Hold Down Strap Capscrew		110	80
	**Oil Cooler Assembly (Big Cam IV and New Big Cam IV)**		45	35
	**Cooler Brace**		10	8
	**Oil Cooler Assembly (88 Big Cam IV)**		45	35
	**Support Bracket to Cylinder Block (2)** **Support Bracket to Rear Oil Cooler Cover (1)**		45 45	35 35
	**Water Header Covers**		12	110 in-lb
	**Water Transfer Hose* Clamps** *On engines equipped with a single pass oil cooler.		5	40 in-lb

Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Water Transfer Tube (Big Cam IV and New Big Cam IV)				
• Retaining Clip		25	20	
Water Transfer Housing to Thermostat Housing		25	20	
Water Transfer Tube (88 Big Cam IV)		45	35	
Hose Clamps		5	40 in-lb	
Water Fill Tube (88 Big Cam IV Only)		45	35	
Aftercooler Coolant Inlet and Outlet Tubes (Big Cam IV and New Big Cam IV)				
• Clamps		5	40 in-lb	
Aftercooler Coolant Inlet and Outlet Tubes (Big Cam IV and New Big Cam IV)				
• Capscrews		12	110 in-lb	
Aftercooler Coolant Inlet and Outlet Tubes (88 Big Cam IV)				
• Clamp		5	40 in-lb	

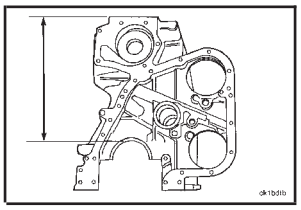
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
 **Aftercooler Coolant Inlet and Outlet Tubes (88 Big Cam IV)**			
• Hose Clamps (1) and (2)		5	40 in-lb
 **Aftercooler Coolant Inlet and Outlet Tubes (88 Big Cam IV)**			
• Capscrew		12	110 in-lb
 **Aftercooler Vent Tube (Big Cam IV and New Big Cam IV)**			
• Rubber Hose Clamps		5	40 in-lb
 **Aftercooler Vent Tube (Big Cam IV and New Big Cam IV)**			
• Steel Tube Nuts		12	110 in-lb
 **Aftercooler Vent Tube (88 Big Cam IV)**			
• Tube nuts		12	110 in-lb
 **Exhaust Manifold**		45 80	35 60
Note: Tighten in the sequence shown.			
 **Turbocharger Mounting Nuts**		45	35
Turbocharger Hose Clamps		8	70 in-lb

Part or Assembly	Step	Torque Values N•m	ft-lb	
Air Crossover Tube Support Clamp(s)		20	15	
Turbocharger				
• Capscrews		45	35	
• Hose Clamps		5	40 in-lb	
Turbocharger Oil Supply Hose Swivel Nuts		35	25	
Bypass Oil Filter Return Tube Swivel Nuts		35	25	
Hose Clamps **Note:** Tighten the hose clamps on Big Cam IV engines which have the bypass oil filter return tube plumbed into the turbocharger oil drain tube.		5	40 in-lb	
Bypass Oil Filter Return Tube Support Clamp Capscrew **Note:** Only on new Big Cam IV and 88 Big Cam IV engines with the single pass oil cooler.		12	110 in-lb	
Alternator Mounting Bracket		45	35	

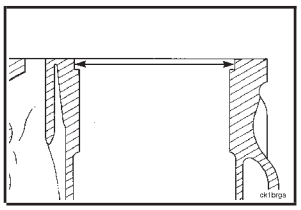
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
 **Alternator Belts**			
• New Belt Tension		620 N	140 lbf
• Used Belt Tension		270-490 N	60-110 lbf
Note: A belt is considered used if it has been in operation for more than 10 minutes.			
 **Adjusting Link Capscrews (Grade 5 or Higher)**			
Bolt Size / Threads/Inch			
5/16 / 18		20	15
7/16 / 14		35	25
1/2 / 13		65	50
 **Alternator to Alternator Support Capscrew and Nut (Grade 5 or Higher)**			
Bolt Size / Threads/Inch			
3/8 / 16		40	35
7/16 / 20		90	65
1/2 / 13		110	80
 **Fan**		45	35
 **Starting Motor**		175	130

Part or Assembly	Ref. Point	mm		in

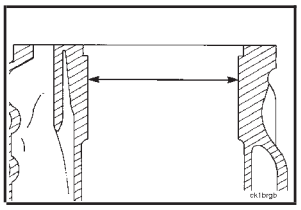
Cylinder Block - Rebuild Specifications



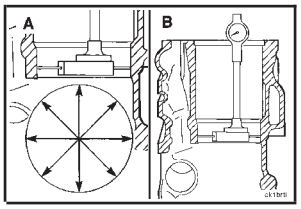
Cylinder Block Height	421.87 422.45	MIN MAX	16.609 16.632



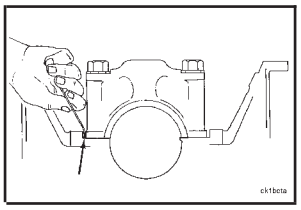
Upper Press Fit Design Counterbore Diameter		
• Standard	166.662 - 166.713	6.5615 - 6.5635
• Oversize	167.170 - 167.220	6.5815 - 6.5835
Lower Press Fit Design Counterbore Diameter		
• Standard	166.725 - 166.878	6.5640 - 6.5700
• Oversize	167.741 - 167.894	6.6040 - 6.6100



Upper Press Fit Design Upper Liner Bore Diameter		
• Standard	160.096 - 160.197	6.3030 - 6.3070
• Oversize	None	None
Lower Press Fit Design Upper Liner Bore Diameter		
• Standard	159.842 - 159.893	6.2930 - 6.2950
• Oversize	160.858 - 160.909	6.3330 - 6.3350

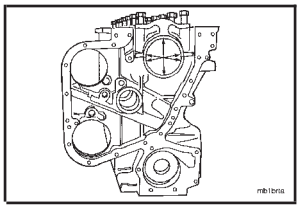


Cylinder Liner Lower Bore I.D.	155.54 155.60	MIN MAX	6.124 6.126

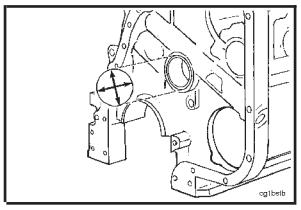


Cylinder Block to Main Bearing Cap Press Fit/Side Clearance			
• Press Fit	0.102	MIN	0.004
• Clearance	0.254*	MAX	0.010

*Measured between the block and either side of the cap.

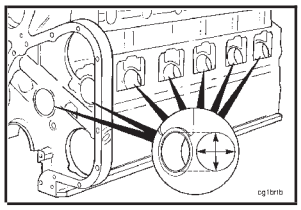
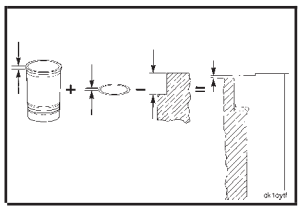
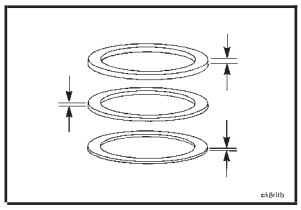
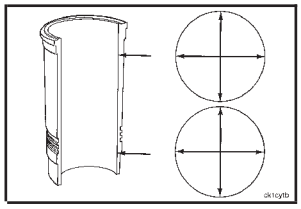
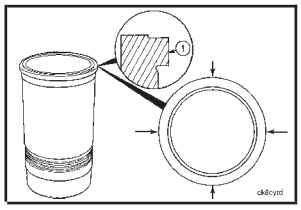
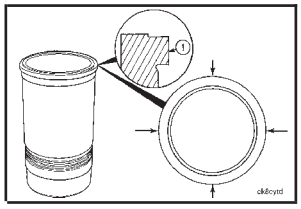


Main Bearing Bore I.D.	120.612 120.663	MIN MAX	4.7485 4.7505

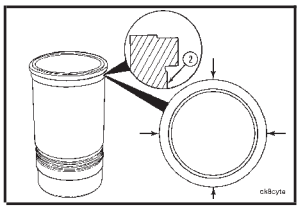


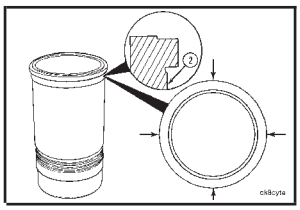
Camshaft Bushing I.D. (Installed)	63.457 63.558	MIN MAX	2.4983 2.5023

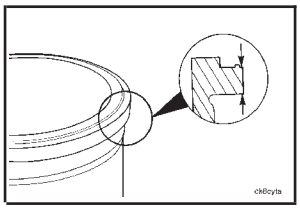
Note: If one of the bushings exceeds the maximum specifications, all of the bushings **must** be replaced.

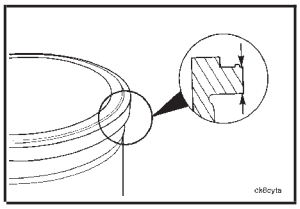
Part or Assembly	Ref. Point	mm		in
 **Cylinder Block Camshaft Bore I.D.**		68.237 68.262	MIN MAX	2.6865 2.6875
 **Cylinder Liner Protrusion**		0.10 0.18	MIN MAX	0.004 0.007
 **Counterbore Sealing Ring Thickness**				
• Standard Lower Press Fit or Upper Press Fit Liners		0.18 0.20 0.23 0.48 0.51 0.53 0.79 1.57		0.007 0.008 0.009 0.019 0.020 0.021 0.031 0.062
• Oversize Lower Press Fit Liners		0.46 0.51 0.56		0.018 0.020 0.022
 **Cylinder Liner I.D.**		139.694 139.827	MIN MAX	5.4998 5.5050
 **Liner O.D. (Upper Press Fit Area) Upper Press Fit Design**				
• Standard		166.72 166.77	MIN MAX	6.564 6.566
• .020 Oversize		167.23 167.28	MIN MAX	6.584 6.586
 **Liner O.D. (Upper Press Fit Area) Lower Press Fit Design**				
• Standard		166.72 166.77	MIN MAX	6.564 6.566
• .040 Oversize		167.74 167.79	MIN MAX	6.604 6.606

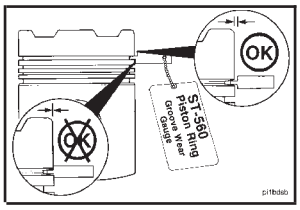
Part or Assembly	Ref. Point	mm		in
Liner O.D. (Lower Press Fit Area) Upper Press Fit Design				
• Standard		159.86	MIN	6.294
		159.99	MAX	6.299
• .020 Oversize		159.86	MIN	6.294
		159.99	MAX	6.299
Liner O.D. (Lower Press Fit Area) Lower Press Fit Design				
• Standard		159.91	MIN	6.296
		159.96	MAX	6.298
• .040 Oversize		160.93	MIN	6.336
		160.98	MAX	6.338
Cylinder Liner Flange Thickness Upper Press Fit Design				
• Standard		9.01	MIN	0.355
		9.04	MAX	0.356
• .020 Oversize		9.27	MIN	0.365
		9.29	MAX	0.366
Cylinder Liner Flange Thickness Lower Press Fit Design				
• Standard		9.01	MIN	0.355
		9.04	MAX	0.356
• .040 Oversize		9.52	MIN	0.375
		9.55	MAX	0.376
Piston Compression Ring Grooves Width Use piston ring groove wear gauge, Part No. ST-560-6. The piston **must** be replaced if the widest part of the gauge touches the piston.				
Piston Oil Ring Groove Width Use a new oil ring and a 0.152 mm [0.006 inch] feeler gauge. If the feeler gauge enters the oil ring groove without resistance, the piston **must** be replaced.				
Piston Skirt Outside Diameter	(A)	139.31	MIN	5.485
		139.47	MAX	5.491
	(B)	139.34	MIN	5.486
		139.52	MAX	5.493

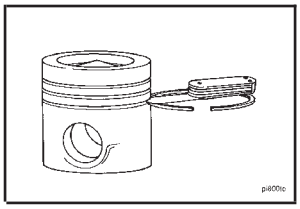


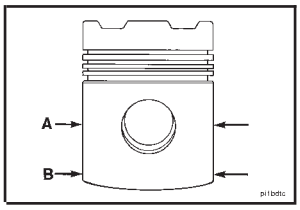


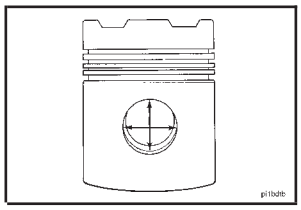
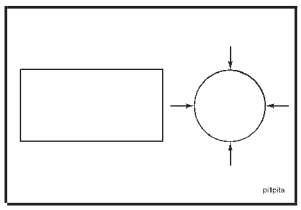
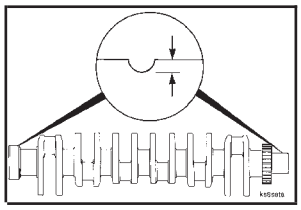
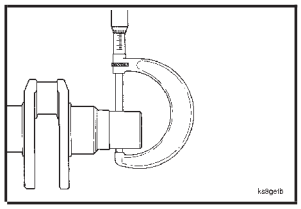
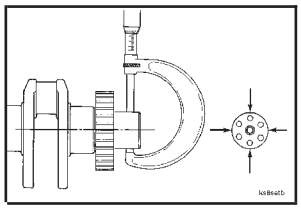
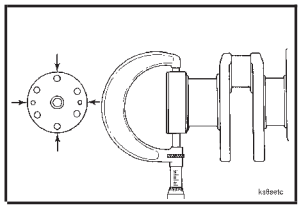
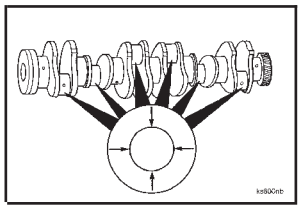


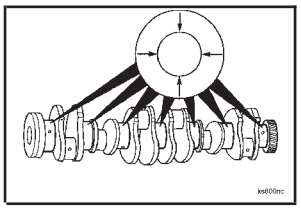
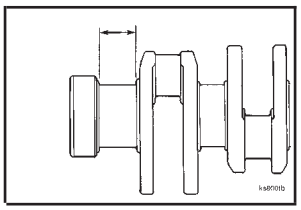
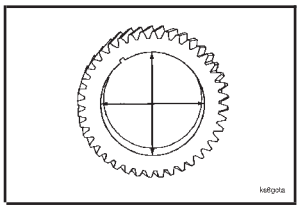
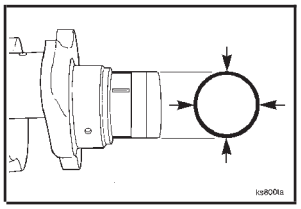
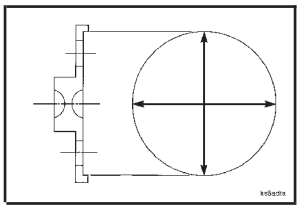
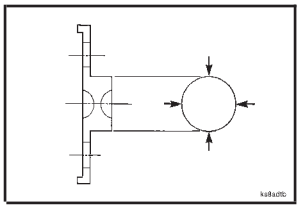




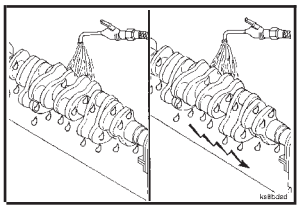


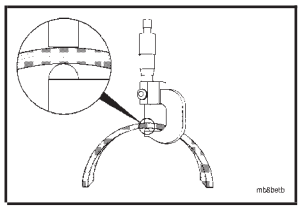
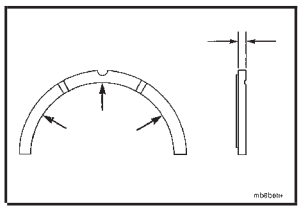
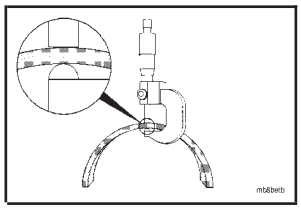
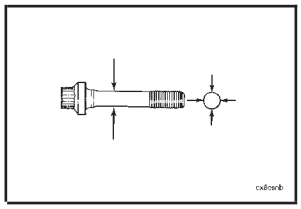
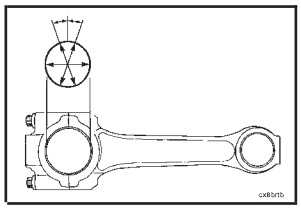
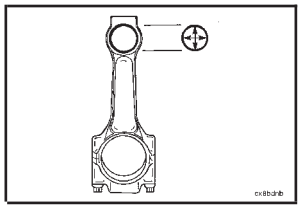
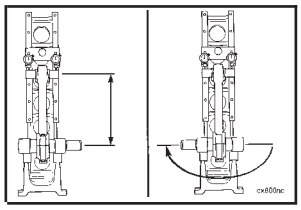


Part or Assembly	Ref. Point	mm		in
 **Piston Pin Bore**		50.762 50.800	MIN MAX	1.9985 2.0000
 **Piston Pin O.D.**		50.762 50.775	MIN MAX	1.9985 1.9990
Note: Discard the piston pin if it is more than 0.03 mm [0.001-inch] out of round.				
 **Crankshaft Oil Seal Wear Groove**		0.25	MAX	0.010
 **Crankshaft Gear Fit Area O.D.**		95.504 95.522	MIN MAX	3.7600 3.7607
 **Crankshaft Front Oil Seal Area O.D.**		92.07 92.10	MIN MAX	3.625 3.626
 **Crankshaft Rear Oil Seal Area O.D.**		152.35 152.40	MIN MAX	5.998 6.000
 **Crankshaft Connecting Rod Journal O.D.**		79.30 79.38	MIN MAX	3.122 3.125

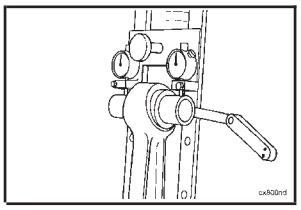
Part or Assembly	Ref. Point	mm		in	
Crankshaft Main Bearing Journal O.D.		114.237 114.300	MIN MAX	4.4975 4.5000	
Crankshaft Thrust Face Width		76.23 76.28	MIN MAX	3.001 3.003	
Crankshaft Gear Bore I.D.		95.394 95.415	MIN MAX	3.7557 3.7565	
Crankshaft Gear Fit Area O.D.		95.504 95.522	MIN MAX	3.7600 3.7607	
Crankshaft Adapter Inside Pilot Diameter		92.10 92.17	MIN MAX	3.626 3.629	
Crankshaft Adapter Outside Pilot Diameter		35.013 35.052	MIN MAX	1.3785 1.3800	

Note: The instructions for performing a magnetic crack inspection and the limits of acceptance for open and subsurface indications are provided in Cylinder Block - Group 01. Refer to Crankshaft - Magnetic Crack Inspection (01-10), Page 1-87.

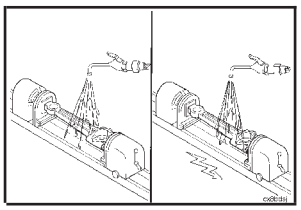


	Part or Assembly	Ref. Point	mm		in
	**Main Bearing Shell Thickness (Standard)**		3.086 3.145	MIN MAX	0.1215 0.1238
	**Thrust Bearing Thickness**		6.210 6.286	MIN MAX	0.2445 0.2475
	**Connecting Rod Bearing Thickness (Standard)**		2.362 2.405	MIN MAX	0.0930 0.0947
	**Connecting Rod Capscrew O.D.**		14.81 14.99	MIN MAX	0.583 0.590
	**Connecting Rod Crankshaft Bore I.D.**		84.219 84.244	MIN MAX	3.3157 3.3167
	**Piston Pin Bushing I.D.**		50.825 50.856	MIN MAX	2.0010 2.0022
	**Connecting Rod - Length**		304.75 304.80	MIN MAX	11.998 12.000
	Connecting Rod - Alignment:				
	• (Without Bushing)		0.25	MAX	0.010
	• (With Bushing)		0.10	MAX	0.004

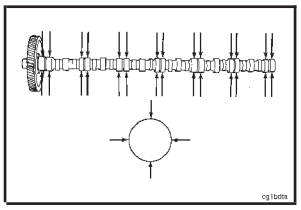
Part or Assembly	Ref. Point	mm		in
Connecting Rod - Twist:				
• (Without Bushing)		0.50	MAX	0.020
• (With Bushing)		0.25	MAX	0.010



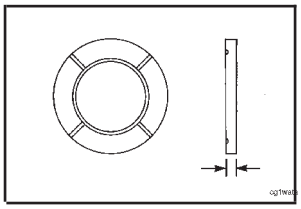
The instructions for performing a magnetic crack inspection of the connecting rod is provided in Group 01. Refer to Connecting Rods - Magnetic Inspection (01-15), Page 1-109.



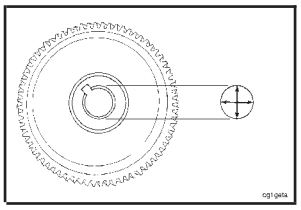
Camshaft Bushing Journal O.D.		63.37	MIN	2.495
		63.42	MAX	2.497



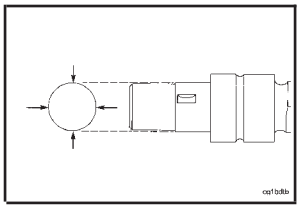
Camshaft Thrust Washer Thickness		2.29	MIN	0.090
		2.49	MAX	0.098



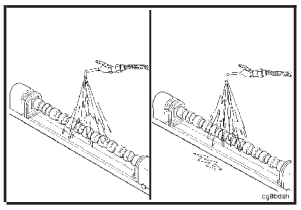
Camshaft Gear Bore I.D.				
• Flanged Camshaft		44.455	MIN	1.7502
		44.475	MAX	1.7510
• Flangeless Camshaft		45.662	MIN	1.7977
		45.682	MAX	1.7985

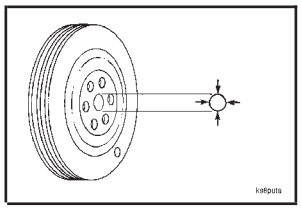
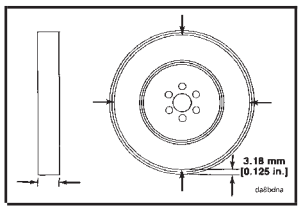
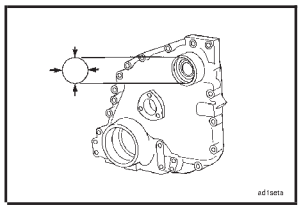
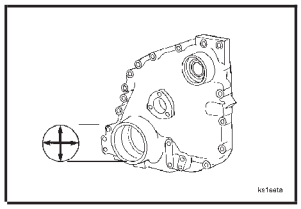
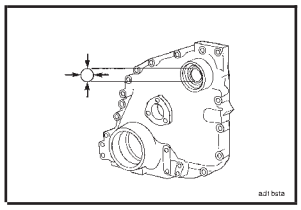
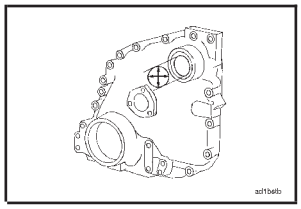


Camshaft Gear Press Fit O.D.				
• Flanged Camshaft		44.526	MIN	1.7530
		44.539	MAX	1.7535
• Flangeless Camshaft		45.733	MIN	1.8005
		45.745	MAX	1.8010

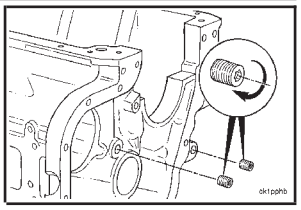
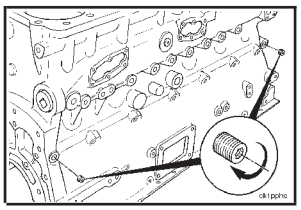
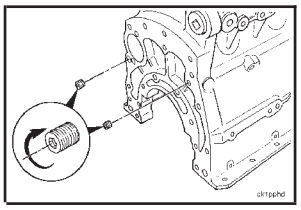
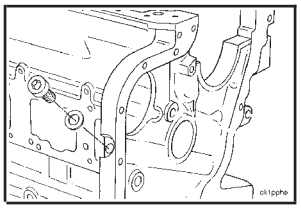
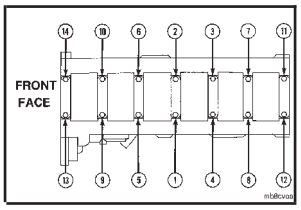
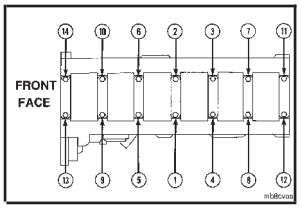
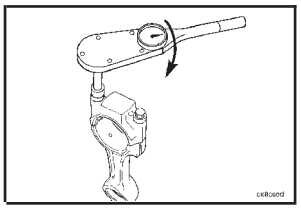


The instructions for performing a magnetic crack inspection of the camshaft and camshaft gear is provided in Group 01. Refer to Camshaft - Magnetic Inspection (01-18), Page 1-118 and Camshaft Gear - Magnetic Inspection (01-19), Page 1-123.

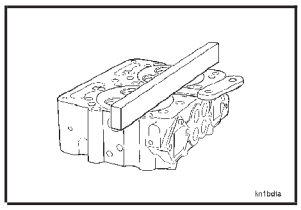
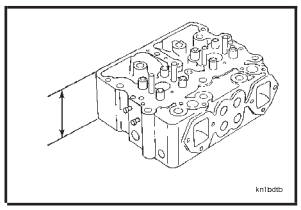
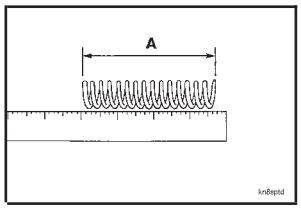
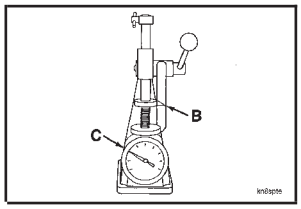
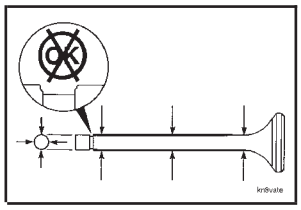
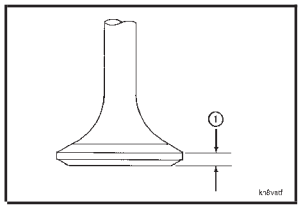
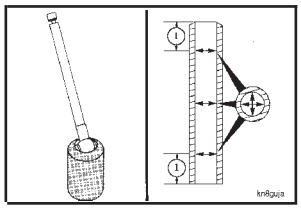


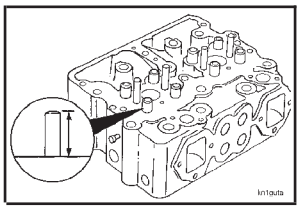
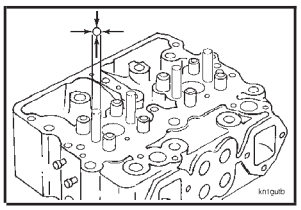
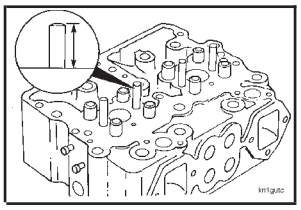
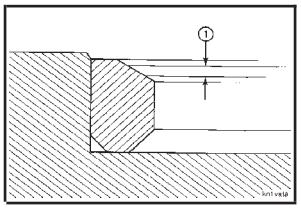
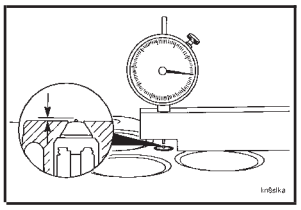
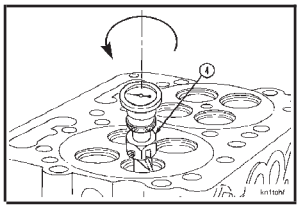
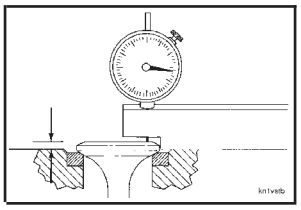
Part or Assembly	Ref. Point	mm		in
 **Crankshaft Pulley I.D.**		35.05 35.10	MIN MAX	1.380 1.382
 **Vibration Damper Thickness** Measure the thickness in four places 90 degrees apart approximately 3.18 mm [0.125 inch] from the outside diameter. The difference between any two of the four measurements **must not** exceed 0.25 mm [0.010 inch].				
 **Accessory Drive Seal Bore I.D.**		80.962 81.038	MIN MAX	3.1875 3.1905
 **Crankshaft Seal Bore I.D.**		120.611 120.688	MIN MAX	4.7485 4.7515
 **Accessory Drive Bushing I.D.**		39.75 39.90	MIN MAX	1.565 1.571
 **Accessory Drive Bushing Bore I.D.**		43.07 43.10	MIN MAX	1.696 1.697

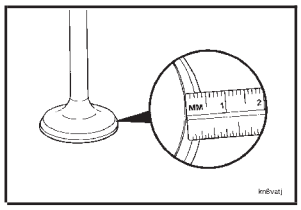
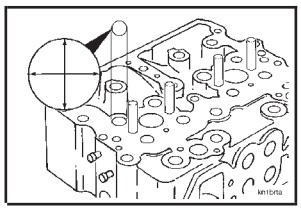
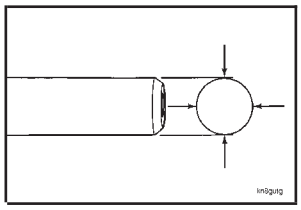
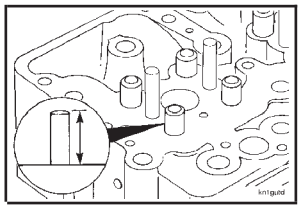
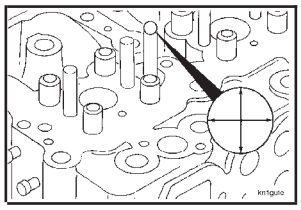
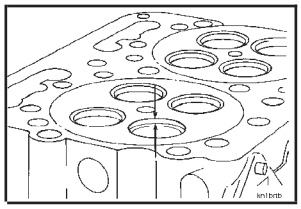
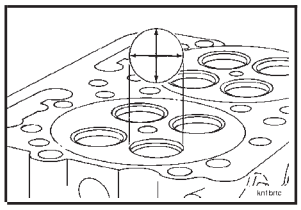
Cylinder Block - Torque Values

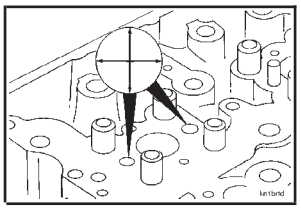
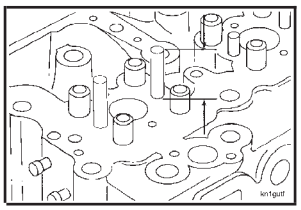
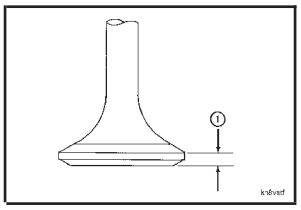
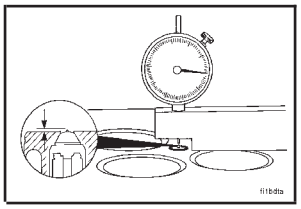
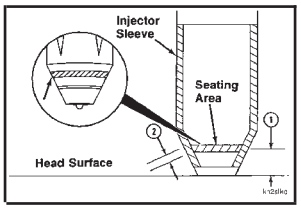
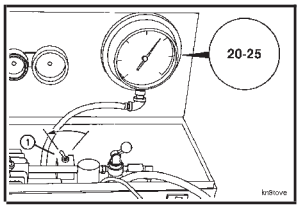
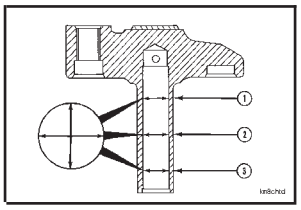
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Cylinder Block Pipe Plugs				
• 1/4-inch		20	15	
• 3/8-inch		25	20	
Cylinder Block Pipe Plugs				
• 3/8-inch		25	20	
• 1/8-inch		15	10	
Cylinder Block Pipe Plugs				
• 1/4-inch		20	15	
• 3/8-inch		25	20	
Cylinder Block Pipe Plug				
• 7/8-18 Straight Threaded Plug		90	65	
Main Bearing Capscrews (1 inch diameter)	1	150	110	
Note: Tighten the main bearing capscrews in the sequence shown.	2	285	210	
	3	415	305	
	4	Loosen All		
	5	150	110	
	6	285	210	
	7	415	305	
Main Bearing Capscrews (3/4-inch diameter)	1	120	90	
Note: Tighten the main bearing capscrews in the sequence shown.	2	230	170	
	3	345	255	
	4	Loosen All		
	5	120	90	
	6	230	170	
	7	345	255	
Connecting Rod Capscrews		100	75	
NOTE: Tighten the capscrews in alternate sequence.		230	170	

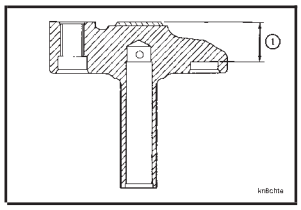
Cylinder Head - Rebuild Specifications

Part or Assembly	Ref. Point	mm		in
				
Cylinder Head Flatness Per 25.4 mm [1.00 in.] of Length		0.020	MAX	0.0008
Cylinder Head Flatness (Total Overall Length)		0.08	MAX	0.003
				
Cylinder Head Thickness		109.85	MIN	4.325
		111.25	MAX	4.380
				
Valve Spring Free Height:	A			
• Valve Spring Part No. 211999		68.20	Nominal	2.685
• Valve Spring Part No. 3035996		66.93	Nominal	2.635
				
Valve Spring Working Height:	B			
• Valve Spring Part No. 211999		43.79	Nominal	1.724
• Valve Spring Part No. 3035996		42.44	Nominal	1.671
Load for Working Height:	C			
• Valve Spring Part No. 211999		295 N	MIN	66.5 lbf
		326 N	MAX	73.5 lbf
• Valve Spring Part No. 3035996		381 N	MIN	85.7 lbf
		412 N	MAX	92.7 lbf
				
Valve Stem O.D.		11.40	MIN	0.449
		11.46	MAX	0.451
				
Valve Head Thickness at O.D.	1	2.90	MIN	0.114
				
Valve Guide I.D. (Installed)		11.506	MIN	0.4530
		11.557	MAX	0.4550

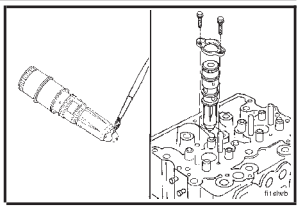
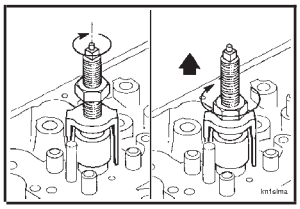
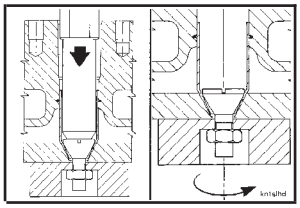
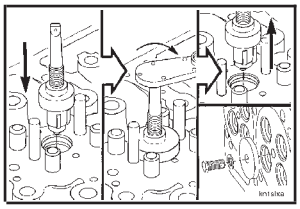
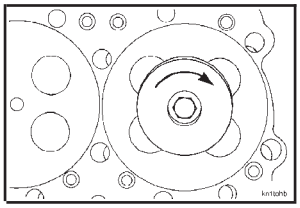
Part or Assembly	Ref. Point	mm		in	
Valve Guide Height (Installed)		32.26 32.51	MIN MAX	1.270 1.280	
Crosshead Guide O.D.		10.975 11.011	MIN MAX	0.4321 0.4335	
Crosshead Guide Height (Installed)		47.25 47.75	MIN MAX	1.860 1.880	
Valve Seat Area Width	1	1.60 3.18	MIN MAX	0.063 0.125	
Injector Tip Protrusion		1.52 1.78	MIN MAX	0.060 0.070	
Valve Seat to Valve Guide Concentricity (Per 360 Degrees)		0.09	MAX	0.0035	
Valve Protrusion					
• Pre-88 NT		2.67 4.19	MIN MAX	0.105 0.165	
• 88 NT		1.40 2.16	MIN MAX	0.055 0.085	

	Part or Assembly	Ref. Point	mm		in
	**Valve Seat Width Limit**		1.60 3.18	MIN MAX	0.063 0.125
	**Valve Guide Bore I.D.**		19.05 19.07	MIN MAX	0.750 0.751
	**Valve Guide O.D.**		19.088 19.101	MIN MAX	0.7515 0.7520
	**Valve Guide Height (Installed)**		32.26 32.51	MIN MAX	1.270 1.280
	**Valve Guide I.D. (Installed)**		11.494 11.557	MIN MAX	0.4525 0.4550
	**Valve Seat Insert Bore Depth (Standard Insert)**		7.24 7.37	MIN MAX	0.285 0.290
	**Valve Seat Insert Bore I.D. (Standard Insert)**		50.787 50.813	MIN MAX	1.9995 2.0005

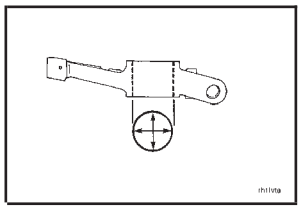
Part or Assembly	Ref. Point	mm		in	
Crosshead Guide Bore I.D.		10.947 10.972	MIN MAX	0.4310 0.4320	
Crosshead Guide Height (Installed)		47.25 47.75	MIN MAX	1.860 1.880	
Valve Head Thickness (at O.D.)		2.90	MIN	0.114	
Injector Tip Protrusion:		1.52 1.78	MIN MAX	0.060 0.070	
Injector to Injector Sleeve Seat Pattern:					
• Distance from Cylinder Head Surface	1	11.91	Approx.	0.469	
• Pattern Width	2	1.52	MIN	0.060	
Valve Seat Leakage (Hg)		508 635	MIN MAX	20 25	
Note: Refer to Cylinder Head - Vacuum Testing Valve Seating For Reuse (02-10), Page 2-38.					
Valve Crosshead Stem Bore I.D.	1 2 3	11.03 11.17	MIN MAX	0.434 0.440	

Part or Assembly	Ref. Point	mm		in
 **Valve Crosshead Stem Pocket to Pad Face**	1	9.65 10.16	MIN MAX	0.380 0.400

Cylinder Head - Torque Values

Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Install the Injectors into the Cylinder Head				
Timing / Capscrew Size				
Fixed 5/16	1	6	4	
	2	12	9	
	3	18	13	
Fixed 3/8	1	14	10	
	2	24	18	
	3	34	25	
STC 3/8	1	48	35	
Note: Refer to Cylinder Head - Rebuild (02-02), page No. 2-17, and Cylinder Head - Replacing the Injector Sleeves (02-07), page No. 2-33.				
Injector Sleeve Puller Small Nut		65	50	
Injector Sleeve Holding Tool Nut		60	45	
Note: This torque value is for installing new injector sleeves. Refer to Cylinder Head - Replacing the Injector Sleeves (02-07), page No. 2-30.				
Injector Sleeve Expander Mandrel		8	75 in-lb	
Injector Sleeve Holding Tool Capscrews	1	5	45 in-lb	
	2	10	90 in-lb	
	3	15	130 in-lb	
Note: This torque value is for pressure testing the cylinder head. Refer to Cylinder Head-Pressure Testing (02-08), Page 2-35.				

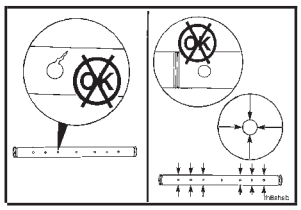
Part or Assembly	Ref. Point	mm		in



Rocker Lever Housing Assembly - Rebuild Specifications

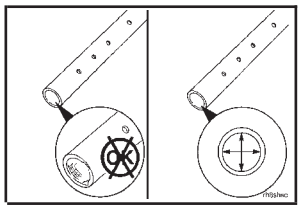
Rocker Lever Bushing Bore I.D. (Installed)

• Pre-88NT	28.562	MIN	1.1245
	28.666	MAX	1.1286
• 88NT	34.886	MIN	1.3735
	34.988	MAX	1.3775

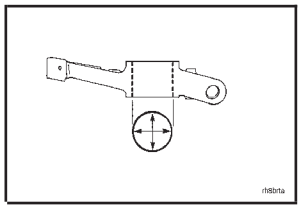


Rocker Lever Shaft O.D.

• Pre-88NT	28.490	MIN	1.1215
	28.540	MAX	1.1235
• 88NT	34.810	MIN	1.3705
	34.860	MAX	1.3725



Rocker Lever Shaft I.D.	16.002	MIN	0.630
	16.052	MAX	0.632

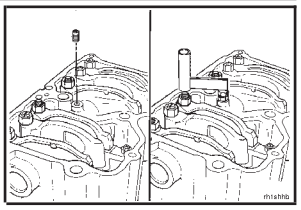


Rocker Lever Bore I.D.

• Pre-88NT	30.15	MIN	1.187
	30.17	MAX	1.188
• 88NT	36.47	MIN	1.436
	36.50	MAX	1.437

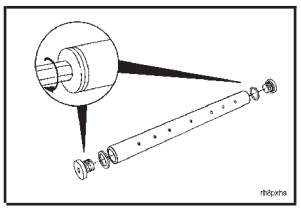
Rocker Lever Housing Assembly - Torque Values

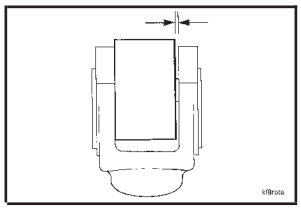
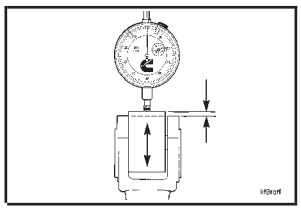
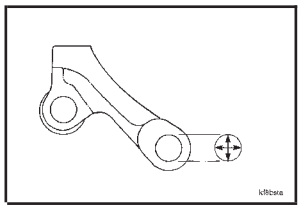
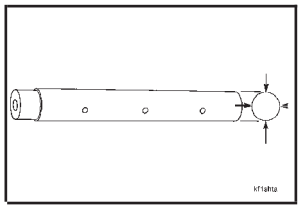
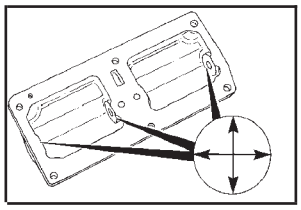
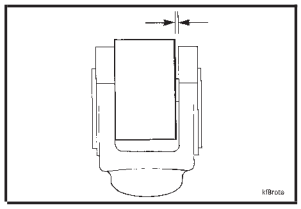
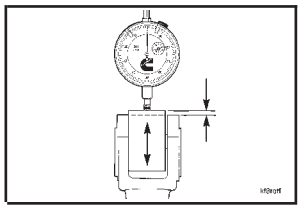
Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
Rocker Lever Shaft Set Screw		11	100 in-lb

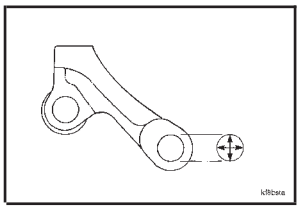
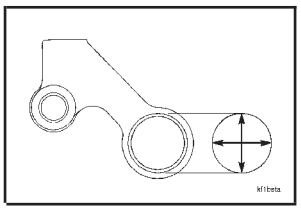
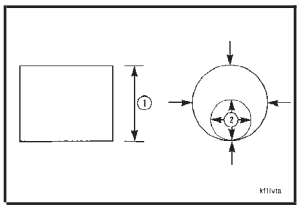
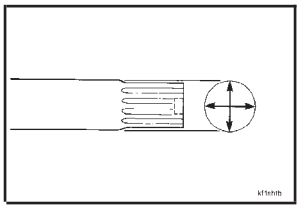
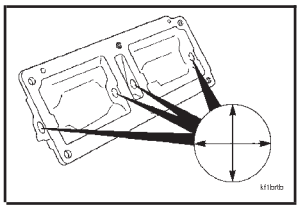
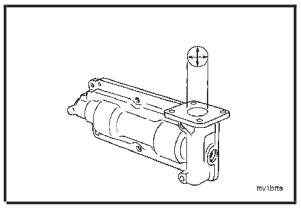
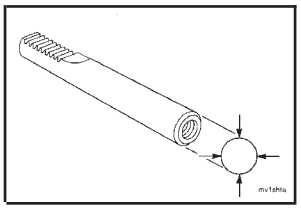


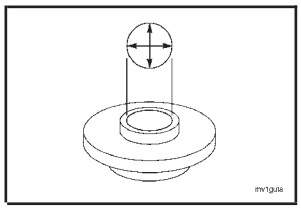
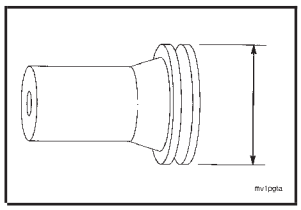
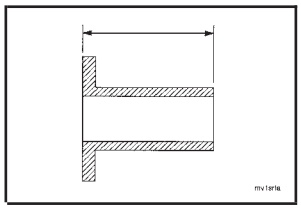
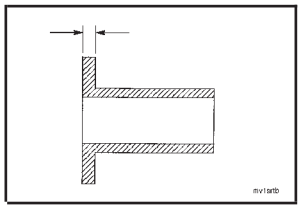
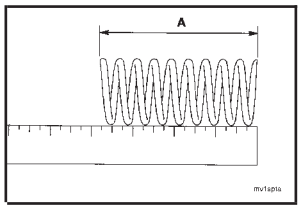
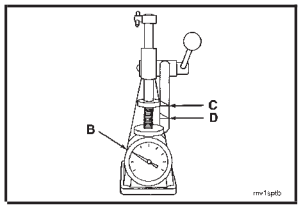
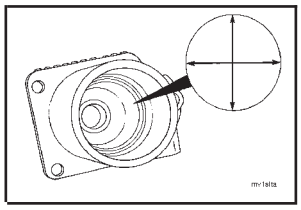
Note: The 80-degree tilt engines use spray nozzles instead of set screws in the rocker lever housings. Spray nozzles **must** be aligned with valve spring spray nozzle locator, Part No. ST-1182.

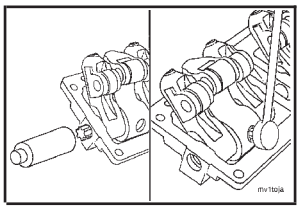
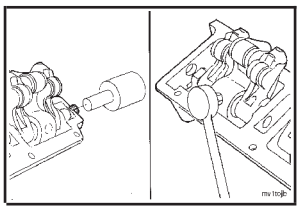
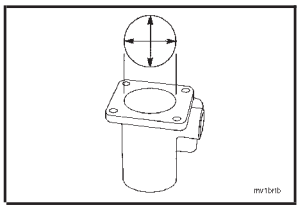
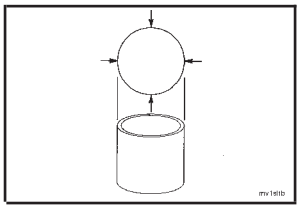
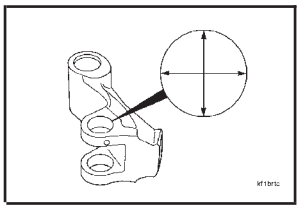
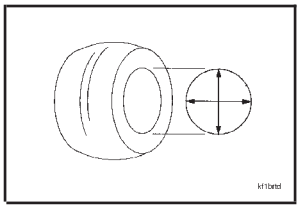
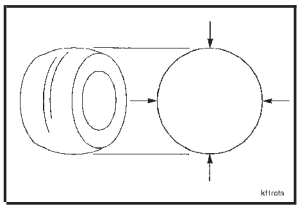
Rocker Lever Shaft Threaded Plugs		95	70

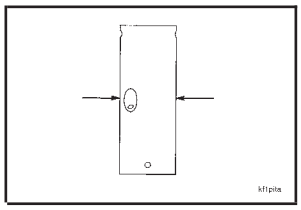
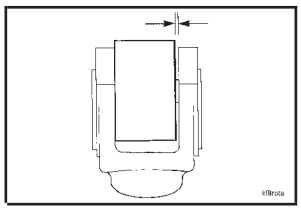
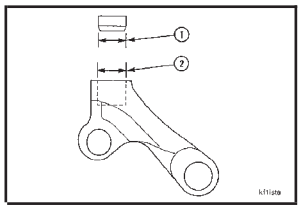
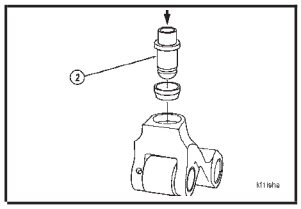


	Part or Assembly	Ref. Point	mm		in
	**Cam Follower Assembly - Rebuild Specifications**				
	Fixed Injection Timing				
	Cam Follower Roller Side Clearance		0.23 0.61	MIN MAX	0.009 0.024
	**Cam Follower Roller to Pin Clearance**		0.08 0.20	MIN MAX	0.003 0.008
	**Cam Follower Lever Bushing I.D.**		19.052 19.100	MIN MAX	0.7501 0.7520
	**Cam Follower Shaft O.D.**		19.00 19.02	MIN MAX	0.748 0.749
	**Cam Follower Shaft Bore I.D.**		19.02 19.05	MIN MAX	0.749 0.750
	**MVT Injection Timing**				
	Cam Follower Roller Side Clearance		0.23 0.61	MIN MAX	0.009 0.024
	**Cam Follower Roller to Pin Clearance**		0.08 0.20	MIN MAX	0.003 0.008

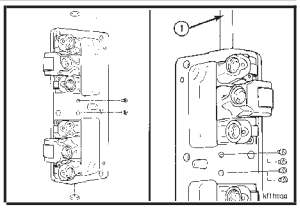
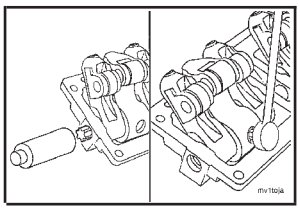
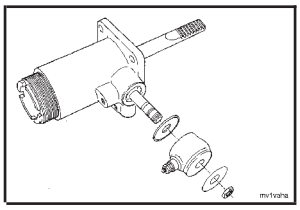
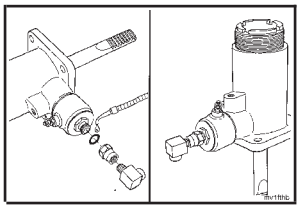
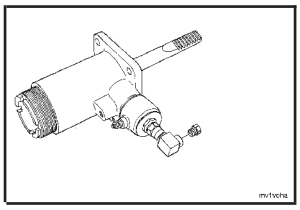
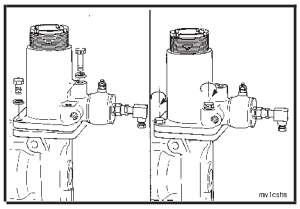
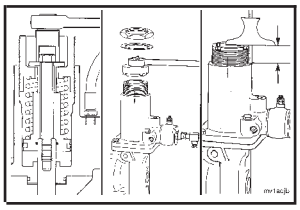
Part or Assembly	Ref. Point	mm		in	
Valve Lever Bushing or Bore I.D.		19.052 19.100	MIN MAX	0.7501 0.7520	
Injector Lever Bushing I.D.		34.963 35.011	MIN MAX	1.3765 1.3784	
Injector Cam Follower Lever Eccentrics O.D.	1	34.900 34.920	MIN MAX	1.3740 1.3748	
	2	19.029 19.055	MIN MAX	0.7492 0.7502	
Cam Follower Shaft O.D.		19.00 19.02	MIN MAX	0.748 0.749	
Cam Follower Shaft Bore I.D.		19.062 19.113	MIN MAX	0.7505 0.7525	
Actuator Shaft Bore I.D.		19.05 19.15	MIN MAX	0.750 0.754	
Actuator Shaft O.D.		18.95 19.00	MIN MAX	0.746 0.748	

	Part or Assembly	Ref. Point	mm		in
	**Actuator Shaft Guide I.D.**		19.28 19.35	MIN MAX	0.759 0.762
	**Actuator Plunger O.D.**		49.60 49.78	MIN MAX	1.953 1.960
	**Timing Spacer Length** Part No. 3021515 3024029 3024030		MIN 35.43mm [1.395in] 30.86mm [1.215in] 37.72mm [1.485in]	MAX 35.68mm [1.405in] 31.11mm [1.225in] 37.97mm [1.495in]	
	**Timing Spacer Flange Thickness**		3.81 4.06	MIN MAX	0.150 0.160
	**Actuator Spring Free Length**		105.38	Nominal	4.149
	**Spring Tester Working Height** **Load for Working Height**	C D C D	67.05 48.76 391N 480N 578N 711N	Nominal Nominal MIN MAX MIN MAX	2.640 1.920 88 lbf 108 lbf 130 lbf 160 lbf
	**Actuator Housing Cylinder Sleeve I.D.**		50.69 50.85	MIN MAX	1.996 2.002

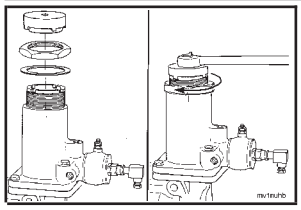
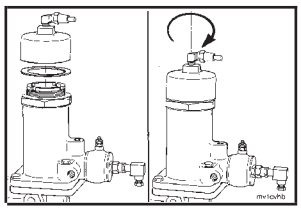
Part or Assembly	Ref. Point	mm		in	
Cam Follower Shaft From Housing Extension Dimension		23.25 23.75	MIN MAX	0.915 0.935	
The Shaft End Opposite the Actuator Must Have a Depth in the Housing as Follows: Dimensions		25.30 25.40	MIN MAX	0.996 1.000	
Actuator Housing Cylinder Bore I.D.		56.97 57.02	MIN MAX	2.243 2.245	
Actuator Housing Cylinder Sleeve O.D.		57.05 57.15	MIN MAX	2.246 2.250	
Valve Lever Roller Pin Bore I.D.		12.674 12.687	MIN MAX	0.4990 0.4995	
Injector Lever Roller Pin Bore I.D.		17.759 17.772	MIN MAX	0.6992 0.6997	
Valve Lever Roller Bore I.D.		12.776 12.801	MIN MAX	0.5030 0.5040	
Injector Lever Roller Bore I.D.		17.856 17.881	MIN MAX	0.7030 0.7040	
Crowned Valve Roller O.D.		31.711 31.762	MIN MAX	1.2485 1.2505	
Crowned Injector Roller O.D.		31.711 31.762	MIN MAX	1.2485 1.2505	

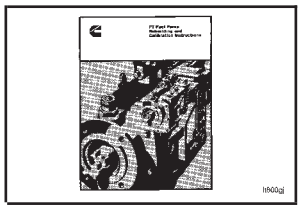
	Part or Assembly	Ref. Point	mm		in
	**Valve Roller Pin O.D.**		12.692 12.700	MIN MAX	0.4997 0.5000
	Injector Roller Pin O.D.		17.772 17.780	MIN MAX	0.6997 0.7000
	**Cam Follower Roller Side Clearance**		0.23 0.61	MIN MAX	0.009 0.024
	**(1) Cam Follower Socket O.D.**		19.063 19.088	MIN MAX	0.7505 0.7515
	(2) Cam Follower Lever Bore I.D.		19.025 19.050	MIN MAX	0.7490 0.7500
	**Press Fit Between Lever and Socket**		0.013 0.064	MIN MAX	0.0005 0.0025

Cam Follower Assembly - Torque Values

Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb	
Cam Follower Shafts Locking Screws		2	15 in-lb	
Eccentric Set Screws		70	50	
Solenoid Valve Jam Nut		5	45 in-lb	
Air Filter Adapter		3	25 in-lb	
Air Filter Elbow		3	25 in-lb	
Air Filter		3	25 in-lb	
Actuator Shaft Capscrews		25	20	
Actuator Shaft Retaining Capscrew		60	45	

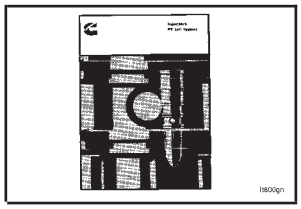
Note: The heads of the locking screws **must** be flush or below flush with the gasket surface of the cam follower housing.

Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
 **Spring Retainer Lock Nut**		45	35
 **Actuator Cap**		40	30



Fuel Pump - Rebuild Specifications

The disassembly, inspection, repair, assembly and calibration procedures for the fuel pump are covered in PT Fuel Pump Rebuilding and Calibration Instructions, Bulletin No. 3379084.



Injectors - Rebuild Specifications

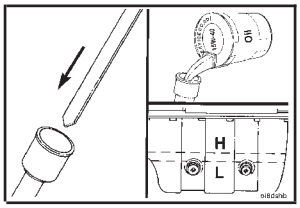
The disassembly, inspection, repair and calibration procedure for the injectors are covered in the following bulletins:

For STC Injectors:
- Shop Manual PT (type D) Step Timing Control Injector, Bulletin No. 3810313.

For Top-Stop Injectors:
- Shop Manual PT (type D) Top Stop Injectors, Bulletin No. 3810344.

Part or Assembly	Ref. Point	Liters		U.S. Gallons

Lubricating Oil System - Capacities



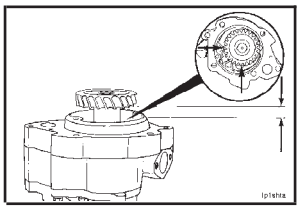
Oil Pan Capacity:

• Automotive		30	Low	8.0
		35	High	9.5
• Industrial		22.7	Low	6.0
		26.5	High	7.0

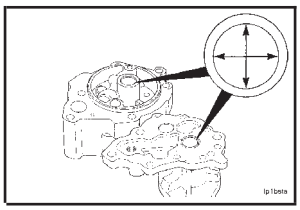
Refer to Lubrication System Specifications, page 18-3, for additional specifications.

Part or Assembly	Ref. Point	mm		in

Lubricating Oil Pump - Inspection Specifications

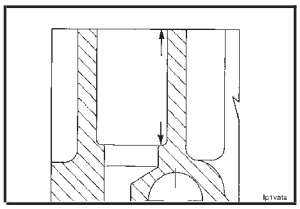


Lubricating Oil Pump Drive Shaft End Clearance	0.05	MIN	0.002
	0.13	MAX	0.005



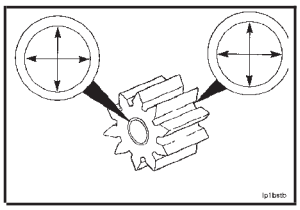
Lubricating Oil Pump Body and Cover Bushing I.D.	22.28	MIN	0.877
	22.33	MAX	0.879

Note: If the bushings are worn larger than the maximum given, the bushings **must** be replaced.



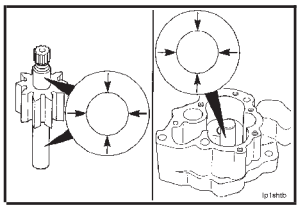
Valve Seat Depth	46.73	MAX	1.840

Note: If the valve seat depth is greater than the maximum specifications given, the oil pump body **must** be replaced.

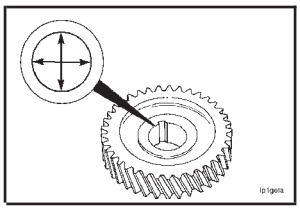


Lubricating Oil Pump Driven Gear Bushing I.D.	22.28	MIN	0.877
	22.33	MAX	0.879

Note: If the bushings are worn larger than the maximum given,the bushings **must** be replaced.

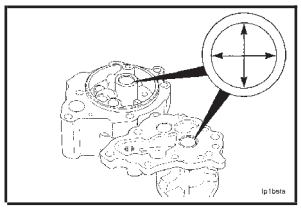
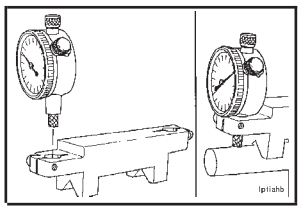
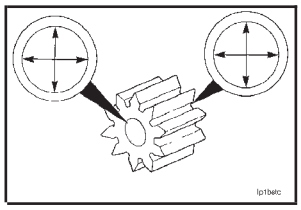
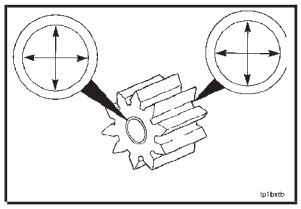
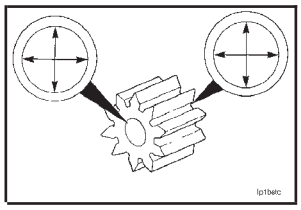
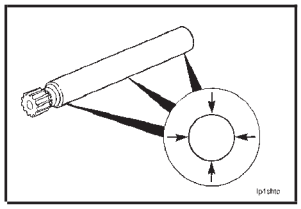
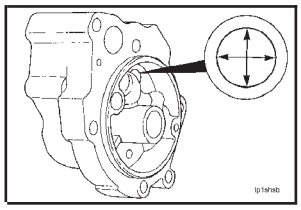


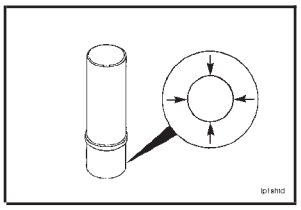
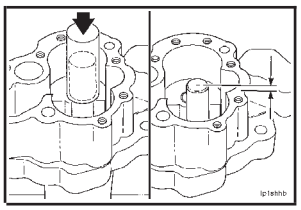
Lubricating Oil Pump Drive Shaft O.D.	22.20	MIN	0.874
	22.22	MAX	0.875

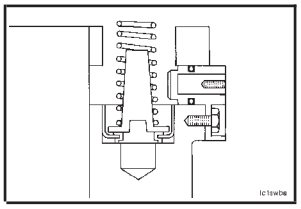
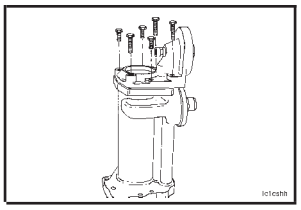
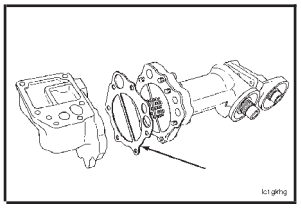
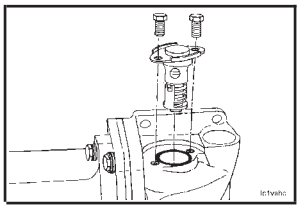
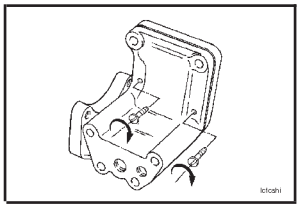


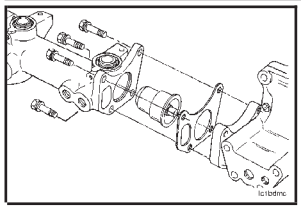
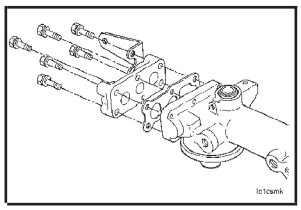
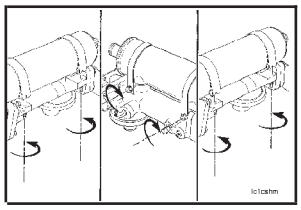
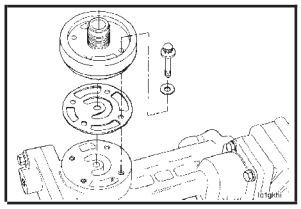
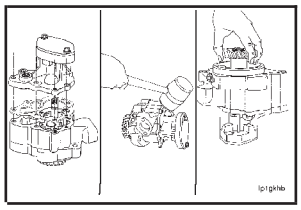
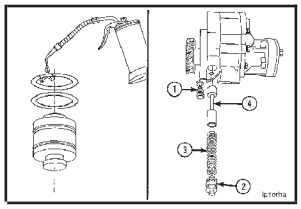
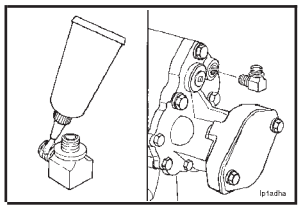
Main Drive Gear Bore I.D.	22.161	MIN	0.8725
	22.187	MAX	0.8735

Note: If the main drive gear bore is worn beyond the maximum limit, the drive gear **must** be replaced.

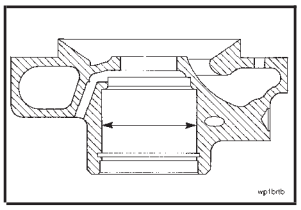
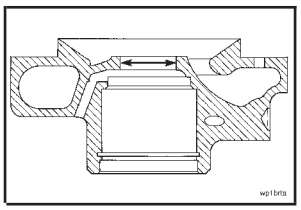
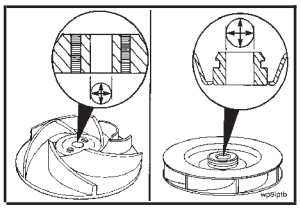
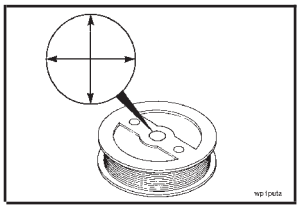
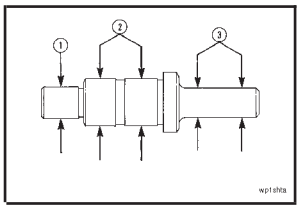
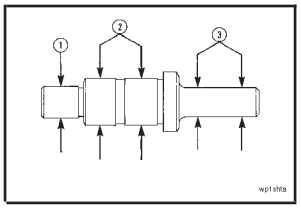
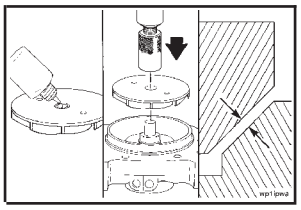
Part or Assembly	Ref. Point	mm		in
 **Lubricating Oil Pump Body and Cover Bushing Bore I.D.**		25.387 25.413	MIN MAX	0.9995 1.0005
 **Bushing I.D. (New)**		22.28 22.30	MIN MAX	0.877 0.878
 **Driven Gear Bushing Bore I.D.**		25.387 25.413	MIN MAX	0.9995 1.0005
Note: If the bushing bore inside diameter is **not** within specifications, the gear **must** be replaced.				
 **Bushing I.D. (New)**		22.28 22.30	MIN MAX	0.877 0.878
 **Drive Gear Bore I.D.**		22.187 22.200	MIN MAX	0.8735 0.8740
Note: If the bore inside diameter is **not** within specifications, the gear **must** be replaced.				
 **Drive Shaft O.D.**		22.20 22.22	MIN MAX	0.874 0.875
Note: Shafts that are damaged or worn smaller than the minimum given **must** be replaced.				
 **Driven Shaft Bore I.D.**		22.263 22.289	MIN MAX	0.8765 0.8775
Note: If the shaft bore diameter is **not** within specifications, the pump body **must** be replaced.				

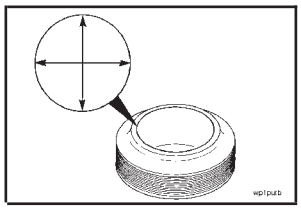
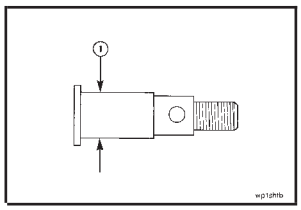
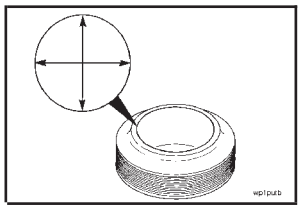
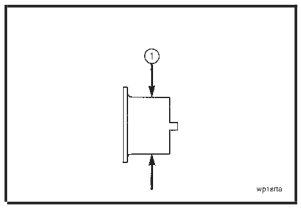
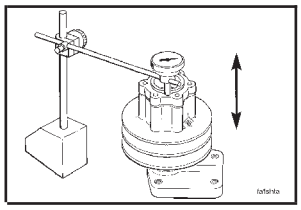
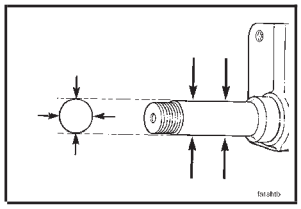
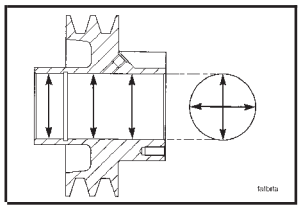
Part or Assembly	Ref. Point	mm		in	
Driven Shaft Press Fit Area O.D.		22.301 22.314	MIN MAX	0.8780 0.8785	
Driven Shaft Protrusion		17.90 18.67	MIN MAX	0.705 0.735	

Part or Assembly	Step	Torque Values N•m	ft-lb	
Lubricating Oil System - Torque Values				
Sending Unit Capscrew (Big Cam IV and New Big Cam IV)		15	120 in-lb	
Filter Head Capscrews (Big Cam IV and New Big Cam IV)		45	35	
Oil Cooler Support to Cooler Housing Capscrews (Big Cam IV and New Big Cam IV)		45	35	
Bypass Valve Capscrews (Big Cam IV and New Big Cam IV)		40	30	
Oil Cooler Support Self-Tapping Screws (88 Big Cam IV)		12	110 in-lb	

	Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
	**Oil Cooler Connection (Housing) to Support Capscrews (88 Big Cam IV)**		45	35
	**Rear Cover to Oil Cooler Connection (Housing) Capscrews (88 Big Cam IV)**		45	35
	**Oil Cooler Core Holddown Clamp Nuts and Capscrews (88 Big Cam IV)** Tighten the nuts and the capscrews in the following sequence: • Nuts **Note:** Tighten the nuts alternately in 3 N•m [25 in-lb] increments: • Capscrews • Nuts		 6 25 8	 50 in-lb 20 75 in-lb
	**Oil Filter Head to Connection (Housing) Capscrews (88 Big Cam IV)**		20	15
	**Lubricating Oil Pump Cover to Body Capscrews**		25	20
	**Oil Pressure Regulator Retainer Plug Capscrew**		25	20
	**DFC Signal Line Adapter Elbow**		11	100 in-lb

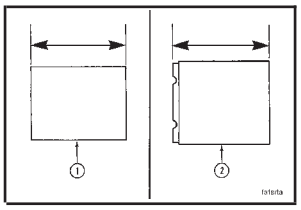
Water Pump Assembly - Rebuild Specifications

Part or Assembly	Ref. Point	mm		in	
Water Pump Body Bearing Bore I.D.		61.991 62.017	MIN MAX	2.4406 2.4416	
Water Pump Body Seal and Seat Assembly Bore I.D.		36.45 36.47	MIN MAX	1.435 1.436	
Water Pump Impeller Bore I.D.		15.85 15.88	MIN MAX	0.624 0.625	
Water Pump Drive Pulley Bore I.D.					
• Pre-88 NT		16.924 16.949	MIN MAX	0.6663 0.6673	
• 88 NT		15.85 15.88	MIN MAX	0.624 0.625	
Water Pump Shaft Journals O.D. (Big Cam IV and New Big Cam IV)	1	17.000 17.008	MIN MAX	0.6693 0.6696	
	2	25.001 25.011	MIN MAX	0.9843 0.9847	
	3	15.905 15.918	MIN MAX	0.6262 0.6267	
Water Pump Shaft Journals O.D. (88 Big Cam IV)	1	15.905 15.918	MIN MAX	0.6262 0.6267	
	2	25.011 25.022	MIN MAX	0.9847 0.9851	
	3	15.905 15.918	MIN MAX	0.6262 0.6267	
Water Pump Impeller Vane To Body Clearance					
• Phenolic		0.25 0.51	MIN MAX	0.010 0.020	
• Cast Iron		0.51 1.02	MIN MAX	0.020 0.040	

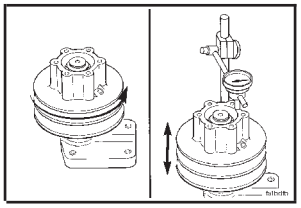
	Part or Assembly	Ref. Point	mm		in
	**Water Pump Idler Pulley Bearing Bore I.D.** **(Big Cam IV and New Big Cam IV)**		61.996 62.012	MIN MAX	2.4408 2.4414
	**Idler Shaft O.D.** **(Big Cam IV and New Big Cam IV)**		24.989 25.011	MIN MAX	0.9838 0.9847
	**Idler Pulley Bearing Bore I.D.** **(88 Big Cam IV)**		51.961 51.986	MIN MAX	2.0457 2.0467
	**Bearing Spacer O.D.** **(88 Big Cam IV)**		24.935 24.986	MIN MAX	0.9817 0.9837
	**Fan Hub Shaft End Clearance**		0.08 0.25	MIN MAX	0.003 0.010
	**Fan Hub Shaft O.D.**		34.912 34.925	MIN MAX	1.3745 1.3750
	**Fan Hub Bore I.D.**		65.038 65.075	MIN MAX	2.5605 2.5620

Fan Hub - Inspection Specifications

Part or Assembly	Ref. Point	mm		in
Inner Bearing Spacer Length	(1)	50.78 50.82	MIN MAX	1.999 2.001
Outer Bearing Spacer Length	(2)	50.67 50.75	MIN MAX	1.995 1.998

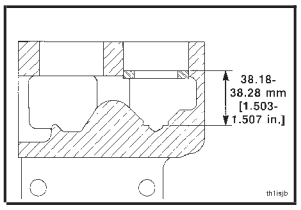


Fan Hub End Clearance		0.08 0.25	MIN MAX	0.003 0.010

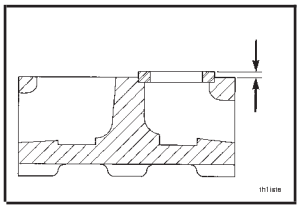


Thermostat Housing Assembly - Rebuild Specifications

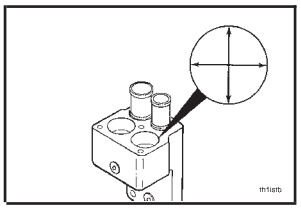
Radiator Thermostat Seat Height (Big Cam IV and New Big Cam IV)		38.18 38.28	MIN MAX	1.503 1.507



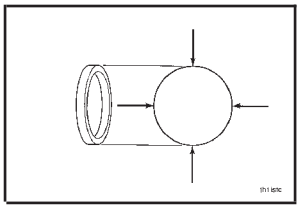
Bypass Thermostat Seat Protrusion (Big Cam IV and New Big Cam IV)				
• 49 State Engine (EPA Certified)		3.18 3.56	MIN MAX	0.125 0.140
• 50 State Engine (EPA and CARB Certified)		4.70 5.00	MIN MAX	0.185 0.197



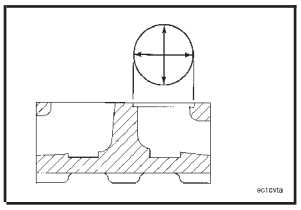
Radiator Thermostat Seat Bore I.D. (Big Cam IV and New Big Cam IV)		44.386 44.437	MIN MAX	1.7475 1.7495

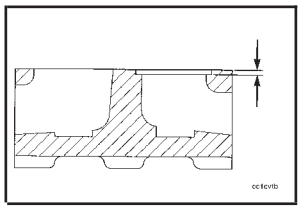
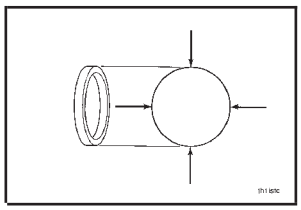
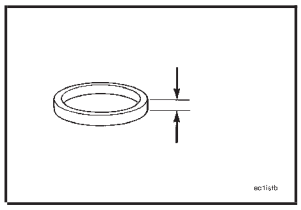
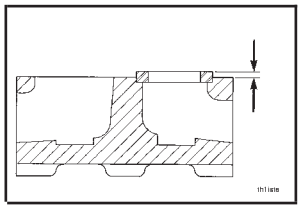


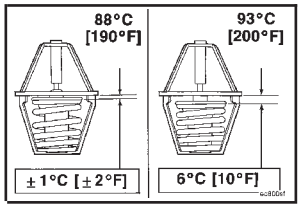
Radiator Thermostat Seat O.D. (Big Cam IV and New Big Cam IV)		44.462 44.513	MIN MAX	1.7505 1.7525



Bypass Thermostat Seat Bore I.D. (Big Cam IV and New Big Cam IV)		44.386 44.437	MIN MAX	1.7475 1.7495



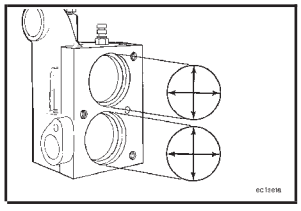
Part or Assembly	Ref. Point	mm		in
 **Bypass Thermostat Seat Counterbore Depth (Big Cam IV and New Big Cam IV)**		2.92 3.17	MIN MAX	0.115 0.125
 **Bypass Thermostat Seat O.D. (Big Cam IV and New Big Cam IV)**		44.462 44.513	MIN MAX	1.7505 1.7525
 **Bypass Thermostat Seat Thickness (Big Cam IV and New Big Cam IV)**				
• 49 State Engine (EPA Certified)		6.35 6.48	MIN MAX	0.250 0.255
• 50 State Engine (EPA and CARB Certified)		7.87 7.92	MIN MAX	0.310 0.312
 **Bypass Thermostat Seat Protrusion (Big Cam IV and New Big Cam IV)**				
• 49 State Engine (EPA Certified)		3.18 3.56	MIN MAX	0.125 0.140
• 50 State Engine (EPA and CARB Certified)		4.70 5.00	MIN MAX	0.185 0.197

Part or Assembly	Ref. Point	Degree °C		Degree °F
				

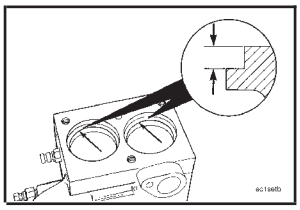
Thermostat (Reserve Flow Cooling) - Operating Temperature

Optimized Aftercooling Thermostat:

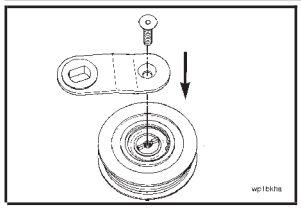
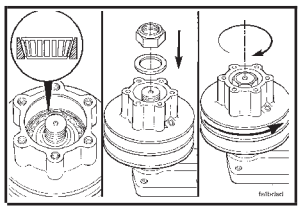
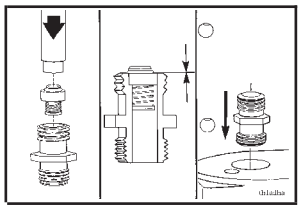
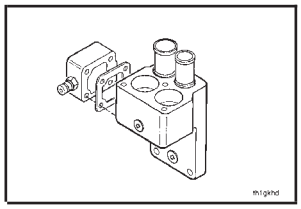
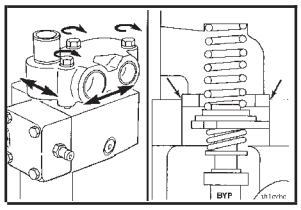
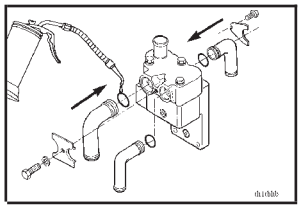
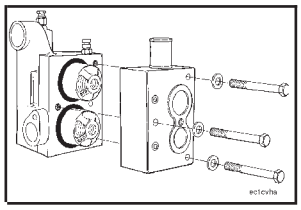
• Initial Opening Temperature	87°C 89°C	MIN MAX	188°F 192°F
• Fully Open Temperature	93°C	MAX	200°F
• Maximum Open Distance	5.08 mm	MAX	0.200 in.

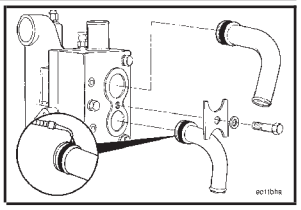
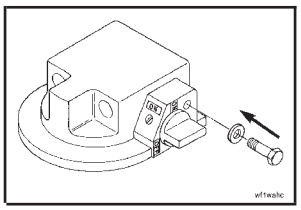
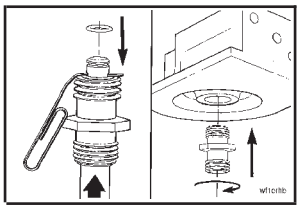
Part or Assembly	Ref. Point	mm		in
 **Thermostat Rectangular Seal Bore I.D.**				
• Radiator Thermostat		66.55 66.80	MIN MAX	2.620 2.630
• Bypass Thermostat		66.55 66.80	MIN MAX	2.620 2.630

Part or Assembly	Ref. Point	mm		in
Thermostat Rectangular Seal Bore Depth				
• Radiator Thermostat		5.03 5.13	MIN MAX	0.198 0.202
• Bypass Thermostat		5.03 5.13	MIN MAX	0.198 0.202

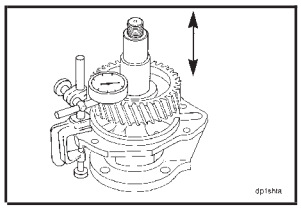
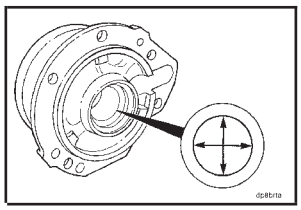
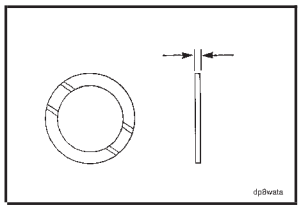
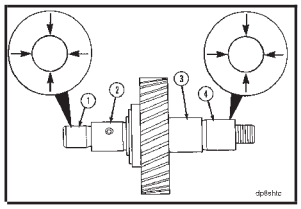
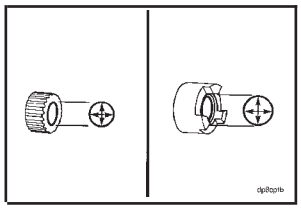
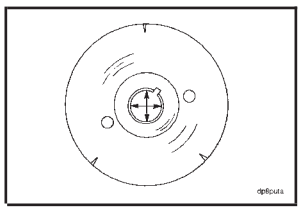
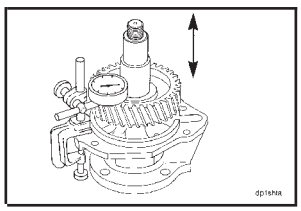


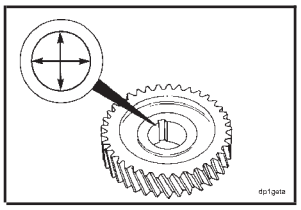
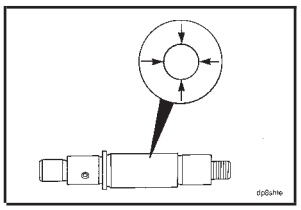
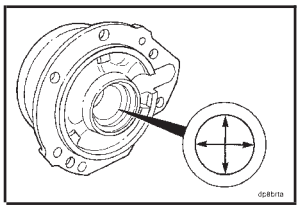
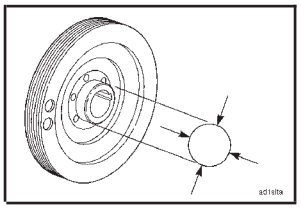
Cooling System -Torque Values

	Part or Assembly	Step	Torque Values N•m	Torque Values ft-lb
	**Assembly of the Water Pump Idler (Flat Head Capscrew)**		40	30
	**Fan Hub Lock Nut**		205	150
	**Filter Head Adapter in the Housing (Big Cam IV and New Big Cam IV)**		45	35
	**Water Transfer Cover to Thermostat Housing (Big Cam IV and New Big Cam IV)**		25	20
	**Bypass Thermostat Seat Cover (Big Cam IV and New Big Cam IV)**		45	35
	Note: Tighten the cover capscrews alternately so the seat enters the bore correctly.			
	**Water Transfer Tube Clamp Capscrews (Big Cam IV and New Big Cam IV)**		45	35
	**Thermostat Cover Capscrews (88 Big Cam IV)**		45	35

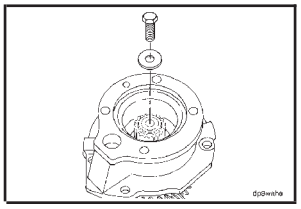
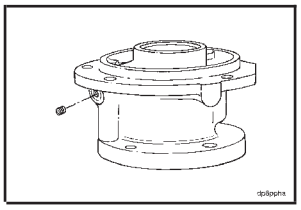
Part or Assembly	Step	Torque Values N•m	ft-lb	
Coolant Transfer Tube Clamp Capscrew (88 Big Cam IV)		45	35	
Coolant Filter Head Retaining Capscrew		20	15	
Coolant Filter Element Adapter		45	35	

Fuel Pump and Compressor Drive - Rebuild Specifications

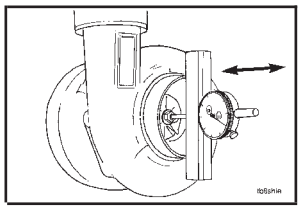
Part or Assembly	Ref. Point	mm		in
				
Drive Shaft End Clearance		0.05 0.30	MIN MAX	0.002 0.012
				
Drive Housing Bushing Bore I.D.		33.43 33.55	MIN MAX	1.316 1.321
				
Thrust Bearing Thickness		2.29 2.41	MIN MAX	0.090 0.095
				
Drive Shaft Journal O.D.				
	1	34.963 34.976	MIN MAX	1.3765 1.3770
	2	39.662 39.674	MIN MAX	1.5615 1.5620
	3	33.274 33.325	MIN MAX	1.3100 1.3120
	4	25.476 25.489	MIN MAX	1.0030 1.0035
				
Splined Coupling I.D.		25.400 25.425	MIN MAX	1.0000 1.0010
Hub Coupling I.D.		25.425 25.438	MIN MAX	1.0010 1.0015
				
Drive Pulley Bore I.D.		34.930 34.950	MIN MAX	1.3752 1.3760
				
Drive Shaft End Clearance		0.05 0.30	MIN MAX	0.002 0.012

Part or Assembly	Ref. Point	mm		in	
Drive Gear Bore I.D.		39.730 39.751	MIN MAX	1.5642 1.5650	
Drive Shaft Gear Fit Journal O.D.		39.789 39.814	MIN MAX	1.5665 1.5675	
Drive Housing Bearing Bore I.D.		36.73 36.75	MIN MAX	1.446 1.447	
Accessory Drive Pulley Wear Sleeve Fit Area O.D.		50.77 50.82	MIN MAX	1.999 2.001	

Fuel Pump and Compressor Drive - Torque Values

Part or Assembly	Step	Torque Values N•m	ft-lb	
Accessory Drive Housing Capscrew		45	35	
Accessory Drive Housing Pipe Plug		8	75 in-lb	

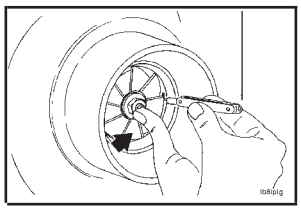
Part or Assembly	Ref. Point	mm		in



Turbocharger - Inspection Specifications

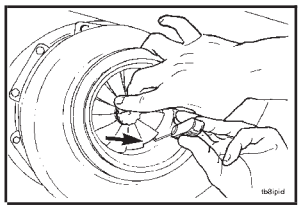
Turbocharger Shaft End Clearance

Model No.			
BHT3B/HT3B	0.03	MIN	0.001
	0.10	MAX	0.004
BHT4C/HT4B	0.05	MIN	0.002
	0.13	MAX	0.005



Turbocharger Compressor Impeller Radial Clearance

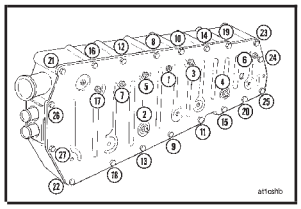
Model No.			
BHT3B/HT3B	0.15	MIN	0.006
	0.46	MAX	0.018
BHT4C/HT4B	0.15	MIN	0.006
	0.46	MAX	0.018



Turbocharger Turbine Wheel Radial Clearance

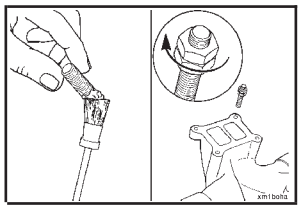
Model No.			
BHT3B/HT3B	0.20	MIN	0.008
	0.53	MAX	0.021
BHT4C/HT4B	0.20	MIN	0.008
	0.53	MAX	0.021

Note: Specifications and instructions for rebuilding the turbocharger are provided in the Turbocharger Component Shop Manuals, Bulletin Nos. 3810230 or 3810241, for Holset turbochargers.



Aftercooler Assembly Capscrews

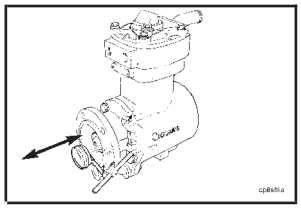
Torque Value: 40 N•m [30 ft-lb]



Exhaust Manifold Flange To Turbocharger Mounting Stud Torque

Torque Value: 40 N•m [30 ft-lb]

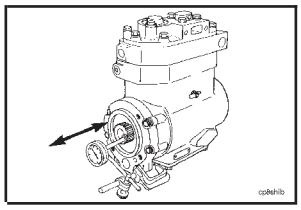
Note: Apply a coat of anti-seize compound to the threads. Use two mounting nuts locked together to tighten the studs.



Air Compressor - Inspection Specifications

Single Cylinder Air Compressor Crankshaft End Clearance	0.05	MIN	0.002
	0.15	MAX	0.006

Note: Specifications and instructions for rebuilding the single cylinder air compressor are provided in the Air Equipment Rebuild Manual, Bulletin No. 3810242.



Two Cylinder Air Compressor Crankshaft End Clearance	0.05	MIN	0.002
	0.19	MAX	0.008

Note: Specifications and instructions for rebuilding the two cylinder air compressor are provided in the Air Equipment Rebuild Manual, Bulletin No. 3810257.

Part or Assembly	Ref. Point	mm	in

Engine Testing - Test Specifications

Note: The specifications and instructions for testing the engine are provided this manual. Refer to Engine Testing - Group 14, Page 14-1.

Vehicle Braking - Rebuild Specifications

Note: The specifications and instructions for rebuilding the Jacobs® Brake are provided in the Jacobs® Brake Installation Manual. Refer to Vehicle Braking - Group 20, Page 20-1.

Section 20 - Vehicle Braking - Group 20

Section Contents

Vehicle Braking - General Information

Jacobs® Engine Brake

For installation and adjustment of the Jacobs® Engine Brake, Models 440 (STC engines) and 445 (CELECT™ engines), refer to the installation and parts manuals. The installation manual and the parts manual can be purchased from a Jacobs® Engine Brake dealer or refer to the manufacturer at the following address:

The Jacobs® Manufacturing Company
Vehicle Equipment Division
22 East Dudley Town Road
Bloomfield, CT 06002
U.S.A.
Telephone: (203) 243-1441

Cummins C Brake

A compression brake is a device that uses the energy of the engine compression to provide vehicle retardation. Cummins C Brakes provide the maximum retarding power at governed engine speeds; therefore, gear selection is important. For installation, operation, maintenance, troubleshooting and repair of the Cummins C Brake, refer to the following service publications:

Bulletin No.	Title of Publication
3810473	Troubleshooting and Repair Manual C-14C Model C-Brake
3810484	Installation Manual C-14C Model C-Brake
3810256	Operation and Maintenance Manual C14C Series Engine Brake

Component Manufacturers

NOTE: The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers can be contacted directly for any specifications **not** covered in this manual.

Air Cylinders

Bendix Ltd.
Douglas Road
Kingswood
Bristol
England
Telephone: 0272-671881

Catching Engineering
2101 Roberts Drive
Broadview, IL 60153
Telephone: (312) 344-2334

Air Heaters

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Kim Hotstart Co.
West 917 Broadway
Spokane, WA 99210
Telephone: (509) 534-6171

Air Starting Motors

Ingersoll Rand
Chorley New Road
Horwich
Bolton
Lancashire
England
BL6 6JN
Telephone: 0204-65544

Ingersoll-Rand Engine
Starting Systems
888 Industrial Drive
Elmhurst, IL 60126
Telephone: (312) 530-3800

StartMaster
Air Starting Systems
A Division of Sycon Corporation
P. O. Box 491
Marion, OH 43302
Telephone: (614) 382-5771

Alternators

Robert Bosch Ltd.
P.O. Box 98
Broadwater Park
North Orbital Road
Denham
Uxbridge
Middlesex UD9 5HG
England
Telephone: 0895-833633

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st St.
Cleveland, OH 44013
Telephone: (216) 431-0740

Auxiliary Brakes

The Jacobs Manufacturing Company
Vehicle Equipment Division
22 East Dudley Town Road
Bloomfield, CT 06002
Telephone: (203) 243-1441

Belts

Dayco Rubber U.K.
Sheffield Street
Stockport
Cheshire
SK4 1RV
England
Telephone: 061-432-5163

T.B.A. Ind. Products
P.O. Box 77
Wigan
Lancashire
WN2 4XQ
England
Telephone: 0942-59221

Dayco Corp.
Belt Technical Center
P.O. Box 3258
Springfield, MO 65804
Telephone: (417) 881-7440

Gates Rubber Company
5610 Crawfordsville Road
Suite 2002
Speedway, IN 46224
Telephone: (317) 248-0386

Goodyear Tire and
Rubber Company
49 South Franklin Road
Indianapolis, IN 46219
Telephone: (317) 898-4170

Clutches

Twin Disc International S.A.
Chaussee de Namur
Nivelles
Belguim
Telephone: 067-224941

Twin Disc Clutch Co.
Racine, WI 53403
Telephone: (414) 634-1981

Coolant Heaters

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Drive Plates

Detroit Diesel Allison
Division of General Motors
Corporation
P.O. Box 894
Indianapolis, IN 46206
Telephone: (317) 244-1511

Electric Starting Motors

Butec Electrics
Cleveland Road
Leyland
PR5 1XB
England
Telephone: 0744-21663

C.A.V. Electrical Equipment
P.O. Box 36
Warple Way
London
W3 7SS
England
Telephone: 01-743-3111

A.C. Delco Components Group
Civic Offices
Central Milton Keynes
MK9 3EL
England
Telephone: 0908-66001

Delco-Remy
P.O. Box 2439
Anderson, IN 46018
Telephone: (317) 646-7838

Leece-Neville Corp.
1374 E. 51st Street
Cleveland, OH 44013
Telephone: (216) 431-0740

Engine Protection Controls

Teddington Industrial
Equipment
Windmill Road
Sunburn on Thames
Middlesex
TW16 7HF
England
Telephone: 09327-85500

The Nason Company
10388 Enterprise Drive
Davisburg, MI 48019
Telephone: (313) 625-5381

Fans

Truflo Ltd.
Westwood Road
Birmingham
B6 7JF
England
Telephone: 021-557-4101

Hayes-Albion
1999 Wildwood Avenue
Jackson, MI 49202
Telephone: (517) 782-9421

Engineering Cooling Systems
201 W. Carmel Drive
Carmel, IN 46032
Telephone: (317) 846-3438

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McCordsville, IN 46055
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8777 Purdue Rd.
Indianapolis, IN 46268
Telephone: (317) 872-0030

Kysor
1100 Wright Street
Cadillac, MI 49601
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Schwitzer
1125 Brookside Avenue
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Indianapolis, IN 46206
Telephone: (317) 269-3100

Fan Clutches

Holset Engineering Co. Ltd.
P.O. Box 9
Turnbridge
Huddersfield
England
Telephone: 0484-22244

Horton Industries, Inc.
P.O. Box 9455
Minneapolis, MN 55440
Telephone: (612) 378-6410

Rockford Division
Borg-Warner Corporation
1200 Windsor Road
P.O. Box 7007
Rockford, IL 61125-7007
Telephone: (815) 633-7460

Transportation Components Group
Facet Enterprises, Inc.
Elmira, NY 14903
Telephone: (607) 737-8212

Filters

Fleetguard International Corp.
Cavalry Hill Industrial Park
Weedon
Northampton NN7 4TD
England
Telephone: 0327-41313

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Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Flexplates

Corrugated Packing and
Sheet Metal
Hamsterley
Newcastle Upon Tyne
Telephone: 0207-560-505

Detroit Diesel Allison
Division of General Motors
Corporation
P.O. Box 894
Indianapolis, IN 46206
Telephone: (317) 244-1511

Detroit Diesel Allison
Division of General Motors
36501 Van Born Road
Romulus, MI 48174
Telephone: (313) 595-5711

Midwest Mfg. Co.
30161 Southfield Road
Southfield, MI 48076
Telephone: (313) 642-5355

Fuel Warmers

Fleetguard, Inc.
Route 8
Cookeville, TN 38501
Telephone: (615) 526-9551

Gauges

A.I.S.
Dyffon Industrial Estate
Ystrad Mynach
Hengoed
Mid Glamorgan
CF8 7XD
England
Telephone: 0443-812791

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Vale Rise
Tonbridge
Kent
TN9 1TB
England
Telephone: 0732-359888

Icknield Instruments Ltd.
Jubilee Road
Letchworth
Herts
England
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21 Princip Street
Birmingham
B4 61E
England
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Cranborne Road
Potters Bar
Herts
EN6 3JP
England
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East Petersburg, PA 17520
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11637 Denton Drive
Dallas, TX 75229
Telephone: (214) 241-2161

Governors

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663/664 Ajax Avenue
Slough
Bucks
SL1 4DD
England
Telephone: 0753-26835

Woodward Governor Co.
1000 E. Drake Road
Fort Collins, CO 80522
Telephone: (303) 482-5811

Barber Colman Co.
1300 Rock Street
Rockford, IL 61101
Telephone: (815) 877-0241

United Technologies
Diesel Systems
1000 Jorie Blvd.
Oak Brook, IL 60521
Telephone: (312) 325-2020

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Priory Road
Strood
Rochester
Kent
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Telephone: 0634-71773

Honeywell Control Systems Ltd.
Honeywell House
Charles Square
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Telephone: 0344-424555

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Cheney Manor Trading Estate
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SN2 2PZ
England
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Sperry Vickers
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Troy, MI 48084
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P.O. Box 1340
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5-9 D7070
Schwaebisch Gmuend
West Germany
Telephone: 7070-7171-31510

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Cookeville, TN 38501
Telephone: (615) 526-9551

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Spokane, WA 99210
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Torque Converters

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Nivelles
Belgium
Telephone: 067-224941

Twin Disc Clutch Co.
Racine, WI 53403
Telephone: (414) 634-1981

Rockford Division
Borg-Warner Corporation
1200 Windsor Road
P.O. Box 7007
Rockford, IL 61125-7007
Telephone: (815) 633-7460

Modine
1500 DeKoven Avenue
Racine, WI 53401
Telephone: (414) 636-1640

Section L - Service Literature

Section Contents

Additional Service Literature

The following publications can be purchased by filling in and mailing the Service Literature Order Form:

Bulletin No.	Title of Publication
3377575	Service Products Catalog
3379000	Air For Your Engine
3379001	Fuel For Cummins Engines
3379009	Operation - Cold Weather
3379035	Alternative Repair Manual
3379071	Injectors PT (All Types) Rebuild Manual
3379084	Fuel Pump PT (Type G and R) Rebuild and Calibration Instructions
3379099	Wiring Diagrams
3379133	Control Parts List
3379209	Fuel System Publications Subscription Service
3379352	Fuel Pump Calibration Values
3379461	Turbocharger Rebuild Manual (H2B, H2C, and HC3)
3379664	Injector Parts Flow and Cross Reference
3387137	Troubleshooting Driveability Complaints
3387251	Coolant Additives and Filtration
3387245	Troubleshooting Excessive Fuel Consumption
3387266	Cold Weather Operation
3387380	Step Timing Control Familiarization
3810230	HT3B Turbocharger Shop Manual
3810242	Single Cylinder Air Compressor Shop Manual
3810255	C Brake Installation Manual
3810256	Operation and Maintenance Manual C-14C Series Engine Brake
3810257	ST677 Two Cylinder Air Compressor Shop Manual
3810303	Parts Reuse Guidelines
3810313	PT Injector - Step Timing Control Shop Manual
3810316	PACE Master Repair Manual
3810329	Standard Repair Times, NT Series Engines
3810387	Analysis and Prevention of Bearing Failures
3810344	PT Injector - Top Stop Shop Manual
3810441	Troubleshooting and Repair Manual - PT Pacer
3810443	PT Pacer Compulink™ Cartridge Manual
3810444	Operation and Maintenance Manual, N14 Automotive Engines, STC and CELECT™ Models U.S.A., Canada, Australia, New Zealand, and Puerto Rico
3810445	Operation and Maintenance Manual, N14 Automotive Engines, STC and CELECT™ Models Worldwide Excluding U.S.A., Canada, Australia, New Zealand, and Puerto Rico
3810450	NH/NT855 Counterbore Troubleshooting and Repair Manual
3810456	N14 Troubleshooting and Repair Manual
3810469	Troubleshooting and Repair Manual, CELECT™ System N14 Engines
3810473	Troubleshooting and Repair Manual C-14C Model C-Brake
3810484	Installation Manual C-14C Model C-Brake
3884359	N14 COMMAND CELECT™ Parts Catalog

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Region	Ordering Location
United States and Canada	Gannett Direct Marketing Services, Inc. 3400 Robards Court P. O. Box 34470 Louisville, KY 40232-4470
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Brazil and Mexico	International Parts Order Dept. Mail Code 40931 Cummins Engine Company, Inc. Columbus, IN 47202
Far East (excluding Australia and New Zealand)	Cummins Diesel Sales Corp. Literature Center 100-G Pasir Panjang Road Singapore 0511
Australia and New Zealand	Cummins Diesel Australia Maroondah Highway, P.O.B. 139 Ringwood 3134 Victoria, Australia

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